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Exeter Quarry extension : environmental impact statement

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Exeter Quarry Extension

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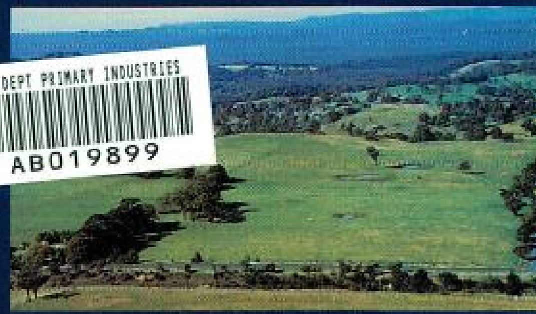

Concrite Quarries Pty. Limited

CONCRITE

A.C.N. 002 232 859

EXETER QUARRY EXTENSION – CONCRITE QUARRIES PTY LTD

Specialist Consultant Studies

VOLUME 1: CONTENTS

READERS – PLEASE NOTE

This document contains a series of reports prepared by Specialist Consultants advising Concrite Quarries Pty Ltd on the design and operation of the Exeter Quarry Extension.

CONCRITE QUARRIES PTY LTD

EXETER QUARRY EXTENSION

EVALUATION OF THE CHARACTERISTICS AND QUALITY OF EXETER BASALTS

Prepared by:

Harold Roper & Associates

8 June, 1999

Specialist Consultant Studies

Volume 1 ▪ Part 1

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EVALUATION OF THE CHARACTERISTICS AND QUALITY OF EXETER BASALTS

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For
CONCRITE QUARRIES PTY LTD

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EXECUTIVE SUMMARY

Concrite Quarries Pty. Ltd. is currently seeking approval for the extension of its hard rock basalt extraction area adjacent to its crushing and screening plant at Exeter. The Company currently extracts basalt from the quarry area adjacent to the proposed extraction area. The Company has been producing high quality crushed basalt aggregate from a series of satellite extraction areas surrounding its crushing and screening plant. Crushing and screening commenced at the plant in 1978. The present application seeks permission to extend the quarrying operations into an area NE of Rockleigh Road.

The products currently being produced are sold to premixed concrete and hot-mix plants, sealing aggregate contractors and to road construction contractors including those of State and Local Government and private developers. The products being produced allow design engineers and specifiers to gain access to concrete and pavement materials of the highest quality, since much of the produced product has properties superior to those of competitive materials.

The superior properties when used in quality concretes result in:

- Very high strength concretes (50 - 100 MPa)
- Very high modulus of elasticity concrete
- Very low shrinkage concrete (600 μ-strain at 56 days)
- Concrete which is required to be innocuous with respect to alkali-aggregate attack
- Concrete which is required to incorporate low totals of chloride and sulphate salts
- Very low permeability

High quality pavement materials and rail ballast rock products are produced from the basalt of the Exeter area. Specifiers of high quality road pavement materials call for:

- Low plasticity
- Minimum wet/dry strength variation
- Low Los Angeles abrasion
- Low loss under sodium sulphate testing

The basalt products from the Exeter area satisfy these requirements.

The specifiers of high quality rail ballast materials, such as those currently specifying materials for use on the high speed sections of the Very Fast Train Project between Sydney and Canberra and beyond, require a very high quality stone. The design engineers engaged on that project specify acceptance with respect to:

- Resistance to attrition, as assessed by the Deval Test
- Fragility, as assessed by the Los Angeles Test
- Instantaneous hardness, determined from the combined results of the above test methods

The Exeter basalt will satisfy the very strict specification outlined by the French Partners in the Very High Speed Rail Consortium.

There is an increasing demand worldwide for quarry products of superior quality to allow design engineers to specify the highest quality engineering works which have the longest maintenance free service lives. It is expected that this demand will continue in Australia. In particular this trend has been evidenced for concrete in the Sydney and adjacent market areas. Exeter basalt products have been proven to satisfy the most exacting demands of design engineers and specifiers of high quality structural and road materials.

1. INTRODUCTORY STATEMENT

Engineers select aggregate materials, including concrete aggregate and pavement materials, which best fulfil requirements governing the construction and service stages of built structures, always provided that such materials are available at viable prices. The cost of aggregate materials depends not only on the intrinsic nature of the material but also on the necessary extractive and preparation procedures, and the locations of the sites from which they are won. This cost is passed on to the consumers and ultimately the owners of the structure. In the case of most large infrastructure projects, the general public are the largest stakeholders, and hence stand to gain most from the availability of economic sources of quality engineering materials which will maximise the service lives of the structures.

Most of the rocks forming the Sydney Basin are unsuitable for the production of high class aggregate materials, as they are predominantly sandstones and shales. Even the rare igneous materials intruded into these are either being rapidly exhausted (Prospect Quarry), or are not suitable for high grade concrete construction (Volcanic Breccias). The gravels of the Penrith area are also quickly being consumed. Information on public record suggests that materials production from Penrith River Gravel sites may be exhausted as early as 2006. Some gravel reserves have been lost as a resource by the encroachment of home building construction.

For the above reasons the centre of the biggest demand for construction materials, the Sydney Construction market, must seek aggregates from well outside the confines of the Sydney Basin. That is not to say that road and rail infrastructure will not place demands for considerable amounts of aggregate supplies throughout the State of New South Wales, but that in general, Sydney will remain the hub from which such routes spread. This means that the greatest demand will remain centred around the area with the least resources.

Consequently the protection (through planning) and development of aggregate resources of premium grade which are readily transported to both the Sydney Area, and to the lines of transportation infrastructure development is an imperative. One such resource is the quarryable rock reserves of the Exeter area. As a rule the igneous hard rock reserves in the Mittagong-Moss Vale Area which have in the past been nominated as important for future use were those expressed as significant positive topographic features on the landscape, such as prominent ridges with bold outcrops.

The Exeter quarryable materials, which are basalts present as caps on the plateau forming the Robertson Tableland, are at this time being successfully worked for concrete aggregate and road pavement materials. Quarryable reserves do not necessarily present as strong topographic features, but rather blend into the gentle undulating countryside. Such is the case in the Exeter Area, where workable deposits of naturally jointed or broken basalt, amygdaloidal basalt and massive fine-grained basalt have been identified. These three classes of basalt have been identified in the existing quarry, from core sections drilled in the proposed extension area, and in outcrops. Potential extraction areas extend West of Werai Road, Lantern Hill, and Green Hills as well as Rockleigh. The Exeter Quarry is recognised by the NSW Department of Mineral Resources as "a resource of regional significance", and extensions to this have also been recognised by that Department as containing regionally significant aggregate resources in advice provided to Wingecarribee Shire Council concerning the Section 117(2) Direction to allow further exploitation of the aggregate materials (See Letter Ref L97/0137, Dated 1/7/1998, from the Department of Mineral Resources to Concrite Quarries).

A detailed geological description of an area close to the presently operating Concrite Quarry in Exeter proposed for development is covered in a Report prepared by R. W. Corkery & Co. Pty Limited, entitled: "Exeter Quarry Extension Environmental Impact Statement" and in the Report by Donald W Barnett entitled: "Supply and Demand of Coarse Aggregate for Wingecarribee Shire and the Sydney Region with Particular Regard to the Exeter Quarry".

2. EXETER ROCK TYPES FOR AGGREGATE PRODUCTION

Three types of hard rock, which broadly relate to classes of aggregate materials, could be produced from any basalt quarry within the Exeter Area. These are:

Broken Basalt - Hard boulders of closely jointed coarse grained, unweathered basalt.
Massive Basalt - The parent materials of the broken basalt boulders.
Amygdaloidal Basalt - Somewhat coarser grained, pneumatologically altered basalt.

Petrographically the basalt is holocrystalline, equigranular and fine to medium grained. Principal minerals are plagioclase, pyroxene, olivine, opaques and apatite, which comprise in the order of 70-80% of the rock mass. Secondary minerals include zeolites, chlorite\clay minerals, olivine alteration products and carbonates in varying proportions.

The proportions of the various classes of materials produced from any given location may be varied during the quarry's lifetime by selective quarrying methods, and the proportions of the materials encountered as the extraction advances.

Broken Basalt from the present Exeter Quarry provides high quality concrete aggregate, with extremely high modulus of elasticity. It can be used to produce very high strength concretes (>80 MPa). These can be used in high rise construction. Exeter Quarry aggregates are in demand for mixes which require controlled low shrinkage and creep properties, for bridge and prestressed concrete works. The Broken Basalts within the proposed extraction area should fill a similar place in the special concrete market which is growing yearly.

The Massive Basalt will provide high grade concrete aggregate of similar properties to those of the Broken Basalts.

Amygdaloidal Basalt from the new quarry will be blended with varying quantities of either Broken Basalt or Massive Basalt to produce concrete aggregates which may be used in normal class concrete. The amygdaloidal basalt when processed, and the fines produced from the crushing of all basalt types will be used to produce pavement materials to comply with the relevant specifications. With the closure of the Penrith Lakes Scheme, there will also be a shortage of concrete making sands available to the Sydney market. Preliminary trials on amygdaloidal basalt fines from Exeter have demonstrated that this material can be used to manufacture a coarse grained crusher sand. It could be expected that in the future this material could mitigate, in some measure, the significant shortfall in coarse grained sand which will arise with the closure of the Penrith Lakes Scheme. The Broken Basalt and the Massive Basalt will also be used to produce pavement materials to the highest levels of specification.

3. AGGREGATE INFLUENCES ON CONCRETE PROPERTIES

Three aspects of concrete technology are uppermost in the minds of design engineers when selection of concrete for a specific purpose is made. These are strength, serviceability and durability. The strength of concrete is governed chiefly by its design load carrying capacity, however at the same time linkage of high strength is made to the mechanical properties of high modulus of elasticity and low creep. The aggregates at present being produced from the Exeter quarry are second to none in producing high strength, high modulus, low creep concretes.

Serviceability criteria include short and long term deflections and cracking. Minimum long term deflections result from the high modulus and low creep of the basalt aggregate concretes being produced with the presently quarried material. Also because of the low shrinkage characteristics which can be attained in the concrete, both cracking and long-term deflections due to drying shrinkage are minimised when this aggregate is used in concrete.

Durability considerations relate to chemical and physical changes in the concrete. These chemical changes are caused by such phenomena as alkali aggregate reactivity, the presence of chlorides and sulphates in the produced material, and the possibility of aggressive species such as carbon dioxide, chloride and sulphate ions diffusing into the concrete.

The presently produced concrete aggregates from the Exeter Quarry are innocuous with respect to alkali-aggregate reaction. This means that no precautions need be taken to prevent this problem from occurring. This is not so for some other materials being supplied to the Sydney Area at this time. There is a distinct advantage in producing innocuous aggregate in that portland cements of any alkali content may be used in the produced concrete without leading to excessive expansions, even when no fly ash or silica fume is present. This allows both a greater range of cements to be used without pozzolans, and permits the production of high strength concretes without resorting to incorporation of relatively expensive silica fume in the mix. Thus general economic savings flow from the production of innocuous aggregates.

The aggregate itself is low in chlorides, which gives additional protection with respect to steel corrosion in marine structures. The aggregates are also low in sulphate ions. Analysis data for chlorides and sulphates on a 14 mm Aggregate from Exeter showed contents of chloride and sulphate as 0.003% and 0.016% respectively.

The aggregates being produced in the Exeter area are dense, and are hence not permeable to aggressive chemical species. The minimisation of cracks also reduces aggressive intrusion of active ions into the concretes made with presently won Exeter aggregates. In Table 1 some properties of the Exeter basalt may be compared with those of other aggregate materials being supplied to the Sydney Basin.

The data in Table 1 show that the basalt is dense; and somewhat denser than competitive aggregates. It exceeds the minimum standard set by *AS2758.1 Aggregate and Rock for Engineering Purpose. Part 1. Concrete Aggregates*, for particle density of not less than 2100 kg/m^3 . The water absorption is low, reflecting the dense and compact rock properties, and the level meets Standard requirements. With respect to the wet/dry strength variation, the 5 to 15% variation is below the maximum value of 25% set in AS 2758.1 for concrete to be used in severe conditions of wetting and drying. With one exception, the presently produced basalt has a wet-dry strength variation less than that of competitive materials.

The Los Angeles Test is designed to measure loss under dynamic loading, and is a measure of resistance to degradation under such action. The data evidences that materials from the producing quarry degrades only a small amount under such action, and less than its competitors. The alkali aggregate data indicates that the aggregate does not swell in the presence of hydrating portland cement, even when pozzolanic materials are absent. The basalt has low total chlorides and sulphates. Basalt has a high modulus of elasticity, and low intrinsic shrinkage.

There is, at present, a strong tendency to specify higher strength and low shrinkage concretes in construction world wide. Australia has followed this trend since it allows financial gains to be made by decreasing concrete sections, leading to a saving of material, and also by improving long-term durability of the structural members. The steel manufacturers have accepted that this trend will continue, and have committed themselves to the production of higher strength steel reinforcement than is available at this time, to take even greater advantage of the now available high strength, low shrinkage concretes.

Such high strength concretes are not only being used for high-rise construction, but are being specified for bridges, tunnels and other infrastructure construction, because of the more rigorous durability demands, such as life service requirements over 100 years. As well, it permits more rapid construction procedures to be implemented, thus allowing cost savings. Thus, even though the strength of concrete in such structures may not be so important per se, the outcome of use of high strength concrete is almost invariably advantageous. Because of the high cement contents of high strength concretes, the properties of aggregate to control shrinkage is crucial to its application.

In order to produce high strength, low shrinkage concretes, at the lowest cost, aggregates with high modulus of elasticity are required to be used. Basalt aggregates have the highest moduli and lowest intrinsic shrinkage of any aggregates available in the Sydney hinterland. This means that demand for such material should continue to increase above that for river gravels, latites and the local dolerites. The concrete strengths, for equal water/cement ratios and using a single cement, are generally in decreasing order from basalt, river gravel, latites, and certain doleritic rock types, the latter giving lowest values. A similar order exists for elastic moduli. For shrinkage the opposite order is observed, with basalts, particularly non-amygdaloidal types, producing the lowest shrinkages.

It would be expected and has been demonstrated that concrete of high modulus and low shrinkage would result from the high aggregate modulus of rock types both from the Exeter Quarry and from the proposed quarry.

Overall demand for high grade basaltic aggregates should continue to grow as higher strength and better long-term durability is specified for many more types of structure than is the case at present.

For special structures where high strength is not a requirement, and may even lead to severe problems due to excessive heat of hydration, such as in mass concrete construction, the materials from Exeter have again properties of considerable worth. These properties include, apart from those already mentioned, high thermal conductivity and capacity, and resistance to thermal cracking. When the heightening of the Warragamba Dam was mooted, the aggregate from Exeter was a serious contender for use due to such properties.

4. AGGREGATE TESTS IN ACCORD WITH AUSTRALIAN STANDARD AS 2758.1

In assessing the acceptability of concrete aggregate from any newly developed quarry, substantial dependence must be placed on Australian Standard AS 2758.1-1998. Part One of the Standard, is the first in a series, which cover specification of aggregates and rock for engineering purposes. Other Parts are as follows:

Part 2: Aggregates for sprayed bituminous surfacing
Part 5: Asphaltic aggregates
Part 7: Railway ballast.

In general, the test requirements in Part 1 are the most stringent of all, and a majority of hard rock materials which pass these are also found to be suitable for use in sprayed bituminous surfacing and asphaltic binding, and as railway ballast. However, railway ballast for proposed high speed rail construction may well be subject to an alternate assessment method, which combines tests of resistance to attrition (Deval Test) and fragility (Los Angeles Test) to give a coefficient of bulk hardness, DRG.

AS 2758.1 - 1998, which is called up as AS 1379, which in turn calls up as AS 3600, Concrete Structures, relies on tests which are outlined in AS 1141, Methods for Sampling and Testing Aggregates, which is designed to include all aggregate tests, including those specific to other than concrete aggregates.

Properties that are required to be known for a concrete mix design, (including particle density, bulk density, water absorption, particle size distribution, alkali aggregate reactivity and soluble salts, if above reportable levels,) are governed by choices or limits in specific works specifications. This allows the designer to include or eliminate materials for use in his/her works which otherwise may have been excluded or included if general limits were to have been stated in the Standard. All of these requirements should be easily met by production run materials.

Durability of coarse aggregate is related to the use of concrete and its exposure, and is therefore not simply a mix design factor. In this case the works specifier is called on to select an exposure classification and to chose one of three methods of assessment. The methods available are: wet strength and wet/dry strength variation, Los Angeles value and sodium sulfate soundness, and Los Angeles and unsound and marginal stone content. Even though limits are given in the Standard, considerable latitude is given to the designer to modify these, if considered appropriate.

5. CONCRETE AND AGGREGATE TESTING TO DATE

The detailed testing, in precise accord with designated Australian Standards, of the individual aggregate types in the proposed extension area must await more extensive bulk sampling of the resource, since strict control on sampling is a requirement of that Standard. Sampling of stockpiles for example cannot be undertaken until some level of on site aggregate production has been undertaken. From bulk sampling of broken basalt from the extension area, it is known that concretes of prior designed strengths can be produced from the various materials, and that shrinkage values of such mixes are in line with expectations. The data are in accord with information obtained from the presently operating quarry, and extrapolations of data from the produced materials to the exploratory ones appears on the available data to be justified. This justification flows from the fact that concretes produced from aggregates won from the presently operating quarry invariably show superior shrinkage performance over materials produced from alternate sources, as can be seen in Table 2.

Compressive strength and drying shrinkage data for trial concrete mixes produced from samples of crushed broken, and massive basalt are presented in Table 3. The tests demonstrate the suitability of the basalts occurring in the Extension area for the manufacture of concrete aggregate.

When Exeter basalt is used exclusively as coarse aggregate in concrete, close checks on both aggregate and concrete production permits rigorous concrete shrinkage control as demonstrated by the results achieved at the Multiplex-Shellharbour Square Project. Details are presented in Appendix 1. These results show an average shrinkage strain after 8 weeks of drying of 449 μ-strain. Somewhat higher values of shrinkage will result when basalt is blended with other aggregate types such as latite, river gravel etc, and when such other aggregates are used unblended in otherwise equivalent concretes.

Shrinkage and concrete strength test results of concretes prepared from broken basalt extracted from the proposed quarry site are presented in Appendix 2.

6. RAILWAY BALLAST

Railway ballast for the proposed high speed rail construction is subject to an alternate assessment method to that given in Australian Standards. This alternate method combines tests of resistance to attrition (Deval Test) and fragility (Los Angeles Test) to give a coefficient of bulk hardness, DRG.

Test data on Exeter Railway Ballast is presented in Table 4.

Basalt from the existing quarry will also meet the strict requirements of the ballast stone for the VFT high speed section. The broken and massive basalt sections of the proposed quarry have similar petrographic properties, and ballast materials derived from these materials could be expected to meet the same specification.

7. ROAD PAVING MATERIALS

Materials for road construction have been supplied from the Exeter Quarry. Depending on the use to which the paving materials are to be put, they are subject to various test procedures. Results relating to paving materials are presented in Table 5.

The Exeter Area should continue to be a source of high grade paving materials, the basalts being a good source rock for such use.

8. CONCLUSIONS

Continued production of high quality quarry materials should flow from the Exeter area provided that the opportunity is given for the continued production of these. The products currently being produced are sold to premixed concrete and hot-mix plants, sealing aggregate contractors and to road construction contractors including those of State and Local Government and private developers. The products being produced allow design engineers and specifiers to gain access to concrete and pavement materials of the highest quality, since much of the produced product has properties superior to those of competitive materials.

The superior properties when used in quality concretes result in:

- Very high strength concretes (50 - 100 MPa)
- Very high modulus of elasticity concrete
- Very low shrinkage concrete (600 μ-strain at 56 days)
- Concrete which is required to be innocuous with respect to alkali-aggregate attack
- Concrete which is required to incorporate low totals of chloride and sulphate salts

High quality pavement materials and rail ballast rock products are produced from the basalt of the Exeter area. Specifiers of high quality road pavement materials call for:

- Low plasticity
- Minimum wet/dry strength variation
- Low Los Angeles abrasion
- Low loss under sodium sulphate testing

The basalt products from the Exeter area satisfy these requirements.

The specifiers of high quality rail ballast materials, such as those currently specifying materials for use on the high speed sections of the Very Fast Train Project between Sydney and Canberra and beyond, require very high quality stone. The design engineers engaged on that project specify acceptance with respect to:

- Resistance to attrition, as assessed by the Deval Test
- Fragility, as assessed by the Los Angeles Test
- Instantaneous hardness, determined from the combined results of the above test methods

The Exeter basalt will satisfy the very strict specification outlined by the French Partners in the Very High Speed Rail Consortium.

There is an increasing demand worldwide for quarry products of superior quality to allow design engineers to specify the highest quality engineering works which have the longest maintenance free service lives. It is expected that this demand will continue in Australia. In particular this trend has been evidenced for concrete in the Sydney and adjacent market areas. The Exeter basalt has proven and demonstrated characteristics which render it highly suitable for use as concrete and sealing aggregate and railway ballast. Its very low moisture movement, low reactivity and high strength in concrete, makes it suitable for uses demanding long design life in the most adverse of serviceability conditions. In this regard it outranks its competitors. The proposed extension to the Exeter Quarry should provide a long-term source of quality aggregate to meet the increasing demands for high performance concretes and road stone for use under special and severe conditions.

Harold Roper B.Sc.(Hons), M.Eng.Sc., PhD
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TABLES

TABLE 1
COARSE AGGREGATE PROPERTIES SUMMARY

Property	Unit	Basalt (Exeter)	Latite (Bombo)	River Gravel (Penrith)	Microsyenite (Compton Park)	Microsyenite (Mt Flora)	Rhyolite (Hartley)	Standard#
Particle Density (Dry)	kg/m^3	*2580-2870	2720-2750	2630-2650	2600	2420-2518	2620	>2100<3200
Water Absorption	%	0.6-1.3	0.63-1.7	0.9-1.3	1.4-1.8	2.3-3.7	0.7	<2.0
Wet/Dry Strength Variation	%	5-15	23-28	20-30	8+	3-20	3	<25
Los Angeles Value	%	9.5-14.5	13-22	17.2-19	20-24	20-30	16	<30
Alkali Reactivity		Innocuous	Innocuous	Innocuous to reactive	Innocuous	Innocuous	Innocuous	**
Chloride content	ppm	10-50	210-350	20-100	NA	NA	NA	**
Sulphate content	ppm	20-150	180-1530	30-870	NA	NA	NA	**
Modulus of Elasticity	GPa	78-86	80	76	NA	NA	NA	**

Modified from Minec Pty Ltd (1999) and Concrite Quarries Pty Ltd.
*Note: * Lower figure of 2580 kg/m^3 obtained for amygdaloidal basalt.*
*# AS 2758.1-1998. ** No standard specified.*

TABLE 2
CONCRETE DRYING SHRINKAGE PERFORMANCE

Coarse Aggregate	Average Shrinkage (μ-strain)	
Period June 1991 to March 1999		
Exeter Basalt	530	
Exeter Basalt blended with Crushed River Gravel	540	
Crushed River Gravel	575	
South Coast Latite	680	
Special Projects		**Location**
Exeter Basalt	450	Shellharbour Shopping Centre
Exeter Basalt blended with Crushed River Gravel	515	Stadium Australia
Crushed River Gravel	580	Stadium Australia
Exeter Basalt blended with Crushed River Gravel	560	Coles Distribution Centre, Smeaton Grange

Source: M Ortiz, Concrite (17 June 1999)
Note: Low shrinkage concrete with Shrinkage Limited Cement and 20mm aggregate.

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TABLE 3

TRIAL MIXES ON SUBMITTED CRUSHED BASALT SAMPLES
(Date of Trials: 1 April 1995)

Ref No.	Docket Marking	Description	Mix Breakdown		Compressive Strengths		Drying Shrinkage µstrain	
12151	(F1 + F2) ½ - 7m	Broken Basalt Bulk Density = 2760	GP	350	7d	25.5 MPa	1 Week	220
			Crushed sample	975	28d	32.0 MPa	2 Weeks	350
			Penrose Sand	950			3 Weeks	430
			MBT 300R (Mls)	875			4 Weeks	490
			Total Water (L)	205			8 Weeks	610
			Slump	65				
12152	(F1 + F2) 31 - 33m	Massive Basalt Bulk Density = 2770	GP	350	7d	32.0 MPa	1 Week	160
			Crushed sample	975	28d	37.0 MPa	2 Weeks	250
			Penrose Sand	950			3 Weeks	300
			MBT 300R (Mls)	875			4 Weeks	360
			Total Water (L)	21			8 Weeks	470
			Slump	70				

ref: C:stuart/personal/bc_tab3

TABLE 4
TEST RESULTS ON EXETER RAIL BALLAST

Test	Unit	Result	Standard Requirement	Standard Reference
Proportion of Weak Particles	%	0.0	Not greater than 0.5%	AS 2758.1-1998 Test method AS1141.32
Percentage of sample passing 2.36mm	%	0.0		Test method AS1141.32
Mean Apparent Particle Density Mean Particle Density (Dry) Mean Particle Density (SSD)	kg/m^3	2920 2870 2890	Not less than 2500 kg/m^3 (dry basis ballast material)	AS 2758.7-1996 Test method AS1141.6.1
Mean Water Absorption	%	0.6	Generally not greater than 2	AS 2758.1-1998 Test method AS1141.6.1
Average Dry Strength Average Wet Strength	KN	364 328	* Class H Min 175 Class N Min 150 Class L Min 110	AS 2758.7-1996 Test method AS1141.22-1996
Wet/Dry Strength Variation	%	10	Class H Max 25 Class N Max 30 Class L Max 40	AS 2758.7-1996 Test method AS1141.22-1996

Source: Concrite Test Certificates

Note: * Class H-track carrying traffic in excess of 6,000,000 gross tonnes per year.
Class N-track carrying traffic from 1,000,000 to 6,000,000 gross tonnes per year.
Class L-track carrying traffic less than 1,000,000 gross tonnes per year.

TABLE 5
TEST RESULTS ON EXETER PAVING MATERIALS

Test	Material	Unit	Result	Standard Requirement	Standard Reference
Max Dry Compressive Strength Corresponding Moisture Content Corresponding Dry Density	DGB 20	(MPa) % t/m^3	4.2-6.4 7.0-7.8 2.23-2.35	Greater than or equal to 1.7	RTA T114
Total Mis-Shapen Particles	DGB 20	Ratio	2:1 ratio = 15 3:1 ratio = 2	Less than or equal to 35	AS 1141.14-1995
Aggregate Wet Strength	DGB 20	kN	315	*Greater than or equal to 60kN	AS1141.22-1996
Wet/Dry Strength Variation	DGB 20	%	14	*Less than or equal to 35	AS1141.22-1996
Liquid Limit Plastic Limit Plastic Index	DGB 20		Non-plastic	Less than or equal to 20. Less than or equal to 20. *Less than or equal to 6.	AS 1289.3.1.1/ AS 1289.3.2.1-1995
Fine Particle Distribution in Road Materials	DGB 20	%	A Ratio: 45 B Ratio 47 C Ratio 39	35-55 35-55 35-60	AS 1141.19-1980/ RTA T107

Source: Concrite Test Results
Note: * Dependant on road classification.

Appendix 1
SHRINKAGE RESULTS FOR MULTIPLEX-SHELLHARBOUR SQUARE

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CONTEST

SHRINKAGE RESULTS FOR MULTIPLEX - SHELL HARBOUR SQUARE

(S40 - 550 microstrain)

Date	Spec' Ident'	Str' Grade	Docket	Slump	Week 1	Week 2	Week 3	Week 4	Week 8
7/8/97	24816	S40	708455	75	190	290	350	380	**460**
7/8/97	24817	S40	708471	75	170	260	330	370	**450**
30/08/97	24833	S40	708870	85	200	300	380	380	**470**
30/08/97	24834	S40	708911	85	190	290	370	370	**450**
3/11/97	24125	S40	709923	80	150	210	300	340	**440**
13/11/97	24966	S40	710179	85	180	270	320	420	**510**
13/11/97	24967	S40	710206	95	160	220	250	340	**450**
20/11/97	24973	S40	710338	80	130	190	290	310	**410**
20/11/97	24975	S40	710358	80	110	180	280	300	**390**
02/12/97	24143	S40	710627	80	170	250	290	330	**450**
02/12/97	24144	S40	710640	90	170	250	280	310	**440**
13/01/98	24164	S40	711134	105	150	260	320	360	**470**

S40 Statistics	Slump	Week 1	Week 2	Week 3	Week 4	Week 8
Average	**85**	**164**	**248**	**313**	**351**	**449**
Minimum	75	110	180	250	300	390
Maximum	105	200	300	380	420	510
St. Dev.	**8.6**	**26.1**	**39.6**	**39.2**	**35.5**	**30.0**
Var. Coeff.	**10%**	**16%**	**16%**	**12%**	**10%**	**7%**

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Appendix 2
SHRINKAGE TRIALS ON NEW EXETER BASALT DEPOSITS

CONTEST CONCRETE TESTING PTY. LTD.
A.C.N. 001 871 067
Telephone: (02) 9601 3422
Fax: (02) 9601 8041
Correspondence: P.O. Box 523, Sutherland, 2232

CONTEST

SHRINKAGE TRIALS OF NEW EXETER DEPOSITS

TRIAL MIX DATA

Mixes consisted of the following mix breakdown:
(figures based on per cubic meter)

Cement - SL	330	330	330	330	330	330
20mm (F3,F4, & F7)	F3 - 740	F3 - 740	F4 - 740	F4 - 740	F7 - 750	F7 - 750
10mm (F3,F4, & F7)	F3 - 340	F3 - 340	F4 - 345	F4 - 345	F7 - 345	F7 - 345
C/Sand - R'mix	560	560	560	560	560	560
F/Sand - Kurnell	260	260	260	260	260	260
Rocla 50/50	@500ml/100kg	@500ml/100kg	@500ml/100kg	@500ml/100kg	@500ml/100kg	@500ml/100kg

Trial Mix Number	F3-A	F3-B	F4-A	F4-B	F7-A	F7-B
Date of mix	26/07/96	29/07/96	26/07/96	29/07/96	26/07/96	29/07/96
Reference No's	17313	17316	17314	17317	17315	17318

Aggregate Type & Density (t/m³)	F3	F4	F7
	F3-20mm-2.83	F4-20mm-2.84	F7-20mm-2.87
	F3-10mm-2.82	F4-10mm-2.87	F7-10mm-2.87

	F3-A	F3-B	F4-A	F4-B	F7-A	F7-B
Total Water (Lt)	**182**	**182**	**172**	**172**	**175**	**175**
Slump (mm)	80	80	80	80	85	85

Average Shrinkage

(Microstrain)

Weeks	F3-A	F3-B	F4-A	F4-B	F7-A	F7-B
1	210	180	200	160	180	150
2	210	280	290	250	260	250
3	390	360	370	340	340	330
4	430	380	410	360	380	360
8	550	510	520	490	500	490
Average @ 8 Weeks	*530*		*505*		*495*	
Increase over F7	*+ 7.1%*		*+ 2.0%*			
12	-----	590 (+15%)	-----	570 (+16%)	-----	570 (+16%)
16	-----	650 (+27%)	-----	620 (+27%)	-----	600 (+22%)
20	-----	680 (+33%)	-----	650 (+33%)	-----	630 +(29%)

Average Compressive Strength (MPa)

	F3-A	F3-B	F4-A	F4-B	F7-A	F7-B
3 days	23.0	22.0	24.5	22.5	23.8	24.5
7 days	31.8	32.0	34.5	33.8	32.3	34.3
28 days	41.3	40.8	44.0	44.0	43.0	43.0
56 days	44.0	42.3	48.3	47.8	46.3	47.5

Note: F3 is a composite of Broken and Amygdaloidal basalt.

ref:d:\ms_office\trials\new_exet.xls

Appendix 3
CURRICULUM VITAE – HAROLD ROPER

CURRICULUM VITAE - H. ROPER.

Harold Roper, B,Sc., B.Sc.(Hons.), M.Eng.Sc., Ph.D., F.I.E.(Aust), F.(Aust)I.M.M., CPEng., formerly an Associate Professor, and Honorary Research Associate in the School of Civil and Mining Engineering, University of Sydney, has purposefully developed a specific balance between teaching, research and consulting in the fields of Civil Engineering and Materials Science.

In the area of corrosion of steel reinforcement in concrete his work is an outgrowth of a need to minimise the large costs of repair by the study of mechanisms of corrosion and possible preventative procedures, and application of currently available materials and practices. He has consulted on the installation of three cathodic protection systems, and holds a joint patent with the NSW Public Works Department on the electro-chemical removal of chlorides from contaminated concrete. He has published widely in the fields of cement and concrete technology and inorganic and organic materials behaviour. Study of creep and shrinkage of concrete have led to several publications, one being determination of the accuracy of predictive equations when applied to available Australian data. Understanding of the movement of water through cracked and sound concrete has been an adjunct to these investigations.

He has specialised in the in-situ measurement of corrosion potential and other electrochemical properties of structural steel and reinforcement in concrete, and has undertaken surveys of structures throughout Australia on behalf of Private and Government Organisations. Wharves in Queensland, Western Australia and N.S.W., and Mine Infrastructure in N.S.W. and W.A have been inspected and repair techniques have been recommended. Concrete investigations on bridges, dams, tunnels, cooling towers, mine shafts, road and airport pavement slabs, rail slabs for underground and high-speed tracks, water and slurry pipelines and crusher plants have been undertaken. Recent consulting assignments include the investigation of failed repairs, sewer and water pipeline degradation and the effects of fire and thermal cracking on concrete structural members. He has been consulted by bridge engineers on topics as diverse as thermal problems relating to heat of hydration, plastic cracking, drying shrinkage and void measurement within prestressing ducts. Problems in mix design, admixture use and pumping have been investigated.

Consulting work has been undertaken on a wide range of topics both within and outside the University sphere. Topics have included concrete mix design, high temperature curing, fibre reinforcement, alkali-aggregate attack, abrasion and cavitation on marine and dam structures, corrosion of reinforcement and prestressed concrete structures and corrosion of metal facade members and pipe materials. Special areas of expertise extend to building facade materials including granite and marble panels and their fixings, concrete surface coatings and sealants. Structures in marine environments have attracted his particular attention. Thermal effects on mass concrete sections have been studied on such diverse structures as the Glebe Island Bridge, Warragamba Dam and Mine Plant Structures in Western Australia.

Apart from his training in the area of civil engineering materials he is skilled in geology, petrology and mineralogy, and has published in this field. He has advised on the establishment and viability of aggregate quarries. Techniques used in the study of rock and minerals have included optical and electron microscopy, differential thermal and differential thermal gravimetric analysis, x-ray diffraction, calorimetry and infra-red analysis. Early in his career he worked as an economic geologist, and has experience in metalliferous and non-metalliferous mining. He spent a study period in Athens working on stone restoration procedures.

His background in mineralogy has stimulated his interest in cement and lime chemistry, including problems associated with the use of magnesite and high alumina cements. Studies of the engineering properties of these materials have extended to consideration of their durability under service conditions. He has consulting experience in the behaviour of glass and rock as building and facade materials. The fixing of granite and glass panels and the properties of adhesives and sealants have received his attention. Study of these organic materials has lead to work on an extensive range of such materials, ranging in topics from behaviour of plastics under service conditions, to paints and coatings.

This consultant has experience in the details of concrete membrane selection, application and service, including interaction with concrete and systems failure. Specific investigations include sprayed and sheet systems on roof-tops in Sydney and Newcastle. A serious failure of a treated slab in the North of Western Australia has lead to investigations to forward a legal matter in which he is at present involved. Detailed work has also been undertaken on the Australian Embassy Building in Beijing, where a whole series of different water-proofing techniques were found to be less than satisfactory. Alternate procedures were recommended in that instance.

He has contributed a Chapter in a book on Australian Concrete Technology, which deals with coatings to concrete surfaces, and the subject is dealt with in another textbook written in co-authorship with D. Campbell-Allen. Because of recent assignments in Taiwan and China necessitating a knowledge of the present state of the art, this Consultant has assembled recent information from the United Kingdom and the United States on these materials.

He has, as well, undertaken work in the fields of geography and hydrology. Included in hydraulic engineering assignments has been the study of service failures of a submarine optical fibre cable, the study of water quality for engineering use, and studies of cement mortar pipe lining changes under service conditions.

Sydney buildings on which he has in the past consulted include The Sydney Opera House, on tile, sealant and corrosion problems, No. 1 York St. on precast concrete panel problems, Capita Project on granite and glass curtain walling, Grosvenor Place on granite fixings, AMP Centre on organic sealants and water ingress through concrete and aluminuim-glass curtain walling, MLC Centre on marble sills and aluminium-glass curtain walling The Commonwealth Centre, Chifley Square on marble panel deformation, Zenith Building on glass panel failures, Market City on piles and The Key Apartments on durability. Highrise building consulting has also been conducted in Canberra, Melbourne, Perth, Adelaide and Newcastle. He has also been consulted on parking station problems. As an outgrowth of these consulting assignments, he has developed a scheme for mapping building facade defects using photo-interpretation techniques. This scheme allows rapid detection and assessment of possible problem areas, which can then be subjected to closer scrutiny. Non-destructive testing methods applied to several structural and durability problems include ultra-sonic, vibrational and corrosion potential techniques.

Problems associated with flooring materials and finishes on which opinions have been sought include concrete surface characteristics, powdering, excessive wear, water ingress, non-polymerising epoxy finishes, tile lifting and magnesite wetting.

In the area of waste product disposal, he has worked on the experimental development of clay-incinerator waste using material from the Waverley/Woollahra Incinerator. Sponsored research was undertaken on behalf of the NSW Electricity Commission and others to assess the production, beneficiation treatments, uses and disposal of fly ash in the State. Work has been undertaken on the use of Slag as cementitious and aggregate materials in Wollongong and Newcastle. Research sponsored by Mt. Isa Mines Pty. Ltd. allowed the investigation of cemented mine fill procedures and materials using base-metal slags and mine tailings from their mine operation in Queensland. Some minor work has been undertaken on a problem associated with red-mud waste derived from alumina extraction in Queensland. The removal of heavy metals from water by natural zeolites has been studied, and waste materials disposal using encapsulation by cementitious products further developed. Reports have been prepared on petroleum product leakage from underground steel storage vessels. He has experience in the identification of asbestos in natural and manufactured products.

Experience in the field of fill materials and pavement durability has stemmed from investigations of mine-fill, pavement and sportsfield failures, and quarry operations. Problems associated with attack on piles by in situ and dumped materials have been studied, as has scour problems in bridge foundations.

A book entitled "Concrete Structures: Materials, Maintenance and Repair", which he co-authored with D. Campbell-Allen, was published. For this publication intensive research of organic and inorganic repair materials and techniques was required. An award has been presented to him by the American Concrete Institute in recognition of his work over 20 years on Durability of Engineering Materials.

Born in South Africa of British parentage in 1932, he migrated via the USA to Australia, where he became a naturalised citizen over 30 years ago. His experience in working in foreign countries apart from Africa and the USA, includes World Bank projects in Thailand and Indonesia, a sabbatical in Greece, consulting assignments in China, Dubai, Italy, New Guinea, and Taipei and lecture presentations in Singapore, Malaysia and Hong Kong.

Harold Roper has experience of presenting written and oral evidence in legal and insurance matters. He has appeared on behalf of litigants in conciliation, arbitration and court cases both in Australia and overseas. A full listing of these cases is available on request.

Acting as a private consultant, clients have included:

ASSET OWNERS AND MANAGERS:

Bright & Duggan, Dalgety Australia, Dubai Dry Docks, Givens Emerson, Harrison Gray, Hones & Associates, Jonathan Abbott, Leighton Holdings Limited, Newcastle Council, Pearls Pty Ltd, Quay Apartments, Sydney Harbour Tunnel Company, Thomas Howell,

CONSTRUCTION VENTURES AND COMPANIES:

Abigroup Construction, Barclay Mowlem, Barclay Mowlem Thiess Joint Venture (Darwin), Baulderstone Hornibrook, Citistate Contractors, Costain, Frankipile, Gary Jenner Masterbuilders, Grindley Construction, John Holland, Market City Development, Theiss Contractors, Transfield, Transfield Bouyges Joint Venture (Sydney),

ENGINEERING AND ARCHITECTURAL CONSULTANTS:

Atlantic Civil Engineering, Beattie and Frost, Candac Limited, Coffey Partners International, Connell Wagner, Engelen Moore, Geoplan, Jack Hodgson Consultants, Longworth and McKenzie, Low and Hooke, McMillan Britton & Kell, MJW Associates, Partridge Partners, Pells Sullivan Meynink, Rankine and Hill, Sinclair Knight Mertz, SMEC International, Stubbs Cruickshank, Taylor Thomson & Whitting, Taywood Engineering, WMC Engineering Services,

CONCRITE QUARRIES PTY LTD

EXETER QUARRY EXTENSION

THE SUPPLY AND DEMAND OF COARSE AGGREGATE FOR WINGECARRIBEE SHIRE AND THE SYDNEY REGION WITH PARTICULAR REGARD TO THE EXETER QUARRY

Prepared by:

Minec Pty Ltd

14 July, 1999

Specialist Consultant Studies

Volume 1 ▪ Part 2

THE SUPPLY AND DEMAND OF COARSE AGGREGATE FOR WINGECARRIBEE SHIRE AND THE SYDNEY REGION WITH PARTICULAR REGARD TO THE EXETER QUARRY

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14 July 1999

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EXECUTIVE SUMMARY

The Report describes the hard rock resources of the Wingecarribee Shire, the classification and testing of coarse aggregates, the coarse aggregate resources within 130 km of Sydney, the Exeter Quarry resource and the demand and supply of coarse aggregate. This report has drawn upon statistical data available at the time of report compilation (1968/9 to 1996/97).

The Exeter Quarry is in the Wollongong Mining District and has operated since January 1978. Concrite Quarries Pty Ltd, then named Southern Highlands Quarries have operated the quarry since 1981. In the 1990's production has averaged 280,000 tonnes per year. About 30 percent of sales are supplied to the Sydney and Wollongong areas and 70 percent to the Wingecarribee Shire and Goulburn areas. Reserves in excess of 21 million tonnes of saleable basalt have been proved. In recognition of local environmental concerns and the term of approved extraction, the current proposed extraction plan provides for the production of up to 8.5 million tonnes of aggregate over an 18 year period.

The pre-mixed concrete market in Sydney requires approximately 4 million tonnes of coarse aggregate per year. Concrite Quarries Pty Ltd has about 10 percent of the Sydney market, requiring about 400,000 tonnes of crushed and broken stone per year, plus it needs to supply its southern market.

Wingecarribee Shire contains many occurrences of basalt and other igneous rocks but only 4 are of commercial significance; Exeter Quarry, Mt Flora, Mt Misery and a small basalt deposit at the Penrose Sand Quarry. The Mt Flora and Mt Misery resources are microsyenite that is not suitable for producing very high performance concrete, whereas basalt is.

The Sydney region consumes on average 7.8 million tonnes of coarse aggregate per year, consisting of crushed and broken stone that is used to produce concrete and other materials requiring high quality aggregate and prepared road base that uses lower quality aggregates. The Wollongong area consumes about 1.3 million tonnes per year of coarse aggregate and the Southern Highlands - Goulburn area consumes at least 0.35 million tonnes per year. Sydney's consumption of coarse aggregate has grown at an average rate of 22,000 tonnes per year. Sydney has not been able to produce enough coarse aggregate to meet its needs and imports aggregate from Wollongong, Exeter and the quarries in the southern Newcastle Mining District, plus minor amounts on an irregular basis from the Central West.

Sydney's production of crushed and broken stone has averaged 3.7 million tonnes per year and has been stable at this level. However, Sydney's self sufficiency will rapidly deteriorate as the Penrith Lakes Scheme that presently supplies about 80 percent of Sydney's production of crushed and broken stone is expected to be exhausted by between 2006 - 2008. Sydney's production of prepared road base has averaged about 3 million tonnes per year but has been falling at an average 29,000 tonnes per year since 1969.

The importing of basalt and latite into the Sydney region has averaged 1.2 million tonnes per year but has increased rapidly from 0.2 million tonnes in 1969 to as much as 2 million tonnes in recent years. About 80 percent of the imports are latite from the Wollongong Mining District with the remaining 20 percent being basalts from the Newcastle Mining Division and Exeter Quarry with small quantities more recently from Oberon.

A survey of coarse aggregate resources within 130 km of Sydney shows that there are no substantive replacements for the Penrith Lakes Scheme river gravels. Although large resources of aggregate occur at Mt Flora and Mt Misery, because of quality differences these deposits cannot fill all the markets met by the Penrith Lakes river gravels. Because of the high capital costs of starting production at Mt Flora and Mt Misery a large production rate is required to amortise the capital and it is likely that neither resource will be put into any or substantial production until the Penrith Lakes Scheme resource is exhausted.

Basalt is a preferred rock type for the production of high performance concrete and is the only aggregate capable of making the very highest quality concrete which includes high strength and low shrinkage concrete. The demand for high performance concrete is growing and will continue to do so for the foreseeable future.

The Exeter Quarry is an important resource for both Concrite Quarries Pty Limited and for the Sydney, Illawarra and the Southern Highlands regions. Concrite Quarries has developed an important market share in the Sydney region in competition against the "traditional" majors and needs a secure source of aggregate. It also supplies an important share of the southern market.

THE SUPPLY AND DEMAND OF COARSE AGGREGATE FOR THE SYDNEY REGION WITH PARTICULAR REGARD TO THE EXETER QUARRY

1. INTRODUCTION

Objectives and introduction to the Issues

Concrite Quarries Pty Limited has requested the author to analyse the past and future demand and supply of coarse aggregate for Sydney and Wingecarribee Shire and to describe the hard rock aggregate resources in the Wingecarribee Shire, to describe the classification of coarse aggregates and the testing of aggregates for suitability for the various possible uses, detail the hard rock aggregate reserves and production within 130 km of the geographic centre of Sydney and to describe the characteristics of the Exeter resource. The overall objective is to ascertain if the market can absorb and, in the public interest, requires increased supply from the company's Exeter Quarry in the Southern Highlands.

This report has drawn upon statistical data available at the time of report compilation (1968/9 to 1996/97).

The Exeter Quarry is in the Wollongong Mining District and has operated since January 1978. Concrite Quarries Pty Limited, then named Southern Highlands Quarries Pty Limited, took over the operation in 1981. Initial production was small but by the mid 1980's had increased to about 200,000 tonnes per annum and in the 1990's output has averaged about 280,000 tonnes per year.

The quality and quantity of the Exeter reserves have been appreciated only relatively recently. The Woodward Commission of 1985 regarded the deposit as not regionally significant, primarily because of the limited reserves that had been proved at that time, the view, that has proved to be incorrect, that the deposit has a high overburden ratio and the apparent lack of appreciation of the increasing significance of the very high quality of the material.

Further exploration by Concrite Quarries has proved insitu reserves in excess of 21 million tonnes of basalt on its land adjacent to the existing processing plant with only 0.65 million tonnes of overburden and up to 2.6 million tonnes of non-saleable rock. The proposed extraction area that is the subject of the current proposal will result in the production of up to 8.5 million tonnes of quality basalt over the 18 year period.

The Sydney region consumes on average 7.8 million tonnes of coarse aggregate per year while the Wollongong area consumes about 1.3 million tonnes per year and the Southern Highlands - Goulburn area consumes at least 0.35 million tonnes of hard rock coarse aggregate per year. Sydney cannot produce enough coarse aggregate to meet its needs and imports aggregate from Wollongong, Exeter and the central coast quarries, Peats Ridge and Kulnura, plus minor amounts on an irregular basis from the Central West. Sydney's self sufficiency will rapidly deteriorate as the quarries that presently supply about 80 percent of Sydney's production are expected to exhaust by between 2006 - 2008. The situation is exacerbated by an increasing trend for the use of very high strength and/or low shrinkage concrete in the construction of large buildings and bridges and these high performance concretes can best be made, and in some cases only made, with basalt aggregate. This places a high premium on the existing basalt quarries to the north of Sydney and on the Exeter Quarry.

Concrete using crushed basalt, latite or river gravel can obtain strengths of 80 - 100 MPa, 4-5 times stronger than the average of strength of normal concrete. However, basalt has an added advantage over river gravel and latite in that the use of basalt aggregate can result in concrete with very low shrinkage characteristics. The use of high strength and/or low shrinkage concrete is increasing in building construction and civil engineering projects.

The Concrite Group operate 12 concrete plants, 6 of which are in the Sydney region and another plant is planned for Blacktown. The Group supplies about 10 percent of the Sydney pre-mixed concrete market of between 2.5 million cubic metres and 3.5 million cubic metres per year. This means Concrite has a potential Sydney market for high quality aggregate in excess of 400,000 tonnes per year. In addition, Concrite supplies about 300,000 tonnes of product (aggregate and road base) per year into the southern market (the southern Sydney, Illawarra and Southern Highlands region). Concrite currently supplies its five non-Sydney concrete plants located in Mittagong, Moss Vale, Picton, Goulburn and Wollongong. The southern market is supplied from the Exeter Quarry. Even if a quarry was opened at one of the large known deposits of hard rock in the Southern Highlands, Concrite would still expect to retain half to two-thirds of its existing southern market plus its existing Sydney market, perhaps even increase its share of the Sydney market and also gain a share of any growth in the Sydney market (Crawley, 1998, personal communication).

Report Author

Professor Donald W Barnett is the author of the Report. Professor Barnett was Director of the Mineral Economic Centre at Macquarie University and presently is Visiting Professor, Mineral Economics, Western Australian School of Mines and is the Principle of Minec Pty Ltd. He holds degrees in geology and economics (U.WA) and a Ph.D in mineral economics from The Pennsylvania State University. He is a Centennial Fellow of the College of Earth and Mineral Sciences, The Pennsylvania State University and is F.AusIMM. His area of expertise is in the supply and demand for aggregates and black coal and has nearly 25 years experience in mineral economics. He also worked as an exploration geologist for BHP for 7 years.

Text in Section 2 relating to aggregate influences on concrete properties and aggregate testing has been provided by Harold Roper and Associates. Professor Roper holds degrees in science (B.Sc. (Hons), engineering (M.Eng.Sc.) and a Ph.D and is F.I.E.(Aust) and F.AusIMM.

Section 3: Characteristics of the Exeter Resource is taken from the **Environmental Impact Statement** on the Exeter proposal prepared by R W Corkery & Co Pty Limited, Geological and Environmental Consultants.

2. CLASSIFICATION OF AGGREGATE and CURRENT USAGE

Introduction

The aggregate market is divided into two very broad categories; coarse aggregate consisting of crushed rock of varying types and specifications and is generally referred to by the general public as aggregate or blue metal, and fine aggregate which is commonly referred to by the general public as sand. The coarse aggregate market is divided into two broad end use categories, hard rock aggregate and prepared road base.

> Hard rock aggregate is generally superior quality aggregate and comprises river gravel and crushed and broken stone (quarried rock which is crushed and screened to produce aggregate of various size gradings). Hard rock aggregate is principally used in concrete, for bituminous road sealing and as railway ballast. In the Sydney region, the principal materials used are river gravel, basalt, dolerite and some better quality volcanic breccia (SREP No.9, p66). Latite is also now widely used.

Basalt is mainly imported into Sydney from the southern Newcastle Mining District but some is imported from Exeter, that is in the Wollongong Mining District, and more rarely from the Central West. Latite, a volcanic rock somewhat like basalt, is imported from the Wollongong Mining District.

Prepared road base is generally produced from lesser quality rock and sometimes is combined with the fines of high quality rock.

> Prepared Road Base (PRB) consists of crushed rock fragments, blended with fine grained material comprising rock dust, decomposed rock or clay, with a grading that will produce maximum density or compaction. Crushed sandstone is included in this category. Fine Crushed Rock is a graded product similar to, though of higher quality than prepared road base. It is composed of sound rock and crusher fines and is used for the layer below the bitumen surfacing on roads ... In the Sydney region, lesser quality aggregate is generally used in the production of prepared road base although some higher quality materials are used in the production of the higher classes of roadbase, the principal rock types used are volcanic breccia, picrite, dolerite, olivine dolerite, basalt (and latite) and crushed sandstone (SREP No.9, p66).

In this study the following classification has been adopted. Crushed and broken stone (CBS) includes all igneous rock and gravel that is crushed and (or) sized and sold as coarse aggregate. The lesser quality rock and the fine crushed rock are classified together as prepared road base (PRB). Even though virtually all sandstone production is used in the preparation of PRB, as it is a distinct rock type at times it is shown as sandstone rather than including it with PRB.

Aggregate Tests to Accord with Australian Standard AS 2758.1

In assessing the acceptability of concrete aggregate from a newly developed quarry, substantial dependence must be placed on Australian Standard AS 2758.1 - 1998. This, Part One of the Standard, is the first in a series, which cover specification of aggregates and rock for engineering purposes. Other Parts are as follows:

Part 2: Aggregate for sprayed bituminous surfacing
Part 5: Asphaltic aggregates
Part 7: Railway Ballast

In general, the test requirements in Part 1 are the most stringent of all, and a majority of hard rock materials which pass these are also found to be suitable for use in sprayed bituminous surfacing and asphaltic binding, and as railway ballast.

AS 2758.1 - 1998, which is called up by AS 3600, Concrete Structures, relies on tests which are outlined in AS 1141, Methods for sampling and testing aggregates, which is designed to include all aggregate tests, including those specific to other than concrete aggregates.

Properties that are required to be known for a concrete mix design, (including particle density, bulk density, water absorption, particle size distribution, alkali aggregate reactivity and soluble salts, if above reportable levels) are governed by choices or limits in specific work specifications. This allows the designer to include or eliminate materials for use in his/her works which otherwise may have been excluded or included if general limits were to have been stated in the Standard.

Durability of coarse aggregate is related to the use of concrete and its exposure, and is therefore not simply a mix design factor. In this case the works specifier is called on to select an exposure classification and chose one of three methods of assessment. The methods available are: wet strength and wet/dry strength variation, Los Angeles value and sodium sulphate soundness, and Los Angeles and unsound and marginal stone content. Even though limits are given in the Standard, considerable latitude is given to the designer to modify these, if considered appropriate.

Aggregates and Concrete Quality

Concretes of normal strength grades, typically 20 to 25 MPa, can be produced with a wide range of igneous rock aggregates and gravel. There is a growing market for high performance concretes, including concretes of very high strength and concretes with very low shrinkage characteristics. The very high strength concretes (80 to 100 MPa compared to the maximum normal class strength of 50 MPa) can normally be produced with high quality aggregates such as basalt, crushed river gravels and latite.

> However, high concrete elastic modulus and low concrete shrinkage may also be required in these concretes and, in this regard, basalts are the preferred aggregates over latites and crushed river gravels (Ortiz, 1997).

Very high strength is often specified for high rise buildings where the smaller structural members that can be produced with the concrete allows significant gains in useable space. Very low shrinkage concrete is used where the building designer requires improved control over concrete drying shrinkage, such as with large warehouse floors and roof slabs. High strength concrete permits more rapid construction procedures to be implemented, thus allowing cost savings. Thus, even though the strength of concrete in such structures may not be so important per se, the outcome of use of high strength concrete is almost invariably advantageous. Because of the high cement contents of high strength concretes, the properties of aggregate to control shrinkage is crucial to its application.

Very low shrinkage concretes typically show shrinkage characteristics of 450 - 500 micro strains (measured after 8 weeks drying). Lesser quality concretes are covered by the Australian Standard AS 1379 that calls for a maximum of 1000 micro strains. I am advised that this would require an average of about 850 micro strains and that the proposed amendment to AS 3600 suggests that designers assume an average of 850 micro strains for normal-class concrete. Very low shrinkage concretes are only produced with true basalt aggregates.

In order to produce high strength, low shrinkage concretes, at the lowest cost, aggregates with high modulus of elasticity are required to be used. Basalt aggregates have the highest moduli and lowest intrinsic shrinkage of any aggregates available in the Sydney area. This means that demand for such material should continue to increase above that for river gravels, latites and the local dolerites. The strengths, for equal water/cement ratios and using a single cement, are generally in decreasing order from basalt, river gravel, latites, and certain doleritic rock types, the latter giving the lowest values. A similar order exists for elastic moduli. For shrinkage the opposite order is observed, with basalts, particularly non-amygdaloidal types, producing the lowest shrinkages. A set of Modulus of elasticity data for some rock types supplied to the Sydney Market is given in Table 1.

It would be expected and demonstrated that concrete of high modulus and low shrinkage would result from the high aggregate modulus of the rock both from the existing extraction area within Exeter Quarry and from the proposed extraction area.

> Another category of high performance concrete is high durability concrete where there is a very long design life and/or exposure to severe conditions. Aggregate parameters which are relevant in optimising concrete durability include high wet strength, low wet/dry strength variation, low alkali reactivity, low chloride content and low sulphate content. In all of the above parameters, the basalts have the significant advantage compared to crushed river gravels and latites (Ortiz, 1997).

Table 1 Modulus of Elasticity of Aggregates

Aggregate Source	Petrological Classification	Modulus of Elasticity (GPa)
Exeter Quarry	Basalt (1)	78
Exeter Quarry	Basalt (2)	86
Prospect Quarry	Dolerite	78
Prospect Quarry	Essexsite	71
Prospect Quarry	Picrite	68
Peats Ridge Quarry	Basalt	88
Nepean River	Dolerite gravel pebble	76

Notes: (1) amygdaloidal basalt; (2) Broken and massive basalt

The demand for basalt aggregate, such as the Exeter Quarry basalt, is increasing. The qualities of typical rocks used for concrete aggregates for the Sydney region are discussed in Harold Roper & Associates (1999). Results show that basalt aggregate consistently out ranks the other rock types in that it has higher bulk density, lower water absorption, greater wet and dry strength and, generally lower wet/dry strength variation, lower shrinkage characteristics (fewer micro strains) and lower Los Angeles value.

Overall demand for high grade basaltic aggregates should continue to grow as higher strength and better long term durability is specified for many more types of structure than is the case at present.

Coarse Aggregates Used in Wingecarribee Shire and the Sydney Region

Wingecarribee Shire

The coarse aggregates most commonly used in the Wingecarribee Shire are basalt from Exeter, Latite from the Wollongong quarries and a rhyodacitic tuff from the Johnniefields Quarry near Marulan. Rhyodacitic tuff is a hard, cohesive volcanic ash. Like the rhyodacitic tuff, basalt and latite are igneous volcanic rocks. The location of these quarries and of the other resources within 130 km of the geographic centre of Sydney are shown in **Figure 1**.

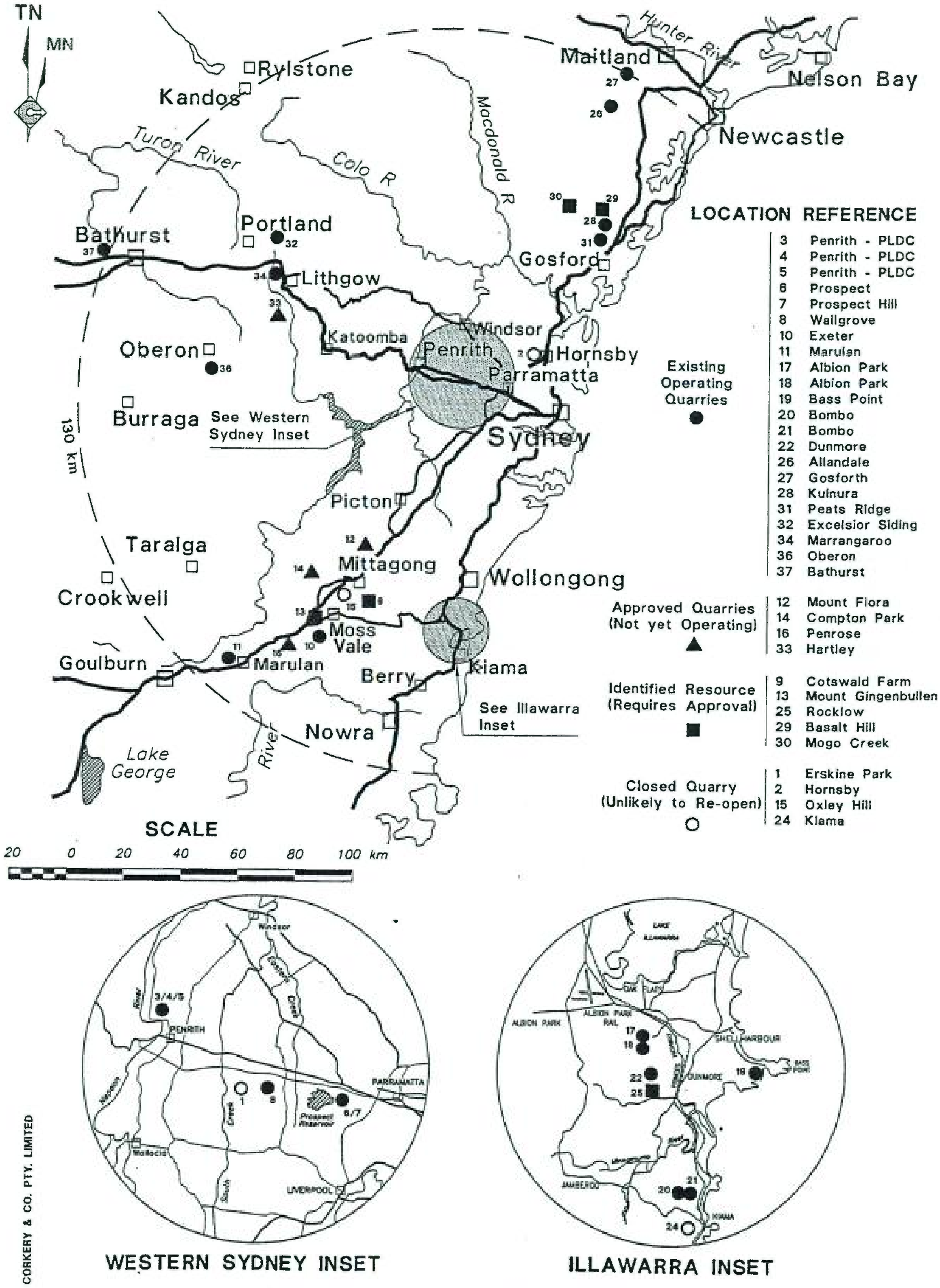
The limestone quarry at Muralan South is owned by Blue Circle Cement and the output is used in the production of cement. Production from the Johnniefields Quarry goes to Rocla's concrete rail sleeper factory in Mittagong, to the RTA for bitumen road sealing and to the railways for ballast (G. McClelland, pers.comm., 1999).

Up to 75 percent of the Exeter Quarry output is consumed in the Southern Highlands and Goulburn. In recent years consumption outside of Sydney and Wollongong has averaged about 180,000 tonnes per year (W Crawley, pers.comm., 1998). About 55 percent of the latite production from the Wollongong area is exported to Sydney, indicating that 45 percent is consumed in the Wollongong - Southern Highlands region; the amount consumed in the Southern Highlands is not known. In 1996/97 the Johnniefields Quarry produced 175,000 tonnes of crushed and broken stone of which most, if not all was consumed in the Southern Highlands - Goulburn area.

Small quantities of blast furnace slag from the Port Kembla steel works is used for the production of normal strength concrete and prepared road base.

The two largest aggregate resources in the Wingecarribee area, the Mt Flora and Mt Misery microsyenite occurrences, have yet to be developed but consent for both have been granted. Microsyenite is an igneous rock and testing shows it is suitable for concrete production.

Figure 1 Location of Coarse Aggregate Resources within 130 km of the Geographic Centre of Sydney



Sources: NSW Geological Survey Hard Rock Aggregate Reserve Data Base, Dec. 1998; SREP N°2, (Draft) Working Papers p.67; V. Smith, 1996; International Environmental Consultants Pty Ltd, 1997; McVeigh, 1998; Sinclair Knight Merz, 1994.

Sydney - Coarse and Broken Stone

Igneous Rock.

In the Sydney region the most widely quarried igneous rocks for the production of coarse aggregate are:

basalt (a basic - low in silica - volcanic rock comprised largely of plagioclase felspar and pyroxene),

latite (a volcanic rock somewhat similar to basalt but with more silica and consisting of plagioclase and orthoclase felspar and augite, hornblende, biotite and olivine),

dolerite (a hypabyssal - medium depth - rock of similar composition to basalt but coarser grained),

volcanic breccia (a volcanic rock formed in the neck of a volcano and subsequently broken up by movement or pressure from the underlying magma and cemented with other igneous rock), and

olivine dolerite (a basic to ultra basic hypabyssal rock rich in olivine).

Crushed and broken stone (CBS) of an igneous origin is generally produced from fresh basalt, latite, dolerite and volcanic breccia, although in recent years in the Sydney region the use of volcanic breccia for this purpose has been declining. The main uses of the CBS are for bituminous road sealing, for railway ballast and as aggregate in concrete production. Very high strength concrete is dependent on high quality aggregate and basalt satisfies this requirement. Concretes that require very low shrinkage characteristics can only be supplied by the basalts from Exeter and the Central Coast at this stage.

The rock is quarried, generally, by excavator with or without drilling and blasting, then crushed and screened to produce aggregate of various size gradings.

The lesser quality igneous rock, including weathered high grade rock , is used to produce prepared road base. Most of the volcanic breccia quarried in the Sydney region is used for this purpose (see below).

River Gravel

River gravel is produced from the Nepean - Hawkesbury River systems between Emu Plains and North Richmond. The gravel is extracted, washed, crushed and screened. The dominant rock types represented in the gravel are quartzite (a metamorphosed sandstone) and porphyry (a plutonic acid (high silica content) igneous rock), with less common chert (a siliceous rock), hornfels (a metamorphosed shale) and quartz. The gravels usually produce a sound coarse aggregate which is regarded as a high quality concrete aggregate.

Very high strength concrete can be produced with the better quality river gravel aggregates. The shrinkage characteristics of concrete produced with river gravels are generally inferior to concretes produced with basalts, but superior to concretes produced with latites (Ortiz, Oct. 1997, Roper, Oct. 1997).

The vast majority of river gravel comes from the Penrith Lakes scheme. However, the reserves are expected to be exhausted by between 2006 and 2008 (see Section 10).

Blast Furnace Slag

Blast furnace slag from the Port Kembla steel works is used as both CBS and as an additive to PRB. In the 1980's the pig iron making process was slightly changed by adding serpentine to the blast furnace, which caused the slag to change from a vitreous form to vesicular. It was found that when the slag was used to produce concrete the vesicles enhanced the adhesion of the cement to the aggregate. Statistics on the consumption of blast furnace slag in the Sydney region are not kept, but the consumption is believed to be relatively modest (Prosser, 1997, personal communication).

The use of slag aggregate in high strength concrete is limited due to the physical and chemical characteristics of slag. Most concrete producers limit its use to normal-class concrete and blend it with natural aggregates to achieve acceptably pumpable concrete. Concrite normally limits its use to a maximum of about 50% of coarse aggregate in concrete and confines its use to lower strength grade concretes (Crawley, 1998, personal communication).

Sydney - Prepared Road Base (PRB)

Most of the volcanic breccia produced in the Sydney region as well as the basalt, dolerite, olivine dolerite and some picrite (a rock consisting of phenocrysts of olivine in a glassy groundmass) from the Prospect quarries are used to produce PRB. The material is frequently stabilised with lime or cement. Crushed blast furnace slag can also be used to improve the quality of the PRB. High quality crushed rock is used, or blended into fine crushed rock, as basecourse or in specialised applications.

Originally sandstone was classified as CBS even though it is not used to produce concrete aggregates, sealing aggregate or rail ballast. Almost all the sandstone produced in the Sydney region is used in the production of PRB. The sandstone is mainly obtained by quarrying, crushing and screening the Hawkesbury Sandstone that is ubiquitous to the Sydney area. The sandstone may be quarried by blasting and/or ripping and is crushed generally to minus 75mm to form a material with a relatively high sand sized fraction and low to medium plasticity. The material is used substantially in road making (as sub-base and shoulders) and may be stabilised with lime. Sandstone tends to abrade faster than crushed igneous rock and therefore is unsuitable as a source of CBS.

3. CHARACTERISTICS OF THE EXETER RESOURCE

Geological Setting

The proposed extraction area is underlain by a series of basalt lava flows and sills thought to be approximately 20 million years old (Resource Planning, 1993). Since the lava flows are thought to have infilled old river valleys, the base of the lowest flow is somewhat variable. For example, within the proposed extraction area, the base of the lowest flow rises from approximately 662 m, AHD on the north-western side of the proposed extraction area to in excess of 705 m, AHD at its outcrop near the south-eastern side of the proposed extraction area.

The flows or sills beneath the proposed extraction area are predominantly olivine basalt that are either fine-grained or amygdaloidal. Each flow or sill is variable in thickness but collectively form a substantial thickness of basalt suitable for extraction. The basalts within the proposed extraction area exhibit varying degrees of hydrothermal alteration principally through the presence of zeolite minerals. Where alteration is substantial, particularly in the amygdaloidal basalts, weathering is assessed to be more prevalent. The basalt flows and sills are underlain by shales and lithic sandstones of the uppermost unit of the Wianamatta Group (the Bringelly Shale). This unit crops out on the steeper sections of the Proposed extraction area and within the Indigo Creek valley, immediately south of Rockleigh Road.

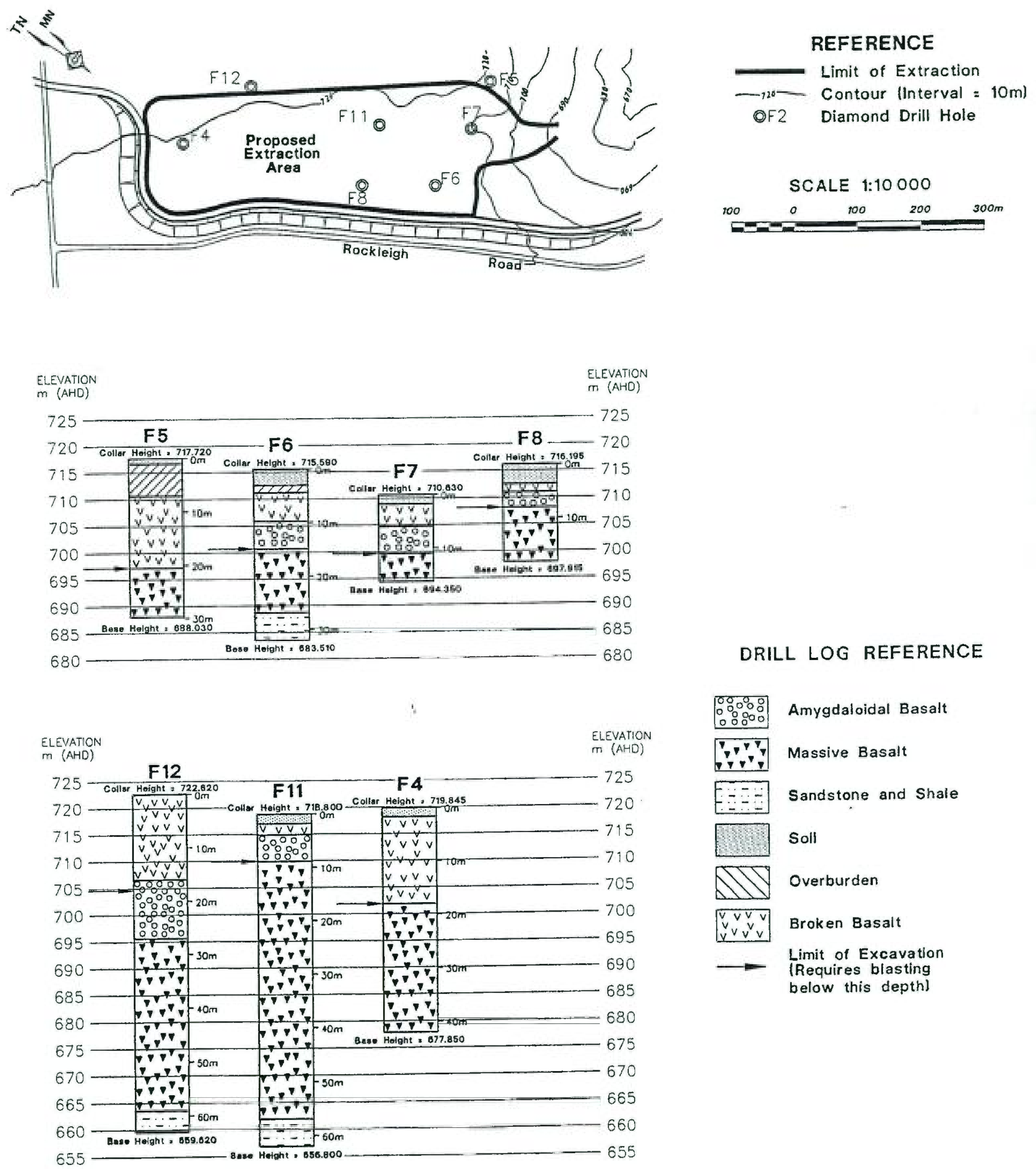
Site Geological Investigations

The Company undertook a range of site geological investigations to determine the extent and nature of the basalt resources within the proposed extraction area. The investigations comprised a diamond drilling programme and a series of costeans or trenches.

Diamond Drilling

Eleven diamond drill holes have been drilled within or immediately surrounding the proposed extraction area, three of which intersected all basalt flows or sills and penetrated the underlying Bringelly Shale (Drill holes F6, F11 and F12). **Figure 2** displays the graphic logs of each of the seven holes drilled.

Figure 2 Graphic Logs DDH Proposed Exeter Extraction Area



GRAPHIC DRILL LOGS*

* Prepared from descriptive logs recorded by Concrite Quarries Pty Ltd

Source: 1999 EIS

R.W. CORKERY & CO. PTY. LIMITED

Figure 2
GRAPHIC LOGS OF DIAMOND DRILL HOLES WITHIN AND SURROUNDING THE PROPOSED EXETER EXTRACTION AREA

Minec Pty Ltd

Costeans

A total of four costeans were excavated within the proposed extraction area to confirm the excavatability of the basalt rock. Furthermore, the costeans provided the Company with an opportunity to recover a bulk sample of each of the main rock types, with the exception of the fine grained massive basalt, to undertake plant trials.

The site geological investigations have identified that there are three main types of basalt within the proposed extraction area.

1. Broken Basalt

An olivine basalt with closely spaced jointing that enables the rock to be extracted by excavator and without drilling and blasting. The joint planes are strongly coated with yellow and orange iron oxides and clay produced from the weathering of the basalt. However, weathering rims of extracted boulders extend only a few millimeters into the otherwise fresh basalt.

This material, which is very similar to the rock being extracted within the existing extraction area, is interpreted to be a separate flow or sill which varies in thickness on site from zero (outcrop) on the south-eastern side of the proposed extraction area to almost 18 m on the north-western side of the proposed extraction area (Drill Hole F4). Notwithstanding the comparatively thick nature of the basalt flow near Drill Hole F4, this flow or sill is comparatively thin elsewhere within the proposed extraction area, varying in thickness from approximately 2 m to 5 m.

Trial bulk samples of the broken basalt were extracted using an excavator and processed in the existing processing plant to yield high quality hard rock aggregates.

The broken basalt from the existing extraction area produces high quality concrete aggregate with an extremely high modulus of elasticity. It is sought for use in very high strength concretes (>80 MPa), for high rise construction, and in mixes which required controlled low shrinkage and creep properties, for bridge and prestressed concrete works. The broken basalts within the proposed extraction area would fill a similar place in the special concrete market that is growing daily.

2. Amygdaloidal Basalt

Over most of the proposed extraction area, the broken basalt is underlain by an amygdaloidal olivine basalt, that is, a basalt containing gas cavities (amygdules). The amygdaloidal basalt varies in thickness from a few metres to almost 25 m. The upper 8 m to 12 m of this unit is sufficiently weathered so that not all of the rock is suitable for use as concrete aggregate or as a component in blended products. Below the limit of excavation shown on **Figure 2**, the amygdaloidal basalt would require blasting.

The amygdaloidal basalt from the proposed extraction area would along, and with some judicious blending with the massive basalt, provide concrete aggregates for use in concrete strength grades up to 32 MPa. The amygdaloidal basalt would also provide crushed rock materials for road construction. The weathered residual material of this rock type may be sought for unsealed or stabilised road-base materials.

3. Massive Basalt

A massive light grey, fine-grained olivine basalt is present beneath the amydgaloidal basalt within the proposed extraction area. This basalt flow lies directly upon the shales and sandstones of the Bringelly Shale. The basalt contains a number of units of hard, light to dark grey, amygdaloidal basalt which is similarly massive and would require drilling/blasting to enable extraction. This basalt varies in thickness from approximately 10 m to at least 40 m (see **Figure 2**).

The massive basalt material is expected to provide high grade concrete aggregate of superior properties to those of the broken basalts.

An important outcome of the geological investigations was the assessment of the recovery rates for each type of basalt given the presence of either weathered or altered material, principally within the broken basalt and amygdaloidal basalt. It is estimated that an average 85 per cent of the broken basalt and 70 per cent of the amygdaloidal basalt is recoverable to produce saleable products. The massive basalt would yield 100 per cent of products.

Resource Assessment

The geological data outlined in Section 3.3.2 of the EIS has provided the basis for a geological assessment of the quantity of resources present.

The boundaries of the proposed extraction area have been defined following a review of a number of constraints. At the outset, it was determined to define an area that could produce approximately 8.5 million tonnes of basalt products. The two principal constraints related to resource occurrence and positioning the extraction area at the lowest possible elevation in the landscape. The defined proposed extraction area contains sufficient basalt to yield products from:

Broken Basalt – 1.5 million tonnes.
Amygdaloidal Basalt – 0.7 million tonnes.
Massive Basalt – 6.3 million tonnes.

Planned Sales

Sales are planned to remain at or below the present rate of 300,000 tonnes per year for a maximum of 3 years until the Exeter intersection bypass is constructed and then gradually increase to a maximum of 450,000 tonnes per year for the remainder of the 18 year consent period sought (Corkery, 1999).

The low waste to saleable rock ratio and the extent of free digging material will cause the Exeter Quarry to continue to be a low cost producer.

4. HARD ROCK COARSE AGGREGATE RESERVES WITHIN 130 KILOMETRE RADIUS OF THE GEOGRAPHIC CENTRE OF SYDNEY

The reserves of hard rock aggregate capable of producing CBS within 130 km radius of the geographical centre of Sydney are shown in **Table 2** and **Figure 1**. The distance of 130 km was selected by the NSW Geological Survey as a reasonable distance to study in terms of transport costs and resource distribution. Small quantities of basalt are imported into Sydney on an irregular basis from the Oberon - Bathurst - Dubbo area and a review of the coarse aggregate resources of this area is also included.

The great majority of the data included in this section was generously provided by the NSW Geological Survey from their computer data bank of the State's aggregate resources. The reserves are given in qualitative as well as quantitative terms. A *huge* resource is one where the reserves are believed to exceed 100 million tonnes, a *very large* resource is one with reserves expected to be between 10 million and 100 million tonnes, a *large* resource is one with expected reserves between 1 and 10 million tonnes, a *medium* resource is one with reserves less than 1 million tonnes but greater than 0.1 million tonnes and a *small* resource is one with expected reserves less than 0.1 million tonnes. *Occurrence* is used where there is too little information to attempt to gauge the size of the resource.

Where quantitative reserves are shown, their category of reliability is also shown. *Measured* reserves are those where there has been extensive drilling, costeaning and perhaps extraction so that there is a high level of geological confidence that the stated reserves are actually present. *Indicated* reserves are those where insufficient drilling, etc has been done to call the reserves measured but there is good geological evidence that the reserves will prove to be there. *Inferred* reserves are estimates based on little outcrop and/or drilling information and it can not be concluded that the reserves are necessarily present. A resource can have measured, indicated and inferred reserves and the total reserves present is given by the sum of the categories present. The date of the latest reserve estimate is shown. Whether a development consent has been granted is shown, and if no development consent has been granted whether the reserves have been secured by a quarrying company. The rock type and whether the reserves are being exploited are also shown, as is the name of the company controlling the resource.

The Sydney region contains 7 operating igneous rock aggregate quarries with measured reserves of about 9.5 million tonnes (assuming the Hornsby and Wallgrove quarries include their reserves within the measured category) and between 30 - 37.5 million tonnes of gravel reserves at the Penrith Lakes scheme. The Penrith reserves of sand and gravel were estimated in 1996 at 75 million tonnes (Smith, 1996) but the amount of gravel was not stated. It is likely that the remaining gravel reserves will comprise between 40 and 50 percent of the total reserves. Total Sydney reserves of hard rock aggregate are estimated at between 39.5 million tonnes and 47 million tonnes.

Table 2: Hard Rock Aggregate Reserves within 130 Km Radius of the Geographic Centre of Sydney

Location Number	Quarry Name	Company	Location	Operating Status	Rock Type	Size Category	Reserves Mill.tonnes	Reserve Category	Date of Estimate	Development Status and/or comments
SYDNEY							39.5-47 mt Total			
1	Erskine Park, Mamre Rd	CSR Readymix		ceased	Volcanic breccia					
2	Hornsby	CSR Readymix	Hornsby	operating	Volcanic breccia	Large	5		1991	SREP No.9 Draft, p.67
3	Penrith	Boral	Penrith Lakes	operating	Gravel	Very large	{estimated	indicated		Reserves sand & gravel
4	Penrith	CSR Readymix	Penrith Lakes	operating	Gravel	Very large	{ gravel	indicated	Oct.1996	Oct 1996 75mt, reserves of
5	Penrith	Pioneer	Penrith Lakes	operating	Gravel	Very large	{ ~30-37.5	indicated		gravel not stated
6	Prospect	CSR Readymix	Prospect	operating	Picrite / dolerite	Large	<1	measured	1990/91	secured
7	Prospect Hill	Boral	Prospect	operating	Picrite / dolerite	Large	<1	measured	1990/91	secured
8	Wallgrove	Pioneer	Minchinbury	operating	Volcanic breccia		2.5		1991	
SOUTHERN HIGHLANDS							115.6-920 mt total			
9	Cotswald Farm			never oper.	Syenite	Occurence				
10	Exeter	Concrite	Exeter	operating	Basalt	Very large	20.8	measured	01-May-92	Development Approval
11	Johnniefields Hardrock	CSR Readymix	near Marulan	operating	Rhyolite	Large	7	inferred	29-Mar-93	consent
12	Mount Flora	CSR - Readymix	North of Mittagong	resource	Micro-syenite	Very large	32.4	indicated	01-Jun-89	DA; Main Hill & N.Slope
							70	inferred	01-Jun-89	Whole resource
13	Mount Gingenbullen			resource	Dolerite	Very large	23	inferred	01-Jan-74	
14	Mount Misery	Rocla	West of Mittagong	resource	Micro-syenite	Very large	23	indicated	30-Sep-89	DA; Initial quarry area
						Huge	790	inferred		Entire extraction area
15	Oxley Hill		2 km west Bowral	ceased	Basalt		2	inferred	27-Feb-84	Weathered, PRB?
							6	inferred	27-Feb-84	Unweathered
16	Penrose Quarry	Heggies Bulkhau	20 km SW Berrima	expansion	Basalt (&sand)		1.6		Oct 97	0.5 mt fresh, 1.1 mt weathered
WOLLONGONG							193 mt total (123 mt measured)			
17	Albion Park Rail Quarry	Cleary Bros	near Shell Harbour	operating	Latite	Large	3.19	measured	1995	unknown
18	Albion Park Rail Quarry	CSR	near Shell Harbour	operating	Latite	Very large	32	measured	01-Nov-95	consent
19	Bass Point	Pioneer	near Shell Harbour	operating	Latite	Very large	37.5	measured	15-Oct-97	consent
20	Bombo	Boral	near Kiama	operating	Latite	Very large	15	measured	01-May-92	consent
21	Bombo	SRA	near Kiama	operating	Latite	Very large	18	measured	01-May-92	consent
22	Dunmore	Boral	near Shell Harbour	operating	Latite	Very large	5	measured	01-May-92	consent
							12	measured	01-May-92	secured, no consent
23	Hyams Beach		South Jervis Bay	never oper.						prospect
24	Kiama		Kiama	ceased						
25	Rocklow Deposit	Boral	Shell Harbour	resource	Latite	Very large	70	inferred	01-May-92	secured, no consent
NEWCASTLE							27.8 mt total			
26	Allandale		near Cessnock	operating	Andesite					
27	Gosforth		Near Maitland	operating	Rhyolite	Medium	0.3	inferred	1995	
28	Kulnura - Basalt Hill	Hymix	Hawksbury	resource	Basalt	Large	5	inferred		
29	Kulnura, George Downes	Hymix	Hawksbury	operating	Basalt		6		1990	
30	Mogo Creek		St Albans, N.of Kulnu	operating	Basalt breccia	Small				
31	Peats Ridge, Bushells Rd	Boral	Hawksbury	operating	Basalt	Very large	12.5	measured	01-Jan-95	
LITHGOW							35.4-115.8 mt			
32	Excelsior Siding	Hyrock	near Lithgow	operating	Limestone					
33	Hartley Rhyolite	Aus10Rhyolite	Hartley, south Lithgow	proposal	Rhyolite	Very large	20	measured	July 1994	resource (secured)
34	Marrangaroo	Metromix	near Lithgow	operating	Quartzite	Large	7.75		15-Jul-95	
OBERON										
36	Langley Heights		Oberon	operating	Basalt					

Sources: NSW Geological Survey Hard Rock Aggregate Reserve Data Base, Dec. 1998; SREP No.2,(Draft) Working Papers p.67; V.Smith, 1996; International Environmental Consultants Pty Ltd, 1997; McVeigh, 1998; Sinclair Knight Merz, 1994.
Minec Pty Ltd, February 1999

The Southern Highlands region has by far the greatest hard rock aggregate resources of the regions near to Sydney. Total resources are placed between 115.6 million tonnes and at least 920 million tonnes, depending on how much of the Mt Flora and Mt Misery resources are included. Only the Exeter reserves of 20.8 million tonnes are classified as measured, but at least some of the 7 million tonnes of inferred reserves at Johnniefields should be regarded as measured as quarrying is ongoing. Mount Flora has indicated reserves of 32.4 million tonnes and inferred reserves of 70 million tonnes of microsyenite. Mount Misery has indicated reserves of 23 million tonnes and inferred reserves of 790 million tonnes of microsyenite. Mount Gingenbullen has inferred reserves of 23 million tonnes of dolerite. Oxley Hill has 2 million tonnes of inferred weathered basalt and 6 million tonnes of inferred unweathered basalt reserves. Cotswald Farm has an occurrence of syenite but the reserve size is unknown. Heggies Bulkhaul Limited have proposed an extension of their Penrose quarry, 20 km south west of Berrima. The quarry produces sand but the expansion includes a small lens of a basalt flow with 1.6 million tonnes of reserves, of which one-third is fresh rock and two-thirds extensively altered (weathered). It is proposed to produce basalt froannum (IEC, 1997).

While the Southern Highlands may have the largest resource base, the Wollongong area has the largest quantity of measured hard rock reserves. The Wollongong area has 120 million tonnes of measured latite reserves, of which 105 million tonnes are held with development consent by companies with quarries presently operating. The largest undeveloped resource in the region consists of 70 million tonnes of inferred latite reserves secured by Boral at Rocklow near Shellharbour, but consent for quarrying the resource has not been given.

The Newcastle District has about 28 million tonnes of hard rock aggregate reserves within 130 km of Sydney. The basalt deposits in the Hawkesbury area contains 23.5 million tonnes of these reserves of which 18.5 million tonnes are either measured or associated with an ongoing quarry. Small reserves of andesite and rhyolite occur in the Maitland - Cessnock area.

The Lithgow/Oberon area contains about 37 million tonnes of approved reserves of hard rock aggregate reserves of quartzite, basalt and rhyolite. The quarry at Marrangaroo has reserves of approximately 7.8 million tonnes of quartzite (a metamorphosed sandstone). A recently developed basalt quarry near Oberon (Langley Heights) is understood to be producing approximately 130 000 tpa. This quarry has total reserves of approximately 40 million tonnes whereas reserves in the initial approved quarry area are stated to be approximately 9 million tonnes. The Hartley rhyolite deposit has 20 million tonnes of measured reserves of rhyolite and is held by a pastoral company and plans are being finalised for development.

5. HARD ROCK AGGREGATE PRODUCTION IN 1996/97 IN SYDNEY, SOUTHERN HIGHLANDS, WOLLONGONG AND THE BATHURST-ORANGE REGIONS

In 1996/97 the hard rock aggregate production in the Sydney, Southern Highlands, Wollongong and Bathurst - Orange regions totalled 12.8 million tonnes, consisting of 11.0 million tonnes of CBS and 1.8 million tonnes of PRB & FCR (**Table 3**). Some of the quarries in the Bathurst - Orange region are outside the 130 km radius of the geographic centre of Sydney but are included in this discussion for completeness as occasionally small quantities of coarse aggregate is imported from quarries in this region.

Quarries in the Sydney Mining District produced a total of 5.1 million tonnes of hard rock aggregate in 1996/97, consisting of 4.1 million tonnes of CBS and 1 million tonnes of PRB & FCR. The Penrith gravel quarries produced 3.3 million tonnes of CBS, or 80 percent of the Sydney CBS production. Prospect Hill produced over 70 percent of the PRB & FCR production.

In the Newcastle District the basalt quarries in the Hawkesbury region immediately to the north of the Sydney District produced 0.8 million tonnes of basalt CBS in 1996/97. The andesite and rhyolite quarries near Maitland and Cessnock produced 0.2 million tonnes of CBS and 0.5 million tonnes of PRB & FCR.

The Wollongong region produced 2.5 million tonnes of latite CBS and 0.3 million tonnes of PRB & FCR in 1996/97.

In 1996/97 the production of hard rock in the Southern Highlands - Goulburn area totalled nearly 3 million tonnes of which 2.6 million tonnes was from the Marulan South limestone quarry owned by Blue Circle Cement and used for cement production. The Exeter Quarry produced 0.15 million tonnes of basalt CBS and 0.15 million tonnes of PRB. The Johnniefields rhyodacitic tuff quarry produced 0.2 million tonnes of CBS.

In the Lithgow area in 1996/97 CBS production consisted of 0.1 million tonnes of limestone and quartzite CBS and 0.1 million tonnes of PRB & FCR, also limestone and quartzite.

In the Bathurst - Evans region 0.2 million tonnes of CBS and 0.1 million tonnes of PRB & FCR was produced from two basalt quarries. In the Dubbo area 0.1 million tonnes of CBS was produced in 1996/97 from CSR Readymix's basalt quarry. No production was recorded from the Oberon region in 1996/97 however, it is now understood to be producing and despatching some of its production to the Sydney market.

Table 3: Hard Rock Aggregate Production in 1996/97 for Sydney Region, Southern Highlands Area, Wollongong Area and Bathurst - Orange

Quarry/Region	Company	Quarry ID	Location/District	Rock Type	Total CBS	PRB & FCR	Total Production
SYDNEY REGION							
Prospect Hill	Boral	621	Sydney	Dolerite	406,862	724,212	1,131,074
Homsby	CSR Readymix	606	Sydney	Volc.Breccia	54,311	46,165	100,476
Prospect	CSR Readymix	1434	Sydney	Dolerite	216,661		216,661
Wallgrove	Pioneer	1145	Sydney	Volc.breccia	129,380	241,611	370,991
Railway St Emu Plains	Boral	1153	Penrith	Gravel	1,038,642		1,038,642
Sheens Lane	CSR Readymix	1155	Penrith	Gravel	1,466,640		1,466,640
Cranebrook	Pioneer	1149	Penrith	Gravel	759,924		759,924
Total Sydney/Penrith					*4,072,420*	*1,011,988*	*5,084,408*
NEWCASTLE							
Peats Ridge, Bushells Rd	Boral	117	Newcastle	Basalt	454,000		454,000
Kulnurra, George Downes Dr	Hymix	1121	Newcastle	Basalt	321,434		321,434
Sub Total Southern Newcastle					*775,434*	*0*	*775,434*
Mogo Ck, St Albans		4474	Newcastle	Basalt	228		228
Allandale	Quarry Product	5100	Newcastle	Andesite	195,938	227,937	423,875
Gosforth		6341	Newcastle	Rhyodacite	30,000		30,000
Sub Total Northern Newcastle					*226,166*	*227,937*	*454,103*
WOLLONGONG							
Dunmore	Boral	1293	Wollongong	Latite	331,800	124,600	456,400
Bombo, Boral	Boral	4233	Wollongong	Latite	360,308		360,308
Albion Park Rail	CSR Readymix	1291	Wollongong	Latite	592,543	25,708	618,251
Albion Park	Cleary Bros		Wollongong	Latite	70,000		70,000
Bass Point	Pioneer	4023	Wollongong	Latite	722,305		722,305
Bombo, SRA	SRA	1091030	Wollongong	Latite	458,600	170,000	628,600
Total Wollongong					*2,535,556*	*320,308*	*2,855,864*
SOUTHERN HIGHLANDS - GOULBURN							
Exeter	Concrite	4809	Southern Highlands	Basalt	286,600		286,600
Johnniefields, Marulan	CSR Readymix	5293	Southern Highlands	Rhyodacitic Tuff	175,365		175,365
Marulan South	Blue Circle Cement	532	Goulburn	Limestone	2,611,046		2,611,046
Total Southern Highlands					*3,073,011*		*3,073,011*
LITHGOW							
Excelsior Siding	Hyrock	2695	Lithgow	Limestone	50,508	82,368	132,876
Marrangaroo, Oakey Forest Rd	Metromix	824	Lithgow	Quartzite	56,892	51,237	108,129
Total Lithgow					*107,400*	*133,605*	*241,005*
BATHURST - EVANS							
West Wyalong,Wargin Rd	Manso Holdings	4585	Bathurst	Basalt	34,409	56,553	90,962
Orange Rd Bathurst	Pioneer	656	Bathurst	Basalt	124,298	57,800	182,098
Caloola	LH McGill	4073	Evans (Bathurst)	Marble blocks	0		0
Total Bathurst - Evans					*158,707*	*114,353*	*273,060*
DUBBO							
Talbragar, Brocklehurst	Boral	737	Dubbo	Basalt	0		0
Dubbo, 10 km east	CSR Readymix	5317	Dubbo	Basalt	118,997		118,997
Total Dubbo					*118,997*		*118,997*
OBERON							
Langley Heights			Oberon	Basalt	NA		NA
Oberon	CSR Readymix		Oberon	Gravel	NA		NA
Shadforth	Boral		Orange	Gravel	NA		NA
Total Oberon							
TOTAL					**11,067,691**	**1,808,191**	**12,875,882**

Minec Pty Ltd, February 1999

6. HARD ROCK AGGREGATE RESOURCES IN THE WINGECARRIBEE SHIRE

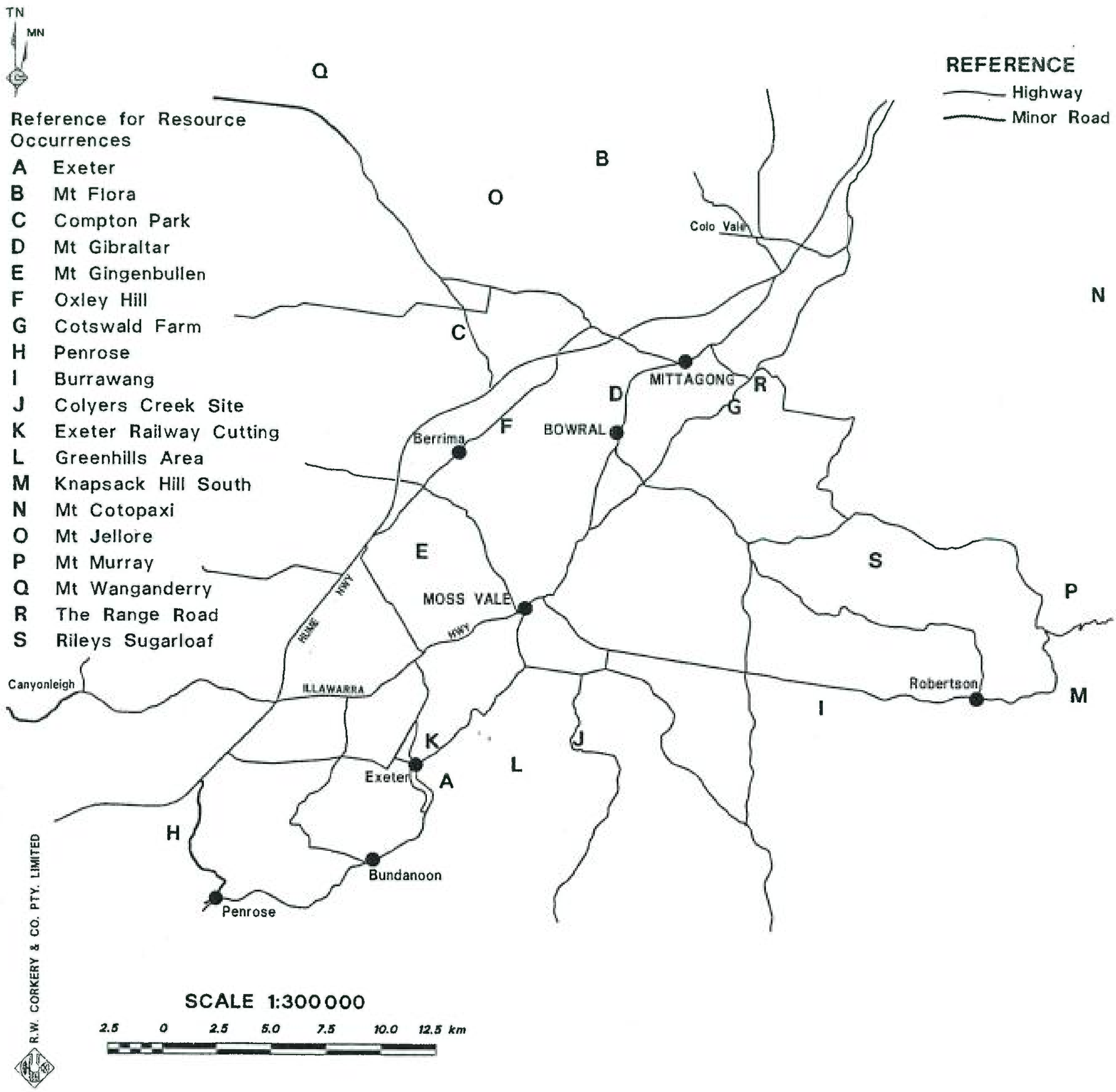
Introduction

We have already seen that the Wingecarribee Shire has the most extensive resource base of hard rock aggregate in the Sydney and surrounding Mining Districts. Not surprisingly, Wingecarribee Shire also has a large number of occurrences of igneous rock that could have the potential for the production of coarse aggregate. However, many occurrences have been subjected to extensive weathering. Gobert (1975) states

> In the Mittagong-Moss Vale area, basic and intermediate igneous rock types are relatively abundant. Varieties represented include fine-grained basalt, syenite and minor amounts of tholeiite and teschenite. The basalt occurs as flows, sills and "cappings" which reach a maximum thickness of approximately 100 m in the Robertson area.... Weathering processes have reduced much of the existing basalt remnants to areas of deep red fertile soil containing basalt boulders.... In places, the degree to which weathering of the basalt has taken place is difficult to detect from the present surface expression.... The intrusive syenite, tholeiite and related rock types occur as isolated outcrops. Generally these form prominent hills with bold outcrops (p22-23).

In addition to weathering, many of the occurrences are not suitable for development because of environmental factors, especially scenic and close proximity to rural residential and sometimes urban developments. Below is a description of known occurrences of igneous rock in the Wingecarribee Shire. The location of the occurrences discussed in this report and of igneous rocks in the area are shown in **Figure 3**.

Figure 3 Hard Rock Occurrences in the Wingecarribee Shire



Major Deposits

A - Exeter

The Exeter Quarry is located about 600 m east of the township of Exeter and approximately 7 km southwest of Moss Vale. The rock is predominantly olivine basalt (see Section 3). Quarrying commenced in 1978 by Belfast Holdings Pty Limited. Southern Highlands Quarries Pty Ltd took over operation of the quarry in 1981 and on 1 July 1996 the company became known as Concrite Quarries Pty Limited. Over the 8 years to 1997/98 production averaged 278,000 tonnes, of which approximately 30 percent was delivered to the Sydney and Wollongong markets, with Sydney taking the majority, and 70 percent consumed in the Southern Highlands region, including Goulburn. About 55 percent of production over this period has been CBS and 45 percent PRB.

Three main types of basalt occur; broken basalt, amygdaloidal basalt and massive basalt (see Section 3). The resource is capable of producing aggregate suitable for producing high performance and low shrinkage concrete, high performance concrete, normal strength concrete, CBS for road construction and PRB.

The high quality aggregate is capable of allowing concrete of 80 - 100 MPa and low shrinkage characteristics to be made. The demand for such specialised concrete is increasing for the construction of large buildings. Exeter is one of the few sources of such high quality aggregate for the Sydney, Illawarra and Southern Highlands markets (Crawley, 1998, pers.comm.).

B - Mt Flora

Mt Flora is located approximately 5 km northwest of Colo Vale and 8 km north of Mittagong. It is a relatively flat,

> monotonous assemblage of microsyenite which has crystallised as a shallow intrusion... The intrusion covers an area of 770 hectares with a maximum thickness of 195 m. Insitu reserves are in excess of 1200 million tonnes... Deuteric alteration of the rock mass and weathered microsyenite are pervasive and widespread throughout the area. This material overlies the fresh and normal microsyenite varying in depth throughout the area... Seismic data and drill hole cores have clearly indicated that the north-eastern ridge and northern edge of the deposit are deuterically altered and partially weathered. Away from the deposit edge and the surficial layers the rock is suitable for road materials and concrete aggregates (Mitchell McCotter, 1990, sect. B1.1-1.2).

Indicated reserves are listed as 32.4 million tonnes for the area covered by the present Development Consent and inferred reserves at 70 million tonnes.

Test results show that the dry bulk density ranges between 2420 - 2518 kg/cubic metre, the water absorption varies between 2.3 and 3.7 percent, the wet/dry strength variation between 3 and 20 percent and the Los Angeles value (B grading) varies between 20 and 30 (Mitchell McCotter, 1990, sect B1.2).

> Test results generally indicate that aggregates and road base made from the microsyenite will meet most specifications, including RTA specifications for sealing aggregates and road base as well as the Australian Standard for severe exposure concrete (Mitchell McCotter, 1990, sect.B1.2).

Mr George McClellan, representing CSR Readymix has stated that although the Mt Flora rock is not as good as Peat Ridge basalt in terms of the production of low shrinkage concrete it meets AS 2758 standards for concrete subject to severe exposure and is suitable for the production of high performance concretes up to 80 MPa provided low shrinkage properties are not required (pers.comm., 1998).

CSR Readymix hold a Consent to produce aggregate from Mt Flora valid for 32 years from December 1995. It is generally recognised that the consent conditions concerning transport facilities make the cost of establishing a quarry very high, and has been a key factor in the delay in development. It is believed CSR Readymix are holding Mt Flora in reserve until the Penrith Lakes river gravels are exhausted. In the mean time they are bringing more south coast aggregate from the Albion Park Rail latite quarry to Sydney.

C - Mt Misery

Mt Misery / Hurdle Ridge is a relatively large intrusion of microsyenite, an intermediate igneous rock located about 6.5 km north of Berrima and 10 km west of Bowral. It covers an area of 3.8 km by 2.0 km and rises to 781 m above sea level and 60 m above the surrounding plateau. Preliminary exploration indicates thickness is in excess of 100 m over most of the area. With the exception of the south western slopes, its sides are steep. On the southwestern margin a small gabbroic plug occurs. The (microsyenite) rock is similar to that occurring at Mt Gibraltar that was mined for about 100 years for dimension stone and course aggregate (Corkery, 1989, p55-56, Gobert, 1975, p 26 and 31).

> Up to 80 percent of the microsyenite investigated at Mount Misery and Hurdle Ridge has undergone a degree of mineralogical alteration during emplacement or shortly thereafter. Used in this sense, the term alteration is not related to weathering and does not necessarily imply a degradation in rock strength or quality.
>
> Alteration has commonly resulted in total, or less commonly, partial replacement of the original ferromagnesian minerals by secondary minerals including siderite, quartz and clay minerals which together comprise up to 20 percent of the rock (Corkery, 1989, p56).

Concern about the impact of the siderite on the rocks performance as a concrete aggregate has been expressed. Ray (1983) states "alteration may affect the use of the microsyenite for concrete". Mr Ian Stewart of the Dept. Main Roads Materials & Research Laboratory (1983) states "Siderite presents a potential problem particularly for aggregates used in concrete". The concerns of Stewart were repeated in the *Report of the Mount Misery/Hurdle Ridge Working Party*, July, 1987, p10.

In the late 1980's testing was undertaken to compare Mount Misery and Hurdle Ridge rock quality.

> The results of "random point load" and "unconfirmed compressive strength" tests indicate the majority of core tested to be of a very high strength classification. Results were confirmed by trial blasting where fragmented rock was noted to be extremely "strong" in geomechanical terms.
>
> Tests utilised to confirm rock durability were: "sulphate soundness", "Los Angeles Abrasion", "Wet/Dry Strength Variation" and "Potential Reactivity". With the exception of a single test result... all test results were well within required specifications and better than equivalent results derived from Mt Misery samples... Test results confirm rock tested to be eminently suitable for the production of road materials and aggregates (Corkery, 1989, p57).

A variable layer of weathered rock between 1 - 6 metres occurs above the fresh rock.

Insitu reserves have been inferred at 790 million tonnes. "Approximately 23 million tonnes has been defined within the initial quarry area" (Corkery, 1989, p56). The reserves in the initial quarry area are in the indicated category.

Mt Misery is held by Rocla Pty Limited and there is a valid Consent for quarrying. The resource has been on the market for over two years but a buyer has yet to be found.

D - Mt Gibraltar

Mt Gibraltar is a prominent hill located between Bowral and Mittagong and composed of microsyenite. It rises 180 m above the surrounding country and has bold cliff faces of 70 m on its western boundary. The deposit was quarried for dimension stone for 100 years and more recently for aggregate. Quarrying has stopped because of the encroachment of urban development from Bowral and Mittagong. Reserves held under title by the two companies quarrying at Mt Gibraltar in the mid 1970's were placed at over 5 million tonnes (Gobert, 1975, p31).

Shaun (1984) states "The Mount Gibraltar site has the greatest general appeal of the Mittagong (Mesozoic Eruptive Centre) sites, with numerous picnic areas and lookouts being found on its slopes. Most of these are found within reserves under Council control". These factors would make development very unlikely.

E - Mt Gingenbullen

Mt Gingenbullen is located 5 km west of Moss Vale, is a flat topped with steep sides rising to a maximum elevation of 798.6 m above sea level and some 120 m above the surrounding plateau. It covers an area of 70 hectares. The rock is a dense columnar tholeiite, a porphyritic basalt, flow or sill about 100 m thick (Gobert, 1975, p35).

Southern Blue Metal Quarries quarried the northern side for railway ballast prior to the 1940's. The rock has a specific gravity of 2.95, is hard, massive and suitable for use as road or concrete aggregate or railway ballast. There is little overburden and weathering is minimal. Insitu reserves are estimated at nearly 70 million tonnes, indicated. A quarry on the northern and possibly on the western slopes would be visible for many kilometres. Blasting and crushing noises would be heard across large tracts of land (Gobert, 1975, p35-36). Residential development since 1975 makes development of a quarry today improbable.

F - Oxley Hill

Oxley Hill or Mt Oxley was the site for the Beaumont Quarry, situated 2 km west of Bowral. Mt Oxley rises 200 m above Bowral township. The rock is columnar basalt, fine grained, dense and with olivine crystals up to 5 mm long and the flow is 30 -45 m thick.. The basalt produced was "of good quality with a tendency to flakiness" (Gobert, 1975, p24). From 1963 to 1974 production ranged from 7,300 tonnes to over 106,000 tonnes and averaged 45,200 tonnes per year but over the final 3 years the average production was double this. The Beaumont quarry was closed when Wingecarribee Council opposed an extension of the lease. Reserves at the quarry site were estimated at about 6 million tonnes (Gobert, 1975, p25). Gobert estimated that total reserves in the eastern face of Mt Oxley could total 30 million tonnes but due to its close proximity to Bowral and the fact that any quarry would be "visible for a considerable tract of country to the south and southeast" (Gobert, 1975, p26).

G - Cotswald Farm

A medium grained, alkali felspar rich microsyenite intrusion occurs at Cotswald Farm, 4 km east of Mittagong. In 1965-66 a small quarry was operated by Pioneer Concrete on a trial basis for the production of dimension stone, but difficulties with colour, the size of the blocks that could be produced and the vesicular nature of the rock caused the quarry to be abandoned. The vesicles are filled with calcite and "may preclude the use of this rock for aggregate purposes" (Gobert, 1975, p29). Indicated insitu reserves are about 8 million tonnes. A quarry would be visible from Range Road.

H - Penrose

The Penrose Quarry is located on the Hume Highway at Paddys River, 20 km south west of Berrima and is operated by Heggies Bulkhaul Limited. The quarry produces high quality sand for local and regional markets. A small basalt flow has been identified and Heggies propose to intermittently operate a basalt quarry to produce an average 100,000 tonnes per annum of crushed and screened aggregates and/or blended road pavement materials. The basalt flow is up to 36 m thick but tapers towards it extremities. The basalt is heavily fractured and appears to be quite heavily altered within the upper and lower thirds (10 - 12 m) of the deposit. The central third of the deposit is interpreted as being of sufficient quality for the manufacture of specified concrete aggregates. Further geological exploration is required to determine preferred end use relative to rock quality. No trial crushing or laboratory testing have been conducted (International Environmental Consultants, 1997).

Insitu reserves of fresh and weathered basalt are estimated at 1.6 million tonnes of which about 500,000 tonnes is believed to be capable of producing premium quality concrete aggregate (International Environmental Consultants, 1997).

Minor Resources

I - Burrawang T.S. (815 m)
Burrawang Trig. Station is a basalt capped hill 1 km west of Burrawang township. Thickness is estimated at 60 m. The rock is a massive olivine basalt and insitu reserves are estimated at about 1.5 million tonnes. The rock appears suitable for aggregate use but testing would be required. A quarry would be visible for some distance to the west and south (Gobert, 1975, p41).

J - Colyers Creek Site
An occurrence of dolerite with a basalt capping outcrops at Coylers Creek, 9 km south of Moss Vale. The basalt capping is less than 30 m thick. The extent of weathering is unknown, nor is the suitability of the rock for aggregate production. Gobert thought a quarry with reserves less than 3 million tonnes may be possible, but extensive drilling would be required to test the rock's suitability. Care would need to be exercised as Colyers Creek flows into Bundanoon Dam (Gobert, 1975, p36-37).

K - Exeter Railway Cutting
A large flow of basalt underlies Exeter township and the surrounding countryside. Over most of the area of basalt outcrop the country is gently undulating and weathering of the basalt is very deep. Approximately 1.6 km north of the Exeter railway station massive columns up to 10 m in height of a fine-grained basalt are exposed in a railway cutting of the Main Southern Line for a distance of some 80 m. The rock is fresh, hard, fine-grained and massive, and would be suitable for aggregate or railway ballast purposes.

...A railway cutting some 200 m further north exhibits massive basalt also. These sites occur on the northern extremity of the basalt flow where the thickness of the basalt would not be in excess of 30 m.

Deep weathering of the basalt is apparent on the hill slopes adjacent to the railway cuttings and ... (I)t is probable that weathering may extend to a depth of 10 - 15 m, and hence the maximum recoverable reserves of hard rock at this site are small (1 million cu.m) and possibly uneconomic...

A quarry developed at this site would be visible for some distance to the north to Moss Vale township. Blasting and crushing operations would also be heard for some distance to the north... (Gobert, 1975, p37-38).

L - "Greenhills" area
A considerable thickness of olivine basalt crops out over a large proportion of "Greenhills" and adjacent properties 4 km to the east of Exeter township.... The basalt here is up to 60 m thick. Good sites for quarries exist on the eastern side of this part of the flow.... There is outcrop along the crests of the ridges suggesting that overburden is possibly less than 10 m.

... A conservative estimate of reserves of good quality rock suitable for hard rock aggregate available within the area ... are 4 million cu. M (about 12 million tonnes). It would be necessary to test the basalt for suitability for aggregate ... (Gobert, 1997, p38).

M - Knapsack Hill South
A basalt flow up to 60 m thick occurs 4.8 km east of Robertson. The rock consists of olivine crystals in a fine grained groundmass and it is thought weathering is not deep. Insitu reserves are estimated at about 6 million tonnes. Before a quarry could be established extensive testing would be necessary. A quarry on the site would be visible for some distance to the south. Its proximity to Robertson could be a problem (Gobert, 1975, p40).

N - Mt Cotopaxi
A microsyenite intrusive outcrops as a small hill 60 m high 14 km north of Mt Murray between Moss Vale and Wollongong. Weathering appears to extend only 5 - 10 m and the fresh rock is extremely hard and massive. Extensive testing would be required to ascertain if the rock was suitable for aggregate. Indicated reserves are small at between 1 - 1.5 million tonnes. The site is in the middle of the catchment area for the Nepean Dam (Gobert, 1975, p 34-35).

O - Mt Jellore
Mt Jellore is located 14 km northwest of Mittagong and consists of a small, steep sided circular plug of trachyte that rises 70 m above the surrounding country. The plug has intruded a teschenite-monzonite sill complex with a thickness of 60 m. The sill covers a large area south of Mt Jellore. The rock at Mt Jellore is relatively fresh and fine grained. Insitu reserves at Mt Jellore are estimated at 10 million tonnes, indicated. The rock in the surrounding sill is too weathered and

variable in grain size to be considered for aggregate. Any quarry at Mt Jellore would be visible for many kilometres in the surrounding country side (Gobert, 1975, p32).

Mount Jellore is another of the Mittagong Mesozoic Eruptive Centre sites, along with Mt Gibraltar, Mount Misery and Mt Flora. Shaun (1984) states "It would be best to leave one site (of the four) in an untouched state, and Mount Jellore would probably be the most suitable choice."

P - Mt Murray

Mt Murray has a basalt capping some 90 m thick and forms a prominent hill rising to 766 m a.s.l. adjacent to the Moss Vale - Unanderra railway line to the northeast of Robertson. The western slopes are steep and weathering appears to be less than 5 m. The rock is untested but appears suitable for aggregate use. Establishing a quarry on the western slopes would be difficult because of the steep slopes. The eastern side was already sterilised in 1975 by residential development (Gobert, 1975, p41).

Q - Mt Wanganderry

Mt Wanganderry is a basalt capped hill 24 km from Mittagong on the Wombeyan Rd and rises 120 m above the plateau to an altitude of 833 m. The basalt is 70 m thick. Weathering extends for 5 - 10 m. The rock is a vesicular olivine basalt with calcite filling the amygdules. Gobert thought a quarry with reserves of about 3 million tonnes could be established on the Wombeyan Cave Road side and would be partially visible from the road. Extensive testing of the rock would be necessary to ascertain if it was suitable for aggregate use because of the calcite present (Gobert, 1975, p33).

R - The Range Road

A basalt flow forms a plateau some 2 km east of Mittagong on The Range Road. The rock is a very fine grained olivine basalt with indication that vesicular material is likely to occur. A quarry with reserves of about 2 million tonnes could possibly be established but extensive testing of the rock quality and thickness would first be necessary Gobert, 1975, p34). Urban development since 1975 would make development most unlikely.

S - Riley's Sugarloaf Hill

A small, massive basalt plug occurs at Riley's Sugarloaf Hill 22 km southeast of Bowral and 8 km northwest of Robertson. The hill has an elevation of 820 m a.s.l. and rises 90 m above the surrounding plateau. The plug has very steep sides and appears to have intruded a basalt flow. Riley's Peak is a prominent hill that is visible for many kilometres to the south and west. Reserves at Riley's Peak are small, estimated at about 1 million tonnes. The basalt ridge extends to the southeast where the thickness is estimated at 30 m. The rock is rather fresh and massive and appears to be suitable for aggregate, but testing would be necessary. A quarry with reserves of about 2 - 2.5 million tonnes may be able to be developed (Gobert, 1975, p39). This deposit is located within the catchment of a Reservoir and development consent is unlikely given the recent non-concurrence from the Sydney Water Corporation and refusal by Wingecarribee Shire Council for the extension of the nearby Kangaloon Sand Quarry.

7. NEW HARD ROCK RESOURCES IN THE WOLLONGONG AREA

In May 1992 a NSW Department of Planning report titled **Blue Metal Quarrying in the Shellharbour & Kiama Municipalities - Working Party Report** was issued detailing the potential resources of hard rock aggregate in the region. The following is taken from this Report.

The latite deposits in the Shellharbour - Kiama area occur in the Bumbo Latite Member of the Gerringong Volcanic facies formed about 250 million years ago (Late Permian - Mid Triassic). All latite production in the Wollongong Mining District is from the Bumbo Latite Member and quarrying has occurred from about 1870. The Bumbo Latite Member is generally about 60 m thick over most of its outcrop area from Yallah in the north to Mount Coolangatta (near Shoalhaven Heads) in the south, to the Illawarra escarpment in the west. It reaches a maximum thickness of about 150 m at Saddleback Mountain (NSW Dept Planning, 1992, p11).

Extensive areas of latite potentially suitable for the production of high quality coarse aggregate occur within the Kiama - Shellharbour area outside existing extraction sites and quarry company landholdings, particularly in the Jamberoo Valley (NSW Dept.Planning, 1992, p13).

Albion Park
An area immediately to the southeast of Albion Park was identified in 1971 as one of the two sites in the Kiama - Shellharbour area considered to offer the highest potential for the development of a new quarry. Much of this area has subsequently been developed for residential purposes and the area can no longer be considered to have any potential for future extraction (NSW Dept. Planning, 1992, p13).

Jamberoo Valley
Large areas within the lower Jamberoo Valley were identified in 1971 as having potential for future extraction.

One specific area, near Jerrara was considered (together with the above-mentioned area at Albion Park) to offer the highest potential for the development of a new quarry. An alternative potential quarry site was also identified to the west of the Jerrara site. All these areas are subject to major environmental constraints which preclude extraction (NSW Dept.Planning, 1992, p13).

Foxground - Saddleback Mountain
Four potential resource areas were identified in 1974. No detailed information was, or is, available on the suitability of the latite in these areas for use as coarse aggregate... Proposals for quarrying of these areas would have to overcome significant environmental constraints including:

1. Impact on existing vegetation (including rainforest)
2. Impact on surrounding rural environment
3. Access problems
4. Significantly increased traffic movements on narrow rural roads
5. Steepness of areas surrounding quarries (NSW Dept.Planning,1992, p14).

The resources already secured by the quarrying industry in the Wollongong area (see Sect. 4) are considered to be the principal areas likely to be developed in the future.

8. NEW HARD ROCK AGGREGATE RESOURCES IN THE LITHGOW AREA

Hartley Rhyolite

AUS10 Rhyolite Pty Ltd propose to establish a hard rock quarry on a rhyolite deposit that occurs on a property at Hartley, about 8 km south of Lithgow and about 80 km west-north-west of Parramatta. The property is owned by the Hartley Pastoral Company, an associated company of AUS10 Rhyolite Pty Ltd. Proved reserves within the initially proposed quarry area total 20 million tonnes and the insitu reserves of the overall deposit are inferred at 100 million tonnes. The rhyolite is a good quality aggregate rock with low water absorption, good particle shape characteristics, wet strength about equal to that of Bombo latite, Penrith gravels and Compton Park microsyenite, but only about two thirds of that of basalt. Its Los Angeles Value is better than Penrith gravel and Compton Park microsyenite and about equal to the average for Bombo latite but not as good as basalt. Its dry strength, however, is lower than that for microsyenite and latite and significantly lower than that for basalt. In 1994 the quarry was projected to start production at 150,000 tpa, to increase to 550,000 tpa by year 5 and to reach a maximum capacity of 620,000 tpa by year 15, markets permitting (Sinclair Knight Mertz, 1994). However, the quarry has yet to commence production .

9. THE CONSUMPTION OF COARSE AGGREGATE IN THE SYDNEY REGION FROM 1968/69 TO 1996/97

The consumption of coarse aggregate in the Sydney region from 1968/9 to 1996/97 is shown in **Figure 4**. Statistics were not kept prior to 1968/9 and statistics for imports into the Sydney region are patchy.

Total consumption of aggregate in the Sydney region has varied between a high of 10.9 million tonnes in 1989/90 and a low of 5.5 million tonnes in 1982/3. The largest component of the coarse aggregate market is crushed and broken stone (CBS), described in Section 10. The second largest component of the coarse aggregate section is the non-sandstone component of prepared road base (PRB) section and the smallest is sandstone, although for some of the 1990's sandstone consumption exceeded non-sandstone PRB. It can be seen from Figure 4 that the CBS section of the market is growing while the PRB section is declining. In recent years sandstone consumption has also fallen away.

The Sydney coarse aggregate market is characterised by sharp swings from year to year. Although the use pattern is volatile on a year to year basis, the average total consumption and trend in the average consumption over the 28 year period is fairly stable. Wallace (1981) undertook the first, detailed analysis of the Sydney region hard aggregate market. Wallace found that the average consumption of hard aggregate in the Sydney region for the period 1968/9 to 1979/80 was 7.8 million tonnes per year and that the consumption for the latest three years in his study, namely 1977/8 to 1979/80 averaged 8.2 million tonnes per year. Wallace therefore used a figure of 8 million tonnes for the base year (1980) consumption in his study. Wallace's estimate of 8 million tonnes per year was adopted by the Department of Environment and Planning (DEP) in its 1984 and 1986 reports on Sydney's Extractive Industry. In SREP No.9 the average consumption of coarse aggregate for the period 1970 to 1991 is stated to be 7.7 million tonnes (p66).

With the addition of a further 6 years data it is found that the average consumption over the 28 year period to 1996/97 is 7.8 million tonnes per year and the average consumption for the last six years is also 7.8 million tonnes.

The regression trend line for consumption of coarse aggregate over this 28 year period shows an average annual increase of 22,000 tonnes per year (**Figure 5**). In SREP No.9 the trend line is shown to increase by 17,700 tonne per year for the period 1970/71 to 1990/91. The trend line in Figure 2 rises from about 7.6 million tonnes in 1969 to about 8.1 million tonnes in 1997. It can be seen that there is a high level of scatter of the actual consumption values about the trend line. The high scatter of observations is reflected in the R-squared of the trend line, the goodness of fit, being only 3 percent (a perfect fit has an R-squared of 100 percent and if there is zero correlation between a "trend line" and a set of observations the R-squared is zero). That is, the trend line could equally show a decrease in consumption over time or no change.

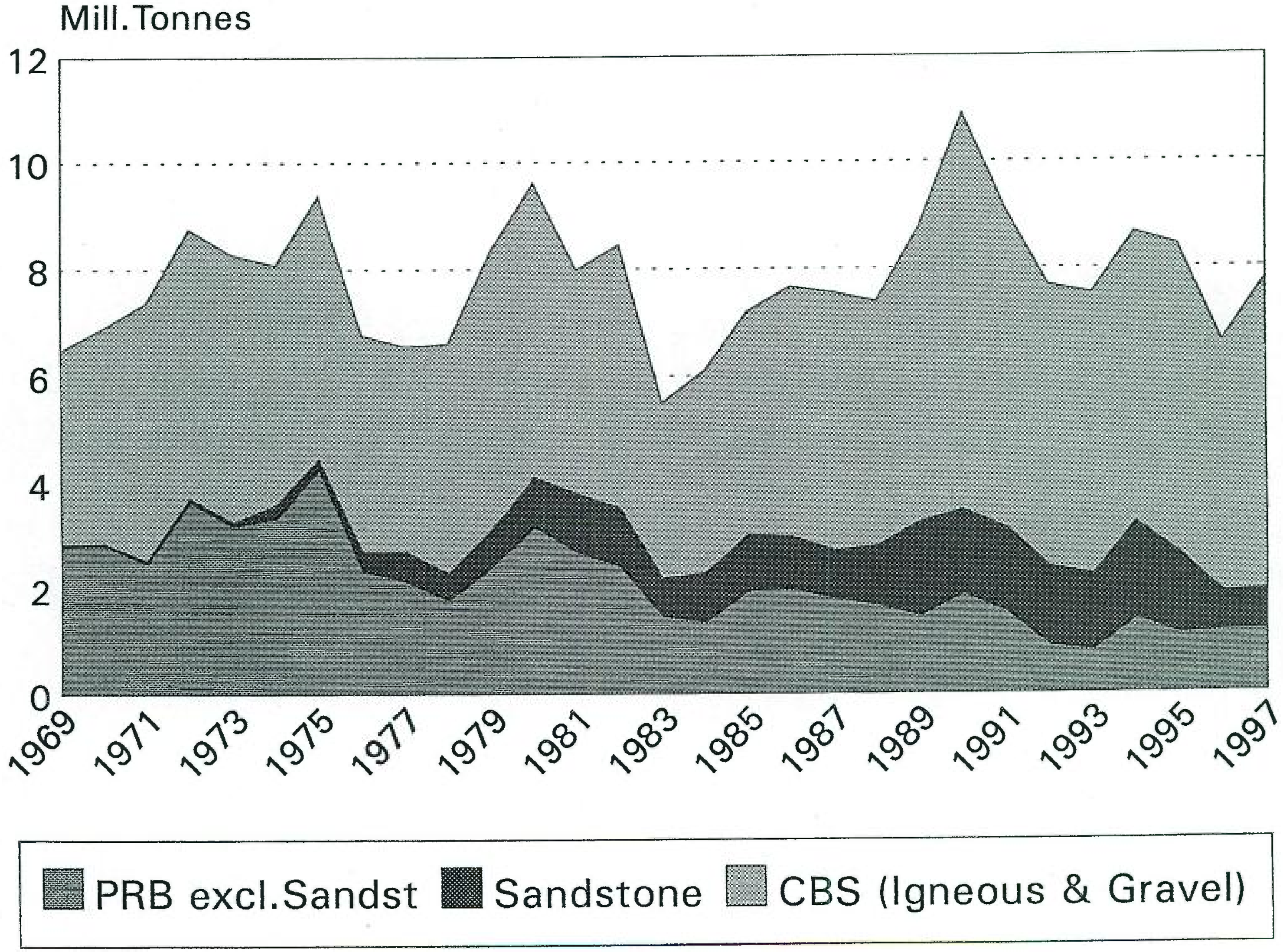


Figure 4 Sydney total Coarse Aggregate Consumption

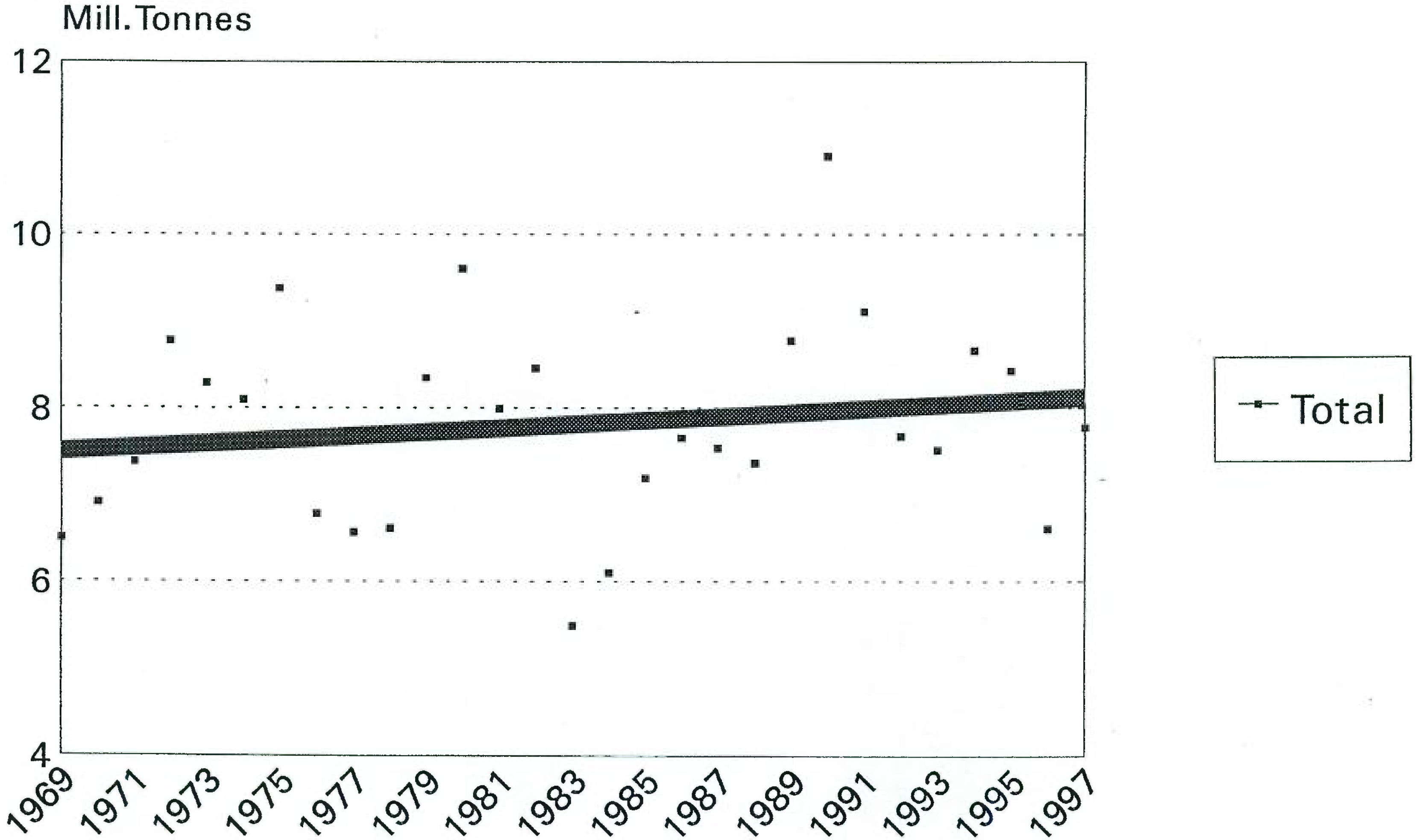


Figure 5 Trend Sydney Coarse Aggregate Consumption

On the evidence presented one should probably conclude that there has been no increase in the consumption of coarse aggregate over the past 28 years and the best predictor for future consumption is the average consumption over the past 28 years, namely 7.8 million tonnes per year. However, one would expect that there would be a positive correlation between population growth and increased economic activity and aggregate consumption. Time is only a crude proxy for these two factors and if a more detailed analysis was undertaken it is likely that some positive correlation in consumption of aggregate with increased population and economic activity would be found. If one takes the average consumption per year over 10 year periods it can be seen that there has been slight positive growth. The annual average consumption in coarse aggregate over the period 1969 to 1978 was 7.53 million tonnes per year, an average of 7.55 million tonnes for the period 1979 to 1988 and 8.38 million tonnes per year over the period 1989 to 1997.

The above supports the regression analysis finding of modest growth in coarse aggregate consumption of 22,000 tonnes per year, and this growth rate will be used for forecasting future consumption.

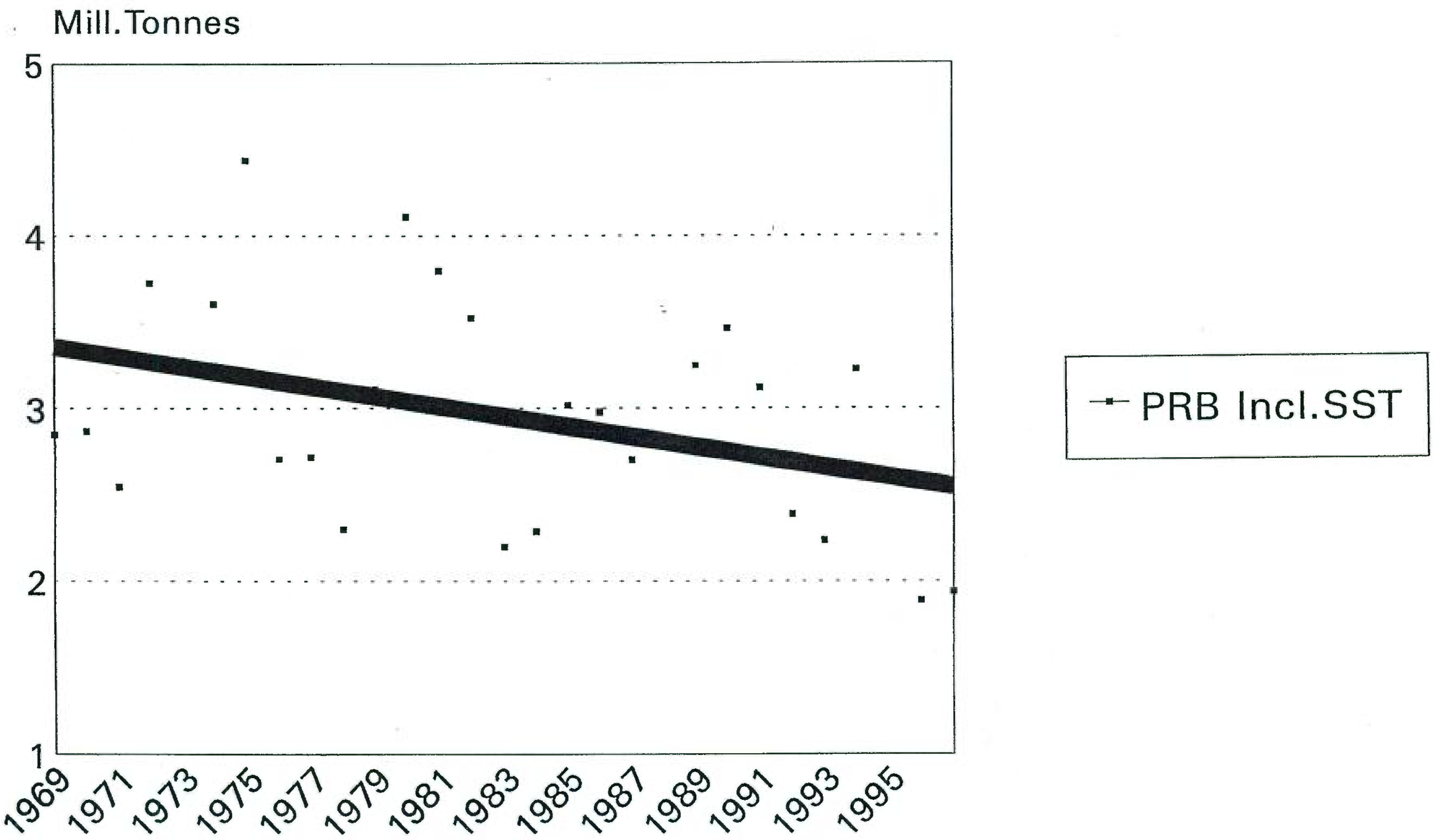
Figure 6 shows the trend line for the consumption of PRB for the period 1969 to 1997. Sandstone is included with PRB. The trend line shows that modest negative growth is the expected outcome, with consumption decreasing by 29,000 tonnes per annum. The regression line, ie, the trend line, is statistically significant but the R-squared is only 15 percent, as is shown by the high degree of scatter of the observations about the trend line. In periods of high road construction the demand for PRB and sandstone rises sharply and in periods of little road construction, it falls sharply.

The annual average consumption in PRB over the period 1969 to 1978 was 3.1 million tonnes per year, 3.0 million tonnes average for the period 1979 to 1988 and 2.7 million tonnes per year over the period 1989 to 1997.

The Sydney region consumption of crushed and broken stone (CBS) is met by the production of igneous rock and gravel from the Sydney region and the import of basalt and latite. The importance of the latite and basalt supply to Sydney is relevant to this study, so I have split Sydney CBS consumption into the locally produced material and imports.

The trend in CBS production is the Sydney Region since 1969 is shown in **Figure 7**. The slope of the trend line is not statistically different from zero and the R-squared for the trend line is zero, that is, there is no correlation between the trend line and the observed data. Production of CBS in the Sydney region has averaged 3.7 million tonnes per year over the past 28 years and, with the flat trend line, this average figure is the best predictor of future production. Of course, actual consumption can fall considerably below or above the trend line.

There has been small variations in average production within the Sydney region from decade to decade. The annual average consumption in CBS over the period 1969 to 1978 was 3.65 million tonnes per year, 3.46 million tonnes per year for the period 1979 to 1988 and 3.95 million tonnes per year over the period 1989 to 1997. The difference between Sydney's production of CBS and its consumption is made up by imported basalt and latite. The imports of basalt and latite is the fastest growing category of Sydney's CBS consumption.



6 Figure Trend Sydney Prepared Road Base Consumption; 1969 - 1997

Virtually all basalt consumed in Sydney is imported from the southern area of the Newcastle Mining District, and Exeter in the southern Highlands. Occasionally small quantities of basalt are imported from areas to the west of Sydney when it is required for high performance concrete and back loading arrangements allow reduced transport costs. All latite consumed in Sydney is imported from the Wollongong Mining District. Detailed records of the level of imports have not been recorded for much of the period and the consumption pattern shown in Figure 5 has been estimated based on industry estimates and figures given in SREP No. 9. It is estimated that the consumption of these two rock types in Sydney has increased from 0.18 million tonnes in 1969 to a maximum of 2.0 million tonnes in 1994 and 1995; consumption in 1997 is estimated at 1.75 million tonnes (**Figure 8**). The majority of the imported aggregate is latite, but the consumption of basalt in the Sydney region is at 0.5 million tonnes in 1997 and over the past decade the consumption of basalt in Sydney average nearly 0.4 million tonnes per year.

The trend line for the consumption of basalt and latite in Sydney is shown in **Figure 9**. The consumption of basalt and latite has been increasing at 48,400 tonnes per year since 1969. The R-squared for the tend line is 69.1 percent, indicating a quite good correlation between the trend line and the observed data. The annual average consumption of basalt and latite over the period 1969 to 1978 was 0.8 million tonnes per year, it then increased to an average of 1.1 million tonnes per year for the period 1979 to 1988 and to 1.85 million tonnes per year over the period 1989 to 1997.

Normal-class concretes can be produced with a wide range of igneous rock and gravel aggregates. There is a growing market for high performance concrete, including concretes of very high strength and concretes with very low shrinkage characteristics. The very high strength concretes (80 to 100 MPa compared to the maximum normal class strength of 50 MPa) can normally only be produced with basalt, crushed river gravels and latite. Only basalt will produce the very low shrinkage concretes (see Section 2).

The Sydney concrete market on average requires about 4 million tonnes of coarse aggregate per year. Concrite management have told me that the high performance concrete segment is in the order of 0.5 million tonnes per year and is growing each year.

The Woodward Commission (1985) stated that the Exeter Quarry can produce "high quality aggregate suitable for producing concrete with low shrinkage characteristics ..." (p.7). Concrite management have told me the Exeter aggregate is very well suited to supply the relatively new and expanding market of very high strength, low shrinkage concrete. Obviously this is a very important market for the Sydney building industry.

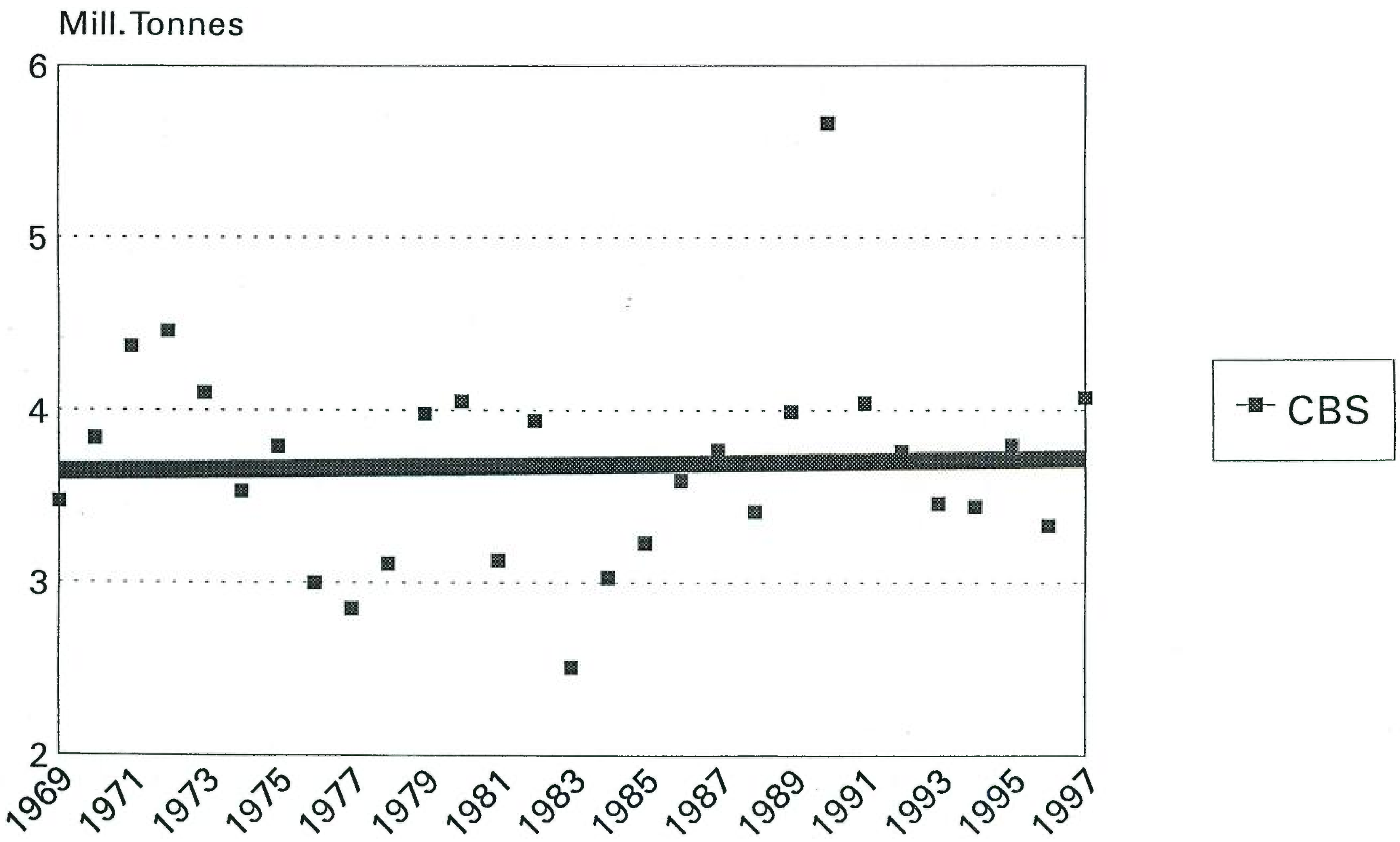


Figure 7 Trend Sydney Crushed & Broken Stone Production

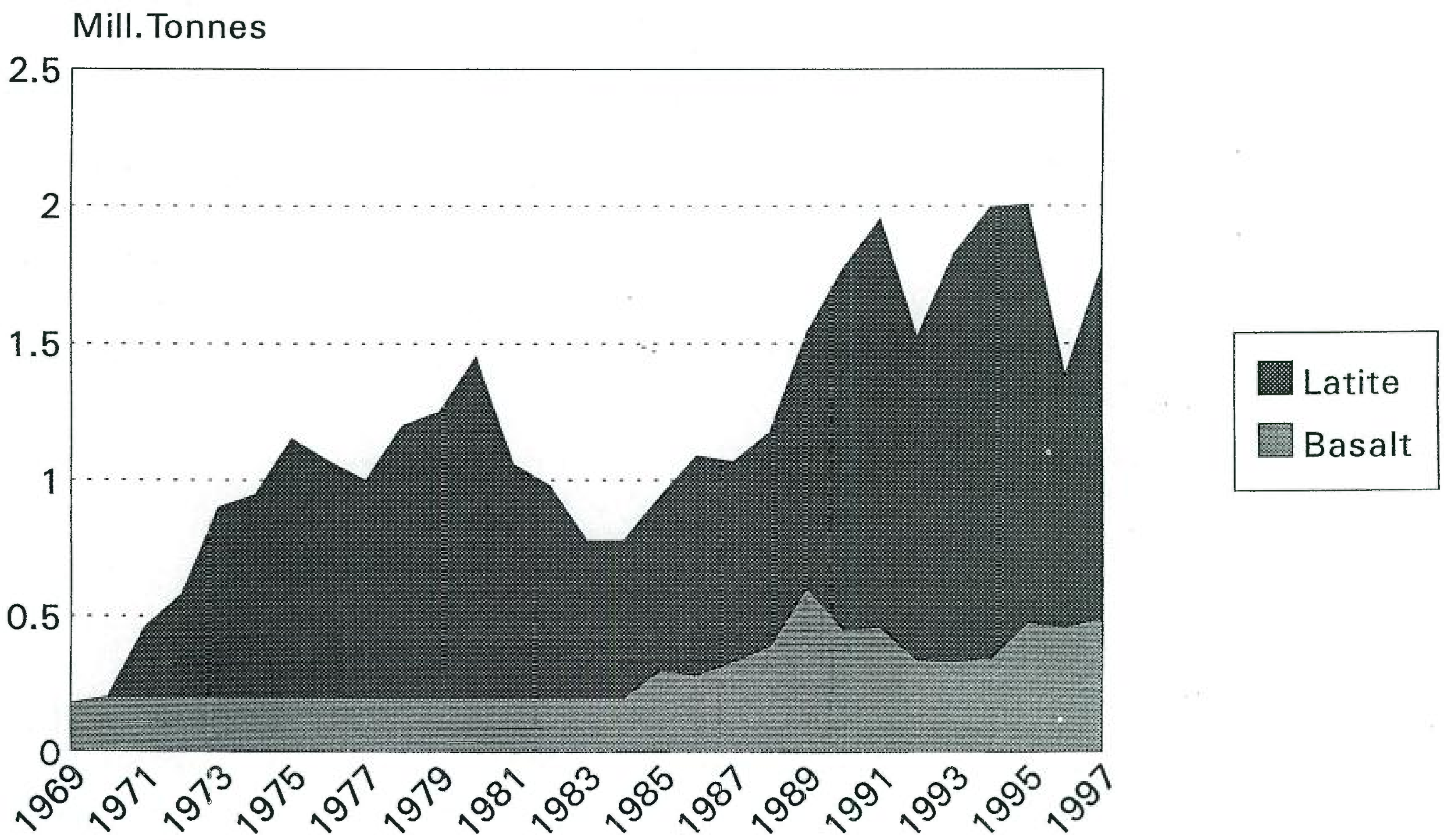


Figure 8 Sydney Consumption of Basalt and Latite CBS; 1969 - 1997

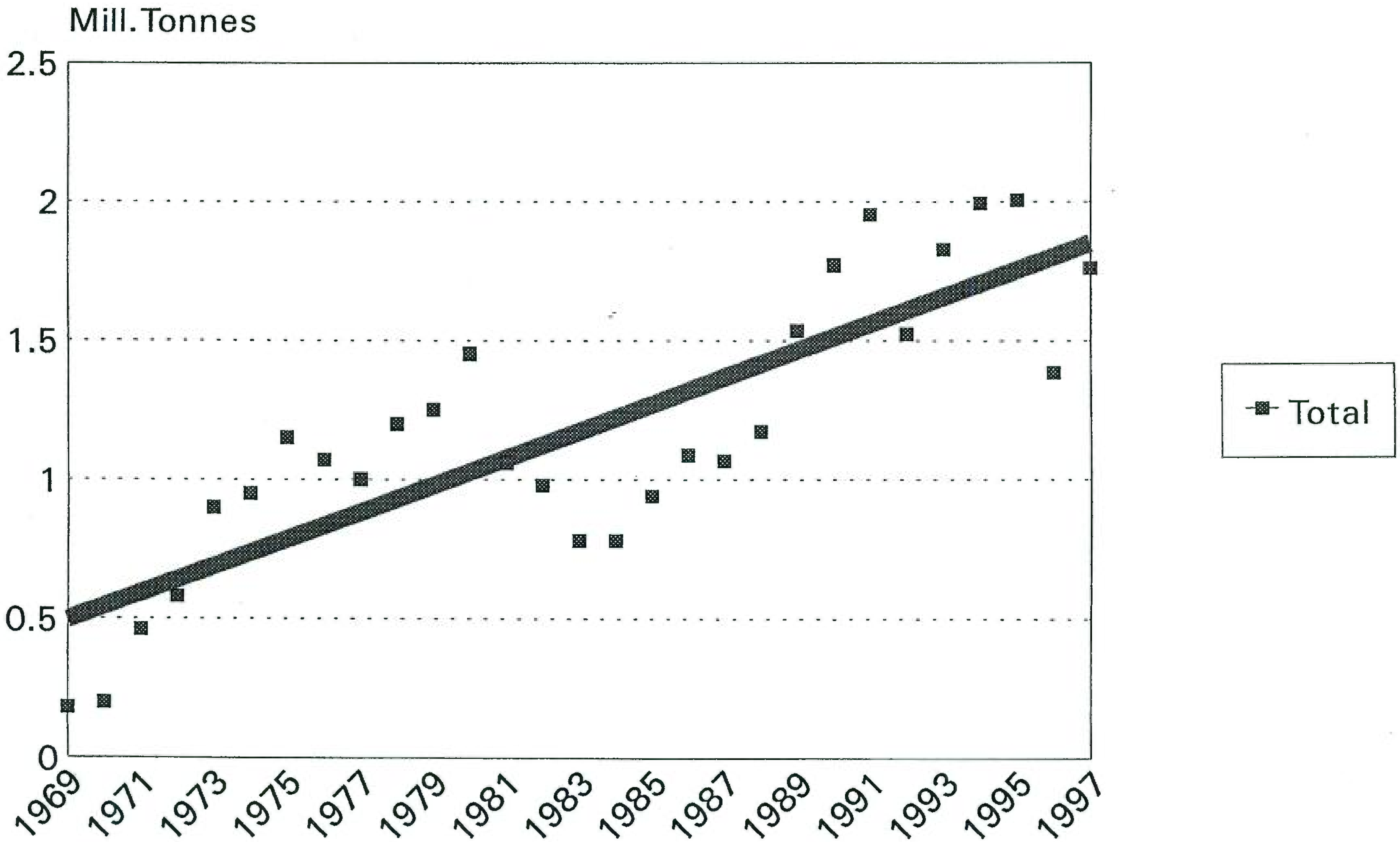


Figure 9 Trend of Sydney Imports of Basalt and Latite CBS; 1969 - 1997

10. SOURCE OF SYDNEY'S HARD ROCK AGGREGATE: 1968/69 to 1996/97

CRUSHED AND BROKEN STONE

Sydney obtains its supplies of CBS from the dolerite quarries at Prospect, from two volcanic breccia quarries at Wallgrove and Hornsby, from gravel quarries in the Penrith Lakes Scheme, from the Peats Ridge - Kulnura basalt quarries to the north of the Sydney region, from latite quarries in the Illawarra region to the south and some basalt aggregate from Exeter. The supply from these various sources for the period 1968/9 to 1996/97 is summarised in **Figure 10**. Occasionally, small quantities of basalt are imported from areas to the west of Sydney such as the CSR Readymix quarry at Dubbo and the Pioneer quarry at Bathurst.

Prospect

The supply of CBS from Prospect peaked in 1972 and has since slowly but steadily declined. Two quarries are operated; one by Boral Resources (NSW) Pty Ltd and the other by the CSR Readymix Group. Over the past 28 years production of CBS averaged 0.7 million tonnes per year; production in 1996/97 was 0.6 million tonnes.

The reserves of rock capable of making CBS were stated as 2 million tonnes in 1991 and "It is expected that production of hard rock aggregate from the Prospect quarries will cease by 2000" (SREP No.9, p.67 - 68). In fact, since 1991 about 2.8 million tonnes of CBS have been produced at Prospect.

Volcanic Breccia

Historically Sydney has obtained volcanic breccia from three quarries; Erskine Park, Wallgrove and Hornsby. Erskine Park is now worked out. Since 1968/9 supply has averaged 0.3 million tonnes per year, with annual production ranging from 0.8 million tonnes in 1970/1 to 0.1 million tonnes in 1993/94. Production in 1996/97 was 0.2 million tonnes. Reserves of CBS in 1991 were stated at 5 million tonnes at Hornsby and 2.5 million tonnes at Wallgrove (SREP No.9, p67). Based on these figures remaining reserves at both quarries are about 6.6 million tonnes of CBS.

Gravel

Over the last 28 years the supply of gravel to the Sydney region has averaged 2.7 million tonnes per year. Only once has supply fallen below 2 million tonnes (in 1982/83) and in the 1990's production has averaged 3.3 million tonnes. Production in 1996/97 was 3.3 million tonnes.

The Penrith Lakes Scheme now supplies all of Sydney's gravel. The Penrith gravel co-exists with commercially valuable sand which is jointly produced with the gravel. In 1984 the reserves at Penrith Lakes were estimated as 50 million tonnes of medium - coarse sand and 113 million tonnes of river gravel (DEP, 1984, p.74). The sand - gravel ratio for the overall deposit was 30:70, but varied throughout the deposit. Initially production was from areas low in sand but the sand - gravel ratio had been increasing over time and by 1990 was significantly higher (I. Patterson, 1990, personal communication). The high sand gravel ratio could place a constraint on the amount of gravel produced as it would raise production costs considerably if sand production was in excess of market demand.

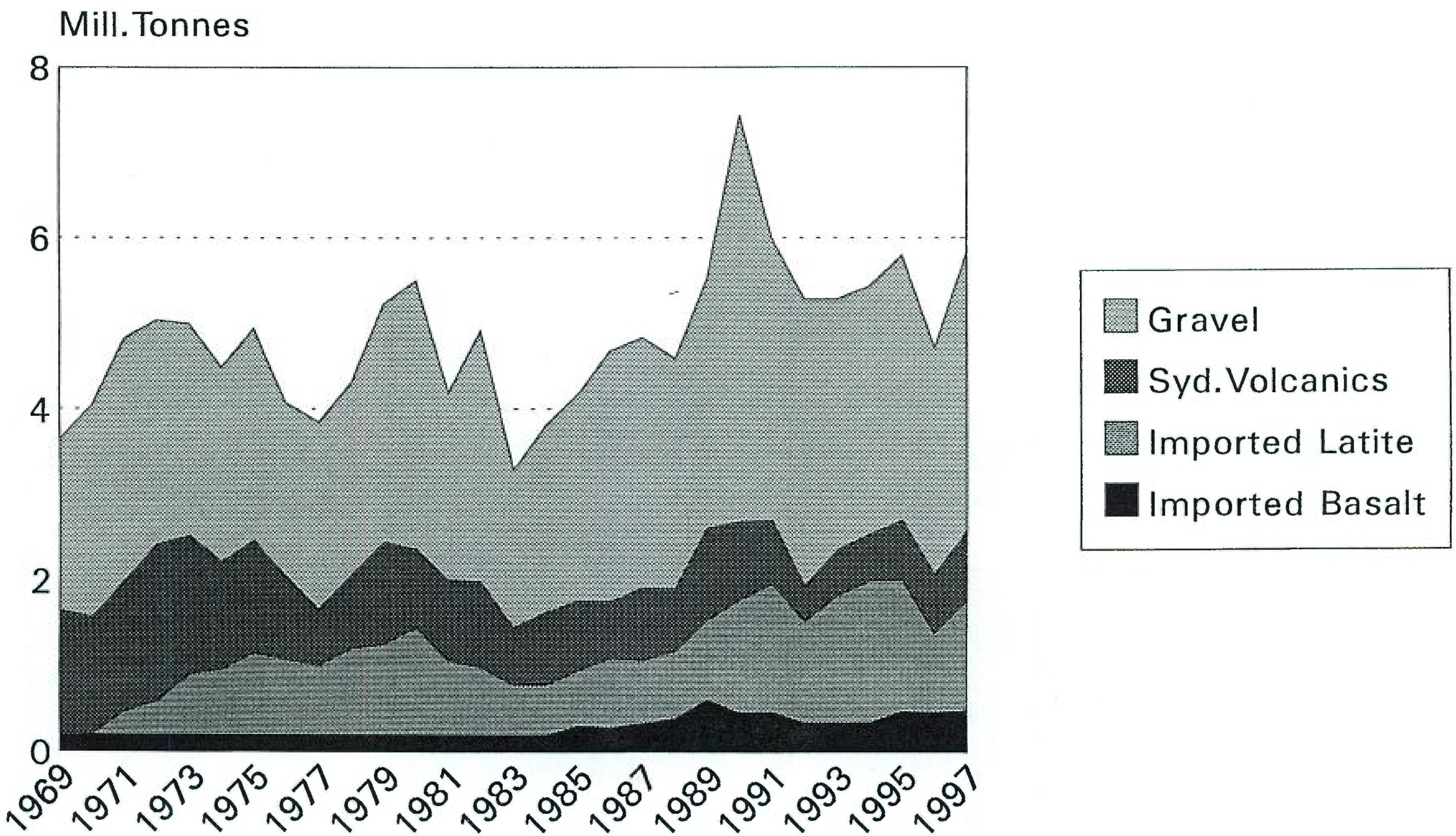


Figure 10 Sydney CBS Consumption by Rock Type

Gravel reserves at Penrith were stated at 80 million tonnes in 1991 and were expected to be largely exhausted by 2016 (SREP No.9, p.67 - 68). A recent detailed geological evaluation has down graded both the total reserves and the gravel reserves.

Extraction in the Penrith Lakes Scheme area has been progressing in a northerly direction and is now in the vicinity of Farrells Lane with most of the area to the south of the lane having been extracted. As extraction neared this point over two years ago, there had been some changes in the resource unit that had an impact on site operations. These changes had included significant depletion of resources, changes in the sand/gravel/silt ratios within the resource horizon, complete removal of the resource in some areas, increases in thickness and changes in the composition of overburden material, and changes in the elevation of the shale floor....The work face was well known. It consisted of a flat shale floor, on which lay approximately 6-8 m of mixed sand and gravel in the ratio of 60% gravel 40% sand/silt, overlain by about 6 m of sandy silt. It had remained fairly consistent like this since the scheme began (Smith, 1996, p1).

The exploration undertaken by Smith shows that:

- The clean sand content increases to the northern end of the scheme area;
- There are a number of extensive areas where the overburden : gravel ratio is equal to or exceeds 5 : 1;
- Reserves in the remainder of the scheme area have been redefined (as at October 1996) to 75 million tonnes of resource and 105 million tonnes of overburden (Smith, 1996, p8-9).

Smith has not broken down the total reserves into sand and gravel. If the average gravel content in the remaining reserves is 50%, gravel reserves would be 37.5 million tonnes; if the gravel content ratio is 40%, gravel reserves would be 30 million tonnes. Over the past 7 years production of gravel has averaged 3.28 million tonnes per year. If production continues at this rate, gravel reserves from the Penrith Lakes Scheme would be exhausted within 9 - 11 years. That is, exhaustion would occur between 2006 and 2008.

Imports

The Sydney region is supplied with imports from the Wollongong Mining District and the Newcastle Mining District and with minor imports from areas to the west of Sydney.

The actual level of imports consumed in the Sydney region are not available for the period after 1984/5, except for 1990/91 where imports from the Illawarra Region were estimated in SREP No.9 to equal 54% of the Wollongong Mining District total production, excluding Exeter. This level has been used for exports to Sydney for the period 1991 to 1997. Prior to 1991 exports from the Wollongong area were estimated at 35 percent of production. Concrite have estimated that in recent years about 30 percent of the Exeter production was exported to Sydney. I have used 30 percent as the level of Exeter production exported to Sydney.

Based on industry advice, I have assumed that since 1989, 50 percent of the production of basalt from the quarries immediately to the north of Sydney are imported into Sydney.

Imports from the Wollongong Mining District

Since 1985 the Wollongong Mining District has produced an average of 2.5 million tonnes per year of coarse aggregate. In 1996/97 five latite quarries operated in the Albion Park - Kiama area (see Table 3) and one basalt quarry at Exeter in the Southern Highlands. In 1990/91 about 54 percent of the Illawarra area production (latite) was exported to Sydney (SREP No.9, p 67). The Working Party Report (Dept Planning, 1992) estimated that 60 percent of the 1989/90 production from the Kiama - Shellharbour area was exported to Sydney. I have assumed that 55 percent of the production is exported to Sydney. It is estimated that since 1985 the Illawarra region has supplied on average 1.3 million tonnes of latite per year to the Sydney region with a high of 2.1 million tonnes on 1994 and a low of 0.8 million tonnes in 1985.

In 1991 secured reserves totalled 72.5 million tonnes but 58 million tonnes of the reserves occurred at only two of the six quarries then in production. Two of the other quarries had unsecured reserves of 83 million tonnes. It appears that all reserves are now secured (see Table 2).

The Exeter Quarry produced 0.15 million tonnes of CBS and 0.15 million tonnes of PBS in 1996/97. In 1997/98 the Exeter Quarry produced 0.16 million tonnes of CBS and 0.1 million tonnes of PRB. Over the period 1990/91 to 1997/98 total production of aggregate from the Exeter Quarry has averaged 278,000 tonnes per year, of which CBS has averaged about 55 percent. In the past, most of the Exeter basalt has been consumed in the southern Highlands - Goulburn area with about 20 - 30 percent of production being exported to the Sydney region and 5 percent consumed in the Wollongong region. In 1996/97, 33 percent of Exeter's production was exported to Sydney and 6 percent was consumed in the Wollongong area and 61 percent was consumed in the Southern Highlands - Goulburn area. In 1997/98 24 percent of Exeter production was exported to Sydney, 9 percent to Wollongong and 69 percent was consumed in the Southern Highlands - Goulburn region (W Crawley, pers.comm., 1998, 1999)

Small amounts of blast furnace slag is imported into Sydney for use in concrete and PRB production but tonnages are not recorded.

Imports from the Newcastle Mining District

Two quarries in the southern region of the Newcastle Mining District supply CBS to the Sydney region. These quarries are the Kulnura quarry, owned by Pioneer Construction Materials Pty Ltd and formerly by Hymix Quarries Pty Ltd and the Peat's Ridge quarry owned by Boral Resources Pty Ltd. Both quarries extract basalt. Since 1985 production has averaged 0.8 million tonnes of CBS per year, that is equal to the 1996/97 production. I have assumed that 50 percent of the production is coming to the Sydney region. This proportion of total production is in line with earlier estimates (Wallace, 1981, p32; Patterson, 1990, pers.comm.).

Reserves in 1991 were listed as 41 million tonnes (SREP No.9, p67). More recent estimates place the reserves at 27.5 million tonnes (Table 2).

PREPARED ROAD BASE

The production of PRB in the Sydney Mining District has been subject to sharp annual variations. Average production over the past 28 years is 3.0 million tonnes but production has been declining over most of this period and production in 1996/97 was 1.8 million tonnes (Figures 4 and 6). This production figure includes sandstone production so is larger than the hard rock PRB figure shown in Table 3. Prepared road base is obtained from the Prospect quarries, the volcanic Breccia quarries, and from sandstone quarries in the Sydney region, as well as imports from the Peat's Ridge and Kulnura basalt quarries, the Wollongong District latite quarries and small amounts of blast furnace slag.

Prospect

The two Prospect quarries have been the main stay of Sydney's PRB supply and production of PRB has averaged 1.2 million tonnes over the past 28 years but has been progressively declining. Production in 1996/97 was 0.7 million tonnes.

The main resource remaining at Prospect is picrite, an unstable rock type quite unsuitable for use as hard rock aggregate, but which can be stabilised and blended with other materials for use in prepared road base. Weathered dolerite, also, is employed in prepared road base. Reserves of picrite and weathered dolerite remaining at Prospect depend, to a large extent, on how deep quarrying proceeds (Wallace, 1981, p.33). Reserves of PRB at Prospect were stated at 18.5 million tonnes SREP No.9, p67) and based on this figure, reserves remaining at July 1997 were 14.5 million tonnes.

Volcanic Breccia

Prepared road base is produced at the Wallgrove and Hornsby quarries in the Sydney region; the rock quarried is volcanic breccia. The Erskine Park quarry has also supplied PRB. Production of PRB from volcanic breccia has averaged 0.81 million tonnes per year since 1968/9. However, production has been declining for some time and from the end of the 1980's has averaged 0.21 million tonnes per year. Reserves were stated at 7.6 million tonnes in 1991 (SREP No.9, p.67) and based on this figure remaining reserves are about 6.6 million tonnes.

Sandstone

Over the 28 year period studied sandstone production averaged 0.8 million tonnes per year. However in the early to mid 1990's production of sandstone averaged nearly 1.5 million tonnes per year but in the last two years production has fallen back to the long term average. Sandstone is produced from a number of quarries in the Sydney area. Total reserves in 1991 were stated at 34.5 million tonnes (SREP No.9, p.67).

Sandstone has the disadvantage that it does not produce as competent a material as does the higher grade igneous rock or crushed gravel. This is balanced to some extent by the fact that it is cheaper to produce, at least on a delivered basis.

Imported PBS

Peat's Ridge and Kulnura (Newcastle District)

Since 1985 production of PRB from Peat's Ridge and Kulnura has averaged 0.15 million tonnes per year; it is not known how much, if any of this material comes into the Sydney market. In 1996/97 these quarries did not produce PRB.

Wollongong Latite

Since 1985 Wollongong District latite quarries have produced on average 0.3 million tonnes of PRB per year; probably about half of the production comes to the Sydney region.

11. FUTURE DEMAND AND SUPPLY OF HARD ROCK AGGREGATE FOR THE SYDNEY REGION

I have established that from 1968/9 to 1996/97 the total demand for coarse aggregate in the Sydney region has averaged 7.8 million tonnes per year and that although one could argue that there has been no real increase in consumption, it appears to make more sense to use the average consumption trend shown in Figure 5 of 22,000 tonnes per year. The demand for prepared road base has averaged 2.9 million tonnes per year since 1968/69 but the consumption trend has decreased at a rate of 29,000 tonnes per year. Over the same period the demand for Sydney produced crushed and broken stone averaged 3.7 million tonnes per year and the consumption trend was zero. The consumption of imported basalt and latite has increased from almost zero in 1969 at an average of nearly 50,000 tonnes per year and over the 28 year period imports have averaged 1.2 million tonnes per year; in the 1990's imports of latite and basalt have exceeded 2 million tonnes per year three times.

The results of the regression analysis of the past 28 years consumption history has been used to forecast the consumption of coarse aggregate by major class for the next 30 years to 2027. The forecasts are shown in **Table 4**. For the period 1998 to 2007 total consumption of coarse aggregate in the Sydney region is expected to total 82 million tonnes at an average of 8.2 million tonnes per year; for the period 2008 to 2017 total consumption is expected to be 84.2 million tonnes at an average of 8.4 million tonnes per year and for the final 10 years total consumption is forecast to be 86.4 million tonnes at an average of 8.6 million tonnes per year.

Consumption of prepared road base is forecast to be 24.5 million tonnes for the period 1998 to 2007, 21.6 million tonnes for the period 2008 to 2017 and 18.7 million tonnes for the period 2018 to 2027. Production of crushed and broken stone from Sydney quarries for the period 1998 to 2007 is forecast to be 37.3 million tonnes, 37.5 million tonnes for the period 2008 to 2017 and 37.8 million tonnes for the final period. The consumption of basalt and latite from the Wollongong and Newcastle Districts for the period 1998 to 2007 is forecast to be 20.2 million tonnes, 25 million tonnes for the period 2008 to 2017 and 29.9 million tonnes for the period 2018 to 2017.

The Penrith Lakes Scheme, that have been supplying on average 3 million tonnes of CBS per year during the 1990's, is expected to be exhausted by 2006 - 2008. The production of CBS from the Prospect quarries, that have been supplying about 0.5 million tonnes of CBS per year, will be exhausted by 2000 (SREP No.9, p.68). The supply of gravel from the Hawkesbury River has ceased. The production of both CBS and PRB from the volcanic breccia quarries has been dwindling in recent years and it is unlikely significant quantities of high grade rock can be obtained from these quarries in the future.

In summary, the supply of CBS from existing sources will fall by at least 0.5 million tonnes by 2000 and by about 3.5 - 4 million tonnes per year by 2006 - 2008. The situation is exacerbated by the growing requirement for both very high strength and very low shrinkage concrete that requires a very high quality aggregate. The Exeter Quarry is one of the very few sources of supply of such rock from both existing and potential quarries.

Table 4 Forecast Sydney Region Consumption of Coarse Aggregate 1998 – 2030 (in Million Tonnes)

Table 4 Forecast Sydney Region Consumption of Course Aggregate 1998 - 2030 (Million Tonnes)

Year	Total	CBS	PRB	Basalt&Latite
1998	8.10	3.71	2.58	1.80
1999	8.12	3.72	2.55	1.85
2000	8.14	3.72	2.52	1.90
2001	8.16	3.72	2.49	1.95
2002	8.18	3.72	2.46	2.00
2003	8.21	3.73	2.43	2.04
2004	8.23	3.73	2.41	2.09
2005	8.23	3.73	2.41	2.09
2006	8.25	3.73	2.38	2.14
2007	8.27	3.74	2.35	2.19
2008	8.29	3.74	2.32	2.24
2009	8.32	3.74	2.29	2.29
2010	8.34	3.74	2.26	2.33
2011	8.36	3.75	2.23	2.38
2012	8.38	3.75	2.20	2.43
2013	8.40	3.75	2.17	2.48
2014	8.43	3.75	2.14	2.53
2015	8.45	3.76	2.11	2.58
2016	8.47	3.76	2.09	2.63
2017	8.49	3.76	2.06	2.67
2018	8.51	3.76	2.03	2.72
2019	8.54	3.77	2.00	2.77
2020	8.56	3.77	1.97	2.82
2021	8.58	3.77	1.94	2.87
2022	8.60	3.77	1.91	2.92
2023	8.62	3.78	1.88	2.96
2024	8.65	3.78	1.85	3.01
2025	8.67	3.78	1.82	3.06
2026	8.69	3.79	1.80	3.11
2027	8.71	3.79	1.77	3.16
2028	8.73	3.79	1.74	3.21
2029	8.76	3.79	1.71	3.25
2030	8.78	3.80	1.68	3.30
Totals for 10 Year Periods 1998 to 2027				
1998-2007	81.9	37.3	24.6	20.1
2008-2017	83.9	37.5	21.9	24.6
2018-2027	86.1	37.8	19.0	29.4
Grand Total	251.9	112.5	65.4	74.0

Minec Pty Ltd, January1999

CBS - Crushed and Broken Stone
PRB - Prepared Road Base

12. NEW POSSIBLE SOURCES OF HARD ROCK AGGREGATE SUPPLY FOR THE SYDNEY REGION

The NSW Geological Survey has listed two general areas as possible locations for new aggregate quarries for the Sydney region. These are the Richmond Lowlands area and the syenite deposits in the Mittagong area (Wallace, 1981, DEP, 1984 and 1986). A possible new quarry to supply western Sydney could be developed via Mt Lambie, at Rydal, west of Lithgow (rock type hornfels).

WEST OF SYDNEY

Richmond Lowlands

The Richmond Lowlands deposit is located immediately north of Richmond and occurs as a broad flat river terrace. It represents the largest known undeveloped deposit of sand and gravel in the Sydney region (DEP, 1984, p.72). Oakes (1980) estimated the reserves as 76.5 million cubic metres of fine sand, 75.9 million cubic metres of medium - sand and 37.65 million cubic metres of river gravel.

Using generalised specific gravity estimates of 1.5 tonnes per cubic metre for sand and 1.6 tonnes per cubic metre for gravel, the reserves equate to 230 million tonnes of sand and 60 million tonnes of gravel. Approximately 90 percent of both the sand and gravel reserves appeared to have economically acceptable overburden ratios (Oakes, 1980).

As Richmond Lowlands is such a large deposit and so well located for the Sydney market it would be logical to advocate its early development. However development would involve major environmental and social concerns.

In its 1984 Report the DEP stated:

> Significant problems are presented by the extraction at the Richmond Lowlands. The area is prone to severe flooding and contains important freshwater wetlands maintained by the shallow water table. The soils are highly productive, currently accounting for about 40 percent of Sydney's turf production. Small pockets of forest red gum (**E. tereticornis**) have conservation value as representatives of a once widespread community.
>
> The shallow watertable and flood liability of the land indicate that a water-based landscape would probably be the only feasible option for restoration. Being immediately north of the Penrith Lakes Scheme area the desirability of two such areas in close proximity need to be established.

> The effects of large scale extraction of the Lowlands on the Hawkesbury River downstream and on groundwater are unknown and should be examined closely prior to consideration being given to extraction in the area.
>
> Access from the deposit to the Sydney market is good but would need to be upgraded if large scale development were to proceed. It is well positioned to serve a growing population in the west of Sydney. Access roads on the deposit are generally single lane and would be inadequate for extractive purposes.
>
> Increasing urbanisation immediately to the south could present problems for transport access to the site. Residents and others overlooking the site, especially from the north and west, would have their views severely affected during any extraction operations.
>
> The deposit is unlikely to be developed for other purposes owing to its flood liability. Extraction is prohibited under the current zoning (DEP, 1984, p72-73).

The amendments to the *Sydney Regional Plan No.9* contained in the *Sydney Regional Environmental Plan No.20 - Hawkesbury - Nepean River* formally acknowledged these concerns.

The concerns about the problems associated with development of the Richmond Lowlands have not diminished and in the most recent *Regional Environmental Plan*, The Department of Planning cast doubt on the wisdom of developing the resource.

> However, the Richmond Lowlands are subject to a variety of environmental constraints and conflicting land use pressures which would have to be resolved before any extraction could proceed and which may severely restrict or preclude future extraction (SREP, No.9, p.68).

Although there may be areas in the Richmond Lowlands that contain more gravel than sand, it appears that the resource contains predominantly more sand than river gravel and perhaps should be regarded as a sand resource rather than a gravel resource. As such it is probably not a replacement for the Penrith Lakes Scheme gravel resource.

In light of the serious environmental and social problems associated with the Richmond Lowlands resource, and that it is really a sand resource rather than a gravel resource, one must disregard the resource as a realistic source of supply of gravel for Sydney.

The Lithgow Region

Mt Lambie at Rydal

In February 1998 Australian Aggregates Pty Ltd sought funding from interested parties to develop the Mt Lambie coarse aggregate quarry at Rydal. The rock is hornfels and testing by Boral Research Materials Laboratory and CSR Readymix Materials Laboratory, as reported by Mr A McVeigh for Australian Aggregates Pty Ltd, indicates the rock should be suitable for concrete aggregate, probably including low shrinkage concrete and sealing aggregate. The initial proposed quarry is for the production of 7.7 million tonnes of product. Potential reserves are stated to be 88 million tonnes. The proposed quarry, originally approved, is currently the subject of an appeal before the NSW Land and Environment Court.

The deposit is on private land and Australian Aggregates have secured rights to quarry it. However the company lacks experience in the aggregate business and in February 1998 was seeking possible joint venture partners from industry majors.

SOUTH OF SYDNEY

Southern Highlands

Mt Flora and Mt Misery

The Mt Flora and Mt Misery resources are more fully described in Section 6. The two deposits contain in the order of 1200 million tonnes insitu and 750 million tonnes insitu of microsyenite, respectively (CSR Readymix). Secured reserves total 59 million tonnes (SREP No.9, p.68). Indicated reserves in the two initial quarry sites total 55.4 million tonnes (NSW Geol.Survey, Table 2).

Although approval for extraction had been given for Mt Flora in 1991 and Mt Misery in 1992, development has yet to occur. With regard to the Mt Misery deposit the Woodward Commission stated "There is significant controversy over the quality of the deposits at Mt Misery-Hurdle Ridge" (p.16) and "...some questions remain about the overall quality of the deposits" (p.45). The Mt Flora deposit may be able to produce CBS suitable for road works and normal concrete but it is not suitable for the production of low shrinkage concrete.

In the case of Mt Flora, the owner has lodged proposals for the expansion of its existing latite quarry at Albion Park. In the case of Mt Misery, the owner (BTR Pty Limited) recently announced its intention to sell its Australian construction materials division. The resource is still for sale. The development of either project is unlikely to proceed in the short run at least, because of high initial capital costs and the unsuitability of the rock for the production of very high strength concrete.

Exeter Proposal

The Exeter resource and proposed expansion is more fully described in Section 3. The Exeter Quarry was not highly regarded by the Woodward Report. The Commissioners were guided by the Department of Mineral Resources as to which deposits of hard rock within the Shire of Wingecarribee were of commercial value. The Commissioners concluded:

> "The Department referred to these resources as "potential resources". A subsequent detailed investigation would prove them to be economic or otherwise. Industry would undertake that assessment" (p.12).
>
> "It is therefore clear the Department of Mineral Resources, in relation to the terms of reference, has not identified any areas of commercial value but has identified areas of potential resources" (p.13).

The Commissioners continued:

> "The type of investigation carried out (by the Department) was not a thorough geological assessment of all reserves... The Department of Mineral Resources does not usually carry out detailed geological investigations of specific reserves... It is,

however, highly unlikely that the estimates of the extent and quality of the deposits are precise" (p.16).

As the Department of Mineral Resources was not equipped to prove up a resource to show if it was economic, not only is it likely that the Department's preliminary valuations would include deposits with no commercial value, it is also likely the Department could exclude some deposits of real commercial value. This is exactly what happened with the Exeter Quarry.

The Commissioners noted that the land on which Exeter Quarry is located contained outcrops of deeply weathered basalt. The Company estimated it has further reserves of 0.6 million tonnes within the current area of operation and have investigated an area to its southwest in which they have established the existence of a further 1.8 million tonnes of extractable material. Furthermore, they estimate that the area within 1 km of the existing plant could contain total deposits in the order of 10 million tonnes (p.7).

The Commissioners also recorded that the then current owners and operators of the quarrying business, XQ Holdings Pty Ltd and Southern Highland Quarries Pty Ltd, claimed that the deposit produces high quality aggregate suitable for producing concrete with low shrinkage characteristics and for road and freeway construction.

The Commissioners ranked the Exeter Quarry fourth out of six deposits considered in terms of quality and added the comment "quality is a doubtful characteristic here" (p.20).

Exploration undertaken by Concrite Quarries subsequent to the holding of the Woodward Commission has identified a number of basalt horizons at Exeter capable of producing high quality aggregate, as well as "normal" quality aggregate and PRB, with reserves in excess of 21 million tonnes (see Section 3).

The high quality aggregate is capable of allowing concrete of 80 - 100 MPa and low shrinkage characteristics to be made. The demand for such specialised concrete is increasing for the construction of large buildings. Exeter is one of the few sources of such high quality aggregate for the Sydney, Illawarra and Southern Highlands markets (Crawley, 1998, pers.comm.).

Penrose Expansion

As part of the proposed expansion of the Penrose sand quarry south west of Berrima it is proposed to produce about 0.5 million tonnes of fresh basalt and 1 million tonnes of weathered basalt on an intermittent basis. Annual production is not expected to exceed a maximum of 100,000 tonnes per annum and at this rate the quarry life would be short.

Wollongong Area

In the 7 year period 1988/89 to 1994/95 the Wollongong area produced an average of 3.25 million tonnes per year of latite. Over the last two years the average annual production fell to about 2.4 million tonnes. It has been suggested that the CSR Readymix quarry at Albion Park Rail could be expanded. The quarry has adequate reserves, 32 million measured tonnes, to handle an expansion. Whether an expansion of capacity at Albion Park would mean that total Wollongong production would rise above that of the 1988/89 to 1994/95 period is not clear. Latite aggregate can not be used to produce the very high strength and low shrinkage concretes that are in increasing demand.

13. FUTURE DEMAND AND SUPPLY BALANCE FOR COARSE AGGREGATE

Over the past 28 years the consumption of coarse aggregate (CBS) in the Sydney region has steadily increased but the progressive average production of CBS in the Sydney region has been very stable. In the short run, the production of igneous rock in the Sydney region will decline as the Prospect reserves soon exhaust. However by mid to late in the next decade the supply situation for Sydney will dramatically worsen. At that time the Penrith Lakes gravel reserves are expected to exhaust. About 80 percent of Sydney's CBS production presently comes from the Penrith gravels.

By the middle of the next decade the Sydney region will face a shortfall of coarse aggregate of about 3 million tonnes per year.

Extensive reserves of gravel occur in the Richmond Lowlands, but the environmental problems with development will make development very difficult. One must consider that it is unlikely that the Richmond Lowlands gravel resources will be developed.

The largest undeveloped resource within at least 150 km of Sydney is the Mt Flora and Mt Misery microsyenite occurrence. It is well known that the development costs of both resources are high, and to repay the capital investment it is necessary for the average production to be high and for the quarry to build up production levels quickly. The Penrith Lakes gravel production is shared between three of the industry majors and each will need to find new supplies to maintain their individual market shares. A cooperative funding and sharing of production of the Mt Flora and Mt Misery resource would help solve both the high development costs and the exhaustion of the Penrith Lakes gravel resources. This makes the Mt Flora and / or Mt Misery resources, either as a single company development or as a joint project, well suited to replace the Penrith Lakes gravel towards the middle or end of the next decade.

The large scale development of the Mt Flora and / or Mt Misery resources would solve the "bulk" aggregate supply problem but not the quality problem. CSR Readymix have stated that the Mt Flora microsyenite will produce satisfactory aggregate for the production of normal concretes with strengths up to 50 MPa and perhaps even as high as 80 MPa provided low shrinkage properties are not required (George McClelland, 1998, Personal communication).We also know that latite aggregate will not produce the very high strength, low shrinkage concrete increasingly required by builders of large buildings. Basalt is the only rock type available that will allow these very high strength, low shrinkage concretes to be produced.

Whether or not Mt Flora and / or Mt Misery are developed, there is a real public need for more basalt production from the Exeter Quarry. Concrite Quarries have a real private need to be able to provide quality aggregate to their concrete plants in southern Sydney, Wollongong and the Southern Highlands. Even here, however, it is in the public interest that Exeter be developed to ensure there is strong competition for the three majors in the concrete industry; increased concentration could lead to higher prices.

14. CONCLUSIONS

Production from the Exeter Quarry in the 1990's has averaged about 280,000 tonnes per year and in recent years an average of 30 percent of production is supplied to the Sydney and Wollongong areas and 70 percent to the Wingecarribee Shire and Goulburn areas.

Wingecarribee Shire contains many occurrences of basalt and other igneous rocks but only 3 are of commercial significance; Exeter Quarry, Mt Flora and Mt Misery. The Mt Flora and Mt Misery resources are microsyenite that is not suitable for producing high performance concrete whereas basalt is.

A survey of coarse aggregate resources within 130 km of Sydney shows that apart from Mt Flora and Mt Misery, there are no replacements for the Penrith Lakes Scheme river gravels, and that there is a shortage of basalt aggregate resources. Because of the high capital costs of starting production at Mt Flora and Mt Misery, a large production rate is required to amortise the capital and it is likely that neither resource will be put into production until the Penrith Lakes Scheme resource is exhausted.

Over the past 28 years the total demand for coarse aggregate in the Sydney region has averaged 7.8 million tonnes per year and the demand trend line is slightly positive, increasing on average by 22,000 tonnes per year. The annual average past consumption in 10 year blocks (9 years for the last block) it is found that consumption of coarse aggregate has increased in each block, from 7.5 million tonnes for 1969 - 1978 to 8.4 million tonnes for 1989 - 1997.

The trend line for the consumption of prepared road base (PRB) for the period 1969 to 1997 has decreased at a rate of 29,000 tonnes per year. Actual annual average consumption has fallen from an average of 3.1 million tonnes for the period 1969 - 1978 to 2.7 million tonnes for the period 1989 - 1997.

The trend line for crushed and broken stone (CBS) produced in the Sydney region over the past 28 years has been flat, at an average production of 3.7 million tonnes per year.

The other component of CBS consumption in the Sydney region, imported volcanic coarse aggregate, has grown very strongly over the past 28 years. Consumption has increased from about 0.2 million tonnes to a peak of 2 million tonnes in 1994 and 1995. Consumption has increased at an average of 48,400 tonnes per year since 1969. The annual average consumption of imported volcanic coarse aggregate has increased from 0.8 million tonnes for 1969 - 1978 to 1.85 million tonnes for 1989 - 1997. About 20 percent of the imports are basalt from the Newcastle Mining District and the Exeter Quarry and 80 percent latite from the Wollongong Mining District.

The Prospect quarries production of dolerite CBS has been steadily declining and was 0.6 million tonnes in 1996/97. The reserves of CBS are expected to be exhausted by about 2000.

Production of volcanic breccia in the Sydney region has been steadily falling and in recent years has been at or less than 0.2 million tonnes per year.

The Penrith Lakes Scheme has been supplying Sydney with between 3 - 4 million tonnes of CBS a year since the end of the 1980's. Reserves were downgraded in 1996 and the gravel production is expected to be exhausted by 2006 to 2008.

The pre-mixed concrete market in Sydney is in the order of about 4 million cubic metres per year, requiring approximately 4 million tonnes of coarse aggregate per year.

Concrite has about 10 percent of the Sydney market, requiring about 400,000 tonnes of CBS per year, plus it needs to supply its southern market. About 70 percent of Exeter's 280,000 tonnes of CBS output is consumed in the southern area and 30 percent is exported to Sydney.

The Woodward Commission did not appreciate the high quality of the Exeter resource nor the size of the overall resource and hence did not list it a resource of regional significance.

The Exeter resource has at least 21 million tonnes of saleable reserves of basalt with a very low overburden and waste to saleable rock ratio. However, in recognition of local environmental concerns and the term of approved extraction, the current proposed quarry plan provides for the production of up to 8.5 million tonnes of aggregate over an 18 year period.

Basalt is a preferred rock type for the production of high performance concrete and is the only aggregate capable of making the very highest quality concrete. The demand for high performance concrete is growing and will continue to do so for the foreseeable future.

Basalt is in scarce supply within a considerable distance of Sydney and the Exeter Quarry is an important source of basalt.

The supply - demand balance for coarse aggregate is slowly tightening as the traditional Sydney igneous supplies are exhausted. The situation will dramatically worsen towards the end of the next decade with the exhaustion of the Penrith Lakes gravel reserves, possibly as early as 2006.

The Exeter Quarry is an important resource for both Concrite Quarries Pty Limited and for the Sydney, Illawarra and the Southern Highlands regions. Concrite Quarries has developed an important market share in the Sydney region in competition against the "traditional" majors and needs a secure source of aggregate. It also supplies an important share of the southern market.

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EXETER QUARRY EXTENSION

DYNAMICS OF MARKET DEMAND FOR HIGH PERFORMANCE CONCRETE AGGREGATE FROM EXETER QUARRY

Prepared by:

Environmetrics Pty Ltd

May, 1999

Specialist Consultant Studies

Volume 1 ▪ Part 3

Dynamics of Market Demand for High Performance Concrete Aggregate from Exeter Quarry

prepared for

Concrite Quarries Pty limited

by

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May 1999

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CONTENTS

Executive summary

1. Basalt from the Exeter Quarry operated by Concrite Quarries Pty Limited has particular value as an aggregate in what is termed high performance concrete. High performance concrete is dimensionally stable, durable and strong. These factors can lead to both short and long term savings in project costs. In particular, the decreased need for maintenance or replacement of structures made from high performance concrete can reduce the cost to the community of essential, shared facilities such as roads, bridges and major public buildings.

2. Sources of aggregate that can provide the properties needed for high performance concrete are extremely limited in the Sydney region. The Exeter Quarry is the source of a particularly high standard stone that allows high performance concrete to be supplied to the market at prices competitive with normal-class concrete.

3. Our investigation suggests that the benefits of high performance concrete are not fully understood by the construction industry *but that this situation is changing rapidly.* As a consequence, the demand for high performance concrete will increase. The increase in awareness will be a function of a number of factors including tightened specifications for public works, the release of new concrete standards and evolving tertiary syllabi.

4. It is likely that even if total demand for ready mixed concrete reduces in the near future, the proportion of the market that consists of high performance concrete will increase. This will be driven by factors such as the cost savings in maintenance and conservation on major private and public works and the increased flexibility of design allowed by high performance concrete.

5. We estimate the market for aggregate for high performance concrete to be between 300,000 and 800,000 tonnes per annum which equates to between 10 - 20% of the pre-mixed concrete market for Sydney, Southern Highlands and Wollongong.

6. The market estimate for superior quality aggregate would be increased by a substantial amount if one or more of a number of planned projects are commenced. These include the construction of the VFT between Sydney and Canberra and the construction of a new Sydney airport. The demand will also increase substantially if the RTA brings the specification for road concrete in line with the current specifications for bridge concrete.

Background to this report

Environmetrics was contracted by Concrite Quarries Pty Limited to prepare a report which examines the demand and supply trends for high performance concrete in the Sydney area.

The basis of this report

This report was prepared after meetings with representatives of Concrite to establish details of the Exeter Quarry production process. Following these meetings we conducted interviews with people who have particular knowledge or expertise in relation to the engineering uses of concrete or are involved in the construction industry.

Some of the people to whom we spoke were chosen because they had participated in a recent conference on high performance concrete[1] and/or are involved in the education of engineers in Australia. Others were chosen because they are involved in the concrete industry or the construction industry. (The list of people to whom we spoke is included as Appendix 1.)

We also consulted a number of sources of statistical information related to concrete production and construction activity in the Sydney area.

1 See Rangan, B. V., and Patnaik, A. K. (Eds.) "High Performance High Strength Concrete: Material Properties, Structural Behaviour and Field Applications", Proceedings of the International Conference, Perth, Australia, August 10-12, 1998.

Exeter Quarry Production

Exeter Quarry produces basalt that is, as a result of the production process, available in a range of sizes. The processing of each tonne of stone produces marketable aggregate ranging from pieces 30 millimetres or more in diameter to crusher dust (i.e. <5 mm in size).

Basalt is heavy and transportation incurs considerable costs. This fact leads to the market being relatively tightly constrained in a geographic sense. For this reason, aggregate from the Exeter Quarry is sold in the local area for a broad range of uses, many of which do not make any great demands on the physical properties of the stone. However, it is in the production of what is termed "high performance concrete" that the Exeter basalt achieves a greater value and is worth shipping into the Sydney and surrounding markets.

Thus, the prime focus for this report is to assess the size of the Sydney market for high performance concrete. This task had two components—establishing the current size of the market in cubic metres and then projecting trends in the market over the next few years.

An important part of the latter task was to identify the underlying forces that might shape demand for high performance concrete in the Australian market in general and the Sydney market in particular. The reason for this is that only three quarries [2] in the Sydney region produce basalt of the particular quality found at Exeter. Hence, developments in the engineering and architectural disciplines that would impact on construction design in Sydney could have a marked influence on the demand for Exeter basalt.

The nature of the high performance concrete

The Australian Standard for normal-class concrete (AS1379) has no definition of high performance concrete. However, for the purpose of this report it is defined as special class concrete specified to have certain high performance requirements, such as one or more of the following:

- Very high strength (up to 100MPa)
- Very high modulus of elasticity
- Low shrinkage (less than 600 microstrain)
- Innocuous with respect to alkali/aggregate reactivity
- low totals of chloride and sulphate salts
- Low permeability

From a marketing perspective, high performance concrete is a complex class of products. This complexity arises from the number of physical properties that can be thought of as potential product benefits when compared to other concrete mixtures.

The strength properties of high performance concrete mean that, in comparison with other mixtures it allows narrower columns in multi-story buildings with the consequent increase in usable floor area. The chemical stability of the product means that less spalling (sometimes referred to as "concrete cancer") is likely to occur and that structures made from it will require less conservation and maintenance. The term "shrinkage" as applied to concrete can refer to a number of processes which have as their end result cracking of the concrete. Thus, where large areas are required, such as in warehouse flooring or parking stations, or where the concrete is used to build a container for liquids, shrinkage is very undesirable. Use of an aggregate with low shrinkage properties is one way in which overall shrinkage can be managed and controlled. High performance concrete using basalt aggregates can have very low shrinkage characteristics.

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2 These are at Peats Ridge (operated by Boral), Kulnura (operated by Pioneer) and Exeter.

The first two examples of the ways in which the properties of high performance concrete impact on structures focus on two somewhat different kinds of benefits. Increased lettable area in a building has immediate financial benefits for the building owners and can thus be seen, in part, as a benefit the impact of which appears early in the life of the project.

The benefits of increased durability are realised in the longer term. From this perspective it can be argued that the use of high performance concrete in structures owned by the community generally provides a long-term community benefit.

An important question is whether basalt used as aggregate confers particular engineering advantages in the manufacture of high performance concrete. From our interviews with people working in the field of concrete technology and engineering we have concluded that while other aggregates or cementitious materials (such as fly ash) can provide some of the physical qualities that define high performance concrete, they do not provide the total spectrum of properties conferred by basalt. In addition, the use of materials such as fly ash is still the subject of research and it will be some time before the full implications for factors such as the durability of the resulting concrete are known.

It was also clear from our interviews and from reviewing relevant web-sites[3] devoted to high performance concrete, that the total spectrum of desirable qualities is not yet fully appreciated in the construction industry. This point will be expanded in the next section of this report.

The perceived nature of high performance concrete

Designers and users of concrete tend to place an emphasis on one physical quality or another in specifying their needs. This selectivity of focus comes about because an engineer working mainly with, say, large flat areas such as warehouse floors will be primarily concerned with shrinkage or creep. In contrast, engineers working on tall structures may have a greater concern with strength or the degree to which the concrete will compress under load. Chemical reactivity will be high on the list of those working on wharves and other structures exposed to hostile environments or using a large amount of steel as reinforcing.

While high performance concrete has a broad profile of *objectively measurable benefits* in comparison with other concrete mixtures, not all of these benefits may be uppermost in the mind of any particular user.

Given the various perspectives from which experts view the market, it makes more sense at the moment to think about *markets* rather than *market* for high performance concrete: each market driven by a different constellation of design demands. When trends in each of these markets is considered, it is obvious that the overall demand for high performance concrete will grow in the near future.

A number of the interviewees remarked on the fact that while the engineering disciplines were becoming increasingly aware of the range of benefits available from high performance concrete, a considerable number of engineers and others in the construction industry had yet to become conversant with it. The process of education is well under way[4] and will be one of the major dynamics driving increased demand.

A second key driver will be price. Market conditions to date have meant that it is relatively rare for basalt (and high performance concrete incorporating basalt) to attract a premium because of its

3 See for example http://hpc.fhwa.gov/about.htm

4 Evidence of this comes from a number of sources. In October, 1997, Mr John Turton of the Cement and Concrete Association of Australia wrote in a letter to Concrite Quarries Pty Limited "...the type of technical enquiries we have been receiving recently reflect a growing number of queries related to high performance concrete issues. "Less than a year later, Dr. E. P Evans, appearing as a keynote speaker at the international "High Performance High Strength Concrete" conference in Perth traced the way in which understanding of concrete had evolved and projected a greatly increased demand for a range of specialised concretes.

particular properties. Rather, the concrete has been supplied at close to the prevailing market price. Competitive advantage has flowed to the supplier because:

1. they can provide concrete with great benefits at an attractive price, and

2. they can provide the production controls necessary to ensure the concrete meets the specifications.

Thus, as the construction industry becomes increasingly aware of the benefits of high performance concrete, they are not faced with a steep price barrier. Hence, in the short term, demand should grow in step with awareness.

In summary, we believe that high performance concrete will follow the demand pattern typical of many products based on rapid technical innovation—that is, an increasingly rapid penetration of the market as the financial and other benefits are appreciated by the end-users.

Current size of the market

Since there appears to be no centralised collection of statistics on high performance concrete manufacture or use, the total size of the current market must be inferred by making some assumptions in relation to the information that is available.

The Australian Bureau of Statistics (ABS) collects information about the total production of ready mixed concrete. Figures for the volume produced excluding any part of the production used on-site at the production facility are available in report 596.01. The most recent report (march 1999) shows that in the Sydney market—defined as the Sydney Statistical Division but excluding Wollondilly, Blue Mountains, Gosford and Wyong—the production for the years 1995 to 1998 was as follows:

Table 1: Production of Ready Mixed Concrete in cubic metres

Period	Sydney Metropolitan	Balance of NSW
1995 - 1996	3,077,000	1,960,700
1996 - 1997	3, 403,700	1,902,300
1997 - 1998	4,052,400	1,965,600
1998 - 1999	4,593,700	2,062,000

For the purpose of estimating the current size of the market we focused on the 1997 - 1998 period. The proportion of the total that was made up of concrete that had been specified to have one or more of the physical qualities of high performance concrete could be estimated by considering a number of known projects for which Concrite are in possession of the specifications and then making assumptions about the volumes of high performance concrete that might have been specified for them. This approach has been used by Concrite in their earlier submissions.

An alternative approach is to ask experts to estimate the size of the market. We did this in our interviews and it was obvious that opinions varied depending on the information available to the interviewees and the focus of their normal work.

People who appeared less directly involved (such as construction engineers who said they kept no more than a general watching brief on trends) tended to see the market as being smaller than did those people actively researching the properties and uses of high performance concrete.

Table 2: Estimate of High Performance Concrete Market Size

Estimate	Number of interviewees
"Small" 1% - 5% of market	3
6% - 10% of market	4
11% - 20%	4
21% - 30%	-
31% - 40%	1
More than 41%	1
No estimate offered	7

Estimates of the current market for HPC as a proportion of total production

Given the lack of generally available statistics on actual consumption, it is our view that the interviewees who ventured an estimate were heavily influenced by their particular kind of contact with the industry. Those who were less actively involved in teaching, research or current use of high performance concrete tended to see the market as small. Those deeply involved with the development or use of high performance concrete tended to give the higher estimates.

It is likely, then, that both the high and low estimates are biased by the perspective of the observer and that the true figure is somewhere between the high and low estimates.[5]

A figure between 10% and 20% would be consonant with the estimate developed by Concrite using their own "window" into the market. This figure would translate into 300,000 to 800,000 tonnes of aggregate.

5 The fact that seven of the interviewees were unable to quantify the size of the market as a percentage of the total production is further evidence of the lack of collated information.

Trends in the market

The overall demand for concrete varies, as would be expected, with the amount of construction taking place in the market. The figures in Table 1 show, for example, that over the years 1995 to 1998 the Sydney market grew while the rest of the New South Wales market tended to be flat, fluctuating around a value of 1.93 million cubic metres.

The opinion was expressed to us by one interviewee that the Sydney market *may* not continue to grow in the period immediately after the construction associated with the Sydney Olympics is completed. In contrast, it can be argued that construction directly linked to the Olympics is a relatively small proportion of the total. In addition, it has been pointed out in presentations[6] and by a number of our interviewees that the decision to build major works such as a super fast train link to Canberra would increase demand substantially. However, whether the total demand continues to grow or goes through a period of contraction, a central question is whether the *proportion* of the production made up of high performance concrete will increase.

The majority of interviewees to whom we spoke believed that the demand for high performance concrete would increase. When asked to estimate the proportion of production that would be made up of high performance concrete in five years time, the pattern of responses was as follows:

Table 3: Forecast proportion of the total ready mixed concrete market

Forecast	Number of interviewees
Will not increase or minor increase	4
Will increase - no quantitative estimate	12
Will increase - between 10%and 15% of market	1
Will increase - 16% to 20% of market	-
Will increase - 25% to 30% of market	1
Will increase - 40% to 50% of market	2

Most interviewees felt unable to put figure on the likely percentage of the market, but those who simply forecast an increase tended to think it would be substantial. (Those people who thought it would be marginal were among the four people shown in the first row of the table.)

Each interviewee was also asked to provide reasons for their forecast of growth in the market and these are summarised in Table 4. The reasons fell into four main categories which were used to structure the summary.

Those people who were more pessimistic cited cost and difficulty of production as factors that would constrain growth in the market.

6 Such as "BEYOND THE 2000 OLYMPICS" presented by Michael Sullivan, Director Olympic Business Services to the Institute of Quarrying, May 1999

Table 4: Factors that will influence Market Growth

Factor leading to growth	Examples given
Economic pressures	• The cycle time for activities such as post-stressing beams can be cut by half • Durability and maintenance cost reduction. • Less material needed in some structures. • More space available within some structures
Increased knowledge	• Engineers are becoming aware that they can specify concrete with desirable properties in addition to compressive strength. • Increased awareness that specifying compressive strength alone does not bring with it other necessary of desirable properties in concrete.
Design aspirations	• Architects and engineers will create designs that reply on the greater strength and stability of new materials and thus start a cycle of demand.
Technological	• Improvements in steel will require increased strength in concrete when the two are used together in a structure. • The suppliers of concrete are increasingly able to control the production process and reliably deliver batches of concrete that meet the requirements specified. • Acceptable way of using some industrial pollutants such as fly ash.

Appendix 1: People interviewed for the preparation of this report

People interviewed for the preparation of this report

Concrite contacts
Bill Crawley, Concrite Quarries Pty Limited
Dr Harold Roper, consultant to Concrite Quarries Pty Limited
Mr Manuel Ortiz, Technical Manager of Concrite Pty Limited & Manager of Contest Concrete Testing Pty Limited.
Industry and Education contacts
Mr. Harold Isaacs, engineer who worked on the previous concrete standards.
Mr. David Morehead- Consulting Structural Engineer on the committee preparing the new standards for high performance concrete.
Mr. John Webb, Structural Consulting Engineer.
Mr. David Beal, consulting engineer,Senior Lecturer and Vice President of The Concrete Institute of Australia
Mr. Rob Wallis- consulting structural engineer- Ove Arup and Partners- key note presenter at Perth High Performance Concrete Conference, Perth
Mr. Richard Hitch runs the training for the College of Structural and Civil Engineers. He works for McMillan Briton and Kell.
Mr Milinov - Consulting Structural Engineer with McMillan Briton and Kell
Mr. Cris Jones- Engineer with Sydney City Council
Mr. Yitzhak Hazan construction manager with KH contractors in Melbourne
Mr A Jansen- Civil engineer in the civil division of McConnell Dowell Constructors Melbourne.
Mr. John Turton Manager Australian Pre-mixed Concrete Association.
Professor Reid, Sydney University.
Mr. Gowrie Palan, research engineer at the University of New South Wales.
Mr. Stephen Foster Senior Lecturer at the School of Civil And Environmental Engineering at UNSW.
Dr. Denis Montgomery, Associate Professor In Civil Engineering University of Wollongong
Dr. Indu Patnaikuni, Senior Lecturer and graduate research coordinator, Department of Civil and Geological Engineering, RMIT University Melbourne
Dr.Vute Sirivivatnanon - Principal Research Scientist and project leader of CSIRO Sydney based concrete research team
Professor B. V. Rangan, Professor of Civil Engineering, Curtin University, Perth
Professor Ian Gilbert - Department of Civil and Environmental Engineering the University of New South Wales
Dr. Stephan Bernard University of Western Sydney, Nepean
Mr. John Ashby, Technical Manager, Taywood Engineering Limited
Mr. Gordon Churguin, Civil Engineering Group, RTA.

Appendix 2: Information about the Author – Rob Hall

Dr Rob Hall, Director, holds a PhD in psychology from Macquarie University. He is a member of the Australian Psychological Society, an Associate of the American Psychological Society and a Member of the Market Research and Statistical Societies of Australia.

Rob has had a long academic career in which he was co-founder of the Architectural Psychology Research Unit at the University of Sydney, and has been a visiting scholar at the University of California. He has held teaching positions in psychology and marketing at a number of Australian universities including Macquarie University and The University of New South Wales. Currently, he is an Honorary Visiting Fellow in both the Schools of Psychology and Marketing at the University of New South Wales and an Honorary Associate at Macquarie University.

He combines academic expertise with the practical knowledge gained from his work with a range of public and private organisations, assisting them to develop appropriate policies to meet their strategic goals. His strengths are his sophisticated grasp of strategic implications and his creative expertise in quantitative data design and analysis. His high-level skills are recognised by the profession in the extent to which he is retained to advise on analysis and to teach others how to conduct sophisticated analysis.

Rob designed, developed and now markets the Environmetrics/Newspoll Venue Monitor®.

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EXETER QUARRY EXTENSION

SOIL & WATER MANAGEMENT PLAN
FOR THE PROPOSED EXETER QUARRY EXTENSION

Prepared by:

Morse McVey & Associates Pty Ltd

May, 1999

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Soil & Water Management Plan

for the Proposed Exeter Quarry Extension

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4.1 Introduction

This study has been undertaken by Morse McVey and Associates Pty Ltd (the Company) at the request of Concrite Quarries Pty Ltd. It relates to a proposed quarry extension off Rockleigh and Werai Roads, Exeter (figure 1). The main purpose of the study is the preparation of a *Soil and Water Management Plan* (*SWMP*) for the proposed works. In doing this, it assesses the soil and surface water management constraints associated with:

< the proposed extraction area and its surrounds
< a road constructed to enable vehicles access to the site and bypassing Exeter township (the Exeter Bypass).

The proposed quarry extension includes the following developments:

< proposed extraction area
< an internal product transport route (sealed)
< a haul road (unsealed)
< a sedimentation dam
< a perimeter bund wall
< an overburden emplacement
< a dual road bund wall.

The Exeter Bypass is on the northwestern side of Werai Road and will provide an internal road across the "Vine Lodge" property from Werai Road to Exeter Road.

4.2 Methodology

Given that the principal output of this study is a *SWMP*, matters investigated include soils, surface water, geomorphology and hydrology following guidelines presented in Department of Housing (1988). To some extent, it draws upon the results of a previous investigation undertaken by Reme Pty Ltd (figure 2) for a larger area and outlined in a previous Environmental Impact Statement (EIS) for the site. This previous investigation involved analysis of topsoils for chemical fertility from nine sites, some of which now lie outside the proposed area of disturbance. However, most of the decisions made here are on the basis of the Company's own investigations.

Land surface and subsurface investigations were undertaken on 11 December 1998 within the Exeter Bypass corridor, and 8 January 1999 on lands east of the proposed extraction area. They were undertaken by the Company's Messrs Rodney Bayley and Sean Harris. The results of their analyses are given in Section 4.3.

General land surface and subsurface attributes investigated included:

(i) site characteristics such as topography, landform attributes, lithology, erosion, etc; and

(i) soil and regolith characteristics, e.g. layer status, colours, mottles, layer boundaries, soil water status, field texture, structure, fabric, coarse fragments, pans, segregations, etc.

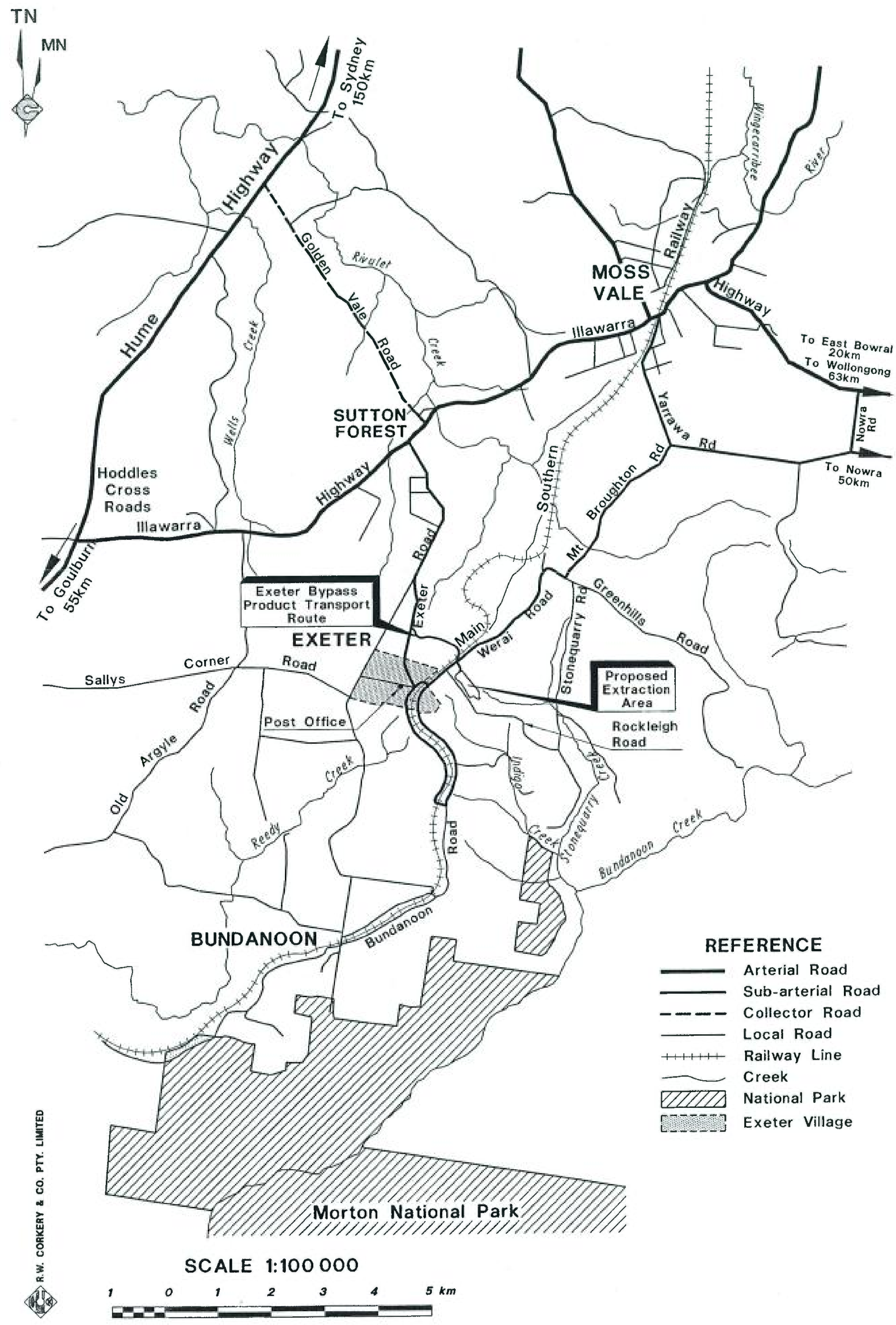

Figure 1 Site location

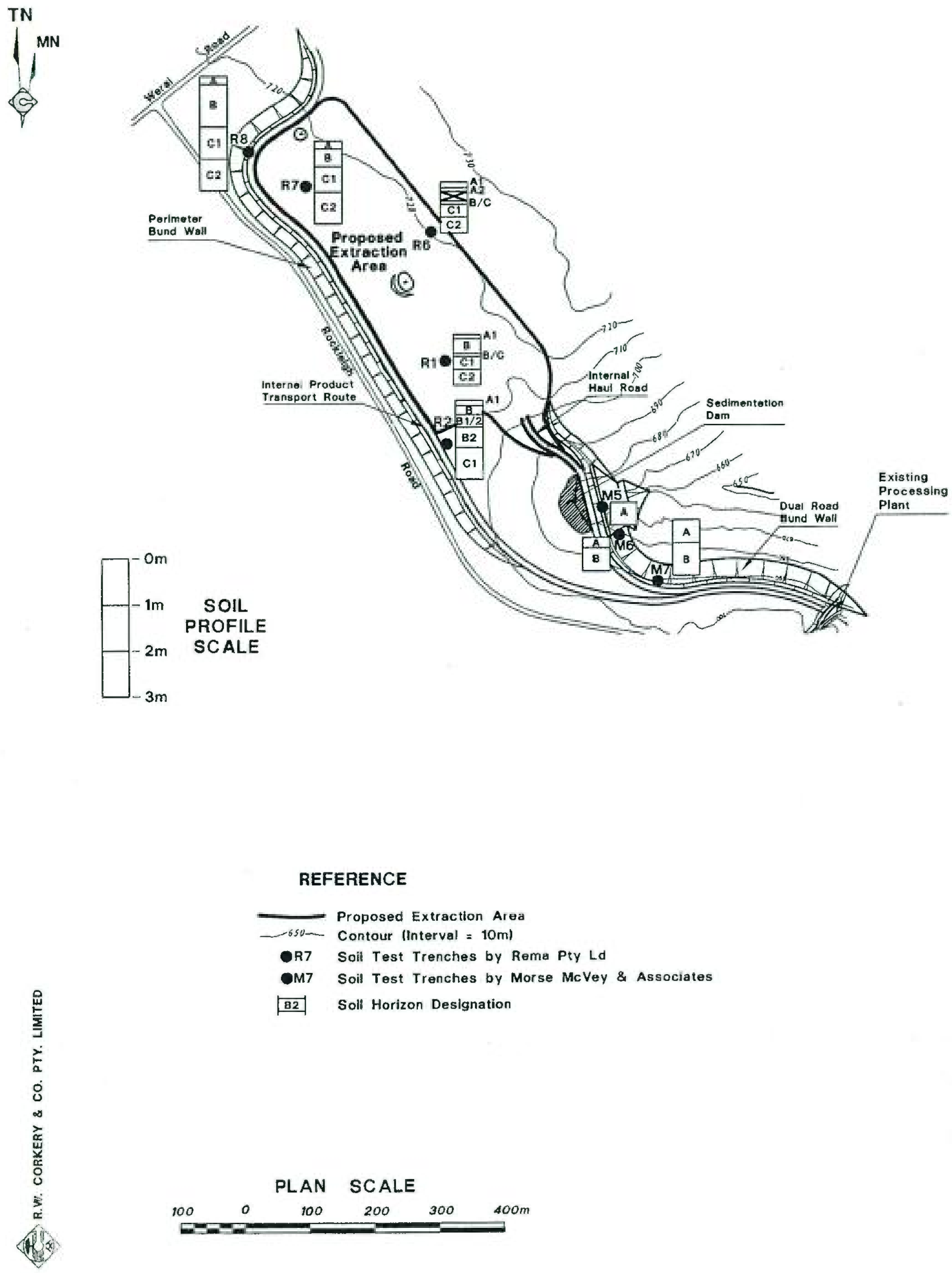

Figure 2 The proposed extraction area, showing Reme's soil test locations

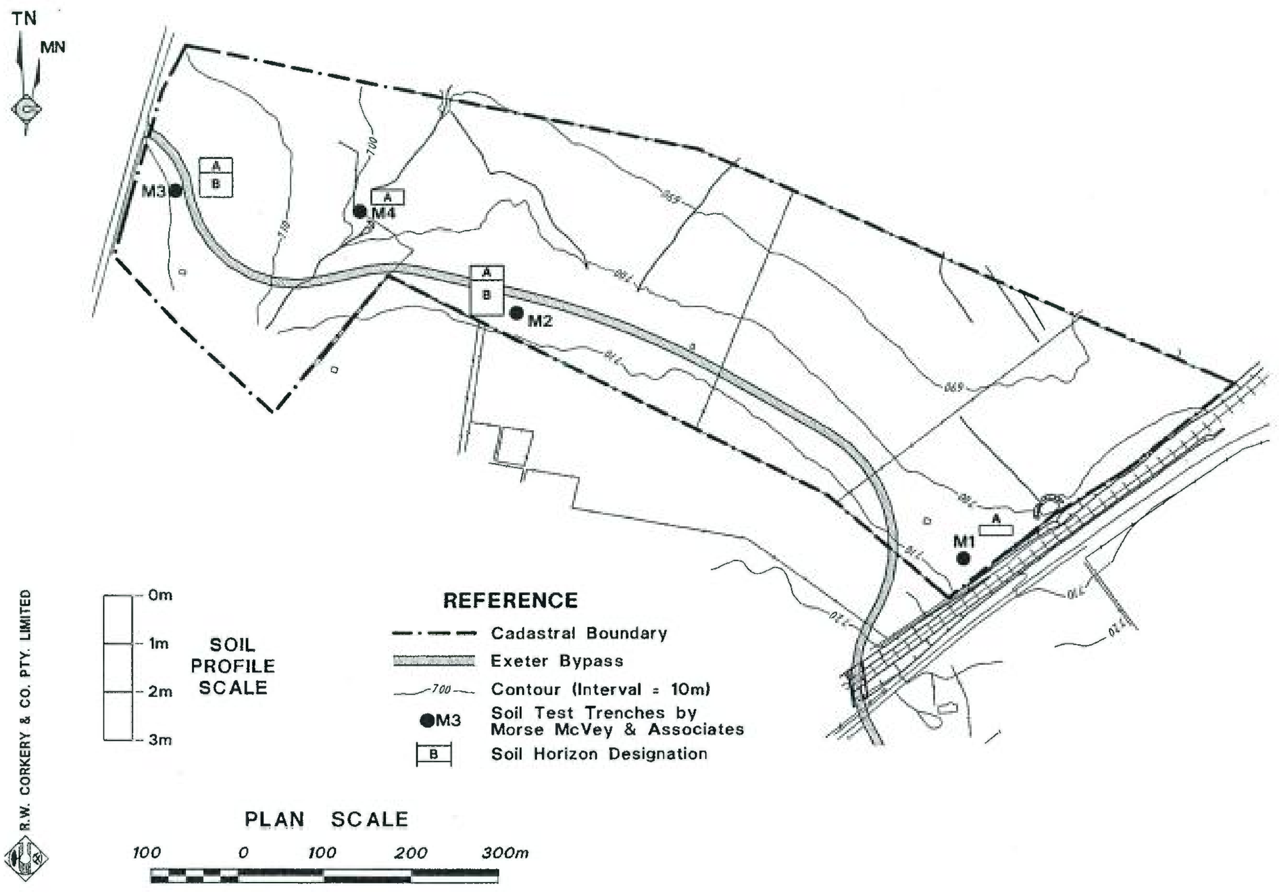

Figure 3 The Exeter Bypass corridor, showing soil sampling locations and textures

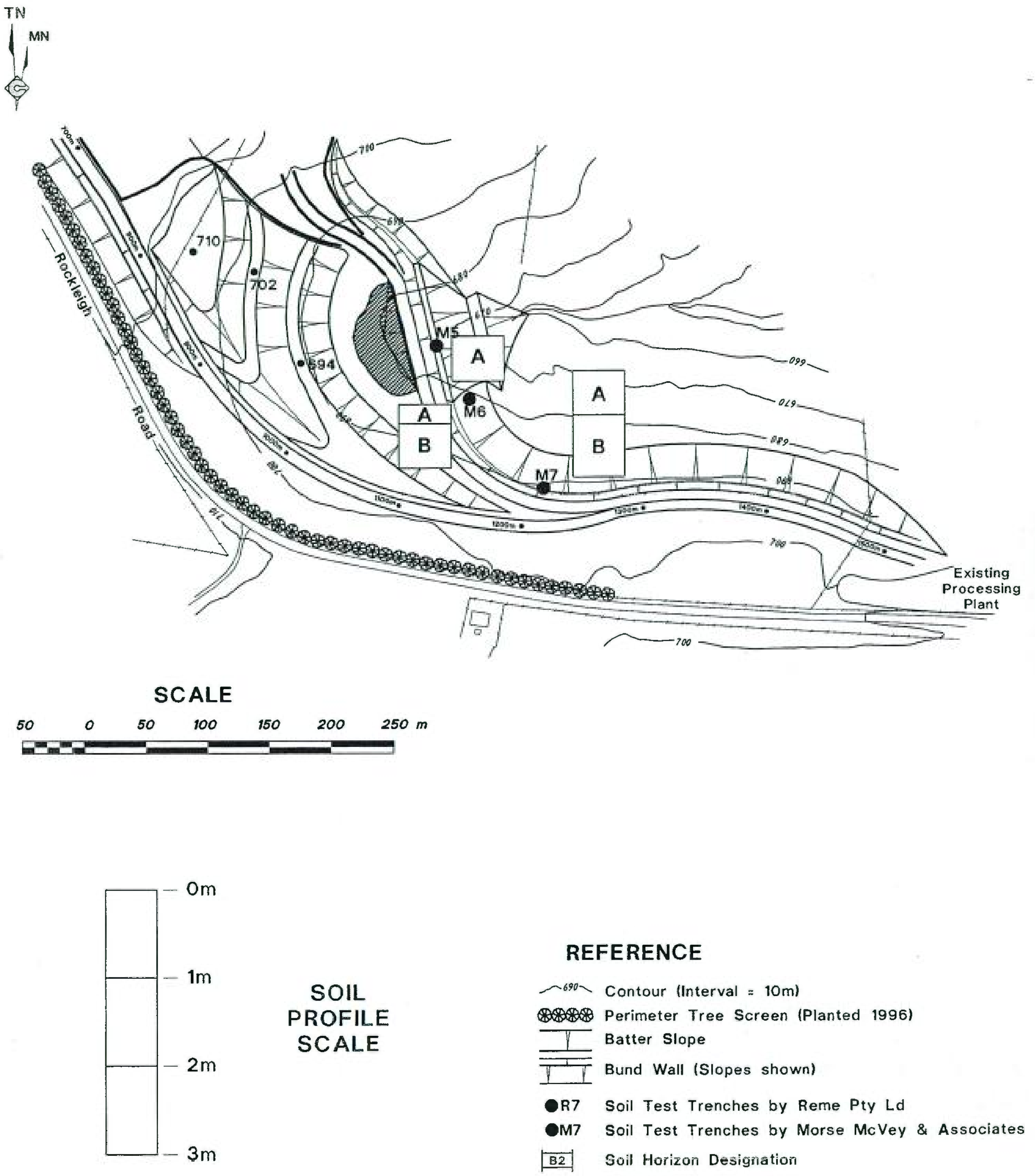

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Figure 4 The haul road corridor and sedimentation dam, showing soil sampling locations and textures

The land surface and subsurface information was combined with hydrologic data for the site to identify the constraints and opportunities to the proposed development. A *SWMP* was prepared that is considerate of these factors to ensure that, if approved, development can proceed with minimal effect on lands and waterways downslope.

Seven soil profiles and the site in general were described, using the Soil Data Cards produced by the Department of Land and Water Conservation (DLWC). Soil profiles were exposed to 750 mm or refusal (average depth of 400 mm) and soil samples were taken from each for laboratory analysis (figures 3 and 4). The soil samples were analysed at the DLWC Research Centre at Scone, a NATA-registered laboratory, for pH, electrical conductivity, organic carbon, particle size analysis, dispersion percentage and Emerson Aggregate Test.

4.3 Results

4.3.1 Topography and Drainage

The study area is characterised by a catchment boundary that divides:

- the Exeter Bypass to the west—draining to the Wingecarribee River and Hawkesbury River Basin
- the proposed extraction area to the eastern side—mostly draining to the Stonequarry and Bundanoon Creeks, and then to the Kangaroo and Shoalhaven Rivers.

Along the Exeter Bypass corridor, slopes range from 2 to 7 per cent, with the steeper slopes being next to an intermittent drainage line near its western end. However, near the proposed sedimentation dam, slopes range from 2 to 25 per cent on a benched topography—the bench tops vary from 2 to 5 per cent, while the sideslopes between each bench range from 10 to 25 per cent. This topography is typical of that given in Hazelton (1992) for the Robertson Soil Landscape, namely undulating to rolling low hills with 30 to 100 metres relief and gradients usually between 5 to 30 per cent.

4.3.2 Soils Assessment

The Exeter Bypass corridor (figure 3) and proposed extraction areas (figure 4) have gradational clay loam soils formed from weathering basalt. Typically, five layers are evident, including:

Layer 1 — 0 mm to 220 mm, brownish (7.5 YR 2/2), clay loam topsoils;
Layer 2 — 220 mm to 750 mm, dark brown (7.5 YR 3/3), clay loam upper subsoils;
Layer 3 — 750 mm to 1,090 mm, dark brown (10 YR 3/3) to bright brown (7.5 YR 5/8), medium clay subsoils;
Layer 4 — 1,090 mm to 1,520 mm, brownish grey (10YR 4/1), medium clay with dark reddish brown (10 YR 5/4) mottles; and
Layer 5 — below 1,520 mm, weathered basalt.

These soils are generally consistent with descriptions given in Hazelton (1992) for soils on the Tertiary Robertson Basalt on the Kiama 1:100,000 sheet—the DLWC have not yet mapped this area (the Moss Vale 1:100 000 sheet). However, colours are generally darker, probably reflecting the lower rainfalls at Exeter.

Soils are similar around the sedimentation dam between the existing processing plant and the proposed extraction area, especially on the upper and mid slopes. However, a change occurs in footslope positions (close to drainage line), where Layers 1 and 2 are deeper, (to 400 mm) and overlie a bleached medium clay subsoil that is subject to gully erosion. Results of the laboratory analysis of the soils are shown in Table 4.2.

4.3.3 Rainfall Erosivity

Rainfall erosivity (*R*-factor) (Department of Housing, 1998) at the site is calculated as moderate (3,010). It is a measure of the ability of rainfall to cause erosion in a normal year and is computed from the equation:

$$R = 164.74\,(1.1177)^{S}\,S^{0.6444}$$

where S is the 2-year ARI, 6-hour storm event (Rosewell and Turner, 1992). The 2-year ARI, 6-hour storm event for Exeter is 11.8 mm (Attachment I). In NSW, the *R*-factor varies from 500 in the far west to 9,500 on the north coast.

The *R*-factor is the long-term average annual sum of the rainfall erosion index (*EI*) at a location. In New South Wales, half-monthly *EI* data are available suggesting when the most and least erosive rains are likely in particular rainfall zones, i.e., their seasonality. The state is in 12 zones with this site being in Zone 5. Table 4.1 suggests that the least erosive rains are likely to occur from mid-May to mid-September and mid-November to mid-January. Being based on average annual data, it cannot be used to predict highly unseasonable events like occurred in August 1998.

Table 4.1 Percentage of Average Annual *EI* that Normally Occurs in The First and Second Half of Each Month for Zone 5 (Rosewell and Turner, 1992)

Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Sum of lowest 12 half months
2	3	7	13	13	10	11	6	3	2	3	2	2	2	1	1	1	3	3	3	3	2	2	2	22

4.3.4 Planning Constraints

The proposed development is classified as a Designated Development under the Environmental Planning and Assessment Regulation, 1994. This requires the proposal to be assessed under Schedule 1 of the State Environmental Planning Policy (SEPP) No. 58— Protecting Sydney's Water Supply. Therefore:

(i) that part of the site that drains to the Hawkesbury River Basin requires the concurrence of the Director General of the Department of Urban Affairs and Planning for development consent;

(ii) that part of the site that drains to the Shoalhaven River Basin will require notification only.

Advice from the Department is that a suitable *SWMP* can provide sufficient detail to meet both sets of needs under SEPP 58.Water Supply. Therefore:

(i) that part of the site that drains to the Hawkesbury River Basin requires the concurrence of the Director General of the Department of Urban Affairs and Planning for development consent;

(ii) that part of the site that drains to the Shoalhaven River Basin will require notification only.

Advice from the Department is that a suitable *SWMP* can provide sufficient detail to meet both sets of needs under SEPP 58.

4.4 Discussion

4.4.1 Particle Size Analysis

Particle size analysis (PSA) influences several aspects related to management of soil and surface waters. For example, the effectiveness of sediment retention structures at any particular site are greatly influenced by the nature of the soil materials at the sediment source with the finer particles (clays and silts) often passing through sediment fences and taking much longer to settle in sediment retention structures. At this site, between half and three quarters the subsoil materials have ultimate particle sizes that are clay-sized, with a further 10 to 25 per cent being silt-sized (Table 4.1). The results in Table 4.2 are based on soils that have been chemically dispersed.

However, these soils are strongly stabilised (probably by iron), meaning that many particles, especially the finer ones, clump together as small aggregates under natural conditions. This reduces the proportion of clay-sized materials and increases the proportion of silts and fine sands (Table 4.3). The results in Table 4.3 are based on soils that have been mechanically dispersed. It has two consequences:

< "silt" fences are more effective

< the soils are more erodible than would otherwise be the case (fine sands and silts are the most erodible fractions—compare Tables 4.1 and 4.2).

Nevertheless, the soils are still classified as fine (*Type F*).

Table 4.2 Results of Soil Tests

Site	Layer	Particle Size Analysis (chemical dispersion) Clay	Silt	Fine Sand	Coarse Sand	Gravel	Dispersion Percentage	Emerson Aggregate Test	Organic Matter (%)	Unified Soil Classification	Electrical Conductivity (dS/m)	pH	RUSLE Structure Grade (Rosewell, 1993)	K-factor (Department of Housing, 1998)
1	*1*	*33*	*26*	*26*	*13*	*2*	*10*	*5*	*8.9*	*CL*	*0.58*	*5.8*	*4*	*0.025*
2	*2*	*56*	*19*	*13*	*12*	*0*	*7*	*5*	*3.3*	*CH*	*0.92*	*5.5*	*3*	*0.012*
3	*2*	*75*	*11*	*10*	*4*	*0*	*9*	*6*	*2.9*	*CH*	*0.94*	*5.3*	*3*	*0.007*
4	*1*	*40*	*20*	*25*	*15*	*0*	*20*	*3(1)*	*8.0*	*CL*	*1.42*	*5.6*	*4*	*0.016*
5	*1*	*15*	*28*	*52*	*5*	*0*	*20*	*8/3(1)*	*6.5*	*SC*	*0.54*	*5.8*	*4*	*0.037*
6	*2*	*54*	*26*	*18*	*1*	*1*	*32*	*3(1)*	*1.1*	*CH*	*0.46*	*4.8*	*3*	*0.026*
7	*2*	*54*	*23*	*21*	*2*	*<1*	*23*	*5*	*1.7*	*CH*	*0.43*	*5.9*	*3*	*0.025*

Table 4. 3. Particle Size Analysis using mechanical dispersion

Site	Layer	Particle Size Analysis (mechanical dispersion)					Corrected *K*-factor
		Clay	*Silt*	*Fine Sand*	*Coarse Sand*	*Gravel*	
1	*1*	*17*	*25*	*29*	*27*	*2*	*0.018*
2	*2*	*34*	*17*	*28*	*21*	*0*	*0.022*
3	*2*	*40*	*12*	*22*	*26*	*0*	*0.016*
4	*1*	*25*	*24*	*23*	*28*	*0*	*0.019*
5	*1*	*5*	*25*	*57*	*13*	*0*	*0.046*
6	*2*	*34*	*28*	*35*	*2*	*1*	*0.043*
7	*2*	*18*	*26*	*49*	*7*	*<1*	*0.057*

Given that the soils are classified as fine, the amounts of sediment generated are likely to be relatively large and that the receiving waters are sensitive, we believe that all sediment control structures here should be designed to capture the whole of the 90th percentile, 5-day rainfall event (Department of Housing, 1998). However, the EPA's advice to the Company was that the sedimentation dam be designed to the 10-year, time of concentration storm event.

4.4.2 Dispersion Percentage

Dispersible soils are structurally unstable in water and readily breakup into their constituent particles. Further, they stay in suspension for far longer periods than expected by physical settling alone (such as computed with Stokes Law). Interpretation of Table 4.2 shows that the soils at the site are in two groups relating to dispersion (Table 4.4):

(i) those beneath the sedimentation dam, which contain significant quantities of dispersible fines in the subsoils (≥10 per cent of the whole soil mass is dispersible); and

(ii) those elsewhere, which generally do not contain significant quantities of dispersible fines (<10 per cent of the whole soil mass is dispersible).

Sediment from soils that contain significant quantities of dispersible fines (≥10%) should be flocculated (Department of Housing, 1998) before waters are discharged from sedimentation dams. All sites are likely to contain these particles and, so, flocculation is necessary.

Table 4.4 Soil Dispersibility

Site	Layer	Dispersion Percentage	Emerson Aggregate Test	Per cent of whole soil dispersible
1	1	10	5	4.6
2	2	7	5	4.6
3	2	9	6	7.2
4	1	20	3(1)	10.0
5	1	20	8/3(1)	5.8
6	2	32	3(1)	21.4
7	2	23	5	15.1

4.4.3 Emerson Aggregate Test

The Emerson Aggregate Test (EAT) is an eight-class classification of soil aggregate coherence (slaking and dispersion) in water (Bond *et al*, 1987) devised by Emerson (1967). It involves the observation of the behaviour of an air-dried ped of soil when it is placed in distilled water. The seven soil samples collected from the study area are in Emerson Classes 3, 5 and 6 (Table 4.2).

EAT Classes 3 and 5 are those that, after remoulding at a water content equivalent to field capacity, show dispersion when immersed in water. Class 5 soils require more effort to cause dispersion than Class 3. Remoulding can occur in the field through normal construction site activities such as pulverising with vehicle wheels when wet. The Class 6 soils flocculate naturally, probably due to a high iron content here.

This information, when considered with other data relating to the Unified Soil Classification System (USCS), PSA, dispersion percentage and propensity to shrink or swell, provides valuable information on the materials and their use in earthworks (Crouch *et al*, 1991). It is summarised in Section 4.4.9, below.

4.4.4 Organic Matter

Organic matter in the soil is very important, influencing:

- chemical fertility
- physical status (especially structure in medium to coarse-textured materials).

The K-factor in the Revised universal Soil Loss Equation is directly affected by organic matter. In short, the higher the amount of organic matter in the soil, the better the fertility and the more stable the soil is likely to be. The soils within the area of proposed activities contain moderate and high organic matter levels in the subsoils and topsoils, respectively.

4.4.5 Unified Soil Classification

The Unified Soil Classification System (USCS) is an engineering classification based on particle size distribution and characteristics of the fine grains in a soil. It is particularly relevant when applied to those materials used in engineering structures, e.g. subsoils. The subsoils here are class CH throughout, i.e. inorganic clays of high plasticity. This information, when considered with other data relating to PSA, dispersion percentages, EATs and propensities to shrink or swell, provides valuable information on the materials and their use in earthworks (Crouch *et al*, 1991). It is summarised in Section 4.4.9, below.

4.4.6 Electrical Conductivity

The electrical conductivity (EC) of soil:water or soil:$CaCl_2$ suspensions are used to detect the presence of soluble salts and, from this, an indication of the salinity level. The main soluble salts are sodium, calcium and magnesium, which might be chlorides, sulfates or carbonates. The standard unit of electrical conductivity in soils is decisiemens per metre (dS/m). EC values for the samples ranged from 0.43 to 1.3 dS/m which are low. These non saline readings do not affect ground cover and consequently do not affect the existing erosion hazard of the site. Further, these levels will not hinder revegetation after installation of the water quality structures.

4.4.7 pH

Soil pH is a measure of the acidity or alkalinity of a soil. Its importance is usually confined to its effect on the availability of elements in the soil and, hence, possible deficiencies and/or toxicities. The pH levels range from 5.3 to 5.9 over six of the seven sites and are moderately to strongly acid (Hazelton and Murphy, 1992); one site has a pH of 4.8, which is very strongly acid. At these levels the following nutrients are most available for plant growth: iron, manganese, boron, copper and zinc. Others, such as phosphorous, potassium, sulfur, calcium and manganese are much less available and plant growth might be affected.

Lime can be used to amend low soil pH problems. However, this might not solve nutrient concerns if the elements are deficient anyway—it simply ensures that the elements are in a form available to plants for growth. It is noted that an analysis of soil fertility undertaken by Reme Pty Ltd suggests that the topsoil within the proposed extraction area is moderately fertile, but will require the addition of phosphorus, potassium and sulfur during the subsequent site rehabilitation program. Reme Pty Ltd also notes that the addition of lime might be required during the rehabilitation program if stockpiling for periods greater than 28 days is required.

4.4.8 Revised Universal Soil Loss Equation

The Revised Universal Soil Loss Equation (RUSLE) is a mathematical equation that estimates average annual soil loss from sheet and rill erosion. It can be used to help in the selection of appropriate on-site erosion-control strategies. Background information on the factors that comprise the RUSLE is in Department of Housing (1998) while specific data relating to the *R*-factor is in Section 4.3.3.

The erodibility of the site's soils is measured by *K*, another factor in the RUSLE. It is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal component affecting *K*, but structure, organic matter and permeability also contribute. Therefore, with soils like these PSA analysis should be undertaken after mechanical dispersion, not chemical dispersion (compare Tables 4.1 and 4.2).

The *K*-factor can be derived from laboratory data using the SOILOSS computer program (Rosewell, 1993). In NSW, it normally ranges from 0.005 (low erodibility) to 0.07 (very high erodibility). The soils within the proposed Exeter Bypass and haul road have low to moderate erodibility ratings (0.016 to 0.022), while those near the sedimentation dam have moderate to high ratings (0.043 to 0.057). It is important to note that the soils are fine (Section 4.4.1) with those near the dam also being highly dispersible (Section 4.4.2).

The soil and water management plan (Section 4.5) makes certain assumptions based on the RUSLE. These are as follows:

(i) slope length will be kept at a maximum of 80 metres;

(i) upper slope gradients typically 7 per cent on the bypass, 20 per cent on the haul road and 15 per cent at the sedimentation dam; and

(i) during works, RUSLE *P*-factors and *C*-factors of 1.3 and 1.0 apply to the site.

Consequently, the lands:

< on the Exeter Bypass have very low erosion hazards (Soil Loss Class 1)
< on the haul road have high hazards (Soil Loss Class 5)
< at the sedimentation dam site have very high erosion hazards (Soil Loss Class 6).

Various options are available to address the high erosion hazards on the haul road and sedimentation dam site, one of which is to confine land disturbance activities to those times of the year when rainfall erosivity is low. Department of Housing (1998) suggests that in average years, rainfall erosivities are sufficiently low on:

< Class 5 lands during January and from May to December, inclusive
< Class 6 lands from mid-June to mid-September and mid-November to mid-January.

4.4.9 Derived Information

Other relevant information affecting soil and water management can be derived from Section 4.3. This includes:

< soil hydrological groups and their effect on peak flow runoff coefficient
< suitability of soils for use in earthworks.

Each of these is discussed below.

Runoff Coefficient

Runoff coefficient are used to set the size of the sedimentation dam and derive the capacity of catch drains (earth banks) and assume:

< Soil Hydrologic Group (Department of Housing, 1998) of:
  _ B on non compacted surfaces
  _ C on compacted surfaces
< Pilgrim (1987) can be used to derive all rural coefficients for peak flow
< Mittagong data can be used for rainfall calculations (Moss Vale data is not given in Department of Housing, 1998).

Where a <u>volumetric runoff coefficient</u> (Department of Housing, 1998) is required (e.g. to calculate the size of the sedimentation dam):

< the rainfall depth (mm) for 90^{th} percentile event is 49.0 mm
< the runoff coefficient:
  _ for Group B soils is 0.42
  _ for Group C soils is 0.58

A <u>peak flow runoff coefficient</u> (Department of Housing, 1993) is used to calculate the size of catch drains and energy dissipaters. The peak flow coefficient is 0.78 for Group B soils and 0.86 for Group C soils.

Suitability of Subsoils for Use in Earthworks

The subsoils along the Exeter Bypass and the internal haul road have the following characteristics:

- Unified Soil Class CH
- more than 40 per cent clay
- dispersion percentage of less than 10
- Emerson Classes of 5 and 6
- low shrink-swell potential.

Such materials are usually well-aggregated and they are here, probably because of iron stabilisation. Consequently, they might not be suitable for formation as water holding structures (dams) unless sealed with clay or treated with an ameliorant to induce dispersion. With dam or road construction, they should be compacted with at least four passes of a sheepsfoot roller when slightly wet of optimum—a vibrating roller should be used with drier materials.

Different subsoils occur immediately below the proposed sedimentation dam from the rest of the site, especially in that they have:

- dispersion percentages in the 30 to 50 range
- Emerson Class 3 soils
- moderate shrink-swell potential.

These factors mean that they are susceptible to cracking, tunnelling or piping failure and must be well-compacted throughout to reduce permeability and saturation settlement following dam construction. The materials should be compacted to at least 85 per cent of Proctor maximum dry density, placed in layers of less than 150 mm and rolled with at least four separate passes of plant. The freeboard should be increased to at least 1 metre above the surcharge to prevent surface cracks extending below the waterline. For additional stability, any dams should be designed with maximum upstream and downstream batter grades of 3.5(H):1(V) and 3:1, respectively. Structures should be designed to retain sufficient water to keep walls moist and minimise crack development.

4.4.10 Summary of Site Constraints/Opportunities

The site constraints/opportunities are summarised in Table 4.5.

4.5 Soil and Water Management Plan Specifications

4.5.1 Introduction

(i) This Commentary accompanies Drawings 995011-01, 995011-02 and 995011-03 (drawings). Together, the commentary and drawings comprise the *SWMP* for the proposed quarry extension.

(i) Contractors will ensure that all erosion and sediment control works are undertaken as instructed in this *SWMP* and constructed following the Department of Housing's guidelines, *Managing Urban Stormwater: Soils and Construction* (1998).

(i) All employees involved with supervision will be informed of their responsibilities in minimising the potential for soil erosion and pollution to downslope areas.

Table 4.5 Management Constraints

Constraint/Opportunity	Value
The development site	
Rainfall erosivity	moderate *(R* = 3,010)
Peak flow runoff coefficient	0.78 (construction areas)
Volumetric runoff coefficient	0.42 (construction areas)
Exeter Bypass and internal haul road	
Soil erodibility (water) for subsoil	low to moderate (*K* = 0.016 to 0.022)
Soil erodibility (wind)	high for dry, pulverised materials
Soil Loss Class:	
—Exeter Bypass	Class 1 (up to 7% gradient)
—haul road	Class 5 (up to 20% gradient)
Percent dispersible (whole subsoil)	4.6 to 10%
Soil texture group (subsoil)	*Type F*
Soil hydrologic group	Group B (uncompacted)
Sedimentation Dam	
Soil erodibility (water) for subsoil	moderate to high (*K* = 0.043 to 0.057)
Soil erodibility (wind)	high for dry, pulverised materials
Soil Loss Class	Class 6 (up to 15% gradient)
Percent dispersible (whole subsoil)	5.8 to 21.4%
Soil texture group (subsoil)	*Type D*
Soil hydrologic group	Group C (uncompacted)

4.5.2 Works Sequence

Stage 1

Before any site disturbance occurs:

(i) Establish the boundary of the prohibited access areas by installing barrier or sediment fence following SD 6-7 (Attachment III), as shown on Drawings 995011-01 and 995011-02; and

(i) Where necessary, build a track along the general alignment of the roads shown on the engineering plans to provide access to works described in Stages 2 and 3.

Stage 2

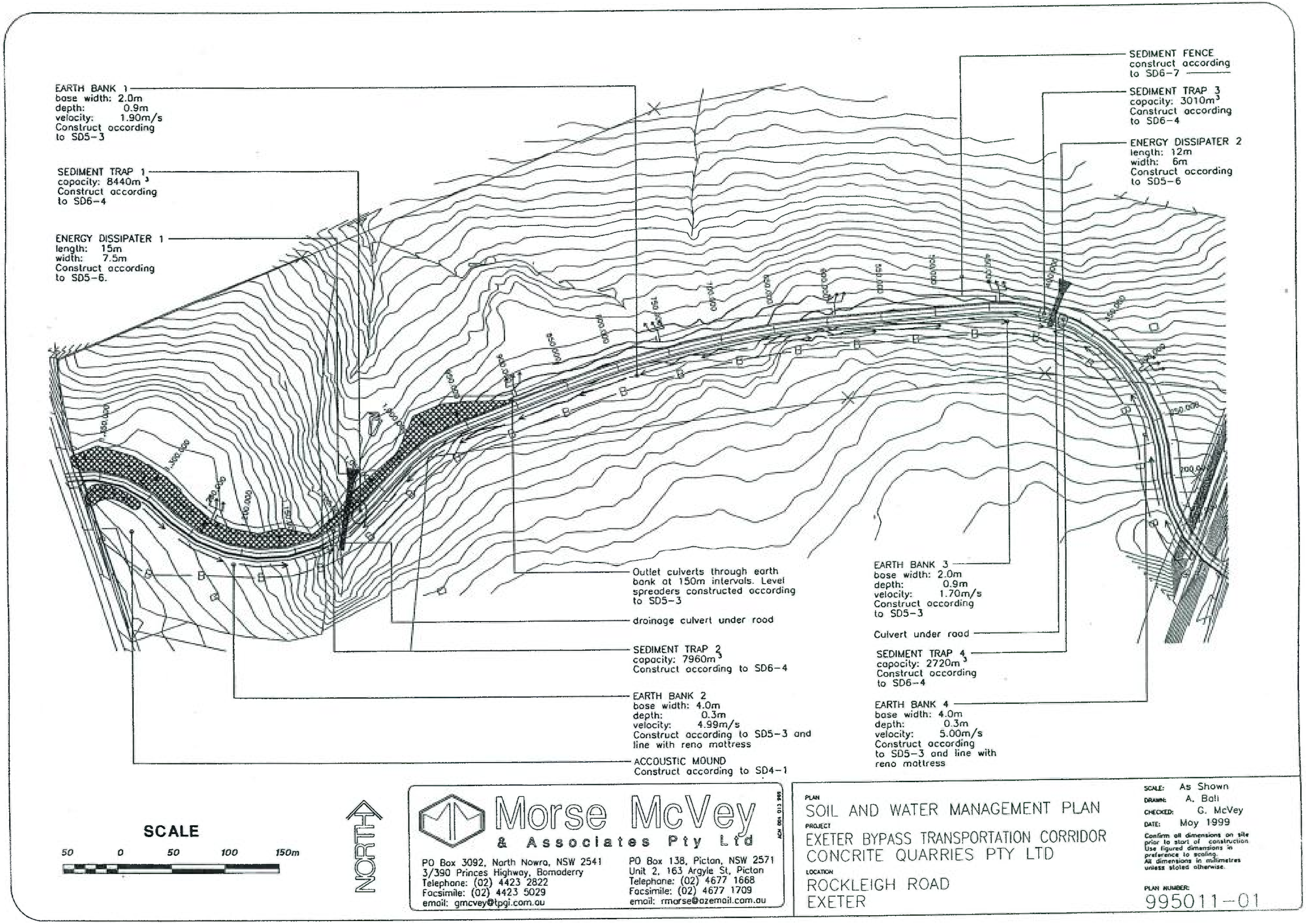
When the works described in Stage 1 are complete, construct:

< Earth Banks 1, 2, 3, 4, 5, 6, 7 and 8 following SD 5-3
< all associated drainage culverts
< Energy Dissipaters 1, 2, 3 and 4 following SD 5-6

as shown on Drawings 995011-01 and 995011-02. Note:

(i) Earth Bank 5 carries clean overland flow from the proposed extraction area before works start—it becomes obsolete only when the entire area is excavated.

(ii) Earth Bank 7 carries sediment-laden waters from the internal haul road to Sediment Trap 5.


EARTH BANK 1
base width: 2.0m
depth: 0.9m
velocity: 1.90m/s
Construct according to SD5-3
SEDIMENT TRAP 1
capacity: 8440m³
Construct according to SD6-4
ENERGY DISSIPATER 1
length: 15m
width: 7.5m
Construct according to SD5-6.
SEDIMENT FENCE
construct according to SD6-7
SEDIMENT TRAP 3
capacity: 3010m³
Construct according to SD6-4
ENERGY DISSIPATER 2
length: 12m
width: 6m
Construct according to SD5-6
Outlet culverts through earth bank at 150m intervals. Level spreaders constructed according to SD5-3
drainage culvert under road
SEDIMENT TRAP 2
capacity: 7960m³
Construct according to SD6-4
EARTH BANK 2
base width: 4.0m
depth: 0.3m
velocity: 4.99m/s
Construct according to SD5-3 and line with reno mattress
ACCOUSTIC MOUND
Construct according to SD4-1
EARTH BANK 3
base width: 2.0m
depth: 0.9m
velocity: 1.70m/s
Construct according to SD5-3
Culvert under road
SEDIMENT TRAP 4
capacity: 2720m³
Construct according to SD6-4
EARTH BANK 4
base width: 4.0m
depth: 0.3m
velocity: 5.00m/s
Construct according to SD5-3 and line with reno mattress
SCALE
50 0 50 100 150m
NORTH
Morse McVey & Associates Pty Ltd
PO Box 3092, North Nowra, NSW 2541
3/390 Princes Highway, Bomaderry
Telephone: (02) 4423 2822
Facsimile: (02) 4423 5029
email: gmcvey@tpgi.com.au
PO Box 138, Picton, NSW 2571
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Telephone: (02) 4677 1668
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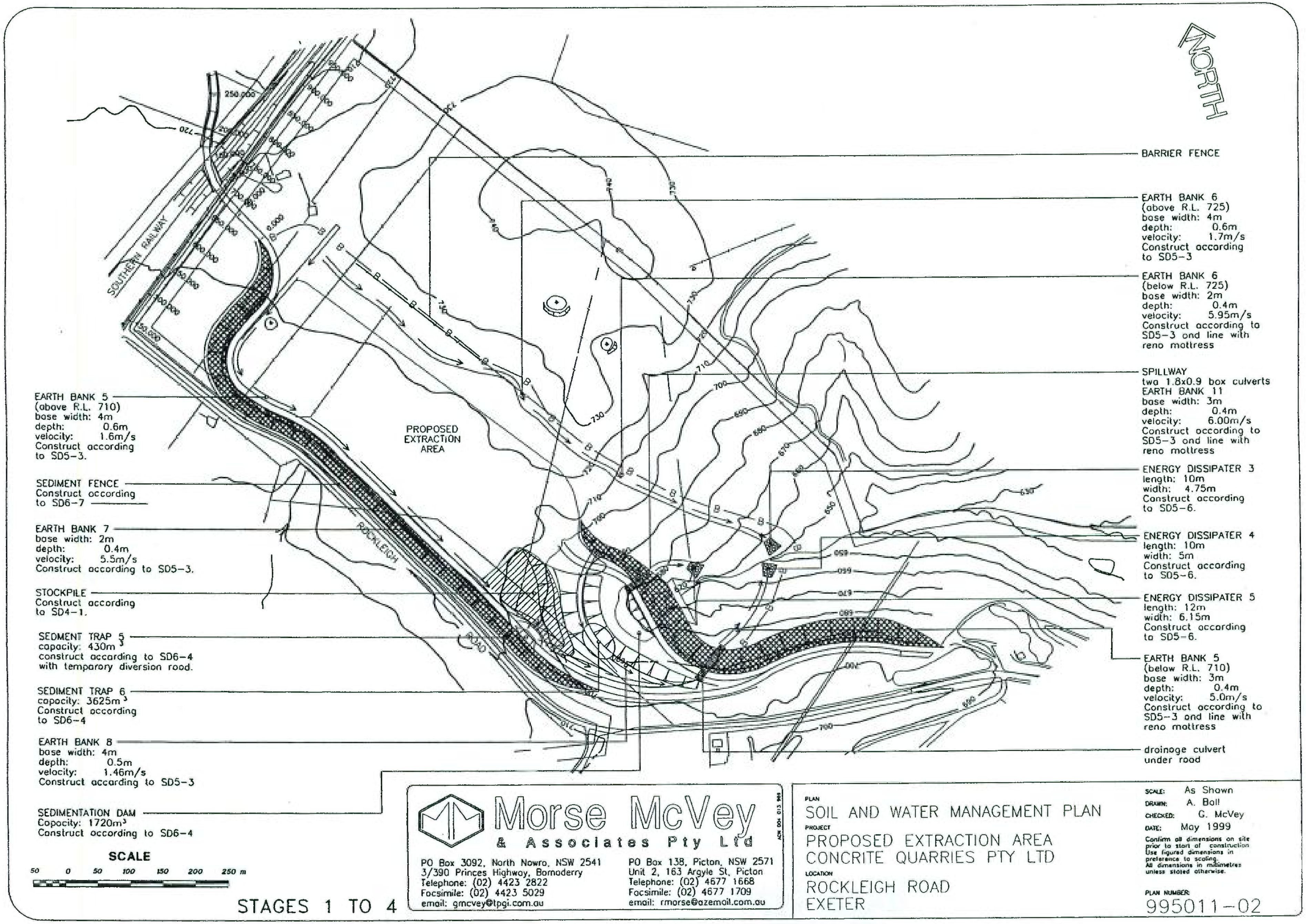
email: rmorse@ozemail.com.au
PLAN
SOIL AND WATER MANAGEMENT PLAN
PROJECT
EXETER BYPASS TRANSPORTATION CORRIDOR
CONCRITE QUARRIES PTY LTD
LOCATION
ROCKLEIGH ROAD
EXETER
SCALE: As Shown
DRAWN: A. Ball
CHECKED: G. McVey
DATE: May 1999
Confirm all dimensions on site prior to start of construction. Use figured dimensions in preference to scaling. All dimensions in millimetres unless stated otherwise.
PLAN NUMBER:
995011-01


NORTH
BARRIER FENCE
EARTH BANK 6 (above R.L. 725) base width: 4m depth: 0.6m velocity: 1.7m/s Construct according to SD5-3
EARTH BANK 6 (below R.L. 725) base width: 2m depth: 0.4m velocity: 5.95m/s Construct according to SD5-3 and line with reno mattress
SPILLWAY two 1.8x0.9 box culverts
EARTH BANK 11 base width: 3m depth: 0.4m velocity: 6.00m/s Construct according to SD5-3 and line with reno mattress
ENERGY DISSIPATER 3 length: 10m width: 4.75m Construct according to SD5-6.
ENERGY DISSIPATER 4 length: 10m width: 5m Construct according to SD5-6.
ENERGY DISSIPATER 5 length: 12m width: 6.15m Construct according to SD5-6.
EARTH BANK 5 (below R.L. 710) base width: 3m depth: 0.4m velocity: 5.0m/s Construct according to SD5-3 and line with reno mattress
drainage culvert under road
EARTH BANK 5 (above R.L. 710) base width: 4m depth: 0.6m velocity: 1.6m/s Construct according to SD5-3.
SEDIMENT FENCE Construct according to SD6-7
EARTH BANK 7 base width: 2m depth: 0.4m velocity: 5.5m/s Construct according to SD5-3.
STOCKPILE Construct according to SD4-1.
SEDMENT TRAP 5 capacity: 430m³ construct according to SD6-4 with temporary diversion road.
SEDIMENT TRAP 6 capacity: 3625m³ Construct according to SD6-4
EARTH BANK 8 base width: 4m depth: 0.5m velocity: 1.46m/s Construct according to SD5-3
SEDIMENTATION DAM Capacity: 1720m³ Construct according to SD6-4
PROPOSED EXTRACTION AREA
SOUTHERN RAILWAY
ROCKLEIGH ROAD
SCALE
50 0 50 100 150 200 250 m
STAGES 1 TO 4
Morse McVey & Associates Pty Ltd
PO Box 3092, North Nowra, NSW 2541
3/390 Princes Highway, Bomaderry
Telephone: (02) 4423 2822
Facsimile: (02) 4423 5029
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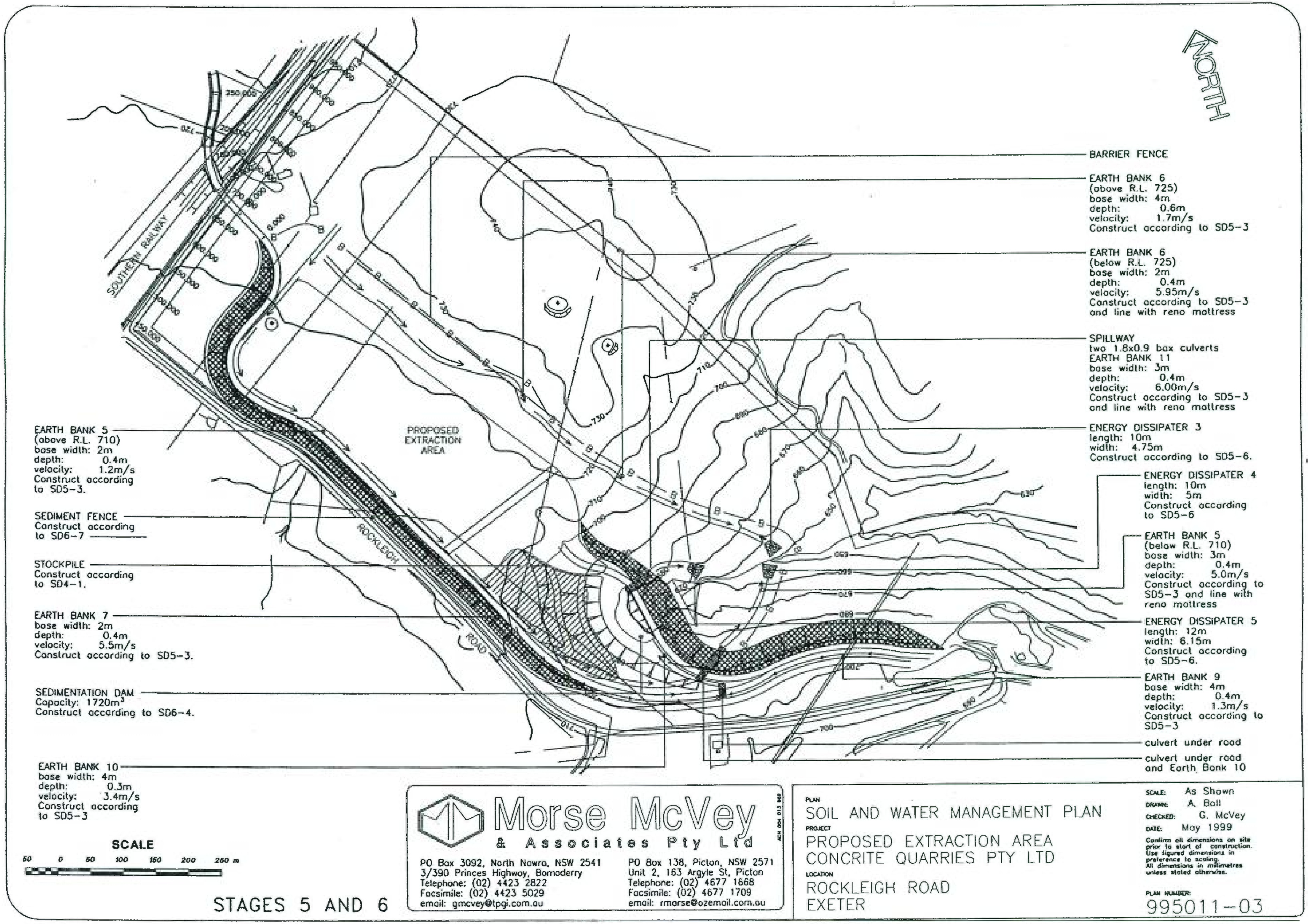
PO Box 138, Picton, NSW 2571
Unit 2, 163 Argyle St, Picton
Telephone: (02) 4677 1668
Facsimile: (02) 4677 1709
email: rmorse@azemail.com.au
PLAN
SOIL AND WATER MANAGEMENT PLAN
PROJECT
PROPOSED EXTRACTION AREA
CONCRITE QUARRIES PTY LTD
LOCATION
ROCKLEIGH ROAD
EXETER
SCALE: As Shown
DRAWN: A. Ball
CHECKED: G. McVey
DATE: May 1999
Confirm all dimensions on site prior to start of construction. Use figured dimensions in preference to scaling. All dimensions in millimetres unless stated otherwise.
PLAN NUMBER:
995011-02


NORTH
SOUTHERN RAILWAY
ROCKLEIGH ROAD
PROPOSED EXTRACTION AREA
BARRIER FENCE
EARTH BANK 6
(above R.L. 725)
base width: 4m
depth: 0.6m
velocity: 1.7m/s
Construct according to SD5-3
EARTH BANK 6
(below R.L. 725)
base width: 2m
depth: 0.4m
velocity: 5.95m/s
Construct according to SD5-3 and line with reno mattress
SPILLWAY
two 1.8x0.9 box culverts
EARTH BANK 11
base width: 3m
depth: 0.4m
velocity: 6.00m/s
Construct according to SD5-3 and line with reno mattress
ENERGY DISSIPATER 3
length: 10m
width: 4.75m
Construct according to SD5-6.
ENERGY DISSIPATER 4
length: 10m
width: 5m
Construct according to SD5-6
EARTH BANK 5
(below R.L. 710)
base width: 3m
depth: 0.4m
velocity: 5.0m/s
Construct according to SD5-3 and line with reno mattress
ENERGY DISSIPATER 5
length: 12m
width: 6.15m
Construct according to SD5-6.
EARTH BANK 9
base width: 4m
depth: 0.4m
velocity: 1.3m/s
Construct according to SD5-3
culvert under road
culvert under road and Earth Bank 10
EARTH BANK 5
(above R.L. 710)
base width: 2m
depth: 0.4m
velocity: 1.2m/s
Construct according to SD5-3.
SEDIMENT FENCE
Construct according to SD6-7
STOCKPILE
Construct according to SD4-1.
EARTH BANK 7
base width: 2m
depth: 0.4m
velocity: 5.5m/s
Construct according to SD5-3.
SEDIMENTATION DAM
Capacity: 1720m³
Construct according to SD6-4.
EARTH BANK 10
base width: 4m
depth: 0.3m
velocity: 3.4m/s
Construct according to SD5-3
SCALE
50 0 50 100 150 200 250 m
STAGES 5 AND 6
Morse McVey & Associates Pty Ltd
PO Box 3092, North Nowra, NSW 2541
3/390 Princes Highway, Bomaderry
Telephone: (02) 4423 2822
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Facsimile: (02) 4677 1709
email: rmorse@ozemail.com.au
PLAN
SOIL AND WATER MANAGEMENT PLAN
PROJECT
PROPOSED EXTRACTION AREA
CONCRITE QUARRIES PTY LTD
LOCATION
ROCKLEIGH ROAD
EXETER
SCALE: As Shown
DRAWN: A. Ball
CHECKED: G. McVey
DATE: May 1999
Confirm all dimensions on site prior to start of construction.
Use figured dimensions in preference to scaling.
All dimensions in millimetres unless stated otherwise.
PLAN NUMBER:
995011-03

(iii) Treated waters discharged from Sediment Trap 5 can be discharged into Earth Bank 5.

(iv) Earth Bank 8 crosses a haul road west of the proposed sedimentation dam. It might be convenient to replace the bank with removable sandbags on the road providing they are in place when rain is expected and during shutdown periods (e.g. at night and at weekends).

(v) There is a requirement for placing one of the culverts to pass under both the road and Earth Bank 10 on Drawing 995011-03.

Revegetate all disturbed lands.

Stage 3

When the works described in Stage 2 are complete, construct temporary Sediment Traps 1, 2, 3, 4, 5 and 6 following SD 6-4 and as shown on Drawings 995011-01 and 995011-02. The upper level of likely waters contained in Sediment Traps 1, 2, 3, 4 and 5 must be lower than any road excavation while that in Sediment Trap 6 must be lower than the floor of Earth Bank 7 on both sides. Treated waters discharged from Sediment Trap 6 can be discharged into Earth Bank 7 on its eastern side. Revegetate any disturbed lands.

Stage 4

When the works described in Stage 3 are complete:

(i) Build the non draining sedimentation dam as described in Section 4.5.3. This will be done jointly with the initial basalt extraction. The downslope edge of the stockpile (overburden emplacement) must not extend lower than RL 695 at this stage, other than for the construction of the sedimentation dam. Note the requirements in Section 4.5.4 (iv) relating to maximum batter gradients.

(ii) Roadworks and construction of adjacent earth bund walls can begin now, following the engineering plans. Works will start from temporary Sediment Traps 1, 2, 3, 4 and 5 and progress upslope so that all sediment laden waters enter them for treatment.

Stage 5

When the works described in Stage 4, part (i) are complete:

(i) Decommission Earth Bank 8 and Sediment Trap 6.

(ii) Construct Earth Banks 9 and 10 following SD 5-3 as shown on Drawing 995011-03. Note that waters from Earth Bank 5 are to bypass all treatment systems, while those from Earth Banks 7, 9 and 10 are to enter the sedimentation dam.

Revegetate all disturbed lands.

Stage 6

When the works described in Stage 5 are complete:

(i) All other roadworks can be started following the engineering plans.

(ii) Undertake basalt extraction according to the operational plans. These works will result in the construction of a sump within the proposed extraction area—the works will be internally drained. The capacity of this sump will meet all requirements of Department of Housing (1998). The sump is likely to move northwest within the quarry floor once extraction moves to a lower level.

(iii) The stockpile (overburden emplacement) can now extend fully.

(iv) Where direct transfer of topsoil is not possible, store topsoil removed from the extraction area in the earth bund wall or the stockpile (overburden emplacement), according to SD 4-1 and as shown on Drawing 995011-03.

(v) Progressively rehabilitate all earth banks, acoustic bund walls, stockpiles and sedimentation dam batters after establishing final batters and respreading topsoil from the stockpiles.

(vi) Ensure suitable management practices are carried out to minimise areas being affected by wind erosion.

(vii) Rehabilitate all disturbed lands after completion of extraction activities and establishment of final levels within 20-working days.

4.5.3 Construction of the Sedimentation Dam

(i) The sedimentation dam (generally following SD 6-4) and Energy Dissipater 5 (SD 5-6) will be constructed as shown on the engineering drawings and Drawing 995011-02.

(ii) The dam will be constructed in the period from:
- mid-May to mid-September
- mid-November to mid-January.

C-factors will be below 0.01 at all other times.

(iii) The dam can be built with either basalt or shale-derived soils:

- If basalt-derived soils are used in the construction of the dam, further soil testing is required first to assess whether sealing of these highly aggregated materials is best achieved with:
  - sodium tripolyphosphate (STPP) or another chemical compound
  - a clay liner.

  They will be compacted with at least four passes of a sheepsfoot roller when slightly wet of optimum—a vibrating roller will be used with drier materials

< If the shale-derived soils are used, they must be well-compacted throughout to reduce permeability and saturation settlement following dam construction. The materials will be compacted to at least 85 per cent of Proctor maximum dry density, placed in layers of less than 150 mm and rolled with at least four separate passes of plant. The freeboard will be increased to at least 1 metre above surcharge to prevent surface cracks extending below the waterline. For additional stability, any dams will be designed with maximum upstream and downstream batter grades of 3.5(H):1(V) and 3:1, respectively. Structures will be managed to retain sufficient water to keep walls moist and minimise crack development.

(iv) One or more outlet devices may be installed. However, the capacity of the major spillway will be designed to cater for the 100-year time of concentration storm event.

4.5.4 Erosion Control

The following erosion controls will be installed throughout the site establishment and operation phases.

(i) The soil erosion hazard on the site will be kept as low as practicable by minimising disturbance. Some ways of doing this are outlined in Table 4.6.

(ii) Extraction will take place within the defined extraction area and materials will be taken to the adjoining processing plant. No vehicular access or land disturbance will occur in the restricted access areas.

(iii) Rehabilitation will commence within 20-working days from the completion of works so that only lands affected by current extraction activities are exposed to accelerated erosion processes. Land not involved directly in the extraction activities will be marked as restricted areas and preserved as pasture.

(iv) Clearly visible barrier fencing will be installed to ensure traffic control and to prohibit unnecessary site disturbance and dust, particularly in the prohibited access areas. Vehicle movements on the site will be limited to those essential for site activities.

(v) All table drains, earth banks and their outlets will be constructed to be stable in the 20-year time of concentration storm event. To help in this, grass will be established on all soil surfaces that are to carry channelised flow. Flows will be limited to maximum channel velocities of:

< 5.0 metres per second for mat or sward-forming grasses with reinforced blankets
< 2.7 metres per second for mat or sward-forming grasses with other UV-stabilised mesh
< 2.2 metres per second for kikuyu grass
< 2.0 metres per second for close-weave, bitumen-sprayed jute mesh
< 1.8 metres per second for sward-forming grasses (e.g. couch or Rhodes grass)
< 1.3 metres per second for other improved perennial grasses.

In addition, rock check dams (SD 5-1) can be placed in the table drain at appropriate intervals to reduce scour.

Table 4.6 Limitations to access

Land use	Access Limitations	Comments
Proposed extraction area	Confine activities to within five (preferably two) metres beyond the edge of the operations shown on the work plans.	All site workers will clearly recognise these areas and they will be clearly marked – suitable materials include barrier mesh, sediment fencing, etc. The project manager shall arrange for the marking of their actual location on site. They can vary in position to conserve existing vegetation best while being considerate of the needs of efficient works' activities.
Access roads	Confine the area of disturbance to a maximum width that is the minimum necessary to allow safe operation of heavy equipment. An 8-metre wide carriage way will be provided for internal haul roads	
Remaining lands	Prohibited except for essential management works.	

(vi) Drainage channels, earth banks (SD 5-2) and culverts will be constructed on the internal haul road at appropriate intervals (ie., 80 metres) to drain runoff from the road for treatment in the sedimentation dam. Any temporary diversions will outlet to stable discharge areas.

(vii) Batter gradients will not exceed those shown in figure 5. The relevant *K*-factors for soils at this site (Table 4.3) are:

- basalt derived materials:
  - topsoils, $K = 0.019$
  - subsoils, $K = 0.022$
- shale derived materials:
  - topsoils, $K = 0.046$
- subsoils, $K = 0.057$

4.5.5 Rehabilitation

(i) Waterways and their inlet and outlet structures will be rehabilitated where they are intended to remain effective for more than two weeks. This will be done when practicable and within two weeks from their final shaping. The program adopted should achieve a C-factor (Department of Housing, 1998) of less than 0.05.

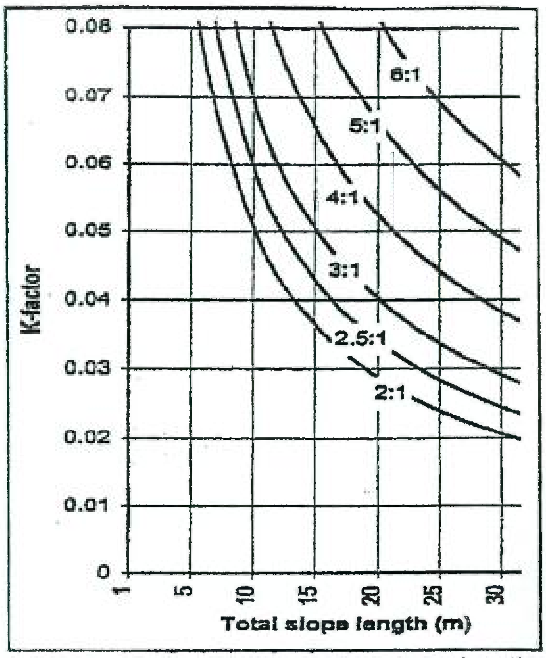


Figure 5 Maximum batter gradients to apply to the site (Department of Housing, 1988)

(ii) Soil stockpiles will be rehabilitated where they are scheduled to remain unattended for a duration of more than two weeks. The program adopted should achieve and maintain a C-factor (Department of Housing, 1998) of less than 0.15.

(iii) Other exposed soil materials will be rehabilitated where they are scheduled to remain unattended for a duration of more than one month. The program adopted should achieve and maintain a *C*-factor (Department of Housing, 1998) of less than 0.15. The *C*-factor can be reduced to these levels with vegetation, mulches, biodegradable blankets, etc. A suggested listing of agricultural species for temporary cover is shown in Table 4.7 (following SD 4-3). Foot and vehicular traffic will be prohibited in rehabilitated areas.

Table 4.7 Plant species for temporary cover

Sowing season	Seed mix
Autumn / Winter	oats @ 40 kg/ha Japanese millet @ 10 kg/ha
Spring / Summer	Japanese millet @ 20 kg/ha oats @ 20 kg/ha

4.5.6 Topsoil Management

(i) Only strip topsoil from lands that must be disturbed as part of these proposed quarrying activities.

(ii) Where possible, newly stripped topsoil will be directly transferred to areas ready for revegetation.

(iii) Where practicable, topsoil will be stripped in moist condition to avoid pulverisation and dust, yet not too moist to result in the breakdown of soil structure.

(iv) Topsoil will be respread onto an even, but roughened surface with moderate compaction for optimum seedbed tilth according to SD 4-2.

(v) If necessary, during windy weather, any large, unprotected areas will be kept moist (not wet) by irrigating with water to keep dust under control. When stored water is not available in sufficient quantities, mains water will be used.

(vi) Schedule landscaping programs so that a duration of less than 20 working days elapses from final land shaping to sowing perennial plant species. The rehabilitation program should ensure that a *C*-factor (Department of Housing, 1998) of less than 0.1 is achieved within 20 working days and a program is set in motion that will ensure it will drop permanently by vegetation, paving, armouring, etc. to less than 0.05 within a further 60 days.

(vii) Follow-up seed and fertiliser will be applied as necessary in areas of minor soil erosion and/or inadequate vegetative protection.

4.5.7 Sediment Control

(i) A road will be constructed from the haul road to the sedimentation dam to provide access for regular cleaning out and to provide a drainage channel for runoff from the haul road.

(ii) Sediment build up will be regularly monitored through the placement of two or more markers within the sedimentation dam that clearly show the level above which contains a capacity of 2,000 cubic metres.

(iii) A capacity of 2,000 cubic metres will be available for collection of overland flow waters within five days from the conclusion of any storm event. This will be achieved through removal of waters or sediment that impinges on this capacity.

(iv) Waters will not be deliberately discharged from the sedimentation dam to receiving waters beyond the site if they contain more than 50 milligrams per litre of suspended solids. This will require flocculation following Department of Housing (1998).

(v) Water retained in the sedimentation dam can be used for dust suppression providing condition (iv), above, is not compromised.

(vi) Sediment removed from any trapping device will be relocated where further pollution to downslope lands and waterways will not occur.

(vii) Sediment fences (SD 6-7) will:

< be installed as shown on Drawings 995011-01, 995011-02 and 995011-03 and elsewhere at the discretion of the project manager to contain the coarser sediment fraction.

< have catchment areas not exceeding 1,500 square metres, a storage depth (including both settling and settled zones) of at least 0.5 metres, and internal dimensions that provide maximum surface area to passage of stormwater.

(viii) Stockpiles (SD 4-1) will be placed as an acoustic bund or stockpile, as shown on Drawings 995011-01, 995011-02 and 995011-03.

4.5.8 Other Matters

With road construction, soils near the Exeter Bypass and the haul road will be compacted with at least four passes of a sheepsfoot roller when slightly wet of optimum—a vibrating roller will be used with drier materials.

4.5.9 Site Monitoring & Maintenance

(i) Waste receptacles will be emptied as necessary. Disposal of waste will be in a manner approved by the project manager.

(ii) The project manager will inspect the site at least weekly paying particular attention to:

< insuring that drains operate properly and effect any necessary repairs

< removal of trapped sediment whenever less than design capacity remains for the sedimentation dam or sediment traps

< ensuring rehabilitated lands have effectively reduced the erosion hazard and initiate upgrading as appropriate

< constructing additional erosion and/or sediment control works as might become necessary to ensure the desired water control is achieved, i.e. make ongoing minor changes to Drawings 995011-01, 995011-02 and 995011-03.

< maintaining all erosion and sediment control measures in a functioning condition until all earthwork activities are completed and the site is rehabilitated

< removal of temporary soil conservation structures as the last activity in the rehabilitation program.

(iii) The project manager will keep a log book, making entries at least weekly and immediately before forecast rainfall and/or site closure, recording:

- the volume of any rainfall events
- the condition of any soil and water management works
- applications of any flocculating agents to sedimentation dams
- volumes of water discharged from sedimentation dams
- remedial works.

The book will be kept on-site and made available to any authorised person on request.

4.6 Attachments

Attachment I IFD Tables for Exeter

Location	EXETER
2I1 (10.-80.)	32.30
2I12 (2.-30.)	8.00
2I72 (0.4-15.)	2.60
50I1 (25.-130.)	65.00
50I12 (5.-50.)	16.00
50I72 (1.-25.)	5.70
G (0.-0.8)	0.03
F2 (3.-5.)	4.29
F50 (13.5-18.5)	15.70

Calc | Load | Save | Graph | Print | Help | Exit

ARI \ DUR	5m	6m	10m	20m	30m	1h	2h	3h	6h	12h	24h	48h	72h	User
1	81	76	62	45.1	36.6	24.9	17.0	13.5	9.12	6.17	4.07	2.63	1.98	0.00
2	104	98	80	58	47.3	32.2	22.0	17.5	11.8	7.98	5.30	3.43	2.59	0.00
5	134	126	103	75	61	42.0	28.6	22.8	15.3	10.4	6.98	4.59	3.50	0.00
10	152	143	117	86	70	47.8	32.6	25.9	17.4	11.8	7.99	5.29	4.06	0.00
20	175	165	135	99	81	55	37.7	30.0	20.2	13.6	9.30	6.20	4.78	0.00
50	206	193	159	117	95	65	44.6	35.4	23.8	16.1	11.1	7.42	5.74	0.00
100	229	215	177	130	106	73	49.8	39.6	26.6	18.0	12.4	8.37	6.49	0.00
User	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Attachment II Engineering Design Calculations

Storm Flow Calculations

Peak flow or discharge is given by the Rational Formula:

$$Q_Y = 0.00278 \times C_{10} \times F_Y \times I_{Y,tc} \times A$$

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 (Section 4.4.9)
F_Y is a frequency factor for "Y" years
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 "tc" (minutes or hours)

Catchment area, A = 7.2 ha

Time of concentration (tc) = $0.76 \times (A/100)^{0.38}$ (Chapter 5 of Pilgrim, 1987)
= $0.76 \times (7.2/100)^{0.38}$
= 0.27 hours
= 17 minutes

Peak flow runoff coefficient C_{10} = 78 %

ARI storm event	Storm intensity (mm/hr)	Frequency factor (F_y)	Peak flow (m^3/s)
1 yr, tc	48.8	0.62	0.46
10 yr, tc	92	1.00	1.44
20 yr, tc	107	1.12	1.87
100 yr, tc	140	2.57	5.61

Sedimentation dam: Settling Zone Volume

(i) Based on Department of Housing, 1998, assuming Type F soils

The settling zone volume for *Type F* and *D* soils is calculated to provide capacity to contain all runoff expected from up to the 90th percentile rainfall event. The settling zone volume (V) can be determined by the following equation:

$$V = 10 \times Cv \times A \times R_{90th\ ile,\ 5\ day}\ (m^3)$$

where 10 = a unit conversion factor

C_v = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the 5-day period (Section 4.4.9)

R = is the 5-day total rainfall depth (mm) which is not exceeded in 90 per cent of rainfall events

A = area of catchment in hectares (ha)

$$V = 10 \times 0.42 \times 7.92 \times 49.0$$
$$= 1{,}630\ m^3$$

(i) Based on 10-year time of concentration event

The EPA (Mr Rod Aubrey) has advised that the sediment Trap volume is to be based on at least the 10 year time of concentration rainfall event. The following calculations are based on this advice:

ARI storm event	Storm intensity (mm/hr)	Peak flow (m^3/s)	Settling zone (m^3)
92.00	0.95	1.33	1,763

This sizing of 1,763 cubic metres has been adopted, being the larger of (a) and (b), above.

Sedimentation dam: Sediment Storage Zone Volume

The sediment storage zone is calculated as equal to the calculated two month soil loss using the RUSLE (Section 4.4.8). Assuming 1.1 hectares of disturbed lands in the 7.92 hectare catchment:

Two month soil loss = $A \times R \times K \times LS \times P \times C \times 1/6$
= $1.1 \times 3{,}010 \times 0.022 \times 7.32 \times 1.3 \times 1.0 \times 0.167$
= 115 tonnes
= 90 cubic metres

Sedimentation dam: Total Volume = sum of the above two volumes
= 1,763 + 90
= 1,853 cubic metres.

Diversion bank and waterway velocity

Earth Bank 1

Width	Depth	Depth with freeboard	Velocity
0.5	0.44	0.9	2.23
1.0	0.36	0.9	2.18
1.5	0.31	0.8	2.10
2.0	0.27	0.8	2.01
2.5	0.24	0.7	1.92
3.0	0.21	0.7	1.84

Earth Bank 2

Width	Depth	Depth with freeboard	Velocity
0.5	0.64	1.1	1.37
1.0	0.55	1.05	1.36
1.5	0.48	0.98	1.33
2.0	0.42	0.92	1.29
2.5	0.38	0.88	1.25
3.0	0.35	0.85	1.12

Earth Bank 3

Width	Depth	Depth with freeboard	Velocity
0.5	0.64	1.1	1.37
1.0	0.55	1.05	1.36
1.5	0.48	0.98	1.33
2.0	0.42	0.92	1.29
2.5	0.38	0.88	1.25
3.0	0.35	0.85	1.12

Earth Bank 4

Width	Depth	Depth with freeboard	Velocity
0.5	0.64	1.1	1.37
1.0	0.55	1.05	1.36
1.5	0.48	0.98	1.33
2.0	0.42	0.92	1.29
2.5	0.38	0.88	1.25
3.0	0.35	0.85	1.12

Earth Bank 5

Width	Depth	Depth with freeboard	Velocity
0.5	0.64	1.1	1.37
1.0	0.55	1.05	1.36
1.5	0.48	0.98	1.33
2.0	0.42	0.92	1.29
2.5	0.38	0.88	1.25
3.0	0.35	0.85	1.12

Energy Dissipater 1

The design is based on guidelines provided by the Department of Housing (1998)

Minimum tailwater conditions
10 yr tc peak flow= 1.39m^3/s
Diameter of pipe = 750 mm
Grade of pipe = 1%
Rip rap size = 0.1d_{so}. m
Length = 10 metres
Width = 4.75 metres

Energy Dissipater 2

The design is based on guidelines provided by the Department of Housing (1998)

Minimum tailwater conditions
10 yr tc peak flow= 1.39m^3/s
Diameter of pipe = 750 mm
Grade of pipe = 1%
Rip rap size = 0.1d_{so}. m
Length = 10 metres
Width = 4.75 metres

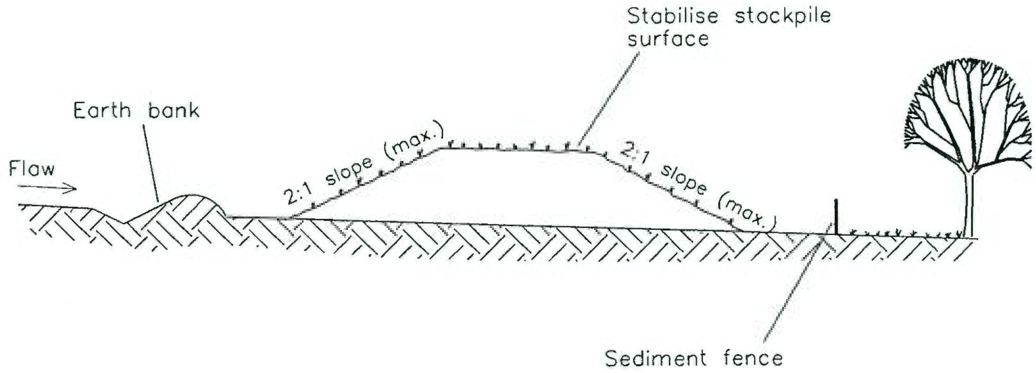
Energy Dissipater 3

The design is based on guidelines provided by the Department of Housing (1998)

Minimum tailwater conditions
10 yr tc peak flow= 1.39m^3/s
Diameter of pipe = 750 mm
Grade of pipe = 1%
Rip rap size = 0.1d_{so}. m
Length = 10 metres
Width = 4.75 metres

Attachment III Standard Drawings

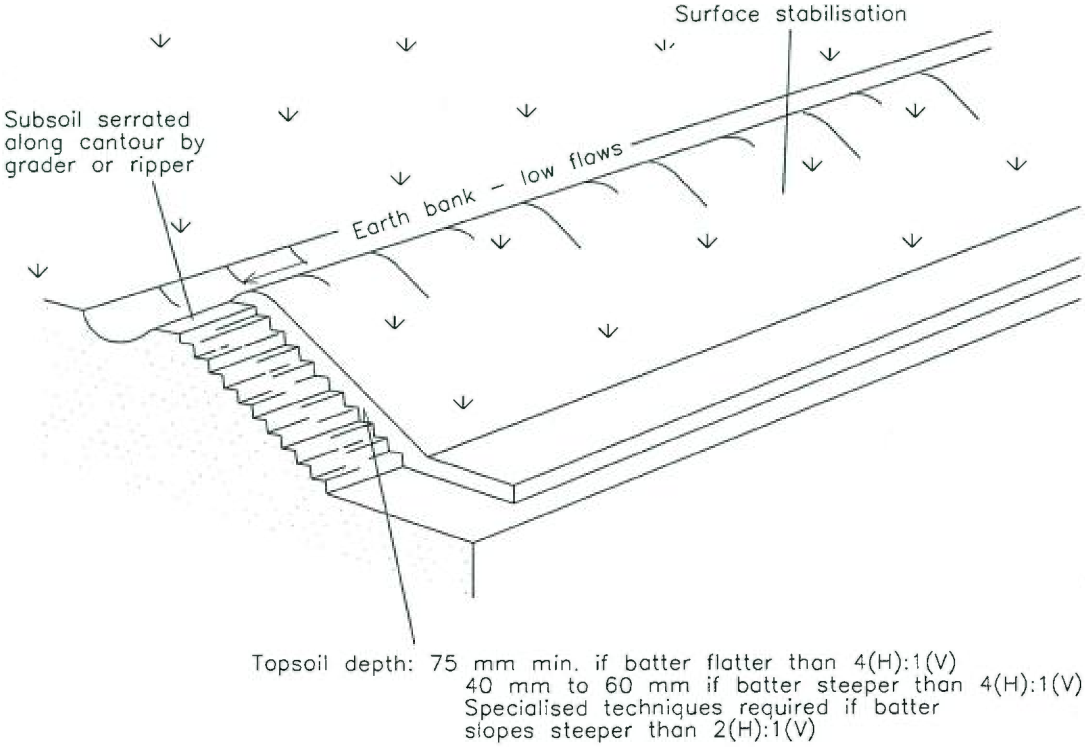
These Standard Drawings have been extracted from the Manual "Managing Urban Stormwater – Soils and Construction" – 3rd Edition compiled on behalf of the Department of Housing 1998.



Construction Notes

1. Locate stockpile at least 5 metres from existing vegetation, concentrated water flows, roads and hazard areas.
2. Construct on the contour as a low, flat, elongated mound.
3. Where there is sufficient area topsoil stockpiles shall be less than 2 metres in height.
4. Rehabilitate in accordance with the SWMP/ESCP.
5. Construct earth bank (Standard Drawing 5–2) on the upslope side to divert run off around the stockpile and a sediment fence (Standard Drawing 6–7) 1 to 2 metres downslope of stockpile.

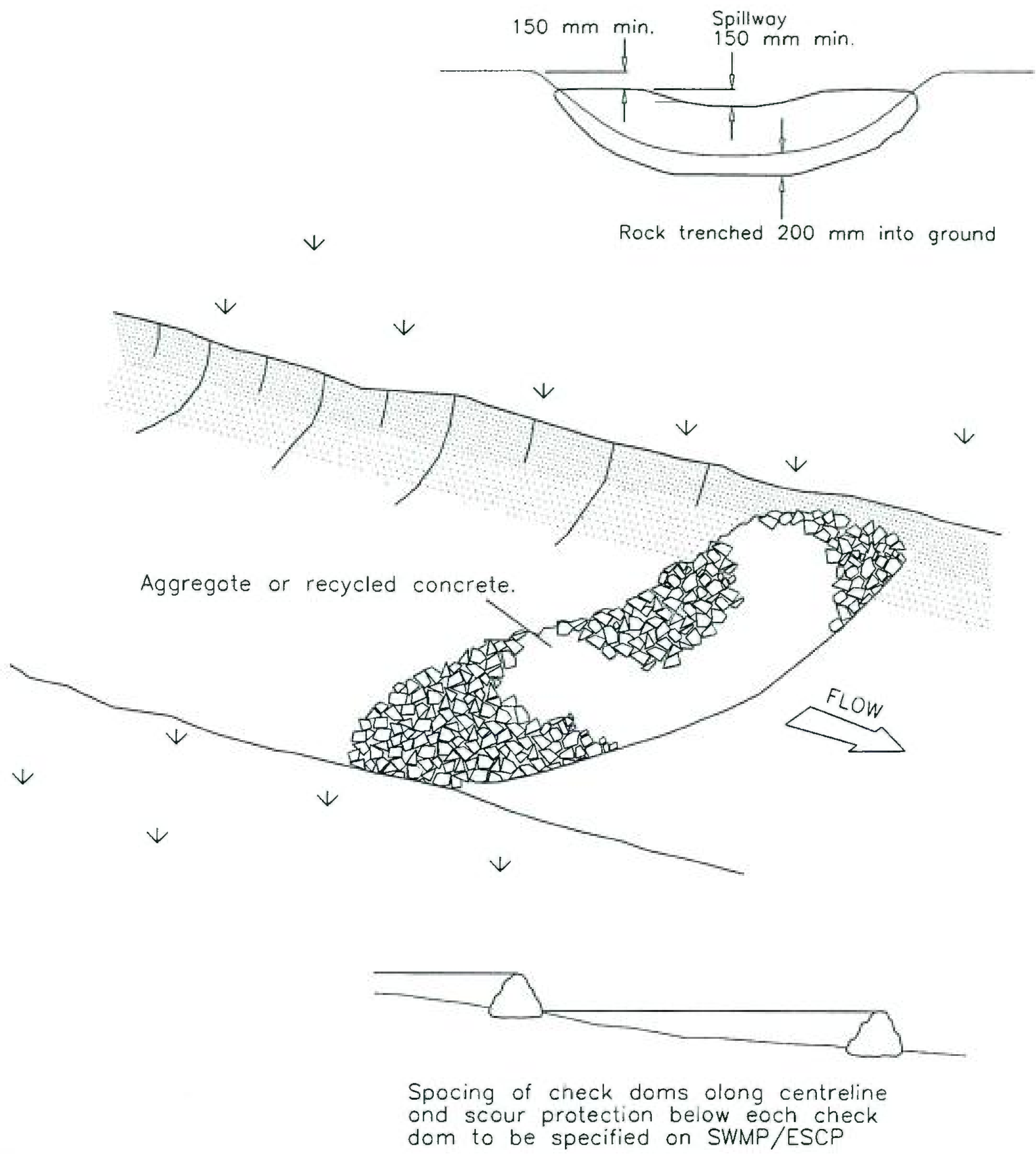
STOCKPILES SD 4–1



Construction Notes

1. Scarify ground surface along the line of the contour to a depth of 50 mm to 100 mm to break up any hardsetting surfaces and provide a good bond between the respread material and subsoil.
2. Add soil ameliorants as required by the SWMP/ESCP.
3. Rip to a depth of 300 mm where a compacted layer occurs.
4. Replace topsoil.

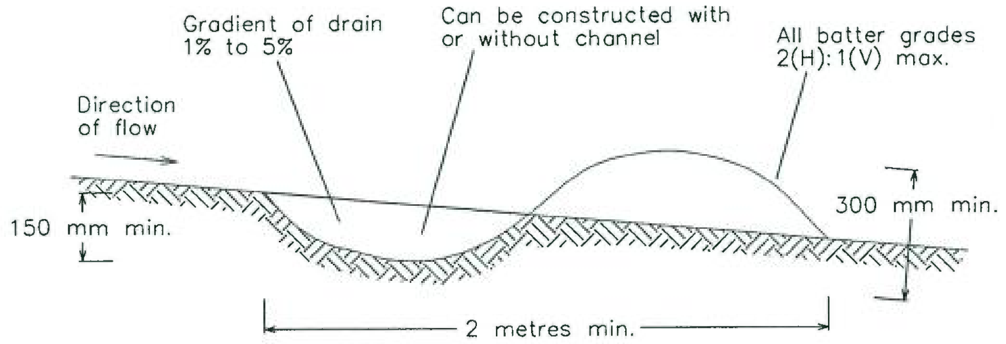
REPLACING TOPSOIL SD 4-2



Construction Notes

1. Trench structure 200 mm into ground surface wherever the structure contacts the gully base. Fill trenches to 100 mm above ground surface to reduce risk of undercutting.
2. Ensure height of spillway is less than 1 metre above the gully floor.
3. Space checks so the toe of the upstream dam is level with the spillway of the next downstream dam.

ROCK CHECK DAM SD 5-1

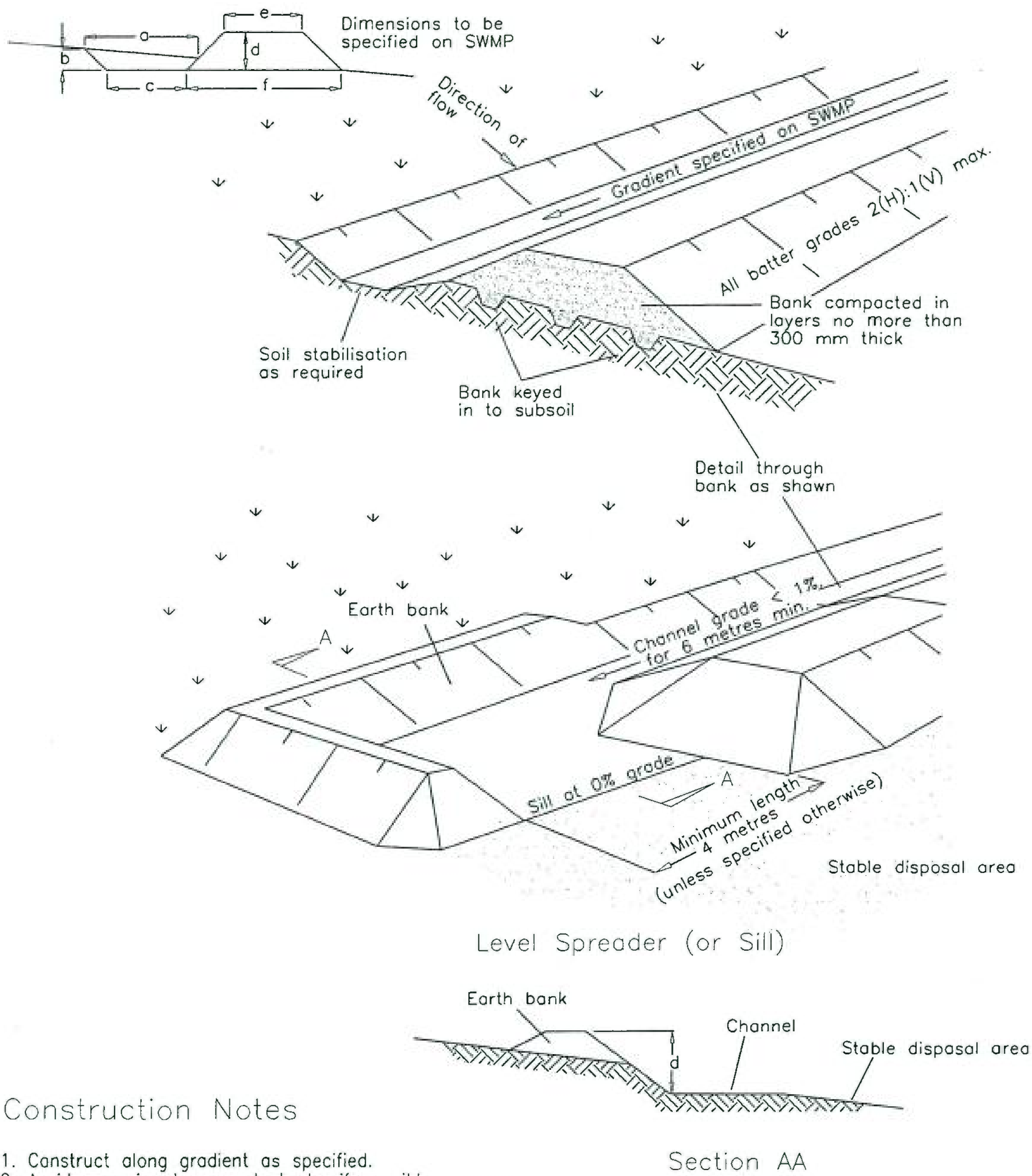


NOTE: Only to be used as temporary bank where maximum upslope length is 80 metres.

Construction Notes

1. Construct with gradient of 1 per cent to 5 per cent.
2. Avoid removing trees and shrubs if possible.
3. Drains to be of circular, parabolic or trapezoidal cross section not V-shaped.
4. Earth banks to be adequately compacted in order to prevent failure.
5. Permanent or temporary stabilisation of the earth bank to be completed within 10 days of construction.
6. All outlets from disturbed lands are to feed into a sediment basin or similar.
7. Discharge runoff collected from undisturbed lands onto either a stabilised or an undisturbed disposal site within the same subcatchment area from which the water originated.
8. Compact bank with a suitable implement in situations where they are required to function for more than five days.
9. Earth banks to be free of projections or other irregularities that will impede normal flow.

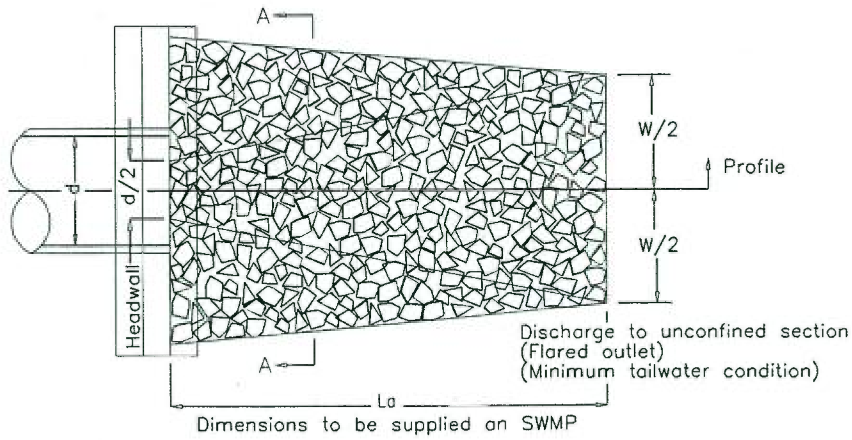
EARTH BANK (LOW FLOW) SD 5-2



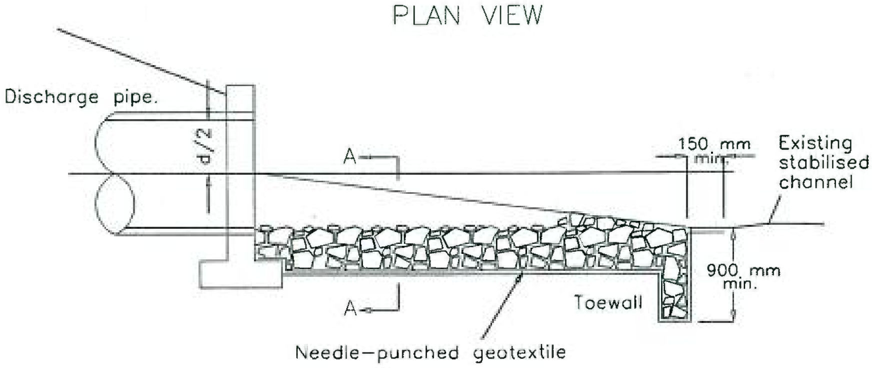
Construction Notes

1. Construct along gradient as specified.
2. Avoid removing trees and shrubs if possible.
3. Drains to be of parabolic or trapezoidal cross section as opposed to V-shaped.
4. Earth banks to be adequately compacted in order to prevent failure.
5. Permanent or temporary stabilisation of the earth bank to be completed within 10 days of construction.
6. All outlets from disturbed lands are to feed into a sediment basin or similar.
7. Discharge runoff collected from undisturbed lands onto either a stabilised or an undisturbed disposal site within the same subcatchment area from which the water originated.
8. Compact with a suitable implement in situations where they are required to function for more than five days.
9. Earth banks to be free of projections or other irregularities that will impede normal flow.

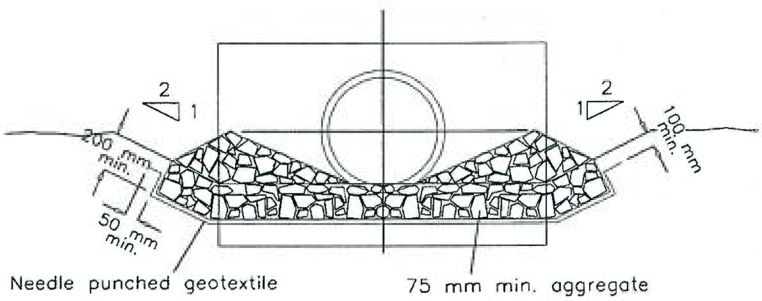
EARTH BANK (HIGH FLOWS) SD 5-3



PLAN VIEW



PLAN VIEW

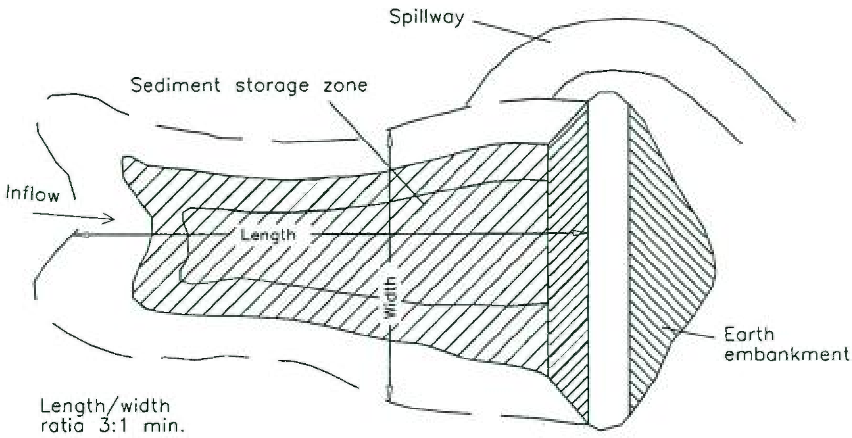


CROSS SECTION AA

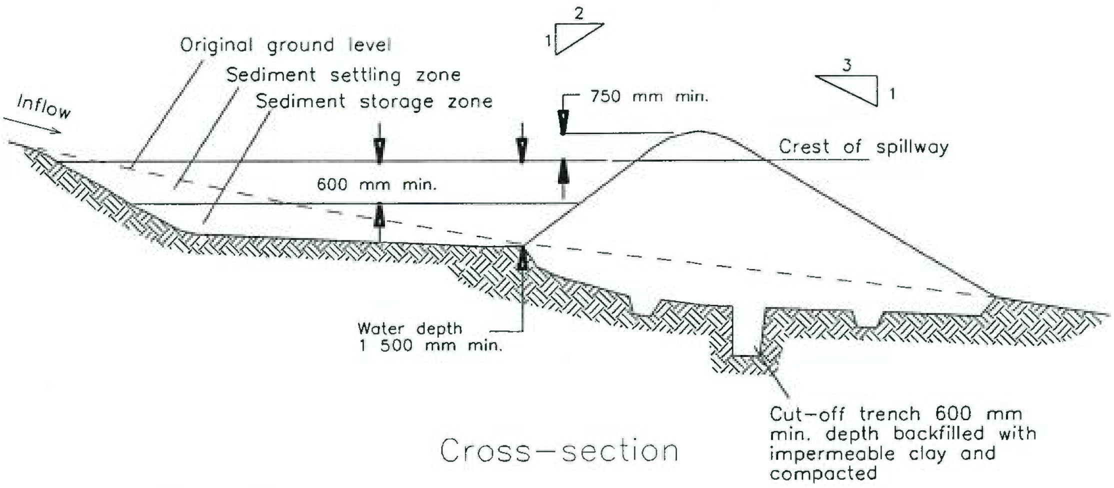
Construction Notes

1. Subgrade fill to be compacted to the density of the surrounding undisturbed material.
2. Ensure that concrete or riprap used for energy dissipater or outlet protection conforms to the grading limits specified on the SWMP/ESCP.
3. Ensure that the geotextile does not sustain serious damage by preparing a smooth, even foundation.
4. Repair minor damage to the geotextile before spreading any aggregate. For repairs, patch one piece of fabric over the damage, making sure that all joints and patches overlap more than 300 mm.

ENERGY DISSIPATER SD 5–6



Plan View



Cross–section

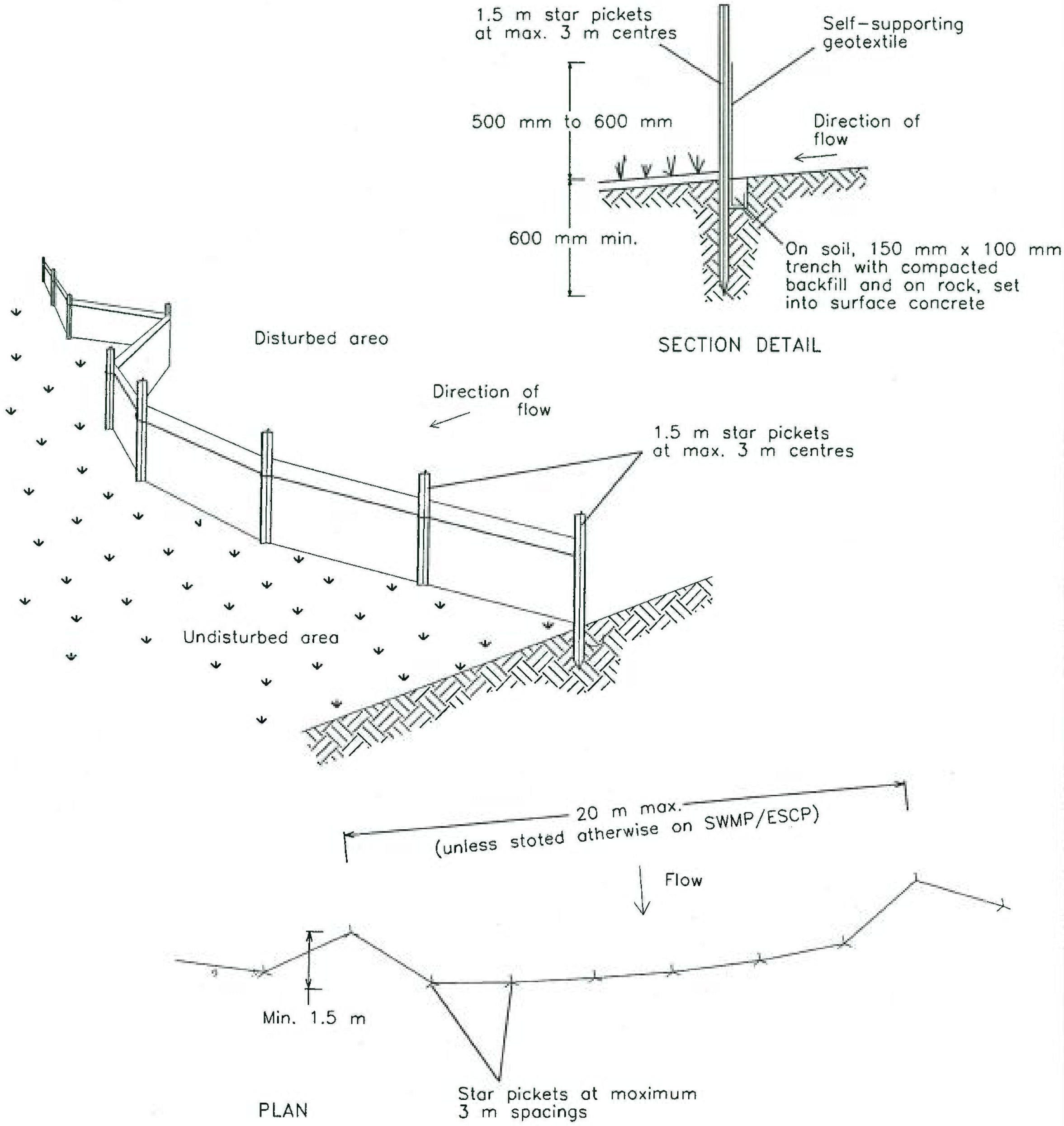
Construction Notes

1. Remove all vegetation and topsoil from under the dam wall and from within the storage area.
2. Construct a cut–off trench 500 mm deep and 1 200 mm wide along the centreline of the embankment extending to a point on the gully wall level with the riser crest.
3. Maintain the trench free of water and recompact the materials with equipment specified in the SWMP to 95 per cent Standard Proctor Density.
4. Select fill according to the directions of the SWMP that is free of roots, wood, rock, large stone or foreign material.
5. Prepare the site under the embankment by ripping at least 100 mm deep to help bond compacted fill to existing substrate.
6. Spread fill in 100 mm to 150 mm layers and compact at optimum moisture content in accordance with the SWMP.
7. Construct emergency spillway.
8. Rehabilitate structure in accordance with the SWMP.
9. Place a "Full of Sediment" marker to show when less than design capacity occurs and sediment removal is required.

EARTH BASIN – WET

(APPLIES TO TYPE D AND TYPE F SOILS ONLY)

SD 6–4



Construction Notes

1. Construct sediment fence as close as possible to parallel to the contours of the site.
2. Drive 1.5 metre long star pickets into ground, 3 metres apart.
3. Dig a 150 mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
4. Backfill trench over base of fabric.
5. Fix self-supporting geotextile to upslope side of posts with wire ties or as recommended by geotextile manufacturer.
6. Join sections of fabric at a support post with a 150 mm overlap.

SEDIMENT FENCE SD 6-7

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Qualifications:

< Certified Professional in Erosion and Sediment Control (# 991)

< Certified Professional Soil Scientist (Leading Professional, Stage 3)

< Bachelor of Arts, (Soil Science, Fluvial Geomorphology, Land Management and Geomechanics), Macquarie University, Sydney

< Diploma in Agriculture, Hawkesbury Agricultural College, Richmond

Expertise:

< soil survey/soil landscape/land capability mapping

< erosion mitigation and rehabilitation, sediment and nutrient control

< preparation of environmental studies

< presentation of texts, seminars/workshops and expert witness on the above topics

Career Highlights:

< Environmental Scientist, Morse McVey & Associates Pty Ltd from 1990 to the present

< preparation of land capability studies, soil surveys, soil landscape maps and water quality analyses for many developments in central and coastal NSW; clients include both private and government developers

< preparation of Soil and Water Management Plans (including design of wetlands) for development of residential and commercial lands, roadworks and recreational facilities

< preparation of a design handbook for the NSW Government *Managing Urban Stormwater: Soils and Construction* (1998) (the "Blue Book"); also prepared the first two editions

< preparation of policies and codes of practice for soil and water management for such sensitive catchments as Berowra Creek south of Berowra Waters

< in 1994/5, chairperson of two Urban Stormwater Task Force Working Groups overseeing the preparation of technical handbooks for the NSW EPA on best management practices for use on construction sites and permanent soil and water management measures on urban lands

< expert witness on various soil and water matters at the Land and Environment Court

< principal teacher and developer of a course on Soil and Water Management run through the University of Western Sydney and of a 2-day course on the same subject for the Australasian chapter of the International Erosion Control Association

< member of International Erosion Control Association, Soil and Water Conservation Society, Australian Society of Soil Science Inc., Stormwater Industry Association, Environment and Planning Law Association (NSW) Inc.

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CONCRITE QUARRIES PTY LTD

EXETER QUARRY EXTENSION

HYDROGEOLOGICAL STUDY
EXETER QUARRY EXTENSION

Prepared by:

C.M. Jewell & Associates Pty Ltd

August, 1999

Specialist Consultant Studies

Volume 1 ▪ Part 5

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HYDROGEOLOGICAL STUDY

EXETER QUARRY EXTENSION

Report No. AJ9859.26

August 1999

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SUTHERLAND NSW 2232

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ACKNOWLEDGEMENT

C.M. Jewell & Associates Pty Ltd would like to acknowledge the co-operation and assistance of the following persons and organisations. Ross and Carol Morrow provided assistance in undertaking fieldwork. Without their co-operation and tolerance, drilling and testing would not have been possible. Wingecarribee Shire Council and Telstra provided prompt clearance for buried services prior to drilling investigations.

EXECUTIVE SUMMARY

This report has been prepared to assess the potential groundwater-related impacts of a proposed extension to a basalt quarry near Exeter, in the Southern Highlands of NSW, which is operated by Concrite Quarries Pty Ltd.

At Exeter, an unconfined aquifer of fractured basalt rock feeds several spring-sets and more diffuse creek-bed seepage in Indigo Creek. Among these is a spring referred to as 'Spring 7' on the "Willowbank" property, identified in previous studies, and recognised to be a small, but reliable source of stock water in the upper reaches of Indigo Creek. Measured depths to water table were between 7 and 13 metres below the ground level of north-eastern "Willowbank" on 11 November 1998. Groundwater flow is promoted by the infiltration of excess soil-water and lateral movement outward to discharge points such as the springs feeding Indigo Creek. Spring 7 is fed from recharge along a flow path which follows a north-north-westerly (NNW) trend, crossing Werai Road.

Concrite proposes to extract basalt to a final depth of approximately 663 metres AHD elevation, on the north-eastern side of Rockleigh Road. The extraction operations may cause the diversion of the pre-existing groundwater flow pattern and depression of the water table around the extraction void.

The degree of diversion and potential diminution of spring flow has been assessed qualitatively. This assessment indicated that, if continuous or interconnected flow pathways are present in or immediately beneath the basalt, between the proposed quarry extension and the springs or their recharge area, then the extraction void may have a substantial impact on spring flows. Conversely, if the flow pathways are limited, the impacts upon spring flows would be small.

In the Exeter hydrogeological environment, such pathways might be formed by jointing or other fractures in the basalt, by interbedded soil/clay horizons within and below the basalt, by sub-basalt soil horizons, or by the clay or metamorphosed contact between the basalt and the underlying shale. However, the presence and continuity of such pathways, while possible, are considered unlikely for the following reasons:

- It is likely that existing flow pathways have developed along structurally controlled fracturing, parallel to the alignment of Indigo Creek.
- Groundwater flow over many centuries is likely to have substantially increased the transmissivity of existing flow paths between the recharge area and the Indigo Creek springs.
- The upper part of the basalts was observed to be more fractured than the lower part. Within Stonequarry and Indigo Creeks, springs and areas of diffuse seepage were observed to be associated with both the upper fractured part of the basalt and with the basal contact.
- Variations in the palaeotopography on the underlying shale contact which would control flow direction at the base of the basalt.

Further hydrogeological investigation has been recommended to demonstrate the presence or absence and significance of any such pathways.

In the event that the presence of such pathways was demonstrated, then a number of potential mitigation measures would be available. These include modification of the quarry design, and/or construction of boreholes to intercept groundwater flow and divert this to the creek.

The impacts of the proposed Exeter Bypass on spring flow and groundwater quality on the Vine Lodge property are generally expected to be small. The road alignment has been located to prevent intersection of groundwater flows.

It is not anticipated that the quality of water in the final quarry void will present problems for the operators; this water would be available for use in flow augmentation measures if required.

1.0 INTRODUCTION

1.1 Background

In 1997 Concrite Quarries Pty Ltd submitted a development application to Wingecarribee Shire Council for an extension of its quarry near Exeter. C.M. Jewell & Associates (CMJA) prepared a report to respond to issues raised by surrounding residents and the Department of Land and Water Conservation (DLWC) concerning that proposal. The response was ultimately considered at a Commission of Inquiry. The Commission of Inquiry was unable to recommend approval of the proposal for a range of reasons related to transport, noise, and visibility.

Concrite Quarries Pty Ltd has prepared a new EIS to support a revised development application. As part of the environmental assessment for the new application the long-term viability of a spring (hereafter identified as "Spring 7") on the property "Willowbank", which is approximately 300 metres south of the proposed extraction area has been considered. The investigations assess whether any groundwater feeding the spring originates from, or in close proximity to, the proposed extraction area and whether the proposed activities will influence the character or flow from Spring 7.

This report also addresses the occurrences of groundwater within and surrounding the proposed extraction area. Much or that information is drawn from the report prepared for the previous Commission of Inquiry (C. M. Jewell & Associates, 1997).

This study also addresses the mitigation measures which might be employed both during the life of the proposed extraction area and in the long term, if it is assessed that there is a potential for extraction activities to affect the yield or quality of this spring.

This study also addresses groundwater occurrences in the vicinity of the Exeter Bypass, a proposed private haul road across the northern lot of the nearby "Vine Lodge" property.

1.2 Objectives and Scope of Work

The objectives of the study were to assess the overall hydrogeological impact of the proposed quarry extension and by-pass construction works with particular emphasis on Indigo Creek and Spring 7, and the impact of the proposed Exeter Bypass.

The objectives of the study in the vicinity of the Spring 7 tributary are listed below.

1) To identify the source area or recharge zone for the groundwater feeding baseflow at the headwaters of Indigo Creek and the tributary to the creek fed by Spring 7.

2) To integrate the current understanding of site hydrogeology into an assessment of the potential and likely impacts of expanded quarrying activities on the headwaters of Indigo Creek and the Spring 7 tributary.

The report prepared by this company for the original proposal identified two possible mechanisms by which the quarry extension could impact upon Spring 7.

A. If the source of Spring 7 is in the north-western half of the proposed extraction area, then the extraction could ultimately impact directly upon the discharge of the spring as it could cut pathways carrying groundwater flow to the spring.

B. If the recharge feeding Spring 7 is derived primarily from the area to the north of the spring, it is possible that the extraction could still impact on the spring discharge by changing the direction and magnitude of the hydraulic gradient, thus possibly diverting some or all of the recharge away from the headwaters of Indigo Creek.

It was recognised in the previous study that groundwater flow in the basalts is controlled by secondary features such as fractures and interflow/subflow palaeosol horizons. Thus for the proposed extraction area to impact upon the springs by Mechanism B, it would be necessary for viable groundwater flow pathways to be present between the recharge area and the proposed extraction area.

Therefore, an understanding of the location and direction of the predominant zones of groundwater flow is crucial to meeting project objectives.

It was considered that this understanding could best be gained from a drilling program designed to:

- provide information on the subsurface geology, including the presence and condition of fracturing;
- allow the depth to groundwater (and thus the elevation of the water table) to be measured; and
- allow groundwater samples to be obtained.

The interpretation phase of the project integrated the field data collected in earlier phases and provided an analysis of the hydrogeological processes impinging on the groundwater flow dynamics of the study area.

1.3 Methodology

Following an initial re-appraisal of existing hydrogeological information, field investigations were undertaken entailing the drilling and construction of four sampling bores/piezometers (Figure 3). These bores were subsequently developed, purged and sampled, and the waters analysed for a range of principal constituents. A water table survey was also conducted by surveying the elevation of each bore collar, plus the invert elevation of springs and Indigo Creek.

The resulting field data were analysed spatially in three dimensions with an emphasis on assessing the groundwater flow direction, zones of groundwater flow, groundwater flow rate and the importance of spring discharge in the local groundwater system. These analyses were used in assessing the scale and nature of any impacts on the groundwater system arising out of the proposed extraction.

1.4 Limitations and Intellectual Property Matters

This report has been prepared by C.M. Jewell & Associates Pty Limited for the use of the client identified in Section 1.1, for the specific purpose described in that section. The project objectives and Scope of Work outlined in Section 1.2 were developed for that purpose, taking into consideration any client requirements and contractual agreements set out in the proposal referenced in Section 1.1.

The work has been carried out, and this report prepared, utilising the standards of skill and care normally expected of professional scientists practising in the fields of hydrogeology and contaminated land management in Australia. The level of confidence of the conclusions reached is governed, as in all such work, by the scope of the investigation carried out and by the availability and quality of existing data. Where limitations or uncertainties in conclusions are known, they are identified in this report. However, no liability can be accepted for failure to identify conditions or issues that arise in the future and which could not reasonably have been assessed or predicted using the adopted scope of investigation and the data derived from that investigation.

Where data collected by others have been used to support the conclusions of this report, those data have been subjected to reasonable scrutiny but have essentially, and necessarily, been used in good faith. Liability cannot be accepted for errors in data collected by others.

This report, the original data contained in the report, and its findings and conclusions remain the joint intellectual property of C.M. Jewell & Associates Pty Ltd and Concrite Quarries Pty Ltd. A licence to use the report for the specific purpose identified in Section 1.1 is granted to the persons identified in that section on the condition of receipt of full payment for the services involved in the preparation of the report.

This report should not be used by other persons or for other purposes than those identified in Section 1.1, and should not be reproduced except in full and with the permission of C.M. Jewell & Associates Pty Ltd.

1.5 Report Structure

Section 2 of this report details the current physical setting of the Exeter area, the proposed extraction area and the "Willowbank" property in particular. Section 3 outlines field investigations undertaken as part of this study. Sections 4 and 5 present the results and interpretations of the latest investigations; and in Section 6 the anticipated impacts of the proposed extraction are assessed in accordance with issues prescribed for extractive industry EIS preparation.

2.0 SITE SETTING

The study area encompasses the proposed extraction area and the headwaters of Indigo Creek between Rockleigh Road and School Lane. The primary focus of this hydrogeological investigation is the set of springs issuing from the ground on the banks of Indigo Creek, specifically the perennial spring identified as 'Spring 7' in the previous CMJA report (C. M. Jewell & Associates, 1997). A significant concentration of these springs is found at elevations between 690 and 700 metres AHD, approximately 150 metres upstream of the unnamed north-western tributary.

2.1 Topographic Setting

The study area is set among rolling hills of the Southern Highlands landform unit. Immediately south of the proposed extraction area, beyond Rockleigh Road, the land slopes sharply to Indigo Creek. Slopes vary from 10° to 15°, although the slopes soften into benches in the north-western reaches of Indigo Creek. The land to the south-east of the proposed extraction area also falls away quickly to a valley within the adjoining Stonequarry Creek catchment. The proposed extraction area is characterised by a flattened ridge with a maximum elevation of about 720 metres AHD. Figure 1 details the land surface relief, drainage features and location of principal features mentioned in the text.

2.2 Surface Water Drainage

Indigo and Stonequarry Creeks and their tributaries incise gullies into their courses. The Indigo Creek headwaters immediately south-east of Werai Road take the form of ephemeral swales. In the wetter parts of the year, the swales intercept soil and groundwater seepage, distinctly below the 700 metre elevation contour. At the downstream boundary of the "Willowbank" property the creek discharge is estimated to be about 5 litres per second and predominantly fed from groundwater seepage. Indigo Creek joins Stonequarry Creek approximately 3.5 kilometres further downstream.

The fractured basalt aquifer provides exploitable groundwater for numerous purposes in the area, with four registered and a number of unregistered boreholes located in the immediate vicinity of the study area. Of the four registered boreholes, three are located on properties fronting School Lane approximately 500 metres on the south-western side of Indigo Creek. Each of these bores draws water from the fractured basalt aquifer which has a standing water level of approximately 13 metres below ground surface. Thickness and depth to the underlying massive basalt/sandstone/shale aquitard is not known for these bores.

2.3 Geological Setting

The study area is underlain by Tertiary-age basalt flows and sills, and then fine-grained sandstones and shale of the Bringelly Shale (the uppermost unit of the Wianamatta Group). The sandstones and shales underlie the basalts along an undulating, palaeo-topographic surface. Figure 3 shows the elevation of the sub-basaltic contact with the sandstone/shale at several points in the proposed extraction area and within the "Willowbank" property. Fresh outcrops of sandstone and shale can be found in the bed of Indigo Creek just downstream of the lowest spring sets.

The basalts beneath the proposed extraction area are differentiated into fractured, massive and amygdaloidal facies within the volcanic pile, as shown on the logs of resource definition boreholes in Figure 7. The olivine basalts are pervasively dissected by past and present erosion and other mass wasting processes such as sapping. The remnant has variable depths of weathering. Pervasive soil and colluvial blanketing has left few outcrops visible, although remnant basalt blocks can be seen along ridges.

2.4 Hydrogeological Setting

The groundwater flow in the vicinity of the proposed extraction area occurs predominantly within the basalt deposits. Groundwater flow within the basalt aquifer is hosted by secondary porosity features such as joints, voids and fractures, and by interflow and subflow paleosol horizons. The underlying sandstone/shale is considerably less permeable to groundwater flow than the basalts and acts as a regional aquitard. Consequently, the intersection of the shale contact with the land surface is often the site of springs issuing from the basalt or associated colluvium. The incision of the land surface by Indigo Creek and its tributaries tends to promote the presence of the springs, especially at the lower margins of the basalt aquifer. Several springs issue immediately above or at the contact between basalt and shale. Individual springs have discharge rates of up to 3 L/s.

Within the Stonequarry Creek catchment, springs appear to discharge from changes of slope at four separate elevations: 720 metres AHD, 700 metres AHD, 692 metres AHD and 680 metres AHD. The slopes are largely scree covered and although the lower two springs can be seen to be discharging at the base of a slope failure beneath basalt scree, the source may be at a higher elevation. The springs in the Stonequarry Creek catchment appear to be flowing at low discharge rates, typically 0.1 to 0.5 L/s.

The primary source of groundwater recharge is infiltration of soil-water (derived from excess precipitation) through the subsoil and unsaturated volcanic rocks to the ambient water table. The water table is not as precisely defined a surface as for granular aquifer materials, being the depth to which interconnecting joints, voids and fractures are water-filled. The interconnected fractures act as an equivalent porous medium in distributing water pressure throughout the fractured rock aquifer. Thus, the depth of saturation measured within a set of fractures will reflect the prevailing water pressure in the vicinity of the measurement.

In general the highest hydraulic conductivities tend to be found in the shallow parts of a fractured aquifer. The principal exceptions to this are lithologically controlled porosity or fracturing caused by deep structural features such as faults. The results of drilling investigations in the proposed extraction area and the "Willowbank" property have tended to reflect this generalisation.

Three existing water supply boreholes are located on properties adjacent to School Lane, approximately 500 metres to the south-west of the proposed extraction area. Another borehole is located approximately 600 metres to the north-east. The locations of these boreholes are shown on Figure 10.

Data for Boreholes 66769 and 66764 show that the water bearing zones occur at between about 700 and 708 metres AHD in Borehole 66769 and between about 694 and 704 metres AHD in Borehole 66764. The regional geology, geological mapping in Indigo and Stonequarry Creeks and geological information obtained from resource definition drilling suggest that the water bearing zones in Boreholes 66769 and 66764 are hosted by basalt, but likely to be immediately above the contact between basalt and the underlying shale or siltstone.

3.0 FIELD INVESTIGATIONS

Field investigations progressed from a preliminary field visit to select the positions of boreholes, through the drilling and bore construction phase, to testing and sampling of the groundwaters thus made accessible. An important part of the investigation was the water table survey, which provided best information on the source of water issuing at Spring 7.

3.1 Preliminary Field Visit

A field visit was made on 24 September 1998. The principal objectives of the visit were to select the optimal and most practicable drilling sites and to map the local hydrogeological features.

Several springs contributing baseflow to Indigo Creek that were noted in earlier investigations - specifically springs numbered 7, 8 and 9 (Figure 6) - were inspected and physio-chemical field parameters compared (Table 1). Spring 8, as identified in C. M. Jewell & Associates (1997), is a diffuse seepage zone on the margins of Indigo Creek. The sites inspected in 1998 are shown on Figure 2.

TABLE 1
Field Measurements of Physio-Chemical Parameters

Site No.	Electrical Conductivity (uS/cm)	pH	Dissolved Oxygen (%)	Temperature (°C)
Site 1, creek	453	7.00	69.2	12.7
Site 2, creek	456	7.34	52.1	12.8
Site 3, creek	476	7.27	49.6	12.5
Site 4, creek	479	7.43	92.5	13.2
Site 5, Spring 7	652	7.41	57.2	14.6
Site 6, creek	576	7.84	74.0	13.6
Site 7, Spring 9	541	7.61	89.1	14.5
Nearby bore (MB3, 11 Nov 98)	735	7.46	48.6	13.9

The general conclusions made from this inspection were as follows.

- The upstream springs grouped into the diffuse spring set numbered 'Spring 8' are of distinctly lower flow rate than downstream springs numbered 7 and 9. Also, the electrical conductivity of spring water from these upstream springs is distinctly lower than downstream springs along Indigo Creek.
- Water from spring sets 7 and 9 has distinctly higher water temperature and electrical conductivity than water from upstream.
- Visual comparison of seepage rate between sites reveals a distinct transition to high flow rate in sites 5 and 7 (spring sets 7 and 9).
- Combining the observations above with a conceptual understanding of the setting, it is concluded that the upstream seepage is derived from shallow levels beneath the water table, and that Springs 7 and 9 draw on deeper groundwater flow within the basalt deposits and at the basalt-shale contact where some mixing with saline Bringelly Shale groundwater may have occurred.

3.2 Drilling Investigations

An Edson 3000 topdrive rig was mobilised to the study area on 22 October 1998. The rig came equipped to core rock at HQ (76mm), including casing and wire-line core barrel. Water and drilling polymer were used as drilling fluid throughout operations. Drilling operations, including construction and development of monitoring wells in each completed borehole (MB/BH1 – 4) consumed approximately 11 days; the boreholes were drilled in numerical order. Table 2 summarises the positional and depth details of the four boreholes, all of which were drilled on the "Willowbank" property.

TABLE 2 Borehole Details						
Code	Easting	Northing	Bore Collar Elevation (m AHD)	Depth to Water 11 November 1998 (m TOC)	Water Table Elevation (m AHD)	Depth of Bore (m)
MB/BH1	237847	1168210	712.55	12.59	699.95	24.5
MB/BH2	237912	1168299	718.24	12.53	705.71	42.2
MB/BH3	237773	1168277	716.58	10.81	705.76	26.6
MB/BH4	237736	1168353	716.84	10.57	706.26	20.55

Borehole MB/BH1 intersected fine sandstone and claystone at 24.4 metres, which was interpreted to represent the aquitard noted in field mapping of the Indigo Creek bed downstream of Springs 7 and 9. Drilling in the remaining boreholes penetrated only superficial materials and basaltic rocks and did not intersect the underlying sedimentary rocks.

3.2.1 Bore Construction

Following the completion of drilling and core recovery, the wells were completed with 50 millimetre diameter PVC casing, gravelpack and bentonite/grout seal. Each borehole was screened in the lower 6 metres, except for MB/BH2, which was completed with a longer screen. Hydrogeological bore logs and well construction logs are provided in Appendix B.

3.2.2 Well Development

Boreholes MB/BH1, MB/BH2 and MB/BH3 were each flushed with a minimum of 1,000 litres of fresh water in order to backwash drilling fluid out of the hole. Following well construction, each bore was bailed, removing several bore volumes of water, until the water was clear.

3.3 Groundwater Sampling

Sampling of groundwater from completed and developed boreholes was undertaken with disposable HPDE bailers. The bailer was used to remove 3 borehole volumes to ensure each bore was sufficiently purged, and then a representative sample was taken. Springs 7 and 9 were grab sampled.

All samples were subsequently chilled to below 4°C and dispatched to Australian Laboratory Services, Sydney laboratory, for analysis. Field measurements of electrical conductivity, pH, dissolved oxygen and water temperature were made at the time of sampling. The sample taken from MB/BH1 showed the residual effects of a saline tracer injection made two days previously. This resulted in apparently elevated sodium and chloride concentrations.

3.4 Water Table Survey

A survey of the elevation of the water table was undertaken in the week following drilling and development.

3.4.1 Level Surveying of Bore Collars

A level survey tied into local AHD benchmarks was undertaken to relate bore collars to a common datum. The invert elevation of several points in Indigo Creek and Springs 7 and 9 were also included. In addition, two water bores in Exeter village screened in the basalt aquifer were surveyed to the common datum. The vertical accuracy of the survey method is ±5 centimetres, or better.

3.4.2 Water Level Measurement
An electronic water level probe was used to measure the depth from bore collar to the standing water table. The accuracy of this method is ±5 millimetres.

3.5 Saline Tracer Test
A saline tracer test was attempted using injection of brine solution into monitoring bore MB/BH1 and monitoring of the electrical conductivity of Spring 7. The tracer was injected at 8:50 am on 10 November 1998. No change in Spring 7 electrical conductivity had manifested by 3 pm on 11 November 1998.

3.6 Additional Spring Survey
An additional survey of springs and seeps in the Indigo Creek and Medway Rivulet catchments was carried out in April 1999. Spring locations were logged using a GPS receiver, and measurements of spring discharge, temperature, electrical conductivity and pH were made.

4.0 INVESTIGATION RESULTS

Information derived from the investigation led to the following conclusions.

4.1 Geological Factors
The contrast in hydraulic conductivity between the basaltic aquifer and the sandstone/shale aquitard has an undoubtedly significant impact on the local groundwater flow pattern. The surface expression of the contact between the basalt and the underlying aquifer corresponds with visible lineations of the spring sets around the hillsides bounding Indigo and Stonequarry Creek. Previous field inspections of the area's spring hydrology (C. M. Jewell & Associates, 1997) show these two distinct zones of seepage in the flanks of each drainage. The higher elevation seepage lines at about 720 metres in the Stonequarry Creek are possibly explained by the measured elevation of the shale contact in this eastern area.

The basalt–shale contact is an erosional unconformity. The palaeo-relief of the shale surface onto which lava flowed resulted in a highly variable thickness of basalt being formed. The sub-basalt surface is not well defined, but is likely to be complex. This aquifer structure may have resulted in the presence of laterally restricted groundwater bodies.

This variability is evident in Figure 3, which shows the measured elevation of the basalt–shale contact.

The lithology of the basaltic pile is also quite variable. The broad classifications for the basaltic rock types encountered are provided in Table 3.

TABLE 3 Classifications for Basaltic Rock Types Encountered	
	Generalised Description
Colluvium	Basalt-derived soil reworked by hillslope processes.
Extremely weathered basalt	Indeterminate, highly altered basaltic material. Commonly clay-rich and highly mottled. Basaltic fragments of variable size
Fractured basalt	Highly fractured and exposed faces variably weathered. Joints and fractures dense in sub-horizontal and sub-vertical planes
Fractured/altered amygdaloidal basalt	Hydrothermal alteration products infilling pre-existing voids are the dominant visible feature. Fracture pattern chaotic and tending to connect zeolite-filled amygdules. Basalt can be highly altered (almost complete) and very weak with significant clay formation
Amygdaloidal basalt	Zeolite-filled amygdules permeating the rock matrix. Variable basalt grainsize in intervening rockmass
Massive basalt	Typically fine grained
Fractured massive basalt	Typically fine grained and sub-vertically fractured

The highest porosity is generally found in fractured/altered amygdaloidal basalt, although fractured basalt and fractured massive basalt also retain significant porosity.

4.2 Hydrogeological Factors

4.2.1 Spring Flow

The natural subsurface hydrology throughout the study area is dominated by diffuse recharge of precipitation excess, saturated flow through the basalt aquifer and discharge at spring sets and seepage lines. The base elevation of the basalt aquifer is the shale contact, so seepage is concentrated along this zone. Indigo Creek streamflow is dominated by the contribution of perennial and periodic spring flow. The baseflow index of Indigo Creek in the headwater section downstream to the "Willowbank" property boundary is estimated to be about 80%[1].

Spring flow in Spring 7 was measured on 10 November 1998 at 0.68 litres per second (58 m^3/d). Several other associated spring sets also discharge into Indigo Creek. The combined baseflow derived from these springs makes up most of the flow of Indigo Creek during periods between rain events, and is estimated to be about 5 litres per second at the "Willowbank" property boundary. The quantity of spring flow, and hence flow in Indigo Creek, will fluctuate with the balance of recharge and discharge. Periods of high recharge cause rises in the water table and subsequent increase in downstream spring flow. However, the fluctuation in both the discharge and water temperature through any period is smoothed by the storage capacity of the basaltic aquifer, leading to relative stability of these parameters in spring flow.

Further downstream, to the south of the existing extraction area, numerous springs and groundwater seeps are evident in several locations and elevations. The majority of the springs appeared to be associated with marked changes in groundslope, possibly correlating with the undulating inter-flow contacts. Discharges observed ranged from less than 0.1 litres per second to

[1] The baseflow index (BFI), expressed as a percentage, is the proportion of streamflow derived from groundwater seepage. Streamflow hydrographs partitioned into runoff and seepage components typically give indices ranging from 10% to 70% in temperate climates. A high BFI indicates predominant spring flow influence.

0.5 litres per second contributing an estimated 40% to the baseflow of Indigo Creek within the upper catchment

4.2.2 Water Table Profile

Several sites of access for measuring level of the ambient water table were available to the study. Two of the water bores along School Lane, four monitoring bores (MB/BH1 – 4), and Springs 9 and 7 were used for this purpose. In general, the subsurface hydrology inferred for the area suggests that the invert of Indigo Creek will act as a receptor of groundwater flow in the aquifer by draining away groundwater where the water table intersects the creek bed.

Figure 4 shows the interpolated water table surface measured on 11 November 1998. The contours of equal water table elevation were interpolated using the kriging geo-statistical method. The water table contours wrap around Indigo Creek, confirming the inferred groundwater flow pattern. Assuming that the water table contours are a valid representation of the water table profile, and also assuming that groundwater flow is not radically diverted by preferential flow paths, then the groundwater flow direction will be perpendicular to the water table contours. Back-tracking from Spring 7, the inferred flow path to the spring is through a line trending north-north-west (NNW), which crosses Werai Road. This indicates that the bulk of groundwater issuing at Spring 7 will have recharged outside the proposed extraction area. Figure 5 shows a hydrogeological cross-section taken parallel to the flow path and including three of the borehole logs.

4.2.3 Hydraulic Properties

The approximate hydraulic properties can be estimated using darcian approximations of the flow field, despite the fact that flow in the basalt is not a classical darcian case. The water table contour map of Figure 4 is used to mark off two flow fronts, i.e. lines perpendicular to the flow paths towards Spring 7, across which the groundwater issuing at Spring 7 will flow.

The gradient of the water table profile is measured at these flow fronts as is the width of each front. The equivalent porous medium transmissivity is estimated using the equation below.

$$T_{EP} = \frac{Q}{Wi}$$

Where:

T_{EP}= equivalent porous medium transmissivity

Q = spring flow at Spring 7

i = water table gradient

W = width of flow front

The estimate for each flow front is given in Table 4.

TABLE 4 Flow Front Estimates				
	Spring 7 Flow (m^3/d)	**Hydraulic Gradient (m/m)**	**Width (m)**	**T_{EP} (m^2/d)**
Flow front 2 (215m NNW of Spring 7)	58.7	0.114	120	4.3
Flow front 1 (90m NNW of Spring 7)	58.7	0.222	60	4.4

These estimates of equivalent porous transmissivity are in reasonable agreement from one flow front to another. No correction from transmissivity to hydraulic conductivity is made due to uncertainty as to the uniformity and total saturated thickness. An equivalent porous medium transmissivity of approximately 9 m^2/d was used in subsequent groundwater modelling.

4.2.4 Groundwater Chemistry

The results of analysis of groundwater conducted on water sampled on 11 November 1998 are given in Table 5.

The water chemistry results indicate the following:

- Relative lateral uniformity exists between samples (allowing for NaCl interference in MB/BH1), at the depths at which piezometers were screened.
- Low severity agricultural influences, discernible in the nitrate and phosphorus concentrations.
- Relatively high redox state (oxygenation) as shown by the dissolved oxygen concentration and the low concentrations of iron and manganese.
- Moderate contact time and interaction with aquifer rock, as indicated by the concentrations of calcium, magnesium and bicarbonate.
- Recharge from a dilute source, such as excess precipitation, without the groundwater having undergone significant evaporation as soil-water.
- The groundwater is of potable quality in respect of the majority of determinands analysed, although aluminium and zinc are above Australian Drinking Water Guideline values.

Microbiological indicators were not analysed.

TABLE 5
Groundwater Analysis

Analysis description	Units	LOR*	MB1	MB2	MB3	Spring 7	Spring 9
Electrical Conductivity	µS/cm		1430	678	735	665	–
pH			7.47	7.79	7.46	7.65	–
Dissolved Oxygen	$\%O_2$		43.7	43.1	48.9	68.4	–
Temperature	°C		15.1	14.7	13.9	14.8	–
Total Hardness as $CaCO_3$	mg/L	1	255	288	249	246	151
Calcium Hardness as $CaCO_3$	mg/L	1	82	95	80	77	60
Calcium - Filtered	mg/L	1	33	38	32	31	24
Magnesium - Filtered	mg/L	1	42	47	41	41	22
Sodium - Filtered	mg/L	1	136[†]	25	30	24	23
Potassium - Filtered	mg/L	1	3	2	2	2	2
Carbonate as $CaCO_3$	mg/L	1	<1	<1	<1	<1	<1
Bicarbonate as $CaCO_3$	mg/L	1	241	269	235	217	103
Sulphate - Filtered	mg/L	1	7	7	11	5	3
Chloride	mg/L	1	202[†]	35	39	42	54
Iron - Filtered	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper - Filtered	mg/L	0.001	0.002	<0.001	0.002	0.002	0.001
Manganese - Filtered	mg/L	0.001	0.061	0.042	0.066	<0.001	0.022
Silicon - Filtered	mg/L	0.1	87	77.3	89.9	79.9	89.5
Zinc - Filtered	mg/L	0.001	0.015	0.004	0.012	1.01	0.008
Aluminium - Total	mg/L	0.01	0.35	0.37	2.44	5.76	0.01
Fluoride - Filtered	mg/L	0.1	0.2	0.2	0.1	0.1	0.1
Ammonia as N	mg/L	0.01	0.03	0.08	0.06	0.03	0.05
Nitrate as N	mg/L	0.01	2.7	2.91	1.74	3.00	3.83
Reactive Phosphorus as P - Total	mg/L	0.01	0.43	0.39	0.42	0.58	0.65
Total Cations	me/L		11.1[†]	6.91	6.33	6.02	4.06
Total Anions	me/L		10.87[†]	6.73	6.16	5.85	3.92
Actual (Anion / Cation) Difference	me/L		0.23	0.18	0.17	0.17	0.14
Allowed (Anion / Cation) Difference	me/L		0.27	0.21	0.20	0.20	0.17

* LOR = Limit of Resolution
† Result affected by residual effects of saline tracer test

5.0 ADDITIONAL SPRING INVESTIGATIONS

5.1 Proposed Exeter Bypass

Three springs were identified along the proposed Exeter Bypass. All of the springs were located on the 'Vine Lodge' property situated to the west of the proposed extraction area. These have been identified as Spring A, Spring B and Spring C on Figure 8.

No further springs were identified on the proposed Exeter Bypass. Results of the field monitoring are presented in Table 6.

TABLE 6
Field Measurements of Physio-Chemical Parameters
Exeter Bypass Springs

Spring	pH	Electrical Conductivity (µs/cm)	Temperature (°C)	Dissolved Oxygen (%)	Discharge (L/s)	Elevation Metres AHD
A; location 1	7.21	618	13.6	32.6	<<0.1	699
A; location 2	7.31	678	13.1	38.1	0.2	696
B; location 1	7.71	992	14.2	44.9	0.1	695
B; location 2	7.71	959	13.2	62.8	0.1	695
C; location 1	7.41	803	15.0	51.3	0.1 (?)	695
C; location 2	7.41	806	15.1	46.7	0.1 (?)	694

The character of the springs differs from that observed within the Indigo Creek catchment, with topography restricting the dispersion of discharge of water from each of the springs.

The relatively low undulating topography of the property has promoted 'soaks' rather than free flowing springs in the area resulting in large areas becoming saturated by semi-stagnant groundwater-derived outflow. There is little evidence of the dispersion of springwater by overland flow.

Thick vegetation communities of water tolerant species have colonised two of the 'soaks' (Spring B and Spring C), hindering all attempts to locate the source of the groundwater. The third spring (Spring A) originates from an erosional 'nick-point retreat' approximately forty metres from where the water collects. The nick-point is situated within an ephemeral creek channel which has been dammed approximately 100 metres up-slope. Water was observed to be exiting the ground from the nick point (Spring A location 1) and from a faster flowing spring also located within the channel approximately 30 metres down-slope (Spring A location 2).

General conclusions which can be made from this inspection are as follows:

- The higher electrical conductivity and pH of Spring B would indicate that the spring derives water from the deeper formation waters of the aquifer.
- The lower electrical conductivity and pH of Spring A would indicate the emission of relatively 'immature' aquifer water and/or excess precipitation water from the unsaturated soil and volcanic pile.

- Combining observations above with a conceptual understanding of the setting, it is concluded that the groundwater derived in each spring is derived from the same aquifer.

- In general, groundwater is assessed to have undergone a longer residence time within the aquifer on the 'Vine Lodge' property than on the 'Willowbank' property and in the Indigo Creek catchment, on the basis of respective electrical conductivities. This would be consistent with the local topography and estimated groundwater discharge volumes from each area.

5.2 Indigo Creek Spring Study

Mapping and field monitoring of the groundwater springs located within the Indigo Creek Catchment was conducted to identify groundwater sources which contribute to the flow in the upper reaches of Indigo Creek and to establish the contribution of flows from Spring 7 in Indigo Creek Catchment.

Results are given in Table 7.

TABLE 7
Indigo Creek Discharge and Spring Characterisation

Location	pH	Electrical Conductivity (µs/cm)	Discharge* (L/s)	Elevation (Metres AHD)	Nature of Flow
Location 1 A	7.74	565	10	607	Indigo Creek
Location 1 B	7.58	594	1.5	607	Tributary
Location 2	8.17	649	2.0	610	Tributary
Location 3	8.19	565	7.0	626	Indigo Creek
Location 4	7.63	474	<0.1	627	Spring
Location 5	7.59	613	<<0.1	634	'Soak'
Location 6	8.35	579	0.5	634	Spring
Location 7	7.96	1980	<0.1	682	'Soak'
Location 8	7.83	540	6.0	665	Indigo Creek
Location 9	7.76	1370	0.2	667	Spring
Location 10	7.64	581	0.1	680	Spring
Location 11	7.96	643	6.0	684	Indigo Creek
Location 12	7.86	589	0.3	693	Spring
Location 12 #	7.69	562	0.2	693	Spring
Location 13	7.62	579	1.1	695	Spring '7'
Location 13 #	7.61	557	0.7	695	Spring '7'
Location 14	7.43	479	1.5	698	Indigo Creek

* Approximate Discharge measurement.
# Field monitoring conducted on 24 September 1998.
Spring '7' relates to Spring 7 of CMJA report AJ9859.5.

Springs and groundwater seeps (or soaks) were observed in several locations within the Indigo Creek catchment. Spring locations are shown on Figure 9. The majority of the springs appear to be associated with marked changes in ground slope possibly correlating with inter-basalt contacts. The locations of the sources of many of the springs were indistinguishable due to excessive vegetation cover and the nature of the boulder-scree slopes.

From Table 2, the following points can be observed:

- Approximately 40% of the observed discharge in the Indigo Creek catchment, during dry weather, is derived from springs and soaks. It is assumed that the remaining 60% is derived from the infiltration of excess precipitation derived from the soil and unsaturated volcanic rocks within the catchment.

- The electrical conductivity and pH of the spring water from the upstream springs (i.e. those above and including Location 14), are lower than those of downstream springs along Indigo Creek. This suggests that upstream groundwater has been derived from shallow levels beneath the water table whereas downstream springs, particularly at lower elevations, draw on the deeper groundwater flow within the fractured basalt aquifer.

- Groundwater from the spring at location 7 and soak at location 9 have a markedly higher electrical conductivity. This could indicate that the water has either been drawn from deeper in of the basalt aquifer, or influenced by the saline waters of the underlying Bringelly Shale.

- There has been a minor change in the pH and electrical conductivity of the springs at locations 12 and 13 since they were initially monitored in September 1998. The electrical conductivity of both springs has marginally declined, possibly as a result of the wet periods experienced in the area before the survey was conducted, indicating the discharge of relatively recently recharged groundwater, or dilution of older groundwater in the upper part of the catchment.

6.0 IMPACTS

Impacts in relation to a development proposal can be defined as any effects which would not occur in the absence of the development. This study is intended to provide information and assessments as background for an Environmental Impact Statement covering the proposed extraction area and construction of the Exeter Bypass. Hence the examination and interpretation of impact will follow as much as possible the EIS guidelines for Extractive Industries – Quarries (Department of Urban Affairs and Planning, 1996). The specific provisions relating to groundwater impacts are contained in 6 E3 (e – i). These provisions are repeated below:

"...

e) potential impacts on groundwater, considering:

i) the quantity, quality and depth of the watertable

ii) any adverse effects on groundwater recharge areas

iii) the likely transference of any pollutants to groundwater

iv) if extraction is below the watertable

f) when dewatering of the proposed extraction area or pit 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 reuse 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."*

6.1 Depression of the Existing Water Table

The groundwater flow profile and directions have been defined above, in Section 4.2.2. The extraction operations may be impacted by the base (or bases) of the proposed extraction area intersecting the existing water table. The proposed extraction plan includes the provision for active extraction below the water table. Therefore, ponding of groundwater will require management. This water management would involve the draining away of any excess water. The ultimate configuration of the proposed extraction area entails a sump approximately 57 metres below the existing land surface at an elevation of about 663 metres AHD.

The current inferred water table elevation is 704 metres AHD, and it is anticipated that the water level in the sump in the final landform will be at 663 metres AHD. Thus a water table depression of 41 metres immediately adjacent to the proposed extraction area is estimated.

6.1.1 Estimation of Water Table Depression

Some qualitative and semi-quantitative estimates of the impact of the quarry on spring flows were made. These estimates were based on the assumption of a continuous porous medium between the extraction area, the springs and their recharge area.

6.2 Diversion of Groundwater from Existing Springs

It is important to emphasise that a precondition of this impact upon spring flow occurring is that a viable groundwater flow pathway exists through the basalt between the recharge area for the springs and the floor of the proposed extraction area extension. The existence of such a pathway has not been established. Indeed, its presence is unlikely for the following reasons:

- It is likely that existing flow pathways have developed along structurally controlled fracturing, parallel to the alignment of Indigo Creek.
- Groundwater flow over many centuries is likely to have substantially increased the transmissivity of existing flow paths between the recharge area and the Indigo Creek springs.
- The upper part of the basalts was observed to be more fractured than the lower part. Within Stonequarry and Indigo Creeks, springs and areas of diffuse seepage were observed to be associated with both the upper fractured part of the basalt and with the basal contact.
- Variations in the palaeotopography of the underlying shale contact which would control flow direction at the base of the basalt.

Further work is required to resolve this issue.

The assessment indicated that, if continuous pathways were present, then there would be a substantial impact on spring flows. Conversely, if continuous pathways are not present, there would be little impact on stream flow.

Following the completion of extraction, the extraction area will be rehabilitated by the placement of overburden to soften the batter slopes, filling with water to a level of 685 metres AHD and the creation of fringing wetlands. Excess water from seepage and rainfall will flow through the topographic low that would exist at the south-eastern end of the final landform. This excess water would thus be conducted to the Stonequarry Creek catchment.

6.3 Impacts on Recharge (Intake) Areas

The Department of Urban Affairs and Planning guidelines require assessment of any potential adverse effects on "groundwater recharge areas". In the case of the basalt aquifer at Exeter, the definition of the term "recharge areas" is slightly different from that which is usually applied. This difference is due to the fact that the basalt aquifer is largely unconfined. By definition, the aquifer receives distributed recharge across the vast majority of its extent, and its balance only changes to discharge across thin strips at the aquifer's margin, or at springs punctuating significant changes in slope. There is no part of the land surface overlying the aquifer that is critically or uniquely important for the maintenance of aquifer flow.

The proposed extraction area will not directly impact on the rate of aquifer recharge, since the excavation process will not make the surface significantly less permeable. Some degree of enhanced runoff may occur as a result of bare rock surfaces, and runoff diversion may result in less soil moisture in parts of the development. The final landform, following the restoration of the site, is likely to have a recharge rate approximately equivalent to the present-day one.

However, maintaining the sump water table elevation at 663 metres (in the worst-case situation) would create a sink in the groundwater system and would have the effect of slightly diminishing the effective recharge area.

6.4 Impacts on Indigo Creek Flow

Potential impacts on Indigo Creek would be driven by the impacts on groundwater levels and spring flows discussed in Sections 6.1 and 6.2. As the upper reaches of Indigo Creek receive a high proportion of their base flow from the springs discussed in Section 6.2, the effect on dry-weather flow in this part of the creek would be correspondingly large, if the continuous pathways exist towards the proposed extraction area.

In the lower part of Indigo Creek the impact on dry-weather flow will be less as this part of the creek receives baseflow from areas outside the influence of the proposed extraction area.

6.5 Impacts on Stonequarry Creek Flow

Dry weather flows in the tributary of Stonequarry Creek which drains the proposed extraction area will be impacted by the reduction in flow of the springs feeding this creek, as discussed in Section 6.2. As previously discussed, this tributary will receive the outflow from the pond in the base of the final void; this will mitigate long term impacts.

Stonequarry Creek itself has a substantial catchment area which extends well to the north-east and east of the proposed extraction area. Baseflows originating from this catchment should not be significantly impacted by the proposed extraction; thus the impact on the creek system as a whole should be small.

6.6 Groundwater Quality Impacts

Groundwater chemistry sampled at three separate points on "Willowbank" is relatively uniform at depth and suggests a common mode of groundwater recharge. Chemistry of *in situ* groundwater and spring water shows little variance, although that of Spring 9 issuing at the south-west bank of Indigo Creek shows some contrasts.

The relative uniformity of groundwater chemistry indicates that the diversion of the groundwater flow is unlikely to result in a large-scale change in the chemical properties of the spring water issuing into Indigo Creek. The base of the proposed extraction area, being stripped of soil during the extractive phase, presents a vulnerability to the basalt aquifer for any spill of fuel or other contaminants. Measures to minimise this risk to groundwater quality should include spill response plans and avoidance of hazardous substance storage in the bunded area.

In a situation such as Exeter, spring water quality is not expected to be significantly affected by the flow path to Indigo Creek springs changing from one source area to another. Without information on the groundwater flow velocity it is difficult to predict what period of time it would take for the actual effect of the change in source area to exert itself. However, hydraulic mechanisms such as storativity and dispersion will lessen the impacts of water quality change arising out of source area switching.

6.7 Impacts on Exeter Bypass Springs

Potential impacts of the extraction area and the proposed Exeter bypass on spring flow and groundwater quality on the Vine Lodge property are expected to be minimal, given the following information:

1. Aquifer recharge will not be affected as the aquifer will continue to receive distributed recharge across the majority of its extent.

2. Spring A is thought to emit relatively immature aquifer groundwater primarily derived from the unsaturated soil and weathered basalt. From the topographic expression of the Vine Lodge property, groundwater was thought to be derived from the south to south-west of the spring, up-hydraulic gradient of the proposed Bypass. However, interception of groundwater flow by road drainage is unlikely to impact this spring.

3. Spring B and Spring C are thought to draw groundwater from the deeper formation waters which have a lower hydraulic conductivity due to their massive character. Groundwater will continue to be drawn from the south; flows are unlikely to be impacted by the road.

4. Groundwater chemistry is not expected to alter in view of the uniform nature of the groundwater major ion composition and the up-hydraulic position of the springs relative to the proposed extraction area.

6.8 Monitoring

It is recommended that a monitoring program be established to quantify any effects which the proposed extraction may have on groundwater levels, groundwater quality and spring flows.

Mitigation measures, discussed in subsequent sections, would be implemented if deemed necessary following evaluation of the results of monitoring.

Monitoring would involve water levels, spring flows and water quality.

Water table level is a relatively straightforward parameter to measure. Four piezometers designed for the water level measurement are already available, on land surrounding the spring-fed portion of Indigo Creek, for long-term monitoring of water table elevation. Spring flow is sensitive to fluctuation of the water table, and water level monitoring provides a valid indication of the impacts on groundwater discharge. Thus any change in the direction of groundwater flow will also be evident from the monitoring of water table elevation in all four monitoring bores.

Spring flow may be measured as individual flows into Indigo Creek or as the aggregate of spring discharges gauged at the shale contact. Conventional stream gauging techniques can be used. Timed filling of a suitable vessel may be used to measure individual spring flows, such as Spring 7.

Water quality monitoring is best undertaken by taking grab samples of spring water. Any alteration in water quality arising out of change in source area would be revealed as a long-term trend.

6.9 Mitigation of Impacts

As extraction from the quarry proceeds below the water table, it will be necessary to pump inflowing groundwater from the quarry - most probably from a sump located in the lowest part of the quarry floor - in order to maintain dry working conditions. Consequently the water table will be depressed, resulting in radial flow towards the sump.

As outlined in previous sections of this report, such flow may divert groundwater that would, ordinarily, have flowed to the springs that maintain base flows in local creeks.

Two options are available to mitigate any such diversion. These are:

1) Construction of boreholes to pump groundwater into the creeks and maintain baseflow. This option would, in effect, intercept and re-divert groundwater before it entered the quarry.

2) Pump water collected in the quarry into the creeks, following settlement.

The pumped borehole (or interception well) option is likely to prove the best long-term alternative.

Using augmentation by interception wells, creek flow could be managed throughout the development of the extraction area, and, if necessary, beyond that time so as to maintain an acceptable creek discharge. Given that the proposed quarry water management will be progressive and will increase with the increasing depth of excavation, the mitigation strategy of creek flow augmentation offers the opportunity to monitor the effects of water table depression and provide compensatory flow in proportion to the net impact.

6.10 Rehabilitation

The proposed rehabilitation of the extraction area involves re-distribution of overburden on the flanks of the batter slopes. The excavation will fill with seepage of groundwater and excess rainfall following the completion of active extraction and cessation of active water management. The filling will stabilise and cease once the water level reaches the level of the exit point of the void in the east of the extraction area. The final water level will be approximately 685 metres AHD.

The new drainage pattern will alter the prior groundwater flow pattern and seepage into the resulting pond will continue, with discharge to the Stonequarry Creek catchment.

No whole-rock geochemical data is available for the basalts (either for the quarry area or the regional deposit).

Petrographic examination of samples of basalt from the quarry did not indicate the presence of sulphide minerals; nor would such minerology be anticipated on petrogenic grounds. There are no visible signs of pyrite or other sulphide oxidation products on exposed rock surfaces in the existing quarry, and it is understood that the current quarrying operation has not experienced problems with acid rock drainage.

It is not, therefore, anticipated that any problems associated with acidification or acid-induced mineralisation will be experienced with the final void water.

This study has shown that groundwater in the basalts is of low salinity. As groundwater seepage, diluted by some rainfall runoff, will form the source of the final void water, it is not anticipated that salinity induced by evaporative concentration will be an issue in final void water quality.

If it is considered necessary to maintain flows in the uppermost 500 metres of Indigo Creek, it may be necessary to continue compensatory pumping after the completion of rehabilitation. Given the low discharges required, this could be achieved in the long term using wind or solar-powered pumps.

6.11 Recommendations for Further Work

Further work is required to establish whether or not potential continuous flow paths, which would allow groundwater currently feeding Spring 7 to drain to the proposed extraction area, exist.

The following scope of work is recommended.

1. A nest of three bores, separately completed within the broken basalt, massive basalt and basalt/shale interface, should be drilled in the proposed extraction area to enable the hydraulic characteristics of each groundwater occurrence to be measured. It would be desirable for this nest of bores to be located at the lowest point on the basalt/shale contact within the proposed extraction area. At this stage, it is understood that the deepest point may be near the centre of the proposed extraction area (Borehole F11). However, data are not available on the location of the base of the basalt in the vicinity of Borehole F4. It is therefore proposed that the initial percussion hole be drilled to the base of the basalt near Borehole F4 and, should it be determined to be the deepest location, the nest of bores would be established at that location. In the event that the percussion borehole near F4 indicates that the shale/basalt interface is deeper than in Borehole F11, then the nest of bores would be positioned near the centre of the proposed extraction area.

2. Three additional monitoring bores would be drilled in the proposed extraction area in locations to be assessed on the basis of a further site visit. It is intended that these bores provide information on the location of the shale/basalt interface and provide for monitoring groundwater levels (and hence directions of groundwater flows).

3. A program of hydraulic testing involving double straddle packer tests would be undertaken during drilling.

If the presence of high permeability pathways is established, then further detailed assessment would be required. This work would include a pumping test and further modelling.

It would be possible to carry out groundwater flow modelling of the proposed extraction area using a numerical modelling code which is able to adequately simulate laterally anisotropic hydraulic conductivity and the existence of vertical stratification (and consequent hydraulic conductivity variation) in the basalt.

Such modelling does, however, require adequate field data to support the assignment of anisotropic hydraulic conductivity.

In our view the required hydraulic conductivity data could only be provided by a long-term pumping test carried out using a pumped borehole or boreholes drilled in the area where the proposed extraction area will reach its maximum depth.

The pumping test would be accompanied by tracer injection into the boreholes recently drilled in the northern part of the Indigo Creek catchment.

Such a pumping test would need to extend over a period of several months. It would require careful planning and execution, with automatic logging of water levels, discharge rates and salinity.

A pumping test of this nature would obviously be a relatively high-cost exercise, and would only be justified if the results of the proposed drilling program indicate the presence of a high-permeability zone in the basalt or at the basalt-shale contact.

Conversely, it is strongly recommended that monitoring of groundwater levels in selected boreholes, using automatic recorders, begin as soon as possible. Such monitoring, extending over as long a period as possible, would provide essential data for model calibration.

REFERENCES

C. M. Jewell & Associates (1997): *Exeter Quarry Extension – Groundwater Related Issues.* Report AJ9736.4. Prepared for R W Corkery and Concrite Quarries Pty Ltd by C. M. Jewell & Associates Pty Ltd, Bullaburra.

Department of Urban Affairs and Planning (NSW) (1996)*: Extractive Industries, Quarries; EIS Guideline.* NSW Government Department of Urban Affairs and Planning, Sydney, pp 42.

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Water and Environmental Management
ACN 056 283 295

IMPORTANT INFORMATION
about your
ENVIRONMENTAL SITE ASSESSMENT

These notes have been prepared by C.M. Jewell & Associates using guidelines prepared by the National Ground Water Association (NGWA) and other sources. They are offered to help you in the interpretation of your Environmental Site Assessment (ESA) reports.

REASONS FOR CONDUCTING AN ESA

ESAs are typically, though not exclusively, carried out in the following circumstances:

- as pre-acquisition assessments, on behalf of either purchaser or vendor, when a property is to be sold;
- as pre-development assessments, when a property or area of land is to be redeveloped or have its use changed - for example, from a factory to a residential subdivision - as a requirement for development approval;
- as pre-development assessments of greenfield sites, to establish "baseline" conditions and assess environmental, geological, hydrological constraints to the development of, for example, a landfill; and
- as audits of the environmental effects of an ongoing operation.

Each of these circumstances requires a specific approach to the assessment of soil and groundwater contamination. In all cases, however, the objective is to identify and if possible quantify the risks which unrecognised contamination poses to the proposed activity. Such risks may be financial (for example, clean-up costs or limitations on site use), or physical (for example, health risks to site users or the public).

THE LIMITATIONS OF AN ESA

Although the information provided by an ESA can reduce exposure to such risks, no ESA, however diligently carried out, can eliminate them. Even a rigorous professional assessment may fail to detect all contamination on a site. Contaminants may be present in areas that were not surveyed or sampled, or may migrate to areas which showed no signs of contamination when sampled.

The extent of sampling and subsequent analysis of soils is necessarily limited, and is generally targeted towards areas where contamination is considered to be most likely, based on the knowledge of the site history and visual observation. This approach maximises the probability of identifying contaminants; however, it may not identify contamination which occurs in unexpected locations or from unexpected sources.

Further, soil, rock and aquifer conditions are often variable, resulting in non-homogenous contaminant distributions across a site. Contaminant concentrations are identified at chosen sample locations; however, conditions between sample locations can only be inferred on the basis of the estimated geological and hydrogeological conditions and the nature and extent of identified contamination. Boundaries between zones of variable contamination are often indistinct, and must be interpreted based on available information and the application of professional judgement. The accuracy with which subsurface conditions can be characterised depends on the frequency and methods of sampling and the uniformity of subsurface conditions and is therefore limited by the scope of works undertaken.

ESA "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site assessment identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists who then render an opinion about overall subsurface conditions, the nature and extent of contamination, its likely impact on the proposed development and appropriate remediation measures. Statistical tools may be used to assist in such assessment, but the validity of conclusions depends entirely on the degree to which the original data reflects site conditions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, and no subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions.

Nothing can be done to prevent the unanticipated, but steps can be taken to help minimise its impact. For this reason, owners should retain the services of their consultants through the development stage, to identify variances, to conduct additional tests which may be

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needed, and to recommend solutions to problems encountered on site.

SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions are changed by natural processes and the activity of man. Because an ESA report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on an ESA report whose adequacy may have been affected by time. Speak with the consultant to learn if additional tests are advisable.

ESA SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS

Every study and ESA report is prepared in response to a specific Brief to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. A report should not be used by other persons for any purpose, or by the client for a different purpose. No individual other than the client should apply a report even apparently for its intended purpose without first conferring with the consultant. No person should apply a report for any purpose other than that originally contemplated without first conferring with the consultant.

AN ESA REPORT IS BASED ON A UNIQUE SET OF PROJECT SPECIFIC FACTORS

Your environmental report should not be used:

- when the nature of the proposed development is changed - for example, if a residential development is proposed instead of a commercial one;
- when the size or configuration of the proposed development is altered;
- when the location or orientation of the proposed structure is modified;
- when there is a change of ownership; or
- for application to an adjacent site.

To help avoid costly problems, refer to your consultant to determine how any factors which have changed subsequent to the date of the report may affect its recommendations.

AN ESA REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when design professionals develop their plans based on misinterpretations of an ESA. To help avoid these problems, the environmental consultant should be retained to work with appropriate design professionals to explain relevant findings and to review the adequacy of their plans and specifications relative to contamination issues.

LOGS SHOULD NOT BE SEPARATED FROM THE GEOLOGICAL REPORT

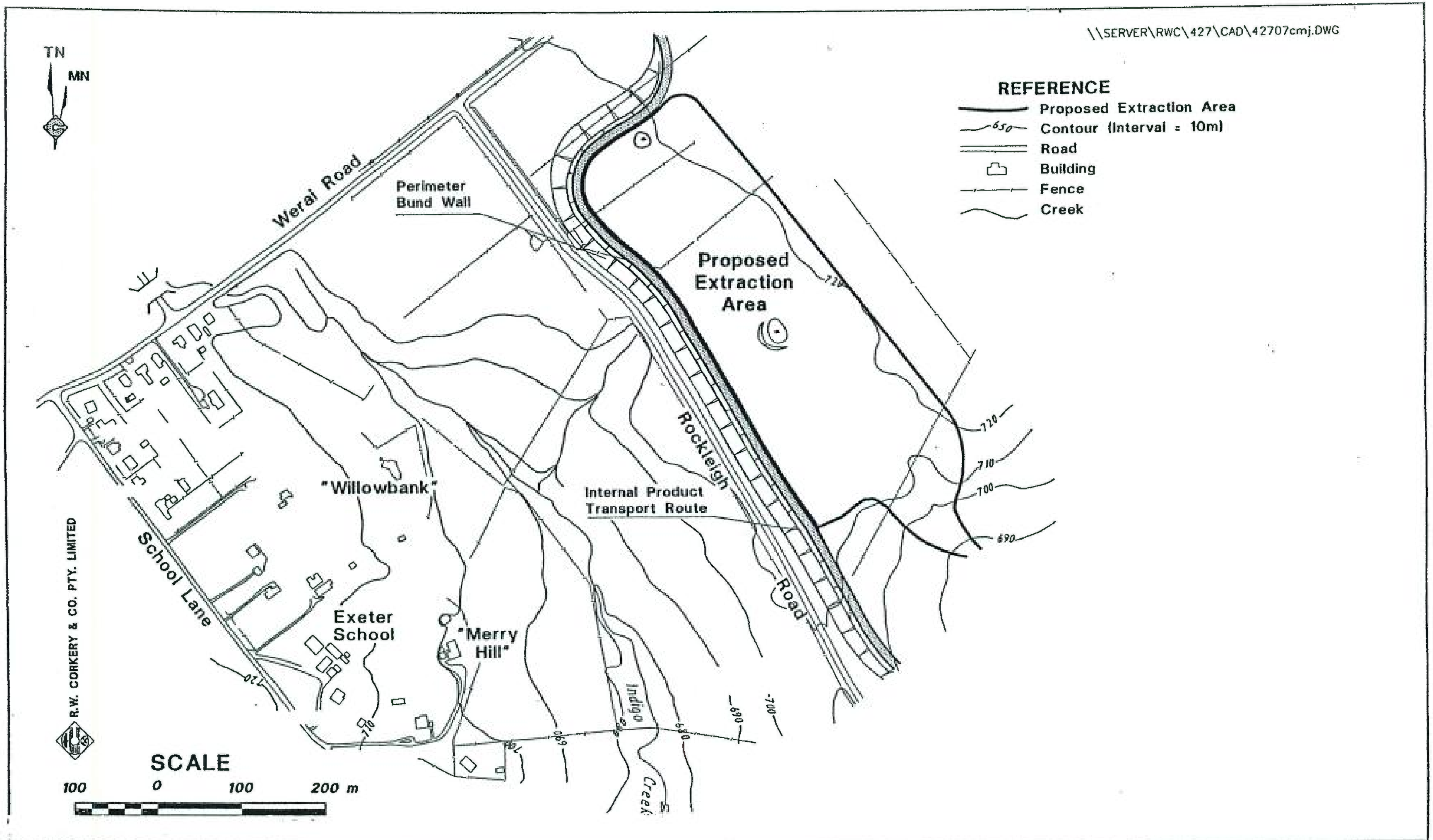
Final borehole or test pit logs are developed by environmental scientists, engineers or geologists based upon their interpretation of field logs (assembled by site personnel) and laboratory evaluation of field samples. Only final logs are customarily included in our reports. These logs should not under any circumstances be redrawn for inclusion in site remediation or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimise the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To reduce the likelihood of borehole log misinterpretation, the complete report must be available to persons or organisations involved in the project, such as contractors, for their use. Those who do not provide such access may proceed under the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing all the available information to persons and organisations such as contractors helps prevent costly construction problems and the adversarial attitudes which may aggravate them to disproportionate scale.

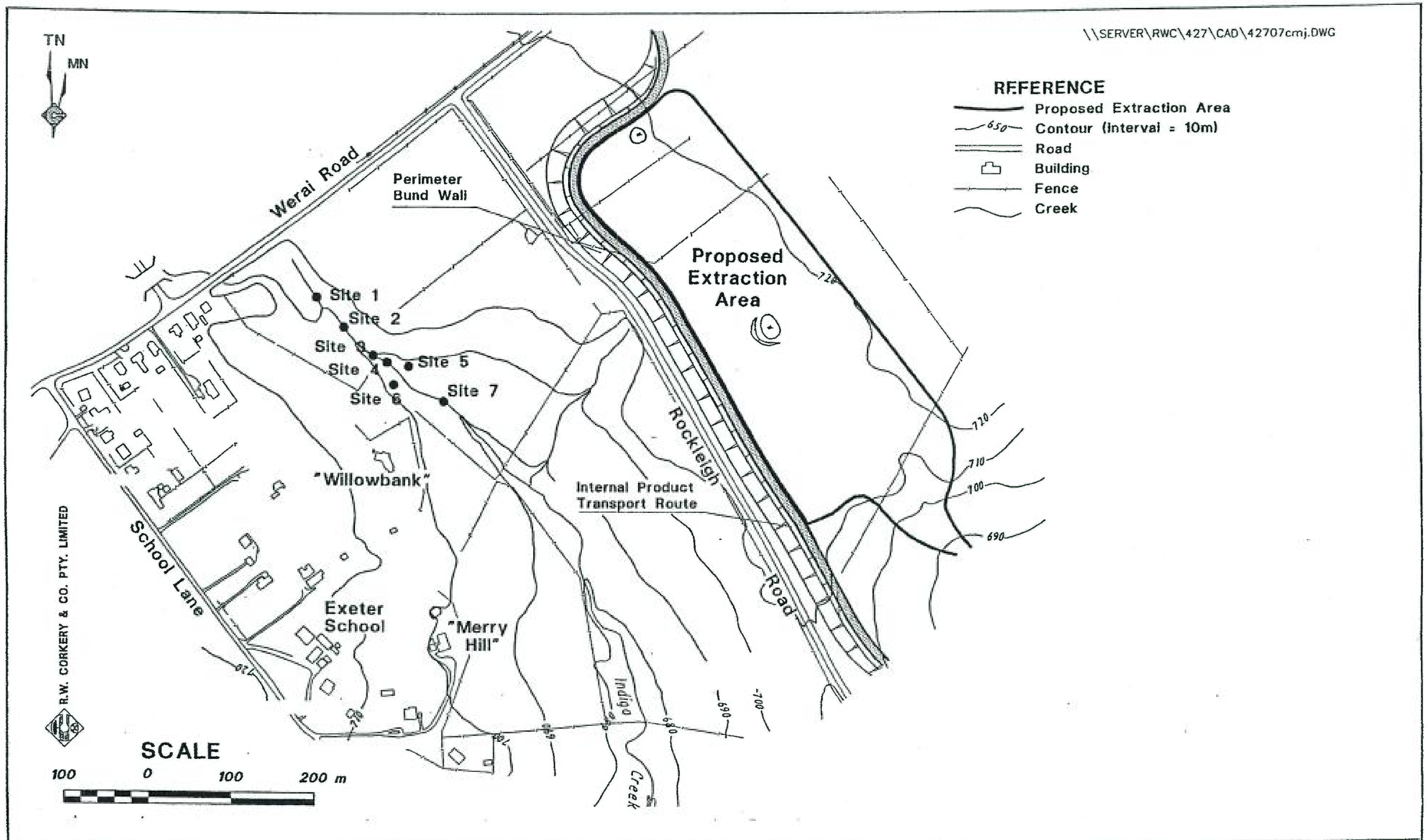
READ RESPONSIBILITY CLAUSES CLOSELY

Because an ESA is based extensively on judgement and opinion, it is necessarily less exact than design documents produced by other disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, model clauses have been developed for use in written transmittals. These are not exculpatory clauses designed to foist liabilities onto some other party. Rather, they are definitive clauses which identify where your consultant's responsibilities begin and end. Their use helps all parties involved recognise their individual responsibilities and take appropriate action.

Some of these definitive clauses are likely to appear in your ESA report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.



	AJ9859: Exeter Hydrogeological Study		
	Topographic Orientation	Document: AJ9859.12 Rev: 1 Date: 27/11/98 Author: JHR	***Figure 1***

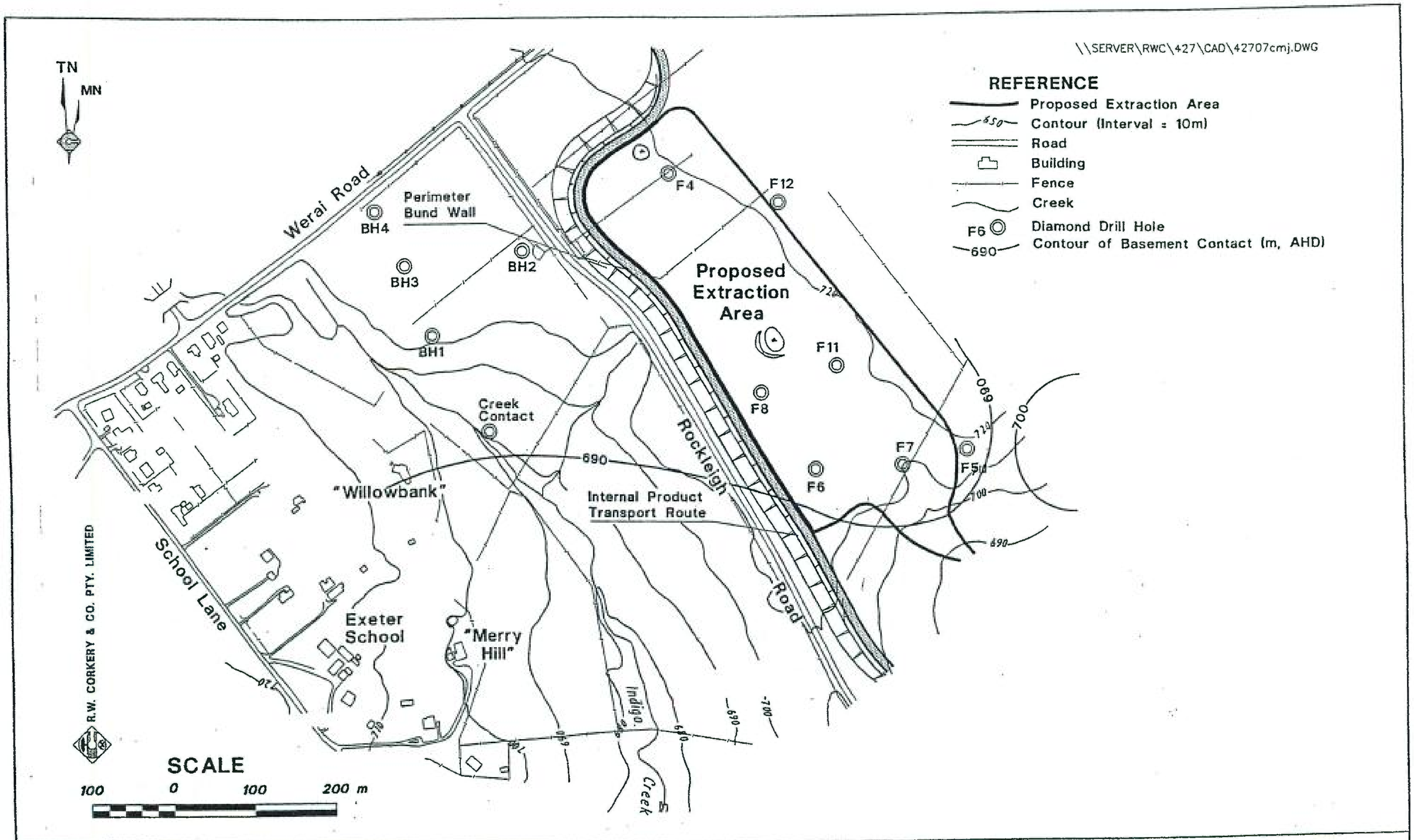


AJ9859: Exeter Hydrogeological Study

Preliminary Sites

Document: AJ9859.12
Rev: 1
Date: 27/11/98
Author: JHR

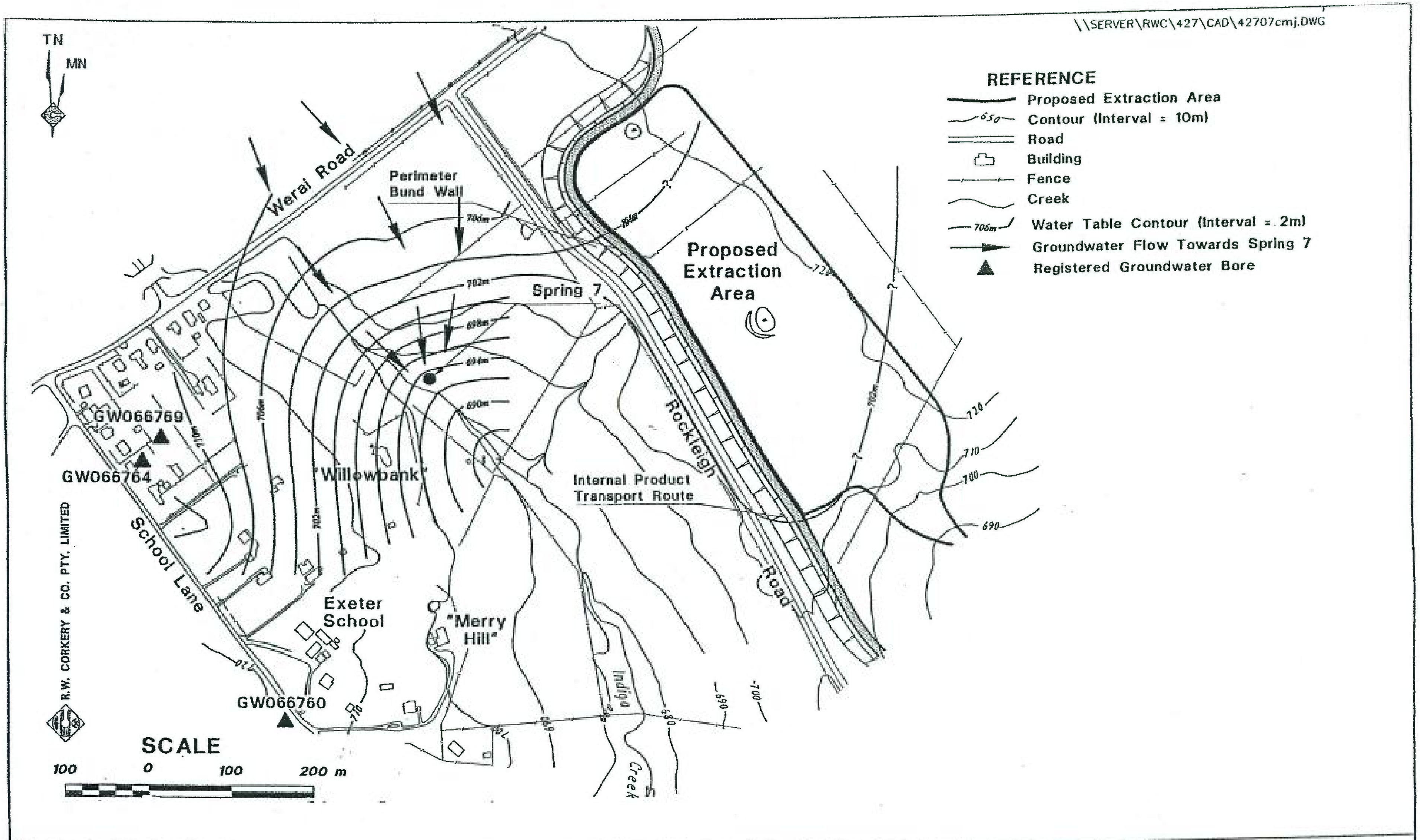
Figure 2



AJ9859: Exeter Hydrogeological Study

Elevation of the Basement Shale Contact

Document: AJ9859.12 Rev: 1 Date: 27/11/98 Author: JHR	**Figure 3**

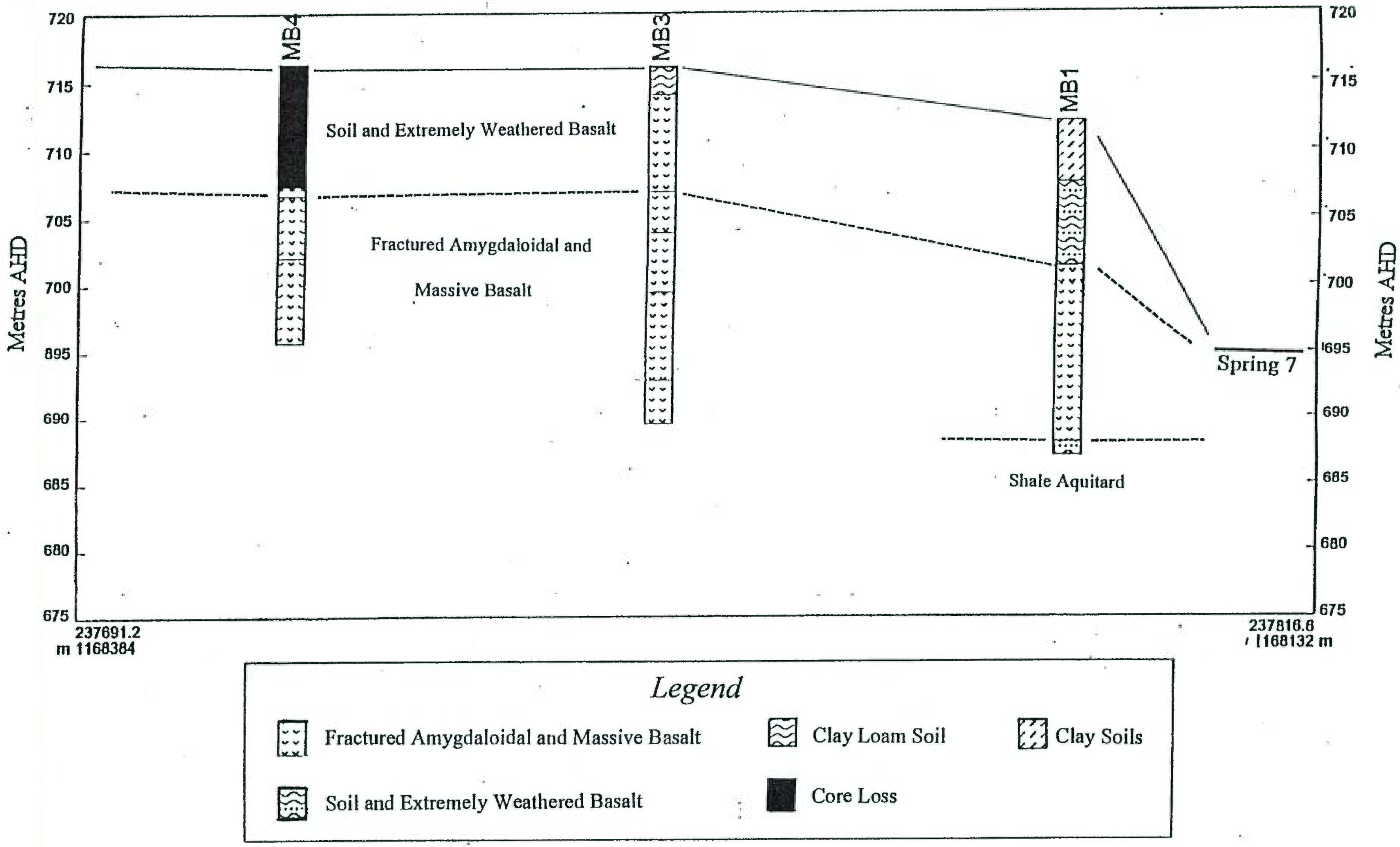


AJ9859: Exeter Hydrogeological Study

Water Table Distribution

Document: AJ9859.12
Rev: 1
Date: 27/11/98
Author: JHR

Figure 4

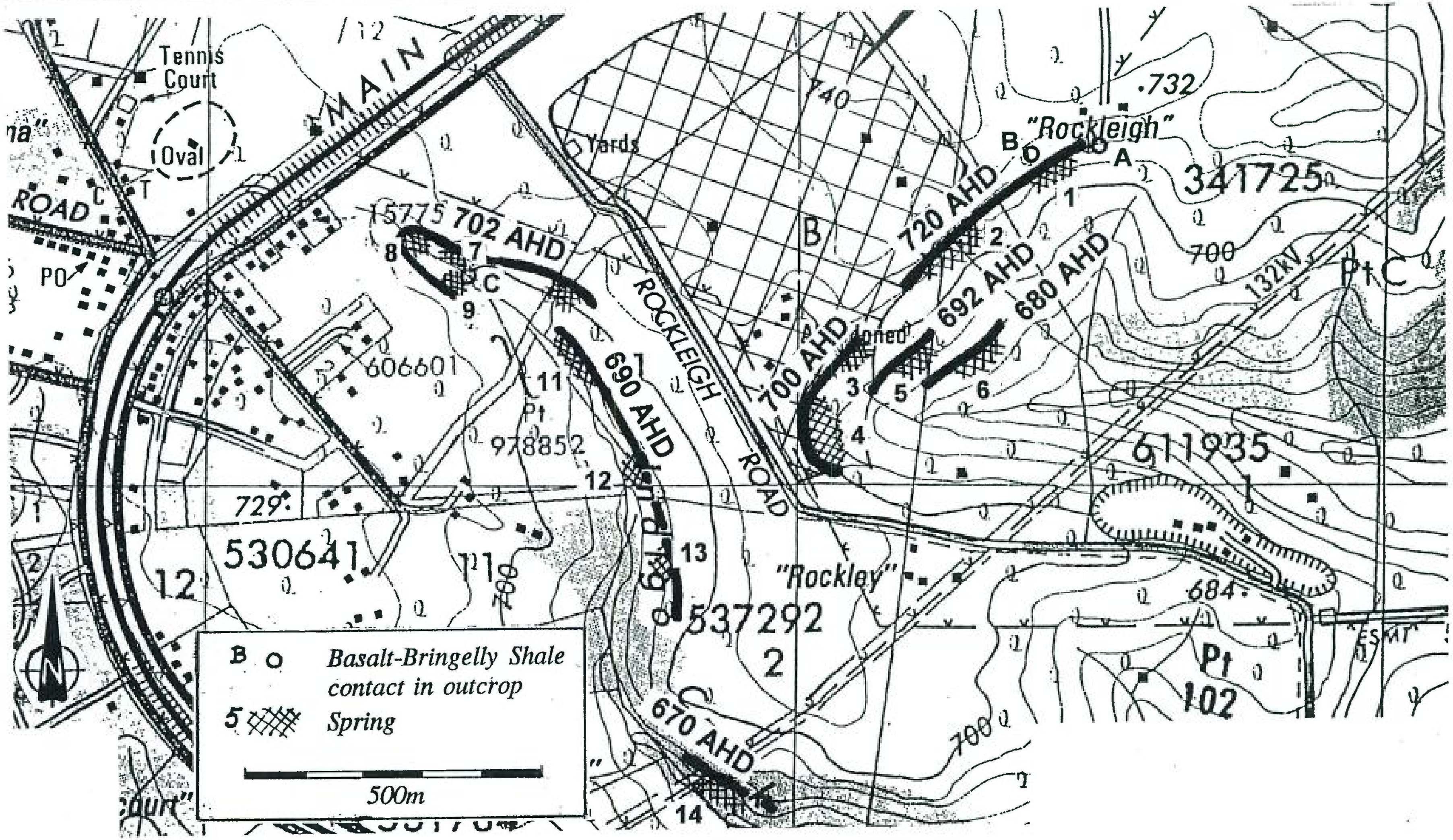


AJ9859.12 Exeter Hydrogeological Study

Cross-section Through MB/BH4-1 and Spring 7

Document: AJ9859.12
Rev: 1
Date: 30/4/99
Author: CMJ

Figure 5

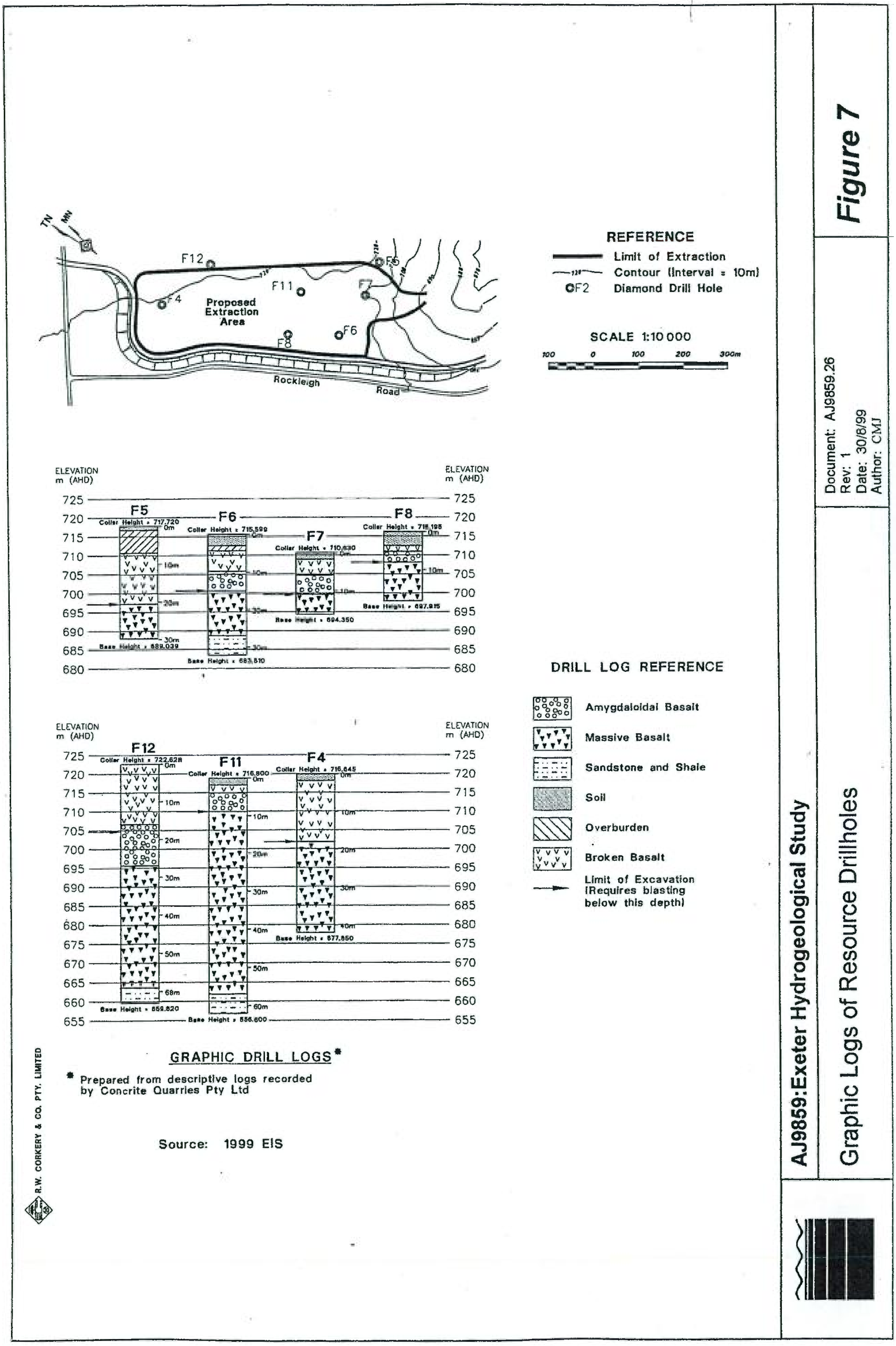


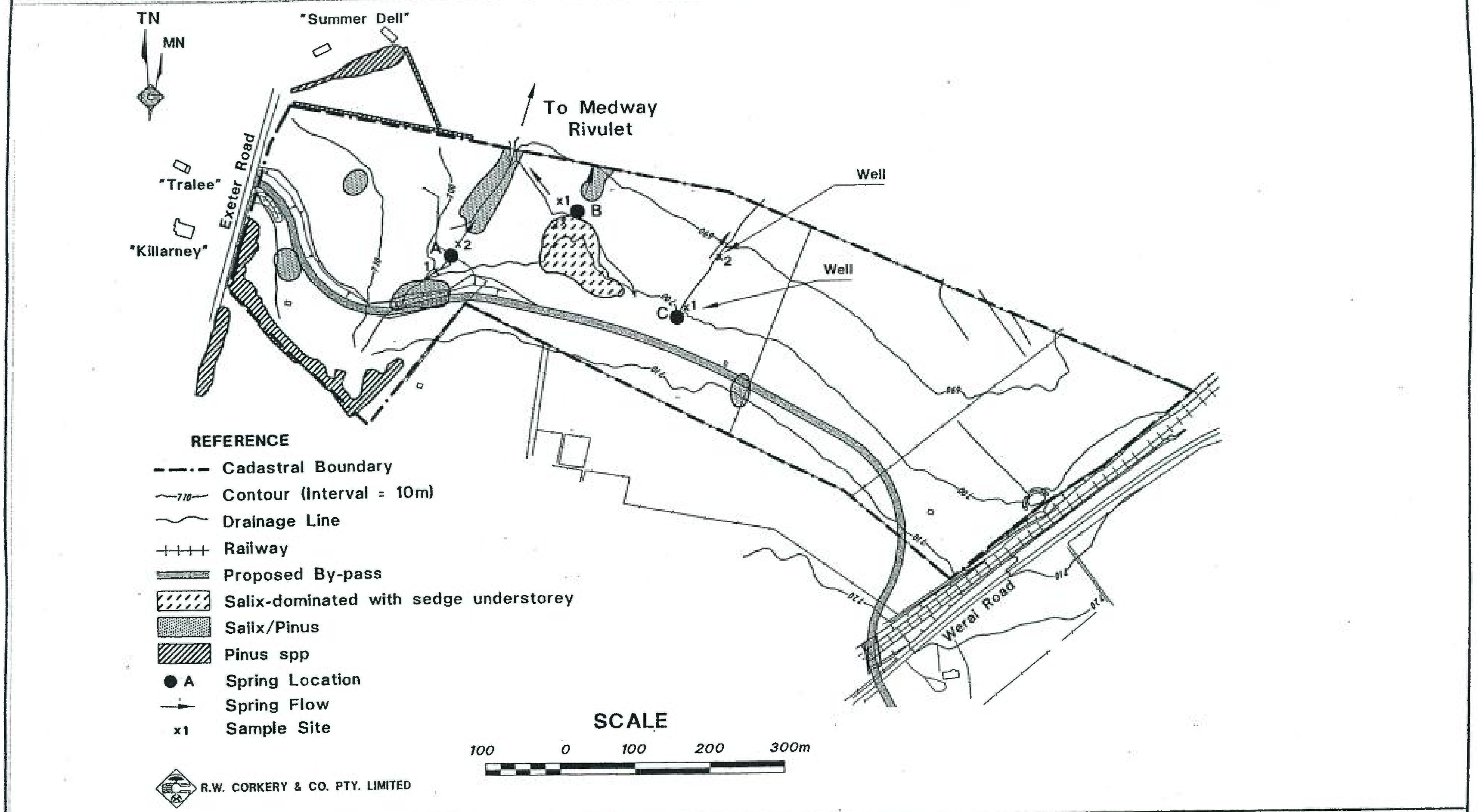
AJ9859:Exeter Hydrogeological Study

Location of Springs Surveyed in 1997

Document: AJ9859.26
Rev: 1
Date: 30/8/99
Author: CMJ

Figure 6


TN
MN
F12
F11
F4
F7
F5
F6
F8
Proposed Extraction Area
Rockleigh
Road
REFERENCE
Limit of Extraction
Contour (Interval = 10m)
F2 Diamond Drill Hole
SCALE 1:10 000
100
0
100
200
300m
ELEVATION m (AHD)
F5
F6
F7
F8
F12
F11
F4
DRILL LOG REFERENCE
Amygdaloidal Basalt
Massive Basalt
Sandstone and Shale
Soil
Overburden
Broken Basalt
Limit of Excavation (Requires blasting below this depth)
GRAPHIC DRILL LOGS*
* Prepared from descriptive logs recorded by Concrite Quarries Pty Ltd
Source: 1999 EIS
R.W. CORKERY & CO. PTY. LIMITED
Figure 7
Document: AJ9859.26
Rev: 1
Date: 30/8/99
Author: CMJ
AJ9859:Exeter Hydrogeological Study
Graphic Logs of Resource Drillholes

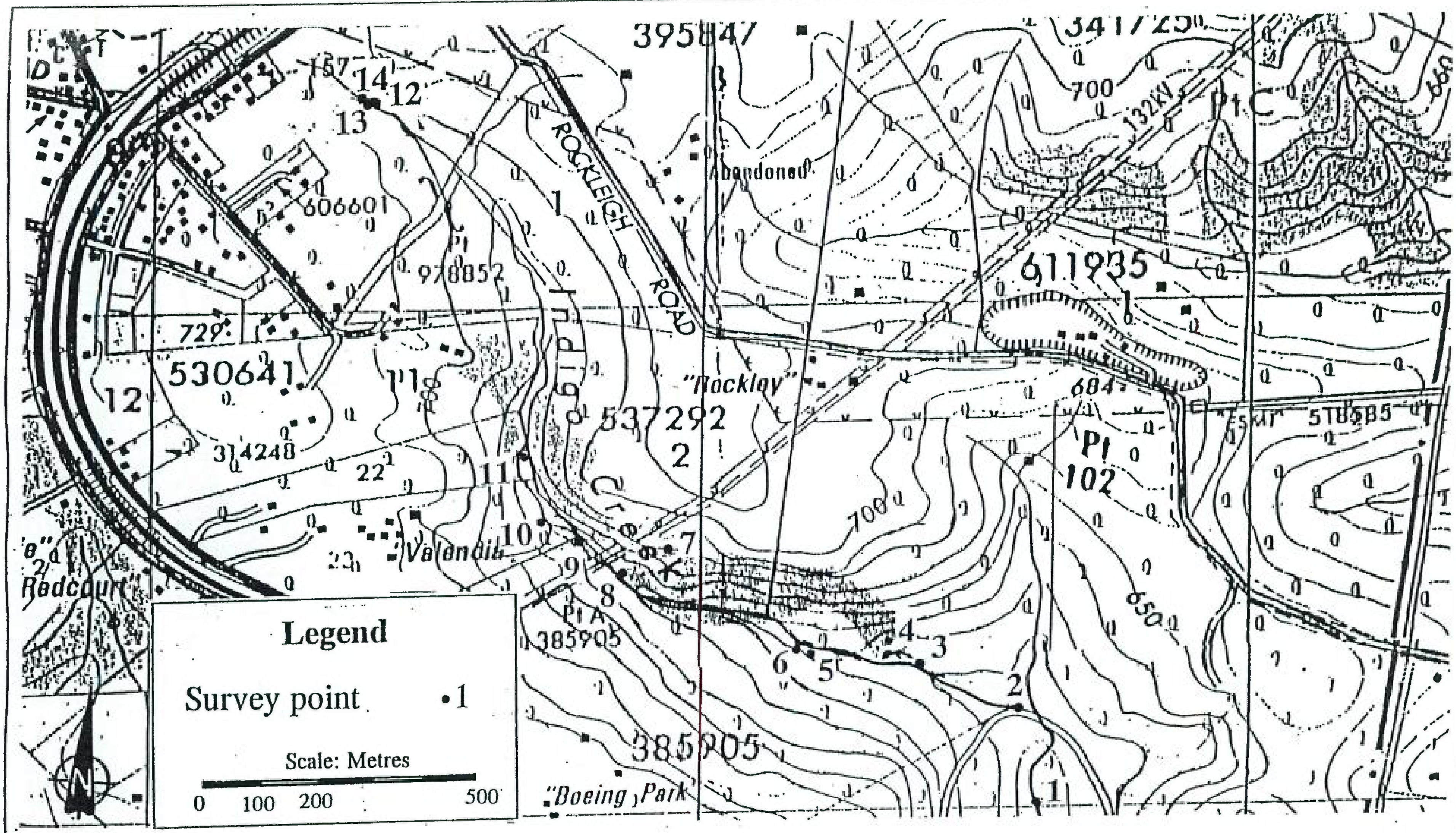


AJ9859.12 Exeter Hydrogeological Study

Location of Exeter Bypass Springs

Document: AJ9859.26
Rev: 1
Date: 30/8/99
Author: CMJ

Figure 8

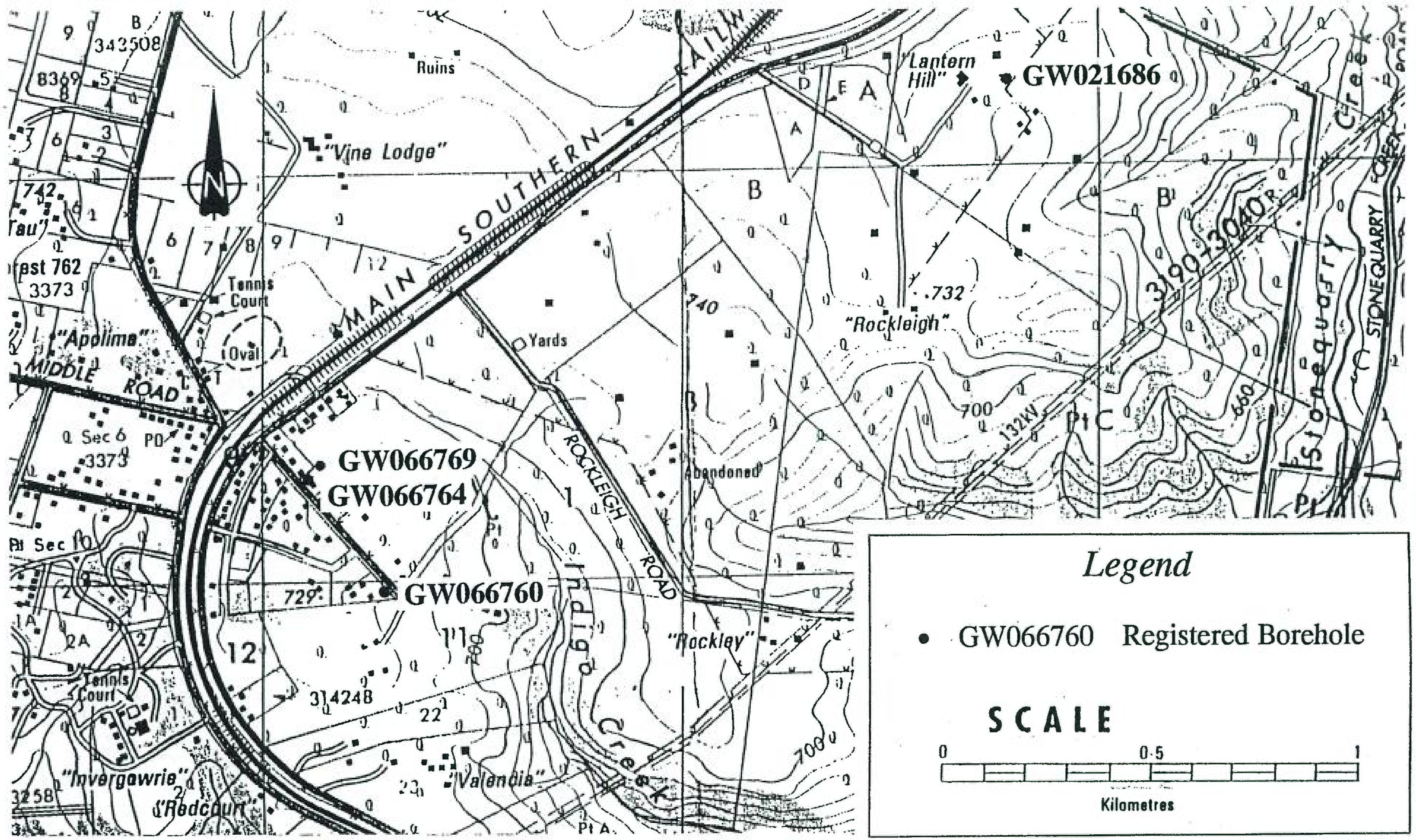


AJ9859.12 Exeter Hydrogeological Study

Locations of Indigo Creek Springs Survey Points

Document: AJ9859.26
Rev: 1
Date: 30/8/99
Author: CMJ

Figure 9



AJ9859.12 Exeter Hydrogeological Study

Location of Registered Water Bores

Document: AJ9859.26
Rev: 1
Date: 30/8/99
Author: CMJ

Figure 10

APPENDIX A

Lithological Data

Location: Rockleigh Road Exeter		BOREHOLE LOG	Hole N°: MB1/BH1
Surface Elevation: 712.548	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type/Method: Edson 3000	Date: 22-26/10/98	Project: AJ9859 Concrete Quarries - Exeter	

ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc	GRAPHIC LOG	R.L Depth metres	CORE RUN / TYPE	% CORE LOST	FRACTURES	Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture	REMARKS
(HW) 20.35	← Zeolite amygdules iron rich, dark-brown in colour, up to 4mm in length and are slightly elongate to sphericed in shape. Very low strength.			HQ3	10		← Fracturing attitudes: i) Sub-horizontal (80%), planar, well developed with high clay content & degree of iron staining. Spacings of 30 - 40 mm. ii) Sub-vertical (20%), discordant, immature with high zeolite & minor clay content. Minor iron staining.	
(MW) 20.60	← Basalt is highly fractured, medium strength of unfractured core with minor zeolite amygdules <3mm in diameter & decreasing with increased depth.		21	HQ3	80		← Core free of zeolite veins. ← Zeolite vein sub-vertical, 4mm width,	
(MW) 21.41	← Highly fractured predominantly sub-horizontal.							
			22	HQ3	50			
BASALT (SW)	Dark Grey, fine to medium grained basalt, Medium strength. Minor (<1%) zeolite amygdules <2mm in length present and are iron rich promoting iron-staining of weathered zones. Core highly friable along fracture zones - Heavily Fractured			HQ3	5		← Fracturing dominantly sub-horizontal or 15° from core axis. Both fracture attitudes are planar, well developed with heavy clay accumulation & iron staining. Sub-horizontal fractures spaced up to 20mm apart. Sub-vertical fractures spaced up to 80mm apart.	
AMYGDALOIDAL BASALT (MW)	Dark Grey, fine to medium grained basalt, Medium to low strength & highly fractured. Minor (<0.5%) Olivine. Amygdules occupied by zeolite, up to 4mm in diameter with minor calcite cavities. Weathering of amygdules increasing with depth.		23	HQ3	10		← Zeolite Vein, 8mm wide, planar basalt contacts, sub-horizontal with heavy iron staining. ← Zeolite vein 2mm wide, planar basalt contacts, sub-horizontal.	
				HQ3	25		← Zeolite vein 4mm wide, planar basalt contacts, iron stained contacts. Sub-horizontal	
(HW) 23.50	← Basalt Low strength.							
(EW) 23.90	← Zeolite amygdules removed by water throughflow.			HQ3	0		← No structural information to the end of core.	← Shale substrata.
IRONSTONE (SW)	Medium grained, dark maroon, sandstone, high strength, thinly laminated. Minor coarse grains (<<1%) evident. Unfractured		24	END OF CORING			END OF CORING @ 24.10 m. Monitoring bore MB1/BH1 Installed.	
SILTSTONE (SW)	Highly sorted, light grey massive siltstone with minor lamination present. Medium strength. Unfractured.							
CLAYSTONE (SW-F)	Ochre to yellow, silty claystone with traces of sand. Colour is highly mottled. Medium strength to low strength Unfractured		25					

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Page 2 of 2

Location: Rockleigh Road Exeter		**BOREHOLE LOG**	**Hole N°:** MB4
Surface Elevation: 716.836	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type: Edson 3000/HQ3	Date: 4-5 Nov 98	Project: AJ9859 Concrite Quarries - Exeter	

	ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc	GRAPHIC LOG	R.L. Depth metres	CORE RUN / TYPE	% CORE LOST	FRACTURES	Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture	REMARKS Core diameter – 65mm Hole diameter – 96mm
				0 – 8				Commenced Coring @ 8.00m.	Tricone drilled through clay soils with basalt debris in various forms of weathering. ← Initial water table.
	X	Core Loss. Expected that bedrock was highly weathered broken basalt which has a low strength		8	HQ3	0	NA NA NA	Core Loss	Coring commenced with polymer mud due to expected bedrock is highly weathered.
8.90	Broken Basalt (XW)	Grey, high strength where not weathered.		9	HQ3			Highly friable, little clay or Fe staining on fracture faces.	
9.03	Fractured Basalt (MW)	Basalt relatively fresh with large weathering [illegible].						Highly fractured, little clay or Fe, 45° to sub-vertical	
9.15	X	Core Loss Expected Highly fractured BASALT.			HQ3	0		Core Loss	
9.50	Fractured Basalt	Relatively fresh Basalt with highly weathered fracture zones						Fractures dominantly 45° to sub-vertical.	
9.56	Amygdaloidal Basalt (XW)	Amygdales 1-2mm, occupied by [illegible] - hydrous yellow-beige massive [illegible].			HQ3			Degree of Basalt alteration to clay extreme with <15% fresh basalt. Fracturing unidentifiable.	
9.85		Core Loss		10		0			

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Location: Rockleigh Road Exeter		**BOREHOLE LOG**	**Hole N°:** MB4
Surface Elevation: 716.836	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type: Edson 3000/HQ3	Date: 4-5 Nov 98	Project: AJ9859 Concrite Quarries - Exeter	

Depth (m)	ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc
	Amygdaloidal Basalt (E/W)	Dark Grey-Dark Brown, high clay content ≈ 45%, hydrous zeolite amygdules 4-5mm, Extremely low strength.
	Core Loss	
	Basalt (E/W)	Dark-brown, highly weathered to residual clay, minor amygdules up to 5mm (< 2%). Zeolite veins up to 15mm wide with varying degrees of iron enrichment. Amygdules spherical to angular with minor calcite & crystalline zeolite (Heulandite). Extremely low strength.
11.05	Amygdaloidal Basalt (HW-E/W)	Dark Grey to brown with large weathering aureoles on basalt fragments, amygdules 1-2mm with zeolite occupation, and are iron enriched. Very low strength. Zeolite veining intersects basalt.
11.70	Zeolite	Cream colour, massive reversable hydrous zeolite. Soapy texture with no identifiable grains or crystals. Extremely low strength.
11.90	Core Loss	Core Loss (11.90 – 13.00)
13.00	Basalt (EW)	Highly fractured & weathered with up to 30% clay matrix. Basalt has extreme weathering aureoles. Weathering decreasing with depth progressing into....
13.90	Basalt (HW)	Amygdaloids up to 1% of core, occupied by reversible-hydrous zeolite. Fracture faces moderately iron stained.
14.18	Basalt - Massive (MW).	Fine grained, E. Low strength, heavily fractured.
14.55	Basalt - Massive (SW)	Fine to medium grained, dark grey, slightly fractured Basalt, very high strength, well developed plagioclase crystals. Minor zeolite amygdules increasing with depth. Fracture zone faces are lined with an unidentified hydrothermal carbonate bearing mineral which has formed 1 to 1mm wide veins. Dominant fractures contain minor clays, well developed weathering aureoles on basalt and very minor iron staining.
16.45		Fracturing increasing to fractured core.
17.10	Amygdaloidal Basalt (EW)	Amygdaloids 5mm in length, occupied by hydrous zeolite.
17.19		Clay content up to 70% of matrix, zeolite amygdules recognisable. Clay is dark-brown, massive, high plasticity with minor residual highly weathered basalt fragments evident.
17.60	(HW)	Vughs up to 30mm in length, cavity minerals include zeolite, quartz, calcite and other unidentified silicate & carbonate species.
17.87		
18.35	(MW)	Amygdules 5-10mm in length, closely spaced with an average spacing of 10mm. Core is Fractured. Vughs upto 40mm in diametre (or length in angular cavities) occupied by numerous zeolite, carbonateous, silicate & accessory mineral species. Amygdaloids highly weathered with vughs acting as a water transporting zone.
19.55	Altered Basalt (EW)	Dark-brown, highly plastic clay with zeolite inclusions
19.68	Amygdaloidal Basalt (HW)	Dark Grey, amygdules 5mm in length, occupied by brown to beige reversable hydrous zeolite, core slightly fractured.

R.L Depth (metres): 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

Core Run / Type		% Core Lost	Fractures
HQ3	0	0	NA
HQ3	0	30	NA
HQ3	0	80	NA (Core Loss)
HQ3	0	0	
HQ3		0	
HQ3		0	
		0	
HQ3		0	
HQ3		0	
HQ3		5	
HQ3		10	
HQ3		0	
HQ3		0	
HQ3		0	
HQ3			

Fracturing, Veining & Discontinuities of Core — Spacing, Attitude, Smoothness, Filling, Coating, Aperture

- No "rock" resemblence, highly characteristic of a clay soil. Fractures & other structural information not recognisable.
- Large degree of clay production via basalt destruction. No structural information recognisable.
- Structural information still void.
- 11.58 Hydrous zeolite vein, 3-4mm wide, sub-horizontal orientation.
- Core Loss.
- 13.17 Zeolite Vein + thin alteration zone, Cream + hydrous zeolite, highly weathered.
- Fracture direction unidentifiable but extensive. Basalt pieces in the order of 30mm.
- 14.18m. Massive Zeolite 46mm thick. Zeolite is cream, reversable hydrous & extremely friable when dehydrated.
- Fracturing both sub-vertical & sub horizontal with little iron staining. Four fractures identified.
- 14.55 Fracturing both sub-vertical & sub horizontal. Fracture surfaces moderately weathered with heavy iron staining. Identified up to 14 fracture surfaces through fine-grained & relatively fresh basalt.
- Fractures dominantly 45° to core axis.
- Fractures dominantly 45° to core axis.
- Fractures dominantly 45° to core axis
- Fractures dominantly 45° to core axis
- 17.15 Extremely weathered Massive Zeolite, reversably hydrous cream colour. Vein 41mm wide & sub-horizontal.
- 17.93 Carbonate species & crystalline zeolite veining, oriented 45° to 60° to core axis, moderate iron staining.
- Fracturing sub-horizontal to 45° from core axis. Fracture faces are clean with minor iron staining. Fracturing also evident along hydrothermal vein fissures. Veins oriented from 45° to 60° from core axis; are 1mm in width and roughly planar.
- 19.57 Massive Zeolite vein, 30mm wide, sub-horizontal orientation. Zeolite has a soapy feel, and dehydrates quickly on exposure to air.
- Fracturing sub-horizontal to 45° from core axis.

REMARKS

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Location: Rockleigh Road Exeter		BOREHOLE LOG	Hole N°: MB4
Surface Elevation: 716.836	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type: Edson 3000/HQ3	Date: 4-5 Nov 98	Project: AJ9859 Concrite Quarries - Exeter	

Depth	ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc	GRAPHIC LOG	R.L Depth metres	CORE RUN / TYPE	% CORE LOST	FRACTURES	Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture	REMARKS
	Amygdaloidal Basalt Continued.	Fracture faces clear of iron staining but slight clay accumulation.			HQ3			Fracturing decreasing with depth.	
20.51	Zeolite	Massive brown-beige reversible hydrous zeolite.						Finished Coring @ 20.55m. MB / BH4 Installed.	
				21					

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Location: Rockleigh Road Exeter		BOREHOLE LOG	Hole N°: MB/BH2
Surface Elevation: 718.242	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type: Edson 3000/HQ3	Date: 27-29 Oct 98	Project: AJ9859 Concrite Quarries - Exeter	

ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc	GRAPHIC LOG	R.L Depth metres	CORE RUN / TYPE	% CORE LOST	FRACTURES	Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture	REMARKS
	Clay Loam Soil. Lightbrown colour, high plasticity. low water content with a uniform texture & fabric.							Core diameter – 65mm Hole diameter – 98mm
			1					
			2					
			3					
			4					
			5					
			6					
			7					
			8					
	8.51 ← Angular fragments of extremely weathered basalt throughout solum. Fragments also of pyroxene with minor (<2%) plagioclase grains identifiable in various degrees of weathering Fragment concentration increasing with depth.							
			9				Commenced Coring @ 9.90m.	
9.90 Broken Basalt (EW)	Dark-grey with clear weathering aureoles on clasts. Basalt is fine to medium grained with a low to		10				Highly fractured with an unidentified attitude. Fracture zones are roughly planar with heavy clay accumulation & iron staining.	

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Location: Rockleigh Road Exeter	**BOREHOLE LOG**	**Hole N°:** MB/BH2
Surface Elevation: 718.242 — Datum:		
Inclination: Vertical — Azimuth:		
Drill Type: Edson 3000/HQ3 — Date: 27-29 Oct 98	Project: AJ9859 Concrite Quarries - Exeter	

Depth	ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc	CORE RUN / TYPE	% CORE LOST	Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture	REMARKS
10.13	BROKEN BASALT Cont.	extremely low strength. Fragments are saturated along major fissures.				
	BASALT (EW)	Basalt undergone a high degree of alteration. Extreme weathering haloes, high clay content and saturated. Core has an extremely low strength. Clay has E.High plasticity.	HQ3	5		
10.61	BROKEN BASALT (SW→F)	Slightly weathered to fresh, fine to medium grained, dark grey BASALT, Very to Extremely high strength				
	10.82 (HW-EW)	Basalt highly friable, extremely low strength. High portion of darkbrown plastic clay.			Multiple fractures with iron staining. Attitude unidentifiable due to friable nature of core.	
	11.30 (HW)	Highly fractured core along hydrothermal veins. Zeolite is highly weathered, extremely low strength.	HQ3	0	Zeolite + Carbonate veining: sub-horizontal attitude, width 1-2mm. Slight iron coating on fissure surfaces.	
	(EW)	Gradual boundary to........				
11.90	ALTERED BASALT (EW)	Highly altered basalt, highly plastic clay with zeolite inclusions. Greatest alteration lining zeolite veins.			Zeolite vein, cream reversible hydrous, 5mm width, sub-horizontal Zeolite vein, cream reversible hydrous, 2mm width, sub-horizontal	Decrease in coring rate & recovery.
12.10	BROKEN BASALT (SW)	Relatively fresh, fine to medium grained basalt, slightly fractured with minor clay within fracture zones.	HQ3	0	Zeolite vein, cream reversible hydrous, 2mm width, 70° from core axis.	
	12.35	Highly fractured with both immature & developed water pathways. Minor zeolite amygdules up to 7mm in length. Slight maroon tint on core.			Two well-developed fractures, 15° from core axis, opposite strikes. Fractures are relatively planar.	12.52 Water Table.
	(EW) 12.65	Highly fractured to fragmented Basalt. Large degree of water permeation has weathered rock to contain up to 30% clay content.			Fracturing dominantly sub-vertical to sub-horizontal. Sub-vertical fractures containing large quantities of clay and saturated on core retrieval. No iron staining on either fracture orientation. Both relative planar fracture surfaces. Fractures increasing with depth.	
	(EW-HW) 13.10	Fragmented Basalt.				
13.30	BASALT (ALTERED). (EW) ↓ (SW)	Highly friable & altered basalt with no identified fresh basalt evident progressing to slightly fractured and stable core. Residual clays lining fractures. Minor amygdules.	HQ3	5	Fractures sub-horizontal, 1mm in width, planar & marked clay deposition.	
13.75	BASALT (SW)	Fine to medium grained, fractured to highly fractured, medium to low strength due to fractures, relatively fresh basalt. Fractures occupied by clay			Fractures sub-horizontal, up to 6mm in width, planar with spacing 30-40mm. Single sub-horizontal fracture in core, no clay.	
	14.28	accumulation & iron staining. Fractured basalt, Medium strength, relatively fresh large fragments.			Fractures sub-horizontal, >0.5mm, <1mm width with minor clay accumulation. Fractures are relatively planar with minor undulations.	
			HQ3	0	Minor carbonate mineralisation represented in veining, sub-horizontal.	
	(EW) 15.10	Extremely fragmented basalt, extremely low strength exhibiting strong weathering of fragments. Clay seems up to 2mm thick with little to no iron staining.			Extremely fragmented both sub-horizontally & sub-vertically.	
					Zeolite vein (no other detail identifiable).	
	(MW) 15.90	Fractured core with core lengths 50-70mm. Basalt fresh except along fractures, basalt high strength, core low strength	HQ3	0	Fractures 50-70mm apart. Fractures are sub-horizontal (±5°), exhibit widths of approximately 1mm and have minor clay occupation and iron staining. Fracture planes are roughly planar.	
	(MW) 16.45	Core fractured to slightly fractured with minor zeolite on several fractures.			Fracturing sub-horizontal, clean planar fractures, clay deposition & iron staining on some fractures and absent on others.	
					Fracture 40° to core axis, well developed, planar with heavy iron staining and clay accumulation. No sub-vertical fractures in core.	
			HQ3	20		
	(MW) 17.40	Core fractured to highly fractured, basalt high strength, fractured core has a low strength.			Fracturing of two orientations:- i) Sub-horizontal, planar with minor clay & iron staining, 30mm spacing ii) 65-70° from core axis, planar with moderate clay & iron staining, 50-60mm spacing, strikes of fractures unidentified. Fracturing increasing with depth.	
	(HW) 17.92	Low to Very low strength, and decreasing with increasing depth.	HQ3	30		
	(EW) 18.35	Friable basalt with up to 15% clay in matrix.				
18.40	AMYGDALOIDAL BASALT. (HW)	Fine to medium grained basalt. Reversable hydrous massive zeolite occupies amygdules which are 4-10mm in length. Minor vugs throughout core, thought to have had zeolite removed rather than true genetic cavities. Core fractured with medium to low strength	HQ3	30	Sub-horizontal fracturing, spacing 30-60mm, planar.	Coring progressing extremely slow. Addition of polymer mud.
			HQ3	25		
			HQ3	50		
	(EW) 19.70	Zeolite amygdules up to 15mm in length and occupied by zeolite. Zeolite also present in horizontal veins. Low to very low strength. Minor weathered vesicules.	HQ3	60	Sub-horizontal zeolite vein, 2mm wide, planar & friable. Little Fe. Sub-horizontal zeolite vein, 4mm wide, planar & friable. Little Fe. Sub-horizontal zeolite vein, 2mm wide, planar & friable. No Fe. Sub-horizontal zeolite vein, 6mm wide, planar & friable. Little Fe.	Core saturated.

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Location: Rockleigh Road Exeter		BOREHOLE LOG	Hole N°: MB/BH2
Surface Elevation: 718.242	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type: Edson 3000/HQ3	Date: 27-29 Oct 98	Project: AJ9859 Concrite Quarries - Exeter	

Depth (m)	ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc
to 20.50	CORE LOSS X	CORE LOSS
20.50	AMYGDALOIDAL BASALT. (HW)	Fine to medium grained, low to <u>extremely low strength</u>, fractured basalt core. Amygdules occupied by reversible-hydrous zeolite, upto 17mm in length and range from spherical to angular. Zeolite in various states of weathering. Vughs occupied by zeolite, carbonate & silicate species.
21.56	(MW)	low strength, amygdules up to 10mm in length.
22.05	(SW)	low strength, highly to fractured core. Amygdules 6-8mm in length and decreasing in size with increased depth. Amygdules occupied by hydrous zeolite & other secondary mineral assemblages.
22.40	(HW)	
22.50	(EW)	Very low strength.
22.50	CORE LOSS X	CORE LOSS Expected E. Weathered, fragmented Amygd. Basalt with extremely low to very low strength Zeolite.
23.20	AMYGDALOIDAL BASALT (HW)	Dark grey, fine to medium grained, low to very low strength and fractured core. Amydules upto 12mm in length, angular to sub-rounded and contain hydrous zeolite. Heavy zeolite veining.
23.60	CORE LOSS X	
23.85	AMYGDALOIDAL BASALT. (HW)	Fractured, very low strength. Zeolite amygdules upto 10mm in length but commonly 5mm.
24.21	(SW)	Medium strength to Low strength - Unfractured basalt very fresh with High to very high strength.
24.40	(HW)	Very low to low strength.
24.60	CORE LOSS X	CORE LOSS
25.10	AMYGDALOIDAL BASALT (HW)	Fractured, very low strength. Zeolite present within amygdules upto 8mm in length.
25.45	(SW)	Slight fracturing, medium strength.
25.60	CORE LOSS X	CORE LOSS
25.91	AMYGDALOIDAL BASALT (MH)	Fine to medium grained, fractured core with Low to very low strength. Amygdules 2mm in length and decreasing in size with increased depth, zeolite occuppied. Minor Vughs up to 15mm present.
26.53	(SW)	<u>Highly fractured</u>, very low strength. Heavy Fe staining. Amygdules not present.
26.95	BASALT (SW)	Fine to medium grained, fractured, medium to high strength BASALT. Zeolite sub-horizontal fractures & veins apparent (<1mm). Basalt not fractured ie extremely fresh with heavy clay accumulation & Fe staining on fracture zones.
27.85		Amygdules upto 5mm in length, reversible-hydrous zeolite. <u>Slight fracturing</u> of core.
28.50	(MW)	Heavy iron staining of fracture faces. High strength. Amygdule size decreased to 2mm.
28.72		Core void of any amygdules. Slight zeolite veining. Low to medium strength core, fracturing increasing slowly with increased depth.
29.20	(SW)	Heavily Fractured, Very low strength, heavy iron staining along fissures. Minor zeolite amygdules upto 2mm in diametre, very spase occurrance.
29.65	AMYGDALOIDAL BASALT (SW-MW)	Fine to medium grained basalt, Low to very low strength, amygdules 2-4mm in length and occuppied by Zeolite

R.L Depth (metres)	CORE RUN / TYPE	% CORELOST	FRACTURES
20–20.5	HQ3	100	NA / NA
20.5–21	HQ3	75	
21–22	HQ3	65	
22–22.5	HQ3	30	
22.5–23.2	HQ3	100	
23.2–23.4	HQ3	80	
23.4–24.2	HQ3	80	
24.2–24.6	HQ3	75	
24.6–25.1	HQ3	100	
25.1–25.6	HQ3	90	
25.6–25.9	HQ3	95	
25.9–26.2	HQ3	90	
26.2–27.3	HQ3	20	
27.3–27.8	HQ3	10	
27.8–29.4	HQ3	0	
29.4–30	HQ3	5	

Fracturing, Veining & Discontinuities of Core — Spacing, Attitude, Smoothness, Filling, Coating, Aperture

- Sub-horizontal planar fracturing up to 40-60mm apart. Heavy deposition of both white & brown plastic clays along fractures.
- Zeolite vein, sub-horizontal, planar, 4mm width.
- Vugh, 50mm length, very deep, large range of mineralisation.
- Zeolite vein, sub-horizontal, planar, 4mm width.
- Fracturing sub-horizontal & up to 70-90mm apart. Iron stained.
- Fracturing sub-horizontal, roughly planar with spacing commonly 30mm. Fractures also containing carbonate & crystalline zeolite species. High clay content on fractures.
- Zeolite vein, 45° to core axis, 3mm wide, planar orientation.
- Zeolite vein, 50° to core axis, 6mm wide, planar orientation.
- Zeolite vein, sub-horizontal, planar 28mm wide. Fracturing 45° to core axis, planar with heavy clay accumulation. Undeveloped fractures oriented 60° to core axis.
- Fractures sub-horizontal, upto 50mm apart, roughly planar, heavy clay coating with weak to strong iron-staining.
- Zeolite veins, sub-vertical orientation, <1mm width, not planar, are disjointed and show several phases of cross-cutting. Upto ten veins identified.
- Fractures sub-horizontal, upto 60mm separation, planar.
- Fractures 70-80° from core axis, planar and no Fe or clay. Minor undeveloped sub-vertical fracturing.
- Zeolite vein, sub-horizontal, 6mm wide with planar orientation.
- Sub-horizontal fracturing 40-80mm separation, planar.
- Sub-horizontal fracturing, 1100mm separation, roughly planar. Fracturing 45° from core-axis, planar, iron stained.
- Fracturing sub-horizontal, planar with 50mm separation.
- Fracturing 45° to core axis through to sub-vertical. Fe stained with planar orientations. Very smooth faces with $CaCO_3$ mineralisation.
- Zeolite Vein 105mm wide, planar orientation, sub-horizontal. Minor (≈5mm alteration zone each side of vein).
- Fracturing 45° to core axis, 4 identified with 90-110mm spacing. Minor sub-horizontal & sub-vertical fracturing with $CaCO_3$ mineralisation present.
- Zeolite vein, 42mm wide, sub-horizontal
- Heavy zeolite veining both sub-horizontally and 45° from core axis.
- Fractures sub-horizontal, roughly planar with only minor clay occurrance.
- Fractures spacing increasing to 65 to 110mm, sub-horizontal.
- Sub-horizontal fractures, separation of approx. 450mm, planar fractures. Well developed fractures 45° to core axis, 1mm wide with clay accumulation.
- Sub-horizontal fractures, well developed, planar orientation, 40mm separation. Sub-vertical zeolite veins, 4 identified in core, 1-2mm wide, roughly planar orientation. Veins traced over 225mm of core.
- Highly fractured to sub-fragmented core with numerous fractures. Too many orientations to identify from core recovery state; heavy iron staining and clay accumulation evident. Slight (<1%) Zeolite occurrance on some fractures.
- Fractures oriented sub-horizontal to 60° from core axis. All fractures well developed with heavy iron staining & clay accumulation.

REMARKS

- Extremely slow coring through zeolite bearing units. Addition of polymer mud little influence on core recovery rate.
- Extremely slow penetration with no core recovery. Addition of additional polymer did not increase or provide core return.
- Addition of polymer mud to hole.
- <u>Extremely slow</u> coring due to weathered nature of bedrock.
- Increase in coring progress rate.
- Slight decrease in core recovery. Addition of polymer.

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Location: Rockleigh Road Exeter		**BOREHOLE LOG**	**Hole N°:** MB/BH2
Surface Elevation: 718.242	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type: Edson 3000/HQ3	Date: 27-29 Oct 98	Project: AJ9859 Concrite Quarries - Exeter	

ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc	GRAPHIC LOG	R.L Depth metres	CORE RUN / TYPE	% CORE LOST	FRACTURES	Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture	REMARKS

Depth scale (metres): 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

Core runs (Core run / type – % core lost): HQ3 – 5; HQ3 – 5; HQ3 – 5; HQ3 – 15; HQ3 – 10; HQ3 – 15; HQ3 – 50; HQ3 – [illegible]; HQ3 – 25; HQ3 – 0; HQ3 – 0; HQ3 – 0

Rock type & degree of weathering / Core description

AMYGDALOIDAL BASALT CONT. — Amygdules 2-5mm in length & zeolite occupied. Fractured.

- (SW) 30.57 — Amygdules 10-15mm in length, Very low strength with minor calcite inclusions. Highly fractured
- (SW) 31.41 — Zeolite amygdules up to 25mm in length, core fractured with Low strength. Basalt shards of core unweathered with High to very high strength.
- (MW) 32.45 — Multiple unidentified secondary minerals in vughs up to 70mm in length & for depth of core. Several amygdules larger than 25mm in length heavily eroded increasing porosity. Heavy iron staining of core.
- (MW) 33.10 — Amygdules decreasing in size to 3-5mm in length. Vughs void from core. Core slightly fractured (immature) with Medium to high strength.
- (SW) 33.90 — Slightly fractured to fractured core, Low to medium strength.
- (SW) 34.05 — Amygdules occupied by an unidentified white silicate mineral which can also be aqua in colour.
  - Olivine present in phenocrysts up to 15mm in length but commonly 10mm. Highly fractured with low to very low strength. Amygdules < 15mm in length.
- (SW) 34.60 — Fractured, Very low strength. Zeolite amygdules upto 30mm in length and very angular.
- (MW) 35.29 — Zeolite amygdules decreasing in size to 4mm in length
- (MW) 35.80 — Highly fractured, Low to very low strength, heavy carbonate & silicate veining throughout core. Basalt is relatively fresh with minor weathering aureoles.
- (MW) 36.18 — Very low strength, high degree of veining through relatively fresh basalt. Zeolite veining increasing with depth whereas amygdule size & quantity decreasing.

36.65 MASSIVE BASALT (SW) — Fine to medium grained, Medium to Low strength, Fractured basalt. Very minor zeolite amygdules upto 2mm in length. Fractures are well developed.

- (MW) 37.13 — Heavy secondary mineralisation in hydrothermal veins. Minerals include apatite, natrolite, heulandite, mesolite, and unidentified carbonate minerals. Aqua coloured phenocrysts of an unidentified silicate mineral upto 25mm in length.
- (SW) 38.45 — Slight fracturing. Medium strength. Basalt shards Very high strength.
- (SW) 38.92 — Slightly fractured to unbroken core. Very high strength

Fracturing, Veining & Discontinuities of Core

- Two fracture attitudes:
  - i) Sub-horizontal, planar, 50-70mm separation
  - ii) Sub-vertical, sub-planar, heavy iron staining & clay content.
- Sub-horizontal fracturing, very planar with separations of 20-40mm. Heavy iron-staining evident on fissures
- Sub-horizontal fracturing dominant with heavy iron staining. Separation of fractures 700-1100mm apart. Fractures are planar and extremely well developed.
- Zeolite vein, 15mm width, 60° to core axis, planar orientation.
- Zeolite vein, 27mm wide, 65° to core axis, planar orientation.
- Zeolite vein, 35mm wide, sub-horizontal, planar orientation.
- Immature sub-vertical fractures with minor clay accumulation.
- Fracturing decreasing in core.
- Fracturing sub-vertical through to 45° from core-axis. Immature with little clay content & slight iron staining. Minor zeolite
- Zeolite vein, sub-horizontal, 3mm width, planar & fresh.
- Carbonate vein, 65° from core axis, undulating orientation.
- Fracturing sub-vertical to sub-horizontal with no preferred orientation & little crosscutting observed in core. Fractures planar with minor zeolite & carbonate mineralization of sub-vertical fissures. Sub-horizontal fracturing separations of 120mm minimum.
- Fracturing sub-horizontal to 45° from core axis. Fracture separation is 20-50mm with planar, iron stained surfaces. High clay content.
- Fracturing only 45° from core axis, planar, smooth with high iron staining.
- Zeolite vein 55mm wide, sub-horizontal, planar boundaries, well developed cleavage, soapy feel & highly friable. 40mm alteration zone each side of vein.
- Fracturing 45° from core axis, planar with heavy iron staining & clay.
- Fracturing sub-vertical & sub-horizontal through relatively fresh basalt. Heavy iron staining & clay accumulation on both orientations.
- Fracturing sub-horizontal with separations of upto 90mm, commonly 40mm.
- Fracturing sub-horizontal through to sub-vertical. Planar, smooth with heavy iron-staining & clay accumulation.
- Heavy veining, no determinable orientation, vast direction changes, widths up to 7mm. Veins are moderately to highly weathered and have an extremely low strength. Identified 7 veins over 0.45m of core. Slight iron staining evident where carbonate removed.
- Subvertical & sub-horizontal fracturing, planar. Heavy Fe staining.
- Zeolite Vein 124mm in width, reversable hydrous massive zeolite, planar contacts with a sub-horizontal. Alteration zone 60mm wide each side.
- Fracturing dominantly 45° from core axis, smooth planar faces, well developed with extreme iron staining & clay content. Minor sub-horizontal fractures with spacings of 40mm to 60mm.
- Disconcordant fracturing with no noticable planar orientation or bearing.
- Sub-horizontal fracturing with separations of upto 1200mm & commonly 800mm. Fractures are well developed with slight secondary mineralisation on one vein. Fractures are planar and semi-smooth.
- Zeolite vein, cross-cutting core at 30° to core axis. Massive, reversable-hydrous cream-beige zeolite. Planar contacts with massive basalt and no alteration zones. Vein 70mm in width, well developed cleavage and very friable.
- Sub-horizontal to sub-vertical fracturing with no identifiable planar orientation ⇒ discordant. Spacing of fractures upto 1.0 metres. Sharp but free of Fe & clay.

Remarks

- Coring rate increasing.
- Coring rate decreasing as zeolite content increasing. The slowest rate encountered, roughly 0.1m per 30 minutes.
- Coring rate increasing.

Location: Rockleigh Road Exeter		BOREHOLE LOG	Hole N°: MB/BH2
Surface Elevation: 718.242	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type: Edson 3000/HQ3	Date: 27-29 Oct 98	Project: AJ9859 Concrite Quarries - Exeter	

ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc	GRAPHIC LOG	R.L Depth metres	CORE RUN / TYPE	% CORE LOST	FRACTURES	Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture	REMARKS
Massive Basalt. Cont.	Phenocrysts/Amygdules decreasing in size to 5mm in length and continue to decrease with depth.		41	HQ3	0			
			42					
			43				Terminated Coring @ 42.20m. Installed MB/BH2.	

Location: Rockleigh Road Exeter		BOREHOLE LOG	Hole N°: MB/BH3
Surface Elevation: 716.575	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type: Edson 3000/HQ3	Date: 29 Oct-2 Nov'98	Project: AJ9859 Concrite Quarries - Exeter	

ROCK TYPE & DEGREE OF WEATHERING	Depth (metres)	CORE DESCRIPTION Colour, Hardness etc	CORE RUN / TYPE	% CORE LOST	Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture	REMARKS
	0.10	Light to mid Brown CLAY LOAM. High plasticity, uniform texture & fabric, heavy bioturbation influence which decreases with depth.	Tricone Drilled.	No Core Produced.		Core diameter – 65mm Hole diameter – 96mm
	0.62	Soil void of bioturbation.				
	1.24	Light Brown CLAY LOAM. High plasticity, uniform texture & fabric with slight grey mottling.				
	2.05	Extremely weathered & friable basalt clasts amongst a dark brown, high plasticity, clay matrix. 'C' Horizon.			Commenced Coring @ 2.7m.	
Core Loss X	2.70	Core Loss. Core loss due to poor casing seal.				Have trouble forming a seal around borehole. Extreme loss of water through poor seal.
Massive Basalt (HW-SW)	3.30	Fine to medium grained, Low strength, Highly fractured with heavy clay accumulation along fracture planes. Basalt is relatively fresh with the majority of weathering confined to fracture zone surfaces. Very minor (<<1% Olivine).	HQ3	5	Two attitudes of fracturing i) Sub-vertical, planar, highly developed with heavy clay accumulation ii) 45° from core-axis, highly developed, curvilinear with heavy clay. Separations of 50-85mm between fractures. Fractures upto 6mm wide.	
(HW-SW)	4.70	Fractured, Medium to Low strength. Zeolite veining cross-cutting core with alteration products.	HQ3	5	Fracturing dominantly sub-vertical with planar faces, smooth surfaces with upto 5mm in width occupied by clay deposition Are well developed. Minor undeveloped sub-horizontal fractures with separations of 60mm common. Zeolite vein, sub-horizontal, 5mm width with planar surfaces & attitude. Zeolite vein, 65° to core axis, 7mm wide with planar surfaces & attitude. Minor alteration zone of 3mm each side of fracture.	Addition of polymers.
(MW)	5.30	Fractured, Medium strength BASALT core.	HQ3	40	Fractures sub-horizontal, well developed with heavy clay accumulation, separation of 80 to 110mm between fractures, very planar orientations with smooth fracture surfaces. Well developed weathering aureoles.	
			HQ3	15		
			HQ3	0		
			HQ3	0		Raised water-table encountered.
(HW)	7.55	Fractured, Medium strength BASALT with minor (<1%) zeolite amygdules up to 2mm in length. Separation of approximately 50mm occurs between zeolite amygdules.	HQ3	60	Fracturing predominantly 45-60° from core axis, well developed, 2mm in width with heavy clay accumulations. Fractures have planar to curvilinear orientation with very smooth but weathered faces. Minor sub-horizontal fracturing evident with separations of 120mm or greater, and are largely undeveloped.	
(HW)	8.15	Amygdules occupied by an aqua-coloured silicate mineral (unidentified) with no occurrence of hydrous zeolite. Separation of amygdules decreased to 30mm on average with size increasing to 4-6mm in length. Large degree of core loss	HQ3	85		
X	8.80	Core Loss	HQ3	10		Large increase in water loss rate. Lost 600 litres. Addition of polymer.
Amygdaloidal Basalt (MW)	9.00	Medium grained Amygdaloidal BASALT, low strength, fractured with reversable-hydrous cream zeolite amygdules 2mm in diameter with spherical shapes. Amygdules size increasing with depth.	HQ3	60	Fracturing through 2 attitudes: i) Sub-vertical, poorly developed with minor clay accumulation, non-planar orientation with rough fracture faces. Minor weathering haloes. ii) Sub-horizontal, poorly to well developed, planar fractions with minor to heavy iron staining. Spacing <50mm.	
Core Loss	9.40					
(HW)	9.50	Degree of weathering greatest at intersecting points of fracture zones.	HQ3	50	Fracturing sub-horizontal to 60° from core axis.	

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Location: Rockleigh Road Exeter		BOREHOLE LOG	Hole N°: MB/BH3
Surface Elevation: 716.575	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type: Edson 3000/HQ3	Date: 29 Oct-2 Nov	Project: AJ9859 Concrite Quarries - Exeter	

ROCK TYPE & DEGREE OF WEATHERING | CORE DESCRIPTION Colour, Hardness etc | GRAPHIC LOG | R.L Depth metres | CORE RUN / TYPE | % CORE LOST | FRACTURES | Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture | REMARKS

Rock Type & Core Description

- (HW) 10.45 – Slight fracturing, medium to high strength
- (HW) 10.92 – Slight fracturing, Low to Medium strength.
- (HW-EW) 11.03 – Slight fracturing, Low to Very Low Strength.
- 11.10 – 12.20: X – Core Loss. Assummed to be Highly Weathered Amygdaloidal Basalt.
- 12.20 – Massive Basalt (HW): Fine to medium grained, well developed plagioclase crystals. Moderate fracturing producing a Low strength of the core, basalt shards have a Medium to High strength. Minor zeolite amygdules upto 3mm in length and decreasing in size and quantity with depth.
- (HW) 13.15 – Core void of amygdules.
- (F - SW) 13.40 – Slight fracturing, Low to Medium strength. Weathering restricted to fracture zones which show slight mineral deterioration but extensive iron staining.
- (SW) 13.65 – Highly fractured, Low to Very low strength. Heavily weathered natrolite on one fracture zone indicating water movement through weathered secondary veining.
- (SW - F) 14.05 – Slightly fractured to unbroken core, High to Very High strength, minor (<1%) aqua coloured spherical amygdules of 2mm diametre
- (HW) 15.00 – Fragmented basalt. Very Low strength.
- (HW) 15.05 – Fractured basalt, Low strength
- 15.25 – Fractured basalt, Low to Medium strength. Basalt is fresh except for fracture zones which show strong weathering surfaces.
- (HW-MW) 16.49 – Slightly fractured Basalt with a low to medium strength. Minor (<<1%) spherical zeolite amygdules with lengths ≤2mm present. Core shows low to moderate degrees of leaching with limonite staining covering core. Original colour no longer recognisable.
- 16.60 – Amygdaloidal Basalt (HW)
- (EW) 17.05
- (EW-MW) 17.43 – Fine grained, low to very low strength with no identifiable fracturing. Basalt has numerous zeolite veins and amygdules which have provided a large degree of alteration to the basalt, particularly at zeolite veins > 20mm in width. Core shows extensive veining & limonite staining with little recognition of fresh core.
- (EW-HW) 18.14 – Amygdules increasing to 10mm in length. Numerous varieties of zeolite and secondary minerals in both amygdules & vughs up to 60mm in length. Slight fracturing
- 18.50 – Amygdules decreasing in size to 8mm in length.
- (HW) 18.74 – Fractured core, low to very low strength. Amygdules approximately 2mm in length.
- 18.85 – Highly fractured core. Heavy zeolite veining, no orientation 2-4mm wide, planar to disjunct.
- (SW) 19.32 – Core unfractured, Very low to Medium strength.
- (EW) 19.43 – Amygdules 6mm in length, occupied by an unknown aqua coloured mineral, are spherical to angular. High degree of hydrothermal alteration.
- (SW) 19.72 – Slightly fractured, amygdules 2-3mm in length. Medium to High strength with minor veining.

Core Runs

Core Run / Type	% Core Lost
HQ3	10
HQ3	100
HQ3	90
HQ3	30
HQ3	28
HQ3	30
HQ3	10
HQ3	65
HQ3	50
HQ3	70
HQ3	40
HQ3	41
HQ3	0

Fracturing, Veining & Discontinuities of Core

- Minor sub-vertical zeolite veining, non-planar, extremely discordant, rough lineation, 2-7mm in width.
- Zeolite vein, sub-horizontal orientation, 7mm wide, planar. No alteration zone.
- 10.94 Zeolite Vein, sub-horizontal orientation, 30mm thick with an alteration zone each side of the vein 20mm wide.
- Fracturing primarily 45° to core axis with minor sub-vertical fractures evident. Degree of fracture development poor to moderate with all fractures relatively planar, high clay and slight iron occurrance.
- Sub-horizontal fracturing, planar, well developed with heavy clay content & minor iron-staining. Slight weathering of fracture faces.
- Fracturing 40-55° from core axis with main fracture actually a weathered vein. Vein is planar with of 2-3mm. Fracturing well developed with moderate iron staining on surfaces & well weathered aureoles. Minor clay. Separation of fractures between 20 and 30 with large variance in strike.
- Fracturing 60° from core axis, well developed with widths up to 7mm. Fractures show little iron staining & minor clay accumulation but have moderately weathered surfaces. Separation of fractures generally 300 to 350mm.
- Sub-horizontal to 30° from core axis. Fractures planar with smooth surfaces, minor iron staining & no clay. Separations of 40-60mm.
- Fracturing evident in three orientations:-
  - i) Sub-horizontal dominant, extremely planar, separations of 40mm, slight iron staining, no clay, up to 3mm in width.
  - ii) Sub-vertical, moderately planar, high clay content, slight iron staining
  - iii) 30-40° from core axis, extremely planar with smooth faces, poor iron staining, no clay, minor weathering and widths ≤1mm.
- Fracturing sub-horizontal.
- Zeolite veining equivalent to a highly fractured core. Veining either
  - i) sub-horizontal to core axis, <1 to 4mm in width & extremely planar
  - ii) 10-15° from core axis, <1-2mm in width & extremely planar
- Zeolite is fresh with minor alteration zones of 4mm, although entire core to 18.20m altered to some degree by fluids.
- Zeolite vein, 40mm wide, planar, sub-horizontal orientation.
- 3x Zeolite veins 35mm wide, planar, sub-horizontal orientation.
- Sub-horizontal Zeolite vein, 30mm wide, planar & iron stained.
- Fracturing sub-horizontal & sub-vertical but restricted between 17.45 & 17.55m.
- Reversable-hydrous Zeolite vein, 255mm wide, horizontal orientation with planar contacts. Alteration zone enhanced up to 45mm from basalt / zeolite contacts.
- Fracturing 60° from core axis, poorly developed, little clay or Fe, <1mm.
- Fracturing 10-15° from core axis, poorly developed, little clay or Fe, <1mm.
- No fracturing.
- Zeolite vein 32mm wide, sub-horizontal, planar with smooth faces.
- Zeolite vein, 70mm wide, oriented 60° from core axis, planar.
- Zeolite vein, 30mm wide, sub-horizontal, planar with smooth faces.
- Fracturing 10-15° from core axis, slight Fe staining & clay, 1-2mm width

Remarks

- Extremely slow coring rate. Addition of polymer mud.
- 10.97 – Free-standing water-table.
- Addition of liquid mud polymer. Extremely slow coring.
- Addition of liquid mud polymer.
- Lost 1000 litres of water due to poor case seal & drilling circumstances.
- Change drill corer and catcher to try and improve core recovery.
- Lost 800 litres of water over last 2 core-runs due to bad case-seal. Core recovery failing.
- Addition of liquid mud polymer.
- Lost 500 litres of water due to poor seal.
- Changed corer & catcher to improve core return.
- Lost 600 litres of water during last core run due to poor case-seal.

Depth scale: 11 – 20 m

C.M. Jewell & Associates Pty Ltd
Water and Environmental Management

Page 2 of 3

Location: Rockleigh Road Exeter		BOREHOLE LOG	Hole N°: MB/BH3
Surface Elevation: 716.575	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type: Edson 3000/HQ3	Date: 29 Oct-2 Nov	Project: AJ9859 Concrite Quarries - Exeter	

ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc	GRAPHIC LOG	R.L Depth metres	CORE RUN / TYPE	% CORE LOST	FRACTURES	Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture	REMARKS
(SW-F) 20.14	Amygdules occupying upto 15% of core in cross-section. High degree of veining with widths of <1 to 2mm, highly variable orientations with numerous minerals identified including natrolite and carbonate species.			HQ3	0		Zeolite Vein 28mm wide, sub-horizontal, planar with smooth basalt contacts. Carbonate & silicate mineralisation occurs on basalt contact. Vein highly weathered & friable but basalt slightly weathered to fresh.	
(MW-HW) 20.77	Amygdules becoming increasingly weathered with depth. Slightly fractured core with Low strength.		21				Fracturing 20-25° from core axis, extremely planar, smooth contacts with extreme iron staining & only minor clay. Widths <<1mm. Fracture separation upto 600 mm.	
							Zeolite vein 42mm wide, sub-horizontal, planar with smooth basalt contacts. Minor silicate inclusions within hydrous zeolite along with very minor (<<1% basalt shards).	Extremely slow coring rate. Loss of 700 litres due to seal problems and loss through drilling.
21.44 ZEOLITE (F-SW).	Reversable-hydrous zeolite, soapy feel, well developed 10mm grains with strong to perfect cleavage. Hardness <3. Heavy iron staining along planar basalt contacts. Highly friable. Very low strength.							
21.97 AMYGDALOIDAL (HW) BASALT	Fine to medium grained, low to medium strength, highly fractured core. Amygdules range in size from 2-25mm and are angular to spherical. Amygdule mineral is hydrous zeolite + an aqua coloured silicate mineral, and occupies upto 20% of core in cross-section.		22	HQ3	0		Fracturing is extremely discordant with no identifiable orientation. Widths of fractures generally. Widths <1m to 3mm. Heavy iron staining on 60% of veins.	
(EW) 22.80	Hydrothermal alteration zone. Highly friable to sugary texture with up to 40% clay. Numerous secondary minerals present.						Loss of fracture definition due to coring.	
(EW) 23.08	Extremely altered Amyg. Basalt. Numerous vughs upto 30mm in length. Vesicules occuppied by crystalline zeolite species with vughs open to metallic species. Mineralisation & cavities occupy upto 75-80% of core volume.		23				Zeolite Vein; Green-beige colour, hardness 3.5 to 4.0, low lustre, highly friable. Iron staining on smooth planar contacts with basalt.	
23.30 MASSIVE BASALT. (MW).	Fine to medium grained, Slightly fractured with Low to very low strength. Minor (<1%) spherical amygdules less than 2mm in diametre. Fracturing progressing with depth.			HQ3	0		Fracturing sub-horizontal to 65° from core axis. Fracture width <<1mm but are heavily iron stained, planar & have smooth fracture faces. Minor 25-30° from core axis fracturing. Not well developed & discontinuous.	Addition of Liquid mud polymer. Marked increase in coring rate assumed due to change in unit.
			24	HQ3	10		Fracturing discordant with no identifiable alignment. No ironstaining, widths << 1mm.	
(MW) 24.85	Highly fractured core, very low strength.						Fracturing sub-horizontal, roughly planar, <1mm width with separations of 10 to 30mm, well developed with moderate ironstaining.	
			25					
(MW-SW) 25.40	Fractured Core, Low strength to very low strength.			HQ3	0		Fractures 40-50° from core axis, <1mm to 2mm in width, moderate iron staining with no clay accumulation. Fractures curvelinear with smooth faces.	
			26					
							Coring Terminated @ 26.60 m	
			27					

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Water and Environmental Management

Page 3 of 3

Location: Rockleigh Road Exeter		**BOREHOLE LOG**	**Hole N°:** MB1/BH1
Surface Elevation: 712.548	Datum:		
Inclination: Vertical	Azimuth:		
Drill Type/Method: Edson 3000	Date: 22-26/10/98	Project: AJ9859 Concrite Quarries - Exeter	

ROCK TYPE & DEGREE OF WEATHERING	CORE DESCRIPTION Colour, Hardness etc	R.L Depth metres	CORE RUN / TYPE	% CORE LOST	Fracturing, Veining & Discontinuities of Core Spacing, Attitude, Smoothness, Filling, Coating, Aperture	REMARKS
BASALT	Highly Disturbed & Weathered.		HQ3	100	Tricone - drilled to a depth of 10.70 after coring failed.	Core diameter – 85mm Hole diameter – 96mm
CORE LOSS	CORE LOSS		HQ3	100	Coring Recommenced @ 10.70m.	Expected bedrock.
10.70 AMYGDALOIDAL BASALT. (EW)	Fine to medium grained, dark grey, fragmented. Amygdales occupied by zeolite and are up to 2mm in length. Minor vughs up to 3mm in length. Very Low to Extremely low strength.	11	HQ3	10	Fracturing either i) Sub-horizontal with separations of 2-3mm, planar, heavy clay. ii) Sub-vertical (10-20° from core axis), planar, heavy clay accumulation. Fissure spacing approximately 60mm.	
11.15	Amygdales ≤1mm in length, spherical.		HQ3	70		
(HW) 11.55	Core fragmented to highly fractured.					
11.65	Amygdales approximately 9mm in length, with vughs occupied by heavy secondary mineral growth.		HQ3	50		
(EW-HW) 11.72	Quartz pebble inclusions with coarse grained angular quartz conds up to 45mm thick. Amygdales 8mm in length.	12	HQ3	50	Fracturing sub-horizontal, planar, well developed with heavy clay accumulation and minor iron staining. Fracture spacing very close, in the order of 30 to 35mm.	
			HQ3	80	Minor sub-vertical veining promoting fracturing of core. Vein surfaces heavily iron stained. Zeolite veining throughout core. Veins <1mm in width, discontinuous & discordant to any features.	Water Table.
(HW) 12.58	Zeolite Amygdales up to 15mm in length. Very low strength of core. 95% Core Loss.	13	HQ3	95		
(EW) 13.78	Brown, highly plastic heavy clays with zeolite amygdales. Minor (<5%) highly weathered basalt pieces amongst matrix. Extreme zeolite veining up to 15mm bisecting the core. Extremely low strength of core	14	HQ3	40	No structural evidence noticed due to alteration of core to clay. Zeolite veining evident, sub-horizontal, planar surfaces, massive with no observable crystal structure, up to 15mm in width.	
			HQ3	60		
(EW-HW) 15.15	Extremely low strength, zeolite present in fracture zones along with heavy accumulations of clays. Minor unaltered basalt fragments (up to 40mm in length). Degree of alteration decreasing with depth.	15			Zeolite vein 60mm wide, planar contacts with smooth surfaces. Vein is 75° from core axis. Multiple zeolite veins, highly disturbed by coring hence depth and thickness cannot be adequately derived.	
		16	HQ3	40		
		17				
(HW) 17.68	Core highly fractured, very low to extremely low strength.	18	HQ3	65	Sub-horizontal fracturing, very planar, smooth surfaces with heavy clay content & iron staining. Well developed with spaces of 30-50mm.	
(HW) 18.38	Core fragmented with unidentifiable structural orientations. Amygdales up to 12mm in length & occupied by zeolite (90%) and calcite (10%). Very minor clay presence within fracture zones. Minor vughs up to 30mm in length present with minor metallic mineralisation. Very low strength				Fracturing primarily sub-horizontal with minor sub-vertical fractures. Heavy clay coatings surround fractured basalt pieces with no certain identifiable orientations.	
		19	HQ3	15	Zeolite vein, sub-horizontal, 25mm in width, reversible-hydrous zeolite, highly friable with Very Low to Extremely Low strength. Vein has extremely planar contacts with basalt.	
		20			Zeolite vein, sub-horizontal, 34mm in width, reversible-hydrous zeolite, highly friable with Very Low to Extremely low strength. Planar contacts	

APPENDIX B

Water Quality Data

AUSTRALIAN LABORATORY SERVICES P/L
A.C.N. 009 936 029

ANALYTICAL REPORT

PAGE 1 of 2

LABORATORY: ENV SYDNEY
BATCH NUMBER: ES13601
SUB BATCH: 0
No. OF SAMPLES: 5
DATE RECEIVED: 18/11/98
DATE COMPLETED: 25/11/98

CONTACT: MR CHRIS JEWELL
CLIENT: C M JEWELL & ASSOC PTY LTD
ADDRESS: P O BOX 10
WENTWORTH FALLS NSW 2782

ORDER No.: AJ9859 SAMPLE TYPE: WATER PROJECT:

Method	Analysis description	Units	LOR	MB1 11/11/98	MB2 11/11/98	MB3 11/11/98	SPRING 7 HILL 10/11/98
EA-065	Total Hardness as CaCO3	mg/L	1	255	288	249	246
EA-066	Calcium Hardness as CaCO3	mg/L	1	82	95	80	77
ED-005F	Calcium - Filtered	mg/L	1	33	38	32	31
ED-010F	Magnesium - Filtered	mg/L	1	42	47	41	41
ED-015F	Sodium - Filtered	mg/L	1	136	25	30	24
ED-020F	Potassium - Filtered	mg/L	1	3	2	2	2
ED-030	Carbonate as CaCO3	mg/L	1	<1	<1	<1	<1
ED-035	Bicarbonate as CaCO3	mg/L	1	241	269	235	217
ED-040F	Sulphate - Filtered	mg/L	1	7	7	11	5
ED-045	Chloride	mg/L	1	202	35	39	42
EG-005F	Iron - Filtered	mg/L	0.1	<0.1	<0.1	<0.1	<0.1
EG-020F	Copper - Filtered	mg/L	0.001	0.002	<0.001	0.002	0.002
	Manganese - Filtered	mg/L	0.001	0.061	0.042	0.066	<0.001
	Silicon - Filtered	mg/L	0.1	87.0	77.3	89.9	79.9
	Zinc - Filtered	mg/L	0.001	0.015	0.004	0.012	0.010
EG-020T	Aluminium - Total	mg/L	0.01	0.35	0.37	2.44	5.76
EK-040F	Fluoride - Filtered	mg/L	0.1	0.2	0.2	0.1	0.1
EK-055A	Ammonia as N	mg/L	0.01	0.03	0.08	0.06	0.03
EK-058A	Nitrate as N	mg/L	0.01	2.70	2.91	1.74	3.00
EK-071A	Reactive Phosphorus as P - Total	mg/L	0.01	0.43	0.39	0.42	0.58
EZ-005	Total Cations	me/L	0.01	11.10	6.91	6.33	6.02
EZ-010	Total Anions	me/L	0.01	10.87	6.73	6.16	5.85
EZ-015	Actual (Anion / Cation) Difference	me/L	0.01	0.23	0.18	0.17	0.17
EZ-020	Allowed (Anion / Cation) Difference	me/L	0.01	0.27	0.21	0.20	0.20

COMMENTS:

Samples digested by USEPA method 3005 prior to the determination of total metals. Silicon spike recovery for sample MB1 not determined due to background levels of this analyte.

• This is the Final Report which supersedes any preliminary reports with this batch number. • Results apply to sample(s) as submitted by client.

Brisbane
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Melbourne
Phone: (03) 9538 4444 Fax: (03) 9538 4400
Perth
Phone: (08) 9249 2988 Fax: (08) 9249 2942

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AUSTRALIAN LABORATORY SERVICES P/L
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ANALYTICAL REPORT

PAGE 2 of 2

CONTACT: MR CHRIS JEWELL
CLIENT: C M JEWELL & ASSOC PTY LTD
ADDRESS: P O BOX 10
WENTWORTH FALLS NSW 2782

LABORATORY: ENV SYDNEY
BATCH NUMBER: ES13601
SUB BATCH: 0
No. OF SAMPLES: 5
DATE RECEIVED: 18/11/98
DATE COMPLETED: 25/11/98

ORDER No.: AJ9859 SAMPLE TYPE: WATER PROJECT:

Method	Analysis description	Units	LOR	SPRING 8 12/11/98
EA-065	Total Hardness as CaCO3	mg/L	1	151
EA-066	Calcium Hardness as CaCO3	mg/L	1	60
ED-005F	Calcium - Filtered	mg/L	1	24
ED-010F	Magnesium - Filtered	mg/L	1	22
ED-015F	Sodium - Filtered	mg/L	1	23
ED-020F	Potassium - Filtered	mg/L	1	2
ED-030	Carbonate as CaCO3	mg/L	1	<1
ED-035	Bicarbonate as CaCO3	mg/L	1	103
ED-040F	Sulphate - Filtered	mg/L	1	3
ED-045	Chloride	mg/L	1	54
EG-005F	Iron - Filtered	mg/L	0.1	<0.1
EG-020F	Copper - Filtered	mg/L	0.001	0.001
	Manganese - Filtered	mg/L	0.001	0.022
	Silicon - Filtered	mg/L	0.1	89.5
	Zinc - Filtered	mg/L	0.001	0.008
EG-020T	Aluminium - Total	mg/L	0.01	0.01
EK-040F	Fluoride - Filtered	mg/L	0.1	0.1
EK-055A	Ammonia as N	mg/L	0.01	0.05
EK-058A	Nitrate as N	mg/L	0.01	3.83
EK-071A	Reactive Phosphorus as P - Total	mg/L	0.01	0.65
EZ-005	Total Cations	me/L	0.01	4.06
EZ-010	Total Anions	me/L	0.01	3.92
EZ-015	Actual (Anion / Cation) Difference	me/L	0.01	0.14
EZ-020	Allowed (Anion / Cation) Difference	me/L	0.01	0.17

COMMENTS:

• This is the Final Report which supersedes any preliminary reports with this batch number.
• Results apply to sample(s) as submitted by client.

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Perth Phone: (08) 9249 2988 Fax: (08) 9249 2942

Laboratories also in: Singapore, Malaysia, Thailand, Hong Kong, New Zealand

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C.M. Jewell & Associates Pty Ltd
Water and Environmental Management
A.C.N. 056 283 295

1/13 Kalinda Road, Bullaburra, NSW 2784
P.O Box 10, Wentworth Falls, NSW 2782
Phone: 02) 4759 3251 Fax: 02) 4759 3257

FAXED

chain of custody

JOB NO:
No.: AJ 9859
Sheet 1 of 1.

Despatch to: ALS
Sampled by: C. WICENCIAK
Despatch date: 18/11/98
Attention: KERRY STEFANOVIC / LEE HILLS
Report to: JENS REKKER
Via: COURIERS PLEASE
Consignment note: SG010-00098280

Sample no.	Preservative	Date	Analysis required	Notes
MB1 (1)	NIL	11 Nov 98	Cl, HCO_3, CO_3, SO_4, PO_4, F	
MB1	H_2SO_4	11 Nov 98	NH_4 as N, NO_3^- as N	
MB1	HNO_3	11 Nov 98	Na, K, Ca, Mg, Fe, Mn, Cu, Zn	
MB2 (2)	Nil	11 Nov 98	Cl, HCO_3, CO_3, SO_4, PO_4, F	ES 13601
MB2	H_2SO_4	11 Nov 98	NH_4 as N, NO_3^- as N	(W) (C)
MB2	HNO_3	11 Nov 98	Na, K, Ca, Mg, Fe, Mn, Cu, Zn.	18.11.98
MB3 (3)	NIL	11 Nov 98	Cl, HCO_3, CO_3, SO_4, PO_4, F	
MB3	H_2SO_4	11 Nov 98	NH_4 as N, NO_3^- as N	5x1L nat
MB3	HNO_3	11 Nov 98	Na, K, Ca, Mg, Fe, Mn, Cu, Zn	5x1L H_2SO_4.
SPRING 7 HILL (4)	NIL	10 Nov 98	Cl, HCO_3, CO_3, SO_4, PO_4, F	5x250ml acid
SPRING 7 HILL	H_2SO_4	10 Nov 98	NH_4 as N, NO_3^- as N	
SPRING 7 HILL	HNO_3	10 Nov 98	Na, K, Ca, Mg, Fe, Mn, Cu, Zn	
SPRING 8 (5)	NIL	12 Nov 98	Cl, HCO_3, CO_3, SO_4, PO_4, F	
SPRING 8	H_2SO_4	12 Nov 98	NH_4 as N, NO_3^- as N	
SPRING 8	HNO_3	12 Nov 98	Na, K, Ca, Mg, Fe, Mn, Cu, Zn.	

CUSTODY Relinquished by	Received by	Date	Time
[signature]	[signature]	18/11/98	11:00am
	K. Stefanovic	18/11/98	3pm

QC level requirements
STANDARD

Special instructions
Plus ~~Conductance (Field)~~, Silica, Total ~~Al &~~ Total ~~hardness for each set~~ ~~fresh~~.

Document Qa-f18 Rev 23/12/97:CMJ

Page: 1 of 1

SRAES13601

RECEIVED
20 NOV 1998

ENVIRONMENTAL
GUARANTEED TESTING

SAMPLE RECEIPT ADVICE

COMPANY: C M JEWELL & ASSOC PTY LTD
ATTENTION: MR CHRIS JEWELL
DATE: Nov. 20, 1998
FROM: Nicole Ladner, ENV SYDNEY

ALS has received samples pertaining to your reference: AJ9859

For future reference the batch number on this order is: ES13601

All samples and paper work were received in good order.
Breaches in recommended extraction/analysis holding times may occur.
See comments section for details.
Samples chilled when received.
Samples received in appropriately pretreated and preserved containers.
Please direct any turnaround/technical queries to MARC CENTNER.
Any queries relating to sample condition/numbering/breakages should be directed to KERRY STEFANOVIC.

You can expect results to be reported as detailed below:

All Environmental Results Dec. 02, 1998

Comments: PO4, NO3 AND ALKALINITY SHOULD BE ANALYSED WITHIN 48 HOURS OF SAMPLING.

A L S - SERVICING YOUR NEEDS BETTER

AUSTRALIAN LABORATORY SERVICES P/L
A.C.N. 009 936 029

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AUSTRALIAN LABORATORY SERVICES P/L

A.C.N. 009 936 029

ANALYTICAL REPORT

PAGE 1 of 1

LABORATORY: ENV SYDNEY
BATCH NUMBER: ES13601
SUB BATCH: 0
No. OF SAMPLES: 5
DATE RECEIVED: 18/11/98
DATE COMPLETED: 25/11/98

CONTACT: MR CHRIS JEWELL
CLIENT: C M JEWELL & ASSOC PTY LTD
ADDRESS: P O BOX 10
WENTWORTH FALLS NSW 2782

ORDER No.: AJ9859 SAMPLE TYPE: QUALITY CONTROL PROJECT:

Method	Analysis description	Units	LOR	MB1 %SPK REC 11/11/98	SPRING 8 CHK 12/11/98	METHOD BLANK 18/11/98
EA-065	Total Hardness as CaCO3	mg/L	1	----	153	----
EA-066	Calcium Hardness as CaCO3	mg/L	1	----	62	----
ED-005F	Calcium - Filtered	mg/L	1	----	25	<1
ED-010F	Magnesium - Filtered	mg/L	1	----	22	<1
ED-015F	Sodium - Filtered	mg/L	1	----	24	<1
ED-020F	Potassium - Filtered	mg/L	1	----	2	<1
ED-030	Carbonate as CaCO3	mg/L	1	----	<1	----
ED-035	Bicarbonate as CaCO3	mg/L	1	----	104	----
ED-040F	Sulphate - Filtered	mg/L	1	----	3	<1
ED-045	Chloride	mg/L	1	103 %	56	<1
EG-005F	Iron - Filtered	mg/L	0.1	101 %	<0.1	<0.1
EG-020F	Copper - Filtered	mg/L	0.001	98.0 %	0.002	<0.001
	Manganese - Filtered	mg/L	0.001	99.0 %	0.023	<0.001
	Silicon - Filtered	mg/L	0.1	Not Det'd	90.9	<0.1
	Zinc - Filtered	mg/L	0.001	107 %	0.008	<0.001
EG-020T	Aluminium - Total	mg/L	0.01	111 %	0.01	<0.01
EK-040F	Fluoride - Filtered	mg/L	0.1	89.0 %	0.1	<0.1
EK-055A	Ammonia as N	mg/L	0.01	102 %	0.04	<0.01
EK-058A	Nitrate as N	mg/L	0.01	104 %	3.86	<0.01
EK-071A	Reactive Phosphorus as P - Total	mg/L	0.01	91.0 %	0.63	<0.01
EZ-005	Total Cations	me/L	0.01	----	4.16	----
EZ-010	Total Anions	me/L	0.01	----	4.00	----
EZ-015	Actual (Anion / Cation) Difference	me/L	0.01	----	0.15	----
EZ-020	Allowed (Anion / Cation) Difference	me/L	0.01	----	0.17	----

COMMENTS:

Results which appear on this report are for laboratory QUALITY CONTROL purposes.

• This is the Final Report which supersedes any preliminary reports with this batch number. • Results apply to sample(s) as submitted by client.

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APPENDIX C

Curriculum Vitae – C.M. Jewell

INFORMATION ABOUT THE AUTHOR

CHRIS JEWELL
BSc MSc CGeol MIWEM
Principal

Chris Jewell obtained a BSc (Hons) degree in Geology, with subsidiary Chemistry and Environmental Biology, from the University of Sheffield in 1974, and an MSc in Hydrogeology from the University of Birmingham in 1977.

He is a Chartered Geologist (UK and EEC), a Fellow of the Geological Society of London, and a Member of the Institution of Water and Environmental Management, the International Association of Hydrogeologists, the Australian Water and Wastewater Association and the Waste Management Association of Australia.

From 1974 to 1976 Chris Jewell worked with the Severn-Trent Water Authority and Water Research Centre in England. After completing his MSc, he worked as a hydrogeologist on a wide variety of water resources projects in the Middle East and Africa, initially for Hunting Technical Services Ltd, and later as a consultant with several British consultancy and aid groups. He joined the Coffey Group as a Senior Hydrogeologist in 1986, and from early 1990 to June 1992 was Manager of the Group's Environmental Division. He set up C. M. Jewell & Associates Pty Ltd in 1992, was appointed as an Environmental Auditor (Contaminated Land) by the Environment Protection Authority, Victoria, in October 1995, and accredited as a Site Auditor by the NSW EPA upon commencement of the Contaminated Land Management Act in June 1998.

He has been responsible for over one hundred soil and groundwater contamination assessment and remediation projects undertaken in all Australian states. These projects have involved contaminated industrial sites; landfill, landfill leachate and landfill gas investigations; leaking underground storage tanks; feedlots; stream and lake-bed sediment evaluations; wastewater disposal; and subsurface waste injection studies.

Major studies undertaken in this field include:

- Homebush Bay and RAN Newington soil and groundwater contamination investigations, Sydney.
- Review of hydrogeological aspects, Lucas Heights Regional Waste Disposal Depot, Sydney, NSW.
- Cockatoo Island environmental audit and forensic studies, Sydney, NSW.
- Groundwater assessment and management plan, "The Mount" Feedlot, Forbes, NSW.
- Assessment of drum reconditioning works, Seven Hills, NSW.
- Investigation of chlorinated hydrocarbon solvent contamination, Perth, WA.
- Groundwater chemistry assessment at aluminium smelter, Tomago, NSW.
- Contamination assessment of former gas works, Brompton, SA.
- Contamination remediation, gas works, Katoomba, NSW.

He has undertaken studies related to mine water management and water resources projects in Australia, Bahrain, Ethiopia, New Zealand, Oman, Saudi Arabia, United Kingdom and Zimbabwe. Examples include:

- Peak Hill Gold Mine Water Supply, NSW, Australia.
- Parkes Water Supply investigation, NSW, Australia.
- Oaklands coal mine and power station dewatering and reinjection, NSW, Australia.
- Andoom Slot dewatering design, Weipa, Qld, Australia.
- Eastern Distributor dewatering investigation, Sydney, Australia.
- Barrytown Ilmenite project hydrological study, New Zealand.
- Victoria Province drought relief drilling project, Zimbabwe.
- Umm er Radhuma groundwater resources study, Bahrain and Saudi Arabia.
- Sohar Copper Project, Sultanate of Oman.
- Shropshire groundwater investigation, England.

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EXETER QUARRY EXTENSION

AIR QUALITY ASSESSMENT OF THE PROPOSED EXTENSION OF HARDROCK QUARRY AT EXETER, N.S.W.

Prepared by:

P. Zib & Associates Pty Ltd

August, 1999

Specialist Consultant Studies

Volume 1 ▪ Part 6

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Concrite Quarries Pty Ltd

AIR QUALITY ASSESSMENT OF THE PROPOSED EXTENSION OF HARDROCK QUARRY AT EXETER, N.S.W.

Revision 2.0

Prepared in association with
R W Corkery & Co Pty Ltd

August 1999

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1. INTRODUCTION

Concrite Quarries Pty Ltd operates a hardrock quarry and processing plant at a site located off Rockleigh Road to the east of the township of Exeter. The Company has proposed to extend the extraction activity into an area which is located immediately to the northwest of the existing operation. The method of extraction of basalt rock would involve excavation and drilling and blasting.

Assessment of air quality resulting from the proposed extension has been undertaken to assist Concrite Quarries design their proposal and to assess its impacts on air quality around Exeter. The meteorology of the area which contains both the existing and the proposed operation is outlined in Section 2. Existing air quality is discussed in Section 3. Section 3 also includes an outline of the regulatory limits which apply to dust deposition rates and concentrations of total suspended particulates (TSP) and particulates smaller than 10 microns (PM10).

The existing operation, dust controls and emissions to air are summarised in Section 4. The proposed extension is outlined and the emissions to air are estimated in Section 5.

The methodology and the results of dust dispersion modelling are presented in Section 6. Mean annual rates of dust deposition are predicted first and related to amenity-based criteria specified by the NSW EPA. Mean annual concentrations of TSP/PM10 are predicted next and the impact of the predicted values is assessed using NSW EPA and NHMRC objectives.

The last part of Section 6 addresses the emissions of dust during the site establishment phase and emissions other than dust.

The main findings of the study are summarised and conclusions are presented in Section 7. A list of references and various attachments complete the report.

2. EXISTING METEOROLOGY

2.1. General Background

The generation of atmospheric particulates (dust) from mineral extraction is, in part, influenced by the prevailing meteorological conditions. The dispersal of airborne pollutants including particulate matter is governed by meteorological conditions which include wind speed, wind direction and the amount of atmospheric turbulence in the atmosphere.

Air temperature, the strength of solar radiation and rainfall are variables which, together with wind speed, play a role in the emission of surface dust.

2.2. Meteorology of the Project Area

The Exeter site lies within a region which is located between the belts of the subtropical highs and the zone of mid-latitude westerlies. In summer, synoptic highs dominate the climate. Low pressure systems pass at regular intervals bringing milder temperatures and southerly winds.

In winter, the main influence on climatic conditions is from the mid-latitude westerlies. The presence of high pressure systems is interrupted by the passage of cold fronts which bring low temperatures and precipitation to the region.

The nearest meteorological stations which are operated on behalf of the Bureau of Meteorology are situated at Moss Vale and Bowral. Standard observations include spot readings of wind speed and wind direction which are taken twice a day at 9 a.m and 3 p.m.

A continuously recording meteorological station was installed at the site of the existing processing plant in September 1997. The station is equipped with sensitive wind sensors and a range of other instruments which provide records of air temperature, solar radiation and rainfall at the site. The station is controlled by an electronic datalogger.

The recorded data are downloaded and processed monthly. Monthly wind rose diagrams and a summary of daily maxima and minima are then prepared. Monthly data checks are carried out to ensure that the sensors and the data logger were performing within specifications. A programme of maintenance and calibration is implemented.

2.2.1. Wind speed and direction

Seasonal and annual wind roses for 1998 are presented in Appendix 1. The wind roses show the frequencies of hourly wind speeds and directions recorded each month at night (00h00 to 06h00), in the morning (06h00 to 12h00), in the afternoon (12h00 to 18h00) and in the evening (18h00 to 24h00).

The summer season, which was defined in the diagrams as an interval of 6 months from January to March, and from October to December, was associated with two main types of winds. North to northeasterly winds were most frequent in the evening and at night. South to south-southeasterly winds were most common during the afternoon but remained evident in the records for all times of the day.

Easterly and southwesterly winds were least frequent. Westerlies developed mostly during the daytime on a few occasions.

The winter season (April to September inclusive) was associated with an increased presence of winds from the western half. West to northwesterlies were quite common. North-northeasterly winds continued as well especially in the evening. South to SSE winds were also evident in the records.

The annual wind rose reflected the seasonal as well as diurnal trends which were identified above. The three prevailing wind directions were from north-northeast, south to south-southeast and west to west-northwest.

Monthly wind roses are presented in Appendix 2.

The period from January to about mid-April was dominated by winds from NNE-NE and from SSE.

A rapid transition from the summertime (onshore) to the wintertime (offshore) air flow was recorded in May. West to west-northwest winds prevailed and were accompanied by S to SSE winds.

West to west-northwesterly winds continued to prevail in June and July. The occurrence of S-SSE diminished and those winds were gradually replaced by N-NNE winds. Southerly winds were most common in August. September was dominated by winds from the northwestern quadrant and from NNE. Similar conditions were recorded in October.

November and December then recorded a majority of onshore winds especially those from NNE and S-SSE.

Maximum wind speeds

Maximum instantaneous wind speeds are summarised in Table 2.1. They represent the highest of the values which were recorded at intervals of 2 seconds. The highest wind speed of 20.3 m/s was recorded on 21st July 1998 at 12h26 EST and again on 6th October 1998 at 09h42 EST. This wind speed was equivalent to about 73 km/hr.

2.2.2. Maximum and minimum temperatures

The highest and lowest instantaneous air temperatures are summarised in Table 2.2.

The highest temperature of 38.8 degrees C was recorded on 18th January 1998 at 12h01 EST. Maximum daily temperatures in excess of 35 degrees C were also recorded in February and March, and then again in December.

The lowest temperature of -0.9 degrees C was recorded on 16th July 1998 at 05h12 EST. June was the other month which recorded daily minima of less than zero degrees C.

Table 2.1. Maximum wind speeds (metres/sec) recorded in 1998.

	Absolute maximum	Day	Time (EST)
January 1998	16.3 m/s	24	13h54
February 1998	15.5 m/s	16	13h07
March 1998	13.9 m/s	6	14h38
April 1998	15.1 m/s	13	12h53
May 1998	17.9 m/s	24	12h17
June 1998	16.7 m/s	23	22h22
July 1998	20.3 m/s	21	12h26
August 1998	19.1 m/s	7	18h30
September 1998	18.7 m/s	15	10h53
October 1998	20.3 m/s	6	09h42
November 1998	12.7 m/s	12	11h10
December 1998	16.3 m/s	27	11h44

2.2.3. Rainfall

A summary of the rainfall data is given in Table 2.3. The total rainfall for 1998 was 1178.2 mm.

The highest monthly total of 438.6 mm was recorded in August. The monthly totals for January and May were also in excess of 100 mm. March recorded the lowest rainfall of 6.0 mm.

Rainfall was frequent throughout the year. There were 170 days in 1998 with rain registrations of, at least, 0.2 mm.

3. EXISTING AIR QUALITY

3.1. General Background

The general area which contains the existing extraction area is mostly of rural character interspaced with isolated residential developments. The township of Exeter is located less than 1 kilometre to the west.

Table 2.2. Maximum and minimum temperatures (degrees C) recorded in 1998.

Month	Absolute maximum deg C)	Day	Time (EST)	Absolute minimum (deg C)	Day	Time (EST)
January 1998	38.8	18	12h01	11.9	29	03h09
February 1998	36.8	26	12h25	6.5	17	05h31
March 1998	38.1	13	12h29	8.1	7	06h00
April 1998	30.1	5	12h40	3.9	14	06h23
May 1998	20.4	12	13h00	0.6	10	06h55
June 1998	20.8	1	12h14	-0.8	18	06h48
July 1998	16.9	5	12h30	-0.9	16	05h12
August 1998	20.0	29	13h02	0.6	1	01h45
September 1998	27.5	30	12h14	1.7	17	04h11
October 1998	29.7	1	12h16	1.6	28	04h40
November 1998	27.5	5	13h25	2.6	1	03h54
December 1998	36.2	13	11h43	6.8	27	04h53

Table 2.3. Total monthly rainfall (millimetres) recorded in 1998.

MONTH	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RAINFALL (mm)												
MONTHLY	110.0	25.6	6.0	82.4	216.6	89.6	33.8	438.6	46.0	28.6	80.0	21.0
TOTAL	110.0	135.6	141.6	224.0	440.6	530.2	564.0	1002.6	1048.6	1077.2	1157.2	1178.2
NO. OF RAINDAYS (days)												
MONTHLY	20	10	9	11	12	14	11	19	15	11	21	17
TOTAL	20	30	39	50	62	76	87	106	121	132	153	170

Agricultural and residential land use as well as road and rail traffic result in the generation of airborne dust which can be expected to be the main component of the impurities found in the ambient air. Drought periods and/or occasional dust storms originating further inland may temporarily increase the existing levels of dust particles in the air.

In addition to atmospheric dust, the air in the Exeter area contains minor quantities of exhaust gases from motor vehicles, and smoke and other products of domestic heating during the cool part of the year.

3.2. Regulatory Limits

In New South Wales, the EPA has adopted amenity based criteria for dust deposition expressed as annual means. The maximum acceptable increase in the mean annual dust deposition rate is 2 g/m2/month in those areas in which the existing rate of dust deposition does not exceed 2 g/m2/month. The criteria seek to limit the total dust deposition rate (the sum of the existing level and the increment due to a new development) to 4 g/m2/month in suburban residential areas and to 5 g/m2/month in rural, semi-rural and commercial and industrial areas.

The health effects of dust are related to the concentration of suspended particles in the air as distinct from dust fallout. The effects of inhaled dust are specifically related to the types of particles inhaled, the particles' sizes, the ability of the respiratory tract to capture and eliminate the particles and the reactivity of the particles with lung tissue.

The National Health and Medical Research Council of Australia (NHMRC) recommended annual concentration of 90 micrograms/m3 as the maximum permissible level of total suspended particulates (TSP) in the air to protect public health in residential environments.

The NSW EPA has also adopted air quality objectives which are specifically designed to address the levels of particles which have aerodynamic diameters of less than 10 microns in size (PM10). By contrast, total suspended particulates range in size to 30 microns and possibly higher. These objectives seek to limit the mean annual concentration of PM10 in residential environments to 50 micrograms/m3.

There is no current assessment criterion or goal which could be applied to emissions of TSP/PM10 from a single development such as the proposed extraction for intervals shorter than one year. This follows a recent withdrawal of a PM10 goal of 150 micrograms/m3 which applied to concentrations over an interval of 24 hours.

In the context of regional air quality and as a goal for air quality in population centres of more than 25000 people, the NSW Action for Air set an interim goal of 50 micrograms/m3 for PM10 concentrations over both 24-hour and annual intervals. Action for Air is a 25 year plan which focuses specifically on the Greater Metropolitan Region of Sydney, the Illawarra and the Lower Hunter. However, as advised by the NSW EPA, this goal is not appropriate for establishing regulatory limits for one particular development (NSW EPA, 1999).

3.3. Monitoring Data

3.3.1. Dust deposition

Regular monitoring of dust deposition in the vicinity of the existing extraction area commenced in January 1994. A total of 6 sampling sites are used to record monthly rates of insoluble matter which is depositing on horizontal surfaces at a height of about 2 metres above the ground.

The results of dust deposition monitoring since 1994 are summarised in Table 3.1.

Table 3.1. A summary of mean annual dust deposition rates (g/m2/30 days) recorded from 1994 to 1998.

Site**		1994	1995	1996	1997	1998
D1	Mean	0.77	0.53	0.67	0.95	0.74
	S.D.	(0.52)	(0.34)	(0.49)	(0.93)	(0.53)
	No.	12	12	12	12	12
D2	Mean	1.59	1.34	0.55	0.80	1.79*
	S.D.	(1.55)	(1.40)	(0.31)	(0.71)	(2.67)
	No.	11	11	11	10	11
D3	Mean	0.82	0.76	0.50	0.90	1.04
	S.D.	(0.84)	(0.50)	(0.32)	(0.61)	(1.50)
	No.	12	12	8	12	11
D4	Mean	0.93	0.71	0.58	0.78	0.81
	S.D.	(1.03)	(1.00)	(0.33)	(0.55)	(1.02)
	No.	12	12	11	12	12
D5	Mean	0.92	1.09	1.34	1.09	0.65
	S.D.	(0.82)	(0.97)	(0.77)	(0.80)	(0.61)
	No.	12	11	10	12	12
D6	Mean	0.64	0.66	0.60	0.76	0.99
	S.D.	(0.58)	(0.60)	(0.33)	(0.81)	(0.88)
	No.	12	12	12	12	12

* Note: See text for further details
** See Figure 3.1 for Site locations

The table shows annual means, standard deviations from the mean and the number of samples collected in each year of monitoring.

The recorded mean annual dust (insoluble solids) deposition rates remained low throughout the entire monitoring interval of 5 years. Even at the nearest monitoring sites, D3, D5 and D6, the mean deposition rates of insoluble solids were around or below 1.0 g/m2/month. Deposition rates of less than 1.0 g/m2/month were recorded at sites D1 and D4.

Mean annual values ranging from 0.55 to 1.79 g/m2/month were recorded at site D2. Standard deviations from the mean were relatively high indicating large variations between the individual records. The standard deviation for 1998 was 2.67 g/m2/month and so about 1.5 times the mean value of 1.79 g/m2/month.

Large variations in the monitoring results for D2 and the presence of extraneous matter not related to surface dust of mineral origin have been reported for this location on several occasions. For instance, in August 1998 when the monthly dust deposition rate reached a high 9.6 g/m2/month, frequent cattle movements were reported near the gauge and were connected with feeding. One isolated record of this magnitude had the effect of raising the annual mean from 1.19 g/m2/month (when excluded) to 1.79 g/m2/month. There were other examples of monthly samples which were subject to contamination by extraneous sources of local origin such as the above activity or the presence of bird droppings in the sample. Whilst these occurrences were sometimes noted in the collection sheets, the anomalous results have not generally been excluded from the calculated annual averages. Had, for instance, the anomalous result for August 1998 been excluded from the annual mean at D2, the mean value for 1998 would be 1.19 g/m2/month instead of 1.79 g/m2/month.

Anomalies of this nature are not uncommon in predominantly rural areas and reflect the general nature of the area as well as a possible presence of local sources of particulate matter resulting from activities which may take place in the immediate vicinity of a monitoring site.

Variations in the monitoring data may result not only from the effects of small scale (local) sources but also as a consequence of large scale events. Examination of the monthly results for 1994 revealed a sharp rise in the recorded deposition of atmospheric particulates during the month of November at all monitoring locations. Deposition rates of about 3 times the annual mean were recorded across the monitoring network. Dust storms occurred over large areas of New South Wales at that time following an extended period of dry weather and the recorded increases in dust deposition were thus attributable to atmospheric particles of regional rather than local origin.

The fact that the recorded annual means remained well within the regulatory limits at all sites in all years of the monitoring confirms that the local as well as regional events do not affect adversely the air quality in the study area.

3.3.2. Concentration of total suspended particulates

Concentrations of total suspended particulates (TSP) in the ambient air were recorded from November 1998 to early February 1999. Sampling during the summer season was selected to coincide with the presence of south to southeasterly as well northeasterly winds. A high-volume sampler was located at the property 'Willowbank' which is close to the village of Exeter and its public school (see Figure 3.1).

The sampling commenced on 15th November 1998 and was carried out every third day for a period of 24 hours from midnight to midnight. The sampling arrangements and procedures were in accordance with Australian Standard AS2724.3-1984.

A total of 28 samples were collected and averaged 24.3 micrograms/m3 with a standard deviation of 14.9 micrograms/m3. Individual 24-hr concentrations of TSP ranged from a low of 5.2 micrograms/m3 on 18/11/98 to a high of 70 micrograms/m3 on 12/12/98.

It may be noted that the highest concentration of 70 micrograms/m3 as well as the second and third highest concentrations of 50 and 49 micrograms/m3 were recorded on days with high air temperatures and north to northeasterly winds, not southeasterlies.

Both the mean concentration and the range of individual 24-hr concentrations of TSP in the ambient air thus remained well within the acceptable limits even during the time of the year when south to southeasterly winds are common and the air temperatures are at the peak.

Concentrations of PM10 in the ambient air are typically about 40 to 50 per cent, and possibly less, of TSP concentrations in areas such as the area surrounding the monitoring location. This ratio of PM10 to TSP thus translates into a mean concentration of PM10 of about 10 to 12 micrograms/m3. Similarly, the maximum 24-hr concentration of PM10 was estimated to be about 28 to 35 micrograms/m3 or less. Both these indicators remain well within the applicable regulatory limits.

4. EXISTING OPERATIONS AND EMISSIONS TO AIR

The current operations result in emissions of particulate matter and vehicle exhaust gases to the atmosphere. In terms of the size of the emission, emissions of particulate matter are the dominant component. Mineral particles (dust) become airborne during the extraction, transport and handling of basalt and overburden.

Disposal of overburden and wind erosion of disturbed areas are another possible source of dust emissions.

Standard dust controls in the existing extraction area and at the processing plant include watering of road surfaces, road marking, the use of fogging sprays and chutes at the main transfer points at the processing plant. Enclosures are provided for the crushing and screening operations.

The operations in the existing extraction area and the existing processing plant are well shielded by the surrounding terrain allowing most of the dust emissions to settle within the confines of the site.

5. PROPOSED EXTENSION AND EMISSIONS TO AIR

5.1. Emission Controls

The current dust controls during the extraction and processing of basalt rock will continue to be applied to the proposed extension. The area of the proposed extension will also continue to be separated from the township of Exeter by a distance which is similar to the separation distance available at the present.

Because of an increased wind exposure of the proposed extraction area in comparison to the existing site, the shielding effect that is provided by the topography of the present will be reduced but not completely eliminated.

The proposed extraction has therefore been designed to incorporate a number of control measures which would, among other things, minimise the exposure of disturbed surface areas to strong winds and thus the potential for wind erosion and subsequent dispersal of dust particles to locations situated outside the extraction site. The proposed controls are detailed in the EIS and include the use of bund walls as well as tree screens and finally the relocation of the product transport route along Rockleigh Road to a position within the bunded area.

5.1.1. Proposed strategy to control dust episodes

Short-term dust episodes are periods of temporary increases in the amount of dust which may be raised mainly from disturbed surfaces and other dust containing areas by strong winds in dry weather conditions.

Because of the prominent role of high winds and dry weather conditions in the formation of a possible dust episode, the best strategy during the operation is to monitor closely the wind conditions on a continuous basis and modify certain activities in certain meteorological situations. The strategy for controlling the occurrence of dust episodes in relation to the proposed development has been devised along those lines.

A weather monitoring station has been installed at the processing plant site and is equipped with sensitive wind sensors and an electronic datalogger to notify the operator that wind conditions may be approaching episodic levels.

The actual wind speed at which the station generates audio and visual signals for the operator has been set to 10 m/s. The wind speed threshold is, however, fully programmable and alternative threshold values could be used. The information is updated every 5 minutes continuously for 24 hours a day.
The operator thus has a continuing choice to modify or curtail operations in order to reduce the risk of a dust episode occurring.

5.2. Emission Estimates

Individual years of the proposed extraction were examined to select those stages of the development which would be used as a basis for conservative impact assessment. Years 4 and 8 of the operation were selected for compilation of detailed dust emission inventories and subsequent modelling of dust dispersion. The production rates in Years 4 and 8 would reach 450 000 tpa.

Backfilling of the void created by the proposed extraction would commence in Year 4. Overburden from each stripping campaign would be placed against the southwestern extraction faces first. Overburden material would first be removed by a face shovel and transported by truck along internal haul roads to the emplacement. Basalt rock would be drilled and blasted and/or excavated by a hydraulic excavator and loaded to haul trucks for transport to the existing processing plant.

Rates of dust emissions were determined for individual extraction activities including drilling and blasting, loading and haulage of both the raw feed and waste rock, and screening in the northern pit. The dust emission factors which were used in the estimates are listed in Table A.3.1 in Appendix 3. Details of the dust emission inventories are also given in Appendix 3 (Tables A.3.2 and A.3.3).

5.2.1. Emissions in Year 4

The extraction activity in Year 4 would take place in the southeastern half of the extraction area. The expected tonnage of raw feed is 485 000 tpa resulting in a production rate of 450 000 tpa of final product. An estimated 39 400 m3 of overburden would also be removed and emplaced in the southwestern section of the void.

The total annual emission of particulate matter (atmospheric dust expressed as total suspended particulates - TSP) was estimated at

104.6 tonnes (Table A.3.2). Extraction and haulage of raw feed were estimated to contribute 73.7 tonnes to the total. Operations involving overburden would add 16.9 tonnes, wind erosion of the disturbed areas a further 14.0 tonnes. It may be noted that all dust particles were assumed to reach the orifice of the open pit irrespective of the depth below the surface at which they were emitted. The fact that no retention of particles in the pit was modelled renders the emission estimates conservative, i.e. the estimates are likely to be higher than the actual amount of particles escaping from the pit area.

5.2.2. Emission in Year 8

Extraction in Year 8 would progress further to the northwest resulting in longer haul distances of both overburden and raw feed than in the previous years. Overburden would be removed at a rate of 31 500 m3 per annum. The location of internal haul roads would be close to the northeastern boundary of the extraction area.

The estimated annual emission of TSP would rise to 128.6 tonnes in Year 8 (Table A.3.3). The highest contribution of 90.6 tonnes would again be by the extraction and haulage of raw feed. Removal and haulage of overburden, and wind erosion of disturbed areas were estimated to add 15.6 and 22.4 tonnes per year respectively.

6. DISPERSION MODELLING AND IMPACT ASSESSMENT

6.1. Modelling Methodology

The estimated rates of dust emissions were applied together with the on-site meteorological data in a computer model of dust dispersion. Directional dependence of the wind erosion component of the dust source term was retained in the model.

It may be noted that the meteorological data file reflected the proposed working hours between 7 a.m and 6 p.m and hence the fact that the winds are generally stronger during this period than at night. Diurnal variations in wind speed and direction were illustrated in Appendix 1.

A computer plotting routine was used to draw isopleths of predicted dust deposition rates and concentrations of total suspended particulates in the ambient air.

6.2. Modelling Results and Impact Assessment

6.2.1. Dust deposition

Year 4

Predicted increases in the mean annual rate of dust deposition from extraction in Year 4 are presented in Figure 6.1 as a set of isopleths. The shape of the dust deposition contours reflected the direction of the main winds and the position of the main dust generating sources from extraction and haulage of hard rock.

Figure 6.1 indicates that increases in the annual dust deposition rate of 2 g/m2/month and above will be restricted largely to the proposed extraction area. Increments of 2 g/m2/month were also predicted for a small portion of the land which is located immediately to the southwest of the extraction site. The land is owned by the Company.

All non-Company owned residences which are located in the vicinity of the proposed extraction area were predicted to receive increases in the mean annual dust deposition rate of less than 0.5 g/m2/month.

A similar situation was predicted for the Exeter School which is located to the west-southwest of the proposed extraction area.

A mean annual increase of about 0.25 g/m2/month was predicted for the nearest section of the school.

All predicted increases remained well within the NSW EPA criterion for protection of amenity which requires the mean dust deposition rate not to increase by more than 2.0 g/m2/month.

Year 8

Figure 6.2 contains a map of isopleths which indicate the predicted increases in the mean annual dust deposition in Year 8 of the proposed extraction. The position of the contour line which corresponds to an increase of 2.0 g/m2/month extended further to the northwest than in Year 4 as a result of the advancing operation. It is evident from the diagram that increases of that magnitude will again be limited to the proposed extraction area itself and a small portion of land to the southwest of the proposed extraction area which is owned by the Company.

The predicted increases in mean annual dust deposition at all non-Company owned residences and at Exeter School will likewise remain well within the acceptable limits in Year 8. The school was predicted to experience a mean increment of about 0.35 g/m2/month, the nearest residences 'Merry Hill' and 'Rockleigh' 0.54 and 0.58 g/m2/month respectively.

6.2.2. Concentrations of total suspended particulates

Year 4

Figure 6.3 shows the predicted increases in the mean annual concentration of TSP in the ambient air. The main trends in the predicted dust levels which were displayed in Figure 6.2 are also evident in the contours of TSP concentrations. The shape of the concentration isopleths was again determined by the location of the main dust sources and the prevailing wind directions.

The NHMRC guideline of 90 micrograms/m3 refers to a total concentration of TSP in residential environments. Recent monitoring results indicated that the existing mean concentrations were limited to less than 25 micrograms/m3 even during the mid-summer and probably less on an annual basis. An increase of at least 65 micrograms/m3 would thus be needed to reach the limit value of 90 micrograms/m3.

Figure 6.3 shows that increments of less than 10 micrograms/m3 of TSP were predicted for all non-Company owned residences. Exeter School was predicted to experience an increase in the mean annual concentration of TSP of about 5 micrograms/m3.

The NSW EPA has also included an annual concentration of 50 micrograms/m3 in relation to that portion of TSP which has an aerodynamic diameter smaller than 10 microns (PM10). As discussed in Section 3, PM10 particles typically form about 40 to 50 per cent of the TSP particles. As a result, the NSW EPA objective for PM10 concentrations would also be met safely at all surrounding residences as well as the school.

Year 8

Predictions for Year 8 of the extraction are presented in Figure 6.4. Increments in the mean annual concentrations of TSP at all non-Company owned residences will remain limited to 10 micrograms/m3 and less. The Exeter School was predicted to experience an increment of about 6 micrograms/m3 of TSP of which up to 3 micrograms/m3 could be in the form of PM10.

6.3. Assessment of the Site Establishment

6.3.1. General

A brief period of site establishment would precede the actual extraction activity at the proposed extraction area. The site establishment phase is expected to be completed within 4 weeks and include the construction of a perimeter bund wall and the internal product transport route together with the required site preparation.

Overburden from construction areas and cuttings would be removed mainly by scrapers and used for the construction of dam wall and the bund walls. Excess overburden would be taken to an overburden emplacement located in the southwestern corner of the development site and adjacent to the proposed extraction area itself. Profiling of both the bund wall and the emplacement surface would be carried out by dozers.

The volume of overburden material which is to be removed during the site establishment phase is expected to total approximately 145 000 m3.

Owing to the short duration of the site establishment phase, an assessment with respect to mean annual rates of dust deposition and concentrations of TSP/PM10 in the ambient air would not be meaningful for this activity. Instead, it may be more appropriate to examine the likely changes in the concentrations of TSP/PM10 over shorter intervals of time such as 24 hours which may be expected as a result of the main construction activities during the site establishment phase.

6.3.2. Emission estimates

The individual construction activities and their timing during the site establishment phase are detailed in the EIS. The main dust producing activities which would take place in the closest proximity to residential properties and Exeter School are the construction of the perimeter bund wall using material removed from the cutting for the internal product transport route, the construction of the overburden emplacement using material removed from the surface of the excavation area, and the construction of the internal haul road, bund wall and dam in the southern part of the development site. It was assumed for the purpose of this assessment that all these activities would be undertaken simultaneously and within the nominated hours from 7 a.m to 6 p.m Monday to Friday and 8 a.m to 1 p.m on Saturdays.

Emissions of PM10 were estimated for each of the activities as follows.

Two scrapers would be removing material from the cutting for the internal product transport route and constructing Section 4 of the perimeter bund wall. At the same time, a dozer would be shaping and profiling section 3 of the perimeter bund wall. Each scraper and the dozer were assumed to operate for 10 hours a day.

An emission factor of 0.75 x $(2.6\ s^{1.2}\ M^{-1.3})$ was applied to calculate the emission of PM10 particulates (USEPA, 1990). For a silt content of 10 per cent and a moisture content of 3.4 per cent, the resulting rate of emission was 1.92 kg of PM10 per hour from each piece of equipment. The selection of the silt and moisture contents followed the recommendations in the USEPA document and was in a general agreement with values which have been applied in similar studies in Australian conditions particularly in New South Wales.

Wind erosion of the construction area was taken as the emission source of PM10 at times outside the working hours. The emission factor for TSP of 0.4 kg/ha/hr (SPCC, 1983) was multiplied by 0.5 to obtain an estimate for PM10 particles (AWMA, 1992).

A further three scrapers were assumed to be working for 10 hours a day (each) in the extraction area together with excavators and haul trucks. An emission factor of 0.029 kg/t was used for the excavators and 2.0 kg/VKT for the haul trucks. The total volume of material handled by excavators and trucks was taken to be 30 000 m^3.

Two scrapers and two dozers were then assumed to be active in the overburden emplacement area, scrapers for 7 hours a day (each), dozers for 3 hours a day (each).

The remaining scraper, two dozers and excavator were placed in the southern section of the development site. The scraper was assumed to operate for 10 hours a day, the dozers for 5 hours a day (each). Haul trucks would pass along this section over a distance of about 400 metres. A summary of the emission estimates is given in the Appendix (Table A.3.4).

Meteorological records for December 1998 and January 1999 and June and July 1998 respectively were processed into the AUSPLUME format to provide seasonally distinct input files for either summer or winter. Periods of 2 months were selected to represent each of the seasons.

6.3.3. Modelling results and impact assessment

AUSPLUME dispersion model was applied to determine concentrations of PM10 in the ambient air over intervals of 24 hours. No gravitational settling of PM10 particles was assumed rendering the results conservative.

An isopleth map showing the predicted mean 24-hour concentrations of PM10 for site establishment period taking place in summer is presented in Figure 6.5. Figure 6.6 shows similar predictions for wintertime meteorological conditions.

The conservatively predicted mean 24-hour concentrations of PM10 at the nearest residences were about 12 micrograms/m3 in summer and 7 micrograms/m3 in winter at Merry Hill, and 5 and 15 micrograms/m3 at Rockleigh. Exeter school was modelled to receive about 9 micrograms/m3 of PM10 should the site establishment phase take place in summer and 5 micrograms/m3 in winter.

As outlined in Section 3.2 of this report, the applicable regulatory limit for mean concentrations of PM10 in the ambient air is 50 micrograms/m3 and is predicted to be met at all surrounding residences and the school.

Estimates of maximum 24-hour concentrations were then obtained for summer meteorology (Figure 6.7) and winter meteorology (Figure 6.8). Inherent in the modelling estimates was the assumption that the worst day in the year of meteorology would occur during the site establishment period of 4 weeks and be accompanied by continuously dry weather conditions.

The results of the predictions provide a general, and most likely conservative, indication of the expected peaks in the dust levels during the most intensive stage of the proposed development in terms of dust emissions.

The predicted maximum concentrations remained within the regional goal for all non-Company owned residences. All predictions were thus well below the previously applicable goal of 150 micrograms/m3 for individual developments.

6.4. Emissions Other Than Dust

The proposed extraction area is located in an area of largely rural character. The surrounding areas are used for agricultural, residential and transport purposes. As a result, the background levels of non-dust pollutants are expected to be low with some contributions from those activities possible under certain meteorological conditions.

The use of explosives in blasting and the operation of mining equipment at the extraction site will result in emissions of exhaust gases and small particulates. The use of diesel fuel will result in emissions of oxides of nitrogen (NOx), carbon monoxide (CO), volatile organic compounds (VOC), particulates and sulphur oxides (SOx).

Carbon monoxide is the pollutant which is produced in the largest quantity from explosive detonation. Emissions of oxides of nitrogen and sulphur are also likely. The emissions will be only minor, disperse rapidly and cause no adverse effects on air quality.

7. CONCLUSIONS

The generation and dispersion of atmospheric dust from the proposed extension of hard rock extraction at Exeter were examined and quantified. The extraction will be carried out with standard dust controls and be subject to a range of approval and licence conditions. Furthermore, additional dust control measures and safeguards have been incorporated into the design of the operation and include the provision of bund walls and tree screens.

The site of the proposed extraction is located adjacent to the existing extraction and processing area. Monitoring results of dust deposition rates in the area surrounding the existing development indicated mean annual levels of less than 2.0 g/m2/month.

The results of dust dispersion modelling indicated that the EPA objective for protection of amenity would be met at all surrounding non-Company owned residences and non-Company owned land.

The modelling predictions also confirmed that the NHMRC and NSW EPA criteria for mean annual concentrations of TSP/PM10 in the ambient air would be met with a large margin of safety.

It is therefore concluded that the proposed extension of extraction activities when operated with the proposed dust controls and safeguards will not have an adverse effect on air quality at the surrounding land and residences including the Exeter School.

8. REFERENCES

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NHMRC (1985) National Guidelines for Control of Emission of Air Pollutants from New Stationary Sources. Australian Government Publishing Service, Canberra.

NSW EPA (1999) Submission in Reply to the Commission of Inquiry into a Proposal to Establish the Mt. Pleasant Open Cut Coal Mine. February 1999.

SPCC (1983) Air Pollution from Coal Mining and Related Developments. ISBN 072405 9369, Sydney.

USEPA (1985,1988,1990,1991) Compilation of Air Pollutant Emission Factors(4th Edition and Supplements). USEPA, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

FIGURES

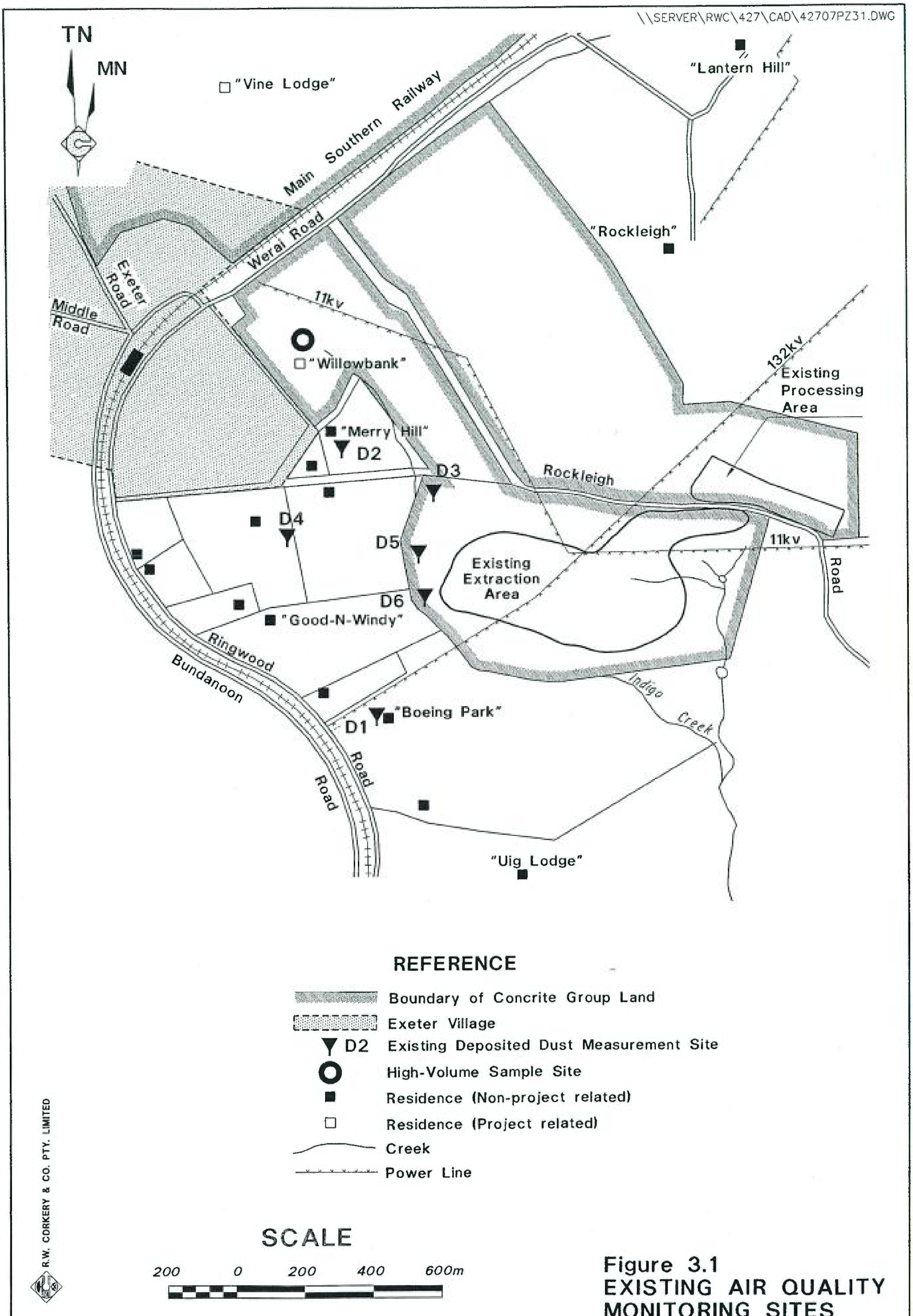


Figure 3.1 EXISTING AIR QUALITY MONITORING SITES

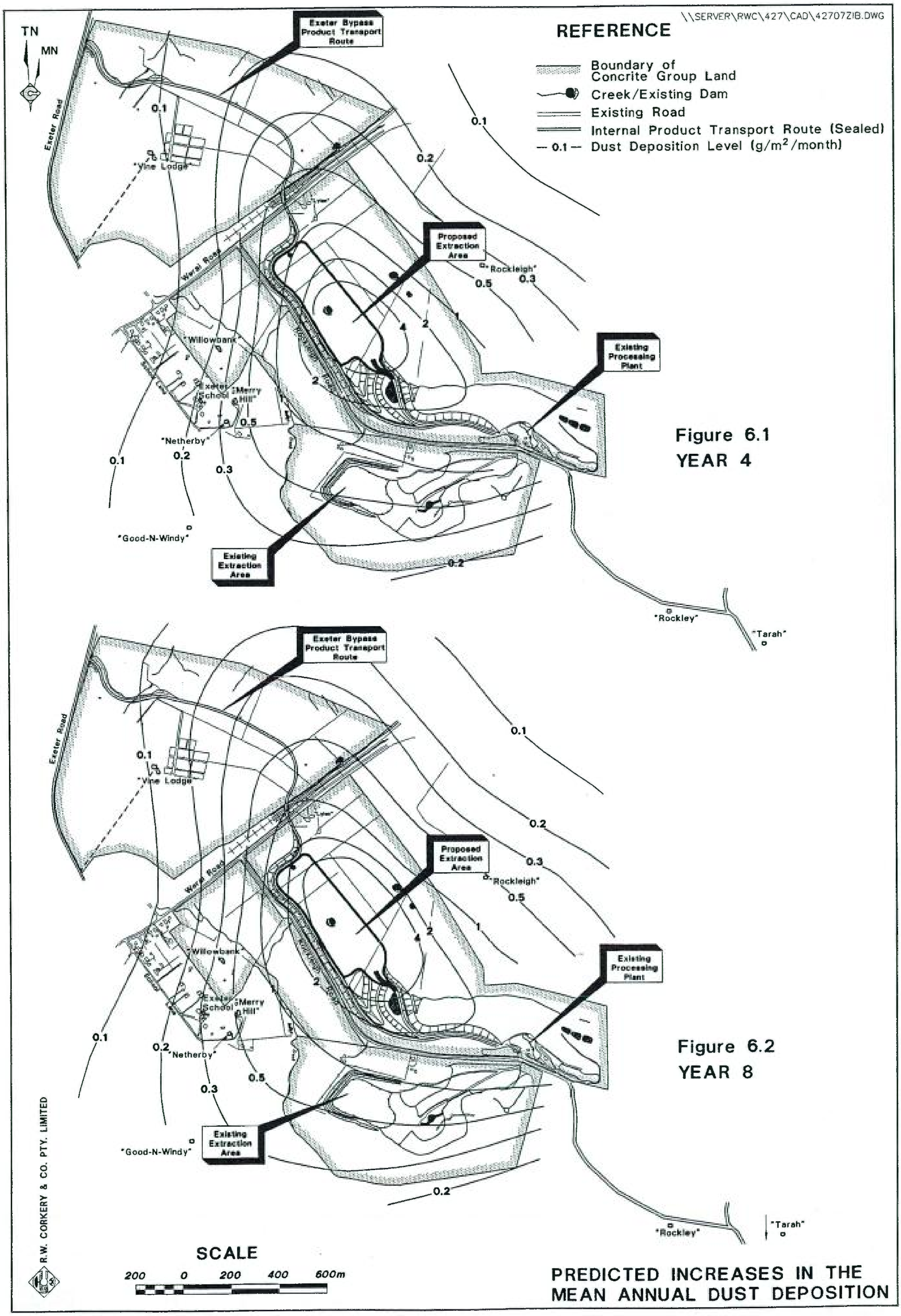
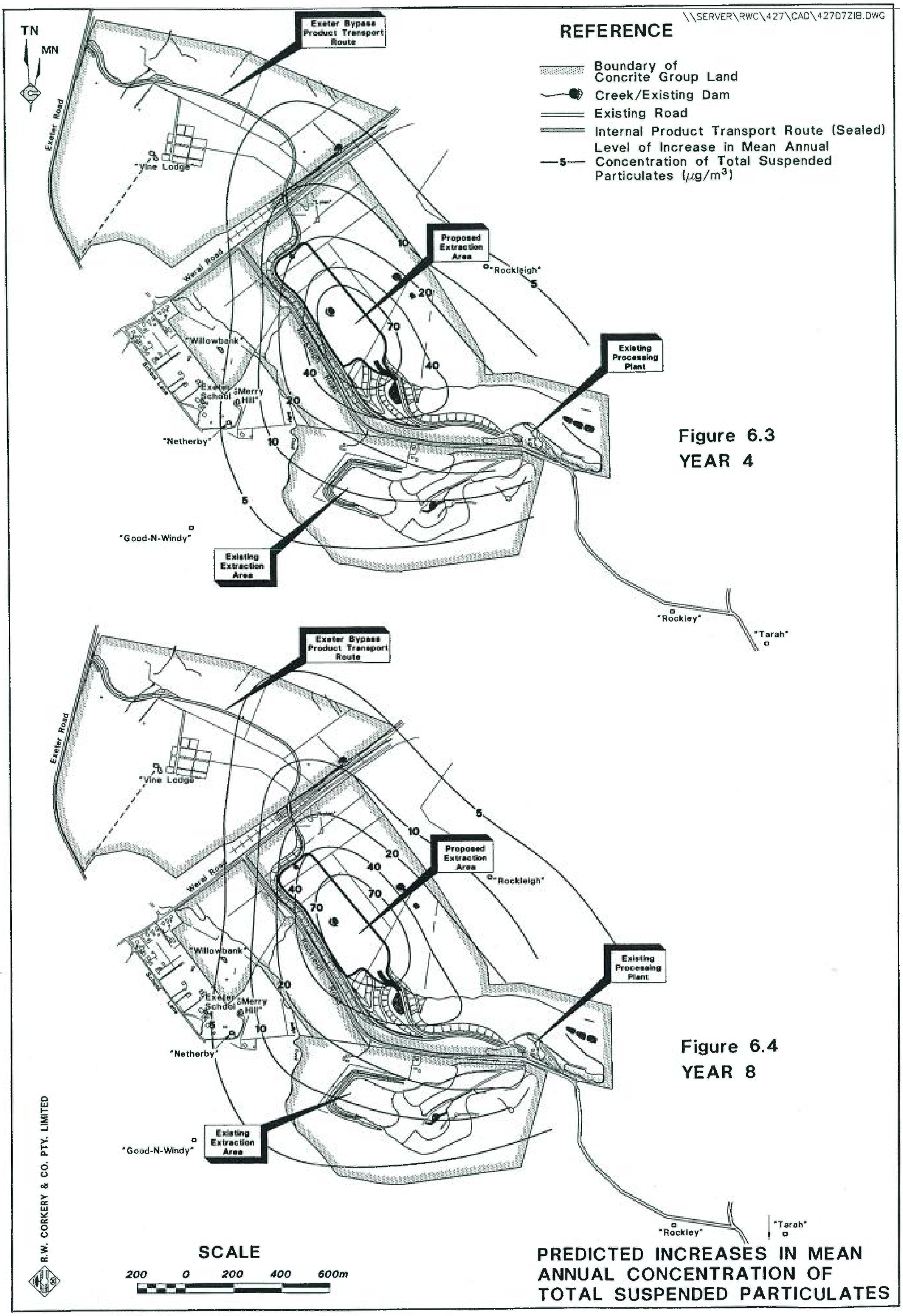


Figure 6.1
YEAR 4

Figure 6.2
YEAR 8

PREDICTED INCREASES IN THE MEAN ANNUAL DUST DEPOSITION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TN
MN
REFERENCE
Boundary of Concrite Group Land
Creek/Existing Dam
Existing Road
Internal Product Transport Route (Sealed)
Level of Increase in Mean Annual Concentration of Total Suspended Particulates (µg/m³)
Exeter Bypass Product Transport Route
Proposed Extraction Area
Existing Processing Plant
Existing Extraction Area
Exeter Road
Werai Road
School Lane
"Vine Lodge"
"Rockleigh"
"Willowbank"
Exeter School
"Merry Hill"
"Netherby"
"Good-N-Windy"
"Rockley"
"Tarah"
5
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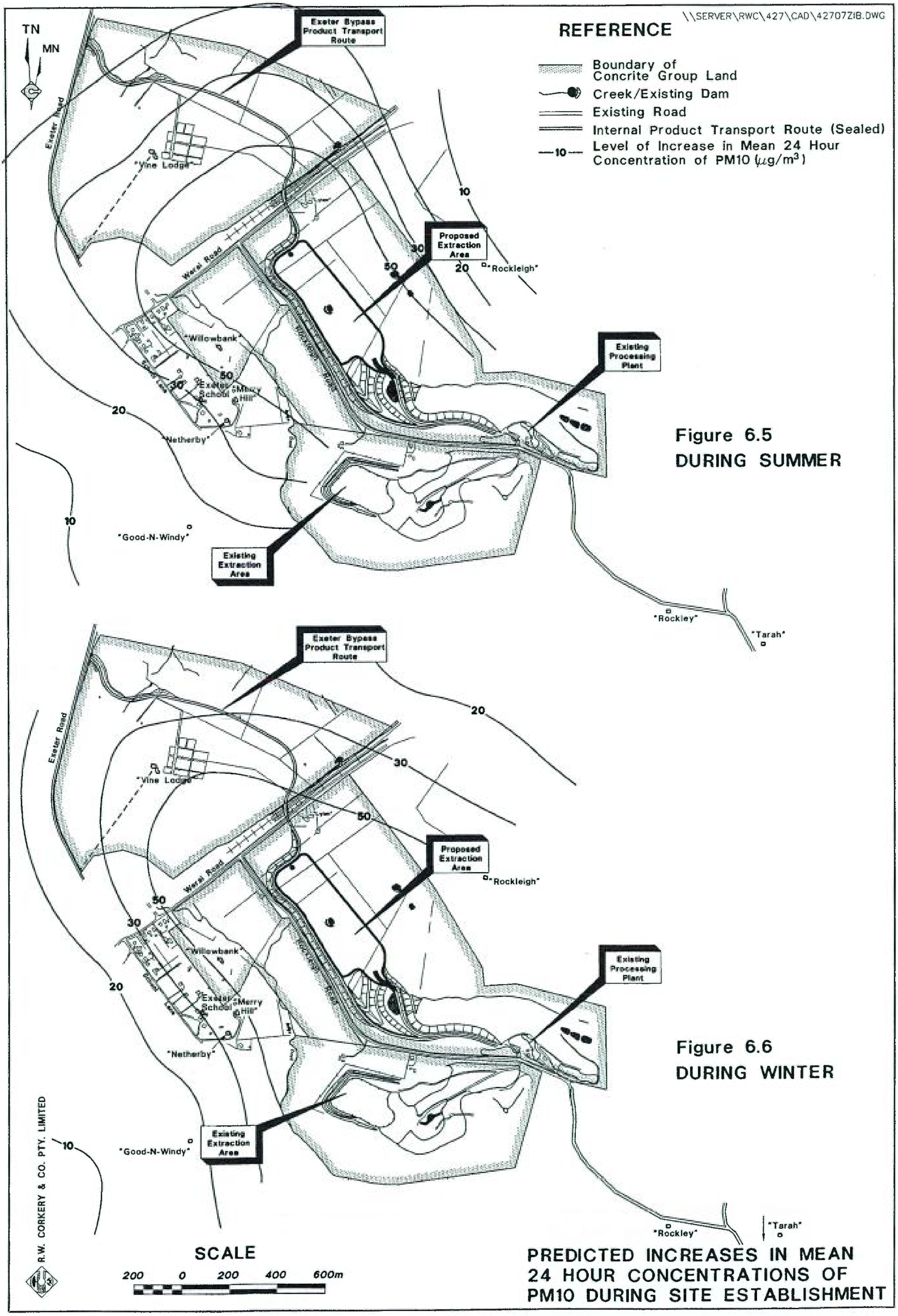
40
70
Figure 6.3
YEAR 4
Figure 6.4
YEAR 8
SCALE
200 0 200 400 600m
R.W. CORKERY & CO. PTY. LIMITED
PREDICTED INCREASES IN MEAN ANNUAL CONCENTRATION OF TOTAL SUSPENDED PARTICULATES



PREDICTED INCREASES IN MEAN 24 HOUR CONCENTRATIONS OF PM10 DURING SITE ESTABLISHMENT

\\SERVER\RWC\427\CAD\42707ZIB.DWG

REFERENCE

- Boundary of Concrite Group Land
- Creek/Existing Dam
- Existing Road
- Internal Product Transport Route (Sealed)
- —10— Level of Increase in Highest 24 Hour Concentration of PM10 ($\mu g/m^3$)

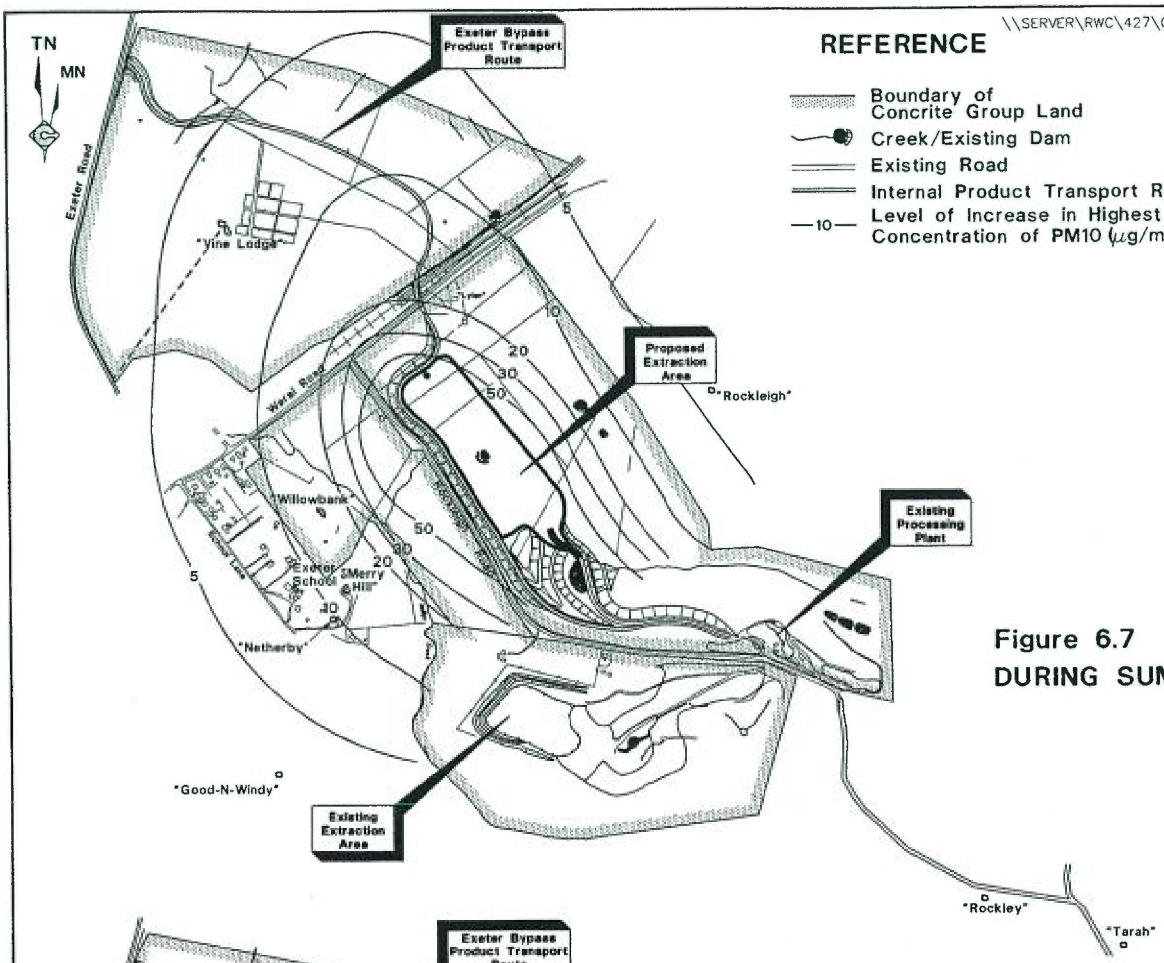


Figure 6.7
DURING SUMMER

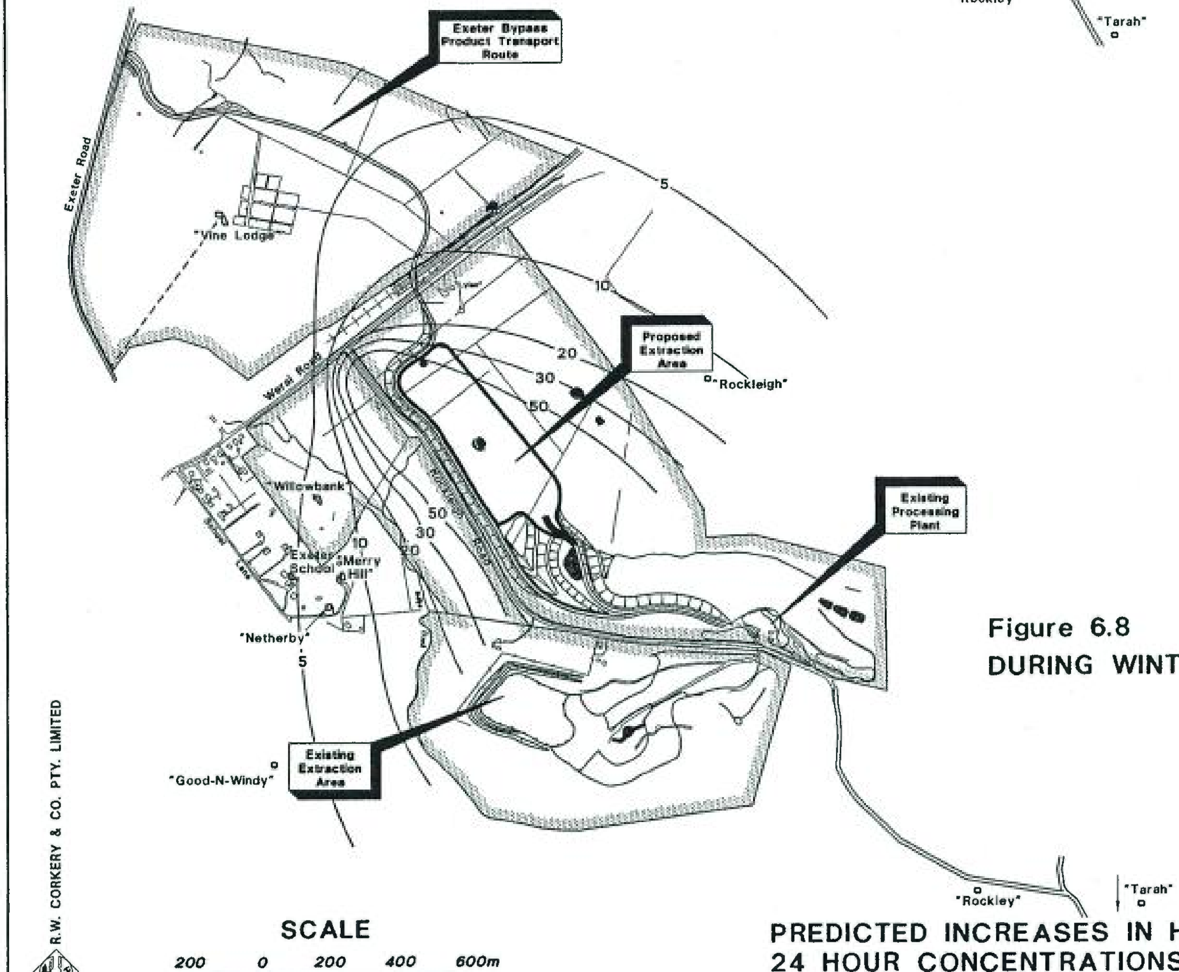
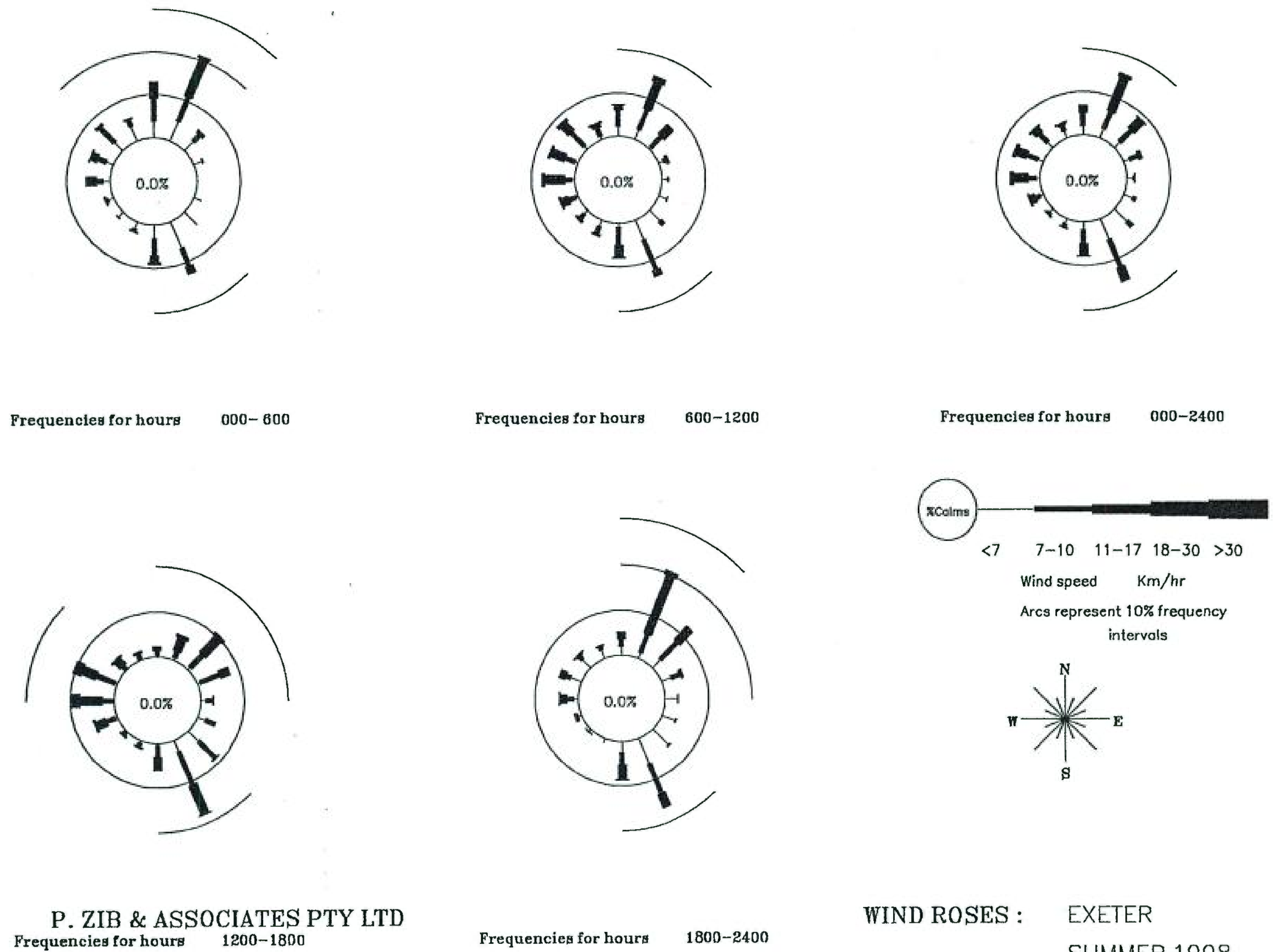


Figure 6.8
DURING WINTER

SCALE
200 0 200 400 600m

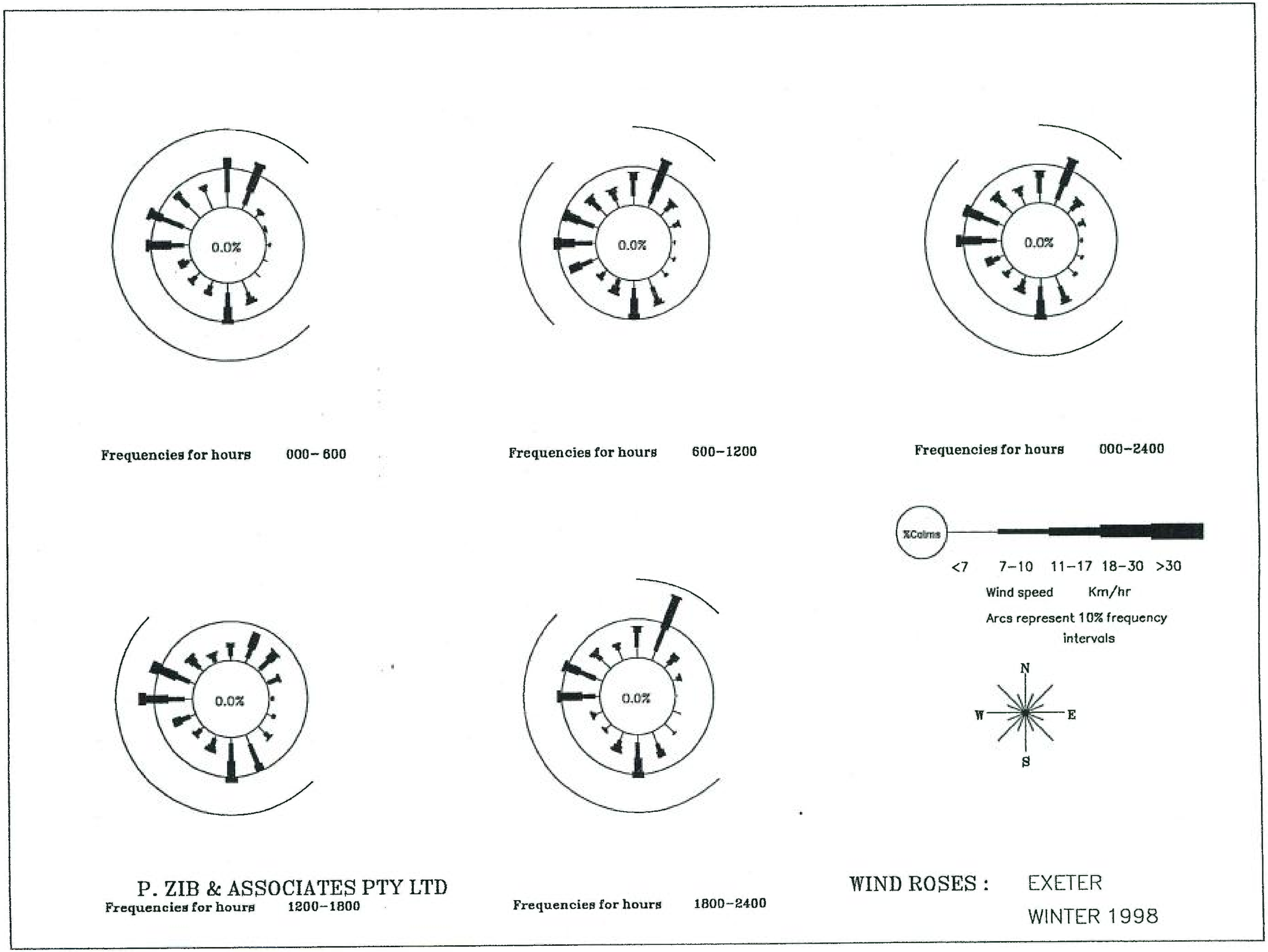
PREDICTED INCREASES IN HIGHEST 24 HOUR CONCENTRATIONS OF PM10 DURING SITE ESTABLISHMENT

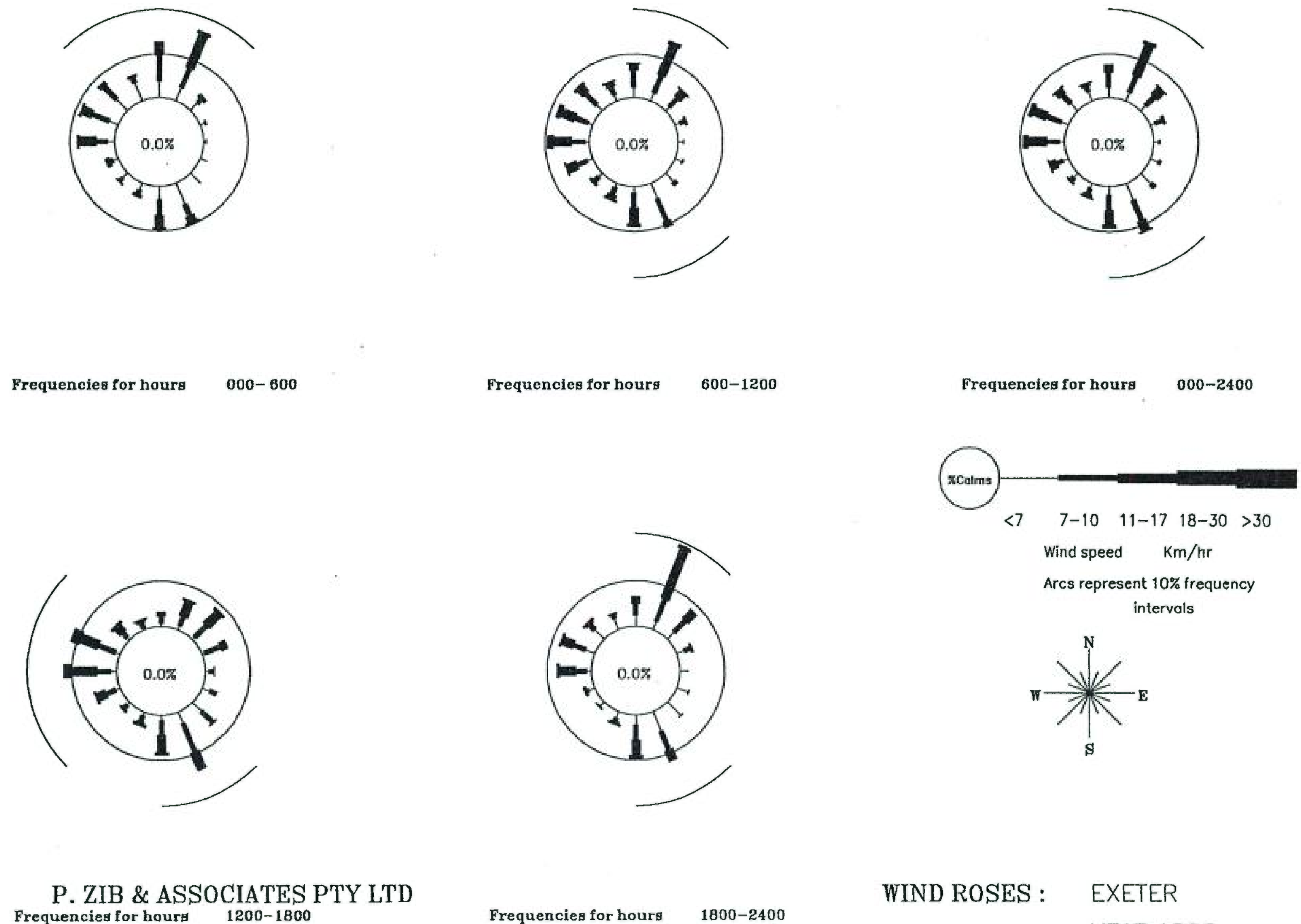
Appendix 1. Seasonal and annual wind roses recorded at Exeter in 1998



WIND ROSES : EXETER
SUMMER 1998

P. Zib & Associates Pty Ltd

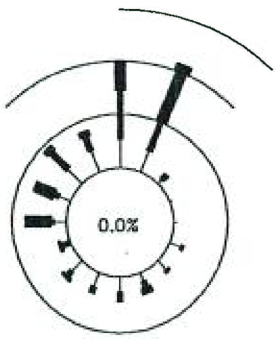




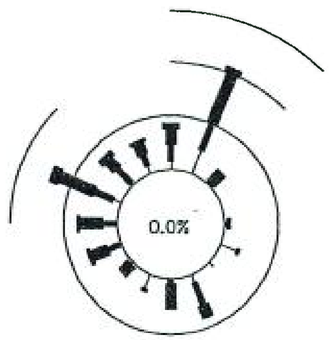
P. ZIB & ASSOCIATES PTY LTD

WIND ROSES : EXETER
YEAR 1998

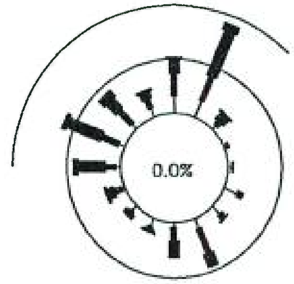
Appendix 2. Monthly wind roses



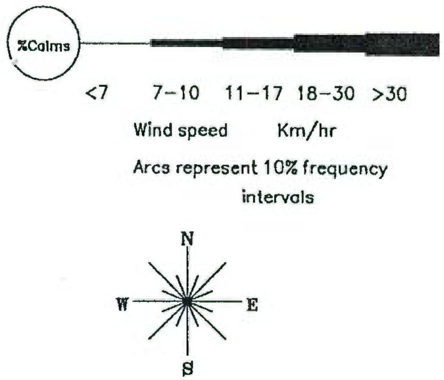
Frequencies for hours 000– 600

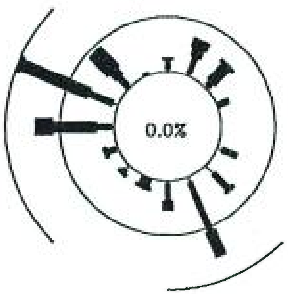


Frequencies for hours 600–1200



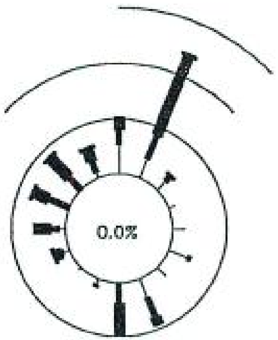
Frequencies for hours 000–2400





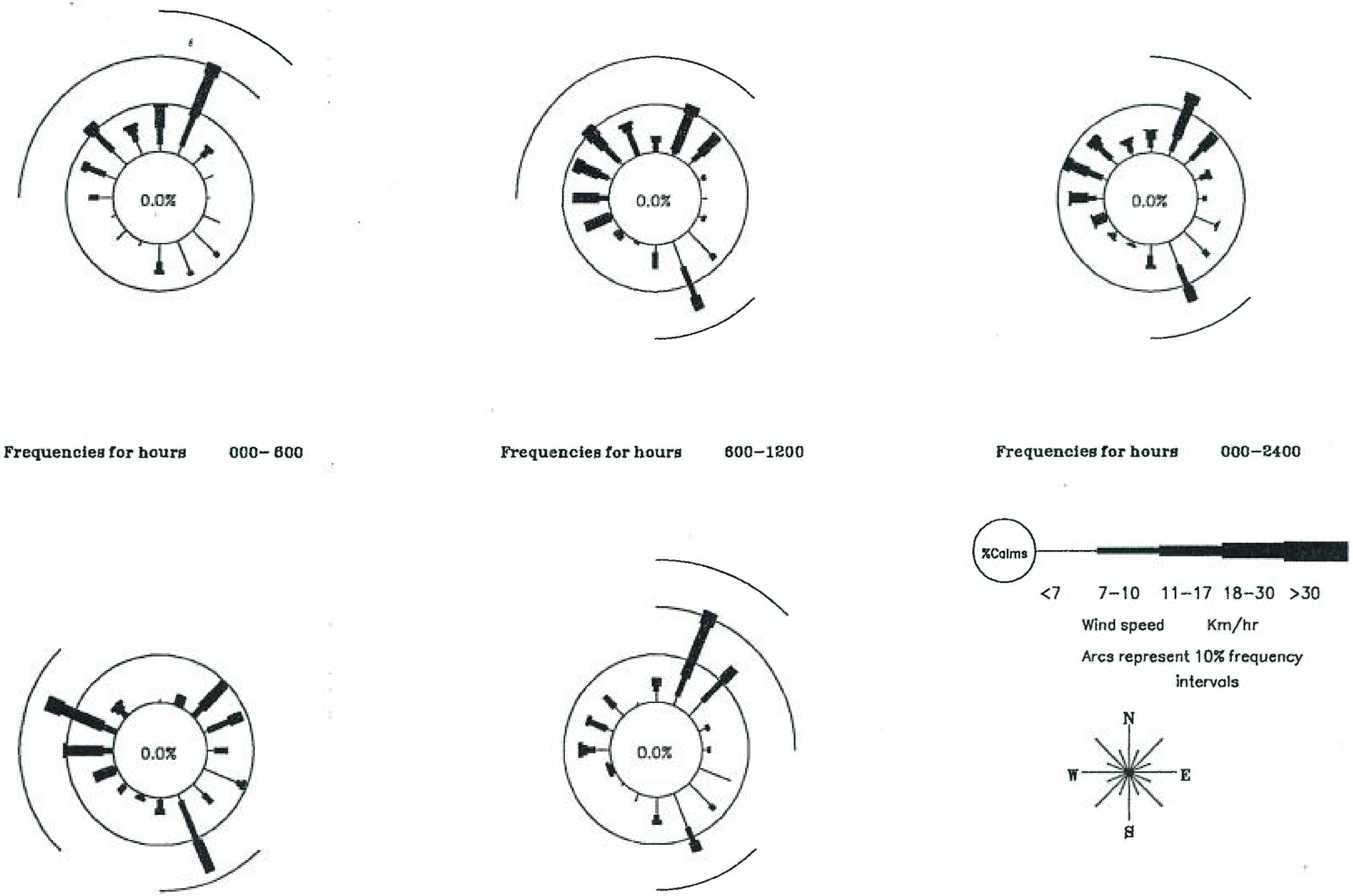
P. ZIB & ASSOCIATES PTY LTD

Frequencies for hours 1200–1800



Frequencies for hours 1800–2400

WIND ROSES : EXETER
OCTOBER 1997



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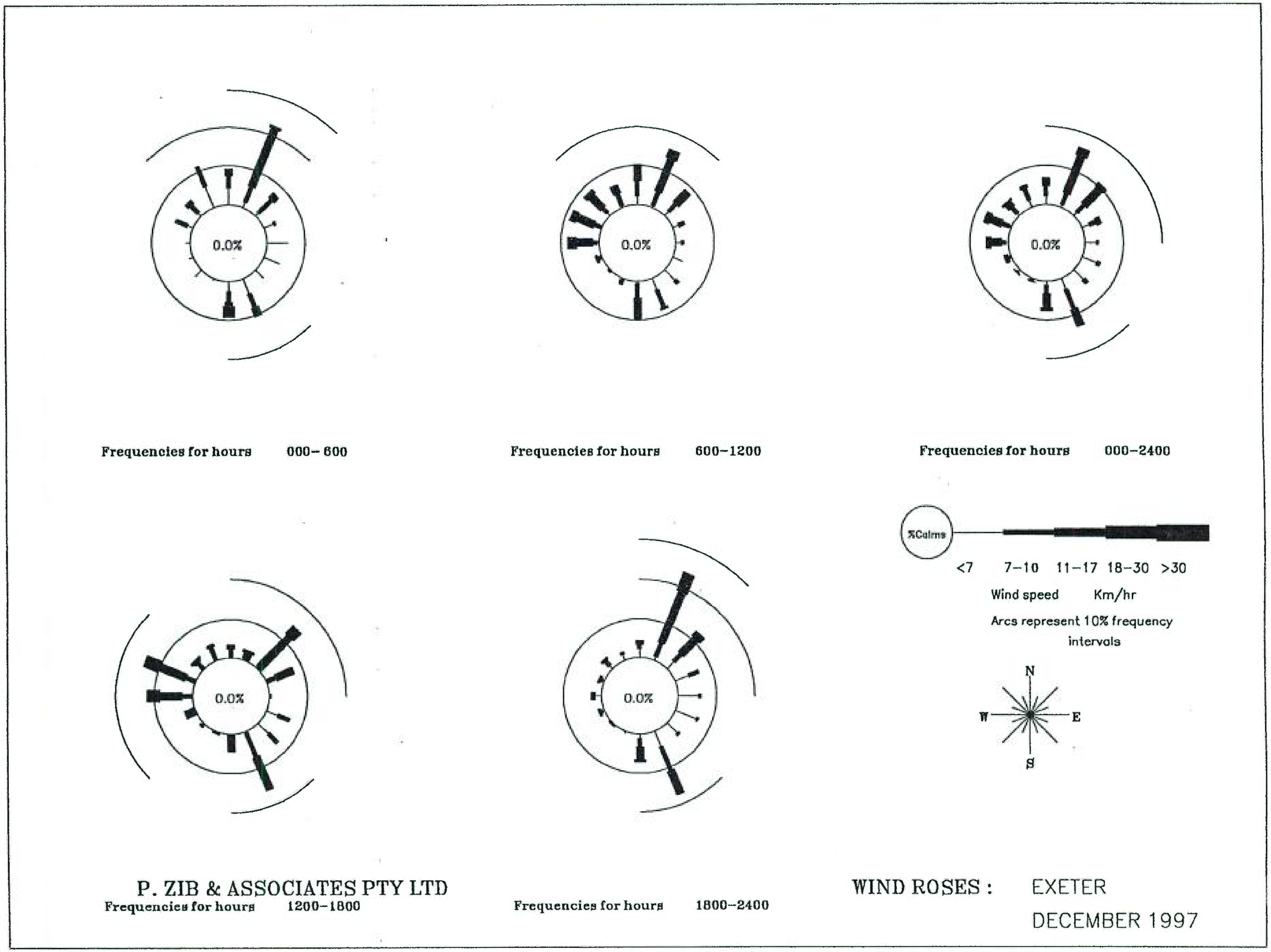
Frequencies for hours 1200-1800

Frequencies for hours 1800-2400

WIND ROSES : EXETER

NOVEMBER 1997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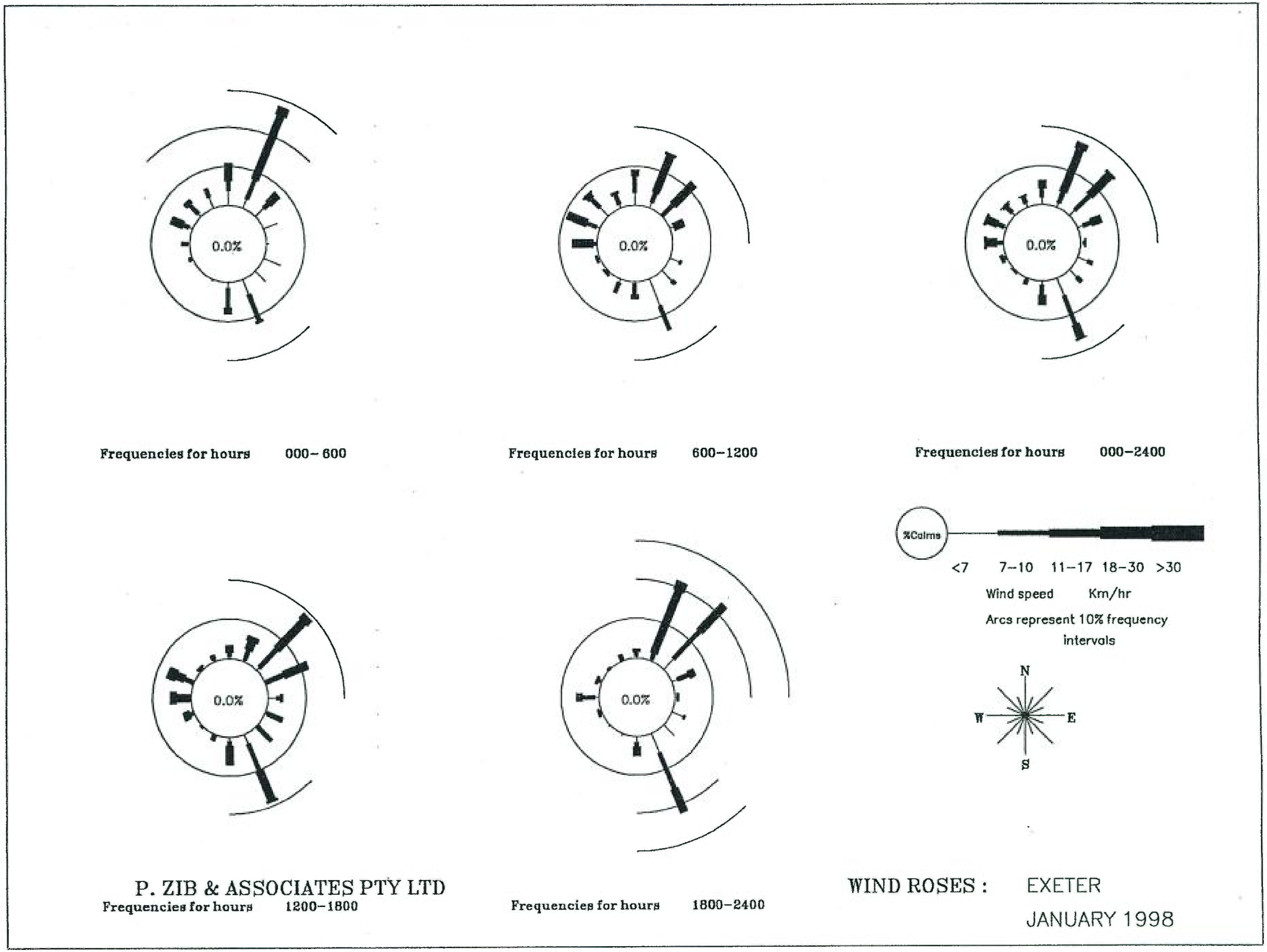
WIND ROSES : EXETER
DECEMBER 1997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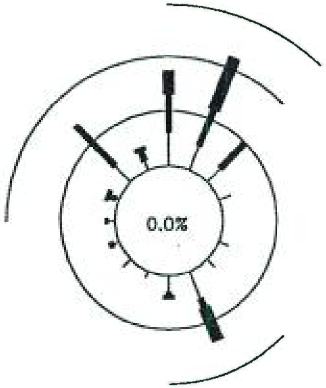
WIND ROSES : EXETER
JANUARY 1998



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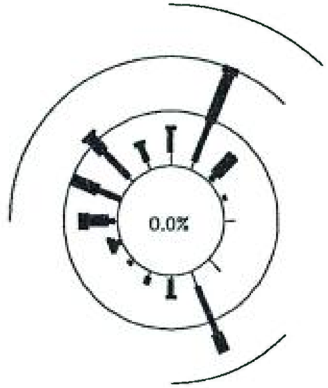

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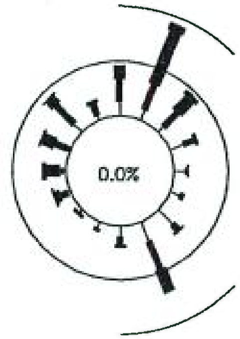

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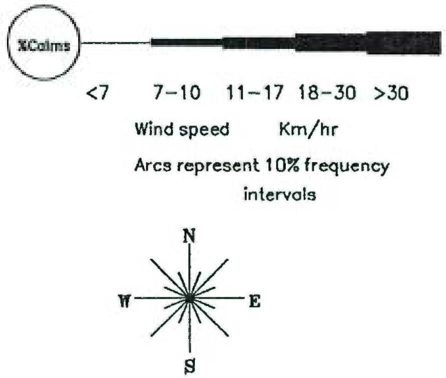

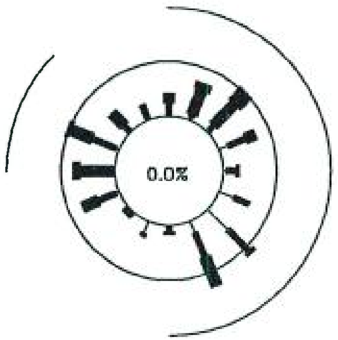

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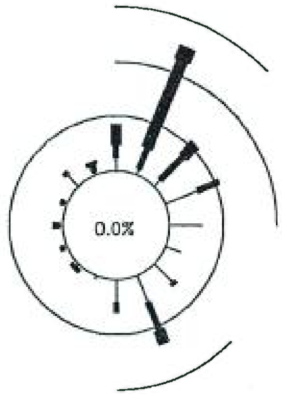
Frequencies for hours 1200–1800



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WIND ROSES : EXETER

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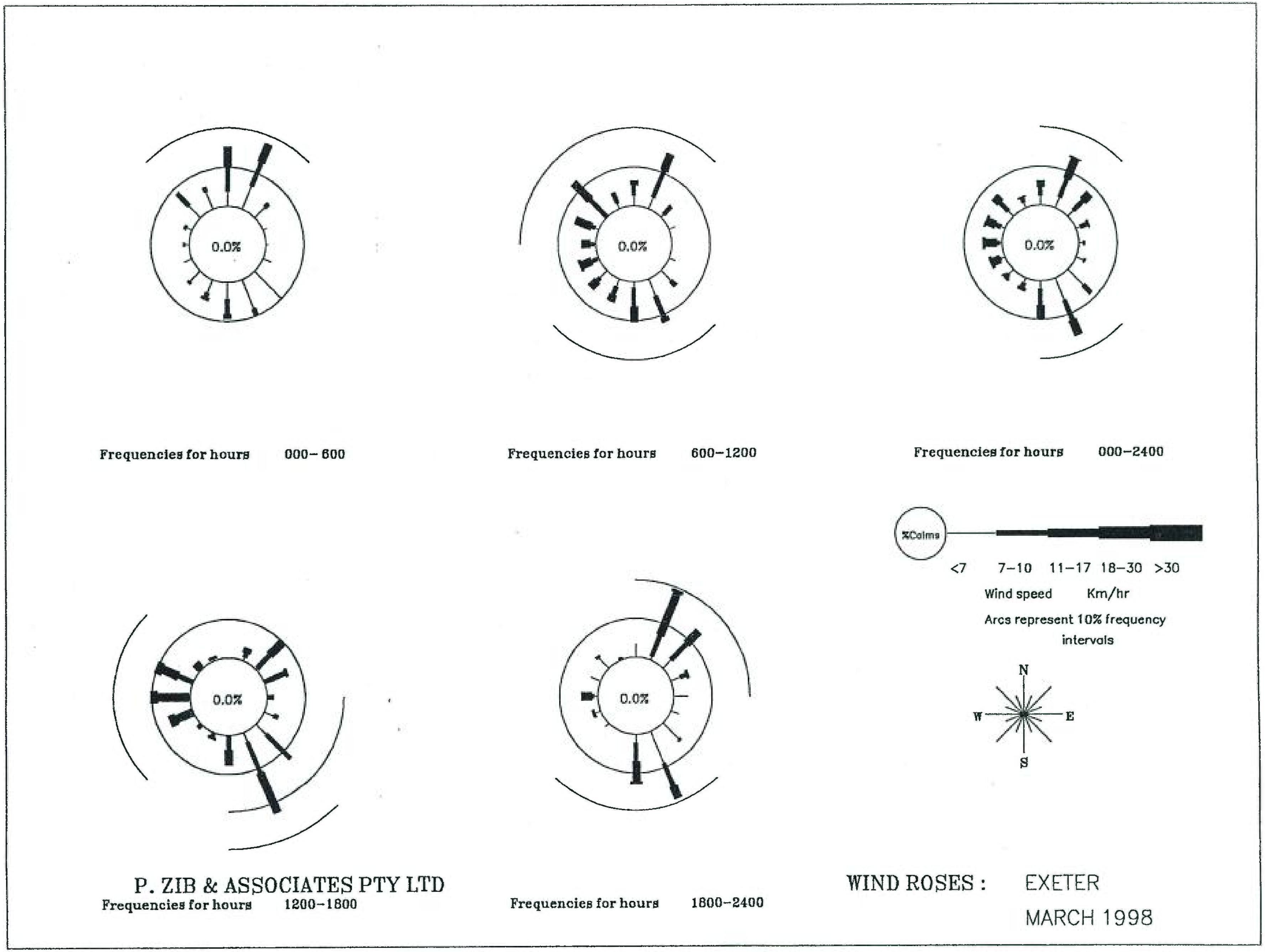
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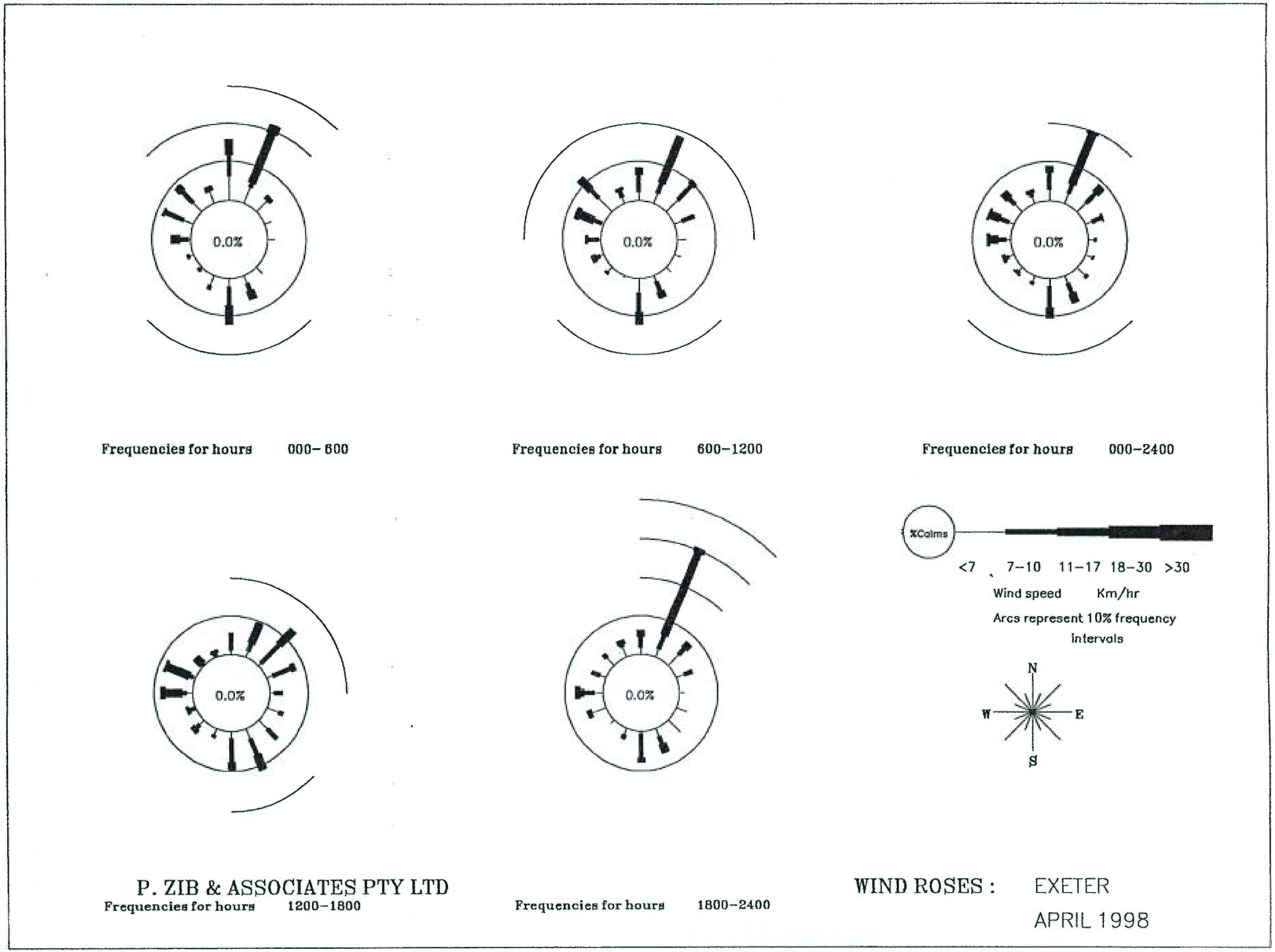
WIND ROSES : EXETER
MARCH 1998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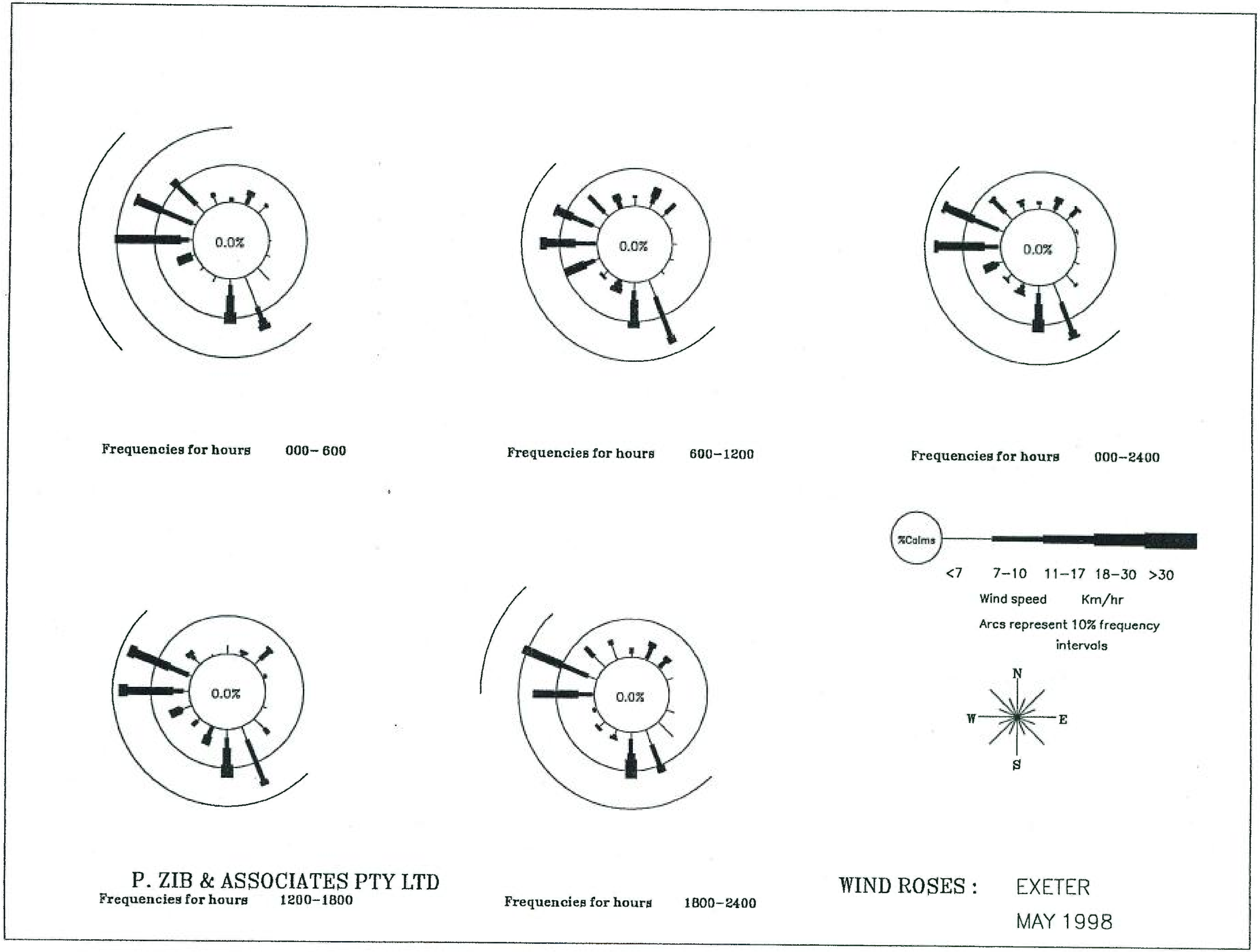
WIND ROSES : EXETER
APRIL 1998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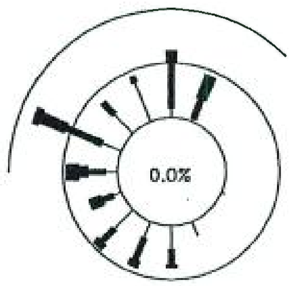
WIND ROSES : EXETER
MAY 1998



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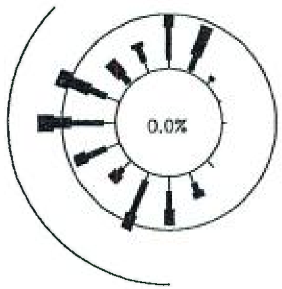

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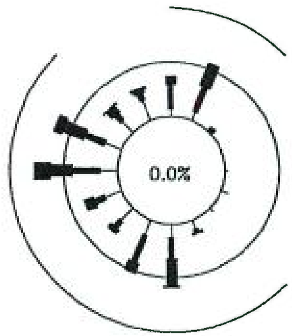

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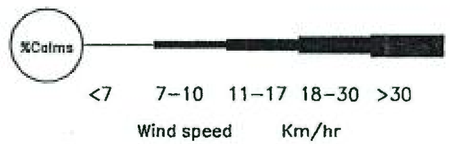
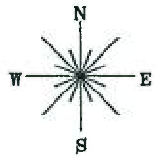
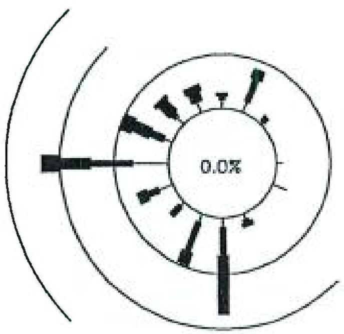


Arcs represent 10% frequency intervals





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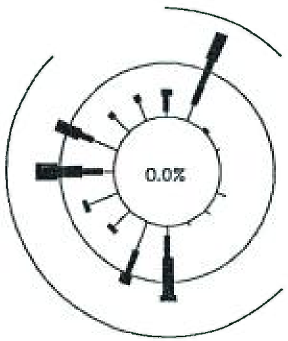
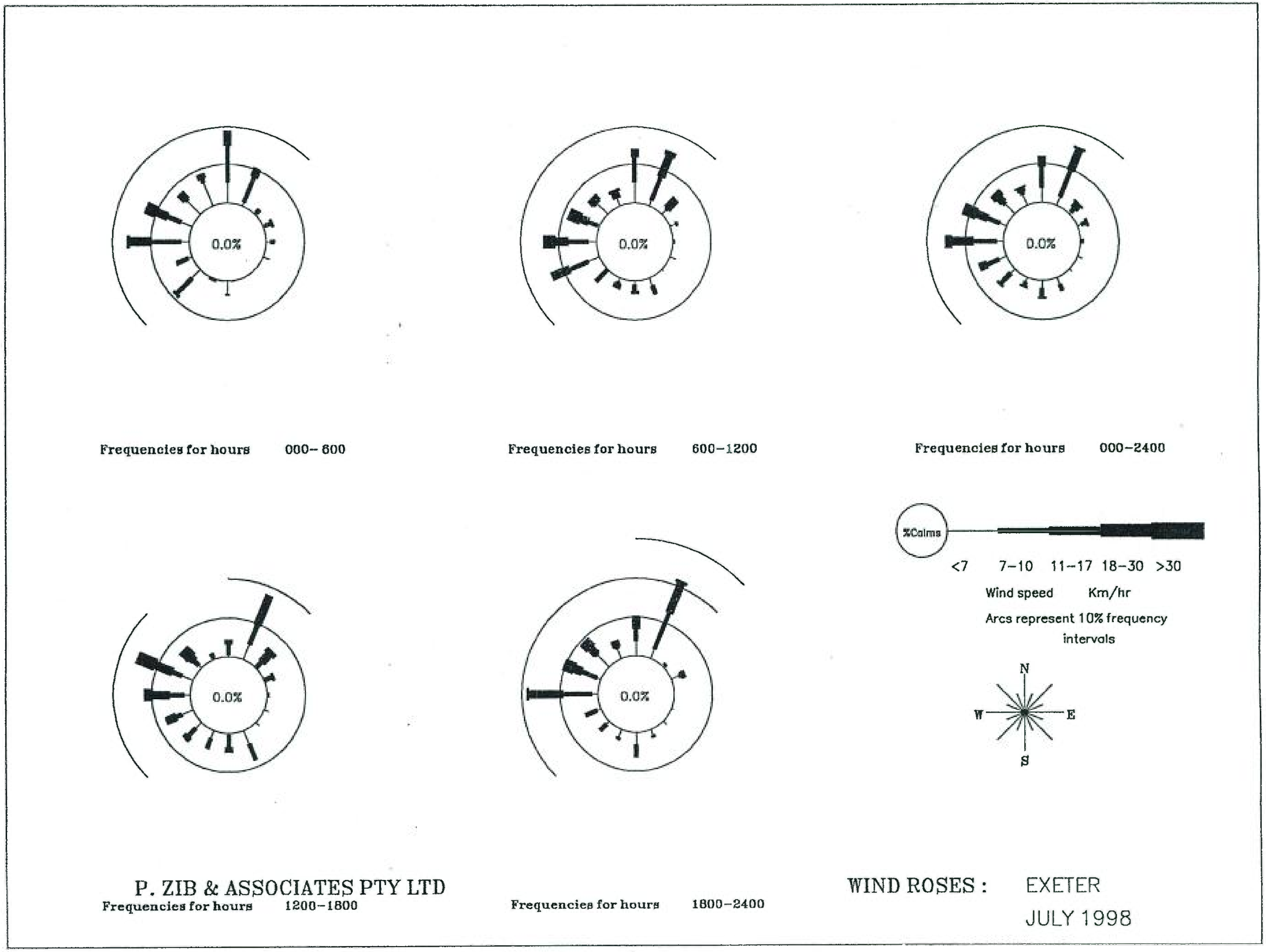


Frequencies for hours 1800–2400

P. ZIB & ASSOCIATES PTY LTD

WIND ROSES : EXETER
JUNE 1998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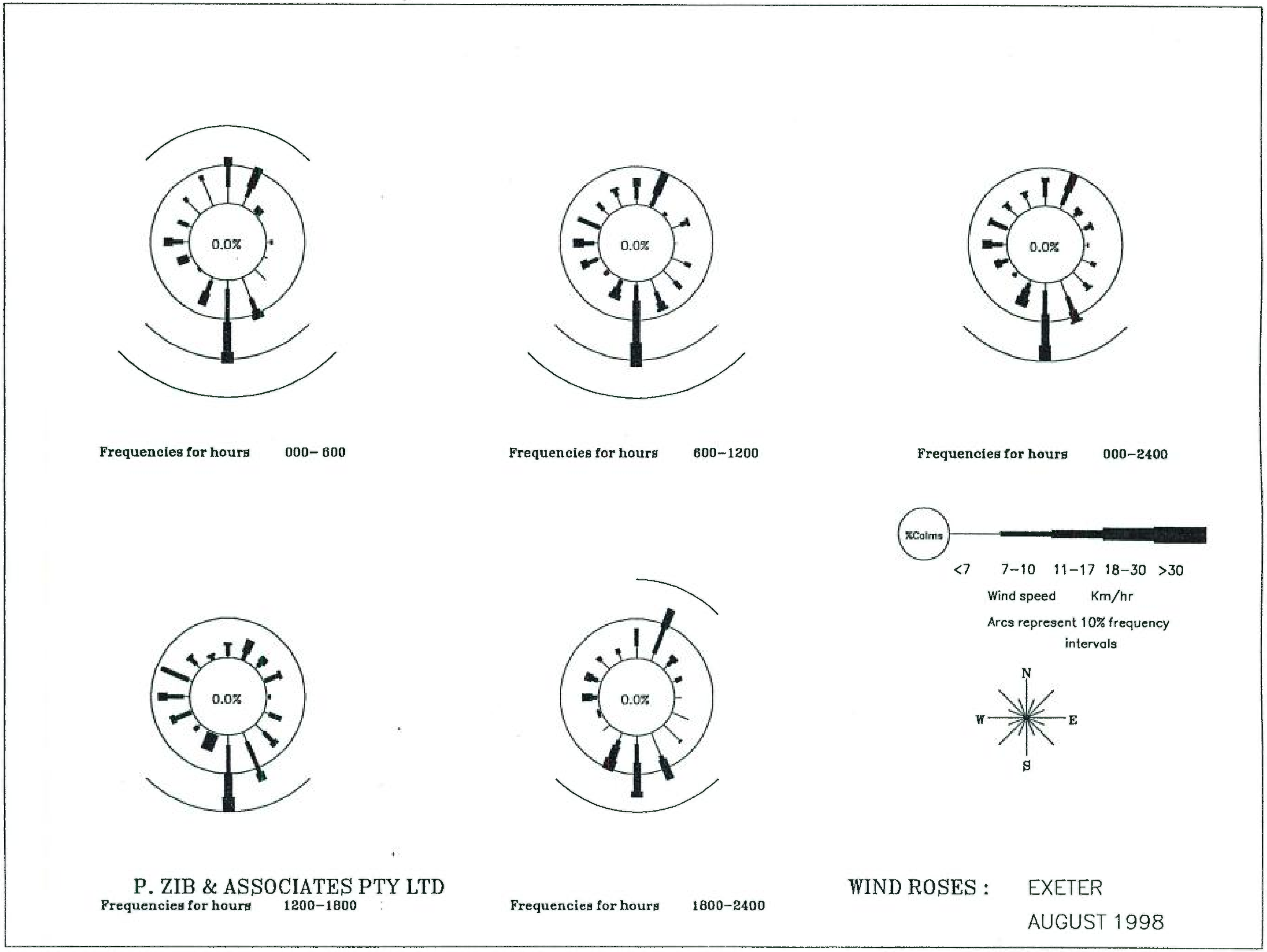
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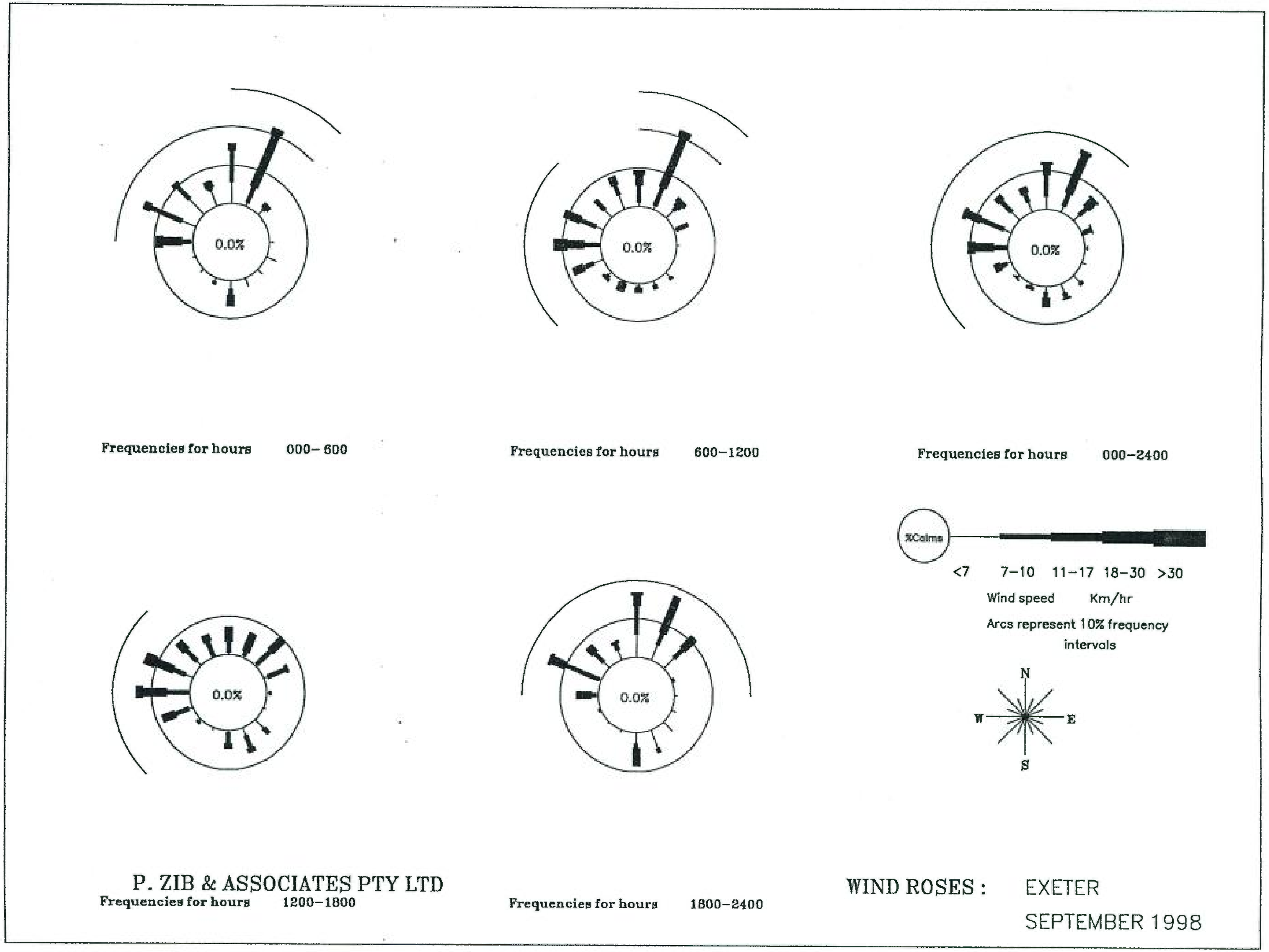
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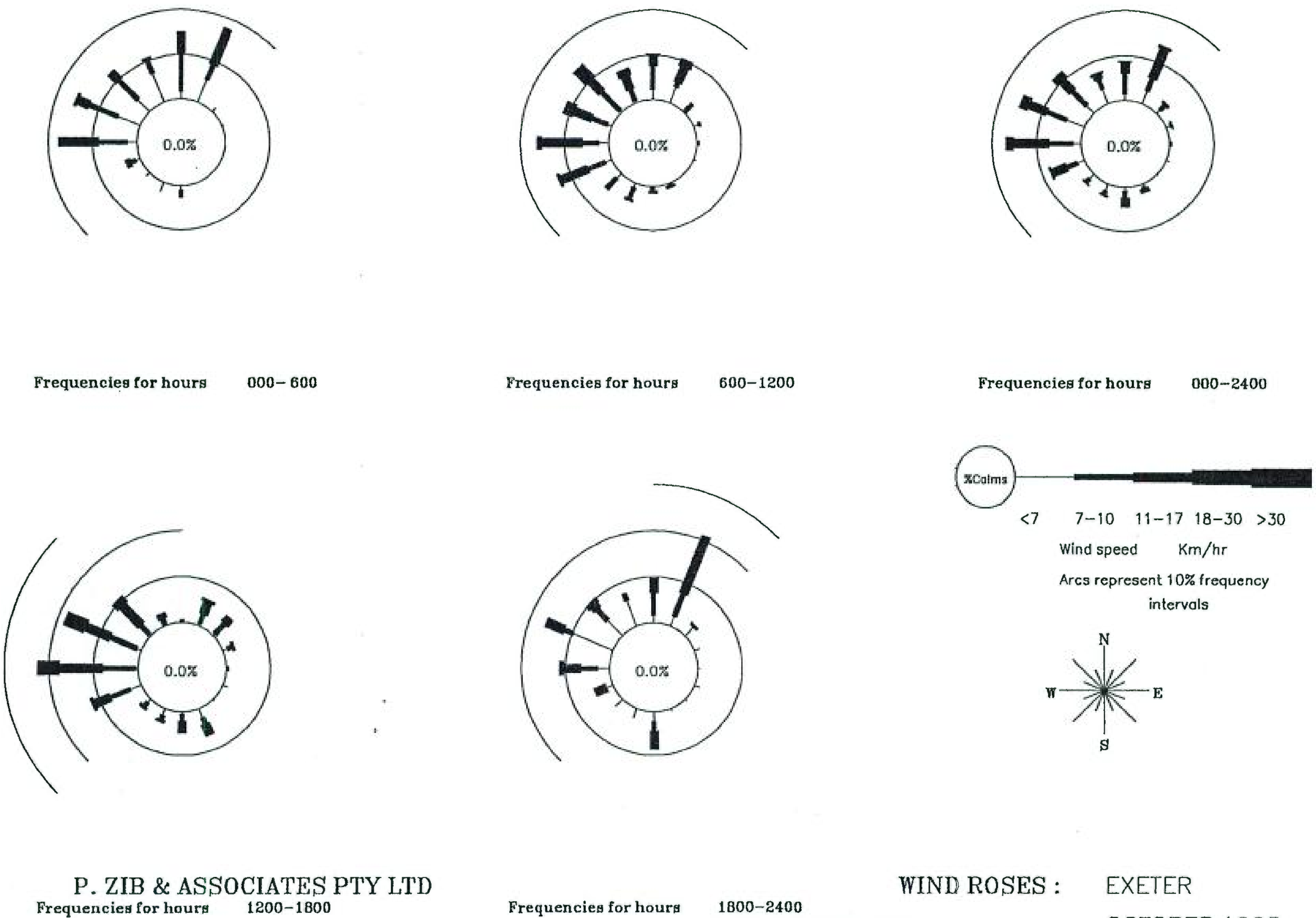

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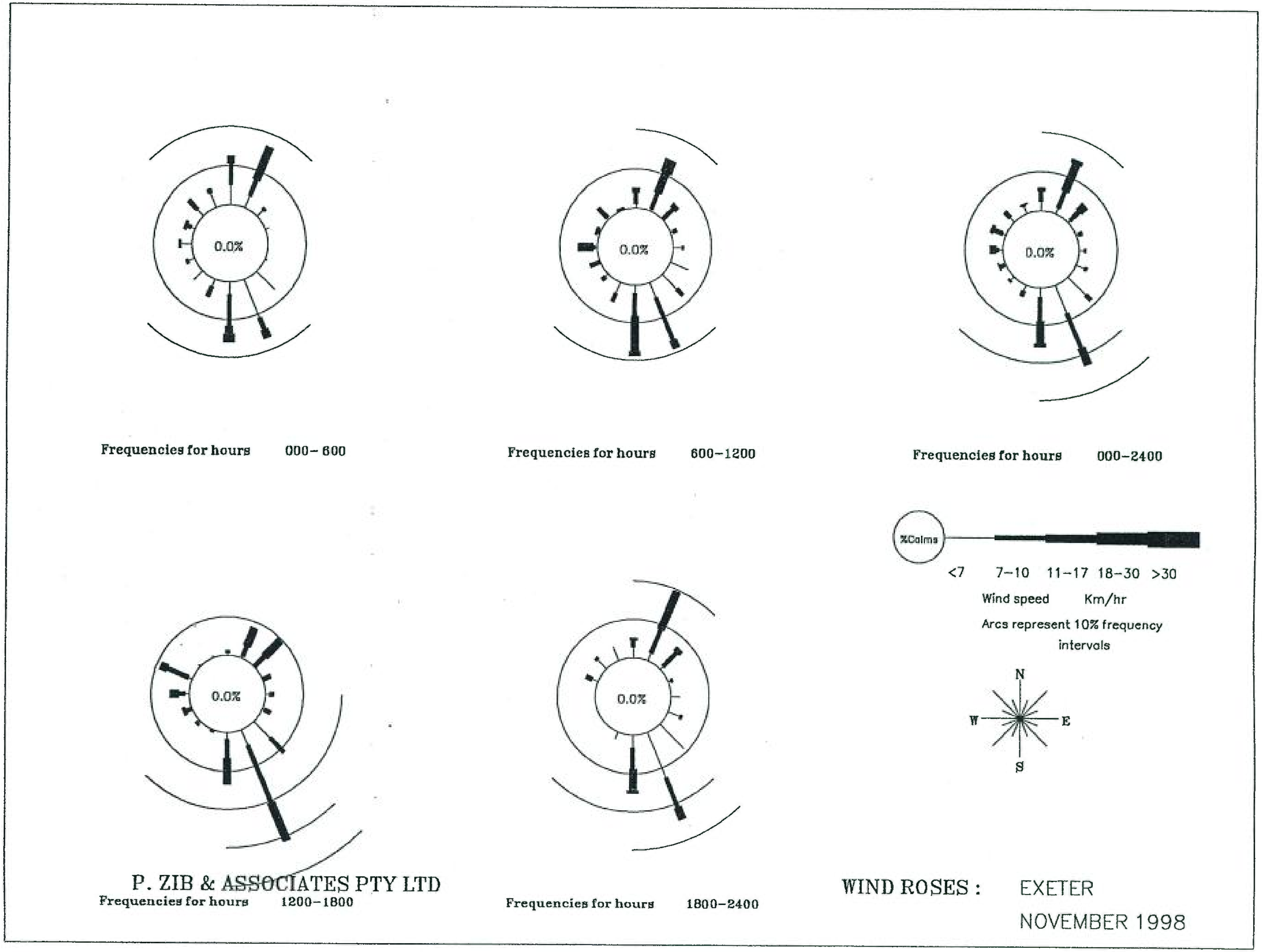
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WIND ROSES : EXETER
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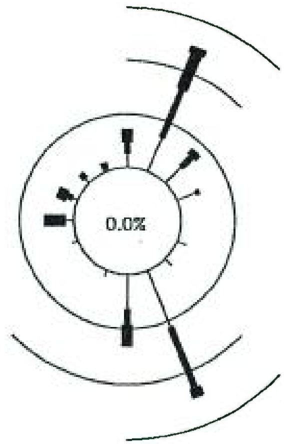

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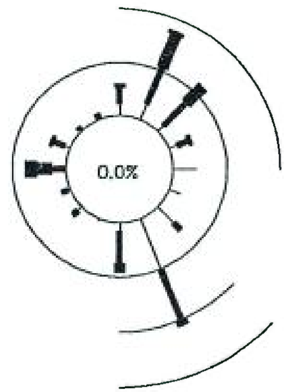

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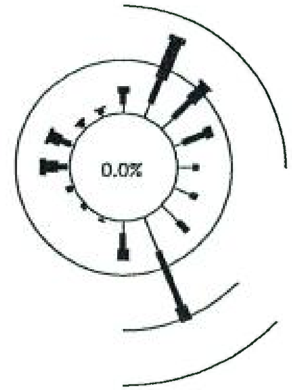

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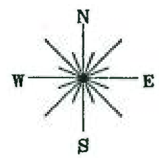

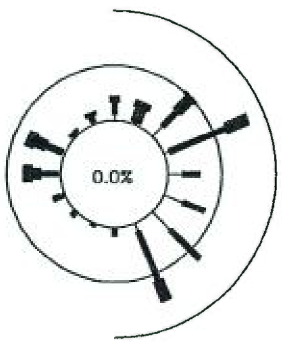

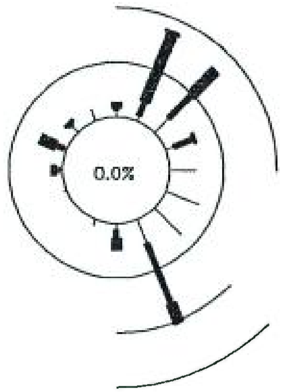

P. ZIB & ASSOCIATES PTY LTD

Frequencies for hours 1200–1800

Frequencies for hours 1800–2400

WIND ROSES : EXETER

DECEMBER 1998

Appendix 3. Dust emissions

Table A.3.1	Dust emission factors used in the study and the source of data
Table A.3.2	Dust emission inventory for extraction in Year 4
Table A.3.3	Dust emission inventory for extraction in Year 8
Table A.3.4	Dust emission inventory for site establishment (4 weeks duration)

Table A.3.1 Dust emission factors used in the study and the source of data

OPERATION	EMISSION FACTOR	REFERENCE
Overburden		
Topsoil removal (scraper)	14.0 kg/hr	SPCC (1983)
O/B loading (shovel)	0.025 kg/t	SPCC et al (1988)
Graders on roads	0.615 kg/km	USEPA (1988)
O/B haulage	2.00 kg/km	SPCC et al (1988) - after watering
O/B dumping	0.012 kg/t	SPCC et al (1988)
O/B spreading, reshaping (dozer)	$2.6\ s^{1.2}\ M^{-1.3}$ --> 16.7 kg/hr (s = 10%, M = 2%)	USEPA (1991)
Stone		
Drilling	0.6 kg/hole	SPCC (1983)
Blasting	$344\ A^{0.8}\ M^{-1.9}\ d^{-1.8}$	USEPA (1985)
Loading (excavator)	0.029 kg/t	USEPA (1988)
Haulage (feed)	2.00 kg/km	SPCC et al (1988) - after watering
Transport of product (sealed road)	$0.022\ I\ (4/n)\ (s/10)\ (L/280)\ (W/2.7)^{0.7}$ --> 0.04 kg/km (I =7, n =1, s =7.1%, L =3.8 kg/km, W = 25t)	USEPA (1990)
Exposed areas		
Wind erosion	0.40 kg/ha/hr	SPCC (1983)

Table A.3.2 Dust emission inventory for extraction in Year 4

OPERATION	EXTENT OF OPERATION	ANNUAL EMISSION	COMMENTS
Overburden			
Topsoil removal (scraper)	24 hrs/yr	0.3 t/yr	
O/B loading (shovel)	94 560 tpa	2.4 t/yr	
O/B haulage (backfilling)	4050 VKT/yr	8.1 t/yr	Mean distance = 0.75 km Load = 35 t/truck Regular watering assumed
O/B emplacement	94 560 tpa	1.1 t/yr	
O/B spreading, reshaping (dozer)	300 hrs/yr	5.0 t/yr	2.5 days/week, 15 weeks/year
	Subtotal	16.9 t/yr	
Stone			
Drilling	370 000 tpa	1.3 t/yr	75 per cent drilled and blasted 60 holes/blast Pattern = 3m x 3m, depth = 8m
Blasting	37 blasts/yr	3.3 t/yr	Area of blast = 540 m2 Emission = 90 kg/blast Moisture = 4%
Loading (to trucks)	485 000 tpa	14.1 t/yr	
Haulage (feed)			Load = 35 t/truck
In-pit Out-of-pit	10 750 VKT/yr 13 430 VKT/yr	21.5 t/yr 26.8 t/yr	0.4 km in-pit 0.5 km out-of-pit Regular watering assumed
Grading of haul roads	7200 VKT/yr	4.4 t/yr	Assumes 6 km/hr for 8 hrs/day, 150 days/year
Transport of product (sealed road)	57 600 VKT/yr	2.3 t/yr	Average load = 25 t/truck Distance = 1.6 km
	Subtotal	73.7 t/yr	

Exposed areas			
Wind erosion	4.0 ha	14.0 t/yr	Area = 250 m x 160 m
	Subtotal	14.0 t/yr	
	TOTAL =	**104.6 t/yr**	

Table A.3.3 Dust emission inventory for extraction in Year 8

OPERATION	EXTENT OF OPERATION	ANNUAL EMISSION	COMMENTS
Overburden			
Topsoil removal (scraper)	16 hrs/yr	0.2 t/yr	
O/B loading (shovel)	75 600 tpa	1.9 t/yr	
O/B haulage (backfilling)	4320 VKT/yr	8.6 t/yr	Mean distance = 1.0 km Load = 35 t/truck Regular watering assumed
O/B emplacement	75 600 tpa	0.9 t/yr	
O/B spreading, reshaping (dozer)	240 hrs/yr	4.0 t/yr	2 days/week, 15 weeks/year
	Subtotal	15.6 t/yr	
Stone			
Drilling	370 000 tpa	1.3 t/yr	75 per cent drilled and blasted 60 holes/blast Pattern = 3m x 3m, depth = 8m
Blasting	37 blasts/yr	3.3 t/yr	Area of blast = 540 m2 Emission = 90 kg/blast Moisture = 4%
Loading (to trucks)	485 000 tpa	14.1 t/yr	
Haulage (feed)			Load = 35 t/truck
In-pit	18 020 VKT/yr	36.0 t/yr	0.65 km in-pit
Out-of-pit	13 860 VKT/yr	27.7 t/yr	0.5 km out-of-pit Regular watering assumed
Grading of haul roads	9600 VKT/yr	5.9 t/yr	Assumes 6 km/hr for 8 hrs/day, 200 days/year
Transport of product (sealed road)	57 600 VKT/yr	2.3 t/yr	Average load = 25 t/truck Distance = 1.6 km
	Subtotal	90.6 t/yr	

Exposed areas			
Wind erosion	6.4 ha	22.4 t/yr	Area = 400 m x 160 m
	Subtotal	22.4 t/yr	
	TOTAL =	**128.6 t/yr**	

Table A.3.4 Dust emission inventory for site establishment (4 weeks duration)

OPERATION	EXTENT OF OPERATION	TOTAL EMISSION	COMMENTS
Construction of perimeter bund wall (7-18 hrs)			
2 x scraper	2 x 10 hrs/day	38.4 kg/day	
1 x dozer	10 hrs/day	19.2 kg/day	
Excavator	3000 t/4 wks	4.3 kg/day	10% of total excavated material
Extraction area (Areas 1 to 3)			
3 x scraper	3 x 10 hrs/day	57.6 kg/day	
Excavator	9000 t/4wks	13.0 kg/day	30% of total excavated material
Overburden emplacement			
2 x scraper	2 x 7 hrs/day	26.9 kg/day	
2 x dozer	2 x 3 hrs/day	11.5 kg/day	
Dual-road bund wall etc.			
1 x scraper	10 hrs/day	19.2 kg/day	
2 x dozer	2 x 5 hrs/day	19.2 kg/day	
Excavator	18 000 t/4wks	26.1 kg/day	60% of total excavated material
Truck haulage	700 VKT/4wks	70.0 kg/day	Mean distance = 0.4 km 35t load
	Subtotal	305.4 kg/day	

Wind erosion (18-7 hrs)			
Bund wall area	1.05 ha	2.7 kg/day	
Extraction area + O/B emplacement	4.2 ha	10.9 kg/day	
Dual road bund, dam etc.	2.0 ha	5.2 kg/day	
	Subtotal	18.8 kg/day	
	TOTAL =	**324.2 kg/day**	

Appendix 4. Curriculum Vitae of Pavel Zib

P. Zib & Associates Pty. Ltd. (A.C.N. 002 577 782)

CONSULTANTS

AIR QUALITY AND POLLUTION CONTROL

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- Air Quality Modelling/Monitoring
- Air Pollution Safeguards
- Expert Evidence
- Odour Assessment
- Surveys of Air Pollution Meteorology
- Processing of Field Data

CURRICULUM VITAE

Name:	Pavel Zib
Birthdate:	1943
Citizenship:	Australian
Affiliation:	Principal, P.Zib & Associates Pty Ltd P.O. Box 662, Warners Bay N.S.W. 2282
Qualifications:	M.E.(Mech.) (Czechoslovakia) Ph.D. (Env.Sci.) (University of Witwatersrand)
Association memberships:	Member, Clean Air Society of Australia and New Zealand Member, Air & Waste Management Association, U.S.A.
Experience:	Dr. Zib has over 25 years of experience in environmental matters with emphasis on air quality, air pollution safeguards and dispersion meteorology. His past activities included research, industry, government service and consulting. His work has been published in technical and scientific journals in several countries.

Dr. Zib has directed air quality and meteorological studies in New South Wales, Tasmania, Victoria, South Australia, Western Australia and Queensland. He has participated in public enquiries under the NSW environmental legislation and has given expert evidence in court cases in NSW, Victoria, Tasmania and Queensland.

Dr. Zib's experience with air quality assessment includes major industrial sources ranging from aluminium and steel production to power generation, chemical and ceramic industries, and extraction of mineral deposits and odour assessments. A full list of representative projects is available on request.

CONCRITE QUARRIES PTY LTD

EXETER QUARRY EXTENSION

FLORA AND FAUNA ASSESSMENT OF VINE LODGE AND PROPOSED EXTRACTION AREA, EXETER

Prepared by:

Australian Museum Business Services

March, 1999

Specialist Consultant Studies

Volume 1 ▪ Part 7

AMBS CONSULTING

Fauna and Flora Assessment of Vine Lodge and Proposed Extraction Area, Exeter

Prepared for R.W. Corkery & Co. Pty Limited

on behalf of

Concrite Quarries Pty Ltd

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March, 99

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Printed - 5 October, 1999

Project Team

Steven Priday...Ecologist (Project Manager)

Tom O'Sullivan...Ecologist (Project Officer)

Annexure 4 presents Curriculum Vitae for both Mr Priday and Mr O'Sullivan.

Summary

Australian Museum Business Services (AMBS) was engaged by R.W. Corkery & Co. Pty Limited on behalf of Concrite Quarries Pty Ltd to undertake an assessment of flora and fauna occurring within the proposed Exeter Bypass corridor within "Vine Lodge" and the proposed extraction area adjacent to the Exeter Quarry. This investigation followed an earlier assessment conducted by AMBS at Exeter Quarry in 1996.

Concrite Quarries Pty Ltd proposes to construct a bypass product transport route through the northern lot of a property known as "Vine Lodge" immediately to the north of the village of Exeter. The proposed extraction area located to the north of the existing extraction area has been reduced from the initial proposal.

Fauna and flora surveys were conducted across three days from 14 December to 16 December 1998. With the exception of microbats which were surveyed using the Anabat call recording system, fauna was surveyed by call recording, active searching and opportunistic observation. Fauna habitat was assessed in both areas. Flora surveys were conducted along the Exeter Bypass corridor using four 20m x 20m quadrats located across the area.

The vegetation on both sites is predominantly pasture dominated by exotic species. A few clumps of trees, mainly *Pinus radiata* and *Salix albens* occur throughout the site. No native tree species are present on the proposed Exeter Bypass product transport route. A small number of Narrow-leaved Peppermint (*Eucalyptus radiata*) occur on the proposed extraction area which is currently grazed by livestock (cattle).

Fourteen species of bird, including two introduced species, and three species of frog were recorded on the Exeter Bypass product transport route. These were all generally common species typical of disturbed habitats. Eleven species of bird and one reptile species were recorded within the proposed extraction area. Calls of at least three species of bat were recorded within the proposed extraction area. Two wombat (*Vombatus ursinus*) burrows and fox scats were observed within the proposed extraction area.

The eight part tests undertaken in the previous AMBS investigation were reviewed and the potential occurrence of any additional species listed on the Threatened Species Conservation (TSC) Act 1995 determined. Due largely to the absence of suitable habitats, none of the threatened vertebrate species identified as potentially occurring in the area were considered likely to occur on the sites. The Giant Dragonfly (*Petalura gigantea*), which has recently been listed on the TSC Act 1995, may occur within the Exeter Bypass corridor. An eight part test was conducted for this species. It was concluded that the proposal will not significantly affect this species.

Contents

Flora and Fauna Assessment of Vine Lodge and Proposed Extraction Area

1. Introduction

Australian Museum Business Services (AMBS) was engaged by R.W. Corkery & Co. Pty Limited on behalf of Concrite Quarries Pty Ltd to undertake an assessment of flora and fauna within the proposed Exeter Bypass within "Vine Lodge" and within the proposed extraction area at the Concrite quarry, Exeter. The two sites are located approximately seven kilometres southwest of Moss Vale.

Concrite Quarries Pty Ltd propose to construct a product transport route bypassing the village of Exeter through the northern lot of a property known as "Vine Lodge" which is located immediately to the north of the village. The proposed extraction area located to the north of the existing extraction area has been reduced from the initial proposal.

The aim of this assessment was to examine the proposal in relation to relevant flora and fauna legislation, specifically the Threatened Species Conservation (TSC) Act 1995.

2. Methods

2.1 Preliminary Investigations

Searches of the National Parks and Wildlife Service wildlife atlas and the Australian Museum databases were undertaken. These were conducted essentially to update the searches carried out by AMBS in the previous investigation (AMBS, 1996). A review of relevant literature was also conducted.

The subsequent field investigations were undertaken generally in the area of the previous survey reported upon in 1996 within the proposed extraction area and a corridor within the northern lot of "Vine Lodge" within which the Exeter Bypass product transport route would be located. For the purposes of this study, the area surveyed on "Vine Lodge" is referred to as the Exeter Bypass corridor.

It is noted that the area now referred to as the proposed extraction area is approximately 30 percent of the area identified as the proposed extraction area in the 1996 report prepared by AMBS. To assist readers, the latter is attached with the only modification being to identify the new proposed extraction area on those relevant plans.

2.2 Flora

Quadrat-based surveys were conducted as per the NPWS guidelines for vegetation mapping. Four quadrats of the dimensions 20m x 20m were located across the Exeter Bypass corridor (see Figure 1). Two quadrats were situated so as to include a portion of two of the clumps of trees on the site. One quadrat incorporated a small area of shrubbery. The remaining quadrat was situated so as to include the margins of a small stormwater retention pond at the western end of the corridor.

All plant species within each quadrat were recorded. No quadrats were located in the proposed extraction area as this area was examined during the earlier investigation by AMBS (AMBS, 1996 – Annexure 2).

2.3 Fauna

With the exception of microbats, which were surveyed using the Anabat call recording system, all fauna were recorded by call recording, active searching and opportunistic observation. Surveys were conducted across three days and two nights from 14 December to 16 December 1998.

Fauna habitats on both the Exeter Bypass corridor and the proposed extraction area were documented. Features such as vegetation structure, the occurrence of rocks and fallen logs and the presence of wetland habitats were noted.

3. Results

3.1 Flora

The two areas are characterised by disturbed pastures dominated by exotic species. The Exeter Bypass corridor contained rank grassland vegetation dominated by *Phalaris aquatica* and weeds such as the thistles *Sylibum marianum* and *Cirsium vulgare*. The lower sections of the western half of the corridor appeared to be subject to soaking and this was reflected in the dense growth of grasses and small sedges such as *Juncus articulatus*. Four small clumps of trees are located on this site. Two of the clumps are dominated by *Pinus radiata*, the other two mainly containing the willows *Salix babylonica* and *S.albens*.

A total of 43 species of plant were recorded on the Exeter Bypass corridor, of which 11 were native species. The flora assemblages on the proposed extraction area, based on the earlier investigation conducted by AMBS and examination during the current investigation, are very similar to those occurring on the Exeter Bypass corridor.

The results of the quadrat-based flora surveys are presented in Annexure 1.

3.2 Fauna

No original fauna habitats remain on the two sites with the exception of a small number of *Eucalyptus radiata*. The major habitats on both sites are open pasture. Rank grasslands and small areas of sedgeland and cumbungi (*Typha orientalis*) occur on the Exeter Bypass corridor. This appears to be related to the high water retaining properties of the ground on the lower slopes and the absence of livestock in the lower paddocks within the corridor.

Fourteen species of bird, including two introduced species, and three species of frog were recorded on the Exeter Bypass corridor. These were all generally common species typical of disturbed habitats. Ten species of bird and one reptile species were recorded from the proposed extraction area. Calls of three species of bat were recorded on the potential extraction area. A further two species may have been recorded but the calls were of insufficient quality to confirm their occurrence. No calls were detected from the Exeter Bypass corridor. Two wombat (*Vombatus ursinus*) burrows and fox scats were observed on the proposed extraction area.

Species commonly found in pastures, including the Stubble Quail (*Coturnix pectoralis*) and the introduced Skylark (*Alauda arvensis*) and Goldfinch (*Carduelis carduelis*), were observed on both study sites.

Table 1. Vertebrate Fauna Species Recorded on the Study Site.

Species	Common Name	Exeter Bypass Corridor	Proposed Extraction Area
Vombatus ursinus (burrows)	Common Wombat		+
Vulpes vulpes (scats)	European Red Fox*		+
Tadarida australis	White-striped Mastiff Bat		+
Chalinolobu gouldii	Gould's Wattled Bat		+
Vespadelus darlingtoni	Large Forest Bat		+
Vespadelus regulus	Southern Forest Bat		(+)
Mormopterus sp.	Free-tailed Bat		(+)
Coturnix pectoralis	Stubble Quail	+	+
Calyptorhyncus funereus	Yellow-tailed Black Cockatoo	+	
Platycercus eximius	Eastern Rosella	+	+
Platycercus elegans	Crimson Rosella	+	+
Eudynamus scolopacea	Koel	+	
Cacomantis flabelliformis	Fantailed Cuckoo		+
Malurus cyaneus	Superb Fairy-wren	+	
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		+
Acanthiza pusilla	Brown Thornbill		+
Rhipidura fuliginosa	Grey Fantail	+	
Gymnorhina tibicen	Australian Magpie	+	+
Corvus coronoides	Australian Raven	+	+
Carduelus carduelus	European Goldfinch*	+	
Alauda arvensis	Skylark*	+	
Acrocephalus stentoreus	Clamorous Reed Warbler	+	
Cisticola exilis	Golden-headed Cisticola	+	
Zosterops lateralis	Silvereye		+
Sturnus vulgaris	Common Starling*		+
Drysdalia coronoides	White-lipped Snake		+
Crinia signifera	Common Eastern Froglet	+	
Lymnodynastes peroni	Striped Marsh Frog	+	
Litoria verrauxi	Verruax Tree Frog	+	

*Introduced species
(+) Echolocation calls probably of these species but recordings of insufficient length to confirm

Suitable habitat of the Giant Dragonfly (*Petalura gigantea*), which has recently been listed on Schedule 1 of the TSC Act 1995, may occur in the wetland area on the proposed Exeter Bypass corridor. This wetland is highly degraded and dominated by exotic species such as *Salix albens* (see Figure 1). The Giant Dragonfly has been recorded at the Wingecarribee Swamp near Moss Vale.

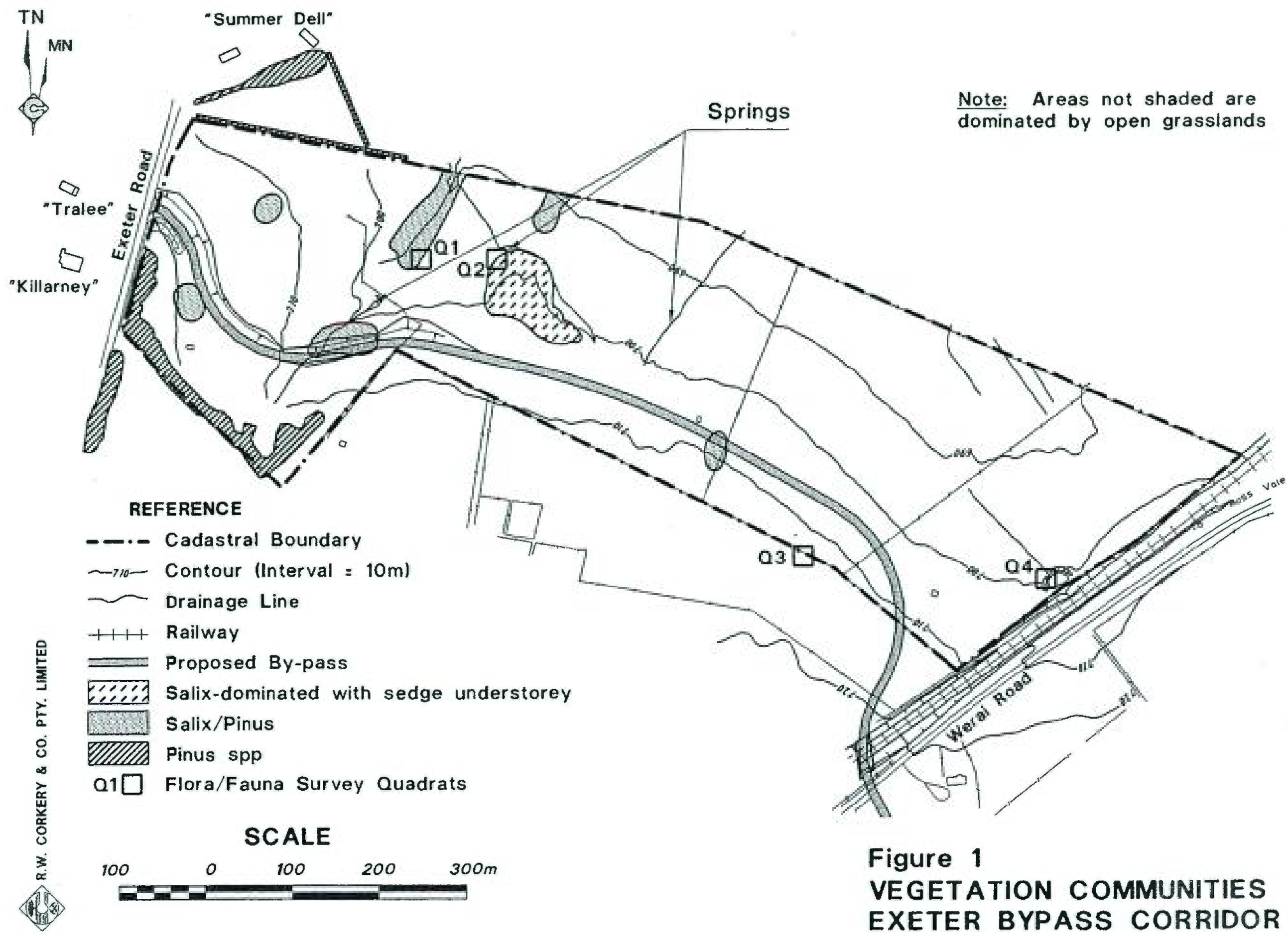

Figure 1
VEGETATION COMMUNITIES EXETER BYPASS CORRIDOR

4. Discussion

There are no major issues concerning fauna and flora with respect to the potential extraction area and the proposed Exeter Bypass corridor at the Exeter quarry. The disturbed nature of the site and paucity of natural habitats precludes the occurrence of most species of conservation significance expected to occur in the region based on database searches and the availability of habitats nearby.

The previous assessment undertaken on the proposed extraction area by AMBS (AMBS, 1996) identified the potential occurrence of five fauna species listed on the Threatened Species Conservation Act 1995 for the study area examined in that investigation. Eight part tests were undertaken for all of these species which are listed below:

- Green and Golden Bell Frog (*Litoria aurea*)
- Powerful Owl (*Ninox strenua*)
- Masked Owl (*Tyto novaehollandiae*)
- Common Bentwing Bat (*Miniopteris schriebersii*)
- Tiger Quoll (*Dasyurus maculatus*)

Of these species, there is potentially suitable habitat for the Green and Golden Bell Frog on the Exeter Bypass corridor. However, this species was not recorded during the surveys during suitable conditions (other frog species were calling). Furthermore, this species has not been recorded from the southern highlands for several years (White and Pyke, 1996). The Common Bentwing Bat, if it occurs in the area may forage sporadically on site but it generally requires larger wooded areas for foraging (AMBS, 1995).

As none of the above species are expected to occur on the study sites, eight part tests were not undertaken. An eight part test was conducted for the Giant Dragonfly. Insufficient information on the biology of the Giant Dragonfly is available at this stage. However, as this species has not been observed for several years in most parts of its distribution, the potential wetland habitat for the species on the site is highly degraded and the proposed transport route will avoid this potential habitat area within the corridor, it is highly unlikely that this species will be affected by the proposal.

There are no issues concerning species listed on the Threatened Species Conservation Act 1995 with respect to the proposed Exeter bypass corridor and the proposed extraction area.

5. Revegetation

All rehabilitation works conducted on the quarry site should be conducted using plants grown from seeds or other propagating material collected from species of local provenance. Rather than using exotic grass species to provide initial stabilisation of soils on the site, a common practice for binding soil in disturbed areas (eg. mine sites, roadsides), native grasses can be used. Species such as *Microlaena stipoides, Themeda triandra, Poa sieberiana* and *Danthonia racemosa* may be suitable for this purpose.

Shrub and tree species can be planted concurrently with grass species. Colonising species such as *Acacia mearnsii* can be either planted from tube stock or directly sown. Common *Eucalyptus* spp. in the area including *E. radiata, E. elata* and *E. quadrangulata* can be planted from tube stock. Shrub species such as *Hardenbergia violaceae* are often used as colonising species for stabilising bare soil. This species may also be planted using seed or tube stock. Following the establishment of vegetation on the site, any of the native herbaceous species recorded in both the 1996 or 1999 investigations may also be planted.

6. References

AMBS (1995). *Fauna Impact Statement for Proposed Demolition of Disused Balmain Power Station – "A" Station.* Unpublished report prepared for Pacific Power.

AMBS (1996). *Flora and Fauna Investigation for Proposed Extension, Exeter, NSW.* Unpublished report prepared for R.W. Corkery & Co. Pty Ltd

White, A.W. and Pyke, G.H. (1996). Distribution and conservation status of the Green and Golden Bell Frog *Litoria aurea* in New South Wales. *Australian Zoologist* 30(2): 177-189.

Annexure 1. Flora Survey Results: Exeter Bypass Corridor

Inc. = Incidental records.

Family	Species	Common Name	Quad. 1	Q2	Q3	Q4	Inc.
CONIFEROPSIDA							
PINACEAE	*Pinus radiata**	Radiata Pine					+
ANGIOSPERMS							
DICOTYLEDONS							
ASTERACEAE	*Cirsium vulgare**	Spear Thistle	+	+	+	+	
	*Conyza bonariensis**	Flax-leaf Fleabane	+				
	Gnaphalium sphaericum	Common Cudweed			+		
	*Hypochaeris radicata**	Cats Ear	+	+	+	+	
	*Sylibum marianum**	Variegated Thistle	+	+	+	+	
	*Sonchus asper**	Rough Sowthistle	+	+	+	+	
	*Sonchus oleraceus**	Common Sowthistle	+				
	*Taraxacum officinale**	Dandelion				+	
BERBERIDACEAE	*Berberis aristata**	Barbery					+
BORAGINACEAE	*Echium plantaginium**	Paterson's Curse			+		
CARYOPHYLLACEAE	*Silene gallica**	French Catchfly		+	+		
DIPSACACEAE	*Dipsacus fullonum* ssp. *fullonum**	Wild Teazle	+	+			
FABACEAE	*Vicia* sp.*	Vetch			+		
	*Trifolium repens**	White Clover	+	+	+	+	
	Trifolium sp.*	Clover			+		
OXALIDACEAE	*Oxalis corniculata**	Yellow Wood Sorrel					+
PLANTAGINACEAE	*Plantago lanceolata**	Plantain	+	+	+	+	
POLYGONACEAE	*Polygonum aviculare**	Knotweed		+	+		
	*Rumex brownii**	Swamp Dock	+	+	+	+	
PRIMULACEAE	*Anagallis arvensis**	Pimpernel			+	+	
RANUNCULACEAE	*Ranunculus* sp.		+	+	+	+	
ROSACEAE	*Rubus* sp.*	Blackberry	+	+	+		
RUBIACEAE	*Galium aparine**	Cleavers			+		
SALICACEAE	*Salix babylonica**		+				
	*Salix albens**		+	+			

Family	Species	Common Name	Quad. 1	Q2	Q3	Q4	Inc.
SOLANACEAE	*Lycium ferocissimum**	African Boxthorn			+		
	*Solanum nigrum**	Blackberry Nightshade					+
MONOCOTYLEDONS							
CYPERACEAE	*Cyperus exaltatus*						
	Cyperus sp.						
	Eleocharis acuta	Common Spikerush		+			
JUNCACEAE	*Juncus articulatus*	Jointed Rush	+	+			
	Juncus sp.						
POACEAE	*Bromus* sp.	Brome					
	Cynodon dactylon	Couch		+			
	*Echinocloa crus-galli**	Barnyard Grass					+
	*Holcus lanatus**	Yorkshire Fog					
	Lolium sp.*	Ryegrass	+	+	+	+	
	*Paspalum dilatatum**	Paspalum	+	+	+	+	
	Paspalum paspalodes	Water Couch				+	
	*Phalaris aquatica**	Phalaris	+	+	+	+	
	*Poa annua**					+	
TYPHACEAE	*Typha orientalis*	Cumbungi		+			

*Introduced Species

Annexure 2. Eight Part Test for the Giant Dragonfly

Giant Dragonfly (*Petalura gigantea*)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction

There is no evidence to suggest that a viable local population of this species occurs on the study site. There is a small degraded wetland on the site dominated by weed species such as *Salix alba*.

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

There are no endangered populations of this species listed in the TSC Act 1995.

(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

The potential habitat of this species on the study site will not be affected by the proposed corridor.

(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

The potential habitat on the study site for the species is currently isolated within an agricultural landscape. The proposal will not result in further isolation of this potential habitat.

(e) whether critical habitat will be affected

Critical habitat for this species has not been defined in the TSC Act 1995.

(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region

This species has been recorded from the Wingecarribee Swamp near Moss Vale. There is insufficient understanding of the abundance of the species to determine its conservation status in reserves in the region (based on information provided in the Final Determination of the NSW Scientific Committee).

(g) whether the development or activity is of a class of development or activity that is recognised as a threatening process

To date, the only threatening processes listed on the schedules of the TSC Act 1995 are predation on native species by the Fox (*Vulpes vulpes*), predation by *Gambusia holbrooki* (Plague Minnow) and invasion of native plant communities by *Chysanthemoides monilifera.*

(h) whether any threatened species, population or ecological community is at the limit of its known distribution

This species is distributed from southern Queensland to Moss Vale. Any populations on the study site would be at the limit of the known distribution of this species.

Conclusion:

Because the proposed road has been aligned to avoid the wetland areas and the wetland on the site is highly degraded, the proposal is unlikely to have a significant affect on habitat of this species. A Species Impact Statement is therefore not required for this species.

Annexure 3. 1996 AMBS Report

Flora and Fauna Assessment of Exeter Quarry

(Note: This report remains unchanged with the exception of Figures 1, 2 and 3 which have been updated to identify the proposed extraction area for the 1999 proposal.)

AMBS
CONSULTING

Flora and Fauna Investigations for proposed extension, Exeter, NSW

for R.W. Corkery & Co. Pty Ltd
on behalf of Concrite Quarries Pty Ltd.

May 1996

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Printed - 27 September, 1996

Contents

APPENDIX 4: CURRICULUM VITAE 55

Summary

This report summarises the findings of a flora and fauna evaluation conducted for the proposed extension of Exeter hard rock quarry. The owner and operator of the quarry, Concrite Quarries Pty Ltd. has recently acquired an area of land immediately to the north-west of their existing approved quarry and processing plant, and propose to extend basalt quarrying into this area. The evaluation was based upon a field survey for flora (22nd and 23rd April 1996), data base searches and literature review.

As a result of past land use much of the original native vegetation has been cleared from the study area, which consists of a plateau in the western portion, and a valley system (including a small creek) in the central and eastern portions. Virtually all that remains of the original vegetation are patches of open forest and woodland in the valley. The understorey of these has been disturbed by grazing and invasion by exotic (weed) species including *Rubus fruticosa* (Blackberry). The plateau and sections of the southern side of the valley have been cleared of the original native vegetation and grassland now dominates. Much of the creekline is significantly impacted by weed invasion, particularly in the central portion of the study area, although several semi-aquatic herbaceous native species, including *Persicaria* spp. (Knotweeds) and ferns still occur.

The wooded vegetation in the valley consists of Open Forest dominated by native species typical of the Southern Highlands Shale Woodlands and Robertson Basalt Tall Forest described in Benson (1995). Dominant canopy species include *Eucalyptus cypellocarpa* (Mountain Grey Gum), *E. quadrangulata* (White-topped Box), *E. globoidea* (White Stringybark) and *E. elata* (River Peppermint). Although much of the native understorey has been cleared, *Poa labillardieri* (Tussock Grass) and *Acacia mearnsii* (Black Wattle) are present as dominant understorey species.

The field survey detected more than 100 species of vascular plants, approximately 70 per cent of these being native species. This number would increase slightly with increased survey effort. National Parks & Wildlife Service (NPWS) database searches revealed that a number of flora species listed in the Threatened Species Conservation Act (1995) are known from the general area. No such species were detected during the current survey. Based on an assessment of vegetation condition and habitat availability, it is unlikely that any of these species occur in the study area.

Habitat analysis revealed that the cleared plateau in the western portion of the study affords poor quality habitat for native fauna, apart from small reptiles (such as skinks) and frogs which may utilise debris (such as corrugated iron) present in the cleared area as sheltering sites. Herbivorous mammals such as *Macropus giganteus* (Eastern Grey Kangaroo) would also be expected to utilise the cleared area, as foraging habitat. In contrast, the open forest and woodland in the eastern portion offer:

- good foraging and nesting habitat for many forest bird species, particularly insectivorous birds;

- marginal nesting/sheltering habitat for hollow-dependent fauna, such as some owl species, arboreal mammals and reptiles;

- good foraging habitat for many mammal species, particularly common species such as *Vombatus ursinus* (Common Wombat), *Petaurus breviceps* (Sugar Glider), *Macropus giganteus* and *Wallabia bicolor* (Swamp Wallaby).

The creek, though disturbed in parts by cattle grazing and past clearing, offers suitable habitat for many aquatic species including frogs, *Crinia signifera* (Common Eastern Froglet) and *Limnodynastes peronii* (Brown-striped Frog) and macroinvertebrates such as *Cherax destructor* (Yabby).

At least 6 species of Threatened fauna, including the *Dasyurus maculata* (Spotted-tailed Quoll), *Phascolarctos cinereus* (Koala), *Petaurus australis* (Yellow-bellied Glider), *Calyptorhynchus lathami* (Glossy Black-cockatoo), *Litoria aurea* (Green and Golden Bell Frog) and *Myxophyes balbus* (Stuttering Frog) have been detected in the vicinity of the study area. No such species, or evidence thereof, were detected during the current survey.

The eight-point test of significance for Threatened species has been applied in this report and based on a habitat assessment, a species impact statement is not required for any Threatened species of flora or fauna.

Measures that could help to ameliorate potential impacts include:

- restriction of quarry extraction to the cleared plateau section of the study area;
- retention of native vegetation within the valley area, to reduce sediment runoff from the quarry site and to maintain habitat for native fauna species such as amphibians;
- control/reduction of weed infestation, particularly along the creekline;
- retention of open forest and woodland in the eastern portion to maintain connectivity with the wildlife corridors extending east and south-east from the study area;
- construction of siltation ponds to minimise impact of runoff and sedimentation on creek system; and
- incorporation of maintenance program for siltation pond into plant operations.

Flora and Fauna Investigations for Proposed Quarry Extension, Exeter, NSW.

1. Introduction

The land proposed for the extension of Exeter hard rock quarry (referred to hereafter as 'the study area') covers an area of approximately 62 ha (Figure 1). The proposed quarry extension is situated adjacent to the existing Exeter quarry and processing plant, which is located approximately 8 km south of Moss Vale and approximately 0.6km east of Exeter Village. The proposed development will be the subject of a Development Application to be lodged with Council, by the quarry owner and operator, Concrite Quarries Pty Ltd.

Australian Museum Business Services was invited by RW Corkery & Co. Pty Ltd (Geological and Environmental Consultants) to undertake an investigation of the flora and fauna occurring on the site of the proposed quarry extension. The aims of this investigation were to:

- Describe the vegetation communities of the study area both structurally and floristically, and to map these;
- Assess the significance of the vegetation communities and plant species and examine the linkages of areas of bushland within the study area with others nearby;
- Determine the fauna habitats present and the fauna communities associated with them within the study area. Provide fauna species lists showing those species detected and those considered likely to occur in the habitats available within the study area, highlighting any endangered fauna listed in Schedule 1 or 2 of the Threatened Species Conservation Act (1995). Map the distribution of fauna habitats on site and assess their values;
- Include an endangered fauna assessment (Section 5A of the Environmental Planning and Assessment Act 1979 as amended by the Threatened Species Conservation Act 1995, known as the eight point test) for any endangered fauna likely to use the study area and indicate the need for a Species Impact Statement;
- Assess the significance of the fauna species and habitats present within the study area and examine the impacts of the proposed development on these. Provide recommendations for any feasible mitigation measures to reduce perceived adverse impacts on fauna;
- Assess the impact of the proposed development on the flora and fauna;
- Assess the need for further field work for flora and/or fauna.

2. Description of Study Area

2.1 Location

The study area is located adjacent to the northern boundary of an existing quarry operated by Concrite Quarries Pty Ltd. The existing quarry is located along Rockleigh Road, approximately 0.6 km east of the village of Exeter, in the Southern Highlands of New South Wales (Figure 2). Agricultural land, with remnants of native vegetation, surrounds the study area to the north and east. The study area is situated approximately 5 km north of Morton National Park and approximately 4 km west of Meryla State Forest.

2.2 Climate

Climate for the Southern Highlands is represented by the climatic data for Mittagong, which has a mean summer maximum of 25°C and a mean winter minimum of 2.5°C. The average annual rainfall for the Southern Highlands is 900 mm per year, most of which occurs during the summer months.

2.3 Topography/Geology

The western portion of the study area consists of a plateau, whilst the central and eastern portions consist of a valley system containing a small creek. Elevation ranges from 600 m a.s.l. to 740 m a.s.l.. Geological units underlying the study area include Triassic Wianamatta Group shale (in the valley) and Robertson basalt (underlying the plateau), resulting in relatively fertile soils.

2.4 Land Use

At present, Concrite Quarries Pty Ltd operates a hard rock processing plant within the study area. This is located on the southern side of the valley, upslope from the creekline. Past logging practices has resulted in removal of much of the open forest and woodland, leaving remnants in the valley system, whilst vegetation clearance has removed most of the original understorey species. Grazing is currently carried out within the study area, including along the creekline.

Land uses, both past and present, have resulted in vegetation communities and associated habitats altered from that which originally occurred within the study area. Such alterations include grassland dominated by exotic species, and the absence of a well-developed native shrub understorey.

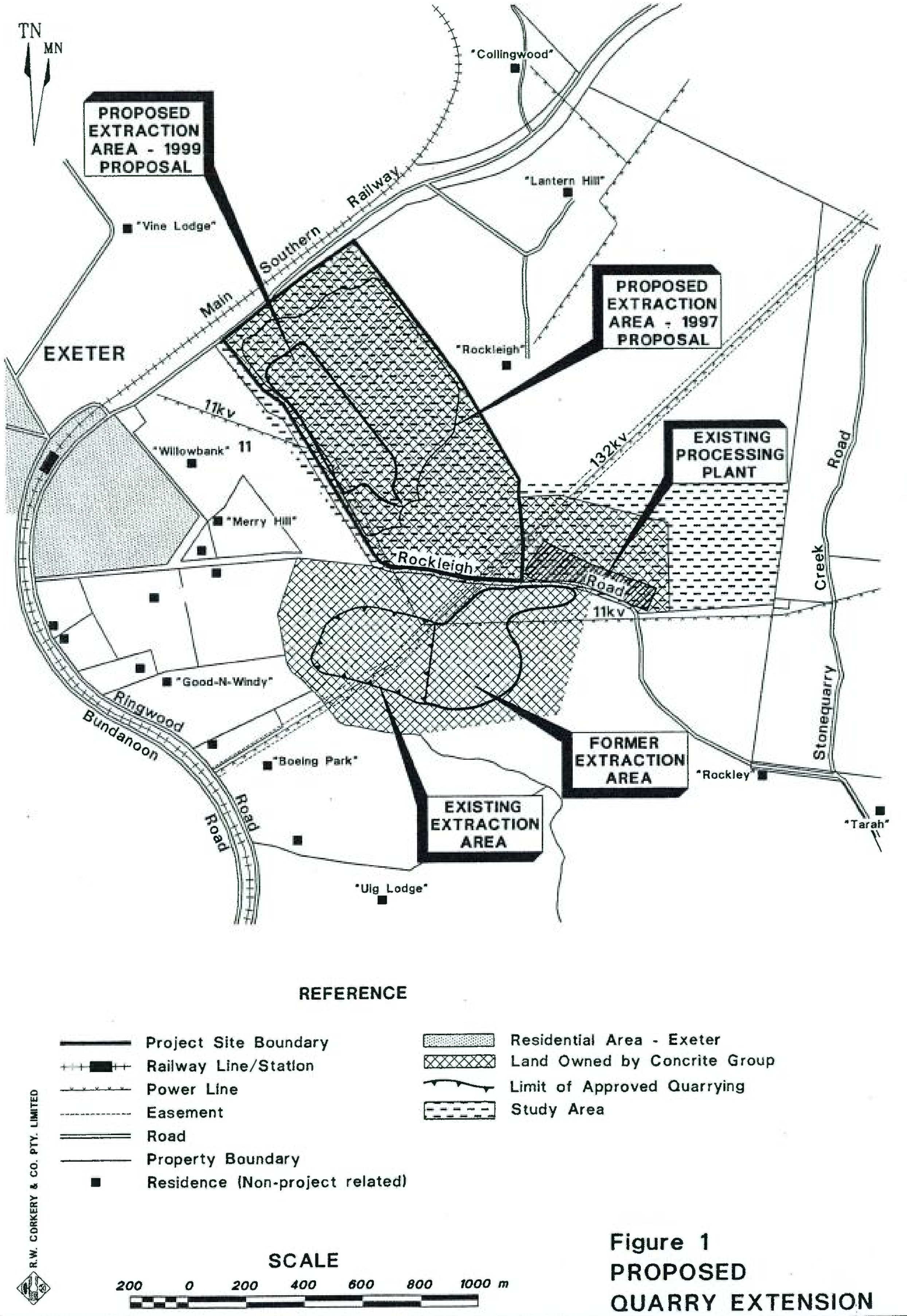

Figure 1
PROPOSED QUARRY EXTENSION

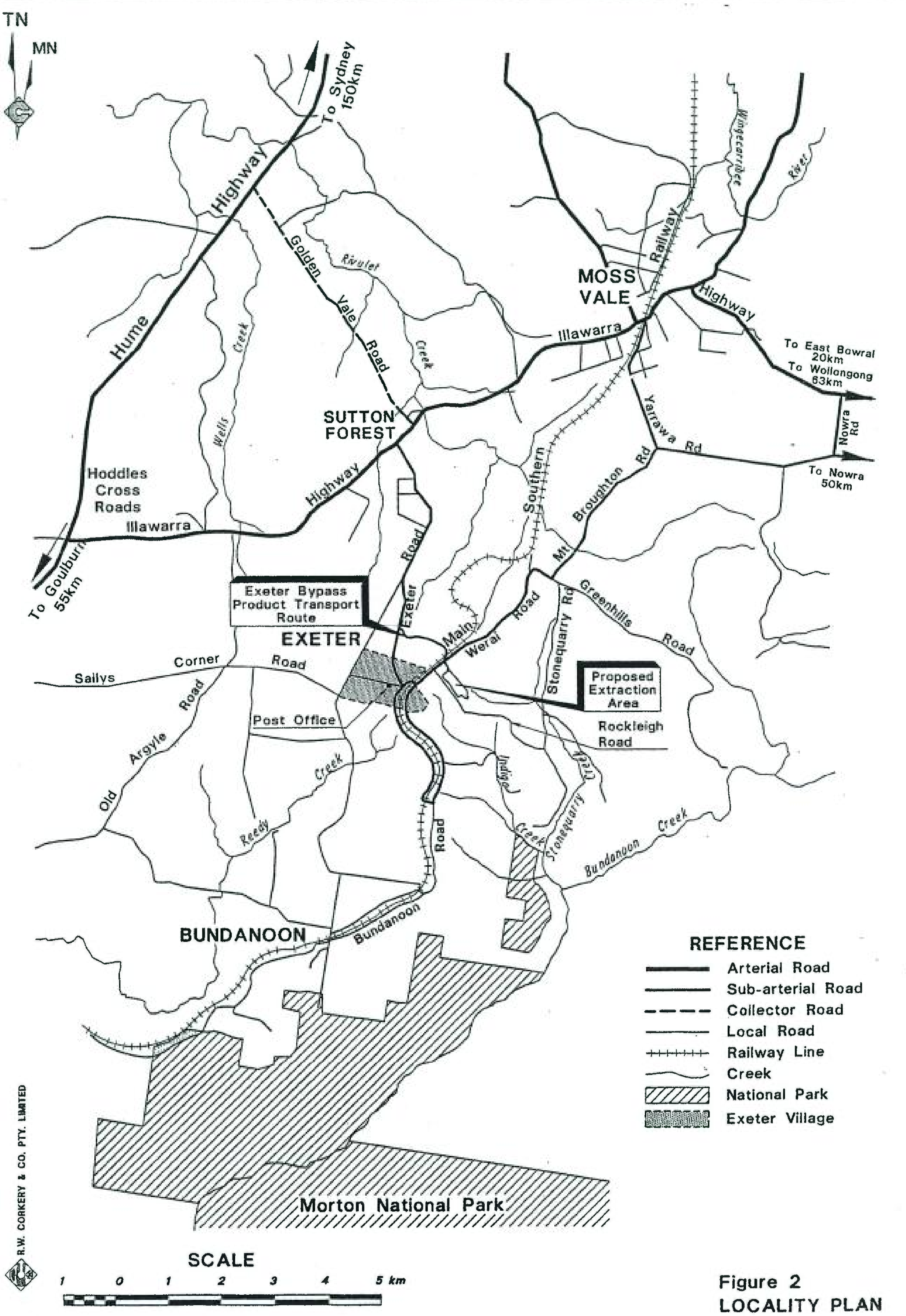

Figure 2
LOCALITY PLAN

3. Methods

The flora and fauna investigations involved a field survey to determine the likely importance of the site for flora and terrestrial vertebrate fauna; literature review and database searches.

3.1 Field Survey

On 22nd and 23rd April 1996, the study area was inspected by an ecologist and a field assistant who traversed the site to note areas which may be of special interest.

Seven quadrats (sample areas), 10m x 10m in size, were used to record occurrence and percentage cover of flora species present in representative vegetation of the study area (Appendix 1). Location of these quadrats is shown in Figure 4. Quadrat results were then summarised and a flora species list compiled (Appendix 2). Species occurring within the study area, but which were outside the quadrats, were also recorded and included in the flora species list. Species identifications were made with the use of Robinson (1991), Costermans (1994), Lamp and Collet (1993), Auld and Medd (1987), Fairley and Moore (1995) and Harden (1990, 1991, 1992 and 1994). Unknown taxa were pressed and preserved for later identification at the Royal Botanical Gardens Herbarium.

A habitat assessment proforma was completed at each quadrat location. The habitat assessment was based on the following criteria:

- size and abundance of tree hollows;
- size, abundance and type of logs;
- rock overhangs and crevices;
- ground, shrub and canopy strata;
- disturbances, including weeds, clearing, rubbish dumping, fire;
- water availability/permanence, both within and adjacent to study area; and
- surrounding habitat, including connectivity to wildlife corridors.

Quantitative sampling for fauna (including trapping and netting) was not carried out during the current survey. Fauna species were recorded in the field as follows:

- opportunistic observations of species including visual and audible detection;

- observations of evidence of fauna species, including scats, burrows and diggings;

- habitat searches eg looking under logs, rocks and debris; and

- spotlighting for nocturnal fauna species such as mammals and owls.

Spotlighting was conducted over one night (22nd April) for a period of 2.5 hrs. Weather conditions during this period were ideal for spotlighting, with no wind, moonlight or rain.

3.2 Database Searches and Literature Review

Records of the Australian Museum and the NPWS Wildlife Atlas were searched for information about flora and fauna records in the vicinity of the study area. The searches of records were used to provide a list of Endangered or Vulnerable fauna and flora species (listed on Schedule 1 or 2 of the Threatened Species Conservation Act, 1996). Literature, including previous assessments of the flora and fauna of the local area, was also searched.

4. Results

4.1 Flora

The field survey detected more than 100 species of vascular plants, approximately 70 per cent of these being native species. More species are likely to occur, however, due to various limiting factors associated with the site inspection, including seasonality of some species, such species may have escaped detection.

Native vegetation generally exists as remnants within the study area. The vegetation currently occurring in the valley consists of Open Forest and Woodland dominated by native species typical of the Southern Highlands Shale Woodlands and Robertson Basalt Tall Forest described in Benson (1995). Dominant canopy species include *Eucalyptus cypellocarpa* (Mountain Grey Gum), *E. quadrangulata* (White-topped Box), *E. globoidea* (White Stringybark) and *E. elata* (River Peppermint). Much of the original understorey has been cleared, although *Poa labillardieri* (Tussock Grass) and *Acacia mearnsii* (Black Wattle) are present as dominant understorey species. Grassland dominated by perennial native species such as *Sorghum leiocladum* (Native Sorghum) also occurs in the valley.

Throughout the study area, the understorey has been disturbed by grazing and invasion by exotic (weed) species including *Rubus fruticosa* (Blackberry), *Verbena bonariensis* (Purpletop), *Cirsium vulgare* (Spear Thistle) and *Dispsacus fullonum* subsp. *fullonum* (Wild Teazle). Few shrub species were detected during the current survey and a well-developed shrub strata is largely absent. Much of the creekline is significantly impacted by weed invasion, particularly in the central portion of the study area, although several semi-aquatic herbaceous native species, including *Persicaria* spp. (Knotweeds) and *Juncus* spp. still occur. Vegetation on the plateau consists primarily of grassland dominated by introduced species.

According to Benson (1995), the Southern Highlands Shale Woodlands, which occur on Wianamatta Shale, are characteristic of the Southern Highlands and extend from west of Mittagong and Bowral, eastwards to the Illawarra Escarpment and south to Bundanoon. The relatively fertile clay soils derived from Wianamatta Shale in the Southern Highlands originally supported a range forest and woodland vegetation, including open forest community dominated by *E. cypellocarpa*, *E. quadrangulata* and *E. globoidea*, much of which has now been cleared for agriculture (Benson, 1995).

Open forest dominated by *E. fastigata* (Brown Barrel), *E. viminalis* (Ribbon Gum), *E. elata* and *E. radiata* subsp. *radiata*, once a widespread community, now occurs as small remnants on the western, drier parts of the Robertson basalt, south of Mittagong (Benson, 1995). The dominant tree species have different habitat requirements and may occur locally as pure or almost pure stands (Benson, 1995). Within the study area, almost pure stands of *E. elata* were detected.

The main vegetation communities are mapped in Figure 3, and illustrated by Figures 4-12. Note that the boundaries indicated in Figure 3 are an approximation only, and are based on vegetation recorded within the quadrats sampled.

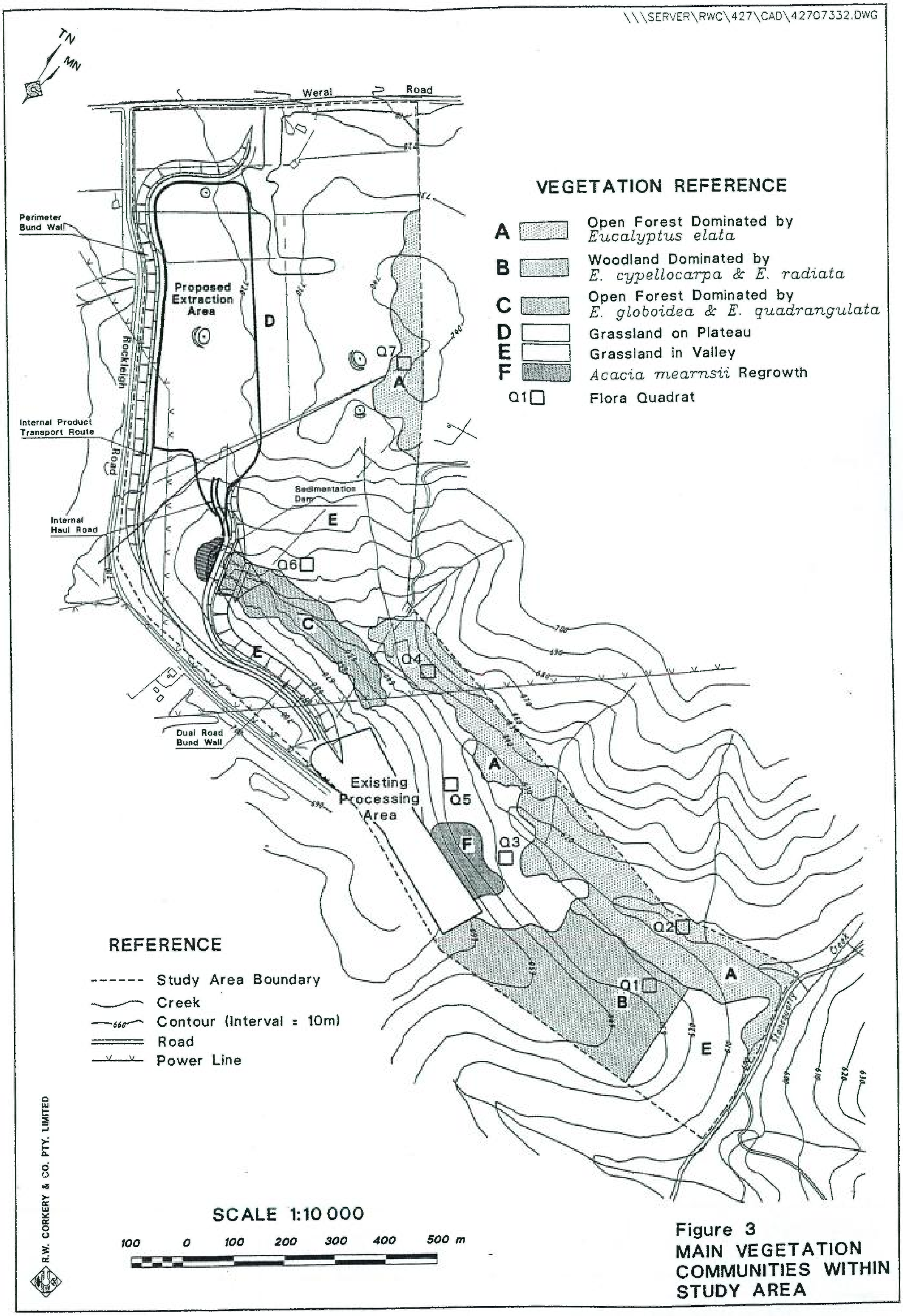

Figure 3
MAIN VEGETATION COMMUNITIES WITHIN STUDY AREA

4.1.1 Flora of Conservation Significance

Threatened Flora Species

NPWS database searches revealed that a number of species of Endangered or Vulnerable flora species currently listed on the Threatened Species Conservation Act (1995) are known from the general area, ie from within a 3 km radius of the study area (Table 1). No such species were detected during the current survey. Based on assessment of the condition of vegetation communities and habitats present within the plateau area, it is considered highly unlikely that such species would occur there. Suitable habitat for one species, (*Typhonium eliosurum*) occurs along less disturbed sections of the creekline in the forested valley. Potential for this species to occur is considered to be low, however, as it was not detected during a search of the creekline.

Table 1: Flora species listed on Schedule 1 (endangered) or Schedule 2 (vulnerable) of the Threatened Species Conservation Act (1996) recorded within 3km of study area.

Family	Scientific Name	Habitat	Likelihood of occurrence within study area
Araceae	*Typhonium eliosurum*	Grows on rainforest margins and along creek banks.	Low likelihood - species not detected during inspection of creekline.
Fabaceae	*Pultenaea villifera*	Dry sclerophyll forest on sandy soil.	Unlikely to occur within study area - suitable habitat not available.
Fabaceae (Mimosoideae)	*Acacia bynoeana.*	Ridge-tops: found on sandy clay soil often with ironstone gravels.	Unlikely to occur within study area - suitable habitat not available.
Liliaceae	*Thysanotus virgatus*	Dry sclerophyll forest and heath on sandy soils, sometimes with ironstone gravels.	Unlikely to occur within study area - suitable habitat not available.
Proteaceae	*Grevillea barklyana*	Low open woodland or shrubland, sandy soils.	Unlikely to occur within study area - suitable habitat not available.
Rutaceae	*Zieria murphyi*	Dry sclerophyll forest on sandy soil.	Unlikely to occur within study area - suitable habitat not available.
Sterculiaceae	*Rulingia hermanniifolia*	Often spreads 1-2m across ground or pendent down rock faces, mostly on sandstone cliffs or along gullies.	Unlikely to occur within study area - suitable habitat not available.

Vegetation Communities

When assessing the conservation significance of flora, consideration should also be given to vegetation communities as a whole. At present, the Threatened Species Conservation Act (1995) does not list Threatened Ecological Communities. Yet many vegetation communities are greatly diminished in distribution and under increasing threat from vegetation clearance.

According to Benson (1995), Robertson Basalt Tall Forest and Southern Highlands Shale Woodland communities have been extensively cleared for agriculture because of the arable soils derived from basalt and Wianamatta Shale. Remnants persist as small, isolated fragments along roadsides or in paddocks where grazing has removed most of the groundcover species, the latter being the case in the study area where isolated trees occur in the grassland on the plateau. Remnant fibrous-barked trees such as the stringybarks, *E. globoidea*, are frequently killed by ringbarking by stock seeking fibrous material. Protection of remnant trees and native understorey in rural areas is an important conservation issue (Benson, 1995). The proposed development should therefore include management of the more extensive stands of forest and woodland within the valley for the purpose of protecting such remnants.

4.1.2 Weed Species

Much of the cleared grassland on the upper slopes of the valley is dominated by exotic flora species generally referred to as "weeds". Of course, not all weed species are a source of concern for land managers, for example some are merely garden or lawn weeds. However, there a number which are highly invasive or are poisonous to livestock and therefore require effective management programs. Those species of highest concern are listed in the Noxious Weeds Act (1993). As per this Act, each council declares certain flora species considered noxious in its local government area. In the Act, four noxious weed control categories are applied:

- W1 Noxious Weed: presence must be notified to local control authority; must be fully and continuously suppressed and destroyed.
- W2 Noxious Weed: must be fully and continuously suppressed and destroyed.
- W3 Noxious Weed: must be prevented from spreading; numbers and distribution must be reduced.
- W4 Noxious Weed: action specified in declaration must be taken.

Of those species declared as Noxious Weeds in the Wingecarribee Shire, at least 2 species *Rubus fruticosus* (Blackberry) and *Nassella trichotoma* (Serrated Tussock) occur in the study area. The first of these species is listed as a W2 noxious weed, whilst the latter is listed as a W3 noxious weed.

Other exotic flora species recorded from the study area which are a management issue include *Hedera helix* (English Ivy), *Ligustrum lucidum* (Large-leaved Privet) and *Salix albens* (White Willow). *Ligustrum lucidum* has become a serious weed problem in many parts of Australia, especially in Sydney and other coastal parts of New South Wales (Mills & Associates, 1995). *Salix albens* reproduces by suckering and can have serious impacts by choking river and stream channels. During the current study, *S. albens* was detected within the creekline. It is recommended therefore that *S. albens*, together with other relevant species, such as *Rubus fruticosus* and *Nassella trichotoma* be included in a weed management strategy for the proposed development.

4.2 Fauna Habitats

Previous disturbances, especially clearing of native vegetation for agricultural use, have greatly reduced the habitat quality of all of the study area. The plateau offers little habitat for native fauna, apart from corrugated iron sheets that may be utilised by frog and reptile species. The study area is also impacted by the proximity of settlement (that is, the village of Exeter), which may result in the incidence of introduced predators such as cats and dogs within the study area. In addition, the existing processing plant area offers no habitat for either flora or fauna to disperse or move into.

The less disturbed patches of open forest and woodland in the valley, particularly the northern and eastern portions, offer the best remaining habitats for native fauna within the study area. In particular, this vegetation affords moderate quality foraging and nesting habitat for many birds, while the creek affords suitable habitat for aquatic species including amphibians and macroinvertebrates. Small terrestrial mammals such as *Antechinus* spp. and *Rattus* spp. are also likely to occur in the less disturbed grassy understorey in the valley.

Habitat values, based on extent, condition, suitability and connectivity with similar habitat outside the study area, have been assessed for each fauna group (Table 2). Across the study area generally there is a scarcity of certain important habitat features such as hollow logs and tree hollows. The absence of a well-developed shrub strata throughout the study area decreases availability of significant foraging and breeding habitat for some bird species, especially nectivores and insectivores, and also foraging areas for some insectivorous bats. However, as was observed during the current survey, *Rubus fruticosa* (Blackberry) which dominates the understorey in much of the study area, is utilised by a range of smaller bird species, particularly wrens and robins, as does the *Acacia mearnsii* regrowth on the southern side of the valley.

Table 2: Current habitat values within study area.

Fauna group	Habitat Value	Availability within study area
Amphibians	High	Creek and associated vegetation; debris (eg corrugated iron) in wetter area downslope of plateau. Small dams on plateau of little value to frogs - devoid of fringing vegetation and highly disturbed by cattle trampling.
Reptiles	Low	Limited number of fallen logs within forest/woodland. Some species may also utilise debris (eg corrugated iron) downslope of plateau.
Non-flying Mammals	Medium	Grassy understorey, trees in forest/woodland and dense *Acacia* regrowth.
Bats	Medium	Few hollows available for hollow-dependent bats; some species expected to forage in forest/woodland areas.
Hollow-dependent Birds	Low	Few tree hollows available as nesting habitat for hollow-dependent birds such as owls. Some species expected to forage within forest/woodland areas.
Birds not requiring hollows	Medium	Forest/woodland, dense blackberry growth, *Acacia* regrowth. Foraging/nesting resources limited by lack of well-developed native shrub understorey.

Based on the assessment of habitat values provided by Table 2, the areas offering the best habitat for native fauna are the forest/woodland areas (indicated on Figure 3 as areas A and B) which form part of native vegetation remnants extending to the north and east, and the creekline. *Acacia* regrowth (Area F) and small remnants of native forest (for example, Area C) offer more marginal fauna habitat, particularly as they are relatively fragmented and more vulnerable to edge effects such as weed invasion and are less continuous with more extensive stands of native vegetation. The grassland in the valley (Area E) offers habitat for a variety of reptiles and amphibians, whereas the grassland on the plateau (Area D) offers little native fauna habitat. The existing processing plant area (Area G) offers no fauna habitat.

4.3 Fauna

Fauna observed opportunistically during the diurnal survey were predominantly bird species common and widespread throughout forests and woodlands in south-eastern Australia. Bird species observed included *Corvus coronoides* (Australian Raven), Australian Magpie (*Gymnorhina tibicen*), *Eopsaltria australis* (Eastern Yellow Robin), *Calyptorhynchus funereus* (Yellow-tailed Black-cockatoo), *Malurus cyaneus* (Superb Fairy-wren), *Dacelo novaeguineae* (Laughing Kookaburra), *Sericornis frontalis* (White-browed Scrubwren), *Platycercus eximius* (Eastern Rosella), *Rhipidura fuliginosa* (Grey Fantail), *Lichenostomus chrysops* (Yellow-faced Honeyeater), *Cormobates leucophaeus* (White-throated Treecreeper) and *Strepera graculina* (Pied Currawong). Evidence (that is, burrows, scats) of *Vulpes vulpes* (Fox), *Oryctolagus cuniculus* (Rabbit), *Macropus giganteus* (Eastern Grey Kangaroo), and *Vombatus ursinus* (Common Wombat) were also detected.

Spotlighting resulted in the detection of several common mammal species including *Petaurus breviceps* (Sugar Glider), *Vombatus ursinus* (Common Wombat), *Macropus giganteus* (Eastern Grey Kangaroo), *Wallabia bicolor* (Swamp Wallaby) and *Vulpes vulpes* (Fox), as well as one frog species *Limnodynastes peronii* (Brown-striped Frog), and one nocturnal bird species, *Podargus strigoides* (Tawny Frogmouth). During spotlighting, *Ninox novaeseelandiae* (Boobook Owl) was also heard calling from the forest in the vicinity of the eastern boundary of the study area.

Habitat searches of logs, rocks and debris (such as corrugated iron sheets) for amphibian and reptile species detected common species such as *Crinia signifera* (Common Eastern Froglet), *Limnodynastes peronii* (Brown-striped Frog), *Limnodynastes tasmaniensis* (Spotted Grass Frog) and *Lampropholis delicata* (Grass Skink). All fauna species recorded during the current survey were detected in the valley, apart from the *Limnodynastes tasmiensis* and *Lampropholis delicata*, which were found under separate sheets of corrugated iron in grassland slightly downslope from the plateau.

All fauna species detected and those considered likely to occur, based on availability of habitat within the study area, distribution range of species and local records, are listed in Appendix 3.

4.3.1 Fauna of Conservation Significance

The database and literature searches revealed that at least nine species of Threatened fauna have been recorded in the vicinity of the study area (Table 3). Of those species, the species which could potentially utilise habitats within the study area are *Miniopterus schreibersii* (Common Bent-wing Bat), *Dasyurus maculatus* (Tiger Quoll), *Ninox strenua* (Powerful Owl), *Tyto novohollandiae* (Masked Owl), and *Litoria aurea* (Green and Golden Bell Frog).

Table 3: Endangered or Vulnerable species (excluding water birds such as sea birds and waders) recorded in vicinity of study area.

Scientific Name	Common Name	Habitat Requirements	Likelihood of Occurrence in study area
Miniopterus schreibersii	Common Bent-wing Bat	Roosting habitat includes caves, old mines, stormwater channels and comparable structures including occasional buildings. Forages above canopy in well-timbered valleys (Dwyer, 1995).	Medium likelihood. Roosting habitat not available, however this species may forage over the forest and woodland in the valley.
Dasyurus maculatus	Tiger Quoll	Recorded from a range of habitats including rainforest,, open forest, woodland, coastal heathland and inland riparian forest. Nesting habitat includes caves, rock crevices and hollow logs (Edgar and Belcher, 1995)	Medium likelihood. Marginal nesting habitat not available within study area, however, may utilise study area as part of large foraging range.
Ninox strenua	Powerful Owl	Wet and dry eucalypt forests and woodlands (Garnett, 1992). Tree hollows, usually within large eucalypts, are used by the Powerful Owl for nests. The main prey of this species are medium-sized arboreal marsupials, particularly the Common Ringtail Possum and Sugar Glider (*Petaurus breviceps*) (Garnett, 1992), although currawongs are a major prey species in some areas.	Medium likelihood. Nesting habitat not available within study area, however this species may utilise study area as part of a large foraging range.
Tyto novohallandiae	Masked Owl	Forests, woodlands and caves (Simpson and Day,1993).	Medium likelihood of occurrence. Nesting habitat not available within study

Scientific Name	Common Name	Habitat Requirements	Likelihood of Occurrence in study area
			area, however this species may utilise study area as part of a large foraging range.
Litoria aurea	Green and Golden Bell Frog	Vegetation within or at the edges of bodies of permanent water, such as streams, swamps, lagoons, farm dams and ornamental ponds (Cogger, 1992). Known to occur in degraded and highly disturbed habitats.	Low likelihood. Marginal habitat associated with the creek.
Pseudophryne australis	Red Crowned Toadlet	Tops and upper slopes of sandstone ridges on which predominant vegetation is dry open forests and heaths. Occasionally occurs in ecotonal areas linking wet and dry sclerophyll forest types (AMBS, 1995).	Unlikely to occur. Suitable habitat not available within study area.
Mixophyes balbus	Stuttering Frog	Usually associated with mountain streams in dense, wet mountain forests. Terrestrial in habit, foraging along stream banks and nearby forest floor in search of small moving prey items. Rarely wanders very far from the banks of permanent forest streams (Tyler, 1992).	Unlikely to occur. Preferred habitat not available within study area.
Phascolarctos cinereus	Koala	Over its range from the tropics to the cool-temperate regions, the Koala is limited to areas where there are acceptable food trees. It feeds predominantly on the foliage of eucalypts, preferring such species as Forest Red Gum, Manna Gum, Swamp Mahogany and Blue Gum (Martin and Handasyde, 1995).	Unlikely to occur. Preferred feed trees not detected within study area.
Calyptorhynchus lathami	Glossy Black-Cockatoo	Dry sclerophyll forest and woodland. Forages solely on *Allocasuarina*, relying heavily on species with	Unlikely to occur. Suitable habitat not available within study area.

Scientific Name	Common Name	Habitat Requirements	Likelihood of Occurrence in study area
		large cones, including Black She-oak (*Allocasuarina littoralis*). Nests in tree hollows.	

4.3.2 Eight point test

Part 5A of the Environmental Planning and Assessment Act (1979) includes an eight-point test of significance for species of flora and fauna listed on Schedule 1 (Endangered) or Schedule 2 (Vulnerable) of the Threatened Species Conservation Act (1995). This test is designed to evaluate whether a proposed development has the potential to significantly impact upon Threatened species of flora or fauna, populations or ecological communities or their habitats, and therefore if a Species Impact Statement is required.

The eight-point test has been applied in this report, and based on a general habitat assessment, a Species Impact Statement is not required for any Threatened species of flora or fauna, provided that the constraints and safeguards described in this report are incorporated into the quarry extension plan.

For the purposes of the Threatened Species Conservation Act (1995), and in the administration of sections 77, 90 and 112 of the EP&A Act (1979) the following factors have been taken into account to decide whether there is likely to be a significant effect on threatened species, considered likely to occur in the Study Area, or their habitats:

1. *in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction;*
2. *in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised;*
3. *in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed;*
4. *whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community;*
5. *whether critical habitat will be affected;*
6. *whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the*

region;
7. *whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process;*
8. *whether any threatened species, population or ecological community is at the limit of its known distribution.*

The threatened species to be assessed under this eight point test are:

Amphibians

Green and Golden Bell Frog

Birds

- Powerful Owl
- Masked Owl

Mammals

- Common Bent-wing Bat
- Tiger Quoll

The following species were not considered under the eight point test, as habitat assessment revealed that they were unlikely to occur within the study area since no suitable habitat was available;

- Red Crowed Toadlet
- Stuttering Frog
- Glossy Black-Cockatoo
- Koala

Common Bent-wing Bat (*Miniopterus schreibersii*)

1. in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction;

The Common Bent-wing Bat, or evidence thereof, was not detected in the Study Area. However, this is based upon flora and habitat evaluation and spotlighting, but not bat survey or trapping. It is therefore possible that this species does utilise part of the study area, but was simply undetected due to survey restrictions. The Study Area may potentially comprise a small part of the foraging range for Bats in the forest and woodland in the valley, however habitat assessments revealed no suitable roosting habitat (caves, old mines, stormwater channels and comparable structures).

The proposed clearing of the grassland plateau will not directly remove any significant habitat. However, removal of the two small areas of open forest, and indirect impacts associated with the grassland clearing, is likely to result in a marginal reduction in potential foraging habitat for this species.

From these findings, it is therefore unlikely that the life cycle of any local populations of the Common Bent-wing Bat will be disrupted by the proposal such that a viable population of this species is likely to be placed at risk of extinction.

2. in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised;

No populations are currently listed under Part 2 Endangered populations of Schedule 1.

3. in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

The proposed development will necessitate clearing of the plateau grassland, a small zone of open forest on the northern side of the site, and a small portion of trees at the overburden site. This proposed clearing is likely to result in only a marginal reduction in potential foraging habitat of the Common Bent-wing Bat.

More suitable potential habitat is provided in the open forest and woodland in the valley habitat and offsite in reserved areas such as Morton National Park. Therefore, in relation to the regional distribution of this species habitat, the area of habitat proposed to be removed is not significant.

4. whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

No part of the study area was confirmed as known habitat for this species. The areas of open forest to be cleared constitute only a minor part of this species potential foraging habitat. It is considered unlikely, therefore, that the proposed development will result in the isolation of potential habitat, from currently interconnecting or proximate areas of habitat

5. whether critical habitat will be affected

No areas of critical habitat have yet been declared under Part 3 of the Threatened Species Conservation Act (1995).

6. whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region;

Records from the search area revealed two sightings of the Common Bent-wing Bat in Crown Reserve 1-2 km south of Bendeela Power Station, near Morton National Park. However, based on this available information, it cannot be determined to what extent these areas adequately conserve the Common Bent-wing Bat or its habitat.

7. whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process;

No key threatening processes are currently listed on Schedule 3 of the Threatened Species Conservation Act (1995).

8. whether any threatened species, population or ecological community is at the limit of its known distribution.

The Common Bent-wing Bat occurs throughout the east coast of Australia. If any local populations were to exist, they would not therefore, be at the limit of the Common Bent-wing Bats' known distribution.

Tiger Quoll (*Dasyurus maculatus*)

1. in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction;

The Tiger Quoll, or evidence thereof, was not detected during the survey. Habitat assessments revealed a scarcity of hollow logs which could be used as nesting habitat and nearby cleared areas which may be used as part of a larger foraging range. However, such areas would not be sufficient to support a viable population.

The proposed clearing of the grassland plateau will not directly remove any significant habitat. However, removal of the two small areas of open forest, and indirect impacts associated with the grassland clearing, is likely to result in a marginal reduction in potential foraging habitat for this species.

Based upon the marginal nesting habitat available, the Tiger Quoll is regarded as having a medium likelihood of occurring within the study area. However, it is unlikely that the life cycle of any local populations of this species will be disrupted by the proposal such that a viable population for these species is likely to be placed at risk of extinction

2. in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised;

No populations are currently listed under Part 2 Endangered populations of Schedule 1.

3. in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

The proposed development will necessitate clearing of the plateau grassland, a small zone of open forest on the northern side of the site, and a small portion of trees at the overburden site. This proposed clearing is likely to result in only a marginal reduction in potential foraging habitat for the Tiger Quoll.

More suitable potential habitat is provided in the open forest and woodland in the valley habitat and offsite in reserved areas such as Morton National Park. Therefore, in relation to the regional distribution of this species habitat, the area of habitat proposed to be removed is not significant.

4. whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

No part of the study area was confirmed as known habitat for this species. The areas of open forest to be cleared constitute only a minor part of this species potential foraging habitat. It is considered unlikely, therefore, that the proposed development will result in the isolation of potential habitat, from currently interconnecting or proximate areas of habitat

5. whether critical habitat will be affected

No areas of critical habitat have yet been declared under Part 3 of the Threatened Species Conservation Act (1995).

6. whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region;

The Tiger Quoll has been recorded on a Crown Reserve west of Fitzroy Falls Reservoir and approximately 9km south of the Study Area, just north of Mount Carnarvon. Based on available information, it cannot be determined to what extent these areas adequately conserve the Tiger Quoll or its habitat, however Strahan (1995) believes the Tiger Quoll to exist mostly in patches in isolated areas that may be too small to support viable long term populations.

7. whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process;

No key threatening processes are currently listed on Schedule 3 of the Threatened Species Conservation Act (1995).

8. whether any threatened species, population or ecological community is at the limit of its known distribution.

The Tiger Quoll is extinct in South Australia, uncommon to rare in Victoria, NSW and Southern Queensland, with its distribution being disjunct over much of its present range. Within NSW, the Quoll occupies the east coast. Any local population would not, therefore, be at the limit of its known distribution.

Powerful Owl (*Ninox strenua*)

1. in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction;

The Powerful Owl, or evidence thereof, was not detected in the study area. However, this is based upon flora and habitat evaluation and spotlighting, but not survey or trapping. It is therefore possible that this species does utilise part of the study area, but was simply undetected due to survey restrictions. Habitat assessments revealed a scarcity of hollow logs which could be used as nesting habitat and nearby cleared areas which may be used as part of a larger foraging range. However, such areas would not be sufficient to support a viable population.

The proposed clearing of the grassland plateau will not directly remove any significant habitat. However, removal of the two small areas of open forest, and indirect impacts associated with the grassland clearing, is likely to result in a marginal reduction in potential foraging habitat for this species.

Based upon the unsuitability of nesting habitat, the Powerful Owl is regarded as having a medium likelihood to occur within the study area as part of a larger foraging range. It is therefore unlikely that the life cycle of any local populations of this species will be disrupted by the proposal such that a viable population for these species is likely to be placed at risk of extinction

2. in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised;

No populations are currently listed under Part 2 Endangered populations of Schedule 1.

3. in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

The proposed development will necessitate clearing of the plateau grassland, a small zone of open forest on the northern side of the site, and a small portion of trees at the overburden site. Assessments of the Study Area indicated an absence of suitable nesting habitat, however, as the Powerful Owl has a large home range, it is possible that the Study Area constitutes a small part of the foraging range for a local Powerful Owl population. This proposed clearing is likely to result in only a marginal reduction in potential foraging habitat of the Powerful Owl.

More suitable potential habitat is provided in the open forest and woodland in the valley habitat and offsite in reserved areas such as Morton National Park.

Therefore, in relation to the regional distribution of this species habitat, the area of habitat proposed to be removed is not significant.

4. whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

No part of the study area was confirmed as known habitat for this species. The areas of open forest to be cleared constitute only a minor part of this species potential foraging habitat. It is considered unlikely, therefore, that the proposed development will result in the isolation of potential habitat, from currently interconnecting or proximate areas of habitat

5. whether critical habitat will be affected

No areas of critical habitat have yet been declared under Part 3 of the Threatened Species Conservation Act (1995).

6. whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region;

The are no records for this species within the search area and therefore, based on available information, it cannot be determined to what extent the Powerful Owl or its habitat are conserved within the area.

7. whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process;

No key threatening processes are currently listed on Schedule 3 of the Threatened Species Conservation Act (1995).

8. whether any threatened species, population or ecological community is at the limit of its known distribution.

The Powerful Owl is found between south-western Victoria and at least as far north as Yeppoon in eastern Queensland Records are concentrated on the coastward side of the Great Dividing Range but in many places its distribution extends to the inland slopes. Any local population would not, therefore, be at the limit of the known distribution.

Green and Golden Bell Frog (*Litoria aurea*)

1. in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction;

The Green and Golden Bell Frog, or evidence thereof, was not detected during the survey. The Green and Golden Bell Frog inhabits vegetation within or at the edges of bodies of permanent water, and is known to occur in degraded and highly disturbed habitats. Habitat assessments of the Study Area revealed only marginal habitat associated with the creek.

The proposed clearing of the grassland plateau will not directly remove any significant habitat. However, removal of the two small areas of open forest, and indirect impacts associated with the grassland clearing, is likely to result in a marginal reduction in potential foraging habitat for this species.

Based upon the marginal suitability of the habitat, the Green and Golden Bell Frog is regarded as having a low likelihood of occurring within the study area. It is therefore unlikely that the life cycle of any local populations of this species will be disrupted by the proposal such that a viable population for these species is likely to be placed at risk of extinction.

2. in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised;

No populations are currently listed under Part 2 Endangered populations of Schedule 1.

3. in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

The proposed development will necessitate clearing of the grassland plateau, a small zone of open forest on the northern side of the site, and a small portion of trees at the overburden site. No part of the study area was confirmed as habitat for the Green and Golden Bell Frog. Assessments of the study area indicated marginal habitat associated with the creek as being suitable for this species. However, given the lack of suitable habitat the Green and Golden Bell Frog is regarded as an unlikely inhabitant of this area.

The proposed clearing of the grassland plateau will not directly remove any significant habitat for this species. Indirect effects are similarly unlikely to effect any potential habitat for this species. Therefore, the proposed development is unlikely to modify or remove an area of known habitat for the Green and Golden Bell Frog.

4. whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

No part of the study area was confirmed as known habitat for this species. The areas of open forest to be cleared constitute only a minor part of this species potential foraging habitat. It is considered unlikely, therefore, that the proposed development will result in the isolation of potential habitat, from currently interconnecting or proximate areas of habitat

5. whether critical habitat will be affected

No areas of critical habitat have yet been declared under Part 3 of the Threatened Species Conservation Act (1995).

6. whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region;

The Green and Golden Bell Frog has been found to occur at Moss Vale, north east of the Study Area in 1964, and at Bundanoon, south of the Study Area in 1939 (White and Pyke, 1996). Based on the small number of sightings and the length of time elapsed since these sightings were made, it is very unlikely that the Green and Golden Bell Frog is adequately represented in conservation areas in the region.

7. whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process;

No key threatening processes are currently listed on Schedule 3 of the Threatened Species Conservation Act (1995).

8. whether any threatened species, population or ecological community is at the limit of its known distribution.

Historically, the Green and Golden Bell Frog extends from East Gippsland in Victoria, north to approximately Byron Bay in northwestern NSW, and west to Bathurst and Tummut (Goldingay, 1996). If any local population were to exist, it would therefore not be at the limit of its known distribution.

Masked Owl (*Tyto novohallandiae*)

1. in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction;

The Masked Owl, or evidence thereof, was not detected in the study area. However, this is based upon flora and habitat evaluation and spotlighting, but not survey or trapping. It is therefore possible that this species does occur in the study area, but was simply undetected due to survey restrictions. It is possible that the Study Area may comprise a small part of the foraging range the Masked Owl, however habitat assessments revealed no suitable roosting habitats.

The proposed clearing of the grassland plateau will not directly remove any significant habitat. However, removal of the two small areas of open forest, and indirect impacts associated with the grassland clearing, is likely to result in a marginal reduction in potential foraging habitat for this species.

From these findings, it is therefore unlikely that the life cycle of any local populations of the Masked Owl will be disrupted by the proposal such that a viable population of this species is likely to be placed at risk of extinction.

2. in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised;

No populations are currently listed under Part 2 Endangered populations of Schedule 1.

3. in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed

The proposed development will necessitate clearing of the grassland plateau, a small zone of open forest on the northern side of the site, and a small portion of trees at the overburden site.

As assessments of the study area indicated the potential for the area to be used as part of a larger foraging range for the Masked Owl, the proposed clearing is likely to result in only a marginal reduction in foraging habitat for the Masked Owl

From these findings therefore, in relation to the regional distribution of this species habitat, the area of habitat proposed to be removed is not significant.

4. whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community

No part of the study area was confirmed as known habitat for this species. The areas of open forest to be cleared constitute only a minor part of this species potential foraging habitat. It is considered unlikely, therefore, that the proposed development will result in the isolation of potential habitat, from currently interconnecting or proximate areas of habitat

5. whether critical habitat will be affected

No areas of critical habitat have yet been declared under Part 3 of the Threatened Species Conservation Act (1995).

6. whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region;

Records from the search area revealed one sighting of the Masked Owl in Crown Reserve Near Gun Rock Creek in 1994, approximately 8km south east from the Study Area. Based on available information, it cannot be determined to what extent this area adequately conserves the Masked Owl or its habitat.

7. whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process;

No key threatening processes are currently listed on Schedule 3 of the Threatened Species Conservation Act (1995).

8. whether any threatened species, population or ecological community is at the limit of its known distribution.

The Masked Owl occurs throughout the entire east coast of Australia. Any local population would not, therefore, be at the limit of its known distribution.

Conclusion

No part of the study area was confirmed as known habitat for each of the five threatened species. Although roosting or nesting habitat was not available for these species, the area had the potential to be used as part of a larger foraging range.

The proposed development will necessitate the clearing of the grassland plateau, and two small zones of open forest on the plateau and in the overburden site within the valley. Clearing of the grassland will not directly remove any potential habitat for these species, however, may indirectly reduce foraging habitat. The removal of the two small areas of open forest will directly remove potential foraging habitat for these species, however, because of the small scale of these areas in relation to habitat provided elsewhere in the region, the loss in potential habitat is expected to be minimal.

As a result it is concluded that the proposed development is unlikely to significantly impact upon the five threatened species or their habitat, and therefore, it is unlikely that a Species Impact Statement will be required.

4.3.3 Fauna of Local Conservation Concern

One species not listed on either Schedule 1 or 2 of the Threatened Species Conservation Act (1995) that deserves consideration is *Ornithorhynchus anatinus* (Platypus). Despite being common over much of its present range, this species is under threat from increasing demand for fresh water for assorted land uses. Dams, irrigation, stream and river bank 'improvements', fish netting and trapping, and chemical pollution are among the hazards that may alienate habitat and lead to reduction or extinction of local populations (Carrick, 1991). *Ornithorhynchus anatinus* is therefore generally considered to be vulnerable to local extinction (K Mills & Associates, 1995; Carrick, 1991).

Ornithorhynchus anatinus has been recorded from the Wingecarribee River and is known to occur in streams on the Southern Highlands (Mills & Associates, 1995). NPWS and Australian Museum fauna databases do not contain records for this species for the study area, nor for Stonequarry Creek, located east of the study area. Furthermore, nocturnal habitat searches of the creekline in the study area during the current survey failed to detect the presence of this species.

It is considered unlikely therefore that individuals of a local population of *O. anatinus* utilise the study area, as this species usually only inhabits streams in a relatively natural condition (Mills & Associates, 1995). However, potential habitat for this species may occur downstream from the study area. As *O. anatinus* may be vulnerable to sedimentation of its aquatic habitat, control of sediment input to the creek is necessary in order to minimise the impact of the proposed development upon potential habitat downstream from the study area. Sediment control will also maintain or even improve habitat for species known to inhabit the creekline, including frog species.

5. Constraints and Safeguards

In terms of native flora species diversity and fauna habitat availability, the open grassland on the plateau poses little constraint to the proposed quarry extension. However, the valley with its open forest, woodland, and small creek, contains habitats for a variety of fauna groups, including forest and woodland bird species, mammals, and amphibians, and exhibits a greater flora species diversity. It is considered therefore, that in spite of the disturbed nature of the remaining forest and woodland (for example, clearance of the understorey and impacts from grazing and weed invasion) the proposed development should be designed in such a way as to minimise impact upon flora, fauna and their associated habitats within the valley system.

Measures that could help to mitigate or ameliorate potential impacts upon native flora and fauna, both within the study area and adjoining habitats, include:

- restriction of quarry extraction to the cleared plateau section of the study area;
- retention of native vegetation along creek, to reduce risk of sedimentation and to maintain habitat for native fauna species such as amphibians;
- control/reduction of weed infestation, particularly along the creekline;
- retention of open forest and woodland in the eastern portion to maintain connectivity with the wildlife corridors extending east and south-east from the study area;
- construction of siltation ponds to minimise impact of runoff and sedimentation on creek system;
- incorporation of maintenance program for siltation pond into plant operations.
- maximise erosion control measures at the head of the valley adjacent to the quarry;
- retention of ungrazed area in the valley;
- plant trees and shrubs in the valley which are native to the area;
- avoidance of tree clearing in the gully.

6. Assessment of Impacts

6.1 Flora

For the purposes of this assessment, it is understood that the location of the proposed quarry extension is to occur predominantly on the grassland plateau, extending into the valley grassland, and will require clearing of two small areas of open forest on the plateau and overburden site.

The direct impact of the proposed development is the removal of this large area of grassland. Such a community, having already been extensively cleared and dominated by introduced herbaceous species, is of little conservation significance. Tree clearance of the open forest dominated by *E.globoidea* and *E.quadrangulata* in the valley, and the open forest dominated by *E.elata,* constitute only a relatively small area of plant communities in relation to the extent of the existing open forest. The proposed extension of the quarry will not involve clearing of the open forest dominated by *E.elata* along the creekline, the woodland and *Acacia mearnsii* regrowth.

The area proposed to be cleared does not contain suitable habitat for any threatened plant species. Suitable habitat for the threatened plant, *Typhonium eliosurum,* however, was found to occur along the less disturbed sections of the creekline in the forested valley, where clearance will not occur.

Indirect impacts of the proposed extension are potentially more significant, however they are harder to accurately assess. Such impacts could include water runoff and the associated erosion and sedimentation, dust pollution and cumulative downstream impacts.

Removal of the grassland and several trees is likely to result in increased water flow and runoff down the valley. This may increase the potential for soil erosion thereby encouraging weed growth within the valley and sedimentation along the creekline. However, several characteristics of the proposed site make it resilient to high levels of runoff and erosion. Firstly, due to the relatively fertile soils, potential for herbaceous regrowth to stabilise is high. Secondly, the absence of livestock grazing in the valley below the quarry has resulted in very thick, stable vegetation cover developing.

It is understood as part of the development proposal, that siltation ponds will be constructed to reduce this runoff and sedimentation. Based on the current works, which have little or no runoff, stable vegetation around the ponds, and the previously mentioned site characteristics, it can be assumed that the impacts associated with runoff at the proposed quarry site will not be significant.

Although there is a paucity of information regarding the effects of dust pollution on flora, dust has been shown to have an adverse impact upon plants but only at exceptionally high concentrations (Lodge *et al.*, 1981; Yang, 1988; Peabody, 1991). Such concentrations would be far greater than those which have been estimated for future production (including the extended area) with standard dust controls and approvals (Zib & Associates, 1996). Thus, it is unlikely that dust will have a significant impact upon the flora of the area surrounding the site, especially as "the criteria designed to protect humans against health and nuisance effects of predicted increased dust levels will also protect vegetation and animals in the environs" (Holmes, 1990).

6.2 Fauna

The proposed clearing of the grassland plateau will not directly result in the loss of suitable habitat for any of the threatened species considered in the eight-point test. However, potential foraging habitat for the Common Bent-wing Bat, Tiger Quoll, Powerful Owl and Masked Owl occurs within the valley and in open forest, where a small area of tree clearing is proposed. Therefore, tree clearing of open forest on both the plateau and in the overburden site will result in a minor reduction in potential habitat for the threatened species.

Due to the open and altered nature of the grassland plateau, and the small scale of open forest to be cleared, the proposed development is unlikely to interfere with any species migratory routes or corridors.

Indirect effects of the proposed extension are largely associated with the impact of runoff and sedimentation on the creekline. However, because of the low flow of the creek and the gully's high potential to revegetate with herbaceous growth, the impact on potential habitat within the valley or creekline is minor. It has also been suggested that dust can have a potential adverse effect on fauna, although a literature review by Peabody, 1991 showed that such claims are largely unsubstantiated. Given the levels of dust expcted to occur (Zib & Associates, 1996), it is unlikely that dust pollution will have a significant impact upon the fauna of the surrounding area (see Section 6.1).

Figure 4: Location of quadrats (Q) and photos (F)

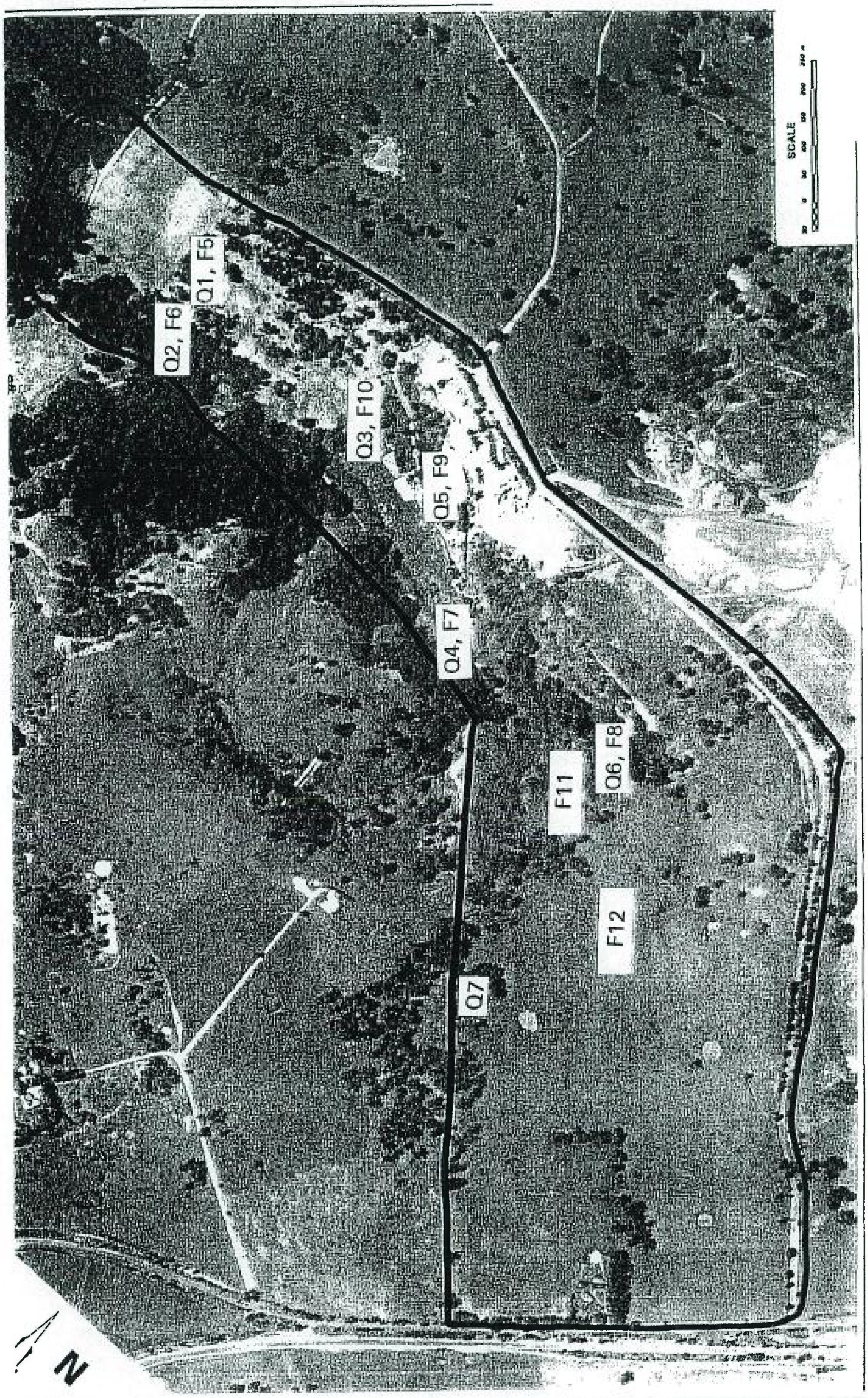

Figure 5: Woodland dominated by *Eucalyptus cypellocarpa* and *E. radiata* (Quadrat 1).

Figure 6: Open forest dominated by *E. elata*, with creekline in centre of photo (Quadrat 2).

Figure 7: Regrowth dominated by *Eucalyptus elata* with mesic understorey species such as the fern *Doodia aspera* (Quadrat 4).

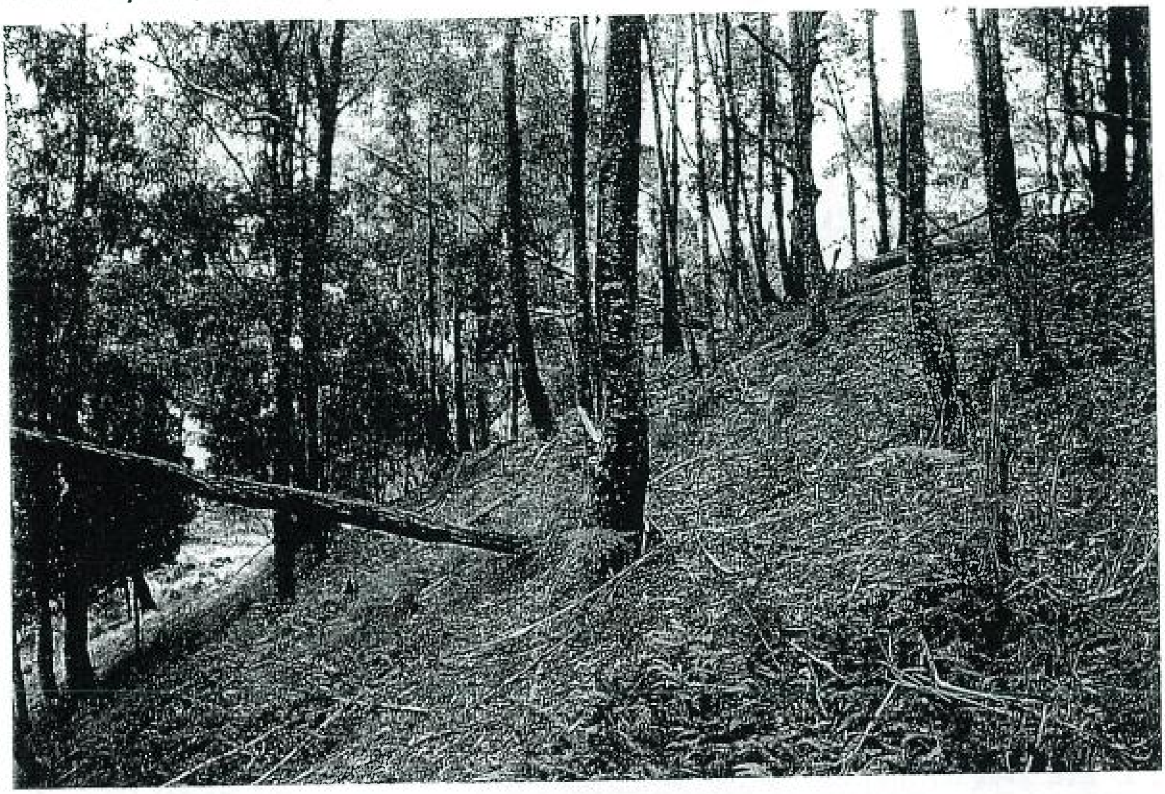

Figure 8: Remnant open forest in valley (Quadrat 6).

Figure 9: Southern side of valley, showing *Acacia mearnsii* (Black Wattle) regrowth in left corner, and small stand of eucalypts, including *Eucalyptus globoidea* (White Stringybark) in top centre of photo (Quadrat 5).

Figure 10: View eastward over open forest and woodland in valley. Note siltation ponds in centre of photo, and grassland dominated by perennial native species in foreground (Quadrat 3).

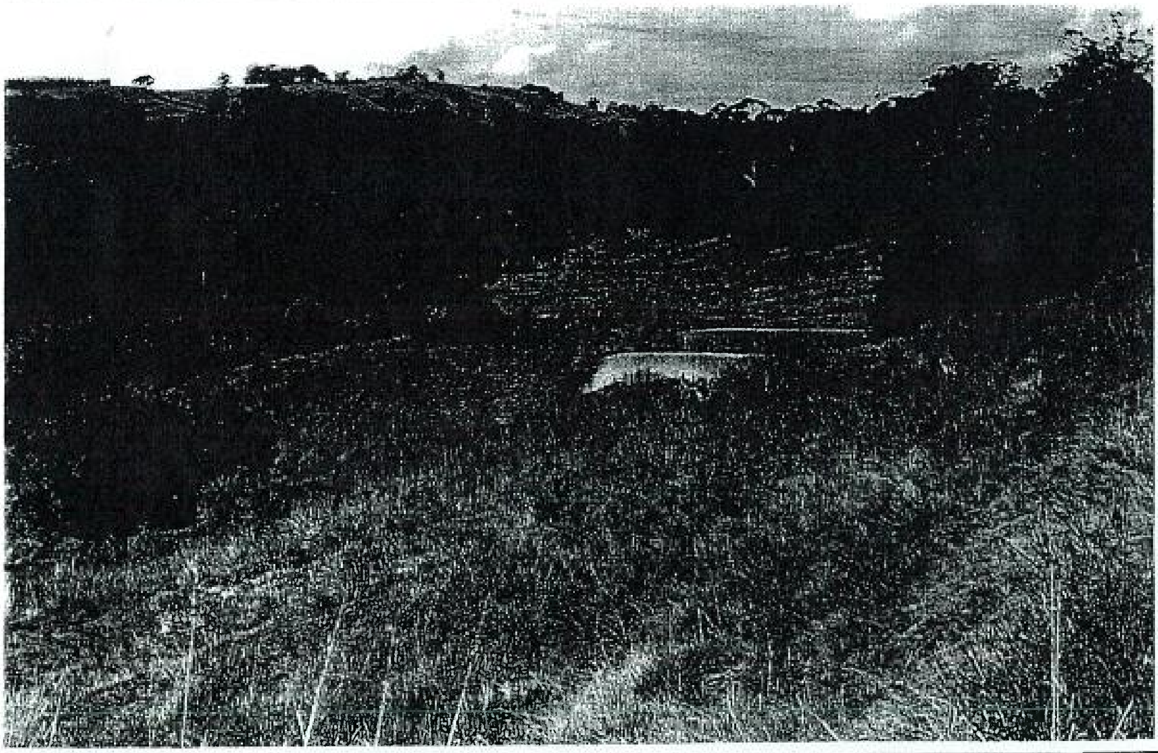

Figure 11: View over study area from eastern edge of plateau. Note blackberry infestation in centre of photo.

Figure 12: Plateau showing grassland dominated by introduced species.

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Appendix 1: Quadrat Data

Quadrat Data for Flora Species found in the study area. All figures are approximate percentages.

+ indicates less than 1%. * indicates exotic species.

	Quadrat Number						
Species recorded within Quadrat	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Trees							
Acacia mearnsii					80	10	
Acacia melanoxylon	+						
Eucalyptus amplifolia subsp. *amplifolia*						15	
Eucalyptus cypellocarpa	5		30				
Eucalyptus elata		30		40			20
Eucalyptus globoidea						20	
Eucalyptus quadrangulata							30
Eucalyptus radiata	40						
Shrubs							
Berberis aristata *							+
Solanum nigra *					+	+	+
Ferns/Fern allies							
Adiantum aethiopicum		+		2			
Doodia aspera				50			
Pteridium esculentum		5		5	2	20	5
Grasses							
Acaena novae-zelandiae	+	+		+			
Bromus sp. *					+		
Dactylus glomerata *			30				
Danthonia racemosa	+				5	1	
Echinopogon ovatus				+			
Lolium sp.		5					
Microlaena stipoides	20		5	20	2	2	5
Nassella trichotoma *						+	
Phalaris aquatica					5	2	5
Phalaris sp.	10	10	30	5			
Poa labillardieri	5	5		+	+	+	5
Poa sieberiana				5			
Sorghum leiocladum							+
Stipa sp.	5	+		+			

Species recorded within Quadrat	Quadrat Number						
	1	2	3	4	5	6	7
Themeda triandra	5					5	
Vulpia sp.			+				
Sedges/Rushes							
Carex sp.							5
Juncus subsecundus	+	+					
Herbaceous Plants							
Acianthus exsertus				+			
Anagallis arvensis *			+				
Asperula conferta	+						+
Cirsium vulgare *			5			+	2
Clematis aristata		+		+			
Conyza bonariensis *					+	+	
Dichondra repens	2	2	+	+		2	2
Geranium solanderi				+	+		+
Glycine microphylla	2	2		+		1	+
Gnaphalium sp.					+	+	
Hardenbergia violoceae	+						
Helichrysum scorpioides				2			
Hydrocotyle sp.		+		2			
Hypochaeris radicata *	2	10	+	+	+	2	2
Phytolacca octandra *					5		+
Plantago lanceolata *	2	2	+		+	2	2
Prunella vulgaris							+
Rubus fruticosa *		1					
Rubus parvifolius	+						
Rumex crispus							
Sonchus oleraceus *					+	+	
Stellaria pungens	2	+		5			
Taraxacum officinale *			2				
Trifolium sp. *	2	5	+	+			+
Verbena bonariensis *					+	+	
Veronica plebeia	1						
Vicia sp. *		+					
Viola betonicifolia		+					
Wahlenbergia stricta							

	Quadrat Number						
Species recorded within Quadrat	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bare Ground	1	+	-	10	5	20	5
Litter	30	30	20	30	30	20	30
Moss	+	-	-	+	-	-	-
Rock	-	-	-	-	-	-	-

Appendix 2: Flora Species List

* denotes exotic species.

FAMILY	BOTANICAL NAME	COMMON NAME
PTERIDOPHYTES		
ADIANTACEAE	*Adiantum aethiopicum*	Common Maidenhair Fern
BLECHNACEAE	*Doodia aspera*	Rasp Fern
	Doodia caudata	
DENNSTEADTIACEAE	*Pteridium esculentum*	Bracken Fern
DICKSONIACEAE	*Dicksonia antarctica*	Soft Treefern
ANGIOSPERMS		
DICOTYLEDONS		
APIACEAE	*Foeniculum vulgare**	Fennel
	Hydrocotyle sp.	Pennywort
ARALIACEAE	*Hedera helix* *	Ivy
ASTERACEAE	*Brachycome* sp.	
	Cassinia longiolia	Long-leaved Cassinia
	Cirsium vulgare *	Spear Thistle
	Conyza bonariensis *	Flax-leaf Fleabane
	Gnaphalium sp.	Cudweed
	Helichrysum scorpioides	Paper-daisy
	Hypochoeris radicata *	Cats ear
	Senecio sp. *	
	Silybum marianum *	Variegated Thistle
	Sonchus oleraceus *	Common Sowthistle
	Taraxacum officinale *	Dandelion
	Trifolium repens *	White Clover
	Trifolium sp. *	
BERBERIDACEAE	*Berberis aristata* *	
BIGNONIACEAE	*Pandorea pandorana*	Wonga-Wonga Vine
BRASSICACEAE	*Rorippa* sp.	Marsh Cress

FAMILY	BOTANICAL NAME	COMMON NAME
CAMPANULACEAE	*Wahlenbergia gracilis*	Native Bluebell
	Wahlenbergia stricta	Tall Bluebell
CARYOPHYLLACEAE	*Stellaria pungens*	Prickly Starwort
CONVOLVULACEAE	*Dichondra repens*	Kidney Weed
DISPSACACEAE	*Dipsacus fullonum* ssp. *fullonum* *	Wild Teazle
FABACEAE	*Glycine microphylla*	
	Goodia lotifolia	Clover-tree
	Hardenbergia violaceae	False Salsparilla
	Vicia sp. *	Vetch
(MIMOSOIDEAE)	*Acacia dealbata*	Silver Wattle
	Acacia mearnsii	Black Wattle
	Acacia melanoxylon	Blackwood
GENTIANACEAE	*Centauria spicata*	Australian Centaury
GERANIACEAE	*Geranium solanderi*	Native Geranium
HALORAGACEAE	*Gonocarpus* sp.	Raspwort
LAMIACEAE	*Prunella vulgaris*	Self-heal
MYRTACEAE	*Eucalyptus amplifolia* subsp. *amplifolia*	Cabbage Gum
	Eucalyptus cypellocarpa	Mountain Grey Gum
	Eucalyptus elata	River Peppermint
	Eucalyptus globoidea	White Stringybark
	Eucalyptus quadrangulata	White-topped Box
	Eucalyptus radiata	Narrow-leaved Peppermint
OLEACEAE	*Ligustrum lucidum* *	Large-leaved Privet
ONAGRACEAE	*Epilobium* sp.	Willow Herb
OXALIDACEAE	*Oxalis corniculata* *	Yellow Wood Sorrel
PHYTOLACCACEAE	*Phytolacca octandra* *	Ink-weed

FAMILY	BOTANICAL NAME	COMMON NAME
PLANTAGINACEAE	*Plantago debilis*	
	Plantago lanceolata *	Plaintain
POLYGONACEAE	*Persicaria hydropiper*	Water Pepper
	Persicaria lapathifolia	Knotweed
	Persicaria strigosa	Spotted Knotweed
	Polygonum aviculare *	Knotweed
	Rumex crispus *	Curled Dock
PRIMULACEAE	*Anagallis arvensis* *	Scarlet Pimpernel
RANUNCULACEAE	*Clematis aristata*	Traveller's Joy
	Ranunculus sp.	Buttercup
ROSACEAE	*Acaena novae-zelandiae*	Bidgee-widgee
	Prunus vulgaris *	
	Rubus fruticosa *	Blackberry
	Rubus parviflora	Native Raspberry
RUBIACEAE	*Coprosma quadrifida*	Prickly Currant Bush
	Asperula conferta	Common Woodruff
SCROPHULARIACEAE	*Veronica plebeia*	Trailing Speedwell
SOLANACEAE	*Datura stramonium* *	Thorn Apple
	Solanum nigra *	Black Nightshade
URTICACEAE	*Urtica dioides* *	Nettle
VERBENACEAE	*Verbena bonariensis* *	Purple Top
VIOLACEAE	*Viola betonicifolia*	Mountain Violet
MONOCOTYLEDONS		
CYPERACEAE	*Carex gaudichaudiana*	
	Carex sp.	
	Cyperus eragrostis *	Sedge
	Eleocharis cylindrostachys	Spike-rush
JUNCACEAE	*Juncus articulatus*	Jointed Rush
	Juncus australis	
	Juncus subsecundus	

FAMILY	BOTANICAL NAME	COMMON NAME
ORCHIDACEAE	*Acianthus exsertus*	Gnat Orchid
POACEAE	*Agrostis avenacea*	Blown Grass
	Anthoxanthum odoratum *	Sweet Vernal Grass
	Bromus sp. *	
	*Bromus unioloides**	Prairie Grass
	Cynodon dactylon	Common Couch
	Dactylis glomerata *	Cock's Foot
	Danthonia racemosa	Wallaby Grass
	Echinopogon ovatus	Hedgehog Grass
	Eleusine tristachya *	Goose Grass
	Entolasia stricta	Wiry Panic
	Lolium sp.	
	Hordeum leporinum *	Barley Grass
	Microlaena stipoides	Weeping Meadow Grass
	Nassella trichotoma *	Serrated Tussock Grass
	Paspalum dilatatum *	Paspalum
	Phalaris aquatica	Phalaris
	Phalaris sp.	Canary Grass
	Phragmites australis	Common Reed
	Poa labillardieri	Tussock Grass
	Poa sieberiana	
	Setaria geniculata *	Slender Pidgeon Grass
	Sorghum leiocladium	Wild Sorghum
	Sporobolus indicus subsp.*capensis* *	Parramatta grass
	Stipa sp.	Spear Grass
	Themeda triandra	Kangaroo Grass
	Vulpia sp.	Fescue
SALICACEAE	*Salix albens**	White Willow
SMILACACEAE	*Smilax australis*	
XANTHORRHOEACEAE	*Lomandra longifolia*	Mat Rush

Appendix 3: Fauna Species List

Species listed include potential occurrences for the study area obtained from database searches of the National Parks and Wildlife Service (**N**) and the Australian Museum database (**A**). Species identified in the study area during the field survey have also been indicated (**I**). Species expected to occur, based on distribution range and habitat availability within study area have been indicated (**E**). Species collected by WIRES (Wildlife Information and Rescue Service) and published in Wingecarribee Shire Council (1994) have also been included (**W**). It is important to note that species listed here do not necessarily occur within the study area itself, but have been detected nearby. Certain faunal groups, such as shorebirds and waders, do not appear on this list as potential habitat does not occur in, or adjacent to, the study area.

Scientific Name	**Common Name**	**Source**
REPTILES		
Family Agamidae		
Tympanocryptis diemensis	Mountain Dragon	N
Family Pygopodidae		
Pygopus lepidopodus	Common Scaly-foot	N
Family Scincidae		
Cyclodomorphus casuarinae	She-oak Skink	N
Eulamprus quoyii	Eastern Water Skink	N
Eulamprus tympanum	Highland Water Skink	N
Lampropholis delicata	Grass Skink	EI
Lampropholis guichenoti	Garden Skink	E
Saproscincus mustelina	Weasel Skink	N
Tiliqua scincoides	Eastern Blue-tongued Lizard	EW
Family Elapidae		
Austrelaps superbus	Copperhead	N
Pseudechis porphyriacus	Red-bellied Black Snake	ENW
Pseudonaja textilis	Eastern Brown Snake	EW
Family Chelidae		
Chelodina longicollis	Eastern Snake-necked Turtle	EW
AMPHIBIANS		
Family Myobatrachidae		
Crinia signifera	Common Eastern Froglet	EIN
Limnodynastes dumerilii	Eastern Banjo Frog	N
Limnodynastes fletcheri	Long-thumbed Frog	N

Scientific Name	Common Name	Source
Limnodynastes peronii	Brown-striped Frog	ENI
Limnodynastes tasmaniensis	Spotted Grass Frog	EI
Mixophyes balbus	**Stuttering Frog**	**A**
Pseudophyrne australis	**Red-crowned Toadlet**	**A**
Pseudophyrne bibronii	Brown Toadlet	N
Family Hylidae		
Litoria aurea	**Green and Golden Bell Frog**	**A**
Litoria caerulea	Green Tree Frog	
Litoria dentata	Bleating Tree Frog	N
Litoria latopalmata		N
Litoria peronii	Peron`s Tree Frog	
Litoria phyllochroa	Leaf Green Tree Frog	
Litoria verreauxii		N
MAMMALS		
Family Ornithorhynchidae		
Ornithorhynchus anatinus	Platypus	WN
Family Tachyglossidae		
Tachyglossus aculeatus	Short-beaked Echidna	EW
Family Dasyuridae		
Antechinus stuartii	Brown Antechinus	N
Dasyurus maculatus	**Tiger (Spotted-tailed) Quoll**	**N**
Antechinus swainsonii	Dusky Antechinus	EWN
Family Phascolarctidae		
Phascolarctos cinereus	Koala	WN
Family Vombatidae		
Vombatus ursinus	Common Wombat	EIWN
Family Phalangeridae		
Trichosurus vulpecula	Common Brushtail Possum	EWN
Family Petauridae		
Petaurus australis	Yellow-bellied Glider	N
Petaurus breviceps	Sugar Glider	IWN
Family Pseudocheiridae		
Pseudocheirus peregrinus	Common Ringtail Possum	EWN
Petauroides volans	Greater Glider	WN

Scientific Name	Common Name	Source
Family Macropodidae		
Macropus giganteus	Eastern Grey Kangaroo	EIWN
Wallabia bicolor	Swamp Wallaby	IWN
Macropus rufogriseus	Red-necked Wallaby	EW
Macropus robustus	Common Wallaroo	W
Eutheria		
Chiroptera		
Family Vespertilionidae		
Chalinolobus gouldii	Gould's Wattled Bat	W
Nyctophilus geoffroyi	Lesser Long-eared Bat	W
Miniopterus schreibersii	**Common Bent-wing Bat**	W
Family Pteropodidae		
Pteropus poliocephalus	Grey-headed Flying-fox	W
Pteropus scapulatus	Little Red Flying-fox	W
Rodentia		
Family Muridae		
Mus musculus	House Mouse ^	N
Rattus fuscipes	Bush Rat	EN
Family Leporidae		
Oryctolagus cuniculus	Rabbit ^	EIN
Family Canidae		
Vulpes vulpes	Fox ^	EI
BIRDS		
Family Ardeidae		
Ardea alba	Great Egret	N
Ardea intermedia	Intermediate Egret	N
Ardea novaehollandiae	White-faced Heron	EWN
Ardea pacifica	White-necked Heron	EN
Family Accipitridae		
Accipiter cirrhocephalus	Collared Sparrowhawk	WN
Accipiter novaehollandiae	Grey Goshawk	A
Accipiter fasciatus	Brown Goshawk	N
Aquila audax	Wedge-tailed Eagle	EN
Elanus axillaris	Black-shouldered Kite	EWN

Scientific Name	Common Name	Source
Family Falconidae		
Falco berigora	Brown Falcon	N
Falco longipennis	Australian Hobby	A
Falco peregrinus	Peregrine Falcon	WNA
Falco cenchroides	Nankeen Kestrel	EWN
Falco subniger	Black Falcon	N
Family Turnicidae		
Turnix varia	Painted Button-quail	A
Turnix maculosa	Red-backed Button-quail	W
Family Rallidae		
Gallirallus philippensis	Buff-banded Rail	W
Rallus pectoralis	Lewin's Rail	A
Family Charadriidae		
Vanellus miles	Masked Lapwing	WN
Family Cacatuidae		
Cacatua galerita	Sulphur-crested Cockatoo	EI
Cacatua roseicapilla	Galah	EIN
Callocephalon fimbriatum	Gang-gang cockatoo	NA
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo	IWN
Calyptorhynchus lathami	**Glossy Black-Cockatoo**	**NA**
Family Psittacidae		
Alisterus scapularis	Australian King Parrot	N
Platycercus elegans	Crimson Rosella	EIN
Platycercus eximius	Eastern Rosella	EIN
Family Cuculidae		
Cacomantis flabelliformis	Fan-tailed Cuckoo	N
Chrysococcyx lucidus	Shining Bronze-cuckoo	A
Family Strigidae		
Ninox novaeseelandiae	Southern Boobook	EWIN
Ninox strenua	**Powerful Owl**	**A**
Family Tytonidae		
Tyto alba	Barn Owl	EW
Tyto novaehollandiae	Masked Owl	A
Family Podargidae		

Scientific Name	Common Name	Source
Podargus strigoides	Tawny Frogmouth	EI
Family Aegothelidae		
Aegotheles cristatus	Australian Owlet-nightjar	N
Family Apodidae		
Hirundapus caudacutus	White-throated Needletail	EWN
Family Halcyonidae		
Dacelo novaeguineae	Laughing Kookaburra	EIN
Family Alcedinidae		
Alcedo azurea	Azure Kingfisher	WA
Family Campephagidae		
Coracina novaehollandiae	Black-faced Cuckoo-shrike	EIN
Family Petroicidae		
Eopsaltria australis	Eastern Yellow Robin	EIN
Microeca fascinans	Jacky Winter	EN
Petroica multicolor	Scarlet Robin	N
Petroica phoenicea	Flame Robin	EN
Petroica rosea	Rose Robin	EN
Family Dicruridae		
Grallina cyanoleuca	Magpie-lark	EWN
Rhipidura fuliginosa	Grey Fantail	EIN
Rhipidura leucophrys	Willy Wagtail	EN
Rhipidura rufifrons	Rufous Fantail	EN
Family Pachycephalidae		
Pachycephala rufiventris	Rufous Whistler	EN
Pachycephala pectoralis	Golden Whistler	EN
Falcunculus frontatus	Crested Shrike-tit	E
Colluricincla harmonica	Grey Shrike-thrush	EIN
Family Maluridae		
Malurus cyaneus	Superb Fairy-wren	EWIN
Malurus lamberti	Variegated Fairy-wren	E
Family Acanthizidae		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	EN
Acanthiza lineata	Striated Thornbill	N
Acanthiza nana	Yellow Thornbill	N

Scientific Name	Common Name	Source
Origma solitaria	Rock Warbler	N
Family Dicaeidae		
Dicaeum hirundinaceum	Mistletoebird	EN
Family Pardalotidae		
Pardalotus punctatus	Spotted Pardalote	EN
Pardalotus striatus	Striated Pardalote	EIN
Acanthiza pusilla	Brown Thornbill	EIN
Sericornis frontalis	White-browed Scrubwren	EIN
Sericornis magnirostris	Large-billed Scrubwren	N
Family Cinclosomatidae		
Psophodes olivaceus	Eastern Whipbird	N
Family Climacteridae		
Cormobates leucophaeus	White-throated Treecreeper	EIWN
Family Meliphagidae		
Acanthorhynchus tenuirostris	Eastern Spinebill	EWIN
Anthochaera carunculata	Red Wattlebird	WN
Anthochaera chrysoptera	Little Wattlebird	W
Lichenostomus chrysops	Yellow-faced Honeyeater	IN
Lichenostomus fuscus	Fuscous Honeyeater	N
Manorina melanocephala	Noisy Miner	EI
Meliphaga lewinii	Lewin's Honeyeater	N
Melithreptus brevirostris	Brown-headed Honeyeater	N
Melithreptus lunatus	White-naped Honeyeater	N
Myzomela sanguinolenta	Scarlet Honeyeater	N
Phylidonyris novaehollandiae	New Holland Honeyeater	N
Phylidonyris pyrrhoptera	Crescent Honeyeater	N
Manorina melanophrys	Bell Miner	E
Family Hirundinidae		
Hirundo neoxena	Welcome Swallow	EN
Hirundo nigricans	Tree Martin	N
Hirundo ariel	Fairy Martin	N
Family Zosteropidae		
Zosterops lateralis	Silvereye	EIN
Family Passeridae		
Neochmia temporalis	Red-browed Firetail	EIN

Scientific Name	Common Name	Source
Steganopleura bella	Beautiful Firetail	N
Steganopleura guttatum	Diamond Firetail	E
Family Sturnidae		
Sturnus vulgaris	Common Starling ^	EN
Family Artamidae		
Artamus cyanopterus	Dusky Woodswallow	EW
Cracticus nigrogularis	Pied Butcherbird	EN
Cracticus torquatus	Grey Butcherbird	EIN
Gynmorhina tibicen	Australian Magpie	EIN
Strepera graculina	Pied Currawong	EIN
Strepera versicolor	Grey Currawong	N
Family Paradiseidae		
Ptilorhynchus violaceus	Satin Bowerbird	N
Family Menuridae		
Menura novaehollandiae	Superb Lyrebird	N
Family Corvidae		
Corvus coronoides	Australian Raven	EIWN

Appendix 4: Curriculum Vitae

DAVID JOHN ROBERTSON - ECOLOGIST

Museum Position Ecologist/Project Manager

Date of Birth 11th January 1959

Nationality Australian

Qualifications

- B.Sc.(Hons)PhD University of Melbourne.

Employment History

- 1995 - Present: Ecologist/Project Manager, Australian Museum.
- 1987 - 1994: Lecturer in ecology, Charles Sturt University, Wagga Wagga
- 1986 - 1987: Research Fellow, School of Environmental Planning, University of Melbourne.
- 1985: Technical Officer, scientific, Victorian National Parks Service.

Expertise

- General interest and knowledge of biodiversity issues.
- Flora and fauna field survey, freshwater ecology, biological monitoring, environmental impact assessment

Relevant Experience

Fauna Impact Statement for Casino Management Areas NSW. Client: State Forests of NSW

Environmental Flow Study Stage 1 Lyell Reservoir NSW. Client: Pacific Power

Fauna Impact Statement: Gloucester and Chichester Management Areas NSW. Client: State Forests of NSW

Wallerawang Flora and fauna survey of proposed channel site NSW. Client: Pacific Power

Lyell Flow Study (Stage 2) NSW (Current). Client: Pacific Power

Licence Decision Report: Wanda Avenue Residential Development Salamander Bay NSW. Client: National Parks Wildlife Service

Walcha-Nundle/Styx EIS Fauna Chapter and FIS Review NSW. Client: State Forests of NSW

Literature Search and Gap Analysis of Western Sydney NSW. Client: National Parks & Wildlife Service

Fauna Impact Statement: Salamander Bay Central School, Port Stephens Shire NSW. Client: State Projects (Public Works)

Flora and Fauna Survey of Grosvenor Street Wahroonga, NSW. Client: Lean & Hayward Pty Ltd

Flora & Fauna Survey Archaeological Retirement Village at Cromer, NSW. Client: Twibill - Devine Erby Mazlin

Public Submission Response For Casino EIS Casino, NSW. Client: State Forests of NSW

Flora and Fauna Investigation of Proposed New Product Conveyor Route Howick Mine Singleton, NSW. Client: Novacoal Australia

Sydney Olympic Stadium Eight Point Test Fauna & Flora Homebush Bay, NSW. Client: Multiplex Constructions Pty Ltd

ANNE FINEGAN - ECOLOGIST

Museum Position	Technical Officer	
Date of Birth	6th October 1965	
Nationality	Australian	
Education	• 1994	Bachelor of Applied Science Charles Sturt University, Wagga Wagga
	• 1989	Bachelor of Business (Year 1 only) University of Technology, Sydney
	• 1986 to 1987	Bachelor of Education (Social Science) Newcastle College of Advanced Education
Employment History	July 1995 to Present:	Casual employment with Australian Museum Business Services
	July 1995 to Nov 1995:	Employed as Clerical Officer Grade 1/2 -NSW National Parks and Wildlife Service, Hunter District (Part-time Maternity Relief)
	Jan 1995 to July 1995:	Employed as Clerical Officer Grade 3 - NSW National Parks and Wildlife Service, Hunter District (Full-time Maternity Relief)
	Aug 1990 to Jan 1995:	Full-time employment - Administrative Assistant, Engineering Services, John Hunter Hospital. Served 2 years as Secretary of John Hunter Hospital Environmental Management Committee.
	July 1989 to May 1990	Full-time employment as Retail Sales Assistant - QANTAS Airways
	July 1987 to July 1989	Full-time employment as Revenue Accounts Clerk - QANTAS Airways

Relevant Experience

Participation in Flora and Fauna survey for Review of Environmental Factors for proposed hazard reduction burning in Nerong area, adjacent to Myall Lakes National Park.

Completion of report on Flora and Fauna investigations for proposed subdivision at Mirrabooka, Lake Macquarie.

Completion of report on Flora and Fauna investigations for developments proposed by Pacific Power for Ash Dam area on Wallerawang Power Station site.

Assistance in the preparation of Fauna Impact Statement for proposed forestry operations in the Casino Management Area.

Assistance in the preparation of Fauna Impact Statement for proposed forestry operations in the Gloucester-Chicester Management Area.

Assistance in the preparation of report on flora and fauna investigations for proposed residential development at Grosvenor Street Wahroonga.

Report Co-ordination for Licence Decision Report for proposed residential development at Medowie Park Estate.

Completion of report on Flora and Fauna investigations for proposed road corridor at Quakers Hill.

Report Co-ordination for Licence Decision Report for proposed residential development at Wanda Avenue, Salamander Bay.

Preparation of Fauna Impact Statement for proposed Salamander Bay Education Centre.

Completion of report on Flora and Fauna investigations for Review of Environmental Factors for proposed road widening at Fairfield.

Completion of report on Flora and Fauna investigations for proposed residential development at Cromer Heights.

Completion of report on pilot study of four wetlands in the Cattai Sub-catchment (Hawkesbury-Nepean Catchment).

Annexure 4. Curriculum Vitae

- **Steven Priday**
- **Thomas O'Sullivan**

STEVEN PRIDAY - PROJECT OFFICER (ECOLOGIST)

Museum position Project Manager

Date of Birth 5th July 1973

Nationality Australian

Qualifications

- 1991-1993:-BSc University of Queensland
- 1994:-BSc (Honours)
- Thesis: Space use and social organisation of a population of a native rodent, *Melomys cervinipes*, in a sub-tropical rainforest.

Employment History•

- 1996 - Present: - Australian Museum Business Services, Project Officer

Relevant Experience

- Surveys of mammals, birds and herpetofauna and preparation of management plans for flora and fauna at Albury-Wodonga, Kapooka and Singleton Military Areas (current) - *Project Manager*
- Surveys of aquatic macroinvertebrates, terrestrial macroinvertebrates and herpetofauna, for the Blue Mountains District Bio-Indicators Survey and Research Project - *Project Manager*
- Investigation of the movements of arboreal marsupials in relation to major roads in the south coast forests (current) - *Project Manager*
- Investigations into the effects of Arsenic and DDT contamination of wildlife in cattle tick dip sites in north-east NSW - *Project Officer*
- Fauna and flora assessments and preparation of Plans of Management for Threatened flora and fauna for the AGL gas pipeline easement in Scheyville, Marramarra, Popran and Brisbane Water National Parks - *Project Manager*
- Fauna and flora assessment of surplus land near Australia's Wonderland, Eastern Creek - *Project Manager*
- Fauna and flora assessment of site of proposed development, Cromer - *Project Manager*
- Fauna and flora assessment of site of proposed development, Penrith Lakes - *Project Manager*
- Fauna and flora assessment of site of proposed development, John Morony Correctional Centre, Windsor - *Project Manager*
- Fauna assessment of Bradleys Head, Sydney Harbour National Park - *Project Manager*
- Fauna assessment of South Head, Sydney Harbour National Park - *Project Manager*
- Fauna assessment of Goat Island, Sydney Harbour National Park - *Project Manager*
- Flora assessment of site of proposed development, Homebush Bay - *Project Officer*
- Co-preparation of the Management Plan for the Green and Golden Bell Frog at Homebush Bay - *Project Officer*
- Monitoring of populations of the Green and Golden Bell Frog at Homebush Bay - *Project Officer*
- Surveys of mammals, birds and herpetofauna for Species Impact Statement for proposed Camden Haven Highschool at North Haven - *Project Officer*

THOMAS NORMAN LESLIE O'SULLIVAN - ECOLOGIST

Museum Position Project Officer
Date of Birth 15 June 1958
Nationality Australian

Qualifications

1997 - present Masters of Wildlife Management (Macquarie University)
1994 - 96 (transferred). Masters of Environmental Studies (University of New South Wales)
1994: Statement of Attainment. Environmental Management. (TAFE)
1992: BA Zoology/Physical Geography (University of New England)

Employment History

1995 - present: Australian Museum Business Services. **Project Officer**
1996 Southern Sydney Regional Organisation of Councils (SSROC). **Contracted Work**
1995: Southern Sydney Regional Organisation of Councils (SSROC). **Contracted Work**
1993 -1995: Birnbaum Gardening Service. **Horticultural & Landscape Assistant**
1993 -1994: Taronga Zoo. **Research Assistant (Voluntary)**
1993: Environmental Defenders Office. **Office Assistant (Voluntary)**
1990 -1992: Academic Pest Control. **Graduate Field Officer**

Relevant Experience

Expert testimony/Preparation of Evidence

- In relation to Species Impact Statement for War Veterans Village Extension, Narrabeen. Cox Richardson P/L. NSW Land and Environment Court, March 1998.
- Preparation of Statement of Evidence for damage to Red-crowned Toadlet Habitat at Somersby, Gosford. NSW National Parks and Wildlife Service, July 1998.

Reports/Field Work

- Investigation of the movements (radiotracking) of arboreal marsupials in relation to major roads in the south coast forests. RTA (current) - *Project Officer*
- Flora and Fauna Habitat Assessment of the Proposed Exclusion Fenceline Easement at Canyon Colliery, Bell. Kinhill. (current) *Project Manager*
- Targeted Flora and Fauna Investigation of the Wilton to Newcastle Gas Pipeline Easement. AGL. (current) *Project Officer*
- Redrafting of Flora and Fauna sections for the Sewerage Overflow Licencing Project EIS. Sydney Water. *Project Officer*
- Flora and Fauna Habitat Assessment for the Proposed Storage Tunnel. Sydney Water. *Project Manager*
- Species Assessment on the Somersby Industrial Park, Gosford. Gosford City Council. *Project Manager*
- Flora and Fauna investigation at Mt Penang, Gosford. Department of Corrective Services. *Project Manager*
- Fauna assessment of Goat Island, Sydney Harbour National Park - *Project Officer*
- Species Impact Statement for War Veterans Village Extension, Narrabeen. Cox Richardson P/L. *Project Officer*
- Species Impact Statement for Grosvenor Street, Wahroonga. Chanrich Properties. *Project Officer*
- Habitat Assessments Tumbarumba. Department of Public Works and Services. *Project Officer*
- Habitat Assessment, Helensburgh. Walker Engineering. *Project Officer*
- Hawkesbury-Nepean Biodiversity Study. National Parks and Wildlife Service. *Project Assistance*
- Fauna Impact Statements for proposed forestry operations in the Urbenville Management Area and Gloucester/Chichester Management Area. State Forests. *Project Assistance*
- Monitoring of populations of the Green and Golden Bell Frog (*Litoria aurea*) at Homebush Bay. *Project Assistance*
- Surveys of mammals, birds and herpetofauna for proposed Camden Haven High School at North Haven. *Project Assistance*
- Surveys of mammals, birds and herpetofauna Albury-Wodonga, Kapooka and Singleton Military

CONCRITE QUARRIES PTY LTD

EXETER QUARRY EXTENSION

AN ARCHAEOLOGICAL INVESTIGATION OF A PROPOSED HARD ROCK QUARRY EXTENSION AND PROPOSED EXETER BYPASS, NEW SOUTH WALES

Prepared by:

Robert Paton Archaeological Studies Pty Ltd

March, 1999

Specialist Consultant Studies

Volume 1 ▪ Part 8

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An archaeological investigation of a proposed hard rock quarry extension and proposed Exeter Bypass New South Wales

A Report to Concrite Quarries Pty Ltd

by

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March 1999

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GLOSSARY

Artefact	An object made by humans, more commonly referring to stone artefacts in an Australian context.
Blade	A long flake, typically twice as long as wide.
Core	A lump or nodule of stone from which a flake or flakes have been removed.
Exposure	Extent to which ground surface has been revealed by erosion or disturbance. Archaeological sites which are covered by sediment or vegetation cannot be detected unless there is sufficient exposure.
Flake	A piece of stone detached from a core and which usually has both a bulb of percussion and a striking platform.
Flaked Piece	A piece of stone which has negative flake scars, indicating that it is an artefact, but does not have the two features which allow its classification as a flake: a striking platform and a bulb of percussion.
Retouch	The removal of flakes from a stone artefact, typically a flake, to either sharpen a blunted edge or to deliberately blunt a stone tool.
Site	Any location which contains significant evidence of past human activity.
Striking Platform	A flat area on a core, struck with a hammerstone to detach a flake.
Usewear	Wear in the form of very fine flakes or polish on the working edge of a tool.

1.0 INTRODUCTION

Concrite Quarries Pty Ltd proposes to extend the Company's existing basalt quarry located approximately 7 km south-west of Moss Vale and approximately 0.6km east of Exeter Village and develop a bypass to direct product trucks around Exeter Village (Figure A). The proposed extraction area lies immediately to the north-west of the existing approved extraction area and processing plant. An initial development proposal was developed in 1997, however, this has since been modified and a revised proposal has been developed.

Concrite Quarries Pty Ltd plans to submit a new Development Application accompanied by an EIS presenting a revised proposal that addresses each of the issues of concern raised with respect to the initial proposal. At this stage it is envisaged that the revised proposal would involve the following main components:

i) Extraction would be confined to a lesser area than the initial proposal with emphasis placed upon limiting extraction to the lower contours of the subject land and maximising the recovery of the broken basalt on the western side of the property (Figure B). Extraction would be confined to an area of approximately 11 ha and generally below the 720 m, AHD contour. Provision has also been made for the transfer of some overburden from the proposed extraction area to the existing extraction area.

ii) The rate of extraction would be maintained at the present rate of 300 000 tpa for a period of three years or sooner within which a bypass of the Exeter intersection would be constructed. Once the bypass is constructed, the rate of extraction would be increased to maximum level of 450 000 tpa for the remainder of the 18 year consent period sought. A quantity of up to 8.5 million tonnes of quality basalt could be extracted in that period.

iii) Product truck traffic would be directed as follows:

- The current traffic distribution pattern would continue until the bypass is constructed and operational.
- A bypass of the Exeter intersection would be constructed within a corridor across land acquired by the Concrite Group, i.e. the "Vine Lodge" property. The exact alignment of the bypass will be established during the preparation of the EIS, however, at this stage it is likely to be positioned generally within the corridor (Figure B).
- Once the bypass is operational, it is proposed that all traffic except local deliveries would travel along the bypass to Exeter Road to Illawarra Highway and then either to Sydney or Goulburn via Hoddles Cross Roads or to the Illawarra via Moss Vale.

As part of the planning for the proposed extension to the existing quarry, a number of environmental factors are being reviewed. One of these factors is the impact of the proposal on heritage / conservation values. To address this issue consultant Robert Paton Archaeological Studies Pty Ltd was commissioned by R.W. Corkery & Co. Pty Ltd on behalf of Concrite Quarries Pty Ltd to undertake a study of Aboriginal archaeological sites.

1.1 Aims of the study

The Study has three main aims:

1. To locate and record any Aboriginal sites in the proposed development area.

2. To consult with the local Aboriginal community regarding the proposed development.

3. To identify any constraints placed on the development by Aboriginal heritage issues.

The field survey of the proposed extraction area was conducted in May 1996 by archaeologist Robert Paton (BA Hons) after consultation with the representative of the Illawarra Local Aboriginal Land Council, Mr Jim Davis. The Exeter Bypass corridor was surveyed in January 1999 by archaeologist Dave Johnston (MA), field assistant P.J. Williams and Illawarra Local Aboriginal Land Council Sites Curator, Jim Davis and his assistant Oscar Page.

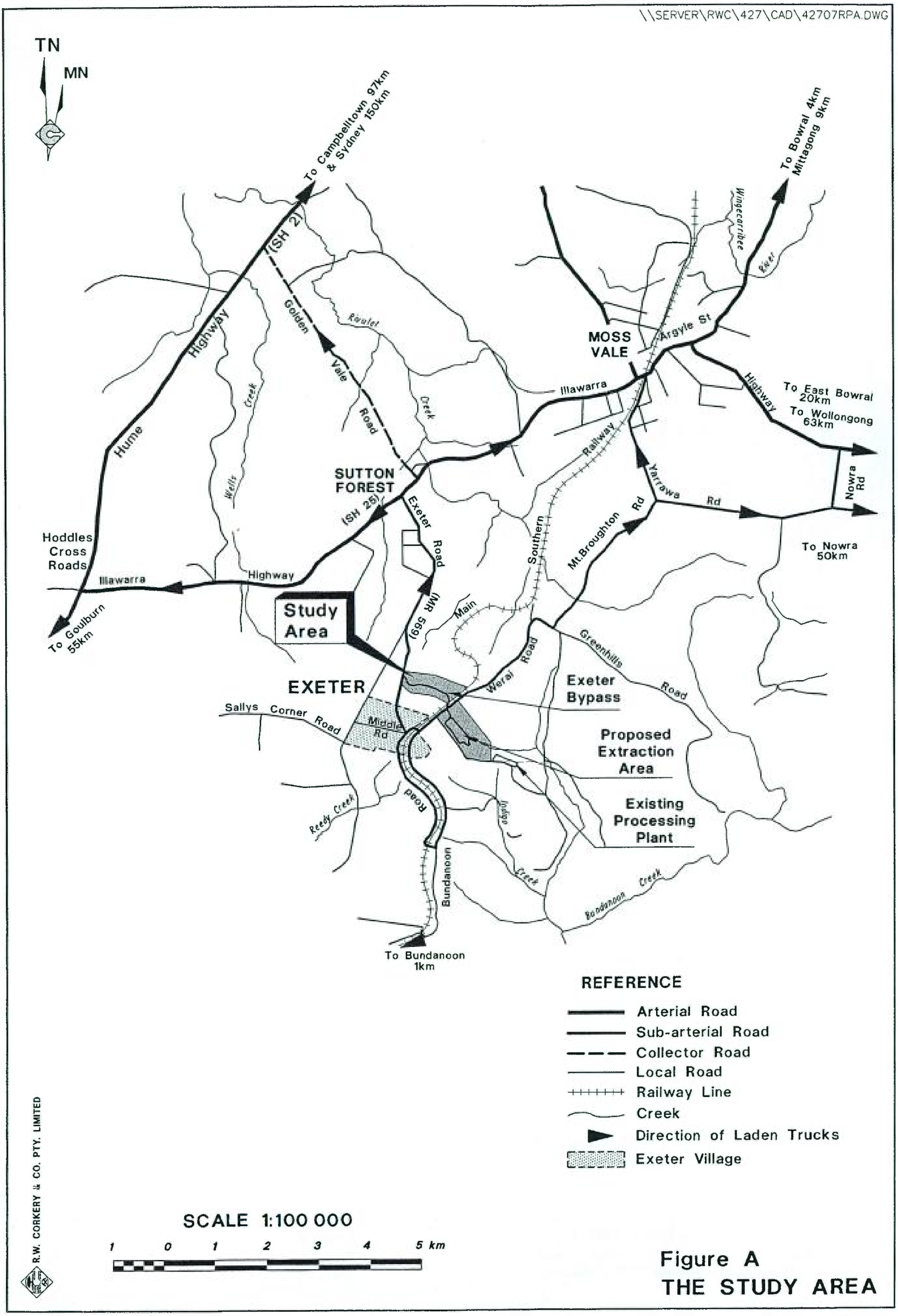

Figure A
THE STUDY AREA

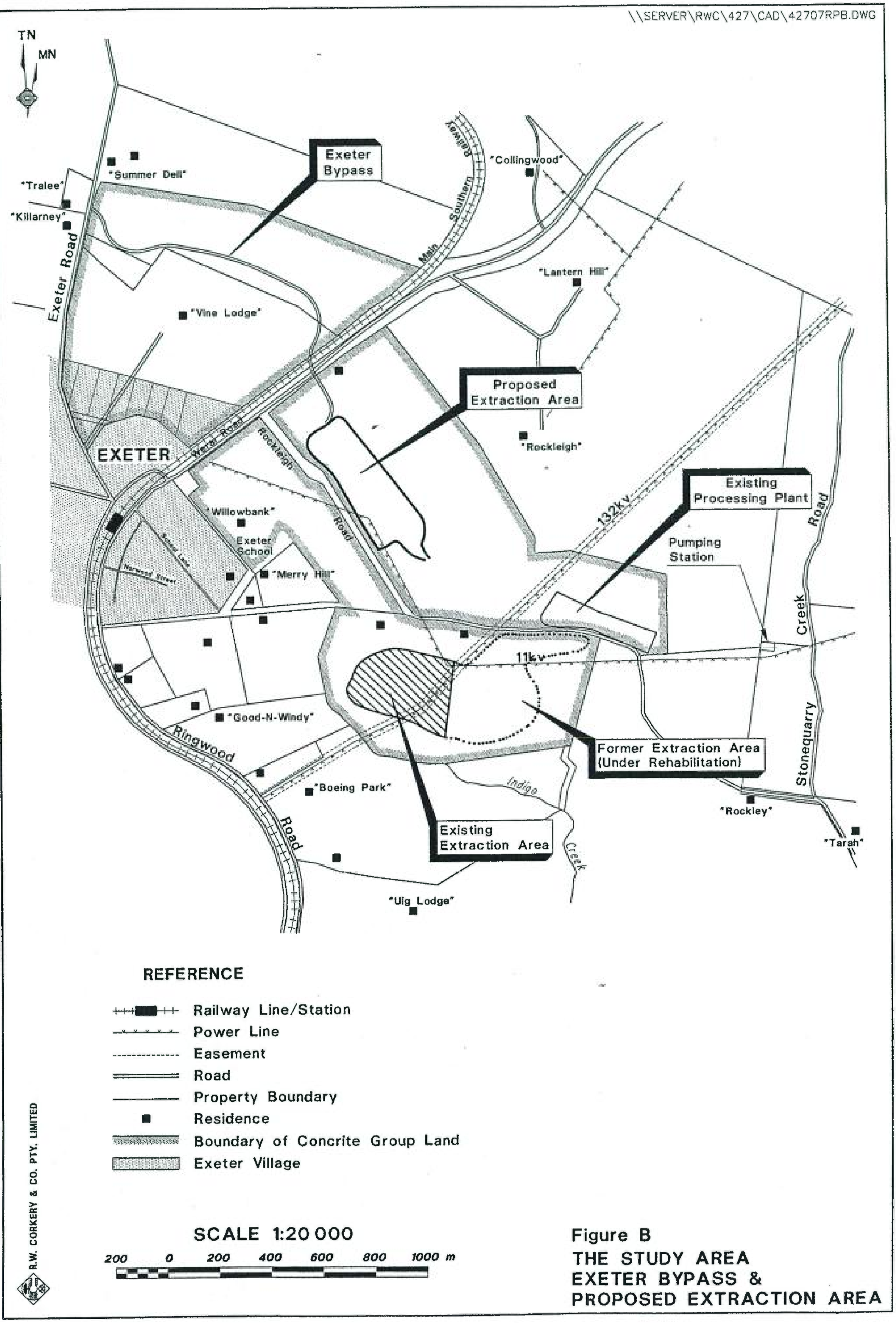

Figure B
THE STUDY AREA
EXETER BYPASS &
PROPOSED EXTRACTION AREA

2.0 ENVIRONMENTAL SETTING

The modified proposed extraction area covers approximately 11 hectares or about one third of the initial proposed extraction area. It is bounded on the northwest by Werai Rd and on the south by Rockleigh Rd. The general area consists of moderately undulating terrain which plateaus at 740 metres. The southern end is drained by a small creek with steep slopes falling to 650 metres.

The Exeter Bypass corridor comprises approximately 40 hectares. It is bound to the west by Exeter Rd and on the east by the Main Southern Railway and Werai Rd. This area, immediately to the northwest of the proposed quarry extension section, also consists of moderately undulating terrain which plateaus at 715 metres. Two small creeks / drainage channels commence in this area, one in the western sector running north and the other commencing in the east and draining to the northwest. What appears to be two closely connected, modified natural soaks, are located in the centre of the Exeter Bypass corridor (the larger one having dam walls and the smaller one containing a cement well).

The hard rock of the area is a Tertiary basalt flow overlying Wianamatta shales which could have served as suitable shelters or overhangs. Soils of the area are red-brown and quite deep in some areas. These soils have been extensively disturbed by ploughing and ripping, and less obviously by animal disturbance and increased erosion promoted by the removal of the natural vegetation. At present the survey area has lightly timbered pockets, with the original vegetation having been cleared and extensively disturbed by farming activities. The majority of the area is covered with pasture grasses with some blackberry bushes and thistles. A total of three dams have been constructed within the proposed area and one dam and two modified natural soaks / springs are located within the Exeter Bypass corridor.

Current land use in the study area is associated with farming. This activity has resulted in a high degree of disturbance throughout the area investigated, with none of the land remaining in a state conducive to the preservation of Aboriginal sites. Certainly, any sites that may by located in the area would be in extremely poor condition.

3.0 ARCHAEOLOGICAL CONTEXT

The NSW NPWS sites register show that there has been no archaeological sites recorded in the proposed development site. One site was known within a 3km radius (NPWS Site 52-5-0193). This site consists of a small open artefact scatter and is situated several hundred metres south east of the study area and should be of no concern in terms of this development.

Very little archaeological investigation has been carried out in the immediate Exeter region. However, it is possible to gain some understanding of the areas archaeology through the systematic surveys undertaken in areas immediately adjacent to the proposed extension.

Brayshaw (1982) located no sites during her survey of the Berrima colliery. Koettig (1981) undertook a survey for the F5 extension between Hoddles Cross Roads and Alpine, primarily over Wianamatta Shale and Hawkesbury Sandstone. She located a total of 24 sites, including thirteen campsites, one of which was associated with a stone tool quarry.

Koettig (1981) observed that the campsites generally occurred in close proximity to watercourses, on flats, elevated areas above creek confluences and on spurs and ridges above the creeks. This general site location prediction was further supported by Rich's (1984) findings at Exeter, in areas immediately adjacent to the present study area.

Rich (1984:5) located one isolated find on the wall of a dam on the upper terrace of the hill. The artefact was a good quality milky quartz blade with retouch on one side. However, being located on the dam wall, it was in a disturbed context and in a later study it could not be relocated (Barber undated). Rich also located one open campsite (NPWS Site 52-5-0193). It was located 20 metres east of an un-named north-south creek close to the junction of Indigo Creek. Elevation was approximately 10m above the creek, with the exposure measuring approximately 25m x 20m. It was not possible to measure the extent of the site, as 100m north the slope becomes steeper and the site probably does not extend onto this steeper slope. The artefacts included flaked pieces and a core of a range of materials such as quartz, silcrete and chert. Two of the flaked pieces and the core displayed evidence of retouch and usewear.

Rich (1984) suggests that the open camp site fits with the general pattern of site location as identified by Koettig (1981) for the area. The isolated artefact located on the upper basalt terrace indicates use and possible occupation of this locality, yet it is observed that the upper terrace has been ploughed and any possible sites will have been destroyed.

A more recent study at Lot 2, DP537292 of the Exeter Quarry (Barber, 1993), although resulting in no archaeological finds, tends to support Rich's model of site patterning.

Based on our understanding of archaeological site patterning in the Exeter region, it seems very unlikely that the study area would contain much evidence of Aboriginal occupation. This assessment is based on several factors:

1. Much of the study area has been very disturbed by European landuse. Although evidence of Aboriginal occupation may still be found in such areas, the probability of finding intact sites is severely diminished.

2. Although the study area contains a creek, its sides are steep and do not feature flat areas which typically contain sites.

3. Most of the study area is comparatively featureless topographically, and does not contain the slightly elevated land where sites are usually found.

4. The study area does not contain deep deposits of surface sands typically associated with archaeological sites.

4.0 PROJECT METHODOLOGY

4.1 Background Work

For this background component of the project, the following tasks were undertaken :

* Establish communications with the NSW NPWS;

* Commence liaisons with the relevant Aboriginal representative bodies for the area. This being the:

- Illawarra Local Aboriginal Land Council.

* A review of the Archaeological Sites Data Base for the study area and surrounds.

* The collation of relevant documentation for the project, including:
  - Maps of the study area;
  - Archaeological reports for the study area, and surrounding region;
  - Environmental reports;
  - References to the land use history of the study area;

* Obtaining the necessary site access clearances for getting onto the site to carry out the field work.

* The development of a field survey design which effectively caters for the specific objectives of this project.

4.2 Fieldwork Methodology

For this stage an archaeological field survey program was undertaken to locate and record any Aboriginal sites that were present within the study area. While the primary aim of this work was for site clearance purposes the archaeological approach was also aimed at collating the survey results to progress an understanding of Aboriginal land usage in the area.

4.2.1 Field Survey Strategy

Prior to the commencement of the fieldwork, a review of topographical maps was carried out so as to become familiar with the landscape and terrain and to assist in the identification of areas of archaeological potential.

Given the relatively small size of the area to be investigated and the fact that there has been so much disturbance to the landscape as a result of pastural activities, the field survey strategy proposed was quite straight forward. The survey team systematically walked all tracks, fencelines and areas where visibility allowed the ground surface to be viewed. In addition areas of ground with lesser visibility were traversed and inspected in detail (Figures C & D).

The field investigation for the proposed quarry extension area was carried out in May 1996 and the Exeter Bypass corridor was surveyed in January 1999.

The 1996 field survey of the proposed extraction area comprised approximately 62.3 hectares of land. The proposed extraction area as mentioned earlier has now been reduced, to 20 ha. The coverage details results of that survey however, are still included in this report.

4.2.2 Recording Methods

For this investigation, if a site was located, the following variables were to be recorded:

Site designation: sites located were to be designated a number in the field.
Site type: The type of site identified eg. surface artefact scatter.
Location: Description of how to get to the site, including the best route either by foot or vehicle.
Grid reference: The location of sites were to be plotted on 1:100,000 standard topographical maps. The grid references were to be identified using Global Positioning System units in conjunction with existing mapping.
Environmental setting: This describes the sites' environmental context including such things as geomorphology, geology, vegetation and local hydrology.
Aspect: Direction and degree of the ground slope at the site. Aspect is thought to be a prime determinant of site location.
Visibility: A measurement of the conditions of ground surface visibility in the surveyed areas. Ground visibility conditions will effect whether sites are detected, and whether their full extent has been recorded.
Site contents: This is a description of the artefacts and/or any other archaeological features that constitute a site. At sites consisting of stone artefact scatters, descriptions involve recording measurements of particular variables on the artefacts, including: raw material, artefact type (See glossary of terms for details), artefact dimensions (L x W x B), presence of retouch or usewear, and any general comments considered relevant. Of course, these variables are only very general in nature, and for this reason any sites considered to have greater research potential would be indicated and the potential avenue of research is discussed. The density and extent of an artefact scatter site would determine if only a sample of the artefacts was to be recorded.
Site size: Refers to the dimensions over which artefacts or features are visible.
Site condition: Describes the condition of the site in terms of factors which may have disturbed it (such as road works, fluvial erosion etc.) or which have the potential to disturb.
Site Significance: An assessment of the archaeological importance of the site.
Management considerations: This details the potential threat to the site specifically in terms of the planned development. In addition, specific ameliorative measures are recommended if warranted.

In the course of surveying, any mature native trees within the survey area were checked for scars of possible Aboriginal origin.

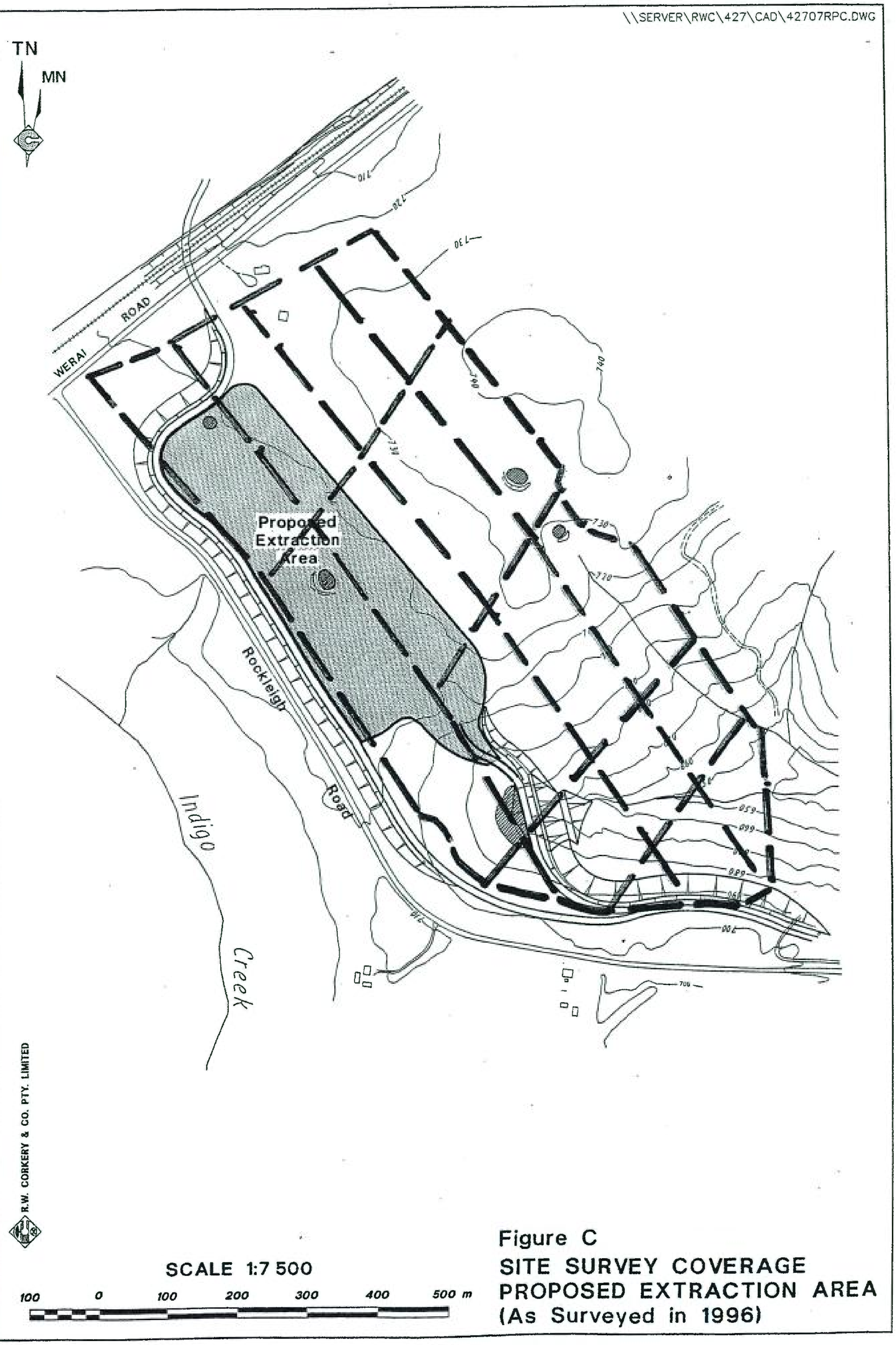

Figure C
SITE SURVEY COVERAGE
PROPOSED EXTRACTION AREA
(As Surveyed in 1996)

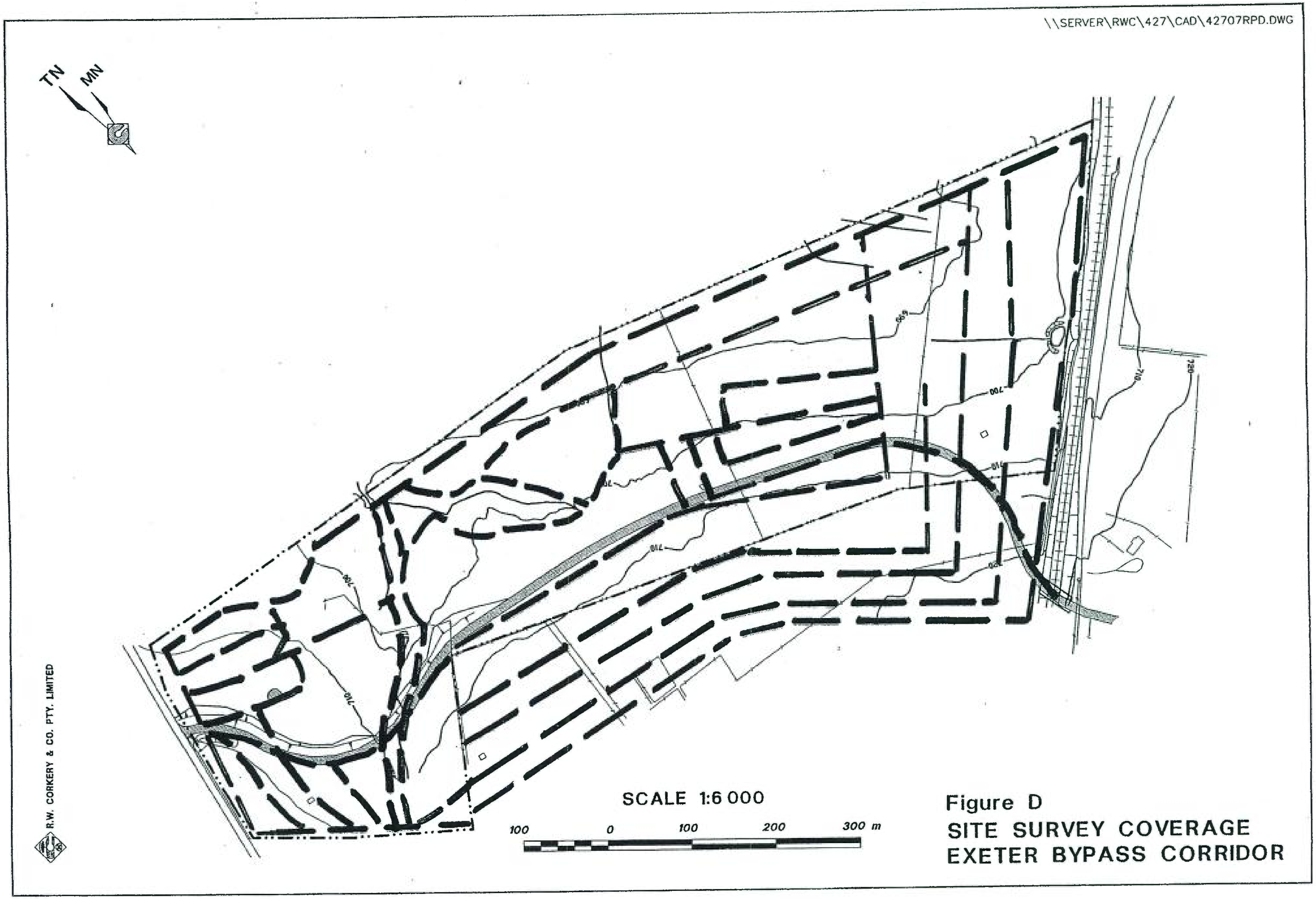

Figure D
SITE SURVEY COVERAGE
EXETER BYPASS CORRIDOR

4.3 Aboriginal Consultation Procedures

Bowdler (1983:26) recognises two kinds of sites that are significant to Aboriginal people. The first relates to pre-contact times, the second to the period since colonisation. Some of these sites may be recognisable due to landscape modification or material remains whereas others may consist of a noticeable but natural physical feature. Bowdler (1983:30) stresses that,

> identification of sacred sites and sites of significance to Aboriginal people is of necessity a matter for Aboriginal people. No-one else can decide either the fact of significance or the degree of that significance to an Aboriginal community, except members of that community.

It is for this reason that members of the Aboriginal community are consulted during heritage studies such as this.

One of the primary tasks of the archaeological project was to consult with the relevant Aboriginal organisation/s regarding the Aboriginal cultural heritage of the study area, so as to document any known heritage information that custodians may have. Following discussions with the identified custodians, the consultant would record any recommendations put forward relating to the heritage of the area. For this area heritage issues are dealt with by the Illawarra Local Aboriginal Land Council. Summaries of the consultations held with the Land Council are included in the Aboriginal Consultation Section (Sect. 7) and specific recommendations are also included in the Recommendations Section (Sect. 8) of this report.

5.0 RESULTS OF THE SURVEY

No Aboriginal sites were located within the two sections of the study area.

No European sites of significance were located during the field survey. Within the proposed extraction area the only European artefacts to be disturbed by construction are items such as fences and some derelict building footings. Within the Exeter Bypass corridor, the ruins (namely foundations) of a relatively recently used building structure (appears to be a farm house, with associated windmill ruins and cement well near by) were observed. Three small modern farm sheds exist on "Vine Lodge" within the study area. All of these European items are well represented locally and none are listed as being significant on the State or Commonwealth Site Registers.

5.1 Conditions of Visibility

Clearly conditions of ground surface visibility will affect how many sites are found. Visibility may also skew the results of a survey. If, for example, conditions of ground surface visibility vary dramatically between environmental zones, then this in turn will be reflected in the numbers of sites reported for each zone. Zones with the best visibility may be reported as having the most sites (because they are visible on the ground), while another zone with less visibility, but perhaps more sites, will be reported as having very little occupation. It is important therefore to consider the nature of ground surface visibility as part of any archaeological investigation.

For this study the conditions of ground surface visibility were fair, being in the range of 5-80 percent. This wide range of visibility is due to the fact that the survey incorporated a majority of area which was mostly grassed (which had a visibility of 5 percent), and higher visibility occurring with soil exposures along tracks, dam walls, at gateways in fences, on occasional stock pads, and at the bases of some trees. Within the proposed extraction area, vehicle tracks, fortunately, were ubiquitous throughout. In addition, within the proposed extraction area there were areas where exploration pits had been dug. These pits provided excellent views of the sub-surface deposits. Ground surface visibility therefore, within the proposed quarry section was greater (average of 50%) than at the Exeter Bypass corridor (average of 10-20%).

Away from the tracks visibility diminished to almost zero, apart from the proposed extraction area. This poor visibility was due to the presence of grasses and leaf litter. The grass was particularly high within the paddocks of "Vine Lodge".

6.0 DISCUSSION & ASSESSMENT OF IMPACT

The results of this investigation were predictable based on the review of environmental factors and previous archaeological studies. As described previously it was considered very unlikely that Aboriginal people would have extensively used the study area, though they may have occasionally passed through. Based on this assessment it is unlikely that the proposed development will affect any Aboriginal relics within the study area, certainly the proposed extraction area. There is a slight possibility that archaeological evidence may be present near the small creek / drainage channels and the soak area. These areas however, have been substantially impacted by previous pastoral activities.

7.0 ABORIGINAL CONSULTATION

The study area is situated within the boundaries of the Illawarra Local Aboriginal Land Council. Two stages of Aboriginal consultation were carried out for this project, corresponding to the dates the two fieldwork phases were carried out.

Prior to the commencement of each of the fieldwork phases, contact was made with Mr Jim Davis from the Illawarra Local Aboriginal Land Council. Mr Davis was informed about the nature and scope of the development as well as the character of the proposed archaeological investigation. Unfortunately, Mr Davis was unable to attend the field study with the archaeologist during the 1996 study of the quarry extension. Maps of the development were forwarded to him and he was able to inspect the area later. During a later phone conversation he reported that no sites were located and that he was happy with the results of this survey. He stated that given the absence of any sites he endorsed the recommendations of this report.

For the 1999 field survey of the Exeter Bypass corridor within "Vine Lodge", Mr Davis and assistant, Oscar Page were able to attend. The Illawarra Local Aboriginal Land Council have stated that they would like one day to inspect the "Vine Lodge" area during the clear and grade stage of the haul road construction, to assess if sub-surface cultural material is present. This focus would be specifically aimed at the small creek / drainage channel and soak area. Although the probability of sites being present is low, the Land Council is concerned that the surface visibility at the time of the survey was relatively poor. A letter from the Illawarra Local Aboriginal Land Council endorsing the recommendations from this study is included as Appendix 1.

8.0 SUMMARY AND RECOMMENDATIONS

No Aboriginal archaeological sites were located in the study area. Given the intensity of this study, it seems unlikely that any other sites would be located by further general survey work.

Based on these findings it is recommended that:

1. The proposed extraction area should be allowed to proceed without further archaeological work.

2. There are no impediments to road construction works commencing along the Exeter Bypass.

3. An Aboriginal Sites Monitor from the Illawarra Local Aboriginal Land Council inspect the Exeter Bypass through "Vine Lodge", for one day during construction to assess if sub-surface cultural material possibly associated to the small creek / drainage channel and soak area is present. Should Aboriginal relics be identified during this phase then works should stop within the immediate area and NSW NPWS be contacted for further advice.

4. It should be noted that all Aboriginal relics in NSW are protected under the NPWS Act. Should any relic be uncovered during construction, work at that part of the development should cease and the NPWS should be informed of the find. A management strategy for the relic can then be devised in consultation with appropriate parties.

5. Three copies of this report should be sent to the NPWS Zone Archaeologist, Southern Region. A copy of the report should also be sent to the Illawarra Local Aboriginal Land Council.

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APPENDIX 1

Letter From the Illawarra Local Aboriginal Land Council

(No. of pages excluding this page = 1)

Illawarra Local Aboriginal Land Council
39 Princes Highway, Dapto N.S.W. 2530 • Phone (042) 62 2978 • Fax (042) 62 2981

Mr. Dave Johnstone,
Australian Archaeological Survey,
Consultants Pty Ltd.,
G.P.O. Box 943,
Canberra A.C.T. 2601.

23rd February, 1999.

Dear Dave,

Re: Archaeological Survey for Exeter Quarry-Vine Lodge

On Thursday 28th January, 1999 I accompanied you on the above survey from which certain information was bought back to the Illawarra Local Aboriginal Land Council for analysis, discussion and recommendations and they are the following:-

1. Visibility in the survey area was extremely poor and no Aboriginal sites or cultural material were detected although their presence cannot be conclusively ruled out.

2. Due to these facts the Illawarra Local Aboriginal Land Council endorse the recommendations presented in the archaeological\ report with emphasis on a day of monitoring to assess if sub-surface cultural material is present.

If these requirements are met the Illawarra Local Aboriginal Land Council have no objection to the construction of the proposed haul road progressing.

Sincerely Yours,

Mr. James Davis,
Senior Aboriginal Sites Officer.

CONCRITE QUARRIES PTY LTD

EXETER QUARRY EXTENSION

ASSESSMENT OF THE POTENTIAL IMPACTS ON:

HERITAGE ITEMS, HERITAGE VALUES OF THE LANDSCAPE AND VISUAL AMENITY

Prepared by:

The University of Sydney

August, 1999

Specialist Consultant Studies

Volume 1 ▪ Part 9

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PROPOSED EXETER QUARRY EXTENSION

ASSESSMENT OF THE POTENTIAL IMPACTS ON:

HERITAGE ITEMS, HERITAGE VALUES OF THE LANDSCAPE AND VISUAL AMENITY

Prepared for: CONCRITE QUARRIES Pty Ltd

THE UNIVERSITY OF SYDNEY
DEPARTMENT OF ARCHITECTURE, PLANNING AND ALLIED ARTS
NSW 2006 AUSTRALIA

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1.0 PURPOSE OF THIS REPORT

This report assesses the potential for impacts on heritage and visual values of a proposed extraction area near the Concrite Quarries Pty Ltd hard rock quarry near Exeter and a bypass route north of Exeter Village. A previous proposal for a further extraction area at the quarry was the subject of a Commission of Inquiry in 1997. That application was for a considerably larger extraction area than is proposed in this application, but among the concerns that were cited by the Commissioner that are relevant to this report, were the perceived impacts on the scenic values of the site and on part of the surrounding landscape, including views from roads, some residences and rural properties in the vicinity of the extraction area. The visual mitigation measures proposed were considered not to sufficiently reduce visual impacts on these areas within a reasonable time frame. The Commissioner supported the view that the haul road for extracted material be within the site and that more extensive set backs of activity from Werai Road would be more beneficial to visual and noise impacts, both of extraction and truck movements to and from the extraction area, a position proposed by Wingecarribee Shire Council.

A significant issue also was the impact on Exeter Village of the transportation of material from the quarry by road on a route that passed through part of the village before joining Exeter Road. Both residents and the Council expressed preference for a Bypass route that would avoid the village of Exeter. This would require the crossing of the main southern railway line and the mitigation of visual impacts of this.

In addition to these concerns, the Commissioner referred to the undesirable level of predicted impacts on some heritage properties and the need for more effective and rapid measures to ameliorate impacts on the scenic qualities of the landscape.

In summary then, the visual and heritage impacts can be seen to be related to four main aspects of the extraction and the related activity. These are:

- the impacts of the extraction area and the extraction activity itself;
- impacts on the immediate landscape, including Werai and Rockleigh Roads, rural properties and the Village of Exeter;
- impacts resulting from the transportation of material: and,
- impacts on the wider landscape.

The report that follows is structured so as to address each of these four aspects of the current proposal, which differs from the former application in several significant ways, each designed to address the concerns expressed to the Commissioner above.

- The proposed extraction area is considerably smaller in area and is set back approximately 150m from Werai Road.
- The proposed extraction area occupies a site lower on the slope than the previous proposal and has much lower potential visibility from surrounding residences and properties. When mitigation measures take effect, the extraction and transportation of material in the extraction area would not be visible.
- The application proposes an internal product transport route within the Company's land, instead of using Rockleigh Road as the main access.
- The application also includes an Exeter Bypass product transportation route across the northern lot of the Vine Lodge property, that avoids Exeter Village for all trucks traffic associated with the extraction activity.

Visual impacts and landscape heritage matters are dealt with together in the report because of their close relationship in the context of the Southern Highlands. The overall structure of the method used:

- assessed the heritage values of the surrounding area and of the extraction area;
- assessed the visual exposure of the proposal when seen from the general area, examples of each kind of viewing place and from heritage sites, assuming initially that no mitigation measures were taken;
- evaluated the degree to which this exposure would be mitigated by the initial design of the proposal;
- recommended principles, where necessary, for the design and location of further ameliorative measures to control or eliminate visual exposure of the proposal;
- assessed the significance of any residual visual and heritage impacts; and,
- weighed up the potential effect on heritage values, visual amenity and scenic protection.

2.0 THE HERITAGE VALUES OF THE AREA

2.1 IDENTIFIED HERITAGE ITEMS IN THE AREA

The heritage values of the surrounding landscape, including the proposed extraction area, were examined using literature survey, historic research, searches of heritage data bases and field assessment. The landscape that is potentially affected by the application is of acknowledged heritage and scenic value. In the vicinity, there are a number of heritage items that are listed on various heritage registers (Register of the National Estate, the National Trust Register, Wingecarribee Local Environmental Plan, Wingecarribee Heritage Inventory (not yet publicly available)). To clarify this, a table was constructed that consolidates into one list all of the properties that have any claimed heritage significance (Appendix 1). There are many inconsistencies among the above sources, as can be seen by inspection of the table.

The most detailed list of heritage properties among the sources above is the National Trust of Australia (NSW) Exeter Sutton Forest Landscape Conservation Area classification, which contains a list of properties within the conservation area, many classified by the National Trust. Of the 50 properties listed, most have no potential for their heritage values to be affected by the development and only 6 are within the potential visual catchment of the site (Figure 2).

2.2 HISTORIC LANDSCAPES OF THE AREA

The list of heritage items, although it identifies what are largely particular buildings with various heritage values, does not provide a way of understanding the landscape of the area that is relevant to this application. While any effects on particular buildings would be a matter of concern, of equal importance are those on landscape heritage values. Two studies that look more specifically at the landscape of the area are more useful. They are a study carried out by Ken Taylor and Landscan for Wingecarribee Council in 1993 and the National Trust of Australia (NSW) Exeter-Sutton Forest Landscape Conservation Area classification (ESFLCA)(1998). Each of the studies takes a wider view of the landscape, but neither speaks specifically about the proposed extraction area or identifies its locality as having particular heritage value. Both studies identify boundaries within which values reside, but in one case (Taylor and Landscan) this encompasses the proposed extraction area and in the other (ESFLCA), takes in only part of it. The property Vine Lodge, across part of which the proposed bypass route passes, is within both boundaries.

Part of the land affected by this application is within "Key Historic Landscape Unit 5A" as identified by Taylor and Landscan, that was later recognised under the Wingecarribee Local Environmental Plan and then zoned 7(b) Environmental Protection (Landscape Conservation Zone), (see Appendix 2).

The identification that was made of the Key Historic Landscape Unit, on the basis of which the present zoning was created, relies heavily upon the historic significance of the region, and more particularly upon the ability to link the present scale of landscape pattern;

> *"with the earliest land grants of the 1820s and 1830s and later post 1860s dairying" (Taylor and Landscan, 1993, at p.5).*

This implies that the landscape patterning presently visible in the area around Exeter is directly related to the organisation shown on the Parish Map, which indicates the boundaries of early land grants in the locality. There were two highly influential early grantee families in the area of the proposed extraction area, Badgery and Throsby. Three portions of the Badgery holdings and two of Throsby's relate to the locality of the extraction area and existing processing plant. The bulk of Exeter village itself is located on what was Henry Badgery's grant Vine Lodge.

Although there is evidence of development that is indicative of the landscape's history in various parts of the locality, there is no easily discernible correlation between the boundaries of the original three grants to the Badgery family (portions 19, 20 (Hamletville, the earliest) and 21) or the Throsby grant (Portion 102), which are most relevant to the extraction area and proposed Bypass route. Some elements such as older road alignments are easily read but much of the patterning in the present landscape of the proposal's locality demonstrates little relationship to these early grant boundaries.

Part of the land affected by this application is also included within the ESFLCA. The ESFLCA boundary does not show any correlation to the factors identified by Taylor and Landscan in the vicinity of the site or in various other parts of the area that it defines. The ESFLCA boundary and the boundaries of relevant early land grants derived from parish maps are shown on Figure 1. In the vicinity of the proposed extraction area, the boundary does not relate either to the location of the Throsby grant, on which part of the site is located, or to the boundaries of the Badgery Hamletville Portion, which contains the remainder. It appears instead to adopt a physical boundary, probably related to topography.

The ESFLCA defines the aesthetic significance of the area as;

> *"...homogenous "English-style" landscape of grand estates, gardens and mature plantings...." (1998, at p.2).*

This criterion of significance does not appear to define the location of the ESFLCA's boundaries generally, since it is different in many parts from the boundaries of the early estates (see for example Figure 1, or Figure B of Taylor and Landscan, 1993 (Appendix 2)). If it was intended instead to encompass their visual catchments, this would be understandable, but the boundary is clearly not a visual one, since it is sometimes located at a property boundary and at others at a natural feature. The aesthetic criterion does not appear to apply to the vicinity of the proposed extraction area either. Certainly it could not be claimed that the proposed extraction area has the characteristics quoted above, being visually indistinguishable from any number of pastoral landscapes in the Southern Highlands and other parts of NSW.

In summarising the relevance of the two studies to this application therefore, it appears that the most important issues are whether the application would destroy or unreasonably change either the evidence of early land grants, or the aesthetic values of grand estates. Since there is little evidence of the early grants or the aesthetic influence of the later estates on the land including the proposed extraction area, it was concluded that the development proposed would not have the effect of destroying or obscuring important elements of the heritage value of the area that relate either to grant boundaries of the past, or to the related aesthetic values of grand estates.

The final justification given for the ESFLCA listing, following the conventions of the Heritage Assessments volume of the NSW Heritage Office' Heritage Manual:

> *"is its intactness and integrity. There has been exceptionally little of cultural heritage value destroyed or compromised within the area." (1998, at p.3).*

This is a rather selective view, to say the least. It implies that the landscape of Exeter-Sutton Forest has developed toward some sort of an ideal in the present, composed only of all the good things from the past. As is pointed out by Taylor and Landscan, the cultural landscape, of which the ESFLCA is an example, continues to grow and change and it is the overlay of successive changes that provides the existing experience and character of the place. The landscape of Exeter Sutton Forest is no different and is changing under different agricultural practices and economics, gentrification, subdivision, rural residential development and other forces. But even if this rather selective view above was agreed to, the development proposed, when put in the context of the whole of the ESFLCA, would have a minimal impact on the identified heritage values.

2.3 EXTRACTIVE INDUSTRY AND THE SETTLEMENT PATTERN

The Wingecarribee Heritage Study states that:

> *"The importance of extractive industry to Wingecarribee's heritage is, however, considerable and has been seriously undervalued".*

Mining played a key role in the development of the area according to the 'Chronology' in the thematic history prepared for the Heritage Study and mines are reported at Bundanoon and Exeter in the 1871-1906 time frame. This is contemporaneous with the establishment of the village of Exeter and the subdivision of land for smaller scale agricultural pursuits, in particular dairy farming. The success of the residential subdivision of Exeter by Badgery and the genesis of the village depended on the employment opportunities present in activities other than declining rural production, including mining. Commercial quarry operations existed in the area since the 1880s and in the immediate vicinity since the 1950s, with private quarries that pre-date both.

Thus the location of the village relates, not only to early grants, but also to it proximity to areas related to resources such as coal, stone and timber. Because of the geology and the early clearing of the interior, quarrying, mining and timber resources were located largely at the margins of the Highlands in places near later settlements such as Exeter, Bundanoon,

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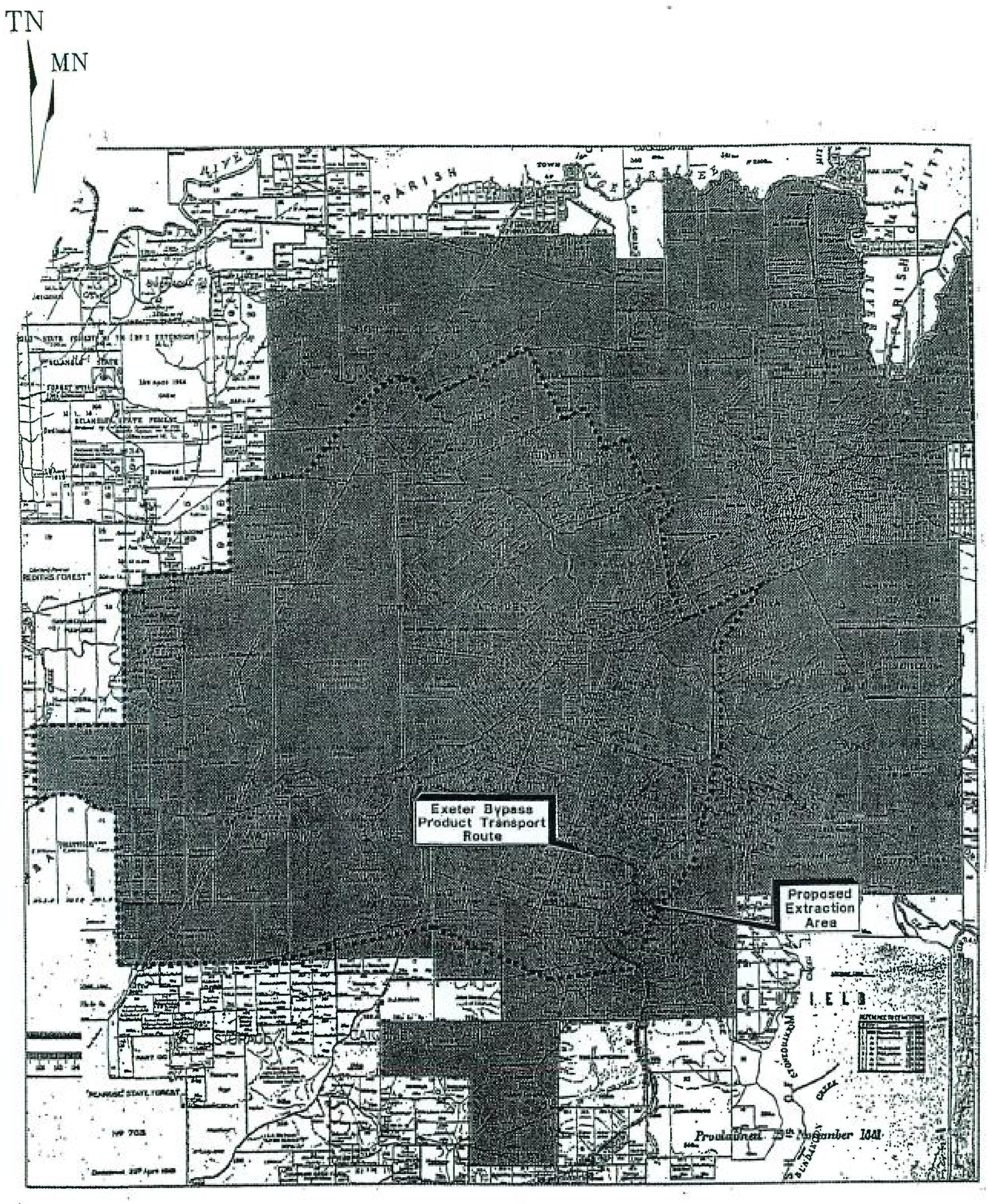

Exeter/Sutton Forest Landscape Conservation Area Boundary

Significant land grants that would be expected to be within the ESFLCA

Figure 1

COMPARISON OF THE EARLY LAND GRANT WITH THE ESFLCA BOUNDARY

Bowral, Mittagong, Kangaloon etc. The continued use of resources provides a relationship with the past development of the region and a clue to the location and development of Exeter, which is quite significant. This is not to say that this theme justifies the continued activity proposed. However, it must be acknowledged that extractive industry is an integral part of the cultural landscape and history of development of the Southern Highlands.

2.4 HERITAGE VALUES OF THE "KEY VILLAGE" OF EXETER

A study carried out for Wingecarribee Council entitled "Historic Cultural Landscape Study" by Taylor and Landscan in 1993 defined the landscape catchment of the village of Exeter. The proposed extraction area and Exeter Bypass route is outside this catchment. Many of the heritage items in the Exeter area are also outside this catchment, such as Ivy Hall, Whare-Tau and Vine Lodge. The development would have a limited ability to affect the heritage values that relate to the identified Key qualities of the village of Exeter and therefore the heritage values that it is designed to protect would not be affected by the proposal.

2.5 HERITAGE VALUES OF VINE LODGE

2.5.1 The setting

The heritage values of Vine Lodge are particularly important to this application, which proposes a product transportation route (the Exeter Bypass) through the northern lot of what remains of the historic property. Set in a pastoral landscape that developed over a considerable time, the Vine Lodge residence's main orientation is to the picturesque valley that opens to the north of the house. The house is set on the brow of a knoll, and the original outbuildings and associated sheds are set to its rear and south eastern side.

Historic access to the property was from the north west, the alignment of which access way is still discernible and marked by conifer planting. It appears that the approach to the house was oblique, as was common throughout the period, and there may have been an earlier carriage loop in the forecourt of the residence. Later, formal access was made from the south, directly from the developing village of Exeter, in the location presently used. It is likely that the arrival at the house and access to the forecourt was altered sometime later, including the fencing of the gardens and construction of an alternative entrance to the carriage loop.

Developments of the property as a centre for the stabling, breeding and use of horses have included additions of buildings and stables to the landscape surrounding Vine Lodge, though largely to the east, west and south of the house. These additions feature avenue and wind break plantings that are also dominated by conifers. The later formal drive consists of a mixture of deciduous species, including oak and elm.

The residence's formal orientation to the carriage loop and vista to the north was framed by conifers and formerly heavily screened by oak trees, several of which appear to have been removed in more recent times. The remnants of the formal garden in the area indicate the typical arrangement of the time, with the prospect of outward views available through a screen of vegetation, but with attention directed inward to the forecourt and entrance to the house.

Seen from the wider landscape, Vine Lodge is similar to many functioning rural properties with modest homes and outbuildings, set among wind break and avenue plantings. Other than for the variety of assembled buildings and stables, it does not have a commanding presence in the landscape. Seen from the landscape to the north, in the direction to which it is oriented, Vine Lodge is dominated by the open rural landscape and the vegetation that surrounds the house and defines its location.

2.5.2 The cultural significance of the residence

An assessment was made of the significance of Vine Lodge to the landscape of Exeter-Sutton Forest and of the critical elements requiring conservation. A further assessment was also made of the significance of the Vine Lodge residence and its two outbuildings (Appendix 3), dealing in particular with the heritage fabric of the place.

It was concluded that Vine Lodge is of historic significance for its association with Henry Badgery and descendants, the establishment of the township of Exeter and pastoral expansion, including the role of the Badgerys in promoting cattle and horse breeding. The building is significant for its length of association with the family (1841-1978), its reflection of 19th century development of the locality and for its role in the increasing prestige of the region derived from its function as a destination for prominent citizens. Vine Lodge generally is of aesthetic significance as contributory to the wider landscape, recently classified by the National Trust of Australia (NSW) and described as the Exeter Sutton Forest Landscape Conservation Area (ESFLCA). The building is of significance as an early example of a colonial homestead and a partially intact residence that dates from the key period of historic significance of the area and is representative of a substantial rural middle class residence. Its orientation to the landscape is representative of the preferences of its time for framing the picturesque view through foreground screening. It has significance for its potential to yield archaeological information and is a rare example of the construction of Georgian architecture with local materials.

2.5.3 The curtilage

Physical (lot boundary) curtilage

Vine Lodge is the existing name of a previously much larger holding, which was assembled by the amalgamation of various land grants and purchases by members of the Badgery family. The present village of Exeter occupies lands that were subdivided from Vine Lodge, then known as the Vine Lodge Estate, beginning in the late 1880s, reflecting a down turn in the fortunes of the Badgerys and the advance of dairying and residential development. The existing residence, original and later formal drives and outbuildings occupy a single lot, the physical curtilage of what remains of Vine Lodge. It is bounded by the Main Southern Railway line on the east, Exeter Road on the west, an approved and subdivided rural residential lot to the south and an unimproved lot to the north.

Visual curtilage

The visual curtilage of Vine Lodge was analysed on the basis of historic research and interpretation, using the guidelines provided in "Heritage Curtilages", a volume in the Heritage Manual, published by the NSW Heritage Office. The curtilage is defined on the south, east and west, where it relates to the lot boundaries, but it cannot be discerned to the north, other than by fence lines. There is therefore no logical or evident limit to the visual catchment in that direction. No substantial evidence of the historic land grants or later subdivisions exists in this view.

The Vine Lodge residence is oriented to the north and the view is framed by the remnants of a formal garden, which until recently featured a very large oak tree directly in front of the former porch. Other oaks and conifers remain. Both the original access from the north, now bypassed by Exeter Road and the later formal drive from the village, are tree lined. To the west of the house within the fenced garden is a small gravelled carriage loop which appears to be later in date than the residence. The outbuildings are functionally oriented to the house and outside spaces rather than having any scenic direction.

The house is extensively screened by vegetation and later buildings in views inward from any direction, other than in distant view from part of Exeter Road, where the front of the house and its setting is evident. This has probably only occurred since the removal of the oak tree.

Thus the curtilage, is visually defined on the south, east and west and it relates to the lot boundaries. The distinction between the lot boundary and the visible landscape to the north cannot be discerned, other than by fence lines. The visual curtilage could be said to extend beyond the lot boundary, but there is no logical or evident limit to this. No evidence of the historic land grants or later subdivisions exists in the view that would justify a curtilage that is expanded beyond the present property boundaries.

It was therefore decided that the lot boundary was a reasonable limit to the curtilage, but that any developments beyond it to the north would need to consider the setting and outlook of the historic buildings and garden and not unreasonably impact on these. In this view, the convex foreground drops away below the view line, leaving the middle distance and background as the main composition elements. Other critical elements are the open landscape setting and the dominance of the historic access ways and surroundings of buildings by plantings of exotic trees, in particular conifers, oaks and elms.

3.0 THE VISUAL VALUES OF THE AREA

3.1 THE VISUAL CONTEXT AND CHARACTER OF THE LOCALITY

The site of the proposed extraction area is in the vicinity of the village of Exeter, Southern Highlands of New South Wales, bounded on its south west side by Rockleigh Road and on the north west by Werai Road. The proposed extraction area is roughly rectangular in shape with the Werai Road boundary its shortest side, situated on the lower side slope of a knoll which slopes gently to the west and south east and more steeply to the east. For the most part, the proposed extraction area is out of view from Exeter village.

The visual character of the proposed extraction area itself and of the surrounding landscape relates to the underlying geology and closely reflects a history of clearing and grazing, with the site extensively cleared and grassed. This landscape and vegetation character is common in the south eastern and eastern most margins of the Southern Highlands.

The alignment of the proposed Exeter Bypass Route is generally to the north west of the proposed extraction area, first crossing Werai Road and the Main Southern Railway line in the immediate vicinity, before crossing open grazed agricultural land to the north of the Vine Lodge property and meeting Exeter Road slightly north of the entrance to the property Tralee. It is effectively out of view from Exeter village.

3.2 VISUAL CATCHMENT

The visual catchment of the proposed extraction area and Bypass route is indicated on Figure 2. The boundary drawn encompasses all the land from which a view to either the extraction area or Bypass would be possible, within which aspects of the proposal would be sufficiently evident for there to be potential for visual impacts. Within the boundary, visual access to the extraction area or Bypass route is frequently restricted by topography, vegetation and buildings. For example, there is no significant visual access to either component of the proposal itself from the village, other than from a part of both School Lane and Norwood Street, from which views are screened laterally and blocked in the foreground by vegetation. There is no significant view access from Exeter School. It can be seen that, within the maximum potential boundary shown on the map, there are extensive areas from which no view is possible because of the effects of vegetation, topography and other blocking features. The boundary was left open toward the east of the extraction area, because of the difficulty and impracticality of accurately defining the boundary there. With the exception of one prominent elevated rural property that has views of the existing processing plant, view lines toward the site of the proposed extraction area from this direction are from wooded country and are level, or upward in angle and from considerable distances. A person would be unlikely to be able to discern any parts of the activity proposed and therefore would not be able to experience any visual impact effects.

A small part of the north eastern slope of the proposed extraction area would be visible at closer range from rural properties to the south and south east of the site, such as, Merry Hill and Willowbank and part of that slope towards its south eastern end is visible from rural properties to the south east of the village, such as Uig Lodge, Boeing Park and some others nearby. The visual exposure of the proposed extraction area to some of these locations, assuming that there were no visual impact amelioration works undertaken are shown on Figures 3a-3h (Visibility Shadow Plans). These show that there would be minimal visual exposure to Uig Lodge and nearby, low visual exposure to Merry Hill and slightly higher visual exposure to Willowbank. When the visual controls such as bund walls and planting are added, the visibility of the extraction activity and of the final landform would be nil.

The south eastern, upper third of the proposed extraction area is also visible, at a greater distance, from elevated locations in the vicinity of Vine Lodge West on the eastern aspect of a gentle ridge which runs away to the north from the Reservoir hill, accessed from Ellsmore Road (Figure 2). Figure 3a shows the extent of visibility of the site surface from the viewing place with the most direct view on Ellsmore Road and from eye height above ground level in the vicinity of the Reservoir. The perimeter bund wall and planting on the north western boundary of the extraction area, both on the batter and between it and Werai Road, would remove any residual visibility of the site or of the extraction from all of these locations and from any others that are at lower elevations, such as Whare-Tau and Tralee.

There would be some visual exposure of the proposed extraction area to one elevated rural residence to the east of the area and some distance away, the location of which is visible from the land proposed for development and from the existing processing plant. A view from this location is shown at Photographic Figure 16 in this report. The property has views of the existing extraction area and processing plant that are restricted by foreground vegetation and opportunities to view the proposed extraction area are limited. However, views of the existing processing plant are possible from some locations on rural land in the vicinity.

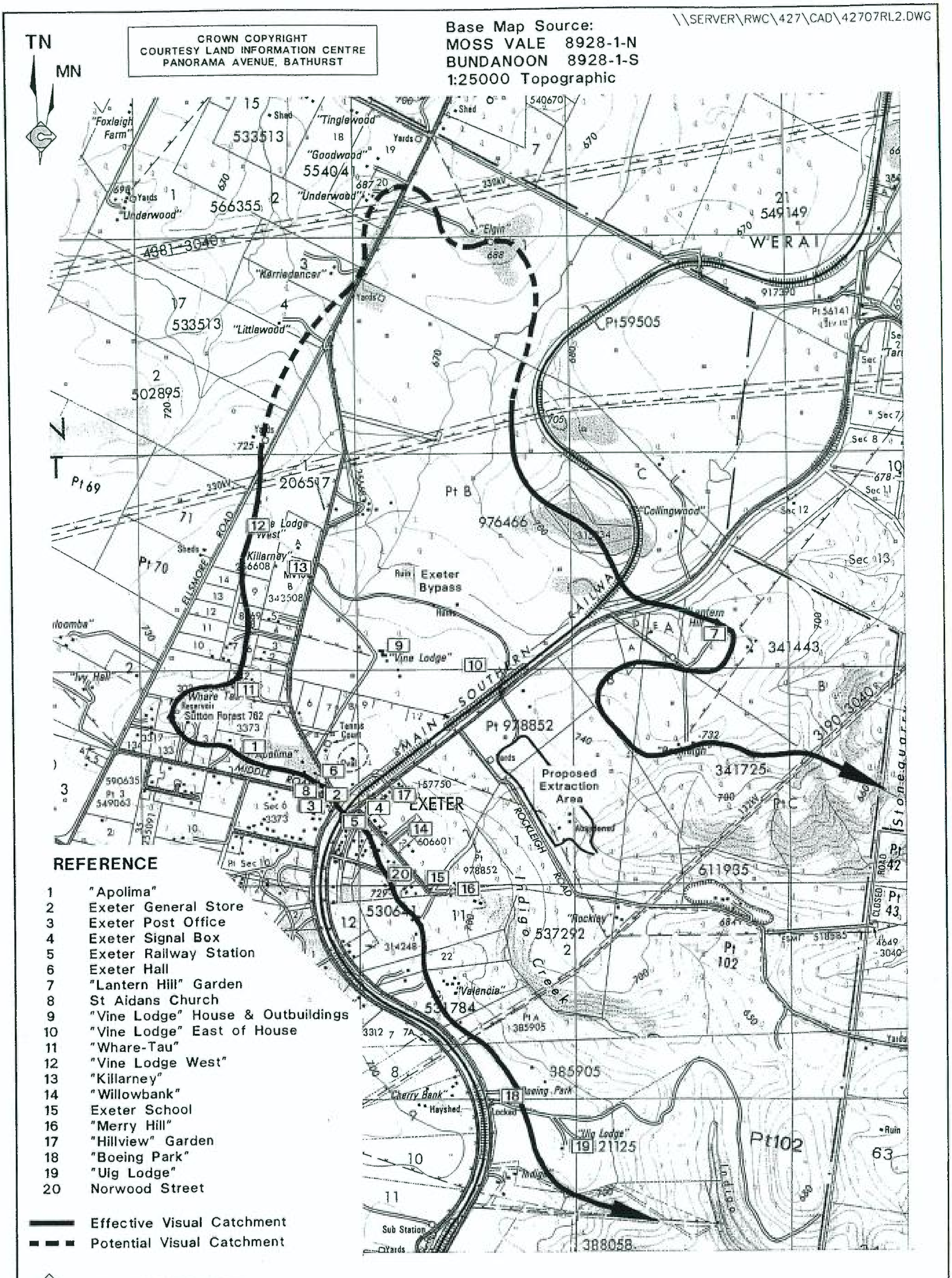

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Figure 2
POTENTIAL VISUAL CATCHMENT OF THE PROPOSED EXTRACTION AREA AND EXETER BYPASS

4.0 ASSESSMENT OF POTENTIAL IMPACTS ON VISUAL AND HERITAGE VALUES

The visual impacts on both heritage and scenic values were assessed using an explicit and systematic method that first assesses the extent of the visual exposure of aspects of the development that would occur and then evaluates their importance, after the effect of amelioration measures is taken into account. The evaluation of impact importance is done by applying weightings that reflect the relative significance of various factors. In the present case, the scenic and heritage context are among the most significant weights to be applied. A description of the method is appended (Appendix 4).

The proposal would have the effect of markedly changing the intrinsic visual character of the parts of the landscape that are affected. Changes to the visual qualities of the landscape would also in part be long term, in the sense that the initial extraction proposed here has a proposed life of approximately fifteen years, perhaps extending for a longer period. These changes are typical and to some extent inevitable consequences of quarrying activity and people may well express the view that extraction areas are unattractive. This may be the basis for an objection to the visual impacts of a proposal on the landscape. Taken in isolation, the appearance of extraction activity may constitute an unacceptable visual impact, however, the question is whether the changes caused by the proposal unacceptably impact on the visual experience of the landscape when seen from outside the site.

To make this assessment it is necessary to assess both the visibility in reality and the capacity of the landscape to absorb the development without unacceptable changes to its character. The ability of the landscape to absorb the development visually is assisted by amelioration measures that can reduce the visibility or the indirect visual evidence of the operation. In the event that the proposal would cause visible changes the issue then becomes one of how important that might be and what measures could be put in place to ameliorate any impacts that are significant, arising from these changes. Residual impacts, ie. impacts that remain after amelioration measures are taken, are of the greatest concern.

The potential visibility of each aspect of the proposal were therefore addressed in the following sequence. The visibility of the proposed extraction area and Exeter Bypass, including the railway overbridge proposed, was first assessed as if no amelioration measures had been taken (4.5 below). This assesses the potential visual exposure of each aspect of the operations. Following this, the reduced visual exposure that would occur after the proposed visual amelioration measures was assessed (4.6 below). Finally, the visual impact of any residual visibility that would occur after the amelioration measures were taken was evaluated. This was done by applying a weighting to acknowledge the importance of factors such as the heritage values of particular items in the landscape and the scenic values of the area generally (4.8 below).

4.1 VISUAL EXPOSURE TO HERITAGE ITEMS IN THE VICINITY

The visual exposure of the proposal to heritage items in the vicinity that are identified on the consolidated list of all such items in the area (Appendix 1) is indicated on Table 4.1 below:

Table 4.1: The visual exposure of the proposed extraction area and of the Exeter Bypass to the identified heritage items in the Exeter locality, prior to the consideration of any amelioration measures that may be necessary. The numbers shown can be related to view point locations shown on Figure 2 (Potential Visual Catchment).

		Extent of visual exposure (assuming no amelioration measures taken)	
Access number (see Map 2)	**Consolidated Heritage List Item (see Appendix 1)**	**Extraction area**	**Exeter Bypass**
1	Apolima	Nil	Nil
2	Exeter General Store	Nil	Nil
3	Exeter Post Office	Nil	Nil
4	Exeter Signal Box	Nil	Nil
5	Exeter Railway Station	Nil	Nil
6	Hall, Exeter	Nil	Nil
	Invergowerie house and garden	Nil	Nil
	Ivy Hall	Nil	Nil
	Redcourt	Nil	Nil
	"Romsey" cottage and garden	Nil	Nil
8	St Aidans Church Group, Exeter	Nil	Nil
9	Vine Lodge, residence and outbuildings	Negligible to low	Low
10	Vine Lodge property to the east of the residence	Low-moderate	Low
11	Whare-Tau	Low	Nil

As can be seen from the above, of the 15 heritage items of the Exeter locality in the local visual catchment, only two have some visual access to the land proposed for development. Only Vine Lodge and part of the lower drive to Whare-Tau have a view and this is to a small part of the proposed extraction area. Vine Lodge residence is oriented to its traditional access ways, both of which are marked by either avenue or windbreak plantings and both are away from the direction of the site. The outbuildings are not oriented or organised in a way that presents views toward the proposed extraction area. Whare Tau is similarly oriented to its driveway entrance and the foreground of views in the general direction of the proposed extraction area are heavily screened by vegetation of the garden and windrow plantings. Recent additions and changes to the garden are increasing this screening effect. The viewing angle toward the proposed extraction area from these two residences is either slightly downward and distant (Whare Tau), or shallow and upward (from part of the Vine Lodge property only, to the east of the residence), meaning that little of the proposed extraction area is visible from either property. It is also screened by vegetation in the middle distance along the margins of the railway cutting and by the railway and road embankments, which are between the houses and the site. The level of visibility for each of the properties can be seen on Figures 3a-3h (Visibility Shadow Maps). The maps do not fully acknowledge the effect of foreground screening of views by vegetation, which would further restrict visibility.

The only heritage item which would be affected by a direct view of part of the development would be part of the Vine Lodge property, other than the heritage listed residence and garden. From the land to the east of the residence and outbuildings, trucks on part of the Exeter Bypass route would be visible on a short section immediately north of the railway line overbridge in the vicinity of the lockable gate, if no measures were taken to control this. The remainder of the Exeter Bypass route would not be visible from the heritage items, but would be visible in closer view from the rural land to the north and north east of the Vine Lodge residence.

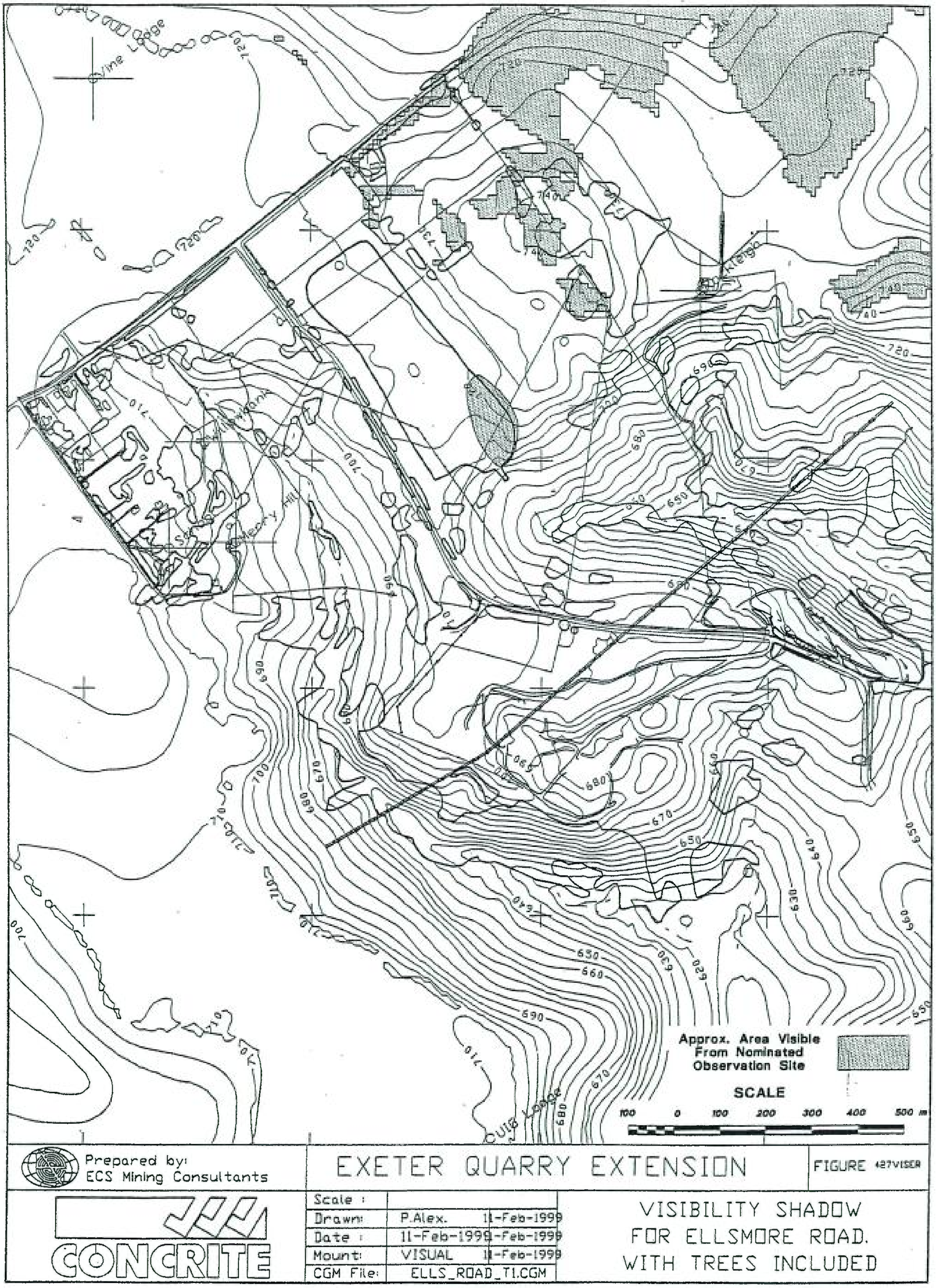
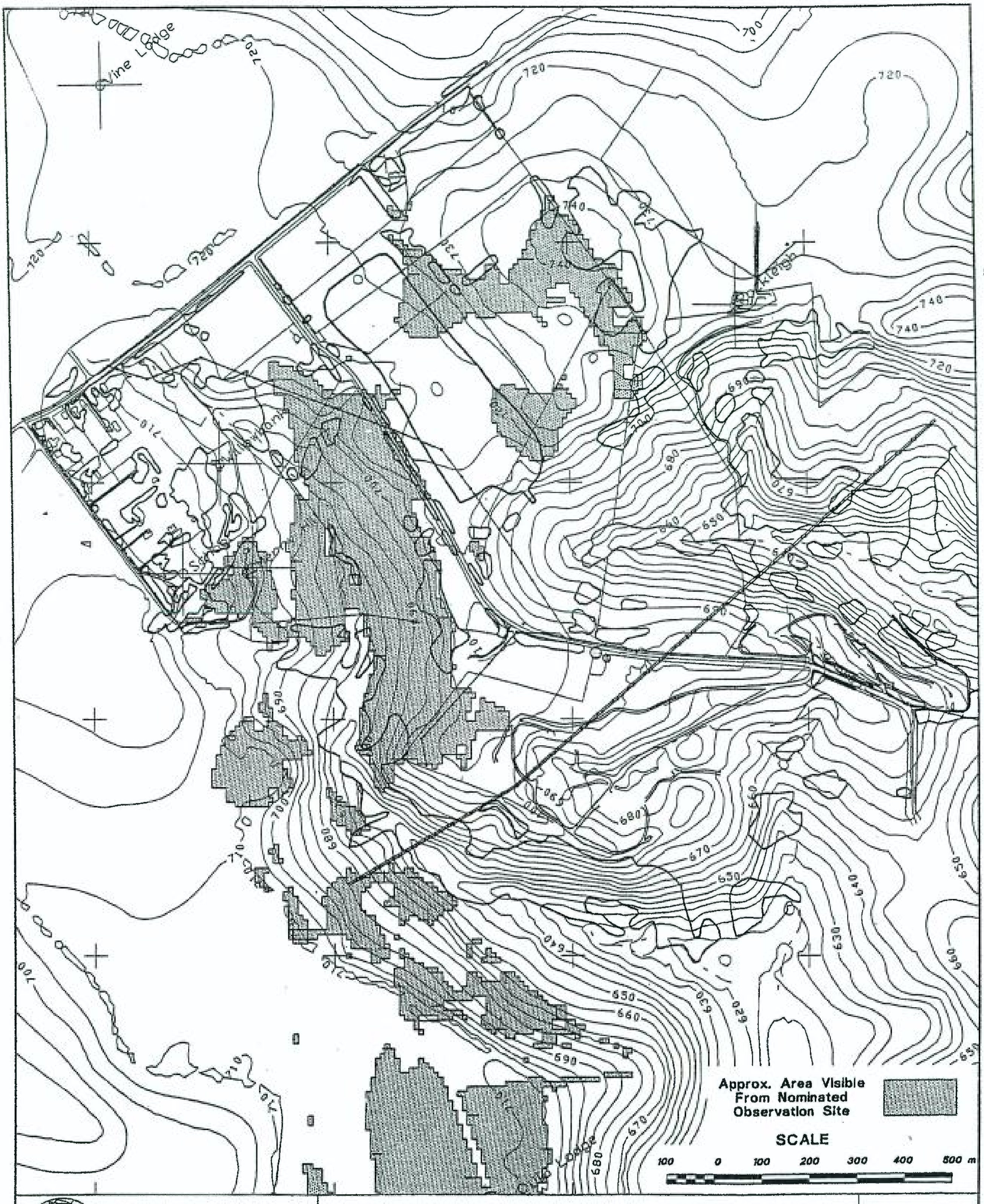

Approx. Area Visible From Nominated Observation Site
SCALE
100 0 100 200 300 400 500 m
Prepared by: ECS Mining Consultants
EXETER QUARRY EXTENSION
FIGURE 427VISER
CONCRITE
Scale :
Drawn: P.Alex. 11-Feb-1999
Date : 11-Feb-1999 -Feb-1999
Mount: VISUAL 11-Feb-1999
CGM File: ELLS_ROAD_T1.CGM
VISIBILITY SHADOW FOR ELLSMORE ROAD. WITH TREES INCLUDED

Figure 3a



Prepared by: ECS Mining Consultants

EXETER QUARRY EXTENSION

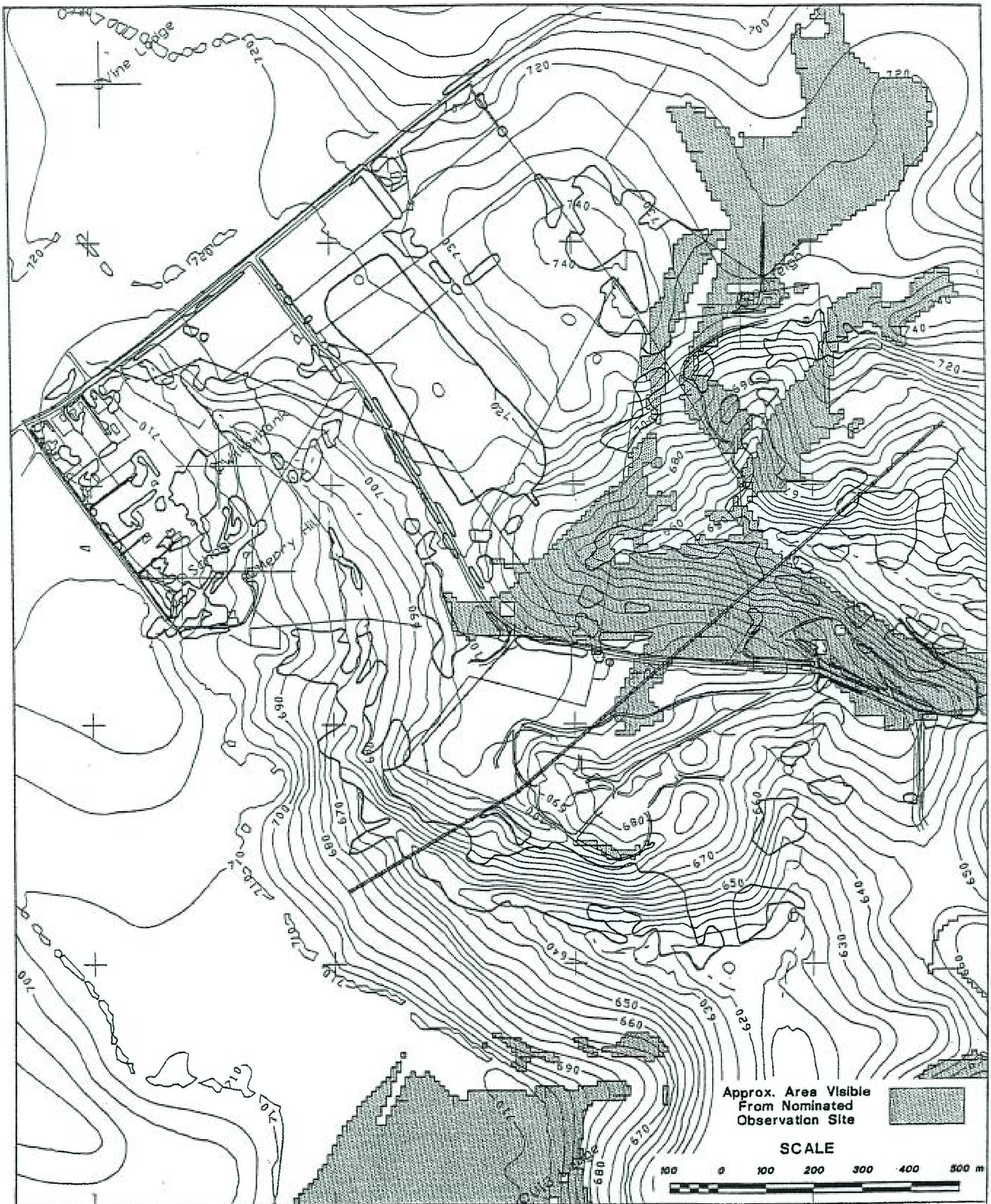
FIGURE 427VISMHI

CONCRITE

Scale :	
Drawn:	P.Alex. 11-Feb-1999
Date :	11-Feb-1999
Mount:	VISUAL
CGM File:	MERRY_HILL_T1.CGM

VISIBILITY SHADOW FOR MERRY HILL WITH TREES INCLUDED

Figure 3b



Prepared by: ECS Mining Consultants	EXETER QUARRY EXTENSION		FIGURE 98028_7
CONCRITE	Scale :	1:10000	VISIBILITY SHADOW FOR ROCKLEIGH WITH TREES INCLUDED
	Drawn:	P.Alex. 11-Feb-1999	
	Date :	11-Feb-1999 11-Feb-1999	
	Mount:	VISUAL 11-Feb-1999	
	CGM File:	ROCKLEIGH_T1.CGM	

Figure 3c

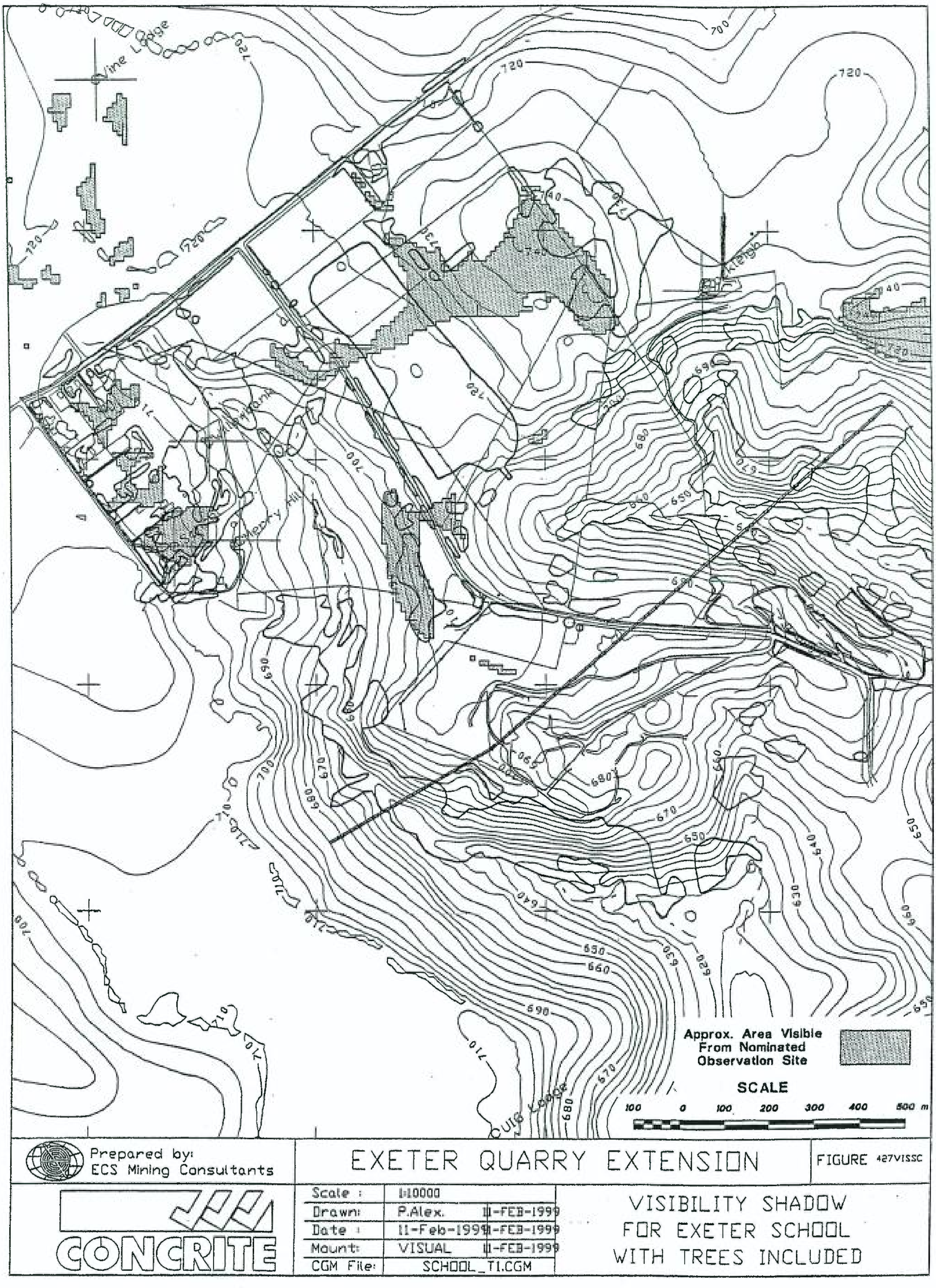

Vine Lodge
Kileigh
Quarry Hill
Cuil Lodge
700
720
740
690
680
670
660
650
640
630
620
710
Approx. Area Visible From Nominated Observation Site
SCALE
100 0 100 200 300 400 500 m
Prepared by: ECS Mining Consultants
EXETER QUARRY EXTENSION
FIGURE 427VISSC
CONCRITE
Scale : 1:10000
Drawn: P.Alex. 11-FEB-1999
Date : 11-Feb-1999 11-FEB-1999
Mount: VISUAL 11-FEB-1999
CGM File: SCHOOL_T1.CGM
VISIBILITY SHADOW FOR EXETER SCHOOL WITH TREES INCLUDED

Figure 3d

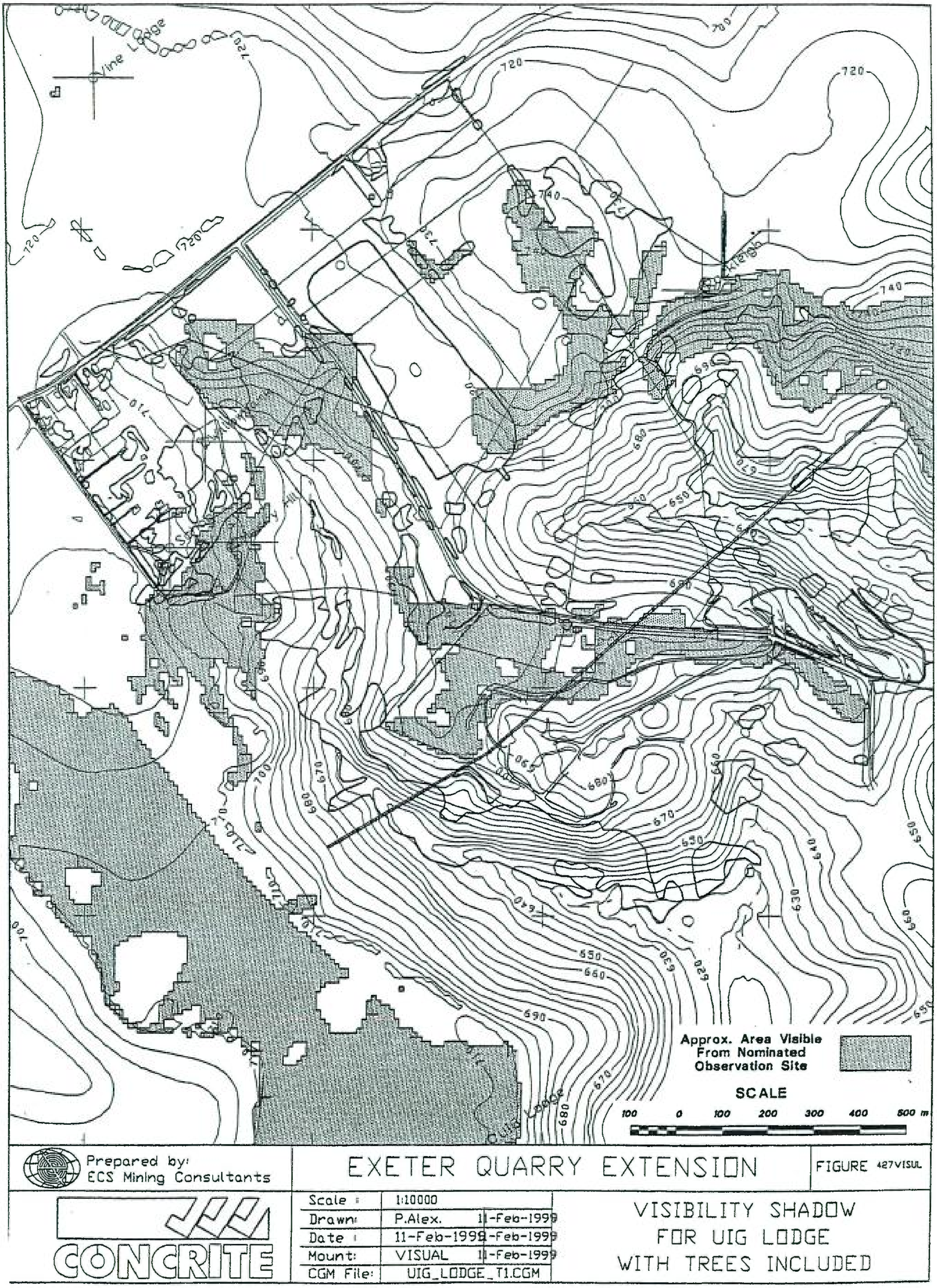

Approx. Area Visible From Nominated Observation Site
SCALE
100 0 100 200 300 400 500 m
Prepared by: ECS Mining Consultants
EXETER QUARRY EXTENSION
FIGURE 427VISUL
CONCRITE
Scale : 1:10000
Drawn: P.Alex. 11-Feb-1999
Date : 11-Feb-1999
Mount: VISUAL 11-Feb-1999
CGM File: UIG_LODGE_T1.CGM
VISIBILITY SHADOW FOR UIG LODGE WITH TREES INCLUDED

Figure 3e

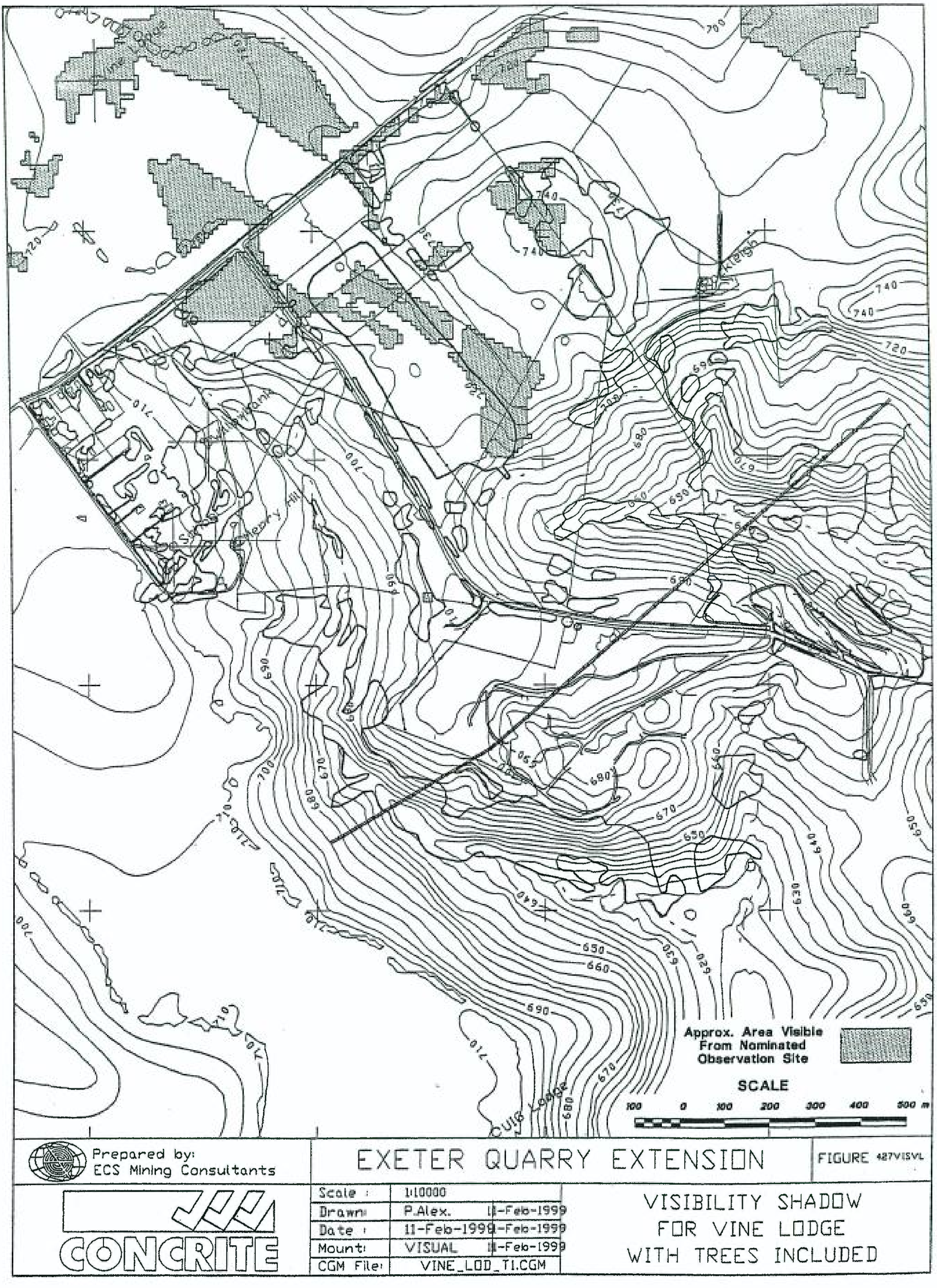

Approx. Area Visible
From Nominated
Observation Site
SCALE
100 0 100 200 300 400 500 m
Prepared by:
ECS Mining Consultants
CONCRITE
EXETER QUARRY EXTENSION
FIGURE 427VISVL
Scale : 1:10000
Drawn: P.Alex. 11-Feb-1999
Date : 11-Feb-1999 11-Feb-1999
Mount: VISUAL 11-Feb-1999
CGM File: VINE_LOD_T1.CGM
VISIBILITY SHADOW
FOR VINE LODGE
WITH TREES INCLUDED

Figure 3f

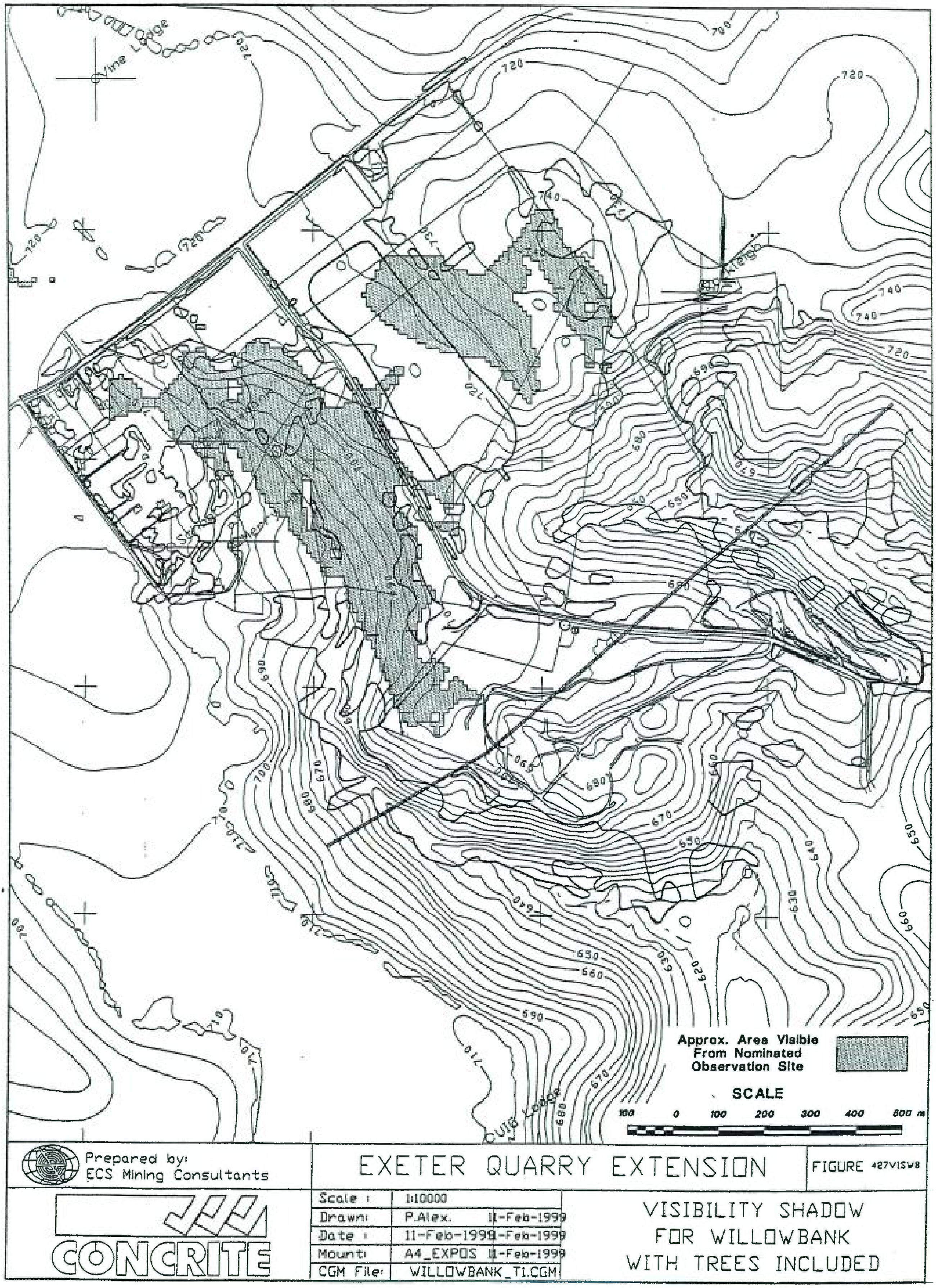
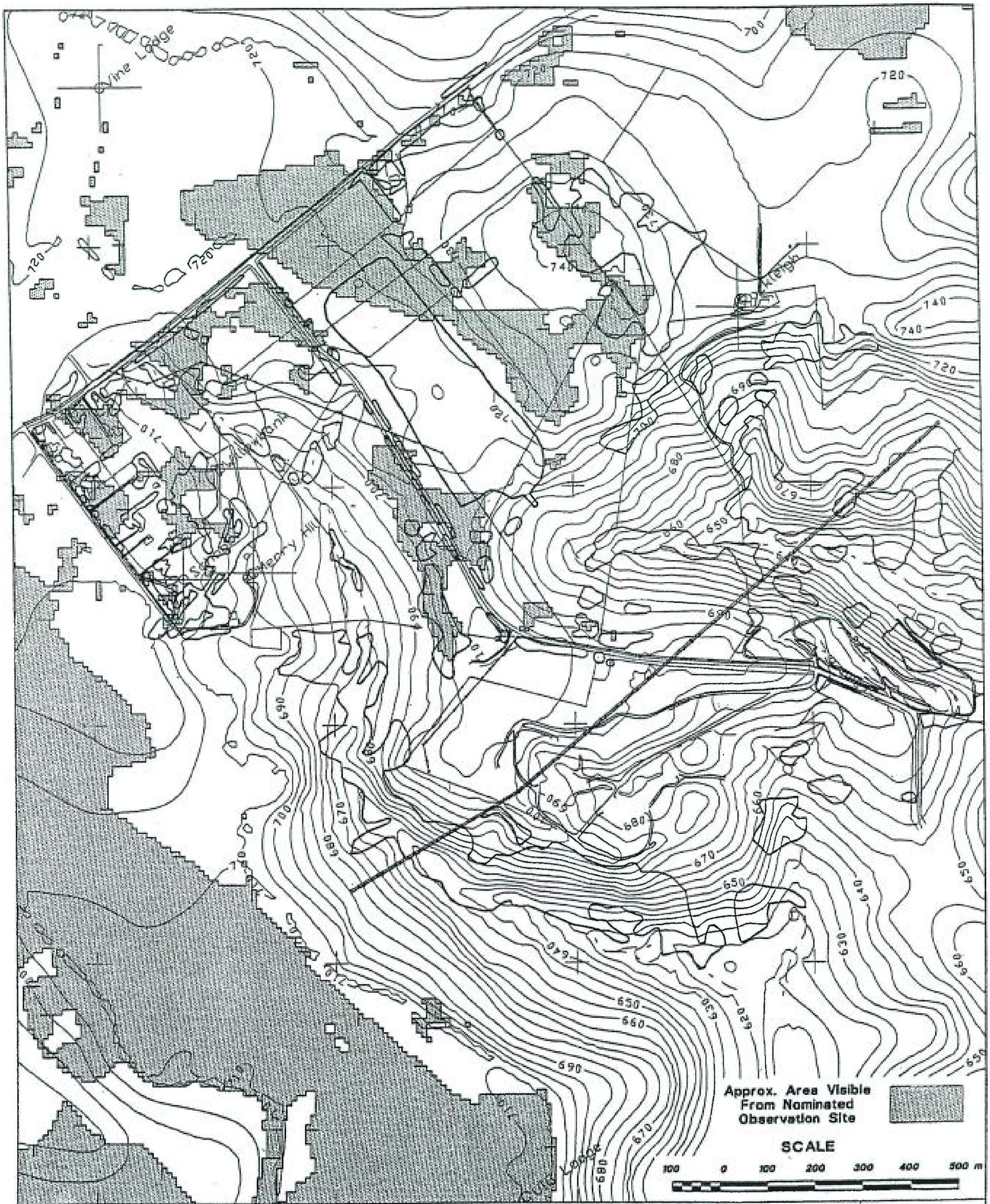

Approx. Area Visible From Nominated Observation Site
SCALE
100 0 100 200 300 400 500 m
Prepared by: ECS Mining Consultants
EXETER QUARRY EXTENSION
FIGURE 427VISW8
CONCRITE
Scale : 1:10000
Drawn: P.Alex. 11-Feb-1999
Date : 11-Feb-1999 11-Feb-1999
Mount: A4_EXPOS 11-Feb-1999
CGM File: WILLOWBANK_T1.CGM
VISIBILITY SHADOW FOR WILLOWBANK WITH TREES INCLUDED

Figure 3g



Prepared by:
ECS Mining Consultants

EXETER QUARRY EXTENSION

FIGURE 427VISWT

Scale :	1:10000	
Drawn:	P.Alex. 11-Feb-1999	
Date :	11-Feb-1999 -Feb-1999	
Mount:	VISUAL 11-Feb-1999	
CGM File:	W_TOWER_T1.CGM	

VISIBILITY SHADOW
FOR WATER TOWER
WITH TREES INCLUDED

CONCRITE

Figure 3h

The proposed extraction area is not within the physical curtilage of any heritage item and could not be claimed to be in the visual curtilage of any either, in the sense that even though it is partly visible from both Whare-Tau and Vine Lodge, neither is directed in a formal way to take account of the part of the landscape occupied by the site. The site area is also not of landmark character when seen from these properties. The visual aspects of the proposed extraction area would not diminish the heritage significance of either of the identified items.

4.2 PLACES WHERE SEQUENCE OF VIEWS ARE POSSIBLE

In addition to views from static locations which can be sustained over longer periods, it is usually accepted that where views of an item occur in a sequence that can be regularly repeated (such as from a regularly travelled road), any visual impacts that can occur are also an important consideration. This is because a three dimensional view can be assembled "in the mind" from a sequence of glimpses, even if each of these is of only part of what is viewed. The only locations from which sustained sequences of views of the proposed extraction site would be possible are on Werai Road and Rockleigh Road. The eastern section of the Exeter Bypass would be visible from a short section of the railway to the north of the overpass bridge.

4.3 VISUAL EXPOSURE TO ROADS AND THE RAILWAY

The visual exposure of the proposed extraction area on the normal expectation of the view and on the usual sequence of visual experiences on the view from Werai Road, in particular, would be marked, if visual amelioration measures were not taken. Rockleigh Road is a local road which serves only a small number of properties. Werai Road is a significant viewing location paralleled for a short distance by the Main Southern Railway Line. From each of the roads, there is the potential for close range views of the north western part of the proposed extraction area over a short distance. Part of the south eastern third of the proposed extraction area is also visible from a section of Exeter Road north of Exeter village in the approximate vicinity of the entrance to Tralee and close to the intersection of the proposed Exeter Bypass product transportation route with Exeter Road.

4.4 VISUAL EXPOSURE OF THE COMPONENTS OF THE PROPOSAL

4.4.1 The proposed extraction area

Staging of development

The initial stage of extraction proposed would have an estimated life span of approximately 15 years and would involve extraction within an 11 hectare area north of Rockleigh Road. There would initially be evidence of earthmoving, but this would soon proceed below the surface, out of sight. At the same time, earth structures for visual and acoustic control would be built and vegetated. The internal product transportation route would be in cut for both sound and visual amelioration and vehicles would not be visible using it over the life of the extraction.

The proposed extraction area would be established sequentially from the south east, progressing to the north west. During each phase of extraction, a face would first be established on the north east side of the site and work would progress toward the south west, in effect the work always being behind the working face, compared to Rockleigh Road.

Because of the deep and narrow form of the extraction area relative to the closest viewing locations to the south, the activity would be below sight lines and out of sight.

Retention of existing features

Conspicuous features of the existing landscape include the dwelling Lylen, its gardens and plantings, the grassy foreground of views from Werai Road and stands of remnant native and exotic vegetation. The latter include mature elm and oak trees located immediately north of the proposed extraction area. These would be retained. The internal product transportation route would be located so as to cause minimal disturbance to both the exotic and native trees on the site and to the existing structure of the Lylen gardens. Any new planting between the extraction area and Werai Road would be designed to blend with this mixture of exotic and native vegetation and be organised in informal groupings, as indicated in principles diagrams (Figures 4a-4b) and photomontages (Figures 5a-5b).

4.4.2 Railway overbridge and intersection on Werai Road

The railway overbridge would be a new feature, but not an unusual visual feature in the locality. There are many overbridges in the area and particularly between Exeter and Bundanoon, each of which feature solid side barriers such as are proposed. The bridge would be similar in scale to others nearby, but would be in cut, below the existing ground surface level, so that none of the structure would be visible from the surrounding landscape or from the Vine Lodge residence precinct. The bridge would be in direct view only from the intersection of the Exeter Bypass route with Werai Road.

The final part of the internal product transport route over the applicant's land, approaching the intersection with Werai Road, would also be visible from Werai Road. This is to ensure safe visibility for approaching vehicles. There may be a need to remove a small proportion of the existing vegetation in the north western end of the established *Pinus radiata* wind break around Lylen to ensure that sight lines are sufficient.

4.4.3 Exeter Bypass product transportation route

Visibility

The route is proposed across land that is largely outside the existing lot on which Vine Lodge homestead and outbuildings now exist (Figure 4e). It has been sited so as to be below the view line from the historic residence and gardens. The route was laid out so that natural ground level was a minimum of three metres below the view horizon. A product truck travelling along the Bypass would therefore be out of sight.

The route location at the western end of the Exeter Bypass was chosen for both acoustic and visual control. It is out of sight of the Vine Lodge residence and garden and is screened by existing vegetation. The road entrance would be visible from outside the property from part of Exeter Road in the vicinity of the entry to Tralee and part of the Killarney property and the location of the route towards its eastern end would be visible from a short section of the road toward Sutton Forest, in the general vicinity of the entrances to the properties Underwood and Elgin and from land in the vicinity of Vine Lodge West. The upper part of vehicles would be evident moving on the road, the surface of which would be out of sight behind a low earth bank. Part of the route of the Exeter Bypass would also be visible from part of the entrance road to one of the residences on the property Summer Dell (closest to Exeter Road), though not from the second, and from rural land to the north and north east of Vine Lodge, including the Summer Dell land, where there are no residences.

The Bypass road would not be intrinsically out of character in the landscape. Rural roads and access ways are a familiar feature of the landscapes of the area and have relatively little visual impact, once established. There are many other linear features that contribute to the character of the area, such as windrows, fences, other roads and tracks, railway embankments etc. The impact of views directly down the road, from part of Exeter Road near its intersection, would be reduced by organising informal groups of trees to interrupt the perception of the line and form of the road. When seen from other directions, the groups of trees would appear similar to other informal groups in the existing landscape and would retain its open character and long vistas. The principle behind this design is shown in Figure 4e.

Effects on landscape heritage of Vine Lodge

It was considered desirable that no proposed development substantially alter the composition of the northern vista from the Vine Lodge residence. The Bypass route was located so that neither it, nor vehicles using it, would be visible in the northerly view cone as seen from the residence and garden. This was achieved by ensuring that it would be well below the foreground horizon of the view, and also that it was largely located outside the lot boundary curtilage of the present property. The western part of the route was also located as far as possible to be screened from the house locality by existing vegetation associated with the original northern entrance way and windbreak planting that already exists to the north west of the house.

A second issue, arising from the open rural setting and significance of tree plantings, was that the Bypass should not diminish the open setting of the historic house and garden, when seen from the main view cone to the north. In this regard it should be kept in mind that Vine Lodge was always a relatively modest residence and in addition it was not designed to dominate its landscape or draw attention to itself as the focus of views inward, as many later and grander properties of the Southern Highlands with extensive formal gardens and designed settings, for example Hillview, Whitley and Highfield, were.

The Bypass would not impact on any specific items of known heritage value, other than by virtue of crossing part of the original Vine Lodge property. The Bypass route would be evident in views from surrounding rural land to the north, but would maintain a wide separation from Vine Lodge, be seen low on the slope and would not diminish the spatial arrangement nor the proportions of the setting of the buildings. So as to maintain the open setting and spatial relationships of the house to its setting, and not present visual conflicts with the existing elements, it was considered that the product route should not otherwise be hidden by excessive formal planting. Its line would be softened by the strategic location of groups of small and larger trees, located so as to interrupt a direct view down the route, in critical view lines from Exeter Road and from residences nearby (Figures 4e-4h). The Bypass Route would also retain and would not conflict with the ability of people in the future to interpret the heritage significance of the original access route to Vine Lodge from the north and would not impact on the historic plantings that mark that route.

4.4.4 Product transportation beyond the Exeter locality

Once the Exeter Bypass is constructed the product truck traffic travelling to and from the existing processing plant would avoid Exeter village altogether. However there would be some visual exposure of this activity, particularly on Exeter Road and the Illawarra Highway. The extent and nature of this is detailed in the report of Transport and Urban Planning Associates and summarised in the EIS.

Properties in the immediate vicinity of the entrance on Exeter Road (ie. Tralee, Killarney and Summer Dell) would be most exposed to the change in traffic conditions and to the effects of traffic entering and leaving the Bypass. Special attention has been paid to the design and location of the entrance, and to diminishing the visibility of both trucks and the Bypass Route, by the use of earth mounding, which also has acoustic control functions and screen planting. Design principles for the entrance and a section showing the view line from Tralee and Vine Lodge West are shown at Figures 4f-4h.

Most viewers on Exeter Road, the Illawarra Highway and further afield, would not be aware of any change in the extent of truck movements, given the low proportion of total traffic movements that would be represented by trucks travelling to or from the processing plant. On the basis that there is both existing traffic and existing truck movements on all the roads used as transportation routes for the material being delivered to markets, and with the knowledge that this will not be dramatically increased by the proposed activity overall, the visual impact could not be regarded as a major intrusion into the existing scene.

The route in the vicinity of Exeter and Sutton Forest, taking in Exeter Road, part of the Illawarra Highway and part of the Hume Highway, traverses parts of the ESFLCA. On the route, particularly in the vicinity of Sutton Forest, are a number of heritage listed properties (see Appendix 6). Most of these are not in a position to be materially affected by views of product transport trucks. There are exceptions to this however, especially in the vicinity of the intersection of Exeter Road and the Illawarra Highway. Both the visual evidence of truck movements and the associated sounds are matters that should be considered in relation to the heritage significance of properties and the landscape generally.

The location of the roads and their use over time are critical aspects of the development of the cultural landscape of the area and they help to describe and define the past and the spatial relationships between settlements such as Exeter and Sutton Forest. While there is no doubt that an increase in truck activity would occur near the identified heritage properties, it is not considered that the marginal change in this constitutes a significant impact on the heritage value of the properties. Increasing traffic of all kinds and increasing heavy vehicle usage of the roads is an existing condition, which must be taken into consideration in judging the impacts of the present proposal. It is not considered that the visual evidence of truck transportation would materially decrease the historic significance of properties in the locality. Also, the findings of Wilkinson Murray Pty Ltd indicate that vibrations from truck traffic do not present any risk to heritage buildings.

When considered impartially, this assessment concluded that the visual exposure of further truck movements would have little, if any, impact on heritage properties. People taking a position against the extraction activity generally, may express the view that all truck movements associated with the activity are unacceptable and they may cite the heritage significance of the area to justify this view. It is considered, looked at more objectively, that this position, while it is understandable, is not supported by the evidence at hand.

4.5 THE OVERALL EXTENT OF VISUAL EXPOSURE OF THE ELEMENTS OF THE PROPOSAL

The extent of visual exposure of the two separate elements of the proposal, ie. the extraction area and the Exeter Bypass, was then assessed on the basis of the appearance of the development, assuming initially that no ameliorative measures had been taken to reduce it. This establishes a base level of visibility, against which the need for and effectiveness of any amelioration measures to be taken can be judged. While visual exposure of most aspects of the development would be low within the visual catchment, there are some locations from which aspects of the operation would be more visible. The extent of the visual exposure to these is shown on Table 4.2 below. The exposure to heritage items has already been addressed above (Table 4.1).

Table 4.2: The extent of visual exposure to viewing locations other than heritage items, prior to the consideration of any amelioration measures that may be necessary.

General Location	**Specific location**	**Extent of exposure**	
		Extraction area	**Exeter Bypass**
Exeter village	Overall	Low to nil	Nil
	Oval, tennis courts etc.	Negligible	Nil
	Part of School Lane/ Norwood Street	Low	Nil
Rural residences near the proposed extraction site	Merry Hill, Willowbank, Boeing Park	Moderate	Nil
	Rockleigh Cottage	Negligible	Nil
	Uig Lodge	Low-moderate	Nil
Residences near the Bypass entrance/exit	Tralee and Killarney	Low	Moderate
	Summer Dell	Negligible	Moderate
Ellsmore Road	Vine Lodge West	Low	Low
	Vicinity of new residence and sheds	Low	Negligible
Exeter Road	Generally	Low-negligible	Low
	Vicinity of Tralee entry	Low-negligible	High
Werai Road	Within the visual catchment of the site	High	High
Rockleigh Road	Within the visual catchment of the site	High	Negligible
Railway	Within the visual catchment of the site	Moderate-high	Moderate

4.6 ASSESSMENT OF MEASURES PROPOSED TO CONTROL VISUAL EXPOSURE

The location of the proposed extraction area is such that much of the extraction activity and the final landscape would be effectively out of sight from most external viewing places. However, if no amelioration measures were taken there would be some locations affected by views of the activity and of the final landform, and these view lines deserve attention in terms of measures to decrease impacts to an acceptable degree. The Exeter Bypass route would also have a low visual exposure in the landscape, but the intersections and associated roads and structures at each end warrant visual control measures.

To ensure the effectiveness of visual impact amelioration measures we have provided design principles for the shapes, contouring and aspects of the siting of bund walls and associated vegetation, for both the extraction site and the Exeter Bypass route (Figures 4a-4h). It is the intention of the proposed principles to minimise the visual exposure of the proposal by employing amelioration devices that are visually not out of character within the existing rural landscape.

4.6.1 Visual effect of bund construction

Figures 3a-h show the extent of present visibility of the proposed extraction area, when seen from the most affected locations. The figures show the visibility of the area to a viewer of average height, standing at the dwellings on the properties indicated. It is evident that even without any amelioration measures the visual exposure is low. In Chapter 3.12 of the EIS there are sight line sections drawn from the properties most affected and it is evident that the bund walling proposed, particularly in conjunction with the vegetation to be planted that would both disguise the bunds and increase their visual control effect, would reduce the visibility of the area to zero. For the closer properties, there would be no view of the proposed extraction area or the activities there by the time the work was moving into the north eastern half of the site, which is the only part which has potential visibility from any of the viewing places, as shown on Figures 3a-3h.

The part of the internal product transport route parallel to Werai Road would be below and behind a wide, gently sloped bund walls, planted with native vegetation to visually blend with the woodland remnants north of the proposed extraction area. This would eliminate visibility of the road cutting when seen from the south west and south, particularly where it crosses to the east of Lylen near the existing stands of trees. The perimeter bund wall would eliminate views into the proposed extraction area from most locations, even without the plantings proposed. By the time a significant amount of the north eastern wall of the quarry was constructed, the bund and vegetation would eliminate views of the wall from off site. This effect would be seen in views from all distances, including elevated locations such as in the vicinity of the Exeter Reservoir.

4.6.2 Principles for Planting and Batters at the Proposed Extraction Site

The major element proposed to deal with visual exposure of the proposed extraction area from off site, documented in the plans which accompany the EIS, is a vegetated bund wall on two sides of the proposed extraction area. The bund wall is necessary on the margins to provide noise attenuation, apart from its visual amelioration function.

In the findings of the Commissioner on the previous proposal for an extraction area that included this site, it was argued that there would be an unacceptable visual impact of the perimeter bund wall itself, even if it could disguise or hide the extraction activities. It was thought the bund wall would be an unusual landscape feature and would have visual impacts in itself, particularly on the Rockleigh Road side of the proposed extraction area. Additionally, it was considered that dense screen planting would increase this undesirable effect. Consequently in the current proposal, close attention has been paid to both the effectiveness in preventing visual access as well as to the final visual appearance of these amelioration measures, compared to the existing landscape. Principles that were recommended to the former Commission of Inquiry were generally applied to the design of the bund walls and vegetation proposed.

The significant difference in this application is that the extraction activity would be confined to an area much lower on the slope toward Rockleigh Road and therefore with less potential visual exposure, meaning that bund walls can be lower in height. Two further major variations from the previously proposed bund walls have been incorporated into the designs in this proposal. These involve reducing their overall height by 3-4m and by lowering the

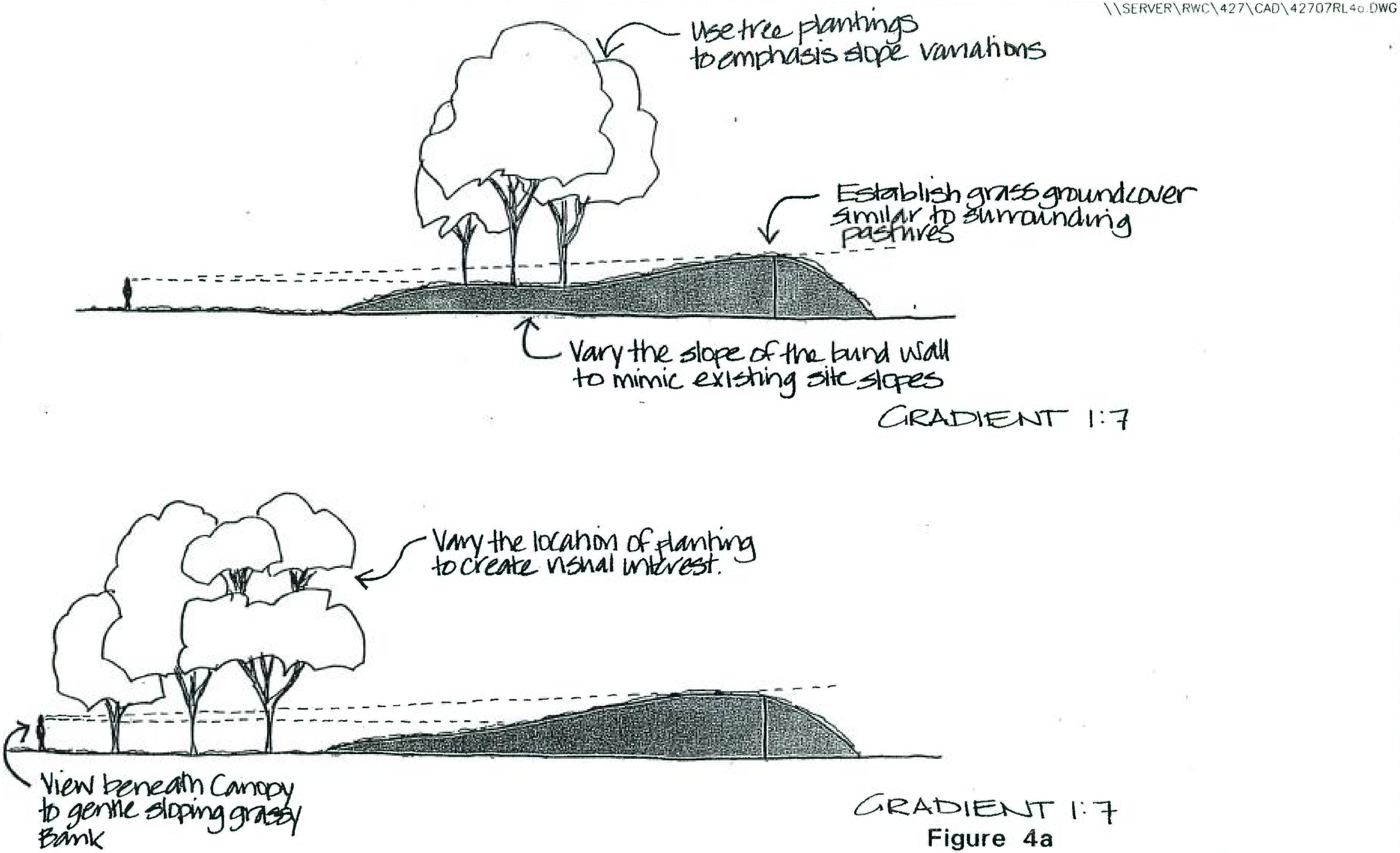


Figure 4a
LANDSCAPE DESIGN PRINCIPLES TYPICAL SECTIONS - BUND WALL FACING WERAI ROAD

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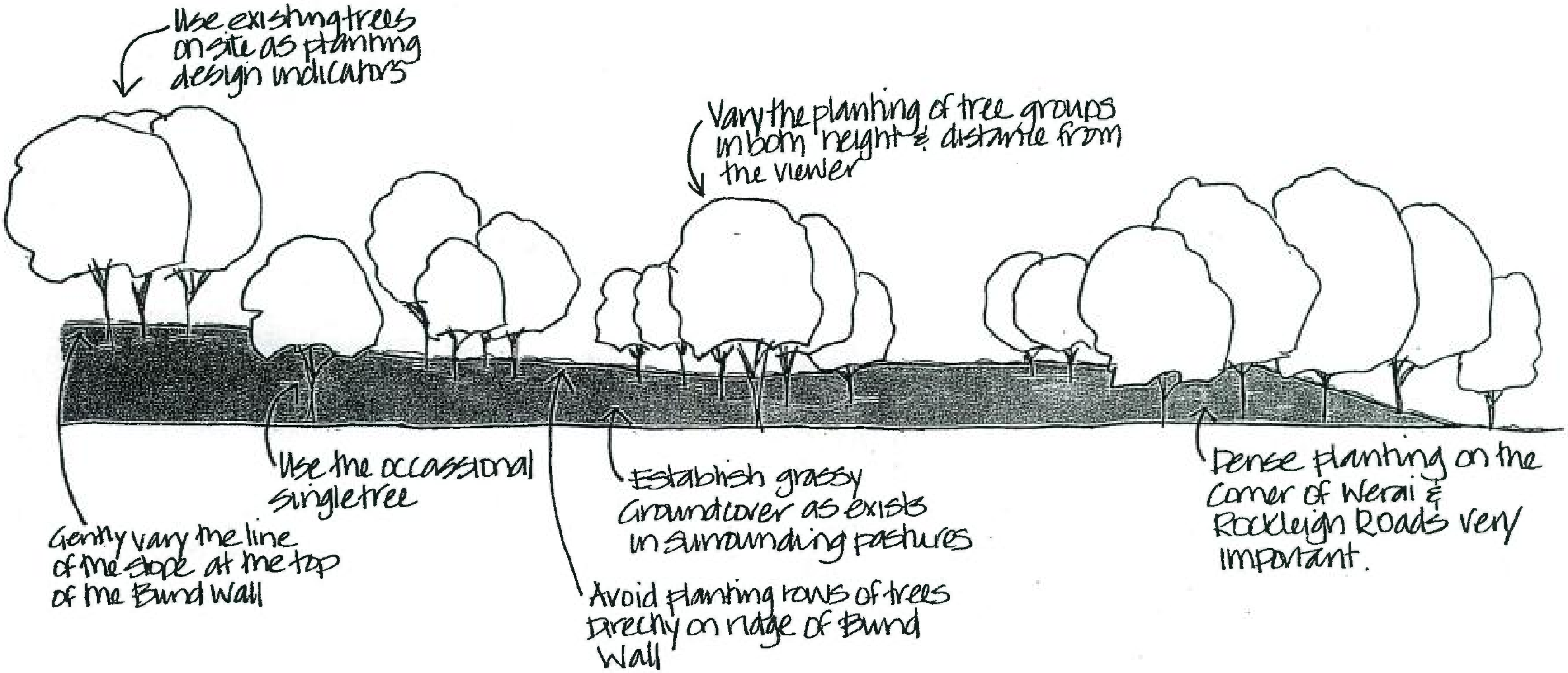

Figure 4b
LANDSCAPE DESIGN PRINCIPLES INTENDED APPEARANCE OF BUND WALL & LANDSCAPE VIEWED FROM WERAI RD

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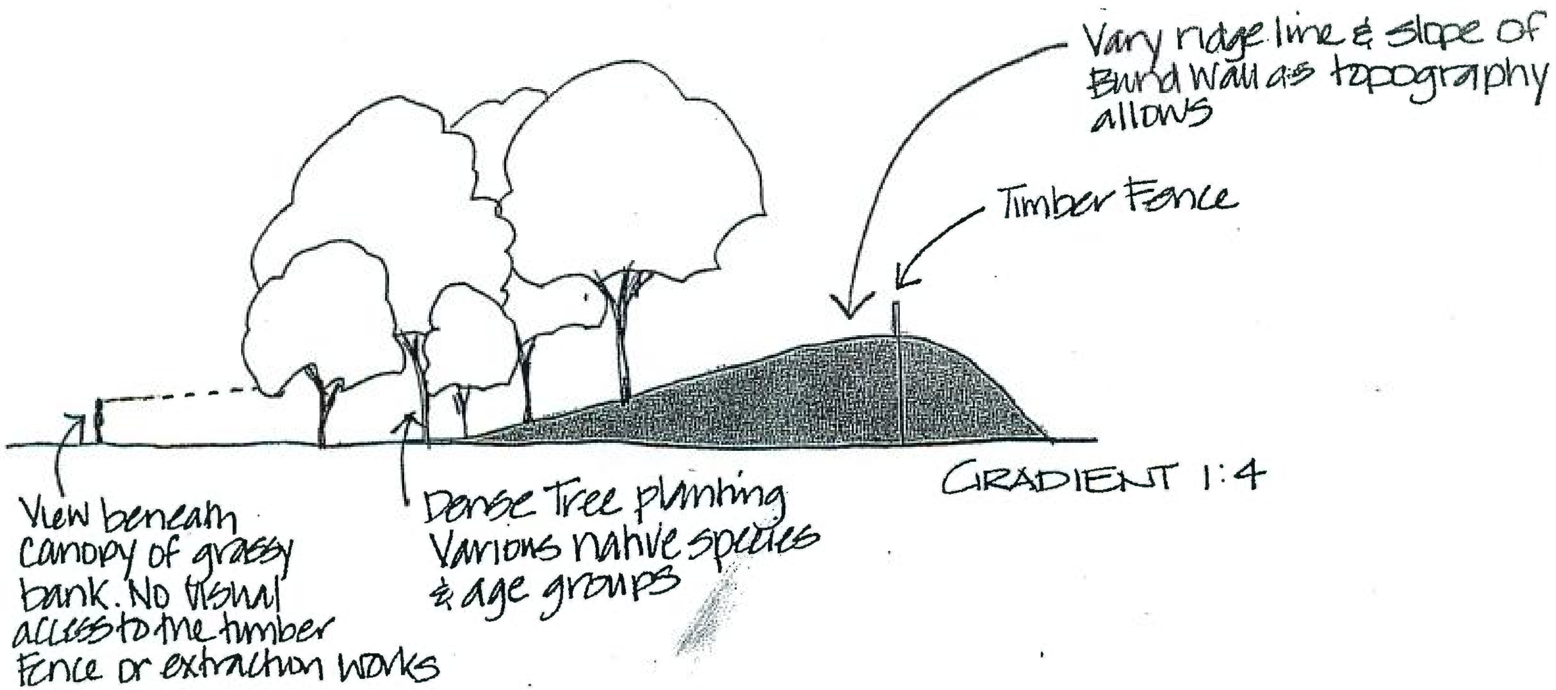


Source: University of Sydney (1999)

Figure 4c
LANDSCAPE DESIGN PRINCIPLES TYPICAL SECTIONS - BUND WALL FACING ROCKLEIGH ROAD

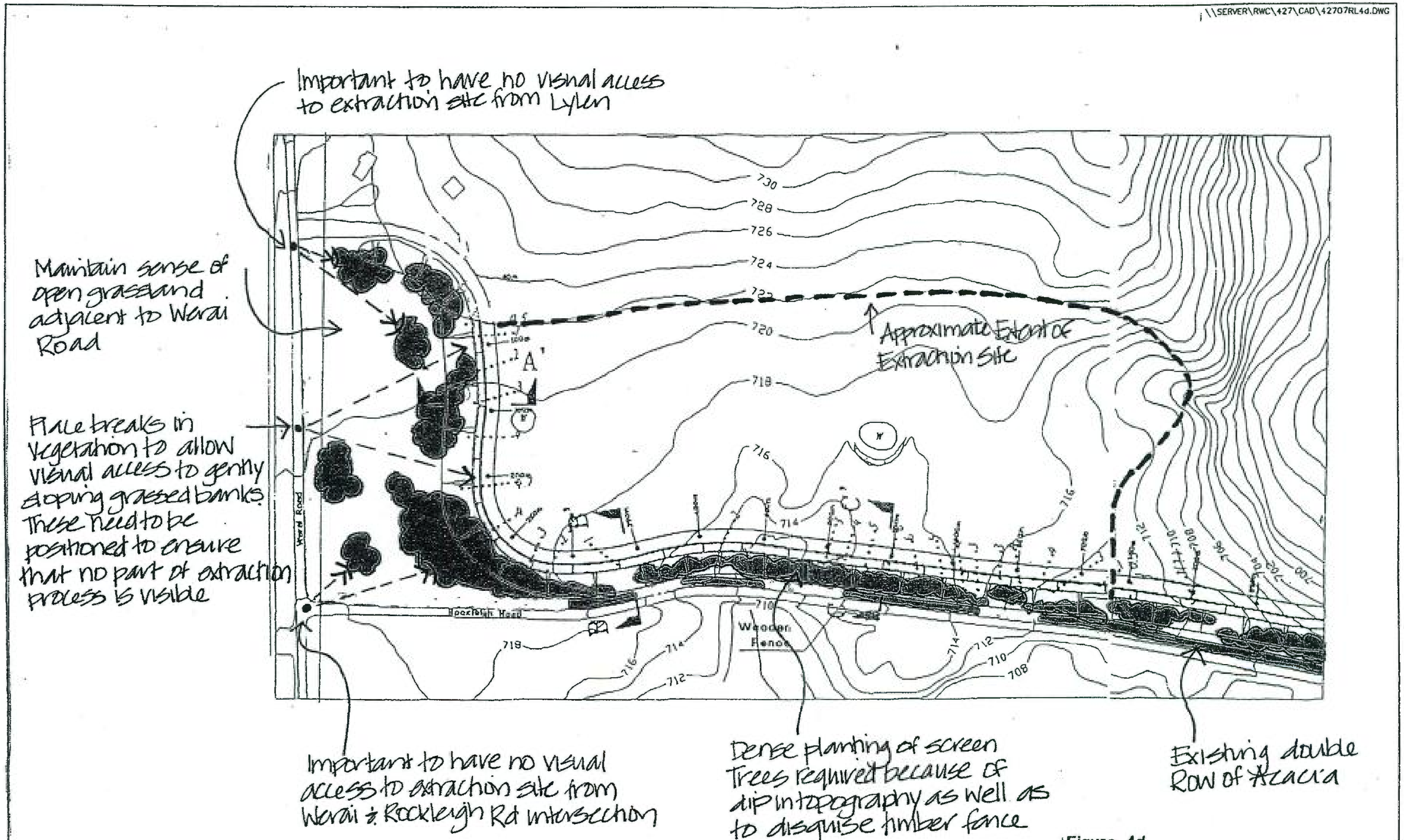


Figure 4d
PLANTING PRINCIPLES
PLAN FOR EXTRACTION AREA & INTERNAL TRANSPORTATION ROUTE

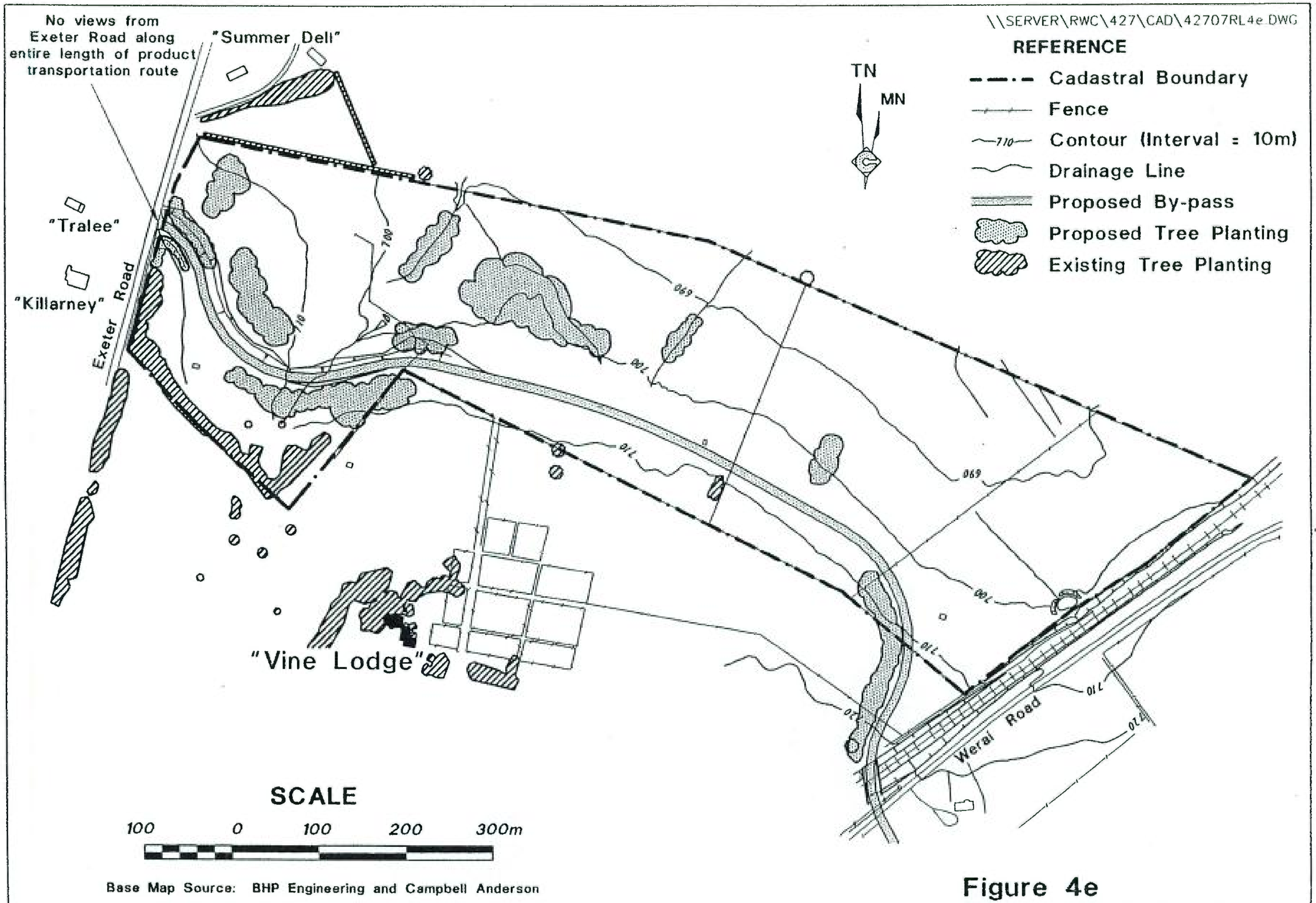


Figure 4e
PLANTING PRINCIPLES
EXETER BYPASS

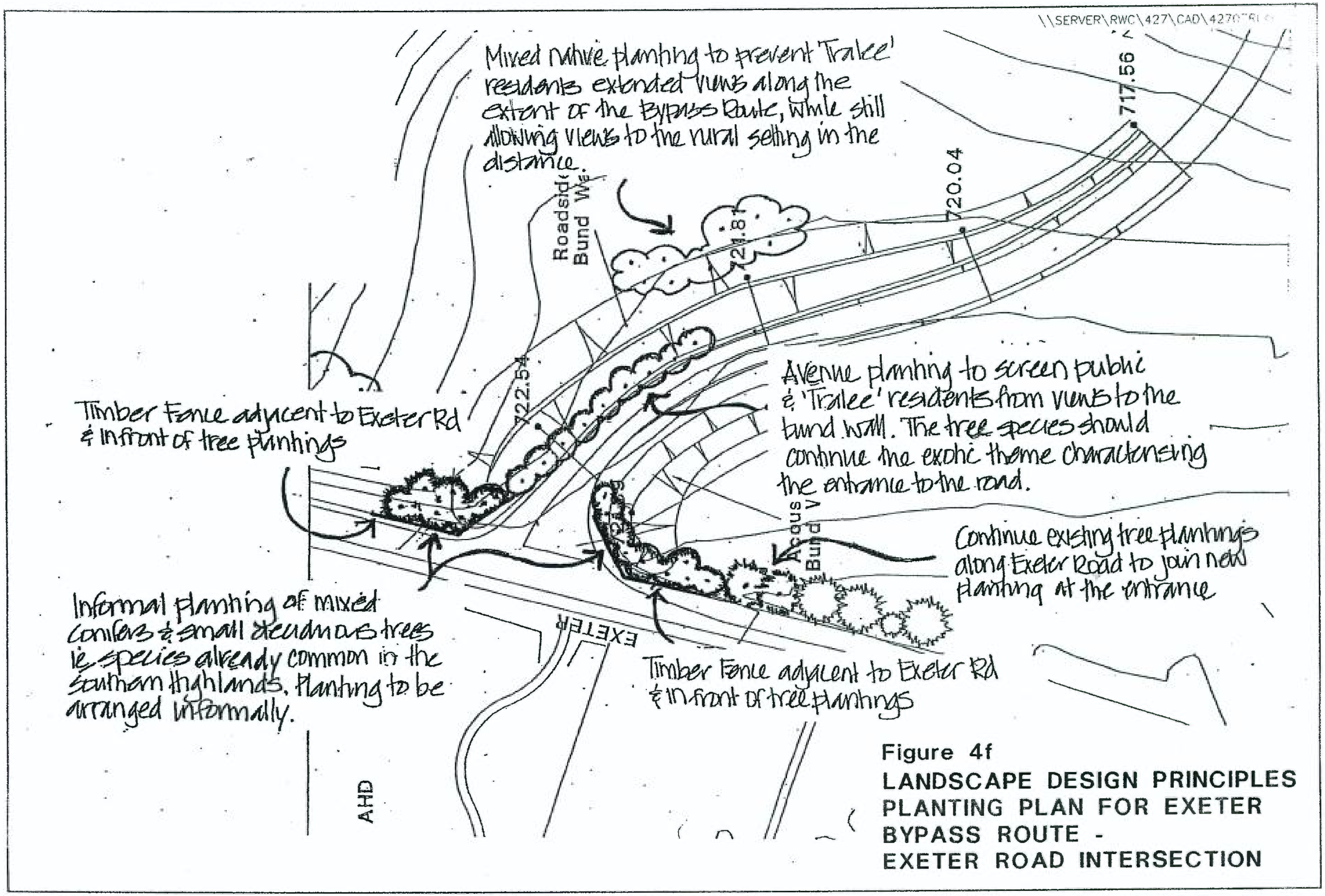
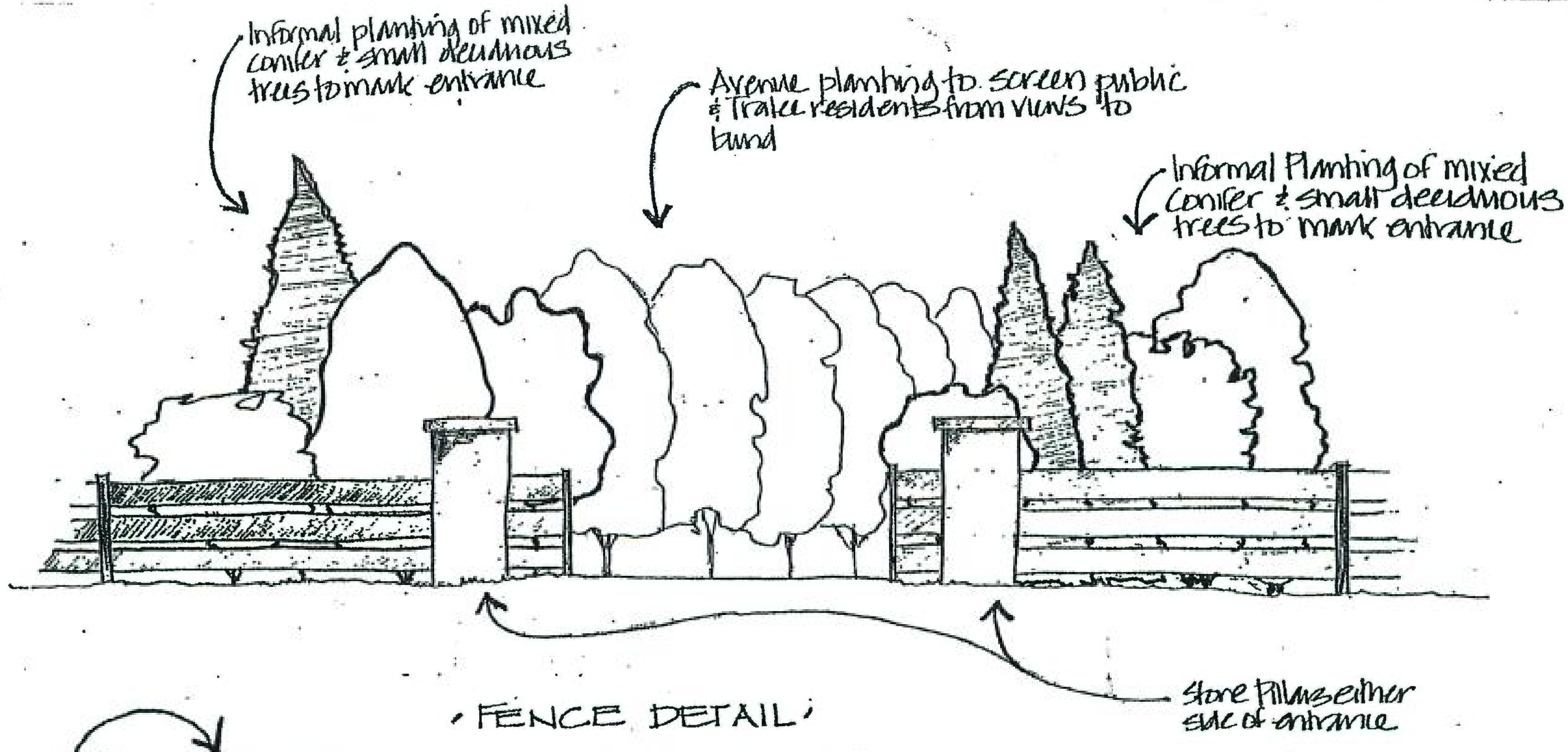


Figure 4f
LANDSCAPE DESIGN PRINCIPLES PLANTING PLAN FOR EXETER BYPASS ROUTE - EXETER ROAD INTERSECTION



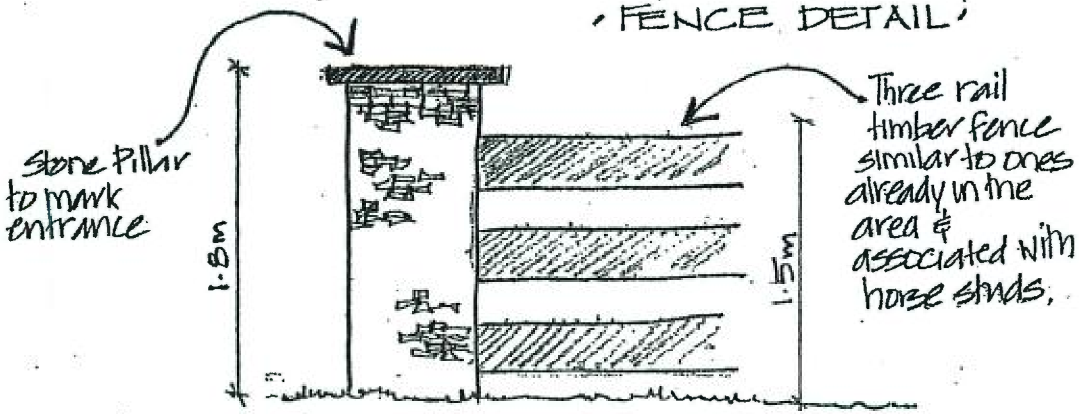


Figure 4g
LANDSCAPE DESIGN PRINCIPLES TYPICAL SECTION - ENTRANCE TO EXETER BYPASS ROUTE FROM EXETER ROAD

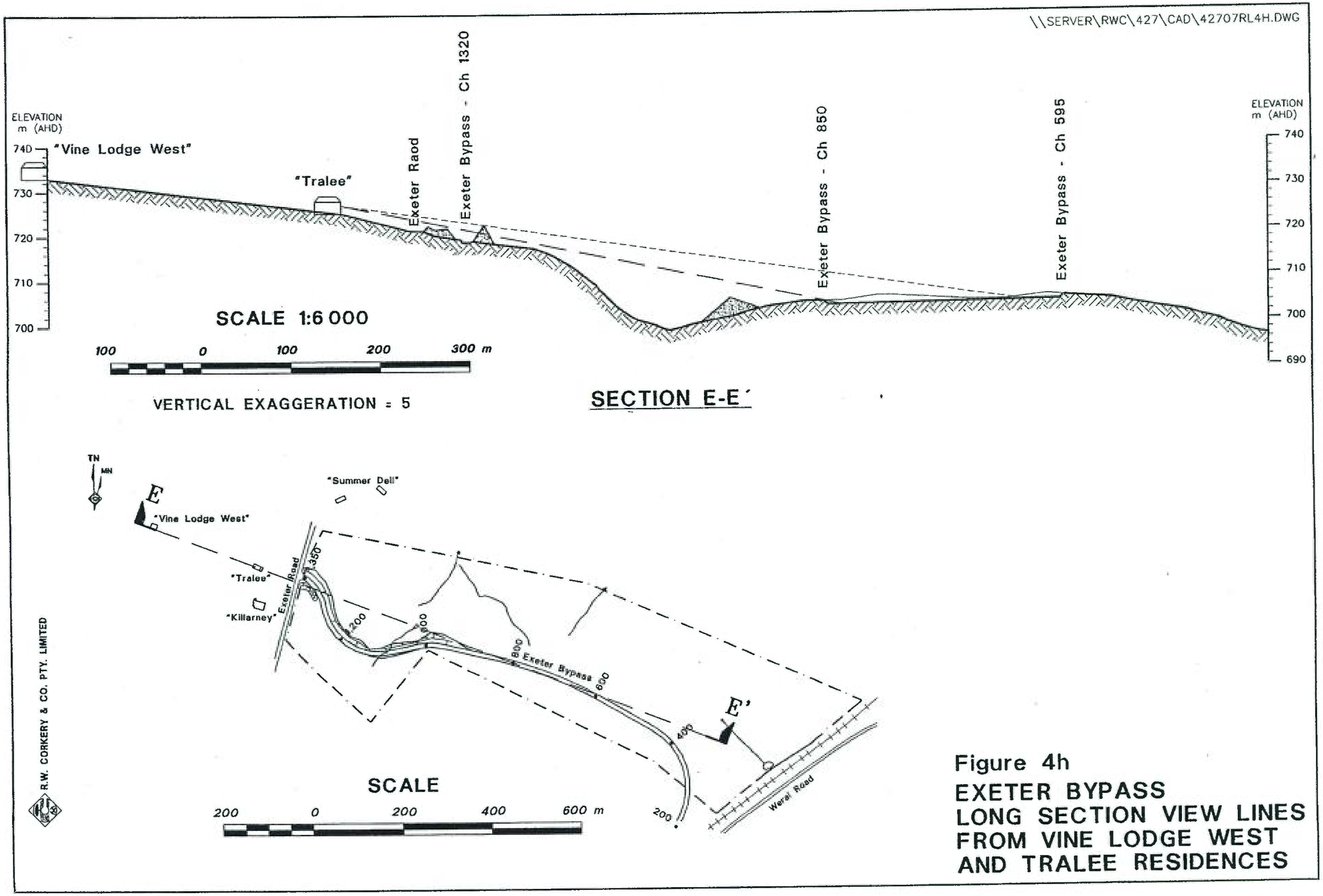


Figure 4h
EXETER BYPASS LONG SECTION VIEW LINES FROM VINE LODGE WEST AND TRALEE RESIDENCES

batter angles of the walls as far as is possible. Batter angles would be typically no more than 1:4 for the section parallel to Rockleigh Road (height less than 4m) and not more than 1:7 for the north western section toward Werai Road (height less than 3m).

The lower bund wall height and batter angles mean that the bund walls would be of significantly lesser visual exposure than those formerly proposed, with long face slopes (from 18-24m approximately, from toe to crest), tending to follow the underlying topography and with variations in the profile of the crest. The low slopes mean that landscape works, such as weed control and plant maintenance, can easily be carried out using standard equipment and the success of plantings can be assured. The lower batter slope also means that stock can graze the area as at present and maintain its active rural management. Rural fences similar to those existing on the land at present would be used to prevent stock from damaging establishing plantings on the bund walls initially. These would later be removed. A second more permanent fence would be placed beyond the crest of the bund wall, to prevent stock straying into the extraction area. The visual presence of the fences would be minimal. The basic structure and intentions of these designs are shown in graphic form in Figures 4a-4d.

One important aspect of the impact of the proposal is the change in the visual character of the view from Werai Road. Compared to the previous proposal, the proposed extraction limit is set further back from Werai Road allowing for the planting of informal groups of native trees in this area before construction commenced. This planting would be carefully designed to eventually create a natural appearance to the area, taking the *Eucalyptus elata* grassy woodland and groups of exotic trees nearby as a model. The vegetation would not grow into a solid screen, but would reduce the view access across the site and the visibility of the gently sloped face of the bund wall. The batter would be planted with grass and groups of trees, to continue the theme that is described above. The screening vegetation would be sufficiently dense to eliminate views into the site or visibility of the north eastern boundary wall of the extraction area. A viewer would experience a gradual change in the character of the scene and its transformation into a more natural appearance. The appearance after 2 years and the final appearance of the proposed extraction area when viewed from Werai Road is depicted in two photomontages (Figures 5a and 5b). The view shown was derived from a panorama of three photographs as is evident in the foreground, so as to give an impression of the total extent of the view.

A similar bund wall would be used on the Rockleigh Road side of the proposed extraction area, planted to merge with existing planting on the road and within the site. The typical details of this are shown in Figures 4c-4d. It would be varied in height and slope to decrease its visual presence and to prevent views into the site from the few locations identified as affected to the south of the site. Part of this perimeter bund wall would be surmounted by a fence for acoustic purposes, that would be removed at the end of extraction. The fence, which is shown in Figures 4c-4d, which would not be erected until about Year 4 of the extraction process, would be disguised by planting on the bund surface, new plantings between it and the site fence and by existing vegetation on the boundary. The bund walls and vegetation would be in place and sufficiently mature so that the fence, by the time it was necessary to be constructed, would not be visible. The final appearance of the proposed extraction area when viewed from Willowbank is depicted in a photomontage, Figure 5c.

At present, a double row linear planting of *Acacia melanoxylon* (blackwood wattle) exists along the Werai and Rockleigh Road site frontages. These trees are well established and are indicative of the success that can be expected in regard to further tree plantings. It is proposed that this screen should remain in place while the plantings described above become established. Once this occurs, the rows of trees, although not alien in the rural landscape in themselves, will be removed on the Werai Road frontage and on the part of the Rockleigh

Figure 5a: Photomontage – Werai Road frontage after 2 years

Figure 5b: Photomontage – Werai Road frontage final appearance

Figure 5c: Photomontage – Rockleigh Road frontage

Road frontage closest to Werai Road. The reason for this is so that the site will not be hidden behind a "wall" of vegetation, but will appear to blend with the character of the more open, partially wooded land which presently surrounds it (Figure 5a). On the remainder of the Rockleigh Road frontage, the plantings will generally be selectively thinned to provide groups of dense vegetation interspersed with open areas, as is common on road verges in other parts of the eastern margins of the Southern Highlands where blackwood wattle is a conspicuous species. The Acacias will remain in place to provide screening to bunds in important view lines, such as the view from Willowbank (Figure 5c) and Merry Hill, where the view composition is similar.

4.6.3 Rehabilitation of the quarry benches and floors

The benches of the extraction area would be sequentially rehabilitated and vegetated with tree and shrub vegetation, using overburden and fine material waste, supplemented if necessary with organic material to make an appropriate growth medium. The success of plants in similar environments and growth mediums can be seen in the vicinity of the existing processing plant. The upper bench would have a variable wall height of 5m to 8m, allowing vegetation established there to quickly overtop the quarry lip. In time, a varied canopy of trees would assist in breaking up the line and form of the final faces that could be visible, particularly in oblique view from elevated locations to the east of the site. The overall visibility of the wall however, even without any amelioration measures being taken, would be minimal in any view.

4.6.4 Planting and batters associated with the Exeter Bypass route.

Special attention has been focused upon the visual character of the intersection with Exeter Road. Without amelioration, there would be visual access to the Bypass corridor. However, the amenity of the views down the corridor from near the intersection can be controlled by strategically located group plantings of native and exotic tree species that are typical of the landscape nearby. The principles for the design of these elements are shown on Figure 4e. Design principles have also been developed for the entrance to the Bypass and for measures to control the visual effects of acoustic bunds near the entrance. The principles are shown in plan (Figure 4f) and in sketch elevation (Figure 4g). When mature, the vegetation planted would have an appearance similar to ornamental landscape plantings common in the Southern Highlands on boundaries and entrances to properties. The entrance would be flanked by gate posts of random stone and contained by a post and rail fence. The Exeter Road entrance to the Bypass would thus have an appearance in sympathy with entrances to rural properties in the area and would not be out of character.

The vegetation to be planted in the vicinity of the Bypass entrance from Exeter Road has been located so as to prevent views from Exeter Road directly along the length of the Bypass road, without producing a dense tree screen in the foreground. Other than at the entrance itself, the Bypass road and vehicles moving on it would generally not be visible from this viewing location. The vegetation and bund walls of the entrance would also be effective in preventing views down the Bypass route from the nearby properties Tralee and Vine Lodge West. This can be seen by inspection of the long section showing view lines from these residences (Figure 4h). Even without any vegetation screening of the entrance bund walls, neither location has a view down the Bypass. Vegetation in the vicinity of the entrance is proposed to be planted as advanced stock so as to bring about rapid screening of the bund walls and reduction in the visibility of trucks approaching the entrance onto Exeter Road. The screening of all of the entrance works would be effective once vegetation had grown to a height of approximately 4m, which could be achieved using advanced stock, within two to three years of establishment.

The final appearance of the proposed Exeter Bypass entrance, when viewed from the air above Exeter Road and showing the design principles above, shown with vegetation at an early stage of maturity, is depicted in a photomontage, Figure 5d. The view shown was derived from an oblique aerial photograph.

It is understood that to provide acoustic control for Summer Dell, the property to the immediate north of Vine Lodge, a roadside bund wall and an acoustic fence surmounting it are required over a short section of the Bypass road near the creek crossing. While the visual presences of these can be controlled by vegetation screening, they are not considered necessary from a visual control point of view and if further consideration lead to the reduction or elimination of these structures, the visual effect would be acceptable, for the reasons detailed below, that apply to the remainder of the route east of the creek crossing.

It is not considered necessary or appropriate to attempt to disguise the Bypass route to the north of Vine Lodge, where it would be seen from rural properties to the north. While it may be possible to do so by having dense or multiple avenue plantings, the visual effect would be out of character with the rural landscape and the open setting. It would also reduce the open prospect of the view outward from the Vine Lodge residence and garden. Instead, it is proposed that informal groupings of native tree species be used to enrich some areas of existing vegetation in drainage swales along the route. These plantings would be located so as not to conflict with water availability to properties downstream (Figure 5d).

As the Exeter Bypass passes through the northern lot of the Vine Lodge property, special attention has been given to the road design to ensure that it does not impinge upon northerly views from the residence and garden. As such, the surface of Exeter Bypass road would be constructed a minimum of 3m below the view horizon from the Vine Lodge residence and garden. The Bypass and also the trucks travelling along it would be out of view from this location.

The roadside bund walls that provide acoustic protection to the nearby property Summer Dell would reduce in height over a distance of 30m to the east of a creek crossing near the Exeter Road Bypass entrance. Plantings of native and exotic tree species are proposed to reduce the visibility of the part of the bypass route west of this point when seen from Summer Dell and Exeter Road. The height of the roadside bund wall and plantings mean that truck movements will not be visible in this part of the route, either from Summer Dell or from Exeter Road. As bund height decreases to the east, truck movements will be visible from the locations on rural land already described above. The remaining low bund wall would have a gentle northern face slope, follow the surface contour of the land, be grassed, grazed by stock, and would blend visually into the surrounding topography. It would have the effect of preventing direct view of the road's surface and would assist in noise attenuation.

The Bypass road would generally not be visible from the surrounding landscape, but evidence of it in the form of a grassed bund would be able to be seen from nearby rural properties to the north. When seen from these, it would not be intrinsically out of character in the landscape, even though truck movements would be seen. Rural roads and access ways and the movement of traffic are a familiar feature of the landscapes of the area and have relatively little visual impact, once established. There are many other linear features that contribute to the character of the area, such as windrows, fences, other roads and tracks, railway embankments etc. The Bypass would be seen, from the limited locations indicated above, within that context.

Figure 5d: Photomontage – Exeter Bypass

The entrance to the Bypass at the Werai Road intersection is depicted in oblique aerial view in a photomontage (Figure 5e). A open stand of vegetation, comprising species common to the roadside in the locality is proposed to be planted on the south western side of the Bypass route soon after it crosses the railway line, to eliminate any visibility of truck movement, when this is seen from the landscape to the east of the Vine Lodge residence and outbuildings. This need only be an open screen because the road in the vicinity is in cut and the likelihood of any truck visibility is minimal. The vegetation will also serve to visually integrate the railway crossing into the immediate landscape, where both Werai Road and the railway embankments feature cultural plantings.

4.6.5 Summary assessment of amelioration measures

The means proposed for the control of visual exposure of the operation, are expected to decrease the visibility of the proposed extraction area to an acceptable level overall. From most locations that would have been affected in some way by the former proposal there would be no visual or heritage impact effects. From those where there is some effect of this proposal, the impacts would be considerably less initially and would rapidly decrease to an acceptable level. This is not to say that there would be no residual evidence of the activity, such as the intersections and entrances to the Bypass route, or indirect visual evidence of transportation or products, such as trucks on the roads at a distance from the extraction area.

Table 4.3: The extent of visual exposure to all viewing locations assessed assuming the implementation of the recommended amelioration measures

General Location	Specific location	Extent of Exposure	
		Extraction area	**Exeter Bypass**
Exeter village	Overall	Negligible	Nil
	St Aidan's Church group	Nil	Nil
	Hall, Exeter	Nil	Nil
	Oval, tennis courts etc.	Nil	Nil
	Part of School Lane/ Norwood Street	Negligible	Nil
Rural residences near the proposed extraction site	Merry Hill, Willowbank, Boeing Park	Nil	Nil
	Rockleigh Cottage	Nil	Nil
Residences near the Bypass entrance/exit	Uig Lodge	Nil	Nil
	Tralee	Nil	Low
	Killarney	Nil	Negligible
	Summer Dell residences	Nil	Negligible
	Summer Dell, property to the east of residences	Nil	Low
	Whare-Tau and nearby residence	Nil	Nil
	Vine Lodge, residence and outbuildings	Nil	Negligible
	Vine Lodge, property to the east of the residence	Nil	Low
Ellsmore Road	Vine Lodge West	Nil	Negligible
	Vicinity of new residence and sheds	Nil	Negligible
Exeter Road	Generally	Nil	Negligible
	Vicinity of Tralee entry	Nil	Moderate
Werai Road	Within the visual catchment of the site	Low	Moderate
Rockleigh Road	Within the visual catchment of the site	Low	Nil
Railway	Within the visual catchment of the site	Nil	Low

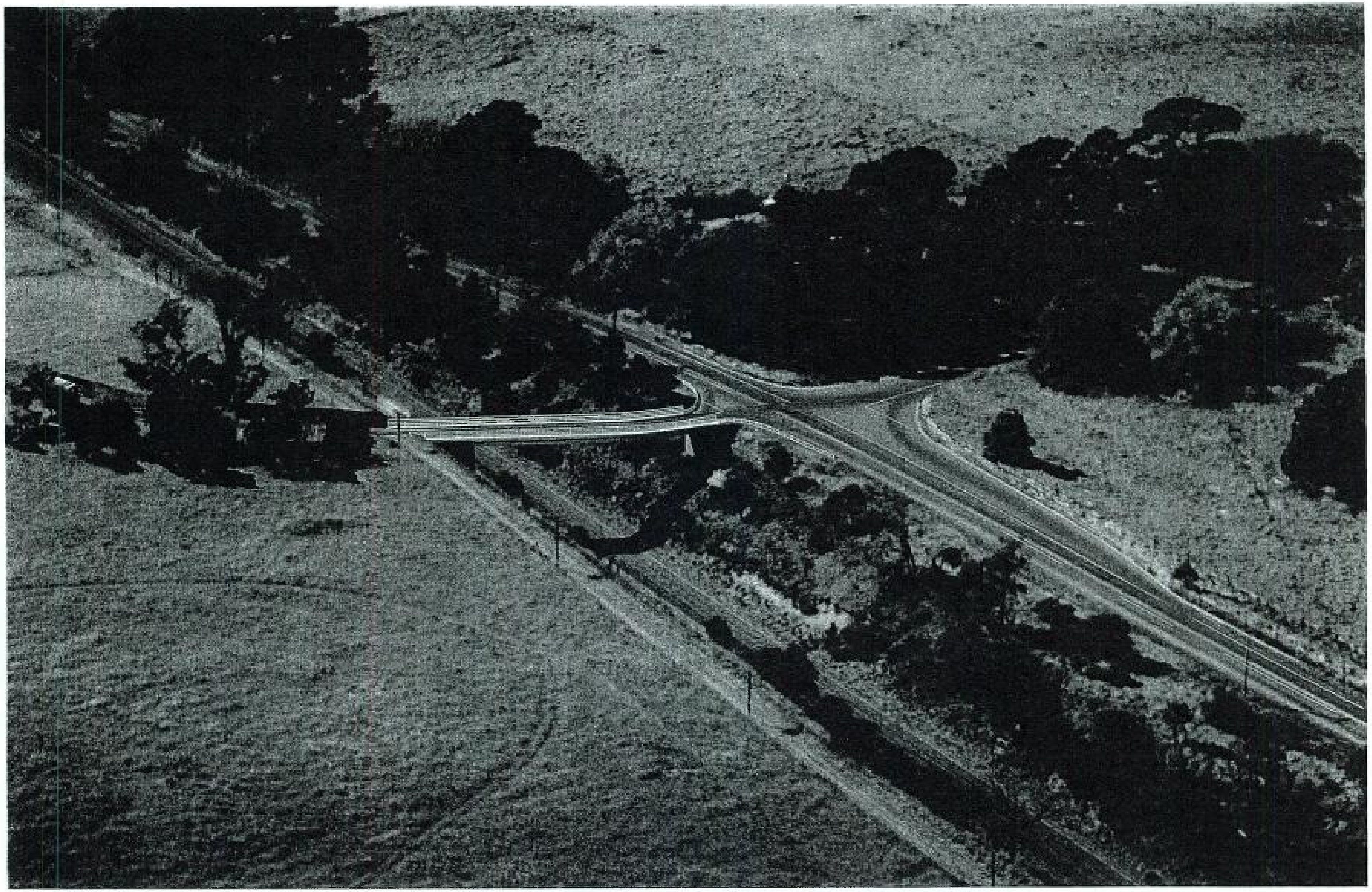


Figure 5e: Photomontage – Railway Overbridge

The extent of the visual exposure of the proposal taken over the effective visual catchment of the development and including all heritage items, as demonstrated by this table, was judged to be low.

4.7 RESIDUAL IMPACTS

Even with the ameliorative measures which are proposed, there would be some residual impacts of the development which would remain until the latter stages of extraction and after the life of the site is over. The most significant effects would be the permanent change to the character and reduction in the extent of the view available from part of the railway, Werai and Rockleigh Roads. The upper slopes, which are a feature of the north east boundary of the Company's land in the vicinity of the proposed extraction area, would remain unaffected by the proposal.

The relatively short life of the initial extraction activity in this application is such that growth and development of planted vegetation and rehabilitation on the upper benches would continue beyond the active life of the quarry and, while these are residual effects, they would contribute positively rather than negatively to the landscape. In a similar way, the vegetation planted to soften the view of the line of the Exeter Bypass route when seen from near its intersection with Exeter Road, would mature and be seen as an integral part of the landscape.

The level of exposure, which would at the worst be modest when seen in the wider context, would be significantly reduced by the measures proposed. Impacts would be eliminated or reduced to an acceptable level for all viewing locations.

4.8 SIGNIFICANCE OF IMPACTS

The final part of this assessment consisted of the assessment of the significance of any residual visual exposure of the development proposed. There are two kinds of elements that were assessed, ie. residual exposure of the extraction activity itself and the remaining visibility of amelioration measures. The assessment of significance of impacts was derived in two steps. The first step was to identify the locations where there would be some residual evidence of the development, derived from Table 4.3 above. The second step was by weighting the visual exposure values. The weighting is to accord levels of importance to the impacts on particular viewing locations. It is necessary to apply this weighting so as to distinguish between the extent of the impact assessed above (how much impact there would be), from the significance (how important the impact is).

The weightings which were applied constitute the basis for the main subjective element of this assessment. The weights which were applied include weighting related to the heritage significance of the identified heritage items and the less tangible aspects of heritage value of the area. In this way, the two sets of factors which are relevant to the significance of impacts were combined. Any location on which there would be a negligible or nil extent of residual exposure was excluded from the weighting process. The weightings that were applied to the remainder were as follows:

4.8.1 Visual sensitivity of the landscape generally.

The higher the visual sensitivity of a viewing location, the more significant the visual impact is, compared to the extent of residual exposure. It was considered that the landscape overall was of moderate-high visual sensitivity for its acknowledged scenic value, and therefore the significance of all impacts on views should be up-weighted, compared to the extent of residual exposure of aspects of the proposed development.

4.8.2 Impacts on heritage properties.

The development would have impacts on views from some heritage properties. There would be no unreasonable effects on their amenity but it was considered that the heritage values should be reflected in the weighting of the significance of impacts. Therefore, it was decided to up-weight the significance of the impacts on heritage properties which had direct views of any aspects of the development. Because heritage significance is independent of ownership of properties, the upweighting was applied to the Vine Lodge property irrespective of it being owned by the Concrite Group.

4.8.3 How the weightings were applied.

The same six point scale of values was used as was employed throughout the assessment process (see Appendix 4, part 1.5). Where an item was upweighted, its value was changed by one unit on the scale. For example, an upweight from a residual exposure rated at Low results in an impact significance of Low-moderate.

The significance of visual impacts, following the weighting of these factors, is shown in Table 4.4 below.

Table **4.4**: Significance of visual impacts on all of the affected viewing locations

General Location	**Specific location**	**Significance of impact**	
		Extraction area	**Exeter Bypass**
Residences near the Bypass entrance/exit	Tralee	Nil	Low
	Summer Dell, property to the east of the residences	Nil	Low-moderate
	Vine Lodge property, to the east of the residence	Nil	Low-moderate
Exeter Road	Vicinity of Bypass entry	Nil	Moderate-high
Werai Road	Within the visual catchment of the site	Low-moderate	Negligible
	Vicinity of Bypass entry	Low	Moderate-high
Rockleigh Road	Within the visual catchment of the site	Low-moderate	Nil
Railway	Within the visual catchment of the site	Nil	Low-moderate

The assessment concluded that there were two locations affected by visual impacts which were above moderate in significance; part of Werai Road and part of Exeter Road in the vicinity of the Exeter Bypass entrance. Werai Road would otherwise experience low-moderate impacts in the short section in the visual catchment of the development proposed. Four other areas would experience low-moderate impacts, i.e. part of the Summer Dell property east of the residences, Vine Lodge property east and north of the residence, Rockleigh Road and the Main Southern Railway. Most locations in the effective visual catchment, including the majority of Exeter village and all of the heritage items in the ESFLCA with the exception of Vine Lodge would experience no impacts. The significance of impacts overall are considered to be at an acceptable level and do not warrant further or exceptional measures to be taken to reduce them. The impacts of rural properties south of the site would be reduced to an acceptable level. The heritage property of Vine Lodge was judged as experiencing acceptable impacts generally, even after these are upweighted to acknowledge its heritage significance.

The highest levels of impact arise in the vicinity only of the entrances to the Exeter Bypass route. The result partly reflects the method used, which relies on residual visual exposure as an objective measure of the visual effect of development. Clearly, there is no way to eliminate visual presence of every part of the development proposed, and therefore the most obvious residual element would be the Bypass route intersections and entrances. Taken within the context of the whole proposal however, where the visual impacts of every other element have been effectively controlled, it is reasonable to conclude that the Bypass entrances are acceptable visually. They represent a choice in the design of the development that was taken, not only to avoid another series of more significant impacts on heritage and visual values, but also because it was a preferred option of the Council and Commission of Inquiry. The location and siting of the amelioration measures related to the entrance would eliminate or reduce the associated impacts to an acceptable level.

5.0 CONCLUSIONS

There are a variety of heritage items in the vicinity of the Exeter Quarry and the village of Exeter. The proposed extraction area is outside the Exeter Key Village and its visual catchment, but it and the Bypass route are within Key Historic Landscape Unit 5A. It was concluded, based on an assessment of the vicinity of the proposed extraction area and Bypass route, as well as the locality, that there is little evidence of the location of early land grants. This was supported by inspection of the boundaries of the ESFLCA. The assessments showed that the development proposed would not have the effect of destroying or obscuring important elements of the heritage value of the area that relates to any grant boundaries of the past.

The development proposed would not affect the heritage values which relate to the Key qualities of the village of Exeter or decrease the interpretative or associative heritage values that were identified by Taylor and Landscan and which resulted in changes to zoning of the land in the vicinity.

The National Trust's ESFLCA would not be substantially affected in any material way by the proposal. The number of heritage items which would be affected by views of the development or by any tangible heritage impacts is very small and the proportion of the proposed extraction area that each can view, even without any amelioration measures being taken, is minimal. The extraction area is not within the physical or visual curtilage of any item, though it is partly visible from the vicinity of Whare-Tau and from part of the land of Vine Lodge. The visual amelioration measures to be taken would remove any visual exposure of the extraction area to these properties.

The one aspect of the proposal that has some significant heritage impacts is the material transport route that bypasses Exeter village. This has the effect of removing the most significant indirect effect of the proposal on the perceived heritage values of Exeter; the truck transport of quarry products. It was concluded that the route did not have an unacceptable impact on the landscape heritage values of Vine Lodge, although it would have some residual visual impacts for the duration of the extraction, associated with the visibility of the entrances. The question to be asked in this regard is whether the residual impacts are reasonable compared to the effect of taking truck traffic entirely out of the village. It is considered that this is a reasonable solution, taking the range of issues that are relevant to visual impacts into account.

The question of compatibility of the proposal with the ESFLCA and the area generally, in heritage terms, also goes to whether there can be a quarry in an area of acknowledged heritage value and in the rural landscape near Exeter. Quarries are not intrinsically foreign to rural landscapes and are a legitimate and often a characteristic part of the cultural landscape; not scenic perhaps, but significant parts of the rural scenic character. They are familiar qualities of many Southern Highlands landscapes at present and they are also found in parts of the "English Countryside", which is referred to in the ESFLCA listing as having similarities with the Exeter/Sutton Forest area. Therefore, it could not be claimed that no rural or heritage landscape could have a quarry located there.

The second issue is whether the heritage value of the area derived from interpretation of the past should be a reason to exclude quarry activity in the future. The area is undoubtedly a cultural landscape of recognised significance, containing many classified heritage properties. Many of these, including simply as examples Vine Lodge and St Aidans, as two heritage items of considerably different ages, demonstrate the use of local extracted natural materials, including stone quarried locally. Thus it can be seen that the cultural landscape and its intrinsic resources are linked historically. Cultural landscapes are not museum pieces and they continue to adapt, transform and change, as acknowledged in both the Taylor and Landscan studies that lead to the zoning of the area, and in the National Trust's ESFLCA listing. The continued gentrification and subdivision of rural land into residential lots is an example of a cultural transformation of the existing landscape that is taking place today. Compared to this proposal, it is responsible for far more widespread impact on the structure and meaning of the cultural landscape of Exeter/Sutton Forest. So while history certainly does not uniquely justify the continuation of quarrying activity, neither does it provide a valid justification for stopping it.

There is no doubt that the proposal would have the effect of gradually changing the intrinsic visual character of the extraction area over a long period, but the visual evidence of the quarry generally would be low. Most of the visual catchment and virtually all of the ESFLCA would not be affected by the development at all. The visibility would be decreased by the proposed amelioration measures but the intrinsic character of views of the site from both Werai Road and Rockleigh Road would be permanently altered.

Various means are proposed for amelioration of visual impacts, including the placement of bund walls, vegetation screens and rehabilitation of benches. These have the potential to decrease the visual impacts of the proposed extraction area, where they exist at all, to an acceptable level. This is not to say that there would be no visual evidence of the work, either during or after its completion.

With the ameliorative measures which are proposed, there would be small residual impacts of the development. Apart from the Bypass entrances, the most significant effects would be the permanent change to the character of the view available from Werai Road and secondarily to the view of the site from Rockleigh Road. The open but partly screened foreground of the Werai Road view would be retained and the backdrop, main topographic elements, natural horizon and familiar cultural features of the view would be retained. The view across the site from Rockleigh Road would be more substantially changed and restricted by vegetation.

Seen in the scenic context, which contains many rural and spectacular expansive natural views, the change to the Werai Road view is acceptable. It would not remove the last or the most significant view of its type. Indeed, it would not remove the most scenic components of the view itself. The Rockleigh Road view would be more affected, but is not a major tourism route or heavily used local road, and the impact needs to be considered in that light.

Local views to the site from the south west (School Lane area) and south (some rural properties) would be very little affected, but where there was visibility to the site, the effect would be increasing middle distance vegetation and a decrease in visibility of the grassy surface of the site. The composition, middle slopes, natural vegetation and horizon, would be unaffected. It is considered therefore, that visual and heritage impacts should not prevent the approval of this application.

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APPENDIX 1:

CONSOLIDATED LIST OF ALL HERITAGE PROPERTIES IN THE EXETER/SUTTON FOREST AREA

Consolidated list of heritage listed properties in the Exeter area, from National Estate and National Trust Registers, ESFLCA listing and the Wingecarribee LEP and Heritage Study Inventories

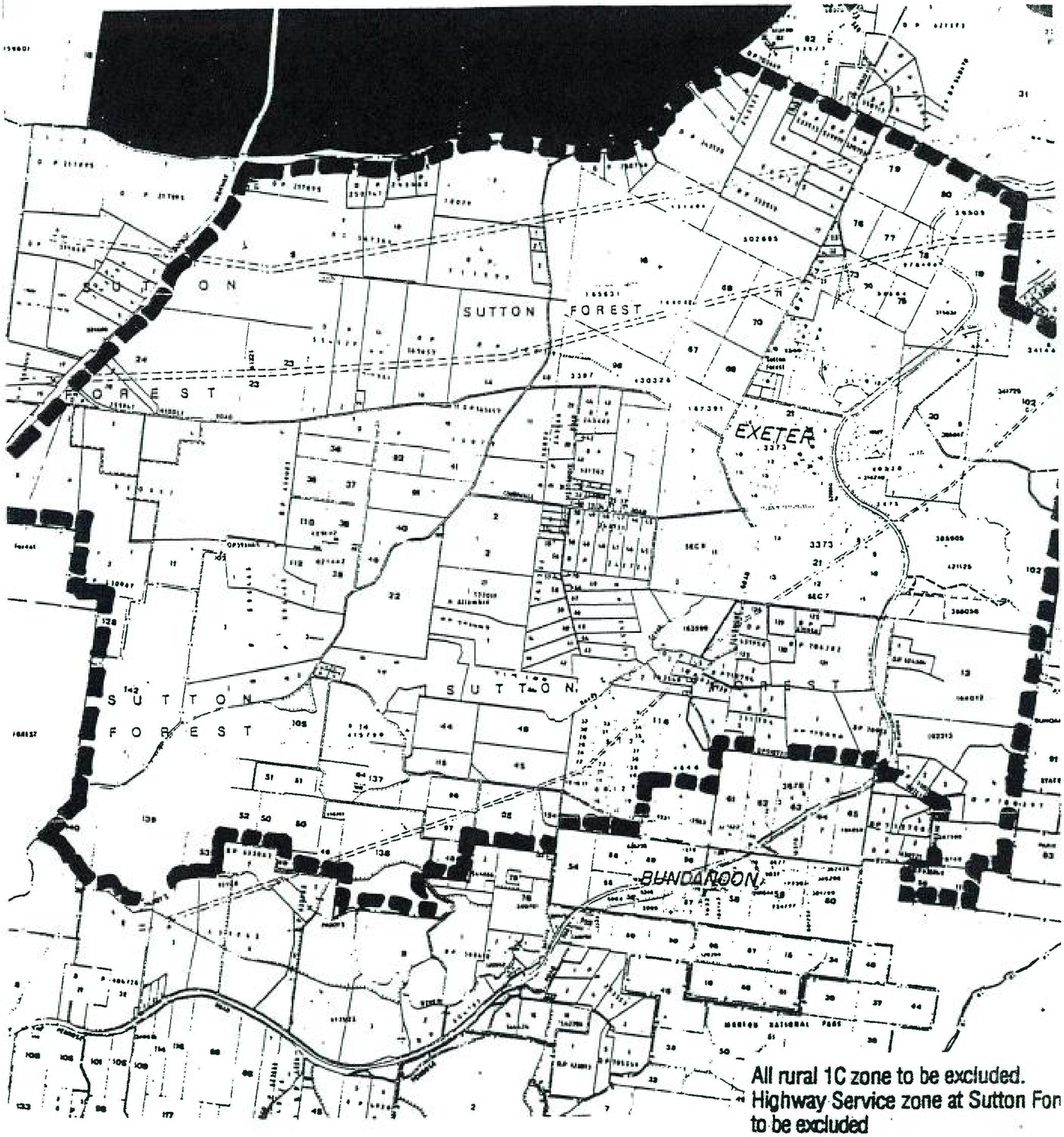
Item or Property	WLEP[1]	WHI[2]	ESFLCA[3]	NTR[4]	RNE[5]
All Saints Cemetery	*		*	*	
All Saints Church and hall	*		*	*	
Apolima			*		
Barnsley's Everything Store	*		*	*	
Barnsley's General Store	*		*	*	
Bindagundra	*		*	*	
Black Bob's Bridge			*	*	
Black Horse Farm	*		*	*	
Bonheur	*	*	*	*	
Boscobel	*		*	*	
Browley Barn	*		*	*	
Clover Hill	*		*		
Comfort Hill	*		*	*	
Cottage at Exeter			*		
Cottages Sutton Forest (2)			*	*	
Ecclestone Park	*		*	*	
Eling Grange	*		*	*	
Exeter General Store			*		
Exeter Post Office			*		
Exeter Railway Station		*	*		
Exeter Signal Box		*			
Golden Vale	*		*	*	
Hall, Exeter		*	*		
Highfield	*		*	*	
Hillview, Sutton Forest	*	*	*	*	
Invergowerie house and garden		*	*	*	
Ivy Hall		*	*		
Kenmore			*	*	
Montrose	*		*		
Mount Broughton Hotel			*		
Mt Valdimar	*		*	*	
Newbury	*		*	*	

Item or Property	WLEP[1]	WHI[2]	ESFLCA[3]	NTR[4]	RNE[5]
Oldbury	*		*	*	
Redcourt		*			
Romsey cottage and garden		*			
Rosedale	*		*	*	
Rotherwood house and gatehouse	*		*	*	
St Aidans Church Group		*	*	*	
St Patrick's Church and cemetery	*		*	*	
Summerlees	*		*	*	
Sutton Farm	*		*	*	
Sutton Forest Post Office	*		*	*	
Sutton Forest Public School			*	*	
The Miller's House			*	*	
The Pines	*		*	*	
Vine Lodge, house and outbuilding	*	*	*	*	
Whare-tau, Exeter Road			*	*	*
Whitley	*		*	*	

[1]Wingecarribee Local Environmental Plan 1989 (as amended 3rd December, 1998)
[2]Wingecarribee Heritage Inventory
[3]Exeter Sutton Forest Landscape Conservation Area (National Trust of Australia (NSW))
[4]National Trust Register
[5]Register of the National Estate (Australian Heritage Commission)

APPENDIX 2:

RECOMMENDED KEY HISTORIC LANDSCAPE UNIT 5A BOUNDARY– TAYLOR AND LANDSCAN 1993



APPENDIX 3:

HERITAGE ASSESSMENT OF VINE LODGE RESIDENCE AND TWO OUTBUILDINGS

A REVIEW OF THE HISTORY, BUILDING FABRIC AND CULTURAL SIGNIFICANCE OF THE 'VINE LODGE' RESIDENCE AND TWO OUTBUILDINGS EXETER N.S.W.

prepared for

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by

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1. EXECUTIVE SUMMARY

1.1. BACKGROUND

The Vine Lodge Residence and two Outbuildings are located within the Vine Lodge property at Exeter. The northern lot of the Vine Lodge property is currently the subject of a development application for the construction and use of a private road for the transportation of products from the proposed Exeter Quarry Extension. Lot 3 DP609857 (35.28ha) was purchased in December 1998 by Exeter Properties (Exeter) Pty Limited for the purpose of construction of an Exeter bypass road. Lot 1 DP596495 (40ha) which contains the Vine Lodge house and buildings and two smaller lots of land within Exeter Village was purchased in December 1998 by Extern Holdings Pty Limited. Control of all land ultimately rests with Jan and Warren Malcolm, owners of the Concrite Group of companies. It is their intention to retain ownership of Vine Lodge Residence and Outbuildings. The current tenancy arrangements have been terminated to enable their occupation of the buildings. Architectural Projects Pty Limited have been engaged to further document the fabric of the buildings and establish a maintenance schedule as part of a first stage of the conservation of the building. Once the owner's requirements for the property are better defined the second stage of the conservation works will commence.

Architectural Projects were commissioned by the applicant Concrite Quarries Pty Ltd, to prepare this Review of the History, Building Fabric and Cultural Significance of the Vine Lodge Residence and two Outbuildings in February 1999. The buildings of Vine Lodge house are identified in Registers of Cultural Heritage being those of the National Trust and Wingecarribee Council.

1.2. SITE LOCATION AND DESCRIPTION

The area is part of Henry Badgery's 1832 land purchase of 1920 acres bounded by the Main Southern Railway line to the east and Exeter Road to the west. The Assessment relates to a study area defined by the area in the immediate vicinity of the Vine Lodge Residence and outbuildings.

1.3. HISTORY OF THE STUDY AREA AND BUILDING

The explorer Dr Charles Throsby was granted permission by Governor Macquarie to move into the so-called New Country south of the Cowpastures in 1819.

White settlement of the area now known as Exeter began when James Badgery took up a 500 acre grant in 1821. He named his holding Spring Grove, thus beginning the long and significant association of the Badgery family with the history and development of Exeter. James and his sons were amongst the earliest settlers in the district.

By 1841 there was a flourishing community on the Badgery properties. The Vine Lodge property alone had 33 residents. It is on part of this property that the present day village of Exeter stands.

In 1863 Henry Badgery applied for a railway siding at Sutton Forest on the new rail line from Picton through Mittagong. When the railway was extended southwards from Mittagong after 1867 the new station was placed at Moss Vale and as a result the Sutton Forest/Exeter Area was not subject to the same development pressures which usually followed the construction of stations. For the Sutton Forest/Exeter Area the major consequences of rail access through the district were an increased emphasis on dairying and more tourists some of whom decided to build homes in the district.

In 1882, the NSW Government purchased Hillview, a property at Sutton Forest as a country residence for the Governor of New South Wales. This gave the area a certain prestige and it soon became a popular holiday destination for the wealthier members of Sydney society.

The development of the village of Exeter began in 1889. A severe economic downturn, beginning in the late 1880s, severely affected the Badgery family business activities. When these conditions deteriorated further into the depression of the early 1890's, the Badgerys sold some small lots in the Vine Lodge Estate but the proceeds were insufficient to cover their debts. In 1892, they consolidated their landholdings and converted them to Torrens Title.

By the mid 1890's the village of Exeter was becoming an entity in itself, not simply an extension of the Badgery domain. By 1895, it had most of the services required by a small community. Exeter was incorporated into the newly formed Wingecarribee Shire Council of 1906 and J.A. Badgery was elected as a councilor. In 1902 a School of Arts building was constructed opposite St. Aidan's Church with new school building erected in 1907. In 1911, land for a park at Exeter was purchased. Further subdivision of the area occurred in 1915.

1.4. GENERAL DESCRIPTION

The existing boundaries of the Vine Lodge property lie within the much larger estate consolidated from 1821 onwards. This estate which underwent two main periods of subdivision from 1889 to 1892 and 1915, and once included the village of Exeter originally known as Badgery's Siding. The site is accessed from Exeter Road and a long tree lined avenue which leads to the Vine Lodge Residence and two Outbuildings which is the main focus of this report.

The Vine Lodge Residence and two Outbuildings comprises a number of buildings arranged in a pattern typical of such estates. The principal residence is linked by a later connection to a group of outbuildings. The northern garden features remnants of an earlier English cultivated garden.

The house retains its simple three part cubic form and much of its early Colonial Georgian detailing. Many of the existing windows and doors are typical of the Colonial Georgian style and feature multipaned glazing and simple four panel timber joinery.

The removal of the verandah original roof and its replacement has radically altered the appearance of the building. The additions of later lean-to wings further conceal the original highly intact core.

The existing roof is a simple gable at ninety degrees to the original roof with an eyelid dormer to the south and a gable dormer to the north, where previously no dormer window existed. The original three hip roof form which related to the tripartite division of the plan can no longer be seen. The central gable dormer to the southern elevation has been removed. The verandah extensions of the main roof have also been removed. The end walls of the house which once supported the hipped roofs of the outer bays have been extended as fibro clad gables each with a central window.

The south façade, which was once protected by an overhanging verandah and dominated by a central gable, now appears quite incomplete.

Two of the original three tuscan columns to the northern verandah remain but are concealed by the later verandah enclosure.

Due to the additions it is difficult to identify the original elevation elements. The east elevation is partly concealed as part of an internal corridor which has been modified. The original gabled timber weatherboard kitchen wing has been demolished and later lean-to additions added.

The house plan is loosely based on a symmetrical nine square grid with a central corridor typical of the Georgian style. This planning shares some similarities with other Georgian style residences that have derived from simple bungalow houses. In terms of the general symmetrical layout parallels have been drawn to Horsley, c.1832, which has been attributed to Francis Greenway, however these features could simply be a characteristic of the style which both houses share.

The house was designed around an entry hall which leads on to a main central room which includes a stair giving access to the attic above. The central room opens onto a verandah which has since been enclosed. Rooms are equally distributed on either side of the house. All rooms are simple, well proportioned, rectangular volumes with windows placed symmetrically in the room. The existing interior remains largely intact with some unsympathetic alterations evident. No significant structures or outbuildings exist within the alignment of the proposed road.

1.5. ASSESSMENT OF CULTURAL SIGNIFICANCE

HISTORIC

The site of Vine Lodge is significant as part of an 1832 land parcel purchased by Henry Badgery after whom the town of Exeter, originally Badgery's Siding, was named. Henry Badgery and his father James were important pastoralists in the Exeter Area and had large holdings in the area and were well known for the quality of their horse and cattle breeding. The Badgery Family were one of Australia's earliest pastoralist settlers, who formed a family dynasty based in Sutton Forest ranging throughout NSW and Queensland. They played a vital role in the development of Australia's cattle and horse breeding and horse-racing industries.

The site of Vine Lodge is significant for its association with the township of Exeter which was once part of the Vine Lodge property and has been closely linked to the Badgery family since their occupation of the area in the 1820's.

The building is significant as the residence of the Badgery family from 1839 to 1978.

The building is significant for its reflection of the nineteenth century development of Exeter and Sutton Forest as a prestige address for prominent citizens from both the South Coast and Sydney environs. The prestige of the area was greatly improved by its association with sixteen NSW Governors who used 'Hillview' as their country residence.

The building is significant for its association with a number of key events in the development of the town of Exeter.

The building is significant for its reflection of Exeter's period of high prosperity in the nineteenth century and twentieth century.

AESTHETIC

The principal residence and outbuildings defined within the Vine Lodge Residence and two Outbuildings are contributing components of the Exeter/Sutton Forest Landscape Conservation Area.

The building plan and form of the building, despite significant roof alterations and additions is significant as an important partially intact residence which dates from the key period of significance of the area.

The site of Vine Lodge contributes to the Exeter/Sutton Forest Landscape Conservation Area which has aesthetic significance as a homogenous "English-style" landscape of grand estates, gardens and mature plantings, meandering country lanes with remnant native vegetation, churches and churchyards, historic railway complex and very impressive residences in a range of architectural styles all in sympathy with and contributing to the aesthetic qualities of this cultural landscape.

Vine Lodge together with other substantial Country residences contribute to the setting of the Exeter/Sutton Forest Landscape Conservation Area.

The building is significant as an early example of a Colonial homestead.

SOCIAL

The building is significant for its reflection of the nineteenth century development of Exeter and Sutton Forest as a prestige address.

TECHNICAL
The area has research significance as much of its landholdings (subdivision patterns and buildings) have remained intact since the days of its first settlement in the 1820's. The area is rich in potential for the study of early horticultural and landscaping practice.

REPRESENTATIVE SIGNIFICANCE
The building is representative of a substantial middle class rural residence erected in the nineteenth century.

The site and buildings of a single family dynasty provide the core and part of a group of houses which are of an exceptional example of a very early landscape which has been enriched by the overlay of a remarkable collection of country estates of many of the most influential and noteworthy persons in New South Wales.

RARE SIGNIFICANCE
The building's ability to represent the occupation of the area by the Badgery family is rare due to the length of occupation and its significance as the family home.

2. INTRODUCTION

2.1. BACKGROUND

The Vine Lodge Residence and two Outbuildings located within the Vine Lodge property at Exeter. The northern lot of the Vine Lodge property is currently the subject of a development application for the construction and use of a private road for the transportation of products from the proposed Exeter Quarry Extension. Lot 3 DP609857 (35.28ha) was purchased in December 1998 by Exeter Properties (Exeter) Pty Limited for the purpose of construction of an Exeter bypass road. Lot 1 DP596495 (40ha) which contains the Vine Lodge house and buildings two smaller lots of land with subdivision potential within Exeter village was purchased in December 1998 by Extern Holdings Pty Limited. Control of all land ultimately rests with Jan and Warren Malcolm. It is the intention to retain Vine Lodge Residence and outbuildings. The current tenancy arrangements have been terminated to enable occupation of the buildings. Architectural Projects Pty Limited have been engaged to further document the fabric of the buildings and establish a maintenance schedule as part of a first stage of the conservation of the building. Once the owner's requirements for the property are better defined the second stage of the conservation works will commence. Architectural Projects were commissioned by the applicant Concrite Quarries Pty Ltd, to prepare this Review of the History, Building Fabric and Cultural Significance of the Vine Lodge Residence and two Outbuildings in February 1999. The buildings of Vine Lodge house are identified in Registers of Cultural Heritage being the National Trust and Wingecarribee Council.

2.2. SITE LOCATION AND DESCRIPTION

The area is part of Henry Badgery's 1832 land purchase of 1920 acres bounded by the Main Southern Railway line to the east and Exeter Road to the west. The Assessment relates to a study area defined by the area in the immediate vicinity of the Vine Lodge Residence and outbuildings.

The Vine Lodge Residence and two outbuildings, located within the Vine Lodge property at Exeter. The northern lot of the Vine Lodge property is currently the subject of a development application for the construction and use of a private road for the transportation of products from the proposed Exeter Quarry Extension. Architectural Projects were commissioned by the applicant Concrite Quarries Pty Ltd, to prepare this document in February 1999 to assess the cultural significance of the Vine Lodge Residence and two Outbuildings. The buildings and their immediate environs include items identified in Registers of Cultural Heritage, the most important being Vine Lodge house.

2.3. AUTHORSHIP

The report has been prepared by a team consisting of the following key members:
Jennifer Hill, Architectural Projects Pty Ltd - Heritage Architect
Elizabeth Gibson, Heritage Architect
Gary O'Reilly, Architectural Projects Pty Ltd - Architect
Annalisa Capurro, Architectural Projects Pty Ltd - Architectural Assistant/Research
Irene Tapu, Architectural Projects Pty Ltd - Clerical Staff

2.4. LIMITATIONS

Access was given to the site and Wingecarribee Shire Council records held by the applicant and Council. No physical intervention was undertaken to prepare this report. No historical archaeological work other than the site surveys provided herein was commissioned for the report.

2.5. METHODOLOGY

The Assessment has been prepared in accordance with the methodology outlined in J. S. Kerr "The Conservation Plan", (The National Trust of Australia, (NSW). Third Edition 1990). The report complies with the principles of the Australian ICOMOS Charter for the Conservation of Places of Cultural Significance (the Burra Charter) and its guidelines. The analysis of significance used the State Heritage Inventory Program criteria for assessing significance.

2.6. ACKNOWLEDGMENTS

National Trust of Australia (NSW), Graham Quint, David Winter
Australian Heritage Commission, Norm Stevenson
Wingecarribee Shire Council, Ian McNeal, Planner
Heritage Office, Dennis McManus
Historic Houses Trust, Megan Martin, Historian/Librarian
Bowral Library Staff
Berrima District Historical & Family History Society, Linda Emery, Max Rogers, Bob Williams
Geoff Webster, Quarry Manager
Stein & Woolley, Tom Pryde
Ray White Real Estate, Moss Vale, Staff
R.W. Corkery and Co Pty Ltd, Rob Corkery
Richard Lamb, Landscape Consultant
Mitchell Library Staff

3. HISTORY OF THE STUDY AREA

3.1. TIMELINE

1799	James Badgery and his wife Elizabeth arrived in Australia on the vessel 'Walker' as free settlers
1819	Dr Charles Throsby moved into the so-called New Country south of the Cowpastures
1821	White settlement of the area now known as Exeter began when James Badgery took up a 500 acre grant
1823	The Badgerys looked to expand their holdings
1825	James leased a further 1200 acres in the Sutton Forest area
1827	James Badgery's death
1832	Henry Badgery, son of James Badgery, purchased 1920 acres which he named Vine Lodge
1839-40	Vine Lodge house was built by Henry Badgery
1841	There was a flourishing community on the Badgery properties
1855	A fire broke out at Vine Lodge
1863	Henry Badgery applied for a railway station at Sutton Forest
1867	The railway was extended southwards from Mittagong
1869	The railway was further extended to Goulburn
1880	November - Henry Badgery died
1880's	In the early 1880's Henry's son, Frank and wife Lizzy Badgery moved into Vine Lodge house
1880's	A severe economic downturn began in the late 1880's
1880's	The gradual sale of the Badgery Estates due to financial difficulties
1881	Formation of the Moss Vale & Sutton Forest Progress Association
1882	The NSW Government purchased Hillview a property at Sutton Forest, as a country residence for the Governor of N.S.W. thus establishing the district as a popular holiday destination
1885	3rd August, a meeting of the Moss Vale & Sutton Forest Progress Association carried a motion that it was desirable to establish a municipality
1888	4th September, Moss Vale Municipality was gazetted
1889	The development of the village of Exeter began
1889	First subdivision of the Vine Lodge property
1890's	By the early 1890's the Badgery's suffered continuing financial difficulties

1890's	By the mid 1890's the village of Exeter was becoming an entity in itself
1890	In March the Railway Commissioners approved the name change from Badgery's Siding, to the Badgery sponsored name, Exeter
1891	A village school was opened in Exeter
1891	21st March, Moss Vale Council Chambers building opened
1892	Continued subdivision of the Vine Lodge property
1892	Special trains ran from Sydney to Exeter to bring potential buyers to two auctions for lots within the Vine Lodge subdivision
1893	In August a Post Office Savings Bank was established in Exeter
1894	Dalgety and Co foreclosed on the heavily mortgaged Badgery estate
1896	St Aidan's Church opened in Exeter
1900	A School of Arts was established in Exeter
1900-1901	The population of Exeter and the surrounding properties had grown to 254
1906	Area around Moss Vale was incorporated into the Wingecarribee Shire Council. November, the election of the new Wingecarribee Shire Council
1907	A new school building was erected in Exeter
1911	Land for a park at Exeter was purchased
1915	Further subdivision of the Vine Lodge Estate occurred
1922	22nd November Exeter Soldier's Memorial was opened
1927	Discussion on a proposal to amalgamate the Moss Vale Municipal Council and the Wingecarribee Shire began
1929	Electricity supply extended to Exeter
1933	10 February, Council merger occurred
1944	Frank Badgery's son Frank, moved into Vine Lodge house following the death of his father
1946	A branch of the Country Women's Association was formed in Exeter
1950's	Cooeeyana, a 20 roomed guest house in Middle Road, Exeter was destroyed by fire in the early 1950's
1956	Frank Badgery organised the construction of a sandstone monument at the gates of the Vine Lodge Estate
1967	Alec Badgery, Frank's son moved from Queensland to Vine Lodge with his wife
1970	Frank Badgery and his wife Annie both died
1978	Vine Lodge property was sold to Mr R. Issac

1978	The contents of Vine Lodge house including rare early Colonial and Victorian items which had been Badgery family possessions for 140 years were auctioned at the Exeter School of Arts

3.2. BUILDING TIMELINE

1832	Vine Lodge Estate is situated on land purchased in January by Henry Badgery, son of James Badgery
1839-40	Vine Lodge house was built by Henry Badgery
1855	A fire broke out at Vine Lodge
1880	November - Henry Badgery died
1880's	Henry's son, Frank and wife Lizzy Badgery moved into Vine Lodge in the early 1880's
1880's	The gradual sale of the Badgery Estates due to financial difficulties
1944	Frank Badgery's son Frank, moved into Vine Lodge after the death of his father
1956	Frank Badgery organised the construction of a sandstone monument at the gates of Vine Lodge
1967	Alec Badgery, Frank's son moved from Queensland to Vine Lodge with his wife
1970	Frank Badgery and his wife Annie both died
1978	Vine Lodge property was sold to Mr R. Issac
1978	The contents of the house including rare early Colonial and Victorian items which had been family possessions for 140 years were auctioned at the Exeter School of Arts

3.3. HISTORY OF THE AREA

Aboriginal Occupation

The Gib Rock and Mount Jellore are two of the numerous remnant volcanic plugs that dominate the landscape of the Southern Highlands. The plugs are believed to have been active many thousands of years ago. The molten matter which flowed from the craters covered the area around Exeter and hardened into rock. These lavas altered the geology and topography of the area, the final result was a soil rich in the mineral elements required by plant life. A rich vegetation developed on the volcanic soils of the district and this provided food for numerous animals. There are no records to show how many indigenous people lived in the district in the past but, due to the plentiful vegetation and wildlife it is certain they camped and hunted in the area.

One of the few recorded Aboriginals was a chief called Cannabyagal. Cannabyagal's followers were feared by the Cow Pastures natives owing to their reputation as fierce mountaineers. Cannabyagal was killed in 1816. Before his death the native chief had given his name to a portion of the country later known as Little Forest which lay between the modern Yerrinbool and Aylmerton called the Callumbigles Plains. The name is no longer in use. A record made in 1826 and 1827 states there were sixty-seven members of the Bong Bong tribe, ten of the Mittagong, and sixty-two of the Nattai still living there. A few indigenous people were still alive in the 1860's. The death of Billy Blue, one of the Bong Bong tribe, occurred in September 1868 and by the 1870's no pure-blooded Aborigines were still living in the district.

First Land Grants/White Settlement

The explorer Dr Charles Throsby was granted permission by Governor Macquarie to move into the so-called New Country south of the Cowpastures in 1819. At that time, the district was known as Sutton Forest, the name Exeter not coming into use until the late 1880s.

White settlement of the area now known as Exeter began when James Badgery took up a 500 acre grant in 1821. He named his holding Spring Grove, thus beginning the long and significant association of the Badgery family with the history and development of Exeter. James and his sons Henry, William, James and Andrew were amongst the earliest settlers in the district.

James Badgery and his wife Elizabeth arrived in Australia on the ship 'Walker' as free settlers in 1799. They soon established themselves on the Hawkesbury on a grant they named Swilly Farm, where they remained until 1809. At that time, the Bringelly area was opening up for settlement and the Badgerys received several grants totaling 840 acres on South Creek which became known as Exeter Farms. James prospered and by 1819, along with many other pastoralists, began looking further afield for land for his increasing stock.

The Spring Grove grant satisfied the need for land for Badgery's increasing stock for only a few years and by 1823, the Badgerys were again looking to further expand their holdings. Henry Badgery and his brother Andrew successfully applied for grants close to their father's land, Henry taking up 300 acres which he named Hamletville and Andrew an adjoining 300 acres, Kirby's Meadows. William remained at Spring Grove and between them, the sons managed the family's holdings not only in the Sutton Forest district, but also extensive grazing activities in the Braidwood and Bega districts.

In 1825 James leased a further 1200 acres in the Sutton Forest area which was later converted to conditional purchase. After his death in 1827 most of this land was included in Henry Badgery's purchase of 1920 acres in 1832, which he named Vine Lodge. By 1841 there was a flourishing community on the Badgery properties. Eleven households, with a total of 79 people are listed in the 1841 Census of NSW. The Vine Lodge property alone had 33 residents including 13 convict and ex-convict workers. It is on this property that the present day village of Exeter stands.

In 1863 Henry Badgery applied for a railway siding at Sutton Forest on the new rail line from Picton through Mittagong. When the railway was extended southwards from Mittagong after 1867 the new station was placed at Moss Vale and as a result the Sutton Forest/Exeter Area was not subject to the same development pressures which usually followed the construction of stations. In 1869 the railway was further extended to Goulburn. For the Sutton Forest/Exeter Area there were two major consequences of rail access through the district. Firstly there was an increased emphasis on dairying. Secondly, greater numbers of holiday makers visited the area and some decided to build homes in the district.

Mining also played a role in the development of the area with mines operating at Bundanoon and Exeter between 1871-1906. Commercial Quarry operations have existed in the area since the 1880's.

In 1882, the NSW Government purchased Hillview, a property at Sutton Forest built by R.P. Richardson of Richardson & Wrench, as a country residence for the Governor of New South Wales. The periodic visits of successive governors gave the area a certain prestige and it soon became a popular holiday destination for the wealthier members of Sydney society, many of whom established their own country estates in the district.

Early Subdivision

The development of the village of Exeter began in 1889. A severe economic downturn, which began in the late 1880s, saw Frank and Charles Badgery, in financial difficulties. From the early 1890s the economic slowdown continued and developed into an economic depression by 1889. To stave off creditors, Frank and Charles sold some small lots in the Vine Lodge Estate but the proceeds were nowhere near enough to service their large borrowings. In 1892, they consolidated their landholdings and converted them to Torrens Title in order to make the Vine Lodge subdivision more attractive to buyers.

Special trains ran from Sydney to Exeter to bring potential buyers to two auctions for farm lots in 1892. A few blocks sold, but overall, land sales were slow during the depression years of the early 1890s and in 1894, Dalgety and Co foreclosed on the heavily mortgaged Badgery estate. Many of the buyers of land during this difficult time for the Badgery brothers were friends or business associates.

The Village of Exeter

The ultimate success of the residential subdivision of Exeter by the Badgerys and the creation of the village of Exeter was dependent on employment opportunities including mining, in a time of declining rural production.

Therefore the location of Exeter relates not only to the early land grants but to its proximity to resources such as coal, stone and timber.

In March of 1890 the Railway Commissioners approved the name change for Badgery's Siding to the Badgery sponsored name Exeter. In 1891 a village school was opened with Frank Badgery unfurling a Union Jack presented by Exeter's namesake cathedral city in England. In August, 1893, an official from the Postmaster-General's Department, after a request from Exeter residents, established a Post Office Savings Bank. In 1894 it was decided to erect a Church of England and tenders for the work were called in January 1895. The foundation stone was laid on 30th March 1895 by Mrs F.E. Badgery and the church opened on 11th January 1896. Prior to the erection of St Aidan's, as the church was called, services were held in Vine Lodge House.

By the mid 1890's the village of Exeter was becoming an entity in itself, not simply an extension of the Badgery domain. By 1895, it had most of the services required by a small community, railway station, school, church, post office, general store and bakery. Land use in the area centered on dairying, cattle and mixed farming, including a number of orchards and vegetable growers as well as quarries. Basalt was quarried on some local quarries and two commercial flower and bulb nurseries were established.

Incorporation

A meeting was held at Moss Vale in November 1881, at which it was decided to form an organization called the Moss Vale and Sutton Forest Progress Committee. On 8th February 1884 a meeting was called to discuss the question of incorporation. On 3rd August 1885, a meeting carried a motion that it was desirable to establish a municipality, but the resolution was not acted upon. On 18th January 1888 a similar motion was carried and the result was a petition for the establishment of a municipality sent to the Government of the day, which was signed by 139 persons, including S.K. Miller, F.A. Badgery, E.H. Badgery, W. McCourt and Rev. D.A. Harnett. As a result the Moss Vale Municipality was gazetted on 14th September 1888. Nominations were called for the New Council on 13th November 1888. At a meeting held in the Court House on 20th November 1888 N.H. Throsby was elected Mayor. Premises in Argyle Street were rented as a Council Chamber. A tender for the erection of a Council Chambers building was accepted in August 1890 and the new structure opened on 21st March 1891.

When the shires were established in 1906 the country around Moss Vale was incorporated in the Wingecarribee Shire which had its headquarters in Moss Vale. A temporary Council including J. A. Badgery, was appointed and the first meeting was held on 23rd June 1906. The temporary Council's duty was to arrange the election of the first Shire Council. The election of the new body was held in November 1906 and included J. A. Badgery.

Discussion on a proposal to amalgamate the Moss Vale Municipal Council and the Wingecarribee Shire began in November 1927. In September 1931 both bodies approved of the proposal but shortly afterwards Moss Vale changed its mind. The question was submitted to a referendum in

April 1932 but was rejected. The Local Government Department held an inquiry into the matter and reported in favour of it. As a result the two councils were merged on 10th February 1933. When the two bodies amalgamated, the Shire officials moved into the Moss Vale Council Chambers, which has been the administrative headquarters since.

Twentieth Century Development

By 1900-1901 the population of Exeter and the surrounding properties had grown to 254 and the village of Exeter became the center for business, social and sporting activities. In 1900 a School of Arts was established and in 1902 a building for the organisation was constructed opposite St. Aidan's. A new school building was erected in 1907 and opened on 29th July, when pictures, sent from Exeter in England, were hung on the walls and a Union Jack from the same place was unveiled by Frank Badgery. In 1911, land for a park at Exeter was purchased, half the money being raised by public subscription, the balance coming from the Government. Further subdivision of the area occurred in 1915.

Village life in Exeter in the early twentieth century was typical of that in many small towns in rural Australia. Entertainment was largely self-generated by the residents, with dances, concerts and card evenings in the School of Arts. In the 1920's a 'picture show man' screened movies once a week. The School of Arts also housed a library and hosted an annual Flower Show, a reflection of the importance of horticulture in the village, both commercial and domestic. Exeter Soldiers' Memorial was opened on 22nd November 1922 The memorial was a brick hall erected in St. Aidan's grounds. It was used for Sunday School purposes and as a meeting place for church organizations. Electricity came to Exeter in 1929. A branch of the Country Women's Association was formed in 1946 and new rooms for the organization were opened on 15th January 1955. F.E. Badgery gave the land on which the building stands.

Exeter became a popular holiday destination and Cooeeyana, a twenty roomed guest house in Middle Road, operated until about 1950. It was frequented mainly by business and professional people from Sydney until it was destroyed by fire during the early 1950's.

Commercial Quarry operations were established in the immediate vicinity of Exeter in the 1950's and have continued to this day. This continued use of resources provide a relationship with the past development on the area and forms part of the history of the location and development of Exeter.

3.4. HISTORY OF THE SITE AND BUILDING

Situated on land purchased on January 1832 by Henry Badgery, son of James Badgery who pioneered the Sutton Forest area, Vine Lodge was built by Henry Badgery during 1839-40. The Badgery's originally lived in Ivy Hall, which was a modest vernacular weatherboard cottage. Vine Lodge house is situated on the edge of a plain gently sloping down to the north-east to provide a wide, view of the distant hills and valleys. Henry Badgery's increased prosperity enabled him to build Vine Lodge to both reflect his status in the district and to house his family.

Vine Lodge house was built using local materials, including stone and timber from Stonequarry Creek, where an abandoned stone and shale quarry still remains at Gumtree Gully. The stone was used to build a large cellar with stone paving and the foundations for the house's walls. The face brick above ground walls are constructed of handmade red clay bricks which were baked in a nearby kiln at Sutton Forest, whilst the interior cedar fittings were obtained from the Shoalhaven gorges. The house originally had eight rooms with a stairway leading to an attic. A verandah with tuscan columns on the ground floor below the attic, also faced the view to the north and opened onto a garden featuring a huge oak tree. This tree has been cut down although the stump still remains.

The roof originally had three hipped bays with a central gable to the southern side. The roof has been completely changed, although some original iron tiles have been reused. The roof alterations may have been the result of a fire which broke out in early 1855, which was extinguished with the help of Mary Anne Badgery, Henry Badgery's second wife. Evidence of this fire still exists in the charred rafters of the roof. Although heavily pregnant at the time, Mary Badgery climbed onto the roof and supervised the fire's extinguishment with wet bags and saved the house.

The twentieth century alterations to Vine Lodge include the north verandah which has been filled in with fibro construction as have the eaves. The original verandah has been removed from the entrance on the south and the north verandah is now glazed-in with additions to the side. To the west of the entrance is a separate wing at right angles to the house. Originally linked by a covered way, this kitchen and office complex augmented the space requirements, which also resulted in the construction of a substantial four stall stable with loft.

Henry Badgery died in November 1880. In the early 1880's Henry's son, Frank and wife Lizzy Badgery moved into Vine Lodge after selling their home, Elsinore, at Sutton Forest to James Withycombe who renamed the residence Boscobel. Financial difficulties in the late 1880's saw the gradual sale of the Badgery Estates and the beginning of a village around the new railway station known as Badgery's Siding. In March 1890 the name changed from Badgery's Siding to the Badgery sponsored name Exeter. In 1901 Vine Lodge came into the ownership of Frank Badgery and the fortunes of the property began to improve.

Frank Badgery's son Frank, moved into the house in 1944 after the death of his father. He organized the construction of a sandstone monument at the gates of the Vine Lodge property with the inscription: "To commemorate the arrival of the pioneer James Badgery. He and his sons settled here in 1819. Erected by the fourth generation in 1956".

Frank and his wife Annie both died within a few months of each other in 1970. Alec Badgery, Frank's son who had moved with his wife from the Darling Downs in Queensland to Vine Lodge in 1967 continued to live at Vine Lodge until 1978 when the property was sold to Mr R. Issac, a Sydney businessman, ending the 140 year Badgery family ownership of Vine Lodge. The contents of the house including rare early Colonial and Victorian items which had been family possessions for 140 years were auctioned at the Exeter School of Arts in 1978.

3.5. HISTORY OF THE BADGERY FAMILY

On November 4th, 1799 James and Elizabeth Badgery arrived at Sydney Cove from Heavitree near Exeter, Devon, England on the supply ship Walker. When they arrived James was thirty years old and Elizabeth was thirty four. James Badgery had developed considerable expertise in cattle and horse breeding and brought these skills with him to the newly founded colony. It is believed that the Badgery's passage was secured by Sir Joseph Banks following James Badgery's caring for the horses of Sir Joseph on his Chelsea estate 'Spring Grove'.

James Badgery first leased a plot of eleven acres on the Hawkesbury River and to supplement his meagre income he also set up as a miller on Castlereagh Street (then Chapel Row).

In 1801 with the success of both ventures he built extensions to his grain grinding operation which had developed into a bakery. A dwelling house, millhouse and pigsty were also added. In 1802 it was recorded that Badgery's Hawkesbury Farm had six acres under cultivation and ran thirteen goats, twenty hogs and one horse. Badgery's success prompted a one hundred acre grant by Governor King and Badgery's attention was then directed away from the Sydney Town enterprise to his new farm. The one hundred acres selected adjoined Yarramundi Lagoon at the confluence of the Grose and Nepean Rivers, at the head of the Hawkesbury. A further thirty nine acres were granted in 1804 as compensation for the swampy nature of the original grant. James Badgery was intent on moving from farming into his preferred and experienced field as a stock breeder, and for these purposes required considerably more land.

In 1809 Colonel Paterson granted a total of 840 acres in four parcels at Bringelly on South Creek in the name of Badgery's children. One of these parcels was called Exeter and another Heavy Tree after the Badgery's former home in Devon, England. On both his Hawkesbury farm and at South Creek James Badgery evicted Aboriginal tribal groups as was the approach used by the new settlers. However, unlike the bloody conflicts reported on other sites there is no record of any conflict on the Badgery's farms.

Over the next six years (1809-1815) James Badgery became known as a cattle breeder of similar status to the Reverend Samuel Marsden, Sir John Jamison and Samuel Laycock. He was also achieving recognition for the quality of his horses. At the second official colonial race meeting held in August 1811 on the Hyde Park course his horse Jackey Boy won the Magistrate's Plate. By 1816 Badgery was facing a severe land shortage for his growing herds, increased by the lack of pasture regrowth on the Cumberland Plain due to the low rainfall and caterpillar plagues.

Between 1817 and 1827 James and son Henry travelled extensively looking for better country. They discovered and explored Kangaroo Valley and were the first white men into the Valley of Araluen.

By 1819 Badgery's Illawarra cattle were grazing in the Southern Highlands on the site later known as Sutton Forest. Towards the end of 1820 Governor Macquarie visited and named Sutton Forest. He also inspected James Badgery's chosen site and allowed him to use convict labour to clear the site.

The title deeds to these five hundred acres were finally issued on 1st November, 1822 and the property was called Spring Grove apparently after Sir Joseph Banks' Spring Grove estate at Chelsea in London. Badgery was then permitted to drive 103 head of cattle through the Cow Pastures on his way from his South Creek Exeter Farm to Spring Grove to supplement the cattle he had already brought up from the Illawarra. Badgery's talent as a horse breeder was confirmed with two wins by this horse Rob Roy, the first in 1819 on the Hyde Park Course and the next in 1821. Badgery also owned the well-known racehorse Hector in 1825 and Prudence in 1826. Badgery's interest in horse racing was maintained throughout his life.

James and his wife had five children, one daughter Ann, born 1800, who later married a Mr Robert, of Braidwood; Henry, 1803; Andrew, 1806; William, 1808; and James, 1812. James Badgery died at Bringelly on December 1, 1827 aged 58 and was buried at Liverpool.

The Government census of 1828 read: Elizabeth Badgery, widow of James Badgery, son Henry and son Andrew, 3100 acres land, total cattle 1025, sheep 2199 and 30 horses. His eldest son, Henry went to live at Spring Grove, Sutton Forest and on November 17, 1829 was granted 1200 acres in the Vine Lodge area (now Exeter). In 1832 he purchased a further 1920 acres which included the site of the present Vine Lodge Buildings. Henry was married twice. He had three sons by his first wife, Elizabeth Dickson, who died in 1833. Henry re-married in 1834 to Mary Anne Riley and they had nine sons (one living only two years).

By the mid 1830's Sutton Forest had become the center of operations for the Badgerys. By 1839 Henry Badgery's landholdings at Sutton Forest had grown to exceed 3,000 acres and included Vine Lodge, the southern half of Spring Grove, Hamletville and various other adjoining properties.

The Badgerys from the earliest days in the Illawarra had ventured further a field and established grazing properties at Braidwood, Talwong on the Shoalhaven River, Nerriga, Bega and the Monaro. Elizabeth Badgery died on 21st December, 1849 aged eighty four, at her son Andrew's property at Braidwood also called Exeter Farm. Henry Badgery was recognised for this thirty years in the district first by nomination to the district council in 1849. He became a magistrate in 1850 and a coroner in 1851. The Braidwood Exeter Farm was also a renowned breeding stud for racehorses. In 1861 the famous horse Archer which won the first Melbourne Cup of 1861, was by William Tell out of Maid of the Oaks, Exeter Farm stock.

The sons of Henry Badgery's first marriage settled in Braidwood, Bombala and the Monaro area. The other eight sons settled first in the Moss Vale, Sutton Forest and Exeter regions on blocks of land their father had been granted or purchased. Son John had Ivy Hall and Arthursleigh; Andrew had Rosewood and Marathan and later Newbury; Henry had Green Hills and Montreal (now called Summerlees); Fred had Clover Hill and The Grange (now called Munro Park), and afterwards St Clair at Lake Bathurst; Edward had Rockleigh and afterwards lived at Caoura, Tallong; Frank built

Elsinore when he married in 1876 and Charlie had Pine Lodge in partnership with Frank. In the late 1870's they had four properties in Queensland: Avington at Blackall, Annie Vale, west of Roma, Roma Downs and Blythwood, in the Roma area. Henry Badgery started the firm of Pitt, Son and Badgery in the late 1870's, with Bob Pitt.

Henry Badgery died in November 1880. In the early 1880's Frank and Lizzy Badgery moved into Vine Lodge and Elsinore was sold to James Withycombe who renamed the residence Boscobel. In 1881 Frank's brother Edward was living at Prospect in Sutton Forest which was owned by his wife Lizzie's uncle, R.P. Richardson. This property was later to be sold to the Government of New South Wales as a residence for the State Governors and renamed Hillview.

Financial difficulties for the family in the late 1880's saw the gradual sale of the Badgery Estates and the establishment of a village around the new railway station known as Badgery's Siding. In March 1890 the name was changed from Badgery's Siding to the Badgery-sponsored name Exeter. A village school was opened in May, 1891 with Frank Badgery unfurling at Union Jack presented by Exeter's namesake cathedral city in England. Vine Lodge came into the ownership of Frank Badgery in 1901 and the fortunes of the property began to improve. Frank Badgery became president of Wingecarribee Shire from its inception in 1907 and in 1913 was the successful candidate for the state seat of Wollondilly. Frank Badgery died in 1915 after serving only two years in State Parliament but was paid high tributes by both the Premier and Leader of the Opposition. Frank's son, Frank, moved in to Vine Lodge during 1944 and later organized the construction of a sandstone monument at the gates of Vine Lodge. Frank's son Alec and his wife moved from Queensland in 1967 to Vine Lodge. Frank and his wife both died in 1970 and Alec and his wife continued to live on the property until they sold it in 1978 to Mr R. Issac, thus ending the 140 year Badgery family ownership of the property.

4. ANALYSIS OF THE BUILDING FABRIC

4.1. DESCRIPTION OF THE AREA

The Exeter/Sutton Forest Landscape Conservation Area is sited in the Southern Highlands of New South Wales 115 kilometres south-west of Sydney and is essentially the area named Sutton Forest by Governor Macquarie in 1820. It includes the more recently named township of Exeter (after 1890) and part of the southern environs of Moss Vale (originally known as Sutton Forest North).

The landscape is essentially a shale-derived soil plateau with basalt -derived soils at Exeter and several other sites across the plateau and a dolerite outcrop at Mt Gingenbullen and the sandstone valley of Black Bobs Creek. The Area is bounded to the east by the edge of the plateau which drops to sandstone gorges, to the north by the southern perimeter of the town of Moss Vale, to the west by the western boundaries of the properties originally forming part of "Sutton Forest" and to the south by the environs of the town of Bundanoon.

The Landscape Conservation Area is essentially a very high quality pastoral landscape with large, well-established and historic country estates dominated by plantings reminiscent of an English countryside which have prospered in the mild Southern Highlands climate. Country lanes throughout the landscape are little changed from their first construction with natural earth pavement, winding through stands of native eucalyptus, bordered by relatively undisturbed bushland and with very fine specimens of the distinctive Ribbon Gum (Eucalyptus viminalis).

The Exeter/Sutton Forest Landscape Conservation Area is traversed by arterial roads such as the Hume & Illawarra Highways and various sub-arterial roads such as Exeter Road and Werai Road, each of which carries about 2000 vehicles per day. Most of these roads have been upgraded both in terms of alignment and condition to meet modern traffic requirements. The majority of the local roads through the landscape are of narrow, low-key character with minimal intrusive signage contributing significantly to the quality of this landscape. The Main Southern Railway Line (constructed through the area in the 1860s) contributes significantly to the landscape particularly the Exeter Railway Station with its intact group of buildings (including its still functional historic signal box) and adjoining railway worker's cottage.

Dominant throughout the area are the various churches which have remained intact since their construction in the 1860s/1870s. All Saints Anglican Church at Sutton Forest was designed by E.T. Blacket. St Aidan's at Exeter, constructed in 1895 is the only Celtic-style church in the Southern Highlands. The churchyards contain graves of the early pioneers of the area including many pre-dating civil registration.

The most distinctive feature of this landscape is the exceptional collection of historic country estates with intact landholdings, landscaping and residences and associated buildings dating from the 1826 Georgian-style Oldbury and the second Badgery Vine Lodge (1840s) to the Vice-Regal Residence Hillview (1850s) and the very grand 1936 Tudor-style Invergowrie with its huge Paul Sorensen designed landscaped grounds.

Forty three properties within the Landscape Conservation Area are already classified and listed on the Register of the National Trust (Extract from National Trust Survey Sheet).

4.2. DESCRIPTION OF THE SITE

The existing boundaries of the Vine Lodge property lie within the much larger estate consolidated from 1821 onwards. This estate which underwent two main periods of subdivision from 1889 to 1892 and 1915, and once included the village of Exeter originally known as Badgery's Siding. The site is accessed from Exeter Road and a long tree lined avenue which leads to the Vine Lodge Residence and two Outbuildings which is the main focus of this report.

A wind break located to both the east and west of the access road largely conceals the farm buildings beyond them. A more random grouping of trees occurs to the north of the Vine Lodge Residence and two Outbuildings which includes the stump of an historically significant oak tree which was planted by the Badgery family sometime between 1840 and 1856.

The Vine Lodge Residence and two Outbuildings comprises a number of buildings arranged in a pattern typical of such estates. The principal residence is linked by a later connection to a grouping of two outbuildings, which are also linked, at right angles to Vine Lodge house. A further outbuilding faces these buildings across a shared access way. The southern garden is partially defined by a painted picket fence which replaces an earlier one, evident in photographs from 1886. The rear, northern garden features remnants of an earlier English cultivated garden. No significant structures or outbuildings exist within the alignment of the proposed road.

4.3. DESCRIPTION OF THE PRINCIPAL RESIDENCE

The house retains its simple cubic form. The original face brick finish is evident to some elevations and features a rectangular window set within a brick arched opening.

Many of the existing windows and doors are typical of the Colonial Georgian style and feature multipaned glazing and simple four panel timber joinery.

The removal of the verandah original roof and its replacement has radically altered the appearance of the building. The additions of later lean-to wings further conceal the original highly intact core.

The existing roof is a simple gable at ninety degrees to the original roof with an eyelid dormer to the south and a gable dormer to the north, where previously no dormer window existed. The original three hip roof form which related to the tripartite division of the plan can no longer be seen. The central gable dormer to the southern elevation has been removed. The verandah extensions of the main roof have also been removed. The end walls of the house which once supported the hipped roofs of the outer bays have been extended as fibro clad gables each with a central window.

South Elevation (Entry Façade)

The south façade, which was once protected by an overhanging verandah and dominated by a central gable, now appears quite incomplete. The symmetrical window and door positions are retained but the original face brickwork has been rendered and painted. The windows appear to be modified by the later inclusion of new sashes of a different pattern and glass. The entry door is non-original, a timber boarded door with a makeshift view panel. The original door appears to have been relocated elsewhere in the house. Remnants of the verandah flagstone still remain. A porch extension occurs centrally in the façade concealing the original entry to the house.

North Elevation (Garden Façade)

The division of the façade into three bays can still be understood although the central verandah has been enclosed. The original face brick finish to the outer bays is still evident. The two outer bays are symmetrical, being defined by piers and a central window.

Two of the original three tuscan columns to the verandah remain but are concealed by the later verandah enclosure.

West Elevation

The façade features an unusual step in the brickwork one third along the wall which appears to relate to the piers of the north elevation. An original window appears to have been infilled using the original bricks. As originally designed, three windows were equally distributed on the façade. These are no longer evident.

East Elevation

Due to the additions it is difficult to identify the original elevation elements. The east elevation is partly concealed as part of an internal corridor which has been modified. The original gabled timber weatherboard kitchen wing has been demolished and later lean-to additions added.

4.4. INTERIOR

The house plan is loosely based on a symmetrical nine square grid with a central corridor typical of the Georgian style. This planning shares some similarities with other Georgian style residences that have derived from simple bungalow houses. In terms of the general symmetrical layout parallels have been drawn to Horsley, c.1832, which has been attributed to Francis Greenway, however these features could simply be a characteristic of the style which both houses share.

The plan of the house was designed to be approached on axis from the south, and entered through a central hall which leads on to a central room which includes a stair giving access to the attic above. The central room opens onto a verandah which has since been enclosed. Rooms are equally distributed on either side of the house. All rooms are simple, well proportioned, rectangular volumes with windows placed symmetrically in the room. The ceilings, where original, are lathe and plaster square set to plaster walls. Most of the cedar architraves and skirtings remain. Some original cedar fireplaces remain. Marble fireplaces occur in two rooms together with an elaborate cedar fireplace which exists in another, but these appear to be later additions. Original wide strip flooring is evident. The existing original windows are double hung Georgian-style six pane windows and feature chamfered reveals. Original doors are four panelled.

The Entry Hall (Room 4)

The room is a rectangular room approximately 1.5 by 4.0 metres with access to two side rooms and the central room at the end of the corridor. A timber picture rail of a simple profile appears to be a later addition. The battened ceiling is also non original.

The Central Room (Room 8)

The room is a rectangular room approximately 4 by 6 metres and accessed from the entry hall. It has two pairs of french doors located symmetrically on the north wall. They feature an off-centre mullion pattern. A marble fireplace is located symmetrically in the east wall but the chimney breast has been modified to accommodate its later incorporation. A timber stair, which provides access to the attic is located on the east wall. The balustrade appears to have been modified and features square balusters and newel posts, and a moulded rail. The timber boarded ceiling appears to date from this modification.

The Enclosed Verandah (Room 1)

The original open verandah has been enclosed and the space rendered internally and painted. Two of the original three tuscan columns have remained insitu but glazed-in to enclose the space. The ceiling and flooring have been modified. Stone thresholds to adjoining rooms have been patched with cement.

Living Area (Room 2)

The room is a rectangular room approximately 4 metres by 6 metres and gives access to both the verandah and the front living space. The doors, windows, and fireplace are located symmetrically or opposite each other. The second window which is evident on the west façade has been infilled. The fireplace includes an original cedar fireplace surround.

Living Area (Room 3)

The room is a rectangular room approximately 4 metres by 6 metres with symmetrically placed windows to the south wall. These have been modified by the replacement of original sashes which would have matched the window in the east wall. A non-original white marble fireplace is located on the north wall, but the chimney breast has been modified to accommodate it.

Living Area (Room 5)

The room is a rectangular room approximately 4 metres by 6 metres and is a mirror reverse of Room 3 with the exception of the off centre doors and door to the kitchen. It features a cedar fireplace surround with a similar detail to the chimney breast.

Room 6

The room was inaccessible due to security concerns of the existing tenant.

Room 7

The room is a rectangular room approximately 4 metres by 4 metres. The original window, evident in the 1890's photo, has been modified to become a door which provides access to the new kitchen and service wing.

Attic

The original attic which comprised a central room within the central gable facing south has been modified with the change of roof form which resulted in an expanded area similar in size to the ground floor plan below. The interior has been rebattened and a dormer provided to both the north and south elevation where there was previously only one gable form dormer to the south.

4.5. THE OUTBUILDINGS WITHIN THE VINE LODGE RESIDENCE AND TWO OUTBUILDINGS

The original weatherboard kitchen wing, evident in the 1886 photos, has been demolished. A masonry wing which contained an earlier kitchen with storage or bedrooms has been built separate to the house. This was probably linked by a timber structure which has since been replaced by a masonry addition which houses the present kitchen.

The building has a symmetrical gable roof form with corrugated iron roofing although there is evidence of an earlier timber shingled roof. Round arch windows are located evenly in the west façade. The building forms an L-shape with the stable wing which is also a simple gable structure. A lean-to roof occurs at the end of this wing. Both buildings have attic lofts. The two buildings form a verandahed space to the north east supported by log columns. The buildings are rendered to the west and south elevations where visible from the house and the main entry, elsewhere they are face brick.

A further outbuilding comprising a simple gable roof and a skillion roof is located opposite these buildings. It has been constructed partly in concrete but also incorporates earlier timber columns and slab timber walls.

5. DISCUSSION OF STATEMENT CULTURAL SIGNIFICANCE

5.1. GENERAL

A statement of cultural significance is a declaration of the value and importance given to a place or item, by the community. It acknowledges the concept of a place or item having an intrinsic value which is separate from its economic value.
There are a number of recognised and pre-tested guidelines for assessing the cultural significance of a place or item established by organisations including among others, the ICOMOS (International Committee on Monuments and Sites, Australia), The National Trust of Australia, The Australian Heritage Commission (Commonwealth Government) and in New South Wales by the State Government, Department of Urban Affairs & Planning.
In the brief for this study the State Heritage Inventory Program (NSW Department of Urban Affairs & Planning) criteria for assessing significance was to be used in the analysis and evaluation criteria of the heritage significance of the study area.

The New South Wales Department of Planning Heritage Manual 1996 provides a rational basis for determining the relative cultural values of listed heritage places. It was evolved from the national evaluation criteria adopted by the Australian Heritage Commission for the Register of the National Estate.

5.2. THE NEW SOUTH WALES HERITAGE INVENTORY EVALUATION CRITERIA

This assessment uses SHI Inclusion/Exclusion Guidelines, in NSW Heritage Manual (Draft) dated February 1996. For an item to be significant, it must meet at least one of the inclusion (nature of significance) guidelines plus at least one of the Representative or Rarity (comparative criteria) guidelines.

<u>Group 1: Nature of Significance</u>

Criterion 1	HISTORIC is concerned with range of context.
Criterion 2	AESTHETIC is concerned with creative or technical accomplishments
Criterion 3	SOCIAL is concerned with community regard or esteem
Criterion 4	TECHNICAL is concerned with research potential or archaeological
Criterion 5	OTHER is concerned with other special values

<u>Group 2: Degree of Significance</u>

Criterion 6	RARE is concerned with the uncommon or exceptional
Criterion 7	REPRESENTATIVE is concerned with the typical or characteristic
Criterion 8	ASSOCIATIVE is concerned with links and connections.

In the process of modification former categories of the State criterion have been restructured and in some cases deleted. This has particular relevance to this study with reference to the following criteria:

<u>In Group 1 category</u> of criterion which have been modified.

<u>Aesthetic Significance</u> - has been modified "in an attempt to clarify the distinction between 'notions of heritage' and 'conservation' on the one hand, and of 'amenity' and 'design' on the other. (also to temper any tenancy towards elitism in those judgements)" and to fully address the question of "whose aesthetics?" Architectural significance has therefore been deleted as a separate criterion. Aesthetic Significance means that an item will be significant for

strong visual or sensory appeal, landmark qualities, creative and/or technical (including architectural) excellence.

It may not be significant if it has lost its design or technical integrity. A place is aesthetically significant at a representative level if it has principal characteristics of an important class or group of items or is part of a group which collectively illustrate a representative type. It would be excluded aesthetically if it is a poor example of a class of items. A place is aesthetically significant at a rare level if it represents a rare, endangered or unusual aspect of our history or cultural environment.

Natural Significance - is not used as an attribute of significance, rather it is now used to distinguish between two contexts of place, natural or cultural.

Other Significance - is left as a safeguard for demonstrable special cultural value which in this report has been given the value of 'View'.

In Group 2 category:
The comparative evaluation attributes of Views, Vista, Landmarks, Group and Integrity have been deleted as separate values. Views, vistas and landmarks are now included for consideration in the Rare Criterion and group value in Representative Criterion. Lastly, the degree of integrity is a quality which is to be taken into account in considering each of the eight criterion (listed above).

Social Significance - Social Significance means that an item will be significant through association with a contemporary community for spiritual or other reasons. It may not be significant if it is only important to the community for other reasons (eg in preference to its replacement). It has to be established that it held in high esteem by an identifiable group in the community. A place is socially significant at a representative level because it represents an important class of significant items or environments and is outstanding because of its integrity. A place is socially significant at a rare level because it represents a rare, endangered or unusual aspect of our history or cultural environment or is a scarce example of a particular style, custom or activity.

Technical Significance - Technical Significance means that an item will be significant because of its contribution or potential contribution to an understanding of our cultural history or environment. It may not be significant if it is a poor example of a class of items. The place is technically significant at a rare level because it represents a rare, endangered or unusual aspect of our history or cultural environment, if it demonstrates designs or techniques of exceptional interest. A place is technically significant if it is a scarce example of a particular style, custom or activity.

6. ASSESSMENT OF CULTURAL SIGNIFICANCE

6.1. HISTORICAL SIGNIFICANCE

6.1.1.
The site of Vine Lodge is significant as part of an 1832 land parcel purchased by Henry Badgery after whom the town of Exeter, originally Badgery's Siding, was named. Henry Badgery and his father James were important pastoralists in the Exeter Area and had large holdings in the area and were well known for the quality of their horse and cattle breeding. The Badgery Family were one of Australia's earliest pastoralist settlers, who formed a family dynasty based in Sutton Forest ranging throughout NSW and Queensland. They played a vital role in the development of Australia's cattle and horse breeding and horse-racing industries.

6.1.2
The site of Vine Lodge is significant for its association with the township of Exeter which was once part of the Vine Lodge property and has been closely linked to the Badgery family since their occupation of the area in the 1820's.

6.1.3
The building is significant as the residence of the Badgery family from 1839 to 1978.

6.1.4
The building is significant for its reflection of the nineteenth century development of Exeter and Sutton Forest as a prestige address for prominent citizens from both the South Coast and Sydney environs. The prestige of the area was greatly improved by its association with sixteen NSW Governors who used nearby Hillview as their country residence.

6.1.5
The building is significant for its association with a number of key events in the development of the town of Exeter.

6.1.6
The building is significant for its reflection of Exeter's period of high prosperity in the nineteenth century and twentieth century.

6.2. SOCIAL SIGNIFICANCE

6.2.1.
The building is significant for its reflection of the nineteenth century development of Exeter and Sutton Forest as a prestige address.

6.3. AESTHETIC SIGNIFICANCE

6.3.1.
The principal residence and outbuildings defined within the Vine Lodge Residence and two Outbuildings are contributing components of the Exeter/Sutton Forest Landscape Conservation Area.

6.3.2
The building plan and form of the building, despite significant roof alterations and additions is significant as an important partially intact residence which dates from the key period of significance of the area.

6.3.3
The site of Vine Lodge contributes to the Exeter/Sutton Forest Landscape Conservation Area which has aesthetic significance as a homogenous "English-style" landscape of grand estates, gardens and mature plantings, meandering country lanes with remnant native vegetation,

churches and churchyards, historic railway complex and very impressive residences in a range of architectural styles all in sympathy with and contributing to the aesthetic qualities of this cultural landscape.

6.3.4
Vine Lodge together with other substantial Country residences contribute to the setting of the Exeter/Sutton Forest Landscape Conservation Area.

6.3.5
The building is significant as an early example of a Colonial homestead.

6.5. REPRESENTATIVE SIGNIFICANCE

6.5.1
The building is representative of a substantial middle class rural residence erected in the nineteenth century.

6.5.2
The site and buildings of a single family dynasty provide the core and part of a group of houses which are of an exceptional example of a very early landscape which has been enriched by the overlay of a remarkable collection of country estates of many of the most influential and noteworthy persons in New South Wales.

6.6. RARE SIGNIFICANCE

6.6.1
The building's ability to represent the occupation of the area by the Badgery family is rare due to the length of occupation and its significance as the family home.

6.7. ASSOCIATIVE SIGNIFICANCE

6.7.1.
The building is significant for its association with the Badgery Family, a significant pastoral family dynasty.

6.8. INTACTNESS SIGNIFICANCE

6.8.1.
The building which has been greatly altered externally has some significance as a remnant building capable of restoration to its former status.

6.9. SEMINAL SIGNIFICANCE

6.9.1.
The research to date has not revealed an aspect of this significance.

6.10. CLIMATIC SIGNIFICANCE

6.10.1.
The research to date has not revealed an aspect of this significance.

6.11. SCHEDULE OF ITEMS OF SIGNIFICANCE

6.11.1.
The schedule of existing fabric notes the relevant area and its level of significance as follows:

A	Exceptional
B	Considerable
C	Some
D	Little/Detracting

THE SITE

THE EXTERIOR

South Garden to Vine Lodge	B
North Garden to Vine Lodge	B
The view from Vine Lodge looking North from the Ground Floor	B
The view from Vine Lodge looking south from the Ground Floor	B

BUILDING

The original fabric of the North Elevation	B
The later additions of the North Elevation	D
The original fabric of the South Elevation	B
The later additions of the South Elevation	D
The original fabric of the West Elevation	B
The later additions of the West Elevation	D
The original fabric of the East Elevation	C
The later additions of the East Elevation	D
The later kitchen link	D
The kitchen wing	B
The stable wing	B
The store	C

INTERIOR

The general planning arrangement of the original building	B
The general planning arrangement of the outbuildings	C
The ground floor rooms of the original building	B
The attic of the original building	C
The attic modification	D

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8. LIST OF ILLUSTRATIONS

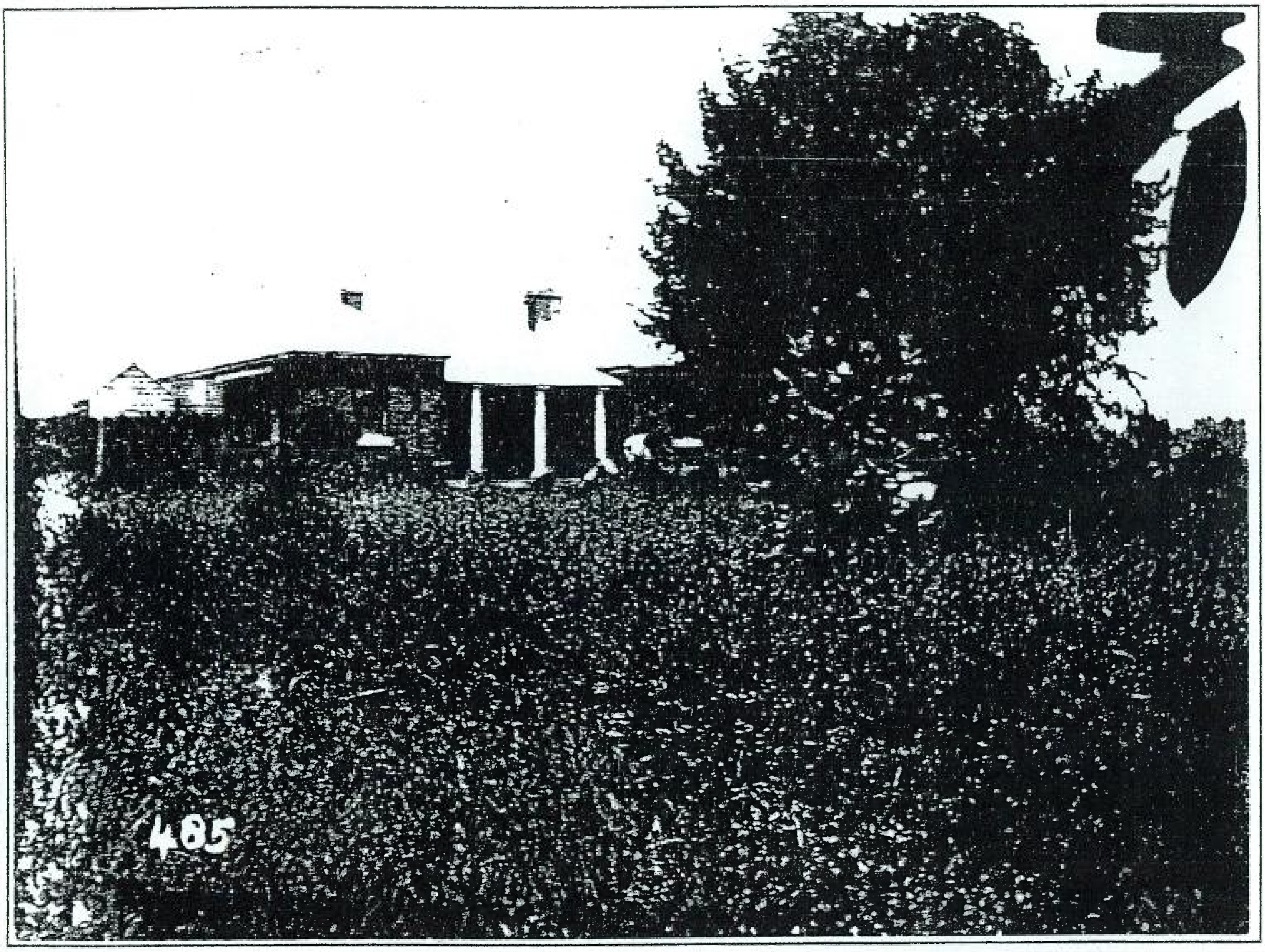


Fig 3.1 1886 Vine Lodge rear elevation (Berrima District Historical & Family History Society)

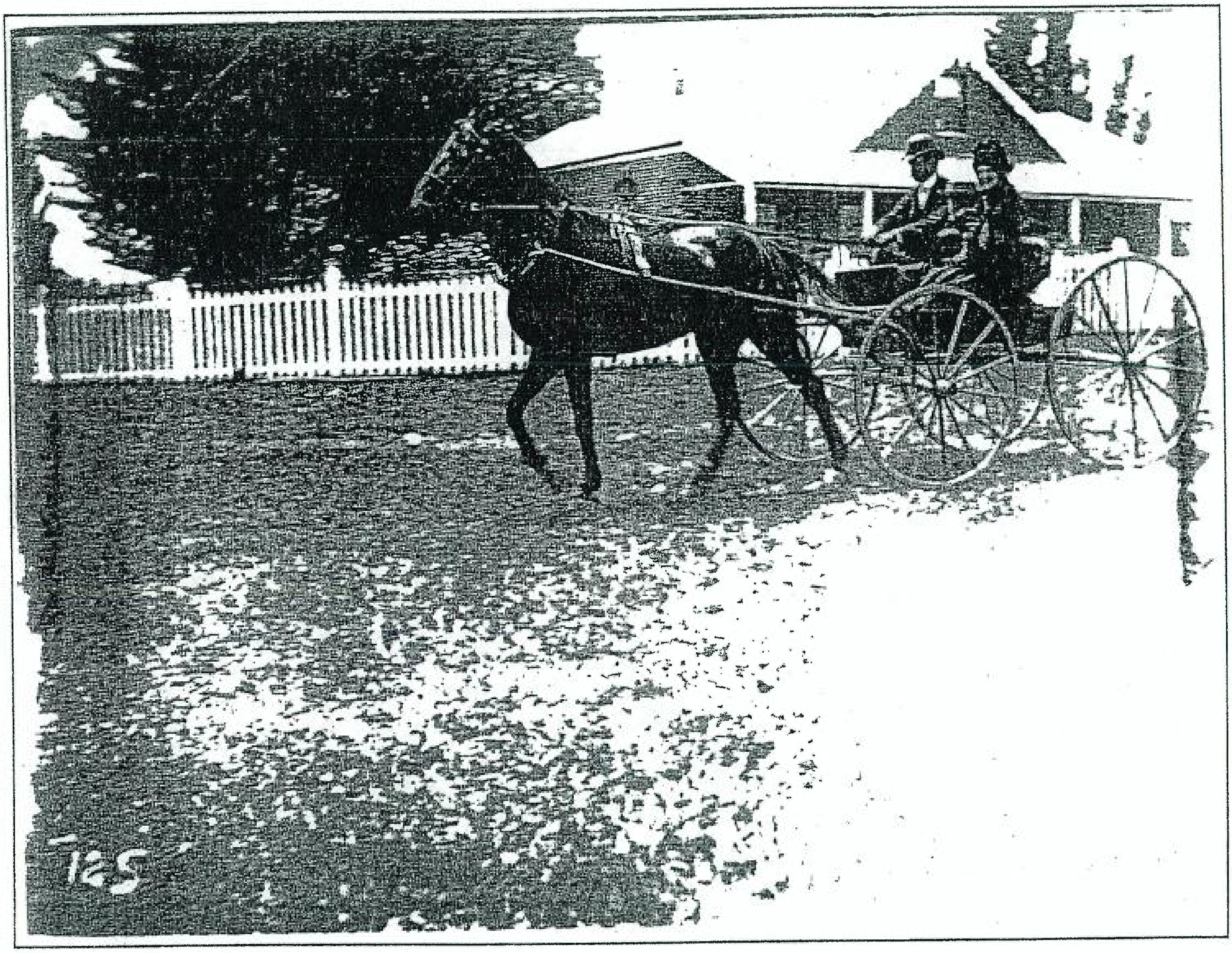


Fig 3.2 1886 Vine Lodge front elevation (Mr & Mrs Frank Badgery in the Buggy) (Berrima District Historical & Family History Society)

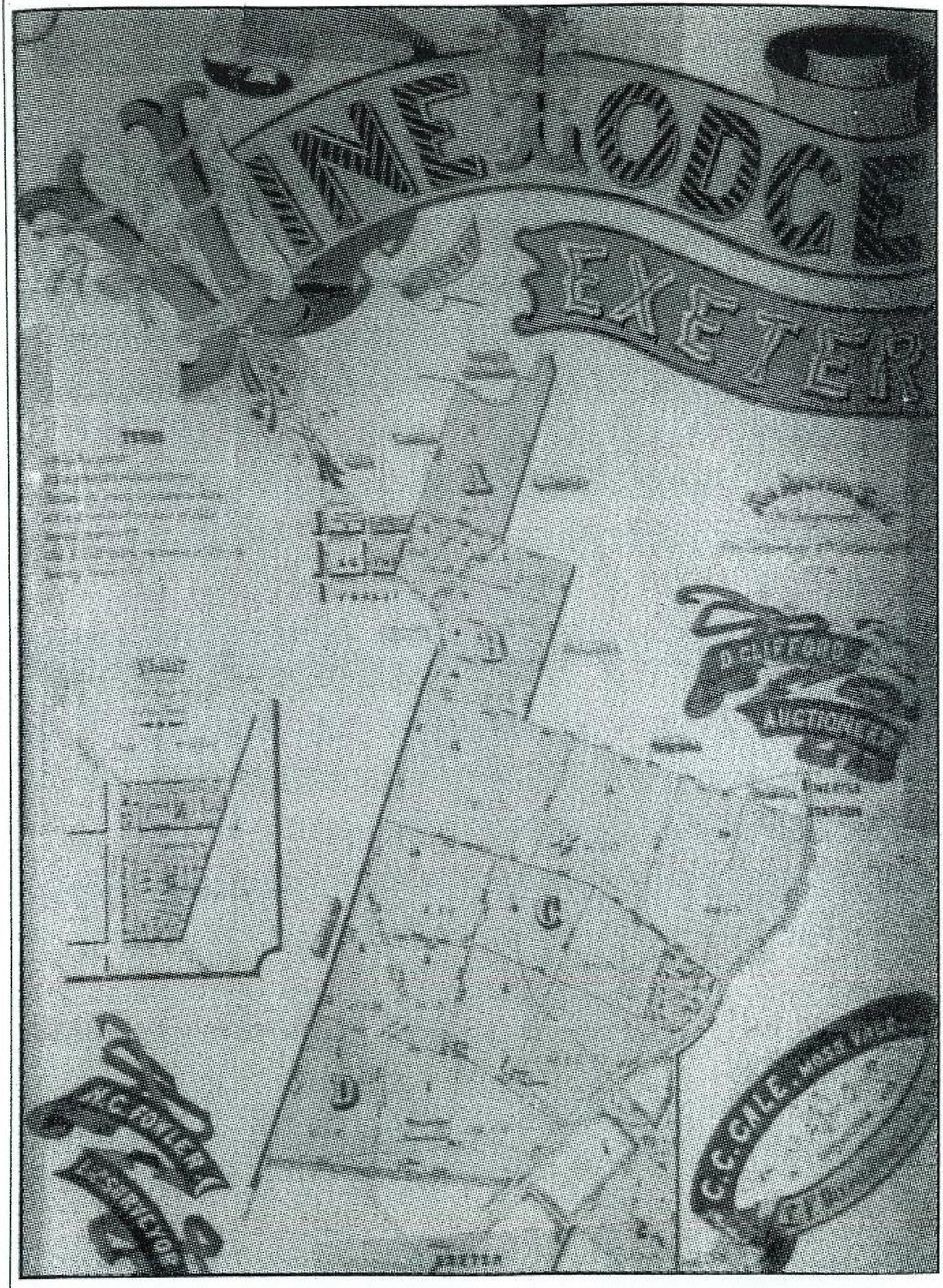


Fig 3.3 Extract of 1892 Vine Lodge Subdivision Poster showing Vine Lodge Homestead

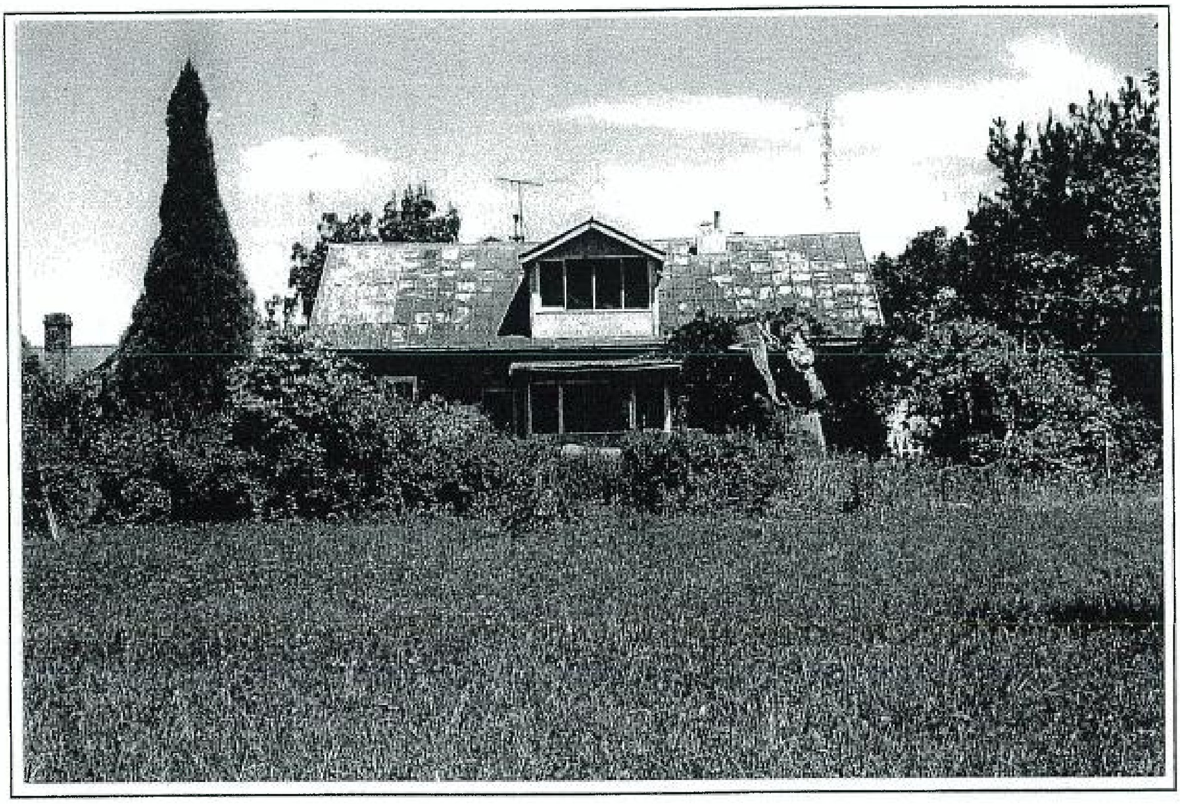


Fig 4.1 View of north elevation of Vine Lodge with original roof form and verandah removed, new enclosed balcony and extension to east where the former kitchen was located

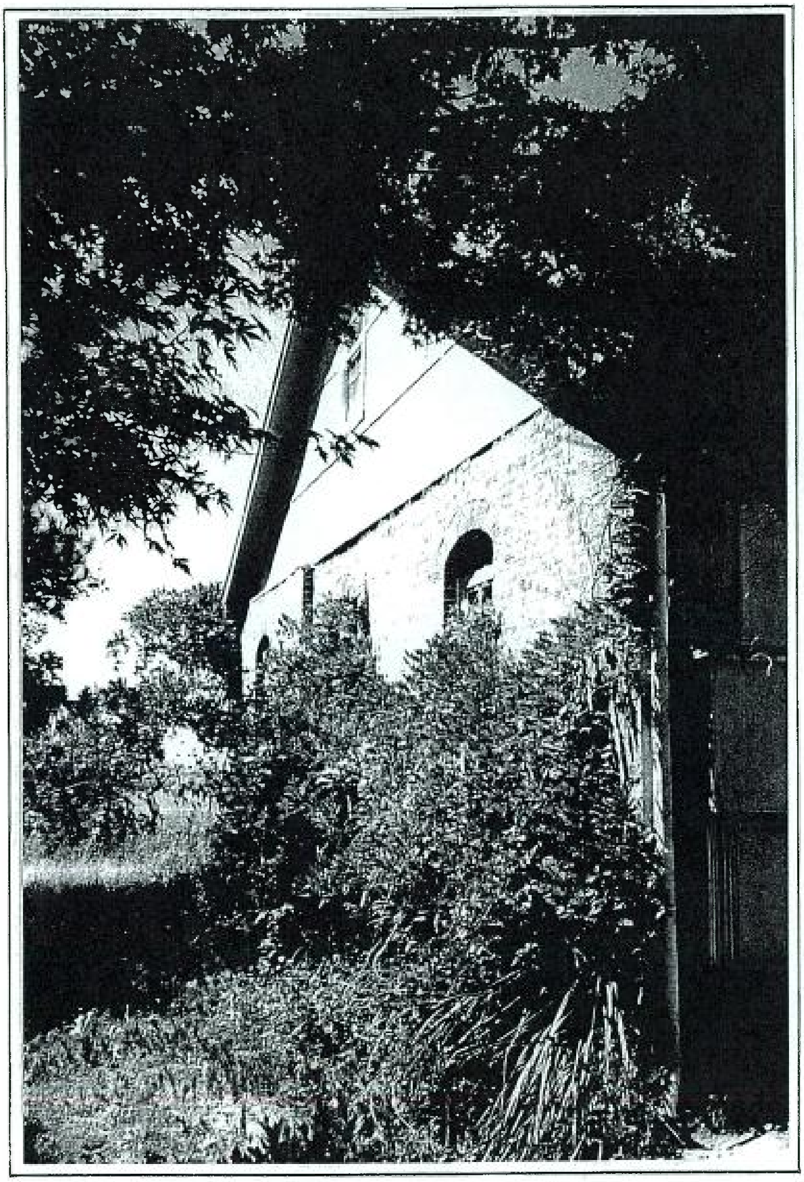
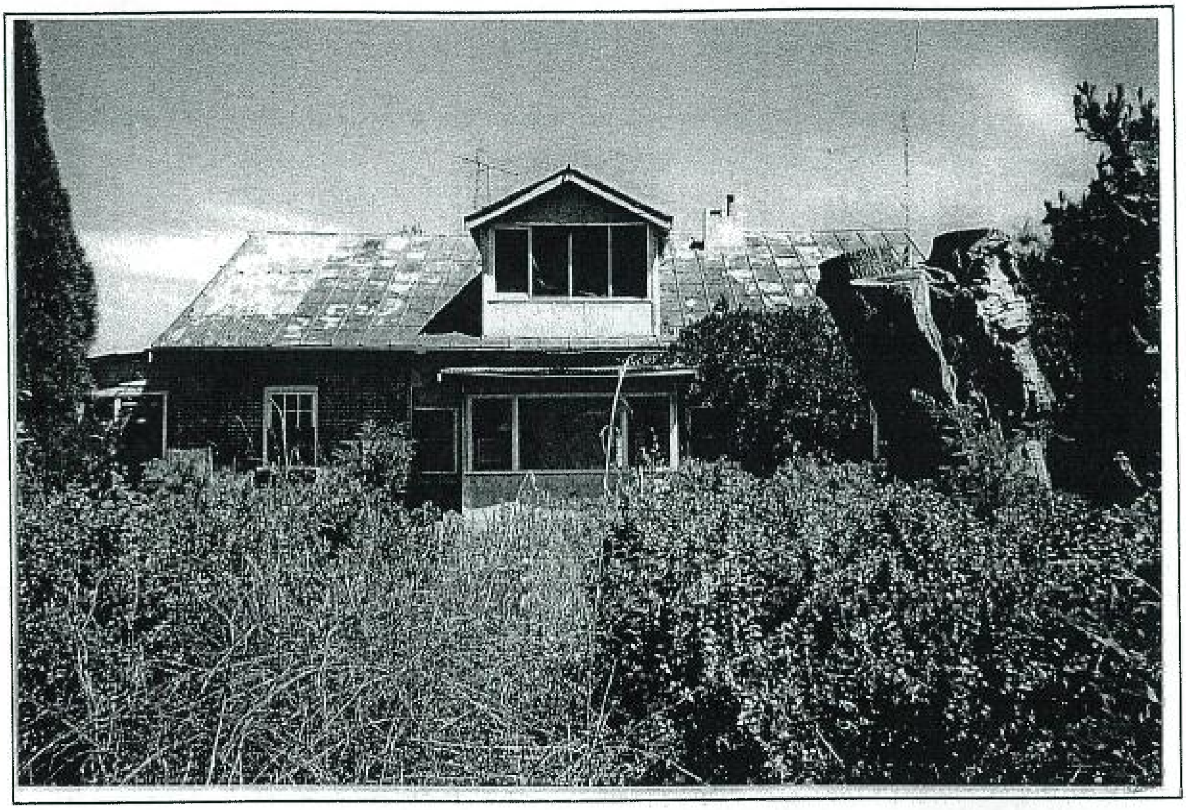


Fig 4.2 View of west elevation of Vine Lodge with original roof form removed and new gable roof and attic extension



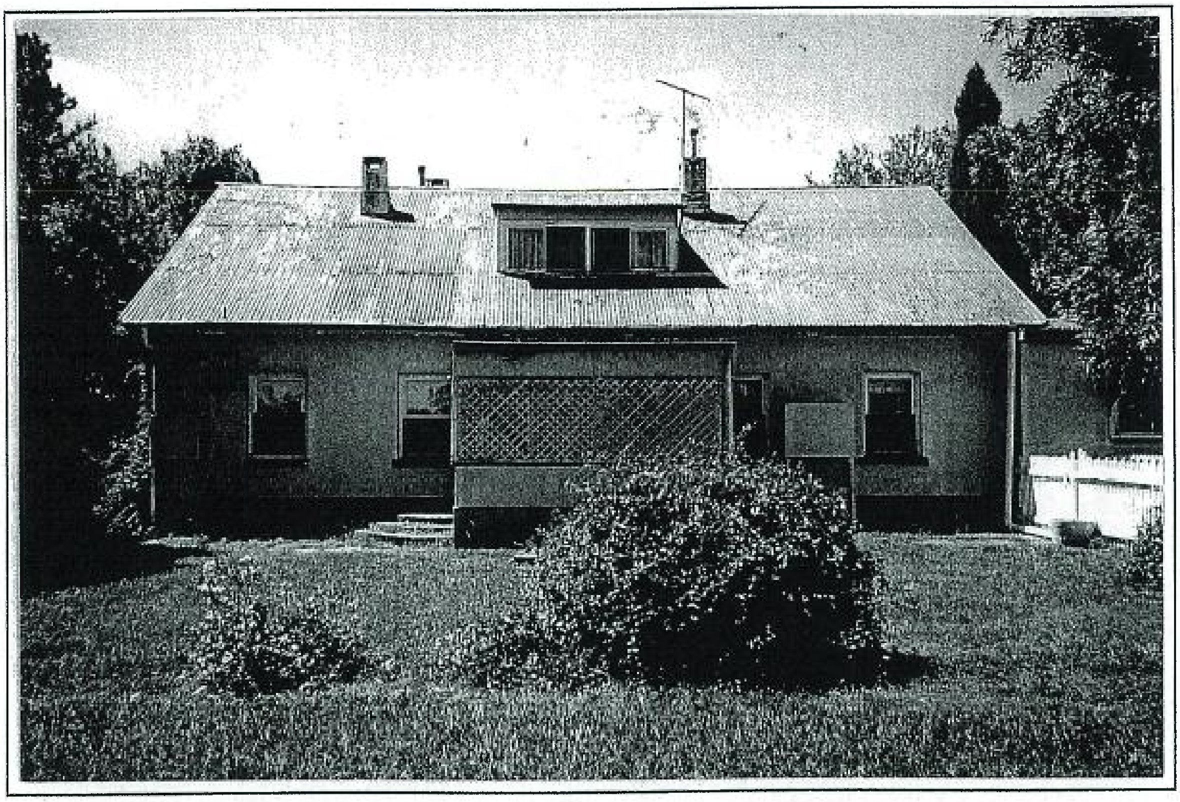


Fig 4.3 View of south elevation of Vine Lodge with original roof form and verandah removed and new lean to addition concealing entry

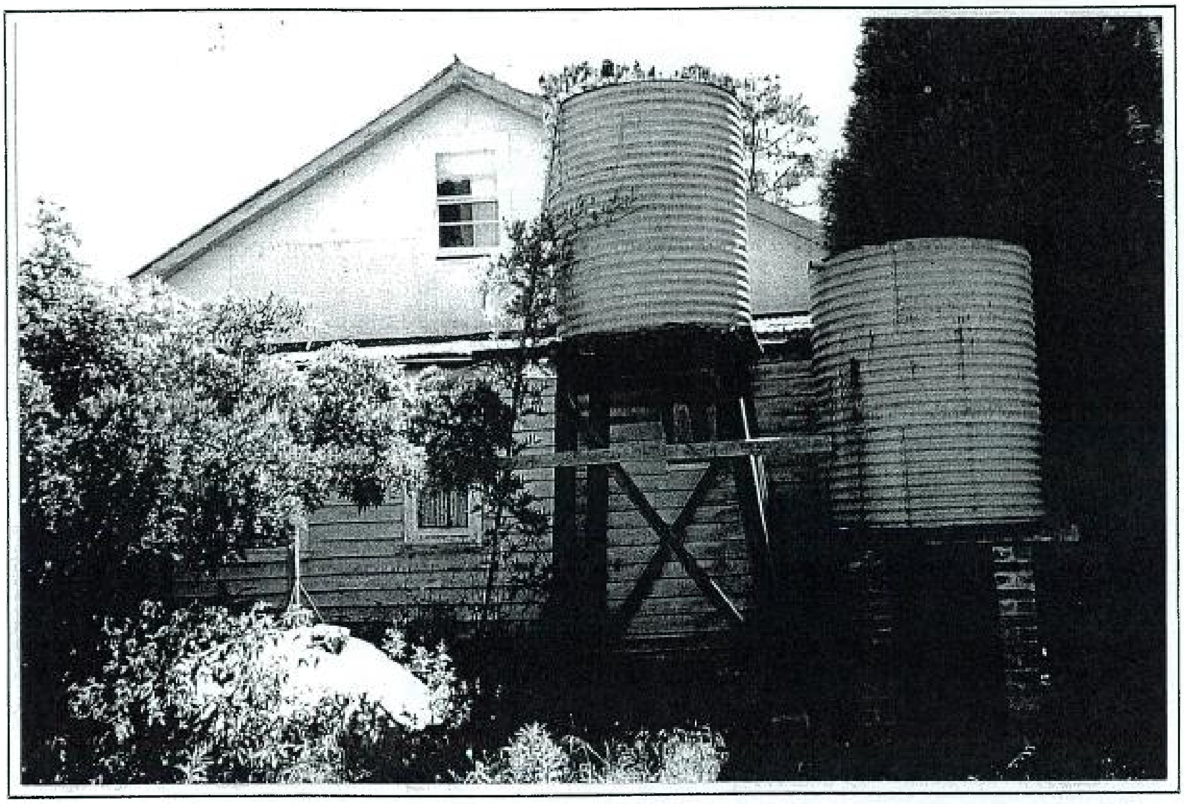


Fig 4.4 View of east elevation of Vine Lodge with original roof form removed and new gable roof and attic extension and kitchen wing extension

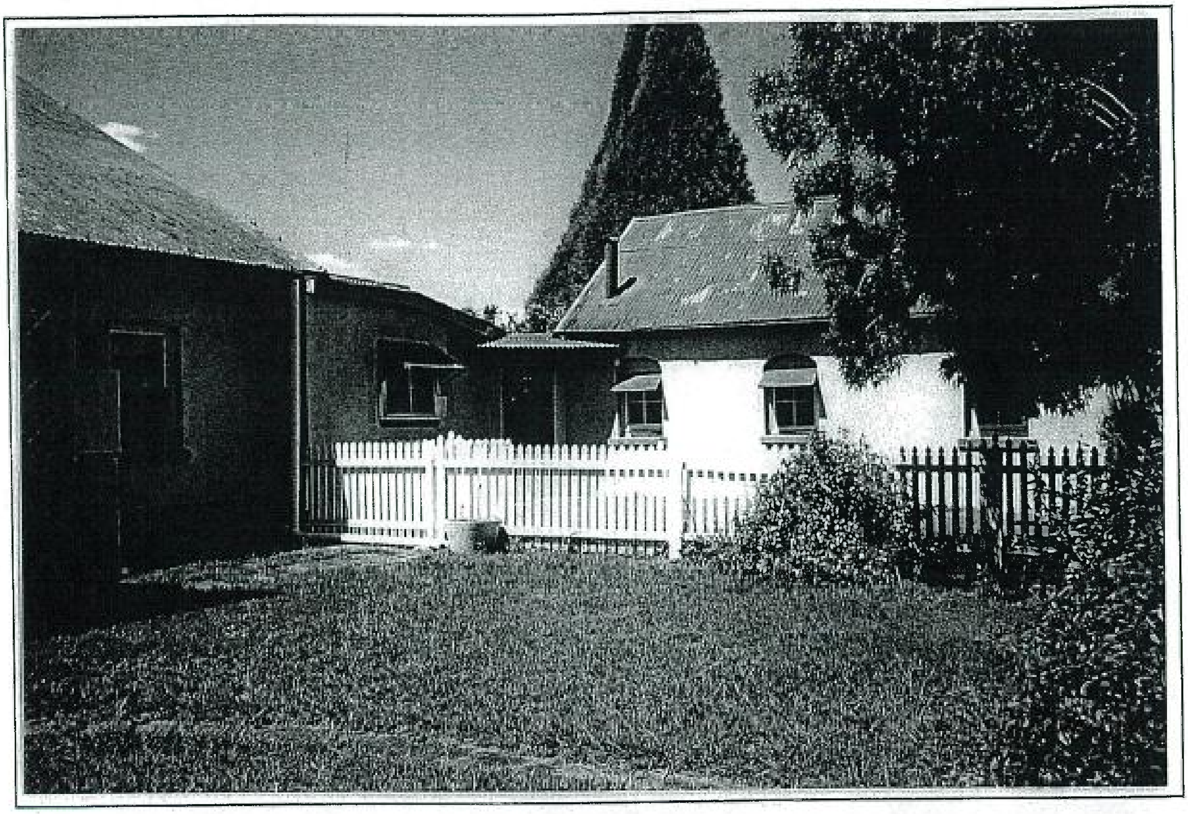


Fig 4.5 View of later kitchen link to early kitchen wing looking east

Fig 4.6 View of early stable wing with forms an L-shape with kitchen looking east

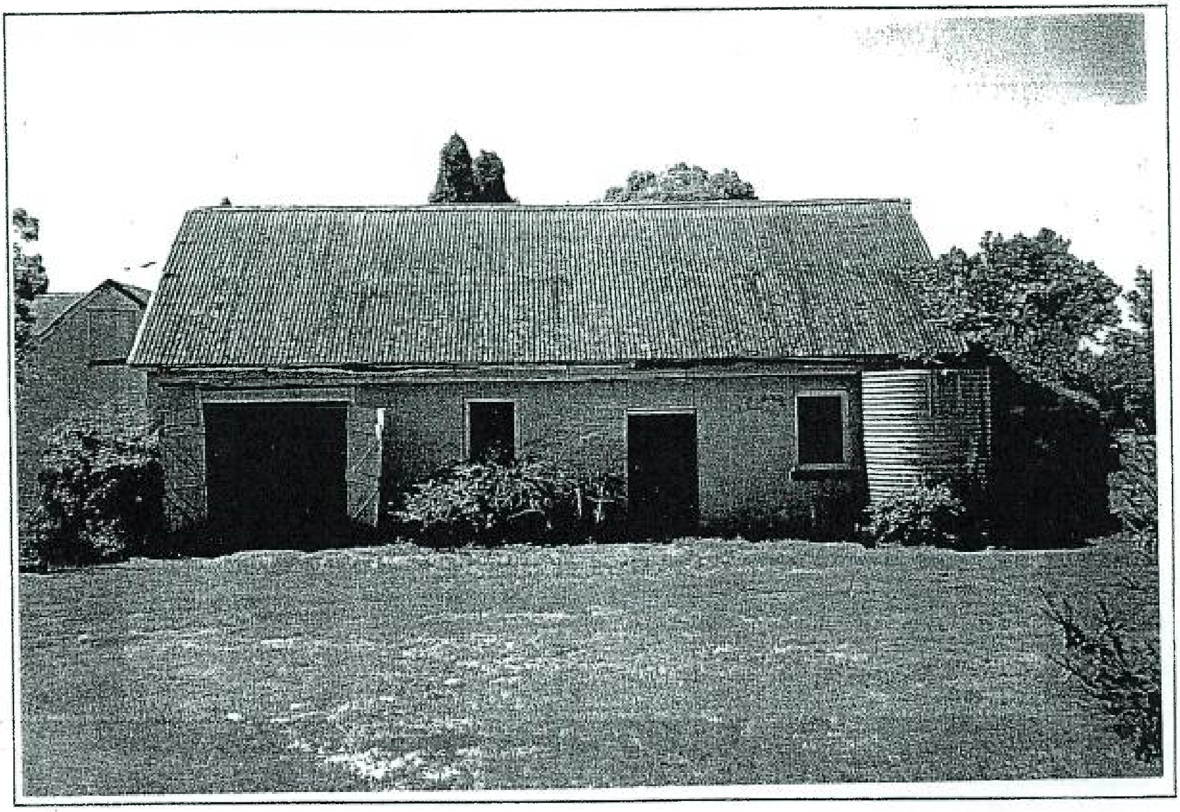


Fig 4.7 View of early stable wing looking north

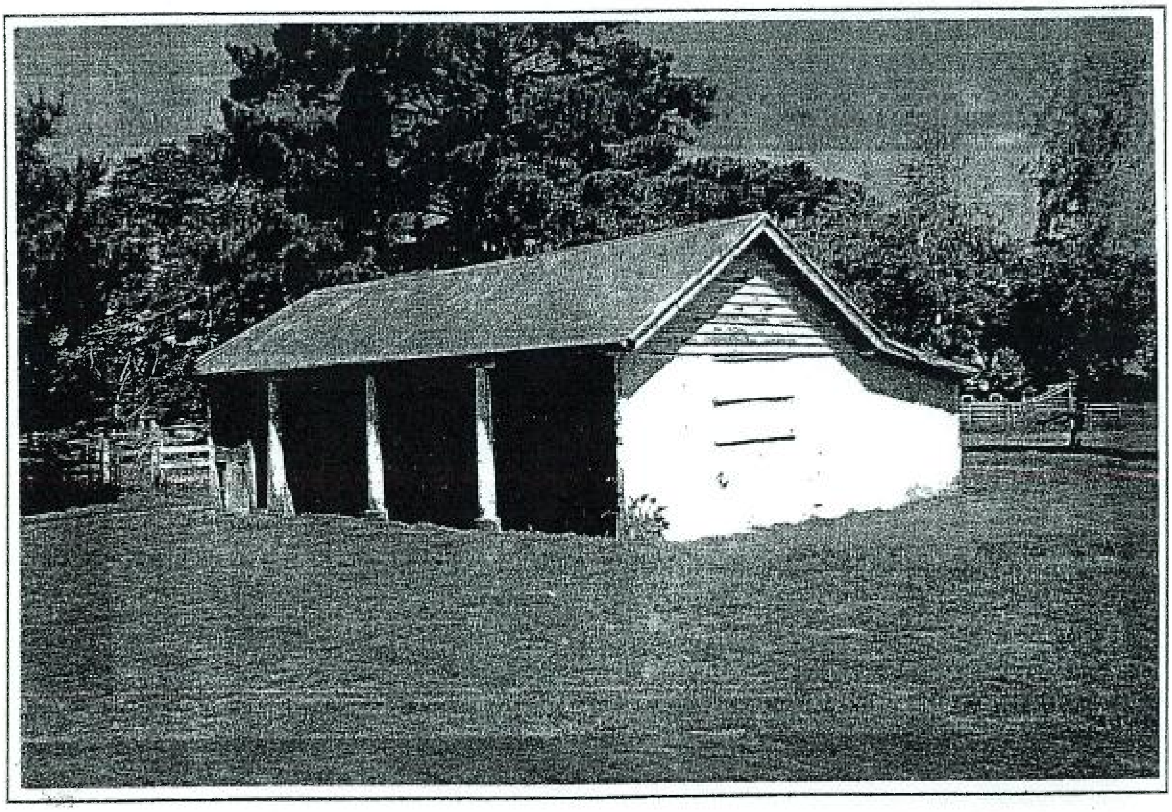


Fig 4.8 View of later storage shed looking east which reuses earlier timber columns

9. LIST OF REFERENCE DOCUMENTS

1. Overall plan
2. Village lot of 12.46 ha, DP 927745
3. Triangular lot adjoining the village, lot of 6,121 msq, DP 660174
4. Vine Lodge property of 40 ha, DP 596495
5. Lot 3 of 35.28 ha, which is inclusive of the 2 ha lot which has been approved but not registered, DP 609857
6. Plan, Vine Lodge and Horsley
7. National Trust Inventory Sheet
8. National Trust Exeter/Sutton Forest Landscape Conservation Area
9. Wingecarribee Council Heritage Inventory Database Sheet
10. Wingecarribee LEP 1989 Schedule 1 and Schedule 2 List
11. Plan showing proposed Road to Vine Lodge property
12. Full historical title

APPENDIX 4:

VISUAL IMPACT ASSESSMENT METHOD

THE HERITAGE VALUES OF THE AREA

•Heritage items are identified and their significance is discussed. Particular attention is given to the:

•History of the area

•Heritage significance of the landscape

•Heritage values of Vine Lodge

1.2 VISUAL VALUES OF THE AREA

•The visual context and character of the locality is first described in terms of:

•Natural and built context

•Scenic qualities of the landscape

•Visual character of the subject land and its setting

•The visual catchment of the proposal and its components

1.3 VISUAL EXPOSURE

•Visual exposure of the proposal is then analysed in terms of:

•Viewing places

•Position and sequence of views

•View composition

•Number and kind of viewers expected to experience the views

These components were used to establish three parameters of relevance to assessing visual impacts;

1. The extent of change to the intrinsic character of the subject land
2. Visual absorption capacity
3. Visual sensitivity of specific viewing places and the landscape generally.

The meaning of each of these parameters is described below:

1. Change to the intrinsic character of the site

The landscape's immediate visual character is often changed by a development, particularly for people who are familiar with the area. Whether this constitutes a visual impact depends on whether the change was perceptible from places outside the subject land and particularly by people who are not familiar with it. People who are familiar with particular areas may express strong emotional attachment to its existing appearance, whereas changes may be acceptable or undetected by others without that emotional involvement.

2. Visual absorption capacity

The visual absorption capacity of a landscape is a qualitative assessment of the degree to which a proposed change to it could be absorbed without either the appearance or the character of the landscape being changed. An area with a high visual absorption capacity for a particular kind of visual element is considered less sensitive to the extent of the change brought about by such an element.

3: Assessment of visual sensitivity of viewing places

Visual sensitivity is a qualitative measure of a location, taking into account the number of viewers who could experience it, the number of viewing places from which it could be experienced and the cultural importance of those places. A location is more sensitive if it is experienced by a large numbers of viewers, from many locations and/or from culturally important places, or is a culturally important location in its own right. A visual impact of a particular magnitude is of greater significance if it affects a sensitive location than one of lesser sensitivity.

1.4 ASSUMPTIONS ABOUT THE VISUAL QUALITIES OF THE PROPOSAL

- The visual qualities of the proposal and its components is assessed in terms of:
- Character of the operation proposed
- Visual qualities of the stages of the proposal
- Retention of existing features
- Visual qualities of associated works and structures
- Visual effects of associated activities

1.5 EXTENT OF VISUAL EXPOSURE

The maximum extent of potential visual exposure of the proposed development is then assessed, assuming at this stage that no measures are taken to decrease or eliminate visibility of the proposal.

The extent of visual exposure is assessed by combining the change to the intrinsic character of the site, the visual absorption capacity of the locality and the degree to which the character of the area would remain. Each of these factors relies on the nature of the specific visual qualities of the proposal.

The extent of visual exposure is then ranked on a six point scale. The scale values and the qualities which are equivalent to each are described in the table below:

Extent of visual exposure	*Qualities*
• Nil	The proposal has no visual effect on the landscape
• Negligible	The visual evidence of the proposal is minimal, because it is screened by intervening elements, unable to be correctly identified, or both.
• Low	The proposal is evident but is subordinate to other elements in the scene by virtue of its small scale, screening by intervening elements, or difficulty of being identified
• Low-Moderate	The proposal is evident and identifiable in the scene, but is less prominent, makes a smaller contribution to the overall scene, or does not contrast substantially with other elements
• Moderate	The proposal is a substantial element, but is equivalent in prominence to other elements and landscape alterations in the scene.
• Moderate-high	The proposal is more prominent than other elements in the scene, by virtue of its size, character, location or a combination of these.
• High	The proposal visually dominates the scene due to its relative size, isolation, location in a focal point, contrast of form, colour or line, or a combination of these

1.7 ASSESSMENT OF MEASURES PROPOSED TO CONTROL VISUAL EXPOSURE

The development proposed is then assessed after measures proposed to control visual exposure and ameliorate any unavoidable visual effects are taken. Any aspects of the activity, either directly, or indirectly, that remain evident after this assessment constitutes a residual exposure. The residual exposure is then assessed in turn, on the basis of how significant (important) it is.

1.8 SIGNIFICANCE OF VISUAL IMPACTS

The significance of residual exposure is then assessed, by applying weightings to the extent of residual visual exposure. This is to distinguish the simple extent (how much is visible) from its significance (how important this is). This relationship is not necessarily direct. For example, a large extent of residual visual exposure could be of low significance, depending on the context (the impact of a new house on a residential subdivision). Alternatively, a small extent of visual exposure could be of large significance (a development affecting a sensitive and scenic location accessible to many people). To arrive at the assessment of significance, weights are applied to the extent of exposure that acknowledge the various issues that may either increase or decrease the significance of residual impacts. The weights that are applied are explicit and are applied in a systematic way so that the effect of each one is accounted for.

APPENDIX 5: PHOTOGRAPHIC FIGURES

Figure 1. View toward the proposed extraction area from near "Boeing Park" residence.
The northern boundary of the extraction area is barely visible. Rockleigh Road is in the middle distance but obscured by trees in the foreground. Vegetation screening and bund walls would remove any visual exposure of the extraction activity.

Figure 2. View toward the School Lane area, from the north eastern corner of the proposed extraction area.
The dwelling with the light coloured roof visible on the left is Merry Hill homestead, one of the few residences with any visual exposure to the extraction area. The vegetation to its right is existing on Rockleigh Road, screening the site from most School Lane properties. It is evident that bund wall construction and vegetation will remove any view of the activity from Merry Hill and other residences in the vicinity.

Figure 3. View toward the proposed extraction area from near the rear of Exeter School (winter view).
The proposed extraction area would not be visible from this location, even if no visual amelioration measures were taken. This view can be compared to the visibility shadow diagram for the school, which does not fully account for the screening effect of the vegetation.

Figure.4. View toward the proposed extraction area from near the residence "Willowbank", (winter view).

The existing visibility of the extraction area is minimal. The bund wall beyond Rockleigh Road, in the middle distance, plus its tree screening vegetation, would remove any visual access to the site. By the time the acoustic fence was constructed in this view line, the vegetation would have grown sufficiently to reduce its visibility to a negligible level.

Figure 5. View toward the existing operations from "Rockleigh Cottage".

The view shows the existing crushing and screening plant (left) and existing extraction area (right centre). The foreground would be unaffected by the proposal. The internal product transportation route would be visible near the mid-ground horizon, but difficult to visually distinguish from the existing Rockleigh Road or to differentiate from another road that crosses the centre of the view. The visual exposure of both road and crushing plant will be reduced by an ongoing program of landscape construction and planting work that is presently being implemented.

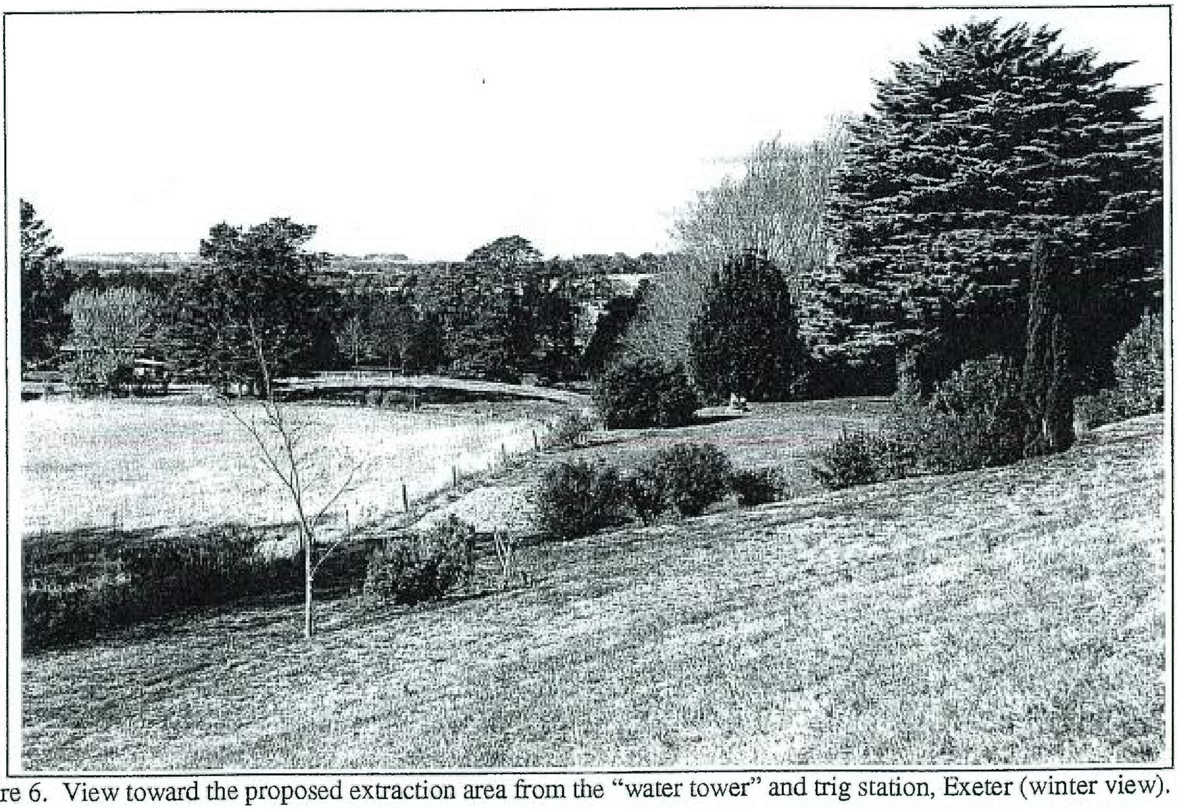


Figure 6. View toward the proposed extraction area from the "water tower" and trig station, Exeter (winter view).

This view composition is typical of those from similar locations on the east and north eastern part of Water Tower Hill. There is no significant visibility of the proposed extraction area.

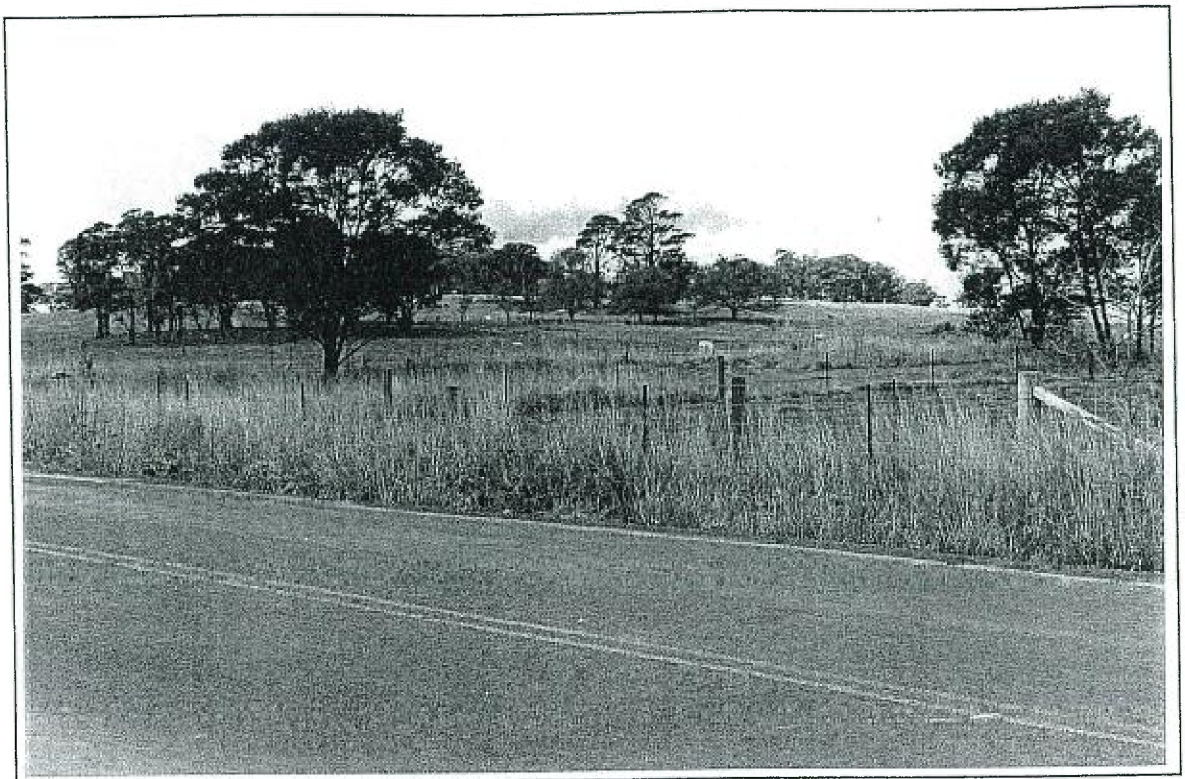


Figure 7. View east across the north western part of the proposed extraction area from a location south of the intersection of Werai Road and Rockleigh Road, Werai Road in the foreground.

The upper boundary of the extraction area is below the level of the trees in the view centre. The visual elements of the view would all be retained as existing. The potential visual exposure of the north eastern wall of the extraction area (to the right of the view) would be controlled by planting and earth wall construction The open, but treed, character of the view would be retained.

Figure 8. View toward the proposed extraction area from part of Norwood Street, looking over School Lane, toward the extraction area.

There would be no significant visual exposure of the extraction area, or of extraction activities, to locations in the vicinity.

Figure 9. View from Exeter Railway Station.

The view shows the typical composition of views in the locality. Parts of the ridge beyond the proposed extraction area can be seen in the background. The view would remain as it appears. There would be no significant visual exposure of the proposal to this location.

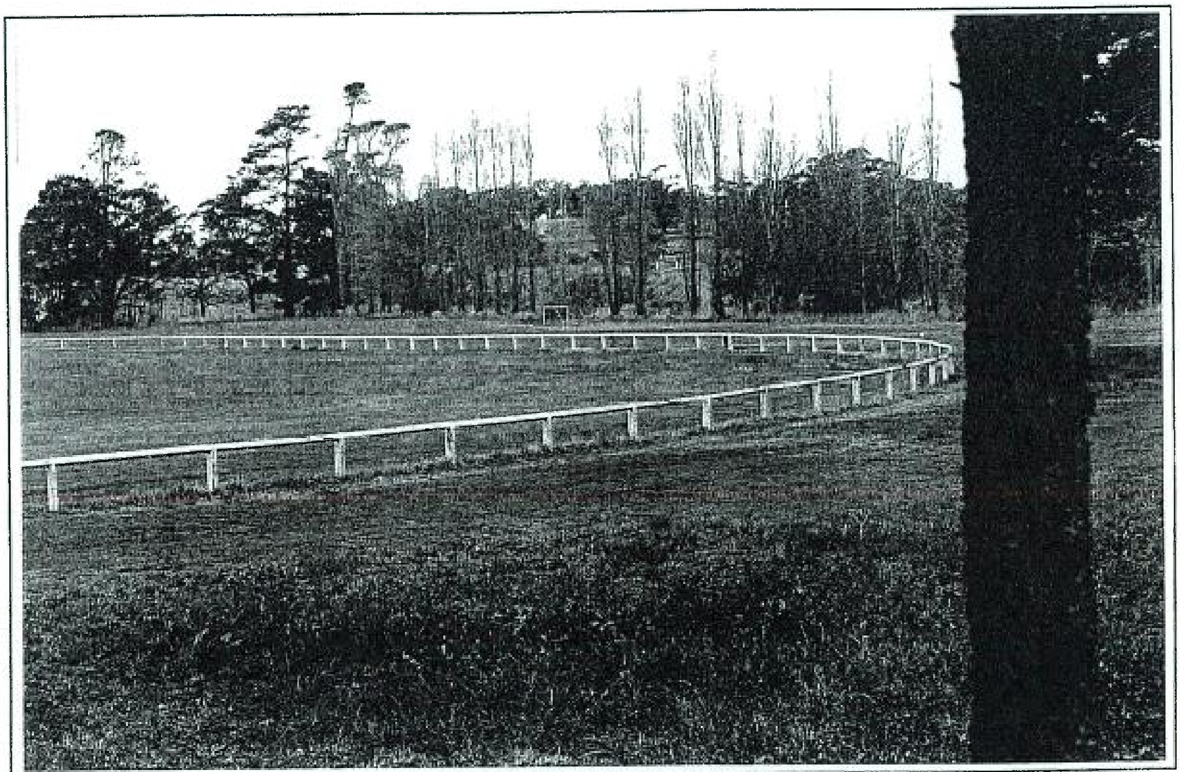


Figure 10. View from near the Exeter Hall, St Aidan's Church etc, beside Exeter Oval (winter view).

The view would remain as at present. Summer visibility in this direction of the proposed extraction area is considerably less because of the increase in foliage on deciduous trees. There would be no significant visual impacts on this view or others from nearby.

Figure 11 View toward the proposed extraction area from the National Estate listed property, Whare-tau, seen over part of Vine Lodge (winter view).

The railway and Werai Road, are about ¾ of the way up the photograph from the bottom. A small part of the extraction area is visible below the horizon and to the right. The composition of the view would remain as at present. There would be no significant effects caused by topography changes to the site or the form of the ridge. Visual exposure would be minimal after amelioration measures were taken.

Figure 12. View toward the proposed extraction area from Exeter Road near the entrance to "Tralee".

The extraction area is effectively out of sight from here and its minimal visibility would be further reduced by bund construction and planting. The Exeter Bypass route would be visible crossing the middle ground toward the viewer on the left of the picture. Its alignment would be screened by carefully located groups of trees, as would the closer part of the road and entrance.

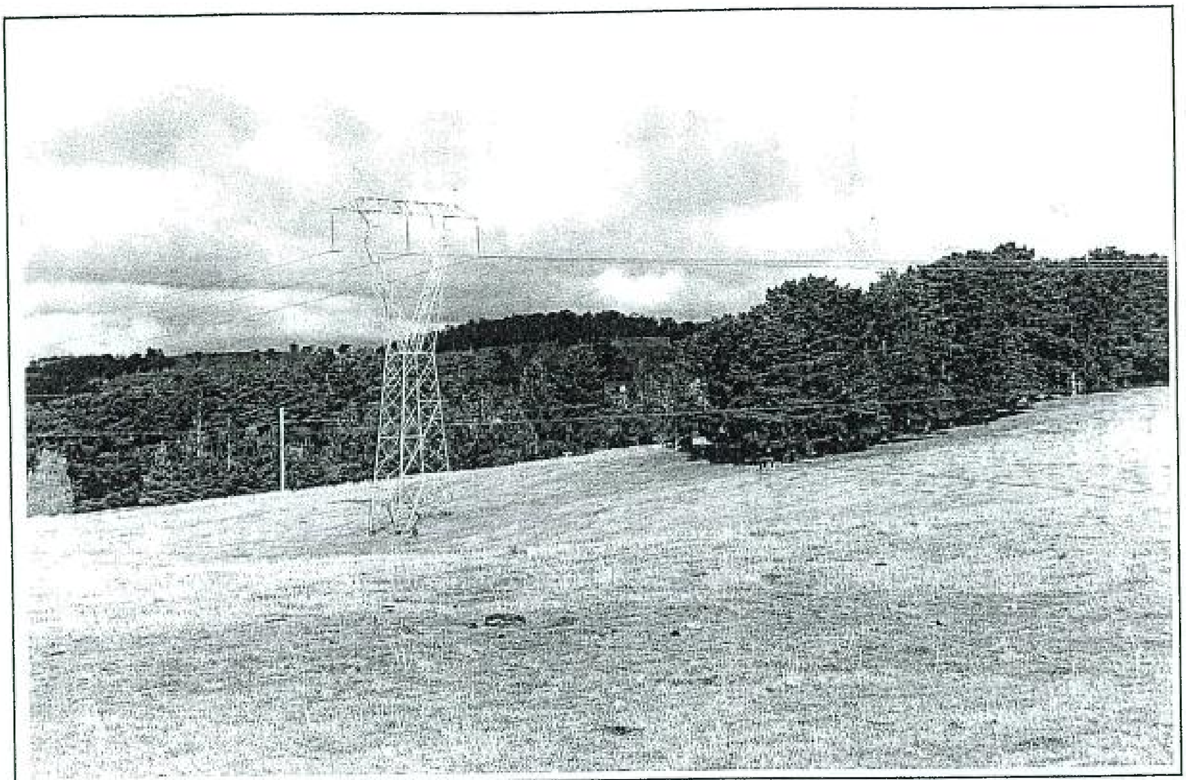


Figure 13. View toward the proposed extraction area from Ellsmore Road to the north of "Vine Lodge West".

The view is typical in composition of others in the vicinity, however they vary according to the location of fore and middle ground vegetation. There would be no significant impacts on these views.

Figure 14. View of the north western margin of the proposed extraction area, from Werai Road.
The extraction area is set back approximately 130m from the road. The area between the road and the extraction area will be screened by foreground planting (to remain until other vegetation is established) and groups of native trees that continue the appearance of the remnant stand on the left, while filtering and screening views toward the bund wall that contains the extraction area. The open grassy character would largely be retained. None of the extraction or transportation of material would be visible.

Figure 15. View of the north western part of the proposed extraction area from Rockleigh Road.
The proposed extraction area would not be visible from this location,. All the existing elements of the view would be retained, other than the open foreground to the right of the view. This area would be screened by vegetation to decrease the visual exposure of the bund wall and internal product transportation route, that runs away up the slope. Neither of these features would be visible. The transportation route would turn to the north west (left) in front of the stand of native trees visible on the left. It would be both in-cut and behind a low vegetated bund wall.

Figure.16. View from part of the former Vine Lodge property of the land across which the Exeter Bypass would be routed.
The road would be cut into the land by 1m, with low earth banks of 1m height to either side. It is not considered necessary to disguise the road with heavy planting parallel to its route, since an avenue-like effect would not be an expected feature of the landscape. Roads and other linear features are common in the locality.

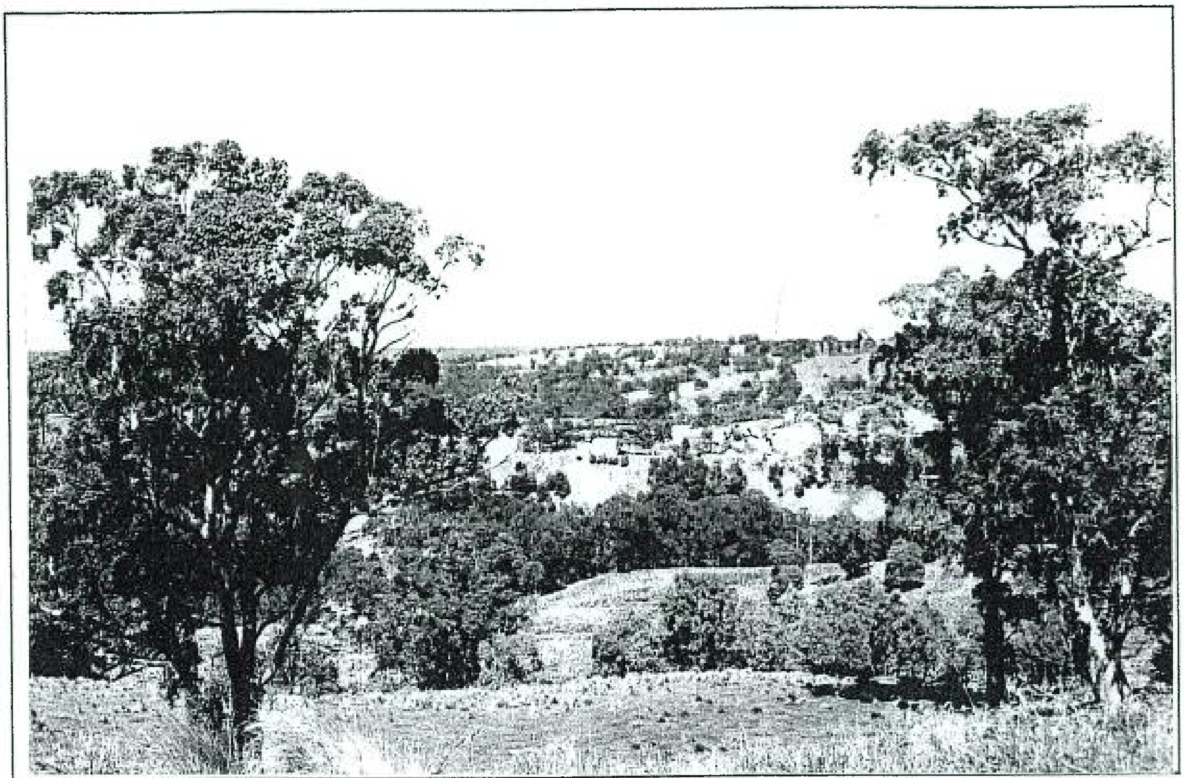
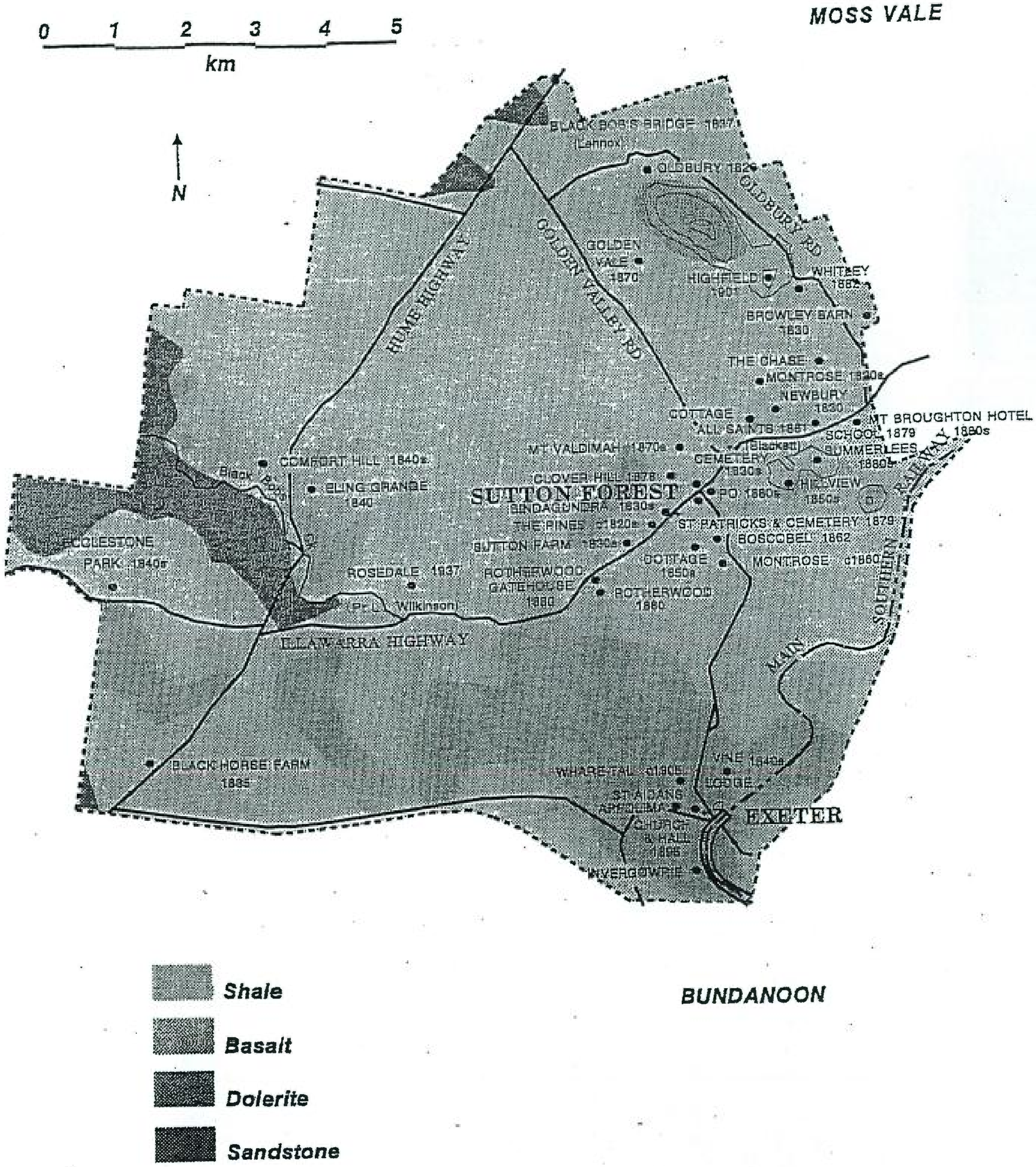


Figure 17. View of the existing processing plant from the access road to an elevated residence to the east of the site. The proposed extraction area would not be visible from this location, which is screened in the foreground by vegetation. However, the rural land in the vicinity may have views that include more of the proposed extraction area.

APPENDIX 6:

NATIONAL TRUST EXETER/SUTTON FOREST LANDSCAPE CONSERVATION AREA LISTING

NATIONAL TRUST



APPENDIX 7:

CURRICULUM VITAE – DR RICHARD LAMB

1.0 I hold a Bachelor of Science degree with First Class Honours from the University of New England awarded with the Prize in Botany in 1971.

I graduated with a Doctor of Philosophy degree from the University of New England in 1975.
I am a:

- Senior lecturer in the faculty of Architecture and in Heritage Conservation, University of Sydney
- Director of Postgraduate Research
- Director of the Master of Heritage Conservation Program.
- Visiting lecturer, University of New South Wales, School of The Built Environment
- Director of Richard Lamb and Associates Consulting and of Lambcon Associates Pty Ltd.

Courses which I have responsibility at the university are:

- Interpretation of Cultural Environments (Heritage Conservation)
- Aesthetic Assessment of Heritage Landscapes (Heritage Conservation)
- Heritage Conservation Research Reports(Heritage Conservation)
- Design in the Natural Environment (Architecture)
- Habitat and Society (Architecture)
- Climate, Landscape and the Built Environment (Architecture)

Since 1980 I have pursued research related to my teaching responsibilities and professional practice. My major research works are in:

- Landscape heritage assessment
- Visual perception
- Landscape assessment and heritage impact assessment
- Social and aesthetic values of the natural and built environment

Publications and presentations relevant to visual perception and assessment of landscapes are listed below (5.0).

From 1980-1987 I was a foundation member of the staff and lecturer in the Landscape Architecture degree course in which I specialised in landscape assessment, environmental perception and landscape field studies.

From 1978-1980 I was also a part-time lecturer in Man-Environment Studies at the University of Sydney Department of Architecture, and tutor in design.

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