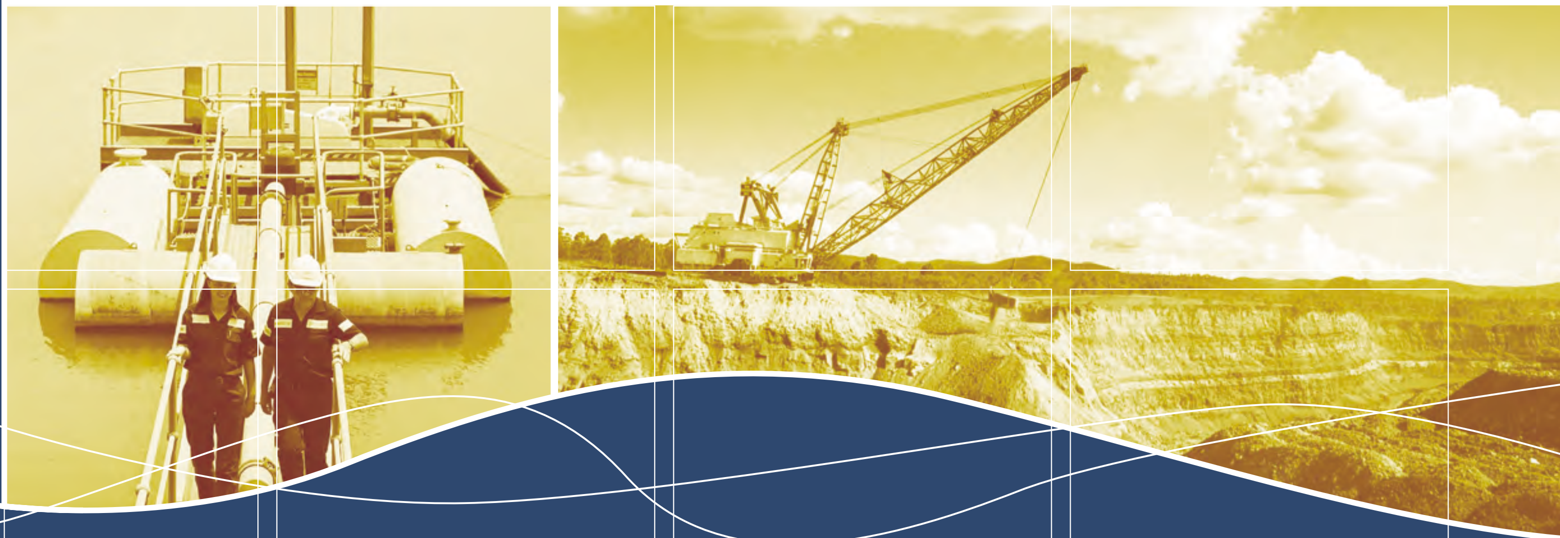
HUNTER VALLEY OPERATIONS

West Pit Extension and Minor Modifications



technical reports

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Hunter Valley Operations
West Pit Extension and Minor Modifications

Technical Reports

for

Coal & Allied Operations

October 2003

COAL & ALLIED

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CONTENTS

PART F

soils and land capability study

F

EXTENSION OF WEST PIT (HUNTER VALLEY OPERATIONS)

SOIL AND LAND CAPABILITY SURVEY REPORT

Prepared for

Coal and Allied Operations Pty Ltd

Prepared by

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R. Masters
Principal
Global Soil Systems

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Issue No. 1
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Project No: CNA 4-1

Title: Extension of West Pit (Hunter Valley Operations)
Soil and Land Capability Survey Report

Project Manager: Rod Masters

Author: Rod Masters

Client: Coal and Allied Operations Pty Ltd (CNA)

Client Contact: Sarah Fish

ISSUE AND AMENDMENT CONTROL HISTORY

Issue	Date	Description	By	Checked
# 1 (Draft)	26/5/03	Issued to CNA	GSS	RM
#2 (Final)	17/6/03	Issued to CNA	GSS	RM

Description
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C O N T E N T S

1.0 INTRODUCTION

1.1 Objectives

Global Soil Systems (GSS) was commissioned by Coal and Allied Operations Pty Ltd (CNA) to undertake soil and land capability surveys of the proposed West Pit extension area. Surveys were conducted by GSS in January 2003 as a component of the environmental impact assessment process for the proposed mine extension. The survey was undertaken in a manner to satisfy the requirements of the Department of Mineral Resources (DMR) with respect to the Mining Operations Plan (MOP) specifications.

The major objectives of these surveys were to:

(1) describe, classify and map soils / land capability within the study area; and

(2) analyse the various soil units to identify their suitability for topdressing of disturbed areas within the study area.

The following report describes the results of the soil and land capability surveys undertaken by GSS.

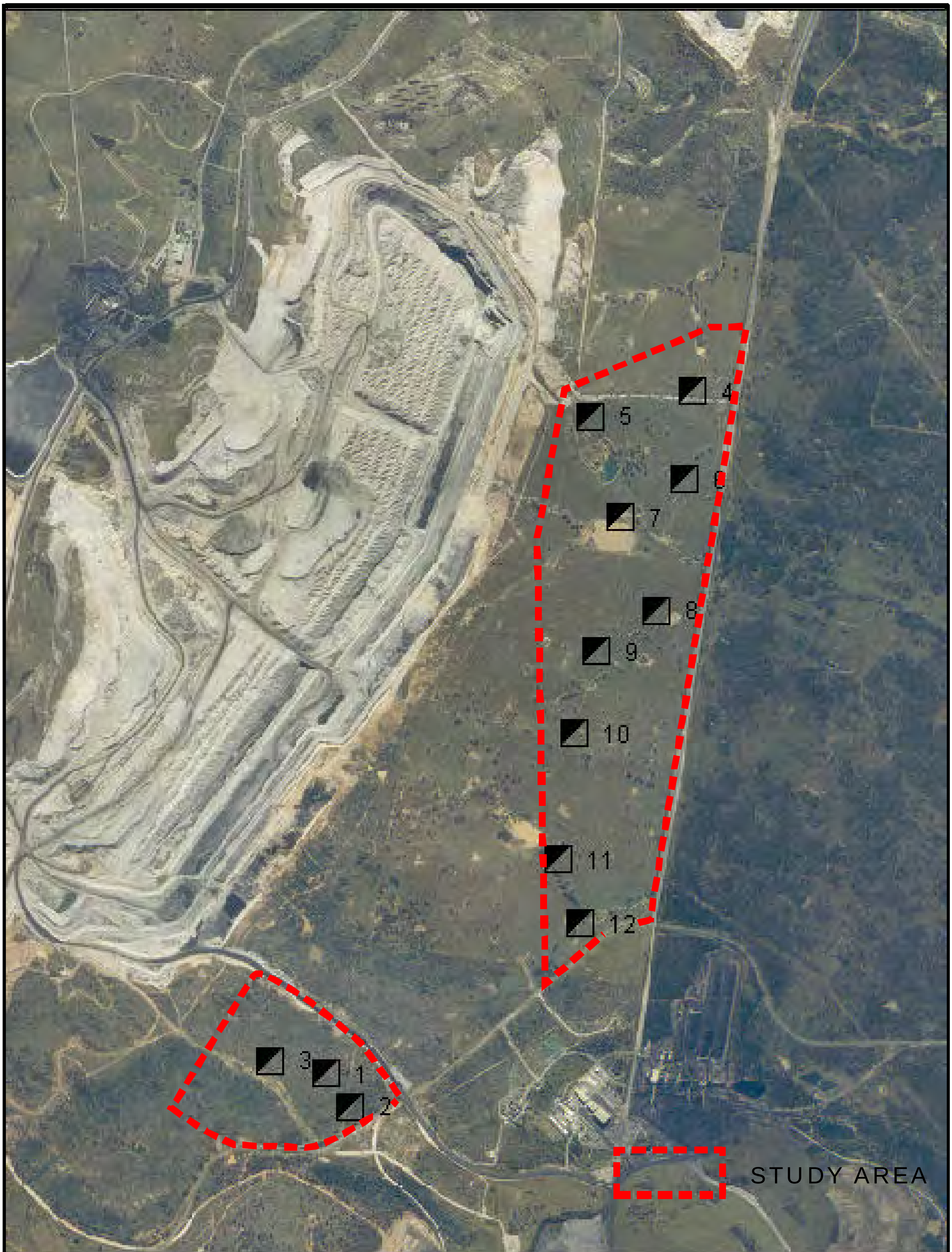
1.2 Location and Access

The West Pit site is located within the Hunter Valley of New South Wales between Singleton and Muswellbrook. Access to the mine is via a private road that joins the New England Highway some 5km north of the village of Ravensworth.

1.3 Regional Setting

The study area, lies to the east of the current mining operation. Belt Line Road forms the eastern limit of the study area (*Figures 1& 2*).

The region is underlain by rich coal resources and several coal mines operate nearby, supplying both domestic and export markets. West Pit is part of CNA's Hunter Valley Operations (HVO) which also contains Hunter Valley North, Carrington, Cheshunt and Riverview pits. Cumnock Mine Lease adjoins the northern boundary. The area lies north of the Hunter River.



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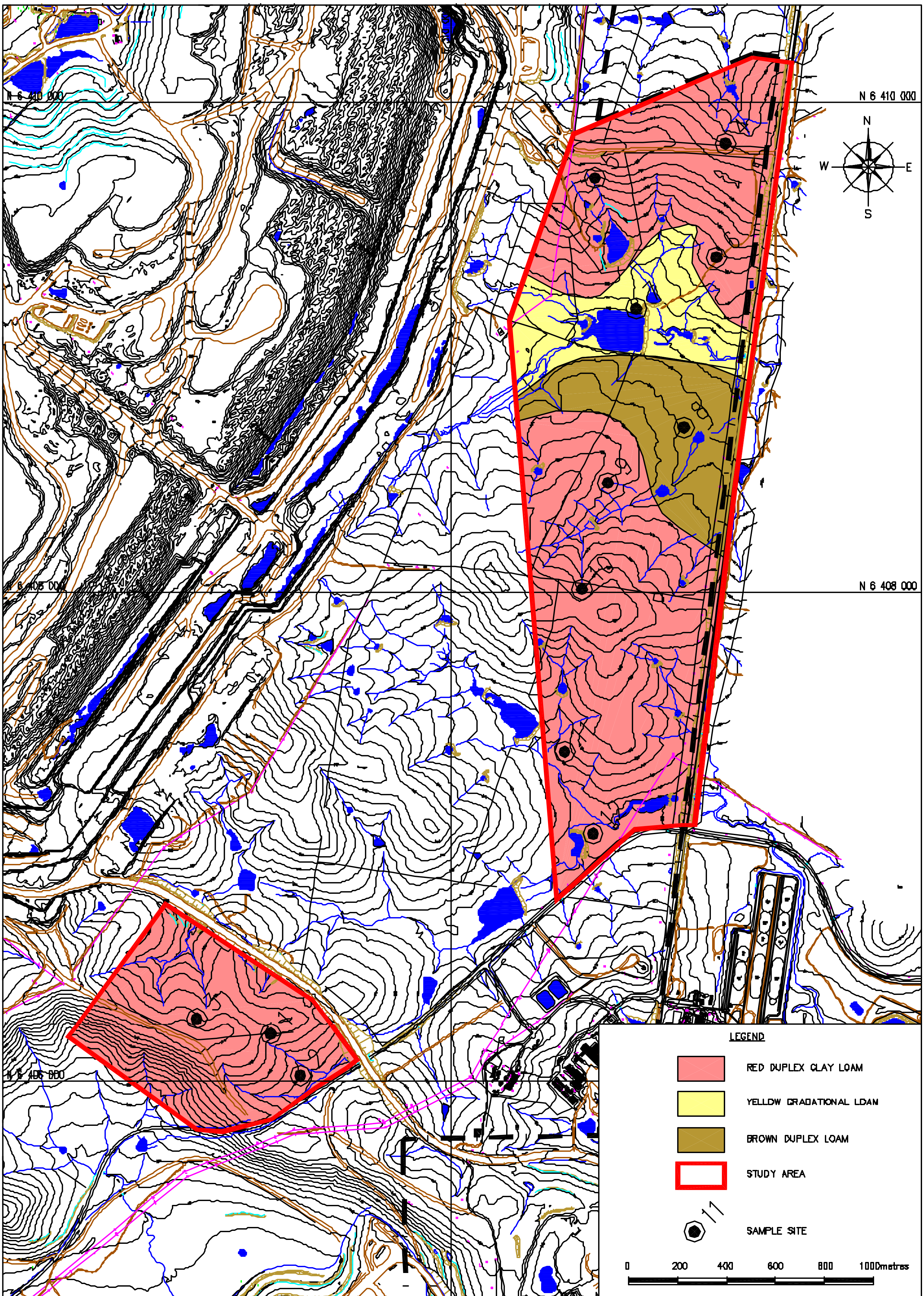
DrawingNo.CNA4-1-1

LOCALITY PLAN

FIGURE1



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Project No. CNA 4-1
Drawing No. CNA 4-1-2

SOIL UNITS

FIGURE 2
SCALE 1:20,000

2.0 PROPOSAL SUMMARY

CNA propose to extend the Hunter Valley Operations (HVO), West Pit east through to the Belt Line Road. The proposal includes continuing all existing operations within West Pit for a period of approximately 21 years. The extension crosses the existing development consent boundary and therefore a new development consent is required. The mine plan also includes open cut mining in the development consent area held by Cumnock No. 1 Colliery. Mining within this area will be conducted in accordance with the conditions of development consent number DA 123-05-01.

A total of approximately 307 ha outside of existing approval limits will be required to be cleared. The vegetation in this area comprises of 242 ha of grazing land and 65 ha of regrowth woodland. The land to be affected by mining is owned by CNA. The extension covers EL5423, ML 1406 and a portion of ML1428 and CML4 that was not previously identified as land to be disturbed.

Under the proposal West Pit will continue to operate as an open cut, multi-seam dragline operation. The seams currently mined are the Broonie, Bayswater, Lemington, Pikes Gully, Arties, Liddell and Barrett seams.

3.0 METHODOLOGY

3.1 Soil Survey

3.1.1 Introduction

The soil survey was undertaken to fulfill the requirements of the Department of Urban & Transport Planning (DUTP), the Department of Mineral Resources (DMR) and the Department of Sustainable Natural Resources (DSNR). Specifically, the soil survey was conducted in a manner which complies with DSNR's *"Specifications for Soil Surveys to Determine the Stripping Depths of Soil Material to be Removed and Used in Association with the Rehabilitation of Land Disturbed during the Period of the Open Cut Approval".*

The broad objective of the survey is to qualify the reserves of suitable topdressing material to assist planning of future rehabilitation operations.

3.1.2 Mapping

An initial soil map was developed using the following resources and techniques:

(i) **Aerial photographs and topographic maps**

Aerial photo and topographic map interpretation was used as a remote sensing technique allowing detailed analysis of the landscape and mapping of features related to the distribution of soils in the area.

(ii) **Previous soil surveys**

A survey of the West Pit (formerly Howick) Lease was undertaken in 1989 by Sinclair Knight & Partners. The survey encompassed the area to the south & west of the lease.

During 1991, Kovac and Lawrie completed a soil survey of all areas contained in the Singleton 1 : 250,000 Sheet. The West Pit Lease area was included in the soil survey.

A soil and land capability survey of the study area was conducted by Veness & Associates Pty Ltd in 1995. The survey was conducted for the Howick Development Project (A72) encompassing land to the west of the study area.

(iii) **Stratified observations**

Upon drafting of mapping units, soil profile exposures were visually assessed to ascertain potential mapping units.

3.1.3 Profiling

During the 2003 GSS survey a total of 12 soil profile exposures were assessed at selected sites to enable soil profile descriptions to be made. The exposure locations were chosen to provide representative profiles of the soil types encountered over the study area. The soil layers were generally distinguished on the basis of changes in texture and/or colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994).

Soil observations were also conducted by GSS to confirm soil units and boundaries between different soils.

3.1.4 Field Assessment

Soil layers at each profile site were assessed according to a procedure devised by Elliot & Veness (1981) for the recognition of suitable topdressing materials. The system is described in ***Appendix 1***.

3.1.5 Laboratory Testing

Soil samples were taken from exposed soil profiles during the soil survey. The samples were subsequently analysed for the following parameters:

- Particle Size Analysis
- Dispersion Percentage
- Emerson Aggregate Test
- pH
- Electrical Conductivity

A description of the significance of each test and typical values for each soil characteristic are included in ***Appendix 2***.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material which is suitable for stripping and re-use for the rehabilitation of disturbed areas. The soil test results for the soil survey are provided in ***Appendix 3***.

3.2 Land Capability Survey

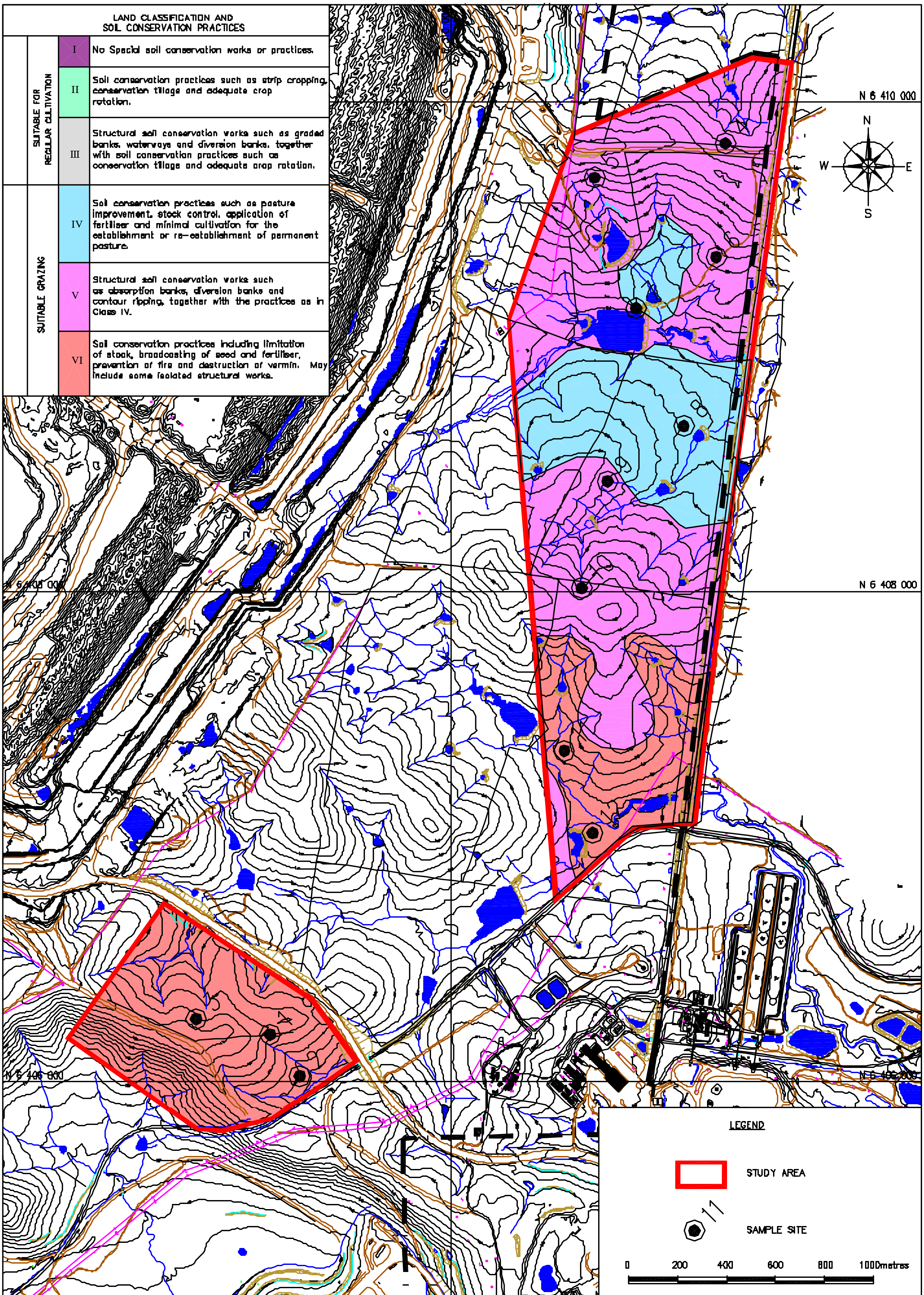
The land capability survey was conducted according to the DSNR rural land capability assessment system. The system consists of eight classes which classifies land on the basis of an increasing soil erosion hazard and decreasing versatility of use. It recognizes the following three types of land uses:

- land suitable for cultivation;
- land suitable for grazing; and
- land not suitable for rural production

These capability classifications identify the limitations to the use of the land as a result of the interaction between the physical resources and a specific land use. The principal limitation recognized by these capability classifications is the stability of the soil mantle (Soil Conservation Service, 1986).

The method of land capability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses. The classification does not necessarily reflect the existing land uses, rather it indicates the potential of the land for such uses as crop production, pasture improvement and grazing.

A summary table specifying the required soil conservation practices for each of the relevant classes is included in *Figure 3.*



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Drawing No. CNA 4-1-3

LAND CAPABILITY

FIGURE 3
SCALE 1:20,000

4.0 RESULTS

4.1 Soils

4.1.1 General

The majority of the survey area is encompassed by the “Liddell” Soil Landscape (Kovac and Lawrie, 1991).

Soil unit classifications for the GSS survey were based on the Northcote (1979) classification system.

The following soil units were identified within the proposed MOP area:

- Red Duplex Clay Loam
- Yellow Gradational Loam
- Brown Duplex Loam

The distribution of these soils is illustrated in *Figure 2*.

The red duplex clay loam dominates the extension area. The soil unit covers approximately 77% of the total study area. The soil is characterised by a greyish brown clay loam surface horizon grading to a bright reddish brown medium clay subsoil.

The yellow gradational loam is located within the major central drainage depression running west-east through the study area. The greyish brown sandy loam surface horizon grades to a dull orange loam and then to a dull reddish brown clay loam. The soil unit encompasses 11% of the study area.

The brown duplex loam is located on the footslope area south of the central drainage depression and encompasses 12% of the study area. The soil is characterised by a dark brown clay loam surface horizon and grades to a brown medium clay and a bright yellowish brown silty clay.

4.1.2 Profile Descriptions

Profile descriptions of all 12 soil profile exposures are provided in ***Appendix 4***.

The following profile descriptions are characteristics of their respective soil unit.

SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.20	Greyish brown (5 YR 4/2), slightly sticky clay loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 20-100 mm breaking to sub-angular blocky, round, granular and crumb peds <2-10 mm diameter. It has 10% rounded to angular, non-weathered, reoriented ironstone fragments 2-60 mm in size; many roots are present. The lower boundary is sharp and wavy to layer 2.
2	0.20 – 0.80	Bright reddish brown (2.5 YR 5/8), slightly to moderately sticky medium clay. It is moderately to very strongly consistent and strongly to very strongly coherent; moderately to strongly pedal with smooth-faced, dense lenticular and sub-angular blocky peds 100-500 mm breaking to angular blocky peds 2-10 mm diameter, and 10-50% cutans on ped faces. 0-20% rounded to angular non-weathered, reoriented or undisturbed ironstone pebbles to rocks 2-200 mm in size may occur; roots are few to common. The lower boundary is clear to diffuse and even to wavy to layer 3.
3	0.80 – 1.30+	White (2.5 YR 8/1) weathered sandstone, few to no roots on rock faces. The lower boundary of this horizon with the underlying, continuous mass of parent rock was not reached at depth.

SOIL UNIT: YELLOW GRADATIONAL LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.05	Greyish brown (5 YR 4/2), sandy loam. It is very weakly to strongly consistent and coherent; weakly pedal with earthy, porous, platy and round peds 5-20 mm diameter, cracks <2 mm wide. It has 0-10% stratified, non-weathered sedimentary rock fragments 2-6 mm in size; abundant roots; variable amounts of bioturbation; no concretions and inclusions. The lower boundary is sharp and wavy to layer 2.
2	0.05 – 0.35	Dull orange (7.5 YR 8/4), bleached, slightly to moderately sticky loam. It is moderately consistent and weakly coherent dry, not coherent wet: weakly pedal with earthy, porous, round and sub-angular blocky peds 20-100 mm diameter; no cutans; cracks <2 mm wide. It has <2% stone; many roots. The lower boundary is sharp and even to layer 3.
3	0.35 – 1.50+	Dull reddish brown (5 YR 5/4) moderately sticky clay loam. It is strongly consistent and coherent; moderately pedal with smooth-faced, porous and dense, lenticular, angular blocky and sub-angular blocky peds 100-200 mm breaking to angular blocky peds 2-5 mm diameter; cracks <2 mm wide. It has <2% stones; some roots of ped faces; no bioturbation; no concretions and inclusions.

SOIL UNIT: BROWN DUPLEX LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.25	Dark brown (7.5 YR 3/4), clay loam. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced, porous, sub-angular blocky peds 20-50 mm breaking to sub-angular blocky, round and granular peds 2-10 mm diameter. Many to abundant roots occur; the soil is moderately bioturbated. The lower boundary is sharp and wavy to layer 2.
2	0.25 – 0.60	Brown (7.5 YR 4/3) medium clay. It is moderately consistent and weakly coherent; weakly pedal with earthy, porous, sub-angular blocky peds 10-50 mm diameter. It has <2% stones; common to many roots in peds; much bioturbation; no concretions and inclusions. The lower boundary is sharp and wavy to layer 3.
3	0.60 – 1.40+	Bright yellowish brown (10 YR 6/6), sometimes mottled, slightly to moderately sticky silty clay. It is moderately to strongly consistent and moderately coherent; moderately pedal with smooth and rough-faced, porous, sub-angular blocky peds 50-200 mm breaking to sub-angular and angular blocky peds 5-10 mm diameter. Strongly weathered claystone occurs at about 1.0 m.

4.1.3 Laboratory Testing

All soil samples taken during the GSS survey were analysed by the Soil Conservation Services' Soil and Water Testing Laboratory at Scone, NSW. All soil analytical results are provided in ***Appendix 3***.

The red duplex clay loam unit generally grades from a clay loam texture to a contrasting medium clay subsoil. The subsurface soil is structurally weak. An alkaline trend occurs down the profile with surface pH recordings of 6.1 to 6.3. Subsurface soil pH often exceeds 9.0 and is structurally unstable (Emerson ratings of 2 and 3). The soils are non-saline.

The yellow gradational loam is texturally sound and is non-saline. An alkaline trend occurs down the profile, however, pH recordings are approximating neutral (pH 6.8 to 7.6). The surface horizon is very stable (Emerson rating of 8).

The brown duplex loam grades from a clay loam to a medium clay. The soil is structurally stable (Emerson rating of 8 to 4), however, the subsurface material is massive due to the high clay content. An alkaline trend occurs down the profile with surface soil pH being slightly acidic (pH 6.3). Subsurface soil can be very alkaline (pH 7.9). The soil unit is non-saline.

4.2 Land Capability

The survey area contains three classes of land capability; Classes IV,V and Class VI land. Class V and VI land, comprise 50% and 32% of the study area, respectively. These areas are not suitable for cultivation owing to considerable biophysical limitations such as fine textured shallow soils and relatively steep slopes. The recommended soil conservation practices for these land classifications include structural soil conservation works (Class V land) and pasture improvement, low stocking rates, fire prevention and vermin control (Class VI land).

Class IV land comprises the better classes of grazing land and whilst it is capable to cultivate for an occasional crop, it is not suitable for cultivation on a regular basis owing to limitations of slope and erosion potential. Approximately 18% of the study area is Class IV land.

Figure 3 shows the pre-mining land capability classification of the study area.

5.0 TOPDRESSING SUITABILITY

Details of the soil test results (refer ***Appendix 4***) were used in conjunction with the field assessment (refer ***Appendix 1***) to determine the depth or thickness of soil materials which are suitable for stripping and re-use for the rehabilitation of disturbed areas.

Structural and textural properties of soils within the study area are the most significant limiting factors for determination of topdressing suitability. The sub-surface horizons of the duplex soils are structurally weak and are considered not suitable for stripping, stockpiling and re-spreading as a topdressing material for reshaped overburden. Limited stripping potential (0.1m) is available on the majority of ridge and upper-slope areas. The combination of fine texture, structural weakness (high ped disruption rating) and high pH of sub-surface horizons translates to these materials being unsuitable as topdressing media. A greater depth of suitable surface horizon (0.2m) for both the red and brown duplex soils is apparent on mid-slope and footslope areas.

The yellow gradational loam unit can be stripped to a depth of 0.3m. The soil unit is texturally and structurally sound, is non-saline and generally has a near neutral pH range.

Individual volumes of available topdressing material for each recommended stripping depth are illustrated in *Table 1*. *Figure 4* delineates the respective stripping depth zones.

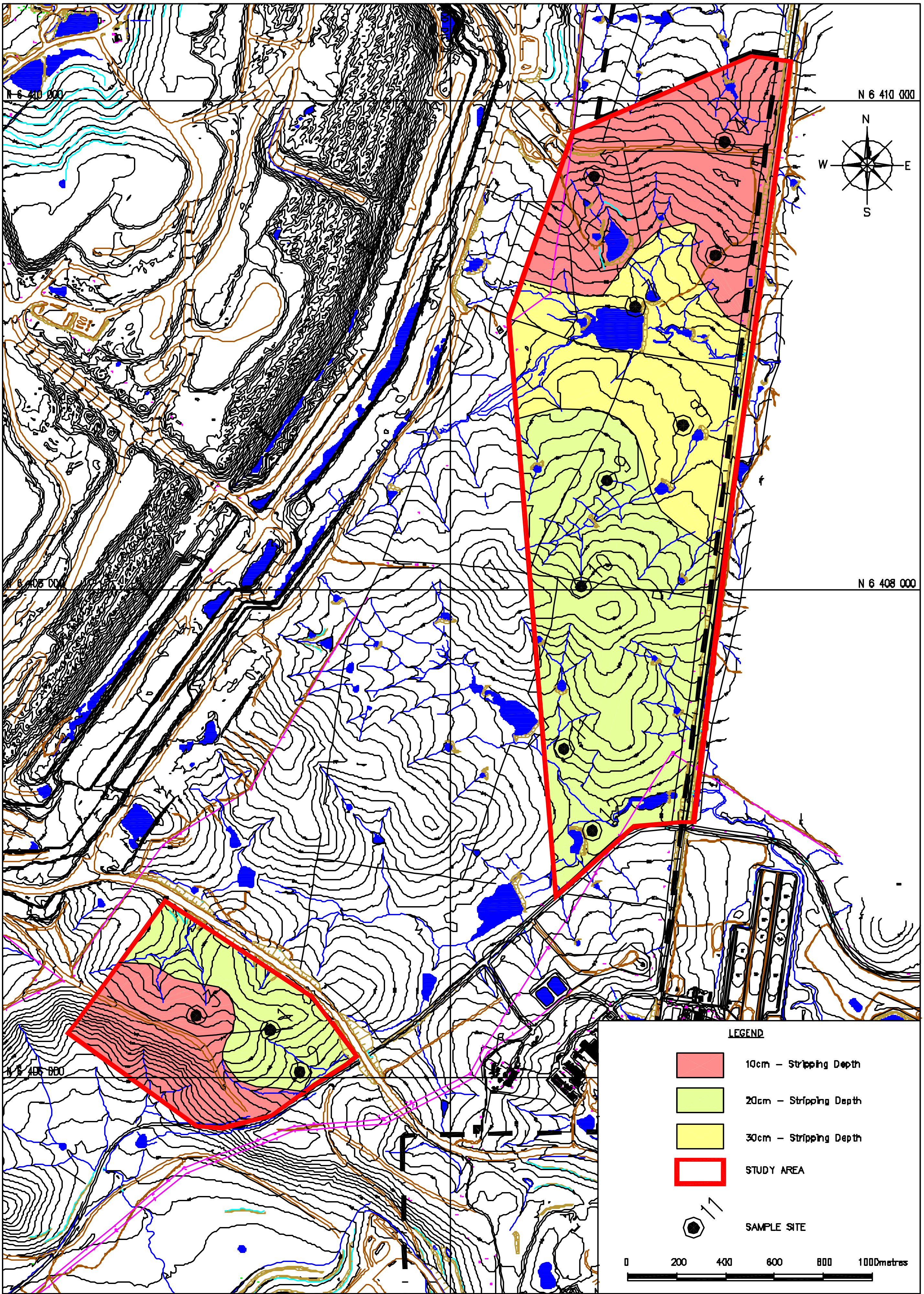
TABLE 1

TOPDRESSING AVAILABILTY

Stripping Depth (m)	Area (ha)	Volume (m^3)
0.1	99.2	99,200
0.2	138.3	276,400
0.3	69.5	208,500
TOTAL	307.0	584,100

Allowing for a 10% handling loss, some 525,690m^3 of suitable topdressing is available within the area to be disturbed. Therefore, topdressing may be placed on the post-mining landform at a theoretical average depth of 0.17m. At other Hunter Valley mines a topdressing depth of 0.1m has been found to be adequate for healthy pasture establishment on rehabilitated spoil material.

The depth of re-spread topdressing material is not critical for tree establishment.



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Project No. CNA 4-1
Drawing No. CNA 4-1-4

SOIL STRIPPING DEPTHS

FIGURE 4
SCALE 1:20,000

6.0 REFERENCES

Elliot, G.L. and Veness, R.A., 1981. Selection of Topdressing Material for Rehabilitation of Disturbed Areas in the Hunter Valley, J. Soil Cons. NSW 37 37-40

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Veness and Associates Pty Ltd, 1995. Soil Survey and Land Capability Report. Howick Development Project – A72.

APPENDIX 1

FIELD ASSESSMENT PROCEDURE

FIELD ASSESSMENT PROCEDURE

Elliott and Veness (1981) have described the basic procedure, adopted in this survey, for the recognition of suitable topdressing materials. In this procedure, the following soils factors are analysed. They are listed in decreasing order of importance.

Structure Grade

Good permeability to water and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade (Charman, 1978) and depends on the proportion of coarse peds in the soil surface.

Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils without pores are considered unsuitable as topdressing materials.

Consistence - Shearing Test

The shearing test is used as a measure of the ability of soils to maintain structure grade.

Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the extraction, transportation and spreading of topdressing material.

Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

Consistence - Disruptive Test

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates.

Mottling

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeabilities; however, some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.

Macrostructure

Refers to the combination or arrangement of the larger aggregates or peds in the soil. Where these peds are larger than 10 cm (smaller dimension) in the subsoil, soils are likely to either slake or be hardsetting and prone to surface sealing. Such soils are undesirable as topdressing materials.

Texture

Sandy soils are poorly suited to plant growth because they are extremely erodible and have low water holding capacities. For these reasons soils with textures equal to or coarser than sandy loams are considered unsuitable as topdressing materials for climates of relatively unreliable rainfall, such as the Hunter Valley.

Root Density and Root Pattern

Root abundance and root branching is a reliable indicator of the capability for propagation and stockpiling.

Field Exposure Indicators

The extent of colonisation of vegetation on exposed materials as well as the surface behavior and condition after exposure is a reliable field indicator for suitability for topdressing purposes. These layers may alternate with other layers which are unsuitable. Unsuitable materials may be included in the topdressing mixture if they are less than 15cm thick and comprise less than 30 per cent of the total volume of soil material to be used for topdressing. Where unsuitable soil materials are more than 15 cm thick they should be selectively discarded.

APPENDIX 2

SOIL INFORMATION

TEST SIGNIFICANCE AND TYPICAL VALUES

Particle Size Analysis

Particle size analysis measures the size of the soil particles in terms of grainsize fractions, and expresses the proportions of these fractions as a percentage of the sample. The grainsize fractions are:

clay	(<0.002 mm)
silt	(0.002 to 0.02 mm)
fine sand	(0.02 to 0.2 mm)
medium and coarse sand	(0.2 to 2 mm)

Particles greater than 2 mm, that is gravel and coarser material, are not included in the analysis.

Emerson Aggregate Test

Emerson aggregate test measures the susceptibility to dispersion of the soil in water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in water. The test indicates the credibility and structural stability of the soil and its susceptibility to surface sealing under irrigation and rainfall. Soils are divided into eight classes on the basis of the coherence of soil aggregates in water. The eight classes and their properties are:

Class 1	-	very dispersible soils with a high tunnel erosion susceptibility.
Class 2	-	moderately dispersible soils with some degree of tunnel erosion susceptibility.
Class 3	-	slightly or non-dispersible soils which are generally stable and suitable for soil conservation earthworks.
Class 4-6	-	more highly aggregated materials which are less likely to hold water. Special compactive efforts are required in the construction of earthworks.
Class 7-8	-	highly aggregated materials exhibiting low dispersion characteristics.

The following subdivisions within Emerson classes may be applied:

(1) slight milkiness, immediately adjacent to the aggregate
(2) obvious milkiness, less than 50% of the aggregate affected
(3) obvious milkiness, more than 50% of the aggregate affected
(4) total dispersion, leaving only sand grains.

Salinity

Salinity is measured as electrical conductivity on a 1:5 soil:water suspension to give EC (1:5). The effects of salinity levels expressed as EC at 25° (*d*S/cm), on plants are:

0 to 1	very low salinity, effects on plants mostly negligible.
1 to 2	low salinity, only yields of very sensitive crops are restricted.
greater than 2	saline soils, yields of many crops restricted.

pH

The pH is a measure of acidity and alkalinity. For 1:5 soil:water suspensions, soils having pH values less than 4.5 are regarded as strongly acid, 4.5 to 5.0 moderately acidic, and values greater than 7.0 are regarded as alkaline. Most plants grow best in slightly acidic soils.

LABORATORY TEST METHODS

Particle Size Analysis

Determination by sieving and hydrometer of percentage, by weight, of particle size classes: Gravel >2mm, Coarse Sand 0.2-2 mm, Fine Sand 0.02-0.2 mm, Silt 0.002-0.2 mm and Clay <0.002 mm SCS Standard method. Reference - Bond, R, Craze B, Rayment G, and Higginson (in press 1990) **Australia Soil and Land Survey Laboratory Handbook**, Inkata Press, Melbourne.

Emerson Aggregate Test

An eight class classification of soil aggregate coherence (slaking and dispersion) in water. SCS Standard Method closely related to Australian Standard AS1289. The degree of dispersion is included in brackets for class 2 and 3 aggregates. Reference - Bond R., Craze, B., Rayment, G., Higginson, F.R., (in press 1990). **Australian Soil and Land survey Laboratory Handbook**, Inkata Press, Melbourne.

EC

Electrical Conductivity determined on a 1:5 soil:water suspension. Prepared from the fine earth fraction of the sample. Reference - Bond R, Craze B, Rayment G, Higginson FR (in press 1990) **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

pH

Determined on a 1:5 soil:water suspension. Soil refers to the fine earth fraction of the sample. Reference - Bond, R., Craze, B., Rayment, G., Higginson, F.R. (in press 1990). **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

APPENDIX 3

SOIL TEST RESULTS

SOIL TEST REPORT

Scone Research Service Centre

REPORT NO: SCO03/007R1

REPORT TO: Rod Masters
Global Soil Systems
PO Box 675
Maitland 2320

REPORT ON: Seventeen soil samples
West Pit Extension Soil Survey

PRELIMINARY RESULTS ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 24 January, 2003

METHODS: Information on test procedures can be obtained from Scone Research Service Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED.
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL.

G Holman

G. Holman
(Technical Officer)

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

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No.: SCO03/007R1
Client Reference: Rod Masters
Global Soil Systems
PO Box 675
Maitland 2320

Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C2A/3	C1A/4
	Sample Id.	clay	silt	f.sand	c.sand	gravel	EAT	pH	EC (dS/m)
1	West Pit 2/1	33	23	34	10	<1	8/3(1)	6.3	0.06
2	West Pit 2/2	60	17	19	4	0	3(1)	6.6	0.05
3	West Pit 2/3	24	13	28	32	3	3(1)	9.3	0.23
4	West Pit 6/1	25	13	46	12	4	8/3(2)	6.2	0.09
5	West Pit 6/2	60	11	24	5	0	3(3)	7.2	0.14
6	West Pit 6/3	41	28	22	8	1	4	9.0	0.92
7	West Pit 7/1	14	7	36	35	8	8/5	6.8	0.08
8	West Pit 7/2	19	10	36	32	3	2(2)	7.6	0.08
9	West Pit 8/1	33	27	27	10	3	8/3(1)	6.3	0.05
10	West Pit 8/2	64	17	14	5	0	8/5	7.9	0.07
11	West Pit 8/3	45	34	11	5	5	4	9.2	0.15

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No.: SCO03/007R1
Client Reference: Rod Masters
Global Soil Systems
PO Box 675
Maitland 2320

Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C2A/3	C1A/4
	Sample Id.	clay	silt	f.sand	c.sand	gravel	EAT	pH	EC (dS/m)
12	West Pit 9/1	22	18	42	13	5	8/3(1)	6.3	0.11
13	West Pit 9/2	54	11	28	7	0	2(1)	6.9	0.14
14	West Pit 9/3	30	31	37	2	<1	2(3)	9.4	0.46
15	West Pit 12/1	24	18	27	14	17	8/3(1)	6.1	0.06
16	West Pit 12/2	60	14	17	9	<1	8/3(3)	6.9	0.17
17	West Pit 12/3	43	19	34	4	<1	4	9.3	0.71

G Holman

END OF TEST REPORT

APPENDIX 4

SOIL PROFILE DESCRIPTIONS

SITE 1		
SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.20	Greyish brown (5 YR 4/2), slightly sticky clay loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 20-100 mm breaking to sub-angular blocky, round, granular and crumb peds <2-10 mm diameter. It has 10% rounded to angular, non-weathered, reoriented ironstone fragments 2-60 mm in size; many roots are present. The lower boundary is sharp and wavy to layer 2:
2	0.20 – 0.80	Bright reddish brown (2.5 YR 5/8), slightly to moderately sticky medium clay. It is moderately to very strongly consistent and strongly to very strongly coherent; moderately to strongly pedal with smooth-faced, dense lenticular and sub-angular blocky peds 100-500 mm breaking to angular blocky peds 2-10 mm diameter, and 10-50% cutans on ped faces. 0-20% rounded to angular non-weathered, reoriented or undisturbed ironstone pebbles to rocks 2-200 mm in size may occur; roots are few to common. The lower boundary is clear to diffuse and even to wavy to layer 3.
3	0.80 – 1.30+	White (2.5 YR 8/1) weathered sandstone, few to no roots on rock faces. The lower boundary of this horizon with the underlying, continuous mass of parent rock was not reached at depth.

SITE 2		
SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.20	Greyish brown (5 YR 4/2), slightly sticky clay loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 20-100 mm breaking to sub-angular blocky, round, granular and crumb peds <2-10 mm diameter. It has 10% rounded to angular, non-weathered, reoriented ironstone fragments 2-60 mm in size; many roots are present. The lower boundary is sharp and wavy to layer 2:
2	0.20 – 0.80	Bright reddish brown (2.5 YR 5/8), slightly to moderately sticky medium clay. It is moderately to very strongly consistent and strongly to very strongly coherent; moderately to strongly pedal with smooth-faced, dense lenticular and sub-angular blocky peds 100-500 mm breaking to angular blocky peds 2-10 mm diameter, and 10-50% cutans on ped faces. 0-20% rounded to angular non-weathered, reoriented or undisturbed ironstone pebbles to rocks 2-200 mm in size may occur; roots are few to common. The lower boundary is clear to diffuse and even to wavy to layer 3.
3	0.80 – 1.30+	White (2.5 YR 8/1) weathered sandstone, few to no roots on rock faces. The lower boundary of this horizon with the underlying, continuous mass of parent rock was not reached at depth.

SITE 3		
SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.10	Greyish brown (5 YR 4/2), slightly sticky clay loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 20-100 mm breaking to sub-angular blocky, round, granular and crumb peds <2-10 mm diameter. It has 10% rounded to angular, non-weathered, reoriented ironstone fragments 2-60 mm in size; many roots are present. The lower boundary is sharp and wavy to layer 2:
2	0.10 – 0.85	Bright reddish brown (2.5 YR 5/8), slightly to moderately sticky medium clay. It is moderately to very strongly consistent and strongly to very strongly coherent; moderately to strongly pedal with smooth-faced, dense lenticular and sub-angular blocky peds 100-500 mm breaking to angular blocky peds 2-10 mm diameter, and 10-50% cutans on ped faces. 0-20% rounded to angular non-weathered, reoriented or undisturbed ironstone pebbles to rocks 2-200 mm in size may occur; roots are few to common. The lower boundary is clear to diffuse and even to wavy to layer 3.
3	0.85 – 1.20	White (2.5 YR 8/1) weathered sandstone, few to no roots on rock faces. Refusal at 1.2 m.

SITE 4		
SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.05	Brown (7.5 YR 4/3), clay loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 10-50 mm. Many roots are present; not much bioturbation because of the degradation of this layer. The lower boundary is sharp and wavy to layer 2:
2	0.05 – 0.30	Dull reddish brown (7.5 YR 5/4), slightly sticky medium clay. It is moderately consistent and coherent; weakly pedal with earthy to rough-faced porous sub-angular blocky peds 20-100 mm diameter. Roots are common. Small amounts of charcoal fragments occur. The lower boundary is diffuse and wavy to layer 3.
3	0.30 – 0.65	Bright brown (7.5 YR 5/6) 6/8, silty strongly weathered sandstone. Refusal at 0.65 m.

SITE 5		
SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.05	Brown (7.5 YR 4/3), clay loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 10-50 mm. Many roots are present; not much bioturbation because of the degradation of this layer. The lower boundary is sharp and wavy to layer 2:
2	0.05 – 0.40	Dull reddish brown (7.5 YR 5/4), slightly sticky medium clay. It is moderately consistent and coherent; weakly pedal with earthy to rough-faced, porous sub-angular blocky peds 20-100 mm diameter. Roots are common. Small amounts of charcoal fragments occur. The lower boundary is diffuse and wavy to layer 3.
3	0.40 – 1.00	Bright brown (7.5 YR 5/6), silty strongly weathered sandstone. Refusal at 1.0 m.

SITE 6		
SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	DEPTH (m)	DESCRIPTION
1	0 – 0.10	Greyish brown (5 YR 4/2), slightly sticky clay loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 10-50 mm. Many roots are present; not much bioturbation because of the degradation of this layer. The lower boundary is sharp and wavy to layer 2:
2	0.10 – 0.25	Dull reddish brown (7.5 YR 5/4), slightly sticky medium clay. It is moderately consistent and coherent; weakly pedal with earthy to rough-faced, porous sub-angular blocky peds 20-100 mm diameter. Roots are common. Small amounts of charcoal fragments occur. The lower boundary is diffuse and wavy to layer 3.
3	0.25 – 1.20+	Orange (5 YR 6/8) slightly sticky silty clay. It is moderately consistent and coherent; weakly to moderately pedal with rough-faced porous (few cutans), sub-angular blocky peds 50-100 mm breaking to 2-10 mm diameter. It has 20-50% rounded to angular, strongly weathered, undisturbed sandstone fragments, 2-100 mm diameter and few roots.

SITE 7		
SOIL UNIT: YELLOW GRADATIONAL LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.05	Greyish brown (5 YR 4/2), sandy loam. It is very weakly to strongly consistent and coherent; weakly pedal with earthy, porous, platy and round peds 5-20 mm diameter, cracks <2 mm wide. It has 0-10% stratified, non-weathered sedimentary rock fragments 2-6 mm in size; abundant roots; variable amounts of bioturbation; no concretions and inclusions. The lower boundary is sharp and wavy to layer 2.
2	0.05 – 0.35	Dull orange (7.5 YR 8/4), bleached, slightly to moderately sticky loam. It is moderately consistent and weakly coherent dry, not coherent wet: weakly pedal with earthy, porous, round and sub-angular blocky peds 20-100 mm diameter; no cutans; cracks <2 mm wide. It has <2% stone; many roots. The lower boundary is sharp and even to layer 3.
3	0.35 – 1.50+	Dull reddish brown (5 YR 5/4) moderately sticky clay loam. It is strongly consistent and coherent; moderately pedal with smooth-faced, porous and dense, lenticular, angular blocky and sub-angular blocky peds 100-200 mm breaking to angular blocky peds 2-5 mm diameter; cracks <2 mm wide. It has <2% stones; some roots of ped faces; no bioturbation; no concretions and inclusions.

SITE 8		
SOIL UNIT: BROWN DUPLEX LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.25	Dark brown (7.5 YR 3/4), clay loam. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced, porous, sub-angular blocky peds 20-50 mm breaking to sub-angular blocky, round and granular peds 2-10 mm diameter. Many to abundant roots occur; the soil is moderately bioturbated. The lower boundary is sharp and wavy to layer 2.
2	0.25 – 0.60	Brown (7.5 YR 4/3) medium clay. It is moderately consistent and weakly coherent; weakly pedal with earthy, porous, sub-angular blocky peds 10-50 mm diameter. It has <2% stones; common to many roots in peds; much bioturbation; no concretions and inclusions. The lower boundary is sharp and wavy to layer 3.
3	0.60 – 1.40+	Bright yellowish brown (10 YR 6/6), sometimes mottled, slightly to moderately sticky silty clay. It is moderately to strongly consistent and moderately coherent; moderately pedal with smooth and rough-faced, porous, sub-angular blocky peds 50-200 mm breaking to sub-angular and angular blocky peds 5-10 mm diameter. Strongly weathered claystone occurs at about 1.0 m.

SITE 9		
SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.20	Dark brown (7.5 YR 3/4) loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 20-80 mm breaking to sub-angular blocky, peds <5 -10 mm diameter. Many roots are present. The lower boundary is sharp and wavy to layer 2.
2	0.20 – 0.60	Reddish brown (2.5 YR 4/6), slightly to moderately sticky medium clay. It is moderately to very strongly consistent and strongly to very strongly coherent; moderately to strongly pedal with smooth-faced, dense sub-angular blocky peds 100-500 mm breaking to angular blocky peds 5-10 mm diameter. 0-20% rounded to angular non-weathered, ironstone pebbles to rocks 2-200 mm in size occur; roots are few to common. The lower boundary is clear to diffuse and even to wavy to layer 3.
3	0.60 – 1.45+	Bright brown (7.5 YR 4/6) silty clay loam. It is moderately to strongly consistent and coherent; moderately to strongly pedal with smooth-faced to rough-faced, porous and dense sub-angular blocky peds 50-500 mm breaking to mainly angular blocky peds 2-10 mm diameter. Angular, non-weathered, undisturbed sandstone fragments, 2-60 mm in size, occur; few roots are present.

SITE 10		
SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.20	Dark brown (7.5 YR 3/4) loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 20-80 mm breaking to sub-angular blocky, peds <5 -10 mm diameter. Many roots are present. The lower boundary is sharp and wavy to layer 2.
2	0.20 – 0.60	Reddish brown (2.5 YR 4/6), slightly to moderately sticky medium clay. It is moderately to very strongly consistent and strongly to very strongly coherent; moderately to strongly pedal with smooth-faced, dense sub-angular blocky peds 100-500 mm breaking to angular blocky peds 5-10 mm diameter. 0-20% rounded to angular non-weathered, ironstone pebbles to rocks 2-200 mm in size occur; roots are few to common. The lower boundary is clear to diffuse and even to wavy to layer 3.
3	0.60 – 1.60+	Bright brown (7.5 YR 4/6) silty clay loam. It is moderately to strongly consistent and coherent; moderately to strongly pedal with smooth-faced to rough-faced, porous and dense sub-angular blocky peds 50-500 mm breaking to mainly angular blocky peds 2-10 mm diameter. Angular, non-weathered, undisturbed sandstone fragments, 2-60 mm in size, occur; few roots are present.

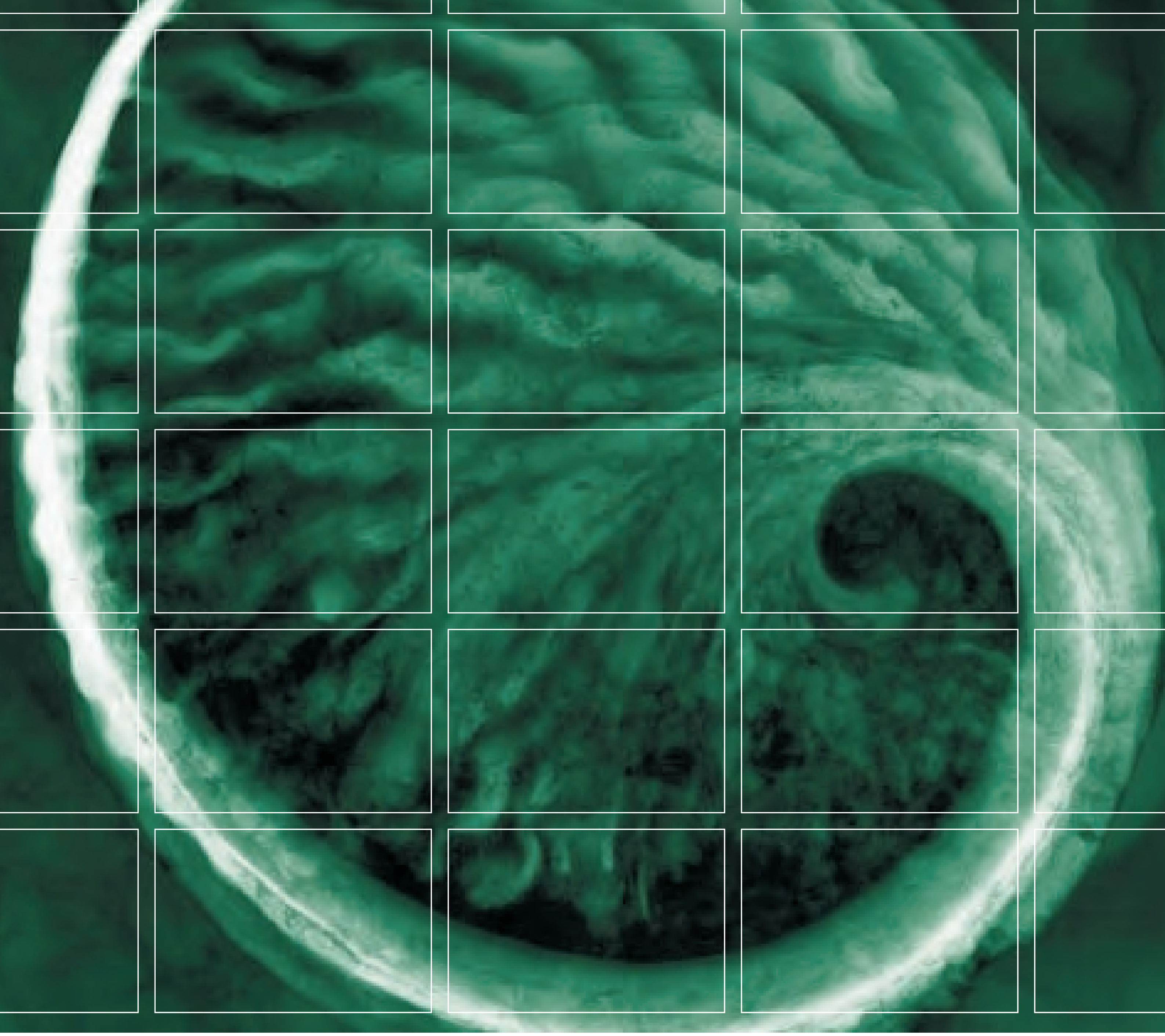
SITE 11		
SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.20	Dark brown (7.5 YR 3/4) loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 20-80 mm breaking to sub-angular blocky, peds <5 -10 mm diameter. Many roots are present. The lower boundary is sharp and wavy to layer 2.
2	0.20 – 0.50	Reddish brown (2.5 YR 4/6), slightly to moderately sticky medium clay. It is moderately to very strongly consistent and strongly to very strongly coherent; moderately to strongly pedal with smooth-faced, dense sub-angular blocky peds 100-500 mm breaking to angular blocky peds 5-10 mm diameter. 0-20% rounded to angular non-weathered, ironstone pebbles to rocks 2-200 mm in size occur; roots are few to common. The lower boundary is clear to diffuse and even to wavy to layer 3.
3	0.50 – 1.50+	Bright brown (7.5 YR 4/6) silty clay loam. It is moderately to strongly consistent and coherent; moderately to strongly pedal with smooth-faced to rough-faced, porous and dense sub-angular blocky peds 50-500 mm breaking to mainly angular blocky peds 2-10 mm diameter. Angular, non-weathered, undisturbed sandstone fragments, 2-60 mm in size, occur; few roots are present.

SITE 12		
SOIL UNIT: RED DUPLEX CLAY LOAM		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.20	Dark brown (7.5 YR 3/4) loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 20-80 mm breaking to sub-angular blocky, peds <5 -10 mm diameter. Many roots are present. The lower boundary is sharp and wavy to layer 2.
2	0.20 – 0.60	Reddish brown (2.5 YR 4/6), slightly to moderately sticky medium clay. It is moderately to very strongly consistent and strongly to very strongly coherent; moderately to strongly pedal with smooth-faced, dense sub-angular blocky peds 100-500 mm breaking to angular blocky peds 5-10 mm diameter. 0-20% rounded to angular non-weathered, ironstone pebbles to rocks 2-200 mm in size occur; roots are few to common. The lower boundary is clear to diffuse and even to wavy to layer 3.
3	0.60 – 1.45+	Bright brown (7.5 YR 4/6) silty clay loam. It is moderately to strongly consistent and coherent; moderately to strongly pedal with smooth-faced to rough-faced, porous and dense sub-angular blocky peds 50-500 mm breaking to mainly angular blocky peds 2-10 mm diameter. Angular, non-weathered, undisturbed sandstone fragments, 2-60 mm in size, occur; few roots are present.

PART G

flora and fauna study

G



Hunter Valley Operations
West Pit Extension & Minor Modifications

Flora and Fauna Study

Coal & Allied

October 2003

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ERM

Delivering sustainable solutions in a more competitive world

Approved by:	*Will Introna*
Position:	Project Manager
Signed:	Will Introna
Date:	*10 October, 2003*
Approved by:	*David Snashall*
Position:	Project Director
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Date:	*10 October, 2003*

Environmental Resources Management Australia Pty Ltd Quality System

8021185RP1V5

FINAL REPORT

Coal & Allied

Hunter Valley Operations
West Pit Extension and Minor Modifications
Flora and Fauna Study

October 2003

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1 *INTRODUCTION*

1.1 *BACKGROUND*

Environmental Resources Management Australia Pty Limited (ERM) have been commissioned by Coal & Allied (CNA) to prepare an environmental impact statement (EIS) to accompany a development application (DA) to the Minister for Infrastructure and Planning for the proposed extension of West Pit at CNA's Hunter Valley Operations (HVO) in the Upper Hunter Valley.

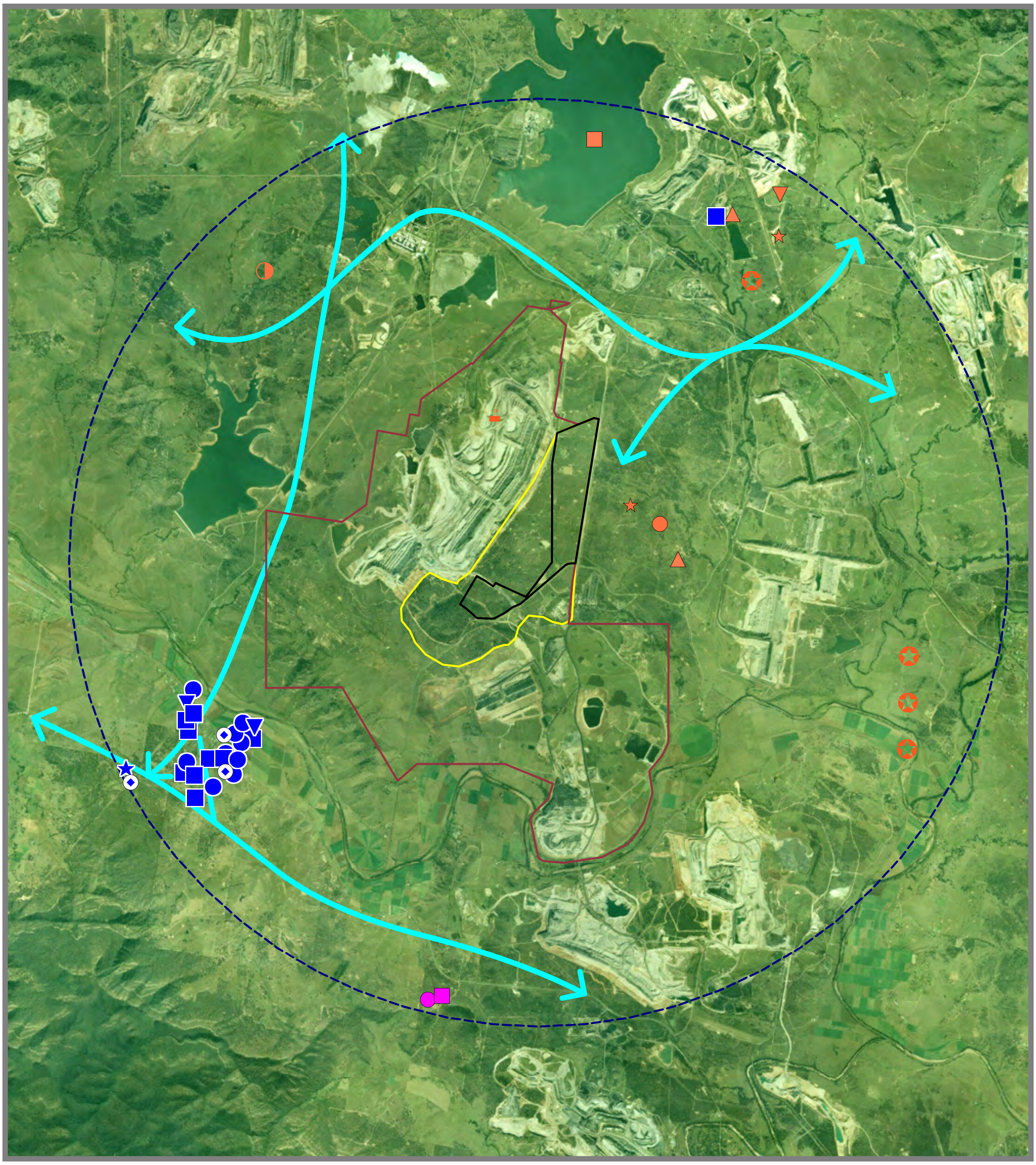
Based on current operations and rates of production at West Pit, the existing development consent boundary is expected to be intersected in mid 2004. To ensure continuity of the operation, development consent for the proposed extension is required by this date.

As part of the DA for the proposed extension, CNA will also be seeking to consolidate all of the existing approvals for HVO's activities north of the Hunter River and the approval of other activities that will enable these operations to be fully integrated.

This report provides the flora and fauna assessment for the extension of West Pit only. However, Section 6 (*Impact Amelioration Measures*) of this report provides rehabilitation strategies and plans for the entire HVO area, which includes West Pit.

A summary of this technical report and the flora and fauna issues in relation to the proposed extension and consolidation of consents for HVO is provided in Chapter 9 of the EIS.

The locality, study area and subject site in terms of flora and fauna assessment are shown in *Figure 1.1*.



ERM

2 0 2 4
Kilometres

FIGURE 1.1

The Locality

- Subject Site
- Study Area
- Locality 10km
- HVO Lease Boundary
- Potential Regional Corridor Routes

Fauna NPWS

- Falsistrellus tasmaniensis Eastern False Pipistrelle
- Miniopterus schreibersii Common Bentwing-bat
- Mormopterus norfolkensis Eastern Freetail-bat
- Myotis adversus Large-footed Myotis
- Petrogale penicillata Brush-tailed Rock-wallaby
- Phascolarctos cinereus Koala
- Pomatostomus temporalis temporalis Grey-crowned Babbler (eastern subsp.)
- Stictonetta naevosa Freckled Duck

Birds Australia

- Ardea alba Great Egret
- Ardea ibis Cattle Egret
- Hirundapus caudacutus White-throated Needletail
- Melanodryas cucullata Hooded Robin
- Pomatostomus temporalis Grey-crowned Babbler

Wambo EIS Fauna

- Climacteris picumnus Brown Treecreeper
- Petaurus norfolcensis Squirrel Glider

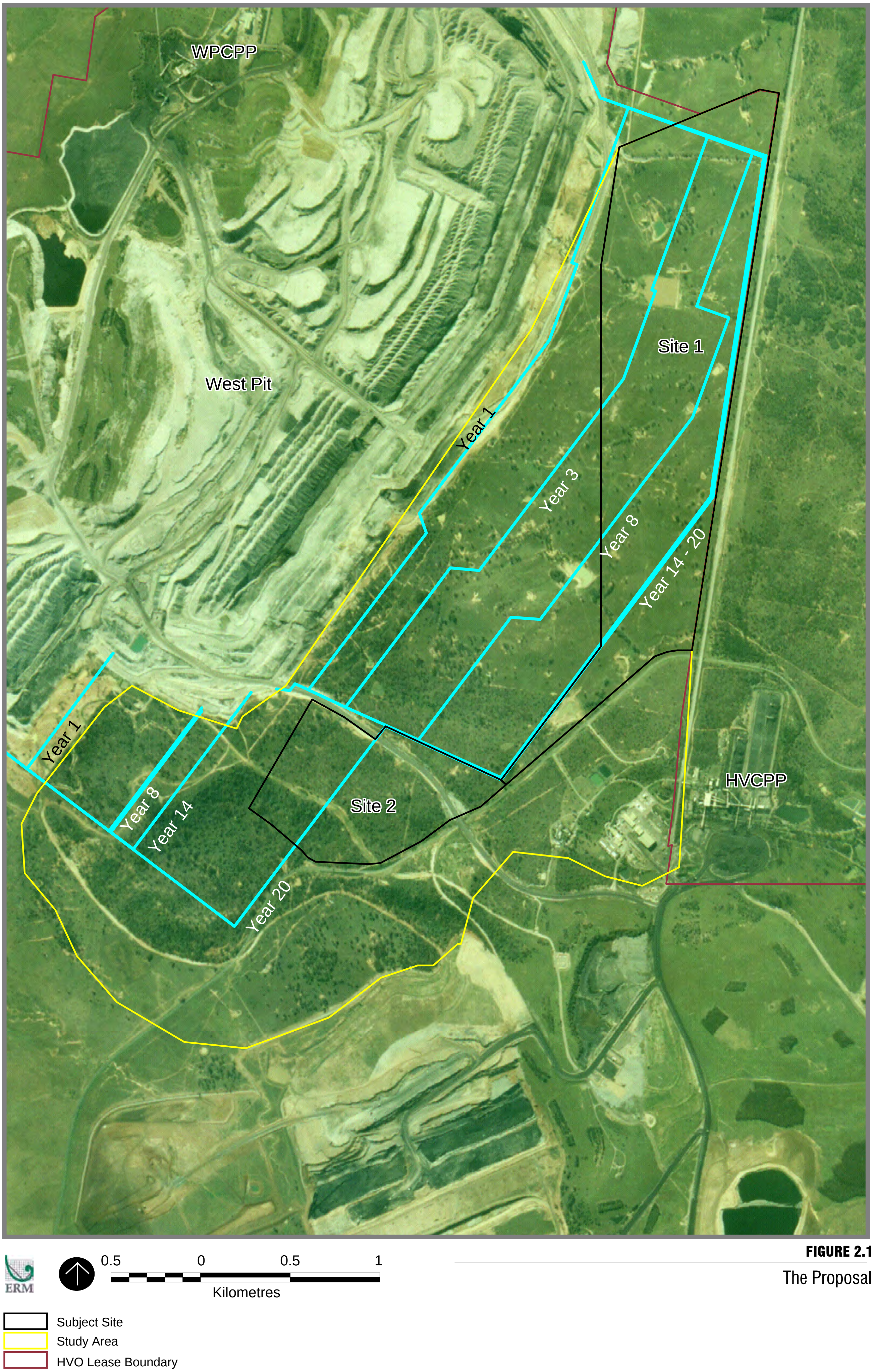


FIGURE 2.1

The Proposal

1.2 PURPOSE AND OBJECTIVES

The purpose of this report is to assess the potential impacts of the proposal on flora and fauna in sufficient detail to address the requirements of the NSW *Environmental Planning and Assessment Act 1979* (*EP&A Act*) and the Department of Infrastructure, Planning and Natural Resource's (DIPNR's) Director-General's requirements for the EIS.

The assessments within this report have covered the potential impacts of the proposal on flora and fauna at local, regional, state, national and international levels.

The key objectives of this report were to:

- describe and map vegetation communities and habitats that may be directly or indirectly affected by the proposal;
- assess the significance of flora and fauna in the study area in a local, regional, state, national or international context, including the significance of habitat corridors and linkages in the study area;
- assess the potential direct and indirect impact on this flora and fauna;
- identify and describe the threatened species and communities known or likely to be present in the study area and assess which species or communities may be affected by the proposal;
- assess the potential affect of the proposal on flora and fauna, including threatened species; and
- describe and assess measures to minimise the impact of the proposal on flora and fauna, especially threatened species, and to enhance their survival in the study area.

1.3 DEFINITION OF KEY WORDS

Definitions of key words used in this report are as follows:

- *Development* has the same meaning as in the *EP&A Act*;
- *Activity* has the same meaning as in the *EP&A Act*;
- *Proposal* is the mining development, activity or action proposed;
- *Subject Site* means the area directly affected by the proposal;

- *Study Area* is the subject site and any additional areas, which are likely to be affected by the proposal, either directly or indirectly. This is shown in *Figure 1.1*;

- *Locality* is the area within 10 km of the subject site;

- *Region* is the North Coast interim biogeographic region (Environment Australia 2000); and

- *Threatened species*, *populations* and *communities* refers to species, populations and communities listed as threatened under the NSW *Threatened Species Conservation Act 1995* (*TSC Act*) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*).

1.4 LEGISLATIVE REQUIREMENTS

1.4.1 Commonwealth Legislation

The *EPBC Act* commenced on 16 July 2000. It prescribes the Commonwealth's role in environmental assessment, biodiversity conservation and the management of matters of national environmental significance (NES).

Under the *EPBC Act*, any action that has, or is likely to have, a significant impact on a matter of NES, may progress only with the approval of the Commonwealth Minister for the Environment. An action is defined as a project, development, undertaking, activity (or series of activities), or alteration to any of these. Matters of NES include:

- world heritage properties;

- Ramsar wetlands of international importance;

- listed threatened species and communities;

- internationally protected migratory species;

- Commonwealth marine areas; and

- nuclear actions.

The proposal will not have an impact on any of the above matters of NES and as such, does not require approval under the *EPBC Act*.

1.4.2 State Legislation

Requirement for Development Consent

Due to the development consent requirements for coal mines within the Rural 1(a) zones under the *Singleton Local Environmental Plan 1996* (*Singleton LEP*) and the *Muswellbrook Local Environmental Plan 1996* (*Muswellbrook LEP*), Part 4 (known as development assessment) of the *EP&A Act* applies to the proposal.

State Significant Development

The proposal is classified as State significant development as it will employ more that 100 persons on a full-time basis.

Under the provisions of the *EP&A Act*, the Minister for Infrastructure and Planning is the consent authority for State significant development. As such, the DA will be submitted to DIPNR for assessment prior to the Minister making his decision.

Designated Development

The proposal will process more than 500 tonne of coal per day and will, over the life of the proposed operations, disturb more than 4 ha of land. Accordingly, the proposal is classified as designated development under Schedule 3 of the *Environmental Planning and Assessment Regulation 2000* (*EP&A Regulation*).

Requirement to Prepare an EIS

The proposed extension to West Pit and additional activities would be assessed in accordance with the framework established by the *EP&A Act*, the *EP&A Regulation* and the *TSC Act*.

Division 4 of the *EP&A Regulation* provides general requirements for EISs, including what an EIS must contain and the need to obtain the requirements of the Director-General of DIPNR concerning the preparation of an EIS. In terms of obtaining Director-General requirements, the *EP&A Regulation* states that the applicant responsible for preparing an EIS must consult with the Director-General and, in completing the EIS, must have regard to the Director-General's requirements. In the case of integrated development, the Director-General must request each relevant approval body to provide the Director-General with that approval body's requirements. Director-General requirements were issued by the Director-General on 13 May 2003.

Species Impact Statements

Pursuant to the *EP&A Act*, a DA in respect of development on land that is, or is part of, critical habitat or is likely to significantly affect threatened species, populations or ecological communities, or their habitats, must be accompanied by a Species Impact Statement (SIS).

The assessment of likely impacts involves assessments under Section 5A of the *EP&A Act* (the Eight Part Test). Based on the results of the Eight Part Test an opinion is provided on the likelihood that a SIS (defined under the *TSC Act*) would be required.

The Minister for Infrastructure and Planning is the consent authority that makes a decision as to whether there is likely to be a significant impact on threatened species and therefore whether an SIS would be required. A copy of the Eight Part Tests was submitted to DIPNR prior to lodgment of this EIS. Following their review of the Eight Part Tests, DIPNR confirmed that an SIS was not required to be prepared for the proposal.

1.5 *STRUCTURE OF REPORT*

The remainder of this report is organised as follows:

- Section 2 provides information about the proposal;
- Section 3 describes the assessment methodology for flora and fauna assessment including flora and fauna surveys and targeted surveys for threatened species that were conducted in the study area;
- Section 4 presents the results of the flora and fauna assessment including information about the significance of flora and fauna of the locality, study area and the subject site and results of the targeted flora and fauna surveys;
- Section 5 assesses the likely impacts of the proposal on flora and fauna;
- Section 6 recommends impact amelioration measures including rehabilitation measures for the HVO north of the Hunter River; and
- Section 7 provides a conclusion to this report.

A number of Annexures provide additional information and these are:

- *Annex A* provides lists of species recorded during surveys for this project;
- *Annex B* provides vegetation community descriptions that have been mapped on the subject site;
- *Annex C* provides profiles of threatened species;
- *Annex D* provides Eight Part Test assessments for each threatened species that has potential to be affected by the proposal;
- *Annex E* provides survey AMG coordinates;
- *Annex F* provides site photographs; and
- *Annex G* provides total areas of vegetation types in Year 0, 10, 20 and 30 for the subject site, study area and HVO north of the Hunter River.

2 THE PROPOSAL

2.1 *EXTENSION OF WEST PIT*

Current operations at West Pit were approved by the then Minister for Planning in 1996 for the production of 12 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal by both dragline and truck and shovel operations. Based on current mining rates, the existing development consent boundary established in the 1996 consent is expected to be intersected by mid 2004. To ensure continuity of the operation, a new consent for the proposed extension is required by this date.

HVO's activities north of the Hunter River are covered by 18 separate approvals, which have resulted from the acquisition of assets, including West Pit and the expansion of the operation since its conception in 1979.

The proposed extension of West Pit provides a good opportunity to restructure and rationalise the approvals for HVO north of the Hunter River so that the operation is fully integrated ensuring the opportunity for best practice environmental controls and management.

The extension proposes mining within Mining Lease 1406 (ML 1406), as well as Exploration Licence 5243 (EL 5243) for which a new mining lease is required. The pit will continue to operate as a multi-seam open cut pit operating 24 hours a day, seven days a week.

2.2 *MINE PLAN*

Because of the timing of mine operations and existing consents, in terms of flora and fauna, the proposal involves impact assessment of mining of two separate locations. These locations are Site 1 and Site 2 and together they make up the subject site (*Figure 2.1*).

Site 1 is located to the east of the existing pit and covers the proposed extension area. It is currently used for cattle grazing and contains cleared pasture and scattered trees, including a small patch of regrowth woodland that has been fenced off and has probably experience a less intensive grazing regime.

Site 2 is located immediately south of the existing pit. It is part of a larger area of remnant woodland that has retained more mature trees and is more steeply sloping than Site 1. This site supports a shrubby and grassy understorey and has experienced a lower intensity of grazing, which has resulted in woodland regrowth. Disturbed areas such as tracks, dirt roads and fencelines support introduced shrubs, grasses and herbs.

Figure 2.1 shows the proposed mining schedule. Mining in the northern section of Site 1 would commence at Year 1. Because of the direction of mining operations, Site 1 would be gradually mined from the north toward the south over a 20 year period.

Mining at Site 2 would commence at Year 15 and be completed at Year 20 and would be undertaken in an east west direction.

2.3 *REHABILITATION*

Rehabilitation of the overburden emplacement at West Pit is considered an integral component of the mining operations and will be conducted progressively over the life of the mine. This approach will minimise the area of disturbance at any point in time and the associated visual and dust impacts relating to unrestricted emplacement material.

The proposed mine rehabilitation schedule of West Pit and the HVO north of the Hunter River is discussed in greater detail in Section 6 of this report and summarised in Section 4 of the EIS.

2.4 *ALTERNATIVES*

Alternatives are discussed in detail in Chapter 4 of the EIS and include:

- extension of West Pit only (Alternative 1);
- consolidation of consents including the extension of West Pit (Alternative 2);
- consolidation of consents excluding the extension of West Pit (Alternative 3); and
- the 'do nothing' alternative (Alternative 4).

2.4.1 *Alternative 1*

The West Pit extension project involves the extension of West Pit into ML 1406 and EL 5243 only and would see an improvement in the efficiency of mining at West Pit. West Pit would continue as an open cut mine as coal in the extension area is in multiple seams, many of which are thin or banded. Underground mining of the extension area is not economically feasible as it would result in only a small percentage of the resource being recovered with the remainder being sterilised. Applying for the extension of West Pit only would result in an additional consent adding further complication to the existing approvals platform.

2.4.2 *Alternative 2*

The second alternative considered included the extension of West Pit, some additional activities to fully integrate West Pit into HVO and the consolidation of the existing consents within HVO north of the Hunter River into a single consent. This option would increase the flexibility of operations within HVO north of the Hunter River by allowing ROM coal, overburden, and reject to be transported between any mining area and any CPP within HVO. In addition, the consolidation of consents would streamline the administration of the approvals for both CNA and the consent authority.

2.4.3 *Alternative 3*

The third alternative considered included the consolidation of consents and minor modifications without the extension of West Pit. This alternative would have all the benefits associated with the consolidation as outlined above while maintaining an inefficient mine plan within West Pit. In addition, mining at West Pit and within HVO north of the Hunter River would finish eight years earlier than with the proposed extension.

2.4.4 *Alternative 4*

Were none of the above alternatives adopted, West Pit would continue to operate until 2017 under the 1996 approval and mine plan design. There would be no improvement in the efficiency of mining and HVO north of the Hunter River would not become an efficiently integrated operation. Consent authorities and CNA would continue to have 18 approvals to administer.

3 ASSESSMENT METHODOLOGY

3.1 INTRODUCTION

An EIS must assess the likely impacts of a proposed development on flora and fauna, including threatened species. In order to do this, information must be obtained about the distribution and abundance of such biota in the study area and their significance in the local, regional, state, national and international context. This information typically comes from both published and unpublished information in reports and databases, and from flora and fauna surveys including surveys targeted at specific species.

Field surveys were undertaken within the study area in October, November and December 2002, and January and February 2003. These were designed to map and describe the vegetation communities and habitats and target threatened flora and fauna that may be directly or indirectly affected by the proposal so that potential impacts on flora and fauna could be assessed.

To comply with the legal requirements of an EIS, targeted surveys must:

- use appropriate methods to detect the target species;
- be conducted during appropriate weather conditions to ensure detection of target species if they are present; and
- be conducted by suitably qualified personnel, as detection of some threatened species is specialised and difficult to achieve.

This section provides a summary of the surveys methods used and the total survey effort for flora and fauna. The surveys have been conducted by suitably qualified personnel with extensive knowledge of flora and fauna assessment. Appropriate methods were used and surveys were generally conducted during suitable weather conditions. Where suitable weather conditions did not occur, the precautionary approach was adopted, which assumed that the targeted species could occur on the site.

Flora and fauna survey techniques are described below. Flora and fauna survey effort is provided in Section *3.12.*

3.2 FLORA AND FAUNA SURVEYS

An initial vegetation assessment and targeted search for threatened plants was undertaken over one day in October 2002. A five day and four night general field survey and targeted surveys for threatened species and communities were undertaken in November 2002. Supplementary vegetation surveys were undertaken in December 2002, January 2003 and February 2003. The survey locations are shown on *Figure 3.1*.

Director-General's requirements for the EIS were received from DIPNR on 13 May 2003. Surveys were commenced prior to Director-General requirements being received so that they could take advantage of the appropriate conditions during spring and summer.

The five day and four night general and targeted surveys were undertaken in November 2002 to increase the likelihood of detecting species that have potential to occur on the subject site. However, because of drought conditions in 2002/2003, the summer was particularly dry and hot. There were no optimum weather conditions to survey for some plants (eg. some orchids, herbs and grasses may not have been visible because of dry conditions) and amphibians (eg. the Green and Golden Bell Frog may not have utilised dams for breeding because of dry conditions).

Therefore, to enable completion of the EIS studies within the time frame available, this report has assumed the presence of such species where potential habitats occur. This has enabled the formulation of mitigation measures for such species as a precautionary measure.

3.3 *IDENTIFICATION OF THREATENED SPECIES, POPULATIONS AND COMMUNITIES*

A large number of species and plant communities occur in the locality but only a subset of these are likely to be impacted by the proposal. The Director-General's requirements (including advice from government agencies to DIPNR) listed some species and communities to be considered for inclusion in this assessment.

This information was used in conjunction with database searches, literature reviews, vegetation maps, habitat assessment, flora and fauna surveys and known habitat requirements to identify which species, populations or communities are likely to be affected by the proposal.

A number of these species included threatened species that have the potential to occur within vegetation communities and habitats identified on the subject site but were not recorded during targeted surveys for a number of reasons. This may be due to time constraints, the season in which surveys were conducted or because such species are cryptic and unlikely to be detected unless extensive surveys are undertaken over a number of years and in excellent weather conditions.

A list of species and communities that may be affected is provided in *Table 4.2 (*Section 4).

3.4 *LITERATURE REVIEW*

Various sources of published information and data are available on threatened flora and fauna and their conservation significance. These references are cited in the text where appropriate and provided in the reference list at the end of the report. However, relatively few flora and fauna studies have been undertaken within the study area. Key studies that have been reviewed and utilised in the preparation of the EIS include:

- Peake T (2000) The vegetation of the mid-Hunter Valley: what state is it in currently? In: **Vegetation Management and Biodiversity Conservation – Hunter Region**. Proceedings of a workshop held in May 2000 organised by the Hunter Environment Lobby Inc. (Ed. M Falding) pp 4-18;

- AMBS (1995a) **Novacoal Howick Mine Extension Project Stage 1 Flora and Fauna Investigations**. Prepared for Novacoal Australia Pty Ltd;

- AMBS (1995b) **Novacoal Howick Mine Extension Project Flora and Fauna Investigations: Addendum.** Prepared for Novacoal Australia Pty Ltd;

- ERM Mitchell McCotter (1997) **Extension of Mining Operations at Ravensworth Mine Environmental Impact Statement.** Prepared for Peabody;

- HLA-Envirosciences (1996) **Environmental Impact Statement for Cumnock No. 1 Colliery Expansion.** Prepared for Cumnock No. 1 Colliery Pty Limited;

- HLA-Envirosciences (2001) **Cumnock No. 1 Colliery Pty Ltd Mine Life Extension Environmental Impact Statement.** Prepared for Cumnock No. 1 Colliery Pty Limited;

- Reid J R W (1999a) **Threatened and Declining Birds in the New South Wales Sheep-wheat Belt: I. Diagnosis, Characteristics and Management.** Unpublished report prepared for NPWS;

- Reid J R W (1999b) **Threatened and Declining Birds in the New South Wales Sheep-wheat Belt: II. Landscape Relationships – Modelling Bird Atlas Data Against Vegetation Cover**. Unpublished report prepared for NPWS; and

- EPA (2002) **Green Offsets for Sustainable Development Concept Paper. For Public Consultation.** Prepared by NSW EPA, NSW Department of Land and Water Conservation, NPWS and PlanningNSW.

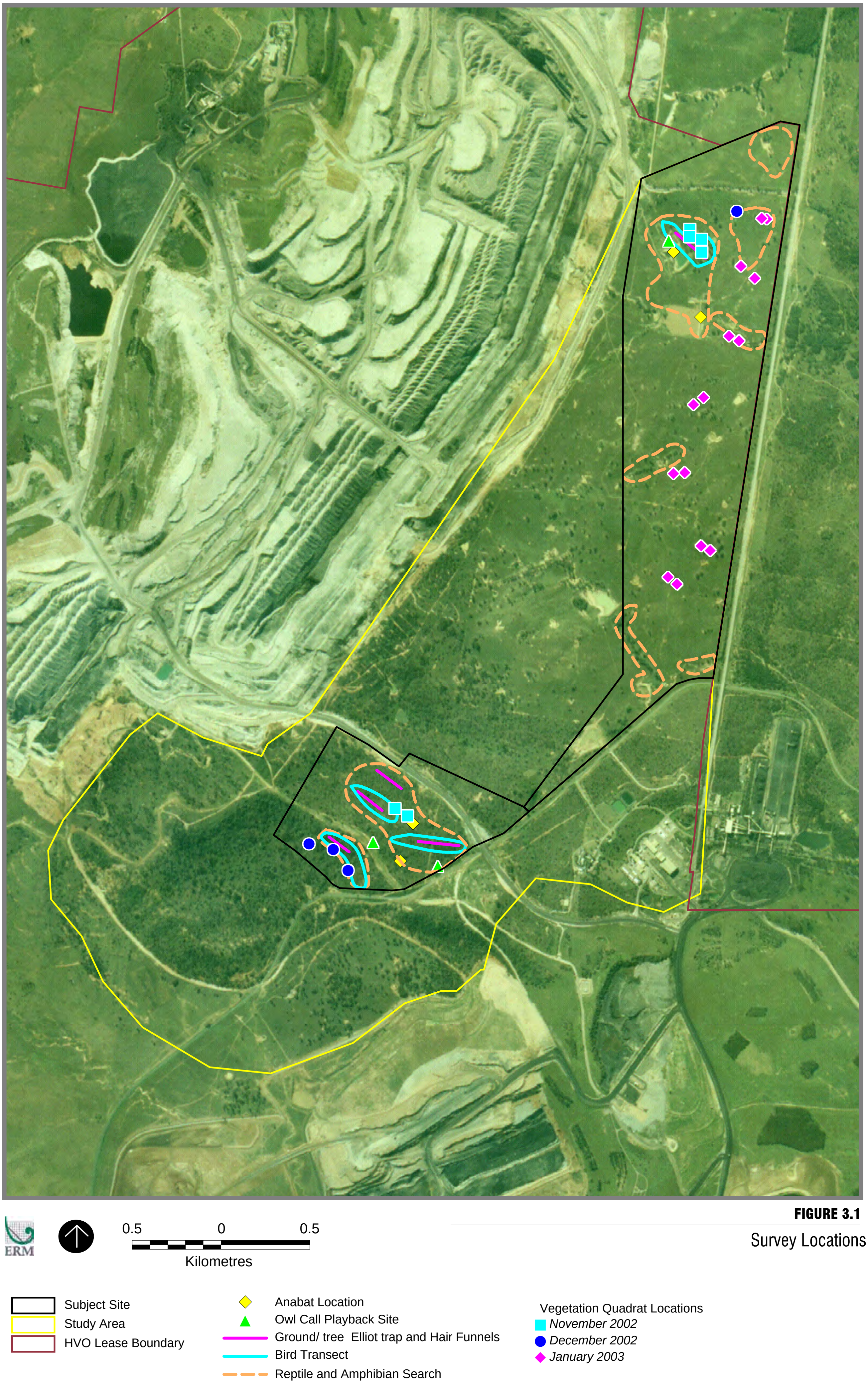


FIGURE 3.1

Survey Locations

3.5 *DATABASE SEARCHES*

Various databases were used to obtain records of significant species and matters of NES within the locality. These include:

- NPWS Wildlife Atlas databases for threatened species listed under the *TSC Act* for the locality;
- Environment Australia online map search for matters of NES listed under the *EPBC Act* that may occur in the locality;
- Birds Australia New Atlas of Australian Birds database for the locality; and
- Annual Bird Reports of the Hunter Region of New South Wales produced by the Hunter Bird Observers Club.

There were no records within the locality from the Australian Museum or Sydney Royal Botanic Gardens databases.

All flora and fauna database records were plotted using a geographic information system and were analysed to determine the likelihood that threatened flora and fauna could occur within habitats on the subject site. The analysis entailed assessment of dates, source reliability and numbers of records to assess the accuracy and current relevance to the subject site. The location of recorded threatened species from the database review are shown in *Figure 1.1*.

3.6 *MAPPING AND INTERPRETATION OF DATA*

The geographic information system, *MapInfo* (Version 5), was an important tool used to map and interpret data in this report. Vegetation communities and available subject species records were plotted on geo-referenced aerial photographs and other maps at scales ranging from 1:16 000 to 1:100 000. Scale plans of the proposal were then overlaid to provide an indication of the plant communities and habitats to be directly and indirectly impacted by the proposal. *MapInfo* was then used to calculate areas and percentages of plant communities and other habitats to be cleared within the study area.

Source material that was used to create the maps in this report and the EIS includes the draft vegetation mapping undertaken by the Hunter Catchment Management Trust (HCMT) as part of the Hunter Remnant Vegetation Project (HRVP), which aimed to map the vegetation on the floor of the mid-Hunter Valley (Peake 2000). Due to confidentiality requirements and timing of the HRVP, only draft vegetation maps of the study area were available at the time of EIS preparation.

The HCMT data included the height and two dominant canopy species of each vegetation type, ground-truthing reliability (ie. mapped, seen from nearby or walked through), presence or absences of understorey, form (tree or shrub), density and other identification of other dominant canopy species.

The identification and mapping of vegetation and habitat in the study area has been based on the HCMT draft vegetation maps, which have been verified and updated by examination of recent colour aerial photographs (2003) and detailed flora surveys undertaken for this EIS. A greater level of assessment was undertaken on the subject site. In the remainder of the study area, the ground-truthing of vegetation communities were based on information provided by HCMT (Peake 2000) and visual assessments, where possible. Other source material included digital contours and engineering plans of the study area from studies undertaken for the proposal.

The methods used to map ecological data have some important limitations that should be understood when interpreting results. These are explained below.

The database records for subject species that were used for plotting by the *MapInfo* program varied in quality, reliability and the accuracy of the geographic co-ordinates. Therefore, some species records are highly accurate in space and time, others are more tentative or only contain estimates of the geographic co-ordinates of the locality. For instance, records from the NPWS database have an accuracy of 1 km and the co-ordinates provided to ERM are of the south west corner of each 1 km grid.

Records of the distribution and abundance of subject species in the locality, as indicated by atlas databases and other sources of information are not exhaustive and are likely to be influenced by survey quality and effort.

3.7 OCTOBER 2002 SURVEY

A one-day site visit and targeted plant search was undertaken on the subject by one ecologist on 23 October 2002. The purpose was to undertake a preliminary inspection of the flora and fauna so that general and targeted surveys could be scoped, and to search for the following threatened species during their flowering period:

- Illawarra Greenhood Orchid (*Pterostylis gibbosa*) – flowers between August and November (Bishop 2000);
- Slaty Red Gum (*Eucalyptus glaucina*) – flowers from September to November (Brooker and Kleinig 1999); and
- *Diuris tricolor* – flowers between September and November (Bishop 2000).

The survey entailed random meander searches in potential habitat in the Sites 1 and 2 by one ecologist for 5 hours on 23 October (*Figure 3.1*). The total survey effort of targeted searches for these species was 5 person hours.

Habitat assessment included making notes on the vegetation layers and dominant species.

3.8 *NOVEMBER 2002 SURVEY*

This survey was conducted from 18-22 November 2002. The purpose was to map and describe the flora and fauna across the subject site and assess the significance at a local, regional, state, national or (if relevant) international level.

November 2002 surveys included targeted and general flora surveys, ground Elliott trapping, tree Elliott trapping, ground hair funnels, spotlighting, ultrasonic bat detection, bird transect surveys, owl and frog call playback and active reptile and amphibian searches. These are described below.

3.8.1 *General Flora*

Vegetation communities within the site were identified and mapped using aerial photographs and quadrat-based field surveys.

Locations of quadrats (vegetation sample areas) were identified by driving and walking through the site, considering the data obtained in November 2002 and examining aerial photographs. Six randomly chosen 20 m by 20 m quadrats were ultimately placed within representative locations in broad vegetation communities (Walker and Hopkins 1990) (*Figure 3.1*).

All vascular plant species within the quadrats were identified and recorded together with the height and percentage cover of the dominant species within each structural layer. Random meander searches were conducted in each of the communities to record any additional species that did not fall within the quadrats.

Vegetation communities were classified and named according to height, percentage cover and dominant species (Specht 1981). Plant species names follow Harden (1992, 1993, 2000 and 2002) or for more recent names, these were provided by the Sydney Royal Botanic Gardens. Species that could not to be identified in the field were retained for later identification by the National Herbarium at the Sydney Royal Botanic Gardens.

3.8.2 *Threatened or Significant Flora Species*

The likelihood of threatened or significant flora occurring on the subject site was determined by consideration of the type and condition of vegetation and habitats on the site and analysis of database records.

Threatened species considered to have potential to occur on the site and for which targeted surveys were conducted include Lobed Blue-grass

(*Bothriochloa biloba*), Slaty Red Gum (*Eucalyptus glaucina*), Illawarra Greenhood Orchid (*Pterostylis gibbosa*), *Diuris tricolor*, Narrow Goodenia (*Goodenia macbarroni*), Basalt Peppercress (*Lepidium hyssopifolium*), *Persoonia pauciflora* and Austral Toadflax (*Thesium australe*) and *Swainsona sericea* (the habitat requirements and likelihood of these species occurring are detailed in *Table 4.2*).

Targeted surveys for both threatened and significant species were incorporated into quadrat surveys, including random meander searches in the subject site to detect any species that did not fall within the quadrats. Slaty Red Gum and *Persoonia pauciflora* were also searched for when walking and driving between sites.

Samples of any potential threatened species were collected and pressed for identification by the Sydney Royal Botanic Gardens.

3.8.3 Threatened or Significant Flora Communities

The likelihood of threatened or significant flora communities occurring on the subject site was assessed by reviewing the vegetation and habitats on the site and by consideration of published data about such communities.

This involved searching for the dominant tree species including White Box (*Eucalyptus albens*), Yellow Box (*Eucalyptus melliodora*) and Blakely's Red Gum (*Eucalyptus blakelyi*). These searches were incorporated into the general flora surveys described above. The presence or absence of significant endangered ecological communities on the subject site was also assessed by analysis of quadrat data and also by later assessments in February 2003 (see Section *3.11*).

The potential for the endangered woodland communities *White Box Yellow Box Blakely's Red Gum Woodland* and *Grassy White Box Woodlands* to occur on the subject site was assessed by comparing data collected during these studies with the description of this community in the Final Determination of the NSW Scientific Committee. These communities will hereafter be referred to as Box-Gum Woodland (NPWS 2002a).

3.8.4 Habitat Types

Habitat Assessment

Vegetation maps were used to identify and assess the distribution of habitat types within the site. Microhabitat diversity for native fauna was also assessed within vegetation quadrats and during traverses of the subject site by documenting the following habitat characteristics:

- the presence of nesting/shelter sites such as tree hollows, litter, fallen timber, hollows logs, decorticating bark and rocks;

- cover abundance of ground, shrub and canopy layers and flowering characteristics of shrubs and trees;
- emergent vegetation within and around waterbodies and the presence of free water;
- rocks and basking sites for reptiles; and
- the extent and nature of previous disturbances.

Habitat Usage

Habitat usage by fauna was documented through analysis of tracks, scats, diggings and other traces. Traces of threatened and significant species that may occur, in particular owls, Koalas (*Phascolarctos cinereus*) and Spotted-tailed Quoll (*Dasyurus maculatus*), were the focus of these surveys. Surveys were conducted during the entire survey period and included;

- searches for owl pellets and other scats;
- searches for raptor nests;
- searches for tracks and diggings;
- road kills; and
- other indicators such as scratches on trees and animal pathways (runways).

3.8.5 General, Significant and Threatened Fauna

Prior to undertaking the fauna surveys, an assessment of the known and potential fauna assemblages of the site was made based on database records, previous reports, habitat mapping during October 2002 and habitat requirements of native fauna species.

The aim of the fauna surveys was to identify fauna assemblages and provide information about the distribution and abundance of fauna on the site, including threatened or significant species.

Survey effort was focused in areas of the site that was most likely to be impacted by the project. *Figure 3.1* shows the location and type of fauna surveys.

Fauna survey techniques included the use of hair funnels and ground A-size Elliott traps, tree B-size Elliot traps, ultrasonic detection of bats, owl and frog call playback, spotlighting for mammals, wandering transect censuses for birds, acoustic detection of frogs and reptile searches. These are described below.

Ground Elliott Traps and Ground Hair Funnels

One hundred Elliott traps were baited with peanut butter, honey and rolled oats and placed in the field along five transects (lines of traps) within the subject site. They consisted of 20 traps placed at intervals of 10 m on the ground per transect. The total number of Elliott trap nights was 400 (where one 'trap night' is defined as one trap set for one night).

One hundred *Faunatech* hair funnels were placed alongside the Elliott traps and left in the field for 21 nights. The total number of hair funnel 'trap' nights was 2,100. Bait was a mixture of peanut butter, honey and rolled oats. Hairs collected by the hair funnels were sent to Barbara Triggs at 'Dead Finish' for identification.

Elliott Tree-trapping

One 100 m long Elliot tree-trapping transect was located at each ground Elliott trap transect. Each transect consisted of ten B-size Elliott traps at 20 m intervals along the transect, or where there was a large tree. They were placed on brackets on the trees between 1.5 to 2 m high on the western side of the trunk.

Traps were baited with a mixture of rolled oats, peanut butter, honey and vanilla essence. Traps were checked each morning. The total number of Elliott tree-trap nights was 200.

Bird Transect Census

All bird species observed or heard during the survey periods were noted. Bird identification was also undertaken along four wandering transects on the subject site each morning and all birds seen or heard over a 30 minute period were recorded. Wandering transect surveys were undertaken each morning between 8:00 am and 10:00 am. Birds were also surveyed at dusk each night at various locations such as the large dam in the north of the subject site and creeklines (*Figure 3.1*).

Bat Detection

Two Anabat detectors (using a delay switch) were used over four nights from dawn to dusk each night. Two different sites were surveyed by one detector each at the same time for two nights. Therefore, four different Anabat sites within the subject site were surveyed for two nights.

Anabat detectors were signal activated and recorded all night and were placed in flyways where possible. Bat tapes were analysed by Glen Hoye of Fly By Night Bat Surveys Pty Ltd.

Spotlighting

Spotlighting was undertaken by two ecologists on the evenings of 18 to 22 November 2002. This activity was commenced just before, and continued for an hour after dusk, and was also undertaken after owl call playback later in the night. Spotlighting after dusk was undertaken on foot along tracks and through the woodland and along wooded drainage lines on Site 1. All fauna detected were recorded. A total of eight dedicated person hours of spotlight survey were undertaken. Other opportunistic spotlighting was undertaken when driving between sites at night and after owl call playback and during reptile searches.

Owl Call Playback

Owl call playback was undertaken at two sites on each night of the survey. The first call playback at the first site commenced between 8:00 and 9:00 pm (at Site 1) and the second call playback at the second site commenced between 10:00 and 11:00 pm (at Site 2).

Calls that were broadcast include those of the Barking Owl (*Ninox connivens*) and the Masked Owl (*Tyto novaehollandiae*). Playback involved an initial 10 minute listening period. This was followed by a 5 minute broadcast and 10 minute listening period for each species. Spotlighting for owls was undertaken at the end of this sequence.

Reptiles and Amphibians

Reptile searches were undertaken in different locations on the subject site over four nights from 18 to 22 November, and also included opportunistic searches while spotlighting and at different times during the day.

Each dedicated site was surveyed by two ecologists for at least 40 minutes between 9:30 and 10:30 pm. Surveys involved active searching under debris, leaf litter, logs, rocks, ant nests, on the trunks of trees, underneath decorticating bark of large ironbarks and stags and under logs and branches in windrows.

Opportunistic searches were undertaken in the open paddocks on Site 1 during the day on the 21 and 22 November. This included overturning rocks within the paddocks by two ecologist for 30 minutes.

Specific searches were made for the Green and Golden Bell Frog (*Litoria aurea*) around farm dams both during the day and with the use of a spotlight at night. The weather conditions were hot during the day and warm to cool at night and was suitable for detecting a wide range of reptiles and amphibians. However, for the Green and Golden Bell Fog, conditions are more appropriate during and after heavy periods of rainfall.

The dedicated survey effort was 5.3 person hours, and opportunistic survey effort was 2 person hours.

3.9 *DECEMBER 2002 SURVEY*

Additional vegetation surveys were undertaken on the 9 and 10 December 2002 by one ecologist. These surveys were undertaken to supplement the vegetation data collected during November and to take advantage of the rainfall a couple of weeks beforehand which resulted in the flowering of some grass species.

Methodology for vegetation surveys was the same as described in Section *3.8.1*. Two quadrats were surveyed in Site 2 and one in Site 1.

The hair funnels placed out during the November 2002 survey were also collected during this survey period.

3.10 *JANUARY 2003 SURVEY*

One day of vegetation surveys, vegetation ground-truthing and targeted plant searches was undertaken on 8 January 2003 by one ecologist. Methodology for vegetation surveys was the same as described in Section *3.8.1*.

Twelve quadrats were surveyed in Site 1. Methodology for vegetation surveys was the same as described in Section *3.8.1*.

During quadrat surveys and walking and driving between sites, targeted surveys were undertaken for the threatened Lobed Blue-grass and for trees characteristic of Box-Gum Woodlands.

3.11 *FEBRUARY 2003 SURVEY*

An inspection and survey of potential areas of Box-Gum Woodlands was undertaken on 25 February 2003 by one ecologist for one day. This survey included identifying all White Box trees within Site 2. The boundary of each area of White Box was mapped using a Global Positioning System (GPS). Notes were taken about the number and growth form of White Box trees in each area, soil characteristics, and the cover and abundance of native and introduced species in the shrub and ground layers. Photographs were taken of each area.

Notes were also taken of the soil characteristics and floristic and structural characteristics of the vegetation adjacent to the White Box areas. A subsequent assessment was undertaken by HWR Pty Ltd (2003) to review the results of this Box-Gum Woodland survey. The potential for this community to occur is discussed in Section *3.8.3*.

3.12 *SURVEY EFFORT*

Survey effort for each survey technique during the survey periods is summarised in *Table 3.1*.

3.13 *WEATHER CONDITIONS*

Weather conditions were noted during all surveys. It was generally warm to hot during the days and warm to mild in the evenings with the highest temperatures in the early afternoon. There was minimal rainfall and low wind and the cloud cover varied from clear sky to full cloud cover daily and nightly.

To provide the opportunity to detect additional plant species, vegetation surveys were conducted after heavy rainfall in December 2002.

In general, these conditions were appropriate to detect the majority of affected and potentially affected species that are the focus of this EIS. However, summer surveys during heavy rainfall would have increased the chances of detecting some species such as reptiles and amphibians if they were present on the subject site.

It was a full moon phase during the November bat detection surveys, which may have affected the activity of some species. Bats are thought to avoid flying during the brightest moon phases to avoid potential predators. The conditions were therefore not ideal for detecting bats. In addition, surveys during a wetter summer would have been likely to record a greater number of bats within the study area.

Consequently, this report has assumed the presence of such species that may have been undetectable where potential habitats occur on site. This has enabled the formulation of mitigation measures for such species as a precautionary measure.

Table 3.1 Survey Effort

Survey Technique	Survey Periods					Total
	27 October	**18-22 November**	**9-10 December**	**8 January**	**25 February**	
Targeted search for threatened plants	5 person hours	16 person hours	1 person hour	2 person hours	-	24 person hours
Flora quadrats	-	12 person hours	3 person hours	5 person hours	-	20 person hours
Habitat assessment	-	3 person hours	-	-	-	3 person hours
Bird censuses	-	8 person hours	-	-	-	8 person hours
Ground Elliott tapping	-	400 trap nights	-	-	-	400 trap nights
Tree Elliott trapping	-	200 trap nights	-	-	-	200 trap nights
Ground hair funnels	-	2100 funnel nights	-	-	-	2100 funnel nights
All-night Anabat recording	-	8 recording nights	-	-	-	8 recording nights
Spotlighting	-	8 person hours	-	-	-	8 person hours
Owl call playback	-	4 person hours	-	-	-	4 person hours
Reptile and amphibian searches	-	7.3 person hours	-	-	-	7.3 person hours
Assessment of Box-Gum Woodlands	-	-	-	-	5 person hours	5 person hours

Table 3.2 Weather Conditions

Weather Parameter	October	November					December		January	February
	27	**18**	**19**	**20**	**21**	**22**	**9**	**10**	**8**	**25**
Temperature 9:00 am (°C)	18.9	21.5	24.7	24	20.4	22.5	28	17.5	-	22.2
Relative Humidity 9:00 am (%)	37	58	46	56	71	72	33	95	-	-
Cloud Cover am (8ths of sky)	6	0	0	2	8	5	2	2	-	2
Wind Speed 9:00 am (km/hr)	15	0	-	0	7	0	3.6	0	-	9.4
Wind Direction 9:00 am	W	-	-	-	SE	-	N	NW	-	SE
Maximum Temperature (°C)	23.3	35.5	37.7	38	27.3	32	38.5	20	37	28.2
Minimum Temperature (°C)	12	10.1	16	13.8	18.5	18.9	11	17.5	12	17.7
Rainfall (mm)	0	0	0	0	2.6	0.8	0	10	-	0
Temperature 3:00 pm (°C)	20.7	35.3	36.8	37.4	21.5	30.5	36.5	15	-	27.4
Relative Humidity 3:00 pm (%)	40	16	16	21	72	39	16	94	-	-
Cloud Cover 3:00 pm (8ths of sky)	7	2	0	8	8	3	2	4	-	3
Wind Speed 3:00 pm (km/hr)	13	2	0	0	2	1	7.6	3.6	-	9.4
Wind Direction 3:00 pm	E	E	-	-	S	SE	NW	N	-	E
Closest Moon Phase (quarters)	Last (29 Oct)			Full				First (12 Dec)	First (10 Jan)	Last (24 Feb)

1. Data from Bureau of Meteorology (BOM) Singleton Weather Station.
2. indicates that no recordings were made by BOM.
3. Moon phase data from the Melbourne Planetarium 2003 (http://www.museum.vic.gov.au/planetarium/info.html). First and last quarter = half moon visible.

4 *RESULTS*

4.1 *INTRODUCTION*

This section provides information about the vegetation communities, fauna habitats and species that are known to be in the study area and adjacent environments. It includes a discussion of both protected and threatened flora and fauna, including threatened species.

4.2 *LOCALITY, STUDY AREA AND SUBJECT SITE*

4.2.1 *Locality*

Location and Topography

The locality is defined as a 10 km radius around the subject site (approximately 7,854 ha in area) and is shown in *Figure 1.1*. It is situated within the mid Hunter Valley, between Singleton and Muswellbrook in the North Coast interim biogeographic region (Environment Australia 2000) and the botanical subdivision of the North Coast (Fairley and Moore 1989; Harden 2000).

The study area is located on the Liddell Soil Landscape (Kovac and Lawrie 1991). The majority of the locality consists of Central Lowlands landscape, which extends from Murrurundi to Branxton and was formed from relatively weak Permian sediments. It includes undulating to flat land on either side of the Hunter River and the predominant land use is mining and cropping and grazing agriculture. The Rylstone Plateau landscape is to the north east of the locality and the Southern Mountains landscape is to the south west of the locality.

Surrounding mines to the east include Ravensworth-Narama (open cut coal mine) and Cumnock No. 1 Colliery (open cut and underground coal mines). These areas have been granted development approval and therefore the vegetation within Ravensworth-Narama would be removed during open cut mining and rehabilitated in the future. Some woodland on Cumnock No. 1 Colliery to the east of the Belt Line Road would be retained because most of the mining is underground.

The land between Cumnock No. 1 Colliery and Ravensworth-Narama is owned by CNA. It is likely that this land would be the subject of future proposals for mining.

The land immediately south of Site 2 also contains woodland that would be cleared under existing approvals for open cut mining. The open land further to the south is cleared and used for grazing and agriculture, especially along the Hunter River. To the west are a number of agricultural land uses as well as power stations and cattle grazing.

The local landscape character determines the surrounding agricultural land uses. More intensive agriculture is largely restricted to rich alluvial soils that occur in narrow corridors along the floodplains of the Hunter River in the south of the locality. Intensive agricultural uses include dairy and beef cattle grazing on improved and non-improved pasture, fodder cropping and the running of horses. The undulating hillslopes in the surrounding areas are generally used for grazing on non-improved pasture.

The area in the immediate vicinity of the subject site is dominated by coal mines and associated industry, agriculture and remnant woodland earmarked for mining as shown in *Figure 1.1*.

Climate

The middle Hunter Valley is influenced by coastal weather patterns and receives greater rainfall than the western part, which is influenced by more inland weather patterns. Singleton has about 118 rainfall days per year (Cohn 1994). Temperature data has been obtained from the HVO's weather station for the 12 months from January to December 2002. The data indicates that the area experiences average monthly temperatures between 16.8 and 38.6 °C during summer and 5.8 and 20.9 °C during winter.

The available long term rainfall data between 1884 and 2001 was obtained from a Bureau of Meteorology weather station at Jerrys Plains. These data indicate that the area experiences average monthly rainfall between 66.8 and 78.1 mm during summer and 36.5 and 46.2 mm during winter. The annual average rainfall between 1884 and 2000 is 642 mm.

Regional and Local Connectivity

Due to the level and nature of fragmentation of remnant patches of bushland in the locality, migratory species such as birds are able to more easily use regional corridors. Though these species are highly mobile, patches of bushland in the landscape are also important resting and foraging areas on their migratory route.

Regional corridor routes in the locality that are likely to be used the most by migratory or nomadic species in the North Coast and (adjacent Sydney Basin) region are shown in *Figure 1.1* and are likely to include:

- east-west 1: from the upper Hunter Valley travelling east and through vegetation around Lake Liddell, then vegetation north of the subject site (Cumnock No. 1 Colliery) and eastwards down the Hunter River;
- east-west 2: from the upper Hunter Valley travelling east and through vegetation near Jerrys Plains to vegetation along the Hunter River; and

- north-south: across the Hunter Valley floor from the escarpment regions south of Jerrys Plains north through vegetation along the Hunter River and then west of the subject site to the northern escarpments.

These routes provide a stepping stone and corridor for many of the more mobile species (eg. bats, birds and wallabies) and facilitate gene flow, for example between the Upper and Lower Hunter Valley or between the ranges on the north and central coasts.

These routes are less likely to be used for the local dispersal and colonisation by flora and fauna that are less mobile, such as ground mammals, amphibians, reptiles and sedentary birds. The success of dispersal and colonisation depends on the extent of local fragmentation and in the ability of these species to disperse into adjacent suitable habitat.

Drainage

The locality is drained by the Hunter River. These catchments include some of the rugged landscapes in Wollemi National Park as well as undulating land and floodplains along these watercourses.

Tributaries of the Hunter River in the east of the locality include Emu Creek and Farrells Creek, which run east from the subject site.

Vegetation and Habitat

The vegetation in the locality has been extensively cleared since European settlement (Peake 2000). Remnant vegetation on the central Hunter Valley floor includes a number of different forests and woodlands types. Vegetation types that dominate the locality include Grey Box (*Eucalyptus molucanna*), White Box (*E. albens*) and Slaty Box (*E. dawsonii*) woodlands with grassy understoreys and Narrow-leaved Ironbark woodland often with a shrubby understorey (Hunter Catchment Management Trust 2003).

Other vegetation types on the Hunter Valley floor that may occur in the locality include Spotted Gum (*Corymbia maculata*), Narrow-leaved Ironbark (*E. crebra*), Broad-leaved Ironbark (*E. fibrosa*), Grey Ironbark (*E. paniculata* spp. *paniculata*) open forests with shrubby understoreys. Bulloak (*Casuarina leuhmannii*) also forms stands in areas with very poor soil fertility and River Oak (*Casuarina cunninghamiana* ssp. *cunninghamiana*) or Swamp Oak (*Casuarina glauca*) also forms stands along creeklines (Hunter Catchment Management Trust 2003).

The locality includes a number of large patches of fragmented remnant bushland:

- a relatively large patch of remnant bushland is located to the east of the Site 1 on Ravensworth-Narama (open cut coal mine), Cumnock No. 1 Colliery (underground coal mine) and CNA owned land;

- a smaller patch of remnant woodland partially linked to the above patch, and surrounded by open cut mines and cleared land. Site 2 is situated within this patch of woodland; and

- a large patch of remnant woodland between Lake Liddell and the dam on Saltwater Creek to the south of Bayswater Power Station.

The remainder of the locality supports smaller isolated patches of remnant of woodland (eg. on ridges and foothills near Jerrys Plain and Wambo Mine in the south of the locality).

4.2.2 *Study Area*

The study area consists of the subject site, which is split into two portions (Site 1 and Site 2) (*Figure 2.1*). It includes open paddocks between Site 1 and the existing West Pit operations and fragmented remnant vegetation around Site 2. This study area aims to encompass the areas that would be directly and indirectly impacted by the proposal in terms of flora and fauna.

The subject site is owned under freehold by CNA and is contained within HVO's mining or exploration leases.

The landscape of the study area is dominated by moderate to gentle undulating slopes, with a locally dominant ridge in the south of the study area. This ridge lies in a semicircular shape and encompasses the southern part of Site 2 (*Figure 2.1*). The highest point on the subject site is 183 m AHD and occurs in Site 2.

Site 1 is currently used for grazing. It contains cleared pasture, scattered trees and remnant woodland in patches and along creeklines. Site 2 is part of a patch of remnant woodland that occurs on undulating land and the south facing slope of a ridgeline.

All of the woodland on the subject site appears to have been logged/cleared or grazed over the last 40 years and is dissected by roads and farm tracks.

More detailed descriptions of the vegetation and habitats of the study area and subject site are provided in Section *4.3*.

4.3 *GENERAL FLORA AND FAUNA*

The study area supports a range of woodland, regrowth and pasture areas that have experienced different disturbance regimes in the past, such as clearing, grazing and fire. These areas support native as well as introduced plants species.

Introduced plant species are abundant in areas that have been most recently disturbed such as along cleared road and track edges, around dams and in improved pasture. They include a range of pasture grasses and weeds, including several species of noxious weeds. A list of native and introduced plant species detected on the subject site is provided in *Annex A*.

The study area also supports a range of native and introduced fauna species. Different groups of native fauna appear to be associated with vegetation of different regrowth age and structure, reflecting past disturbance regimes. These provide particular habitat resources, including hollow-bearing trees in remnant woodland and open pasture with scattered trees.

Birds are more represented in the woodland and regrowth areas in Site 2 compared to the open paddocks and scattered trees in Site 1. Other fauna that occur more frequently on Site 2 include ground and arboreal mammals, reptiles and amphibians.

Introduced fauna such as wild dogs and rabbits are widespread throughout the study area, especially in areas that have been most recently disturbed or where grazing currently occurs. A list of the animal species recorded in the study area is provided in *Annex A*.

4.3.1 Soils

The soils and land capability of the subject site are discussed in Chapter 8 of the EIS. The subject site includes the Liddell soil landscape (Kovac and Lawrie 1991) and general soil characteristics include:

- Yellow Soloths – a brown loamy sand to sandy loam topsoil which is single grained at the surface and massive below and has a pH of 6.0-6.5. This overlies the A2-horizon which is bleached light grey or dull orange yellow sandy loam or sandy clay loam with a pH of 6.0–6.5 (depth to 25 cm). A subsoil which has a sharp or clear change to bright brown or dull orange sandy clay with weak or strong structure and distinct brown or orange mottles and has a pH of 6.0-6.5;

- Yellow Solodic Soils – topsoil with a dark brown loam, weak structure and a pH of 6.5. The A2-horizon is bleached dull orange clay loam with weak structure and a pH of 6.0 (depth to 20 cm). The is a clear change to the subsoil which is a reddish brown light clay with strong angular blocky structure and a pH of 6.5 and becomes more yellowish brown with depth and with orange and grey mottles;

- Earthy Sands – topsoil with a dark brown sandy loam, single grained at the surface and massive grained below with pH of 6.0-6.5 (depth to 40cm). There is a gradual change to the subsoil which is a dull yellowish brown sandy loam, massive and earthy fabric and pH of 7.0; and

- Silaceous Sands – topsoil is a brown sand to loamy sand, single grained and massive below surface with a pH or 6.0 (depth to 40 cm). There is a gradual change to the subsoil which is a bright brown loamy sand, massive and with an earthy fabric.

4.3.2 *Vegetation*

Introduction

Vegetation types on the subject site and in the study area include cleared land, native pasture, areas of regrowth dominated by saplings and scattered mature trees. The quality of this vegetation on the subject site varies due to past disturbance regimes such as clearing, logging and different grazing regimes over the last 40 years. Other disturbances include erosion, roads, tracks and powerline easements.

Sites 1 and 2 have different habitat values based on the intensity of past clearing and grazing and the degree of weed invasion and regrowth of native vegetation. More extensive clearing, grazing, dam construction and pasture improvement has occurred on Site 1. It supports some clumps of mature trees near dams and along watercourses, but overall has lower value for flora, vegetation communities and native fauna due to pasture improvement and grazing.

In comparison, Site 2, although impacted by a former road through the centre and associated weed species, has greater flora and fauna value and supports a greater diversity of flora species and vegetation communities.

Aerial Photographs

Aerial photographs from 1958, 1967, 1982 and 1993 are shown in *Figure 4.1*, *Figure 4.2*, *Figure 4.3* and *Figure 4.4,* respectively. The most recent aerial photograph (2001) of the study area is shown in *Figure 1.1*.

- 1958

In 1958, Site 1 had been cleared, probably for grazing. Some mature trees were retained along the fenceline in the north and as a clump in the north west and as isolated individuals in cleared land. Site 2 had also been cleared, probably for grazing. Mature trees were retained in small clumps and as scattered individuals. The remainder of the study area had also experienced extensive clearing, with some scattered mature trees being left. Some areas of regrowth were also present. The area east of the subject site has been extensively cleared with only scattered clumps of mature trees remaining.

- 1967

In 1967, nine years later, it does not appear that any further clearing has taken place on the subject site. The lack of regrowth on the subject site suggest that these areas appear to have been continually grazed. The vegetation immediately north of Site 2 appears to have been cleared and grazed, with only scattered trees remaining. The remainder of the study area has also remained cleared probably because of continued grazing and/or slashing.

Overall the study area and adjacent areas appears to have been maintained in a cleared and grazed state.

- 1982

In 1982, another 15 years later, the grazing and disturbance regimes on Site 1 appear to have been maintained. Some mature trees appear to have been cleared from the clump of trees in the north, but otherwise there does not appear to be any other major change. In Site 2, regrowth appears to have occurred on the south facing slopes, south of the track that dissects this site.

More mature trees appear to have been cleared to the north of this track. However, there also appears to be some regrowth in these areas.

In the remainder of the study area and on adjacent land, the clearing and grazing regime appears to have been lessened and regrowth of saplings and shrubs has occurred beneath remnant mature trees within areas previously cleared.

- 1993

In 1993, another 11 years later, the grazing and disturbance regimes of 1982 appear to have been maintained in Site 1. Some new dams have been constructed for the mine to the east and no regrowth of saplings or shrubs appears to have occurred on this site.

The grazing and disturbance regimes in Site 2 appears to have lessened and more substantial regrowth of Bulloak, saplings and shrubs appears to have occurred on this site. This regrowth has also occurred in the surrounding vegetation in the study area and in the area east of the Belt Line Road.

- 2001

In 2001, another 12 years later, the disturbance and clearing regimes appear to have been maintained on the subject site and no major changes in land use, apart from expanding open cut coal mines, appear to have taken place. This has included maintenance of cleared and grazed land in Site 1 and continued regrowth in Site 2 and the surrounding areas. Extensive regrowth has occurred in the vegetation east of the Belt Line Road. Current vegetation within the study area is described in more detail below.

Vegetation Communities

The vegetation of the subject site and study area is shown in *Figure 4.5*. Vegetation community classification and boundaries on the subject site are generally similar to draft vegetation mapping undertaken by HCMT (Peake

2000) (see Section *3)*. Vegetation communities on the subject site have been verified at a relatively high level of accuracy in this report.

Vegetation communities on the subject site were ground-truthed by visual assessment and quadrat surveys. However, vegetation in other parts of the study area have been mapped using the vegetation community boundaries of HCMT (Peake 2000) and past vegetation assessments for proposed coal mines or their extensions.

Site 1 supports large areas of native pasture with some dry sclerophyll woodland with little to no understorey in clumps and along drainage lines. There are also scattered individual trees throughout the native pasture.

Site 2 supports regrowth dry sclerophyll woodland and bulloak woodland of varying quality.

Each vegetation community that has been surveyed for this EIS, and the areas on the subject site are shown in *Table 4.1*. Descriptions of each surveyed vegetation type on the subject site are provided below and in *Annex B* and photographs are provided in *Annex F*. The local and regional significance of these communities is discussed in Section *4.3.5*.

Table 4.1 Vegetation Communities and Approximate Areas

Vegetation Community	Subject Site (ha)		
	Site 1	**Site 2**	**Total**
Narrow-leaved Ironbark/Grey Box Woodland	3.3		3.3
Narrow-leaved Ironbark/Grey Box Woodland (regrowth)	3.7	52.7	56.4
Narrow-leaved Ironbark/Kurrajong Woodland		13.3	13.3
Rough-barked Apple/Narrow-leaved Ironbark Woodland	2.6		2.6
Swamp Oak Woodland	1.0		1.0
Bulloak Woodland (regrowth)		2.6	2.6
Native Pasture	220.4		220.4
Cleared Land		6.8	6.8
TOTAL	**230.9**	**75.5**	**306.4**

- Narrow-leaved Ironbark/Grey Box Woodland

This community occurs near the northern dam and in two small clumps in Site 1. It has been disturbed by past clearing and continued grazing for more than 40 years, dam construction, erosion, weed invasion, feral animals, tracks and soil disturbance. A portion of this community near the northern dam has been fenced off and contains regrowth grasses and some saplings. It is dominated by mature Narrow-leaved Ironbark, Grey Box and Forest Red Gum (*Eucalyptus tereticornis*). In grazed areas the ground layer is very sparse and dominated by both introduced grasses although there are also native species present. The total weed cover in the community is estimated to be 20 %.

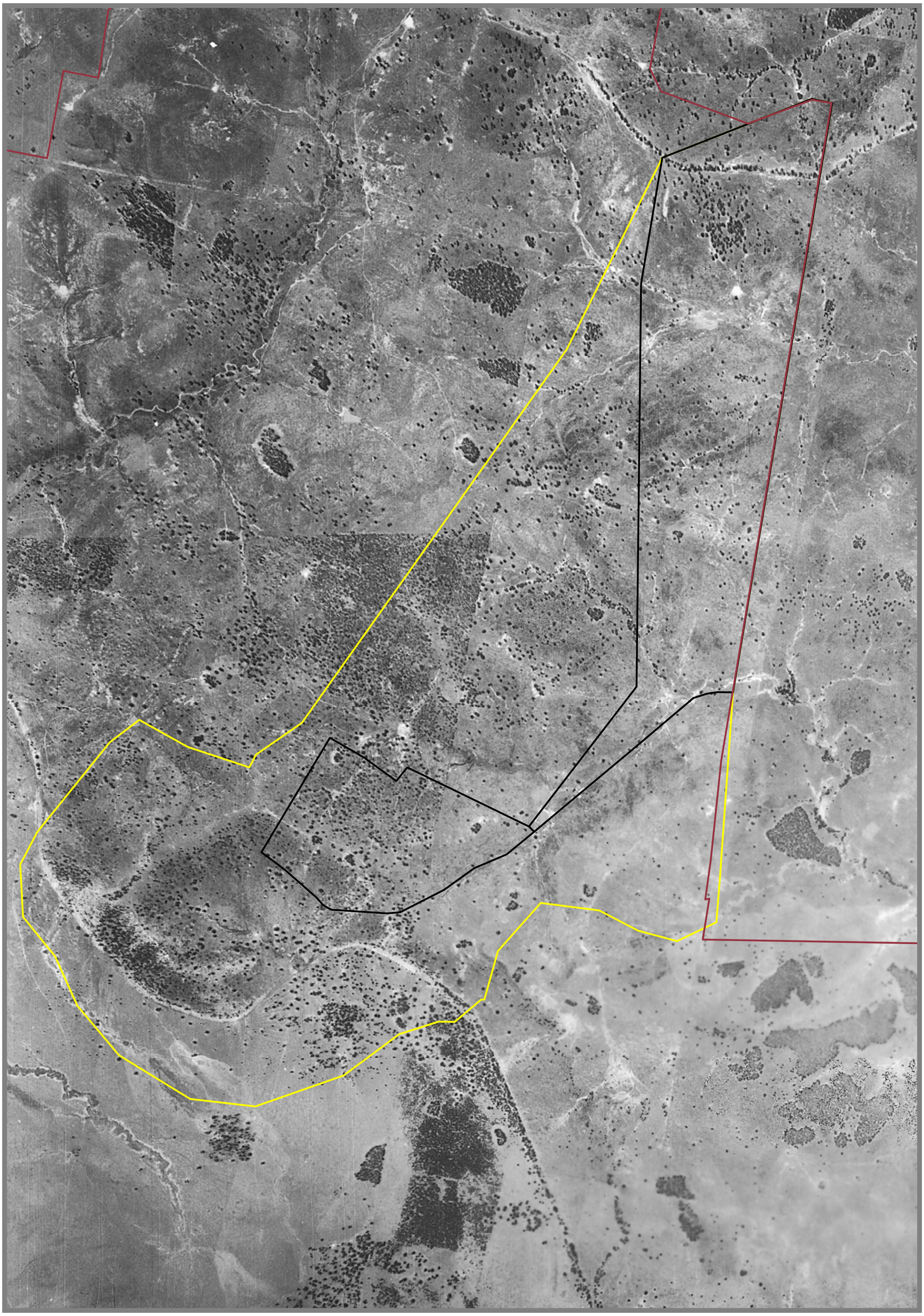


FIGURE 4.1

1958 Aerial Photograph

Subject Site
Study Area
HVO Lease Boundary

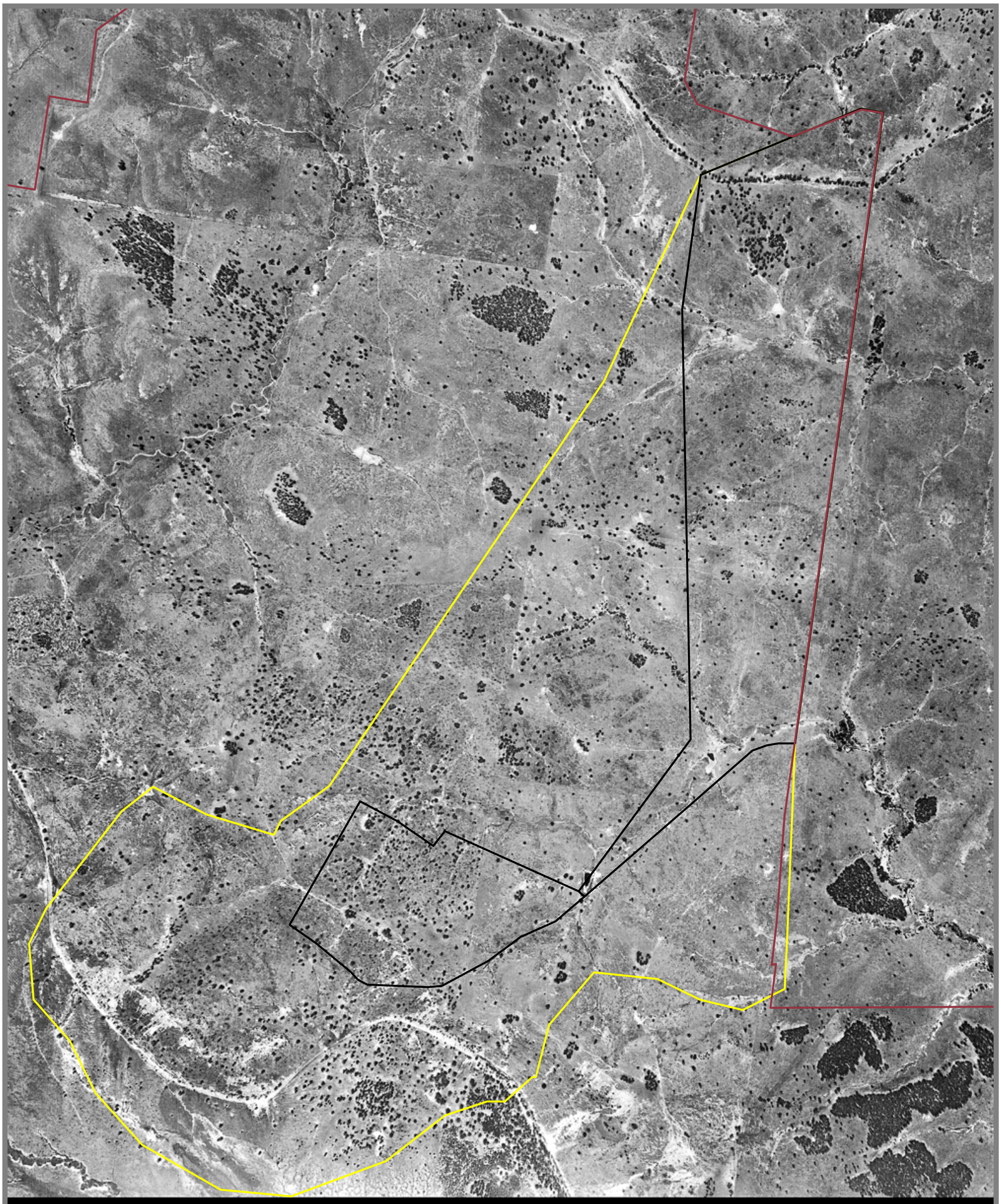


FIGURE 4.2

1967 Aerial Photograph

0.5 0 0.5 1

Kilometres

Subject Site

Study Area

HVO Lease Boundary

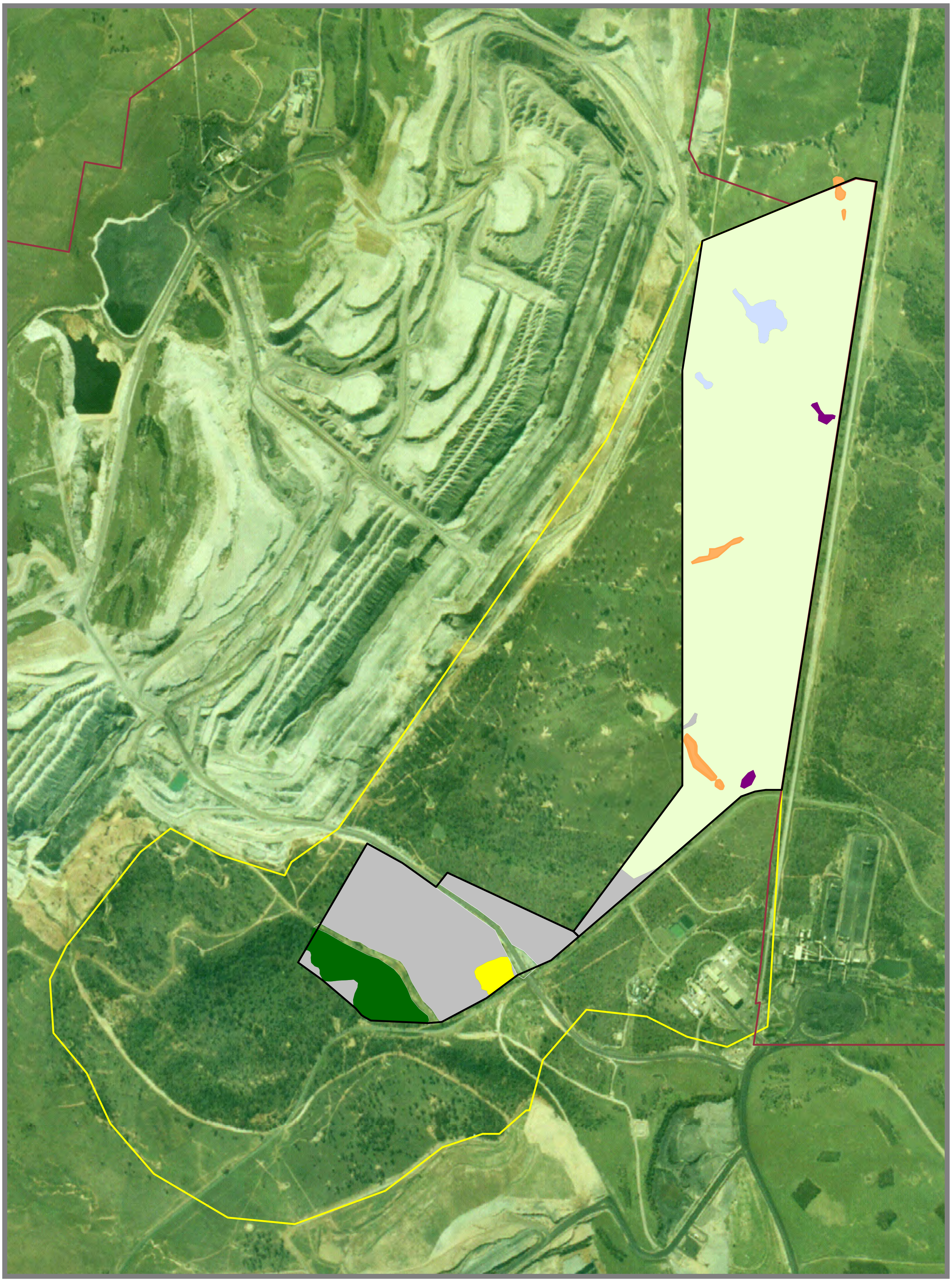
FIGURE 4.3

1982 Aerial Photograph

ERM

FIGURE 4.4

1993 Aerial Photograph



ERM

0.5 0 0.5 1

Kilometres

FIGURE 4.5

Vegetation of the Subject Site

Vegetation Communities

- Subject Site
- Study Area
- HVO Lease Boundary

- Bulloak Woodland (regrowth)
- Narrow-leaved Ironbark/Grey Box Woodland
- Narrow-leaved Ironbark/Grey Box Woodland (regrowth)
- Narrow-leaved Ironbark/Kurrajong Woodland
- Native Pasture
- Rough-barked Apple/Narrow-leaved Ironbark Woodland
- Swamp Oak Woodland

- Narrow-leaved Ironbark/Grey Box Woodland (regrowth)

This community occurs within Site 2 on gently sloping land north of the east west track and also on flatter land in the south of this site. It also occurs on Site 1 near Lemington Road. It has been disturbed by past clearing, erosion, tracks, roads, and invasion of introduced plants and feral animals. It is a structurally and floristically variable community with scattered mature eucalypts but is generally dominated by younger and smaller trees of Narrow-leaved Ironbark and Grey Gum. In some places there is a shrub layer dominated by Native Olive (*Notelaea microcarpa* var. *microcarpa*) and Blackthorn (*Bursaria spinosa*), particularly along drainage lines. The ground layer is generally dense and grassy and dominated by native grasses and herbs. Introduced flora species are dominant in disturbed areas such as roads and tracks. The total weed cover in the community is estimated to be 5 %.

- Narrow-leaved Ironbark/Kurrajong Woodland

This community occurs on the south facing steeper slopes in Site 2. It has been disturbed by past clearing, erosion, tracks, roads, and invasion of introduced plants and feral animals. However, the past grazing and clearing regime appears to have been less frequent compared to the remainder of the subject site. It is a structurally and floristically variable community with scattered mature eucalypts but is generally dominated by Narrow-leaved Ironbark and Kurrajong. The shrub layer is dominated a range of shrubs including by Blackthorn and Native Olive. The ground layer is generally dense and grassy and dominated by native grasses and herbs. Introduced flora species are dominant in disturbed areas such as drainage lines and tracks. The total weed cover in the community is estimated to be 5 %.

- Rough-barked Apple/Narrow-leaved Ironbark Woodland

This community occurs on more sandy soil in drainage lines on Site 1. It has been severely disturbed by past clearing, grazing and severe erosion and invasion of introduced plants and feral animals, to the point where there is no vegetative ground cover. It is generally dominated by Rough-barked Apple (*Angophora floribunda*) and in some cases by Narrow-leaved Ironbark and River Oak. There is usually no shrub layer and very few grasses or ground layer species. Introduced flora species occur in disturbed areas and the total weed cover in the community is estimated to be 2 %.

- Swamp Oak Woodland

This community occurs in small sections along creeklines on Site 1. The creekbed has been severely disturbed by erosion and invasion of introduced sedges (*Juncus* spp.). However, some native riparian species still occur and provide habitat for fauna including the Clamorous Reed Warbler (*Acrocephalus stentoreus*). It is dominated by Swamp Oak (*Casuarina glauca*). Introduced flora species occur in disturbed areas and the total weed cover in the community is estimated to be 50 %.

- Bulloak Woodland (regrowth)

This community occurs in the south eastern section of Site 2. It has been disturbed by clearing, grazing, erosion and introduced flora and fauna species. It is dominated by young and mature Bulloaks and contains one or two scattered mature eucalypts. The shrub layer is sparse and the groundlayer has been suppressed in dense areas by the accumulation of Bulloak leaves. In more open areas, the ground layer is usually thick and is dominated by native grasses. The total weed cover in the community is estimated to be 5 %.

- Native Pasture

This community occurs throughout Site 1 and has been continually grazed for at least 40 years and has been highly disturbed by clearing, invasion of introduced flora and fauna species and erosion. It consists of pasture improved land that is dominated by native pasture species such as Redleg Grass (*Bothriochloa decipiens*) and is regularly grazed by cattle. Introduced grasses and herbs dominate along areas that have been disturbed for track, dam and fence construction or erosion. The total weed cover in this community is estimated to be 30 %.

- Cleared Land

Cleared Land has been mapped in Site 2 and consists of highly disturbed soil from road construction through the middle of this site. It also occurs on smaller tracks and areas around dams that are too small to map. It is characterised by open earth and is dominated by a high diversity of weed species including Coastal Galenia (*Galenia pubescens*), *Solanum* spp. and thistles. The total weed cover in this community is 100 %.

4.3.3 *Major Habitat Features*

The varying degrees, age and types of past disturbances have created a mosaic of fauna habitats that support a wide range of fauna species and assemblages across the study area. Roads and tracks are located across the subject site and sheet and gully erosion are also present on both sites.

On the subject site, habitats range from regrowth woodland dominated by native plant species with microhabitats for a wide range of fauna species, to woodland, to open pastures dominated by introduced plant species that provide limited habitat for fauna. These habitats are also generally present within the study area, north, west and south of the subject site.

Habitat for arboreal mammals such as possums is relatively sparse and only present in the regrowth woodland on Site 2, which contains some sparse mature and dead trees with hollows. Resting and roosting habitat includes scattered trees with hollows, and native vegetation in the tree, shrub and ground layers, which provide foraging resources. Due the scarcity and isolation of mature trees on Site 1 there is very limited habitat for native arboreal mammals.

On Site 2, fallen logs and branches in the ground layer in the regrowth woodland and Bulloak woodland provide ground-based refuge areas for small ground mammals such as Antechinus (*Antechinus* sp.). Introduced mice and rats are also present in these areas. Woodland also provides resources for macropods and introduced species such as wild dogs. On Site 1 there are very few resources such as logs and branches on the ground, and these are restricted to the woodland areas.

There is potential roosting and known foraging habitat for insectivorous bats within the woodland and regrowth habitats on both Site 1 and Site 2. Dams on Site 1 also provide foraging resources such as flying insects. There are no culverts or mines that would provide roosting habitat for bats on the subject site.

The native regrowth woodland on Site 2 provides habitat for a wide range of forest and woodland bird species. Woodland habitats support different bird species compared with more open habitats on Site 1, where birds that prefer more open paddocks and grassy areas are found.

Habitats for reptiles and amphibians include native and introduced grasses, regrowth woodland habitat of varying quality, farm dams, drainage lines and associated riparian vegetation, dead trees, decorticating bark and logs and litter on the ground. Loose stones on the ground in the native pasture provide habitat for native skinks and legless lizards.

4.3.4 Fauna

A list of fauna species recorded on the subject site and in the study area is provided in Annex A. A total of 46 birds, 20 mammals (including five introduced mammals), six reptiles and five amphibians were recorded. The population distribution, conservation status, habitat values and utilisation of the subject site and study area by threatened fauna is discussed in Section *4.4*.

Birds

A total of 46 birds species were recorded during surveys on the subject site (Annex A). The majority of these species are widespread and/or abundant species that commonly occur in woodland, regrowth and various other habitats.

Nine of these species are water birds and are expected to occur within lakes and farm dams in other locations in the study area.

A total of two threatened birds listed under the *TSC Act*, the Speckled Warbler (*Pyrrholaemus saggitata*) and the Grey-crowned Babbler (*Pomatostomus temporalis temporalis*), were recorded on the subject site and are discussed in Section *4.4.3*.

Mammals

No gliders were detected by spotlighting or captured by tree traps. Brush-tailed Possums (*Trichosurus vulpecula*) and Ring-tailed Possums (*Pseudocheirus peregrinus*) were recorded in woodland on Site 2. Macropods including the Eastern Grey Kangaroo (*Macropus giganteus*) and Red-necked Wallaby (*Macropus rufogriseus*) were recorded on both Sites 1 and 2.

One native ground mammal, the Brown Antechinus (*Antechinus stuartii*) was recorded in the woodland on Site 2. Introduced species including the Black Rat (*Rattus rattus*) and the House Mouse (*Mus musculus*) were recorded in the woodland on Site 2. The Black Rat was also recorded on Site 1.

A total of ten insectivorous microbats were detected across the subject site. This indicates that foraging and potential roosting habitat occurs within woodland vegetation on both Sites 1 and 2. Dams also provide foraging habitat for insectivorous bats. Of these ten species of insectivorous microbats, two species are listed as threatened under the *TSC Act*. The Eastern Freetail-bat (*Mormopterus norfolkensis*) was recorded on both sites and the Large Bentwing Bat (*Miniopterus schreibersii oceanensis*) was recorded on Site 1. These are discussed in Section *4.4.3*.

Reptiles and Amphibians

Relatively few reptiles were detected on the subject site (Annex A). Species detected include a legless lizard (*Delma plebia*), Rainbow Skink (*Carlia tetradactyla*) Striped Skink (*Ctenotus robustus*) and the Wood Gecko (*Diplodactylis vittatus*). They were recorded in regrowth woodland and regrowth habitat on Site 2 amongst vegetation, beneath rocks and under logs, beneath decorticating bark and in crevices in trees and logs. The Striped Skink and *Delma plebia* were also recorded beneath rocks in Native Pasture on Site 1.

Amphibians recorded around the dams on Site 1 include Dwarf Green Tree Frog (*Litoria fallax*), Peron's Tree Frog (*Limnodynastes peronii*) and the Broad-palmed Frog (*Litoria latopalmata*). The Common Eastern Froglet (*Crinia signifera*) was recorded on Site 2. It is expected that more surveys of the study area in wetter weather conditions would record these species as well as additional frogs, lizards, skinks, dragons, snakes and geckos.

4.3.5 Local and Regional Significance

The subject site is located on the central valley floor and provides some regional corridor function both east to west along the valley and north to south across the valley. This is likely to be utilised by some highly mobile migrating and nomadic species such as birds and insectivorous bats. At the local scale, the woodland on Site 2 is likely to be used as local dispersal habitat for some plants and sedentary or territorial birds, mammals, amphibians and reptiles.

Analysis of past aerial photos suggests that Site 1 has probably been cleared before the 1960s and has been grazed for at least 40 years. It provides very limited corridor and local dispersal habitat due to its cleared and highly disturbed nature and is unlikely to be regionally significant for flora and fauna.

Flora

Peake (2000) suggests that a number of vegetation associations in the mid-Hunter are uncommon and possibly threatened on a regional basis and are described as of Preliminary Regional Importance. The Hunter Rare Plants Database (Bell *et al.* 2003) also lists regionally significant plant communities in the Hunter Valley. However, none of these communities are present on the subject site.

No regionally significant species of Rare or Threatened Australian Plants (RoTAP) (Briggs and Leigh 1995) were recorded on the subject site.

Regionally significant species that have the potential to occur in the locality, ie. *Isotropis foliosa* and *Macrozamia flexuosa* (pers. comm. Hunter Catchment Management Trust 2003), were not recorded on the subject site and are unlikely to occur.

Fauna

No fauna species of regional significance were recorded on the subject site. The subject site is likely to provide some regional corridor function for migrating/nomadic birds such as honeyeaters.

4.3.6 *State Environmental Planning Policy No. 44 (SEPP 44)*

One threatened species, the Koala (*Phascolarctos cinereus*), is also protected by SEPP 44. The main aim of SEPP 44 is to:

"... encourage the proper conservation and management of areas of natural vegetation that provide habitat for Koalas, to ensure permanent free-living populations over their present range and to reverse the current trend of population decline ..."

Under SEPP 44, it is necessary to investigate potential and core Koala habitat before seeking development consent in scheduled LGAs. Scheduled LGAs are located within the known state-wide distribution of the Koala and Singleton Shire Council is a scheduled LGA.

Potential Koala habitat, defined as vegetation which incorporates a minimum of 15 % of tree species in the upper or lower strata of the tree component, is listed in Schedule 2 of SEPP 44. The consent authority may grant development consent if the subject land does not contain core Koala habitat.

The most recent record of the Koala is in the north west of the locality near Bayswater Power Station in 1954 (*Figure 1.1* (NPWS Wildlife Atlas 2003). One

Schedule 2 feed tree species, Forest Red Gum (*E. tereticornis*), occurs in scattered locations on Site 1 and Site 2. However, it does not constitute more that 15 % of the total tree species on these sites. Consequently, these sites would not support potential Koala habitat. Koalas or signs of their presence such as scats, were not seen on the subject site and are not likely to occur there. Accordingly, the subject site does not constitute core habitat and the Koala is unlikely to occur.

4.3.7 *Matters of National Environmental Significance*

Matters of NES that have the potential to occur in the study area include listed threatened species and communities and listed migratory species. These are listed in *Table 4.2*.

All of the species listed under the *EPBC Act* have been assessed as part of this EIS. Their potential abundance and distribution in the study area and potential impacts and amelioration measures are discussed in the following sections. Movement corridors for migratory species have also been discussed above.

4.4 *THREATENED FLORA AND FAUNA*

A list of threatened flora and fauna listed under the *TSC Act* and the *EPBC Act* that have been recorded in the locality or with potential to occur in the locality were assessed for their potential to occur on the subject site. This was based on the results of database searches, vegetation mapping, habitat assessment and flora and fauna surveys including targeted surveys and their known habitat requirements.

Figure 1.1 shows the locations of database records of threatened species within the locality. These records are from the NPWS Wildlife Atlas Database (February 2002) and the Birds Australia database (July 2002). There were no records of threatened species for the locality from the Australian Museum or the Sydney Royal Botanic Gardens. The records from the Birds Australia database are assumed to be identical to the Hunter Birds Observers Club (HBOC) database. The vegetation and habitat mapping and results of flora and fauna surveys have been provided in Section *4*.

The following four threatened species, two woodland birds and two insectivorous bats, were recorded on the subject site (*Figure 4.6*):

- Speckled Warbler (*Pyrrholaemus sagittata*);
- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*);
- Large Bentwing-bat (*Miniopterus schreibersii oceanensis*);
- Eastern Freetail-bat (*Mormopterus norfolkensis*).

Table 4.2 lists those threatened species that have been recorded in the locality and species that have the potential to be found in the locality based on existing habitat. Of these, the following have some potential to occur on the subject site, since their presence or absence cannot be ruled out. These species are either wide-ranging and rare or cryptic species that are difficult to detect unless conditions are ideal (eg. season, temperature and rainfall):

- Lobed Blue Grass (*Bothriochloa biloba*);
- Illawarra Greenhood Orchid (*Pterostylis gibbosa*);
- *Diuris tricolor* (syn. *D. sheaffiana*);
- Glossy Black-cockatoo (*Calyptorhynchus lathami*);
- Brown Treecreeper (*Climacteris picumnus victoriae*);
- Painted Honeyeater (*Grantiella picta*);
- Swift Parrot (*Lathamus discolor*);
- Diamond Firetail (*Stagonopleura guttata*);
- Black-chinned Honeyeater (*Melithreptus gularis gularis*);
- Regent Honeyeater (*Xanthomyza phrygia*);
- Large-eared Pied Bat (*Chalinolobus dwyeri*);
- Eastern Falsistrelle (*Falsistrellus tasmaniensis*);
- Little Bentwing-bat (*Miniopterus australis*);
- Large-footed Myotis (*Myotis adversus*);
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*);
- Greater Broad-nosed Bat (*Scoteanax rueppellii*);
- Green and Golden Bell Frog (*Litoria aurea*);
- Pale-headed Snake (*Hoplocephalus bitorquatus*); and
- Pink-tailed Worm Lizard (*Aprasia parapulchella*).

This EIS includes a discussion of the local and regional abundance, local and regional corridors, habitat assessment, conservation status, and assessment of likely direct and indirect impacts on these species. Survey results and discussion of habitat utilisation of all threatened species that have been recorded on the subject site are provided in Section *4*.

FIGURE 4.6

Threatened Fauna in the Study Area

Table 4.2 *Identification of Threatened Species and Communities that may be affected by the proposal*

Common Name/Scientific Name	Legislative Status		Habitat Requirements	Presence and Habitat Utilisation	Eight Part Test Required?
	TSC Act	*EPBC Act*			
Plants					
Lobed Blue-grass (*Bothriochloa biloba*)	V	V	Eucalyptus woodland on basaltic hills and grassland on drainage slopes on rich black or red soil.	Potential habitat on the subject site. Not recorded on the subject site after targeted surveys. Potential to occur on the subject site.	Potential to be affected. **Yes**.
Cynanchum elegans	E	E	Ecotone between dry subtropical rainforest and sclerophyll forest/woodland communities.	No habitat on the subject site. Not recorded on the subject site. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**
Darwinia biflora	V	V	Edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone.	No habitat on the subject site. Not recorded on the subject site. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**
Finger Panic Grass (*Digitaria porrecta)*	E	E	Tropical and subtropical rainforest and tropical and subtropical sub-humid woodlands.	No habitat on the subject site. Not recorded on the subject site. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**
Dillwynia tenuifolia	V	V	Dry sclerophyll woodland on sandstone, shale or laterite, from the Cumberland Plain and Blue Mountains to Howes Valley area.	No habitat on the subject site. Not recorded on the subject site. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**
Diuris tricolor (syn. *D. sheaffiana*)			Western slopes, usually in grassy *Callitris* woodland, growing in sandy soil, in flat country or often on top of small hills. Flowers September to November.	Potential habitat on the subject site. Not recorded on the subject site after targeted surveys. Potential to occur on the subject site.	Potential to be affected. **Yes**.
Slaty Red Gum (*Eucalyptus glaucina*)	V	V	Low coastal ranges and tablelands of central New South Wales, Taree to Broke, also near Casino.	Potential habitat on the subject site. Not recorded on the subject site.	Unlikely to be affected. **No.**
Narrow Goodenia (*Goodenia macbarroni*)	V	V	Damp sandy soils, south from Guyra and Inverell districts. Flowers October to March.	Potential habitat on the subject site. Not recorded on the subject site.	Unlikely to be affected. **No.**
Basalt Peppercress (*Lepidium hyssopifolium*)	E	E	Grassland and grassy woodland on flat ground on both light and heavy soils.	Potential habitat on the subject site. Not recorded on the subject site.	Unlikely to be affected. **No.**

Common Name/Scientific Name	Legislative Status		Habitat Requirements	Presence and Habitat Utilisation	Eight Part Test Required?
	TSC Act	*EPBC Act*			
Melaleuca groveana	V	-	Grows in heath, often in exposed sites; rare, restricted to higher areas, coastal districts north from Port Stephens.	No habitat on the subject site. Not recorded on the subject site.	Unlikely to be affected. **No.**
Olearia cordata	V	V	Dry sclerophyll forest and open shrubland on sandstone chiefly from Wisemans Ferry to Wollombi.	No habitat on the subject site. Not recorded on the subject site.	Unlikely to be affected. **No.**
Persoonia pauciflora	E	-	Grey soils derived from silty sandstones of the Farley Formation in dry sclerophyll woodland or open forest in the Hunter Valley area.	No grey soils derived from the sandstones on the subject site. Not recorded on the subject site after targeted surveys.	Unlikely to be affected. **No**.
Rufous Pomaderris (*Pomaderris brunnea*)	V	V	In open forest, confined to the Colo River and upper Nepean River.	No habitat on the subject site. Not recorded on the subject site.	Unlikely to be affected. **No.**
Illawarra Greenhood Orchid (*Pterostylis gibbosa*)	E	E	Open forest or woodland on flat or gently sloping poorly drained soils.	Potential habitat on the subject site. Not recorded during seasonal survey. Potential to occur on the subject site because of drought during survey.	Potential to be affected. **Yes.**
Swainsona sericea	V	-	Grassland and eucalypt woodland, sometimes with *Callitris* species, widepsread. This species is at it's eastern distributional limit in the Hunter Valley.	Potential habitat on the subject site. Not recorded on the subject site after targeted surveys.	Unlikely to be affected. **No.**
Austral Toadflax (*Thesium australe*)	V	V	Grassland or woodland, often in damp sites; widespread but rare.	Potential habitat on the subject site. Not recorded on the subject site after targeted surveys.	Unlikely to be affected. **No.**
Amphibia					
Green and Golden Bell Frog (*Litoria aurea*)	E	V	Large permanent ponds and swamps with shallow, still and chemically unpolluted water, with a substrate of sand, and some aquatic vegetation,	Potential habitat on the subject site. No surveys during ideal weather conditions possible. Potential to occur on the subject site.	Potential to be affected. **Yes.**

Common Name/Scientific Name	Legislative Status		Habitat Requirements	Presence and Habitat Utilisation	Eight Part Test Required?
	TSC Act	*EPBC Act*			
			especially emergent reeds.		
Aves					
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	V	-	Forest with tree hollows for breeding; key *Allocasuarina* species for foraging.	Potential breeding and foraging habitat on the subject site. Not recorded in the locality. Potential to occur on the subject site.	Potential to be affected. **Yes**.
Powerful Owl (*Ninox strenua*)	V	-	Coastal forests and ranges of eastern and south-eastern Australia, within 200 km of the coast. It is a generalist predator feeding mainly on arboreal mammals, but will also take ground dwelling mammals. The species roosts by day in dense foliage often within ridges covered by eucalypt forest. The species depends upon large mature hollow eucalypts for nesting, generally in areas with a range of vegetation communities that sustains a high diversity of ground dwelling mammals and avifauna.	Not recorded in the locality or subject site despite surveys. It is unlikely to occur on the subject site due to the low availability of roosting and nesting sites and the low diversity of ground dwelling mammals.	Not recorded on the subject site or in the locality. Highly unlikely to occur due to past clearance. **No.**
Barking Owl (*Ninox connivens*)	V	-	Open forests, woodlands, dense scrubs, foothills, river red gums, other large trees near watercourses, open country, paperbark woodlands. It roosts in dense streamside vegetation including thickets of acacia, casuarina and eucalypts and forages in adjacent woodland. It nests in large hollows in big old eucalypts.	Not recorded in the locality or subject site despite surveys. The subject site provides some habitat with low potential for this species to occur. It has low potential to support this species because there are few large hollows in big eucalypts on the subject site where this species can nest, nor are there any vegetation thickets along streams for roosting.	Not recorded on the subject site or in the locality. Highly unlikely to occur due to past clearance. **No.**
Masked Owl (*Tyto novaehollandiae*)	V	-	Mature large-hollow bearing eucalypts in forest interiors. Drier forests with an open understorey and a mosaic of dense and sparse ground cover.	Potential habitat on the subject site. Not recorded on the subject site. Potential to occur on the subject site.	Potential to be affected. **Yes**.
Brown Treecreeper (*Climacteris picumnus*	V	-	Eucalypt woodland (>200 ha), particularly open woodland lacking dense understorey, tree hollows	Potential habitat on the subject site. Database records at Bayswater Colliery and Ravensworth-	Unlikely to be affected. **Yes, as a precaution.**

Common Name/Scientific Name	Legislative Status		Habitat Requirements	Presence and Habitat Utilisation	Eight Part Test Required?
	TSC Act	*EPBC Act*			
victoriae)			for breeding; trees and leaf litter for foraging.	Narama and Cumnock No. 1 Colliery in the locality. Not recorded on the subject site after targeted surveys. Unlikely to occur on the subject site.	
Black-chinned Honeyeater (*Melithreptus gularis gularis*)	V	-	Box–Ironbark, River Red Gum woodlands and drier coastal woodlands; trees for nesting and eucalypts for foraging.	Potential breeding and foraging habitat on the subject site. Not recorded on the subject site.	Potential to be affected. **Yes**.
Black-necked Stork (*Ephippiorhynchus asiaticus*)	V	-	Large open terrestrial wetlands and swamps, permanent pools, lagoons, estuarine mudflats and mangrove swamps for breeding and foraging.	Potential habitat on the subject site. Not recorded in the study area. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**
Diamond Firetail (*Stagonopleura guttata*)	V	-	Eucalypt woodlands, forests and mallee, trees and bushes for breeding, grassy understorey for foraging.	Potential habitat on the subject site. Three database records in the locality. Not recorded on the subject site after targeted surveys. Unlikely to occur on the subject site.	Potential to be affected. **Yes.**
Hooded Robin (*Melanodryas cucullata cucullata*)	V	-	A range of eucalypt woodlands, mallee, acacia shrubland and open forests. It favours areas with dead timber and sparse shrubland that adjoins large areas of woodland. It appears unable to survive in remnants less than 100-200 ha and has a home range of 10 –20 ha. It breeds in a cup nest in a fork, crevice, hollow or near dead wood. Critical habitat features include large trees for protective cover, areas of grass that support insects, and other invertebrates, perching sites within these grassy areas and trees to provide nesting.	Recorded at Jerrys Plains in the south west of the locality and on Hunter Valley Mine No. 2, south of the Hunter River (Croft and Associates 1984). This area has been mined and partly rehabilitated for grazing and this species is unlikely to be present there. Not recorded on the subject site despite targeted surveys. The subject site provides some potential habitat. This species is unlikely to occur on the site because the sites past clearing regime and isolation from other areas.	Not recorded on the subject site. Highly unlikely to occur due to past clearance and current isolation. **No.**
Freckled Duck (*Stictonetta naevosa*)	V	-	Large well-vegetated swamps, open lakes in dry periods.	Record in the locality. No potential habitat on the subject site. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**

Common Name/Scientific Name	Legislative Status		Habitat Requirements	Presence and Habitat Utilisation	Eight Part Test Required?
	TSC Act	*EPBC Act*			
Painted Honeyeater (*Grantiella picta*)	V	-	Eucalypt forests and woodlands for breeding; mistletoe berries for foraging (and sometimes mistletoe and eucalypt nectar and insects).	Potential breeding and foraging habitat on the subject site. Not recorded in the study area. Potential to occur on the subject site.	Potential to be affected. **Yes.**
Swift Parrot (*Lathamus discolor*)	E	E	Eucalypt woodland and open forest with winter-flowering eucalypts for foraging. Breeds in Tasmania.	Potential foraging habitat on the subject site. Potential to occur on the subject site.	Potential to be affected. **Yes.**
Turquoise Parrot (*Neophema pulchella*)	V	-	Steep rocky ridges and gullies, rolling hills, valleys and river flats and nearby plains of the Great Dividing Range. Eucalypt woodlands and open forests with a ground cover of grasses and low understorey of shrubs. It is a locally common but partly nomadic species that feeds on seeds of grasses, herbaceous plants and shrubs and requires a reliable supply of drinking water. Distribution of this species is patchy, determined by areas of suitable habitat.	Not recorded in the locality or subject site despite surveys. The subject site provides potential habitat. The closest known habitat is at Wambo mine, south of the locality near the Golden Highway (Resource Strategies 2003). Due to the past clearing of woodland in the locality and the current isolation of the study area from this known habitat south of the Hunter River, it is unlikely that this species would have colonised the subject site from currently know habitat.	Not recorded on the subject site or in the locality and highly unlikely to occur due to past clearance and current isolation. **No.**
Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)	V	-	Open woodlands dominated by mature eucalypts with regrowth, tall shrubs, intact ground layer for breeding and foraging.	Known breeding and foraging habitat on the subject site. Recorded on the subject site.	Known breeding and foraging habitat removed. Likely to be affected. **Yes.**
Speckled Warbler (*Pyrrholaemus saggitata)*	V	-	Eucalypt woodland (>100 ha) with grass tussocks, dense litter and fallen branches for breeding; ground layer and understorey for foraging.	Known breeding and foraging habitat on the subject site. Recorded on the subject site.	Known breeding and foraging habitat removed. Likely to be affected. **Yes.**
Regent Honeyeater	E	E	Eucalypt woodland and open forest for foraging and	Potential foraging habitat on the subject site.	Potential to be affected.

Common Name/Scientific Name	Legislative Status		Habitat Requirements	Presence and Habitat Utilisation	Eight Part Test Required?
	TSC Act	*EPBC Act*			
(*Xanthomyza phrygia*)			breeding.		**Yes.**
White-throated Needletail (*Hirundapus caudacutus*)	-	M	Airspace over forests, woodlands, farmlands, plains, lakes, coasts and towns. It breeds from western Siberia and the Himalayas to eastern Japan and is a regular summer migrant to Australia. Feeding companies frequently patrol back and forth along favoured hilltops and timbered ranges.	Not recorded. Potential to occur on the subject site and study area.	Not listed under the TSC Act. **No.**
Rufous Fantail (*Rhipidura rufifrons*)	-	M	Undergrowth of rainforests and wetter eucalypt forest, gullies, monsoon forests, paperbarks, sub-inland and coastal scrubs, mangroves, watercourses, parks and gardens. It breeds in summer in south-eastern Australia and is a regular autumn-winter migrant to Papua New Guinea across the Torres Strait.	Not recorded on the subject site. Potential to occur on the subject site and study area.	Not listed under the TSC Act. **No.**
White-bellied Sea Eagle (*Haliaeetus leucogaster*)	-	M	A sedentary and dispersive species that occurs in coastal Australia and is also associated with larger rivers, lakes and storages. Its range includes India, southeast Asia to Papua New Guinea and the Solomon Islands.	Not recorded. Unlikely to occur on the subject site. Occurs in the locality	Not listed under the TSC Act. **No.**
Black-faced Monarch (*Monarcha melanopsis*)	-	M	In NSW it inhabits open woodlands. Resident in north east Queensland and is a summer breeding migrant to coastal south east Australia from August to April.	Not recorded. Database records in the study area. Potential to occur on the subject site.	Not listed under the TSC Act. **No.**
Mammalia					
Large Pied Bat (*Chalinolobus dwyeri*)	V	V	Caves, underground mines and unused bird nests for roosting, woodland and forest for foraging.	Potential foraging habitat on the subject site. Not recorded in the study area. Potential to occur on the subject site.	Potential foraging habitat removed. **Yes**.

Common Name/Scientific Name	Legislative Status		Habitat Requirements	Presence and Habitat Utilisation	Eight Part Test Required?
	TSC Act	*EPBC Act*			
Spotted-tailed Quoll (*Dasyurus maculatus*)	V	V	Sclerophyll forest and woodlands, coastal heathlands and rainforest. It is partly arboreal living in rainforest, woodland, coastal heath, inland riparian forest, Red Gum forest along the Murray River, and even up to snowlines in some areas. The Spotted-tail Quoll has a large home range and is highly mobile. It requires suitable den sites (hollow logs, tree hollows, rock outcrops of caves) and an abundance of food (birds and small mammals).	Not recorded in the locality or subject site despite surveys. The subject site provides low quality potential habitat. It is unlikely to occur on the subject site or in the locality due to the paucity of suitable den sites and scarcity of ground mammals, which would be due to past clearing and isolation.	Not recorded on the subject site or in the locality and unlikely to occur due to past clearance and current isolation. **No.**
Eastern Falsistrellus (*Falsistrellus tasmaniensis*)	V	-	Tree hollows, caves and abandoned buildings for roosting; forest and woodland for foraging.	Potential breeding and foraging habitat on the subject site. Not recorded in the study area. Potential to occur on the subject site.	Potential foraging and breeding habitat removed. **Yes.**
Little Bentwing-bat (*Miniopterus australis*)	V	-	Caves for breeding; a range of eucalypt forest and woodland for foraging.	Potential foraging habitat on the subject site. Not recorded on the subject site. Potential to occur on the subject site.	Known foraging habitat removed. **Yes**.
Large Bentwing-bat (*Miniopterus schreibersii oceanensis*)	V	-	Mainly caves for breeding (also man-made structures such as culverts); a range of eucalypt forest and woodland for foraging.	Known foraging and potential breeding habitat on the subject site. Recorded on the subject site.	Known foraging and potential breeding habitat removed. **Yes.**
Eastern Freetail-bat (*Mormopterus norfolkensis*)	V	-	Tree hollows, crevices, under bark, caves and buildings for roosting, eucalypt wet and dry forest, woodland and rainforest for foraging.	Known foraging and potential breeding habitat on the subject site. Recorded on the subject site.	Known foraging and potential breeding habitat removed. **Yes.**
Large-footed Myotis (*Myotis adversus*)	V	-	Mainly caves for breeding (also tree hollows, vegetation and man-made structures such as tunnels and mines); a range of forest types with permanent creeks, rivers and dams for foraging.	Potential breeding and foraging habitat on the subject site. Not recorded on the subject site. Recorded in the study area.	Potential breeding and foraging habitat removed. **Yes.**
Yellow-bellied Glider (*Petaurus australis*)	V	-	Tall open sclerophyll forest with mature trees that provide tree hollows for breeding, a mix of eucalypts, eucalypt nectar and sap, honeydew, manna, pollen	No habitat on the subject site. Not recorded on the subject site. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**

Common Name/Scientific Name	Legislative Status		Habitat Requirements	Presence and Habitat Utilisation	Eight Part Test Required?
	TSC Act	*EPBC Act*			
			and invertebrates under decorticating bark.		
Squirrel Glider (*Petaurus norfolcensis*)	V	-	Woodlands and forest with abundant tree hollows for breeding; a mix of eucalypts, acacias and banksias that provide nectar, pollen, flowers, acacia gum, and insects (particularly caterpillars) for foraging.	Low quality potential habitat on the subject site. Not recorded on the subject site after targeted surveys including trapping and spotlighting.	Unlikely to be affected. **No.**
Brush-tailed Rock-wallaby (*Petrogale penicillata*)	V	V	Steep rugged rocky sites with associated dry sclerophyll or rainforest vegetation.	No habitat on the subject site. Not recorded on the subject site. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**
Koala (*Phascolarctos cinereus*)	V	-	Eucalypt forest and woodland with preferred *Eucalyptus* sp. for foraging.	No habitat on the subject site. Not recorded on the subject site. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**
Grey-headed Flying Fox (*Pteropus poliocephalus*)	V	V	Rainforest, woodland and forest with *Eucalyptus*, *Melaleuca* and *Banksia* nectar and pollen, fruits of rainforest trees and vines for foraging and breeding (camp sites).	Unlikely to forage on the subject site. Not recorded on the subject site. Unlikely to occur on the subject site.	Potential foraging habitat removed. **No.**
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	V	-	Tree hollows, abandoned nests of Sugar Gliders (*Petaurus breviceps*), animal burrows for roosting; almost all habitats including forest and woodland for foraging.	Potential breeding and foraging habitat on the subject site. Not recorded in the study area. Potential to occur on the subject site.	Potential foraging and breeding habitat removed. **Yes.**
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	V	-	Tree hollows and branches and roofs of old buildings for roosting; forest and woodland for foraging.	Potential breeding and foraging habitat on the subject site. Not recorded in the study area. Potential to occur on the subject site.	Potential foraging and breeding habitat removed. **Yes.**
Reptilia					
Pink-tailed Worm Lizard (*Aprasia parapulchella*)	V	V	Former and occupied ant colony nests under rocks and logs for shelter in open areas with little or no woody vegetation; small black ants of genus	Potential habitat on the subject site. Not recorded. Potential to occur on the subject site.	Potential habitat removed. **Yes**.

Common Name/Scientific Name	Legislative Status		Habitat Requirements	Presence and Habitat Utilisation	Eight Part Test Required?
	TSC Act	*EPBC Act*			
			Iridomyrex for foraging.		
Pale Headed Snake (*Hoplocephalus bitorquatus*)	V	-	Tree hollows for nesting; large mature trees, decorticating ironbarks, vertebrates such as skinks and frogs for foraging.	Potential habitat on the subject site. Not recorded. Potential to occur on the subject site.	Potential habitat removed. **Yes**.
Broad-headed Snake (*Hoplocephalus bungaroides*)	E	V		No habitat on the subject site. Not recorded on the subject site. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**
Stephens Banded Snake (*Hoplocephalus stephensii*)	V	-	Wet or dry sclerophyll forests and or rainforest edges in ranges and foothills. Tree hollows for nesting; large mature trees, decorticating ironbarks, vertebrates such as birds, lizards, skinks and frogs for foraging.	Low potential habitat on the subject site. Not recorded on the subject site. Unlikely to occur on the subject site.	Unlikely to be affected. **No.**
Endangered Ecological Communities					
White Box Yellow Box Blakely's Red Gum Woodland/Grassy White Box Woodlands	E	E	Relatively fertile soils on the tablelands and western slopes of NSW, generally between the 400 and 800 mm isohyets extending from the western slopes, at an altitude of c. 170 m to c. 1200 m, on the northern tablelands.	Not recorded within the study area. Not recorded on the subject site.	Unlikely to be affected. **No.**

1. E = Endangered , V = Vulnerable, M = Migratory,
2. Habitat requirements for species are from: Harden (1992, 1993, 2000, 2002), Churchill (1998), NPWS (1996), NPWS (2000), NPWS (2001b), Pizzey and Knight (1998), Garnett and Crowley (2000), Cogger (1996) and Ehmann (1992).

4.4.1 *Potential of Occurence of Endangered Ecological Communities*

The potential for the occurrence of the endangered ecological community of Box-Gum Woodlands on the subject site was assessed by a review of the literature describing this community and targeted field surveys to collect structural and floristic vegetation data. Assessment of the vegetation on Site 2 indicated that White Box (*Eucalyptus albens*) trees were present in a number of areas. These are small areas (from 20 x 20 m to 50 x 50 m in area) where box gums dominate on darker more clayey soil, compared to the surrounding vegetation. Therefore, surveys were undertaken to collect information about these areas and compared to the NPWS guidelines for identification of this community and the description of this community in its Final Determination under the *TSC Act*.

A peer review of this information was undertaken by HWR Pty Ltd (2003). This included a field inspection and comparison of the site's characteristics with the criteria listed in the Final Determination.

The ranges of White Box (*Eucalyptus albens*) (a western species) and Grey Box (*E. molucanna*) (a coastal species) overlap in the Hunter Valley, where they form intergrading populations (Harden 2000). The trees on Site 2 that were initially identified as White Box were identified by the Royal Botanic Gardens as 'specimens showing more influence of *Eucalyptus molucanna* than of *Eucalyptus albens*' (HWR Pty Ltd 2003). It was concluded that the areas of regrowth woodland that were initially assessed do not clearly comply with the criteria in the Final Determination of Box-Gum Woodland because of the following:

- the site is not on the tablelands nor on the western slopes. HWR Pty Ltd (2003) noted that the NPWS guidelines do not include consideration of whether a subject site is on the tablelands or western slopes and considers that this is an omission in interpreting the Final Determination; and

- it is not clear that White Box is present on the site, nor are Yellow Box (*Eucalyptus melliodora*) or Blakely's Red Gum (*E. blakelyi*).

In addition, it would be inappropriate to include these small areas as a separate community from the surrounding woodland. These areas would be minor local variations within the surrounding Narrow-leaved Ironbark/Grey Box Woodland (HWR Pty Ltd 2003).

4.4.2 *Threatened Flora*

No threatened plant species were recorded on the subject site. However, the following three species have the potential to occur on the subject site (see *Table 4.2*):

- Lobed Blue Grass (*Bothriochloa biloba*);

- Illawarra Greenhood Orchid (*Pterostylis gibbosa*); and
- *Diuris tricolor* (syn. *D. sheaffiana*).

4.4.3 *Threatened Fauna*

The following four threatened species, two woodland birds and two insectivorous bats, were recorded on the subject site (*Figure 4.6*):

- Speckled Warbler (*Pyrrholaemus sagittata*);
- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*);
- Large Bentwing-bat (*Miniopterus schreibersii oceanensis*);
- Eastern Freetail-bat (*Mormopterus norfolkensis*).

Habitat values, utilisation, corridors and other known populations in the locality for these species are discussed below.

Speckled Warbler

Habitat Values, Utilisation and Corridors

Speckled Warblers were observed once at one location on Site 2 during surveys in November 2003 (*Figure 4.6*). Two individuals were observed in Narrow-leaved Ironbark/Grey Box Woodland (regrowth) on the branches of Bulloak and on the ground amongst the grass.

This species lives in separate pairs or trios and has a home range of 6-12 ha. It inhabits eucalypt woodland (>100 ha) with grass tussocks, dense litter and fallen branches for breeding; ground layer and understorey for foraging. There is no habitat for this species on Site 1, therefore it would not occur there.

Site 2 is 61 ha in area and surrounded by similar vegetation which would create a patch that is greater than 100 ha. Therefore, there is potential for between six to 10 separate groups to be breeding on Site 2 (Gardner 2002). Individuals on Site 2 are likely to be part of a viable local population that occurs within the study area. This species has also been recorded at Ravensworth-Narama (ERM Mitchell McCotter 1997) and is also highly likely to occur at Cumnock No. 1 Colliery. Therefore, the individuals on Site 2 are likely to be part of a local population that extends into this regrowth woodland.

Given that the subject site and surrounding areas were cleared in the past it is likely that this species colonised Site 2 and the surrounding vegetation after disturbance regimes had been altered.

Individuals in this population are likely to disperse to more open habitats if woodland regenerates with a grassy understorey and it is likely that this species is not currently declining on Site 2 nor in the surrounding vegetation.

Site 2 is part a small remnant that is connected to more extensive vegetation to the east of the Belt Line Road. This habitat is surrounded by cleared land to the south and West Pit to the west. Therefore, it is not likely to be part of a regional dispersal corridor for this species.

Other Known Populations

The Speckled Warbler has been recorded at Ravensworth-Narama and is likely to occur in other large woodland remnants within the locality. It has been moderately and often recorded in the central and western parts of the Hunter Region (HBOC 1997).

Grey-crowned Babbler

Habitat Values, Utilisation and Corridors

Grey-crowned Babblers inhabit open woodlands dominated by mature eucalypts with regrowth, tall shrubs, and intact ground layer for breeding and foraging. This species has previously been recorded at Ravensworth-Narama (ERM Mitchell McCotter 1997) and at Cumnock No. 1 Colliery (HLA Envirosciences 1996).

Grey-crowned Babblers were regularly observed on the subject site and within the remainder of the study area during surveys in November and February (*Figure 4.6*). Grey-crowned Babblers were observed in groups from three to seven birds in all woodland communities within both Sites 1 and 2. Nests in groups of two to five were located in five sites on the subject site. Nests were observed in the tops of Bulloaks and also in outlying branches of large Grey Box and Narrow-leaved Ironbark trees in the woodland communities.

Given the paucity of habitat on Site 1 it is likely that only two or three family groups occur on the subject site. The individuals on the site are likely to be part of a local viable population that occurs within the vegetation on and surrounding the subject site and in the adjacent woodland in Ravensworth-Narama and Cumnock No. 1 Colliery.

As noted for the Speckled Warbler, the location and distribution of habitats in the study area have been dynamic in response to clearing and grazing pressures. It is unlikely that Grey-crowned Babblers were present on the subject site in 1958 since there was very little vegetation on the subject site and probably no suitable habitat available at that time. However, it is likely that it has maintained populations across the landscape, and has colonised the subject site as suitable habitat became available.

The more open woodland remnants with adequate foraging and nesting resources within the study area are likely to be important dispersal corridors for this species. The subject site is unlikely to be part of a north south corridor for this species because there is a wide expanse of cleared land to the south of the study area.

Other Known Populations

There have been many recordings of this species in the north of the locality and also in the south of the locality near Jerrys Plains (*Figure 1.1*). This species is widely and moderately recorded in the Hunter Region (HBOC 1996).

Insectivorous Bats

Habitat Values, Utilisation and Corridors

The Large Bentwing-Bat and the Eastern Freetail-bat were detected on the subject site (*Figure 4.6*).

Known foraging habitat for these species occurs widely across the subject site, and includes regrowth woodlands and farm dams, that provide foraging resources (insects) and potential roosts (mature trees with hollows and cracks and crevices). The subject site does not provide breeding habitat for the Large Bentwing-bat since this a cave-roosting species (Churchill 1998).

The Eastern Freetail-bat has varied roosts including tree hollows, crevices, under bark, caves and buildings. Woodland on Site 2 could provide potential roosts for this species due to the scattered mature trees containing hollows. Site 1 is unlikely to provide roosts because there are far fewer trees and these are in open paddocks, which is likely to afford less protection for bats from predators because of the low foliage cover. There are no abandoned buildings or culverts on the site that would provide roosting sites for these bats.

Other Populations

The subject site and the surrounding study area provides known and potential foraging for a number of these bat species. The individuals on the subject site and in the study area are likely to be part of a local population that occurs in the study area, locality and the region.

5 *ASSESSMENTS OF LIKELY IMPACTS*

5.1 *INTRODUCTION*

There is a range of potential impacts arising from the proposal that could affect native flora and fauna that occur in the study area. The potential impacts are predicted to vary in magnitude depending upon the species and their dependence on habitats within the study area. The purpose of this section is to identify the potential impacts of the proposal on flora and fauna including significant species and affected species. Amelioration measures are discussed in Section *6*.

5.2 *POTENTIAL IMPACTS OF THE PROPOSAL*

The proposal will directly clear a small portion of woodland (79.2 ha) of a relatively large remnant of native woodland vegetation that occurs in the study area (372.5 ha) and in adjacent parts of the locality. Site 1 would be gradually cleared from Year 5 to Year 20 and Site 2 would be gradually cleared from Year 15 to Year 20 (*Figure 2.1*).

The remnant woodland surrounding the study area would also be cleared during this time under existing approvals. Therefore, once clearing of Site 2 commences, the value of this site for flora and fauna would be reduced because the size of the remnant of which it was a part would have been reduced under existing approvals.

Nonetheless, direct impacts include the gradual removal over 20 years of vegetation and habitat on the subject site. This vegetation has regenerated after being almost totally cleared at least 40 years ago (*Figure 4.1*). The gradual removal of habitat on Site 1 and Site 2 is likely to allow flora and fauna species to disperse and colonise adjacent suitable habitat over the 20 years of mining.

Indirect impacts include habitat fragmentation which adds to a small reduction in regional connectivity. Other potential indirect impacts include changes to hydrology and water quality in the study area. This is unlikely to be significant since the study area would also eventually be mined over the 20 years. The proposal also has the potential to result in the spread and establishment of weeds and feral animals in the study area.

The significance of these impacts on flora and fauna in the study area at the local and regional level is discussed below.

5.3 GENERAL AND SIGNIFICANT FLORA AND FAUNA

5.3.1 *Vegetation Clearance and Habitat Loss*

Direct impacts include removal of vegetation and habitat, which is listed as a key threatening process under both the *TSC Act* and *EPBC Act*. The amount of each vegetation community that would be removed and the area of each of these vegetation communities in the study area is shown in *Table 5.1*.

Table 5.1 Direct Impacts on Vegetation Communities (hectares)

Vegetation Community	Area to be removed from the Subject Site		
	Site 1	**Site 2**	**Total**
Narrow-leaved Ironbark/Grey Box Woodland	3.3		3.3
Narrow-leaved Ironbark/Grey Box Woodland (regrowth)	3.7	52.7	56.4
Narrow-leaved Ironbark/Kurrajong Woodland		13.3	13.3
Rough-barked Apple/Narrow-leaved Ironbark Woodland	2.6		2.6
Swamp Oak Woodland	1.0		1.0
Bulloak Woodland (regrowth)		2.6	2.6
Native Pasture	220.4		220.4
Cleared Land		6.8	6.8
Total	**230.9**	**75.5**	**306.4**

The proposal will result in the gradual reduction in area of vegetation communities and flora and fauna and their habitat on the subject site over a 20 year period. This would add to the cumulative impact of the removal of vegetation and habitat within the study area and adjacent areas under existing consent.

The proposal is likely to result in the following changes to natural habitats on the sites:

- removal of native vegetation and loss of flora and fauna species from the subject site;
- an increase in the partitioning of remaining habitat, reducing the size of a fragment of remnant woodland in the locality;
- potential increased weed invasion; and
- changes to water runoff, volume and quality.

The nature of the proposal means that these impacts on native flora and fauna are unavoidable. These impacts can be mitigated to some degree so that there will not be a significant loss of flora and fauna habitat within the locality. Amelioration measures are discussed in detail in Section *6*. In addition, because the subject site will be gradually cleared over a 20 year period, the potential impact of vegetation removal will be minimised by enhancing the quality of flora and fauna habitat on the subject site and in other locations in the study area where these communities will be retained.

5.3.2 *Habitat Fragmentation*

Potential impacts on flora and fauna include the gradual removal of vegetation from the subject site. Adjacent mining operations at Ravensworth-Narama, and the existing approval for West Pit will mean that vegetation on Site 2 will become isolated from vegetation on Cumnock No. 1 Colliery in the future. This will mean that the area of remnant vegetation in the study area will gradually become smaller in size as a result of existing mining approvals, which will decrease the size of populations of flora and fauna in the study area. This will reduce the connectivity value of the subject site. Therefore, the removal of Site 1 and Site 2 will add to the cumulative impact of habitat fragmentation within the locality.

The proposal will therefore fragment this remnant at the regional level and modify the level of interactions of flora and fauna between this remnant and other remnants in the region. Potential interactions between flora and fauna in the study area and in other remnants within the region include migration of highly mobile species (such as Yellow-faced Honeyeaters and White Throated Needletails) down and across the Hunter Valley and dispersal and colonisation of less mobile flora and fauna species.

West Pit, situated to the west of the study area, currently limits direct interactions of species between the study area and other regional vegetation remnants to the west, especially dispersal, colonisation and inter-population interactions of less mobile species. Therefore, the proposal will not have significant impacts on the movement of flora and fauna species in this direction.

Flora and fauna on the subject site are more likely to interact with other remnants surrounding Site 2 and to the east and north of the subject site where the surrounding areas are not as hostile. Impacts on regional connectivity are discussed below in Section *5.3.3*.

Therefore, the impact of fragmentation at the local level, while adding to the cumulative impact of vegetation clearance in the area, is not likely to be significant since clearing of the surrounding vegetation under existing approvals will result in a reduction of the value of the subject site as flora and fauna habitat and corridor function.

Potential impacts in the study area from an increase in the edge/area ratio (which can cause changes in microclimate and increase susceptibility to invasion from non-indigenous species) would be minimised by the gradual removal of vegetation over 15 years and management of vegetation and habitat on the subject site and adjacent areas before it is cleared.

5.3.3 *Regional Connectivity*

The proposal has the potential to add to the cumulative impact of a decrease in the area of vegetation and habitat within the locality. This is unlikely to increase the existing barriers to regional connectivity for flora and fauna in the Hunter region. As noted above, the current mine operation is a barrier to movement of species directly to the west and open land inhibits movement to the south. The likely regional migratory routes have been indicated in *Figure 1.1* and these are not likely to be significantly impacted by the proposal.

Migratory species are likely to have covered large areas of open land before they reach the study area and are likely to use it as resting and foraging habitat. While the proposal will reduce this area, it is not likely to constitute a barrier to movement of migratory species.

At the regional scale, the proposal will add to the cumulative effect of reducing the area that is available for local dispersal and colonisation of non-migratory flora and fauna such as terrestrial and arboreal mammals, reptiles and amphibians and bird species that avoid open habitats. These fauna groups are likely to disperse to the north and east of the study area if habitat is allowed to regenerate and corridors maintained over 20 years.

Overall impacts on regional connectivity are unlikely to be significant due to the proposed rehabilitation and regeneration of selected areas in HVO's lease areas.

5.3.4 *Hydrology and Water Quality*

The proposal is unlikely to significantly impact on the hydrology and water quality of the surrounding study area. However, the loss of sections of Emu and Farrells Creeks has the potential to affect breeding conditions for amphibians and microhabitats for flora and fauna downstream of the subject site. This will be minimised by proposed erosion control and sedimentation measures which will enhance the stream health before and during clearing of the subject site and is unlikely to be significant for flora and fauna.

5.3.5 *Other Indirect Impacts*

Other indirect impacts that could arise from the proposal include:

- weed infestation;
- alteration to the fire regime; and
- disturbances from noise and dust.

Weeds are a potential threat to any site that experiences soil disturbance. The subject site has been disturbed in the past and supports many weeds. Therefore, there is potential for weeds to spread and establish in areas that are to be cleared, before they are mined. Weeds may also establish on spoil piles or in areas that are to be rehabilitated. Weed control strategies outlined in Section *6* will control and monitor any threats from weeds as a result of the proposal. Therefore, impacts from weeds as a result of the proposal are not likely to be significant.

The subject site and study area are likely to have experienced a high frequency of fire in the past. Maintenance of the subject site and other areas identified for woodland regeneration and rehabilitation will aim to reduce the fire frequency in these areas. This is expected to benefit flora and fauna within the study area.

Noise and dust are expected to slightly increase as a result of the proposed mine operations. This will initially result in disturbance to some species. However, animals can become accustomed to noise and can remain in areas subject to noise provided that the habitat is present. For example, many species of fauna have been recorded on the subject site, which is close to existing operations. In addition, these impacts will be minimised by measures outlined in Chapter 19 of the EIS. The mine works will be rehabilitated in the long term, which will minimise long term impacts from dust. Noise and dust are not expected to have a significant impact on flora and fauna of the study area.

Feral animals are already present on the subject site and in the study area. The management of habitat on the subject site and within areas proposed for woodland regeneration are likely to reduce the available habitat for these species.

5.3.6 *Key Threatening Processes*

The following key threatening process is considered relevant to the proposal:

- Clearing of native vegetation (*TSC Act*) and land clearance (*EPBC Act*).

The purpose of this EIS is to assess impacts and recommend amelioration measures to minimise the net impact that clearing native vegetation would have in the locality. The proposed amelioration measures will ensure that these key threatening process will not have a significant impact on biodiversity in the locality. These measures will ensure that there will not be a significant cumulative loss of flora and fauna habitat and biodiversity within the region.

Other key threatening processes that may be relevant include:

- predation by the European Red Fox (*Vulpes vulpes*) (*TSC Act* and *EPBC Act*);
- predation by the Feral Cat (*Felis catus*) (*TSC Act* and *EPBC Act*);

- predation on tadpoles by the Plague Minnow (*Gambusia holbrooki*) (*TSC Act*); and
- inappropriate fire regimes (*TSC Act*).

The proposed amelioration measures and management of habitat will ensure that these processes will not be exacerbated by the proposal and that they are unlikely to have a significant impact on biodiversity in the study area.

5.4 *THREATENED SPECIES*

Four threatened species are known, and 20 more species have the potential to occur on the subject site and in the study area (*Table 4.2*). Impacts on threatened flora and fauna are based upon the knowledge of the distribution and abundance of each species and habitat and known or estimated utilisation of suitable habitat on the subject site and in the study area in relation to the proposal.

Indirect impacts such as fragmentation at a local scale and a small reduction in regional connectivity corridors are not expected to be significant for these species. This is because the proposed amelioration measures will maintain habitat (including habitat for potential pollinators such as birds and wasps) and cease harmful processes such as grazing. This will increase the potential for these species to germinate and establish and therefore increase the chances of dispersal and colonisation in the north and east of the study area. This will also increase the chances of colonisation to areas outside the study area.

Indirect impacts such as changes to water quality and hydrology are likely to be minimal and are not likely to significantly affect the potential habitat of this species on the subject site or in the study area.

Eight Part Tests (*Annex D*) were undertaken for the following species that are known to occur on the site or that have the potential to occur and be affected:

- Lobed Blue Grass (*Bothriochloa biloba*);
- Illawarra Greenhood Orchid (*Pterostylis gibbosa*);
- *Diuris tricolor* (syn. *D. sheaffiana*);
- Glossy Black-cockatoo (*Calyptorhynchus lathami*);
- Masked Owl (*Tyto novaehollandiae*);
- Brown Treecreeper (*Climacteris picumnus victoriae*);
- Painted Honeyeater (*Grantiella picta*);
- Swift Parrot (*Lathamus discolor*);

- Black-chinned Honeyeater (*Melithreptus gularis gularis*);
- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*);
- Speckled Warbler (*Pyrrholaemus sagittata*);
- Diamond Firetail (*Stagonopleura guttata*);
- Regent Honeyeater (*Xanthomyza phrygia*);
- Large-eared Pied Bat (*Chalinolobus dwyeri*);
- Eastern Falsistrelle (*Falsistrellus tasmaniensis*);
- Little Bentwing-bat (*Miniopterus australis*);
- Large Bentwing-bat (*Miniopterus schreibersii oceanensis*);
- Eastern Freetail-bat (*Mormopterus norfolkensis*);
- Large-footed Myotis (*Myotis adversus*);
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*);
- Greater Broad-nosed Bat (*Scoteanax rueppellii);*
- Green and Golden Bell Frog (*Litoria aurea*);
- Pale-headed Snake (*Hoplocephalus bitorquatus*); and
- Pink-tailed Worm Lizard (*Aprasia parapulchella*).

The Eight-Part Tests indicate that the proposed development is unlikely to significantly impact on threatened species provided that amelioration measures are implemented. Therefore an SIS is not required for these species.

5.5 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

All threatened species listed under the *EPBC Act* in *Table 4.2* that have any potential to be affected by the proposal have been addressed as part of this assessment.

The project is unlikely to impact on these species or any other matters of NES and therefore the proposal need not be referred to Environment Australia for approval.

6 *IMPACT AMELIORATION MEASURES*

6.1 *INTRODUCTION*

Amelioration measures for West Pit are designed to minimise the direct impact of the gradual clearance of native vegetation on the subject site and indirect impacts on the adjacent study area over 30 years. They include:

- vegetation and habitat clearance protocols;
- progressive subject site rehabilitation; and
- study area regeneration.

These amelioration measures will compliment the proposed integration of rehabilitation, regeneration, best practice environmental controls and management for HVO north of the Hunter River.

The integration of rehabilitation and regeneration measures over HVO north of the Hunter River will have a greater beneficial effect in the long term for flora and fauna on West Pit and in HVO north of the Hunter River, compared to rehabilitation undertaken separately for each pit in HVO north of the Hunter River. Beneficial effects in the long term include an increase in areas of naturally regenerated woodland which will enhance biodiversity habitat and an increase in connectivity across a landscape that is currently highly fragmented.

The integration of rehabilitated and regenerated areas and increases in connectivity will promote local and regional habitat corridors on HVO north of the Hunter River in line with the Department of Mineral Resources (DMR's) *Synoptic Plan: Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of New South Wales* (NSW Department of Mineral Resources 1999) (the Synoptic Plan).

Amelioration measures for West Pit and rehabilitation of HVO north of the Hunter River are discussed in the following sections.

6.2 *WEST PIT VEGETATION AND HABITAT CLEARANCE PROTOCOLS*

CNA have developed two procedures to manage impacts on flora and fauna. These procedures include Procedure 5.1 (Rehabilitation) and Procedure 10.2 (Flora and Fauna).

These procedures include protocols for vegetation and habitat clearing, including the following:

- avoid and retain existing native vegetation during mining and clearing operations where practicable;
- identify and delineate areas earmarked for avoidance or regeneration with clearly marked fencing to prevent accidental damage;
- wherever possible, reuse cleared vegetative material in rehabilitation and collect seed prior to clearance to use in rehabilitation;
- salvage and reuse fauna habitat features such as fallen logs, fence posts, large rocks and large hollows, which will be used to enhance regeneration and rehabilitation areas;
- identify topsoil resources to be used in rehabilitation or regeneration, strip and stockpile these resources and respread and re-seed in regeneration or rehabilitation areas in before the seed viability has been depleted;
- install artificial nest/roost boxes within areas to be retained for regeneration and in areas of rehabilitation to provide habitat for insectivorous bats and arboreal fauna;
- undertake pre-clearing surveys during breeding seasons for nests of threatened woodland birds known to occur on the subject site and roosting habitat for threatened insectivorous bats; and
- undertake annual flora and fauna surveys and develop appropriate amelioration measures should additional threatened species be detected.

6.3 WEST PIT PROGRESSIVE REHABILITATION

Rehabilitation is defined as the active landscaping, replanting and management of created habitats within native flora and fauna in areas that have been disturbed by mining.

Rehabilitation plans are developed as part of the Mine Operations Plan (MOP) which is approved by the DMR. These plans will include strategies for rehabilitation and regeneration of the West Pit study area and how this rehabilitation is linked to all rehabilitation undertaken in HVO north of the Hunter River.

The mining method, including topsoil stripping and pre-clearing surveys, is discussed in Chapter 4 of the EIS. The rehabilitation plan is discussed in Chapter 4 of the EIS and outlines regulatory requirements, rehabilitation planning, landform design, revegetation and rehabilitation techniques and final land use. This section will outline the extent and nature of rehabilitation that will aim to provide biodiversity habitat.

Rehabilitation will be integrated with the principles and strategies outlined in the Synoptic Plan and will be undertaken in consultation with the DMR.

Progressive rehabilitation will occur following mining to the west. The shaping of emplacements and rehabilitation will follow the creation of unshaped emplacements as the mine progresses. The aim of rehabilitation on the subject site will be to:

- create a large patch of vegetation that links with existing remnants, adding to a more uniform cover of vegetation throughout the Hunter Valley floor; and
- to restore the landscape to a state that provides habitat for populations of threatened species that are currently known on the subject site.

The existing (Year 0), short term (Year 10 years), mid term (Year 20) and long term (Year 30) West Pit landforms are shown in *Figure 6.1*, *Figure 6.2*, *Figure 6.3* and *Figure 6.4* respectively.

It is proposed to establish 30 % of the West Pit rehabilitation area for biodiversity habitat. These areas will link up with regeneration areas on West Pit and will enhance the local connectivity in the final landform by linking habitat north and south of the subject site. Other areas will be rehabilitated for grazing, which are also likely to provide biodiversity values. An unavoidable exception to this will be the loss of land associated with the final void, which will be unsuitable for any form of rehabilitation.

6.4 WEST PIT REGENERATION

Regeneration is defined as the natural or assisted regeneration of native flora to provide habitat for flora and fauna in areas that have not been mined but which have been cleared or grazed in the past.

During the 20 years of the proposal, areas that will not be cleared for mining will be allowed to naturally regenerate. Grazing and clearing will be removed and/or managed to protect and increase biodiversity values. Areas identified for regeneration on West Pit are shown in *Figure 6.2*, *Figure 6.3* and *Figure 6.4*.

Regenerated areas will facilitate the spread and establishment of populations of affected species across the study area during the life of the mine. This will protect and increase the biodiversity value of the subject site and facilitate the spread and establishment of populations of affected species across the study area.

In addition, vegetation and habitat will be managed for 15 years on Site 2 before it is cleared. This will allow threatened fauna that may occur on the subject site to disperse and colonise adjacent regeneration areas. This will promote the continuation of the life-cycles of threatened species on this site.

6.5 HVO REHABILITATION AND REGENERATION

As noted above, current rehabilitation and regeneration measures for pits in HVO north of the Hunter River will be integrated during the mine plan approvals.

The rehabilitation plans will also incorporate other considerations such as conservation objectives, community expectations, pre-mining land use, final land use, drainage, stability, soils, erosion control and visual compatibility. It will also follow the principles and strategies outlined in the Synoptic Plan and will be undertaken in consultation with the DMR.

6.5.1 Vegetation Categories

The current (Year 0) short term (Year 10), mid term (Year 20) and long term (Year 30) vegetation categories for HVO north of the Hunter River are shown in *Figure 6.1*, *Figure 6.2*, *Figure 6.3* and *Figure 6.4* respectively. The final landform vegetation categories for HVO north of the Hunter River will include:

- Regenerated Woodland (biodiversity);
- Regenerated Woodland (grazing);
- Regenerated Grassland (grazing);
- Rehabilitated Woodland (biodiversity);
- Rehabilitated Woodland (grazing);
- Rehabilitated Grassland (grazing); and
- Mine Disturbance/Final Void/Dam.

The areas in hectares of broad vegetation types in the subject site, study area and on HVO north of the Hunter River for Year 0, 10, 20 and 30 are provided in *Table G.1, Table G.2*, *Table G.3*and *Table G.4* respectively.

6.5.2 Rehabilitation Techniques

The existing rehabilitation program at HVO north of the Hunter River is currently aimed at creating pasture suited to cattle grazing as a future land use. The areas more suitable to grazing such as the flatter areas on less problematic soils and with access to water will continue to be sown for pasture. Local native grass species are predominantly used on site with a variety of native trees also planted within the pasture to give shade and shelter for stock.

A number of techniques have been developed that will be applied across HVO north of the Hunter River including:

- establishing forests by direct seeding. These have been successfully grown by directly seeding overburden emplacements or washery reject without topsoil. Fertilisers are applied with the initial seeding;

- growing pastures on overburden emplacements with and without topsoil. An application of fertiliser is made with the initial seeding and further applications made annually;

- developing a pasture mix that provides year round grazing capacity; and

- managing rehabilitated areas so that viable grazing land is maintained.

Plowing

All areas sown to pasture or planted with trees will be plowed. This provides a seed bed and improves rainfall infiltration. Cultivation equipment will be selected to minimise stones on the surface, while erosion will be reduced by cultivating along topographic contours.

Pastures

Pasture will be sown into cultivated topsoil in spring or autumn, depending on rainfall. This gives the best opportunity for seeds to germinate and successfully grow. Seed will be mixed with fertiliser and spread from a tractor-mounted broadcaster working along contours where possible, allowing seeds to be uniformly distributed.

Rehabilitation for Biodiversity

Rehabilitation for biodiversity will be undertaken in conjunction with and draw upon successes with similar rehabilitation activities. Rehabilitation for biodiversity will be promoted by:

- using native endemic seeds (to match those already found on the subject site) where possible, for seeding and replanting programs;

- rehabilitate groundcover, understorey and canopy species by seeding and planting (planting understorey and tree species will be undertaken where grass competition restricts the use of direct seeding);

- planting a variety of species as opposed to a monoculture, especially species that flower at different times of the year or that provide foraging resources for affected species;

- creating a diversity of landforms and habitats such as woodland, regrowth and open forest on ridgetops and lower slopes;

- placement of habitat features such as logs, rocks and dams; and

- linkage of rehabilitated areas with trees with adjacent remnant vegetation to promote regional corridors.

Up to 30% of rehabilitated areas in HVO north of the Hunter River will be planted with a mix of native trees, shrubs and groundcover. Local and regional wildlife corridors will be constructed to allow flora and fauna to disperse between patches of wildlife habitat. Preserving or establishing corridors to link habitats are practical conservation measures, which can ameliorate habitat loss and fragmentation effects. Native species will be selected to match the existing vegetation on HVO north of the Hunter River.

6.5.3 Final Landform

The final landform will have a mix of rehabilitated and regenerated areas. This will include pasture areas for agriculture and grazing and woodland areas for both biodiversity and grazing. In areas rehabilitated for biodiversity, the rehabilitation strategy will incorporate a variety of local native forest species to promote regrowth and the re-establishment of local habitats. The revegetation strategy in areas rehabilitated for agriculture and grazing will incorporate a variety of native and introduced pasture species.

Progressive rehabilitation will occur following the mine plans for West Pit, Carrington, North Pit and the Alluvial Lands. The shaping of emplacements and rehabilitation will follow the active mining areas, within Carrington and West Pit minimising the area of disturbance at any point in time throughout the mine plan. Mining within North Pit and the Alluvial Lands is expected to be complete by the end of 2003. Rehabilitation in this area will continue under the existing mine plan to restore pre-mining and in some instances improved land capabilities.

The aim of rehabilitation will be to provide a final landform to:

- restore 70 % of mined land for grazing with native or introduced pasture crops, which will provide some biodiversity values for native fauna species that are able to persist in grazed or disturbed areas;

- restore 30 % of the mined land to a state that provides potential habitat for populations of threatened species that are currently known from HVO north of the Hunter River; and

- create a patch of vegetation that links with existing remnants, adding to a more uniform cover of vegetation throughout the Hunter Valley floor. Specifically, the aim will be to link up the rehabilitated and regenerated woodland in HVO north of the Hunter River with a patch of remnant woodland east of HVO and with the north south regional corridor outlined in the Synoptic Plan.

The extent of rehabilitated woodland on Carrington has been expanded to link with regenerated woodland to the north of Carrington and ultimately to the patch of remnant woodland to the east of HVO.

Woodland will also be regenerated to the south of the West Pit extension to link up regional corridors. This will promote a north south corridor of rehabilitated and regenerated woodland and potentially link up with the regional north south corridor that runs to the west of HVO north of the Hunter River.

The extant areas of rehabilitated woodland in HVO north of the Hunter River under existing consents will add to the 'refuge' and 'stepping stone' habitat in a mostly rehabilitated final landform. In addition, land used for final voids will be filled with water and will provide some potential habitat for water birds and common amphibians and reptiles.

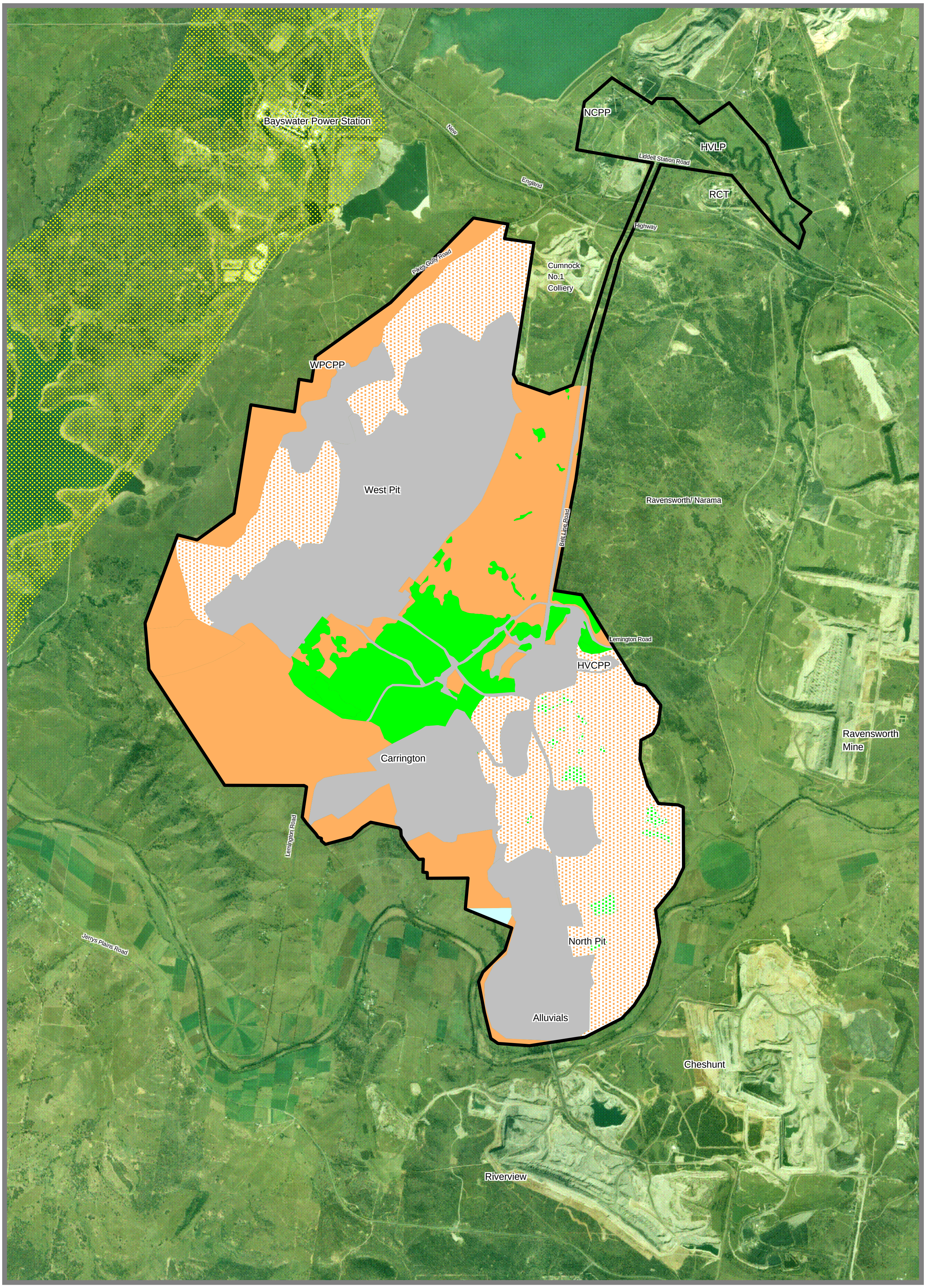


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FIGURE 6.1

Year 0 Vegetation Types (2004)

Regenerated
- Woodland (biodiversity)
- Woodland (grazing)
- Grassland (grazing)

Rehabilitated
- Woodland (biodiversity)
- Woodland (grazing)
- Grassland (grazing)

- Synoptic Plan Regional Corridor
- Development Consent Boundary
- Final Void/Dam/Active Mining Area
- Cropping Land

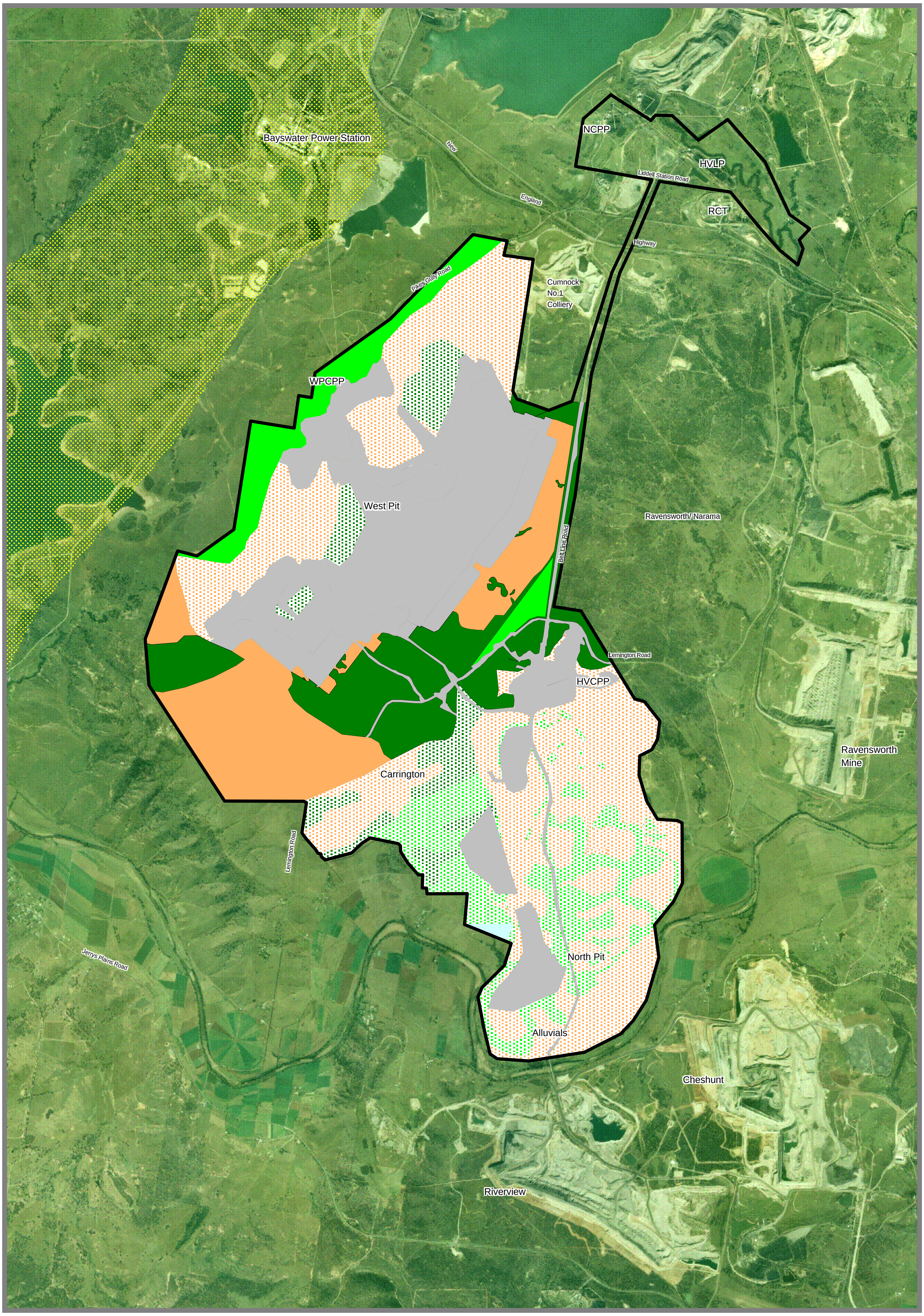

FIGURE 6.2

Short Term Vegetation Types Year 10 (2014)

Regenerated	Rehabilitated	
Woodland (biodiversity)	Woodland (biodiversity)	Synoptic Plan Regional Corridor
Woodland (grazing)	Woodland (grazing)	Development Consent Boundary
Grassland (grazing)	Grassland (grazing)	Final Void/Dam/Active Mining Area
		Cropping Land

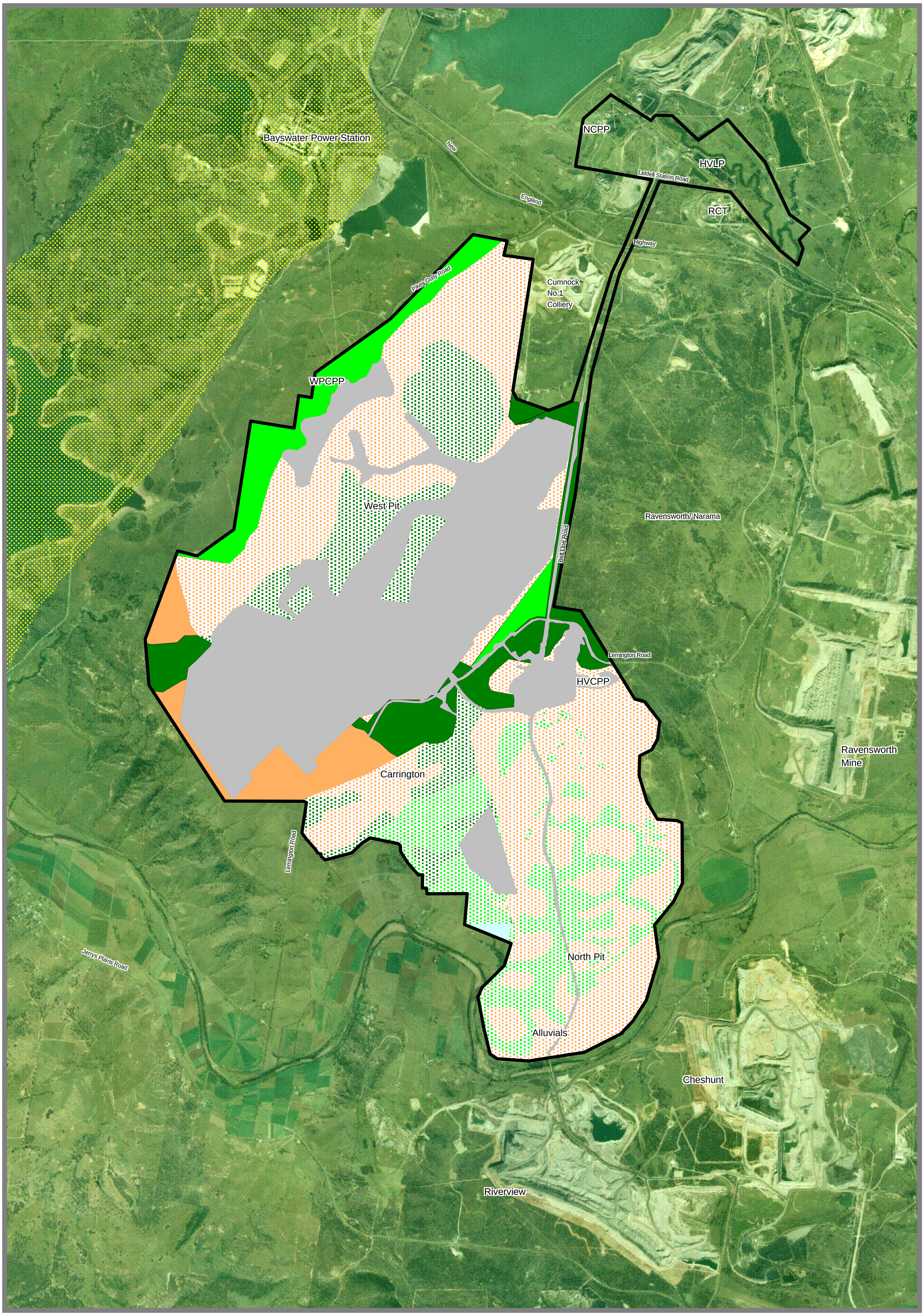

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FIGURE 6.3

Medium Term Vegetation Types Year 20 (2024)

Regenerated	Rehabilitated	
Woodland (biodiversity)	Woodland (biodiversity)	Synoptic Plan Regional Corridor
Woodland (grazing)	Woodland (grazing)	Development Consent Boundary
Grassland (grazing)	Grassland (grazing)	Final Void/Dam/Active Mining Area
		Cropping Land

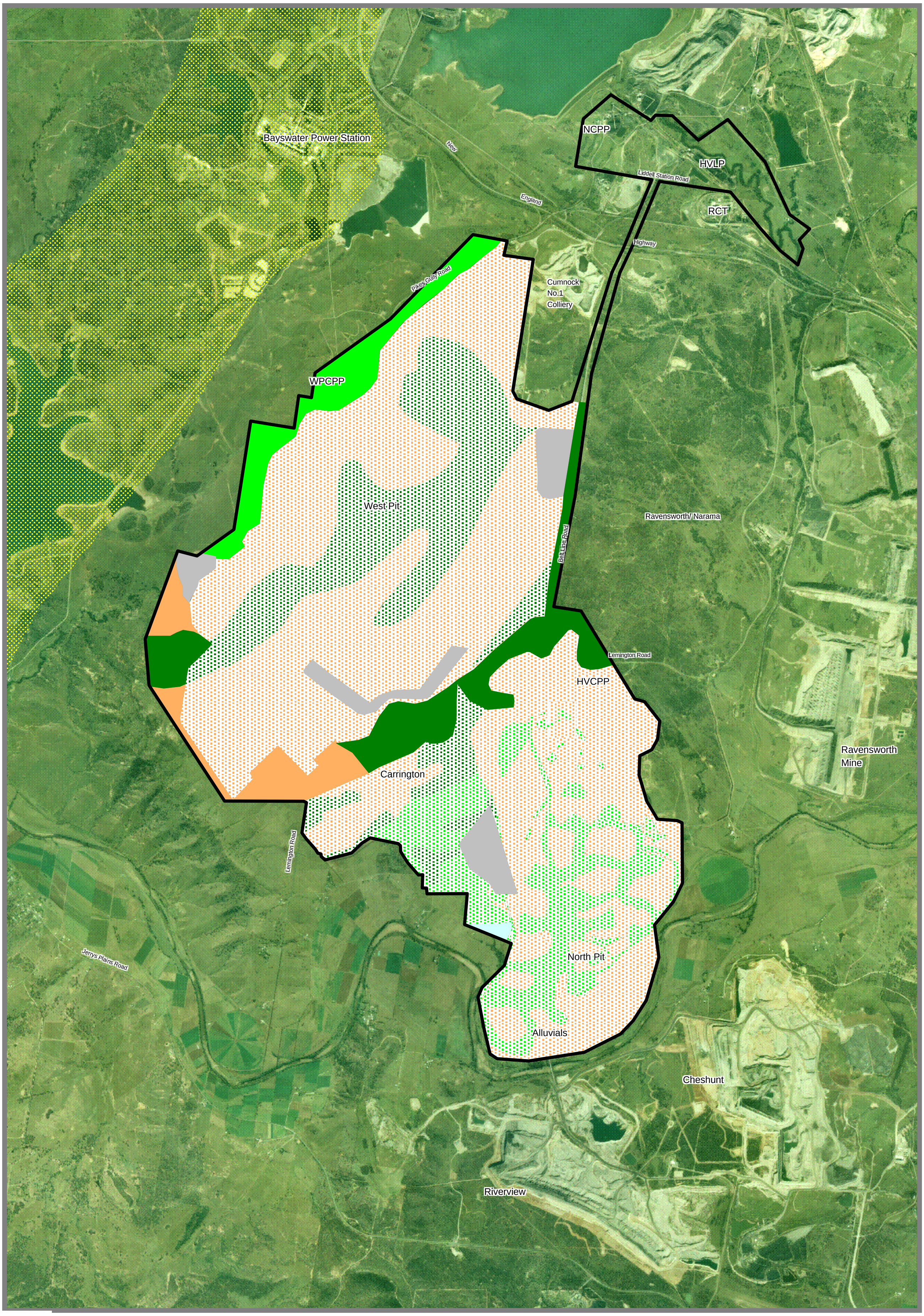

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FIGURE 6.4

Long Term Vegetation Types Year 30 (2034)

Regenerated	Rehabilitated	
Woodland (biodiversity)	Woodland (biodiversity)	Synoptic Plan Regional Corridor
Woodland (grazing)	Woodland (grazing)	Development Consent Boundary
Grassland (grazing)	Grassland (grazing)	Final Void/Dam/Active Mining Area
		Cropping Land

7 CONCLUSIONS

The proposed amelioration measures, including the long term rehabilitation plans, will mitigate the potential impact of the proposed mine extension for the duration of the impact. In the long term, it will result in a net improvement in the ecological value of habitats within the study area as well as regional connectivity.

The subject site comprises woodland and regrowth and cleared grazing country that provides habitat for a range of vegetation communities and flora and fauna. This includes habitat for threatened species including woodland birds and insectivorous bats and provides potential habitat for threatened amphibians and reptiles.

It is also part of a fragmented patch of bushland that forms part of potential north south and east west regional corridor routes across and down the Hunter Valley for highly mobile and migratory species such as birds, insectivorous bats and flying mammals. It also provides some dispersal and colonisation habitat for more sedentary or territorial species (such as plants, ground and arboreal mammals, reptiles, amphibians and sedentary birds) and as such is an important regional connectivity and dispersal corridor.

The majority of the subject site (Site 1) is currently grazed and is under threat from gradual clearing for grazing and infrastructure and threatening processes such as weeds, feral animals and disturbance. Combined with the fragmented nature of the study area, these processes also diminish the corridor value and this site has low ecological value. Site 2 supports regrowth and better quality habitat for threatened species and has medium ecological value. This value will be reduced over time as the surrounding vegetation is cleared under existing consents.

Amelioration measures will ensure that vegetation and habitat is conserved and managed to enhance its ecological value and offset the proposed mining of the subject site. In the long term, habitat within HVO north of the Hunter River will be enhanced over time and will provide habitat for the dispersal and colonisation of affected species as well as increase local and regional connectivity. This connectivity will also be enhanced by the rehabilitation of woodland and open woodland and resultant connectivity with surrounding vegetation.

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Annex A

Species Lists

Table A.1 Plant Species List

Scientific Name	Common Name	Vegetation Community/Quadrat Number																						
		7	7	7	7	7	7	7	7	7	7	7	7	7	7	1	1	1	1	2	2	3	3	3
		Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q17**	**Q18**	**Q19**	**Q20**	**Q21**	**Q22**	**Q23**
Acanthaceae																								
Pseuderanthemum variabile	Pastel Flower	1	1		1			2	2	2	2									1				
Aizoaceae																								
*Galenia pubescens**	Galenia	1	2	2		1			1	1	1	1	2	2	2			1	2					1
Asclepiadaceae																								
*Gomphocarpus fruticosus**	Narrow-leaved Cotton Bush	1																						
Asteraceae																								
Brachycome multifida var. dilatata	Cut-leaved Daisy				1	2	1																	
Calotis cuneifolia	Purple Burr-daisy	2	2					2		1	1	2	2							1				
*Carthamus lanatus**	Saffron Thistle	1	2																					1
Chrysocephalum apiculatum	Yellow Buttons	2	2	3	2	1		2	2	1	2	2	1	2	1	2	2			1				
*Cirsium vulgare**	Spear Thistle						1				1													
*Conyza bonarienis**	-															1								
Conyza canadensis var. *canadensis**	Canadian Fleabane																							
*Hypochaeris radicata**	Cat's Ear			2	1											1								
*Richardia stellaris**	-	1	1																					
*Senecio madagascariensis**	Fireweed	1			1	1	1	1	1							2			1		1			
*Senecio jacobaea**	Ragwort					2	1																	
*Taraxacum officinale**	Dandelion			2																				
Vernonia cinerea	-												1								1			
Capparaceae																								
Capparis mitchellii	Wild Orange																					2	1	
Cactaceae																								
*Opuntia stricta**	Common Prickly Pear							1						1	1					1	1	1	1	
Casuarinaceae																								
Casuarina luehmannii	Bulloak															2	2		1			1		
Chenopodiaceae																								
Maireana microphylla	-	2	2	1	1	1		1	1	1		1	1	1	1	1							1	
Einadia nutans ssp. *linifolia*	-											1			1									
Enchylaena tomentosa	Ruby Saltbush																						1	
Chloanthaceae																								
Spartothamnella juncea	-																					1	1	
Convolvulaceae																								
Convolvulus erubescens	Australian Bindweed	1	1	1																				
Euphorbiaceae																								
Phyllanthus hirtellus	Thyme Spurge	2	1	2	1			1																
Fabaceae (Faboideae)																								
Daviesia ulicifolia	-																						2	
Desmodium brachypodum	-																1							
Glycine clandestina species complex	Love Creeper	2	2																					
Glycine tabacina	Love Creeper	2	2						1															
Glycine sp.	-			2	2	1		2	2	2	2	2	2	2	2	1			1	1				1
Kennedia rubucunda	Dusky Coral Pea																			1				
*Medicago polymorpha**	Burr Medic				1	2	1			1	1			1										
Fabaceae (Mimosoideae)																								
Acacia amblygona	Fan Wattle																1			1	2	3	2	
Acacia falcata	-																					l	2	
Acacia paradoxa	-															2								
Aacaia salicina	-																			1	1	2	2	
Goodeniaceae																								
Goodenia bellidifolia ssp. *bellidifolia*	Daisy-leaved Goodenia	2	2					2			1	2		2	2									

Table A.1 Plant Species List

Scientific Name	Common Name	Vegetation Community/Quadrat Number																						
		7	7	7	7	7	7	7	7	7	7	7	7	7	7	1	1	1	1	2	2	3	3	3
		Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q17**	**Q18**	**Q19**	**Q20**	**Q21**	**Q22**	**Q23**
Lauracea																								
Cinnamomum camphora	Camphorlaurel																							1
Loranthaceae																								
Amyema pendulum subsp. *pendulum*	Mistletoe																						1	
Malvaceae																								
*Sida rhombifolia**	Cobbler's Peg	3	2	1	2	1	1	1	2	2	2	2	2	2	2	1	1		1	1	1			3
Myoporaceae																								
Myoporum parvifolium	Creeping Boobialla									1	1	1	1	1	1	1				1	1			
Myrtaceae																								
Angophora floribunda	Rough-barked Apple																1							
Euclayptus albens/molucanna hybrid	White Box/Grey Box hybrid																						1	
Eucalyptus blakelyi	Blakely's Red Gum																							
Eucalyptus crebra	Narrow-leaved Ironbark									1	1						2	2	2	2	2	3		
Eucalyptus moluccana	Grey Box											1	1				1							
Oleaceae																								
Notelaea microcarpa var. *microcarpa*	Native Olive																			1	1	1	2	
Oxalidaceae																								
Oxalis perennans	-	1	1																					
Pittosporaceae																								
Bursaria spinosa subsp. *spinosa*	Blackthorn										1	1		1		2				1		2	2	
Polygonaceae																								
Rumex brownii	Swamp Dock	1														1								
Plantaginaceae																								
Plantago debilis	-														1									
*Plantago lanceolata**	Lamb's Tongue	1																						
Rubiaceae																								
Asperula confertus	-									2	1													
*Richardia huistrata**	-	1																						
Santalaceae																								
Exocarpus cupressiformis	Native Cherry																					I		
Scrophulariaceae																								
Veronica plebia	Trailing Speedwell																							1
Solanaceae																								
Solanum cinereum	-	1			1			1				1	1			2			1	1	1	1	1	1
Streculiaceae																								
Brachychiton populneus	Kurrajong																					1	1	
Verbenaceae																								
*Verbena bonariensis**	Purpletop	1		1	1											1								
Violaceae																								
Viola sp.	-								1					2										
MONOCOTYLEDONS																								
Campanulaceae																								
Wahlenbergia communis	Tufted Bluebell							2	2	1		1	1	1	1									1
Cyperaceae																								
Fimbristylis dichotoma	Early Spring Grass			2	1	2	2																	
Juncaceae																								
Juncus usitatus	-					I																		
Junucus acutus	-						I																	
Lomandraceae																								
Lomandra multiflora	-		1														1		1	2	2	2	2	

Table A.1 Plant Species List

Scientific Name	Common Name	Vegetation Community/Quadrat Number																						
		7	7	7	7	7	7	7	7	7	7	7	7	7	7	1	1	1	1	2	2	3	3	3
		Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q17**	**Q18**	**Q19**	**Q20**	**Q21**	**Q22**	**Q23**
Poaceae																								
*Aira caryophyllea**	Silvery Hairgrass				1									1										
Aristida jerichoensis var. *subspinulifera*	Jericho Wiregrass	3	3	4	3	2	3	3	3	3	3						3					1	3	
Aristida sp.	-											3	1	3	2			2	2	2	2	2	3	1
Aristida ramosa var. *ramosa*	-									3	3					1	1							
Austrodanthonia longifolia	Wallaby Grass	1	1		1													1						
Austrostipa scabra	Spear Grass									2	2	3	3				1		2	3	2	2	2	
Austrostipa verticillata	-																1				2	2		
Bothriochloa decipiens	Redleg Grass	4	3	3	3	1	2					2	1	2	1	3								
Bothriochloa macra	Red Grass			1	1	2	3	2	1															
Chloris truncata	-		1			1						1				1	1			3	2	2	2	
Cymbopogon refractus	Barbed Wire Grass							4	3			2	3	3		3					3			1
Cynodon dactylon	Common Couch				1	3	1										1							
Dichelachne micrantha	Shorthair Plumegrass				1											1								
Echinochloa sp.	-	1			1											1								
Elymus scaber	-															1								
Eragrostis brownii	Brown's Lovegrass			1									1				1	1	1			2	2	
Eragrostis leptostachya	Paddock Lovegrass																					1		
*Pennisetum clandestinum**	Kikuyu				1							1												
Setaria gracilis	Slender Pidgeon Grass	1	1																					
Sporobolus creber	Slender Rat's Tail Grass	1	2	2	2	3								1	1				1					
*Stenotaphrum secundatum**	Buffalo Grass						1											2	1					
Themeda australis	Kangaroo Grass		1		1					1	1					2	3		2	3	3	4	3	1
FERNS																								
Sinopteridaceae																								
Cheilanthes sieberi	Rock Fern			1						1	1						1			2	1	2	1	

Note:
* = introduced species
I = incidental
1 = cover less than 5% of quadrat and uncommon
2 = cover less than 5% of quadrat and common
3 = cover 6-20%
4 = cover 21-50%

Survey Dates
Quadrats 1 - 14 = 8 Jan 2003
Quadrats 15 - 20 = 20 - 21 Nov 2002
Quadrats 21 - 23 = 19 Dec 2002

Vegetation Communities
1 = Narrow-leaved Ironbark/Grey Box Woodland
2 = Narrow-leaved Ironbark/Grey Box Woodland (regrowth)
3 = Narrow-leaved Ironbark/Kurrajong Woodland
4 = Rough-barked Apple/Narrow-leaved Ironbark Woodland
5 = Swamp Oak Woodland
6 = Bulloak Woodland (regrowth)
7 = Native Pasture

Table A.2 Bird Species List

Scientific Name	Common Name	Site 1	Site 2
WETLAND BIRDS			
Anatidae			
Anas superciliosa	Pacific Black Duck	x	
Aythya australis	Hardhead	x	
Chenonetta jubata	Australian Wood Duck	x	
Ardeidae			
Ardea novaehollandiae	White-faced Heron	x	
Charadriidae			
Vanellus miles	Masked Lapwing	x	
Podicipedidae			
Tachybaptus novaehollandiae	Australasian Grebe	x	
Sylviidae			
Arcocephalus stentoreus	Clamorous Reed-warbler	x	
Threskiornithidae			
Platalea regia	Royal Spoonbill	x	
BIRDS OF PREY			
Accipitridae			
Aquila audax	Wedge-tailed Eagle		x
Elanus axillaris	Black-shouldered Kite	x	
Falconidae			
Falco cenchroides	Nankeen Kestrel	x	
Falco berigora	Brown Falcon	x	
FOREST/WOODLAND BIRDS			
Tree-hollow dependant species			
Aegothelidae			
Aegotheles cristatus	Australian Owlet-nightjar	x	
Alcedinidae			
Dacelo novaeguineae	Laughing Kookaburra		x
Cacatuidae			
Cacatua roseicapilla	Galah	x	x
Psittacidae			
Platycercus eximius	Eastern Rosella	x	x
Psephotus haematonotus	Red-rumped Parrot	x	
Strigidae			
Tyto novaeseelandiae	Southern Boobook	x	
FOREST/WOODLAND BIRDS			
Other forest/woodland birds			
Alaudidae			
Anthus novaeseelandiae	Richard's Pipit	x	
Alcedinidae			
Todiramphus sanctus	Sacred Kingfisher		x
Artamidae			
Artamus cyanopterus	Dusky Woodswallow	x	
Cracticus nigrogularis	Pied Butcherbird	x	
Cracticus torquatus	Grey Butcherbird		x
Campephagidae			
Coracina novaehollandiae	Black-faced Cuckoo-shrike		x
Columbidae			
Ocyphaps lophotes	Crested Pigeon	x	x
Corcoracidae			
Corcorax melanorhamphos	White-winged Chough		x
Corvidae			
Corvus coronoides	Australian Raven/Crow	x	x
Cracticidae			
Gymnorhina tibicen	Australian Magpie	x	x

Scientific Name	Common Name	Site 1	Site 2
Strepera graculina	Pied Currawong		x
Cuculidae			
Cuculus pallidus	Pallid Cuckoo		x
Scythrops novaehollandiae	Channel-billed Cuckoo		x
Dicruridae			
Grallina cyanoleuca	Australian Magpie-lark	x	
Hirundinidae			
Hirundo neoxena	Welcome Swallow	x	
Meliphagidae			
Manorina melanocephala	Noisy Miner	x	x
Pacycephalidae			
Pachycephala rufiventris	Rufous Whistler		x
Rhipidura fuliginosa	Grey Fantail		x
Rhipidura leucophrys	Willie Wagtail	x	x
Pardalotidae			
Acanthiza nana	Yellow Thornbill		x
Acanthiza reguloides	Buff-rumped Thornbill		x
Gerygone olivacea	White-throated Gerygone		x
Pyrrholaemus saggitata	Speckled Warbler		x
Pardalotus striatus	Striated Pardalote	x	x
Petroicidae			
Petroica goodenovii	Red-capped Robin		x
Pomatostomidae			
Pomatostomus temporalis temporalis	Grey-crowned Babbler	x	x
Sturnidae			
Sturnus vulgaris	Common Starling	x	
SCRUBLAND BIRDS			
Maluridae			
Malurus cyaneus	Superb Fairy Wren	x	x

1. x = recorded
2. Threatened species are in bold

Table A.3 Mammal and Herpetofauna Species List

Scientific Name	Common Name	Site 1	Site 2
MAMMALS			
GROUND MAMMALS			
Canidae			
*Canis vulpes**	Red Fox	S	
Dasyuridae			
Antechinus stuartii	Brown Antechinus		T
Macropodidae			
Macropus giganteus	Eastern Grey Kangaroo	O	O
Macropus rufogriseus	Red-necked Wallaby	O	O
Leporidae			
*Lepus capensis**	Brown Hare	O	O
*Oryctolagus cuniculus**	European Rabbit	O	O
Muridae			
*Mus musculus**	House Mouse		H
*Rattus rattus**	Black Rat	H	H
ARBOREAL MAMMALS			
Phalangeridae			
Trichosurus vulpecula	Common Brushtail Possum		O, H
Pseudocheridae			
Pseudocheirus peregrinus	Common Ringtail Possum		O

Scientific Name	Common Name	Site 1	Site 2
BATS			
Molossidae			
Mormopterus sp.2	Freetail-bat	Po	Po
Mormopterus nofolkensis	**Eastern Freetail-bat**	**D, Po, P**	**D**
Mormopterus planiceps (lge penis form)	Freetail-bat	D	D
Nyctinomus australis	White-striped Freetail-bat	D	D
Vespertilionidae			
Chalinolobus gouldii	Gould's Wattled Bat	Po	Po
Chalinolobus morio	Chocolate Wattled Bat	Po	Po
Miniopterus schreibersii oceanensis	**Large Bentwing-bat**	**Po, P**	
Scotorepens balstoni	-		P
Vespadelus regulus	Southern Forest Bat		Po
Vespadelus vulturnus	Little Forest Bat	Po	P
HERPETOFAUNA			
LIZARDS			
Pygopodidae			
Delma plebiae		O	O
GECKOS			
Geckonidae			
Diplodactylis vittatus	Wood Gecko		O
SKINKS			
Scincidae			
Carlia tretradactyla	Rainbow Skink		O
Ctenotus robustus	-	O	O
Lampropholis delicata	Delicate Garden Skink		O
TURTLES			
Chelidae			
Chelodina longicollis	Long-necked Tortoise	O	
GROUND FROGS			
Myobatrachidae			
Crinia signifera	Common Eastern Froglet		He
Uperoleia laevigata	Smooth Toadlet	He	
TREE FROGS			
Hylidae			
Litoria fallax	Dwarf Green Tree Frog	O	
Litoria latopalmata	Broad-palmed Frog	O	
Litoria peronii	Peron's Tree Frog	O, He	

1. Threatened species are in bold
2. O = observed
3. S = detected via signs such as scats, tracks, nests
4. H = detected via hair funnels
5. He = heard call
6. T = trapped in Elliot traps
7. D = detected via Anabat
8. P = probable identification
9. Po = possible identification
10. * = introduced species

Annex B

Vegetation Community Descriptions

Narrow-Leaved Ironbark/Grey Box Woodland

Approximately 3.3 ha of this vegetation type is located in the north of Site 1. The canopy is 18 – 20 m, has a cover of approximately 15 percent and dominant species include Narrow-leaved Ironbark *(Eucalyptus crebra*) and Grey Box *(E. molucanna*). Other canopy species include Forest Red Gum *(E. tereticornis*). The shrub layer less than 1 m, has a cover of 20 – 25 percent and dominant species include *Maireana microphylla* and Galenia (*Galenia pubescens*). The ground layer is less than 1 m, has a cover of 5 – 10 percent and dominant species include Spear Grass (*Austrostipa scabra*) and *Aristida* sp. Other native species include Kangaroo Grass (*Themeda australis*) and Redleg Grass (*Bothriochloa decipiens*) and Barbed-wire Grass *(Cymbopogon refractus*).

Narrow-Leaved Ironbark/Grey Box Woodland (regrowth)

This is a very variable community and the height and cover of the shrub and ground layers varies considerably in relation to the degree and timing of past clearing. Approximately 3.7 and 52.7 ha of this vegetation type is located on Site 1 and 2 respectively. The canopy is 8 – 20 m, has a cover of approximately 5 - 20 percent and dominant species include Narrow-leaved Ironbark. Other canopy species include Grey Box and Grey Box/White Box hybrid. The upper shrub layer is 1 – 6 m, has a cover of approximately 5 percent and dominant species include Native Olive (*Notelaea microcarpa* var. *microcarpa*), Wild Orange (*Capparis mitchellii*), Bulloak (*Casuarina leuhmanii*) and Blackthorn (*Bursaria spinosa*). The lower shrub layer is 1 - 2 m, has a cover of 1 – 10 percent and dominant species include *M. microphylla*, *Acacia salicina*, and Fan Wattle (*Acacia amblygona*). The ground layer is less than 1 m, has a cover of approximately 20 - 80 percent and dominant species include Redleg Grass, Kangaroo Grass, Barbwire Grass and *Chloris truncata*.

Narrow-Leaved Ironbark/Kurrajong Woodland

This is also a variable community. Approximately 13.3 ha of this vegetation type is located in the southern part of Site 2. The canopy is 12 – 20 m, has a cover of 7 - 8 percent and dominant species include Narrow-leaved Ironbark and Kurrajong (*Brachychiton populneus*). Other canopy species include Grey Box. The upper shrub layer is 2 – 6 m, has a cover of 5 percent and the dominant species includes juvenile Narrow-leaved Ironbark, *Acacia flacata* and *A. salicina*. The lower shrub layer is 0.5 – 4 m, has a cover of 5 percent and dominant species include Fan Wattle, Kurrajong, *A. falcata* and *A. salicina*. The ground layer is less than 1 m, has a cover of 5 – 70 percent and dominant species include Kangaroo Grass, Redleg Grass, Barb-wire Grass.

Rough-barked Apple/ Narrow-leaved Ironbark Woodland

Approximately 2.6 ha of this vegetation type is located on drainage lines and creek lines in Site 1. The canopy is 15 – 20 m, has a cover of 30 – 60 percent and dominant species include Rough-barked Apple (Angophora floribunda) and Narrow-leaved Ironbark. Other species include Swamp Oak (*Casuarina glauca*) and Bulloak. This ground layer is very variable but mostly very sparse and includes native grasses and sometimes clumps of *Juncus* sp.

Swamp Oak Woodland

This vegetation type is located on eroded creek banks in Site 1. The canopy is 4 – 8 m, has a cover of 5 – 60 percent and dominant species include Swamp Oak. The ground layer is 1 - 2 m, has a cover of 5 – 100 percent and dominant species include *Juncus acutus*.

Bulloak Woodland (regrowth)

This is a very variable community and the height and cover of the shrub and ground layers varies considerably in relation to the degree and timing of past clearing. This vegetation type is located in Site 2. The canopy is 4 – 8 m, has a cover of 5 – 60 percent and dominant species include Bulloak. The lower shrub layer is 1 – 3 m, has a cover of 5 – 20 percent and dominant species include Bulloak. The ground layer is less than 1 m, has a cover of 5 – 10 percent and dominant species include Kangaroo Grass and Barb-wire Grass.

Native Pasture

This community has been subject to clearing and disturbed areas are dominated by introduced species. It is located throughout the middle of the subject site in between regrowth woodland and cleared areas. The canopy is less than 1, has a cover of 5 – 100 percent (depending on seasonal coverage of grasses and herbs) and dominant native species, Red Leg Grass, Barbed-wire Grass, *M. microphylla*, Yellow Buttons (*Chrysocephalum apiculatum*), Jericho Wiregrass (*Aristida jerichoensis* var. *subspinulifera*), Slender Rat's Tail Grass (*Sporobolus creber*) and Kangaroo Grass. Introduced species include Kikuyu (*Pennisetum clandestinum*), Cobbler's Peg (*Sida rhombifolia*) and Buffalo Grass (*Stenotaphrum secundatum*).

Cleared Land

This community has been subject to clearing is dominated introduced weeds including thistles and grasses and occurs mainly on a cleared ridge top easement in Site 2.

Annex C

Threatened Species Profiles

Profiles of threatened species that are the subject of Eight Part Tests in this report are provided below. These profiles are from various published literature sources. Since the publishing of these profiles and the preparation of this report, some common and scientific names have changed. Therefore, to avoid confusion, the names of threatened species used in this report and the corresponding names of species used in the profiles are provided in *Table C.1* below.

Table C.1 Threatened Species Names

Flora and Fauna Report		Threatened Species Profiles	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Guild 1 – Plants			
Lobed Blue-grass	*Bothriochloa biloba*	Lobed Bluegrass	*Bothriochloa biloba*
Illawarra Greenhood Orchid	*Pterostylis gibbosa*	Illawarra Greenhood Orchid	*Pterostylis gibbosa*
-	*Diuris tricolor* (syn. *D. sheaffiana*)	-	*Diuris tricolor*
Guild 2 – Forest Birds			
Glossy Black-cockatoo	*Calyptorhynchus lathami*	Glossy Black-cockatooo	*Calyptorhynchus lathami*
Masked Owl	*Tyto novaehollandiae*	Masked Owl (southern Australia)	*Tyto novaehollandiae novaehollandiae*
Brown Treecreeper	*Climacteris picumnus victoriae*	Brown Treecreeper	*Climacteris picumnus victoriae*
Painted Honeyeater	*Grantiella picta*	Painted Honeyeater	*Grantiella picta*
Swift Parrot	*Lathamus discolor*	Swift Parrot	*Lathamus discolor*
Black-chinned Honeyeater	*Melithreptus gularis gularis*	Black-chinned Honeyeater (eastern subspecies)	*Melithreptus gularis gularis*
Grey-crowned Babbler	*Pomatostomus temporalis temporalis*	Grey-crowned Babbler (eastern subspecies)	*Pomatostomus temporalis temporalis*
Speckled Warbler	*Pyrrholaemus sagittata*	Speckled Warbler	*Pyrrholaemus sagittata*
Diamond Firetail	*Stagonopleura guttata*	Diamond Firetail	*Stagonopleura guttata*
Regent Honeyeater	*Xanthomyza phrygia*	Regent Honeyeater	*Xanthomyza phrygia*
Guild 3 – Microchiropteran Bats			
Large-eared Pied Bat	*Chalinolobus dwyeri*	Large Pied Bat	*Chalinolobus dwyeri*
Eastern Falsistrelle	*Falsistrellus tasmaniensis*	Great Pipestrelle	*Falsistrellus tasmaniensis*
Little Bentwing-bat	*Miniopterus australis*	Little Bent-wing Bat	*Miniopterus australis*
Large Bentwing-bat	*Miniopterus schreibersii oceanensis*	Common Bent-wing Bat	*Miniopterus schreibersii*
Eastern Freetail-bat	*Mormopterus norfolkensis*	Eastern Little Mastiff Bat	*Mormopterus norfolkensis*
Large-footed Myotis	*Myotis adversus*	Large-footed Mouse-eared Bat	*Myotis adversus*
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*
Greater Broad-nosed Bat	*Scoteanax rueppellii*	Greater Broad-nosed Bat	*Scoteanax rueppellii*
Guild 4 – Amphibians			
Green and Golden Bell Frog	*Litoria aurea*	Green and Golden Bell Frog	*Litoria aurea*
Guild 5 - Reptiles			
Pale-headed Snake	*Hoplocephalus bitorquatus*	Pale-headed Snake	*Hoplocephalus bitorquatus*

Flora and Fauna Report		Threatened Species Profiles	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
Pink-tailed Worm Lizard	*Aprasia parapulchella*	Pink-tailed Worm-lizard	*Aprasia parapulchella*

Profile sourced from: Sharp and Simon (2002)

Bothriochloa biloba S.T.Blake

Common name

Lobed Bluegrass

Derivation

Bothriochloa Kuntze, *Revis. Gen. Pl.* 2: 762 (1891); from the Greek *bothros* (pit) and *chloa* (grass), alluding to the pitted glumes.

biloba- from the Latin *bis* (twice) and *lobus* (lobe). Lemmas notched.

Published in

Univ. Queensland Dept. Biol. Pap. 2(3): 27 (1944).

Habit

Perennial, tufted. Culms erect or geniculately ascending, 50–100 cm tall, 3–7-noded. Mid-culm internodes channelled. Mid-culm nodes glabrous. Lateral branches branched. Ligule a fringed membrane, 1–2 mm long. Leaf-blades flat or revolute, 7–20 cm long, 3–5 mm wide. Leaf-blade surface glabrous or pilose, with tubercle-based hairs. Leaf-blade margins scaberulous.

Inflorescence

Inflorescence digitate, with ramose branches. Peduncle 2.5–10 cm long. Rames 3–6, 4–10 cm long. Central inflorescence axis 0.7–1.5 cm long. Rhachis fragile at the nodes, flattened, glabrous on surface, ciliate on margins. Rhachis hairs 4.5–6 mm long. Rame internodes linear, 3.5–4.6 mm long. Rame internode tip transverse. Raceme-bases brief, pilose, hairy in axils.

Spikelets

Spikelets in pairs, one sessile and fertile and the other (companion) spikelet pedicelled. Pedicels linear, flattened, 3.5–4.6 mm long, with a translucent median line (also present in internodes), ciliate or villous, with white or purple hairs. Companion spikelets developed, sterile, comprising 2 subequal glumes without lemmas, linear or lanceolate, 4.2–5.7 mm long, shorter than fertile. Companion spikelet glumes glabrous. Fertile spikelets 2-flowered, comprising 1 fertile floret, lower floret sterile, upper fertile, without rhachilla extension, linear or lanceolate or elliptic, dorsally compressed, acute, 6.5–8 mm long, falling entire, deciduous with accessory branch structures. Spikelet callus 0.7–1 mm long, bearded, base obtuse, attached transversely. Spikelet callus hairs 2 mm long.

Glumes

Glumes dissimilar, firmer than fertile lemma. Lower glume elliptic, 100% of length of spikelet, chartaceous, keel-less except near apex, 13–15-nerved, midnerve scabrous. Lower glume surface concave. Lower glume surface asperulous, pilose, hairy below. Lower glume apex truncate or acute. Upper glume lanceolate, 1-keeled, 0-nerved. Upper glume surface asperulous, rough above. Upper glume apex mucronate.

Florets

Basal sterile floret 1, without significant palea. Lemma of lower sterile floret lanceolate or ovate, 66–75% of length of spikelet, hyaline. Fertile lemma oblong, 3–4.3 mm long, hyaline, 3-nerved. Lemma apex lobed, 2-fid, with filiform lobes, with lobes 0.75–1.5 mm long, incised 25–33% of lemma length, 1-awned. Median (principal) awn from a sinus, geniculate, 20–25 mm long overall, with a twisted column. Column glabrous. Palea lanceolate or ovate or obovate, 1–2 mm long, 25–33% of length of lemma. Anthers 3, 1.5–1.8 mm long. Grain 3.2–3.5 mm long.

Continental Distribution:

Australasia.

Australian Distribution:

Queensland, New South Wales.

Queensland: Darling Downs. **New South Wales:** North Coast, Central Coast, Northern Tablelands, North-Western Slopes, Central-Western Slopes, North-Western Plains.

Classification. (GPWG 2001):

Panicoideae: Andropogoneae

Notes

Endemic. Found on clay soils of the Darling Downs, Qld and the tablelands and western slopes of the Gt Divide in northern N.S.W. extending to Sydney. It is thought to be of limited fodder value. Flowers Nov.–Jun.

Images

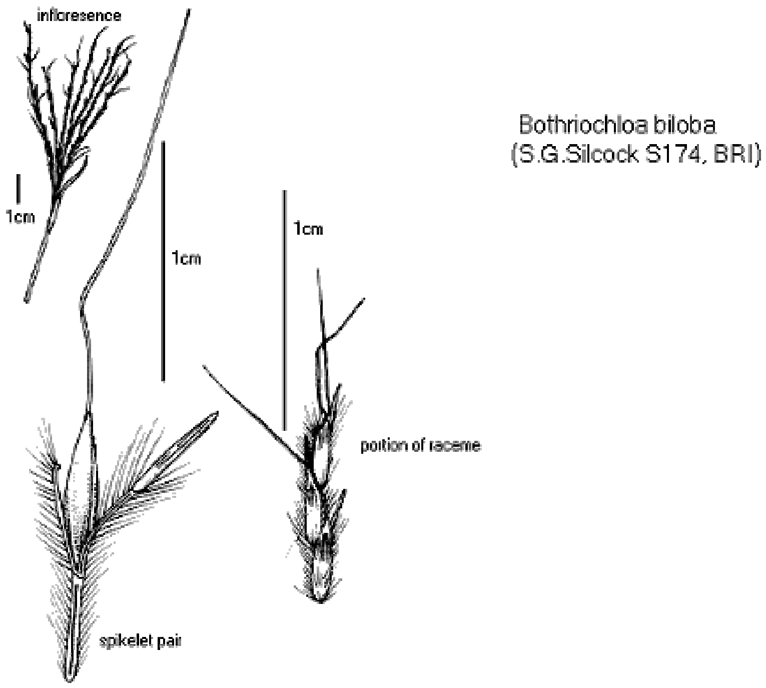
Inflorescence (photo)

Sharp 453

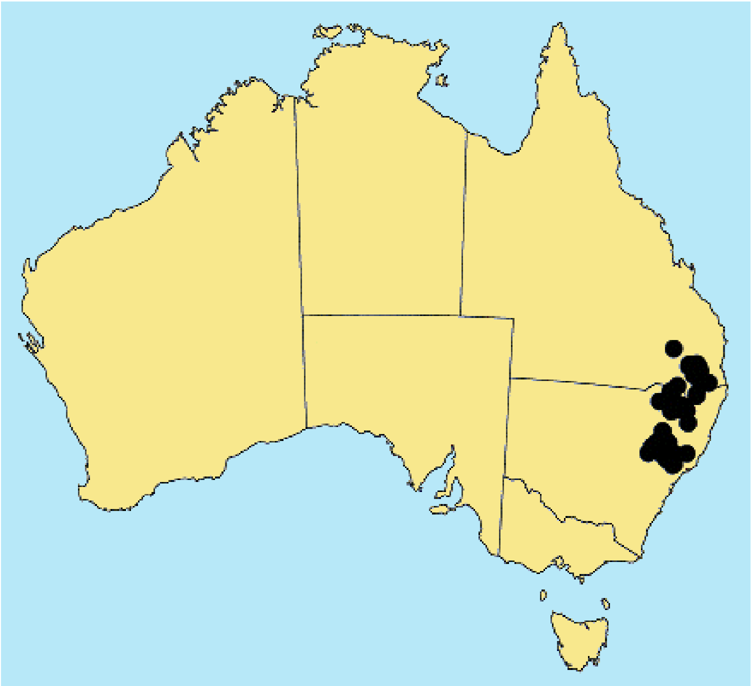
by D.Sharp

Inflorescence (scanned specimen)

by Will Smith



Inflorescence, raceme and spikelet (line drawing)
© Queensland Herbarium
by Will Smith



Australian Distribution
© ABRS

Pterostylis gibbosa

R.Br.

Illawarra Greenhood Orchid

Conservation Status

Pterostylis gibbosa is listed as an **endangered species** on Schedule 1 of the NSW *Threatened Species Conservation Act* 1995 and as an **endangered species** under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.

Description

P. gibbosa (Orchidaceae) is a perennial terrestrial orchid. It belongs to the "greenhood" group of orchids that are characterised by green, hood-shaped flowers (Dressler 1981).

Leaves are elliptic to ovate in shape, 1.5 to 3.5 cm long, entire and arranged in a small basal rosette (Jones 1993).

Photo: R. Tunstall

The inflorescence consists of two to seven flowers held on a single scape (stalk) to 45 cm high with three to six closely sheathing stem leaves (Harden 1990).

Flowers are bright green with transparent areas in the galea (hood) and petals although light reddish-brown flowers have been observed (Jones & Clements 1997). The labelum (lip) is strongly exserted, brownish-black to black, with a deep central groove and thick basal lobe (Jones & Clements 1997).

Photo: L. Johnston

Distribution

P. gibbosa is presently known from five locations: three sites in the Illawarra (two sites at Yallah and one at Albion Park); one site near Nowra in the Shoalhaven; and one site at Milbrodale in the Hunter Valley.

The original or "type" specimen of *P. gibbosa* was collected in 1803 in western Sydney (NPWS 2000). Extensive surveys in recent years have failed to relocate the species in western Sydney and it is now considered likely to be extinct in that area (NPWS 2000).

Recorded occurrences in conservation reserves

P. gibbosa has been recorded from one conservation reserve, Worrigee Nature Reserve (previously part of Currambene State Forest), near Nowra.

Habitat

All known sub-populations of *P. gibbosa* occur in open forest or woodland on flat or gently sloping land with poorly drained soils.

In the Illawarra, *P. gibbosa* occurs on soils derived from Permian sedimentary rocks of the Berry formation at an altitude of 10 to 20 metres. Associated vegetation is woodland dominated by *Eucalyptus tereticornis* (Forest Red Gum) and *Melaleuca decora* (White Feather Honey-myrtle) with an open grassy understorey.

Near Nowra, *P. gibbosa* also occurs on soils derived from rocks of the Berry formation although at a slightly higher altitude of 20 to 30 metres. Associated vegetation is open forest dominated by *Eucalyptus maculata* (Spotted Gum) and *Eucalyptus paniculata* (Grey Ironbark) with an open grassy understorey.

The Milbrodale sub-population of *P. gibbosa* occurs at an elevation of 150 to 160 metres on soils derived from Triassic sedimentary rocks of the Narrabeen group. Associated vegetation is open woodland dominated by *Eucalyptus crebra* (Narrow-leaved Ironbark) and *Eucalyptus molucanna* (Grey Box), with *Callitris endlicherii* (Black Cypress Pine) present as a sub-dominant. The understorey at this location contains dense stands of the native shrub, *Dodonaea cuneata*.

Ecology

P. gibbosa is a deciduous orchid that is only visible above the ground between late summer and spring. Its rosette of leaves emerges from an underground tuberoid during late summer and autumn. A flower scape develops on mature plants over winter. Flowering occurs between September and October, after which the leaf rosette withers and seed capsules develop.

P. gibbosa flowers are thought to be pollinated by male fungus gnats (Genera *Mycomya* and *Heteropterna*) (NPWS 2000). The fruit is a dry, dehiscent, obovoid capsule containing thousands of minute, wind dispersed seeds (NPWS 2000).

P. gibbosa does not spread vegetatively to any great extent (NPWS 2000).

A study by Sharma *et al* (2000) found a high mean viability rate (76%) for seeds collected from each known sub-population of the species.

P. gibbosa is capable of surviving occasional fire due to the regenerative capacity of the tuberoid (NPWS 2000).

Threats

Habitat loss from urban development and agriculture has greatly reduced the area of available habitat for the species. Further habitat loss will threaten the long-term viability of the species by further reducing population sizes and rendering extant sub-populations more vulnerable to stochastic events (NPWS 2000).

Frequent fires, particularly between March and November, are a potential threat to the species. Such fires will destroy above ground parts of the plant and may prevent flowering, seed set and the establishment of seedlings. Over time this may lead to the elimination of sub-populations. Frequent fire may also change the composition of surrounding vegetation by encouraging more fire tolerant species that may disadvantage *P. gibbosa* (NPWS 2000).

Fire exclusion may also threaten *P. gibbosa* as occasional fire may be necessary to provide conditions suitable for recruitment and growth of the species. The build up of leaf litter in the absence of fire will also increase the risk of high intensity fires that are more likely to kill tuberoids than low intensity fires (NPWS 2000).

Other potential threats to the species include: degradation of habitat through weed invasion, particularly by *Lantana camara* and *Pittosporum undulatum*; uncontrolled vehicular and pedestrian access to sites; and the collection of *P. gibbosa* by orchid enthusiasts (NPWS 2000).

Management

Future management must aim to increase the level of legislative protection afforded land upon which the species occurs. This can be facilitated on public and private land through a range of mechanisms including Voluntary Conservation Agreements, Joint Management Agreements, Property Management Plans etc.

Appropriate threat and habitat management practices include: weed removal to maintain suitable habitat; fencing to exclude vehicles and prevent rubbish dumping; and the establishment of appropriate grazing and fire regimes where necessary.

Further research and monitoring is required to gain a better understanding of the species and in particular, its response to different fire regimes.

Targeted survey is required to locate other extant populations of the species and so determine the full extent of the species distribution.

Recovery Plans

A draft recovery plan has been exhibited for *P. gibbosa*.

For Further Information contact

Threatened Species Unit Conservation Programs and Planning Division, Central Directorate NSW NPWS PO Box 1967, Hurstville NSW 2220 Phone 02 9585 6678. www.npws.nsw.gov.au

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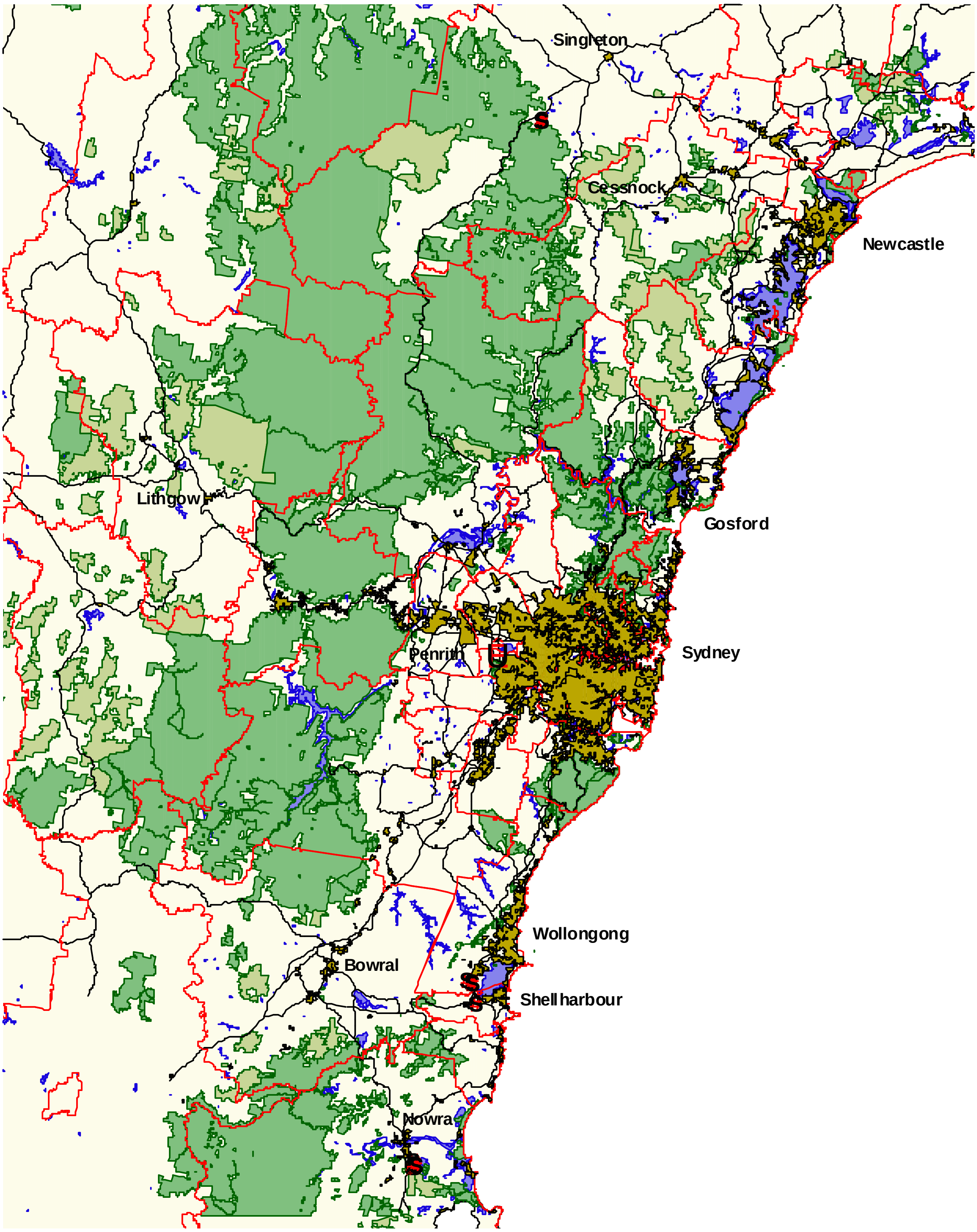

Û	presumed extinct
s	post 1980 record
	Built Up Areas
	Local Govt Areas
	Main Roads
	NPWS Estate
	SFNSW Estate
	Waterbodies

Pterostylis gibbosa

Illawarra Greenhood Orchid

Species Distibution Map

Projection: AMG Zone 56

N
W E
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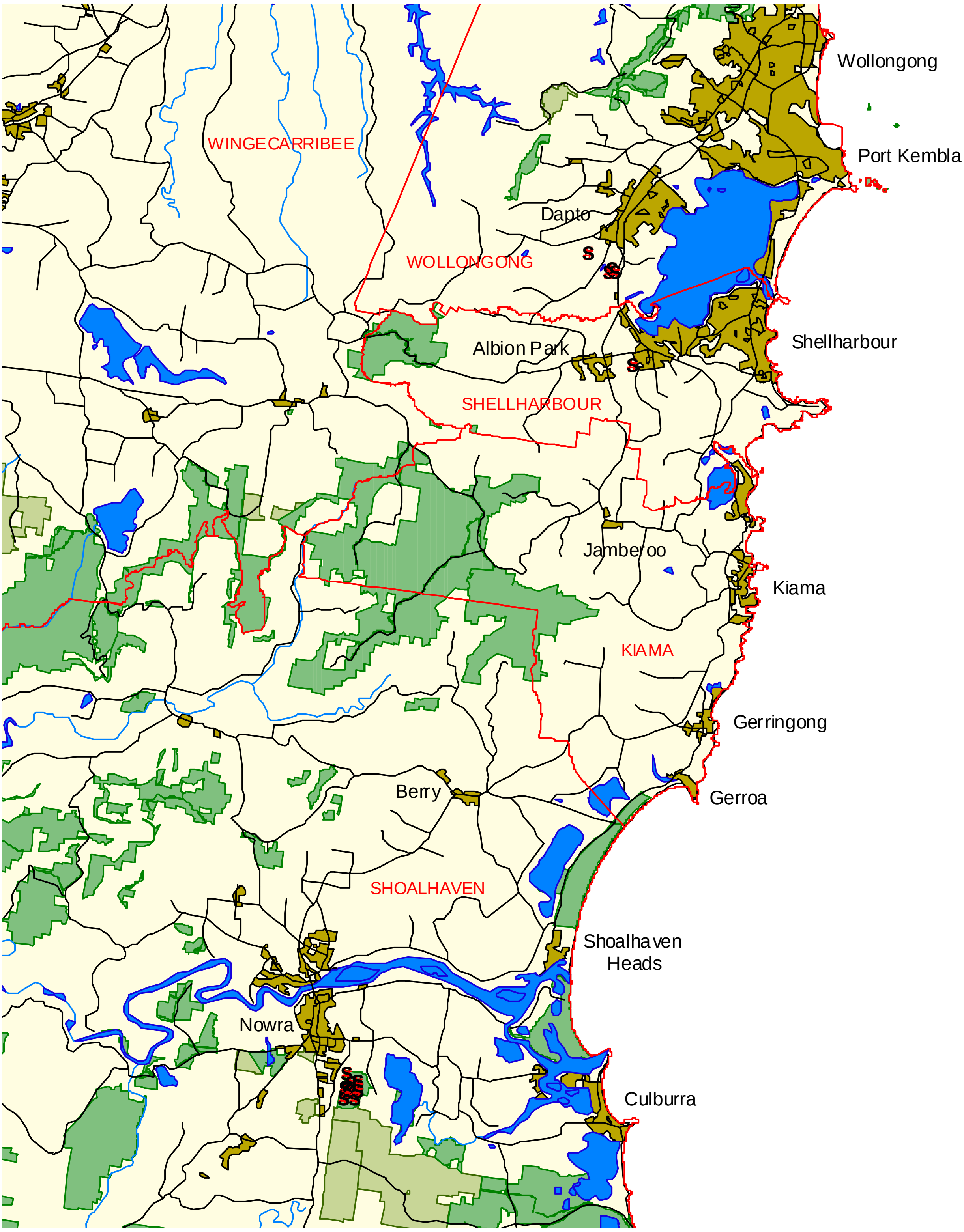
9 0 9 18 Kilometres

Printed By
Central CPPD-TSU
08 April 2002



S post 1980 record
Local Govt Areas

Motorway
Highway
Major Road
Minor Road

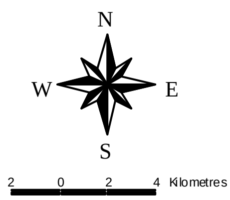
Major Rivers
Built Up Areas
NPWS Estate
State Forests

Pterostylis gibbosa

Illawarra Greenhood Orchid

Illawarra Distribution Map

Projection: AMG Zone 56



Central CPPD-TSU

21 September 2001

Profile sourced from: Bishop (2000)

Diuris tricolor

Description

Leaves 1-3, linear, to 30 cm long. Flowering stem to 40 cm, with up to 6 flowers. Flower 25 mm across, rich yellow with variable reddish or purple suffusions and spots on base of dorsal sepal and labellum; callus ridges white speckled purple. Dorsal sepal ovate, 11 mm by 7 mm, somewhat recurved at tip. Lateral sepals about 40 mm long, hanging down or pointing stiffly forwards, often crossed. Petals with claw 6 mm long and the ovate to obovate lamina 10 mm by 7 mm; directed to sides of flower. Labellum 10 mm long; lateral lobes spreading, oblong to cuneate, 2 mm wide; midlobe broad-ovate to rhombic or elliptic with broad, short claw-like base, 9 mm long by 9 mm wide when flattened, weakly folded; callus of 2 ridges 4 mm long.

Distribution and habitat

NSW, also Qld. Predominantly of western slopes, extending from south of Narrandera all the way to the far north of New South Wales, but sporadically distributed. Usually in grassy *Callitris* woodland, growing in sandy soils, in flat country or often on top of small hills.

Identification

Orange-yellow diuris with purple and white markings, with lateral sepals twice as long as the labellum.

Similar species

Unlikely to be confused with any other species.

Notes

This is one of the most variable species in the genus. Flowers vary greatly in size and colour, with a broad tendency for southern populations to have large, richly coloured flowers and northern ones to have small rather pale ones.

Images

Diuris tricolor (Bishop 2000)

Glossy Black-cockatoo

Calyptorhynchus lathami (Temminck, 1807)

Other common names Glossy Cockatoo, Casuarina Cockatoo, Leach's Black Cockatoo, Leach's Red-tailed Cockatoo, Latham's Cockatoo

Conservation status

The Glossy Black-cockatoo is listed as a **Vulnerable Species** on Schedule 2 of the New South Wales *Threatened Species Conservation Act, 1995* (TSC Act).

Description (summarised from Crome & Shields 1992)

Length
480mm
Wing
350mm
Tail
215mm
Bill
46mm
Tarsus
25mm
Weight
425g

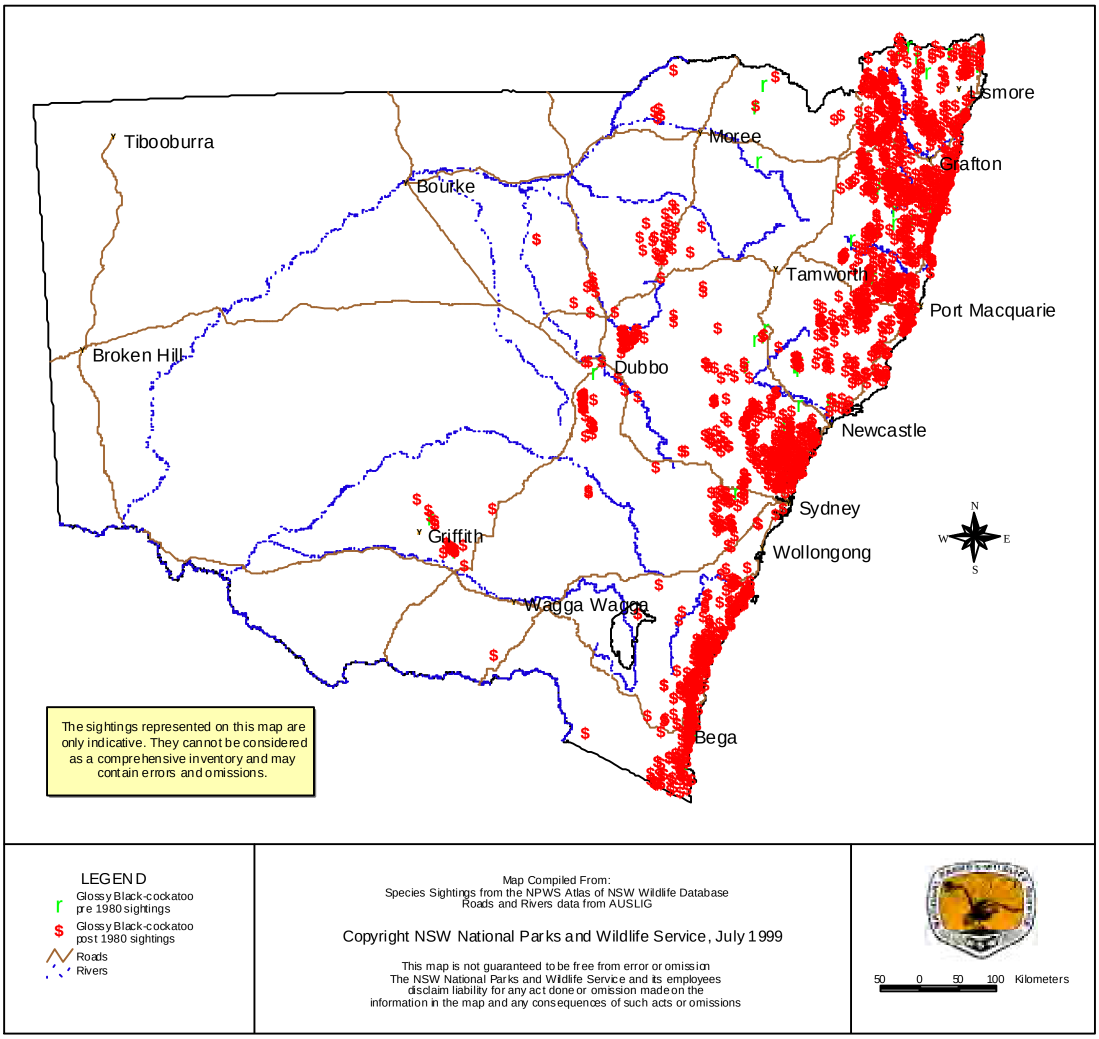
The adult male Glossy Black-cockatoo has mainly dull black plumage that may be tinged brownish. Two bright red panels are visible on the tail. The bill, eye ring and legs are dark grey. Flight is buoyant with shallow, effortless wing-beats. Individuals often fly at considerable height when travelling between feeding areas.

The female is similar in appearance to the male except for irregular yellow patches around the neck, head and orange-red tail panels. Immature birds are similar to the female with more yellow below and on wings and a paler bill.

Individuals differ from the Red-tailed Black-cockatoo due to their inconspicuous crest and distinctive calls that are soft, wavering and plaintive, disyllabic *kaa-er* and a harsh alarm screech.

Glossy Black-cockatoo - male and female

NSW NATIONAL PARKS AND WILDLIFE SERVICE



NPWS records of the Glossy Black-cockatoo in NSW

Distribution

The Glossy Black-cockatoo is sparsely distributed along the east coast and immediate inland districts from western Victoria to Rockhampton in Queensland (Crome & Sheilds 1992). In NSW, the species is found as far west as Cobar and Griffith in isolated mountain ranges (Pizzey 1991). Isolated populations of the species inhabit King Island in Bass Strait and Kangaroo Island off the coast of South Australia (Schodde *et al.* 1993).

The inland distribution of the species is restricted by the occurrence of the various casuarina species (Ayers *et al.* 1996).

Recorded occurrences in conservation reserves

Various conservation reserves throughout eastern and central NSW (NPWS 1999).

Habitat

The Glossy Black-cockatoo characteristically inhabits forests on sites with low soil-nutrient status, reflecting the distribution of **key** *Allocasuarina* spp. (Tanton 1994). The drier forest types with intact and less rugged landscapes are preferred by the species (NPWS 1994).

Ecology

The Glossy Black-cockatoo is probably the most specialised member of its family feeding exclusively on seeds extracted from the wooden cones of casuarinas (she-oaks). The bill is used to remove the tough outer hull while the cone is rotated in the left foot. The exposed seeds are then stripped away and eaten. The art of opening a casuarina cone is apparently learned behaviour, as immature birds frequently seem to have trouble manipulating the cones into the correct position (Crome & Shields 1992).

Adults only breed during the autumn and winter. During the 29 days of incubation the female is dependent on the male for food as she usually remains on the nest in a large tree hollow, lined with chips and dust (Crome & Shields 1992). Only one young bird is raised per season and a juvenile may associate with its parents for an indefinite period after fledging at approximately 60 days.

The species is gregarious, usually recorded in family parties of seldom more than 10. Locally nomadic, small flocks roam in search of feeding areas and roost communally.

Threats (summarised from Crome & Shields 1992; NPWS in prep.)

- Natural and other hazards may fragment habitat
- Loss of habitat through clearing and associated activities, including intensive logging, burning and grazing
- Logging of nest trees within the proximity of food resources
- Inappropriate fire regimes reducing its range by removing nesting and feeding resources

Management (summarised from Crome & Shields 1992; NPWS in prep.)

- Protection and maintenance of known or potential habitat
- Replanting areas with casuarina trees and promotion of their growth and development in areas from which they have been eliminated
- Alteration of prescribed burning and grazing regimes to ensure the enhancement and maintenance of the vegetation within known or potential habitat

Recovery plans

A recovery plan has not been prepared for this species.

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For further information contact

Threatened Species Unit, Policy and Science Directorate Phone 02 9585 6540.
General enquiries: 43 Bridge St Hurstville NSW 2220 Phone 1300 36 1967 or 02 9585 6333.
Web site www.npws.nsw.gov.au

NSW NATIONAL PARKS AND WILDLIFE SERVICE

TAXON SUMMARY

Masked Owl (southern Australia)

1	Family	Tytonidae
2	Scientific name	*Tyto novaehollandiae novaehollandiae* (Stephens, 1826)
3	Common name	Masked Owl (southern Australia)
4	Conservation status	Near Threatened: a

5 Reasons for listing

The area occupied by this subspecies is thought to have declined by at least half, particularly in the semi-arid zone (Near Threatened: a).

	Estimate	*Reliability*
Extent of occurrence	*4,000,000 km²*	*high*
trend	*stable*	*medium*
Area of occupancy	*35,000 km²*	*low*
trend	*stable*	*medium*
No. of breeding birds	*7,000*	*low*
trend	*stable*	*medium*
No. of sub-populations	*2*	*medium*
Largest sub-population	*6,500*	*low*
Generation time	*5 years*	*low*

6 Infraspecific taxa

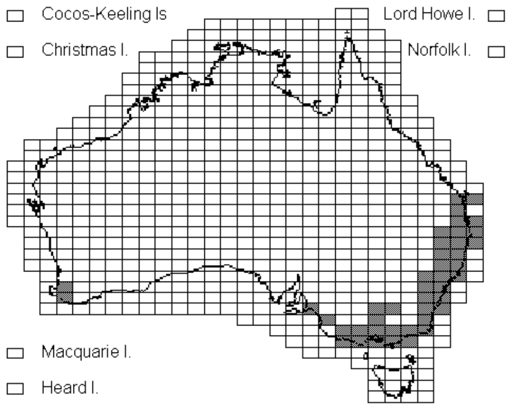
T. n. castanops (Tasmania, introduced to Lord Howe I.) and *T. n. melvillensis* (Tiwi Is, N. T.) are Endangered, *T. n. kimberli* (northern mainland Australia, including north-east Queensland; after Debus, 1993, Higgins, 1999) is Near Threatened. There are four other subspecies in New Guinea and nearby islands. The species 'global status is Least Concern.

7 Past range and abundance

Sparsely distributed through subcoastal mainland Australia from Fraser I, Qld, to Carnarvon, W. A., including Nullarbor Plain. Also occurs inland of Great Dividing Ra. (Schodde and Mason, 1980, Higgins, 1999). Generally found in sub-coastal habitats, but also inland along watercourses (Schodde and Mason, 1980, Debus, 1993). Fossil evidence of wider inland distribution during wetter climates (Rich *et al.*, 1978).

8 Present range and abundance

Numbers reduced in inland New South Wales, South Australia, and on the Nullarbor Plain (Schodde and Mason, 1980, Smith *et al.*, 1995, Higgins, 1999). In Western Australia, restricted to south-west (Johnson and Storr, 1998). Recently located at only 5 of 100 sites surveyed in southern forests, all records from the southern coastal strip between Margaret R. and Manjimup (R. Kavanagh), but also recorded further north, including woodland areas, such as Dryandra (A. A. Burbidge). In Victoria, population estimated at 300-400 pairs, mostly in East Gippsland (Peake *et al.*, 1993). New South Wales: 1,500-2,000 pairs in north-east (Higgins, 1999); 190 pairs in 3,200 km² of State Forests and protected area in south-east (Kavanagh, 1997).



9 Ecology

The southern subspecies of Masked Owl occupies a home range of 5-10 km² within a diverse range of wooded habitats that provide large hollow-bearing trees for roosting and nesting and nearby open areas for foraging (Kavanagh and Murray, 1996, Higgins, 1999). This can include forests, remnants within agricultural land or almost treeless inland plains (Schodde and Mason, 1980, Peake *et al.*, 1993, Debus and Rose, 1994, Higgins, 1999). Nests and roost sites are usually in hollows of large trees, often in riparian forest. Clutch size is usually 3-4 (Schodde and Mason, 1980, Kavanagh, 1996). Masked Owls also roost, and less commonly nest, in caves (Debus, 1993, Peake *et al.*, 1993, Debus and Rose, 1994). Prey are principally terrestrial mammals, including rodents and marsupials (Debus, 1993, Kavanagh, 1996), although possums, gliders, bats, birds, lizards and rabbits may be taken opportunistically (Schodde and Mason, 1980, Hollands 1991, Debus, 1993, Debus and Rose, 1994, Kavanagh, 1996, Higgins, 1999).

10 Threats

Clearance for agriculture has certainly affected abundance in many parts of the species 'range, particularly Western Australia and South Australia (Higgins, 1999), and is the principal reason for listing the subspecies. The reason for the low density of Masked Owls, however, is unknown. Although food does not appear to be limiting on the east coast (Kavanagh, 1996), the apparent decline in arid

Australia may be linked to that of mammals of between 50 and 200 g (Burbidge and McKenzie, 1989). However, Masked Owls may never have been common in dry areas (Debus, 1993). Within forests on the east coast, the availability of nest trees could be declining (Peake *et al.,* 1993, Kavanagh, 1996), but the scarcity of Masked Owls from logged forest in New South Wales (Kavanagh and Bamkin, 1995, Kavanagh *et al.*, 1995) is more likely to be because the vigorous regrowth after logging makes the habitat less suitable for foraging (Kavanagh *et al.*, 1995).

11 Recommended actions

11.1 Undertake follow-up surveys in New South Wales forests to determine trends in abundance and further baseline surveys in forests of south-western Western Australia and south-east Queensland.

11.2 Undertake further modelling work in Victoria to assess habitat requirements and predict distribution.

11.3 Maintain a diverse mosaic of fire ages within forest habitats to keep patches of understorey open.

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Comments received from

Andrew Burbidge, Stephen Debus, Rod Kavanagh, Richard Loyn, Penny Olsen.

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Threatened Species Conservation Act 1995
NSW Scientific Committee

Final Determination

The Scientific Committee, established by the Threatened Species Conservation Act, has made a Final Determination to list the Brown Treecreeper (eastern subspecies) *Climacteris picumnus victoriae* (Mathews, 1912), as a VULNERABLE SPECIES on Schedule 2 of the Act. Listing of Vulnerable Species is provided for by Part 2 of the Act.

The Scientific Committee found that:

1. The eastern subspecies of the Brown Treecreeper *Climacteris picumnus victoriae* is distributed through central NSW on the western side of the Great Dividing Range and sparsely scattered to the east of the Divide in drier areas such as the Cumberland Plain of Western Sydney, and in parts of the Hunter, Clarence, Richmond and Snowy River valleys.

2. The western boundary of the range of *Climacteris picumnus victoriae* runs approximately through Wagga Wagga, Temora, Forbes, Dubbo and Inverell and along this line the subspecies intergrades with the arid zone subspecies of Brown Treecreeper *Climacteris picumnus picumnus* (Schodde and Mason 1999).

3. The Brown Treecreeper is a medium-sized insectivorous bird that occupies eucalypt woodlands, particularly open woodland lacking a dense understorey. It is sedentary and nests in tree hollows within permanent territories, breeding in pairs or communally in small groups (Noske 1991). Birds forage on tree trunks and on the ground amongst leaf litter and on fallen logs for ants, beetles and larvae (Noske 1979).

4. The broad range of the Brown Treecreeper has not changed but it is now extinct in parts of its range. Declines in populations have been recorded from the Cumberland Plain (Hoskin 1991; Keast 1995; Egan *et al*. 1997), the New England Tablelands (Barrett *et al.* 1994), the Inverell district (Baldwin 1975), from Munghorn Gap Nature Reserve near Mudgee, and from travelling stock routes in the Parkes district (N. Schrader, unpublished). Reid (1999) identified the Brown Treecreeper as a ‘decliner’ in a review of bird species’ status in the NSW sheep-wheatbelt.

5. Brown treecreepers are threatened by clearance and the fragmentation of the woodland habitat including removal of dead timber. Increased isolation decreases treecreeper vagility and increases the vulnerability of populations to extinction as a result of stochastic events. This species appears unable to maintain viable populations in remnants less then 200ha and its abundance decreases as remnant size decreases (Barrett *et al.* 1994). Fragmentation also leads to a skewed sex ratio in Brown Treecreeper populations because female birds are unable to disperse to isolated remnants, increasing the chance of local extinctions (Walters *et al.* 1999).

6. Habitat degradation, including loss of hollow bearing trees, threatens Brown Treecreeper populations. Grazing by stock in woodland areas leads to a decrease the diversity of ground-dwelling invertebrates (Bromham *et al.* 1999) decreasing the availability of food for the birds. In addition, Brown Treecreepers are likely to be threatened by such factors as increased competition with aggressive honeyeater species and increased levels of nest predation that are a consequence of fragmentation of habitat (Major *et al.* 1998).

7. In view of the above points, the Scientific Committee is of the opinion that the sub-species of the Brown Treecreeper (eastern subspecies) *Climacteris picumnus victoriae*, is likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate, and is therefore eligible for listing as a vulnerable species.

Gazettal date: 26/10/01
Exhibition period: 26/10/01 – 31/11/01

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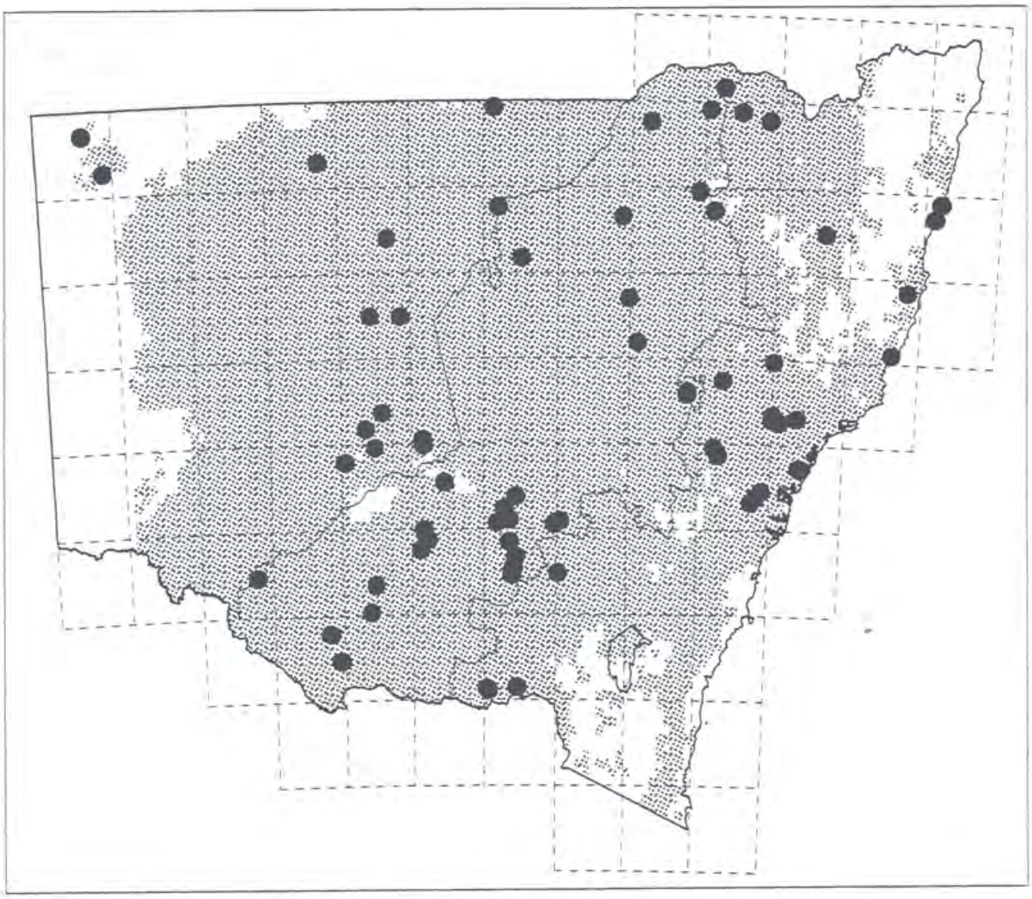
Last amended: 10 July 2002:

Painted Honeyeater

Grantiella picta

Species Code 0598 **TSC Act status** Vulnerable

Distribution



Distributed across inland eastern Australia where it is more likely to be seen in the north during winter and south during summer as it follows the fruiting patterns of mistletoes parasitic on eucalypts, casuarinas and acacias (Pizzey 1980). In the Western Zone the Painted Honeyeater has been recorded along the Warrego, Culgoa and Bogan Rivers, west of Byrock, on the Fletchers Creek floodplain near Dareton and in Willandra National Park (J. Brickhill pers. comm.). Can be found virtually anywhere with mistletoe (P. Ewin pers. comm.).

Ecology *G. picta* inhabits open eucalypt forests and woodlands, areas of Belah and other casuarinas, Mulga and other acacias (including Boree woodlands in the Riverina), and mallee, usually associated with heavy mistletoe *Amyema* infestations (Pizzey 1980). In the Western Zone this habitat is mainly along floodplains or drainage lines. These birds construct a frail cup nest of fibrous rootlets, casuarina needles or grass bound with spider web, within the leafy extremities (twigs) of drooping eucalypt, casuarina or paperbark branches, 3-20 m above the ground (Pizzey

1980, Slater *et al.* 1986). Their diet is primarily mistletoe berries but insects and the nectar from mistletoe or eucalypt flowers are occasionally eaten (Barker and Vestjens undated b). Young are fed mainly on insects. Painted Honeyeaters are uncommon and nomadic in eastern Australia (Reader's Digest 1986).

Threats

The Painted Honeyeater has always been regarded as rare but local declines have been noted in a number of areas, the causes of which are largely unknown.

Competition - with other species such as the Mistletoebird and Spiny-cheeked Honeyeater may be implicated in the local decline of Painted Honeyeater populations (P. Ewin pers. comm.).

Clearing - eliminates habitat for the parasitic mistletoe on which this species depends. The tendency to push trees with mistletoe infestations, or to cut mistletoe may have impacted on the species.

Selective thinning - of trees infected with mistletoe because they are thought to be 'weaker' and exhibit slower growth than uninfected trees is a usual forestry practice. This too would reduce the availability of suitable habitat for the Painted Honeyeater.

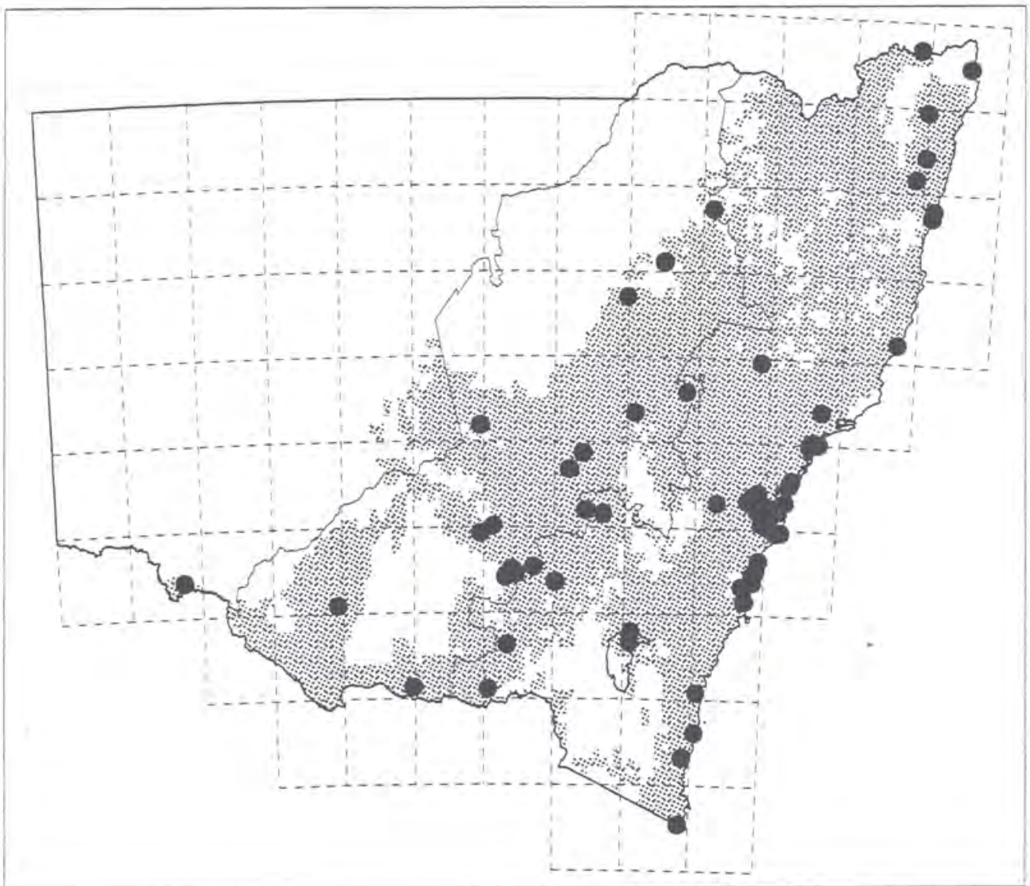
Swift Parrot

Lathamus discolor

Species Code 0309

TSC Act status Vulnerable
National status Vulnerable

Distribution



The Swift Parrot breeds in Tasmania and its nearby islands (including the Furneaux group) and migrates to mainland Australia to feed during winter (Slater *et al.* 1986). On the mainland they inhabit suitable areas between the Mount Lofty Ranges (South Australia) and south-eastern Queensland. Within NSW these parrots are mostly found in the south-east (Sydney-ACT region) but do occur inland as far as Ivanhoe, Griffith and Warialda (Pizzey 1980). Generally regarded as an infrequent visitor to the Western Zone (P. Ewin pers. comm.).

Ecology Swift Parrots migrate to south-eastern mainland Australia in February-April to feed on winter blossoms and return to breed in Tasmania between September and November. On the mainland they occur in a wide variety of habitats, depending on where there are flowering blossoms. Drier sclerophyll forests and woodlands, other timbered countries, plantations, parks, gardens or city streets and occasionally green grasslands are all used by these birds (Pizzey 1980, Simpson and Day 1993). They feed alone and in parties, mostly within the topmost branches of eucalypt trees, often hanging upside down to reach the blossoms (Reader's Digest 1986). Principal foods are eucalypt nectar and pollen, as well as sugary lerps, although banksia nectar, insects and their larvae (weevils and caterpillars), seeds (e.g. grass), fruits and berries (including cultivated species) and some vegetative matter are also eaten (Pizzey 1980). These parrots only venture onto the ground when drinking and feeding on fallen seeds and flowers (Reader's Digest 1986). Wintering flocks of Swift Parrots are nomadic in response to the availability to blossoms and other food sources. If sufficient food is available they may remain within the same district for about a week, returning to the same tree each night to roost (Pizzey 1980).

Threats
Clearing - of food trees in particular is likely to constitute the major threat to this species within mainland Australia. Removal of significant numbers of such trees from an area are likely to cause these nomadic birds to feed in other districts. However, given the infrequency with which these birds visit the Western Zone of NSW, even this is not likely to be a major threat.

Trapping - some birds may be trapped for the bird trade during the non-breeding season (Garnett 1992).

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Threatened Species Conservation Act 1995
NSW Scientific Committee

Final Determination

The Scientific Committee, established by the Threatened Species Conservation Act, has made a Final Determination to list the Black-chinned Honeyeater (eastern subspecies) *Melithreptus gularis gularis* (Gould 1837), as a VULNERABLE SPECIES on Schedule 2 of the Act. Listing of Vulnerable Species is provided for by Part 2 of the Act.

The Scientific Committee found that:

1. The eastern form of the Black-chinned Honeyeater is found predominantly west of the Great Dividing Range in a narrow belt through NSW into southern Queensland, and south into Victoria and South Australia where it occupies eucalypt woodlands within an approximate annual rainfall range of 400-700mm (Blakers *et al.* 1984). In NSW, the species is mainly found in woodlands containing box-ironbark associations and River Red Gum. Black-chinned Honeyeaters are also known from drier coastal woodlands of the Cumberland Plain, Western Sydney and in the Hunter, Richmond and Clarence Valleys.

2. The Black-chinned Honeyeater is a medium-sized green and white passerine bird with a black head. The species builds compact, cup-shaped nests and feeds on arthropods, nectar and lerp from eucalypt foliage and bark (Blakers *et al.* 1984).

3. Black-chinned Honeyeaters were widely distributed and occurred naturally at low densities. Black-chinned Honeyeaters were recorded at densities ranging between 0.02 to 0.26 per hectare in box-ironbark forests in Victoria (Traill 1995) and in northern NSW at 0.28 per hectare (Oliver *et al.* 1999).

4. The Black-chinned Honeyeater has declined in numbers and is no longer found in parts of its range. For example, population declines have been reported from the Cumberland Plain, Western Sydney (Hoskin 1991; Keast 1995; Egan *et al.* 1997) and the species was absent throughout a survey of 195 remnants near Forbes (Major *et al.* 1998). Incidental reports also show a decline in the occurrence of birds with the species now only occasionally recorded at a site near Moree where once they were regular, and an apparent 10 year absence from a once regular recording site near Wagga Wagga. The species does not persist in remnants less than 200 ha in area. Reid (1999) identified the species as a 'decliner' in a review of bird species' status in the NSW sheep-wheatbelt.

5. Black-chinned Honeyeaters are threatened by clearance and the fragmentation of woodland habitat. Reductions in remnant habitat size leads to the isolation of honeyeater populations which increases their vulnerability to extinction from stochastic events, and decreases their genetic viability in the long term. As the species occurs at low densities and is only found in relatively large remnants, this further exacerbates the species vulnerability.

6. Black-chinned Honeyeaters are likely to experience high levels of competition from aggressive honeyeater species such as Noisy Miners or White-plumed Honeyeaters, both of which occur at high densities in small remnants of Red Gum and box-ironbark associations. In addition, increased nest predation is expected from increasing populations of predators such as Pied Currawongs and Australian Ravens, particularly in small remnants (Major *et al.* 1998).

7. In view of the above points, the Scientific Committee is of the opinion that the sub-species of the Black-chinned Honeyeater (eastern subspecies) *Melithreptus gularis gularis,* is likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate, and is therefore eligible for listing as a vulnerable species.

Proposed Gazettal date: 26/10/01
Exhibition period: 26/10/01 – 30/11/01

References

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Threatened Species Conservation Act 1995
NSW Scientific Committee

Final Determination

The Scientific Committee, established by the Threatened Species Conservation Act, has made a Final Determination to list the Grey-crowned Babbler (eastern subspecies), *Pomatostomus temporalis temporalis* (Vigors and Horsfield, 1827), as a VULNERABLE SPECIES on Schedule 2 of the Act. Listing of Vulnerable Species is provided for by Part 2 of the Act.

The Scientific Committee found that:

1. The eastern form of the Grey-crowned Babbler *Pomatostomus temporalis temporalis*, formerly ranged throughout eastern Australia from South Australia, through Victoria and broadly through NSW and central Queensland up into southern New Guinea. The Grey-crowned Babbler is now extinct in South Australia, coastal Victoria and the ACT. In NSW, the Grey-crowned Babbler occurs on the western slopes and plains but was less common at the higher altitudes of the tablelands. Isolated populations are known from coastal woodlands on the North Coast, in the Hunter Valley and from the South Coast near Nowra (Blakers *et al.* 1984, Schodde & Mason 1999).

2. Grey-crowned Babblers occupy open woodlands dominated by mature eucalypts, with regenerating trees, tall shrubs, and an intact ground cover of grass and forbs. The species builds conspicuous dome-shaped nests and breeds co-operatively in sedentary family groups of 2-13 birds (Davidson and Robinson 1992). Grey-crowned Babblers are insectivorous and forage in leaf litter and on bark of trees.

3. The Grey-crowned Babbler has declined in numbers and disappeared from large parts of its range. The species is extinct in the Orange area (Heron 1973) and possibly also from around Bathurst, where A. Fisher (pers.comm.) has made no record of the species in a study of almost 300 sites. Recent surveys (A. Overs, unpubl.) show a decline in the number of family groups that remain in the southern portion of its range, such that approximately five groups remain in Boorowa Shire, less than 10 around Wagga Wagga, and less than 30 groups in the shires of Young, Junee and Harden. A survey of 96 woodland sites in Holbrook Shire revealed only four groups (S. Collard, unpubl.). Further, the species has apparently disappeared from the Shires of Gundagai, Gunning, Yass and Yarrowlumla.

4. There are probably no Grey-crowned Babblers left on the New England Tableland (H. Ford, pers. comm.) and they are now very uncommon in the Hunter Valley with most family groups reduced to two or four members (P. Cowper, pers. comm.)

5. In southern NSW, the size of Grey-crowned Babbler family groups is also reduced. In a three year study of 15 family groups near West Wyalong, the mean number of birds in each group was four (A. Overs, unpubl.). Such groups are much smaller than those recorded further north near Peak Hill, where groups averaged 8-13 birds (A. Overs, unpubl.). The impact of reduced family groups on breeding success is unknown, although it is likely to be detrimental.

6. The Grey-crowned Babbler is threatened by clearance and the fragmentation of habitat including removal of dead timber. The species occupies woodlands on fertile soils of plains and undulating terrain. Therefore, Grey-crowned Babbler habitat has been disproportionately cleared for agriculture. Isolation of populations in scattered remnants is exacerbated by the apparent reluctance of birds to traverse tracts of cleared land. As reduced family groups, these isolated small populations are vulnerable to extinction via stochastic events and to loss of genetic viability in the long term.

7. Habitat degradation threatens Grey-crowned Babblers, particularly as a result of weed invasion and grazing by stock. In addition, it is likely that increased abundance of competitors, such as Noisy Miners, and nest predators, including the Pied Currawong and Australian Raven (Major *et al*. 1996) threaten Babbler foraging efficiency and breeding success.

8. In view of the above points, the Scientific Committee is of the opinion that the Grey-crowned Babbler (eastern subspecies) *Pomatostomus temporalis temporalis*, is likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate, and is therefore eligible for listing as a vulnerable species.

Proposed Gazettal date: 26/10/01
Exhibition period: 26/10/01 – 30/11/01

References

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Schodde, R. and Mason, I.J. (1999) 'The Directory of Australian Birds: Passerines'. CSIRO:Melbourne

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Last amended: 26 October 2001

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Threatened Species Conservation Act 1995
NSW Scientific Committee

Final Determination

The Scientific Committee, established by the Threatened Species Conservation Act, has made a Final Determination to list the Grey-crowned Babbler (eastern subspecies), *Pomatostomus temporalis temporalis* (Vigors and Horsfield, 1827), as a VULNERABLE SPECIES on Schedule 2 of the Act. Listing of Vulnerable Species is provided for by Part 2 of the Act.

The Scientific Committee found that:

1. The eastern form of the Grey-crowned Babbler *Pomatostomus temporalis temporalis*, formerly ranged throughout eastern Australia from South Australia, through Victoria and broadly through NSW and central Queensland up into southern New Guinea. The Grey-crowned Babbler is now extinct in South Australia, coastal Victoria and the ACT. In NSW, the Grey-crowned Babbler occurs on the western slopes and plains but was less common at the higher altitudes of the tablelands. Isolated populations are known from coastal woodlands on the North Coast, in the Hunter Valley and from the South Coast near Nowra (Blakers *et al.* 1984, Schodde & Mason 1999).

2. Grey-crowned Babblers occupy open woodlands dominated by mature eucalypts, with regenerating trees, tall shrubs, and an intact ground cover of grass and forbs. The species builds conspicuous dome-shaped nests and breeds co-operatively in sedentary family groups of 2-13 birds (Davidson and Robinson 1992). Grey-crowned Babblers are insectivorous and forage in leaf litter and on bark of trees.

3. The Grey-crowned Babbler has declined in numbers and disappeared from large parts of its range. The species is extinct in the Orange area (Heron 1973) and possibly also from around Bathurst, where A. Fisher (pers.comm.) has made no record of the species in a study of almost 300 sites. Recent surveys (A. Overs, unpubl.) show a decline in the number of family groups that remain in the southern portion of its range, such that approximately five groups remain in Boorowa Shire, less than 10 around Wagga Wagga, and less than 30 groups in the shires of Young, Junee and Harden. A survey of 96 woodland sites in Holbrook Shire revealed only four groups (S. Collard, unpubl.). Further, the species has apparently disappeared from the Shires of Gundagai, Gunning, Yass and Yarrowlumla.

4. There are probably no Grey-crowned Babblers left on the New England Tableland (H. Ford, pers. comm.) and they are now very uncommon in the Hunter Valley with most family groups reduced to two or four members (P. Cowper, pers. comm.)

5. In southern NSW, the size of Grey-crowned Babbler family groups is also reduced. In a three year study of 15 family groups near West Wyalong, the mean number of birds in each group was four (A. Overs, unpubl.). Such groups are much smaller than those recorded further north near Peak Hill, where groups averaged 8-13 birds (A. Overs, unpubl.). The impact of reduced family groups on breeding success is unknown, although it is likely to be detrimental.

6. The Grey-crowned Babbler is threatened by clearance and the fragmentation of habitat including removal of dead timber. The species occupies woodlands on fertile soils of plains and undulating terrain. Therefore, Grey-crowned Babbler habitat has been disproportionately cleared for agriculture. Isolation of populations in scattered remnants is exacerbated by the apparent reluctance of birds to traverse tracts of cleared land. As reduced family groups, these isolated small populations are vulnerable to extinction via stochastic events and to loss of genetic viability in the long term.

7. Habitat degradation threatens Grey-crowned Babblers, particularly as a result of weed invasion and grazing by stock. In addition, it is likely that increased abundance of competitors, such as Noisy Miners, and nest predators, including the Pied Currawong and Australian Raven (Major *et al*. 1996) threaten Babbler foraging efficiency and breeding success.

8. In view of the above points, the Scientific Committee is of the opinion that the Grey-crowned Babbler (eastern subspecies) *Pomatostomus temporalis temporalis*, is likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate, and is therefore eligible for listing as a vulnerable species.

Proposed Gazettal date: 26/10/01
Exhibition period: 26/10/01 – 30/11/01

References

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Schodde, R. and Mason, I.J. (1999) 'The Directory of Australian Birds: Passerines'. CSIRO:Melbourne

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Last amended: 26 October 2001

Threatened Species Conservation Act 1995
NSW Scientific Committee

Final Determination

The Scientific Committee, established by the Threatened Species Conservation Act, has made a Final Determination to list the Speckled Warbler *Pyrrholaemus sagittata* (Latham 1802), as a VULNERABLE SPECIES on Schedule 2 of that Act. Listing of Vulnerable Species is provided for by Part 2 of the Act.

The Scientific Committee found that:

1. The Speckled Warbler is distributed from south-eastern Queensland, through central and eastern NSW to Victoria. In NSW, Speckled Warblers occupy eucalypt and cypress woodlands on the slopes west of the Great Dividing Range, with an extension of range into the cypress woodlands of the northern Riverina. Populations also occur in drier coastal areas such as the Cumberland Plain, Western Sydney and the Hunter and Snowy River valleys (Blakers *et al.* 1984, Schodde & Mason 1999).

2. Speckled Warblers inhabit woodlands with a grassy understorey, often on ridges or gullies. The species is sedentary, living in pairs or trios and nests on the ground in grass tussocks, dense litter and fallen branches. They forage on the ground and in the understorey for arthropods and seeds (Ford *et al*. 1986). Home ranges vary from 6-12 hectares.

3. The Speckled Warbler has declined in numbers from large parts of its range. Declines have been reported from the Cumberland Plain (Hoskin 1991; Keast 1995; Egan *et al.* 1997), the New England Tableland (Barrett *et al*. 1994), and from around Parkes (N. Schrader, unpubl.). Fisher (1997) predicted Speckled Warblers would become extinct in the Bathurst area if current land management practices were not reversed. Further, Reid (1999) identified the species as a ‘decliner’ in a review of bird status in the NSW sheep-wheatbelt.

4. The Speckled Warbler is threatened by clearance and fragmentation of habitat including removal of dead timber. Barrett *et al*. (1994) found that the species decreased in abundance as woodland area decreased, and it appears to be extinct in districts where no fragments larger than 100ha remain. Isolation of Speckled Warbler populations in small remnants increases their vulnerability to local extinction as a result of stochastic events and decreases their genetic viability in the long term. Low population densities and relatively

large home range requirements also would exacerbate their vulnerability to habitat loss.

5. The preferred foraging habitat of Speckled Warbler is areas with a combination of open grassy patches, leaf litter and shrub cover. This habitat is susceptible to degradation by stock and weed invasion. Nesting on the ground also makes them vulnerable to predation from exotic mammalian predators such as foxes and cats.

6. In view of the above points, the Scientific Committee is of the opinion that the Speckled Warbler *Pyrrholaemus sagittata*, is likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate, and is therefore eligible for listing as a vulnerable species.

Proposed Gazettal date: 26/10/01
Exhibition period: 26/10/01 – 30/11/01

References

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Last amended: 26 October 2001

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Related information

- Black-throated finch - draft recovery plan (PDF -755KB)
- Black-throated finch - endangered species listing
- Star finch - presumed extinct species listing

Diamond firetail - vulnerable species listing

NSW Scientific Committee - final determination

The Scientific Committee, established by the Threatened Species Conservation Act, has made a Final Determination to list the Diamond Firetail *Stagonopleura guttata* (Shaw 1796), as a VULNERABLE SPECIES on Schedule 2 of the Act. Listing of Vulnerable Species is provided for by Part 2 of the Act.

The Scientific Committee found that:
1. The Diamond Firetail is distributed through central and eastern NSW, extending north into southern and central Queensland and south through Victoria to the Eyre Peninsula, South Australia. In NSW, the species occurs predominantly west of the Great Dividing Range, although populations are known from drier coastal areas such as the Cumberland Plain of western Sydney and the Hunter, Clarence, Richmond and Snowy River valleys (Blakers et al. 1984, Schodde & Mason 1999).

2. The Diamond Firetail is a brightly coloured finch that occupies eucalypt woodlands, forests and mallee where there is a grassy understorey. Firetails build bottle-shaped nests in trees and bushes, and forage on the ground, largely for grass seeds and other plant material, but also for insects (Blakers et al. 1984, Read 1994).

3. The Diamond Firetail has disappeared from parts of its former range and has declined in numbers in many areas. Declines have been recorded on the Cumberland Plain, western Sydney (Hoskin 1991; Keast 1995) with a local extinction near Scheyville (Egan et al. 1997).

On the New England Tableland, declines in populations are apparent (Barrett et al. 1994) and the species has become extinct within Imbota Nature Reserve and surrounds (H. Ford, pers. comm.). Reid (1999) identified the species as a 'decliner' in a review of bird status in the NSW sheep-wheatbelt; and Fisher (1997) predicted that Diamond Firetails would significantly decline from the Bathurst District if current trends in land management persisted.

4. The Diamond Firetail is threatened by clearance and fragmentation of habitat. Isolation and reductions in remnant area inhibit dispersal and increase their vulnerability to local extinction via stochastic events. Small, isolated populations also lose their long term genetic viability (Barrett et al. 1994). Further, Diamond Firetail populations appear unable to persist in areas which lack remnants of native vegetation larger than 200ha (N. Schrader, pers. comm.).

5. Habitat degradation, particularly overgrazing of the grass understorey, threatens the granivorous Diamond Firetail. In addition, an increased abundance of predators such as Pied Currawongs and Australian Ravens may increase nest predation in fragmented woodland remnants (Major et al. 1996).

6. In view of the above points, the Scientific Committee is of the opinion that the Diamond Firetail, *Stagonopleura guttata*, is likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate, and is therefore eligible for listing as a vulnerable species.

Proposed Gazettal date: 26/10/01
Exhibition period: 26/10/01 – 30/11/01

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About the NSW Scientific Committee

Regent Honeyeater

Xanthomyza phrygia **(Shaw, 1794)**

Other common names None

Conservation status

The Regent Honeyeater is listed as an **Endangered Species** on Schedule 1 of the New South Wales *Threatened Species Conservation Act, 1995* (TSC Act). This species is also listed as an **Endangered Species** on Schedule 1 of the Commonwealth *Endangered Species Protection Act, 1992*.

Description (summarised from Menkhorst 1993)

Length
200-220mm
Wingspan
mm
Tail
mm
Bill
mm
Tarsus
mm
Weight
41-46g

The Regent Honeyeater is a medium-sized honeyeater with black, white and bright yellow plumage. Black plumage is dominate on the head, neck, breast and back are predominately black. The black plumage on the wings is edged with white and the outer feathers are bright yellow.
A distinguishing, large patch of bare, cream-coloured warty skin surrounds each eye.

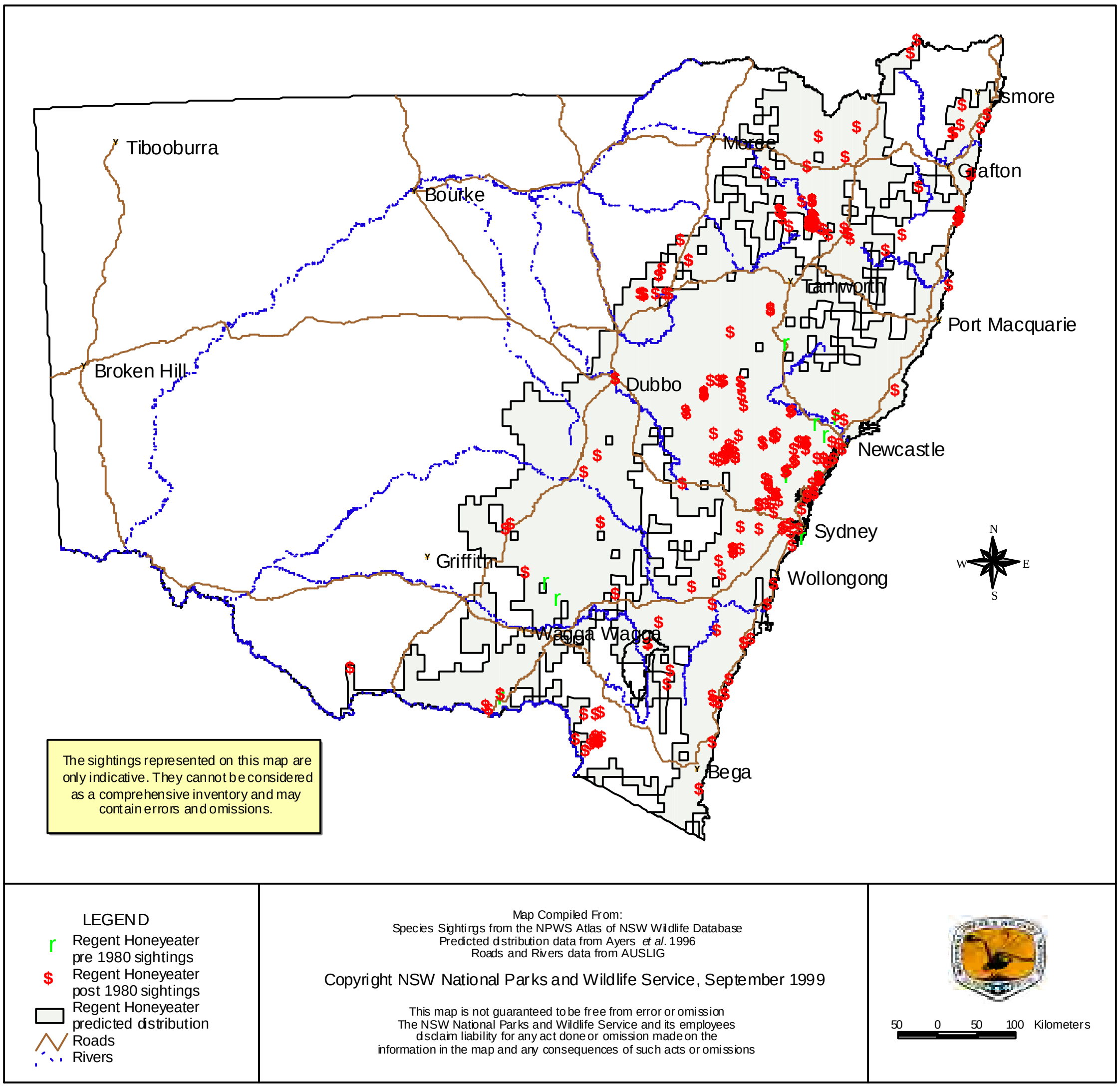
Distribution

Historically this species was distributed from Kangaroo Island in South Australia along the eastern coastline of Victoria and NSW, to Dalby in Queensland and from the coast to the western slopes of the Great Dividing Range as far inland as Narrabri, Parkes and Warrumbungle National Park (Peters 1979). However, the species has declined greatly in numbers and disappeared from some parts of its former range as a result of clearing of large areas for agriculture (Blakers *et al.* 1984).

Though the species is widely dispersed, the range of this once abundant honeyeater has contracted dramatically (UBBS 1996). The species distribution is now extremely patchy, with the population having declined to less than 1500 individuals (NPWS 1997). There are now only a small number of known breeding sites in NSW, the most important of which are: Warrumbungles NP, Pilliga NR, Barraba district, central coast around Gosford, Hunter Valley, and Capertee Valley (UBBS 1996; Ayers *et al.* 1996; NPWS 1997).

Regent Honeyeater

NSW NATIONAL PARKS AND WILDLIFE SERVICE



NPWS records of the Regent Honeyeater in NSW

In 1994, the largest aggregate of birds since the 1900s (approximately 152), was located in the Capertee valley during the 1995 breeding season (Ayers *et al.* 1996).

Recorded occurrences in conservation reserves

Munghorn Gap NR, Pilliga NR, Cocklebay NR, The Charcoal Tank NR, Yengo NP, Warrumbungle NP, Wollemi NP, Scheyville NP, Goulbourn River NP, Broadwater NP, Bundjalung NP, Yuraygir NP, Nattai NP, Brisbane Waters NP, Ingalba NP, Hat Head NP, Royal NP, Seven Mile Beach NP (NPWS 1999).

Habitat

The Regent Honeyeater is a semi-nomadic species which occurs in temperate eucalypt woodlands and open forest in south-eastern Australia (Pizzey 1980). Most records of the species are from box-ironbark eucalypt associations, and wet lowland coastal forests dominated by Swamp Mahogony, Spotted Gum and Riverine Casuarina woodlands (NPWS 1997). Remnant stands of timber, roadside reserves, travelling stock routes and street trees also provide important habitat at certain times (Ayers *et al.* 1996).

Ecology

The Regent Honeyeaters diet comprises of nectar and arthropods. Studies undertaken by Webster &Menkhorst (1992) indicate the main dietary item is nectar taken from 16 species of eucalypt and 2 species of mistletoe. However, the most frequent nectar sources are 3 species of eucalypt; Red Ironbark, White Box and Yellow box (Webster & Menkhorst 1992).

Nests are frequently located in Red Ironbark and Red River Gum but may also be in other eucalypts, mistletoe clumps and casuarinas. During the breeding season which occurs between July and November, 1-3 eggs are laid and incubated for a period of bzzzt days. Fledgling success may be dependant on the abundance of nectar from eucalypt flowers, predation and nests being damaged or blown down (Webster & Menkhorst 1992)

Threats

- Loss of habitat and fragmentation of habitat through clearing for agriculture, fenceposts and firewood, particularly in box-ironbark woodlands
- Slow incremental reduction in tree age classes
- Reduction in large flowering eucalypts in woodlands
- Grazing by domestic stock and rabbits prevents habitat regeneration
- Competition with other honeyeater species
- Tree decline and dieback on rural properties

Management

- Protection and maintenance of known or potential habitat, including the implementation of protection zones around recent records
- Control of feral animals around potential habitat areas, specifically targeting foxes

Recovery plans

A recovery plan has not been prepared for the species.

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For further information contact

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General enquiries: 43 Bridge St Hurstville NSW 2220 Phone 1300 36 1967 or 02 9585 6333.
Web site www.npws.nsw.gov.au

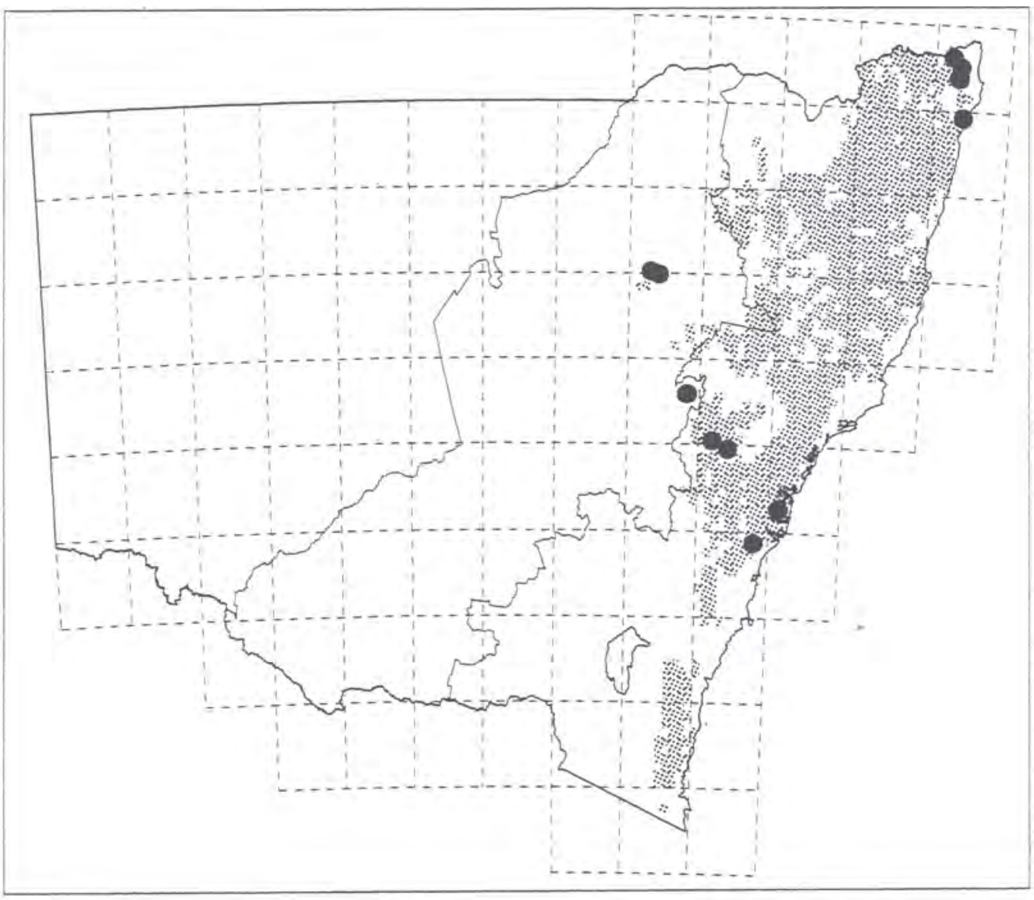
NSW NATIONAL PARKS AND WILDLIFE SERVICE

Large Pied Bat

Chalinolobus dwyeri

Species Code 1353 **TSC Act status** Vulnerable

Distribution



Found across south-eastern Queensland and eastern NSW (Hoye and Dwyer 1995). Occurs in the Pilliga Nature Reserve.

Ecology Inhabits moderately-well wooded habitats. Roosts during the day in small colonies on the ceilings of disused mine tunnels, caves and in the abandoned bottle-shaped mud nests of Fairy Martins (Hoye and Dwyer 1995). Based on its wing morphology, the Large Pied Bat probably forages for small flying insects below the forest canopy. Individuals are thought to disperse from colonies during winter and spend the coldest months in hibernation (Hoye and Dwyer 1995).

Threats

Clearing - and logging remove suitable foraging and possible roosting sites, thereby reducing the availability of suitable habitat for this species.

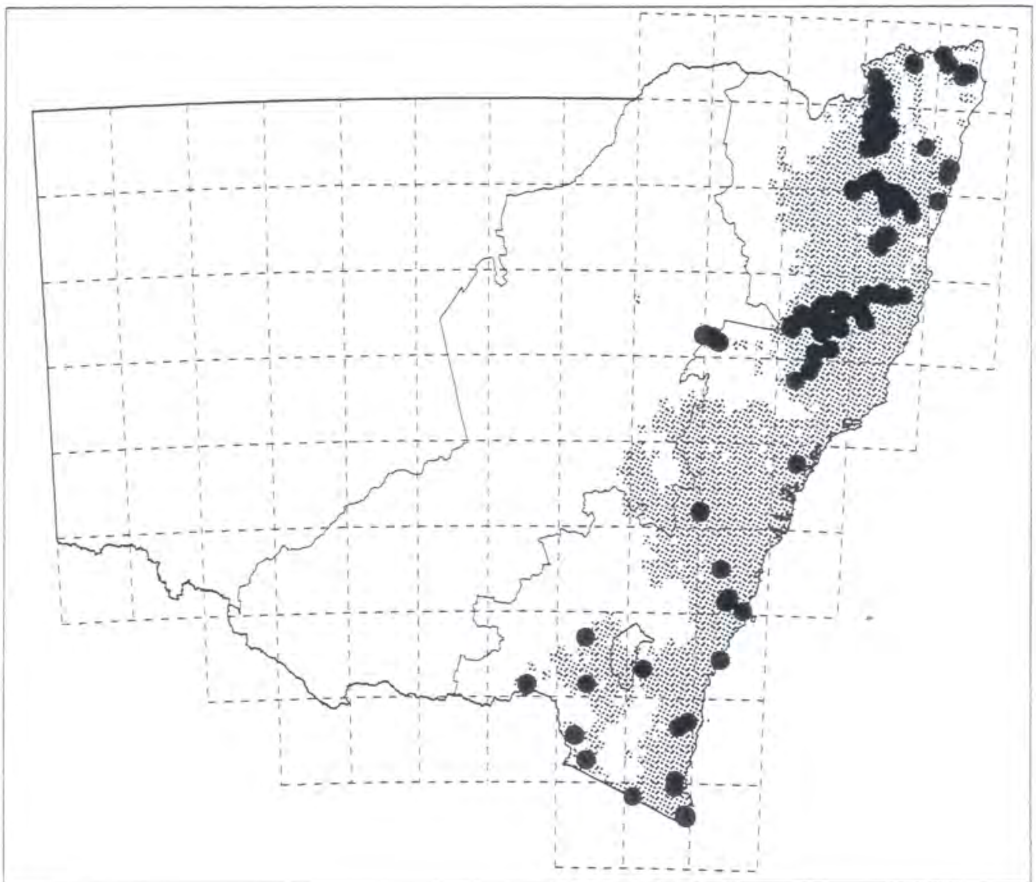
Roosting requirements - the population concentrates into a few locations for part of the year making catastrophic events at roost sites a major threat (Lunney *et al.* 1995).

Great Pipistrelle

Falsistrellis tasmaniensis

Species Code 1372 **TSC Act status** Vulnerable

Distribution



Distributed in Tasmania, south-eastern Queensland, and in a strip down eastern NSW through to far south-western Victoria (Phillips 1995). In the Western Zone it has been located near Coolah Tops.

Ecology Normally roosts in tree hollows within the higher rainfall forests within its range, as well as in caves and abandoned buildings (Parnaby 1983). Females appear to form maternal colonies, breeding and weaning young over summer (Menkhorst and Lumsden 1995).

F. tasmaniensis has a swift, direct flight pattern, with limited manoeuvrability. Foraging is typically around or just below the canopy in open woodland or over water (Menkhorst and Lumsden 1995, Phillips 1995). The species feeds on moths, beetles, weevils, bugs, flies and ants (Menkhorst and Lumsden 1995).

Some populations migrate from highland to coastal areas in winter, while others may hibernate during the coldest months (Parnaby 1983).

Threats

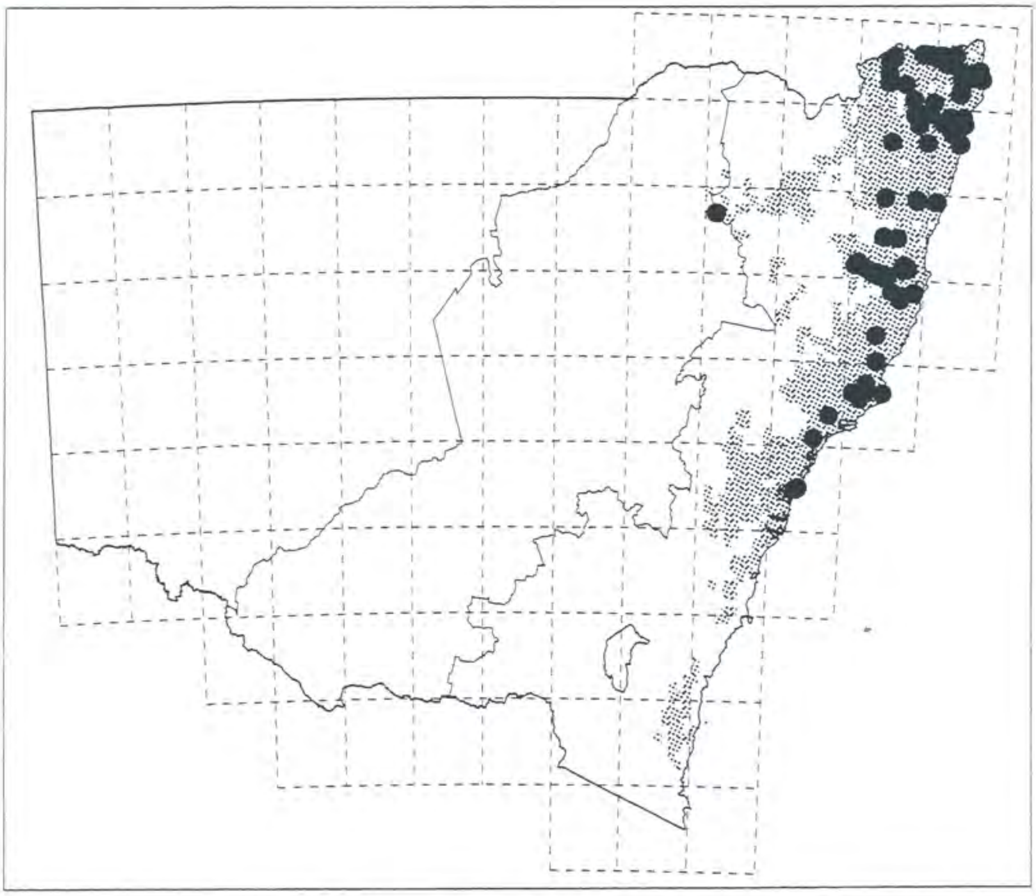
Harvesting - of native hardwoods by forestry operations results in a loss of roosting trees (Parnaby 1983).

Little Bent-wing Bat

Miniopterus australis

Species Code 1346 **TSC Act status** Vulnerable

Distribution



Occurs in mesic areas from Cape York Peninsula south into mid-northern NSW. Distribution becomes increasingly coastal towards the southern limit of their range in NSW. The southern-most breeding population is in the Macleay River watershed (Dwyer 1995a). Within the Western Zone the Little Bent-wing Bat is known only from an unconfirmed record in Mt Kaputar National Park (P. Ewin pers. comm.).

Ecology *Miniopterus australis* is usually found in well-timbered habitats. It roosts during the day in colonies within caves, tunnels and occasionally houses, frequently in association with Common Bent-wing Bats and usually near extensive areas of relatively dense, well timbered vegetation either of forest, *Melaleuca* swamp or scrub (Dwyer 1968, Dwyer 1995a). The distribution of this species is dependent upon the presence of specific nursery sites characterised by high temperatures. If such nursery site temperatures are as important for the Little Bent-wing Bat as for the Common Bent-wing Bat, then it is probable that the former species is dependent on the latter for satisfaction of reproductive requirements (i.e. *M. australis* may need a large colony of *M. schreibersii* at its nursery sites for development of the young) (Dwyer 1995a). Forages beneath the canopy and above the shrub layer for small flying insects (Dwyer 1983). Known to enter torpor during winter (Dwyer 1968).

Threats
Disturbance - of overwintering and also nursery sites is the principal threat to the long-term survival of Little Bent-wing Bats (Dwyer 1995a).

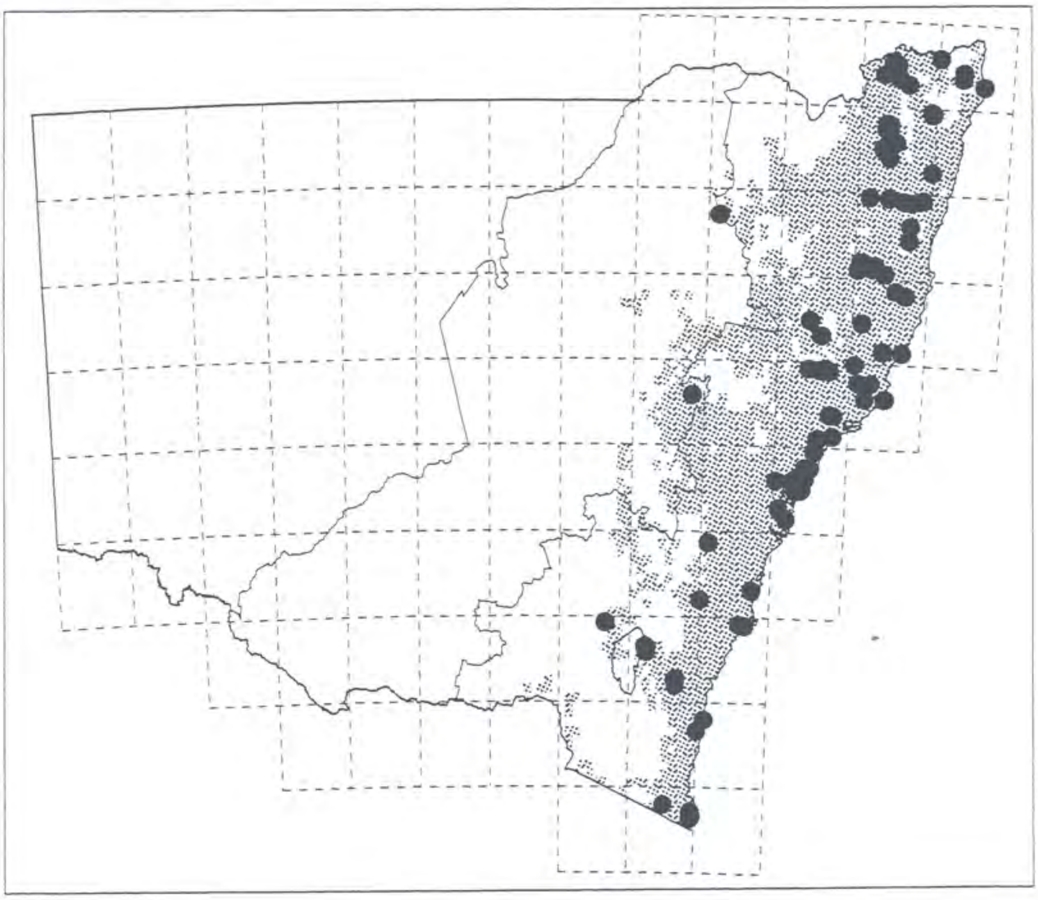
Predation - by owls, pythons, foxes, Green Tree Frogs and predatory Ghost Bats in Queensland is known to occur, but the effects on populations are unknown (Dwyer 1995a).

Common Bent-wing Bat

Miniopterus schreibersii

Species Code 1341 **TSC Act status** Vulnerable

Distribution



Two subspecies of the Common Bent-wing Bat exist, one in north-western Australia (Northern Territory and Western Australia), and the other (*M. s. blepotis*) in a coastal strip from Cape York Peninsula through to south-eastern South Australia (Dwyer 1995b). Generally found near the coast, the species is known only from Mt Kaputar National Park in the Western Zone of NSW (P. Ewin pers. comm.). The distribution and seasonal movement of these bats is dictated by local climatic conditions and the availability of suitable breeding sites (Dwyer 1995b).

Ecology Common Bent-wing Bats occupy a range of habitats from grasslands through to subtropical rainforests but are typically found in well-timbered valleys (Dwyer 1968). Colonies are established by these bats to meet certain social or physiological needs and include maternity colonies within breeding caves (used for the rearing of young), special wintering colonies (consisting of adults or juveniles), transient colonies of juveniles (formed during autumn) and diurnal roosting colonies (Dwyer 1966). Roosting sites are frequently shared with *M. australis* and include caves, old mine tunnels, stormwater channels and occasionally inside buildings (Dwyer 1995b). Nursery caves are of a more specific nature than normal roosting sites, being characterised either by constantly high temperatures and humidity throughout the year or being shaped such that the air warmed by the bats' activities is retained within the cave whilst the colony is present (Dwyer 1981). These bats are strong fliers and may travel long distances between different roost sites according to their changing seasonal requirements. Site attachment is well developed in adults, but less so in juveniles which disperse over many hundreds of kilometres when the nursery colonies disband (Dwyer 1966, 1981, 1995b). Known to travel at least 65km in a single night (Dwyer 1966).

When foraging for small airborne insects such as moths and mosquitoes the Common Bent-wing Bat flies level and fast, making rapid shallow dives for their prey above the canopy (Dwyer 1981, Dwyer 1995b, Reardon and Flavel 1987). These bats have a capacity to lay down fat reserves before winter, although this ability does vary between areas, and in many areas feeding virtually ceases during the coldest months, not least because of the scarcity of insect foods (Dwyer 1966, 1968, 1981). During this time the bats occupy special winter caves or specific sites within roost caves which are typified by cold temperatures and a stable humidity (Hall 1982). Many individuals also enter torpor to help them survive the winter period, changing from being homeothermic (maintaining a high body temperature) to poikilothermic (having a variable body temperature that changes with the temperature of the roost site) (Dwyer 1968). Torpor has also been observed in this species during summer (Dwyer 1968).

Threats

Frequent disturbance - of hibernation roosts seriously increases winter mortality within this species (Dwyer 1995b).

Destruction - or damage of the relatively few nursery caves jeopardises the existence of entire populations (Dwyer 1995b).

Predation - by owls, pythons, feral cats and especially foxes, is known to occur but its long-term effects are as yet unstudied (Dwyer 1995b).

Crowding - at maternity caves and the concomitant competition for food places additional pressure on individual bats within each population. This competition is enhanced during periods when the availability of insect prey species is reduced by local weather conditions (Dwyer 1966).

Eastern Little Mastiff Bat *Mormopterus norfolkensis*

PROFILE

Status:

Mormopterus norfolkensis is listed as **Vulnerable** on Schedule 2 of the NSW *Threatened Species Conservation Act*, 1995. Prior to this it was listed as **Vulnerable** and **Rare** on Schedule 12 of the *NSW National Parks and Wildlife Act*, 1974 for the following reasons: *"Population and distribution suspected to be reduced; threatening processes moderate; ecological specialist."*

Distribution:

Mormopterus norfolkensis is distributed from far south-east Queensland, south to Pambula in eastern NSW. All records are east of the Dividing Range. The species is known from less than about 15 widely scattered localities within its range, and appears to be sparse and localised in NSW. It is known to occur in the following Management Areas of north-east NSW: Bulahdelah, Cessnock and Chichester.

General Ecology:

Habitat requirements of the Eastern Little Mastiff Bat are poorly defined, but the species is known to roost in tree hollows (Allison 1989). Most records of this species are from dry sclerophyll forest and woodland, with a limited number from rainforest. The species appears to forage in more open vegetation or above the canopy, but foraging habitat and diet are poorly understood.

Threatened Species Conservation Act Status:

Recovery Plan:

The Recovery Plan for *Mormopterus norfolkensis*, as defined by the *Threatened Species Conservation Act*, 1995, has not yet been developed.

Critical Habitat:

N/A.

Endangered Population:

Endangered Population listings have not yet been developed.

Potential Threats:

Modification and alteration of roosting and foraging habitat, especially the loss of mature hollow bearing trees, is a major threat to *M. norfolkensis* (Gilmore & Parnaby 1994). Changes to the age structure of forests from logging interfere with the continual succession of mature hollow bearing trees (Gibbons 1994). Most eucalypt species take several hundred years to reach senescence, and at least 150 years to form suitable hollows (Saunders 1982; Mackowski 1984; Gruen *et al*. 1989). This is compounded by the mortality of existing senescent trees which could take many decades to be replaced by trees old enough to have formed hollows.

Logging may adversely impact the invertebrate food resource of this species by altering forest microclimate, forest age structure, tree canopy density, forest soil structure and understorey vegetation. Many flying insect species are potentially vulnerable to logging operations since they have pupal stages in the soil and are associated with specific plant hosts.

Logging may alter the hydrological cycles of catchment areas, and result in decreased stream flow rates (Cornish 1993). This could result in an increased fire risk from the drier conditions prevailing in logged areas. Changes to the hydrological regime are also likely to impact the invertebrate food resource of this species.

Control burning and grazing could effect this species by altering vegetation composition and structure. Fires associated with grazing could also increase destruction or disruption of roost sites and foraging habitats. Grazing may impact the invertebrate food resource by altering understorey vegetation and soil structure.

Introduced bees may compete with *M. norfolkensis* for roost sites by occupying a significant number of available tree hollows in an area (Olroyd *et al.* 1994). In south-east Australia hollow roosting bats were thought to be displaced from their roosts by feral bees (Tideman & Flavel 1987).

Bees are known to harvest a significant proportion of available nectar and pollen (Paton 1993) and may influence the invertebrate food resource available to bats. This may be caused indirectly as a result of changed plant communities through varied pollination regimes or directly through alteration of insect communities from competition with a wide range of insects for pollen and nectar resources (Paton 1993).

Pesticides and herbicides are also potential threats to this species. Their use may reduce number of invertebrates on which *M. norfolkensis* feeds, or result in bio-accumulation of toxic residues in the fat stores of bats (Dwyer 1965; Dunsmore *et al.* 1974).

Status and Distribution Across Land Tenures:

The accompanying species map displays the NPWS Wildlife Atlas statewide records for the Eastern Little Mastiff-bat. The associated species table indicates records in both reserved and unreserved areas within NSW, divided according to State Forests Management Areas

Management Objectives:

1. Protect known roost sites.
2. Protect areas of foraging habitat that are likely to be important.

Management Guidelines:

1. Locate individuals and roost sites through survey.
2. Establish protection zones around roost sites.
3. Where the species is located, protection zones should be established around foraging habitat which includes high site quality forest over a topographic range.

4. Prescribed burning and grazing regimes should not be detrimental to floristic and structural diversity.

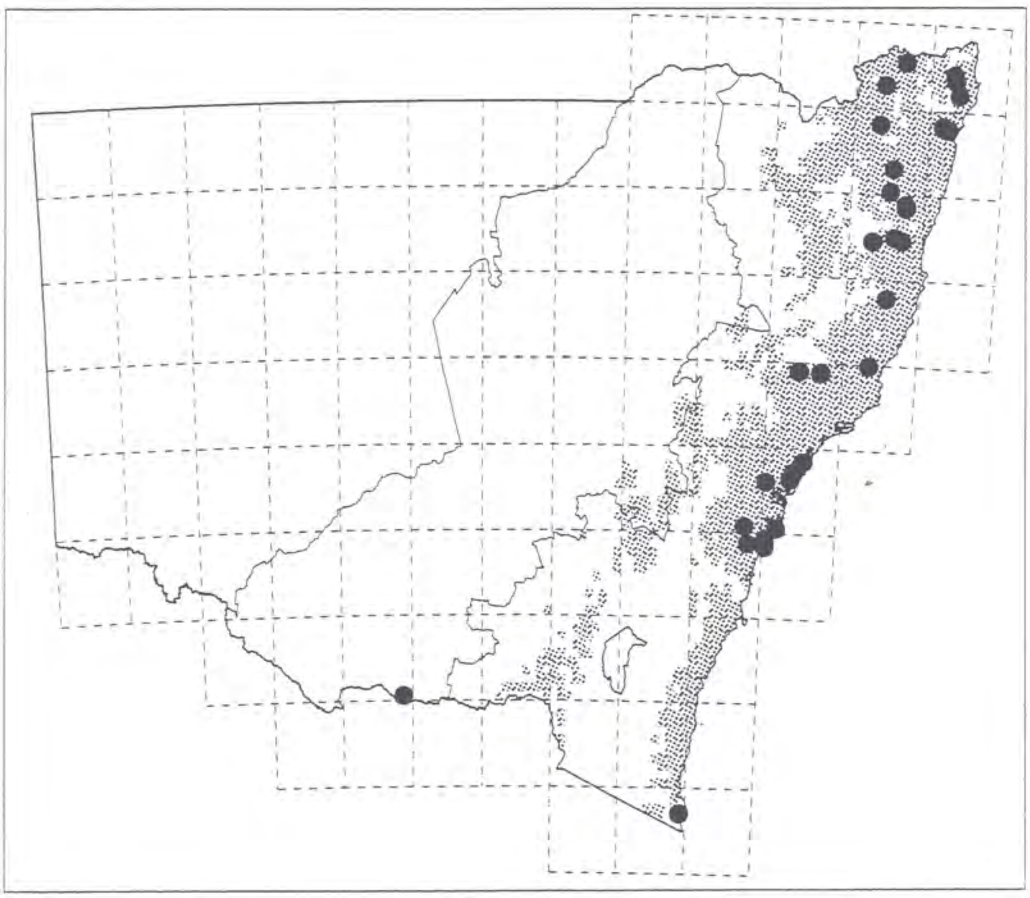
Large-footed Mouse-eared Bat

Myotis adversus

Species Code 1357 **TSC Act status** Vulnerable

This species is currently being revised, and may be divided into three separate species; *Myotis adversus* distributed between Lismore and Murwillumbah, *M. moluccarum richardsi* distributed northwards from the Queensland/NSW border and *M. macropus* distributed south from approximately Taree down to Victoria and eastern South Australia (Richards and Hall 1996).

Distribution



Locally common in a wide coastal band in eastern and northern Australia from northern Western Australia, across the Northern Territory, Queensland, NSW, Victoria and into far south-eastern South Australia (Richards 1995c). Distribution also extends inland from coastal South Australia along the Murray River, where it is likely to be a common species along certain sections (Reardon and Flavel 1987).

Ecology The Large-footed Myotis roosts close to fresh water (rainforest streams, large lakes and reservoirs) in colonies of 10-15, or occasionally of up to several hundred individuals (Richards 1995c). Roost sites are located primarily in caves, also in mines, tunnels, buildings, trees, under bridges and, in the northern part of its range, in dense foliage. Within the larger breeding colonies small clusters of one male and a harem of females are formed (Richards 1995c). Males roost alone when not breeding.

Large-footed Myotis feed alone, in pairs or in groups by swooping over water and raking its surface with the sharp recurved claws on their back feet. In this way, they catch insects just below, on or above (up to 40 cm) the surface. (Reardon and Flavel 1987, Richards 1995c). The tail membrane also dips into the water with the feet and is used as a scoop to take items from the surface (Lumsden and Menkhorst 1995). Small fish are also caught in the water by this method. Flying insects may be caught as the bats spiral downwards through the air. Individuals from NSW and Victoria are known to enter torpor in winter to survive adverse conditions (Richards 1995c).

Threats

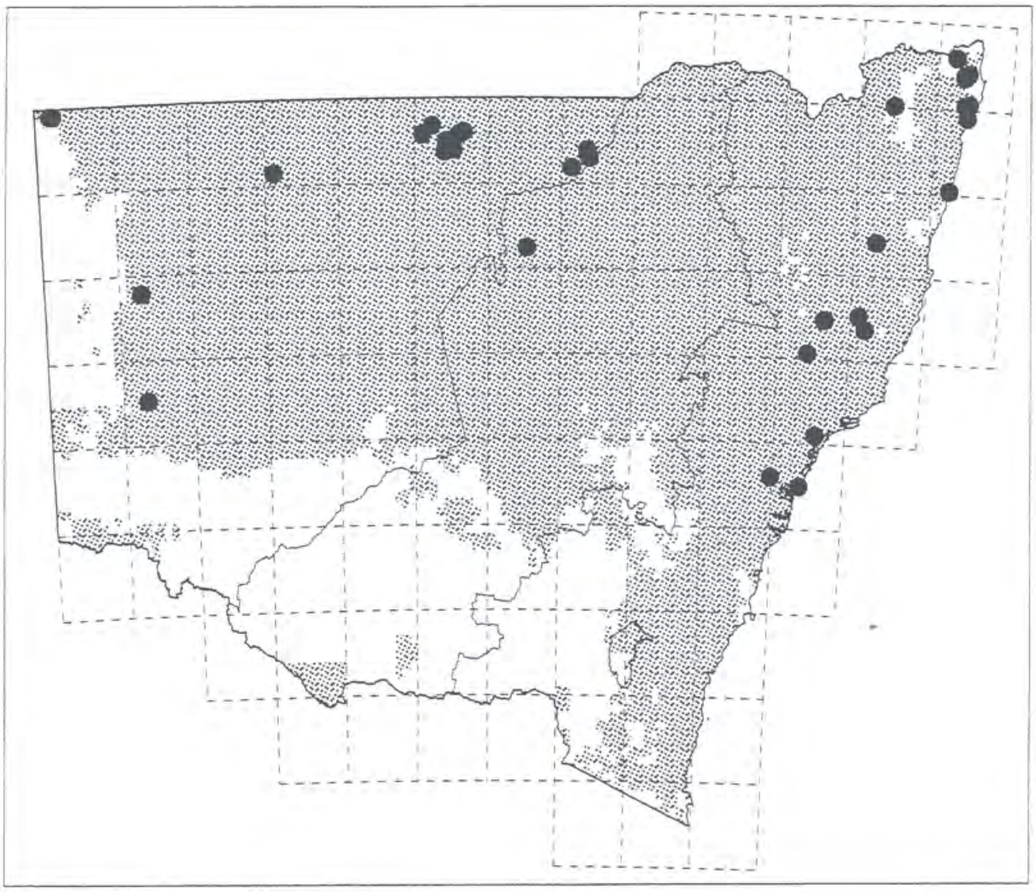
Disturbance - to colonies, particularly during the colder months when hibernating, may cause populations to desert the caves and can result in heavy mortality (Hyett and Shaw 1981, Reardon and Flavel 1987).

Yellow-bellied Sheathtail-bat

Saccolaimus flaviventris

Species Code 1321 **TSC Act status** Vulnerable

Distribution



Widespread across eastern and northern Australia but rarely recorded because of its high and rapid flying habit (Dickman *et al.* 1993, Richards 1995a). Recently caught around watering points in a variety of semi-arid woodlands east of Enngonia and at several sites between Bourke, Walgett and Collarenebri. Identifications from calls indicate the species may be more common than previously thought. May be a seasonal visitor to Victoria (Richards 1995a).

Ecology Yellow-bellied Sheathtail-bats occur in most wooded habitats. During the day they roost in large tree hollows and sometimes also the abandoned nests of Sugar Gliders (Richards 1995a). At night they forage for airborne insects (largely beetles and moths) above the canopy, although in open woodlands and mallee country they also feed closer to the ground (Hall and Richards 1979, Richards 1995a). In the southern portion of its range it is thought to undergo a winter migration to warmer areas. During this time it has been recorded from a variety of other habitats, and has been observed resting on the walls of buildings in daylight (Richards 1995a). The population is suspected to be reduced (Lunney *et al.* 1995).

Threats

Clearing - of old trees with hollows eliminates roosting sites.

Grazing - at severe levels may reduce regeneration of roost trees.

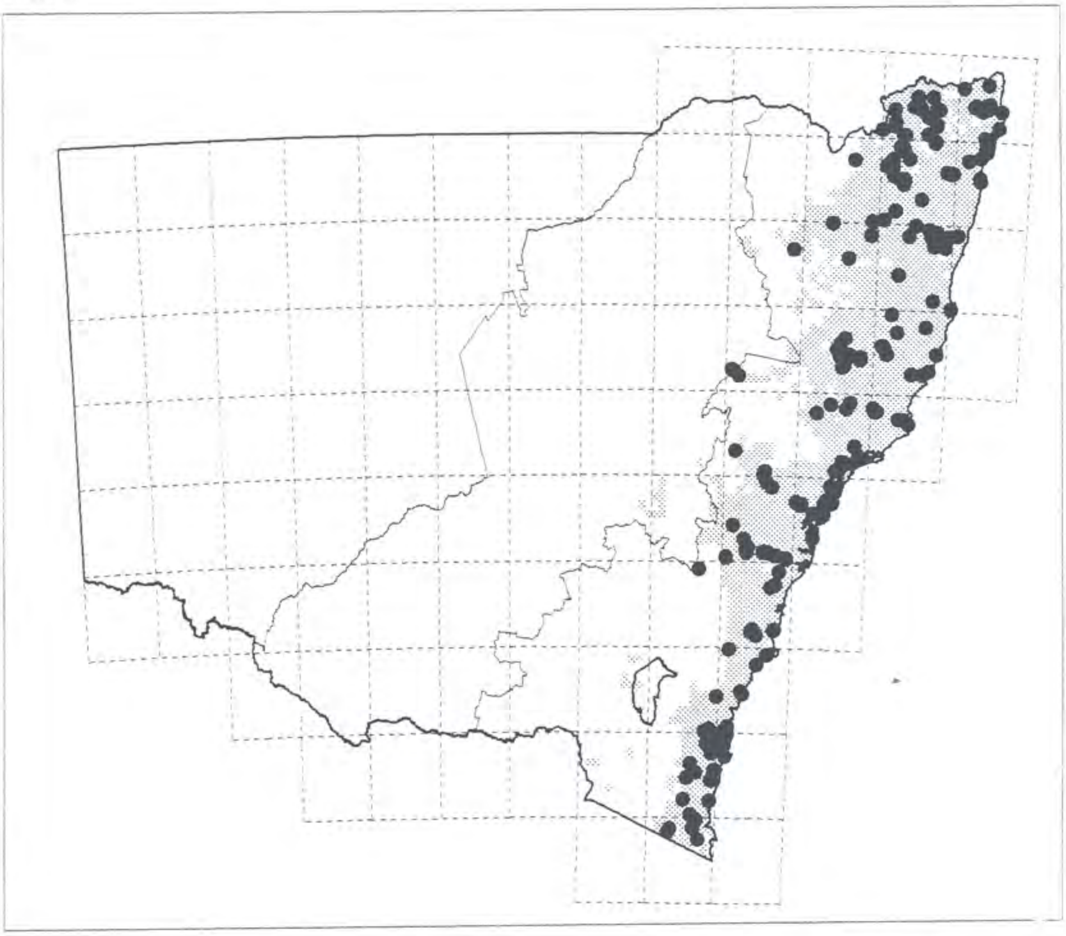
Predation - by feral cats at roost sites may have localised impacts.

Greater Broad-nosed Bat

Scoteanax rueppellii

Species Code 1361 **TSC Act status** Vulnerable

Distribution



The Greater Broad-nosed Bat is distributed throughout drainages flowing off the Great Dividing Range from the Atherton Tableland area of Queensland to the East Gippsland district of eastern Victoria extending down onto the coastal plains (Hoye and Richards 1995). Simpson and Hamilton-Smith (1965) reported that this species was banded at a site near Narrabri in the early 1960s, much further west than indicated by Hoye and Richards (1995). Contrary to Hoye and Richards' (1995) claim that the species does not occur above 500m above sea level, there are many records of the species from locations above this altitude. For example, Smith and Smith (1990) and Barker *et al.* (1994) report records at locations well above 500m. There is no doubt that this species is uncommon throughout its range.

Ecology Several reported observations indicate that the Greater Broad-nosed Bat has a slow and direct mode of flight and has limited manoeuverability, deviating only slightly from its flight path to capture prey (Dwyer 1965, Calaby 1966, Woodside and Long 1984, Hoye and Richards 1998). It typically patrols repeatedly along linear features such as roads and tracks, stream-side vegetation and over waterways where ever there is sufficient open space to accommodate its limited agility in the air (Hall and Richards 1979, Hoye and Richards 1995). In one survey to the east of the Great Dividing Range, Richards (1992) found the species exclusively in wet gullies with tall tree cover. This species hunts relatively close to the ground – 3 to 6 metres according to Hoye and Richards (1995), but Calaby (1966) observed them hunting at between 10 and 20 metres.

The Greater Broad-nosed Bat feeds on large insects including moths, large flies, wasps and beetles (Dwyer 1965, Vestjens and Hall 1977, Woodside and Long 1984) and on other species of microchiroptera in captivity or during capture (Long 1983, Woodside and Long 1984).

Tree hollows are used as roosts but this species may occasionally be found in buildings (Dew 1965, Hall and Richards 1979, Hoye and Richards 1995). Colonies may be relatively large, with one report of 48 individuals being found in a tree hollow near Narrabri (Simpson and Hamilton-Smith 1965). Maternity sites are tree hollows, and a single young is born in January (McKean and Hamilton-Smith 1967, Hoye and Richards 1995).

Threats

Habitat loss and disturbance – loss of roost sites in mature, hollow-bearing trees.

Text prepared by Peter Wilson, Winmalee.

Pale-headed Snake *Hoplocephalus bitorquatus*

PROFILE

Status:

Hoplocephalus bitorquatus is listed as **Vulnerable** on Schedule 2 of the *Threatened Species Conservation Act*, 1995. Prior to this it was listed as **Vulnerable** and **Rare** on Schedule 12 (Endangered Fauna) of the NSW *National Parks and Wildlife Act*, 1974 for the following reasons: *"Population suspected to be reduced; distribution severely reduced; threatening processes moderate; ecological specialist"*.

Distribution:

Hoplocephalus bitorquatus has an extensive but discontinuous range which extends from north-east NSW to north Queensland. In Queensland, it is distributed in coastal and hinterland areas. The NSW distribution includes drier woodland habitats on both sides of the Great Dividing Range, as far south as Tuggerah (Gilmore and Parnaby 1994). In north-east NSW it is restricted to warmer sites at lower elevations.

Historical records exist from the central coast and hinterland around Tuggerah and Wyong (Swan 1990) and lowland coastal areas to the Clarence Valley, but the lack of recent records seems to indicate that the species is genuinely rare in coastal NSW. *H. bitorquatus* is also known from around Moree, Mungindi and the Pilliga Scrub and northern hinterland around Bonalbo, Casino and Tooloom. This species was not recorded during survey work for the SFNSW FISs, or in the NEFBS or NRAC surveys.

The distribution of *H. bitorquatus* in Queensland is more extensive and includes the southern tablelands (Stanthorpe, Wallangarra), hinterland, coast and coastal ranges north to the Rockhampton area with an apparently isolated population in far north Queensland (Longmore 1986).

The total range of this species is estimated to be between 300,000 to 1 million km^2 (Ehmann 1992).

General Ecology:

H. bitorquatus is a relatively slender, moderate sized (to 95cm total length according to Ehmann (1992)), venomous Elapid snake which together with its 2 congeners possesses a pair of ventral keels (Cogger 1992), regarded as an adaptation for climbing (Ehmann 1992). These keels take the form of sharply angled ridges which extend the length of the body near the junction of the dorsal and ventral scales. Similar ventral keels are present in certain other arboreal snake species, such as the Green Tree Snake *Dendrelaphis punctulata* (Ehmann 1992).

Hoplocephalus bitorquatus species is so poorly known that critical or key resources cannot confidently be identified. Habitats utilised by *H. bitorquatus* include a range of woodland and forest types. Open forest and woodland are utilised in the drier and western parts of the range, while rainforest and wet sclerophyll forest are occasionally used on the coast (Ehmann 1992; Gilmore and Parnaby 1994). Elements within these broad categories which are recorded as being significant for the species include *Callitris* open woodland (Ehmann 1992) and watercourses (Wilson and Knowles 1988). Habitat preferences of coastal NSW populations are poorly known (Gilmore and Parnaby 1994).

The extent and nature of seasonal variation, if any, in habitat utilisation by this species is not known. However, it is likely that at least some nocturnal predation of frogs occurs in terrestrial situations, probably during and after summer storm events (Fitzgerald 1996). An extensive telemetry study of a congener (*H. bungaroides*) revealed occasional large-scale movements by individual snakes (600m) as well as seasonal movements of adult snakes from rock crevice shelter sites to hollow trees (Shine and Webb 1995). Seasonal variation in habitat and shelter site use, patterns of movement and resource use and the importance of arboreal microhabitat, previously not known for that species, was recorded during this study (Webb and Shine 1995).

Shelter sites utilised by this species include decorticating bark (Gow 1976; Swan 1990; Gilmore and Parnaby 1994), tree hollows (Gilmore and Parnaby 1994; Fitzgerald 1996) and tree scars (Ehmann 1992). Decorticating bark on senescent and dead standing or fallen trees, rather than the seasonally shed bark of live trees, may be preferred (Fitzgerald 1996). As *H. bitorquatus* is a relatively long-lived species (Fitzgerald 1996) the need for persisting shelter sites is likely to result in the selection (cf. *H. bungaroides*) of more or less permanent refugia. *H. bitorquatus* is infrequently encountered in shelter sites; it is more commonly detected while moving on the ground at night on tracks and roads (Fitzgerald 1996).

H. bitorquatus is variously described as mainly arboreal (Gow 1976), partly arboreal (Swan 1990; Cogger 1992) and strictly arboreal (Ehmann 1992). Ehmann (1992) provides no supporting references as to its strict arboreality. Hence, the nature and extent of exploitation of arboreal environments by *H. bitorquatus* is not known. Prey items include both terrestrial and arboreal species (Shine 1983).

The use of exfoliating granite and sandstone environments is reported for the two congeners (Swan 1990; Ehmann 1992). However, it is not known to what extent *H. bitorquatus* utilises rocky environments. While *H. stephensii* and *H. bitorquatus* are regarded as primarily arboreal, *H. bungaroides* climbs upon rock surfaces, as well as in trees. It is probable that the adaptation for climbing in *H. bitorquatus* also facilitates movement on logs, in vines and in shrublayer vegetation (Fitzgerald 1996). Arboreality in Carpet pythons confers safety from predators and efficient opportunities for thermoregulation in winter (Shine and Fitzgerald 1996). Significantly, *H. bitorquatus* is not found in recently regenerating vegetation, or in grossly disturbed environments (Fitzgerald 1996).

H. bitorquatus is sometimes discovered by removing decorticating bark from dead standing trees (Fitzgerald 1996). Individuals of this species have been seen at night climbing on trees in low vegetation and in a flooded road gutter (Fitzgerald 1996). A Clarence Valley specimen was located in a letterbox (Fitzgerald 1996).

The diet of *H. bitorquatus* includes skinks, geckoes, frogs and mice (Shine 1983). Bats (Ehmann 1992; Gow 1976) and birds (Covacevich 1970) have also been recorded as prey. The diet of this species may vary in different parts of its range with arboreal lizards (especially geckoes) likely to be important in western woodland and forest (Fitzgerald 1996).

Three of the four lizard species recorded as prey by Shine (1983), were arboreal or shrub-dwelling species. The one skink species, one mammal species and two frog species consumed were all terrestrial. Of the 17 frog species recorded as prey items for *H. bitorquatus,* 15 were Hylid or Tree Frogs (Shine 1983). Predation in this species is therefore assumed to take place largely in trees (Shine 1983). Many tree frog species within the range of *H. bitorquatus* are commonly encountered on the ground at night after heavy rain (Fitzgerald 1996), and breeding aggregations of frogs around waterbodies provide terrestrial opportunities for frog predation which is likely to be exploited by this and other primarily arboreal species (such as *H. stephensii* and *Dendrelaphis punctulatus*).

This species is nocturnal (Shine 1983; Swan 1990; Gilmore and Parnaby 1994), secretive, poorly known and infrequently encountered in coastal NSW (Fitzgerald 1996). Throughout the species' total range, specimens are most frequently encountered while active on the ground at night through spotlighting activities, both on foot and from vehicles (Fitzgerald 1996). Apart from Shine's (1983) paper which is based upon the dissection of 215 museum specimens, accounts in the literature tend to be based on isolated and often accidental encounters with the species.

Key elements of the species ecology which necessarily influence management decisions are not known. These include the nature of shelter site use, extent and seasonal timing of movements, range size and response to disturbance processes.

Movements of up to 600m have been reported for *H. bungaroides* (Webb and Shine 1995). *H. bitorquatus* is only slightly smaller and occupies an environment in which both shelter sites and prey may be less densely concentrated in the landscape (Fitzgerald 1996). It is therefore probable that *H. bitorquatus* ranges at least as far or more widely than *H. bungaroides*. The availability of both shelter sites and prey species in forests adjacent to core refugia may be critical for normal ranging behaviour to occur.

Under these circumstances, the provision of 40m wide riparian zones and 100m exclusion or buffer zones around known shelter sites are likely to be spatially inadequate for the conservation of *H. bitorquatus;* this factor may help explain the current rarity of the species.

H. bitorquatus bears few (2-11, average clutch size 4.7) large (approximately 180mm) live young every two years on average (Shine 1983). It is suggested that such low reproductive frequencies have evolved in species with "costs of reproduction that are relatively independent of fecundity, low rates of food intake and high survivorship" (Shine 1983). "Sexual maturity is probably attained in the third or fourth year of life (first ovulation at approximately 33 or 45 months of age" (Shine 1983).

Threatened Species Conservation Act Status:

Recovery Plan:

The Recovery Plan for *Hoplocephalus bitorquatus*, as defined by the *Threatened Species Conservation Act,* 1995, has not yet been developed.

Critical Habitat:

N/A.

Endangered Population:

Endangered Population listings have not yet been developed.

Potential Threats:

Critical threatening processes for *H. bitorquatus* are poorly known. However, clearance of forest habitat is a recognised cause of range reduction in this species (SFNSW 1995g, 1995e).

The loss of large, dead and senescent trees which provide shelter sites for this species and for prey species (skinks, geckoes, bats, tree frogs) through fire and logging (Gilmour and Parnaby 1994), and inadequate recruitment and replacement of these trees in forests managed for timber production, poses a serious threat to this species. The loss of large, living trees and the shelter they provide is also a threat to *H. bitorquatus*. This loss is attributable to timber harvesting, grazing and frequent burning (Gilmore and Parnaby 1994). Large trees provide extensive areas of decorticating, thick bark and remain standing as dead trees for a relatively long time compared to trees of smaller diameter (Gilmore and Parnaby 1994).

H. bitorquatus is occasionally discovered in hollow limbs (Fitzgerald 1996). Logging therefore constitutes a threatening process in that potential shelter sites may be destroyed and individual mortality is likely. Regeneration of suitable tree hollows may take >100 years (Ambrose 1982, cited in Smith *et al.* 1995).

The reduction in density of large fallen logs and the associated reduction of the shrub understorey from frequent fire and high intensity grazing, and the subsequent reduction in frog abundance are also potential threats. While environmental pressures on *H. bitorquatus* are unknown, they may include "reduction in the number of tree hollows as a result of harvesting, and any effects on prey species and ground cover" (SFNSW 1995c). The main pressures on the habitat of this species are logging of dry hardwood in State Forests, a high fire frequency, and grazing (SFNSW 1995f).

Principle threats to *H. bitorquatus* include: a reduction in the abundance of large fallen logs (Smith *et al.* 1995), shelter sites, fire and drought refuges, prey species (skinks, frogs, small mammals), vines, ground layer and shrub layer vegetation through burning and grazing; loss of foraging sites, a reduction in prey species abundance, and increased risk of exposure to predation in open understorey habitats (SFNSW 1995a); loss of vines and leaf litter resources and modification of the soil/leaf litter interface by overly frequent fire, grazing and trampling by livestock; disturbance resulting in a loss of invertebrate abundance and species diversity (Taylor 1991) leading to reduction in prey species diversity and abundance (Fitzgerald 1996).

Increased predation pressures arising from the increased/high levels of feral predators invading disturbed forest environments is another potential threat. The highly toxic Cane Toad *(Bufo marinus)* is also present in part of the range of *H. bitorquatus* and may represent potential prey around the margins of habitat. Timber stand improvement, and the practice of replacing multi-aged and heterogeneous species composition forests with single-aged stands comprising a few commercial species, eliminates/degrades habitat for this species (Gilmour and Parnaby 1994).

Given the wide range of prey animals taken by *H. bitorquatus* (Shine 1983; Ehmann 1992; Cogger 1992), the presence or absence of a particular prey species may not constitute a limiting factor as appears to be the case for *H. bungaroides* where a Velvet Gecko *(Oedura leseueri)* comprises a major dietary item (Webb and Shine 1995). The predominance of tree frogs in the diet of *H. bitorquatus* may result in problems during drought periods and in other situations where favoured prey species decline in abundance. It is not known whether individual snakes are capable of 'prey-switching' or if particular individuals or populations specialise in particular dietary items.

The most sensitive habitat requirement for *H. bitorquatus* is likely to be the availability of suitable shelter sites throughout the normal range of adult snakes. Particular shelter sites may be significant resources at the population level, as well as for individual snakes. This situation is recorded for *H. bungaroides* (Webb and Shine 1995). The use of dead and senescent standing trees as shelter sites renders *H. bitorquatus* susceptible to fire, particularly in more fire-prone forest types. Proximity to refuges from fire (eg,. wet forest types, moist gullies, and rocky environments), may be vital for the conservation of the species and for post-fire recolonisation of habitat.

Status and Distribution Across Land Tenures:

The accompanying species map displays the NPWS Wildlife Atlas statewide records for the Pale-headed Snake. The associated species table indicates records in both reserved and unreserved areas within NSW, divided according to State Forests Management Areas.

Management Objectives:

1. Protection of the foraging and sheltering habitat of *H. bitorquatus*.
2. Protection of hollow-bearing trees and dead stags in known habitat.

Management Guidelines:

1. Locate *H. bitorquatus* species by survey or occasional searches.
2. Reserve known habitat by establishing protection zones around all records.
3. Standard habitat tree retention should be implemented throughout the range of the species.
4. Prescribed burning and grazing regimes should not be detrimental to floristic and structural diversity.

Green and Golden Bell Frog

*Litoria aurea (*Lesson, 1829)

Other common names Swamp Frog, Smooth Swamp Frog, Growling Grass Frog

Conservation status

The Green and Golden Bell Frog is listed as an **Endangered Species** on Schedule 1 of the New South Wales *Threatened Species Conservation Act, 1995* (TSC Act).

Description

The Green and Golden Bell Frog is a relatively large frog with stout body form. Adult size ranges from approximately 45mm to approximately 100mm snout to vent length (SVL) with most individuals being in the 60-80 mm size class. Males are generally smaller than females (maximum size 70mm) and when mature, tend to have a yellowish darkening of the throat area. Males also develop nuptial pads on the inner finger and appears as a brown pigmented patch. Mature females are larger bodied (maximum size 90-100mm) (White & Pyke 1996).

The dorsal colouration is quite variable being a vivid pea green splotched with an almost metallic brass'brown or gold. The backs of some individuals may be almost entirely green whilst in others the golden brown markings may almost cover the dorsum. When the frogs are inactive colouration can darken to almost black. A glandular creamish white stripe extends from behind the eye almost to the groin. The lower margin of this dorso-lateral stripe is black or dark brown, the upper margin is edged gold.

Green and Golden Bell Frog

The belly is usually an immaculate granular creamish white. The lateral margins of the body are adorned with raised glandular creamish spots of irregular size. Legs are a variegated green and gold with the groin area and inside leg a brilliant electric blue. The fingers and toes have expanded terminal pads but are barely wider than the toe/finger itself. The toes are heavily webbed. The eye has a horizontally elliptical pupil and a golden yellow iris. Juveniles are similar to adults and metamorphose at 25-30mm SVL.

Tadpoles are relatively large reaching 65-80mm. They are deep bodied and possess long tails with a high fin that extends almost to mid-body. They swim actively and evade capture. As tadpoles become larger the golden dorsolateral stripe and a green tinge to the back can be observed just before limb growth commences (White 1995; R. Wellington pers. obs.).

Distribution

The Green and Golden Bell Frog was formerly distributed from the NSW north coast near Brunswick Heads southwards along the NSW coast to Victoria where it extends into East Gippsland (White & Pyke 1996; Gillespie 1996) west to Bathurst, Tumut and the ACT (Moore 1961; Osborne *et al.* 1996). There are records from the NSW tableland areas such as Armidale/Ulong, (New England Tableland) and Canberra, Cobargo and Jindabyne (Monaro Tableland).

In the 1960s the species was considered widespread, abundant and commonly encountered. They were even regularly used as dissection material for university students (Dakin 1948) and anecdotal accounts report their regular use as food by snake keepers such was their abundance (R. Wells; I. McArtney; J. Cann pers. comm.). Declines were noticed in the late 1970s and became severe in the 1980s such that today the species exists as a series of isolated coastal populations within its former known range.

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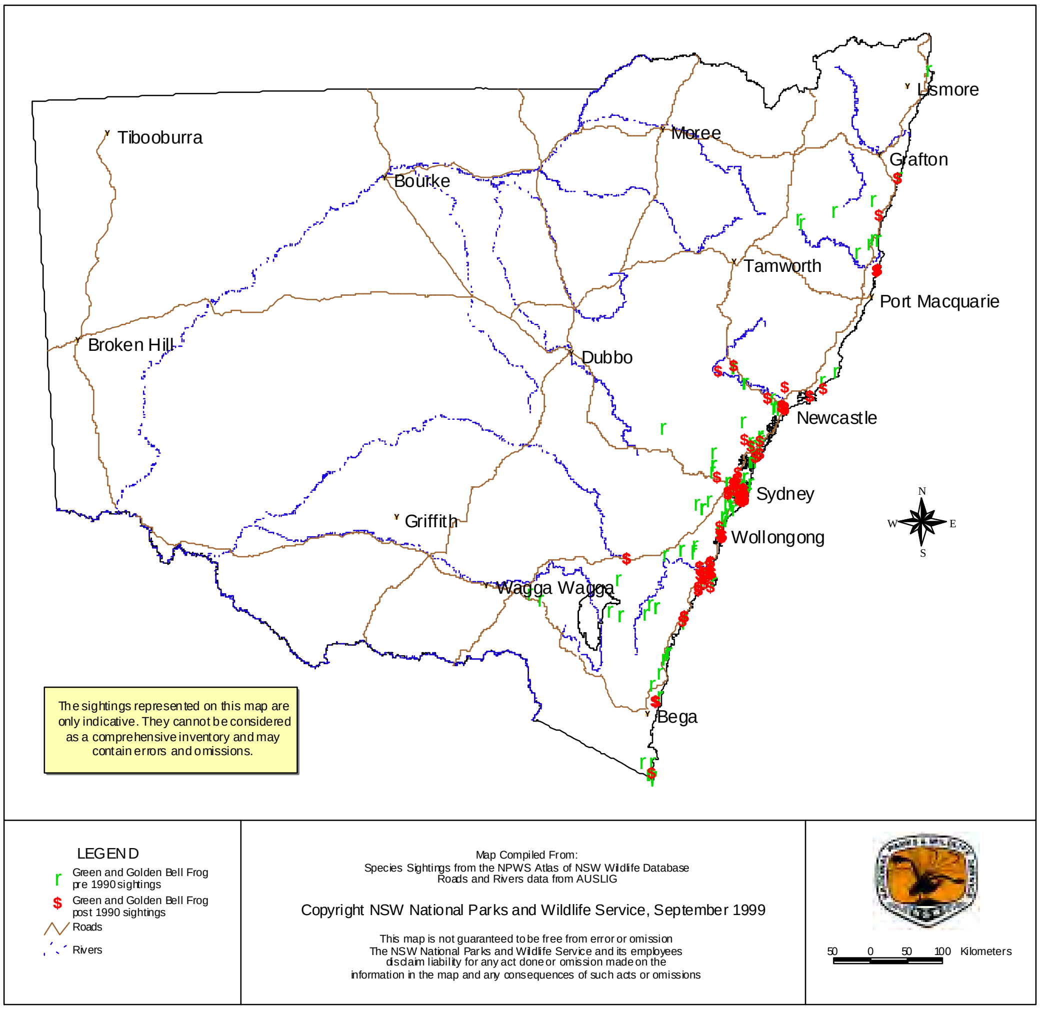

NPWS records of the Green and Golden Bell Frog in NSW

In the last 5 years, surveys of known sites have failed to find any highland populations and fears are that these populations are now extinct. Many former coastal populations have also dramatically declined or disappeared altogether (White & Pyke 1996).

Current distribution consists of isolated pockets from various scattered locations throughout its former range. Most are coastal or near coastal with inland, upland and northern populations most affected. Since 1990 there have been approximately 50 locations in NSW where the species is confirmed to still exist (only 11 within conservation reserves). There are 6 populations of substantial size (numbers over 300, two are located in the metropolitan area of Sydney, two in the Shoalhaven and two on the mid north coast (one an island population) (White & Pyke 1996).

Recorded occurrences in conservation reserves

Ben Boyd NP, Botany Bay NP, Hat Head NP, Jervis Bay NP, Kooragang Island NR, Killalea SRA, Myall Lakes NP, Nadgee NR, *Royal NP, Seven Mile Beach NP, Towra Point NR, *Tyagarah NR, Yuraygir NP (NPWS 1999).
[* no longer considered present]

Habitat

The Green and Golden Bell Frog inhabits marshes, dams and stream sides, particularly those containing bullrushes *Typha* spp. or spikerushes *Eleocharis* spp. Optimum habitat includes water bodies which are unshaded, free of predatory fish *Gambusia holbrooki*, have a grassy area nearby and diurnal sheltering sites available such as vegetation and/or rocks (White & Pyke 1996). Some sites, particularly in the Greater Sydney region, are in highly disturbed areas such as disused industrial sites, brick pits, landfill areas and even cleared land.

Ecology

The Green and Golden Bell Frog is frequently active by day and usually breeds in summer when conditions are warm and wet (Cogger 1992). Males call whilst floating in water and females produce a raft of eggs which initially float before settling to the bottom often amongst vegetation (Harrison 1922). Tadpoles take approximately 6 weeks to develop though this varies considerably and is dependent on temperature and other conditions (A. White pers. comm.; Pyke & White 1996). Tadpoles feed on algae and other vegetative matter adults are voracious insect eaters and will also readily eat other frogs and even juveniles of their own species. They are naturally preyed upon by various wading bird species and snakes and are also presumably fed on as larvae by tortoises, eels and other fish.

Threats

- Alteration of drainage patterns and stormwater runoff (White & Pyke 1996)
- A fungal pathogen (Berger & Speare 1998)
- Changes to water quality (Goldingay 1996)
- Predation by feral animals such as foxes and cats (Daly 1995 & 1996)
- Herbicides and other weed control measures.
- Road mortality where populations are already small due to other threats (Daly 1996)

Green and Golden Bell Frog - juvenile

Green and Golden Bell Frog - tadpole

- Predation by exotic fish particularly the Plague Minnow *Gambusia holbrooki* (Morgan & Buttemer 1996). Recently listed as a key threatening process under the TSC Act, 1995
- Loss of suitable breeding habitat through alteration by infilling and destruction of wetlands (Morgan & Buttemer 1996; Clancy 1996)

Management

- Development of measures to control or eradicate the introduced Plague Minnow *Gambusia holbrooki*
- Strategies to provide for the development or enhancement of frog habitat to improve reproductive success and recruitment at known sites.
- Protocols for the handling of frogs and educational strategies to minimise the inadvertent spread of fungal pathogens from site to site.
- Development of Environmental Impact Assessment Guidelines
- Development of site specific Plans of Management to improve conservation outcomes for targeted populations.
- Community awareness programs highlighting presence of populations and catchment management approaches to improving stormwater quality, habitat retention and management.
- Maintenance of captive bred populations for future possible re-introduction programs.

Recovery plans

A recovery plan is currently being prepared for the Green and Golden Bell Frog. This plan will be exhibited and finalised during 2000.

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For further information contact

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General enquiries: 43 Bridge St Hurstville NSW 2220 Phone 1300 36 1967 or 02 9585 6333.
Web site www.npws.nsw.gov.au

NSW NATIONAL PARKS AND WILDLIFE SERVICE

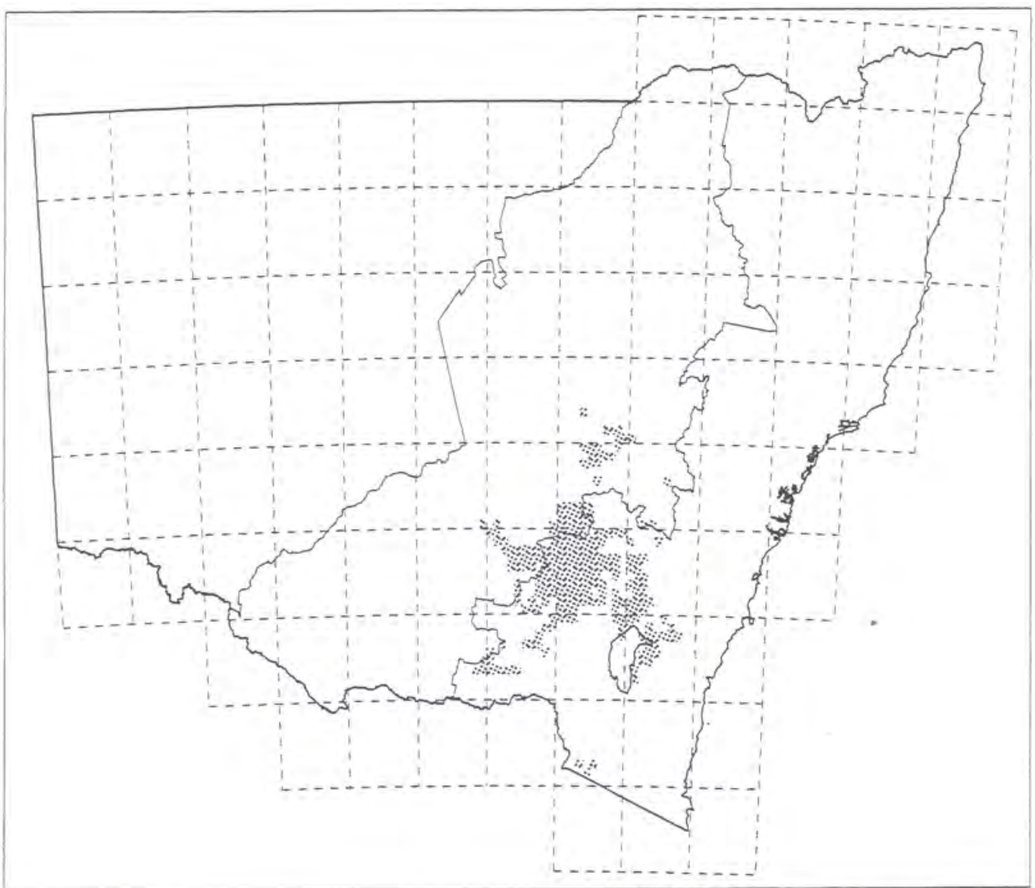
Pink-tailed Worm-lizard

Aprasia parapulchella

Species Code 2144

TSC Act status Vulnerable
National status Endangered

Distribution



The Pink-tailed Worm-lizard exhibits a disjunct distribution within NSW, Victoria and the ACT. Recorded from Coppins Crossing on the Molonglo River, ACT, and very recently from near Bendigo, Victoria. In NSW this species is known from near Tarcutta, Cootamundra and 45km north of Bathurst (Cogger 1994, G. Waters pers. comm.). *Aprasia* specimens from Buddigower, near West Wyalong (thought to resemble *A. parapulchella* but tentatively assigned to *A. pseudopulchella*) (Swan 1990, Osborne *et al.* 1991) have now been confirmed as *A. parapulchella* (W. Osborne pers. comm.).

Ecology A fossorial species found under rocks (or very occasionally logs) in open areas with little or no woody vegetation, a predominantly native grass understorey (particularly of *Themeda triandra,* Kangaroo Grass), well-drained soil, rock outcrops or an extensive scatter of partially buried rocks and little or no leaf litter (Swan 1990, Osborne *et al.* 1991). This habitat is essentially confined to small rocky clearings in tall shrubland or woodland, or is in native grassland (Osborne

1994a). In contrast, the Bendigo specimens were found in whipstick country (W. Osborne pers. comm.).

These morphologically degenerate lizards (lacking external limbs, eyes reduced to small black dots under scales, no visible ear opening) live beneath the rocks in burrows which were apparently formed by ant colonies. In the Bathurst region, rocks under which these lizards were found varied in diameter from approximately 100 to 500mm (G. Waters pers. comm.). In areas of higher *A. parapulchella* densities more than one animal may be found beneath the same rock. They have also been found in occupied ant nests (Osborne *et al.* 1991). Pink-tailed Worm-lizards are nocturnal and feed on small black ants of the genus *Iridomyrex*, as well as their eggs and larvae (Swan 1990, Osborne *et al.* 1991). This species is considered to have a reduced range, be under severe threat and have poor recovery potential within NSW (Lunney *et al.* 1995).

Threats

Habitat loss - through site degradation by agricultural and pastoral practices (especially heavy and uncontrolled livestock grazing and pasture improvement practices), urban development and pine plantations is the major threat to this species (Osborne *et al.* 1991). Almost all populations occur on private property habitat (W. Osborne pers. comm.), thus very few populations are protected from loss of habitat. The Tarcutta population was almost destroyed when the Hume Highway was widened a few years ago (W. Osborne pers. comm.).

Removal of rocks - for landscape gardening purposes or in the course of rock raking can greatly reduce the availability of suitable shelter sites for this species (Osborne *et al.* 1991). Disturbance of rocks can have the same effect if rocks are not replaced. The Bathurst site was almost destroyed in this manner by those who discovered the population approximately five years ago (G. Waters pers. comm.).

Frequent grass fires - would reduce the cover of native grasses in those areas inhabited by *A. parapulchella*, thereby reducing the suitability of such areas to population by these lizards.

Stochastic population events - such as random changes in the sex ratio or population fertility are always a potential problem for small populations. Similarly, local catastrophes such as disease, drought, habitat disturbance (e.g. fire, woody weed invasion) and predation can easily cause the extinction of small populations. The isolated nature of the remaining Pink-tailed Worm-lizard populations reduces the likelihood of recolonisation of such areas should such a local catastrophe occur. Finally, the small size of the remaining isolated populations could potentially lead to the loss of genetic diversity through inbreeding and genetic drift (Osborne *et al.* 1991).

Annex D

Eight Part Tests

D.1 INTRODUCTION

When deciding whether a development or activity is likely to significantly affect threatened species, populations or ecological communities, or their habitats, the 'Eight Part Test of Significance' must be applied.

The Eight Part Test is a standard set of questions devised by the Scientific Committee established under the *Threatened Species Conservation Act 1995* (*TSC Act*). The Test is applied individually to all threatened species, populations and ecological communities and their habitats that are likely to be present in the study area.

The results of an Eight Part Test help determine the nature and significance of impacts of the proposed development and whether the preparation of a Species Impact Statement (SIS) is required.

The questions that form the Eight Part Test are as follows:

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.*

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.*

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.*

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.*

e) *Whether critical habitat will be affected.*

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.*

g) *Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.*

h) *Whether any threatened species, population or ecological community is at the limit of its known distribution.*

D.2 SPECIES GUILDS

For the purposes of this study, the Eight Part Tests were performed on guilds of threatened species rather than on individual species. This is because species that occupy similar ecological niches are at risk from the same threats and are likely to be impacted upon in similar ways by the proposed development.

The relevant guilds and the species within them are listed below:

Guild 1 - Plants

- Lobed Blue-grass (*Bothriochloa biloba*);
- Illawarra Greenhood Orchid (*Pterostylis gibbosa*); and
- *Diuris tricolor* (syn. *D. sheaffiana*).

Guild 2 – Forest/Woodland Birds

- Glossy Black-cockatoo (*Calyptorhynchus lathami*);
- Masked Owl (*Tyto novaehollandiae*);
- Brown Treecreeper (*Climacteris picumnus victoriae*);
- Painted Honeyeater (*Grantiella picta*);
- Swift Parrot (*Lathamus discolor*);
- Black-chinned Honeyeater (*Melithreptus gularis gularis*);
- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*);
- Speckled Warbler (*Pyrrholaemus sagittata*);
- Diamond Firetail (*Stagonopleura guttata*); and
- Regent Honeyeater (*Xanthomyza phrygia*).

Guild 3 – Microchiropteran Bats

- Large-eared Pied Bat (*Chalinolobus dwyeri*);
- Eastern Falsistrelle (*Falsistrellus tasmaniensis*);
- Little Bentwing-bat (*Miniopterus australis*);
- Large Bentwing-bat (*Miniopterus schreibersii oceanensis*);
- Eastern Freetail-bat (*Mormopterus norfolkensis*);

- Large-footed Myotis (*Myotis adversus*);
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*); and
- Greater Broad-nosed Bat (*Scoteanax rueppellii*).

Guild 4 – Amphibians

- Green and Golden Bell Frog (*Litoria aurea*).

Guild 5 – Reptiles

- Pale-headed Snake (*Hoplocephalus bitorquatus*); and
- Pink-tailed Worm Lizard (*Aprasia parapulchella*).

D.3 *EIGHT PART TESTS*

D.3.1 *Guild 1 - Plants*

- **Illawarra Greenhood Orchid (*Pterostylis gibbosa*)**; and
- **Lobed Blue-grass (*Bothriochloa biloba*)**.
- ***Diuris tricolor* (syn. *D. sheaffiana*)**.

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.*

Lobed Blue-grass flowers from November to June (Sharp and Simon 2002). Due to drought conditions during the survey periods, and despite some rain during the survey periods, this species may not have been detectable during surveys. Notwithstanding this, due to the disturbed nature of Site 1 and the nature of woodland within Site 2 there is a low potential for this species to occur within Native Pasture and Narrow-leaved Ironbark/Grey Box Woodland (regrowth) within these sites.

Illawarra Greenhood Orchid flowers between August and November (Bishop 2000). If it occurs on the subject site it may have been incapable of producing a rosette or flower during the survey period because of the drought conditions, making it undetectable (NPWS 2002). There is a low potential for this species to occur in Narrow-leaved Ironbark/Grey Box Woodland (regrowth) within Site 2. It is unlikely to occur on Site 1 because the habitat on this site has been highly disturbed in the past by clearing , grazing and weed invasion.

Diuris tricolor flowers between September and November (Bishop 2000). As for the Illawarra Greenhood Orchid, if it occurs on the subject site it may have been incapable of producing a flower during the survey period because of the drought conditions, making it undetectable. There is a low potential for this species to occur in Ironbark/Grey Box Woodland (regrowth) on Site 2. This species is also unlikely to occur on Site 1 because the habitat on this site has been highly disturbed in the past by clearing, grazing and weed invasion.

These species were not recorded on the subject site, nor have they been recorded during past flora and fauna surveys in the locality. Past aerial photographs show that the subject site and the surrounding land within the locality has been cleared and grazed for at least 40 years. The subject site has undergone a more frequent regime of disturbance compared to the woodland east of the Belt Line Road. Therefore, there is a higher likelihood that these species will occur in the woodland east of the Belt Line Road, if at all, compared to the subject site.

Due to the high level and extent of disturbance on the subject site (especially Site 1), the potential for these species to occur is relatively low. In addition, the flora and fauna habitat value of Site 2 is linked to the extent of surrounding vegetation. That is, Site 2 has more value as flora and fauna habitat when connected to adjacent vegetation, compared to if it was an isolated patch of vegetation within a cleared or rehabilitated landscape.

The vegetation surrounding Site 2 has approval to be cleared for open cut mining and is therefore likely to be cleared under existing operations. This will reduce the value of Site 2 for flora and fauna, because the reduced size will limit the viability of Site 2 to provide long-term habitat for flora and fauna species.

The clearance of Site 2 will result in a small increase in the potential cumulative impact of existing and future operations within the locality. Therefore, the potential impact on these plant species is likely to be low because they are unlikely to occur on low quality habitat with relatively low long-term viability.

This potential cumulative impact will be ameliorated by the proposed rehabilitation of woodland habitat within the study area and the locality. This will offset some habitat of low quality and low viability for these species and mitigate against the cumulative impact of clearance of woodland within the locality.

Therefore, the proposal is not likely to disrupt the life cycle of these species such that a viable local population of the species is likely to be placed at risk of extinction.

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.

No endangered populations of these species have been identified by the Director-General of the National Parks and Wildlife Service (NPWS).

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.*

Illawarra Greenhood Orchid has been found in the Illawarra, Shoalhaven (near Nowra) and at Milbrodale in the Hunter Valley. Lobed Blue-grass occurs from the Darling Downs in Queensland to the North Coast, Central Coast, Northern Tablelands, North-Western Slopes, Central-Western Slopes, North-Western Plains in New South Wales. *Diuris tricolor* occurs in NSW on the western slopes, south of Narrandera to the far north of NSW (and in Queensland).

These species are unlikely to occur on the subject site. Therefore, the area of low quality potential habitat for these species that will be removed (approximately 41 ha for the orchids and 255 ha for Lobed Blue-grass) is unlikely to be significant for these species within the region.

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.*

There is no known habitat within the subject site or within the locality for these species. The proposal will not separate or isolate any known habitat within the region. Therefore, no known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for these species.

e) *Whether critical habitat will be affected.*

No critical habitat for these species has currently been identified by the Director-General of the NPWS.

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.*

Illawarra Greenhood Orchid has been recorded in one conservation reserve, Worrigee Nature Reserve (previously part of Currambene State Forest), near Nowra. Lobed Blue-grass is not represented in any reserves in the region. *Diuris tricolor* is unlikely to be significantly represented in any reserves within the region. Therefore, these species are not adequately represented in conservation reserves or similar protected areas within the region.

g) *Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.*

Vegetation clearance that results in habitat loss is a listed key threatening process under the *TSC Act*. The proposed mine extension will involve removal of low quality, potential habitat for these species. However, the likelihood of these species occurring on the site is low. The viability of the site is also low due to the future removal of surrounding vegetation under existing approvals. Therefore, the potential clearance of vegetation within the site is unlikely to be significant for these species and the proposal is not considered to be a key threatening process.

Other key threatening processes identified for these species such as inappropriate fire regimes and land degradation from rabbits are unlikely to be exacerbated by the proposal. These threatened plant species are unlikely to occur on the subject site and are therefore unlikely to be affected by clearance of vegetation and any associated key threatening processes. In addition, potential threatening processes will be actively managed in woodland areas earmarked for rehabilitation as part of amelioration measures.

h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

Illawarra Greenhood Orchid has been found in the Illawarra, Shoalhaven (near Nowra) and at Milbrodale in the Hunter Valley. This species will be at the northern limit of its distribution if it occurred on the subject site. Lobed Blue-grass occurs from the Darling Downs in Queensland to the North Coast, Central Coast, Northern Tablelands, North-Western Slopes, Central-Western Slopes, North-Western Plains in New South Wales. This species will not be at the limit of its known distribution if it occurred on the subject site. *Diuris tricolor* occurs on the western slopes and will be at the eastern limit of its distribution if it occurred on the subject site.

Conclusion

The proposal is unlikely to have a significant impact on these plant species for the following reasons:

- the habitat on the subject site has been disturbed in the past by clearing and grazing and is unlikely to support these species;
- the surrounding vegetation is likely to be removed under existing approvals, which reduces the value and viability of the subject site for these species; and
- proposed amelioration measures will minimise any potential impacts on low potential habitat for these species.

D.3.2 Forest/Woodland Birds

- **Glossy Black-cockatoo (*Calyptorhynchus lathami*);**
- **Masked Owl (*Tyto novaehollandiae*);**
- **Brown Treecreeper (*Climacteris picumnus victoriae*);**
- **Painted Honeyeater (*Grantiella picta*);**
- **Swift Parrot (*Lathamus discolor*);**

- **Black-chinned Honeyeater (*Melithreptus gularis gularis*);**
- **Grey-crowned Babbler (*Pomatostomus temporalis temporalis*);**
- **Speckled Warbler (*Pyrrholaemus sagittata*);**
- **Diamond Firetail (*Stagonopleura guttata*); and**
- **Regent Honeyeater (*Xanthomyza phrygia*).**

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.

Glossy Black-cockatoo

There is low potential foraging habitat for the Glossy Black-cockatoo on the subject site. The dominant She-oak on the subject site is Bulloak (*Allocasuarina leuhmannii*), which has small cones and is not a preferred feed tree for the Glossy Black-cockatoo. The preferred feed tree, Forest She-oak (*Allocasuarina littoralis*), is not present on the subject site or in the study area. Further, no chewed cones that indicate foraging of this species were detected.

There is some potential breeding habitat for the Glossy Black-cockatoo (tree hollows) in the regrowth woodland on Site 2. However, the vegetation surrounding Site 2 has approval to be cleared for open cut mining and is therefore likely to be cleared under existing operations. This reduction in size of regrowth vegetation in the study area will reduce the value of Site 2 as breeding habitat for this species. This will limit the viability of Site 2 to provide long-term breeding habitat.

The subject site is only likely to provide marginal foraging habitat or stepping-stone habitat for members of a family group of the Glossy Black-cockatoo. The species is likely to use more extensive vegetation within the locality or within the escarpment landforms to the north and south of the Hunter Valley. It is unlikely the subject site has any special significance for this species. Therefore, the proposal is not likely to disrupt a local viable population of the Glossy Black-cockatoo such that it is likely to be placed at risk of extinction.

Masked Owl

This species was not recorded on the subject site. A dead specimen of the Masked Owl has previously been observed in the locality on the New England Highway, approximately 400 m west of the Lemington Road intersection (HLA-Envirosciences 2001). The Masked Owl has large home ranges (5-10 km^2) and the subject site is likely to be within its home range. Masked Owls predominantly feed on terrestrial mammals, including rodents and marsupials. Possums, gliders, birds, bats, lizards and rabbits may be taken opportunistically (Garnett and Crowley 2000).

Although there are trees with hollows on Site 2, this species was not recorded on the subject site and is unlikely to be breeding on the subject site. It has potential to use the subject site as a foraging resource. The vegetation surrounding Site 2 has approval to be cleared for open cut mining and is therefore likely to be cleared under existing operations. The reduction in size of regrowth vegetation in the study area will reduce the value of Site 2 as potential breeding or foraging habitat for this species.

The subject site is unlikely to be significant for this species, and is only likely to provide foraging habitat or stepping-stone habitat for members of a family group of the Masked Owl. This species is likely to use more extensive vegetation within the locality or within the escarpment landforms to the north and south of the Hunter Valley. Therefore, the proposal is not likely to disrupt a local viable population of the Masked Owl such that it is likely to be placed at risk of extinction.

Brown Treecreeper

The Brown Treecreeper is a sedentary species that inhabits eucalypt woodland (>200 ha), particularly open woodland lacking dense understorey, with tree hollows for breeding, and trees and leaf litter for foraging. No Brown Treecreepers were recorded on the subject site. There is no habitat for this species in Site 1 and therefore it is unlikely it will occur there.

This species was not recorded on Site 2, but has previously been recorded near Lake Liddell to the north of the locality. There is some potential habitat for the Brown Treecreeper in the regrowth woodland on Site 2. However, past disturbances and fragmentation of the vegetation within and surrounding Site 2 have precluded viable family groups from inhabiting the area.

The vegetation surrounding Site 2 has approval to be cleared for open cut mining and is therefore likely to be cleared under existing operations. This reduction in size of vegetation in the study area will further reduce the value of Site 2 as potential habitat for this species and will limit the viability of Site 2 to provide long-term breeding habitat. It is unlikely that the subject site has any special significance for this species. Therefore, the proposal is not likely to disrupt a local viable population of the Brown Treecreeper such that it is likely to be placed at risk of extinction.

Painted Honeyeater

The Painted Honeyeater has not been previously recorded within the study area or within the locality. The subject site contains relatively few mature trees and mistletoe and is only likely to provide marginal foraging habitat at best or stepping-stone habitat. It is unlikely that the subject site has any special significance for this species. Therefore, the proposal is not likely to disrupt a local viable population of the Painted Honeyeater such that it is likely to be placed at risk of extinction.

Swift Parrot

The Swift Parrot was not detected during surveys and has not been recorded within the locality. This species is known to follow flowering of Box-Ironbark woodlands on the western slopes and also coastal spotted gum and swamp mahogany forests. This bird is a migratory species which breeds in Tasmania with a wide foraging distribution of habitat within the upper Hunter Valley. The subject site is not likely to be of special foraging significance for this species. Therefore, the proposal is not likely to disrupt a local viable population of the Swift Parrot such that it is likely to be placed at risk of extinction.

Black-chinned Honeyeater

The Black-chinned Honeyeater has previously been recorded within the locality to the south west of the study area. It inhabits Box-Ironbark, River Red Gum woodlands and drier coastal woodlands and uses trees for nesting and eucalypts for foraging. The subject site contains relatively few mature eucalypts and will only provide potential stepping-stone habitat for this species. It is unlikely to be significant foraging or breeding habitat for this species. Therefore, the proposal is not likely to disrupt a local viable population of the Black-chinned Honeyeater such that it is likely to be placed at risk of extinction.

Grey-crowned Babbler

Grey-crowned Babblers inhabit open woodlands dominated by mature eucalypts with regrowth, tall shrubs, and intact ground layer for breeding and foraging. This species has previously been recorded at Ravensworth-Narama (ERM Mitchell McCotter 1997) and at Cumnock No. 1 Colliery (HLA Envirosciences 1996). The individuals recorded on the subject site are likely to be part of a local viable population that occurs within the vegetation on the subject site, the adjacent woodland in Ravensworth-Narama and Cumnock No. 1 Colliery and the vegetation south of the subject site.

The woodland surrounding the subject site has approval to be cleared for open cut mining and is therefore likely to be cleared under existing operations. The consequent isolation of the subject site will reduce the value of the subject site as breeding and foraging habitat for the Grey-crowned Babbler. This will limit the viability of Site 2 to provide long-term breeding habitat for this species.

The clearance of the subject site will result in a small increase in the potential cumulative impact within the locality. This potential cumulative impact will be ameliorated by the proposed rehabilitation of woodland habitat within the study area and the wider locality, including the adjacent Ravensworth-Narama. This will provide stepping stone and connectivity habitat in the locality for this species in the long term which will offset the loss of low quality and low viability habitat on the subject site for the Grey-crowned

Babbler and mitigate against the cumulative impact of clearance of woodland within the locality on this species.

The local population of the Grey-crowned Babbler is likely to persist in the rehabilitated areas around Hunter Valley Coal Preparation Plant (HVCPP) and on Cumnock No. 1 Colliery. The rehabilitated areas on the subject site and on Ravensworth-Narama will help to maintain connectivity between remnants of rehabilitated areas for this species. Therefore, the proposal is not likely to disrupt the life cycle of the Grey-crowned Babbler such that a viable local population of this species is likely to be placed at risk of extinction.

Speckled Warbler

The Speckled Warbler is a sedentary species that lives in separate parties or trios with home range of 6-12 ha. It inhabits eucalypt woodland (>100 ha) with grass tussocks, dense litter and fallen branches for breeding; ground layer and understorey for foraging. Two Speckled Warblers were recorded within the Narrow-leaved Ironbark/Grey Box Woodland (regrowth) on Site 2. Site 2 has varying quality woodland and regrowth Bulloak that is likely to support at least two family groups of this species. There is no habitat for this species at Site 1.

The Speckled Warbler has been previously recorded at Ravensworth-Narama (ERM Mitchell McCotter 1997) and is also highly likely to occur at Cumnock No. 1 Colliery. The Speckled Warblers recorded in Site 2 are likely to be part of a local viable population that occurs within the vegetation on the subject site, the adjacent regrowth woodland in Ravensworth-Narama and Cumnock No. 1 Colliery and the vegetation south of the subject site.

The woodland surrounding the subject site has approval to be cleared for open cut mining and is therefore likely to be cleared under existing operations. This species is known to decline in areas where patches are less than 100 ha. Therefore, the approved clearing in the study area and on the adjacent Ravensworth-Narama mine is likely to result in a non-viable area for this species. As a result, this species is expected to persist only on regrowth woodland on Cumnock No. 1 Colliery to the north of Ravensworth-Narama.

Cumulative impacts will be ameliorated by proposed rehabilitation of woodland at HVO. The current proposal will not result in the removal of vegetation on Site 2 until 15 years. During this time the rehabilitating woodland will provide habitat for the breeding and dispersal of this species.

Therefore, the proposal is not likely to disrupt the life cycle of this species such that a viable local population of the species is likely to be placed at risk of extinction.

Diamond Firetail

The Diamond Firetail is a sedentary species that lives in flocks and inhabits a range of eucalypt dominated vegetation communities that have a grassy understorey including woodland, forest and mallee (>200 ha). It requires water and trees for drinking and shelter. It feeds mostly on grass seeds but also on insects, and at dusk, flocks return to dense shrubs or specifically built nests to roost.

The Diamond Firetail has not been recorded in the locality. Site 1 consists of scattered trees within over a cleared and grazed paddock and is not remnant woodland greater than 200 ha. Therefore, this species is unlikely to occur on Site 1. Although there are water sources at Site 1, it is unlikely that this species utilises them because of the lack of shrubs or undergrowth to provide shelter.

Site 2 and the surrounding vegetation provide potential habitat for this species since it consists of woodland with a native grassy and shrubby understorey. There are also a number of dams to the north of Site 2 that provide potential water resources for this species. Potential habitat for this species also occurs on the regrowth woodland on Ravensworth-Narama and Cumnock No. 1 Colliery.

Any Diamond Firetails that may be present on the subject site would be part of a local population that would occur within the woodland on and surrounding Site 2 and within the adjacent regrowth woodland in Ravensworth-Narama and Cumnock No. 1 Colliery.

The woodland surrounding Site 2 has approval to be cleared for open cut mining and is therefore likely to be cleared under existing operations. This species is known to decline in areas where patches are less than 200 ha. Therefore, the approved clearing in the study area and on the adjacent Ravensworth-Narama mine is likely to result in a non-viable area for this species. As a result, potential habitat for this species would persist only on regrowth woodland on Cumnock No. 1 Colliery to the north of Ravensworth-Narama.

Cumulative impacts will be ameliorated by proposed rehabilitation of woodland at HVO. The current proposal will not result in the removal of vegetation on Site 2 until 15 years. During this time the regenerating and rehabilitating woodland will provide potential habitat for the breeding and dispersal of this species.

Therefore, the proposal is not likely to disrupt the life cycle of this species such that a viable local population of the species is likely to be placed at risk of extinction.

Regent Honeyeater

The Regent Honeyeater has not been recorded within the locality. This species is highly migratory and follows flowering of Box-gum woodlands on the western slopes and coastal Spotted Gum and Swamp Mahogany forests. There is a wide distribution of habitat within the upper Hunter Valley. It is known to forage on nectar, insect arthropod and lerp resources on ironbark and spotted gum vegetation within the Hunter Valley to the south east of the locality at Warkworth and around Wollombi Brook (ERM 2002).

The subject site contains no Spotted Gums and relatively few mature eucalypts and will only provide potential stepping-stone habitat for this species. It is unlikely to be significant foraging or breeding habitat. Therefore, the proposal is not likely to disrupt a local viable population of the Regent Honeyeater such that it is likely to be placed at risk of extinction.

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.*

No endangered populations of these species have been identified by the Director-General of the NPWS.

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 study area is located within the North Coast biogeographic region. The extent of past clearing in the Hunter Valley has resulted in fragmentation and isolation of habitats for these species. The regional distribution of habitat is limited to relatively small and isolated fragments of woodland within the region.

Known habitat and connectivity for the species that occur on the subject site (Speckled Warbler and Grey-crowned Babbler) will be retained and managed within the study area and adjacent vegetation and local populations of these species are not likely to be placed at risk of extinction. Therefore, the proposal will not result in the removal of a significant area of known habitat for these species.

Some potential habitat for the remainder of these bird species is also present within the study area and in the locality. However, this habitat is of low quality due to fragmentation and age of regrowth, and unlikely to be significant for these species. Therefore, the proposal is unlikely to include removal and modification of a significant area of potential habitat for these species in the region.

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 woodland that is currently extant to the south of the subject site will be cleared as part of existing approvals for West Pit. The clearance of the subject site will result in a small increase in the potential cumulative impact within the locality. The land further south is open cleared grazing land and is unlikely to provide significant flora or fauna corridor function in that direction.

Areas of known habitat for these species are not likely to become isolated from currently interconnecting or proximate areas because adjacent vegetation (north and south of Site 2 and west of Site 1) will already be cleared. The proposal is not likely to result in further isolation of known habitat for these species.

e) Whether critical habitat will be affected.

No critical habitat for this species has currently been identified by the Director-General of the NPWS.

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.

These birds generally prefer woodland habitats on the western slopes, which have relatively few large conservation reserves, and specific sub-coastal habitats such as winter-flowering eucalypts, relatively unfragmented woodlands and forests with hollow-bearing trees and *Allocasuarina* sp. These habitats are unlikely to be adequately represented in conservation reserves within the region.

g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Vegetation clearance that results in habitat loss is listed as a key threatening process under the *TSC Act*. The proposed mine extension will involve removal of approximately 61 ha of low quality potential regrowth woodland habitat and 221 ha of native pasture habitat for these species. The proposal will have an increase in the cumulative impact of clearing on these species in the locality. However, for the reasons noted above, this is unlikely to significantly add to impacts that will already occur as a result of existing approvals.

The impact of removal of vegetation from the subject site will be ameliorated by rehabilitation of similar woodland habitat within HVO. Therefore the proposal is not considered to be a key threatening process and the clearance of this vegetation is unlikely to be significant for these species.

Other key threatening processes that could affect these species such as inappropriate fire regimes and land degradation from rabbits are unlikely to be exacerbated by the proposal. In addition, these potential threatening processes will be managed in woodland areas earmarked for rehabilitation as part of amelioration measures.

h) *Whether any threatened species, population or ecological community is at the limit of its known distribution.*

Habitat for the Speckled Warbler, Diamond Firetail, Grey-crowned Babbler, Black-chinned Honeyeater and Painted Honeyeater includes the western slopes of the Great Dividing Range. Therefore, these species are at the eastern limit of their distribution in the Hunter Valley. The Regent Honeyeater, Swift Parrot, Masked Owl and Glossy Black-cockatoo are known to occur in both inland areas and along the coast of NSW and would not at the limit of their distributions if they occurred on the subject site.

Conclusion

Known and potential habitat for these forest/woodland bird species occurs on the subject site and in the study area and will be impacted by the proposed mine extension. However, areas of known and potential breeding, shelter and dispersal habitat will be rehabilitated and managed in the study area. Local populations of the Speckled Warbler and Grey-crowned Babbler will persist on rehabilitated woodland in the study area and woodland in the wider locality such as woodland on Ravensworth-Narama and Cumnock No. 1 Colliery. Therefore, the proposal is unlikely to result in the loss of potential local populations of these species. This is because:

- the viability of the local populations of Speckled Warbler, Grey-crowned Babbler and Diamond Firetail (if it occurred there) are already threatened from clearing under existing approvals, which will reduce the viability and significance of the subject site as habitat for these species;

- the proposal will have a relatively small increase on the cumulative impacts on the Speckled Warbler and Grey-crowned Babbler in the locality;

- the habitat on the subject site has been disturbed in the past by clearing and grazing and is unlikely to be significant for the Glossy Black-cockatoo, Brown Treecreeper, Painted Honeyeater, Swift Parrot, Black-chinned Honeyeater and Regent Honeyeater; and

- proposed amelioration measures will minimise any potential impacts on the low quality potential habitat for these species.

D.3.3 Guild 3 – Michrochiropteran Bats

- **Large-eared Pied Bat (*Chalinolobus dwyeri*);**

- **Eastern Falsistrelle (*Falsistrellus tasmaniensis*);**

- **Little Bentwing-bat (*Miniopterus australis*);**

- **Large Bentwing-bat (*Miniopterus schreibersii oceanensis*);**
- **Eastern Freetail-bat (*Mormopterus norfolkensis*);**
- **Large-footed Myotis (*Myotis adversus*);**
- **Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)**; and
- **Greater Broad-nosed Bat (*Scoteanax rueppellii*).**

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.*

Only the Large Bentwing-bat and Eastern Freetail-bat were detected on the subject site. No other threatened bats were recorded. However, the subject site and study area provides known or potential foraging habitat for all these bat species and they have potential to occur on the subject site.

Of these bats, only the Little Bentwing-bat is restricted to caves for breeding. Therefore, the subject site is not breeding habitat for this species. Future clearing under existing approvals will further reduce the significance of the subject site as foraging habitat since it will reduce its size and increase fragmentation in the study area. Therefore, the proposal is not likely to disrupt the life-cycle of the Little Bentwing-bat such that a viable local populations of this species is placed at risk of extinction.

All the other bats have potential to roost on the subject site. Potential roosting habitat also occurs in vegetation north and south of Site 2 and in woodland on Ravensworth-Narama and Cumnock No.1 Colliery. Bats recorded on the subject site are likely to be part of local populations that also occur throughout the study area and adjacent vegetation.

As noted above, under existing approvals, the vegetation surrounding the subject site will be cleared for open cut mining. This will reduce the size of vegetation in the study area and will reduce the value of the subject site as foraging and roosting habitat for these species. This will result in a small increase in the potential cumulative impact of the removal of known foraging and potential roosting habitat for these species.

Potential cumulative impacts will be ameliorated by the proposed rehabilitation of woodland within the study area and the locality. This will offset some known and potential foraging habitat for these species and mitigate against the cumulative impact of clearance of woodland within the locality. In addition, roost boxes will be placed in regeneration areas to offset the loss of potential roost sites that will be removed from the subject site.

Therefore, the removal of potential habitat on the subject site is unlikely to place local viable populations of these species at risk of extinction.

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.*

No endangered populations of these species are currently listed on Schedule 1 of the *TSC Act*.

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.*

Suitable habitat for these species occurs throughout the region. The proposal will involve an increase in the cumulative impact of removal of known and potential foraging and breeding habitat for these bats (no breeding habitat for the Little Bentwing-bat will be removed). However, similar habitats will be conserved in the remainder of the study area and there is extensive habitat for these species which is conserved within the North Coast region. Therefore, it is unlikely that a significant area of known habitat will be modified or removed as a result of the proposed mine extension.

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 proposal will result in the removal of potential habitat for these species. However, they are wide-ranging, adaptable and highly mobile. The proposed mine extension is not likely to isolate currently interconnecting or proximate areas of habitat for these species.

e) *Whether critical habitat will be affected.*

No critical habitat for this species has currently been identified by the Director-General of the NPWS.

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.*

Foraging habitat for these species is likely to be adequately represented in conservation reserves within the region. However, roosting habitats such as caves are unlikely to be adequately reserved within the region. The proposed mine extension will not impact on any caves.

g) *Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.*

Vegetation clearance that results in habitat loss is a listed key threatening process under the *TSC Act*. The proposed mine extension will add to the cumulative impact of removal of potential foraging and roosting habitat for these bats (except roosting habitat for the Little Bentwing-bat) in the locality. However, amelioration measures include rehabilitation of woodland in HVO and installation of roost boxes for these species. Therefore, the proposal is not considered to be a key threatening process.

h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

None of these species are at the limit of their distribution within the site.

Conclusion

The subject site provides known or potential foraging habitat for these bat species. These mobile species are likely to forage and roost throughout the study area and nearby habitats. The increase in cumulative impact due to the removal of known or potential habitat on the subject site will be ameliorated by rehabilitation of woodland (for 15 years before Site 2 will be cleared) at HVO and installation of roost boxes in this woodland. Therefore, it is unlikely that the proposal will have a significant impact on these species.

D.3.4 Guild 4 – Amphibians

- **Green and Golden Bell Frog (*Litoria aurea*).**

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.

This species was not recorded on the subject site despite targeted surveys. While conditions during surveys on the subject site were suitable for detecting a wide range of reptiles and amphibians, conditions for the Green and Golden Bell Fog are more appropriate during and after heavy periods of rainfall in hotter weather during early and mid summer.

Within the locality, NPWS records indicate that the species has been recorded east of the subject site on a dam in Ravensworth-Narama. It is also likely to occur in woodland on Cumnock No. 1 Colliery. The habitat for the Green and Golden Bell Frog on woodland east of the Belt Line Road is of higher quality than the habitat on the subject site. This is because the dam (potential breeding site) east of the Belt Line Road is located amongst regrowth woodland, which will provide much higher quality over-wintering, shelter and foraging habitat for the Green and Golden Bell Frog.

This species is known to travel over long distances. However individuals of local populations are only likely to attempt to utilise the dams on the subject site for breeding during summers with appropriate weather (heavy rain in summer and high temperatures). Therefore, a local population of this species is likely to be centred in the regrowth woodland on Ravensworth-Narama and Cumnock No. 1 Colliery.

The two large dams on the subject have almost no emergent reeds. One smaller dam between these two large dams is dominated by reeds with little to no open water. The habitat on the subject site is therefore of relatively lower quality compared to that on Ravensworth-Narama. Therefore, the subject site is not likely to be significant for this population.

The proposal will remove potential breeding habitat for this species from the subject site. However, this breeding habitat is unlikely to be critical for the local populations of this species. Following mining, rehabilitation will include at least three dams, which will be constructed so as to provide potential breeding habitat for these species.

Therefore, the proposal is unlikely to disrupt the life cycle of a local viable population of this species which is likely to be centred on Ravensworth-Narama and Cumnock No. 1 Colliery such that it will be placed at risk of extinction.

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.*

No endangered populations of this species have been identified by the Director-General of the NPWS.

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.*

As stated above, the subject site is not known habitat for this species, and is not likely to be significant for the local viable populations of this species, which is likely to be centred off site in woodland east of the Belt Line Road. The proposal will remove a small proportion of the low potential breeding, shelter and foraging habitat for this species in the study area.

The area of potential habitat for this species that is to be removed is unlikely to be significant for this species because it is of low quality and is small compared to potential habitat within the region. In addition, some potential breeding habitat (dams) will be protected and created in HVO.

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 subject site is located on the western edge of a larger area of known habitat for this species. Therefore, known habitat will not become isolated as a result of this proposal.

e) *Whether critical habitat will be affected.*

No critical habitat for this species has currently been identified by the Director-General of the NPWS.

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 is known to occur in 11 conservation reserves throughout NSW (NPWS 2000). This species has been recorded in Ben Boyd, Botany Bay, Hat Head, Jervis Bay, Myall Lakes, Seven Mile Beach and Yuraygir National Parks, Kooragang Island, Nadgee and Towra Point nature reserves and Killalea State Recreation Area (NPWS 1999). Only Myall Lakes, Hat Head, Seven Mile Beach and Yuraygir National Parks occur within the region. It is unknown at this stage whether this represents adequate conservation of the species. Due to the propensity of threats such as Plague Minnow (*G. holbrooki*) to impact on habitat in reserved areas, it is possible that reservation as a measure on its own, will not ensure the continuity of the species.

g) Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Vegetation clearance that results in habitat loss is listed as a key threatening process under the *TSC Act*. The proposed extension of West Pit will involve removal of three dams with low potential as breeding habitat and associated low quality potential foraging habitat. The proposal will have a slight increase in the cumulative impact of clearing on this species in the locality. However, for the reasons noted above, this is unlikely to add significantly to impacts that will already occur as a result of existing approvals.

Therefore, the potential clearance of this vegetation is unlikely to be significant for this species. Nonetheless, the impact of removal of vegetation from the subject site will be ameliorated by rehabilitation of similar woodland habitat within HVO and from construction of dams with potential breeding habitat within the rehabilitated landscape. Therefore the proposal is not considered to be a key threatening process.

Other key threatening processes that could affect this species such as predation by the Mosquito Fish, inappropriate fire regimes and land degradation from rabbits are unlikely to be exacerbated by the proposal. In addition, potential threatening processes, where possible, will be managed in woodland areas earmarked for rehabilitation as part of amelioration measures.

h) Whether any threatened species, population or ecological community is at the limit of its known distribution.

The distribution of the Green and Golden Bell Frog is eastern and south-eastern NSW, and far eastern Victoria, particularly in the lower latitudes. This species will not be at the limit of its known distribution at the subject site.

Conclusion

The Green and Golden Bell Frog has not been recorded within the subject site but has previously been recorded at Ravensworth-Narama, to the east of the subject site. Low quality potential breeding habitat for this species occurs on the subject site and in the study area and will be impacted by the proposed mine extension. However, areas of potential breeding, shelter and dispersal habitat will be maintained east of the subject site, where the local populations of this species are likely to be centred. In addition, potential breeding habitat will be created in the study area. Therefore, the proposal is unlikely to result in the loss of a local population of this species and it is unlikely to have a significant impact on this species.

D.3.5 Guild 5 – Reptiles

- **Pale-headed Snake (*Hoplocephalus bitorquatus*)**; and
- **Pink-tailed Worm Lizard (*Aprasia parapulchella*).**

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.

Neither species has been recorded on the subject site and there are no records of these species in the locality. Low quality potential habitat within the subject site includes a relatively small area of regrowth woodland where there are sheltering sites and decorticating bark and logs in Site 2 that has undergone extensive clearing and disturbance in the past. However, there are no good water supplies near this woodland to provide an abundance of amphibians as foraging resources for the Pale-Headed Snake. The subject site is not likely to be significant habitat for these species.

The vegetation surrounding Site 2 has approval to be cleared for open cut mining and is therefore likely to be cleared under existing operations. The reduction in size of vegetation in the study area will reduce the value of Site 2 as habitat for these species. This will limit the viability of Site 2 to provide long-term habitat.

The subject site is only likely to provide marginal habitat for these species and it is highly unlikely that the subject site has any special significance for these species. Therefore, the proposal is not likely to disrupt a local viable population of the Pale-headed Snake or Pink-tailed Worm Lizard such that they are likely to be placed at risk of extinction.

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.

No endangered populations of these species are currently listed on Schedule 1 of the *TSC Act*.

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 subject site is not known habitat for these species. The extent of previous disturbance on the subject site limits the suitability of habitats. The area of potential habitat for these species is not considered to be regionally significant.

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 area of potential habitat for these species that is to be removed is unlikely to be significant because it is of low quality and is small compared to potential habitat within the region. The subject site is unlikely to be significant as a regional dispersal corridor for these species due to the extensive cleared land to the south west and the extant mine to the west.

It is unlikely that the proposal will isolate currently interconnecting or proximate areas of habitat for the Pale-headed Snake or Pink-tailed Worm Lizard.

e) *Whether critical habitat will be affected.*

No critical habitat for this species has currently been identified by the Director-General of the NPWS.

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.*

The Pale Headed Snake is expected to be adequately conserved within the escarpment and tableland national parks in the North Coast region. Almost all populations of Pink-tailed Worm Lizard occur on private property. This species and its habitat are not considered to be adequately conserved.

g) *Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.*

Vegetation clearance that results in habitat loss is a listed key threatening process under the *TSC Act*. The proposal will directly impact potential habitat that is of low significance for these species on the subject site. No potential local populations are likely to be placed at risk of extinction. Therefore, the proposal is not considered to be a key threatening process.

h) *Whether any threatened species, population or ecological community is at the limit of its known distribution.*

The Pale-headed Snake occurs from the Central Coast to northern Queensland. If this species occurred on the subject site it would be approaching the southern limit of its distribution.

The Pink-tailed Worm Lizard occurs in south-eastern Australia where it is known from two disjunct areas, the ACT and surrounding areas of NSW, and north central Victoria. This species, if present, will be at the northern limit of its distribution in the study area.

Conclusion

Neither species has been recorded in the study area and there are no records of these species in the locality. The vegetation on the subject site is of limited suitability for these species. It is unlikely that the proposal will place local populations of these species at risk of extinction.

Annex E

Survey AMG Co-Ordinates

Table E.1 Vegetation Quadrat Survey AMG Coordinates

Vegetation Quadrat	Easting	Northing
1	311161	6409653
2	311134	6409657
3	311021	6409387
4	311100	6409321
5	310961	6408994
6	311018	6408970
7	310826	6408648
8	310769	6408606
9	310727	6408225
10	310663	6408219
11	310827	6407817
12	310877	6407791
13	310643	6407637
14	310693	6407599
15	310730	6409585
16	310729	6409544
17	310797	6409531
18	310800	6409460
19	309205	6406264
20	309134	6406305
21	308791	6406067
22	308654	6406097
23	308875	6405959

1. Coordinate system = WGS 84

Annex F

Photographs

Photograph F.1 Narrow-leaved Ironbark/Grey Box Woodland (1)

Photograph F.2 Narrow-leaved Ironbark/Grey Box Woodland (2)

Photograph F.3 Narrow-leaved Ironbark/Grey Box Woodland (regrowth)

Photograph F.4 Narrow-leaved Ironbark/Kurrajong Woodland

Photograph F.5 Rough-barked Apple/Narrow-leaved Ironbark Woodland

Photograph F.6 Swamp Oak Woodland

Photograph F.7 Bulloak Woodland (regrowth)

Photograph F.8 Native Pasture 1

Photograph F.9   Native Pasture 2

Annex G

Vegetation Totals

Table G.1 - Existing Land Types in Year 0

All Areas in Hectares

Land Type	Subject Site	Study Area	HVO north of the Hunter River
REHABILITATED LAND			
Woodland (biodiversity)			
Woodland (grazing)			35.2
Grassland (grazing)			1228.4
Sub-total	**0.0**	**0.0**	**1263.6**
REGENERATED LAND			
Woodland (biodiversity)			
Woodland (grazing)	80.3	372.5	422.7
Grassland (grazing)	216.3	505.7	1415.4
Sub-total	**296.6**	**878.2**	**1838.1**
OTHER LAND TYPE			
Mine Disturbance	8.7	100.3	1872.8
Cropping Land			9.3
Sub-total	**8.7**	**100.3**	**1882.1**
TOTAL	**305.3**	**978.5**	**4983.8**

Table G.2 - Short Term Land Types in Year 10

All Areas in Hectares

Land Type	Subject Site	Study Area	HVO north of the Hunter River
REHABILITATED LAND			
Woodland (biodiversity)		3.9	258.9
Woodland (grazing)			448.0
Grassland (grazing)		9.7	1456.6
Sub-total	**0.0**	**13.6**	**2163.5**
REGENERATED LAND			
Woodland (biodiversity)	92.1	383.7	537.5
Woodland (grazing)	34.8	34.8	244.9
Grassland (grazing)	96.2	218.0	621.3
Sub-total	**223.1**	**636.5**	**1403.7**
OTHER LAND TYPE			
Mine Disturbance	82.2	328.4	1407.3
Cropping Land			9.3
Sub-total	**82.2**	**328.4**	**1416.6**
TOTAL	**305.3**	**978.5**	**4983.8**

Table G.3 - Mid Term Land Types in Year 20

All Areas in Hectares

Land Type	Subject Site	Study Area	HVO north of the Hunter River
REHABILITATED LAND			
Woodland (biodiversity)		4.6	499.3
Woodland (grazing)			533.5
Grassland (grazing)	19.0	74.1	1740.4
Sub-total	**19.0**	**78.7**	**2773.2**
REGENERATED LAND			
Woodland (biodiversity)	24.9	171.8	330.2
Woodland (grazing)	36.2	36.2	245.2
Grassland (grazing)		38.8	192.7
Sub-total	**61.1**	**246.8**	**768.1**
OTHER LAND TYPE			
Mine Disturbance	225.2	653.0	1433.2
Cropping Land			9.3
Sub-total	**225.2**	**653.0**	**1442.5**
TOTAL	**305.3**	**978.5**	**4983.8**

Table G.4 - Long Term Land Types in Year 30

All Areas in Hectares

Land Type	Subject Site	Study Area	HVO north of the Hunter River
REHABILITATED LAND			
Woodland (biodiversity)	41.0	97.6	822.3
Woodland (grazing)			533.7
Grassland (grazing)	196.9	615.3	2760.4
Sub-total	**237.9**	**712.9**	**4116.4**
REGENERATED LAND			
Woodland (biodiversity)	3.4	155.6	311.3
Woodland (grazing)			208.5
Grassland (grazing)		10.6	159.4
Sub-total	**3.4**	**166.2**	**679.2**
OTHER LAND TYPE			
Final Void	64.0	99.4	178.9
Cropping Land			9.3
Sub-total	**64.0**	**99.4**	**188.2**
TOTAL	**305.3**	**978.5**	**4983.8**

PART H

surface and groundwater management study

H

HUNTER VALLEY OPERATIONS
WEST PIT EXTENSION & MINOR MODIFICATIONS
SURFACE & GROUNDWATER MANAGEMENT STUDIES
SEPTEMBER 2003

prepared by ..

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SUMMARY OF FINDINGS

Coal and Allied is seeking consent to continue mining operations in the West Pit (formerly known as Howick) located in the north western part of Hunter Valley Operations (HVO). The continuation of mining provides for the extraction of 12 Million tonnes per annum (Mtpa) of ROM coal over a further period of 21 years to 2025. Extended mining will result in continued depressurisation of groundwater within the coal seams and the adjacent interburden as the pressure wave induced by pit deepening expands. Spoils will be progressively emplaced in the pits as mining progresses and re-saturation in the long term will affect groundwater quality in the voids. During mining, pit dewatering and runoff will also lead to changes in supply and demand on the existing mine water management system.

Detailed water management studies have been conducted for the extension of mining in order to address the identified issues. These studies have included an evaluation of the existing and proposed mine operations in respect of groundwater storage and seepage to current and future open pit operations. Studies have also included surface watershed assessments in relation to runoff, and mine water system modelling to assess future system response and management. Within the constraints and limitations imposed by the available database and analytical methods, the following conclusions can be drawn.

The hardrock coal measures aquifer system provides limited groundwater storage and transmission capacity. Interburden lithologies comprising sandstones, siltstones and shales are noted to possess extremely low permeabilities with groundwater transmission characteristics governed by the occurrence and frequency of jointing. Water quality in the coal seams is saline with dissolved salts concentrations ranging from less than 1300 to more than 7150 mg/l (2000 to +11000 uS/cm EC units).

Proposed continuation of mining will access seams within the Vane Subgroup on the easterly dipping but southerly plunging limb of the Muswellbrook anticline. As the pit progresses down dip, the zone of depressurisation within the coal measures will expand and continue to merge with depressurisation zones already established around neighbouring pits and mines including Hunter Valley North, Carrington and Cumnock underground and open cut.

A computer based aquifer model of the region has been developed in order to understand the many complex groundwater flow processes that will evolve during the pit deepening. Computer simulations demonstrate continued mining will maintain inward draining hydraulic sinks around the existing mine pits for a distance of up to 3.5 km from the pit highwall and end wall crests. Mine pit seam seepage is predicted to rise from a current rate of less than 0.1 ML/day to a rate of 0.54 ML/day by 2025 although the final seepage rate may be lower depending upon prevailing climate and the significant effect of evaporative losses in the deeper areas of the pit(s). The relatively low rate when compared to other mine pits in the region is attributed to the presence of low permeability strata and the influence of depressurisation from Cumnock underground dewatering in the Liddell seam(s) and other open cut operations.

There are no identified boreholes or groundwater users that are likely to be 'yield affected' within the predicted cone of depressurisation. Nearest privately owned groundwater abstraction bores are situated nearly 4 km to the south-west of the pit highwall crest within the alluvial lands on the western side of the Hunter River. Since the depressurisation zone does not extend beneath either the alluvial lands or Plashett Dam, these large water stores will also remain unaffected by continued mining.

If operations cease after the 21 years of mining water will accumulate and water levels will recover in the final void. A period of more than 100 years would be required for an equilibrated system to re-establish at about –30 mAHD based on groundwater seepage alone. The period will be reduced through contributions from final landform runoff. However water levels will never fully recover to pre-mining levels due to changed conditions within the coal measures where relatively permeable spoils have replaced impermeable intact coal measures. The elevation of the recovered water table

is predicted to be lower than 50 mAHD due to sustained evaporative losses from the void water surface.

Recovery of water levels will re-saturate approximately 320 million cubic metres of spoils and this process is predicted to remobilise salts released by the fragmentation of interburden during mining. An estimate of the final void water quality has been calculated from salt load estimates generated through leachate trials on interburden core. This predominantly sodium bicarbonate load has been calculated to range between 2.99 and 4.77 kg per cubic metre of saturated spoils or 97430 to 1547600 tonnes depending on the fragmentation characteristics. The lower limit of this range reflects coarse materials distribution achieved through optimal blast fragmentation of spoils while the upper limit reflects a significant fines content through less efficient blasting or increased jointing in interburden. The calculated load is considered to be an 'instantaneous' load assuming all salts are remobilised and no salts are removed from the system during the mine life.

Mixing of rainfall, leachate and coal measures groundwaters during the void recovery period will produce a water quality between sodium-calcium and chloride-bicarbonate end types tending towards sodium chloride in the long term. Void groundwater salinity is calculated to fall in the range 14550 to 29910 mg/l at the commencement of recovery and to rise steadily with evaporative concentration.

In respect of surface water, clean water runoff will continue to be segregated from mine water via the maintenance of contour drains, sedimentation dams and mine water dams. Continued mining will have some impact on local and regional watersheds. East of the pit, headwaters of Emu Creek and Farrells Creek catchments will be consumed while rehabilitated catchments on the western side of the mine pit will enhance runoff to Parnells Creek.

Continued mining to greater depths will attract slightly more groundwater and surface water into the mine water system than is currently managed. However water management simulation modelling indicates the likelihood of deficits in dry years and surpluses in wet years. Testing against 100 years of daily rainfall records indicates surpluses can be managed providing most HRSTS high and flood flow discharge opportunities arising in the future, are utilised. However only a limited number of discharges may need to be utilised if surplus water is directed to North Pit operations where a deficit is predicted for increased HVCPP throughput of 20 Mtpa. West Pit deficits can be met by drawing water from Liddell Colliery Dam 13 or water sharing with Hunter Valley North and Carrington pits.

An overview of the water balance for North Pit operations including HVCPP throughput of 20 Mtpa, supports the need water surpluses at West and South pits to be directed to North Pit. A continuing input from Dam 13 (Liddell Colliery) to West Pit and to the overall system, and input from the Hunter River at a variable rate of up to 1.5 ML/day may be required. At least 2000 ML of storage is recommended as staging capacity for the more extreme climatic conditions. Storage of this magnitude is available through a combination of existing dams at North Pit and storage within the rehabilitated Alluvials Pit (as subsurface spoils porosity) following cessation of mining.

In order to update knowledge and understanding in respect of surface/groundwater interactions, an expanded groundwater and surface monitoring programme is recommended throughout the remaining mine life. Existing groundwater monitoring bore locations around North Pit, Carrington, and Alluvials pits should be maintained and a number of additional bores constructed at locations around West Pit. Monitoring bores should also be constructed in spoils following reshaping to verify and validate water seepage and quality predictions. Surface water monitoring should continue for key pit sumps and dam storages throughout the operational areas. Monitoring data should continue to be retained in existing databases and data transferred at appropriate reporting intervals to DIPNR.

All data accumulated during the next 14 years should be reviewed and utilised in refining final void designs and close out strategies 5 to 7 years in advance of closure. A subsequent care and control period will be required for monitoring and analysis of void water level recovery in order to provide for implementation of appropriate strategies to mitigate impacts of void water salinity.

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Appendices

1. INTRODUCTION

Coal and Allied is seeking consent to continue mining operations in the West Pit (formerly known as Howick) located in the north western part of Hunter Valley Operations (HVO). The continuation of mining provides for the extraction of 12 Million tonnes per annum (Mtpa) of ROM coal over a further period of 21 years to 2025. Mining will continue within the existing pit(s) advancing south-eastward and down dip for a distance of about 1.4 kilometres beyond the present highwall crest. The north-east to south-west extent of the pit including West Pit North, West Pit South and Wilton Pit will remain at about 4.7 kilometres length with the three pit areas merging. Coal will be won from numerous seams, the pit floor being located at the base of the Barrett seam.

Mine pit development will result in continued depressurisation of all exposed coal seams and interburdens. Such depressurisation may lead to changed groundwater flow directions within the coal measures and the potential for increased leakage from surface drainages and water storages. Spoils will continue to be emplaced in the pit as mining progresses and re-saturation will change the long term ‘recovered’ pit water level and water quality. In addition to potential impacts arising from continued operations below the regional water table, the mine pit(s) will also affect local drainages as watershed areas are mined, back filled and rehabilitated. Mine water runoff and pit dewatering will also lead to changes in supply and demand on the existing mine water management system.

The Environmental Planning & Assessment Act requires the impact of mining on regional groundwater and surface water systems to be addressed. Potential areas of concern in relation to water management have been summarised by the Director General for Planning NSW, and are broadly identified as follows:

- assessments in relation to groundwater aquifers including predicted hydrogeologic and hydrochemical impacts during and post mining;
- assessments in relation to surface hydrology including existing watersheds, stored waters, changes to the local hydrology and management of runoff via diversions and storages;
- mine water management assessments including water storage and details of the locations and structures that may be used in the future for discharge of mine water as part of the Hunter River Salinity Trading Scheme (HRSTS);

In addition to the foregoing, Coal & Allied propose to consolidate the existing approvals for their Hunter Valley operations north of the Hunter River (granted over a long period of time) in order to more efficiently manage the overall operations within 3 active mining areas known as West Pit (including Wilton and Mitchell pits), Carrington and Alluvials. Accordingly, the impacts arising from this consolidation need to be reviewed.

Mackie Environmental Research was commissioned by Coal and Allied in 2003 to undertake water management studies for West Pit and to provide advice in respect of future measurement and monitoring of aquifer conditions, surface drainages and mine water management. The contained report provides results of those studies and includes groundwater and surface water hydrological data for the region, computer simulations of aquifer systems, assessment of impacts on aquifers and drainages, and detailed analysis of the mine water management systems. Appraisal of impacts of consolidated operations is also included.

2. HISTORY OF MINING IN THE AREA

Coal and Allied conduct mining operations in a number of areas in proximity to the West Pit. These include the final stage of North Pit known as the Alluvials Pit, and Carrington Pit. In addition, Cumnock Colliery has conducted underground and open cut operations in an area immediately to the north as indicated on Figures 1 and 2. Situated further to the east is the open cut operation of Narama mine.

Mining in the West Pit area (formerly known as Howick Mine) has been conducted since 1952. During this time, coal has been progressively extracted through the development of a number of open cut pits, the most recent being three pits – West Pit North situated north of the central ramp, West Pit South situated south of the central ramp, and Wilton Pit located further to the south-west. All pits extract coal from the lowermost Barrett seam to the uppermost Bayswater seam although some coal has also been won from the Broonie seam where it subcrops. Production is currently between 5 and 6 Mtpa ROM. Coal is processed through the West Pit Coal Preparation Plant (WPCPP – formerly known as the Howick washery) at a rate of about 3.1 Mtpa ROM and product is loaded through the Newdell load out facility (NCPP). The remaining ROM is processed through the Hunter Valley Coal Preparation Plant (HVCPP) where product is transported by conveyor northwards to the Hunter Valley Loading Point (HVLP) located about 1km south-east of the NCPP. To-date there have been no significant difficulties or impediments to the mining operation in respect of pit groundwater seepage or surface water management.

Mining within Alluvials Pit is the last stage of open cut operations within the North Pit area (formerly known as Hunter Valley No.1 mine) which commenced operations in 1979. Coal is won from three seams including the lowermost Vaux seam, the overlying Piercefield seam and the uppermost Mt. Arthur seam. Production is currently about 4.2 Mtpa ROM and all coal is processed through the HVCPP. The alluvial lands mining stage is located adjacent to the Hunter River and commenced in 1996 after construction of a bentonite barrier wall along the entire reach of the river. This wall was designed to prevent seepage from the river alluvium to the mine pit and over the course of mining, it has performed to design expectations. To-date there have been no significant difficulties or impediments to the mining operation in respect of pit groundwater seepage or surface water management.

Mining within Carrington Pit commenced in 2001. Coal in this area is won from two seams – the Bayswater seam (floor seam) and the shallower Broonie seam which are located beneath an ancient palaeo-channel associated with the Hunter River. Production from Carrington Pit is currently about 6Mtpa ROM and all coal is processed through either the WPCPP or HVCPP. Since operations are a significant distance from the river and the palaeo-channel materials are relatively less permeable than the alluvial lands of North Pit, there has been no need to-date, to install a barrier wall to prevent seepage from the Hunter River. There have been no significant difficulties or impediments to the mining operation in respect of pit groundwater seepage or surface water management.

In addition to Coal & Allied operations, mining at the adjacent Cumnock underground has been undertaken since 1951. Coal is sourced from the Liddell and Arties seams (known as the Pikes Gully seam at Cumnock). Underground operations in the Liddell seam will cease in 2003. Open cut mining was introduced in 1992 with Stage 1 and Stage 2 pit developments being completed in the northern part of the Cumnock lease. Stage 3 immediately north-east of West Pit, is currently being developed with extraction of coal from the southern part of the lease. These three open cut pits directly overly the underground operations.

3. REGIONAL SETTING

In a regional context, the area comprises undulating hills and grasslands with the overall physiography influenced by regional geological structure and differential weathering of the underlying rock strata.

3.1 Rainfall and recharge

The climate is temperate and is influenced by both coastal weather patterns and conditions within the Upper Hunter region generally. Rainfall averages about 603mm per annum as measured at Jerrys Plains.

Rainfall infiltration and recharge to the shallow groundwater systems contained within the regolith is variable but higher than recharge to the underlying coal measures. The regolith acts as a temporary water store during sustained wet periods and provides a source for recharge to the underlying coal measures. Recharge to the coal measures is inferred to be very low to negligible based upon measured hydraulic conductivities of different strata and observed water level movements in monitoring bores throughout the region. Rainfall recharge to alluvial lands is known to be high and of the order of 15% or more of annual rainfall.

A number of periods during the last decade have witnessed below average annual rainfalls with moderately dry years occurring from 1994 to 1997 and exceptionally dry conditions occurring throughout 2002-2003. The pattern of rainfall during these years has not been conducive to significant recharge and has resulted in regional water table declines in the shallow regolith and in some parts of the alluvial aquifer systems associated with the Hunter River and other major drainages. These dry years have also proven to be beneficial to many mining operations with significant reductions in water management issues.

3.2 Drainage and runoff

West Pit is situated at the headwaters of numerous creeks that drain in all directions away from the mine site. These creeks include Parnells Creek draining southwards to the Hunter River, Farrells Creek draining eastward then southward to the Hunter River, Emu, Davis and Pikes creeks that flow eastward into Bayswater Creek then southward to the river, and several un-named drainages that flow westward into Plashett Dam which is situated in Saltwater Creek catchment. Figures 1 and 2 show these drainages which are all ephemeral.

Mine development over the last 15 to 20 years has mostly impacted Parnells Creek catchment but in future years will consume the headwater areas of Farrells and Emu creeks.

3.3 Geology

Regional geology is summarised on the published 1:100,000 Geological Map (Dept. Mineral Resources) and described by Beckett (1988).

West Pit, North Pit and the Alluvials Pit currently conduct open cut operations predominantly in the Vane Subgroup and the lower part of the Jerrys Plains Subgroup within the Wittingham Coal Measures. Locally, these coal measures comprise south-easterly dipping seams and interburden located on the southward plunging eastern limb of the Muswellbrook Anticline.

Exploited coal seams at West Pit include (from deep to shallow), the Barrett, Liddell, Arties, Pikes Gully, Lemington, and Bayswater seams as identified in the stratigraphic summary on Figure 3. Minor occurrences of the Broonie seam are also exploited. Seams mined at Carrington include the Bayswater and Broonie while at Hunter Valley North, the Vaux, Piercefield and Mt. Arthur seams are mined. This succession of coal and interburden was deposited during the Permian period (+250 million years ago) under conditions ranging from lower deltaic to upper deltaic (Beckett,

1988) and including inter-distributary bay regimes, overbank and swamp environments, and emerging beach conditions. Upper deltaic conditions were more prevalent following deposition of the Vaux seam and were sustained until deposition of the Glen Munro seam (not present in the area) at a time when marine incursions were again more prevalent. These depositional environments have resulted in an interburden stratigraphy comprising well cemented sandstones, siltstones and shales with relatively low to negligible hydraulic conductivity (permeability) and variable salts content.

3.3.1 Structural features

Regional east-west compression of the coal measures has resulted in the development of a number of structural features. Most significant in a hydrogeological context is the occurrence of the Muswellbrook anticline, the axis of which is located immediately west of West Pit. The anticline plunges to the south thereby imparting the regional south-easterly to southerly dip of about 5^o in the strata located on the eastern limb.

The proximity of the anticline axis to the west of West Pit together with the rising axis northward has resulted in exposure of the underlying Saltwater Creek Formation and the deeper Mulbring Siltstone around Plashett Dam and further north. The latter provides a thick and relatively impermeable succession of siltstones and claystones that probably serves to isolate groundwater movement from the Jerrys Plains Group coal measures, towards Plashett Dam and the surrounding catchment of Saltwater Creek.

Several faults have been encountered in West Pit. These are normal faults that strike in a south-easterly direction and offset strata by up to 20m. The mapped extents are indicated on Figure 4. This general south-east strike on faults is also evident in Carrington and North pits. Significant regional faults include the Hunter Valley Cross Fault to the south and the Davis Creek fault to the east. The latter demarks the eastern limit of underground mining operations in the Liddell seam at Cumnock underground. Where faults significantly offset strata, they may act as barriers to groundwater flow.

A number of dykes are noted throughout the area and have been encountered in most pit operations. The most significant dyke extends from North Pit in a north-easterly direction through the Ravensworth West area and is known locally as the Hunter Valley Dyke. Dykes are generally known to act as barriers to groundwater flow.

Jointing has not been extensively mapped but is generally infrequent in the more massive sandstones with spacing greater than 1 or 2 metres. Thinly bedded strata exhibit increased joint frequency as expected. Jointing at shallow depths is observed to facilitate groundwater transmission especially following periods of extended rainfall. Jointing is also observed to be associated with the faults.

3.4 Existing bores and wells in the region

Department of Infrastructure Planning and Natural Resources (DIPNR – formerly Dept. Land and Water Conservation) retain a database of registered bores and wells in NSW. This database includes both exploration/test wells which may not have been completed as permanent structures, observation/monitoring bores and privately owned bores and wells currently in use or abandoned.

Figure 5 identifies bore/well locations registered on the DIPNR database and situated within five kilometers of mining operations together with temporary observation piezometers (Carrington). Both observation and pumping (abstraction) locations are shown. Bores within a few kilometers of West Pit are owned and maintained by Coal & Allied for the purpose of monitoring groundwater levels in the vicinity of Carrington or Alluvials pits. Nearest privately owned bores or wells are located in the alluvial lands adjacent to the Hunter River near Jerrys Plains road. These are generally more than 4 kilometres from the pit highwall crest with most bores situated on the western side of the river and beyond the direct influence of mining.

4. GROUNDWATER HYDROLOGY

4.1 Aquifer systems

The Upper Hunter Region hosts three recognised types of aquifer systems – the coal measures, the shallow weathered zone or regolith, and the alluvial deposits adjacent to major drainages like the Hunter River.

The main aquifer systems in the area around West Pit include the low permeability coal measures often referred to as aquitards, and parts of the overlying weathered zone/regolith. Due to the relatively low order drainages in the area (1^{st} and 2^{nd} order), valley infill deposits comprising colluvial and alluvial materials are fairly limited. As such, valley infill deposits do not constitute a significant aquifer resource in the area. Further to the west, south and south-east occur alluvial deposits associated with the Hunter River and the Carrington palaeo-channel. Groundwater contained within the alluvial lands associated with the Hunter River is recognized as a significant resource while groundwater contained within the palaeo-channel is not, due to the relatively high salinity in that area.

Water tables in the low permeability coal measures aquifers/aquitards are sustained by rainfall percolation at a generally low rate with estimates of rainfall recharge varying from zero to no more than 2% of annual rainfall based upon previous studies in the region. In contrast, the alluvial lands are recharged at much higher rates through infiltration of rainfall, downwards percolation of runoff, and lateral seepage from the river via extensive sand deposits. An exception is noted for the Carrington area paleo-channel deposits where the unconsolidated deposits are capped by several metres of impermeable clay. Historical monitoring in this area has indicated stable groundwater levels with negligible response to rainfall recharge (MER, 1999).

4.2 Groundwater piezometric surface

The groundwater pressure distribution within coal measures in the vicinity of West Pit has changed since mining commenced in 1952. Originally the regional piezometric surface undoubtedly reflected topography with elevated water levels/pressures in the area of mining and hydraulic gradients established towards the major drainages including Saltwater Creek to the west and north-west, Bayswater Creek to the east and the Hunter River to the south and south-west.

Pit development has now created a groundwater sink around the mine site. This depressurisation has been maintained essentially at the crest of a groundwater/drainage divide and has therefore had relatively little impact regionally. Underground operations at Cumnock have also induced depressurisation of the Liddell and Arties seams and overlying strata. Such depressurisation has undoubdetdly merged with depressurisation around West Pit (northern end) to create a wider zone which has probably reduced groundwater seepage into both West Pit and Cumnock open cut. However, since groundwater observation piezometers are not established in the area, actual pressures cannot be determined. The approximate geometry of the water table can therefore only be estimated by interpolation of known levels in other areas and consideration of the recharge and groundwater migration processes occurring within the coal measures.

Coal and Allied currently maintains a network of observation piezometers within and around the Carrington and Hunter Valley North pits. Regional piezometric data is also available from past studies. In particular MER (1997) provides a piezometric surface for the area between West Pit and Ravensworth-Narama operations as measured in 1997 while HLA (2001) provides more recent measurements in the same area.

In order to generate a regional piezometric surface with the limited availability of water level measurements, a ‘probable’ pressure distribution has been generated by utilising the above noted data in addition to aquifer modelling methodologies (see Section 5) with regionally distributed rainfall, river bed elevations and the current mine pit development. Figure 6 provides an estimate of the surface in the shallow interburden zone. Reference to this plot shows groundwater sinks around West Pit, North Pit (Alluvials), Carrington Pit and Cumnock underground. Elevated pressures (+60 mAHD) are noted beyond West Pit. Flow paths are indicated by the arrows on Figure 6.

Depressurisation within low permeability strata associated with the Saltwater Creek Formation and the Mulbring Siltstone to the west and north-west, is assumed to be minor.

4.3 Coal measures hydraulic properties

Hydraulic properties for specific coal seams have not been measured within the immediate area of interest for extended mining. However testing has been conducted in adjacent areas over a number of years and this data has been used to develop an understanding of the likely bulk permeability of coal measures. The following Table 1 provides a summary of measured seam permeabilities. Further details are provided in Appendix C.

Table 1: Coal measures hydraulic conductivity estimates

Strata	K (m/day)
Pikes Gully seam	2.70E-02
Arties seam	2.60E-01
Liddell seam	5.70E-02
Barrett seam	4.19E-02
sandstone	3.00E-05
siltstone	2.00E-06
shale	1.00E-07

K = horizontal permeability

4.4 Coal measures water quality

Data relating to coal measures water quality at West Pit is sparse. Some data has been sourced from the current sampling/monitoring regime. This data reflects a composite of pit water and rainfall runoff (sampling at Parnells Dam) with increased salinity during dry and drought periods and decreased salinity during wet periods. Older data relating to Howick Open Cut before West Pit was developed has also been sourced (Elliot, 1987) and is summarised in Appendix D. In general most data reflects a poor quality saline water in coal measures that has no identifiable beneficial use. Established water quality guideline data are summarised in the following Table 2 together with typical mine water and groundwaters sampled in the region.

Salinity data (Appendix D) for dams and borehole locations are shown on Figure 7. Since the data is both discrete (boreholes at specific seam depths) and composite (dam water) it is not feasible to develop a representative salinity distribution. Reference to this figure indicates a range in salinity for coal measures piezometers from less than 2000 to more than 11000 uS/cm with salinities above 3000 uS/cm dominating. Surface water sampling at Parnells Dam which is most representative of mine water, ranges from 2400 to more than 6300 us/cm.

Table 2: Generalised water quality criteria and comparison with pit waters

TDS (mg/L)	Equivalent EC (uS/cm)	Beneficial use
1000 [1]	1540	acceptable taste limit for humans
1500	2300	general upper limit based on taste
1300 [2]	2000	approx. limit for lucerne on alluvial lands
3000 [2]	4600	limit for poultry and pasture/fodder
4000 [2]	6100	limit for dairy cattle
32500	50000	sea water
2387	3673	*typical Parnells Creek Dam*
2036	3133	*typical Dam 15N (HV North)*
393	605	*typical Emu Creek Dam 12W*
5110	7860	*average groundwater from Elliot (1987) data*

Source: 1=ADWG - 1996, 2=ANZECC, 2000

Speciated groundwater is shown on the tri-linear plot (Figure 8). This representation facilitates classing of the water types. Ionic speciation for major cations and anions indicates a classing of waters where sodium chloride or primary salinity dominates in the hardrock areas to the south east around Carrington while historical sampling around the old Howick pit(s) indicates a trend between sodium bicarbonate and sodium chloride with increased sulphates probably attributable to the lower deltaic depositional environment of deeper seams.

pH values ranging from 7 to 8.5 are also consistently recorded at sampling locations. The high pH reflects an environment offering significant buffering (mitigating acid generation) as is observed in most mining areas of the Upper Hunter region.

5. PREDICTION OF GROUNDWATER IMPACTS

Continued mining of coal seams will expand the depressurisation surface around the current pit. The extent to which depressurisation will become more ‘regionalised’ depends upon a number of factors including aquifer/aquitard hydraulic properties, variation in stratigraphy, structural features including dykes and faults, and recharge sources. The spatial distribution and interaction of these various components cannot be evaluated using simple mathematical (analytical) expressions. Rather, computer based numerical modelling which permits the introduction of spatial and temporal variability, must be employed.

An aquifer model of the region has been developed in order to assess the likely impacts arising from continued mining. The model employs a finite difference scheme (ModFlow) for solving a set of differential equations known to govern groundwater flow. The simulation method requires dividing the overall area of interest into rectangular cells or blocks with the number of cells in the model grid being determined by the general juxtaposition of existing and proposed mining operations, and the expected hydraulic gradients developed in the course of mining.

The simulation model is a simplified representation of the aquifers. The extent of the regional model is indicated in Appendix E on Figure E1 and includes the nearby Cumnock operations, Carrington and North Pit (Alluvials). The model is a variably saturated scheme and comprises three transversely anisotropic layers with 54960 cells per layer. Total modelled area is 201sq. km with cell areas varying from 1 ha (100 m x 100 m) to 0.25 ha (50 m x 50 m). Cells have been designed to represent both West Pit and HVO north of the river, Plashett and Liddell dams, the Hunter River and regional drainages together with the alluvial aquifers and the regional coal measures. Three layers have been adopted for simplicity since a large part of the area to the north comprises the deeper Saltwater Creek Formation and the relatively impermeable Mulbring Siltstone.

Model layers, stratigraphy and assigned permeability values are provided in the following Table 3. Horizontal permeabilities (hydraulic conductivities) have been calculated as the harmonic means of known seam values and interburden estimates provided in Appendix C. Vertical permeabilities have been assigned at one tenth the horizontal value although in many instances this could be much lower due to the frequently observed presence of siltstones, claystones and laminites. Use of a 10:1 ratio also supports conservative (high) estimates of depressurisations since calculation of transverse anisotropy based on laboratory measured core conductivities suggests the ratio is nearer 1000:1.

Table 3: Model layer-stratigraphy and assigned conductivity

Layer	Stratigraphic boundary zones	Horizontal K (m/day)
1	arbitrary division of coal measures + alluvium	6.0E-03 (alluv = 1E+01)
2	base of Vane Subgroup	6.0E-03
3	Saltwater Creek Formation + Mulbring siltstone	1.0E-07

K = permeability

5.1 Model properties and initial conditions

Properties assigned to the model include hydraulic conductivity (permeability), storativity and porosity. As noted above initial conductivity values were adopted from consolidated values determined from interburden core tests and historical packer test results for different seams (Appendix C). All conductivities have been assigned constant within each layer.

River type cells have been assigned to the Hunter River as this drainage maintains some flow at all times. Bed elevations have been calculated for separate reaches based on limited survey data. River type cells have also been adopted for Plashett Dam and Lake Liddell. Drainage type cells have been located over regional ephemeral creeks with bed elevations estimated from the 5m digital terrain model or 1:25000 topographic maps with a uniform negative adjustment of 4m to account for localised drainage profiles or root zone extinction. Rainfall recharge has been applied at an average rate of 3 mm/year in coal measures equivalent to about 0.5% of annual rainfall. A much higher rate of 90 mm/year has been assigned to alluvial lands (14% of annual rainfall).

5.2 Open cut depressurisation

The aquifer model has been used to simulate past and future depressurisation of the coal measures. The commencement of simulations (penetration of the shallow water table) is 1980. Thus the model has been run for a period of 24 years before planned commencement of extended mining in 2004. This procedure has been adopted in order to generate estimates of seepage and formation depressurisation to the present time. Simulations have then been conducted for a further period of 21 years (to 2025) to generate estimates of aquifer depressurisation and pit seepage over the proposed mine life. North Pit (Alluvials), Carrington Pit and Cumnock have each been simulated in a similar manner with 1 year of mine life remaining in the alluvial lands, about 8 years life remaining at Carrington. The proposed Mitchell Pit has not been included in the model.

Pressure/drawdown distributions have been determined at 2003 (current), 2009, 2014, 2019, and the end of 2025. Simulated mining has been scheduled by assigning seam floor elevations to pit cells in accordance with planning data supplied by Coal & Allied. The resulting pressure distributions have then been computed for all model layers.

Figure 9 shows the simulated aquifer pressures for an initial condition representing mine development in 2003/4 and a final condition at the end of 2025 (left plot). Differential pressures or drawdowns since 1980 are also plotted (right plot). Appendix E provides model responses at the alternate times indicated above. Both Figure 9 and Appendix E illustrate a current depressurisation surface that extends about 1.5 km from West Pit and may connect with the depressurisation surface now emerging from Carrington Pit although piezometers near Carrington suggest minimal impact from West Pit at the present time. This surface is observed to gradually expand outwards as mining is conducted at increased pit depths down dip, merging with depressurisations from Carrington, Hunter Valley North and Cumnock to create a cumulative pressure loss, regionally. The surface expands in a westward and south-westward direction with model results suggesting potentially a 1 metre pressure loss near the Hunter River. While the model predicts this scenario, it is improbable since the area between West Pit and the river hosts westerly dipping strata on the western limb of the Muswellbrook Anticline. These strata are effectively rotated so that pressure losses would need to migrate across relatively impermeable strata rather than within strata. A subdued response is noted in a northward direction, this being attributed to the presence of impermeable strata associated with the Mulbring Siltstone.

Figure 10 shows the calculated pit seepage rates over the mine life. Present seepage rates attributed to depressurisation of the coal measures (2003) are estimated to be of the order of 0.35 ML/day. However since the pit wall and floor exposure is expansive, most seepage is lost to evaporation (average rate of 4 mm/day) leaving less than 0.1 ML/day to enter the pit. Long term seepage is expected to rise to an estimated 0.54 ML/day at the completion of mining before evaporative losses accrue. The adjusted seepage entering the mine water system after evaporation, is estimated to remain less than 0.3 ML/day by the end of mining in 2025. However this will depend to some extent upon prevailing climate since periods of sustained rainfall can contribute significant volumes directly to the pit or through spoils infiltration or as seepage from the shallow regolith.

5.3 Mine pit groundwater quality

The quality of groundwater entering the mine pits will continue to reflect an average of water quality for the coal measures spoils (toe seepage and runoff), and contributions from the surrounding coal measures. The quality is expected to remain in the range 2400 to 6300 uS/cm as measured at Parnells Creek Dam. Future ionic speciation is expected to be similar since interburden is similar.

All pit water will remain within the mine water system as a result of the now developed inward flow regime or groundwater sink which is predicted to prevail at all times - mine water will not migrate beyond the pit area.

5.4 Recovery of aquifer pressures post mining

Following cessation of mining, regional water levels/pressures will recover. The rate of recovery will depend upon the remaining water held in storage within the coal measures, the hydraulic properties of spoils, rainfall recharge through spoils and runoff entering the final void.

An estimate of the rate of recovery of pressures has been made using the aquifer simulation model with the pressure distribution defined in Figure 9 at completion of mining (2025/2026) as the initial condition for recovery. Spoils emplaced within the pit shell will exhibit different properties to the intact coal measures. A conductivity of 1m/day and a consolidated drainable porosity of 20% have been applied to the emplaced spoils. In addition, contributions via spoils infiltration and percolation have been assigned a rate of 50 mm/year (8.3% of annual rainfall) or approximately half that of the relatively flat lying alluvial lands.

Simulation output is provided on Figure 11 for 50 and 100 years post mining. Water level distributions show a recovery elevation of only –30 mAHD after 100 years based on groundwater seepage and spoils percolation.

Rainfall and runoff contributions to the void have also been calculated from the final landform shown on Figure 12. In order to estimate an average annual runoff, 100 years of daily rainfall data have been processed via a runoff simulation model. The model incorporates soil-spoils interception, infiltration and percolation in estimating the runoff from a void scenario comprising 497 ha of contributing catchment (rehabilitated spoils and pit walls). These boundary conditions lead to an estimate of about 580 ML per annum from the catchment. Allowing for this contribution to the void and simultaneously considering evaporative losses, the period for equilibration of a void water levels is estimated to be nearer 200 years with an equilibrated level below 50 mAHD. This level is below the regional water table and is therefore expected to maintain the void as an evaporative sink.

5.5 Final void groundwater quality

The hydrochemistry of recovering groundwater within the void will reflect contributions from coal measures seepage, contributions from spoils seepage and contributions from rainfall runoff entering the void as noted above.

Void water is expected to remain largely isolated from the regional coal measures and surficial aquifers through the maintenance of inward hydraulic gradients during the recovery process and an evaporative sink condition that will continue to attract groundwater flow to the void (at a low rate) in the long term.

Estimates of the overall total dissolved solids and ionic speciation characteristics of void water have been made using recently developed methodologies. Representative core samples obtained from exploration hole EL5243B situated within the area of planned mining, have been subjected to leach trials to ascertain the likely long term characteristics of groundwater within emplaced spoils. Trials comprised crushing of core, sieving to smaller and more uniform grain size fractions followed by leaching for 3 months before samples were dispatched for laboratory analyses of major ions. This procedure facilitates reconstruction of fragmentation distributions and improved estimation of leachable salt load. Appendix F summarizes methodologies and calculations.

An average leachable and mobilisable load has been determined for two limiting spoils fragmentation distributions. A total load mobilisable salt of between 2.99 and 4.77 kg per cubic metre of spoils has been determined based on projection of leachate trials to 100 years. An estimate of the void water quality has been made by assuming this salt mobilisation rate will prevail throughout all spoils (including those presently emplaced) which re-saturate during the recovery period. As noted, a final void recovery level is predicted to remain below 50 mAHD (+100 years post mining). This will result in about 320 million cubic metres of spoils being re-saturated. If a final emplacement bulk porosity of 20% is assumed, then the calculated mobilisable salt load is estimated to lie between 974300 and 1547600 tonnes (Appendix F). Using a mass balance approach and mixing this load with open void water derived from rainfall runoff and coal measures seepage water, leads to an ‘instantaneous’ void/spoils water quality in the range 14550 to 22910 mg/l.

In reality, the salt load will be generated over the full recovery time frame of more than 100 years. Hence the load is likely to vary - evaporative concentration or dilution from rainfall within the final voids will govern the long term salinity but since an evaporative sink is the most likely pit closure scenario, void water can be expected to exhibit a steady increase in dissolved salts.

Speciation analyses of leachate samples (Appendix F) indicates the overall quality of void groundwater will tend towards a sodium bicarbonate water rather than a chloride or primary salinity type groundwater. A pH in the range 7.5 to 8.5 is predicted to prevail.

6. SURFACE WATER HYDROLOGY

Current operations at West Pit occur within a number of catchments that are affected by mining operations. These include Davis, Emu and Farrells creeks on the east side of the pit and Parnells Creek to the south of Wilton Pit. All are ephemeral and first or second order as identified from 1:25000 topographic map. Upper reaches of the creeks and catchments often transgress outcrop while lower lying areas exhibit bank and rill erosion in places.

During the planned 21 years of mining, further catchment will be consumed east of the mine pit mainly within the catchments of Emu and Farrells creeks. Those catchments situated on the western side of the pit and beyond rehabilitated areas will remain unaffected by continued mining. Rehabilitated areas will however progressively contribute to runoff in Parnells and Davis creeks. The following Table 4 provides a summary of impact on drainage catchments at 2003, 2017 and 2025 while Appendix G Figures G1 to G3 show the changing catchments over the mine life.

Runoff to Davis Creek will be impacted during development of Cumnock Stage 3 open cut operations. However most will be reinstated during the course of continued mining at West Pit.

No creek diversions are planned. However a few sedimentation dams will be relocated on the upper reaches of the eastward draining creeks between years 5 and 10 of the continued mining period. Sedimentation dams will also be constructed adjacent to the Belt Road if/when this road is utilised for haulage. These sedimentation dams will be constructed in accordance with design criteria provided in Housing NSW, 1988.

Table 4: Impact of continued mining on surface drainages

	Watershed	Undisturbed (ha)	Rehab (ha)	Total (ha)	change %	Comment
2003	Davis Creek	1088	68	1156	0	Cumnock Stg.3 not included
	Emu Creek	912	0	912	0	
	Farrels Creek	886	0	886	0	
	Parnells Creek	78+163+902	53+65	1261	0	
2017	Davis Creek	1071	306	1377	+19.1	Cumnock Stg.3 completed
	Emu Creek	715	0	715	-21.6	
	Farrels Creek	677	0	677	-23.5	
	Parnells Creek	78+163+902	67+186	1396	+10.7	
2025	Davis Creek	1329	107	1436	+24.2	Part may be directed to Emu Ck
	Emu Creek	714	90	804	-11.8	
	Farrels Creek	617	65	682	-23.0	
	Parnells Creek	78+163+902	104+152	1399	+10.9	

Percent change relative to current catchment areas

Typical water salinities expressed as electrical conductivities in the drainages are monitored semi regularly and are indicated in the following Table 5. Salinity ranges are characteristic of many of the drainages in the Upper Hunter Region, falling to very low levels during periods of sustained runoff and rising to high levels as runoff decreases. Emu Creek is an exception due partly to the monitoring location at Emu Creek Dam (headwaters area).

Table 5: Average water quality parameters in local drainages

Catchment	pH	EC – uS/cm
Davis Creek*	7.7 to 8.4	767 to +8000
Emu Creek	7.5 to 8.8	365 to +1000
Farrells Creek	7.0 to 9.2	195 to +12000

* source Cumnock EIS, 2001

7. MINE WATER MANAGEMENT

Future water management at West Pit will utilise the existing water management system with minor changes and provisions for water sharing across all operations. The main goals of the mine water management system include:

- diversion of natural catchment runoff around the mine site where practically feasible
- capture and storage of pit seepage and disturbed area runoff in order to maintain site workability
- efficient usage of stored water for process water supply in the coal preparation plant (WPCPP)
- watering for dust minimisation on haul roads, trafficable areas and stock piles
- minimisation of river make up water during dry and drought periods
- maximisation of surplus water utilisation and re-cycling across all operations.

7.1 Water management system description

Since mining commenced, the water management system has operated with both a deficit and a surplus in supply depending upon the prevailing climatic conditions. Any deficit in supply has been met by drawing water from Dam 13 at Liddell Colliery while surpluses have been generally contained on site or discharged from Parnells Creek Dam via the Hunter River Salinity Trading Scheme (HRSTS).

Figure 13 shows catchments contributing to the system in 2003 with the various areas and water storage dams identified. Figure 14 provides a simplified schematic giving an overview of the mine (dirty) water system with catchments identified on Figure 13 being assigned to specific storages. In addition, Figure G5 (Appendix G) shows the current mine plan with topography and main water management elements including dams, contour drains, local drainages diversion and pipelines.

Operation of the system provides for the following:

- Rainfall runoff on the western side of the main haul road (west of the pit) is either diverted off site or managed within the mine water system. A 4.7 km long contour drain system diverts runoff from undisturbed catchment lying above the drain (UD3 on Figure 13), in a south westerly direction into Parnells Creek. The drain also partly conveys runoff from the undisturbed catchment UD1 into Dam 18W. This dam can either direct water into Parnells Dam or divert the water around the western side of the Parnells Dam into Parnells Creek.

- Runoff below the 4.7 km long contour drain is managed in a number of ways. Runoff from catchment UD2 migrates to the south-east into Dam 3W from where it can be pumped back to the contour drain. Runoff from the hardstand area HS1 (plant + facilities) is directed to Dam 4W. Surplus can then be pumped to Dam 2W. Runoff within tailings dams TD1 and TD2 (Bobs Dump Tailings Dam) is contained within those dams and mixes with the supernatant tailings bleed water which is then pumped back to the coal washery (HWCPP) for re-use.

- Runoff from rehabilitated areas immediately east of the main haul road is mostly diverted off site. Runoff from RH1a enters the low lying sump area known as Dam 6W. Runoff from RH1b is managed through contour banks and drains to a diversion drain located adjacent to the haul road. This drain conveys runoff to a culvert at the southern end of the drain where it is conveyed beneath the haul road and along another rock lined channel to Dam 18W. Runoff from catchment RH2 is managed through contour banks and drains to a diversion drain located at the base of the rehabilitated area. This channel conveys runoff to a sump immediately north-east of Dam 5W then through a culvert under the road to Dam 4W. Runoff from RH3 in the south-west is managed through contour banks and drains to a diversion drain located at the base of the rehabilitated area which conveys runoff to a culvert opposite Parnells Creek Dam. This runoff is then diverted around the southern side of the dam into Parnells Creek. Rehabilitated areas further north (RH4, RH5, RH6) discharge into the headwaters of Davis Creek via a sedimentation dam.
- Rainfall runoff on lands east of the pit highwall flows away from the mine workings into the natural drainages of Davis Creek, Emu Creek and Farrells Creek.
- Rainfall runoff over the remainder of the area is generated from shaped spoils (SS1, SS2, SS3), unshaped spoils (US1, US2, US3, US4) and pit strip and bench areas (SB1, SB2, SB3). All runoff and percolation through spoils migrates to sumps situated in West Pit North, West Pit South and Wilton Pit, and is contained within the mine water system.
- West Pit North mine water is either pumped eastward to Dam 15W then from Dam 15W to Dam 2W or westward to Dam 4W. West Pit South mine water is pumped up the centre or southern ramps into a common main (pipeline) located immediately west of the rehabilitated areas and adjacent to the haul road. This common pipeline then conveys the pit water to Dam 4W. Wilton Pit water is pumped up the pit ramp into Parnells Dam.
- Dam 4W water may be pumped to Dam 2W or to Parnells Dam where a large capacity of about 750 ML is available. Parnells Dam water may in turn be pumped to WPCPP or Dam 2W.
- WPCPP pumps water from Dam 2W or from the tailings decant water. If additional water is required in the system during dry or drought periods, it may be pumped from Dam 13 located at Liddell Colliery into Dam 2W. Dam 13 is normally maintained in a near full state and is supplied from water pumped from the old Liddell underground workings.
- Surplus mine water may be discharged from Parnells Dam via the Hunter River Salinity Trading Scheme (HRSTS). The dam has a licensed discharge capacity of 130 ML/day.

In addition to the above and in order to maximise recycling, water may be transferred in the future between West Pit and Hunter Valley North operations via a pipeline connecting Dam 9N (Carrington) and the southern end of the common main (near Parnells Dam) noted above.

7.2 Mine site water balance

The mine water balance is a representation of all inflows, ouflows and changes in storage for the water management system. It provides an understanding of the need for storage and the impacts of seasonal and climate change. In the current study, a computer based simulation model has been used to assess the dynamics of the system under conditions of varying rainfall and groundwater seepage rather than a simple wet and dry year water balance. The adopted approach provides a probabilistic outcome and is considered more accurate than a simple balance type model as the latter cannot easily address varying catchment areas, varying groundwater seepage or rainfall runoff accumulations over an extended period of time. A simple balance is however provided as a means of overviewing the West Pit, HV North and HV South water balance (see Section 7.2.4).

The model develops a daily water balance for West Pit for wide ranging climatic conditions by utilising historical rainfall and evaporation records to generate catchment runoff estimates. It also provides for pumping and accumulation of mine water, transfer of mine water between dams, losses related to WPCPP, dust suppression etc. and discharges to the Hunter River in compliance with the HRSTS if required. Appendix G gives a summary of the main components of the water management simulation model.

7.2.1 WPCPP, dust suppression and other water usage rates

System water usage can be attributed to two areas – the washery (WPCPP) and dust suppression including haul roads, other roadways and stockpile areas. Estimates of these usage rates have been either calculated indirectly or determined from monitoring data.

The increase in moisture content from ROM to product and waste represents the major component of mine water usage. Losses on a 'per tonne' (ROM) basis have been estimated by calculating the mass balance for WPCPP operations. Table 6 provides a balance for a production rate of 4.5 Mtpa (ROM) with tailings being pumped at about 1.16 SG and having an initial 46% residual moisture content following beaching, supernatant bleed and percolation to spoils. Results of the balance indicate an average make up water requirement of about 145 litres per tonne of processed ROM. This estimate is expected to vary seasonally with higher (evaporative) losses in mid summer and lower losses in mid winter.

Table 6: WPCPP water loss calculations

Annual ROM production	4.5	Mtpa
Production weeks	52	weeks
Scheduled ROM production	182692	t/week
Equivalent day rate at pit moisture for model purposes	26027	t/day
Equivalent day rate for model purposes – dry weight	24049	t/day
ROM % to product - dry weight	71	%
ROM % to coarse rejects - dry weight	20	%
ROM % to tailings - dry weight	9	%
ROM moisture content	7.5	%
Product moisture content	9.0	%
Coarse rejects moisture content	17	%
Tailings moisture content	68.5	%
Supernatant return as % of rejects total moisture	25	%
Tailings seepage return (infiltrated) as % of tails moisture	10	%
Tailings percolation lost to spoils storage as % of tails moisture	15	%
Supernatant + seepage return water to CPP	781	kL/day
Product tonnes per day – dry weight	8097	t/day
Coarse rejects tonnes per day – dry weight	2281	t/day
Tailings tonnes per day – dry weight	1026	t/day
Product water content	801	kL/day
Coarse rejects water content	467	kL/day
Tailings water content	2232	kL/day
Evaporative losses from tailings dam (6Ha min & 4mm/day)	240	kL/day
Supernatant bleed to tailings decant reservoir	558	kL/day
Infiltration/leakage of supernatant to pit	223	kL/day
Infiltration/leakage to spoils storage increase	335	kL/day
Initial moisture retained in tailings	876	kL/day (44% moisture)
Key usage figures		
CHPP water consumption daily (no supernatant return)	2575	kL/day

CHPP water consumption per tonne (without supernat. return)	209 L/t
CHPP water consumption with supernatant return	**1794 kL/day**
CHPP water consumption per tonne with supernatant return	**145 L/t**

Note: Figures averaged to daily rate for modelling purposes

Table 7: Summary of current and future mine water usage rates

CPP (3.1 Mtpa) – current loss rate	1.20 ML/day
CPP (4.5 Mtp) – future loss rate	1.80 ML/day
Dust suppression on haul roads	1.15 ML/day
Stockpile watering	0.04 ML/day
Truck wash down	0.01 ML/day

Dust suppression on haul roads and other areas is estimated to range from 0.8 to more than 1.3 ML/day depending upon prevailing weather conditions. Future usage is calculated to average about 1.1 ML/day. Stockpile usage is estimated at about 0.12 ML/day while truck wash down is of the order of 0.03 ML/day. Table 7 provides a summary of usage/loss rates.

7.2.2 West Pit water management simulation model

As noted, the water balance simulation has been designed to include variable catchment areas over the mine life. That is, changing pit operations including pit stripped and benched areas, spoils, rehabilitated areas etc. have been included as variable catchments based on mine planning data. Table 8 provides a summary of catchment types prescribed in the model.

Table 8: Mine catchment types assigned to model

Type	Code	Characteristics
undisturbed	UD	grassed with occasional tree cover, dispersive soils, low infiltration
pit strip and bench	SB	stripped, broken ground with high infiltration in shallow zone
unshaped spoils	US	high infiltration and percolation to base of spoils
shaped spoils	SS	moderate to low infiltration (dispersive) , high percolation
rehabilitated	RH	grassed, immature tree development, low infiltration
hardstand	HS	permeable stockpiles and impermeable base, admin + plant areas

Simulation of the mine water management system has been conducted for projected future mine/pit catchments over the next 21 years (to 2025) using historical rainfall periods extracted from the Jerrys Plains rainfall record. Figures G4 to G9 in Appendix G provide mine plans, topography and main water management elements from 2003 to 2025. Figure 13 shows the mine water catchments at year 10 while Figure 14 gives a schematic of the system showing contributing catchments. Appendix G Figures G10 to G14 provide catchment plans for years 2007 to 2025.

Separate rainfall periods of 21 years duration have commenced in 1900 with each subsequent period offset by 10 years. In this manner, the mine water system has been tested against 100 years of record for last century.

Initial storage conditions in all dams have been assigned to approximate current storage levels. A provision for pit groundwater seepage has been included with seepage assigned as a rising component from an initial rate of 0.1 ML/day (after evaporative losses) to a 2025 rate of 0.4 ML/day accumulated from all pits over the term.

Pumpage and usage has been adjusted for WPCPP operations at an average 4.5 Mtpa ROM with tailings delivered initially to TD or BD-TD. Other usage rates like dust suppression and truck wash down are assumed to be the same as the ‘calibrated’ model. All dam to dam transfer rates remain fixed during the 21 years term of modelling except when dam storage levels are below the assigned daily pumping rate –transfer rates are then adjusted downwards to remaining storage. If pumpage from one dam to another encounters a storage that is at capacity, then an overflow occurs to the next nominated storage with all surplus water accumulating in Parnells Dam. If the system is at capacity then water is retained in pit.

HRSTS discharges have been included by examining 100 years of synthesised river flow data and determining when discharge opportunities would have occurred (see Appendix G). HRSTS maximum discharge rate is the currently licensed rate of 130 ML/day (adopted for flood discharges) while a maximum high flow discharge rate of 15 ML/day has been adopted. This rate has been calculated as a proportion of the total allowable discharge (TAD) average for the HRSTS lower sector (from river flow and salinity records), and the current number of salinity credits retained by Coal and Allied. Discharges are only triggered if Parnells Dam exceeds 50% of capacity ie. storage is greater than 375 ML.

Appendix G provides graphical output for a period from 1940 to 1958 containing very wet years, a dry period from 1930 to 1948 (1939 drought) and a relatively average period from 1970 to 1988 – Figures G16 to G18. Storage exceedance probability (percentile) plots have also been generated for all model simulations for the key storages including the mine pits and the main dams. These plots (Figure G18) illustrate the percentage of time a particular storage is equalled or exceeded over the 21 years term of modelling and provide a useful risk profile.

Model simulations indicate the following:

- West Pit (North and South) are maintained in a dewatered state 90 to 95% of the time for a modelled pit pumping capacity of 25 ML/day (290 L/s continuous operation) from the pit area (Figure G19a). Wilton Pit is pumped at a rate of 8.6ML/day and remains dry 97% although this assumes water concentrates within the sump(s) rapidly. Any non draining bench areas will of course present problems with short term ponding. During the remaining 5% to 10% of the time, storage could rise above 200 ML if the more extreme rainfall periods are encountered like the third quarter in 1950. Increased pumping capacity would reduce the risk of impairing workability but additional storage would be required to contain pumped water.
- Total mine storage is predicted to be mostly below 1000 ML as indicated on Figure G16b lower plot. For the remaining time the storage rises to a predicted maximum of about 2000 ML during the 1910 to 1931 test period. A median response of 1500 ML is shown.
- Parnells Dam (Figure G21a upper plot) is predicted to be less than half full for 50% of the time. This is attributed to an aggressive HRSTS discharge regime where all flood and high flow opportunities are utilised providing the stored water exceeds 50% of capacity with high flow discharges ranging from zero to a maximum of 130 ML/day.
- System make up water is required for up to 20% of the time at a rate of 2.5 to 3.0 ML/day.

While the above provides predicted outcomes based on model parameters, in reality it is likely that some HRSTS discharge events will not be utilised, pumps may fail or Parnells Dam water quality may rise and reduce the high flow discharge rate in terms of salt tonnes exported from site. As a result it is likely that pit water storage may rise and be retained for longer periods. Additional HRSTS salinity credits may then need to be applied to boost high flow discharge rates and recover system balance. Since Coal and Allied retain more than 200 credits, sufficient flexibility should be available to counter imbalances.

7.2.3 North Pit, Alluvials and Carrington Pit water management

Water management at North Pit has been previously assessed (MER 1999, MER 2000). Simulations addressed a number of scenarios including the alluvial lands, Carrington operations and inclusion of West Pit coal processing through HVCPP. This system is summarised on the water management schematic – Figure 15. A summary of the system is as follows:

- Dam 15N serves as a central storage for distributing water to the various other HVCPP dams and directly to the preparation plant. Localised catchment runoff is ultimately pumped through the mine water system to the Dam 15N or during wet periods, migrates as overflows from the other dams. Water levels in Dam 15N may oscillate during dry times primarily due to draw-off to feed HVCPP directly or through pumpage to the 2 x 17 ML dams (Dam 17N), but levels are generally maintained near capacity.
- The Dam 16N receives water recycled from HVCPP. Water is also pumped from Dam 11 if levels are low.
- The Dam 17N acts as a header dam for HVCPP and is maintained at relatively constant levels. The dam(s) receives mine water from North Pit via Dam 11 and makeup water during dry times is pumped in from the Hunter River. Similarly, the 2 x 13 ML dams (Dam 18N) acts as a header for both firewater purposes and HVCPP. The Dam 18N sources water from the Dam17N.
- The 10 ML Hardstand Dam (19N) receives runoff from the administration facilities and a small undisturbed catchment. It is maintained at a near capacity except during dry periods. Overflows are directed to the Dam 15N.
- Dam 9N situated between Carrington and Hunter Valley North, accepts groundwater from both the mine pit at Carrington and the dewatering slot constructed to the south-east of the pit. Water is pumped from Dam 9N to the Eastern Dam. Water may be pumped from the Eastern Dam to Dam 11N.
- Dam 11N may discharge surplus water in accordance with HRSTS regulations. Dam 11N receives surplus water from Dam 15N and pumped water from the Eastern Dam. Makeup water from the Hunter River has historically been required at an average rate of approximately 2 ML/day. However for the last 3 years the mine has operated in a self-sufficient manner by sourcing water from storage in the Eastern Dam and from Hunter Valley South operations, and groundwater pumped from both Carrington and the Alluvials pits.
- Rainfall runoff from the rehabilitated lands north of an imaginary line connecting the Central tailings and Eastern Dam accumulates in drains that flow into sedimentation dams before decanting offsite. Minor runoff from less significant areas of rehabilitation adjacent to and down gradient of this line is collected as mine water.
- Runoff from the Belt Road should be captured if coal haulage is undertaken along this road in the future. Capture should be achieved through the construction of drains on either side of the roadway. These drains should report to sedimentation-retention dams located above Farrells, Emu and Davis Creeks. If water quality in these dams is found to be impaired (eg. after a sustained dry period), then stored water will need to be conveyed to either West Pit (from Davis and Emu Cks. via Dam 15 or via water cart pump down) or North Pit (Farrells Creek) systems.

Water management system simulations (MER, 2000) assumed continued processing of coal from HVO pits south and north of the river through HVCPP over a term of 5 years indicated a reasonably balanced system for the first two years with a decline in storage thereafter. These scenarios included groundwater seepage at a rate of about 1.3 ML/day from the Alluvials Pit and utilisation of all available high and flood flow HRSTS discharges. The HVCPP loss rate was estimated at about 2.63 ML/day (150L/t ROM) based on a throughput of 6.4 Mtpa. Cessation of HRSTS discharges would lead to an improvement in the water balance.

Inclusion of groundwater seepage to Carrington Pit at a rate of 3 ML/day and processing of coal from West Pit in the model indicated mine water storage would probably remain above 1000 ML. If Carrington dewatering declined significantly, then an improved balance would result with surpluses expected during the more extreme wet periods and deficits occurring during dry and drought periods. Seepage to Carrington Pit has indeed declined and averages about 0.6 ML/day. Thus the system remains in reasonable balance.

Closure of the Alluvials Pit will facilitate a significant increase in available storage in spoils now emplaced within the pit. This staging capacity is likely to reduce demand on pumped water from the Hunter River and reduce the frequency of discharges of mine water to the river. The additional storage (if used) is also likely to lead to a reduction in mobilisable salts within the spoils through dissolution and export in product coal.

Installation of a pipeline between Dam 9N (Carrington dewatering) and Parnells Dam at West Pit will provide increased flexibility in water sharing and water storage.

7.2.4 HV Operations water balance

Dynamic water balance simulations discussed above, have been used to develop a water balance for HV North operations. This has also included results from dynamic simulations to assess mine water catchment runoff undertaken for Cheshunt (MER, 1998). A simplified 'static' balance has been used to assess the system for 10, 50 and 90 percentile wet years. Representative years have been extracted from the Jerrys Plains rainfall record and a balance or change in storage calculated. This change in storage has then been summated across the operations and the overall balance considered with varying input from Dam 13 (Liddell) or from the Hunter River.

The following Table 9 provides details. Carrington and Alluvials pits are included in the HV North balance. Reference to Table 9 indicates a future balance can be reasonably achieved for a planned HVCPP throughput of 20 Mtpa assuming Dam 13 can continue to provide system make up water at a rate of 730 ML/annum (2 ML/day). In addition, a continuing water supply from the Hunter River at a rate of 550ML/annum (or additional water drawn from Dam 13) will be required. This demand may also be met in part by contributions from Carrington Pit when future dewatering slots are constructed (maximum provision of 3 ML/day from Carrington Pit previously assessed) thereby reducing the need to draw from the Hunter River. Coal & Allied retain Hunter River allocations totalling 4175 ML/annum.

Approximately 2000 ML of storage will be needed. The storage would need to be utilised during wet years (no HRSTS discharges) in order to store and provide a resource for the dry years. Significant storage is already available within the Eastern Dam with additional storage in spoils becoming available in 2004 when mining in the Alluvials Pit has ceased. This 'porous' storage is estimated to be greater than 10000 ML. Utilisation of the latter is likely to assist in the removal of mobilisable salts from spoils (via product or HRSTS discharges).

Table 9: HV Operations water balance for dry, average and wet years

Source-Use	10% wet year	50% wet year	90% wet year
WP: mine water runoff	+1592	+1193	+434
WP: groundwater seepage	+120	+50	+10
WP: make up water (Dam 13 Liddell)	+0	+20	+550
WP: coal prep plant (WPCPP) – 4.5 Mtpa	-657	-657	-657
WP: haul road dust suppression	-320	-360	-401
WP: truck was + other usage (fire etc.)	-37	-37	-37
WP: Change in storage (balance)	+698	+209	-101
HV North: mine water runoff	+1238	+828	+275

HV North: groundwater seepage	+547	+500	+450
HV North: make up water	0	0	0
HV North: coal prep plant (NPCPP) – 20Mtpa	-2920	-2920	-2920
HV North: haul road dust suppression	-219	-255	-300
HV North: truck was + other usage (fire etc.)	-40	-40	-40
HV North: Change in storage (balance)	-1394	-1887	-2535
HV South: mine water runoff	+860	+360	+120
HV South: groundwater seepage	+590	+501	+410
HV South: make up water	0	0	0
HV South: haul road dust suppression	-240	-290	-340
HV South: truck was + other usage (fire etc.)	-60	-60	-60
HV South: Change in storage (balance)	+1150	+511	+130
Total change in storage (Balance)	454	-1167	-2506
Add Dam 13 maximum input	730	710	180
Add Hunter River Draw Off (minimum)	550	550	365
Operations balance:	1734	93	-1773

8. POTENTIAL ENVIRONMENTAL IMPACTS

The proposed extension of mining at West Pit will continue to induce change to the local groundwater and surface water environments. Potential impacts arising from the development will include:

- Continuing loss of coal measures aquifer pressures
- Change in groundwater quality in coal measures
- Leakage of groundwater from shallow aquifers
- Loss of catchment runoff
- Change in runoff water quality
- Salinisation in the final void(s) following cessation of mining
- Change in the site water balance
- Temporary crossing of the Hunter River

8.1 Continuing loss of coal measures aquifer pressures

Future mining will continue to induce loss of aquifer pressures in the seams and in formations overlying the seams with pressure losses sustained after cessation of mining for a period of more than 200 years. Coal measures pressures will never recover to pre mining levels since the area of mine development (including neighbouring mines), now retains different hydraulic properties with spoils permeability being 3 to 4 orders of magnitude higher than undisturbed coal measures. The net effect of changed properties will be a relatively flat water table over the mined area at a maximum elevation of about 50 mAHD or lower. Since the area of extended mining is located at the headwaters of a number of catchments, the overall impact is not considered to be significant.

Depressurisation of the coal measures and depressurisation impacts are predicted to extend between 2 and 3 km from the pit perimeter over the remaining mine life. Cumulative depressurisation arising from Carrington Pit may extend the distance to about 3.5 km (south-west).

Loss of aquifer pressures is not predicted to impact Hunter River alluvium nor any existing water supply bores or wells since all bores and wells are located within shallow alluvium.

8.2 Change in groundwater quality in coal measures

Groundwater within the coal measures is highly saline with salinity levels often observed to be above 10000 uS/cm. These elevated salinities may reflect deeper coal seams within which the monitoring piezometers have been located. Pumped pit water qualities reflect a composite but lower range from less than 3000 to 6500 uS/cm suggesting mixing of improved quality coal measures water, seepage from the shallow regolith and rainfall runoff within the pit.

Continued mining is expected to sustain a similar groundwater quality range as has been observed since the commencement of mining many decades ago. It is highly improbable that coal measures groundwaters will exhibit a fall in salinity to the point where beneficial usage is increased.

8.3 Leakage of groundwater from shallow aquifers

The alluvial lands associated with the Hunter River and other major drainages represent an important groundwater resource within the region. Numerical modeling of the groundwater system indicates coal measures pressure losses generated from continued mining of West Pit will not migrate beneath the Hunter River and as such, leakage losses from the alluvium will not occur.

No other shallow groundwater systems have been identified within the predicted zone of depressurisation.

8.4 Loss of catchment runoff

There will be a continuing loss of runoff in local catchments as they are consumed by the mine pit. The main drainages impacted include Emu Creek and Farrells Creek where 12% and 23% of the catchment above Bayswater Creek totalling about 1486 ha will be consumed. Rehabilitation of areas in the northern and western part of the mine site will re-instate runoff to Davis Creek and Parnells Creek where 24% and 11% of the catchment totaling about 2835 ha will be reinstated. Thus a net increase in catchment runoff will occur by the completion of mining.

These drainages are ephemeral with catchment losses restricted to the head waters that tend to drain rapidly after rainfall events. As such, impacts on aquatic systems are considered to be negligible.

8.5 Change in runoff water quality

Runoff water quality in rehabilitated areas is likely to exhibit a reduced salt load in the longer term compared to other local drainages unaffected by mining. This is mostly attributed to the removal of regional aquifer pressures within the coal measures that would otherwise contribute saline seepage to the drainages.

Runoff from the Belt Road should be captured and directed to sedimentation dams when the roadway is converted to a haulage road. There will be no impact on undisturbed catchment runoff traversed by this roadway.

All areas planned to be returned to the natural catchment will need to be carefully monitored at the sedimentation dam exit points during early years of rehabilitation to ensure water qualities (suspended and dissolved constituents) are acceptable.

8.6 Salinisation in the final void

An open pit (free water) void is predicted to remain on completion of mining. Depending upon the final closure plan, the void will exhibit a salinity higher than existing pit water due to leaching of salts from spoils, and evaporative processes. Some cyclic variability is also predicted as runoff from adjacent rehabilitated areas dilutes salinity and evaporation concentrates salinity. The extent to which catchment runoff is directed to the voids, should be determined through runoff monitoring during the last 7 years of the mine life and detailed design during closure planning.

For the current void design, the leachable salt load (over 100 years) is estimated to lie between 9.8 x 10^5 tonnes and 1.5 x 10^6 tonnes generating a void water quality of between 14550 and 22910 mg/l before any evaporative concentration is included. Inclusion of evaporation will significantly escalate the salinity of void water in the long term. The runoff area contributing to the void is sufficiently small to ensure that evaporation dominates and the void remains as a long term groundwater sink thereby attracting seepage from the surrounding strata (at a very low rate) and inhibiting advective dispersion of salinity back into the coal measures.

8.7 Change in the site water balance

Simulation of the site water balances using a dynamic catchment modelling approach indicates near balanced systems providing HRSTS discharges (high and flood flows) are utilised and make up water remains available from Liddell Dam 13 or from the Hunter River. The demand for make up water and the need for discharges will be reduced if storage within the Alluvials Pit is utilised. Connection of the mine water systems through construction of a pipeline between Dam 9N and Parnells Dam will facilitate water transfers between the two systems and maximize use of this storage. Re-use of stored water is also expected to initiate a reduction or removal of mobilisable salts within the alluvial lands spoils through coal washing and export of salts in product. Remobilisation will however only occur in spoils that are re-saturated.

8.8 Temporary crossing of the Hunter River

A temporary crossing of the Hunter River has been previously constructed in 1997 and 2001 to facilitate movement of a dragline and shovel between mining operations on either side of the river. The crossing is required since the haul road bridge is not designed for the very heavy loads associated with this equipment. The crossing has previously been constructed immediately upstream of the bridge. In future years it may be required as often as once per year. The planning, construction and removal period is in the order of 10 to 20 days while movement of equipment is normally accomplished within a day.

A Statement of Environmental Effects (SEE) was prepared for the 2001 crossing. This document provides construction details, assessment of the hydrology and geomorphology, and assessment of the likely impacts associated with the crossing. Key hydrological issues addressed included the probability of floodwaters overtopping the crossing, the ability of the crossing to withstand the impact of overtopping (scouring etc.), flood levels and flow velocities with and without the crossing, river bank stability, materials leachability and other water quality aspects.

Construction is undertaken in two stages due to the presence of a high and low flow channel at the crossing location. The high flow channel is first transgressed by constructing the temporary crossing and installing culverts within that crossing. Immediately prior to the planned movement of equipment, the low flow channel is diverted to the high flow channel and the temporary crossing extended across the entire river by selective materials emplacement. Equipment is then moved and the works removed. River materials excavated in the course of construction are then carefully replaced and the banks re-instated and stabilized. During this process, weather patterns and river flows are carefully monitored.

Construction and removal of the crossing in 2001 has demonstrated that a temporary crossing can be undertaken without measurable impact on water qualities /flows or bank stability.

9. DLWC LICENSING REQUIREMENTS

Licensing of certain aspects of the mining operations is normally required under Part 2 and Part 5 of the Water Act, the Water Management Act, and the Rivers and Foreshores Improvement Act.

9.1 Part 2 (Water Act) Licensing – surface water facilities

The existing mine infrastructure will be used for future operations. Current infrastructure relating to management of surface water runoff, erosion and sedimentation controls is either licensed or does not require licensing. Since future operations do not provide for harvesting of runoff or conveyance of runoff between catchments beyond that already approved, licensing is not likely to be required. However should water management plans change in the future, then applications should be made where appropriate. Appendix H provides a summary of current licenses pertaining to water management structures.

9.2 Part 5 (Water Act) Licensing – groundwater seepage

Licensing relating to groundwater seepage to the mine pit may be required under Part 5 of the Water Act if pumped water has a beneficial use. Separate borehole licenses will need to be sought/maintained for any future observation piezometers.

9.3 Part 3a (Rivers & Foreshores Improvement Act) approvals - structures

Part 3a approvals will be required for the temporary crossing of the Hunter River which is constructed from time to time to facilitate movement of a dragline or shovels between operations on the north side of the river and operations on the south side of the river.

10. IMPACTS ASSESSMENT CRITERIA

The establishment of impact assessment criteria is an important element of future monitoring of both the groundwater and surface water regimes. The criteria establish a series of benchmarks against which, impacts can be measured, alert protocols developed and mitigative actions initiated. While these criteria (and impacts) can be relatively easily established for surface waters, significant difficulties arise in respect of groundwater since aquifer/aquitard flows in both a regional and local context, are difficult to quantify.

10.1 Groundwater assessment criteria

Impacts in respect of groundwater relate to two key areas

- physical depressurisation of the rock strata and potential indirect impacts on other aquifer systems like Hunter River alluvium, and;
- changes to groundwater hydrochemistry induced by regional depressurisation.

Depressurisation is calculated by regular measurement of prevailing groundwater levels in the rock strata and comparing these levels with those measured prior to mining impacts. Coal & Allied currently monitors groundwater levels at a limited number of borehole locations around Carrington and North Pit operations. Falling water levels/pressures are already evident at a number of these locations and these falling trends are expected to continue as the mining in each of the pits, continues. The rate of fall will vary depending upon the location and monitoring depth of each piezometer. In addition to these locations, a further five monitoring bores are recommended around West Pit while exchange of data with Cumnock in respect of monitoring bores in the area east of Cumnock South Stage 3 Pit, is encouraged. The Hunter River alluvium is the only identifiable groundwater resource in proximity to West Pit having beneficial value. A decline in pressure towards the river and any similar changes in piezometers situated between mining operations and the river would signify an increase in the potential for leakage from the alluvial aquifers if the pressure wave was to ultimately migrate beneath the alluvium.

Groundwater impact assessment should therefore be based on the measured change in regional aquifer systems pressures, flows and hydrochemistry. Identified systems include coal measures strata and the Hunter River alluvium. All measurement and monitoring should be conducted using appropriately constructed piezometers and suitably calibrated instrumentation.

Depressurisation monitoring should include:

- Construction of four piezometers to permit shallow coal measures depressurisation measurement in the region between West Pit and the Hunter River. Locations for these piezometers are identified on Figure 16 subject to consultation and agreement with DIPNR. Permeability testing should be completed on new piezometers in order to facilitate estimation of subsurface flows.
- Construction of two new piezometers in rehabilitated spoils areas at locations to be determined in consultation with DIPNR and installed prior to closure of the mine pit(s). The purpose of these piezometers will be monitoring of void/spoils water level recovery and water quality post mining.
- Monthly monitoring of water levels in all existing piezometers shown on Figure 16 and in new piezometers.
- Daily monitoring of water levels by installed auto recorders 3 existing piezometers and in 3 of the 6 new piezometers (shallow zone) in order to discriminate between oscillatory groundwater movements attributed to rainfall recharge, and longer term pressure losses related to mining.

Recommended groundwater quality monitoring includes:

- Bi-monthly monitoring of basic water quality parameters pH and EC in all existing and new piezometers.
- Six monthly measurement of total dissolved solids (TDS) and speciation of water samples in 8 piezometers. Speciation shall include major ions Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4 (or S) and elements/metals including Al, As, B, Ba, Fe (soluble), Li, Mn, Rb, P, Se, Si, Sr, Zn.
- Graphical plotting of data and identification of trend lines and statistics including mean and standard deviation calculated quarterly. Comparison of trends with rainfall and any other identifiable processes that may influence such trends.

Impact analyses should include:

- Bi-monthly assessment of departures from identified monitoring or predicted data trends. If consecutive data over a period of 6 months (minimum of three consecutive readings) exhibit an increasing divergence in a negative impact sense from the previous data or from the established or predicted trend then such departures shall initiate further action. This may include a need to conduct more intensive monitoring (including installation of additional piezometers) or to invoke impacts re-assessment and/or remedial actions if causality is attributed to mining operations and is assessed to be detrimental to the environment beyond impacts predicted in the EIS.

- Formal review of depressurisation of coal measures and comparison of responses with aquifer model predictions biennially. Expert review shall be undertaken by a suitably qualified hydrogeologist if measured depressurisation in shallow coal measures (to 100 m depth) exceeds predicted depressurisation for the designated period.
- Annual reporting (including all water level and water quality data) to DIPNR in an agreed format.

10.2 Surface water assessment criteria

Operational impacts in respect of surface waters relate to three areas

- Diversion of run off from surrounding undisturbed catchments to minimize contributions to the mine water system;
- Capture and treatment of all runoff from disturbed areas to minimise impacts on natural drainage (including the Belt Road).
- Maintenance of a mine water system balance to ensure

Diversion drains are generally operational for periods of many years (eg. catchments in advance of the mine pit) or for the mine life. Similarly, capture and treatment of internal mine water runoff is a dynamic system where a combination of long term and short term catch drains and dams act to convey and store mine water in a manner that ensures minimal impact on undisturbed water courses while contributing to the overall mine water balance. Impact assessment criteria should therefore relate to external impacts and most specifically should include reference to diversions and to discharge of mine water to the HRSTS. Assessment should be based on the relativity of water quality parameters as measured in existing water courses and in sedimentation or discharge dams at locations shown on Figure 16 or as amended and approved by EPA. All measurement and monitoring must be conducted using appropriate sampling techniques and suitably calibrated instrumentation.

Design, construction and monitoring of all clean water dams and diversions should ensure that:

- All new banks, channels and similar works constructed to divert stormwater runoff away from disturbed land surfaces including mine workings, waste rock dumps, haul roads and coal handling facilities do not cause damage to, or interfere with the stability or water quality of existing water courses.
- All new and existing banks, channels and similar works are to be maintained in a stable form to minimize scouring and erosion. Impacts of such works should be measured by monitoring of water quality parameters pH, EC and non filterable residue (NFR) at discharge sediment dam locations at monthly intervals and comparing such measurements to measured water qualities in local undisturbed water courses. The latter should be determined by periodic sampling during or following storm events. If consecutive data measured at sediment dam monitoring locations over a period of 6 months (minimum of three consecutive readings) exhibit an increasing divergence in a negative impact sense from the previous data or from the established or predicted trend then such departures shall initiate a need to conduct more intensive monitoring or to invoke remedial actions if causality is attributed to mining operations.

Design, construction and monitoring of all mine water dams and diversions:

- The existing mine water management system will need to incorporate rehabilitated areas until such time as runoff water quality from these areas is equivalent to or better than water quality measured through periodic sampling in local undisturbed water courses. Water quality may be determined by measurement of pH, EC and TSS on a monthly basis.
- Contour banks and catch drains should be constructed in a manner that does not cause damage to, or interfere with the stability of existing water courses or their water quality.
- Six monthly measurement of NFR, TDS and speciation of water samples in Parnells Dam, Dam 2W, Dam 4W and Dam 18W. Speciation should include major ions Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4 (or S) and elements/metals including Al, As, B, Ba, Fe (soluble), Li, Mn, Rb, P, Se, Si, Sr, Zn.
- Graphical plotting of data and identification of trend lines and statistics including mean and standard deviation calculated quarterly. Comparison of trends with rainfall and any other identifiable processes that may influence such trends.

Dam design should be undertaken with regard to the following criteria:

- New sedimentation dams in rehabilitated areas are to have a design capacity based upon a 1 in 20 years ARI storm event and inlet/spillway structures designed to convey a 1 in 10 years ARI storm event and/or to meet design criteria prescribed in Managing Urban Stormwater – Soils and Construction (NSW Dept. of Housing, 1988) for Type C or D basins and/or other design criteria considered appropriate to local conditions and micro climate influences.
- Mine water storage dams must be maintained or constructed to ensure containment in accordance with mine water balance assessments. Such containment should include contingency storage (freeboard) to facilitate management and/or disposal of excess mine water in a compliant manner.

Mine pit water monitoring should allow for:

- Weekly measurement of the volume of water pumped from the mine pit(s). Such measurement may be conducted using either flow meters, weirs, flumes, pump operational hours (combined with appropriate pump curves) or other suitable methods that result in an estimation error of less than 10%.
- Monthly monitoring of mine pit(s) water quality by measurement of pH and EC in the receiving dam(s).

Mine water balance validation/verification should include:

- Monthly simultaneous (same day) measurement of volumetric storage in all mine water storage facilities.
- Graphical plotting of data and identification of trend lines and statistics including mean and standard deviation calculated quarterly. Comparison of trends with rainfall and any other identifiable processes that may influence such trends.
- Annual re-assessment of the site water balance through comparison with predictions generated provided in the EIS.
- Annual re-calculation of the basic water balance identifying rainfall runoff receipts, water importation, water usage and surplus water discharges via the HRSTS.

In addition to the above and as part of overall quality procedures, the monitoring programme should be subject to review annually by Coal and Allied environmental services group and/or their appointed consultants.

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IMPORTANT INFORMATION ABOUT YOUR HYDROLOGICAL REPORT

The science of hydrology (groundwater and surface water) is based upon analysis of historical data and prediction using various analytical tools. Often historical data is sought from various sources including clients of Mackie Environmental Research (MER), Government data repositories, public domain reports and various scientific and engineering journals. While these sources are generally acknowledged within the report, the overall accuracy of such data cannot be established. Indeed some Government agencies specifically require indemnification before releasing data. MER conducts certain checks and balances and employs advanced data processing techniques to establish broad data integrity where uncertainty is suspected. However the application of these techniques does not negate the possibility that errors may be carried through the analytical process. MER does not accept responsibility for such errors.

In addition, it is important to note that in the earth sciences more so than most other sciences, conclusions are drawn from analyses that are based upon limited sampling and testing eg. drilling of exploration and test boreholes, flow monitoring, water quality sampling and many other types of data gathering. While conditions may be established at those discrete sampling locations, there is no guarantee that such conditions prevail over a wider area. Indeed it is not uncommon for some measured geo-hydrological properties to vary by orders of magnitude over relatively short distances. In order to utilize discrete data and render an opinion about the overall surface or subsurface conditions, it is necessary to apply certain statistical measures and other tools that support scientific inference. Since these methods require some simplification of the systems being studied, results should be viewed accordingly. Importantly, predictions made may exhibit increasing uncertainty with longer prediction intervals. Verification therefore becomes an important post analytical procedure and is strongly recommended by MER.

Scale 1:65000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

creeks

railway

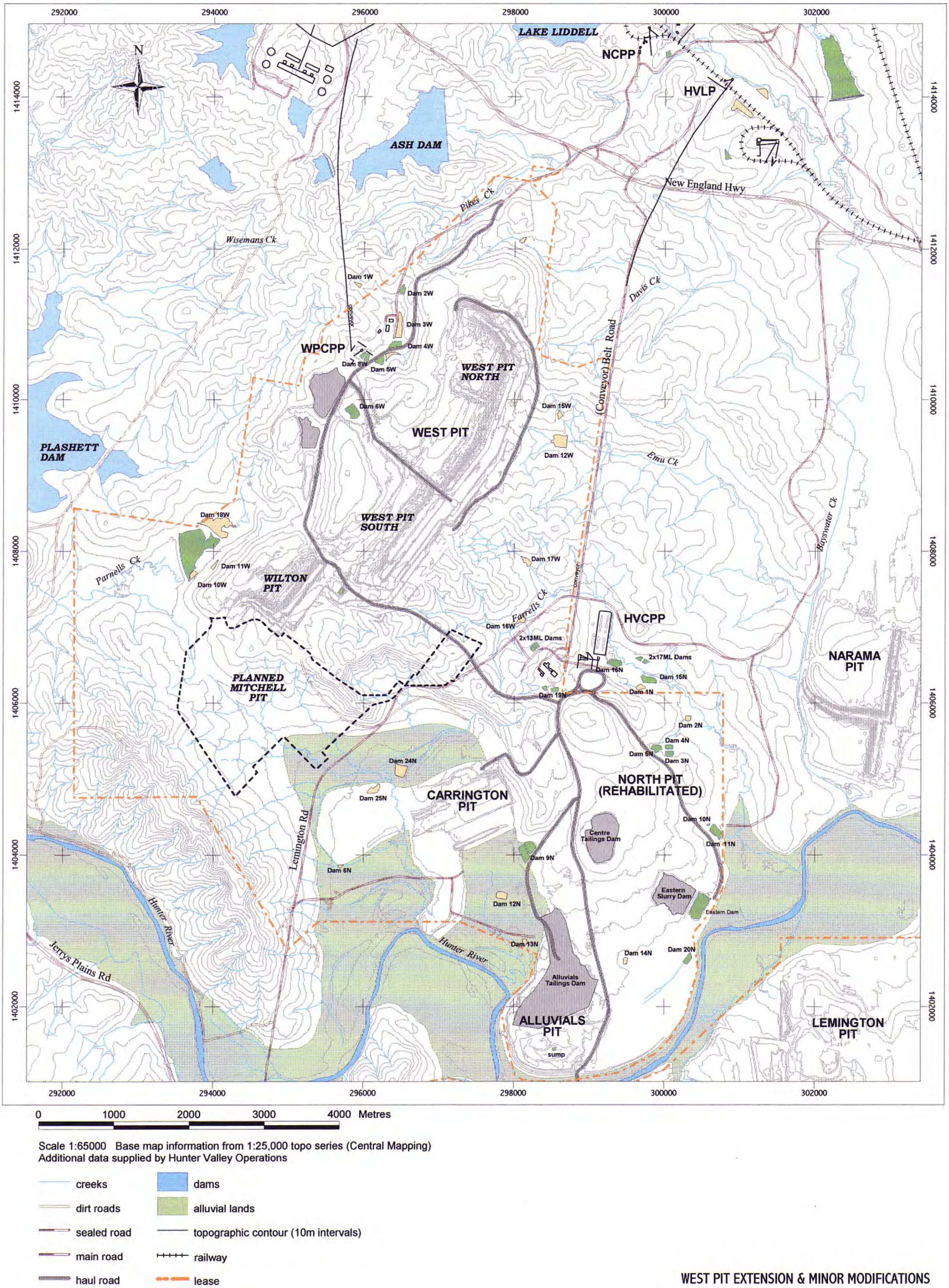
lease

WEST PIT EXTENSION & MINOR MODIFICATIONS

Pit locations and regional infrastructure

Mackie Environmental Research

Figure 1



WEST PIT EXTENSION & MINOR MODIFICATIONS

Regional topography and drainage

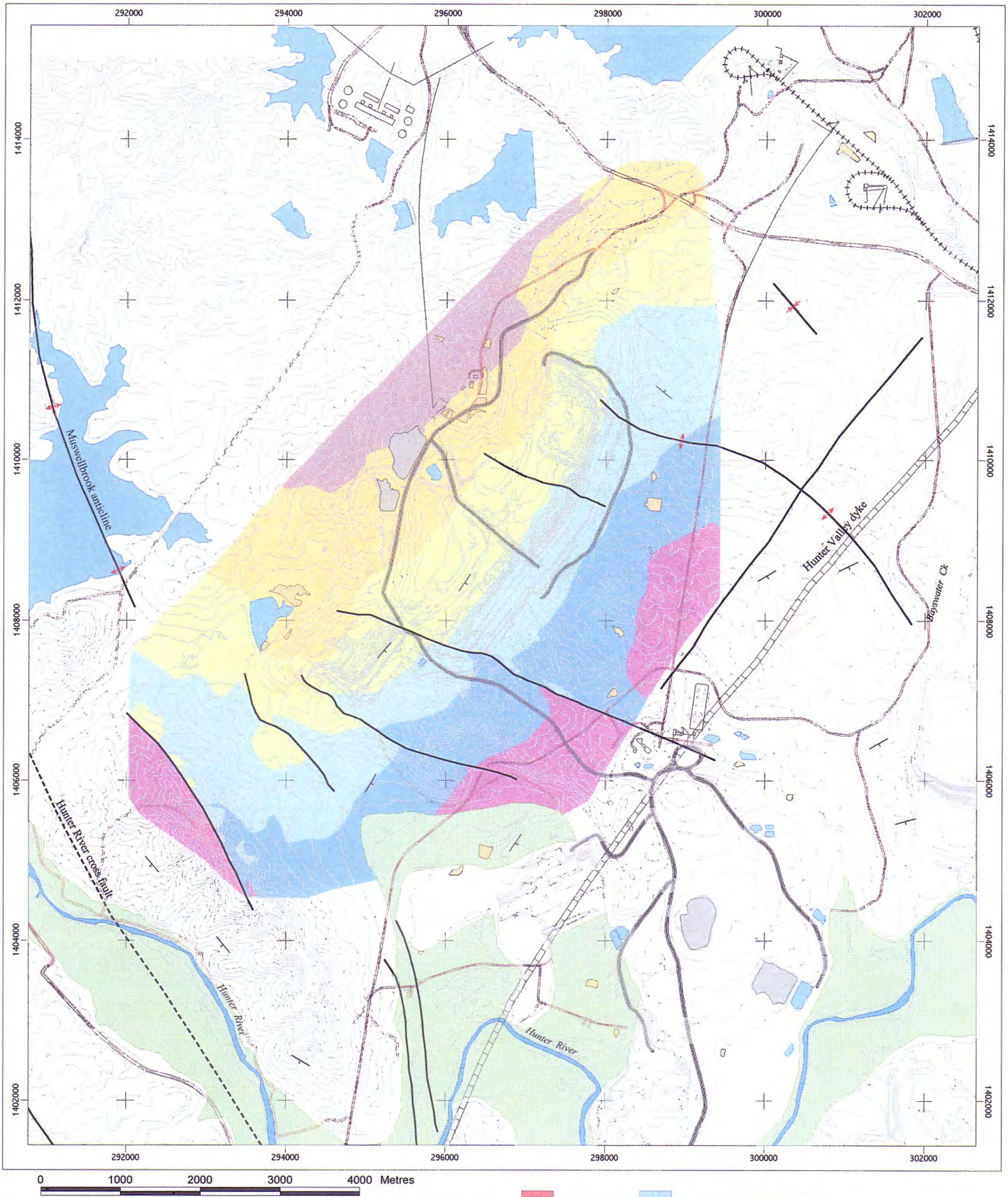
Mackie Environmental Research

Figure 2

STRATIGRAPHY OF THE SINGLETON SUPER GROUP

SINGLETON SUPER GROUP	WOLLOMBI COAL MEASURES	GLEN GALLIC SUBGROUP	GRIEGS CREEK COAL	*GRIEGS CREEK SEAM*	coal
			REDMANVALE CK FORMATION		conglomerate
			DIGHTS CREEK COAL	*HILLSDALE COAL MBR*	coal
				NALLEEN TUFF	tuffaceous sandstone
				HOBDEN GULLY COAL MBR	coal
		DOYLES CREEK SUBGROUP	WATERFALL GULLY FORMATION		sandstone, siltstone, claystone
			HAMBLETON HILL SANDSTONE		sandstone, siltstone
			PINEGROVE FORMATION	*WYLIES FLAT COAL MBR*	coal inc. splits
			GLENROWAN SHALE		shale, claystone
		HORSHOE CREEK SUBGROUP	LUCERNIA COAL	*EYRIEBOWER COAL MBR*	coal seams
				LONGFORD CREEK SILSTONE	siltstone
				ROMBO COAL MBR	coal seams
				HILLSDALE CLAYSTONE	claystone
				CARRAMERE COAL MBR	coal seams
			STRATHMORE FORMATION		predominantly siltstone
			ALCHERINGA COAL	*ALCHERINGA SEAM*	thin coal seams
			CLIFFORD FORMATION		sandstone, minor claystone
		APPLE TREE FLAT SUBGROUP	CHARLTON FORMATION	*STAFFORD COAL MBR*	coal inc. splits
			MONKEY PLACE CK TUFF		tuffaceous sandstone, siltstone
			ABBEY GREEN COAL	*ABBEY GREEN SEAM*	coal inc. splits
			WATTS SANDSTONE		sandstone, minor congl. marker bed
	WITTINGHAM COAL MEASURES		DENMAN FORMATION		sandstone, siltstone, laminite
		JERRYS PLAINS SUBGROUP	MOUNT LEONARD FORMATION	*WHYBROW SEAM*	coal inc. splits
			ALTHORP FORMATION		claystone
			MALABAR FORMATION	*REDBANK CREEK SEAM*	coal inc. splits
				WAMBO SEAM	coal inc. splits
				WHYNOT SEAM	coal inc. splits
				BLAKEFIELD SEAM	coal inc. splits
				SAXONVALE MBR	coal inc. splits
			MOUNT OGILVIE FORMATION	*GLEN MUNRO SEAM*	coal inc. splits
				WOODLANDS HILL SEAM	coal inc. splits
			MILBRODALE FORMATION		claystone
			MOUNT THORLEY FORMATION	*ARROWFIELD SEAM*	coal inc. splits
				BOWFIELD SEAM	coal inc. splits
				WARKWORTH SEAM	coal inc. splits
			FAIRFORD FORMATION		claystone – marker bed
			BURNAMWOOD FORMATION	*MT. ARTHUR SEAM*	coal inc. splits
				PIERCEFIELD SEAM	coal inc. splits
				VAUX SEAM	coal inc. splits
				BROONIE SEAM	coal inc. splits
				BAYSWATER SEAM	marker seam
			ARCHERFIELD SANDSTONE		lithic sandstone – marker bed
		VANE SUBGROUP	BULGA FORMATION		sandstone, siltstone, laminite
			FOYBROOK FORMATION	*LEMINGTON SEAM*	coal inc. splits
				PIKES GULLY SEAM	coal inc. splits
				ARTIES SEAM	coal inc. splits
				LIDDELL SEAM	coal inc. splits
				BARRETT SEAM	coal inc. splits
				HEBDEN SEAM	coal inc. splits
			SALTWATER CREEK FORMATION		sandst. siltst, laminate – marine/lower delta
MAITLAND GROUP			MULBRING SILTSTONE		siltstone claystone - marine
			MUREE SANDSTONE		sandstone, siltstone, congl. – marine regression
			BRANXTON FORMATION		sandstone, siltstone, congl. - marine

Figure 3



Scale 1:65000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

creeks
dirt roads
sealed road
main road
haul road
lease
dams
alluvial lands
topographic contour (10m intervals)
railway
bedding strike and dip
anticline axis
-200 to -150
-150 to -100
-100 to -50
-50 to 0
0 to 50 m(AHD)
50 to 100
100 to 150
150 to 200
axis
dyke
fault
inferred fault

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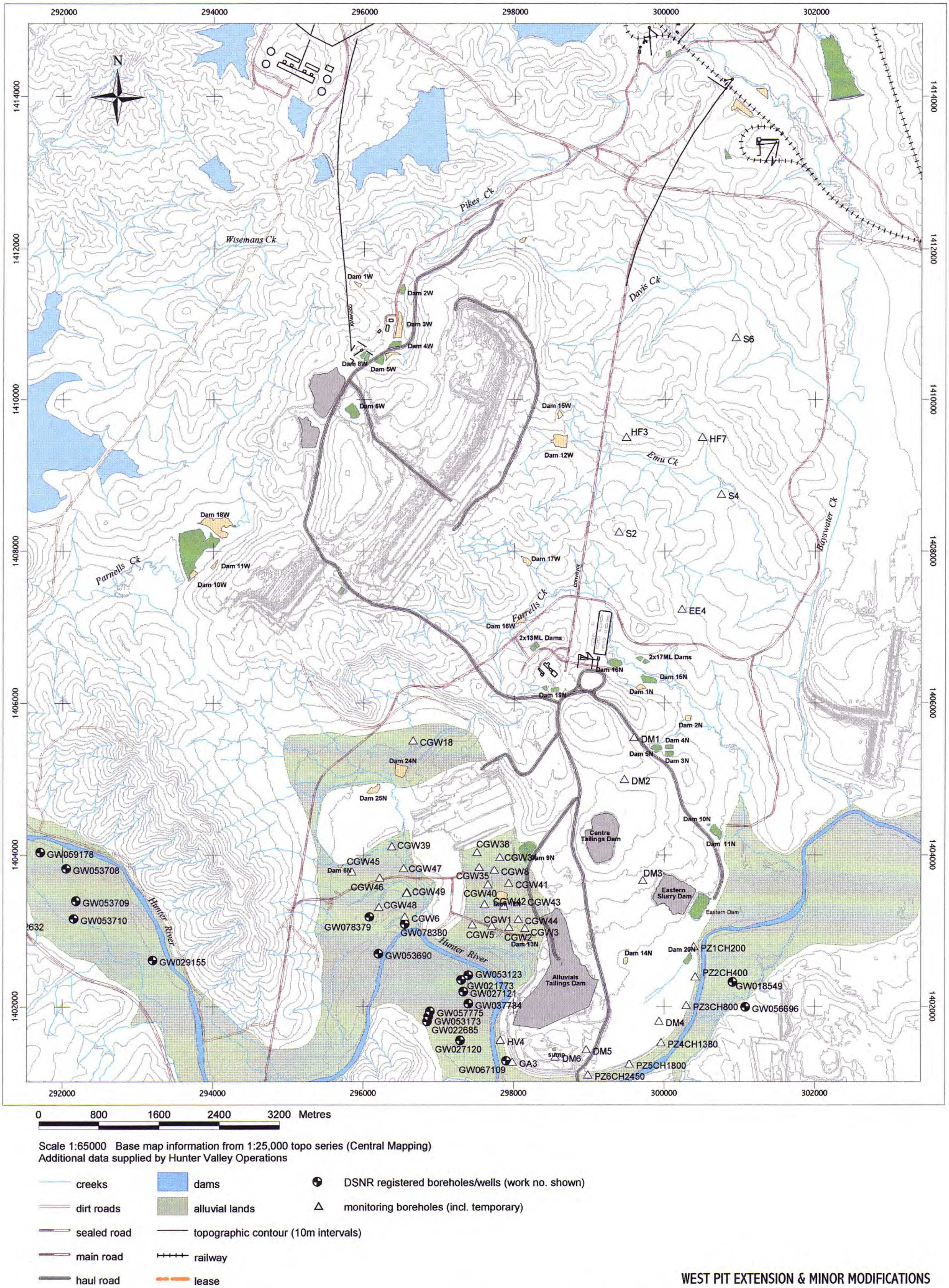
WEST PIT EXTENSION & MINOR MODIFICATIONS

Barrett Seam floor structure contours, local faults and dykes

Figure 4



WEST PIT EXTENSION & MINOR MODIFICATIONS

DIPNR registered boreholes/wells and monitoring piezometers

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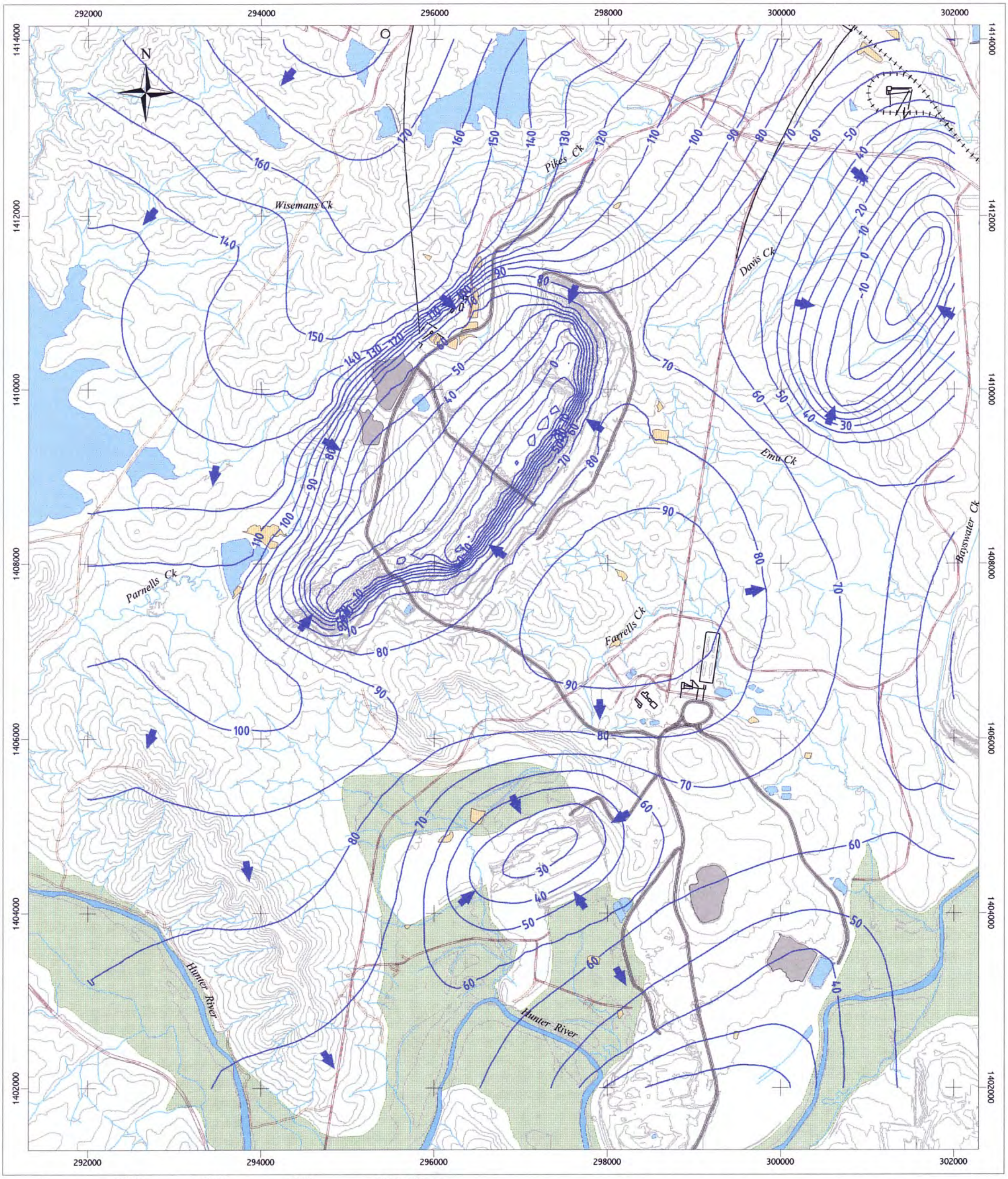
Figure 5



0 1000 2000 3000 4000 Metres

Note: composite surface from various data sources - arrows indicate flow direction

Scale 1:60000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- dams
- alluvial lands
- topographic contour (10m intervals)
- railway
- lease
- groundwater equipotential m(AHD)

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WEST PIT EXTENSION & MINOR MODIFICATIONS

Regional piezometric surface - shallow zone

Figure 6

0 1000 2000 3000 4000 Metres

EC measurements from consolidated historical data

Scale 1:65000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- dams
- alluvial lands
- topographic contour (10m intervals)
- railway
- lease
- △ sampling location (EC - uS/cm)

WEST PIT EXTENSION & MINOR MODIFICATIONS

Regional salinity (EC) values

Figure 7

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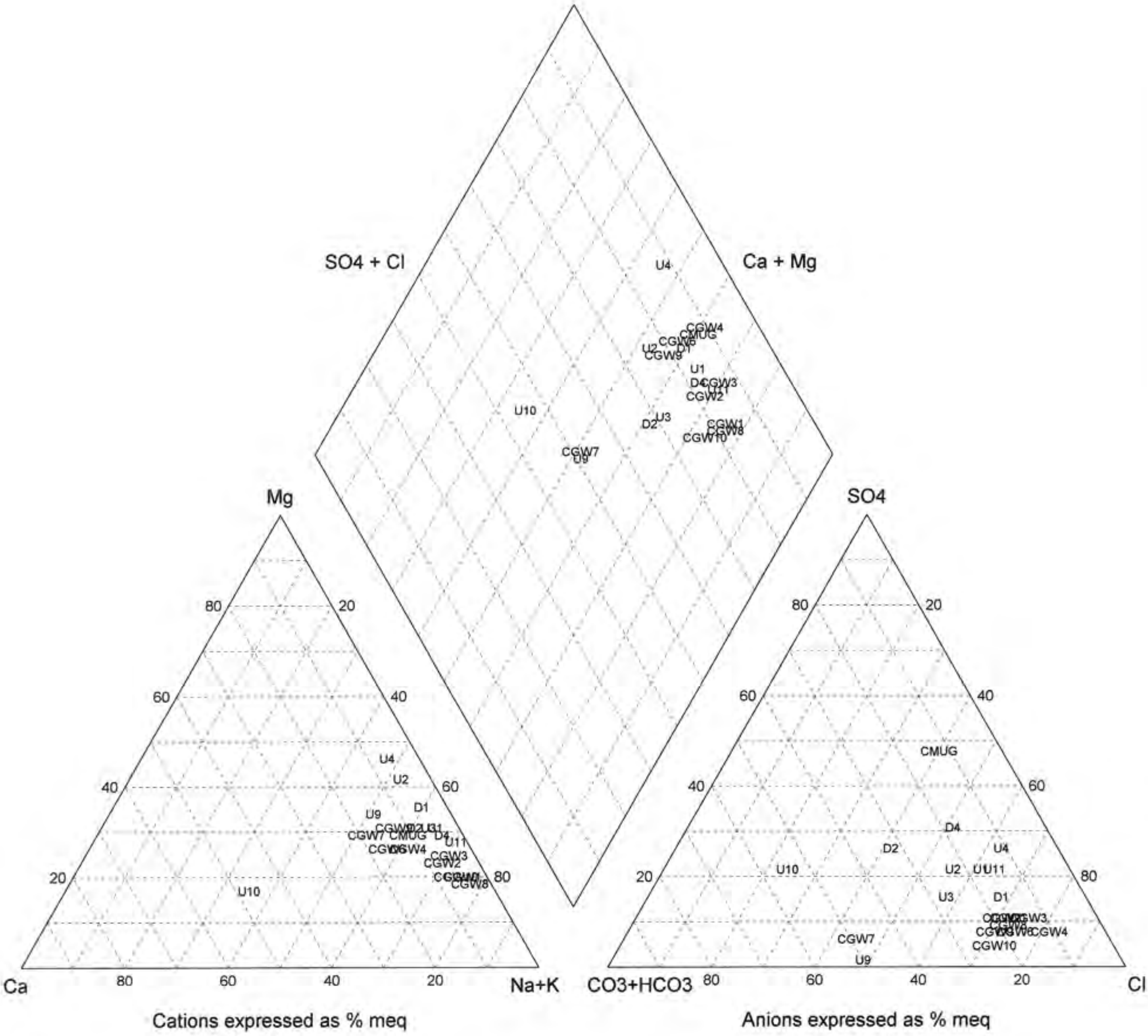

IONIC SPECIATION SUMMARY (milligrams per litre)

Sample	TDS	Ca	Mg	Na	K	CO3	HCO3	SO4	Cl
CMUG	5800	177	276	1105	5		589	1830	1130
CGW1	5710	91	235	1680	16		967	469	2380
CGW2	6360	154	330	1810	25		1210	531	2740
CGW3	6100	111	339	1830	31		923	540	3030
CGW4	4980	226	296	1270	15		606	304	2550
CGW6	3670	205	210	843	7		653	238	1610
CGW7	1220	92	82	275	5		618	65	332
CGW8	5340	88	217	1670	21		991	426	2310
CGW9	4600	201	307	1040	11		1010	297	1890
CGW10	4070	101	179	1250	18		1000	178	1780
U11	10405	100	639	3051	63		1458	1585	3509
U10	2138	291	63	241	12		982	307	241
U9	639	28	39	106	12		287	5	163
U1	3074	48	196	763	23		500	504	1039
U2	7548	158	650	1570	39		1611	1201	2318
U3	1326	26	78	290	39		342	144	408
U4	11253	255	1190	2239	43		1269	2248	4009
D1	8086	144	540	1699	47		1428	961	3268
D2	5161	132	280	1021	27		1556	975	1170
D4	4739	54	250	1030	23		860	1138	1382

HYDROCHEMICAL FACIES DIAGRAM

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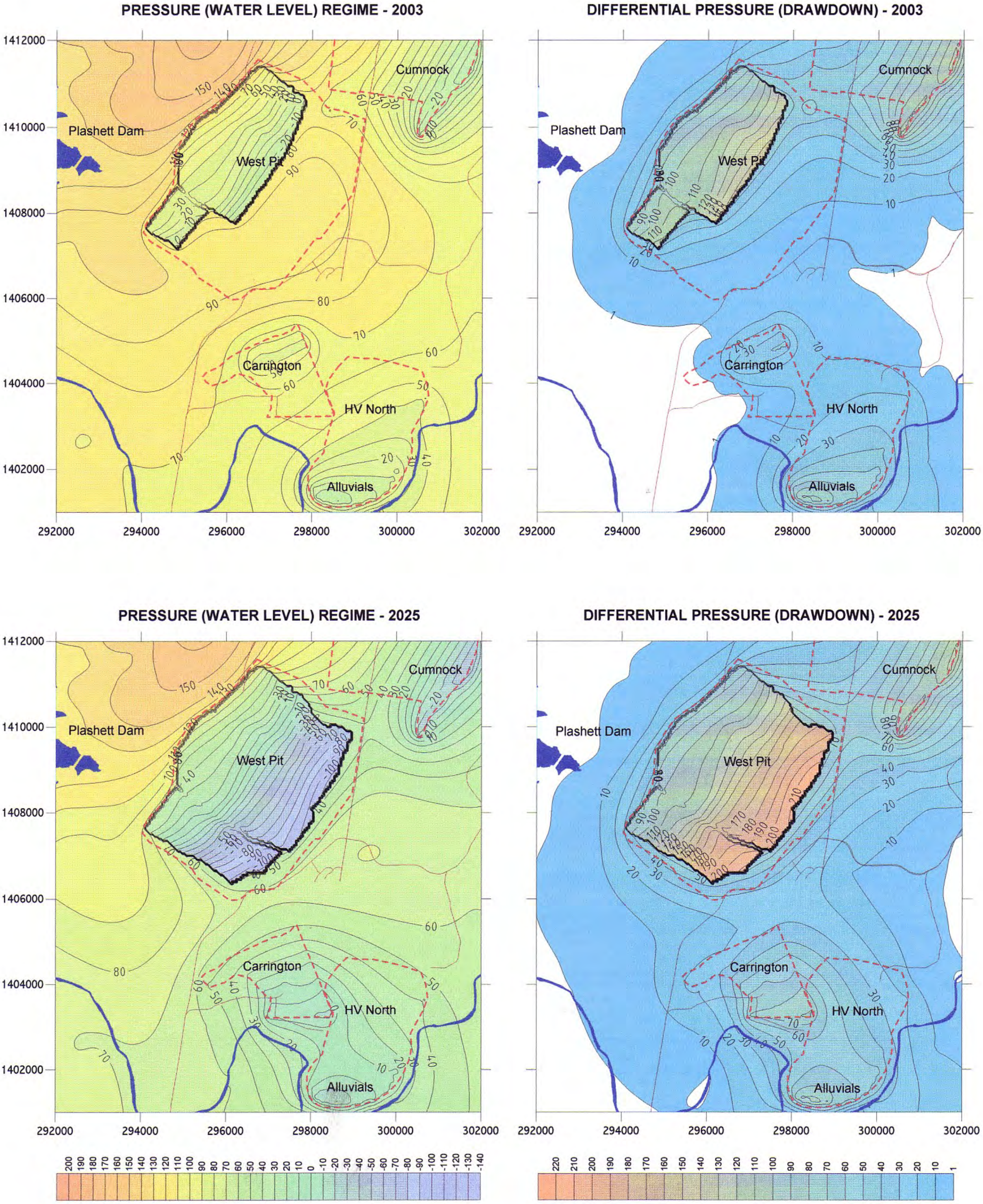
Figure 8



Pressures for model layer 2 shown
Aquifer pressures (left hand plots) in metres (AHD)
Open cut pit outlines shown in red
Loss of pressure (right hand plots) in metres of water
Contouring based on 20 metre interpolation interval

WEST PIT EXTENSION & MINOR MODIFICATIONS

Pressure and drawdown distributions - 2003 and 2025

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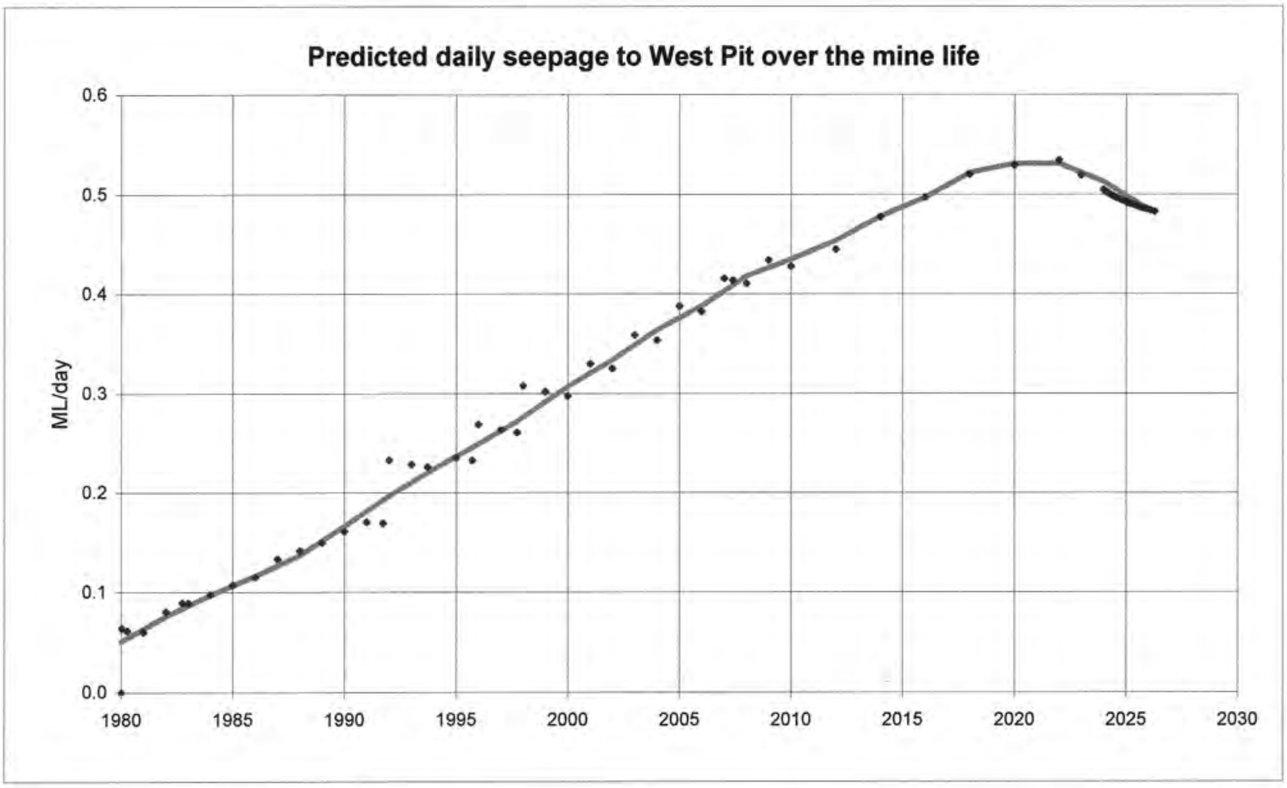
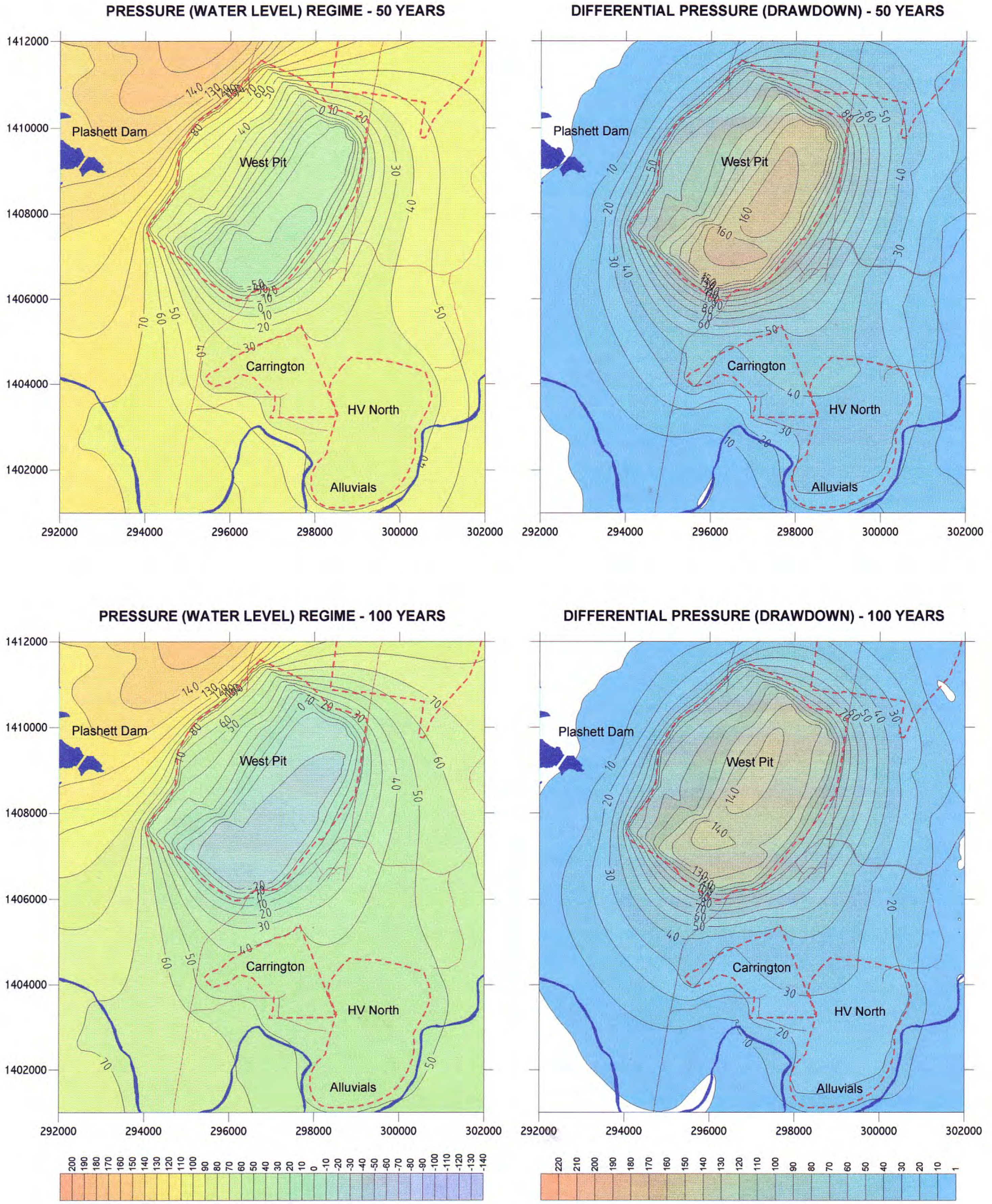
Figure 9



Model predicted seepage assumes negligible increase in horizontal conductivity from jointing. Evaporative losses are not included but may be of the order of 0.3ML/day or more during summer months.

Predicted groundwater seepage rates to mine pit



Pressures for model layer 2 shown
Aquifer pressures (left hand plots) in metres (AHD)
Open cut pit outlines shown in red
Loss of pressure (right hand plots) in metres of water
Contouring based on 20 metre interpolation interval

WEST PIT EXTENSION & MINOR MODIFICATIONS

Pressure and drawdown distributions - 50 and 100 years post mining

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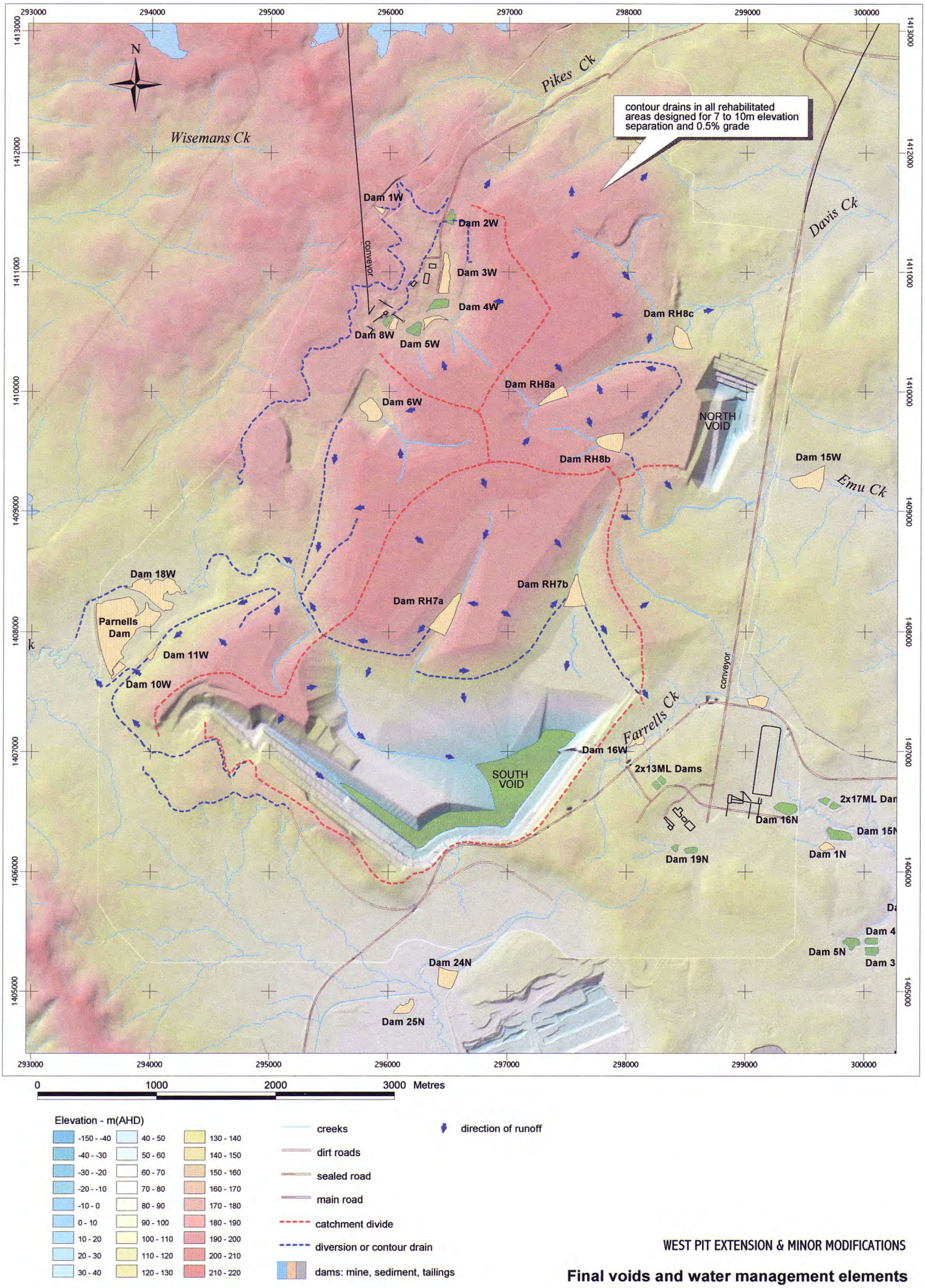
Figure 11



WEST PIT EXTENSION & MINOR MODIFICATIONS

Final voids and water management elements

Figure 12

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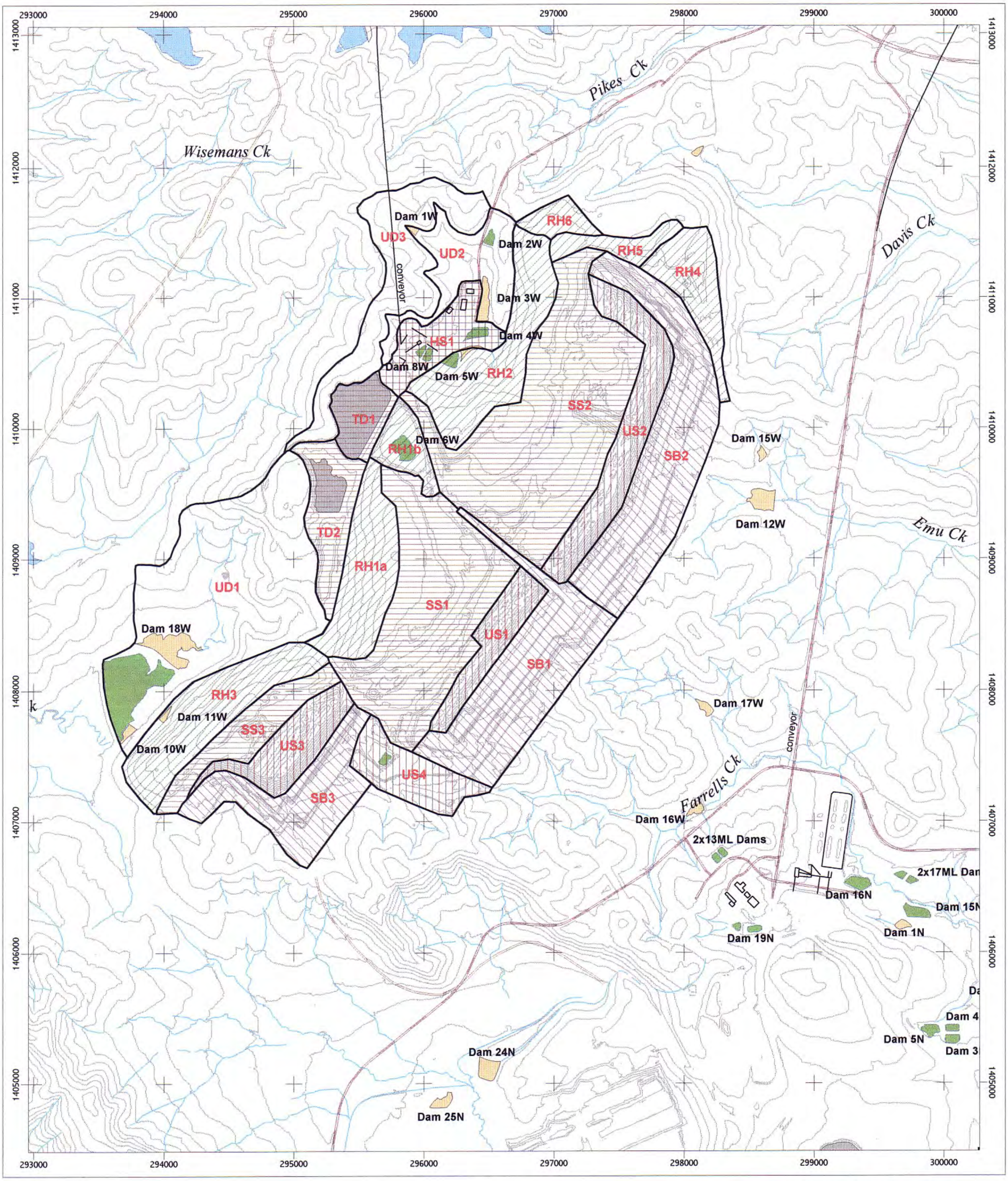

0 1000 2000 3000 Metres

catchment identifiers shown by red text

Scale 1:40000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- railway
- dams: mine, sediment, tailings
- alluvial lands
- topographic contour
- lease
- drain
- pipe
- hardstand
- rehabilitated
- strip and bench
- shaped spoils
- undisturbed
- unshaped spoils

WEST PIT EXTENSION & MINOR MODIFICATIONS

Water management catchment areas - 2003/4

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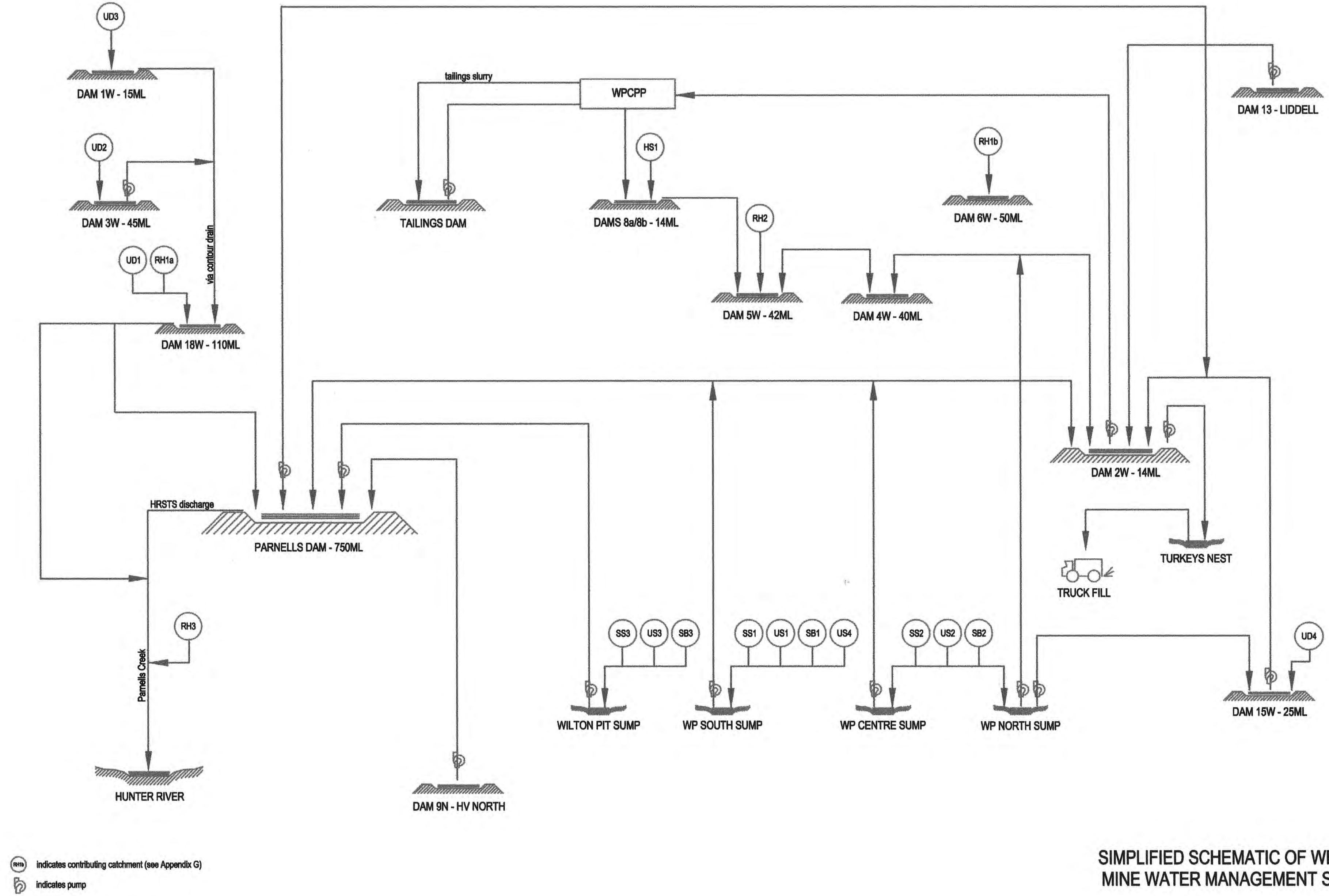
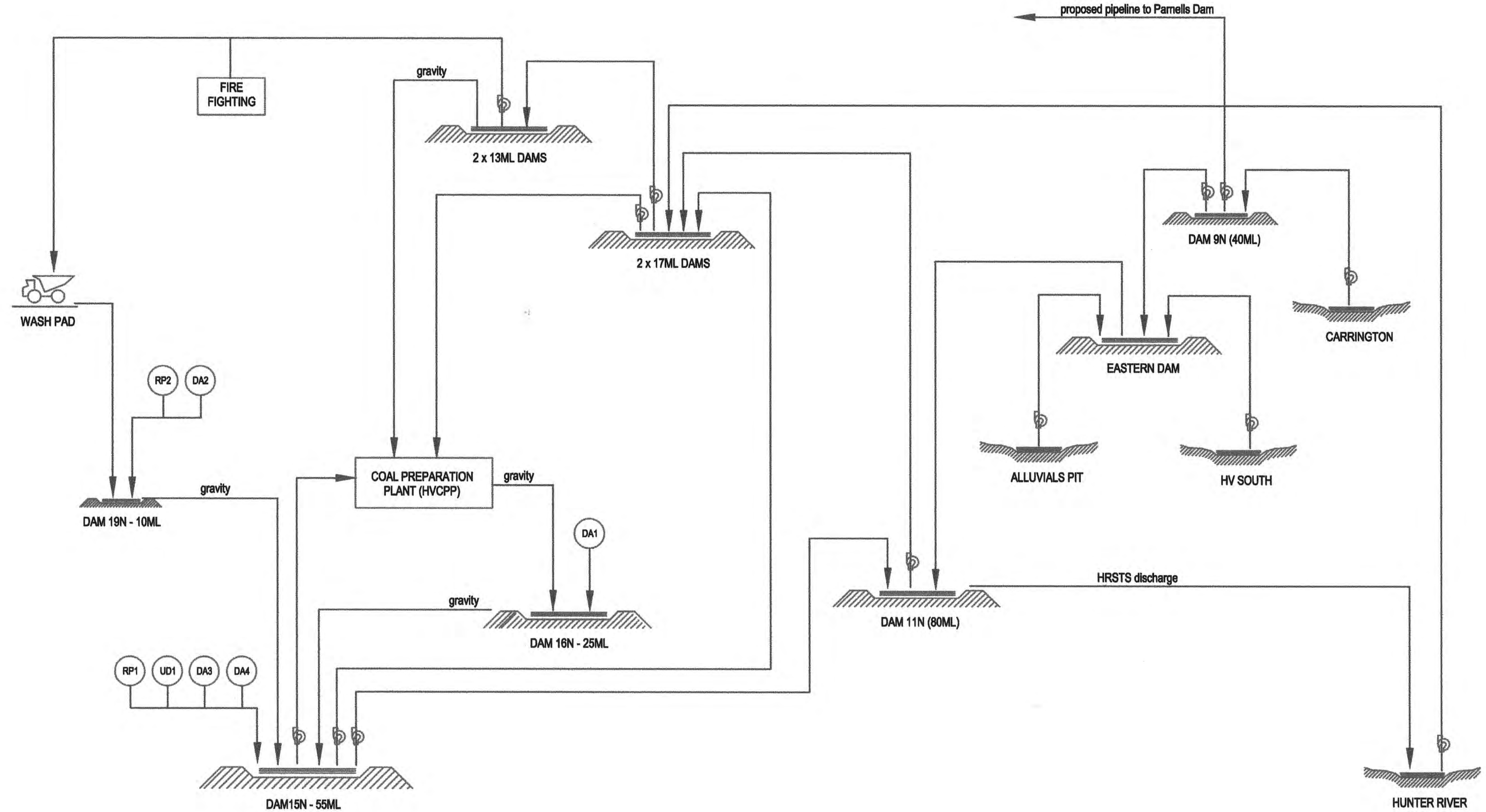
Figure 13

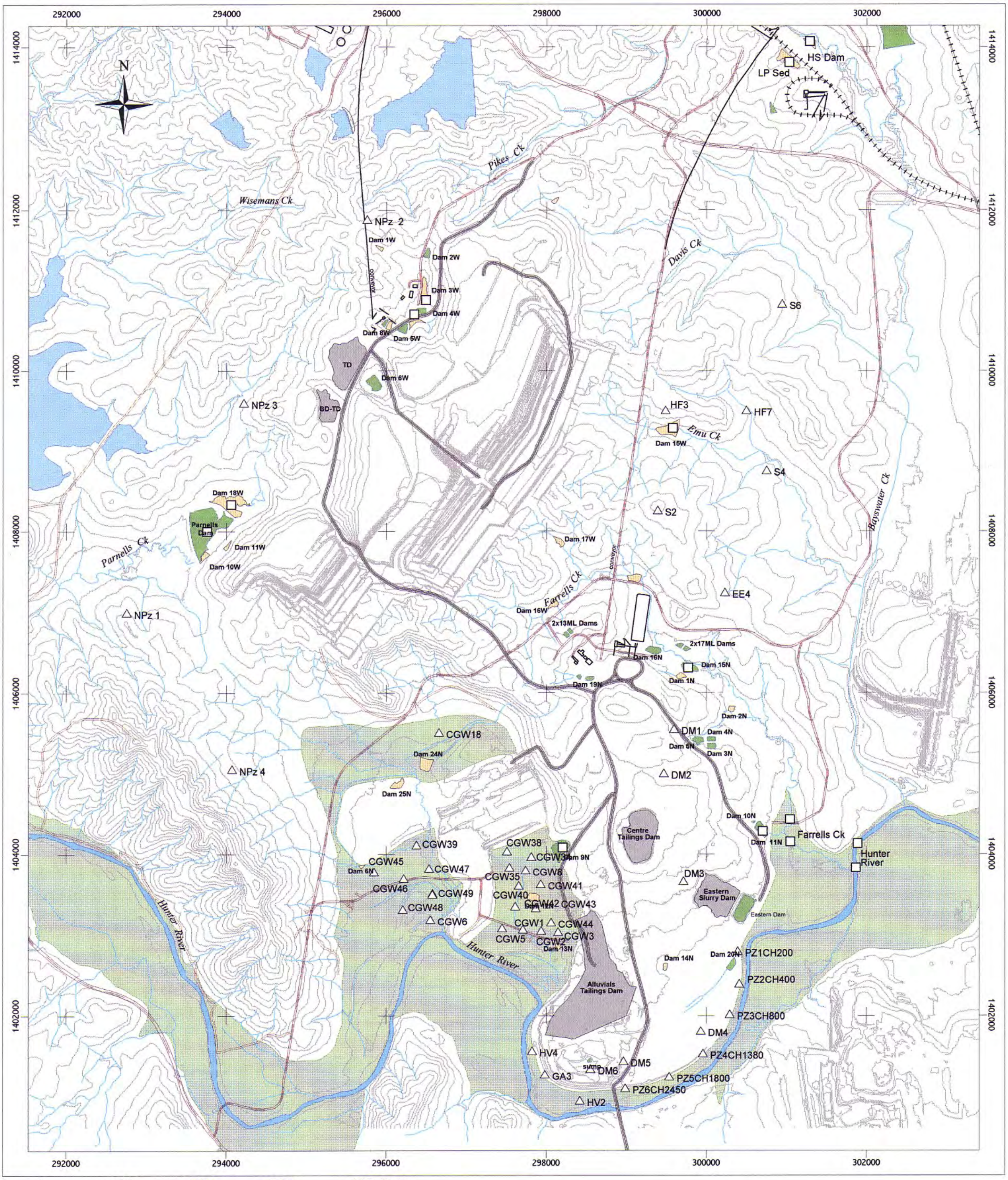


SIMPLIFIED SCHEMATIC OF WEST PIT MINE WATER MANAGEMENT SYSTEM

Figure 14



GENERALISED SCHEMATIC OF HV NORTH PIT
& CARRINGTON MINE WATER MANAGEMENT SYSTEM
Figure 15



0 1000 2000 3000 4000 Metres

Scale 1:65000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- dams: mine, sediment, tailings
- alluvial lands
- topographic contour (10m intervals)
- railway
- lease
- □ surface water sampling locations
- △ monitoring boreholes (incl. temporary)
- △NPz1 new piezometer

WEST PIT EXTENSION & MINOR MODIFICATIONS

Proposed future monitoring network

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Figure 16

APPENDIX A: CLIMATE DATA

Climate data has been sourced from the Bureau of Meteorology for use in mine water management system modelling. All data has been installed in MER database environment to facilitate processing and evaluation.

Long term data for Jerrys Plains, Singleton and Broke have been reviewed and compared to available local mine data. All stations exhibit reasonably close correlation in respect of key statistics like average monthly and annual rainfalls. Jerrys Plains rainfall has been used in water management simulations where testing has been conducted against the historical record. In addition, data for the more complete Jerrys Plains gauging station has been processed to generate recurrence intervals and average exceedance probabilities for specified rainfall durations up to 20 days. The following Table A1 provides a summary.

Table A1: Longer term intensity, frequency, duration statistics for 115 years of data.

ARI	AEP %	1 day	2 day	3 day	4 day	5 day	6 day	8 day	10 day	15 day	20 day
once in 1 years	63.2	48	65	72	78	82	87	93	99	115	126
once in 2 years	39.3	61	84	93	100	105	110	118	125	144	158
once in 5 years	18.1	79	109	121	131	136	141	152	160	182	199
once in 10 years	9.5	93	129	142	154	160	165	178	187	210	230
once in 20 years	4.9	107	148	164	178	185	189	203	214	239	261
once in 50 years	2.0	125	174	193	210	217	221	238	249	276	302
once in 100 years	1.0	140	195	216	235	243	246	264	277	306	333

Durations are based on screening of daily Jerrys Plains data within each year of available records from 1884 to 2000 **-** a log normal distribution is assumed.

ARI (Average Recurrence Interval) means – the average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. For example, a rainfall total of 99 mm over 10 days has an average recurrence interval of 1 year.

AEP (Average Exceedance Probability) means – the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. For example, a rainfall total of 99 mm over 10 days has a 63.2% probability of being equaled or exceeded in any one year.

Evaporation data is summarised in the following Table A2.

Table A2: Average potential daily evaporation (Pan A) in mm - Scone.

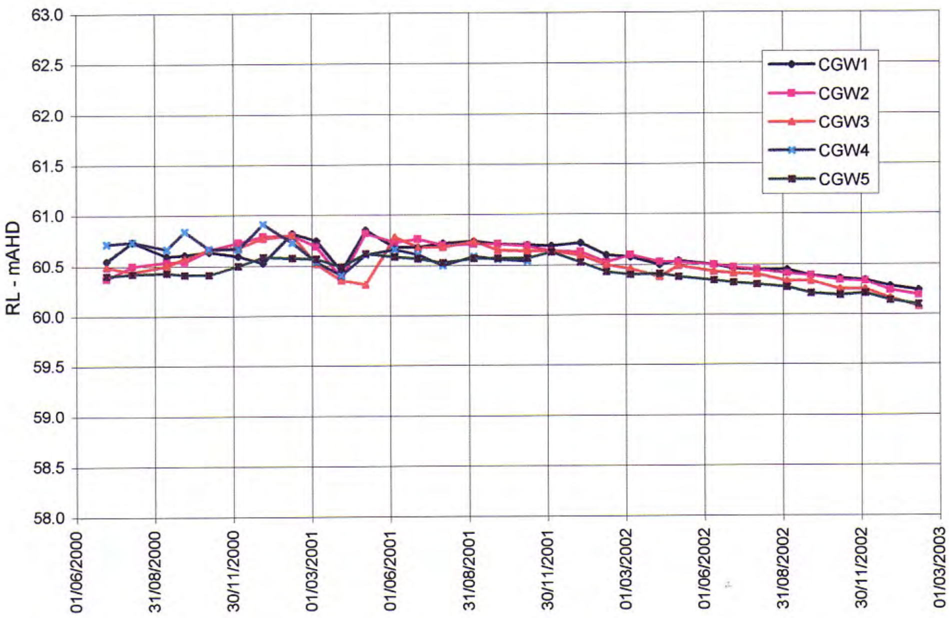
Jan	Feb	Mar	Apl	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec
8.8	7.2	5.5	4.3	2.8	2.1	2.5	3.2	4.2	5.4	7.6	9.2

APPENDIX B: MINE WATER MONITORING DATA

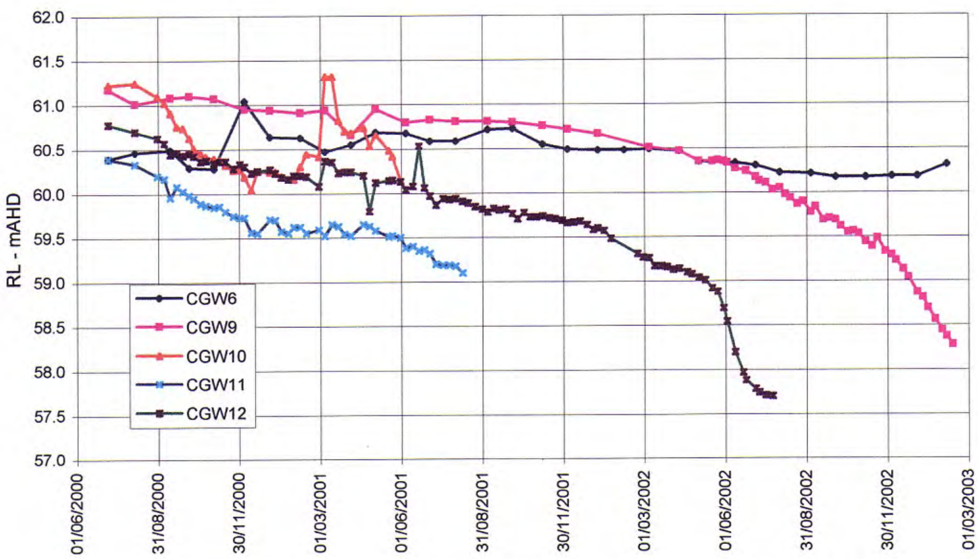
There are no long term groundwater monitoring locations close to West Pit. Nearest locations are to the south east in the Carrington area where the shallow water table within palaeo-channel deposits has been monitored over the last 4 to 5 years.

Figure B1 provides plots for the shallow water table. These plots reflect the influence of dewatering of the alluvial deposits following commencement of mining in 2000. Trends in these piezometers are consistent with predicted trends.

Carrington - Piezometers CGW1, 2, 3, 4, 5



Carrington - Piezometers CGW6, 9, 10, 11, 12



WEST PIT EXTENSION & MINOR MODIFICATIONS

Piezometric responses in the Carrington Pit area

APPENDIX C: AQUIFER HYDRAULIC PROPERTIES

Aquifer testing provides a means of estimating the groundwater transmission and storage characteristics of a geological formation. Various procedures can be employed depending upon the saturated aquifer thickness, regional extent, transmission properties and bore completions. Testing in the West Pit area is limited to historical packer testing of seams (AGC, 1984) and laboratory core testing of interburden. Other useful conductivity data in the area includes core testing at Carrington and Ravensworth West, and airlift testing of piezometers in the Ravensworth West area.

C1.1 Historical packer test data

AGC (1984) provide packer test estimates of hydraulic conductivity for the Barrett, Liddell, Arties and Pikes Gully seams. Reported values are represented in Table C1 for completeness. These tests support a mean value (log normal) of about 0.066 m/day. This conductivity is higher than is generally expected as a mean value for seams in the region but has been adopted in bulk conductivity estimates in the absence of more recent data. The high values for all seams could be attributed to dilation, rupture or even poor sealing (to packers) when compared to interburden sections. The reported values are considered to reflect an upper limit to seam conductivities.

Table C1: Hydraulic conductivity estimates from packer tests (source AGC, 1984)

Seam	Depth (m)	Kxy (m/day)
Howick South - Barrett	75	0.16
Howick South - Barrett	140	0.02
Howick South - Barrett	108	0.006
Howick South - Barrett	84	0.16
Howick South - Liddell	42	1.01
Howick South - Liddell	56	0.05
Howick South - Liddell	104	0.11
Howick South - Liddell	109	0.012
Howick South - Liddell	121	0.012
Howick South - Liddell	72	0.12
Howick South - Liddell	92	0.015
Howick South - Liddell	53	0.15
Howick South - Liddell	69	0.098
Howick South - Liddell	54	0.017
Howick South - Arties	18	0.7
Howick South - Arties	77	0.3
Howick South - Arties	51	0.38
Howick South - Arties	60	0.03
Howick South - Arties	36	0.5
Howick South - Pikes Gully	27	0.005
Howick South - Pikes Gully	27	0.006
Howick South - Pikes Gully	41	0.16
Howick South - Pikes Gully	46	0.11

C1.2 Piezometer airlift tests

Airlift V-notch weir measurements were conducted on exploration holes in the Ravensworth West area (MER, 1997). These measurements were conducted at locations shown on Figure C1 and provide an indication of the bulk conductivity of coal measures strata immediately east of the area of interest. An average value for the coal measures (mainly coal seams) is 0.013 m/day.

C1.3 Interburden core tests

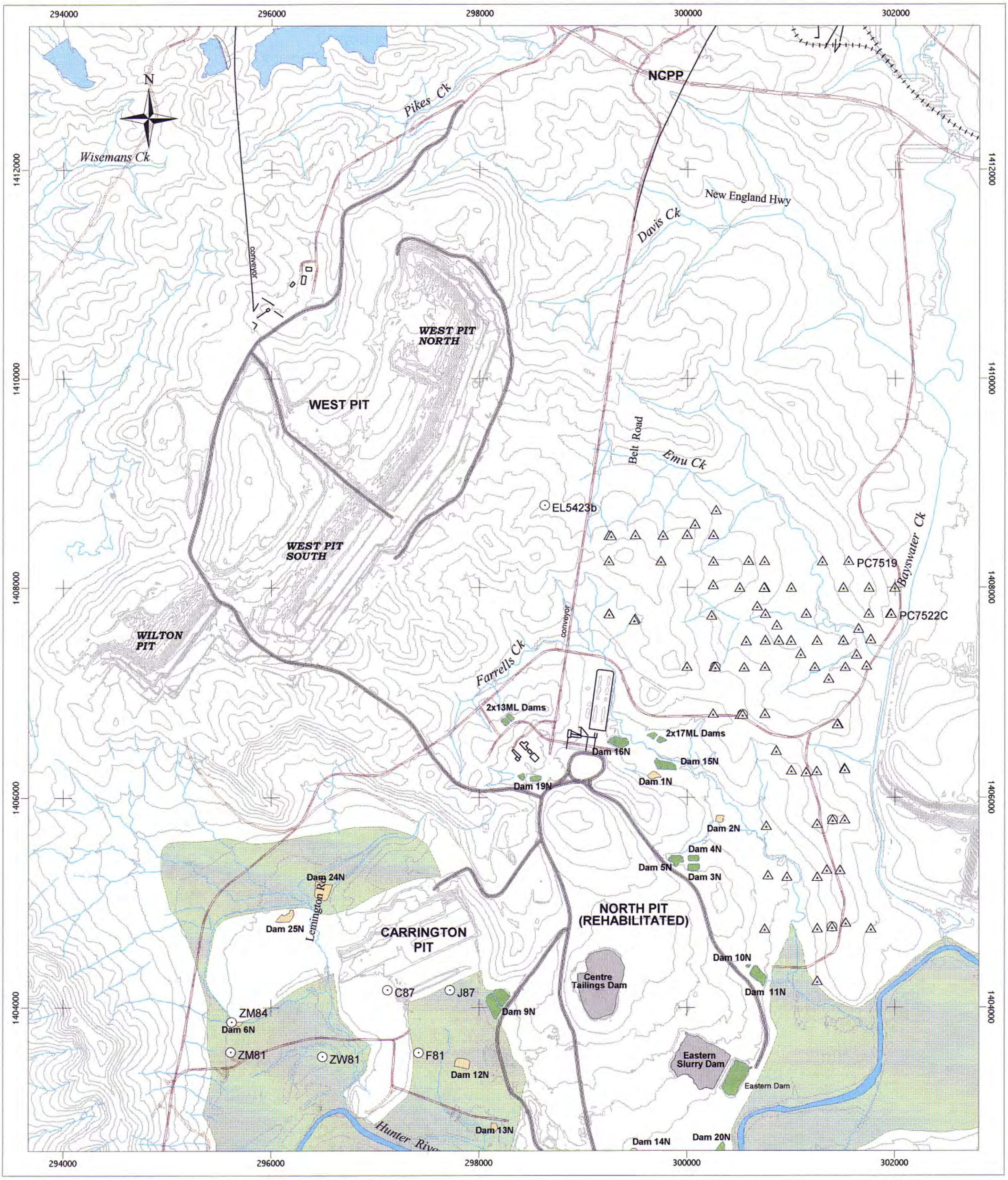
Laboratory core testing provides a means of determining the hydraulic conductivity of materials at an intergranular scale consistent with porous media (Darcian) flow. This estimate is typically the lowest conductivity for a specific rock type and is most representative of strata where fracturing and jointing is limited, or where fractures and joints are relatively disconnected.

Core from EL5243b was inspected and representative samples taken from sections displaying relatively uniform properties in respect of rock type, grain size, etc. Mudstone was not selected since this rock type tends to fail during cutting of test slugs. Consequently, sandstones, siltstones and laminites were generally selected.

All core samples were tested by Core Laboratories Australia at a confining pressure of 6.9 Mpa. The test method employed helium gas as the test 'fluid' and generated an estimate of Klinkenberg permeability (K_{inf}). Conversion has provided a measure of the saturated hydraulic conductivity at 20^{o}C. Certain core slugs were cut in both the vertical and horizontal directions thereby enabling an estimate of the prevailing 'micro' anisotropy within a specific rock type. Results are summarised in the following Table C2. Conductivity tests have also been conducted on core obtained from exploration holes in the Carrington area (MER, 1999) and Ravensworth West area (MER, 1997). Results are summarised in Table C2.

Table C2: Hydraulic conductivity estimates for interburden from core laboratory tests

Area	Depth (m)	Core	Stratigraphic location	Kxy (m/day)	Kz (m/day)	Anisotropy
West Pit ext.	13.8	sandstone - fg with lams of siltstone	between Lemington seams	7.67E-06	6.60E-06	1.16
West Pit ext.	33.3	sandstone - fg with lams of siltstone	between Lemington seams	4.92E-06		
West Pit ext.	47.6	sandstone - fg with frequent lams of siltstone	between Lemington seams		2.16E-06	
West Pit ext.	66.3	sandstone - fg	between Pikes Gully seams	1.00E-05	2.57E-06	3.92
West Pit ext.	77.0	siltstone - mfg with finer lams	below Pikes Gully seams		2.03E-06	
West Pit ext.	86.0	sandstone - mfg to fg	above Arties seam		1.20E-05	
West Pit ext.	101.4	sandstone - laminated with silty bands	between Arties seams	1.05E-05	3.74E-06	2.80
West Pit ext.	115.0	siltstone - laminated	below Arties seam		8.00E-07	
West Pit ext.	117.5	sandstone-siltstone - laminated	below Arties seam		1.18E-06	
West Pit ext.	126.4	sandstone - mg	above Liddell seam	4.60E-05		
West Pit ext.	145.6	sandstone - mg with carb lams	between Liddell seams	2.80E-06	2.46E-06	1.14
West Pit ext.	166.3	sandstone - mg with carb lams	above Barrett seam	2.67E-06		
West Pit ext.	178.0	sandstone - mg with carb lams	below Barrett seam	1.66E-06	1.49E-06	1.12
Ravensworth	70.3	sandstone - mg well cemented	Archerfield Sandstone	1.25E-05	1.99E-05	0.63
Ravensworth	52.3	siltstone	between Broonie seams	2.49E-06		
Ravensworth	56.5	sandstone		2.32E-05	1.08E-05	2.15
Ravensworth	51.6	sandstone		3.82E-05	2.82E-05	1.35
Ravensworth	97.5	siltstone	above Bayswater seam		8.30E-07	
Ravensworth	60.9	sandstone - siltstone	between Broonie seams	8.30E-07	8.30E-07	1.00
Ravensworth	90.5	sandstone - mfg	between Broonie seams		5.93E-06	
Ravensworth	91	sandstone	between Broonie seams	1.25E-05	7.47E-06	1.67
Ravensworth	63	sandstone	between Broonie seams		1.58E-05	
Ravensworth	59	sandstone - mg	between Broonie seams		5.06E-05	
Ravensworth	84.1	sandstone - cg	between Broonie seams	1.29E-04	1.11E-04	1.16
Ravensworth	88.9	sandstone - mg well cemented	Archerfield Sandstone	8.30E-06		
Carrington	45	sandstone mg to fg	between Broonie seams	4.76E-04	4.10E-05	11.61
Carrington	34.9	sandstone - silty	above Broonie seam	4.19E-06	3.46E-06	1.21
Carrington	52	sandstone - mg	between Broonie seams	4.57E-05	3.02E-05	1.51
Carrington	62.5	sandstone - mg	between Broonie seams	3.15E-04	2.04E-04	1.54
Carrington	51	sandstone - mg	above Bayswater seam		2.13E-05	
Carrington	33.2	sandstone - mg weathered	between Broonie seams	8.07E-03	2.32E-03	3.48
Carrington	35.8	sandstone - mg weathered	between Broonie seams	6.77E-03	2.37E-03	2.86
Carrington	63	sandstone - mg	above Bayswater seam	4.60E-04	5.08E-04	0.91



0 900 1800 2700 Metres

Scale 1:50000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- railway
- dams
- alluvial lands
- topographic contour (10m intervals)
- lease
- airlift tests
- core laboratory tests

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WEST PIT EXTENSION & MINOR MODIFICATIONS

Bore locations for hydraulic conductivity estimates

Figure C1

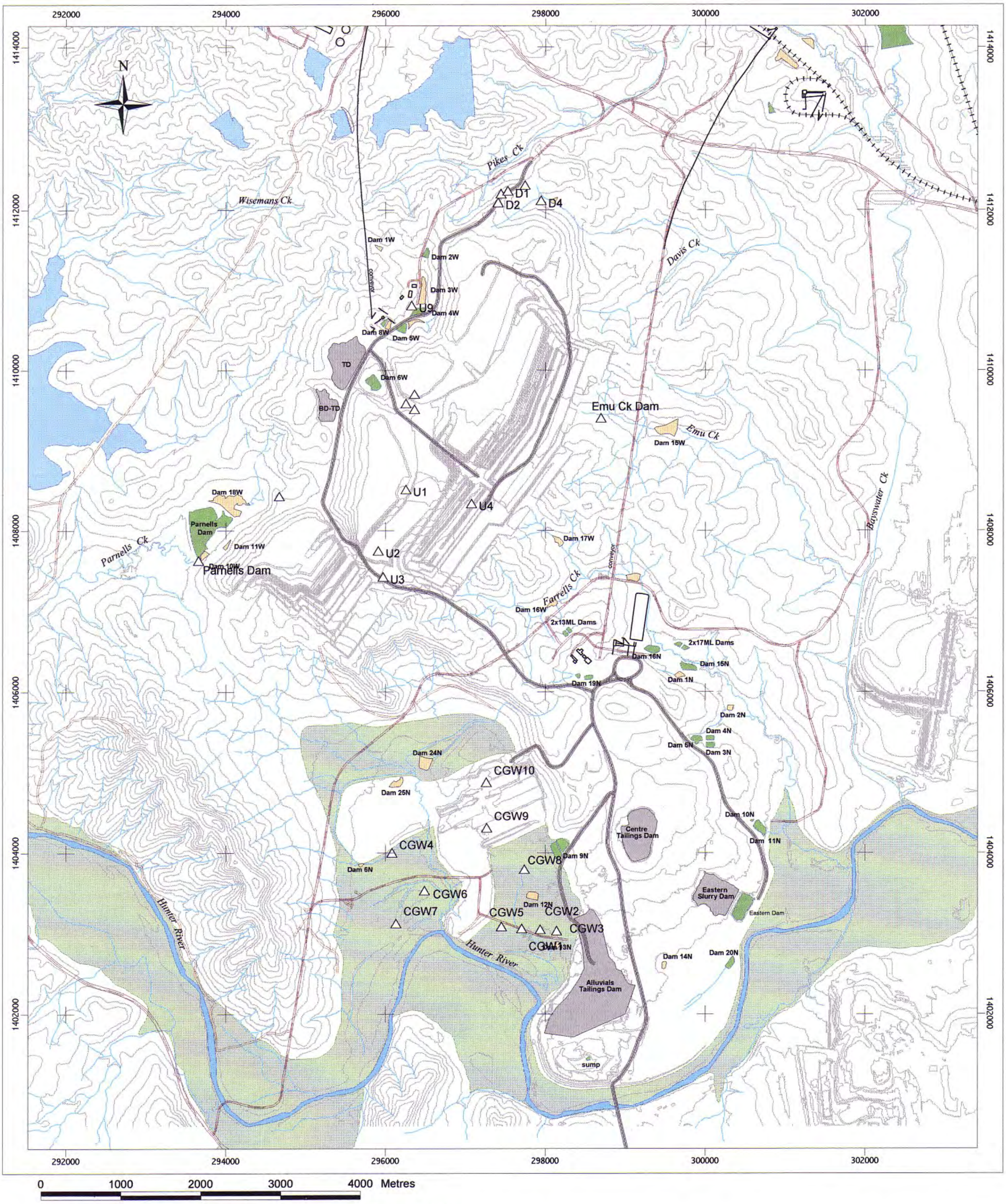
APPENDIX D: HYDROCHEMICAL DATA

Groundwater monitoring in proximity to West Pit is restricted to relatively recently installed piezometers in the Carrington area. Older monitoring data relating to the pit area before open cut mining has been sourced from Elliot, 1987 while monitoring of Parnells Dam water tends to reflect a composite pit water sample derived from groundwater seepage, spoils (rainfall) infiltration and pit runoff. Surface water qualities in some drainages have been monitored. Parameters determined include pH, electrical conductivity (EC), total dissolved solids (TDS), non filterable residue (NFR) and limited cations and anions.

Figure D1 provides groundwater and surface water sampling locations. Basic data are summarised in the following Table D1.

Table D1: Basic water quality parameters

ID	Area	Location	EC	pH
U3	Howick	Yards bore	2070	6.65
U2	Howick	Fault bore	10320	6.85
U4	Howick	Road bore	15240	6.96
U1	Howick	Hillsdale bore	4510	6.46
U8	Howick	Parnell Creek	1120	7.47
U6	Howick	salt flat	1230	8.19
U7	Howick	gully to Parnell Creek	370	7.86
U5	Howick	surface storage dam	170	8.18
U9	Howick	Parnell Creek Well	890	7.34
D4	Howick	Howick Pit	4480	7.67
D2	Howick	South bore	10950	7.24
D5	Howick	surface storage dam	230	7.67
D1	Howick	North bore	10600	7.53
D3	Howick	haul road seepage	5190	7.55
CGW1	Carrington	temp. piezo	14560	7.63
CGW2	Carrington	temp. piezo	19100	7.35
CGW3	Carrington	temp. piezo	10300	7.53
CGW4	Carrington	temp. piezo	13640	7.56
CGW5	Carrington	temp. piezo	8800	6.72
CGW6	Carrington	temp. piezo	10300	7.55
CGW7	Carrington	temp. piezo	4020	7.45
CGW8	Carrington	temp. piezo	14770	7.81
CGW9	Carrington	temp. piezo	12050	6.95
CGW10	Carrington	temp. piezo	11350	7.03
Parnells Dam	West Pit	Parnells Creek Dam	3673	8.5
Emu Dam	West Pit	Emu Creek Dam	605	8.17



Scale 1:65000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- dams: mine, sediment, tailings
- alluvial lands
- topographic contour (10m intervals)
- railway
- lease
- △ sampling location

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WEST PIT EXTENSION & MINOR MODIFICATIONS

Historical hydrochemical sampling locations

Figure D1

APPENDIX E: AQUIFER NUMERICAL MODEL DEVELOPMENT

The application of computer based numerical models to problem solving in groundwater engineering provides a powerful tool for the rationalization of spatially and temporally varying field conditions. The modelling process utilizes a system of mathematical equations for water flow through porous media subject to prescribed boundary conditions. The process requires definition of the aquifer system in respect of geometry, hydraulic properties and applied stresses including rainfall, pumpage, creek and alluvium leakage and pit seepage.

In the present study, a finite difference approach (ModFlow) has been utilized due to the large area, variable topography, extensive drainage systems and the extent of the depressurisation halo that will evolve with continued mining. The method requires dividing the overall area of interest (domain) into a large number of separate cells defined by a nodal point at the centre of each cell. The number of cells defined in the model mesh has been determined by the prevailing drainage system, the mine pit geometry and the expected hydraulic gradients developed in the course of modelling.

The model is a variably saturated scheme and comprises three transversely anisotropic layers with 54960 cells per layer. Total modelled area is 201 sq. km. (Figure E1) with cell areas varying from 1 ha (100m x 100m) to 0.25 ha (50m x 50m). Cells have been designed to represent both West Pit and HVO north of the river, Plashett and Liddell dams, the Hunter River and regional drainages together with the alluvial aquifers and the regional coal measures. Three layers have been adopted for simplicity since a large part of the area to the north comprises the deeper Saltwater Creek Formation and the relatively impermeable Mulbring Siltstone.

Three separate models have been designed to represent

- approximate steady state conditions for the period before mining activity commenced (below the water table);
- transient simulation over a period of mining from 1980 through to the present time then forward for a period of 21 years to 2025. The simulation includes development of Hunter Valley North Pit, Alluvials Pit and Carrington Pit;
- post mining recovery for a final void scenario.

E1. Model geometry

Layer 1 represents the topographically elevated hardrock across the model domain and includes the alluvial lands adjacent to the Hunter River. The base of layer 1 beneath these alluvial lands has been interpolated to reflect a generalised grade downstream based on detailed terrain mapping in areas near the current mining operations (HVO) and a thickness of alluvium of 25 m. In other areas beyond the unconsolidated alluvials, the base of layer 1 is at about 80 mAHD. Layer 2 represents coal measures from the base of layer 1 to the base of the Vane Subgroup at a depth of about 50 m below the Barrett Seam. Layer 3 represents the underlying Saltwater Creek Formation and the Mulbring Siltstone.

E2. Model hydraulic properties

Hydraulic conductivities assigned to each layer have been calculated by a process of ‘assignment by lithologic type’ followed by consolidation to hydraulically equivalent model layers. The methodology comprised calculation of the vertical conductivity distribution at exploration borehole EL5243B which is considered to be reasonably representative of the strata likely to be mined. Laboratory core analyses (Appendix B) were used in generating representative hydraulic conductivities for lithologies given in the following Table E1. These conductivities were then used to develop a full vertical section for EL5243B as indicated on Figure E2 based on detailed logging of core by site geologists. The full section was then reduced to hydraulically equivalent layer conductivities and transverse anisotropies using established formulae.

Table E1: Representative hydraulic conductivities for different lithologies

Lithology	H. conductivity (m/day)
alluvium	2.5E+01
sandstone	3.0E-05
siltstone	1.0E-05
mudstone	1.0E-07
claystone	1.0E-07
shale	1.0E-07
coal – average	5.0E-02
shaley coal	1.0E-04

Since jointing is relatively infrequent and has not been mapped in detail, correction for enhanced conductivity that might be attributed to jointing has been applied in an arbitrary but conservative manner by raising the calculated vertical conductivity determined from Figure E2, by two orders of magnitude.

Compressibility and subsequent estimates of specific storage (as S_s) have been calculated from regional measurements of Youngs Modulus for typical interburden core. These estimates range from 1.00E-06 to 3.2E-06 for a Modulus range from 10 to 30 GPa.

Table E2 provides a summary of properties used in the aquifer model.

Table E2: Hydraulic properties assigned to the aquifer model

Layer	Lithology	Kxy (m/day)	Kz (m/day	Ss (1/m)
1	alluvium/coal measures	2.5E+01 / 6.0E-03	2.5E+01/6.0E-04	.25 / 2.0E-06
2	coal measures	6.0E-04	61.0E-04	2.0E-06
3	sandstone-siltstone	1.0E-07	1.0E-07	2.0E-06

Kxy = horiz. conductivity, Kz = vert. conductivity, Ss = specific storage

E3. Boundary conditions

Boundary conditions assigned to an aquifer model are those conditions that constrain or bound the model domain mathematically. The conditions are applied to the physical outer boundary of the model and throughout internal parts of the model. They include constant groundwater levels (1st type – conductance limiting) within Plashett Dam, Lake Liddell and along the Hunter River, drain nodes (flux constrained 1st type) along creeks and in pit areas, and distributed elemental flux conditions to represent regional rainfall recharge. Utilisation of 1st type conditions along the river enforces seepage from surrounding areas of elevated water table to the river, or seepage from the river to surrounding strata if pressures in those strata are lower than river levels. Drain nodes have also been assigned to pit floor elevations in accordance with the mining history.

Rainfall recharge has been applied at a constant rate of 3 mm/annum over hardrock areas. The coal measures rate has been determined through a number of steady state simulation trials where recharge was progressively increased until regional pressures broadly matched the sparse regional field data. Since the model is fundamentally a forward model based on determination of prevailing conductivities, the actual rainfall recharge is relatively insensitive to the simulated depressurisation process. Recharge at a rate of 90 mm/annum has been applied over alluvial lands along the river where sandy soils and sands are known to facilitate rapid infiltration during sustained rainfall periods. Infiltration could vary over short distances but the use of an average figure provides a simplification and is considered adequate for planning purposes. Because the rate for the alluvium is much higher than for hardrock areas, it is also a relatively insensitive boundary condition in respect of deeper hardrock depressurisation.

E4. Simulation scheme

All simulations have utilised a discrete time stepping for the iterative process in meeting a specified solution error margin. Model output for each stage of mining has been examined for nodal water balance budgets together with vertical and horizontal components of flux.

E5. Calibration

Crude calibration of the aquifer model has been undertaken by comparing pit seepage based on observations over recent years, with seepage predicted by the model.

The water balance for mining operations suggests the approximate dry weather, winter season pit water make is less than 0.1 ML/day. This rate is subsequent to evaporative losses from the walls, floors and sumps. During the summer months of 2002 and 2003 the rate was negligible.

A predicted model seepage rate for 2002 to 2003 is 0.22 to 0.25 ML/day before evaporative losses are taken into account. This range compares favourably with observed rates after allowing for evaporative losses.

E6. Pit seepage

Simulation of the mine plan has been conducted for a period of 21 years commencing in 2004. Results are provided for model layer 2, the layer immediately below the river alluvium and representing the greater part of the coal measures that will be intersected by extended mining in the pit. Figure E3 gives the predicted regional pressure-water table distribution for the 21 years period from 2004 to 2025.

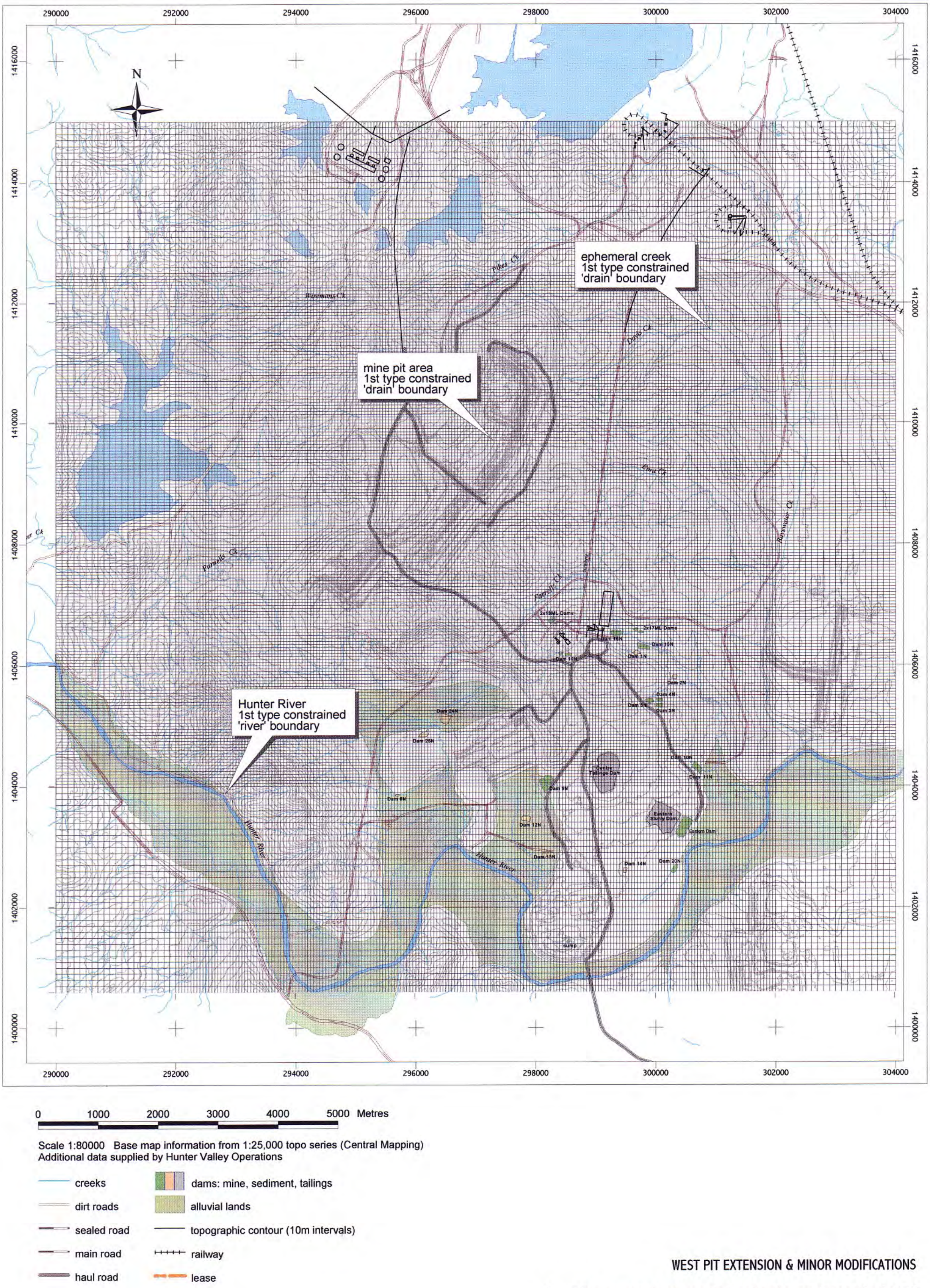
On completion of model simulations, flux balances have been reviewed and specific zone budgets extracted to provide mine water influx estimates given in Table E4.

Table E4: Model predicted seepage rates to mine pit

Year	Project year	Pit seepage (ML/day)
1990	-	0.16
1995	-	0.24
2000	-	0.30
2004	0	0.35
2009	5	0.41
20143	10	0.46
2019	15	0.52
2025	21	0.49

E7. Recovery of coal measures water table

Recovery of the water table within the coal measures has been simulated by adopting the regional water table – pressure distribution at cessation of mining in late 2025, and allowing the model to recover. Pit boundary conditions have been removed and pit hydraulic properties amended to reflect the presence of spoils ie. porosity and permeability have been raised to 20% and 1m/day respectively. The planned void area has been changed to reflect open storage. All other boundary conditions remain the same.



WEST PIT EXTENSION & MINOR MODIFICATIONS

Aquifer numerical model extents and mesh detail

Figure E1

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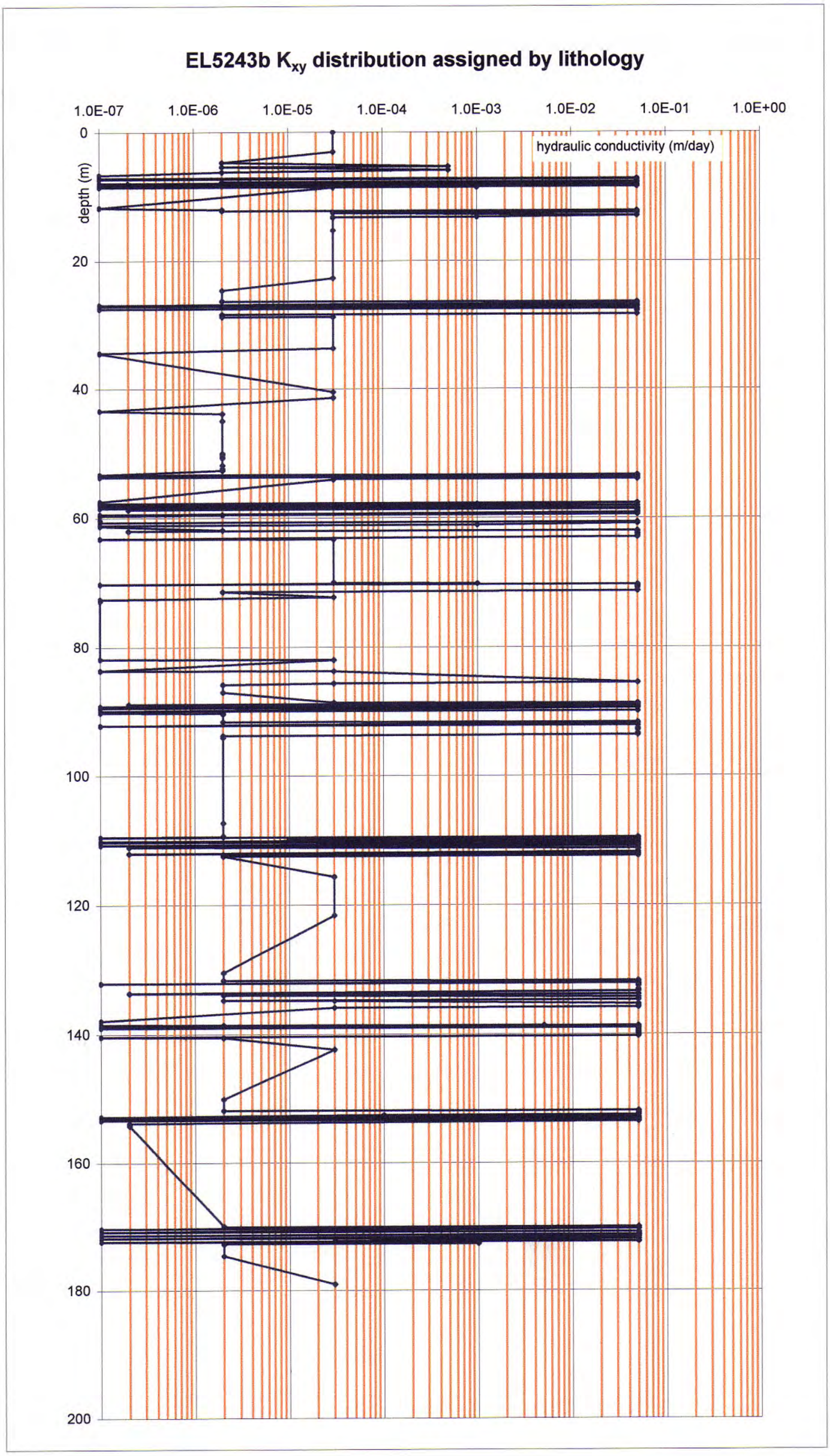
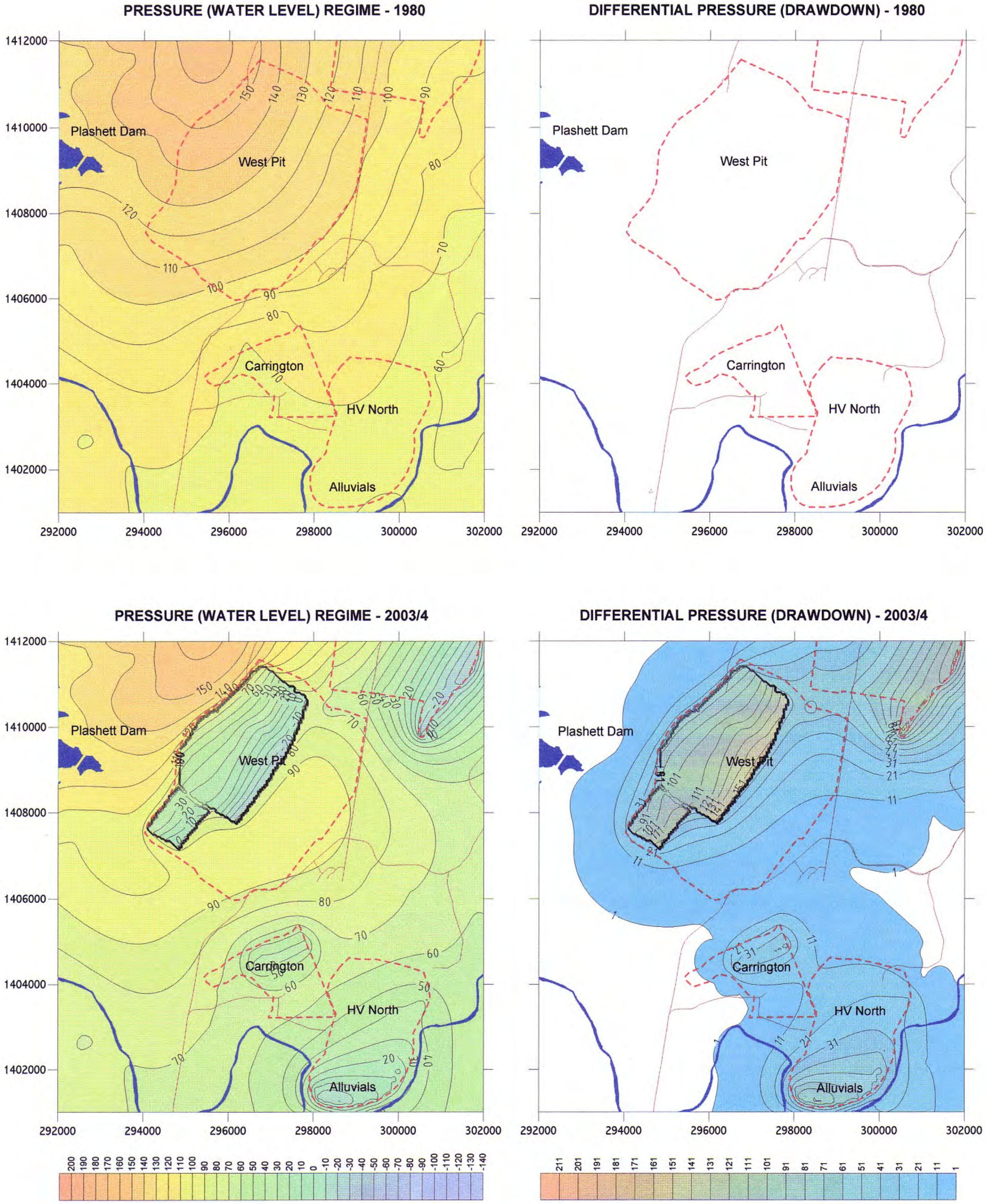

EL5243b Kxy distribution assigned by lithology
1.0E-07
1.0E-06
1.0E-05
1.0E-04
1.0E-03
1.0E-02
1.0E-01
1.0E+00
hydraulic conductivity (m/day)
depth (m)
0
20
40
60
80
100
120
140
160
180
200

Figure E2



Pressures for model layer 2 shown
Aquifer pressures (left hand plots) in metres (AHD)
Open cut pit outlines shown in red
Loss of pressure (right hand plots) in metres of water
Contouring based on 20 metre interpolation interval

WEST PIT EXTENSION & MINOR MODIFICATIONS

Pressure and drawdown distributions - Pre mining and 2003/4

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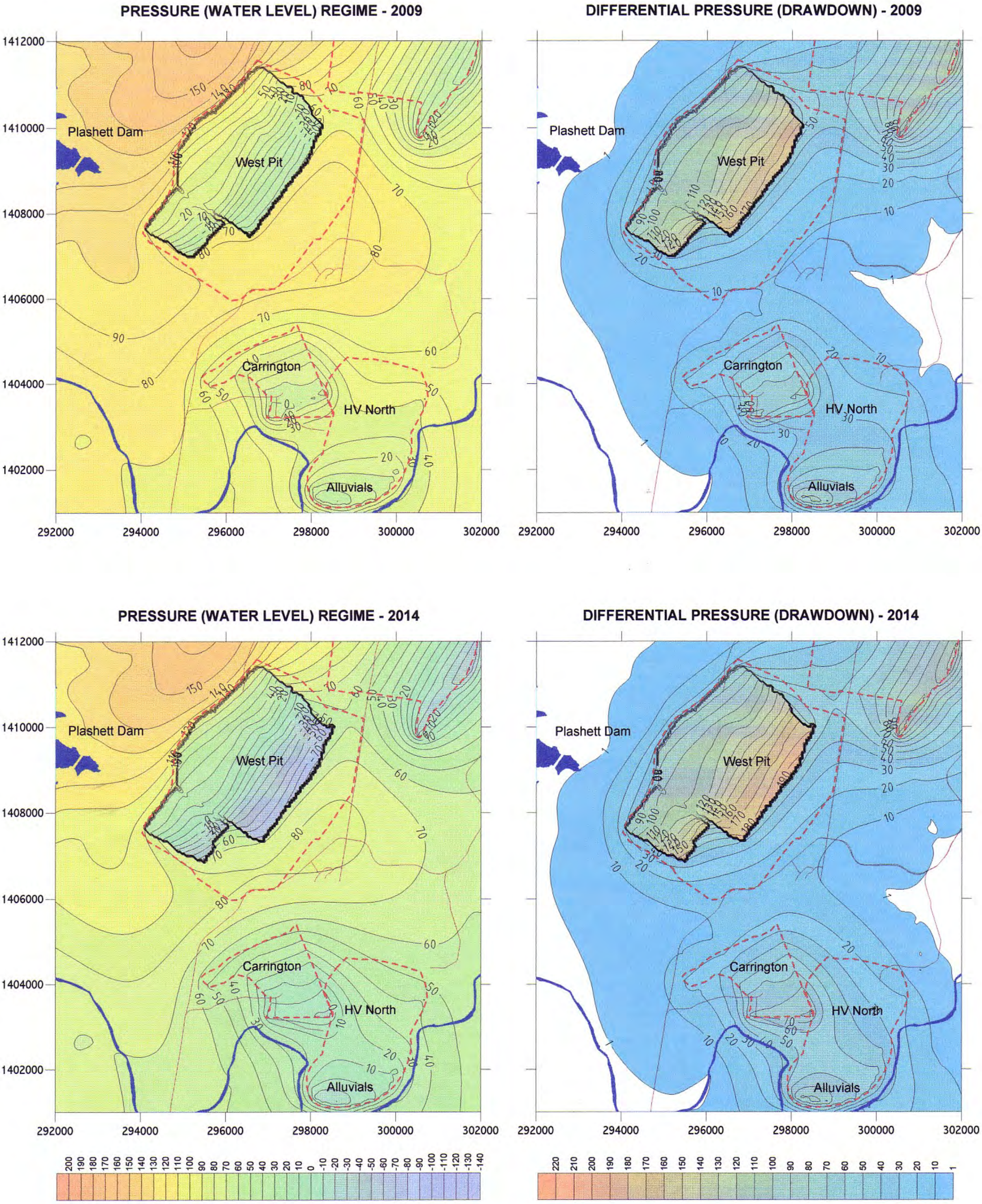
Figure E3



Pressures for model layer 2 shown
Aquifer pressures (left hand plots) in metres (AHD)
Open cut pit outlines shown in red
Loss of pressure (right hand plots) in metres of water
Contouring based on 20 metre interpolation interval

WEST PIT EXTENSION & MINOR MODIFICATIONS

Pressure and drawdown distributions - 2009 and 2014

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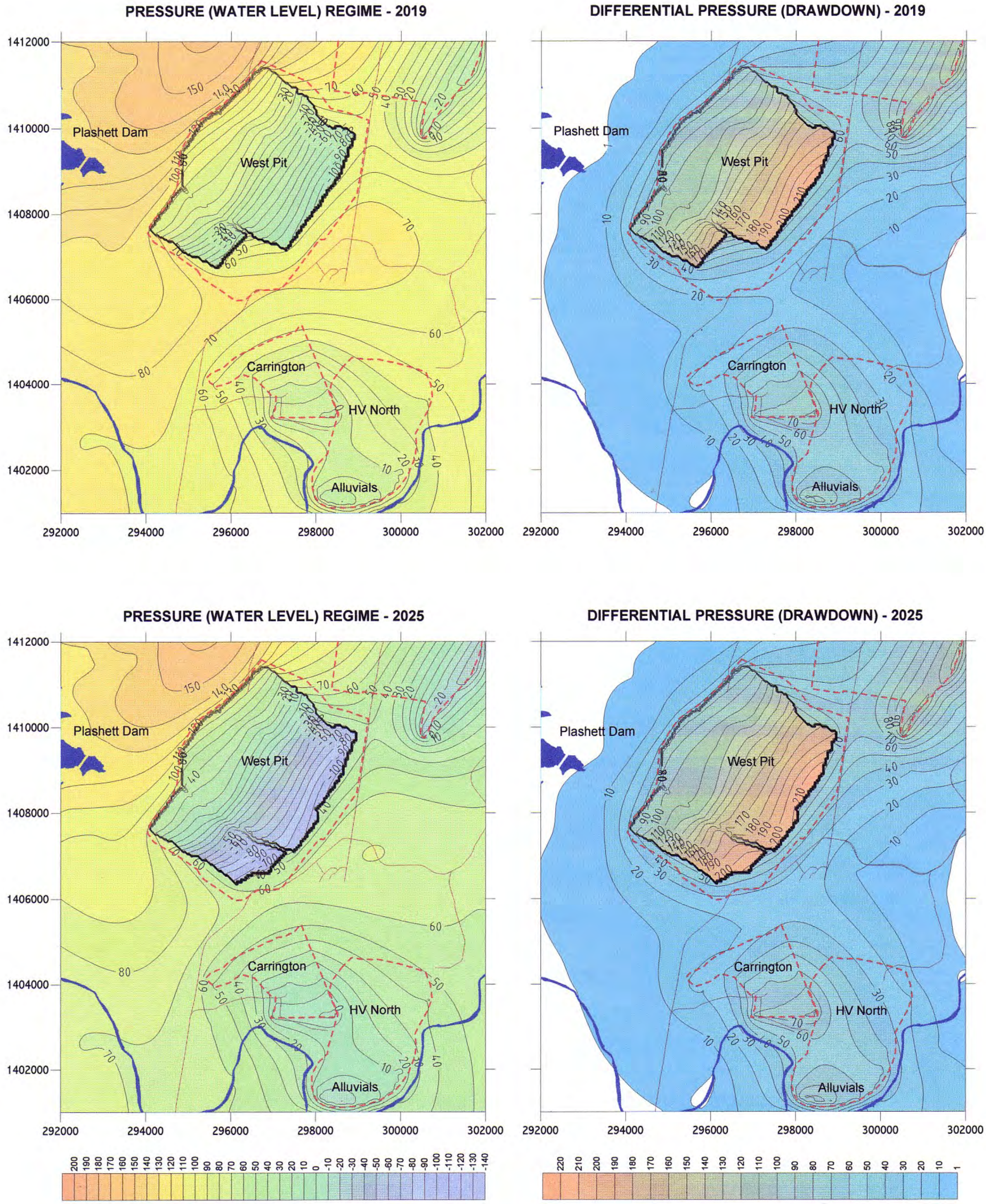
Figure E4



Pressures for model layer 2 shown
Aquifer pressures (left hand plots) in metres (AHD)
Open cut pit outlines shown in red
Loss of pressure (right hand plots) in metres of water
Contouring based on 20 metre interpolation interval

WEST PIT EXTENSIONS & MINOR MODIFICATIONS

Pressure and drawdown distributions - 2019 and 2025

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Figure E5

APPENDIX F: SPOILS LEACHATE

Interburden spoils have the potential to generate leachate in the long term. The process comprises two phases – leachate generation during mining, and leachate generation post mining.

During mining, rainfall percolates into mine spoils areas through unshaped, shaped and rehabilitated areas. The rate of infiltration/percolation varies significantly for the different catchment types. Percolating rainfall below about 5 metres depth (beyond evaporative and root zone influences) is most likely to remain as soil moisture and to migrate to the base of the spoils. The pathway adopted by infiltrating rainfall is preferential due to the nature of emplacement – highly variable grain size from less than 1mm to more than 1 metre diameter leaves many open voids. Leaching of salts occurs along this pathway, the efficiency of the leaching process being governed by the grain size distribution. Large rocks remain essentially impermeable and have poor leaching characteristics while crushed rocks offer improved leaching characteristics due to the reduced grain size and increased surface area per unit volume.

While leachate generation occurs during the 21 year mine period, all leachate during this period is retained within the mine water system since it generally emanates at the toe of the pit low wall and is subsequently used in coal washing, dust suppression and other activities. When mine pit operations cease and rainfall or groundwater begins to accumulate in the final void and beneath the shaped spoils profile, the groundwater quality will reflect a mixture of rainfall, percolating rainfall (through spoils), runoff and regional groundwater. Based on computer simulations of the recovery process and estimation of percolation components, about 70% of void water is expected to be sourced from rainfall either directly to the void or via percolation through spoils.

Since void water level recovery will fully saturate the spoils emplaced below the water table, the salt contribution can be estimated by conducting leachate trials on rock samples having a similar grain size distribution to spoils emplaced. Such distribution is governed by blast fragmentation during mining and is often approximated by the well-known Rosin-Rammler distribution.

F1. SAMPLE PREPARATION

In order to undertake leachate trials, eight core samples were selected from borehole EL5243B at differing depths. This bore is located within the area of the extended pit and is considered representative of the strata that will be mined during the remaining mine life. Core was jaw crushed to –20 mm to facilitate fractionation of samples.

The leachate technique adopted was a simple closed system comprising submergence of samples in de-ionised water and subsequent monitoring of pH and electrical conductivity (EC) over the following weeks. Based upon current research, this approach is considered to provide a reasonable representation of conditions prevailing in spoils at depth. Since EC is a good indicator of dissolved salts, monitoring over time permits extrapolation to limiting values for a crushed sample.

Prior to commencement of the trials, samples were sieved and different fractions separated. By undertaking trials on sieved samples, it was possible to re-constitute different distributions and determine with improved accuracy, the leachable salt load (LSL) for any distribution. Sieved samples included the following fractions +0.18 mm, +0.9 mm, +4.5 mm and +12.5 mm. Sample weights ranged from 50 to 180 grams. Measurement procedure comprised decanting approximately 50 ml of leachate for measurement of parameters. A TPS MC84 meter was used for all EC measurements while a Lutron pH-206 meter was used for all pH measurements. Instruments were calibrated prior to commencement and following completion of measurements. Drift was noted to be insignificant on all occasions. All samples were maintained in the temperature range 18.0 to 21 degrees during the trials.

EC measurements were converted to represent milligrams dissolved salts (using a conversion factor of 0.65) per gram of spoils and then extrapolated to an end point at 100 years for subsequent calculation of mobilisable salt load. Data used for extrapolation of results are shown on Figure F1. End point LSL determinations were conducted by fitting an equation of the following form – coefficients are summarised in Table F1:

$$LSL = (a + b * \ln(t))^2$$

where: LSL = end point (g/kg)
a = coefficient
b = coefficient
t = time in days

Table F1: Summary of leachate samples

Sample	lithology	depth (m)	fraction (mm)	Coeff a	Coeff b	100 years load (gm/kg)
5243/1	sandstone - medium grained	21.7	12.5	1.026	0.021	1.6
			4.7	1.020	0.026	1.7
			0.9	1.002	0.045	2.2
			0.18	1.016	0.031	1.8
5243/2	siltstone - with minor carb fleks	36.3	12.5	0.511	0.150	4.3
			4.7	0.434	0.177	5.3
			0.9	0.428	0.202	6.5
			0.18	0.310	0.376	18.2
5243/3	siltstone - with minor carb fleks	77.0	12.5	0.322	0.202	6.0
			4.7	0.298	0.224	77.0
			0.9	0.255	0.258	8.8
			0.18	0.162	0.421	21.0
5243/4	siltstone - with minor carb fleks	101.4	12.5	0.361	0.150	3.7
			4.7	0.274	0.172	4.3
			0.9	0.205	0.212	5.9
			0.18	-0.152	0.378	14.6
5243/5	sandstone - fine grained	126.4	12.5	0.577	0.063	1.5
			4.7	0.527	0.072	1.7
			0.9	0.537	0.081	1.9
			0.18	0.568	0.098	2.5
5243/6	sandstone - fine grained	145.6	12.5	0.030	0.214	5.2
			4.7	0.036	0.246	6.9
			0.9	-0.013	0.260	7.4
			0.18	0.026	0.246	6.8
5243/7	siltstone - with minor carb fleks	149.6	12.5	0.124	0.192	4.6
			4.7	0.056	0.214	5.3
			0.9	0.050	0.221	5.6
			0.18	0.091	0.265	8.3
5243/8	sandstone fine grained	166.3	12.5	0.165	0.164	3.6
			4.7	0.115	0.176	3.8
			0.9	0.213	0.161	3.6
			0.18	0.486	0.111	2.7

Carb. means carbonaceous laminations

After 12 weeks, +12.5 mm samples sieve were dispatched for laboratory determination of major ions and selected rare elements (Genalysis Laboratory Services). Results are provided as the laboratory data sheets.

Laboratory data has been used to generate a tri-linear speciation Figure F2 for the purpose of classing the leachate and understanding the relationship between leachate chemistry and regional groundwaters. Cations and anions are plotted in the lower left and lower right triangular fields respectively and these points have been projected into the central diamond field. Nearly all samples plot in an area dominated by sodium with minor contributions from calcium and magnesium. Bicarbonate is the dominant anion with subordinate chloride and sulphate contributions. No sample exhibits a strong primary salinity (NaCl).

F2. SALT REMOBILISATION ANALYSIS

Estimates of the leachable salt load at 100 years have been used to determine the LSL per cubic metre of spoils. The estimation adopts an equation that reflects a falling LSL for increasing particle size. While this does not include reactive or weathering components, there is increasing evidence to suggest this assumption is reasonable; most interburden units comprise clastic sediments with quartzose granular structure resulting from the depositional environment, and most spoils are emplaced and covered fairly rapidly.

F2.1 Salt load estimation

Blasting operations will generally aim to optimise fragmentation towards the larger rock sizes. The resulting distribution can be approximated by the Rosin-Rammler formula shown on Figure F3. Two limiting plots are indicated – the maximum sizing assumes efficient blasting and blocking with reduced handling, while the reduced sizing assumes lower fragmentation efficiency leading to an increase in smaller sized fragments.

Laboratory analyses and end point (100 years) estimates for the leachate trials have been used to upscale smaller fragment results to a full fragment distribution using an equation that reflects a reducing LSL with increasing particle size. The equation is of the form:

$RR_{100} = a + b*\ln(\text{size})$ where: RR_{100} = salt leached over 100 years (gm/kg of sample)

$a = 5.9$

$b = -0.65$

size = average (retained sieve) fragment size

Tables F2 and F3 provide summaries of theoretical particle distributions for a 10 tonne sample together with the calculated salt load based on measured release rates and the above equation, and an estimated cumulative (total) salt load for each of the distributions shown on Figure F3. Assuming a spoils average emplaced density of about 1.9 t/m^3, the equivalent mobilisable salt loads per cubic metre of spoils for the optimal and reduced size distributions are 2.99 kg and 4.77 kg respectively.

Table F2: Calculated mobilisable salt (10t spoils) – optimal fragmentation distribution

Screen size (mm)	weight passing (%)	weight retained (mg)	Projected dia. (mm)	calc. salt load (gm/gm)	cum. salt load Load (gm)
<0.18	3.24E-08	0.3	0.09	0.002	0.002
0.18 to 0.4	160E-07	1.6	0.29	0.009	0.011
0.4 to 0.9	8.10E-07	8.1	0.65	0.040	0.051
0.9 to 2.1	4.41E-06	44.1	1.5	0.203	0.254

2.1 to 5	2.50E-05	250	3.5	1.045	1.299
5 to 10	1.00E-04	1000	7.5	3.400	4.700
10 to 20	4.00E-04	3999	20	11.90	16.600
20 to 50	2.50E-03	24969	35	75.30	91.900
50 to 100	9.95E-03	99502	75	230.6	322.40
100 to 200	3.92E-02	392110	150	773.4	1095.8
200 to 500	2.21E-01	2212000	350	3807.8	4903.7
500 to 1000	6.32E-01	6321200	750	6562.2	11465.9
1000 to 2000	9.82E-01	9816800	1500	4007.7	15473.6

Table F3: Calculated mobilisable salt (10t spoils) – reduced fragmentation size

Screen size (mm)	weight passing (%)	weight retained (mg)	Projected dia. (mm)	calc. salt load (gm/gm)	cum. salt load Load (gm)
<0.18	0.0006	5998	0.09	44.8	44.8
0.18 to 0.4	0.0013	7322	0.29	49.1	93.9
0.4 to 0.9	0.0030	16580	0.65	102.5	196.3
0.9 to 2.1	0.0070	39800	1.5	224.3	420.7
2.1 to 5	0.0165	95300	3.5	483.8	904.5
5 to 10	0.0327	162000	7.5	743.6	1648.1
10 to 20	0.0645	318000	20	1257.0	2905.1
20 to 50	0.1530	885000	35	3176.3	6081.4
50 to 100	0.2830	1300000	75	4021.7	10103.1
100 to 200	0.4860	2030000	150	5365.5	15468.6
200 to 500	0.8111	3251000	350	6802.2	22270.8
500 to 1000	0.9640	1529000	750	2441.8	24712.5
1000 to 2000	0.9987	347000	1500	397.8	25110.4

F2.2 Void water quality

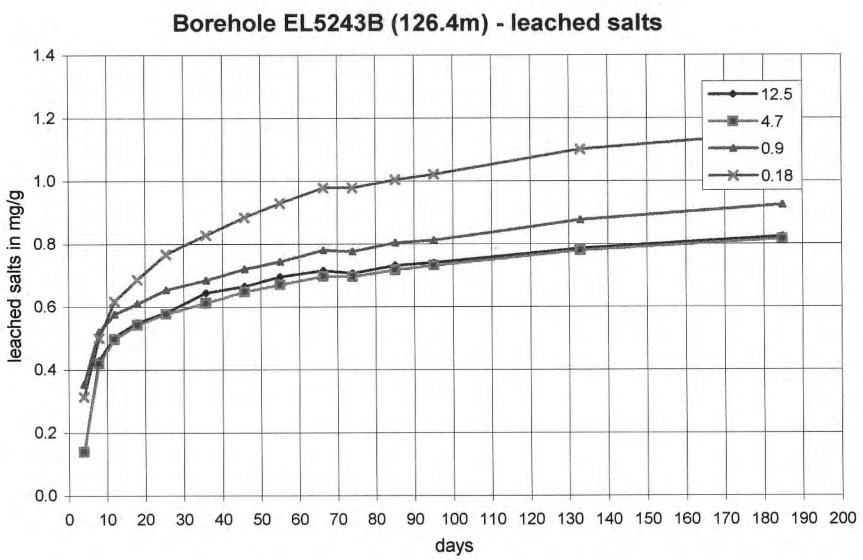
Numerical modelling of the recovery process with rainfall recharge through spoils and direct rainfall to the void, indicates that the void water level will be below –30 mAHD at 100 years post mining. The recovery process can be accelerated by directing rainfall runoff from the rehabilitated spoils areas into the void however there is a limit to this contribution when evaporative losses balance contributions. Using a final void contributing catchment area of about 497 ha, the average annual contribution from runoff is estimated at 580 ML or 58000 ML per 100 years. Combining this contribution with the contribution from groundwater recovery, the estimated water level after 100 years is predicted to be about 30 mAHD.

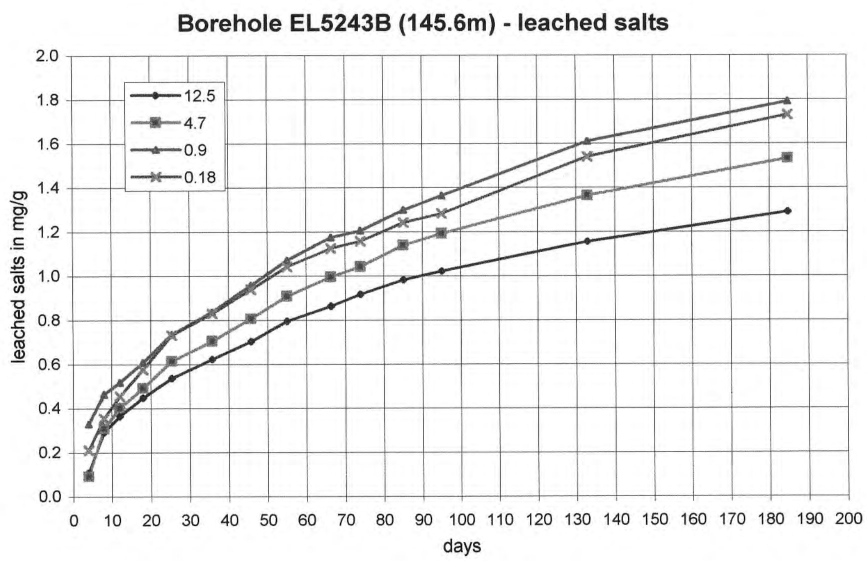
In order to assess the water balance and confirm that an evaporative sink can prevail in the long term, a void simulation model has been used to determine the level at which evaporative losses balance runoff contributions. Through an iterative process involving many simulations, the equivalent water surface that will balance runoff contributions is approximately 130 ha which is equivalent to a void water level just below 50 mAHD. This level would be achieved in a period nearer 200 years. The level is also about 50 m below the planned south void spill point and about 35 m below the original regional water table. Hence an evaporative sink is likely to prevail in the very long term.

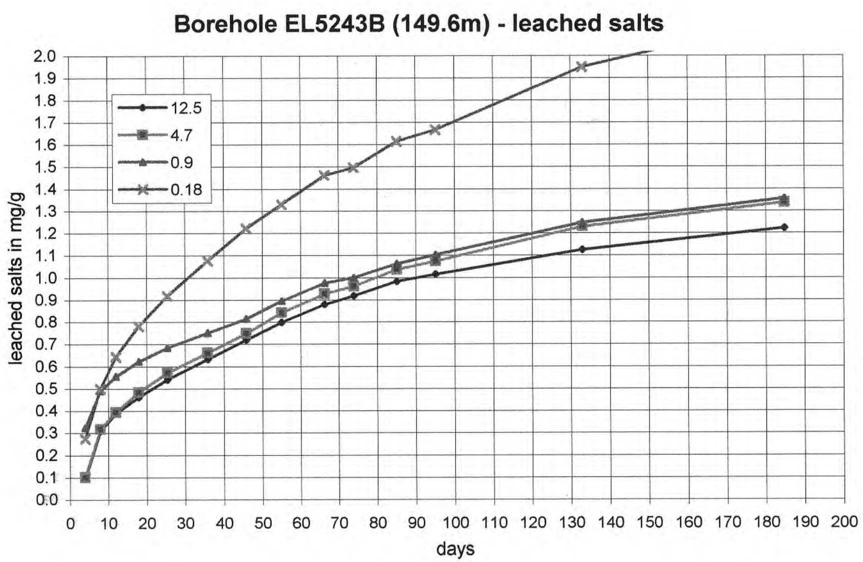
Final void water quality has been estimated by calculating the 'instantaneous' salt load based upon the projected LSL from spoils, dilutions derived from open void storage and a bulk spoils porosity of 20%. The volume of spoils emplaced in the pit below 50 mAHD is estimated at 320 million cubic metres. The void air space that will fill from rainfall runoff and coal measures seepage is estimated to total 52 million cubic metres (see Figure F4 for stage ratings). The following Table F4 provides results of calculations based on leachable salt loads determined for each of the fragmentation distributions given in Tables F2 and F3 and for recovered water table elevations ranging from –60 mAHD to 60 mAHD. Estimates assume 85% of void/spoils water derives from rainfall and runoff while 15% derives from coal measures groundwater seepage with a total dissolved salts content averaging 1950 mg/L (approximately 3000 uS/cm EC). Evaporative concentration effects are not included. The relatively high values are attributed to the high LSL determined for interburden and the large volume of emplaced spoils relative to open water/void conditions.

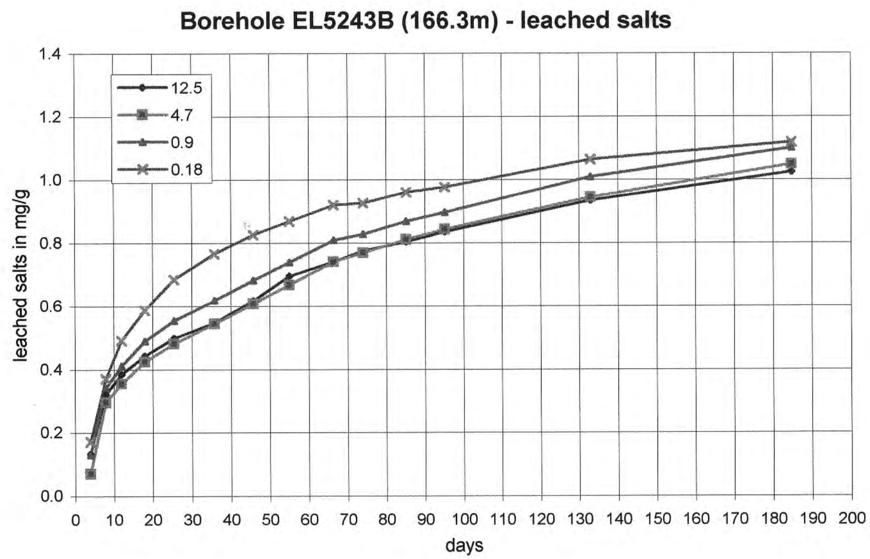
Table F4: Void water quality for recovered levels from –60 to +60mAHD

	units	Optimal fragmentation	Reduced size fragmentation
Leachable salt load per cubic metre	kg/m^3	2.99	4.77
Void water quality RL-60mAHD	mg/l	15438	24318
Void water quality RL-30mAHD	mg/l	15438	24318
Void water quality RL- 0mAHD	mg/l	15228	23985
Void water quality RL30mAHD	mg/l	14874	23420
Void water quality RL60mAHD	mg/l	14391	22651



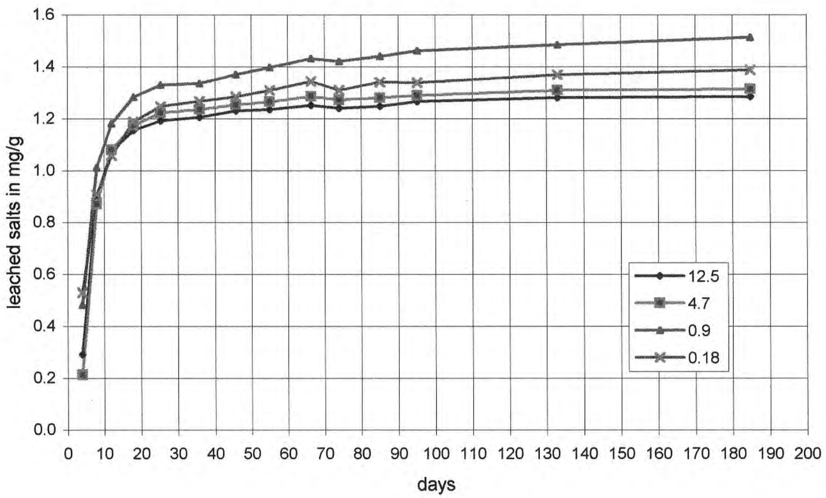




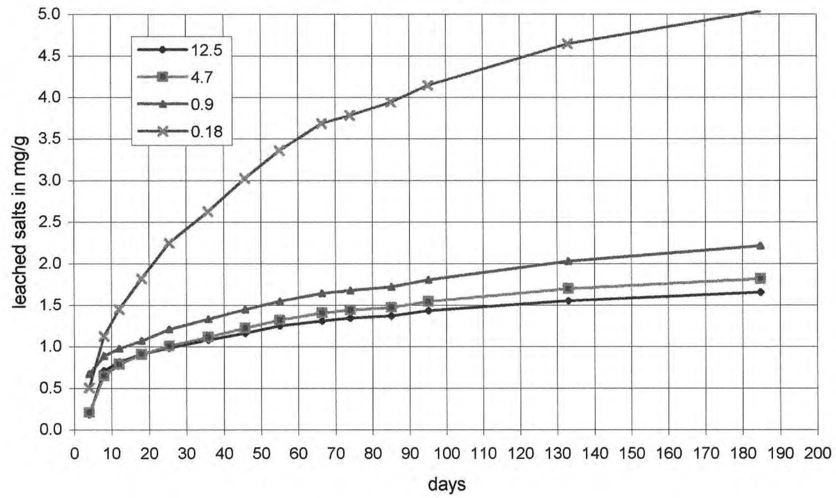


Leachable salt trials on core

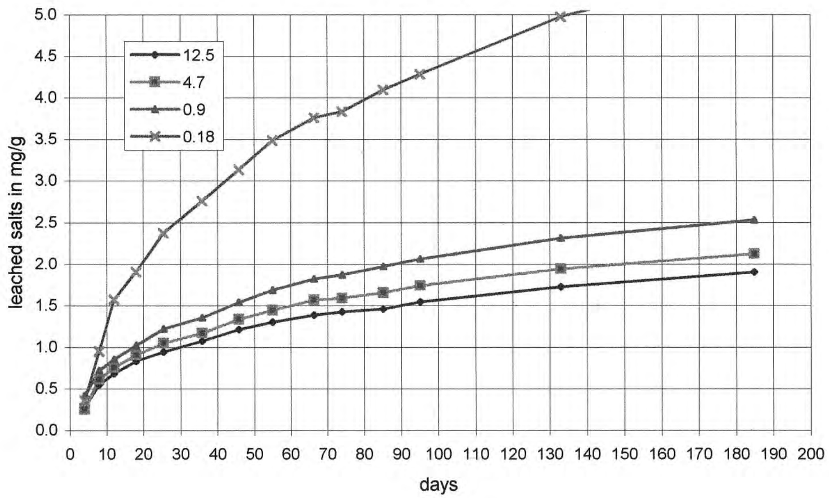
Borehole EL5243B (21.7m) - leached salts



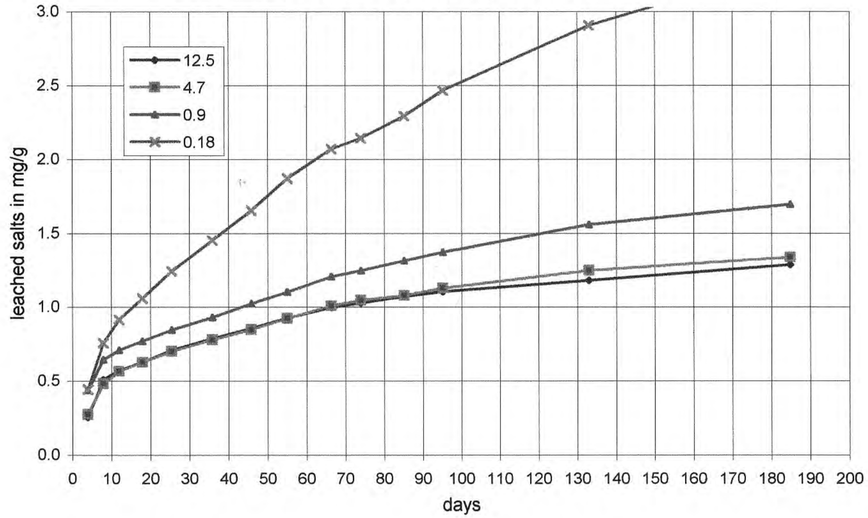
Borehole EL5243B (36.3m) - leached salts



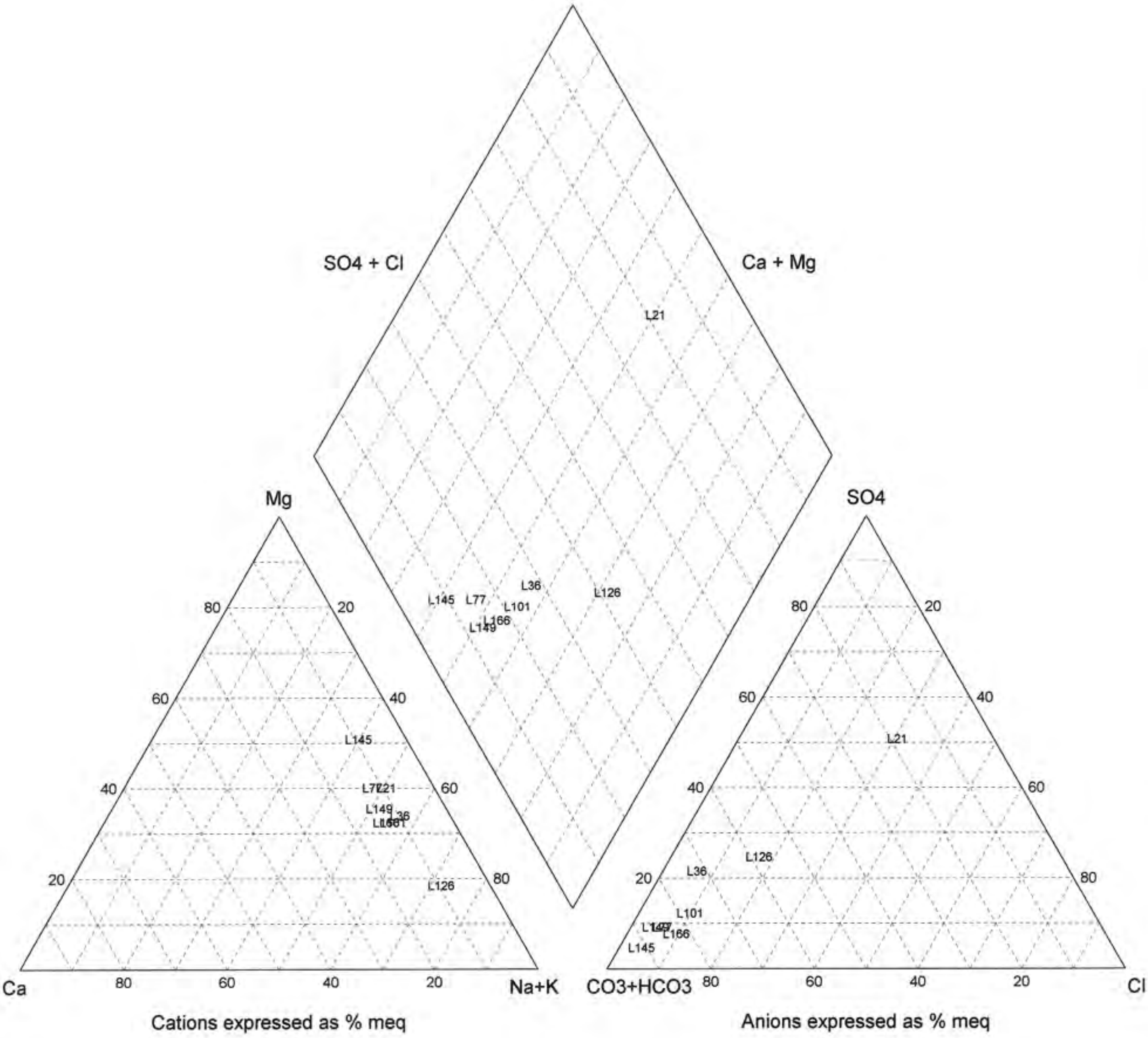
Borehole EL5243B (77.0m) - leached salts



Borehole EL5243B (101.4m) - leached salts



Leachable salt trials on core



IONIC SPECIATION SUMMARY (milligrams per litre)

Sample	TDS	Ca	Mg	Na	K	CO3	HCO3	SO4	Cl
L21	580	17	43	102	9		98	219	96
L36	760	25	58	172	13		592	138	32
L77	850	37	78	164	16		830	76	30
L101	530	23	37	118	11		445	58	32
L145	650	21	69	99	9		689	31	16
L126	290	9	11	77	6		171	56	28
L149	510	24	39	105	8		470	42	14
L166	460	22	33	99	6		421	33	26

HYDROCHEMICAL FACIES DIAGRAM

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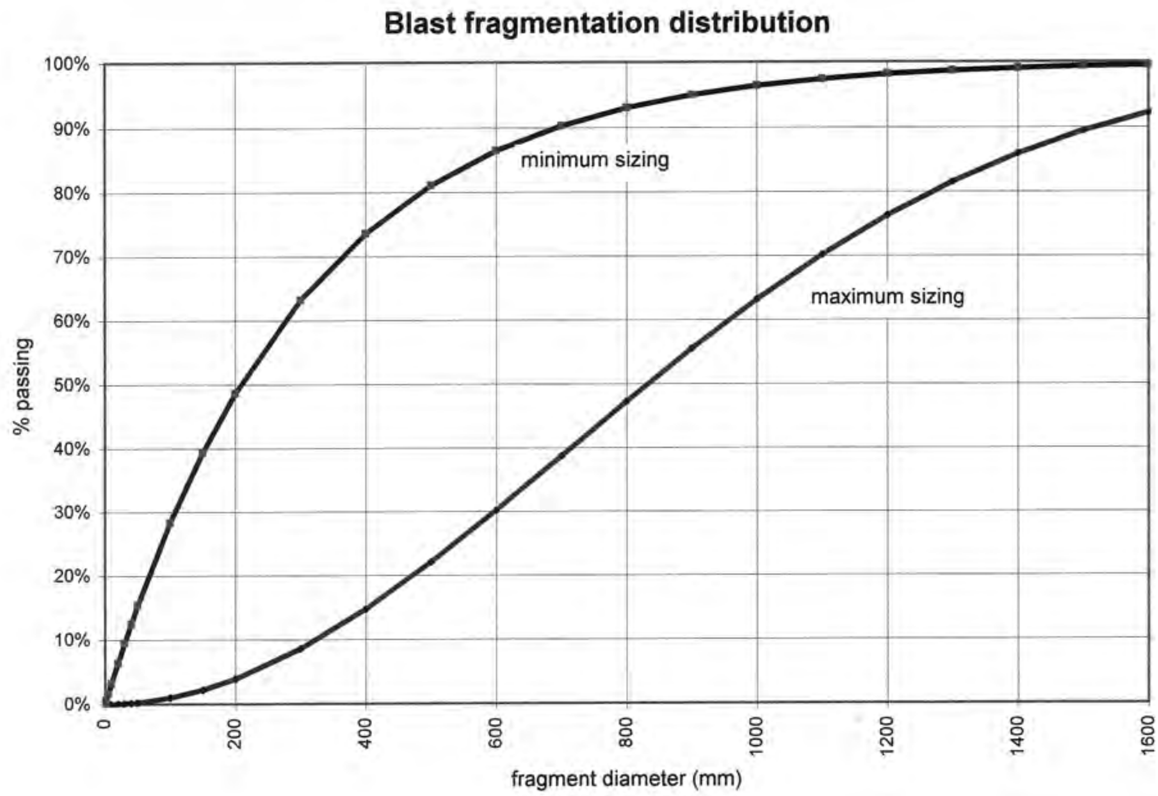
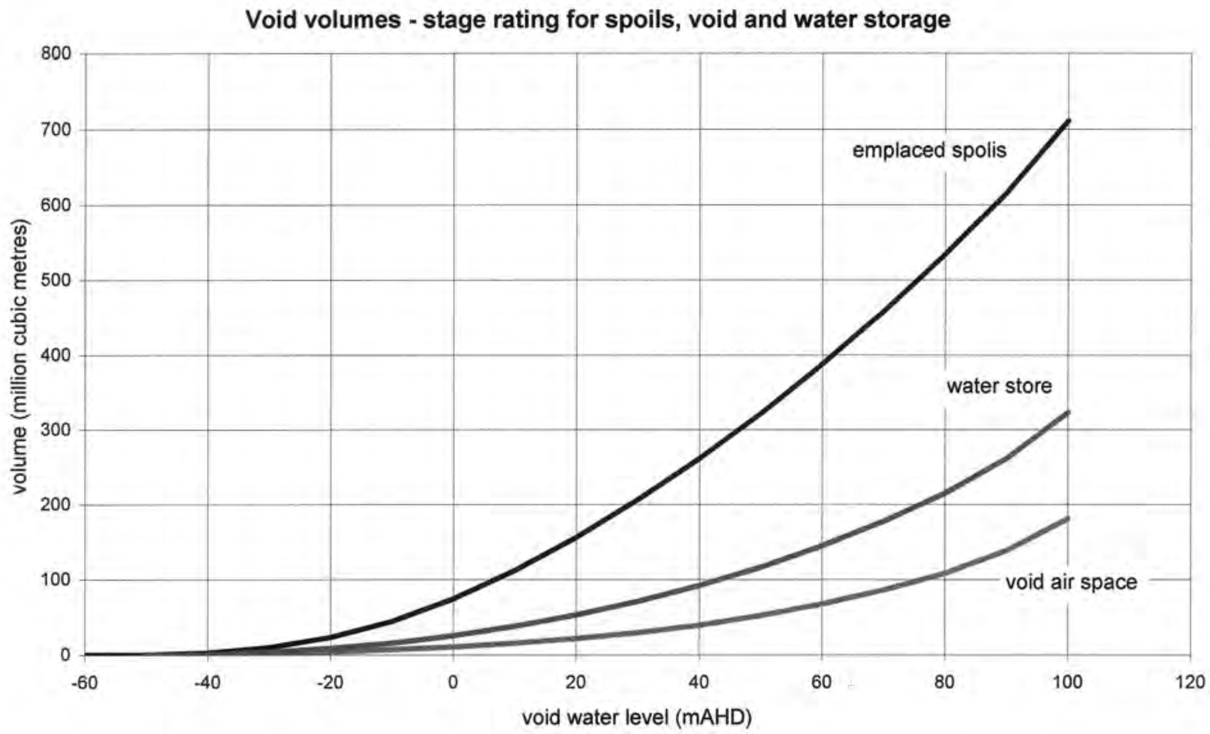
Figure F2

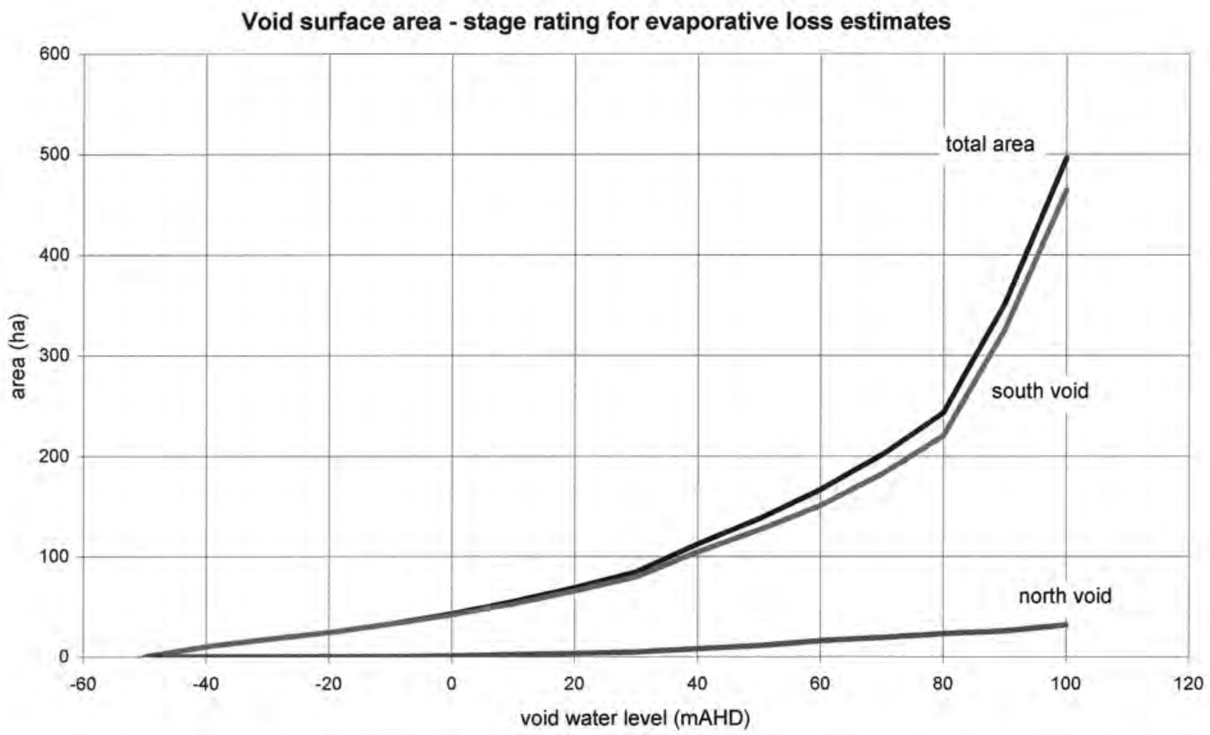


Grain size distribtions assume Rosin - Rammler equation for optimal blast fragmentation. Minimum sizing (increased contribution from fines) has been adopted as the base case for calculating mobilisable salt load. Maximum sizing results in a lower overall mobilizable load.

WEST PIT EXTENSION & MINOR MODIFICATIONS

Assumed spoils fragmentation distributions





WEST PIT EXTENSION & MINOR MODIFICATIONS

Stage rating curves for emplaced spoils and open voids

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Figure F4

APPENDIX G: WEST PIT MINE WATER MANAGEMENT SYSTEM

G1. Regional catchments

Continued development of West Pit will affect regional drainages. Parts of Emu Creek and Farrells Creek catchments will be consumed over the 21 years period of mining while runoff from rehabilitated areas will be progressively directed back to natural runoff – mainly within Parnells Creek and Davis Creek catchments. Figures G1, G2 and G3 illustrate the changing catchment areas (see main text Section 5 for details).

G2. Mine water management simulation model

The WaterLog-5 dynamic catchment simulation and water balance model is a computer based scheme that has been designed and tested over a number of years. The model was developed in recognition of the need to understand mine water management system responses to rainfall and to establish storage capacities to meet most mine site operational conditions.

The proprietary computer model (written in Fortran 90) incorporates a number of published algorithms and estimation techniques, and includes rainfall and runoff from both undisturbed and disturbed catchments with provision for changing catchment areas, percolation to groundwater, pit seepage, accumulation of runoff in designated storage dams, siltation of dams, pumpage (transfer) between dams and pumpage from dams for mine site usage. The model also includes a module for discharge of surplus water from a system at nominated rates and at specified times to facilitate review of system response to external constraints such as the Hunter River Salinity Trading Scheme (HRSTS).

Like many soil moisture accounting techniques, the catchment runoff modules are based on a lumped parameter design utilising daily rainfall records and monthly evaporation potentials. The following schematic shows the general design of the runoff analytical process while the following provides an overview of components.

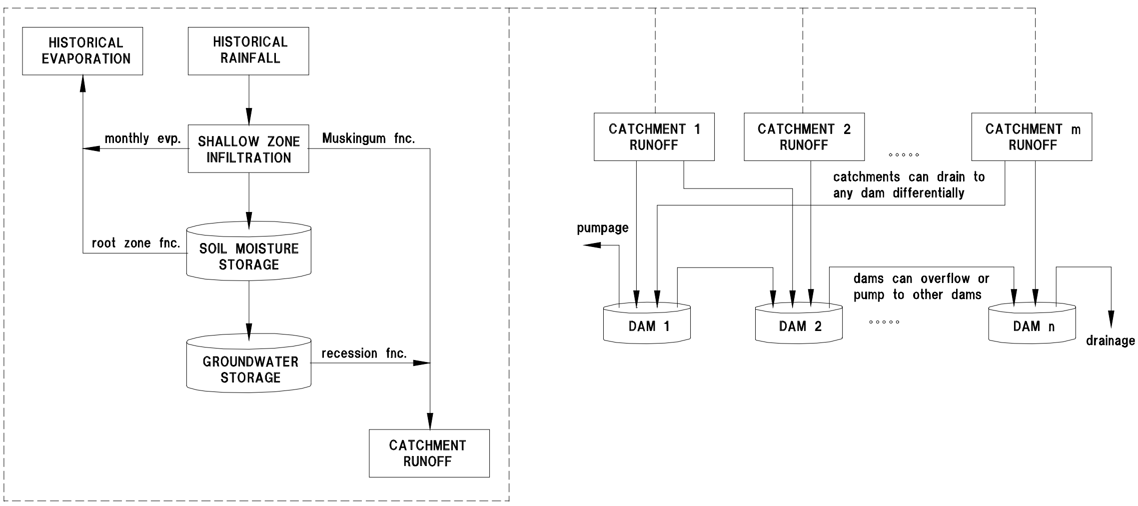


Fig G4: Generalised layout of water management model

Fundamentally the model calculates and accumulates runoff from any number of specified catchment types based on daily rainfall and evaporation, and balances the water budget on a daily basis. The model is broadly subdivided into catchment contributions and storage management.

Catchment areas: Catchment areas (including underground operations) are assigned but may be varied during the course of a model simulation. Variable catchment areas are particularly useful for generating simulations of mine and other developments where for example, strip and bench, pit, spoils and rehabilitated areas are steadily expanding during development. The smallest incremental change in a catchment area is monthly.

Rainfall: Daily rainfall data is used for all simulations. However to account for variability in rainfall and variability in infiltration, the model disaggregates daily receipts into a sequence of hourly receipts based upon a generalised relationship between absolute rainfall received, and event duration (Pitman, 1973). Once the duration of rainfall (less than 1 day) is established, the rate of fall is then adjusted to reflect a steady increase in intensity followed by a steady decrease in intensity over the period, the total mass received being equivalent to the recorded daily rainfall. Model time stepping is then adjusted accordingly. In this manner a more realistic accounting of evaporation and infiltration is implied but the procedure also constrains rainfall to the daily measurement period. Continuous rainfall over a number of days is treated as separate 24hr events for each day.

Evaporation: Evaporation is assigned as monthly mean Pan A adjusted by an open water or crop/tree loss factor etc. and is calculated and applied daily to both catchment soils and water bodies. Evaporation may also be estimated using the Penman-Thornwaite equations.

Interception storage: Initial losses from any rainfall event are incurred by interception within the canopy or grass cover, or by wetting of the soil surface before any infiltration can occur. Normally this amounts to only 1 or 2 mm of rainfall and is removed from the model accounting process at the average potential evaporation rate.

Surface runoff: This component is comprised of runoff from impervious areas and runoff attributed to surplus rainfall not able to infiltrate the soil zone when soil moisture is at a maximum or when rainfall intensity is higher than the soil infiltration capacity. Runoff from impervious rock outcrop is calculated by simply assigning a percentage of a catchment adjacent to drainage. Impervious areas can be estimated by geological inspections or air photo analysis. Runoff arising from surplus soil moisture is calculated by first accounting for a number of subsurface processes described below and including infiltration and percolation.

Infiltration: Soil seepage throughout a catchment is unlikely to be uniform. In order to address possible variance a symmetrical triangular frequency distribution (Pitman, 1973) may be utilised whereby minimum and maximum expected infiltration rates are assigned and the mass infiltration is then calculated. Other distributions may also be adopted. Infiltrated rainfall enters a nominated soil storage zone from which losses are then incurred via evaporative root zone uptake or downward percolation to a deeper aquifer. Surplus rainfall not able to be infiltrated at the specified rate, is assigned to surface runoff. Soil infiltrometer testing or experience at other locations can provide estimates of parameters governing infiltration. A number of measurements have been conducted in the Upper Hunter region to improve parameter selection.

Evapotranspiration: Loss from the soil storage zone is calculated by a pre-determined relationship between storage and evaporation. Pitman (1973) adopts two loss functions based on a linear relationship between potential evaporation and soil moisture. Additional routines provide options for the root zone (inc. rehabilitated areas).

Groundwater percolation: Downward migration of soil moisture is governed by a simple power relationship with the maximum percolation occurring when soil moisture storage (assigned as mm of water storage) is at a maximum. Once moisture has departed the shallow storage zone, evaporative processes no longer apply and the infiltrated volume is then assigned to shallow groundwater storage. Shallow groundwater storage is regarded as that component providing base flow to runoff in drainages or via the regolith to mine pits.

Groundwater seepage: Migration of shallow groundwater within the catchment normally results in bank seepage along drainage lines or seepage from the toe of spoils in mine areas. This process is simulated by a relationship where the rate of seepage is proportional to the square root of groundwater storage. As storage falls, seepage declines exponentially. Introducing an integer number of days before seepage emanates at the catchment exit accommodates lagging along this flow pathway. Lag may be extended from days to months to account for situations like mine spoils where rapid infiltration may occur but migration to the toe of spoils (in pit) may take a considerable time depending upon pit floor geometry and the emplaced spoils characteristics. An additional direct component of seepage calculated from alternative aquifer modelling techniques (analytical or numerical modelling) may be applied to a specific catchment to replicate mine pit or underground seepage contributions from floor and highwall or longwall areas.

Runoff: Surface runoff is attenuated by application of the well known Muskingum equation with a weighting factor set to zero for reservoir type storage attenuation.

Storages: Runoff from any number of catchments (each with differing properties) can be directed into storages. Runoff may also be split proportionally and assigned to different storages. The storages are assigned a maximum and minimum operating level together with a siltation rate designed to reduce storage in time. Rainfall and evaporation processes apply to each storage. Since evaporative losses depend upon surface water area, each water surface may also be adjusted on a prescribed volume/area relationship derived from a stage relationship and calculated daily. Storage can overflow by gravity drainage to another storage, or be depleted or replenished by pumping. Response plots for a mine site can then be generated for any part of the rainfall history. A storage may also be triggered to discharge at a prescribed time and rate (extremely useful for HRSTS compliant discharge assessments).

Pumping: Any number of pumps may be assigned to transfer water between storages or to pump water to a particular usage. Pumping rates can only be defined on a long-term average daily basis.

G2.1 Model calibration

The water management model has been previously calibrated in a coarse manner based on the system shown on Figure 14 (main text) and utilising pumping data, measured water levels in storages and anecdotal information. A history matching was generated for the period from 1995 to 1999 (MER, 1999). Model response plots indicated the system tended to operate with a deficit if all HRSTS opportunities were exercised. In extended dry or drought periods, the system would require make up water supply from external sources as pit groundwater seepage is low to negligible. Surpluses arose only during extreme wet periods.

Qualifications applying to the model included the following:

- Catchments were assigned uniform infiltration parameters (for each catchment type) and changing areas during the mine life. This generalisation could result in extended lag times between rainfall receipts and runoff entering the mine water system. The loss to evaporation and to groundwater infiltration resulting from the lagging could introduce errors. It was not possible to address these errors globally without conducting extensive runoff measurements across the entire mine site.

- Mine usage rates for coal production (CPP) were average rates. These rates could vary significantly depending upon the quality of ROM being washed, the yield and the prevailing climatic conditions. This variability could introduce short term departures between observed and predicted stored water volumes;
- Accurate apportioning of dust suppression water usage was not possible as climatic and seasonal conditions may have lead to wide variance. Assigned values in the model were therefore based on average conditions;
- Pumping between storages and pumping for different usages was maintained constant during the simulation period. Hence some storages may have reflected higher simulated levels than measured levels at certain times. However higher levels in one storage would have been offset by lower levels in other storages.

These same qualifications apply to modelling of the future system response.

G2.2 Salinity trading scheme

Only a few discharges were incorporated in the calibrated model period. However future water management will rely upon HRSTS discharges. This scheme provides opportunity for release of impaired quality mine water to the Hunter River at times when the river can best accommodate elevated salt levels. The scheme operates through the provision of salt credits (first issued January 1996) and advice from DIPNR regarding times of release. Discharge opportunities are governed entirely by flow and salinity conditions within the river and all releases occur into specified blocks of 24 hours duration.

A block is identified through careful evaluation of catchment rainfall distributions and responding river levels/flows. If river flow observations confirm a block will meet specified HRSTS criteria, then appropriate notification is given (by DIPNR) and participants may then release mine water to the river.

Table G1 provides a summary of impending constraints on releases to the river. Three flow regimes are prescribed with discharges only permissible during ‘high’ or ‘flood’ flows. High flows require a calculation of the absolute salt load transferred to the river, the maximum load (and hence discharge) being determined by the number of salt credits held. Coal and Allied currently retain more than 200 credits.

During high flows, the discharge limit imposed on the Parnells dam is based upon a percentage of the total allowable discharge (TAD) and is calculated by dividing the assigned salt credits by the total of salt credits (1000). The TAD is determined during a high flow by the difference between the measured river salinity, which is usually between 600 and 1000 uS/cm, and the sector assigned salinity (900 uS/cm) calculated in equivalent tonnes of salt. If the measured river salinity is below 900 uS/cm then mine water may be discharged. In this manner a percentage of the TAD is allocated to West Pit (Hunter Valley Operations).

In order to determine an average TAD for the middle sector, river flow and salinity data for Glennies Creek gauge has been processed over the period 1995 to 2002. By extracting high flow days and their equivalent salinity, it has been determined that an average TAD is about 645 t. Hence the average discharge limit could exceed 129 t or about 60 ML/day based upon an average long term discharge dam salinity of 3300 uS/cm (range 2000 to +6000 uS/cm) and application of 200 credits. 15 Ml/day could be discharged on high flow events if only 50 credits are applied.

Table G1: Hunter Salinity Trading Scheme definitions

River sector	Gauge	High flow salinity (EC - uS/cm)	Low flow (ML/day)	High flow (ML/day)	Flood flow (ML/day)
Upper	Denman	600	<1000	1000 to 4000	>4000
Middle	Glennies Ck	900	<1800	1800 to 6000	>6000
Lower	Singleton	900	<2000	2000 to 10000	>10000

all flood flow salinities are 900EC

G2.3 Calculation of HRSTS release opportunities

In order to determine historical HRSTS release opportunities applicable to historical rainfalls (for mine water system modelling), synthesized river flow data generated by DIPNR has previously been processed assuming a minimum 2 days lead time for high and flood flow events in the upper sector and 1 day in the middle sector. If flood flows enter the middle sector above Denman but reduce to high flows, then a high flow is assumed to occur in the middle sector rather than a flood flow. High flows must satisfy salinity constraints on all sectors to carry through to the lowest scheme gauge at Singleton.

G2.4 Model simulations

The mine water management model has been used to assess system response to changing catchment areas and variable climatic conditions over the remaining mine life. Figures G5 to G10 show pit development and the main water management elements to 2025 while Figures G11 to G15 show catchments contributing in full (or in part with diversions) to the mine water system. The following Table G2 provides a schedule of catchment areas and Table G3 gives the main catchment parameters adopted in the model.

Table G2: Summary of catchment areas 2003/4 to 2025 (ref. Figures G11 to G15)

	2004	2007	2012	2017	2022	2025
HS1	35	35	35	35	35	35
RH1a	53	63	63	185	187	152
RH1b	19	19	19	19	19	19
RH2	68	105	105	305	308	107
RH3	65	67	67	67	67	104
RH4	34	32	32	32	32	32
RH5	15	15	15	15	15	15
RH6	12	12	12	12	12	12
RH7	0	0	0	0	0	309
RH8	0	0	0	0	0	409
SB1	100	113	108	96	97	104
SB2	119	150	144	134	175	58
SB3	62	123	123	130	236	0
SS1	141	188	239	215	212	372
SS2	190	192	268	182	151	0
SS3	36	47	47	87	87	0
TD1	23	23	23	23	23	23
TD2	39	39	39	39	39	39
UD1	195	195	195	195	195	195
UD2	47	47	47	47	47	47
UD3	78	0	0	0	0	0
US1	29	42	60	26	25	0
US2	61	57	80	45	33	0
US3	36	37	37	10	0	0
US4	35	0	0	0	0	0

Table G3 Summary catchment infiltration/runoff control parameters

Catchment	Pow	Smin (mm)	Smax (mm)	Sseep (mm/day)	Kmin (mm/hr)	Kmax (mm/hr)	Int. (mm)	Lag days
undisturbed	2	0	50	0.05	0	30	2.5	0
strip-bench	2	0	20	0.5	0	80	2	0
unshaped spoils	2	0	400	5	0	200	2	1
shaped spoils	2	0	250	2	0	80	2	10
rehabilitated area	2	0	150	0.5	0	30	2	10
hard stand	2	0	1	0.01	0	0.1	2	0

Where:

Pow is a power exponent for the seepage equation
Smin is the minimum soil moisture storage capacity
Smax is the maximum soil moisture storage capacity before runoff is initiated
Sseep is the rate of percolation to the shallow (regolith) aquifer
Kmin is the minimum surface infiltration rate
Kmax is the maximum surface infiltration rate
Int is the interception storage (does not enter the soil store)
Lag is the travel time in days for percolation seepage emanating at wall toe

Runoff from each catchment has been accumulated in specific storages noted in Table G4. The remaining 21 years of pit life has been tested against historical rainfall periods of equivalent length (daily rainfalls). Selected periods have commenced in 1900 and have been offset by 5 years thereby overlapping model responses.

The 21 years period of mining (West Pit) includes the following constraints and controls:

- CPP usage (as a loss rate for 4.5 Mtpa) – 1.8 ML/day
- Dust suppression as water cart usage at an average rate of 1.1 ML/day
- Truck wash, plant wash losses etc. at a rate of 0.05 ML/day
- and stockpile dust control at a rate of 0.05 ML/day
- variable catchment areas;
- rainfall entering the pit(s) is pumped rapidly to nominated dams in order to maintain pit/seam workability;
- redirection of runoff from rehabilitated areas out of the mine water system and back to the regional catchments.

Results of selected simulation periods are provided in the following Figures G16 to G18. These periods include the wettest term (1940 to 1958), the driest term (1930 to 1948) and a period during which, climate was less extreme (1970 to 1988).

All model simulations have been summarised in the form of percentile (probability) exceedance plots for the main pits, the main dams and total mine water storage – Figure G19.

Table G4: Mine water system – main storages

Title	Capacity (ML)	Name & characteristics
Parnells Dam	750	The main mine water storage dam supplying. Licensed HRSTS discharge (130ML) to Parnells Creek. Water may be pumped to Dam 2W or Dam 4W.
Dam 1W	15	Sedimentation-staging dam for contour drain
Dam 2W	14	Accepts water from West Pit North and from Dam 15W. Water is drawn for the washery (WPCPP), for fire water and for supply to the Turkeys Nest at the truck fill point (dust control)
Dam 3W	45	Sedimentation dam – can be pumped to contour drain above Dam 1W
Dam 4W	40	Accepts water pumped from Parnells, south and centre ramps, and Dam 5W. Water may be pumped to Dam 2W
Dam 5W	42	Accepts water from Dam 8W and Dam 4W. Water may be pumped to Dam 4W
Dam 6W	50	Acts as a local sump for runoff.
Dam 8W	14	Accepts runoff from hardstand facilities, washery etc. Overflows to Dam 5W
Dam 15W	25	Accepts water from pumped from West Pit North and pumps water to Dam 2W
Tailings Dam	+50	May hold water temporarily but decant is generally pumped to WPCPP. Leakage down dip through spoils
Bobs Dump Tailings Dam	+100	May hold water temporarily but decant is generally pumped to WPCPP. Leakage down dip through to spoils
Emu Creek Dam	15	Sedimentation dam on Emu Creek

G2.5 Sedimentation dams in rehabilitated areas

Rehabilitated areas have been diverted from the mine water management system and have not been included in water management system modelling. These diverted areas are assumed to be sufficiently regenerated to permit runoff to return the natural watersheds with sediment control established at the watershed discharge points. Sediment dams will be maintained or constructed on a needs basis. Where new dams are to be constructed, design criteria will comply with the following and will aim to minimize release of impaired quality water:

- design capacity based upon a 1 in 20 years ARI (t_c) storm event and inlet/spillway structures designed to convey a 1 in 10 years ARI (t_c), minimum settling depth of 0.6m.
- and/or prescribed in *Managing Urban Stormwater – Soils and construction* (NSW Department of Housing, 1998) for Type C or D basins
- and/or other design criteria considered appropriate to local conditions and appreciation of micro climate influences.

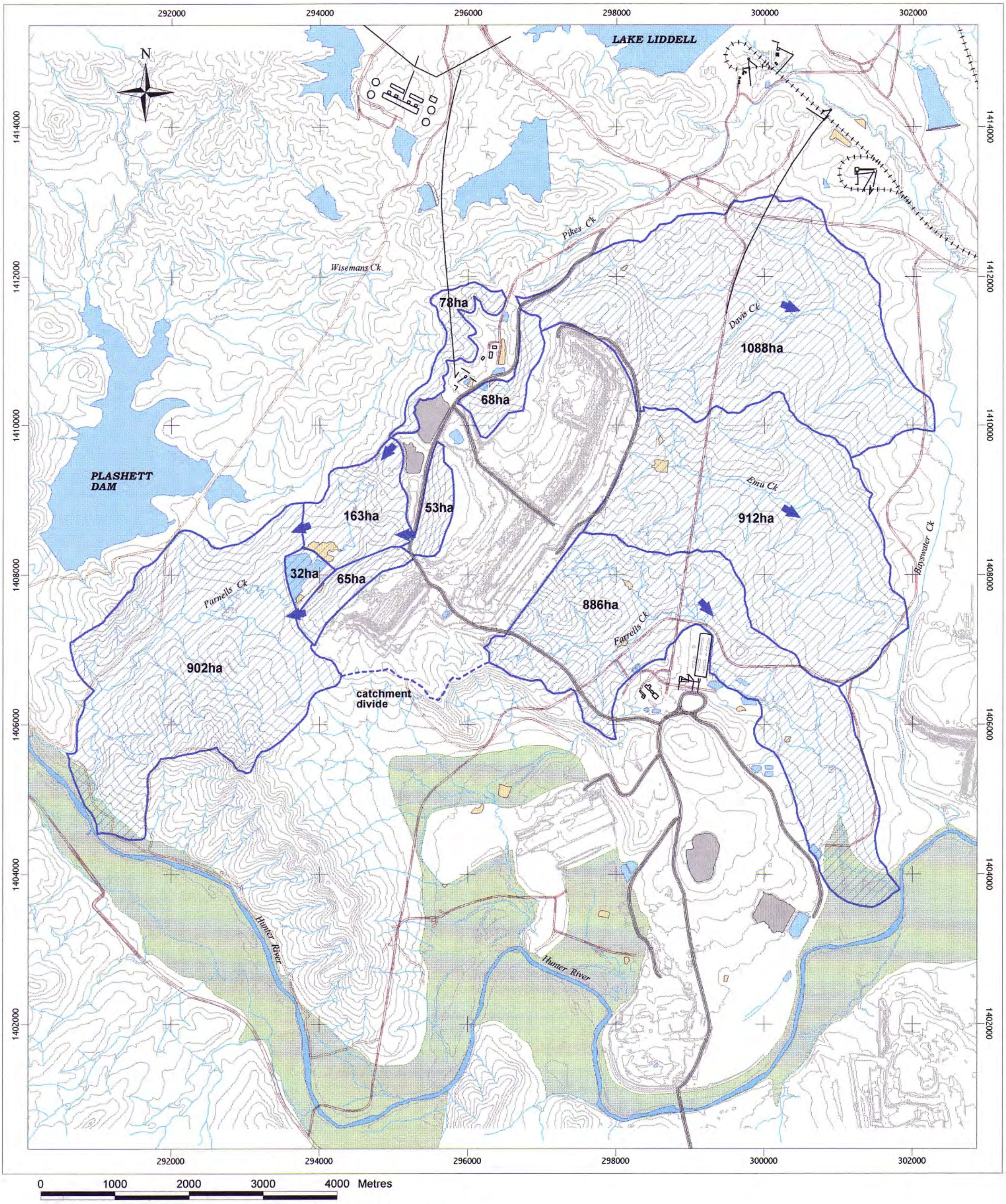
A schedule of indicative sedimentation dam capacities for the current watersheds and rehabilitation stage, is provided in the following Table G5 assuming:

- a high top soil erodibility with moderate subsoil erodibility
- low to moderate infiltration capacity (shallow permeability and moisture store)
- average slope of 14% and contour bank spacing of about 7m vertically or approx. 50 metres laterally.
- an average soil erodibility factor of 0.05
- a rainfall erosivity of 1750
- a volumetric runoff coefficient of 0.5

Table G5: Schedule of sedimentation dam storage needs

Dam ID	Year 2010		Year 2020	
	Runoff area - ha	Storage - ML	Runoff area - ha	Storage - ML
Dam 15W *	4	20	4	20
RH7a	121	40	121	40
RH7b	116	40	116	40
RH8a	41	25	41	25
RH8b	43	25	43	25
RH8c	-	-	161	45

* relocated to east side of the conveyor belt



Scale 1:70000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- dams: mine, sediment, tailings
- alluvial lands
- catchment divide
- topographic contour (10m intervals)
- railway
- lease

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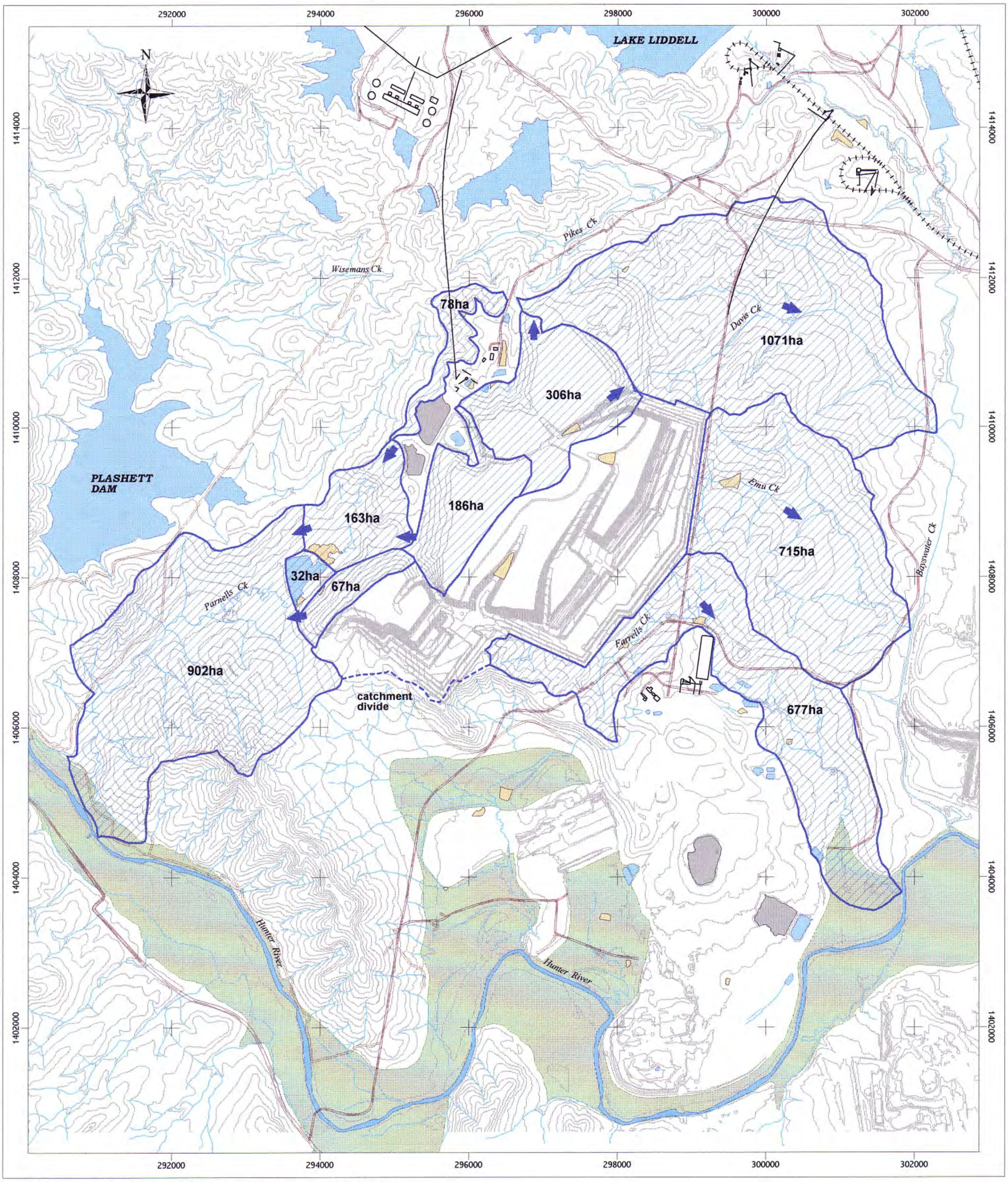
WEST PIT EXTENSION & MINOR MODIFICATIONS

Regional watersheds affected by continued mining in 2003/4

Figure G1



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Scale 1:70000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- dams: mine, sediment, tailings
- alluvial lands
- catchment divide
- topographic contour (10m intervals)
- railway
- lease

WEST PIT EXTENSION & MINOR MODIFICATIONS

Regional watersheds affected by continued mining in 2017

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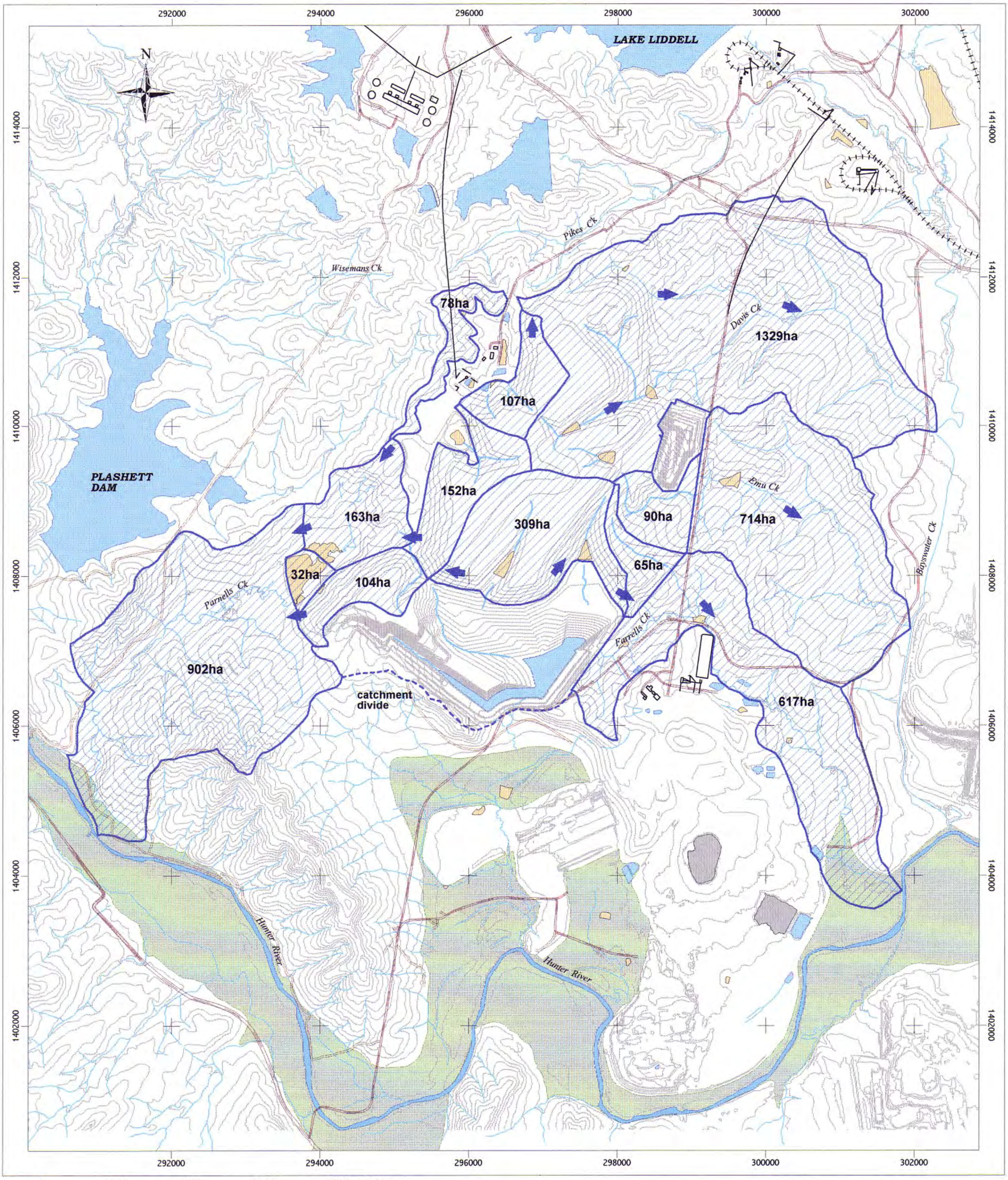
Figure G2



Scale 1:70000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- dams: mine, sediment, tailings
- alluvial lands
- catchment divide
- topographic contour (10m intervals)
- railway
- lease

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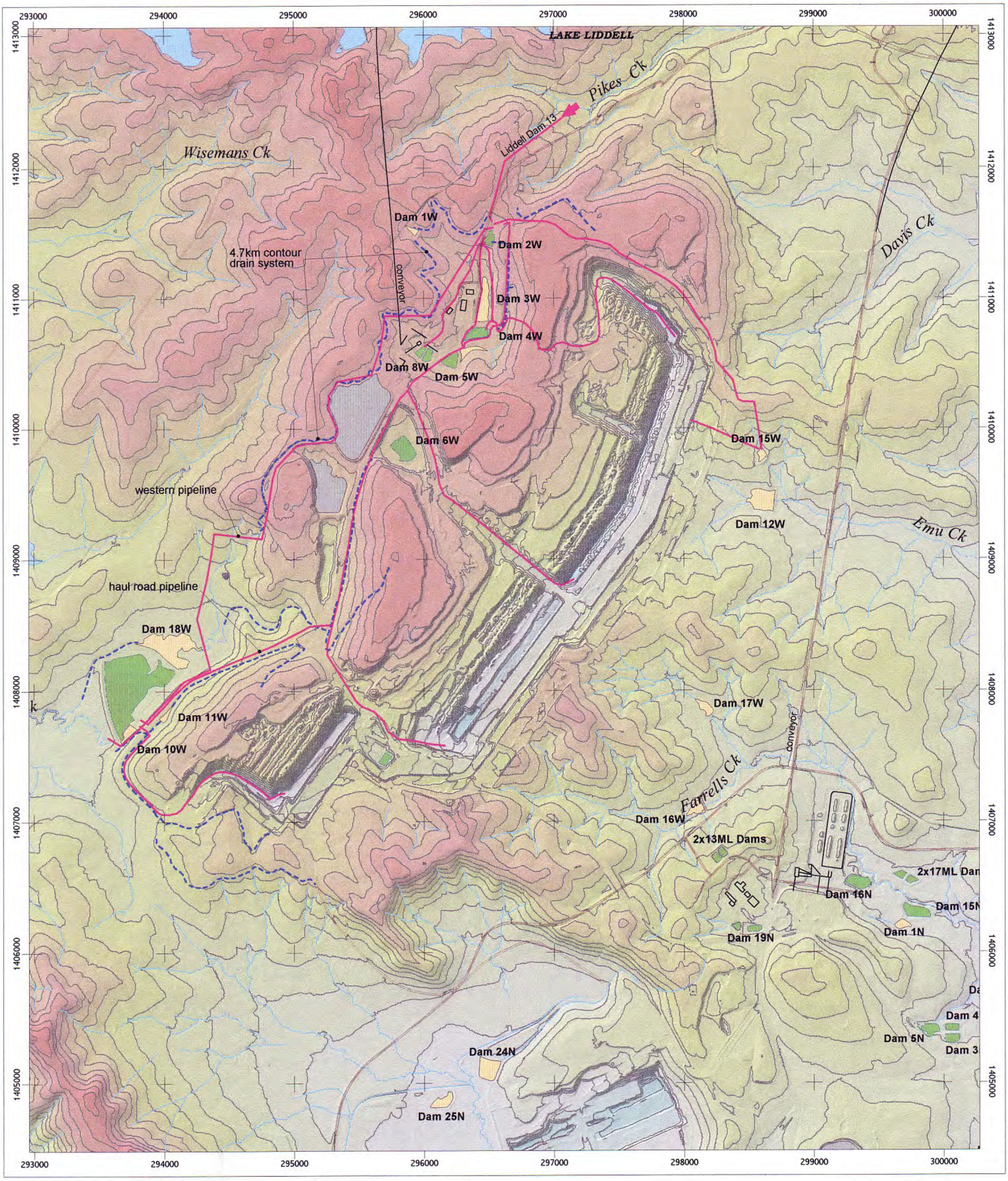
WEST PIT EXTENSION & MINOR MODIFICATIONS

Regional watersheds affected by continued mining in 2025

Figure G3



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Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- railway
- dams: mine, sediment, tailings
- alluvial lands
- topographic contour (10m intervals)
- lease
- drain
- pipe

WEST PIT EXTENSION & MINOR MODIFICATIONS

2003/4 water management system elements

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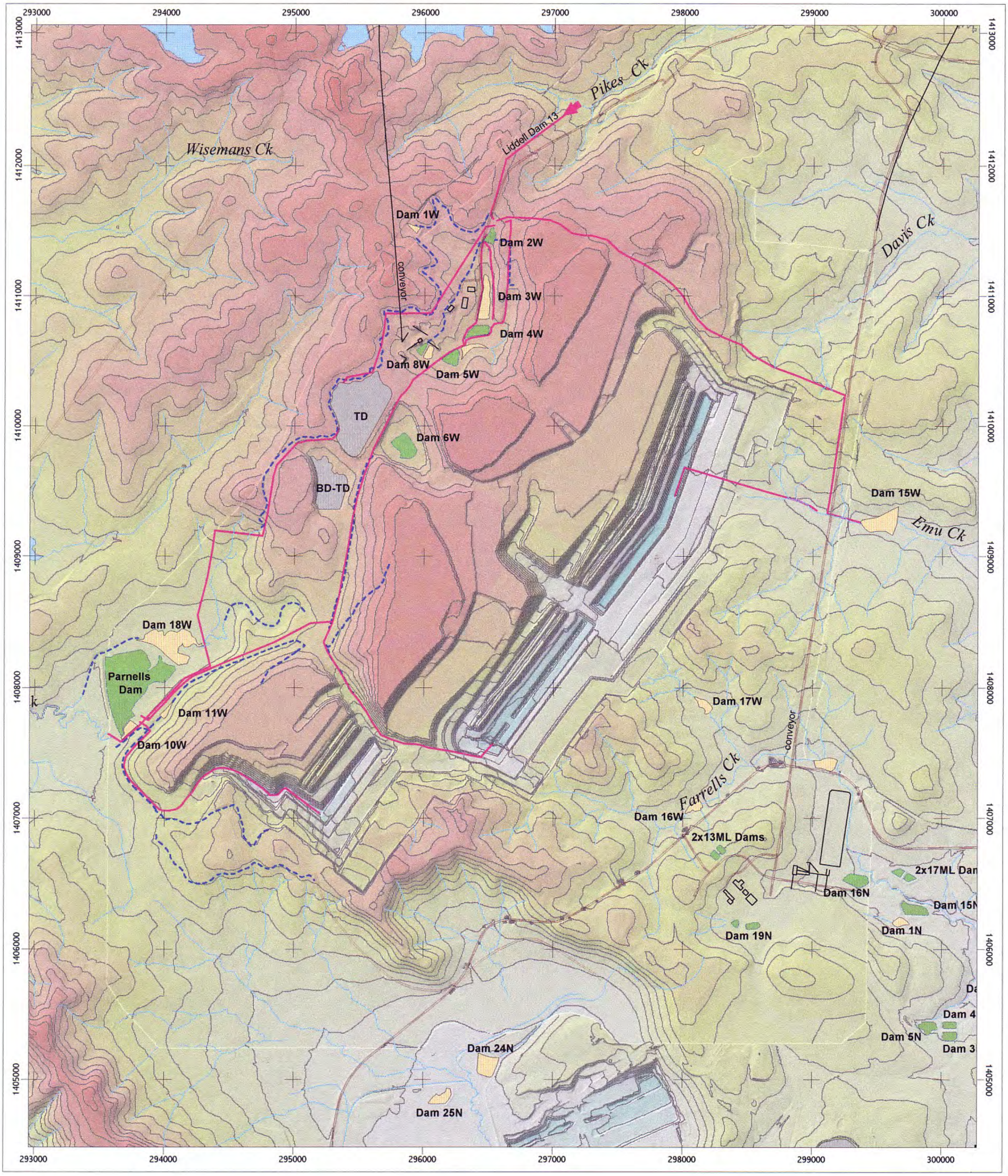
Figure G5



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Scale 1:40000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- railway
- dams: mine, sediment, tailings
- alluvial lands
- topographic contour (10m intervals)
- lease
- drain
- pipe

WEST PIT EXTENSION & MINOR MODIFICATIONS

2007 water management system elements

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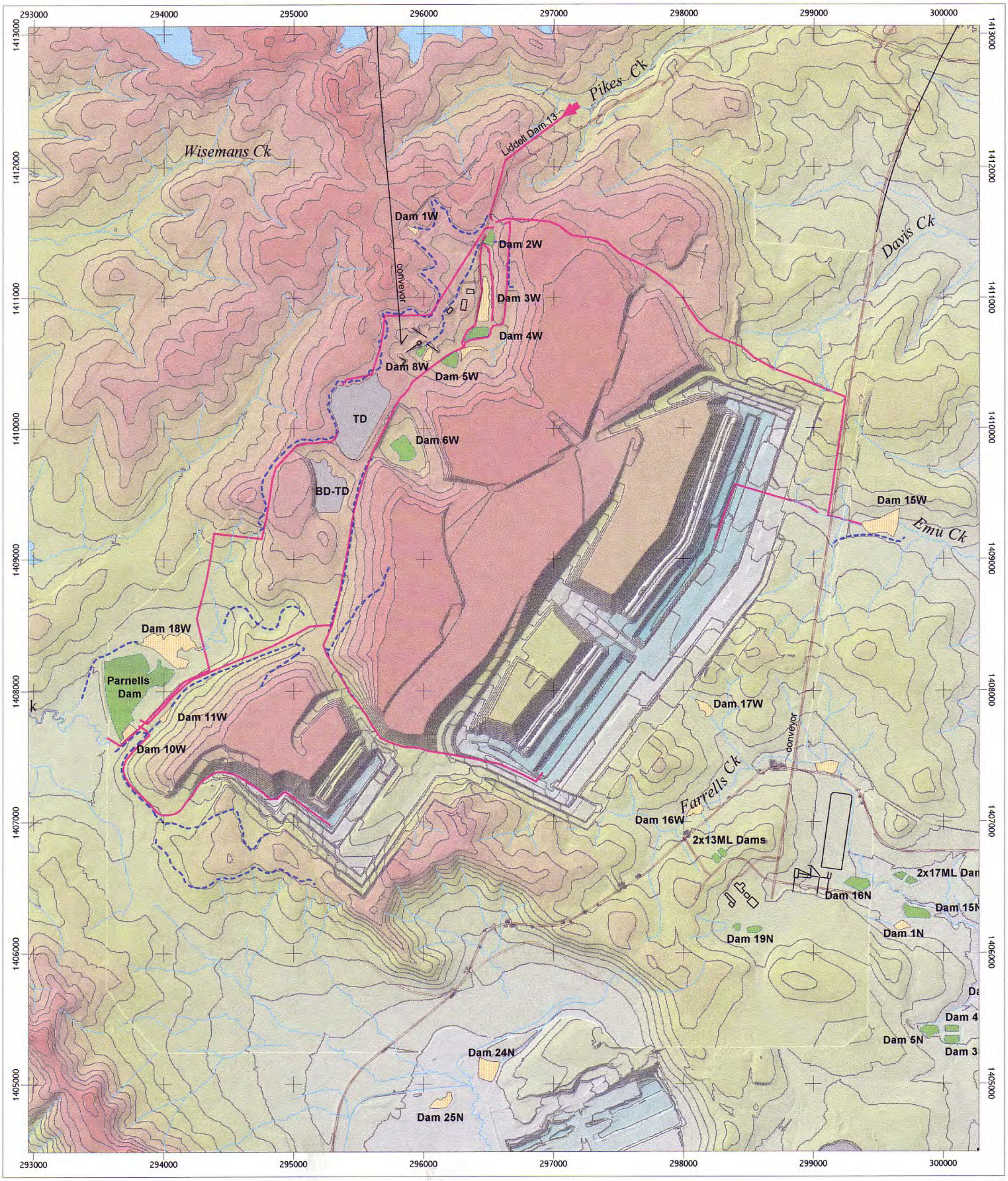
Figure G6



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Scale 1:40000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

creeks
dirt roads
sealed road
main road
haul road
railway
dams: mine, sediment, tailings
alluvial lands
topographic contour (10m intervals)
lease
drain
pipe

WEST PIT EXTENSION & MINOR MODIFICATIONS

2012 water management system elements

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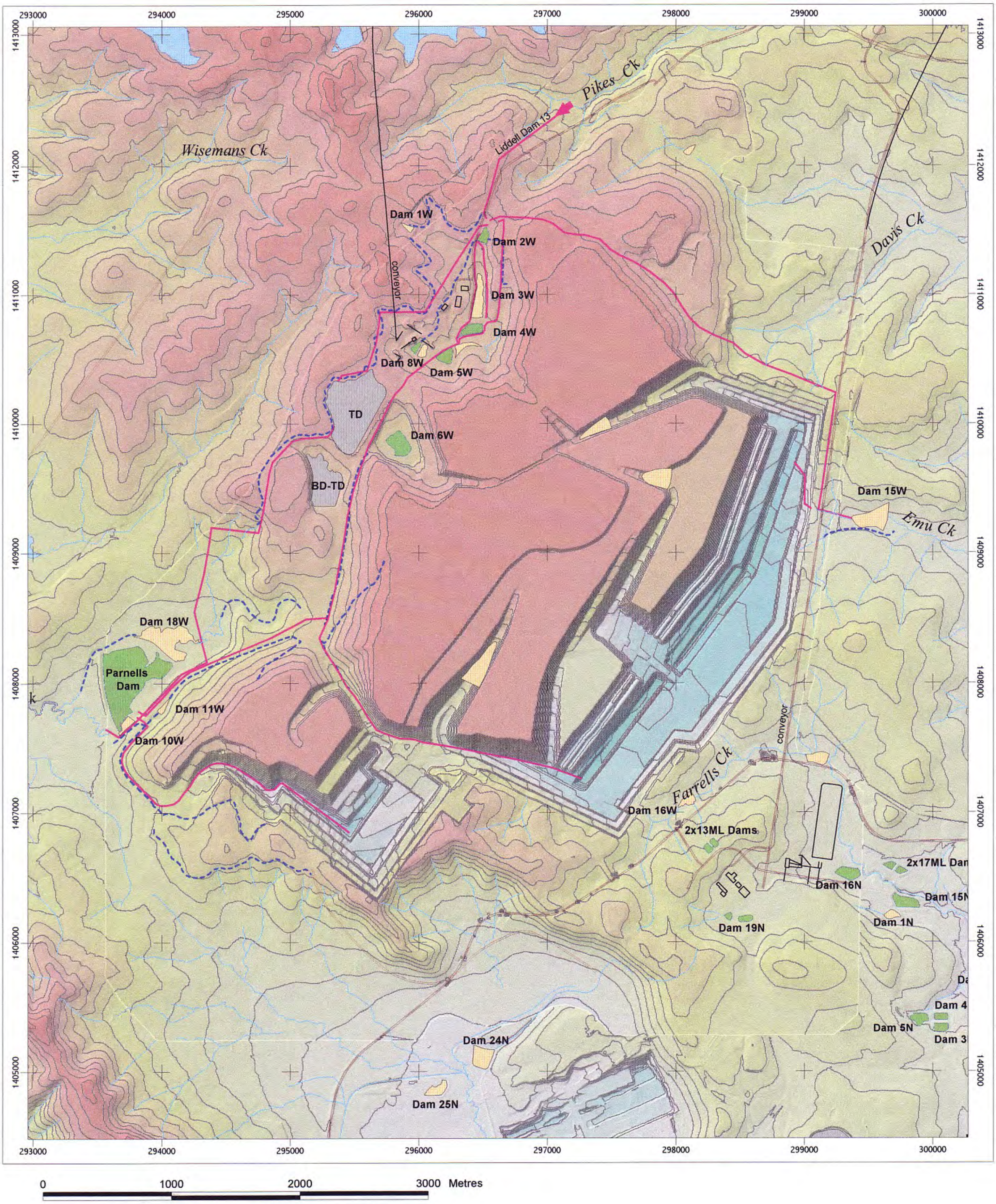
Figure G7



Scale 1:40000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- railway
- dams: mine, sediment, tailings
- alluvial lands
- topographic contour (10m intervals)
- lease
- drain
- pipe

WEST PIT EXTENSION & MINOR MODIFICATIONS

2017 water management system elements

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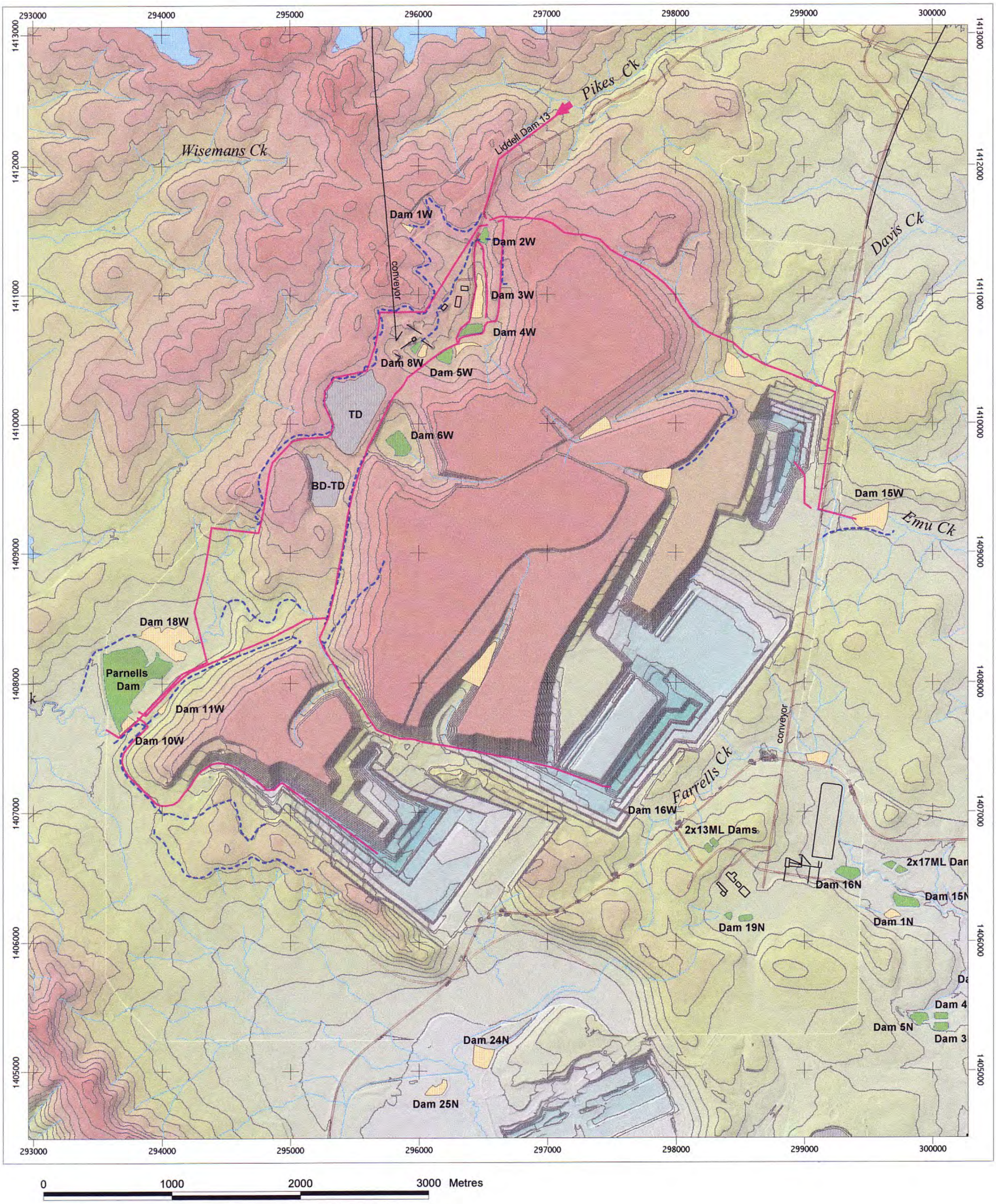
Figure G8



Scale 1:40000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

creeks	dams: mine, sediment, tailings
dirt roads	alluvial lands
sealed road	topographic contour (10m intervals)
main road	lease
haul road	drain
railway	pipe

WEST PIT EXTENSION & MINOR MODIFICATIONS

2022 water management system elements

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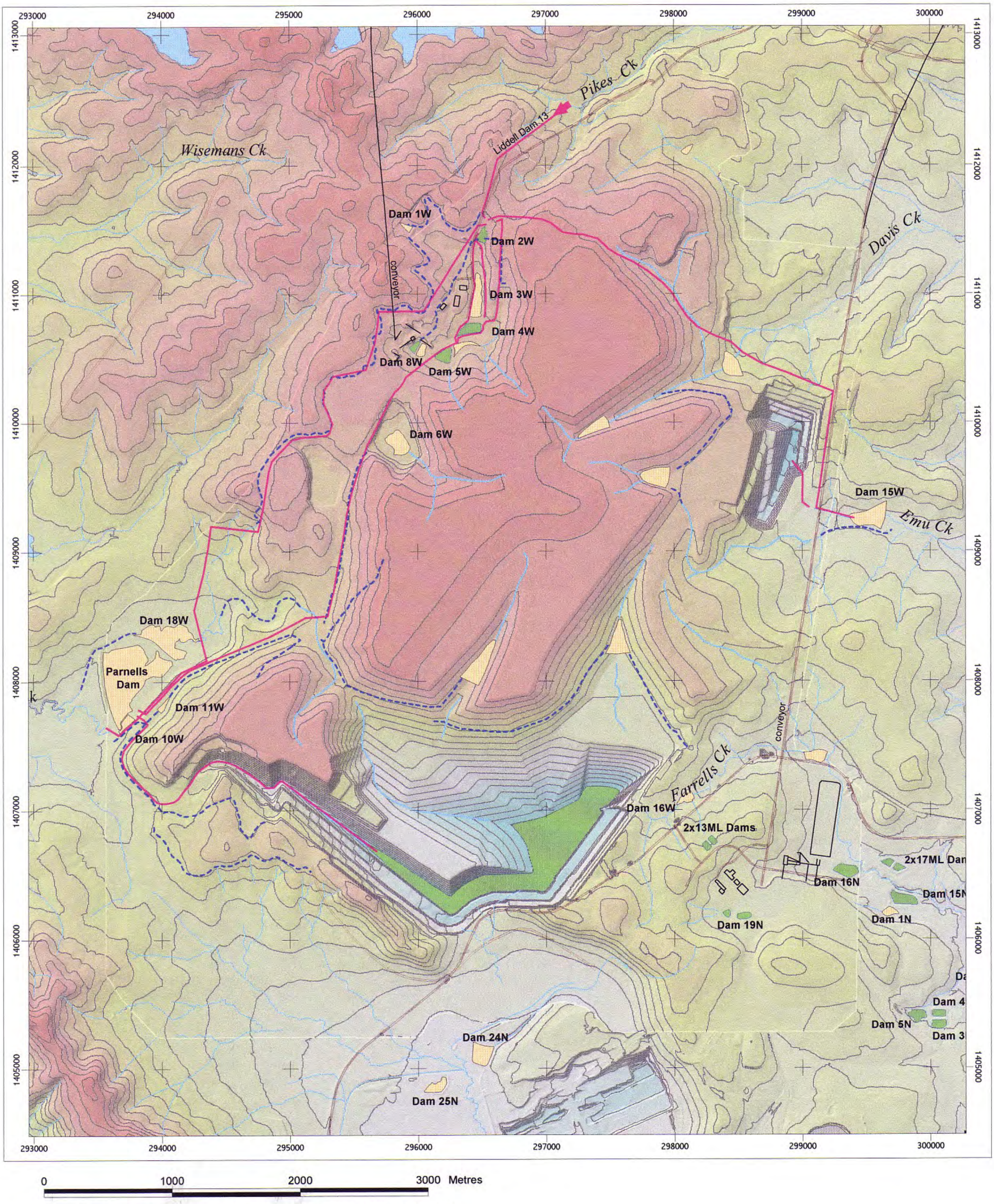
Figure G9



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Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- railway
- dams: mine, sediment, tailings
- alluvial lands
- topographic contour (10m intervals)
- lease
- drain
- pipe

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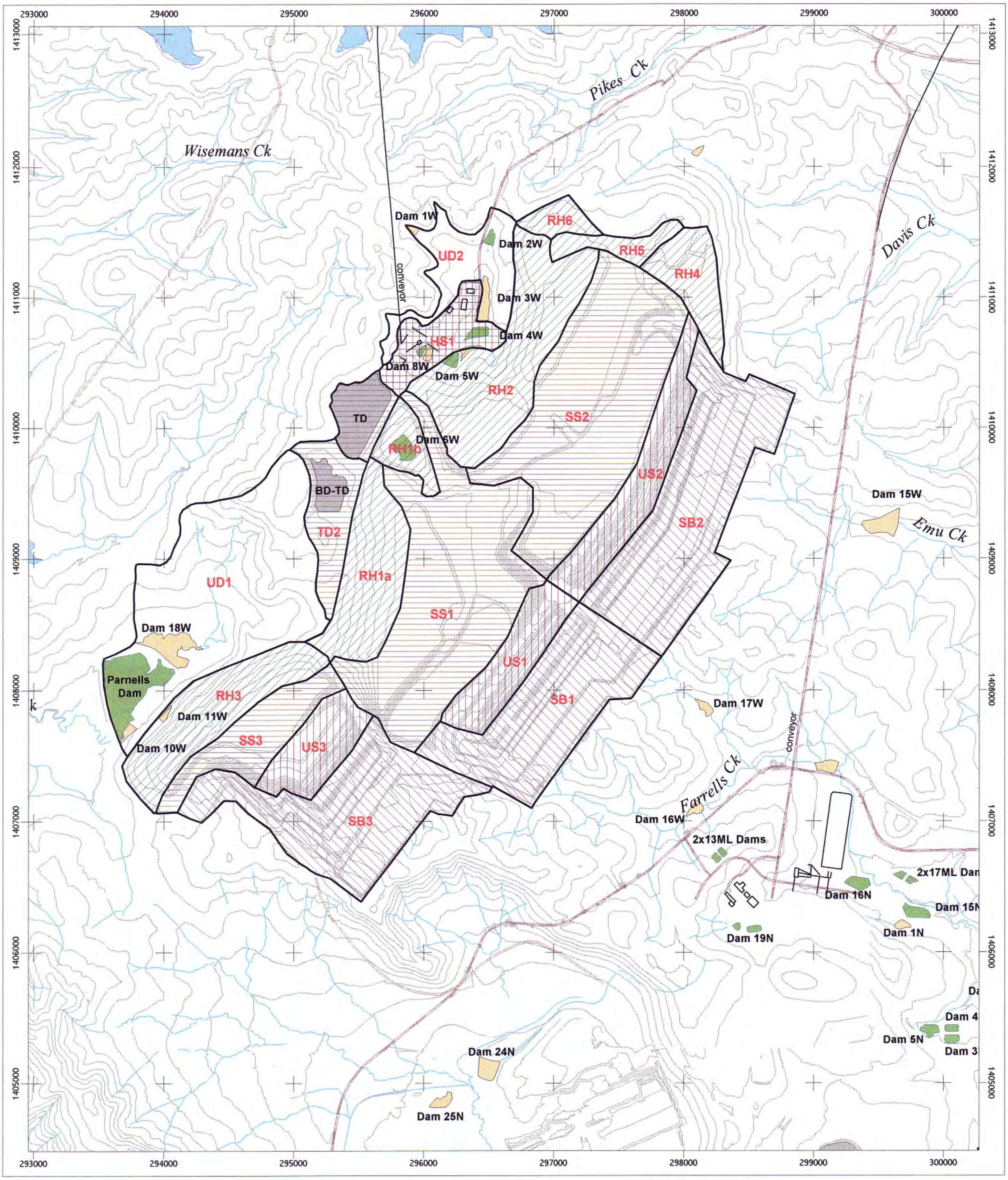
WEST PIT EXTENSION & MINOR MODIFICATIONS

2025 water management system elements

Figure G10



0 1000 2000 3000 Metres

catchment identifiers shown by red text

Scale 1:40000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- railway
- dams: mine, sediment, tailings
- alluvial lands
- topographic contour
- lease
- drain
- pipe
- hardstand
- rehabilitated
- strip and bench
- shaped spoils
- undisturbed
- unshaped spoils

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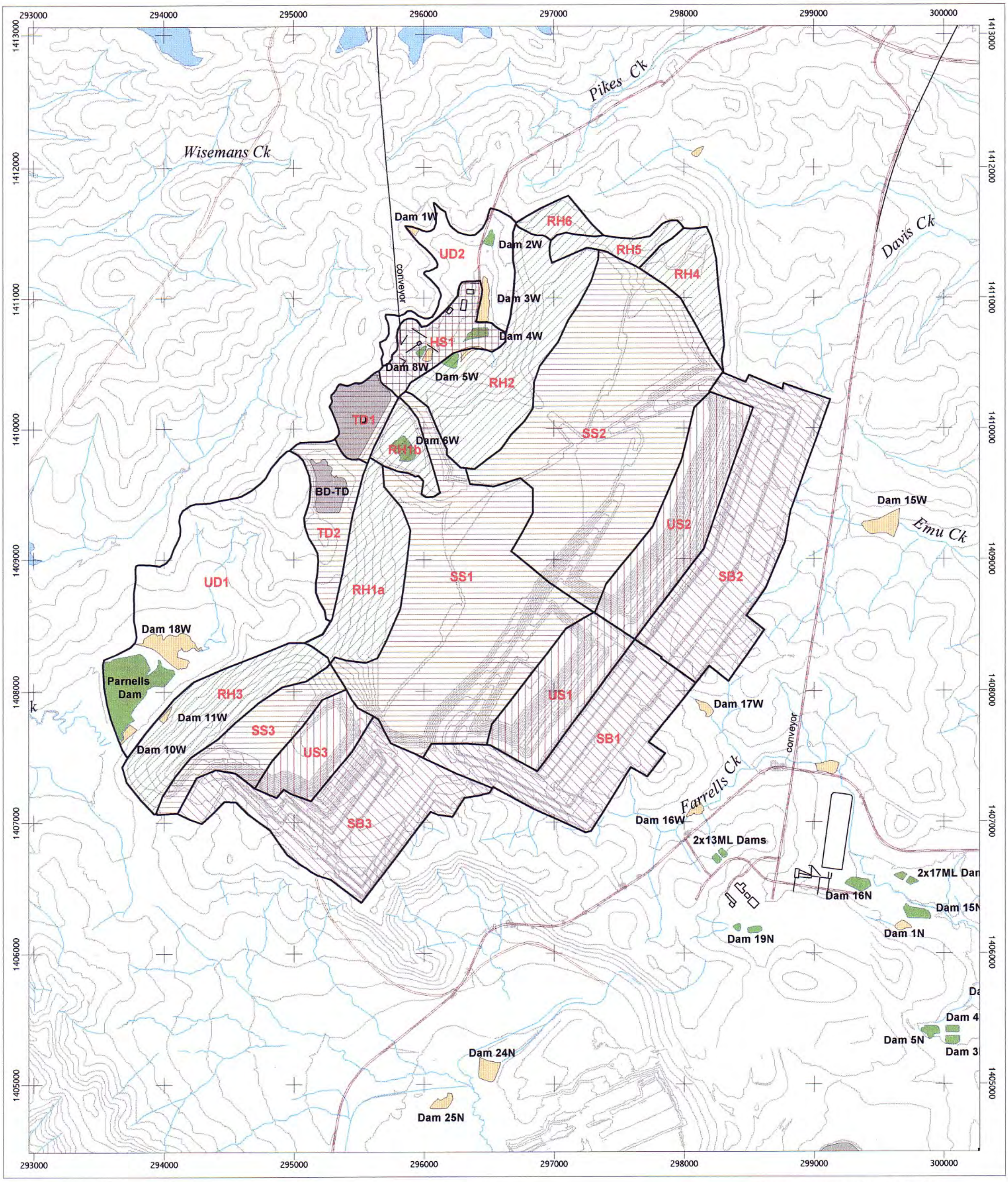
WEST PIT EXTENSION & MINOR MODIFICATIONS

Water management catchment areas - 2007

Figure G11



0 1000 2000 3000 Metres

catchment identifiers shown by red text

Scale 1:40000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

creeks	dams: mine, sediment, tailings	hardstand
dirt roads	alluvial lands	rehabilitated
sealed road	topographic contour	strip and bench
main road	lease	shaped spoils
haul road	drain	undisturbed
railway	pipe	unshaped spoils

WEST PIT EXTENSION & MINOR MODIFICATIONS

Water management catchment areas - 2012

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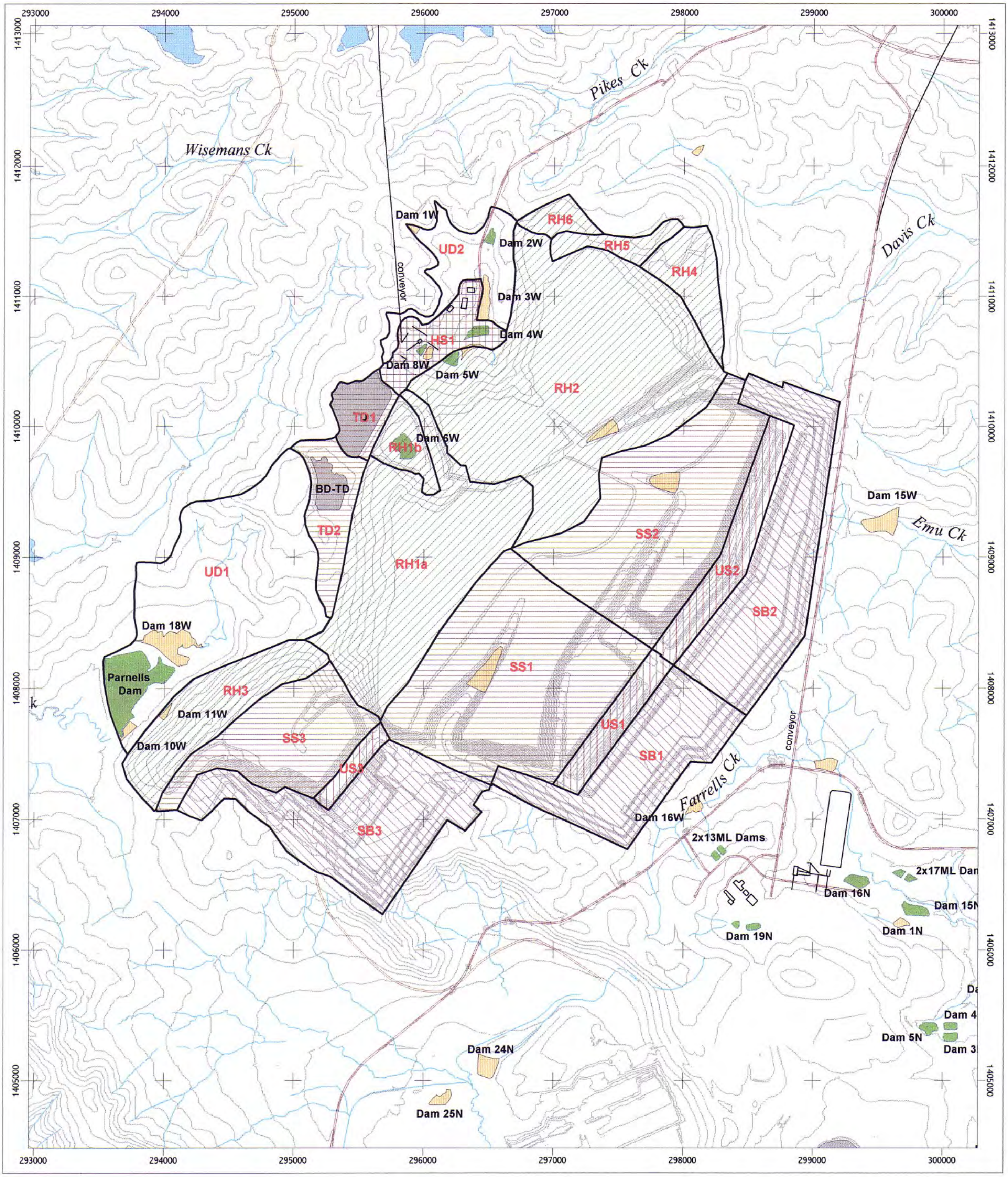
Figure G12



0 1000 2000 3000 Metres

catchment identifiers shown by red text

Scale 1:40000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- railway
- dams: mine, sediment, tailings
- alluvial lands
- topographic contour
- lease
- drain
- pipe
- hardstand
- rehabilitated
- strip and bench
- shaped spoils
- undisturbed
- unshaped spoils

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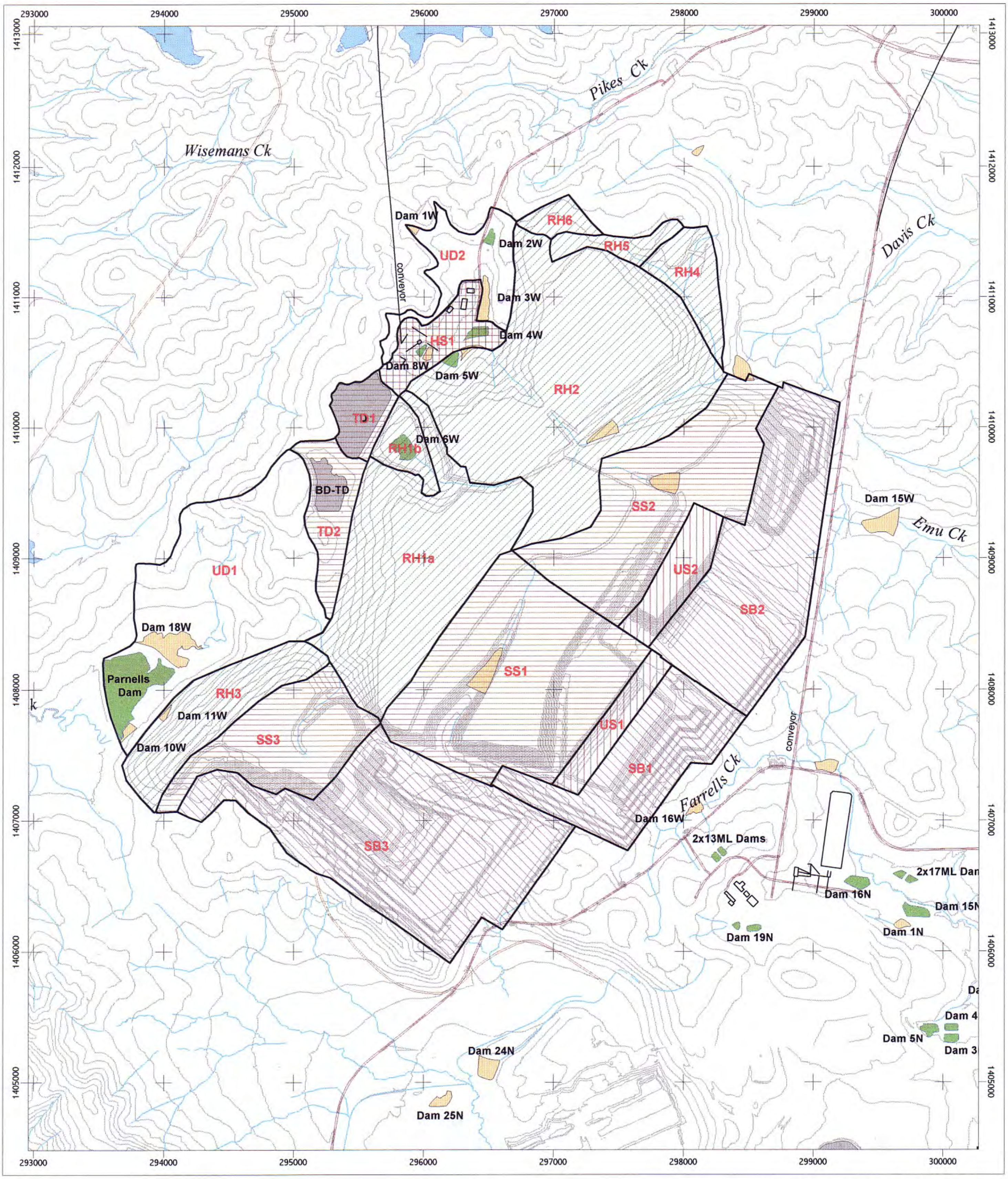
WEST PIT EXTENSION & MINOR MODIFICATIONS

Water management catchment areas - 2017

Figure G13



Scale 1:40000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

creeks	dams: mine, sediment, tailings	hardstand
dirt roads	alluvial lands	rehabilitated
sealed road	topographic contour	strip and bench
main road	lease	shaped spoils
haul road	drain	undisturbed
railway	pipe	unshaped spoils

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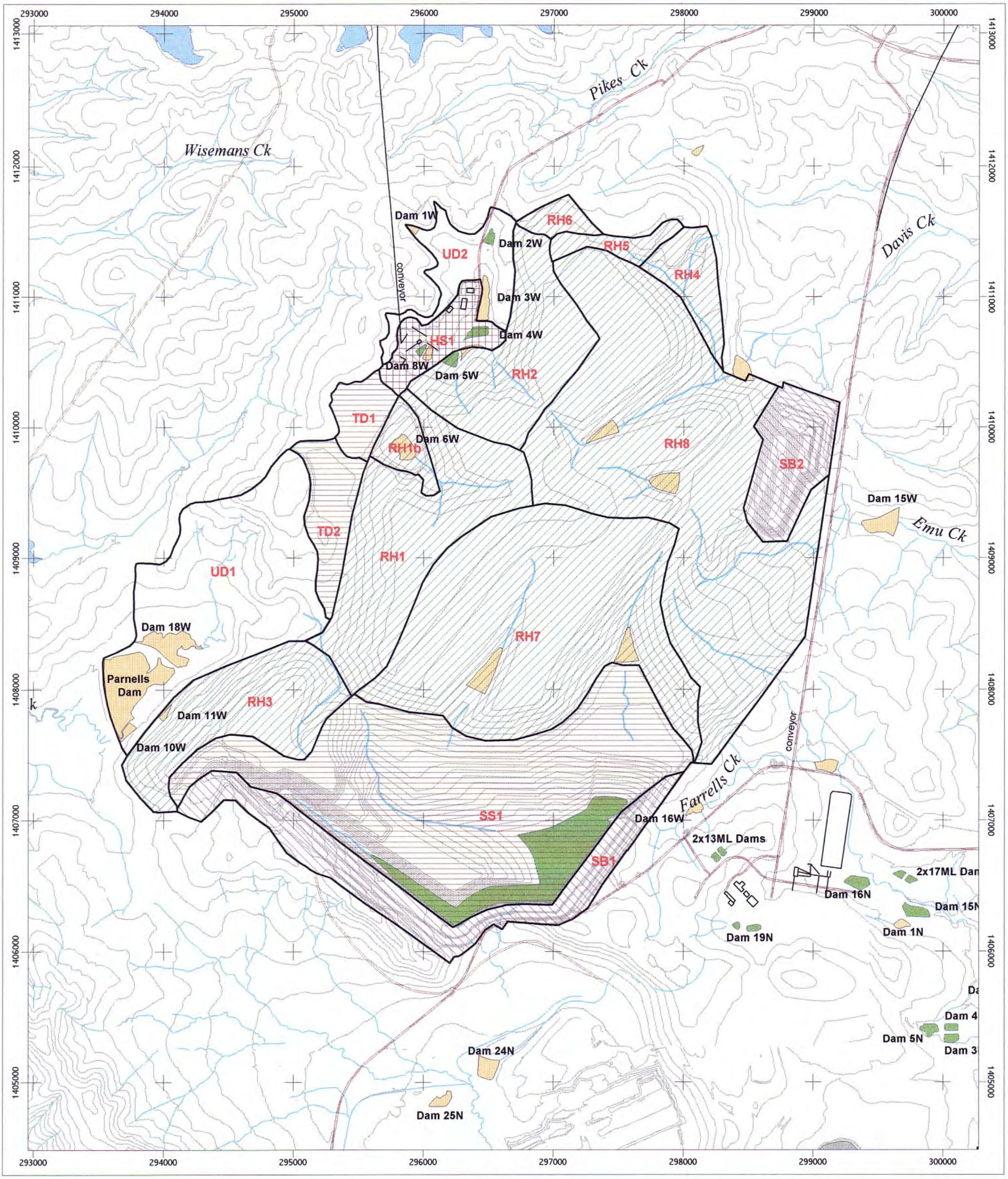
WEST PIT EXTENSION & MINOR MODIFICATIONS

Water management catchment areas - 2022

Figure G14



0 1000 2000 3000 Metres

catchment identifiers shown by red text

Scale 1:40000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- railway
- dams: mine, sediment, tailings
- alluvial lands
- topographic contour
- lease
- drain
- pipe
- hardstand
- rehabilitated
- strip and bench
- shaped spoils
- undisturbed
- unshaped spoils

WEST PIT EXTENSION & MINOR MODIFICATIONS

Water management catchment areas - 2025

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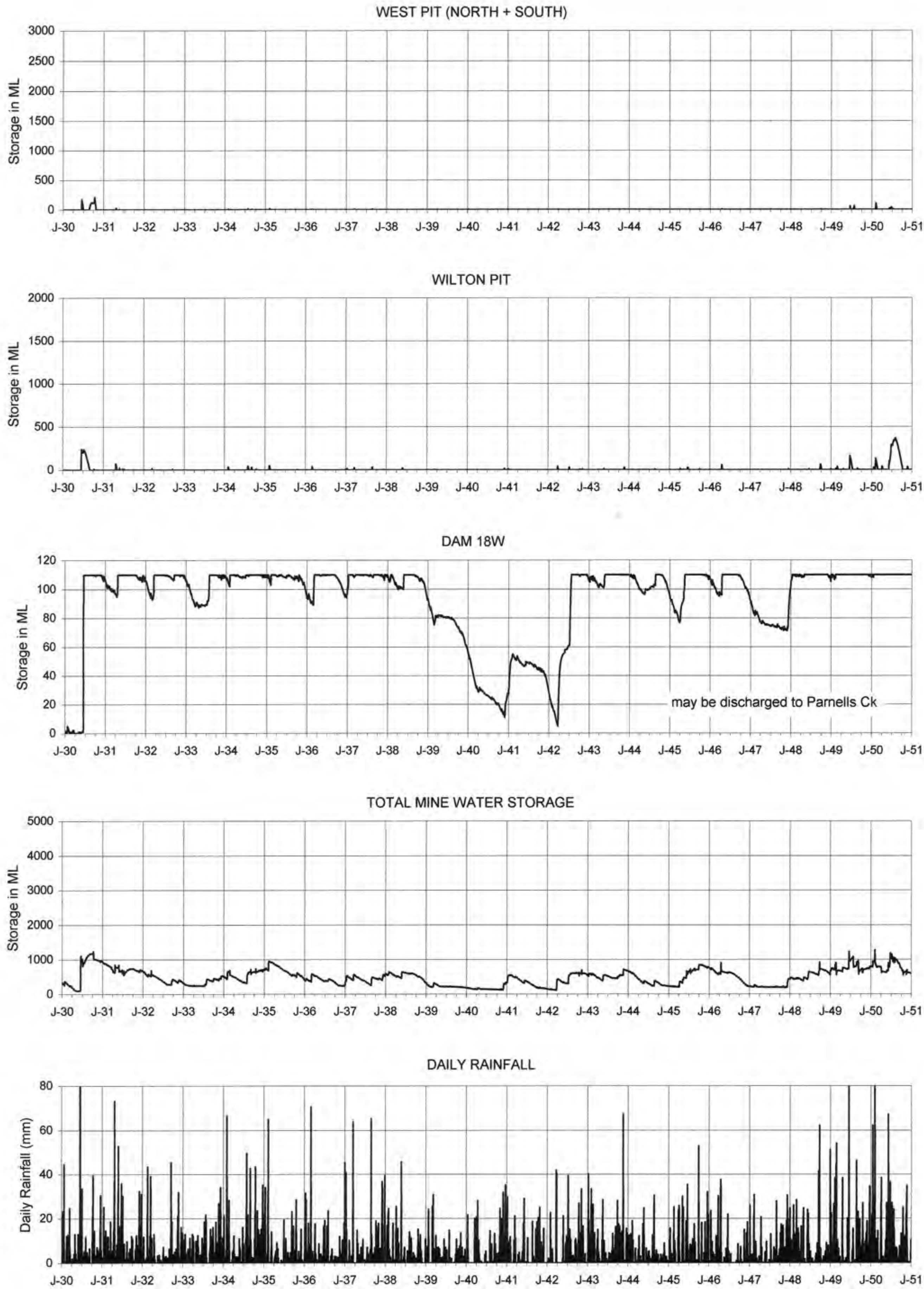
Figure G15

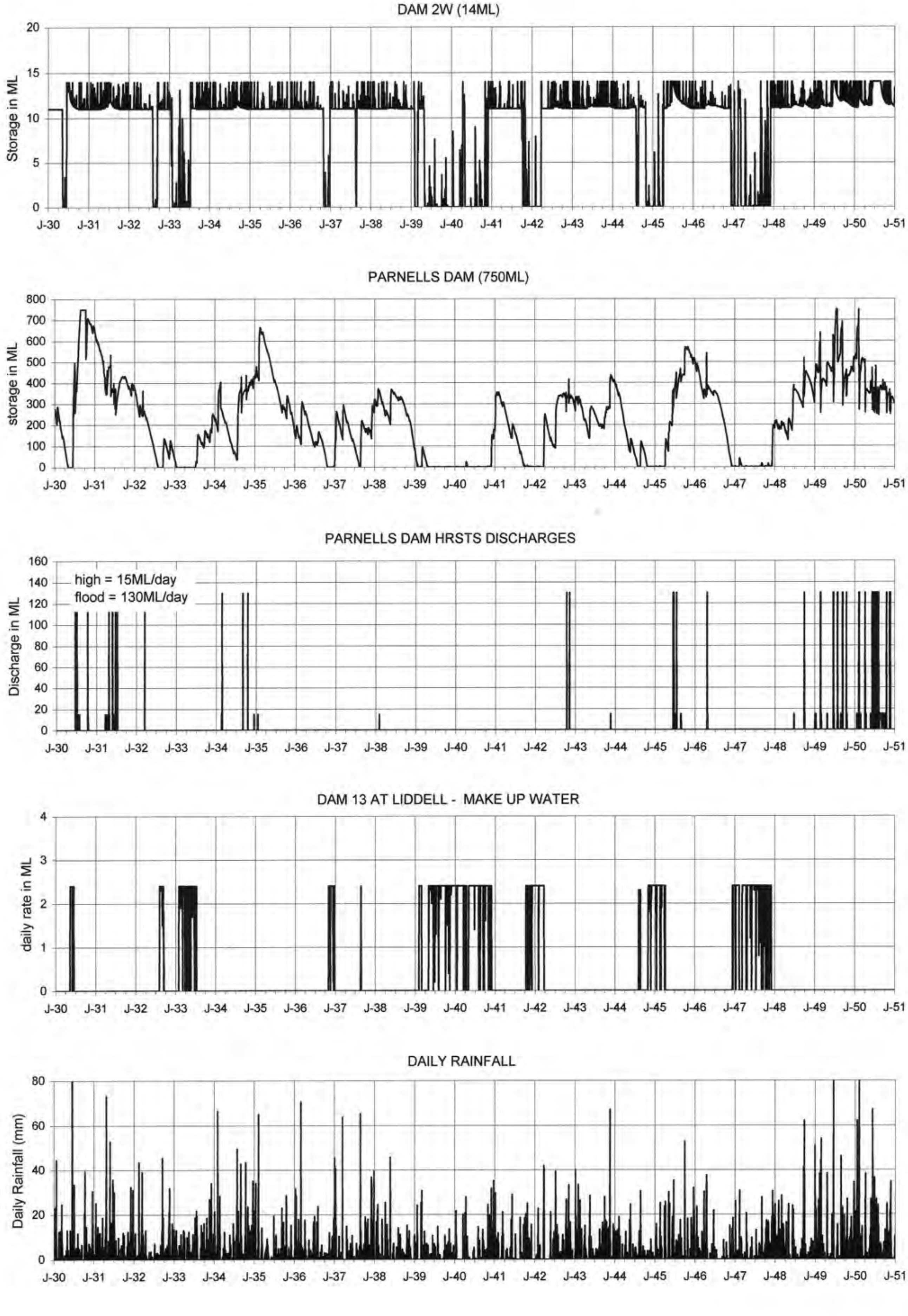


West Pit Extension & Minor Modifications

Simulated system response for 1930 to 1951 rainfall period
Discharges from Parnells Dam when storage above 50% capacity

Figure 16a

Mackie Environmental Research



West Pit Extension & Minor Modifications

Simulated system response for 1930 to 1951 rainfall period
Discharges from Parnells Dam when storage above 50% capacity

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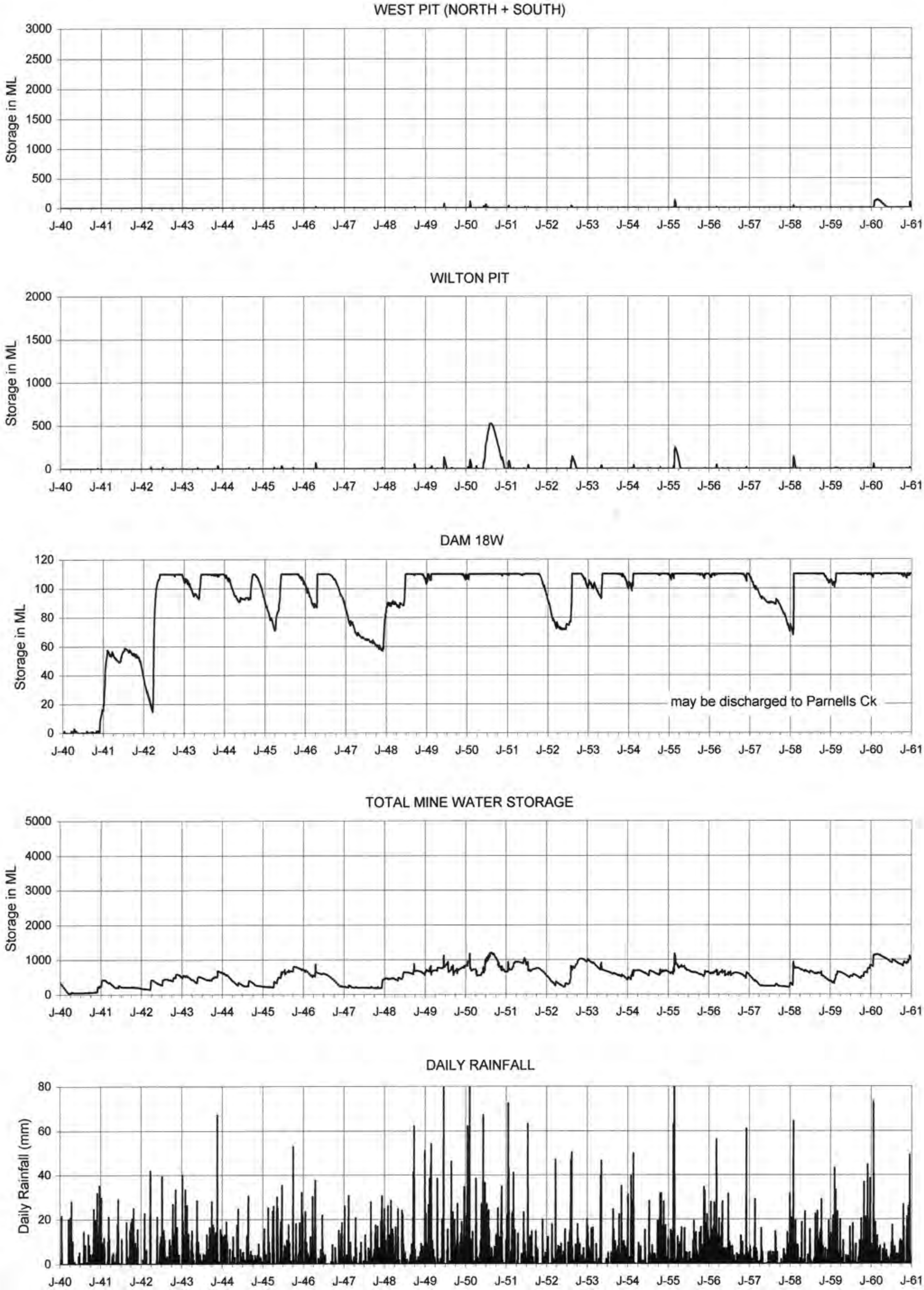
Figure G16b



West Pit Extension & Minor Modifications

Simulated system response for 1940 to 1960 rainfall period
Discharges from Parnells Dam when storage above 50% capacity

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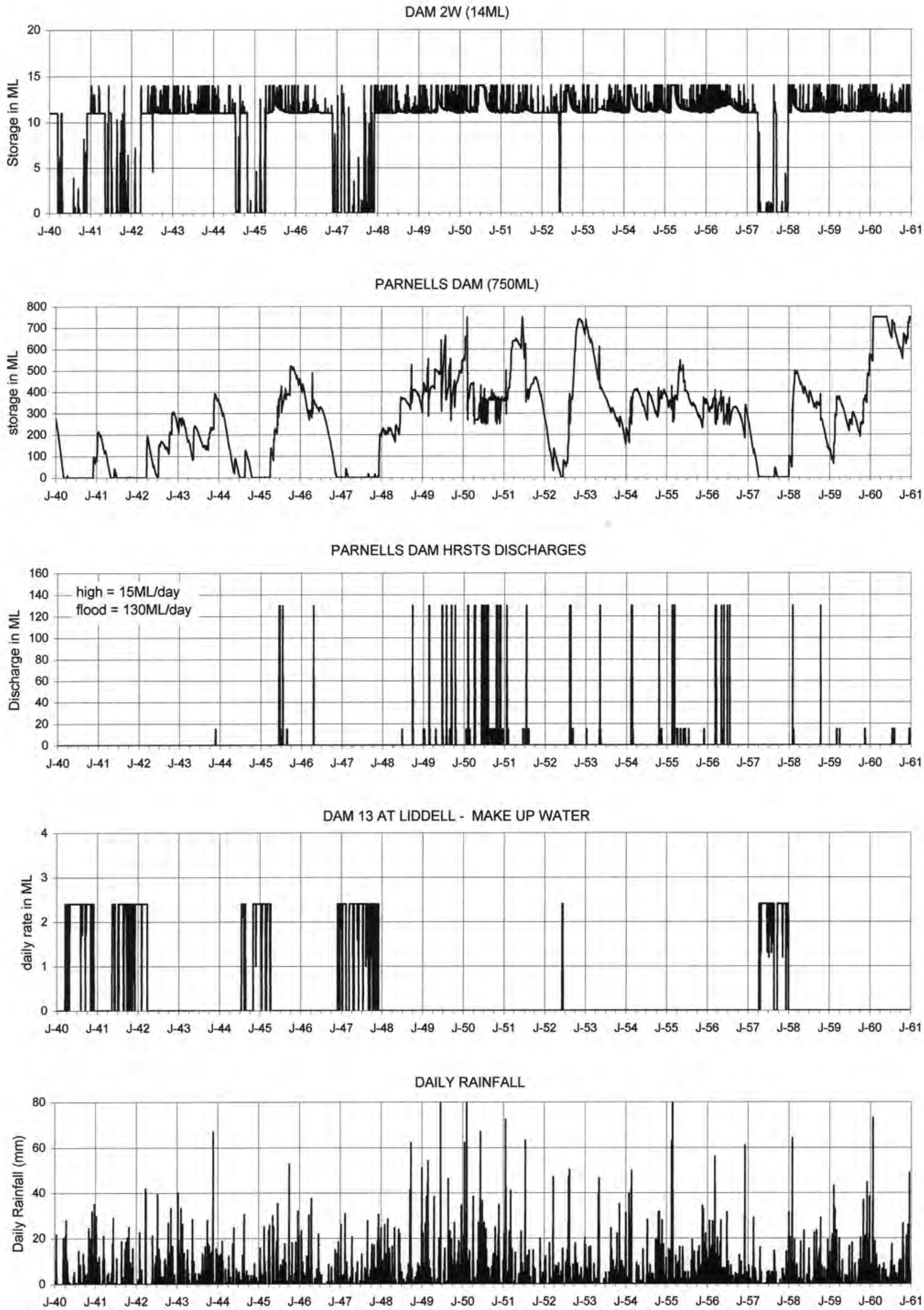
Figure G17a

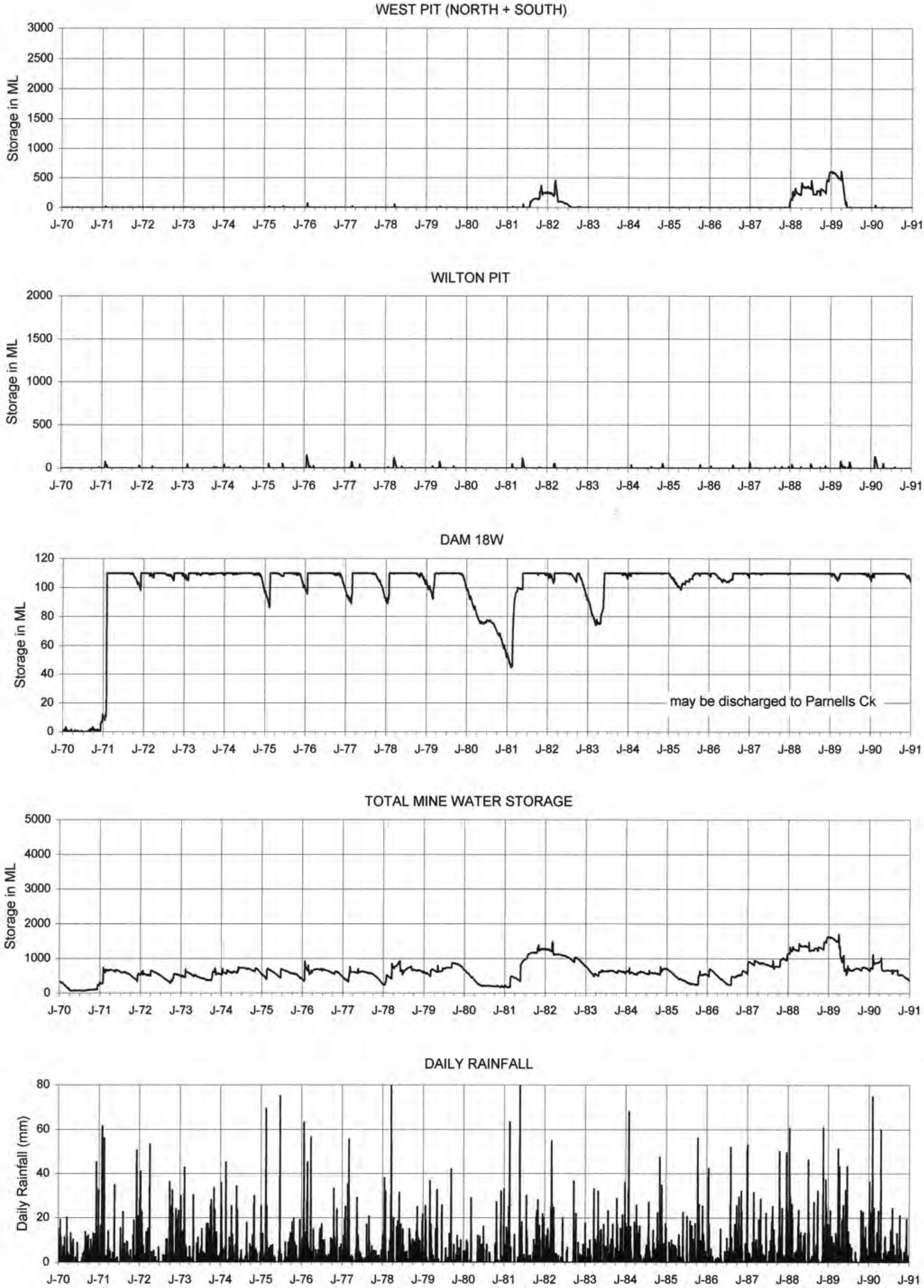


West Pit Extension & Minor Modifications

Simulated system response for 1940 to 1960 rainfall period
Discharges from Parnells Dam when storage above 50% capacity

Mackie Environmental Research

Figure G17b

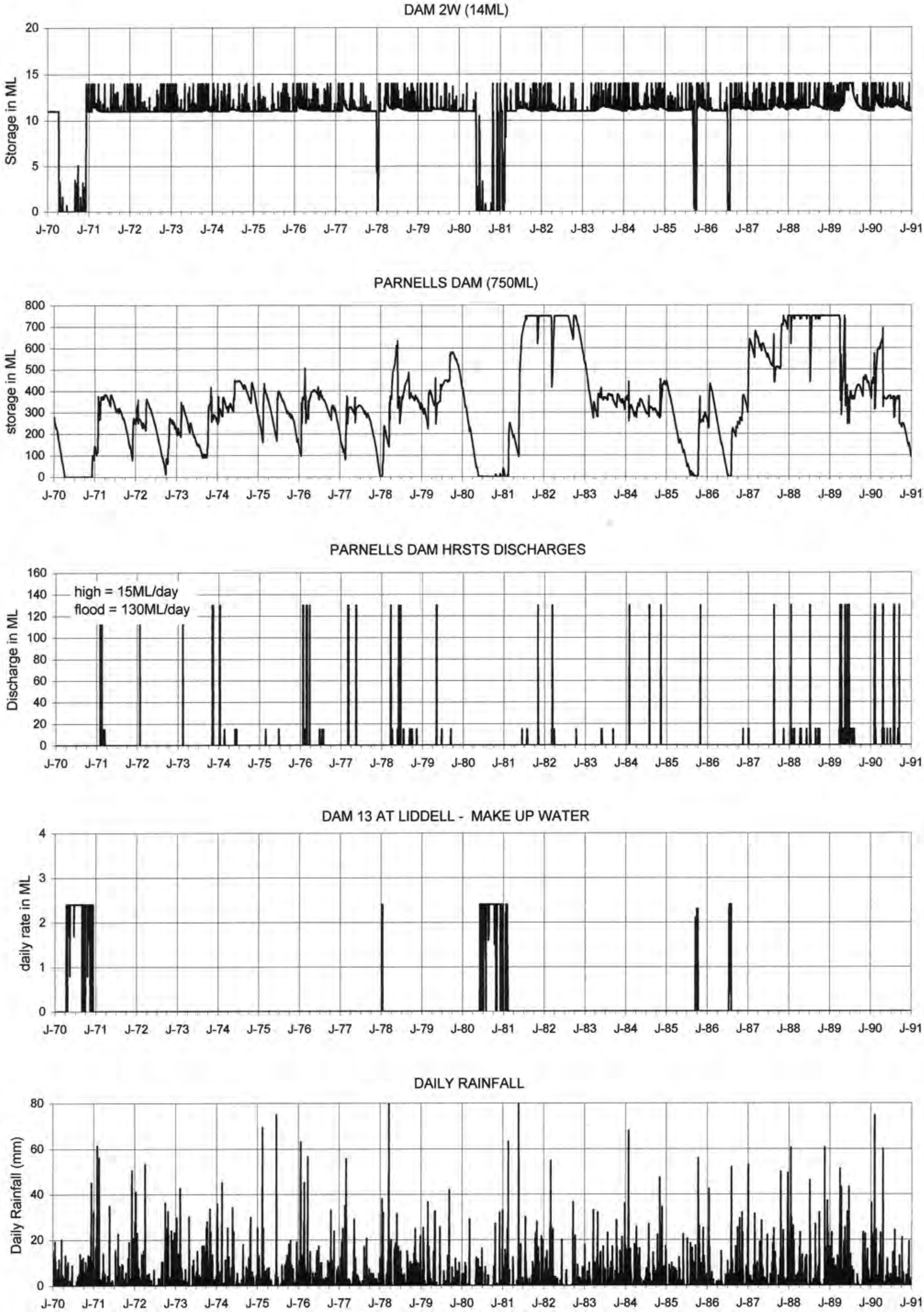


West Pit Extension & Minor Modifications

Simulated system response for 1970 to 1991 rainfall period
Discharges from Parnells Dam when storage above 50% capacity

Mackie Environmental Research

Figure G18a



West Pit Extension & Minor Modifications

Simulated system response for 1970 to 1991 rainfall period
Discharges from Parnells Dam when storage above 50% capacity

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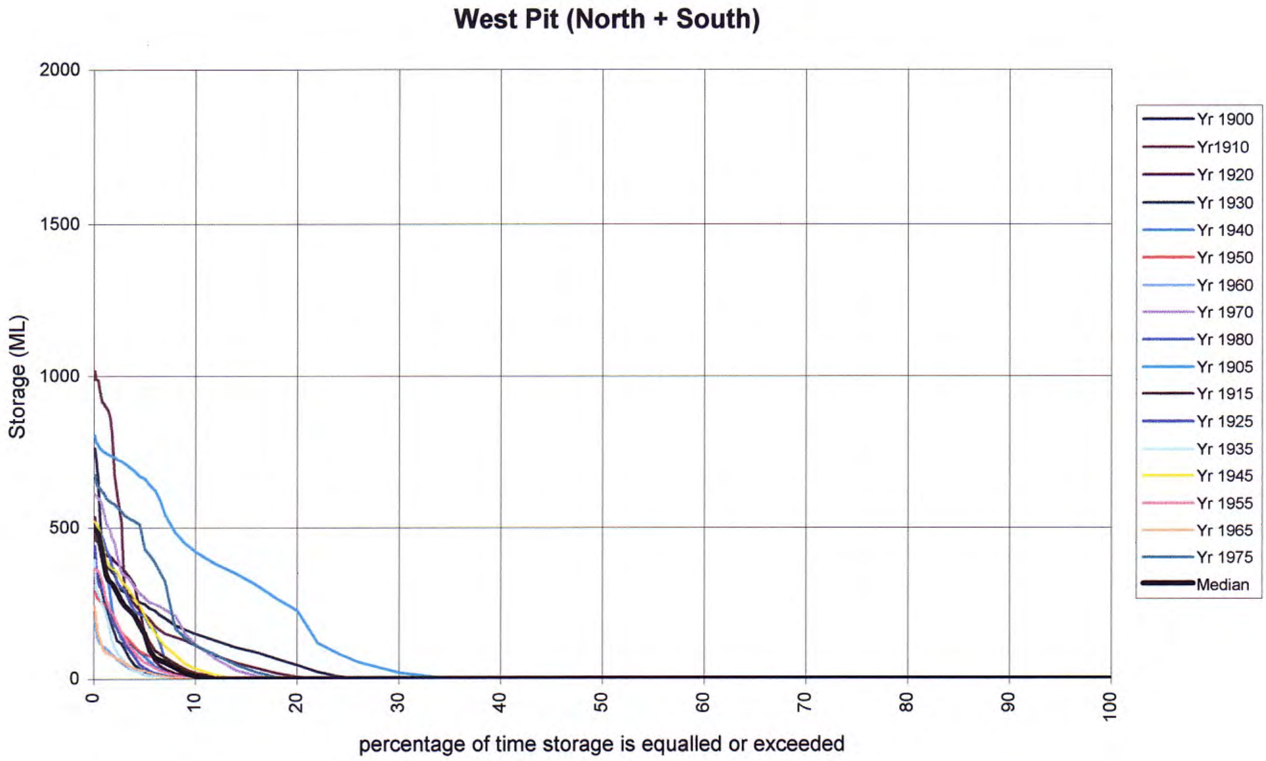
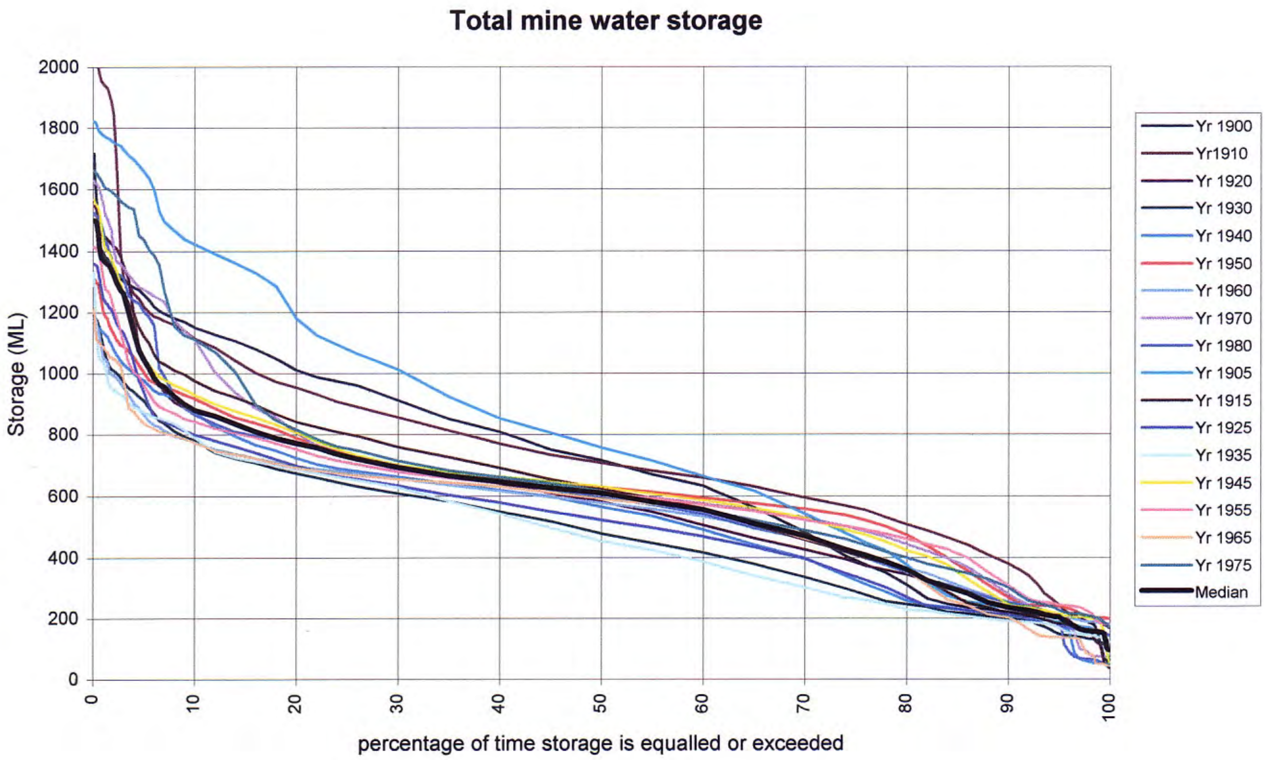
Figure G18b





West Pit Extension & Minor Modifications

Percentile plots: Parnells Dam with HRSTS discharges
West Pit and total mine water storage

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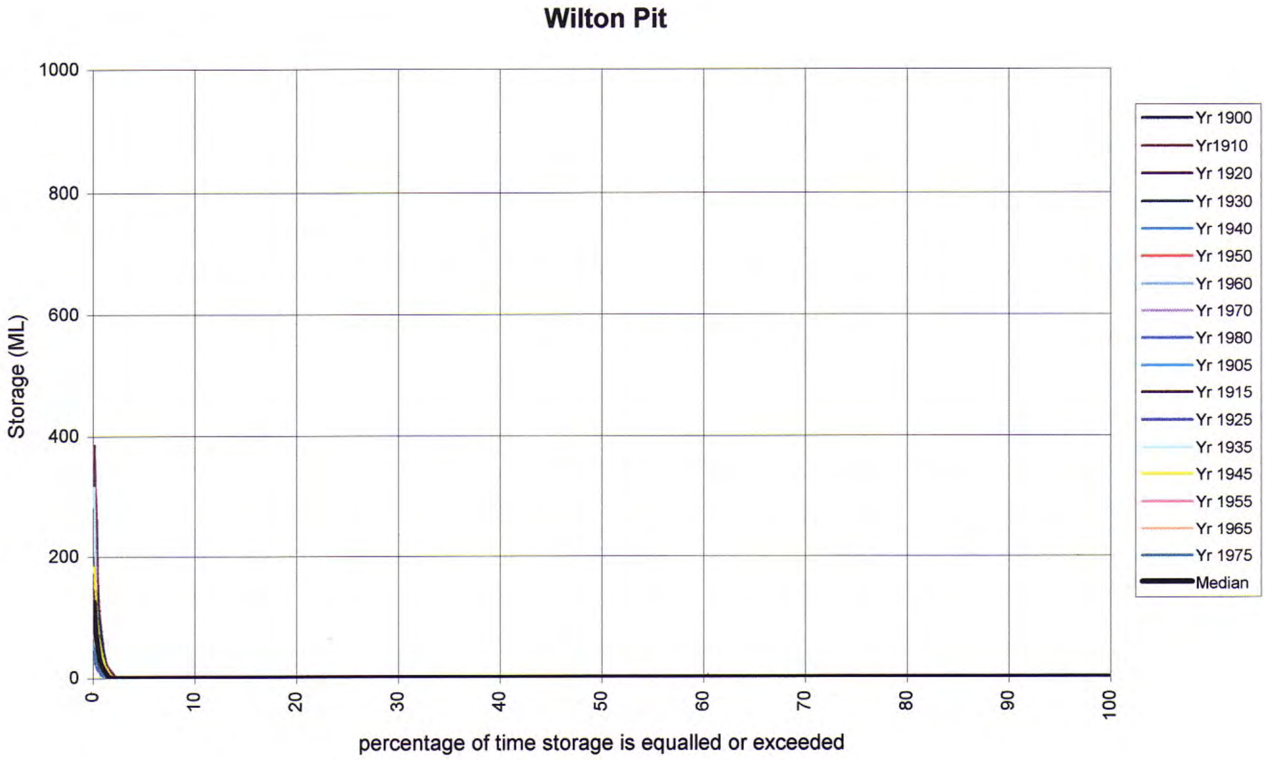
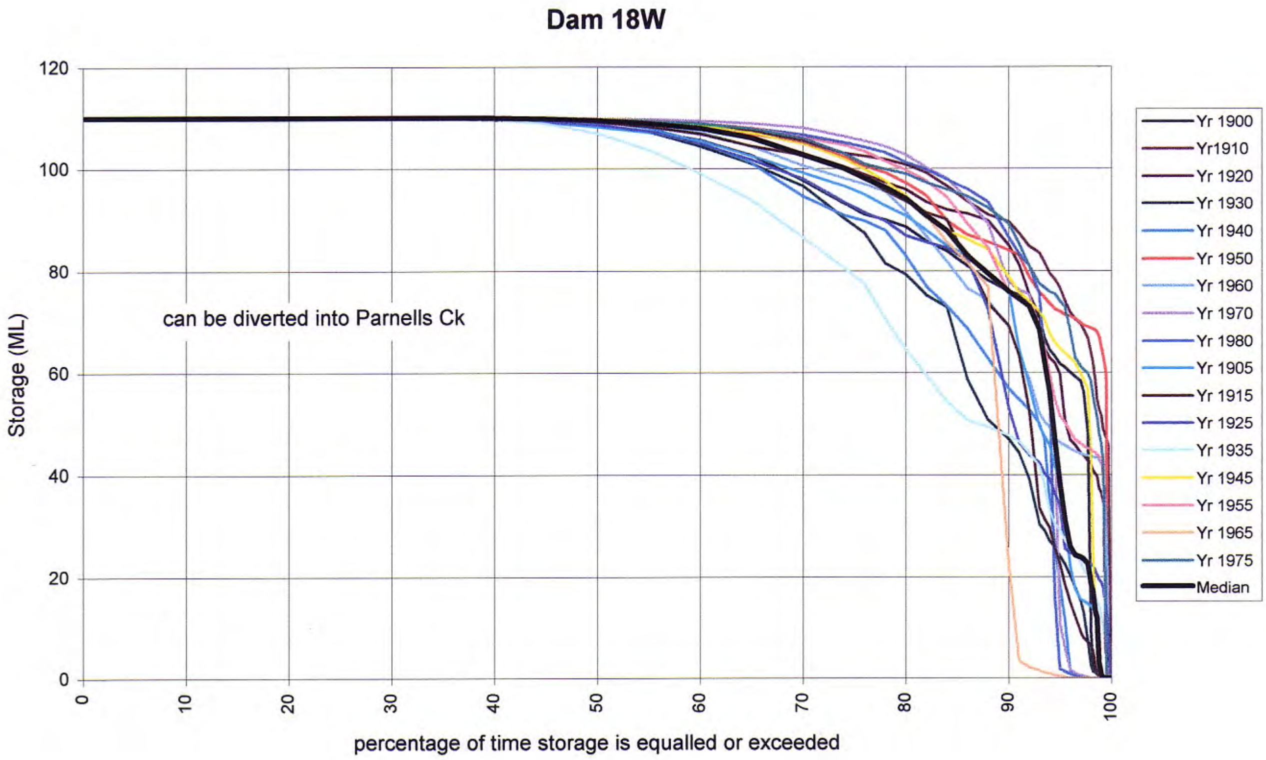
Figure G19a





West Pit Extension & Minor Modifications

Percentile plots: Parnells Dam with HRSTS discharges
Wilton Pit and Dam 18W

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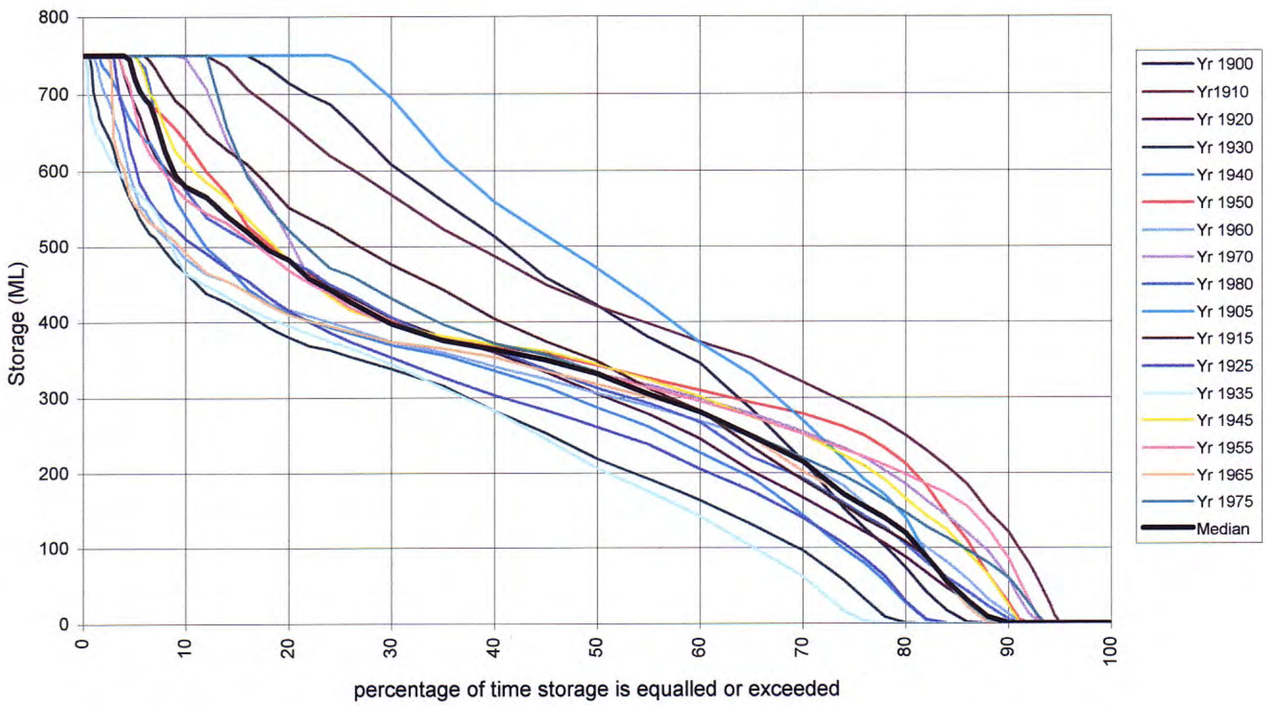
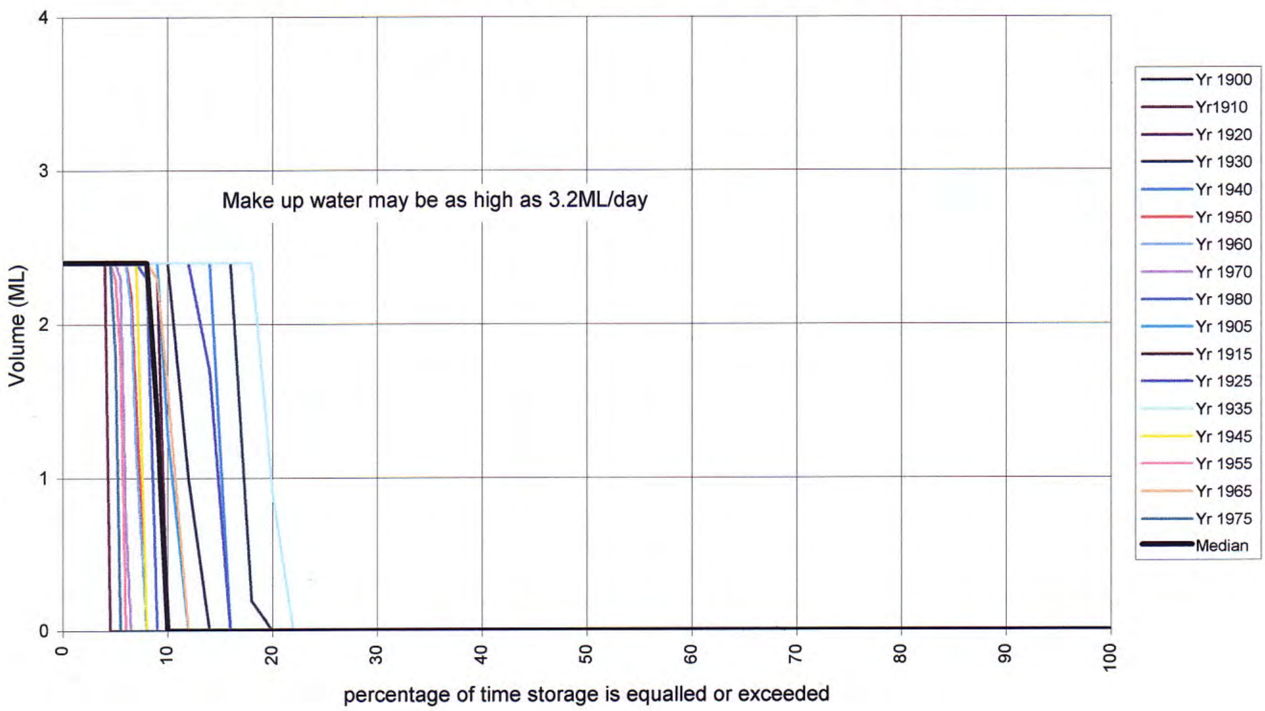
Figure G19b

Parnells Dam



System make up water from Liddell Dam 13 or other sources



West Pit Extension & Minor Modifications

Percentile plots: Parnells Dam with HRSTS discharges
Parnells Dam and make up water requirements

APPENDIX H: WATER MANAGEMENT LICENSES

Licence No.	Description	Site	Land Identifiers	Property name
20BL166175	Mining	HVO	LOT 10 DP740183	HV No 1 Mine
20BL166176	Mining	HVO	LOT 10 DP740184	HV No 1 Mine
20BL167799*	Dewatering Slots	HVO	LOT 161 DP705454 LOT 165 DP727718 LOT 2 DP808301	Carrington
20SL042746	Pt 89 Liddell	HVO	PART LOT 89 DP752470	Load point Pump
20CW801475	1 Levee Various parts	HVO	PART LOTS 1 DP191982 (FORMERLY PORTION 130 REM), 20 REM AND DP752481, 1 DP729048 (FORMERLY CLOSED ROAD), 98, 164 127 121 AND 120 DP752481 AND LOT 10 DP740183 (FORMERLY PORTIONS 114, 112 AND PART 132) & ROADS	HV No 1 Mine
20SL029752	1 x 100mm Centrifugal Pump	HVO	LOT 127 DP752481	Ravensworth - Durham
20BL153705	Bore Licence	HVO	PT130 (LT1 DP191982) 20REM PT98 117-127 PT170 (LT170 DP752481) LOTS 1 & 2 DP114966 LT1 DP729048 17 18 21 22 PT89 164 ROADS PT132 (LT10 DP740183)	Alluvial Lands
20CW800913	1 x Levee	HVO	LOT 132 DP 752481	HV No 1 Mine
20BL167860	Groundwater Licence	HVO	LOT 161 DP705454 LOT 165 DP727718 LOT 2 DP808301 LOT 128 DP752468	Carrington
20CW802600	1 x Levee	HVO	LOT 161 DP705454 (FORMERLY POR 129) and LOT 165 DP727718 (FORMERLY POR 130)	Carrington
20SL033624	1 x 100mm Centrifugal Pump	HVO	PT20 DP752481	North Mine
20CW802606	1 x Levee	HVO	LOT 128 DP752468 LOT 161 DP705454 LOT 165 DP727718	Carrington
20BL120968	1 x Bore	HVO	LOT 10 DP740183 (FORMERLY PART PORTION 132)	
20SL061104	1 X Cutting	HVO	LOT 165 DP727718	Carrington
20SL050903	Pt 6/11 Howick	HVO	LOT 1 DP625507 (FORMERLY PART PORTION 6)	Parnells Dam
20SL050995	2 x 250mm Centrifugal Pump	HVO	LOT 131 DP752481 LOT 19 DP753792	HVM Mining
20BL167718	Monitoring Bore	HVO	LOT 2 DP808301 (FORMERLY PORTIONS 96, 172 & 174) LOT 165 DP727718 LOT 128 DP752468	Carrington
20BL150179	Excavation	HVO	PORTION 120	Ravensworth - Durham
20BL166957	Groundwater Licence	HVO	LOT 2 DP808301 (FORMERLY PART 94)	Carrington
20BL166958	Groundwater Licence	HVO	LOT 161 DP705454 (FORMERLY PORTION 129)	Carrington
20BL166637	Test Bore Licences	HVO	LOT 127 DP753792	Carrington
20BL166638	Test Bore Licences	HVO	LOT 128 DP753792	Carrington
20BL166639	Test Bore Licences	HVO	LOT 130 DP753792	Carrington
20BL166640	Test Bore	HVO	LOT 93 DP753792	Carrington

	Licences			
20BL166641	Test Bore Licences	HVO	LOT 95 DP753792	Carrington
20BL166642	Test Bore Licences	HVO	LOT 96 DP753792	Carrington
20CW802604	1 x Block Dam	HVO	LOT 2 DP808301 LOT 175 DP46779 Part Portion 20 Conv. Reg No 568 Book 3269	HV North Pit - West Side
20AE302664	Water Amnesty Reg.	HVO	Novacoal	Various Dams
20AE302282	Water Amnesty Reg.	HVO	Esso Australia Lemington Coal Mines	Various Dams
20AE302663	Water Amnesty Reg.	HVO	Coal & Allied Operations Pty Ltd	Various Dams

HVO = Hunter Valley Operations

October 2003

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New South Wales 2007
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Hunter Valley Operations West Pit Extension and Minor Modifications

Volume 1 Environmental Impact Statement (Part A-E)

Volume 2 Technical Reports (Part F-H)

Volume 3 Technical Reports (Part I-L)

Volume 4 Environmental Impact Statement Figures