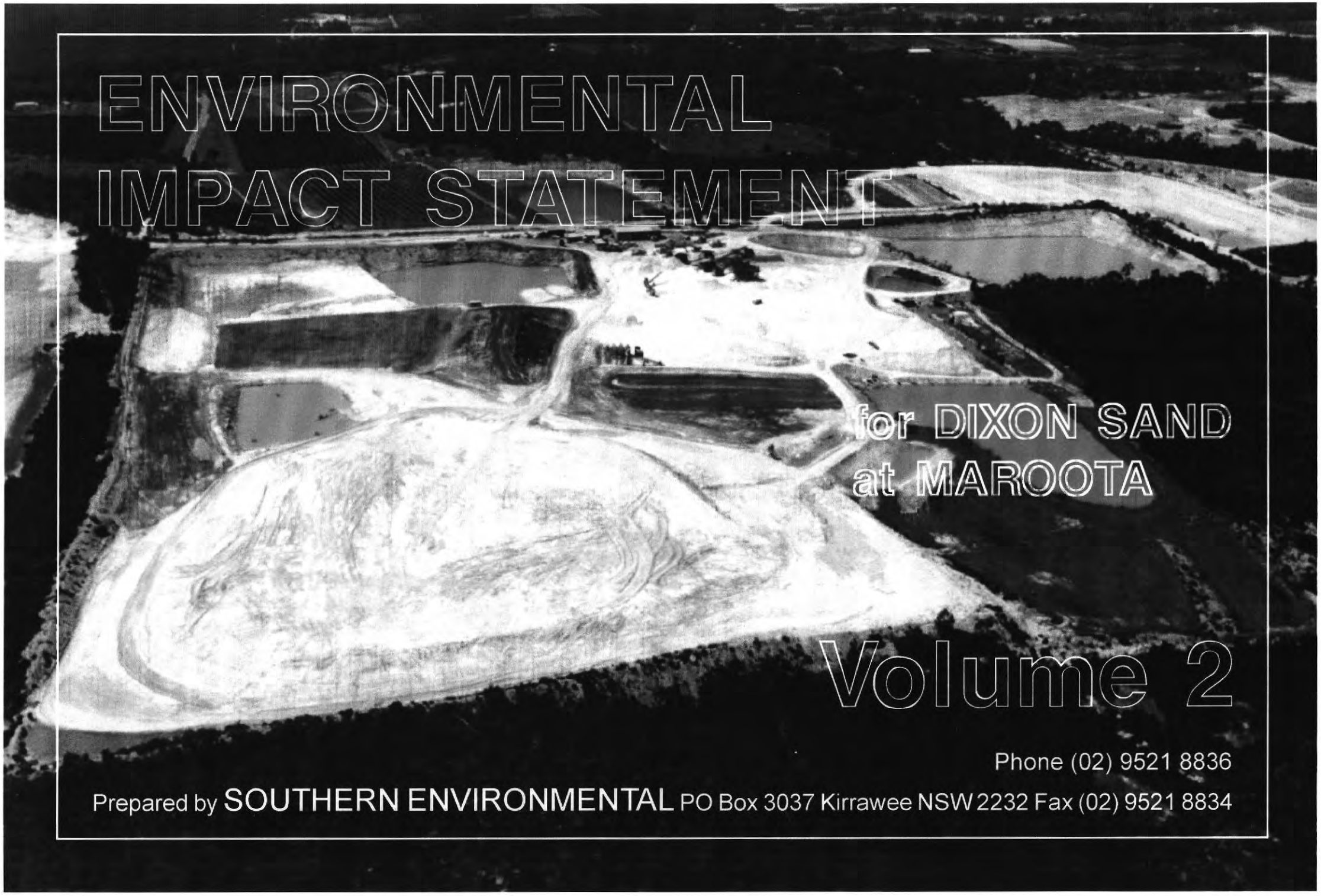

ENVIRONMENTAL IMPACT STATEMENT

for DIXON SAND at MAROOTA

Volume 2

Phone (02) 9521 8836

Prepared by SOUTHERN ENVIRONMENTAL PO Box 3037 Kirrawee NSW 2232 Fax (02) 9521 8834

DIXON SAND (PENRITH) PTY LTD

EXTRACTION, REHABILITATION AND PROCESSING OF CONSTRUCTION SANDS, LOTS 196 AND 29, DP 752025 NORTH MAROOTA, NSW

VOLUME 2: EIS APPENDICES

Prepared by:

SOUTHERN ENVIRONMENTAL Pty Ltd
in association with

Benbow Group
Gunninah Environmental Consultants Pty Ltd
Keown & Drummond Pty Ltd
Lyle Marshall & Associates Pty Ltd
P A Eiszele Consulting Engineer Pty Ltd
Soil Consult Pty Ltd
Tessa Corkhill
The Technical Assistance to the Draft Stage:
Lyall & Macoun Consulting Engineers

Preface

Volume 2 of the EIS contains the various supporting study reports prepared for the purposes of compiling the EIS.

They are grouped in three (3) categories:

A. *General*
B. *Background*
C. *Planning and Environmental Assessment*

All of the B and C reports are specialist reports prepared by specialist consultants from within the EIS study team.

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Appendices

CATEGORY A – GENERAL

Appendix A1 – Form 2 Certificate

Submission of Environmental Impact Statement (EIS) prepared under the Environmental Planning and Assessment Act, 1979, Section 73A(8)

FORM 2	**SUBMISSION OF ENVIRONMENTAL IMPACT STATEMENT (EIS)** Prepared under the Environmental Planning and Assessment Act 1979 – Section 78A (8)
EIS Prepared By Name: Qualifications: Address:	 Stephen Smith B.Sc.Eng., Meng. Sc. 36 Peebles Ave., Kirrawee NSW 2232
Development Application Applicant Name: Applicant Address: Address of Development: Proposal:	 DIXON SAND (PENRITH) PTY LIMITED ACN 002 278 686 PO Box 148 Penrith NSW 2751 Lots 29 &196, DP 752025 North Maroota NSW Extraction, Rehabilitation and Processing of Construction Sands.
CERTIFICATE Signature	I certify that I have prepared the contents of this Statement and to the best of my knowledge ◆ It is in accordance with Clause 54A and 55 of the *Environmental Planning and Assessment Regulation 1994*, and ◆ It is true in all material particulars and does not, by its presentation or omission of information, materially mislead. Stephen Smith June 1, 1999

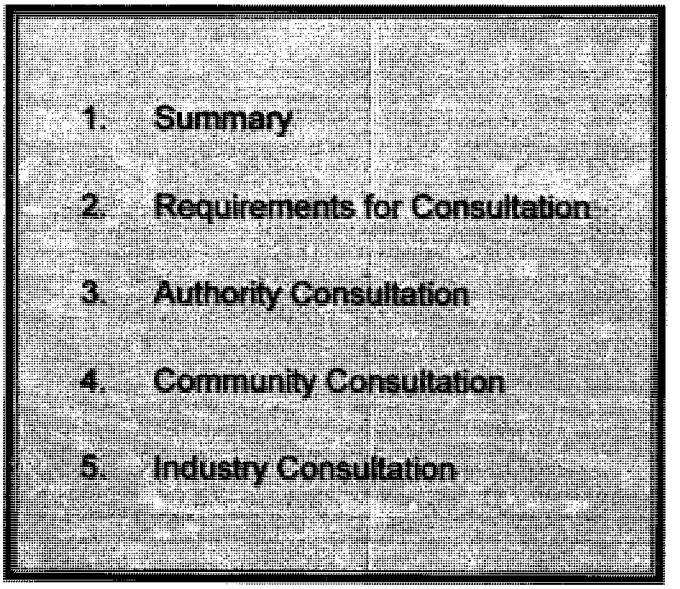
Appendix A2 – Study Team

EIS CONTRIBUTORS

Author	Affiliation	Area of Contribution
Carl Vincent	DLWC	Rehabilitation
Steve Smith	Southern Env.	Water Management
Lyle Marshall	Lyle Marshall & Associates	Traffic
Malcolm Drummond	Keown & Drummond	Land and Quantity Survey
Dominic Fanning	Gunninah Environmental Consultants	Flora and Fauna
Derek Langgons	Benbow Group	Noise Assessment
Phil Eiszele	P Eiszele Consulting Engineering	Materials Handling and Processing
Tessa Corkhill	Archaeics	Archaeology
Jill Wright	LMCE	Community Consultation
Steve Smith	Southern Env.	Document Co-ordination

ACKNOWLEDGEMENTS
There have been many Government offices, Councils and Community Groups that have contributed to this EIS by the provision of information. Their assistance has been highly valued and appreciated.

Appendix A3 – Consultation



Prepared by Southern Environmental Pty Ltd

This Annexure was updated from a draft prepared by Lyall & Maccoun Consulting Engineers, who undertook the earlier community surveys.

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1.0 INTRODUCTION

The EIS that this Annexure is attached to has been written after a consultative process with the local community as well as the relevant Statutory Authorities including Baulkham Shier Council. After the preparation of the EIS a public exhibition of the Development Application and a wide ambit for consultation is to be further undertaken. All of this exercise is to ensure that the community is not unfairly disadvantaged by the proposal. This is reinforced by the principles of Ecologically Sustainable Development (ESD).

Indeed, two of the key principles of (ESD) are:

- Intergenerational equity; and
- Intragenerational equity

One of the other principles of ESD is related to the "internalisation" of "intangibles". This is one way of ensuring that all environmental costs and benefits are somehow quantified and incorporated into the decision making process, to ensure that there is an appropriate balance between project benefits and project costs, (or at the least the decision maker is aware of the full contect).

All development has the potential to create adverse impacts. The planning system for new developments starts from the *"do nothing"* proposition. However, development is only put forward if it can create economic benefits and it is a role of the EIS to evaluate both benefits and impacts, so as to attempt to support the development, but only provided that the development is sustainable (in an ecological sense) and that the impacts can be managed to levels determined by the Government agencies (on behalf of the community) as being acceptable.

Hence, one of the key tasks in the preparation of any EIS, is to identify the issues that may be of concern to the community, Government agencies, etc. and this is done through the process of consultation.

Consultation plays a key part in any EIS preparation and it is identified as such in all EIS guidelines, such as DCP 500 and the DUAP EIS Guidelines.

There are many interested parties of stakeholders with most developments. They are:

- The community, and particularly, the local community (because they have the greatest potential for being adversely affected by the development).
- The Government, including Local, State and sometimes Federal Government, who may have legislative responsibilities for the management of the industry, the

management of "resources" utilised by the industry or more often, the management of the environmental effects of the project.

- The consumers or purchasers of the product.

It is appropriate to consider the views, concerns, etc. of all parties.

This report provides:

- A review of the requirements for consultation.
- Details of the consultation with Government authorities.
- Details of the consultation with the community.
- Details of the consultation with the industry.

There are also a series of attachments provided and copies of other documents.

2.0 REQUIREMENTS FOR CONSULTATION

2.1 DCP 500

Section 2.1, Community Participation, of the DCP, sets the following objectives:

- *"To achieve internationally and nationally recognised environmental standards and practices.*
- *To promote sustainable local economies and associated employment opportunities.*
- *To assist in the conservation of the cultural and biological diversity of the Shire.*
- *To maintain the overall quality of life existing in future Shire residents."*

The performance criteria and protective measures are summarised below:

- Community participation should be undertaken in the preparation of an assessment for the management of extractive industries.
- Proponents are encouraged to interact with the permanent residents and local community groups.
- Proponents should ensure that community views, values and concerns are identified, recognised, assessed and responded to.
- Proponents are encouraged to engage local community groups to assist in the planning, operation and management of the project.
- Proponents may be required to establish a management committee, to include local representatives.
- Proponents are encouraged to promote a better understanding of the industry, by becoming involved with the community.

Figure 3, Development Application Process, contained within DCP 500, identifies the role of both the steps in community and Government consultation. At the outset, consultation is suggested with Government agencies, community groups and Council's Development Control Department. Proponents should also arrange a public meeting with the local community.

Several meeting have been held with Council pior to the lodgment of this EIS. .

Opportunities for comment and review by the community, Council and public authorities are provided during the exhibition period when the EIS must be placed on public exhibition for a minimum 30 day period.

2.2 DUAP EIS Guidelines

The Guideline in Section 3, entitled Consultation, starts with:

> *"Early consultation with the local community, industry, councils and government agencies can be of great assistance when making a preliminary assessment of the potential viability of a proposal at a particular site. It can also assist in assuring that the EIS is focussed on those matters which will add value to the decision making process."*

This section goes on to recommend various consultation procedures with Government agencies, the community and the requirement under the legislation for formal consultation with the Director General of the Department.

In the section on consultation with the community, the following recommendations are made:

> *"The community likely to be affected whether directly or indirectly should be informed of the proposal and consulted early in the EIA process. Consultation should aim to included affected individuals, community groups and groups with special interests such as Local Aboriginal Land Councils."*
>
> *For major or controversial projects a program of community consultation may need to be undertaken as part of the preparation of the EIS. This program would usually include two phases, one seeking to inform the community (for instance, involving public meeting, public display or newsletters) and one seeking to gain input on issues of community concern, to identify community values and to identify and evaluate alternatives (for instance, involving community focus meetings, issues workshops and community surveys).*

3.0 AUTHORITY CONSULTATION

3.1 Planning Focus Process

A planning focus process was undertaken with the relevant Government agencies. The process involved:

- Letters to all Government agencies, advising them of the proposal to prepare an EIS, outlining the scope of that EIS and requesting their attendance at a meeting on-site, to obtain a further briefing on the scope of the development and importantly, to inspect the site of the development.

- A first planning focus meeting on-site was held on 27th May 1998. The following agencies attended:
  - Department of Land and Water Conservation
  - Department of Mineral Resources
  - Roads and Traffic Authority
  - NSW Agriculture
  - Cattai Catchment Management Committee
  - Hawkesbury-Nepean Catchment Management Trust
  - Baulkham Hills Council
  - Environment Protection Authority
  - Department of Urban Affairs and Planning

- A second meeting was held on 10th February 1999, to review the findings of the EIS and to discuss with representatives, issues that had arisen, solutions that were proposed and specific matters that had not been resolved. The following agencies were in attendance:
  - Department of Land and Water Conservation
  - National Parks and Wildlife Service
  - Department of Mineral Resources
  - Department of Agriculture
  - Department of Education
  - Baulkham Hills Council

At both of the meetings, some one or two agencies were unable to attend. Each agency invited however, was provided with a copy of the Briefing Papers, attendance list, agenda and in the case of the first meeting, the findings and recommendations that came from the meeting.

In most cases, the agencies that attended the first planning focus meeting had provided responses as to their requirements for the EIS, prior to the meeting. Those responses were reviewed and in a number of cases, supplementary letters were provided to clarify certain matters and issues or to add additional issues.

At the second planning focus meeting, a month or so before the lodgement of the development application, additional letters of clarification were sought to resolve key issues that at that time, were still outstanding.

In addition, throughout the process of the EIS preparation, that extended from April 1998 to June 1999 (a period of 14 months), a series of *Briefing Papers* were issued by Lyall 7 Macoun Consulting Engineers at approximately 6 to 8 week intervals, over that period. The Briefing Papers provided a summary of progress on preparation of the EIS, issues that had arisen since the last Briefing Paper had been issued and an update on the likely timing for completion of the EIS.

3.2 Government Authorities Feedback

There were in fact two consultations with Government. In early July1998, agencies were consulted when it was proposed to extend operations on Lots 1 and 2 to the east. Responses to this proposal have not been discussed here, and this proposal is no longer included in this application.

The following organisations provided written requirements for the EIS:

- Department of Urban Affairs and Planning (DUAP)
- Department of Land and Water Conservation (DLWC)
- Department of Mineral Resources (DMR)
- Hawkesbury-Nepean Catchment Management Trust (HNCMT)
- National Parks and Wildlife Service (NP&WS)
- NSW Agriculture (NSW Ag)
- Environment Protection Authority (EPA)
- Roads and Traffic Authority (RTA)
- Baulkham Hills Shire Council (BHSC)

Summaries of the issues raised in the submissions received are as follows:

❖ Department of Urban Affairs and Planning (DUAP)

DUAP, in their letter of 18th May 1998, set out, under Clause 52, certain key issues:

- *"Sydney Regional Environmental Plan No. 9 (2) Extractive Industry*
- *Sydney Regional Environmental Plan No. 20 – Hawkesbury-Nepean River*

- *State Environmental Planning Policy No. 11 – Traffic Generating Developments*
- *State Environmental Planning Policy No. 33 – Hazardous and Offensive Development*
- *Potential impact on Maroota Sands Swamp Forest, an endangered ecological community, and any other species under the Threatened Species Conservation Act 1995*
- *Potential groundwater and other water quality impacts*
- *Baulkham Hills Development Control Plan No. 500 – Extractive Industry"*

In a further response to a separate matter DUAP provided comment on the relevance of State significance development.

❖ NSW Department of Land and Water Conservation

The Department provided two responses, by letters of 19th and 28th May.

In their letter of 19th May 1998, the DLWC addressed the standard water resources documents that provide for the EIS. The letter also addressed runoff issues including control structures, buildings located close to Crown land and overland flow controls. Requirements for construction of a Crown road and common boundaries with Crown land were also mentioned.

The Department, in their letter of 28th May 1998, specified the following key issues to be addressed in the EIS.

- Crown Lands Issues:
  - setbacks from Crown land
  - use of land that was not identified as suitable under the Crown Lands Act, 1989
  - the depth where freehold title ends and Crown land begins, which limits depth of mining and requires the original topography of the site to be known in detail.
  - closure of Crown roads.
- Groundwater Issues:
  - the position of the watertable needed to be determined as it could restrict the depth of mining
- Soil Conservation Issues:
  - an Erosion and Sediment Control Plan should be prepared in order to comply with the Soil Conservation Act (1938).
  - the DLWC also offered guidelines for the environmental assessment of soil and land management.

❖ NSW Department of Mineral Resources

The DMR, in their letter of 14th May 1998, advised that the Maroota area was classified as containing sand resources of regional significance under Sydney Regional Environmental Plan No. 9 Extractive Industry (No. 2). The DMR advised that the following should be included in the EIS:

- The amount, characteristics and quality of the material to be produced.
- Anticipated annual production and life of operation.
- Alternative sources to the proposal, hence justification for this proposal.

❖ Hawkesbury-Nepean Catchment Management Trust

The HNCMT, in their letter of 18th May 1998, requested that the following issues be addressed:

- Water quality and quantity, including: restrictions on impacts on downstream hydrology; meeting ANZECC and NHMRC guidelines for water quality; and the protection of groundwater.
- Final landform: should not change the rainfall recharge rate that existed prior to disturbance of the site and should be geomorphically stable.
- Protection of flora and fauna: the biodiversity and the ecological integrity of the surrounding streams should be maintained.
- Air quality: dust suppression should be undertaken.
- Rehabilitation: an Environmental Management and Rehabilitation Plan should be prepared.

❖ NSW National Parks & Wildlife Service

The NPWS, in their letter of 18th May 1998, supplied a copy of the Service's *General Guidelines for Impact Assessment*. This document recommended the following issues be addressed in the EIS:

- Environment modification.
- The Local Environmental Plans, Regional Environmental Plans and State Planning Policies should all be considered.
- The past and present uses of the site and surrounding areas.
- Research and consideration of all flora and fauna in the area, especially that of local, regional or State conservation significance. Also, how the site can be adapted to lessen the impact upon these species.
- The impact upon land dedicated under NP&WS.
- Aboriginal heritage issues and community consultation.

- The threatened species legislation enacted in January 1996.

❖ NSW Agriculture

The Department of Agriculture, in their letter of 12th May 1998, suggested the following issues be addressed in the EIS:

- The direct alienation of agricultural land.
- Potential conflict with agricultural activities.
- Potential impact on surface and groundwater quality, quantity and reliability of supply.
- Proposed methods of rehabilitation.

❖ NSW Environment Protection Authority

The EPA, in their letter of 20th May 1998, required that the following issues be addressed:

- Surface water management: a detailed surface water management plan should be included, considering runoff in storm events as well. Preferably it would be a closed system.
- Groundwater management; the impact on groundwater should be assessed, particularly the location of the watertable.
- Air pollution; existing dust levels should be assessed and the deposition that would result from the proposed quarrying estimated. Management strategies need to be addressed to ensure the dust deposition is below EPA limits.
- Noise impact assessment; a noise impact statement should be included which determines the present ambient level, predicts the noise levels at residences and provide noise mitigation measures considered necessary.
- All statutory requirements need to be considered and complied with.

❖ Roads and Traffic Authority

The RTA, in their letter of 14th May 1998, stated they would like the EIS to address the following:

- The proposed means of access to the site.
- Likely daily traffic movements generated by development.
- Assessment of likely impact of truck traffic upon nearby residential areas.
- Details of the anticipated route of trucks through metropolitan road network.

Since their letter of May 1998 the RTA have confirmed that the proposed intersection design for the access road junction with Old Northern Road, see ***Figure 6.13A*** in ***Volume 1***, is acceptable to them.

❖ **Baulkham Hills Council**

The Baulkham Hills Council, in their letter of 7th May 1998, required the assessment of all of the requirements of the following be addressed and complied with in the EIS:

- DCP 500;
- SREP No. 9 and No. 20;
- Baulkham Hills LEP 1991;
- Section 90 of EP&A Act, 1979; and
- Schedules 2 and 3 of EP&A Regulations 1994

The Statutory Requirements for the Preparation of an Environmental Impact Statement under Part 4 of the EP&A Act 1979 and the Department's EIS Guideline "Extractive Industries/Quarries" were also cited as key references.

4.0 COMMUNITY CONSULTATION

4.1 Consultation Methodology

A community consultation program was put in place from the start of the EIS program by Lyall and Macoun. The aim was to inform the community of the proposed Dixon development, and to ascertain and address the concerns of the community

There were a number of phases to the program:

- Conducting a local attitudinal survey
- Establishing of a contact telephone number for enquires about the project
- Mail-out of information brochures, (Briefing Papers) providing regular updates on the EIS preparation.

Residents within a 1 km radius were visited in May 1998 followed up in and July 1998. They were provided with an Information Booklet, and later with updates of the development progress. Those residents absent at the time of the visits were provided with information brochures and a contact telephone number for later discussion of any issue of concern. Amore resent survey of the local residents was undertaken in April 1999. This survey gave general support to the Dixon operation.

Community groups were also identified, and mailed copies of both the booklet and Briefing Papers, encouraging them to convey any concerns to Lyall & Macoun. Copies of the various documents were also posted on the notice board at the primary school.

The Community Groups consulted were:

- Derrubbin Local Aboriginal Land Council
- Maroota Public School Parents & Citizens Association
- Maroota & Districts Residents Association Inc
- Eastbend Community Research Team
- Maroota Planning Group

There are approximately 25 residences located within a 1 km radius, with a community of approximately 80 people. This community ranges from elderly retired couples to young families. 96% of these residents were spoken to directly and surveyed.

The majority of the residences to the north of the site were owner occupied, with families of varying ages. The land associated with these residences was predominantly used for market gardening purposes. To the south, owner occupation was 45%, the balance being rental properties. In the majority of rental cases, tenants

were young couples with children under the age of 10 years. Owner occupants were generally market gardeners.

4.2 Survey Results.

Two written responses were received from the local Primary School

- Maroota Public School Headmaster
- Mr. R Greatrix

The issues raised in discussions were as follows:

- **Truck Traffic** - there were two key issues relating to truck movements. The first was the speed at which the trucks traveled along Old Northern Road, and the second was the noise and dust caused by the trucks.

  There was concern of parents that trucks traveled at what was generally considered to be "excessive" speeds.

  Many of the houses are also located within 100m of Old Northern Road, and as such are subject to noise generated by trucks passing at speed. This is a particular concern to the school. Morning assembly is held at the school at 9.00 am every morning, and in the Headmaster's opinion, there are have been times when announcements at the assembly have had to halted due to excessive noise levels from passing trucks. It was suggested that extractive operators schedule their operations to have no trucks passing the school from 8.45am to 9.15 am.

- **Visual Amenity** - The quarry could be seen from only 10% of the residences within the 1km radius. Visual affects were not ranked highly in discussions although one resident did note that five years ago you could not see any sand mining from Old Northern Road.

- **Dust Generation** - Dust generation did not, in general, pose a problem to residents. Residents did note however, that sections of Old Northern Road are too narrow, causing trucks to travel on not sealed shoulders and thereby generate dust.

  Market gardeners in close proximity to the quarry commented that at times excessive dust is generated by trucks passing along the site's Crown access road. Whilst this road is sealed, sandy material is carried onto this sealed section by the tyres of vehicles leaving the quarry. The dust this then produces adheres to the surface of the fruit and is extremely difficult to remove. It was requested that a road watering program be established to keep the dust levels down at all times.

A number of dust related issues were also raised by the Maroota Public Scholl headmaster:

- possible silicosis effects
- possible link with childhood asthma

- **Operational Noise** - Some residents expressed concern as to the overall level of noise produced by the quarrying operation. With the majority of residences, a low hum was all that could be heard. This was not however disturbing to residents, and all reported that once inside the house (with the exception of one residence), this hum could no longer be heard. Of greater concern was the noise of traffic

- **Other Concerns** - one resident was particularly distraught by the presence of the quarry operations. In this persons opinion, the tranquillity of the region has been disturbed both visually and acoustically by the activities associated with quarries. Issues raised by this resident included the loss of water to the town supply as a result of diversions and consumption of natural flows for quarry use. Another issue was that the quarries were altering the nature of the community. Formerly it had been a peaceful district into which to retire, whilst now is was becoming increasingly "industrialised". This resident believes that no extractive industry should be carried out at Maroota, and that alternate sites should be found.

- **Effect on Land Values** – residences were concerned with the effects on land values, as a resulting of expanded sandmining.

- **Rehabilitation** – one resident criticised the general lack of rehabilitation across all quarry operations in Maroota.

4.3 Public Meeting

One aspect of the community consultation program that has not been able to be organized has been a public meeting.

The local community groups that were contacted, has included as in ***Section 4.1*** above, the Maroota and District Residents Association. Unfortunately, correspondence with this organisation has been returned to sender and despite calls to Council, the existence of the organisation and their location, were unable to be resolved. It is noted that the list of local community groups, shown in ***Section 4.1***, is extracted from DCP 500.

It has now been established that the only representative group for the community within Maroota, representing the majority of Maroota residents, is the Eastbend Community Research Team.

Eastbend Rural Communications Inc, since the middle of 1998, have been producing a Maroota and district news entitled "Living Heritage". This newsletter, produced quarterly, provides an excellent coverage of current news events, local history, pit news and Eco news.

The newsletter has strong environmental tone and it is understood it has been very well received throughout the community.

Contact has been made with the Eastbend Community Research Team, to seek a public meeting during the exhibition period of the EIS.

2.4 Latest Public Survey

A community questionnaire was distributed in April 1998 was answered by 24 of the adjoining and nearby residents. This survey indicated general support for the Dixon Quarry. There were concerns expressed about noise and dust, theses, however related to an adjoining operation (not operated by Dixon Sand).

5.0 INDUSTRY CONSULTATION

5.1 Industry Feedback

A number of items of correspondence were forwarded to the Company and to Council, following the Court's decision of 18th December 1998. The letters provided testimony to the effects created by the inability of the Company to continue to supply sands to the industry.

Comments included:

- We supply major home builders ..... We have worked with Dixon Sand for many years, to have a mix that meets Australian standards ..... Our builders are left with incomplete projects because there are no other products in the market place that matches their existing brickwork ..... We will be forced to put off our sub-contractors and at least two of our permanent staff. (Demarco All Sands Pty Ltd)

- We have purchased white graded sand from Dixon for a number of years to produce two of our sand stock range of bricks. If we cannot obtain the sand it will mean we can no longer produce the bricks to match existing stock. With partly finished projects, this becomes a serious issue with potentially severe penalties to our company. (Austral Brick Company Pty Ltd)

- I supply three large Sydney project builders who purchase through me, special sands for their building needs. One in particular is the "light yellow", which is only available from Dixon's Maroota operation. (Perce Hall Pty Ltd)

6.0 ATTACHMENTS

AUSTRAL
Build a better home

13 January 1999

Dr G Brooke-Cowden
The Lord Mayor
Baulkham Hills Shire Council
172 Showground Road
CASTLE HILL NSW 2154

Dear Sir,

When our Company recently tried to purchase some sand from Dixon Sands at Maroota, we were advised that we could not, possibly for several months, as the operation had been closed down due to the lack of an EIS. We were advised that this included trucking out of stockpiled material.

While the need for an EIS is accepted and understood, we feel we must advise you of the potential hardship the decision could cause to Austral Bricks.

We have purchased white graded sand from Dixons for a number of years to produce two of our sandstock range of bricks. The sand is quite critical to the appearance of these bricks. If we cannot obtain the sand it will mean we can no longer produce the brick to match existing stock. With partly finished projects, this becomes a serious issue with potentially severe penalties to our Company.

We would request therefore, that Council do everything in its power to ensure a speedy resolution to this problem. Allowing the Company to deliver from its stockpiles may be one solution that prevents some flow-on effect to Dixons' customers but ensures Council's requirements will be met.

Yours faithfully
AUSTRAL BRICK CO PTY LTD

PETER J MAHONY
GENERAL MANAGER – MANUFACTURING

cc: P Rasmussen – Fax (02) 4776 1601
G Ackers

DJD Masonry Contractors Pty Limited

COMMERCIAL & INDUSTRIAL
BRICK & BLOCKLAYERS

Director:
Dennis Souvleris
Mobile: 018 241 016
A.C.N. 073 837 733

28 Meta Street
Caringbah 2229
Phone 9540 3855
Fax 9540 4190

22nd December, 1998

Baulkham Hills Shire Council
PO Box 75
Castle Hill NSW 1765

Attention: Counsellor Geoff Brooke-Cowden

Dear Sir

DJD Masonry Contractors is one of the largest and well respected Bricklaying companies in Sydney. We are presently contracting to major building companies such as Civil & Civic, Walkers Group, A.W Edwards, Multiplex and Concrete Constructions. Some of our current projects include: Olympic Village Mariners Cove, Qantas Terminal, Waverley Library, International Airport 2000 and Fox Studios.

We write to you to express our serious concern with regard to our inability to continue to provide these prestigious projects with consistent sand colours for the mortar joints in the brickwork & blockwork.

For many years our supplier, United Bricklaying Supplies Pty Ltd has been sourcing our various sand requirements from the reputable Dixon Sands at Maroota. We have recently learnt, due to a technicality, we are no longer able to draw our products from Dixon Sands.

Realizing the very serious ramifications that will arise as a result of Dixons closure, both United Bricklaying Supplies and ourselves have gone to great lengths and expense to try and find sand that will colour match to the sand that Dixon has been providing, so that there will be no colour difference in the mortar joints of the brickwork as the projects continue to be constructed.

At the time of writing, all of our projects have basically ground to a halt, as we are unable to provide our men with sand suitable for a reasonable colour match to our jobs using white sand, or our jobs using yellow sand.

It is now apparent that sand with suitable colour match is unavailable and the only way for most of these projects to continue is for us to demolish new work and reconstruct using another colour sand. Given the number of projects we are presently constructing, I am sure you could imagine the tremendous costs involved.

22nd December, 1998

Baulkham Hills Shire Council
PO Box 75
Castle Hill NSW 1765

However we hope that common decency and commonsense will prevail and this highly volitile situation can be defused before any litigation proceedings are instigated.

Should you feel the need to discuss this serious matter, please do not hesitate to call.

Yours Sincerley
DJD Masonry Contractors Pty Ltd

Dennis Souvleris
Managing Director

Cnr. Old & New Windsor Ro
Kellyville, N.S.W. 2
Phone: (02) 9629 2C
Fax: (02) 9629 3

FACSIMILE TRANSMISSION

Date : 21/12/98.

Fax To : Ken Dixon

Fax Number : (02) 9566- 8295

Attention : Doc

Subject : Yr. comments pls.

I will fax to Geoff as soon as you ring me.

Regards : Naomi C.

Number of pages, including header : 3

If on receipt of this, any/all/part of the transmission is incomplete, please contact this office on the above.

Cnr. Old & New Windsor Roa
Kellyville, N.S.W. 21
Phone: (02) 9629 20
Fax: (02) 9629 37

The Mayor, Clr (Dr.) G. Brooke-Cowden
Baulkham Hills Shire Council
Showground Road
Castle Hill NSW 2153

Our Ref: F:\OFFICE\DOC\DIXON.D98

18th December 1998

Re: Forced (*sudden*) closure of Dixon's Sands, Maroota.

Dear Geoff
I write to you in relation to the above matter and, whilst I do not profess to understand the isuses to hand, I am alarmed at the need for a closure in such a dramatic fashion and to alert you to the possible unforseen consequences and potenial injury to my business and the livelyhood of trades people that the sudden *(our truck was infact the last truck permitted to load out of Dixons on Friday 18th dec 1998)* closure will have on the building industry in our Hills Shire.

My understanding is that there are two main suppliers of **Brickies Sand** to the Sydney building industry, and that they both supply two coloured sands, namely a **White** & a **Yellow Brickies** which are not inter-changeable. In particular, that the *Yellow Brickies*, supplied by Dixon's & PF Formations, are distinctly different shades. Also, in relation to the White Brickies sand, I have been reliably informed that PF Formations, will not be able to cope with the sudden increase in demand that the forced closure of Dixon's has created.

This company currently supplies Dixon manufactured sand to its customers who include many of the region's builders, specifically:

Civil & Civic's job for QIC (extension of Castle Towers)
Henley Properties
Peter Campbell's Clarendon Homes
(Peter) Binet Homes
Ian McDonald Homes
Denton Homes
Fred Lowry's Homes
Wayne Fitzsimmons

Claron Constructions
Dick Hoyle's, Barrina Properties
Grant Constructions
Denmay Homes and
Richard Crookes Constructions to name but a few of the larger buliders. You will recognize some of these builders as they have been participants, and in some cases winners, in the Council sponsored ***Building Design Awards.***

We also supply the product to many small home owners in the Shire wishing to add B-B-Ques and such like beautifications to the houses.

Some of these builders and owners have **part-complete** brick & stone work using Dixon manufactured sand that they will not be able to finish with anyone else's sand. The added pressure is that some houses may have been on target to finish by Christmas.

This will make for some very irate Construction managers and ratepayers come Monday morning.

The longer term consequences are that your Council is handing to the remaining manufacturer an almost monopolistic market with the inherent pricing *not controlled* by market forces which will almost certainly lead to price increases for these products.

Geoff, I am sure that you personally would not have been made aware of the consequences that the dramatic closure on Friday meant in inconvenience and disruption to my business and those of the people of the Shire.

I urge you to intervene and direct those responsible in the Council's beauracacy to permit a more orderly transition, even as a temporary measure, so that it may allow construction jobs in hand be completed.

Yours faithfully, a supporter of both Baulkham Hills Council & its Mayor!

Thomas Cann
General Manager.

United Bricklaying Supplies Pty Ltd

22 - 26 Meta Street, CARINGBAH NSW 2229
A.C.N. 057 068 274
Phone: 9540 3181 Mobile: 019 914469 Fax: 9526 2497

22nd December, 1998

Baulkham Hills Shire Council
PO Box 75
Castle Hill NSW 1765

Attention: Mr David Mead - General Manager

Dear Sir

Our Company has been distributing both white & yellow sand from Dixon Sand Pty Ltd for a number of years. We bag the sand in 1000kg bulker bags and deliver these to many job sites throughout Sydney. Our customers include builders & major bricklayers alike.

The sand we provide is mixed with cement on site, to make the mortar for the Bricklayers. In many instances the Bricklayers are erecting facework and should the colour of the sand being used vary in any way, it will be rejected by the Builder, the Architect, and the Developer. A change in sand would be just as noticeable as a change in bricks half way through a project, and we are sure you could imagine how that would look.

In an effort to keep the colour change to a minimum we have obtained samples from surrounding quarries and the difference is unfortunately unacceptable. We have also noticed an instant price rise of 20% in the cost of sand from surrounding quarries since the recent closure of Dixon Sand.

We chose Dixon as our supplier as they easily demonstrated their professionalism and dedication to the industry. They own various properties in the Baulkham Hills area, which have the ability to yield high quality products well into the next century.

United Bricklaying Supplies Pty Ltd is just one of over one hundred & twenty companies distributing sand from Dixon to many bricklayers and builders all over Sydney. We alone presently supplying sand to over twenty five building sites. On average each distributor is supplying approximately five building sites multiplied by 120 distributors amounts to 650 building sites that will be immediately effected. On average each site

employs approximately 20 people from various trades, which in effect equals a staggering 13,000 people who will be directly affected, let alone the hundreds of thousand of dollars lost in wages and production.

The result of the closure of Dixon Sand is now clear. We urge you to re access the reasons for the closure and grant Dixon Sand extra time on compassionate ground, and in doing so prevent many innocent Companies and individuals from experiencing financial hardship and possible ruin.

I thank you for your time in looking into this situation.

Yours Sincerley,
United Bricklaying Supplies Pty Ltd

Guy Mainsbridge
General Manager

DJD Masonry Contractors Pty Limited

COMMERCIAL & INDUSTRIAL
BRICK & BLOCKLAYERS

Director:
Dennis Souvleris
Mobile: 018 241 016
A.C.N. 073 837 733

28 Meta Street
Caringbah 2229
Phone 9540 3855
Fax 9540 4190

22nd December, 1998

Baulkham Hills Shire Council
PO Box 75
Castle Hill NSW 1765

Attention: Counsellor Geoff Brooke-Cowden

Dear Sir

DJD Masonry Contractors is one of the largest and well respected Bricklaying companies in Sydney. We are presently contracting to major building companies such as Civil & Civic, Walkers Group, A.W Edwards, Multiplex and Concrete Constructions. Some of our current projects include: Olympic Village Mariners Cove, Qantas Terminal, Waverley Library, International Airport 2000 and Fox Studios.

We write to you to express our serious concern with regard to our inability to continue to provide these prestigious projects with consistent sand colours for the mortar joints in the brickwork & blockwork.

For many years our supplier, United Bricklaying Supplies Pty Ltd has been sourcing our various sand requirements from the reputable Dixon Sands at Maroota. We have recently learnt, due to a technicality, we are no longer able to draw our products from Dixon Sands.

Realizing the very serious ramifications that will arise as a result of Dixons closure, both United Bricklaying Supplies and ourselves have gone to great lengths and expense to try and find sand that will colour match to the sand that Dixon has been providing, so that there will be no colour difference in the mortar joints of the brickwork as the projects continue to be constructed.

At the time of writing, all of our projects have basically ground to a halt, as we are unable to provide our men with sand suitable for a reasonable colour match to our jobs using white sand, or our jobs using yellow sand.

It is now apparent that sand with suitable colour match is unavailable and the only way for most of these projects to continue is for us to demolish new work and reconstruct using another colour sand. Given the number of projects we are presently constructing, I am sure you could imagine the tremendous costs involved.

22nd December, 1998

Baulkham Hills Shire Council
PO Box 75
Castle Hill NSW 1765

However we hope that common decency and commonsense will prevail and this highly volitile situation can be defused before any litigation proceedings are instigated.

Should you feel the need to discuss this serious matter, please do not hesitate to call.

Yours Sincerley
DJD Masonry Contractors Pty Ltd

Dennis Souvleris
Managing Director

PERCE HALL PTY. LIMITED

PHONE: 9626 9313
PHONE: 9626 9048
FAX: 9626 9313

695-703 RICHMOND ROAD,
COLEBEE 2761.

SAND — METAL
SOIL — CEMENT, ETC

21st December 1998

The Mayor
Baulkham Hills Shire Council
129 Showground Road
CASTLE HILL

Dear Sir

I was shocked to hear Friday, Council's decision to close, without notice, Dixon Sand Maroota operation.

This action by Council has put me and I know many other sand and gravel retailers in a very bad position.

In my business I supply 3 large Sydney project builders –

Huxley Homes 10 Phillip Street Parramatta Ph: 9842 9888	Long Homes 122 Station Street Wentworthville Ph: 963[illegible] 0700	Bellevale Homes Unit 25, 15-17 Kildare Road Blacktown Ph: 9622 9455

who purchase through me special sands for their building needs. One in particular is the light yellow which is only available from Dixon's Maroota operation. This does not diminish in any way the amount of white sand I purchase from its quarry for these builders plus many others. Whilst I am able to hold in stock over 500 tonne of white, this only affords me 3-5 days of supply.

I am sure you can see by the closure of this quarry the position it puts me in, and as I have said, many others like me who are supplying builders all over Sydney who are in various stages of development and we can no longer supply a sand to finish their work. A sand from a different location will produce a different coloured mortar joint which will cause all sorts of problems in owners and builders sueing for compensation. My question to you is, "Who is responsible?". Advice I have been given is that Council ultimately would be, as it was their action of closing the quarry immediately without a closing down period or notice.

I am not thoroughly conversant as to why nor can I understand why it was necessary for Council to act in such a manner or so quickly but I can assure you that if we are unable to resume our supply of sand, many problems are going to result. One of which could be the closure of our business after 50 years – ours is a second generation business.

PERCE HALL PTY. LIMITED

PHONE: 9626 9313
PHONE: 9626 9048
FAX 9626 9313

695-703 RICHMOND ROAD,
COLEBEE 2761.

SAND — METAL
SOIL — CEMENT, ETC

I emplore you to look carefully at your decision to close this sand source as it is vital to the Sydney building industry and is certainly vital to our business We need to be able to procure sand from there immediately, already I have orders in sand for 2,500 tonne for the first week of January 1999 – orders I cannot fill from other quarries as they are jobs already started and the mortar has to be matched.

Yours faithfully
PERCE HALL PTY LTD

Kenneth P. Hall.

Ken Hall
MANAGING DIRECTOR

CRISSO TRANSPORT

A.C.N. 065 768 452
825 FIFTEENTH AVE. WEST HOXTON. 2171.
9606 9161

21st DECEMBER, 1998.

URGENT,
BAULKHAM HILLS CITY COUNCIL,
TO MAYOR COUNCILMAN GEOFF BROOKE COWDEN

DEAR SIR,

WE AT CRISSO TRANSPORT ARE EFFECTED BY THE SUDDEN CLOSURE OF DIXON SAND QUARRY AT MAROOTA.

WE FEEL IT IS UNFAIR TO OUR BUSINESS BY THIS CLOSURE THAT 45% OF OUR CUSTOMERS ARE RESELLERS OF SAND OBTAINED BY US FROM DIXON SAND AT MAROOTA QUARRY. THEY ARE LOOKING TO US WHO WILL REBUT THEM FOR THE LOST OF BUSINESS SALES AND ATTEMPT TO SUE FOR UNFINISHED HOMES BUILDINGS AND GOVERNMENT PROJECTS.

OUR CUSTOMERS ARE IN A PANIC STATE AS ATTEMPTS TO SUBSTITUTE WHITE AND YELLOW SAND FROM ANOTHER QUARRY IS VERY MUCH DIFFERENT TO THE ONE AT DIXON SAND AT MAROOTA. OUR CUSTOMERS CUSTOMERS ARE VERY ANGRY AND ARE LOOKING TO SUE,

WHAT DO YOU WANT ME TO DO.

YOURS SINCERELY,

MANAGER,
DOMENIC CRISAFULLI

DIMARCO
ALLSANDS
PTY. LIMITED
A.C.N. 078 164 915
19 ASHFORD AVE., MILPERRA, N.S.W. 2214, PH: 9772 4000

21ST DECEMBER 1998

THE MAYOR
BAULKHAM HILLS COUNCIL
129 SHOWGROUND RD
CASTLE HILL NSW 2154

RE: CLOSURE OF DIXON SANDS AT MAROOTA

WE AT DIMARCO ALLSANDS PTY LIMITED ARE SUPPLIERS OF RAW BUILDING MATERIALS IN PARTICULAR WHITE BRICKLAYING SAND. WE ARE KNOWN THROUGHOUT THE BUILDING INDUSTRY FOR THE QUALITY OF OUR WHITE BRICKLAYING SAND, WHICH IS WHY WE SUPPLY MAJOR HOME BUILDERS SUCH AS MASTERTON HOMES, BEECHWOOD HOMES, AVERY HOMES, AUSTEC HOMES ETC.

WE HAVE WORKED WITH DIXON SANDS FOR MANY YEARS TO HAVE A MIX THAT MEETS AUSTRALIAN STANDARDS AND AT THE SAME TIME KEEPS BUILDERS HAPPY BECAUSE OF THE SIMPLICITY TO WORK WITH THE SAND AND IMPRESSIVE FINISH

DUE TO THE CLOSURE OF DIXON SANDS ALL OF OUR BUILDERS ARE LEFT WITH INCOMPLETE PROJECTS BECAUSE THERE IS NO OTHER PRODUCT IN THE MARKET PLACE THAT MATCHES THEIR EXISTING BRICK WORK. IE. (COLOUR VARIATION).

IF THIS CLOSURE CONTINUES WE WILL BE FORCED TO PUT OF OUR SUBCONTRACTORS AND AT LEAST TWO OF OUR PERMANENT STAFF. THIS CLOSURE ALSO THREATENS THE FUTURE OF OUR COMPANY WHICH HAS OPERATED FOR OVER 40 YEARS.

WE ARE EAGERLY ANTICIPATING A DECISION.

YOURS SINCERELY

A. Cavallaro

A CAVALLARO
DIRECTOR

BEXLEY CARINGBAH SAND SUPPLY
ACN 000 [illegible] 304
YARD: 42 Parraweena Road, Caringbah 2229
Tel: (02) 9525 0838 Fax: (02) 9524 1078

BEXLEY HARDWARE
True Value HARDWARE
SHOP: 479 Forest Rd, Bexley 2207
Tel: (02) 9599 4822 Fax: (02) 9597 4085

The Mayor
Baulkham Hills Shire Council
Baulkham Hills

Re Dixon Sands Council Meeting 6.30pm 22/12/1998

Dear Mayor,

We are a customer of Dixon Sands and have been for many years. I am not aware of all the circumstances surrounding the decision by Baulkham Hills Council to effectively close down there operations but would like you to know it's impact on us.

We were notified by "Doc" Halliday at 12.00 on Friday the 18/12/1998 that we were unable to purchase from them any more sand, immediately we were faced with the problem of finding a new supplier. As far as I know these people are the only alternative suppliers for white Brickies Sand which we purchase from Dixon.

1. Campsons Sands at Calga spoke to Ralph Betts, they can't match the price and are having quality and supply problems.
2. P.F Formations next door to Dixons ,spoke to Paul, can't match price and said will probably have supply problems now Dixon are closed.
3. Benedicts at Kangaloon, spoke to Nicole, can't match price plus cartage would be more expensive plus they are having consistency problems and may close down inside 12 Months.

4. Rocla at Mittagong , spoke to Arthur Togias, can't match price, plus cartage would be more expensive, but is closest colour match to Dixons Maroota Sand.

We use approximately 1000t per month of this Sand so at the moment we have a dilemma. We have up to 100 customers currently using this sand that we have to send out the enclosed note.

21st December 1998

VALUED CUSTOMER PLEASE NOTE

There will be possible variance in white brickies sand colour. Our usual white brickies sand supplier informed us at 12.00pm 18/12/98. he can no longer supply us with white brickies sand, as Baulkam Hills Council temporarily has in junction on him preventing him from operating without further notice. Our new stock is the closest match available to our previous supplier. We apologise for any inconvenience.

Thankyou

Mark Parsons

Mark Parsons
Managing Director.

I am not looking forward to the phone calls when there are builders and Bricklayers half way through a job and there will be a variance in the colour of the joint.

Business is hard enough as it is with out the Drama of last minute changes to our Sand Suppliers, especia ly if this situation could have been avoided.

I am all in favour of a level playing field for companies in competition and company's abiding by Government and Council regulations. I have been told this is not happening. If Dixon Sand is at fault, then it is my poor judgemen' for dealing with a company I presumed to be reputable. If however it is Dixon Sands who are at the mercy of Bureaucratic Bungling, and being victimised while others are not ,then it is Baulkham Hills Council that has some answering to do.

Please reply to your thoughts on the above issues so the situation can be resolved as soon as possible.

Yours faithfully

Mark Parsons
Managing Director.

PETITION

The Mayor,
BHSC,
Showground Rd,
Castle Hill, 2154.

Dear Geoff,

I, as a local member of the community, do not support Council's decision in persuing the temporary closure of Dixon Sands Maroota, Dixon Sands employs local's and supports local small business's . I am deeply concerned about the issues of Sand Mining at Maroota, and believe the temporary closure of Dixon Sands to be extremely harsh. I am also concerned about the way that this community is being represented to Council by certain isolated groups. My signature confirms my view of the above mentioned issues.

ORLANDO GIGLIO	LOT 13 WISEMANS FERRY RD. MAROOTA	O. Giglio
SAM GIGLIO	LOT 1 Old Northern Rd Maroota	S. Giglio
GEORGE GIGLIO	MAROOTA MOTORS	G. Giglio
SALVATORE GIGLIO	MAROOTA MOTORS	S. Giglio
NATALINA GIGLIO	LOT 1 OLD NORTHERN RD MAROOTA.	N Giglio
JESSIE SCIBERRAS	LOT 2 OLD NORTHERN MAROOTA	J Sciberras
CHARLIE SCIBERRAS.		C Sciberras.
M KAZZI	PORTION 370 Old Northern Rd MAROOTA	M Kazzi
M Kazzi	"Glenauchey" OLD NORTHERN RD GLENORIE.	M.A. Kazzi
KAREN DAY	145a Wisemans Ferry Rd, Maroota	K Day
CHRIS DAY	145A WISEMANS FERRY RD MAROOTA	CADay
David Taylor	AMB 145 Wisemans Ferry Maroota	
Lorraine Ramm	143 Wisemans Ferry Rd Maroota	L. Ramm
Hanna Ramm	143 WISEMANS FERRY RD. MAROOTA.	J Ramm

PETITION

The Mayor,
BHSC,
Showground Rd,
Castle Hill, 2154.

Dear Geoff,

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ILONA RAMM	145 WISEMANS FERRY RD MAROOTA	Ilona Ramm
ERNEST RAMM	"	E H Ramm
LEANNE MARTIN	9-10 WISEMANS FERRY RD MAROOTA	
RYAN LAMBERT	9-10 WISEMANS FERRY RD MAROOTA	
Michelle Scerri	11 Wisemans Ferry Rd Maroota	
Alan Modde	9 McGrath Rd McGraths Hill	
	LOT 1 OLD NORTHERN RD MAROOTA	A. Grieve.
NOELENE HITCHCOCK	155 ROBERTS RD MAROOTA.	
Colin Martin	16 Bay Rd Arcadia 2159	
Phillip RAMM	Old Telegraph Rd Maroota	
John Ramm	Old Telegraph Rd Maroota.	John Ramm.
TONY PORTELLI	OLD TELEGRAPH RD MAROOTA	
Rose Portelli	MAROOTA COTTAGE MAROOTA	
E. Portelli.		C Portelli.

PETITION

The Mayor,
BHSC,
Showground Rd,
Castle Hill, 2154.

Dear Geoff,

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BRUCE RAMM	O.N.Rd MAROOTA	B.R.Ramm
LYNE RAMM	O N Rd. MAROOTA	L.C.Ramm
MARTIN REUTER	ON Rd Maroota	
[illegible]	O N Rd Maroota	
[illegible] O'Brien	O.N Rd. Maroota	
[illegible]	O.N. Rd Maroota	
JILLIANA XUEREB	MAROOTA	J Xureb
Josephine Dominello	ON RD MAROOTA	
CHARLIE CHIMILLERI	C/O NORTHERN RD MAROOTA	
Ian Simpson	ONR Maroota	
ALAN JONES	OLD TELEGRAPH RD MAROOTA	
Alan & Toni McDonough	Old Telegraph Rd Maroota	

We believe that given the time that Dixon sands has operated that a reasonable period of time should be granted to allow compliance

Vaughan Parker	HART RD MAROOTA	
Leanne Parker	" "	
~~F.J. Gray~~ F.J. GRAY	OLD NORTHERN RD MAROOTA	F J Gray

PETITION

The Mayor,
BHSC,
Showground Rd,
Castle Hill, 2154.

Dear Geoff,

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Albert f Ford	Old Northern Rd Maroota	Al Ford
ROSE M. WILLIAMS	R.H. Roberts Rd. Maroota	
Jim Williams S.P.	5A ROBERTS RD MAROOTA	
R RAMM	Wisemans Ferry Rd Maroota	
J R CLOHAM	LOT A. WISEMANS FERRY RD MAROOTA	
B. CLOHAM	LOT A WISEMANS FERRY RD MAROOTA	
KRIS VALTCHEFF	19C Old Northern Rd Maroota	
D. Milder	918A OLD NORTHERN RD GLENORIE	
K BOMBARDIERE	LOT 2 OLD NORTHERN RD MAROOTA.	T. RAYMOND.
	Lot 92 WISEMAN Rd MAROOTA.	K. Bombardiere
	430 WISEMANS FERRY MAROOTA	
RON RAMM	Maroota	Ron Ramm

PETITION

The Mayor,
BHSC,
Showground Rd,
Castle Hill, 2154.

Dear Geoff,

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[signature]	1438 Wisemans Ferry Rd	Maroota
[signature]	1438 Wisemans Ferry Rd	Maroota

PETITION

The Mayor,
BHSC,
Showground Rd,
Castle Hill, 2154.

Dear Geoff,

I, as a local member of the community, do not support Council's decision in persuing the temporary closure of Dixon Sands Maroota, Dixon Sands employs local's and supports local small business's . I am deeply concerned about the issues of Sand Mining at Maroota, and believe the temporary closure of Dixon Sands to be extremely harsh. I am also concerned about the way that this community is being represented to Council by certain isolated groups. My signature confirms my view of the above mentioned issues.

L. S. MARTIN M A Black J K Black A Zerilli G Henderson	Hitchcock Rd, Maroota " CR. WISEMANS RD MAROOTA. CR WISEMANS RD MAROOTA.	Black Mrs L Black A. Zerilli G Henderson.

PETITION

The Mayor,
BHSC,
Showground Rd,
Castle Hill, 2154.

Dear Geoff,

I, as a local member of the community, do not support Council's decision in persuing the temporary closure of Dixon Sands Maroota, Dixon Sands employs local's and supports local small business's . I am deeply concerned about the issues of Sand Mining at Maroota, and believe the temporary closure of Dixon Sands to be extremely harsh. I am also concerned about the way that this community is being represented to Council by certain isolated groups. My signature confirms my view of the above mentioned issues.

	2. [illegible]	
	6 LAUGHTONDALE GULLY RD MAROOTA	

PETITION

The Mayor,
BHSC,
Showground Rd,
Castle Hill, 2154.

Dear Geoff,

I, as a local member of the community, do not support Council's decision in persuing the temporary closure of Dixon Sands Maroota, Dixon Sands employs local's and supports local small business's . I am deeply concerned about the issues of Sand Mining at Maroota, and believe the temporary closure of Dixon Sands to be extremely harsh. I am also concerned about the way that this community is being represented to Council by certain isolated groups. My signature confirms my view of the above mentioned issues.

NAME	ADDRESS.
D.G LANE	LOT 6 ONR MAROOTA
Adeline Connell	Lot 6 O.N.R. Maroota
Vincenzo Baillaro	LOT 2. OLD. NORTHERN. ROAD. MAROOTA.
C. Baillaro	Lot 2 Old Northern Rd MAROOTA.

PETITION

The Mayor,
BHSC,
Showground Rd,
Castle Hill, 2154.

Dear Geoff,

I, as a local member of the community, do not support Council's decision in persuing the temporary closure of Dixon Sands Maroota, Dixon Sands employs local's and supports local small business's . I am deeply concerned about the issues of Sand Mining at Maroota, and believe the temporary closure of Dixon Sands to be extremely harsh. I am also concerned about the way that this community is being represented to Council by certain isolated groups. My signature confirms my view of the above mentioned issues.

MAROOTA

W. FERRY

CATEGORY B – BACKGROUND

Appendix B1 – Sydney Construction Sands – Resource and Market

Appendix B1 – Sydney Construction Sands – Resource Availability and Market Demand

Prepared by Lyall & Macoun Consulting Engineers

DIXON SAND (PENRITH) PTY LTD

SYDNEY CONSTRUCTION SANDS – RESOURCE AVAILABILITY AND MARKET DEMAND

Prepared for

DIXON SAND (PENRITH) PTY LTD

February 1999

Prepared by:

Lyall & Macoun Consulting Engineers
Suite 602
Level 6, 2 Help Street
West Chatswood NSW 2067

Tel: (02) 9413 3411
Fax: (02) 9413 3471
Email: lmce@netro.com.au

Job No.: OW560 File: J:/OW560/Maroota/Vol2.doc	Date: 15 February 1999 Rev No.: 2.0	Author: JW Reviewer: TWM

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1.0 SUMMARY

It has been forecast that there will be a major shortfall in the availability of construction sands in the Sydney region in the near future (DMR, 1995) (DUAP, 1996). It has been estimated by government, that by the year 2000 this shortfall could amount to 2.4 million tonnes each year. This shortfall will only be met by imports from outside the region.

Up to the early 1980s, the Sydney market was self-sufficient. Imports have been growing steadily ever since then, as local production has been insufficient to meet the Sydney market demands

Most of the major Sydney resources are nearing their final stages. Sydney has long relied on the sand dunes and estuarine deposits of the Kurnell Peninsula and the sand and gravel deposits associated with the Hawkesbury/Nepean River, as its principal sources of construction sand.

With the effective depletion of the Kurnell resource, a major problem has developed in the supply of fine sands. It is also predicted that by the year 2010, with the completion of the Penrith Lakes Scheme, extraction of coarse grain sands will face a similar supply problem to that which currently exists for fine sands.

Maroota has been identified as a strategically located future resource of both fine and coarse grain sands. It is in close proximity to the major Sydney markets and has the potential to be one of the major suppliers to the Sydney market.

Most new extractive industry development proposals have a degree of environmental sensitivity and increasingly, this is becoming a major factor for the industry. Although Maroota is favourably located, has a high quality resource and can supply all the market needs, of both concrete and mortar sands, the environmental issues that have arisen from the early days of sand extraction at Maroota, could be a significant factor in the future of extraction of this resource.

2.0 INTRODUCTION

New South Wales consumes approximately 12 million tonnes of construction sand annually, with some 6-7 million tonnes of this being required in the Sydney region.

There has been a gradual yet consistent growth in the demand for construction sands in the Sydney region since the 1970s. For the period 1971 to 1989/90, this demand grew in line with population growth at a rate of approximately 1% per annum. This trend is expected to continue.

Prior to 1979, the region was self sufficient. Since 1980 however, there has been a gradual increase in the quantities of sand required to be imported from outside the Region and in 1995, these imports amounted to 15% of total demand within the Sydney region. This has resulted because of depletion of established resources of sand and has resulted in increases in the average price of sand delivered into the market.

The resulting increase in truck movements and associated environmental impacts has also become an issue of concern to the community.

This report examines the construction sands industry, the demand for its products and the future resource availability within the Sydney region. The objective is to establish the need or otherwise, for the further development of the Maroota deposit.

In the following sections, the following is described:

- **Section 3** describes the form of natural deposits of construction sands.
- **Section 4** describes the various forms of use of construction sands.
- **Section 5** looks at the various sources, both existing and future, that has the potential for development for future supply sources.
- **Section 6** looks at future market demand.
- **Section 7** provides a review of Maroota as a major supply source, to meet future Sydney market demands.
- **Section 8** provides concluding remarks

Section 8 provides a listing of the various references used in assembling this report. Most of the information is obtained from various Department of Mineral Resources and Geological Survey reports into this industry.

Construction sand is not classified as a mineral under the Mining Act, 1992 and consequently, the Department of Mineral Resources has no statutory control over its extraction, apart from its role under the Mines Inspection Act, 1901, pertaining to the safe conduct of quarrying operations. There is also a concurrence role, with respect to development within or adjacent to certain resources under SREP No. 9 – Extractive Industry (No. 2). (There is one form of deposit in which the Department has jurisdiction. In the case of offshore sand deposits, which are classified as a marine aggregate under the Mining Act, the Minister for Mineral Resources does have jurisdiction.)

Notwithstanding jurisdictional boundaries, the Department of Mineral Resources and to a lesser extent, the Department of Urban Affairs and Planning, are both involved in the assessment and monitoring of the construction sands industry. The Department of Urban Affairs and Planning recently established a Task Force on the Supply of Construction Sand. The Department of Mineral Resources is constantly monitoring the supply and availability of construction sands and with the Department of Urban Affairs and Planning, has developed, established and reviewed SREP No. 9, Extractive Industries.

3.0 NATURAL SAND TYPES AND USES

Sands are comprised predominantly of mineral quartz (SiO_2), with varying amounts of impurities including clay, iron oxide, rock fragments, shell and organic matter. There are five principal sources of natural sands in and around the Sydney region, namely:

- **Friable Sandstone** - Sandstones are termed friable due to either poor initial sedimentation of the sand grains, or the loosening of grain bonds due to weathering. Friable sandstones can be readily broken down to their original sand grains by ripping and washing. Grain sizes usually range from fine through to coarse.

- **Remnant Terrace Deposits** - Also known as 'high-level' deposits, they are generally found above flood plains and are often clay rich. The sand is generally fine to medium grained.
- **Dune Sands** - Generally very fine-grained sands of size range 0.6mm–0.15mm. Dune sands are often used as the fine additive sand for concrete making.

- **River Sand** - Fluvial deposits are poorly sorted, with typical vertical gradation in grain size. In general, fluvial deposits in the Sydney region contain medium to coarse-grained sands, often exhibiting large gravel contents.

- **Estuarine/Beach Deposits** - These are a fine-grained sand, usually well sorted and poorly graded, but often contain a high shell content. They often require blending with coarser grained sand for use in concrete.

Grain size and the clay content are the dominant factors in the classification of sands for industrial use. Wallace (1980) defined three categories of sand:

- **Medium to coarse grained sand** – predominantly river sand
- **Fine to medium grained sand** – predominantly from dune and estuarine deposits
- **Clayey sands** – fine to coarse-grained sand containing clay. Generally friable deposits.

4.0 USES OF CONSTRUCTION SANDS

It is estimated that 97% of the sand produced in the Sydney region is employed in construction (DOP, 1993), with the major uses being for the manufacture of concrete (concrete contains 60-80% sand by volume), and bricklaying mortar. Other uses include general construction, asphalt, horticulture and fill sand.

A continuous supply of construction sand is essential to the sustained development of any community. In Sydney, sand is consumed in large quantities, with the key factor to its production being is its low unit value. It must therefore be obtained close to markets in order to minimise transport costs. Any increase in transport costs is eventually passed onto consumers through higher prices and increased building and construction costs.

A breakdown of the forms of sand usage is given **Figure 1**, below.

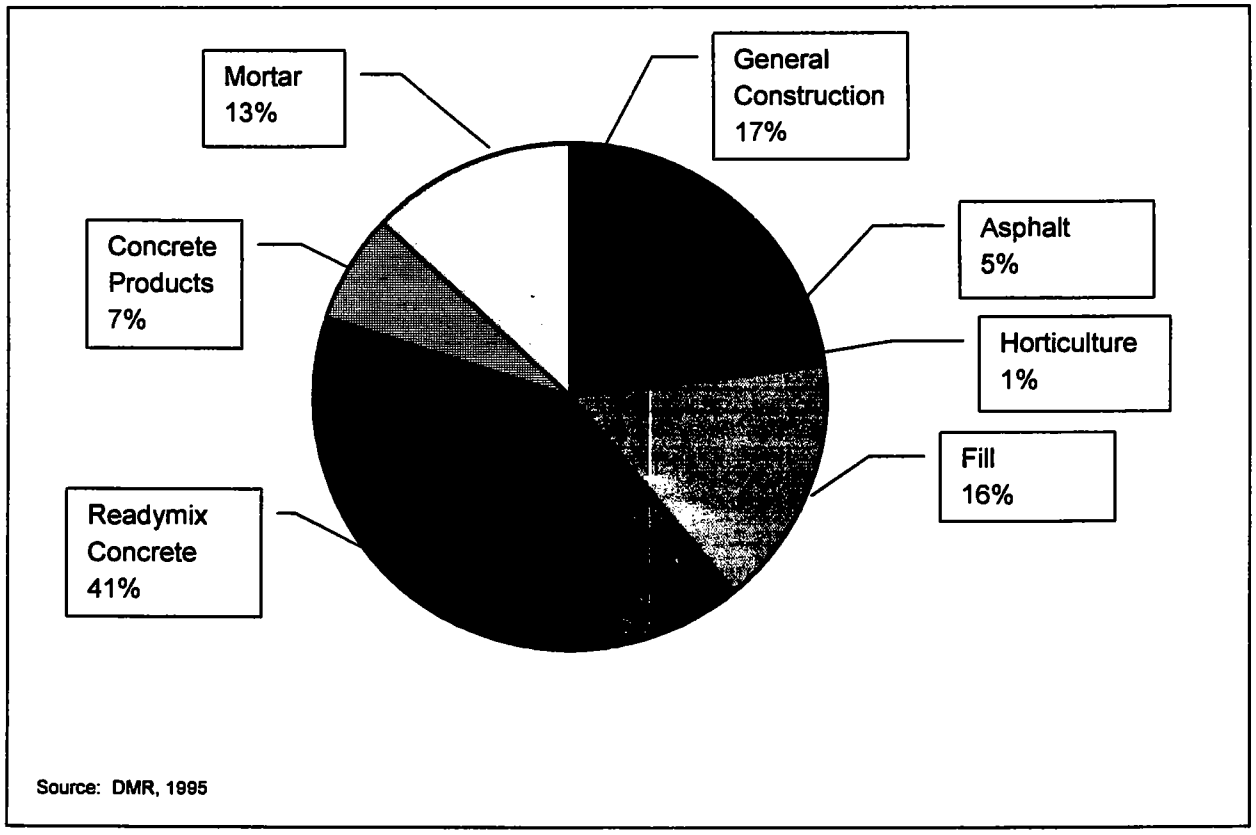


Figure 1 Uses of Sand in the Sydney Region, 1996

Spackman (1992) classified the end use of sands by grain size in **Table 1**:

Table 1
Sand Classification by Grain Size (Spackman, 1992)

GRADE	USES
Ultra Fine (<0.06 mm)	Industrial uses, glass, abrasive cleaners, foundry, toothpaste, paper impregnation.
Fine (0.06–0.236 mm)	Brick mortar, concrete sheeting, concrete spun linings, glass.
Medium (0.236–0.475 mm)	Concrete, masonry blocks, pavers, roof tiles, decorative wall panels, asphalt.
Coarse (0.475–0.950 mm)	Sand for blast grit, filter media for drainage, water filters, general filters, additive to fine sands.

Most construction sand use to-date has been from naturally occurring deposits. Increasingly however, the industry is looking at sand sized slag derivatives and particularly, crusher fines from coarse aggregate operations.

Each market sector has quite different requirements, ranging from specific specifications to market preference.

Table 2 provides typical details of sand use by market sectors.

Concrete Sand - The sand must comply with AS2758.1-1995. Preferably medium grained, grains may vary in size and shape. In the Sydney market it is common to blend medium to coarse-grained river sands with fine to medium grained dune sands. This allows for the maximum strength and minimum volume. Grain roundness is important as it influences the ability of the material to be pumped, with roundness enhancing ease. The sands need to be clean, with the presence of fines (clays <0.075mm size) having a deleterious effect on concrete strength.

Mortar Sand - Contains high portions of clay (15-25%) to provide good slump and workability. This decrease is the material strength however, and "cleaner" sand specifications are likely in the future. Colour is also an important consideration, with there being a preference generally, for the lighter 'off-white' Maroota Sands.

Concrete Products - End uses such as masonry blocks, concrete roof tiles, and concrete poles & pipes generally require a rounded sand particle for reduced abrasiveness accompanied with a fines fraction to enhance water proofing qualities.

Fill Sand & Asphalt Sand - Asphalt sands are required to have coarse and angular grains with a minimum of fines. Fill sands need to be clean and not too fine.

Table 2
Sand Production (Million Tonnes) in the Sydney Region by End Use- 1989-90

Use	Sand Type			
	Medium/Coarse	**Fine/Medium**	**Clayey**	**Total**
Concrete	1.53	0.55	0.49	2.57 (40.6%)
General Construction	0.32	0.69	0.09	1.09 (17.3%)
Fill	0.04	0.69	0.3	1.03 (16.3%)
Mortar	0.0	0.01	0.83	0.85 (13.4%)
Concrete Products	0.17	0.06	0.20	0.43 (6.8%)
Asphalt	0.23	0.05	0.01	0.29 (4.6%)
Horticulture	0.02	0.02	0.03	0.07 (1.1%)
Total	**2.31 36.5%**	**2.07 32.7%**	**1.95 30.8%**	**6.33 100%**

Source: DMR, 1995

Examination of Table 2 shows the following:

- Concrete is the major construction sand use.
- There is a roughly even contribution of the requirements for various sand types from fine medium to medium coarse to clayey.
- Sand use for concrete, general construction fill and mortar sand makes up almost 90% of total sand use.
- Uses of fine to medium grained sands are equally spread between concrete, general construction and fill, again comprising some 90% of the total market demand.

5.0 SOURCES OF CONSTRUCTION SAND.

Sydney has adequate resources of medium to coarse-grained sand to meet the demands in the short to medium term (up to 2001-2006), but the long-term outlook is less clear (DMR, 1995). Shortages are expected to arise, and become acute around the year 2010.

Substantial resources of clayey sand are already secured in areas adjoining the Sydney region, however, sources within the Sydney region are scarce.

The situation for clean fine to medium-grained sand is very different. Declining production from established sources has meant that sands have had to be imported from adjoining regions, with the trend likely to continue. The deposits of fine/medium grained sand are assessed in the following section.

Figure 2, Deposits of Sand in the Sydney Region shows the location of the deposits discussed below.

5.1 Major Deposits of Fine / Medium Grained Sand.

5.1.1 Kurnell Peninsula

These dune deposits have been the major source of clean, fine to medium grained sand for the Sydney region for the past 20 years. Production is however expected to cease by 2005, based upon the currently approved production rate of 1.2 million tonnes per year, and the remaining resource of some 20 million tonnes. The resource is well located to the major markets, with 85% of the sand produced being consumed within the eastern metropolitan area.

Good access and close proximity to markets has made Kurnell the most cost effective source of fine sand. The future role of Kurnell is dependant upon future approvals being granted and the suitability of sand in the remaining reserves. Decisions of final land use will be a critical factor in the granting of future approvals.

If Kurnell closes or even reduces production, there is will be a major shortfall in the supply of fine sand. It is estimated that the current decline in Kurnell will lead to a shortfall of 2.4 million tonnes of fine sand in the Sydney region by the year 2000. Considering that there is already an estimated 1 million tonnes of fine sand to be imported, Kurnell's depletion will result in an overall shortfall of 1.4 million tonnes of fine sands.

5.1.2 Maroota

The Tertiary and friable sandstone deposits of Maroota are identified as a large resource of fine to medium and medium to coarse grained sands. It is estimated that there are over 90 million tonnes of sand available for extraction, with 50 million tonnes of this being fine to medium grained sands. The currently approved annual production is approximately 0.5 million tonnes per year.

Maroota lies within 35 km of the Sydney Market. The associated transport costs are relatively low. These low transport costs are enhanced by the minimal level of material processing required, reducing production costs and further reducing the overall cost of the sand supplied to the market.

Maroota deposit has the potential to supply Sydney with 2 million tonnes of sand per year (DOP, 1993). However, as noted in SREP No. 9, Working Papers, the major constraint to large scale extraction is the inadequate condition of both Old Northern Road and Wisemans Ferry Road.

The SREP No. 9 did not favour any major increase in the scale of extraction until the main road servicing area were brought up to an adequate standard.

The Regional Plan also noted that other environmental constraints to large scale extraction included the disposal of tailings and the impact of extraction on drainage, groundwater and on the erodibility of soils.

Since 1993, other issues including threatened species and the natural environment, the environmental impacts of transport and community concerns have added to the environmental and social pressures on extraction within the Maroota area.

5.1.3 Somersby Plateau

The Somersby Plateau area is an important source of fine to medium grained sand, with resources estimated to be more than 100 million tonnes. There is an approved production capacity of 0.5 million tonnes per year. The area supplies both the northern Sydney region and the central coast markets.

There are two problems with this region in regard to supplying the Sydney market. Development will be limited by the high agricultural value of the area, and by the fragmented nature of land ownership. SREP 8 gives preference to agricultural development in the area. The other issue is that of the continuing growth of the Central Coast region is projected to consume an increasing portion of sand from the plateau.

5.1.4 Newnes Plateau

One of the three principal supplementary sources identified by the Department of Mineral Resources (DMR, 1995), the Newnes Plateau, east of Lithgow, possesses a vast resource of friable sandstone. The resource is believed to be more than 500 million tonnes, lying within several 'preferred extraction areas'. Approved operations have a life expectancy of around 20 years, given the current approved extraction of 400,000 tonnes per year (1996). Some 100,000 tonnes per year is supplied to the Sydney market.

SREP 9(2) identified the Newnes Plateau as a potential long-term option to supply Sydney after the year 2001. Despite concerns regarding tailings disposal and to the proximity of National Parks/wilderness areas, there appears ample opportunity to expand the current supply to the Sydney region. The greatest problem with the expansion of operations is that at 135 km form Sydney markets, not only will the cost of transportation impact heavily upon the price of the sand, but road haulage and road standards could hinder the development of the deposit.

5.1.5 Southern Highlands

This is the second of the three key supplementary sources identified by the Department (Penrose area and Soapy Flats). These deposit are similar in character to those of the Newnes Plateau, containing vast reserves of friable sandstone.

Heggies at Penrose currently has consent to produce 550,000 tonnes per year (1996) over an unlimited period. Rocla at Soapy Flat is producing 250,000 tonnes per year (1996) and is seeking to expand to 400,000 tonnes per year.

At a transport distance of 150 km from the Sydney market transport costs will again limit the viability of the resource where more cost competitive resources closer to the market are available. A benefit of this location however is the ready access to rail link to the Sydney region.

As with most friable deposits, there is a relatively high clay content (5-30%), which presents a challenge regarding tailings disposal. This could have an effect on the potential for future growth, given the proximity of National Parks/conservation areas.

5.1.6 Stockton Bight (Williamtown)

Stockton Bight contains an estimated resource of 100 million tonnes of fine to medium grained sand, which is suited to all applications. Of this, 1 million tonnes per year has been approved for a period of 20 years. The 190 km haulage distance means however, that only 150,000 tonnes per year is supplied to the Sydney market, with the greater portion supplying the Newcastle markets.

The resource itself is contained in a dual barrier dune sequence, which parallels the present shoreline. There is increasing competition for use of the land for conservation and housing purposes. The potential of the region as a supplier to the Sydney market is limited by three factors; high costs of transportation, the importance of the region to the Newcastle market, and land competition.

5.1.7 Hawkesbury-Nepean River (Gunderman –Catti Creek area)

There is a medium grained sand deposit of some 25-40 million tonnes. There is an approved production capacity of 300,000 tonnes per year, with 100,000 tonnes per year going to the Sydney region. This resource is however limited by the prohibition of extraction downstream of Wallacia Bridge. In general, access to the area is poor.

5.1.8 Chipping Norton

There are only minor reserves of this riverine sand remaining. There can be no significant production expected beyond the short term.

5.1.9 Agnes Banks/Londonderry

A Permanent Conservation Order imposed in 1988 has significantly reduced the reserves available for extraction. At present the region produces approximately 220,000tpa, and the life of production is projected under the current management plan only to 2010.

5.1.10 Elderslie

Approximately 210,000 tonnes per year, up until the year 2005, will be available.

5.2 Minor Deposits of Fine to Medium-Grained Sand.

A number of other deposits containing generally limited resources contribute to the supply of sand to the Sydney market. These include Glenfield, Narrabeen Lagoon, Georges River and Cattai. Although individual outputs are small, the collective contribution is substantial, especially in meeting local demand and thereby reducing pressure for greater imports from other regions.

5.3 Major Potential Sources of Construction Sands

5.3.1 Maroota

Extensive resources of high quality sand are present in both the unconsolidated Tertiary sediments and the soft friable Hawkesbury Sandstone. The SREP No. 9(2) embraces most of the resources, to date only a small portion are secured for extraction, with large reserves awaiting development approval.

5.3.2 Wrights and Wellums Creeks

A total identified reserve of 40 million tonnes of fine to medium grained sand is available at Wrights & Wellums Creeks, on the north-western outskirts of Sydney. To date there has been no development approval for extraction, with the biggest problem posed by this region being that of transportation. Access roads are narrow and winding, and cross the Hawkesbury River by vehicular ferry at Wiseman's Ferry. These difficult transport conditions have a substantial impact upon the economic viability of the deposits. There are also a number of environmental concerns that will need to be addressed prior any approval of future operations.

5.3.3 Marine Aggregates

Substantial resources of fine to medium grained sands exist offshore of Sydney, offering an estimated total resource of 100 Mt of fine concrete and general construction sand which could provide Sydney with a long term low cost supply.

Future for marine aggregate extraction is doubtful. The decision in 1994, to refuse the proposal by Metromix to mine construction sand (marine aggregate) from deposits offshore

from Sydney probably meant the end for this as a potential future source. The need for study on the accessibility on marine aggregate was raised at the Commission of Enquiry into the Metromix proposal and subsequently suggested by the Coastal Council of NSW. However, to-date no such study has been forthcoming.

5.3.4 Port Hacking

This large resource contains a high shell content and as such the sands are best suited for use in concrete. Environmental constraints are dominant in this area however, considerably diminishing the potential of the area.

5.4 Minor Potential Sources of Construction Sands

There are a number of other small deposits, including the clayey fine-grained sands of Pitt Town, the fine-grained sand of Berowra Creek, the Belmont-Redhead deposits on the Central Coast, the George River State Recreation Area, Narrabeen Lakes and the dune deposits of Bonnie Doon Golf Course.

Development of these deposits is doubtful.

5.5 Current Supply Situation

Table 2 gave a breakdown of the 1989/90 production levels for medium coarse, fine medium and clay sands, in total making up a construction sand annual production level of 6.3 million tonnes. **Table 2** showed that demand for each of the three sand types was fairly evenly spread, with the medium coarse sand being the slightly dominant type at 2.3 million tonnes per annum.

Table 3 below summarises the major supply sources for each of the three sand types. The Table identifies that:

- The dominant supply source for medium coarse sands is Penrith Lakes. The future potential however, is limited with resource estimated to be fully extracted by the year 2010.

- Again, the dominant supply source for fine medium sands is the Kurnell Peninsula, again the future potential being limited by the likely phasing out of extractive operations, as pressure for alternative land uses become greater.

- In regard to clay sands, there is no single dominant source, with the major supplies to the Sydney market being the Elderslie area, the Londonderry area, Maroota and the Newnes Plateau.

At this time, the Maroota area predominantly supplies clay sands. Of all the Sydney market sources and the sources remote from the Sydney market, it is the best located in terms of distance from market, product quality and other constraints.

Table 3
Sources of Sand Production for the Sydney Region (1995)

SAND TYPE	*DEPOSIT*	*ESTIMATED PERCENTAGE OF TOTAL SAND SUPPLIED TO SYDNEY*	*FUTURE POTENTIAL*
Medium – Coarse Sands	Hawkesbury-Nepean River	6.2%	Due to be completed by 2010
	Penrith Lakes	31.5%	
		37.7%	
Fine-Medium Sands	Kurnell	20.4%	Phasing Out – Uncertain Future
	Chipping Norton	7.3%	Closing Stages
	Other (river)	2.1%	
	Other (dune/estuarine)	2.9%	
		32.8%	
Clay Sand	Elderslie	6.6%	Diminishing resources- final stage
	Londonderry	7.1%	Resources declining rapidly
	Maroota	6.3%	Good expansion potential
	Other (Sydney)	0.2%	
	Newnes	5.5%	
	Somersby	1.3%	Constrained by distance
	Southern Highlands	2.4%	Major source to the Central Coast
			Distant but good transport links
		29.4%	

6.0 FUTURE DEMAND FOR CONSTRUCTION SANDS

6.1 Demand Projections

Demand for construction sands is linked closely to the state of the economy, exhibiting a cyclical behaviour, as shown in **Figure 3**.

Figure 3, shows supply over the period from 1970 to 1994, with there being three pronounced economic cycles varying in period from approximately 5 years to some 10 or 11 years.

Since 1970, the Sydney Region demand for construction sand has experienced an average long term growth rate of 1.6%. It is considered that this is likely to continue although there will be the economic fluctuations within the industry, depending on the health of the construction industry.

Currently, a high level of construction activity, primarily built around the 2000 Olympics, has meant that the current sand requirements would be expected to be close to or in excess of 7 million tonnes per year.

Construction activity after the turn of the century is forecasted to decline although this may not occur until a number of years after the year 2000, based on the number of infrastructure projects (road and rail) that have been announced that will be still within their construction phases in some 4 or 5 years time. A decision on the second Sydney airport will be also another major factor and will determine the activity within the construction industry in the short to medium term future.

It could be reasonably concluded that the construction industry will continue to expand and continue to demand an ever increasing supply of construction materials, including the range of construction sands considered in this report.

6.2 Manufactured Sands

There has been discussion, over recent years within the industry, primarily related to the shortfall in supply capacity within the Sydney market and elsewhere, of the potential for substituting various forms of artificial sand in lieu of natural sands.

Substitutes for coarse sand can include slag and crushed rock, however, it is generally considered that this reduces both pumpability and workability of the concrete. Blast furnace slag and crushed rock can also be used as a substitute for fine sand. Unfortunately, the level of crushing required, substantially increases the price of this material and the grain characteristics are largely lost.

Natural quartz sand is considered to be superior fine aggregate. This is due to its physical nature of durability, grain shape and size. Substitutes of comparable strength are regarded by the industry to be both of an inferior product and currently at a greater cost. However, artificial products currently make up some 17 % of the fine sands used in concrete in NSW, being drawn principally from blast furnace slag and recycled concrete.

6.3 Factors Effecting Growth in the Natural Sands Market

Analysis of the change in the relative proportions of the different sand types over the period 1979 to 1990, shows a disproportionate proportion increase in the supply of clay sands as distinct to fine/ medium and coarse/ medium sands. This could indicate that increasingly, a proportion of clay sands are being used in the construction industry for the manufacture of concrete.

One of the factors in the use of natural sands in the future, will be the environmental problems associated with the removal of the fine fraction from natural sands, to produce a clean sand suitable for concrete purposes. Increasingly, disposal of tailings is becoming a major issue, with development consents in some locations in Australia, in close proximity to urban areas, requiring mechanical de-watering of the fine fraction. This adds significantly to production costs and will work against the future use of natural sands for fine concrete sands.

7.0 THE FUTURE POTENTIAL AT MAROOTA

7.1 The Issues

Maroota is currently the third largest producer of clayey sands in the Sydney region, and its potential as a producer of clean sands is yet to be realised. As the depletion of currently developed sand reserves continues, it will become increasingly important that resources such as Maroota are developed to their full extractive potential.

The next 5 to 10 years will see a number of the historically dominant sand operations including Penrith Lakes, Londonderry and Kurnell reduce and cease production, leaving a significant shortfall in the region's ability to service its own demand for construction sands. Two options exist to mitigate this shortfall. The first is to develop identified resources within the Sydney Region, and the second is to increase the importation from external reserves.

Government and the industry are certainly concerned about the future supply of construction sand to the Sydney market.

The Taskforce on Supply of Construction Sand, which was established in 1995/96, was established to address the problem of the resource depletion of the current and historical supply sources in most of Sydney's construction sands. Coupled with increasing environmental pressures to not develop certain of the potential deposits has meant that it is unclear what the future supply strategy will be and how it will evolve.

The taskforce explored experiences internationally, examined the capacity to use substitute materials and considered environmental, social and economic constraints and opportunities in examining the various supply sources.

That report has never been released and it is unclear as to the use to which it has been put.

It is clear that there will be a number of issues that will determine the future supply sources. It may be that the market will determine the sources and the approval or otherwise of new sources be determined on local issues rather than by any government strategy.

SREP No. 9 has sought to protect the resources and has gone someway towards facilitating future development approvals. However, the government's planning instrument cannot determine exactly which resources will be developed, it can only determine those that will not be developed.

In examining the Maroota situation, it will come down to a comparison on specific issues with other available resources. The issues that will determine whether Maroota and/or other resources are developed are as follows:

- Transport issues and the cost effectiveness of transport
- Environmental issues
- Product type and quality

Product type and quality cannot be effected and is largely a given parameter.

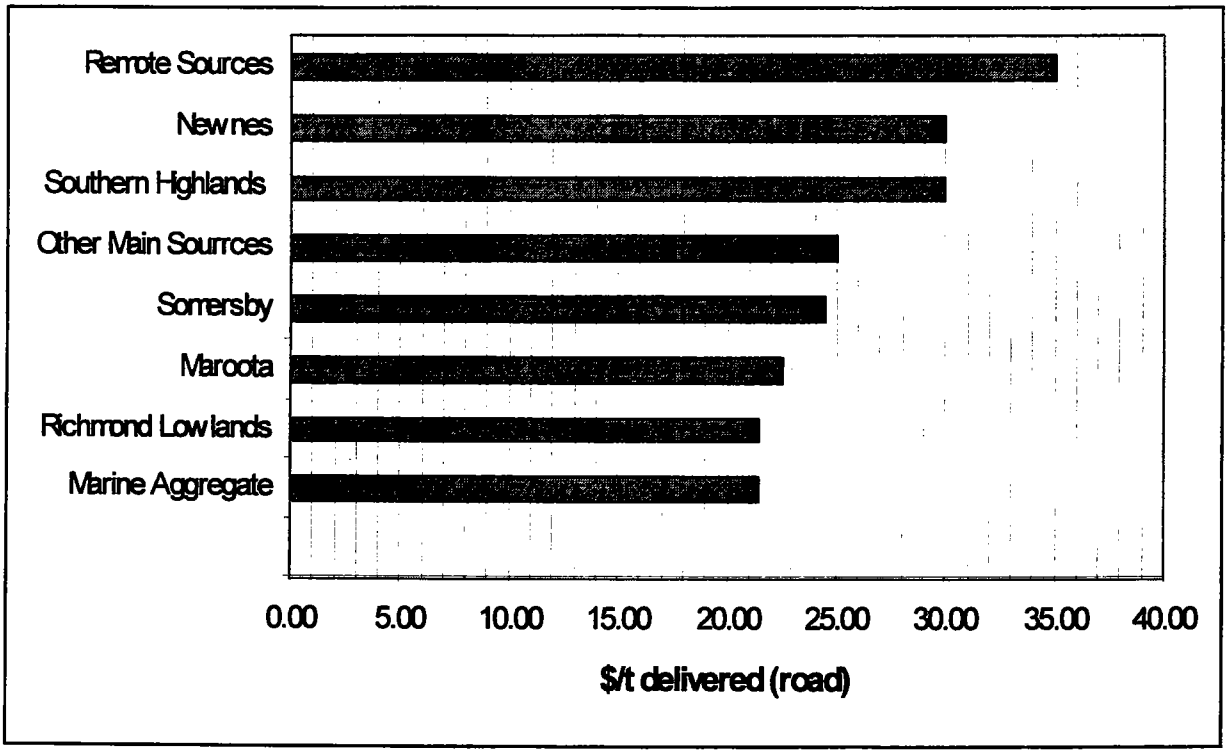
Transport is simply a function of geography and the transport issues are examined in the following section.

Environmental issues are the key. Many potential deposits are unlikely to be developed because of environmental pressures. The situation regarding the development to full potential of the Maroota deposit is examined in **Section 7.3**.

7.2 Transport Issues

The contribution of individual suppliers is largely dependant upon their delivered price competitiveness, assuming comparable sand quality. Supply sources at the higher end of the price curve are hence at the greatest risk of loosing markets, since any market contraction or new entrant supplier positioned lower in the price curve, will reduce the competitiveness of that supplier.

Figure 4.
Comparative Transport Costs for Various Sand Resources.



If the construction industry is to continue to be supplied with sand at low unit cost in the future, resources will need to be developed within the Sydney Region. Due to its low unit value, sand cost as a commodity is largely affected by transportation costs, which can constitute up to 50% of its value. Whilst the Richmond Lowlands and marine aggregate deposits are large scale potentially, low cost sources of sand, their development must at this time be unlikely.

The data in **Figure 4** has been projected based upon inflation of estimated current transport costs. From this data it can be seen that the Maroota resources are ranked favorably in regards to transport costs. The large reserve deposits of Newnes and the Southern Highlands must be regarded as high investment risks. Large yet constant transportation costs rank them at the upper limits of the commodity cost curve, causing these deposits to be vulnerable to economic fluctuations. These fluctuations will impact upon the price and thus the market competitiveness of the sand produces at these sites.

7.3 Environmental Issues

Environmental issues will be the key to the future development of any deposit which has the potential to be a major supply source, given its location and product quality.

SREP No. 9(2) and other Departmental comparisons of the various potential future sources have all ranked Maroota relatively highly.

The key environmental issues that cloud Maroota's future potential have been identified as:

- Poor road access
- Problem of tailings disposal
- The impact of extraction, on drainage and groundwater systems, given the location of the deposit and the surrounding natural environment areas
- Conflict between agriculture and resource extraction

SREP No. 9(2) required the preparation of a new Development Control Plan for any further development could occur at Maroota. Such a plan was produced in 1997 (and used in draft in 1996) and since that time, there has only been one, albeit major, development approved. That development took some 2.5 years to gain an approval although, given problems of both the new DCP and the appeal that was made to the Court, the approval period was not that excessive.

From that example however, it would seem that major sand resource extraction is unlikely to be approved at Maroota, except under strict planning, environmental protection and environmental due diligence terms.

SREP No. 9(2) did identify that the Maroota deposit had the potential to supply the Sydney region, with 2 million tonnes of sand per year. With a likely total market of in excess of 7 to 8 million tonnes per year by the time such development potential is reached, the Department is suggesting that Maroota has the potential to be supplying approximately 25% of the Sydney market. This production level would represent a significant increase of the order of 400% from the existing level of production. Environmentally, it is not clear whether the area has the potential to absorb that level of extractive activity.

8.0 CONCLUSION

The industry recommended strategy from DMR, 1995 for the future supply of construction sands to this market was as follows:

- There should be optimum utilisation of all resources under existing approved operations.
- Further planning should be undertaken to examine the possibility of development of the major undeveloped deposits within the Sydney region, namely the Richmond Lowlands, the Somersby Plateau, offshore marine aggregates, the Maroota deposits and the Wrights and Wellums Creek deposits.
- There should be developed a range of sand types from a number of major sources. This was considered important to ensure that the industry's requirements are met at minimum environmental and other cost to the community and to also encourage continued competition, thereby reducing the likelihood of price increases.
- There should be a review of the potential for alternative methods of transport, particularly rail and sea transport remote, to the Sydney market. This is to at least examine the potential to make resources more economically feasible.

Since 1995, the potential for development of all of the major new resources has probably been somewhat diminished. The likelihood of offshore marine aggregate developments has decreased, Richmond Lowlands are unlikely to be developed and the other deposits all suffer from transport problems more significant than those that confront supply from Maroota.

As regards Maroota, there has been a significant upgrading on the main road system linking Maroota with Sydney's western and north western suburbs.

There has been a significant upgrading of Maroota's extractive industry planning regime and these requirements are now being introduced. It is possibly a little early to judge whether this new regime will achieve the standards necessary but the indicators to date are positive.

9.0 REFERENCES

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Appendix B2 – Draft Conditions of Development Consent

Prepared by Lyall & Macoun Consulting Engineers

This appendix examines and comments on the detail of each of the draft conditions of the Development Consent, set out in Attachment 5 of DC8500.

This purpose is to:

i. ***establish whether compliance with the particular issue has been addressed in the EIS***

ii. ***establish whether compliance with the particular issue is able to be achieved.***

IT IS NOTED THESE CONDITIONS ARE DRAFT CONDITIONS ONLY AND ARE CLEARLY TO BE AMENDED IN ANY ACTUAL CONSENT.

DRAFT CONDITION	*RESPONSE*

PART 1: GENERAL

1.1:	The staged development being carried out substantially in accordance with Development Application No.98/000 lodged with Council on ..... and supplementary information received by Council on ..... except where amended by the following conditions of consent.	
1.2	Submission to and approval by Council of a building application for all intended temporary and permanent structures. Plans submitted with the building application are to demonstrate compliance with the Building Code of Australia and conditions of this consent.	***Building application/certificates have already been lodged for the plant. BA to be lodged for workshop extensions and associated works***
1.3	The proponent is to lodge a separate application for any alterations and/or expansion to the approved extraction activities including vehicle ingress/egress arrangements and the erection of any signs.	***Noted and agreed***

PART 2: PRIOR TO COMMENCEMENT OF WORKS

2.1:	Two (2) groundwater monitoring bores with multiple observation tubes are to be installed prior to the commencement of extraction. Specifically, one monitoring bore is to be installed within or near the extraction area whilst the other monitoring bore is to be installed at some other location, within the subject site, beyond the radius of any mining influence. The actual location and depth of each bore is to meet the requirements of both Council and the Department of Land & Water Conservation.	***Three monitoring bores already installed. DS1 is located in the centre of Lot 196 adjacent to the main storage pond. It is downslope from all extractive operations. DS2 and DS3 are located on adjacent properties to the east of Lot 29, some 300 m and 100 m respectively. No additional monitoring bores are proposed.***
2.2:	The proponent is to obtain all necessary operating licenses and permits from all relevant public authorities including the Environment Protection Authority and the Department of Land & Water Conservation and details of which are to be submitted to Council prior to the commencement of all on-site works.	***All licences, approvals and permits requirements already determined. Applications will be lodged prior to issue of any development consent.***

2.3: Prior to commencement of the quarry operations the proponent is to undertake the following:

(a) Construct all internal all-weather surfaced access tracks with crossfall and associated table drains and lead outs, designed to carry the extraction vehicle loading;

(b) Provision of headwalls, scour protection and sedimentation traps for all drainage systems and leadouts mentioned in (a) above:

(c) The provision of erosion and sedimentation controls. Details to be shown on engineering plans and the devices to be established prior to the commencement of engineering works;

(d) Include all recommendations from the Authorities in preparation of the engineering plans in respect of access and transport of materials, extraction activities and rehabilitation works. The particular Authorities must include:

(i) Department of Urban Affairs & Planning;
(ii) Hawkesbury-Nepean Catchment Management Trust;
(iii) N.S.W. Department of Agriculture & Fisheries;
(iv) Environment Protection Authority; and
(v) Department of Land & Water Conservation.

(e) Provision of safety protection fencing and guard rail where vertical faces are proposed in the quarry area and adjacent to the access track.

Prior to commencement of operations, engineering plans will be produced to detail all additional works required to upgrade the sites road, drainage and sediment control works

2.4: Prior to construction, Council will require the following:

(a) The submission for approval of detailed engineering plans in respect of Condition No.2.3 above. In this regard, satisfactory engineering plans are required drawn to scale, showing a north point, contours, benchmark, catchment area, batter slopes for cut and fill and drainage calculation. The plans are to include details of all stages of erosion and sedimentation control, preliminary, temporary and permanent.

Receipt of such plans does not imply automatic approval of the plans.

The submissions to the EIS will be used on the basis of identifying Authority requirements

	Further, Council requires payment of the engineering plan assessment fee of $150 as prescribed in Council's Schedule of Fees and Charges. These plans are to be accompanied by advice from the relevant Authorities, that their requirements are met.	***Detail engineering plan (see above) will be submitted to Council for approval and no works on extractive operations undertaken until written approval has been received. The Plans will be submitted to those authorities prepared to undertake a review and certification.***
(b)	The lodgement of a suitable undertaking to complete all engineering works within the site boundaries. Such works are to be completed: (i) prior to and during the operation of the proposed extraction activities; and (ii) prior to final approval for the rehabilitation required when extraction activities cease.	
2.5:	Prior to the commencement of extraction, the proponent shall lodge with Council a Rehabilitation Bond sufficient in amount to cover the cost of rehabilitating the approved extraction area and other likely disturbed areas. In this regard, the proponent shall pay a rehabilitation bond based upon $2.00 per square metre of extracted area in accordance with the revised Rehabilitation Strategy required by Condition No.5.2(?) of this consent.	***A Rehabilitation Bond of $200 000, equivalent to a 10 hectare area, is already held by Council. The total area of rehabilitation is greater than 10 ha. and the necessary additional bond monies will be negotiated with Council prior to the commencement of extraction.***

PART 3: OPERATIONAL

3.1:	Consent for the staged extraction of material and rehabilitation is limited to a period of **ten (10) years** effective from the endorsed date of this consent, based upon a high level of performance and terminating in the year **2009**.	***A consent for staged extraction and rehabilitation of ten (10) years duration is sought.***
	The performance of the operation shall be assessed and reviewed by Council every five (5) years from the endorsed date of consent having regard to the findings and recommendations of the management plans referred to in Part of this consent.	***Noted and agreed.***

3.2:	The area of land disturbed for the purpose of extraction shall not exceed the overall extraction site as identified in the Environmental Impact Statement and supplementary information accompanying the application.	***Noted and agreed.***
	In this regard Extraction activities are not to encroach within the following setbacks:	***Noted. Setback distances have already been established to most external boundaries as a result of previous operations. The only new setbacks to be established are around the boundaries of Precinct 11 in Lot 29.***
(a)	30m from Old Northern Road and Wiseman Ferry Road;	
(b)	50 m from critical habitats of threatened species:	
(c)	10 m from all property boundaries not associated with the extraction operation.	
3.3:	The proponent may work from multiple extraction stages subject to achieving the operational and rehabilitation performance criteria set out in the approved development application and conditions of this consent.	***Two concurrent extraction operations are proposed.***
3.4:		
(a)	The number of laden vehicle movements are not to exceed a combined total of **60** laden movements per day being the proponent company's total vehicle movements for existing combined extractive industry operations at Maroota.	***Maximum number of laden vehicles proposed is 60/day from the site. Up to 4/day laden vehicles will also enter the site. Such vehicles will be included with the 60/day that will leave the site.***
(b)	All vehicles are to enter and leave the site in a forward direction and prominent and permanent signposting to this effect is to be provided and maintained at all times.	***(The purpose of this clause is not understood).***
3.5:	The depth of extraction is not to exceed the depths as specified in the EIS. Extraction depths may increase to no more than two (2) metres above the wet weather high groundwater level in accordance with the Maroota Groundwater Study together with the requirements of Council and the Department of Land & Water Conservation.	***Noted and agreed.***
3.6:	The proponent is to ensure at all times that ground water is not breached nor contaminated. In event of groundwaters being breached or contaminated, operations are to cease and Council together with the Department of Land & Water Conservation are to be immediately consulted to	***Noted and agreed.***

	determine the basis upon which extraction may recommence.	
3.7:	The annual volume of material to be extracted shall be in accordance with the details in the Environmental Impact Statement and accompanying documents.	***Noted and agreed.***
3.8:	In the event any archaeological material is found during extraction, operations are to cease immediately and the National Parks & Wildlife Service and Council are to be consulted.	***Noted and agreed.***
3.9:	Operations involving extraction, transportation and processing or running of machinery for maintenance purposes shall not take place on the land except between 7.00 a.m. and 5.00 p.m. Monday to Friday and 7.00 a.m. to 12.00 noon Saturday, and at no time on Sundays and Public Holidays. The applicant shall ensure that its drivers and clients do not arrive at the site prior to 6.45 a.m. on any day. In this regard, the hours of operations are to be carried out in accordance with the requirements of the State Pollution Control Act, 1975.	***The application is to seek extended hours of operation, subject to controls, from 6am to 6pm, Monday to Saturday, inclusive. In addition, loading of vehicles between 5.30 am and 6.00am is also sought.***
3.10:	Care is to be taken at all times to ensure that all natural bushland directly adjoining the extraction site is not damaged or disturbed.	***Noted and agreed.***

PART 4: AIR QUALITY

4.1:	The proponent shall comply with the provisions of the Clean Air Act (1961), including the controlling of equipment on premises other than scheduled premises' as stated under Section 19 & 19A of the Act.	***Noted and agreed.***
4.2:	The proponent shall comply with the provisions of the Noise Control Act (1975), including the attainment of a licence pursuant to Section 27 of the said Act	***Noted and agreed.***
4.3:	The proponent shall ensure employees are not subjected to noise or dust levels greater than those specified and prescribed by the WorkCover Authority and the Department of Mineral Resources and the Factories Health & Safety Hearing Conservation Regulation	***Noted and agreed.***
4.4:	The proponent shall ensure that construction and operational noise does not exceed the background noise level when measured at her receivers boundary, by no more than 5dB(A) or otherwise to the	***Noted and agreed. Verification survey to be undertaken within 6 months of operations commencing.***

	requirements of the Environment Protection Authority and Council's Director-Planning Services Group.	
4.5:	Dust suppression equipment is to be fitted to all processing equipment and is to be maintained on a minimum of a six monthly basis and details of which are to be submitted to Council in accordance with Condition No.6.1 of this consent and to any other relevant authority referred to under Section 23 of the Clean Air Act 1961	***There is no specific dust suppression equipment proposed to be fitted to the processing equipment. The approval of the EPA will be sought at the time of the application for the Pollution Control Approval and Operating Licence.***
4.6:	The proponent shall install wind activated sprinkler systems capable of suppressing dust from all exposed/disturbed areas, internal access tracks and other sources.	***Not considered necessary. Dust monitoring will be used to demonstrate adequacy and again, the EPA's approval will be sought.***
4.7:	The proponent is to monitor dust generation from the extractive operation and associated activities and the results of which are to be detailed in the Air Quality report referred to in Condition No.6. 1 of this consent. In the event of dust nuisance being identified, the proponent shall immediately inform Council's Manager- Development Control and implement any mitigation practice as required.	***Noted and agreed.***
4.8:	Native bush regeneration techniques shall be used to stabilise the semi-permanent topsoil and overburden bunds surrounding the extraction area. The specialised techniques shall be carried out under the direction of a qualified Plant Ecologist. The techniques used shall include the re-use of stored topsoil that has not been contaminated with exotic grasses or weed species and the collection and propagation of species from the site.	***Noted and agreed. A Plant Ecologist has been engaged as a consultant.*** ***Noted and agreed. (Refer to Rehabilitation and Vegetation Strategy).***
4.9:	Stockpiles of material and other sediment laden areas are to be maintained so as to prevent dust nuisance. In this regard, arrangements satisfactory to Council's Director- Planning Services Group are to be made for dust suppression from topsoil stockpiles until such time as vegetative consolidation takes effect and details of which are to be confirmed prior to the commencement of on-site works.	***Noted and agreed.*** ***Noted and agreed. Will also include overburden and interburden stockpiles.***

4.10:	Prior to leaving the site, all loaded trucks must have their payloads fully covered by a suitable material to prevent spillage from the trucks onto the roads.	***Noted and agreed. See EMP provisions.***
4.11:	Mitigation measures to control soil erosion, sediment and surface water runoff are to be in accordance with Department of Land and Water Conservation guidelines. This is to include regular monitoring in conjunction with relevant Officer(s) from the Department of Land and Water Conservation.	***Noted and agreed.***

PART 5: REHABILITATION

5.1:	The extraction area is to be backfilled only with earth and rock materials sourced as a result of extraction operations in the Maroota area. No solid waste or putrescible materials are to be disposed on the subject site.	***Noted and agreed.***
5.2:	The site is to be progressively rehabilitated in accordance with the rehabilitation provisions of the Environmental Impact Statement and the regularly endorsed Rehabilitation Management Plan subject of Condition No.6.3 of this consent.	***Noted and agreed.***

PART 6: MONITORING & MANAGEMENT

6.1:	The proponent is to submit to Council every twelve (12) months after the endorsed date of this consent an Air Quality Report in which Council is to be satisfied that dust and noise levels generated by the extraction operation comply with the established practises and standards including the Environmental Noise Control Manual.	***Noted and agreed. (Please note: ENCM however does not specify dust control matters).***
6.2:	The proponent is to submit every twelve (12) months after the endorsed date of this consent a Water Management Plan in which Council is to be satisfied that adequate means of transferring and/or discharging the build up of ground & surface waters is maintained and monitored, particularly in relation to the following:	***Noted and agreed.***
(a)	Certified and suitable arrangements for dewatering water pits including contingency arrangements;	
(b)	Means of treating polluted (including sediment laden) waters;	

(c)	Means of maintaining/monitoring current surface and sub surface water quality.	
(d)	Identification and adequacy of existing destination points for waters collected within the extraction area;	
(e)	Maximum and average water levels experienced and the capacity of the existing water sump to sustain major storm events;	
(f)	On-site reuse of collected water and other potential uses; and	
(g)	State of significant site features, ground water recharge areas and natural springs;	
(h)	Achievement of qualitative and quantitative criteria of the approved Water Management Strategy including any improvements and/or adjustments now needed.	
6.3:	To ensure rehabilitation progresses in an orderly and efficient manner the proponent is to submit every twelve (12) after the endorsed date of this consent an Rehabilitation Management Plan in which Council is to be satisfied of the following:-	***Noted and agreed.***
(a)	the rate of rehabilitation is similar to the rate of extraction and cleared/disturbed areas minimised ;	
(b)	vegetative buffer zones and rehabilitated areas are maintained;	
(c)	vegetation outside the extraction area are successfully retain and protected;	
(d)	progressive rehabilitation integrates with the surrounding terrain and approved final landform;	
(e)	vegetative covers are established at the earliest possible opportunity	
(f)	assessment/comment on the progress of rehabilitation carried out under the direction of the nominated supervisor; and	
(g)	method and progress of the rehabilitation of extracted areas are in accordance with current environmental laws standards and practices including guidelines published by the Australian Federal Environment Department and the Department of Land and Water Conservation.	
6.4:	The proponent is to ensure the conservation and on-going management of threatened species, populations and ecological communities, in particular those of Ironbark Turpentine at all times and details of which are to be incorporated within the Rehabilitation Management Plan subject of Condition No.6.3 of this consent.	***Noted and agreed.*** ***(This clause seems misplaced).***

	The proponent shall submit to Council every twelve (12) after the endorsed date of this consent, a Social Impact Management Plan in which Council is to be satisfied that extraction operations effectively manage and monitor social impacts upon the local community including:-	***Noted and agreed.***
(a)	Impact Management Planning which clearly identifies adjusted operating objectives & procedures undertaken to minimise social impact;	
(b)	Monitoring & mitigating procedures involving the collection of information about actual impacts which is then applied to specific operating procedures to mitigate and manage social effects; and	
(c)	Evaluating involving the retrospective review of the overall performance of extraction and assesses the effectiveness of the management process itself with the view to rectify any deficiencies	
6.5:	The proponent shall submit to Council every twelve (12) months after the endorsed date of this consent an in which Council is to be satisfied of the overall performance and management of the operation. The Environmental Management Plan should refer to the objectives and principles of Ecologically Sustainable Development (ESD) and may use and/or reference as chapters and the respective management plans required by Condition Nos. 6. I to 6.5 of this consent in order to address the following matters:-	***Noted and agreed.***
(a)	Acquisition of all necessary licences and permits;	
(b)	On-site materials management;	
(c)	Water Management;	
(d)	Acoustic Management;	
(e)	Air quality Management;	
(f)	Transport routes, access & movements	
(g)	Rehabilitation Management including results of flora and fauna monitoring programs;	
(h)	Soil Conservation including geo-technical appraisal of tailing system and erosion and sediment controls;	
(i)	Social impact management including consultation with community groups, nearby residents together with the views of the Management Committee referred to in Condition No.6.6 of this consent;	
(j)	Identification, assessment and evaluation of risks, safeguards and the confidence level of contingency/emergency plans;	

	(k) Statement of Compliance with the approved EIS documentation, conditions of this consent and the objectives of Council's DCP No.500 - Extractive Industries; **(l)** Advice and recommendations of all relevant state government agencies; **(m)** Reference to International Standards (ISO) 14001-14004 relating to Environmental Management Systems, which should address issues such as:- • The capacity and support mechanisms necessary to implement and: achieve the proponent company's environmental policy, objectives and targets; and • the means by which the proponent company measure, monitor and evaluate its environmental performance; and **(n)** Recommendations to adjust operation procedures to improve the overall performance of the operation;	
6.6:	The Proponent shall establish a Management Committee to oversee the extractive industry and make necessary recommendations to improve the day to day performance of the operation including input into the proponent company's environmental management system and details of which are to be recorded in the annual Environmental Management Plan required by Condition No.6.5 of this consent. This Management Committee shall convene at least twice each year during the life of the operation and shall consist of the following representatives:- **(a)** no less than two (2) permanent residents not associated with the proponent company. **(b)** Baulkham Hills Shire Councillors and/or Council Officer, **(c)** Officers from relevant state government agencies; and **(d)** any other relevant person/s as may be considered appropriate by the Committee.	***Noted and agreed. Various Company management committees have been established and two planning focus meetings held with State Government agencies during the EIS preparation. The makeup of this full Management Committee will be established once consent is issued.***

PART 7: DEVELOPER CONTRIBUTIONS

7.1:	The applicant shall pay or procure payment to the Council of a contribution under Section 94 Environmental Planning and Assessment Act (1979) at the rate of sixty one cents per tonne of all processed material transported from the subject site, and in respect of the said contribution, the following provisions shall apply:	***Noted and agreed.***

(i) The said contribution will be calculated and paid monthly from the date on which and within development consent became effective.

(ii) The said contribution will be indexed and adjusted annually as from the date the consent became effective, in accordance with the Consumer Price index applicable to each year ending 30th June, commencing 1st July, 1992 for the duration of the development consent and the said adjustment to the contribution shall take effect from and including July each year, commencing 30th June ..... for the duration of the consent.

(iii) On or before the fourteenth day of each month of the duration of the consent the applicant shall deliver or procure delivery to the Council of true certified copy weighbridge or other returns or records showing the true quantities of extracted material transported from the property during the immediately preceding month and the Council will then, as soon as it can conveniently do so, issue to the applicant or its consenting assignee, who will pay to the Council within fourteen (14) days of the date thereof.

(iv) The Council will pay all of the said contribution payments into a specially identified trust account for payment towards the rehabilitation, restoration, repair and/or maintenance of Old Northern Road and Wisemans Ferry Road, between its intersection with Old Northern Road and the Baulkham Hills Shire Boundary at Cattai Creek and other projects identified in its Contributions Plan No.6 – Extractive Industries.

CATEGORY C – PLANNING AND ENVIRONMENTAL ASSESSMENT

C1.	EXTRACTION PLAN
C2.	REHABILTATION AND REVEGETATION STRATEGY
C3.	INTEGRATED SURFACE WATER MANGEMENT
C4.	NOISE ASSESSMENT
C5.	GROUNDWATER IMPACT ASSESSMENT
C6.	TRAFFIC AND TRANSPORTATION ASSESSMENT
C7.	FLORA AND FAUNA ASSESSMENT
C8.	FLORA AND FAUNA ASSESSMENT – CROWN ROAD
C9	VISUAL AMENITY ASSESSMENT
C10	DRAFT ENVIRONMENTAL MANAGEMENT PLAN

Appendix C1 – Extraction Plan

Appendix C1 – Extraction Plan

1. SCOPE
2. BASIS OF PLANNING
3. FINAL LANDFORM PLANNING
4. EXTRACTION STRATEGY
5. EXTRACTION QUANTITIES
6. EXTRACTION AND REHABILITATION SEQUENCING
7. TAILINGS MANAGEMENT

Prepared by Southern Environmental Pty Ltd

EXTRACTION PLAN FOR FINAL STAGES OF EXTRACTION LOTS 196 AND 29, NORTH MAROOTA

Prepared for

DIXON SAND (PENRITH) PTY LTD

Prepared by:

Southern Environmental Pty Ltd

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ATTACHMENTS

1. SCOPE

This report documents the extraction plan upon which the EIS is based.

It will form the basis of:

- **Quarry development planning**, including the sequence of quarry development by Precinct, the site road system, water storage dams, tailings dams and sediment control structures.
- **Water management planning**, including the staged development of the quarry's water storages and sediment control structures, and the associated drainage and erosion control systems.
- **Rehabilitation planning**, including the progressive rehabilitation by Precinct, and associated strategies for topsoil and overburden/interburden management.

The site is defined as all of Lot 196 and Lot 29 (DP 752025), with the exception of those areas excluded from extraction for environmental protection reasons. Most of the Precincts within Lots 196 and 29 have been quarried in the past.

The extraction planning process has been as follows:

1. Zoning the site into Precincts on the basis of whether they have been or are:
   (i) fully extracted, or
   (ii) partly extracted, or
   (iii) tailings disposal areas, or
   (iv) unworked areas

2. Calculating the sand reserve quantities in each precinct, making allowances for waste material.

3. Defining the requirements for:
   (i) water storages
   (ii) tailings storages
   (iii) first flush runoff storages

Quarry development and water management plans have been developed from this report. They show the progressive development of the site over the life of the final extraction/rehabilitation phase of all of the extractive areas of Lots 196 and 29.

2. BASIS OF PLANNING

The assumptions upon which planning has been based are as follows:

- Existing setbacks for the existing quarry areas are maintained, with new setbacks provided in accordance with DCP 500 for any area where excavation has not commenced.
- The internal access road separating Lot 29 from Lot 196 will remain in place and will effectively create two sites in the short term. (Council has objected to the road closure application). Council has also clearly indicated that the road issue needs to be resolved to achieve a uniform final landform.
- Extraction is to be limited to the 15.2 m maximum depth within Lots 196 and 29 and to a level of 2 m above the groundwater table, whichever be the determining requirement. (It is noted that design of a final landform, in practice, often results in full depths not being able to be extracted). The groundwater table is currently being monitored on Lot 196 and on adjacent Lots 1 and 2. (Groundwater table interim levels are assessed separately).
- Moisture content has not been taken into account in calculating sand reserves.
- The minus 60 µm particle size fraction (all silts and clays) has been assumed at 15% (for calculating washing yields).
- Extraction of white and yellow sands is in accordance with their defined markets. (It is noted that yellow sand comprises most of Lot 196, with white sand comprising the eastern boundary of Lot 196 and all of Lot 29).

The Dixon operation has experienced in recent years a preference in the market for white 'brickies' sand. That market demand on its own almost exceeded the old consent limitations (of 40 loads per day, for 5.5 days per week).

The 40 loads per day is equivalent to approximately 40 x 24 = 960 tonnes per day (based on average loads that vary between 11 and over 30 tonnes). This is equivalent to a maximum annual sales of 250,000 tonnes, allowing for 10 public holidays and 19 wet days per year when sales would not be possible (net 257 full sales days/year).

It is estimated that the existing market over the next 7 years might allow up to:

- 40 loads per day of brickies sand (six days per week)
- 20 loads per day of "washed" sand (six days per week)

It is proposed, that with the new washing circuits on the processing plant and with a certain quantity of coarse sand being imported (to blend with Maroota sands), a concrete sand will be produced that is estimated to have a market of up to 20 loads per day. This would require the importation of up to 7% of the concrete sand volume, of coarse sand, in order to provide the necessary grading.

It is therefore proposed that the year 1 market will be a minimum of 40 loads per day, which would grow to a total of 60 loads, of which some 20 loads will be washed sand (mainly for concrete sands) and will be predominantly of yellow sand. The 40 loads of brickies sand will be predominantly white sand. This will provide a continuing bias towards the white sand.

The rate at which the increase from 40 to 60 loads per day occurs is a function of market conditions. The Company will be in a position to supply and would seek to market up to 60 loads per day from the start. For the purposes of this analysis, it has been assured that the initial rate would be 40 loads per day, reaching 60 by year 5. Approval for 60 loads per day from day 1, is to be sought. (It is noted all impact assessment studies assume 60 loads per day from day 1).

The assumptions made for both tailings and other waste material losses are:

- washed sands – 15% tailings fraction (compares with the crushed sandstone particle size analysis (see Attachment 1) of 12.2% of less than 0.02 mm)
- interburden/overburden waste – 5% (for both yellow and white sand deposits)

The above waste material percentages are based on operating experience and some materials analysis. The tailings fraction assumed is supported by the particle size analysis. It is noted that other sand washing operations in the Maroota area are producing higher tailings percentages. The overburden/interburden fraction is low because most areas have been stripped.

(The overburden waste, in the white sands areas, includes a clay material below the topsoil and a 'creamy' coloured sand below the clay. This material is stockpiled as overburden and with topsoil, can comprise a surface layer up to 1.2 m in depth.)

There is minimal waste interburden material in the white sands deposits. However the only area with remaining overburden is the white sand area (Precinct 11).

The yellow sands include a similar overburden material but also includes interburden material that comprise clay seams, ironstone bands, etc. Most overburden has already been stripped.

The assumed sales figures are summarised in **Table 1**.

TABLE 1

FORECAST PRODUCTION
(Truck Loads/Day)

YEAR	TOTAL DAILY/SALES	COMPONENT SALES	
		Mortar Sand	Concrete Sand
1	40	40	0
5	60	40	20

Note: year five(5) is forecast to be the peak production year.

The previous production figures were based on a 5 ½ day per week production. It is proposed that this be increased to 6 days per week (6am to 6pm Saturday). This will provide an additional 26 effective sales per day, or an annual total of 283 days.

Based on a net 24 tonne load per truck and 257 sales days per year, the sales figures are shown in **Table 2**. For year 5, average tonnages have been increased to 29 tonnes/truck.

TABLE 2

PREDICTED ANNUAL SAND SALES
(Tonnes)

YEAR	TOTAL SALES	COMPONENT SALES	
		Mortar Sand	Concrete Sand
1	140,000	70,000	70,000
5*	300,000	140,000	160,000

*NOTE: Year five is predicted to be the peak production year, with years 6 and 7 reflecting falls in production.
Total production tonnages are then calculated by:

- assuming all "concrete sands" are washed sands and making an allowance for tailings losses of a net 15% (allowing for some washing for blending)
- assuming mortar sand is unwashed (although in practice it is blended with 8% washed sand).
- allowing 5% for total overburden/interburden/topsoil loss on total raw sand production.
- allowing 5% for imported coarse sand in concrete sand sales.

Table 3 calculates future raw sand production requirements to meet projected sales forecasts.

TABLE 3

FUTURE RAW SAND REQUIREMENTS
(Tonnes)

YEAR	SITE WASHED SAND SALES	TAILINGS PRODUCTION	IMPORTED COARSE SAND	MORTAR SAND	OVERBURDEN/ INTERBURDEN LOSSES	TOTAL STRIPPING REQUIREMENTS
1	140,0000	21.0000	7,000	250,000	7,000	157,500
5	300,000	\45,000	15,000	140,000	15,000	328,500

Note year five is the peak production year.
Table 4 provides cumulative annual site production forecasts of raw sand, tailings and waste material.

TABLE 4

SITE CUMULATIVE RAW SAND AND TAILINGS PRODUCTION
(Tonnes)

YEAR	ANNUAL STRIPPING	CUMULATIVE TOTAL	ANNUAL TAILINGS	CUMULATIVE TAILINGS
1.	157,500	157,500	23,625	23,625
2.	234,000	391,500	35,100	58,725
3.	270,000	661,500	40,500	99,225
4.	328,500	990,000	49,275	148,500
5.	328,500	1,318,500	49,275	197,775
6.	300,00	1,618,500	45,000	242,775
7.	216,000	1,834,500	32,400	246,015

The assumption inherent in all of the above is that all materials are at the same moisture content (around 7%). The moisture content for the insitu material is approximately 7% (see **Attachment 1**). Tailings however discharge from the plant at around 93% moisture content (1.1 T/m^3), settle rapidly to around 80% moisture content (1.3 T/m^3) and will naturally dewater to around 50% moisture content (1.7 T/m^3) over time. Hence, for approximately each tonne of (dry) tailings, there is approximately 0.5 T of water bound to the fine particles. (This is equivalent to 0.5 ML per 1000 tonnes of dry tailings).

Finally, a comment on the rate of tailings production. The tailings production, in **Table 4** is only indicative. It is a function of:

i) the tailings percentage (taken as 15%)

ii) the production level in total and particularly, washed sand production. That is, the rate of growth from 40 loads to 60 loads per day and the break-up between washed and unwashed production.

The **Table 4** tailings figures could be considered to be a lower bound estimate.

3. FINAL LANDFORM PLANNING

The preferred proposal for the site's final landform is shown on **Figure 6.7 of the EIS Volume 1**,. **Figure 1,** of C1, shows the original topography of the site, the basis then for calculating maximum permissible extraction depths (which are limited to 15.24 m).

The final landform is a function of primarily the extraction strategy, the quantity of tailings to be disposed on site, and various site constraints, including non quarriable areas, drainage lines, erosion control requirements, and of course the adoption of the preferredf landform without the land bridge.

The final landform, as shown on **Figure 6.7 of the EIS Volume 1**, has the following features:

- No level changes in the works and adjacent stockpile area in the central part of Lot 196.
- A single, final water storage in the southern part of the site, the size and capacity of which, to comply with of the DLWC's recently announced farm dams policy.
- The major east west drainage line, re-established across the site and discharging directly into the downstream water course, thereby re-establishing the continuity of at least part of that water course.
- Tailings storage being mostly confined to the north eastern part of this site, thereby allowing that area of the site, being approximately one third of Lot 196, to be at a higher level.
- The integrating of the extracted part of the Lot 196 site with the area of Lot 196 that has been protected and preserved from any effects of quarrying.

It is also noted that if the inability to achieve closure of the Crown reserve road separating Lots 196 and 29 persists, then the site and the final rehabilitation of the two Lots will have to be carried out separately. The objective, however, is to seek to remove the sand contained within the Crown reserve easement and thereby provide a continuity of landform and drainage across Lots 196 and 29.

4. EXTRACTION STRATEGY

The site has been divided into Precincts, in which the state of extraction within each precinct is approximately the same. **Figure 3**, Extraction Precincts, shows the location of some eleven Precincts, two within Lot 29 and nine within Lot 196. In outline, there are:

- Three Precincts which are at final rehabilitation levels (Precincts 1, 2 and 7)
- Two Precincts which have had Stage 1 rehabilitation completed (Precincts 2 and 7)
- Three Precincts where further extraction is required but where the predominant extraction has already occurred (Precincts 4, 8 and 10)
- Three Precincts which will provide the majority of future extraction quantities (Precincts 5, 9 and 11)

Details of each of the precincts are as follows:

- Precincts 1, 2, 3 and 6 have been excavated to their final depths. All have been backfilled with tailings and are close or at their final levels (Precinct 3, the current tailings dam will be completed as regards filling in the next few years). Specific details are as follows:
  - Precinct 1 is the Works and Processing Area and has been previously excavated and previously fully filled. It will continue to operate as the works and processing area for the life of these operations and for potential future operations. There is some minor filling required in the southern part of the works area, to accommodate the final extent of the works area layout and the new roadway system.
  - Precinct 2 has also been filled with tailings from past operations. It has been capped with 1 or 2 m of clean fill and recently seeded. Further rehabilitation works are planned.
  - Precinct 3 is a currently operating tailings pond. Its final tailings filling level will be approximately 177/179 m AHD and capping will increase the final finished surface level between 179 and 181 m AHD.
  - Precinct 6 has been previously worked and refilled with tailings. This precinct contains a large topsoil stockpile and this stockpile will be required for the rehabilitation of all of the areas of Lot 196.

- Precinct 7 was partly extracted previously and then used for tailings disposal. The decision has been taken to not extract remaining reserves but to complete the precinct's rehabilitation. This has now been completed by capping, topsoiling and initial grassing.

- Precincts 5, 8 and 9, to be extracted for yellow sand and Precinct 4 with some remaining white sand, are the **remaining sand resources in Lot 196**. The details of future extraction, subsequently rehabilitation planning, are as follows:
  - Precinct 4, in the southern part of Lot 196 has been largely excavated. It currently operates as an overflow storage. The northern part of Precinct 4 will, in its final form, contain the creek line transferring runoff from the upstream catchment through the site

discharge into the downstream drainage line. The creek will drop in a series of steps, from the haul road at 177 m AHD to the north east corner of Precinct 4, to a level of approximately 165 m AHD – a fall of 12 m. The creek will then be relocated along the northern boundary of Precinct 4 in a reconstituted natural drainage line.

- Precinct 5 has been extensively worked although there are considerable depths of sand still to be extracted, including, if feasible, by an extension into the Crown road reserve. Precinct 5 will be used as the future tailings pond after the Precinct 3 pond is full. Final levels of filling will be to between 181 m AHD and 183 m AHD. Sand depths remaining are of the order of 8 m.
- Precinct 8 covers all of the area of the existing main storage pond (TWL 165 m AHD), an additional area at the western end and an area which is an existing stockpile adjacent to the central part of the pond. Current bottom levels of the pond are 161 m AHD. The groundwater table, as monitored in DS1, is approximately 158 m AHD. Accordingly, the pond cannot be excavated. Pre-mining levels were of the order of 165 m AHD to 170 m AHD. However, in the western extension of the pond, sand depths of up to 7 m can be extracted (from 168 m AHD to 161 m AHD). The enlarged pond bed therefore will stay at approximately 161 m AHD throughout.
- Precinct 9 is a very large area and contains the bulk of the remaining resource of yellow sand. It is all of the north west quadrant of Lot 196. The original level of this area varied from approximately 170 m to 185 m AHD. It is proposed that it be extracted to levels that will vary from 165 m AHD, at the edge of the final storage pond in the southern part of Precinct 9, to levels up to 170 m AHD in the central part of the precinct. The area will have cut batters on three sides and a rise in the middle. The area will drain to the main storage pond and the drainage line will be located along both east and west boundaries. A batter will separate this area from the upper bench area, comprising all of Precincts 1, 2, 6, 3, 5 and 7.

- **Precincts 10 and 11 are the development areas to supply white sand.** They will be separate from the Lot 196 operation because of the Crown road reserve. The Company will operate Lots 196 and 29 as separate drainage operations and accordingly, separate rehabilitation and drainage programs have been developed.

  - Precinct 10 is the current area of extraction for white sands. It is constrained on its northern side by the internal access road occupying the Crown Road Reserve and on its eastern side, by the right of way being preserved for a future relocation of that haul road. That relocation will now not occur and hence, that right of way can now be extracted. Precinct 10 will be progressed into Precinct 11, with Precinct 10 operating as the drainage pond for localised runoff.
  - Precinct 11 will be developed from the south, as a front advancing in a northerly direction.

5. EXTRACTION QUANTITIES

The existing mobile plant and equipment, as listed below, is adequate to maintain the raw sand production feed required from those quantities previously calculated. The plant list is as follows:

- 2 Caterpillar 637D scrapers (40 tonnes)
- 1 Komatsu 420 front end loader
- 1 Komatsu 500 front end loader
- 2 Komatsu 375 dozers
- 1 Case 580C front end loader
- 1 Komatsu 300 front end loader
- 1 water cart (10,000 L)
- 1 grader (Cat 12)
- 1 Komatsu PC 400 excavator
- 4 x mobile water pumping stations

The extraction available from those precincts containing residual reserves of yellow sands is calculated in **Table 5**.

5.1 Yellow Sand Extraction – Precincts 5, 8 and 9

The extraction available from those precincts containing residual reserves of yellow sands are set out in **Table 5**.

TABLE 5

EXTRACTION PLANNING – YELLOW SAND

Precinct No.	Existing Excavated Level (m AHD)	Final Excavation Level (m AHD)	Final Rehab Level (m AHD)	*Approximate Remaining Reserves*		Tailings Storage Available (m^3)
				Average Sand Depth	*Tonnage*	
5	177 E/184/W	170/173	181/183	6/12	180,000	120,000
9	174/181	164/170	164/170	10/11	700,000	–
8	161/168	160/161	Pond (TWL 165)	0/6-7	80,000	–

The quantities have been calculated by Keown and Drummond (Surveyors) and assume an insitu sand density of 1.7 tonnes per m^3. The "Tailings Storage Available" is the volume available within Precinct 5, when the resource has been extracted. This needs to be compared with the estimated tailings production (see **Table 4**) to determine the adequacy for storage of future volumes.

The majority of the yellow sand reserves are in Precinct 9. There has been relatively little extracted from this area to-date and its large area, combined with an excavation depth in excess of 10 m, provides a large reserve.

Precinct 8 was originally to include the lowering of the bed of the main storage pond.

For Precinct 8, only the western end and the central extension containing the existing stockpile, will provide the remaining reserve in this area.

The quantity of yellow sand remaining to be extracted is of the order of 960,000 tonnes.

5.2 White Sand Extraction – Precincts 4, 10 and 11

For white sand extraction, **Table 6** sets out the available resource.

TABLE 6

EXTRACTION PLANNING – WHITE SAND

Precinct No.	Existing Excavated Level (m AHD)	Final Excavation Level (m AHD)	Final Rehab Level (m AHD)	*Approximate Remaining Reserves*	
				Average Sand Depth	*Tonnage*
4	163/173	163/164	163/164	0/10	50,000
10	164/184	163/170	163/170	0/15	80,000
11	180/185	163/172	163/172	15	550,000

It should be noted that extraction over the last 6 months of 1998, since the survey was prepared, has mainly been from Precinct 10. All of the western end (the dogleg) has been extracted to the full depth. The final depth in this area can be seen to be from 163 m AHD, at the western end, to 170 m AHD at the eastern end. The only remaining reserves are in the eastern end.

In Precinct 11, setbacks have been provided to the Crown road and to Lot 117 to the north.

The total sand resource of white sands is of the order of:

- **Lot 196 – 50,000 tonnes (Precinct 4)**
- **Lot 29 – 630,000 tonnes (Precincts 10 and 11)**

A summary of the resource estimates is given in **Table 7**.

TABLE 7

REMAINING RESOURCE (LOT 196 & PORTION 29)

Lot	Precinct No.	Sand Type/Use	Estimated Reserves (Tonnes)
196	5	Yellow/concrete	180,000
196	9	Yellow/concrete	700,000
196	8	Yellow/concrete	80,000
196	4	White/mortar	50,000
29	10	White/mortar	80,000
29	11	White/mortar	550,000

The resource can be divided into:

- Concrete sand – 960,000 tonnes
- Mortar sand – 680,000 tonnes
- Total – 1,640,000 tonnes

In **Section 2** of this report, it was forecast that future stripping production would commence at 262,000 tonnes per year in year 1 and increase to approximately 538,000 tonnes in year 5. Mortar sand would be produced at 40 loads per day from day 1 and concrete sand would grow from 0 sales in year 1 to 20 loads per day by year 5. On this basis, the life of the extraction operation would be as set out in **Table 8**. (This split is not exact because of greater losses for the yellow or concrete sands, because of washing).

TABLE 8

CUMULATIVE STRIPPING REQUIREMENTS (INDICATIVE ONLY)
(tonnes)

Year	Total Yearly Stripping	Concrete Sand		Mortar Sand	
		Annual	Cumulative	Annual	Cumulative
1	157,500	70,000	70,000	70,000	70,000
2	234,000	90,000	160,000	120,000	190,000
3	270,000	120,000	280,000	130,000	320,000
4	328,500	160,000	440,000	140,000	460,000
5	328,500	160,000	600,000	140,000	600,000
6	300,000	180,000	780,000	80,000	680,000
7	216,000	180,000	960,000 (resource limit of 960,000 tonnes)		680,000 (resource limit of 680,000 tonnes)

The assumption here is that, when the mortar sand is depleted, all the production continues of the yellow sand until it is also depleted.

If 60 loads per day were able to be supplied from the outset (at an average load of 24 tonnes), equivalent to an annual stripping rate of some 450,000 tonnes per year, then the mortar or white sand would last approximately 2 years and the concrete or yellow sands, less than 4 years.

So in summary, the development proposal that will see the finalisation of resource extraction on Lots 196 and 29 and will involve the extraction of some 1.7 million tonnes, producing approximately 1.4 million tonnes of sales products. The life of the operation will depend upon the level of market demand. With the most optimistic scenario of 60 loads per day from day 1, the operation will be completed in less than 4 years. At a more gradual build-up from 40 to 60 loads per day, the total resource will be extracted in 7 years.

It will be proposed however, that a consent be sought for a period of 10 years so as to ensure there is sufficient time, not only to complete the extraction and marketing of the resource but also to complete the site's rehabilitation, which will, given the extent of current operations, be a task that will likely extend past the completion of resource extraction. It is however noted that wherever possible, parallel rehabilitation of completed Precincts will be carried out in line with the completion of extractive operations in other Precincts..

6. EXTRACTION AND REHABILITATION SEQUENCING

Parallel yellow and white sand operations will be necessary to meet market demands from both concrete and mortar sand markets.

With mortar sand maintaining its dominance as the major product to be produced, the following sequence of extraction and rehabilitation can be is proposed for mortar/white sand areas:

- Precinct 4 – maintained as principal operating water storage for Lot 196; northern end excavated and developed as Processing Area's sediment or catch ponds in year 1.
- Precinct 10 – completed in year 1; developed as Lot 29 principal water storage.
- Precinct 11 – worked for all three of the years 1, 2 and 3. Rehabilitation will commence at end of extraction.

For the concrete/yellow sands, the sequence would be:

- Precinct 5 – extraction carried out in years 1/2. Immediately transferred to operation as site tailings pond.
- Precinct 3 –rehabilitation commences in year 2/3.
- Precinct 9 – excavation over years 2 onwards, at completion of Precinct 5
- Precinct 8 – excavation of western end will be linked to extraction of Precinct 9. Its rate of extraction will also be linked to market demand.

De-watering of the overflow storage pond (Precinct 4) will commence in the last year of extraction, with the re-establishment and rehabilitation of the creek line being completed in the first stages of rehabilitation.

7. TAILINGS MANAGEMENT

7.1 Tailings Characterisation

Approximately 7% to 10% of the raw feed processed at the north Maroota operation can be classified as fines or tailings. However, in effect, the tailings percentage is higher than that because of the carry over (through the processing of the raw feed) of a certain percentage of the coarse silt and fine sand fraction.

Fines are considered to be all clays and fine silts. Clays are materials of a particle size of less than 0.002 mm (or 2 μm) and fine silts are particles between 2 μm and 6 μm.

There may be a difference in tailings percentages between the yellow and white sands but it is minimal. There is a greater variation across a deposit, and on average, a figure of 15% has been adopted as representing the tailings loss.

Set out in **Table 9** below, is a particle size characterisation of the raw feed material from north Maroota, presented to the processing plant.

TABLE 9

PARTICLE SIZE DISTRIBUTION - RAW SAND
NORTH MAROOTA (percentages)

Clay	Silt			Sands		
< 2 μm	Fine < 6 μm	Medium < 20 μm	Coarse < 60 μm	Fine < 200 μm	Medium < 600 μm	Coarse < 2000 μm
6	3	3	6	6	30	46

The grading shows effectively, a coarse sand. It was taken from a surface site which had not been worked for some time and therefore some of the finer fractions has clearly been lost. The material at Maroota is generally classified as a fine medium sand, with some limited areas of medium coarse sand.

Table 10 shows the particle size distribution of the North Maroota tailings.

TABLE 10

PARTICLE SIZE DISTRIBUTION - TAILINGS (percentages)

Clay	Silt			Sands		
< 2 μm	Fine < 6 μm	Medium < 20 μm	Coarse < 60 μm	Fine < 200 μm	Medium < 600 μm	Coarse < 2000 μm
30	10	10	25	25	0	0

As can be seen, there is half the material above medium silt, which could lead to the conclusion that tailings percentages should be higher than the 15% that will be used.

However, it is noted that the percentage of particle sizes less than 200 μm, in the finished washed product for concrete sand is less than 15% and less than 100 μm, it is less than 1%. There is therefore a residual percentage of silts in the washed product but equally, there is also a significant loss of coarse silts and fine sands to the tailings.

Improvements to the washing process will have the effect of lowering this carry over.

The percentage allowance for tailings loss is important, as it affects not only the requirements for tailings storage but also the net sales quantities that can be produced.

In summary, the following percentages have been used in the resource assessment:

- Tailings loss, 15%
- Overburden and inter-burden loss, 5%
- Topsoil, 0%

It is noted that these percentages are not typical of sand mining operations at Maroota or anywhere else. The fact that most of the topsoil has been stripped from Lot 196 and Lot 29, is the reason for the 0% for topsoil. The percentage for tailings and the percentage for overburden and inter-burden, at 5%, reflects the fact that most of the overburden has been stripped from the remaining sand resource and accordingly, effectively only inter-burden allowances need to be made. It is also noted that the loss of product, through scalpings (over sized material) is also included in the overburden/inter-burden figure.

The tailings percentage of 15% is higher than originally adopted but reflects the need to be somewhat conservative, in order to provide sufficient tailings storage. Improvements to the washing circuits may have an effect in the future on reducing this loss.

Other characteristics of the North Maroota tailings are:

- They settle rapidly and dewater reasonably well; (see the high hydraulic conductivity figure in **Attachment 1**).
- Achieve a final moisture content before rehabilitation of around 30% to 35% (approximately 1.5 tonnes per m^3 density). They are discharged from the wash plant at around 95% moisture content (1.1 tonnes per m^3) and settled within a relatively short period to around 80% moisture content or approximately 1.3 tonnes per m^3.
- The dispersion percentage is low, which is identified in the Environmental and Soil Laboratory analytical report, as *"being a result of the extreme acidity and high aluminium levels, which are aiding the flocculation of the clays and suppressing some of the dispersion"*.
- Low salinity.
- Low nutrient status.

7.2 Tailings Management Issues

In the quarrying and mining industry, any process that involves washing the ore or extractive material produces tailings which, by the nature of the process, is the unwanted fraction. The washing of sand is to remove clays and silts, in order to meet specifications for say, concrete sand or any other form of washed sand. (The washing of coal is to remove the non-carbonaceous material or at least, a proportion of it).

In any washing or beneficiation, the process is never perfect. There is a carry over of carbonaceous material in fine coal tailings (and hence they are still combustible). In sand processing, the carry over of too much fine sand is obviously a loss of marketable product.

Washing obviously is a wet process. The key management issue is to reduce the moisture content to the extent possible. The normal process in tailings operations is to go through some form of *"thickening"* process to reduce the volume that needs to be discharged to a storage.

Further dewatering, once placed in a storage or tailings dam, is then by decanting and to an extent, seepage and evaporation.

Mechanical dewatering can provide a far more effective moisture reduction, using equipment such as filter presses, belt presses, etc. These processes are prohibitly expensive and generally only used for dewatering sewage sludges, etc. There are however, a number of isolated instances where they have been used in the sand industry.

Sand tailings are easier to manage than many mineral tailings. They have two principal advantages:

- They are generally not as fine as mineral tailings. Mineral tailings are produced from a crushing process with the ore, which renders the particle sizes much smaller, and hence provides a much more difficult material to handle (thixotropic effects).
- Mineral tailings can often have reagent chemicals carried over from the processing (eg. cyanide in gold processing).

Table 11 below, incorporating both the table and graph, is adapted from a paper on tailings management (Fell, 1993). The table and graph show differences between a range of other tailings and the North Maroota sand tailings. The grading curves show a range of iron ore, coal and bauxite tailings. There is also an average tailings range for sand tailings provided, extracted from a recent paper by Corkery, 1998. The Maroota raw sand particle size analysis is also shown.

It can be seen that sand tailings are not that different from many other tailings. The North Maroota tailings have a number of distinguishing characteristics that however do aid in their handling and dewatering:

- Relatively low percentages of clay and finer fractions in comparison with mineral tailings.
- A higher percentage of coarse silts and fine sands than other tailings.

Tailings management also includes the form of tailings disposal and/or storage.

Many tailings storages are dams, constructed behind walls that are progressively raised as the tailings level increases. There is always the potential for such dam walls to fail. (There have been some major tailings dam failures around the world in recent years). The geotechnical design of such structures is important. The benefit they do provide however, is that the walls can be designed as filter walls, to enable the dewatering of the tailings insitu.

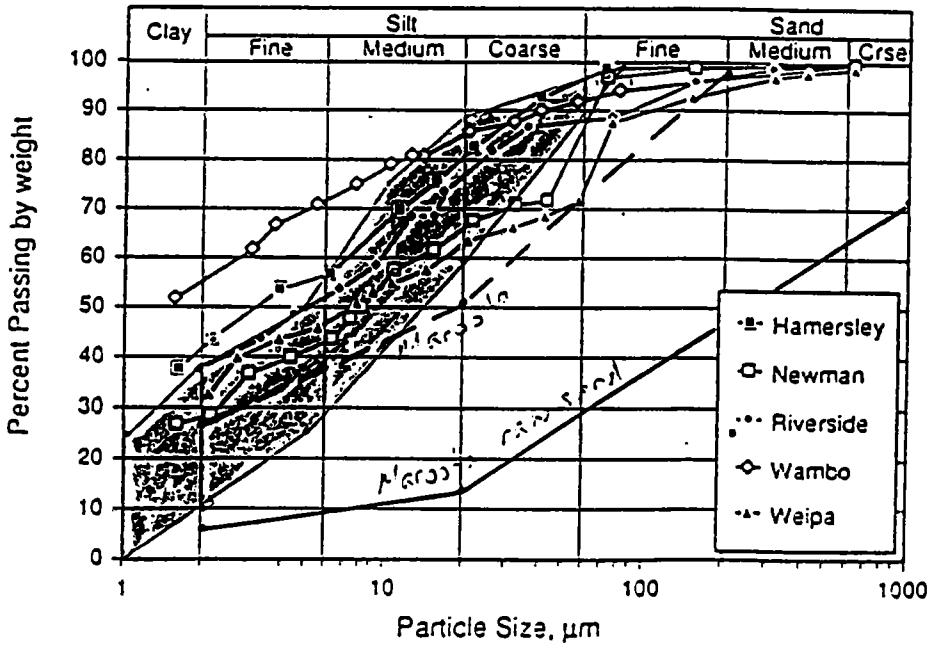
TABLE 11

COMPARATIVE TAILINGS PROPERTIES

. Soil mechanics properties of tailings as discharged

Mine	Type	% Solids	Discharge Void Ratio	Soil Particle Density	Liquid Limit	Plasticity Index	% Clay (< 2 µm)	% Sand (> 0.6 mm)
Hamersley	Iron ore beneficiation	37	5.95	3.50	30	9	42	4
Newman	Iron ore beneficiation	34	7.20	3.70	33	11	29	13
Riverside	Coal washery	29	4.25	1.74	44	16	39	12
Wambo	Coal washery	20	7.45	1.86	74	46	57	8
Weipa	Bauxite	22	10.1*	2.85	43	17	32	28
Maroota	- - -	65					29	< 1

*No thickening is undertaken at Weipa



The North Maroota process has always been to dispose of tailings within excavated pits. This has a number of benefits:

- There is not the danger of embankment walls failing.
- The tailings generally, are better contained.

One disadvantage is that the tailings may be difficult to dewater further and the latter stages of dewatering largely relies upon a downward movement of the water fraction and its discharge by seepage.

7.3 Tailings Storage and/or Reuse

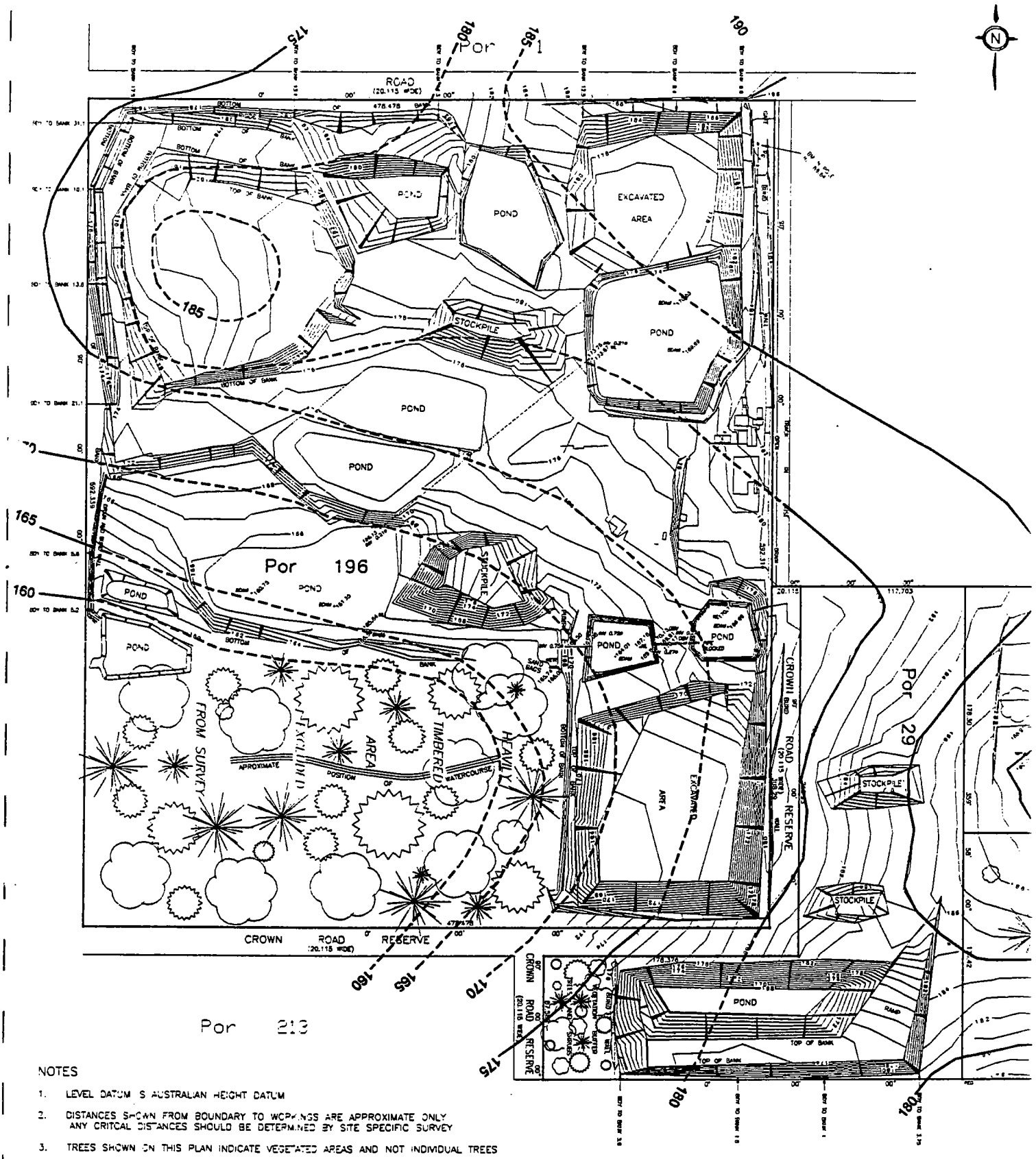
Tailings disposal considerations include the following:

- Tailings need to be able to be recovered in the future, should a market develop.
- The surface of the tailings storage needs to be able to be rehabilitated with a suitable vegetation cover.
- Drainage from the insitu tailings should not adversely impact on groundwater or surface water qualities.
- Infiltration of surface water should generally be discouraged.

All of the north eastern part of Lot 196 has and will continue to be for the purpose of tailings storage. Excavation in this area has been followed over the life of the site, with the discharge of tailings into old pit areas. The planning for the final stages of extraction and rehabilitation of this site envisages a continuation of that strategy.

The effect of the tailings disposal will be that the final contours of that area of Lot 196, effectively making up some 50% of the total extracted area of the site, will have final contours very similar to its pre-quarrying condition. At the northern boundary, previous natural surface levels varied from 185 m AHD to 188 m AHD and final levels will be approximately 2 m lower. Adjacent to the final storage dam, the original surface levels were approximately 171 m AHD and the final levels will be brought back approximately to that level.

The consideration and management of the drainage issues from tailings storages, as it may effect groundwater, is considered in **Appendix C5**, Groundwater. Rehabilitation issues associated with tailings storages are addressed in **Appendix C2**, Rehabilitation.



NOTES

1. LEVEL DATUM IS AUSTRALIAN HEIGHT DATUM
2. DISTANCES SHOWN FROM BOUNDARY TO WORKINGS ARE APPROXIMATE ONLY ANY CRITCAL DISTANCES SHOULD BE DETERMINED BY SITE SPECIFIC SURVEY
3. TREES SHOWN ON THIS PLAN INDICATE VEGETATED AREAS AND NOT INDIVIDUAL TREES
4. ORIGINAL CONTOURS FOR N.W. CORNER FROM 'FIGURE 4 SITE LAYOUT PLAN' EIS (1992)

LEGEND

- Original contours
- Existing contours

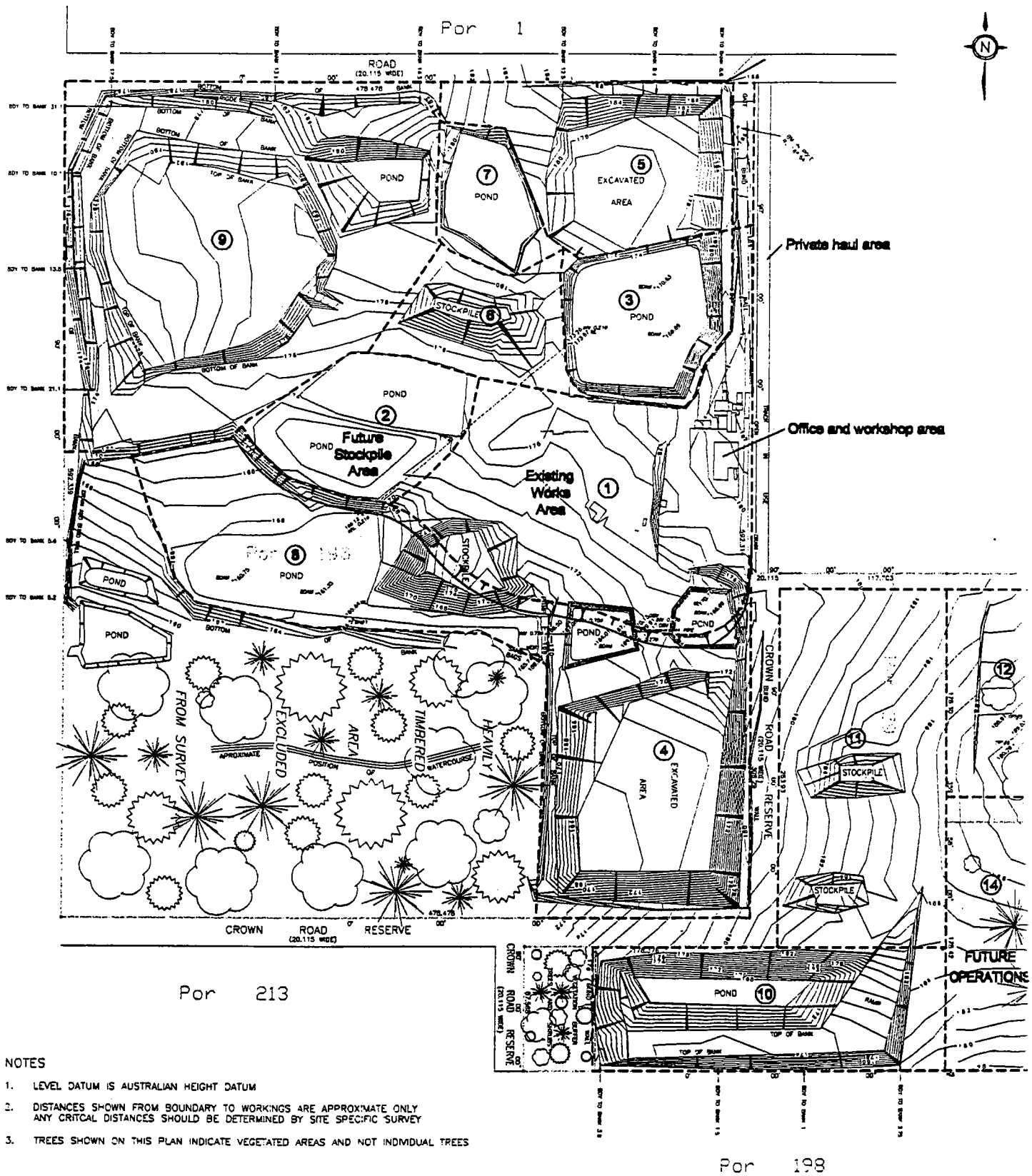
0 20 40 60 80 100m
SCALE

NORTH MAROOTA OPERATION, NSW

Figure 1

ORIGINAL SITE TOPOGRAPHY

3W560\WORK\CADD\TOPO1.dwg



NOTES

1. LEVEL DATUM IS AUSTRALIAN HEIGHT DATUM
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3. TREES SHOWN ON THIS PLAN INDICATE VEGETATED AREAS AND NOT INDIVIDUAL TREES

LEGEND

(7) Precinct numbers

Precinct boundaries

Buffer zone

00 20 40 60 80 100m

SCALE

NORTH MAROOTA OPERATION, NSW

Figure 3

EXTRACTION PRECINCTS

ATTACHMENTS

Soil Physics Profile No. 1

Test Type I Perm,PSA,MC,Disp%
Order No Job No:
Reference
Sample Name Tailings
Sample No. 39314a
Date Received 14/9/98 Total No Pages: 2
Client: Layll & Macoun Consulting Engineers
Timothy Macoun
Level 2, 4 Help St
CHATSWOOD NSW 2067

Certified Laboratory Practice

Sydney Environmental and Soil Laboratory

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CHARACTERISTIC		RESULT	COMMENTS
Texture			
Emerson Stability Class			
Dispersion %		18.8	
Particle Size Analysis (PSA)			
> 2mm	Gravel	0.0	
2 - 0.2 mm	Coarse Sand	0.9	
0.2 - 0.02 mm	Fine Sand	48.8	
0.02 - 0.002 mm	Silt	21.7	
< 0.002 mm	Clay	28.6	
Sieve Analysis			
> 4 mm	Gravel		
2-4 mm	Coarse Sand		
1-2 mm			
0.5-1 mm	Medium Sand		
0.25-0.5 mm			
0.1-0.25 mm	Fine Sand		
< 0.1 mm	Very Fine Sand		

Recommendations

Total Solids Ratio: 65%, Moisture content: 0.53 g water/g dry soil
Saturated Hydraulic Conductivity: 14.8cm/hr

The dispersion percentage of this material is low relative to the clay content. The extreme acidity and high aluminium levels are probably aiding in flocculating the clays and suppressing some of the dispersion. Saturated hydraulic conductivity is surprisingly good for such a fine textured and poorly structured material.

Explanation of the Methods:
Texture:- Charman & Murphy (1991). **Emerson's Aggregate Test:-** Charman & Murphy (1991) . **Dispersion %:-** Ritchie (1963). **Particle Size Analysis & Sieve Analysis:-** Modified Black (1983) Method 43-1 to 43-6.

Checked by Principal.....
Simon Leake Date of Report 18/9/98

Consultant.....
J. Selvey

Soil Chemistry Profile

Test Type: BS,TN,TP
Order No: Job No:
Reference
Sample Name: Tailings
Sample No: 39314
Date Received 14/9/98 Total No Pages:
CLIENT: Layll & Macoun Consulting Engineers
Timothy Macoun
Level 2, 4 Help St
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Pennant Hills NSW 2120
Telephone (02) 9980 6554
Facsimile (02) 9484 2427
Email: sesl@sesl.com.au

TEST	RESULT	COMMENTS
pH in water 1:2	5.1	
pH in $CaCl_2$ 1:2	4.3	very acidic
EC mS/cm 1:2	.06	low salinity
Chlorides mg/kg		

CATION ANALYSIS

TEST	SOLUBLE		EXCHANGEABLE		
Unit	meq%	Comment	meq%	% of ECEC	Comment
Sodium			.09	1.10	good
Potassium			.19	2.40	low
Calcium			< 0.20	2.00	very low
Magnesium			.27	3.30	very low
Aluminium			7.35	91.20	198ppm
		ECEC	8.06		
		Ca/Mg	0.60		low

	mg/kg	
Phosphate - P	<0.80	low
Ammonium - N		
Nitrate - N		
Sulphate - S		
Iron		
Zinc		
Copper		
Manganese		
Boron		

Recommendations

Total Phosphorus - 38 mg/kg
Total Nitrogen - 350 mg/kg

In terms of revegetation, the chemistry of this material is very hostile for plant growth owing to the acidity, and the complete dominance of the cation exchange capacity by aluminium (which is phytotoxic). Large additions of dolomitic limestone would be required to raise the pH, reduce aluminium levels and raise the Ca/Mg ratio. Existing available phosphorus levels are low. Total phosphorus levels are low.

Total phosphorus and nitrogen tested at AGAL

Explanation of the Methods:
pH, EC, Soluble Cations, Nitrate: Bradley et al (1983). **Exchangeable Cations, ECEC:** Method 15A1 Rayment & Higginson (1992)
Chloride: Vogel (1961). **Aluminium:** Method 3500 APHA (1992). **Phosphate:** Method 9E1 Rayment & Higginson (1992). **Ammonium, Sulphate, Iron, Copper, Manganese + Zinc:** Method 83-1 to 83-5 Black (1983). **Boron:** Method 12C2 Rayment & Higginson (1992).

Checked by Principal.....
Simon Leake Date of Report 18/9/98

Consultant.....
J. Selvey

Soil Chemistry Profile

Test Type: pHEC,MC,PSA,Disp%,TN,TP
Order No: Job No:
Reference
Sample Name: Crushed sandstone
Sample No: 39315
Date Received 14/9/98 Total No Pages: 2
CLIENT: Layll & Macoun Consulting Engineers
Timothy Macoun
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Facsimile (02) 9484 2427
Email: sesl@sesl.com.au

TEST	RESULT	COMMENTS
pH in water 1:2	6.7	
pH in $CaCl_2$ 1:2	4.6	very acidic
EC mS/cm 1:2	.03	low salinity
Chlorides mg/kg		

CATION ANALYSIS

TEST	SOLUBLE		EXCHANGEABLE		
Unit	meq%	Comment	meq%	% of ECEC	Comment
Sodium					
Potassium					
Calcium					
Magnesium					
Aluminium					
		ECEC			
		Ca/Mg			

mg/kg

Phosphate - P
Ammonium - N
Nitrate - N
Sulphate - S
Iron
Zinc
Copper
Manganese
Boron

Recommendations

Total Phosphorus - <1 mg/kg
Total nitrogen: 110mg/kg
TN and TP tested at AGAL

the pH of this material is highly acidic, and large additions of liming agents are required. Salinity levels are very low which indicates virtually nothing apparent in the way of nutrients.

The clay in this sample is highly dispersive

Explanation of the Methods:
pH, EC, Soluble Cations, Nitrate: Bradley et al (1983). **Exchangeable Cations, ECEC:** Method 15A1 Rayment & Higginson (1992)
Chloride: Vogel (1961). **Aluminium:** Method 3500 APHA (1992). **Phosphate:** Method 9E1 Rayment & Higginson (1992). **Ammonium, Sulphate, Iron, Copper, Manganese + Zinc:** Method 83-1 to 83-5 Black (1983). **Boron:** Method 12C2 Rayment & Higginson (1992).

Checked by Principal.....
Simon Leake Date of Report 18/9/98

Consultant.....
J. Selvey

Soil Physics Profile No. 1

Test Type I pHEC,MC,PSA,Disp%,TN,TP
Order No Job No:
Reference
Sample Name Crushed sandstone
Sample No. 39315
Date Received 14/9/98 Total No Pages:
Client: Layll & Macoun Consulting Engineers
Timothy Macoun
Level 2, 4 Help St
CHATSWOOD NSW 2067

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Specialists in Soil Chemistry and Agronomy

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CHARACTERISTIC	RESULT	COMMENTS
Texture		
Emerson Stability Class		
Dispersion %	46.2	

Particle Size Analysis (PSA)

>2mm	Gravel	0.2
2 - 0.2 mm	Coarse Sand	76.3
0.2 - 0.02 mm	Fine Sand	11.4
0.02 - 0.002 mm	Silt	6.1
< 0.002 mm	Clay	6.1

Sieve Analysis

>4 mm	Gravel
2-4 mm, 1-2 mm	Coarse Sand
0.5-1 mm, 0.25-0.5 mm	Medium Sand
0.1-0.25 mm	Fine Sand
< 0.1 mm	Very Fine Sand

Recommendations

Total Phosphorus - <1 mg/kg
Total nitrogen: 110mg/kg
Total solids ratio: 94%, Moisture Content: 0.07 g water/g dry soil
TN and TP tested at AGAL

The pH of this material is highly acidic, and large additions of liming agents are required. Salinity levels are very low which indicates virtually nothing apparent in the way of nutrients.

This material has a relatively low clay content, but almost half of this is prone to dispersion. This represents a significant risk of erosion and potential failure of earthen structures.

Explanation of the Methods:
Texture:- Charman & Murphy (1991). **Emerson's Aggregate Test:-** Charman & Murphy (1991) . **Dispersion %:-** Ritchie (1963). **Particle Size Analysis & Sieve Analysis:-** Modified Black (1983) Method 43-1 to 43-6.

Checked by Principal.....
Simon Leake Date of Report 18/9/98

Consultant.....
J. Selvey

APPENDIX C2 – REHABILITATION AND REVEGETATION STRATEGY

REHABILITATION AND REVEGETATION STRATEGY

RECOMMENDATIONS AND
METHODOLOGIES

DIXON SAND (PENRITH) PTY LTD - NORTH MAROOTA OPERATIONS

Prepared for
Lyall and Macoun Consulting Engineers

FEBRUARY 1999

Prepared by:

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Job No: 7862432 File No: MC 290	Date: 22 February 1999 Revision No 2.0	Author: CVincent Reveiwed By: MSabolch

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1.0 SUMMARY

A Rehabilitation and Revegetation Strategy has been prepared for the continued sand extraction operations proposed by Dixon Sand Penrith at North Maroota. The Strategy has been prepared in accordance with the requirements of Baulkham Hills Shire Council's Development Control Plan number 500 as well as those of other agencies.

The objective of Strategy is to result in rehabilitation works which;

- are able to be implemented in a progressive manner in line with the continued extraction process,
- enhance the scenic and environmental quality of the site,
- provides opportunity for increased habitat for threatened flora and fauna species,
- utilises areas which are suitable for use in agricultural pursuits such as hydroponics or vermiculture, and
- are consistent with other environmental and extraction plans relating to the site.

The site had been broken into revegetation classes using the criteria of anticipated substrata and the depth of growing material. The presence of tailing storage under areas will be a factor affecting the suitability of certain species for use in the revegetation strategy. Each Rehabilitation Class has a specific strategy designed to address anticipated limitations, to result in a vegetative cover which is sustainable and in accordance with the objective of the Strategy mentioned above.

A structured Revegetation Methodology has been prepared detailing recommended works to be undertaken on an area by area basis, along with anticipated limitations relating soil characteristics. A comprehensive suite of soil tests is proposed for the analysis of all material used in the revegetation process. Such analysis is to be performed prior to the initiation of the rehabilitation strategy for each area. Requirements relating to fertilisers and soil ameliorants are to be determined through analysis of soil and overburden material and interpretation of results.

A selection of appropriate species for use as cover crops and as standing mulches has been recommended with comments on appropriate sowing times and other applicable management considerations. Cover crop species have been selected that will not spread into adjacent areas of native vegetation.

A list of native plant species, known to be occurring in the immediate vicinity has been prepared. This list provides a species composition which mimics the floristics of recognised local communities so that once established the visual and ecological texture of the site will be contiguous with that of the surrounding vegetation. Comments on the suitability of each species for use with each Rehabilitation Class has been included as well as whether local provenance seed is known to be available.

Methodologies for the planting of native species have been proposed in the revegetation methodology.

2.0 PREAMBLE

As part of the Environmental Impact Assessment report for the North Maroota Extraction Site, Dixon Sand is required to outline the program to progressively rehabilitate the site in conjunction with the extraction process. Soil Consult has been engaged as a subconsultant by the lead Environmental Impact Assessment Consultant, Lyall and Macoun Consulting Engineers, to prepare the revegetation portion of the Rehabilitation Strategy.

The following document details Rehabilitation Strategy Recommendations proposed for Dixon Sand Pty Ltd. It provides methodologies for the implementation of works and specific consideration relating to species selection, soil condition and constraints as well as annual reporting and maintenance of the rehabilitated areas through to establishment of final vegetation consistent with the planed final land use for each area. This document makes reference and functions in conjunction with elements of the:

Integrated Water Management Strategy and Sediment and Erosion Control Plan,
Final Site Topography Plan
Flora and Fauna Constraints - Gunninah Environmental Consultants 1998 (draft -unpublished).

2.1 EXISTING SITE CONDITIONS AND SURROUNDS

The Maroota operations site is located off the Old Northern Road (Portions 29 and 196 DP 752025) approximately 1.5 km north west of the centre of Maroota within Baulkham Hills Local Government Area. Surrounding land uses include orcharding, rural residential and sand quarrying with large areas of native vegetation remaining to the west and south west of the site.

The area and surrounds consists of undulating hills of "Sydney Town" Erosional soils over Hawkesbury Sandstone. These soils range from Sandy Earths, Earths and Siliceous Sands to heavier Podsolic soils in areas associated with shale lenses (Soil Landscapes of the St Albans 1:1000 Sheet, Department of Land and Water Conservation 1997). The original vegetation, of low Eucalypt woodland and scrub heath is now largely absent, however small pockets of original communities remain (Flora and Fauna Constraints - Gunninah Environmental Consultants 1998 (draft -unpublished). The vegetation of the site would have originally been a transitional zone to the native vegetation located to the west and the south west of the site, which changes to dense closed forest on colluvial soils.

2.2 REQUIREMENTS OF PUBLIC AUTHORITIES

This Strategy is prepared so as to address, as a minimum, the requirements and interests of: Baulkham Hills Shire Council - Draft Development Control Plan (DCP) 500, with:

Key objectives being;

- *To ensure that extraction sites are fully rehabilitated in an orderly, progressive and controlled manner.*
- *To maintain and enhance the scenic, heritage and environmental quality of the shire.*
- *To conserve and protect the environment of threatened species.*
- *To facilitate and ensure a final landform capable of supporting sustainable agricultural production or other post-extraction land use compatible with the rural/residential character of the region.*

Performance criteria being;

- *The submission of a rehabilitation strategy for the site with the development application as well as the annual submission of a Rehabilitation Management Plan.*
- *Due regard to the ecology and requirements of native plants and animals within the site and surrounds.*
- *Each extraction area to be rehabilitated under the direction of a qualified person.*
- *Appropriate management of stockpiled topsoil and overburden material to maintain the viability of soil and seed material within the stockpile.*
- *Maintenance of disturbed areas until rehabilitation is well established*
- *Progressive rehabilitation and establishment of vegetative covers to minimise the amount of disturbed land within the extraction area.*

&

NSW Department of Land and Water Conservation -Correspondence (28th May 1998), whose key concerns relating to the rehabilitation program, being that.

- *The proposed expansion of extraction operations is compatible with the required environmental outcomes and with restrictions relating to soils and hydrology.*
- *That factors relating to the implementation of erosion and sediment control are considered within the rehabilitation process.*

&

NSW Department Of Agriculture - Correspondence (20th July 1998), with the following concerns relevant to the rehabilitation of the site be included in the assessment of possible impacts:

- *The direct alienation of agricultural reserves.*
- *The impact on surface water and groundwater quantity, quality and supply.*
- *Proposed methods of rehabilitation with a view that disturbed areas will be rehabilitated to a level of at least pre-disturbance agricultural suitability.*
- *That mechanisms for the monitoring and management response to adverse monitoring response be clearly identified.*

2.3 REHABILITATION STRATEGY OUTLINE

The final landscape plan (prepared by Lyall and Macoun Consulting Engineers) indicated that the site is to be formed into a number of broad gentle slopes and undulations ranging from 2% to 5%. These slopes are to be broken by drainage structures, banks and channels to limit slope lengths to the order of 70m to 100m or less. It is recommended that considerations relating to the movement of surface waters should be taken into account when planning plantings. Areas where soil moisture or soil depth may be maximised due the construction of banks or other land forming, should be exploited from a revegetation perspective. As such, all revegetation operations should be undertaken with consideration to the Site Erosion Control Plan and the Site Drainage Control Plan.

The final landform can be divided into three rehabilitation classes according to the anticipated underlying soil conditions effecting the rehabilitation methodology. The location of Rehabilitation Classes are shown in **Appendix 1**

Rehabilitation Class 1

Comprising Precinct 9 and part of precinct 8 (as per the extraction plan) excavated to RL (relative level) 170m - RL 162m PLUS precincts 4, 10 & 11 excavated to RL 171m to RL 162m overlying native Hawkesbury Sandstone.

As it is not planned that any tailings are to be buried in these areas, the limitations to plant growth will relate to depth of soil, variable permeability of sub strata, soil chemistry and the nutrient status of top soil and sub strata.

These two broad areas would be suitable for a range of end uses. Perimeter batters and the periphery may be rehabilitated and revegetated with local native species using a variety of techniques. The use of native plant species in these areas will have a softening effect on hard edges improving the scenic and habitat value of the site as well as providing an extension of the conservation area located in the south west. The central portion of these areas could be rehabilitated into native heathland or scrubland or, given suitable silvicultural practices, limited orcharding enterprises.

Rehabilitation Class 2

Comprising precincts 1,2,3,5,6 &7. These portions will be entirely over tailing ponds capped, with native sandstone/clay overburden, to a depth of 1 to 1.5 metres with greater depth created by the formation of diversion banks or similar. This tailings storage will result in this area having a final landform ranging from RL 183 to RL 172, approximately 10m higher than the adjacent areas. In addition to the limitations described for Rehabilitation Class 1, there will be further restrictions imposed on the selection of revegetation species to those with root growth predominantly limited to the depth of the capping material. This area should be ultimately rehabilitated to a large expanse of native grassland, heath or low woodland while, at a latter stage, this area could also be suitable as a site for the limited trial of the establishment of citrus and other orchard species over capped tailing ponds, given further improvement of soil conditions and depth through mounding or similar. Any such trials should only be undertaken once the entire area has been successfully revegetated so as to limit impact on adjacent areas through the localised removal of established vegetation.

Precincts 1 and 2, within this class, are currently used as works sites and would be the most suitable areas for above ground agricultural operations such as hydroponics given the level of compaction achieved within these areas. Alternatively, long term staged rehabilitation of the area could be achieved through alleviation of the compaction (by deep ripping) and the importation and spreading of a suitable top soil material. Further addition and incorporation of soil ameliorants such as organic mulches or gypsum may be required to improve infiltration and root penetration. It is recommended that an analysis of soil conditions, at depth, be undertaken prior to revegetation of this area. This will involve numerous core samples to a depth of 1 metre or greater. Interpretation of the analysis results will guide the implementation of revegetation techniques.

Rehabilitation Class 3

Comprising a portion of precinct 8. This area is to be the site of the final water storage. No tailings are to be buried in this area.

3.0 REVEGETATION METHODOLOGY

The revegetation strategy for the various areas within the Dixon Sand Site will vary according to the underlying soil and strata conditions, location of tailing storage, depth of capping material and the desired final land use for each area. The following are the recommended procedures that should be followed in order to highlight and accommodate anticipated variation within the site.

3.1 SOIL TESTING

It is recommended that prior to commencement of the rehabilitation process for each area, numerous random samples from available top soil material, as well as any sub strata such as capping material, be taken for analysis. This analysis should be performed at a NATA registered laboratory. These soils should be subjected to, at a minimum, a standard revegetation test suite examining the following anolytes (or similar);

pH,
Electrical Conductivity (EC),
Texture,
Available Phosphorus,
Cation Exchange Capacity (CEC) and
Emerson Aggregate Test .

The results of these tests should be interpreted by a suitably qualified person with consideration to the intended rehabilitation strategy. This interpretation should be in the form of recommendations for the addition of fertilisers and/or soil ameliorants during the revegetation operation.

Further soil testing is recommended prior to each application of seed or broad scale planting exercise. Supplementary testing may be required in areas where plant establishment is unsatisfactory.

3.2 SOIL CONDITIONERS AND FERTILISERS

Preliminary testing of top soil and capping material will identify deficiencies or limitations relating to soil chemistry and soil fertility of the subject samples. Soils of the "Sydney Town" soil landscape can be expected to possess characteristics such as low pH with accompanying high aluminium and low fertility and low organic matter thoughout the soil horizon. As the top soil material available for the rehabilitation process is locally sourced it is anticipated that this material will display these characteristics. Initial testing of soil and overburden material from around the site will confirm these soil conditions (see **Appendix 4** for results).

For any revegetation strategy to succeed, these limitations must be addressed through the addition of fertilisers and/or soil conditioners, such as lime, dolomite or gypsum to adjust pH or soil structure. Interpretation of the soil analysis by a qualified soil scientist is recommended in order to identify requisite soil additives and ideal rates of application.

In areas where long term establishment of native species is desirable it is recommended that continued re-application of fertilisers be avoided unless specifically indicated as necessary through soil analysis. The maintenance of high nutrient status within the subject area will serve to promote the invasion or establishment of non native species in direct competition with the natives. In these situations it is recommended that the areas be allowed to establish their

own natural nutrient cycling within the soil once satisfactory establishment of the native species and their companion cereals and legumes (if used) is achieved. The use of low nutrient mulches such as clean straw or native brush may be used to assist this process.

The addition and/or incorporation of organic based fertilisers or mulches should also be considered in key areas at the initial stages of the revegetation process such as prior to the application of seed. Such organic material will improve the nutrient status and structure of the soil in the long term and increase the ability of the soil to retain moisture.

Care should be taken however when using nutrient rich organic material such as composted sewerage or spent mushroom compost, that this material is not allowed to enter drainage lines or water bodies as addition of nutrient rich organic matter can have a rapid and marked effect on the chemical and biotic components of aquatic ecosystems.

A further technique to improve the structure of a subject top soil is the use of sacrificial cover crops. These cereal crops not only act as a standing mulch, their root systems help to improve the structure of the top soil and improve water penetration through the profile.

3.3 COVER CROP USE AND SPECIES SELECTION

Due to the loose sandy fabric of the subject soils and their susceptibility to erosion where vegetative cover is absent, it is recommended that use of cover cropping is undertaken as a uniform practice during the rehabilitation of the site. The rapid establishment of non invasive, annual cover crop species will serve to stabilise areas prior to the implementation of further revegetation techniques. These cover crops can also be used as a valuable source of organic matter in the form of a standing mulch which may be slashed or incorporated into the soil prior to secondary application of seed or the planting of tube stock. Perennial and annual cover crop species (cereals or legumes) may also be applied in conjunction with native plant seed to stabilise the site and provide shelter to these species during their establishment (sometimes referred to as companion cropping).

The selection of cereal species to be used as cover crops should be done in consultation with qualified persons such as a rehabilitation consultant or a reputable seed merchant. Factors such as the time (season) of sewing, access to irrigation and persistence characteristics need to be taken into account. Due to the location of the site in respect to conservation areas and drainage lines/streams it is recommended that only species which will not become invasive or have low fecundity (production of viable seed head) be used. **Appendix 2** provides a indicative list of species suitable as cover crops.

It is recommended that cover crops also be used to stabilise sites such as stockpiles or work sites temporally excluded from the extraction process. Characterisation of soil nutrient status and chemistry prior to application will allow the selection of requisite fertiliser and ameliorants to provide the best possible result.

3.4 FINAL VEGETATION SPECIES SELECTION

Where the establishment of native vegetation is desired it is recommended that species locally occurring are used in order to maintain consistency in visual texture as well as in ecological characteristics, such as species composition and habitat. These benefits are further increased if seed or propagated plant material is used which is of local provenance (ie being of the same geographic site of origin).

Locally occurring, but poorly represented, are two committees of native heath, the Ridgetop Scrub Heath and the Maroota Sands Dry Heath, with grasses, low shrubs and mallee form trees suitable for planting over areas where soil depth may be limited by the presence of tailings. Included in this community are several taller species which may be used over areas where there is no buried tailing storage to create visual filters or similar. The floristic composition of these communities may be used as a guide to the selection of species used in the rehabilitation and as a long term goal for the final species composition of the rehabilitated areas. Through following the floristic composition of local heath communities, the long term benefits in relation to visual and environmental value of the area can be maximised (see Flora and Fauna Constraints - Gunninah Environmental Consultants 1998 (unpublished) and also Flora Appendixes of Western Sydney, Urban Bushland Biodiversity Survey - Vol 2, National Parks and Wildlife Service 1997). **Appendix 3** provides a list of species selected from the floristic of local vegetation communities which would be suitable for use in the revegetation program.

3.5 SEED APPLICATION TECHNIQUES

Some quantities of local provenance seed has been sourced and collected form the site. These species have been marked on the native species list **Appendix 3.** Where sufficient quantities are available, this native seed should be applied in conjunction with non native cereals and legumes (ie companion cropping) over large areas using techniques such as direct drilling or hydroseeding. Where local provenance seed and plant material is available, but in insufficient quantities for such application, it is recommended that this material be propagated for selective planting as tube stock. Correctly collected, stored and propagated seed will produce vastly greater numbers of seedlings per seed quantity than through direct broad acre application. The establishment of a small nursery structure for the purposes of propagating local seed would greatly enhance the development of the rehabilitation project as seedlings could be "hardened" to the exact local conditions.

An alternative to propagation from seed is the use of brush matting using locally collected cut stems. The cut material, containing mature fruit is lain over soils which have been prepared (scarified) to accept the seed. As the cut material dries the seed is released directly into the soil. The remaining brush material serves to create an ideal environment for germination. Brush matting has the added benefit of providing erosion protection especially on steep sites where the brush may be held in place with wire mesh and pegs.

Where freshly stripped (6 -12 months) top soil is available, this material may also represent a valuable source of local seed and should be utilised in the revegetation process.

Note: All collection of seed or other plant material should be carried out by experienced and competent personnel in order to limit impact on the collection areas. In cases where collection areas contain threatened, rare or otherwise protected species or communities a permissive licence to collect plant material is often required. Prior to collection in such areas the seed collection contractor should contact all relevant authorities such as the local council and the National Parks and Wildlife Service. All implementation of bush regeneration techniques above should be supervised by experienced personnel.

4.0 PROGRESSIVE REHABILITATION STRATEGY

The following outlines the recommended approaches to the staged rehabilitation. Refer to **Appendix 1** (Precinct Plan and Rehabilitation Classes) for location of areas. Final location of area boundaries may vary slightly due to site management and landforming restrictions. **Appendix 5** (Final Contours and Vegetation Plan) provides an indication of final vegetation for the site.

The Rehabilitation Strategy can be broken into 3 time periods based on the anticipated requirements of the extraction program.

Early Phase - 0 to 2 years

Latter Phase - 2 years and beyond

Final Phase - undertaken at the completion of site extraction.

4.1 PRECINCTS 6,7 & 2 (part)

Rehabilitation class 2
Initiation date December 1998 (Early Phase)

Site Conditions

This portion of the rehabilitation strategy pertains to the areas referred to as precinct 7, precinct 6 and precinct 2, representing a total area of approximately 3 Ha. The final landform of this area is to be a gentle slope of around 300m in length with a vertical rise totalling approximately 10m leading to a slope varying from 3% to 4%.

The anticipated final land use for the area will be hydroponics or some similar type of above ground agricultural production, with the remainder of the area being returned to native open bushland/ grassland. This is to form a swath of native vegetation , running north south through the area.

It is recommended that the majority of this corridor be ultimately revegetated predominantly with native grasses, sedges and local species of low shrubs. Where soil conditions allow, taller shrub/tree species may be utilised in a landscaping context to provide visual screens as well as to better approximate the natural species composition of the area.

Soil Limitations

Six random samples were taken from the existing stockpile of top soil located on Precinct 9 and was analysed to identify possible limitations to the successful establishment of vegetation on the site. (see results **Appendix 4 part A**). In general terms, these considerations may be summarised as follows:-

1. The material is generally a sandy clay loam with a low organic matter component. This soil typically will have moderate moisture retention. All soil samples were found to have generally low nutrient status being deficient in one or more key nutrients.

2. The material is highly acidic with a pH ranging from pH 4.9 to pH 5.3.

3. The material is quite stable with only very low to slight dispersion characteristics and low to moderate erodability. As the anticipated slope of the area will be of the order of 3% to 4%, it is not expected that that stability of the final vegetated surface should be a consideration as long as:-

   (a) Non-concentrated surface water flows are maintained
   (b) Slope lengths are limited to around 70 -100m or less.

In areas where concentrated surface flows are created as part of the surface water management of this area, then other surface protection such as jute mesh or liners may be required (Refer to the Erosion Control Plan).

Revegetation Strategy

In order to address the limitations expressed above, the following three phase revegetation strategy is proposed.

STEP 1 - Land Forming Prior To Revegetation
(Refer also to the surface water management/drainage plan)

A diversion bank is proposed for the area which is currently just North of the boundary of precincts 7&6. The outlet from this bank will be designed so that excess flows will be directed into the existing drainage infrastructure located to the West. The existing stockpiled top soil on precinct 6 is to remain until required for rehabilitation of future precincts. The toe slopes of this stock pile should be suitably formed and revegetated as it will act to divert flows from the southern end of precinct 7 predominantly towards the existing drainage infrastructure to the West.

In order to maximise the opportunities for retention of moisture available to plants through maximising infiltration, the base capping material is to be ripped along the contour to a depth of 150mm or greater.

Once the base landform has been achieved, the available stockpiled soil material will be spread over the area to a depth of 50 to 100mm with a greater depth of topsoil being utilised in the vicinity of contour banks or other diversion structures providing contour strips where:-

(i) Capping depth is maximised
(ii) Soil depth is maximised
(iii) Available moisture is maximised

The small quantity of recently salvaged topsoil (located on the boundary of precinct 2&9) should be judiciously spread in the key areas such as on the bank crests or within the depression undulations. It is anticipated that this fresh soil material may contain quantities of viable seed and as such will be placed in a location where soil/moisture conditions are most favourable for germination and establishment.

Phase 1 target completion date - first week in January 1999.

STEP 2 - Initial Cropping With Cereal

Immediately after the completion of phase 1, it is recommended that the area be contour ripped again to aid moisture retention and to key the topsoil material with the base capping material prior to application of seed, fertiliser and soil ameliorants.

Seed - Shirohie Millet a non persistent cereal species which produces a considerable amount of plant mass (straw and blade) is to be sown at a rate of 100kg/Ha.

Fertiliser - an initial fertiliser application of a standard N:P:K mix be applied with the millet to aid rapid establishment and stabilisation of the ground surface.

Soil Ameliorants - soil analysis suggested that application of ameliorants lime and dolomite is warranted to correct the soil pH. In order to achieve a target pH of 6 - pH6.5, the ameliorant be applied at a rate of 2 tonne/Ha (one tonne of each).

STEP 3 - (Approximately 6 Weeks Following The Completion Of Phase 2)

Once the standing crop of millet has matured and browned off, it should be slashed to create a layer of organic mulch. Further soil analysis should be performed to ascertain any subsequent fertiliser/ameliorant requirements for the second application of seed. Where required regular applications of small quantities of inorganic fertilisers may be undertaken to assist establishment whereas in key areas organic fertiliser or composted material may be used as part of the seed bed preparation as a soil conditioner.

It is recommended that the area should be lightly cultivated along the contour to incorporate the mulched material into the topsoil and left in a roughened state ready for seeding.

The second application of seed, as well as any required addition/incorporation soil ameliorants and fertilisers, should be carried out in late February or as soon as possible after the cultivation of the site using hydroseeding.

The recommended seed mix for the second application is as follows:-

Annual Cover	-	"Annual Rye"	@ 20kg/Ha
Perennials Cover	-	"Bermuda" Couch	@ 5kg/Ha
		"Rhodes Grass"	@ 5kg/Ha
		"Fescue"	@ 25kg/Ha
		"White Clover"	@ 5kg/Ha
Native Grasses		"Danthonia"	@ 1kg/Ha
(Local Seed)		"Themeda"	@ 1kg/Ha

If available in sufficient quantities, native grass seed collected from adjacent areas should be included in the seed mix at a rate approximately 2kg (woody spp) + ½kg ground covers/sedges per Ha. A list of seed currently collected for this application is attached (**Appendix 3**). Alternatively, commercially obtained seed may be used, however emphasis on correct species should be maintained if adequate quantities of local seed is not available.

Long Term Considerations

It is recommended that this area be monitored to gauge the establishment of the native plant species. In areas where native plant establishment has been less than satisfactory, secondary techniques should be utilised such as brush matting, using locally collected plant material or direct planting of tube stock propagated from locally collected seed. Further application of fertilisers, mulches or soil conditioners may be undertaken according to specific site requirements.

4.2 PRECINCTS 4, 10, & 11

Rehabilitation class 1
Latter Phase

Site Conditions

This portion of the rehabilitation strategy pertains to the areas referred to as precinct 4, precinct 10 and precinct 11 representing a total area of approximately 7 Ha. The final landform of this area is to be a gentle slope of around 230m in length with a vertical rise totalling approximately 8m leading to a slope varying from 3% to 4% over the entire length. The area will be bisected by the elevated crown road running around the perimeter of what is now precinct 4. (refer to **Appendix 5**- Final Contours and Vegetation Plan)

It is recommended that these areas be rehabilitated to native vegetation predominantly in precinct 10 and to the Northern end of precinct 11, as per the species list attached (**Appendix 2**), with the central area of precinct 11 and precinct 4 being suitable for either native vegetation or orcharding enterprises.

Soil Limitations

It is not intended that there will be any tailings storage in this area. Limitations to successful vegetation establishment in this area will relate to the depth of available soil material and the permeability of the sandstone sub strata. Given the local soil conditions it is anticipated that there will be some considerations relating to nutrient status and chemistry of the top soil material. It is recommended that comprehensive soil test be undertaken in accordance with the methodology statement 2.1 to ascertain soil additive requirements.

Revegetation Strategy

In order to address soil limitations in this area, the following revegetation strategy is recommended:

STEP 1 - Ripping Prior To Revegetation
(Refer also to the surface water management/drainage plan)

In order to maximise the opportunities for retention of moisture and assisting in root penetration, the underlying sandstone strata should be ripped along the contour to a depth of 300mm or greater. Once this has been achieved it is recommended that available overburden material be spread over the area with care taken to minimise compaction of the material

Once the base landform has been achieved, the available stockpiled soil material should spread over the area to a depth of 100 mm to 150 mm and lightly scarified along the contour to aid moisture retention and to key the topsoil material with the base capping material prior to application of seed, fertiliser and soil ameliorants.

STEP 2 - Initial Cropping With Cereal

An initial cover crop of an annual cereal is recommended to act as a standing mulch and to provide rapid stabilisation of the ground surface. The suitable species should be selected from **Appendix 2** according to seasonal considerations. Once the standing crop has matured and browned off, it should be slashed to create a layer of organic mulch. Further soil analysis should be performed to ascertain any subsequent fertiliser/ameliorant requirements for the

second application of seed. Where required regular applications of small quantities of inorganic fertilisers may be undertaken to assist establishment. In key areas, organic fertiliser or composted material may be used in seed bed preparation as a soil conditioner. The area should then be lightly cultivated along the contour to incorporate the mulched material into the topsoil and left in a roughened state ready for seeding or planting.

STEP 3 - Final Vegetation.

1. Native vegetation areas

It is recommended that the second application of seed, as well as any required addition/ incorporation soil ameliorants and fertilisers, should be carried out as soon as possible after the cultivation of the site using hydroseeding.

The seed mix for the second application should be according to that outlined in **Appendix 2** according to seasonal considerations. Once establishment of these species has begun, supplementary planting of tube stock propagated from local province seed should then be undertaken with care not to disturb the establishing seedlings. With careful selection and use of propagated material, a revegetation composition may be achieved which approximates the core composition of locally occurring communities (refer to **Appendix 3**). In areas where native plant establishment has been less than satisfactory brush matting, using locally collected plant material or direct planting of tube stock may be necessary to obtain acceptable coverage of the area.

2. Other Vegetation.

In areas where the long term land use does not involve the establishment of native vegetation it is recommended that the second application of seed utilise perennial cereals and legumes so that the site is rapidly stabilised. This vegetation should be maintained, where possible as steps are taken to improve soil condition and depth according to the requirements of the desired land use. Suitable species may be selected from **Appendix 2** according to seasonal conditions. Care should also be taken that where cereal species are used which produce fertile seed heads (such as oats) that these crops are slashed prior to the setting of seed to prevent invasion of adjacent areas. Mowing/slashing of perennial grasses will also promote increased root and stem development

Problem areas

The steep batter which separates this area from the upper area to the North West may possibly be a site where acidic leachate generated from the buried tailings ponds will be a consideration. It is recommended that as part of the leachate management plan the toe of this batter should include a lined swale to separate this leachate from the soil and vegetation of adjacent areas. Attempts should be made to establish vegetation on this batter. In areas where leachate seeps through the face it is expected that successful long term establishment may not be possible and other means of stabilisation may need to be undertaken.

4.3 PRECINCTS 9 & 8 (part)

Rehabilitation Class 1
Latter Phase

This portion of the rehabilitation strategy pertains to the areas referred to as precinct 9 and the western end of precinct 8 representing a total area of approximately 5 Ha. The final landform of this area is to include a centralised mound 5 metres in height with side slopes 60 to 100 m long and varying from 6% to 8%. (Refer to **Appendix 5** - Final Contours and Vegetation Plan"). A small portion in the South of precinct 9 is to form part of the final water storage for the site.

It is recommended that the northern and western perimeter of this area be rehabilitated with native vegetation, as per the species list attached (**Appendix 3**), with the remainder of precinct 9 being suitable for either native vegetation or orcharding enterprises. Revegetation of perimeter areas should be undertaken as soon as possible in accordance with section 4.6 of the Progressive Rehabilitation Strategy.

Soil Limitations

It is not intended that there will be any tailings storage in this area. Limitations to successful vegetation establishment in this area will relate to the depth of available soil material and the permeability of the sandstone sub strata. Given the local soil conditions it is anticipated that the there may be some considerations relating to nutrient status and chemistry of the top soil material. It is recommended that a comprehensive soil test be undertaken in accordance with the methodology statement to ascertain soil additive requirements.

Revegetation Strategy

In order to address soil limitations in this area above, the following revegetation strategy is recommended.

STEP 1 - Ripping Prior To Revegetation
(Refer also to the surface water management/drainage plan)

In order to maximise the opportunities for retention of moisture and assisting in root penetration available, the underlying sandstone strata should be ripped along the contour to a depth of 300mm or greater. Once this has been achieved it is recommended that available overburden material spread over the area with care taken to minimise compaction of the overburden material.

Once the base landform has been achieved, the available stockpiled soil material should spread over the area to a depth of 100 mm to 150 mm and lightly scarified along the contour to aid moisture retention and to key the topsoil material with the base capping material prior to application of seed, fertiliser and soil ameliorants.

STEP 2 - Initial Cropping With Cereal

An initial cover crop of an annual cereal is recommended to act as a standing mulch and to provide rapid stabilisation of the ground surface. The suitable species should be selected from **Appendix 2** according to seasonal considerations. Once the standing crop has matured and browned off, it should be slashed to create a layer of organic mulch. Further soil analysis should be performed to ascertain any subsequent fertiliser/ameliorant requirements for the

second application of seed. Where required regular applications of small quantities of inorganic fertilisers may be undertaken to assist establishment whereas in key areas organic fertiliser or composted material may be used as part of the seed bed preparation as a soil conditioner. The area should then be lightly cultivated along the contour to incorporate the mulched material into the topsoil and left in a roughened state ready for seeding or planting.

STEP 3 - Final Vegetation.

1. Native vegetation areas

It is recommended that the second application of seed, as well as any required addition/incorporation soil ameliorants and fertilisers, should be carried out as soon as possible after the cultivation of the site using hydroseeding or direct drilling.

The seed mix for the second application should be according to that outlined in **Appendix 2** according to seasonal considerations. Once establishment of these species has begun, supplementary planting of tube stock propagated from local province seed should then be undertaken with care not to disturb the establishing seedlings. With careful selection and use of propagated material a revegetation composition may be achieved which approximates the core composition of locally occurring communities. (Refer to **Appendix 3**). In areas where native plant establishment has been less than satisfactory brush matting, using locally collected plant material or direct planting of tube stock may be necessary to obtain acceptable coverage of the area.

2. Other Vegetation

In areas where the long term land use does not involve the establishment of native vegetation, it is recommended that the second application of seed to utilise perennial cereals and legumes so that the site is rapidly stabilised and maintained as such steps are taken, overtime to improve soil condition and depth according to the requirements of the desired land use. Suitable species may be selected from **Appendix 2** according to seasonal conditions. Care should also be taken that where cereal species are used which produce fertile seed heads (such as oats) that these crops are slashed prior to the setting of seed to prevent invasion of adjacent areas.

Problem areas

The steep batter which separates this area from the upper area to the east may be a site where acid leachate generated from the buried tailings ponds will be a consideration. It is recommended that as part of the leachate management plan, the toe of this batter include a lined swale to separate this leachate from the soil and vegetation of adjacent areas. Attempts should be made to establish vegetation on this batter. In areas where leachate seeps through the face it is expected that successful long term establishment may not be possible and other means of stabilisation may need to be undertaken.

4.4 PRECINCTS 3 & 5

Rehabilitation class 2
Latter Phase

This portion of the rehabilitation strategy pertains to the areas referred to as precincts 3 and 5, representing a total area of approximately 3 Ha. The final landform of this area is to be a gentle slope of around 300m in length with a vertical rise totalling approximately 5m leading to a slope varying from 2 % to 3%. It is anticipated that in the future portions of this area may be utilised purposes of hydroponics or similar types of above ground agricultural production or possible limited trial of orcharding enterprises, with the remainder of the area remaining as native open bushland/grassland.

It is recommended that the majority of this area be revegetated predominantly with native grasses, sedges and local species of low shrubs. Where soil conditions allow, taller shrub/tree species may be utilised in a landscaping context to provide visual screens as well as to better approximate the natural species composition of the area. Once the site is stabilised, localised changes in land use and the construction of structures may be undertaken without detrimentally effecting the stability of revegetated areas

Soil Limitations

It is intended that there will be tailings storage under most of this area. Limitations to successful vegetation establishment relate to the depth of available soil and capping material and the permeability of the capping material. Given the local soil conditions it is anticipated that the there will be considerations relating to nutrient status and chemistry of the top soil and capping material. It is recommended that comprehensive soil analysis be undertaken in accordance with the methodology statement to ascertain soil additive requirements

In order to address soil limitations in this area above, the following revegetation strategy is recommended

STEP 1 - Land Forming Prior To Revegetation
(Refer also to the surface water management/drainage plan)

The capping material and other available overburden is to be formed so as to continue the land form of the area to the West. In order to maximise the opportunities for retention of moisture and assisting in root penetration the capping material should be ripped along the contour to a depth of 300mm or greater. Once the base landform has been achieved, the available stockpiled soil material should spread over the area to a depth of 100 mm to 150 mm greater depth of topsoil being utilised in the vicinity of any banking structures (refer to site drainage plan) to utilise area where soil conditions such as soil depth, moisture retention and capping depth is maximised. The area should them be lightly scarified along the contour to aid moisture retention and to key the topsoil material with the base capping material prior to application of seed, fertiliser and soil ameliorants.

STEP 2 - Initial Cropping With Cereal

An initial cover crop of an annual cereal is recommended to act as a standing mulch and to provide rapid stabilisation of the ground surface. The suitable species should be selected from **Appendix 2** according to seasonal considerations. Once the standing crop has matured and browned off, it should be slashed to create a layer of organic mulch. Further soil analysis should be performed to ascertain any subsequent fertiliser/ameliorant requirements for the

second application of seed. When required regular applications of small quantities of inorganic fertilisers may be undertaken to assist establishment. In key areas organic fertiliser or composted material may be used as part of the seed bed preparation as a soil conditioner.

The area should be lightly cultivated along the contour to incorporate the mulched material into the topsoil and left in a roughened state ready for further seeding or planting.

STEP 3 - Final Revegetation.

It is recommended that the second application of seed, as well as any required addition/ incorporation soil ameliorants and fertilisers, should be carried out as soon as possible after the cultivation of the site using hydroseeding.

The seed mix for the second application should be according to that outlined in **Appendix 2** according to seasonal considerations. Once establishment of these species have begun, supplementary planting of tube stock propagated from local province seed should then be undertaken with care not to disturb the establishing seedlings. With careful selection and use of propagated material a revegetation composition may be achieved which approximates the core composition of locally occurring communities. (refer to **Appendix 3**). In areas where native plant establishment has been less than satisfactory brush matting, using locally collected plant material or direct planting of tube stock may be necessary to obtain acceptable coverage of the area.

Long Term Considerations

It is recommended that this area be monitored to gauge the establishment of the native plant species. In areas where native plant establishment has been less than satisfactory, secondary techniques should be utilised such as brush matting, using locally collected plant material or direct planting of tube stock propagated from locally collected seed. Further application of fertilisers, mulches or soil conditioners may be undertaken according to specific site requirements.

4.4.1 SPECIAL NOTE

Although the final landscape and vegetation is recommended as per **Appendix 5**, work scheduling restrictions are such that a tailings pond will be required to be maintained in the north east of precinct 5 (as noted on **Appendix 5**) until sometime around the end of year 7. It is anticipated that some form of farm water supply structure may be constructed in this area as part of a gravity feed irrigation system to proposed hydroponic operations.

4.5 PRECINCTS 1 & 2 (part) - Rehabilitation class 2
Final Phase

This portion of the rehabilitation strategy pertains to the areas referred to as precincts 1 and 2, representing a total area of approximately 4 Ha. The final landform of this area is to be a gentle slope of around 250m in length with a vertical rise totalling approximately 5m leading to a slope varying from 4 % to 5%. In the short to medium term this area is to remain the works processing area. The final rehabilitation strategy for this area is as an agricultural processing area involving hydroponics, worm farming etc. The remainder would be rehabilitated to open bushland/grassland utilising both native and non native pasture species.

Soil Limitations

There tailings storage under most of this area and it is expected that compaction of the soil surface in this arc due to its usage as a works processing area is extreme. Limitations to successful vegetation establishment relate to the depth and permeability of capping material .

Revegetation Strategy

In order to address soil limitations in this area above, the following strategy indicated steps which should be taken once the long term usage of this area is clarified and areas requiring revegetation become evident. It is recommended that analysis of soil conditions, at depth, be undertaken prior to revegetation of this area is attempted; this may involve numerous core samples to a depth of 1 metre or greater. Interpretation of analysis results will aid and guide the implementation of revegetation techniques.

PHASE 1 - Land forming Ripping Prior To Revegetation
(Refer also to the surface water management/drainage plan)

In order to maximise the opportunities for retention of moisture and assisting in root penetration, revegetation areas should be ripped along the contour to a depth of 300mm or greater. Available overburden material spread over the area, to create the desired final landform with care taken to minimise compaction of the material in the spreading process.

Once the base landform has been achieved, the available stockpiled soil material should spread over the area to a depth of 100 mm to 150 mm and lightly scarified along the contour to aid moisture retention and to key the topsoil material with the base material prior to application of seed, fertiliser and soil ameliorants.

PHASE 2 - Final Revegetation

It is recommended that the application of seed, as well as any required addition/incorporation soil ameliorants and fertilisers, should be carried out as soon as possible after the final preparation of the surface using broad acre techniques such as direct drilling or hydroseeding. All fertiliser and soil ameliorant application should be done in accordance with recommendations derived from comprehensive soil testing.

Depending on species selection, regular application of inorganic fertiliser may be requires throughout the establishment of a complete cover and may form part of the regular maintenance requirements.

4.6 PERIPHERAL AREAS - Set backs, Boundaries and Cut Batters

Early and Latter Phases

Currently the set back areas along the lower boundary of the site (Western edge) are formed by a rough sandstone and clay soil bank, with a gradient on the outer face in the order of 100% (1:1). These outer faces have roughened rocky surfaces although there has been minor natural re-colonisation by hardy native species including Hakeas spp, Acacia spp, Petrophile spp and Grevillea spp. Due to the bare nature of these batters there are some areas where minor sediment loss from these batters is evident, however, this sedimentation has not preceded substantially past the toes of the subject batters due to the dense native vegetation to the west.

It is recommended that rehabilitation of areas peripheral to extraction and operation sites be undertaken as a priority in order to stabilise all bare areas and to improve the visual amenity of the site. As extraction proceeds and areas become available for final rehabilitation, revegetation of batters and slopes should proceed as soon as landforming has been completed.

Landforming Recommendations

Although it seems that there has never been any formal landforming of these bund areas, it is not recommended that any reforming of the outer slopes and crowns be undertaken. This would disturb the naturally establishing vegetation. It is recommended that the inward face of these boundary banks be reformed, utilising available overburden material to create a face slope of no grater than 1:2, with slopes approaching 1:3 being preferable. This material should be left in a roughened state ready for revegetation.

Revegetation Recommendations

It is recommended that both the internal and external batters be treated with a hydromulch application of native grass and shrub species with an annual cereal cover. **Appendix 2** provides a list of suitable species and a competent seed merchant will be able to best inform an effective species mix dependant on availability. In the longer term areas where establishment has not been completely successful or areas where rapid improvement in visual amenity is desired, supplementary measures such as planting of tube stock and/ or staking and wiring of local native brush matting material may be undertaken.

Sites where continued or more significant erosion should be addressed on a case by case basis (See **Appendix 7** for examples). Sediment control measures should be installed down slope of all these areas until successful stabilisation has been achieved.

Inward facing cut batters should be revegetated where slope and soil conditions permit using hydromulch application and supplementary planting. Where batter slopes are too extreme or there is inadequate soil material to allow satisfactory vegetation establishment, engineering solutions may required to stabilise slopes which are not naturally stable.

It is recommended that all set backs are to be in accordance with Baulkham Hills Shire Council's Development Control Plan - 500 and that where practical plantings of Native species be undertaken so as to maximise their potential to function as visual and acoustic screens. Suitable species may be selected from **Appendix 3**.

4.7 WATER STORAGE AREAS

Latter Phase

Part of what is now Precinct 8 will be retained as water storage and will not be subject to any rehabilitation revegetation works other than some minor plantings around the perimeter as per section 4.6.

4.8 RESTORATION OF CREEK LINE

Final Phase

Appendix 5 - Final Contours and Vegetation Plan shows the location of a creek line through Precinct 4 which is to be restored once the extraction process has been completed. This creek line should be reconstructed with bed structures and bank works to mimic the natural morphology of the creek line occurring in the reserved area to the south. The reserved area should also be utilised to source suitable native plant material for the propagation of riverine species to be planted within the creek banks.

All works involved in the restoration of the creek line should be undertaken in consultation with the Department of Land and Water Conservation and designed by a suitably qualified environmental consultant. "Riverwise - Guidelines for Stream Management" - NSW Department Water Resources outlines considerations which should be addressed within the design.

5.0 MONITORING AND REPORTING

5.1 REHABILITATION MANAGEMENT PLAN

In accordance with Baulkham Hills Shire Council, Development Control Plan Number 500, a Remediation Management Plan (RMP) should be prepared. This document (Rehabilitation and Revegetation Strategy) is structured so as to be suitable as the basis of the RMP, providing recommendations on implementation and methodology. Section 4 of this report may be utilised as the Structure for monitoring and reporting. Each rehabilitation area (4.1 - 4.8) may be treated as a separate entity for the purpose of recording results of soil tests, species selection and soil ameliorants used. Any deviation form the standard revegetation methodology (section 3) should be also recorded in order to be able to gauge and repeat possible improvements on the methodology.

DCP 500 requires that a Rehabilitation Management Plan be submitted annually. A brief report on the status of each rehabilitation area with annexure of any results and records of rehabilitation works implemented, since the previous RMP, implemented should be submitted along with a updated site diagrams and photos. Such a reporting structure will provide clear indication of the status, rate and success of the Staged Rehabilitation process. This report should be complementing by the establishment of an Environmental Management System (EMS) and Environmental Management Plan (EMP) which records results of internal auditing processes and confirmation of compliance with development and licensing conditions.

6.0 REFERENCES

The following publications were used as sources relating to rehabilitation practices and methodologies, reference information as well as the requirements of public Authorities. Through the engagement of competent rehabilitation personnel, the proponent of the extraction process, may ensure that up to date best management practices are cited and utilised.

Baulkham Hills Shire Council :

- Draft Development Control Plan (Extractive Industries) No 500, 1997

Department of Land and Water Conservation :

- Soil Landscapes of the St Albans 1:100,000 Sheet, 1997.

National Parks and Wildlife Service:

- Flora Appendixes of Western Sydney, Urban Bushland Biodiversity Survey - Vol 2, 1997

Department of Conservation and Land Management:

- Urban Erosion and Sediment Control, 1992.

NSW Department of Housing

- Managing Urban Stormwater- Soils and Construction, 1998

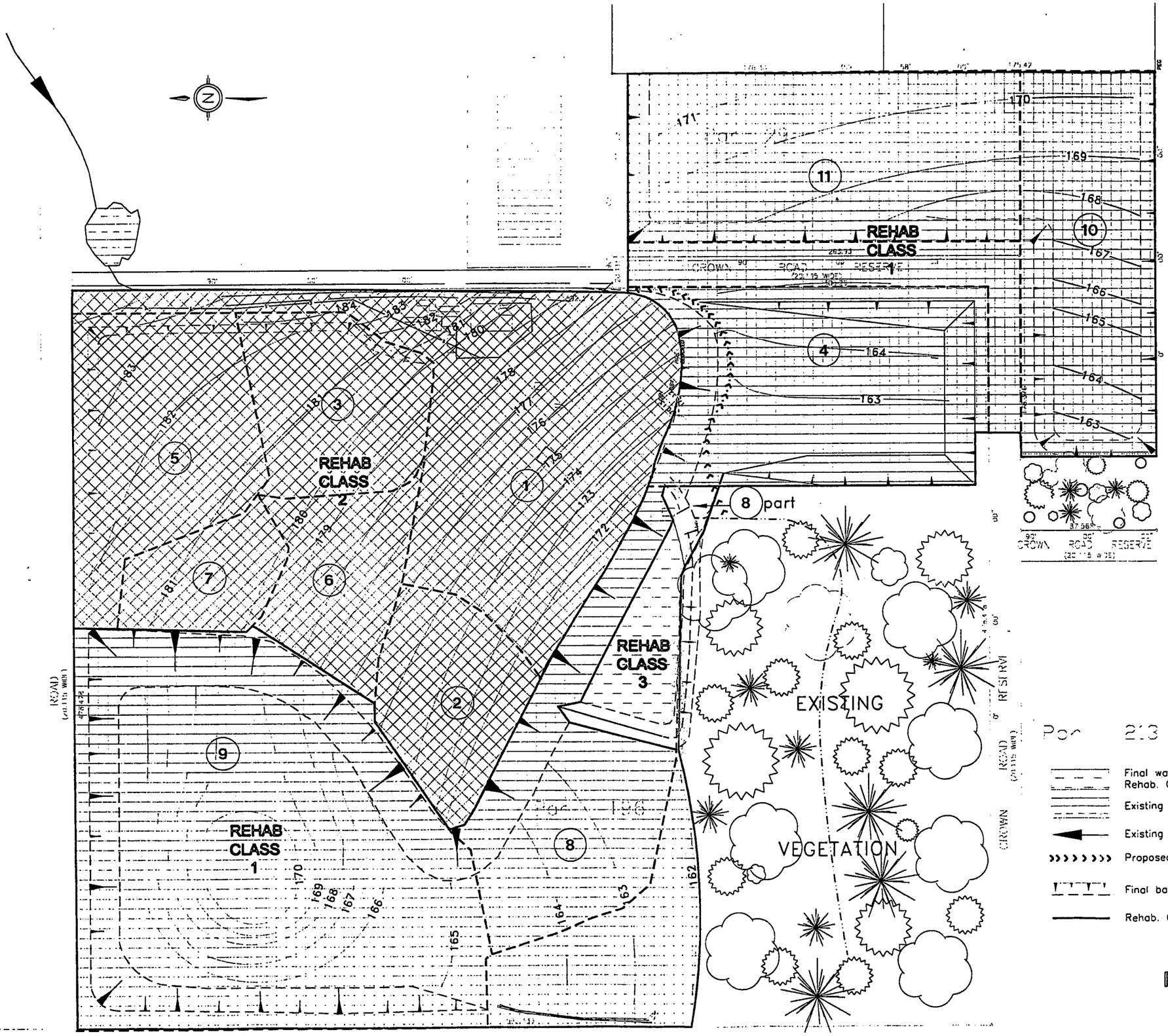
NSW Department Water Resources

- Riverwise: Guidelines for Stream Management

APPENDIX 1

Por 198

Por 213



NOTES

1. LEVEL DATUM IS AUSTRALIAN HEIGHT DATUM
2. DISTANCES SHOWN FROM BOUNDARY TO WORKINGS ARE APPROXIMATE ONLY.
   ANY CRITCAL DISTANCES SHOULD BE DETERMINED BY SITE SPECIFIC SURVEY.
3. TREES SHOWN ON THIS PLAN INDICATE VEGETATED AREAS AND NOT INDIVIDUAL TREES.
4. FUTURE BATTONS ARE NORMAL 1:1 SLOPES

LEGEND

- Final water storage Rehab. Class 3
- Existing water storage
- Existing watercourse
- Proposed watercourse
- Final batter
- Rehab. Class boundary
- Rehab. Class 1
- Rehab. Class 2
- (5) Precinct Number
- Precinct Boundary

PRECINCT PLAN AND REHABILITATION CLASSES

00 20 40 60 80 100m

SCALE

APPENDIX 2

Cover Crop and Grasses Species List Suitable for use in Site Revegetation
(After "Urban Erosion and Sediment Control- Section 4.2")

Species	Established	Purpose	Advantages	Cautionary Notes
Warm Season				
Annuals				
Japanese Millet (Shirohie Millet)	Seed Spring To Autumn	Rapid temporary cover only, useful as a standing mulch	Easy/ rapid establishment on a wide range of soils, non invasive hybrids available	Active growth h in summer only.
Sudan Grass	Seed Spring To Autumn	Rapid temporary cover only, useful as a standing mulch	Very Durable Stem Material, excellent as a mulch	High growth pattern - requires regular slashing, Active summer growth only, young growth not suitable for grazing
Perennials				
Bermuda couch	Seed Spring to Summer	provided good low permanent cover	Rapid cover once plants established, low maintenance, good on hot dry sites	Difficult to establish from seed, frost sensitive (ie needs to be included with companion crops).
Rhodes Grass	Seed Autumn to Winter	Intermediate to short term cover	Rapid cover from seed, good in wet areas	Warm areas only. Rank growth a fire risk- mow regularly.
Carpet Grass	Seed Spring to Summer	Intermediate to short term cover	good on infertile soils, low maintenance, low fire risk	Nil
Legumes				
Red Clover	Seed Spring to Summer	Intermediate to short term cover only	Good establishment from seed Improves nitrogen levels in soil	requires well drained fertile soils (ie fertiliser required) Short lived
White Clover	Seed Spring to Autumn	Intermediate to short term cover only	Perennial Clover Tolerates acid soils	Nil

Species	Established	Purpose	Advantages	Cautionary Notes
Cool Season				
Annuals				
Ryecorn	Seed Autumn to Spring	Rapid temporary cover only, useful as a standing mulch	As for Jap Millet good companion with cool season perennials, good on acid sandy soils	Can be a summer fire risk
Barley	Seed Autumn to Spring	Rapid temporary cover only, useful as a standing mulch	Good as a companion crop species	fire risk in summer,
Oats	Seed Autumn to Spring	Rapid temporary cover only, useful as a standing mulch	very good root development, hood stem and leaf for mulching	must be slashed before seed is set - may become invasive
Perennials				
Perennial Rye	Seed Autumn to Winter	Intermediate to short term cover only	Good Companion Species Good on Moist soils	Short lived in warm dry areas
Legumes				
White Clover	Seed Spring to Autumn	Intermediate to short term cover only	Perennial Clover Tolerates acid soils	Nil

Local Native Species suggested for use in rehab program.
*** Denotes local provenance seed available**
**** Denotes seed known to be commercially available (non Provenance)**

Species (Common Name)	Growth Habit	Comments/ Applications
Corymbia gummifera (Red Bloodwood) **	Tree	Perimeter areas and filter strips, rehab class 1 only .
Eucalyptus racemosa (Snappy Gum)*	as above	as above
E. haemastoma (Scribbly Gum) *,**	Tree, often Mallee form	All areas, esp set backs good brush mating species
E. squamosa (Scaly Barked Gum)	Tree	Perimeter areas and filter strips, rehab class 1 only .
Angophora bakeri (Narrow Leafed Apple	as above	as above
Synocarpia glomifera (Turpentine)	as above	as above
Angophora Hispeda (Dwarf Apple) *	Small tree/ heavy shrub	All areas, esp set backs good brush matting species
Allocasuarina littoralis (Black She Oak) *,**	Tree/ tall shrub	all areas esp set backs
Banksia ericifolia (Heath Banksia)*	Small tree/ heavy shrub	all areas
Hakea sericea (Needle bush) * Hakea dactyloidies (Broad Leafed Hakea) **	Large shrub	All areas, esp set backs good brush mating species
Leptospermum trinervium, Leptospermum arachnoidies **	Large to medium shrub	All areas, esp set backs good brush matting species
Grevillia buxifolia ssp buxifolia (grey Spider Flower)*,**	small to medium shrub	all areas esp set backs
Acacia linifolia (Flax Wattle) *,**	Small Shrub	all areas, good with cover crops, good hydromulch species.
Isopogon anemonifolus (Drum Sticks)*,**	Small shrub	All areas, esp set backs good brush matting species
Kunzea ambigua(Tick Bush) **	Small shrub	All areas, esp set backs
Kunzea capita ((Pink Kunzea) **	Small shrub	All areas, esp set backs
Petrophile pulchella (cone Sticks *,**	Small shrub	All areas, esp set backs good brush mating species
Themeda triandra (ne' australis) Kangaroo grass **, *	Grass	all area, good with cover crops, good hydromulch species.
Lomandra Species (rush grass, bladey grass)	tussock grass	excellent for stabilising areas, recommend that L. longifolia is avoided as is not present on site and will dominate areas- propagate from local material
Other grasses		refer to Flora report, propagate from local material.

Note: The above table provides useful species for the rehabilitation process however it will create a community composition which is, floristically, simple. As the area is stabilised other species may naturally begin to co-colonise areas. Alternatively, if bush regeneration personnel are available who have access to local provenance propagated material, then supplementary planting into native regeneration areas will greatly enhance the speed of rehabilitation and the floristic texture of the of subject sites.

APPENDIX 4.

SOIL TEST REPORT

Scone Research Service Centre

REPORT NO:	SCO98/513R1
REPORT TO:	Carl Vincent DLWC PO Box 3935 Signature Tower Level 10, 2-10 Wentworth Street Parramatta 2124
REPORT ON:	Nine soil samples Sand extraction quarry, Maroota
PRELIMINARY RESULTS ISSUED:	24 December, 1998
REPORT STATUS:	Final
DATE REPORTED:	6 January, 1999
METHODS:	Information on test procedures can be obtained from Scone Research Service Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED.

G. Holman
(Technical Officer)

Gundy Road Scone NSW 2337 P.O. Box 283 Scone NSW 2337 DX 4206
Telephone (02) 65451666 Facsimile (02)65452520

Department of Land and Water Conservation
Soil and Water Testing Laboratory

Recommendations

- Application of organic fertilisers/mulch can help to improve soil structure, reduce erosion and increase the level of both macro and micro nutrients for plant growth. Addition of organic matter may also help to reduce the level of Al available to plant species.
- The use of slow release fertilisers or alternatively regular applications of inorganic fertilisers a low rates will help to maximise plant uptake and minimise leaching/loss of nutrients.
- Initial applications of fertilisers are suggested as follows:
  - superphosphate (plus Mo) at a rate of 100 kg/ha;
  - potassium nitrate at a rate of 100 kg/ha;
  - (Alternative complete fertilisers may also be used).

Application of limes and dolomite is recommended. The amount of lime required to raise the pH 6.5 (in 1:5 soil:water) is listed below:

Lab. No.	Sample Id	Lime application rate* (tonnes/ha)	Dolomite application rate* (tonnes/ha)
1.	No. 1 Topsoil	1.0	0.5
2.	No. 2 Topsoil	1.3	0.6
3.	No. 3 Topsoil	0.6	0.6
4.	No. 4 Topsoil	1.0	0.5
5.	No. 5 Topsoil	1.0	0.2
6.	No. 6 Topsoil	1.0	1.0
7.	No. 7 Topsoil	1.0	0.9
8.	No. 8 Topsoil	0.7	0.4
9.	No. 1/1 Capping material	0.6	0.3

*Using good quality agricultural lime/dolomite with a neutralising value of 100% and assuming a soil bulk density of 1.5 g/m^3. If the neutralising value of the liming material is less than 100% the liming rate should be adjusted accordingly.

This interpretation is based on:
1. the samples supplied being representative,
2. literature guidelines.

SR Young

Stephen Young
Laboratory Manager
Scone Research Service Centre
8 January, 1999

Department of Land and Water Conservation
Soil and Water Testing Laboratory

Laboratory No.: SCO98/513R1

Client: Carl Vincent
DLWC
P.O. Box 3935
Parramatta, 2124

Scope: Revegetation

Interpretation: Nine soil samples

Electrical Conductivity and soil pH

The electrical conductivity (EC) indicates that all samples tested (Lab. No. 1, 2, 3, 4, 5, 6, 7, 8 and 9) have low salinity. The pH of these samples is strongly to very strongly acidic. The application of lime/dolomite will be required to raise the soil pH and improve plant growth (especially plant species sensitive to acidic soil).

Phosphorus

For samples No. 6 Topsoil and No. 7 Topsoil the available phosphorus (P) is very high and for sample No. 2 Topsoil available P is high. Available P is low/moderate in samples No. 3 Topsoil and No. 4 Topsoil, is low in samples No. 1 Topsoil and No. 8 Topsoil and very low in samples No. 5 Topsoil and No. 1/1 Capping material. Samples No. 1 Topsoil, No. 3 Topsoil, No. 4 Topsoil, No. 5 Topsoil, No. 8 Topsoil and No. 1/1 Capping material will benefit from the application of phosphate fertiliser.

Cation exchange capacity and exchangeable cations

The cation exchange capacity (CEC) is a measure of the soils ability to store cations. The five most abundant cations in soil are calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and aluminium (Al).

All samples tested (Lab. No. 1,2,3,4,5,6,7,8 and 9) have a very low CEC and low to very low concentrations of exchangeable Ca, Mg, K and Na. The percentage of exchangeable Al is high in all samples, except No. 7 Topsoil, such that the growth of many plant species will be decreased. The application of lime will increase the soil pH and decrease the percentage of exchangeable Al and hence improve conditions for plant growth.

Dispersion

The Emerson Aggregate Test (EAT) indicates that samples No. 1 Topsoil, No. 2 Topsoil, No. 3 Topsoil, No. 4 Topsoil, No. 6 Topsoil, No. 7 Topsoil and No. 8 Topsoil are slightly dispersible. The EAT indicates that samples No. 5 Topsoil and No.1/1 Capping material have very low dispersion and are aggregated. These results indicate that all samples test are generally stable in water.

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SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No.: SCO98/513R1
Client Reference: Carl Vincent
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Parramatta 2124

Lab. No.	Method	C1A/3	C2A/2	C8A/2	C3A/2	P9B/2	C5A/3 CEC & exch. cations (me/100g)						
	Sample Id.	EC (dS/m)	pH	P (mg/kg)	Lime Requ. to pH 6.5 ($CaCO_3$kg/t)	EAT	CEC	Na	K	Ca	Mg	Al	Texture
1.	No. 1 Topsoil	0.05	4.9	4	1.01	5	3.3	0.2	0.1	1.0	0.6	0.7	loamy sand
2.	No. 2 Topsoil	0.04	5.4	33	1.35	3(1)	3.3	0.2	0.2	1.7	0.8	0.5	loamy sand
3.	No. 3 Topsoil	0.05	5.2	14	0.81	5	2.6	0.2	0.1	1.2	0.3	0.6	sandy loam
4.	No. 4 Topsoil	0.04	5.2	11	1.02	5	3.0	0.2	0.1	1.2	0.6	1.1	loamy sand
5.	No. 5 Topsoil	0.04	4.8	1	0.80	6	4.9	0.2	0.1	0.5	0.7	1.3	sandy loam
6.	No. 6 Topsoil	0.05	5.1	123	1.35	3(1)	2.8	0.1	0.3	1.6	0.4	0.2	loamy sand
7.	No. 7 Topsoil	0.05	5.4	175	1.27	3(1)	3.2	0.1	0.2	1.6	0.5	nd	loamy sand
8.	No. 8 Topsoil	0.04	5.2	5	0.72	5	3.4	0.1	0.1	0.9	0.5	0.8	loamy sand
9.	No.1/1 Capping material	0.04	5.0	nd	0.63	6	3.6	0.1	0.2	0.7	0.4	1.6	sandy loam

nd = not detected

Holman.

END OF TEST REPORT

Department of Land and Water Conservation
Soil and Water Testing Laboratory

Laboratory No.: SCO98/513R1

Client: Carl Vincent
DLWC
P.O. Box 3935
Parramatta, 2124

Scope: Revegetation

Interpretation: Nine soil samples

Electrical Conductivity and soil pH

The electrical conductivity (EC) indicates that all samples tested (Lab. No. 1, 2, 3, 4, 5, 6, 7, 8 and 9) have low salinity. The pH of these samples is strongly to very strongly acidic. The application of lime/dolomite will be required to raise the soil pH and improve plant growth (especially plant species sensitive to acidic soil).

Phosphorus

For samples No. 6 Topsoil and No. 7 Topsoil the available phosphorus (P) is very high and for sample No. 2 Topsoil available P is high. Available P is low/moderate in samples No. 3 Topsoil and No. 4 Topsoil, is low in samples No. 1 Topsoil and No. 8 Topsoil and very low in samples No. 5 Topsoil and No. 1/1 Capping material. Samples No. 1 Topsoil, No. 3 Topsoil, No. 4 Topsoil, No. 5 Topsoil, No. 8 Topsoil and No. 1/1 Capping material will benefit from the application of phosphate fertiliser.

Cation exchange capacity and exchangeable cations

The cation exchange capacity (CEC) is a measure of the soils ability to store cations. The five most abundant cations in soil are calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and aluminium (Al).

All samples tested (Lab. No. 1,2,3,4,5,6,7,8 and 9) have a very low CEC and low to very low concentrations of exchangeable Ca, Mg, K and Na. The percentage of exchangeable Al is high in all samples, except No. 7 Topsoil, such that the growth of many plant species will be decreased. The application of lime will increase the soil pH and decrease the percentage of exchangeable Al and hence improve conditions for plant growth.

Dispersion

The Emerson Aggregate Test (EAT) indicates that samples No. 1 Topsoil, No. 2 Topsoil, No. 3 Topsoil, No. 4 Topsoil, No. 6 Topsoil, No. 7 Topsoil and No. 8 Topsoil are slightly dispersible. The EAT indicates that samples No. 5 Topsoil and No.1/1 Capping material have very low dispersion and are aggregated. These results indicate that all samples test are generally stable in water.

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SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No.: SCO98/513R1
Client Reference: Carl Vincent
DLWC
PO Box 3935
Signature Tower
Level 10, 2-10 Wentworth Street
Parramatta 2124

Lab. No.	Method	C1A/3	C2A/2	C8A/2	C3A/2	P9B/2	C5A/3 CEC & exch. cations (me/100g)						
	Sample Id.	EC (dS/m)	pH	P (mg/kg)	Lime Requ. to pH 6.5 ($CaCO_3$kg/t)	EAT	CEC	Na	K	Ca	Mg	Al	Texture
1.	No. 1 Topsoil	0.05	4.9	4	1.01	5	3.3	0.2	0.1	1.0	0.6	0.7	loamy sand
2.	No. 2 Topsoil	0.04	5.4	33	1.35	3(1)	3.3	0.2	0.2	1.7	0.8	0.5	loamy sand
3.	No. 3 Topsoil	0.05	5.2	14	0.81	5	2.6	0.2	0.1	1.2	0.3	0.6	sandy loam
4.	No. 4 Topsoil	0.04	5.2	11	1.02	5	3.0	0.2	0.1	1.2	0.6	1.1	loamy sand
5.	No. 5 Topsoil	0.04	4.8	1	0.80	6	4.9	0.2	0.1	0.5	0.7	1.3	sandy loam
6.	No. 6 Topsoil	0.05	5.1	123	1.35	3(1)	2.8	0.1	0.3	1.6	0.4	0.2	loamy sand
7.	No. 7 Topsoil	0.05	5.4	175	1.27	3(1)	3.2	0.1	0.2	1.6	0.5	nd	loamy sand
8.	No. 8 Topsoil	0.04	5.2	5	0.72	5	3.4	0.1	0.1	0.9	0.5	0.8	loamy sand
9.	No.1/1 Capping material	0.04	5.0	nd	0.63	6	3.6	0.1	0.2	0.7	0.4	1.6	sandy loam

nd = not detected

Holman.

END OF TEST REPORT

Soil Physics Profile No. 1

Test Type I Perm,PSA,MC,Disp%
Order No Job No:
Reference
Sample Name Tailings
Sample No. 39314a
Date Received 14/9/98 Total No Pages: 2
Client: Layll & Macoun Consulting Engineers
Timothy Macoun
Level 2, 4 Help St
CHATSWOOD NSW 2067

Certified Laboratory Practice

Sydney Environmental and Soil Laboratory

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Australia
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Pennant Hills NSW 2120
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Facsimile (02) 9484 2427
Email: sesl@sesl.com.au

CHARACTERISTIC		RESULT	COMMENTS
Texture			
Emerson Stability Class			
Dispersion %		18.8	
Particle Size Analysis (PSA)			
> 2mm	Gravel	0.0	
2 - 0.2 mm	Coarse Sand	0.9	
0.2 - 0.02 mm	Fine Sand	48.8	
0.02 - 0.002 mm	Silt	21.7	
< 0.002 mm	Clay	28.6	
Sieve Analysis			
> 4 mm	Gravel		
2-4 mm	Coarse Sand		
1-2 mm			
0.5-1 mm	Medium Sand		
0.25-0.5 mm			
0.1-0.25 mm	Fine Sand		
< 0.1 mm	Very Fine Sand		

Recommendations

Total Solids Ratio: 65%, Moisture content: 0.53 g water/g dry soil
Saturated Hydraulic Conductivity: 14.8cm/hr

The dispersion percentage of this material is low relative to the clay content. The extreme acidity and high aluminium levels are probably aiding in flocculating the clays and suppressing some of the dispersion. Saturated hydraulic conductivity is surprisingly good for such a fine textured and poorly structured material.

Explanation of the Methods:
Texture:- Charman & Murphy (1991). **Emerson's Aggregate Test:-** Charman & Murphy (1991). **Dispersion %:-** Ritchie (1983). **Particle Size Analysis & Sieve Analysis:-** Modified Black (1983) Method 43-1 to 43-6.

Checked by Principal.....
Simon Leake Date of Report 18/9/98

Consultant.....
J. Selvey

Soil Physics Profile No. 1

Test Type I pHEC,MC,PSA,Disp%,TN,TP
Order No Job No:
Reference
Sample Name Crushed sandstone
Sample No. 39315
Date Received 14/9/98 Total No Pages:
Client: Layll & Macoun Consulting Engineers
Timothy Macoun
Level 2, 4 Help St
CHATSWOOD NSW 2067

Certified Laboratory Practice

Sydney Environmental and Soil Laboratory

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CHARACTERISTIC		RESULT	COMMENTS
Texture			
Emerson Stability Class			
Dispersion %		46.2	
Particle Size Analysis (PSA)			
> 2mm	Gravel	0.2	
2 - 0.2 mm	Coarse Sand	76.3	
0.2 - 0.02 mm	Fine Sand	11.4	
0.02 - 0.002 mm	Silt	6.1	
< 0.002 mm	Clay	6.1	
Sieve Analysis			
> 4 mm	Gravel		
2-4 mm	Coarse Sand		
1-2 mm			
0.5-1 mm	Medium Sand		
0.25-0.5 mm			
0.1-0.25 mm	Fine Sand		
< 0.1 mm	Very Fine Sand		

Recommendations

Total Phosphorus - <1 mg/kg
Total nitrogen: 110mg/kg
Total solids ratio: 94%, Moisture Content: 0.07 g water/g dry soil
TN and TP tested at AGAL

The pH of this material is highly acidic, and large additions of liming agents are required. Salinity levels are very low which indicates virtually nothing apparent in the way of nutrients.

This material has a relatively low clay content, but almost half of this is prone to dispersion. This represents a significant risk of erosion and potential failure of earthen structures.

Explanation of the Methods:
Texture:- Charman & Murphy (1991). **Emerson's Aggregate Test:-** Charman & Murphy (1991) **Dispersion %:-** Ritchie (1963). **Particle Size Analysis & Sieve Analysis:-** Modified Black (1983) Method 43-1 to 43-6.

Checked by Principal.....
Simon Leake Date of Report 18/9/98

Consultant.....
J. Selvey

Soil Chemistry Profile

Test Type: BS,TN,TP

Order No: Job No:

Reference

Sample Name: Tailings

Sample No: 39314

Date Received 14/9/98 Total No Pages:

CLIENT: Layll & Macoun Consulting Engineers
Timothy Macoun
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CHATSWOOD NSW 2067

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TEST	RESULT	COMMENTS
pH in water 1:2	5.1	
pH in $CaCl_2$ 1:2	4.3	very acidic
EC mS/cm 1:2	.06	low salinity
Chlorides mg/kg	-	

CATION ANALYSIS

TEST	SOLUBLE		EXCHANGEABLE		
Unit	meq%	Comment	meq%	% of ECEC	Comment
Sodium			.09	1.10	good
Potassium			.19	2.40	low
Calcium			< 0.20	2.00	very low
Magnesium			.27	3.30	very low
Aluminium			7.35	91.20	198ppm
		ECEC	8.06		
		Ca/Mg	0.60		low

	mg/kg	
Phosphate - P	<0.80	low
Ammonium - N		
Nitrate - N		
Sulphate - S		
Iron		
Zinc		
Copper		
Manganese		
Boron		

Recommendations

Total Phosphorus - 38 mg/kg
Total Nitrogen - 350 mg/kg

In terms of revegetation, the chemistry of this material is very hostile for plant growth owing to the acidity, and the complete dominance of the cation exchange capacity by aluminium (which is phytotoxic). Large additions of dolomitic limestone would be required to raise the pH, reduce aluminium levels and raise the Ca/Mg ratio. Existing available phosphorus levels are low. Total phosphorus levels are low.

Total phosphorus and nitrogen tested at AGAL

Explanation of the Methods:
pH, EC, Soluble Cations, Nitrate: Bradley et al (1983). **Exchangeable Cations, ECEC:** Method 15A1 Rayment & Higginson (1992)
Chloride: Vogel (1961). **Aluminium:** Method 3500 APHA (1992). **Phosphate:** Method 9E1 Rayment & Higginson (1992). **Ammonium, Sulphate, Iron, Copper, Manganese + Zinc:** Method 83-1 to 83-5 Black (1983). **Boron:** Method 12C2 Rayment & Higginson (1992).

Checked by Principal.....
Simon Leake Date of Report 18/9/98

Consultant.....
J. Selvey

Soil Chemistry Profile

Test Type: pHEC,MC,PSA,Disp%,TN,TP

Order No: Job No:

Reference

Sample Name: Crushed sandstone

Sample No: 39315

Date Received 14/9/98 Total No Pages: 2

CLIENT: Layll & Macoun Consulting Engineers
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Certified Laboratory Practice

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Facsimile (02) 9484 2427
Email: sesl@sesl.com.au

TEST	RESULT	COMMENTS
pH in water 1:2	6.7	
pH in $CaCl_2$ 1:2	4.6	very acidic
EC mS/cm 1:2	.03	low salinity
Chlorides mg/kg	–	

CATION ANALYSIS

TEST	SOLUBLE		EXCHANGEABLE		
Unit	meq%	Comment	meq%	% of ECEC	Comment
Sodium					
Potassium					
Calcium					
Magnesium					
Aluminium					
		ECEC			
		Ca/Mg			

mg/kg

Phosphate - P
Ammonium - N
Nitrate - N
Sulphate - S
Iron
Zinc
Copper
Manganese
Boron

Recommendations

Total Phosphorus - <1 mg/kg
Total nitrogen: 110mg/kg
TN and TP tested at AGAL

the pH of this material is highly acidic, and large additions of liming agents are required. Salinity levels are very low which indicates virtually nothing apparent in the way of nutrients.

The clay in this sample is highly dispersive

Explanation of the Methods:
pH, EC, Soluble Cations, Nitrate: Bradley et al (1983). **Exchangeable Cations, ECEC:** Method 15A1 Rayment & Higginson (1992)
Chloride: Vogel (1961). **Aluminium:** Method 3500 APHA (1992). **Phosphate:** Method 9E1 Rayment & Higginson (1992). **Ammonium, Sulphate, Iron, Copper, Manganese + Zinc:** Method 83-1 to 83-5 Black (1983). **Boron:** Method 12C2 Rayment & Higginson (1992).

Checked by Principal.....
Simon Leake Date of Report 18/9/98

Consultant.....
J. Selvey

APPENDIX 4 – A.

Department of Land and Water Conservation
Soil and Water Testing Laboratory

Laboratory No.: SCO99/18R1

Attention: Carl Vincent
DLWC
P.O. Box 3935
PARRAMATTA, 2124

Scope: Revegetation

Interpretation: Six soil samples

Salinity, pH and Lime Requirement

The electrical conductivity (EC) indicates that all samples tested (48893, 48894, 48895, 48928, 48929 and 48930) have low salinity. The pH is strongly to very strongly acidic. To improve conditions for growth of plant sensative acidic conditions, agricultural lime and dolomite should be applied at the rates listed below and incorporated into the soil to a depth of 10cm. The pH of the soil should be moniotred after the application of lime/dolomite.

Lab No.	Sample Id.	Application Rate*	
		Lime (tonnes/ha)	Dolomite (tonnes/ha)
1.	48893	0.7	0.7
2.	48894	0.7	0.7
3.	48895	0.8	0.8
4.	48928	0.8	0.8
5.	48929	0.65	0.65
6.	48930	0.65	0.65

* Using liming material with a neutralising value of 100% and assuming a soil bulk density of 1.5 tonnes/m^3. If these values do not apply then the liming rate should be adjusted accordingly.

Available Phosphorus

The available phosphorus (P) is low to very low. Application of phosphate fertiliser will be required for optimum plant growth.

CEC and Exchangeable Cations

For all samples tested (48893, 48894, 48895, 48928, 48929 and 48930) the cation exchange capacity (CEC) is low to very low. The concentration of exchangeable sodium (Na) is low, exchangeable potassium (K) is high, exchangeable calcium (Ca) is low and exchangeable Mg is low to moderate. The high exchangeable K may lead to deficiencies of exchangeable Mg. Lime and dolomite should be applied at the rates listed above.

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SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No.: SCO99/18R1
Client Reference: Carl Vincent
DLWC
P.O. Box 3935
PARRAMATTA, 2124

Lab. No.	Method	C1A/3	C2A/2	C8A/2	C3A/2	P9B/2	C5A/3 CEC & exch. cations (me/100g)						
	Sample Id.	EC (dS/m)	pH	P (mg/kg)	Lime Requ. to pH 6.5 ($CaCO_3$kg/t)	EAT	CEC	Na	K	Ca	Mg	Al	Texture
1.	48893	0.04	5.2	2	0.96	3(1)	5.8	0.2	0.8	3.2	1.2	0.2	sandy clay loam
2.	48894	0.05	5.1	2	0.92	5	7.4	0.2	0.9	4.5	1.2	nd	sandy clay loam
3.	48895	0.06	4.9	2	1.05	5	6.5	0.3	0.9	3.0	1.2	0.2	sandy clay loam
4.	48928	0.05	4.9	8	1.09	5	6.0	0.2	0.9	3.1	1.0	nd	sandy clay loam
5.	48929	0.05	5.3	3	0.87	3(1)	8.7	0.2	1.4	4.0	1.4	nd	sandy clay loam
6.	48930	0.04	5.2	1	0.87	5	5.7	0.1	0.8	2.5	0.7	0.2	sandy clay loam

nd = not detected

END OF TEST REPORT

Department of Land and Water Conservation
Soil and Water Testing Laboratory

Emerson Aggregate Test

The Emerson Aggregate Test (EAT) indicates that these samples (48893, 48894, 48895, 48928, 48929 and 48930) are slightly dispersible and hence generally stable.

This interpretation is based on:
1. the samples supplied being representative,
2. literature guidelines.

S R Young

Stephen Young
Laboratory Manager
Scone Research Service Centre
2 February, 1999

Scone Research Service Centre
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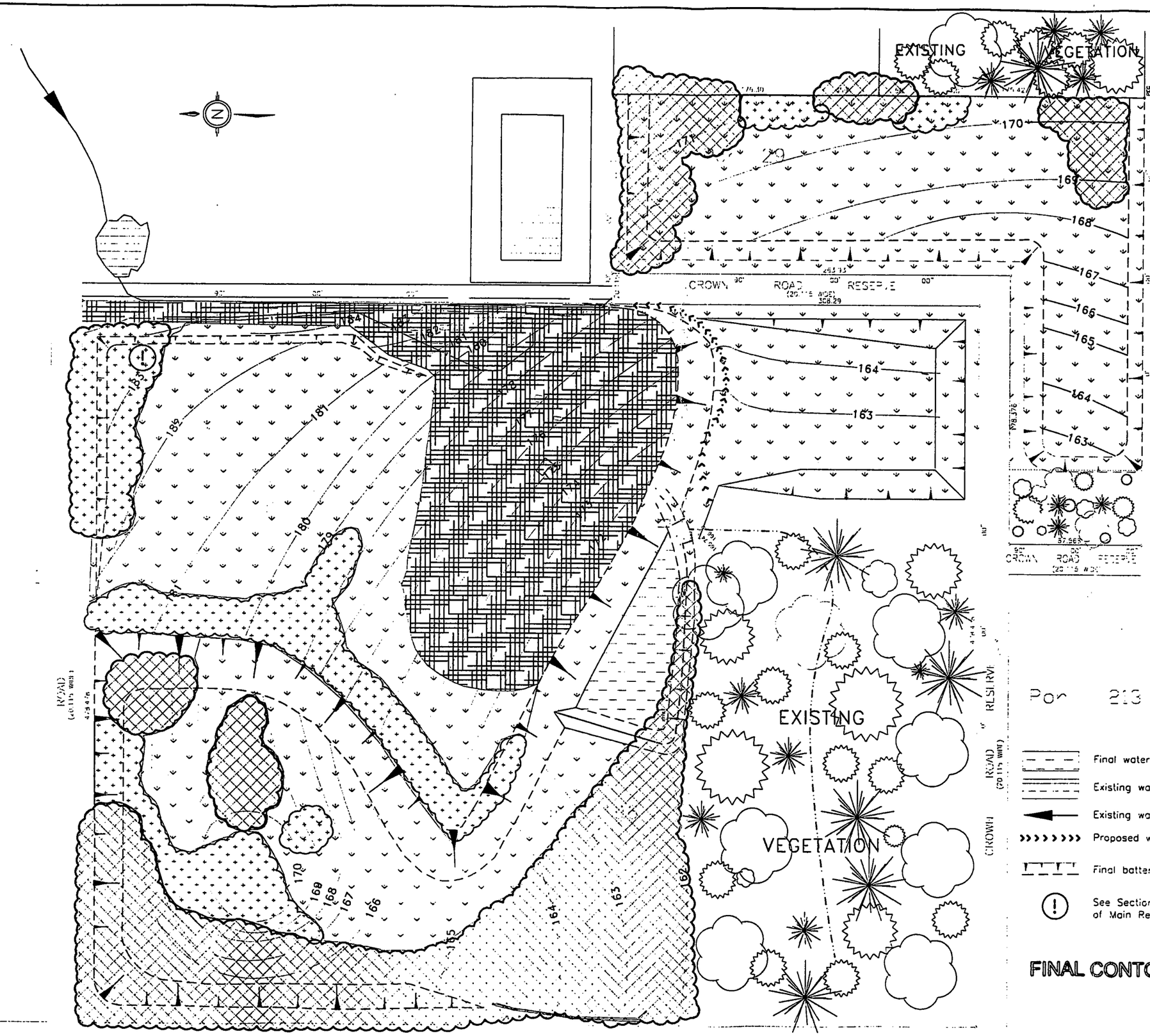
APPENDIX 5



NOTES

1. LEVEL DATUM IS AUSTRALIAN HEIGHT DATUM
2. DISTANCES SHOWN FROM BOUNDARY TO WORKINGS ARE APPROXIMATE ONLY. ANY CRITCAL DISTANCES SHOULD BE DETERMINED BY SITE SPECIFIC SURVEY.
3. TREES SHOWN ON THIS PLAN INDICATE VEGETATED AREAS AND NOT INDIVIDUAL TREES.
4. FUTURE BATTONS ARE NORMAL 1:1 SLOPES

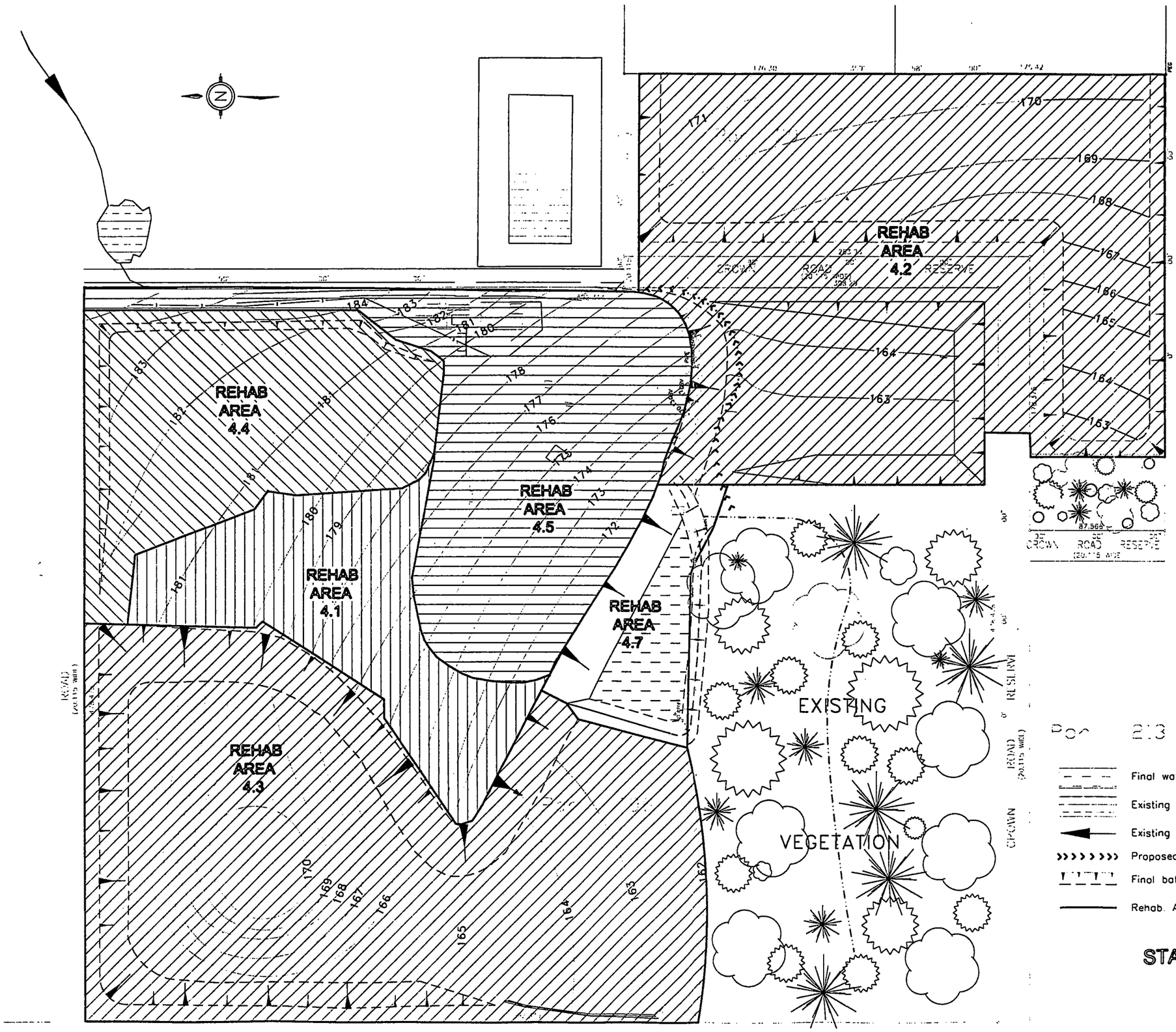
LEGEND

- Final water storage
- Existing water storage
- Existing watercourse
- Proposed watercourse
- Final batter
- (!) See Section 4.4.1 of Main Report
- Native heath land Grasses and small shrubs Passibly some limited non native tree trials
- Mallee form trees Mid storey and lower
- Full floristics (incl. overstorey spp)
- Works area medium to long term, mown non native spp and structures

FINAL CONTOURS AND VEGETATION PLAN

00 20 40 60 80 100m
SCALE

APPENDIX 6



NOTE
Rehabilitation areas refer to corresponding sections of main report.

NOTES

1. LEVEL DATUM IS AUSTRALIAN HEIGHT DATUM
2. DISTANCES SHOWN FROM BOUNDARY TO WORKINGS ARE APPROXIMATE ONLY.
   ANY CRITCAL DISTANCES SHOULD BE DETERMINED BY SITE SPECIFIC SURVEY.
3. TREES SHOWN ON THIS PLAN INDICATE VEGETATED AREAS AND NOT INDIVIDUAL TREES.
4. FUTURE BATTONS ARE NORMAL 1:1 SLOPES

LEGEND

- Final water storage
- Existing water storage
- Existing watercourse
- Proposed watercourse
- Finol batter
- Rehab. Areo boundory
- Rehab. Area 3.1
- Rehab. Area 3.2
- Rehab. Area 3.3
- Rehab. Area 3.4
- Rehab. Area 3.5

STAGED REHABILITATION PLAN

00 20 40 60 80 100m
SCALE

APPENDIX 7

COMMENTS ON 2 SITES LOCATED ON THE PERIMETER OF OPERATIONS

BACKGROUND

Soil Consult was requested by Dixon Sands to inspect 2 sites identified as being of possible concern by the Baulkham Hills Shire Council.

The Council's concern is that these sites are current sources of significant amounts of sediment mobilised and transported into the lower areas and that this sediment is of a sufficient quantity to adversely effect the vegetation below.

Soil Consult was further requested to inspect the Western (lower) perimeter in general for signs of sediment transport into the bush areas and to make recommendations to address any areas of concern identified.

Site 1

Description:
This site is located in the North Western corner of the site where the outer batter is quite long and steep. At the toe of this batter, 2 low bunds have been formed as ends of drainage channels from both the South and the North. At their convergence. these two channels form a single channel leading to the West (ie. 3 channels in the shape of a "Y").

The batter above the channels is steep (1:1 or greater) and is in a bare and uneven state.

There is evidence of sediment (from the batter and adjacent areas) accumulated at the base of the batter within the channel. Sediment control structures (straw bales staked with star pickets and sediment fence) have been installed at various points within the 3 channels and although there is some sand / sediment located down slope of the final structure, the amount of loose debris/leaf litter over the sediment and the emergence of grasses through this sediment suggests that this sand plume is not fresh.

Although the existing sediment control structures seem to have arrested the movement of sediment off site from this area, straw bales and loose constructed sediment fence (between star pickets) are considered temporary measures only. It is therefore recommended that more permanent structures be installed until the sites adjacent and above can be satisfactorily rehabilitated and stabilised.

Recommendations

Refer to Diagram 1.

Construct a check dam (A) at the junction of the 2 low bunds. This check is to be constructed from large aggregate (to 300mm) wrapped in geotextile. The dam should be keyed into the surrounding channel base and sides to a depth of 200mm and the geotextile should also be trenched in at the leading edge (see attached diagram 2). The lower edges of the geotextile should extend for no less than 2 metres past the check dam and be weighted down with a complete covering of course aggregate rip rap. Rip rap should extend the entire length of the westward channel and 1 metre past outlet point (B). Care should be taken that a defined spillway is provided in the centre of the check

dam at least 150mm lower than the outer ends of the check dam. The height of the check dam should be a further 150mm lower than the adjacent bunds.

Further rip rap (~300mm aggregate - loosely spaced) should be placed with the two feeder channels.

Once these structures have been installed the batter (above) and the bunds below should be revegetated according to the recommendations detailed in section 3.6 of the rehabilitation report.

Site 2

Description: This site is located in the upper South Western corner at the head of the creek and below the spillway of the main storage pond (precinct 9).

Immediately above the old sand and cement bag wall constructed across the head of the creek. There is a considerable amount of sediment piled up in front of the wall. Within this sediment there are grass species establishing as well as a lone Eucalypt which seems to be around 4-6 years old.

The purpose of this wall is unclear due to its age, however one likely possibility is that it was constructed to form a permanent water source by damming water from the clean water spring immersing from the rock face immediately above.

At the base of the wall there is a small (4") steel pipe (now rusted) which may be stoppered to cause a pond to form behind the wall. It maybe that the sand material, now piled behind the wall, was moved to one side to clear this pipe and to maintain flows along one side.

It cannot be commented on how long the main body of sediment has been contained by the wall but given the establishment of vegetation in the disturbed pile it could be in excess of 5 years.

Inspection of the stream bed sediments immediately below the wall showed that although fine sands have been deposited past the wall, they have been well coloured by either organic tannins (from the decomposition of leaf litter) or from oxidised iron and do not seem to be fresh.

Recommendations

In order to address concerns of the sediment behind the wall being transported, via the pipe at the base of the wall; into the lower creek area, it is recommended that the sediment backing up against the pipe be removed and that the existing pipe be extended (if possible) or replaced with a section of galvanised pipe (or pvc) returning into the up-stream area with a vertical "elbow" to a height of approx. 300. above the existing level of sediment.

This area should be monitored to ensure that the sediment levels are maintained at least 100mm below the outlet level (top of the new pipe). Periodically the surface waters may be siphoned off the base sediments in the pond to allow for these sediments to be manually removed.

Other Areas

Refer to section 3.6 of main report for recommendations on the rehabilitation of the remaining set back areas.

Diagram 1

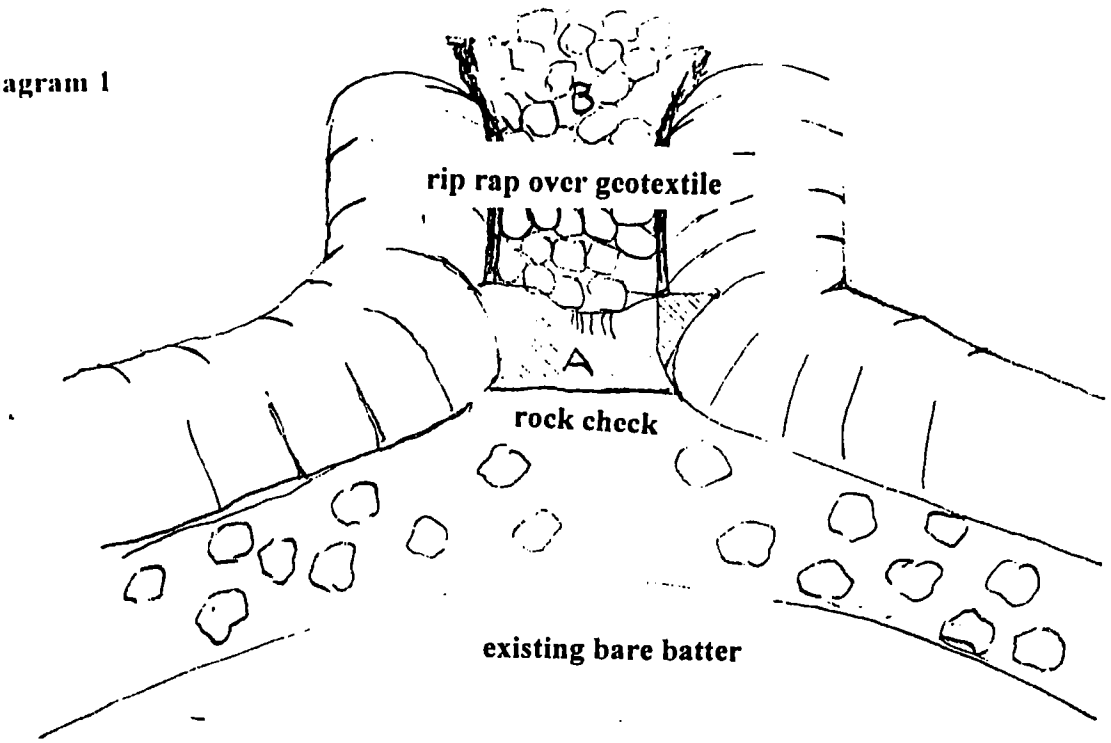
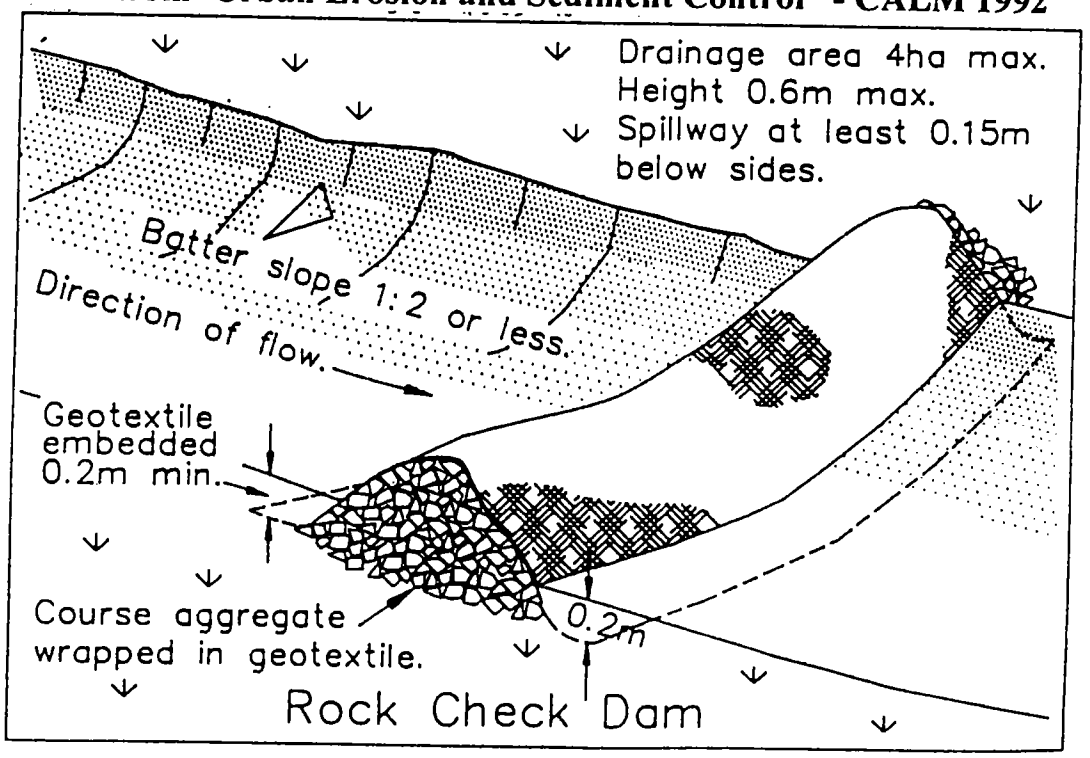


Diagram 2

Taken from 'Urban Erosion and Sediment Control" - CALM 1992



Appendix C3 – INTEGRATED SURFACE WATER MANAGEMENT STRATEGY

INTEGRATED SURFACE WATER MANAGEMENT STRATEGY AND SEDIMENT AND EROSION CONTROL PLAN FOR DIXON SAND (PENRITH) PTY LIMITED MAROOTA OPERATION

APPENDIX C3

Prepared for

DIXON SAND (PENRITH) PTY LTD

April 1999

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ANNEXURES

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EXECUTIVE SUMMARY

This Appendix (C3) has been prepared as supporting document to the Environmental Impact Statement - ***COMPLETION OF EXTRACTION, REHABILITATION AND PROCESSING OF CONSTRUCTIONS SANDS, LOTS 196 AND 29 NORTH MAROOTA.*** The Appendix provides an overview and an examination of the water management facilities required to ensure that stormwater runoff and its quality do not have a detrimental affect upon downstream areas.

The site under review is located nominally 300 west of Wisemans Ferry Road and 6 km south of Wisemans Ferry. The site covers 34 Ha. It is also located at the junction of two catchments which drain to an unnamed interment creek, which in turn drains to the Hawkesbury River at Lower Half Moon Bend, some 6 km downstream.

The site has a history of sand extraction and processing until December 1998 This extraction has occurred progressively over Lots 196 and 29 for over 15 years. The exception to the site development as a sand mine is the area occupying the southwest corner of Lot 196. This area has been retained in its natural state as native vegetation around the unnamed creek that drains the site. Progressive rehabilitation involving capping of disused tailing ponds, the spreading of topsoil and revegetation has been undertaken in several areas of the site. This rehabilitation is proposed to continue as an integral part of the Consent sought under the planning application described in the body of the EIS that this Appendix is attached to.

Several water management facilities have been previously constructed to meet the developing needs of the extraction and processing operation. These are:

- sedimentation ponds to capture and treat stormwater runoff from disturbed and rehabilitating areas.
- diversion banking which directs water to defined water courses and acts to separate clean and dirty runoff.
- storage ponds which capture and store stormwater runoff for reuse within the site.
- a tailings pond to capture suspended material in wash water used in the processing of sand.

Table ES1 summarizes the performance requirements set by Baukham Shire Council and other Statutory Authorities. This summarization details the requirements that are to be met by the water management system.

TABLE ES1 – STATUTORY SPECIFIC REQUIREMENTS FOR WATER MANAGEMENT STUDY

1. PLAN PREPARATION AND CONTEXT

AGENCY	REQUIREMENT/ISSUE	RESPONSE	REPORT SECTIONS
EPA	Detailed surface water management plan including design and operational details.	Detailed plan outlining runoff control, erosion control, sedimentation and site water management	Whole report particularly Chapter 4
EPA	Precautionary Principle.	Sand mining has been carried out in the Maroota area for over 25 years and the impacts of sand mining on the surface water, groundwater and local ecology are well understood.	
DUAP	Condition of natural waterbodies, wetlands or sensitive areas that could be impacted by changes in flow or water quality.	Pristine bushland immediately downstream shows minimised impact from previous operations	Section 3.6
BHSC	Water Management Strategy to be submitted with DA.	Requirement fulfilled by this report	Whole report
BHSC	Annual Water Management Plan required.	To be prepared once consent granted	
BHSC	System capable of maintaining and monitoring drainage outlets together with pre-existing groundwater flows and quality.	Main outlets remain the same as current. Monitoring program proposed.	Chapter 4

2. WATER QUALITY

AGENCY	ISSUE	RESPONSE	REPORT SECTIONS
EPA	Identify and quantitatively assess impacts to surface water quality.	Water quality monitoring undertaken and impacts shown to be minimal	Sections 2.6 and 3.6
EPA	Measures for preventing pollution from fuel storage, machinery operation and maintenance areas.	Measures will meet requirements, by providing bunding or covering work areas.	Main EIS
DUAP	Description of potential sources of water pollution (sediments, sewage, oil, leachates) and proposed control systems.	Report identifies key sources and proposed control measures	Chapter 4
DUAP	Controls for accidental spillages.	Proposals set out in EIS	Main EIS
DUAP	Ongoing monitoring and maintenance of water quality.	Ongoing program proposed	Section 4.6
HNCMT	Water quality should not compromise guidelines for aquatic ecosystems or visual amenity for primary contact recreation,	Water quality meets these requirements in all respects except low pH which is characteristic of local groundwater	Section 2.6

3. WATER FLOW AND RE-USE

AGENCY	ISSUE	RESPONSE	REPORT SECTIONS
EPA	Prefer closed water management system.	Water management system is closed except for large storms	Sections 3.5, 4.5
DUAP	Diversion of uncontaminated runoff.	Runoff from upstream catchments kept separate from site runoff	Sections 2.5, 3.1 and 4.2
DUAP	Dependence on off site water and its impact on surface or groundwater.	System relies primarily on collection of site runoff. Site water balance shows net increase in downstream flows	Section 4.5 Figures 8, 9
DUAP	Wastewater storage and reuse to avoid dry weather discharge and restore dam capacity.	Closed water recycling system does not involve discharge during dry weather. Restoration of dam capacity is not required for sedimentation basins designed to capture coarse sediments according to requirements in DOH, 1998.	Chapter 4
HNCMT	No alteration of downstream hydrology (frequency or peaks) for all events up to 1 in 2 year 30 min. event.	This requirement conflicts with EPA and BHSC requirements for a closed system maximising reuse. Once dams are full, system is designed to route all flows from upstream catchments through the site including low flows.	Section 4.2
BHSC	Procedures capable of maintaining natural surface water flow and quality conditions along downstream boundaries.	See above. All discharging points remain the same as current conditions	Section 4.2
HNCMT	No alteration downstream peak for events up to 1 in 100 years.	Site storages provide attenuation of flood peaks from upstream catchment	Section 2.5.2
BHSC	Site investigations to identify and classify catchment origin, drainage patterns, water flow and water quality.	Internal and external catchments defined together with drainage patterns and estimated flows (storm and annual). Water quality monitored on and off site.	Chapter 2.
BHSC	Source quantity and quality of water to provide a reliable supply of water to the operation.	Operation will utilise runoff from the site supplemented with runoff flowing into the site from upstream catchments. Reliability of supply will be achieved with two storage dams. Reliability has been demonstrated by past operations and by computer modelling of future operations.	Section 4.5

3. WATER FLOW AND RE-USE – continued

AGENCY	ISSUE	RESPONSE	REPORT SECTIONS
BHSC	Procedures for minimising importation of water.	Water re-use system is a closed system during dry weather.	Section 4.5
BHSC	Procedures for maximising re-use and recycle of collected waters particularly during extreme climatic conditions.	Water re-use system relies primarily on recycling of water captured from the site	Section 4.5 Figures 9 and 10
BHSC	Destination points for collected waters are retained within the extraction site.	All site discharge has and will occur from a single point that remains unaltered.	Figures 6 and 7
BHSC	Design, location and likely impact of any temporary diversion of drainage patterns within the extraction site.	Details of layout of water management system are provided.	Chapter 4
BHSC	Procedures for ensuring that contaminated waters are contained on site during the 1% AEP (event).	This requirement is based on the premise that stormwater must be captured and held to achieve treatment. For Class C soils (as found on this site), procedures laid out in DOH, 1998 allow basins sizing based on sedimentation principles. Proposed system includes sedimentation basins designed according to DOH requirements. These discharge to a Storage Pond which provides adequate sedimentation capacity during a 1% AEP event.	Section 4.3
BHSC	Risks, safeguards and contingency plans for extreme climatic conditions or operational hazards including breach or contamination.	System has two levels of protection against sediment discharge: • Primary sedimentation basins • Main Storage Pond which catches overflow from sedimentation basins and will operate as a large sediment pond in extreme events	Section 3.1.4

4. EROSION AND SEDIMENT CONTROL

AGENCY	ISSUE	RESPONSE	REPORT SECTIONS
EPA	Erosion and sediment controls based on "Managing Urban Stormwater : Soils and Construction."	Sedimentation basins, diversion drains and waterways designed according to requirements in the referenced manual.	Section 4.3
DUAP	Flow control measures appropriate for site conditions.	Sedimentation basins, diversion drains and waterways designed according to requirements in the referenced manual.	Section 4.3
DUAP	Sedimentation dams to minimise risk of discharge of contaminated waters.	Sedimentation basins all designed according to latest guidelines in "Managing Urban Stormwater : Soils and Construction". All sedimentation basins discharge into larger water storage ponds prior to discharge from the site.	Section 4.3
DUAP	Assessment of need to treat stormwater or process water.	1. Sedimentation basins are sized to treat sediment sizes from the site. 2. Tailings pond appropriately sized to capture clay sized particles without chemical assistance.	Section 4.3
DUAP	Methods for dewatering and handling of sludges and slimes.	Requirement will be minimal as site is well developed already.	-
BHSC	Progressive clearing of minimal area required for operations.	Staged development and rehabilitation proposal	Section 4.2
BHSC	Sediment and erosion control throughout clearing, operation and rehabilitation.	Site planning is designed to meet this requirement	Chapters 3 and 4
BHSC	Protection of natural vegetation.	Areas of pristine bushland (6 ha) to be retained	Figure 2
BHSC	Nominated supervisor responsible for soil conservation.		
BHSC	Soil stripping, storing and replacement according to guidelines.	Rehabilitation Plan includes requirements for topsoil management.	Separate Rehabilitation Plan
BHSC	Drainage controls designed for 1 in 20 AEP with 1 m freeboard.	Banks, waterways and sediment basins designed for 20 year ARI. Freeboard dependent on control structure.	Section 4.3
BHSC	Sediment control dams to have sediment trapping capacity of half the vol. of tailings dam.	Main Storage Pond is located downstream and would act as a sediment trap in an emergency.	Section 3.1.4

4. EROSION AND SEDIMENT CONTROL continued

AGENCY	ISSUE	RESPONSE	REPORT SECTIONS
BHSC	Flood water should not affect adjoining lands.	All discharge from the site occurs at the original point.	Figures 1,6,7.
BHSC	Tailings dam location/design.	Existing Tailings Pond is excavated into rock and has capacity to settle sediment coarser than 0.002 mm	Section 3.1.2

1.0 INTRODUCTION

1.1 Overview

This document is the report on the results of an assessment of the Water Management of the site at North Maroota that is to be utilized as a sand quarry. The intent of the report is to review the site on an holistic or integrated manner.

This report has been prepared at the direction of Dixon Sand (Penrith) Pty Ltd by Southern Environmental and forms an appendix to the Environmental Impact Statement that reviews the impact of renewed extraction and rehabilitation of the existing North Maroota Quarry.

The quarry is located on the western side of Wisemans Ferry Road and nominally 6 km south of Wisemans Ferry ***(Figure 1)***. It is located within the headwaters of an unnamed natural bushland creek, which drains into a listed wetland (No. 88) at Lower Half Moon Bend on the Hawkesbury River.

This report details the exiting water management system on site. It also outlines the existing and proposed stormwater management facilities required to ensure that the management of runoff and water quality is acceptable. The proposals set out in this report provide an integrated approach to all aspects of water management on the site including the collection and reuse of runoff for production processes and day to day site management.

The remainder of ***Chapter 1*** outlines the Statutory Authority and Council policies, guidelines and requirements that have been taken into consideration in preparing an appropriate strategy for managing water on the site.

1.2 Statutory Authority Requirements

This section details the Statutory Authoritys' policies, guidelines and requirements that have been taken into account in setting water quality objectives and developing the water management strategy and erosion and sediment control plan for the site.

1.2.1 Environment Protection Authority (EPA)

EPA has set out both general and specific requirements for this project (reference letter dated 20 May 1998 – refer EIS ***Appendix A3 – Authority Consultation***):

General Requirements

The Protection of the Environment Administration Act (administered by the EPA) maintains that ESD requires the effective integration of environmental and economic considerations in decision-making and also that ESD can be achieved by the implementation of such principles and programs as:

- the precautionary principle - namely, that if there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environment degradation;

- intergenerational equity - namely that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;

- ecological integrity; and conservation of biological diversity and improved valuation and pricing of environmental resources.

The EPA also requires the EIS to identify, describe and quantitatively assess the impacts that may be caused to surface water quality both during the site establishment and operating stages.

Specific Requirements

The EPA has stated as a matter of policy that it prefers the water management system to be operated as a closed system. The specific requirements are:

- Preparation of a detailed surface water management plan that should include:
  - catchment areas, basin, spillway and flow diversion design and sizing
  - detail how the runoff contained on the site will be managed following storm events in order to return the system to its design capacity.
  - measures to prevent pollution from fuel storage, machinery operation and maintenance areas on the site.
  - Measures to control potential pollution derived from sewage.

- The EPA policy states that the recently published manual *Managing Urban Stormwater: Soils and Construction.* (Department of Housing, 1998) be utilised in the design and management of a site's water management system.

1.2.2 Department of Urban Affairs and Planning (DUAP)

The DUAP's EIS Guideline for "*Extractive Industries - Quarries*" outlines the areas detailed when considering water management these are:

(a) "a description of potential sources of water pollution....

(b) the condition of any natural water bodies, wetlands, coastline or environmentally sensitive areas which could be impacted....

(c) the drainage and sediment management system....

(d) water balance,

(e) potential impacts on groundwater,

(f) when dewatering of the quarry or pit is proposed to facilitate extraction, any effects on the local or regional watertable

(g) the adequacy of measures to ensure the watertable will not become contaminated during and after extraction because of the final use of the area

(h) the impact on the aquifer intake area and the adequacy of the protection of this area

(i) a plan for the ongoing maintenance and monitoring of water quality controls to ensure their correct installation, operation and effectiveness.

1.2.3 Department of Land and Water Conservation (DLWC)

The requirements of the DLWC (reference their letter of 28 May 1998 – ***Appendix A3 Consultataion***) are the same as that stipulated by the EPA.

1.2.4 Hawkesbury Nepean Catchment Management Trust (HNCMT)

Central to the HNCMT's requirements (letter of 18 May 1998 – ***Appendix A3 Consultataion***) is that the EIS address the impact of the proposal upon the Hawkesbury-Nepean River and its catchment. Specifically the Trust has recommended that the following issues be addressed in terms of water quality and quantity:

- *The project should satisfy the Trust's policy that any development must not lead to a deterioration of the ecosystem or compromise its environmental values. Therefore if the quality of water (both surface and groundwater) emanating from an area is satisfactory, then any proposed development should not result in a decrease in this quality; alternatively if the quality is not satisfactory, then any proposed development should result in an improvement to this quality.*
- *Any water flow or changes in flow from the area should not alter the downstream natural hydrology (frequency or peaks) for all events up to the one in two year storm (30 minute event), and should not alter the downstream peak levels for events up to the 1 in 100 year event.*

- *All development shall be designed to maintain or enhance water quality to a standard that would not compromise the:*
  - *ANZECC Guidelines standard for healthy waters – protection for aquatic ecosystems; and*
  - *NHMRC Guidelines for visual amenity and primary contact recreational water quality.*
  - *Groundwater, for drinking water supply, should be protected from the impacts of any contaminated surface waters."*

1.2.5 Baulkham Hills Shire Council (BHSC)

The Planning Services Group of BHSC issued the *Extractive Industries Development Control Plan (DCP), No. 500* in 1997 (see the relevant extracts at Annexure A), which outlines Council's requirements with respect to a preferred water management strategy. The plan states that proponents should employ operational practices capable of maintaining and monitoring drainage outlet points at downstream boundaries together with pre-existing groundwater flow and quality conditions.

Section 2.4, Water Resources, of the DCP requires a Water Management Strategy that outlines a framework for all phases of development that classifies and manages the (surface) water cycle, and includes:

- *site investigations used to identify and classify catchment origin, drainage patterns, water flow and water quality;*
- *source, quantity and quality of water required to provide a reliable supply of water to the operations;*
- *procedures for minimising importation of water;*
- *procedures for maximising re-use and recycle of collected waters particularly during extreme climatic conditions;*
- *procedures capable of maintaining natural surface water flow and quality conditions along downstream boundary alignments;*
- *destination points for collected waters are retained within the extraction site;*
- *the design, location and likely impact of any temporary diversion of drainage patterns within the extraction site;*
- *procedures for ensuring that contaminated waters are contained on-site during the 1% AEP;*
- *risks, safeguards and contingency plans for extreme climatic conditions or operational hazards including breach or contamination;*
- *procedures for monitoring groundwater flow, quality and recharge areas within catchments having regard to the recommendations of the Groundwater Impact Assessment Report*

Section 2.8, Soil Conservation, of the DCP requires a Sediment and Erosion Control Plan that outlines the facilities which are to be implemented on the site to control both soil degradation and erosion, and should include measures to manage the following three items:

1. Site Clearing
2. Sediment and Erosion Control
3. Tailing (Sludge) Ponds

1.2.6 Other Documentation

Other manuals and guidelines referred to in the preparation of this report include:

- Department of Housing (1998), *Managing Urban Stormwater: Soils and Construction.*
- Department of Planning (1993), *Better Drainage.*

2. SITE CHARACTERISTICS

This section describes the various characteristics of the site and region related to the surface water hydrology and water quality.

2.1 Location

The site is located on the western side of Wisemans Ferry Road, nominally 6 km south of Wisemans Ferry – ***Detailed at Figure 1***. It comprises all of Lots 196 and 29 (DP 752025), a total area of approximately 34 ha. The site is located at the confluence of two watersheds that feed an unnamed natural creek which eventually drains to the Hawkesbury River at Lower Half Moon Bend, some 6 km downstream.

2.2 Catchments, Land Use and Drainage System

The quarry is located in the upper reaches of one of several small creek systems which drain to the Hawkesbury River at Lower Half Moon Bend. Prior to discharging into the river, flows from the creek passes through a large wetland. This wetland has been listed by the DLWC (Listed Wetland No. 88) as a wetland with significant environmental importance. The catchment draining to the wetland is about 2,300 ha and consists of deeply eroded valleys with steep inclines. The majority of the catchment area lies within the Dryabbin Nature Reserve. Small scale farming and sand quarrying operations occupy the flatter ridges which form the southern and eastern catchment boundary.

As mentioned in ***Section 2.1 – Location*** , the quarry is located at the confluence of two small catchments with a total area of about 49 ha. The first catchment, denoted North East Farmed, is 33.6 ha in area and its catchment is mainly farmland. Runoff from the catchment drains to a small creek that flows in a generally westerly direction before flowing beneath the internal access road located along the western boundary of Lot 117 (not part of this proposal).

At this point stormwater flows into a diversion channel that commences near the northwest corner of Lot 196 between the access track and Dixon's site entrance road. The presence of a low bund wall fronting the length of the channel within Lot 196 prevents runoff from draining onto the site entrance road. The channel conveys flows from the rural farmland catchment to the north west corner of Lot 29 where it crosses the Crown Road as overland flow and enters into Lot 196. There is significant evidence that this farm run-off is contaminated with rural sourced nutrients.

The second watershed, denoted Eastern Bushland, drains a catchment of 15.4 ha. The catchment comprises both remnant bushland and rural farmland located in Lot 1 and Lot 117 to the east of the quarry.

At the northern boundary of Lot 29, drainage from the North East Farmed Catchment joins drainage from the Eastern Bushland Catchment and enters the eastern side of Lot 196 where it discharges into a series of storage ponds. These ponds store and treat runoff from the upstream catchments as well as runoff from the site, which has a contributing catchment area of around 19 ha, prior to water discharging to the downstream bushland creek. Further details of the existing drainage and water management facilities on the site are set out in Section 2.5.

The quarry has been in operation for over 15 years and the majority of Lot 196 and Lot 29 have been disturbed. Prior to December 1998 rehabilitation had been commenced in an area of about 4 ha within Lot 196. ***Table 2.1*** summarises the land uses within Lot 196 and Lot 29 as of April 1999.

TABLE 2.1
Land Uses Within Lot 196 and Lot 29

Land Use	Area (ha)
Disturbed for extraction and operations	19
Water storage and sedimentation ponds	4
Undisturbed bushland	7
Revegetated	4

2.3 Rainfall and Evaporation

In order to characterize the local climate and to provide data for computer modelling of the water management system (see ***Chapters 3 and 4***) climatic data for the area has been utilized. In order to undertake computer modeling of the water management system a complete daily record of both rainfall and evaporation was required for a period of 21 years.

The rainfall gauging station, Maroota (Old Northern Road, Station No. 67014) located about 2 km from the site, has daily records since 1925. Unfortunately records are incomplete for 10 years including four years since 1980. A complete daily rainfall record does exist, however, for the 21 year period from 1972 to 1992 at Glenorie (Old Northern Road, Station No 67010) located 20 km from the site.

A comparison of both Maroota and Glenorie's average annual totals for the years where complete records were available (1972-1985) indicated that the average annual rainfall at the two gauges is similar (938 mm at Maroota compared to 990 mm at Glenorie). Substituting the Glenorie data for the missing Maroota data, the average annual rainfall comparisons are 1022 mm at Maroota compared to 1049 mm at Glenorie, a differential of 2.5%. In view of this minor differential, the Glenorie record has been adopted for the water balance analysis, thus achieving the desirable 21 years of uninterrupted record.

The long term average annual rainfall (1913 to 1998) at Glenorie is 976 mm compared to 1049 mm for the 21-year period adopted for this study. This indicates that the 21-year period is

representative of a slightly wetter period than average and that volumes of surface runoff generated by the contributing catchments are therefore larger than the long-term average. This should generate a small factor of safety in the hydraulic model.

Evaporation data from Station 67021 (Richmond UWS Hawkesbury) were adopted for the same 21 year period. ***Tables B1 and B2*** presented in ***Annexure B*** summarise this data which has been used in the computer modeling of runoff and site water balance (outlined in ***Section 3.5***).

Table 2.2 summarises the average monthly variability of rainfall and pan evaporation. It can be seen that precipitational depth is greater in January to March (120-130 mm) and lower in July to September (about 50 mm). As expected the pan evaporation ranges from a maximum in December and January (about 200 mm) to a minimum in May to July (50-60 mm).

TABLE 2.2
Monthly Variation of Rainfall and Evaporation (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Rain	119	133	121	98	82	102	49	57	52	84	84	68	1,049
Evap	196	152	137	100	64	53	63	91	126	157	176	219	1,533

Annual rainfall and evaporation variability for the period 1972 to 1992 is illustrated by the data in ***Table 2.3*** below. Note that wet and dry years were assumed to be represented by the 90 and 10 percentile rainfalls respectively. The opposite applies for evaporation. In ***Table 2.3***, the rainfall deficit represents the difference between rainfall and the evaporation that would occur from an open water body (taken to be 0.8 x pan evaporation).

TABLE 2.3
Climatic Variability (1972 – 1992)

	Dry Year	Average Year	Wet Year
Rainfall (mm)	674	1,015	1,610
Pan evaporation (mm)	1,751	1,523	1,304
Rainfall deficit (mm)	627	254	-463

The data in ***Table 2.3*** indicates that in a median rainfall year there would be a net loss of about 250-mm from a water storage pond. In a dry year this would increase to about 630 mm loss and in a wet year the pond would gain about 460 mm. (Note: the depths quoted in ***Table 2.3*** are for each independent and not from the same years.

The rainfall intensity has been tabulated against the recurrence interval in ***Table 2.4***. This table summarizes the rainfall intensity data for Maroota based on the data presented in *Australian Rainfall & Runoff: Vol 2* (Institution of Engineers, Australia, 1987) after analyzing with the RAINER computer program (Soil Conservation Service, 1993)

TABLE 2.4
Short Duration Rainfall Intensity (mm/h) for Maroota

Average Recurrence Interval (years)	Storm Duration					
	5 min	10 min	20 min	30 min	1 h	2 h
1	82	63	46	37	25	17
2	105	80	59	48	32	21
5	133	101	74	60	40	27
10	148	113	82	67	45	30
20	170	130	94	76	51	34
50	198	151	109	88	60	40
100	219	167	121	97	66	45

The RAINER program estimates annual average erosivity for Maroota at 2,410mm.

2.4 Soils and Vegetation

The operation of the quarry was concentrated, at the time of closure in December 1998, on the extraction of sand from Lot 196 and Lot 29. Quarrying on these Lots has been carried out since at least 1973. The previous operations have lead to the majority of Lot 196 being in a state of exposed Maroota Sandstone devoid of vegetation. Within the southwest corner of Lot196, on either side of a small unnamed creek, the company have preserved an area of about 7 ha of pristine native vegetation.

Lot 29 has been partially mined with an extraction pit of around 9 m depth being created along its southern leg. Within the western corner of Lot 29, an area of about 0.4 ha of remnant vegetation has been retained. The remainder of the Lot, although not yet mined, has been cleared of vegetation.

Rehabilitation involving capping of disused tailing ponds, planting of trees along embankments, the spreading of topsoil and revegetation is has been undertaken within the quarry in several areas. The original sandy topsoil being used in the rehabilitation process had been previously stockpiled prior to quarrying.

Sydney Soil Environmental Laboratory tested representative samples of materials present on the site in September 1998. These samples included freshly ripped crushed sandstone (SS#1)

and wash water tailings from the settling pond (SS#2). ***Figure 2*** details s the sampling locations while ***Table 2.5*** outlines the results of the testing. The laboratory reports that both crushed sandstone and tailings have low salinity but are acidic and would require the addition of lime for revegetation purposes. Nutrient levels are low in both samples, particularly the freshly crushed sandstone.

TABLE 2.5
Representative Soil Analysis

ANALYTE	SS#1	SS#2
pH in water	6.7	5.1
pH in $CaCl_2$	4.6	4.3
Conductivity (dS/m)	0.03	0.06
Total Phosphorus (mg/kg)	<1	38
Total Nitrogen (mg/kg)	110	350

Note: all samples were tested with soil/water ratio of 1:2

Overburden, topsoil or spoil left on the scoured surface will be available for transport by stormwater in areas that are in the process of being mined. The rate of erosion from the surface will be governed by the erosivity of the rainfall, the erodibility of the sand and the effectiveness of any erosion control measures. Results of the particle analysis (given in ***Table 2.6)*** show that the material that could be expected to be washed off the surface (crushed sandstone – sample SS#1) has only 12% of particles finer than 0.02 mm and can therefore be classified as a Type C soil according to the criteria set out in *Chapter 6 of Managing Urban Stormwater: Soils and Construction* (Department of Housing, 1998).

TABLE 2.6
Soil Physical Properties

Particle Size	Percentage Retained	
	SS#1	SS#2
Gravel (>2 mm)	0.2%	0.0%
Coarse Sand (2 – 0.2 mm)	76.3%	0.9%
Fine Sand (0.2 – 0.02 mm)	11.4%	48.8%
Silt (0.02 – 0.002)	6.1%	21.7%
Clay (<0.002)	6.1%	28.6%
Dispersion	46%	19%
Erodibility	0.021	0.049

Although the dispersion percentage of the crushed sandstone sample (SS#1) is high (46%) it has a relatively low clay content (6%) indicating that that the total percentage of dispersible material of about 4%. Within the settling pond tailings (SS#2), the dispersion percentage is lower at 19%, but there is a greater proportion of clay sized particles. The dispersible fraction of the total tailings mass is therefore about 5%.

The erodibility of the crushed sandstone is in line with quoted values for soils in the area (McInnes,1997). Although the tailings (SS#2) are highly erodible, they are always contained within an enclosed pond and not subject to being eroded off site.

In terms of erosion and sediment control, there are four types of materials present on the site:

- Newly crushed sandstone (represented by SS#1) which is transported from the quarry face to the processing area as soon as it has been quarried. Only small amounts of this material are left on the rock surface at the quarry face or on other exposed sandstone areas en route to the processing area.

- Stockpiled processed sand from which the silt and clay fractions have been washed

- Tailings from the washing process which are deposited in a tailings pond. Because the tailings are held in a closed pond, the erosion characteristics of this material are not relevant to erosion and sediment control on sit, provided these are always covered with water (or later after rehabilitation topsoil).

- Topsoil which has been stockpiled for re-use on rehabilitated areas immediately prior to revegetation.

The erosion rates occurring on the site for the various materials are outlined at ***Table 2.7***. The erosion rates shown have been estimated using the revised USLE Method (Department of Housing, 1998) and an average rainfall erosivity for Maroota of 2,410. The soil erodibility has been derived using the procedures set out in SOILOSS5 (Soil Conservation Service, 1993) supplemented with data taken from Department of Housing (1998) for the Sydney Town soil landscape unit found on the site. The erodibility values quoted are consistent with data quoted by Morse McVey & Associates (1998) for another sand extraction site in Maroota (soil erodibility 0.013 to 0.029).

TABLE 2.7
Anticipated Erosion Rates

	Crushed Sandstone	Washed Sand	Rehabilitated with Topsoil - Unvegetated	Rehabilitated with Topsoil - Vegetated
Soil erodibility	0.021	0.018	0.025	0.025
Typical slope (%)	3%	3%	5%	5%
Typical slope length (m)	80	80	100	100
LS factor for RUSLE	0.65	4.98	1.35	1.35
Practice factor (P)	1.3	1.3	0.8	0.8
Conservation factor (C)	1.0	1.0	0.15	0.02
Average annual soil loss (t/ha/y)	43	37	10	1.3

The data in ***Table 2.7*** indicates that during the quarrying process the site has very low erosion hazard (Soil Loss Class 1 according to the criteria set by Morse and Rosewell, 1996). For the Sydney region, sites with very low erosion hazard (Class 1) can be operated throughout the year with routine erosion control measures. The data also indicates that after rehabilitation and revegetation erosion rates of the order of 1 t/ha/year should be achieved.

2.5 Drainage and Hydrology

2.5.1 Site Drainage

This section of the report describes the general flow paths through the site. The details of the dimensions and operational procedures of the water and sediment control facilities are set out in ***Chapter 3 – Existing Water Management and Erosion Control System.***.

The site drainage arrangements have been placed in position in conjunction with previous quarrying operations. ***Figure 3 – Water Management System Existing Conditions*** shows the various storage ponds and overland flow paths present within the site as at December 1998. A simplified schematic diagram of the flow paths through the site is detailed at ***Figure 4 – Schematic Existing Site Water Management*** .

Two watersheds totaling around 49 ha drain in a westerly direction to the eastern boundary of the site (reference Section 2.1). Runoff from both catchments converges at the eastern boundary of Lot 196 and west of the internal access road used by P F Formation Pty Ltd. Runoff from these catchments joins stormwater from the internal access road and enters the site to the south of the *Maintenance Area*. Once within the site, runoff passes through a sediment trap that has been installed and is maintained by P F Formation Pty Ltd. It then flows into a *Primary Catch Pond* from which flow is directed into the *Overflow Catch Pond* from which off-site discharge is made.

The Secondary Catch Pond and other *Sedimentation Basins* collect sediment from the operating areas within Lot 196 prior to discharge into the *Main Storage Pond*. *An Overflow Weir* at the eastern end of the *Main Storage Pond* controls the water level and discharges into the natural creek system, located in the *Heavily Timbered Area*.

The northern leg of Lot 29 has been cleared in readiness for the commencement of mining operations. Runoff from this area drains in a northerly direction to mix with runoff from the catchments east of the internal access road and discharge into the sediment basin operated by P F Formation Pty Ltd. Within the southern leg of Lot 29 quarrying has been undertaken to a level below the existing landform. Consequently all stormwater runoff from this area is captured within the works area.

Except for 7 ha of pristine bushland in the SW corner, all of Lot 196 has been subject to previous quarrying operations and the site layout as at December 1998 is shown on ***Figure 3.*** The operational areas include:

- *The Yellow Sand Extraction Site* located in the north west corner which drains *via Sedimentation Basin No 3* into the *Main Storage Pond,*
- *The North-east Extraction Area* which drains to the *Tailings Pond.*

- *The Rehabilitation Area* shown on ***Figure 3*** from which runoff is directed by a series of diversion banks and waterways into *Sedimentation Basin No 2* which also drains to the *Main Storage Pond,*

- *The Wet Production Area* which primarily drains to the *Secondary Catch Pond* and then to the *Main Storage Pond.* In conditions of heavy runoff some surface runoff may also drain to *Sedimentation Basin No 1.*

- *The Tailings Pond* which receives sediment laden wash water from the *Wet Production Area* as well as runoff from the *Site Access Road* and the *North-east Extraction Area.* Supernatant water from the *Tailings Pond* drains back to the *Main Storage Pond.*

- *The Stockpile Area* that contains stockpiles of processed material awaiting dispatch. This area drains via *Sediment Basin No 1* to the *Main Storage Pond.*

- The Site Office and Maintenance Area that drain to Sediment Basin No 1 and thence to the *Main Storage Pond.*

As described above, all runoff from the quarry site and upstream watersheds is eventually directed towards the *Main Storage Pond.* Within the *Main Storage Pond* water levels are controlled by a concrete weir situated at the southeastern corner of the storage in the vicinity of the pump station. A low flow pipe maintains a constant water level about 0.5 m below the crest of the weir. In times of heavy rainfall, flows surcharge the concrete weir and find their way into the natural creek which conveys flows in a generally westerly direction towards the Hawkesbury River.

2.5.2 Local Catchment Hydrology and Model Calibration

There are no flow records from the site, downstream of the site or from any adjacent catchments. The hydrology of the site and its upstream catchments has, therefore, been assessed using two types of analysis:

- Estimation of peak flow rates through the site as a result of individual storms. This analysis used a runoff routing model (described below);
- Assessment on long term site water balance by means of a water balance model that is described in ***Chapter 3.***

The computer runoff-routing model called RORB (Laurenson & Mein, 1992) has been used to estimate the event based runoff generated by both the quarry site and the upstream catchments. The model has also been used to assess the effects of the water storages located within the quarry on peak flows leaving the site. A more detailed explanation of the model and its set-up is presented in ***Annexure C – HYDROLOGIC MODELING***. Rainfall data for the model was derived from the data outlined in ***Section 2.3 – Rainfall and Evaporation*** together with design rainfall patterns given in *Australian Rainfall and Runoff, Vol 2 (I E Aust, 1987).*

Two models were set up with their downstream outlets adjacent to the outlet weirs to *the Main Storage Pond* and *Overflow Catch Ponds*. For model calibration purposes, the RORB models were initially set up to represent the catchment in its natural rural condition, (ie prior to quarrying so that storage effects and impervious surfaces within the quarry would not affect calibration).

Peak flows were also estimated using the Probabilistic Rational Method (PRM) for rural flood estimation as detailed in *Chapter 5 of Australian Rainfall and Runoff, Vol 1* (I E Aust, 1987) and the RORB model parameters adjusted until the models reproduced PRM values. Thus the model was calibrated.

The catchment characteristics in the model were then altered to represent existing conditions. It was assumed that all storages apart from the *Overflow Catch Pond* were full at the commencement of each storm event – this allows an element of conservatism. *The Overflow Catch Pond* was assumed to have been maintained at a constant level of RL 168 m AHD, approximately 2 m below the top of the pond embankment. ***Table 2.8 - Peak Stormwater Discharge Volumes*** details the results of the analysis for design storm events from Recurrence Intervals between 2 and 100 years, all for a 30 and 120 minute storm duration.

Table 2.8
Peak Discharges and Stormwater Runoff Volumes

Storage	Storm Event (ARI)	Peak Inflow (m^3/s)		Peak Outflow (m^3/s)		Volume of Inflow (ML)	
		30 min.	120 min.	30 min.	120 min.	30 min.	120 min.
Overflow Catch Pond	2	2.2	1.6	0	0	6.5	8.0
	10	5.0	4.3	0	0.4	12	18.5
	20	6.4	5.7	0	1.0	15	24
	100	9.7	9.7	0.82	2.3	22	36
Main Storage Pond	2	1.3	1.3	0.02	0.03	2.4	4.0
	10	2.2	2.2	0.02	0.5	3.7	6.4
	20	2.65	2.74	0.03	0.8	4.4	7.6
	100	3.5	3.5	0.6	1.4	5.9	10

Note: The peak discharges are reduced for the full range of design storm events modeled in comparison with peak inflows. This occurs due to the surcharging that occurs. This comes about as the outflow pipes and weirs restrict the outflows.

2.6 Water Quality

Water quality sampling and testing has been carried out for the present study by Lyall & Macoun staff and Australian Water technologies (a commercial division of Sydney Water). Six samples of both stormwater runoff within upstream creeks and site storages were taken between the months of August 1998 and January 1999. Lyall & Macoun reported that the first set of samples were taken in August 1998 and that they were taken five days after a heavy rainfall event. The November 1998 samples were taken within a relatively dry period. The final set of samples taken in January 1999 followed a localised storm event. The locations of the sample sites are shown on ***Figure 2*** *and are:*

- **SW1 –** In the main creek line draining Lot 117 and adjacent areas, at the point of discharge onto the Dixon site.
- **SW2 –** From the Primary Catch Pond.
- **SW3 –** Taken on the secondary drainage line following the southern boundary of Lot 117.
- **SW4 –** From the Main Storage Pond downstream of the site's water management system and the point from which off-site discharges occur from the Dixon operation.
- **SW5 –** From the Overflow Catch Pond.
- **SW6 –** From the dam located within Lot 2.

The results of sampling at the six sites are detailed at ***Table 2.9 – Water Quality Analysis Results.*** These results show that there is elevated turbidity and suspended solids levels within all samples collected on 25 August 1998 (following heavy rainfall). Based upon observations during runoff producing rainfall events it is apparent that the main source of turbidity is runoff from the *Internal Access Road,* to the east of the site. The road is not sealed and spillage of fine dispersive sand onto the road from the quarrying operation to the north of Lot 196 and Lot 117, appears principally responsible for the high turbidity levels in samples from sites SW2 (*Primary Catch Pond*), SW5 (*Overflow Catch Pond*) and SW4 (*Main Storage Pond*). (Note that on that occasion, some runoff discharged from the *Primary Catch Pond* into *the Secondary Catch Pond* and then into the *Main Storage Pond.*) A further aspect of note is that the high turbidity water in the *Primary Catch Pond (*SW2) on 25/8/98 subsequently discharged into the *Overflow Catch Pond* (SW5) had, by 23/11/98, reduced turbidity to only 14.5 NTU. Results of the January 1999 analysis indicate that high turbidity levels are present in runoff from the *Internal Access Road* and within the *Primary Catch Pond* from a localised storm event. A comparison of turbidity levels within the *Overflow Catch Pond* for the dry period (November 1998) and a frequent wet weather event (January 1999) indicated that the pond significantly reduces turbidity levels in incoming flows for these type of events.

High levels of Total Nitrogen (TN) and Total Phosphorus (TP) occurred in runoff entering the site from the upstream catchments (particularly sites SW1 on 25 August 1998). Inflows from the North East Farmed Catchment have TN up to 4 times higher than the recommended ANZECC guidelines for ecosystem protection and TP almost 3 times higher than the recommended limit. From a comparison of samples SW1 and SW3 it can be seen that the runoff produced by the North East Farmed Catchment has levels close to 10 times that of the Eastern Bushland Catchment, indicating the farmed catchment is the main source of nitrogen and phosphorus. The results of this analysis are further supported by high algal counts (21,000 cells/mL) in runoff from this catchment. As expected, the mixing of water from these two sources (sample SW2) gives water quality that is an average of the two.

Most pH results are just above the ANZECC guideline of a minimum pH of 6.5 while the others lie significantly below the limit. In particular pH readings for SW4 (*Main Storage Pond*) are below the limit. During dry weather the pH reduces in the pond as indicated by the August and November samples but with the inflow of stormwater runoff increases again as indicated by the January 1999 sample. The generally low pH values in runoff from the two upstream catchments (SW1 and SW3) are a likely reflection of the acidic nature of the soils in the area (McInnes 1997). This is not an uncommon feature with the soils along the Australian east coast typically acidic in character. The lower pH in the *Main Storage Pond* is explained by the oxidation of ferrous iron contained in the quarried sandstone and the subsequent precipitation of ferric iron. This precipitation process lowers the pH, as well as resulting in iron oxide staining. This is a natural phenomenon found in the sandstone areas around Sydney. The acidity generated by this process is retained in the *Main Storage Pond*. This pond acts as the source from which process water is recycled.

TABLE 2.9
Water quality Analysis Results

Sample	Date of Sampling	pH	TSS mg/L	Turbidity NTU	Sol. React. Phos. mg/L	Total P mg/L	Total N mg/L	E C DS/m
SW1	25/8/98	6.65	76	27	0.086	0.264	2.90	11.0
	23/11/98	No Runoff						
	28/1/99	5.65		280	0.015	0.128	1.40	3.8
SW2	25/8/98	6.64	239	198	0.073	0.172	1.78	8.1
	23/11/98	6.6	103	154	0.007	0.052	0.93	8.5
	28/1/99	6.38		280	0.004	0.072	0.58	6.8
SW3	25/8/98	6.46	82	119	<0.002	0.031	0.39	6.0
	23/11/98	No Runoff						
	28/1/99	No Runoff						
SW4	25/8/98	5.64	211	58	0.032	0.141	1.42	12.0
	23/11/98	4.9	10	3.5	0.004	0.004	0.26	7.0
	28/1/99	5.72		14.7	0.002	0.012	0.16	7.7
SW5	25/8/98	No Sampled						
	23/11/98	6.5	29	14.5	0.006	0.033	0.40	6.0
	28/1/99	6.44		13.1	0.005	0.024	0.25	5.8
SW6	25/8/98	Not Sampled						
	23/11/98	6.2	5	4.4	0.004	0.006	0.36	13.0
	28/1/99	6.45		3.8				12.2

Note : Results tabulated from AWT Laboratory results.

3. EXISTING WATER MANAGEMENT AND EROSION CONTROL SYSTEM

This chapter outlines the facilities on the site for managing and storing stormwater runoff. It also describes current water usage practices on the site and presents the results of the water balance study.

3.1 Site Stormwater Management

The existing site facilities comprise sediment basins and storage ponds that control the quality of water discharged from the site. These facilities also make provision for the storage of water for re-use in the production process. ***Table 3.1 – Water Management Facilities and Contributing Catchments*** details the facilities on the site implemented to manage, contain and provide clarification for stormwater runoff and sediments. The catchment areas, which drain to the various facilities, are also detailed in this table.

Figure 4 – SCHEMATIC EXISTING SITE WATER MANAGEMENT is a diagram showing the existing site water management system and ***Figure 3 – WATER MANAGEMENT SYSTEMS EXISTING CONDITIONS*** details the location of each component within the site.

TABLE 3.1
Water Management Facilities and Catchment Areas

Facility	Catchment Description	Catchment Area (ha)
Primary Catch Pond	North East Farm Land	33.6
	Eastern Bushland	15.4
	Internal access road	0.6
	Northern Leg of Lot 29	2.7
	Local Catchment	0.2
Secondary Catch Pond	Local Catchment	0.2
	Wet Production Area	0.6
Overflow Catch Pond Tailings Pond	Local Catchment	2.9
	Site Entrance Road	0.6
	North East Extraction Area	1.4
	Local Catchment	0.3
Sediment Basin No. 1	Site Office and Maintenance Area	0.7
	Stockpile Area	1.0
Sediment Basin No. 2	Rehabilitation Area	3.6
Sediment Basin No. 3	Yellow Sand Extraction Area	4.8
Main Storage Pond	Local Catchment	1.8

In order to describe the scale and operation of the various water management facilities, the sections that follow are specifically presented to distinguish between the two intended ranges of purpose, as follows:

I. Sediment and Erosion Control Facilities (eg contour drains and sediment basins) whose primary function is erosion and sediment control and
II. Storage and Catch Ponds that have both water storage and sedimentation functions.

3.2 Sediment and Erosion Control Facilities

3.2.1 Inflow to the Site

Several sediment traps have been constructed within the Crown Road to treat stormwater runoff from the internal access road used by P F Formation Pty Ltd. However, Tan inspection in April 1999 revealed that there is no sediment control structures along the 340 m internal access road within Lot 117 and stormwater runoff flows uncontrolled in a southerly direction to the north west corner of Lot 29.

A small sediment trap that is owned and operated by P F Formation is located immediately outside the boundary of Lot 196 at the point where the upstream catchments drain into the quarry site. The structure consists of a rock gabion wall wrapped in a geotextile fabric and of approximately 1 m height fronting a bay area of around 5 m^2. The structure acts to catch some of the coarse sediment which has been entrained in the flow prior to it entering the Primary Catch Pond located to the south of the site Maintenance Sheds. At the time of this study the structure was full of sediment and was not functioning to remove sediment from the incoming stormwater.

3.2.2 Primary Catch Pond

The Primary Catch Pond has a water surface area of nominally 1,400 m^2 and is drained by twin 270 mm diameter pipes. The invert of the catch pond is approximately 4 m below the invert level of the outlet pipes which gives the pond approximately 4.7 ML of storage for either sediment or stormwater runoff. The pond acts to capture sediment from the internal access road within Lot 117 that is not retained by the Gabion box sediment trap.

Under normal operating conditions, stormwater which passes through the twin 270 mm diameter outlet pipes will flow into the Secondary Catch Pond located directly to the west of the Primary Catch Pond.

In times of either high flows or observed high levels of turbidity entering from upstream areas, flows are diverted via an overflow weir to the Overflow Catch Pond which has been excavated in the south-eastern corner of Lot 196. Water that enters this Overflow Catch Pond and is stored or either pumped to the Main Storage Pond when levels within the Main Storage Pond

are low. When the levels are at or near Top Water Level the flows spill over an emergency spillway located within the south-west corner of the pond.

As an example of the flexibility of the system:
In the later half of 1998 the twin pipes draining the Primary Catch Pond were blocked and all stormwater was being diverted to the Overflow Catch Pond due to high levels of turbidity entering from the upstream catchments.

3.2.3 Secondary Catch Pond

The Secondary Catch Pond has a surface area of 1,300 m^2 and is drained by a single 750 mm diameter pipe. The invert of the pond is approximately 3 m below that of the outlet pipe and the available dead storage is around 4 ML. Outflow from the pond drains directly to the Main Storage Pond.

Within the Wet Production Area, where quarried sand is processed, diversion banks have been constructed inside the ring road to direct all runoff from the area to the head of a pipe which drains to the Secondary Catch Pond. Sand which has fallen from either the processing plant or heavy machinery enters the pond where it settles out of suspension.

3.2.4 Sedimentation Basin No. 1

Both wet and dry processed sand is stockpiled to the west of the Wet Production Area. Stormwater runoff from this area is directed towards Sedimentation Basin No. 1 located at the western end of the Main Storage Pond. The basin is around 20 m in length, 10 m in width and is approximately 1.7 m deep. The primary outlet to the structure consists of a concrete inlet pit connected to a 600 mm diameter pipe which drains to the Main Storage Pond. Five 250 mm diameter pipes are located within the southern earth and rock embankment of the basin fronting the Main Storage Pond. The invert of the pipes is around 1.2 m above the invert of the basin. The outlet of the pipes extends out past the base of the embankment. The pipes act to evacuate the basin in times of high flows. Stormwater runoff in excess of the piped outlets will overtop the southern embankment and flow into the Main Storage Pond.

Runoff generated from the Site Offices and Maintenance Area flows overland into Sediment Basin No 1 before draining to the Main Storage Pond.

3.2.5 Sedimentation Basin No 2

Sediment Basin No 2, which is located to the north of the Main Storage Pond, is approximately 30 m in length, 10 m in width and 3 m depth. The primary outlet to the basin consists of a 500 mm pipe which drains beneath a site access track and into a second water capture structure. This structure directs water into three 300 mm diameter pipes which project out over the Main Storage Pond. The spillway to Sediment Basin No. 2 is located along the southern side of the basin fronting the Main Storage Pond and is approximately 10 m in width.

To the west of the Tailings Pond several disused tailings ponds have been capped and have been rehabilitated. In addition a drain has been constructed to collect and drain runoff. The drain runs in a north south direction and drains to Sediment Basin No. 2. The channel has been piped beneath the access track leading to the Yellow Sand Extraction Site

Sedimentation Basin No. 2 also treats water from the access track which has been constructed leading to the Yellow Sand Extraction area. Runoff from the track finds its way around the Rehabilitation Area before entering Sedimentation Basin No. 2.

3.2.5 Sedimentation Basin No. 3

A diversion channel has been constructed along the northern and western site boundaries to capture stormwater runoff from the Yellow Sand Extraction Area. The diversion drain directs water around to the southern side of the hillside where it flows down a rock ramp and into a Sedimentation Basin No. 3 prior to it entering the Main Storage Pond.

Sedimentation Basin No. 3 is approximately 40 m in length, 13 m in width and 1.5 m depth. Stormwater enters the northern end of the basin and exits via a spillway at its southern end, adjacent to the Main Storage Pond.

3.2.6 Tailings Pond

The Tailings Pond was a resultant of the quarrying of sandstone, leaving the excavation. This Pond treats wash-water from the sand washing plant, located within the Wet Production Area. An excavated area, totaling around 1.6 ha (the North East Extraction Area) also drains to the Tailings Pond. A 210 mm diameter pipe located at the southwestern corner of the pond drains treated wash water back to the Main Storage Pond. The Tailings Pond has a water surface area of around 6,000 m^2 and an available water/sediment storage of approximately 30 ML.

Entry to the site is via a sealed entrance road within the eastern boundary of Lot 196. As mentioned previously a small bund wall along the eastern side of the site entrance road prevents water from the adjacent v-drain entering onto the site entrance road and visa versa. Runoff generated from the entrance road flows in a southerly direction along the western edge of the road at the base of a small embankment. Flows follow the embankment to the Site Office And Maintenance Area before turning west and entering the Tailings Pond.

3.2.7 Other Diversion Structures

Within the north-western corner of Lot 196 a low earth embankment wall has been constructed to aid in the diversion of stormwater away from surrounding bushland areas. Some vegetation has established itself along the length of the embankment. A filter fence is present along the base of the embankment fronting the road to the north. The filter fence does not, however, extend along the western boundary of Lot 196.

In the vicinity of the western end of the Main Storage Pond finished contours grade towards the bushland watercourse to the south and is vegetated with a dense cover of native grass.

Along all other site boundaries internal drainage from disturbed surfaces is directed into the site.

3.3 Adequacy of Sediment and Erosion Control Facilities

Table 3.2- Required and Actual Capacity of Sedimentation Basins and Ponds summarizes the characteristics of the various sedimentation basins in terms of the criteria specified in *Managing Urban Stormwater: Soils and Construction* (Department of Housing, 1998) for Type C soils. The required capacity for each structure has been determined on the following basis:

- Design flow is 25% of 1 year ARI flow
- 1 year ARI flow for upstream catchments derived using the Probabilistic Rational Method
- 1 year ARI flow within the site determined using the deterministic rational method with an assumed runoff coefficient of 0.72.
- Design surface area based on providing for settlement of particles of 0.02 mm diameter.
- Settling zone depth taken to be 0.6 m deep.
- Length : width ratio of at least 2:1.

Sediment storage volume taken as the volume of sediment that would erode from the contributing catchment in 6 months based on the erosion rates estimated in ***Table 2. – Anticipated Erosion Rates.***

TABLE 3.2
Required and Actual Capacity of Sedimentation Basins and Ponds

Basin	Catchment Area (ha)	Design Flow (m^3/s)		Surface Area (m^2)	Settling Zone Depth (m)	Length: Width Ratio	Sediment Storage Capacity (m^3)
Primary Catch Pond	52.3	0.25	Required	850	0.6	1.5:1	620
			Actual	1,400	0.6	1:1	4,700
Secondary Catch Pond	0.8	0.03	Required	100	0.6	2:1	18
			Actual	1,300	3.0	1:1	4,000
Sedimentation Basin 1	1.7	0.06	Required	200	0.6	2:1	12
			Actual	200	0.6	2:1	60
Sedimentation Basin 2	3.6	0.04	Required	140	0.6	2:1	45
			Actual	200	1.5	2:1	140
Sedimentation Basin 3	4.8	0.15	Required	517	0.6	2:1	60
			Actual	520	0.6	3:1	160
Tailings Pond	2.3	0.02	Required	70	0.6	2:1	30
			Actual	7,800	3.0	1:1	30,000

3.3.1 Sedimentation Basins

The data in ***Table 3.2*** shows that Sedimentation Basins Nos.1 – 3 have:

- Effective surface area greater than that required for Class C soils.
- Have a length to width ratio greater than 2:1.
- Have sediment storage capacity well in excess of that required.

3.3.2 Catch Ponds

The Primary and Secondary Catch Ponds operate in distinctly different manners as follows :

- The Primary Catch Pond acts as a primary settlement basin for coarse sediments contained in runoff from the upstream catchments. This water is diverted into the Overflow Catch Pond that acts as a large sedimentation basin as well as a water storage. As shown in ***Table 3.2***, the Primary Catch Pond has more than ample capacity to function as a sedimentation basin for the upstream catchments.

- The Secondary Catch Pond functions as a sedimentation basin for surface runoff from the Wet Processing Area. As shown in ***Table 3.2***, it has more than enough surface area and sediment storage capacity to fulfil this role. Its only design shortcoming is that it is nominally square in plan, but this is more than compensated for by having a surface area about 20 times that required.

3.3.3 Tailings Pond

Table 3.2 shows that the Tailings Pond has more than adequate capacity to deal with the localized catchment runoff. Its primary function, however, is to settle out the fine clay and silt sized particles that are removed from the crushed sandstone in the washing process. ***Table 3.3 – Particle Size and Settlement Velocity*** is derived from the settling velocity data outlined in *Table 6.2 of Managing Urban Stormwater: Soils and Construction* (Department of Housing, 1998) and shows the required hydraulic loading rate for particles down to 0.002 mm (clay size).

TABLE 3.3
Particle Size and Settlement Velocity

Particle Size (mm)	Settling Velocity (m/s)	Basin Surface Area Required ($m^2/m^3/s$)
0.1	0.0070	140
0.05	0.0019	530
0.02	0.00029	3,400
0.01	0.000073	13,700
0.005	0.000018	55,600
0.002	0.0000028	357,000

Operations involving washing of 65,000 tonnes of sand per year use of nominally 190 ML of water which is recirculated through the system. The washing process is proposed to occur on average about 10 hours a week over a 3 days period. The hydraulic loading to the Tailings Pond will therefore occurs over a relatively short period. This will be followed by a longer period of settlement. The effective basin area over the whole year has a surface area to inflow rate of Nominally 1,300,000 $m^2/m^3/s$. Even allowing for the episodic nature of the inflows, it can be seen that the hydraulic loading rate is sufficiently low to settle out particles less than 0.002 mm in diameter.

3.3.4 Diversion Banks and Channels

The site has various diversion banks and channels constructed to control slope lengths and to divert water to the required locations. As part of the proposed upgrading of facilities, these diversion and conveyance structures will, where necessary, be upgraded to comply with the requirements set out in *Managing Urban Stormwater: Soils and Construction* (Department of Housing, 1998).

3.4 Water Storages

Several water-retaining bodies are located within the site. These water storage areas act to both treat stormwater runoff and to retain water for the operation of the quarry.

3.4.1 Main Storage Pond

The Main Storage Pond for the quarrying operation is located in the southwest corner of the site fronting the natural bushland stream. All runoff generated from the site and the catchments to the east eventually reach this pond unless lost to evaporation in upstream storages. The pond has a surface area of around 8,600 m^2 and has a maximum depth of nominally 4m. The pond has an approximate storage volume of 32 ML.

At the south- eastern end of the Main Storage Pond a concrete weir, of nominally 5m width, has been constructed. A 150mm diameter pipe, through the weir, controls the water level at a constant 500mm below the top of the weir and approximately 1 m below the top of the southern embankment. The water that drains through this pipe enters the bushland creek downstream of the quarry.

3.4.2 Overflow Catch Pond

The Overflow Catch Pond has a water surface area of nominally 14,000 m^2 and a maximum capacity of nominally 58 ML at the assumed top operating level (TWL RL 168 m AHD). This pond receives runoff from the upstream catchments. These flows cannot be conveyed along the original flow line because of mining in this area by previous operations and the current existence of key water control facilities.

3.4.3 Other Storages

The other storages on the site that play a relatively insignificant role in the overall water management are:

- A pond has been created by excavation of sandstone in an area immediately east of the Yellow Sand Extraction Site near to the northern boundary of Lot 196. This pond is only a temporary feature of the site and will be subsumed when further extraction from the Yellow Sand Extraction Site occurs. In the meantime, the pond acts as a small self contained catchment and plays no role in the site water management.
- Two disused ponds are located immediately west of the Main Storage Pond. These ponds are a relic of previous operations by others and play no role in site water management.
- Water is also retained within the dead storage areas allocated for the capture of sediment and tailings within the Primary and Secondary Catch Ponds and the Tailings Pond and amounts to a maximum dead storage of around 39 ML. This storage volume is highly variable given that the Secondary Catch Pond and Tailings Pond accept either tailings or

sediment laden wash runoff from the Wet Production Area. Water within the dead storage areas is lost to evaporation.

3.5 Storage Operation in High Flows

In times of high rates of runoff from the upstream catchment and from the site, the Overflow Catch Pond and the Main Storage Pond will act as flow through sedimentation basins and protect the downstream catchments from sediment discharge. ***Table 3.4 - Sediment Capture Performance of Ponds*** summarizes the hydraulic loading and sediment capture performance of these two ponds during 120 minute duration high flow events.

TABLE 3.4
Sediment Capture Performance of Ponds

Pond	ARI Storm (years)	Outflow (m^3/s)	Sediment Size Captured (mm)
Main Storage Pond	10	0.5	0.009
	20	0.8	0.011
	100	1.4	0.015
Overflow Catch Pond	10	0.4	0.007
	20	1.0	0.010
	100	2.3	0.015

In ***Table 3.4***, the sediment sizes captured in larger storms are based on the settling velocity and hydraulic loading rate data in ***Table 3.3***. ***Table 3.4*** shows that the Main Storage Pond will capture sediment up to 0.015 mm in diameter in a 100 year ARI storm. The pond would therefore trap over 90% of any materials washed off the operating area.

3.6 Site Water Usage

Sand quarried from the site can be either washed to remove fines or simply stockpiled directly from the crushing plant. The quantity of crushed sandstone that is washed is dependent on both the quality of sand quarried and market demand. The Maroota quarry was producing up to 250,000 tonnes of sand per year, one-quarter of which consisted of washed product.

To produce the washed sand the washing plant is currently operational on average around 10 hours per week. Water for the plant is pumped via a pipeline. This pipeline extracts water from the eastern end of the Main Storage Pond.

The pump, which supplies water to the processing plant, has a volumetric pump rate of nominally 6,000 L/min resulting in nominally 0.72 ML of water being pumped from the Main Storage Pond per day. This daily rate or volume represents approximately 2% of the total storage available in the pond.

After being utilized as washing process water, it is then gravity fed to the Tailings Pond. Here it either evaporates or is re-circulated back to the Main Storage Pond.

When washed the sand is stockpiled with a moisture content of around 8-10% by weight. Depending on the length of time the sand is stockpiled determines the moisture content of the sand prior to it being trucked from the site. Typically sand sold to the market place contains around 5% water by weight with the difference evaporating from the stockpiles. In-situ sand has a moisture content of around 2-3%, indicating that up to 8% of water by weight of wash water is lost to product. Given that around 62,500 tonnes of sand is washed per year then it could be expected that around 5 ML of water per year is lost due to the washing process.

Dust suppression is undertaken throughout the year on all roads. A water cart is located on site and has an approximate carrying capacity of 15,000 L. The amount of water used for dust suppression is highly dependent on rainfall and is therefore highly variable. It is estimated that the cart is used on dry days, on average, 4 times a day in summer and 3 times a day in winter. Water for the cart is drawn from the Main Storage Pond.

3.7 Domestic Water and Wastes

The Site Office and amenities are located near the eastern boundary of Lot 196 about mid way between the southern and northern boundaries. The arrangements for water supply and wastewater disposal are addressed specifically in the EIS. The water storage ponds to not contribute to this water usage. Effluent disposed of from the on-site sewage treatment system does not enter the site pondage system.

3.8 Maintenance and Refueling

Maintenance and refuelling of machinery occurs in the Maintenance Area. This area includes enclosed facilities for maintenance. Facilities for management and treatment of runoff from this area is addressed in the EIS. The water storage ponds to not contribute to water used in this area, nor do they receive contaminated runoff from this area.

3.9 Site Water Balance

In order to assess the overall site water balance under current and future conditions, a detailed water balance analysis has been undertaken using two computer models. The first model, called Boughtons Model or AWBM, was used to generated stormwater runoff volumes from each of the contributing catchments. The model utilizes daily climatic data (rainfall and evaporation) to analyze the status of elements of the water system such as soil moisture levels and runoff volumes.

The second model, called IQQM, was used to monitor the behaviour of the various storage areas within the site. The model takes account of processes such as runoff into the storages, evaporation from and direct rainfall into each storage, seepage into groundwater, water abstractions for the processing of sand and dust suppression, and overflows into the downstream watercourse.

A detailed description of both computer models is presented in ***Annexure C3-C – Hydraulic Modeling*** to this Report.

For the purposes of this report the models were used with 21 years of daily rainfall and evaporation data from Glenorie and Richmond respectively.

The AWBM was run for the 21 years of recorded data and tuned to produce annual average volumetric runoff coefficients of 25% and 60% for the rural and bushland catchments and the disturbed areas within the quarry respectively. Rehabilitation areas were assigned a runoff coefficient of 25%.

Results of the modelling are presented in ***Table 3.5 - Stormwater Runoff Generated by Contributing Catchments.*** This Table gives the average annual volumes of stormwater runoff generated by the contributing catchments draining to the Overflow Catch Pond and Main Storage Pond.

TABLE 3.5
Stormwater Runoff Generated
by Contributing Catchments

Facility	Catchment Area (ha)	Average Annual Volume (ML)
Overflow Catch Pond	55.4	159.3
Main Storage Pond	15.0	82.3

The AWBM results indicate that the average annual depth of runoff for the two types of land-uses (farmland, bushland and rehabilitated land versus disturbed quarry surfaces) to the storage ponds are 263.2 mm and 638.8 mm respectively. The quarry is therefore generating an additional 375.6 mm of runoff per unit area of catchment each year than would occur if the catchment was in its natural state. The average annual volume of runoff which could therefore be expected to have been generated by the catchment prior to the commencement of quarrying is around 185 ML. According to the model the quarry has therefore increased catchment yield by approximately 30% or around 57 ML per year on average.

A current water management practice undertaken on site is to pump water from the Overflow Catch Pond to the Main Storage Pond when water levels within the pond drop to too low a level. For modelling purposes a decision rule was adopted whereby if the water level in the Main Storage Pond is observed to drop to a level of RL 164 m AHD, the approximate level when water ceases to reach the pump house located at the eastern end of the pond, 2 ML/day of water is pumped from the Overflow Catch Pond to the Main Storage Pond the next day. This allows for a minimum storage of 20 ML to be maintained within the Main Storage Pond while water is available in the Overflow Catch Pond.

Currently there is no low flow outlet pipe within the Overflow Catch Pond. Water will therefore pond to the level of the spillway outlet at an elevation of around RL 169 m AHD. The spillway outlet is located in the south west corner of the pond.

The main components of the water balance analysis for the Overflow Catch Pond and Main Storage Pond are detailed at ***Table 3.6- Site Water Balance*** and in ***Figure 5,*** which shows the annual average water balance for all the water storage bodies within the site. In ***Table 3.6*** the apparently anomalous figure for inflow to the Main Storage Pond includes all water recycled from the processing plant and Tailings Pond.

From the analysis it can be seen that on an average annual basis around 195 ML of water will discharge from the site and enter the bushland creek. Although the quarry is generating around 30% more runoff than would occur under pre-quarry conditions, the operation of the quarry and the presence of the water storages leads to a volume of flow entering the creek similar to that which would occur under pre-quarry conditions of 185 ML.

TABLE 3.6
Site Water Balance
(all values in ML)

Storage		Inflow	Water Pumped to Main Storage Pond	Pumped to Processing Plant	Outflow to Creek
Overflow Catch Pond	Average Annual	159	8	-	138
	Dry Year	25	20	-	0
	Median Year	168	8	-	148
	Wet Year	321	0	-	318
Main Storage Pond	Average Annual	266	-	188	57
	Dry Year	227	-	188	3
	Median Year	265	-	188	57
	Wet Year	335	-	188	130

Note: the apparently anomalous figure for inflow to the Main Storage Pond includes all water recycled from the processing plant and Tailings Pond.

3.10 Downstream Impacts

The downstream conditions have been assessed by Gunninah Environmental Consultants who reported the following:

"the creekline is generally considered to be in good condition, and does not appear to have been adversely affected to any significant degree by the current sand extraction operations. In addition, it is not expected that the proposed extension of sand extraction activities (assuming the implementation of any necessary extension of management controls and features), will involve any significant adverse impacts on the creekline."

3.11 Performance of The Existing Water Management System

The principal features of the performance of the existing water management system are:

- The existing sedimentation basins generally meet the requirements for flow through sedimentation basins set out in *Urban Stormwater Management: Soils and Construction*. The basins also meet Council's design requirement for being capable of handling the 20year ARI storm from the contributing catchment.
- The site is self sufficient for water supply from the Main Storage Pond into which all sedimentation basins drain. A low flow outlet from the Pond provides a base flow to the downstream creek after a rainfall event.
- Detailed water balance analysis indicates that on an average annual basis the site utilizes most of the additional volume of water generated by the quarry and that the volume of flow entering the downstream bushland creek is similar to that which occurred under pre-quarry conditions.
- The water management arrangements are complicated by the fact that the site lies at the confluence of two watercourses that drain catchments totaling about 50 ha. Currently flows from the upstream catchments are directed into a Overflow Catch Pond and are pumped to the Main Storage Pond for release by means of the low flow discharge pipe.
- The site water management system meets EPA and Council requirements for being independent of external water sources and for maximizing the re-use of water captured on the site.
- All tailings from the operation are placed in ponds that are excavated below the natural surface. Design requirements for freeboard to protect the integrity of a tailings dam embankment do not, therefore, apply.

It should be noted that the system does not adequately cope with contamination from the discharge of runoff from upstream areas to the site.

4. PROPOSED WATER MANAGEMENT AND EROSION CONTROL

4.1 Introduction

The proposals set out in this chapter address issues related to the future development of water management and sediment control facilities. These proposals supplement proposals prepared by the consultants appointed to deal with related issues:

- Rehabilitation and Revegetation Strategy prepared by the Soil consultant (*see* ***Appendix C2*** to the EIS)
- Proposals for upgrading the management of oil and fuel spills (see the main EIS report)
- Proposals for upgrading the wastewater treatment and disposal facilities to current standards

4.2 Management Strategy and Performance Objectives

The overall strategy to be adopted for water management and sediment control are that the site should:

1. Be self sufficient in water supply for operating purposes and should re-cycle water to the greatest extent possible. The performance objective is to require no additional water from outside sources.

2. Subject to 1 above, the water management system should seek to mimic the pre-existing flow regime downstream of the site. The performance objective is that the downstream flows should reflect flow rates and hydrographic shapes experienced under natural conditions.

3. Protect downstream ecosystems from pollution by sediments, oils and other pollutants. The performance objective for this is that the water quality discharged from the site meets ANZECC criteria for protection of ecosystems for turbidity, salinity, and plant nutrients. (Note that, because of the naturally acidic nature of the soils and groundwater in the area, pH is not included.)

4. Allow some flow from upstream catchments to flow through the site. The performance indicator is that the site operations should permit downstream flow volume, rate and quality adequate for the maintenance of downstream environments.

5. Minimize the disturbed area of the site by only clearing an area immediately prior to mining and progressively rehabilitating areas where operations have been completed.

4.3 Future Site Development

The extraction and rehabilitation operations at the site are proposed to continue for a further 10 years, with the processing approximately 35 years. The sections below set out the proposed staging and design requirements for development of the water management system based on these two time frames.

4.4 Commencement of Operations

Figure 6 shows the general landform and water management system at the commencement of operations. The main proposed actions to be implemented are:

1. Re-configure the outlet arrangements from the Overflow Catch Pond to:

    a) provide for direct discharge of low flows from the upstream catchments to the downstream creek when the Pond is full and,

    b) provide water to the Main Storage Pond in extended dry periods.

    Details of the proposed arrangements are set out in ***Section 6.3.3 of the EIS.***

2. Relocate Primary Catch Pond to the south of its current position

3. Relocate the low flow pipe draining the Wet Production Area to eastern end of Secondary Catch Pond

4. Relocate Sedimentation Basin No.1 to the west of Wet Production and Stockpile Area, away from the outlet to the Main Storage Pond. This basin will treat stormwater runoff from the Stockpile Area over the life of the quarry.

5. Construct sedimentation basin in north-west corner of Lot 29. This basin will be in operation until surface levels within the quarry allow for positive drainage to the storage area located in the southern leg of Lot 29.

4.5 Final Stages of Operations

Nearing the completion of extraction of all of the available sand resource on Lot 196 and Lot 29, the site's layout will be as shown in ***Figure 6.6- Final Site Rehabilitation*** of the EIS or more preferably ***Figure 6.7- Preferred Final Landform***. The option that will prevail will depend upon Baulkham's Hills Shire Council's determination to use its statutory powers to achieve the latter layout which is a desirable uniform landform. The water management system at this time will have the following features:

1. The Main Storage Pond will continue to provide the downstream storage facility for most of Lot 196. Sediment control provision will be provided within this area of Lot 196 up to the time of rehabilitation of all disturbed areas.

2. The operating Tailings Pond will be moved to the north east corner of Lot 196. This pond will continue to receive tailings through to the completion of quarrying under the new consent.

3. A catch pond will be constructed in the south west corner of Lot 29 and will be connected to Lot 196 by a decant pipe thrust bored through the Crown road reserve. This pond will capture all runoff from Lot 29 and subsequently Lots 1 and 2. (subject to the approval of a future application to extract from those lands).

The final Main Storage Pond will have a TWL of 165m AHD and a bed level of 160/161m AHD. The final surface area of 22,000 m^2 and provide a total water storage volume of between 88 and 110 ML. The enlargement of the pond will be as a result of extractive operations at its western end.

4.7 Sediment and Erosion Control Plan

4.7.1 Overview

Figures 6 details the overall layout of the proposed erosion and sediment control works at the commencement of operations. The main elements of the works are:

- Contour banks on rehabilitated areas to provide slope length of no more than 100 m for erosion control purposes.
- Perimeter banks along the northern and eastern boundary of Lot 29 to divert clean water from works areas.
- Waterways to convey runoff from rehabilitated areas to a safe discharge point (usually a storage pond).
- Diversion drains to convey runoff from active working areas to sedimentation basins.
- Sediment basins that provide the primary means of sediment trapping before water is discharged into a storage pond. Basins are to be provided to treat runoff from both disturbed and rehabilitating areas. Following full rehabilitation of the contributing catchment the basin will be filled and
- Storage ponds that function as a back-up sediment capture system as well as providing water for sand processing.
- Waterways to convey runoff from rehabilitated areas to a safe discharge point (usually a storage pond).

Design criteria adopted for these systems and the design details are summarized in ***Section 4.3.2 – Design Criteria*** below.

Figures 6.6 and 6.7 detail the quarry layout nearing the completion of operations within Lots 196 and 29. Site sediment and erosion control measures will follow those set out for the commencement of operations to ensure all water from disturbed areas is treated prior to its discharge to the downstream watercourse.

A key element of the erosion and sediment control plan will be the implementation of the Rehabilitation and Revegetation Strategy (see separate report prepared by the soil consultant).

4.7.2 Design Criteria

All sediment and erosion control measures are to be designed in accordance with the recently published manual *Managing Urban Stormwater: Soils and Construction.* (Department of Housing, 1998). Additionally, the requirements set out in BHSC's DCP 500 are to be adopted.

The proposed design criteria and sizing of individual structures are:

- Contour Banks and Drains
- Grassed Waterways
- Sediment/Silt Fences
- Sedimentation Basins
- Proposed Overflow Catch Pond Arrangement
- Tailings Ponds

4.7.3 Contour Banks and Drains

Contour banks are to be provided where overland flow lengths exceed 100 m. Design requirements for diversion banking are presented in ***Annexure D – Sediment and Erosion Control Design Requirements***.

Diversion drains are to be provided at the ends of contour banking to convey stormwater to a sedimentation basin prior to it discharging into a water storage. Details of diversion drains are given in ***Annexure D.***

All internal roads are to grade to table drains which are to convey flows to diversion drains.

Perimeter banks are to be provided along the northern and eastern boundaries of Lot 29. Banks are to have minimum freeboard of 0.5 m (see **Figure D1** in Annexure C4-D for further details).

4.7.4 Grassed Waterways

The following criteria apply channels and land slopes that will be expected to transport water during rainfall in the catchment:

- Where channel is constructed in other than rock (OTR) channel to be grassed over full extent.

- Maximum side slopes to be no greater than:
  1 vertical : 2 horizontal in OTR.
  1 vertical : 3 horizontal elsewhere.

4.7.5 Sediment/Silt Fences

Sediment fences are to be provided where future operations lead to runoff from disturbed areas entering onto adjacent undisturbed or rehabilitated areas. See ***Figure D1*** in ***Annexure C4-D*** for further details.

4.7.6 Sedimentation Basins

Additional sedimentation basins(2) are proposed within the quarry to treat stormwater runoff. The first involves relocating Sedimentation Basin No. 1 to the west of Wet Production and Stockpile Area as shown in ***Figure 6 - Water Management System at Commencement of Operations***, away from the outlet to the Main Storage Pond. This basin will treat stormwater runoff from the Stockpile Area over the life of the quarry. The basin will accept flows from both its eastern and western ends. The primary outlet will therefore need to be located away from the basin inlets to ensure particles settle out of suspension. ***Table 4.1- Sedimentation Basin Design Criteria*** gives the size and outlet arrangement details for the basin.

The second basin (denoted Sedimentation Basin No. 4, see ***Figure 6***) is to be located within the north-west corner of Lot 29. The basin will treat stormwater runoff from the northern leg of Lot 29 in the early stages of quarrying. Once surface levels have been lowered sufficiently to allow all stormwater runoff to be directed towards the catch pond located in the southern leg of Lot 29, this basin will be removed. ***Table 4.1*** gives the size and outlet arrangement details for the basin.

Requirements for the design of sedimentation basins for the quarry are as follows:

- basin to be capable of capturing a 'design particle' of 0.02 mm diameter.
- a design flow equal to one-quarter of the 1 year ARI flow (ie 0.25 $Q_{tc,1yr}$)(as an approximation of the 3-month ARI flow).
- a minimum settling zone depth of 0.6 m.
- a length:width ratio of no less than 2:1 and where site constraints allow 3:1.
- a sediment storage volume equal to the settling zone volume.
- a primary outlet designed to:
    a) have a capacity to pass the peak flow from the 5 year ARI storm.
    b) have a level at least 300 mm below any emergency outlet.
- an emergency spillway to:
    a) have a capacity to pass the peak flow from the 20 year ARI storm.
    b) may be either of open construction or pipe outlet. Due to risk of pipe blockage in rehabilitation areas piped outlets to be used only where flows originate from work areas.

- internal batter gradients to be a maximum of:
  - 2.5(H):1(V) on earth structures
  - 0.5(H):1(V) on rock gibber structures
  - 1(H):4(V) on Gabion baskets
  - 1(H):4(V) on stacked (rough squared) rock structures
- Grass or rock protection of both primary and emergency outlets to ensure the minimisation of scour.

TABLE 4.1
Sedimentation Basin Design Criteria

Details	Relocated Sedimentation Basin No. 1		Sedimentation Basin No. 4
	Flow from West	Flow from East	
Catchment Area (ha)	2.1	0.7	2.7
3 month ARI discharge (m^3/s)	0.07	0.02	0.09
5 year ARI discharge (m^3/s)	0.57	0.19	0.75
20 year ARI discharge (m^3/s)	0.84	0.27	1.1
Surface Area (m^2)	240	70	310
Settling Zone Depth (m)	0.6		0.6
Sediment Storage Depth (m)	0.6		0.6
Length : Width Ratio	2:1		2:1
Sediment Storage Capacity (m^3)	102		102
Primary Outlet Arrangement	600 dia. pipe connected to riser		600 dia. pipe connected to riser
Emergency Spillway Arrangement	10 m spillway		10 m spillway

Design sheets have been provided in ***Annexure D*** to provide for the layout of basins and their associated outlet works should any future variations in site layout create the need for additional basins.

4.7.7 Proposed Overflow Catch Pond Arrangement

To provide for the discharge of low flows from the upstream catchments a low flow outlet pipe of 100 mm diameter is to be placed within the western embankment of the Overflow Catch Pond. The pipe is to have an upstream invert level of 168 m AHD. This will control water levels within the pond at this level and offer a 2m freeboard to the top of the western earthen embankment.

A pipe is to be located between the Overflow Catch Pond and Main Storage Pond and will allow for the passage of flows between the two water storages. A valve is to be placed on the pipe and will be operated in extended dry periods when the water level in the Main Storage Pond drops to a level which prevents pumping of water to the processing plant. The invert of the pipe within the Overflow Catch Pond is to be set below R.L. 168 m AHD to allow for drawdown of the storage.

4.7.8 Tailings Ponds

The required storage capacity of the Tailings Ponds will be based on storage capacity considerations). All discharge from the Tailings Pond will be diverted to the Main Storage Pond after settlement.

4.8 Water Storage and Treatment

4.8.1 Re-use of Stormwater Runoff

All stormwater runoff generated by the quarry will be captured following treatment by sedimentation basins located at strategic locations within the site. Water from the ponds will be used for the washing sand and dust suppression.

4.8.2 Site Water Balance

Upon commencement of operations the rate of production of washed sand to produce increased quantities of concrete sand will increase. The quantity of water therefore pumped to the processing plant and the subsequent loss of water to product will also increase. A detailed site water balance analysis was undertaken for the proposed future conditions and is detailed in ***Annexure C.***

The key difference between existing and proposed water management practices which affect site water balance are as follows:

- The re-configuring of the outlet arrangements from the Overflow Catch Pond to provide for discharge of low flows from the upstream catchments as outlined in Section 4.3.3.
- Increased duration of pumping from the Main Storage Pond to the processing plant.

- Increased volume of water lost to product.
- Increase in the size of the Main Storage Pond nearing the completion of operations.

Key elements to the water balance analysis for the Overflow Catch Pond and Main Storage Pond at the commencement of operations are tabulated in ***Table 4.2 - Annual Site Water Balance – Commencement of Operations***. ***Figure 8*** shows the annual average water balance for all the water storage bodies within the system. ***Annexure C*** contains plots of the responses of the Overflow Catch Pond and Main Storage Pond under these conditions.

In ***Table 4.2*** the apparently anomalous figure for inflow to the Main Storage Pond includes all water recycled from the processing plant and Tailings Pond. *Figure 8* clearly shows that in an average rainfall year the total outflow from the site (site runoff and runoff from upstream, catchments) is 23 ML greater than the inflow to the site from upstream catchments. In a dry year, however, total site discharge will be less than the inflow.

Results of the analysis show that there is sufficient storage within the site to maintain the increase production rate of wash sand and that in an average rainfall year the total volume of flow entering the downstream creek is only slightly less than would occur under natural conditions.

TABLE 4.2
Annual Site Water Balance – Commencement of Operations
(all values in ML)

Storage		Inflow	Water Pumped to Main Storage Pond	Pumped to Processing Plant	Outflow to Creek
Overflow Catch Pond	Average Annual	159	17	-	131
	Dry Year	25	28	-	0
	Median Year	168	16	-	140
	Wet Year	321	2	-	316
Main Storage Pond	Average Annual	1012	-	941	50
	Dry Year	974	-	941	3
	Median Year	1009	-	941	48
	Wet Year	1076	-	941	116

At the time when the completion of the quarry operations is approaching a large proportion of Lot 196 will be rehabilitated leading to an decrease in the annual volume of runoff. Additionally all of the runoff from Lot 29 will be captured in the storage located in the southern leg of Lot 29. ***Table 4.3*** **- Annual Site Water Balance – Nearing Completion of Operations** and ***Figure 9*** show the results of a water balance analysis for the quarry nearing its completion. Again note that the apparently anomalous figure for inflow to the Main Storage Pond includes

all water recycled from the processing plant and Tailings Pond. ***Annexure C*** contains plots of the responses of the Overflow Catch Pond and Main Storage Pond under these conditions.

Results of the analysis indicate that in a dry year the Overflow Catch Pond empties and cannot supplement the water storage of the Main Storage Pond. Within a dry year the Main Storage Pond will be drawn down to a minimum volume of 10 ML. It should be noted that the runoff from Lot 29 was not included in the analysis and the additional water stored in the southern leg of Lot 29 could be used to supplement the Main Storage Pond during the dry period.

TABLE 4.3
Annual Site Water Balance – Nearing Completion of Operations
(all values in ML)

Storage	Rainfall Statistic	Inflow	Water Pumped to Main Storage Pond	Pumped to Processing Plant	Outflow to Creek
Overflow Catch Pond	Average	151	24	-	118
	Dry Year	24	27*	-	0
	Median Year	161	36	-	120
	Wet Year	306	0	-	301
Main Storage Pond	Average	987	-	941	20
	Dry Year	948	-	941	2
	Median Year	1000	-	941	12
	Wet Year	1021	-	941	76

* Note: Overflow Catch Pond empties

4.8.3 Discharge Water Quality

Water discharged from the site will be subject to sediment removal in sedimentation basins and the Main Storage Pond. Low pH water will be discharged. However, this pH level will not exacerbate existing conditions.

4.8.4 Monitoring

The proposed monitoring program will involve continued monitoring at the existing sites on the following schedule:

- Monthly collection of surface water samples at the locations marked on ***Figure 2***. These samples are to be sent for laboratory analysis. The monitoring locations, frequency of monitoring and the range of physical and chemical tests should be reviewed annually. Provided the data adequately characterizes the nature and variability of water quality entering and leaving the site, consideration should be given to reducing the number of sites, the frequency of sampling and the range of physical and chemical tests.

- At least twice per year samples should coincide with a high flow event, should it occur in that year.
- In-situ testing for pH, conductivity and turbidity at each of the monitoring locations at the time of collection of water samples and on each day when the rainfall exceeds 20 mm, as determined by the rainfall gauge on site.

4.8.5 Collection of Water Samples

Water samples are to be collected in new clean 500 mL or one(1) litre polyethylene bottles. The sample bottle is to be filled to the top and the cap replaced so as to exclude as much air as possible. The sample number, location and time of collection must be clearly written on each bottle. The same information must be recorded in a water monitoring field record book. Immediately after collection each bottle is to be placed in an esky. Once all samples have been collected for one day, the esky should be filled with ice and promptly dispatched to the laboratory for analysis. Duplicate samples will need to be held on site for 30 days following sampling.

At the time that a water sample is collected, in-situ meter readings of pH, conductivity and turbidity should be made (see ***section 4.6.3*** below) and is also to be recorded in the water monitoring field record book.

4.8.6 Laboratory Testing of Water Samples

Water quality samples are to be analyzed at a NATA registered laboratory and should reach the laboratory within 12 hours of collection. If samples are expected to take longer to be dispatched for analysis, they should be frozen prior to placement in an esky for dispatch.

Water samples should be analyzed for the following parameters:

- Total phosphorus
- Total Kjeldahl nitrogen
- Total suspended solids
- pH

One sample, randomly selected, in each batch should also be analysed for the following parameters in order to check on the reliability of the field monitoring results:

- Turbidity
- Conductivity

4.8.7 Field Monitoring

Field monitoring should be undertaken using portable electronic meters or a single meter capable of measuring pH, conductivity and turbidity. Immediately it has been taken, each reading must be recorded in the water monitoring record book.

All meters must be calibrated at least once per month using standard test solutions provided by the supplier of the meter or a NATA registered laboratory. A record of the calibration tests must be kept in the water monitoring record book.

4.8.8 Reporting

Any abnormal water quality results must be reported immediately to the Quarry Manager who will take appropriate action to determine the source of any contamination and take steps to minimize escape of any pollutants from the site.

The water quality monitoring results should be compiled into an annual report for review and assessment by management.

5. REFERENCES

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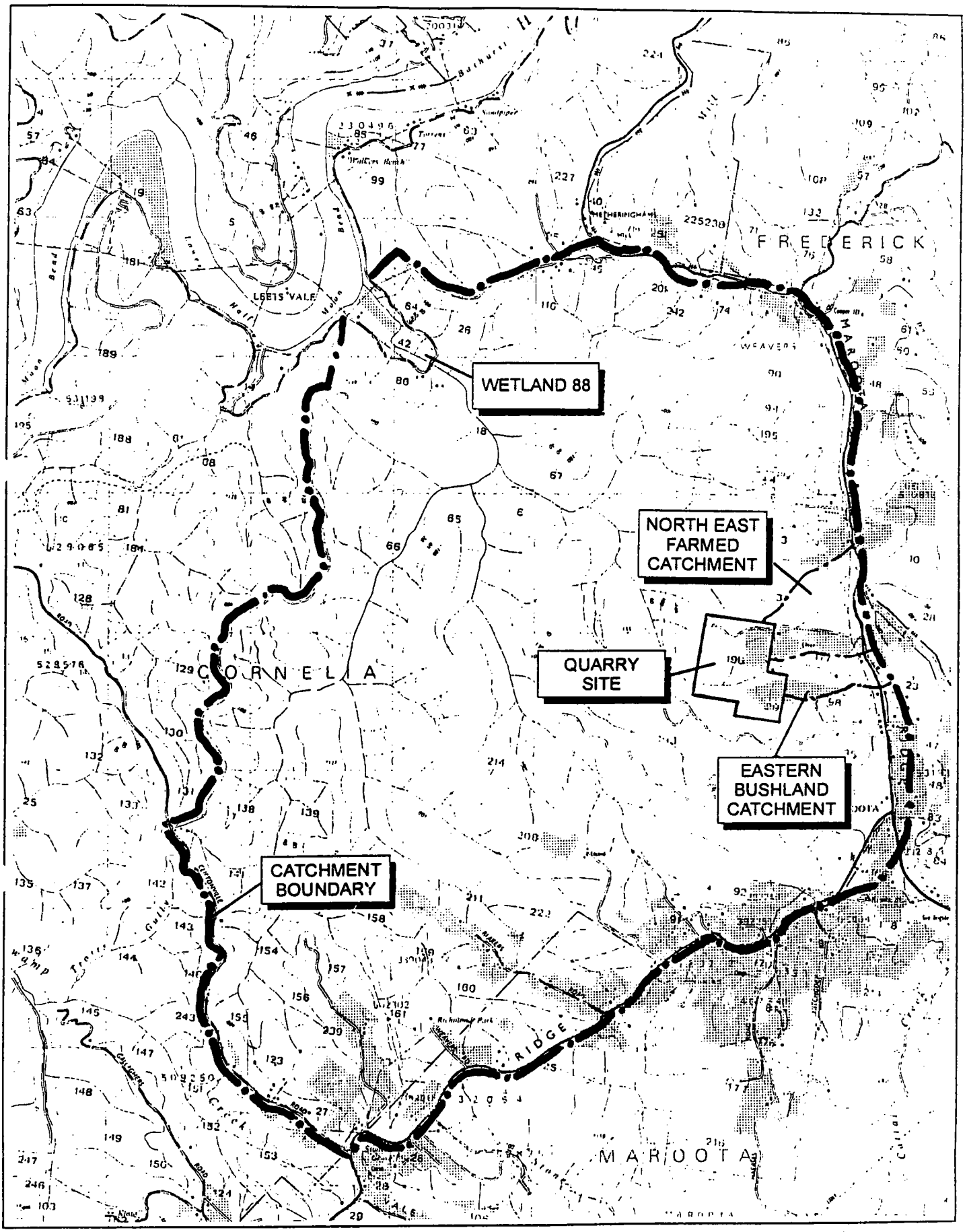
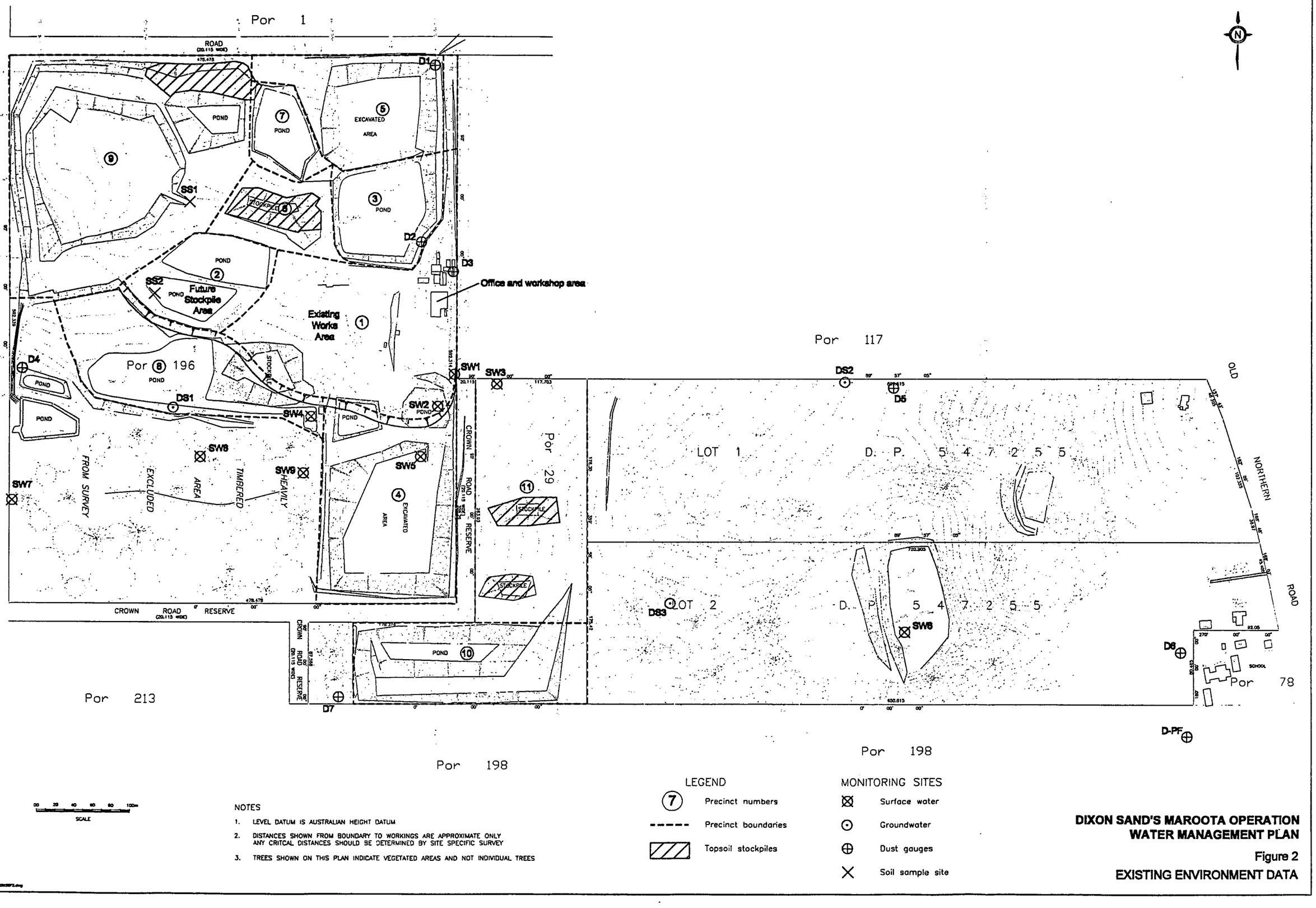


DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure 1

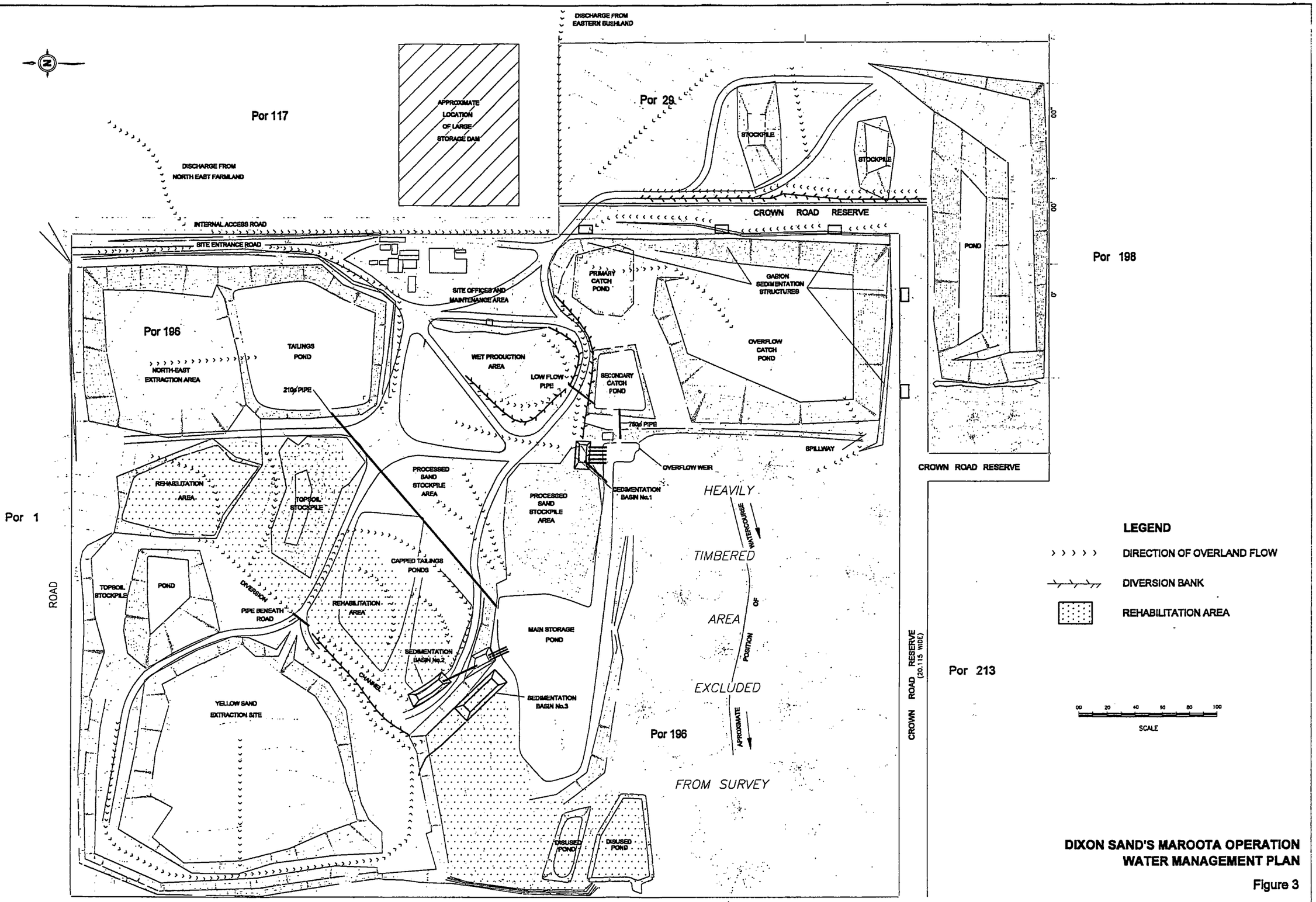
CATCHMENT PLAN



DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure 2

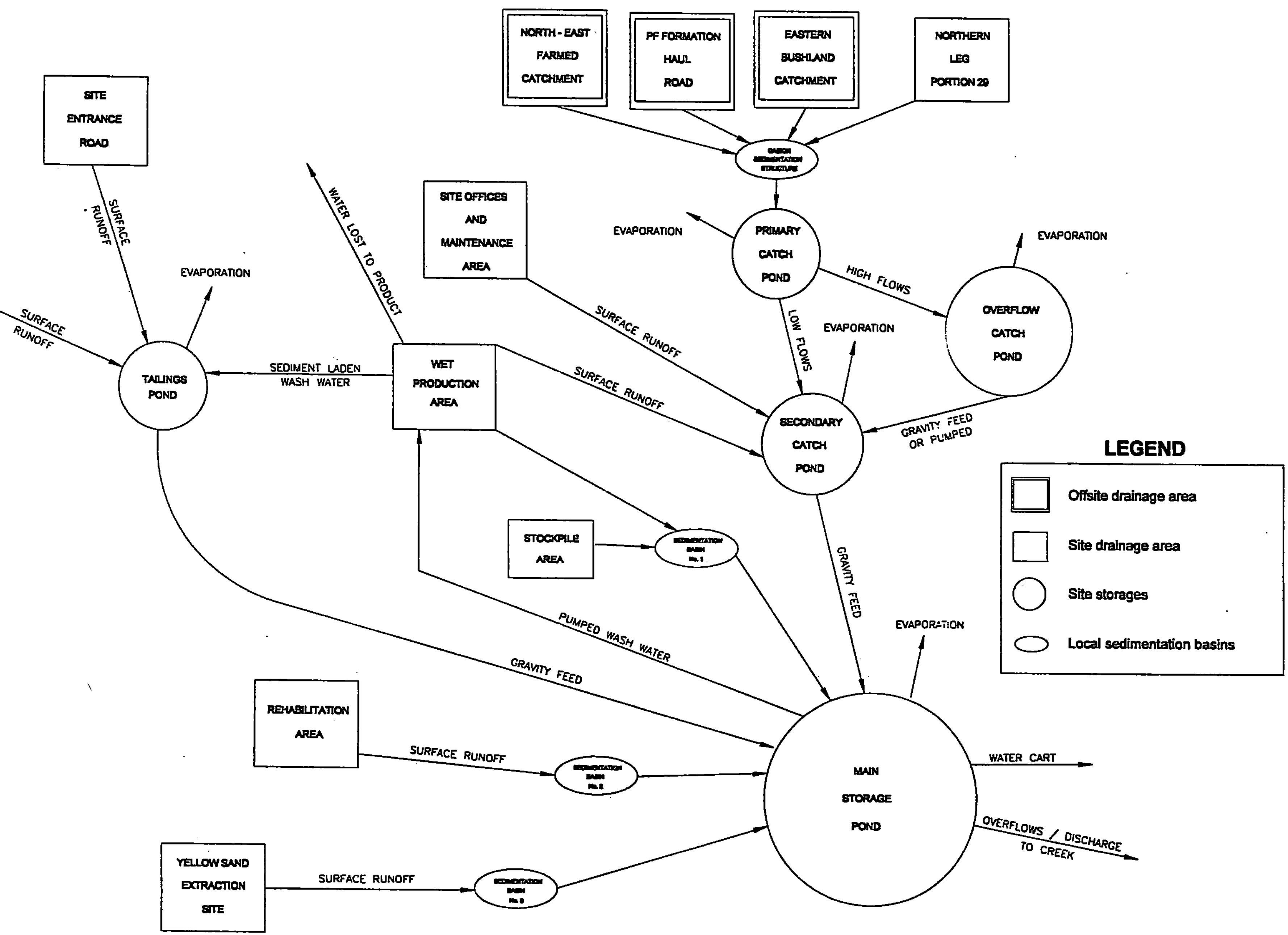
EXISTING ENVIRONMENT DATA



DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure 3

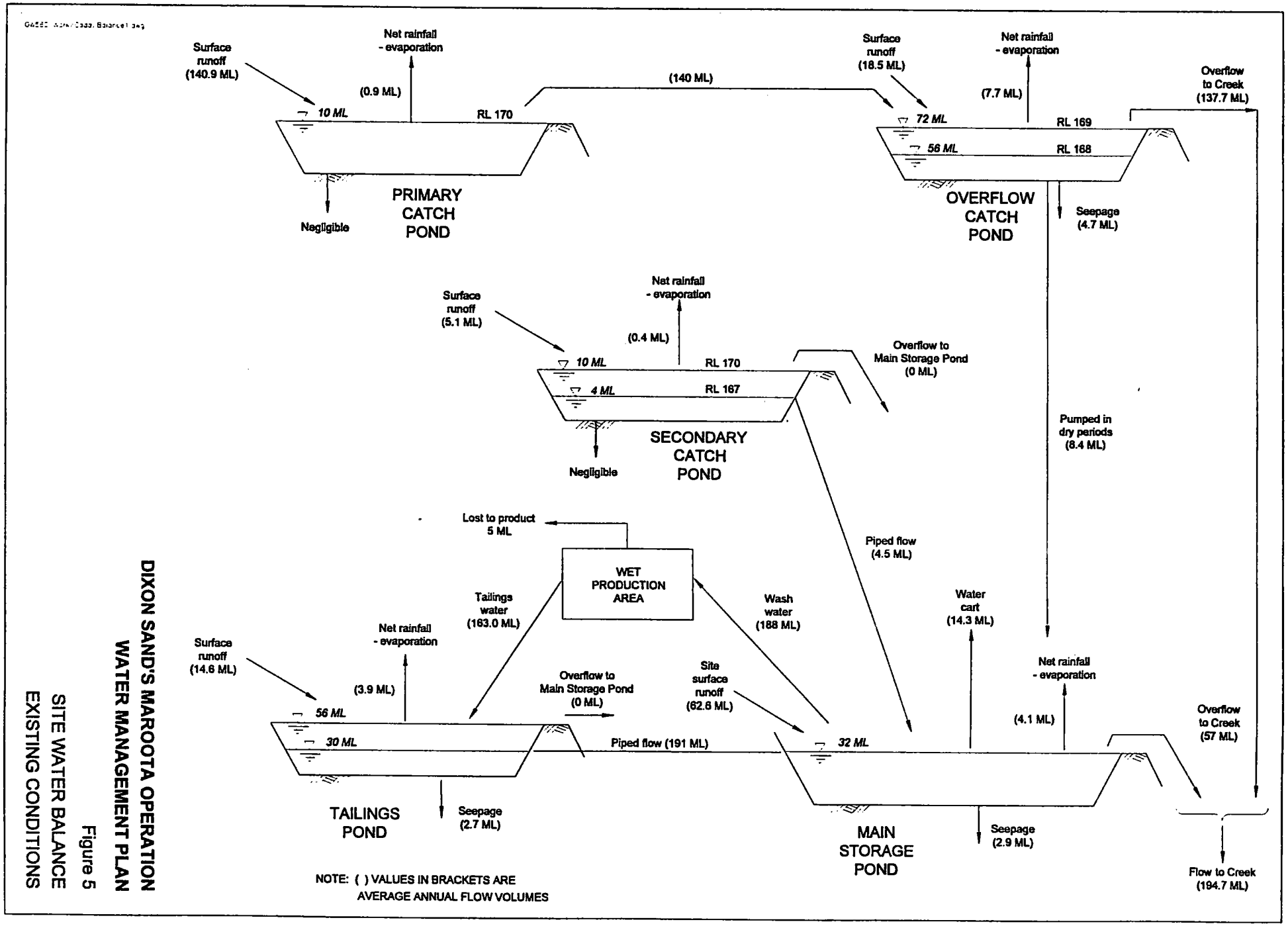
WATER MANAGEMENT SYSTEM
EXISTING CONDITIONS



DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure 4

SCHEMATIC - EXISTING SITE WATER MANAGEMENT



DIXON SAND'S MAROOTA OPERATION

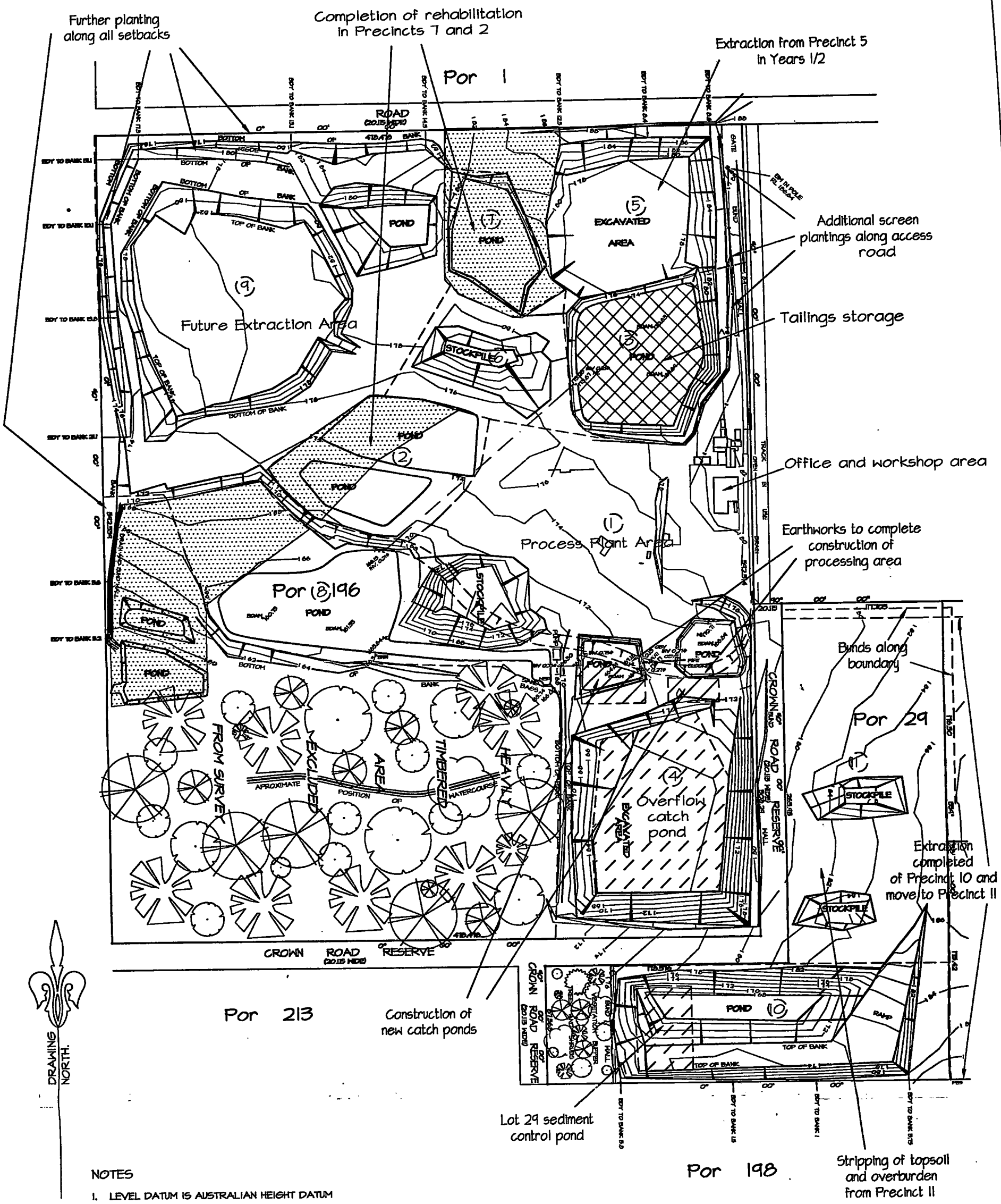
WATER MANAGEMENT PLAN

Figure 5

SITE WATER BALANCE

EXISTING CONDITIONS

NORTH MAROOTA OPERATION NSW



NOTES

1. LEVEL DATUM IS AUSTRALIAN HEIGHT DATUM
2. DISTANCES SHOWN FROM BOUNDARY TO WORKINGS ARE APPROXIMATE ONLY ANY CRITCAL DISTANCES SHOULD BE DETERMINED BY SITE SPECIFIC SURVEY
3. TREES SHOWN ON THIS PLAN INDICATE VEGETATED AREAS AND NOT INDIVIDUAL TREES

00 20 40 60 80 100m
SCALE

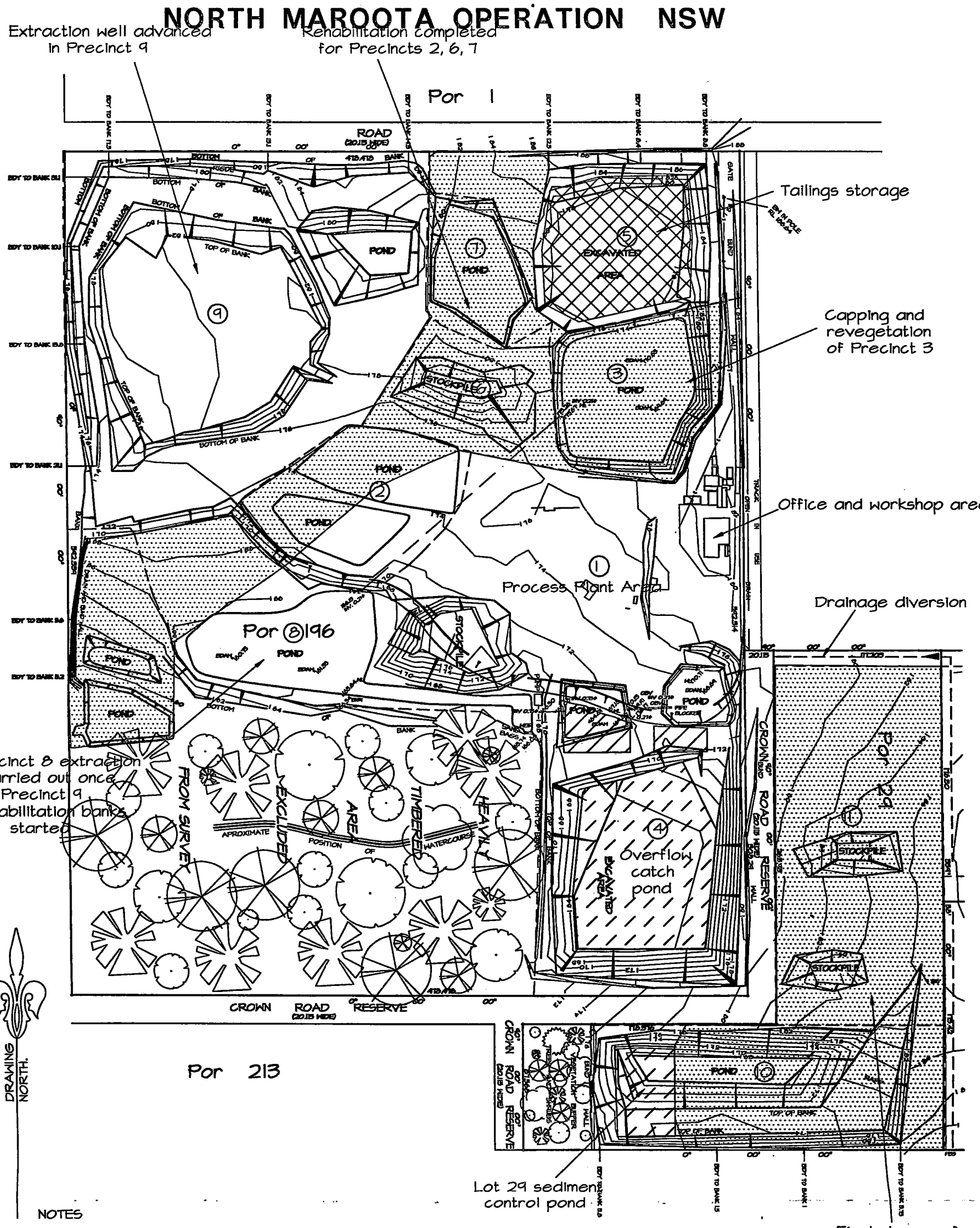
LEGEND

- (7) Precinct numbers
- Precinct boundaries
- Drainage diversion
- Temporary water storage
- Water storage
- Rehabilitation

QUARRY DEVELOPMENT (initial years)

FIGURE 6.4

NORTH MAROOTA OPERATION NSW



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3. TREES SHOWN ON THIS PLAN INDICATE VEGETATED AREAS AND NOT INDIVIDUAL TREES

00 20 40 60 80 100m
SCALE

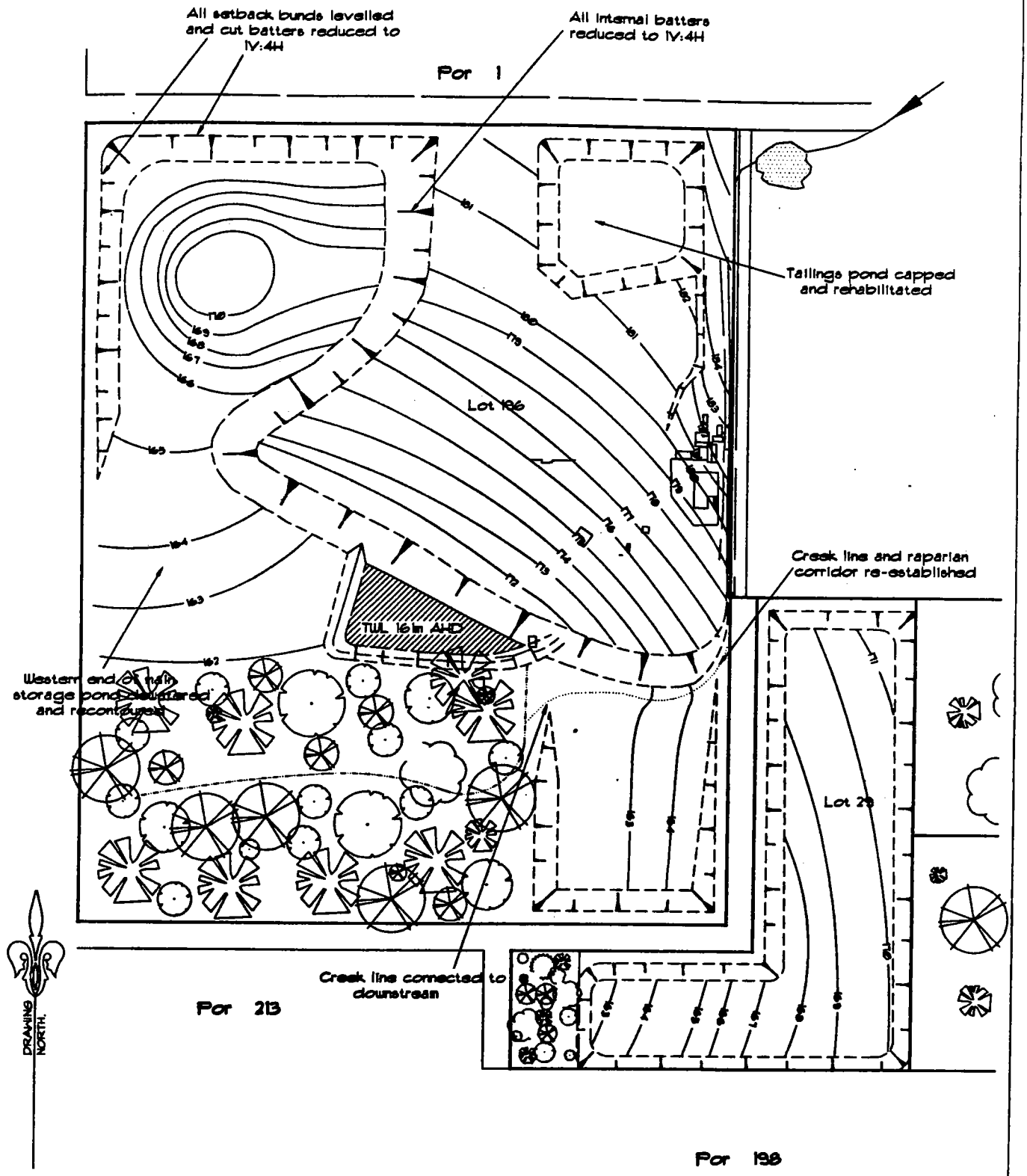
LEGEND

- (7) Precinct numbers
- Precinct boundaries
- Drainage diversion
- Temporary water storage
- Water storage
- Rehabilitation

QUARRY DEVELOPMENT (final years)

FIGURE 6.5

NORTH MAROOTA OPERATION NSW



NOTES

1. LEVEL DATUM IS AUSTRALIAN HEIGHT DATUM
2. DISTANCES SHOWN FROM BOUNDARY TO WORKINGS ARE APPROXIMATE ONLY ANY CRITICAL DISTANCES SHOULD BE DETERMINED BY SITE SPECIFIC SURVEY
3. TREES SHOWN ON THIS PLAN INDICATE VEGETATED AREAS AND NOT INDIVIDUAL TREES
4. FUTURE BATTERS ARE NORMAL TO SLOPES

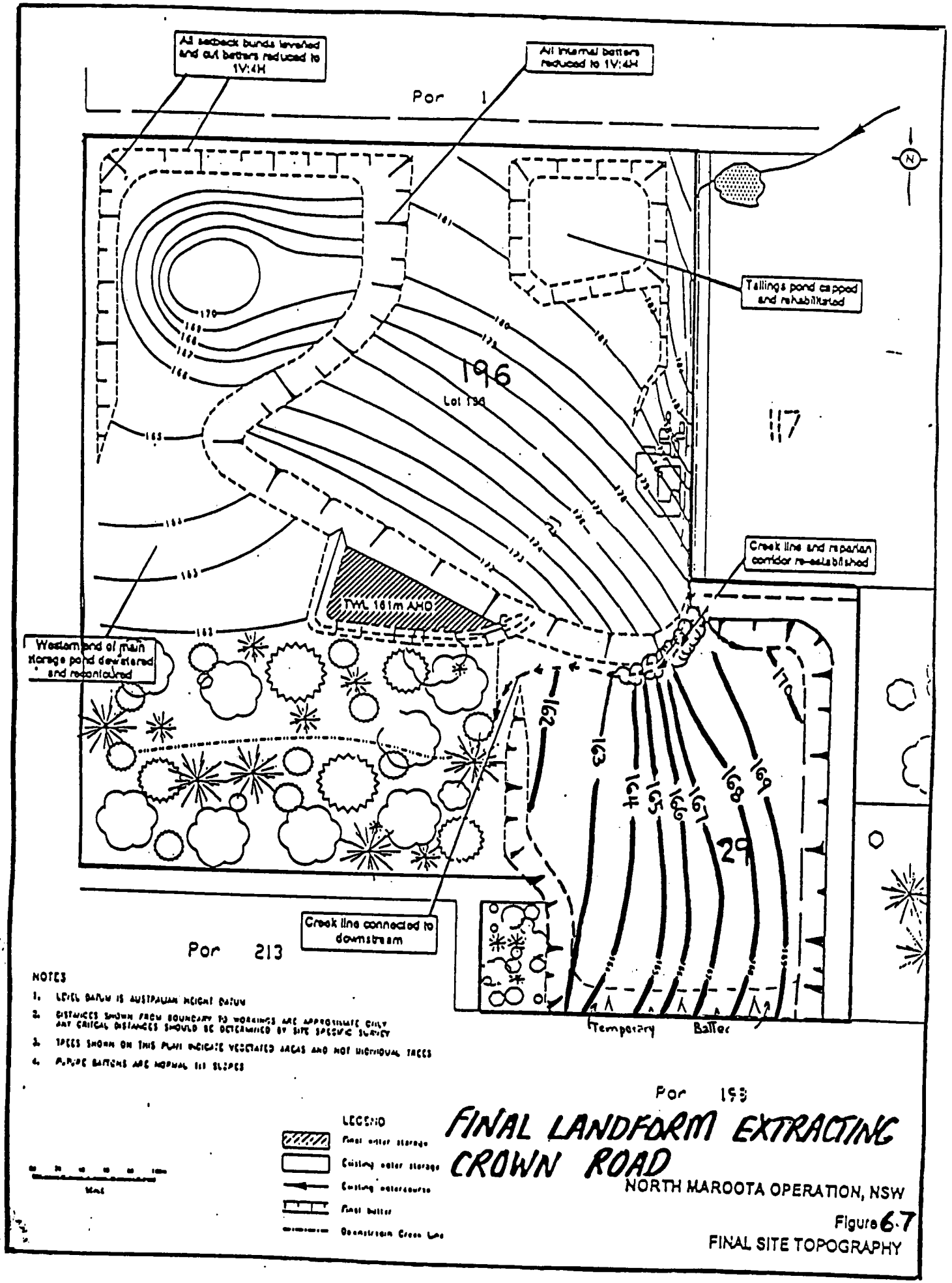
SCALE

LEGEND

- Final water storage
- Existing water storage
- Existing watercourse
- Final batter
- Downstream Creek Line

FINAL SITE REHABILITATION

FIGURE 6.6

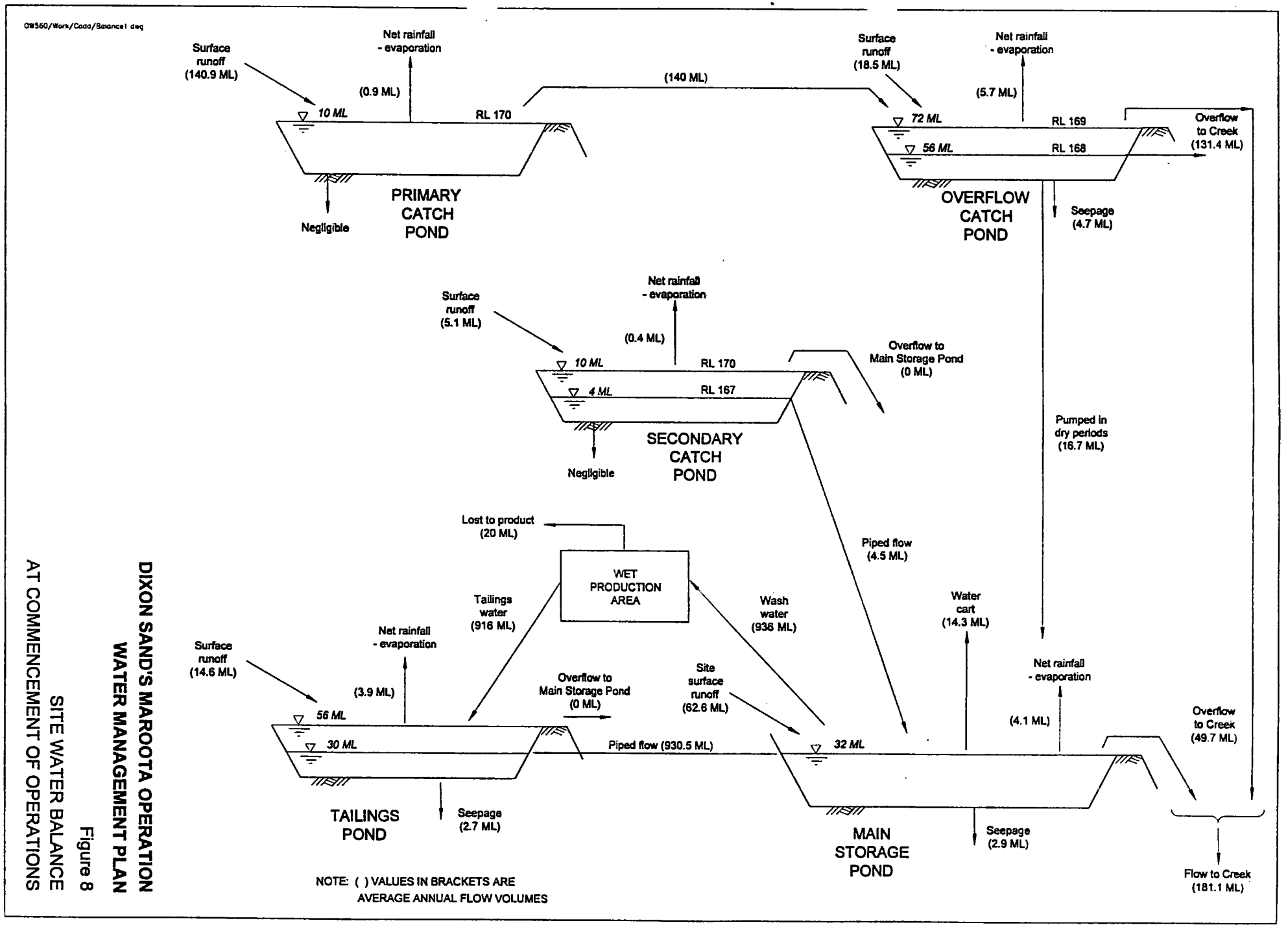


FINAL LANDFORM EXTRACTING CROWN ROAD

NORTH MAROOTA OPERATION, NSW

Figure 6.7

FINAL SITE TOPOGRAPHY



DIXON SAND'S MAROOTA OPERATION

WATER MANAGEMENT PLAN

Figure 8

SITE WATER BALANCE

AT COMMENCEMENT OF OPERATIONS

ANNEXURE C4 - A

EXTRACTS FROM
BAULKHAM HILLS SHIRE COUNCIL'S
DCP 500

2.4 WATER RESOURCES

Element Objective

- ***To conserve the integrity and quality of the ground water resources of the Shire;***
- ***To protect groundwater dependent and riparian ecosystems and natural habitats;***
- ***To conserve and effectively manage the sustainability of water supplies and resources of the Shire;***
- ***To protect downstream drainage patterns including location, quantity and quality of waters;***
- ***To protect ground water dependent ecosystems and natural habitats.***

Performance Criteria

- Proponents should employ operational practices capable of maintaining and monitoring drainage outlet points at downstream boundaries together with pre-existing groundwater flow and quality conditions;

  This should be demonstrated by way of submitting:-
  - A *Water Management Strategy* with each development application; and
  - An annual *Water Management Plan.*

- Proponents should determine the likely impact upon groundwater and nominate an effective freeboard above wet weather high ground water level capable of conserving water flow patterns and water quality on each extraction site.

  This may be demonstrated by way of submitting with each application a *Groundwater Impact Assessment Report.*

Prescriptive Measures

- The *Groundwater Impact Assessment Report* should:--
  - identify & classify aquifer systems;
  - identify all ground water dependent land uses & environments within catchment areas;
  - assess vulnerability of ground water;
  - identify freeboard level (to AHD) above high groundwater level capable of protecting groundwater flow patterns & water quality;
  - identify potential sources of impacts including seepage from tailing dams; and
  - outline procedures for monitoring ground water flow and quality;

- Extraction should not occur within 2m of the wet weather high groundwater level or otherwise to the requirements of the Department of Land & Water Conservation;

- Proponents should ensure that all bores and extraction operations which intercept the water table and/or require pumps meet the requirements of the Department of Land & Water Conservation;

- Proponents may be required to install groundwater monitoring bores as a condition of consent.

- Proponents should refer to Section 2.18 for further guidance on the preparation of an annual Water Management Plan;

- The Water Management Strategy should outline a framework for the identification, classification and management of artificial and natural surface and sub-surface water cycles.

  This framework should incorporate details for all phases of development including:-
  - site investigations used to identify and classify catchment origin, drainage patterns, water flow and water quality;
  - source, quantity and quality of water required to provide a reliable supply of water to the operations;
  - procedures for minimising importation of water;
  - procedures for maximising re-use and recycle of collected waters particularly during extreme climatic conditions;
  - procedures capable of maintaining natural surface water flow and quality conditions along downstream boundary alignments;
  - destination points for collected waters are retained within the extraction site;
  - the design, location and likely impact of any temporary diversion of drainage patterns within the extraction site;
  - procedures for ensuring that contaminated waters are contained on-site during the 1% AEP;
  - risks, safeguards and contingency plans for extreme climatic conditions or operational hazards including breach or contamination;
  - procedures for monitoring groundwater flow, quality and recharge areas within catchments having regard to the recommendations of the Groundwater Impact Assessment Report.

2.8 SOIL CONSERVATION.

Element Objective

- ***To minimise wind, water, & soil erosion of disturbed and rehabilitated areas***; and
- ***To implement and maintain effective sediment and erosion control measures for the protection of downstream properties and areas of environmental sensitivity.***

Performance Criteria

- Proponents should limit the extent of cleared areas at any one time by ensuring that soil surface conditions on extraction sites are protected & maintained by natural or manufactured material or mulch or by any other acceptable soil stabilisation technique;
- Proponents should ensure that drainage control measures are provided for up stream catchments from runoff may by pass the extraction site. They should also ensure infiltration into and control runoff from the subject site;
- Proponents should ensure the long term stability of natural channels downstream of the site by maintaining pre-existing rates, volumes and quality of channel flow. Protection measures may include controlled entry and exit points from sub-catchments;
- Sediment control dam designs should include details of the proposed dewatering method for the settling volume, spillway configuration, energy dissipation, and the design life of the structure;
- *Sediment & Erosion Control Plan* should be submited with each application and which indicates:-
  - site investigations used to determine areas most & least suited to extraction operations;
  - clearing, grading & drainage plans for the site layout;
  - procedures for installing & maintaining devices for all phases of extraction;
  - procedures for removal of the controls;
  - method of controlling water from the top through to and beyond the bottom of the site;
  - procedures for maintaining protective ground covers;
  - refer to *Sample Sediment & Erosion Control Plan*;

Prescriptive Measures

Clearing Control Measures:

- Proponents should install sediment and erosion control measures prior to clearing and during extraction and up to the rehabilitation of the site to the final landform;
- Proponents should ensure that the natural vegetation outside the extraction site is protected at all times by the installation & maintenance of sediment control devices;
- Proponents should ensure that progressive clearing is contained within the approved boundaries of the extraction area;
- Proponent should nominate a qualified supervisor responsible for soil conservation measures to the ensuring of the requirements of environmental standards including the Soil Conservation Act, 1938;
- Soil stripping, storing, and replacement methods should consider the following criteria:-
  - removal of tpsoil removed in two (2) parts by saving the organic layer first, being 100 - 300mm;
  - flat and low stockpiles no more than 3m high to ensure survival of organic material and aerobic organisms;
  - stockpiles kept free of traffic and away from drainage lines;
  - stockpiles stored for as brief a period as possible and no more than twelve (12) months at a time; and that
  - stockpiles created for each soil type and which should not be mixed;

Sediment Control Measures:

- Proponent should ensure that wind breaks including trees, shrubs and bund walls are of a height, length, orientation, location & permeability capable of reducing wind velocity across extraction areas, see Figure 5: *Windbreak Design Layouts*;

- Proponents should ensure that drainage control measures such as diversion channels or holding structures including graded banks, drains or dams are designed for a peak discharge of a 1 in 20 Annual Exceedence Probability (AEP) storm event with a minimum 1m flood freeboard margin;

- Proponents should ensure that sediment control dams are located downstream of wet screening plants and between tailing dams and downstream boundaries. These structures should have a sediment trapping capacity of at least half the volume of the largest tailing dam.

- Proponents should ensure that all sediment control dams are of sufficient capacity to retain no less than the equivalent volume of 10mm of runoff over the entire disturbed area it served.

  The settling volume should provide an active storage with a minimum depth of 0.6m. A sediment storage volume of at least half of this allowance should be provided below the settling volume in accordance with the '*Urban Erosion and Sediment Control, 1992*'.

- Proponents are to ensure that all batters of dams and detention basins have a preferred gradient of 4H:1V which should be stabilized by vegetation or other appropriate measure.

  Sediment loss should be controlled by the installation of up stream diversion channels, catch drains and sediment traps along the downstream toe of the embankment. These should be maintained until vegetation cover is achieved.

- Proponents should design overland flow paths & spillways to ensure that flood waters do not affect adjoining lands so that storm water runoff which exceeds the design capacity of all channels, watercourses & structures is provided for;

- Proponents should refer any excavation with an embankment height of 5m or more to the Dam Safety Committee;

Tailing (Sludge) Pond Measures:

- Proponents should design Tailing (sludge) ponds having regard to:-
  - site investigations including soil profiles, water table level, & in-situ materials;
  - site suitability, including topography, geotechnical, & meteorological conditions of the locality;
  - physical, mineral, & chemical properties of tailings;
  - stability of embankments including height, slope, nature, strength, materials & degree of compaction of foundations
  - potential seepage into groundwater including high pressure groundwater levels resulting from high water table levels within the embankment; and
  - potential seepage through embankments to surface water streams or overtopping from heavy storm events.

- Proponents should implement conventional or progressive techniques for constructing tailing dams including:-
  - permeable embankments to allow control of piezometric (groundwater) pressures while still filtering the tailings;
  - water ponds kept away from the edge of embankments to prevent excessive build up of piezometric (groundwater) pressures; and
  - controlled placement of tailings include keeping ponded water away from the outer embankment through maximized beaching;
  - deposition methods including the Sub-aerial deposition involving the discharge of tailings via discharge points for sorting & drying of tailings;
  - Centreline Construction, Co-disposal, Down stream or Upstream Construction methods should be considered with the advice of the Department of Mineral Resources and Dam Safety Committee;
  - Operation and maintenance procedures to minimize water loss and pollution should be included in the *Water Management Strategy* referred to in Section 2.4.

- Proponents should ensure that Tailing ponds are capped / closed with reference to:-
  - preventing leaching into ground & surface waters;
  - surface drainage and erosion control to prevent tailing laden waters leaving storage area;
  - stabilized surface cover to prevent wind erosion;
  - minimize maintenance by designing a cover which provides an effective infiltration rate that prevents surface erosion, saturation of topsoil layer & to function as a capillary barrier; and
  - refer to Figure 7: Typical covers of Tailing Ponds for other endorsed techniques.

- Proponents may be required to regularly certify the stability and operation of tailing systems in accordance with the development consent.

ANNEXURE C3 – B

RAINFALL
And EVAPORATION DATA
Source Bureau of Mererology

TABLEC3- B1
Rainfall Data for Glenorie (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1972	279	69	132	73	42	65	3	41	18	189	86	48	1,044
1973	74	288	37	14	26	39	90	64	27	133	117	46	956
1974	169	87	192	162	173	246	7	29	20	50	73	19	1,227
1975	19	103	101	62	21	198	132	22	56	145	32	22	913
1976	217	287	293	27	21	92	101	25	36	175	49	35	1,357
1977	125	164	171	7	158	114	2	21	46	14	33	51	906
1978	301	9	370	45	121	335	9	20	144	63	154	76	1,646
1979	77	27	98	17	99	113	10	8	37	19	33	11	550
1980	104	52	33	12	132	58	34	10	1	79	30	129	674
1981	120	187	16	128	138	27	35	9	4	184	166	44	1,058
1982	78	55	195	3	1	34	21	1	170	59	7	18	641
1983	14	52	140	57	112	50	13	11	53	111	27	116	756
1984	218	144	163	91	59	90	156	8	50	23	187	45	1,232
1985	11	21	42	185	107	95	42	23	72	164	85	58	905
1986	160	22	12	30	40	10	38	329	61	57	232	24	1,015
1987	45	57	153	52	71	45	35	308	12	196	116	67	1,157
1988	204	165	65	432	107	51	129	42	122	0	139	154	1,610
1989	103	44	158	301	115	156	18	32	10	21	46	64	1,068
1990	93	539	80	263	122	17	80	183	131	40	24	51	1,623
1991	51	59	27	11	41	222	59	1	6	10	39	183	708
1992	41	354	56	77	19	81	6	18	14	40	96	170	973
AVG	**119**	**133**	**121**	**98**	**82**	**102**	**49**	**57**	**52**	**84**	**84**	**68**	**1,049**

TABLE B2
Evaporation Data for Richmond (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1972	180	172	146	115	70	55	91	117	171	155	178	289	**1,738**
1973	253	114	146	122	92	61	54	87	151	162	183	229	**1,652**
1974	136	136	134	84	68	54	102	95	132	147	181	285	**1,552**
1975	262	176	130	96	79	61	70	95	107	137	196	195	**1,603**
1976	170	127	113	101	69	64	53	102	117	121	166	322	**1,523**
1977	250	159	138	120	71	64	76	98	104	186	199	285	**1,751**
1978	174	193	142	99	67	57	75	85	101	142	154	192	**1,479**
1979	233	213	131	122	66	44	69	88	136	178	192	317	**1,788**
1980	229	199	182	146	63	55	68	110	207	188	241	262	**1,950**
1981	182	129	160	92	61	64	69	114	129	175	144	205	**1,524**
1982	185	158	100	98	72	56	19	83	108	149	196	182	**1,407**
1983	219	160	159	84	55	42	48	66	123	118	169	168	**1,411**
1984	144	136	136	80	49	39	53	99	107	145	169	241	**1,397**
1985	245	147	152	103	67	49	62	82	98	116	152	201	**1,474**
1986	206	149	158	137	59	57	76	82	119	162	160	222	**1,586**
1987	217	173	138	87	63	41	60	29	123	128	164	170	**1,392**
1988	177	146	122	72	70	48	57	85	113	228	164	149	**1,429**
1989	145	145	101	61	40	44	47	81	131	185	142	181	**1,304**
1990	133	86	105	67	47	51	56	89	89	144	201	188	**1,257**
1991	208	174	168	129	54	51	55	126	148	183	192	182	**1,669**
1992	167	108	121	77	53	49	61	91	125	151	156	142	**1,301**
AVG	**196**	**152**	**137**	**100**	**64**	**53**	**63**	**91**	**126**	**157**	**176**	**219**	**1,533**

ANNEXURE C3 - C

HYDROLOGIC MODELLING

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C1. EVENT RAINFALL RUNOFF ROUTING MODELLING

C1.1 Introduction

The RORB hydrologic computer model has been utilized to determine the magnitude of stormwater runoff generated for various design storm events from the quarry and upstream catchments to the Dixon site at Maroota. The model converts storm rainfall to discharge hydrographs using a procedure known as runoff-routing.

Two models were set up to estimate the peak discharges and volumes of stormwater runoff entering both the Main Storage Pond and the Overflow Catch Pond for the 2, 10, 20 and 100 year ARI design storm events.

C1.2 Brief Review of RORB Modelling Approach

The RORB program assumes that the catchment comprises of a series of concentrated storages, which represent sub-catchments defined on watershed lines, plus concentrated special storages which represent dams and additional stream routing effects.

All storage components within the catchment are represented via the storage-discharge equation:

$$S = kQ^m \qquad (3.1)$$

where
- S = volume of storage
- Q = discharge
- k = a storage delay parameter
- m = a measure of the catchment's non-linearity. When m is set equal to unity the catchment's routing response is linear.

The storage parameter "k" within the general storage equation is modified to reflect the catchment storage and the reach storage as follows:

$$k = kc.kr \qquad (3.2)$$

where
- kc = an empirical coefficient applicable to the entire catchment and stream network
- kr = a dimensionless ratio called the relative delay time, applicable to an individual reach storage

RORB has been used extensively throughout Australia on a wide range of rural and urban catchments. Calibrated values for kc and m for a large number of regions have been developed and have been used to estimate flows on ungauged catchments.

C1.3 RORB Model Layouts

In order to determine the peak discharges and volumes of stormwater runoff entering the two main water storage facilities in the quarry two RORB catchment models were set up:

a) Inflows to the Overflow Catch Pond from the catchments to the east of the site (model denoted Overflow.mod).

b) Inflows to the Main Storage Pond generated by runoff from Lot 196 (model denoted Main.mod).

The sub-catchments within each model are presented in ***Table C1.1 – Model Sub-catchments***

TABLE C1.1
RORB
MODEL SUB-CATCHMENTS

RORB Model	Catchment Description	Catchment Area (ha)
Overflow.mod	North East Farmed	33.6
	Eastern Bushland	15.4
	Haul Road	0.6
	Northern Leg of Lot 29	2.7
	Primary Catch Pond	0.3
	Local Catchment	2.9
Main.mod	Site Office and Maintenance Area	0.7
	Wet Production Area	0.6
	Secondary Catch Pond	0.3
	Stockpile Area	1.0
	Rehabilitation Area	3.6
	Yellow Sand Extraction Area	4.8
	Local Catchment	1.8

C1.4 RORB Model Calibration

There were no historic flood data for storm rainfalls and flows in the tributaries adjacent to the site, thus a the procedure was adopted for the calibration of the RORB models involved a tuning process . This involved estimation of peak discharges at the outlet of the model by the Probabilistic Rational Method (PRM) for rural flood estimation as detailed in *Australian Rainfall and Runoff, Vol 1* (I E Aust, 1987), and then adjusting the parameters in the RORB model so as to produce the same peak discharge.

I. Model Parameters

The RORB model in its rural (undeveloped) state was calibrated to the 100 year ARI peak discharges obtained by the PRM. This was achieved by running various storm durations with the constant values of m, and CL and varying kc and IL to obtain correspondence with the PRM result.

There are four parameters of interest when running a RORB model :

I.	Routing parameter	m
II.	Lag parameter	kc
III.	Initial Loss	il
IV.	Continuing loss	cl

Routing parameter m

The parameter m is a measure of the catchment's non-linearity with a value of unity implying a linear catchment. A linear catchment is one where the peak discharge increases proportionately with the intensity of the rainfall producing the runoff. Most catchments behave in a non linear fashion with the discharge increasing at a greater rate. Non linear catchments have m values less than 1. For this analysis, an m value of 0.8 was used in conformity with recommendations in the RORB manual for flood estimation on ungauged catchments.

Lag parameter kc

The parameter kc, which is the principal parameter of the RORB model, provides a measure of the storage delay time within a catchment. Decreasing kc increases the peak discharge and decreases the catchment lag, while increasing kc has the opposite effect.

The value of kc is dependent on the catchment area, peak discharge and the parameter m. However, if m is fixed at 0.8, then kc becomes dependent only on the size of the catchment area.

For initial calibration purposes a value of kc was determined for the 30 minute storm duration by adopting constant values of m, IL and CL. This duration approximates the time of concentration associated with the PRM.

Initial and Continuing loss

The initial loss (IL) and continuing loss (CL) are other important parameters. Altering the value of these parameters will cause significant changes in the shape of the computed hydrograph peak.

For the purpose of initial calibration to the PRM result an IL of 10 mm and continuing loss of 2.5 mm/h were adopted in conjunction with the 30 minute storm

II. Calibration Results

The peak 100 year ARI discharges at the outlet of each of the models were:

- 9.7 m^3/s entering the Overflow Catch Pond
- 3.0 m^3/s entering the Main Storage Pond

When modeling the case of the quarry and its various ponds, it is also necessary to model longer duration storms which become critical because of the routing effects of the storages. The value of kc derived for the 30 minute storm was adopted and the IL's for the longer duration storms were varied to obtain correspondence with the PRM result. This is because in order to be consistent with the derivation of design rainfalls in ARR, the design initial loss should increase with increasing duration (see publication entitled *Empirical Analysis of Data to Derive Losses for Design Flood Estimation in South Eastern Australia* (Hill, 1996)). Therefore, for design, losses should be larger for longer duration storms and smaller for short duration design storms which are really bursts imbedded in larger duration rainfall, as

Two design storm events of 30 and 120 minutes duration were used in the calibration process. The results of the calibration process are given in ***Tables C1.2 - Derived AROB Parameters, Overflow Catch Pond Model*** and ***C1.3 - Derived AROB Parameters, Main Storage Pond Model***

TABLE C1.2
DERIVED RORB PARAMETERS
100 YEAR ARI CALIBRATION
OVERFLOW CATCH POND MODEL

Storm Duration	IL (mm)	CL (mm/hr)	kc	m
30	10	2.5	0.52	0.8
120	24	2.5	0.52	0.8

TABLE C1.3
DERIVED RORB PARAMETERS
100 YEAR ARI CALIBRATION
MAIN STORAGE POND MODEL

Storm Duration	IL (mm)	CL (mm/hr)	kc	m
30	10	2.5	0.2	0.8
120	25	2.5	0.2	0.8

C1.5 Design Storm Events

The parameters used to determine in the calibration process the RORB model was then used to determine the peak discharge and volumes of flow generated from the catchment for the 2, 10, 20 and 100 year ARI design storm events. The two main water storages were incorporated into the model. Sub-catchment characteristics were altered to represent current land-use practices such as quarried and rehabilitated areas.

The following assumptions were made when setting up the models.

1. That during a short duration design storm event, runoff generated by the Site Entrance Road and North-East Extraction Area would be captured by the Tailing Pond and not contribute to the peak discharge entering the Main Storage Pond..

2. Both the Primary and Secondary Catch Ponds would have negligible attenuating effects on peak flows for the range of storm events modelled. Runoff from the surface areas of both ponds however was incorporated in each model but the storage characteristics were omitted.

3. The water surface elevation within the Overflow Catch Pond is at RL 168 m AHD and the spillway to the pond is at RL 169 m AHD.

4. The water surface elevation within the Main Storage Pond at the onset of rain is at the invert of the low flow pipe outlet of RL 165.5 m AHD.

The results of the analysis are presented in ***Table C1.4 – Peak Discharge and Volumes of Stormwater Runoff.***

TABLE C1.4
PEAK DISCHARGE
AND
VOLUMES OF STORMWATER RUNOFF

Storage	Storm Event (ARI)	Peak Inflow (m^3/s)		Peak Outflow (m^3/s)		Volume of Inflow (ML)	
		30 min.	120 min.	30 min.	120 min.	30 min.	120 min.
Overflow Catch Pond	2	2.2	1.6	0	0	6.5	8.0
	10	5.0	4.3	0	0.4	12	18.5
	20	6.4	5.7	0	1.0	15	24
	100	9.7	9.7	0.82	2.3	22	36
Main Storage Pond	2	1.3	1.3	0.02	0.03	2.4	4.0
	10	2.2	2.2	0.02	0.5	3.7	6.4
	20	2.65	2.74	0.03	0.8	4.4	7.6
	100	3.5	3.5	0.6	1.4	5.9	10

C2. DAILY RAINFALL RUNOFF ROUTING MODELLING

C2.1 Introduction

A daily streamflow generation model was used to convert daily recorded rainfall into stream flows for input to a daily water quantity balance model. For this purpose the AWBM computer streamflow generation program was employed in the estimation of runoff from the various catchments both upstream and within the quarry site.

C2.2 Model Background

The AWBM is a catchment water balance model that can relate runoff to rainfall with daily or hourly data, and calculate losses from rainfall for flood hydrograph modelling. The structure of the model is shown in *Figure C1.*

The model uses three conceptual surface stores to simulate partial areas of runoff. The water balance of each surface store is calculated independently of the others. The model calculates the moisture balance of each partial area at either daily or hourly time steps. At each time step, t, rainfall is added to each of the three surface moisture stores and evapotranspiration is subtracted from each store. The water balance equation at time t+1 is:

$$store_{n,t+1} = store_{n,t} + rain_t - evapotranspiration_t$$

where n = 1 to 3

If the value of moisture in the store becomes negative, it is reset to zero. If the value of moisture in the store exceeds the capacity of the store, the moisture in excess of capacity becomes runoff and the store is reset to the capacity.

When runoff occurs from any store, part of the excess becomes recharge of the baseflow store if there is baseflow in the streamflow. The fraction of the runoff used to recharge the baseflow store is BFI * excess, where BFI is the baseflow index, ie the ratio of baseflow to total flow in the streamflow. The remainder of the excess, i.e. (1.0 - BFI) * excess, is surface runoff The baseflow store is depleted at the rate of (1.0 - K) * BS where BS is the current moisture in the baseflow store and K is the baseflow recession constant of the time step being used (daily hourly).

The surface runoff can be routed through a store if required to simulate the delay of surface runoff reaching the outlet of a medium to large catchment. The surface store acts in the same way as the baseflow store, and is depleted at the rate of (1.0 - KS) * SS, where SS is the current moisture in the surface runoff store and KS is the surface runoff recession constant of the time step being used.

The surface stores are assigned with a surface storage capacity value as well as partial areas. A preset pattern of partial areas and surface capacities are incorporated into the program such that a single value of average surface capacity can be disaggregated into a pattern of capacities and areas. The preset pattern for each surface store and the average storage capacity are given by:

Capacity of smallest store, C_1	= 0.5 x average capacity
Capacity of middle store, C_2	= 0.75 x average capacity
Capacity of largest store, C_3	= 1.5 x average capacity

For partial areas, the default values were employed and are shown below:

Partial area of smallest store, A_1	=	0.2
Partial area of middle store, A_2	=	0.4
Partial area of largest store, A_3	=	0.4

On small ephemeral catchments without base flow (assumed for this study), where runoff data are not available for calibration of the model parameters, it is recommended that the AWBM be used as a 1 parameter model by undertaking the following steps.

1. Set the baseflow index (BFI) = 0 so that all runoff is surface runoff.
2. Set the surface runoff recession coefficient (KS) = 0.
3. Use the preset pattern of disaggregation to determine the capacities and partial areas of the surface stores.
4. Vary the value of average surface storage capacity until the rainfall-runoff coefficient is equal to a pre-adopted value.

C2.3 Rainfall and Evaporation Data

The program requires the input of recorded daily rainfall as well as daily average evapotranspiration for each month. Tables of monthly rainfall and evaporation data used for the study are presented in Annexure B.

Daily rainfall data were obtained from the Bureau of Meteorology for Station 67010 (Glenorie, Old Northern Road) for the 21 year period from 1972 to 1992 which was adopted as the period of simulation.

Evaporation data from Station 67021 (Richmond UWS Hawkesbury) were adopted for the same period. Daily average evaporation in any one month was derived by summing the total evapotranspiration for the month and then divided by the number of days in that month.

C2.4 Model Calibration and Results

Calibration of the model involves varying the average surface storage capacity (in mm) until an appropriate average annual rainfall-runoff coefficient is achieved. The adoption of an appropriate rainfall runoff coefficient is dependent on catchment characteristics eg land-use and topography.

To determine an appropriate rainfall-runoff coefficient for the upstream rural and bushland catchments an analysis was undertaken of four streamflow gauging stations, details of which are given in ***Table C2.1 – Runoff Characteristics at Gauging Stations.*** Streamflows recorded at each station over a duration ranging between 2 and 10 years were converted to a depth of runoff from each catchment and compared to recorded rainfall for the same period. From ***Table C2.1*** the rainfall-runoff coefficients for the four gauges vary from between 0.19 to 0.3.

TABLE C2.1
RUNOFF CHARACTERISTICS AT GAUGING STATIONS

Station Name	Station No.	Area (km^2)	Average Annual Rainfall/Runoff Co-efficient
Second Ponds Creek	212051	7.8	0.30
First Ponds Creek	212052	9.8	0.19
South Creek	212048	250.5	0.24
Ropes Creek	212049	41.5	0.28

Given the nature of the catchments controlled by the gauges ie largely rural farmland, it was deemed appropriate to adopt a value for tuning the Maroota catchments which fell in the range given above. For the purpose of modelling streamflows a value of 25% was adopted for the upstream catchments.

Within the quarry, most of Lot 196 and Lot 29 have been disturbed. Areas within the quarry consist of exposed Maroota Sandstone or are works areas. For the purpose of modelling these areas were classed as impervious surfaces and a rainfall-runoff coefficient of 60% was adopted which would take into account some losses due to depression storage.

In the 4 ha area currently being rehabilitated a runoff coefficient of 25% was adopted as for the upstream catchments.

The adopted average surface storage capacities and the resultant annual runoff are given in ***Table C2.2 – Results of AWBM Calibration.***

TABLE C2.2
RESULTS OF AWBM CALIBRATION

	Upstream Catchments and Rehabilitation Area	Disturbed Quarry Areas
Average Annual Rainfall (mm/year)	1049	1049
Adopted Rainfall-Runoff Coefficients	25%	60%
Average Surface Storage Capacities (mm)	60	5
AWBM Runoff Coefficient	25%	60.9%
Calculated Average Annual Runoff (mm/year)	263.2	638.8

The calculated daily runoff for each catchment was then used as input to the IQQM computer model to simulate the water balance within the water storages located within the site.

The calculated daily depth of runoff generated by the model was converted to a volume of runoff by multiplying each value by the corresponding catchment areas. ***Table C2.3 - VOLUME OF SURFACE WATER RUNOFF*** gives the average annual volumes of surface water runoff generated by each catchment over the 21 years of historic record analysed.

AWBM results indicate that the average annual depth of runoff for the two types of land-uses ie farmland, bushland and rehabilitated land versus disturbed quarry surfaces, contributing flows to the storage ponds are 263.2 mm and 638.8 mm respectively. The quarry is therefore generating an additional 375.6 mm of runoff per unit area of catchment each year than would occur if the catchment was in its natural state. The average annual volume of runoff which could therefore be expected to have been generated by the catchment prior to the commencement of quarrying is around 185 ML. The quarry has therefore increased catchment yield by approximately 30% or around 57 ML per year on average.

TABLE C2.3
VOLUME OF SURFACE WATER RUNOFF

Facility	Catchment Description	Catchment Area (ha)	Average Annual Volume (ML)
Primary Catch Pond	North East Farmed	33.6	88.4
	Eastern Bushland	15.4	40.5
	Haul Road	0.6	3.8
	Northern Leg of Lot 29	2.7	7.1
	Local Catchment	0.2	1.0
Secondary Catch Pond	Local Catchment	0.2	1.3
	Wet Production Area	0.6	3.8
Overflow Catch Pond	Local Catchment	2.9	18.5
Tailings Pond	Site Entrance Road	0.6	3.8
	North East Extraction Area	1.4	8.9
	Local Catchment	0.3	1.9
Sediment Basin No. 1	Site Office and Maintenance Area	0.7	4.5
	Stockpile Area	1.0	6.4
Sediment Basin No. 2	Rehabilitation Area	3.6	9.5
Sediment Basin No. 3	Yellow Sand Extraction Area	4.8	30.7
Main Storage Pond	Local Catchment	1.8	11.5

C3. DAILY WATER BALANCE SIMULATION MODELLING

C3.1 Introduction

A daily water balance simulation model was used to monitor the fluctuation in the various water storages within the quarry. For this purpose the Integrated Quantity-Quality Model (IQQM) developed by the Department of Land & Water Conservation (DLWC) was used.

C3.2 Model Background

IQQM is a generalised hydrologic simulation package which is capable of application to regulated and unregulated streams, and is designed to be capable of addressing water quantity and quality as well as environmental issues. IQQM is structured as a modelling shell with component modules linking together to form an integrated package. The main components of IQQM are:

- User interface shell,
- In-stream water quantity,
- In-stream water quality,
- Rainfall-runoff,
- Pollutant wash-off and export,
- Groundwater quantity and quality,
- Statistical tools,
- Climate data tools.

The IQQM model has been widely used by the DLWC to model several large river systems in NSW. Due to round-off in the model code a revised version of the model was purchased by LMCE to allow for the fluctuation in the smaller storages to be computed.

The Maroota study involved using only the water quantity shell incorporated in IQQM. The AWBM model was used in preference to the rainfall-runoff generator supplied with the IQQM package. AWBM requires fewer calibrating parameters and was considered more appropriate for small catchments.

The in-stream water quantity module simulates the movement of water through the stream system by representing the stream system by a series of nodes connected by links. The major processes that are simulated include:

- Flow routing in rivers, effluent systems and irrigation channels,
- Reservoir operation,
- Resource assessment,

- Irrigation,
- Urban water supply and other consumptive uses,
- Wetland and environmental flow requirements

C3.3 Existing Site Water Balance

C3.3.1 Model Setup

A daily water balance model is needed to simulate all of the water management practices currently being undertaken within the quarry. Using a series of links and nodes the model was set up to include all of the site water storages, which form an integral part of the site water management system. Inputs to the system and outputs were then added to model which included:

I. Surface water inflows.

II. Rainfall on and evaporation from open water surfaces.

III. Wash water requirements.

IV. Water lost to product.

V. Seepage from water storages

VI. Dust suppression.

VII. Management of water storages ie the pumping of water from the Overflow Catch Pond to maintain levels within the Main Storage Pond.

Figure C2 is a schematic of the model showing the branches and nodes used in the model as well as inputs and outputs.

Surface water inflows to each storage were calculated using daily depths of flow per hectare generated by the AWBM for the two types of land-use. A multiplier was applied to these values within the program to obtain volumes of surface runoff from each sub-catchment.

Historic rainfall and evaporation data for 21 years of record (1972 to 1992) from Glenorie and Richmond respectively were used to account for direct rainfall on and evaporation from each of the water storages.

As outlined in *Section 3.2* of the EIS, water is pumped to the washing plant from the Main Storage Pond on average 10 hours a week. The pump unit has a volumetric pump rate of around 6000 L/min leading to around 0.72 ML of water being pumped from the pond each day.

When washed, the sand is stockpiled with a moisture content of around 8-10% by weight. The length of time the sand is stockpiled determines the moisture content of the sand prior to its being trucked from the site. Typically sand sold to the market contains around 5% water by weight with the reduction in incoming moisture due to evaporation from the stockpiles. In-situ sand has a moisture content of around 2-3%, indicating that up to 8% of water by weight of wash water is lost to product. Given that around 62,500 tonnes of sand is washed per year then it could be expected that around 5 ML of water per year is lost due to the washing process.

Seepage from the water storages within the site was taken into account by extracting 1mm/m^2/day.
Dust suppression on the site is undertaken using a water cart. The use of the cart on any one day is dependent on the amount of rainfall experienced at the site. A decision rule was adopted whereby:

- if more than 10 mm fell in a day the cart was not used, or
- if more than 30 mm fell in three consecutive days the cart was not used on the third day.

When required, the frequency of the cart usage was varied between 4 times a day in summer and 2 times a day in the winter months, leading to 0.06 ML/d extracted in summer and 0.03 ML/d in winter.

A water management practice undertaken on site until the date of closure in December 1998 was to pump water from the Overflow Catch Pond to the Main Storage Pond when water levels drop to too low a level. The decision adopted for modeling purposes was that should the water level in the Main Storage Pond drop to a level of RL 164 m AHD (a height of 1.5 m below the invert of the low flow outlet pipe) 2 ML of water is pumped from the Overflow Catch Pond to the Main Storage Pond the next day. This allows for a minimum storage of 20 ML to be maintained within the Main Storage Pond while water is available in the Overflow Catch Pond.

Currently there is no low flow outlet pipe within the Overflow Catch Pond. Water therefore will pond until it can escape via the spillway located at the southern end of the pond. The spillway is set around RL 169 m AHD, providing a total water storage of around 72 ML.

C3.3.2 Model Results

The results of the daily water balance simulation modelling for the existing site and water management practices are presented in ***Table C3.1 – Annual Site Water Balance – Existing Conditions***. ***Figure C3*** shows the fluctuation in water surface elevation in the Overflow Catch Pond and Main Storage Pond.

From the analysis it can be seen that on an average annual basis around 195 ML of water will discharge from the site and enter the bushland creek. Although the quarry is generating around 30% more runoff than would occur under pre-quarry conditions, the operation of the quarry and the presence of the water storages leads to a volume of flow entering the creek similar to that which would occur under pre-quarry conditions of 185 ML.

Table C3.1
Annual Site Water Balance – Existing Conditions
(all values in ML)

Storage	Precipitation Statistic	Inflow	Water Pumped to Main Storage Pond	Pumped to Processing Plant	Outflow to Creek
Overflow Catch Pond	Average	159	8	-	138
	Dry Year	25	20	-	0
	Median Year	168	8	-	148
	Wet Year	321	0	-	318
Main Storage Pond	Average	266	-	188	57
	Dry Year	227	-	188	3
	Median Year	265	-	188	57
	Wet Year	335	-	188	130

Note: The apparently anomalous figure for inflow to the Main Storage Pond includes all water recycled from the processing plant and Tailings Pond.

C3.4 Future Site Water Balance

Two models were set up to analyse the fluctuation of the various water storages under future site conditions. They were:

I. Upon commencement of operations, and

II. nearing the end of Operations.

The two major differences between the two models, ie for the existing site conditions and for the conditions at the end of extraction and rehabilitation are:

I. Upon commencement of operations the rate of production of washed sand will increase and the outlet arrangement to the Overflow Catch Pond will be altered.

II. Nearing completion of operations the majority of Lot 196 will be rehabilitated while the size of the Main Storage Pond will be increased.

C3.4.1 Model Setup

I Commencement of Operations

Upon commencement of operations the rate of production of washed sand will increase from 62,500 tonne/year to around 250,000 tonne/year. The plant will be in operation 10 hours per day for up to 6 days per week. The quantity of water pumped to the processing plant and the subsequent loss of water to product will also increase.

As mentioned previously the pump unit has a volumetric pump rate of around 6000 L/min leading to around 3.6 ML of water being pumped from the Main Storage Pond each day. Given the percentages of water lost to product mention previously, it is expected that approximately 20 ML of water per year is lost due to the washing process.

As outlined in *Section 4.3.3* of the EIS, the outlet arrangement to the Overflow Catch Pond is to be altered to provide for the discharge of low flows from the upstream catchments when the pond is full. A 100 mm diameter outlet pipe is to be placed within the western embankment of the Overflow Catch Pond with an upstream invert level of 168 m AHD. This will provide a standing water level within the pond at this level and provide a 2 m freeboard to the top of the western earthen embankment.

All other inputs and outputs listed in ***Section C3.3.1 a) to g),*** including catchment characteristics were the same.

II Nearing Completion of Operations

Nearing completion of operations the Main Storage Pond will have been enlarged as a result of quarrying operations. The pond will have an approximate surface area of 22,000 m^2, a depth of around 4 to 5 m and a volume of water storage of between 88 and 110 ML.

At this time the majority of Lot 196 will be rehabilitated leading to a reduction in the annual volume of runoff.

Both of the above alterations to the site layout were incorporated in to the IQQM model to ensure that sufficient water is available for production until the completion of quarrying operations.

C3.4.2 Model Results

I Commencement of Operations

The results of the daily water balance modelling for the site upon commencement of operations are presented in **Table C3.2 – Annual Site Water Balance – Commencement of Operations.** ***Figure C4*** shows the fluctuation in water surface elevation in the Overflow Catch Pond and Main Storage Pond.

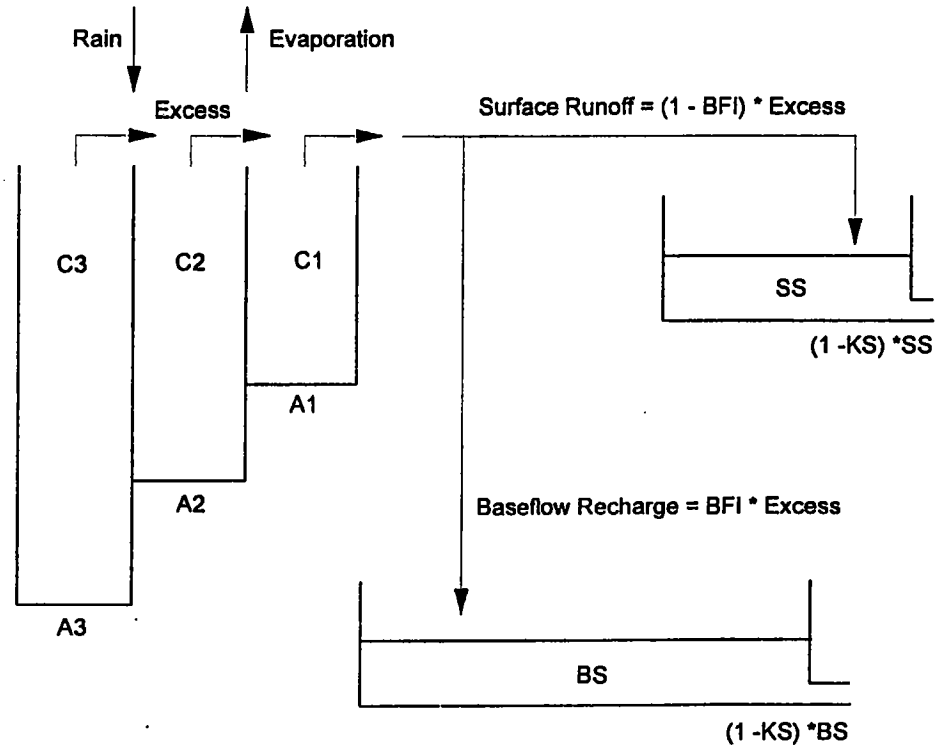
From ***Table C3.2*** it can be seen that in an average rainfall year the total outflow from the site (site runoff and runoff from upstream, catchments) is 23 ML greater than the inflow to the site from upstream catchments. In a dry year, however, total site discharge will be less than the inflow.

Results of the analysis show that there is sufficient storage within the site to maintain the increase production rate of wash sand. Although more water is pumped to supplement the Main Storage Pond the inclusion of the low flow pipe in the Overflow Catch Pond, allowing for a lesser volume of water to be stored, leads to a similar through flow which occurs under existing conditions. In an average rainfall year the total volume of flow entering the downstream creek from both storages is only slightly less than would occur under natural conditions.

TABLE C3.2
Annual Site Water Balance – Commencement of Operations
(all values in ML)

Storage	Precipitation Statistic	Inflow	Water Pumped to Main Storage Pond	Pumped to Processing Plant	Outflow to Creek
Overflow Catch Pond	Average Annual	159	17	-	131
	Dry Year	25	28	-	0
	Median Year	168	16	-	140
	Wet Year	321	2	-	316
Main Storage Pond	Average Annual	1012	-	941	50
	Dry Year	974	-	941	3
	Median Year	1009	-	941	48
	Wet Year	1076	-	941	116

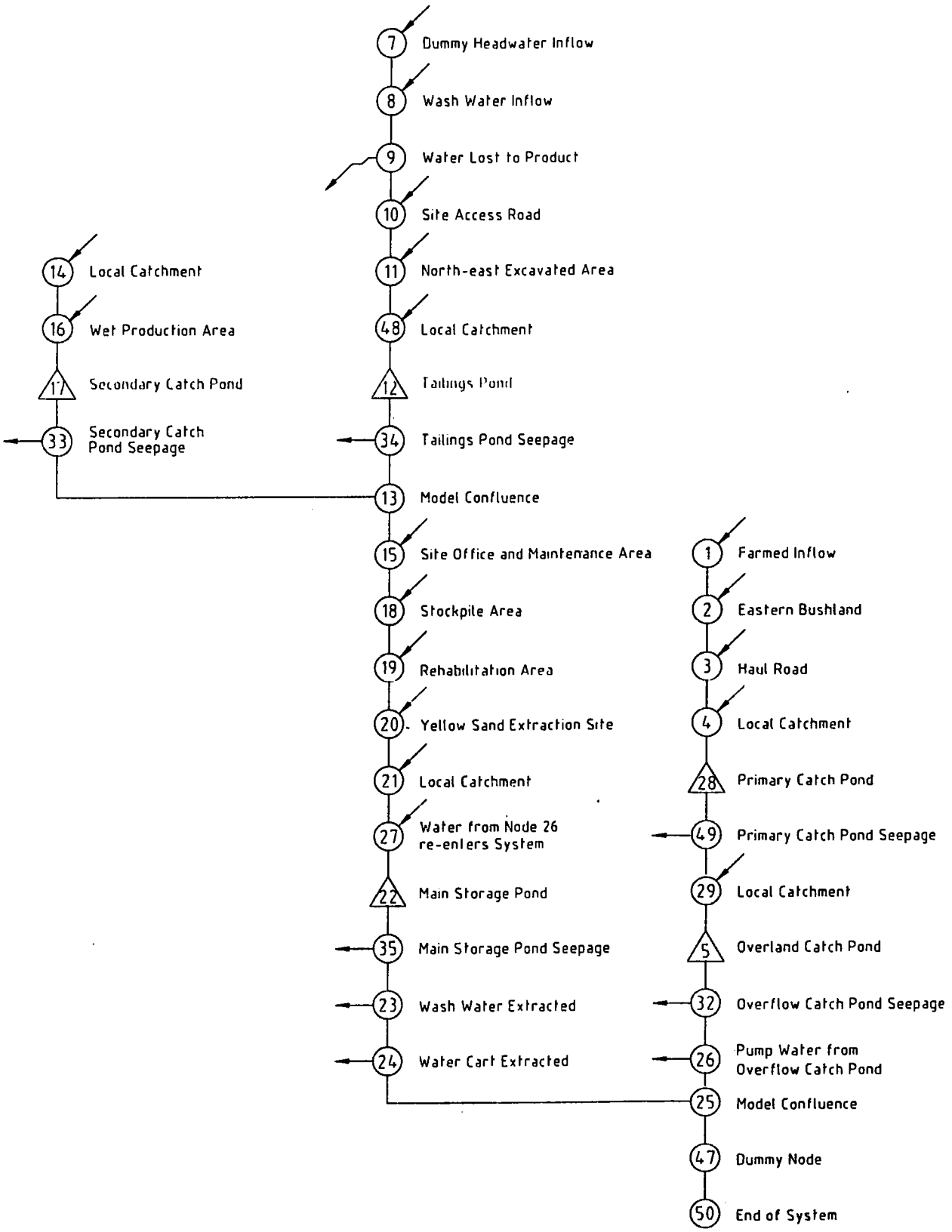
Note: the apparently anomalous figure for inflow to the Main Storage Pond includes all water recycled from the processing plant and Tailings Pond.



DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure C1

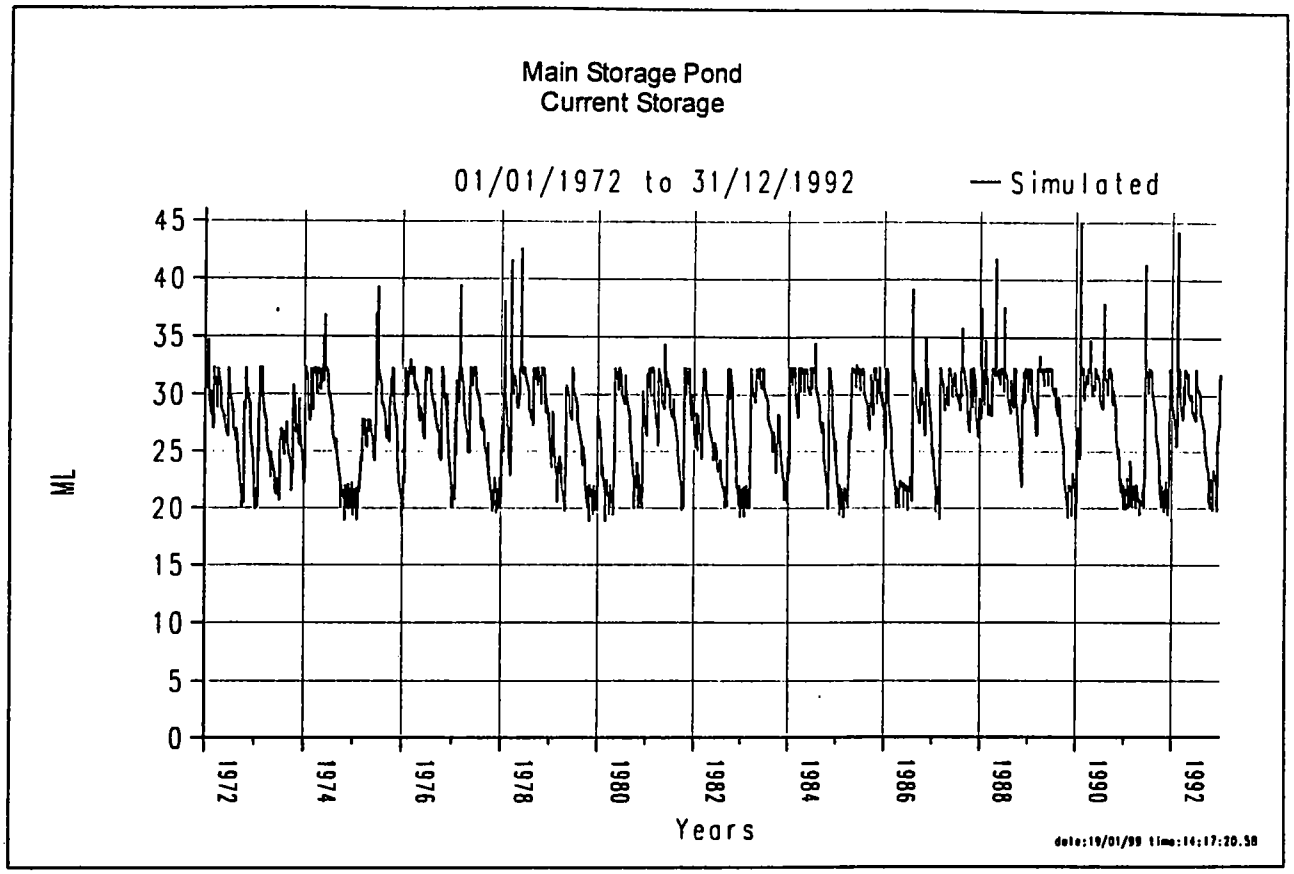
STRUCTURE OF THE AWBM

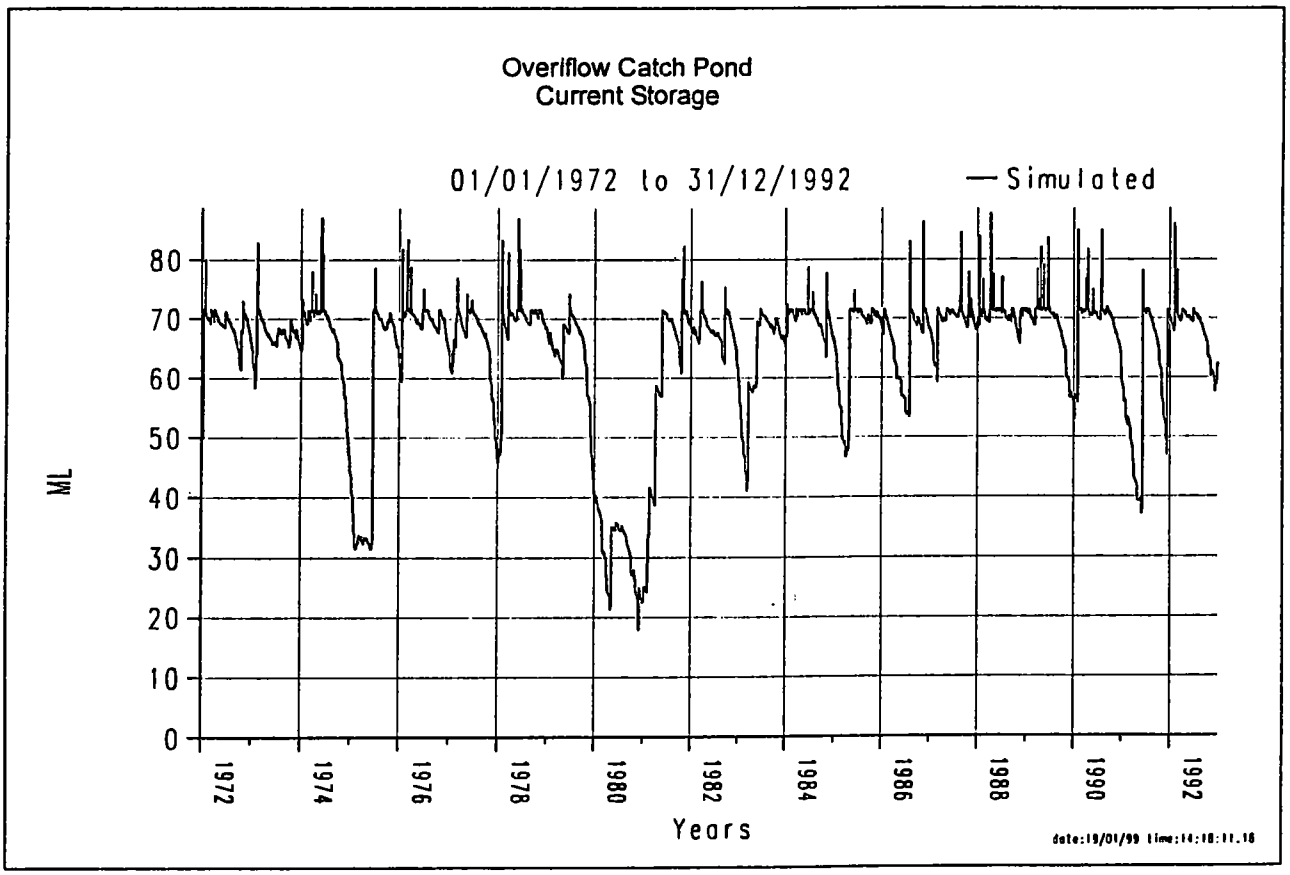


DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure C2

IQQM MODEL SCHEMATIC LAYOUT

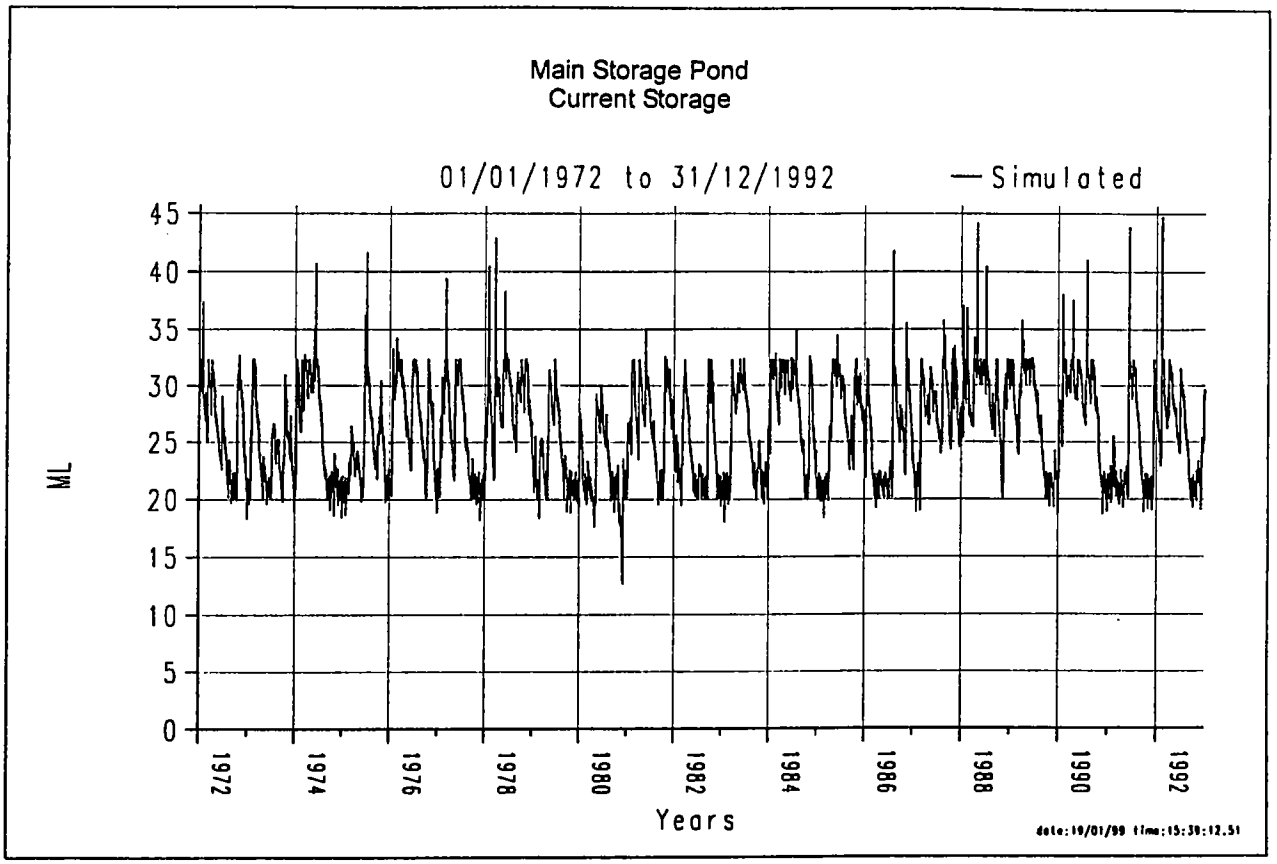


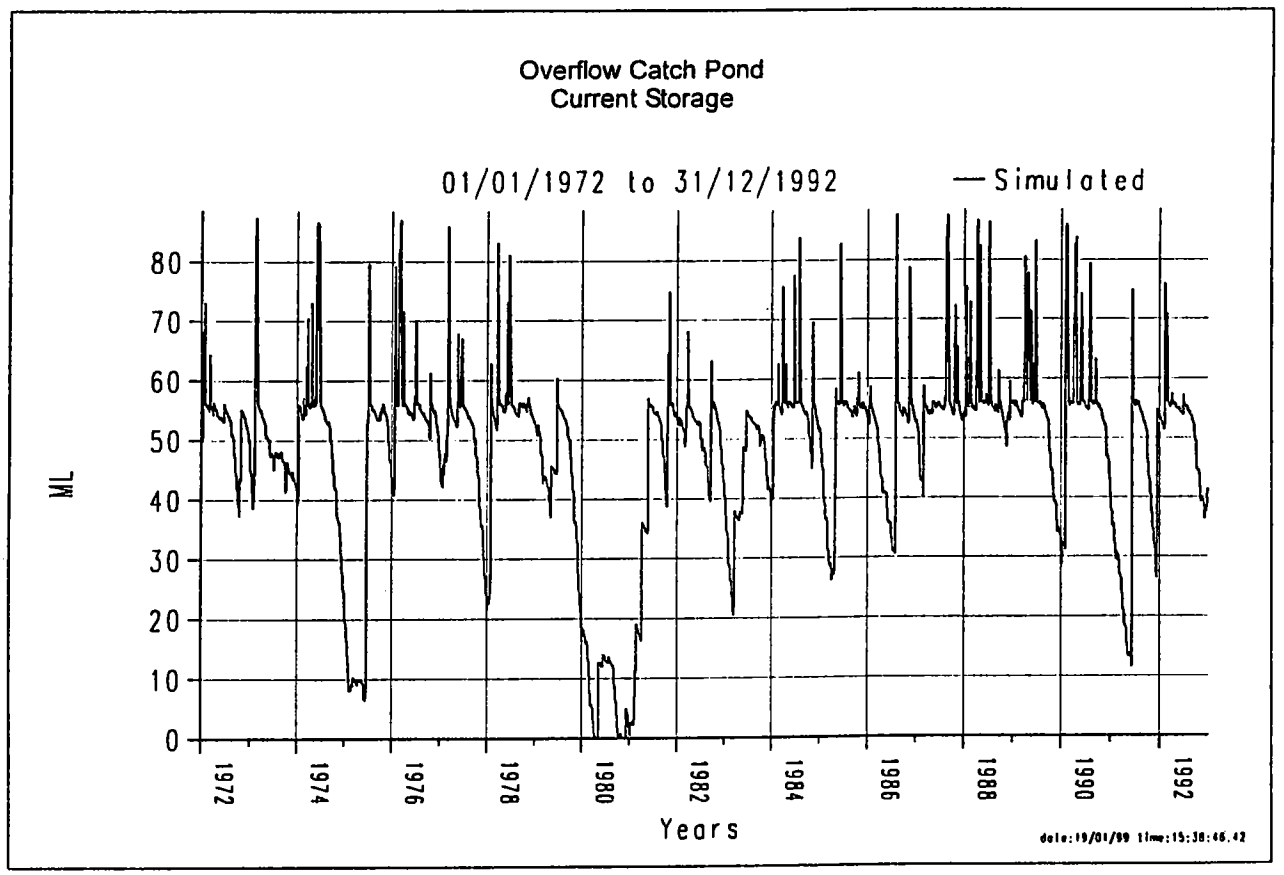


DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure C3

POND BEHAVIOUR
EXISTING CONDITIONS

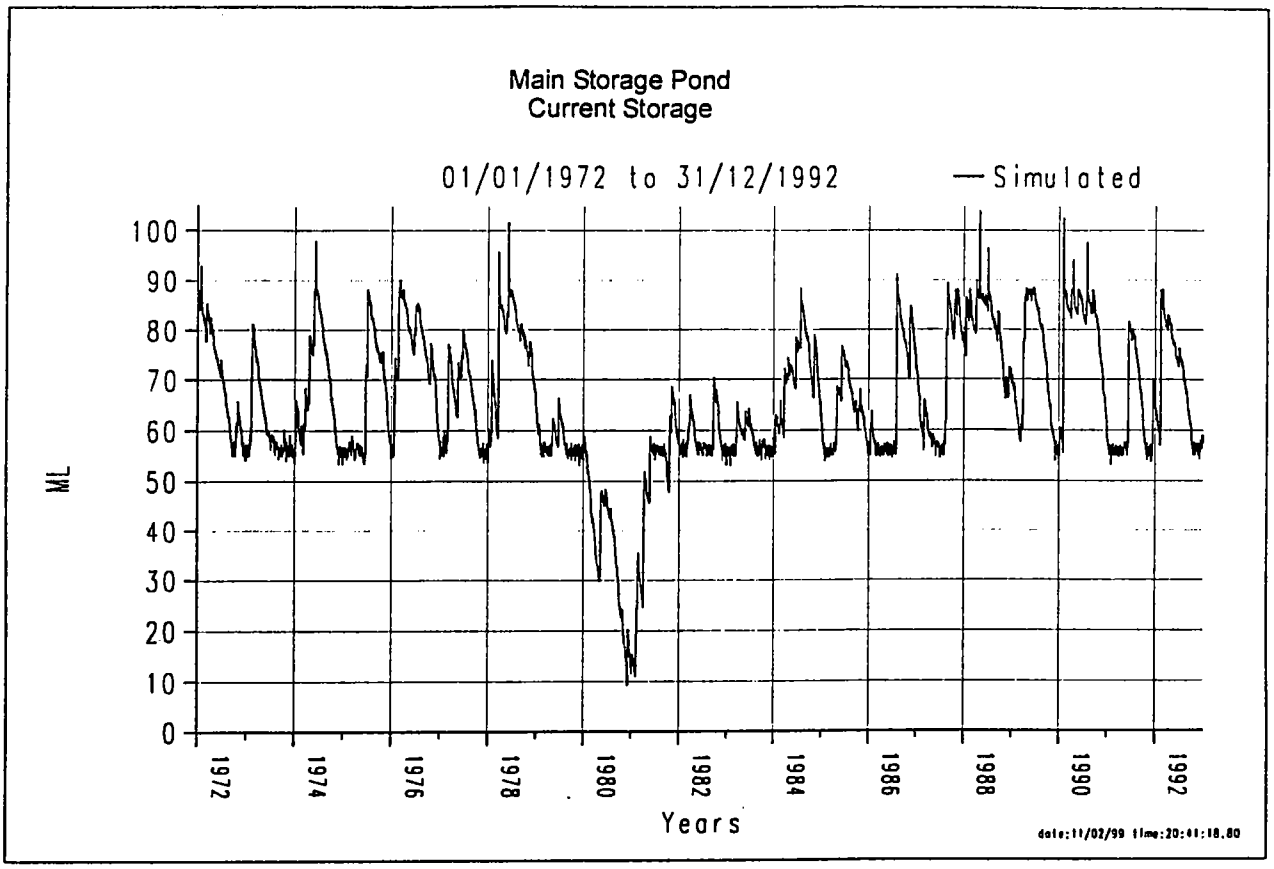


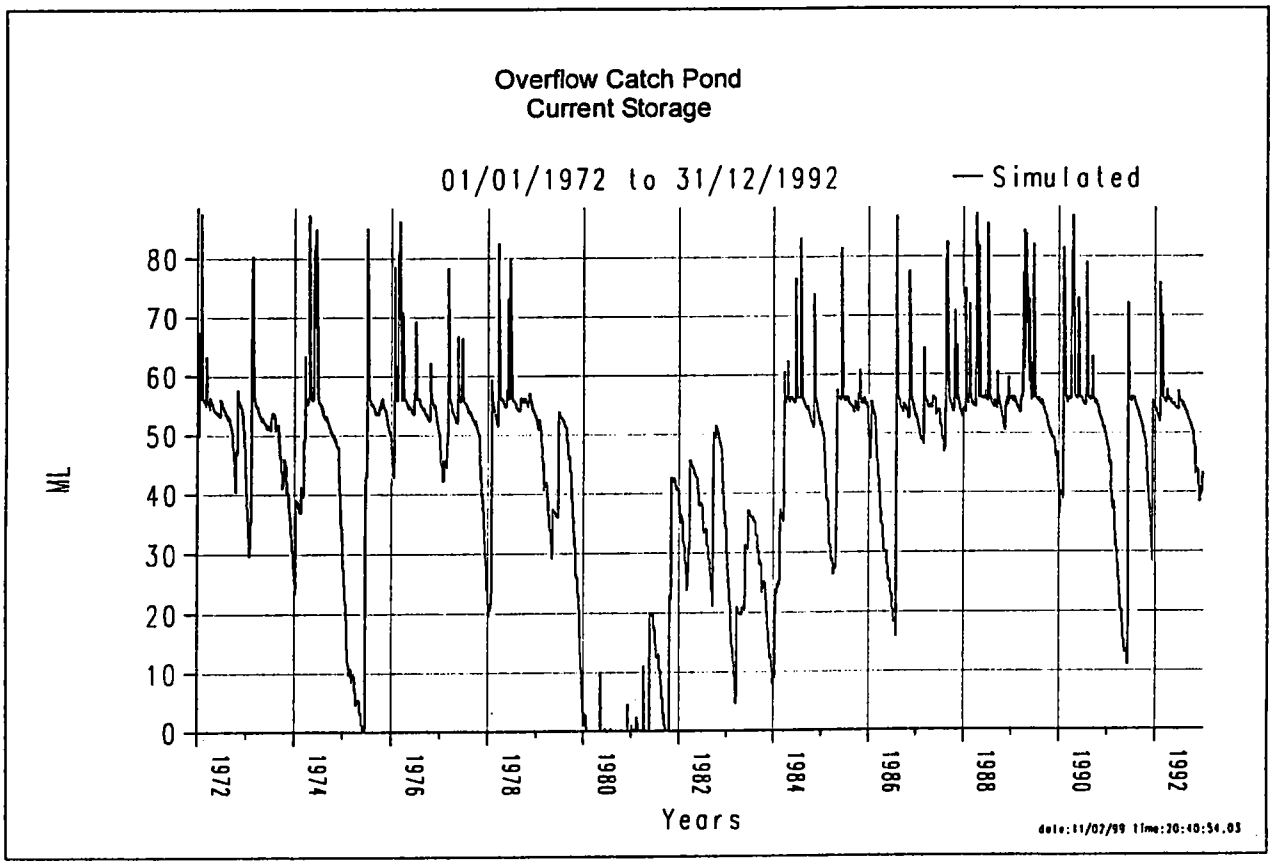


DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure C4

POND BEHAVIOUR
AT COMMENCEMENT OF OPERATIONS





DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure C5

POND BEHAVIOUR
NEARING COMPLETION OF OPERATIONS

ANNEXURE C3 - D

SEDIMENT AND EROSION CONTROL

DESIGN REQUIREMENTS

TABLE OF CONTENTS

LIST OF FIGURES

D1. SEDIMENT AND EROSION CONTROL

D1.1 Introduction

Detailed in this Annexure are the procedures for the sizing of erosion and sediment control measures such as:

- sedimentation basins,
- contour banks and
- diversion channels.

These procedures for the sizing of the various measures are in accordance with the manual *Managing Urban Stormwater: Soils and Construction* (Department of Housing, 1998) and several drawings from the manual have been reproduced (See ***Figure D1)***.

Table D1 – Design Average Recurrence Intervals for Erosion and Sediment Control Measures gives the design average recurrence intervals for the various measures to be used in sizing calculations.

TABLE D1
DESIGN AVERAGE RECURRENCE INTERVALS
FOR EROSION AND SEDIMENT CONTROL MEASURES

Control Measure	Design ARI (years)
Diversion Bank	20
Level Spreader	20
Waterway	20
Sediment Basin Primary Outlet	5
Sediment Basin Emergency Outlet	20
Sediment Trap	5
Outlet Protection	20
Grade Stabilisation Structure	20
Waterway Diversion	20

D1.2 Contour Banking and Diversion Drain Sizing

Standard curves have been produced to allow for the sizing of both contour banking and diversion drains based on the required design discharge. The steps that should be undertaken are as follows:

1. Determine the ARI of stormwater discharge required to configure the various components of the basin (see ***Table D1***).
2. Estimate discharges for the design ARI. A different method is to be adopted for estimating runoff from either rehabilitation areas (use **Standard Sheet 1**) and disturbed areas (use **Standards Sheet 2**).
3. Enter either **Figure D2** or **Figure D3** with the design discharge and read off the appropriate height of bank or depth of channel.

Typical drawings have been provided at the end of this annexure on the construction of both contour banking and diversion drains. Further design criteria has been provided in the Sediment and Erosion Control Plan (see Section 4.3 of main document).

D1.3 Sediment Basin Sizing

Detailed in this section are procedures for the sizing of sedimentation basins within the quarry site for the treatment of runoff from both rehabilitating and disturbed areas. The following steps should be undertaken to determine the size of key elements in the design of the basins.

1. Determine the ARI of stormwater discharge required to configure the various components of the basin (see Table D1).
2. Estimate discharges for the various ARI's. A different method is to be adopted for estimating runoff from either rehabilitation areas (use **Standard Sheet 1**) and disturbed areas (use **Standards Sheet 2**).
3. Size basin according to procedures outlined in **Standard Sheet 3**.

Typical drawings have been provided at the end of this annexure on the construction of sedimentation basins. Further design criteria has been provided in the Sediment and Erosion Control Plan (see Section 4.3 of main document).

D1.4 Standard Worksheets and Drawings

Standard worksheets have been produced to allow for the sizing of sedimentation basins within the site. The following sheets have been put together following guidelines set out in Appendix I of the manual *Managing Urban Stormwater: Soils and Construction* (Department of Housing, 1998).

Standard Sheet 1
Storm Flow Calculations – Rehabilitation Areas

Peak flow or discharge is given by the Rational Formula:

$$Q_Y = 0.00278.C_{10}.F_y.I_{y,tc}.A \ldots\ldots \text{(Eqn. D1)}$$

where:

Q_Y is peak flow rate (m^3/sec) of average recurrence interval (ARI) of "Y" years

C_{10} is the runoff coefficient (dimensionless) for ARI of 10 years
= 0.50 for Maroota *(Volume 2 of ARR, 1987)*

F_y is a frequency factor for "Y" years
= given in Table below

A is the area of catchment in hectares (ha)

$I_{y,tc}$ is the average rainfall intensity (mm/hr) for an ARI of "Y" years and a design duration of "t_c" (minutes)
= see Table D1 - Intensity Frequency Data

Calculation of t_c

Catchment area A = (ha)

Time of Concentration (t_c) $= 0.76 \times (A/100)^{0.38}$

$= 0.76 \times (\quad /100)^{0.38}$

= _____ hours

= _____ minutes

Peak Flow Calculations

Enter values into **Eqn. D1** to obtain peak flow from catchment for each ARI.

ARI storm event	Storm intensity (mm/hr)	Frequency factor (F_y)	Peak flow (m^3/s)
1 yr,t		0.72	
5 yr,t		0.88	
20 yr,t		1.12	

Standard Sheet 2
Storm Flow Calculations – Disturbed Areas

Peak flow or discharge is given by the Rational Formula:

$$Q_Y = 0.00278.C_y.I_{y,tc}.A \text{.....(Eqn. D2)}$$

where: Q_Y is peak flow rate (m^3/sec) of average recurrence interval (ARI) of "Y" years

C_y is the runoff coefficient (dimensionless) for an ARI of "Y" years and is constant assuming a 100% impervious surface.
= given in Table below

A is the area of catchment in hectares (ha)

$I_{y,tc}$ is the average rainfall intensity (mm/hr) for an ARI of "Y" years and a design duration of "t_c" (minutes)
= see Intensity Frequency Table

Calculation of t_c

For catchments with impervious surfaces the recommened relation for time for overland flow is the "kinematic wave" equation (Ragan and Duru, 1972),

$$t = 6.94\ (L.n^*)^{0.6}/I^{0.4}.S^{0.4} \text{.....(Eqn. D3)}$$

where ***t*** is overland flow time (minutes),
L is flow path length (m),
n* is a surface roughness or retardance factor,
L is rainfall intensity,
S is slope (m/m).

To obtain ***t*** the following steps need to be followed:

1. Estimate overland flow path length (***L*** in m) and slope (***S*** in m/m),
2. Adopt value of 0.02 for ***n****,
3. Calculate value of $t.I^{0.4}$ by the following equation:

$$t.I^{0.4} = 6.94\ (L.n^*)^{0.6}/S^{0.4} \text{.....(Eqn. D4)}$$

4. For each ARI storm analysed enter **Table D2** with $t.I^{0.4}$ and read off representative storm duration ***t*** adjacenct to value.

5. Enter **Table D1** and read off storm intensity for each ARI analysed.

Peak Flow Calculations

Enter values into **Eqn. D2** to obtain peak flow from catchment for each ARI.

ARI storm event	Storm intensity (mm/hr)	Runoff Coefficient (C_y)	Peak flow (m^3/s)
1 yr,t		0.72	
5 yr,t		0.86	
20 yr,t		0.95	

Standard Sheet 3
Sediment Basin Volume – *Type C* Soils

Basin Volume = Settling Zone Volume + Sediment Storage Volume

Settling Zone Volume

The settling zone volume for Type C Soils is calculated to provide capacity to allow the "design particle" (e.g. 0.02mm in size) to settle in the peak flow expected from the design storm (e.g. 0.25 year ARI). The volume of the basin's settling zone (***V***) can be determined as a function of the basin's surface area and depth to allow for particles to settle.

Peak flow/discharge for the 0.25-year, ARI storm is by the following equation:

$$Q_{tc,0.25} = 0.25 \times Q_{1,t} \quad (m^3/sec)$$

where: $Q_{1,t}$ was determined for either rehabilitation or disturbed areas following the procedures outline previously

The basin surface area (A) is dependent on the flow rate into the basin ($Q_{tc,0.25}$ above) and the settling velocity of the soil particles ($Vel_{settling}$ = 0.00029m/s for Maroota sands)

Basin surface area (A) = $(Q_{tc,0.25})/(Vel_{settling})$

= $(Q_{tc,0.25})/(0.00029)$

= _____ m^2

The basin settling volume can be calculated using a minimum depth of 0.6 metres.

Settling Zone Volume = ***Basin Surface Area (A)*** x ***Depth***

= _____ x _____

= _____ m^3

Sediment Storage Volume

As it has been shown that the disturbed areas within the quarry have a low erodibility the sediment storage zone can be calculated by:

Sediment Storage Volume = 100% of Settling Zone Volume

= _____ m^3

Total Basin Volume = ***Settling Zone Volume*** + ***Sediment Storage Volume***

= _____ + _____

= _____ m^3

Table D1:- Intensity Frequency Data

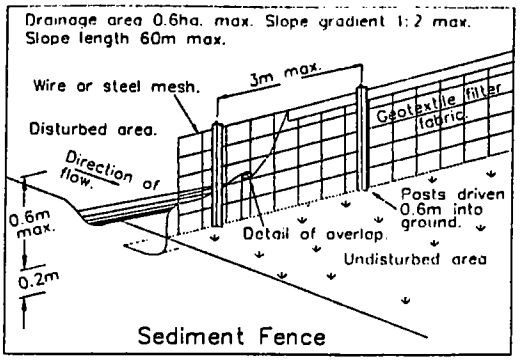
For use in calculating runoff from Rehabilitated and Disturbed Areas

Storm Duration min	Storm Intensity, I (mm/hr)					
	1 yr ARI	2 yr ARI	5 yr ARI	10 yr ARI	20 yr ARI	100 yr ARI
6	69	89	117	134	156	206
7	65	84	110	126	147	195
8	61	80	105	120	139	185
9	58	76	100	114	133	176
10	56	73	96	109	127	168
11	54	70	92	105	122	162
12	52	67	88	101	117	155
13	50	65	85	97	113	150
14	48	63	82	94	109	145
15	47	61	80	91	106	140
16	45	59	77	88	103	136
17	44	57	75	86	100	132
18	43	56	73	83	97	128
20	41	53	69	79	92	122
25	36	47	62	71	82	109
30	33	43	56	64	74	99
35	30	39	52	59	68	91
40	28	37	48	55	64	84
45	26	34	45	51	59	79
50	25	32	42	48	56	74
55	23	30	40	46	53	70
60	22	29	38	43	50	67
75	20	26	34	38	44	59
90	18	23	30	35	40	53
120	15	20	26	29	34	45

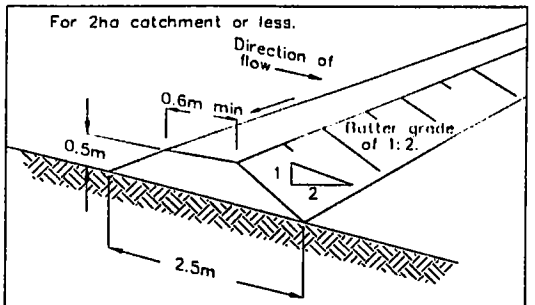
Table D2 - Values of $t*I^{0.4}$

For use in calculating runoff from Disturbed Areas

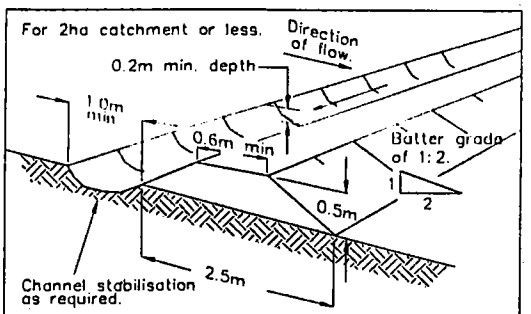
Storm Duration min	$t*I^{0.4}$					
	1 yr ARI	2 yr ARI	5 yr ARI	10 yr ARI	20 yr ARI	100 yr ARI
6	33	36	40	43	48	51
7	37	41	46	48	55	58
8	42	46	51	54	62	65
9	46	51	57	60	68	71
10	50	56	62	65	74	78
11	54	60	67	71	80	84
12	58	65	72	76	86	90
13	62	69	77	81	92	96
14	66	73	82	86	98	102
15	70	77	86	91	104	108
16	74	82	91	96	109	114
17	77	86	96	101	115	120
18	81	90	100	106	120	126
20	88	98	109	115	131	137
25	105	117	130	137	156	163
30	121	135	150	158	180	188
35	137	152	170	179	203	212
40	152	169	188	198	225	236
45	167	185	206	217	247	258
50	181	201	224	236	268	280
55	194	216	241	254	288	301
60	208	231	257	271	308	322
75	247	274	306	322	366	383
90	285	316	352	371	421	441
120	355	394	439	463	525	549



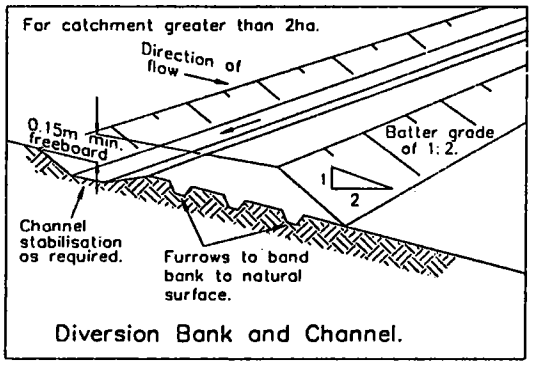
Sediment Fence



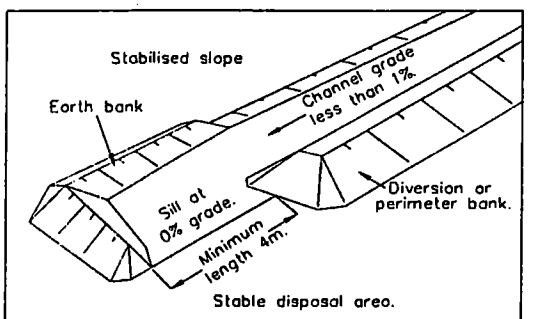
Perimeter Bank (without channel)



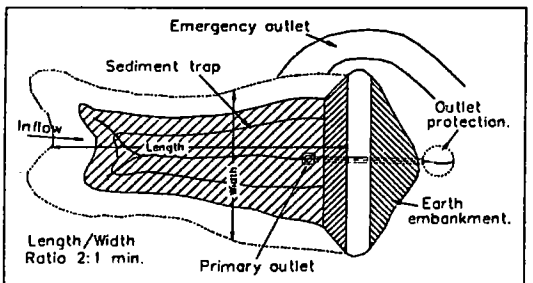
Perimeter Bank (with channel)



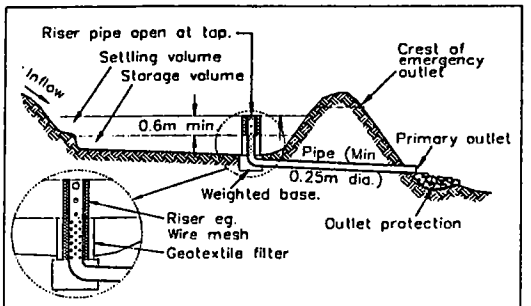
Diversion Bank and Channel.



Level Spreader (or Sill)



Plan View of Typical Sediment Basin



Cross Section of Typical Sediment Basin.

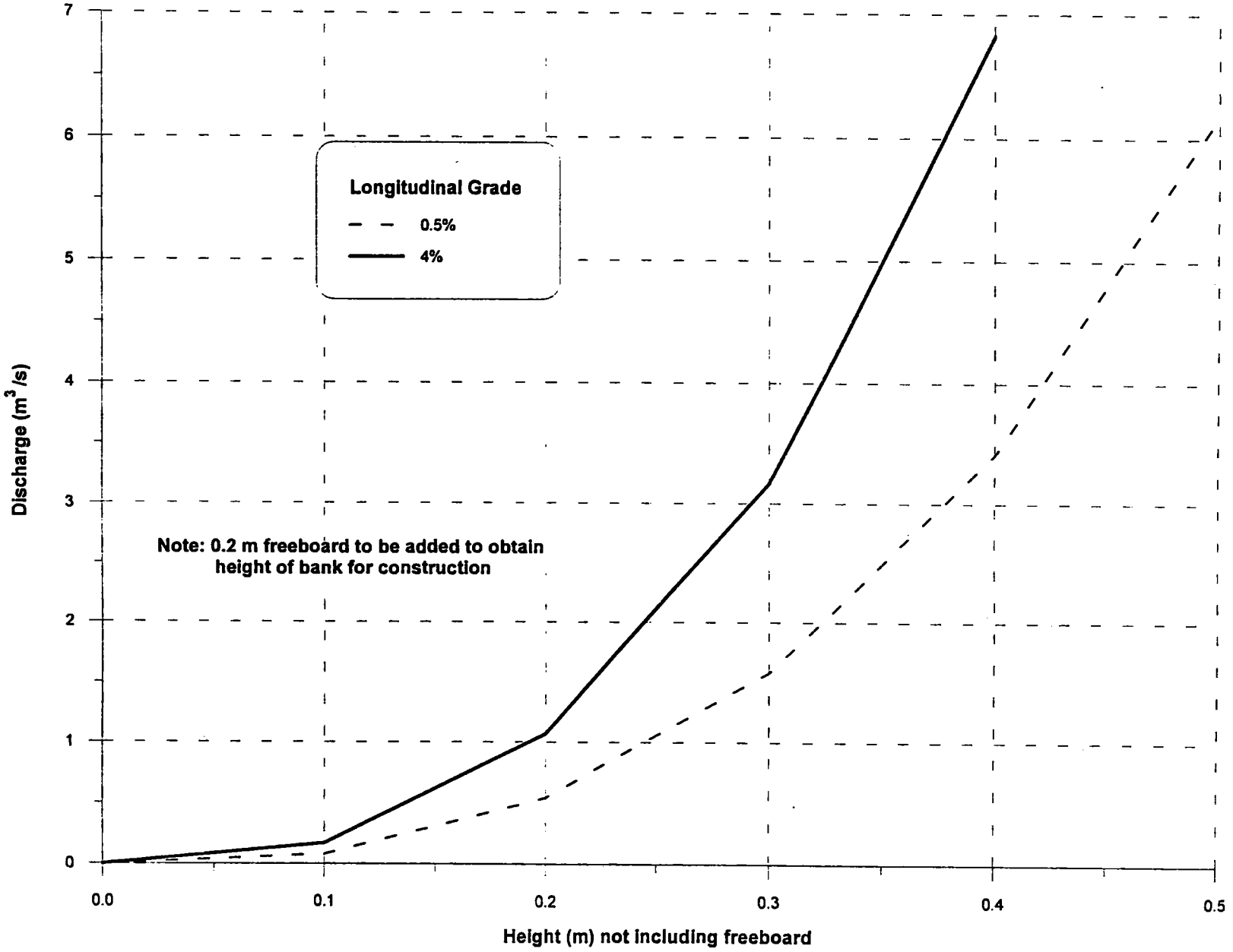
NOTE: See Section 4.3.2 and Annexure C4-D for various sizing criteria

DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure D1

EROSION AND SEDIMENT CONTROL PLAN
STRUCTURE SPECIFICATIONS

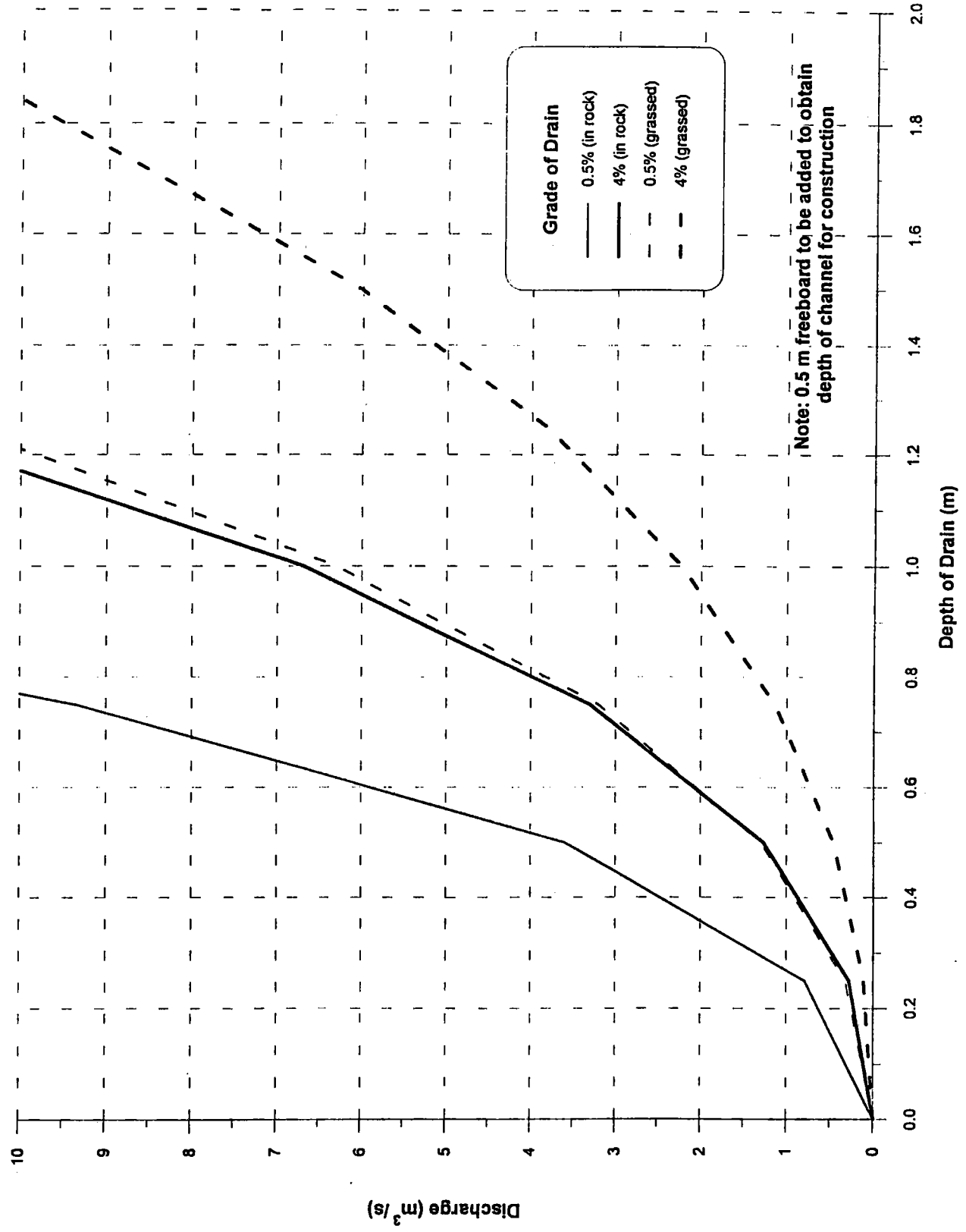
DM560/Wrm/Cads/Basance3.dwg



DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure D2

DISCHARGE vs HEIGHT
CONTOUR BANKING



DIXON SAND'S MAROOTA OPERATION
WATER MANAGEMENT PLAN

Figure D3

DISCHARGE vs HEIGHT
DIVERSION DRAIN