NORTH

Cowal Gold Project

ENVIRONMENTAL Impact Statement

4

Appendices E – K

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ENVIRONMENTAL Impact Statement

Volume 4 Appendices E – K

Appendix E

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Archaeology and Ethnography

Overview of Archaeological Information for Cowal Gold Project

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TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION

This report is an amalgamation of five other reports. They deal with different aspects of the Aboriginal cultural heritage of Lake Cowal and were commissioned at different stages in the process of environmental assessment associated with planning the Cowal Gold Mine by North Limited.

Exploration commenced at the lake in the early 1980s and culminated in the discovery of gold in 1988. Preliminary archaeological inspections were made at the lake in 1989 (Paton 1989) and between then and 1994, 450 drill holes were placed in the deposit to define the extent of mineralisation and the quality of the resource.

Project feasibility studies were approved by North Limited in early 1995 and a second, more detailed, archaeological investigation was conducted along the lake shore, in the vicinity of the gold bearing ore and the potential infrastructure of the mine (Cane 1995a). Subsequent development planning led to another archaeological survey of a possible access road, a water pipeline and a transmission line for the proposed mine (Huys and Johnston 1995). A further archaeological investigation was conducted for the proposed tailings storages later that year (Cane 1995b). These reports are presented in the Lake Cowal Gold Project Environmental Impact Statement (NSR 1995).

Following the rejection of North Limited's 1995 Development Application a reassessment of the project's environmental impacts and the physical placement of mining infrastructure was undertaken by the company. These changes have led to another archaeological survey of new locations for the tailings storages, part of the original pipeline, a small road realignment and a new electricity transmission line route to the south of the lake (Nicholson 1997).

The key findings of these five reports have been amalgamated in the following account, although each report may be read separately for more details regarding each survey, their findings and interpretations. Management recommendations are presented in Section 8 of this report.

1.1 Survey Goals

The primary goals of the archaeological surveys associated with the Cowal Gold Project were to:

- report on the location of any archaeological sites within the proposed development locations, including the possibility of burial sites;
- assess the impact of development on any Aboriginal sites located in the proposed development areas; and
- propose management recommendations for those sites.

The areas investigated are marked on Figure E-1 and included:

- the western edge of Lake Cowal, where the mine itself will be located (called **the pit** in this report);
- the **lake shore** where mining infrastructure will be placed;
- the **gilgai plains** west of the Lake, between the pit and the rail line, including the proposed **tailings storages**;
- the north east of the Lake, where a **water pipeline** is proposed;
- an area to the south along a proposed **electricity transmission line** (see Appendix D); and
- an area to the west of the Lake, along a **proposed road realignment**.

1.2 Environmental Considerations

1.2.1 Lake Cowal: the Pit and Lake Shore

The development area adjacent to Lake Cowal covers some 15 sq km (Figure E-1). The lease extends over the Lake floor which is frequently under water. The rest of the lease forms a rectangular area due west from the Lake. It contains:

- the pit area on the margin of the Lake;
- waste emplacement areas, mill workshop and administration area in a band one kilometre to the west of the pit area and next to Cowal West Hill; and
- two tailings storages extending over a 1.3 x 2.6 km area, 3.5 km to the west of the Lake. These were originally located on the plains adjacent to and west of the waste emplacement areas. These plains are now undeveloped except for service and access roads which cross them.

The landward component of the lease is located on undulating farming country – normally used for grazing and cropping. All this terrain (including the lakebed) has been disturbed. The paddocks have been cleared and cropped. Fences have been constructed, dams dug and roads graded; small sand ridges adjacent to creeks have been ripped to displace rabbits.

This level of disturbance, combined with the severity of drought since 1990 has resulted in excellent circumstances for finding archaeological materials. One impediment to that visibility is a pervasion of gravel eroding out of the clayey soils. Elsewhere the clayey top soil confine visibility to small windows where the soil has receded or been eroded. These windows are sufficient for detecting the presence/absence of cultural material in the area.

1.2.2 The Tailings Storages

The location for the tailings storages is 3.5 km to the west of Lake Cowal (Figure E-1). The northern part of the area consists of gently undulating plains with intermittent gilgais associated with shallow drainage lines. The area is currently used for grazing and at times cropping, and has been disturbed through initial clearing, ploughing, track and dam construction. A number of tracks provide access to the area and erosion provides ready visibility for detecting archaeological materials.

A remnant of natural vegetation has been grazed in the north western part of the tailings storage area, leaving the gilgai depressions comparatively undisturbed. The southern part of the area is under crop but a number of tracks cross

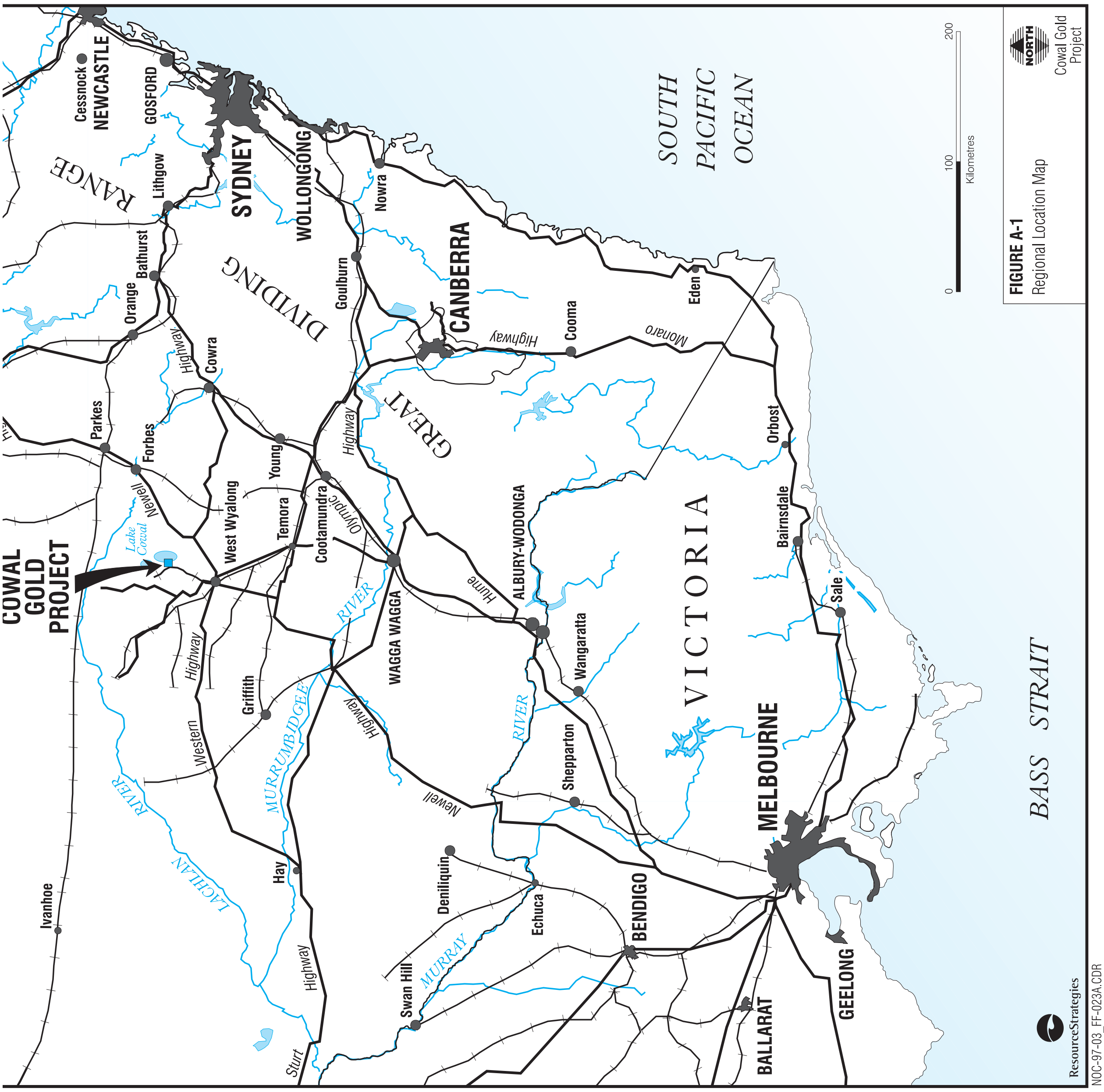

FIGURE A-1
Regional Location Map

the paddocks allowing adequate opportunity to determine the nature and extent of the archaeological record.

The present location for the tailings storages overlaps slightly with a former location for these features as described above. The original tailings storages were surveyed in 1995, and the findings are summarised in Sections 5.3 and 6.3 as well as in the original report (Cane 1995b).

1.2.3 The Pipeline Route

The water pipeline route (Figure E-1) was surveyed by Huys and Johnston (1995). The proposed route runs from the mine site, across Lake Cowal, and terminates at the borefield approximately 17 km to the north-east of the mine. A considerable portion of the route to the north-east of the Lake follows an existing vehicle access track and an artificial water channel. The last 100 m of the proposed route traverses the eastern shores of Lake Cowal and then travels underneath the Lake for a distance of approximately 9 km. No sites were found along the pipeline route by Huys and Johnston (1995).

A portion of the route within 2 km of the north east corner of Lake Cowal was resurveyed for this study as there was concern there may have been sand bodies and possible burials around the Lake margins. The survey revealed that the proposed pipeline crosses the flood plain away from the lake. No sand bodies are encountered. The route follows an existing fence line in this area and, consistent with the results of Huys and Johnston (1995), no archaeological sites were located.

1.2.4 The Access Road

The proposed Cowal Gold Project mine site is to be accessed via existing roads. The proposed access route is shown on Figure E-1. Two minor realignments of the existing road are proposed. One of these is in the vicinity of Billys Lookout. At this point the road winds between two low, rocky hills. The road is to be straightened and this will involve a minor realignment. The area where this is proposed has been disturbed by previous road maintenance activities and the extraction of gravels. No archaeological materials were located in this area.

The other proposed realignment extends for a few hundred metres along the stretch of road adjacent to Lake Cowal siding. The area is close to the existing road and has been subject to alterations in the past. No likely site locations were identified and no archaeological materials were found.

1.2.5 The Electricity Transmission Line

An electricity transmission line is planned to supply power to the mine site from Temora, 100 km to the south of Lake Cowal. This development is somewhat detached from the primary impacts of the mine at Lake Cowal and is reported on separately (Nicholson 1997) (Appendix D of EIS).

An earlier electricity transmission line was planned from the township of Forbes. A survey of this earlier route was conducted by Huys and Johnston (1995), and four sites were recorded between Nerang Cowal and Lake Cowal (Figure E-1). These sites are summarised in Section 6.5 to provide a description of sites in the area. The terrain in this area is largely low lying plains. Some of this land has been cultivated. During wet periods, the plains are inundated with water and the raised areas of land remain relatively dry. A number of these are associated with evidence of past camping activities.

2.0 ETHNOGRAPHIC BACKGROUND

There appears to be very little historical information about the first inhabitants of the Lake Cowal region (Cane 1995a and the Bland Historical Society (BHS) 1993). The most immediate sources invariably refer to extracts from Wilson (1923) and Musgrave (1979) (see Doolan 1950, BHS 1993a&b, English n.d.). This material is discussed in detail in Cane (1995a). A summary of key points follows.

2.1 Settlement at Lake Cowal

Wilson (1923) notes "the Aborigines had large camps on the site of the present day Lake Cowal Station Homestead… numerous middens were about here" and English (n.d.) records that when settlers first arrived "there appeared to be substantial evidence that the area had been inhabited by numbers of Aborigines of almost tribal proportions". English (n.d.) observes The Bland was known as a "meeting place of the tribes of the Lachlan and Murrumbidgee Rivers".

Sarah Musgrave (1979) describes territorial conflict in the area and notes "the last fight between the Lachlan and Murrumbidgee blacks" occurred on the Bland.

2.2 Ritual and Mythology at Lake Cowal

Musgrave (1979) refers to initiation rites of the "Lachlan and Murrumbidgee tribes" and that "the place where these initiation services took place is now the township of Wyalong". The ceremonial ground was accidentally discovered by a man called John Reagan and "the custom ceased then, as it was considered by the blacks that the ground had been desecrated".

Gammage (1986) notes that the Lachlan River and the Milky Way had the same spirit (gular) and this may have extended as far south as Lake Cowal. He specifically notes a Wiradjuri interest in the solar system (especially the Milky Way) and H.P. (1896) records that the people on the Bland had myths about the Sun and the Moon and "repeat a number of stories about the stars, and have names for all the bright ones".

2.3 Nomenclature

The name Lake Cowal comes from the local Aboriginal word for a "large water" (Woolrych 1890). Nerang Cowal means little water (narang = little). Bogandillon, a waterhole to the north, comes from the word Buggin (large) and dil-lan (meaning blocked). Cowal and Buggin (also Bugon) are adjectives – and were used together for added emphasis, eg Lake Cowal may originally have been something like Cowal Cowal Bugon meaning the largest lake but was shortened to Cowal by Europeans (Woolrych 1890).

The junction of the Bland, Sandy Creek and Lake Cowal were called Terra-galonga, from "Ter'ra" (meaning "like two arms") and ga'long, ("where they meet") according to Woolrych (1890). The junction was also called "The Levels" by Mitchell (1839) and was finally named "Bland" after a physician.

There was a waterhole on the creek called Yeo Yeo, and this is where the earliest name for the Bland was derived – Yeo Yeo Creek. Yeo Yeo apparently meant "Devil Devil" (Woolrych 1890) and the Aboriginal people who lived in the area were called the Yeo Yeo Tribe (Graham 1963) or the Levels Tribe by settlers. Woolrych also says there was a permanent spring near the Bland called Thooroong-galee.

The second major station established near Lake Cowal (1842) was the Billabong pastoral run. This name, according to the Bland Historical Society was "The official name applied to the Bland Creek in the Lake Cowal and Marsden areas at that period" (BHS 1993b).

In the case of "Billabong", the location was "pointed out to Mr. Trott in 1842 by a black" (Musgrave 1979), but in those days it was a Wiradjuri term – foreign to settlers, and pronounced Billybung (according to a descendant of one of the early miners in the area (White 1928 in BHS 1993a). Historically the word is recorded as meaning the Milky Way[1] and originally came from the Lachlan area (also see Mitchell 1839 for the Goobang River (called "Billibang"), 20 km north of the Bland, running south into the Lachlan River) and by Rev. Gunther for Bell River (60 km away and running north towards Wellington) (Dixon et al. 1992).

2.4 Historic Experience

There is an historic reference to a 'Black's Camp' "situated along the eastern banks of Lake Cowal" and mapped at Marsden, about four blocks from "the first police station" (English n.d.). Musgrave (1979) records that the area was known by Aborigines as Billabong Station until 1854 – when it was named after a new owner, Mr. Marsden. There is no reference to any other Aboriginal people living there – no family, relations or camps on the property. Most seem to have left the area by the mid 1800s (Musgrave 1979). Some people mixed with the settlers – integrating a number of the original inhabitants with the pioneering families, acquiring the names such as Glass, Trott and Sloane (Read 1983).

A large number of Aboriginal people may have left the region as settlers arrived. Read (1983, from Curr) notes that most of the people from the "back country" (north of the Murrumbidgee) had settled on that river by 1885. It may be that, as Mr. Reagan discovered at Wyalong, people simply left the landscape once they felt it had been "desecrated" by European settlement. Disease is also likely to have impacted the Indigenous community – smallpox, typhoid, diphtheria, measles and influenza. Lawrence Struilby records the death of at least two members of the "Yeo Yeo tribe" from measles in the early years (Graham 1963).

It also would be a fair guess that those not killed by disease were killed by settlers. It is well known that the Wiradjuri were in a state of virtual warfare with the settlers until about 1840. Read (1983) and Gammage (1983) document this situation in unpleasant detail. Records indicate that hostilities in the interior were much greater than publicly known; "extermination is the word… dreadful tales of cold blooded carnage" (Colonel Munday 1952, quoted in Read 1983). Lawrence Struilby makes an adventure out of murdering two people near the Bland (Graham 1963). By 1875 the region had been sufficiently cleared for the Sydney Morning Herald to be able to write "there is a large vacant space between the Murrumbidgee and the Lachlan" (in Read 1983). This implies the "Yeo Yeo tribe", amongst others, had gone.

It is also likely that remnants of the Yeo Yeo people lived on in the "Black's Camp" at Marsden. Others probably continued to wander around their homelands – now circumvented by pastoral boundaries, without presenting a threat to the new land owners. "Curraburrama Jimmy", as an example, only travelled between three stations to the south of Lake Cowal – Morangorell, Burrangong and Curraburrama (Musgrave 1979). They were about 70 km apart – consistent with the size of a traditional Aboriginal estate.

The earliest movements of indigenous people into settlements seemed to follow traditional trade routes (Read 1984) but as they settled towns people invariably complained and the refugees were moved. The governments policy of dispersal caused major upheaval after the initial phase of dispossession. Bill Rutter, from the West Wyalong Local Aboriginal Land Council, thinks earlier inhabitants of the region may have gone to Grenfell, and then on to Young. He says there was a pattern of movement in the northern part of Wiradjuri country between Euabalong, Condobolin, Cowra and back through Peak Hill. He said people also went to Dubbo and back to Condobolin. It is also possible that the people from Marsden went to Forbes. There were 79 Aboriginal people camped at Forbes in 1909, but this camp was dispersed by the Government soon after. By 1915 there was only one Aboriginal person left in town (Read 1984).

The result of government dispersal was that many Wiradjuri people ended up living a long way from where they started. West Wyalong is a case in point. It contains a core Aboriginal population of about 30 people (although the Census records list 104): the Rutter, Hampton, Clark and Kennedy families who come from as far afield as Menindee, Murrumbidgee, Combolong, Carowra Tank, Yass, Nyngan, Euabalong, Girilambone and Lake Cargelligo. There seem to be no descendants from Lake Cowal.

[1] This reference comes from a hand written list on a piece of cardboard displayed at the Bland Historical Society. No-one knows where it came from, but all testify that it has been with the museum for as long as the museum has been in existence. Its authenticity is enhanced by other words scrawled of the cardboard: cowl – waterhole, Condobolin - hop bush, Cootamundra – low area, Barrallen – meeting of water, Mirool – pipe clay, Willandra – little water.

3.0 ARCHAEOLOGICAL BACKGROUND

Very little archaeological material has been recoded at Lake Cowal. There are, for example 113 sites documented on the Forbes 1:25,000 map sheet of which only three (below) are connected with Lake Cowal. A fourth site relates to artefacts, axe grinding grooves and a water hole at Manna Mountain. The record contains 31 references to camp sites, over half of which were recorded by Paton and Hughes (1984) near the Lachlan River. The great majority of the sites are scarred trees (45; produced by the removal of bark for domestic activities), carved tree (31). The remaining sites include smaller numbers of burials (9), axe grinding grooves (3), stone quarries (2), stone arrangements (3) and one shell midden and one rock shelter.

It is important to note that no burials are recorded around Lake Cowal, although the southern end of the Lake is reported to have contained a burial ground (see Cane 1995a). Several sand deposits are located in the lease area which could contain burials. These were inspected for human remains. The sand deposits have been ripped up to destroy rabbit burrows, allowing an excellent opportunity to examine subsurface materials and detect any fragment human bone. None were seen and it seems unlikely that any human remains existed or have survived in the lease area.

Government site records note two carved trees and a small camp site near Lake Cowal itself. The locations of the carved trees is not known and they have long since been removed. Available evidence suggests they were located south of the Lake, near the Bland. The trees may still be in existence in collections in Brisbane or Canberra (Cane 1995a). The third site is referred to as a "campsite" on the south end of Lake Cowal. It contained "scrapers and an axe".

Apart from these brief records a preliminary investigation at Lake Cowal by Paton (1989) suggests a comparatively limited cultural heritage with artefact densities in the order of one per 25 square metres in the core parts of the lease area. The archaeological evidence available prior to this investigation suggests that the intensity of site usage at Lake Cowal is not as great as one would expect given its significance as a water body and its brief ethnographic history. Our own surveys tend to confirm a limited cultural resource at Lake Cowal, at least on the western shores of the Lake.

3.1 Other Surveys

Other surveys with some relevance to Lake Cowal have been conducted at Forbes (Lance 1985), West Wyalong (Silcox 1986) and Parkes (Brayshaw 1993). These reports provided a limited amount of information, summarised below.

3.1.1 Site Location

All reports reinforce the general theme that water was a major factor influencing the location of sites and that site densities dropped dramatically as one moved away from water. Sites inland were small and sparse. The richest site contained only 1 artefact per 10 sq m near West Wyalong (Silcox 1986).

3.1.2 Raw Materials

The studies also noted a dominance of quartz in artefact assemblages, except near Parkes where quartz only accounted for 25% of assemblages. The remainder was yellow chert (50%), silcrete (12.5%) and basalt (12.5%).

3.1.3 Artefact Types

Sites typically contain a majority of flake pieces (57%), flakes (30%), modified flakes (7.5%), cores (3.5%), hammer stones (0.5%) and microliths (1.5%). Grindstones and heat retainers were also noted in most sites.

3.1.4 Artefacts Size

Approximately three quarters of the artefacts were less than 3 cm long. The quartz component of the assemblage appears to have been generally larger than the chert component – with about 10% of the quartz artefacts being larger than 5 cm and 3% of the chert artefacts being larger than 5 cm.

4.0 ABORIGINAL INVOLVEMENT

Aboriginal involvement in the cultural surveys commenced with the initial survey of Lake Cowal and has continued through subsequent surveys.

Consultation for this project commenced in late 1994. The Wiradjuri Regional Aboriginal Land Council was notified of an intended survey and their site curator (Roley Williams) contacted the West Wyalong Local Aboriginal Land Council (Bill Rutter, Chairperson). Project timing, approach, consultative mechanisms and likely outcomes were discussed with the client (North Limited) and their environmental consultant (NSR) and representatives of Wiradjuri Regional and West Wyalong Local Aboriginal Land Councils at West Wyalong.

Field work was conducted with Roley Williams in early 1995 and coordinated from the West Wyalong Aboriginal Land Council each day. Bill Rutter made a site visit towards the end of the survey. Attitudes towards the proposed mining operation and site management options were discussed.

A visit was made to Wagga Wagga to brief the Wiradjuri Regional Aboriginal Land Council and an informal meeting was organised between North Limited and representatives of the West Wyalong Local Aboriginal Land Council. This was coordinated by the Wiradjuri Regional Aboriginal Land Council. Roley Williams also gave a public talk at the West Wyalong TAFE about regional heritage issues, the findings of the Lake Cowal survey and possible management options. Mining officials attended the presentation.

Management options were formalised in a draft report circulated to the Wiradjuri Regional Aboriginal Land Council, West Wyalong Local Aboriginal Land Council, North Limited and NSR for comment. The management recommendations were endorsed by the Wiradjuri Regional Aboriginal Land Council in February 1995.

Attitudes towards the proposed development were reassessed through the course of the Commission of Inquiry in late 1995, and the Wiradjuri Regional Aboriginal Land Council and NSW Aboriginal Land Council became more actively involved. Bill Rutter tabled a letter with the Commission on behalf of the West Wyalong Local Aboriginal Land Council. This letter expressed concern about the environmental impacts of cyanide use at the proposed mine site, and sought to ensure that adequate site protection measures were employed if mining proceeded:

The second concern again is our sites, you have a scarred tree that is being conserved and relocated to the Aboriginal Land Council, also there are other sites which need more recordings on them, and what I would like to see happen is that we have an Aboriginal Sites Curator who is assisting on this, and record who could supervise the fencing and any excavation or additional recording (Letter from Bill Rutter n.d. 1995).

Some informal contact was maintained between the representatives of the Land Council and the archaeologists after the Commission of Inquiry and more formal discussions recommenced with the West Wyalong Local Aboriginal Land Council and NSW Aboriginal Land Council in September 1997. Discussion continued through the month and additional field work was undertaken in October and November. The work was conducted by Roley Williams from The Wiradjuri Regional Aboriginal Land Council and Wonita Darcy from the West Wyalong Local Aboriginal Land Council. Daily discussion were held with Bill Rutter as the field work progressed.

A draft report was sent to the Local, Regional and NSW Aboriginal Land Councils for comment and a meeting was held in West Wyalong in January 1998 to discuss the management recommendations outlined in the draft. Representatives from the Local, Regional and NSW Aboriginal Land Councils were present and all parties agreed to the proposed recommendations. Details relating to the implementation of the management recommendations were discussed and will be the subject of ongoing discussions between North Limited and the Land Councils.

5.0 THE ARCHAEOLOGICAL SURVEY

5.1 The Pit Area

The impact of the pit area on the lake shore measures about 1 km long by 250 m. This area has been grazed and cropped for over 100 years. It is partially disturbed and has excellent exposures for finding archaeological materials. Most of the pit area was inspected for archaeological materials. Archaeological visibility is estimated to be as high as 75% and effective survey coverage to be 54%[2] (Cane 1995a).

[2] The area investigated covered approximately 250,000 sq. m.. About 90% of the area was examined and approximately 75% of the ground surface was exposed. Visibility within these exposures was high, probably as high as 90% although background interference from natural gravels and quartz was also high, again probably as high as 90%. This interfered with the effect coverage, resulting in a confident archaeological assessment of some 54% of the area.

5.2 The Tailings Storages

Two tailings storages, each measuring 1.3 x 1.3 km, are proposed for construction on the undulating gilgai plains 3.5 km to the west of Lake Cowal. Several farm tracks cross the tailings storage area and these, together with exposures associated with cropping and grazing activities, provided adequate opportunities to investigate the areas archaeological potential.

The northern tailings storage (Cell 1) has two main tracks crossing it; one running east west, the other north south. These, together with minor track along fence lines were inspected for archaeological materials. Other exposures investigated included erosional scalds associated with a dam and drainage line in the centre of Cell 1. In the southern tailings storage (Cell 2) there are several tracks along fence lines. These provided exposures to investigate for archaeological remains in an area which is largely under crop. A track runs roughly north south through Cell 2, another heads east out of the tailings storage area towards Lake Cowal, and a third extends west to the railway line.

The survey provided general coverage of about 30% of the tailings storages, with detailed investigations of exposures corresponding to about 6% of the tailings storage area[3]. Visibility along the tracks and other exposures was high, ranging from 70-100%. A background scatter of natural gravels of quartz and fragmented shales was present across most of the exposures, averaging 30% cover of the ground surface. Estimates suggest that within the areas targeted for detailed investigation, an effective coverage of 28% was achieved.

[3] The tailings storages survey is estimated to have covered approximately five linear kilometres. If it is assumed that, on average, a 200 m wide corridor (centred around the track) was viewed, then 1,000,000 sq m, or 30% of the tailings area was inspected during the survey. Detailed inspection took place at six locations (3 areas of 250 x 250 m, and 3 areas of 200 x 30 m), corresponding to 205,500 sq m, or 6% of the total area impacted by the tailings storages (approx. 3,380,000 sq m).

5.3 The Remainder of the Lease

5.3.1 The Plains

The plains behind the pit were investigated as part of an earlier survey associated with the original location of the tailings storages. The area was investigated from three tracks which intersect the area. One track passes the southern foot of Cowal West Hill. A second track runs through the centre of the area towards some wheat silos and then joins a third track which passes to the west of the plains and then returns east towards Lake Cowal and Cowal West Homestead.

In each case the tracks provided ready access to a number of exposures in the paddocks and pastures across the plains. They provide a general survey coverage in the order of 45% of the total plains area investigated although the exposures themselves amounted to about 4.5% of the total area[4].

[4] It is estimated that 6 linear kilometres were viewed with a viewing radius of 150 m each side of the track = 1,800,000 sq m seen. Eight specific areas of about 150 x 150 = 22,500 sq m were targeted for more detailed inspection = a detailed survey area of 180,000 sq m or 4.5% of total impact area (3 sq km). Artefact recording took place within an area of 13,044 sq m, or .3% of the total area.

5.3.2 The Creeks and Lake Shore

Archaeological investigations were also conducted along the Lake shore and creek lines running from the plains into Lake Cowal. Visibility varied in these areas. To the north the grey top soil covered some archaeological materials although exposures were numerous enough to indicate that artefacts are scattered consistently along the Lake shore to the north of the pit area. Effective coverage was estimated to be in the order of 14%[5] – sufficient to confidently recognise the existence of an evenly distributed background scatter of material.

To the south of the pit the situation was essentially the same, with the exception of a 600 metre section of the shoreline which had been severely eroded. This portion of the Lake edge looked particularly arid, with large gutters cut through the clay and gravel ridge line. There was no top soil here – and no artefacts either.

Each of the creeks flowing into Lake Cowal were also inspected. These contained the greatest concentrations of artefacts.

6.0 SURVEY RESULTS

The location of all archaeological material discovered during the surveys are shown on Figure E-2.

6.1 Sites in the Pit Area

Site P1

The Pit area contains a continuous scatter of artefacts which appeared to concentrate in a band 50 – 100 metres from the lake shore. This concentration had a fairly low density of artefacts (generally less than one artefact per 40 square metres) with the highest concentrations in the order of one artefact per 20 sq m.

Vehicle, cattle and plough disturbance has distorted the appearance of the assemblage in the pit area suggesting some artefact types might be under estimated (modified flakes constitute just 4%) while others may be over estimated (cores account for 10%). Twenty percent of the material has been broken (snapped) by vehicular traffic.

Site P1	Description
Density	1/40 sq.m.
Artefacts	
Flake	66%
Mod Flake	4%
Flaked piece	1%
Core	10%
Backed blade	6%
B. blade blank	5%
Blade	3%
Hammer	1%
Burin	3%
Adze	1%
Materials	
Chert	75%
Quartz	19%
Silcrete	4%
Quartzite	2%

[5] The area investigated near the Lake margin covered some 175,000 sq m. About 80% of this was inspected but exposures were few, probably less than 20% of the area inspected. Visibility was high in these exposures (100%) but a considerable portion of the surface was covered by natural gravel (90%). This suggests the effective coverage of the area investigated was about 14%.

The assemblage was recorded as being dominated by unmodified flakes (66%) and cores (10%), with a high proportion of backed blades, blades and small blades (14% of the site).

The majority of the artefacts were made of a fine black chert (75% of the assemblage). This is a very high quality material and, with the exception of one silcrete blade, all the precision implements were made of it. The other materials included quartz, silcrete and local quartzite.

Site P2

Site P2 is a scarred tree on the south west margin of the proposed mining pit. The tree, an older red gum, is located on the edge of the lake floor. The scar is 35 centimetres wide and 1.2 metres long – broadly oval in shape. Regrowth has extended 10 centimetres in from the original scar outline onto the inner wood. This wood is now dead, and the top of the scar can be seen as a convex crack in the dead wood.

6.2 Sites around the Lake Shore

Some general comments are needed to introduce the sites in this area and so avoid repetition in each site description.

- Artefact concentrations increased at each creek line. Five creeks are present in the study area and each was associated with a site.
- One site, LC1 (Lake Cowal 1) was located some distance from reliable water.
- Each of the creeks had been disturbed to some degree through farming activity. Sites LC3 and 4 were probably the most disturbed – being associated with a number of dams and roads.

Site LC 1	Description
Density	1/2-3 sq.m.
Artefacts	
Flake	56%
Flaked piece	13%
Core	13%
Backed blade	3.5%
B. blade blank	3.5%
Blade	4%
Hammer	2%
Burin	2%
Adze slug	1%
Grind St.	2%
Materials	
Chert	71%
Quartz	17%
Silcrete	4%
Quartzite	3.5%
Sandstone	3.5%
Ferecrete	1%

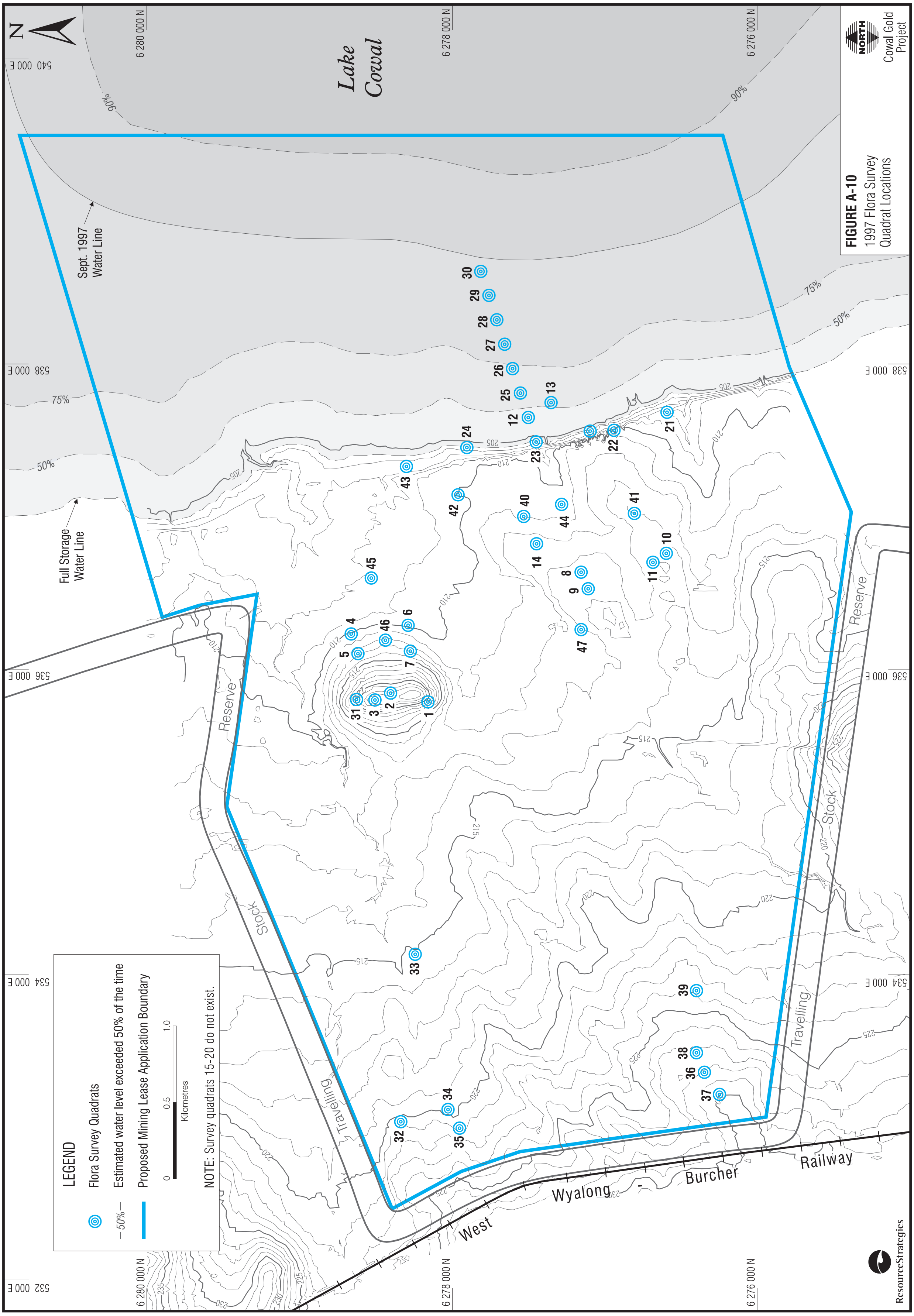

FIGURE A-10
1997 Flora Survey Quadrat Locations

- Disturbance had damaged and rearranged artefacts at these sites. The most frequent damage was artefact breakage – snapping between 4 and 13% of the assemblage.
- Sites LC2, 4, 5 and 6 are associated with small (100 x 40 metre) sand ridges. These have been 'ripped' up to destroy rabbit burrows. The dunes are therefore highly disturbed and free of vegetation.
- No human remains were located in the survey area. All sand bodies were inspected. Each had been 'ripped' to remove rabbit burrows. This provided an unexpected opportunity to search for fragmented bone that may have once been under the surface. No evidence of human remains were seen and the extent of disturbance suggests that burials are unlikely to have survived even if they had been once placed in the sand deposits.

Site LC1 (Lake Cowal 1)

Site LC1 is a comparatively rich site. It contains one artefact for every two to three square metres, 20 times higher than in the pit area just to the south.The site also contains a range of artefacts characteristic of a number of men's activities – adze flakes, burins, cores and backed blades. Other tools such as seed grinding implements and modified artefacts are notably absent. Three hearths with heat retainers were located. The site is located about 150 metres west of the Lake shore. It is thought to be a men's activity area (Cane 1995a).

Site LC2

Site LC2 is more typical of a "base camp" with flaked material scattered along both sides of a stream running into Lake Cowal. Artefact densities are as high as four to five per square metre, but average at about one per square metre over the larger site area. The raw materials present were typical of the other sites with about 60% of the assemblage composed of fine black chert.

The proportion of chert is slightly less than at LC1 and P1 because of the presence of artefacts made of sandstone – including ground pieces, flakes, and flaked pieces. Overall, however the site was "better balanced" in terms of artefact content. It contained flakes, flaked pieces, cores, modified flakes, backed blades, blades, hand axes, hammerstones, adze flakes and ground artefacts.

Site LC3

This site was small and sparse. It contained 28 artefacts in a sampled area of 400 square metres – a density of about one artefact per 15 square metres. The area has also been disturbed by the construction and use of four dams, camping on the Lake shore, and vehicle access along fence lines, through gates and around the dams. The site is thus not thought to have a great deal of interpretative value. The sample is also too small to be very meaningful and seems to be skewed towards an unusually high proportion of flaked pieces (25%) – a product of breakage through farm disturbance. The proportion of conventional flakes is lower (40%) than found elsewhere because of the high number of flaked pieces. Backed blades and blades are also found at the site in comparatively high frequencies (14% in total) and there are some cores, hammerstones, one ground piece of sandstone and one modified flake. The artefacts are highly reduced.

Raw materials included chert (60%), quartz (32%) and some silcrete and sandstone. The high proportion of quartz is worth noting as it is a recurrent feature of sites on the southern side of the pit area (Sites LC4, 5 and 6).

Site LC 2	Description
Density	1/1 sq.m.
Artefacts	
Flake	60%
Mod Flake	3%
Flaked piece	14%
Core	13%
Backed blade	5%
Blade	1%
Hammer	1%
Axe	1%
Adze	1%
Grind St.	2%
Materials	
Chert	60.5%
Quartz	27%
Sandstone	11.5%
Quartzite	1%

Site LC 3	Description
Density	1/15 sq.m.
Artefacts	
Flake	40%
Mod Flake	3%
Flaked piece	25%
Core	7%
Backed blade	7%
Blade	7%
Hammer	3.5%
Grind St.	2.5%
Materials	
Chert	60%
Quartz	32%
Silcrete	4%
Sandstone	4%

Site LC4

Site LC4 is a also a sparse, small artefact scatter adjacent to a small creek. Forty four artefacts were recorded in an area of 360 square metres – a density of about 1 artefact every 10 square metres. The site has been disturbed by dam construction and vehicle movement along fence lines to the lake shore. Broken (snapped) artefacts account for 14% of the total.

The range of artefacts is broadly similar to site LC3 with a high proportion of flaked pieces, blades, backed blades, adze flakes and burins. The artefacts are highly reduced and this may be associated with hunting and woodworking or be the result of artefact breakage through disturbance. The assemblage is dominated by chert and quartz.

Site LC5

This site contains artefacts scattered at a density of one artefact per 60 square metres. Only 18 artefacts were noted and these included flakes, cores with a few hammers, grindstone fragments and an axe. The materials on which the artefacts are made, and the size of the artefacts is similar to the other sites.

Site LC6 (a and b)

Site LC6 has been divided into two parts: LC6a and LC6b.

Site LC 4	Description
Density	1/10 sq.m.
Artefacts	
Flake	61%
Flaked piece	18.5%
Core	4.5%
Backed blade	4.5%
Blade	4.5%
Burin	2%
Adze	4.5%
Materials	
Chert	65%
Quartz	28%
Quartzite	7%

Site LC 5	Description
Density	1/60 sq.m.
Artefacts	
Flake	74%
Core	11%
Hammer	5%
Axe	5%
Grind St.	5%
Materials	
Chert	38%
Quartz	28%
Quartzite	12%
Sandstone	17%
Volcanic	5%

Site LC6a represents the accumulation of artefacts along the upper reaches of a creek, at least two kilometres west of Lake Cowal. It consists of a continuous scatter of material along the creek and has an artefact density of between 1/5-15 sq m. The density of material increases closer to the Lake shore. The site has a comparatively high proportion of quartz artefacts (39%). Chert constituted 54% of the sample.

The artefactual assemblage is dominated by unmodified flakes, cores, flaked pieces and blades.

Site LC6b is was represented by an extensive scatter of artefacts within 100 metres of the shore of Lake Cowal. The artefacts were exposed in open hard pan areas at densities as high as four artefacts per square metre, with more general densities of at least two artefacts per square metre. Site LC6b was also dominated by black chert (68%), with little quartz (16%).

The artefacts at LC6b include flakes, backed blades, cores and adzing tools. Only two small pieces of ground sandstone were noted, one of which had been used to sharpen ground edged axes.

The assemblage at LC6b has been greatly reduced, with long thin flakes indicating precision flaking, economic use of available material and the production of microlithic preforms.

Site SC1

Site SC1 is located on the southern end of Lake Cowal, well outside the proposed development area.

The site reveals an artefact density of about 1 artefact per 5-10 square metres. The assemblage was similar to other sites: backed blades and blades constituted 10% of the assemblage, unmodified flakes 62%, cores 7% and flaked pieces 7%. The proportion of adze flakes (7%) was slightly higher than at other sites, and this may reflect an increase in woodworking activities associated with the availability

Site LC 6	Description	
	LC 6a	LC6b
Density	1/10	4/1
Artefacts		
Flake	59%	83%
Flaked piece	13%	0
Core	15%	4%
Backed blade	1%	7%
Blade	7%	0
Adze	1%	3%
Point	1%	0
Axe	1%	0
Sharpening St.	0	1.5%
Grind St.	2%	1.5%
Materials		
Chert	54%	68%
Quartz	39%	16%
Quartzite	3%	6%
Sandstone	4%	3%
Silcrete	0	7%

of wood in forested areas around the floodplains of Sandy Creek and the Bland.

The proportion of raw materials at the site is also consistent with the region generally. Chert constituted 65% of the material, although it is interesting to note that 7% of this was a yellow chert, not seen at the other sites.

The general trends reflected in artefact type and raw material, and the reduced size of the artefacts reflects a technology directed toward the production of microliths – long, slender, thin blades, presumably used for hunting.

6.3 Archaeological Exposures on the Plains

A survey was undertaken to the west of the pit area, on the gilgai plains towards and overlapping with the new location for the tailings storages. Eight sites were located in this area. All had a number of common features. These included:

- A dominance of quartz (77%) and less chert (13%) than found in sites nearer the Lake.
- Each scatter of artefacts was located next to a gilgai depression or creek. The gilgai seemed to hold more accessible water at the time of our survey – and thus may have been preferred camping locations in the past.
- There is a density of around 1 artefact per 20 sq m at most sites similar to that at site P1 and characteristic of the background scatter around Lake Cowal.
- The distribution of material suggests an uneven, but continual background of artefacts across the plains and the distribution of individual "sites" are really "windows" into a larger variable background of cultural material. The sites are reported as "exposures" of cultural material as a consequence.

Site SC 1	Description
Density	1/15 sq. m.
Artefacts	
Flake	62%
Core	7%
Flaked piece	7%
Backed b./b.	10%
Adze	7%
Materials	
Chert	72%
Quartz	23%

Exposure A	Description
Density	1/350 sq. m.
Artefacts	
Core	2 (100%)
Materials	
Quartz	50%
Quartzite	50%

Exposure A

This exposure is located on the south east side of Cowal West Hill. Two artefacts were located in an area measuring 50 x 40 m. These included one quartz core and one quartzite block with recent fractures. Visibility was about 35% – so more material may be present in this area. An artefact density of 1/350 sq m is inferred from the effective coverage.

Exposure B

Exposure B is located to the west of the foot slopes of Cowal West Hill near a number of gilgai depressions. Thirteen artefacts were seen in an area of about 40 x 100 m. Most were quartz flakes and the number of artefacts recorded implies a density of about 1/300 sq m, although the artefacts clustered in small areas next to gilgais (between 1 and 3 artefacts/sq m).

Exposure C

This exposure is located half a kilometre to the west of Cowal West Hill. Artefacts were found exposed in an area measuring 30 x 25 m under a tree. This exposure had been caused by sheep (or cattle) resting under the tree. Visibility was excellent (100%).

The exposure revealed 26 artefacts the majority of which were quartz. The density of material was one artefact per 23 sq m – similar to the background scatter at Site P1.

Exposure D

This exposure was located a short distance from an ephemeral drainage line running diagonally across the plains to the west of Cowal West Homestead. The channel was also inspected for artefacts, but exposures were poor and no artefacts were seen. A few pieces of mussel shell were noted, but these may be natural rather than cultural in origin. Eighty four percent of the artefacts were quartz flakes (84%). Three hearths were also noted.

Exposure B	Description
Density	1/300 sq. m.
Artefacts	
Flake	11 (92%)
Grind St.	1 (8%)
Materials	
Quartz	75%
Chert	17%
Sandstone	8%

Exposure C	Description
Density	1/23 sq. m.
Artefacts	
Flake	32 (97%)
Grind St.	1 (3%)
Materials	
Quartz	79%
Chert	9%
Sandstone	3%
Silcrete	6%
Quartzite	3%

Visibility was about 70% over the sample area of 50 x 30 m, giving a density of 1/79 sq m, or a corrected density of 1/55 sq m.

Exposure E
Exposure E was recorded in a cleared area of about 30 x 25 m under a tree within a larger area adjacent to a discrete gilgai. Thirty nine artefacts were recorded, most of which were quartz. Five heat retainers were also noted. The area under the tree was slightly deflated, providing excellent visibility (100%) and suggesting an artefact density of 1/19 sq m.

Exposure F
Exposure F is located next to a dam, two wheat silos, water troughs and a gate on the eastern margin of the proposed tailings storage area. There is a focus for vehicle and cattle movement and artefactual materials have been disturbance and breakage broken as a consequence. Regardless, 35 artefacts were noted in an area of 70 x 50 m – or a density of 1/100 sq m. Visibility was poor (25%) because of vegetation and soil cover so a corrected density would be more like 1/25 sq m.

Quartz made up 86% of the material recorded. A sparse scatter of mussel shell was also noted. The scatter was slightly more dense and concentrated than in Exposure D and may be cultural.

Exposure G
Exposure G is located on a scald, next to a small gilgai in the middle of the proposed tailings storage area. Nineteen artefacts were noted in a small area measuring 12 x 12 m, giving a density of 1/8 sq m. These artefacts included a wider range of materials than at the other exposures: quartz, chert, ground sandstone, volcanic and quartzite (also three heat retainers).

Exposure H
This scatter of artefacts is located on exposures associated with a track adjacent to the same creek line that passes Exposure D. Thirty artefacts were recorded in an area measuring 40 x 10 m, giving a density (corrected for 80% visibility) of 1/11 sq m – although this should be about 1/5 sq m because the material tended to concentrate in two areas within the exposure examined. The material consisted primarily of quartz and chert. A large (45 x 35 cm) slab of sandstone was also noted with two patches of grinding on it.

6.4 Archaeological Exposures in the Tailings Storages

Exposures in this area have a number of similarities with the exposures on the gilgai plains closer to Lake Cowal. They were found in similar locations, close to gilgais and creek lines, and overall contained similar densities of artefacts and similar ranges of tool types and raw materials. However, they also displayed significant differences:

- the exposures in the tailings storages contained less quartz (av. 29%) and more chert (av. 41%) than exposures recorded on the adjacent plains although proportions of chert still remained lower than around Lake Cowal itself.

Exposure D	Description
Density	1/55 sq. m.
Artefacts	
Flake	18 (95%)
Hammer	1 (5%)
Materials	
Quartz	84%
Chert	11%
Quartzite	5%

Exposure E	Description
Density	1/19 sq. m.
Artefacts	
Flake	38 (97%)
Grind stone	1 (3%)
Materials	
Quartz	90%
Chert	8%
Sandstone	2%

Exposure F	Description
Density	1/25 sq. m.
Artefacts	
Flake	35 (100%)
Materials	
Quartz	86%
Chert	14%

Exposure G	Description
Density	1/8 sq. m.
Artefacts	
Flake	16 (84%)
Hammer	1 (5%)
Grind stone	2 (11%)
Materials	
Quartz	59%
Chert	24%
Sandstone	12%
Quartzite	5%

Exposure H	Description
Density	1/5 sq. m.
Artefacts	
Flake	29 (97%)
Grind stone	1 (3%)
Materials	
Quartz	68%
Chert	21%
Sandstone	4%
Silcrete	7%

Exposure I	Description
Density	1/25 sq.m.
Artefacts	
Flake	13 (61%)
Mod Flake	4 (19%)
Flaked Piece	1 (5%)
Core	1 (5%)
Grind St.	2 (10%)
Materials	
Quartz	38%
Chert	38%
Sandstone	10%
Silcrete	10%
Quartzite	4%

Exposure J	Description
Density	1/11 sq.m.
Artefacts	
Flake	8 (38%)
Mod Flake	3 (14%)
Flaked Piece	3 (14%)
Backed blade	1 (5%)
Axe	1 (5%)
Grind St.	5 (24%)
Materials	
Quartz	10%
Chert	32%
Sandstone	29%
Quartzite	19%
Volcanic	10%

Exposure K	Description
Density	1/ sq.m.
Artefacts	
Flake	25 (86%)
Mod Flake	2 (7%)
Core	2 (7%)
Materials	
Quartz	38%
Chert	48%
Volcanic	7%
Silcrete	7%

Exposure L	Description
Density	1/200 sq.m.
Artefacts	
Flake	4 (80%)
Hammer	1 (20%)
Materials	
Quartz	60%
Chert	20%
Quartzite	20%

- the density figures remain the same (1/20 sq m) as on the plains and on the lake shore, suggesting the exposures here also reflect windows into a larger background scatter.
- two exposures, however, (J and K) contain more distinctive assemblages attributable to more recognisable patterns of human behaviour. Exposure J contains a wide range of tool types indicative of base camp activities and Exposure K contains evidence of stone tool manufacture.

The difference between the archaeological materials in respective zones around Lake Cowal is thought to reflect different patterns and intensities of settlement. Sites at Lake Cowal appear to reflect consolidated settlement and subsistence activities while exposures in the tailings storages (3.5 km to the west) appear to reflect regular, but somewhat less consolidated evidence of settlement. The exposures on the plains in between suggests movement between these areas and contain archaeological material indicative of sporadic camping and subsistence activities as people moved from the Lake inland. In other words there appears to be a "ring" around Lake Cowal with comparatively little archaeological material reflecting minimal settlement between the hinterland and the Lake.

Exposure I

Artefacts were found scattered across exposures associated with a track which extends east west through the northern tailings storage (Cell 1). Artefacts were found along the track and on adjacent exposures, across an area measuring 60 x 20 m. Visibility was high (100%) and twenty-one artefacts were recorded in a 500 sq m sample area, giving an average density of 1/25 sq m. These were mostly flakes made of quartz (39%) and chert (39%). Two ground fragments of sandstone were also recorded. Several hearth features consisting of burnt clay nodules were visible in the exposures next to the track. Other cultural material included fragments of mussel shell and broken quartzite pebbles.

Exposure J

This exposure was also identified on the track which runs east west through Cell 1 and is located 200 m to the west of Exposure I. Artefacts were found scattered across an exposure associated with the track and across adjacent grass covered areas. Twenty one artefacts were recorded in a 15 x 15 m sample area, a density of 1/11 sq m. Visibility was around 40% and many of the artefacts were either broken pebbles (19%) or fragments of ground stone (29%). Flakes, one backed blade, a ground edge axe, heat retainers and several fragments of mussel shell were also recorded.

Exposure K

This exposure was identified near a dam on a drainage line to the south of Exposures I and J. A high density scatter of chert and quartz flakes was identified on an eroded area 50 m from the dam (visibility 90%). Twenty nine artefacts were recorded in a 100 sq m sample area, an average density of 1/3 sq m. Silcrete and chert cores, broken hammer stones, heat retainers and mussel shell fragments were found elsewhere on the exposures.

Exposure L

A small scatter of artefacts was recorded in the central part of the southern tailings storage (Cell 2). Exposure I was identified in a narrow band of remnant scrub between two cropped paddocks (visibility 5%). A broken hammer stone, three quartz flakes and a chert flake were found scattered over an area of 100 x 10 m along a track. The artefacts were associated with a gilgai depression.

Exposure M

Artefacts were found scattered along a track which leads south through Cell 2. A drainage line is located immediately to the east, outside the tailings storage area. Fifteen artefacts were recorded over a 500 sq m sample area along the track and adjacent exposures; an average density of one artefact per 33 sq m. Most were chert flakes (53%). A couple of cores (quartz, quartzite and chert) and several broken quartzite pebbles were also identified. A cluster of burnt clay nodules was visible eroding out of the ground indicating the remains of a hearth.

Exposure N

Another exposure was recorded 200 m. to the south of Exposure M, on the margin of the tailings storage area. Twenty three artefacts were found scattered over a 120 m. length of track, or 400 sq m, giving a density of 1/17 sq m.

Exposure M	Description
Density	1/33 sq.m.
Artefacts Flake	6 (40%)
Mod Flake	4 (27%)
Flaked Piece	3 (20%)
Core	2 (13%)
Materials Quartz	7%
Chert	53%
Silcrete	13%
Quartzite	27%

Exposure N	Description
Density	1/17 sq.m.
Artefacts Flake	16 (70%)
Mod Flake	2 (9%)
Flaked Piece	1 (4%)
Core	3 (13%)
Grind stone	1 (4%)
Materials Quartz	35%
Chert	39%
Sandstone	4%
Silcrete	9%
Quartzite	4%
Volcanic	9%

Quartz (35%) and chert (39%) artefacts dominated the sampled assemblage. These were mostly flakes with cores and a fragment of ground sandstone also present.

6.5 Results of the Pipeline Route Survey

The survey of the portion of the pipeline route adjacent to Lake Cowal found that the route passes across low lying floodplain. No sand bodies were present and no archaeological materials were recorded.

6.6 Results of the Access Road Survey

The two proposed realignments are located in disturbed areas and are close to the existing road. No archaeological materials were identified in either location.

6.7 Sites to the North of Lake Cowal

A number of sites were located to the north of Lake Cowal by Huys and Johnston in 1995 (Figure E-1). The sites are not located in the project area but are included here to provide an indication of the regional cultural heritage. The following account is taken directly from Huys and Johnston (1995).

Four artefact scatters were recorded between Nerang Cowal and Lake Cowal.

Site FAS3

Site FAS3 is located on a raised area adjacent to the northern extent of the flood plains of Lake Cowal. A sample of 28 artefacts were recorded within an area measuring approximately 100 m x 60 m. It is likely that this site is considerably larger, both in terms of size and artefact numbers. However, it does not appear that the site extends down on to the lake flood plains. The range of artefact types represented in the assemblage of this site indicates that a number of activities were undertaken in this area.

Sites FAS4 and FAS5

Both these sites were located on Bogeys Island. Site FAS4 is situated on the lower western slopes of Bogeys Island. Nine artefacts are scattered along an erosion scald measuring approximately 15 m x 10 m. Visibility beyond this erosion scald is reasonably good, however no artefacts were recorded in the surrounding area. It is therefore unlikely that the site is much larger in extent.

FAS5 is a small artefact scatter comprising 12 artefacts. The site is located on a vehicle track, on the basal eastern slopes of Bogeys Island. Visibility to the east of the site, on the flood plains, was relatively good, however no artefacts were located in this area. Further up the slope from the artefact scatter surface visibility is extremely poor due to heavy vegetative cover. It is possible that the site extends some way up this slope, with the artefacts being presently obscured by vegetation.

Site FAS6

Site FAS6 is located on a small rise above the north-western shores of Lake Cowal. Six artefacts are scattered over an area measuring 20 m x 10 m. Visibility in the vicinity of the site is good. It is therefore unlikely that the site is much larger in extent.

7.0 INTERPRETATIONS

A number of inferences can be drawn from the archaeological material recorded around Lake Cowal. These are summarised below and discussed more fully in Paton (1989) Cane (1995a and b), Huys and Johnston (1995) and Nicholson (1997).

- There is considerably less archaeological material in the vicinity of Lake Cowal than might be expected from the environmental context of the Lake and the ethnographic information available for the Lake.
- Sites near the shores of Lake Cowal display a comparative abundance of backed blades (blanks and blades generally) and a relative absence of other typologically pieces; modified flakes, scrapers, adze slugs and seed grinding implements.
- Archaeological materials away from the Lake shore are comparatively sparse. Sites are small and low density.
- Sites closer to Lake Cowal are dominated by chert.
- The sites on the plains adjacent to Lake Cowal are characterised by higher proportions of quartz.
- Sites 4 km from the Lake shore contained increased amounts of chert.
- Sites between Nerang Cowal and Lake Cowal are located on raised ground.

In summary therefore the sites surrounding Lake Cowal are thought to reflect:

- the lease area reveals a settlement pattern which incorporates some locations used for artefact manufacture, base camps and hunting.
- the abundance of backed blades is thought to reflect hunting along the lake shore. People may have been attracted to the "significant bird habitat and breeding area" (AHC media release) for which Lake Cowal is well known.
- the exploitation of the significant bird population and breeding area of the Lake was the primary reason for occupation.
- the occupation at Lake Cowal was greatest in the early spring of years when the lake was full and the population of migratory and breeding birds was greatest.
- that the development and use of a characteristic microlithic technology was targeted at hunting, with the additional possibility of use in warfare and ritual.
- there are not enough ground artefacts at sites in the region to support seed processing and consumption as a major economic activity in the area.
- there are not enough modified flakes and woodworking tools to suggest that the construction, use and maintenance of wooden tools, such as digging sticks, boomerangs, clubs and wooden dishes, used in routine subsistence was a significant activity at sites near the Lake.
- that sites were occupied from at least 2000 years ago. Some sites may reveal occupation in different (pre and post backed blade) timeframes.
- that sites reflect the movement of people and chert into the area from the north.
- chert may be a cultural marker which, along with the distinctive carved trees of the region, may help define broader social and cultural patterns between the "Lachlan and Murrumbidgee tribes".
- the quartz material recorded in the area reflects nomadic life in the hinterland of Lake Cowal whereas the chert material reflects more complicated cultural processes and behaviour (trade, ritual, migration, technology and economic specialisation).
- settlement patterns were more consolidated close to the Lake and 4 km from it.
- sites on the flood plains north of Lake Cowal were used during periods of flood.

The primary activities displayed at each site are interpreted as follows:

P1 – incidental camping and hunting activities.

LC1 – men's area, microlithic workshop and some base camp functions. Site may date between 4000 and 1500 years – coinciding with the time span of the backed blade tradition in Australia.

LC2 – base camp activities associated with routine subsistence.

LC3, 4, and 5 – hunting areas, quartz based industries supplementing backed blade industry and occupied within the last 2000 years.

LC6 – source route for quartz materials, raw material exchange, intensified manufacture of microlithic tools.

SC1 – outside this land use system; hunting and woodworking.

Exposures A to I and L to M – nomadic camping around the principle food and water resource of Lake Cowal itself.

Exposure J – more diverse base camp activities.

Exposure K – artefact manufacture.

Sites FAS3 to 6 – reflect camping on raised ground in the flood plains north of Lake Cowal during the winter.

8.0 MANAGEMENT RECOMMENDATIONS

8.1 Direct Consultation and Negotiation

Land Council representatives expressly requested direct contact with the company in order to explain their views on the development and to negotiate management preferences. The advantage (and intention) of this approach is to encourage a cooperative management process.

Local Aboriginal representation would also be desirable on any local committees established to monitor or liaise with the mining operators or managers.

8.2 Increased Cultural Knowledge

Site management should be directed towards protecting sites as well as enhancing local knowledge and appreciation of the cultural heritage of Lake Cowal. This may involve assisting the museum run by the West Wyalong Local Aboriginal Land Council by:

i) establishing displays reflecting aspects of the cultural heritage of Lake Cowal;

ii) sponsoring a booklet that provides a readable account of Aboriginal heritage and history at Lake Cowal and West Wyalong; and

iii) sponsoring the search for and return of the carved trees originally taken from the Bland (Cane, 1995a).

8.3 Site Management

There was general agreement that North Limited should sponsor a Land Council position specifically for the purpose of cultural heritage management at Lake Cowal as required over the construction and establishment phase of the mine. The task would be one of coordinating and managing the site works (described below) as well as advising the company, NPWS and Land Council as circumstances necessitated. It was also agreed that North Limited should sponsor a team of three local people to work with the site manager to help undertake the site management program.

The site management program would involve the following tasks.

8.3.1 Sites near Lake Cowal

Site P1: Background scatter of artefacts
Collection of artefacts recorded during the field survey and storage at the West Wyalong Local Aboriginal Land Council.

Site P2: Scarred tree
Removal of the scarred section of the tree by professional conservators. Presentation and **display** of the scar in a protective display case at the West Wyalong Aboriginal Land Council.

Site LC1: "Men's site"
North Limited to sponsor an open area **excavation** of the site to be conducted by the Local and Regional Land Councils, with specialist advice where needed. The purpose of the excavation would be to determine the chronology and function of the site with a view to understanding its purpose in the context of the Lake Cowal region.

Site LC2: Base camp
Site to be **fenced** around area of major artefact concentration and **sign posted** to avoid damage to artefacts extending up the creekline. Sign posting should be general in nature, indicating the presence of "cultural materials" and placed so as not to draw attention to key components of the sites but to remind workers of the proximity of archaeological materials and ensure they are not accidentally damaged during construction activities nearby or vehicle movement through the area.

Sites LC3, 4 and 5: Small sites
Fencing and **sign posting** (as above); artefact collection if the sites become threatened.

Site LC6a and b: Microlithic industry and quartz dominated assemblage to the south of the project area. Resident property not intended for purchase as part of the lease development, but in line with one of the proposed transmission line corridors (mid route). No transmission line poles should be placed within 100 m of the creek (unnamed) unless the actual location at which the line will cross the creek is inspected and found to be clear of cultural material. The archaeological survey of the electricity transmission line corridors is presented in Nicholson 1997.
Site SC1: outside the area.
No action required.

8.3.2 Sites on the Plains and near the Tailings Storages

Artefacts are likely to be scattered across the gilgai plains behind Lake Cowal and throughout the entire tailings storage area. As such it is anticipated that much of the area's cultural heritage will be disturbed by construction and operational activities within the lease area or buried by the tailings storages. A number of points need to be taken into account when considering management arrangements for the cultural material.

a) the cultural material is not particularly unusual;

b) much of the cultural material is already disturbed;

c) the distribution and density of material across the gilgai plains is comparatively sparse; and

d) similar material is present in exposures outside the immediate area of development.

The material nevertheless has some interpretive value as an archeological resource and has cultural value to the local community. As a consequence it is recommended that additional field work be undertaken in the area in accordance with the following guidelines:

a) this field work proceeds with the input and assistance of the Site Curator from the Wiradjuri Regional Aboriginal Land Council and assistance from the West Wyalong Local Aboriginal Land Council;

b) a representative sample of material should be collected, bagged and labelled for curation by the West Wyalong Local Aboriginal Land Council; and

c) the better exposures be recorded so as to determine the nature of human land use, economic and technological behaviour in the area.

Specifically it would be helpful to:

i) quantify and explain the differences in site contents between the Plains and the Lake Cowal shoreline (and the tailings storage area);

ii) determine the functions of the recognisable tool types, manuports and heat retainers; and

iii) define the patterns of stone tool production, use and discard within the plains area and in comparison to the shore of Lake Cowal.

d) These investigations would entail:

i) detailed documentation of artefactual material at and around the richer **Exposures C, E, H and K**. These exposures contain the most representative and informative artefactual assemblages and provide a reasonable cross section through the gilgai plains and tailings storage area.

ii) Further investigation near **Exposure G and J** so as to provide a comparative record for Exposures C, E and H. Exposures G and J contained a more diverse range of raw materials and tool types than other exposures recorded on the plains and in the tailings storages.

iii) Further examination of the plains between **Exposures C, E, and F** and in the vicinity of **Exposures M and N** to add to the current information and to provide an opportunity to make a comprehensive record of the archaeological materials within the lease area. There are sufficient exposures throughout the area to facilitate additional investigation without the need for excavation.

e) These investigations should be undertaken following excavations at Site LC1 so as to have a comparative archeological account for interpretive purposes.

8.3.3 Sites Recorded North of Lake Cowal

Sites **FAS3, 4, 5 and 6** were located between Nerang Cowal and Lake Cowal during a survey of an earlier transmission line. This is not the current preferred electricity transmission line route and therefore no management recommendations are proposed for these sites.

8.3.4 Burials

The West Wyalong Local Aboriginal Land Council is concerned about the possibility of human remains being disturbed with the lease area. Field indications suggest this is unlikely as sand bodies have already been severely disturbed by farmers who have ripped up rabbit burrows within them. Examination of these disturbed deposits did not locate any fragmented bone suggesting it is unlikely that any skeletal remains are contained within these deposits.

Burials are, however, a sensitive issue so it may be wise to investigate their possible existence more fully. There are a number of ways of doing this. The best non destructive method would be to use Ground Penetrating Radar (GPR) and related data processing. This technique is normally used by the mining industry to locate mineral deposits but has been used successfully on Rottnest Island (WA) in the detection of human burials. However, we would recommend an alternative, more convenient and practical method, in which;

- the Sites Manager supervise earthworks in the vicinity of the small sand bodies near the lake in case skeletal materials are unearthed.

We should stress that field inspections suggest that this possibility is unlikely.

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Appendix F

Water Management

Cowal Gold Project
Water Management Study

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

1.0 INTRODUCTION

This report presents and backgrounds the water management system for the proposed Cowal Gold Project. It draws on the results of various investigations undertaken as part of the original EIS and subsequent studies that address recent changes to the Project.

This report outlines and explains the strategies for managing water on-site from construction through to closure, identifies potential environmental impacts associated with the site hydrological cycle, and details how these will be mitigated.

The Project site is situated adjacent to Lake Cowal, which is recognised as a significant habitat for waterbird species. As a consequence the overriding water management issue is the control of water on-site such that it does not impact on the integrity of the Lake, either during the active project phase or post-closure.

This report outlines the hydrological characteristics of the site and how they will be affected by the Project. Strategic plans for the management of water together with design details of the works necessary for implementation of these plans are provided. The performance of the proposed site water management system is also assessed via the results of various predictive modelling studies.

2.0 OVERVIEW OF SITE HYDROLOGY

2.1 Surface Water Hydrology

The Cowal Gold Project is located on the western side of Lake Cowal in the central west of New South Wales. Lake Cowal is an ephemeral, fresh water lake filled by runoff from the Bland Creek catchment to the south and flood breakout from the Lachlan River to the north. The Lachlan River is the major regional surface water system, forming part of the Murray-Darling Basin. During periods of flood, (when flows at Jemalong Weir exceed 15,000 to 20,000 ML/day) the Lachlan breaks out at two points known as the 17 and 21-mile breakouts. The breakout flows then combine and flow via the Lake Cowal floodway into Lake Cowal. Water balance studies, (Gilbert and Sutherland, Oct. 1997) indicate that breakout flows from the Lachlan account for some 35% of total Lake inflows. The Bland Creek system, which drains a catchment area of some 9,500km^2, is thought to contribute some 38% of total Lake inflows, with the remainder being contributed by incident rainfall on the Lake itself.

Lake Cowal is a large, shallow water body covering an area of some 10,500 ha and holding some 150,000ML of water when full. The Lake forms part of the Wilbertroy-Cowal wetlands that are situated on the Jemalong Plain. The Lake overflows into Nerang Cowal, an ephemeral Lake to the north of Lake Cowal. Water balance studies and historical observations suggest that the Lake is substantially full seven years out of ten.

The area covered by the Cowal Gold Project proposed Mining Lease Application (MLA) is drained by three small ephemeral drainage lines. The northern-most sub-catchment collects runoff from an area of 37.5km^2. The central sub-catchment takes in the central Project site and drains a total area of 28km^2. The southern sub-catchment (3.75km^2) borders the project site and takes in a portion of the proposed southern mine waste rock emplacement area.

The Cowal region is semi-arid with an average annual rainfall of some 440 mm compared to average pan evaporation of 1740 mm. Rainfall is typically highest in winter. Flow records for the gauging station on the mid reaches of Bland Creek indicate that runoff is low and averages less than 5% of annual rainfall. Average runoff at the mine site as a proportion of rainfall would also be expected to be small due to the flat, poorly drained nature of the terrain. Rainfall intensities for the area are also relatively low (compared to coastal areas of NSW) contributing to the low overall runoff potential.

Baseline water quality monitoring in Lake Cowal has been undertaken by North between 1991 and 1992. The sampling programme, which included both water and sediment sampling, was conducted at 34 monitoring sites along four transects over the period March 1991 to June 1992. The available results indicate Lake waters are typically slightly to moderately alkaline (pH 8.27 to 8.67). Dissolved oxygen concentrations were also found to be high (7.3 to 11.5 mg/L). Measured suspended solids concentrations in the Lake waters showed considerable scatter (24 mg/L to 222 mg/L) consistent with many "freshwater" inland water systems. This variability may be due to climatic conditions such as the effects of wind driven turbulence entraining bottom sediments into the water column and turbid catchment inflows during rainfall events. Conductivity is inversely related to Lake volume – indicating the dominance of evapo-concentration effects. Metals (cadmium, arsenic lead, mercury and zinc) were generally low, although particulate copper levels exceeded ANZECC (1992) guideline levels for aquatic ecosystems.

2.2 Groundwater Hydrology

The Cowal Gold Project is located in the Lachlan Fold Belt. The Cowal orebody is hosted in an Ordovician aged volcanoclastic sequence informally referred to as the Lake Cowal Volcanic Complex. The host rocks are overlain by Quaternary aged sediments. Two separate groundwater aquifers (separated by aquitards) have been identified in the upper Quaternary sediments. A third aquifer occurs in the weathered and fractured Ordovician basement rocks.

Local groundwater movement is influenced by an irrigation mound that causes flow at the Project site to be generally from east to west. The aquifers are typically low yielding and highly saline. Groundwaters associated with the basement aquifer are dominated by sodium chloride with lesser but significant concentrations of sulphate and magnesium ions. Total dissolved solids concentrations ranging from 31,000 to 38,300 mg/L are reported by Coffey (April 1995). Water in the shallower sedimentary aquifers was found to be similar with very high TDS levels dominated by sodium chloride.

3.0 WATER MANAGEMENT OBJECTIVES

The objectives of water management for the Cowal Gold Project are to:

- protect the environmental integrity of Lake Cowal during all phases of the Project;
- provide a reliable supply of water for processing; and
- control water on-site in a manner consistent with safe and efficient mining and processing operations.

Different water management issues and requirements are anticipated at different phases of the Project. These are outlined below.

3.1 Construction Phase

(i) Up-catchment Diversion System. Runoff from catchment areas up-slope of the mine site itself are to be permanently diverted via stable high capacity drains around the perimeter of the mine site.

(ii) Development of an Internal Catchment Drainage System to isolate the mine site hydrological cycle from the external environment.

(iii) Provision of an Integrated Erosion, Sediment and Salinity Control System for both the construction and operational phases.

3.2 Operational Phase

(i) Water supply - security of adequate supplies for ore processing and potable requirements.

(ii) Dewatering and ongoing depressurisation of the open pit (to ensure stability) is predicted to generate significant volumes of high salinity water. This water will be used directly as make-up to the processing plant. Incident rainfall over the pit and runoff from catchment areas adjacent to the pit will be managed by in-pit pumping to a contained water storage.

(iii) Runoff and potential seepage expression from the waste emplacements and ore stockpile areas are predicted to contain elevated levels of salt (principally sodium, chloride and lesser sulphate salts). This water will be retained on-site as will all runoff from the processing plant where specific provision for the containment of accidental spills will be made.

(iv) Contingency water management measures to prevent migration of potential contaminants, off-site and into Lake Cowal as a result of accidental spillages and/or climatic extremes.

3.3 Post-Closure

(i) Permanent isolation of mine site runoff (including the void) from Lake Cowal.

(ii) Long term void water quality and void hydrology.

(iii) Long term stability of the permanent Up-catchment Diversion System and Internal Catchment Drainage Systems after mine closure.

The philosophy adopted for water management is to hydrologically isolate the mine site from Lake Cowal in both the short and long term. This is readily achievable in the long term because of the significant negative water balance that occurs at the site, and the robust, long term drainage regime (for both surface and groundwaters) that will result in all site water reporting to the final void, which will act as a permanent sink.

During the operational phase of the Project the water cycle that will operate on the site also has a significant negative balance. As a result, all site water is expected to be either reused (as make-up water) or to be reliably 'disposed' of by natural evaporation from contained water storage areas including the tailings storage.

4.0 GEOCHEMICAL CHARACTERISTICS OF TAILINGS, WASTE ROCK AND LOCAL SOILS – IMPLICATIONS FOR WATER MANAGEMENT

The likely geochemical characteristics and behaviour of tailings, mine waste rock, and local soils likely to be used in construction have been evaluated via a series of laboratory tests conducted by Environmental Geochemistry International (EGi, 1997)

The pertinent conclusions of this work in regard to site water management are:

(i) Tailings: Both oxide and primary tailings are non-acid forming. The primary tailings, however, contain moderate amounts of reactive sulphur which would generate relatively high concentrations of sulphate salts when exposed to oxidation conditions. There were no other elements found in concentrations or soluble forms likely to affect seepage water quality.

With respect to cyanide in the tailings, North have undertaken to achieve the following limits on WAD cyanide levels through the use of recycling within the process and the utilisation of a cyanide destruction plant on-site:

- The concentration of WAD cyanide in tailings at the discharge to the tailings storages shall not exceed 30 mg/L at any time
- For 90% of time the tailings slurry discharge shall contain no greater than 20 mg/L WAD cyanide.

It is expected that further rapid decay of WAD cyanide within the tailings storages after discharge and that levels within the decant storages and pore waters within the deposited tailings would be correspondingly lower.

The chemistry of tailings pore water and therefore any seepage from the tailings storage facility is expected to change with differing ore type and with the composition of process make-up water. During the initial phases of the project the make up water will be dominated by mine groundwater which is highly saline. The tailings slurry waters during this phase of the

Project is expected to have total dissolved solids (TDS) concentrations in the range 35,000 to 45,000 mg/L. During the later stages of the project the contribution of mine groundwater will decline with a corresponding decline in tailings TDS to 9,000 to 16,000 mg/L. The effect of ore type will likely be seen as a modest reduction in overall TDS as oxide ore gives way to primary ore and an increase in sulphate concentration.

(ii) Temporary Isolation Bund: Construction materials used for the mine perimeter bund are expected to be non-saline and non-sodic, slightly alkaline and non-acid forming. Runoff from the bund is likely to have a long-term steady state salinity of between 100 and 200 mg/L (TDS).

(iii) Waste Rock Emplacements: The oxide and primary wastes are slightly alkaline. The oxide waste is likely to be highly saline while the primary waste is likely to be moderately saline. Both the oxide and primary wastes are non-acid forming although the presence of reactive sulphides and an abundance of acid neutralising capacity in the primary wastes will result in generation of significant sulphate salts such as gypsum.

- Seepage from oxide waste is likely to have a salinity of 2,000 to 2,500 mg/L dominated by sodium and chloride.
- Seepage from primary waste is likely to have a lower salinity (in the range 1,500 to 2,000 mg/L) with a significant proportion comprising sulphate salts.
- Direct runoff from waste rock materials is likely to have a low salinity possibly up to 100mg/L (TDS).

5.0 CONSTRUCTION WATER MANAGEMENT

5.1 Introduction

Construction of mine infrastructure is scheduled to begin some 18 months prior to commencement of ore processing. During this period the following infrastructure components will be constructed:

- site access road;
- Up-catchment Diversion System;
- Internal Catchment Drainage System;
- processing plant and administration facilities;
- tailings storages;
- Run-of-Mine (ROM) and low grade ore stockpiles;
- topsoil and sub-soil stockpiles;
- temporary isolation bund;
- lake protection bund;
- perimeter waste emplacement;
- haul roads;
- power and external water supply reticulation works; and
- the pit dewatering borefield.

The significant water management issues during the construction and commissioning of these infrastructure components are:

(i) Early construction of the Up-catchment Diversion System and Internal Catchment Drainage System to isolate the mine site water cycle from the adjacent environment.

(ii) Construction of temporary isolation and lake protection bunds to isolate the project site and associated construction activities from the Lake.

(iii) Implementation of a comprehensive erosion, sediment and salinity control system.

(iv) Containment and early re-use of the saline extracted open pit groundwater on-site.

5.2 Up-Catchment Diversion System

Runoff from the small catchment areas up land of the tailings storages will be unaffected by mining operations and will be diverted to permanent, enhanced peripheral drainage features to be constructed on both the northern and southern perimeters of the site (refer Figure F-1). The Up-Catchment Diversion System will be developed in stages throughout the mine life. During the construction phase the western edge of the diversion surrounding the tailings storages will be formed. In Year 3 the northern section and southern section around the Southern Waste Emplacement will be constructed. The Up-catchment Diversion System will be constructed to simulate endemic drainage features that are known to be stable in the prevailing hydrological regime. The channel will incorporate features such as low flow and overbank zones, meanders and pool/riffle sequences. Riparian vegetation is also important in the stability of tributary creek systems and will be incorporated into the proposed diversion system.

5.3 Internal Catchment Drainage System

The Internal Catchment Drainage System is also a permanent water management feature designed to operate during the life of mine and after rehabilitation and closure. The system involves the development of a new permanent catchment divided in the form of a low mound running from Cowal West Hill, surrounding the tailings storages (on three sides) and extending to the processing plant area (Figure F-1). The dividing mounds will be sized for extreme hydrological conditions (1 in 1,000 year average recurrence interval event).

Isolation of groundwaters within the Internal Catchment Drainage System would be achieved by virtue of the permanent groundwater sink that would be formed as a result of open pit dewatering. The effect of the open pit would be to locally depress the groundwater table (potentiometric surface) such that all groundwater movement in the surrounding area would be towards the void.

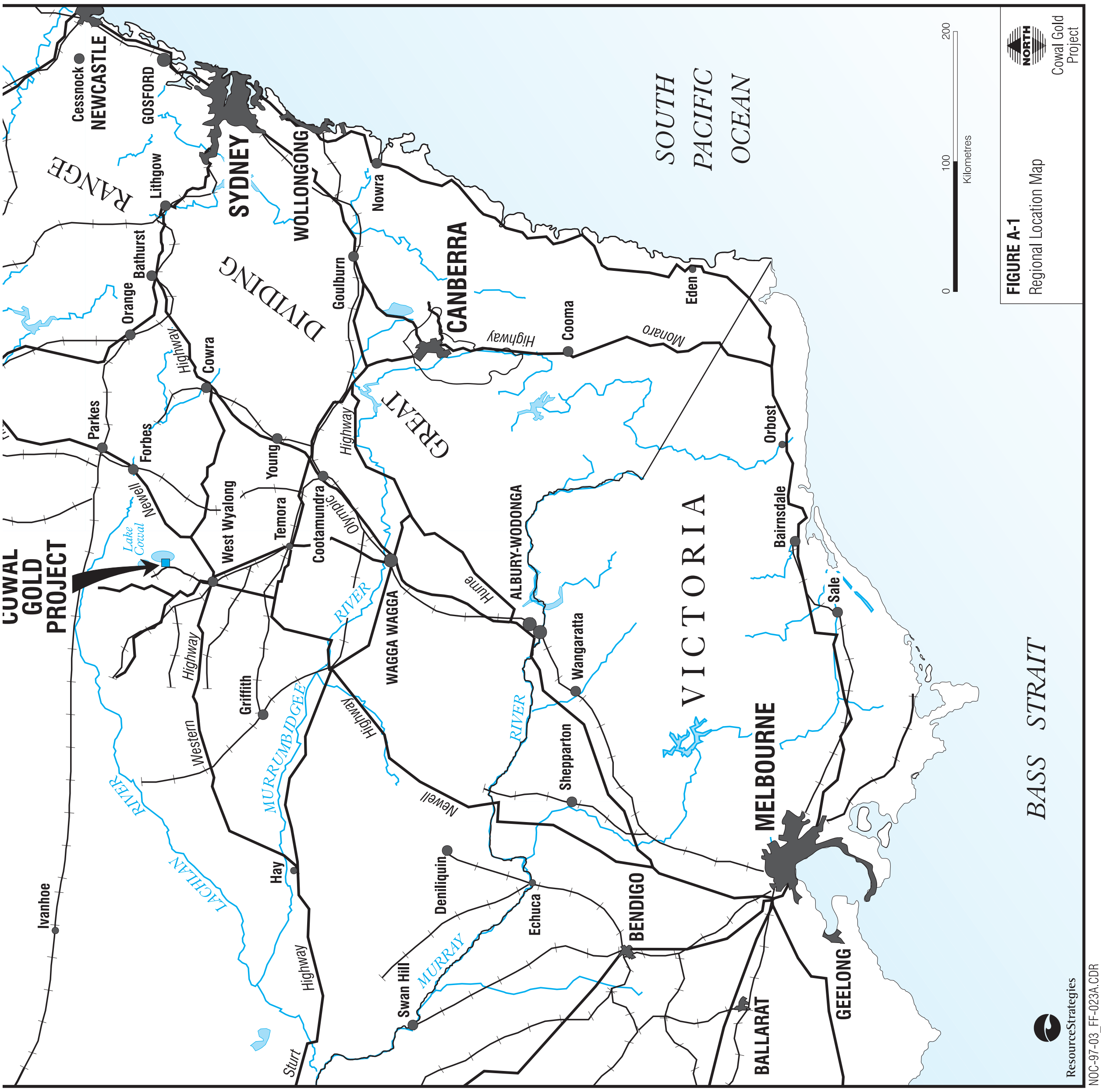

FIGURE A-1
Regional Location Map

5.4 Lake Isolation System

In order to provide a barrier between the open pit and Lake Cowal a Lake Isolation System has been designed to hydrologically isolate the two areas during project development, mining and post-closure. The Lake Isolation System consists of three components that will combine to provide a permanent arc around the open pit area (temporary isolation bund, lake protection bund and perimeter waste emplacement). As the Lake Isolation System is developed it will be concurrently rehabilitated to provide a new lake foreshore.

The temporary isolation bund will be constructed early in the construction phase. Once constructed its function will be to prevent Lake water inflow into the open pit development area during the construction of the lake protection bund. The temporary isolation bund will be constructed using inert waste rock to form batter slopes of 1(V):5(H) and 1(V):4(H) on the Lake and open pit sides respectively. The height of the bund will increase from zero at the edges of the arc to a maximum of up to 2 m in the centre. Prior to the construction of the temporary isolation bund, a continuous silt curtain will be erected around the construction zone of the temporary isolation bund. The silt curtain will be installed prior to construction commencing in order to trap fine sediment and prevent suspended material migrating into the main body of the Lake.

The lake protection bund is a low permeability embankment designed to prevent water inflow from the Lake into the open pit over the life of mine and post-closure. The lake protection bund will be constructed approximately 10 m behind the temporary isolation bund (closer to the pit). It will be constructed to a maximum height of 4 m as a two zone earth embankment design. The bund will be formed using suitable low salinity lake sediments sourced from within the open pit development area.

Run-of-mine oxide waste rock taken from the open pit during the pre-stripping phase will be placed behind the lake isolation bund. This waste will form the third component of the Lake Isolation System, the perimeter waste emplacement. This emplacement will be progressively rehabilitated concurrent with construction.

Once the temporary isolation bund is constructed any water collecting behind the bund will migrate to a temporary collection pond located in the centre of the arc (Figure F-1). Any water collected in this area will be pumped to the process water storage for use during construction. Following stabilisation and revegetation of the outer batters of the Lake Isolation System, any runoff from these surfaces is anticipated to be of suitable quality (comparable to runoff from undisturbed areas) to enable release to the Lake.

5.5 Erosion, Sediment and Salinity Control System

The potential for erosion and sediment migration in site runoff is likely to be high during the project construction phase. Given the project's proximity to Lake Cowal and the ecological status of the Lake, prevention of sediment-laden runoff from the mine site discharging into the Lake is the primary objective of the system.

The proposed strategy for erosion and sediment control is based on the well-developed and accepted procedures as outlined in manuals such as – Technical Handbook No. 5 Design Manual for Soil Conservation Works – Soil Conservation Service of NSW 1988, and Urban Erosion and Sediment Control Soil Conservation Service of NSW 1992.

Soil and waste rock characterisation programmes have identified materials to be disturbed during the construction phase that have the potential to generate salinity (CaLM, 1994; Resource Strategies, 1997; EGi, 1997). Accordingly, the water management strategy incorporates design elements to contain surface runoff or seepage likely to contain increased salt concentrations.

The erosion, sediment and salinity control strategy involves scheduling and sequencing the construction works so as to minimise the total area of disturbance at any time. The major construction activities will be concentrated in two separate areas of the site, the mine area itself that includes the waste emplacements and processing area on the eastern area of the site, and the western area that contains the tailings storages. The construction sequence for works in both areas will be such that the Up-catchment Diversion System, the Internal Catchment Drainage System and Lake Isolation System will be constructed prior to any other component of infrastructure. In addition, specific sediment control protection works will be put in place prior to initiation of other earthworks at all construction-sites. This policy will require that there be adequate sediment control measures, (capable of intercepting and retaining on-site sediment) in place before any surface disturbance. Immediately upon completion of earthworks, batter stabilisation and revegetation of disturbed areas will be undertaken.

Some waste rock and subsoil materials are expected to be moderately to highly saline. Runoff and seepage from these materials would have the potential to impede revegetation and impact on local water resources if not controlled. The proposed water management scheme therefore incorporates interception drains (toe drains) and collection storages (temporary sediment dams and contained water storages) around all stockpile areas and waste emplacements containing saline materials. Water that accumulates in these storages would be used for construction water supply or transferred to the temporary containment cells in the tailings storages.

The proposed layout of drainage and sediment control works for the construction phase are shown on Figure F-1. It is envisaged that the bulk of the sediment control works would be decommissioned following stabilisation of disturbed areas during the mine life.

Table F-1 provides a summary of the erosion, sediment and salinity control measures proposed for the major mine landforms.

Table F-1 Erosion, Sediment and Salinity Control Concepts

Activity	Approx. Area of Disturbance (ha)	Erosion, Sediment and Salinity Control Measures	Likely Construction Duration	Comments
Access Road within Proposed MLA Area	4.4	• Minimise disturbance to watercourses that cross the road. • Provision of culverts and diversions for runoff from undisturbed areas • Erection of silt fences downslope of small, disturbed areas. • Provision of settlement storages for concentrated runoff areas. • Stabilisation of access road surface. • Rapid stabilisation and revegetation of road batters.	1 to 2 months	Diversions, silt fences and settlement storages to be in place before commencement of road construction
Temporary Isolation Bund	59	• Erection of continuous silt curtain around construction zone. • Provision of clean water diversion and settlement storages for runoff control at borrow areas. • Stabilisation and revegetation to occur in parallel with construction.	3 to 4 months	Measures to be in place before commencement of bund construction
Tailings Storages	400	• Up-catchment diversion around construction area • Runoff containment/settlement storage downslope of construction area/s • Rapid stabilisation – revegetation of completed embankment batters. • Provision of silt fences and filter dams around down-slope perimeter of disturbed areas • Provision of sediment retention/settlement dams.	6 to 8 months	Sediment control measures to be in place prior to construction
Processing Plant (Mill)	21.5	• Settlement/plant runoff storage • Silt fences • Runoff collection drains to convey all runoff from construction area to plant runoff storage dam. • Dewatering of settlement storage following rainfall events (to tailings dam and/or reuse on-site).	3 to 4 months	Sediment control measures to be in place prior to commencement of construction
Up-catchment Diversion System and Internal Catchment Drainage System	32.6	• Construction and stabilisation of creek diversions prior to commencement of internal catchment containment bund construction. • Silt fences & hay bale weirs downslope of all disturbed areas.	1 to 2 months.	Sediment control measures to be in place prior to commencement of construction

5.6 Management of Water Recovered from Pit Dewatering

The Cowal orebody will be mined by open pit methods with pit development occurring in several stages. The first stage (pre-stripping) will be completed during the mine site construction phase (prior to the commencement of ore processing) and result in an open pit some 45 m deep (Figure F-1). This will necessitate mining through the main groundwater aquifer zones during the first two years.

The proposed pit dewatering system will involve the construction of a perimeter borefield to dewater the open pit area in advance of mining. Results of groundwater modelling studies (Coffey, Oct, 1997) indicate yields averaging 10 ML/day for the first 3 months with a progressive decline over the subsequent 12 to 18 months to 5 ML/day. The range of likely groundwater dewatering rates predicted by Coffey are summarised in Table F-2.

Prior to plant commissioning (at the start of mine Year l), the only consumptive demand for water on-site will be for dust suppression and moisture conditioning of soils used in earthworks construction. The water extracted during pit dewatering will be highly saline and unsuitable for uses other than in the processing plant. As a result, during the construction phase water requirements will be provided by non-saline surface runoff and groundwater sources.

Table F-2 Predicted and Likely Range of Pit Dewatering Yields (After Coffey, Oct 1997)

Period	Predicted Dewatering Rate (ML/day)	Likely Range of Cumulative Yield (ML)
First three months of Year -1	10.1	450-1100
Second three months of Year -1	7.3	780-1900
Third three months of Year -1	6.6	1100-2600
Fourth three months of Year -1	5.4	1300-3200
First 6 months of Year 1	5.1	1800-4300

In order to accommodate the excess saline groundwater generated during pit dewatering, there will be a need for temporary on-site storage prior to start up of the processing plant. It is proposed to construct temporary water storage cells within the tailings storages for short term storage of this water. These cells will be sized to store the maximum anticipated groundwater extraction during the construction phase. Once the plant is commissioned this water will be progressively used in the Processing Plant. The temporary water storage cells are expected to be emptied in Year 1. These areas will then be used for tailings storage.

The mine pit (and dewatering system) will intersect a series of three shallow aquifers. Groundwater in the lower fractured rock aquifer has very high measured conductivities (salinity) values ranging from 50,000 µS/cm to 63,700 µS/cm. Groundwaters in the upper alluvial aquifers are less saline although still highly saline with conductivities ranging from 32,400 µS/cm to 72,000 µS/cm. This water would not be suitable for dust suppression on areas where the soils are to be revegetated.

The performance and workability of the proposed strategy for managing extracted groundwater prior to plant commissioning has been assessed using a water balance simulation model of the site. The model was set-up to simulate the first 18 month period prior to plant commissioning and the first 2 years of operations after commissioning of the processing plant. The model was run to simulate a range of climatic, operational and dewatering rate scenarios. Details of the model structure and results are given in Attachment A.

Results of the modelling indicate that:

- Climatic conditions are unlikely to contribute significantly to the volume of water that will need to be stored on-site over the construction phase.
- The simulated range of peak storage requirements for saline groundwater during the construction phase is 1500 to 3500 ML. (for the range of predicted dewatering rates).

Table F-3 Water Management System – Hydrological Design Criteria

Component	Aspect	Design Criteria	Consequence of Design Event Exceedance
Tailings Storage	Containment Capacity	Max. net accumulation of water from a 1 in 1,000 year ARI event of 3 months duration	Controlled overflow to contained water storages or open pit
Processing Plant Contained Water Storage (D5)	Containment Capacity	Runoff from a 1 in 1,000 year ARI storm of 48 hr duration	Controlled overflow to contained water storage D3 or open pit
Temporary Diversion Bund/Toe Drains (around waste emplacements)	Conveyance Capacity	Peak discharge from the critical duration 1 in 100 year event	Short duration or overflow to adjacent drainages/Lake foreshore
Waste Emplacement Contained Water Storages (D1, D2, D3, D4, D8)	Storage Capacity	Runoff from contributing catchment resulting from a 1 in 100 year ARI rainfall event lasting 48 hours	Overflow to adjacent drainage/Lake foreshore
Temporary Sediment Dams	Storage Capacity	Runoff from the 1 in 20 year 1 hr rainfall event	Controlled overflow to contained water storages or open pit
Decant Pond/Process Water Storage (D6, D7)	Containment Capacity	Runoff from a 1 in 1,000 year ARI storm of 48 hrs duration above normal operating level	Controlled overflow to contained water storages D5, D3 or open pit
Up-catchment Diversion System	Conveyance Capacity	Peak discharge from enhanced 'green house' 1 in 1,000 year ARI rainfall event (refer Section 7.5)	Controlled overflow to contained water storages or open pit

- The groundwater that accumulates during construction will be effectively consumed in the processing plant during the first 6 to 18 months after commissioning of the processing plant.

6.0 OPERATIONAL WATER MANAGEMENT

6.1 Introduction

The main issues relevant to the operational phase of the Project are:

- Supply of suitable quantities and qualities of water for ore processing and potable use.
- Maximising the reuse of saline water from pit dewatering.
- Provision of full containment for mine site water through the Up-catchment Diversion System and Internal Catchment Drainage Systems (described in Sections 5.2 and 5.3).
- Control of runoff from major mine landforms (waste emplacements and tailings storage) in a manner consistent with efficient and safe mining operations.

The water management system comprises the structures and associated operational procedures that would be used to manage water on-site. These structures are shown on Figure F-2. Selection of design criteria for the various components of the system have been based on consideration of:

- Criteria used or recommended by the regulatory authorities.
- Accepted good practice and criteria recommended by industry groups
- Consideration of hazards and acceptable or reasonable risk

In general, a criteria of 1 in 1,000 average recurrence interval (ARI) has been selected for containment of process water or other waters likely to contain process water during the mine life. In the event of a spill any waters which escaped from a containment storage would be fully contained within the Internal Catchment Drainage System and would ultimately report to storage D3 (Figure F-2) or the open cut. A criteria of 1 in 1,000 year has been selected to ensure that there would be a low risk of spill during the mine life but in the knowledge that any spill would be fully contained and would not impact Lake Cowal.

The design criteria for the Up-catchment Diversion System has also been set to the 1 in 1,000 year average recurrence interval. The consequences of this system overtopping would be a temporary and relatively small influx of runoff water to the site. Both during mine operation and post-mining, any such event would either be captured in contained water storages (during mine operation) or would ultimately report to the open pit/final void with no material consequence to the open pit/void and no risk to Lake Cowal.

An outline of the hydrological design criteria is summarised in Table F-3.

6.2 Open Pit

The open pit will ultimately comprise an oval shaped hole approximately 1 km by 800 m extending some 325 m below current ground level. Investigations by Coffey (1997) indicate that three aquifers will be encountered during mining and these will need to be dewatered ahead of mining.

Water extracted from this borefield (prior to ore processing) will be stored in temporary cells with the tailings storages ahead of plant commissioning and will be used during Year 1. After these cells are emptied water yielded from the pit dewatering will be supplied directly to the process water storage.

During periods of heavy rain it is anticipated that water derived from incident rainfall and runoff will accumulate in the open pit. A diversion bund/drain will be constructed around the western (upslope) end of the pit to minimise pit inflows (Figure F-2). A sump and pump-out system would be used to maintain dry mining conditions (contained water storage D3 – Figure F-2). The water would be pumped to the process water storage, which will have capacity to store runoff from the 1 in 1,000 year, 48 hour event above its normal operating level.

Pit dewatering will result in the open pit becoming a groundwater sink for areas surrounding the pit, including the waste emplacements and tailings storages. The direction of groundwater flow from these areas will be toward the open pit. These flow directions will be maintained during and after mining as the steady-state water level (post-closure) in the final void will be lower than the current (pre-mine) levels. The formation of this groundwater sink precludes the possibility of groundwater flow from the mine site reaching the Lake. The lakebed itself is significantly (20-30m) higher than the mine site groundwater and there can be no movement of groundwater from the mine site to the Lake (Kalf and Associates, 1997).

6.3 Mine Waste Rock Emplacements – Water Management

Waste rock from mining will be placed in three out-of-pit emplacements surrounding the open pit (northern, southern and perimeter waste emplacements – Figure F-2). During the operations phase direct runoff from the freshly placed waste rock surfaces is likely to be small and limited to periods of intense rainfall. By comparison, a significant proportion of incident rainfall is likely to infiltrate into the waste rock mass. Freshly placed waste rock is likely to absorb a significant proportion of infiltrating water however some may flow through the waste pile and appear as seepage.

Over time the moisture content of the waste rock emplacements will increase, with the potential for a perched water table to develop at the base of the waste emplacements. The movement of water in this saturated zone is likely to be toward the lowest edges of the waste emplacement.

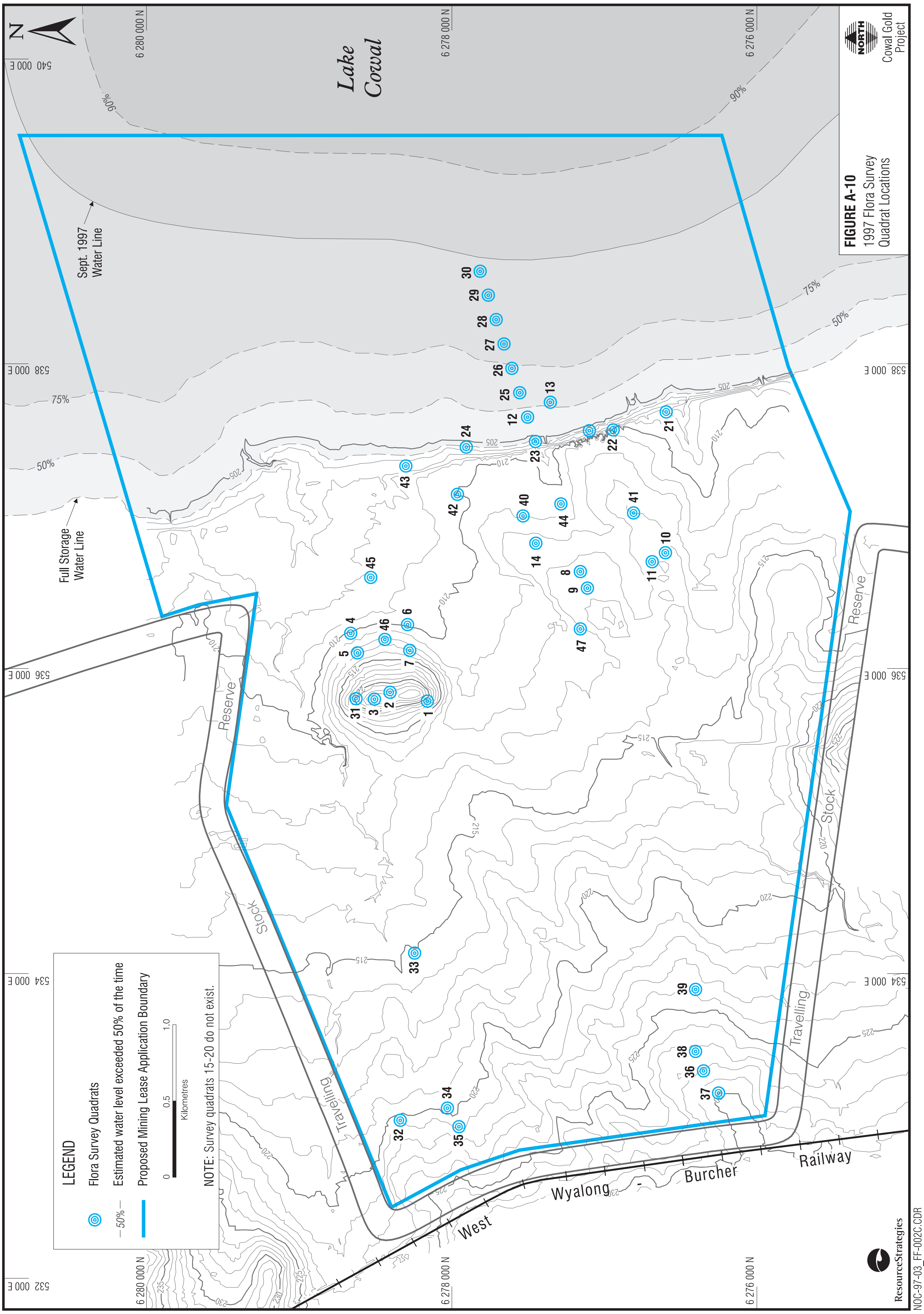
FIGURE A-10
1997 Flora Survey
Quadrat Locations
NORTH
Cowal Gold Project
Lake Cowal
N
540 000 E
538 000 E
536 000 E
534 000 E
532 000 E
6 280 000 N
6 278 000 N
6 276 000 N
90%
75%
50%
Sept. 1997 Water Line
Full Storage Water Line
Reserve
Stock
Travelling
West
Wyalong
Burcher
Railway
205
210
215
220
225
230
235
LEGEND
Flora Survey Quadrats
50% Estimated water level exceeded 50% of the time
Proposed Mining Lease Application Boundary
0
0.5
1.0
Kilometres
NOTE: Survey quadrats 15-20 do not exist.
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ResourceStrategies
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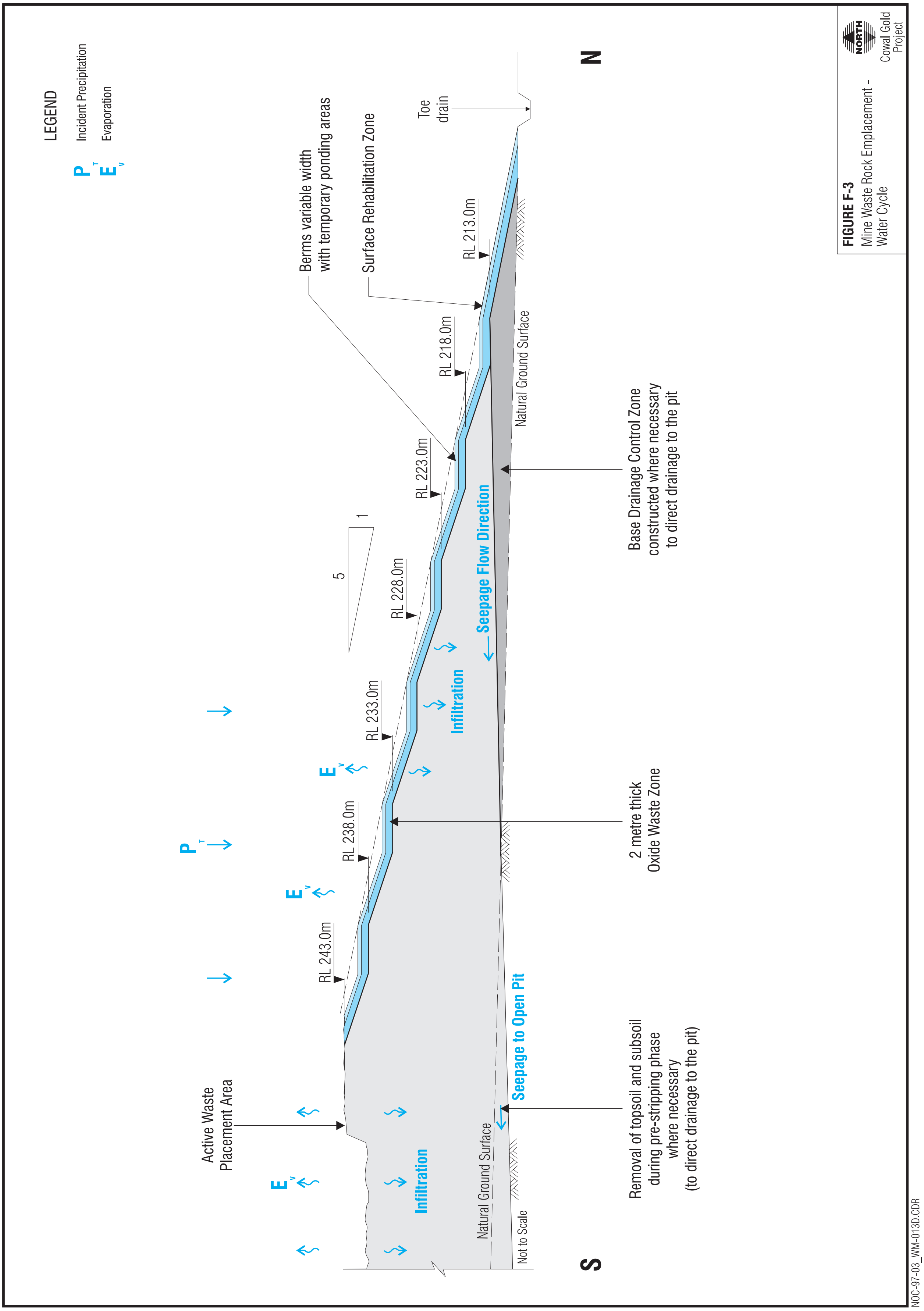

FIGURE F-3
Mine Waste Rock Emplacement - Water Cycle

There would also be potential for some downward percolation to the underlying groundwater table. This water would slowly migrate with underlying highly saline groundwaters toward the pit. Over time infiltration rates are likely to reduce as the near surface materials oxidise and break down. Revegetation of the waste emplacement surfaces will also reduce percolation rates through enhanced evapotranspiration.

The existing basal contours in the northern waste emplacement area are such that seepage would tend to appear along the northern (outer) perimeter of the waste emplacement if waste rock were to be placed directly on the existing land surface. This situation is contrary to the design objective of hydrological isolation of the mine site. Therefore, it is proposed to reverse the grade of the emplacement floor by a combination of sub-excavation, (to recover suitable soils for eventual rehabilitation of the completed waste emplacement), and construction of a lower permeability basal layer that will slope toward the mine pit area (refer Figure F-3.)

The southern waste emplacement is situated over a low ridgeline and without altering the existing basal contours, seepage would likely be expressed on both northern and southern sides. As with the northern waste emplacement it is proposed to reverse the grade the floor by a combination of sub-excavation and construction of a low permeability basal layer sloping toward the mine pit area.

The predicted elevated salinity of any potential seepage generated from the emplacements (Section 4) dictates that it be contained via interception toe drains and contained water storages around the perimeter of the waste emplacements (Figure F-2). The proposed toe drains will be sized to convey runoff from a 1 in 100-year ARI rainfall event. Seepage and runoff intercepted by this system would be pumped to the process water storage (D6 on Figure F-2) for re-use in the processing plant.

6.4 Tailings Storage

Tailings produced as a by-product of gold processing will be discharged to two purpose-built tailings storages located 3.5 km west of the Lake shoreline. Free water liberated by settling and consolidation of the tailings will be decanted under gravity to an external decant pond (D7 on Figure F-2) and from there it will be returned to the process water storage for re-use.

Sufficient free-board will be maintained in the tailings storages to store excess water generated from the contingency rainfall event, which has been set at 1 in 1,000 year ARI. The required free-board will be maintained during the Project life as the storage fills with tailings via a series of embankment lifts.

An Up-catchment Diversion System (refer Figure F-2) will be constructed upslope (west) of the tailings storages to divert runoff from the 325 ha catchment area west of the storages to the two drainage lines which flank both the northern and southern sides of the MLA (Section 5.2). Temporary toe drains and containment bunds will be constructed around the tailings storage embankments to collect runoff from the external batters and any accidental spills from the tailings reticulation lines.

Results of solute transport modelling (Kalf and Associates, June 1997) indicate that there will be insignificant movement of cyanide from the tailings storage during the mine life. Under 'worst case' conditions (assuming development of steady state conditions), cyanide concentrations near the base of the tailings storage would be about 0.1% of those within the deposited tailings mass. Arsenic and zinc were found to be effectively immobilised.

6.5 Water Supply

The main water usage for the Project will be associated with ore processing. Other water supply requirements include water for dust suppression on haul roads and internal roads, potable and non-potable uses around the mine site.

Table F-4 Summary of Water Containment Structures

Storage Number and Name	Function	Approx. Design Capacity (ML)
D1 – Northern Waste Emplacement Contained Water Storage	Runoff/seepage collection storage for northern perimeter of the northern waste emplacement. Water pumped to process water storage D6	60
D2 – ROM Pad/Northern Waste Emplacement Contained Water Storage	Runoff/seepage collection storage for low grade ore and ROM pad. Water pumped to process water storage D6	120
D3 – Lake Protection Contained Water Storage	Runoff storage for open pit area and perimeter waste emplacement. Water pumped to process water storage D6	105
D4 – Southern Waste Emplacement Contained Water Storage (South Side)	Runoff/seepage collection storage for southern perimeter of the southern waste emplacement. Water pumped to process water storage D6	35
D5 – Processing Plant Contained Water Storage	Processing plant runoff storage. Water pumped to process water storage D6	55
D6 – Process Water Storage	Process water storage. Main storage for plant make-up water supply	20
D7 – Tailings Storages and D7 (Reclaim Dam)	Tailings and rainfall runoff containment. Water pumped to process water storage D6	15
D8 – Southern Waste Emplacement Contained Water Storage (North Side)	Runoff/seepage collection storage for northern perimeter of the southern waste emplacement. Water pumped to process water storage D6	70

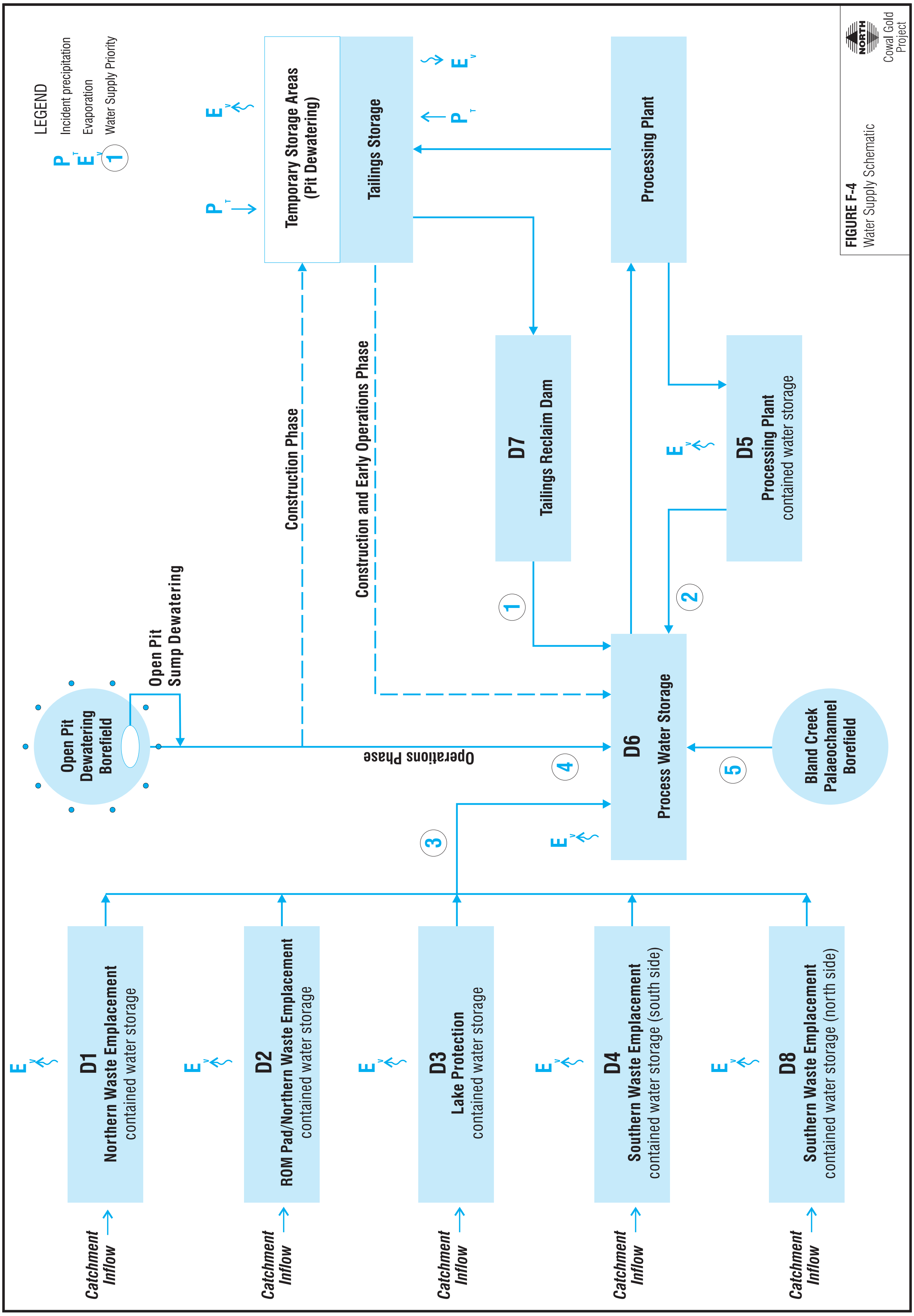

FIGURE F-4
Water Supply Schematic

Processing water demand will vary according to ore type but is expected to range between 16 ML/day for soft oxide ore and 7 ML/day for primary ore. Additional water demand for other mine site activities is expected to be between 0.5 to 1 ML/day.

It is expected that for the majority of the time the processing water demand will be supplied by on-site sources (ie. tailings decant, pit dewatering, and re-use of site runoff and seepage captured in the various site collection systems). Where water make-up demand exceeds the quantity available from the on-site sources, additional make-up water will be supplied from an external borefield developed in the Bland Creek Palaeochannel aquifer system located 20 km east-northeast of the Project site. Figure F-4 is a water schematic indicating the sources of make-up water and the order of supply priority.

The proposed Bland Creek Palaeochannel borefield would comprise 4 bores reticulated to site via a buried pipeline. Based on test pumping of a production bore drilled for groundwater exploration purposes, individual bore yields of 50 L/s have been predicted (Coffey, June 1994). Groundwater samples taken from the borefield area show low salinities (900 to 970 mg/L TDS), and low iron and manganese concentrations.

6.6 Processing Plant

The processing plant area will be bunded and graded such than any surface runoff, accidental spills of processing water or other potentially hazardous liquids will report to a processing plant contained water storage (D5 on Figure F-2). The storage water level will be kept as low as possible by regularly transferring accumulated water to the process water storage for use in the processing plant. The processing plant contained storage will be provided with sufficient storage for containment of the 1 in 1,000 year ARI 48 hr event.

6.7 Site Water Balance

A site water balance model was set up to simulate the likely performance of the proposed water management system under a range of climatic and operational conditions. The various components of the mine water management system are shown on Figure F-4. The system includes some eight collection and containment storages which taken together provide for control of site water. The function of these contained water storages is summarised in Table F-4.

The contained water storages and other components of the water management system have been sized to hydrological criteria set according to regulatory guidelines, or, on the basis of risk assessment. The water balance model provides a means of assessing how the water management system as a whole would perform under various conditions.

The water balance model was set-up as a "spreadsheet" model incorporating all the catchment areas contained within, or which contribute to the mine site area and operation of the various collection and containment storages proposed. The model is shown in schematic form on Figure F-4 and is described in detail in Attachment A. The model is based on the conservation of water (ie. inflow – outflow is equal to change in storage) and operates on a monthly time step. The model was used to simulate various 14 year mine lives (selected to represent different climatic conditions). Changes in the area and status of such things as the mine waste emplacements and open pit area were simulated through the mine life.

Runoff and infiltration rates through the waste emplacements were estimated using a separate model (SoilCover Version 4, 1997 – MEND). Other inputs such as pit dewatering rates were derived from modelling studies conducted by Coffey (October, 1997).

Three climatic scenarios were simulated: extreme wet, extreme dry (taken as the wettest and driest sequence on record) and the median sequence to represent 'average' conditions. The wet or dry sequences were selected to reflect unusually wet or dry conditions over the mine life and extreme wet and dry conditions for the first 3 years – corresponding to the construction and early mining phases.

Results of the modelling have been used to show the likely range of water movements around the site and storage fluctuations in the various on-site containment storages. The simulated average water flows in ML/day for the median, extreme wet and extreme dry sequences are shown on Figures F-5, F-6 and F-7 respectively.

The following implications for site water management can be drawn from the results of simulation modelling:

(i) The water management system meets Project water management objectives for all three scenarios modelled. In particular, no spillage from the site was modelled even when the wettest sequence on record was utilised.

(ii) On average there will be a negative water balance on-site with a corresponding requirement to import make-up water from the Bland Creek Palaeochannel Borefield.

(iii) Depending on the volume of water which accumulates in temporary storage facilities during the construction phase (in particular the water recovered from pit dewatering and temporarily stored within the tailings storages – refer Section 5.6 and Figure F-1), it is unlikely that there will be a need to import water during the first year or so after ore processing commences.

(iv) Once drawn down, further accumulation of free water within the tailings storage would be of a short term transient nature.

(v) There would be no need to accumulate water in water management structures other than the tailings storages and process water storages following specific high rainfall-runoff events.

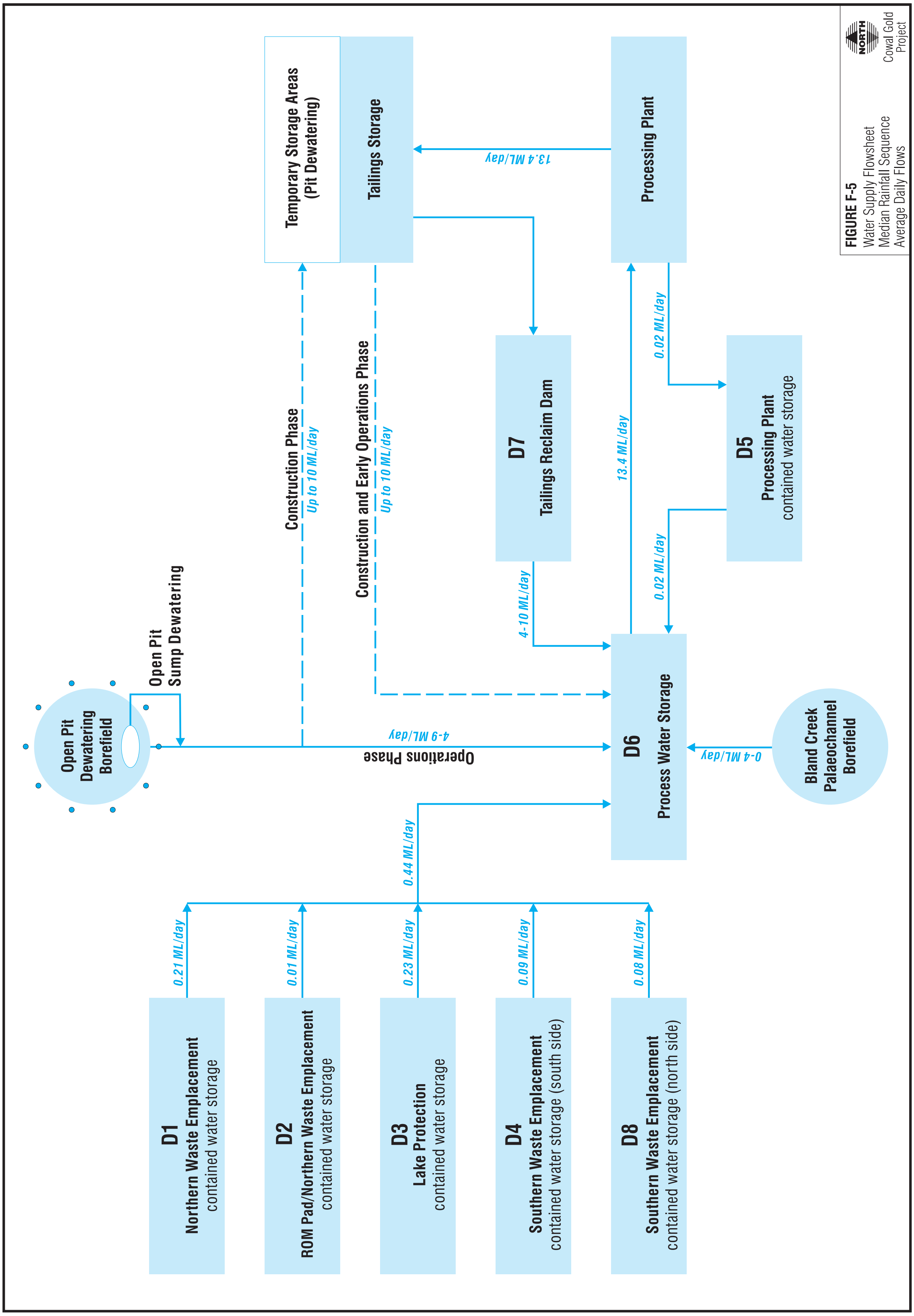

FIGURE F-5
Water Supply Flowsheet
Median Rainfall Sequence
Average Daily Flows

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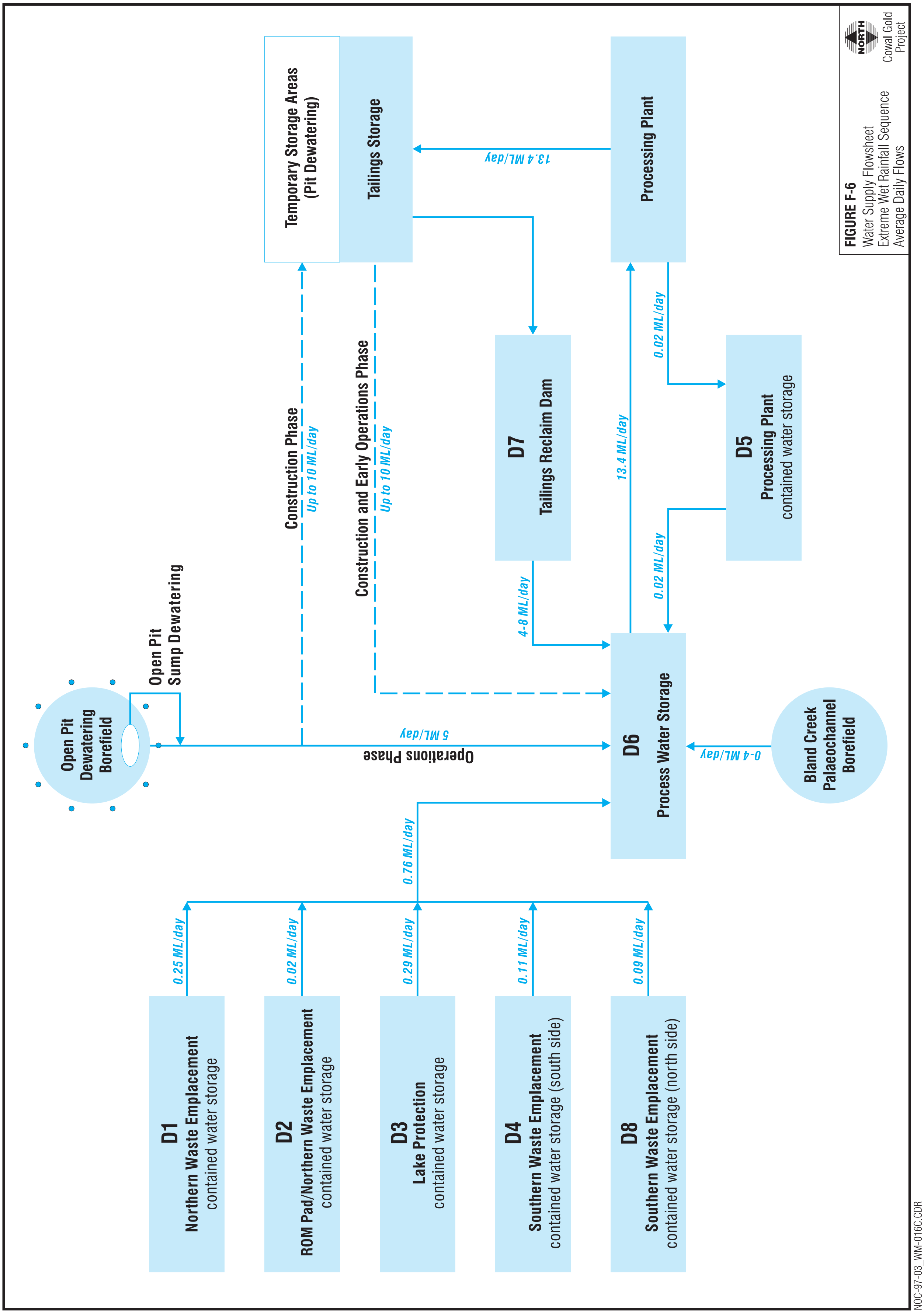


FIGURE F-6
Water Supply Flowsheet
Extreme Wet Rainfall Sequence
Average Daily Flows

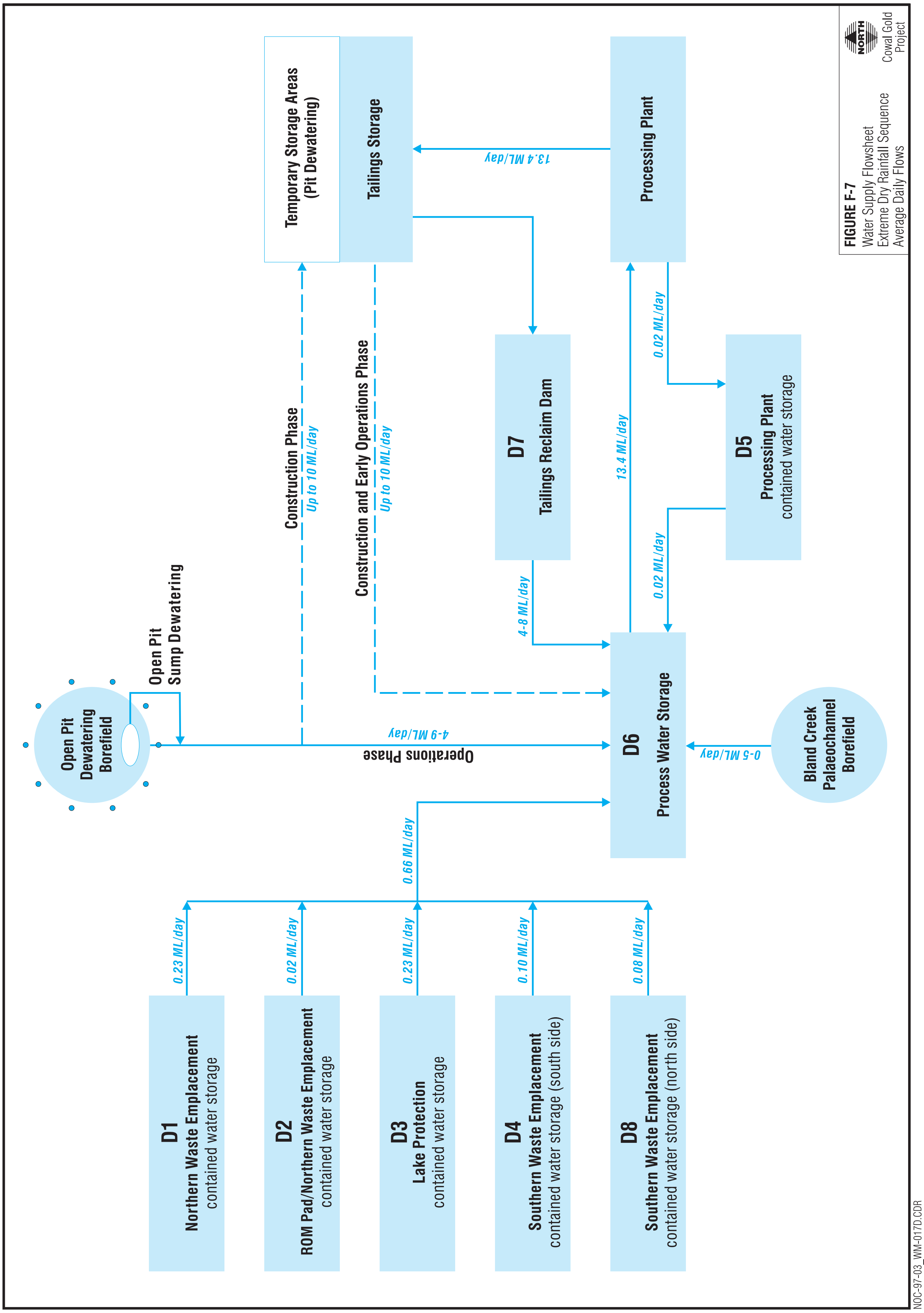


FIGURE F-7
Water Supply Flowsheet
Extreme Dry Rainfall Sequence
Average Daily Flows

7.0 POST-CLOSURE WATER MANAGEMENT

7.1 Introduction

At the cessation of mining and on-site ore processing, the processing plant and other moveable components of project infrastructure would be removed from site. Reshaping and revegetation of the remaining areas of the tailings storages and waste rock emplacements would be completed in accordance with the long-term revegetation objectives. The following section outlines rehabilitation concepts related to long-term site water management.

The proposals outlined below should be regarded as preferred concepts at this stage. Post-closure water management provisions, as with final Project area rehabilitation requirements, will be formulated in consultation and with the agreement of key government agencies and other stakeholders.

Final post-closure water management and Project rehabilitation designs will be further developed and confirmed from the outcomes of this consultation process and on the basis of further, more detailed design studies to be undertaken during the preparation of management plans prior to the development proceeding. Site trials will then be carried out as early as possible over the mine life to refine these designs and confirm performance.

7.2 Mine Waste Rock Emplacements

As part of construction, the outside batters of the waste emplacements will be formed at an overall slope of 1 in 5 and covered with low salinity sub-soil overlain by topsoil. These slopes will be progressively revegetated with suitable plant species.

At the completion of mining, it is proposed to grade the top surface of the northern and southern waste emplacements such that any runoff will flow toward the final void. The graded surface will then be covered with a layer of low salinity sub-soil overlain by topsoil (originally removed and stockpiled from the footprint of the emplacements).

The objective of post-closure water management is to minimise runoff from the emplacement surface. This will be achieved by provision of a relatively thick soil cover that can absorb and store excess moisture for use by the vegetation (evapotranspiration). Propagation of deep rooting – high transpiration capacity plants will ensure high transpiration losses are maintained. The surface of the emplacement will be purposefully left with a high degree of irregularity (roughness) to promote surface retention of rainfall-runoff. This will be further enhanced by construction of low mounds and swale-like features to encourage runoff retention and infiltration during high intensity rainfall events. The swale-like features will be incorporated into the final surface topography such that any runoff generated under extreme intensity rainfall events will flow via these features to the final void. Drainage pathways to the final void will be formed on the northern and southern waste emplacements to control any overflow.

The outer face of the waste emplacements will be constructed in lifts and feature a series of batters and berms at intervals of about 5 m. The concept for drainage control on these outer faces is to minimise runoff by providing runoff retention areas within the berms. The retention areas would be formed with sufficient capacity to absorb runoff from intense rainfall events. The system would operate such that water which accumulated in these storages would seep into the dump or be otherwise lost to evaporation during periods between major events. A deep soil and vegetation cover on the berms would enable significant sub-surface storage and on-going high evapotranspiration losses between events.

The berms would be formed with suitable reverse grades to prevent spillage down batters. Berms would also be developed with variable width to enable runoff retention areas to be formed at various intervals along each berm.

7.3 Tailings Storages

As with the mine waste rock emplacement, the outside surfaces of the tailings storages will be covered and rehabilitated progressively. At the cessation of tailings deposition and prior to rehabilitation, the final surface of the tailings storages will slope from the outer perimeter in to the decant area near the centre of each storage. As with the mine waste rock emplacements, the final surfaces of the tailings storages will be rehabilitated to minimise runoff.

This will be achieved by:

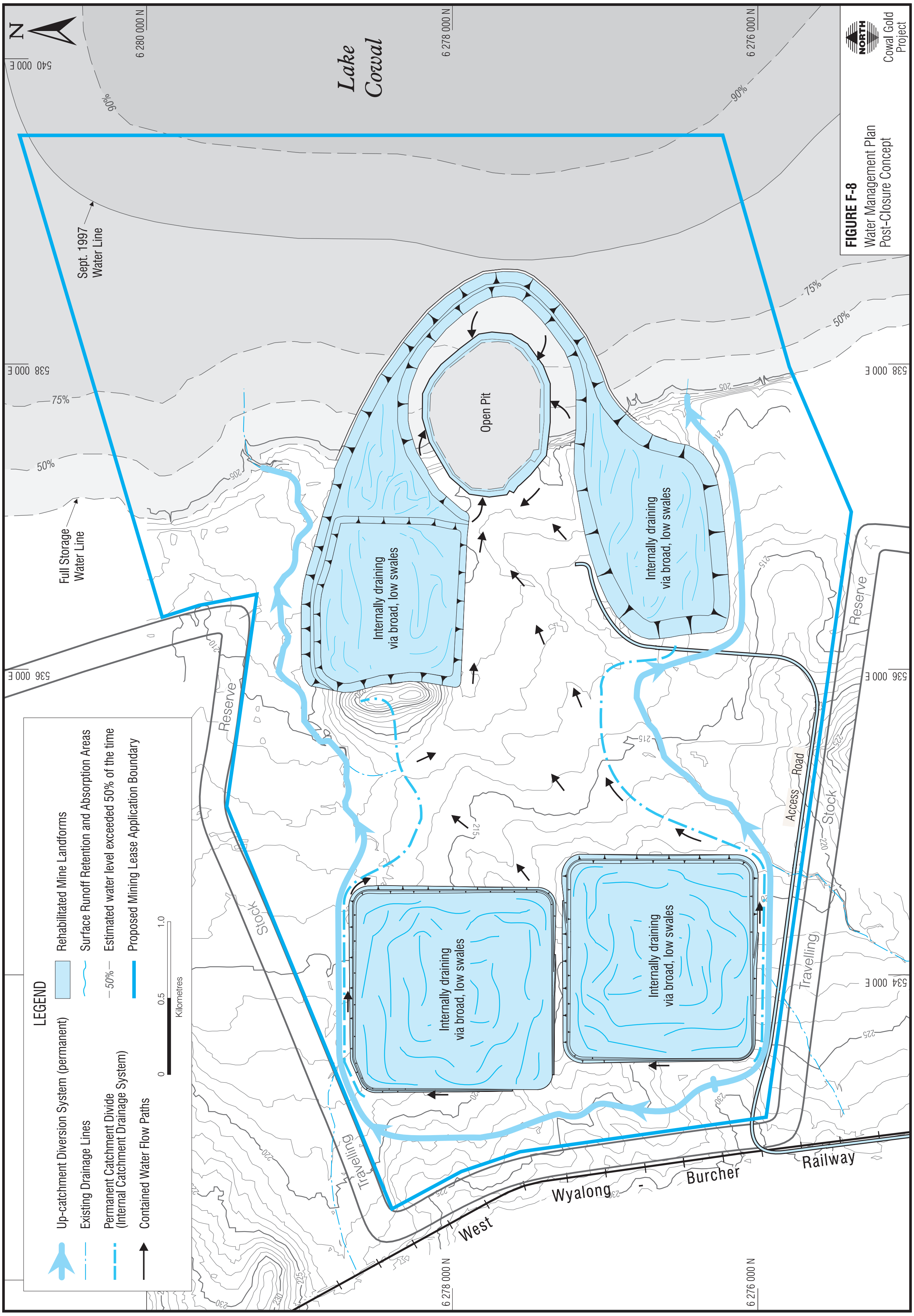
- Provision of a relatively thick layer of low salinity sub-soil and topsoil layer to support a deep rooting plant cover. A capillary break layer will also be required between the final tailings surface and the soil cover to prevent salt rise into the soil covers.
- Propagation of appropriate deep rooting vegetation with high transpiration capacity.
- Forming surface irregularities and a series of mounds and swale-like features to provide large scale surface retention and absorption of runoff during high intensity rainfall events

Simulation modelling indicates that provided sufficient surface retention capacity is available it is possible to effectively prevent runoff from the surface of the rehabilitated tailings storages. The combined runoff retention, absorption and storage potential inherent in the shape of final surface of the of the storage is such that there is an insignificant probability that there would ever be spill from the surface. However, as an added safety measure, overflow pathways will be provided to facilitate flow of any spill water to the final void.

7.4 Site Drainage

On completion of mining the open pit will be left as a void of some 80,000 ML capacity.

The overall approach to post-closure drainage of surface water within the Project site is to provide stable drainage



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channels to convey runoff to the void. The Up-catchment Diversion System and Internal Catchment Drainage System will be left to facilitate permanent drainage of adjacent areas upslope of the mine site to Lake Cowal via existing creek lines where possible. Figure F-8 shows the water management strategy following mine closure.

7.5 Final Void Filling

At the completion of mining, pit dewatering will be stopped and groundwater inflow and runoff from the internal mine site area will be allowed to accumulate in the final void. Over time the void will fill with water ultimately reaching a pseudo steady state level reflecting a balance between inflows (comprising mine site runoff, incident rainfall and groundwater inflow) and outflows (which will be dominated by evaporation).

The long-term water quality and containment of water stored in the void has been assessed using a monthly water and salt balance simulation. The likely time required for the void to fill to an equilibrium level was estimated using a simple water balance model. Details of the model are given in Attachment A.

The water balance model simulated rainfall/runoff inflows based on a long sequence of recorded (historical) rainfall records, evaporative losses from water surface in the pit, seepage inflows on the basis of groundwater modelling studies undertaken by Coffey (1995) and Kalf and Associates (1997). Groundwater inflow rates are predicted to be constant during the initial filling stage when hydraulic gradients toward the void are steepest, and to reduce as the void fills past the aquifer level in the pit. In contrast, evaporation losses will tend to increase over time as the void fills due to increasing surface area and increasing potential evaporation rates associated with greater exposure to surface winds.

Modelling indicates the void will take a considerable period of time to fill to a final level (in the order of one hundred years). The rate of filling is expected to be relatively rapid initially and to decline as the pit water level approaches the long-term steady state level. The predicted long-term water level is expected to be around RL 180 (some 22 to 24 m below the full storage water line of the Lake). The final water level in the void is likely to oscillate over several meters in response to climatic variability.

The quality of groundwater inflows to the void are expected to be similar to the existing water quality in the local aquifers in the vicinity of the ore body. Testing shows that these waters are highly saline with reported total dissolved solids concentrations ranging from 31,000 to 38,000 mg/L. Salinity is dominated by sodium chloride ions with lesser concentrations of calcium, magnesium and sulphate ions.

There is no monitoring information available for the likely quality of surface runoff inflows to the void, however, it is believed that the recorded water quality data for Bland Creek is likely to contain similar chemical constituents on the basis that it is derived from runoff over similar terrain.

To provide an understanding of the likely bulk water quality in terms of salinity in the lake and how it would change over time, a salt mass balance for the Lake was calculated over the void filling period and beyond. Because the void has no outflow, salt concentrations are predicted to increase over time as a result of evapo-concentration. Model predictions indicate that this will be a slow but steady process with average salt concentrations increasing from 40,000 mg/L to 62,000 mg/L over a 114 year period. The results of the salt flux modelling indicate that the void salinity will progressively increase over a long period of time (hundreds of years). The rising salinity will also have the effect of reducing the rate of evaporation from the void surface although this is not predicted to significantly change the long-term water balance to any significant degree.

The likely water quality in the pit will vary with depth as a result of variable mixing and stratification processes that will occur due to temperature and salinity differentials in the water column. Assessment of the long-term water quality of the final void was undertaken by Tropical Water Solutions (1997) – refer Appendix N. The following conclusions were made based on this analysis:

"During the filling stage the final void will exhibit a steady progression toward seasonal stratification. After filling, the long-term scenario will include a trend in deep water toward hyper-salinity. In the surface mixed layer there will be a mid-year (approx. June-August) seasonal increase in salinity from that approximating sea-water to levels approaching twice that of sea-water. During the summer months the concentration of salinity will return to about sea-water levels.

It is likely that the final void will support salt tolerant species of phytoplankton similar to those found in Australia's natural salt lakes. Similarly, specialised macrophytes may establish around the voids edges. Some of these species may require introduction to the void from other regions (eg. natural salt lakes)."

The long time required for the void to fill means that any future trends in climate change will also affect the void water balance and potentially the final water level. To assess the possible effect of climate change, the climatic scenarios used in the filling model were changed to account for a range of current predicted climate change scenarios. Currently the only information available on future changes to rainfall in this area is limited to predictions of general trends. These indicate that average rainfall in the Lake Cowal area is likely to decrease under enhanced greenhouse conditions. Rainfall intensities however are expected in increase. Recent data provided by the Atmospheric Research Centre, CSIRO is summarised below:

Projected global warming (°c) for low and high scenarios:

Year	Low	High
1990	0.00	0.00
1995	0.06	0.09
2000	0.11	0.19
2010	0.20	0.38
2020	0.27	0.57
2050	0.54	1.34
2075	0.74	2.29
2100	0.87	3.53

The predicted percentage changes in monthly rainfall and evaporation per degree increase in temperature for Lake Cowal are summarised below:

	Rainfall (%)	Potential Evaporation (%)
January	0.9	3.9
February	-15.0	4.1
March	-3.5	5.3
April	-4.2	5.1
May	-1.9	6.0
June	-13.9	7.1
July	-8.8	8.6
August	-4.8	7.8
September	-0.7	6.4
October	-2.5	4.7
November	3.4	4.0
December	-4.1	3.1

The application of these results to the final void water balance will result in reduced overall inflows and increased evaporative losses. The overall effect will be a lower final water level. There will be a small offset effect of the higher rainfall intensity associated with the climate change resulting in higher runoff. This effect may partially offset the lower total rainfall, however it is likely to be minor. More significant would be if there were an increase in rainfall (rather than a decrease) which would result in higher final water levels in the void. It is known that there is still considerable uncertainty involved in the prediction of future climatic trends. To test for the possible effect of increasing rainfall the following scenario taken from results of work done in the late 1980's (Weeks, 1989) on climate change was used in a void water balance simulation run.

Average changes in rainfall by the year 2030

January	+50%
February	+40%
March	+30%
April	+10%
May	0%
June	-20%
July	-20%
August	-20%
September	0%
October	+10%
November	+30%
December	+40%

The rainfall data sequence used in the model was adjusted such that the amount of rainfall for each month was factored (up or down) by a linear proportion of the relevant monthly adjustment factor for the first 30 years after which a constant factor was used. It should be noted that the CSIRO have indicated that they believe these conditions are unrealistically wet (Dr Roger Jones pers. comm.)

Results of the modelling indicate that void filling under these conditions will take a similar time frame – in the order of one hundred years. The predicted final pseudo steady state water level was some 4 to 5 m higher in the pit. This is still well below the spill level.

8.0 ASSESSMENT AND CONCLUSIONS

A comprehensive water management system has been developed for the Cowal Gold Project. It is based on the permanent isolation of surface and groundwaters on the mine site from Lake Cowal. This will be achieved by development of an Up-catchment Diversion System to route runoff from areas unaffected by mining around the perimeter of the site and an Internal Catchment Drainage System which will see capture of all site runoff and seepage for re-use in the processing plant and in the longer term isolation in the final void. The void will become a permanent sink for groundwater and surface runoff within the Internal Catchment Drainage System. The long term void water balance is such that it will not spill under any conceivable climate conditions.

The operational site water balance is such that there will be a moderate negative water balance. Depending on the actual mine groundwater yields encountered during mining, the requirement to import water from the Bland Creek Paleaochannel borefield will vary.

The mine waste rock has the potential to generate moderately saline seepage and could result in migration of elevated salinity in seepage/runoff, particularly during the active mining phase. A low permeability basal layer beneath the waste rock emplacements will accordingly be graded back toward the void to ensure on-site containment of seepage in both the mining and post-closure phases.

The tailings storage has been designed to contain a 1 in 1,000 ARI event with negligible risk of spill during the mine life. A back-up to this system exists with any spillage reporting to the mine pit. Seepage studies show that there is a low potential for seepage from the tailings storage and that it would be unlikely to be detectable during the mine life. Notwithstanding this, any seepage would migrate in the highly saline groundwater toward the void which would ultimately become the sink for all groundwater.

In the longer term (post-closure), there will be little potential movement of either surface or groundwater from either the waste emplacements or seepage from the tailings storage (Kalf, 1997). Use of suitable soils and vegetation communities to cover the waste rock emplacements and tailings storage will result in low salt fluxes in surface waters consistent with regional runoff quality.

9.0 REFERENCES

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Attachment A

Attachment A

Water/Salt Balance Modelling

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

A1.0 INTRODUCTION

A combined water/salt balance model was developed to simulate the water balance and salt balance characteristics of the Cowal Project site during operations for a range of climatic and groundwater scenarios, as well as long-term following decommissioning.

The operating mine site water balance comprised a 14 year period covering construction and operation for three differing climatic scenarios:

1. Extreme Wet Sequence – The 14 year rainfall sequence with the first two years corresponding to the highest consecutive two year rainfall total on record (see note (a) in Table A-1).
2. Median Sequence – The 14 year rainfall sequence with the first two years corresponding to the median consecutive two year rainfall total on record (see note (b) in Table A-1) and;
3. Extreme Dry Sequence – The 14 year rainfall sequence with the first two years corresponding to the lowest consecutive two year rainfall total on record (see note (c) in Table A-1.

The rainfall sequences along with the most recent 14 years of rainfall record are shown on Table A-1.

For each climatic scenario, two cases of groundwater inflow to the open cut were modelled encompassing the range of potential inflows simulated by Coffey in their groundwater report (October 1997).

Long-term water balance modelling of the final void was undertaken utilising a long-term composite rainfall record generated from nearby rainfall gauging stations (see Appendix 1).

Table A-1 Modelled Rainfall Sequences

Year	Extreme Wet Sequence	Median Sequence	Extreme Dry Sequence
3 to 14	**From: July 1949 To: December 1962**	**From: July 1925 To: December 1938**	**From: July 1912 To: December 1925**
1 to 2	1,364.5	792.3	421.8
3	397.0	354.3	326.4
4	621.3	599.4	711.1
5	407.9	353.6	665.3
6	493.6	466.5	330.4
7	581.8	663.2	327.7
8	866.1	471.8	476.0
9	270.7	434.7	550.8
10	498.5	643.8	352.2
11	516.2	325.8	405.4
12	577.9	601.0	648.9
13	632.5	373.0	514.7
14	600.7	346.3	586.6
Total	7,828.7	6,425.7	6,317.3

The model was set up as a "spreadsheet" using a monthly time-step. Inflows to the water balance portion of the model consist of rainfall/runoff generated on each component area of the mine site, and groundwater seepage inflows to the open void. Outflows from the system include evaporation from the open water surfaces within the mine site and implied losses associated with rainfall and proportional runoff generation (infiltration, evapo-transpiration).

The salt balance component of the model tracks movement of salt as a mass flux and in combination with the water balance component of the model was used to predict average salt concentrations in water contained on-site. Inflows of salt to the mine site system were associated with high salinity groundwater inflow to the open cut.

The objectives of the water/salt balance model were to assist in the determination of a water management plan for the mine site and to assess the performance of the system under a range of potential climatic conditions. In addition, the model was used to assess the long-term characteristics of the final void under the proposed rehabilitation scheme in terms of hydrology and salinity.

A2.0 COMPONENT WATER BALANCE EQUATIONS

The following sections and equations describe the component water balances of the two modelling cases (operating and post-mining) and detail the inflows and outflows pertaining to each.

The water balance model for the operating mine site simulation provides predictions of the volume of water stored and/or re-use within the project area as well as the salinity of that water for each month of the mines operating life. The post-mining balance simulates volumes and salinity of water contained within the final void, which is proposed to be used for long term containment of site water following decommissioning.

A2.1 Mine Site Water Balance (Operating)

$\Delta V_{ms} = R/R_{ms} + PD - EVAP$

Where: ΔV_{ms} = Change in on-site water storage volume (+ve = increase);

R/R_{ms} = Rainfall and runoff from variuos components of the mine site catchment;

PD = Pit dewatering;

EVAP = Evaporation from open water surface;

A2.2 Open Void Water Balance (Post-mining)

$\Delta V_{VOID} = R/R_{VOID} + SEEP - EVAP$

Where: ΔV_{VOID} = Change in open void storage volume (+ve = increase);

R/R_{VOID} = Rainfall and runoff generated from open void, Waste rock emplacement and associated mine catchment;

SEEP = Groundwater seepage inflows;

EVAP = Evaporation from open water surface.

A3.0 COMPONENT SALT BALANCE EQUATIONS

As described above, the salt balance model has been set up as a connected but separate model from the water balance model. As with the water balance, the salt balances were determined for the operating mine site as well as for the post-mining case. The equations used are detailed below.

A3.1 Mine Site Salt Balance (Operating)

For each individual site water storage a salt balance was calculated based on the inflows and outflows of the individual storage. A mine site balance has been simulated incorporating the sum of inflows and outflows of the component storages.

A3.2 Final Void Salt Balance (Post-mining)

ΔS_{VOID} = |g/w| * SEEP + |inf| * inf

Where: ΔS_{VOID} = Change in mass of salt contained in open void (+ve = increase);

|g/w| = Salinity (mg/L) of groundwater;

SEEP = Inflow volume groundwater seepage;

|inf| = Salinity (mg/L) of overland inflow to pit;

inf = Inflow volume of overland flow to pit.

A4.0 INPUT DATA AND PARAMETERS

In order to assess the behaviour of the mine site water balance both during operation and post mining, a data series of monthly rainfall totals was generated. Using this data, three life of mine modelling runs were undertaken (representing the climatic sequences as outlined in Section A1.0) for the operating mine site case. A single, long-term modelling sequence was run to simulate the post-mining case. The model parameters used for each modelling run are summarised below.

Rainfall data generation and seepage rates are given in Appendices 1 and 2 respectively.

Table A-2 Runoff Characteristics – Operating Mine Site Catchment

Catchment Type	Runoff Coefficient
Undisturbed surfaces	
Hilly	0.25
Flat	0.1
Lake Bed	0.3
Reformed surfaces	0.25
Waste (including infiltration)	0.15
Pit area	0.85
Water Storage	0.95
Hardstand	0.9
ROM Pad and low grade including seepage	0.5
Tailings Storages (wet beach)	0.9

A4.1 Runoff Characteristics

A4.1.1 Operating Mine Site

Water balance modelling for the mine site included runoff from a number of differing catchment types. Table A-2 lists the component catchment types and corresponding runoff coefficients adopted in the modelling.

A4.1.2 Post-mining

As for the operating mine site, simulated runoff to the void post-mining included components of inflow from a number of catchment types. For ease of calculation during the modelling phase single "effective" values for the catchment area and runoff coefficient for the overall void catchment contributing runoff to the pit were determined. Table A-3 lists the component catchment types, runoff coefficients and catchment areas, and shows the resultant effective parameter values.

A4.2 Pan Factors

A4.2.1 Operating Mine Site

Pan factors used with the water balance modelling have been based on the results of studies undertaken by the Australian Water Resources Council summarised in "Technical Paper No. 41: Field Study of Lake Evaporation – Analysis of Data from Phase 2 Storages and summary of Phase 1 and Phase 2", 1979. The annual pan factors relevant to water bodies associated with the mine site are likely to be dependent upon similar climatic factors as the annual pan coefficient for Lake Wyangan South (the closest lake to the Cowal Project site in the study group of the above study). As such, a pan factor of 0.82 was selected.

A4.2.2 Post-mining

Pan factors in open cut mines are generally significantly lower than for shallow, non wind-protected bodies of water such as Lake Wyangan South. The pan factor used for the open void was 0.7, which represents a value at the lower end of a range of pan factors determined within the above study.

Table A-3 Runoff Characteristics – Post-mining Catchments

Catchment Type	Catchment Area (ha)	Runoff Coefficient
Open Void (includes batters)	70 ha	0.8[2]
Natural catchment and rehabilitated waste emplacement plateau	272 ha	0.05[1]
Waste emplacement batters	33 ha	0.3[2]
Infiltration through waste emplacement	65 ha	0.05[2]
Tailings Dam and catchment runoff	330 ha	0.05
Effective	**770 ha**	**0.129**

[1] Determined from ratio of mean annual Bland Creek flow at Morangarrel to average annual rainfall.

[2] Based on previous modelling undertaken for similar projects.

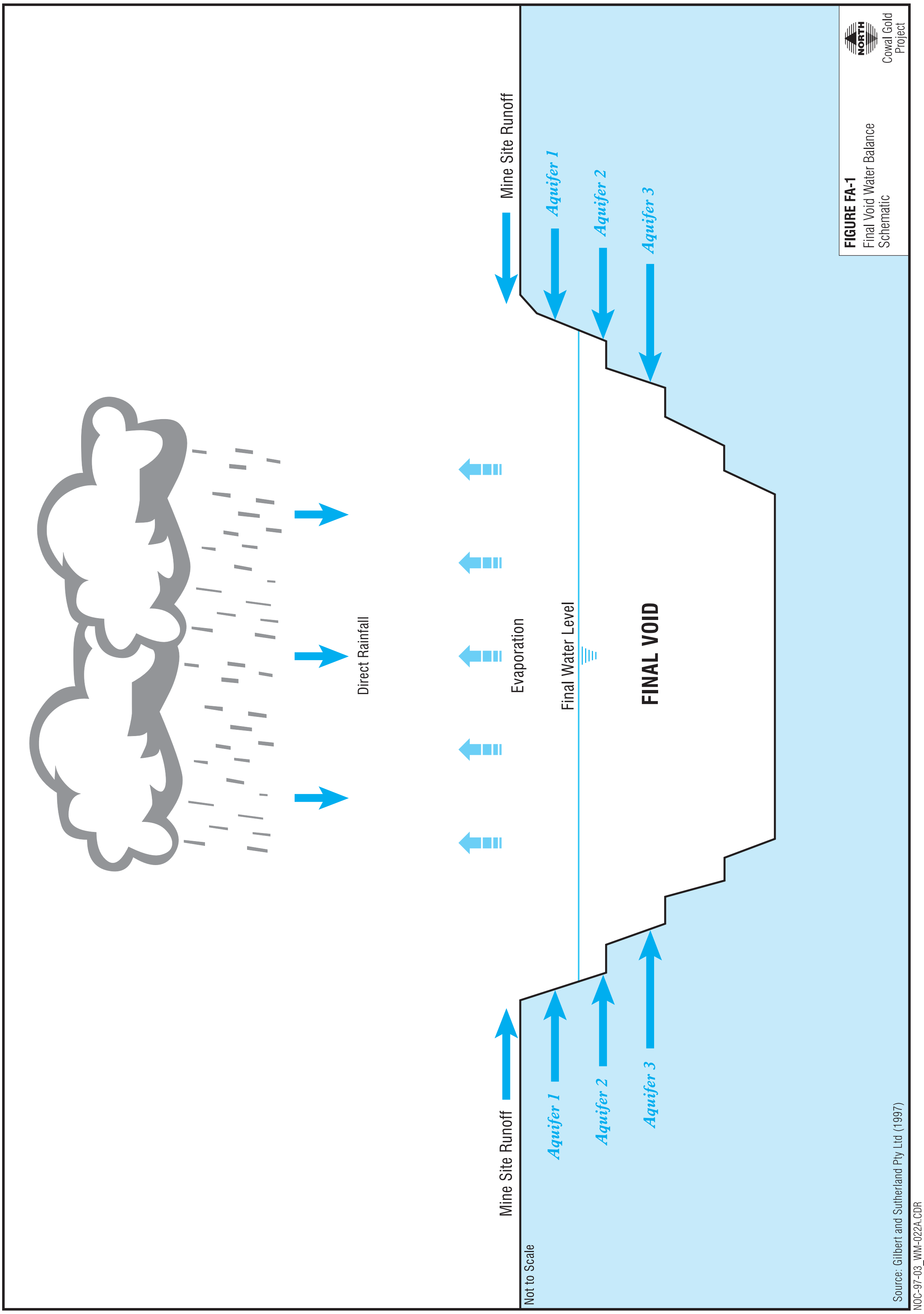

FIGURE FA-1
Final Void Water Balance Schematic

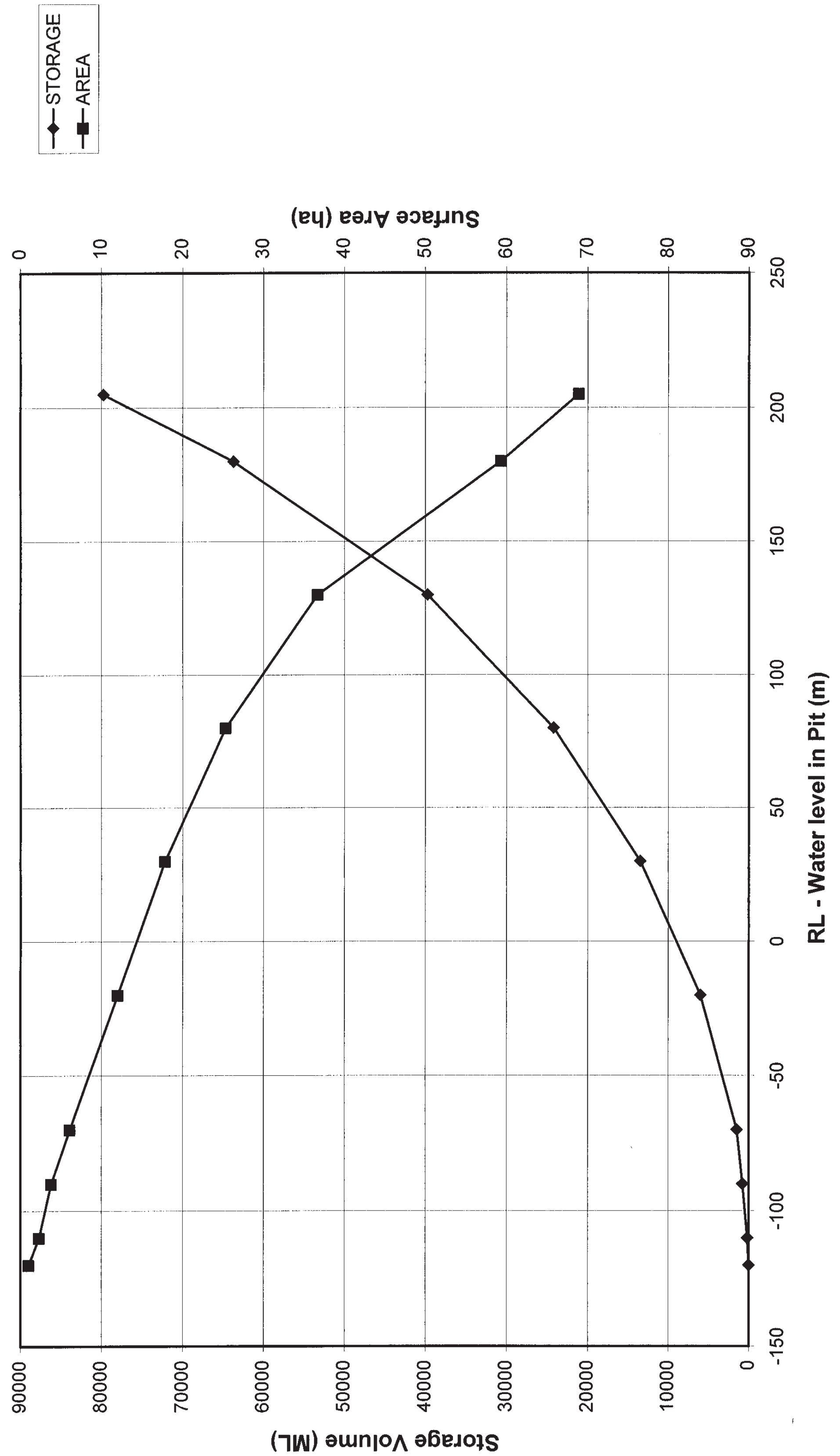

FIGURE FA-2
Final Void
Storage Characteristics

NORTH
Cowal Gold Project

NOC-97-03_WM-028A.CDR

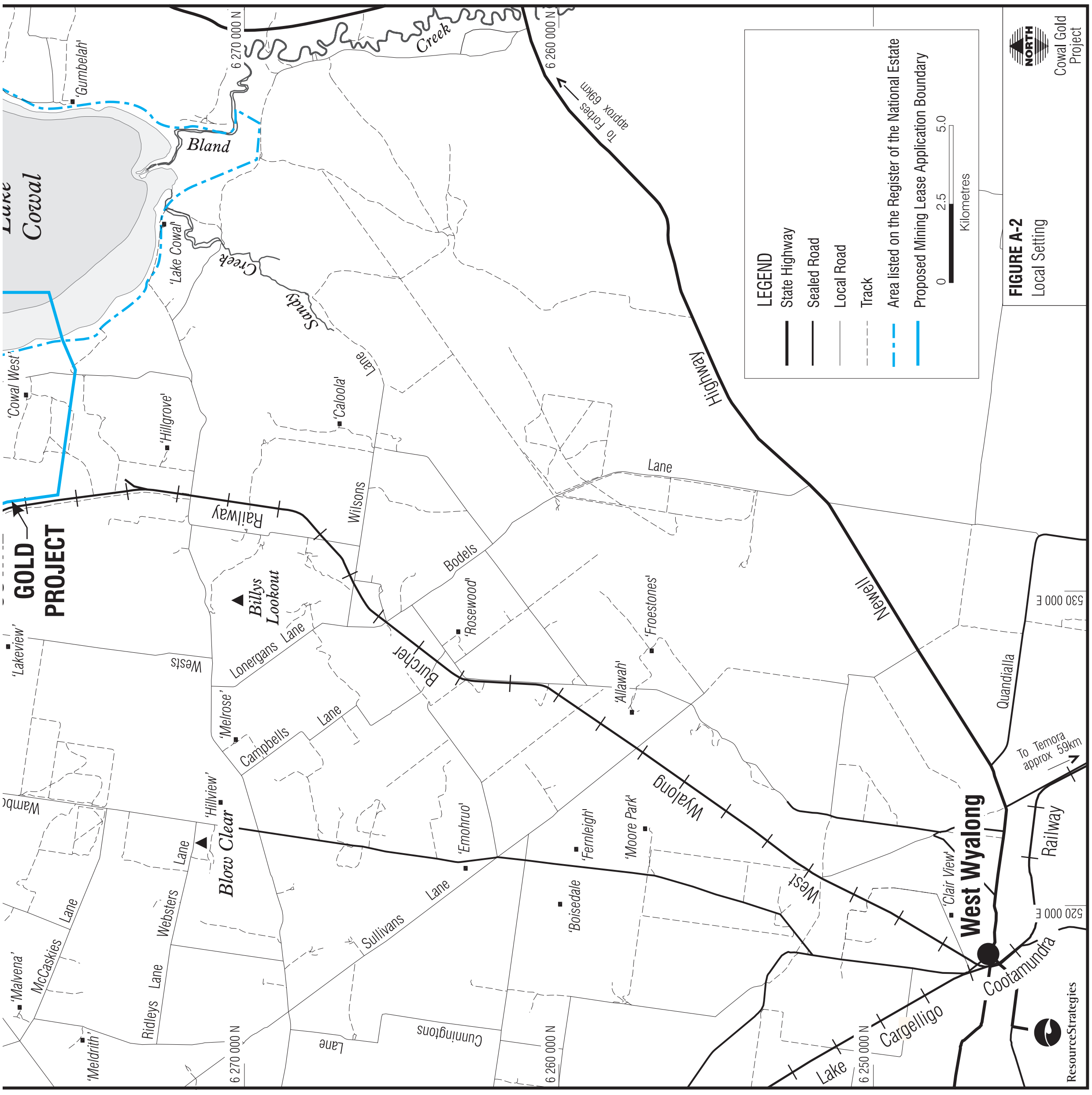

FIGURE A-2
Local Setting

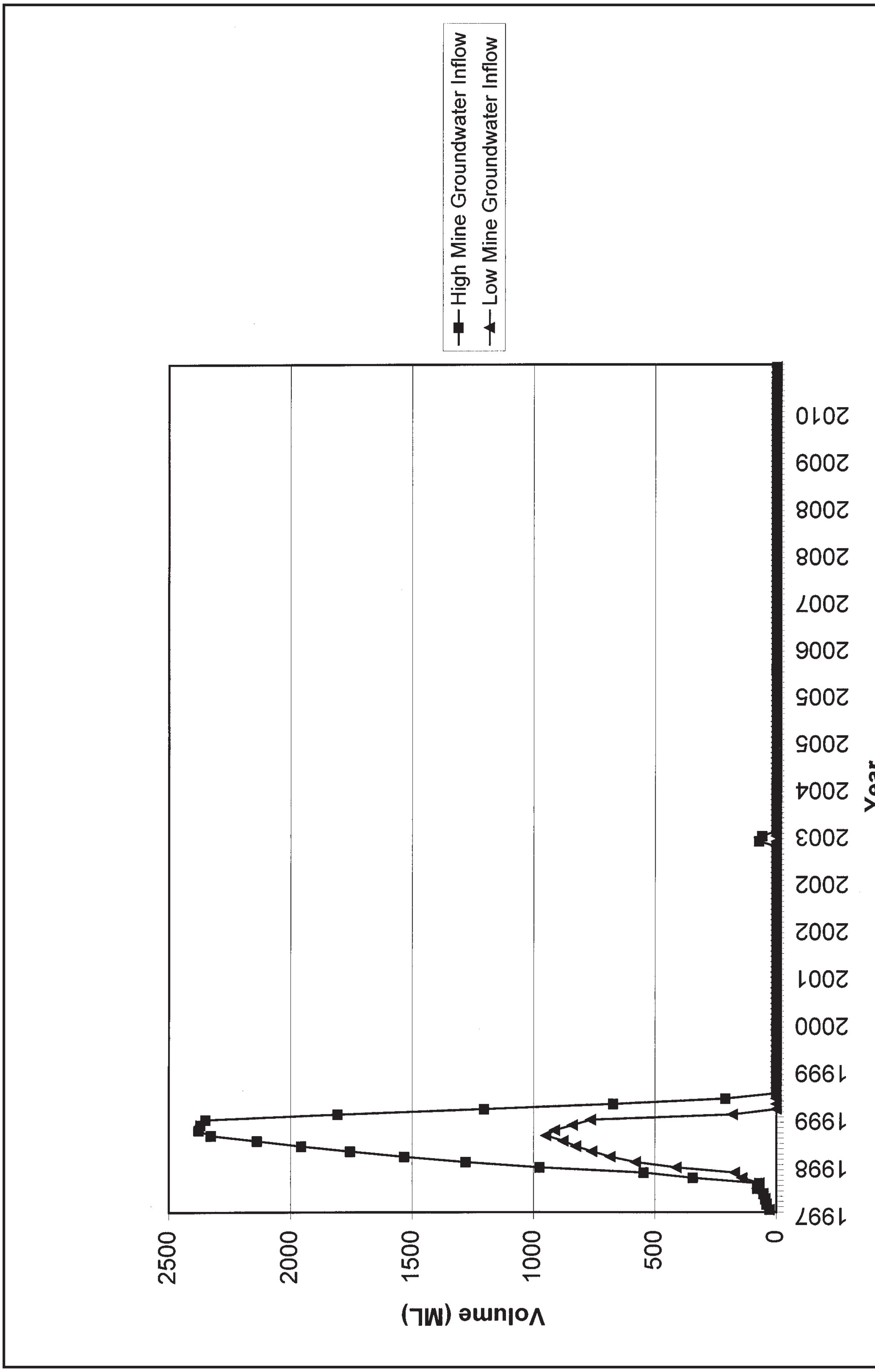

FIGURE FA-4
Simulated Excess Water
Median Climatic Sequence

NOC-97-03_WM-029A.CDR

A4.3 Storage Characteristics

Open pit storage characteristics for long-term post-mining modelling were estimated from final pit layout plan produced and supplied by North Limited. Figure FA-1 shows the final void water balance schematic. Figure FA-2 shows the adopted storage characteristics.

A4.4 Monthly Evaporation

Recorded monthly evaporation data is available for Condobolin, situated some 40 km to the north/north-east of Lake Cowal. Long-term monthly average evaporation rates were calculated from this data. Mean recorded Condobolin evaporation (approx 2,000 mm/yr) has been reported as being erroneously high (Booth Associates, 1966) with a suggested average rate of 1,730 mm for the district. An estimate of the expected mean annual evaporation was determined from the Climatic Atlas of Australia. Estimation of the equivalent monthly evaporation rates for Lake Cowal was undertaken via scaling the recorded Condobolin values to yield the equivalent annual total evaporation for Lake Cowal (1,750 mm), as taken from the Climatic Atlas of Australia.

A4.5 Salinity of Inflows

Inflow of salt to the modelled mine site system was via two components: groundwater seepage to the open pit; and salt contained in site generated runoff (eg: through infiltration of the waste rock emplacement). Water quality data has been taken for groundwater within the area and estimates made of the potential salinity of natural surface runoff, leachate through the waste rock emplacements and runoff from the pit area. The following values were adopted for modelling:

- Pit groundwater inflow: 35,000 mg/L[3];
- Natural surface runoff: 100 mg/L;
- Pit area runoff: 300 mg/L;
- Waste emplacement runoff (including infiltration): 2,000 mg/L.

[3] Based on data from Coffey report – Lake Cowal Project Hydrogeological Modelling and Dewatering Study, April 1995.

A5.0 SUMMARY OF RESULTS

A5.1 Water Balance

Figures FA-3 to FA-5 summarise modelling results in terms of monthly volumes requiring containment/re-use within the mine site for the three climatic scenarios under operating conditions. Figure FA-6 shows the simulated monthly storage volumes for the open void post-mining.

A5.2 Salt Balance

Figure FA-7 shows the simulated salinity levels within the open void over the long-term post-mining.

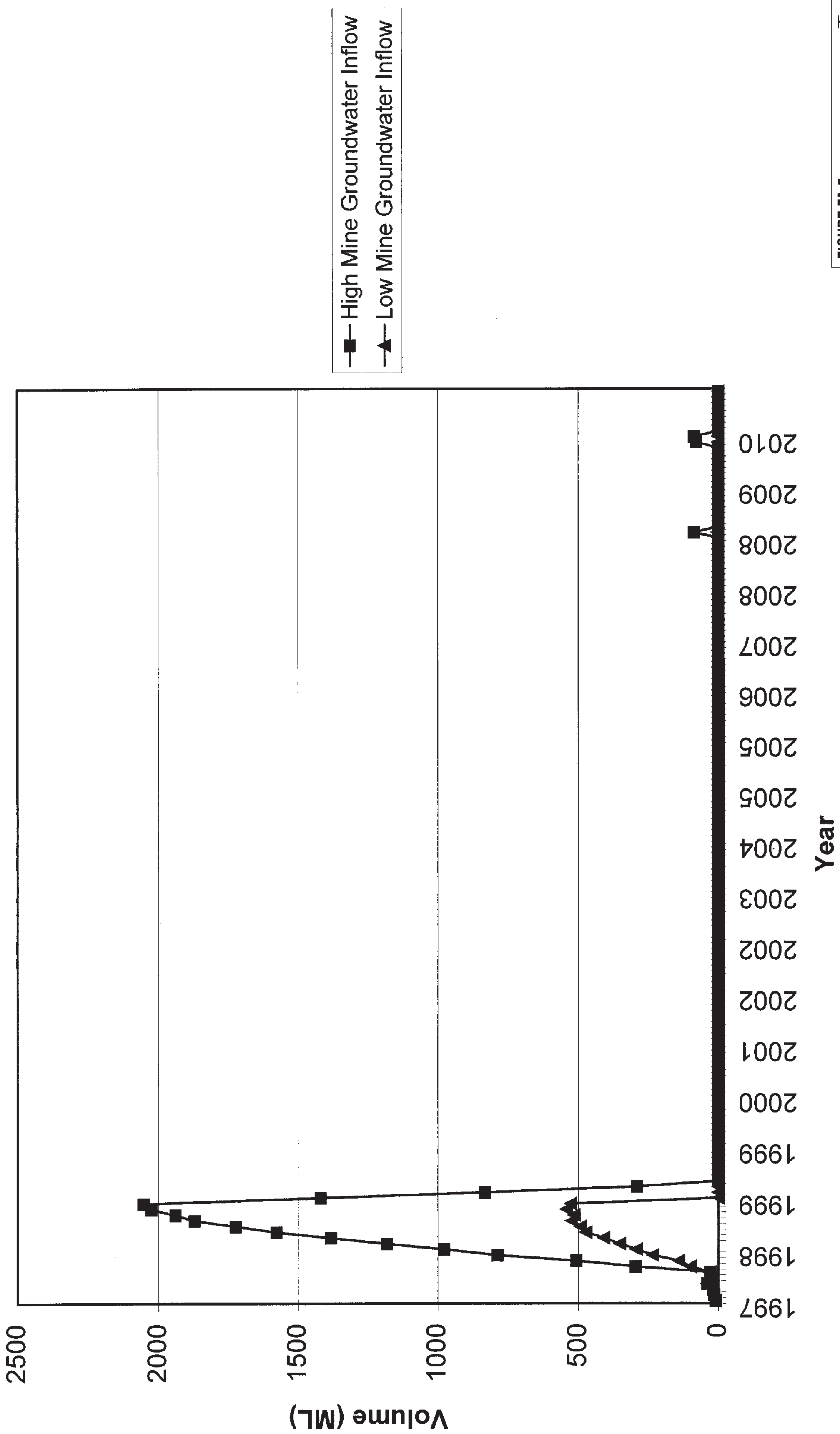

FIGURE FA-5
Simulated Excess Water
Extreme Dry Climatic Sequence

Cowal Gold Project

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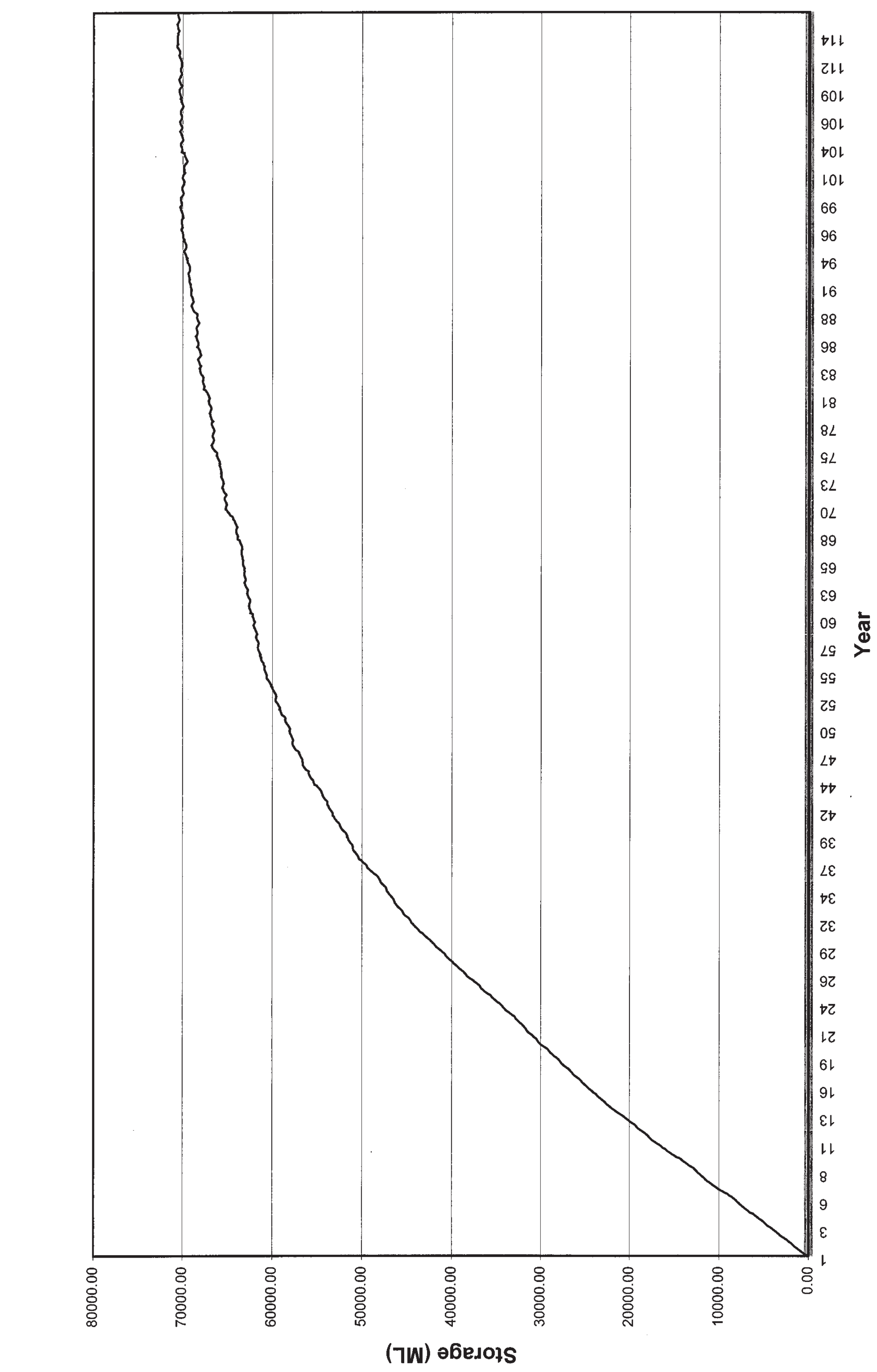


FIGURE FA-6
Simulated Void Filling

NORTH
Cowal Gold Project

NOC-97-03_WM-031A.CDR

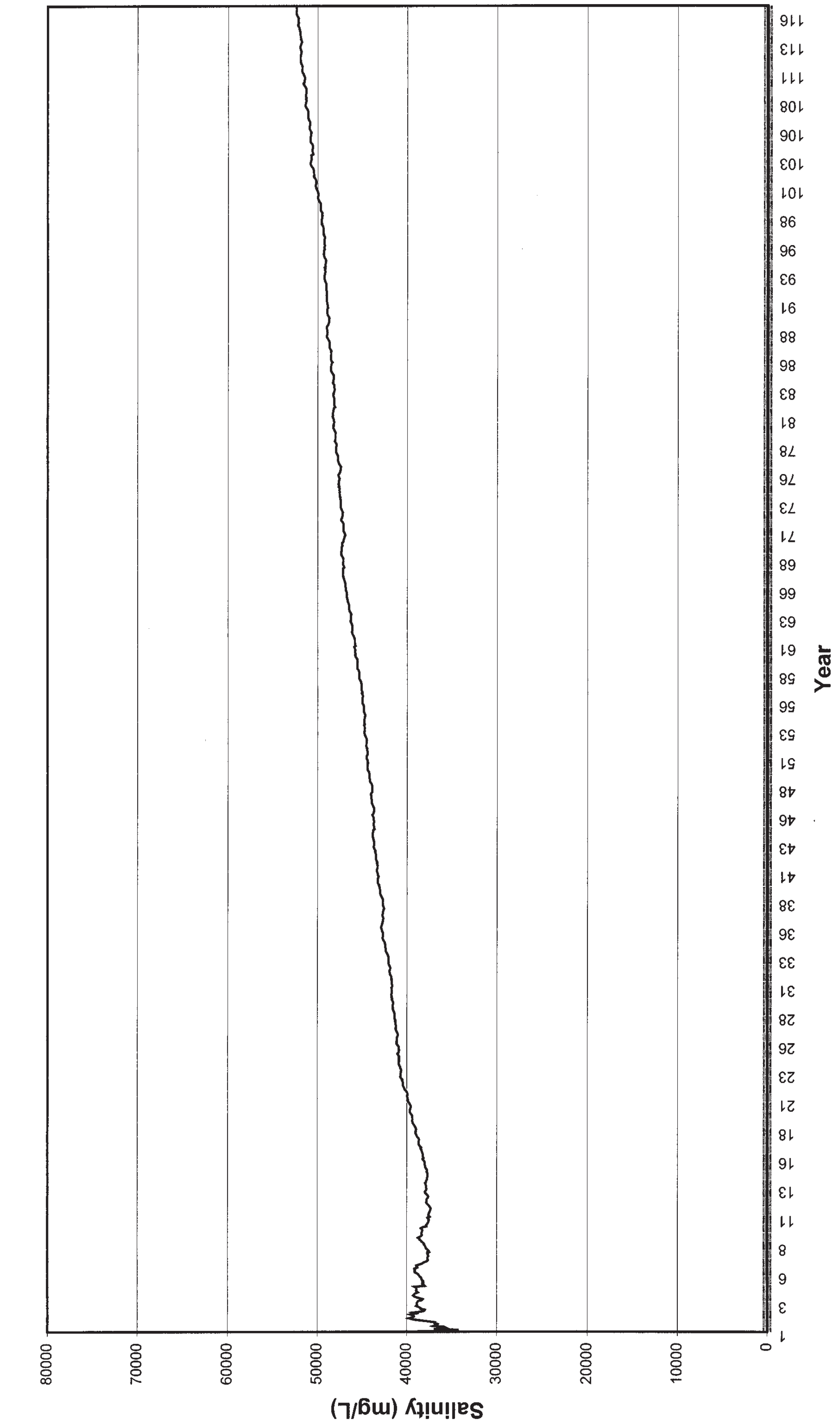


FIGURE FA-7
Simulated Salinity
During Void Filling

NORTH
Cowal Gold Project

NOC-97-03_WM-032B.CDR

Appendices 1-2

Appendices 1-2

Rainfall Data and Pit Seepage Inflow Data

APPENDIX 1 Rainfall Data

Rainfall Data

A long-term monthly rainfall sequence for the mine site was compiled using daily recorded data from four rainfall stations within and adjacent to the Lake Cowal catchment. Table FA1-1 lists the stations and corresponding periods of record.

Table FA1-1 Rainfall Gauging Stations

Rainfall Gauging Station	Station No.	Period of Data
Lake Cowal	050 022	1880 - 1950
Caragabal PO	073 008	1916 - 31/12/1995
Wyalong PO	073 054	1895 - 20/03/97
Condobolin PO	050 014	1881 - 28/02/1997

Daily rainfall values assumed to be representative of the entire Lake Cowal catchment were estimated as the average of values from each station with a recorded value for that day (i.e all available data). The estimated daily averages were then summed to give monthly totals for use as input to the water balance model. Figure FA1-1 illustrates the monthly rainfall data used for the modelling.

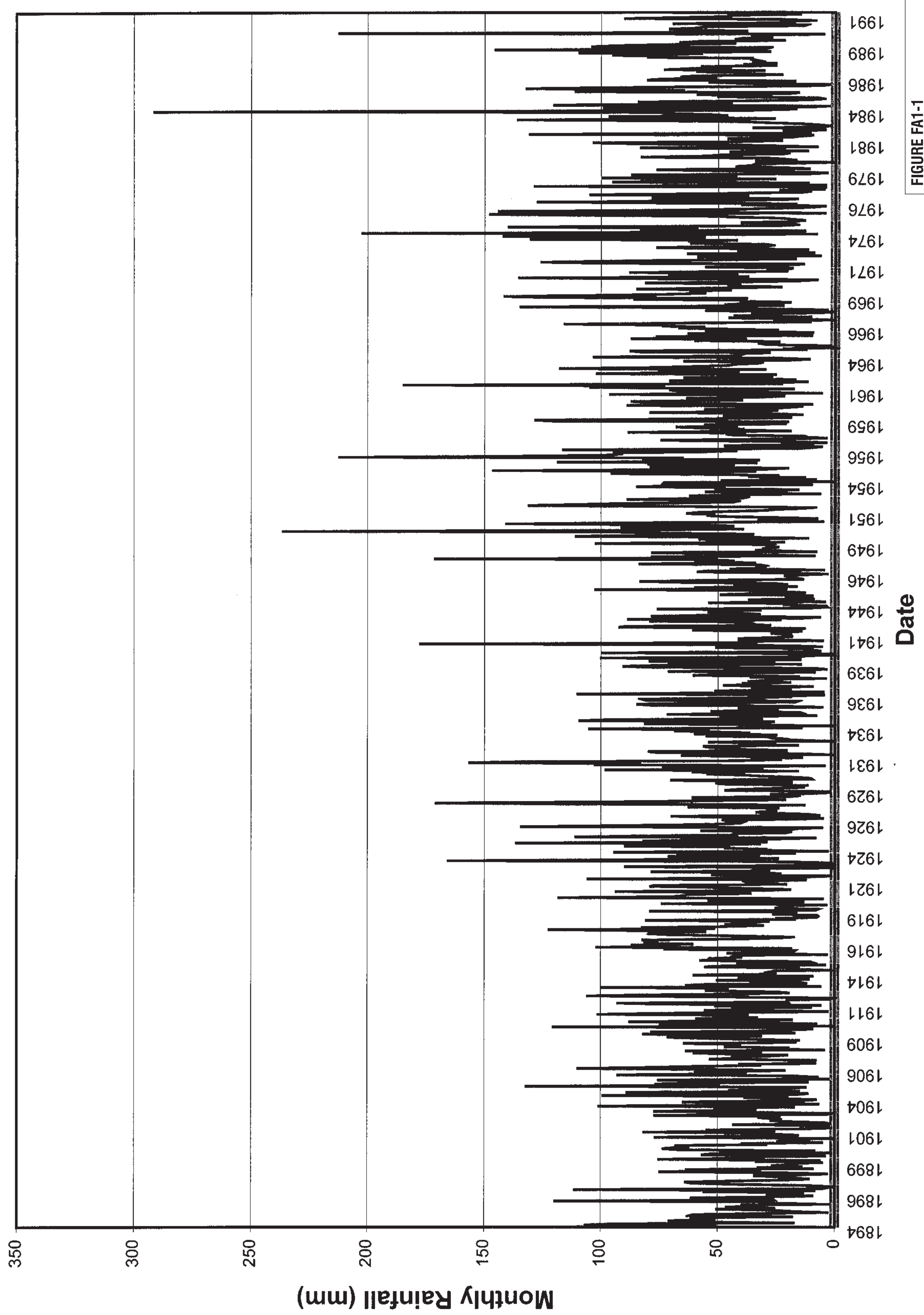


FIGURE FA1-1
Generated Lake Cowal Rainfall Sequence

NORTH Cowal Gold Project

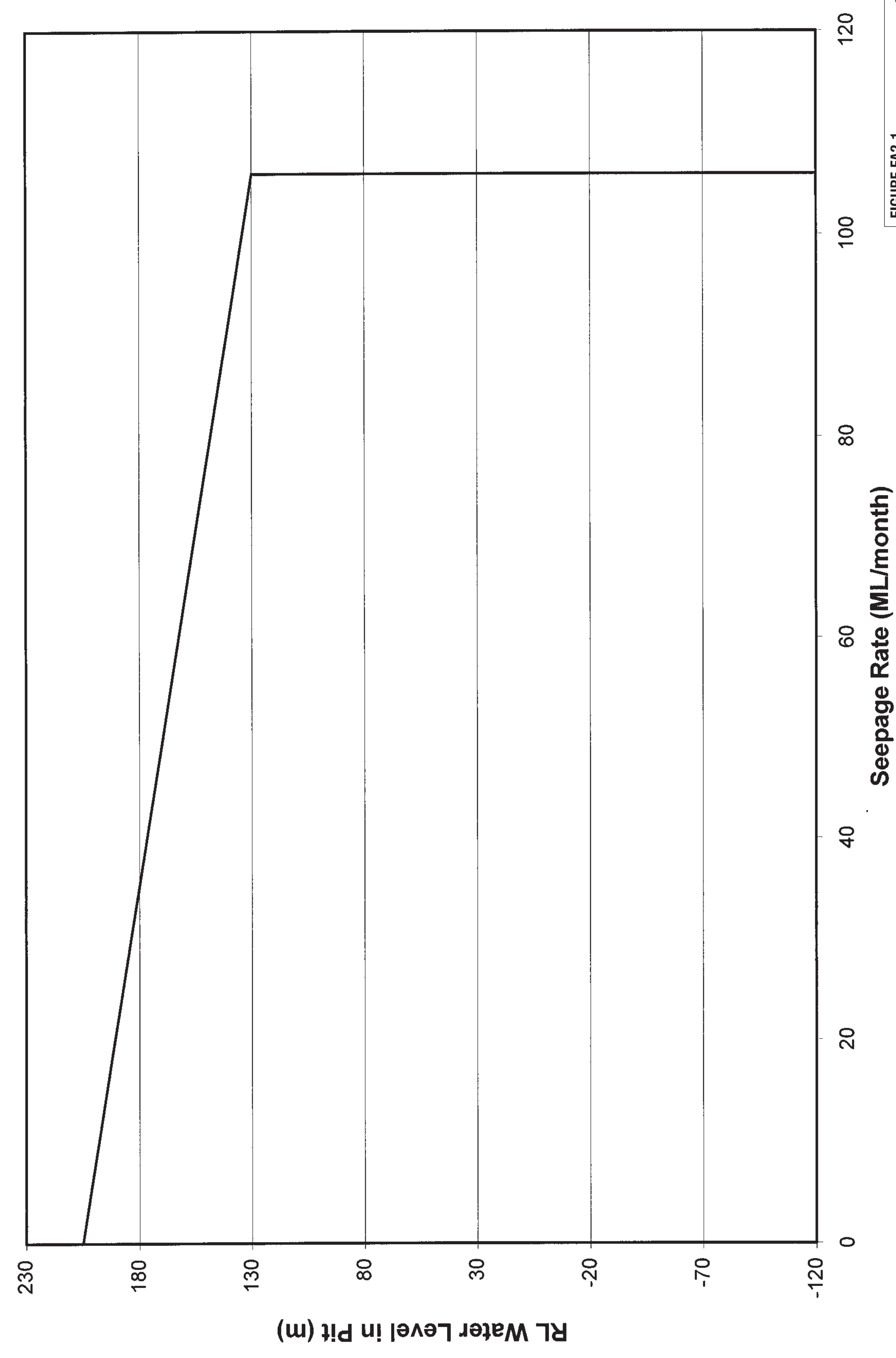
NOC-97-03_WM-033A.CDR

APPENDIX 2 Pit Seepage Inflow Data

Seepage

Coffey Partners International undertook seepage modelling studies for the proposed Lake Cowal project in April 1995, for determination of long-term pit groundwater inflow. More recently, Kalf and Associates have sought to refine the results of this seepage modelling and undertook studies related to potential pit seepage rates. Results from the two sets of studies were used to provide estimates of long-term seepage rates used for the post-mining water balance model simulations, shown in Figure FA2-1.

Recent changes to the mining schedule necessitated revision of the short-term seepage rates expected for the open cut (Coffey, Oct. 1997). The monthly seepage rates (upper and lower seepage rate cases) used for the operating mine site modelling runs have been based on these revised values, and are shown in Figure FA2-2.



Source: Coffey/Kalf & Associates

FIGURE FA2-1
Predicted Groundwater Void Inflows During Filling

Cowal Gold Project

NOC-97-03_WM-034B.CDR

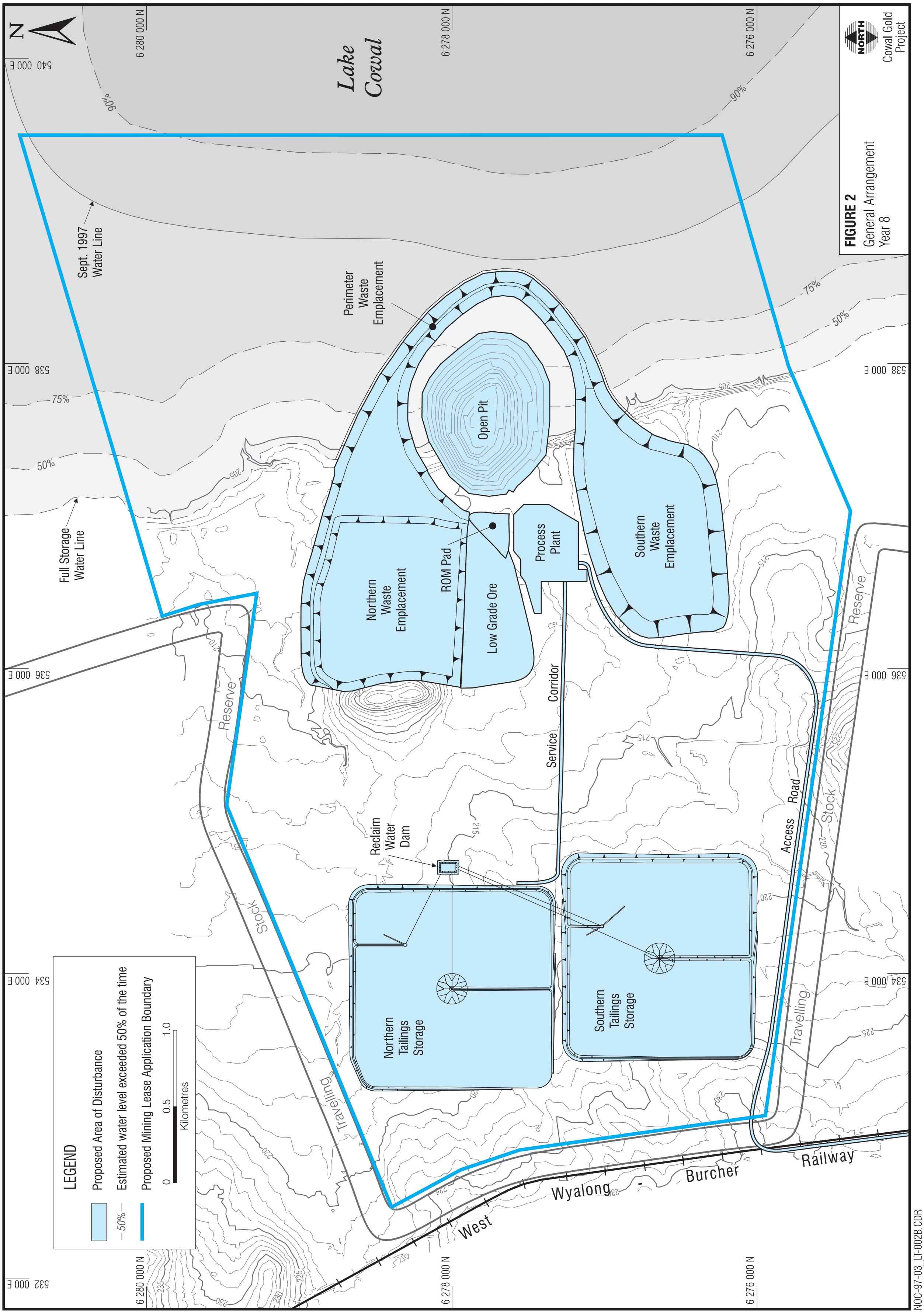


FIGURE 2
General Arrangement
Year 8
Cowal Gold Project
N
Lake Cowal
90%
75%
50%
Sept. 1997 Water Line
Full Storage Water Line
Perimeter Waste Emplacement
Open Pit
Southern Waste Emplacement
Process Plant
ROM Pad
Low Grade Ore
Northern Waste Emplacement
Service Corridor
Access Road
Reclaim Water Dam
Northern Tailings Storage
Southern Tailings Storage
Travelling Stock Reserve
West Wyalong - Burcher Railway
540 000 E
538 000 E
536 000 E
534 000 E
532 000 E
6 280 000 N
6 278 000 N
6 276 000 N
LEGEND
Proposed Area of Disturbance
50% Estimated water level exceeded 50% of the time
Proposed Mining Lease Application Boundary
0 0.5 1.0
Kilometres
NOC-97-03_LT-002B.CDR

Appendix G

Appendix G

Use of Cyanide at Cowal Gold Project

Use of Cyanide at Cowal Gold Project

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November 1997

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This report provides background on the use, toxicity and management of cyanide at the Cowal Gold Project.

Cyanide leaching has been found to be the only proven method for extracting gold at the Cowal Project. Possible alternative leaching agents such as thiourea or thiosulphate are either ineffective or uneconomic.

The milling process at the Cowal Gold Project involves two cyanide destruction points and recycling of cyanide solutions in the mill process. The desired level of cyanide at the discharge to the tailings is a maximum of 30 mg/L CN_{WAD} operating at below 20 mg/L CN_{WAD} for 90% of the time.

Once in the tailings storage at the Cowal Project a range of natural degradation processes occur, the most significant being volatilisation of HCN gas to the atmosphere. Up to 90% of the CN_{FREE} remaining in the tailings stream could be degraded in this way. Other processes cause the oxidation of cyanide to cyanate and ammonia which themselves break down to innocuous species such as nitrates or are immobilised in the tailings mass. The metals associated with cyanide either precipitate out or are similarly immobilised in the solid tailings mass. Long term movement of cyanide from the tailings storage has been shown not to be significant.

In terms of toxicity, cyanide acts as an asphyxiant but can be quickly detoxified to below lethal levels. Research on chronic (sub-lethal) toxicity shows that sensitive tissues can restore critical respiration processes following detoxification.

Of the cyanide decay products, ammonia followed by cyanate, then thiocyanate are all less toxic than cyanide.

The proposed cyanide destruction method at the Cowal Project is by Caro's acid. This method has been tested on oxide and primary ore from the Cowal Project and found to deliver fast and effective destruction down to committed tailings discharge levels of a maximum of 30 mg/L CN_{WAD} and 90% of the time below 20 mg/L CN_{WAD}. The method can effect destruction below these levels but at increasing cost. The main product from this process is cyanate which itself will decay through natural processes.

Several monitoring measures have been proposed for the use of cyanide at the Cowal Project including on-line monitoring at the point of discharge and cyanide analyses to set laboratory standards. Visual monitoring of the tailings storage is also proposed.

1.0 INTRODUCTION

The purpose of this paper is to provide background on the use, toxicity and management of cyanide at the Cowal Gold Project.

Section 2 of this report assesses the selection of cyanide as the agent to recover gold from mined ore at the Cowal Project and the alternatives considered. Section three discusses the chemistry of cyanide and the likely decay products while section four reviews information on the toxicity of cyanide to wildlife potentially exposed to cyanide at the Cowal Project. Section five assesses the alternatives considered for destroying or recycling cyanide and the impact of residual products. The final section discusses possible regulatory and monitoring arrangements at the mine as they relate to cyanide.

1.1 Background on Cyanide

The worldwide annual production of cyanide in all forms is about 300,000 tonnes. The main commercial method of production is the Andrussaw process which is based on the following reaction:

$$CH_4 + NH_3 + 1.5O_2 \rightarrow HCN + 3H_2O$$

The primary environmental concerns of cyanide relate to the potential for impact on humans and animals. The main areas of interest are:

- health and safety of workers who use cyanide;
- impact of release of cyanidated waters into ecosystems outside of an operation, and
- movement of animals on to areas where cyanide residues are stored.

Cyanide is sold in liquid form or more commonly as a solid briquette. Within Australia, cyanide is manufactured at Kwinana, Western Australia (about 32,000 tonnes per year) and at two facilities in Gladstone Queensland (about 36,000 and 28,000 tonnes per year). In Australia, total cyanide production (NaCN) is therefore around 96,000 tonnes per year.

North Limited has committed the Cowal Gold Project to meeting a discharge cyanide level to the enclosed tailings storage system of a maximum of 30mg/L CN_{WAD} operating for 90% of the time at below 20 mg/L CN_{WAD}. This value is measured at the point of discharge to the tailings storage.

2.0 SELECTION AND USE OF CYANIDE AT COWAL

The gold found within rock at the Cowal Project is finely disseminated and locked up with other constituents of the rock. Gold extraction, in common with all gold mines, requires the separation and concentration of the gold. However, the particulate nature of the gold at the Cowal Project means that physical extraction processes alone are not economically viable and a chemical means of extracting and separating the gold is required. Typically this chemical process requires a leaching agent.

2.1 Alternative Leaching Agents

The most common leaching agent in the gold industry since the 1890s has been cyanide although research into alternative leachants is ongoing. Possible alternative leaching agents for gold recovery include thiourea, thiosulfate, and various halides. The selection of the leaching agent is based on a range of factors built around the nature of the ore being processed and process economics, in particular the likely recovery rates of gold from the use of the reagent. Cases where alternative leaching agents may be possible include where (Von Michaelis, 1987):

- the ore is refractory in nature (requiring very high temperatures for mineral extraction);
- the ore contains cyanicides which cause excessive cyanide consumption;
- the ore concentrate is acidic and a reagent that leaches gold in an acid environment may be attractive;
- environmental reasons rule out the use of the leaching agent such as in areas of high rainfall where water needs to be released off site;
- the alternative reagent results in reduced cost of mill infrastructure;
- the cost of the reagent delivered to point of use proves uneconomic.

A detailed review of the chemistry of alternative leaching agents is presented in a review by the Department of Minerals and Energy, in WA, 1996. Key points are summarised below.

Thiourea
Thiourea has been in use since the 1940s and has a much lower acute toxicity than cyanide, producing more stable complexes with metals than cyanide equivalent complexes. Thiourea is a more rapid leaching agent than cyanide but is however a suspected carcinogen.

Thiosulfate
Recovery of gold from thiosulfate solutions has been shown to be problematic with no simple process for its use is currently available.

Thiosulfate works well with refractory ores producing faster reaction kinetics. Thiosulfate has low toxicity although high concentrations of reagents are required to the point that some form of thiosulfate recovery is required from an economic point of view. There is also no simple and cost effective method of recovering gold from thiosulfate leach solutions.

Halides
The use of halides as leaching agents pre-dates the use of cyanide and includes bromine, chlorine and iodine based reagents.

Despite substantial effort in recent years to increase knowledge in the area of halide leaching no pilot or demonstration studies have been reported on the use of halide based systems. Cost considerations and the corrosive nature of the reagents has inhibited the extension of this technology to commercial operations.

Studies on the use of chlorine-based leach systems shows that generally high reagent consumption is required with the resulting resin requiring burning to recover gold.

Of the halides, chlorine appears the most economical, however no method has been found to recover the carbon required to absorb the gold after leaching. Chlorine systems although no longer in use for treating primary ore, have been proposed for the treatment of refractory or carbonaceous ores.

Research on iodine based systems shows low consumption although iodine is an expensive reagent. The use of iodine has been proposed for insitu (in ground) gold recovery.

Limited bench top studies have been completed on bromide based systems with two experimental process systems having been developed. No commercial applications are currently in operation.

Selection of Cyanide at the Cowal Project
In common with the majority of gold mines around the world cyanide has been selected by North Limited for the recovery of gold at the Cowal Project because of its effectiveness as a leaching agent and because of the proven level of the technology.

Of the alternatives available, North Limited has ruled out halide and thiosulfate systems due to the unproven nature of the technology.

Studies were however completed in Ontario, Canada on the possible use of thiosulphate. The recovery of gold using thiosulphate was low making the use of this leaching agent uneconomic.

This testwork was conducted in May-June 1997 as part of the re-examination of the development options for the Cowal Gold Project. Samples of Cowal ore (oxide and primary) were sent to Canada for the tests.

The use of thiosulphate (as ammonia thiosulphate) was found to deliver gold recoveries at about 85% compared with expected recoveries of 93% using cyanide. The anticipated consumption and cost of thiosulphate was shown to be about 25%[1] cheaper than cyanide, however the significant reduction in gold recovery rendered the option unviable.

[1] Anticipated consumption of ammonia thiosulphate was estimated to be 10 times that for cyanide, however costs per tonne were 15 times cheaper.

2.2 Use of Cyanide at Cowal

2.2.1 Overview of Milling Process

The Cowal orebody comprises two types of ore: oxide or weathered ore, which comprises about 20% of the orebody, and primary ore, comprising about 80% of the orebody.

The process flow sheets for the treatment of oxide and primary ore are discussed in detail in the EIS (Section 2.6). In brief however, the process flow sheet for the processing of oxide ore requires crushing and grinding of the ore to a fine slurry before passing to a leach circuit where it is cyanidated. The leached gold is then adsorbed onto carbon before passing to a gold recovery circuit where in an enclosed system hot cyanide is used to remove the gold from the carbon. The gold is then plated out as a metal in electrowinning cells.

The processing of primary ore requires crushing and grinding before passing to a flotation circuit where the pyrite mineral containing the gold is concentrated before passing to the leach circuit. As approximately 92% of the mass of primary ore is removed by the flotation process a smaller leach circuit is required. The gold is won from the leach process in the same way as that for oxide ore.

The leaching circuit for the primary ore consists of eight tanks each with a capacity of about 365 m^3 measuring about 7.6 m in diameter by about 8 m high. The oxide leaching circuit contains ten tanks each with a capacity of 3,200 m^3, measuring about 16.5 m in diameter and about 16 m high. The tanks are enclosed by grilled walkways for worker access.

Oxide ore cannot be pre concentrated in any way because the gold is finely disseminated in the ore. This prevents the use of any physical concentration methods such as gravity separation. In addition there are no host minerals (eg. the pyrite that is present in primary ore) which could permit the use of chemical-based concentration methods.

2.2.2 Cyanide Flows

Figures G-1 and G-2 show the flows of cyanide for the processing of oxide and primary ores.

Cyanide will enter the site by a licensed road transport contractor direct from the manufacturer in Queensland. The cyanide will likely be in a solid briquette form packaged in either dedicated isotainers or a heavy plastic bag (capable of taking the weight of all of the 1 tonne of contents). The bag will be contained within a plywood box for additional security. Whatever the form cyanide arrives at the Project, it will be transported in accordance with government regulations for hazardous substances. On entering the site, the packaged cyanide will be either dissolved and placed into storage tanks loaded or directly into the Project's store located near the process mill area. About 200 tonnes of cyanide is expected to be in store.

The cyanide will be retrieved from the store as required, unpackaged from the plywood box and mixed in a dedicated cyanide mixing tank within a bunded area. The tank will have a capacity of about 125 m^3 sufficient to receive and dissolve about 16 tonnes of cyanide in 15 minutes. The mixing area encompasses an enclosed mixing tank and hopper.

The 1 tonne plastic bag containing the cyanide will be lowered by forklift over the hopper and onto a series of spikes which cut the bag. The hopper has a hood and once within the hopper rubber doors seal in around the forks holding the bag. Once ruptured water sprays are used to wash the solid cyanide into the mixing tank. A dust extraction system collects any fine cyanide dust from the hopper. This passes to a water extraction point which washes any dust back into the mixing tank. The dust extraction system keeps the mixing tank under negative pressure.

The cyanide solution (mixed to 30%) is conveyed to a storage tank then to the leaching circuit entering the oxide leaching circuit at three points and the primary circuit at one point. The oxide process requires more cyanide addition than that for primary ore and is required to be added in stages.

Consumption of cyanide during the primary ore processing is expected to be approximately 0.3 kg of cyanide per tonne of ore. Consumption during oxide ore processing will be about 0.8 kg/tonne of oxide ore.

On exiting the leach circuit the barren slurry (also referred to as tailings) passes to a thickener (in the case of oxide ore) or through a detoxification point before passing the thickener (in the case of the primary ore). In the case of primary ore the tails from the flotation process (that is the 95% of the ore which contains no economically recoverable gold) is recombined with the barren slurry from the leach circuit in the thickener reducing cyanide levels by a 20:1 dilution.

The thickener is designed to remove water and therefore thicken the tailings. In the case of oxide ore this process recycles about 25% of the cyanide for reuse. On exiting the thickener cyanide remaining in the oxide tailings is destroyed down to licensed levels. The primary tailings also pass through this destruction point and are treated where necessary to ensure licensed levels are met.

The tailings are transported to the tailings storage by a lined carbon steel pipeline run at ground level through a bunded corridor; the bunded area will drain back either to the thickener area or intermediate collection sumps from where it would be recovered. The tailings pipeline will be fitted with a low flow alarm linked to the central control room with automatic shutdown capability.

The hot cyanide used in the removal of gold from carbon (carbon is added to the leach circuit to adsorb the leached gold) passes to the electrowinning circuit where it is recycled.

2.2.3 Employee Safety Issues

The issues associated with the employee safety at the mill locations where cyanide will be in use include:

- the safe storage of cyanide,
- safety measures at the initial mixing point;
- safety measures at the liquor addition points; and
- safety measures above the leach tanks.

Storage of Cyanide

At the Cowal Project cyanide will be stored under cover and will be appropriately signposted and in line with hazardous chemical regulations. Rainwater contact with stored cyanide will be prevented. Cyanide will be stored away from acids and oxidising agents. Specific (non-water) fire extinguishment measures will be provided.

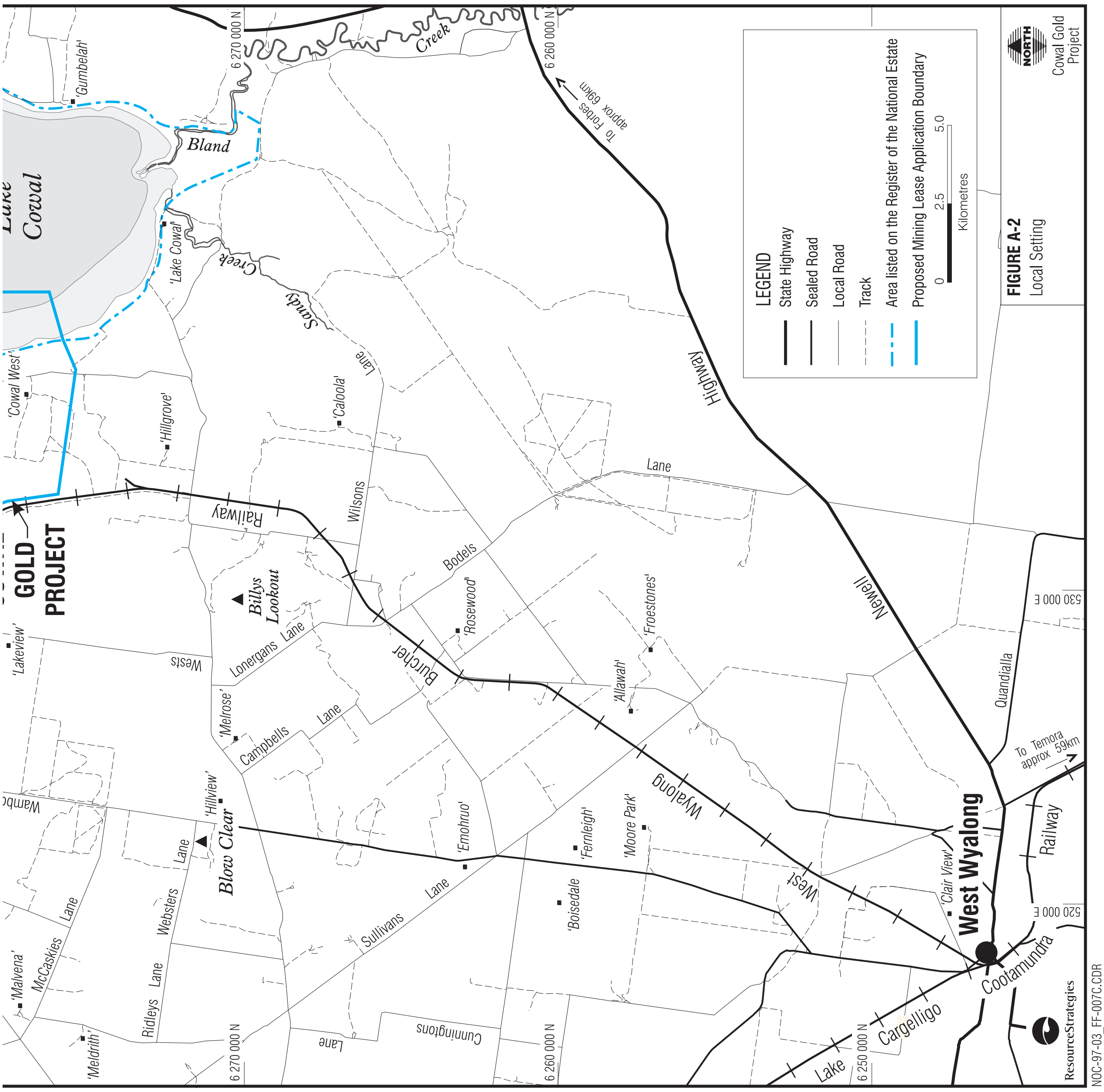

FIGURE A-2
Local Setting

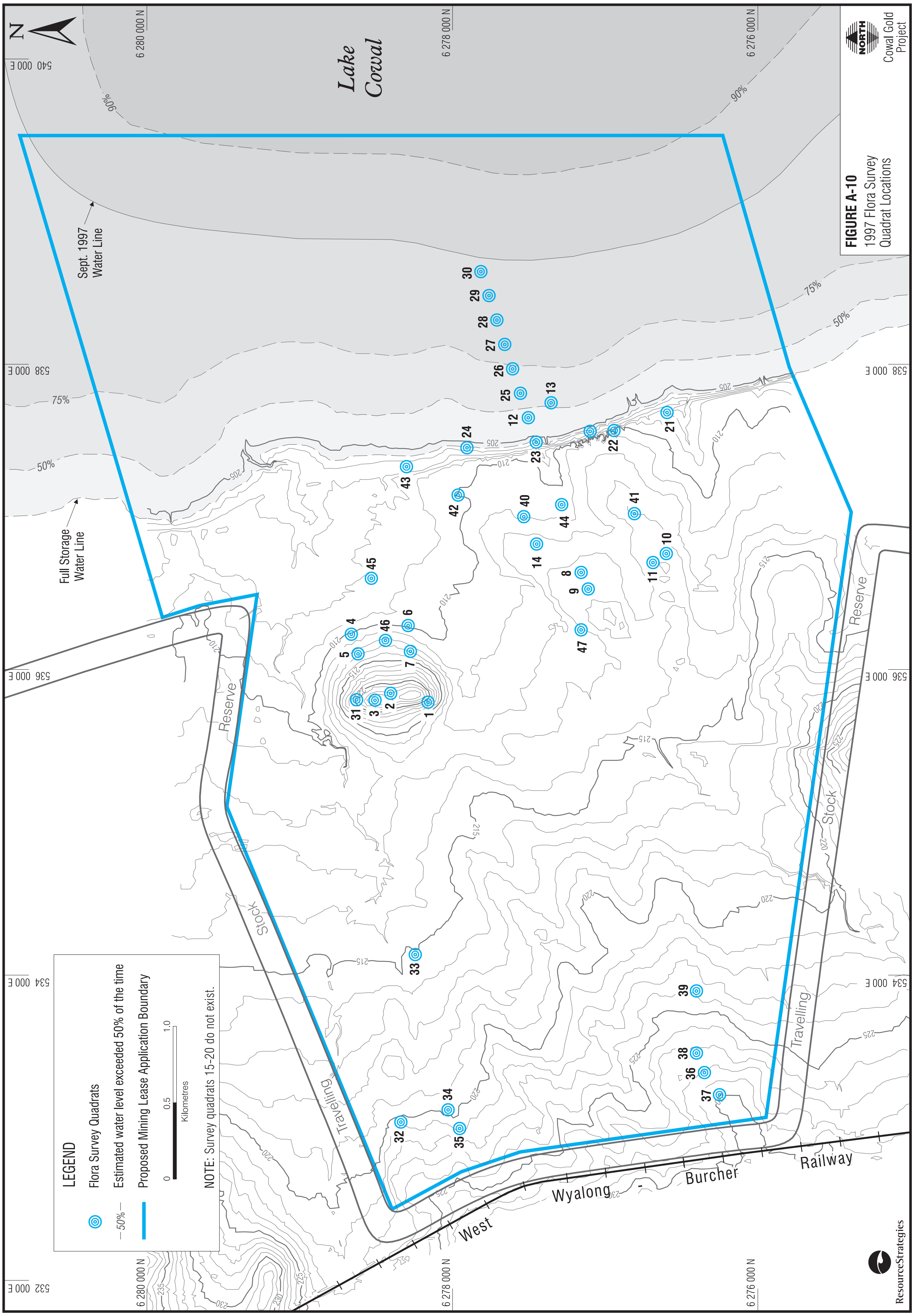

FIGURE A-10
1997 Flora Survey Quadrat Locations

Cyanide Mixing Areas
The two potential issues here are fine cyanide dust and HCN gas which might be released during mixing. Proper design can overcome dust issues combined with a mechanical handling system as proposed at the Cowal Project. The tank at the Cowal Project will also be covered and operate under negative pressure. Operators will be required to wear disposable overalls, protective gloves and a full face respirator. Only fully trained operators will be permitted to perform this function.

HCN gas risk is reduced by keeping the pH of the mixing liquor as alkaline as practicable. Empty containers will be immediately removed from the area and detoxified (usually with ferrous sulphate solution) before disposal or being returned to the supplier. A spill management and containment procedure will be in place. All staff will be trained and competency tested.

Cyanide Addition Points to Leach Circuit
The safest way to add cyanide to the leach circuit is, from industry experience, at the first leach tank or if quantities require, the second and third tanks. Adding cyanide prior to this, such as at the exit to the grinding mill increases volumes of HCN gas due to likely pH levels. All pipes carrying cyanide will be clearly labelled.

Leach Tank Areas
Typically the concentration of HCN above leach tanks at gold mines is rapidly dispersed by air currents. Nonetheless, standard industry practice is to install warning devices to alert employees to elevated HCN levels and this will be done at the Cowal Project. Levels of cyanide will be continously monitored.

2.2.4 Transport Issues

Transport issues are addressed in Appendix J. North will have in place detailed emergency response plans that involve the supplier and local authorities.

3.0 CYANIDE CHEMISTRY

3.1 Forms of Cyanide

The major forms of cyanide at the Cowal Gold Project (ranked in decreasing order of toxicity) can be classified as follows:

- Free Cyanide — CN, HCN
- Simple Compounds — NaCN, Ca $(CN)_2$
- Weak Complexes — $[Zn(CN)_4]^{2-}$, $[Cd (CN)_3]^{-}$, $[Cd (CN)_4]^{2-}$
- Moderately Strong Complexes — $[Cu(CN)_2]^{1-}$, $[Cu (CN)_3]^{2-}$, $[Ni (CN)_4]^{2-}$
- Strong Complexes — $[Fe(CN)_6]^{4-}$, $[Fe (CN)_6]^{3-}$
- Inorganic Complexes — SCN^-, CNO^-

The toxicity of cyanide generally relates to level of stability or ease to disassociate from a metal to free cyanide.

Free and Simple Forms are considered to be the most toxic forms of cyanide but are also the most readily broken down through natural degradation or destroyed by cyanide destruction methods.

Weakly to Moderately Bound forms of cyanide complex are associated with metals such as copper, cadmium, nickel and zinc. Such forms are also known as weak acid dissociable cyanide (CN_{WAD}) due to their tendency to dissociate from the metal under weak acid conditions to free cyanide. The measurement of CN_{WAD} includes CN_{FREE}.

Strongly Bound Complexes includes iron complexes. The measurement of CN_{TOTAL} measures such stable complexes as well as simple and free cyanide forms.

Inorganic Complexes includes thiocyanate and cyanate which result from cyanidation processes in leach tanks or through natural or chemical degradation of cyanide complexes.

The relationship between the different forms of cyanide is shown in Figure G-3.

3.2 Tails Chemistry at Cowal

The chemistry of the tailings from the mill after the destruction of cyanide for the Cowal Gold Project have been investigated most recently by EGi (EGi 1997).

From bench testwork by EGi, the expected pH of oxide tailings at the Cowal Gold Project is approximately 9.8 while for the recombined primary ore tailings the pH is about 9.5. The predominant metal-cyanide complexes in the tailings are Fe, Cu, and Zn. Seventy five percent of CN_{WAD} expected in the tailings is presented as CN_{FREE} and is expected to decay rapidly.

EGi report that removal of CN_{FREE} (the first cyanide component which would be removed by the destruction process) could be expected to reduce CN_{WAD} concentrations to about 5-10 mg/L in the oxide tailings liquor and 10-15 mg/L in the primary tailings liquor (as measured in the decant pond or reclaim water dam).

On cessation of use of the tailings storage EGi consider that within 2-3 months the CN_{WAD} complexes will decay to very low levels. Testwork by EGi shows ongoing cyanide transformation from Cu-CN complexes to more stable Fe-CN complexes in the entrained liquor in the tailings (ie. reactions which take place between water and particles trapped in the tailings mass). The effects of seepage from the tailings storage were modeled by Kalf (1997) and are discussed in Section 3.4.2 of this report.

It should also be noted that with the use of a flotation process in the current mill for the Cowal Gold Project, levels of cyanide above 1-5 mg/L CN_{WAD} can have a negative effect on the operation of the flotation circuit. Return water must therefore be maintained below these levels. There exists a commercial imperative to keep levels very low in the tailings storage during the processing of primary ore.

3.3 Decay Paths for Cyanide

Once cyanide enters a tailings storage, it decays through one of several decay paths. These are summarised in Figure G-4 and discussed below.

The level of cyanide as it enters the tailings storage will not exceed 30 mg/L CN_{WAD}. Cyanide from the Cowal Project mill

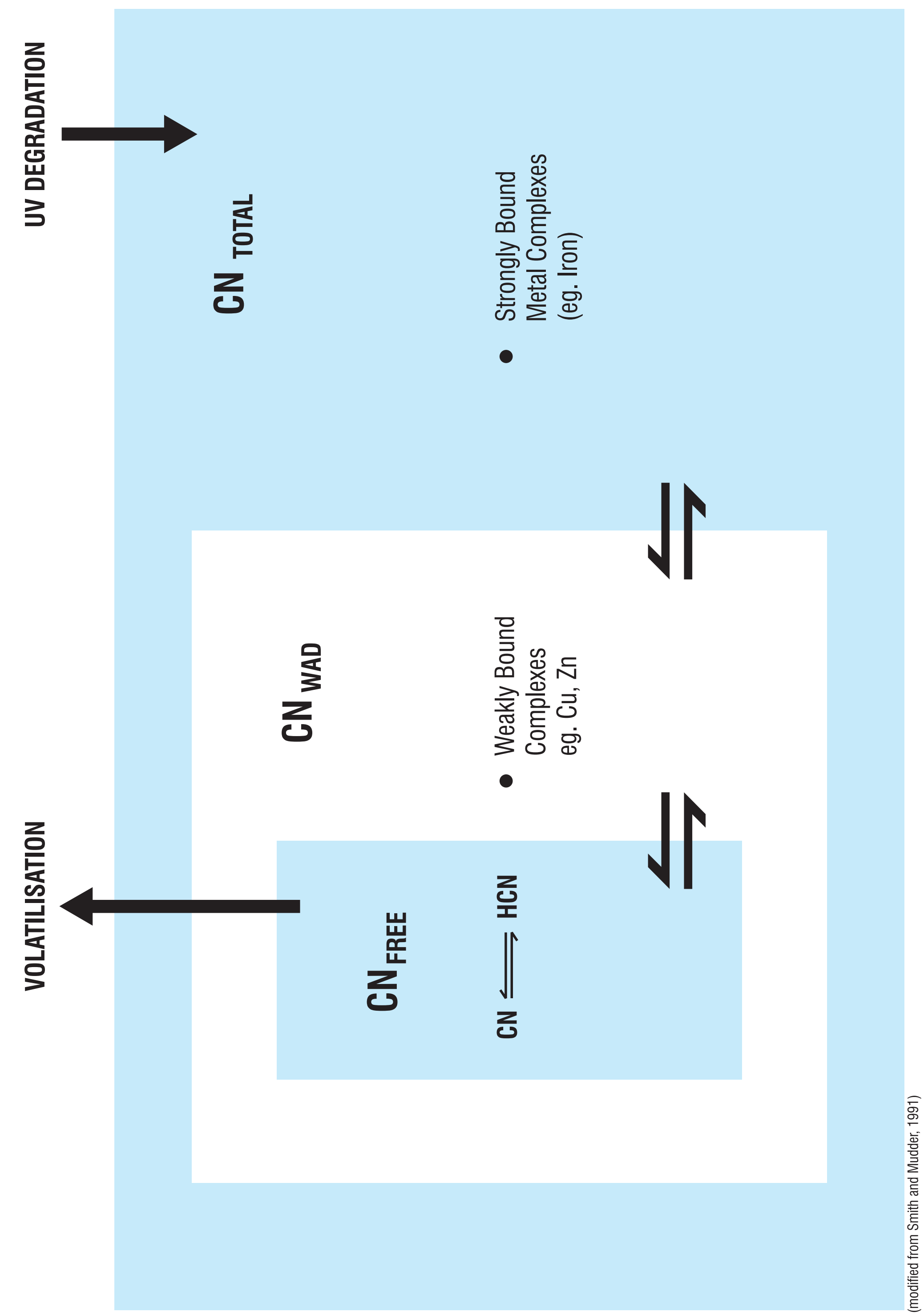

FIGURE G-3
Simplified Cyanide Geochemistry

NORTH
Cowal Gold Project

NOC-97-03_CM-001E.CDR

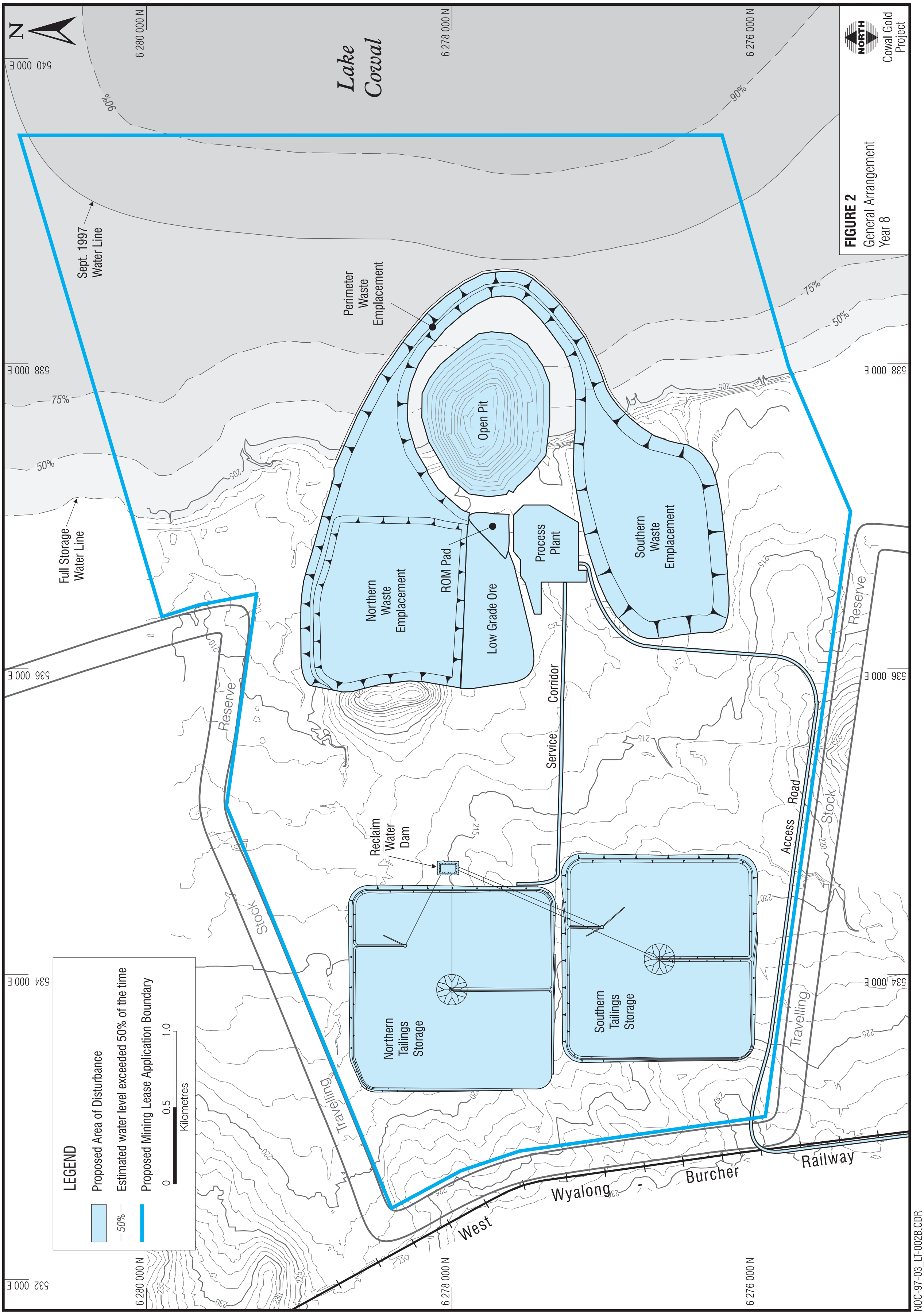
FIGURE 2
General Arrangement
Year 8
NORTH
Cowal Gold Project
Lake Cowal
N
Sept. 1997 Water Line
Full Storage Water Line
Perimeter Waste Emplacement
Open Pit
Northern Waste Emplacement
ROM Pad
Low Grade Ore
Process Plant
Southern Waste Emplacement
Service Corridor
Access Road
Reclaim Water Dam
Northern Tailings Storage
Southern Tailings Storage
Travelling Stock Reserve
West Wyalong - Burcher Railway
90%
75%
50%
540 000 E
538 000 E
536 000 E
534 000 E
532 000 E
6 280 000 N
6 278 000 N
6 276 000 N
LEGEND
Proposed Area of Disturbance
Estimated water level exceeded 50% of the time
Proposed Mining Lease Application Boundary
0
0.5
1.0
Kilometres
NOC-97-03_LT-002B.CDR

can arrive at the tailings storage in three forms, as free cyanide, as a range of cyano-metal complexes or as thiocyanate. These are interchangeable depending on the chemical make-up of the liquor in the tailings storage.

The bulk of decay happens through the process of volatilisation or release to atmosphere of very low levels of HCN from surface ponds within the tailings storage. This process occurs through a lowering in the pH of tailings pond by uptake of CO_2 from air and rainwater. It is estimated that 90% CN_{FREE} is lost through volatilsation and the rest through oxidation (Simovic *et al*, 1985).

The decay which takes place within the pond appears to be irrespective of pond depth although a slight time lag exists in deeper ponds. Volatilisation increases if a pond is stirred or mixed (eg through wind action or convection). Decay can be maximised by constructing a pond with large surface area and shallow depth. The predominant south-west wind component at the Cowal Project and the large surface area of the tailings storage is expected to benefit this process.

Other significant decay paths include:

- the association/disassociation of metal complexes and subsequent oxidation or volatilisation;
- anaerobic biodegradation to relatively innocuous non-cyanide species; and
- degradation of iron cyanide complexes by UV radiation to WAD and FREE cyanide species.

All of the decay paths lead to the immobilisation of cyanide species in the tailings mass or breakdown to less toxic species. All may be the first of a series of steps which ultimately lead to non-toxic final products (Department of Minerals and Energy, 1996).

3.4 Potential Release Paths

Possible releases of cyanide or cyanide decay products from the Cowal Project can happen through air-dispersion, seepage or from surface releases.

3.4.1 Airborne Releases

Potential airborne pathways include particulate dispersion and HCN evolution.

The potential HCN evolution points are:

- at the solids/liquid mixing point at the beginning of the mill process;
- at the open oxide leach tanks at the mill;
- on the surface of the tailings storage.

Monitors at the mixing point and on top of the leach tanks will be used to ensure HCN levels remain below threshold levels for employees. The material safety data sheet for cyanide puts the threshold limit value (TWA) of 5 mg/m^3 or 5 ppm CN_{FREE} in the air. Mudder and Smith (1994) note that the onset of minor symptoms (eg. giddiness, nausea) requires several hours of exposure at 4-8 times this threshold limit.

On the tailings storage surface, levels are expected to be well below threshold levels due to the considerable dispersion potential. It is unlikely, given the CN destruction and control techniques proposed, that HCN in the air above the tailings storage would be at detectable levels.

In terms of particulate dispersal, this can only occur if cyanide metal complexes precipitate to the dried surface of the tailings storage. However, given the decay chain for cyanide entering the storage, the only cyanide complexes likely to be available through precipitation are iron cyanates. The more likely breakdown of these complexes is through UV light whilst in solution.

3.4.2 Seepage/Leaching

Seepage and leaching relates to long term movement of cyanide from the base of the tailings.

The movement of cyanide from the tails storage through seepage into groundwater was modelled by Kalf and Associates, 1997. This modelling assumed a conservative half life for cyanide of 300 days. (Laboratory tests show half life 3.6 to 30 days (Schmidt *et al*, 1981) can be expected in the field. Burden & Kidd (1987) demonstrate 36 to 300 day half lifes in laboratory tests).

Results from the modelling by Kalf showed the maximum extent of 0.1% cyanide concentration plume (which would represent a concentration significantly less than the drinking water standard for cyanide) reached a steady state condition with cyanide decaying faster than it is being transported within eight years.

Under the most severe modelled conditions, the cyanide plume would not move more than 200 m from tailings storage. Under the most probable modelled conditions, the plume would not move significantly beyond the base of the tailings storage.

Cyanide concentrations in the tailings mass were modelled to degrade to very low levels within 10 years on cessation of deposition (at a half life of 300 days).

3.4.3 Surface Releases

Potential surface release sources could result from failure of the tailings storage embankment or overtopping. The risk of these events happening has been addressed in other sections of the Cowal Project EIS. Essentially, however, the studies reported elsewhere in the Cowal Project EIS have found that:

- the design of the tailings storage has been based around the maintenance of stability under a wide range of conditions (including severe earthquake loading) and therefore the risk of failure is extremely low;
- the design of the tailings storage provides for substantial freeboard to be maintained at all times over the operating life of the facility. In addition, site drainage has been designed to route all spillages to on-site containment structures thereby precluding any risk that tailings storage waters could be released off the site through overtopping.

4.0 CYANIDE TOXICITY

The two groups of animals which might be affected by exposure to cyanide in water at the Cowal tailings storage are birds and any animals not excluded by the fence around the tailings storage. Birds however are the only group of wildlife which are likely to arrive in significant numbers regularly at the site.

4.1 Toxicity Pathways

Cyanide in the Cowal Project's tailings storage could be either ingested by birds through drinking of water, inhaled as HCN gas or absorbed through skin contact with water or tailings slurry.

Once absorbed into the bloodstream, cyanide bonds strongly with iron, copper and sulfur which are constituents of many enzymes and proteins, in particular, the enzyme cytochrome oxidase which is essential to the utilisation of oxygen (Smith and Mudder, 1991). The inactivation of the enzyme leads to cellular asphyxiation and tissue death. Rapid damage to the central nervous system and the heart can also result from breathing high levels of cyanide over a short time which can result in respiratory arrest and death.

All available evidence suggests that cyanides are neither mutagenic, teratogenic or carcinogenic (Ballantyne, 1987). Hagelstein (1997) also notes there are no reports of cyanide biomagnification or cycling in living organisms, probably due to its rapid detoxification.

Detoxification occurs when the absorbed cyanide metabolises through transulfuration in the presence of enzymes to produce thiocyanate which is excreted. This is a rapid detoxification process and animals can ingest high sub-lethal doses of cyanide over extended period without harm (Eisler, 1991). Thiocyanate is about 120 times less toxic than cyanide however it may accumulate in tissues and has been associated with developmental abnormalities. A minor detoxification pathway is through exhalation as HCN and CO_2.

4.2 Cyanide Toxicity to Birds

The research on cyanide toxicity to birds to date (summarised in Table G-1) shows that the sensitivity to cyanide toxicity appears not to be related to size but diet. Birds which feed predominantly on flesh appear more sensitive to those which feed predominantly on plant material. The exception is the Mallard Duck, a plant eater, which appears the most sensitive of bird species examined to date. Usually toxicity data is related to amount ingested versus body mass (ie. mg/kg or similar units) as shown in Table G-1). Due to the apparent unrelatedness of cyanide ingestion to body mass for birds, toxicity levels are more frequently quoted in this instance to concentrations of cyanide, ie. mg/L.

Testing on the Mallard Duck (Fletcher, 1996, 1997 - unsighted) showed an LC_{50} value (the concentration which is lethal to 50% of the sample population) of between 181 to 212 mg/L CN_{FREE} (for tap and mine waste water). Using this data, the LC_1 value was estimated to be 50 mg/L CN_{FREE}.

Tissue specific biochemical effects of cyanide have also been studied with the Mallard Duck (Ma and Pritsos, 1997). Sub-lethal doses of 10 mg/L KCN to 80 mg/L were administered under laboratory conditions with ATP levels (adenosine triphosphate which is associated with the cellular respiratory process levels) in the brain, heart and liver measured two hours after exposure.

Ma and Pritsos (1997) found ATP depletions in the brain and liver were dose dependent. At 40 mg/L KCN, an initial decrease in all tissues occurred with a subsequent increase approaching control levels in more exposed tissue at 24 hours. In the brain levels in excess of control levels were achieved by 12 hours with a return to control levels by 24 hours.

Ma and Pritsos (1997) conclude that these studies suggest that 50 mg/L CN_{WAD} is not a safe level of cyanide in water where avian wildlife exposure can occur. A similar conclusion is reached in Pritsos and Ma (1997). Hagelstein (1997) concludes from this work that the Mallard Duck's detoxification mechanisms were not overwhelmed by cyanide, since the ATP levels returned to control levels after 24 hours exposure, and that an exposure to 40 mg/L CN_{FREE} did not impair the organisms physiological detoxification mechanisms since enzyme levels returned to control levels in 24 hours.

Reece (1997) notes that as birds do not have a bladder and a substantial amount of water excreted by the kidneys is reabsorbed via the intestinal tract, thiocyanate will be reabsorbed but considers that as thiocyanate is relatively harmless, any reabsorption will have little detrimental effect.

4.3 Toxicity of Cyanide Decay Products

4.3.1 Thiocyanate

Thiocyanate is considered considerably less toxic than free cyanide (for example the 96-hour LC_{50} for fish is 50-200 mg/L – Speyer, 1981). Free cyanide (as HCN) LC_{50} has been estimated for sensitive fish at 0.05-0.18 mg/L or about three orders of magnitude more toxic than thiocyanate.

Increased hardness of waste waters has been shown to reduce thiocyanate toxicity (Smith and Mudder, 1991).

Table G-1 Acute Oral Toxicity of Cyanide (Adult Birds)

Bird Species	LD_{50}: mg, CN/kg Body Mass for 50% Mortality of Test Population
Domestic Chicken	11.1
European Starling	9.0
Japanese Quail – female – male	 4.5 5.5
Eastern Screech Owl	4.6
Black Vulture	2.54
American Kestral	2.12
Mallard Duck	1.43

Adapted from Hagelstein, 1997 and largely based on data from US Department of the Interior, Fish and Wildlife Service, 1991 (unsighted)

Mine waste waters, such as those expected at the Cowal Project, generally exhibit elevated hardness.

4.3.2 Cyanate

Cyanate is considered more toxic to fish than thiocyanate but one-hundred fold less toxic than free cyanide. The toxicity of cyanate is reported to be at levels >100 mg/L (AMIRA, 1997). The mechanism does not seem to be due to a reduction to cyanide. Acidification and dilution of cyanate leads to hydrolysis of cyanate to the ammonium ion which is suspected to be the major cause of the toxicity of cyanate.

5.0 CYANIDE CONTROL

Cyanide can either be controlled through destruction techniques or through regeneration methods which recycle cyanide or through a combination of both.

The selection of process depends on a range of factors including:

- cyanide concentration in the tailings;
- the mineralogy of the tailings;
- the volume to be treated;
- the desired end level of cyanide;
- availability and cost of reagents;
- potentially adverse effects of resultant chemicals for wildlife and the reuse of water.

In general the greater the stability of the metal complex, the harsher the conditions that will be required to destroy the cyanide acceptable levels, although some strongly complexed (stable) compounds should not necessarily be destroyed due to their low toxicity.

A summary of the main destruction and regeneration methods and their advantages and disadvantages are shown in Table G-2. This table also shows the basic operation of the technique and the reagents used.

A recent report by AMIRA (1997) analysed twenty-one different regeneration and destruction technologies at various stages of development. The conclusions from this study are:

- On the whole, in terms of minimising environmental effects from both reagents used and reaction products, oxidative technologies (which are generally the destruction technologies) are more appropriate than non-oxidative technologies.
- The disadvantage of oxidative technologies however is that they can produce cyanate.
- Oxidative technologies are inappropriate to recovery of cyanide (because they are designed to destroy cyanide).
- On the whole, oxidative technologies are better at producing low cyanide levels.

5.1 Assessment of Control Options for Cowal

Several destruction and recovery options have been investigated by North Limited for the Cowal Gold Project between 1994 and 1997. A brief history of these studies is presented in this section. An initial assessment was made in November 1994 (Johnson, 1994) which assessed both destruction and regeneration technologies.

Two regeneration processes – cyanisorb and vitrokele – were examined but found to have high capital costs with vitrokele being at the time unproved technology. Cyanide residues from the Cowal Gold Project would also have insufficient cyanide and gold quantities to make the process economically attractive.

The Degussa/H_2O_2 and Inco processes were considered the most attractive oxidative or destruction technologies at the time of the 1995 Development Application for the mine, although additional work was required to confirm reagent consumption. In the end, Inco was identified as the preferred option due to cost considerations and performance.

Further assessment completed on the Inco process (AMMTEC, 1995), found that the process provided excellent elimination of CN_{FREE} and CN_{WAD} with modest reagent use. Residual CN_{WAD} levels of 1 mg/L could be achieved with dosing of 5 g SO_2 per g CN_{WAD} and with the addition of 10 mg/L of Cu^{2+} as a catalyst. Reagent consumption was nonetheless higher than previously expected and the process was difficult to control which could only be overcome by overdosing with reagents.

The vitrokele technology was revisited by North Limited in 1996 (Signet, 1996) finding that a net revenue was possible from the vitrokele regeneration process compared to the operating cost of cyanide destruction. The testwork however showed potential problems with contamination of the resin in the process which would require some form of cleaning. The testwork was also completed on a tails solution and not a slurry but yielded expected CN_{WAD} levels of <10 mg/L. Processing of a slurry by vitrokele treatment eventually yielded the method uneconomic.

5.2 Preferred Treatment Process

Late in 1996 the Solvay Interox Caro's acid process was proposed to North Limited for evaluation and has become North Limited's preferred control technology.

In addition to Caro's acid destruction of residual cyanide, the Cowal Project will recycle cyanide (about 25%) during the processing of oxide ore.

Previously the use of Caro's acid had been hampered by high capital costs associated with the need to remove heat from the reaction of sulphuric acid and hydrogen peroxide to produce Caro's acid prior to storage and use. A new process (trade named Efflox) however can now produce Caro's acid continuously, with no storage requirements. The absence of storage vessels and heat removal components has significantly reduced the capital costs of this technology.

Table G-2 Summary of Main Destruction and Regeneration Methods

Technique	Type	Basic Operation	Reagents	Advantages	Disadvantages
AVR (Acidification Volatilisation Reneutralisatlon)/ Cyanisorb	R	Acidification of slurry/solution, HCN is volatilised and recovered in a caustic spray, remaining solution is neutralised and passed to tailings storage.	Sulphuric Acid Lime Caustic Soda	• CN_{WAD} levels can be lowered to 10 mg/L CN_{WAD} • Heavy metals removed through precipitation • Proven technology	• Thiocyanate and strongly bound cyanide complexes not destroyed/recovered. • High capital costs. • Cost of recovered cyanide likely to be greater than cost of CN.
Vitrokele	R	Uses an ion exchange resin which is stripped in two stages - a gold solution and cyanide solution which passes through an AVR type process.	Sulphuric Acid Zinc oxide Caustic Soda Lime	• Relatively new technology • Being trialled at the May Day operation NSW	• May not be applicable to a slurry. • Not used on large scale. • Economics to be proven.
Alkaline Chlorination	D	Oxidation to destroy FREE and WAD cyanide forms. Can also remove thiocyanate, cyanate, ammonia and nitrate although noxious by-products likely.	Chlorine	• Well-established process • Can achieve low CN levels • Heavy metals precipitated	• Produces chlorinated organics considered more harmful and long lasting than cyanide. • Requires careful pH control to avoid release of cyanogen chlorine. • Cyanide in tailings slurry may not be effectively destroyed.
Biological Degradation	D	Oxidation by bacteria to free metals which are adsorbed/precipitated. Main application in the decommissioning of heap each pads.	Phosphoric Acid Soda Ash	• Simple process design and operation. • Thiocynanate and ammonia are oxidised. • Heavy metals removed through adsorption and precipitation.	• Suitable microbial populations may not be found locally. • Not well proven technology. • Temperature can affect oxidation process.
Natural Degradation	D	Uses natural processes to degrade in complexes (discussed in detail in Section 3).	None	• No known formation of new toxic by-products. • Low CN_{WAD} levels (<0.50 mg/L possible) over time.	• Large surface area required. • Oxidation effected by severe cold and sunlight. • Levels reached over time - not instantaneous.
Inco/SO_2	D	Oxidises free and complexed cyanides to cyanate in pH range 8 to 10, cyanate decomposes to CO_2 and ammonia.	SO_2 or sodium metabisulfate Copper sulfate Lime	• Does not produce toxic intermediates. • Can destroy down to low levels. • Able to destroy iron cyanides. • Heavy metals removed through precipitation. • Case history of use. • Can reduce CN levels to below 10 mg/L.	• Additional treatment may be necessary for thiocyanite, cyanate, metals and ammonia if release criteria are required. • Strict control of process variables required.
Caro's Acid	D	Caro's acid produced by reaction of hydrogen peroxide and sulphuric acid (to produce Caro's acid and water).	Hydrogen Peroxide Sulphuric Acid Lime	• Proven use. • No catalyst required. • Very fast reaction allowing tight control of treatment performance. • Can treat to very low levels. • Heavy metals precipitated from WAD cyanide complexes. • Can treat thiocyanate.	• Produces cyanate.
Degussa/H_2O_2	D	Oxidation of cyanide to cyanate by hydrogen peroxide. Thiocyanate can also be oxidised to cyanate.	Hydrogen Peroxide Copper Sulphate	• Simple process and design. • Close pH control not required. • Heavy metals reduced through precipitation. • All forms of CN (including Fe complexes) can be reduced. • Can reduce CN levels to less than 10 mg/L. • Widely used.	• Process does not remove thiocyanate. • High consumption of hydrogen peroxide in presence of sulfide mineralisation. • Relatively high cost. • Process reactions slow and requires catalyst (eg. Cu). • Adding catalyst reduces reagent efficiency.

Key R = Regeneration Method D = Destruction Method

Testwork using Caro's acid on both primary and oxide tailings from the Cowal Project showed (Solvay Interox, 1996):

- kinetics of the cyanide destruction reactions were quick (under one minute);
- higher slurry densities produced better use of reagents;
- cyanide could be treated to below committed tailings discharge levels if necessary (but with increased reagent cost);
- reactions allowed a rapid response to perturbations in treatment minimising excursions from any set limit.

With the confirmation of a flotation circuit for primary ore for the new DA for the Cowal Gold Project, batch tests were completed using Caro's acid on both oxide and primary ore.

The samples were easily treated down to about 20 mg/L CN_{WAD} with acceptable reagent consumption.

Another feature of the primary ore at Cowal of importance to cyanide breakdown is the presence of iron. Readily oxidisable forms of iron are not present to any significant extent in the oxide ore although can be elevated in the primary ore. The level of Fe-CN complexes in the final tailings stream will be dependent on the performance of the leach circuit. Sub-optimal performance of the leach circuit will increase anticipated levels of Fe-CN complexes. Fe-CN complexes will not be completely destroyed by Caro's acid. Once in the tailings storage however, it can be expected that these will breakdown through UV light effects. Once in the CN_{FREE} form research shows about 90% is removed through volatilisation (Schmidt, 1981) and that this is a rapid process.

Xanthates, which are proposed to be used in the flotation process at the Cowal Project, are expected to decay to carbonates, sulphates and carboxylic acids under the treatment of Caro's acid.

The Caro's acid system in recent years has become the chosen destruction technology for several gold mines in Nevada, USA.

5.2.1 General Control Philosophy

Two destruction points and recycling of cyanide solutions within the mill are proposed for the Cowal Project. The destruction points will be served by two dedicated Caro's acid mixing chambers which in turn will be served by a common storage vessel for the sulfuric acid (50 m^3) and hydrogen peroxide (28 m^3) (Figure G-5).

The delivery system to the Caro's acid reaction chambers will be by stainless steel hoses served by a pump and back-up pump. The regulation of the dosage (and hence draw on the primary storage levels) is by on-line CN_{FREE} measurement (ie. destruction will occur down to a CN_{FREE} level). The reaction rates in the Caro's acid mixing chamber are controlled by a temperature probe in the mixing vessel.

The concept of two Caro's acid addition points provides back-up if one system fails. During the processing of oxide ore it is proposed to have on stand-by a second destruction point at the line entering the thickener in case of failure at the detoxification point at the end of the thickener. This Caro's acid mixing chamber will be switched to the tails from the primary leach circuit during the processing of that ore.

5.2.2 Process Control

The following issues emerge in terms of ensuring that committed levels of cyanide are met at the discharge to the tailings storage:

- During the processing of oxide ore almost all cyanide will be CN_{FREE} due to no significant quantities of mobile metals available to form CN_{WAD} complexes.
- During the processing of primary ore CN_{WAD} species will be present due to elevated copper and zinc.
- No on-line methods exist for determining CN_{WAD} although approximations can be made to CN_{FREE}:CN_{WAD} levels.
- Automated samplers for determining CN_{WAD} are available however they are not an accredited analytical procedure for reporting requirements.
- The Caro's acid system will require an on-line CN_{FREE} system to ensure correct dosage and to enable system alarms and shutdown procedures to be triggered should set levels be exceeded.
- CN_{WAD} levels, for reporting purposes, will need to be tested against approved standards.
- Elevated iron cyanide complex levels may exist in the tailings storage which bypass standard destruction by Caro's acid.

The following monitoring programme is proposed to overcome these issues:

- installation of an automatic CN_{WAD} sampler after destruction point B (ie. at the discharge to the tailings storage);

Table G-3 Test Results Using Caro's Acid on Cowal Ore

Ion (mg/L)	Untreated Primary[1]	Destruction Point A[2]	Destruction Point B[3]
CN_{WAD}	56	18	23
CN_{TOTAL}	60	ND	ND
CN_{FREE}	35	6	5
Cyanate (CNO)	2	ND	74
Ammonia (NH_3)	0.3	1.9	1.4

ND Not determined 1. Flotation tailings and leach tailings have been recombined without treatment 2. Leach tailings treated with Caro's acid then recombined with flotation tailings 3. Recombined leach and flotation tailings treated with Caro's acid

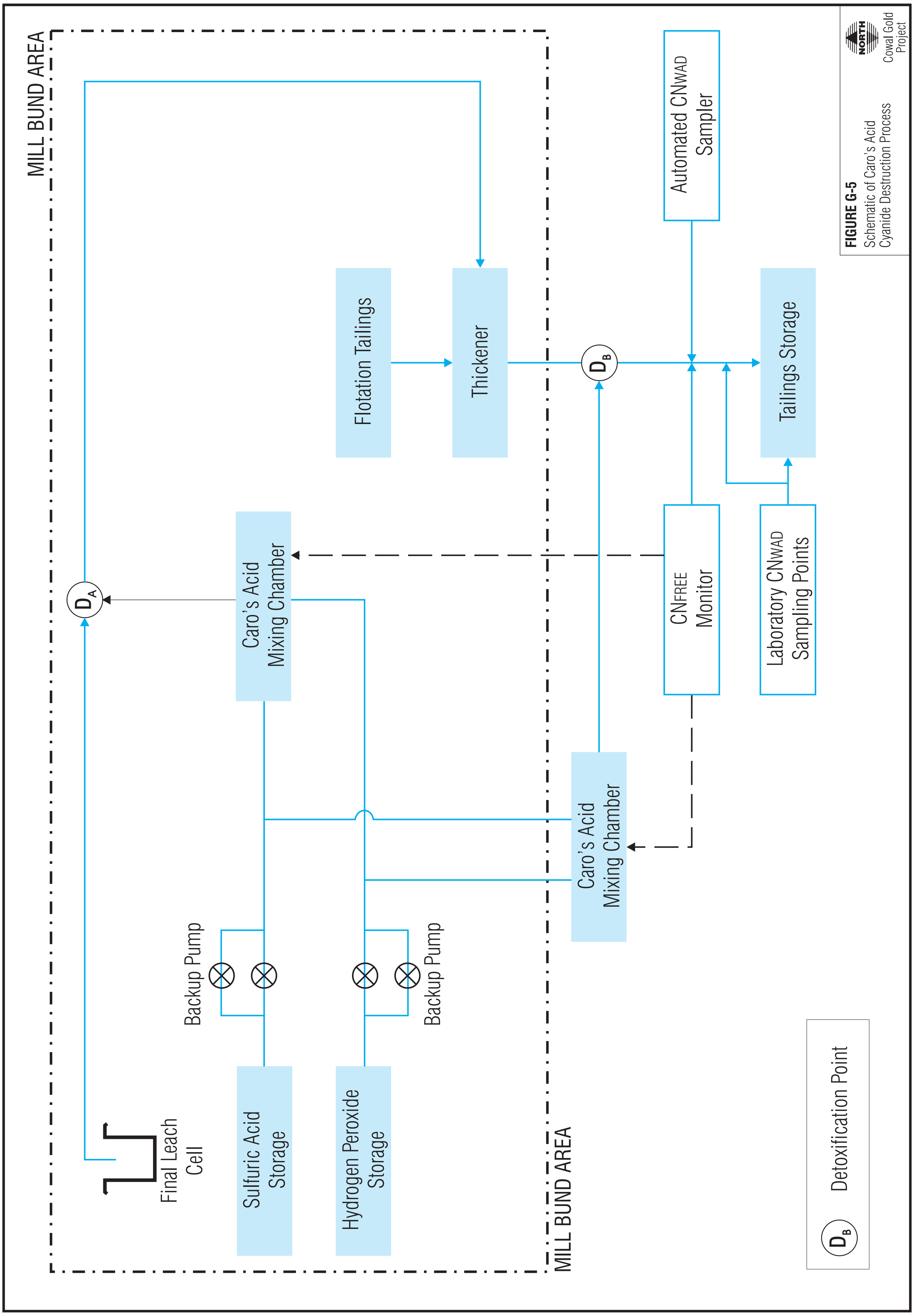

FIGURE G-5
Schematic of Caro's Acid Cyanide Destruction Process

- twice daily CN_{WAD} analysis from samples drawn at the discharge to the tailings storage and at the tailings storage to suitable accredited standards;
- on-line CN_{FREE} measurements at the destruction points;
- on start-up (ie. during commissioning, or during a changeover in mill feed from primary to oxide or transitionary ore), the operation of the Caro's acid plant to assume all CN_{WAD} is CN_{FREE} until the ratio can be established by sampling; and
- routine geochemical assays of ore feed so that the anticipated CN_{WAD} levels can be derived from known concentrations of Cu and Zn.

The chemical sampling programme would need to be matched by an observation progamme of the tailings storage which could conceivably occur when the twice daily samples are being collected from the storage.

There will however be a necessary time delay for determining CN_{WAD} levels and at all times a conservative relationship between CNFREE and CN_{WAD} will have to be assumed for the purposes of operating the Caro's acid plant.

6.0 CYANIDE REGULATION

The issue of appropriate levels of cyanide was discussed in detail at the Commission of Inquiry into the first Development Application for the Cowal Gold Project in December 1995 and January 1996.

The Commissioners noted in their report that the control level of cyanide was the major unresolved issue before the Inquiry. North Limited had built a case for a 50 mg/L CN_{WAD} discharge level based on:

- toxicological studies in the US on the Mallard duck;
- experience at US mines where a similar level was considered a rule of thumb for preventing bird deaths;
- experience at the Northparkes mine where a large number of bird deaths had been investigated providing anecdotal evidence of all but incidental bird deaths at below 50 mg/L CN_{WAD}.

The NSW EPA, in combination with NPWS and DUAP, proposed a maximum level of 30 mg/L CN_{WAD} at the discharge to the Cowal tailings storage but operating 90% of the time at below 20 mg/L CN_{WAD} . The EPA also indicated that if bird deaths occurred at this level then the level would be reviewed, possibly reduced to 5 mg/L CN_{WAD}.

In their report of March 1996, the Commission of Inquiry concluded that:

"The evidence before the Inquiry does not convince us the Company can achieve the aim of zero bird deaths as a result of cyanide toxicity if the cyanide levels in the tailings discharge is controlled to a maximum of 50 mg/L CN_{WAD}. There are too many uncertainties and the empirical data indicates otherwise. It may not be possible at the EPA's suggested cyanide level, but there would be greater certainty of achieving zero bird deaths at that level."

The Commissioners ultimately recommended that the discharge level should be a maximum of 50 mg/L CN_{WAD}.

In a press release dated 15 April 1996 and after the Inquiry had handed down its recommendation on a control level, North Limited stated it had not ruled out the EPA level. Subsequent to this North has said that it is prepared to meet the EPA level which it considers appropriate for the location of the project.

6.1 Support for the EPA Level

In its submission to the second session of the Commission of Inquiry, the EPA gave a detailed and reasoned justification for the proposed cyanide level at the Cowal Project. These points, in summary, were:

- the need for conservatism due to difficulty of setting a universal cyanide threshold for protecting birds due to highly individualistic behaviour of birds and differences between mines;
- a recognition of industry experience which indicates bird mortalities are only "virtually" eliminated at 50 mg/L CN_{WAD};
- consideration of the potential for chronic and sub-lethal effects and synergistic effects from other chemicals in tailings;
- consideration of likely natural degradation in conjunction with the attractiveness of the delta or beach habitat created near the discharge point;
- practical management and economic considerations;
- large numbers of birds which use Lake Cowal and the likelihood of the significant use of the tailings storages.

In a report prepared for North Limited, Terry Mudder, a recognised expert on cyanide management at mine developments, concluded on cyanide levels (Times, 1995) that:

"In general bird mortality was eliminated when WAD cyanide levels were reduced to below 50 mg/L. However, in a few instances mortalities were noted below this value, while no mortalities were noted above 50 mg/L and below 100 mg/L. ... The current policy in the southwestern United States is to moving toward reducing the WAD cyanide level to below 25 mg/L in ponds and impoundments which are not netted. At WAD cyanide levels below 25 mg/L bird mortality due to toxicity is considered curtailed."

In reviewing Times (1995) and assessing all available evidence, the EPA concluded before the 1995/96 Inquiry that:

"The levels determined by the EPA present a precautionary assessment of the information available and the range of uncertainty expressed in the literature and implicit in the paucity of it. The 20 mg CN_{WAD}/L 90 percentile limit was based on agreement with Mr Mudder's original conclusion that below 25 mg CN_{WAD}/L was the desirable level and that if a percentile level was set below this process fluctuations and in-pond variabilities, that is day to day fluctuations beyond the reasonable control of the operator, should not be an issue. The use of an absolute limit set significantly above the percentile limit is designed to ensure a tight management regime whilst also allowing for reasonable fluctuations.

The EPA also quoted an opinion from the Centre of Ecotoxicology, a joint EPA and University of Technology centre, supporting an upper limit of 20 mg CN_{WAD}/L. The basis of the conclusion was:

"In setting water quality criteria, safety factors are applied to acute and chronic data depending on the nature and quality of the data. In the case of only one piece of acute data being available, a safety factor of 1000 would normally be applied to the Lethal Concentration/Lethal Dose 50 value. To break this down, a factor of ten is applied to account for variation between species, a factor of ten is applied to account for chronic effects, and a further factor of ten is applied to account for extrapolation to field (community) effects.

In the present case, the application factor accounting for chronic effects may not be applicable given the short nature of avian visits to Lake Cowal. Further, avifauna appear to recover quickly from cyanide poisoning if below lethal levels. No long term damage appears to be likely though this is presently under investigation (eg. Dr Pritsos) [Ma & Pritsos, 1997 and Pritsos & Ma, 1997].

The LC_{50} values for the species potentially visiting Lake Cowal are unknown, and assuming that the Mallard Duck is the most sensitive is without scientific basis. Thus, a criterion based solely on this one species is not acceptable. The OECD (1992, 1995) recommended an application factor of 10 if only one or two acute values are available, but not if more.

Based on the LC_{50} values of between 181 and 212 mg/L for the Mallard Duck, a criterion of 20 mg/L is derived, which has a safety factor of 10 to allow for between species-variation."

The 20 mg/L level was for CN_{FREE} however the factors of safety referred to remain valid.

6.2 Physical Deterrents

Measures other than chemical reduction of cyanide have been used at mines particularly in the US. The advantages and disadvantages are listed in Table G-4.

The use of physical deterrents has generally been ruled out at the Cowal Project due to the size of the two tailings storages.

A stand-by system to scare birds off the tailings storage will be maintained.

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Table G-4 Advantages and Disadvantages of Physical Deterrents

Technique	Advantages	Disadvantages
Netting	• Proven deterrent on small tailings storages.	• Can pose hazard to birds at night. • Retrieval of birds difficult. • Expensive and structurally difficult for large tailings storages. • Visual impact.
Hazing/Propane gas guns	• Immediate success at deterring birds but needs to be varied to avoid habitation by birds.	• Noise impacts on neighbouring properties. • Can lose effect over time. • Large area to cover.
Balls in ponded areas	• Easily deployed. • Proven on small ponds only.	• Visual impact. • Large volume required. • High capital cost.
Landing decoys	• Isolated reports of success at deterring birds from landing due to take-off difficulties (eg. swans and ducks).	• May not deter all types of bird species expected.

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Appendix H

Appendix H
Noise and Blasting

Cowal Gold Project Noise, Transportation and Blasting Impact Assessment

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TABLE OF CONTENTS

TABLE OF CONTENTS Continued

LIST OF TABLES

LIST OF TABLES Continued

LIST OF FIGURES

LIST OF ATTACHMENTS

Note: **Attachments B-J (inclusive) are not included in this report.**
They contain a large number of graphs generated by statistical Summer and Winter noise level monitoring at the selected residences discussed in this report.
A sample graph is attached.
Full data sets can be obtained from North Limited (02) 6972 4500.

1.0 INTRODUCTION

Subsequent to the original Development Application for the Cowal Gold Project in 1995, Richard Heggie Associates was commissioned by Resource Strategies Pty Ltd on behalf of North Limited to undertake an assessment of noise, transportation and blasting impacts of the current proposal for the operation of a gold mine at Lake Cowal.

The sources of noise generation at the mine include a processing plant, drills, trucks and mobile earthmoving equipment. Mining methods will include blasting, resulting in the need to assess airblast and ground-borne vibration.

2.0 SITE DETAILS

The Project area is shown on the Locality Plan attached as Attachment A.

The region in which the Project area is located is part of the extensively cleared agricultural land of the Central West of New South Wales. Remnant bushland and bush regrowth occurs on rocky elevated ground, while the majority of the lower slopes and flat land has been cleared for agriculture. The Project area is cleared grazing land, with scattered remnant trees and woodland on a low hill to the west of the mine area.

Lake Cowal is a recognised bird habitat for many species that congregate when conditions suit. Bird breeding predominantly occurs in a restricted area of remnant Red Gum and Lignum habitat at the north of Lake Cowal with feeding extending to and in the Nerang Cowal. Prime breeding areas are more than 4 km away from the Project area.

3.0 PROJECT DESCRIPTION

The Project uses conventional modern mining and processing methods. The Project parameters are summarised in Table 3.1.

3.1 Construction

The following works are required before gold production commences:

- Establishment of the sound/lake protection bund, which provides hydrologic protection to the lake and sound protection around the entire perimeter of the mine, waste dumps and process plant.
- Stripping of waste from the open pit.
- Commencement of dewatering of the aquifers to be intersected by the open pit.

Table 3.1 Project Operational Parameters

Waste	128 Mt
Peak mining rate	32.8 Mt/year
Pit diameter	1000 m
Pit depth	325 m
Mine life	8 years
Mine life including low grade	13 years

- Construction of the tailings storages.
- Construction of the water supply borefield and pipeline across Lake Cowal.
- Construction of the 132-kV electricity transmission line.
- Upgrading of the access road from West Wyalong.
- Fabrication and erection of the processing plant.

3.2 Operations

3.2.1 Mining

Material to be mined will be blasted, picked up by the excavator and trucked to the process plant, low grade stockpile or waste dump.

Mining will be undertaken by specialist contractors, 7 days per week. Mining will be completed in 8 years.

3.2.2 Ore Processing and Tailings Management

Ore will be campaign-milled 24 hours per day, seven days per week, and will be processed according to type. Oxide ore will be cyanide-leached in a conventional carbon-in-leach (CIL) process. Primary ore will be upgraded by flotation to a sulphide concentrate, which will be reground ahead of cyanide leaching and CIL. Both tailings streams will be processed through a cyanide destruction plant prior to discharge at the tailings storage.

4.0 HOURS OF OPERATION

4.1 Construction

One 12 hour shift Monday to Saturday (7.00 am to 7.00 pm).

4.2 Operation

The hours of mining and processing operations will be 24 hours, Monday to Sunday (ie. 7 days per week).

4.3 Blasting

Ore and waste blasting will be confined to the following times:

Monday to Saturday 9.00 am to 5.00 pm

5.0 EXISTING ACOUSTICAL ENVIRONMENT

Ambient noise surveys were conducted in July and August 1994 in order to characterise and quantify the existing acoustical environment in the area surrounding the proposed mine site. An unattended noise logger and weather station were positioned at the base monitoring location, Residence 1 (Cowal West), for a period of 19 days. During this period, a second unattended noise logger was rotated, about four other monitoring locations, namely Residences 2 (Coniston), 3 (Lakeside), 4 (Lake Cowal) and 5 (Gumbelah). These locations were selected to be representative of the residential receiver locations in the various directions from the mine.

Table 5.1 presents the locations and durations for which the ambient noise monitoring was conducted.

In order to supplement the unattended noise logger measurements and to assist in identifying the character and duration of ambient noise sources, operator-attended surveys were also conducted at all monitoring locations at various intervals throughout the measurement period.

The ambient noise monitoring surveys were conducted in accordance with Australian Standard 1055-1989 "Acoustics - Description and Measurement of Environmental Noise" and the Environment Protection Authority's (EPA's) Environmental Noise Control Manual. An ARL environmental noise logger Model EL-015 was positioned at each location to obtain continuous statistical noise exceedance levels over 15 minute intervals. The noise loggers were calibrated before and after the survey period, with the variation in calibrated levels not exceeding ±0.5 dBA.

In addition, to quantify prevailing meteorological conditions throughout the ambient noise monitoring survey, a Monitor Sensors Automatic Weather Station Model AWS-01 was positioned at Residence 1 (Cowal West).

The measured noise levels from Residences 1 to 5 together with the measured weather conditions at Residence 1 (Cowal West) are presented in Attachment B to Attachment F respectively.

5.1 Statistical Analysis

Environmental noise levels vary with time and consequently it is necessary to describe the noise in terms of statistical descriptors. The statistical noise exceedance levels (L_{AN}) are the levels exceeded for N% of the interval period. The L_{A90} represents the level exceeded for 90% of the interval period and is referred to as the "average minimum" noise level. Similarly, the L_{A10} and L_{A1} are the levels exceeded for 10% and 1% of the time and are usually referred to as the "average maximum" and "maximum" noise level respectively. The L_{Aeq} is the equivalent continuous sound pressure level and represents the steady sound level which is equal in energy to the fluctuating level of the interval period.

The "minimum repeated" Wintertime L_{A90} background noise levels during the proposed hours of operation are presented in Table 5.1.1.

Only the survey results for Residences 2 to 5 are given in Table 5.1.1 as Residence 1 (Cowal West) will be purchased by the proponent.

Table 5.1 Ambient Noise Monitoring Locations

Residence Number	Residence	Monitoring Duration
1	Cowal West	28.7.94 to 15.8.94
2	Coniston	28.7.94 to 1.8.94
3	Lakeside	1.8.94 to 4.8.94
4	Lake Cowal	4.8.94 to 9.8.94
5	Gumbelah	9.8.94 to 15.8.94

Analysis of the ambient noise data in Attachment B to Attachment F clearly shows the noise levels falling abruptly at nightfall, ie at around 6 pm. The winter daytime and night-time periods are therefore taken as 7.00 am to 6.00 pm and 6.00 pm to 7.00 am respectively.

However, it was recognised that this may not be the situation during other seasons of the year, particularly in summer. Consequently, further ambient noise surveys were conducted in December 1994 and January 1995.

During these surveys, an unattended noise logger and weather station were positioned at Residence 3 (Lakeside) for a period of 16 days. Loggers were also installed at Residences 2 (Coniston), 4 (Lake Cowal) and 5 (Gumbelah) over the same period.

The measured noise levels and weather conditions from Residence 3 (Lakeside), together with the measured noise levels at Residences 2 (Coniston), 4 (Lake Cowal) and 5 (Gumbelah) are presented in Attachment G to Attachment J respectively.

The "minimum repeated" Summertime L_{A90} background noise levels during the proposed hours of operation are presented in Table 5.1.2. The results of all attended noise surveys are presented in Attachment K.

6.0 IMPACT ASSESSMENT PROCEDURES

6.1 Airborne Noise Emission – General Objectives

Responsibility for the control of noise emission in New South Wales is vested in Local Government and the Environment Protection Authority (EPA) which administers the *Noise Control Act, 1975*. In implementing its environmental noise control policy, the EPA has two broad objectives:

Table 5.1.1 Wintertime L_{A90} Ambient Noise Levels – Monday to Sunday (dBA)

Residence Number	Residence	Daytime (7.00 am - 6.00 pm)	Night-time (6.00 pm - 7.00 am)
2	Coniston	30	25
3	Lakeside	30	25
4	Lake Cowal	30	25
5	Gumbelah	29	27

Notes: All night-time levels are likely to have been determined by the noise logger's electronic noise floor.

Table 5.1.2 Summertime L_{A90} Ambient Noise Levels – Monday to Sunday (dBA)

Residence Number	Residence	Daytime (7.00 am - 10.00 pm)	Night-time (10.00 pm - 7.00 am)
2	Coniston	27	26
3	Lakeside	31	34
4	Lake Cowal	30	25
5	Gumbelah	31	32

a. That the noise from any single source does not intrude greatly above the prevailing background noise level.

b. That the background noise level does not exceed the level appropriate for the particular locality and land use.

6.2 Quarry Operational Noise Emission Design Goals

To assist in balancing possible adverse effects on individuals and potential benefits to the broader community arising from infrastructure development and resource use (especially in the light of its social worth or as a result of government decisions), the EPA has drafted a schedule of recommended L_{A90} background noise levels for various land-use categories. An extract from the schedule relating to the three most stringent classifications is represented in Table 6.2.1.

In order to satisfy Item a of Section 6.1, the EPA recommends that the L_{A10} noise level contribution from the source or sources under consideration should not exceed the L_{A90} background level by more than 5 dBA.

In localities where there is likely to be on-going industrial or commercial development, consideration needs to be given to the cumulative effects of noise from successive developments in order to avoid what is known as a "creeping background noise" effect.

For such situations, the EPA recommends certain planning noise levels for residential receivers. These recommended planning levels are given in Table 6.2.2.

The results of the background noise measurements at the residences surrounding the Project area are presented in Table 5.1.1 and Table 5.1.2. On the basis of these background noise levels and Table 6.2.2 (Table 20-1 from the EPA's Noise Control Manual), the recommended daytime and night-time L_{A10} design limits for noise emissions for winter and summer are presented in Table 6.2.3 and Table 6.2.4 respectively, for Monday to Sunday operations.

The L_{A10} noise level design given in Table 6.2.3 and Table 6.2.4 are based on the EPA's recommended procedures for determining L_{A90} planning levels (Table 6.2.2). However, as previously discussed, these planning level procedures are

Table 6.2.1 EPA Recommended Outdoor Background Noise Levels

Zoning Description	Time Period	Recommended Limits – L_{A90} Acceptable	Maximum
Residences in Rural Areas (Approximately R1 in AS 1055)	Day Night	45 dBA 35 dBA	50 dBA 40 dBA
Residences in Residential Areas (Approximately R1-R2 in AS 1055)	Day Night	45 dBA 35 dBA	50 dBA 40 dBA
Residences Near Industrial Areas or on Busy Roads (Approximately R1-R3 in AS 1055)	Day Night	50 dBA 40 dBA	55 dBA 50 dBA

Notes: 1. For Monday to Saturday, "day" is defined at 7.00 am to 10.00 pm 2. On Sundays and Public Holidays, "day" is defined as 8.00 am to 10.00 pm

Table 6.2.2 Recommended Procedure for Determining Planning Levels

Existing Background Noise Level at the most Sensitive Point in an Affected Residential Area	Recommended Maximum Noise Level, for Planning Approval Purposes, at that point as a Result of a Proposed New Noise Source
A. Background is above relevant acceptable level (from Table 6.2.1)	Preferably, set maximum planning level 10 dBA or more below acceptable level or at least 10 dBA below existing background level.
B. Background is at acceptable level	Set maximum planning level 10 dBA below acceptable level.
C. Background is below acceptable level by:	Set maximum planning level:
1 dBA	9 dBA below acceptable level
2 dBA	5 dBA below acceptable level
3 dBA	3 dBA below acceptable level
4 dBA	2 dBA below acceptable level
5 dBA	2 dBA below acceptable level
6 dBA or more	5 dBA above background level

Table 6.2.3 EPA Acceptable L_{A10} Contributed Noise Level Design Goals for Wintertime- Monday to Sunday (dBA)

Residence Number	Residence	Daytime (7.00 am - 6.00 pm)	Night-time (6.00 pm - 7.00 am)
2	Coniston	35	33
3	Lakeside	35	33
4	Lake Cowal	35	33
5	Gumbelah	35	33

Table 6.2.4 EPA Acceptable L_{A10} Contribution Noise Level Design Goals for Summertime – Monday to Sunday (dBA)

Residence Number	Residence	Daytime (7.00 am - 10.00 pm)	Night-time (10.00 pm - 7.00 am)
2	Coniston	35	33
3	Lakeside	36	25
4	Lake Cowal	35	33
5	Gumbelah	36	32

only recommended for localities where there is likely to be ongoing industrial or infrastructure development in order to reduce the cumulative effects of noise from successive developments. On this basis it is not essential that consideration be given to this occurring in the area surrounding the Project area. However, in order to err on the side of conservatism, it is our recommendation that the L_{A10} design goals presented in Table 6.2.5 be adopted for the purpose of noise impact assessment during the proposed hours of operation Monday to Sunday.

The daytime and night-time design goals in Table 6.2.5 are based on the EPA's procedure for establishing acceptable design goals with the assumption that the summertime background noise levels at Residence 3 (Lakeside) and Residence 5 (Gumbelah) would often fall below the measured levels of 34 dBA and 32 dBA respectively, shown in Table 5.4, resulting in a design limit of 33 dBA for both residences.

6.3 Noise Limits and Noise Emission Variability

The NSW EPA is currently reviewing guidelines in relation to noise emission from industry. At present, the EPA appears to have no definitive position in regard to permissible levels of noise emission under various (non-neutral) weather conditions.

There is an awareness that some marginal exceedances of "nominal" noise level limits may not cause any appreciable adverse impact, provided the margins of exceedance are small, and/or their frequency of occurrence is not too great.

Nevertheless, it is important to have some knowledge of the particular weather patterns likely to prevail at a particular site, so that some degree of statistical analysis can be performed to determine the relationships between weather and noise emission variations, and their consequent acoustical impacts.

As stated in Section 6.2, the widely-adopted methodology used in NSW during the EIS process for arriving at the L_{A10}(15minute) noise level limits set out in this clause of the Consent is described in Chapters 19, 20 and 21 of the EPA's Environmental Noise Control Manual (ENCM).

The Environmental Noise Control Manual makes no mention of the weather conditions under which compliance with the "planning levels" derived using this methodology should occur.

It is generally recognised that weather conditions cause significant variations in noise emission levels over the relatively long propagation distances to residences near mining developments. It seems reasonable to assume therefore that the EPA's L_{A10} noise planning levels (derived from Chapters 19, 20 and 21 of the ENCM) apply to an "average" type situation, since the applicable weather conditions are unidentified. Conversely, it would be unreasonable to require compliance with these limits under all weather conditions.

Until further guidance is issued by the EPA, the current ENCM methodology may be interpreted as setting L_{A10}(15minute) planning noise emission limits for neutral atmospheric conditions, in light of the following:

- Under neutral atmospheric conditions (still air, no temperature inversion and moderate air temperature, or under certain combinations of temperature gradients and wind), there is effectively no enhancement or diminishing of noise propagation. Under "adverse" weather conditions (eg temperature inversions and/or light downwind breeze), received noise levels will be higher than those prevailing under neutral atmospheric conditions. Under "favourable" weather conditions (eg a light wind blowing from receiver towards the noise sources and/or temperature lapse conditions) received noise levels will be lower. Noise levels under neutral conditions are therefore probably representative of an "average" situation.
- The computer modelling tools enabling noise emission calculations to be readily performed for various weather conditions have become available only relatively recently, whereas the methodology for setting noise planning levels contained in the Environmental Noise Control Manual has remained in place and unchanged for 15 years. It is therefore highly likely that the original intent of the methodology was to address the "average" weather-related noise propagation conditions for which calculation algorithms were available at that time (recognising that noise emission levels would still be affected by weather, and would sometimes be higher than and sometimes lower than the noise design goals for "average" conditions).
- This interpretation is consistent with that used in recent Conditions of Consent for coal mines in NSW, which have clearly stated that the consent noise limits apply for neutral (or "average") weather conditions.

Table 6.2.5 Recommended L_{A10} Contributed Noise Level Design Goals – Monday to Sunday (dBA)

Residence Number	Residence	Winter Daytime (7.00 am - 6.00 pm)	Winter Night-time (6.00 pm - 7.00 am)	Summer Daytime (7.00 am - 10.00 pm)	Summer Night-time (10.00 pm - 7.00 am)
2	Coniston	35	33	35	33
3	Lakeside	35	33	36	33
4	Lake Cowal	35	33	35	33
5	Gumbelah	35	33	36	33

A new mining operation should therefore be required to comply with the EPA L_{A10}(15minute) planning noise limits under neutral atmospheric conditions, recognising that actual weather-affected L_{A10}(15minute) noise emission levels will sometimes be lower than these "neutral" levels, and sometimes higher.

Again, it must be understood that while the Consent condition requires compliance with limits under "neutral" atmospheric conditions, this compliance could be "computed", based on monitoring results conducted in other than neutral weather conditions.

6.4 Effects of Noise on Wetlands Bird Life

No firm policy or guidelines exist as to the noise levels considered acceptable, or conversely, the level or character of noise that may disturb or otherwise affect the feeding or breeding pattern of wetland birds.

In order to determine the extent of acceptable noise limits on the wetland birds, the National Parks and Wildlife Service (NP&WS) was contacted, and a set of possibly relevant technical references was supplied. A computer-based literature search of DIALOG and other scientific databases was also conducted.

After review of these references, and particularly a paper by the NSW Department of Agriculture and Fisheries (Poole 1982) and a study by the Swedish University (Algers *et al* 1978) on the effect of continuous noise on animals, it was concluded that birds tend to accept and/or adapt to constant steady noise levels, even of a relatively high level in the order of 70 dBA. Poole 1982 found that continuous exposure to higher noise levels (from 70 dBA to 85 dBA and above) may cause some degree of behavioural changes in birds (non specific to species).

Observations of behaviour patterns also indicate tolerance to intermittent, moderate level noise events such as road traffic.

Sudden loud or impulsive or impact noises may be capable of causing birds to become startled, which if repeated in the longer term, may affect feeding and possibly breeding habits in some bird species. However, a more detailed assessment of potential impacts of noise emissions on avifauna is provided in Section 6.8 of the Species Impact Statement (Appendix A).

6.5 Blast Emissions Criteria

6.5.1 Vibration Effects on Structures

Guidelines from Australian Standard 2187

The vibration velocity "damage" criteria recommended in the Standards Association's Explosives Code, AS 2187:Part 2-1993, vary according to the type of building and are defined in terms of peak particle velocity (PPV), as shown in Table 6.5.1.1.

The potential for damage in residential areas starts to increase at ground vibration levels above 10 mm/s (peak particle velocity). Structures which may be particularly susceptible to ground vibration (eg heritage buildings and the like) should be examined on an individual basis. Peak particle velocity may not be the appropriate criterion for determination of damage. In the absence of a particular site-specific study which may determine the appropriate damage criterion, peak particle velocity is suggested as the damage criterion and a maximum level of 5 mm/s is recommended for blast design purposes, as experience has shown that damage is unlikely to occur at ground vibration levels below this level.

The actual levels of vibration induced by sources outside a building are a function of the particular ground conditions, the foundation/footing interaction, location of the receiver within the building and the nature of the building and its floor and walls, as well as the magnitude of the vibration generated by the source.

Guidelines from DIN 4150

German Standard DIN 4150:Part 3-1986 "Structural vibration in buildings. Effects on structures" provides guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 6.5.1.2.

The minimum "safe limit" of peak vibration velocity at low frequencies for commercial buildings and buildings of similar design is 20 mm/s (Group 1). For dwellings and buildings of similar design and/or use it is 5 mm/s (Group 2) and for structures which may be particularly sensitive to ground vibration, such as historic buildings with preservation orders (Group 3), it is 3 mm/s. This latter criterion could also be applied to buried archaeological artefacts.

It should be noted from Table 6.5.1.2 that levels higher than these minimum figures for low frequencies may be quite "safe", depending on the frequency content of the vibration.

It should also be noted that these levels are "safe limits", up to which **no damage** due to vibration effects has been observed for the particular class of building. "Damage" is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

Table 6.5.1.1 Recommended Peak Particle Velocity – AS 2187.2 (1993)

Type of Building or Structure	Particle Velocity (Vp)
Houses and low-rise residential buildings; commercial buildings not included below	10 mm/s
Commercial and industrial buildings or structures of reinforced concrete or steel construction	25 mm/s

Source: Australian Standard 2187: Part 2-1993

Note: 1. This table does not cover high-rise buildings, buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals, or buildings housing scientific equipment sensitive to vibration. These require special considerations which may necessitate the taking of additional measurements on the structure itself, to detect magnification of ground vibrations which might occur within the structure. Particular attention should be given to the response of suspended floors.

2. In a specific instance, where substantiated by careful investigation, a value of peak particle velocity other than that recommended in the table may be used.

Should such damage be observed without vibration levels exceeding the "safe limits" then it should be attributed to other causes. DIN 4150 also states that when vibration levels higher than the "safe limits" are present, it does not necessarily follow that damage will occur.

The levels of tactile human perception to vibration are well below the "damage" levels specified by Group 3 in DIN 4150 for the most sensitive of structures. This comparison assists in giving an understanding of the relationship between human response to vibration and perceived potential for damage. It is obviously quite likely that people will be able to detect vibration at levels much lower than those required to cause even superficial damage to the most susceptible class of building.

Guidelines from BS 7385

In terms of the most recent relevant vibration damage criteria, British Standard 7385:Part 2-1993 is a definitive standard against which the likelihood of building damage from ground vibration can been assessed.

Although there is a lack of reliable data on the threshold of vibration-induced damage in buildings both in countries where national standards already exist and in the UK, BS 7385: Part 2 has been developed from an extensive review of UK data, relevant national and international documents and other published data. The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration which are considered in the standard include blasting (carried out during mineral extraction or construction excavation), demolition, piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

As strain imposed on a building at foundation level is proportional to the peak particle velocity but is inversely proportional to the propagation velocity of the shear or compressional waves in the ground, this quantity (ie peak particle velocity) has been found to be the best single descriptor for correlating with case history data on the recurrence of vibration-induced damage.

The guide values from this standard for transient vibration judged to result in a minimal risk of cosmetic damage to residential buildings and industrial buildings are presented numerically in Table 6.5.1.3 and graphically in Figure 6.5.1.1.

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 6.5.1.3, and major damage to a building structure may occur at values greater than four times the tabulated values.

Table 6.5.1.2 DIN 4150 – Structural Damage – Safe Limits for Building Vibration

		Vibration Velocity in mm/s			
		At Foundation At a Frequency of			Plane of Floor of Uppermost Storey
Group	Type of Structure	Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (eg buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Source: German Standard DIN 4150:Part 3-1986

Note: For frequencies above 100 Hz, the higher values in the 50 Hz to 100 Hz column should be used

Table 6.5.1.3 Transient Vibration Guide Values for Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse: 4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 6.5.1.3 should not be reduced for fatigue considerations.

It is noteworthy that extra to the guide values nominated in Table 6.5.1.3, the standard states that:

"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."

6.5.2 Airblast – Structural Damage

Based largely on work carried out by the US Bureau of Mines, the US Office of Surface Mining has presented the following regulatory limits for airblast from blasting (depending on the low frequency limit of the measuring system):

Low Frequency Limit	Peak Airblast Level Limit
2 Hz or lower	132 dB (Linear)
6 Hz or lower	130 dB (Linear)

These levels are generally consistent with the level of 133 dB (Linear) nominated in AS 2187.2-1993.

The US criteria are structural damage limits based on relationships between level of airblast and probability of window breakage, and include a significant safety margin. It has been well documented that windows are the elements of residential buildings most at risk to damage from airblast from blasting.

While cracked plaster is the type of damage most frequently monitored in airblast complaints, research has shown that window panes fail before any other structural damage occurs (USBM, RI 8485-1980). The probabilities of damage to windows exposed to a single airblast event are as shown in Table 6.5.2.1.

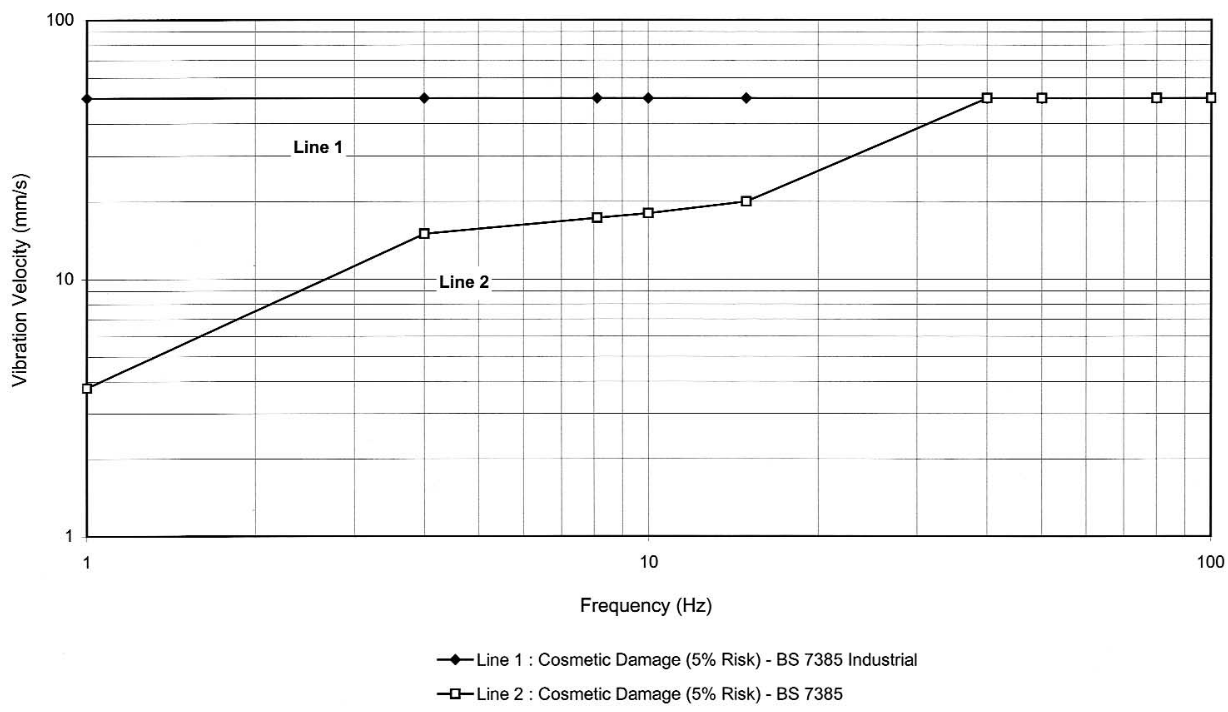
6.5.3 Human Comfort and Disturbance Considerations

The ground vibration and airblast levels which cause concern or discomfort to residents are significantly lower than the damage limits. Humans are far more sensitive to some types of vibration than is commonly realised. They can detect and possibly even be annoyed at vibration levels which are well below those causing any risk of damage to a building or its contents.

Table 6.5.2.1 Probability of Window Damage from Airblast

Airblast dBLinear	Level kPa	Probability of Damage	Effects and Comments
140	0.2	0.01%	"No damage" – windows rattle
150	0.6	0.5%	Very occasional failure
160	2.0	20%	Substantial failures
180	20.0	95%	Almost all fail

Figure 6.5.1.1 Graph of Transient Vibration Guide Values for Cosmetic Damage



The recommended criteria for blasting in NSW, based on human discomfort, are contained in the EPA's Noise Control Manual (Chapter 154). The limiting criteria for the control of blasting impact at residences is reproduced in Table 6.5.3.1.

Figure 6.5.3.1 illustrates this difference in susceptibility by comparing widely accepted human disturbance criteria (BS 6472) with various threshold damage levels (DIN 4150, US Bureau of Mines, BS 6472 and BS 7385).

Airblast exceedance is to be limited to 120 dB (Linear) for not more than 5% of the total number of blasts.

Ground vibration exceedance is to be limited to 10 mm/s (PPV) for not more than 5% of the total number of blasts.

The Australian Standard 2187.2-1993 does not give human comfort criteria for ground vibration from blasting. It does however make mention of human comfort level for airblast in saying that "A limit of 120 dB for human comfort is commonly used".

Note: The 95 dB to 105 dB airblast levels set down by the EPA for extended hours or weekends are considered overly restrictive, and are lower than the thresholds at which building occupants would perceive any appreciable effect of the blast event. Should blasting be anticipated to occur during periods when these limits would apply, then application should be made to the EPA (with supporting technical data), for a variation in the limits.

6.6 Effects of Blasting on Wetlands Birdlife

Of the ground vibration and airblast associated with blasting at the Cowal Gold Project, only airblast has the potential to affect birds. Further information on airblast effects was therefore sought.

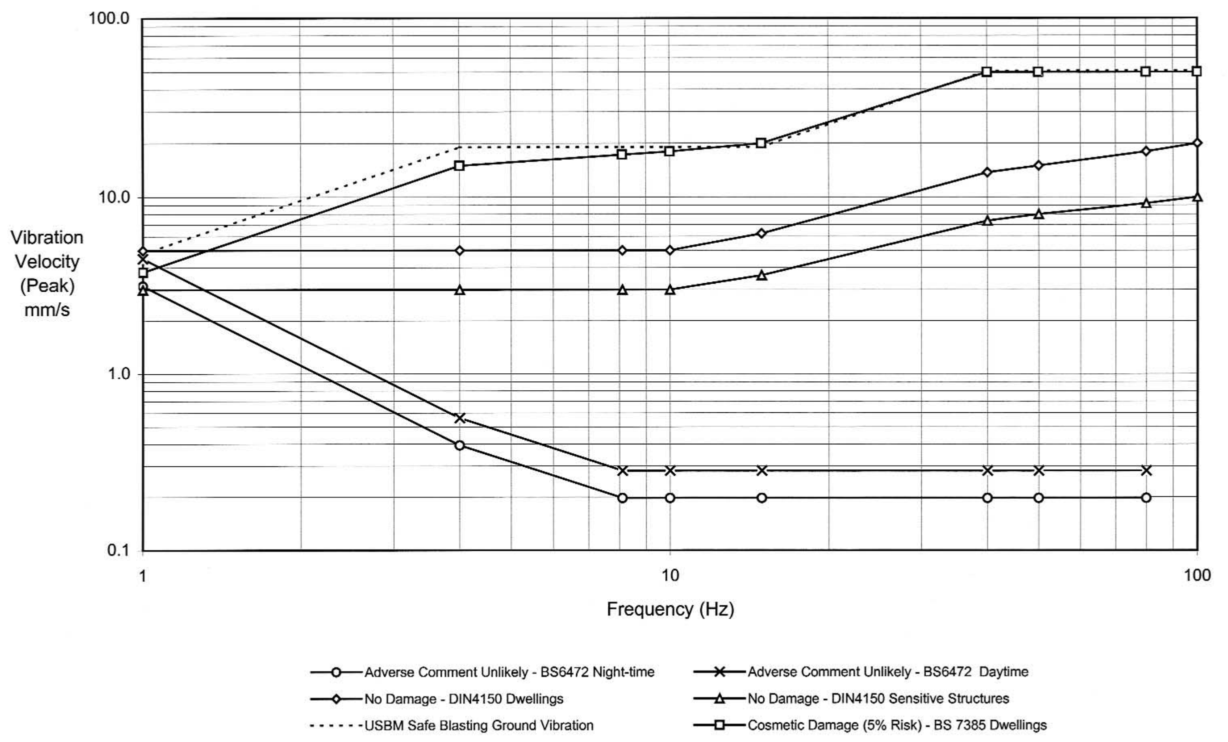
The most extensive relevant studies found were those of the effects of sonic booms from aircraft on poultry (sonic booms being similar in character to airblast from blasting). A study by Heinemann (1970) investigated the effects of sonic booms on eleven poultry farms all having two or more poultry barns housing over 10,000 birds in each.

Over 600 low-level missions were flown which produced sound pressure levels of 85 dB to 140 dB in the barns. During the overflights the bird community stopped their

Table 6.5.3.1 Limiting Criteria for the Control of Blasting Impact at Residences

Time of Blasting		Airblast (dBLinear)	Ground Vibration, Peak Particle Velocity (mm/sec)
Monday – Saturday	0900 hrs to 1500 hrs	115	5
Monday – Saturday	0600 hrs to 0900 hrs 1500 hrs to 2000 hrs	105	2
Sunday and Public Holidays Any day	0600 hrs to 2000 hrs 2000 hrs to 0600 hrs	95	1

Figure 6.5.3.1 Human Disturbance Criteria and Building Damage Limits



Notes: BS 6472 "Adverse Comment" disturbance criteria are for continuous vertical vibration at point of entry to body DIN 4150 "No Damage" threshold criteria are peak particle velocity on building footings BS 7385 5% Risk of Cosmetic Damage criteria are peak particle velocity on building footings (or in ground nearby) US Bureau of Mines Safe Blasting criteria are peak particle velocity in the ground.

usual activities and exhibited what could be termed an "alert" reaction. They quietened down, attempted to locate the source of the noise, and then either maintained their position or moved away from the area from which the aircraft was approaching. When flock "movement" occurred it was never a panicky stampede but merely a shift of the flock away from the approach-side of the building.

Young chicks tended to move a greater distance in response to the approaching aircraft than did broiler-sized birds in larger flocks. Crowding and piling up was never a problem. No injured, smothered, or crushed birds were ever seen falling on overflight.

There was no evidence from production records that egg production, weight gains, feed efficiency or flock mortality were altered by the aerial operations.

A second study, by Stadleman (1958), showed that aircraft noise of 96 dB inside an incubator and 131 dB outside caused no damaging effects to eggs. Sounds of 115 dB did, however, interrupt the setting tendencies of broody hens. His experiments with day-old broiler chicks continuing through to market age showed no adverse effect from recorded aircraft noise.

6.7 Road Traffic Noise Design Goals

Whilst operating on privately owned property, the noise assessment procedure for road traffic noise is as previously outlined in Section 6.2. That is, the predicted L_{A10} noise contributions are added to the predicted L_{A10} noise level of the items of processing plant and mobile equipment. On public roads, different noise assessment criteria apply.

The EPA's criteria for traffic noise on public roads having volume flows of less than about 1000 vehicles per day are described under the section "Intermittent or Low Traffic Flow" in their Manual and employ an $L_{Aeq,T}$ descriptor. The time interval generally used is 60 minutes.

For rural situations the EPA recommends that residences should have an $L_{Aeq,T}$ of not more than 50 dBA for new developments and 55 dBA for existing situations during daytime hours. An $L_{Aeq,T}$ 5 dBA below these levels is generally acknowledged as applicable to night-time hours (10.00 pm to 7.00 am).

The preferred hours of operation for truck movements as recommended by the EPA are:

Monday to Saturday	7 am - 6 pm
and at other times:	
6.00 am - 7.00 am 6.00 pm - 10.00 pm	"Substantially reduced frequency"
10.00 pm - 6.00 am	"Minimal or isolated occurrence"

Based upon the foregoing, the design goals for road traffic noise at residences along the access roads to the Cowal Gold Project are an $L_{Aeq,T}$ level of 50 dBA for daytime vehicle movements with an $L_{Aeq,T}$ level of 45 dBA recommended for any vehicle movements between 10.00 pm and 7.00 am.

7.0 MAJOR SOURCES OF EMISSION

The major sources of noise and vibration emissions may be grouped into four distinct areas for the purpose of impact assessment and are as follows:

- Noise emission from mobile plant and equipment during the construction phase.
- Noise emission from mining operations including fixed processing plant and mobile equipment.
- Ground vibration and airblast emissions resulting from blasting operations.
- Noise emission from Project associated traffic on public roads.

8.0 MINE NOISE IMPACT ASSESSMENT

8.1 Evaluation of Noise Emission Levels – General Discussion

In order to determine the acoustical impact from mining operations, a computer model was developed incorporating the significant proposed noise sources, the surrounding terrain and nearby potentially affected residences.

The Cowal Gold Project computer model was prepared using RTA Software's Environmental Noise Model (ENM for Windows Version 3.06), a commercial software system developed in conjunction with the NSW Environment Protection Authority. Although the present state of knowledge in respect to atmospheric propagation and ground effects is incomplete, the acoustical algorithms utilised by this software have been endorsed by the Australian and New Zealand Environment Council and all State Environmental Authorities throughout Australia as being one of the most appropriate currently available.

The model was used to predict the maximum contributed noise emission levels in octave bands from each source to the receiver locations considered potentially most affected by the mining Project. All initial calculations were based on "neutral" atmospheric conditions (ie 20°C, 70% relative humidity, 0°C/100 m temperature gradient and 0 m/s wind speed).

8.2 ENM Noise Model Data

Development of the noise level predictions were based upon specific noise measurements supplemented by file data of mobile equipment and fixed processing plant conducted at other sites, together with computer generated cross-sections of the terrain surrounding the proposed processing and pit areas. The noise level data were incorporated into the computer model to derive the maximum noise levels at the respective receiver locations from the concurrent operation of all processing plant and mobile equipment.

Attached as Attachment L is the ENM noise model data sheet which provides the following information:

a. The year of Project and number of items of plant and equipment operating.

b. A description of fixed plant and mobile equipment.

c. The operating location for each item during each development stage.

d. The overall "A" weighted sound power level for each item.

e. The linear octave band sound power level for each item.

Topographic sections were computer generated from the digitised plan to determine the noise levels for the mobile equipment operations during the construction stage of Year -1 and for the mobile equipment and processing plant in Years 3 and 8 of the mining operations.

The noise levels were developed as "maxima", assuming all plant was operating simultaneously. Based on monitoring of noise emissions from large mining developments, the difference between the L_{Amax} and L_{A10} noise levels can be up to 10 dBA. Here, a conservative reduction of 5 dBA was applied to convert the L_{Amax} noise levels to L_{A10} levels in accordance with EPA assessment requirements.

The schedule of plant and equipment operations for the various operational scenarios modelled are shown in Attachment L. The total overall A-weighted sound pressure levels have been determined at the four nearby representative residences/residential areas.

Based on the maximum overall sound power levels given in Attachment L, the contributed L_{A10} noise emission levels are presented in Table 8.2.1 for typical operations during the construction phase and mining stages of the Project.

Also presented in the table are the respective noise level design goals (from Table 6.2.5).

Notwithstanding the fact that the noise level design goals apply to neutral atmospheric conditions (see Section 6.3), further to the preliminary noise level predictions given in Table 8.2.1, predictions were subsequently made for a 1.5 m/s wind blowing from the noise sources towards the receiving residence and a 3°C/100 m temperature inversion, each together with an air temperature of 20°C and relative humidity of 70%. The predicted noise levels under these adverse weather conditions are given in Table 8.2.2.

Reference to Table 8.2.1 and Table 8.2.2 indicates that at all the closest representative receivers and receiver areas, the predicted L_{A10} noise levels comply with the respective daytime and night-time noise level design goals under neutral and adverse weather conditions.

8.3 Noise Contour Diagrams

The contributed L_{A10} noise level contour diagrams for the construction phase (Year -1), and Year 3 and Year 8 mining stages are presented in Attachment M under neutral and adverse weather conditions.

8.4 Mine Noise Impact on Wetlands Bird Life

As discussed in Section 6.3, research has found that birds tend to accept and/or adapt to constant steady noise levels, even if a relatively high level in the order of 70 dBA. It was also found that continuous exposure to higher levels (70 dBA to 85 dBA and above) may cause some degree of behavioural changes in birds (non specific to species).

In the subject Project noise levels have been predicted at various distances from the near edge of Lake Cowal for the various phases of the construction and mining operations, under adverse weather conditions (1.5 m/s wind).

Table 8.2.1 Predicted L_{A10} Noise Contributions under Neutral Conditions Construction Year -1 and Mining Year 3 and Year 8

		Predicted L_{A10} Noise Contribution – dBA			Recommended L_{A10} Design Goal – dBA			
		Construction	Mining		Winter		Summer	
Residence Number	Location (Resident)	Year -1	Year 3	Year 8	Daytime (7 am - 6 pm)	Night-time (6 pm - 7 am)	Daytime (7 am - 10 pm)	Night-time (10 pm - 7 am)
2	Coniston	16	11	21	35	33	35	33
3	Lakeside	20	10	19	35	33	36	33
4	Lake Cowal	16	14	13	35	33	35	33
5	Gumbelah	19	9	11	35	33	36	33

Table 8.2.2 Predicted L_{A10} Noise Contributions Under Adverse Weather Conditions

		Predicted L_{A10} Noise Contribution – dBA					
		3°C/100 m Inversion			1.5 m/s Wind		
		Construction	Mining		Construction	Mining	
Residence No.	Location	Year -1	Year 3	Year 8	Year -1	Year 3	Year 8
2	Coniston	24	22	27	26	26	31
3	Lakeside	22	20	24	25	23	28
4	Lake Cowal	24	20	19	25	22	22
5	Gumbelah	20	16	15	21	17	17

These noise levels are presented in Table 8.4.1.

It can be seen from Table 8.4.1 that the maximum operational noise level at approximately 1.5 km, the closest conceivable bird breeding area of significance on Lake Cowal, under adverse weather conditions, is 53 dBA. This level is clearly well below (more than 7 times lower than) the level of 70 dBA above which some degree of environmental changes in birds have been observed and is therefore not likely to have any adverse impact on the wetlands bird life.

Table 8.4.1 L_{Amax} Noise Levels Across Lake Cowal

Project Phase	Distance From Lake Edge Closest to Operations/L_{Amax} Noise Level (1.5 m/s wind) – dBA						
	1.5 km	2 km	4 km	5.5 km	6 km	7 km	10 km
Construction (Year -1)	53	44	35	29	30	26	25
Mining (Year 3)	45	38	31	27	26	23	22
Mining (Year 8)	44	37	32	28	27	23	22

Table 9.1.1 Typical Existing Blast Design Details

Blast Design Parameter	Typical Dimension
Number of Holes	170
Number of Rows	5
Hole Diameter	165 mm
Hole Inclination (to vertical)	10°
Bench Height	10 m
Burden	5 m
Spacing	6 m
Subdrill	1.5 m
Stemming Depth	3.0 m
Delay Timing	Nonel
Column Explosive	ANFO Slurry
Powder Factor	0.71 kg/bcm
Maximum Instantaneous Charge (MIC)	213 kg

9.0 BLAST EMISSIONS IMPACT ASSESSMENT

9.1 Proposed Blasting Practices

The proposed method of material extraction (ore and waste) is by drill and blasting techniques as described in Section 3. A summary of the blast design details are presented in Table 9.1.1.

9.2 Blast Emission Levels

The maximum production rate will be approximately 36 million tonnes per annum. A proposed production blast design has therefore been developed to meet this production rate. The production blast design is attached as Attachment N.

The blast pattern, consisting of five rows of 34 holes, has been designed to fragment approximately 51,000 m^3 of material and allows one blasthole per delay producing a maximum instantaneous charge (MIC) of 213 kg.

By adopting the suggested blast design, the level of blast emissions can be predicted using Figure J3 of AS 2187-1993, applicable to free face blasting in "average field conditions ". A similar approach is advocated by ICI Australia in regard to prediction of airblast emissions. The relevant formulae used are as follows:

PVS = 1140 (R/Q ^0.5)^-1.6

dB = $164.2 - 24(\log_{10} R - 0.33 \log_{10} Q)$

Where,

PVS = Peak Vector Sum ground vibration level (mm/s)

dB = Peak airblast level (dB Linear)

R = Distance between charge and receiver (m)

Q = Charge mass per delay (kg)

Table 9.2.1 Predicted Levels of Blast Emission

Residence	Distance from Blasting	PVS Ground Vibration Velocity	Peak Airblast
Coniston	4.7 km	0.11 mm/s	95 dB Linear
Lakeside	5.1 km	0.10 mm/s	94 dBLinear
Lake Cowal	5.7 km	0.08 mm/s	93 dB Linear
Gumbelah	7.2 km	0.06 mm/s	90 dB Linear

Figure 9.2.1 Peak Vector Sum Ground Vibration

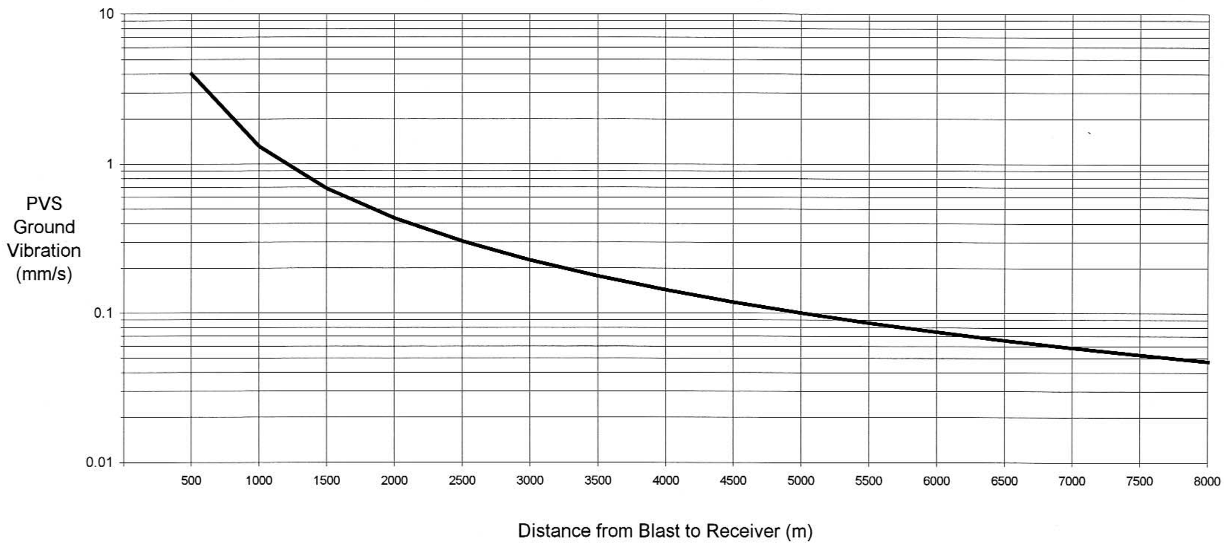
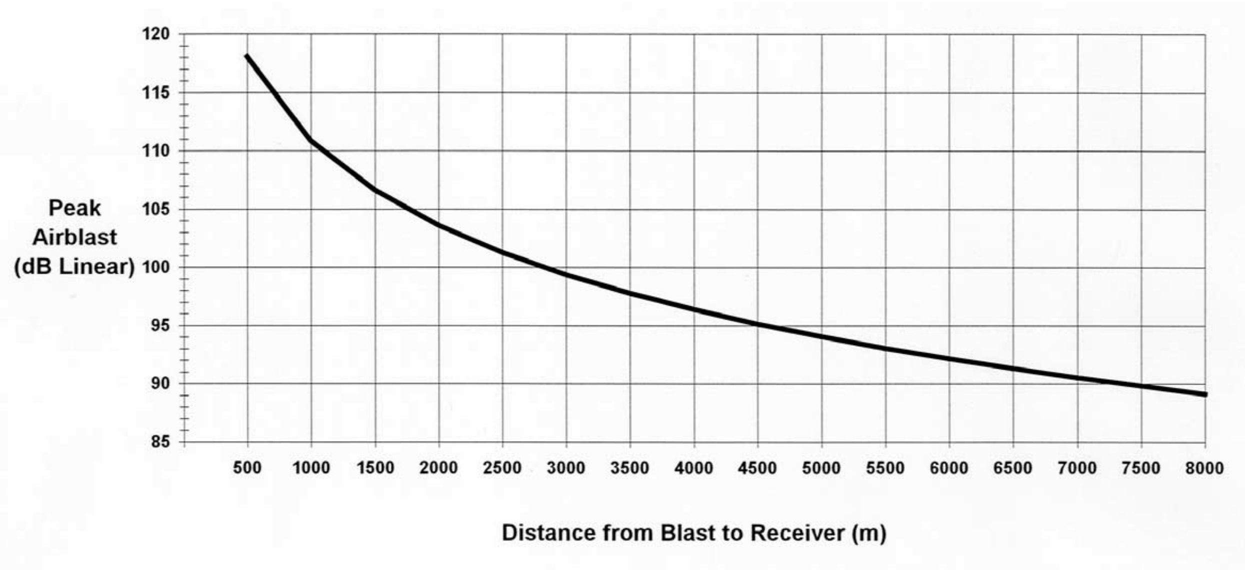


Figure 9.2.2 Peak Airblast



The relationship between distance and the peak vector sum (PVS) ground vibration and peak airblast from blasting on the subject site are presented in Figure 9.2.1 and Figure 9.2.2 respectively, for a maximum instantaneous charge weight of 213 kg.

The predicted level of blast emissions at the nearest potentially affected properties can be determined using the appropriate distances to extractive areas provided in Table 9.2.1. The predicted levels of PVS ground vibration velocity and peak airblast based on an MIC of 213 kg are presented in Table 9.2.1 for the blast location in closest proximity to the property.

The following information is derived from the predicted levels of blast emissions given in Table 9.2.1:

a. The predicted levels of ground vibration at all nearby properties comply with the EPA human comfort criterion of 5 mm/s.

b. The maximum predicted ground vibration level of 0.11 mm/s occurs at Coniston and clearly complies with even the stringent structural damage criterion recommended for historic buildings of 3 mm/s to 5 mm/s.

c. The predicted levels of peak airblast at all properties comply with the recommended EPA general human comfort criterion of 115 dB Linear.

d. The predicted levels of peak airblast are therefore well below the US Bureau of Mines structural damage limit of 132 dB Linear (2 Hz cut off).

e. In the event that blast emission levels may, at times, exceed the predicted levels, it is recommended that a thorough blast emission monitoring programme be implemented for the proposed mine development.

f. The predicted level of airblast at 1.5 km from the proposed blasting (the closest conceivable bird breeding area of significance on Lake Cowal) is 107 dB Linear.

This level of airblast is 45 times and 16 times respectively lower than the maximum levels of 140 dB and 131 dB measured in the studies of the effects of blasting on birds given in Section 6.6.

10.0 ROAD TRAFFIC NOISE IMPACT ASSESSMENT

The US Environment Protection Agency's method for the prediction of $L_{Aeq,T}$ was employed to calculate the $L_{Aeq(1hour)}$ noise level for vehicle movements generated during construction and during the normal operation of the mine. Table 10.1 shows the estimated vehicle movements under normal operating conditions.

In summary, the total construction phase traffic generation will be as given in Table 10.1.

As indicated by the figures in Table 10.1, a peak hour generation of about 37 vehicles will be generated by the site during busy construction periods. These will generally be inbound in the morning and outbound in the afternoon.

Correspondingly, the total traffic generation during peak years of normal mine operation, as adopted as a worst case for assessment purposes, will be as given in Table 10.2.

As shown in Table 10.2, the site generates a total of 140 vehicle trips per day, including all classes of vehicles. The vast majority of this traffic will travel between West Wyalong and the mine site. Specifically, a total of 90 vehicle trips per day will travel exclusively to and from West Wyalong, with the balance of 50 vehicle trips per day being dispersed generally throughout the region, including 32 car and 18 truck movements daily.

The distribution of the external traffic has taken account of major townships in the region, while the distribution of truck trips has been based on detailed information from North Ming relating to the source of individual consumables. In this regard, it is evident that of the 24 daily truck trips, 6 are sourced from West Wyalong, 2 are sourced from Gladstone, and the remaining 16 are sourced from Sydney.

In terms of the peak hourly traffic generation during mining, Table 10.2 indicates that there would be a total of 51 vehicle trips.

Based on Table 10.1 and Table 10.2, the peak hour traffic generation for the construction and mine operational phases expressed as vehicle type are:

Construction Phase

Trucks = 1 per hour
Buses = 10 per hour
Light Vehicles = 26 per hour

Mine Operations

Trucks = 2 per hour
Buses = 6 per hour
Light Vehicles = 43 per hour

Approximately 30 residences are situated adjacent to the vehicle access route between West Wyalong and the Project area, at offset distances of between 30 m and 1,100 m from the roadway. The closest 18 residences nominated in Table 10.3 and Table 10.4 are shown on the figures given in Attachment O, together with their offset distances.

The $L_{Aeq(1hour)}$ noise levels were calculated at the offset distance of the closest residences to the access route for the combined peak hourly vehicle trips (or passbys) of trucks and buses during the construction phase, ie 11 passbys, together with 26 light vehicle passbys. The results of these calculations are shown in Table 10.3.

The corresponding $L_{Aeq(1hour)}$ noise levels during the mine operational phase are given in Table 10.4, together with the maximum permissible number of heavy vehicle movements per hour to comply with the recommended 50 dBA "daytime" and 45 dBA "night-time" design goals.

The calculation of the $L_{Aeq(1hour)}$ was based upon an average noise level of 85 dBA at 7 m from passing heavy vehicles and of 73 dBA at 7 m from light vehicles travelling at an average speed of 100 km/h.

Review of the results in Table 10.3 for the construction phase indicates that the daytime design goals are met at all residences adjacent to the roadway. It is not proposed to conduct construction works at night.

From the results shown in Table 10.4, it is apparent that the recommended design goals are met during daytime at all receiver locations for the estimated maximum vehicle trips (or passbys).

During the night-time, heavy vehicle movements should be limited to five per hour to ensure that the 45 dBA design goal is not exceeded at the three residences located 30 m from the access route.

Table 10.1 Construction Phase Traffic Generation

Scenario	Vehicle Type	Vehicle Trips In	Vehicle Trips Out	Vehicle Trips Total
Daily trips (vehicle/day)	Mini buses (12 seater)	10	10	20
	Employee Cars	25	25	50
	Visitor Cars	5	5	10
	Trucks	2	2	4
	Total Daily trips	**42**	**42**	**84**
Hourly Trips (am peak hour) (vehicle/hour)	Mini buses (12 seater)	10	–	10
	Employee Cars	25	–	25
	Visitor Cars	1	–	1
	Trucks	1	–	1
	Total Hourly Trips	**37**[1]	**–**[1]	**37**

Note 1: These flow directions are generally reversed in the pm peak period, with workers departing the site at the end of the shift.

Table 10.2 Maximum Operational Phase Traffic Generation

Scenario	Vehicle Type	Vehicle Trips In	Vehicle Trips Out	Vehicle Trips Total
Daily trips (vehicle/day)	Day Worker Cars	36	36	72
	Shift Worker Cars	7	7	14
	Mini Buses	10	10	20
	Visitors	5	5	10
	Trucks	12	12	24
	Total Daily trips	**70**	**70**	**140**
Hourly Trips (am) (vehicle/hour)	Day Worker Cars	36	–	36
	Shift Worker Cars	3	3	6
	Mini Buses	3	3	6
	Visitors	1	–	1
	Trucks	1	1	2
	Total Hourly Trips	**44**	**7**	**51**

Table 10.3 Predicted $L_{Aeq(1hour)}$ Noise Levels from All Road Traffic during Construction

Receiver Offset Distance	No of Residence	Combined $L_{Aeq(1hour)}$ Noise Level
30 m	5	49 dBA
50 m	7	46 dBA
75 m	4	43 dBA
100 m	2	42 dBA

Table 10.4 Predicted $L_{Aeq(1hour)}$ Noise Levels from All Road Traffic and Maximum Permissible Heavy Vehicle Passbys during Mine Operations

Receiver Offset Distance	No of Residences	Combined $L_{Aeq(1hour)}$ Noise Level	Maximum Allowable Truck Passbys Daytime	Maximum Allowable Truck Passbys Night-time
30 m	5	49 dBA	15	5
50 m	7	45 dBA	31	10
75 m	4	42 dBA	56	18
100 m	2	41 dBA	86	28

11.0 EFFECTS OF METEOROLOGY ON NOISE LEVELS

11.1 Wind Effects

Steady light to moderate winds produce higher noise levels downwind, and lower noise levels upwind from a given source than in still air due to two factors. The first effect at a source directly downwind or upwind is that the attenuation at a given receptor is equivalent to that in still air at a distance determined by the difference between the sonic velocity and the wind velocity. As sonic velocity is 344 m/s, the velocity difference and this effect are relatively small.

The second effect, caused by the wind velocity profile in a vertical plane, has a greater effect, and causes refraction of sound radiated at small angles above the horizontal. Some of the upward-directed sound returns to ground level at some distance away, thereby focussing and increasing the sound intensity at that location.

Strong winds tend to increase local ambient noise, due to turbulence or movement of trees and shrubs, which can mask noise from more distant sources.

A steady, gentle breeze of less than about 1.5 m/s can enhance noise levels without increasing background noise levels, whereas winds of higher velocity tend to increase background levels and obscure other noise sources. Downwind, winds of velocities up to about 1.5 m/s can enhance noise levels by in the order of 5 dBA relative to still conditions. Conversely, noise levels up wind may be reduced by a similar amount.

Airblast is similarly affected by an increase in wind velocity with altitude. The rate of change of sound speed with altitude modifies the wave front as it propagates from the blast and creates the path that the wave front will follow.

A difference of 5 dB may occur within a 180 degree range in location to the wind direction at the same distance to the blast site.

11.2 Vertical Temperature Gradients

Air temperature normally decreases with altitude, a condition known as temperature lapse. Conversely, a temperature inversion occurs when a layer of air has its temperature increasing with altitude, or at the boundary between a lower cool layer and a higher warm layer.

Four types of inversion are commonly described: radiation, subsidence, turbulence, and frontal.

Radiation inversions result from cooling of the ground on a clear night, with associated radiant cooling of a layer of air near the ground.

Subsidence inversions result from descent of air over a large area such that the upper layers descend further than, and therefore are heated more than, the lower descending layers. This implies an anticyclone, with the inversion above divergent flow at low levels.

Turbulence inversions result from mixing of a layer of stable air near the ground, due to wind flow around rough terrain. The inversion is formed at the interface between the layers.

Frontal inversions are part of either a cold front, as cold air wedges under a warm air mass, or a warm front, as warm air overrides a cooler air mass.

Radiation inversions are normally surface inversions, while the other types are usually upper inversions. It is possible to have simultaneous inversions at different levels.

The acoustical effect of temperature inversions is due to the increase of sonic velocity with increased air temperature. In a temperature lapse condition, sound rays will be refracted upwards, and there will be a decrease in received sound intensity at a distant location on the ground.

Under temperature inversion conditions, air temperature increases with altitude, and sound rays are diffracted downwards. This causes focussing of sound intensity at some radius from the source, and an increase in received sound levels.

Low to moderate intensity inversions typically produce a significant acoustical effect at distances of 1 km to 2 km or more from the source. More intense inversions have a significant effect at 300 m to 400 m, and may have an effect at long distance, depending on the depth of the inversion layer. Only surface (ie radiation) inversions are significant at shorter ranges.

Radiation inversions are broken by thermal instability in the inversion layer, due to solar heating of the ground. As the inversion breaks, warmer air from above is mixed down into the inversion layer. In winter, inversions commonly break by mid to late morning but can last all day if the upper atmosphere becomes overcast. The break-up is commonly experienced as a very cold morning which becomes quite mild in mid-morning. It can be seen in winter when the brown haze trapped in a distinct layer rapidly spreads to higher levels at some time in the morning. In summer, radiation inversions normally break up within 2 hours to 3 hours after sunrise.

In winter, radiation inversions are normally associated with drainage flows. The drainage flow is modified by topography and the extent of this effect would depend on the depth of the inversion layer.

Wind and temperature inversion effects generally apply to all noises, except that inversions appear to affect low frequency sound more than higher frequency sound.

Airblast levels at certain points can be raised by the focussing effects occurring with a temperature inversion. Alternatively sound shadow zones may occur in warmer conditions (towards the middle of the day), in which the airblast levels are lower than would be expected.

Since temperature inversions normally appear at night and disperse an hour or two after sunrise, blasting should not be conducted during these periods.

Under extremely adverse temperature inversion conditions, an increase of between 8 dB and 20 dB may be possible at a radius of 2 km or more from the blast site. Similarly, low cloud cover 'reflects' sound waves increasing their intensity on the ground. This is possibly due to the existence of atmospheric temperature gradients which occur in the presence of cloud cover, rather than a true "reflection". Consequently blasting on the subject site will only be conducted between 9.00 am and 5.00 pm, after dispersion of temperature inversions.

12.0 QUALITATIVE NOISE IMPACT ASSESSMENT

In the process of assessing the likely noise impacts from industrial operations in qualitative terms, consideration has been given to our current appreciation of the EPA's noise amenity criteria, and also taking account the following:

- The high level of variation of mine noise emissions due to changing operational and atmospheric conditions. The noise model predictions have been conducted for specific "snapshots" of mining activity, however it must be appreciated that conditions are actually constantly changing. In general, measurements and predictions attempt to identify the typically worst case circumstances, and actual emission levels should therefore be somewhat lower than the reported levels for a significant proportion of the time.
- The high level of variation between the noise sensitivity of individuals and their responses to mine noise emissions. In general, EPA "amenity criteria" are usually set at a level where 10% of the exposed population would be "highly annoyed". In practice, this "level" is somewhat difficult to define numerically, given the great variations in noise levels, sensitivities, quarry operations, seasonal effects, etc.

In quantitative terms, the relative levels of impact can be based (as far as practical) on the following:

- Mine noise emissions which no more than marginally (1 dBA to 2 dBA) exceed the recommended (neutral conditions) design goals throughout the life of the Project, under most atmospheric conditions, would be acceptable to most people and therefore corresponds to a subjectively "Negligible" noise impact.
- Mine noise emissions with a moderate (3 dBA to 4 dBA) level of exceedance of the recommended (neutral atmospheric) design goals with an approximate frequency of occurrence of 20% would generally be acceptable to most people and therefore corresponds to a subjectively "Low" noise impact.
- Mine noise emission with an appreciable (5 dBA to 7 dBA) level of exceedance of the recommended (neutral atmospheric) design goals throughout the life of the Project, with an appropriate frequency of occurrence of 20%, would generally be acceptable to some people but may be unacceptable to others and therefore corresponds to a subjectively "Moderate" noise impact.
- Mine noise emissions with a significant (8 dBA or greater) level of exceedance of the recommended (neutral atmospheric) design goals throughout the life of the Project, with an approximate frequency of occurrence of 20% or more, would generally be unacceptable to most people and therefore corresponds to a subjectively "High" noise impact.

13.0 CONCLUSION

An assessment of the noise and blasting impacts on surrounding rural properties from the proposed Cowal Gold Project has been undertaken.

An evaluation of the ambient noise environment has determined the acceptable contributed L_{A10} noise levels from construction and mining operations at residences surrounding the proposed site. These levels range from 35 dBA to 36 dBA for daytime and 33 dBA for night-time.

An assessment of noise emission levels for construction and mining operations, during Years -1, 3 and 8, to the respective receivers has been conducted assuming concurrent operation of all items of mobile equipment and processing plant under still and adverse meteorological conditions. The contributed L_{A10} noise emission levels at all rural residential properties comply with both the daytime and night-time noise level design goals, with a maximum level of 31 dBA at Residence 2 (Coniston) under adverse weather conditions.

The potential noise impact of the subject operations on the closest conceivable bird breeding area of significance on Lake Cowal has also been assessed as 53 dBA. The maximum noise level (of 53 dBA) is over 7 times lower than the level of 70 dBA above which research indicates that some degree of behavioural changes has been observed. Noise from the construction and mining operations is therefore not likely to have any adverse impact on the bird life.

The levels of ground vibration and airblast have been predicted for the proposed ore and waste blasting operations. Compliance with the EPA's recommended general human comfort criteria for ground vibration and airblast are predicted to be met a distances of 435 m and 670 m respectively. All residences are located greater than 4.5 km from the pit, blast emissions at all surrounding residences consequently clearly comply with the EPA criteria. The potential blast emission levels at the closest residence, Residence 2 (Coniston), are 0.1 mm/s (ground vibration) and 95 dBA Linear (airblast).

The predicted maximum level of airblast, at approximately 1.5 km is between 16 times and 45 times lower than those used in studies on the effects of blasting on birds, at which no effects were observed.

Calculations of noise emissions from road traffic associated with the Cowal Gold Project were conducted using the US Environment Protection Agency's method for the identification of the $L_{Aeq(1hour)}$ at receiver locations along the access route between West Wyalong and the Project area.

The results of the calculations show that, for the proposed vehicle movements during daytime and at night, the $L_{Aeq(1hour)}$ design goals of 50 dBA (daytime) and 45 dBA (night-time) are met at all residences except the five residences situated 30 m from the road, where a 4 dBA exceedance of the night-time design goal is predicted.

On the basis of this assessment, it is apparent that the proposed development of the Cowal Gold Project will not result in a significant reduction in the existing acoustical amenity of surrounding rural residences located beyond the proposed land acquisition area. In addition, the Project is not likely to have any adverse effects on the wetland bird life on Lake Cowal.

14.0 REFERENCES

Australian Standard 1055-1989, "*Acoustics – Description and Measurement of Environmental Noise*".

Australian Standard 2187.2-1993, "*Explosives – Storage, Transport and Use, Part 2: Use of Explosives*".

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Environmental Noise Control Manual, NSW Environment Protection Authority (EPA), 1994.

Noise Control Act, 1975.

"*Effects of Sonic Booms on the Hatchability of Chicken Eggs and Other Studies of Aircraft – Generated Noise Effects on Animals in Physiological Effects of Noise*", Heinemann, J.M. (1970) Edited by B.L. Welch, A.S. Welch, Plenum Press, New York – London, 307.

"*Sound Advise*", Poole G, Poultry Notes, NSW Department of Agriculture and Fisheries, July 1982.

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"*Structures Response and Damage Produced by Airblast from Surface Mining*", US Bureau of Mines, Report of Investigations 8485, 1980.

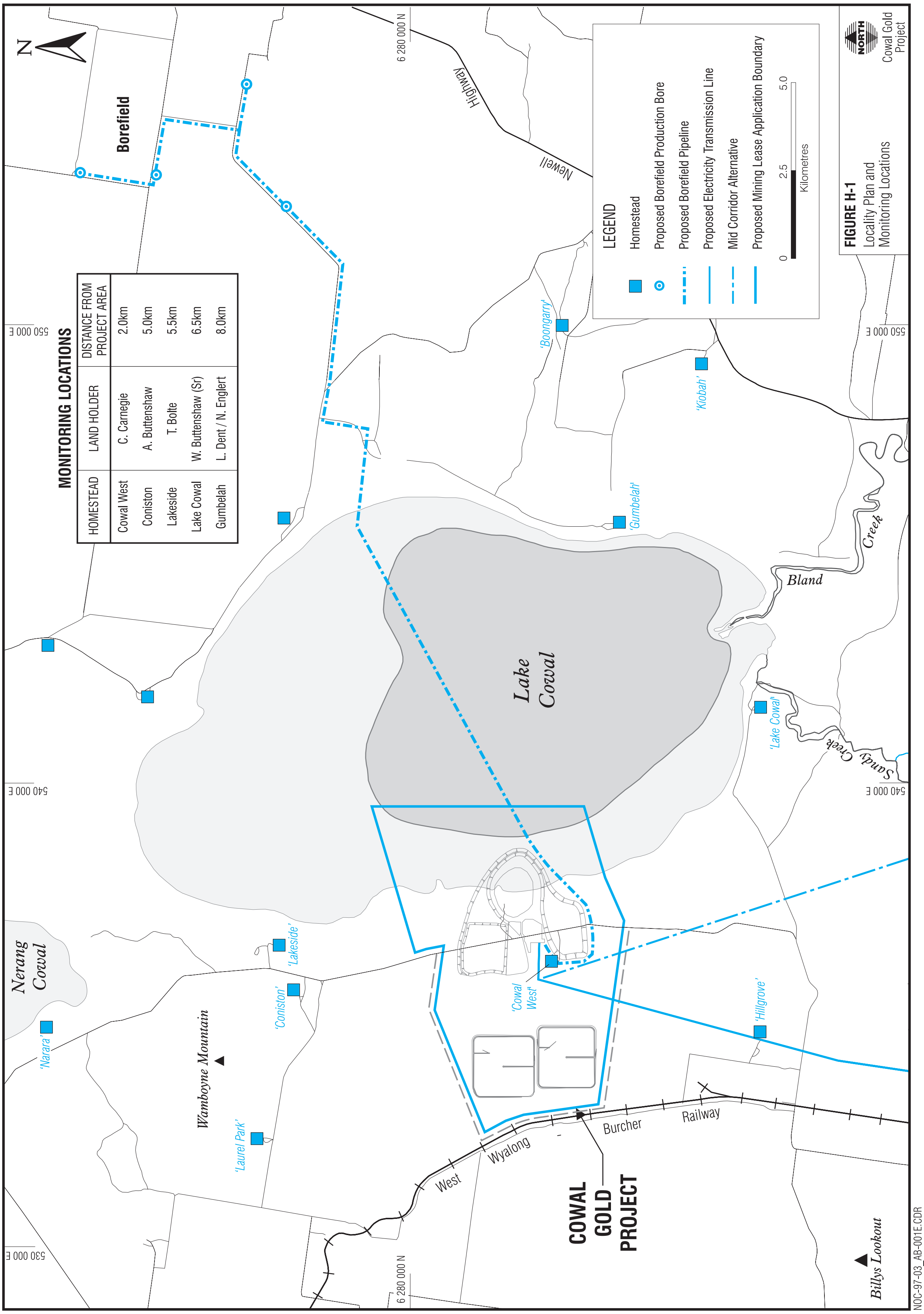
"*The Impact of Continuous Noise on Animal Health*", Algers, B *et al*, Acta Veterinaria Scandinavica, Suppl. 67, 1978.

US Office of Surface Mining, "*Use of Explosives: Control of Adverse Effects*", Federal Register, V48, 1983.

Attachment A

Attachment A

Locality Plan and Monitoring Locations


MONITORING LOCATIONS
HOMESTEAD | LAND HOLDER | DISTANCE FROM PROJECT AREA
Cowal West | C. Carnegie | 2.0km
Coniston | A. Buttenshaw | 5.0km
Lakeside | T. Bolte | 5.5km
Lake Cowal | W. Buttenshaw (Sr) | 6.5km
Gumbelah | L. Dent / N. Englert | 8.0km
N
Borefield
Newell Highway
6 280 000 N
530 000 E
540 000 E
550 000 E
Nerang Cowal
'Narara'
Wamboyne Mountain
'Laurel Park'
'Coniston'
'Lakeside'
'Cowal West'
Lake Cowal
'Gumbelah'
'Boongarry'
'Kiobah'
'Lake Cowal'
'Hillgrove'
Bland Creek
Sandy Creek
West Wyalong Burcher Railway
COWAL GOLD PROJECT
Billys Lookout
LEGEND
Homestead
Proposed Borefield Production Bore
Proposed Borefield Pipeline
Proposed Electricity Transmission Line
Mid Corridor Alternative
Proposed Mining Lease Application Boundary
0 2.5 5.0
Kilometres
NORTH
Cowal Gold Project
FIGURE H-1
Locality Plan and Monitoring Locations
NOC-97-03_AB-001E.CDR

Attachments B–J (inclusive)

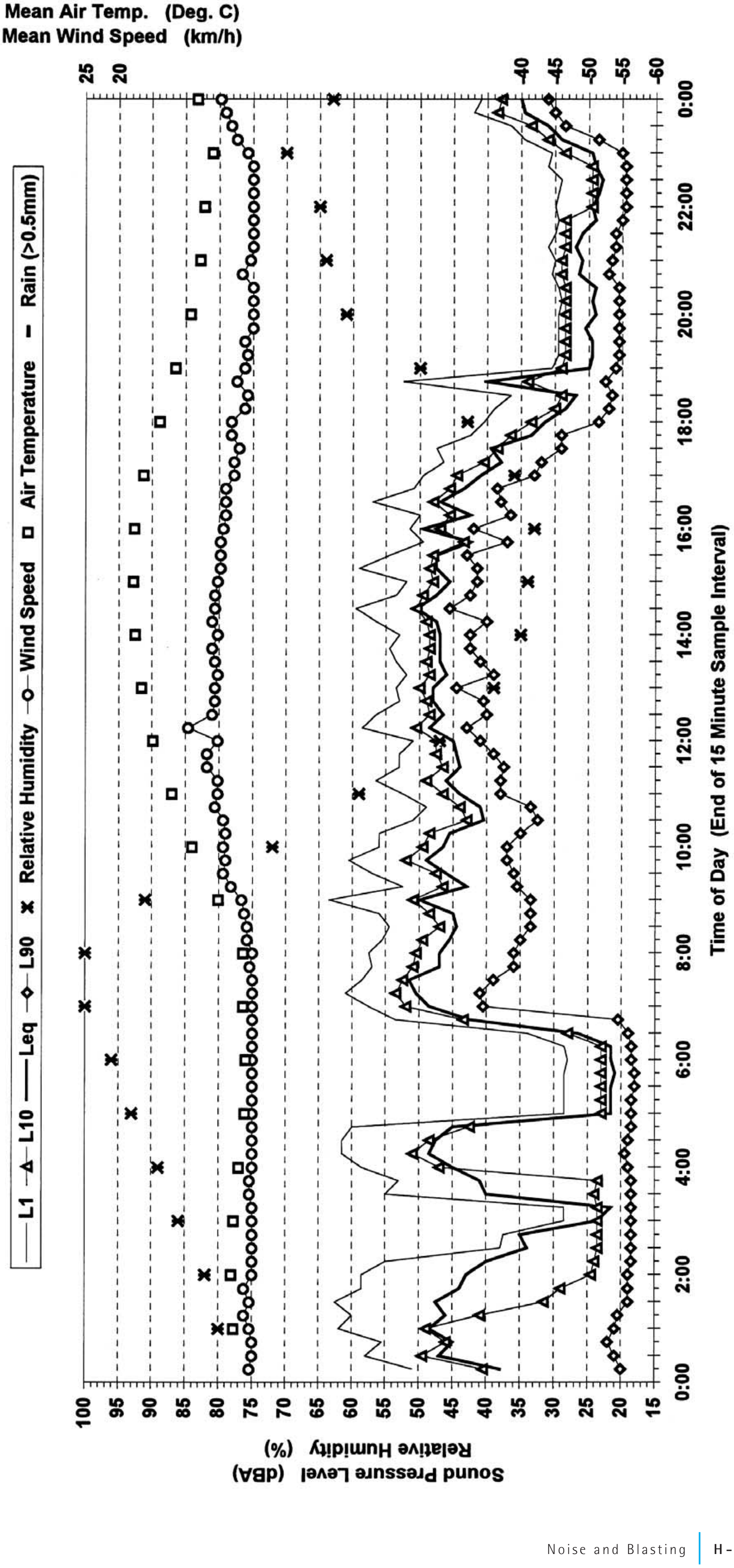
Attachments B–J (inclusive)

Contain a large number of graphs generated by statistical Summer and Winter noise level monitoring at the selected residences discussed in this report.

A sample graph is attached.

Full data sets can be obtained from North Limited (02) 6972 4500.

Ambient Noise Levels and Meteorological Conditions – Cowal Gold Project
Residence 1, Cowal West – Friday 29 July 1994



Attachment K

Attachment K

Attended Ambient Noise Levels Survey Results

Short Term Statistical Noise Level Surveys

	Location (Resident)	Date	Starting Time	Statistical Sound Level (dBA) LAeq	LA1	LA10	LA90	Noise Sources	Weather Conditions
1	"Cowal West" (Carnegie)	28.7.94	11.20 am	41	49	44	36	Birds, wind in trees, other fauna	90% medium high cloud, some blue sky, dull, wind from SW occasionally still, average 0.5-1 m/s, gusts to 2.5 m/s
2	"Coniston" (A Buttenshaw)	28.7.94	12.05 pm	37	49	41	<30	Sheep, birds, wind in trees (intermittent), farming equipment	90% med high cloud, some blue sky, dull, wind from SW often still, ave 0.5-1 m/s, gusts to 2 m/s
		22/12/94	10.15 am	44	57	44	30	Birds squawking, flies, rustling leaves, resident shouting	
		22.12.94	6 pm	54	66	55	45	Flock of birds, bird squawking, rustling of leaves	
		22.12.94	8 pm	41	48	44	35	Birds squawking, rustling leaves	
		22.12.94	10.15 pm	35	38	35	34	Insects, cicadas	
		23.12.94	8.15 am	39	49	41	28	Birds squawking, insects, mooing cow	
		5.1.95	1.30 am	33	40	27	23	Insects	Wind speed 0-1 m/s
		5.1.95	9.45 pm	39	49	41	33	Birds squawking, sheep, insects	Wind speed 1 m/s
3	"Lakeside" (T Bolte)	28.7.94	12.45 pm	40	51	42	29	Wind in trees, birds, insects	90% med high cloud, some blue sky, sunny, wind from SW often still, av 0.5-1 m/s, gusts to 2 m/s
		21.12.94	4.30 pm	44	53	48	36	Wind rustling leaves	
		22.12.94	9.45 pm	39	49	40	33	Motor-generator, garden sprinkler, flies	
		22.12.94	5.30 pm	53	58	56	50	Bird squawking, rustling of leaves, dogs barking, residential swing chair	
		22.12.94	7.30 pm	49	54	52	44	Birds squawking, rustling leaves, rain drops	
		22.12.94	9.45 pm	48	49	49	47	Insects, cicadas	
		23.12.94	7.45 am	43	53	41	25	Bird squawking, dog barking, insects	
		5.1.95	12.30 am	44	46	45	42	Insects, flag flapping	Wind speed 1-2 m/s
		5.1.95	5.00 pm	50	60	52	44	Thunder rumble, insects, flag flapping	Wind speed 1-2 m/s
4	"Lake Cowal" (W Buttenshaw)	28.7.94	1.52 pm	39	46	42	33	Wind in trees, birds, other fauna, distant traffic	90% medium high cloud, some blue sky, dull, wind from SW often still, average 0.5-1 m/s, gusts to 2 m/s
		22.12.94	11.15 am	45	51	47	38	Dogs barking, birds squawking, resident talking, rustling leaves	
		22.12.94	6.45 pm	49	62	52	41	Residential door slam, rustling leaves, birds squawking, vehicle passby, dogs barking	
		22.12.94	9.00 pm	37	42	39	34	Thunder-rumble, rustling leaves, bird squawking, insects, cicadas	
		22.12.94	11.00 pm	33	44	35	27	Insect, rain drops	
		23.12.94	9.00 am	37	46	40	27	People talking, birds squawking, insects, dogs barking	
		5.1.95	2.30 am	36	38	37	35	Insects	Wind speed 0 m/s
		5.1.95	10.45 pm	46	51	50	39	Crickets, rustling of leaves	Wind speed 2 m/s

Short Term Statistical Noise Level Surveys Continued

	Location (Resident)	Date	Starting Time	Statistical Sound Level (dBA) LAeq	LA1	LA10	LA90	Noise Sources	Weather Conditions
5	"Gumbelah" (B Dent)	28.7.94	3.30 pm	45	54	44	29	Birds, goats, dogs, waterfowl, farming machinery, very occasional wind intrees, plane, traffic on Lake Road	80% medium high cloud, generally still, occasional gentle breeze to 0.5 m/s from SE
		21.12.94	6.00 pm	43	42	45	40	Water pumping in the distance, bird squawking	
		21.12.94	11.30 pm	40	47	40	35	Crickets, cicadas, rustling leaves	
		21.12.94	12 midnight	42	47	43	39	Crickets, cicadas, mosquitoes, dogs barking	
		22.12.94	1.15 pm	52	60	55	46	Birds squawking, wind rustling leaves	
		23.12.94	10.30 am	34	43	37	27	Tractor start up - 3 minutes, birds squawking, cicadas, aeroplane passby	
		4.1.95	4.15 pm	52	60	55	46	Wind effected	Wind speed 6-9 m/s, dribbling rain
		4.1.95	8.30 pm	38	46	41	34	Insects, bird squawking, sheep	Wind speed 0-2 m/s
		4.1.95	9.00 pm	38	40	39	37	Insects, sheep, bird squawking	Wind speed 0-2 m/s
		5.1.95	11.30 am	45	53	48	38	Rustling leaves, bird squawking, insects, waves	Wind speed 3-6 m/s
		5.1.95	12 noon	46	53	49	42	Majority of 15 minutes wind affected above 5 m/s, rustling of leaves	Wind speed 4-7 m/s
		6.1.95	5.00 am	37	41	39	36	Crickets, insects, sheep	
		6.1.95	5.30 am	37	42	39	34	Crickets, insects, sheep	
		6.1.95	6.00 am	39	50	42	28	Bird squawking, insects	
		6.1.95	6.30 am	45	57	42	29	Bird squawking, insects, sheep	
		6.1.95	7.00 am	40	52	39	28	Birds squawking, insects, sheep	

Attachment L

Attachment L

ENM Noise Model Input Data

ENM Noise Model Sound Power Level Data Sheet

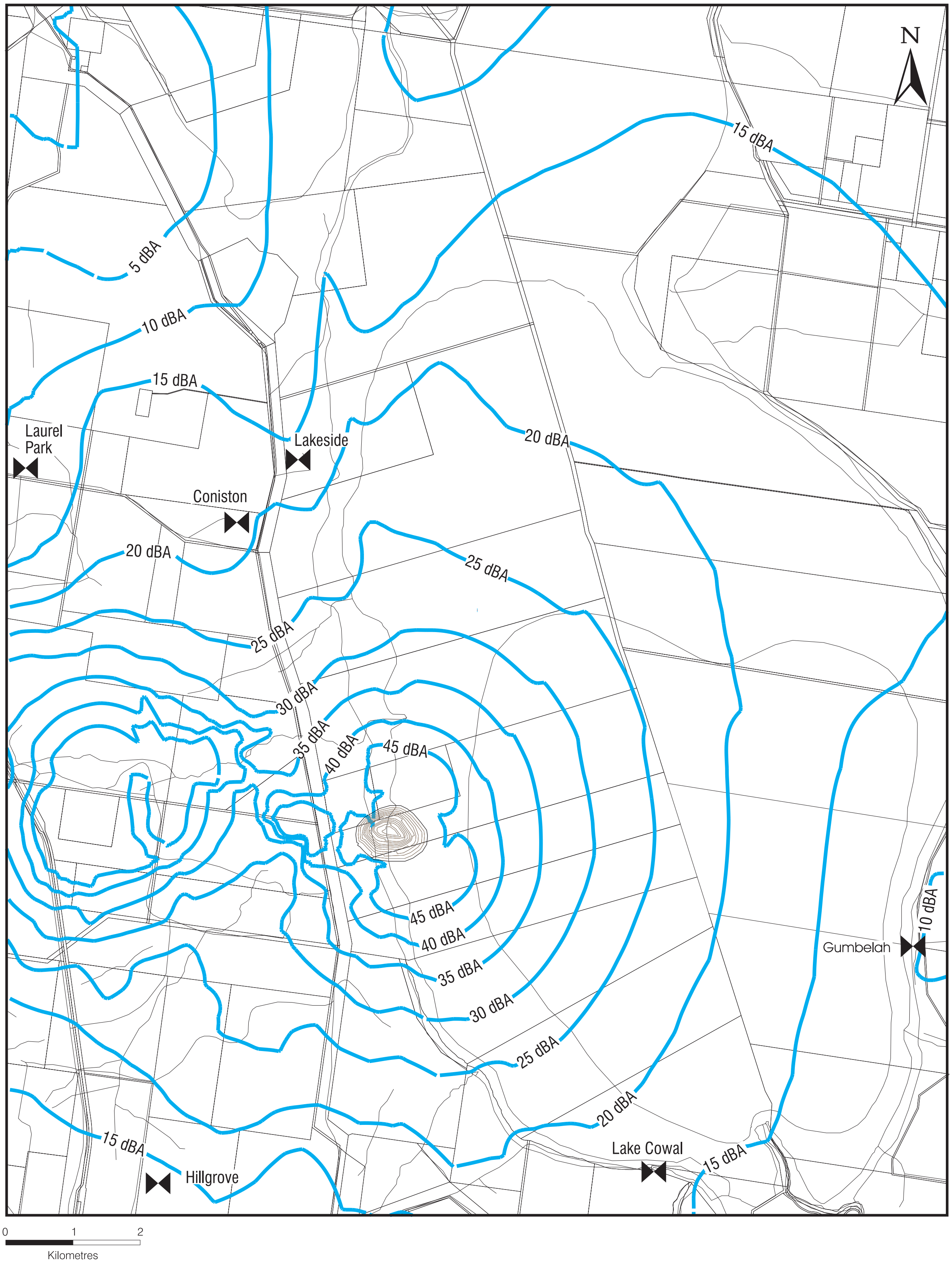
Date/ Project Year	No of Items	Item Description	Overall SWL dBA	Linear Sound Power Level dB re 1 pW 1/1/ Octave Band Centre Frequency (Hz) 31.5	63	125	250	500	1k	2k	4k	8k	Height (m)	Item 1 Coordinate mE	mN	Gr	Item 2 Coordinate mE	mN	Gr	Item 3 Coordinate mE	mN	Gr	Item 4 Coordinate mE	mN	Gr	Item 5 Coordinate mE	mN	Gr
		Receivers												Lakeside			Coniston			Gumbelah			Lake Cowal			Laurel Park		
		Rural Residential Receivers											1.5	6343	13237	220.0	5430	12304	210.0	15496	6000	205.0	11638	2649	205.0	2287	13113	220.0
		Construction Year -1																										
1998/-1	3	CAT 773 Truck (5208)	120	115	125	122	117	114	112	116	104	95	2.5	3060	7950	222.5	3060	7480	222.5	3370	8640	222.5						
1998/-1	2	Compactor	110	99	104	109	112	107	105	102	96	90	2.9	3470	7300	222.5	3850	7300	222.5									
1998/-1	1	Scraper – CAT 637E (5208)	111	108	116	115	109	107	106	104	97	92	3.0	3350	7850	222.5												
1998/-1	2	Wheel Dozer (K57)	109	114	115	114	101	105	104	102	94	88	2.9	4380	7800	222.5	6400	7900	209.5									
1998/-1	1	CAT D9L Dozer (K57)	109	114	115	114	101	105	104	102	94	88	2.9	4380	8200	222.5												
1998/-1	1	CAT 5130 Excavator (5208)	117	113	122	120	113	114	112	109	104	98	4.0	4420	8650	214.0												
1998/-1	4	CAT 789B Haul Truck (K57)	115	100	103	104	113	108	108	108	107	105	4.0	7480	8550	216.0	6510	7700	209.5	7310	7700	200.0	7850	7730	182.0			
1998/-1	2	CAT D10 Dozer (K57)	118	112	115	119	117	115	113	110	103	96	2.9	8100	8300	223.0	7880	7030	216.0									
1998/-1	2	350t Excavator (K57)	117	113	122	120	113	114	112	109	104	98	6.0	7460	7500	160.0	7620	7870	160.0									
1998/-1	1	Grader – CAT 16G (K57)	113	103	104	110	109	113	105	102	99	–	3.1	8430	7220	203.5												
1998/-1	1	Water Tanker (K57)	115	100	103	104	113	108	108	108	107	105	2.5	8350	7720	203.5												
		Operations Year 3																										
2001/+3	5	CAT 789B Haul Truck (K57)	115	100	103	104	113	108	108	108	107	105	4.0	6150	7720	229.0	6750	7830	229.0	6830	8630	226.5	6880	6500	223.0	7190	7100	223.0
2001/+3	4	CAT 789B Haul Truck (K57)	115	100	103	104	113	108	108	108	107	105	4.0	7175	7610	205.0	7820	7980	140.0	7840	7520	70	7390	7760	1.0			
2001/+3	1	Front End Loader	115	115	113	119	117	110	108	107	101	97	3.0	6490	7720	229.0												
2001/+3	1	Water Tanker (K57)	115	100	103	104	113	108	108	108	107	105	2.5	6800	8200	226.5												
2001/+3	1	Grader – CAT 16G (K57)	113	103	104	110	109	113	105	102	99	–	3.1	7250	7750	202.0												
2001/+3	2	350t Excavator (K57)	117	113	122	120	113	114	112	109	104	98	6.0	7550	7650	1.0	7580	7910	1.0									
2001/+3	3	Drill (5208)	116	108	110	121	115	111	111	108	101	95	3.0	7810	7775	1.0	7840	7775	1.0	7840	7970	1						
		Operations Year 8																										
2006/+8	5	CAT 789B Haul Truck (K57)	115	100	103	104	113	108	108	108	107	105	4.0	6610	7900	243.0	6600	8380	243.0	6630	8690	243	7925	7860	96.0	7500	7700	-12.0
2006/+8	3	Drill (5208)	116	108	110	121	115	111	111	108	101	95	3.0	7520	7775	-110.0	7540	7775	-110.0	7565	7775	-110						
2006/+8	2	350t Excavator (K57)	117	113	122	120	113	114	112	109	104	98	6.0	7600	7875	-110.0	7750	7775	-120.0									
2006/+8	2	CAT D10 Dozer (K57)	118	112	115	119	117	115	113	110	103	96	2.9	7775	8025	65.0	6850	8650	243.0									
2006/+8	1	Water Tanker (K57)	115	100	103	104	113	108	108	108	107	105	2.5	6750	8530	243.0												
2006/+8	1	Grader – CAT 16G (K57)	113	103	104	110	109	113	105	102	99	–	3.0	6770	8380	243.0												
2006/+8	1	Wheel Dozer (K57)	109	114	115	114	101	105	104	102	94	88	2.9	6800	8160	243.0												
2006/+8	1	Front End Loader	115	115	113	119	117	110	108	107	101	97	3.0	6620	7790	245.0												
		Processing Plant																										
	1	Processing Plant (4288)	121	112	117	115	116	118	116	114	111	105	3.0	6690	7385	210.0												

Attachment M

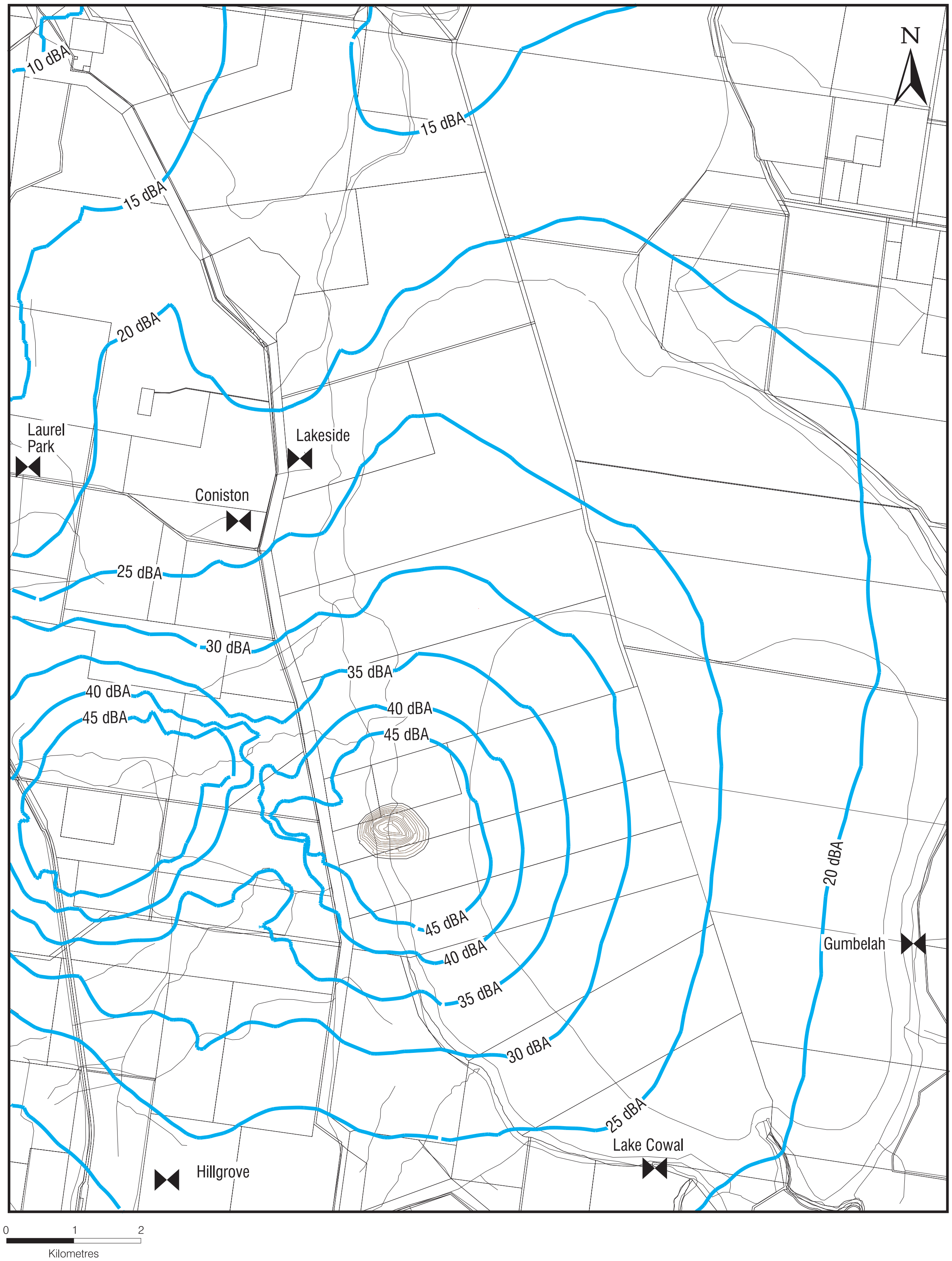
Attachment M

L_{A10} Noise Level Contours under Neutral and Adverse Weather Conditions

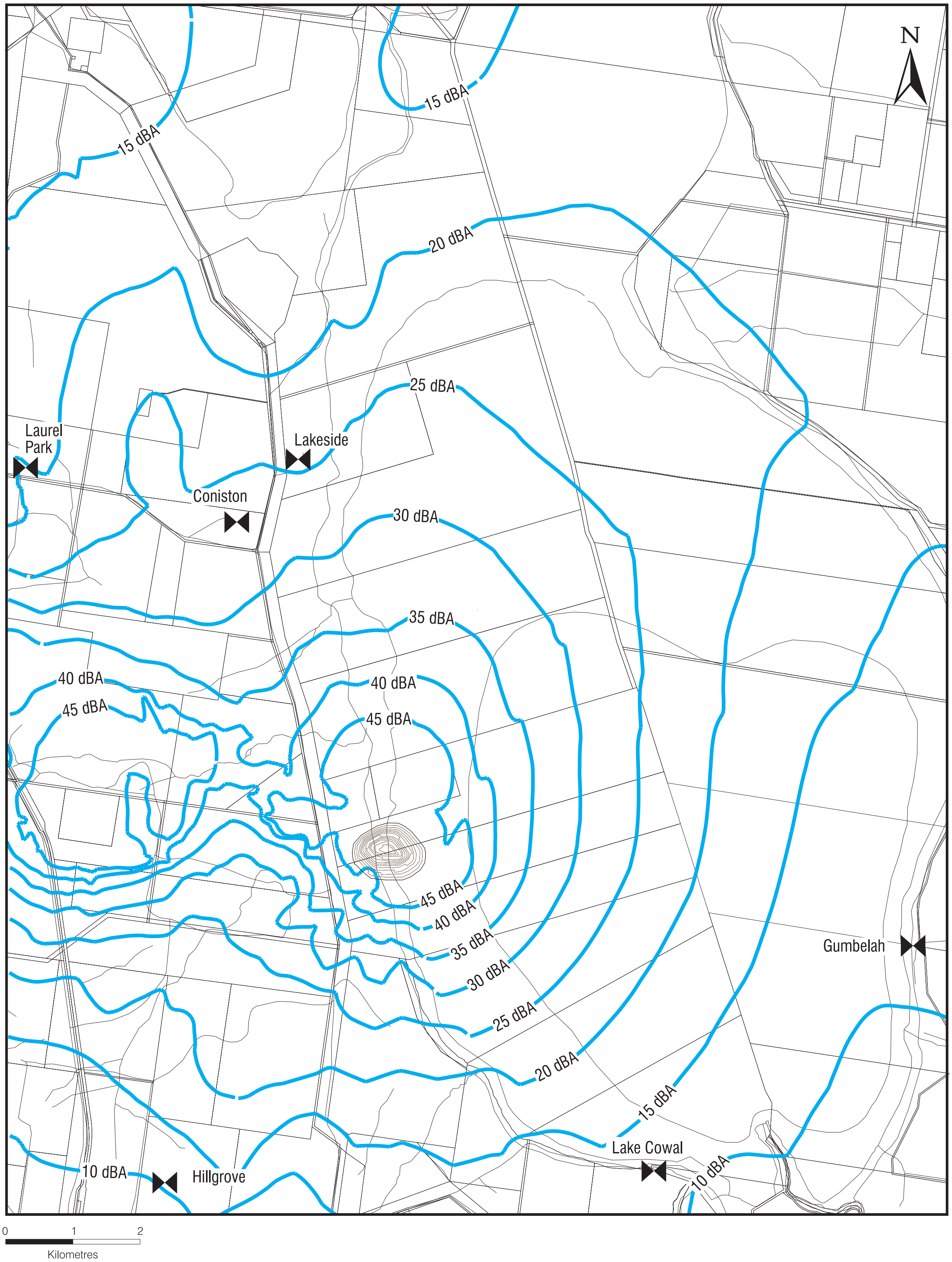
Year -1 – Construction L_{A10} Noise Emission Contours Neutral Conditions



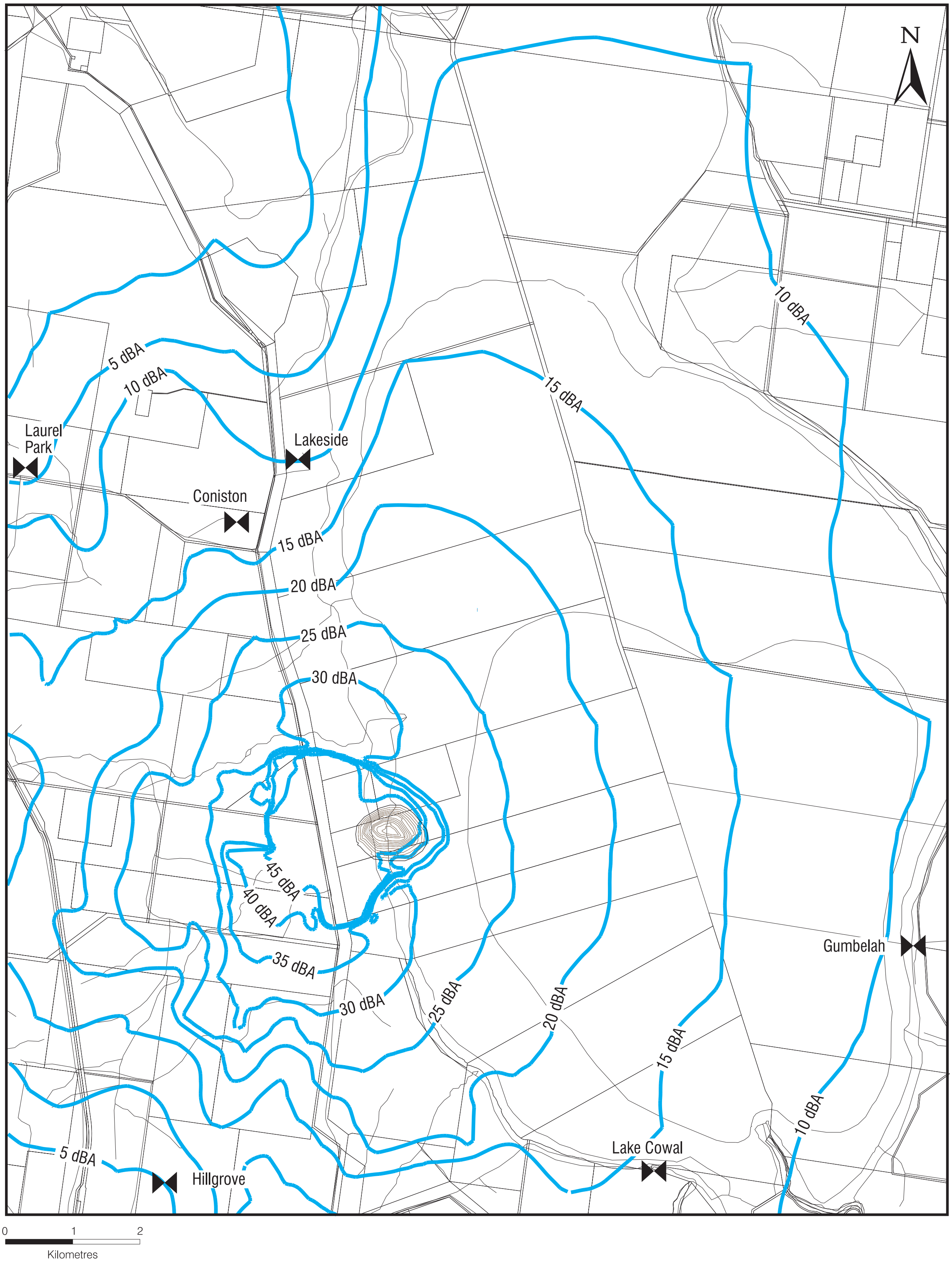
Year -1 – Construction L_{A10} Noise Emission Contours 3°C/100 m Temperature Inversion



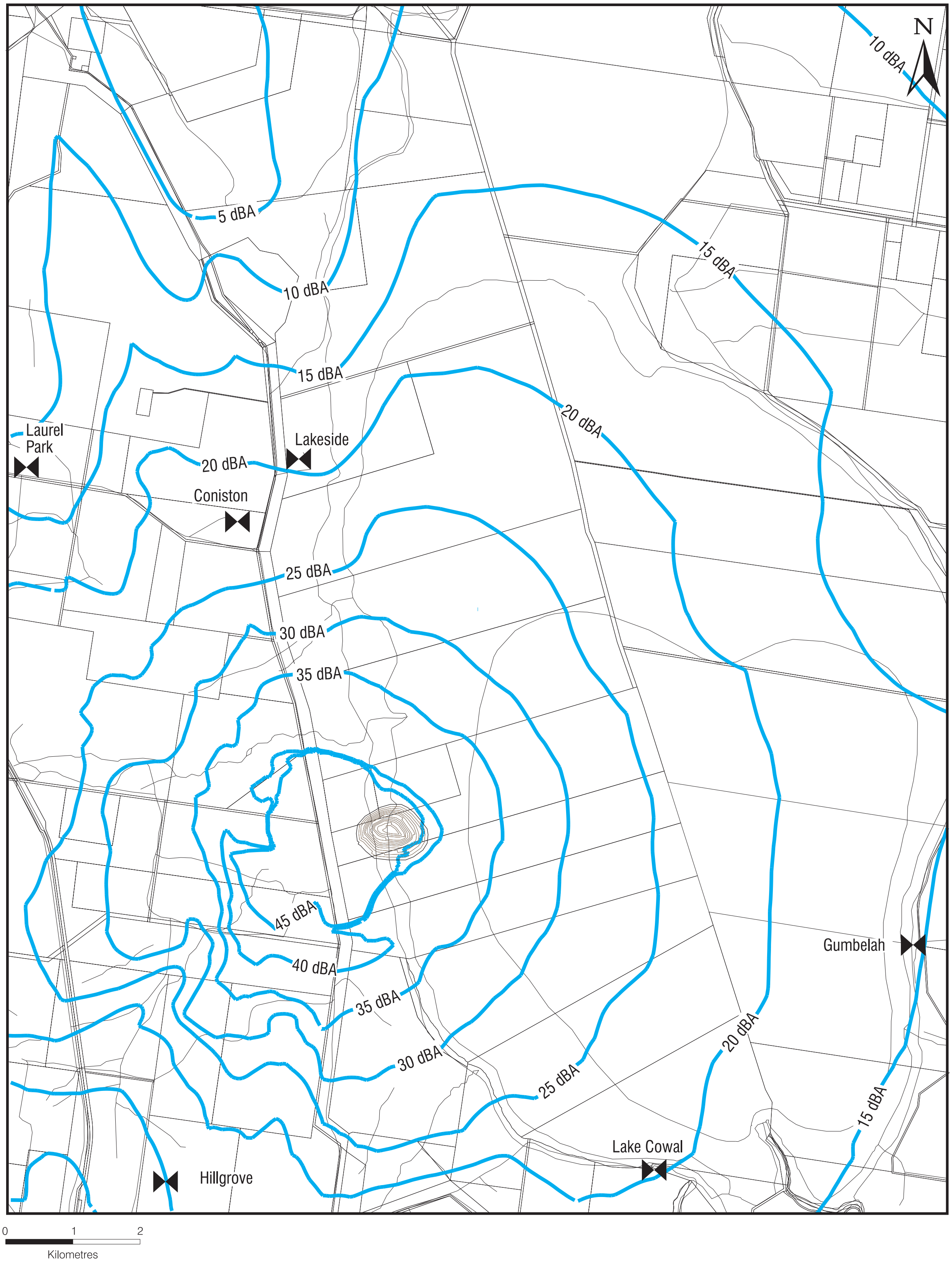
Year -1 – Construction L_{A10} Noise Emission Contours 1.5 m/s Wind to Coniston



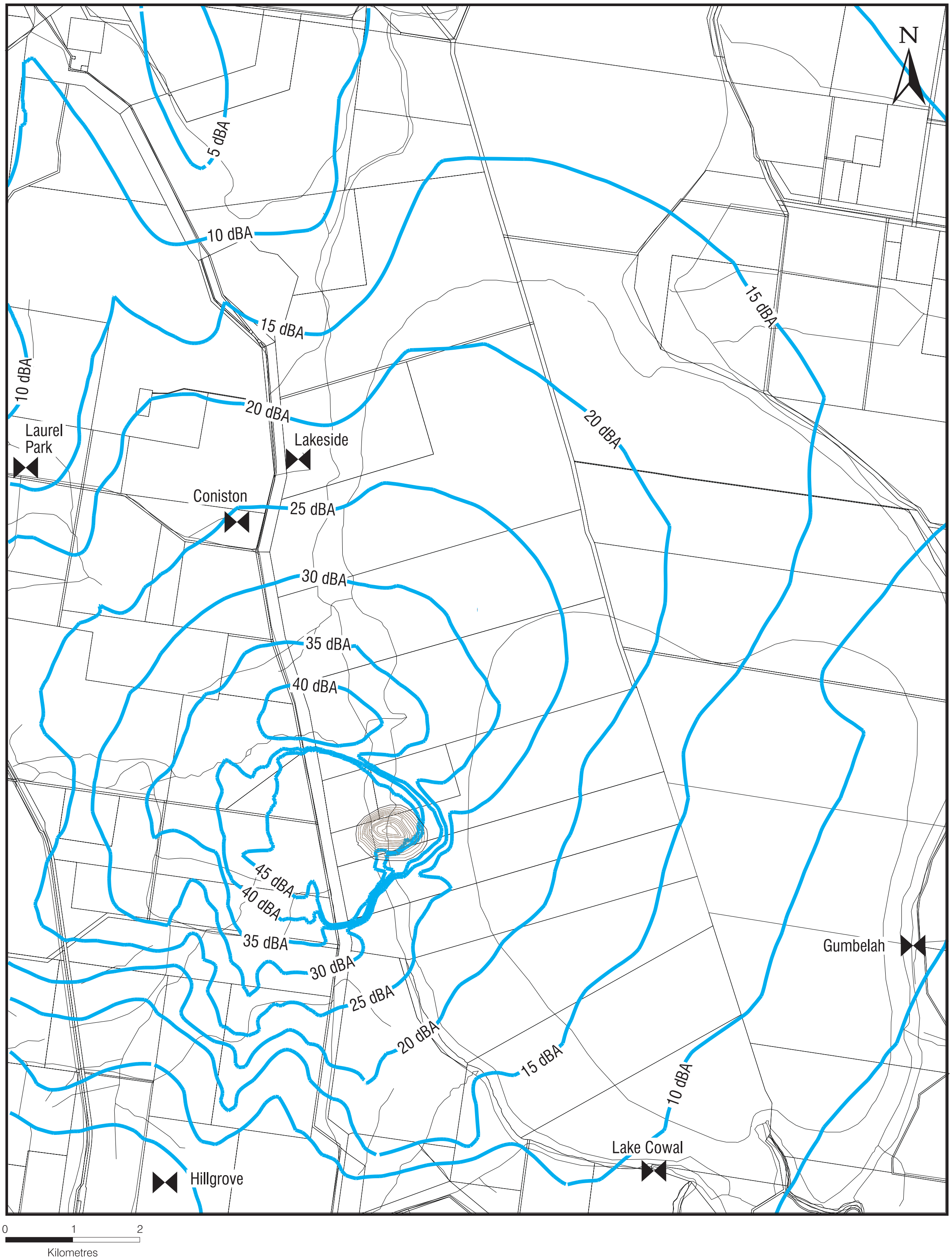
Year 3 – Mining Operations L_{A10} Noise Emission Contours Neutral Conditions



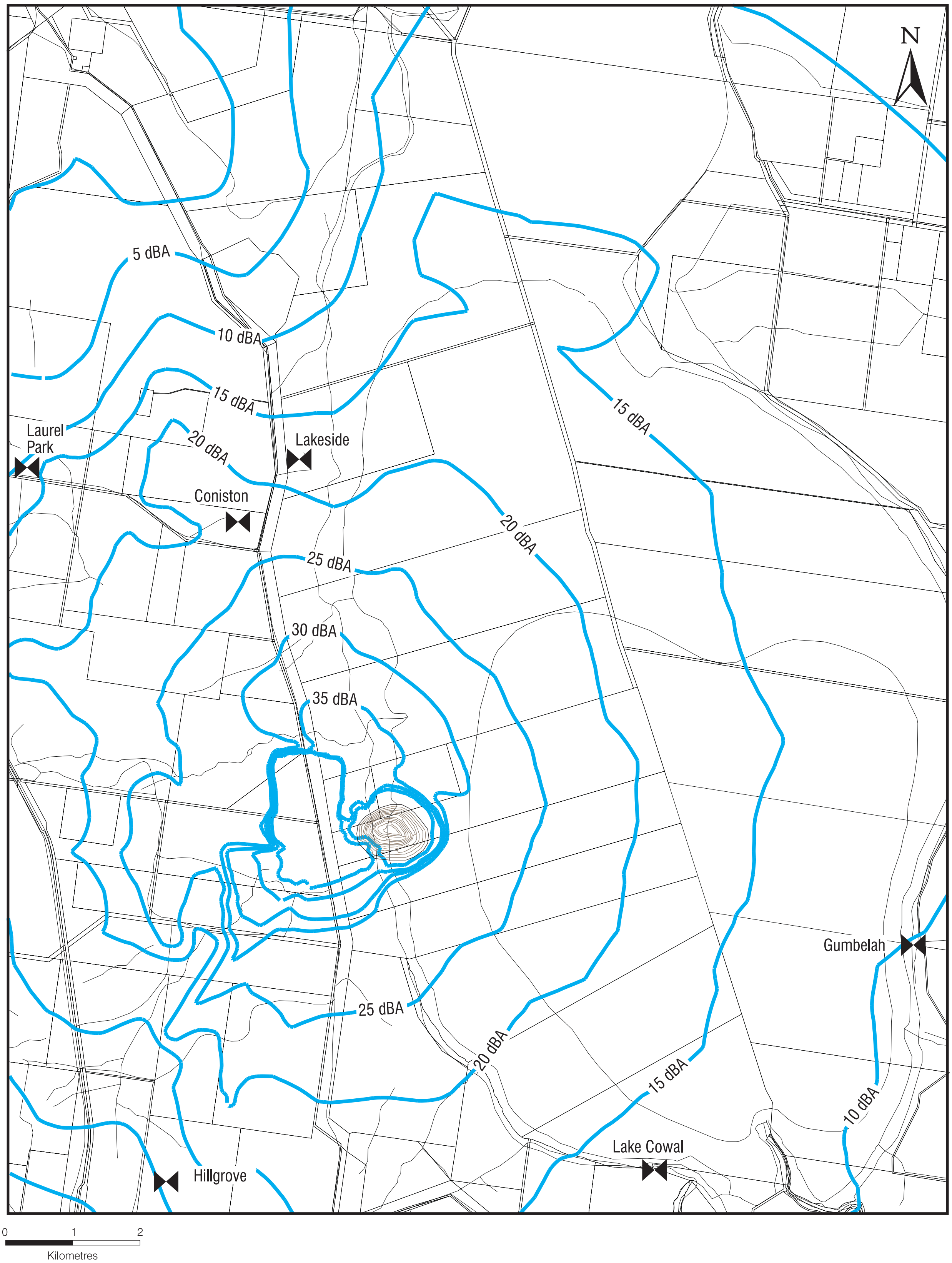
Year 3 – Mining Operations L_{A10} Noise Emission Contours 3°C/100 m Temperature Inversion



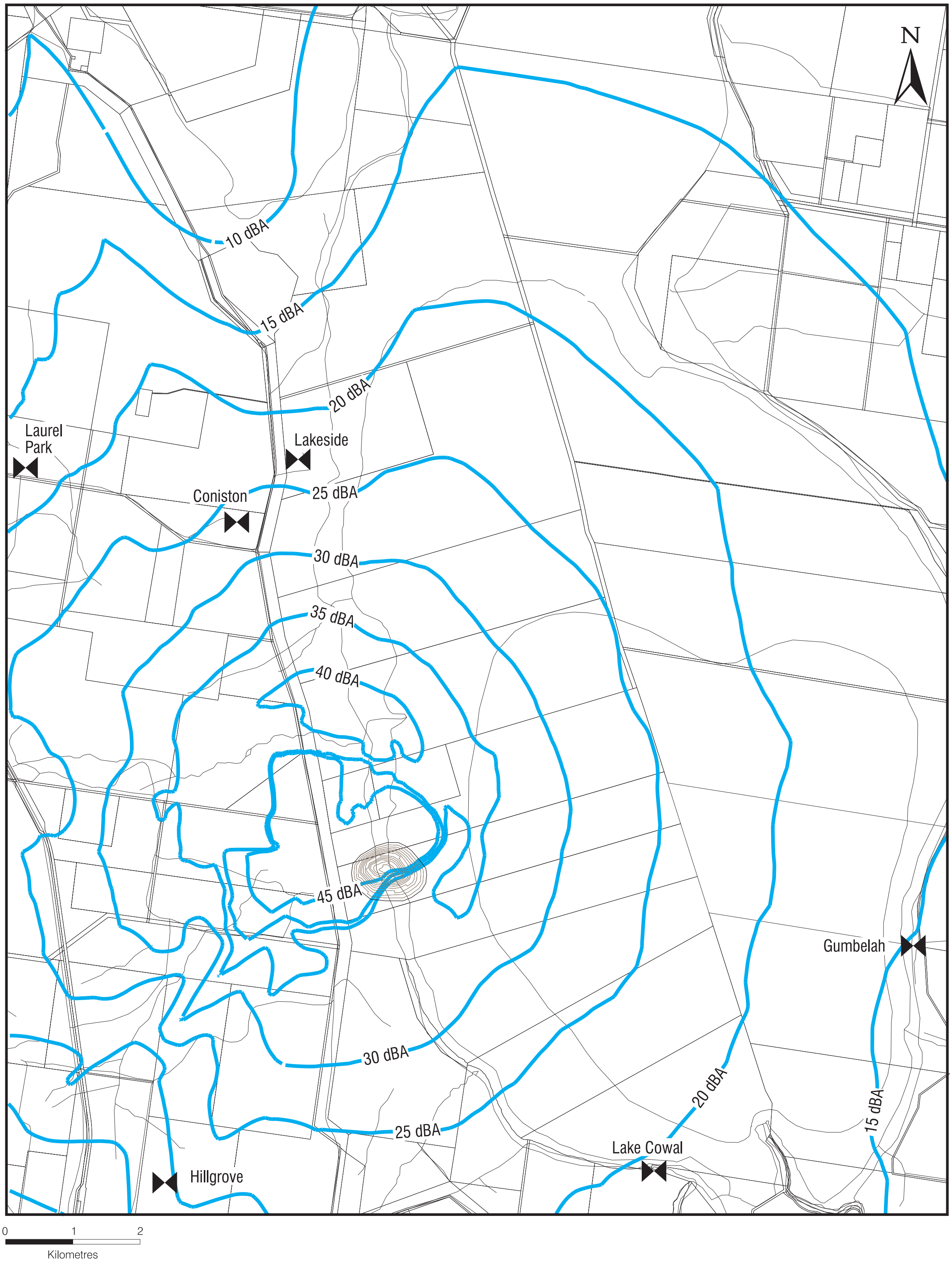
Year 3 – Mining Operations L_{A10} Noise Emission Contours 1.5 m/s Wind to Coniston



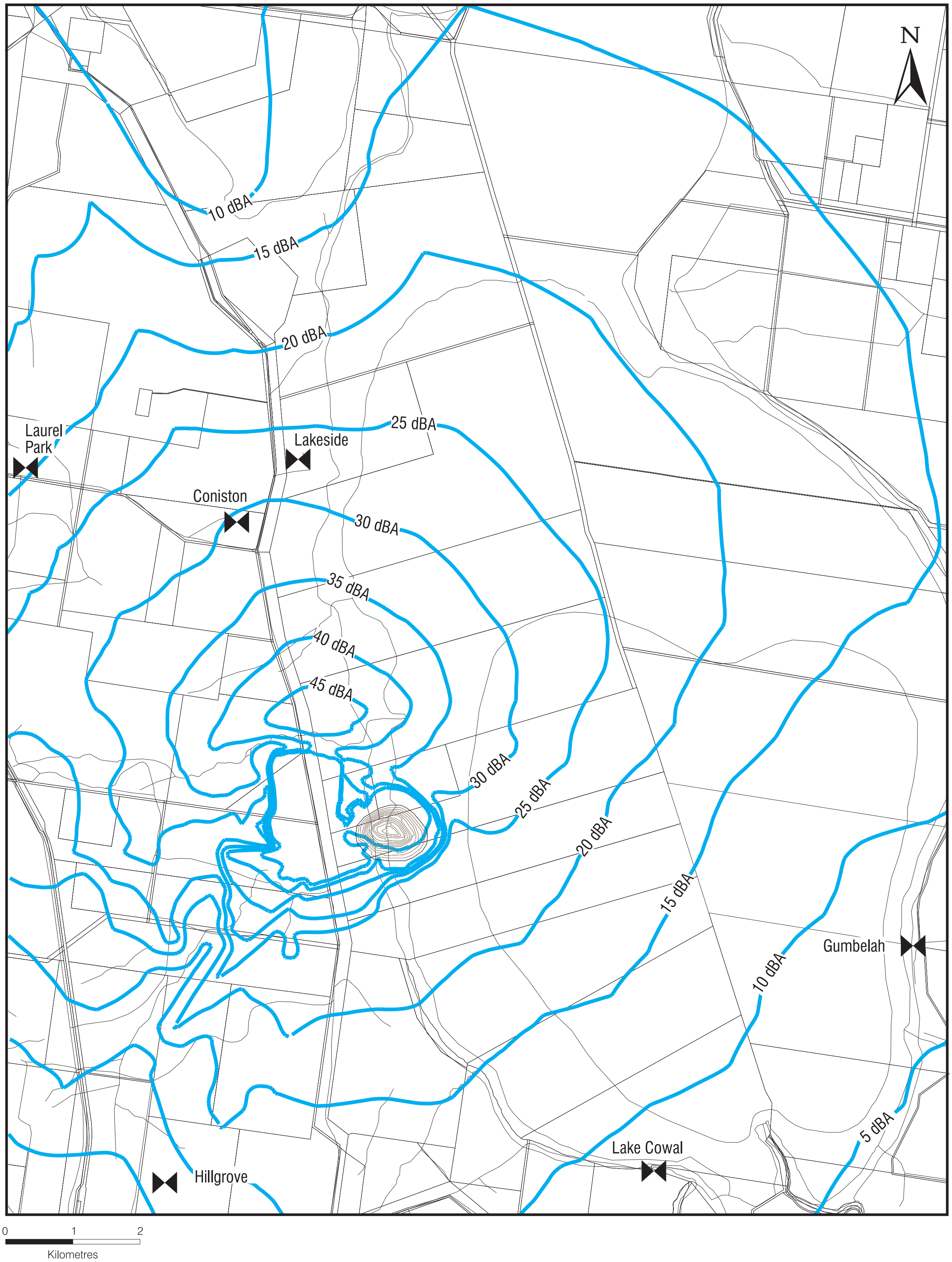
Year 8 – Mining Operations L_{A10} Noise Emission Contours Neutral Conditions



Year 8 – Mining Operations L_{A10} Noise Emission Contours 3°C/100 m Temperature Inversion



Year 8 – Mining Operations L_{A10} Noise Emission Contours 1.5 m/s Wind to Lakeside



Attachment N

Attachment N

Blast Design Details

Blast Design Calculations – Ore and Waste

Required Annual Production Weight	tonnes/yr	**35802000**
Bulk Density of Material	kg/cu m	**2700**
Required Annual Production Volume	cu m/year	**13260000**
Number of Weeks/Year Blasting Occurs		**52**
Number of Blasts per Week		**5**
Required Weight Yield per Blast	kg	**137700**
Required Volume Yield per Blast	cu m	**51000**
Bench Height	m	**10.0**
Stemming Length	m	**3.0**
Subdrilling	m	**1.5**
Fallback	m	**0.0**
Actual Burden First Row	m	**5.0**
Actual Burden Other Rows	m	**5.0**
Actual Spacing	m	**6.0**
Number of Holes per Row		**34**
Number of Rows per Blast		**5**
Total Number of Holes		**170**
Effective Blast Volume	cu m	51000
Effective Powder Factor	cu m/kg	0.71
Hole Diameter	mm	**165**
Hole Angle to Vertical	degrees	**10**
Length of Base Charge	mm	**340**
Diameter of Base Charge	mm	**55**
Base Charge Weight	kg	**1.04**
Relative Base Charge ANFO Weight Strength	%	**118**
Column Charge Bulk Density	kg/cu m	**1200**
Relative Column Charge ANFO Weight Strength	%	**96**
Free Length of Column Charge	m	8.63
Free Volume of Column Charge	cu m	0.185
Net Volume of Column Charge	cu m	0.184
Total Weight of Column Charge	kg	220.5
ANFO-Corrected Base Charge Weight	kg	1.2
ANFO-Corrected Column Charge Weight	kg	211.7
Total ANFO Corrected Charge Weight	kg	212.9
Sensitising Factor	%	**100**
Effective Total ANFO-Corrected Charge Weight/Hole	kg	212.9
Effective Total ANFO-Corrected Charge Weight/Blast	kg	36194
Depth of Burial to C of G	m	**7.3**
Scaled Depth of Burial to C of G	m/kg^0.33	1.2
Scaled Depth of Burden	m/kg^0.33	0.8
Distance to Receiver	m	**2000**
ICI PVS Ground Vibration	mm/s	0.4
ICI Airblast Overpressure	dB Linear	103.6
Airblast – C of G as Depth of Burial	dB Linear	92.9
Airblast – Burden as Depth of Burial	dB Linear	96.2

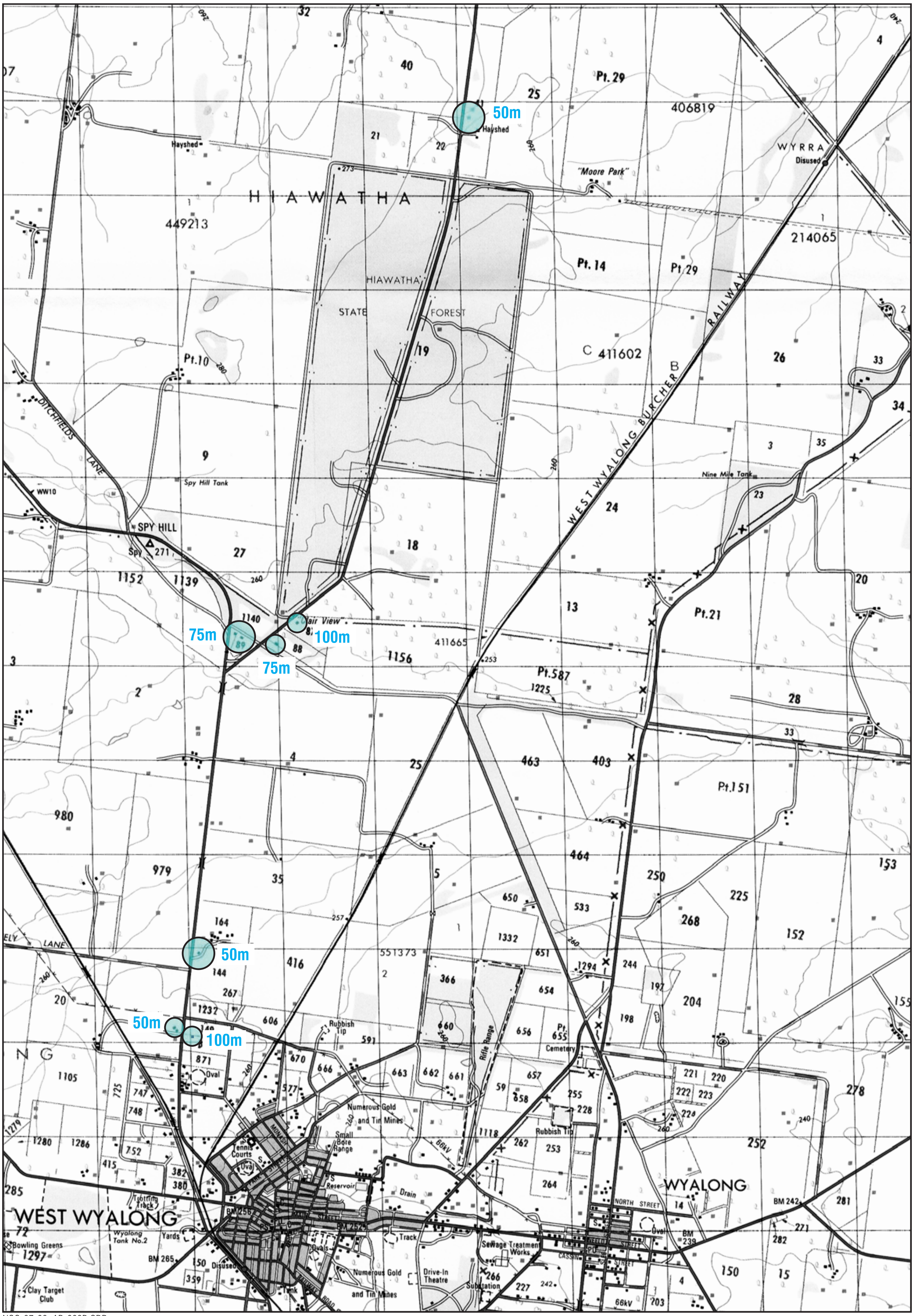
Attachment O

Attachment O

Plan of Closest Residences to Mine Access Roads

Figure O-1 Plan of Closest Residences to Mine Access Roads

Figure O-2 Plan of Closest Residences to Mine Access Roads



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Appendix I

Appendix I

Air Quality

Assessment of Air Quality for the Proposed Cowal Gold Project at Lake Cowal, NSW

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November 1997

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

1.0 INTRODUCTION

This report provides the basis for assessment of the effects of the proposed open cut gold mine and processing plant at Lake Cowal on air quality. A study of the generation and dispersion of atmospheric dust emissions has been requested by Resource Strategies for inclusion in the Environmental Impact Statement (EIS) for the development.

Existing air quality in the Project area is discussed in Section 2. A brief description of the proposal is given in Section 3. The description includes the main aspects of mining by conventional open cut methods and outlines the techniques to be used for ore handling and processing prior to gold recovery.

The potential for generation of atmospheric dust and the proposed air quality safeguards are outlined in Section 4. Details of the dust emission factors used in the compilation of dust emission inventories are given together with information concerning particle size distributions.

The methodology of dust dispersion modelling is introduced in Section 5. Criteria for the selection of representative years for inclusion in the modelling are given and inventories of dust emissions for the selected years are presented. The meteorological data used in the model are introduced next. An outline of the dust dispersion model completes the presentation in Section 5.

The results of dispersion modelling are presented in Section 6. Long-term rates of dust deposition predicted to result from the operation are given first and related to amenity-based criteria which were specified by the EPA. The predictions are shown in a series of isopleths superimposed on the Project area and the impact is assessed for a variety of receptors and land uses including nearby residences.

Predictions of long-term concentrations of total suspended particulates in the ambient air, relevant air quality guidelines and the impact assessment of long-term concentrations are presented in the second part of Section 6.

The main findings of the study are summarised and the conclusions are presented in Section 7. A list of references, attachments and a glossary of terms complete the report.

2.0 EXISTING AIR QUALITY

Air quality in the region containing the Project area at Lake Cowal is determined by atmospheric emissions from mostly farming activities, road and rail traffic, and isolated residential activities. There are no significant industrial installations near Lake Cowal which would emit large amounts of waste gases into the air. The general level of typical industrial pollutants such as oxides of sulphur and nitrogen, ozone and carbon monoxide is therefore expected to be low. The main component of foreign material in the ambient air is particulate matter (atmospheric dust).

2.1 Dust Deposition

A monitoring programme of dust deposition rates was established at the Project area in 1994. The purpose of the monitoring was to characterise the existing air quality in terms of atmospheric dust. Atmospheric dust is generated by a range of activities which take place in the Lake Cowal area including agriculture, rail and vehicular traffic on paved and unpaved roads. The action of strong winds on dry, barren areas may also result in the generation of airborne dust at times.

Three dust deposition gauges were installed to determine monthly rates of dustfall at locations near the Lake. All 3 sites are near or within the high water mark of the Lake.

The locations of the individual sampling sites are shown in Figure I-1. The network is under review at present and additional deposition gauges will be installed prior to operations commencing.

Deposition gauges were maintained over a period of approximately 30 days, collected and sent to the laboratory for analysis. The mass of dried insoluble solids was determined for each sample.

The mean deposition rates of atmospheric particulates at each sampling site are summarised in Table I-1. Standard deviations from the mean rate are also shown.

The mean deposition rates ranged from 1.0 g/m^2/month recorded at site DM54 to 1.62 g/m^2/month at site DM51. The standard deviations from the mean were between 65 and 85 per cent of the mean values. The monitoring results were in agreement with results which were obtained in other rural locations in NSW (Newcrest Mining, 1995; Concrite Quarries, 1996).

Table I-1 Mean Dust Deposition Rates (g/m^2/month) in the Lake Cowal Area

Deposition Rate Water Insoluble	Site	
	Mean (g/m^2/month)	Std. Dev.
DM 51	1.62	(1.06)
DM 52	1.38	(1.04)
DM 54	1.00	(0.86)

2.2 Concentrations of TSP/PM10

There are no records of concentrations of total suspended particulates (TSP) and particles with a diameter less than 10 microns (PM10) in the ambient air at Lake Cowal. Given the consistently recorded low levels of dust deposition, the concentrations of TSP/PM10 are also expected to be correspondingly low. Mean annual TSP concentrations of not more than 20 to 30 micrograms/m^3 are normally found in areas similar to the area which includes the Project area. PM10 concentrations are generally less than a half of the TSP concentrations.

3.0 DESCRIPTION OF THE PROPOSAL AND MINING SEQUENCE

North Limited proposes to develop an open cut mine at Lake Cowal to obtain approximately 76 Mt of gold bearing ore for subsequent recovery.

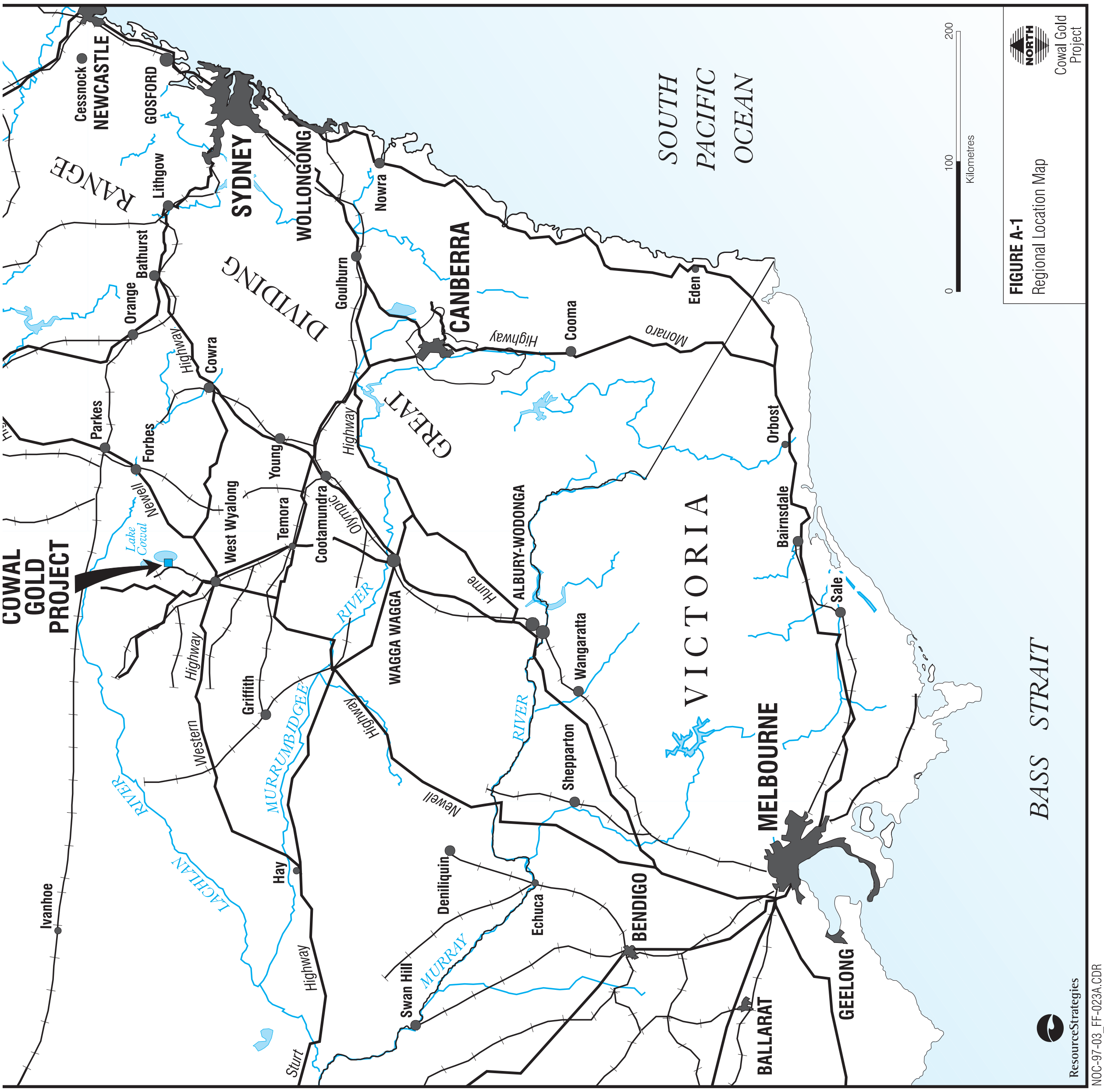

FIGURE A-1
Regional Location Map

The first two years of the Project will be construction. The construction of a perimeter waste emplacement will commence on the eastern side of the proposed open cut between the pit and the Lake. Two tailings storage areas will be constructed in the west. The construction stage of the Project has been marked for the purpose of this assessment as Year-1.

Two types of gold bearing ore will then be mined. Oxide or weathered ore is located near the surface of the deposit and constitutes about 20 per cent of the orebody. Primary ore is located generally deeper and will require drilling and blasting.

Mining will be carried out by conventional open cut methods in benches of 10 m. Excavators will be used to load the material to trucks. Ore will be hauled to a primary crusher located at the processing plant, crushed and conveyed to a ROM stockpile in the processing area.

Low grade ore will be stored initially in a stockpile adjacent to the main emplacement area and recovered later for processing. Waste will be emplaced in emplacement areas located to the east, north and south of the pit and plant areas.

Mining in the pit will cease in Year 8 while processing will continue to Year 13. The pit will have reached a depth of 325 m by the end of mining.

Rehabilitation of the Project area will take place throughout the life of the mine and be completed at the end of the operation.

4.0 GENERATION OF DUST AND AIR QUALITY SAFEGUARDS

Atmospheric dust would be the main component of air emissions from the Project. Other possible sources of air emissions would be exhaust fumes from mobile equipment, blasting fumes, and evaporative emissions from the processing area. All these emissions are expected to be minor.

A range of air quality safeguards will be implemented to minimise the generation of atmospheric dust from the open cut operation. These safeguards will be based on current control techniques as recommended for open cut mining in New South Wales by the EPA. The main components of the controls can be summarised as follows.

During the construction period, watering of disturbed surfaces as well as access roads will be used to reduce dust emissions. Restricting the size of the surface area which would be disturbed at any given time is an effective approach to dust control and will be applied as often as possible.

Maintaining small total areas exposed to dust generation by wind erosion, regular watering of dusty surfaces, and watering and clear route marking of haul roads will be the main aspects of the air quality safeguards during the operation.

The other aspects of dust control will include collection of fine dust from drilling, prevention of truck overloading and the resulting spillage of waste material and ore during loading and hauling, and regular maintenance of all haul roads. Watering and regular maintenance are expected to result in a control efficiency of at least 50 per cent.

The waste emplacement area will be progressively reshaped and revegetated to minimise the potential for wind erosion.

The proposed air quality safeguards at the processing plant are extensive and designed not only to minimise emissions to air but also to retain as much of the valuable gold bearing ore as possible for further processing.

A water spray dust suppression system would be used at the primary crusher bin during truck dumping of raw ore. Crushed material would be discharged while a baghouse dust collection system will be installed to control the emission of fine particles from the crusher discharge. All conveyors will incorporate wind covers as necessary.

The coarse ore stockpile will be protected by a hood to prevent wind erosion of its surface. Reclamation will be via feeder points under the stockpile.

5.0 MODELLING APPROACH AND METHODOLOGY

Dust particles will be generated by a multitude of operating equipment and range in size from minute particles in the submicron range to much heavier particles which settle rapidly not far away from the place of their origin.

The particles remaining in the air are carried by wind and dispersed by the action of the atmosphere. The weight of the particles and the uptake characteristics of the surface cause the particles to deposit on the surface at various distances from the operations under continuously changing atmospheric conditions.

Detailed emission inventories of atmospheric dust were prepared using a range of dust emission factors for individual types of mining and material handling and processing activities. The resulting dust emission rates were divided into three particle size categories corresponding to fine, inhalable and coarse dust.

A computer model of dust dispersion was then invoked to obtain predictions of mean annual dust deposition rates and concentrations of total suspended particulates in the ambient air, and to facilitate plotting of dust contours.

5.1 Emissions of Dust

The rates of dust emissions were determined for individual groups of mining and material handling operations using the projected extent of operations together with emission factors for each unit operation. The dust emission factors for open cut mining were recently reviewed as part of a study directed by the EPA (formerly the SPCC) and NSW Coal Association and funded by the National Energy, Research, Development and Demonstration Council (NERDDC). The study report (SPCC,1988) listed emission factors which were experimentally determined at surface coal mines in the Hunter Valley of New South Wales. Emission factors for those activities which were not tested in the conditions prevailing in New South Wales, were adapted from the published results of experiments undertaken in the United States (USEPA, 1981, 1988). A list of emission factors and the source of the data is shown in Table I-2.

Four individual years of mining were selected for inclusion in the quantitative assessment of dust emissions. They included three years of operation (Years 1, 3 and 6) and one year of construction. The latter represents a special (transient) activity and is therefore presented after the years of typical activities corresponding to normal operation. Mining during Year 1 will be associated with waste emplacement in the perimeter waste emplacement which will be located to the east of the pit. At the same time, mining in the pit area will be mostly on the upper benches. The pit will then become progressively deeper with a resulting reduction in the potential for dust emissions. Year 1 was thus selected to assess the combined effect of mining and waste emplacement on air quality in the area to the east of the Project area and including the lake.

The volume of mine waste is expected to peak at about 27.5 Mt in Year 3 of the operation. Drilling and blasting frequencies will also peak. The pit will be deepening rapidly. Waste will be emplaced in the main as well as the southern emplacement areas. Rehabilitation of the perimeter waste emplacement will continue.

By Year 6, the volume of mine waste will have dropped while the heights of the waste emplacement areas as well as the low grade ore stockpile will be close to their respective maximum values.

Finally, dust emissions during the construction period were included in a hypothetical Year-1. The construction period will be 18 to 24 months but for the purpose of air quality assessment, the main construction activities were condensed into an interval of 12 months. The main activities included prestripping and initial mining of the pit area, construction of the perimeter waste emplacement, roads and tailings storage areas. Wind erosion of construction sites of the processing plant, the ROM pad and oxide ore stockpiles was also included in the estimates.

5.1.1 Emissions in Year 1

The total annual emission of atmospheric dust in Year 1 of the operation was estimated at 4459.5 tonnes. Details of the emission inventory are shown in Table A-1 in Attachment A.

The open cut operation was estimated to result in an emission of 1305.5 tonnes of atmospheric dust per year. Included in this subtotal was the contribution to the

Table I-2 Dust Emission Factors used for the Cowal Gold Project and the Source of Data

Operation	Emission factor	Reference	Control efficiency included in the emission factor
Open cut mining			
Topsoil removal, clearing (scraper, dozer)	14.0 kg/hr	SPCC (1983)	
Drilling	0.6 kg/hole	SPCC (1983)	
Blasting (Note 1)	0.00022 A1.5	USEPA (1988)	
Loading – excavator	0.025 kg/t	SPCC *et al* (1988)	
Ripping, removal – dozer	3.29 kg/hr	USEPA (1988) – Silt = 4%, moisture = 3%	
Graders on roads	0.615 kg/km	USEPA (1988)	
Haulage roads	2.00 kg/VKT (Note 2)	SPCC *et al* (1988)	Watering – 50%
Truck dumping	0.012 kg/t	SPCC *et al* (1988)	
Waste spreading – dozer	7.30 kg/hr	USEPA (1988) – Silt = 5%, moisture = 2%	
Ore handling			
Active storage pile (ROM pad)	14.8 kg/ha/day	USEPA (1991)	
Reclaiming (loader)	0.025 kg/t	SPCC *et al* (1988)	
Unloading (to crusher)	0.01 kg/t	USEPA (1988)	Watering – 50%
Primary and secondary crushing and screening	0.002 kg/t	USEPA (1988)	Enclosure and filtering – 99%
Loading to stockpile	0.0016 kg/t	USEPA (1988) – Moisture = 2%	
Conveyor transfer	1.9×10^{-4} kg/t	USEPA (1988)	Enclosure, fogging
Unsealed roads			
(not haul roads)	4.00 kg/VKT	SPCC *et al* (1988)	
Exposed areas			
Wind erosion of exposed areas	0.40 kg/ha/hr	SPCC (1983)	

Note 1: Emission factor in (kg/blast) A is the area to be blasted (m^2) Note 2: VKT = vehicle kilometres travelled

emission of dust from hauling mined ore to the primary crusher. In relative terms, the open cut operation was estimated to generate about 30 per cent of the total dust generation rate in Year 1.

Haulage of low grade ore to the stockpile area and the activities at the processing plant were estimated to generate 315.8 tonnes of atmospheric dust per year or about 7 per cent of the total.

Emplacement of waste rock in Year 1 will take place in both the perimeter waste emplacement and the main emplacement. The haulage, dumping and spreading of waste were estimated to generate 444.2 tonnes of atmospheric dust per year at the perimeter waste emplacement and 500.9 tonnes per year at the main emplacement. The combined contribution of waste emplacement to the total emission of dust in Year 1 was 21 per cent.

Wind erosion of exposed areas in the eastern section of the Project area was estimated to result in the emission of 776.4 tonnes per year or 18 per cent of the total.

Finally, operations in the western section of the Project area (tailings storages and internal roads) and wind erosion of their dry surface areas were estimated to contribute 992.8 tonnes of atmospheric dust per year.

It may be useful to make a comparison between the estimated total emission for Year 1 of mining and the emission of atmospheric dust from a sizeable agricultural source such as a 1000-hectare cropping farm. A similar inventory of dust generating activities would have to be compiled including travelling distances, a number of vehicles in operation and details of cropping activities throughout the year to achieve a direct comparison.

In order to draw a simple example, only an emission of dust from ploughing a total of 1000 hectares was estimated. For an emission factor of 30.5 kg of dust per hectare (USEPA, 1985), the total emission is 30.5 tonnes. Estimating wind erosion of the freshly ploughed surface in a manner which is identical to the estimates of wind erosion from disturbed mine areas would add a further 134.4 kg per hectare or a total of 134.4 tonnes.

The above estimates assumed a mean silt content of the soil to be 18 per cent and the wind erosion only to last for 14 days. A higher silt content than the mean value of 18 per cent for U.S. soils, further use of agricultural machinery on the field following ploughing, and longer periods of wind erosion than 14 days would all contribute to higher annual dust emission levels.

The total estimated emission from 14 days of ploughing is thus, at least, 164.9 tonnes. Over a corresponding period of time, the mean emission from the operation of the mine (which includes numerous dust controls) in Year 1 was estimated to be 171.5 tonnes. Although the above comparison is, by necessity, only rather simple, it illustrates the expected size of dust generation in the context of other activities which may take place in the area containing the Project area.

5.1.2 Emissions in Year 3

The total emission rate of atmospheric dust in Year 3 of the operation was estimated to rise to 5445.7 tonnes per year.

Emissions would rise in both the eastern and western sections of the Project area. The rise in the western section is due to an increase in the area of dry surface at the tailings storages.

Table A-2 in Attachment A contains details of the estimates. The emission from the pit area was estimated to increase to 1877.1 tonnes per year. A retention factor of 30 per cent was applied to those extraction operations which would take place at or near the floor of the deep pit (Cole *et al*, 1984).

The main sources of atmospheric dust in Year 3 will be the pit with approximately 25 per cent, wind erosion with 15 per cent and waste emplacement with 16 and 12 percent in the main and southern emplacement areas respectively. The contribution from the western section of the Project area was estimated at 1343.2 tonnes per year or 25 per cent of the total.

5.1.3 Emissions in Year 6

Having peaked in Year 3, the annual dust emission will decline to 2975.0 tonnes per year in Year 6 of the operation. The pit will become very deep with most of the activities taking place near its floor. A retention factor of 50 per cent was therefore applied to the dust particles emitted by those activities.

Wind erosion of the main emplacement area and the adjacent low grade oxide stockpile was estimated to be the strongest contribution with 15 per cent of the total. The pit area will add about 13 per cent.

Almost one half (45 per cent) of the total emission was estimated to originate from the western section of the Project area including the tailings storages. Details of the emissions inventory are presented in Table A-3.

5.1.4 Emissions for the Construction Period (Year-1)

The main dust generating activities during a construction period of 18 to 24 months were included in an annual emission rate of 3835.9 tonnes per year (Table A-4 in Attachment A). The estimate thus represents a conservatively determined annualised emission which, in fact, will occur over an interval longer than one year.

Operations in the pit area, waste emplacement in the perimeter waste emplacement and wind erosion of the exposed areas were estimated to be the strongest sources of dust emissions in the eastern section of the Project area contributing 17, 15 and 15 per cent respectively.

Construction and wind erosion of exposed surface areas in the western section of the Project area were estimated to result in an emission of 1834.5 tonnes or 48 per cent of the total annualised emission of 3835.9 tonnes.

5.1.5 Summary of Dust Emissions

The results of dust emission estimates for Years 1, 3 and 6 of the operation, and for the construction (Year-1) are summarised in Table I-3. The table also shows the quantities of ore and waste to be mined during the respective years, and the amounts of atmospheric dust thus generated in the process of mining and processing of one tonne of ore (dust to ore ratios) in each of the modelled years of operation.

The calculated dust to ore ratios ranged from 0.39 kg/t in Year 6 to 0.51 kg/t in Year 3. No dust to ore ratio was calculated for the construction period as construction activity is not usually characterised by a reference to dust to ore ratios which are applicable to operation.

5.2 Particle Size Distributions

Three particle size classes were used to divide the atmospheric dust into fine, inhalable and coarse fractions corresponding to aerodynamic diameters ranging from 0 to 2.5, 2.5 to 15.0 and 15.0 to 30.0 microns. The mean diameters in each class, for the purpose of modelling, were assigned values of 1.0, 6.1 and 21.1 microns.

In the process of assigning particle size distributions to the individual dust generating activities, the results of a study undertaken at selected Hunter Valley mines in 1986 (Dames & Moore, 1986) were used. Experimental data published by Axetell et al (USEPA, 1981) for a number of surface coal mines in the United States were used to assign particle size distributions to dust emissions from those mining activities which were not studied in the Hunter Valley.

The particle size distributions for atmospheric emissions from ore processing including crushing, screening and conveying and transfer were estimated using the generalised particle size distributions for unprocessed ores published recently by the USEPA (USEPA, 1988).

The applied particle size distributions are shown together with the source of the data in Table I-4.

5.3 Meteorological Data

The generation of atmospheric particulates (dust) in the mining area is, in part, influenced by the prevailing meteorological conditions. The dispersal of airborne pollutants including particulate matter is also governed by

Table I-3 Summary of Dust Emission Estimates for the Proposed Operation

Year	Annual Emission of Dust (tonnes/year)	Mined Quantities Ore (Mtpa)	Waste (Mtpa)	Dust: Ore Ratio (kg/tonne)
Construction Year -1	3835.9	1.68	13.8	–
Operation Year 1	4459.5	11.27	18.5	0.40
Year 3	5445.7	10.69	27.5	0.51
Year 6	2975.0	7.71	2.5	0.39

Table I-4 Particle Size Distributions used for the Cowal Gold Project and the Source of Data

Operation	Particle size ranges FP 0-2.5 µm	IP 2.5-15 µm	CP 15-30 µm	Reference
Open cut mining				
Topsoil removal	19.6	54.0	26.4	USEPA (1981)
Ripping (dozer)	2.6	22.5	74.9	USEPA (1991)
Ore and waste drilling	9.0	62.0	29.0	Dames & Moore (1986)
Ore and waste blasting	5.1	46.0	48.9	USEPA (1981)
Ore and waste loading (excavator)	7.0	50.0	43.0	USEPA (1991)
Grading of roads	5.5	48.0	46.5	USEPA (1981)
Ore and waste haulage	6.0	53.0	41.0	Dames & Moore (1986)
Waste dumping	4.0	44.0	52.0	Dames & Moore (1986)
Waste spreading, shaping (dozer)	19.6	54.0	26.4	USEPA (1981)
Wind erosion	3.5	67.0	29.5	USEPA (1981)
Ore handling				
Unloading	4.0	44.0	52.0	Dames & Moore (1986)
Crushing and screening	15.0	60.0	25.0	USEPA (1988)
Conveyors, transfer points	15.0	60.0	25.0	USEPA (1988)

meteorological conditions which include wind speed, wind direction and the amount of atmospheric turbulence in the atmosphere.

Wind direction determines the general direction in which the dust particles are transported while wind speed determines the amount of initial dilution of the airborne material and the speed with which the material is moving. Atmospheric turbulence determines the rate at which the material is spreading in the vertical and lateral directions during its transport by wind.

A minimum of one year of data is needed to include seasonal variations in the data base. Continuous measurements of meteorological parameters commenced at the Project area at the end of 1993. As a result of the monitoring, 12 months of continuous records were used in the analysis and included in the air quality modelling. The basic recording interval was one hour.

Seasonal and annual wind roses for the Project area are shown in Attachment B.

The most common winds at the Project area were from the south-western sector. These winds were present during both the summer (October to March) and the winter (April to September) seasons. The strongest winds were also associated with the south-western sector and especially the west.

Winds from the eastern half were more common during the daytime than in the evening and at night. Easterly winds were generally lighter particularly during the winter months.

The least frequent winds were from the north-west and south-east.

5.4 Dispersion Model

The estimated rates of dust emissions were applied together with the meteorological data in a computer model of dust dispersion. The model was based on the ISCLT model, validated and applied previously in many applications to open cut operations.

Neutral atmospheric stability conditions were assumed to be associated with the wind data at all times. This approach was necessitated by the absence of additional monitoring information which would allow a more detailed determination of atmospheric stability. Neutral atmosphere represents average dispersion conditions which normally occur on a majority of times. It may also be noted that dispersion of mining dust is less affected by variations in atmospheric stability than dispersion of industrial gases and emissions from large elevated sources.

Directional dependence of the wind erosion component of the dust source term was retained in the model by invoking the contribution by wind erosion when the wind speed exceeded a threshold value of 5.4 m/s in that particular direction. The total frequency in the meteorological data of wind speeds in excess of the threshold value was 14.0 per cent.

A computer plotting routine was used to draw isopleths of predicted dust deposition rates and concentrations of total suspended particulates in the ambient air.

6.0 MODELLING RESULTS AND IMPACT ASSESSMENT

Atmospheric dust is the only type of air pollutant which will be released from the mining operation in a quantity that is of consequence in air quality considerations. Many dust particles generated from the mining operation tend to be of a rather large size resulting in a rapid settling at relatively short distances from the location of the emission. Depending on the size of the particulate matter, the air quality criteria for particulate matter thus distinguish between dust deposition and concentration of suspended dust particles in the ambient air.

6.1 Dust Deposition

6.1.1 Air Quality Guidelines

Depositing dust (dustfall) if present at sufficiently high levels, can reduce the amenity of an area which is used for living, farming and other activities to such an extent that they cease to be either enjoyable or viable. The specific effects contributing to this degradation of amenity include mainly the presence of visible dust either in the air or on surfaces, and soiling of surfaces and materials. In New South Wales in the past, the EPA used an annual average of 4.0 g/m^2/month as the level at which amenity was likely to be affected causing complaints of nuisance dust. More recently, the EPA adopted incremental amenity based criteria for dust deposition. The EPA criteria are summarised in Table I-5.

The maximum acceptable increase in the mean annual dust deposition rate is thus 2 g/m^2/month in those residential areas in which the existing rate of dust deposition does not exceed 2 g/m^2/month. For those areas the criteria seek to limit the total dust deposition rate (the sum of the existing level and the increment due to a new development) to 4 g/m^2/month expressed as an annual mean.

Similarly, the criteria allow for an increment of up to 2 g/m^2/month in the mean annual dust deposition rate in those rural and semi-rural as well as commercial areas in which the existing dust deposition does not exceed 3 g/m^2/month. For these locations, the maximum acceptable total dust deposition rate is 5 g/m^2/month expressed as an annual mean.

Table I-5 NSW EPA Criteria for Dust Fallout

Existing Dust Level (g/m^2/month)	Maximum Acceptable Increase over existing Dust Level (g/m^2/month)	
	Residential Suburban	Rural, Semi-Rural Urban Commercial and Industrial
2	2	2
3	1	2
4	0	1

Note: If the existing dust level in any area is greater than 4 g/m^2/month (i.e. 5 or above) then no increase in dust fallout is acceptable as a result of any proposed dust emitting works.

Monitoring results of existing dust deposition rates in the area containing the Project area were presented in Section 2. The existing levels fall within the definition of the EPA criteria above. As a result, when applied to the proposed development at Lake Cowal, the criteria specify a mean annual increment of 2.0 g/m^2/month as the maximum acceptable increase over the existing levels for all land located outside the Project area.

6.1.2 Predicted levels

Increases in the mean annual rate of dust deposition during selected years of operation were predicted first. The results of the predictions are presented as a set of isopleths (dust contours) in Figures I-2 to I-5.

The shape of the dust deposition contours reflected the direction of the main winds as well as the position and configuration of the main dust generating sources including the pit, waste emplacement areas and the tailings storages. The contribution of operations at the processing plant is also discernible from the dust contours.

Inherent in the results presented in Figures I-2 to I-5 was the assumption that the dust emissions would be able to follow a path free of obstructions through the air to the grid points at which the modelling calculations were carried out. Physical obstacles located along the path in the form of trees, other types of vegetation and rising terrain can be expected to interfere with the dispersing cluster of atmospheric particles and so remove a portion of the dust from the air. However, the complexities of describing this removal mechanism in acceptably reliable mathematical terms prevented its inclusion in regulatory dispersion models rendering the results to be conservative in the majority of cases.

Retention of a portion of the atmospheric particulates generated within a deep pit by the pit itself is a well known phenomenon (Cole *et al*, 1984, SPCC, 1983, SPCC *et al*, 1988, 1989) which increases with increasing depth of the pit floor in relation to the surrounding terrain. Retention of up to 60 per cent and possibly as much as 80 per cent of the atmospheric particulates generated within the pit has been quoted in the above studies.

The depth of the pit at the Project area will gradually increase reaching a depth of 325 m at the end of the development. It was assumed for the purpose of modelling that all atmospheric dust would be able to escape from the pit (no retention) in Years-1 and 1 of the operation. Retention of 30 per cent of the pit emissions was assumed for Year 3 and 50 per cent for Year 6. These assumptions were again conservative and so likely to have resulted in higher predicted levels of dust deposition outside the pit.

Figures I-2 to I-5 show the predicted increases in the mean annual dust deposition rate for 4 selected years of mining which were described in the previous section. Incremental levels corresponding to 0.5, 1.0, 2.0, 3.0, 4.0 and 8.0 g/m^2/month were drawn on the map containing the Project area. These levels provide a representative range for subsequent impact assessment. Lower levels than 0.5 g/m^2/month outside the Project area and higher levels than 8.0 g/m^2/month within the Project area do not influence the assessment.

Year 1

The predicted increases in the mean annual rate of dust deposition in Year 1 are shown in Figure I-2. The emphasis was placed in Figure I-2 on determining the approximate position of the contour line which corresponds to an incremental value of 2.0 g/m^2/month (annual average).

This line was predominantly confined to the Project area. Very minor excursions beyond the boundary of the Project area were predicted to the east of the perimeter waste emplacement and to the north of the main emplacement area.

Mean dust deposition in excess of 2.0 g/m^2/month was predicted to occur within the Project area at locations close to the pit, waste emplacement areas, major haul roads, tailings storages and the processing plant. The mean rate of dust deposition will diminish at locations which are situated further away from the dust generating sources.

The mean rate of dust deposition will fall more rapidly in the direction of infrequent winds notably towards the north-west and south-east. The dust contours in Figure I-2 showed the effect of west to south-westerly winds on dispersion of atmospheric particulates from the proposed operation.

All occupied residences in the vicinity of the Project area are located at distances at which the increases in the mean annual dust deposition will be less than 0.5 g/m^2/month.

Year 3

Waste emplacement in Year 3 will advance to the main emplacement area which is located to the north-west of the pit. The predicted dust deposition contours are in Figure I-3. The contour line representing an increase in the mean annual dust deposition rate of 2.0 g/m^2/month was again predicted to be predominantly confined to the Project area. A minor excursion beyond the boundary of the Project area was predicted to occur immediately to the north of the main emplacement area.

The predicted increases in dust deposition at occupied residences outside the Project area remained below 0.5 g/m^2/month.

Year 6

The pit will deepen further and the total volume of waste rock will be reduced resulting in lower dust emission rates. Lower dust deposition rates were thus predicted for Year 6 as shown in Figure I-4.

The contour line which corresponds to a predicted increase of 2.0 g/m^2/month was predicted to be fully confined within the boundaries of the Project area.

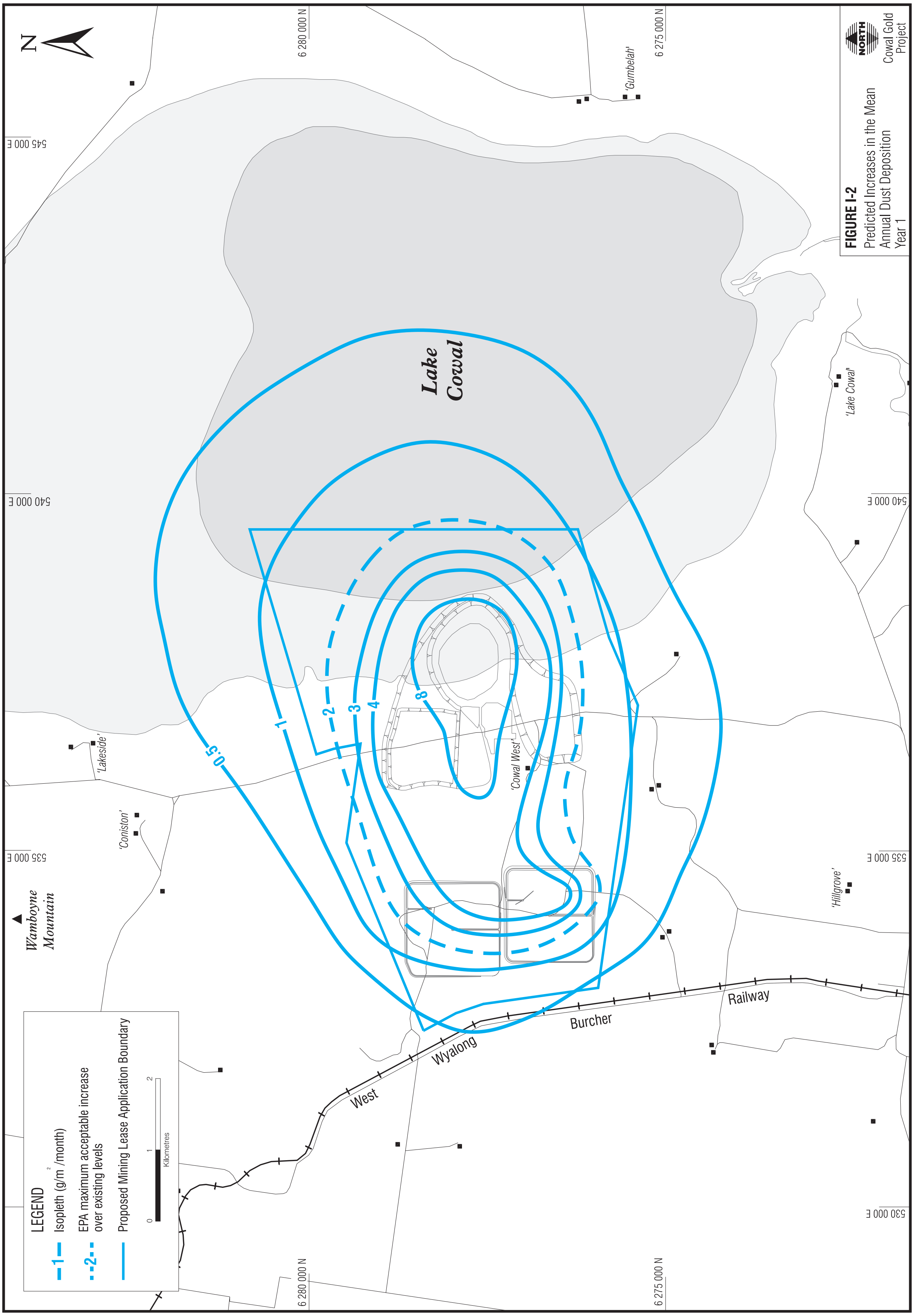

FIGURE I-2
Predicted Increases in the Mean Annual Dust Deposition
Year 1

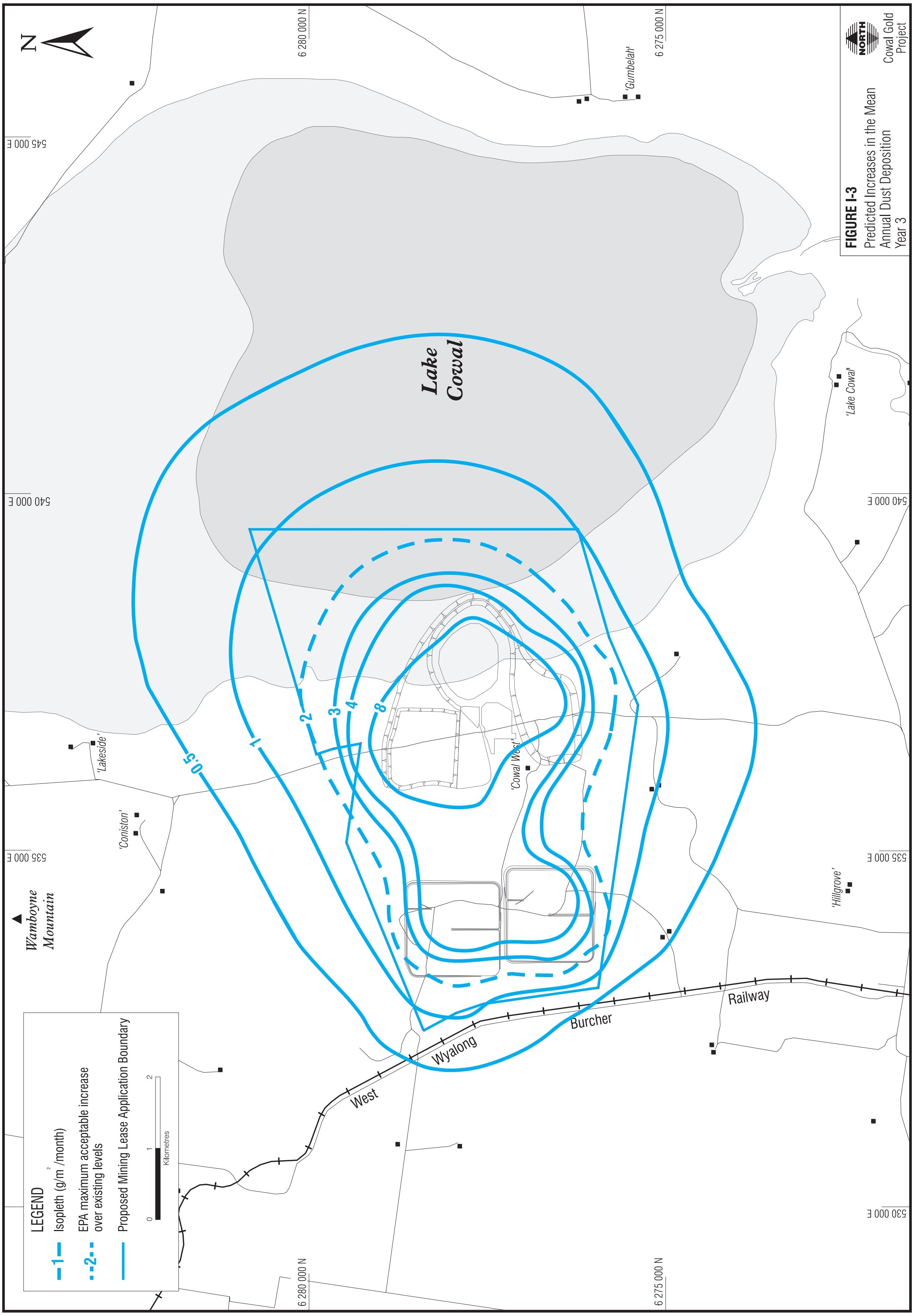

FIGURE I-3
Predicted Increases in the Mean Annual Dust Deposition
Year 3

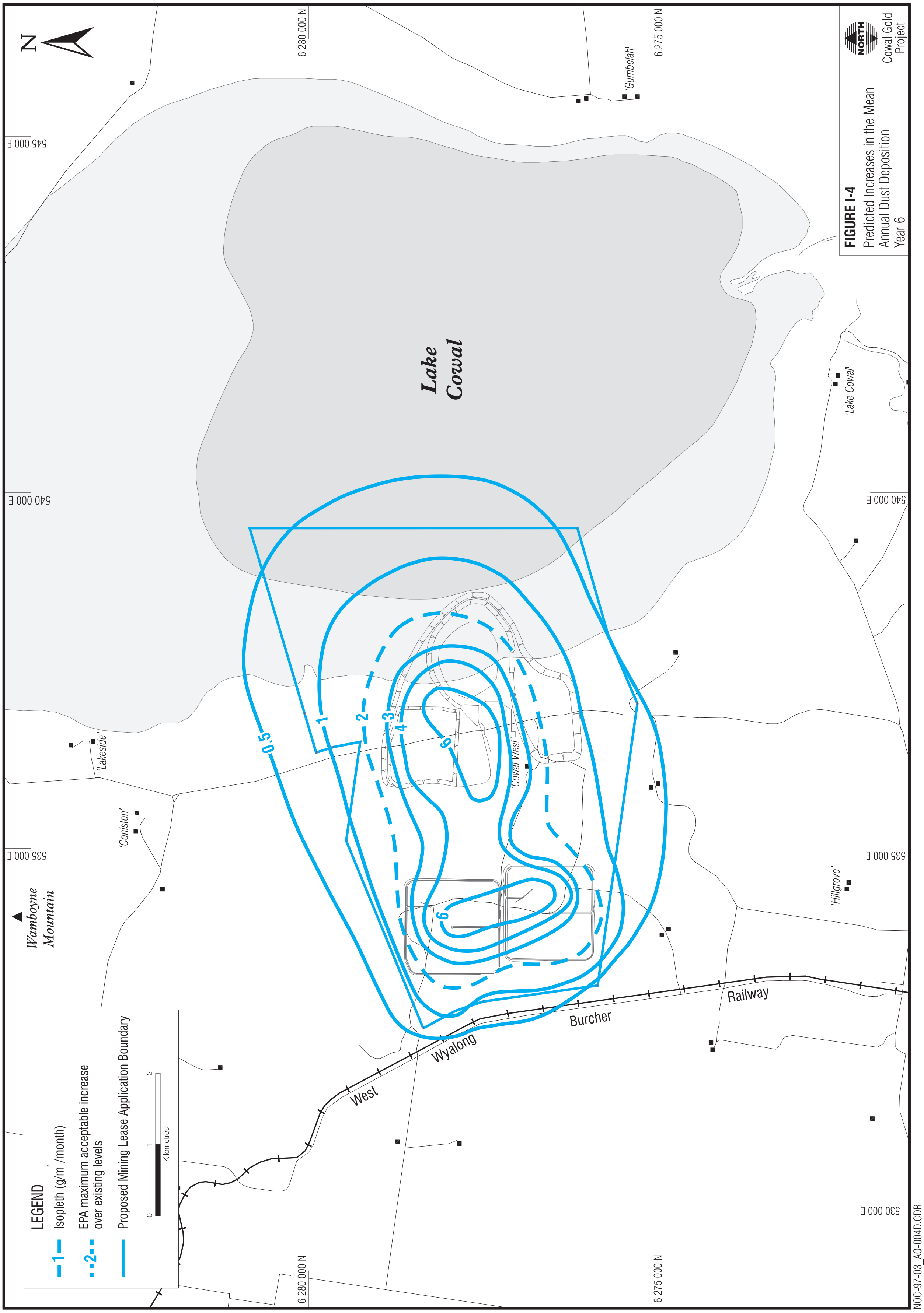

FIGURE I-4
Predicted Increases in the Mean Annual Dust Deposition Year 6

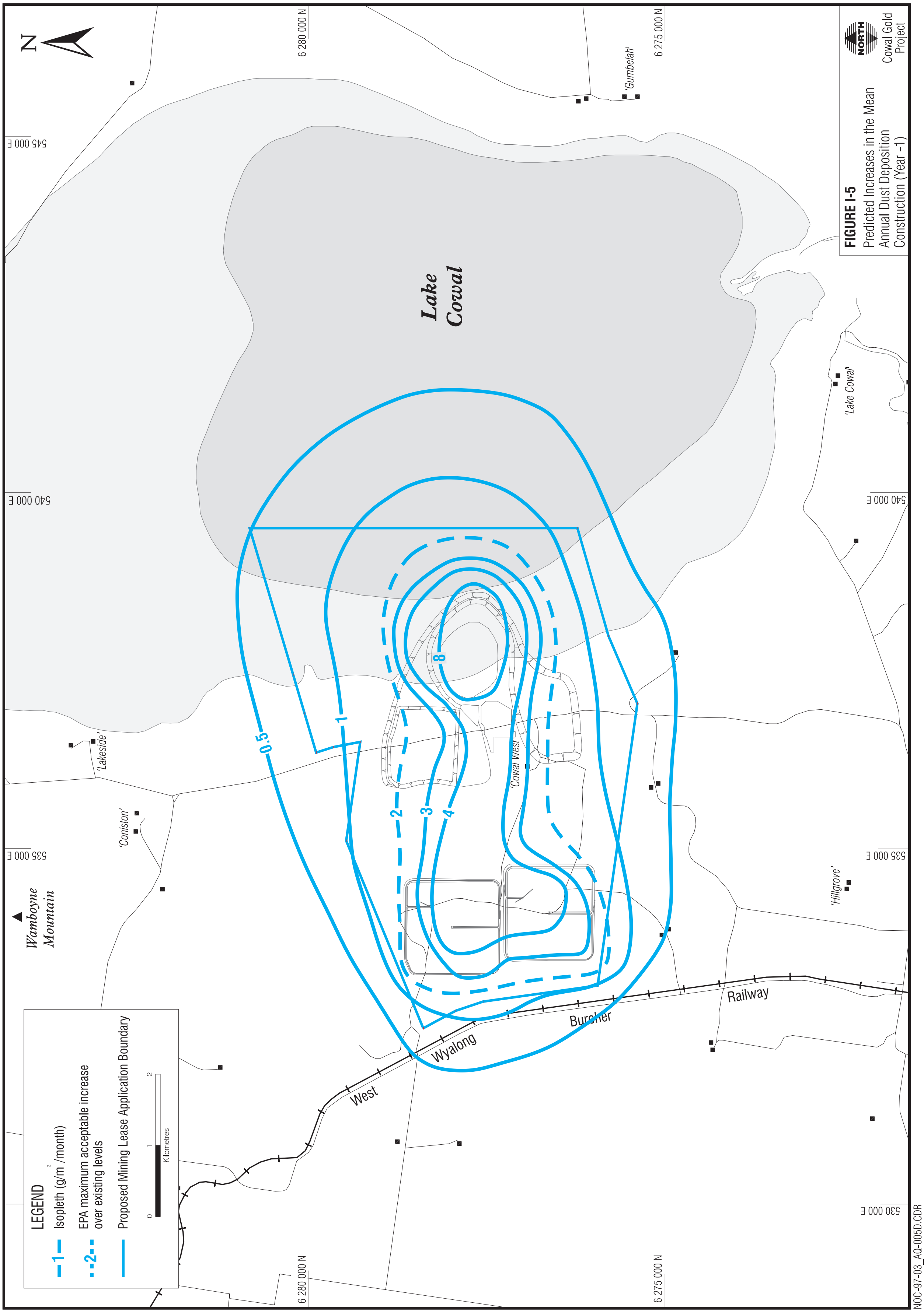

FIGURE I-5
Predicted Increases in the Mean Annual Dust Deposition Construction (Year -1)

The predicted increases in dust deposition at occupied residences were again less than 0.5 g/m^2/month.

Construction (Year-1)

Predicted increases in the mean dust deposition rates during the construction stage are shown in Figure I-5. As explained in Section 5.1, annualised emission data for Year-1 were used as a basis for the predictions. Increases of 2.0 g/m^2/month and above will be confined to the Project area. A very small excursion beyond the boundary of the site was predicted to the south of the southern tailings storage as a result of its construction.

The predicted increases in dust deposition at occupied residences during the construction period remained well below 0.5 g/m^2/month.

6.1.3 Impact assessment

The impact of dust emissions from the proposed development was assessed in terms of the EPA objective for protection of amenity by comparing the predicted mean annual increases in dust deposition with a maximum acceptable value of 2.0 g/m^2/month.

The results of dust dispersion modelling showed that the EPA objective will be met with respect to all land outside the Project area. The amount of dust emissions will vary throughout the period of proposed operation of 13 years.

Notwithstanding the variations, the EPA objective will be met at all non-Company owned residences at all stages of the development with a substantial margin of safety. Because of a variety of dust controls and operational measures to reduce emissions of dust as well as the considerable separation distances which exist between even the nearest occupied residences and the main sources of dust emissions within the Project area, the maximum increases in the mean annual dust deposition rates were predicted to remain less than 25 per cent of the EPA objective.

Minor excursions in the position of the 2.0 g/m^2/month contour line beyond the boundary of the Project area were predicted to occur at certain times of the proposed development. The locations and times of possible minor excursions were the southern boundary to the south of the tailings storage area during construction (Year-1), the eastern boundary to the east of the perimeter waste emplacement in Year 1, and a small portion of land which is located to the north of the main emplacement area in Years 3 and 6.

The predicted excursions are only minor and temporary and will not impact adversely on the land adjacent to the Project area. There is continuing evidence from studies in New South Wales and elsewhere which shows that agricultural land use as well as livestock and native flora and fauna are protected with even a much larger margin of safety by the EPA amenity criteria than residential amenity.

6.2 Concentration of Total Suspended Particulates

6.2.1 Air Quality Guidelines

The health effects of dust are related to the concentration of suspended particles in the air as distinct from dust deposition. The effects of inhaled dust are specifically related to the types of particles inhaled, the particles' sizes, the ability of the respiratory tract to capture and eliminate the particles and the reactivity of the particles with lung tissue (SPCC, 1983).

The National Health and Medical Research Council of Australia (NHMRC, 1985) recommended annual concentration of 90 µg/m^3 as the maximum permissible level of total suspended particulates in the air to protect public health in residential environments. Exposure periods shorter than one year are not covered by the NHMRC goals.

More recently, the USEPA and regulatory authorities in a number of European countries adopted air quality objectives which were specifically designed to address the levels of particles which have aerodynamic diameters of less than 10 microns in size (PM10). By contrast, total suspended particulates which are covered by the objectives listed above range in size to 30 microns and possibly higher.

In recognition of these developments, the NSW EPA has now listed the USEPA ambient air standards for PM10 concentrations among its objectives. **These objectives seek to limit the mean annual concentration of PM10 in residential environments to 50 micrograms/m^3**. Similarly, the maximum concentrations of PM10 over an interval of 24 hours are limited to 150 micrograms/m^3.

No air quality guideline values are available either in Australia or overseas which would relate to the concentration of total suspended particulates in the air during brief dust episodes. The episodes are the result of adverse weather conditions, usually strong winds and dry weather, sometimes coinciding with higher than normal emissions of dust. Wind erosion of dusty surfaces is often the main component of the emission which may last for a few hours.

6.2.2 Predicted Levels

The results of modelling predictions of mean annual dust concentrations during four selected years of the proposed development are shown in Figures I-6 to I-9. The contour lines indicate the predicted increases in the mean annual concentrations of total suspended particulates in the ambient air. Contour levels corresponding to increments of 10, 20, 40, 60, 90 and 120 micrograms/m^3 were used in the figures.

The levels were again selected to provide a representative range of concentration values for subsequent assessment.

It may be noted that the NHMRC guideline of 90 micrograms/m^3 refers to a total concentration of TSP in residential environments. It was estimated in Section 2.2 that the existing mean annual concentrations may be not more than 20 to 30 micrograms/m^3. An increase of about 60 to 70 micrograms/m^3 would thus be needed to reach a limit value of 90 micrograms/m^3.

Year 1

The predicted increases in the mean annual concentration of total suspended particulates (TSP) in the ambient air in Year 1 are presented in Figure I-6.

The main trends in the predicted dust levels which were displayed earlier by the dust deposition contours were repeated in the contour maps of TSP concentrations. The shape of the predicted concentration isopleths reflected the location of main dust sources and the prevailing wind directions.

Mean annual concentrations of TSP at the Project area were predicted to increase by about 60 micrograms/m^3 or more in the vicinity of the main dust generating sources. Increments of 40 micrograms/m^3 will be almost entirely confined to the Project area as well.

An increase of between 40 and 60 micrograms/m^3 in the mean annual concentration of TSP was predicted for a small area located just outside the northern boundary of the Project area and immediately to the north of the main emplacement. This small portion of land is not used for residential purposes. The nearest residences were predicted to receive an increase in the mean annual concentration of TSP of less than 10 micrograms/m^3.

Year 3

A further displacement in the TSP concentration contours towards the north was predicted in Figure I-7 as a result of increased utilisation of the main emplacement area. Despite the displacement, however, the predicted increases in the mean annual concentrations of TSP in the ambient air of 40 micrograms/m^3 and higher remained confined to the Project area with the exception of the small portion of land immediately to the north of the main emplacement area.

Likewise, the predicted increments in the ambient air at all occupied residences remained below 10 micrograms/m^3.

Year 6

Figure I-8 shows the predicted increases in the mean annual concentrations of TSP in the ambient air in Year 6. This year represents a deep pit and reduced dust emission rates resulting in a reduction in the predicted increases in the TSP concentrations.

Mean annual concentrations of TSP equal to 40 micrograms/m^3 and higher were predicted to be fully confined within the boundary of the Project area.

All occupied residences were predicted to receive less than 10 micrograms/m^3 as a result of the operations in Year 6.

Construction (Year-1)

Contours of incremental TSP concentrations during the construction were predicted in Figure I-9.

All of the occupied residences were again predicted to receive increments of less than 10 micrograms/m^3 in the mean annual concentrations of TSP in the ambient air.

The highest increments of about 40 to 60 micrograms/m^3 were predicted just outside of the Project area immediately to the south of the tailings storages during the construction. Except for this very minor excursion, all other locations outside the boundaries of the Project area were predicted to receive concentrations of less than 40 micrograms/m^3.

6.2.3 Impact Assessment

The mean annual concentrations of TSP at all occupied residences were predicted to increase by less than 10 micrograms/m^3 throughout the life of the Project. **The resulting total concentrations of TSP will thus remain well below the NHMRC guideline value of 90 micrograms/m^3.**

Particulate matter with diameters of less than 10 microns (PM10) usually constitutes about 50 per cent or less of the total suspended particulates (TSP) in the ambient air. **When a ratio of 50 per cent is applied to the emissions from the proposed development, the mean annual concentrations of PM10 at all residences are expected to be less than 5 micrograms/m^3. As a result, a mining operation which incorporates the use of standard dust control measures and safeguards as proposed will not adversely affect public health at the surrounding residential properties.**

Short-term dust episodes

Short-term dust episodes are periods of temporary increases in the amount of dust raised mainly from disturbed surfaces and other dust containing areas by strong winds in dry weather conditions. As outlined in Section 5.4 of this report, the contribution of erosion of disturbed surface by winds in excess of about 20 kph to the total dust emission was included in the modelling of annual dust deposition rates and TSP concentrations.

The wind records which were collected in the Project area indicated that the potential for the occurrence of frequent dust episodes is not very high. Wind speeds of 20 kph and higher were recorded with a relatively low annual frequency of 14.0 per cent.

There are no set numerical criteria which could be applied to brief intervals of time associated with dust episodes. Hence, any modelled results for dust episodes are not able to be assessed in terms of impact.

Because of the prominent role of high winds in the formation of a possible dust episode, the best strategy during the operation is to monitor closely the wind conditions on a continuous basis and curtail certain activities in certain meteorological situations. The strategy for controlling the occurrence of dust episodes in the vicinity of this development has been proposed along those lines.

A weather monitoring station has been installed in the vicinity of the proposed pit area (Figure I-1). The station is equipped with sensors and an electronic datalogger which could be used to notify the operator that wind conditions may be approaching episodic levels.

When considering a strategy for controlling the occurrence of dust episodes, it is necessary to bear in mind experience

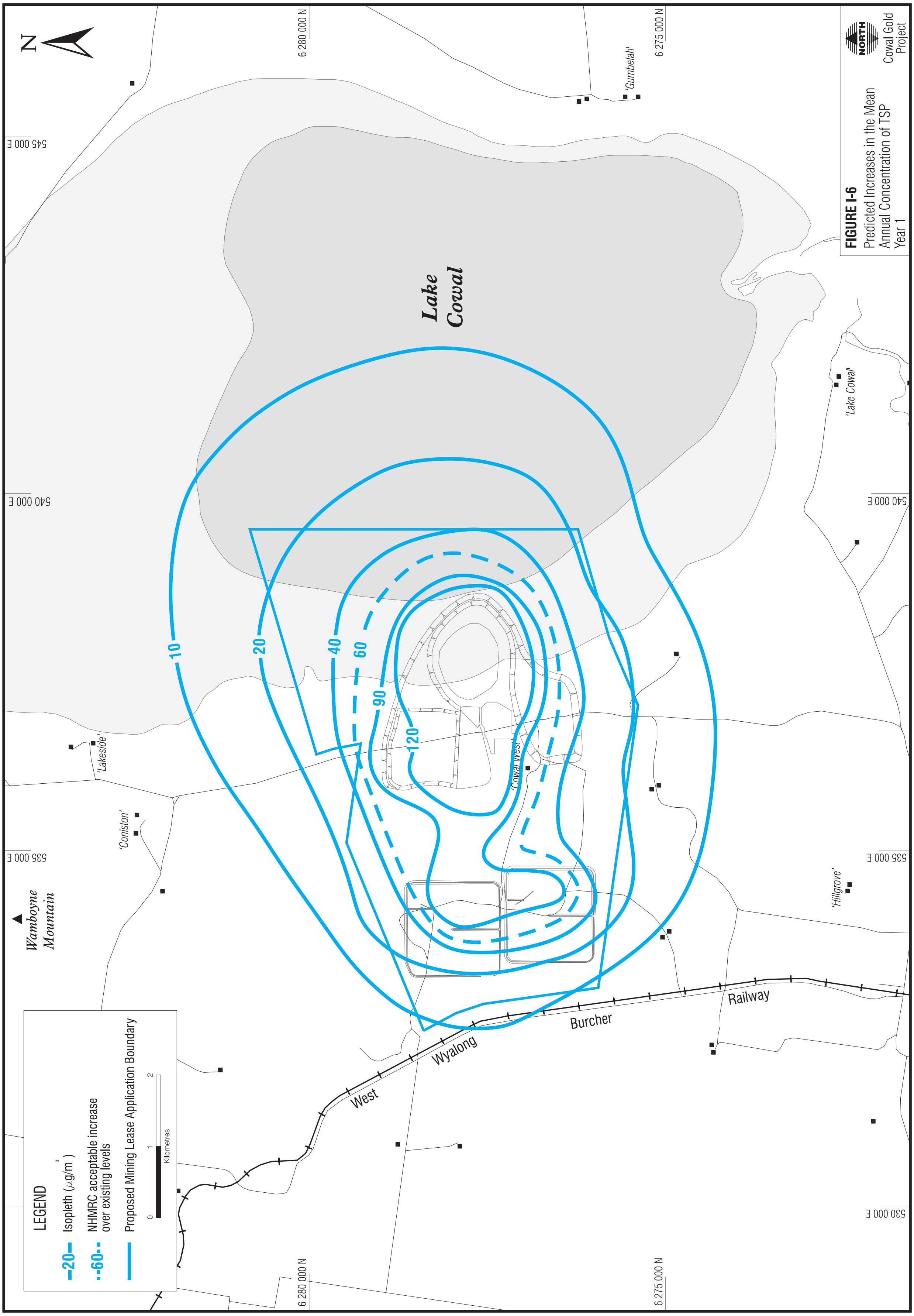

FIGURE I-6
Predicted Increases in the Mean Annual Concentration of TSP
Year 1

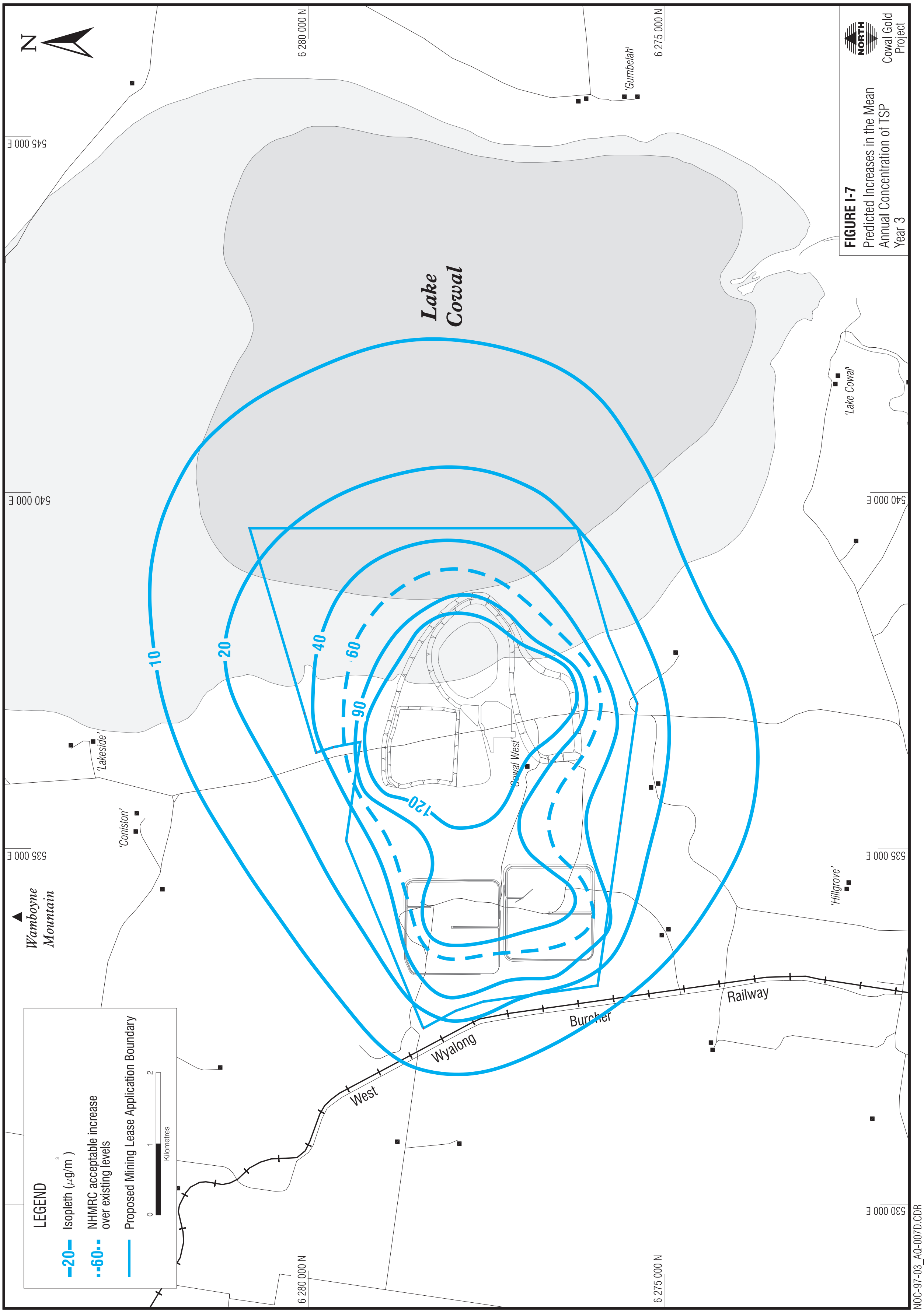

FIGURE I-7
Predicted Increases in the Mean Annual Concentration of TSP
Year 3

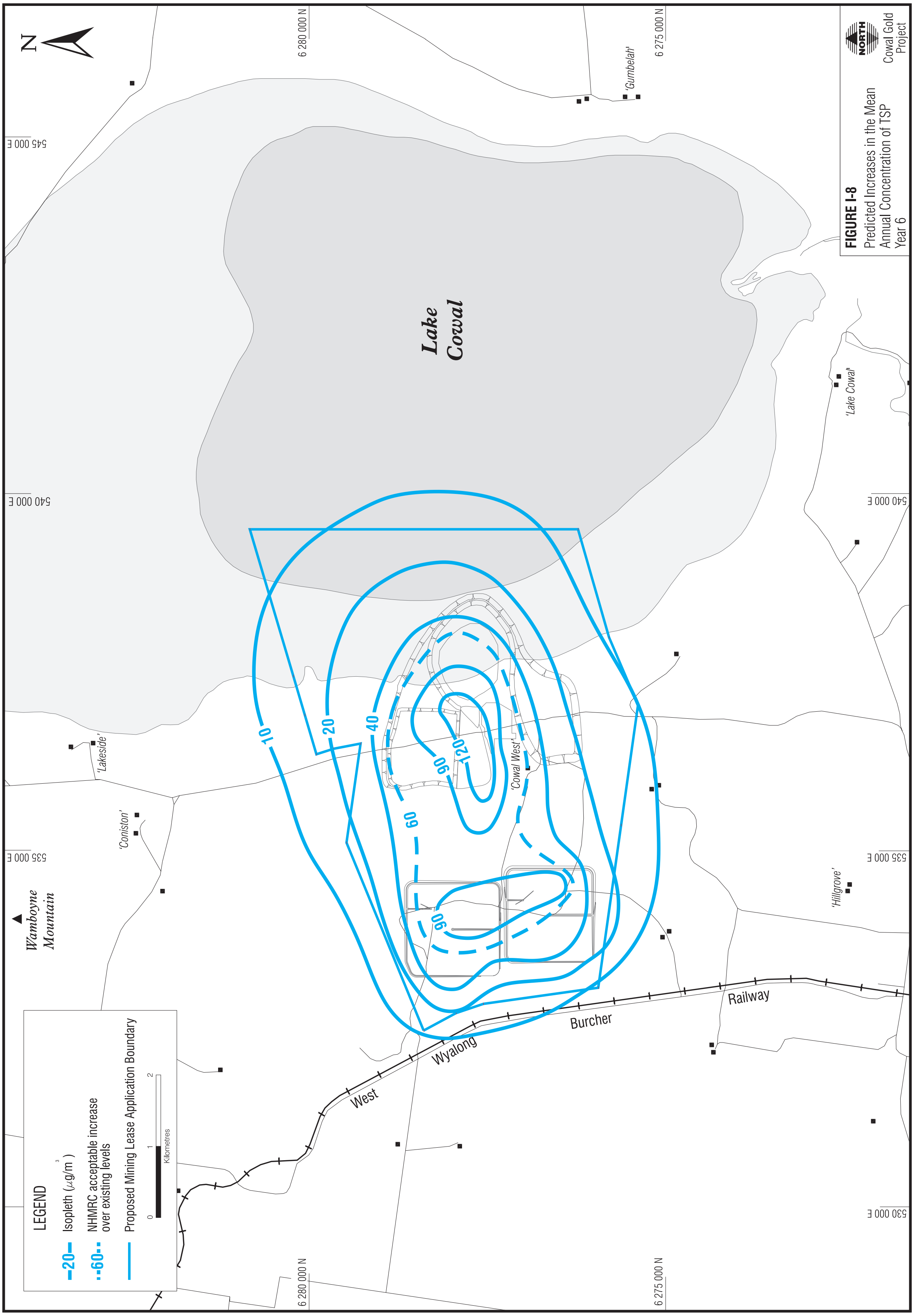

FIGURE I-8
Predicted Increases in the Mean Annual Concentration of TSP
Year 6

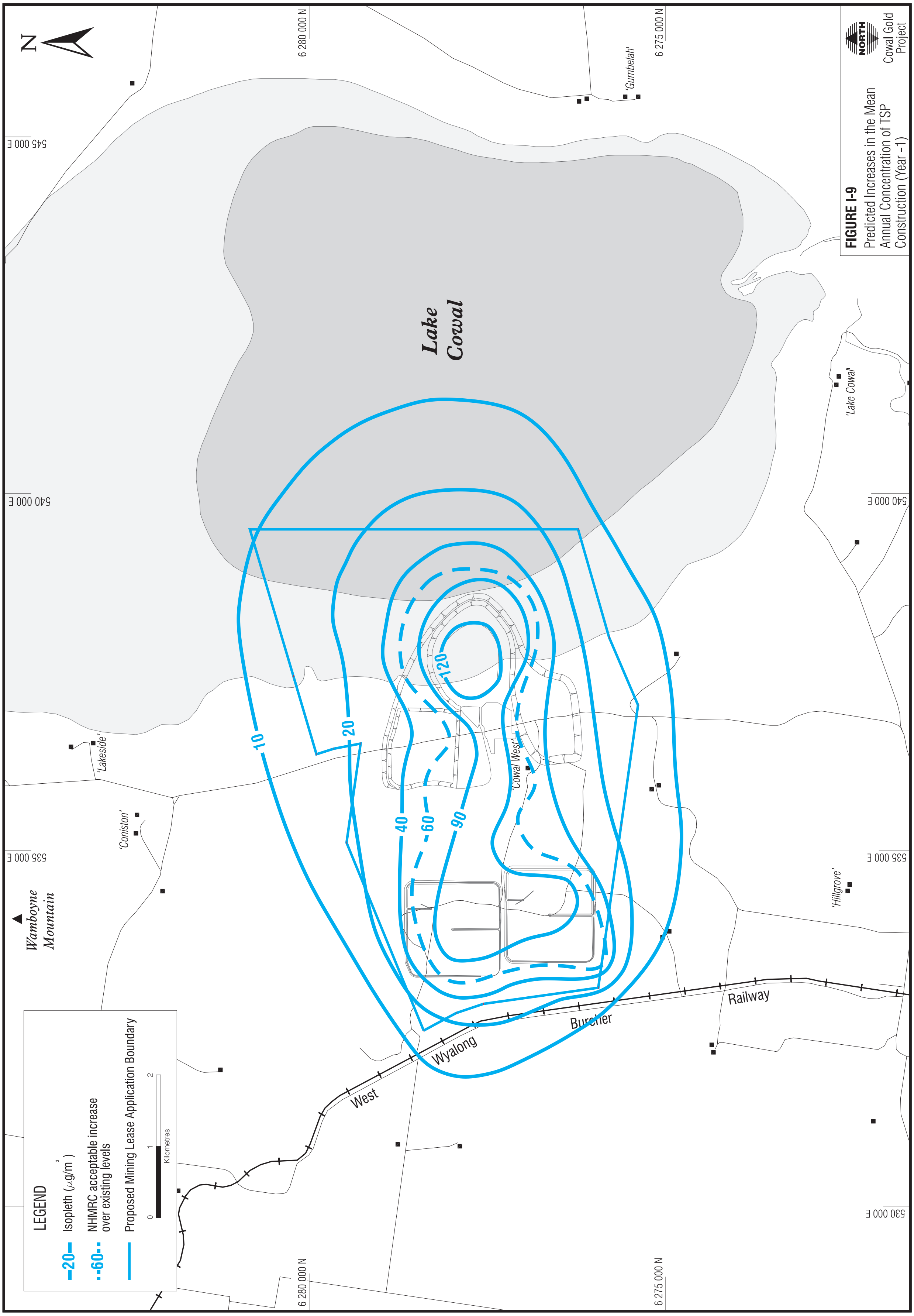

FIGURE I-9
Predicted Increases in the Mean Annual Concentration of TSP Construction (Year -1)

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with similar conditions which has been made in other areas and results of studies regarding the possible effects of any such episode.

The Upper Hunter Cumulative Impact Study which was recently undertaken by the Department of Urban Affairs and Planning in an area containing large open cut coal mines stated in relation to short-term air quality that despite the occurrence of short-term episodic events, there appeared to be no evidence to suggest that long-term pollution goals were being exceeded.

The study also found that the short-term dust episodes had only localised effects and were limited to impacts on amenity, not on health.

7.0 CONCLUSIONS

The generation and dispersion of atmospheric dust from the proposed gold Project at Lake Cowal was examined and quantified. The open cut mine will operate with best practice dust controls including road watering, covered stockpile, water sprays and conveyor wind covers and be subject to a range of approval and licence conditions by the EPA.

Four years of the proposed development including Years 1, 3 and 6 and the construction period (Year-1) were used to develop inventories of dust emissions.

The impact of dust emissions on air quality was assessed using dispersion modelling techniques which included the use of meteorological data collected at the Project area. The predicted increases in dust deposition and dust concentration in the ambient air were assessed by reference to the applicable EPA and NHMRC air quality objectives. Results of on-site monitoring of existing levels of atmospheric dust in the area containing the Project site were included in the assessment.

Results of dispersion modelling confirmed that the EPA amenity-based criteria will not be exceeded outside the Project area. All occupied residences were predicted to receive mean annual increments of less than 0.5 g/m^2/month. Residential amenity as well as other land use will not be affected by dust deposition resulting from the proposed operation.

Minor excursions in the position of the 2.0 g/m^2/month contour line beyond the boundary of the Project area were predicted to occur at certain times of the proposed development. The locations and times of possible minor excursions were the southern boundary to the south of the tailings storage area during construction (Year-1), the eastern boundary to the east of the perimeter waste emplacement in Year 1, and a small portion of land which is located to the north of the main emplacement area in Years 3 and 6.

The predicted excursions are only minor and temporary and will not impact adversely on the land adjacent to the Project area. There is continuing evidence from studies in New South Wales and elsewhere which shows that agricultural land use as well as livestock and native flora and fauna are adequately protected by the EPA amenity criteria which are applicable to residential land.

The mean annual concentrations of TSP and PM10 in the ambient air will remain at levels well below the applicable guideline values. No adverse effects on public health were thus predicted as a result of the proposed and safeguarded operation. Similarly, livestock and native flora and fauna are also expected to be adequately protected by the application of the NHMRC guideline.

A dust monitoring programme has been implemented at the Project area. It is recommended that this monitoring programme be audited prior to its expansion before operations commence. The monitoring is expected to be expanded and to continue throughout the life of the mine or as required by the NSW EPA. The monitoring results will be able to be used to assess compliance of the operating mine with the air quality objectives and licence conditions.

Atmospheric dust will be the main component of emissions to air from the proposed development. Other emissions will include exhaust fumes from mobile equipment, blasting fumes and evaporative emissions from the processing area including odours. All these emissions will remain only minor and will be confined to the Project area.

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Attachments A-1 A-4

Attachments A-1 – A-4

Dust Emission Inventories

TABLE A-1 Dust emission inventory for Year 1 of the Cowal Gold Project

Operation	Extent of operation	Annual emission	Comments
Pit operations			
Dozer (in pit)	8760 hrs/yr	28.8 t/yr	Assume continuous operation
Ore and waste drilling	25 500 holes/yr	15.3 t/yr	Bench height = 10 m, 170 holes/blast
Ore and waste blasting	150 blasts/yr	5.6 t/yr	37.6 kg/blast Area of blast = 3080 m^2
Ore and waste loading (excavator)	29.7 Mtpa	742.5 t/yr	
Waste haulage (in pit)	138 370 VKT/yr	276.7 t/yr	Average distance = 600 m (in pit) Load = 160 t/truck
Ore haulage (in pit)	67 620 VKT/yr	135.2 t/yr	Average distance = 600 m (in pit) Load = 200 t/truck
Ore haulage (out of pit)	50 715 VKT/yr	101.4 t/yr	Average distance = 450 m
	Subtotal	1305.5 t/yr	
Processing plant			
High grade ore			
Reclaiming from high grade oxide stockpile (FEL)	0.5 Mtpa	12.5 t/yr	
Active ROM pad	0.67 Mtpa	10.8 t/yr	Includes loading to pad, wind erosion, equipment traffic Area = 1.95 ha
Reclaiming from ROM pad	0.67 Mtpa	16.8 t/yr	Assumes 10% via ROM pad
Ore dumping (to crusher)	7.22 Mtpa	72.2 t/yr	Includes 0.5 Mtpa from high grade oxide stockpile
Primary crushing and screening	7.22 Mtpa	14.4 t/yr	
Conveying to main stockpile	7.22 Mtpa	4.1 t/yr	Includes 3 transfers
Loading to main stockpile	7.22 Mtpa	11.6 t/yr	Stockpile is hooded
Secondary grinding and milling	7.22 Mtpa	14.4 t/yr	Assumes controls and emission equal to primary crusher
Low grade ore			
Haulage to stockpile	27 300 VKT/yr	54.6 t/yr	4.55 Mtpa to low grade stockpile Mean distance = 600 m
Dumping	4.55 Mtpa	54.6 t/yr	
Shaping, spreading	4380 hrs/yr	32.0 t/yr	Assumes 4380 hours
	Subtotal	315.8 t/yr	
Waste emplacement – Perimeter bund			
Waste haulage (to emplacement area)	80 720 VKT/yr	161.4 t/yr	Average distance = 400 m Load = 160 t/truck
Waste haulage (in emplacement area)	69 190 VKT/yr	138.3 t/yr	Average distance = 600 m Load = 160 t/truck
Waste dumping	9.4 Mtpa	112.5 t/yr	50% to perimeter bund
Waste spreading, shaping (dozer)	4380 hrs/yr	32.0 t/yr	1 dozer – 50% of time
	Subtotal	444.2 t/yr	
Waste disposal – Main emplacement			
Topsoil removed	2400 hrs/yr	33.6 tyr	Assumes 2400 hrs per year
Waste haulage (to emplacement area)	46 120 VKT/yr	92.2 t/yr	Average distance = 400 m Load = 160 t/truck
Waste haulage (in emplacement area)	115 310 VKT/yr	230.6 t/yr	Average distance = 1.0 km Load = 160 t/truck
Waste dumping	9.4 Mtpa	112.5 t/yr	50% to main emplacement
Waste spreading, shaping (dozer)	4380 hrs/yr	32.0 t/yr	1 dozer - 50% of time
	Subtotal	500.9 t/yr	

TABLE A-1 Dust emission inventory for Year 1 of the Cowal Gold Project Continued

Operation	Extent of operation	Annual emission	Comments
Remaining sources			
Unsealed (internal) roads	29 200 VKT/yr	116.8 t/yr	Assumes 20 traffic movements per day on internal roads other than haul roads
Grading of roads	11 520 km/yr	7.1 t/yr	Assumes 8 hrs/day at 8 km/hr
	Subtotal	123.9 t/yr	
Wind erosion			
Pit area (total)	69.0 ha	241.8 t/yr	
Waste emplacement			
Perimeter	68.7 ha	240.7 t/yr	
Main	52.0 ha	182.2 t/yr	
Low grade oxide stockpile	24.5 ha	85.8 t/yr	
High grade oxide stockpile	7.4 ha	25.9 t/yr	
	Subtotal	776.4 t/yr	
	(EASTERN SECTION) SUBTOTAL	3466.7 t/yr	
Tailings storage			
Wind erosion	200 ha	700.8 t/yr	Assumes 1/2 of total storage area is dry
Unsealed roads	73 000 VKT/yr	292.0 t/yr	Assumes 50 traffic movements on internal roads to tailings storage and around
	(WESTERN SECTION) SUBTOTAL	992.8 t/yr	
	TOTAL	4459.5 t/yr	

Note: Refer to Section 5.4 for description of the application of wind erosion components in the dispersion model.

TABLE A-2 Dust emission inventory for Year 3 of the Cowal Gold Project

Operation	Extent of operation	Annual emission	Comments
Pit operations			
Dozer (in pit)	8760 hrs/yr	28.8 t/yr *	Assume continuous operation
Ore and waste drilling	76 500 holes/yr	45.9 t/yr	Bench height = 10 m, 306 holes/blast
Ore and waste blasting	250 blasts/yr	22.7 t/yr	90.7 kg/blast Area of blast = 5540 m^2
Ore and waste loading (excavator)	38.2 Mtpa	955.0 t/yr *	
Waste haulage (in pit)	292 400 VKT/yr	584.8 t/yr *	Average distance = 850 m (in pit) Load = 160 t/truck
Ore haulage (in pit)	90 950 VKT/yr	181.9 t/yr *	Average distance = 850 m (in pit) Load = 200 t/truck
Ore haulage (out of pit)			
to plant	15 525 VKT/yr	31.1 t/yr	Average distance = 250 m
to low grade pad	13 470 VKT/yr	26.9 t/yr	Average distance = 300 m
	Subtotal	1877.1 t/yr	
* less 30% of in-pit emissions (due to pit retention)	less	525.1 t/yr	
	Subtotal	1352.0 t/yr	
Processing plant			
High grade ore			
Active ROM pad	0.62 Mtpa	10.8 t/yr	Includes loading to pad, wind erosion, equipment traffic Area = 1.95 ha
Reclaiming from ROM pad	0.62 Mtpa	15.5 t/yr	Assumes 10% via ROM pad
Ore dumping (to crusher)	6.2 Mtpa	62.0 t/yr	
Primary crushing and screening	6.2 Mtpa	12.4 t/yr	
Conveying to main stockpile	6.2 Mtpa	3.4 t/yr	Includes 3 transfers
Loading to main stockpile	6.2 Mtpa	9.9 t/yr	Stockpile is hooded
Secondary grinding and milling	6.2 Mtpa	12.4 t/yr	Assumes controls and emission equal to primary crusher
Low grade ore			
Haulage on stockpile	22 450 VKT/yr	44.9 t/yr	4.49 Mtpa to low grade stockpile Mean distance = 500 m
Dumping	4.49 Mtpa	53.9 t/yr	
Shaping, spreading	4380 hrs/yr	32.0 t/yr	Assumes 4380 hours
	Subtotal	257.2 t/yr	
Waste emplacement – Main emplacement			
Waste haulage (to emplacement area)	154 800 VKT/yr	309.6 t/yr	Average distance = 900 m Load = 160 t/truck
Waste haulage (in emplacement area)	189 200 VKT/yr	378.4 t/yr	Average distance = 1100 m Load = 160 t/truck
Waste dumping	13.76 Mtpa	165.1 t/yr	50% to main emplacement
Waste spreading, shaping (dozer)	4380 hrs/yr	32.0 t/yr	1 dozer - 50% of time
	Subtotal	885.1 t/yr	

TABLE A-2 Dust emission inventory for Year 3 of the Cowal Gold Project Continued

Operation	Extent of operation	Annual emission	Comments
Waste disposal - Southern emplacement			
Waste haulage (to emplacement area)	68 800 VKT/yr	137.6 t/yr	Average distance = 400 m Load = 160 t/truck
Waste haulage (in emplacement area)	154 800 VKT/yr	309.6 t/yr	Average distance = 0.9 km Load = 160 t/truck
Waste dumping	13.76 Mtpa	165.1 t/yr	50% to southern emplacement
Waste spreading, shaping (dozer)	4380 hrs/yr	32.0 t/yr	1 dozer - 50% of time
	Subtotal	644.3 t/yr	
Remaining sources			
Unsealed (internal) roads	29 200 VKT/yr	116.8 t/yr	Assumes 20 traffic movements per day on internal roads other than haul roads
Grading of roads	23 040 km/yr	14.2 t/yr	Assumes 8 hrs/day at 8 km/hr
	Subtotal	131.0 t/yr	
Wind erosion			
Waste emplacement			
Perimeter	29.8 ha	104.4 t/yr	
Main	95.9 ha	336.0 t/yr	
Southern	75.9 ha	266.0 t/yr	
Low grade oxide stockpile	36.1 ha	126.5 t/yr	
	Subtotal	832.9 t/yr	
	(EASTERN SECTION) SUBTOTAL	4102.5 t/yr	
Tailings storage			
Wind erosion	300 ha	1051.2 t/yr	Assumes 3/4 of total storage area is dry
Unsealed roads	73 000 VKT/yr	292.0 t/yr	Assumes 50 traffic movements on internal roads to tailings storage and around
	(WESTERN SECTION) SUBTOTAL	1343.2 t/yr	
	TOTAL	5445.7 t/yr	

Note: Refer to Section 5.4 for description of the application of wind erosion components in the dispersion model.

Table A-3 Dust emission inventory for Year 6 of the Cowal Gold Project

Operation	Extent of operation	Annual emission	Comments
Pit operations			
Dozer (in pit)	8760 hrs/yr	28.8 t/yr *	Assume continuous operation
Ore and waste drilling	25 500 holes/yr	15.3 t/yr	Bench height = 10 m, 170 holes/blast
Ore and waste blasting	150 blasts/yr	5.6 t/yr	37.6 kg/blast Area of blast = 3080 m^2
Ore and waste loading (excavator)	10.17 Mtpa	254.2 t/yr *	
Waste haulage (in pit)	46 125 VKT/yr	92.2 t/yr *	Average distance = 1500 m (in pit) Load = 160 t/truck
Ore haulage (in pit)	115 650 VKT/yr	231.3 t/yr *	Average distance = 1500 m (in pit) Load = 200 t/truck
Ore haulage (out of pit) to plant to low grade pad	 24 000 VKT/yr 6 840 VKT/yr	 48.0 t/yr 13.7 t/yr	 Average distance = 400 m
	Subtotal	689.1 t/yr	
* less 50% of in-pit emissions (due to pit retention)	less	288.8 t/yr	
	Subtotal	400.3 t/yr	
Processing plant			
High grade ore			
Active ROM pad	0.67 Mtpa	10.8 t/yr	Includes loading to pad, wind erosion, equipment traffic Area = 1.95 ha
Reclaiming from ROM pad	0.60 Mtpa	15.0 t/yr	Assumes 10% via ROM pad
Ore dumping (to crusher)	6.0 Mtpa	60.0 t/yr	
Primary crushing and screening	6.0 Mtpa	12.0 t/yr	
Conveying to main stockpile	6.0 Mtpa	3.4 t/yr	Includes 3 transfers
Loading to main stockpile	6.0 Mtpa	9.6 t/yr	Stockpile is hooded
Secondary grinding and milling	6.0 Mtpa	12.0 t/yr	Assumes controls and emission equal to primary crusher
Low grade ore			
Haulage on stockpile	8550 VKT/yr	17.1 t/yr	1.71 Mtpa to low grade stockpile Mean distance = 500 m
Dumping	1.71 Mtpa	20.5 t/yr	
Shaping, spreading	4380 hrs/yr	32.0 t/yr	Assumes 4380 hours
	Subtotal	192.4 t/yr	
Waste disposal - Main emplacement			
Waste haulage (to emplacement area)	12 300 VKT/yr	24.6 t/yr	Average distance = 400 m Load = 160 t/truck
Waste haulage (in emplacement area)	30 750 VKT/yr	61.5 t/yr	Average distance = 1.0 km Load = 160 t/truck
Waste dumping	2.46 Mtpa	29.5 t/yr	100% to main emplacement
Waste spreading, shaping (dozer)	8760 hrs/yr	64.0 t/yr	1 dozer - 100% of time including rehabilitation
	Subtotal	179.6 t/yr	

Table A-3 Dust emission inventory for Year 6 of the Cowal Gold Project Continued

Operation	Extent of operation	Annual emission	Comments
Remaining sources			
Unsealed (internal) roads	29 200 VKT/yr	116.8 t/yr	Assumes 20 traffic movements per day on internal roads other than haul roads
Grading of roads	11 520 km/yr	7.1 t/yr	Assumes 8 hrs/day at 8 km/hr
	Subtotal	123.9 t/yr	
Wind erosion			
Waste emplacement Main	90.6 ha	317.5 t/yr	
Low grade oxide stockpile	36.9 ha	129.3 t/yr	
	Subtotal	446.8 t/yr	
	(EASTERN SECTION) SUBTOTAL	1631.8 t/yr	
Tailings storage			
Wind erosion	300 ha	1051.2 t/yr	Assumes 3/4 of total storage area is dry
Unsealed roads	73 000 VKT/yr	292.0 t/yr	Assumes 50 traffic movements on internal roads to tailings storage and around
	(WESTERN SECTION) SUBTOTAL	1343.2 t/yr	
	TOTAL	2975.0 t/yr	

Note: Refer to Section 5.4 for description of the application of wind erosion components in the dispersion model.

Table A-4 Dust emission inventory for construction (Year-1) of the Cowal Gold Project

Operation	Extent of operation	Annual emission	Comments
Pit operations			
Topsoil stripping	624 hrs/yr	8.7 t/yr	Assume 3 months of stripping
Dozer (assisting, ripping)	8760 hrs/yr	28.8 t/yr	Assume continuous operation
Ore and waste loading (excavator)	15.5 Mtpa	387.5 t/yr	
Waste haulage (in pit area)	103 650 VKT/yr	207.3 t/yr	Average distance = 600 m Load = 160 t/truck
Ore haulage (in pit area)	10 080 VKT/yr	21.2 t/yr	Average distance = 600 m Load = 200 t/truck
	Subtotal	653.5 t/yr	
Processing plant			
High grade ore			
Haulage to stockpile	1000 VKT/yr	2.0 t/yr	0.5 Mtpa to high grade stockpile Mean distance = 200 m
Dumping	0.5 Mtpa	6.0 t/yr	
Shaping, spreading	1460 hrs/yr	10.7 t/yr	Assumes 1460 hours
Low grade ore			
Haulage to stockpile	9440 VKT/yr	18.9 t/yr	1.18 Mtpa to low grade stockpile Mean distance = 800 m
Dumping	1.18 Mtpa	14.2 t/yr	
Shaping, spreading	2920 hrs/yr	21.3 t/yr	Assumes 2920 hours
	Subtotal	73.1 t/yr	
Waste emplacement - Perimeter bund			
Waste haulage (to emplacement area)	103 650 VKT/yr	207.3 t/yr	Average distance = 600 m Load = 160 t/truck
Waste haulage (in emplacement area)	69 100 VKT/yr	138.2 t/yr	Average distance = 400 m Load = 160 t/truck
Waste dumping	13.82 Mtpa	165.8 t/yr	100% to perimeter bund
Waste spreading, shaping (dozer)	8760 hrs/yr	64.0 t/yr	1 dozer - 100% of time
	Subtotal	575.3 t/yr	
Remaining sources			
Unsealed (internal) roads	29 200 VKT/yr	116.8 t/yr	Assumes 20 traffic movements per day on internal roads other than haul roads
Grading of roads	23 040 km/yr	14.2 t/yr	Assumes 8 hrs/day at 8 km/hr all year
	Subtotal	131.0 t/yr	
Wind erosion			
Pit area	69.0 ha	241.8 t/yr	
Waste emplacement Perimeter	59.0 ha	206.7 t/yr	
Processing plant area	21.3 ha	74.6 t/yr	
Low grade oxide stockpile	3.1 ha	10.9 t/yr	
High grade oxide stockpile	7.4 ha	25.9 t/yr	
ROM pad	2.3 ha	8.6 t/yr	
	Subtotal	568.5 t/yr	
	(EASTERN SECTION) SUBTOTAL	2001.4 t/yr	

Table A-4 Dust emission inventory for construction (Year-1) of the Cowal Gold Project Continued

Operation	Extent of operation	Annual emission	Comments
Tailings storage			
Construction (northern storage)			
Topsoil stripping	1872 hrs	26.2 t/yr	Assumes 6 months
Dozers (shaping etc.)	3744 hrs	27.3 t/yr	Assumes 2 dozers for 6 months
Waste loading	1.0 Mtpa	25.0 t/yr	Assumes 1.0 Mt
Waste haulage	15 600 VKT/yr	62.4 t/yr	Assumes 50 trips per day at 4.0 kg/VKT Mean distance = 2.0 km
Wind erosion	400 ha	1401.6 t/yr	Assumes 100% of total storage area is dry
Unsealed roads	73 000 VKT/yr	292.0 t/yr	Assumes 50 traffic movements on internal roads to tailings storage and around
	(WESTERN SECTION) SUBTOTAL	1834.5 t/yr	
	TOTAL	3835.9 t/yr	

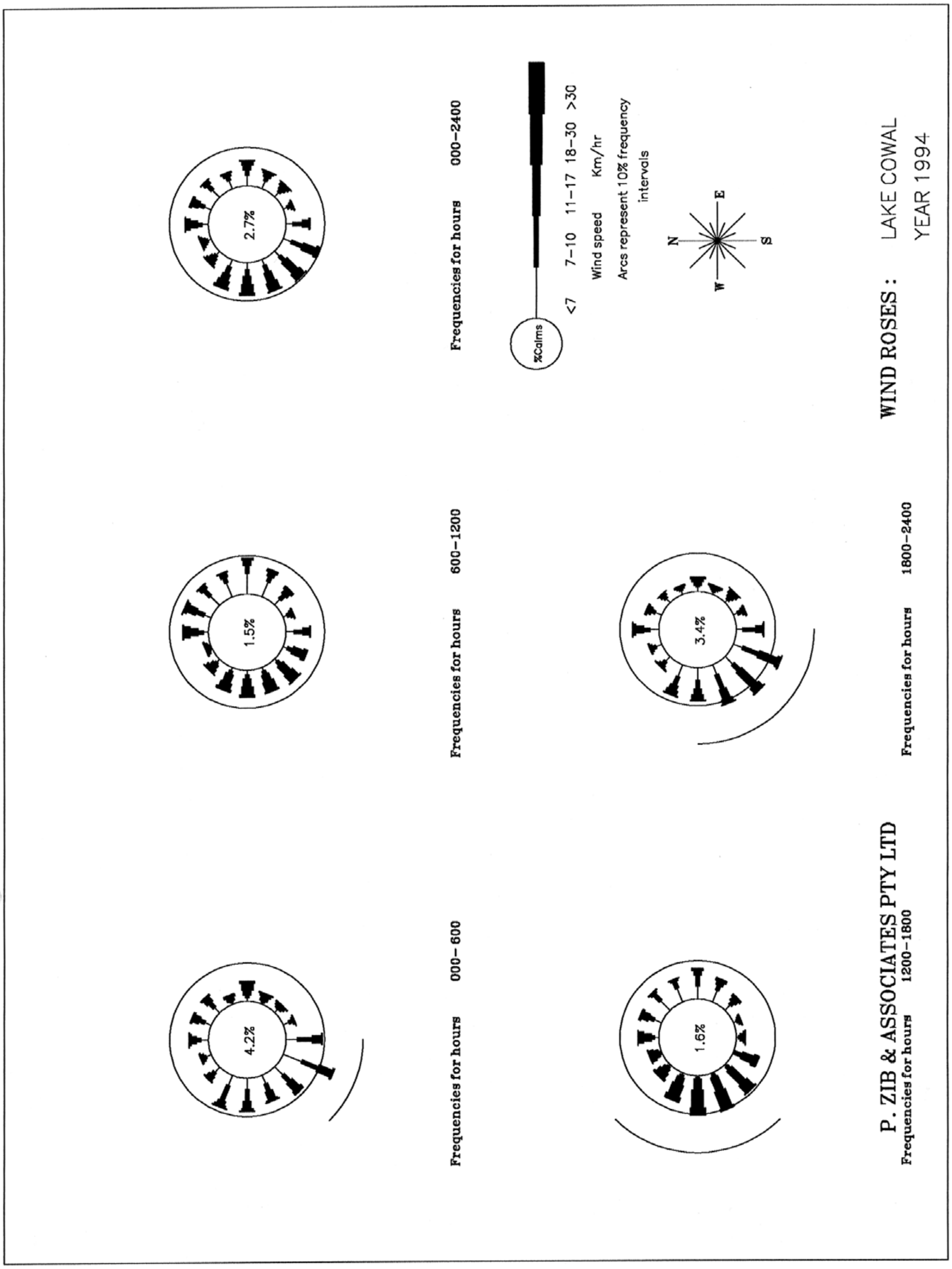
Note: Refer to Section 5.4 for description of the application of wind erosion components in the dispersion model.

Attachment B

Attachment B

Wind Rose Diagrams

Annual and Seasonal Wind Roses for the Project Area
(December 1993 to November 1994)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Frequencies for hours 600-1200
Frequencies for hours 000-600
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Frequencies for hours 1200-1800
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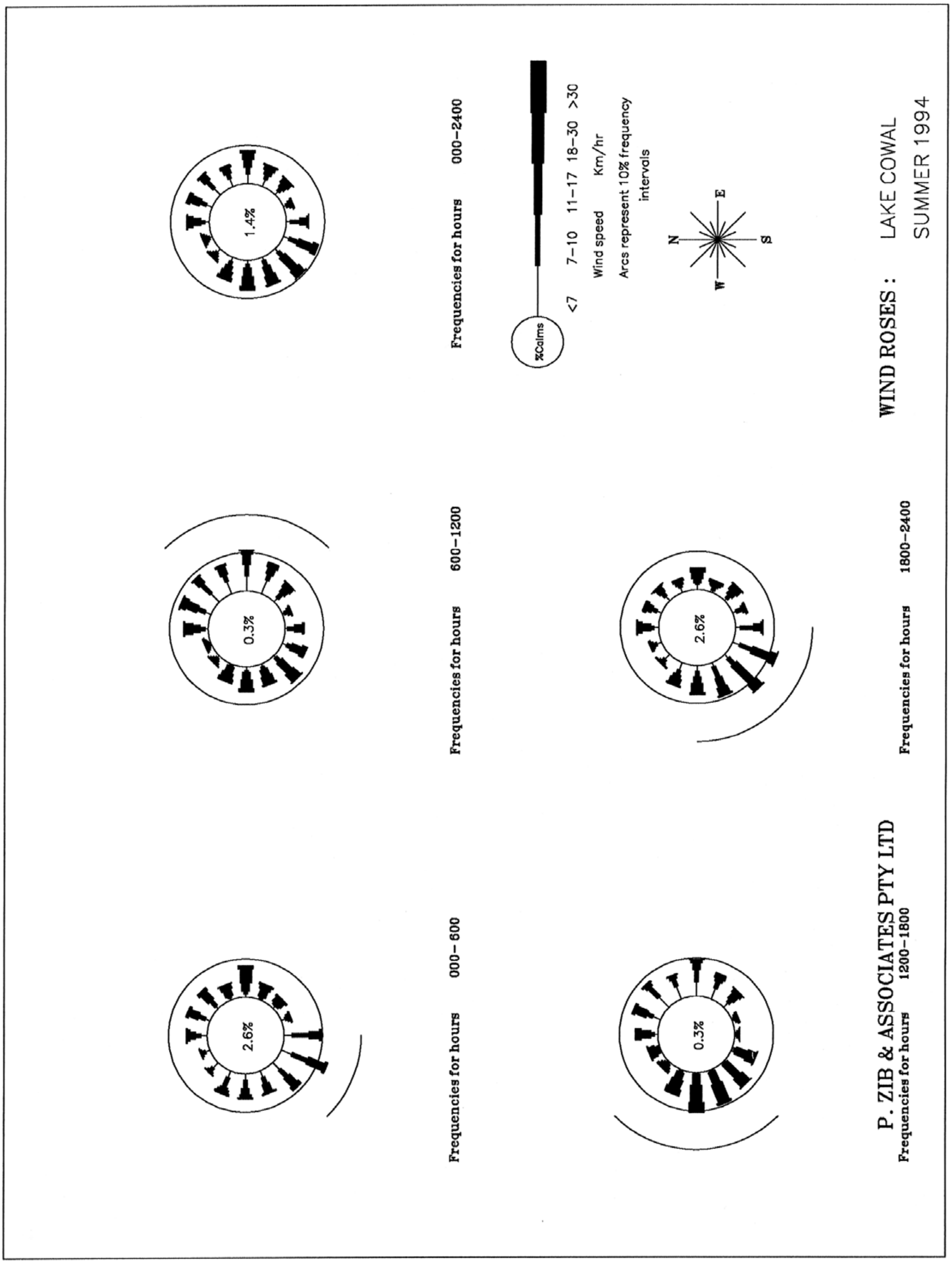
1.5%
4.2%
3.4%
1.6%
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W
WIND ROSES : LAKE COWAL
YEAR 1994
P. ZIB & ASSOCIATES PTY LTD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Frequencies for hours 600-1200
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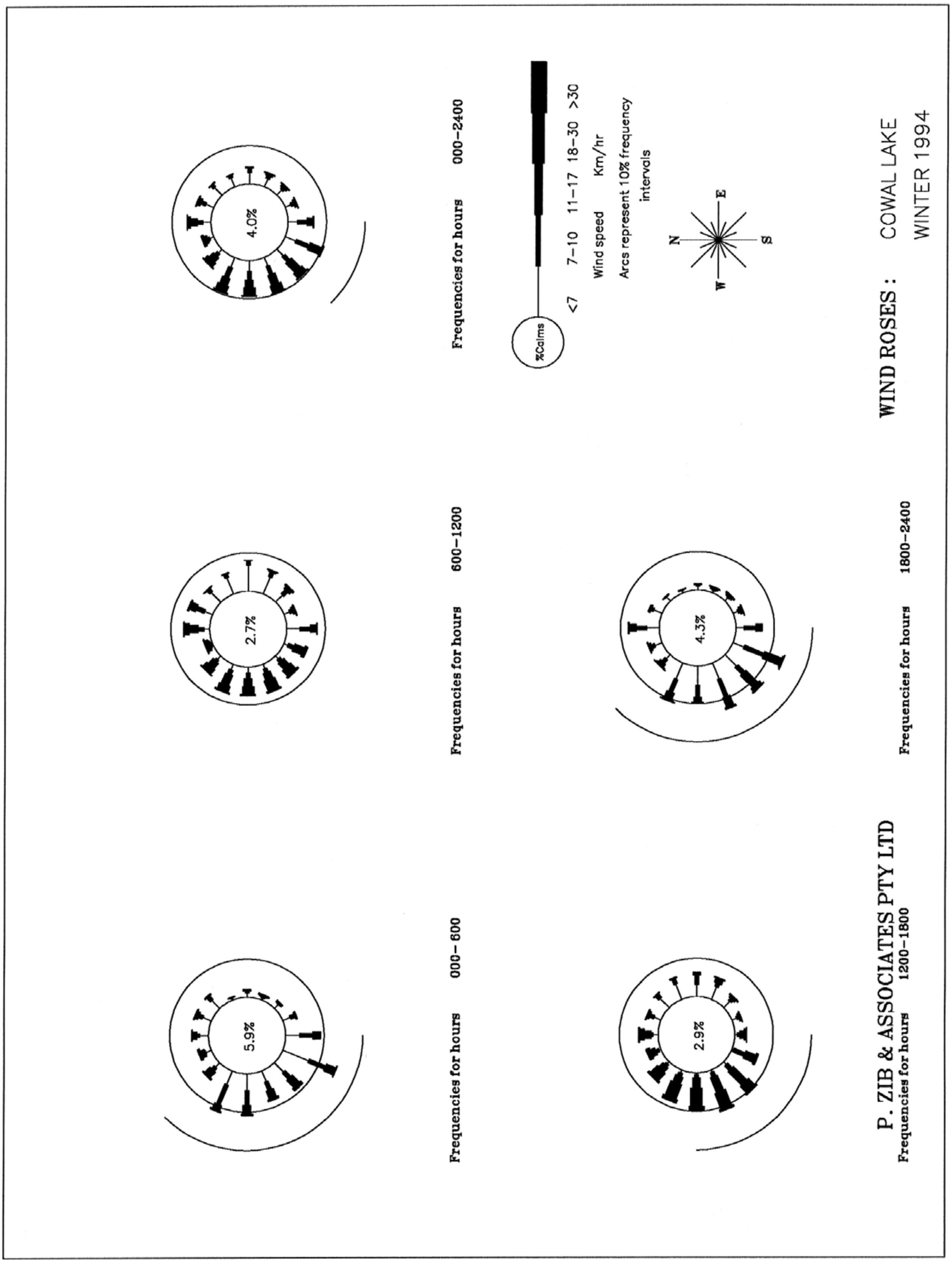
Frequencies for hours 000-2400
1.4%
Frequencies for hours 1200-1800
0.3%
Frequencies for hours 1800-2400
2.6%
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N E S W
P. ZIB & ASSOCIATES PTY LTD
WIND ROSES : LAKE COWAL
SUMMER 1994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Frequencies for hours 600-1200
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Frequencies for hours 000-2400
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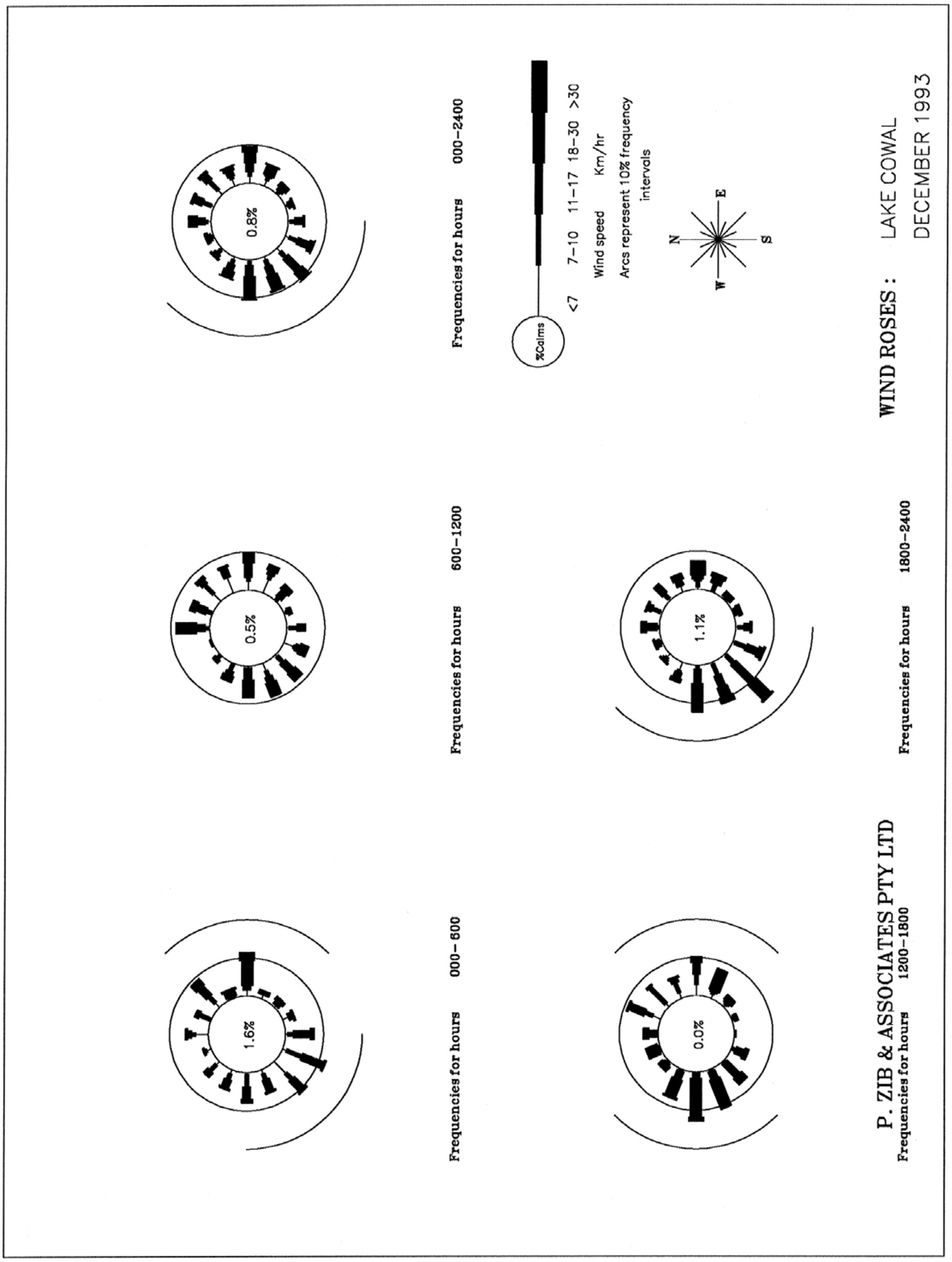
Frequencies for hours 1200-1800
2.9%
Frequencies for hours 1800-2400
4.3%
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W
P. ZIB & ASSOCIATES PTY LTD
WIND ROSES : COWAL LAKE
WINTER 1994

Monthly Wind Roses for the Project Area
(December 1993 to November 1994)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Frequencies for hours 600-1200
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Frequencies for hours 1200-1800
0.0%
Frequencies for hours 1800-2400
1.1%
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
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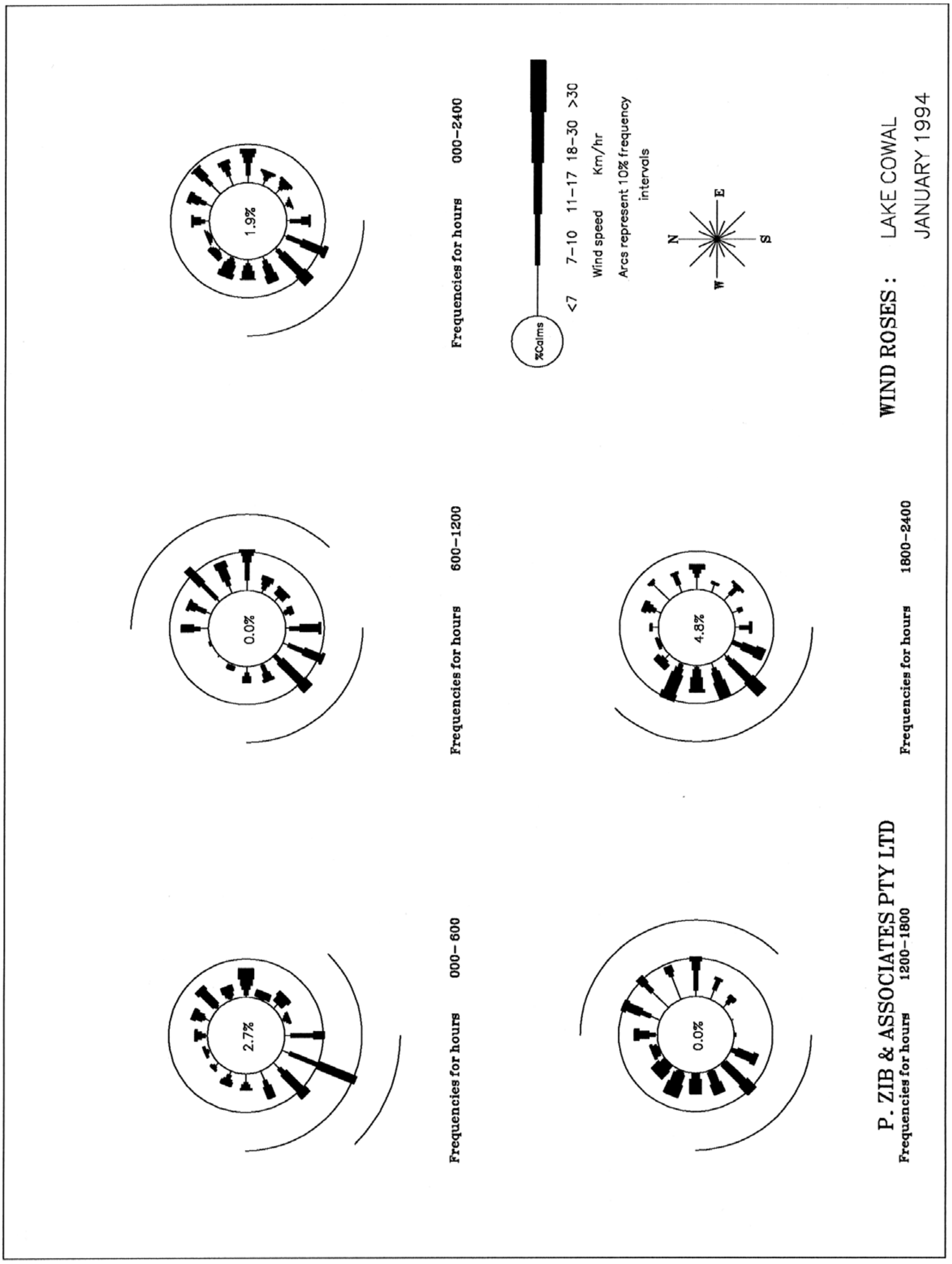
W
WIND ROSES : LAKE COWAL
DECEMBER 1993
P. ZIB & ASSOCIATES PTY LTD


WIND ROSES : LAKE COWAL
JANUARY 1994
P. ZIB & ASSOCIATES PTY LTD
2.7%
Frequencies for hours 000-600
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Frequencies for hours 600-1200
1.9%
Frequencies for hours 000-2400
0.0%
Frequencies for hours 1200-1800
4.8%
Frequencies for hours 1800-2400
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
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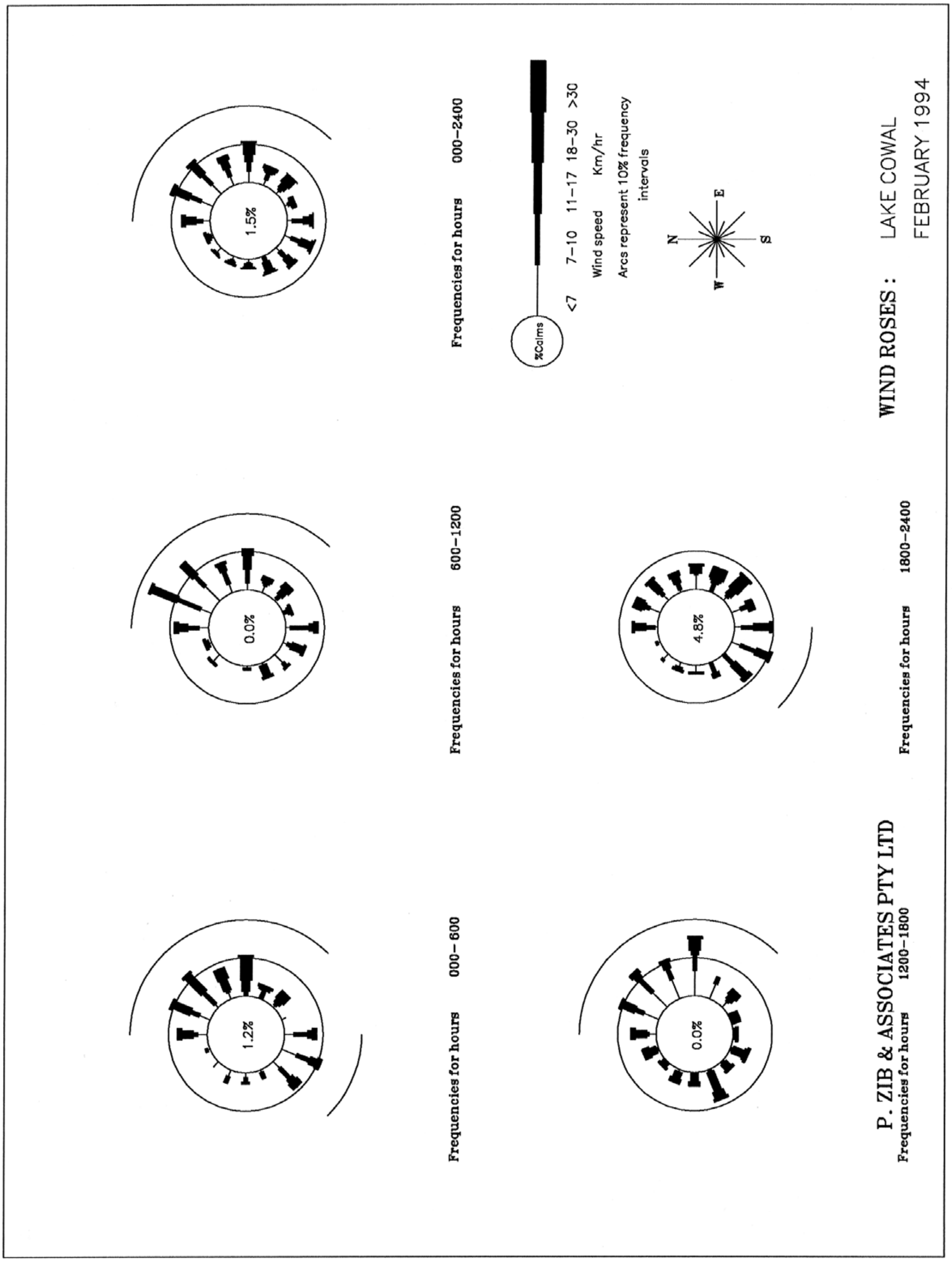
W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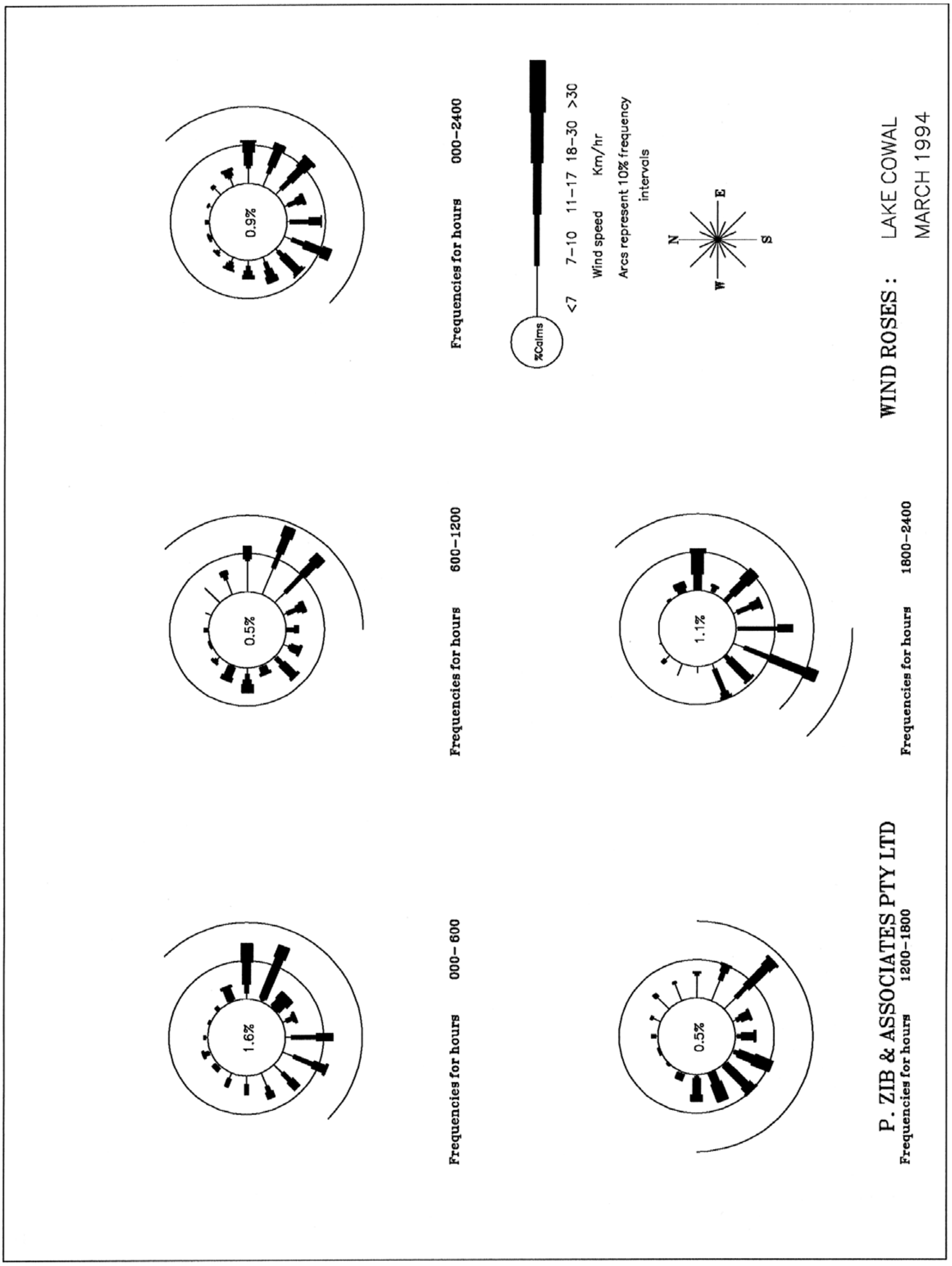
1.5%
0.0%
4.8%
Frequencies for hours 000–600
Frequencies for hours 600–1200
Frequencies for hours 000–2400
Frequencies for hours 1200–1800
Frequencies for hours 1800–2400
%Calms
<7 7–10 11–17 18–30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W
WIND ROSES : LAKE COWAL
FEBRUARY 1994
P. ZIB & ASSOCIATES PTY LTD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Frequencies for hours 600-1200
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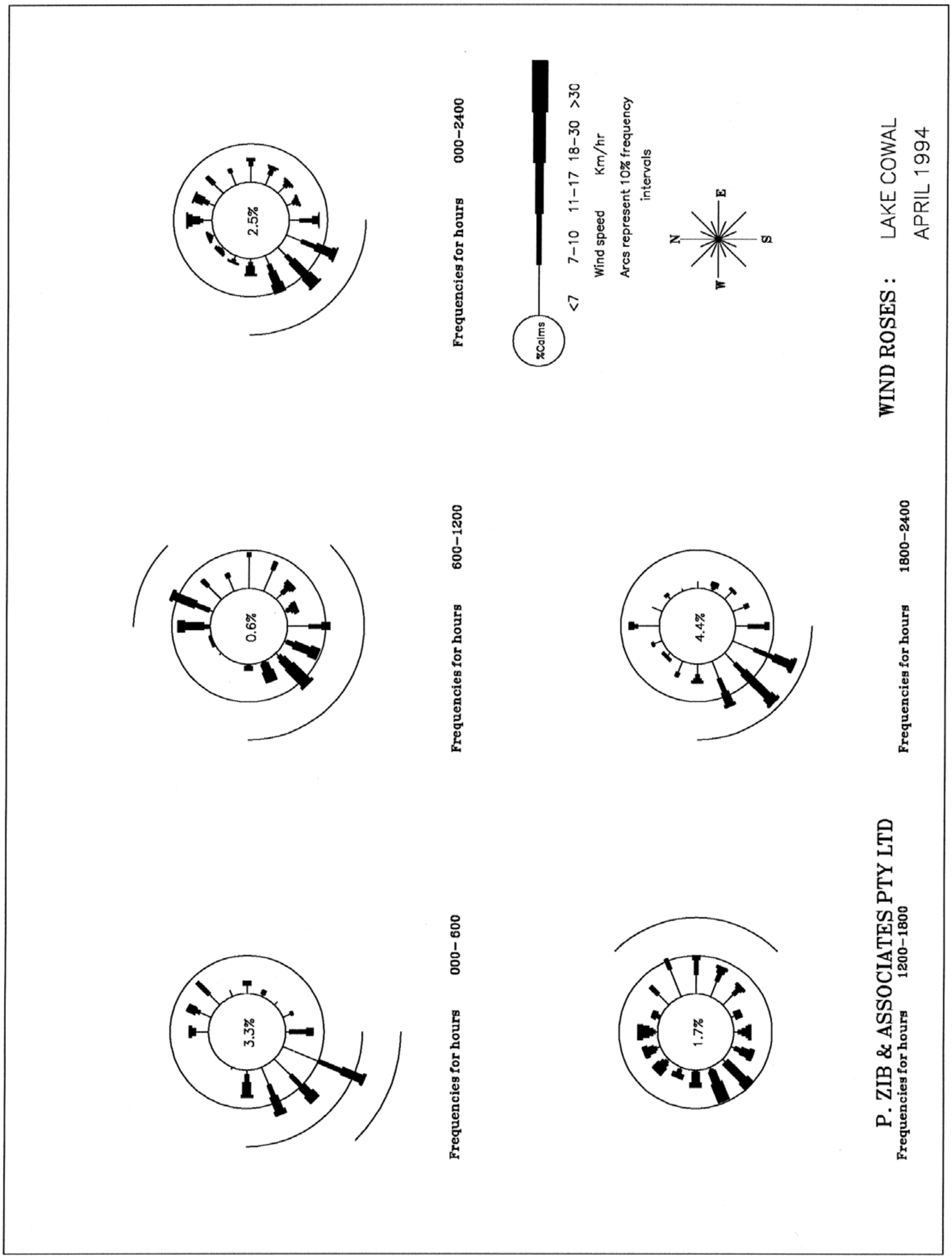
Frequencies for hours 000-2400
0.9%
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 1200-1800
0.5%
Frequencies for hours 1800-2400
1.1%
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W
WIND ROSES : LAKE COWAL
MARCH 1994


WIND ROSES : LAKE COWAL
APRIL 1994
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 000–600
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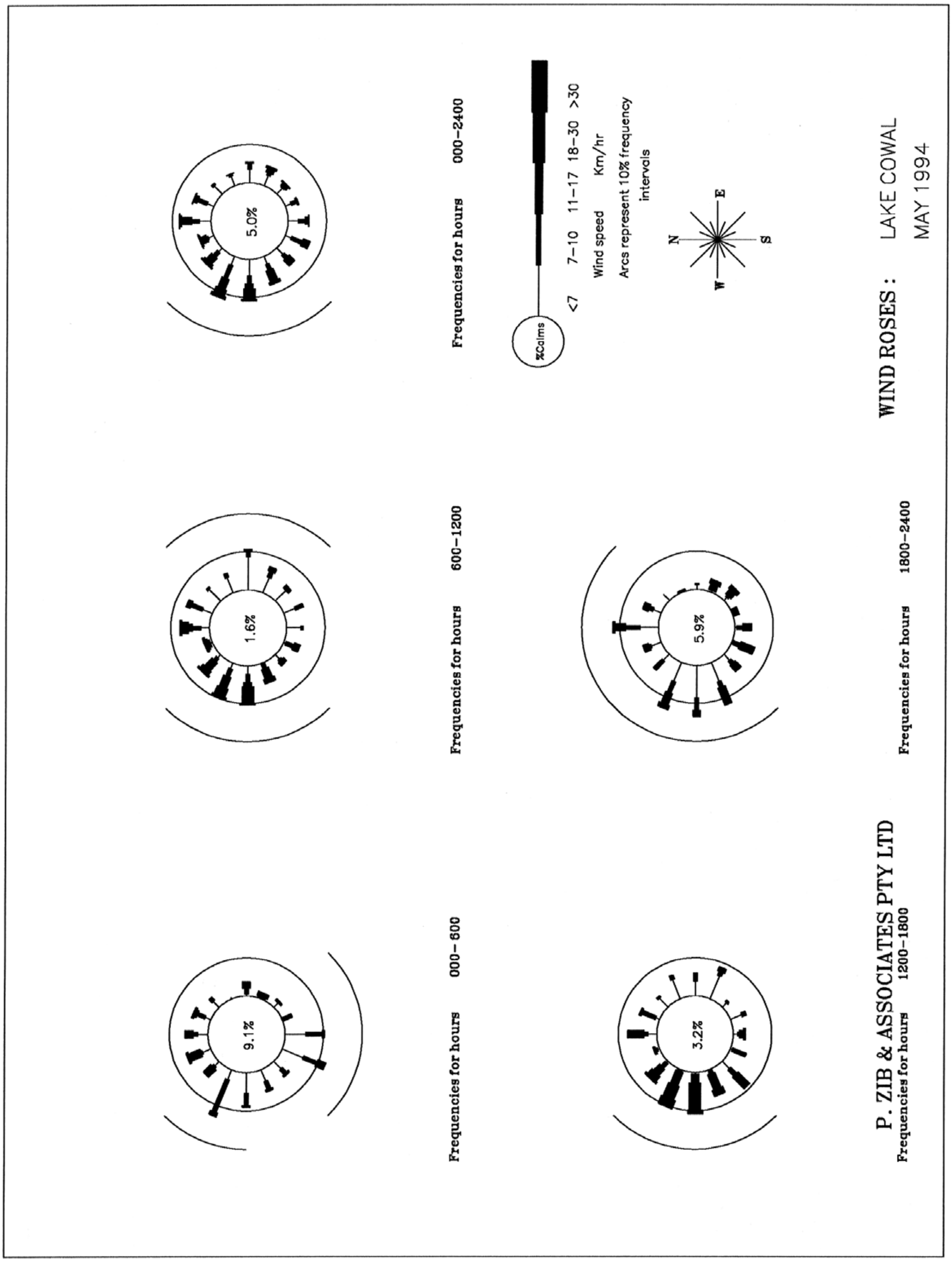
Frequencies for hours 600–1200
0.6%
Frequencies for hours 000–2400
2.5%
Frequencies for hours 1200–1800
1.7%
Frequencies for hours 1800–2400
4.4%
%Calms
<7 7–10 11–17 18–30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W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Frequencies for hours 000–2400
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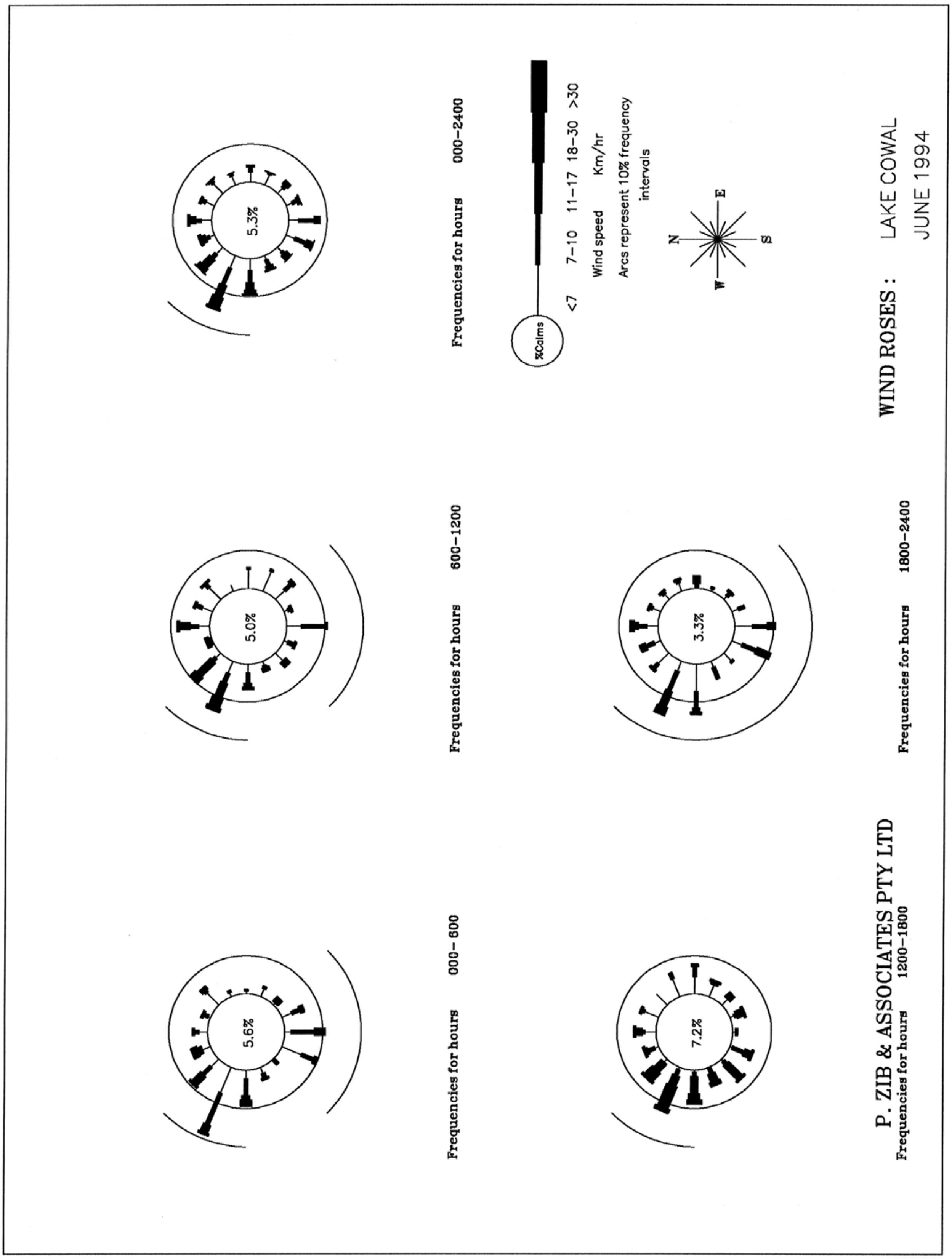
Frequencies for hours 1200–1800
3.2%
Frequencies for hours 1800–2400
5.9%
%Calms
<7 7–10 11–17 18–30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W
WIND ROSES : LAKE COWAL
MAY 1994
P. ZIB & ASSOCIATES PTY LTD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Frequencies for hours 000–2400
%Calms
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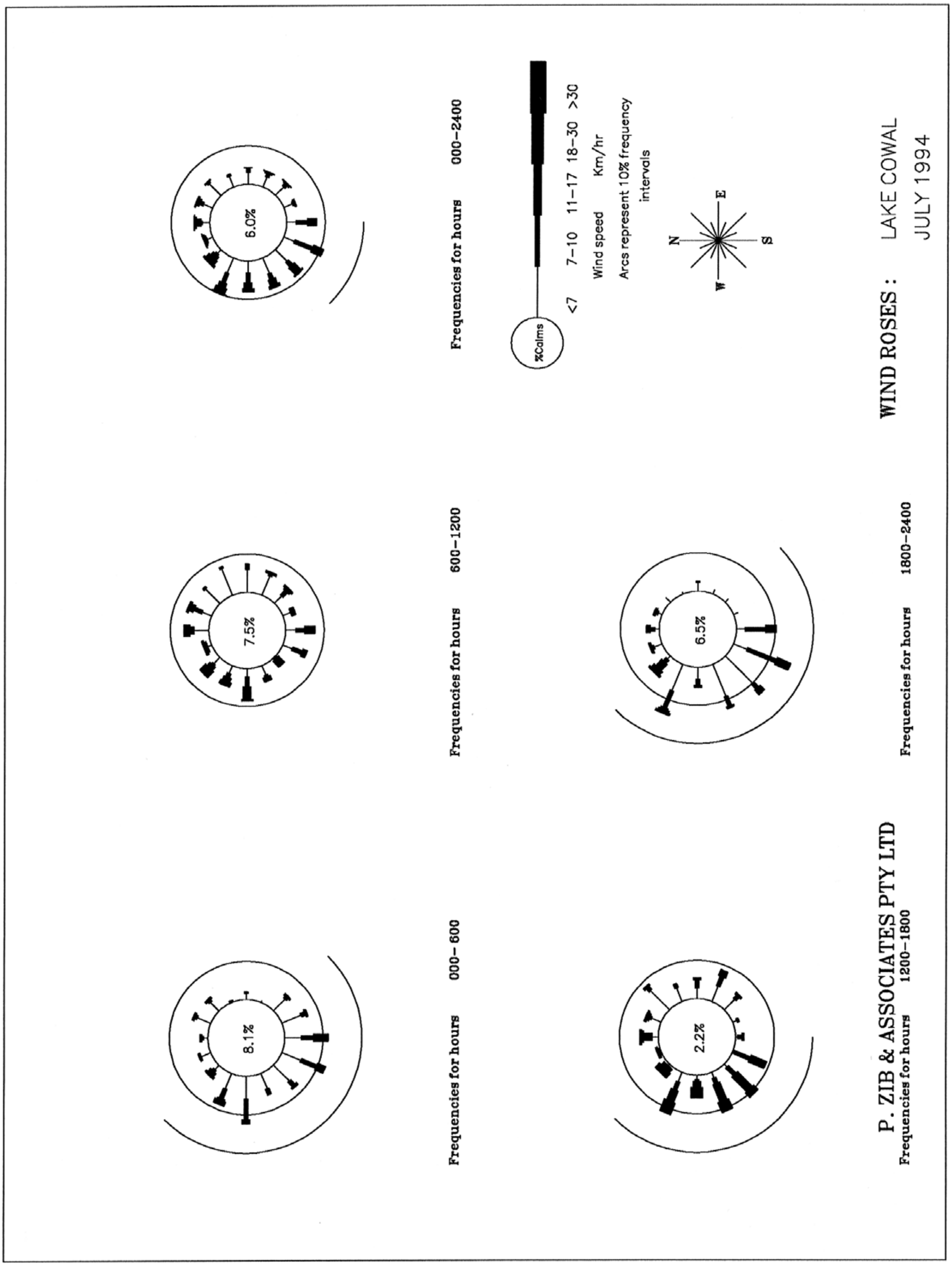
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W
WIND ROSES : LAKE COWAL
JUNE 1994
5.0%
Frequencies for hours 600–1200
3.3%
Frequencies for hours 1800–2400
5.6%
Frequencies for hours 000–600
7.2%
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 1200–1800


WIND ROSES : LAKE COWAL
JULY 1994
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 000–2400
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Frequencies for hours 600–1200
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Frequencies for hours 1800–2400
6.5%
Frequencies for hours 1200–1800
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%Calms
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Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
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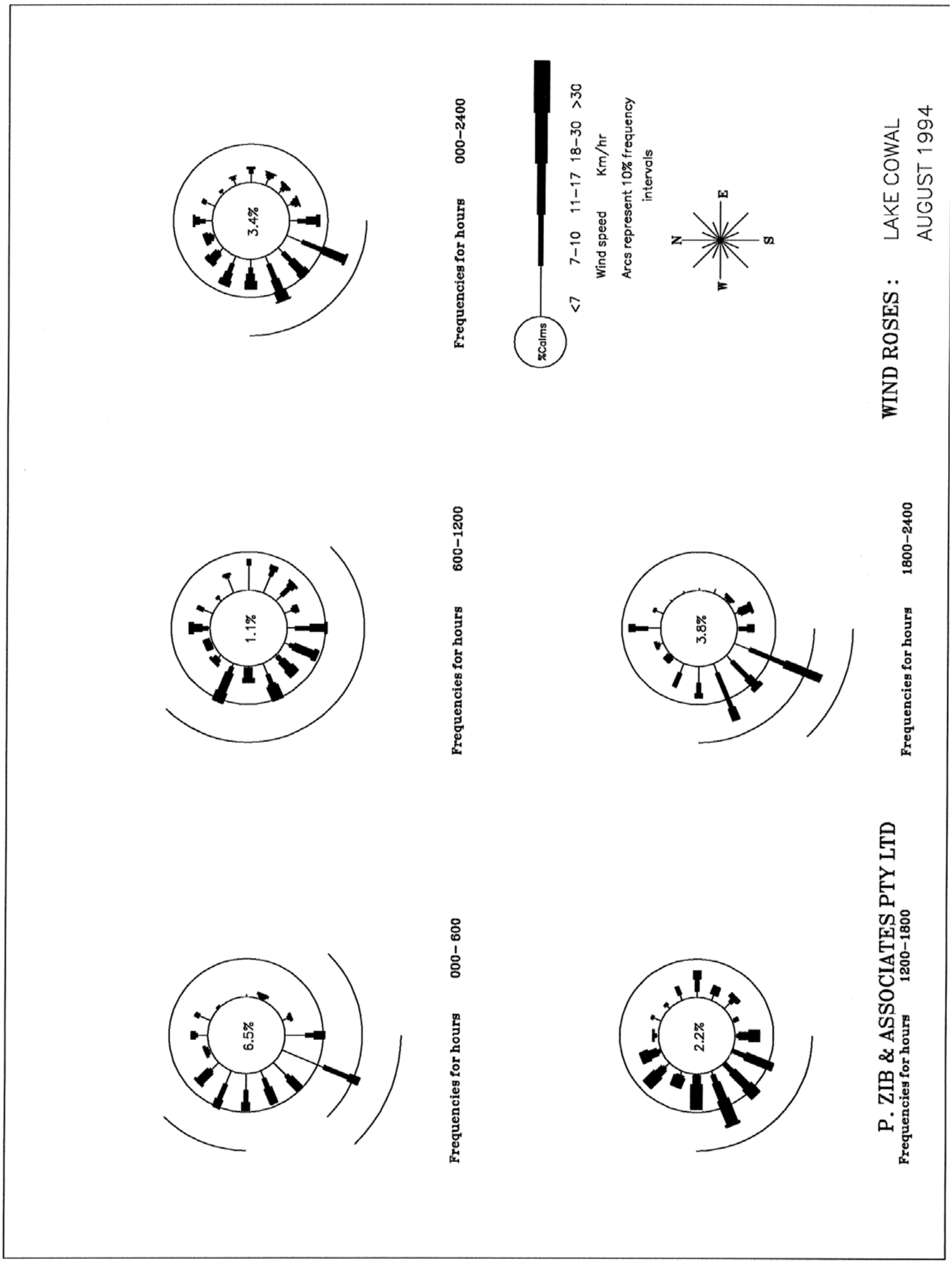
W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Frequencies for hours 600-1200
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Frequencies for hours 000-2400
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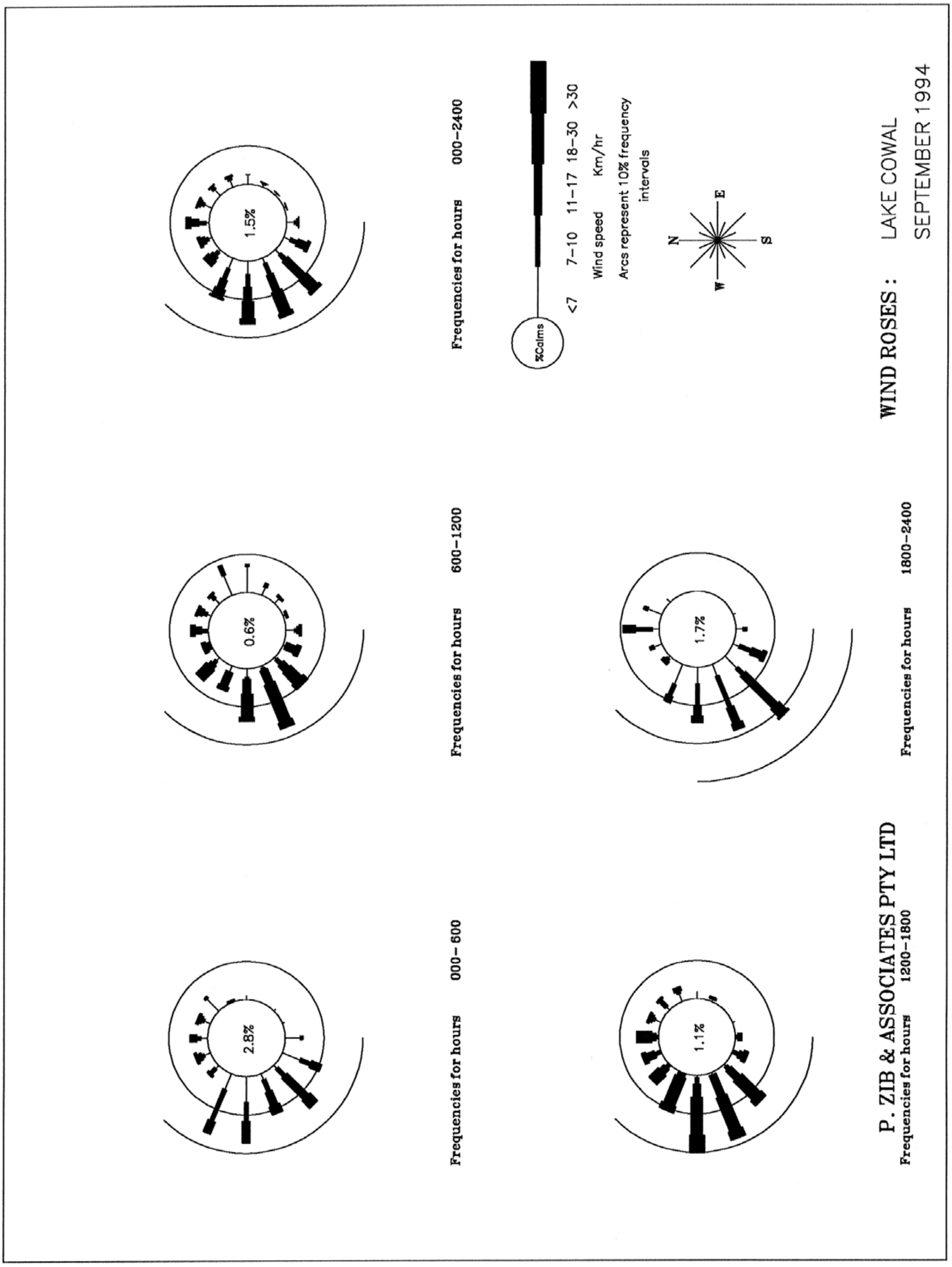
Frequencies for hours 1200-1800
2.2%
Frequencies for hours 1800-2400
3.8%
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W
P. ZIB & ASSOCIATES PTY LTD
WIND ROSES : LAKE COWAL
AUGUST 1994


WIND ROSES : LAKE COWAL
SEPTEMBER 1994
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 000-600
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Frequencies for hours 600-1200
0.6%
Frequencies for hours 000-2400
1.5%
Frequencies for hours 1200-1800
1.1%
Frequencies for hours 1800-2400
1.7%
%Calms
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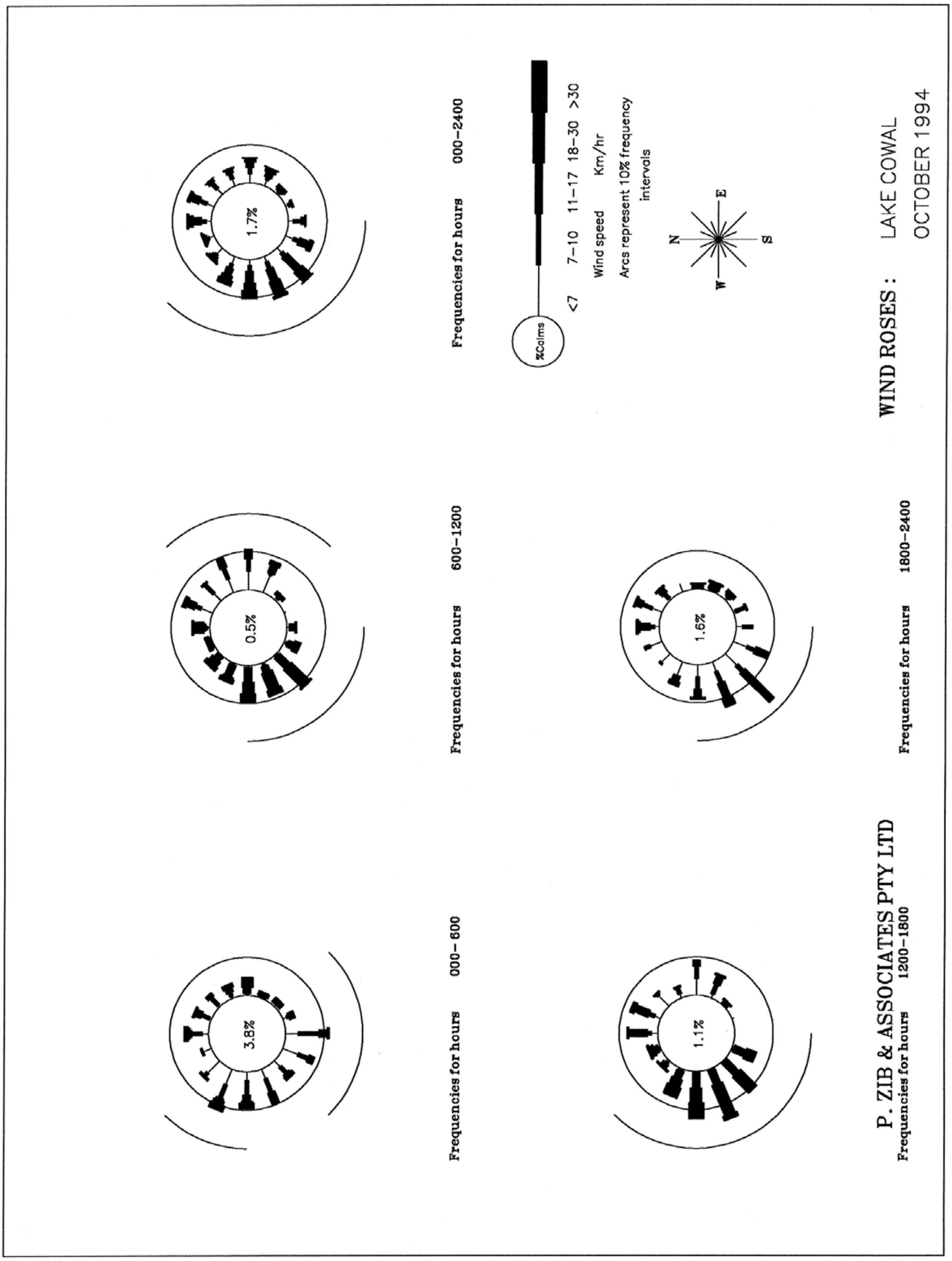
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W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Frequencies for hours 600-1200
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Frequencies for hours 000-2400
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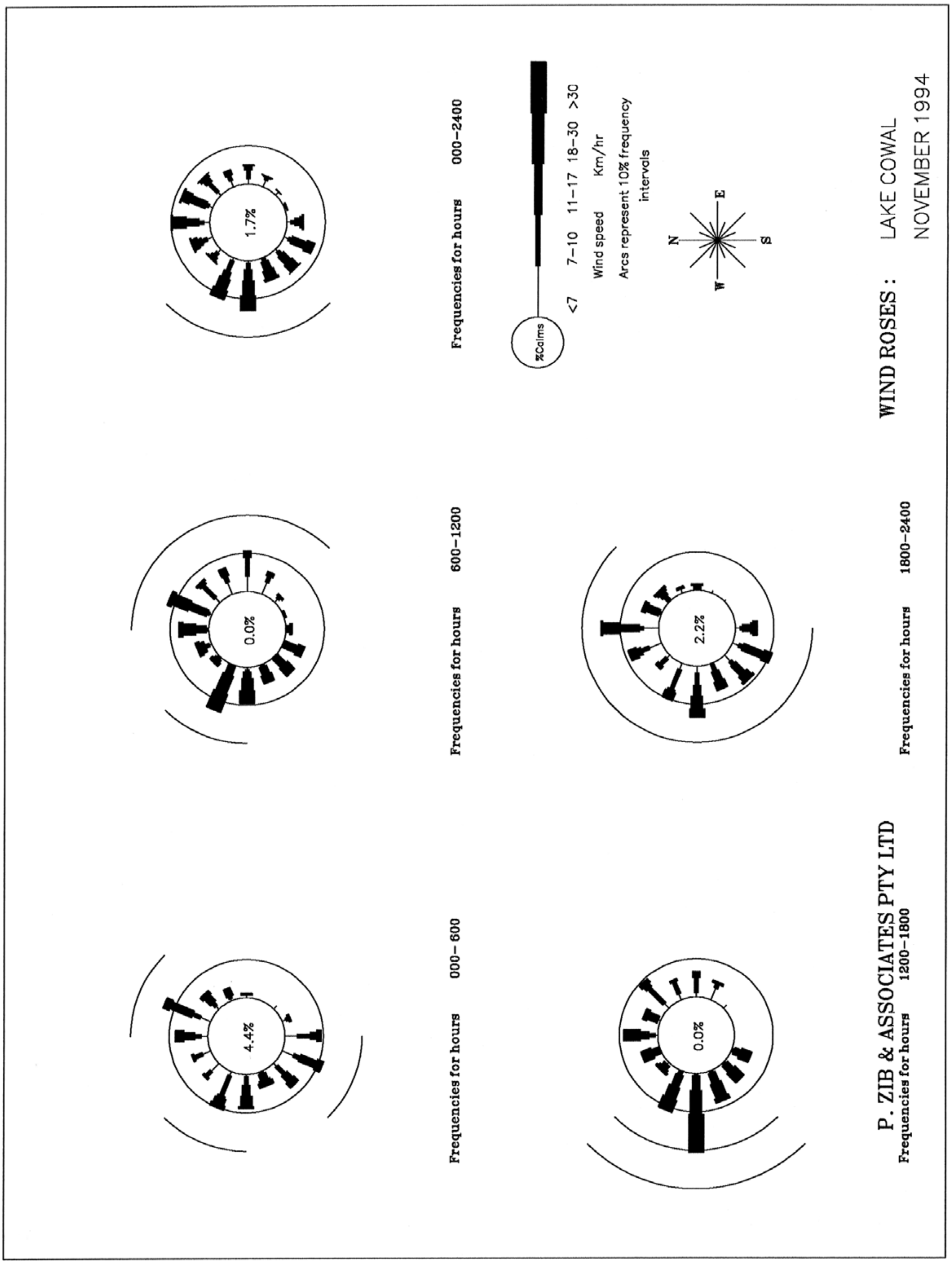
Frequencies for hours 1200-1800
1.1%
Frequencies for hours 1800-2400
1.6%
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W
P. ZIB & ASSOCIATES PTY LTD
WIND ROSES : LAKE COWAL
OCTOBER 1994



WIND ROSES : LAKE COWAL
NOVEMBER 1994
P. ZIB & ASSOCIATES PTY LTD
Frequencies for hours 000-2400
1.7%
Frequencies for hours 000-600
4.4%
Frequencies for hours 600-1200
0.0%
Frequencies for hours 1200-1800
0.0%
Frequencies for hours 1800-2400
2.2%
%Calms
<7 7-10 11-17 18-30 >30
Wind speed Km/hr
Arcs represent 10% frequency intervals
N
E
S
W

Attachment C

Attachment C

Glossary of Terms

Air pollutant
A substance in ambient atmosphere resulting from the activity of man or from natural processes and causing adverse effects to man and the environment.

Air pollution
Presence of air pollutants.

Air pollution emissions inventory
An information, collection and processing system containing data on emissions of, and sources of, air pollution from both man-made and natural causes.

Ambient air
Outdoor air to which people, structures, plants and animals are exposed.

Ambient air quality
The quality of the ambient air near ground level, expressed as concentrations of deposition rates of air pollutants.

Ambient air quality criteria
Quantitative relationship between a pollutant's dose, concentration, deposition rate or any other air quality-related factors, and the related effects on receptors, e.g. humans, animals, plants or materials. Air quality criteria serve as the scientific basis for formulating ambient air quality standards or objectives.

Area source
A group of pollutant-emitting facilities on surfaces which are evenly distributed across a well defined region.

Atmospheric stability
A measure of turbulence which determines the rate at which the effluent is dispersed as it is transported by the wind.

Background level
The concentration (deposition) level of a pollutant which must be added to the concentration (deposition) level of the modelled sources in order to obtain a total.

Concentration
The amount of a substance, expressed as mass or volume, in a unit volume of air.

Dispersion/Diffusion
A mixing process in which air motions mix a pollutant plume over an ever increasing volume, thereby diluting the concentration of the pollutant in the ambient air.

Dispersion model
A set of mathematical equations relating the release of air pollutant to the corresponding concentrations in the ambient atmosphere or deposition on the surface.

Dispersion parameters
The parameters which describe the growth of the dimensions of a Gaussian plume as a function of travel distance or travel time. The dispersion parameters are classified according to diffusion categories, which describe the influence of different turbulence conditions in the atmospheric boundary layer on the dispersion.

Dust
Particles of mostly mineral origin generated by the mining and handling of materials and erosion of surfaces.

Emission
The release of air pollutants into the atmosphere.

Emission factor
An expression for the rate at which a pollutant is generated as a result of some activity, divided by the level of that activity.

Fugitive emissions
Emissions not entering the atmosphere from a stationary vent (stack). Examples of fugitive dust sources include vehicular traffic on unpaved roads, handling of raw materials, wind erosion of dusty surfaces etc.

Gaussian plume model
An approximation of the dispersion of a plume from a continuous point source. The concentration distribution perpendicular to the plume axis is assumed to be Gaussian. The plume travels with a uniform wind velocity downwind from the source. Its dimensions perpendicular to the wind direction are described by dispersion parameters as a function of distance or travel time from the source. The dispersion coefficients depend on diffusion categories and sometimes also on the source height and the surface roughness. The basic assumption underlying the Gaussian plume model is that the dispersion takes place in a stationary and homogeneous atmosphere, with a sufficient wind speed (>1 m/s).

Gravitational fall
The downward settling of particles in the atmosphere due to the effects of gravity. The rate of descent of a particle depends on the balance between the aerodynamic drag and the gravitational acceleration (Stokes law). For particles with approximately the density of water and a diameter of less than 20 microns the fall velocity is small compared with the vertical velocities in the atmosphere, so that these particles can remain aloft.

Ground level concentration
Applied to the concentration, calculated or observed, in the neighbourhood of the ground surface.

Line source
A pollutant producing activity which is uniformly spread out along a narrow band.

Long-term
A period of time associated with annual air quality standards. Long-term models usually address pollutant concentrations over several seasons to one year.

Meteorological episode or event
A short period of time, varying between one hour and a few days, over which a single class of weather conditions is dominant.

Mixing height
The vertical depth of the atmosphere through which air pollutants can be dispersed.

Neutral atmosphere
The atmospheric condition for which the vertical temperature profile is equal to the adiabatic lapse rate over the whole boundary layer. Vertical air motions are neither enhanced nor suppressed. The turbulence intensity is moderate.

Particulate matter
Small solid or liquid particles suspended in or falling through the atmosphere. Sometimes expressed by the term particulates.

Physical removal process
A series of events which lead to the direct depletion of an air pollutant in the ambient atmosphere without chemical transformation. Several physical mechanisms include settling of heavy particles, impaction on vegetation and structures, and rainout.

Plume
The shape of the concentration distribution of the emissions from a point source when transported by the mean wind and dispersed by turbulence.

Point source
A single activity that causes the release of a pollutant plume from a stationary vent. Large smoke-stack emissions are modelled as a single point source.

Receptor point
The geographical point where an air pollutant concentration (deposition) is measured or calculated by means of an air pollution dispersion model.

Short-term
A period of time associated with air quality standards for pollutant exposures ranging between one hour and twenty four hours.

Source
The place where pollutants are emitted into the atmosphere. Sources may be point, area or line sources. Often the term 'source' is used for a whole plant or an installation. In air pollution modelling, the terms 'continuous source' and 'instantaneous source' are used:

- Continuous source: Source which emits pollution continuously over a time period much larger than the travel time to a point where the concentration is considered. Usually it is assumed that during this time period the emission is constant.
- Instantaneous source: Source which emits pollution over a time period much shorter than the travel time of the emission to a point where its concentration is considered.

Stable
Used with respect to the atmospheric boundary layer, when the vertical temperature gradient is greater than the adiabatic lapse rate. Vertical air motions are suppressed. The turbulence intensity is low resulting in poor dispersion conditions.

Temperature inversion
An increase in air temperature with height.

Turbulence
Any irregular or disturbed flow in the atmosphere that produces gusts and eddies.

Wind direction
The direction from which the wind, averaged over a certain period of time, is blowing.

Appendix J
Traffic Impact Assessment

Traffic impact assessment of proposed Cowal Gold Project West Wyalong

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October 1997

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

1.0 INTRODUCTION

TRAFFIX has been commissioned by Resource Strategies Pty Ltd acting on behalf of North Mining Limited to prepare a traffic impact assessment report relating to a proposed gold mining project at Lake Cowal. This report documents the findings of our investigations and should be read in the context of the overall Environmental Impact Report prepared by Resource Strategies Pty Ltd.

The traffic impact assessment has been undertaken generally in accordance with the requirement of the Roads & Traffic Authority's guidelines. In particular, it will be noted that the project is a Schedule 1 development for the purpose of State Environmental Planning Policy No. 11 and accordingly will require referral to the Roads and Traffic Authority's Regional Advisory Committee, which comprises representatives of the Authority, Council and the NSW Police Service.

The report is structured as follows:

Section 2:	Site and Location
Section 3:	Existing Road Hierarchy
Section 4:	Existing Traffic Conditions
Section 5:	Traffic Impact Assessment
Section 6:	Recommended Traffic Management Improvements
Section 7:	Conclusions

In addition, it will be appreciated that previous investigations have been undertaken relating to the traffic impacts associated with the proposed gold mine, notably the report prepared by Sinclair Knight Merz in April 1995[1]. This previous report provides relevant background information.

[1] *Lake Cowal Gold Project: Traffic Issues*, Sinclair Knight Merz – April 1995.

2.0 SITE AND LOCATION

The Project area is located about 50 kilometres north of West Wyalong by road, and lies on the western shore of Lake Cowal. The site is located within Bland Shire.

A location and site plan are presented in Figures J-1 and J-2 respectively.

3.0 ROAD HIERARCHY

3.1 Regional Network

In a regional context, West Wyalong is located at the confluence of the Newell Highway (State Highway No. 17) and the Mid Western Highway (State Highway No. 6). Accordingly, the site enjoys good regional accessibility. This is evident from Figure J-3 which shows the regional road network within about 150 kilometres travel distance to the site by road.

Distances to important local townships from West Wyalong are generally as follows:

Rankin Springs:	91 km to the west via the Mid Western Highway
Forbes:	105 km to the north-east via the Newell Highway
Cowra:	159 km to the east via the Newell and Mid Western Highways
Temora:	69 km south-east via Main Road 57
Wagga Wagga:	158 km south-east via Main Road 57
Ardlethan:	70 km south-west via the Newell Highway
Narrandera:	136 km south-west via Newell Highway MR387

Distances to the site from these townships require the addition of about 50 km by road to the above distances. It will be appreciated that all of these townships are therefore within 2 hours driving time of the site.

The most important regional roads which provide access to the site are as follows:

- To the North:
  - Main Road 57 providing access to Condobolin
  - Newell Highway (State Highway No. 17) providing access to Forbes and Parkes. The Newell Highway is part of the National Road Network and is funded by the Commonwealth.
- To the East:
  - Mid Western Highway (State Highway No. 6), providing access to Sydney via Bathurst
- To the South-East:
  - Main Road 57 and Main Road 84, providing access to Wollongong via the Hume Highway
- To the South:
  - Main Road 57 and Main Road 78, providing access to the Hume Highway via Wagga Wagga
- To the South-West:
  - Newell Highway (State Highway No. 17), providing access to Melbourne via Narrandera
- To the West:
  - Mid Western Highway (State Highway No. 6), providing access to Rankin Springs and Griffith

The performance of these roads is discussed further in Section J4.

3.2 Local Network

In a more local context, it will be evident that there are several routes which are potentially available to gain access to the Project area. These are shown in Figure J-4, which shows three local access route options connecting to West Wyalong as follows:

Route Option 1: Provides access to the site via Ungarie Road, Wamboyne Road, Billys Lookout Road.

Route Option 2: Provides access to the site via Clear Ridge Road, Lonergan's Lane, Wilson's Lane and Lake Cowal Road.

Route Option 3: Provides access to the site via the Newell Highway, Bodels Lane, Lonergan's Lane, Wilson's Lane and Lake Cowal Road.

It is apparent that these routes have previously been carefully assessed having regard to their respective engineering and economic viability, with the conclusion that Route Option 1 is the preferred option. This route has therefore been assumed for the purpose of this report.

The route may be described as follows:

- The Project area essentially straddles Lake Cowal Road which is a gravel road in this vicinity and is depicted in Photos 1 and 2. This road is however not proposed to be relied upon for access to the site and is not part of the preferred route. It is shown only to gain an appreciation of the nature of the existing road environment within the proposed Project area.
- Access from the Project area is proposed via a track which is parallel to the West Wyalong-Burcher Railway on its western side, in the vicinity of the Lake Cowal Station Silo (refer Photos 3 and 4 in Attachment B). The road is presently used for access to the Silo only on a seasonal basis. This will require the sealing and upgrading of 3.5 km of gravel track parallel to the railway line.
- Proceed west along Billys Lookout Road for a distance of 10.5 kilometres to its intersection with Wamboyne Road at Blow Clear. This section requires sealing of the existing gravel road and improved alignment at two locations, these being in the vicinity of Billys Lookout and near the turn-off to the Silo track.
- Proceed south along Wamboyne Road for a distance of 18.7 kilometres to its intersection with Ungarie Road. This requires local widening over a distance of 0.5 kilometre to improve bends.
- Proceed south along Ungarie Road to its intersection with the Mid Western Highway.

It is evident from previous work that the required upgrading of this Option involves preliminary costs of $2.5 million.

4.0 EXISTING TRAFFIC CONDITIONS

4.1 General Description

The road network has been appraised through site investigations. In this regard, the main road network, which comprises State Highway and classified main roads, is generally constructed to a satisfactory standard in the region in accordance with required standards. This incorporates generally single lane flow conditions in each direction, with local widenings at intersections, consistent with their relative importance. Notwithstanding, some local improvements are considered necessary essentially on safety grounds, as discussed in Section 6.

Road conditions along the preferred access route are summarised below. Comments are cross-referenced to Figure J-5 (with chainages starting at the mine access road with Billys Lookout Road) and to relevant photographs shown in Attachment B.

1. The road reserve following the western boundary of the West Wyalong-Burcher railway is presently closed north of its intersection with Billys Lookout Road. South of the Silo it is a gravel road constructed on a narrow formation (refer Photo 3, and note also that this intersection has been designated as chainage 0.0 km). To the north of the Silo, the road narrows to a gravel track.

Table J-1 Existing Regional Traffic Volumes and Heavy Vehicle Proportions

Map Identifier	RTA Station No	Location	Daily Traffic Volume[1]	% Heavy Vehicles
1	N/A	Ungarie Road, south of Wamboyne Road	752	14
2	N/A	Newell Highway, south of West Wyalong (National Highway)	1,860	26
3	N/A	Barmedman Road, south of Mid Western Highway	916	29
4	95,377	Mid Western Highway, east of Barmedman Road	3,786	28[2]
5	93,114	Mid Western Highway, east of Marsden	324	28[3]
6	93,103	Mid Western Highway, east of Cowra	2,983	18[3]
7	99,001	Mid Western Highway (SH5), east of Evans Shire boundary	5,445	21[3]
8	94,001	Hume Highway (SH2), east of Bowning (National Highway)	15,422	21
9	95,137	MR78 (Wagga Road), north of Wagga Wagga	4,268	29[2]
10	95,081	Newell Highway (SH17), east of Narrandera (National Highway)	2,568	28[4]
11	95,154	MR57 (Wagga Road), north of Temora	1,567	29[2]
12	N/A	Mid Western Highway, west of Ungarie Road	749	25
13	93,869	Newell Highway (SH17), south of Forbes (National Highway)	2,665[5]	N/A

Note: 1. 1997 Volumes 2. Estimated 3. 1996 data 4. 1995 data 5. 1992 data

2. Between Wests Lane and Bodels Lane, the road is constructed on a gravel surface with formation width of generally 8 metres. The road is characterised by several bends and the carriageway is reduced in width in the vicinity of Billys Lookout (refer Photos 4, 5 and 6). This section extends to Wests Lane at chainage 15.3 km.
3. Billys Lookout Road extends between Wests Lane and Wamboyne Road and is constructed on a gravel surface with formation width generally 8 metres. It connects to Wamboyne Road at chainage 21.3 km (refer Photos 8 and 9).
4. Wamboyne Road between Billys Lookout Road at Blow Clear and Ungarie Road is a sealed rural road of width generally 6 metres, with gravel shoulders. This width reduces to 5 metres in proximity to its intersection with Billys Lookout Road (refer Photo 9). The pavement is generally in good condition with some rough edges (refer Photo 10). Wamboyne Road forms a priority controlled T-junction with Ungarie Road at chainage 40.0 km (refer Photos 11, 12 and 13).
5. Ungarie Road between Wamboyne Road and the Mid Western Highway is a two lane rural road constructed on a 6.5 metre carriageway with broken separation lines along its length. Gravel shoulders are generally provided, with some rough edges (refer Photo 14). Ungarie Road forms a priority controlled intersection with the Mid Western Highway where it forms a T junction (refer Photo 15), at chainage 46.0 km.

4.2 Daily Traffic Volumes and Heavy Vehicles

Traffic volumes on roads in the region which are likely to be relied upon by traffic associated with the mine have been obtained from all available sources and have been supplemented by surveys as appropriate.

The location of these counts is presented in Figure J-6. This figure includes counts on routes connecting to townships in the region, as well as to major port destinations. The results of the surveys, including the percentage of heavy vehicles in the total vehicle fleet, is shown in Table J-1.

It is evident that flows on all routes examined are significantly less than their capacity, at level of service B, as demonstrated by Table J-2 below.

Table J-2 Volume/Capacity Ratios of Key Roads

Road	Existing Daily Flow (vpd)	Capacity (vpd)	Vol/Capacity Ratio
Newell Highway – south of West Wyalong	1,860	4,800[1]	0.38
Mid Western Highway – west of West Wyalong	749	2,000[2]	0.37
– east of West Wyalong	3,786	4,800[1]	0.79
Ungarie Road	752	2,000[2]	0.79
Wamboyne Road	150	500[2]	0.30

Note: 1. Based on NAASRA Roadway Capacity Guide. Assumes Level of Service B and a K factor of 0.10. 2. Based on RTA Road Design Guide

In addition, the proportion of heavy vehicles varies between 14 percent and 20 percent, which is within the typical range for rural highways. These heavy vehicle proportions are averaged over both directions of flow.

Notwithstanding, the most relevant use of the above tables is in determining the relative change in parameters under future traffic loadings, ie with the impacts of the mine traffic superimposed. This is discussed further in Section 5. Daily flows on Ungarie Road are also presented in the graphs in Attachment D to enable an appreciation to be gained of the distribution of volumes over the day on week days and weekend-days. This route has been selected as it is on the main access route to the Project area.

4.3 Existing Intersection Performances

The two critical intersections along the access route to the mine which are of immediate interest are as follows:

- Wamboyne Road/Ungarie Road
- Ungarie Road/Mid Western Highway.

Traffic volumes at these intersections during the morning peak period are shown in Figure J-7. The performance of these intersections has been assessed.

Using the Intanal computer model. This model produces a range of outputs, the most useful of which are the Degree of Saturation (DOS) and the Average Delay per Vehicle (AVD). The AVD in turn relates to a level of service criteria. These performance measures can be interpreted using the following explanations:

- **DOS** – the DOS is a measure of the operational performance of individual intersections. As both queue length and delay increase rapidly as DS approaches 1, it is usual to attempt to keep DS to less than 0.9. When DS exceeds 0.9 residual queues can be anticipated.
- **AVD** – the AVD for individual intersections provides a measure of the operational performance of an intersection. In general, levels of acceptability of AVD for individual intersections depend on the time of day (motorists generally accept higher delays during peak commuter periods) and the road system being modelled (motorists are more likely to accept longer delays on side streets than on the main road system).
- **LOS** – this is a comparative measure which provides an indication of the operating performance of an intersection as shown below:

LOS	Average Delay per Vehicle (secs)	Traffic Signals and Roundabouts	Give Way and Stop Sign
"A"	less than 14	Good operation	Good operation
"B"	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
"C"	29 to 42	Satisfactory	Satisfactory but accident study required
"D"	43 to 56	Operating near capacity	Near capacity and accident study required
"E"	57 to 72	At capacity; at signals incidents will cause excessive delays. Roundabouts require other control mode.	At capacity and requires other control mode.
"F"	more than 72	Unsatisfactory and requires additional capacity.	Unsatisfactory and requires other control mode.

Table J-3 Existing Intersection Performances – Weekday AM

Intersection	Control Type[1]	Degree of Saturation (DOS)[2]	Average Vehicle Delay (AVD) (secs)	Level of Service (LOS)
Ungarie/ Wamboyne	Priority	0.04	1.2	A
Ungarie/Mid Western Highway	Priority	**0.04**	**2.9**	**A**

The results of the analysis of existing intersections are presented in Table J-3.

It can be seen that both intersections presently operate very satisfactorily during the morning peak period with moderate delays and associated good levels of service. Again, it is emphasised that the most relevant use of these results is in the assessment of the **relative** change in intersection performances under future predicted traffic loadings, as discussed further in Section J5. It can be expected that similar performance characteristics to that will be presented in Table J-3 evident during the evening peak period.

5.0 TRAFFIC IMPACTS OF THE PROPOSED DEVELOPMENT

The traffic impacts arising from the proposed development have been assessed during both the mine construction phase and the mine operational phase. These are discussed separately below.

5.1 Construction Traffic Phase

5.1.1 General

The construction phase is programmed to occur over an 18 month period, with the level of activity varying significantly over this period.

The following manning levels are anticipated over the construction period:

Month	Employees
0-3	63
3-6	115
6-9	158
9-12	192
12-15	215
15-18	217
18-21	270

For assessment purposes, it is proposed to analyse the traffic impacts on the basis of a workforce of 200. This generally equates to the 85th percentile design level and is appropriate for assessment, and in fact can be regarded as a worst-case scenario which will be exceeded only for a short 3-month period at the completion of the construction phase.

5.1.2 Traffic Generation

On this basis the traffic generation from the site will be associated with the movement of 200 employees on a daily basis, six days per week. Workers will be deployed over a single 12 hour shift, with 60 percent (120) expected to be imported from other areas with the balance of 40 percent (80) being drawn from the local population including all townships within reasonable proximity to West Wyalong.

It is expected that 75 percent of the total workforce (150 employees) will be based in West Wyalong, with the balance (50 employees) being based in the general region.

North Limited propose to implement a transport system which makes use of a fleet of 12 seat capacity mini buses. These will provide a shuttle service between West Wyalong and the Project area. It is anticipated that 120 employees will be transported by the bus fleet. Use of the shuttle-bus service will be actively encouraged (and could be enforced if necessary) to ensure maximum usage. The balance of 80 workers (including 30 from West Wyalong and 50 from the townships) will make use of private cars, with car pooling actively encouraged by North Limited. In this regard, an average car occupancy of 3.2 has been assumed and is considered achieveable.

In addition to the above, an average of 4 truck trips per day are anticipated (2 in, 2 out) during the construction period, with an additional one oversize vehicle arrival per week on average.

In summary, total traffic generation will be as shown in Table J-4.

The above trips have been superimposed on the road network and the results are discussed below.

5.1.3 Traffic Impacts

The traffic impacts have been assessed under two scenarios, *viz:* the impacts on daily traffic flows and the impacts during peak periods. These are discussed separately below.

Daily Traffic Volumes

It will be appreciated that the vast majority of traffic generated by the site will travel between West Wyalong and the Project area. In particular, 60 vehicle trips per day will travel to and from West Wyalong, with the balance of 24 vehicle trips being dispersed throughout the region. Accordingly, flow increases on individual routes will be as shown in Table J-5.

It can be seen that flow increases on individual routes will be significant between West Wyalong and the Project area, but negligible on all other roads in the region. The performance of these latter roads will be unchanged, and existing levels of service will be maintained.

Table J-4 Construction Phase Traffic Generation

Scenario	Vehicle Type	Vehicle trips In	Vehicle trips Out	Vehicle trips Total
Daily trips (veh/day)	Mini buses	10	10	20
	Employee cars	25	25	50
	Visitors cars	5	5	10
	Trucks	2	2	4
	Total daily trips	**42**	**42**	**84**
Hourly Trips (am) (veh/hr)	Mini buses	10	–	10
	Employee cars	25	–	25
	Visitors cars	1	–	1
	Trucks	1	–	1
	Total hourly trips	**37**[1]	**–**[1]	**37**

Note 1: These flow directions are generally reversed in the pm peak period, with workers departing the site at the end of the shift.

Peak Hour Volumes

It is evident from Table J-4 that a peak hour generation of about 37 vehicles will be generated by the site during busy construction periods. These will be generally in in the morning and out in the afternoon.

These flows have been superimposed onto the road network and turning movements at the critical intersections have been determined. These are shown in Figure J-8. These intersections have been remodelled using the Intanal computer model with the result that the average delays are only marginally increased while levels of service remain unchanged. Notwithstanding, some improvements to these intersections is considered desirable and this is discussed further in Section 6.

5.2 Operational Mine Phase

5.2.1 General

The operation of the mine will span a 12 year period, with operations being scheduled over 7 days per week, 52 weeks per year. This incorporates an 8 year mine life followed by a 4 year processing stage. The detailed operational characteristics of the site are outlined elsewhere within the Environmental Impact Statement.

5.2.2 Traffic Generation

The mine will be operated by a total of 200 employees, comprising 80 day workers and 120 shift workers. The latter will be rostered over three 12 hour shifts on a rotational basis with some overlap, so that only 80 shift workers will be present on site at any one time. It is expected that 75 percent of the workers will be based in West Wyalong[2].

[2] The Social and Economic Significance of a Resource Development Project for Country NSW – Final Report, Centre for International Economics, May 1997.

The shift workers will mainly be transported to/from site using the mini-bus shuttle service, while day workers are expected to make use mainly of private cars, with an average car occupancy of 2.2 assumed.

In addition, an average of 10 visitor trips per day (5 in, 5 out) is expected over the life of the mine.

The movement of heavy vehicles to and from the mine will be related to deliveries of diesel fuel and other process

Table J-5 Predicted Change In Daily Traffic Volumes

Route	Map Identifier[1]	Existing Daily Flows	Additional Flow	Resultant Total Flow	Percentage Increase
Billys Lookout Road	N/A	20	80	100	500
Wamboyne Road	N/A	150	80	230	53
Ungarie Road	1	752	80	832	11
Mid Western Highway (W)	12	749	2	751	0.2
Newell Highway (S) (National Highway)	2	1,860	3	1,863	0.2
Barmedman Road	3	916	5	921	0.5
Mid Western Highway (E)	5	324	5	329	1.5
Newell Highway (N) (National Highway)	13	2,665	3	2,668	0.1

Note 1: Refer to Figure J-6 or Table J-1

consumables. This will vary in total between 4,226 truck loads per annum in years 1 and 9 (oxide phase), to 2,083 truck loads per annum in all other years (primary phase). The former (higher) level has been assumed for assessment purposes. Specific truck loads for individual consumables is shown in Table J-6.

It is evident from Table J-6 that the site will generate a maximum average of 24 truck trips per day (12 in, 12 out) over the life of the mine in years 1 and 9, with volume reductions of about 50 percent at other times. In addition, it is apparent that mining is completed in year 9 and that after that time, while process consumables will remain generally at the above levels, diesel fuel deliveries will reduce. In summary, total traffic generation during the mine operation during peak years, as adopted as a worst case for assessment purposes, will be as shown in Table J-7.

The above trips have been superimposed onto the road network and the results are discussed below.

5.2.3 Traffic Impacts

The traffic impacts have been assessed under two scenarios, *viz:* impacts on daily traffic flows and impacts during peak periods. These are discussed separately below.

Daily Traffic Volumes

As is evident from Table J-7, the site generates a total of 140 vehicle trips per day, including all classes of vehicles. The vast majority of this traffic will travel between West Wyalong and the Project area. Specifically, a total of 90 vehicle trips per day will travel exclusively to and from West Wyalong, with the balance of 50 vehicle trips per day being dispersed generally throughout the region, including 32 car and 18 truck movements daily.

The distribution of the external traffic has taken account of major townships in the region, while the distribution of truck trips has been based on detailed information from North Mining relating to the source of individual consumables. In this regard, it is evident that of the 24 daily truck trips, 6 are sourced from West Wyalong, 2 are sourced from Gladstone, and the remaining 16 are sourced from Sydney.

Accordingly, flow increases on individual routes will be as shown in Table J-8.

It can be seen that flow increases on individual routes will be significant between West Wyalong and the Project area, but negligible to marginal on all other roads in the region. The performance of these latter roads will be unchanged, with existing levels of service being maintained. The most significant relative increase will occur on the Mid Western Highway east of Marsden, although the volume to capacity ratio will remain at a low level, increasing from 0.16 to 0.18. This increase relates to about 3 vehicle trips per hour, which will clearly have negligible impact on traffic conditions.

Flow increases on the only National Highway route in the area (the Newell Highway) are minimal, in the order of 0.2 percent.

Peak Hour Volumes

It is evident from Table J-8 that a peak hour generation of about 50 vehicles per hour will be generated by the site during the morning and evening peak periods.

These flows have been superimposed on the road network and the resultant turning movements at critical intersections have been established, as shown in Figure J-9. The intersections have been reanalysed using the Intanal computer program with the results shown in Table J-9.

Table J-6 Transport and usage of Process Consumables

Process Consumable		Truck Loads (average load = 25 t) No. pa Oxide[1]	Primary[2]
Mill Steel (as grinding medium)		415	415
LPG		7	7 (18 t loads)
General Flotation Reagents			91
CN	Oxide	244	
	Primary		72
Lime	Oxide	2,268	
	Primary		10
H_2O_2	Oxide	56	
	Primary		504
H_2O_4	Oxide	336	
	Primary		504
AN		300	300
Diesel Fuel		600	600
Total Loads Per Annum		**4,226**	**2,083**

Note 1: Occurs in each year of mine years 1 and 9.
2: Occurs in each year of mine years 2 to 8, and 10 to 12 inclusive

Table J-7 Maximum Operational Phase Traffic Generation

Scenario	Vehicle Type	Vehicle trips In	Out	Total
Daily trips (veh/day)	Day worker cars	36	36	72
	Shift worker cars	7	7	14
	Mini buses	10	10	20
	Visitors cars	5	5	10
	Trucks	12	12	24
	Total daily trips	**70**	**70**	**140**
Hourly Trips (am) (veh/hr)	Day worker cars	36	_	36
	Shift worker cars	3	3	6
	Mini buses	3	3	6
	Visitors cars	1	_	1
	Trucks	1	1	2
	Total hourly trips	**44**	**7**	**51**

It can be seen that both intersections will continue to operate satisfactorily. Notwithstanding some improvements to these intersections is considered desirable on safety grounds. This is discussed further in Section 6.0.

6.0 RECOMMENDED TRAFFIC MANAGEMENT IMPROVEMENTS

It is evident from the above analysis that the regional road system will perform satisfactorily under predicted future traffic levels, during both the construction and operational phases of the mine. In particular, maximum traffic volume increases on any main road equates to 24 vehicles per hour during peak periods, including 1 truck movement. Clearly, this will have negligible impact and the increased traffic volumes can be readily accommodated, with no need for capacity improvements.

Nevertheless, several improvements are considered desirable in a local context to provide safe and convenient access to the site. These incorporate the various route improvements discussed in Section 3.2, which have been previously established.

However, other intersection improvements are also considered desirable in order to improve the safety and/or operational efficiency of the preferred site access route. It is emphasised that these improvements are necessary under existing traffic conditions, and that their need does not arise from the subject development proposal. That is the development will merely exacerbate existing considerations. The improvements are however low cost items in the context of the overall road infrastructure improvements already identified for the project, as discussed in Section 3.2.

The improvements are shown in Attachment C and include the following:

1. Provision of a short passing lane within Wamboyne Road at Billys Lookout Road, together with improved priority control
2. Provision of a short passing lane in the Mid Western Highway at Ungarie Road, together with improved priority control, improved line marking and improved road shoulders within the intersection.

Subject to these improvements, traffic generation associated with the proposed Cowal Gold Project can be readily accommodated by the road system, during both the construction and operational phases. These improvements are expected to cost in the order of $25,000.

Finally, it is acknowledged that the potential exists for traffic associated with the mine to make use of the two alternate local access routes, as shown in Figure J-5. These include access via Clear Ridge Road or Bodel's Lane. It is considered however, that this potential is limited, given the proposed construction of a high standard access (and associated reduced travel times) along the preferred access route via Billys Lookout Road, Wamboyne Road and Ungarie Road.

Hence, use of these alternate routes is expected to be minimal. Indeed, any upgrading of these alternative routes would likely be counter productive as it could attract unnecessary traffic volumes. To the limited extent that reliance by private cars on these routes may occur, no problems are expected to arise either in terms of the available road capacity or from the point of view of safety considerations.

Table J-8 Maximum Predicted Change In Daily Traffic Volumes

Route	Map Identifier[1]	Existing Daily Flows	Additional Flow	Resultant Total Flow	Percentage Increase
Billys Lookout Road	N/A	20	135	155	775
Wamboyne Road	N/A	150	135	285	90
Ungarie Road	1	752	132	884	18
Mid Western Highway (W)	12	749	2	751	0.4
Newell Highway (S) (National Highway)	2	1,860	4	1,864	0.2
Barmedman Road	3	916	7	923	0.8
Newell Highway (E of West Wyalong)	4	3,786	25	3,811	0.7
Mid Western Highway (E of Marsden)	5	324	20	344	96.2
Newell Highway (N of Marsden) (National Highway)	13	2,665	5	2,670	0.2

Note 1: Refer to Figure J-6 or Table J-1

Table J-9 Future Intersection Performances – AM Peak

Intersection	Control Type	DOS		AVD		LOS	
		Existing	Future	Existing	Future	Existing	Future
Ungarie/Wamboyne	Priority	0.04	0.06	1.2	3.0	A	A
Ungarie/Mid Western Highway	Priority	0.04	0.07	2.9	3.6	A	A

7.0 CONCLUSIONS

On the basis of the above assessment, the following conclusions may be drawn:

- The preferred access route to the Project area is via Ungarie Road, Wamboyne Road and Billys Lookout Road, connecting to the roadway parallel to the West Wyalong-Burcher railway line. This route will carry the vast majority of traffic associated with the mine and will be upgraded to provide a 6 metre wide sealed carriageway over its entire length, with appropriate geometric and structural improvements as have been identified in earlier reports.
- Predicted traffic volumes during the construction phase have been assessed on a worst-case design scenario, with a construction workforce of 200 employees. The traffic generation during this period (18 months) can be readily accommodated by the local road network subject to the identified improvements being implemented.
- The impact of construction-related traffic on the regional network is negligible, with a maximum increase in daily flows on any single route of 5 vehicles per day, including 1 or 2 truck trips. These flows represent increases of less than 1 percent and their impact will be imperceptible.
- Predicted traffic volumes during the operational phase can similarly be readily accommodated by the local road network, subject to the implementation of identified improvements.
- The impact of mine traffic on the regional road network during the operational phase is also negligible, with a maximum increase of 24 vehicles per day on any one route, or 2 to 3 vehicles per hour during peak periods, including 1 truck movement. Again, the impacts will be imperceptible.
- The improvements which have been identified will overcome any concerns relating to the safety or efficiency of the preferred access route, and are supported. It should be noted however, that the improvements respond to existing deficiencies and are not required solely to support the proposed mine.
- Internal traffic arrangements will be designed in accordance with appropriate guidelines, including the movement of vehicles and the parking requirements for employees and visitors.
- The proposed development is supportable in terms of its traffic impacts.

Attachment A

Attachment A

Figures

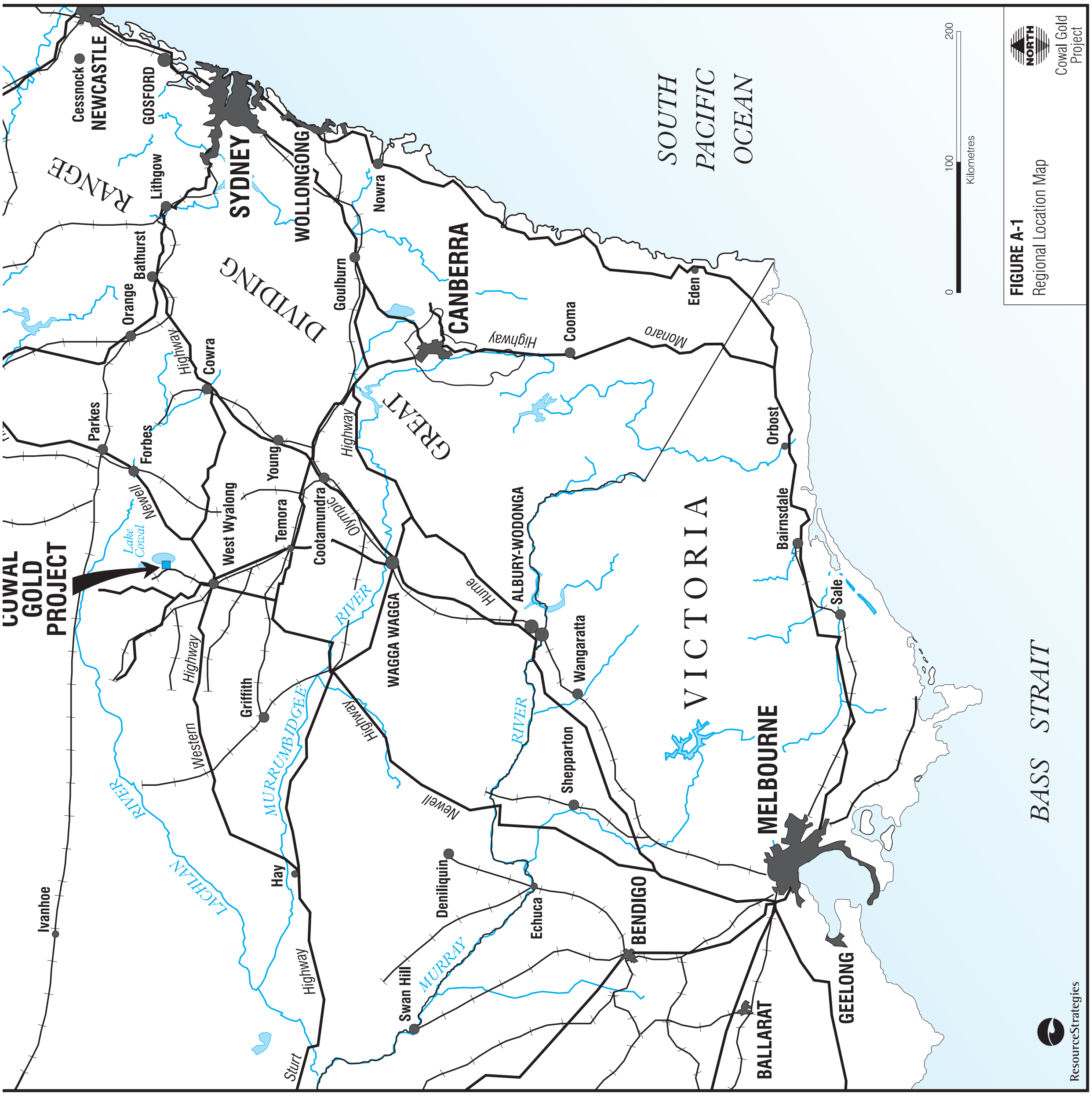


FIGURE A-1
Regional Location Map

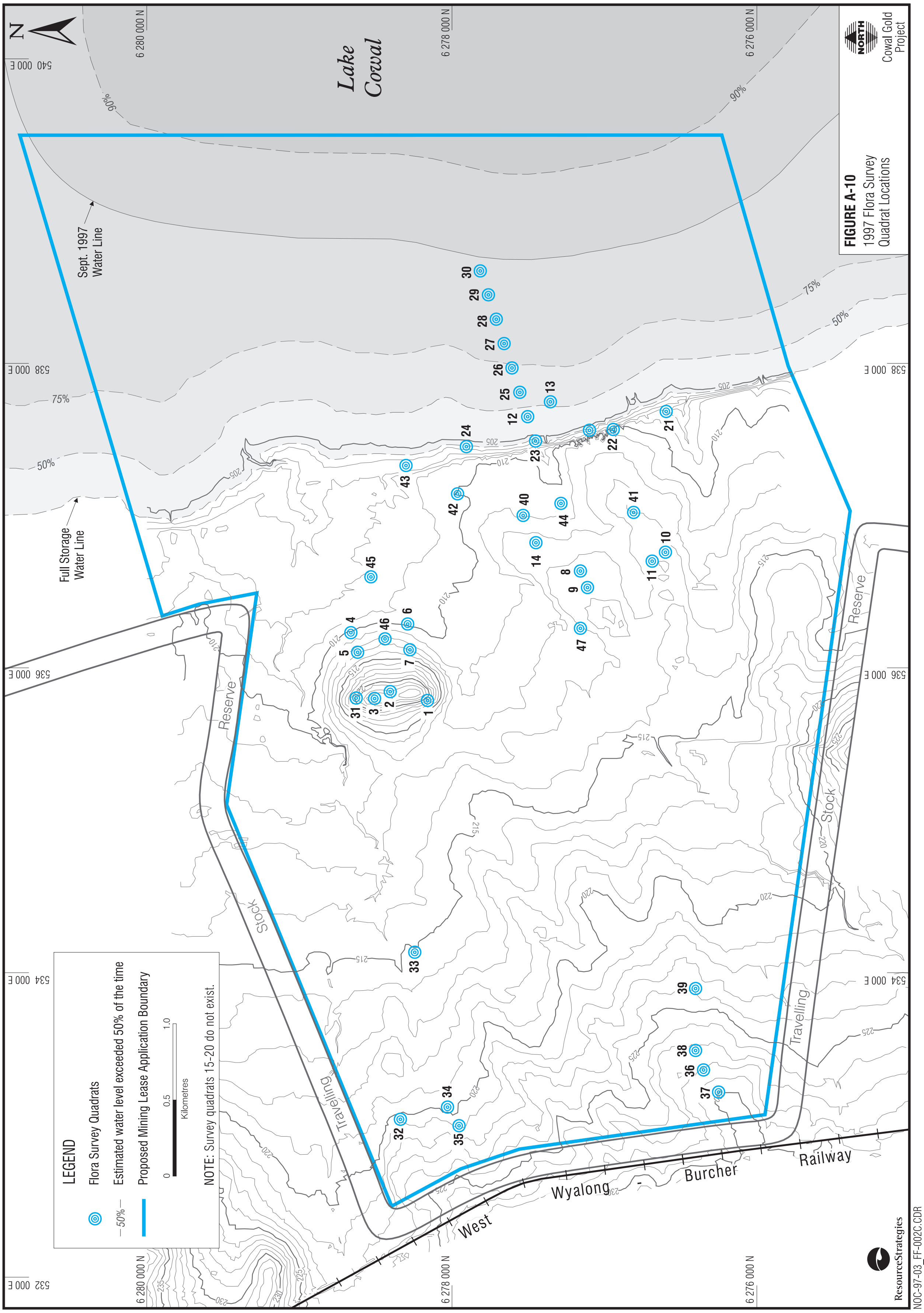


FIGURE A-10
1997 Flora Survey
Quadrat Locations
Cowal Gold Project
NORTH
Lake Cowal
Sept. 1997 Water Line
Full Storage Water Line
90%
75%
50%
LEGEND
Flora Survey Quadrats
Estimated water level exceeded 50% of the time
Proposed Mining Lease Application Boundary
0
0.5
1.0
Kilometres
NOTE: Survey quadrats 15-20 do not exist.
540 000 E
538 000 E
536 000 E
534 000 E
532 000 E
6 280 000 N
6 278 000 N
6 276 000 N
Travelling Stock Reserve
West Wyalong - Burcher Railway
ResourceStrategies
NOC-97-03_FF-002C.CDR

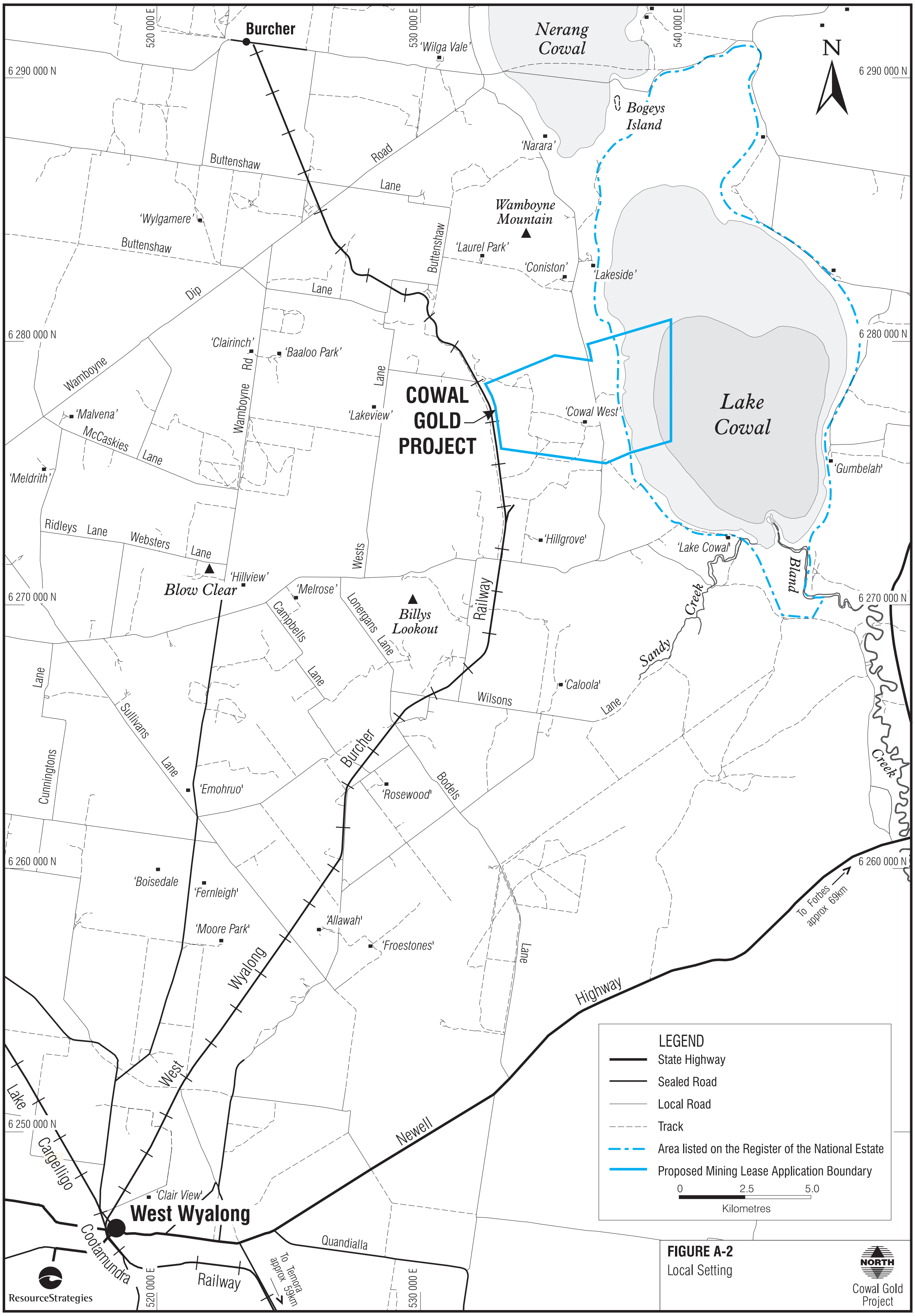
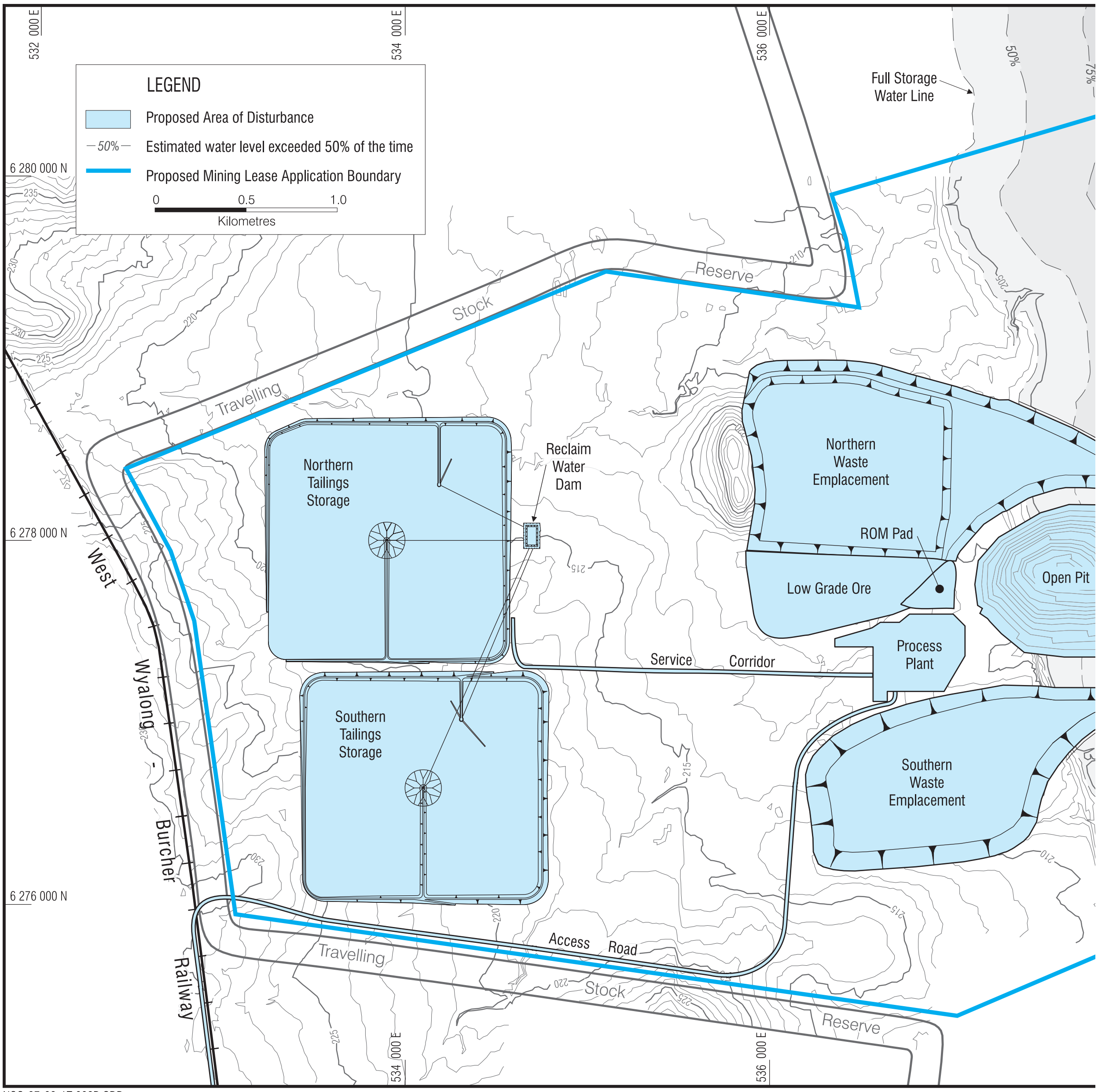


FIGURE A-2
Local Setting

NOC-97-03_FF-007C.CDR



NOC-97-03_LT-002B.CDR

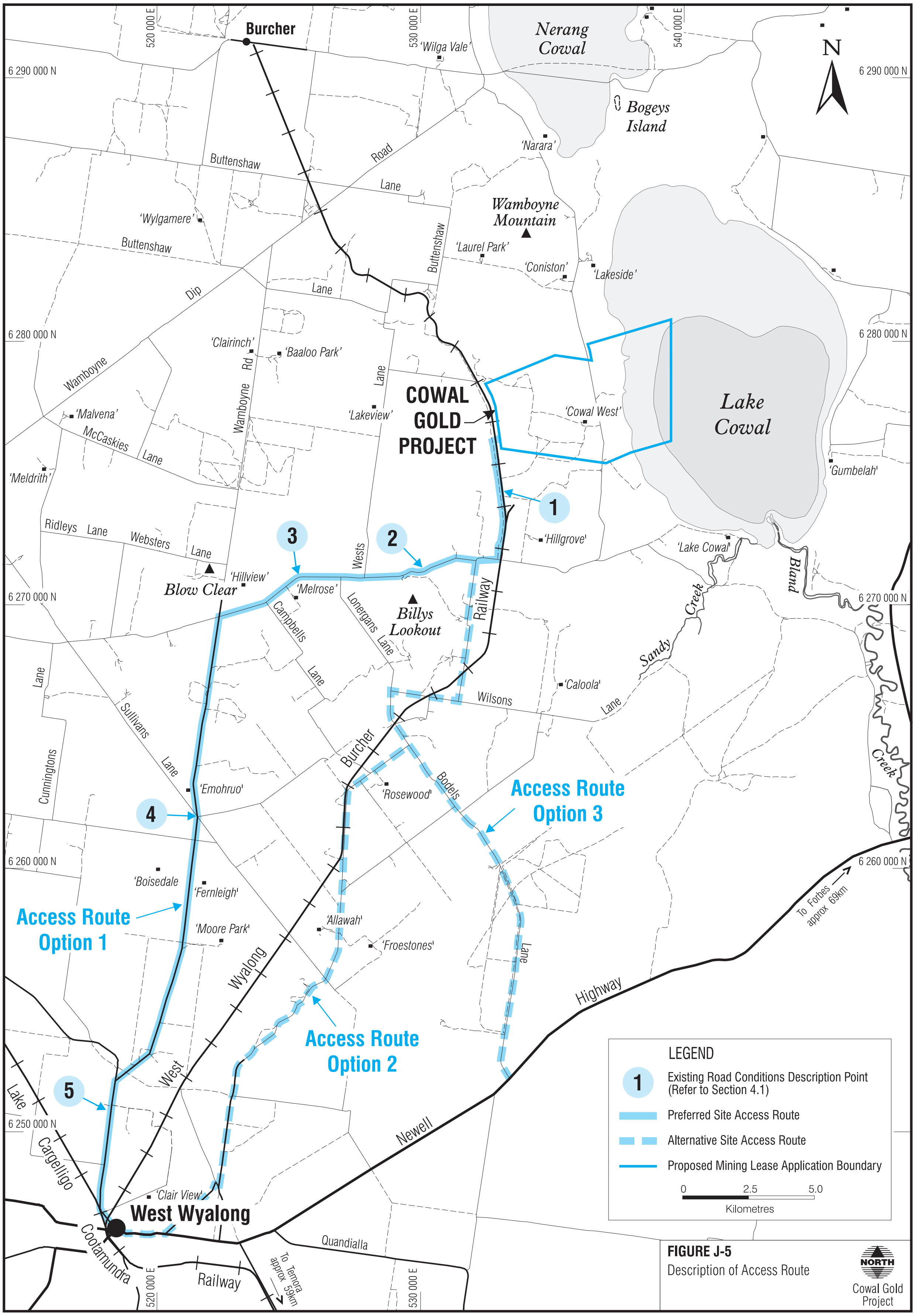


FIGURE J-5
Description of Access Route

NOC-97-03_TR-005E.CDR

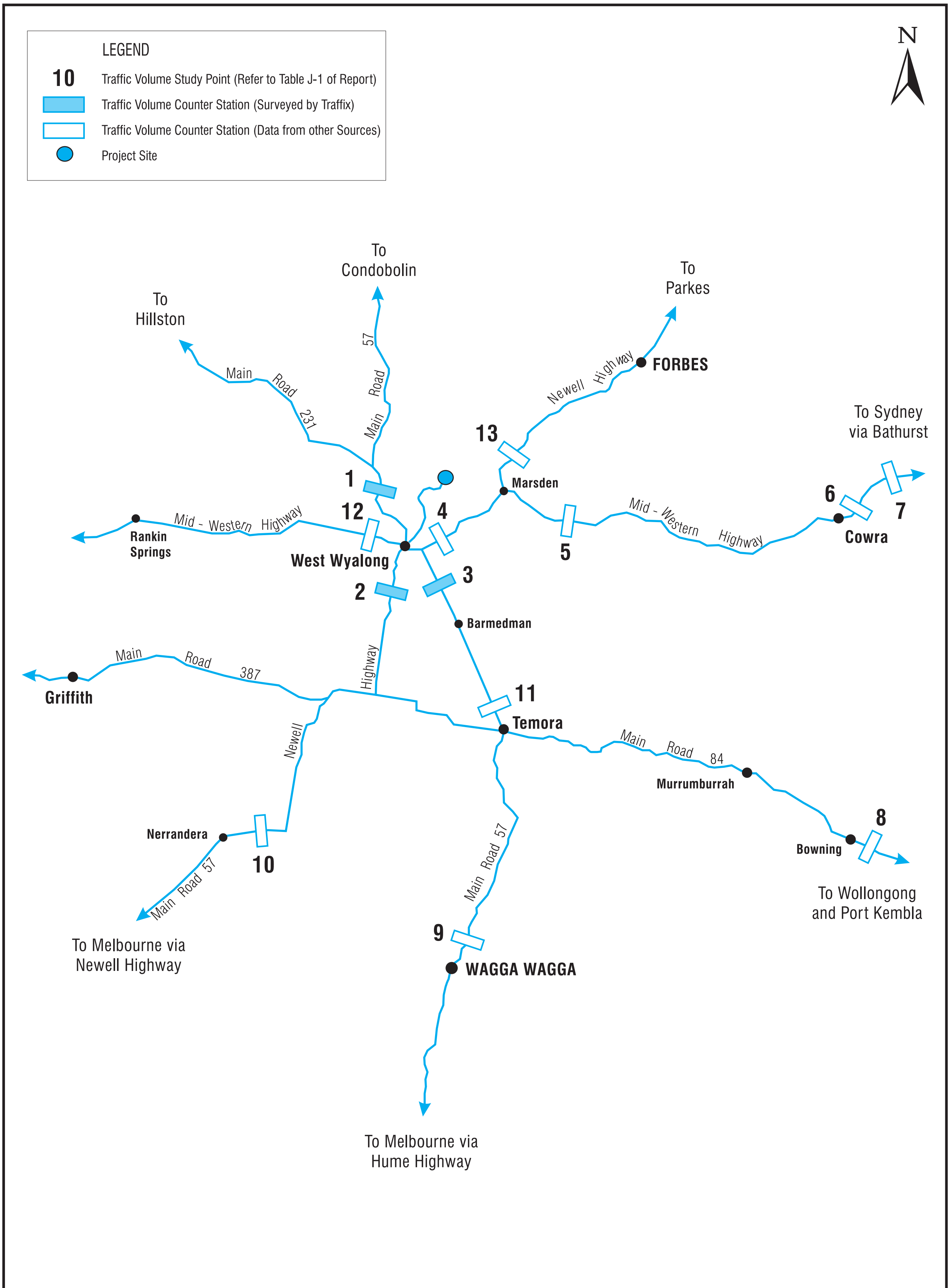
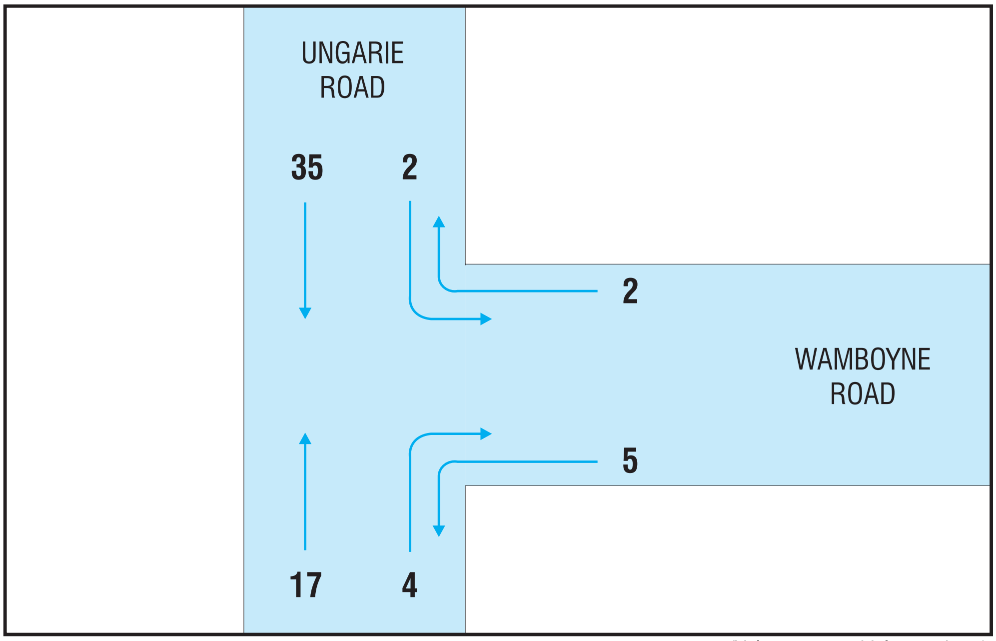
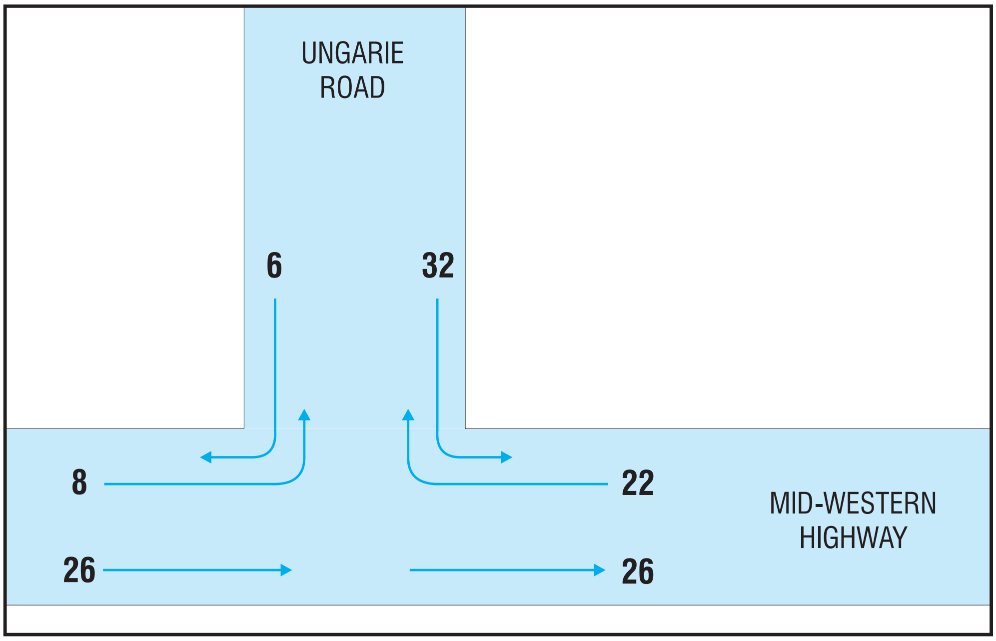


FIGURE J-6
Daily Traffic Volume Locations

NOC-97-03_TR-006D.CDR



(Volumes are vehicles per hour)

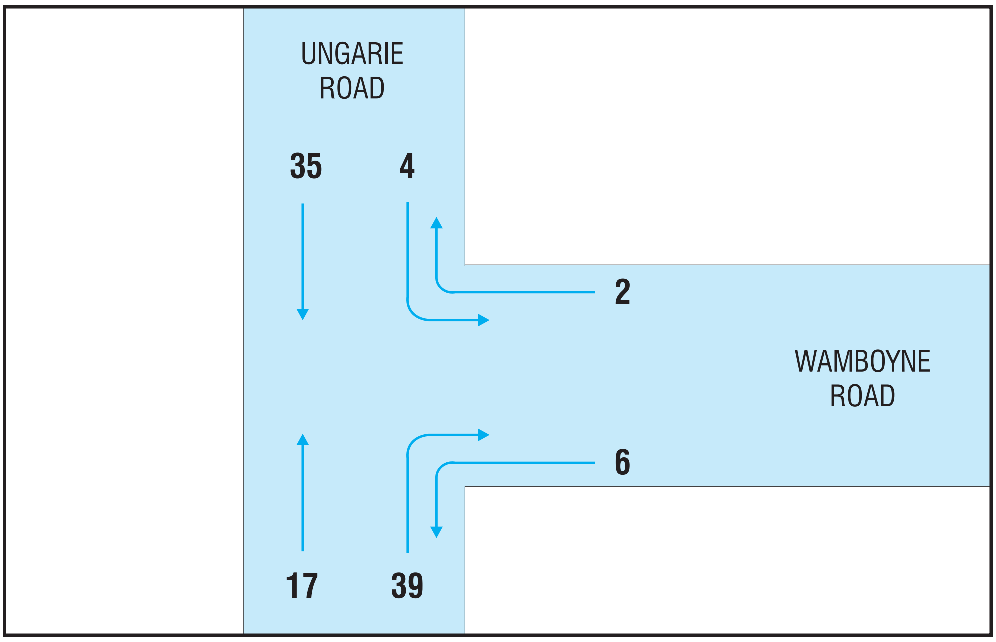


(Volumes are vehicles per hour)

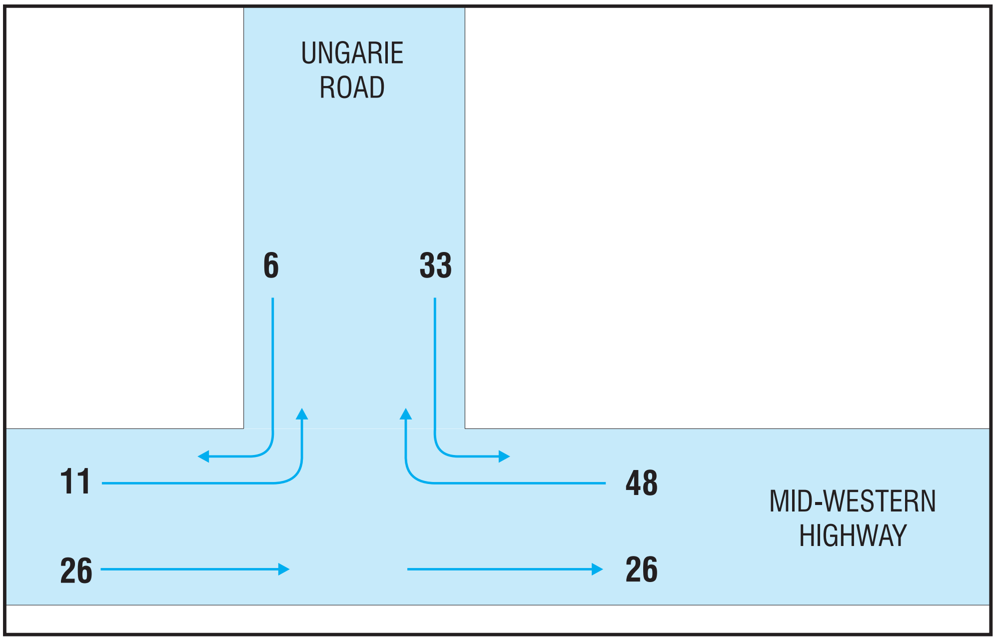
FIGURE J-7
Existing Intersection Volumes

NORTH
Cowal Gold Project

NOC-97-03_TR-007D.CDR



(Volumes are vehicles per hour)

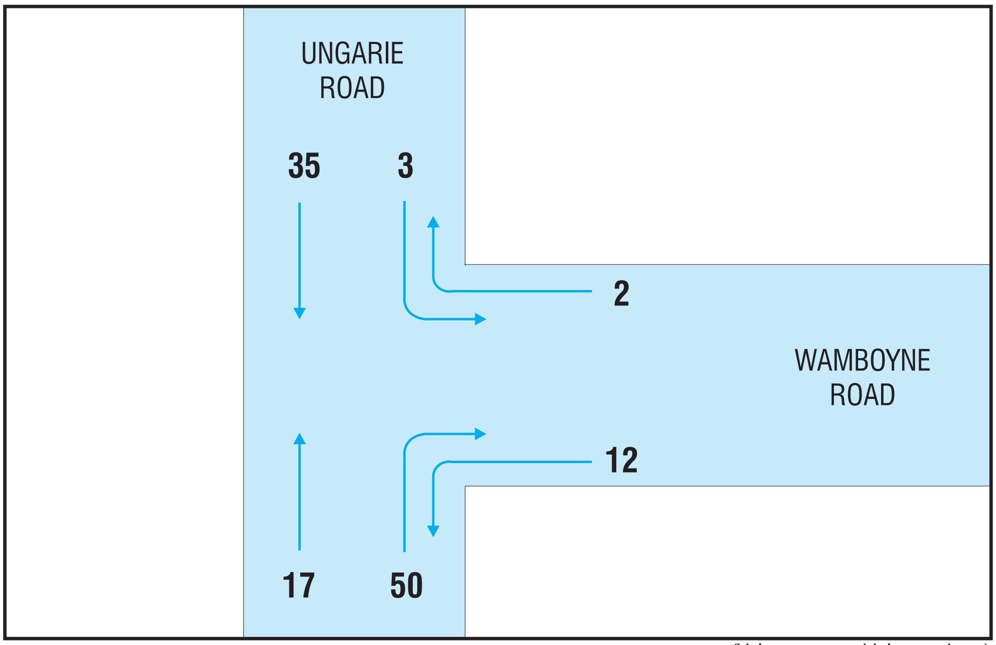


(Volumes are vehicles per hour)

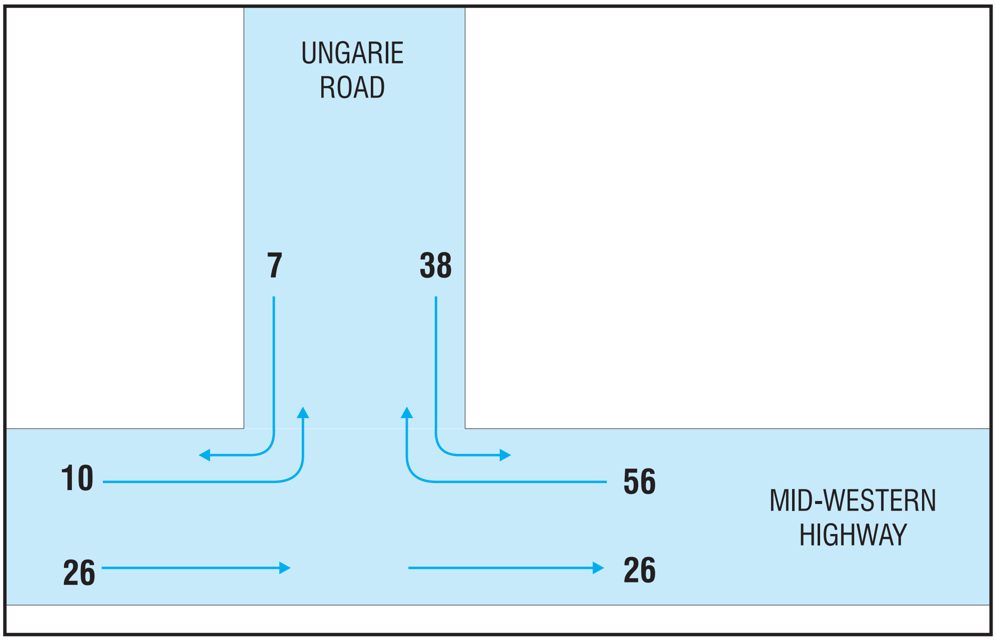
FIGURE J-8
Intersection Volumes
during Mine Construction

NORTH
Cowal Gold
Project

NOC-97-03_TR-008D.CDR



(Volumes are vehicles per hour)



(Volumes are vehicles per hour)

FIGURE J-9
Intersection Volumes
during Mine Operations

NORTH
Cowal Gold
Project

NOC-97-03_TR-009D.CDR

Attachment B

Attachment B

Photographic Record

Photo 1
View looking north along Lake Cowal Road in vicinity of Site Access.

Photo 2
Reverse view looking south along Lake Cowal Road.

Photo 3
View looking north along disused road adjacent to silo (Chainage 0.0).

Photo 4
View looking east along Lake Cowal road with disused road on left of photo (Chainage 0.0).

Photo 5
View looking west along Billys Lookout Road, with Wests Lane on right of photo (Chainage 15.3 km).

Photo 6
View looking north along Wests Lane (Chainage 15.3 km).

Photo 7
View looking west along Billys Lookout Road at Lonegans Lane (Chainage 16.2 km).

Photo 8
View looking west along Billys Lookout Road towards Wamboyne Road (Chainage 21.3 km).

Photo 9
View looking south along Wamboyne Road towards Billys Lookout Road.

Photo 10
View looking south along Wamboyne Road (Chainage 31.9 km).

Photo 11
View looking south along Wamboyne Road towards Ungarie Road (Chainage 40.0 km).

Photo 12
View looking north along Ungarie Road at Wamboyne Road intersection (Chainage 40.0 km).

Photo 13
Reverse view looking south along Ungarie road (Chainage 40.0 km).

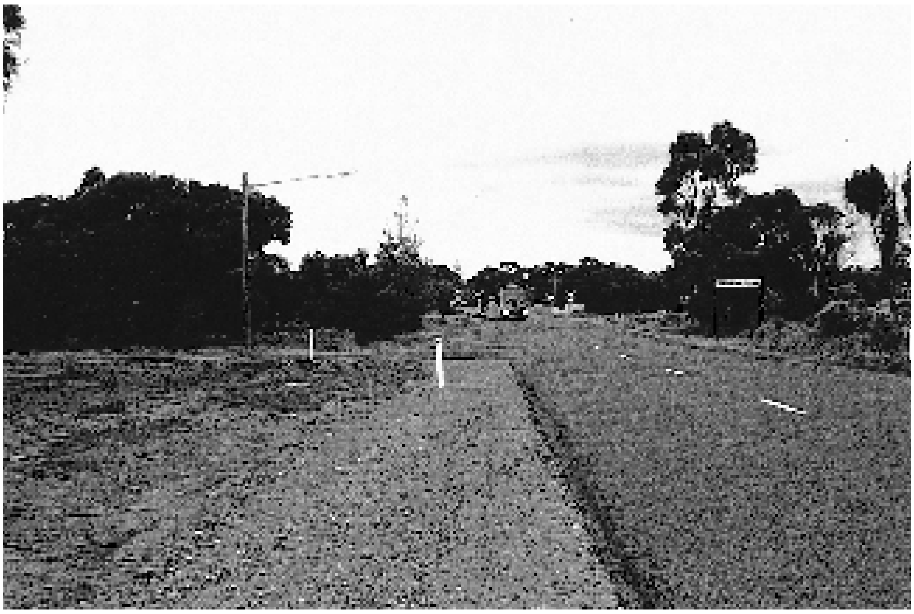


Photo 14
View looking south along Ungarie Road at turn off to rubbish tip (Chainage 43.9 km).

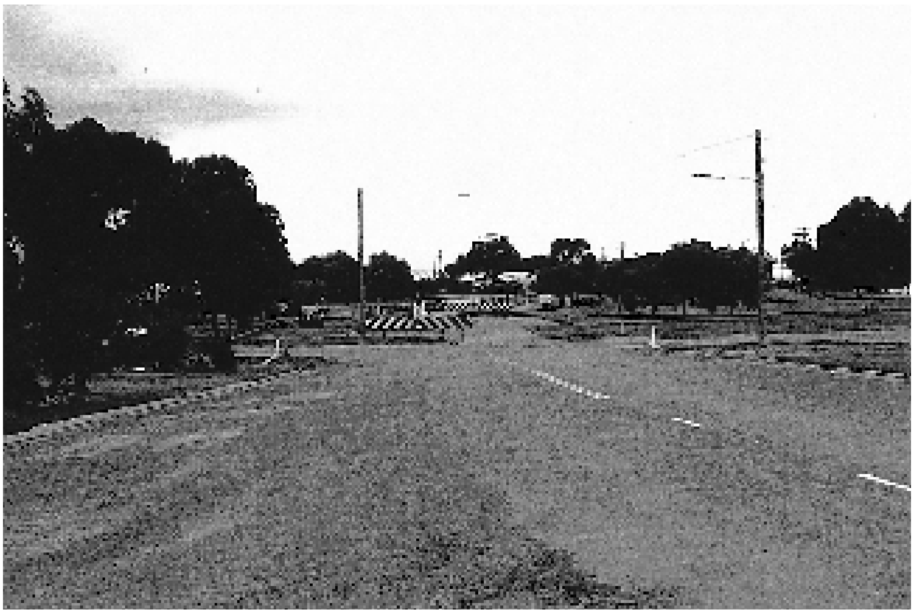


Photo 15
View looking south along Ungarie Road towards Mid-West Highway (Chainage 46.0 km).

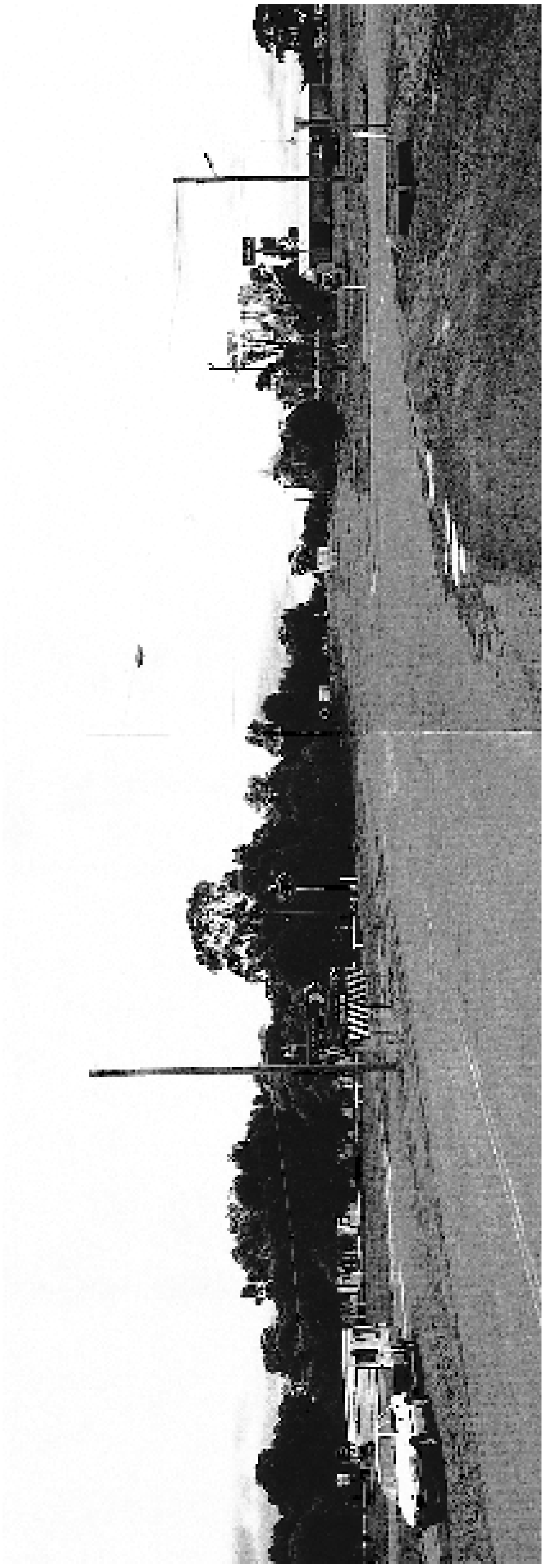


Photo 16
View looking west along Mid-West Highway at intersection with Ungarie Road (Chainage 46.0 km).

Photo 17
View looking east along Mid-West Highway with Water Street on right of photo.

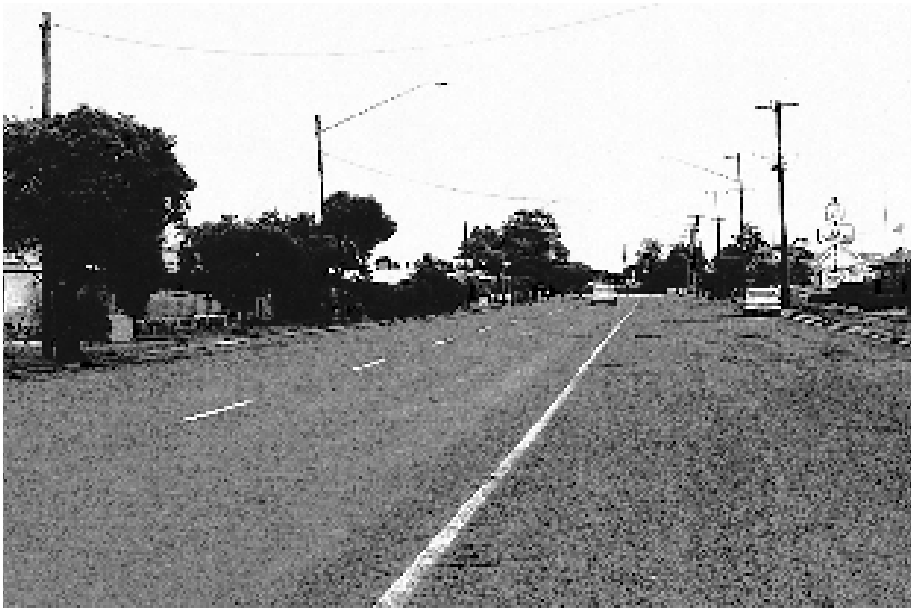


Photo 18
View looking west along Mid-West Highway from Cleer Ridge Road.

Photo 19
View looking east along Mid-West Highway at intersection with Cleer Ridge Road.

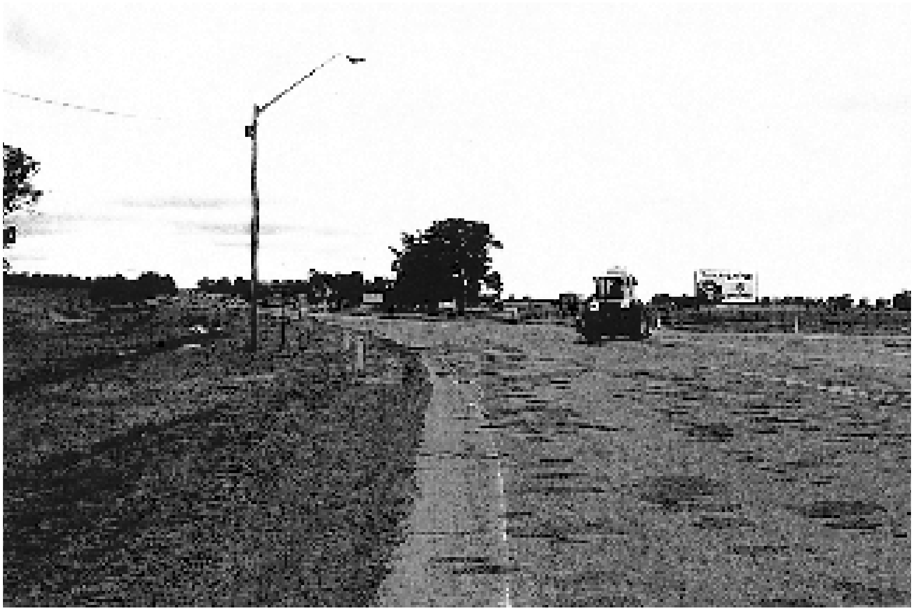


Photo 20
View looking east along Mid-West Highway towards intersection with Barmedman Road (to Wagga).

Photo 21
Reverse view looking west.

Photo 22
View looking east along Mid-West Highway with Bodels Lane on left of photo.

Attachment C

Attachment C

Traffic Management Improvements

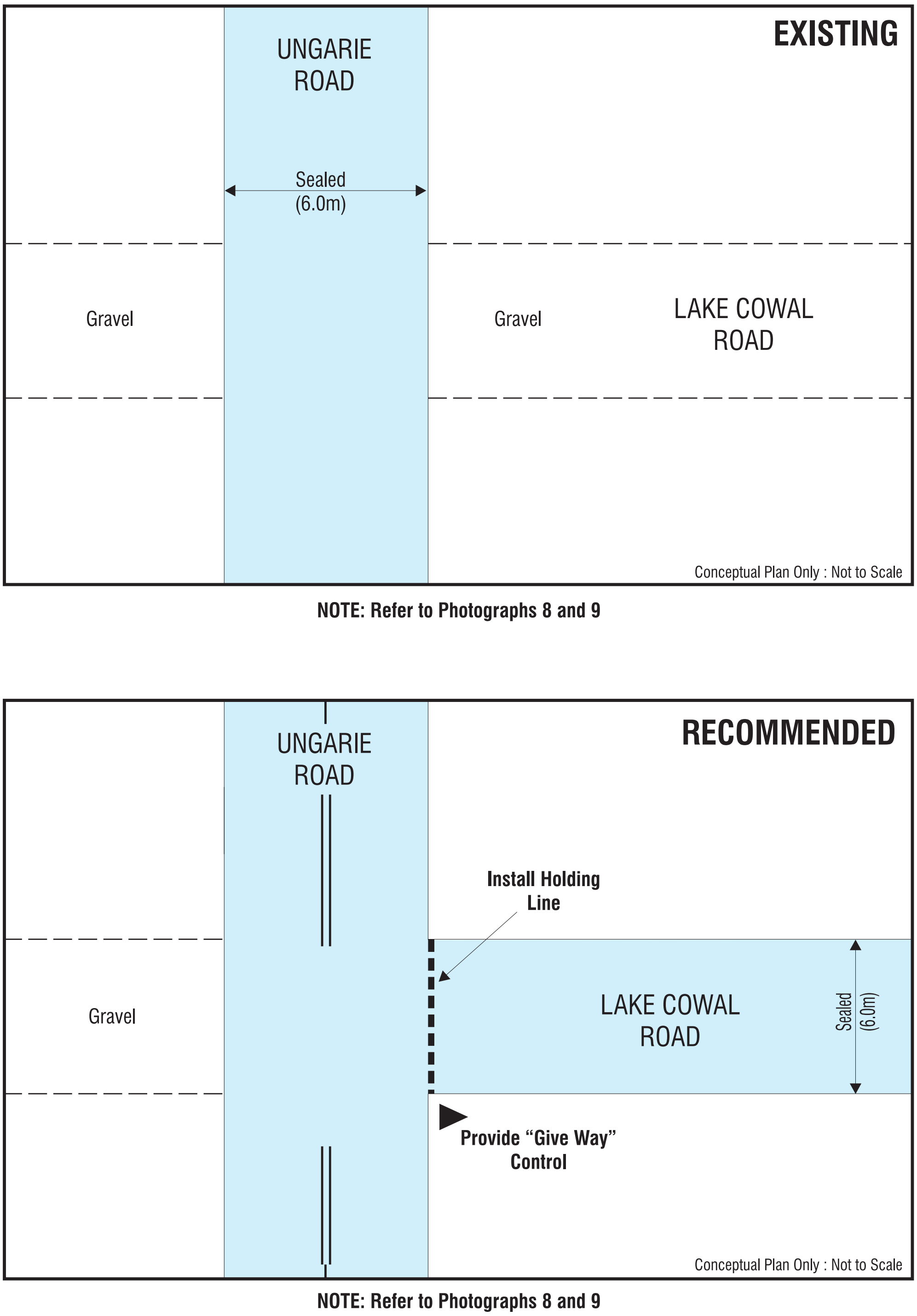
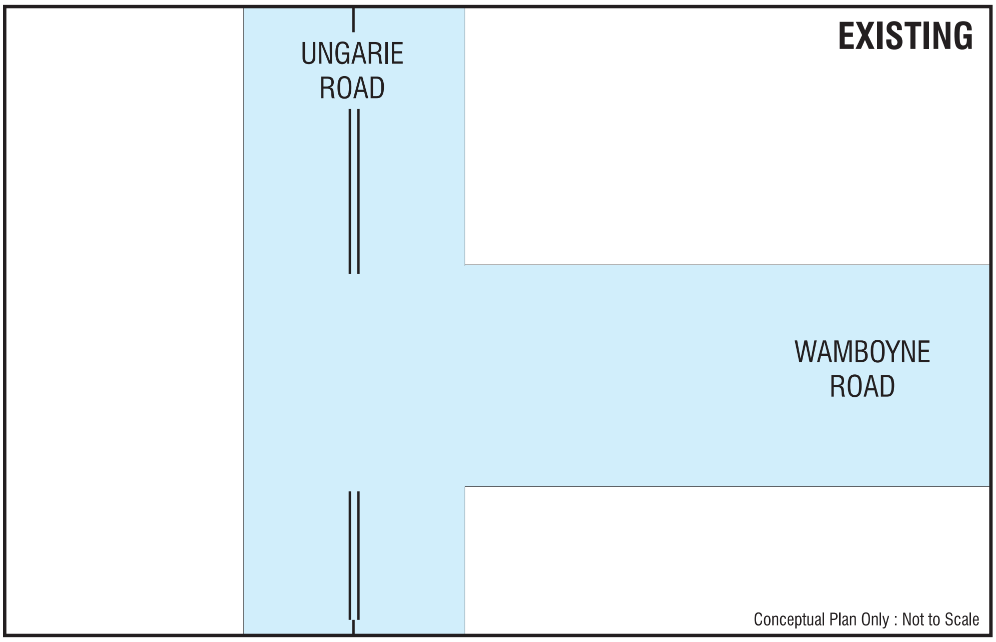


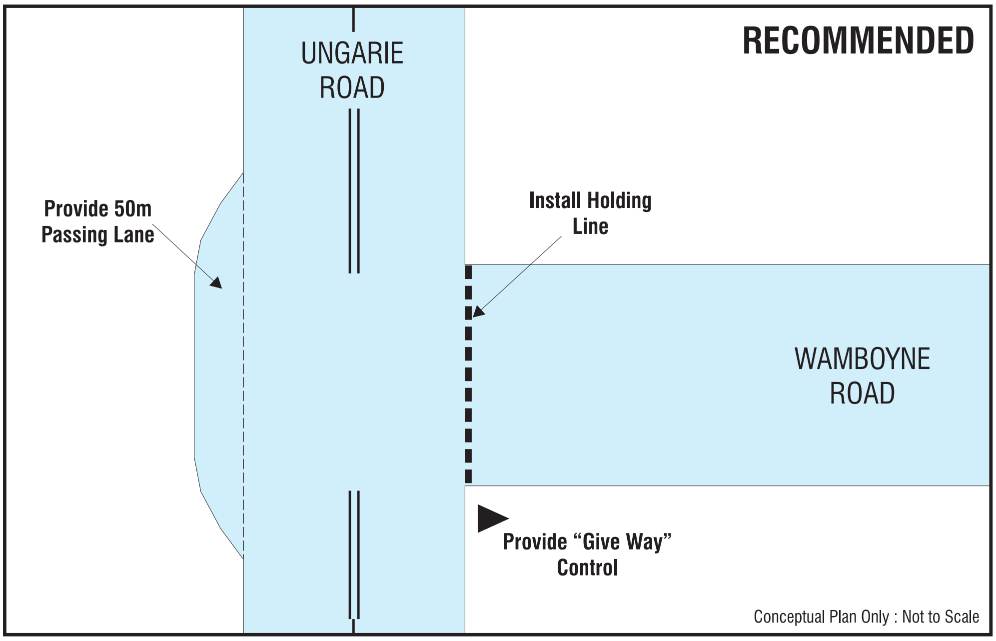
FIGURE C-1
Traffic Management Improvements

Cowal Gold Project

NOC-97-03_TR-011D.CDR



NOTE: Refer to Photographs 12 and 13



NOTE: Refer to Photographs 12 and 13

FIGURE C-2
Traffic Management
Improvements

NORTH
Cowal Gold
Project

NOC-97-03_TR-010D.CDR

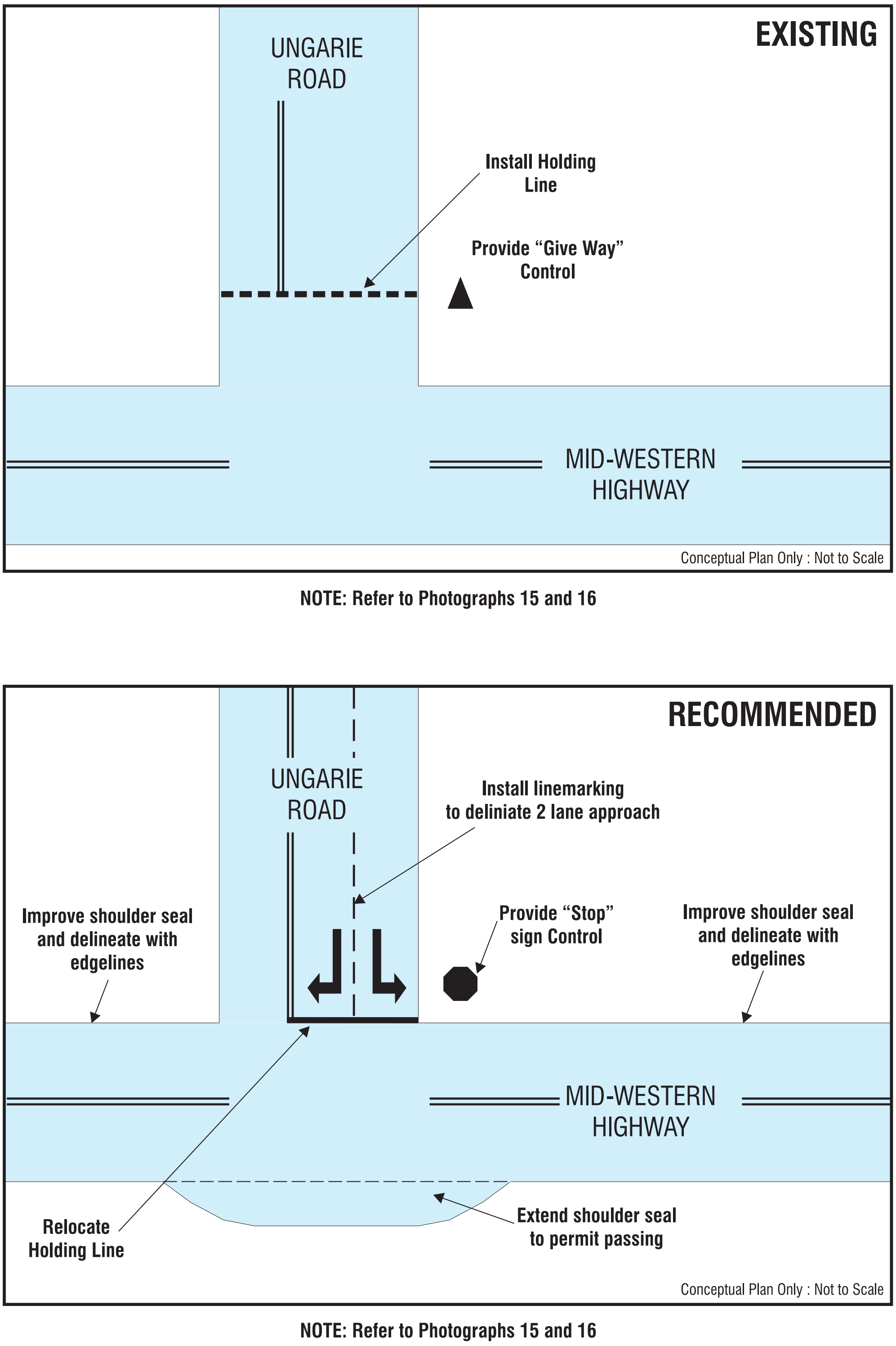


FIGURE C-3
Traffic Management Improvements

NORTH
Cowal Gold Project

NOC-97-03_TR-012D.CDR

Attachment D

Attachment D

Traffic Survey Data

Attachment D contains a large number of tables and graphs generated from Traffic Survey Data.

Full data sets can be obtained from North Limited (02) 6972 4500.

Appendix K

Socioeconomics and Multi-Criteria Analysis

The social and economic significance of a resource development project for country New South Wales

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May 1997

TABLE OF CONTENTS

LIST OF TABLES

LIST OF CHARTS

LIST OF BOXES

LIST OF ATTACHMENTS

EXECUTIVE SUMMARY

"…With poor employment prospects, residents, especially the younger residents of Bland Shire, are moving out of the region. This net out-migration… further reduces prospects for businesses and employment, reinforcing incentives for seeking opportunities outside of the shire…" (this report, Section 3.0).

The Centre for International Economics (CIE) has researched the current and forecast social and economic dynamics of a country shire in inland New South Wales, to compare the future prospects for the region *with* and *without* a major resource development project.

The case study is centred on the town of West Wyalong, in Bland Shire. The proposed resource development project is the Cowal Gold Project.

The key findings of the study are as follows.

Current and Forecast Situation without the Lake Cowal Mine

- Bland Shire, through lack of economic impetus, has experienced significant out-migration of workforce-aged people and a consequent ageing of the population in recent years. If current rates of decline continue the population could fall from 6,600 to 5,500 over the next ten years.
- The medical services provided in West Wyalong are vulnerable to any further decline in population. Despite the prospect of a new hospital, the range of services it can provide, the related attraction and retention of medical professionals is population dependent.
- Without the Project, annual population-based health service funding would fall significantly and the viability of the general medical practice in West Wyalong would be threatened.
- The sole high school in the shire has managed to avoid a significant fall in student numbers, despite population decline. However, if population trends continue, it is in danger of losing three full time staff over the next 10 years, and with them a capability to offer some advanced courses. Attraction of students from competing schools will be only a short term palliative.
- Community organisations such as the bushfire brigade and sporting groups are already experiencing difficulties in recruiting volunteers. This is symptomatic of a weakened community spirit in the shire which has adverse impacts on the community's welfare and business confidence in the region.
- While the value of Australian farm production has grown by 2.1 per cent over the past decade, in Bland Shire it has fallen by 4.3 per cent in real terms.
- The shire's economy remains heavily unbalanced with agriculture dominant and production in that sector weighted towards wool and wheat products. Employment prospects in these activities have progressively declined.
- Farm amalgamations, low farm profitability and reduced use of hired farm labour have all contributed to reduced job prospects in the region's biggest industry. Hence, poor employment opportunities have led to out-migration rather than high recorded local unemployment.
- Poor job prospects will encourage further migration out of the region – especially by young job seekers entering the workforce. If all these out-migrants remained in the shire, unemployed, then the unemployment rate would be approximately 10 percentage points higher.
- Forty-three per cent of households in Bland Shire have incomes less than $20,000, compared with a state average of around 26 per cent. This situation may be exacerbated further in the absence of the Project.
- While local government shire revenue has held up well, it will inevitably suffer if rural property values fall further.
- Local government-provided services must be considered vulnerable to the long term decline in rateable property values that will accompany population decline.

Probable Scenario with the Cowal Gold Project

To establish the likely effects of establishment of the Project within Bland Shire, we have drawn on the experience of a neighbouring shire (Parkes) which has recently had a copper and gold mine developed within its boundaries.

The experience of Parkes Shire suggests that the Cowal Gold Project will have a significant positive impact on Bland Shire. The past three to four years since the Northparkes mine has been operating in Parkes Shire there has been:

- increased population growth;
- reduced unemployment;
- new businesses established;
- increased demand for new housing; and
- increased provision of child care and recreational facilities.

While not an absolute indicator of the possible impacts of a mine at Lake Cowal, it is reasonable to expect that similar benefits would arise in Bland Shire.

By making some reasonable assumptions about key economic and demographic variables, a picture of the broad dimensions of the economic and social impact of establishing a mine at Lake Cowal can be obtained. Table E-1 presents some indicative outcomes for key socioeconomic variables.

Table E-1 Indicative Impacts on Key Socioeconomic Variables

Parameter	Current	2007 without gold mine	2007 with gold mine
Population	6,600	5,545	6,029
Population in 20-40 year old cohort (%)	25.2	24.2	25.1
No. of pensioners in shire	1,031	1,068	1,072
Unemployment – measured (%)	3.2	3.2	3.2
Migration corrected unemployment (%)	16.9	26.6	21
Index of retail activity in West Wyalong	100	84	119
Value of farm production ($m)	99.7	118.4	118.4
Gross value of resource production (agricultural and other) in Bland Shire ($m)	99.7	118.4	254.4
Health service funding ($m)	2.5	2.1	2.3
High School enrolments	383	318	321
Population aged 0-9 years (pre and primary school aged children)	1,029	748	837
Dentists in West Wyalong	1 part-time	1 part-time	1 full-time
Doctors in West Wyalong	2 full-time, 1 part-time	2 full-time	4 full-time
Full post offices in shire	1	0	1
Local government annual income – rate revenue ($m)	3.1	3.3	4.5
Number of daily air services: Sydney to West Wyalong	2/day	1/day	2/day

[a] Unemployment measure correcting for understatement due to out-migration.

Source: CIE projections.

Major conclusions are as follows:

- Compared with a "*no mine*" scenario, the Lake Cowal project would produce in Bland Shire:
  - a reduction in the rate of decline in population;
  - gains in population in the critical 20-40 years age group;
  - significantly improved job opportunities leading to a reduction in a migration-corrected measure of unemployment;
  - more than 100 per cent increase in the value of resource production in the shire;
  - improvements in health service funding and staffing; and
  - large gains to local government revenues.
- The number of jobs created by the Project and potentially open to local residents would equate to the size of the present pool of (measured) unemployed in the shire.
- There would be a clear gain in population in the 20-34 years age group compared with a *no mine* scenario. This would yield significant gains to the community of Bland Shire in terms of improved prospects for health, education and general retail activity.
- There would be an increase of around 12 per cent in the shire of pre and primary-aged children, compared with a *no mine* scenario. An increase in high school aged children would occur beyond the ten year horizon.
- An injection of population in the critical young adult age group would help to break the vicious circle affecting the provision of medical and hospital services.
- By the year 2007, the population of Bland Shire is expected to be 484 persons higher than if there were no mine.
- At a broader economy level, modelling indicates that the Project would produce an increase in New South Wales Gross State Product of $190 million and create in the order of 740 jobs statewide.
- Specifically, the Cowal Gold Project would provide 180 jobs and $9 million in wages and salary income of $9 million in wages and salaries in the region, with the construction phase of the project providing up to 300 jobs and around $220 million in capital expenditure.
- The flow-on effects of the employment of 180 persons at the mine and the associated wage and salary income of $9 million could give rise to an additional 52 jobs and $4 million in income throughout the shire.
- Expenditure in the shire induced by new wage and salary payments could be as high as $5.1 million a year. This represents 25 per cent of the estimated current retail turnover in Bland Shire.

- Around $22 million of the construction expenditure will occur within the shire. Temporary accommodation of workers could increase accommodation takings in the shire by up to $3 million.
- The mine is expecting to incur $79 million a year in nonlabour operating expenses. If the experience of the Northparkes Mine (Parkes Shire) is an indication, then Bland Shire could conservatively gain from an estimated $7.1 million of direct expenditure by the Project in the shire.
- Over the life of the project the mine is estimated to produce total output to the value of $1.3 billion. It is expected to outlay a total of $905 million in operating expenditure comprising $305 million in mining related expenditure, $509 million in processing related expenditure, $32 million in royalties and $59 million of other expenditure.
- Additional benefits to the community from the mine include improvements to the viability of the current air service and increased activity in the residential property market where turnover has been low.
- A direct demand of thirty-four houses by North Limited would provide a large, positive boost to the flat residential property market in West Wyalong. Property turnover will stimulate the real estate services sector.
- By providing sustained increases in demand, the establishment of a mine in Bland Shire will tend to increase the confidence of business in their employment and investment decisions.

1.0 INTRODUCTION

In 1995 North Limited proposed the establishment of an open cut gold mine in Bland Shire in an area south-west of Lake Cowal in central western New South Wales. The Cowal Gold Project proposal would see mining and processing activity at the site for 12 years after an 18 month construction phase, providing direct employment for up to 300 people during the construction phase and 180 on-going direct jobs during mine operation.

The Project would provide a welcome boost to the Bland Shire region where structural changes and drought have depressed activity in the agricultural sector, leading to downstream impacts on the service town of West Wyalong and surrounding villages. A sustained fall in population as younger residents migrate to larger centres in search of employment has been the result of these adverse conditions. This prolonged contraction impacts on the sustainability of a range of community, social and economic institutions and activities.

The original development application for the Project was rejected by the state government despite a favourable recommendation by a Commission of Inquiry into the project (December 1995 to March 1996). The main reason for the government's decision appears to be concern over possible environmental impacts on the ecosystem of Lake Cowal – a water resource on the register of the National Estate and regarded as having a high conservation value.

The Centre for International Economics (CIE) has been commissioned to undertake a socio-economic study for the Bland Shire Council. The objective of the study is to examine current socio-economic trends in West Wyalong and the broader Bland Shire area with a view to establishing the likely consequences should these trends continue in the absence of the Cowal Gold Project. Having established a "*without mine*" scenario, a further objective is to investigate how the establishment of a mine at Lake Cowal would affect these outcomes.

Current trends in key economic and demographic aggregates are discussed in Section K2 and the implications of these trends for the town of West Wyalong and the broader Bland Shire are discussed in Section K3. Section K4 presents the broad dimensions of the proposed Cowal Gold Project. Possible impacts of a mine at Lake Cowal on the future direction of Bland Shire are presented in Section K5. The experience of Parkes Shire, where a significant copper and gold mine development operates, is used to draw inferences about these likely impacts on Bland Shire.

2.0 PROFILE OF BLAND SHIRE

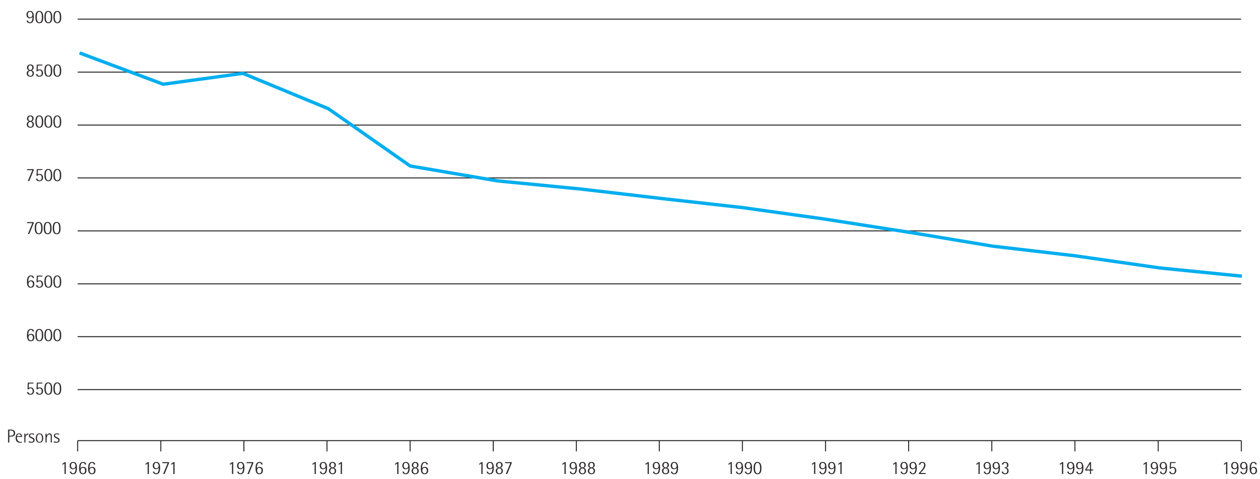
2.1 Population Trends in Bland Shire

The 1991 census recorded Bland Shire's population at 7,100. Since then, the Australian Bureau of Statistics estimates that the Shire's population has fallen to around 6,600. Chart 2-1 illustrates how Bland Shire's population has changed over the past 30 years. From 1966 the population in Bland Shire has fallen by an average 0.9 per cent per year – which compares to an average increase in population in New South Wales of 1.4 per cent. Over recent years, the rate of decline in population in Bland Shire has accelerated, with an average decline in population since 1986 of 1.4 per cent and over the past five years of 1.6 per cent. If the present rate of decline (1.6 per cent) continues then the population of the shire could fall to 5,500 over the next ten years.

While New South Wales has been gaining population, Bland Shire has been losing numbers at an accelerated rate over the past decade.

Chart 2-2 illustrates the components of the change in population in Bland Shire since 1966. It is immediately apparent that net migration out of the region has been the key driver in the decline in population. This has been in the order of 700 to 800 over the last four census periods – equivalent to an annual net loss of around 2 per cent of

Chart 2-1 Estimated Resident Population – Bland Shire



Data source: ABS 1996a.

Bland Shire's total population. Flood *et al* (1991) note that net migration trends tend to be driven by those not employed (such as pensioners, those in receipt of unemployment benefits and the retired) with movements within the 15-30 age group primarily toward capital cities seeking better employment and consumption opportunities.

A picture of who is migrating can be obtained from examining changes to the age profile of Bland Shire between census years. The 1986 age profile of Bland Shire is presented in Table K-1. Changes to a particular age cohort (the group of people falling in the same age bracket) over the five years to the next census count will be affected by natural ageing (and births in the case of the 0-4 cohort), deaths, and net migration into and out of the region. Natural ageing implies that at the next census count, persons counted in the 0-4 cohort in 1986 will be recorded in the 5-9 cohort in 1991, those in the 20-24 cohort in 1986 will be in the 25-29 cohort in 1991 and so on for other age groups. By deducting five years from each 1991 cohort definition and lining up with the corresponding 1986 cohort, the effect of natural ageing can be netted out. This will then allow a picture of net migration to be obtained. This is illustrated in Table K-1.

Recorded deaths by age group are not readily available at the local government area level, so the estimates of net migration overstate actual migration levels by the number of deaths in each age cohort. It would be expected that this would mainly affect the older age cohorts. It is clear from Table K-1 that net migration is concentrated in the younger age groups (10-24 – aged between 15 and 29 at the 1991 census). A significant proportion of the 35-45 age group (aged 40-50 in 1991) also migrated from Bland Shire

Table K-1 Net Migration by Age Group

1986 Age Cohort	1986 Population	Adjusted[a] 1991 Population	Absolute Change in Population	Percentage Change
0-4	670	641	-29	-4%
5-9	680	622	-58	-9%
10-14	670	460	-210	-31%
15-19	510	362	-148	-29%
20-24	540	480	-60	-11%
25-29	600	554	-46	-8%
30-34	560	526	-34	-6%
35-40	500	423	-77	-15%
40-44	410	360	-50	-12%
45-49	410	384	-26	-6%
50-54	420	401	-19	-5%
55-59	400	392	-8	-2%
60-64	390	336	-54	-14%
65-69	300	238	-62	-21%

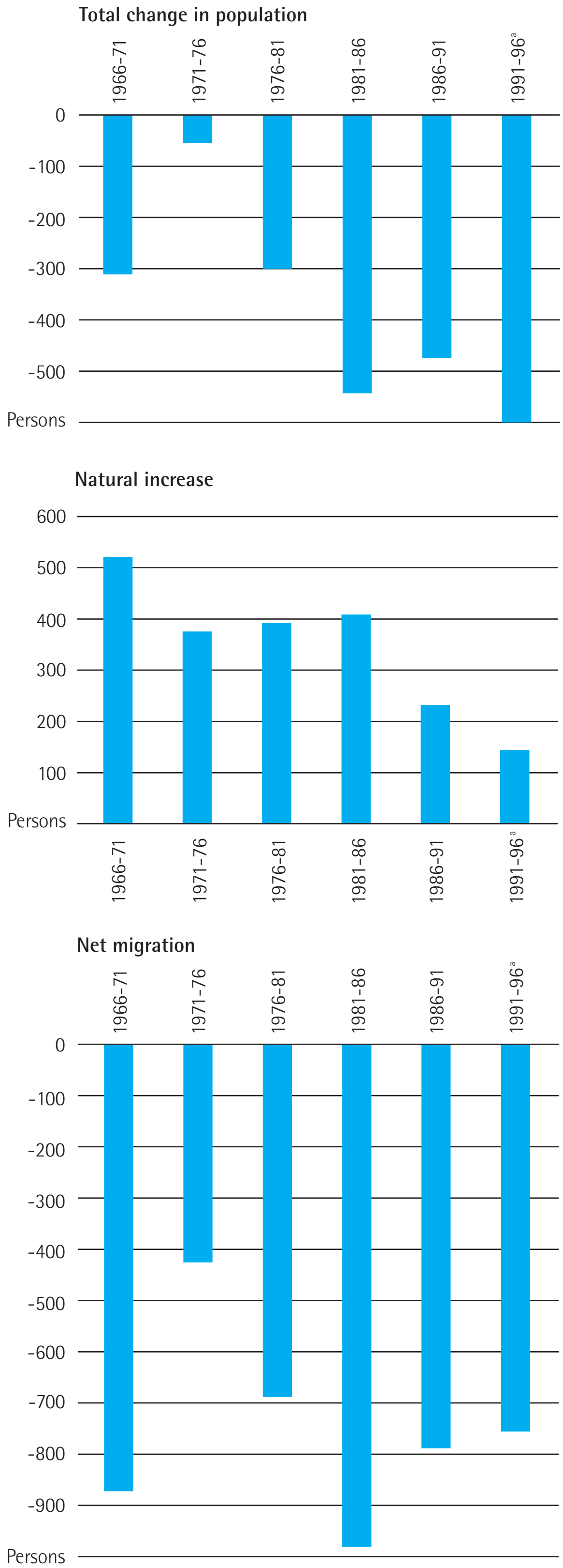
[a] See text for discussion.

Note: Age cohorts 70 and above omitted because of insufficient data to estimate 'ageing impact'. *Source:* CIE estimates, ABS 1996a.

between 1986 and 1991. The large spike in number for the older cohorts (60-70) would reflect higher death rates in this group.

Net out-migration has been particularly strong among teenagers, young adults and the 35-44 age group.

Chart 2-2 Components of Population Change



[a] Estimated from actual changes 1992-1994.

Data Source: ABS, 1996a.

The natural increase in population (the difference between births and deaths) has partially offset the loss through migration but has been insufficient to prevent the overall decline in population. It is evident from Chart 2-2 that over recent years the natural population increase has fallen off. This is in part reflective of the loss of population of child bearing age as a result of the high incidence of migration out of the region in this critical age group.

Chart 2-3 shows that since 1986 significant falls have occurred in the age groups 20 to 34 and under 10 years while the opposite is evident for the over sixty age group.

When compared with New South Wales, Bland Shire has a significantly lower proportion of persons aged between 20 and 35 and a greater proportion aged above 60 years. This gap is likely to widen with out-migration among the 20-35 year olds as a major contributing factor.

2.2 Economic Activity, Employment and Unemployment

2.2.1 Economic Activity

Bland Shire's economic base is concentrated in agriculture, with over 71 per cent of businesses in Bland Shire involved in the agriculture sector (Chart 2-4). This is in strong contrast to wider New South Wales where around 20 per cent of businesses are involved in that sector. Other significant areas of activity include wholesale and retail trade, recreation, personal and other services.

Chart 2-3 Age Distribution

Data source: ABS, 1996a.

This dominance of agriculture is reflected in the employment profile of Bland Shire. Around 38 per cent of employed persons in 1991 engaged in agriculture, forestry, fishing and hunting activity. Other significant sectors in terms of employment include wholesale and retail trade, and community services.

2.2.2 Unemployment

Measured unemployment in Bland Shire is low by New South Wales standards, averaging around 5 per cent over recent years. This measured rate will, however, understate the actual extent of the unemployment problem in the region. Out-migration of unemployed persons in younger age groups will be a major factor in reducing the measured unemployment rate. Under-employment among the farming community will similarly depress measured unemployment.

Poor employment opportunities in Bland Shire are reflected in out-migration statistics rather than in unemployment statistics.

The most recent unemployment figure for June 1996 shows unemployment falling to 3.2 per cent (down from 5 per cent in the March quarter). This represents a 36 per cent decline in unemployment (equivalent to 70 jobs) in three months. Discussions with Bland Shire Council staff indicate that no increase in activity, which would absorb labour of that magnitude, has occurred. Given the sensitivity of these unemployment estimates to population size, this estimate should be viewed with caution.

2.2.3 Changes in the Agricultural Sector

With the heavy dependence of the region on agriculture, it is not surprising that the prospects for the region mirror those of the local agricultural sector. Weak prices for agricultural products, farm amalgamations and increasing use of labour shedding technology, have all impacted on Bland Shire and on the service town of West Wyalong in particular.

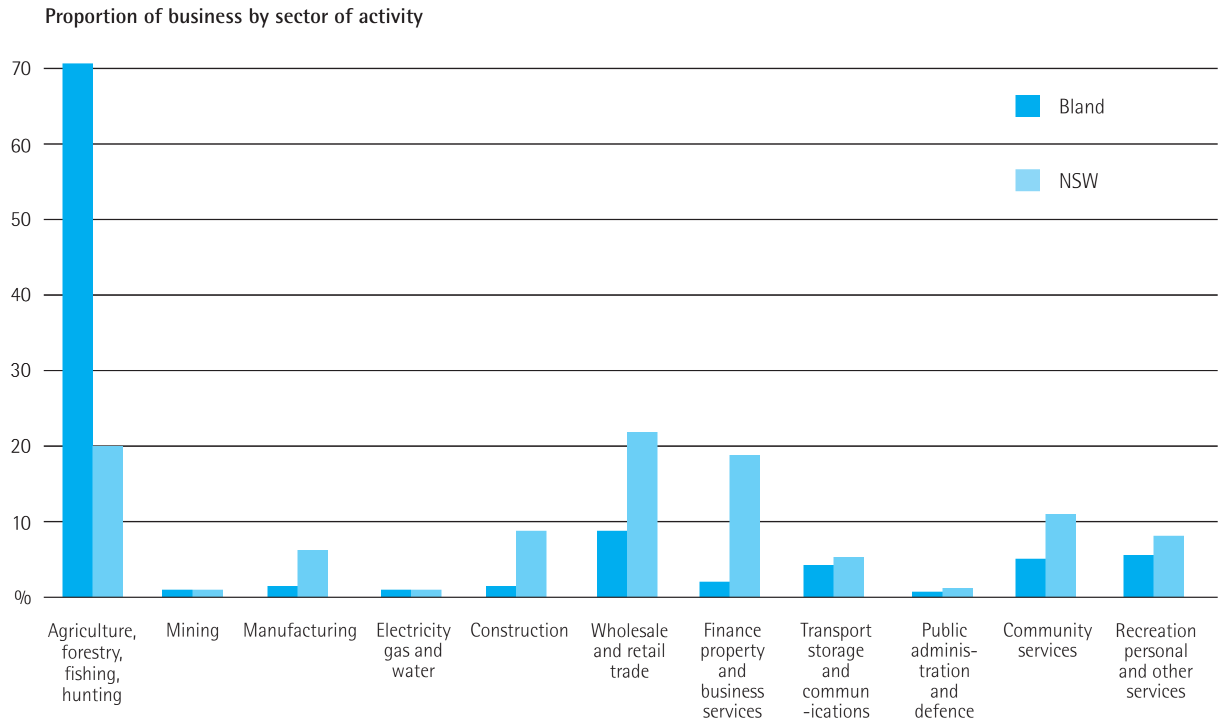
Wheat and ovine products are the predominant agricultural commodities while smaller amounts of oats and other cereals, cattle and pigs are also produced. Total agricultural produce for Bland Shire in 1993-94 was valued at $99.6 million (ABS 1996b). This compares with a total value of production in 1985-86 of $89.6 million amounting to real growth of -4.3 per cent. Over the same period real GDP for Australia grew by around 2.7 per cent on average and the farm component of GDP grew by 2.1 per cent.

While Australian farm production has grown by 2.1 per cent over the past decade, it has fallen by 4.3 per cent in real terms in Bland Shire .

Pressures on farm profitability have led to farm amalgamations throughout New South Wales, resulting in fewer but larger farms. This has also been the trend in Bland Shire. In 1985-86 there were 722 agricultural establishments in the shire with an average area of 1,111 hectares, while in 1993-94 the number of establishments had fallen to 604 with an average area of 1,245 hectares (ABS 1996b). Anecdotal evidence from Bland Shire suggests that many of the displaced farmers have left the area.

Tight profit margins on farms in the area, especially through recent drought periods, has led to a general fall in the amount of on-farm labour employed in the shire. Land owners and their families have tended to increase their effort at the expense of hired labour. Owners tend to do

Chart 2-4 Proportion of Business by Sector of Activity



Data source: ABS 1995.

much of their own repair work, land preparation and other on-farm duties where they previously employed help.

Business rationalisation in the agricultural goods and services sector has led to the relocation of business out of West Wyalong to larger rural services centres such as Griffith and Wagga Wagga. These trends have been reflected in the reduction in the numbers of large machinery dealers. Previously, eight dealers had operations in West Wyalong, but now only three operate.

The impact of changes in the agricultural sector on West Wyalong and Bland Shire generally have been notable. These include:

- generally depressed levels of expenditure due to limited growth in on-farm profits and migration out of the area;
- increased use of labour saving machinery on-farm;
- reduced employment as a result of reductions in hired labour on-farm; and
- fewer agricultural services enterprises and associated employment.

Given these features of the recent economic performance of the shire, it is not surprising that 43 per cent of households in the 1991 Census had incomes less than $20 000 – a proportion nearly one and half times the equivalent figure for New South Wales.

3.0 IMPLICATIONS OF TRENDS FOR BLAND SHIRE

The previous section discussed how low farm product prices, depressed farm incomes, a narrow economic base dominated by agriculture, structural change in the agricultural and agricultural services sectors were interacting to depress economic activity in Bland Shire. With poor employment prospects, residents, especially the younger residents of Bland Shire, are moving out of the region. This net out-migration (and the associated loss of purchasing power) further reduces prospects for businesses and employment, reinforcing incentives for seeking opportunities outside of the shire.

The recent economic climate and loss of population have affected the range of goods and service providers in the shire in a variety of ways. In analysing these impact it is useful to distinguish between three broad types of goods and service providers – private, public and voluntary. Private providers rely on direct sales to customers for their income (for example, farm suppliers, supermarkets and clothing stores). Public service providers rely on central funding for their operations and include services such as hospitals, schools and fire services. The final category, voluntary services, includes organisations such as the bushfire brigade, school committees and other community groups.

In this section the recent performance and prospects for each of these broad groups is examined. In assessing the recent performance of organisations in these groups, it is necessary to be mindful that some change to the structure of service provision occurs as a result of wider changes in technology, and philosophies with respect to customer service and general business operation. Such change cannot be attributed to the particular circumstances facing Bland Shire.

3.1 Private Service Providers

3.1.1 Retail Activity

While no recent independent statistics on retail activity in Bland Shire are available, it is apparent that retail activity in the shire has declined over recent years. Symptoms of the down turn in retail activity include:

- workforce downsizing;
- reduced level of consumer activity along the main shopping street;
- low stock holdings – although some businesses, such as car dealerships, have increased stock following a recent upturn in the agricultural sector;
- business closures (recent examples include the Grace Bros store and two of three supermarkets); and
- long standing empty shopfronts (eight Main Street vacancies at present).

Reduced stocking levels tend to be part of a vicious circle of depressed retail activity. Reduced product range encourages "one stop shopping" elsewhere. Reduced stocking by one type of business can have externality effects on others.

Retailers in West Wyalong face significant competition from outside the shire. Improved transportation and communication infrastructure has reduced the costs of shopping around. Because West Wyalong is small relative to other nearby centres, such as Wagga Wagga and the number of competing businesses is lower, there is a strong perception, accurate or otherwise, that goods and services are more expensive in West Wyalong. This provides strong incentives for residents to buy outside the region.

Depressed retailing establishes self-reinforcing contractionary trends. Inadequate product range and perceptions of local monopoly pricing are components of this. Bland Shire's major town of West Wyalong is at risk of experiencing these downward dynamics.

As more services (such as medical, agricultural and government service) locate outside of the shire there is increased scope for retail expenditure services to leak out of the region.

3.1.2 Banking, Postal and Related Services

The level of service provision of this sector in Bland Shire has declined significantly in recent years. Currently there is one Official Post Office and eight Licensed Post Offices (postal agencies). Two of these Licensed Post Offices were converted from Official Post Offices during the past five years. The Official Post Office in West Wyalong has been suffering a decline in profitability and, according to the Postal Manager, is at risk of being downgraded to a Licensed Post Office.

West Wyalong has full branches of the Westpac, Commonwealth and National Australia banks. A service centre for the Colonial State Bank (recently downgraded from a full branch operation with resident manager) also operates in the town. Westpac and National Australia Bank shut branches in the neighbouring villages of Ungarie and Barmedman, and Westpac has disposed of surplus real estate assets. All banks have reduced staff numbers over recent years.

The recent upturn in the agricultural sector after a drought period has strengthened the deposit base of some banks and enabled significant improvements in farmers' equity. However, the banks in this shire remain exposed to the essentially marginal nature of the regional wheat-sheep economy given the combination of prevailing rainfall and soil conditions and long term price expectations in the key commodities.

Much of the change in the structure of banking and postal services in the region has been a result of changes to organisational philosophy and technical change in the banking sector. Economic conditions have not been a major influence on recent changes. However, weak economic conditions may hasten further reforms and downgrades in service, especially for those banks whose share of agriculture based business is relatively low. These banks are relatively exposed to a decline in demand for other business loans in an area where new home lending is weak.

3.1.3 Medical and Dental Services

There are currently two full-time doctors and one part-time doctor in West Wyalong and one full-time doctor in Ungarie. The sole dentist in West Wyalong is in the process of relocating to a larger town for economic reasons. Dental services have been downgraded to three days a week.

The number of medical practitioners has fallen from five full-time and one part-time doctor in 1992. The council reports that it has had considerable trouble in recruiting medical staff for the shire. At one stage, the council took over ownership of the medical centre and hired locums to service it. It has subsequently sold the practice to the current medical practitioners.

Demand for and supply of medical services in West Wyalong are locked in a "low level trap" situation. While there is apparently more than enough work to keep three full-time medical practitioners occupied, attracting additional staff is difficult. Aside from lifestyle considerations, a key factor in the attractiveness of a medical practice to a potential staff member is its growth potential. Without a growing population, the growth potential for the practice in West Wyalong is limited and so, therefore, is its attractiveness to potential staff. An unstable situation prevails, whereby existing practitioners are overstretched. Any further reduction in doctors numbers could see a decline in service levels.

The presence of a well functioning hospital where a doctor can maintain his or her surgical skills is also important. The planned upgrade of the West Wyalong hospital theatre facilities may increase the attractiveness of West Wyalong as a location to practice (although the problem of population loss would remain). The provision of hospital services is discussed further below.

3.1.4 Agricultural Services

The agricultural service sector in West Wyalong has also been subject to structural change over recent years. The number of large machinery dealers in West Wyalong has fallen from eight to three and existing operators have downsized their workforces. As with the banking sector, much of the change has been due to industry rationalisation with consolidation and relocation of businesses to larger rural centres such as Griffith or Wagga Wagga.

However, despite hardship in the agricultural sector during recent droughts, some businesses are continuing to prosper and grow. This is in part due to managerial innovation and in part due to the nature of their clientele and the products they purchase. While farm incomes will decline during droughts, essential spending on some farm inputs remains steady. Agricultural input suppliers report that during drought periods some shifts in expenditure occur, but items like piping and some farm chemicals remain in strong demand. To make this possible, cuts to capital expenditure on farm equipment and spending on "luxuries" (such as replacing motor vehicles) take place. As discussed in the previous section, much more "do-it-yourself" repair work is conducted by farm operators rather than hiring in these services. Some farm owners interviewed conceded that this might be resulting in long term deterioration of the capital stocks represented by these items of equipment.

3.2 Public Service Providers

This group is particularly vulnerable to changes in population – especially if funding is directly related to the population serviced. The hospital and schools are obvious examples of where this is the case.

3.2.1 Hospital and Health Services

The Wyalong Health Service currently operates a 39 bed hospital which includes 13 nursing home beds. No theatre services currently operate because of an inadequate theatre and only low risk maternity patients are accepted at the hospital. Capital funding of $6.1 million has been approved by the state government for the construction of a new 22 bed hospital to replace the existing facility. Once constructed, the improved theatre facilities will allow theatre use by visiting medical teams. Construction is expected to commence in August 1997 and be completed by April 1998.

As of the next financial year, the Wyalong Health Service, as well as other health services in the Greater Murray Area Health Service's jurisdiction, will be funded according to a formula directly related to the population to be serviced. A continued decline in population will impact directly on the Health Service's funding. Changes to funding arrangements will also require that Wyalong Health Service pay for services provided to its patients by other health services as part of reforms to clarify purchaser-provider arrangements in the health sector.

The hospital believes that, if present trends continue over the next ten years, current levels of maternity services might be reduced. A key determinant for the delivery of such services is the cost of medical insurance or, more accurately, the cost of insurance per patient. As patient numbers decline, the cost per patient rises, reducing the incentive for doctors to provide such services. Maternity patients would therefore need to be serviced by larger health services in nearby regions – at a cost to patient comfort and safety and at a financial cost to the Wyalong Health Service under future funding arrangements. Further loss of population in the child bearing 20-34 age cohort would further reduce the viability of maternity services at West Wyalong. Losses of services, such as maternity, would reduce the attractiveness of the shire to families or individuals who are likely to call upon these services.

Essential emergency room services at the hospital will remain. The critical immediate attention provided at emergency rooms located closeby cannot be provided by any other practical means. Community care services would also be expected to be retained.

Since 1989-90, staff numbers at the hospital have fallen from 73 full time equivalents to 55 full time equivalents. As with other small towns, the hospital has difficulty in recruiting staff for health care positions above enrolled nurse level. While not unique in this regard, continued falls in population and service provision would make recruitment increasingly difficult.

Population related hospital funding could add further pressure to hospital funding, especially in the face of adverse population dynamics in the family raising age groups. It would exacerbate the problems already discussed in retention of medical practitioners seeking exposure to the full range of demands on their skills.

3.2.2 Education

West Wyalong High School is the sole public high school in Bland Shire with 383 students enrolled and 34.3 full-time equivalent staff. All public primary schools feed students to West Wyalong High School. St Mary's Catholic School also provides places for students up to year 10. Since 1992 student and staff numbers have fallen moderately. Chart 3-1 shows that over the past five years student numbers have fallen around 9 per cent – a figure broadly in line with the decline in population in that age cohort. Staff numbers have fallen by around 7 per cent over the same period.

The school estimates that, given present staff and student numbers, 19 student enrolments are required to support one additional teaching position. At present enrolment levels, the high school estimates that if enrolments declined by a further 12 students then it would lose funding for one full-time teacher. Table K-2 projects enrolments over the next ten years if the recent rate of decline in student numbers continues. On this basis, student numbers would fall to 318 by 2007 and the number of staff would be reduced to 31.4 full time equivalents – a net loss of over three full time positions. Given that West Wyalong High School is the sole public high school in the shire, it is likely that these staff will leave the region.

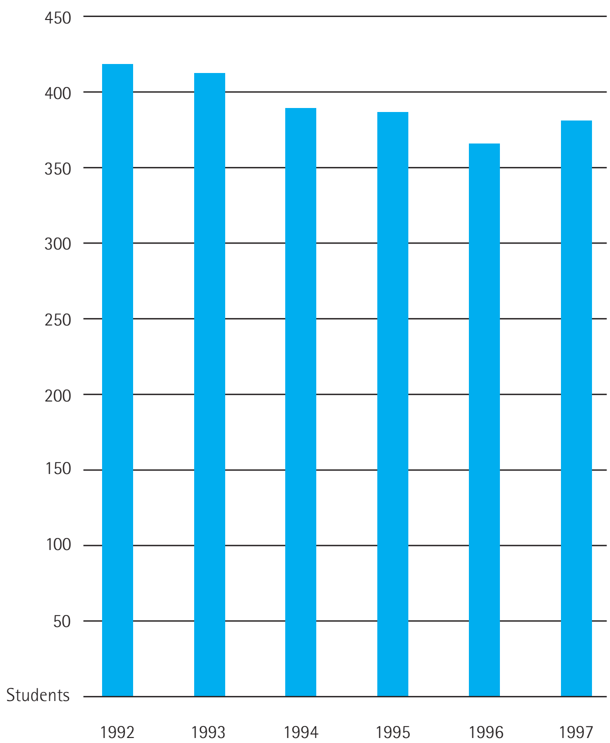
Staff losses tend to reduce flexibility in offering courses. Typically, a staff reduction will mean that remaining staff will be required to teach outside their area of expertise, reducing the quality of education for students. The ability to offer specialised courses is also reduced. This may create acute problems in offering advanced science courses, for instance.

Table K-2 Projected High School Enrolments

Year	Enrolment	Staff
1997	383	34.8
1998	376	34.4
1999	369	34.1
2000	362	33.7
2001	356	33.4
2002	349	33.0
2003	343	32.7
2004	337	32.4
2005	330	32.0
2006	324	31.7
2007	318	31.4

Source: CIE projections.

Chart 3-1 Enrolments at West Wyalong High School



Data source: West Wyalong High School.

Being in an area with a very narrow economic base has limited the range of *vocational* education that the high school can offer. Student options have been broadly limited to hospitality and some automotive training. Any further decline in the provision of these services in the shire will further limit the school's ability to offer vocational training. While the area has an obvious advantage in terms of agricultural training and the school has an excellent agricultural science facility, the number of students undertaking agricultural courses, especially in the higher grades, is low – between four to eight students in higher grades were enrolled in such courses in recent years out of a total school enrolment of 383. It appears that poor prospects in the agricultural sector have tended to encourage students to focus on non-agricultural courses.

The Riverina Institute of TAFE operates a campus in West Wyalong with enrolments of around 580 students (full-time and part-time). Enrolment numbers are declining at the West Wyalong campus. The numbers in 1995 were down from 3.2 per cent the previous year. Courses offered include computing, welding, wool classing, fashion and general education. While no trade courses are offered, the TAFE has indicated a capacity to provide on-demand courses. The Northparkes Mine used this capacity in Parkes, providing the trainer while the local TAFE facilitated the organisation of courses. A similar opportunity exists for the TAFE in West Wyalong.

3.2.3 Local Government Services

The Bland Shire council provides a range of local government services – including, health and community services, road maintenance, and water and waste water service provision. Total expenditure in 1995-96 was $8.2 million compared with total operating revenues of $10.2 million. While there appears to be some scope for maintaining current service levels given current revenues, long term sustainability of services in the face of a declining population and weak property values is in doubt.

Rateable values of residential lots will fall eventually in the face of a declining demand for urban properties. Some migration of older farming families into the town may have helped to sustain present values.

3.2.4 Governmental Service Agencies

Services provided by the Department of Social Security (DSS), Commonwealth Employment Service (CES) and the New South Wales Department of Community Services (DOCS) are currently at minimal levels. DSS runs a visiting service to the shire of five hours per month. The CES and DOCS provide on demand service with interviews through CES arranged by telephone and DOCS services provided through the Condobolin branch. There appears to be little scope for further reductions in these services.

3.3 Voluntary Service Providers

The volunteer bush fire brigade is an integral institution in many rural towns, relying on volunteers and support from the communities in which they protect. West Wyalong has experienced recent difficulties in recruiting volunteers for their brigade. Population loss is a key cause of this shortage. Another factor is that there is increased levels of "do-it-yourself" on-farm at the expense of hired labour. Increased on-farm work by farm owners, leaves less time available for volunteer community work. Other volunteer committees report similar difficulties in recruiting residents to serve. Similarly, sporting groups, including the local rugby league, have also experienced a drop off in player numbers and an inability to field teams.

A number of people who were interviewed during a field trip to Bland Shire reported a weakening of community spirit – especially after the announcement of the state government's decision not to allow the proposed mine to proceed. While community spirit is intangible, it is nonetheless important for the region's welfare. Few would disagree that strong community spirit is important in terms of improving the quality of life of residents. While not the only determinant, general attitudes in the community affect business confidence and investment.

Strong community spirit – which, until recently, has been one of the defining characteristics of western New South Wales communities – is difficult to measure but has real impacts on both the local economy and community welfare. It is a necessary motivating force to induce effort on the part of citizens to produce local services on a voluntary basis – services that would otherwise become a community service obligation for government, if they were to be produced at all.

It is within this context of declining economic opportunity, service potential and investment confidence that the Cowal Gold Project proposal must be considered.

4.0 THE COWAL GOLD PROJECT PROPOSAL

4.1 Introduction

North's proposal for the Cowal Gold Project would establish an open cut mine and associated processing operations in the Bland Shire for a minimum of 12 years. A detailed specification of the dimensions of the proposed project are included in Table K-3. Broadly, the Project would produce output to the value of $136 million annually and provide 180 jobs in mining and processing operations. On present resource estimates, mining operations would cease after eight years but processing operations would continue for a further four years. It is expected that 70 of the 180 employees would be employed by North Limited directly, with the remainder employed by contractors.

An 18 month construction period is planned. During this time the mine site and associated infrastructure would be developed and processing plant built. Total capital expenditure would be in the vicinity of $220 million. The construction period of the project would be expected to require a work force of around 200 persons, with up to 300 persons employed at the peak of construction activity.

4.2 Employment

As discussed above, the Cowal Gold Project would provide 180 jobs during the operations phase. Around 110 of these jobs would be provided by the mining contractor and 70 directly by North Limited. It is expected that 40 per cent of jobs provided by North would be filled by present North employees or skilled workers from outside the region. These would be mainly managerial or professional positions. The remaining positions would be open to local residents to apply. While not all of these lower level positions will be necessarily filled by existing residents of Bland Shire, the long term nature of the positions suggests that the majority of employees (high and low level) will reside in the shire for at least the term of their employment at the mine.

Mining operations will be subject to tender with the contractor required to maximise local employment under the terms of the tender. It is impossible to predict the likely mix of employees in terms of where they originate, although it is reasonable to expect that the contractor would bring in senior operators and maintenance personnel from other jobs. It is unlikely, given relocation costs, that the contractor would bring in staff to fill lower level positions. These would be open to local residents to apply. A significant proportion of these positions would call for diesel machinery operators – positions which could be readily filled by persons with experience in the operation of farm machinery or with similar skills.

The construction of the mine and processing plant will also be open to tender and so the source of employees is similarly unknown. It is likely that the majority of the employees will be skilled labour sourced from outside the region. There is likely to be some scope for general labouring positions which could be filled by local residents – again, there would be competition for these positions from outside of Bland Shire.

Assuming a similar proportion (60 per cent) of jobs provided by the mining contractor are open to local people as are North Limited-provided jobs, then a total of 110 permanent jobs open to local job seekers would be created by the project. Additional part time and temporary work will be created in the construction phase.

4.3 Mine Expenditure

West Wyalong has traditionally been a service town for agricultural establishments and, despite its historical significance as a gold mining area, it has a limited ability to provide mine supplies. Because of this, much of the mine expenditure will occur outside of the region. Table K-4 provides a breakdown of expected capital expenditure for the mine project. It is clear that around 10 per cent of capital expenditure will occur in the local region. Of the remainder, the majority will be sourced within Australia with only about 11 per cent of capital expenditure on imported goods.

Over $22 million in capital expenditure will occur in Bland Shire over an 18 month period and 89 per cent of a total $220 million in capital expenditures will be made in Australia.

At this stage of planning it has not been possible to provide an equivalent breakdown by source for operations expenditures. Major expenditure items during the operations phase will be labour, drilling and blasting, fuel, maintenance and spares, tyres, power and chemical reagents. Expenditures related to mining operations average around $37 million a year for the first eight years, with expenditures related to processing expected to be around $43 million a year on average. Labour costs are expected to be in the order of $9 million per year for the first eight years of the project. Gold royalties vary annually with production but will average $2.6 million over the life of the mine.

Table K-3 The Cowal Gold Project in Detail

Project life	12+ years			
Construction period	1.5 years			
Production	**Units**	**First 8 years**	**Last 4 years**	**Aggregate Value over Project Life**
Production	oz/year	272,000	112,000	2,624,000 oz
Capital expenditure[a]	$m	220		
Operating expenditure[b]				
Mining	$m/year	36.6	3.1	$305.2m
Processing (milling)	$m/year	42.6	42.0	$508.8m
Royalty	$m/year	3.5	0.9	$31.6m
Other	$m/year	5.2	4.4	$59.2m
Total	$m/year	**87.9**	**50.4**	**$904.8m**
Value of production (@A$500/oz)	$m/year	136	56	$1312m
Employment				
Construction	no.	200[c]		
Operations	no.	180	70	

[a] Outlaid during 18 months construction period.
[b] Figures in 1996-1997 dollar terms averaged over period indicated.
[c] Average workforce over 18 month construction period.
Source: North Limited.

Table K-4 Capital Expenditure by Category and Source

	Local $m	Australia $m	Overseas $m	Total $m
Mine prestrip	3.2	12.7		15.9
Mine development	0.7	6.3		7.0
Ore treatment plant		87.4	21.0	108.4
Infrastructure	9.6	11.9	4.0	25.5
Owner's costs	8.7	54.2		62.9
Total	**22.2**	**172.5**	**25.0**	**219.7**

Source: North Limited.

4.4 Infrastructure Requirements

Located as it is, some 40 kilometres from West Wyalong, the establishment of the mine at Lake Cowal will require the extension and development of service infrastructure such as electricity, water, telecommunications and roads.

The electricity demands of the processing plant require the construction of a 132 kV power line to the mine site. This line could be constructed from the north at Forbes or from the south from Temora. The capital cost of constructing the transmission line (around $6 million) would be borne by the proponent.

The southern option would allow an upgrade of the existing 66 kV supply to West Wyalong. The benefits of this to West Wyalong would only be realised if there were sufficient growth in the town to require this additional supply capacity. Such growth would be unlikely to emerge in the absence of the mine. The construction of the transmission line is likely to impact on landowners whose land the line is built upon. Submissions to the Commission of Inquiry on behalf of land holders for a proposed route from Forbes noted that landowners objected to the construction of the line because of feared loss of visual amenity and adverse impacts on farm profitability (through loss of land area).

A water supply pipeline is also required to provide water for the processing plant and dust suppression. Usage is expected to be 7 ML per day on average, with a peak demand in the order of 15 ML. The pipeline would transport water from the Bland Creek Palaeochannel Borefield on the eastern side of Lake Cowal. At the end of the mining project the pipeline would be left in place for use by others – if there is a need. A license fee of $5 000 per year would be payable to the Department of Land and Water Conservation for the right to draw water from the bores. With reforms to bulk water pricing still under review in New South Wales, it is possible that further revenue could accrue to the state from the imposition of usage charges on a megalitre basis, but the total revenue effect is likely to be small relative to other taxes royalties and charges.

A section of access road, which is currently gravel, will require sealing. This will improve access to a number of properties.

While the value of spin-off benefits from new water and power infrastructure developed for the project is likely to be low for existing producers, the development of such infrastructure may lower the cost of establishment for any other projects that may wish to base themselves in the region.

5.0 POSSIBLE IMPACTS OF THE PROJECT ON BLAND SHIRE

The two distinctive stages of the mine project (the construction and operations phases) will have differing impacts on Bland Shire – both in terms of the magnitudes and the nature of impacts. The short duration of the construction phase (18 months) and the nature of the workforce – mainly transient workers – suggests that the effects on Bland Shire and the surrounding region are likely to be transitory. The operations phase and its permanent workforce will, however, provide significant long term economic benefits to Bland Shire. This section attempts to estimate the impacts of these two stages of the project and identify who the main beneficiaries are likely to be.

5.1 Quantifying the Impacts of Mining Activity

Establishing a mine at the Lake Cowal site will have beneficial impacts on the economy of Bland Shire and on the wider regional, state and national economies. Impacts can be characterised as direct impacts, arising from direct

Table K-5 Multiplier Estimates from Other Studies

Study	Multiplier type	Area	Value
Doug Martin and Associates (1988)	Employment	Armidale	2.37
NSR Environmental Consultants (1989)	Employment	Cobar	1.35
Woodward Clyde (1995)	Employment – Construction Phase Employment	Cadia	1.35 - 1.65 1.77
ACIL (1995)	Expenditure – Construction Phase Income Employment	Lake Cowal	1.8 1.45 1.29
Clements and Qiang (1995)	Output Income Employment	State (WA)	2.1 3.0 4.1

[a] For operations phase unless otherwise specified.

expenditure by the mine and its employees, and indirect impacts, arising from expenditure induced by the initial expenditures by the mine and its employees. One means of measuring the indirect (flow-on) effects is through the use of input-output multipliers. Input-output models produce a set of multipliers which measure the flow-on effects of industries in a region. These multipliers variously show output, income and employment effects. Table K-5 presents some estimates of multipliers associated with gold mine operations in New South Wales. Table K-5 also presents multiplier estimates from a recent study on the effects of mining in Western Australia for comparison purposes (Clements and Qiang 1995).

The various multiplier estimates in Table K-5 range fairly widely, which in part reflects differences in the structure of regional economies. Bland Shire's economic base is narrow and geared mainly toward agricultural activity. This means that the "leakages" of expenditure outside the region are likely to be larger than for areas where a mining sector is well established and local industries are able to provide a significant services to a mine. In this respect it seems appropriate to draw upon the most conservative multiplier estimates when estimating possible impacts on the Bland Shire economy.

5.2 Construction Phase Impacts

As outlined in the previous section, the construction workforce will average around 200 employees. Where these employees would be drawn from would depend to a large extent on the successful construction tenderer. However, given a high requirement for specialised, skilled labour and the limited availability of this labour in Bland Shire, a large proportion of the workforce is likely to be sourced outside the region. There may be some job opportunities for diesel operators who could be drawn from local workforce.

In terms of a capacity to provide temporary accommodation, West Wyalong is well placed. The town has 14 motels and 2 caravan parks. The present accommodation capacity reflects the strategic position of West Wyalong on the intersection of the Newell and Mid-Western highways, and its location on the main inland route linking Melbourne and Brisbane. With occupancy rates in the town low (around 42 per cent room occupancy and 25 per cent bed occupancy) there is potential to accommodate 158 construction employees (1 per room) in motels alone. Existing motel and accommodation operators will, therefore, be direct beneficiaries from construction activity at the project site.

Assuming an average room tariff of $245 per week then the 18 month construction phase could add $3 million to existing accommodation takings of approximately $2.2 million per year.

Depending on the extent to which the existing accommodation industry workforce is working to capacity, there would be flow-on benefits in terms of increased employment in this sector. Local suppliers of goods and services would also benefit from increased demand for temporary accommodation. Leakage of accommodation demand to other localities, such as Forbes Shire, and the "crowding out" of other demands, such as holiday makers travelling through the shire, will reduce the net benefit to Bland Shire. However, in the absence of a mine at Lake Cowal, declining occupancy rates are a risk. Improved roads and vehicle performance and the possibility of Melbourne travellers expanding their journey as far as Parkes or more northerly rest points may reduce demand for accommodation in West Wyalong. Other beneficiaries from the temporary accommodation of the construction workforce include: food outlets, local hotels and clubs, and general goods retailers.

Local businesses will benefit from expenditure by contractors during the construction phase. Assuming all capital expenditure occurs during the construction phase, then the local economy will receive a one-off injection in the order of $22 million (Table K-4). Part of this outlay is for the purchase of land, some of which is already acquired. How landowners disburse this income will depend on individual circumstances. Debt reduction with the banks will represent a leakage out of the region, while machinery or personal expenditure is likely to be retained within the region.

Flow-on benefits from direct expenditure within the region will depend upon the extent to which local businesses increase employment levels and source inputs locally and on how local business owners distribute their profits. A narrow industrial base and the temporary nature of this construction phase expenditure will be limiting factors in terms of the size of these flow-on benefits. ACIL (1995) suggests that a total multiplier of up to 1.8 may apply. This would imply that the expenditure of $22 million would generate flow-on benefits of up to $17.6 million for the shire – although payments to landowners will tend to reduce this amount if used to reduce debt or are otherwise spent outside the region.

Total direct expenditure by the mine in Bland Shire of $22 million during construction activity, is likely to generate flow-on benefits of up to $17.6 million within the shire.

5.3 Operations Phase Impacts

The 12 year project life is of sufficient length to provide long term benefits to Bland Shire. Unlike the construction phase, the length of the operations phase is sufficient to allow local businesses to undertake investment and increase workforces in order to meet any sustained increase in demand they may face. The Cowal Gold Project will benefit Bland Shire in two broad ways:

- directly, through any expenditures it might make in the shire and the associated flow-through effects of that expenditure; and
- indirectly, through increased employment and incomes in the shire.

5.3.1 Mine Expenditure

The projected expenditure during the operations phase of the Cowal Gold Project were outlined in the previous section. Overall, around $88 million worth of expenditure each year is expected to occur. This should be compared with a gross value of agricultural production in the shire of $99.6 million. The proportion of this mine expenditure disbursed in the local region is uncertain – the choice of mining contractor being a significant determinant of this local spending.

Likely beneficiaries of expenditures on inputs by the Project in Bland Shire include:

- local suppliers of minor inputs such as fencing, spare parts and transport services;
- local agents for suppliers of inputs such as tyres and fuel;
- accommodation operators; and
- air service operators.

Some estimate of likely expenditure patterns can be gained from consideration of expenditure patterns at a comparable mine operation. The Northparkes Mine at Parkes offers such a basis of comparison. Box B-1 presents a profile of the Northparkes operation and discusses some of the impacts the mine has had on Parkes Shire. Table B-1 shows that 18 per cent of non-salary operating expenditure by Northparkes occurs within Parkes Shire. Given a reasonably developed mining support sector in Parkes, and the close proximity of Parkes itself to the Cowal Gold Project site, it is expected that this figure would overstate the share of expenditure within Bland Shire by a mine at Lake Cowal. However, even if the corresponding figure for the Cowal Gold Project were half that of Northparkes, then with an average non-salary operating expenditure of $79 million (Table K-3) then Cowal Gold Project would yield approximately $7.1 million in expenditure in the shire.

Northparkes Mines spends 18 per cent of its operating expenditures within Parkes Shire, if the corresponding figure for the Cowal Gold Project is half that of Northparkes, then Bland Shire would benefit from an additional $7.1 million in non-salary expenditure annually.

Box B-1 Relevant experience in a neighbouring shire at Northparkes Mine and Parkes Shire

The experiences of a neighbouring shire which supports a large commercial copper and gold mine – Parkes may prove useful in determining the likely impact of the proposed Cowal Gold Project on the economy and demography of Bland Shire. The geographical distribution of expenditure by the mine and the workforce impact on population numbers and age distribution are worthy of examination.

North Limited operates the Northparkes Mine located 27 km out of Parkes. Established in 1992, Northparkes produces significant quantities of gold and copper by both open cut and underground methods. The mine provides direct employment opportunities for approximately 500 people in mining, administration and processing (180 employed by Northparkes and 320 employed by contractors), and is widely acknowledged as having been responsible for a significant boost to the economy of Parkes since its inception.

While the regional experience of Parkes Shire in the early-mid 1990s cannot be directly translated to Bland Shire, the figures on local and regional spending provide some insight into the way in which expenditures on non-labour inputs of a large commercial gold mine are distributed between the locality and region within which it is located, the state, the nation and overseas. Table B-1 illustrates this expenditure pattern.

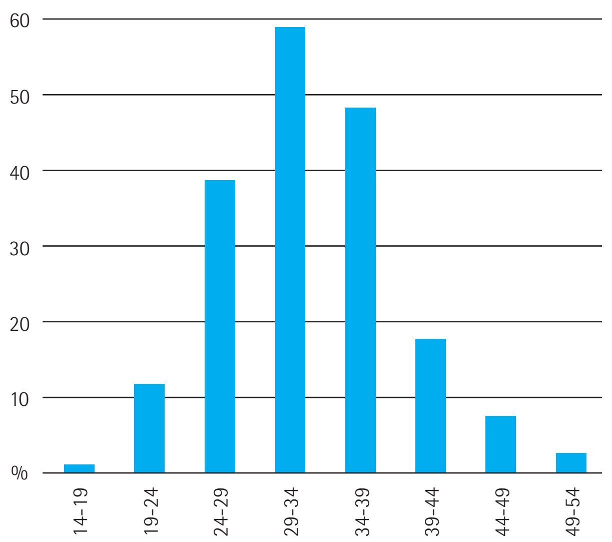
Table B-1 presents a breakdown of non-salary expenditure by the Northparkes Mine operation based upon an analysis of payment destinations (by postcode) conducted by Resource Futures Pty Ltd. In some cases, payment addresses do not correspond to that of the supplier of the goods and services (for example, a payment address in a city for services provided by a rural branch office of a business). However these are understood to be isolated cases and unlikely to affect the conclusions to be drawn from the data presented in Table B-1.

Table B-1 Northparkes Expenditure by Destination 1993-94

Region	Expenditure $	Share %
Parkes Shire	11 109 100	17.5
Central West Tablelands (excluding Parkes Shire)	7 985 800	12.6
Rest of New South Wales	29 717 600	46.7
Rest of Australia	14 795 100	232.2
Overseas	9 400	0.01
Total	**63 617 000**	**100**

Source: Resource Futures Pty Ltd

Chart B-1 Age Profile of Northparkes Mines Employees



Data source: Northparkes Mines.

Over 76 per cent of expenditure by the mine occurred in New South Wales with around 18 per cent occurring within Parkes Shire itself and 30 percent in the region containing Parkes Shire.

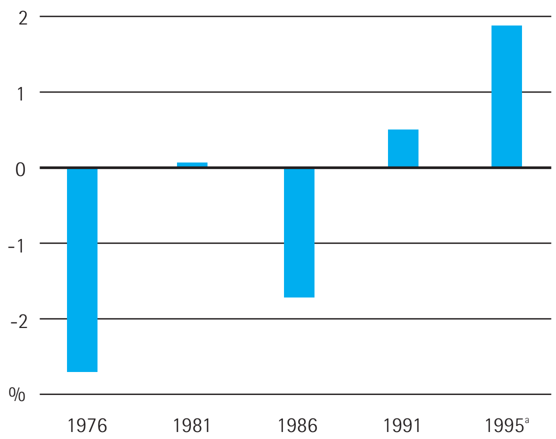
The majority of the workforce of approximately 500 are housed within Parkes Shire (some live in Forbes Shire, which is a relatively short commute). The majority of the workforce is male, although females make up a sizeable 20 per cent of total workers at the mine. Chart B-1 illustrates the age profile of the Northparkes Mine employees (excluding contractors). It is clear that the majority are under 35 with a large number between 29 and 34 years of age.

This concentration of employment in the younger age groups is likely to be a contributing factor in the recent growth in population (Chart B-2). Through the seventies and early eighties Parkes experienced a decline in population. The 1991 census recorded a significant rise over the previous census and estimates for 1995 show an even larger increase. With improved job prospects, population decline in the younger age groups has slowed with some younger age cohorts even increasing their share of total population (Chart B-3).

As well as the mine providing increased job opportunities, there has been employment growth as other businesses have established themselves in Parkes. some of these are directly mine-related, including a new supplier of specialist hydraulic engineering supplies and the expansion of an existing firm. Others include Austops (a wool processing company), Harvey Norman, KFC, and McDonalds. The Business Enterprise Centre reports the establishment of 30 new shops in the past 3 years. Population growth has also increased demand for new houses, with council reporting construction of more than 100 per year over the past 4 years. Additional child care and recreational facilities (with flow on effects for employment) have included a $700 000 early childhood centre and a $380 000 neighbourhood centre.

While the mine cannot be claimed as the sole reason for the improvement of prospects in Parkes Shire, it has undoubtedly contributed to increases in business confidence which has allowed the expansion of businesses and employment in the shire. This has seen the unemployment rate fall from 11.7 per cent in 1993 to 5.3 per cent in 1996 (DEETYA 1996).

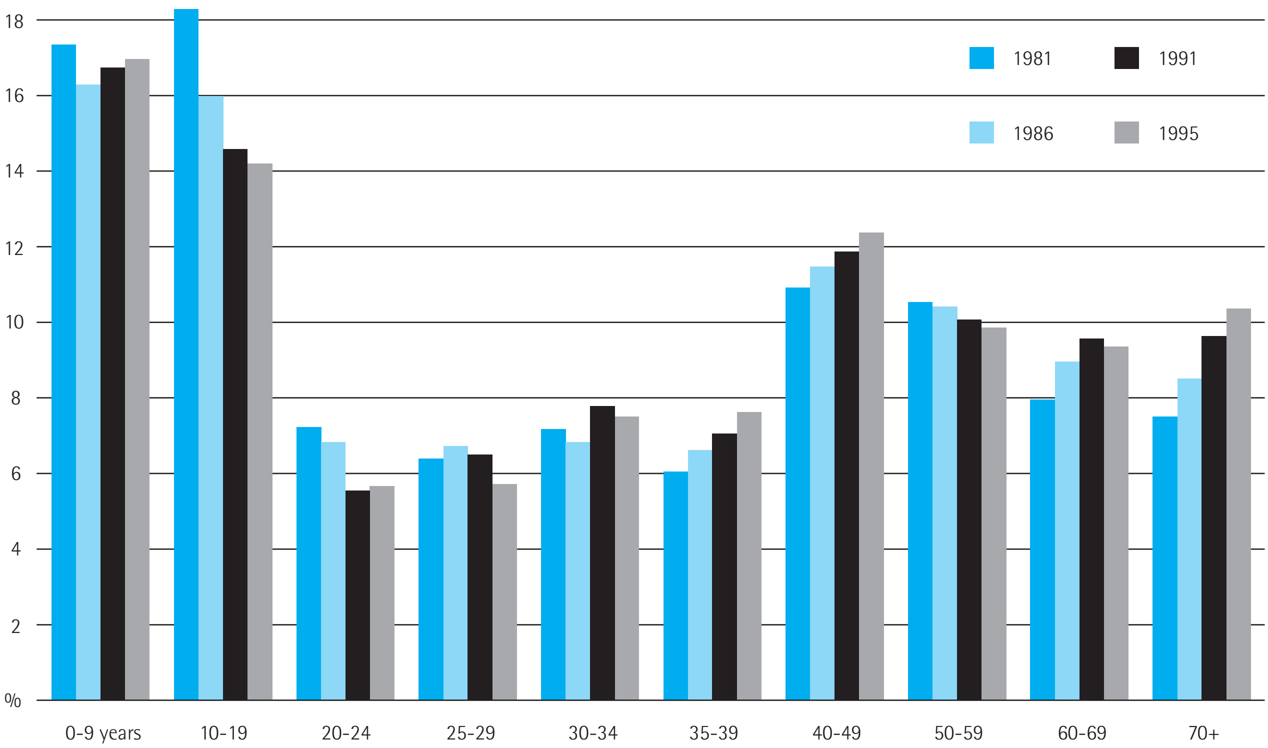
Chart B-2 Percentage Change in Parkes Shire's Population over Intercensal Periods



[a] Four year period only.

Data source: Parkes Shire Council (1996).

Chart B-3 The Changing Age Distribution in Parkes Shire



Data source: Parkes Shire Council (1996).

While Parkes has benefited from the establishment of the Northparkes Mine, the close proximity of the town of Forbes will mean some leakage of benefits would occur. With West Wyalong located further from other major towns, compared with Parkes, then similar leakage may be smaller. Temora, with an established mining operation, may be one significant source of leakage.

The benefits to air service operators must be seen in the context of a regulated regional air service market facing deregulation. Currently West Wyalong is serviced by two daily flights by a single operator. In a submission to the Independent Pricing and Regulatory Tribunal, the Bland Shire Council outlined its concerns that possible deregulation of regional routes in New South Wales may lead to rationalisation and consequent termination of services to West Wyalong – a route long regarded as marginal, requiring links with other towns to produce a viable operation. Termination of this service would mean overland transport or air travel from Wagga Wagga, or Parkes, for persons wishing to travel to Sydney. Whichever the method of transport, the cost of travelling to Sydney in terms of travel time and inconvenience would increase, further increasing the isolation of the West Wyalong community.

A regular demand from mine or head office employees may improve the viability of an air service to West Wyalong and increase the likelihood of a continuation of services in the face of deregulation.

North Limited estimates that it would purchase 34 houses to house staff. Around 17 of these would be newly constructed, built on new plots or on plots cleared of existing dwellings. Council has indicated sufficient availability of suitable blocks, some of which are already serviced, to meet the expected increase in demand. For a number of these blocks, an administrative issue related to possible subsidence stemming from past mining activity beneath the town would need to be resolved prior to release.

The stimulation provided by North's demand in the residential property market would provide a welcome boost to a market which, over recent years, has been very flat. A contributing factor to low activity in this market appears to be high reservation prices that many sellers in West Wyalong place on their properties. Sellers are prepared to wait rather than sell the properties at prices which equivalent properties in other towns would achieve. It is unclear what is driving these high reservation values. Increased demand through direct purchases by North Limited and other demands from employees may, depending on supply conditions, allow residents to achieve their reservation prices.

A direct demand of 34 houses by North Limited would provide a large, positive boost to the flat residential property market in West Wyalong. Depending on supply, this demand may allow the turnover of houses whose owners have been waiting for higher prices. Property turnover will stimulate the real estate services sector.

5.3.2 Employment, Income and Indirect Effects

As discussed in Section K4, the Cowal Gold Project would create 180 jobs in the region with wages and salaries of $9 million. Some 60 per cent of jobs provided by North Limited are likely to be open to existing residents. If we assume a similar proportion of contractor-provided positions are also available to local residents, then a total of 110 jobs could potentially be filled by existing residents of Bland Shire – the actual number would depend on the availability of suitably skilled residents to meet this demand. In the context of current labour market conditions, this represents a significant boost to employment opportunities. Given a labour force of 3500 in Bland Shire, a measured unemployment rate of 3.2 per cent (DEETYA 1997) represents unemployment of 112 persons.

The 110 "local" jobs created by the mine represents 98 per cent of measured unemployment in the shire.

While the proportion of mine jobs that would be filled by current residents of Bland Shire is uncertain, the long term nature of the project will mean that the majority of employees will reside in the shire. In this respect, the establishment of the mine is likely to have the greatest impact on the region. Increased employment implies increased household expenditures (through either an increased number of households or higher incomes for existing households). A sustained increased in expenditure in the region will be of direct benefit to a currently weak retail sector in the shire.

The extent to which expenditure by mine employees is retained within the shire will depend on the ability of local suppliers to meet demands and the prices at which goods and services are offered. The greater the demand satisfied by suppliers within the region, the greater the net benefit to the Bland Shire community.

While the Australian Bureau of Statistics (ABS) publishes data on how New South Wales residents spend their incomes, there is no corresponding information on *where* the expenditures are made. In the absence of a comprehensive survey of expenditure patterns of residents in the shire then some estimate of the proportion of expenditure occurring within the shire can be made with the aid of the ABS's Household Expenditure Survey (HES). HES expenditures can be allocated according to a 'best guess' as to where expenditure on each category item occurs. For example, rental payments or grocery purchases would occur within the region while motor vehicle registration or insurance would be "out of region" expenditures. (Such "out of region" expenditures may nevertheless support branch office activities which contribute to the regional economy). For other expenditure items, such as clothing and footwear, and major household items, the distinction is less clear. By allocating nonmetropolitan New South Wales residents' HES expenditures for each item to "inside" or "outside" the region categories, and assuming that 50 per cent of expenditures in those categories which are less clear occur within the region, we estimate that 57 per cent of total expenditure would occur within Bland Shire.

Given wages and salaries of $9 million then the establishment of a mine in Bland Shire would result in an increase in expenditure by wage and salary earners of up to $5.1 million in the shire.

While no information on total expenditure in Bland Shire is available, the ABS publishes retail turnover statistics (a component of total expenditure). Scaling the 1991-92 figure for Bland Shire of $15.9 million (the most recent available) for recent retail sales growth of 8 per cent per year (the New South Wales average since 1992), yields an estimated retail sales figure for Bland Shire of $20.5 million. The $5.1 million in total expenditure generated by the wages and salaries paid by the mine then represents 25 per cent of this estimated retail turnover.

This estimate of $5.1 million is a measure of the direct impact of increased employment and associated incomes, successive rounds of expenditure would increase the total (direct plus flow-on) benefit to the region. To the extent that the mine would employ existing residents of Bland Shire (who already undertake expenditure in the shire) then this estimate will tend to overstate the net gain to the shire. Increased leakage of expenditures to other locations or remittances of incomes outside the region would similarly reduce the expected gain to Bland Shire.

The flow through effects of increased expenditure both by households and the mine itself, can be estimated with the aid of appropriate input-output multipliers for the shire. ACIL (1995) estimate that a (total) employment multiplier of 1.29 is appropriate for the shire. On this basis an additional 52 jobs would be created in the shire giving a total boost to employment in the shire of 232 positions. ACIL estimates that the corresponding income multiplier estimate is approximately 1.45 – indicating a total increase in incomes in the shire of $13 million.

The flow-on effects of the employment of 180 persons at the Cowal Gold Project and the associated wage and salary income of $9 million could give rise to an additional 52 jobs and $4 million in income throughout the shire. Such a boost in regional incomes would be welcome in a shire where 43 per cent of households have incomes less than $20 000.

The hospital does not expect that the operation of the proposed mine would directly affect demands on the emergency room at the hospital – it expects that seriously injured persons at the mine site would evacuated by air to the larger base hospital at Wagga Wagga. Indirectly there would be some increase in demand as a result of any increase in population induced by the mine activity (for example, injuries to mine employee family members).

5.3.3 Statewide Effects

The impacts at the wider state and national levels will arise via the flow through effects of mining activity at Lake Cowal. These wider effects on output have been modelled using an economywide model of the Australian economy – the FH-ORANI model. Given the large contribution that the New South Wales economy makes to national GDP, the structure of the FH-ORANI model broadly reflects that of New South Wales and so can be used to model the statewide effects of the Cowal Gold Project.

Economywide models such as FH-ORANI take account of key linkages between industries, imports, exports and households. The analysis has a short term focus. Specifically we assume that real wage rates are not influenced by the employment demands of the Cowal Gold Project and so positions are filled by employees from an existing pool of unemployed.

The results of economywide modelling suggests that New South Wales Gross State Product (GSP) would increase by a total $190 million annually.

Models such as FH-ORANI are not ideally suited to take account of slack capacity in the economy, so output increases, which will generate increased demand for labour and capital, will generally be accompanied by increases in employment and capital usage. In reality, especially in rural New South Wales, there is likely to be some degree of slack capacity so that output increases can be met, to some extent, with currently employed factors. This suggests that, while providing a reasonable indicator of output effects, FH-ORANI will tend to overstate employment effects of the Cowal Gold Project. For this reason we have opted not to report the employment results of the modelling which could give a misleading impression of likely statewide employment effects.

It is nevertheless important to obtain some estimate of the likely statewide employment impacts of the Cowal Gold Project. Clement and Qiang (1995) report that for every job created in metallic mineral mining in Western Australia, 3.1 additional jobs are created throughout the state. If similar employment multipliers were observed in New South Wales then the Cowal Gold Project could create a total of 740 jobs statewide. If an expenditure pattern similar to Northparkes Mine were observed – where 30 per cent of expenditure occurs in the Central West region of New South Wales – then it is likely that a significant proportion of these jobs would be created in rural New South Wales.

5.4 Business Confidence

An upturn in the prospects of the agricultural sector following a recent drought has shown signs of increasing business confidence in the shire with some retailers increasing stock levels. The establishment of a mine in the shire would result in improved prospects for businesses through higher incomes and increased numbers of consumers.

Demand increases as a result of mine operations in Bland Shire would build upon recent improvements as a result of an upturn in agricultural incomes.

The benefits induced by mining activity will tend to be of a steady and sustained nature, lasting for at least the planned life of the mine and contrast with equivalent gains in the agricultural sector where fluctuations in yields and commodity prices tend to increase the volatility of such gains. Increases in the certainty of future revenue streams tend to increase the confidence with which firms make employment and investment decisions.

By providing sustained increases in demand, the establishment of a mine in Bland Shire will tend to increase the confidence of businesses in their employment and investment decisions.

5.5 Impact on Population Decline

The impact that a mine at Lake Cowal would have on population decline in Bland Shire will depend on a number of factors. These include:

- the population increase as a result of direct employment at the mine;
- the level of employment creation induced via the flow-on effects of a increased expenditure levels in the shire; and
- the impact on births and, therefore, the natural increase component of population change.

The first of these factors will depend on the availability of suitably qualified applicants within the shire and is difficult to gauge without an accurate profile of the labour force in the shire. The second of these will largely depend upon the complex interaction of business confidence and levels of consumer spending. Input-output multiplier analysis suggests that up to 52 additional jobs could be created which would represent a sizeable improvement in employment opportunities.

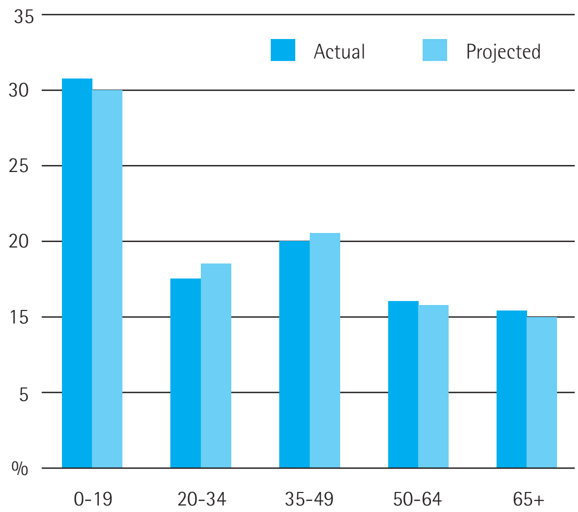
Some idea of the likely impact on the population of child bearing age can be gauged by considering the experience of the Northparkes Mine and its workforce. Chart B-1 showed that the majority of workers at Northparkes Mine are in the 24-34 years age group. If half of the 180 jobs at the mine were filled by persons from outside the shire and each new migrant were accompanied by an average of one other family member (for example, a spouse) then there would be a initial boost to the population of 180 persons. Assuming a similar age profile for these initial 180 migrants, as for Northparkes, then there would be a significant gain in population in the 20-34 age cohort. Chart 5-1 illustrates this impact.

If a similar age profile emerged at Lake Cowal, depending on the extent to which jobs are filled by nonresidents, the mine could have a significant impact on population growth in the critical 20-34 age group of Bland Shire.

The prospects for the 20-34 age group are a critical factor in the future prospects for Bland Shire. As the key child bearing age group, population increases in the 20-34 age cohort will tend to lift the natural rate of population growth and help offset any losses through out-migration. Higher birth rates and the associated growth in the younger age groups will yield significant benefits to the shire. Higher population and higher demands for health services (especially maternity) will improve the hospital's funding basis and improve its ability to attract staff. There is also potential for the hospital to increase the range of services it offers.

Prospects for educational services, such as schools and TAFE whose funding is also population dependent, will improve.

Chart 5-1 Projected Age Distribution



Data source: ABS Age and Sex Distribution of the Estimated Resident Population of Statistical Local Areas, cat. no. 3209.1 and CIE projections.

While the benefits for the high school from any increase in the birth rate will tend to be longer term, the primary schools will be direct beneficiaries in the short to medium term.

Expenditures by younger age groups tend to be higher than those by older age groups where incomes tend to be fixed. General retailers would be obvious beneficiaries from higher incomes and higher spending.

A population increase in the 20-34 years age group is likely to lead to improved prosects for health, education and general retail activity.

5.6 Indicative Outcomes for Bland Shire

The outcomes for Bland Shire of having a mine established at the Lake Cowal site will be the result of complex interactions between mine activity, consumer spending patterns, business confidence and demographic impacts. To predict outcomes with any degree of certainty is impossible. However, by making some reasonable assumptions about key economic and demographic variables, a picture of the broad dimensions of the economic and social impacts from the Cowal Gold Project can be obtained. Table K-6 presents some indicative outcomes for key socioeconomic variables. The assumptions underlying the results in Table K-6 are presented in Attachment A.

By year 2007 under the *with mine* scenario, the population of Bland Shire is expected to be 484 persons higher than if there were no mine. These gains would be concentrated in the 0-9 years and 40-49 years age groups. Strong gains would also be made in the 20-40 years age groups. The gains to the 40-49 age group reflect initial migration at the start of the project for employment at the mine concentrated around the 30-35 years age group.

Table K-6 Indicative Impacts on Key Socioeconomic Variables

Parameter	Current	2007 without gold mine	2007 with gold mine
Population	6,600	5,545	6,029
Population in 20-40 year old cohort (%)	25.2	24.2	25.1
No. of pensioners in shire	1031	1068	1072
Unemployment – measured (%)	3.2	3.2	3.2
Migration corrected unemployment (%)	16.9	26.6	21
Index of retail activity in West Wyalong	100	84	119
Value of farm production ($m)	99.7	118.4	118.4
Gross value of resource production (agricultural and other) in Bland Shire ($m)	99.7	118.4	254.4
Health service funding ($m)	2.5	2.1	2.3
High School enrolments	383	318	321
Population aged 0-9 years (pre and primary school aged children)	1,029	748	837
Dentists in West Wyalong	1 part-time	1 part-time	1 full-time
Doctors in West Wyalong	2 full-time, 1 part-time	2 full-time	4 full-time
Full post offices in shire	1	0	1
Local government annual income – rate revenue ($m)	3.1	3.3	4.5
Number of daily air services: Sydney to West Wyalong	2/day	1/day	2/day

[a] Unemployment measure correcting for understatement due to out-migration.

Source: CIE projections.

The gains to the younger age group result from in-migration and the retention of population in the child bearing age group 20-35 years as a result of improved employment opportunities.

There are not expected to be significant gains to the over 65 population whose share of population increases over time through natural ageing of the baby boom generation. Similarly, gains to the 10-19 years age groups are likely to be small because those who migrate (both into and out of the region) are likely to be the most mobile – for example, singles, childless couples and couples with young children. Migration is expected to have relatively less initial impact on the high school aged population than on other age groups. While over the ten year horizon considered in Table K-6, the high school is not projected to be a significant gainer under the *with mine* scenario, the large gains in the primary aged population suggests that over a 15 year horizon the school would gain significant enrolments. Teacher numbers would also increase in line with these enrolments.

Because measured unemployment is currently low (and is perhaps an underestimate – Section K2) it is probably mainly frictional unemployment which is unlikely to be affected to a great degree by the mine so that measured unemployment is not projected to change over time or with the introduction of the mine. A measure of unemployment correcting for the fact that unemployment tends to show up in net-migration rather than unemployment figures, shows greater variation. In the absence of the mine, this measure would increase by over 57 per cent to 26.6 per cent. The establishment of a mine at Lake Cowal prevents migration corrected unemployment rising above 21 per cent.

Under planned population based funding, health service funding would fall to $2.1 million in the absence of the mine. With the higher population projected under the *with mine* scenario, health service funding would be $2.3 million. The number of full-time doctors in West Wyalong is expected to double under the *with mine* scenario. This is anticipated on the basis of a current under supply of practitioners in the shire, improved economic prospects attracting new staff, and possible increases in demand as a result of population growth in the 0-9 age group.

Other anticipated gains include increases in rate revenue for the council, increased retail activity and improved viability of the present air service.

5.7 Conclusion

While the construction phase will yield significant benefits to Bland Shire, it is the operations phase where sustained gains are likely to be realised. Total direct gains to annual expenditure in the shire could be up to $5.1 million from wages and salaries and a further $7.1 million in direct expenditure by the mine. Employment at the mine will bring people into the region, offsetting current out-migration trends. The extent to which population decline would be arrested is unclear, but given employment patterns at a similar development at Northparkes, the biggest gains are likely to be made in the age group where population decline has been fastest – the 20-34 age group. This would improve the prospects for public services such as health and education, which are funded on the basis of population serviced.

There will be significant gains to the private sector, with mine suppliers benefiting directly from mine purchases and the broader retail sector benefiting from increased activity through an increased market and potentially higher incomes within that market. Overall, there is likely to be a positive effect on business confidence in the region, which although immeasurable, is nonetheless critical in terms of encouraging investment and additions to workforces. Parkes Shire, where a similar scale copper and gold mine currently operates has seen considerable increases in business numbers, employment and population (Box B-1).

The experience from Parkes Shire suggests that Bland Shire could benefit greatly from the establishment of a mine at Lake Cowal. This combined with improved prospects in the agricultural sector could yield significant gains to the shire's economy.

6.0 REFERENCES

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Attachment A

Attachment A

Assumptions Underlying Table K-6

A-1 POPULATION

Population projections for Bland Shire are published by the Department of Urban Affairs and Planning (DUAP). The latest revision was published in 1994 (DUAP 1994). These projections, when compared with actual values for 1996 (based on ABS estimates of resident population), tend to understate the rate of decline in population by about 23 percent. Given this, the baseline population estimates, *without the mine* in Table K-6 are based on the DUAP growth rate estimates, scaled by 23 percent (Table A-1).

The *with mine* population projections are based on the experience of Parkes with the Northparkes Mine. Chart B-2 showed that the population growth rate in Parkes averaged 0.48 percent a year between 1991-1995 – a period which included the commencement of operations at Northparkes. This compares with an average annual growth rate of 0.1 percent for the five year period from 1986-1991. If all the additional growth in population of 0.38 percent per year could be attributed to the stimulus of a mine in the shire, and allowing for a population base in Bland about half that of Parkes, then the population growth rate in Bland could be 0.76 percent per year higher than in the baseline projection. The *with mine* population projection reflects this lower rate of population decline.

A-2 AGE DISTRIBUTION

In the absence of any published age distribution projections for the shire, the baseline age distribution for 2007 is derived by extrapolating the historical average change (since 1981) of each age cohort's share of population. This yields the projected *without mine* age distribution in Table A-2.

Table A-1 Population Growth Assumptions

Period	Without Mine Growth Rate	With Mine Growth Rate
1997-2001	-1.51%	-0.75%
2002-2007	-1.30%	-0.54%

Table A-2 Projected Age Distributions

Age cohort	Without Mine 2007 %	With Mine 2007 %
0-9	13.5	14.1
10-19	14.0	13.2
20-29	8.6	9.5
30-39	15.5	15.6
40-49	12.4	13.6
50-59	9.9	9.8
60+	26.1	24.2

Source: CIE projections

The *with mine* age projection is based on the following assumptions:

- Half of the 180 jobs are filled by persons from outside of the region, and each of these is accompanied by an average of one other person of similar age.
- A distribution of employees at the Cowal Gold Project similar to that of Northparkes (see Chart B-1).
- An average of one child is born over the period 1997-2007 for every two additional persons in the child bearing age cohorts of 20-35 years.
- The remainder of the total increase in population of 484 persons over baseline levels in 2007, represent persons who decide not to migrate from the shire and have an age profile similar to that presented in Table K-1 (with no net migration for age cohorts 60+ assumed).

These assumptions yield the age distribution for the *with mine* scenario presented in Table A-2.

A.3 PENSIONER NUMBERS IN BLAND SHIRE

These are assumed to be equal to the number of persons over the age of 65.

A.4 UNEMPLOYMENT – MEASURED

As noted in Section K2, unemployment in Bland Shire tends to show up in net migration rather than in unemployment statistics. The low level of measured unemployment is probably mainly frictional unemployment (short term, temporary unemployment created as individual switch jobs and new entrants enter the job market). The level of frictional unemployment tends to be relatively constant over time with frequent changes in its composition. While the mine is likely to provide employment opportunities for local residents and reduce out-migration, it is less likely to impact on frictional unemployment. For this reason, the measured unemployment rate is assumed to be constant at its current level under both scenarios – that is, the *number* of employed is assumed to decline in line with the decline in the size of the workforce (see below).

A-5 MIGRATION CORRECTED-UNEMPLOYMENT

Since 1986, 1,540 persons (net) migrated out of Bland Shire. If we assume that all migration occurs as a result of employment (or lack of employment) reasons then we can make some estimate of the unemployment rate corrected for net migration. The size of the labour force will vary with the number of persons entering and exiting as a result of age and with the level of net migration. For our purposes, we assume that the number of persons entering and exiting as a result of ageing are the same, so that with zero net migration the size of the labour force would remain constant over time. This abstracts from actuality where the ageing population would tend to drive down the size of the labour force in the absence of any net migration.

Based on the estimates in Table K-1 then 61 per cent of persons who migrate are of working age (15+). Assuming the New South Wales average labour force participation rate of 62 per cent applies for Bland Shire then net migration of 1,540 represents a reduction in the labour force of 582 persons. DEETYA (1997) estimates that current unemployment is 112 persons and the labour force is 3,523 persons. If all 582 persons lost from the labour force remained in Bland Shire as unemployed, then the current labour force would be 4,105 (3,523 + 582) and the current unemployment rate would be (112 + 582)/4,105 = 16.9 per cent.

Under the *without mine* scenario, population decreases by 1,055 persons. Assuming the same working age and labour force participation ratios apply then this represents a net loss to the labour force of 399 persons. If all these persons were added to the current adjusted pool of unemployment then the unemployment rate at 2007 would be (112 + 582 +399)/4,105 = 26.6 per cent. To the extent that an ageing population would tend to decrease the size of the labour force then this represents an underestimate of the unemployment rate.

The *with mine* scenario would see 484 fewer people leave the shire, 374 of these being of working age. With a labour force participation rate of 62 per cent this represents 232 fewer people leaving the labour force than under the *without mine* scenario. If all these persons remain because they are unable to obtain employment then the (migration-correct) unemployment rate would be (112 + 582 + 399 – 232)/4,105 = 21 per cent.

A.6 INDEX OF RETAIL ACTIVITY

As population declines, then with a constant per capita level of retail expenditure, total retail expenditure would be expected to decline in line with the rate of population decline. The *without mine* retail index reflects the 16 per cent decline in population projected over the 10 years to 2007. To the extent that an increased amount of expenditure leaks out of the region as a result of business closures in the region or developments elsewhere, then this figure would tend to be an overestimate of retail activity.

In Section K5, it was estimated that wages and salaries paid by the mine and generated by flow-on effects could total $13 million. If around 57 per cent of expenditures occur within Bland Shire (Section K5) then an additional $7.4 million in total expenditure could be generated by the mine. If 50 per cent of this expenditure is on retail goods then, with an estimated retail expenditure of $20 million in the shire, there would be an 18.5 per cent increase in expenditure.

To the extent that population decline reduces retail expenditure, then this estimate tends to overstate the effect on retail expenditure, although no measure of retail expenditures by the mine itself are included in this estimate. Retail expenditures by the mine would increase the impact on retail activity.

A.7 VALUE OF FARM PRODUCTION

Since 1985-1986 the nominal value of agricultural production in the shire has grown at an average rate of 2.8 per cent per year. This rate of growth is projected to continue to 2007 in the baseline scenario. Given the limited land area occupied by the mine, no change in the value of agricultural production is expected under the *with mine* scenario compared with the *without mine* scenario.

A.8 HEALTH SERVICE FUNDING

As discussed in Section K3, future funding for the Wyalong Health Service is expected to be on the basis on population. Current funding for the hospital is $2.5 million or $379 per head of population. The *with* and *without mine* scenarios for hospital funding are derived assuming that the per head level of hospital funding remains constant and population declines in the manner described above.

A.9 HIGH SCHOOL ENROLMENTS

Since 1992, high school enrolments have fallen by around 1.8 per cent per year. This rate of decline is projected to continue under the baseline scenario. Under the *with mine* scenario the high school age cohort 10-14 population is expected to be 1 per cent higher than under the baseline scenario. The *with mine* scenario for high school enrolments reflects this higher population.

A.10 DENTISTS IN WEST WYALONG

In the absence of the mine, the current part-time operation is assumed to continue. Improved prospects (lower population decline and higher incomes) are assumed to encourage a full-time practitioner to establish a business in West Wyalong under the *with mine* scenario.

A.11 DOCTORS IN WEST WYALONG

The current workload at the medical practice is apparently sufficient to keep three full-time practitioners working quite hard. The presence of a mine in the shire and the improved prospects it would deliver may be sufficient to attract a further doctor to the practice. Strong growth in the 0-9 years age group could add further demand on medical services (maternity, etc.). The four full-time doctors assumed under the with *mine scenario* reflects this possible increase in demand.

A.12 FULL POST OFFICES

The present Official Post Office is apparently in danger of closing due to falling profitability. Population decline under baseline assumptions would further weaken its profitability. Under baseline assumptions the post office is expected to be downgraded. Reduced population decline and business from the mine and its suppliers would tend to shore up it revenue base. Under the *with mine* scenario the post office would remain full service.

A.13 LOCAL GOVERNMENT REVENUE

Prior to 1991, the council's rate revenue grew steadily. However, since then, this growth has fallen off as the property market has stagnated. Under the *without mine* scenario this low growth is expected to continue following a logarithmic trend. Under the *with mine* scenario, stronger demand in the property market is expected to improve rateable values and increase growth in rates revenue. Rate revenues are projected to increase according to a linear trend.

A.14 GROSS VALUE OF RESOURCE PRODUCTION

The output of the mine valued at $136 million per year is expected to increase resources production under the *with mine* scenario. Agricultural production is projected to grow as outlined above.

A.15 NUMBER OF AIR SERVICES

Demand associated with the mine and the higher population under the *with mine* scenario is assumed to allow current levels of services to be maintained. Weak demand in the absence of the mine is expected to reduce services although it is unlikely that services will cease completely.

Attachment B

Attachment B

Multi-Criteria Analysis of Options

B.1 INTRODUCTION

Multi-criteria analysis (MCA) provides a framework within which alter-native plans or options can be rated against multiple objectives. These objectives might include minimising environmental damage or maximising community benefits. MCA requires:

- the specification of a set of mutually exclusive alternatives;
- a set of criteria against which alternatives are to be judged; and
- a method of ranking the alternatives given their performance against the selected criteria.

Broadly, the MCA process involves giving each alternative a score against each of the specified criteria, standardising these scores (for example, converting scores to a standardised score between 0 and 1), and generating a total score for each alternative which forms the basis for ranking. In this paper, we report the results for two MCAs - one for the process and siting of the Cowal Gold Project and one for the supply of electricity to the mine project.

Box 1 outlines the strengths and weaknesses of the MCA approach. Fundamentally, while MCA provides a framework for comparing alternatives, it does not provide a solution about how individual criteria should be weighted in the decision process. That is, MCA identifies the trade offs which must occur in making a decision but does not provide guidance on how criteria (and their associated objectives) should be traded off. This is ultimately a choice for the decision maker.

B.2 SELECTING THE OPTIONS AND THE CRITERIA

B.2.1 The Options

In both analyses, only financially viable options are considered. In the case of the Cowal Gold Project itself, this means only those project configurations with a net present value[1] (NPV) of the project cashflows (including construction and rehabilitation costs) which is greater than or equal to zero are considered. This is based on recent historical and projected financial assumptions for the project. The financially viable options analysed for the Cowal Gold Project were:

1. No development.
2. Development as proposed by the 1995 EIS and as presented to the Commission of Inquiry which assessed the 1995 Development Application.
3. New development scenario with a change in the mill process – that is, introduction of flotation for the treatment of primary ore with the tailings storages moved away from the mine so they are about 3.5 km from the high water edge of Lake Cowal. This is, the development scenario proposed for the current Development Application.
4. As for 3 but with the tailings storages 1.5 km from the high water edge of Lake Cowal (as proposed in the 1995 development proposal).
5. Remote location (>10 km) of both the mill and tailings storage for the mine.
6. Remote location (>10 km) of tailings storage only.

Other options involving underground mining, backfilling the mine void, alternative treatment technologies, trucking ore to other mines such as Northparkes for treatment are either not technically feasible or are not financially viable and so have been excluded from the analysis.

While both the gold mine and electricity supply projects could be analysed together, this would require a significant increase in the number of options, thereby reducing the tractability of the analysis. To avoid this, we treat the electricity supply project separately from the main project. Recognising the relationship between the cost of the electricity supply option and the financial viability of the project, we assume that:

- financial viability for the electricity supply project means supply options which do not reduce the NPV of the main mine project below zero; and that
- the NPV calculated for each of the mine configuration options assumes the least cost electricity supply option.

[1] Net Present Value is the difference, in current dollar terms, between the cash inflows of the project and the cash outlays.

Box B-1 Strengths and Weaknesses of Multi-criteria Analysis

Strengths

- provides structure for decision making while still allowing flexibility;
- particularly useful for complex problems;
- follows naturally from the way people tend to approach problems with multiple objectives;
- flexible data requirements – methods are available for qualitative data, quantitative data, or a mixture of both;
- allows different points of view to be dealt with explicitly through the use of weights;
- allows information that is agreed upon by all parties to be distinguished from areas of contention (indicated by different weights);
- amenable to sensitivity analysis to determine how robust the final results are to changes in the underlying assumptions and methods;
- does not require assignment of a monetary value to all quantities;
- can identify where additional data would be useful and where additional data would have little impact on the final decision.

Weaknesses

- does not overcome fundamental problems associated with comparing quantities that some would argue are not comparable, but does provide more flexibility than is available with, say, benefit-cost analysis;
- a variety of other evaluation methods are available without any clear indication that one is better than another;
- since many of the methods are complex and remain a 'black box' to the decision maker they can lead to either mistrust or excessive faith in the results;
- concentration on the definition of explicit weights can provide a false sense of objectivity about the remainder of the analysis – there are opportunities for introducing implicit weights at all stages of the analysis and these may remain undetected;
- considerable effort is needed to obtain the information for rating against selected criteria and the weights;
- methods for incorporating uncertainty explicitly into the analysis are not yet well developed.

Source: Resource Assessment Commission 1992

It is not expected that these assumptions would affect the conclusions of the MCA in any material way.

The options analysed for the powerline included that proposed at the time of the 1995 Development Application (option 1) plus two other options from Forbes which were under consideration by North during the First Commission of Inquiry and during the 1997 Long Term Compatibility Study. The four options for a transmission line from Temora to the Cowal Gold Project are as proposed during a consultation process by Great Southern Energy.

On-site generation would be possible, but has not been considered as its capital cost would mean the mine project would not be financially viable. A no development option in this case is not feasible as the mine's power needs would go unsatisfied.

B.2.2 The Criteria and Rating the Options

The options for the Cowal Gold Project are rated against three broad criteria:

- environmental;
- social environment; and
- financial viability.

Environmental criteria are further divided into three categories – long term risks to critical conservation values, operational risks to critical conservation values and other environmental issues. The critical conservation values for Lake Cowal were identified in a long term compatibility study for the project (see North Ltd 1997 for details). Other environmental issues relate to the impact and risks of the use of cyanide both in terms of cyanide levels in the tailings dam and also in terms of possible handling and transportation risks associated with different volumes of cyanide under the development scenarios. It is important to note that the risk rankings are relative assessments of one option versus another.

The social environment category includes employment and material supply inputs as a measure of the direct impacts of the mine project in the local and state economies. Given that flow-on multipliers are likely to be the same across the development options, these measures will also reflect the indirect impacts of mining activity. For confidentiality reasons, NPV (measuring net financial benefits from undertaking the project) has been included as a rating rather than a dollar value.

For the electricity supply project a similar breakdown between environment, social environment and financial cost is used. The sub-criteria for the environmental category reflect the likely environmental impacts of the various options. Greenhouse gas impact was also considered as a criterion but was excluded as no variation was expected across the viable options. Construction and maintenance employment, and operating costs were excluded for the same reason.

For each of the two analyses, the various options were rated against each of the criteria. The ratings were based upon the findings of the compatibility study and its supporting research papers, North Ltd financial modelling, and the findings of CIE's (1997) socioeconomic assessment of the Lake Cowal project. The criteria and the raw scores for each option are presented in Tables B-1 and B-2.

B.3 THE RESULTS

B.3.1 The Cowal Gold Project

Table B-3 presents the results of the MCA for the Cowal Gold Project assuming different weights for the three broad categories. Within the categories, individual criteria have been weighted equally. Options which rate with higher scores are preferred development scenarios. Option 4 – the new proposal with flotation and a close in tailings storage (that is, located at the 1995 site) – scores highest across what might be regarded as reasonable relative weightings. However, while option 4 is marginally superior, there would appear to be little to separate it from the third option (where the tailings storage is moved further away from the lake) – especially when environmental outcomes are more heavily weighted.

The no development option becomes favourable only when a dramatic weighting of above 70 per cent is put upon environmental outcomes with weightings of 20 per cent and 10 per cent applied to social and financial outcomes for the project. The original 1995 proposal would only be selected if a very low weighting were placed on environmental outcomes. (about 10 per cent compared with a 60 per cent weighting on financial outcomes). The more expensive remote tailing and milling, and remote tailing storage options (5 and 6) would not be favoured at all when uniform weights are applied within the environmental category.

Table B-1 Multi-Criteria Analysis – Cowal Gold Project Raw scores

Criteria	Units	Options					
		1 No develop-ment	2 1995 proposal (no flotation)	3 New proposal, moved tailing storage (with flotation)	4 New proposal, tailings close in (with flotation)	5 Remote milling & tailings (with flotation)	6 Remote tailings & onsite milling
Long term risks to critical conservation values							
Hydrological cycle	Rating 0-10[a]	0	2	2	2	1	1
Water quality	Rating 0-10	0	3	2	2	2	2
Aquatic ecosystem	Rating 0-10	0	6	3	4	2	2
Terrestrial ecosystem	Rating 0-10	0	3	1	2	3	3
Visual character	Rating 0-10	0	6	6	6	7	8
Operational risks to critical conservation values							
Hydrological cycle	Rating 0-10	0	3	3	3	2	2
Water quality	Rating 0-10	0	3	3	2	6	5
Aquatic ecosystem	Rating 0-10	0	6	3	4	3	3
Terrestrial ecosystem	Rating 0-10	0	10	10	10	10	10
Visual character	Rating 0-10	0	6	7	6	8	8
Other environmental issues							
Cyanide levels	Max mg/L	0	50	30	30	30	30
Water usage[b]							
pit saline	ML	0	16,500	19,000	19,000	19,000	19,000
borefield fresh	ML	0	18,000	20,300	20,300	20,300	20,300
Power consumption[b]	GWh	0	2,530	2,500	2,500	2,600	2,500
Cyanide consumption[b]	tonnes	0	74,000	31,500	31,500	31,500	31,500
Social environment							
Material supplies and wages[b,c]							
local	1997 $m	0	134[d]	175	175	175	175
national	1997 $m	0	1,035[d]	1,332	1,332	1,332	1,332
overseas	1997 $m	0	21[d]	25	25	25	25
Employment[b]							
construction	Person years	0	350	350	350	350	350
operation	Person years	0	1,660	2,050	2,050	2,050	2,050
Financial viability							
Net present value (NPV)	Rating 0-10[e]	0	8	6	7	2	3

[a] Ratings: 0 = lowest risk, 10 = highest risk expected [b] Totals over life of project [c] Direct demands only, including construction [d] From CIE (1997) [e] Rating increases with project NPV

Table B-2 Multi-Criteria Analysis – Powerline Raw scores

Criteria	Units	Options						
		1 Line from Forbes between Lake Cowal & Nerang Cowal	2 Line from Forbes north of Nerang Cowal	3 Line from Forbes south of Lake Cowal	4 Line from Temora western route	5 Line from Temora mid route	6 Line from Temora eastern route	7 Line from Temora 66 kV route
Environmental risks								
Potential bird strike	Rating 0-10[a]	10	6	5	2	2	4	2
Tree clearances	Rating 0-10	7	6	10	8	3	3	3
River crossings	Rating 0-10	8	8	8	2	3	5	2
Public amenity impacts								
Visual character	Rating 0-10	8	8	10	7	8	7	9
Properties traversed	Rating 0-10	8	8	8	6	6	6	6
Safety	Rating 0-10	3	3	3	2	2	2	2
Social environment								
Material supplies and wages during construction[b]	1997 $m	8.3	8.6	8.6	10.0	9.3	9.3	9.6
Financial costs								
Capital costs	1997 $m	8.3	8.6	8.6	10.0	9.3	9.3	9.6

[a] Ratings: 0 = lowest risk, 10 = highest risk expected [b] Total over life of project

A simulation which gave greater weight within the environmental category to wetland values – that is, hydrological cycle, water quality and aquatic ecosystem – was also conducted, assuming an overall weighting for the environment of 50 per cent. This brought the scores for options 3 and 4 (the two proposals with flotation and on-site processing and storage) closer together, but generally did not alter the ranking of the options. With the emphasis on wetland values, and with a combination of a high weighting on environmental values (65 per cent), and an extremely low weighting on financial viability (of less than 5 per cent), the remote milling and storage options become favourable – by a very slim margin – over the on site milling options.

B.3.2 The Electricity Supply Project

Table B-4 presents the results of the MCA for the power supply project. The results show a clear leaning toward a line from Temora along the existing 66 kV route. The 66 kV route option (option 7) was rated highest for most of the weighting combinations considered. There was little difference between the scores for this option and the scores for the mid route option (option 5) which follows the existing 66 kV route for half the distance to Wyalong. This result is driven by the superior environmental outcomes offered by the Temora line options compared with the Forbes options, for relatively little extra cost. Only when a very low weighting is placed upon environmental outcomes does a line from Forbes look increasingly favourable.

B.4 CONCLUSION

MCA provides a means of ranking competing options against a specified set of criteria and allows different points of view to be dealt with explicitly through variation of relative weights. In this study we have performed two MCAs for the Cowal Gold Project and its associated electricity supply project, rating various options against environmental, social and financial outcomes.

The analysis for the Cowal Gold Project suggests that an option utilising flotation for the treatment of primary ore with the tailings storage close to the mine would be favoured. However, there is little to distinguish this option from a similar option with the tailings storage located further from the mine site. A no development option would only be preferred if a subjectively high weighting were placed on environmental outcomes. The MCA for the electricity supply project suggests that a line following the existing 66 kV route from Temora would be preferred. A mid route from Temora also rated highly.

MCA's strength is that it makes explicit the trade offs that are required for decision making. However, because the weights are an input to the analysis, it is the decision maker who determines how competing objectives should be traded off.

B.5 REFERENCES

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Table B-3 MCA Results for the Cowal Gold Project

	Options[b]					
Weighting[a]	1	2	3	4	5	6
10:30:60	9	**86**	78	85	48	55
20:40:40	19	76	76	**81**	56	61
33:33:33	31	66	69	**72**	52	56
50:10:40	47	55	56	**60**	35	40
50:25:25	47	53	60	**62**	46	49
60:30:10	56	46	**57**	**57**	50	52
70:20:10	**65**	36	50	50	43	45

[a] Environment: Social environment: Financial viability

[b] Options are:
(1) No development (2) 1995 proposal (no flotation) (3) New proposal (with flotation), moved tailing storage (at the 1997 proposed site) (4) New proposal (with flotation), tailing storage close in (at the 1995 site) (5) Remote milling and tailings (with flotation) (6) Remote tailings and on site milling (with flotation)

Source: CIE calculations.

Table B-4 MCA Results for the Electricity Supply Component

	Options[b]						
Weighting[a]	1	2	3	4	5	6	7
5:30:65	**92.6**	91.4	91.2	88.4	90.6	90.1	89.8
10:30:60	90.3	89.5	89.0	88.8	**90.8**	89.8	90.3
20:40:40	84.0	84.5	83.5	91.1	91.6	89.6	**92.2**
33:33:33	79.1	80.1	78.3	90.9	92.0	88.5	**92.9**
50:10:40	75.4	76.0	73.5	88.0	91.9	86.7	**92.3**
50:25:25	72.9	74.4	71.9	90.5	92.4	87.2	**93.8**
60:30:10	67.4	70.0	67.0	92.1	93.1	86.8	**95.2**

[a] Environment: Social environment: Financial viability

[b] Options are:
(1) Line from Forbes between Lake Cowal and Nerang Cowal (2) Line from Forbes north of Nerang Cowal (3) Line from south of Lake Cowal (4) Line from Temora (western route) (5) Line from Temora (mid route) (6) Line from Temora (eastern route) (7) Line from Temora (66 kV route)

Source: CIE calculations.

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