Environmental Impact Statement

Camberwell Coal Project

Glennies Creek, NSW

CAMBERWELL COAL JOINT VENTURE

October, 1989

EPPS & ASSOCIATES Pty. Ltd.

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6. REHABILITATION

6.1 LEGISLATIVE REQUIREMENTS

The NSW Department of Minerals and Energy (DM&E)[9] is responsible for the specification of rehabilitation standards and the granting of approval for compliance following completion of rehabilitation works.

The assessment of the success of rehabilitation includes a comparison of the pre-mining and post mining land capability or sustained stock carrying capacity as well as an evaluation of the vegetative cover.

Following Development Consent and granting of a Coal Lease, detailed rehabilitation plans must be prepared and approved by the DM&E prior to commencement of mining. Approval is for a period of five to seven years during which time annual rehabilitation reports must be submitted to the Department. These plans are required to show the extent of mining, proposed landforms following mining, including drainage patterns and an assessment of topsoil quantities and suitability for topdressing purposes.

Security deposits must be lodged with the Department to ensure that the site can be rehabilitated should the mining company be unable to fulfil its rehabilitation commitments. The amount retained is calculated according to the maximum area unrehabilitated at any time.

6.2 POST MINING LAND USE

6.2.1 Alternatives

It is necessary to assess preferred post mining land uses prior to mining in order that criteria to accomodate these uses can be incorporated into the final landform. These include considerations of slope, drainage and distribution of stripped topsoil. As disturbed areas will be progressively rehabilitated it is important that post mining land uses are compatible with the on-going land management plan for the site.

A range of post mining land uses were evaluated for the Project, but due to the uncertainty of the long term future of the site (which includes the possibility of underground mining with access from the South Pit) the assessment cannot be definitive. The site master plan will be flexible enough to cater for changes on the site, alterations to land use on adjacent sites and changing economic and usage patterns in the community.

The alternative uses evaluated were:

Grazing. This represents the major land use for the site, adjacent properties and the Hunter Valley. Existing property sizes vary from smaller properties of 80 to 120ha to the average size of about 400ha.

A grazing post mining land use results in the least number of constraints to rehabilitation planning as the development of a satisfactory pasture sward can be established within one to three years after reinstatement of the surface. This land use is best restricted to slopes less than 10°.

The re-establishment of pastures for grazing use on land rehabilitated following mining has been developed to a stage where a high level of confidence can be predicted. The results of a recently completed five year field trial has indicated that rehabilitated mining sites are capable of sustaining similar or better stocking rates than native pastures on equivalent land (Dyson et al). In this trial, ground coverage was found to improve from 50% to 90% over a five year period for one of the study areas which did not receive topdressing material.

9 Provisions relating to rehabilitation are set out in Part VII of the Coal Mining Act, 1973. Section 41 (6) of the Act, provides legislative responsibility for the Soil Conservation Service to approve of conditions included in the coal lease for the reinstatement, levelling, regrassing, reafforesting and contouring of land. One of these conditions is that disturbed land should be returned to at least its former stability, capacity and productivity.

Forestry. Coverage of the site by Eucalypt woodland (both remnant natural and regenerative) amounts to about 25% of the Authorisation area, as depicted in Figure 7.6.1. The site, in common with most of the Upper Hunter Valley is not capable of producing marketable timber from the establishment of Eucalypt forest. The alternative of recreating Eucalypt woodland similar to the present natural vegetation is feasible, as demonstrated by the results at the Saxonvale Mine and from trials conducted at the Hunter Valley No 1 Mine and the Drayton Mine.

Recreational Use. The Project site is approximately 10km from Singleton and therefore is probably too far for consideration as an area for active recreational use, given the adequate supply of sporting facilities within close proximity to the town. Recreational use of restricted sections of the site for picnicking, camping and a caravan park, related to the large water storage dams along the eastern side of the site may be feasible.

Waste Disposal. A void is proposed to remain within the South Pit at the end of the 21 year lease period as a means of entry to underground resources. This would be available in the long term for the disposal of coal washery reject material from the Camberwell Project should underground mining be developed and adjacent projects if required. The disposal of urban waste material from Singleton represents a further long term alternative use of the void which could be investigated during the latter part of the initial lease period.

6.2.2 Preferred Post Mining Land Use

A broadscale post mining land use strategy for the site comprises a combination of all the above alternatives, with grazing as the predominant use.

The redevelopment of small farm units will enable the site to be integrated with the existing farm management practices of the surrounding buffer zone and nearby farms. Rehabilitation of the mined land to a standard suitable for grazing should be readily accomplished by adoption of proven practices.

Natural timbered areas will be established along ridgelines, watercourses, gullies and on slopes exceeding 10° with the objective of re-establishing the current landscape character and ensuring surface stability of land with a higher erosion potential.

Limited recreational use of the SLA area, related to the larger water storage dams would represent a desirable component of the end land use of the site.

6.3 LANDFORM DESIGN

6.3.1 Design Criteria

Post mining topography has been designed to fulfil the following objectives:

- compatibility with adjacent natural land surfaces;
- creation of a stable, erosion-free surface suitable for the proposed end land use;
- minimisation of overburden rehandling and haulage distance consistent with the Project's economic criteria; and
- progressive rehabilitation of backfilled areas to ensure disturbed areas are kept to a minimum.

To achieve these criteria, slopes will be reformed predominantly at less than 10° (1V:6H) and where possible not exceeding 6° (1V:10H). Drainage density will be increased above the present density and where possible an additional stream order will be incorporated within the new landform compared to the existing four and five order drainage pattern. Numerous small dams will be located on reformed watercourses and drainage gullies to provide short term retention and erosion control functions in the early establishment period. The larger dams in this system will be retained for stock watering purposes and possible recreational use as part of the post mining land use proposal.

An overburden swell factor of 30% has been assumed for the purposes of landform design.

6.3.2 Interim and Final Landforms

North Pit and Out-of-Pit Overburden Emplacements

Out-of-pit dumping of overburden generated from the North Pit will occur during the first six years of operation. From Year 3 overburden will also be backfilled into the North Pit.

Dump areas will be prestripped ahead of dumping operations and prestripped soil material stockpiled. This material will be respread at the earliest opportunity.

Initial dumping of overburden along the northwestern boundary of the pit will create an effective bund to ameliorate potential noise, dust and visual impacts as well as provide protection to the pit from floodwaters. It will be constructed during the first year of operations and revegetated immediately.

Emplacement within the main overburden dump located east of the North Pit (see Figure 3.1.3) will commence from the eastern boundary. This will provide an effective visual screen to later overburden emplacement and mining activities in the North Pit when viewed from the almost one km distant Bridgman Road. The dump will initially be constructed with two areas of operation – one for daytime dumping and a second for night-time dumping set back from the perimeter to ameliorate night-time noise impact. This eastern section of the dump will be rehabilitated within the first two years of operations.

The dump will extend over the worked out North Pit as soon as mining conditions permit (Figure 3.1.5). The South Pit overburden will be dumped in the North Pit up to Year 13. Coal preparation reject material will be disposed of within the defined spoil areas.

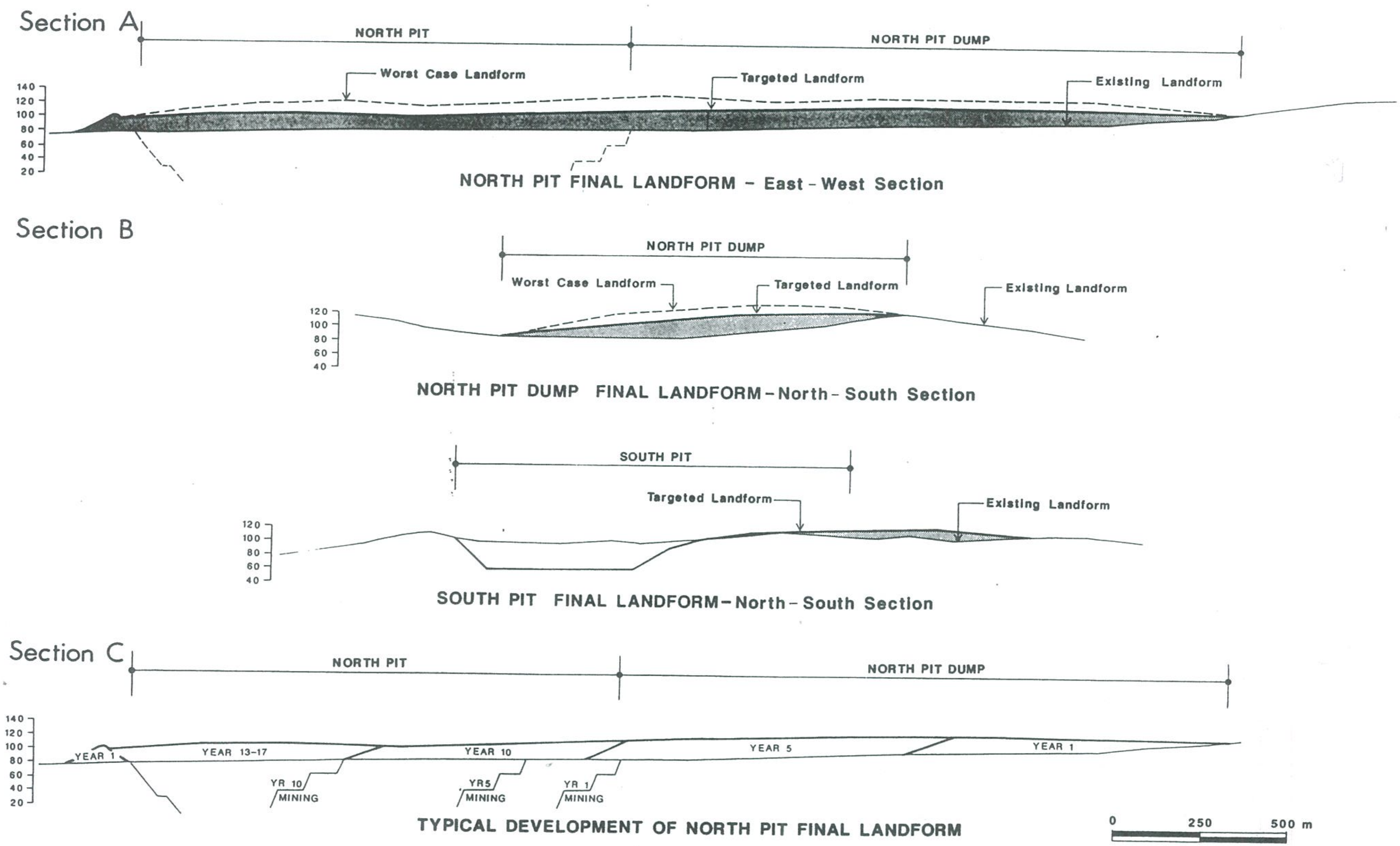
The overburden dump east of the North Pit has been designed to represent a southern extension of the existing east-west orientated major ridgeline. An objective of the rehabilitation programme will be to endeavour to restrict all dumping below the crown of the ridge. Overburden will be emplaced along a north-south front which will progress in a westerly direction. The "targeted" maximum fill height for the dump will be RL 120 which is 5m below the top height of the existing ridgeline. The "worst case" scenario, presented in Figures 3.1.3 to 3.1.9 has a maximum height of RL 130. Slopes of the new landform will vary between a maximum of 1V:5H (20%) to a minimum of 1V:70H (1.5%).

The distribution of slope classes for the two alternative proposed landforms is shown in Table 6.3.1.

TABLE 6.3.1

COMPARISON OF PRE-MINING & POST MINING TOPOGRAPHY

Slope Class %	Pre-mining Landform	"Targeted" Landform %occurrence	"Worst Case" Landform
North Pit & Dump			
0-1	27	–	–
1-5	36	80	27
5-10	31	17	48
10-15	6	1	23
15-20	-	2	2
South Pit & Dump			
0-1	–	–	
1-5	40	43	
5-10	56	40	
10-15	4	15	
15-20	–	2	



CAMBERWELL COAL PROJECT	Date	Figure 6.3.1
FINAL LANDFORM SECTIONS		

This analysis of topography indicates that for either scenario, maximum slopes of the recreated North Pit landform are within acceptable limits based upon stability criteria, viz. less than 1V:6H (16.5%). Section A of Figure 6.3.1 illustrates typical profiles of the two alternative proposed landforms in comparison with the existing surface.

To compensate for the increase in surface slopes and the backfilled nature of the landform, drainage density[10] of the proposed land surfaces will be increased from 0.047 at present, to 0.031.

The targeted landform has a capacity of approximately 135 x 10^6m^3 while the "worst case" landform will accommodate about 180 x 10^6m^3. Both emplacement alternatives occupy an area of approximately 435ha, which includes 155ha of the North Pit.

Rehabilitation of the North Pit will be undertaken sequentially in a southeast to northwest direction, as an extension of the landform described for the overburden emplacement. While some backfilling will occur within the North Pit from Year 3 onwards, at the same time as overburden is being emplaced out-of-pit, final reshaping within the Pit will not occur until about Years 5 to 6.

Final rehabilitation will be undertaken by about Year 13 for the targeted landform and by Year 17 for the "worst case" landform.

South Pit and Out-of-Pit Overburden Emplacements

Pre-stripping within the northwestern corner of the South Pit is scheduled to commence from Year 7, with overburden being emplaced out-of-pit (Figure 3.1.6).

The spoil emplacement south east of the South Pit could have a capacity of approximately 2.5 x 10^6m^3, established within the existing north to northeast trending valley. The upper reaches of this valley are hidden from the Main Northern Railway by a prominent knoll rising to a maximum height of 110m. At the northern end, the emplacement will finish at least 100m from the Railway in order to allow vegetative screening to be established.

Where possible, in accordance with the land ownership situation prevailing at the time, bunding along the western margin of the South Pit could be constructed as an extension to the knolls and ridges located on either side of the northwest orientated valley. It is anticipated that the bunding could be constructed by Year 9 with progressive rehabilitation being undertaken to ensure quick integration with adjacent landforms. This bund construction would ameliorate the noise, dust and visual impacts generated during the early stages of the South Pit mining operations for the benefit of residences located along the Glennies Creek alluvial flats.

It is planned that major in-pit dumping could commence in Year 13. It is not practical to commence in-pit dumping at an earlier stage in the South Pit because of the need to retain numbers of working faces and to provide practical working room. The advancing face of a multi-bench mine is about 16° which consequently extends over a large area of both these relatively small pits. The South Pit does not have the advantage of the North Pit in working from the subcrop of the lowest coal bed allowing early back fill into the pit. Some of the spoil from the South Pit will be placed in the North Pit until in-pit dumping can commence. Scheduling requirements determining the duration of this spoil transferral, will determine whether the "targeted" landform for the North Pit can be achieved.

Rehabilitation will be progressive behind the advances in mine development. However, as in-pit dumping occurs late in the life of the South Pit, a final void of about 70ha in area and up to 80m deep will remain. This final void is a desirable feature with regard to potential future access to underground resources and provision of space for pit head facilities or as a base for deepening the Pit should economic conditions allow for this.

Final topography of the 185ha area rehabilitated at Year 20 will be generally similar to the pre-mining landform. As depicted in Table 6.3.1 there will be an increase within the 10 to 15% slope class. Section B of Figure 6.3.1 illustrates the post-mining landform in comparison with the existing land surface.

10 Drainage density is the catchment area in hectares divided by the total channel length in metres.

Table 6.3.2 provides a comparison of the area disturbed and rehabilitated during the life of the open cut. The extent of progressive rehabilitation is shown graphically in Figures 5.4.2 to 5.4.4, whilst schematic development of the post-mining landform is shown in Section C of Figure 6.3.1.

TABLE 6.3.2

COMPARISON OF AREA DISTURBED & AREA REHABILITATED

Year	Area Disturbed (ha)	Progressive Total of Area Disturbed (ha)	Area Rehabilitated (ha)	Progressive Total of Area Rehabilitated (ha)
North Pit & Dump				
1	153	153	–	–
2	93	246	110	110
5	154	400	105	215
10	34	434	129	344
13	–	434	5	394
17	–	434	40	434
20	–	434		
South Pit & Dump				
1	–	–	–	–
2	–	–	–	–
5	–	–	–	–
10	180	180	64	64
13	63	243	–	64
17	7	250	17	81
20	4	254	104	185 (final void 69ha)

Post Mining Land Capability

Table 6.3.3 provides a comparison between the rural land capability at present (as defined in Section 7.9.2) and the capability of the final landform at Year 20.

The analysis for the North Pit shows that the post mining land surface should be capable of supporting a similar land use to that which exists at present. This interpretation is supported by the slope and terrain classes being less than 25% and the intention of respreading a minimum of 10cm of topdressing material over a reasonably well drained substratum of compacted overburden (<4mS/cm salinity).

The South Pit final landform, whilst resulting in a higher proportion of Class IV and V land than prior to mining, will inherit a significant percentage of Class VIII land due to the presence of the void.

TABLE 6.3.3

COMPARISON OF PRE-MINING & POST MINING LAND CAPABILITY

Rural Land Capability Class	Premining Landform %	Targeted Landform %	Worst Case Landform %
North Pit & Dump			
IV	20	90	70
V	67	5	27
VI	8	–	–
VII	5	5	5
South Pit & Dump			
IV	39	58	
V	36	15	
VI	25	–	
VII	–	–	
VIII	–	27 (final void)	

6.4 REVEGETATION PROCEDURES

6.4.1 Guidelines

Revegetation of landforms resulting from open cut mining has developed to a sophisticated level as a result of collaboration between many Hunter Valley mining companies, the Soil Conservation Service of NSW, the Forestry Commission of NSW and the input of numerous research projects including those funded under the NERDDC[11] programme.

Where appropriate these guidelines will be altered to suit site specific circumstances, particularly with respect to the results of on-site revegetation trials.

Clearing

The majority of the site which is proposed to be disturbed has been cleared previously of vegetation and exists as grazing land. The northeastern and southwestern sections of the South Pit represent the main areas where clearing of woodland vegetation would be undertaken.

Timber suitable for use as fence posts, milling and for landscaping purposes will be removed prior to clearing. Remaining timber will be cleared and windrowed by bulldozer and burnt in accordance with the requirements of the local bushfire brigade. Consideration will be given to the chipping of smaller diameter vegetative material to be used as a mulch in landscaped areas and for use as organic material in the rehabilitation programme.

Topsoil Stripping

Vegetation and topsoil stripping will be limited to a zone varying between two and three mine strips or 60m to 240m in advance of mining. Wherever possible, topsoil will be respread onto current rehabilitation areas soon after stripping in order to maintain its viability. For certain areas such as the surface facilities site it will be necessary to stockpile topsoil for up to one or two years. These stockpiles will be limited to 60cm in height and sown with a cover crop to maintain viability and to prevent surface erosion.

11 National Energy Research Development and Demonstration Council.

Stripping will be undertaken to the extent and depths shown on Figure 7.2.3, using either scraper loaders or a combination of bulldozer, loader and truck.

Calculations summarised in Table 6.4.1 indicate that sufficient topdressing material will be available for respreading over the final landforms to an average depth of 10cm. Surplus material stripped from the North Pit and Dump would enable respreading to a thicker depth along gullies, water courses and areas of steeper slope. These calculations do not allow for the long term storage of topsoil for later treatment of the final void.

TABLE 6.4.1

ESTIMATED QUALITY OF SUITABLE TOPDRESSING MATERIAL

Stripping Depth (cm)	Area (ha)	% Occurence	Volume (m^3)
North Pit & Dump			
0	73	17	0
10	118	27	118,000
15	115	26	172,000
20	112	26	224,000
25	16	4	40,000
	434	100	554,000
South Pit & Dump			
0	63	25	0
10	191	75	190,000
	254	100	190,000
Surface Facilities			
0	3	10	–
10	–	–	–
15	26	90	39,000
	29	100	39,000

Suitability of Overburden and Interburden.

Analysis of representative overburden and interburden material as described in Section 5.7.2 has shown the material to be largely representative of coal measures strata elsewhere within the Hunter Valley. The main difference is the acid nature (pH 5.7 to 6.3) compared with the predominantly alkaline material (pH 7 to 9) normally encountered on other sites.

The material is non-acid forming and therefore leachate from overburden dumps and the pits is expected to be of satisfactory quality. Salinity levels are moderate with average values within the range 2 to 3mS/cm for saturated extracts and a maximum value of 6.9mS/cm being recorded. Relatively high salinity levels have been identified in a couple of strata units. Geochemical tests are in progress from additional sites within the Pits to further clarify the suitability of overburden for final placement. Monitoring of salinity and other tests addressed here will continue during mine operations. High salinity material will not be placed on or close to the final surface.

Sodium absorption ratios are high (7 to 28) indicating that surface setting will be a problem in inhibiting germination and creating excessive surface erosion. This sodium imbalance will be ameliorated by the addition of gypsum to the overburden at a rate of about 5t/ha and by the use of topsoil for the creation of a suitable seed bed.

In common with most coal measures material, the overburden and interburden has a low fertility status. It will require initial fertiliser addition followed by top dressing applications at regular intervals as scheduled in Table 6.4.2.

Final Shaping

Overburden will be placed approximately to the contours shown on Figures 3.1.3 to 3.1.9, subject to verification by subsequent, more detailed rehabilitation plans prepared to a scale of 1:4000. This will be undertaken as part of the detailed mine planning process.

The removal of large surface rocks in excess of 50cm diameter, deep ripping along the contour and final shaping of surfaces to optimal slope profiles will be undertaken by appropriately-sized machinery. Drainage lines, small sedimentation dams and graded banks will be constructed as part of the rehabilitation programme prior to topsoil respreading. The surface will be left in a rough state to promote infiltration and minimise surface erosion.

Surface Preparation

Approximately 75% of the fertiliser specified in Table 6.4.2 will be incorporated into the overburden prior to topsoil spreading. This is to encourage deeper root penetration and increase the drought resistance of the sown pastures.

Topsoil will be spread over the overburden by shallow ripping along the contour, to produce a suitable seed bed. Areas of higher erosion potential, including drainage lines, dam walls, erosion control structures and areas of steep slope will receive thicker coverage of topsoil.

Seeding

Seeding of rehabilitated areas will be undertaken in autumn or spring in accordance with the seed and fertiliser requirements listed in Table 6.4.2. These represent general recommendations provided by the Soil Conservation Service of NSW for the Whittingham Coal Measures. Variations to this specification are likely to occur depending upon the results of on-site revegetation trials and continuing rehabilitation procedures.

The remainder of the fertiliser not incorporated into the overburden prior to topsoiling, will be ground broadcast with the seed by agricultural implements following cultivation and the onset of suitable rain.

TABLE 6.4.2

RECOMMENDED FERTILIZER & SEED APPLICATION FOR REVEGETATION

			kg/ha
Fertilizer	Initial application	Starter 15	400
	Maintenance applications	Starter 15	200
		Nitram	100
Species	Autumn sowing:	Rhodes grass	8–15
		Couch	4–6
		Wimmera rye	4–8
		Lucerne	2–4
		Sephi barrel medic	4–8
		Sub-clover	2–4
		Bambatsi or green panic	6–12
			30–57
	Spring Sowing:	Rhodes grass	8–15
		Bambatsi or green panic	6–12
		Couch	4–6
		Lucerne	2–4
			20–37
Cover Crops	Spring	Pearl Millet	5–10
	Autumn	Cooba oats	5–10

Tree planting

It is proposed to re-establish areas of open forest vegetation type on the newly contoured surfaces typical of the Hunter Valley forest that was originally cleared for farming.

Broad plantings of trees to similar densities as the existing remnant woodland will be established along ridge lines, water courses and areas of steep slope (ie. steeper than 10°). Figure 6.4.1 provides an indication of the extent of planting envisaged at the end of Year 20. It is anticipated that these areas will be established by direct seeding techniques involving the ground broadcasting of suitable indigenous tree and shrub seed together with a quick growing cover crop as listed in Table 6.4.3. The intention of the cover crop is to provide fast cover to the ground surface, minimising surface erosion and dust generation until the tree and shrub species become established.

Within the areas of pasture establishment, shade trees will be planted as tube stock and protected by fencing from stock.

TABLE 6.4.3

SPECIES LIST FOR FORWARD TREE PLANTING PROGRAMME AND REHABILITATION

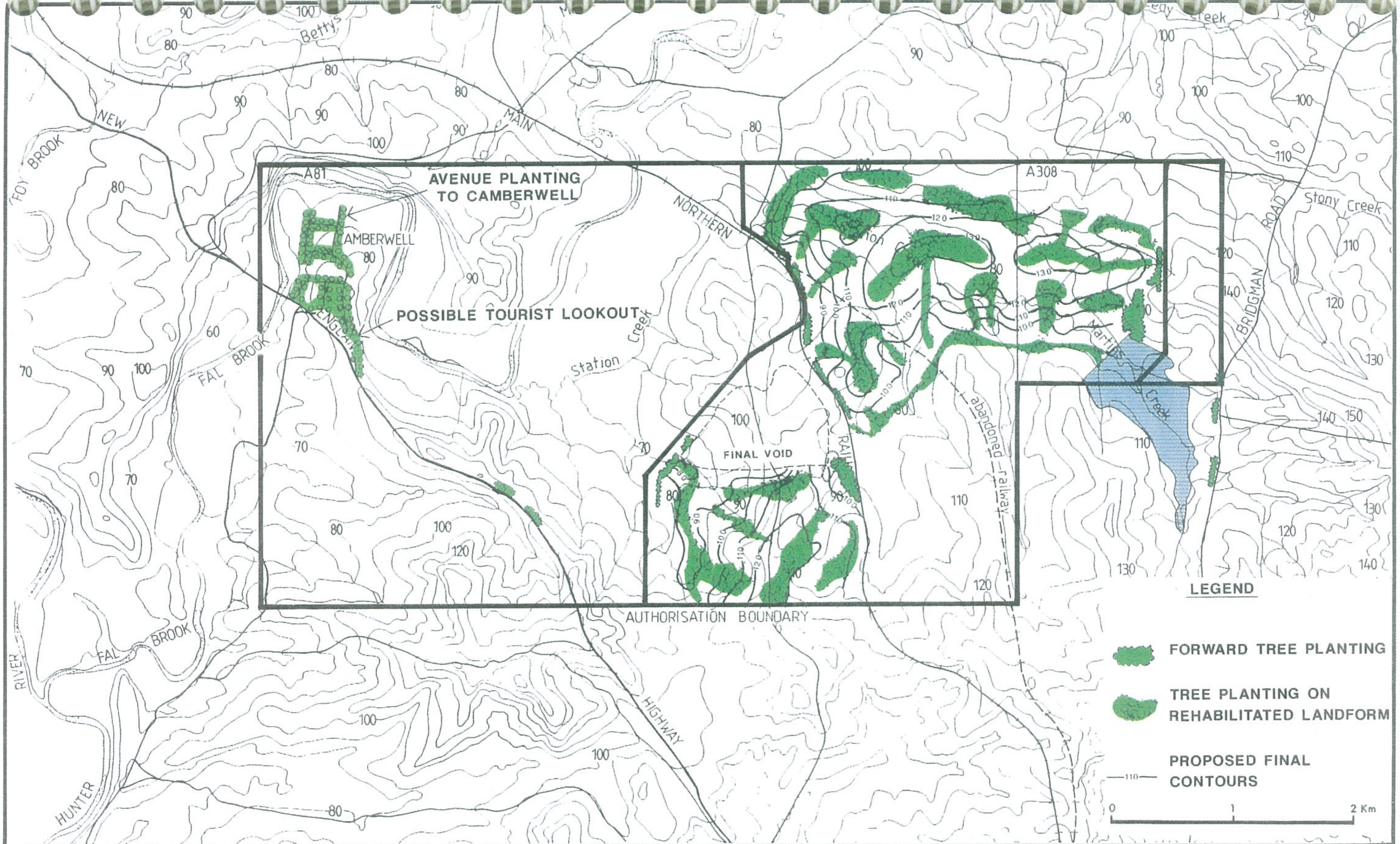
	Scientific Name	Common Name
Shrubs	Acacia amblygona	Fan Wattle
	A. decora	Western Silver Wattle
	A. falcata	Sickle Wattle
	A. salicina	Cooba
	Indigofera australis	Indigo
Trees	Allocasuarina leuhmannii	Bull Oak
	Angophora floribunda	Rough-barked Apple
	Casuarina glauca	Swamp Oak
	C. stricta	Drooping Sheoak
	Eucalyptus crebra	Narrow-leaved Ironbark
	E. moluccana	Grey Box
	E. maculata	Spotted Gum
	E. tereticornis	Forest Red Gum

6.4.2 Field Trials and Monitoring of Rehabilitation

Ample research and experimentation concerning the rehabilitation of opencut coal mines in the Upper Hunter has been undertaken in recent years for example, NERDDC funded programmes on coal mine rehabilitation (Dyson et al) and the reafforestation of open cut coal mines using direct seeding techniques (Burns).

Characterisation of overburden, interburden and soils (Sections 5.7.2 and 7.2) has shown the materials on this site to be generally typical of materials on adjoining sites and elsewhere within the Upper Hunter Valley.

For these reasons field trials will be limited to the development of optimal rehabilitation techniques. These will include the amelioration of material deficiencies by varying rates of gypsum, fertiliser type and application rates, optimal thickness of topdressing materials, pasture seed mixes and the direct seeding of tree and shrub species. Trials would be undertaken on the outer faces of out-of-pit overburden dumps.



CAMBERWELL COAL PROJECT	Date	Figure 6.4.1

AREAS PROPOSED FOR FORWARD TREE PLANTING

Monitoring techniques to assess the effectiveness of site rehabilitation will be selected from a number of methods, such as:

- Aerial photographs taken on a regular basis (annually, for example), provide a means of assessment for the comparison of rehabilitated land and adjacent undisturbed land. Factors to be assessed include vegetative coverage, erosion and landscape character.
- Ground measurements of vegetation density and species diversity can be made within specified plots. Measurement of the growth rates of stock over specified periods provides an additional method of monitoring the viability of the recreated pasture (Dyson et al).

Periodic testing of overburden, interburden and topdressing material will be undertaken over the life of the Project. This willl ensure that any deleterious horizons are identified and that adjustments to fertiliser and gypsum rates can be made if necessary.

6.4.3 Land Management Plan

The site land management plan will combine management objectives and procedures for the buffer zone, the North and South Pits and rehabilitated areas following the completion of mining. The total area under management as defined in Plate 2.8.1 is expected to be approximately 2,000ha.

It is anticipated that all agricultural land will be managed by a CCJV appointed farm manager who will work in conjunction with the Company's environmental officer with respect to rehabilitated areas. Detailed arrangements of the land management scheme will be prepared after receival of Development Consent and finalisation of land purchases.

A number of alternative means of managing the land are possible and the final land management plan may comprise a combination of these. Alternatives include:

- the owner leasing the property back from the Company and continuing existing agricultural pursuits;
- grazing by agistment under the control of the Company's representative; or
- the Company managing the site as a large grazing concern.

Following mining and rehabilitation, it is expected that grazing of rehabilitated land would not take place for at least two or three years. During this period, management practices would include weed control by spraying, maintenance applications of the fertilisers recommended in Table 6.4.2 for up to five years and if necessary the slashing of pasture grasses to encourage the growth of a healthy sward. Grazing on rehabilitated land will be controlled to ensure that ground cover is maintained at not less than 70% as this is considered the minimum value required to control erosion (Dyson et al).

Fencing to protect rehabilitated areas will be electric-type, temporary fencing in the initial years. Following the development of a healthy pasture on sufficient area, permanent fencing to define paddocks will be installed. Paddocks will be designed to suit the recreation of similar sized farming units to that which existed prior to mining.

Once rehabilitated areas have been approved by the DM&E, consideration will be given to the resale of these farming units provided that an adequate buffer zone exists around the current mining area.

7.3 HYDROLOGY AND WATER QUALITY

7.3.1 Hydrology

The Project area is essentially drained by the Station Creek catchment. This system drains into Glennies Creek which joins the Hunter River 10km below Camberwell. Station Creek generally flows east to west and has as its tributaries the northward flowing Martins Creek, Blackwall Creek and two other unnamed creeks. Figure 7.3.1 shows the creeks together with their catchment boundaries.

Monitoring of streamflows in Glennies Creek has been carried out by the Water Resources Commission (and now the Department) for almost 30 years. Two gauging stations are currently being maintained, one immediately downstream of Glennies Creek Dam and the other at Middle Falbrook which lies just to the north of the Authorisation areas. Results from the gauging station at Middle Falbrook have the most relevance for estimating flood levels at the site.

Records for the Middle Falbrook gauging station are available for the period 1956 to 1983. Two basic types of data are available:

- mean daily flow rates and daily "instantaneous" peaks; and
- mean daily stream heights and daily "instantaneous" peaks.

The former would be calculated directly from the latter using stage/discharge rating curves.

The other available data source for flooding, is the records kept by the Department of Water Resources of heights reached by the Hunter River during the 1955 flood. In the vicinity of the Mine Site these consist of a number of spot levels along the main stream of the Hunter River.

Glennies Creek Flood Levels

Basis of Calculations

No detailed survey data could be obtained of historic flood levels along Glennies Creek. In addition, no information is available on the effects of Glennies Creek Dam upon flood levels in the lower reaches of the creek. The Dam is located about 40km upstream of the Hunter River Junction, or 28km upstream of the Bridge where the Main Northern Railway crosses Glennies Creek near Camberwell. The Dam controls a significant percentage of the total drainage catchment, including high rainfall areas in the headwaters of the creek.

There are two potential types of flooding in Glennies Creek near the proposed Mine.

(i) Backwater flooding caused by a surcharge of the Hunter. This can be estimated using historical levels from the 1955 flood.

(ii) Flooding due to storms in the Glennies Creek subcatchment. This can be determined from gauging data and conventional hydrological analysis.

1955 Flood Levels

One recorded flood level of relevance to the site is available from the 1955 flood of the Hunter River. The 1955 flood is considered to be approximately equivalent to a 1 in 100 year flood in the main channel of the Hunter, although this may not be the case for all its tributaries. The recorded level was taken opposite the confluence of Glennies Creek and the Hunter River and indicated a maximum height reached of 62.6m AHD[16]. Backwater calculations were performed on Glennies Creek by conservatively extrapolating this level at the bed slope of the creek. This gave an estimated flood level of 65.7m AHD at the confluence of Glennies Creek and Station Creek.

16 Australian Height Datum.

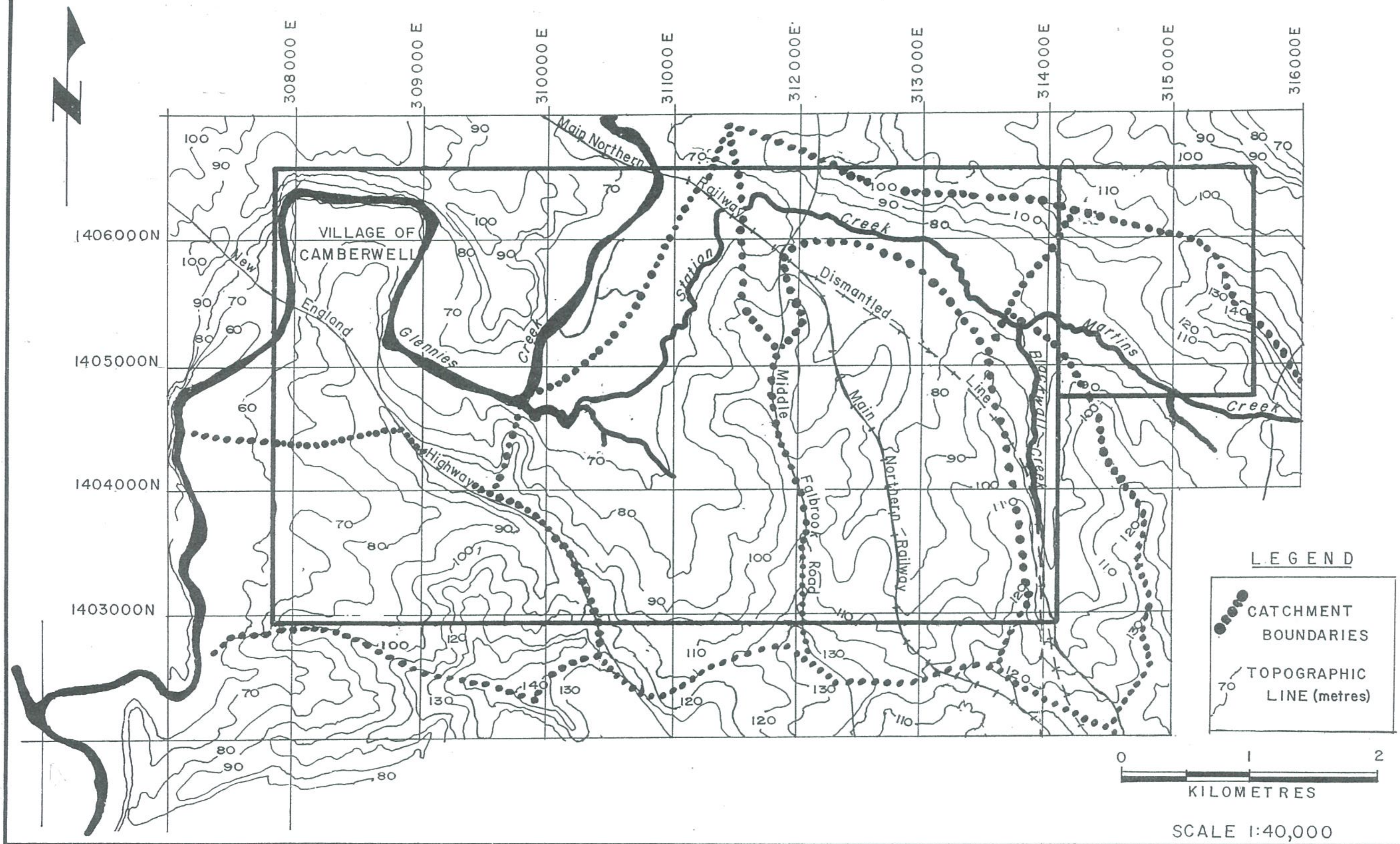


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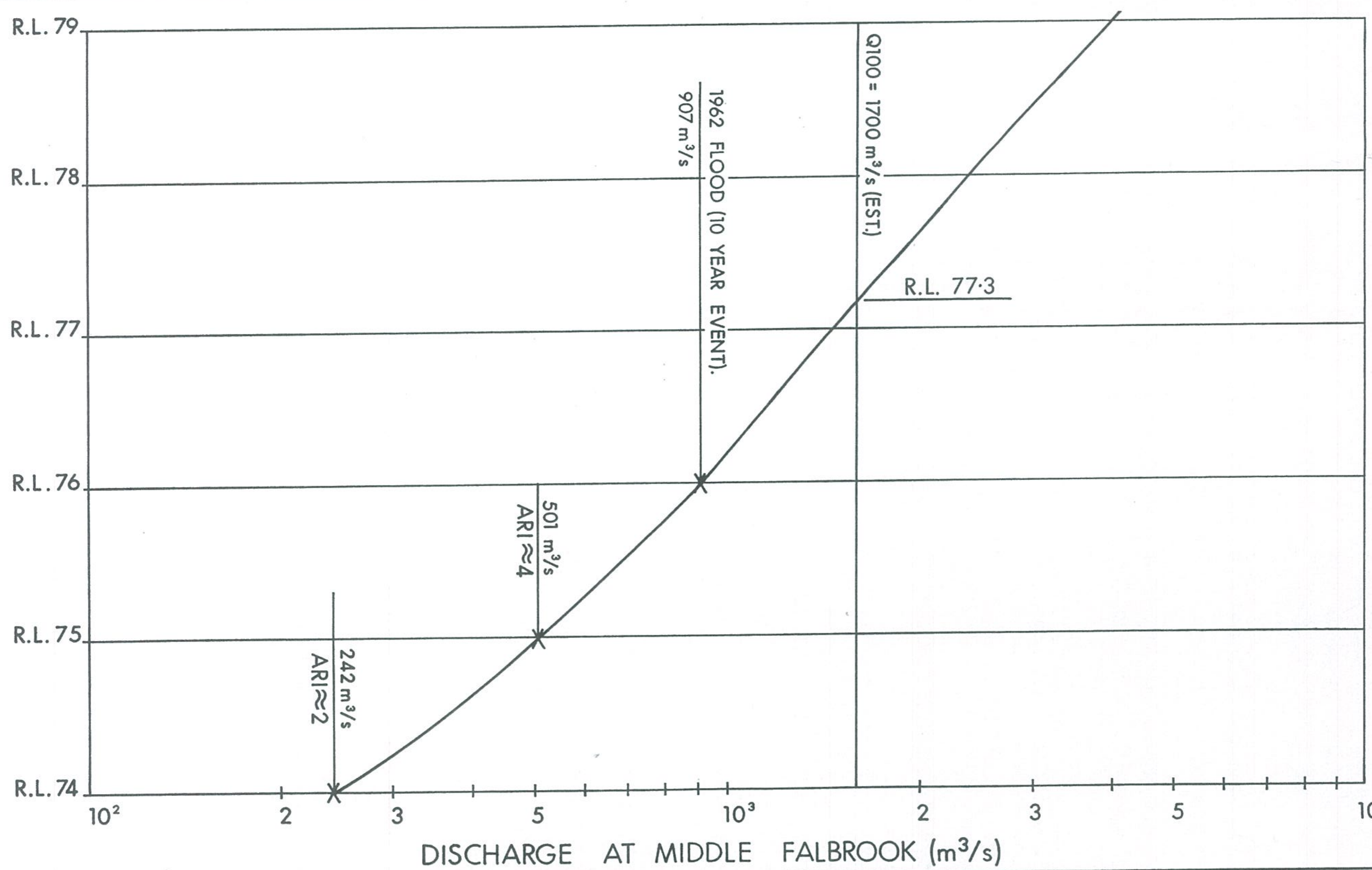
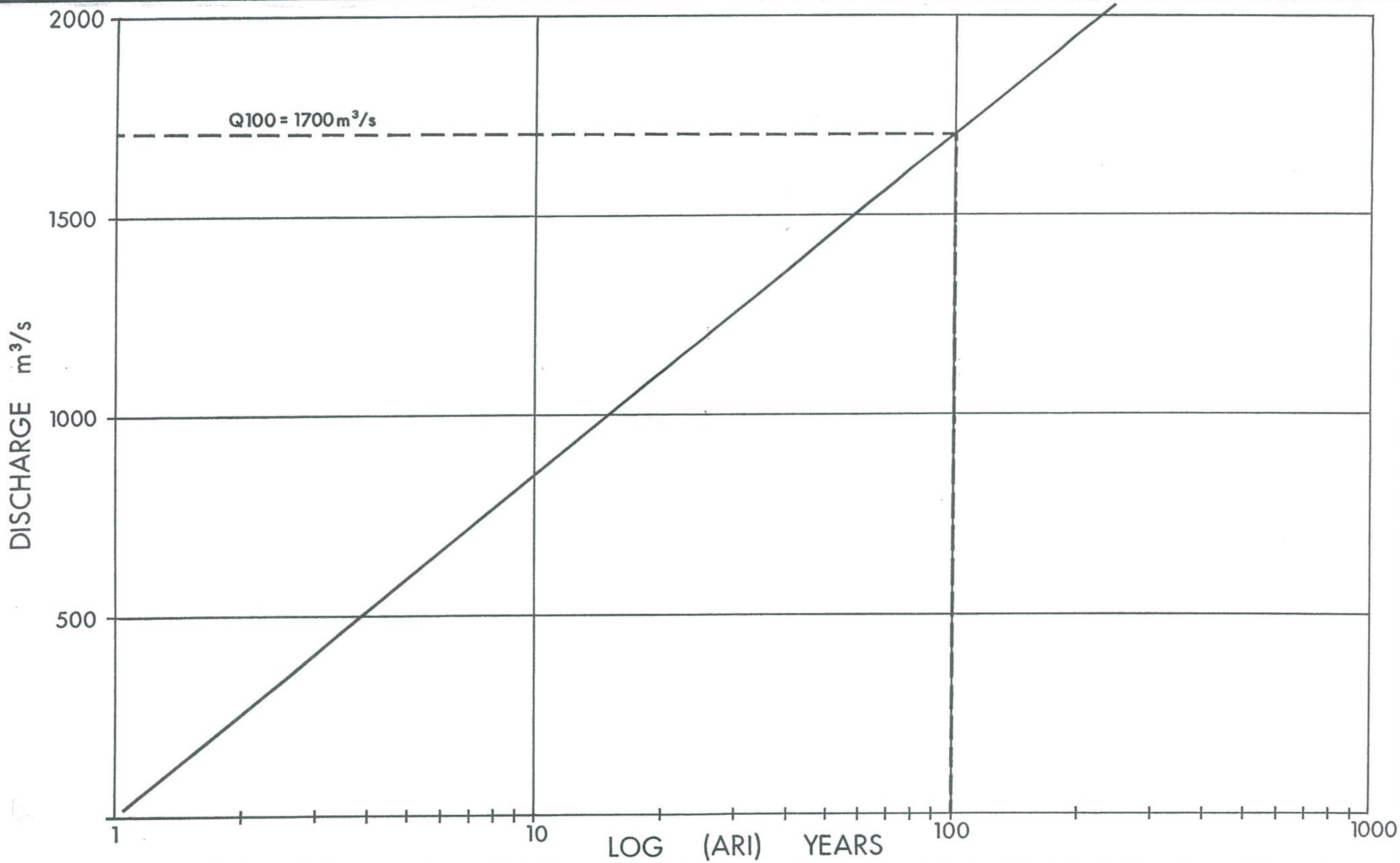
Figure 7.3.1

MAIN CATCHMENT BOUNDARIES



CAMBERWELL COAL PROJECT	Date AUG.'89	Figure 7.3.2

FLOOD LEVEL vs DISCHARGE AT MIDDLE FALBROOK GAUGE STATION



CAMBERWELL COAL PROJECT

Date AUG.'89 | Figure 7.3.3

DISCHARGE vs AVERAGE RECURRENCE INTERVAL OF GLENNIES CREEK

The flow rate and flood level in 1955 have been estimated using frequency analysis and extrapolating from the available records. This information is shown in Figure 7.3.2 which relates flood level to discharge at the gauge site, and Figure 7.3.3 which relates discharge to average recurrence interval. The estimated 100 year discharge is 1,700m^3/s. The records are useful in determining not only peak flow rates, but also minimum rates and long term averages (ie. 30 years in this case).

Examination of flow rates both before and after construction of the Glennies Creek Dam gives an indication of the effect which the Dam has had on the downstream flow rates. Since construction of the Dam insufficient years have elapsed for a definite pattern to emerge, however it is interesting to note that a flood which occurred in 1985 was the fourth highest on record and was only 10% lower than the highest recorded event. This would suggest that the Dam has had little effect on peak discharge rates.

It would be expected that even if the Dam was full, the effects of reservoir routing would generally decrease downstream flood heights. This may not be the case however if a lagged hydrograph caused flooding to coincide with peak discharges in the mainstream of the Hunter River.

Estimates of Flows

Estimates of streamflows have been made for the creeks draining into Glennies Creek.[17] Flow rates have been determined for several storm recurrence intervals commonly used for design purposes. These are 1 in 10 year, 1 in 20 year, 1 in 50 year and 1 in 100 year return periods. These intervals correspond to rainfall events which have a probability of occurring in any one year of 10%, 5%, 2% and 1% respectively. Table 7.3.1 summarises streamflow estimates for the locations given on Figure 7.3.1.

TABLE 7.3.1

GLENNIES CREEK TRIBUTARIES - STREAMFLOW ESTIMATES

Stream Location	Catchment Area (hectares)	1 in 10 yr	1 in 20 yr	1 in 50 yr	1 in 100 yr
1. Martins Creek	750	10.9	15.0	22	27
2. Blackwell Creek	280	7.4	10.5	13.8	16.6
3. Unnamed Creek	575	10.6	15.1	21	26
4. Upper Station Creek	1,030	14.9	21	30	36
5. Middle Station Creek	1,705	7.6	13.6	23	34
6. Lower Station Creek	2,285	8.3	9.5	18.3	33
7. Unnamed Creek	250	6.6	9.4	12.8	15.6
Total	6,875				

17 The estimates have been made using the rational method as detailed in Australian Rainfall and Runoff (Institution of Engineers, Australia, 1977).

7.3.2 Surface Water

Usage

Water flows in Glennies Creek are regulated by Glennies Creek Dam, built in the upper catchment of the creek. A major reason for construction of the Dam was to replace waters extracted from regulated releases of Glenbawn Dam for the Bayswater Power Station (Coulter, 1981).

Flows in Glennies Creek are used for agricultural irrigation. The Department of Water Resources advised that at the end of 1987 there were 57 authorised irrigation users licensed for 963ha. Since that time a further approximately 50ha have been licensed. The maximum land area within the Glennies Creek catchment to be supplied by irrigation is 1,500ha. The maximum annual allocation for non-permanent plantings is 6Ml/ha/a indicating a peak irrigation allocation of 9,000Ml/a. Glennies Creek Dam also provides regulated flow to the Hunter River and in 1989/1988 41,000Ml was released for irrigation purposes.

Water from Glennies Creek Dam is used in the town water supply for Singleton. A supply pipeline extends from the Dam to the town passing along Bridgman Road to the east of the Mine Site. There is currently surplus capacity in the pipeline.

Water Quality

Monitoring Programme

Two data sources are available to characterise the water quality of surface waters within and adjacent to the proposed Mine. A two year baseline monitoring programme was performed over the period September 1985 to August 1987 by Southland Coal Pty Limited. In addition the Department of Water Resources maintains two gauging stations on Glennies Creek where water samples are periodically collected for analysis.

The Southland Coal Pty Limited programme regularly sampled water quality in four watercourses: Martins Creek, Station Creek, Glennies Creek (also referred to as Fal Brook) and the Hunter River. The programme obtained baseline information on the existing water quality of watercourses potentially affected by proposed mining activities.

Figure 7.3.4 shows the location of the nine monitoring sites, while Table 7.3.2 describes each site and the reason for the site selection. The rationale behind the programme was to obtain baseline information on existing water quality in watercourses that may be affected by proposed mining activities.

In addition to the main watercourses, four farm dams as shown on Figure 7.3.4 were regularly sampled. These provided information on water presently used for stock watering and other agricultural purposes.

Monitoring results are presented in Tables 7.3.3 to 7.3.14.

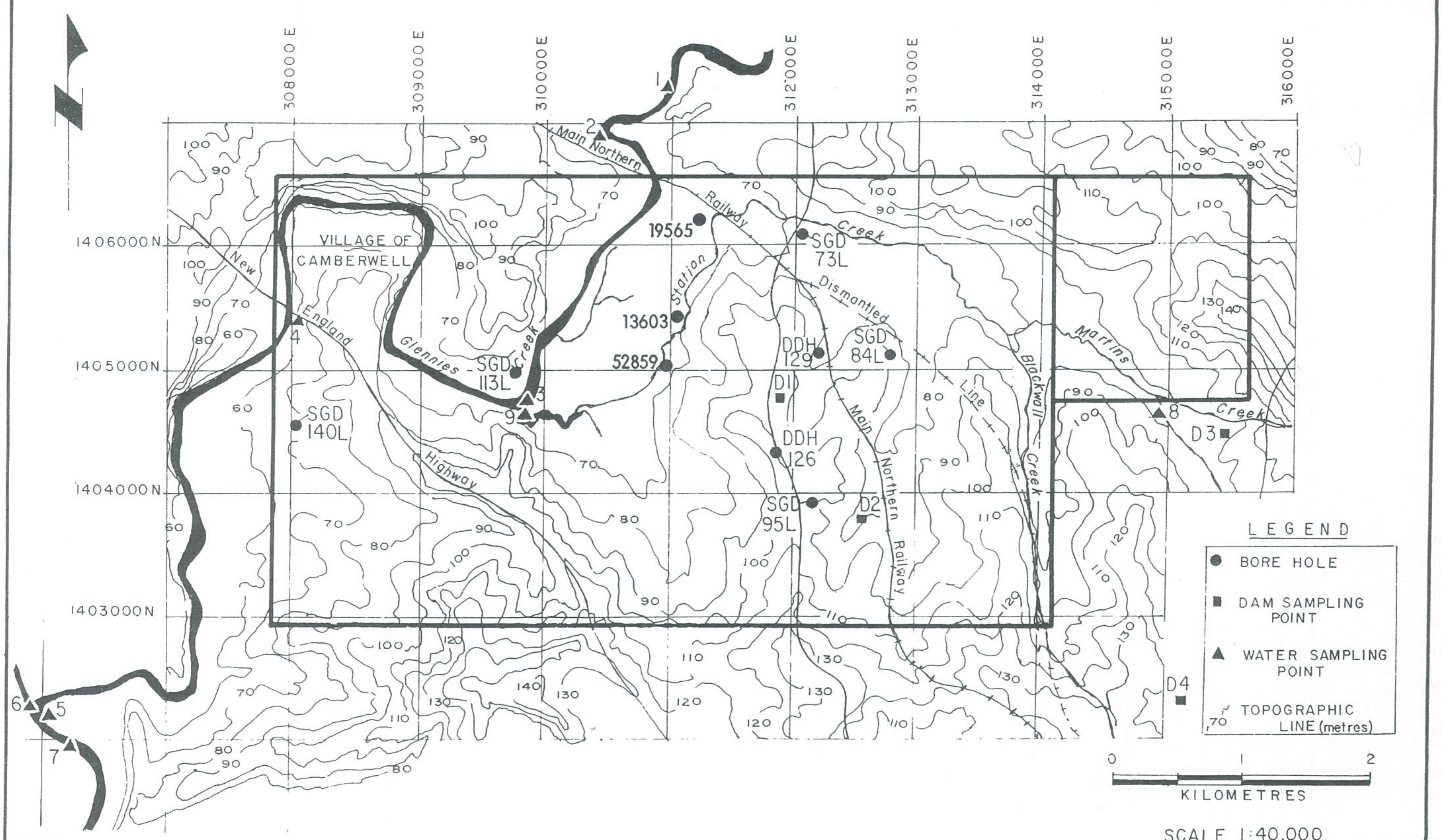


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Figure 7.3.4

WATER MONITORING LOCATIONS

TABLE 7.3.2

DESCRIPTION OF SURFACE WATER MONITORING SITES

Number	Location	Rationale
1.	Glennies Creek at Nobles Crossing	Quantifies water quality upstream of the site.
2.	Glennies Creek at Main Northern Railway Crossing	Almost on the Authorisation boundary. Downstream of Main Creek a major tributary of Glennies Creek.
3.	Glennies Creek upstream of Station Creek	Station Creek is the main drainage catchment within the Authorisation. This station monitors water quality in Glennies Creek prior to Station Creek contribution.
4.	Glennies Creek at New England Highway crossing	This station is on the downstream Authorisation boundary.
5.	Glennies Creek at the confluence of the Hunter River	Provides data on the contribution of Glennies Creek to the Hunter River.
6.	Hunter River upstream of Glennies Creek	Quantifies water quality upstream of Glennies Creek.
7.	Hunter River downstream of Glennies Creek	Quantifies water quality downstream of Glennies Creek. Acts as a check on the results of Stations 5 and 6.
8.	Martins Creek at Authorisation Boundary	Martins Creek drains a large area upstream of the proposed Mine Site. The station monitors water quality entering the site.
9.	Station Creek prior to entering Glennies Creek	Quantifies water quality of the main drainage catchment of the proposed Mine.

TABLE 7.3.3

WATER MONITORING RESULTS – pH

Sampling Location	No of Samples	Median	Range
1	24	7.5	7.3 – 8.1
2	23	7.6	7.3 – 7.9
3	24	7.6	7.1 – 8.1
4	23	7.8	7.5 – 8.5
5	24	7.7	7.4 – 8.0
6	23	8.3	7.8 – 8.6
7	24	7.8	7.4 – 8.1
8	10	6.5	6.0 – 7.5
9	24	7.6	6.5 – 8.4
Dam 1	24	7.1	6.2 – 8.9
Dam 2	24	6.6	5.6 – 7.2
Dam 3	24	6.9	6.0 – 7.6
Dam 4	24	6.5	5.7 – 7.7

TABLE 7.3.4

WATER MONITORING RESULTS – Conductivity (micro siemens/cm)

Sampling Location	No of Samples	Median	Range
1	16	450	310 – 720
2	16	540	350 – 1,150
3	16	620	400 – 1,010
4	15	660	400 – 940
5	16	725	430 – 920
6	15	740	480 – 1,070
7	16	725	430 – 920
8	7	835	590 – 1,830
9	16	850	680 – 11,750
Dam 1	16	155	90 – 270
Dam 2	16	200	130 – 280
Dam 3	16	210	60 – 270
Dam 4	16	180	90 – 240

TABLE 7.3.5

WATER MONITORING RESULTS – Total Dissolved Solids (mg/l)

Sampling Location	No of Samples	Median	Range
1	16	290	200 – 460
2	16	345	220 – 736
3	16	400	255 – 645
4	15	420	255 – 600
5	16	455	275 – 580
6	15	475	305 – 685
7	16	465	275 – 590
8	7	535	380 – 1,170
9	16	545	275 – 7,520
Dam 1	16	100	60 – 175
Dam 2	16	125	85 – 180
Dam 3	16	110	40 – 175
Dam 4	16	115	60 – 155

TABLE 7.3.6

WATER MONITORING RESULTS – Suspended Solids

Sampling Location	No of Samples	Median	Range
1	16	4.5	ND – 48*
2	16	2.5	ND – 18
3	16	3	ND – 114
4	15	2	ND – 10
5	16	3	ND – 178
6	15	3	ND – 23
7	16	2	ND – 48
8	7	187	11 – 339
9	16	9	3 – 319
Dam 1	16	57	8 – 93
Dam 2	16	30	9 – 552
Dam 3	16	44	4 – 777
Dam 4	16	390	51 – 711

* ND = Not detected

TABLE 7.3.7

WATER MONITORING RESULTS – Turbidity

Sampling Location	No of Samples	Median	Range
1	16	2	ND – 5
2	16	2	ND – 5
3	16	2	ND – 7
4	15	2	ND – 4
5	16	2	ND – 5
6	15	1	ND – 7
7	16	1	ND – 5
8	7	125	10 – 210
9	16	5	ND – 100
Dam 1	16	26	11 – 90
Dam 2	16	30	10 – 93
Dam 3	16	16	2 – 280
Dam 4	16	240	160 – 600

TABLE 7.3.8

WATER MONITORING RESULTS – Sodium (mg/l)

Sampling Location	No of Samples	Median	Range
1	5	–	25 – 59
2	5	–	30 – 279
3	5	–	37 – 75
4	5	–	39 – 69
5	5	–	37 – 69
6	5	–	25 – 78
7	5	–	39 – 69
8	3	–	76 – 230
9	5	–	55 – 2,370
Dam 1	5	–	10 – 30
Dam 2	5	–	16 – 32
Dam 3	5	–	6 – 18
Dam 4	5	–	10 – 23

TABLE 7.3.9

WATER MONITORING RESULTS – Potassium (mg/l)

Sampling Location	No of Samples	Median	Range
1	5	–	2 – 3
2	5	–	2 – 3
3	5	–	2 – 3
4	5	–	2 – 4
5	5	–	2 – 4
6	5	–	2 – 4
7	5	–	2 – 4
8	3	–	5 – 8
9	5	–	2 – 6
Dam 1	5	–	4 – 8
Dam 2	5	–	4 – 8
Dam 3	5	–	3 – 8
Dam 4	5	–	4 – 10

TABLE 7.3.10

WATER MONITORING RESULTS – Calcium (mg/l)

Sampling Location	No of Samples	Median	Range
1	5	–	18 – 39
2	5	–	18 – 123
3	5	–	18 – 40
4	5	–	18 – 38
5	5	–	20 – 37
6	5	–	29 – 42
7	5	–	20 – 38
8	3	–	12 – 47
9	5	–	13 – 100
Dam 1	5	–	2 – 4
Dam 2	5	–	2 – 4
Dam 3	5	–	2 – 12
Dam 4	5	–	2 – 4

TABLE 7.3.11

WATER MONITORING RESULTS – Magnesium (mg/l)

Sampling Location	No of Samples	Median	Range
1	5	–	15 – 35
2	5	–	15 – 35
3	5	–	17 – 35
4	5	–	17 – 33
5	5	–	19 – 36
6	5	–	30 – 47
7	5	–	19 – 38
8	3	–	26 – 91
9	5	–	19 – 456
Dam 1	5	–	3 – 10
Dam 2	5	–	4 – 9
Dam 3	5	–	3 – 14
Dam 4	5	–	4 – 12

TABLE 7.3.12

WATER MONITORING RESULTS – Bi-carbonate (mg/l)

Sampling Location	No of Samples	Median	Range
1	8	125	92 – 195
2	8	134	92 – 189
3	8	138	98 – 195
4	8	137	93 – 189
5	8	137	104 – 189
6	8	216	195 – 293
7	8	140	104 – 214
8	4	–	25 – 91
9	8	186	76 – 914
Dam 1	8	34	18 – 55
Dam 2	8	24	16 – 57
Dam 3	8	40	4 – 91
Dam 4	8	27	8 – 60

TABLE 7.3.13

WATER MONITORING RESULTS – Chloride (mg/l)

Sampling Location	No of Samples	Median	Range
1	8	76	57 – 138
2	8	95	57 – 156
3	8	117	71 – 167
4	8	103	71 – 150
5	8	103	74 – 166
6	8	114	60 – 174
7	8	102	74 – 168
8	4	–	35 – 330
9	8	182	89 – 3,213
Dam 1	8	25	5 – 71
Dam 2	8	37	7 – 53
Dam 3	8	26	18 – 50
Dam 4	8	28	7 – 50

TABLE 7.3.14

WATER MONITORING RESULTS – Sulphate (mg/l)

Sampling Location	No of Samples	Median	Range
1	8	5	1 – 50
2	8	6	1 – 14
3	8	10	2 – 32
4	8	10	1 – 19
5	8	10	1 – 54
6	8	58	5 – 101
7	8	12	3 – 25
8	4	–	50 – 950
9	8	41	2 – 1,683
Dam 1	8	4	0.5 – 25
Dam 2	8	3	0.5 – 59
Dam 3	8	3	ND – 5
Dam 4	8	4	0.5 – 104

The CCJV's monitoring programme has been supplemented by information available from the Department of Water Resources' two gauging stations on Glennies Creek (Fal Brook), where water samples are periodically collected for analysis (see Table 7.3.15 and 7.3.16).

TABLE 7.3.15

GLENNIES CREEK WATER QUALITY - STATION 210 044 MIDDLE FALBROOK JULY 1979 TO OCTOBER 1985 (Source: Department of Water Resources)

Parameter	No of Samples	Median	Statistical Analysis 25*	75*	Range
1. pH	34	7.9	7.80	8.11	7.50– 8.80
2. Turbidity (Formazin Units)	35	1.1	0.7	1.5	0.2 – 70
3. Colour	34	12	8	17	0 – 76
4. Electrical Conductivity (µS/cm @ 25°C)	35	600	369	759	259 – 1,163

* 25 = 25th Percentile
75 = 75th Percentile

TABLE 7.3.16

GLENNIES CREEK WATER QUALITY - STATION 210 084 THE ROCKS NO 2 JULY 1979 TO OCTOBER 1985 (Source: Department of Water Resources)

Parameter	No of Samples	Median	Statistical Analysis 25*	75*	Range
1. pH	71	7.83	7.6	8.12	6.7 – 10.4
2. Turbidity (Formazin Units)	74	2.7	1.5	9	1.0 – 350
3. Colour	33	12	9	20	5 – 50
4. Electrical Conductivity (µS/cm @ 25°C)	75	405	240	598	171 – 2,950
5. HCO_3 (mg/l)	33	138	116	161	12 – 234
6. Cl (mg/l)	34	85	66	120	39 – 320
7. Fe (mg/l)	30	0.17	0.07	0.33	ND – 7.04
8. NO_3 (mg/l)	34	0.05	0.02	0.25	ND – 3.85

*** 25 = 25th Percentile**
75 = 75th Percentile
****ND = Not detected at the limit of measuring**

Results

The monitoring programme has shown that:

- Water from all sources can generally be considered of a reasonable quality, classed as low to medium salinity, low sodium water, suitable for almost all current agricultural uses in the Hunter Valley. Median suspended solids concentrations for Glennies Creek are low at only 3 to 4mg/l. During wet weather suspended solids levels increase, but do not become excessively high.
- There are no significant variations in water quality along the section of Glennies Creek surveyed although there is a steady increase in dissolved solids from station 1 through to station 5. This is usual for most river systems including the Hunter itself. The increase could be due to irrigation return waters, evaporation and groundwater accession.
- The Hunter River is of similar quality to Glennies Creek although the river consistently had higher concentrations of dissolved solids.
- The quality of water in Station Creek is generally poorer than Glennies Creek having higher concentrations of dissolved and suspended solids. There is also a wider range of results in the parameters tested probably due to runoff from the smaller catchment of Station Creek having a greater sensitivity to rainfall events. Martins Creek upstream of the Authorisation is moderately saline, with total dissolved solids (TDS) concentrations ranging up to 5,337 mg/l. The water is slightly more acid than elsewhere in the immediate area, but this could be more related to the small catchment size and ephemeral nature of flows rather than substantive geological differences. Samples are consistently relatively high in suspended solids, which indicates possible localised soil erosion. The level of suspended solids is slightly unusual in moderately saline natural creeks, and points to possibly high sodium absorption ratio soils in the subcatchment.
- Farm dam waters generally have higher concentrations of suspended solids than water courses, but lower concentrations of dissolved solids.

7.3.3 Groundwater

Groundwater Study

A preliminary hydrogeological study has established general background data on groundwater occurrence, flow patterns, and quality (see Table 7.3.17). Flow tests have been carried out on several exploration holes, and standing water level data from all existing holes has been analysed.

There appear to be three main aquifer types in the Project area:

- unconsolidated surficial sediments associated with Glennies Creek and Station Creek,
- weathered rock, and
- coal seams.

In the latter two the groundwater is primarily contained and transmitted in fractures and bedding planes. The rock itself, including the sandstone, is generally either cemented or has argilliceous material in the matrix between the sand grains. In the unconsolidated material the water is contained and transmitted by way of pores or voids between the grains of sediment.

An analysis of standing water level data in all previous holes indicates a continuous groundwater system throughout the coal measures strata. Recharge is by means of rainfall infiltration through the soils and discharge by upward seepage to the weathered zone and alluvium particularly along Station Creek. The weathered rock aquifers are apparently connected to Glennies Creek and receive recharge from this source. High permeabilities exist in the shallow weathered rock zones along the western boundary, and along Station Creek.

The groundwaters are consistent in quality and are typical of those from the coal measures strata in the Hunter Valley. Results from the site boreholes indicate a saline water with total dissolved solids ranging from 6,200mg/l to 7,200mg/l. Sodium and chloride are the dominant ions. These waters would not be suited for agricultural usage.

Marine sediments of the Maitland Group underlie the Wittingham Coal Measures. They outcrop to the east of the SLA and in the core of the Camberwell Anticline which bisects the underground coal resource area. This unit is probably responsible for most of the brackish groundwater that seeps into Station Creek and its tributaries and sustains the creek during low flow conditions.

Aquifer Characteristics

A series of short airlift/recovery type pumping tests were performed in several boreholes to determine the transmissivity and permeability of the various aquifer types (Table 7.3.18). This method of testing generally produces only approximate results, but these are considered sufficiently reliable to estimate the order of magnitude of likely groundwater inflows, particularly since there is a relatively good data base on the characteristics of the coal measure aquifers in the Upper Hunter for comparison.

Hole LDH3 (SGD 73L) has the main inflow from a depth of 4 to 8m in alluvium and weathered rocks. The inflow contribution and transmissivity of lower coal seams was relatively small.

Hole LDH4 (SGD 84L) was virtually impermeable with low inflow from the Barrett Seam and none from the Hebden.

Hole LDH5 (SGD 95L)also was fairly impermeable with low inflows from the Middle and Lower Liddell Seams and none from the Barrett and Hebden Seams.

In general, the eastern or open pit (low dip) areas are of low permeability and low potential inflow. Inflow problems could exist along the Station Creek area from shallow weathered rock and alluvium aquifers.

The potentiometric surface generally reflects the topographic drainage but in a subdued manner. There are a number of local irregularities in the surface which may be due to either anomalous data, or local geological features, eg. faults. The standing water levels are typically between 10 and 15m below the surface.

Groundwater is moving from the higher ground towards the lower ground where it discharges from coal seams to weathered rock and alluvium and thence into local streams, eg. Station Creek, as brackish seepages when the water table is relatively high. Rates of groundwater movement are expected to be very slow due to the low permeability of the rock mass and the relatively shallow hydraulic gradient. Recharge is from general infiltration of rainfall.

Groundwater Monitoring Programme

Standing water levels at six locations were periodically measured as part of the environmental monitoring programme. (See Table 7.3.19). Figure 7.3.4 shows the locations of the boreholes where the water levels were measured.

The results were reasonably consistent over time with the exception of SGD 126 which showed a variation of 4.3m. Low standing water levels were recorded during or immediately following periods of low flow in Glennies Creek.

In 1985 water samples were taken from selected drill holes (LDH 3, 4 and 5) and analysed at the Soil Conservation Service laboratory at Scone. In 1989 additional samples were analysed by the Australian Coal Industry Research Laboratories (DDH 60, 74, 57 and 98). The results of both lots of samples are presented in Table 7.3.20.

TABLE 7.3.17
CAMBERWELL BOREHOLE TEST DATA

Hole (LDH)	SWL (m)	Test Depth (m)	Transmissivity (m^2/day)	Discharge (l/sec)	Salinity (mg/l)	Date (1985)	Notes
3	1.6	40.40	9.9	1.5	6800	19/11	Cased to 8m
		75.10	3.3	1.1	8000	27/11	Cased to 13.25m
		117.03	4.0	1.63	7200	3/12	
3R	4.1	65.64	2.5	0.55	-	17/12	No casing
4	10.18	29.6	3	0.01	-	27/9	Main aquifer
		42.26	2.3	0.01	6300	29/9	
		56.2	2.3	0.2	7500	1/10	
5	36.95	60.0	V. Low	Seep	-	11/11	
		89.29	0.2	0.3	5500	12/11	
		110.00	0.1	0.3	5700	14/11	
		121.60	0.8	0.42	5300	18/11	

TABLE 7.3.18
ESTIMATED TRANSMISSIVITY AND PERMEABILITY OF COAL MEASURES AQUIFERS

Bore	Depth Interval (b) (m)	Transmissivity (T) (m)	Permeability m/day	Permeability m/s	Coal Seam
LDH3	8* - 40.1	9.9	0.31	3.6×10^{-6}	U. Liddell
	13.25 - 75.1	3.3	0.05	5.5×10^{-7}	M/L. Liddell
	75.1 - 117.03	0.7	0.02	2.5×10^{-7}	Barrett/Hebden
LDH4	10.01 - 29.6	3.0	0.15	0.15×10^{-6}	Barrett
	11.0 - 56.2	Low	-	-	Arties/U. Liddell
	60.0 - 89.3	0.2	0.007	8.3×19^{-8}	M/L.Liddell
	89.3 - 121.6	Low	-	-	Barrett/Hebden

* Casing length

NB: Permeability (T/b) calculated is the average effective value for the section of the hole tested. In practice the permeability would be confined to smaller specific zones of higher value.

TABLE 7.3.19
MONITORING OF STANDING WATER DEPTHS IN DRILL HOLES

Date	Hole Number LDH3	LDH4	LDH5	DDH126	DDH129
1/2/86	1.54	10.16	36.41	20.74	9.73
7-8/3/86	2.45	10.12	36.34	19.81	9.80
5-6/4/86	2.30	10.10	36.40	20.90	9.80
7-8/6/86	2.25	10.33	36.47	21.38	9.98
5-6/7/86	2.32	10.31	36.53	21.26	10.05
2-3/8/86	2.40	10.38	36.45	17.26	10.04
6-7/9/86	2.30	10.50	36.50	17.40	10.05
4-5/10/86	2.24	10.40	36.45	17.30	10.15
1-2/11/86	2.20	10.53	36.72	21.55	10.25
6-7/12/86	2.00	10.20	36.30	21.25	9.80
10-11/1/87	#	9.80	36.20	20.05	9.90
6-7/2/87	-	10.35	36.25	17.30	9.85

\# Bore hole caved in

TABLE 7.3.20

CHEMICAL ANALYSIS OF GROUNDWATER

Drillhole	LDH3	LDH4	LDH5	DDH60	DDH74	DDH57	DDH98
Date	03.12.85	01.10.85	18.11.85	1989	1989	1989	1989
Depth	117.03	56.2	121.6	60	30	62	105
pH	7.7	7.5	7.5	7.6	7.4	7.0	7.1
T.D.S.* (mg/l)	9,190	8,755	6,988	6,600	7,000	7,600	6,200
Hardness (mg/l $CaCO_3$)	1,865	3,065	2,215				
E.C. (mS/cm 25°)	14.36	13.68	10.92	11.2	11.2	11.8	9.5
Na (mg/l)	2,750	2,302	1,824	2,100	2,200	2,300	1,800
K (mg/l)	12	39	20	20	15	20	17
Ca (mg/l)	88	162	130	82	130	140	210
Mg (mg/l)	400	647	460	200	300	320	370
HCO_3 (mg/l)	1,238	1,129	763	1,100	1,000	1,050	850
SO_4 (mg/l)	470	1,633	764				
Cl_4 (mg/l)	4,200	3,426	3,638				

* calculated from E.C. x 640

Electrical Conductivity measurements in the field indicate a saline groundwater between 5,000-7,000mg/l total salts (Table 7.3.17). The groundwaters sampled are all of the same sodium chloride rich facies. They are brackish with TDS concentrations ranging from 6,500 to 9,200mg/l. This groundwater is unsuitable for irrigation on the soils available but may be suitable for certain stock and industrial uses.

Existing Registered Groundwater Bores

The records of the Department of Water Resources contain three registered groundwater bores within the Authorisation. The locations of these bores are given on Figure 7.3.4. Details are summarised in Table 7.3.21.

No data are available on the yield of the bores nor the strata in which they were drilled. However they appear to be located in alluvial material. The two bores on Station Creek are recorded as having fair and hard water flows. This suggests an interconnection between the bores and surface water systems.

Bore 19565 is nearer to Glennies Creek and has better quality water.

TABLE 7.3.21

REGISTERED GROUNDWATER BORES

Bore No	Total Depth (m)	Standing Water Level (m)	Salinity	Use
13603	12.8	7.9	Fair	Irrigation
19565	7.3	6.1	Good	Stock and Domestic
52859	9.1	3.7	Hard	Stock and Domestic

Source: Water Resources Commission, June 1986

7.3.4 Impact Assessment – Hydrology and Water Quality

Surface Waters

The site of the proposed Mine is contained within the catchment of Station Creek. A range of safeguards is proposed to control the quality of surface runoff.

Saline groundwater inflows into the pits and rainfall runoff within the disturbed mining area will be fully utilized on site. There will be no need to discharge such waters from the site. All other surface runoff liable to contamination with suspended solids, will be directed to sedimentation ponds which will remove most non soluble materials.

Trade and domestic wastes will be separately collected, treated and disposed of on site by land irrigation. There will be no discharge of such waters from the site.

The combination of water controls and consumption of poorest quality waters on site will safeguard the integrity of Station Creek. A surface water monitoring programme will be maintained during the operational phase of the Mine. This will be developed in consultation with the SPCC to verify the satisfactory environmental operation of the Mine.

Abstraction from Glennies Creek

The Mine and its upstream catchments will not be sufficient to satisfy the Mine's requirements under all meteorological conditions. It is proposed to supply this deficit with water pumped from Glennies Creek. Water would be pumped to Dam C2 from which potable and non-potable demands will be met. Maximum withdrawal from Glennies Creek would occur during two successive drought years and nil groundwater inflow. Under these conditions abstraction would be necessary between 8% and 16% of the time with a maximum annual withdrawal of 674Ml. This maximum annual withdrawal is 1.4% of the regulated base allowance from Glennies Creek Dam. Any harvesting of unregulated flows will reduce this relatively small percentage even further.

The proposed Glennies Creek and Rixs Creek coal mines will also require make-up water. The EIS for Rixs Creek indicates that make-up water if required, will be drawn from the Singleton pipeline, not directly from Glennies Creek. No formal documentation is available for the Glennies Creek Mine. However, it is understood that non potable make-up water is proposed to be drawn from the creek. The mine will produce a maximum of 3.9Mtpa and the maximum annual extraction from Glennies Creek is assumed to be around 600Ml. The cumulative effect of Camberwell and Glennies Creek Mines will be to extract about 2.6% of the regulated base allocation for Glennies Creek Dam. However, should it be necessary to impose restrictions upon irrigation water extraction, then the effect of the Mine would be to increase the length and extent of restrictions. This assumes that all Mine requirements are met from the current irrigation allowance.

Groundwater

The quantities of groundwater inflows to the Mine have been estimated from the data currently available. Significant inflows could cause a localised decline in the potentiometric head of the surrounding groundwater system. As the coal seams have low permeability, the areal extent of any reduction in potentiometric head would be confined to the vicinity of the Mine. By comparing permeabilities with other open cuts in similar hydrogeological settings in the Upper Hunter Valley, the expected pumping rates from inpit sumps could be between 300 and 600m^3/day. This water will be saline.

Provision will be made to cut off the alluvium and the deep weathering zones across the Station Creek valley, which would otherwise be main inflow zones for groundwater.

There are three registered bores located adjacent to Station Creek. These are all shallow bores extracting groundwater flows from the surficial sediments. As these are only surface bores it is unlikely these would be affected by any local decline in groundwater potentiometric head. However, this would be reviewed once the local groundwater flow characteristics have been determined.

Mining impacts upon the quality of local groundwaters similarly depend on the local groundwater flow regime. Geochemical investigations completed for the Project indicate that geochemical issues are unlikely to be a concern (Stuart Miller & Associates, 1989). The limited amount of analysis performed indicates that the quality of long term drainage through the spoil and overburden emplacement will not be dissimilar to the local groundwaters.

No existing users of the saline groundwater in the coal measures aquifers have been identified within the radial area expected to be influenced by mining. Along Station Creek there are numerous small dams essentially collecting rainfall runoff but perhaps also depending upon some groundwater inflow during drought periods. These dams will be lost to the open cut areas.

The impact of mining on existing users of groundwater is considered to be negligible. The main water source for water users in this area is Glennies Creek. It is expected that groundwater changes due to mining activities will not affect this flow.

Large scale on-site harvesting of surface water in the catchment of Station Creek could deplete reserves available for alluvial recharge.

7.4 CLIMATE AND AIR QUALITY

7.4.1 Climate

Data Sources

The Camberwell Project is located approximately 10km northwest of Singleton. Climatic data are available from long term Bureau of Meteorology records and from the Singleton Army meteorological station. Wind data recorded from the Glendell Project area (located approximately 6km northwest of the Camberwell Project) are also used, as it is the wind monitoring station most relevant to the proposed development.

Wind

Figure 7.4.1 illustrates the difference in the distribution of winds between day and night for the Glendell meteorological data set,[18] for the periods 7am to 7pm and 7pm to 7am. There is very little difference in the distribution of winds with direction, although as would be expected, the diagrams show that there is a marked reduction in average wind speed for the night period.

Figure 7.4.2 shows seasonal and annual windroses derived from Glendell. For these diagrams, Summer has been taken as December to February, Autumn as March to May, Winter as June to August and Spring as September to November. The windroses show the strong northwest-southeast alignment of winds which is characteristic of much of the Hunter Valley (for example windroses for Lochinvar and Jerrys Plains exhibit similar wind patterns). As with other parts of the Valley, a marked seasonal variation is also apparent, with the prevalent winds in Summer and Autumn being from the southeast, and in Winter from the northwest. Winds in Spring are reasonably evenly distributed between the northwesterly and southeasterly directions.

From a mine planning point of view, the diagrams indicate that dust transport will mostly occur to the northwest in the warmer months and southeast in the cooler periods. Figure 7.4.3 shows the pattern for Summer and Autumn combined and Winter and Spring combined.

The annual average wind speed for the Glendell site was 3.3m/s, which can be compared with the value of 3.5m/s at Lochinvar and 3.6m/s at Lemington.

18 Dames & Moore 1986

Exceedances of the damage criteria recommended in AS 2187 by ground vibration levels is also predicted using the ICI formula. In practice however, the blast emission levels will be likely to be lower than those predicted by the ICI formula, and it is proposed to minimise any potential adverse effects of blasting by optimising blast design during a period of trial blasting.

There will be an ongoing monitoring programme for ground vibration and airblast overpressure and where necessary nearby residences will be inspected, and their condition referred to a pre-blast survey and monitored for structural damage.

This assessment of blasting has been conducted using the "worst case" situation of blasting 25m benches at the near point of the extraction boundary to the residences, however benches this deep occur in only a small proportion of the extraction area and most benches will generally be less than 10m high. If the trial blast programme shows it to be necessary, the higher benches in critical locations could be fired in stages.

The effects from blasting in the North and South Pits will be felt and heard at the closest residences only when high benches are being blasted in close proximity, and at more distant residences only during adverse weather conditions. These occurrences will be minimised by drilling faces in advance and only firing certain faces when conditions are favourable.

The blast emissions associated with the proposed Camberwell Project are likely to have minimal adverse effect on the surrounding residences and then only for a relatively short time when blasting high (20m to 25m) benches at the near point of the extraction boundary to individual residences.

7.6 VEGETATION

A vegetation survey of the Project area was conducted by T.J. Fatchen & Associates over three days in July 1985, in conjunction with the fauna survey (T.J. Fatchen & Associates, 1985).

In common with most of the coal producing areas of the middle Hunter Valley, Authorisations 81 and 308 at Camberwell have a long history of clearing and agricultural or pastoral land use which has resulted in considerable modification of remaining native vegetation and faunal habitat.

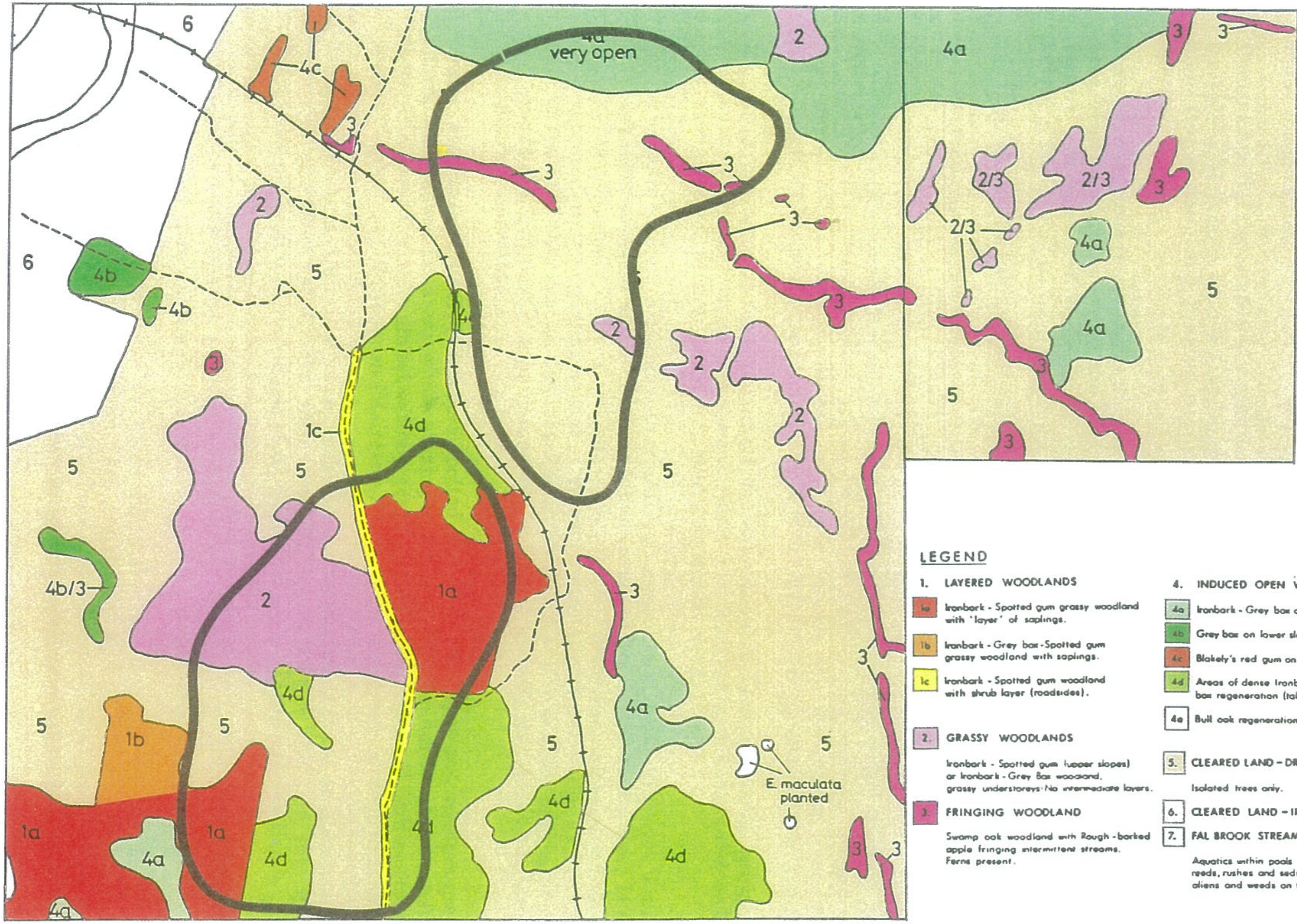
Figure 7.6.1 shows the distribution of vegetation in the Authorisations. The bulk of the area has been cleared for pasture with irrigation on the Glennies Creek floodplain. Clearing has resulted either in grassland devoid of trees, or in an artificially induced open woodland with scattered mature trees (cover 5%) remaining. There are, however, considerable cleared areas on the poorer soils which through a reduction in domestic grazing pressure now show major tree regeneration.

Woodland of narrow-leaved grey ironbark, spotted gum and grey box are present on higher ground, largely in the southern portion of the area. These woodlands have also been modified depending on land use. Areas released from grazing display active and strong regeneration of tree species, although the woodland plant communities as a whole can be considered floristically depauperate. Fringing woodland of swamp oak persists in a discontinuous band along Station and Blackwall Creeks, but the original river oak fringing woodland along the perennial Glennies Creek has been much reduced in area and greatly modified by the incursion of alien species.

Eucalypt woodlands are present on the higher and steeper terrain in the southwestern part of Authorisation 81, with another area of woodland about Middle Falbrook Road in the centre of the Authorisation and extending onto the area of the southern open-cut operation. Casuarina fringing woodlands are found along the subsidiary drainage of Station and Blackwall Creeks, and partially along the course of Glennies Creek.

Species recorded in the vegetation mapping units are given in Table 7.6.1. None of the species on the threatened lists of Leigh et al. (1981) are present, however the maidenhair fern (Adiantum aethiopicum) is protected under the National Parks and Wildlife Act 1974.

A high proportion of alien species shown in Table 7.6.1 is indicative of the extent to which land alteration has taken place.



LEGEND

1. LAYERED WOODLANDS

1a Ironbark - Spotted gum grassy woodland with 'layer' of saplings.

1b Ironbark - Grey box - Spotted gum grassy woodland with saplings.

1c Ironbark - Spotted gum woodland with shrub layer (roadsides).

2. GRASSY WOODLANDS

Ironbark - Spotted gum (upper slopes) or Ironbark - Grey Box woodland, grassy understoreys. No intermediate layers.

3. FRINGING WOODLAND

Swamp oak woodland with Rough - barked apple fringing intermittent streams. Ferns present.

4. INDUCED OPEN WOODLANDS

4a Ironbark - Grey box on upper slopes.

4b Grey box on lower slopes.

4c Blakely's red gum on clay flats.

4d Areas of dense Ironbark - Grey box regeneration (tall shrubland).

4e Bull oak regeneration (tall shrubland).

5. CLEARED LAND - DRY PASTURE

Isolated trees only.

6. CLEARED LAND - IRRIGATED

7. FAL BROOK STREAM AND TERRACES

Aquatics within pools. Banks with cumbungi, reeds, rushes and sedges. Numerous aliens and weeds on terraces.

CAMBERWELL COAL PROJECT

Date Sept 88

Figure 7.6.1

VEGETATION TYPES

7.6.1 Woodland

Most of the areas shown as woodland are remnant vegetation only in the sense that some of the major species originally present have persisted despite European land use. The plant communities reflect past land use and vegetation alteration rather than resembling a pre-settlement state ie they are not relict communities.

Recognising the importance of vegetation structure in determining animal, especially bird habitat, woodlands have been classified as layered woodland, grassy woodland (both with eucalypts as the main tree species) and fringing woodland on drainage lines (with Casuarina spp. as the main species).

Layered woodlands *(Mapping unit 1)* have an intermediate shrub layer with a grassy ground cover. Tree height and cover are in the ranges 15-20m and 15%-25% respectively. Trees are generally mature and hence can probably be regarded as remnants rather than secondary growth. The following three variants have been mapped.

1a. On the shallower soils of crests and upper slopes, narrow-leaved red ironbark ("ironbark", eucalyptus crebra) and spotted gum (E. Maculata) are the main trees. Grey box (E. Moluccana) is frequently present, and a few individuals of forest red gum (E. Tereticornis) have been noted. The intermediate layer is provided by saplings of ironbark and spotted gum. Height and cover of this intermediate layer varies from place to place, in response to differences in past land management. Height is generally between 2 and 4 m, with cover as high as 40% in places.Some western silver wattle (Acacia decora) is also present. Ground cover is grass, particularly aristida, danthonia, stipa and themeda spp. Mat-rushes (Lomandra spp.), rock fern (Cheilanthes sieberi) and dianella laevis are locally common in this grassy layer.

1b. Grey box becomes more important on lower slopes with deeper soils, joining ironbark and spotted gum as a major tree species. Apart from a higher contribution of grey box saplings in the intermediate layer, the unit is otherwise similar to 1a.

1c. The third variant is confined to roadsides, largely along Middle Falbrook Road. Tree species are identical to 1a and 1b but as well as some sapling development, there is a more diverse shrub component. Calytrix tetragona, blackthorn (Bursaria spinosa), native cherry (Exocarpos cupressiformis), drooping sheoak (Casuarina stricta) and myoporum montanum are present, if sparse. Other species are indicated in Table 7.6.1. The greater development of shrubs on roadsides is probably a joint function of limited grazing and absence of burning or other clearing operations.

Grassy woodlands *(Unit 2)*, of ironbark-spotted gum on upper slopes and ironbark-grey box on lower slopes, are mapped for areas where grazing pressure has prevented the development of a sapling layer. The ground cover is almost entirely grassy, with an assortment of both native and introduced species (Table 7.6.1). Cottonbush (Maireana microphylla) is sparsely present in some areas.

Fringing woodland *(Unit 3)* of swamp oak (Casuarina glauca) is found on the intermittent streams of Station and Blackwall Creeks, with some outliers on upslope drainage. Interspersed with the swamp oak are scattered individuals of rough-barked apple (Angophora floribunda).

The woodland is present as a very narrow band of timber. Tree heights reach 15m along stream courses, and cover may be as high as 80% in places, hence much could be regarded as forest formation rather than woodland. The band is not completely continuous, however.

There is very little cover under the trees themselves. Maidenhair and necklace ferns (Adiantum aethiopicum, asplenium flabellifolium) are present but sparse. Stream beds and levees carry a mixture of grasses and sedges such as three-awns (Aristida spp.), red-leg grass (Bothriochloa macra), couch (Cynodon dactylon), plume grass (Dichelachne micrantha), with rushes and sedges juncus, eleocharis and gahnia spp. (Table 7.6.1). Small areas of reed (Phragmites australis) are present, although usually better developed around dams.

Only patches remain of the river oak woodlands (Casuarina cunninghamiana) which once would have fringed the course of Glennies Creek. The fringing woodland now includes willow (Salix spp.), with an understorey dominated by alien herbs and grasses (Table 7.6.1)

7.6.2 Induced Open Woodland and Wholly Cleared Land

Unit 4: Open woodland (tree cover under 10% and over most of the area under 5%) has been created from the former forest and woodland through clearing. The original pattern of tree distribution is still evident with ironbark-grey box on upper slopes *(Unit 4a)*, grey box on deeper soils of lower slopes *(Unit 4b)* and some very small remnants of Blakely's red gum (Eucalyptus blakelyi, *Unit 4c*) on the clay flats of lower Station Creek. Pastures are grass, with red-leg grass, three-awns, couch, wallaby grasses (Danthonia spp.) and spear grasses (Stipa spp.) most common. Where there has been at least a partial release from grazing, ironbark and grey box in particular are freely regenerating *(Unit 4d)*. At the extreme, in the subdivisional area east of Middle Falbrook Road, the saplings are 3-4m tall with cover 30-40%, the mature trees being present as scattered emergent individuals. Limited areas of fan wattle (Acacia amblygona) are also present.

Regeneration on the common at Camberwell *(Unit 4e)* is 3-6m bull oak (Casuarina luehmanii) with cover up to 40% under a very open woodland of mature to senescent grey box *(Unit 1e)*.

Cleared land has been shown either as dryland pasture *(Unit 5)* or irrigated land *(Unit 6)*. The former is grassland with occasional trees and species a combination of native and alien grasses. Irrigated land is used both for cropping and pasture. Cover primarily comprises alien species including numerous undesirable species (eg skeleton weed, saffron and spear thistles). Some small plantations of spotted gum are present in grassland in the southeastern portion of the Authorisation.

7.6.3 Farm Dams and Glennies Creek

Individual farm dams *(Unit 7)* have not been shown on the map. They share with scattered pools in the minor creeks a mixture of semi-aquatic and aquatic vegetation. Swamp lily (Ottelia ovalifolia) and water ribbons (Triglochin procera) are the most obvious aquatic species, in very turbid water. Dams and pools are fringed by common reed and cumbungi (Typha orientale) with other sedges and rushes (Table 7.5.1), particularly the introduced sharp rush (Juncus acutus).

Pools within Glennies Creek have well developed aquatic vegetation, with water ribbons and pondweeds (Potamogeton spp.). Banks are lined with reed, cumbungi, sedges and rushes (Table 7.5.1) but also with numerous introduced species, particularly fennel (Foeniculum vulgare) and verbena hispida.

7.6.4 Impact Assessment – Vegetation

Open cut development itself will take place largely on cleared land, much of which is, in any case the site of past mine workings. Eucalyptus woodland east of Middle Falbrook Road will be affected either by pit or infrastructure development, and some loss of woodland and woodland habitat in the short term is anticipated. Further, there is likely to be a loss of swamp oak woodland along watercourses within the eastern part of the Authorisation.

The effect of the development will only be of local significance, given that:

- The woodlands have been highly modified by past land use (indeed much of the woodland is a direct derivative of that land use), and
- The plant communities and habitats involved are widespread in the region.

TABLE 7.6.1.
VEGETATION SPECIES LIST

FAMILY/Scientific Name	Common Name	Vegetation Unit 1	2	3	4	5	6	7	8
Pteridophytes									
ADIANTACEAE									
Adiantum aethiopicum L.	Maidenhair fern	.	.	+	.	.	.	.	+
Cheilanthes sieberi Kunze	Rock fern	+	+	.	+	+	.	.	.
ASPLENIACEAE									
Asplenium flabellifolium Cav.	Necklace fern	.	.	+	.	.	.	.	.
DENNSTAEDTIACEAE									
Pteridium esculentum (Forst. F.) Cockayne	Bracken	+	.	.	+	.	.	.	+
Angiosperms – Monocotyledons									
CYPERACEAE									
Eleocharis acuta R.Br.		.	.	.	.	.	+	+	+
Eleocharis sp.		.	.	+	.	.	+	+	+
Gahnia aspera (R.Br.) Spreng.		.	.	+	.	.	.	+	+
HYDROCHARITACEAE									
Ottelia ovalifolia (R.Br.) L.C. Rich	Swamp lily	.	.	.	.	.	.	+	.
JUNCACEAE									
* juncus acutus L.	Sharp rush	.	.	+	.	.	+	+	.
Juncus sp.		.	.	.	.	.	.	.	+
Juncus usitatus L.A.S. Johnson	Common rush	.	.	.	.	.	+	+	+
JUNCAGINACEAE									
Triglochin procera R.Br.	Water ribbons	.	.	.	.	.	.	+	.
LILIACEAE									
Dianella laevis R.Br.		+	.	+	+	+	.	.	.
POACEAE									
Agropyron scabrum (Labill.) Beauv.	Common wheat grass	+	+	.	+	+	.	.	.
Agrostis avenacea gmel.	Blown grass	+	+	.	+	+	.	.	.
Aristida sp.		+	+	+	.	.	.	.	.
Aristida vagans cav.	Three-awn		+	+	+	+	+	.	.
Bothriochloa macra (Steud.) S.T. Blake	Red-leg grass	+	+	+	+	+	+	.	+
* Bromus unioloides kunth	Prairie grass	+	+	+	+	+	.	.	.
* Chloris gayana Kunth.	Rhodes grass	.	.	.	.	+	+	.	.
Cynodon dactylon (L.)Pers.	Couch	.	.	+	.	+	+	.	+
Danthonia sp.		+	+	.	+	+	.	.	.
Dichelachne micrantha (Cav.) domin	Short-haired plume grass	+	+	+	+	+	.	.	.
* Hordeum leporinum link	Barley grass	.	.	.	.	+	.	.	.
* Paspalum dilatatum Poir.	Paspalum	.	+	.	.	+	+	+	
Paspalum paspaloides (Michx.) Scribn	Water couch	.	.	+	.	.	+	.	+
* Pennisetum clandestinum hochst. Et chiov.	Kikuyu grass	.	.	.	.	.	+	.	+
Phragmites australis (Cav.) Trin.	Common reed	.	.	+	.	.	.	.	+
* Sorghum halepense (L.) Pers.	Johnson grass	.	.	.	.	.	+	.	+
sporobolus virginicus (L.) Kunth	Saltwater couch	.	.	.	.	.	.	.	+
stipa ramosissima Trin.		+	+	.	+	+	.	.	.
Stipa scabra (complex)	Rough speargrass	+	+	.	+	+	.	.	.
Stipa sp.		.	+	.	.	.	.	.	.
Stipa variabilis (complex)	Spear grass	+	+	.	+	+	.	.	.
Themeda australis (R.Br.) Stapf	Kangaroo grass	+	+	.	+	+	.	.	+

FAMILY/Scientific Name	Common Name	Vegetation Unit 1	2	3	4	5	6	7	8
POTAMOGETONACEAE									
Potamogeton pectinatus L.	Sago pondweed	.	.	.	.	.	.	+	+
Potamogeton perfoliatus L.	Clasped pondweed	.	.	.	.	.	.	.	+
TYPHACEAE									
Typha orientale presl	Cumbungi, Bullrush	.	.	.	.	.	.	+	+
XANTHORRHOEACEAE									
Lomandra longifolia labill.	Spiky mat-rush	+	.	+	+	.	.	+	+
Lomandra multiflora (R.Br.) J. Britt.		+	.	.	+	.	.	.	.
Angiosperms – dicotyledons									
AIZOACEAE									
* galenia secunda (L.f.) Sond.	Galenia	.	.	.	.	.	.	.	+
ANACARDIACEAE									
* Schinus molle L.	Pepper tree	.	.	.	.	+	+	.	+
APIACEAE									
* Foeniculum vulgare mill.	Fennel	.	.	.	.	.	.	.	+
* Hydrocotyle bonariensis Lam.	Pennywort	+	.	.	.	.	.	.	+
APOCYNACEAE									
Parsonsia straminea (R. Br.) F. Muell.		.	.	.	+	.	.	.	.
ASCLEPIADACEAE									
* Gomphocarpus fruticosus (L.)R.Br.	Swan plant	.	.	.	.	.	.	.	+
ASTERACEAE									
* Carthamus lanatus L.	Saffron thistle	+	+	.	+	+	.	.	+
* Chondrilla juncea L.	Skeleton weed	.	.	.	.	+	.	.	.
* Cirsium vulgare (Savi) Ten.	Spear thistle	.	.	.	+	+	.	.	+
* Conyza albidus willd. Ex Spreng.	Tall fleabane	+	+	+	+	+	.	.	+
* Conyza bonariensis (L.) cronquist	Flax-leaf fleabane	+	+	+	+	+	.	.	+
Cotula coronopifolia L.	Water buttons	.	.	.	.	.	.	.	+
Gnaphalium luteo-album L.	Jersey cudweed	+	.	.	+	.	.	.	.
Helichrysum apiculatum (Labill.) D. Don	Yellow buttons	+	.	.	.	.	.	.	.
Helichrysum semipapposum (Labill.) DC		.	.	.	.	+	.	.	.
Senecio glossanthus (Sond.) Belcher	Slender groundsel	.	.	.	.	.	.	.	+
Senecio lautus	Groundsel	+	+	+	+	+	.	.	.
(ASTERACEAE)									
* Senecio spp.		.	.	.	.	.	.	.	+
* Sonchus asper (L.) Hill	Milk thistle	.	.	.	.	.	+	.	+
* Taraxacum officinale Wever ex Wiggers	Dandelion	.	.	.	+	+	.	.	+
* Xanthium spinosum L	Bathurst burr	.	.	.	.	.	.	.	+
CACTACEAE									
* Opuntia stricta (Haw.) Haw.	Prickly pear	+	+	+	+	+	.	.	+
CASUARINACEAE									
Casuarina cunninghamiana miq	River oak	.	.	.	.	.	.	.	+
Casuarina glauca sieb. Ex spreng.	Swamp oak	+	.	+	.	.	.	.	.
Casuarina luehmanii R.T. Baker	Bull oak	+	.	.	+	.	.	.	
Casuarina stricta		+	.	.	.	.	.	.	.
CELASTRACEAE									
Maytenus silvestrus (present near study area in C. Luehmanii woodland)									
CHENOPODIACEAE									
Maireana microphylla (Moq.) P.G. Wilson	Cottonbush	.	+	.	+	+	.	.	.
CONVOLVULACEAE									
Dichondra repens Forst. et f.	Kidney weed	+	.	.	.	.	.	.	.

FAMILY/Scientific Name	Common Name	Vegetation Unit 1	2	3	4	5	6	7	8
DILLENIACEAE									
Hibbertia spp		+	.	.	.	.	.	.	.
FABACEAE									
Glycine clandestina Wendl.	Glycine pea	+	.	.	+	.	.	.	.
Hardenbergia violacea (Schneev.) Stearn		+	.	.	+	.	.	.	.
Indigofera australis var australis Willd.	Indigo	+	.	.	.	.	.	.	.
* Trifolium sp.	Trefoil	.	.	.	+	+	+	.	+
LORANTHACEAE									
Amyema miquelii (Lehm. Ex Miq.) Tiegh.	Mistletoe	+	+	+	+	.	.	.	+
MIMOSACEAE									
Acacia amblygona A. Cunn. Ex benth.	Fan wattle	+	.	.	+	.	.	.	.
Acacia decora Reichb.	Western silver wattle	+	.	.	+	+	.	.	.
MYOPORACEAE									
Myoporum montanum R.Br.		+	.	.	+	.	.	.	.
MYRTACEAE									
Angophora floribunda (Sm.) Sweet	Rough-barked apple	.	.	+	+	.	.	.	+
Calytrix tetragona labill.		+	.	.	.	.	.	.	.
Eucalyptus blakelyi Maiden	Blakely's red gum	.	.	.	+	.	.	.	.
Eucalyptus crebra F. Muell.	Narrow-leaved red ironbark	+	+	.	+	.	.	.	.
Eucalyptus maculata Hook.	Spotted gum	+	+	.	.	.	.	.	.
Eucalyptus moluccana Roxb.	Grey box	+	+	.	+	.	.	.	.
Eucalyptus tereticornis sm.	Forest red gum	+	.	.	.	.	.	.	.
ONAGRACEAE									
* Oenothera stricta Ledeb. Ex Link	Evening primrose	.	.	.	.	+	+	.	+
OXALIDACEAE									
Oxalis corniculata L.		+	.	.	.	.	.	+	+
PITTOSPORACEAE									
Bursaria spinosa cav.	Blackthorn	+	.	.	.	.	.	.	.
PLANTAGINACEAE									
Plantago varia R.Br.		.	.	.	.	.	+	.	+
POLYGONACEAE									
* Rumex spp.	Dock	.	.	.	.	.	+	.	+
ROSACEAE									
* Rosa rubiginosa L.	Sweet briar	.	.	.	+	+	.	.	+
SALICACEAE									
* Salix babylonica L.	Willow	.	.	.	.	.	.	.	+
SANTALACEAE									
Exocarpos cupressiformis labill.	Native cherry	+	.	.	.	.	.	.	.
VERBENACEAE									
* Verbena hispida Ruiz et Pav.		.	.	.	.	.	+	.	+

Vegetation units:

1. Ironbark-Spotted gum grassy woodland with layering of saplings.
2. Ironbark-Grey box (lower slopes) or ironbark-Spotted gum woodland with grassy understorey, no shrubs or saplings.
3. Swamp oak low woodland to low open-forest along local drainage.
4. Ironbark-Grey box induced open woodland over pasture. Some areas of regenerating ironbark included.
5. Grassland (cleared land)
6. Irrigated pasture, cropland (not closely examined)
7. Farm dams and surrounds
8. Glennies Creek stream and terraces.

* alien species

7.7 FAUNA

A field survey was conducted in the Project area over three days in July 1985 in conjunction with the vegetation survey. The highly altered nature of the landscape and the considerable amount of survey information already available, made the value of further survey work questionable.

The woodlands remaining on the Authorisations contribute significantly to the maintenance of bird species diversity in the district, however the avifauna is typical of similar areas in this part of the Hunter Valley. Eastern grey kangaroos are the most abundant of the native mammals as they appear to have been favoured by existing land use patterns. The remaining mammal fauna is believed not to include any animal which might preclude or otherwise limit the development. Reptiles and amphibians have not been examined in any detail, but those observed suggest again that the total fauna is unlikely to be significantly different from elsewhere in the district.

7.7.1 Birds

Forty-seven bird species were recorded during the field survey. The species, the habitats in which they were seen and an indication of relative abundance are given in Table 7.7.1. Habitat types 1-8 are largely equivalent to the vegetation mapping units described in Section 7.6.

Further species may well utilise the area in different seasons. In particular, more waterbird species could be expected to utilise the perennial stream at Glennies Creek over a complete year than Table 7.7.1 would suggest.

Nevertheless the overall view is of an assemblage of relatively common bird species normally associated with woodland and grassland, with no significant departure from those which would be expected in a much altered district. All species except the Starling and House Sparrow are native.

The most common species in woodland and open woodland was the Eastern Rosella, and in grassland or very open woodland habitat, the Australian Magpie and the Starling.

For most species, however, absolute numbers were generally low. Cleared dryland pastures contributed least to bird diversity, although irrigated pasture and cropland provided feeding habitat for some waterbirds and waders which would otherwise not be present within the Authorisation area. The wooded areas provided habitat for the majority of species. Habitat 3, dense swamp oak along secondary creeks, contained some of the smaller passerines which were poorly represented in or absent from other habitats. Welcome Swallows utilised abandoned mine adits on the Rosedale property as nesting sites.

Three Wedge-tailed Eagles were seen during the survey. Comments from local residents suggest that there is only one group which visits the Authorisation area and that nesting sites are northeast of the Authorisation, not within it.

7.7.2 Mammals

Mammal species known to be present in the Authorisation area are listed in Table 7.7.2. The most evident native mammal is the Eastern Grey Kangaroo. Between the New England Highway and the railway line, (some 6km along Middle Falbrook Road), dawn and dusk counts returned between 11 and 16 individuals usually within 0.5km of layered woodland (mapping unit 1) and approximately half on and half immediately south of, the Authorisation area. Residents report that up to 30 individuals have been seen in the northeast corner of the Authorisation, where it abuts a dense bull oak woodland along Stoney Creek. There appears to be two resident populations on or near the Authorisation, associated with layered or dense woodland. A large population[31] inhabits the southern part and adjoining wooded land, and a smaller population is resident outside the north-east part of the Authorisation but ranges onto it from time to time.

31 Of the order 100-200 given the limited area actually sampled and the extent of the woodlands to the south of the Authorisation.

TABLE 7.7.1.
BIRD SPECIES

Common Name	Scientific Name	Habitats 1	2	3	4	5	6	7	8	9	10	Relative Abundance
Hoary-headed Grebe	Poliocephalus poliocephalus							x	x			R
Little Pied Cormorant	Phalacrocorax melanoleucos								x	x		R
White-necked Heron	Ardea pacifica						x					R
White-faced Heron	Ardea novaehollandiae						x	x	x			R
Straw-necked Ibis	Threskiornis spinicollis						x		x			MC
Royal Spoonbill	Platalea regia							x				R
Black Duck	Anas superciliosa							x	x			MC
Grey Teal	Anas gibberifrons								x			R
Wood-duck	Chenonetta jubata						x	x				MC
Wedge-tailed Eagle	Aquila audax.								x			R
Nankeen Kestrel	Falco cenchroides					x						R
Brown Falcon	Falco berigora					x						R
Brown Quail	Coturnix australis.				x							U
Swamp Hen	Porphyrio porphyrio								x			R
Masked Lapwing	Vanellus miles					x						R
Coot	Fulica atra								x			R
Crested Pigeon	Ocyphaps lophotes				x	x						MC
Sulphur-crested Cockatoo	Cacatua galerita				x							R
Eastern Rosella	Platycercus eximius	x	x		x							VC
Red-rumped Parrot	Psephotus haematonotus				x							R
Pallid Cuckoo	Cuculus pallidus	x			x							U
Boobook Owl	Ninox novaeseelandiae		x									R
Laughing Kookaburra	Dacelo novaeguineae	x	x		x	x						MC
Sacred Kingfisher	Halcyon sancta				x							R
Welcome Swallow	Hirundo neoxena				x	x					x	MC
Richards Pipit	Anthus novaeseelandiae	x	x		x	x						MC
Black-faced Cuckoo-shrike	Coracina novaehollandiae	x			x							U

Common Name	Scientific Name	Habitats 1	2	3	4	5	6	7	8	9	10	Relative Abundance
Little Grassbird	Megalurus gramineus			x								U
Brown Songlark	Cincloramphus cruralis				x	x						MC
Weebill	Smicrornis brevirostris	x		x	x							C-VC
Yellow-rumped Thornbill	Acanthizia chryssorhoa	x		x								VC
Yellow Thornbill	Acanthizia nana			x								MC
Speckled Warbler	Sericornis sagittata	x		x	x	x						MC
Grey Fantail	Rhipidura fuliginosa	x		x								U
Willie Wagtail	Rhipidura leucophrys	x		x	x	x						U
Restless Flycatcher	Myagra inquieta	x		x								U
Rufous Whistler	Pachycephalax rufiventris			x								MC
Varied Sitella	Daphoenositta chrysoptera	x										U
Noisy Miner	Manorina melanocephala	x	x	x	x	x						C
House Sparrow	Passer domesticus						x				x	U
Australian Raven	Corvus coronoides		x		x	x	x					MC
Starling	Sturnus vulgaris					x	x					VC
Australian Magpie-lark	Grallina cyanoleuca		x		x	x	x					MC
White-winged Chough	Corcorax melanoramphos	x	x		x							U
Pied Butcherbird	Cracticus nigrogularis	x	x		x							MC
Grey Butcherbird	Cracticus torquatus		x		x							U
Australian Magpie	Gymnorhina tibicen.	x		x	x	x						VC

Habitats:
1. Ironbark-Spotted gum woodland with understorey of immature eucalypts.
2. Ironbark-Grey box and Ironbark-Spotted gum woodlandwith grassy understorey, no shrubs or immature trees.
3. Low woodland to low open-forest of Casuarina glaucaalong drainage (dense cover)
4. Ironbark-Grey box induced open woodland over pasture, including some areas of regenerating ironbark.
5. Grassland: cleared land, dryland pasture
6. Irrigated pasture, cropland.
7. Farm dams and surrounds
8. Major stream and surrounds
9. Overhead (not assignable to specific habitats withinstudy area)
10. Buildings, mineshafts.

Relative abundances:

VC	very common	groups seen frequently every day
C	Common	groups seen every day
MC	Moderately common	Several observations during study
U	Uncommon	4-10 birds seen during study
R	Rare	No more than 3 birds seen seen during study

The clearing of pastures and subsequent regeneration of tree species has probably favoured the Eastern Grey Kangaroo, through an increase in extent and quality of grass pastures together with the maintenance or creation of resting and hiding places in the woodlands.

Other species seen were largely alien. Rabbits are numerous about old mine workings on Rosedale but apparently not frequent elsewhere. Hares were seen in grassland. One Common Brushtail was observed in the proposed open cut area but residents have indicated that the species is not common in the Authorisation area.

Residents report very infrequent incursions by Dingoes (rather than feral dogs).

The bull oak stands along Stoney Creek, just beyond the northeast corner of the Authorisation, appear to be much more significant as mammal habitat than any of the lands within the Authorisation. Although stocked, these stands appear little grazed by domestic stock. The cover is high (50-70%) and, unlike the relatively clear-floored woodlands on the Authorisation, there is considerable variety in ground microhabitat created by outcropping rock and fallen trees. During the survey, evidence of the Red-necked Wallaby, the Wombat and Echidna were noted. The habitat here also matches that elsewhere in the district in which the Yellow-footed Antechinus has been found (Croft 1984).

7.7.3 Reptiles and Amphibians

The season and cold conditions during the survey mitigated against a comprehensive examination of the herpetofauna. Species present or likely to be present are listed in Tables 7.7.3 and 7.7.4.

The provision of numerous farm dams, and mine subsidence on the Rosedale property, may have favoured some frog species and is certainly a major factor in maintaining what appears to be, even on very limited inspection, a moderate to large population of the Long-necked Tortoise within the Authorisation area.

7.7.4 Impact Assessment – Fauna

The effect of the development will only be of local significance as the known and probable faunal assemblages are generally typical of this part of the Hunter Valley.

Nevertheless the woodlands provide maintenance of local wildlife populations in a largely cleared district, even if these populations themselves reflect the extent of landscape alteration. The loss of some of the remaining woodland, unavoidable in planning for mine development and infrastructure, will be compensated for by the development of similar woodland elsewhere in the Authorisation and on rehabilitated areas. This will avoid a further incremental loss in wildlife habitat diversity and a consequent loss in wildlife diversity.

In the case of eucalypt woodlands, most of the bird and larger terrestrial vertebrates would be displaced, but would not necessarily be able to re-establish in nearby unaffected woodlands because of the wildlife populations already resident. In the case of swamp oak fringing woodland, the habitat is only represented within the eastern part of the Authorisation.

The rehabilitation programme will include a staging process involving establishment of woodland in mined areas as well as enhancement of the woodland already existing on former cleared land at an early stage of the construction programme.

Widening of Middle Falbrook Road, will result in the virtual elimination of mature representatives of shrub species which have all but vanished from the woodlands on private grazed land. Use of these species in the rehabilitation programme will ensure that the species do not disappear from the area irreparably.

TABLE 7.7.2

MAMMAL SPECIES‡

Common Name	Scientific Name	Comment
(a) Known to be present within study area		
Eastern Grey Kangaroo	Macropus Giganteus	Between 11 and 20 seen in4 consecutive dawn or duskroad surveys in study area.group of up to 30 reported to enter NE corner of study area. Very common.
Common Brushtail	Trichosurus vulpecula	One only sighted.
Unidentified Microchiropteran bat		
* Red Fox	Vulpes vulpes	
* European Hare	Lepus eruipaens	
* Rabbit	Oryctolagus cuniculus	
* House Mouse	Mus musculus	
* Black Rat	Rattus rattus	
* Cat	Felis catus	
(b) Reported within study area		
Dingo	Canis familiaris dingo	Residents indicate very occasional intrusions.
(c) Observed near study area		
Red-necked Wallaby	Macropus rufogriseus	In dense bull oak NE of study area. Uncommon.
Common Wombat	Vombatus ursinus	Hole showing recent activity in same area as preceding.
Echidna	Tachyglossus aculeatus	Diggings in same area as preceding.
(d) Potentially present in or near study area		
Water Rat	Hydromys chrysogaster	Probably present in pools of Fal Brook
Yellow-footed Antechinus	Antechinus flavipes	Expected in bull oak area NE of study area.

* alien species (domestics not included)
‡ Nomenclature follows Strahan 1983 with reference to Ride 1970

TABLE 7.7.3

REPTILE SPECIES‡

Common Name	Scientific Name	Observed	Comment
(a) Reptiles observed on site			
Lace Monitor	Varanus varius	1	Residents report 2-3 in woodland, uncommon
Tree Skink	Egernia striolata	2	Probably very common
—	Morethia boulengeri	1	Probably very common
Long-necked Tortoise	Chelodina longicollis	1 + shells	Common
(b) Reptiles reported by residents, not observed			
Eastern Blue-tongued Lizard	Tiliqua scincoides		Uncommon
Red-bellied Black Snake	Pseudechis porphyriacus		Common
Eastern Brown Snake	Pseudonaja textilis		Common
Eastern Tiger Snake	Notechis scutatus		Uncommon
(c) Reptiles recorded in the district and likely to occur on site			
Eastern Water Dragon	Physignathus lesueurii		
Bearded Dragon	Amphibolurus barbatus		
Skink	Ctenotus robustus		
Red-throated Skink	Leiolopisma platynotum		
Wood Gecko	Diplodactylus vittatus		
Red-naped Snake	Furina diadema		

‡ Nomenclature follows Cogger 1983

TABLE 7.7.4

FROG SPECIES‡

Common Name	Scientific Name	Comment
(a) Observed on site		
Leseur's Frog	Litoria leseurii	Common
Verreaux's Tree Frog	Litoria verreauxii	Common (calls)
Spotted Grass Frog	Lymnodynastes tasmaniensis	Common
(b) Probably present, recorded for similar sites in the region		
Green Tree Frog	Litoria caerulea	
Dainty Green Tree Frog	Litoria gracilenta	
Dwarf Tree Frog	Litoria fallax	
Peron's Tree Frog	Litoria freycinetti	
Ornate Burrowing Frog	Lymnodynastes ornatus	

‡ Nomenclature follows Cogger 1983

7.8 HISTORICAL BACKGROUND

7.8.1 Local History

The history of the Glennies Creek – Camberwell area has been well researched and documented in Lillian M. Noble's *"The Glennies Creek Story"* (1988).

This history documents early aboriginal settlement of the area, the early history of white man's penetration into the district and describes the personalities, the rural and industrial development and the everyday life in the district from those early days through to the present.

The Glennies Creek Story encapsulates many of the elements of the country's early development and the countryside is today still closely tied to the original history and families of the early settlers. Many of the descendants of those original families are still living in the district.

The history of the Glennies Creek area is closely tied to the development of coal mining in NSW, with the first attempts to mine coal commencing in the mid 1800's and continuing through to 1921. Since that time many of the residents have maintained their connections with the coal industry by working in the mines in the surrounding districts.

7.8.2 Archaeology

A number of archaeological surveys have already been carried out in the immediate region. Table 7.8.1 compares the data from these other studies with the results of the recent survey of the Project area. (Brayshaw & Associates 1986)

Brayshaw's survey identified 31 sites and 13 isolated artefacts, of which three locations have particular archaeological interest (see Figure 7.8.1).

1. Martins Creek, towards the east of the area studied, represented by sites GCC1-15;
2. Upper Blackwall Creek (in the south east corner) notably sites GCC19 and 20; and
3. Site GCC27 on the central creek, with a large volcanic flake.

Martins Creek

In terms of their position in the landscape, these sites are typical of many other sites already subjected to salvage investigation elsewhere in the Hunter Valley. However the value of this location is the high concentration of sites in a small area. Construction of the Project's water storage system will affect many of these sites, thus necessitating further investigation prior to permits being issued and necessary salvage work commencing.

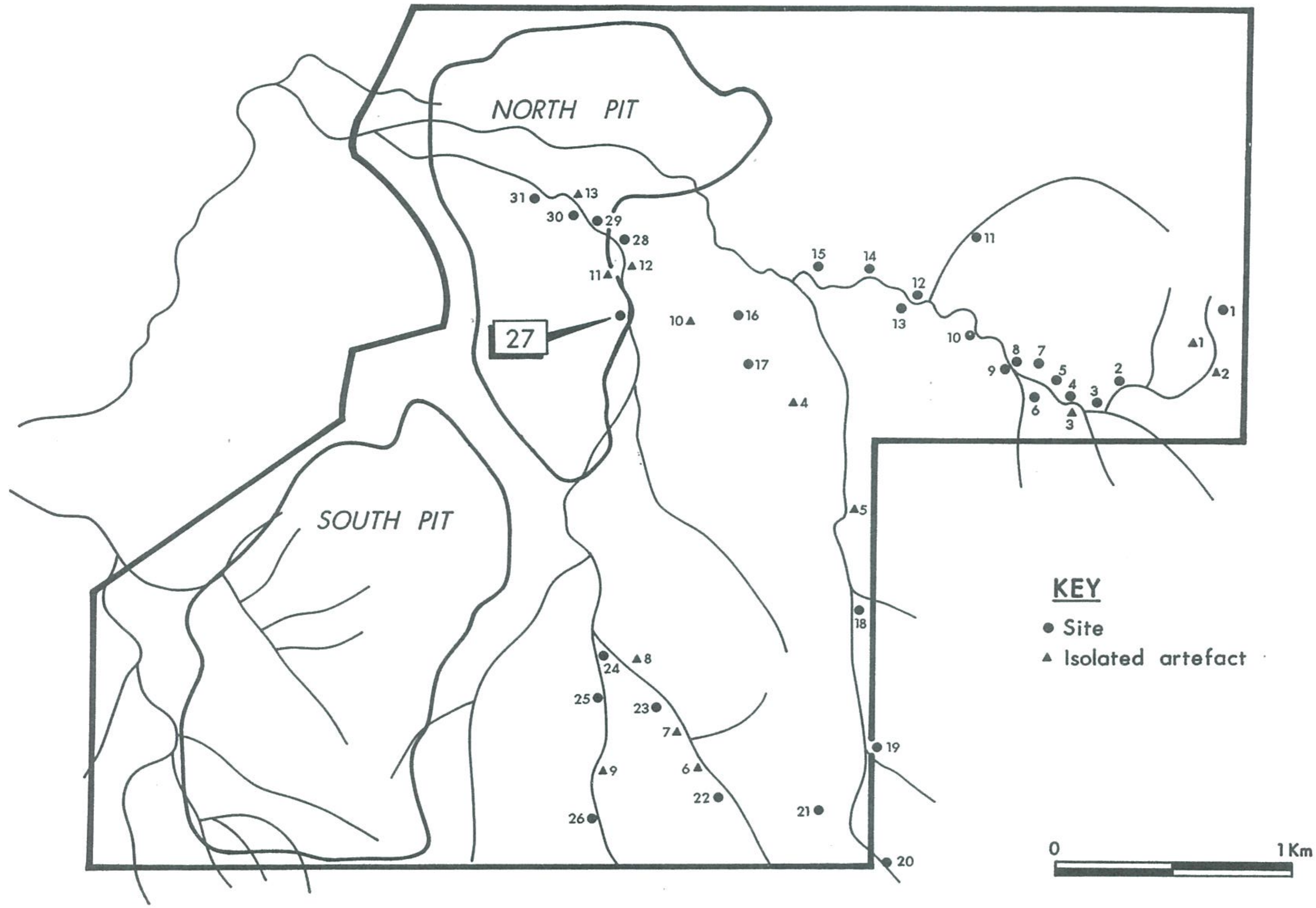
Upper Blackwall Creek

GCC19 and 20 are among the richest and most artefactually dense sites in the area studied, both with undisturbed deposit. Being situated high on the hillslope distinguishes them from other sites so far selected for salvage excavation in this area of the Hunter region. Site GCC19 is on the very edge of the area studied and GCC20 is well outside it, and therefore neither site will be affected by the development.

Site GCC27

The large volcanic flake found at this site closely resembles artefacts recently dated to the Pleistocene period. Consequently this site has a significance which will warrant further investigation prior to issuing of a permit and conducting salvage work. Figure 7.8.1 illustrates the proximity of this site to development of the proposed North Pit and hence the need to salvage the site.

The Wanaruah Local Aboriginal Land Council, representing the local Aboriginal community, have been advised about the development and the results of the survey. The assistance of the Council will be sought for any salvage work required.



CAMBERWELL COAL PROJECT	Date Sept 88	Figure 7.8.1

ARCHAEOLOGICAL SITES

TABLE 7.8.1

ARCHAEOLOGICAL DATA

Comparison With Data From Other Studies In The Region – Excavated and Surface Assemblies

Area	No of Sites	No of Artifacts	% Indurated Mudstone	% Silcrete	% Other	Number Backed Pieces	% Modified	Number Modifed	% Total
Hunter Valley Extended *(Brayshaw 1983b)*	1	822	39	40	21	7	29	24	2.9
Ravensworth No 2 *(Brayshaw & Haglund 1984)*	19	3645	21	72	7	27	36.9	73	2
Rix's Creek *(Brayshaw 1983a)*	7	326	60.8	32.8	6.4	7	77.8	9	2.7
Hunter Valley No 2 *(Brayshaw & Haglund 1983)*	1	2665	66.5	20.3	13.3	17	24.2	70	2.6
BBC-84 *(Brayshaw 1984)*	4	691	71.3	17.9	10.5	18	28.5	63	9.1
CSR [BBC]-86 *(Brayshaw 1986)*	4	161	41.6	53.4	5	0	0	9	5.6
North Singleton *(Stern & Attenbrow 1981)*	52	541	63	26	11	3	2	120	22
Singleton Heights *(Dallas & McDonald 1986)*	17	157	30.5	25.5	43	0	0	22	15.3
Camberwell *(Brayshaw 1986)*	20	303	58.7	31	10.2	1	2.3	44	14.5