REVIEW OF ENVIRONMENTAL FACTORS

PROPOSAL TO UPGRADE M4 MOTORWAY

FROM CHURCH STREET, PARRAMATTA TO COLEMAN STREET, MAYS HILL AND PROSPECT TO EMU PLAINS

Prepared by
Environmental Planning Pty Ltd
Tele/Fax (02) 440 0150
PO Box 390
Pymble, NSW, 2073

for
Roads and Traffic Authority
Sydney Region

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EXECUTIVE SUMMARY

The M4 Motorway is part of the RTA's metropolitan road network which includes 1,300 km of main roads in western Sydney. The RTA is committed to delivering better and safer roads in metropolitan and western Sydney. Strategies in developing the road network in western Sydney include supporting the growth areas by developing arterial links to established suburbs and maintaining essential links. Projects in the State Roads Development Programme to achieve the strategies and to implement the State Government's transport policies include the widening of the the M4 Motorway. Traffic growth in western Sydney has been estimated at 2% per annum for the next decade with 3% growth per annum a possibility without taking into account the effect of State Government strategies moderating traffic growth.

On 15 August 1995 the NSW Premier announced that the M4 Motorway would be upgraded with an extra lane each way along the non-tollroad sections between Parramatta and Penrith. This decision would be consistent with the RTA's objectives of improving the existing road network and the draft *State Road Network Strategy*. The result would be a six lane high speed arterial road with improved safety, higher level of service and capacity for future growth from Parramatta to the foot of the Blue Mountains.

The RTA proposes to upgrade 2.5 km of the M4 Motorway between Church Street, Parramatta and Coleman Street, Mays Hill (the eastern section) from five lanes to seven lanes and 20 km of the M4 Motorway between Prospect and Mulgoa Road, Penrith from four lanes to six lanes. The Proposal also involves the rehabilitation of existing pavement between Prospect and Russell Street, Emu Plains (the western section). In addition collector-distributor lanes would be provided to separate locally entering and exiting westbound traffic between Church Street, Parramatta and Coleman Street, Mays Hill from the higher speed through traffic. Median barriers would be installed wherever necessary to reduce the risk of head-on accidents. Infrastructure for an incident management system would be installed. The existing four lanes of flexible pavement would also be rehabilitated to improve durability, riding quality and safety.

Roadsides and interchanges would be landscaped in accordance with a RTA landscape plan. Detention basins and artificial wetlands would be constructed where feasible along the length of the Proposal to remove pollutants from pavement stormwater run-off. Noise attenuation barriers, mostly in the form of landscaped earth mounds would be installed in the road reserve near residential areas along the Motorway in accordance with the RTA's *Interim Traffic Noise Policy (1992)*. Lighting standards would be relocated as required, some roadside vegetation removed and utilities adjusted where necessary. Traffic management measures would be implemented during construction.

Objectives of the Proposal are as follows:

- to upgrade and improve the M4 Motorway in accordance with RTA design criteria.
- to increase capacity and enhance traffic flow along the M4 Motorway.
- to improve the M4 Motorway safety and performance.
- to minimise disturbance to the natural and built environments by implementing appropriate safeguards consistent with the RTA environmental policy which states '*the RTA is committed to using best practical environmental technology, planning and management techniques in all its activities.*'
- to provide for the economic development and efficient movement of goods and people in the Sydney metropolitan area.
- to allow the implementation of the measures to moderate traffic growth by encouraging car pooling and express bus transport.
- to satisfy efficient expenditure of public funds by achieving a benefit cost ratio greater than 2.

The M4 Motorway upgrading would be designed in detail and constructed by a contractor. The preliminary estimate of cost of the Proposal is $100 million. The Proposal would be constructed as one contract with design development commencing in early 1996; construction over three years from mid-1996 to 1999 commencing with the eastern section between Church Street, Parramatta and Coleman Street, Mays Hill; and completion of construction in mid-1999. The extra lanes would be progressively opened to traffic as sections between interchanges were completed. The requirements of the contract would include completion of the artificial wetlands, landscaping and noise attenuation barriers at an early stage of construction. The Proposal would comply with all relevant standards, plans, policies and legislation.

Major beneficial effects of the M4 Motorway upgrading would be improved capacity, enhanced traffic safety including better pavement ride, improved traffic flow, better roadside landscaping, improved water quality, lower vehicle operating costs, greater travel time savings, reduced potential for accidents and reduced traffic noise for adjacent residential areas.

Adverse effects of the Proposal include delays to traffic along the M4 Motorway during construction and short-term loss of roadside vegetation. There would be some moderate adverse effects (eg increased noise, traffic generation and dusts) on the surrounding communities during construction and operations of the Proposal offset by road user and other benefits. Traffic may increase along some feeder routes to the M4 Motorway.

Impacts during construction would be short-term, adverse and generally localised. The main construction impacts include construction noise, loss of vegetation and disruption to traffic. The risk of sedimentation to waterways would be minimised by effective sediment controls including use of gross pollutant traps and artificial wetlands. The extent of the positive impacts during operations would be long-term, beneficial and cumulative on a regional scale and include enhanced Motorway safety, improved traffic flow and improved water quality. The long-term local impacts during operations include improved roadside landscaping, reduced traffic noise and a marginal decline in some components of air quality for nearby residents.

To minimise environmental impacts a number of safeguards detailed in Section 8.1 would be implemented during construction and operations via an Environmental Management Plan. The successful tenderer for the design and construction of the Proposal would be required to prepare an Environmental Management Plan before construction commences as part of the contract to meet the necessary specifications and safeguards for submission to the RTA and Environment Protection Authority for comment. The Environmental Management Plan would include provision for hold points where irreversible environmental damage may occur, regular reports and audits on the environmental management of the project, details of non-conformances, verification activities and emergency responses. In addition, all activities carried out on site would comply with the relevant provisions of all legislation including regulations relating to construction, operations and maintenance of the project. All components of the environment would be covered in implementation of the Environmental Management Plan. A community consultation programme would also be implemented prior to and during construction of the Proposal.

SECTION A - PRELIMINARIES

1. Introduction

The M4 Motorway runs in an east west direction through metropolitan and semi-rural areas of Sydney between Concord and Lapstone. The section of Motorway between Concord and Mays Hill was completed in 1986; the section between Mays Hill and Prospect was completed as a private toll road in 1992; the section between Prospect and Emu Plains was completed in 1974; and the section from Emu Plains to Lapstone was completed in 1993. The M4 Motorway is part of the metropolitan arterial road system and carries between 50,000 and 110,000 vehicles per day on various sections of the route. The NSW State Government has made a commitment to upgrade the M4 Motorway over the next four years including provision of an extra lane in each direction on the non-toll section between Church Street, Parramatta and Mulgoa Road, Penrith. The Proposal is to upgrade 2.5 km of the M4 Motorway between Church Street, Parramatta and Coleman Street, Mays Hill (the eastern section) from five lanes to seven lanes and 20 km of the M4 Motorway between Prospect and Mulgoa Road, Penrith from four lanes to six lanes. The Proposal also involves the rehabilitation of existing pavement between Prospect and Russell Street, Emu Plains (the western section). In addition to the extra lanes and pavement rehabilitation, the Proposal includes the provision of noise attenuation barriers, landscaping improvements, water quality improvements for stormwater run-off and installation of civil works for an incident management system.

2. Proposal Identification

Name of Proposal: M4 Motorway Upgrading Project.

Region/Zone: Sydney Region.

Local Government Areas: Cities of Holroyd, Blacktown and Penrith.

Construction Program: State Roads Development Program.

Plan Registration Number: Not Available

Roadloc Co-ordinates: Eastern Section. Start: 6004, beginning of link 1110, B and C.
Eastern Section. End: 6004, beginning of link 1135, B and C.
Western Section. Start: 6004, link 1201, B and C, distance 1.66 km.
Western Section. End: 6004, beginning of link 1290, B and C.

3. Proposal Description

3.1 Location

The Proposal is located in two discrete sections at each end of the existing M4 Motorway between Parramatta near the geographic centre of metropolitan Sydney and Emu Plains at the foot of the Blue Mountains. A location plan of the Proposal is shown in Figure 1. The eastern section of the Proposal between Church Street, Parramatta and Coleman Street, Mays Hill is 2.5 km long and would occupy part of the road reserve which is of variable width but generally 70 metres wide. The western section of the Proposal between Prospect and Emu Plains is 20 km long and would occupy part of the road reserve which is of variable width but generally 120 metres wide. The section of the M4 Motorway between Mays Hill and Prospect which is a private tollroad, owned and operated by Statewide Roads, is not included in the Proposal. Concurrent widening of the private tollroad is being assessed as a separate proposal.

The widening of the M4 Motorway on the eastern section would take place within the median and would also require some widening of earth formations in both cuttings and fills. Widening of the Burnett Street bridge and some retaining walls may be required. All construction would take place within the existing road reserve and no property acquisition would be required in the eastern section.

The widening of the Motorway on the western section would take place within the median in both the eastbound and westbound directions. All construction would take place within the existing road reserve and no bridge widening works or property acquisition would be required in the western section.

3.2 General Features

The Roads and Traffic Authority (the RTA) proposes to upgrade the M4 Motorway between Church Street, Parramatta and Coleman Street, Mays Hill and between Prospect and Emu Plains as described in Section 1 above. The existing Motorway is on a relatively straight alignment and would be upgraded as one contract while allowing uninterrupted traffic flow along the M4 Motorway. The section of Motorway between Church Street, Parramatta and Coleman Street, Mays Hill generally has a 30 metre formation width which includes two 3.7 metre wide eastbound lanes and three 3.3 metre wide westbound lanes adjacent to a concrete median barrier. The section of Motorway between Prospect and Emu Plains generally has a 44 metre wide formation which includes two 3.7 metre wide lanes, an outer shoulder of 3.0 metres and an inner shoulder of 2.4 metres in each direction separated by a grassed and landscaped median. The Proposal would generally involve adding another lane in each direction. In addition collector-distributor lanes would be provided to separate locally entering and exiting westbound traffic between Church Street, Parramatta and Coleman Street, Mays Hill from the higher speed through traffic. Median barriers would be installed wherever necessary to reduce the risk of head-on accidents. Infrastructure for an incident management system would be installed. The existing four lanes of flexible pavement would also be rehabilitated to improve durability, riding quality and safety.

Roadside areas and interchanges would be be provided with substantial improvements to landscaping in accordance with a RTA landscape concept plan. Detention basins and artificial wetlands would be constructed where feasible along the length of the Proposal to remove pollutants from pavement stormwater run-off. Noise attenuation barriers, mostly in the form of landscaped earth mounds would be installed in the road reserve near residential areas along the Motorway where feasible in accordance with the RTA's *Interim Traffic Noise Policy (1992)*. Lighting standards would also be relocated as required, some roadside vegetation removed and utilities adjusted as required. Temporary traffic controls would be installed during construction.

The M4 Motorway upgrading would be designed in detail and constructed by a contractor. Figure 2 shows typical cross sections of the proposed M4 Motorway for the eastern and western sections.

3.3 Costs

The preliminary estimate of cost of the Proposal is $100 million.

E

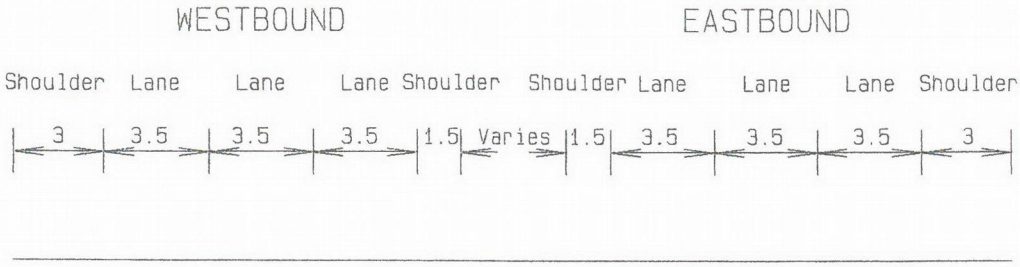
Church Street to Coleman Street (2.5km) - Eastern Section of the proposal

Statewide Roads Tollroad - not in this proposal

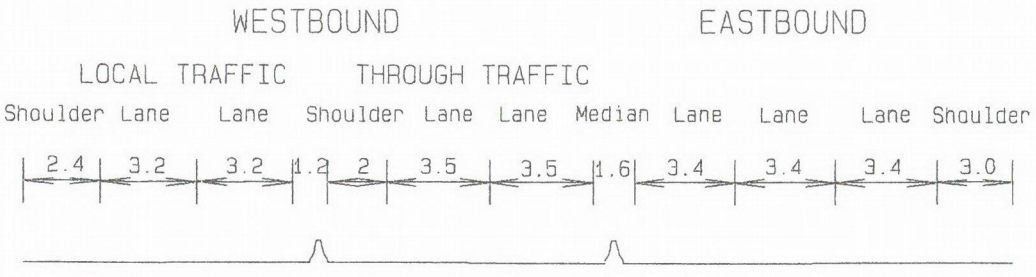
Prospect to Russell Street (22km) - Western Section of the proposal

W

Figure 1. Location Plan of Proposal



PROSPECT to MULGOA ROAD



CHURCH STREET to COLEMAN STREET

Figure 2. Proposed Typical Cross Sections

3.4 Timing

The Proposal would be constructed as one contract with the following programme.

• early 1996	Design development.
• mid 1996 to 1999	Construction over three years commencing with the eastern section between Church Street, Parramatta and Coleman Street, Mays Hill. The western section between Prospect and Emu Plains may be constructed concurrently with the eastern section.
• mid 1999	Completion of construction.

The extra lanes would be progressively opened to traffic as sections between interchanges were completed. The requirements of the contract would include completion of the artificial wetlands, landscaping and noise attenuation barriers at an early stage of construction.

4. Specialist Studies and Community Involvement

4.1 Specialist Studies

Engineering studies have been completed for the concept design of the M4 Motorway reconstruction including structural and traffic characteristics. Specialist environmental studies completed for the Proposal include noise measurements and predicted noise levels, air quality impact assessments, landscape concept plans and identification of road side flora and potential fauna populations.

In addition the RTA commissioned an M4 Motorway Study in 1994 in response to existing peak period congestion and accident problems which prevail within the section of the M4 between Church Street, Parramatta and Wallgrove Road, Eastern Creek. The relevant key recommendations of the study include:

- implementation of third lanes east and west bound between Church Street, Parramatta and Cumberland Highway as soon as possible with additional collector/distributor lanes adjacent to westbound traffic lanes.
- additional lanes west of Cumberland Highway within the study corridor by 1996.

4.2 Community Involvement

The nearest identifiable communities located near the Proposal are the residential areas of Granville, Mays Hill, Merrylands, Michinbury, St Clair, Colyton, Glenmore Park, Orchard Hills, Jamisontown, Regentville, Emu Plains and Leonay. The work forces in the industrial areas of Prospect, Huntingwood, Arndell Park and Michinbury abutting the Motorway are other identifiable groups that are likely to have an interest in the development of the Proposal. In addition there would be a large number of recreationists using the numerous parks and recreation facilities such as the Eastern Creek recreation area located on either side of the M4 Motorway. The M4 Motorway Study between Church Street, Parramatta and Wallgrove Road, Eastern Creek has already involved a community consultation programme including distribution of 7,000 leaflets inviting public comment, public displays, a workshop, free-call phone service, press releases and advertisements for local and metropolitan papers.

A community consultation programme would be conducted by the RTA and the contractor prior to and during construction of the Proposal for the total length. The contractors community consultation programme would be prepared to the satisfaction of the RTA and include consultation with representatives of potentially affected communities including residential, industrial and recreation areas abutting the Motorway plus Holroyd, Blacktown

and Penrith City Councils in accordance with RTA requirements. The community consultation programme would include provision for community input into the location, height and type of noise attenuation barriers; location of artificial wetlands; and working hours for night time construction. Residents, emergency services, media traffic journalists and workers would be informed directly or by public notices and media releases of the Proposal before construction commences. Residential areas near construction areas would be informed at least three days before any construction work was undertaken at night or if any traffic switches were required. The Environment Protection Authority's Hotline on 131 555 would be informed of any night construction works and the name of the project or site manager to contact in an emergency.

Utility providers would be consulted by the contractor during the detailed design stage and their requirements would be addressed in the final design of the Proposal.

SECTION B - ENVIRONMENTAL IMPACT ASSESSMENT

5. Strategic Stage

5.1 General

The M4 Motorway is part of the metropolitan main road system which includes 1,300 km of main roads in western Sydney. The RTA is committed to delivering better and safer roads and Motorways in metropolitan and western Sydney. Strategies in developing the road network in this region include supporting the growth areas by developing arterial links to established suburbs and maintaining essential links. Projects in the State Roads Development Programme to achieve the strategies and to implement the State Government's transport policies include the widening of the the M4 Motorway. The result would be a six lane high speed arterial road with improved safety, higher level of service and capacity for future growth from Parramatta to the foot of the Blue Mountains.

5.2 Planning and Strategic Background

The draft *State Road Network Strategy* was released in January 1995 and set out a framework for planning and managing the NSW road network over the next 20 to 30 years. The main themes of the *State Road Network Strategy* are to:

- facilitate and support State and regional economic development.
- moderate traffic growth rather than strive to satisfy unrestrained demand for travel.
- progress towards the achievement of ecologically sustainable development objectives.

The six objectives of the draft *State Road Network Strategy* for the road network are:

- moderated demand for roads and balanced use of transport.
- a road network promoting economic development and meeting community needs.
- a road network maintained in acceptable condition at minimum long-term cost.
- reduced transport costs and improved vehicle efficiency.
- road safety with fewer road deaths and serious injuries.
- care for the environment during road planning, construction, maintenance and use.

The draft *State Road Network Strategy* is based on analyses of population growth and distribution, urban growth, economic change, development opportunities, environmental constraints and the total transport needs of passengers and freight - all within a framework of ecologically sustainable development objectives. The strategy recognises population growth in the greater metropolitan area will increase the spread of the conurbation and exacerbate the demand for travel, particularly unrestrained demand for peak-hour private commuter travel on the road system.

5.3 Strategic Justification and Needs Definition

Strategies to address the objectives of the draft *State Road Network Strategy* include development of the metropolitan strategic road network. Even with moderation of traffic growth the strategy recognises that existing road network and traffic control systems will not be able to meet the demand for travel and freight movements arising from forecast economic growth, population growth and demographic changes. Traffic in Sydney will continue to grow even with full implementation of integrated demand management. Selected key arterial routes and corridors will need to be upgraded. Traffic growth in western Sydney has been estimated at 2% per annum for the next decade with 3% growth per annum a possibility.

The strategic road network identified for the Sydney metropolitan area as part of the draft *State Road Network Strategy* consists of a hierarchy of major routes, comprising both

corridors which support interstate and inter-regional movement and purely intra-urban routes. The M4 Motorway has been identified as a strategic corridor for development. Of critical concern along the M4 Motorway are the existing high peak hour traffic flows with some intersections at and just below saturation levels along both sections of the Motorway.

The Proposal is necessary to accommodate future traffic growth and improve accessibility in the western Sydney region generated by population growth (for example, an anticipated population increase of 30,000 at St Marys plus major residential growth north of Penrith), employment locations and freight movements (for example, associated with development of Badgerys Creek airport). Funding priorities and the standards and timing of the Proposal have been determined within the context of the *State Road Network Strategy* and overall priorities set for the greater metropolitan Sydney area. The Proposal conforms with the draft *State Road Network Strategy* hierarchy of major routes for the metropolitan area and is a key section of the M4 Motorway that needs upgrading to meet future needs. The extra lanes and widening of shoulders on the eastern section would allow for future implementation of high occupancy vehicle lanes to encourage car pooling and the operation of express buses. These initiatives would assist in the moderation of future traffic growth.

5.4 Economic Justification

The Sinclair Knight Merz *M4 Motorway Study* completed in March 1995 included an economic analysis showing that widening the M4 Motorway to six lanes between Parramatta and Wallgrove Road would have a benefit cost ratio of 28. On that basis the eastern section of the Proposal would have a benefit cost ratio in excess of 20. The western section of the Proposal between Prospect and Emu Plains would have a benefit cost ratio in excess of 2.

6. Concept Stage

6.1 Objectives

The objectives of the Proposal are as follows:

- to upgrade and improve the M4 Motorway in accordance with RTA design criteria.
- to increase capacity and enhance traffic flow along the M4 Motorway.
- to improve the M4 Motorway safety and performance.
- to minimise disturbance to the natural and built environments by implementing appropriate safeguards consistent with the RTA environmental policy which states *'the RTA is committed to using best practical environmental technology, planning and management techniques in all its activities.'*
- to provide for the economic development and efficient movement of goods and people in the Sydney metropolitan area.
- to allow the implementation of the measures to moderate traffic growth by encouraging car pooling and express bus transport.
- to satisfy efficient expenditure of public funds by achieving a benefit cost ratio greater than 2.

Some of the above objectives can be translated into measurable performance indicators including an improved level of service between B and E; improved safety with an accident rate under 50 accidents per hundred million vehicle kilometres travelled; and an increase in average travel speeds of 10 km/hour along the Motorway by 2006.

The objectives for the Proposal are in accord with the objectives of the draft *State Road Network Strategy*. In addition the draft *State Road Network Strategy* objective of care for the environment during planning, construction, maintenance and use of the road system has a number of relevant strategies including:

- work towards achievement of ecologically sustainable development.

- continue to examine, develop and support cost-effective means of improving energy efficiency, reducing fuel consumption and reducing "greenhouse gas" emissions.
- assist in improving local and regional air quality in the greater metropolitan area.
- reduce traffic and road construction noise with all major new works to comply with the *RTA's Interim Traffic Noise Policy (1992)* and Guidelines.
- promote recycling programs and encourage waste minimisation in road construction and operation.
- implement other environmental strategies in the areas of environmental planning and impact assessment, fauna and flora protection, protection of Aboriginal sites and other heritage items and protection of water quality.

The above strategies would be implemented during construction and operations of the Proposal via relevant safeguards and world best construction and traffic management techniques.

6.2 Options

Generally, where no major environmental constraints or other constraints exist, the most efficient and economical alignment along a corridor is a straight line between the end points of the corridor. As the Proposal is on a relatively flat and linear alignment abutting the existing M4 Motorway the Proposal is consistent with this concept. The Motorway between Parramatta and Regentville was originally designed to accommodate future widening to six lanes. This is reflected in the wide road reserve and the width of bridges originally constructed to accommodate six lanes.

Any feasible alternatives would vary only slightly from the proposed M4 Motorway widening. Any significant deviation from the Proposal would involve acquisition from public and private land uses including residential, industrial and recreational lands. Alternative transport modes such as upgrading public transport systems including bus and rail were also considered able to meet the objectives set out in Section 6.1. These issues have been considered in publications such as the Department of Urban Affairs and Planning *Metropolitan Strategy,* and the Department of Transport's *Integrated Transport Strategy* and *A Balanced Transport Future for Sydney* which details the plans and actions for a quality transport system. In western Sydney these plans include provision of additional rail facilities such as station car parks and bus-rail interchanges.

The 'do nothing' or 'do minimum' alternative is not considered to be a viable option by the RTA due to existing peak hour congestion, delays and accidents and the opportunity to widen the existing Motorway to enhance road user and community benefits such as installation of noise attenuation barriers and landscaping.

6.3 Proposal Selection

The only realistic options considered were widening of the M4 Motorway and the 'do nothing' or 'do minimum' option. The 'do nothing' or 'do minimum' option was not considered appropriate as accident rates would increase to unacceptable levels and the level of service would continue to decline to the detriment of the community and constraint of potential residential, industrial and commercial development in western Sydney. The widening option was selected because it would meet State Government policy and the objectives for the strategic road network identified for the Sydney metropolitan area in the draft *State Road Network Strategy* . The Proposal also satisfies the RTA's objectives and is an economic solution that can be constructed safely within the existing Motorway reserve. The Proposal can be justified on safety, functional, strategic, environmental, engineering and social grounds. In addition the Proposal is in accord with the principles of ecologically sustainable development.

On 15 August 1995 the NSW Premier announced that the M4 Motorway would be upgraded with an extra lane each way along the non-tollroad sections between Parramatta and Penrith. This decision would be consistent with the RTA's objectives of improving the existing road network and the draft *State Road Network Strategy* .

6.4 Statutory Planning

6.4.1 Zoning

The Proposal is located within Holroyd, Blacktown and Penrith City Council areas and is affected by the following Local Environmental Plans:

- Holroyd Local Environmental Plan 1991.
- Blacktown Local Environmental Plan 1988.
- Penrith Planning Scheme and various Interim Development Orders and Local Environmental Plans.

Under the various Local Environmental Plans the M4 Motorway is zoned as Existing or Proposed Arterial or County Road. The Proposal would be contained within the Motorway reserve and does not require the consent of Councils.

6.4.2 State Environmental Planning Policies

State Environmental Planning Policy No. 29 - *Western Sydney Recreation Area* applies to the land in the vicinity of Eastern Creek south of the M4 Motorway. The provisions of the policy enable development for recreational, sporting and cultural purposes and would not affect the construction and operations of the Proposal. There are no other provisions in any other State Environmental Planning Policies that apply to the Proposal.

6.4.3 Regional Environmental Planning Policies

There are a number of Sydney Regional Environmental Plans that indirectly apply to the Proposal including:

- Regional Environmental Plan No. 9 - Extractive Industry (No. 2) which facilitates the development of extractive resources of regional significance in proximity to the population of the Sydney metropolitan area.
- Regional Environmental Plan No. 13 Mulgoa Valley which aims to protect the rural landscape and heritage resources by guiding development within the valley.
- Regional Environmental Plan No. 18 Public Transport Corridor which makes provision for improved access by public transport into Parramatta by reserving a corridor from Hoxton Park to Baulkham Hills via the Parramatta city centre.
- Regional Environmental Plan No. 20 Hawkesbury/Nepean River which aims to provide a single overall framework to guide future planning and development throughout the catchment of the river.
- Regional Environmental Plan No. 25 Orchard Hills which aims to protect the rural scenic landscape as a buffer and a gateway to Penrith.

The provisions of State Environmental Planning Policy No. 4 *Development Without Consent* enables the RTA to construct the Proposal and associated works in the Motorway reserve without the consent of Councils or the Department of Urban Affairs and Planning which are the determining authorities for Regional Environmental Plans that affect the Proposal.

6.4.4 Legislation

The requirements of the following legislation and regulations apply to the Proposal and would be complied with. Of particular note is Section 88 of the *Roads Act, 1993* that

allows the RTA to remove vegetation to enable construction and operation of a road.

Clean Air Act, 1961
Clean Waters Act, 1970
Dangerous Goods Act, 1975
Endangered Fauna (Interim Protection) Act 1991
Endangered Fauna (Interim Protection) Amendment Act 1995
Environmental Offences and Penalties Act, 1989
Environmental Planning and Assessment Act, 1979
Environmentally Hazardous Chemicals Act, 1985
Heritage Act, 1977
National Parks and Wildlife Act 1974
Noise Control Act, 1975
Noxious Weeds Act 1994
Pollution Control Act, 1970
Roads Act, 1993
Soil Conservation Act, 1938
Waste Disposal Act, 1970.

7. Detailed Assessment Stage

7.1 Design Considerations

7.1.1 Existing and Proposed Motorway

Characteristics of the existing Motorway are compared to the RTA design criteria for the proposed Motorway upgrading in Table 1.

Table 1 Existing and Proposed Motorway Characteristics and Design Criteria

Design Criteria	Existing Motorway	Proposed Motorway
Accident Rate	Up to 63.5 per 100 mvkt*	Below 50 per 100 mvkt*
Horizontal Alignment	110 km/hour	110 km/hour
Vertical Alignment	110 km/hr stopping sight distance	110 km/hour stopping sight distance
No.Lanes/ Width East Section	2 x 3.7 m eastbound 3 x 3.3 m westbound	3 x 3.4 m eastbound 2 x 3.5m & 2 x 3.2m westbound
No.Lanes/ Width West Section	2 x 3.7 m eastbound and westbound	3 x 3.5 m eastbound and westbound
Shoulder Width East Section	1.2 m eastbound 2.5 m westbound	3.0 m eastbound 2.0 m and 2.4 m westbound
Level of Service#	C to F at peak hours	B to E at peak hours (2006)
Benefit Cost Ratio	Not applicable	>>2

** million vehicle kilometres travelled.*
 # In accordance with AUSTROADS 2 - Level of Service B is stable flow where drivers have reasonable freedom to select their speed. Level of Service C also has stable flow but most drivers have restricted freedom to select their speed, change lanes and overtake. Level of Service D approaches unstable flow with nearly all drivers restricted. Level of Service E is for traffic volumes near capacity. Level of Service F is forced flow operation at low speeds caused by demand exceeding capacity.

The existing Motorway has a relatively high accident rate for a freeway standard road. There were 394 reported accidents east of Wallgrove Road in the three year period 1991-93, over 50% of which were rear end collusions due to high speeds and congestion at interchanges. Speed limits have been reduced and central traffic barriers provided along the Motorway west of Parramatta in order to reduce the number of accidents. For the proposed Motorway upgrading the existing outside shoulders would be retained or widened and central traffic barriers provided wherever required. Existing traffic hazards would be eliminated, relocated outside the clear zone or provided with safety barriers as part of the upgrading works.

The speed limit along the Motorway is 90 km/hour from Parramatta to Wallgrove Road, Eastern Creek and 100 km/hour between Wallgrove Road and the Nepean River. These speed limits would be retained with the Proposal. Stopping restrictions apply all along the M4 Motorway and would be retained for the Proposal.

7.1.2 Existing and Forecast Traffic

The M4 Motorway has existing Annual Average Daily Traffic volumes that vary between 45,000 and 107,000 vehicles a day depending on the section of Motorway. More vehicles use the Motorway eastbound in the morning peak and more traffic westbound in the evening peak. Near St Clair on the M4 Motorway heavy vehicles comprise 6.5% of total traffic with a slightly higher proportion near Parramatta. There would be no pedestrians except for motorists walking to emergency telephones. Some cyclists use the M4 Motorway and cyclist safety would be addressed by the wide shoulders and smooth asphalt wearing surface. The existing traffic volume is forecast to increase at a compound rate of around 2% per annum. Based on the RTA's network modelling for future years using the EMME2 road traffic modelling software, 2% is a conservative figure for long term traffic growth. Forecast traffic is estimated between 56,500 and 133,000 vehicles per day in 2006 depending on the section of Motorway. The proportion of heavy vehicles may increase to approximately 7.5 % of total traffic due to major industrial developments in the western region of Sydney. Table 2 shows the existing and forecast Annual Average Daily Traffic volumes for various sections of the Motorway.

Table 2 M4 Motorway Existing and Forecast Traffic

Section of M4 Motorway	1995 Average Annual Daily Traffic	2006 Average Annual Daily Traffic*
Church Street to Coleman Street	107000	133000
Reservoir Road to Wallgrove Road	72500	90000
Wallgrove Road to Roper Road	71700	89200
Roper Road to Mamre Road	62700	78000
Mamre Road to Northern Road	59200	73600
Northern Road to Mulgoa Road	45400	56500

* Based on 2% compound growth per year.

If traffic growth was assumed to be 3% compound growth per year then the 2006 estimated traffic volumes shown in Table 2 would increase by approximately 11%. These forecasts do not take into account the effect of other State Government strategies to moderate traffic growth. The increase in forecast traffic would be expected to be generally distributed over the metropolitan road network in similar proportions to the existing travel patterns and

flows. However as there may be some impacts on feeder roads and intersections the RTA would complete before and after traffic studies to assess any changes as a result of the Proposal and the associated need for traffic management measures.

7.1.3 Design Parameters

New pavement would consist of an open graded asphaltic concrete wearing course overlaying a concrete pavement with a design life of at least 40 years or a flexible or semi-rigid pavement with a design life of at least 20 years. The wearing course would have a minimum design life of 7 years when resurfacing would be required. All design criteria would be based on AUSTROADS and RTA guides and the works constructed in accordance with RTA specifications and world best practice. The Proposal would be designed in accordance with the RTA criteria shown in Table 1 and other specifications including requirements of this document and:

- Roads and Traffic Authority *Road Design Guide*
- Roads and Traffic Authority *Delineation Policy*
- Roads and Traffic Authority *Interim Traffic Noise Policy (1992)*
- AUSTROADS Guides
- Australian Rainfall and Run-off 1987
- the Roads and Traffic Authority *Environment Manual*
- Australian Standards 1742 and 1743.

These criteria would ensure the Proposal is appropriately designed and constructed to operate with improved safety and capacity for the next twenty years.

The design speed of the M4 Motorway would be 110 km/hour for horizontal and vertical alignment. Grades on the through carriageways would not exceed 5%. The capacity of the M4 Motorway design would be sufficient to meet expected traffic growth for the next twenty years although level of service E would be evident at the eastern section during peak periods. There are no known constraints to the proposed upgrading of the M4 Motorway. Some minor utilities including RTA roadside lighting may need relocation.

The drainage system for the Proposal plus the existing four lanes of pavement would provide for a 2.5% to 3% crossfall with pavement stormwater discharging where feasible into artificial wetland detention basins to be provided within the road reserve to accommodate runoff from a yet to be determined Average Recurrence Interval storm and duration and first flush runoff from intense storm events. Overflows and excess runoff which bypasses these basins would discharge directly to drainage lines along the Motorway and into existing waterways. The aim would be to direct all pavement stormwater wherever possible into the artificial wetland detention basins to achieve capture of pollutants. The artificial wetlands would be vegetated with macrophytes (water plants) and regular monitoring of capacity and condition would be undertaken.[1] Where provision of wetland detention basins are not practicable (for example, due to lack of space in the road reserve) or are not acceptable to the adjacent community, gross pollutant traps would be constructed wherever practicable. Sediments and pollutants would be removed from the wetland detention basins and gross pollutant traps on a regular basis and the contents analysed for research and disposed of in accordance with the requirements of the Environment Protection Authority.

Detailed landscaping plans would be prepared by the contractor in accordance with the Landscape Concept Plans shown in Attachment 6. The detailed landscape treatments and associated maintenance plan would meet RTA specifications before construction commences. The landscaping would be installed as soon as possible around the major interchanges which would have individual identity themes. The interchanges with preferential landscaping treatment include the intersection of the M4 Motorway and Church

[1] An example of the preferred type of functioning artificial wetland is located off Plassey Road, North Ryde.

Street, Parramatta; Wallgrove Road, Eastern Creek; Roper Road, St Clair; Mamre Road, St Marys; The Northern Road, Orchard Hills; and Mulgoa Road, Jamisontown.[2] The intent is to establish a native landscape theme for each interchange consistent with RTA landscape objectives and to enhance the M4 Motorway with mature landscaping in time for Sydney's Olympics 2000.

Noise attenuation barriers would be installed in the road reserve near residential areas so that the noise level objectives in the RTA's *Interim Traffic Noise Policy (1992)* would be met.

The complete detailed design would provide for:

- economy in construction costs.
- geometric design.
- drainage design.
- structural design.
- traffic management during construction.
- construction of an extra traffic lane in each direction between Church Street, Parramatta and Coleman Street, Mays Hill and between the service centres at Eastern Creek and Mulgoa Road, Penrith.
- provision of collector-distributor lanes between Church Street, Parramatta and Coleman Street, Mays Hill.
- rehabilitation of existing pavement.
- median barriers.
- civil works for an incident management system.
- design and construction of artificial wetlands and gross pollutant traps.
- design and construction of noise attenuation barriers comprising landscaped earth mounds wherever practicable.
- installation of landscaping within the road reserve.
- line marking, sign posting and sign structures.
- preparation of an Environmental Management Plan.

7.1.4 Construction Activities

The Proposal would be constructed within three years from mid-1996. Construction would be completed as one contract with both carriageways of the M4 Motorway upgrading constructed simultaneously and opened in stages between interchanges. A dilapidation survey would be carried out by the contractor prior to construction in areas adjacent to residential areas.

The location of construction compounds would be restricted to within the road reserve and at least 100 metres from any watercourse, detention basin or artificial wetland or near the flora of conservation significance at Ropes Creek. Construction compounds would be security fenced and include amenities sheds, portable toilets, plant and equipment storage areas, bunded areas for storage of petroleum, distillate and other chemicals to comply with Environment Protection Authority and WorkCover requirements.

Construction hours would generally be from 7 am to 5 pm Monday to Friday and 7 am to 1 pm on Saturdays. Work would not be permitted on Sundays and public holidays. However night work would be necessary for some activities to minimise inconvenience to road users at peak travel times. Any night work would follow the existing procedure used by the RTA Sydney Region and endorsed by the Environment Protection Authority with regard to night time roadworks noise.

Construction would be carried out and supervised by the contractor awarded the design and construct contract for the Proposal. Construction is likely to involve a number of gangs of

[2] Examples of appropriate landscaping are provided at the M4 interchange with Russell Street, Emu Plains and the Victoria Road/James Ruse Drive interchange at North Parramatta.

up to six or seven persons with a peak work force of up to 100 people.

Construction equipment expected to be used on-site includes the following mobile plant and equipment as required:

- rock breakers
- front end loaders
- excavation plant
- back hoes
- trenching machines
- mulching/chipping machines
- chain saws
- jack hammers
- cranes
- dump trucks
- bulldozers
- graders
- vibrating rollers
- concrete agitator trucks
- concrete and asphaltic paving machines
- water tankers
- light commercial and passenger vehicles.

Upgrading of the Motorway would follow normal roadworks procedures including the following general sequence of activities for construction of the additional lanes on both sides of the Motorway:

- dilapidation and existing noise surveys of adjacent residential areas.
- installation of temporary erosion, sedimentation and drainage controls.
- removal, reuse and recycling of vegetation as green waste.
- relocation of any affected utilities.
- drainage lines excavated by backhoe or excavator.
- topsoil stripped and stockpiled on-site by bulldozers, graders, loaders and trucks.
- surface preparation by graders.
- construction of noise attenuation barriers.
- construction of artificial wetlands and gross pollutant traps.
- recycling of suitable excavated Motorway material including concrete and pavement material and incorporation of unsuitable material in earth mounds within the road reserve.
- compaction by rollers and vibrating compactors with trimming by graders.
- batched concrete, quarry products and asphalt placed on-site by pavers, autograde machines and graders and compacted by rollers.
- application of asphaltic concrete wearing surface by pavers and rollers.
- planting for landscape works along the road reserve.
- installation of line marking, sign structures and sign posting.
- site clean up and disposal of all surplus waste materials.
- commissioning.

The RTA would be responsible for the overall implementation of the Proposal. Construction would conform to Quality Assurance in accordance with AS 2990-1987 or AS/NZS ISO 9001-1994. The safeguards in this Review of Environmental Factors and those to be described in an Environmental Management Plan would be implemented by the contractor (unless specifically excluded in the contract) throughout the sequence of activities described above. Earthworks would be expected to be in balance with excavated material from the two additional lanes and artificial wetland basins to be used in the noise attenuation earth mounds.

No blasting or on-site batching of concrete would be permitted. The construction site would be maintained in a clean and tidy at all times. Construction equipment would be maintained to meet Environment Protection Authority requirements. No vehicle maintenance would be permitted outside the construction compounds. Cleaning out of batched concrete mixing plant would only be permitted in designated areas or off-site at approved facilities.

Construction would be carried out under traffic. Professional and diligent traffic management would be required to construct the Proposal. Two lanes each way would be available for traffic between 5 am and 8 pm. One traffic lane may be closed to enable essential work to be carried out in safety at night between 8 pm and 5 am. The remaining lane would operate at a temporary maximum speed limit of 60 km/hour. On Thursdays the 5 am to 8 pm requirement would be changed to 5 am to 10 pm for westbound traffic.

7.1.5 Waste Disposal

Any surplus waste material from construction would be disposed of in a legal manner. Construction works would include clearing of vegetation from the road reserve. Cleared vegetation under 150 mm diameter would be chipped on-site and used for mulch in roadside landscaping works as a first priority or transported as green waste for off-site recycling.

Any excavated or excess pavement material and concrete would be incorporated in the construction of noise mounds as a first priority or for off-site reuse. Any steel waste resulting from construction would be removed from the site area for recycling as a first priority or disposal by the contractor at a licensed landfill.

All other non-recyclable waste generated during construction (for example, unsuitable spoil that cannot be used in the noise mounds or earth formations, domestic waste and other surplus construction material) would be removed from the site for disposal at waste transfer stations or legally operating waste disposal sites. Workmen would use on-site domestic waste and sullage facilities at each construction compound. No waste would be permitted to be buried or burnt on-site.

7.1.6 Demand Upon Resources

In addition to labour, plant, equipment and energy inputs the Proposal would require concrete, steel, concrete, quarry products and asphaltic concrete. Any prefabricated metalwork and precast concrete items required would be transported to the site. The off-site batched concrete, asphaltic concrete and quarry products would be sourced from commercial outlets near the Motorway. Import of these resources would involve a number of heavy vehicle loads to be transported along main roads and the M4 Motorway with minimal impact. Actual quantities and number of loads may vary depending on the final M4 Motorway design. The Proposal would not affect any resources in short supply.

7.2 Description of Site and Surroundings

7.2.1 Site

The existing M4 Motorway is part of a relatively straight alignment traversing the Cumberland Plain with gentle slopes in an east-west direction between Parramatta and Emu Plains. Travellers have an impression of a semi-rural environment in the western section of the Proposal between Eastern Creek and Emu Plains where it is vegetated with introduced grasses and native shrubs either side of the Motorway and in the median. The road corridor is of moderate visual and scenic quality in this section of Motorway. In the urbanised eastern section of the Motorway between Parramatta and Mays Hill views of noise attenuation measures, residential, commercial and other road developments form an area of average visual and scenic quality. The noise environment along both sections of the Proposal is dominated by traffic noise.

Photographs of the M4 Motorway along the route from east to west including examples of noise attenuation mounds are shown in Photographs 1 to 12.

7.2.2 Surroundings

The eastern section of the Proposal and surroundings are generally characterised by land developed for residential, commercial and industrial uses. The surrounding residential and industrial areas are fully serviced with water, sewerage, main drainage, electricity, gas and telecommunications systems which are integrated with the metropolitan systems. The western section of the Motorway and surroundings are generally characterised by a semi-rural environment and rural land uses except for abutting residential areas. Urban development is more evident near the Nepean River. Landform in the area surrounding the Proposal is of moderate slope.

Residential areas abutting the Proposal include Granville, Mays Hill, Merrylands, Hewitt, Michinbury, Chatsworth, Colyton, Glenmore Park, Jamisontown, Regentville, Emu Plains, Orchard Hills and Leonay. Industrial areas abutting the Proposal include Prospect, Huntingwood, Arndell Park and Michinbury.

There is a high degree of physical and chemical disturbance along both sections of the M4 Motorway corridor. Chemical disturbance would include fertilisers, herbicides and pesticides, hydrocarbons and heavy metals from Motorway runoff.

Photograph 1 M4 Motorway View Westwards Near Church Street, Parramatta

Photograph 2 Landscaped Noise Attenuation Mound Between M4 Motorway and Railway Street, Parramatta

Photograph 3 M4 Motorway View Eastwards From Pitt Street, Parramatta

Photograph 4 M4 Motorway View Westwards Towards Burnett Street, Mays Hill

Photograph 5 M4 Motorway View Eastwards From Wallgrove Road, Eastern Creek

Photograph 6 M4 Motorway View Westwards From Wallgrove Road, Eastern Creek

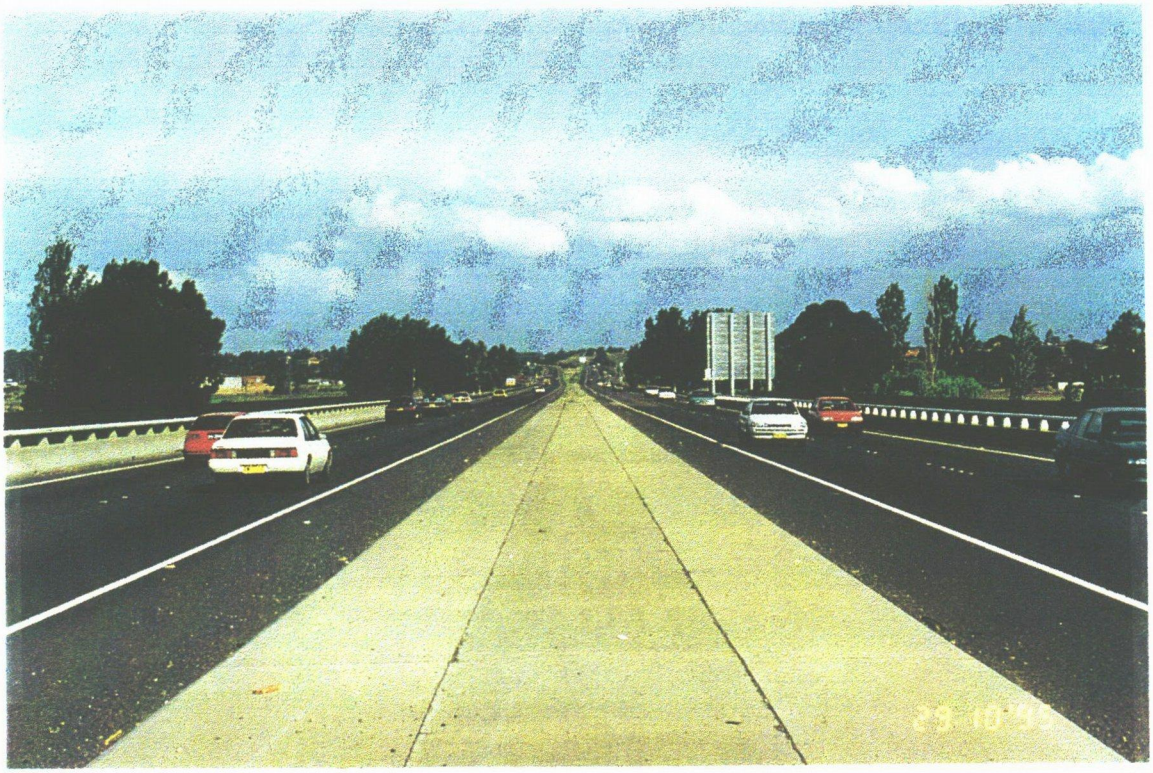
Photograph 7 M4 Motorway View Westwards From Mamre Road, St Marys

Photograph 8 Noise Attenuation Mound Under Construction Between M4 Motorway and Oliver Crescent, St Clair

Photograph 9 M4 Motorway View Eastwards From The Northern Road, Orchard Hills

Photograph 10 M4 Motorway View Westwards From Mulgoa Road, Jamisontown

Photograph 11 M4 Motorway View Westwards Over Nepean River, Regentville



Photograph 12 M4 Motorway View Eastwards From Russell Street, Emu Plains

7.3 Environmental Impacts

7.3.1 Landforms

The existing M4 Motorway alignment traverses land of low relief generally under 30 metres with well rounded hills in an undulating landscape and slopes less than 5%. Due to the Proposal following the existing Motorway of low relief, no adverse environmental impacts are envisaged with landform.

7.3.2 Geology and Soils

The geology of the region is sandstone, shale, siltstone, mudstone, claystone and conglomerate of Triassic age including the Wianamatta Group soils. The predominate soil landscape along the M4 Motorway is Blacktown residual type soils interspersed with South Creek fluvial type soils along the creeklines.

The Blacktown residual type soils landscape have gently undulating rises on Wianamatta Group shales. Local relief is up to 30 metres and slopes are generally under 5%. Typical features are broad rounded crests and ridges with gently inclined slopes. Soils are shallow to moderately deep (under 1 metre) hardsetting mottled texture contrast soils, red and brown podzolic soils on crests grading to yellow podzolic soils on lower slopes and in drainage lines. Limitations of the Blacktown soils include moderately reactive highly plastic subsoil, low soil fertility and poor soil drainage.

The South Creek fluvial soil landscapes encompass the environs of Eastern Creek, Ropes Creek, Byrnes Creek, South Creek and Surveyors Creek which the M4 Motorway traverse. South Creek soil landscape includes floodplains, valley flats and drainage depressions of the creek channels which are usually flat with incised channels. The soils are often very deep layered sediments over bedrock or relict soils with structured plastic clays or structured loams immediately adjacent to drainage lines. Limitations of the South Creek soil landscape are erosion hazard and frequent flooding.

Other soil landscapes along the Motorway include:

- the Glenorie type west of Parramatta with limitations of high erosion hazard and localised impermeable highly plastic subsoil that is moderately reactive.
- the Luddenham erosional soils between Surveyors Creek and the Nepean River with limitations of high erosion hazard and localised impermeable highly plastic subsoil that is moderately reactive.
- the Freemans Reach fluvial soil landscape on the east banks of the Nepean River with limitations of high river bank erosion hazard and frequent flooding.
- the Richmond fluvial soil landscape on the west banks of the Nepean River with limitations of high erosion hazard on terrace edges and minor localised flooding.

The above soil landscapes would require installation of erosion and sedimentation control structures in the road reserve during construction. On the existing Motorway alignment cut batter slopes at 2:1 slope with catch drains and batter drains are stable.

There are no known contaminated soils or commercial mineral deposits within the area of the Motorway reserve.

7.3.3 Climate

Western Sydney experiences hot summers and mild winters. The annual average rainfall at Parramatta is 911 mm including peak rainfall in summer. The growing season is over nine months of the year.

Climatic factors would not constrain the construction of the Motorway works. The Proposal would be located adjacent to the existing M4 Motorway, the operations of which are not constrained by climatic factors. Heavy and prolonged rainfall in the Nepean River catchment would cause localised flooding above the 1 in 100 year level along the western section of the M4 Motorway which would close the Motorway. It is unlikely climatic factors such as fogs and frosts would impact on operations of the Proposal.

7.3.4 Landform Stability and Erosion Hazard

Components of the physical environment include low flat relief and erosion potential of the soils. The moderate erosion potential along the Motorway alignment would require safeguards to minimise the potential adverse impacts of construction works. These safeguards would include installation of selected sedimentation controls (eg cutoff drains, detention basins, geofabric silt fences and geofabric covered hay or straw bales secured around all stormwater inlets) along the M4 Motorway. The controls would need to be specified in the form of a soil and water management plan to be submitted by the contractor to the RTA and Environment Protection Authority. The sedimentation controls would be maintained in a functioning condition until all construction activities are completed and the earthworks areas are stabilised.

Installation of these sediment controls and landscaping works would minimise adverse impacts both during construction and operation of the Proposal. The stable landforms, moderate climate and long growing season in the area would enhance the growth of landscaping plants.

7.3.5 Air Quality

During construction of the Motorway upgrading there would be increases in the local incidence of dust due to use of heavy plant and equipment and also due to wind erosion from exposed surfaces. While these adverse impacts would be fairly short term and localised, dust control measures would be necessary to ensure that effects are minimised. It is important that exposed areas be stabilised as quickly as possible and that emissions be controlled by the use of water tankers. In extreme weather conditions, that is very dry windy days, construction work would be suspended by the contractor to prevent excessive dust creation. No blasting would be undertaken at any construction site. Odour from construction activities is not expected to cause any problems.

Motor vehicle emissions are a major source of air pollution in Sydney. As well as local impacts they contribute significantly to regional air pollution, nitrogen oxides and reactive hydrocarbons being the major precursors of photochemical smog. Major studies of the Sydney airshed including the Sydney oxidant study[3] carried out in the late 1970's and the 1990 pilot study of Hyde and Johnson[4] have identified major air flows in the Sydney basin and it is recognised that on occasions air pollution generated in the north and east of Sydney is transported to the south and west.

In the past the State Pollution Control Commission (now the Environment Protection Authority) has acted to control smog by reducing the amount of hydrocarbons emitted into the Sydney air, mainly through the use of catalytic converters on motor cars using unleaded petrol and by other controls on stationary sources. This has led to a substantial reduction in hydrocarbon emissions from individual vehicles although at the same time there has been an increase in the number of vehicle kilometres travelled. The decrease achieved in

[3] Carras J N and Johnson G M, 1982, *The Urban Atmosphere - Sydney a Case Study*, proceedings of a conference organised by the CSIRO Division of Fossil Fuels, Leura 5-6 May.

[4] Hyde R and Johnson G M, 1990, *Pilot Study: Evaluation of Air Quality Issues for the Development of the Macarthur South and South Creek Valley Regions of Sydney.*

hydrocarbon emissions has not been paralleled by a decrease in nitrogen oxides emissions.

The pilot study by Hyde and Johnson identified further specific issues which include:

- the Environment Protection Authority's network may be underestimating the severity of photochemical smog in the Sydney airshed.
- there were deficiencies in knowledge of the causes and distribution of photochemical smog in Sydney.
- the air quality goals for photochemical smog may not be sufficient to protect the community.
- in the absence of further pollution controls smog concentrations in western Sydney would increase over the next twenty years by 50% as a result of urban growth.
- there would be a degradation of visual amenity in western Sydney.

This study preceded the commissioning of the Metropolitan Air Quality Study which has upgraded and extended the Environment Protection Authority's air quality monitoring network over a much wider area; further refined the understanding of the chemistry and air movements in the Sydney airshed; and updated the emissions inventories. Part of the aim of the Metropolitan Air Quality Study was to develop an airshed model which could estimate the effect of urban development options on regional air quality, particularly with respect to photochemical smog. At this stage the model is not available to be applied to the Proposal. However in general, major developments in western Sydney will need to be considered in the light of their potential impact on regional air quality.

For the Proposal, while the improved traffic flow and hence better fuel economy should generally lead to reduced greenhouse emissions and reduced emissions of hydrocarbons, the increase in traffic speed would lead to increased emissions of nitrogen oxides which are precursors of photochemical smog. The effects of increased nitrogen oxides emissions into the Sydney airshed is likely to initially deplete ozone concentrations near the area of emissions and ultimately lead to higher concentrations being formed further downwind. However the the effect of the Proposal set against the whole of the Sydney network would be very small.

Nitrogen oxides emissions from passenger vehicles are currently being controlled through the use of three-way catalytic converters which have been fitted on all new passenger vehicles in Australia since 1990. The existing fleet of diesel trucks are a major source of nitrogen oxides emissions, however newly imported vehicles will have to comply with emissions standards in their country of origin. The full effect of this technology would be felt as the fleet turns over and it is possible that the Environment Protection Authority's Environmental Management Plan, following the Metropolitan Air Quality Study and due to be released shortly, will address the control of nitrogen oxides further.

An air quality assessment completed for the Proposal is detailed in Attachment 1 and the assessments concluded that:

- the present emission controls on motor vehicles and the projected traffic conditions for the year 2006 are not expected to exceed the Environment Protection Authority's carbon monoxide 1-hour or 8-hour goals for any section of the route.
- the under 10 microns particulate matter annual and 24-hour maximum air quality goals are not predicted to be exceeded with the Proposal.
- the predicted concentration of nitrogen dioxide indicate that the Environment Protection Authority's goals would not be exceeded at residences but would be close to the goals at the kerbside if 3% annual traffic growth is assumed.
- no exceedances of air quality goals are predicted at nearby sensitive receptors.

7.3.6 Hydrology and Water Quality

The Motorway upgrading would be at the same level as the existing Motorway which provides flood immunity from at least a 1 in 100 year flood. The hydrology of the area indicates that the Motorway upgrading can be safely constructed and operated for at least the 100 year Average Recurrence Interval flow. No bridge widening over waterways or removal of creek side vegetation would be required for the Proposal.

The drainage system for the Proposal (described in Section 7.1.3) plus the existing four lanes of pavement would provide for pavement stormwater to generally discharge into artificial wetland detention basins to be provided within the road reserve to accommodate runoff from a yet to be determined Average Recurrence Interval storm and duration and first flush runoff from intense storm events. Overflows and excess runoff which bypasses these basins would discharge directly to drainage lines along the Motorway and into existing waterways. The artificial wetlands would be vegetated with macrophytes to filter pollutants from road run-off.[5] Where provision of wetland detention basins was not practicable gross pollutant traps would be constructed. Sediments and pollutants would be removed from the wetland detention basins and gross pollutant traps on a regular basis. There would be regular monitoring of the artificial wetlands and gross pollutant traps capacity and condition to ensure that they perform in a functioning condition at all times.

The design and construction of the wetland detention basins would be carried out and/or reviewed by suitably qualified and experienced personnel experienced in the provision of wetland ecosystems for water quality improvements.

The hydrology and water quality impacts would be similar for both the existing M4 Motorway and the upgrading although a small improvement in water quality of nearby waterways could be expected. Recent studies completed by CSIRO for the RTA concluded that road runoff from road with less than 30,000 vehicles per day exhibited minimal impact on receiving waters although it is desirable that discharges be kept as clean as possible. Although work on this issue is limited in Australia, the United States of America has undertaken a considerable amount of work and its experience suggests that water quality problems associated with road runoff are primarily related to lead from leaded petrol, zinc from vehicle tyres, and copper from vehicle brakes. Lead levels will decline as the consumption of leaded petrol declines. Pollutants in water such as lead, zinc and copper attach to fine particles and dirt sediments. Therefore by effectively controlling sedimentation, lead, zinc and copper as well as tyre rubber, dirt and other pollutants, the quality of M4 Motorway stormwater runoff into nearby waterways would be improved by the Proposal.

Aquatic ecosystems are not expected to be affected by the Proposal. No water would be extracted from any waterway for construction purposes.

The Motorway drainage improvements would have a beneficial impact on water quality in the long term despite increased leakages of fuel, lubricants, hydraulic fluids, coolants and particulate matter (tyre rubber, brake and clutch linings) from future increased traffic volumes being flushed from the pavement by stormwater runoff. This impact would be complemented to some extent in the short-term by the Motorway upgrading reducing wear

[5] The major processes operating in a wetland system resulting in pollutant reduction include:

- physical sedimentation of larger particles with associated pollutants from reduced velocities. Most heavy metals and 70% to 80% of nitrogen and phosphorus are associated with particulate matter.
- physical filtering of particulate matter by emergent and submerged macrophytes.
- uptake of nutrients (nitrogen and phosphorus) by plants.
- gas loss to atmosphere (ammonia, nitrogen, methane, hydrogen sulphide).
- disinfection of microbial material by sunlight.
- entrapment of surface oils by macrophytes and evaporative loss.

and tear on vehicles. Pollutants from road runoff would be captured in the artificial wetlands and gross pollutant traps that would be regularly maintained by the RTA and the contractor. The artificial wetlands would also have the advantages of containing accidental spills, promoting ecological sustainability and enhancing the roadside environment. However vegetation die-off during times of drought would reduce nutrient removal efficiency until regeneration. Experience shows that potential problems of safety, mosquitoes, algae and species dominance in artificial wetlands can be overcome with good design, maintenance and management.

7.3.7 Vegetation

The original vegetation of the area (grey gum - red gum woodland with grass understorey) has been highly disturbed and the existing vegetation of the road reserve along both sides of the M4 Motorway is predominantly shrubs and grasses prone to fires during summer. Vegetation in large sections of the road reserve consists of mown grass or horticultural plantings of native and introduced trees and shrubs. Maintenance of the grass and plantings varies according to location. Some stands of native vegetation occur in the road reserve although it is possible that these stands would not be affected by the Proposal. One plant species of national conservation significance *Dillwynia tenuifolia* was recorded near Ropes Creek with up to 40 specimens in the road reserve. *Grevillea juniperina* considered to be endangered by housing development was also recorded in this location. Seventeen plant species of regional conservation significance were recorded near the road reserve.

A flora assessment of the road reserve is provided in Attachment 2. As a safeguard a more detailed flora survey would be carried out near Ropes Creek before construction commences to further evaluate the flora species of conservation significance. Native seeds would also be collected from the M4 Motorway road reserve and propagated for use in landscaping works.

7.3.8 Wildlife and Habitat

A limited survey of the road reserve, a review of past studies undertaken in the area, searches of the NSW National Parks and Wildlife Service 1:100,000 scale and Australian Museum databases were carried out to identify fauna species recorded or expected to occur in the area of the Proposal. The limited survey of the road reserve identified 3 mammals, 43 birds, 4 reptiles and 1 frog with none being of conservation significance as defined under Schedule 12 of the *National Parks and Wildlife Act 1974*. Previous studies and fauna surveys in the region have identified a further 67 birds, 11 native and 6 introduced mammals, 22 reptiles and 14 amphibian species. Five of these species, the Green and Golden Bell Frog, Australasian Bittern, Swift Parrot, Superb Parrot and Regent Honeyeater are of conservation significance as defined under Schedule 12 of the *National Parks and Wildlife Act 1974.*

Section 4A of the *Environmental Planning and Assessment Act 1979* was used to decide whether there is likely to be a significant effect on the environment of endangered fauna by taking into account a number of factors. These tests of significance for the five endangered fauna species are provided in Attachment 3 along with more detail on the fauna assessment for the Proposal. The conclusions of the fauna assessments for the five endangered fauna species was that the Proposal is unlikely to have any significant impact on the species. As a safeguard a more detailed fauna survey would be carried out by the contractor before construction commences to evaluate the conservation significance of the impact of the Proposal on the five endangered species. Vegetation to be removed from the road reserve would be outside the nesting season of native birds.

The provision of artificial wetlands would also have the advantages of promoting ecological sustainability for flora and fauna. Artificial wetlands promote and maintain bio-diversity by

replacing lost aquatic habitat and protecting existing natural systems.

7.3.9 Socio-economic Considerations

The residents of nearby residential areas abutting the M4 Motorway would be likely to experience adverse impacts due to elevated levels of dust, noise, traffic generation and general disruption during the construction period. Local access would not be affected. There would be short term inconvenience to travel during construction. No land acquisition would be required for the Proposal. There would be no property severance as a result of the Proposal.

Following completion of the Proposal the residents of western Sydney would have marginally improved access to destinations within and outside the region. A before and after traffic study would be undertaken by the RTA on feeder roads likely to be affected by changed traffic patterns. Traffic management measures would be implemented where warranted to address any major adverse traffic changes caused by the Proposal. There would be no significant changes to land use. The Proposal would not affect local businesses following completion of construction. Economic pursuits in the area would able to be maintained during construction and operation of the Proposal. Local businesses nearby the M4 Motorway would benefit from reduced travel times generated by the Proposal.

To minimise disruption to travellers traffic management measures would be implemented by the contractor during construction of the Proposal to reduce delays with two lanes open in both directions during 5 am to 8 pm. A temporary speed restriction of 60 km/hour would be imposed on some lanes during construction. The procedures for the installation and operation of traffic control devices established in AS 1742.3-1985 *Traffic Control Devices for Works on Motorways* would be followed wherever possible. Only the minimum practicable length and width of M4 Motorway would be closed off at any one time to minimise disruption and inconvenience to Motorway users.

7.3.10 European Heritage

The existing M4 Motorway and the widening would be constructed within areas already disturbed. There are no known items of European heritage within the road reserve. However if relics more than 50 years old were affected by the Proposal during construction then an excavation permit to allow the destruction or removal of the relic would be obtained from the Heritage Council.

7.3.11 Aboriginal Heritage

In 1986 an archaeological survey was completed along the road reserve between Mays Hill and Prospect. No Aboriginal sites or relics were found in the survey.

The Aboriginal Sites Register of the National Parks and Wildlife Service shows that there are no known sites or items of Aboriginal heritage within the proposed works area. The Daruk Local Aboriginal Land Council has been consulted and as requested a preliminary archaeological survey would be completed before construction commences. The Daruk Local Aboriginal Land Council would require its site officer to monitor stripping of the first metre of earthworks for subsurface Aboriginal sites or artifacts during construction. There are no known Native Title land claims along the M4 Motorway.

If any archaeological sites or relics were found during the preliminary archaeological survey or during construction then work in the vicinity would cease immediately and the NSW National Parks and Wildlife Service would be contacted promptly for further advice prior to recommencing construction in the area.

7.3.12 Landscape and Visual Considerations

The Proposal would include detailed landscape plans to be prepared and implemented by the contractor in accordance with the landscape concept plans shown in Attachment 6. Landscaping of the road reserve would be carried out to these specifications. Native trees and shrubs would be planted and maintained by the contractor until full establishment in accordance with the approved landscape plan. The noise attenuation barriers would be integrated with landscape treatments. Topsoil would need to be managed during earthworks operations to prevent the spread of weed species and reduce future fire risk.

The undulating topography, vegetation and land use pattern provides a semi-rural landscape quality of moderate scenic quality in the western section of the Proposal. In the urbanised eastern section of the Motorway between Parramatta and Mays Hill visual and scenic quality is average. The existing visual quality for residents of the closest dwellings would be improved by the Proposal following installation and maturing of landscaping. The landscape treatment would have the benefit of improving scenic quality for Motorway users and viewers and integrating the road side into the adjacent residential and recreational environments. Overall the surrounding semi-rural landscape character and moderate scenic quality in the western section would remain intact as the proposed upgrading would occur with no change to the vertical and horizontal alignment within the existing Motorway corridor. The landscape and visual quality of the urbanised eastern section would be improved with implementation of the landscape plans although the built environment character of the Motorway would remain. For both sections of the Proposal residents with views of the Motorway would have improved views where landscaped noise attenuation mounds interrupted existing direct road views. In addition where artificial wetlands were installed the roadscape would be more interesting and softened making travel safer and more enjoyable.

7.3.13 Noise and Vibration Effects

To reduce the impact of construction noise the hours of construction would be standard working hours except where night work is essential. Mufflers to Environment Protection Authority requirements would be fitted to construction plant and equipment. Construction noise would be limited to Environment Protection Authority requirements.

There may be localised short term adverse vibration impacts from operation of construction equipment such as rock breakers and jack hammers. Hydraulic rock breakers operating in hard sandstone typically have ground vibration levels of 0.4 mm/sec at 20 metres distance and 0.14 mm/sec at 40 metres distance. Typical vibration levels from heavy trucks passing over normal road surfaces generate relatively low vibration levels in the range of 0.01mm/sec to 0.2 mm/sec at the footings of buildings located 10 metres to 20 metres from a roadway. The closest dwelling is located approximately 50 metres from the proposed construction areas. At 0.35 mm/sec the typical perception of vibration for humans is barely noticeable. The vibration levels from machinery and equipment operating along the road reserve would likely be below the threshold of possibility of damage to the closest structures to the Motorway. Vibration from machinery and equipment would involve low risk over distance and no damage to the closest residential or industrial areas would be expected. A dilapidation survey would be carried out by the contractor prior to construction in areas adjacent to residential areas.

A detailed traffic noise assessment for the eastern section of the Proposal is provided in Attachment 4. To meet the RTA's *Interim Traffic Noise Policy (1992)* criteria noise attenuation barriers of different heights for the eastern section would be required as shown in Figure 3. A detailed traffic noise assessment for the western section of the Proposal is provided in Attachment 5. To meet the RTA's *Interim Traffic Noise Policy (1992)* criteria noise attenuation barriers of different heights would be required for the western section as

shown in Figures 4.1 and 4.2.

The community would be consulted with regard to the final location, design, type and height of the noise attenuation barriers. Wherever practicable noise barriers would comprise landscaped noise attenuation mounds using surplus material from construction of the Motorway upgrading.

7.4 Cumulative Environmental Impacts

The Proposal is necessary to accommodate future traffic growth and improve accessibility in the western Sydney region. Since development in the area would progress regardless of the upgrading of the M4 Motorway the cumulative impact for the Proposal would be beneficial in the long term with improvements in traffic flow including public transport, traffic safety, access, convenience and landscaping contributing towards the economic and community development of the western Sydney region. In summary the cumulative impacts of the Proposal include:

- reduced traffic noise for nearby communities.
- marginally reduced air quality for nearby residents.
- roadside landscaping enhancing scenic quality.
- improved traffic flow and level of service.
- enhanced traffic safety including better pavement ride.
- reduced vehicle operating costs.
- changes to traffic on feeder routes.
- contribution towards the economic development of western Sydney.

Based on the concept design and with the safeguards implemented it is considered that the cumulative environmental impacts of the Proposal are generally positive. These cumulative environmental impacts would be enhanced with other developments in western Sydney including:

- population growth with for example, an anticipated population increase of 30,000 at St Marys plus major residential growth north of Penrith.
- industrial development and freight movements generated by the development of Badgerys Creek airport.
- development of the national highway western Sydney orbital from Cecil Park to west Baulkham Hills via Wallgrove Road which intersects the M4 Motorway.
- other road (for example, completion of the Mamre Road interchange presently under construction) and rail transport improvements in western Sydney.

The Proposal could induce traffic growth along the Motorway and exacerbate peak hour, business hours and 24 hour traffic flows. Other transport proposals including upgrading of feeder roads and traffic management measures as a result of traffic studies would contribute towards the enhancement of the road network in the metropolitan area. The cumulative environmental impacts of the Proposal would be amplified by any extension of the Motorway, additional linkages to the metropolitan road network and continued residential and industrial development in western Sydney. The changing land use patterns and traffic generating developments in western Sydney would contribute to the cumulative impacts of the Proposal. In addition the assessed bio-physical impact of the Proposal is limited since most of the Motorway corridor is through ecologically disturbed urban and semi-rural land.

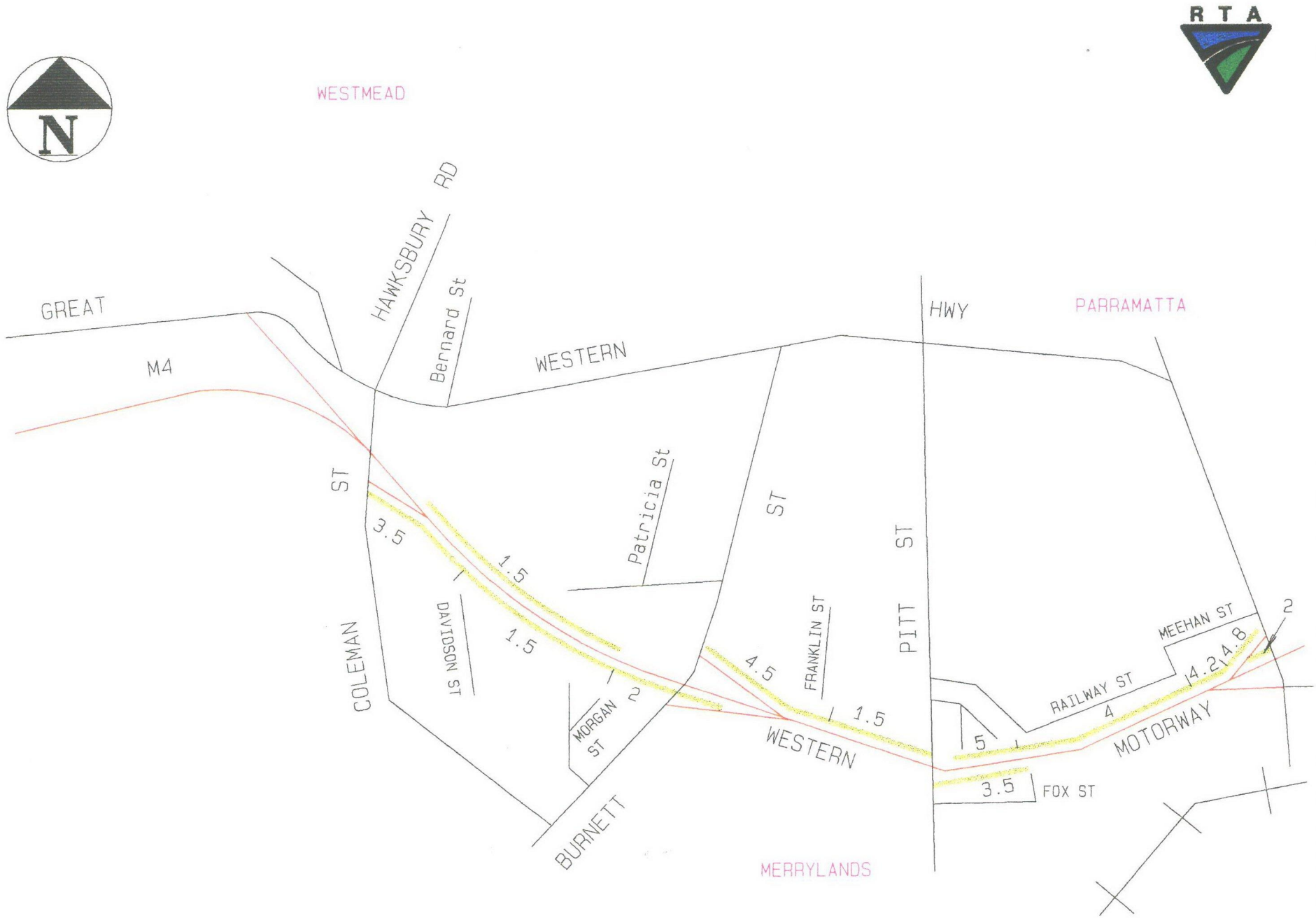


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Figure 3 - NOISE BARRIERS CONCEPT - Eastern Section

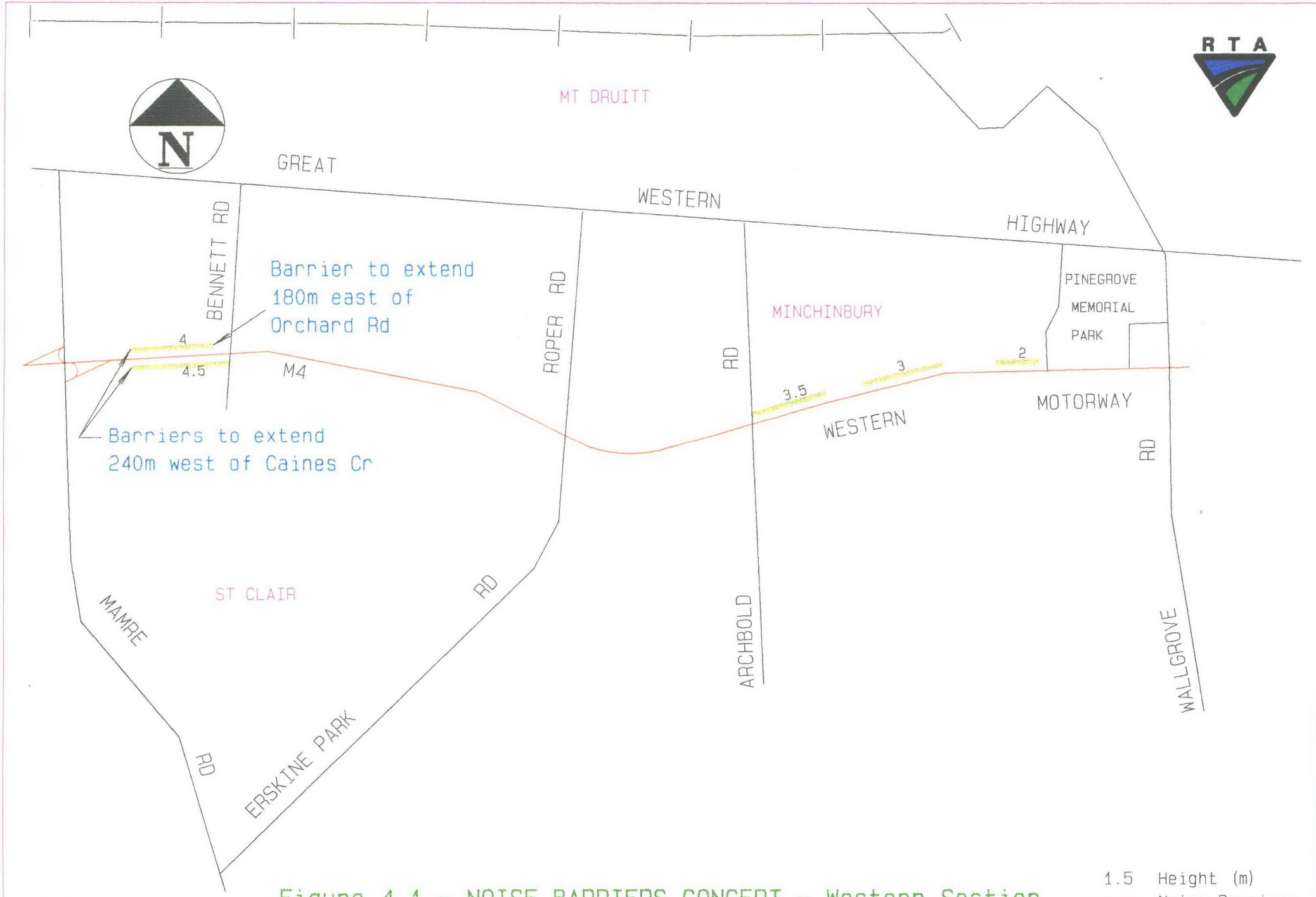

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Figure 4.1 - NOISE BARRIERS CONCEPT - Western Section

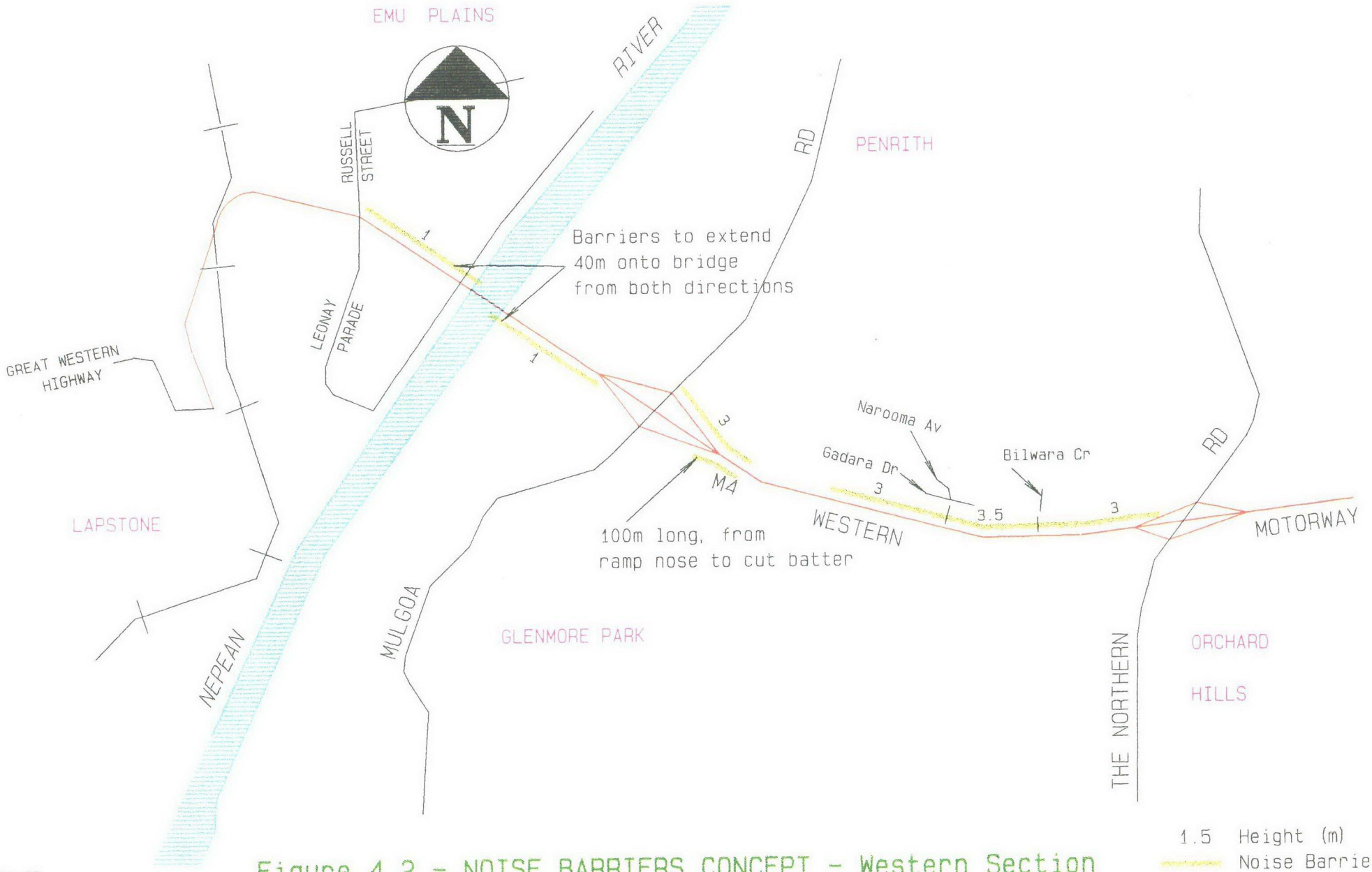

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Figure 4.2 - NOISE BARRIERS CONCEPT - Western Section

8. Implementation Stage

8.1 Summary of Proposed Safeguards

There would be some short-term and medium-term localised and adverse environmental impacts particularly during construction requiring safeguards. During operations the adverse environmental impacts would be reduced through installation of noise attenuation barriers, gross pollutant traps, artificial wetlands and landscaping. The safeguards for construction of the Proposal would be included in an Environmental Management Plan which would be prepared by the contractor prior to construction and submitted to the RTA and Environment Protection Authority with the necessary actions, responsibilities, procedures, timing, verification, conformance and audit activities specified. The Environmental Management Plan would include all measures that might reasonably be taken to minimise adverse environmental impacts before and during construction and following commissioning. Any adverse impacts of constructing the Proposal would be outweighed by the long term beneficial effects of the Proposal, especially during post construction operations and maintenance of the Proposal. In summary the safeguards that would be implemented for the Proposal based on the Review of Environmental Factors requirements include:

- inconvenience to Motorway users and residential communities would be minimised through world best construction and traffic management practices.
- use of current and world best available design criteria to ensure the Proposal is correctly constructed, maintained and operated with adequate safety and capacity to meet all reasonable traffic needs for the next twenty years.
- a more detailed flora survey would be carried out near Ropes Creek before construction commences to further evaluate the two flora species of conservation significance.
- a more detailed fauna survey would be carried out before construction commences to further evaluate the conservation significance and safeguard requirements for the five endangered species that could occur in the region.
- a dilapidation survey would be carried out by the contractor prior to construction in areas adjacent to residential areas.
- implement environmental protection requirements of the RTA's Contract Manual which includes the following model specifications as a minimum:

Part R1	Control of Erosion and Sedimentation
Part R2	Temporary Erosion and Sedimentation Control
Part R5	Stormwater Drainage
Part R13	Drainage Structures
Part R17	Clearing and Grubbing
Part R18	Earthworks (Balanced Cut-Fill)
Part R80	Vegetation
Part G5.1.1	Requirements of Environmental Assessment
Part G5.1.2	Licences
Part G5.2.1	Legislation
Part G5.2.2	General
Part G5.2.3	Prevention of Nuisances
Part G5.2.4	Fire Precautions
Part G5.2.5	Herbicides and Other Toxic Chemicals
Part G5.2.6	Emergency Spillage Procedures.

- preparing and implementing a traffic management plan in accordance with the requirements of the RTA to ensure minimum delays along the M4 Motorway with two lanes open in both directions between 5 am and 8 pm.
- implementation of a before and after traffic management study to identify changes in traffic on feeder routes due to the Proposal and any associated need for traffic management measures.

- management of topsoil during earthworks operations to prevent spread of weed species and reduce future fire risk.
- sedimentation potential from roadworks requiring installation of selected sedimentation controls (eg cutoff drains, detention basins, geofabric silt fences and geofabric covered hay or straw bales secured around all stormwater inlets) along the M4 Motorway. The controls are to be specified in the form of a soil and water management plan to be submitted by the contractor to the RTA and Environment Protection Authority.
- wherever practicable, cost effective and acceptable to adjacent communities stormwater runoff from the Motorway to be discharged into artificial wetlands located within the road reserve and designed to capture runoff from a yet to be determined rainfall event and duration before discharge into the existing stormwater system and nearby natural waterways.
- the design and construction of the wetland detention basins would be carried out and/or reviewed by suitably qualified and experienced personnel experienced in the provision of wetland ecosystems for water quality improvements.
- where stormwater runoff from the Motorway cannot be discharged into artificial wetlands then gross pollutant traps would be installed prior to stormwater discharge into nearby natural waterways.
- regular monitoring and maintenance of all artificial wetlands and gross pollutant traps to ensure that they perform in a fully functioning condition at all times.
- sediments and pollutants would be removed from the wetland detention basins and gross pollutant traps on a regular basis and the contents analysed for research and disposed of in accordance with the requirements of the Environment Protection Authority.
- location of construction compounds restricted to within the road reserve and at least 100 metres from any watercourse, detention basin or artificial wetland or the flora of conservation significance near Ropes Creek.
- construction compounds would be security fenced and include amenities sheds, portable toilets, plant and equipment storage areas, bunded areas for storage of petroleum, distillate and other chemicals to comply with Environment Protection Authority and WorkCover requirements.
- no blasting would be permitted during construction.
- exposed earthworks areas would be stabilised as quickly as possible.
- on very dry windy days construction work would be suspended by the contractor to prevent excessive dust creation.
- provision of on-site domestic waste and sullage facilities at each construction compound.
- any excess vegetation being recycled for use as mulch in on-site landscaping works or as green waste off-site.
- any excavated or excess pavement material and concrete being incorporated in the construction of noise attenuation mounds as a first priority or for off-site use.
- disposal of all non-recyclable waste at legally operating waste disposal sites or waste transfer stations.
- no burning or burying of wastes permitted on-site.
- maintenance of a clean and tidy construction site.
- maintenance of construction equipment to meet Environment Protection Authority requirements.
- no vehicle maintenance permitted outside the construction compounds.
- completion of a pre-construction and post-construction noise survey along adjacent residential areas.
- construction of noise barriers to meet the RTA's *Interim Traffic Noise Policy (1992)* in accordance with Figures 3 and 4.
- construction hours would be from 7 am to 5 pm Monday to Friday and 7 am to 1 pm Saturday excluding Sundays and public holidays unless otherwise approved by the RTA and the Environment Protection Authority to enable night works.

- construction noise to be limited to Environment Protection Authority requirements.
- mufflers would be fitted to all construction plant and equipment to meet Environment Protection Authority requirements.
- heavy vehicle traffic generation during construction being confined to the M4 and other main roads.
- transport of concrete from legally operating established concrete batching plants located near the Motorway.
- cleaning out of batched concrete mixing plant in designated areas or off-site at approved facilities.
- transport of quarry products from legally operating established facilities.
- preparation of detailed landscape treatments and maintenance plan in accordance with the attached landscape concept plans to RTA specifications before construction commences.
- collection and propagation of native seeds from the M4 Motorway road reserve for use in landscaping works.
- removal of vegetation in the road reserve outside the nesting season of native birds.
- loss of vegetation in the Motorway reserve being replaced wherever practicable with locally indigenous native trees and shrubs in roadside landscaped areas in accordance with the landscape concept plans.
- installation of landscaping as a priority around all interchanges within the eastern and western sections of the M4 Motorway.
- maintenance of all landscaped areas including vegetation on noise mounds and artificial wetlands within the Motorway reserve until full establishment of the vegetation.
- noise attenuation barriers and mounds would be integrated with landscaping.
- the contractor would check with public authorities and utility providers with a potential interest in the Proposal for any relevant issues that need addressing during the detailed design development stage prior to construction.
- the relevant and reasonable requirements of the public authorities and utility providers that would be consulted would be addressed in the final design of the Proposal.
- meeting the requirements of all relevant legislation relating to air quality, water quality and noise.
- obtaining all approvals and licences needed to construct the Proposal including air, noise and water pollution approvals and licences from the Environment Protection Authority.
- the RTA would complete before and after traffic studies to assess any changes and the associated need for traffic management measures on feeder routes.
- completing a preliminary archaeological survey in consultation with the Daruk Local Aboriginal Land Council before construction commences.
- engaging a site officer from the Daruk Local Aboriginal Land Council to monitor preliminary earthworks for subsurface Aboriginal sites or artifacts during construction.
- if any Aboriginal archaeological sites or artifacts were found during construction then work would cease immediately in the vicinity and the NSW National Parks and Wildlife Service would be contacted promptly for further advice and action.
- if any European relics more than 50 years old were affected by the Proposal then an excavation permit to allow the destruction or removal of the relic would be obtained from the Heritage Council.
- preparation of a community consultation programme to the satisfaction of the RTA.
- undertaking a community consultation programme with representatives of potentially affected communities including residential, industrial and recreation areas abutting the Motorway plus Holroyd, Blacktown and Penrith City Councils in accordance with RTA requirements.

- the community consultation programme to include provision for community input into the location, height and type of noise attenuation barriers; location of artificial wetlands; and working hours for night time construction.
- informing residents, emergency services, media traffic journalists and workers directly or by public notices and media releases of the Proposal before construction commences.
- informing nearby residential areas at least three days before any construction work was undertaken at night or if any traffic switches were required.
- informing the Environment Protection Authority's Hotline on 131 555 with advice of any night construction works and the name of the project or site manager to contact in an emergency.
- incorporation of all the safeguards in an Environmental Management Plan to be prepared by the contractor before construction commences for implementation to minimise adverse environmental impacts. The Environmental Management Plan would include provision for hold points where irreversible environmental damage may occur, regular reports and audits on the environmental management of the project, details of non-conformances, verification activities and emergency responses.

The above list of safeguards is a minimum for implementation and may not be exhaustive and change as a result of public authorities requirements, changes in legislation, community consultation and detailed design development.

8.2 Implementation Process

The successful tenderer for the design and construction of the Proposal would be required as part of the contract to meet the specifications and safeguards detailed in this Review of Environmental Factors. The safeguards include all measures that might reasonably be taken to minimise adverse environmental impacts during construction and operations of the Proposal. Specifically all activities must comply with the environmental provisions set out in this Review of Environmental Factors and Assessment Report for the Proposal and project specifications. The collective safeguards would be included in an Environmental Management Plan to be prepared by the contractor for submission to the RTA and Environment Protection Authority for comment before construction commences for implementation and monitoring. In addition, all activities carried out on site must comply with the relevant provisions of all legislation including regulations relating to construction, operations and maintenance of the project.

SECTION C - FINALISATION

9. Summary of Key Issues

9.1 Major Beneficial Effects

The major beneficial effects of the M4 Motorway upgrading would be improved capacity, enhanced traffic safety including better pavement ride, improved traffic flow, better roadside landscaping, improved water quality, lower vehicle operating costs, greater travel time savings, reduced potential for accidents and reduced traffic noise for adjacent residents.

9.2 Major Adverse Effects

The major adverse effects of the Proposal include delays to traffic along the M4 Motorway during construction and short-term loss of roadside vegetation. There would be some moderate adverse effects (eg increased noise, traffic generation and dusts) on the surrounding communities during construction and operations of the Proposal offset by road user and other benefits. Traffic may increase along some feeder routes to the Motorway.

9.3 Characteristics

The roadway design characteristics of the Proposal are similar to the existing M4 Motorway with the upgrading on the same alignment, at the same location and to be constructed using similar design and materials. Upon completion of the upgrading the characteristics of the Proposal would be different from the existing Motorway with increased pavement width, improved and more extensive landscaping, installation of artificial wetlands and gross pollutant traps and noise attenuation barriers. The interactions between the upgrading and the affected roadside environment would be generally localised except for some M4 Motorway travellers being inconvenienced during construction.

9.4 The Extent of the Impacts

The adverse impacts during construction would be short-term and generally localised. The main construction impacts include construction noise, loss of vegetation and disruption to traffic. The risk of sedimentation to waterways would be minimised by effective sediment controls. The extent of the positive impacts during operations would be long-term, beneficial and cumulative on a regional scale and include enhanced Motorway safety, improved traffic flow and improved water quality. The long-term local impacts during operations include improved roadside landscaping, reduced traffic noise and a marginal decline in air quality for nearby residents. It is considered the long-term local and regional benefits of the Proposal outweigh the short-term localised and acceptable environmental impacts with the safeguards implemented.

9.5 The Nature of the Impacts

Based on construction experience of similar roadway widening projects the level of confidence in the prediction of environmental impacts is high. It is anticipated that the affected environment would have the resilience to cope with the predicted environmental impacts. With the safeguards implemented during construction via an Environmental Management Plan it is considered the environmental impacts would be minimised and that they are manageable. The Proposal would comply with all relevant standards, plans, policies and legislation. There is considerable public interest in the Proposal and this would be addressed by a community consultation programme. Any adverse environmental impacts of the Proposal would be accommodated with best construction and traffic management techniques and implementation of the Environmental Management Plan and safeguards.

10. Consideration of Clause 82 Factors

In assessing the impact of the Proposal for the purposes of Part V of the *Environmental Planning and Assessment Act* the following Clause 82 factors for consideration of likely impact of an activity on the environment are summarised.

(a) any environmental impact on a community;
There would be some moderate environmental impacts (eg increased noise, traffic generation, dust and improved landscaping) on the surrounding communities during construction and operations of the Proposal offset by road user and other benefits. Following commissioning the environmental impacts would relate to visual impact, better landscaping, improved water quality, lower vehicle operating costs, greater travel time savings and reduced potential for accidents.

(b) any transformation of a locality;
Compared with the existing M4 Motorway there would be a long term transformation of approximately 160 hectares of roadside vegetated area to additional pavement area, artificial wetlands and gross pollutant traps, landscaped area and noise attenuation barriers required for upgrading of the M4 Motorway.

(c) any environmental impact on the ecosystems of the locality;
There would be minor environmental impact on local ecosystems due to the modified nature and managed land uses in the road reserve and adjacent localities.

(d) any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality;
There would be no known reduction in the recreational, scientific or other environmental quality or value of any locality outside the road reserve due to the Proposal. There would be a moderate reduction in the aesthetic quality of the locality in the short-term with the removal of roadside vegetation until the landscaped areas and artificial wetlands vegetation matured.

(e) any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations;
There would be no known adverse impacts on a locality, place or building of significance for present or future generations.

(f) any impact on the habitat of any protected or endangered fauna (within the meaning of the National Parks and Wildlife Act 1974);
With respect to the above Act and Section 4A of the *Environmental Planning and Assessment Act, 1979*, the threat to any protected or endangered fauna would be further assessed including a detailed fauna survey before construction commences.

(g) any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air;
No known endangering of any species as a consequence of the Proposal is anticipated although additional flora and fauna surveys would be completed before construction commences.

(h) any long-term effects on the environment;
There would be some long term effects on the environment including reduced road traffic noise for adjacent residential areas, enhanced landscaping and improved water quality along the road reserve.

(i) any degradation of the quality of the environment;
No degradation of the quality of the environment would occur except for some loss in air quality for nearby residents.

(j) any risk to the safety of the environment;
No risk would occur to the safety of the environment except during construction with increased potential for traffic accidents. Appropriate safeguards would be implemented to minimise these risks. The risk of grass fires along the Motorway would be reduced with installation of landscaping.

(k) any reduction in the range of beneficial uses of the environment;
There would be no change to any beneficial use of the environment apart from a moderate loss of vegetated roadside area for the Proposal.

(l) any pollution of the environment;
No additional pollution would be generated by the Proposal except for increased air and noise emissions from increased traffic flows in future. Noise attenuation barriers would be installed to reduce traffic noise levels and meet RTA noise objectives for adjacent residential areas.

(m) any environmental problems associated with the disposal of waste;
All generated wastes including green waste, unsuitable and pavement materials would be recycled as a first priority or contained and removed from the construction site for safe disposal according to statutory requirements. No environmental problems are anticipated with the disposal of waste.

(n) any increased demands on resources (natural or otherwise) that are, or are likely to become in short supply;
No extraordinary demands would be made on the use of resources which are, or are likely to become in short supply.

(o) any cumulative environmental effect with other existing or likely future activities;
The cumulative environmental effects of the Proposal would contribute towards the development of the metropolitan network and enhance accessibility for other developments in western Sydney. The Proposal may induce further traffic growth along the M4 Motorway and along feeder routes.

11. Declarations

This Review of Environmental Factors provides a true and fair review of the Proposal in relation to its potential effects on the environment. It addresses to the fullest extent possible all matters affecting or likely to affect the environment as a result of the Proposal.

Signed : B.R. Adcock Date: 14th November 1995.
Environmental Planning Pty Ltd

Signed : _____ Date: 14 November 1995.
Project Manager Sydney Region
Roads and Traffic Authority

ATTACHMENT 1

AIR QUALITY ASSESSMENT M4 MOTORWAY UPGRADE

November 1995, Nigel Holmes and Associates

CONTENTS

TABLES

FIGURES all figures at end

1.0 INTRODUCTION

This report has been prepared by Nigel Holmes & Associates on behalf of Environmental Planning Pty Ltd who are acting for the Roads and Traffic Authority of NSW. Its purpose is to assess the air quality impacts of the proposed upgrade of sections of the M4 Motorway from Parramatta to Emu Plains (see **Figure 1**). The report provides information on the following aspects of the air quality assessment:

- Emissions from various segments of the roadway involved in the development;
- Kerb side concentrations of roadway air emissions.

The assessment of the impacts of motor vehicle emission is based on the use of a computer model to determine the dispersion of emissions and to predict ground-level concentrations of the various exhaust components in the area close to the road. It has been assumed that in the year of assessment (2006) motor vehicles will be powered almost exclusively with unleaded petrol or diesel and thus the primary podlutants of concern will be carbon monoxide, hydrocarbons, nitrogen oxides and particulate matter.

The report comprises the following sections:

- a description of the proposed development;
- a review of the dispersion meteorology of the area and existing air quality;
- a discussion of the model used to assess the impacts and a review of relevant air quality criteria;
- a description of the methods used to estimate vehicle emissions and a summary of the calculated emissions for different sections of the road; and
- predictions of ground-level concentrations of emissions and an assessment of their impacts.

Air quality monitoring was undertaken in a previous study by WorkCover Authority. A review of this information is contained in this report.

2.0 DESCRIPTION OF THE DEVELOPMENT

The M4 Motorway is an existing arterial road extending from Concord to Lapstone, west of Penrith. Since the section from Mays Hills to Prospect was opened, the section of the Motorway between Church Street, Parramatta and Wallgrove Road, Eastern Creek has experienced a significant increase in traffic activity. Growth in peak period traffic has been accompanied by an increased traffic accident rate, poor traffic flow efficiency and stop start driving conditions.

The RTA plans to upgrade sections of the Motorway from Church Street to Coleman Street in the east and from Prospect to Emu Plains in the west. The upgrading will involve an extra traffic lane in each direction between Church Street Parramatta and Coleman Street, Mays Hill and between the Service Centres at Eastern Creek and Mulgoa Road, Penrith. In addition, collector-distributor lanes will be provided to separate local entering and exiting westbound traffic between Church Street and Coleman Street from the higher speed through traffic. The proposed crosssections are shown in **Figure 2.**

3.0 AIR QUALITY CRITERIA

This section discusses the ambient air quality goals which relate to motor vehicle emissions.

The New South Wales Environment Protection Authority (NSW EPA) notes air quality goals for nitrogen dioxide, carbon monoxide, and particulate matter determined by the World Health Organisation (WHO), the United States Environment Protection Agency (US EPA) and the National Health and Medical Research Council of Australia (NH&MRC). Air quality goals for hydrocarbons have been used previously, but these have been discarded because they are not specific for **reactive** species which are the important elements in the formation of photochemical smog.

Table 1 lists the EPA's air quality goals for New South Wales. Not all of these are major motor vehicle emissions. The basis of these air quality goals and the safety margins which they provide are outlined below.

3.1 Carbon monoxide

Carbon monoxide can be harmful to man because its affinity for haemoglobin is more than 200 times greater than that of oxygen. When it is inhaled it is taken up by the blood and therefore reduces the capacity of the blood to transport oxygen. This process is reversible and lowering of the ambient concentration will lead to the establishment of a new equilibrium with a period of three hours being the approximate time required to reach 50% of the equilibrium value.

Symptoms of carbon monoxide intoxication are lassitude and headaches, however these are generally not reported until the concentrations of carboxyhaemoglobin in the blood are in excess of 10% of saturation. This is approximately the equilibrium value achieved with an ambient atmospheric concentration of 70 mg/m^3 for a person engaged in light activity. However, there is evidence that there is a risk for individuals with cardiovascular disease when the carboxyhaemoglobin concentration reaches 4% and the WHO recommends that ambient concentrations be kept to values which would protect individuals from exceeding the 4% level.

The 15-minute, 1-hour and 8-hour goals adopted by the EPA provide a significant margin for safety, however this is appropriate for this type of guideline, which is designed to protect a wide range of people in the community including the very young, the elderly and the infirm.

3.2 Nitrogen oxides

Nitrogen oxides (NO_x) emitted by motor vehicles are comprised mainly of nitric oxide (NO, approximately 95% at the point of emission) and nitrogen dioxide (NO_2, approximately 5% at the point of emission). Nitric oxide is much less harmful to man than is nitrogen dioxide and is not generally considered a pollutant at the concentrations normally found in urban environments. Concern with nitric oxide relates to its transformation to nitrogen dioxide and its role in the formation of photochemical smog. Nitrogen dioxide has been reported to have an effect on respiratory function although the evidence concerning effects has been mixed and conflicting. The EPA has not set any air quality goals for nitric oxide however it has set 1-hour and annual average and longterm goals for nitrogen dioxide.

3.3 Hydrocarbons

Hydrocarbons alone do not generally pose a problem in the urban environment at the concentrations commonly experienced. However, some hydrocarbons such as benzene are known to have an adverse effect on human health (see later), but the effects are thought to occur at concentrations much higher than the levels of exposure that are found at roadsides from traffic emissions. Hydrocarbons do play a significant role in photochemical smog formation and until recently the air quality standards adopted by the US EPA for non-methane hydrocarbons have been applied in NSW. However it has been recognised that this goal does not distinguish the reactive species which are involved in smog formation from the total hydrocarbon concentration and this air quality goal has been abandoned by the US EPA and the NSW EPA.

There is growing concern about the amount of benzene released in motor vehicle emissions, especially in Europe where fuel has a higher benzene and aromatic content than in Australia. At present NSW has no ambient air quality goals for benzene. The Victorian EPA currently has a limit of 0.10 mg/m^3 (0.033 ppm) (3-minute average). Many in the scientific community hold the view that there is no safe limit for benzene. The WHO specifies a risk factor for developing leukaemia of $4x10^{-6}$ for a lifetime exposure to 1 $\mu g/m^3$. The United Kingdom is about to set an annual average ambient benzene goal of 5 parts per billion (ppb) or 15 $\mu g/m^3$ with a view to reducing this to 1 ppb.

TABLE 1- NEW SOUTH WALES AIR QUALITY GOALS

POLLUTANT	STANDARD*	AGENCY
Total suspended particulate matter (TSP)	90 $\mu g/m^3$ (annual mean)	NH&MRC
Particulate matter < 10 μm (PM_{10})	50 $\mu g/m^3$ (annual mean) 150 $\mu g/m^3$ (24-hour maximum)	US EPA US EPA
Lead	1.5 $\mu g/m^3$ (90-day average)	NH&MRC
Carbon monoxide	87 ppm or 108 mg/3 (15-minute maximum) 25 ppm or 31 mg/m^3 (1-hour maximum) 9 ppm or 11 mg/m^3 (8-hour maximum)	WHO WHO NH&MRC
Nitrogen dioxide	0.16 ppm or 328 $\mu g/m^3$ (1-hour maximum) 0.05 ppm or 103 $\mu g/m^3$ (annual mean)	NH&MRC US EPA
Ozone	0.12 ppm or 258 $\mu g/m^3$ (1-hour maximum)	NH&MRC
Sulphur dioxide	50 pphm or 1400 $\mu g/m^3$ (10-minute maximum) 25 pphm or 700 $\mu g/m^3$ (1-hour maximum) 2 pphm or 60 $\mu g/m^3$ (annual mean) 17.5 pphm or 500 $\mu g/m^3$ (10-minute maximum) 12 pphm or 350 $\mu g/m^3$ (1-hour maximum)	NH&MRC NH&MRC NH&MRC WHO WHO
Suspended matter	40 $\mu g/m^3$ (annual mean)	WHO

* all concentration units have been converted at 0°C

3.4 Particulate matter and lead

The presence of particulate matter in the atmosphere can have an adverse effect on health and amenity. Particles lodged in the lungs can affect the respiratory system, especially if they contain adsorbed acid gases such as sulphur dioxide.

The NSW EPA adopts the US EPA 24-hour air quality standard of 150 $\mu g/m^3$ and annual average standard of 50 $\mu g/m^3$ for particles less than 10 μm (PM_{10}).

The EPA also adopts the NH&MRC's 90 $\mu g/m^3$ annual average goal for total suspended particulate matter (TSP). This level is recommended as the maximum permissible level in urban environments.

Lead is a cumulative poison which exerts its toxic effects on the kidneys, blood and central nervous system. It is now generally agreed, that while the effects are not readily discernible on an individual basis, on a population basis, lead exposure in young children can lead to an IQ deficit of between 2 to 3 points for each 10 $\mu g/dl$ increment in blood lead (EPA, 1993). As environmental lead has now emerged as a public health issue, governments in Australia have developed strategies to reduce the levels of lead exposure.

It has been estimated (ABS, 1992) that about 90% of the lead in air arises from motor vehicle emissions, apart from areas where there are significant local lead industries. However ingestion, rather than inhalation is the more significant route lead intake for young children who absorb lead very efficiently, up to 50% of ingested lead compared to 10-15% in adults. Most ingested lead is from contaminated soil and dust which children take in through exploratory hand to mouth activities. This is particularly true in older houses, where flakes from leaded house paint can accumulate in house and carpet dust, or in soil near the house. Home renovations involving the removal of leaded paints therefore present a high risk potential to young children. Some measures to reduce lead intake through ingestion include washing of children's hands and faces before meals, regular washing of outside toys and planting grass or ground cover on exposed areas of soil in the yard.

The goal for lead is 1.5 $\mu g/m^3$ (90-day average) and is currently under consideration for revision downwards. Lead emissions have not been considered in this report as it has been assumed that by 2006 the majority of motor vehicles will be fitted with catalytic converters and will therefore use unleaded petrol. Since the introduction of unleaded petrol there has been a steady and unambiguous decline in lead emissions (VEPA, 1991) and in the concentration of lead in the air in urban environment, clearly demonstrating the effectiveness of this strategy. EPA monitoring data in NSW shows the same trend. From 1986 when unleaded petrol was introduced to 1991, the lead levels in air have been reduced by a factor of two in suburban Sydney (see **Figure 3**).

3.5 Ozone

Ozone is a powerful oxidant, formed in the atmosphere in the presence of sunlight, nitrogen oxides and reactive hydrocarbons. Because of its highly reactive nature, ozone can combine with virtually all classes of biologically active molecules including enzymes, proteins and lipids. Cellular membranes are a target for ozone which has also been

reported to have an irritant effect on the respiratory system. The air quality goal at present is 257 $\mu g/m^3$ (0.12 ppm) (1-hour maximum) however it is likely to be revised downward in the near future to 0.08 ppm.

3.6 Sulphur dioxide

Sulphur dioxide is an acid gas which can have harmful effects on the respiratory system as well as on vegetation and building materials. It is however a minor component of motor vehicle emissions and has not been assessed quantitatively in this study. For example MAQS estimates that for the 1992 fleet, average SO_2 emissions under arterial travel conditions are 0.065 g/km compared to emissions of nitrogen oxides of 2.33 g/km for the same conditions. In addition transient emissions of above average levels of odorous sulphur compounds such as hydrogen sulphide and carbonyl sulphide (which may be smelt at concentrations as low as 5 ppb) have been noted from vehicles fitted with catalytic converters, While these compounds may produce a local short term nuisance, they do not represent significant emissions under normal running conditions.

4.0 DISPERSION METEOROLOGY AND AIR QUALITY ISSUES

4.1 Preamble

This section describes the dispersion meteorology, general climate and air quality in the study area. As well as information on prevailing wind patterns, historical data on temperature, humidity and rainfall are presented to give a more complete picture of the local climate. Air quality issues relating to emissions from motor vehicles are also discussed.

4.2 Meteorology

4.2.1 Wind data for Silverwater and Penrith

The closest meteorological monitoring station with data which can be considered as representative of the eastern end of the route is at Silverwater. **Figure 4** presents the seasonal and annual wind rose diagrams compiled from data collected in 1981/1982 by Macquarie University, using a Lambrecht (Model 1482) wind recorder installed at 10 m above local ground level. On an annual basis, the most frequent winds are from the W, WNW and SE. This pattern persists in spring and autumn, while in winter the winds shift more to the west. In summer there are winds from the SSE anti-clockwise to the ENE, with few winds from the north.

The closest meteorological station with data representative of wind patterns at the western end of the route is at Penrith Lakes, Data collected by Australian Water and Coastal Studies in 1990 are presented in **Figure 5**. On an annual basis most winds are from the SSW, S and SW. A similar pattern persists throughout the year although in winter the winds are more to the west and in summer more to the east.

4.2.2 Rainfall, temperature and humidity

Table 2 presents the temperature, humidity and rainfall data for Seven Hills (**Bureau of**

Meteorology, 1988). Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean and median monthly rainfall and the average number of raindays per month.

From temperature data recorded over 11 years, the annual average maximum and minimum temperatures experienced are 23.4°C and 11.3°C. The average maximum temperatures recorded were 28.3°C for the month of January and 28.2°C for December. July is the coldest month, with an average minimum temperature of 4.6°C.

The annual average humidity reading from 11 years of data collected at 9 am was 71%. The months with the highest humidity on average were June, July and May with average readings of 82%, 77% and 77%, respectively. No afternoon data were recorded.

Rainfall data collected over 37 years show that March and January are the wettest months, with mean rainfall readings of 114 mm and 112 mm, respectively. The average number of raindays for these months is 11 for March and 10 for January. The average annual rainfall is 932 mm and the average number of raindays is 109.

4.3 Air quality issues

4.3.1 Vehicle emissions and photochemical smog

Apart from local air quality impacts, motor vehicle emissions have the potential to contribute significantly to photochemical smog in an urban environment. Photochemical smog is formed by the reaction between nitrogen oxides and reactive hydrocarbons in the presence of sunlight. Models for the formation of photochemical smog envisage hydrocarbon emissions mostly from motor cars, facilities for the storage of hydrocarbons or spray painting operations and so on, mixing with nitrogen oxides from either industrial sources or from motor cars. The mixture of pollution from these sources then reacts photochemically to form photochemical smog comprising mainly ozone, but also including other oxidants. At sufficient concentrations the smog can affect the eyes and respiratory system and can adversely affect plants and materials.

Part of the aim of the Metropolitan Air Quality Study (MAQS) was to develop an airshed model which could estimate the effect of urban development options on regional air quality, particularly with respect to photochemical smog. At this stage this model is not available to be applied to this project.

TABLE 2- TEMPERATURE HUMIDITY AND RAINFALL DATA FOR SEVEN HILLS EXPERIMENTAL FARM
(Station Number 067026 Latitude 33 Deg 47 Min S Longitude 150 Deg 56 Min E Elevation 55.0 m)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Temperatures (C) and Relative Humidity (%) (11 years of record)													
Dry-bulb	22.5	22.2	20.7	17.7	13.4	10.6	9.7	12.0	15.3	18.4	20.2	22.0	17.1
Wet-bulb	18.7	19.1	17.7	15.2	11.4	9.2	7.9	9.2	11.8	14.7	16.2	18.1	14.1
Humidity	68	73	73	75	77	82	77	67	63	65	64	67	71
3 pm Mean Temperatures (C) and Mean Relative Humidity (%)													
Dry-bulb													
Wet-bulb													
Humidity													
Daily Maximum Temperature (C) (11 Years of record)													
Mean	28.3	28.1	27.0	24.3	20.2	17.5	17.6	18.8	21.5	24.0	25.8	28.2	23.4
86 Percentile	33.9	32.7	31.3	28.5	23.3	20.0	20.2	21.9	26.2	29.5	31.8	34.2	
14 Percentile	23.0	23.3	22.5	20.5	16.7	15.3	15.3	15.7	17.2	19.2	20.3	22.8	
Daily Minimum Temperature (C) (11 Years of record)													
Mean	16.9	17.1	15.3	12.2	8.3	6.4	4.6	6.2	8.2	11.6	13.5	15.7	11.3
86 Percentile	20.0	19.7	18.3	15.6	11.8	10.4	8.0	9.7	11.8	15.0	16.2	18.6	
14 Percentile	13.9	14.4	12.2	8.7	4.4	2.5	1.3	2.8	4.8	8.1	10.2	12.5	
Rainfall (mm) (37 Years of record)													
Mean	112	107	114	60	69	95	43	59	43	78	80	72	932
Median	82	94	99	38	36	58	31	36	36	56	65	49	913
Raindays (Number) (37 Years of record)													
Mean	10	11	11	8	8	9	7	8	8	11	9	9	109

Source: **Bureau of Meteorology (1988)**

4.3.2. Existing air quality

Monitoring for carbon monoxide and nitrogen oxides in the vicinity of the M4 has been undertaken by **WorkCover Authority (1993)**. Monitoring took place before and after the opening of the M4 Motorway at the locations shown in **Figure 1**. The only location relevant to the proposed upgrade is at the Emergency Bay at Pendle Hill (location B.) A summary of the data is presented in **Appendix A**.

Monitoring prior to the study showed low levels of carbon monoxide and nitrogen dioxide, up to 0.1 ppm for carbon monoxide and up to 4 pphm for nitrogen dioxide. After opening the one hour average levels of carbon monoxide were generally higher in the afternoon, with peak levels up to 20 ppm compared to the goal of 25 ppm. In general nitrogen dioxide levels were below the goal of 16 pphm, although on one occasion a level of 37 pphm was recorded, due to one very high individual peak reading of 880 pphm.

5.0 METHODS FOR ASSESSING IMPACTS

The Caline4 dispersion model has been used to estimate the concentration of oxides of nitrogen, carbon monoxide, hydrocarbons and particulate matter that are likely to be produced in the vicinity of the route.

This model is an upgrade of Caline3, the most recent US EPA approved model, and is a steady state Gaussian model which can determine concentrations at receptor locations downwind of "at grade", "fill", "bridges" and "cut section" highways located in relatively uncomplicated terrain. The model is applicable for any wind direction, highway orientation and receptor location.

Although it is technically possible to assess air quality impacts at every sensitive receptor along the route, taking account of local terrain, road grade and distance of the receptor from the road, it is neither feasible within the scope of an Environmental Impact Assessment nor indeed necessary to do so for an extended road such as the M4 Motorway. The very detailed approach is warranted when model validations are being carried out, where actual traffic counts and identification of vehicle types can be matched with contemporaneous monitoring data. Such a study which validated the Caline4 model used in this report has been undertaken in Sydney by **Williams and others (1994)** for the RTA. Other studies are being carried out currently by the RTA in a range of typical situations which frequently arise in road impact assessments.

The approach in this report has been to identify "worst" case conditions which comprise peak hour traffic flow combined with the poorest dispersion conditions, equivalent to atmospheric inversions with very light winds. The traffic flow has been assumed to be constant (at peak levels) along sections of the route, and although this is clearly a simplification, it is a reasonable approximation to what will happen in practice.

6.0 METHODS FOR ESTIMATING EMISSIONS

This section provides a brief description of the methods used to calculate the major emissions from vehicles, namely nitrogen oxides, carbon monoxide, hydrocarbons and particulate matter. This information is required as input to the dispersion models used to predict ground-level concentrations of the various pollutants.

An estimation of these emissions has been made by **Pengilley (1989)** and US EPA emission factors **(US EPA, 1985).** These data have been used in previous roadway studies, however a comprehensive emissions inventory which relates vehicle emissions to different travel conditions in NSW has now been prepared for MAQS (**Carnovale 1995**). These emission rates have been combined with traffic flow data provided by the RTA to determine air quality impacts of the proposed upgrade in 2006. **Appendix B** provides a detailed description of the calculation of vehicle emissions for 2006. It has been assumed that peak traffic flow would be in the morning.

6.1 Carbon monoxide

The way in which vehicle emissions vary with speed is fundamental to the understanding of the analysis presented in this report. The relationship between speed and carbon monoxide emission is shown in **Figure 6** where the estimated CO emission rates in the years 1988 and 2000 are presented for light duty petrol vehicles (hot start). It is assumed that approximately 30% and 96% of cars are fitted with catalytic converters in 1988 and 2000 respectively. At present about 50% of the fleet are fitted with catalytic converters and so the year 2000 assumption of 96% may be an overestimate. For cars without catalytic converters, there is a marked decrease of emissions with speed. Fitting cars with catalytic converters reduces the overall emissions and again the same pattern of decreasing emission rate with speed is observed (**Pengilley 1989, US EPA 1985**).

The emissions of CO from vehicles were determined for previous studies using the relationship. The emissions inventory prepared for MAQS takes a different approach. Although the similar principles apply in terms of the relationship between speed and emissions, the roads are divided into different categories and emissions from the mix of traffic on that type of road is determined. The categories are as follows:

Arterial	Major roads with moderate average speeds (say 20-40 km/h), moderate congestion levels (say 20% idle time) and low proportion of heavy duty vehicles (say less than 7% of total fleet vehicle kilometres travelled (VKT)).
Freeway/Highway	Major roads with relatively high average speeds (say in excess of 40 km/h), low congestion levels (say less than 5% idle time) and low proportion of heavy duty vehicles.
Commercial-Arterial	Major roads with moderate average speeds and congestion levels and moderate proportions of heavy duty vehicles (say greater than 7% of total fleet VKT).

Commercial-Highway	Major roads with relatively high average speeds, low congestion levels and moderate proportions of heavy duty vehicles.
Residential/Minor	Secondary roads with moderate average speeds, negligible levels of congestion and a very low proportion of heavy duty vehicles (say one half the arterial road level).

Emission rates for different vehicle categories and different roadway classifications have been determined. Details of these are presented in **Appendix B**.

6.2 Oxides of nitrogen

Oxides of nitrogen emissions show a different trend with speed from carbon monoxide and this is illustrated in **Figure 7**. As in the case of carbon monoxide, catalytic converters reduce the overall NO_x emission rate, however the trend with increasing speed is reversed, that is NO_x increases with increasing speed, although the effect is more gradual.
As for carbon monoxide, while the same trend remains, these emission factors have been replaced by those determined for MAQS (see **Appendix B**).

6.3 Hydrocarbons

Hydrocarbon emissions vary with speed in a similar way to carbon monoxide and have been determined for MAQS in the same way (see **Appendix B**).

6.4 Particulate matter

Particulate matter emission rates for the different road categories are presented in **Appendix B**. These comprise exhaust emissions as well as emissions from tyre and brake wear.

7.0 ESTIMATED EMISSIONS

Emission rates during peak hour for different sections of the route are estimated from the total traffic volume and the emission rate per vehicle. The estimated morning peak hour traffic flow in 2006 is summarised in **Table 3**.

TABLE 3 - ESTIMATED PEAK HOUR (AM) TRAFFIC FOR 2006

	Roadway Section	1 hour AM peak			
		Without upgrade		With upgrade	
	2006				
Section		Vehicles	Speed (km/h)	Vehicles	Speed (km/h)
1	Church Street to Coleman Street	5100	30	6180	48
2	Reservoir Road to Wallgrove Road	4670	35	4670	73
3	Wallgrove Road to Roper Road	4850	34	4850	70
4	Roper Road to Mamre Road	3230	70	3230	85
5	Mamre Road to Northern Road	3930	52	3930	81
6	Northern Road to Mulgoa Road	3400	66	3400	84

Emission estimates for the proposed road are presented in detail in **Appendix B** and are summarised in **Table 4**. Emissions were calculated for peak hour traffic in 2006 for three sections along the route, taken to represent the worst-case, namely Sections 1, 3 and 5. On the basis of traffic speed it was assumed that traffic flow on the M4 in the vicinity of Church Street changed from congested to the equivalent of arterial flow with the upgrade. The section from Wallgrove Road to Roper Road was assumed to change from congested to freeway mode and the section from Mamre Road to Northern Road was considered as changing from arterial mode to freeway mode.

TABLE 4 - ESTIMATED PEAK HOUR TRAFFIC EMISSIONS FOR 2006 (kg/km/hour)

Roadway Section			Carbon monoxide	Nitrogen oxides	HC	PM_{10}
2006						
Section 1	Church Street to Coleman Street	with upgrade	54.07	14.98	4.78	1.43
		without upgrade	50.02	12.26	4.81	1.18
Section 3	Wallgrove Road to Roper Road	with upgrade	41.34	13.68	3.85	0.64
		without upgrade	47.57	11.75	4.58	1.12
Section 5	Mamre Road to Northern Road	with upgrade	33.50	11.08	3.12	0.52
		without upgrade	34.38	9.53	3.04	0.91

8.0 PREDICTION OF AIR QUALITY EFFECTS AND ASSESSMENT OF IMPACTS

This section assesses the air quality impacts of the proposed upgrade by comparing the predicted ground-level concentrations of roadway emissions and comparing them with air quality goals or other air quality criteria where specified goals are not available. The impacts of roadway have been assessed with and without the upgrade.

Table 5 presents the maximum predicted 1-hour average increase in ground-level concentrations of carbon monoxide, hydrocarbons, nitrogen oxides, nitrogen dioxide and particulate matter at a distance 10 m from the kerb. It has been assumed that the wind is blowing at 90 degrees to the road at 0.5 m/s and that F-class stability conditions occur. It should be noted that sections of the route may include noise barriers. In the absence of information to the contrary, it has been assumed that these will not significantly affect dispersion. The RTA is currently undertaking monitoring studies to determine this.

Carbon monoxide

It can be seen from **Table 5** that the highest predicted 1-hour carbon monoxide concentration 10 m from the roadside of 4.1 mg/m^3 is along the Church Street section of the route. The predicted concentrations are the same with and without the upgrade. This is because the increased traffic flow with the upgrade is offset by the decreased emissions due to more freeflowing traffic. This value is well below the EPA's 1-hour goal of 31 mg/m_3. The average "background" level measured along the route is likely to be of the order of 2 mg/m^3. If the maximum measured level of 20 ppm or 25 mg/m^3 is added to the predicted levels due to roadway emissions the maximum total predicted carbon monoxide level is still below the 1-hour air quality goal. Adding the maximum measured level to the maximum predicted level is of course a very cofservative approach and involves a large element of double-counting. It should be noted that the predicted carbon monoxide levels in 2006 are below the measured levels in 1992. This is due to the improved control technology with which most of the fleet will be equipped in 2006.

TABLE 5- PREDICTED INCREASE IN 1-HOUR AVERAGE GROUND-LEVEL CONCENTRATIONS OF VEHICLE EMISSIONS 10 m FROM KERB IN 2006

Roadway Section		Carbon monoxide (mg/m^3)	Nitrogen oxides (μg/m^3)	Nitrogen dioxide (μg/m^3)	HC (mg/m^3)	PM_{10} (μg/m^3)
2006						
Church Street to Coleman Street	with upgrade	4.1	1132	226	0.36	108
	without upgrade	4.1	1020	202	0.39	96
Wallgrove Road to Roper Road	with upgrade	3.0	988	198	0.28	46
	without upgrade	3.8	923	185	0.36	89
Mamre Road to Northern Road	with upgrade	2.5	818	164	0.23	38
	without upgrade	2.8	772	154	0.25	74

* Assumed to be 20% by weight of total nitrogen oxides

Nitrogen dioxide

Estimating nitrogen dioxide concentrations is more complicated than estimating carbon monoxide concentrations. Nitrogen oxides are initially emitted as a mixture of nitric oxide and other oxides of nitrogen, which are rapidly oxidised to nitrogen dioxide. At the point of emission the mixture is generally about 5% nitrogen dioxide by mass. At ten metres from the road the nitrogen oxides would be unlikely to contain more than twenty per cent (by mass) nitrogen dioxide. It is estimated (**WHO, 1987**) that 50% conversion of nitric oxide would take place in less than one minute at a nitric oxide concentration of 188 $\mu g/m^3$ (0.1 ppm) in the presence of ozone at a concentration of 200 $\mu g/m^3$ (0.1 ppm), which is a mid to high ozone concentration for Sydney. For a very light 0.5 m/s wind the exhaust emission from a vehicle would have travelled 30 m in this time under the specified conditions. In practice "high" concentrations of nitrogen oxides are associated with low ratios of nitrogen dioxide and vice versa. The rapid dilution due to dispersion more than counteracts the increase of proportion of nitrogen oxides in the form of nitrogen dioxide with time.

It is considered that 20% is a conservative estimate for the ratio (by mass) of nitrogen dioxide to nitrogen oxides. With this assumption the maximum 1-hour nitrogen dioxide concentration at 10 m from the roadway is predicted to be 226 $\mu g/m^3$. This is below the EPA goal of 328 $\mu g/m^3$. The predicted level is predicted to occur along the Church Street section. Monitoring studies of NO_2 levels in the Sydney (**Stephenson, 1992** and **Rust PPK, 1995**) indicate that it is reasonable to assume "background" levels of the order of 60 $\mu g/m^3$. Adding this level to the maximum predicted NO_2 levels, would result not in exceedances of the air quality goal at 10 m from the roadway. It should be noted also that these predictions assume "worst-case" conditions. They also do not take into account fully the benefits of three-way catalytic converters which are fitted to all new passenger vehicles in Australia and which substantially reduce NO_x emissions.

Hydrocarbons

Hydrocarbon concentrations are no longer specified in the EPA's air quality goals. This is largely due to the fact that a simple hydrocarbon concentration goal is now recognised as not being useful for the purposes of assessing health impacts or identifying the need for air quality management requirements. More detailed information on specific hydrocarbons is required. As noted in **Section 3.3** hydrocarbons, in particular those associated with motor vehicles are a common contaminant of urban atmospheres and have been for many years. Emission controls on Australian cars and equivalents since 1978 have resulted in a considerable reduction in both evaporative and exhaust emissions of hydrocarbons.

One of the components of hydrocarbons that has become a concern in the community is benzene, which is a known carcinogen (**WHO 1987**). **Appendix C** (data from **Nelson and Quigley, 1982**) shows an analysis of the hydrocarbon content of fuel and exhaust. It can be seen that benzene is a component of petrol comprising approximately 2.6%. It can also be seen that the percentage of benzene (by mass) in vehicle exhausts was approximately 5% (note these data relate to leaded petrol, but there has not been any substantial change in the benzene content with the introduction of unleaded petrol).

The Victorian EPA 3-minute design ground-level concentration for benzene is 0.10 mg/m^3 (0.033 ppm), but this goal explicitly excludes petrol and liquid mixtures containing 1% or less of benzene.

From **Table 5** the predicted maximum 1-hour increases of total hydrocarbons for the upgrade is of the order of 0.36 mg/m^3 at 10 m from the kerb along the Church Street section. Assuming a 5% benzene composition in the exhaust the benzene concentration at 10 m from the kerb would be approximately 0.018 mg/m^3 or 18 μg/m^3 (1-hour average), under unfavourable dispersion and with peak traffic flows. This is approximately 18% of the Victorian EPA design 3-minute goal, which as noted before specifically excludes petrol, and is just above the proposed UK goal of 15 μg/m^3, which relates to longterm exposure. Concentrations would of course be substantially lower at the locations of residences. It is nevertheless recognised that there may be no safe limit for residents to benzene, but the risks to a particular individual over a lifetime is small and on a population and individual basis would be offset by lower risks through safer roads.

Particulate matter

The predicted levels of PM_{10} are for 1-hour averaging periods however the air quality goal refers to a 24-hour period. Considering the 1-hour predictions as equivalent to a 24-hour value is a cofservative approach (that is an over-prediction) as the maximum predicted 1-hour average will always be higher than the predicted 24-hour average.

The predicted increases in PM_{10} at 10 m from the kerb are less than 110 μg/m^3 for all cases even under the worst-case dispersion condition combined with peak traffic flow. Concentrations over a 24-hour period would be substantially less and concentrations at sites further removed from the road would again be further reduced. The emissions from the road would be unlikely to cause the PM_{10} goal of 150 μg/m^3 (24-hour average) or the 50 μg/m^3 annual average goal to be exceeded. Similarly the NH&MRC 90 μg/m^3 (annual average) TSP goal is unlikely to be exceeded.

Average background PM_{10} levels are likely to be in the range 15-30 μg/m^3. Adding this level to the predicted 1-hour level of 108 μg/m^3 at the Church Street section gives a very conservative estimate of 138 μg/m^3 for the 24-hour PM_{10} kerbside concentration, which is nevertheless still below the 24-hour air quality goal.

Effect of increased growth

For the purposes of the above assessment, a growth rate of 2% has been used. If a growth rate of 3% is assumed, this would result in an increase in traffic volume of 11% by 2006. Increasing all the emissions by 11% would still not result in exceedances of air quality goals, although it would put the nitrogen dioxide and PM_{10} close to the goal.

Construction Impacts

Dust will be generated from earthworks associated with the construction of the new road. The total amount of dust generated will depend on the silt and moisture content of the soil and the types of operations being carried out.

Estimates of dust emissions from construction operations can be made using emission factors developed by the **SPPC (1983)** and the **US EPA (1981)**. These emission factors relate the amount of dust generated by different types of equipment and operations

associated with construction work. The most likely equipment to be used in the project includes dozers, back hoes, rollers, scrapers, excavators, pavers, concrete trucks, mobile cranes, truck-mounted boring rig, jackhammers and haul trucks. The major sources of dust will be the dozers, excavators, scrapers and wind erosion. An estimate of the amount of dust generated by each operation per day is summarised below:

- Three dozers, assuming ten-hours of operation per day generating dust at the rate of 2.75 kg/h, would give a total of 82.5 kg/day.

- Dust from loading of material by excavator to trucks assuming dust is generated at the rate of 0.01 kg/t and that 50 x 15 cubic metre trucks loads are removed in a ten-hour day, making a total of approximately 750 m^3 or approximately 1125 t of material removed per day gives a total of 11.25 kg/day.

- Scrapers generate dust at a rate of between 3 to 9 kg/kilometre of travel depending on soil silt content, soil moisture and the weight of the scraper. Watering the travelling surface would reduce this emission by between 50 and 80%. A scraper working for ten hours could be expected to travel approximately 70 to 100 km. Taking account of laden and unladen trips and 50% dust control the scraper would be expected to generate up to 300 kg of dust in a working day. With intensive watering of the travelling surface this could be reduced to 120 kg/day per scraper. A total of three scrapers would give 360 kg/day.

- Dust from trucks travelling on the unsealed road surface assuming a 400 m round trip distance, five movements per hour and 2 kg of dust/vehicle/km (after taking account of dust suppression by watering of the trafficked areas) would generate 40 kg during a ten-hour working shift.

- Dust from wind erosion from an exposed area of 200 m long by 30 m wide (the exposed area will be greater than this but the area which could contribute significant amounts of dust to a particular residence would be unlikely to be larger) assuming an erosion rate of 0.4 kg/ha/hour gives a total of 2.4 kg in ten hours.

Thus the total dust generated in a ten-hour working day would be expected to be approximately 500 kg. On a hot, dry, windy day the amount of dust from wind erosion could be much higher, and would have to be controlled using water sprays. It is possible that under some extreme wind conditions, construction activities would be stopped.

The appropriate air quality goal for determining impacts from construction work is the EPA 24-hour goal for PM_{10}. This is approximately equivalent to the former EPA 24-hour goal of 260 $\mu g/m^3$ for total suspended particulate matter (TSP). It is still useful to refer to this goal as historical measurements are for TSP.

Previous dispersion modelling studies (**Stephenson, 1991**) indicate that this level of dust generation associated with road construction work can under "worst-case" meteorological conditions result in short-term dust impacts, that is exceedances of the 24-hour air quality

goal for TSP, out to 600 m or more under "worst-case" dispersion conditions and out to 300 m for typical conditions. As construction is likely to continue for several years, it is important that exposed areas be stabilised as quickly as possible and that appropriate dust suppression methods be used to keep impacts to a minimum.

Greenhouse Issues

The temperature of the earth's atmosphere is determined by the balance between incoming solar radiation and the loss of heat energy by radiation from the earth and atmosphere to outer space. This balance is in turn affected by a complex set of processes, acting on a global scale, which control the way in which heat is transported around the earth by winds and ocean currents, and by the quantities of energy that are reflected and absorbed by the earth's surface. While the broad principles of the way in which these processes work to control the temperature of the earth's atmosphere are understood, the details, which may well be very important in determining the final temperature that is achieved at the earth's surface, are still the subject of scientific research.

One of the important factors in determining the amount of radiant energy absorbed in the atmosphere is the concentration of carbon dioxide. Changes in this concentration are likely to cause changes in the temperature of the earth's atmosphere near the earth's surface. Increases in carbon dioxide concentration are expected to cause increases in temperature.

Australia is signatory to the "International Frame-work Convention on Climate Change" (Rio Convention), which commits Australia to programs of monitoring and reporting on greenhouse gas emissions. A target of the Rio Convention is that signatory countries should attempt to reduce greenhouse gas emissions to the levels that applied in 1990.

The RTA is committed to ensuring that its environmental goals and policies are consistent with those outlined in the 1992 Intergovernmental Agreement on the Environment. This agreement addresses a number of globally important environmental issues including the greenhouse effect. This commitment is facilitated through the RTA's environmental vision which addresses greenhouse gas emissions and also energy consumption.

Approximately one quarter of NSW's total carbon dioxide emissions came from the transport sector (NSW Office of Energy and ANZECC - 1991 data). At a broad level, the RTA has been involved in and implemented several strategic initiatives to address the issue of road transport related greenhouse gas emissions. These are:

* National Greenhouse Response Strategy

  This strategy was adopted by the Council of Australian Governments in 1992 and aims to contribute to the national commitment to the National Strategy for Ecologically Sustainable Development. The RTA contributed to the development of this strategy and is the NSW representative on the Transport Working Group for the development of a greenhouse gas emissions inventory. With respect to transport, the response strategies include reducing fuel consumption in motorised transport; improving the technical and economic efficiency of operation of the road network and traffic management; and to encourage the use of bicycles. This proposal contributes to these initiatives.

* RTA Greenhouse Plan

  The RTA is in the process of preparing a plan at a strategic level to address and provide policy guidelines in relation to greenhouse gas emissions resulting from its road building activities. When this plan is developed, the RTA would incorporate any relevant measures into this proposal to assist in mitigating the impacts of greenhouse gas emissions.

Emissions of carbon dioxide from motor vehicles are directly proportional to fuel consumption. They cannot be reduced by emission control technologies except where they result in an improvement in fuel consumption. RTA programs which encourage better vehicle maintenance and hence better fuel economy will be beneficial.

In terms of the contribution of the proposed M4 Motorway upgrade to greenhouse emissions, the development is likely to result in lowered emissions due to improved traffic flow.

9.0 CONCLUSIONS

The air quality studies undertaken for this EIS are summarised below.

1. The present emission controls on motor vehicles and the projected traffic conditions for the year 2006 are not expected to exceed the EPA's carbon monoxide 1-hour or 8-hour goals for any section of the route.

2. The PM_{10} annual and 24-hour maximum air quality goals are not predicted to be exceeded by the road development.

3. The predicted concentration of nitrogen dioxide indicate that the EPA's goals will not be exceeded at residences but will be close to the goals at the kerbside if 3% growth is assumed.

As discussed earlier, the introduction of catalytic converters has resulted in a substantial reduction in carbon monoxide and hydrocarbon emissions from motor vehicles. This is also true for nitrogen oxides, as all new passenger vehicles are fitted with three-way catalytic converters which reduce nitrogen oxide emissions. However the increased speed on upgraded roads results in increased nitrogen oxide emissions and this has offset to some extent the gains from the improved technology.

For the roadway under consideration here, no exceedances of air quality goals are predicted at nearby sensitive receptors. However the general issue of controls on nitrogen oxides and particulate emissions is being addressed by the Environmental Management Plan for the Sydney region which is currently being developed from information provided by MAQS.

In addition the RTA is developing strategies to help reduce greenhouse and other vehicle emissions. These include the strategies outlined in **Section 8** and additional approaches including:

- o emission controls though the development of new Australian Design Rules for motor vehicles;

- o working with the EPA to implement the State's Motor Vehicle Maintenance Program for lowering emissions;

- o carrying out a series of monitoring studies to improve roadway air quality models with the view to better planning decisions.

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APPENDIX A
SUMMARY OF WORKCOVER MONITORING REPORT

TABLE 1 - CARBON MONOXIDE COMPARISON
1 HOUR MAXIMUM LEVELS
M4 TOLLWAY

		PRE		1 MONTH		6 MONTHS	
	TIME	DATE	PPM	DATE	PPM	DATE	PPM
	AM	10/04/92	1.4 - 2.3	05/06/92	nd - 1.0	18/11/92	nd - 0.1
		13/04/92	0.3 - 2.3	12/06/92	nd	14/12/92	nd - <0.1
SITE 4A		24/04/92	0.2 - 0.7	13/07/92	nd	15/12/92	0.1 - 0.9
RESIDENTIAL	PM	10/04/92	0.4 - 2.5	05/06/92	nd - 0.1	18/11/92	nd - 1.0
		13/04/92	nd	12/06/92	nd - <0.1	14/12/92	0.1 - 1.0
		15/04/92	nd - 0.1	13/07/92	nd - 0.1	15/12/92	0.2 - 0.3
	AM	10/04/92	1.3 - 4.1	05/06/92	1.4 - 2.7	18/11/92	2.2 - 8.9
		13/04/92	3.9 - 7.7	12/06/92	1.6 - 2.5	14/12/92	1.3 - 4.8
SITE 4A		24/04/92	0.7 - 2.4	13/07/92	0.5 - 1.2	15/12/92	nd - 0.3
HIGHWAY	PM	10/04/92	7.8 - 14	05/06/92	2.5 - 9.5	18/11/92	nd - <0.1
		13/04/92	5.1 - 11	12/06/92	1.5 - 5.2	14/12/92	0.6 - 1.1
		15/04/92	13 - 16	13/07/92	2.1 - 6.8	15/12/92	0.8 - 1.5
	AM	03/04/92	nd - <0.1	01/06/92	4.5 - 5.6	08/02/93	2.7 - 4.8
		06/04/92	nd - <0.1	19/06/92	3.4 - 4.0	03/02/93	5.9 - 6.6
SITE 4B		08/04/92	nd - <0.1	24/06/92	8.6 - 11	05/02/93	nd - 1.1
	PM	03/04/92	nd	01/06/92	8.7 - 20	08/02/93	5.4 - 9.8
		06/04/92	nd - <0.1	19/06/92	4.4 - 17	03/02/93	7.4 - 8.7
		08/04/92	nd - <0.1	24/06/92	3.7 - 7.0	05/02/93	3.4 - 5.1
	AM	01/04/92	0.1 - 0.5	10/06/92	1.5 - 3.0	30/11/92	2.4 - 3.8
		03/04/92	0.4 - 1.1	24/06/92	<0.1 - 2.7	11/12/92	2.1 - 3.4
SITE 4C		06/04/92	0.9 - 2.5	28/08/92	2.4 - 6.2	10/02/93	nd - 0.1
	PM	06/04/92	nd - <0.1	24/06/92	2.3 - 3.7	30/11/92	1.7 - 5.6
		03/04/92	nd - 0.1	14/08/92	0.8 - 4.2	11/12/92	0.6 - 1.5
		06/04/92	nd	28/08/92	3.1 - 3.9	10/02/93	1.0 - 2.5
	AM	23/03/92	1.3 - 2.4	10/06/92	nd - 0.6	30/11/92	2.2 - 3.1
		27/03/92	2.6 - 3.9	22/06/92	0.2 - 0.5	11/12/92	1.2 - 2.1
SITE 4D		31/03/92	5.1 - 6.1	14/08/92	0.1 - 0.4	10/02/93	nd
	PM	23/03/92	nd - 0.2	01/06/92	nd - 1.3	30/11/92	0.5 - 1.6
		27/03/92	nd	22/06/92	nd - 1.0	11/12/92	nd - 0.1
		31/03/92	0.2 - 0.8	14/08/92	1.4 - 2.0	10/02/93	nd

nd - nil detected < - means less than

SOURCE : WORKCOVER AUTHORITY, "F4 TOLLROAD BEFORE AND AFTER AIR QUALITY STUDY SIX MONTHS AFTER OPENING"

TABLE 2 - NITROGEN DIOXIDE COMPARISON
1 HOUR MAXIMUM LEVELS
M4 TOLLWAY

		PRE		1 MONTH		6 MONTHS	
	TIME	DATE	PPHM	DATE	PPHM	DATE	PPHM
	AM	10/04/92	nd	05/06/92	nd	18/11/92	nd
		13/04/92	nd	12/06/92	nd	14/12/92	nd
SITE 4A		24/04/92	nd	13/07/92	nd	15/12/92	nd
RESIDENTIAL	PM	10/04/92	nd	05/06/92	nd	18/11/92	nd
		13/04/92	nd	12/06/92	nd	14/12/92	nd
		15/04/92	nd - 0.3	13/07/92	nd	15/12/92	nd
	AM	10/04/92	nd - 2	05/06/92	nd	18/11/92	nd
		13/04/92	0.7 - 2	12/06/92	nd	14/12/92	nd - 2
SITE 4A		24/04/92	0.2 - 2	13/07/92	nd	15/12/92	nd
HIGHWAY	PM	10/04/92	0.2 - 11	05/06/92	nd - 3	18/11/92	nd
		13/04/92	0.3 - 5	12/06/92	nd - 0.1	14/12/92	nd
		15/04/92	00.5 - 6	13/07/92	nd - 0.5	15/12/92	nd
	AM	03/04/92	nd - 0.1	01/06/92	nd	08/02/93	nd - 0.1
		06/04/92	nd - 0.1	19/06/92	0.1 - 0.2	03/02/93	nd - 0.2
SITE 4B		08/04/92	nd - 0.1	24/06/92	1 - 4	05/02/93	nd - 7
	PM	03/04/92	nd	01/06/92	nd - 0.4	08/02/93	nd - 1
		06/04/92	0.3 - 4	19/06/92	nd - 37	03/02/93	0.1 - 0.2
		08/04/92	nd - 0.1	24/06/92	2 - 14	05/02/93	0.1 - 1
	AM	01/04/92	nd	10/06/92	nd - 0.2	30/11/92	nd
		03/04/92	nd - 0.3	24/06/92	nd	11/12/92	nd
SITE 4C		06/04/92	nd - 0.5	28/06/92	nd	10/02/93	nd - 0.1
	PM	08/04/92	0.1 - 1	24/06/92	nd - 0.8	30/11/92	nd
		03/04/92	nd - 0.2	14/08/92	nd	11/12/92	nd - 0.4
		06/04/92	nd - 0.1	28/08/92	nd	10/02/93	nd
	AM	23.03/92	nd	10/06/92	nd	30/11/92	nd
		27/03/92	nd	22/06/92	nd	11/12/92	nd - 0.3
SITE 4D		31/03/92	nd - 0.2	14/08/92	nd - 1	10/02/93	nd
	PM	23/03/92	nd - 0.1	01/06/92	nd	30/11/92	nd - 0.2
		27/03/92	nd - 0.1	22/06/92	nd - 0.5	11/12/92	nd
		31/03/92	nd - 2	14/08/92	nd - 0.2	10/02/93	nd

nd - nil detected < - means less than

SOURCE : WORKCOVER AUTHORITY, "F4 TOLLROAD BEFORE AND AFTER AIR QUALITY STUDY SIX MONTHS AFTER OPENING"

APPENDIX B

VEHICLE EMISSION FACTORS

The emissions from vehicles on NSW roads were assumed to all fit into three classes:

1. Light duty petrol vehicles (LDPV)
2. Heavy duty petrol vehicles (HDPV)
3. Heavy duty diesel vehicles (HDDV)

These classes of vehicles account for more than 99% of all vehicle kilometres travelled on Sydney's roads (**Pengilley 1989**). The following assumptions were made regarding the vehicles in the year 2006:

* 100% of petrol vehicles were using catalytic converters as emission control in 2006

* Of the heavy vehicles category, 90% are considered to be HDDV and 29% are considered to be HDPV.

The emissions of CO, NO_x, HC and particulate matter were taken from estimates in the Sydney Metropolitan Air Quality Study (MAQS). The roadway assignments were made on the basis of traffic speeds and are indicated in the tables which follow. It was also assumed that the deterioration of catalytic converters was as in the 1992 MAQS estimates of passenger vehicle emission rates.

The emission of particulate matter from vehicles is made up of lead salts, organic and sulphate components. The total emissions comprise exhaust emission plus airborne brake wear particulate emission and airborne tyre wear particulate emissions. In the case of passenger vehicles, the PM_{10} fraction comprises 74% of the total particulate exhaust emissions. The PM_{10} fraction of HDDV and HDPV particulate exhaust emissions is 100% and 64% respectively. Brake and tyre emissions are assumed to be essentially all PM_{10}.

Calculation of vehicle emission rates

Details of emission calculations for the route sections at peak hour for 2006 are presented in the following tables.

Emission rates for CO, NO_x, hydrocarbons (HC) and particulate matter corresponding to the to a given section of the route are presented for each class of vehicle and expressed as g/km/vehicle. The total emissions (tot CO etc) during the peak period have been calculated by multiplying the emission rate by the total number of vehicles estimated to be using the road in the one hour peak period. These values are expressed as g/km/h. Finally these values have been converted to kg/km/h and g/vehicle mile (the latter is used as input to the model).

M4 Upgrade 2006 Emissions

Section	Church Street to Coleman Street with upgrade									
Arterial			Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		6180.00								PM10
total heavy		618.00								
LDPV		5562.00	7.58	1.07	0.51	0.037	42159.96	5951.34	2836.62	205.79
HDDV		556.20	8.01	15.72	2.80	2.090	4455.16	8743.46	1557.36	1162.46
HDPV		61.80	120.62	4.59	6.30	0.147	7454.32	283.66	389.34	9.08
Brake & Tyre						0.009				55.62
Total kg/km/h							54.07	14.98	4.78	1.43
g/v-mi							14.00	3.88	1.24	0.37
Section	Church Street to Coleman Street without upgrade									
Arterial congested			Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		5100.00								PM10
total heavy		510.00								
LDPV		4590.00	8.35	1.07	0.60	0.037	38326.50	4911.30	2754.00	169.83
HDDV		459.00	9.53	15.72	3.59	2.090	4374.27	7215.48	1647.81	959.31
HDPV		51.00	143.49	4.59	8.08	0.147	7317.99	234.09	412.08	7.50
Brake & Tyre						0.009				45.90
Total kg/km/h							50.02	12.36	4.81	1.18
g/v-mi							15.69	3.88	1.51	0.37
Section	Wallgrove Road to Roper Road with upgrade									
Freeway			Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		4850.00								PM10
total heavy		485.00								
LDPV		4365.00	7.57	1.51	0.56	0.021	33043.05	6591.15	2444.40	91.67
HDDV		436.50	7.11	15.72	2.58	1.150	3103.52	6861.78	1126.17	501.98
HDPV		48.50	107.09	4.59	5.82	0.081	5193.87	222.62	282.27	3.93
Brake & Tyre						0.009				43.65
Total kg/km/h							41.34	13.68	3.85	0.64
g/v-mi							13.64	4.51	1.27	0.21
Section	Wallgrove Road to Roper Road without upgrade									
Arterial congested			Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		4850.00								PM10
total heavy		485.00								
LDPV		4365.00	8.35	1.07	0.60	0.037	36447.75	4670.55	2619.00	161.51
HDDV		436.50	9.53	15.72	3.59	2.090	4159.85	6861.78	1567.04	912.29
HDPV		48.50	143.49	4.59	8.08	0.147	6959.27	222.62	391.88	7.13
Brake & Tyre						0.009				43.65
Total kg/km/h							47.57	11.75	4.58	1.12
g/v-mi							15.69	3.88	1.51	0.37

M4 Upgrade 2006 Emissions

Section	Mamre Road to Northern Road with upgrade								
Freeway			Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		3930.00								PM10
total heavy		393.00								
LDPV		3537.00	7.57	1.51	0.56	0.021	26775.09	5340.87	1980.72	74.28
HDDV		353.70	7.11	15.72	2.58	1.150	2514.81	5560.16	912.55	406.76
HDPV		39.30	107.09	4.59	5.82	0.081	4208.64	180.39	228.73	3.18
Brake & Tyre						0.009				35.37
Total kg/km/h							33.50	11.08	3.12	0.52
g/v-mi							13.64	4.51	1.27	0.21
Section	Mamre Road to Northern Road without upgrade									
Arterial			Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		3930.00								PM10
total heavy		393.00								
LDPV		3537.00	7.58	1.07	0.51	0.037	26810.46	3784.59	1803.87	130.87
HDDV		353.70	8.01	15.72	2.80	2.090	2833.14	5560.16	990.36	739.23
HDPV		39.30	120.62	4.59	6.30	0.147	4740.37	180.39	247.59	5.78
Brake & Tyre						0.009				35.37
Total kg/km/hr							34.38	9.53	3.04	0.91
g/v-mi							14.00	3.88	1.24	0.37

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LOCATIONS OF IDENTIFYING FEATURES ALONG THE M4 CHURCH STREET TO WALLGROVE ROAD

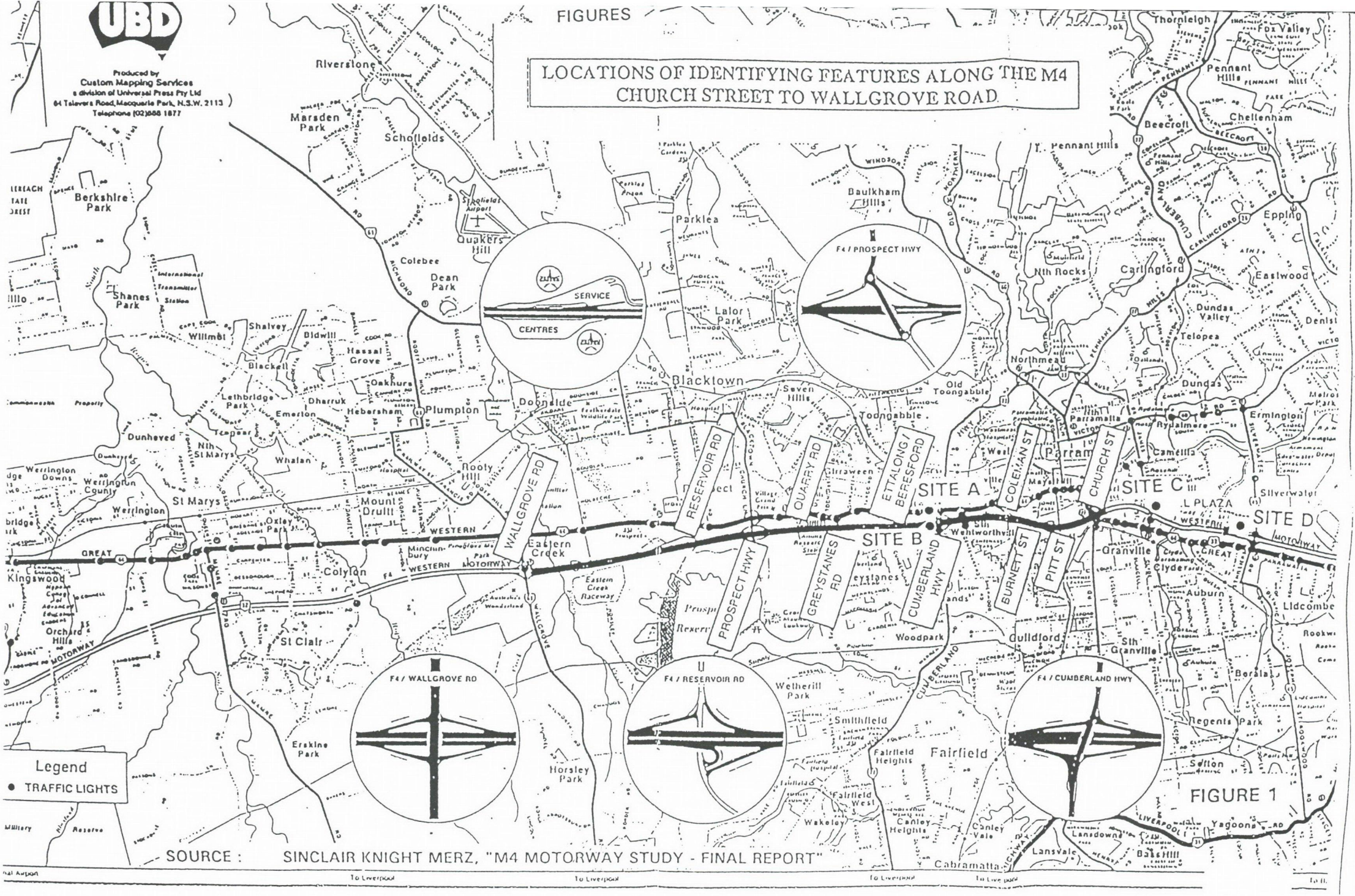
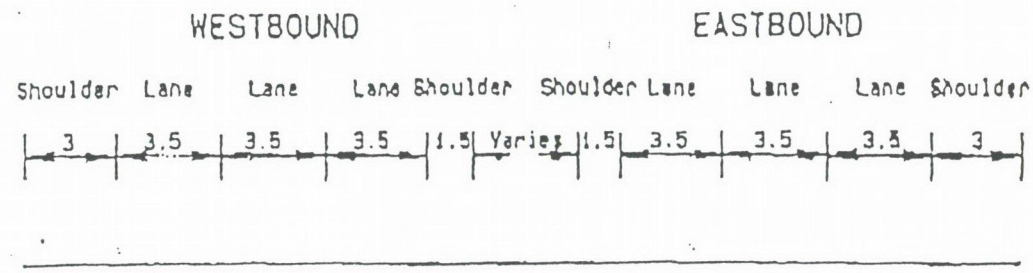
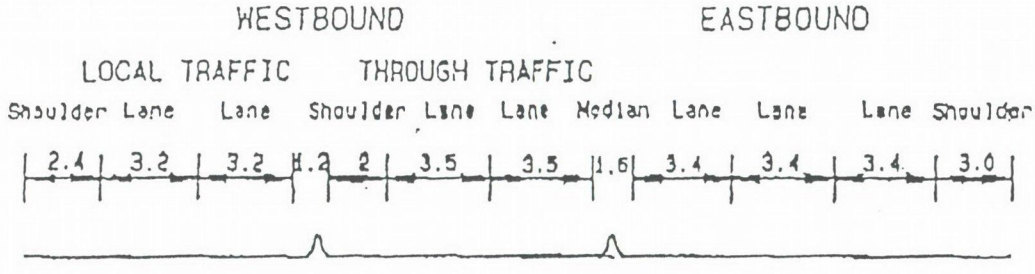


FIGURE 1

SOURCE : SINCLAIR KNIGHT MERZ, "M4 MOTORWAY STUDY - FINAL REPORT"



PROSPECT to MULGOA ROAD



CHURCH ST TO COLEMAN ST

M4 UPGRADING PROJECT
PROPOSED TYPICAL CROSS SECTIONS

FIGURE 2

LEAD LEVELS - SYDNEY SUBURBS
(MONTHLY AVERAGES - ROZELLE & LANE COVE)

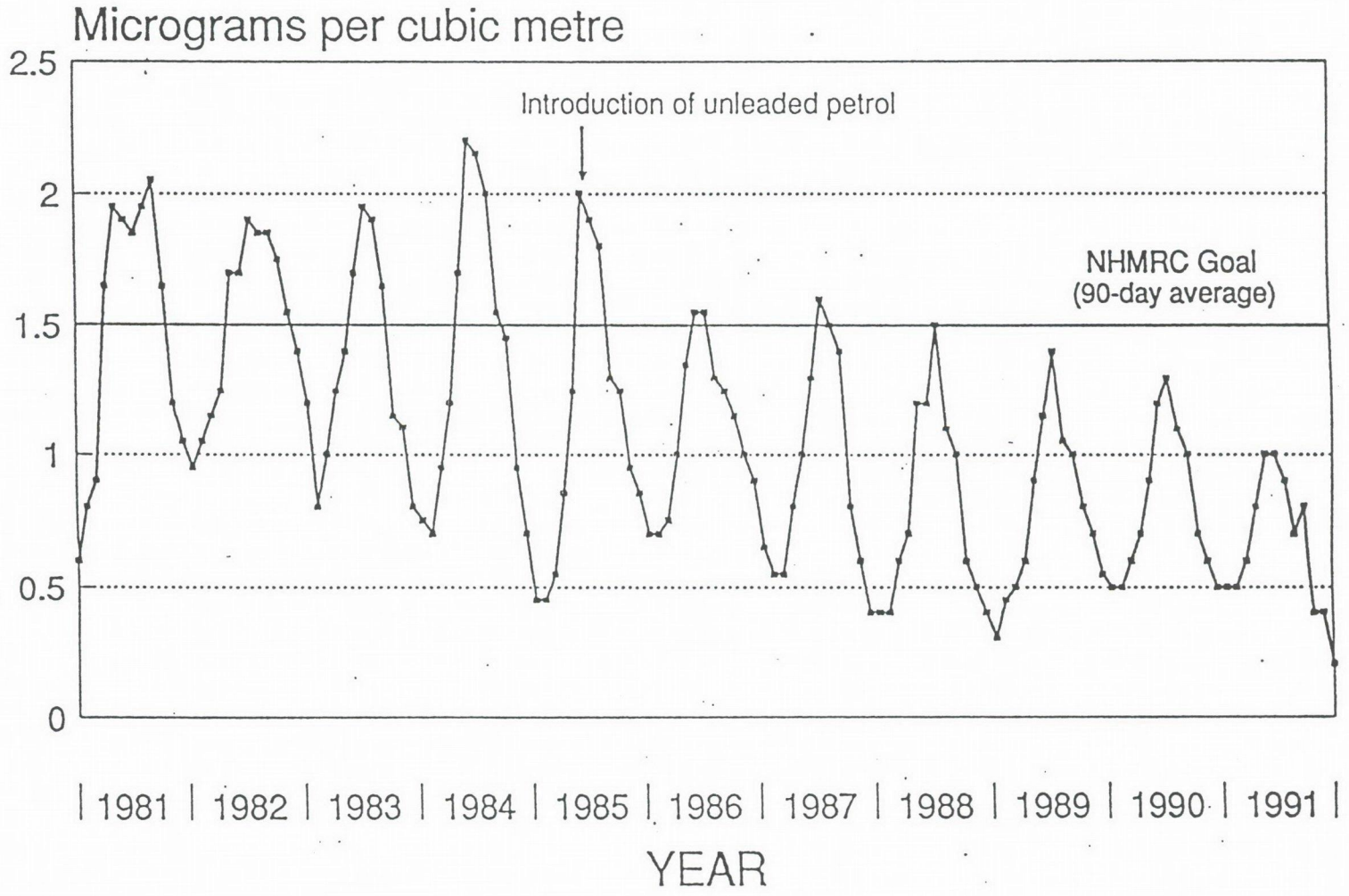
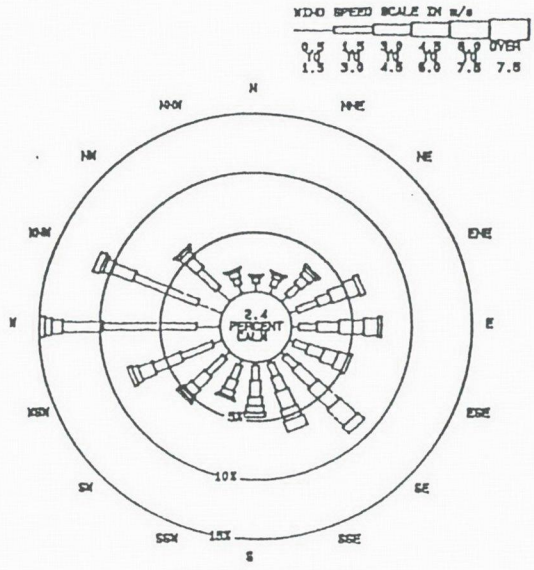
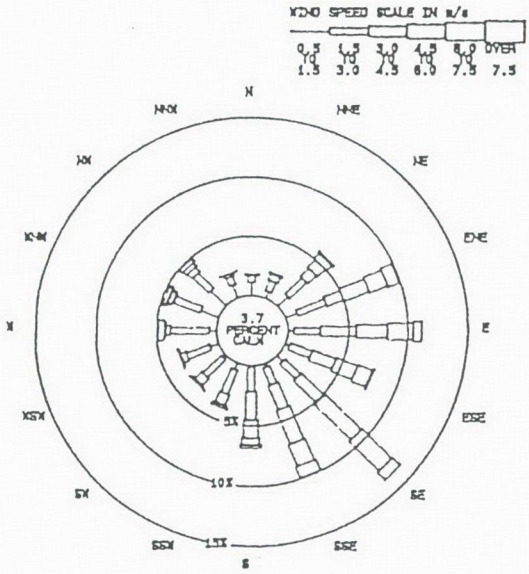


FIGURE 3

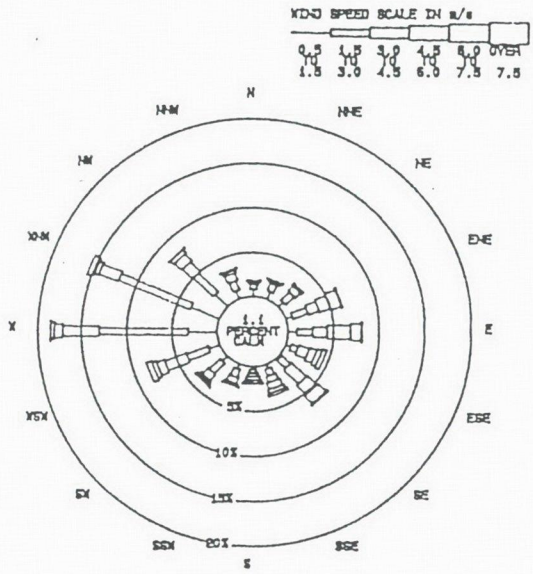
ANNUAL AND SEASONAL WINDROSES FOR SILVERWATER (1981/82)



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Silverwater 1981/82 Composite Annual



DISTHIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Silverwater 1981/82 Composite - Summer



DISTRIBUTION OF WINDS
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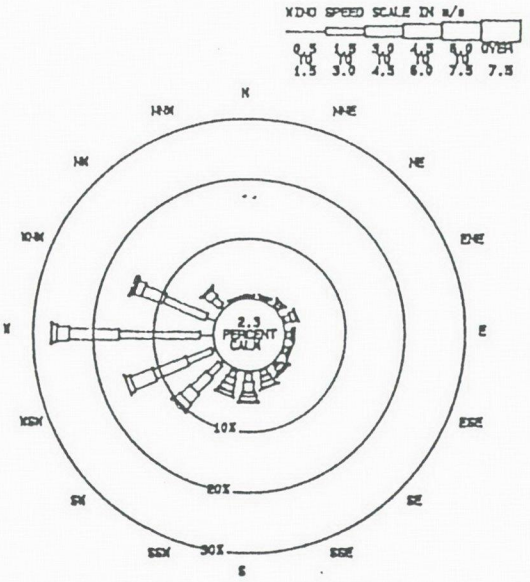
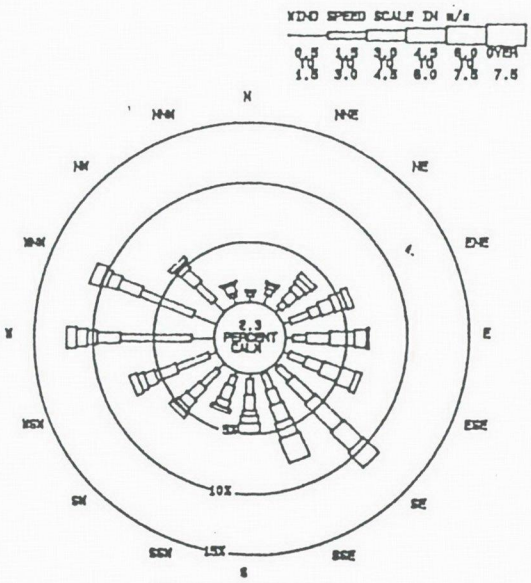
Silverwater 1981/82 Composite - Autumn



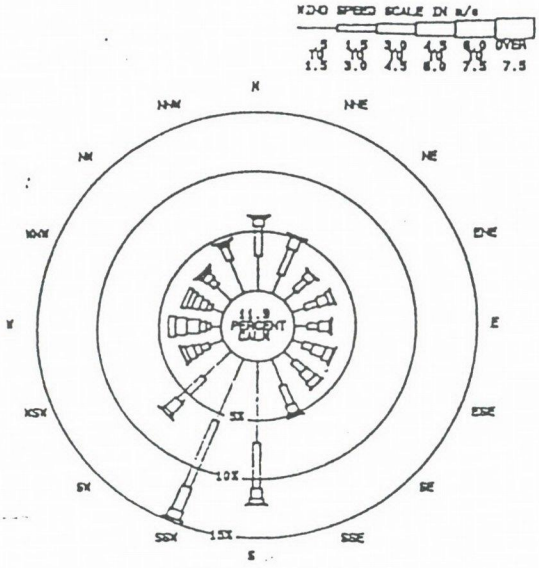
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Silverwater 1981/82 Composite - Winter



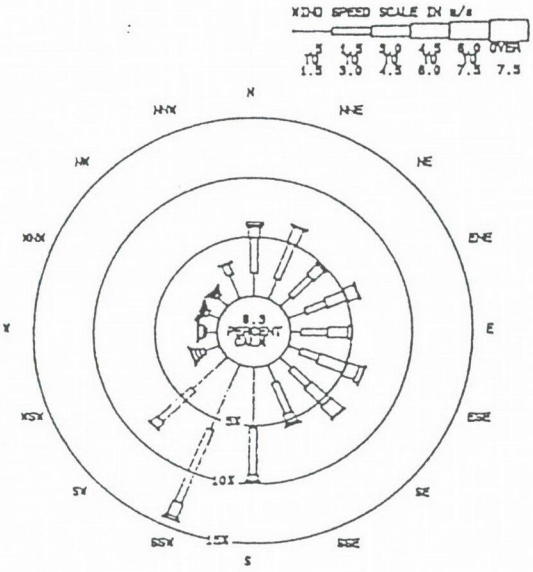
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Silverwater 1981/82 Composite - Spring

FIGURE 4

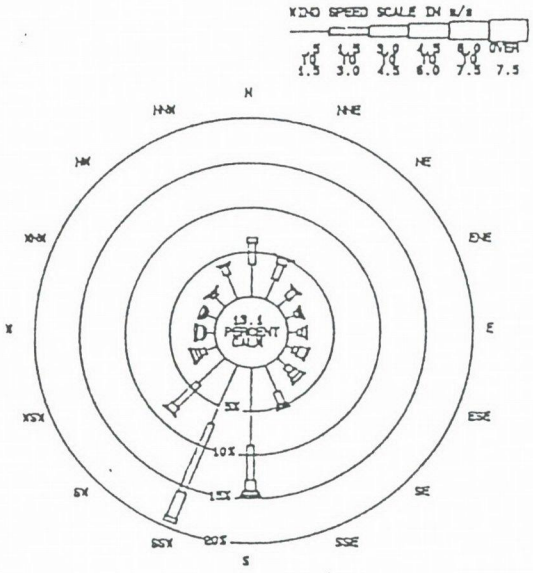
ANNUAL AND SEASONAL WINDROSES DOR PENRITH (1990)



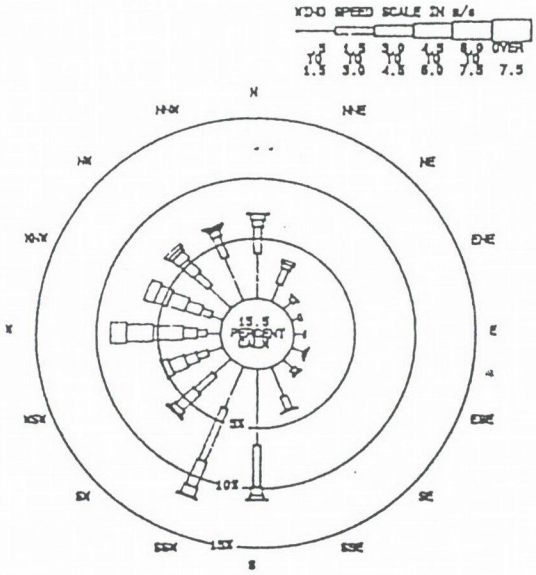
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Penrith 1990



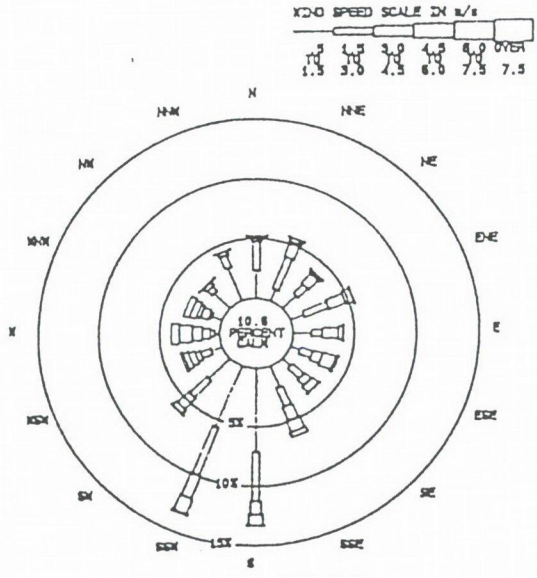
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Penrith 1990 - Summer



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Penrith 1990 - Autumn



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Penrith 1990 - Winter



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Penrith 1990 - Spring

FIGURE 5

EMISSION RATE OF CO vs SPEED FOR LIGHT DUTY PETROL VEHICLES - YEARS 1988 AND 2000

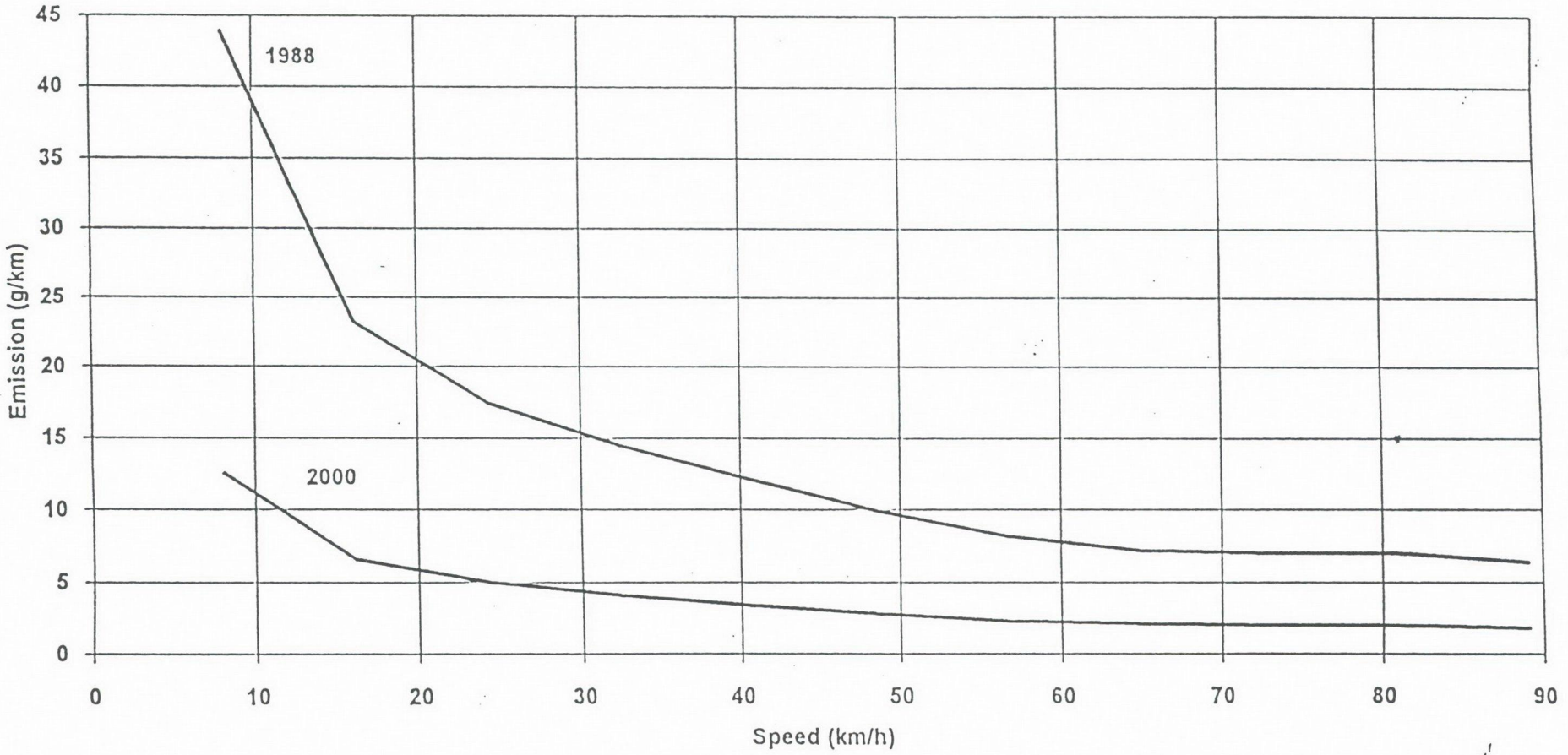


FIGURE 6

EMISSION RATE OF NOx vs SPEED FOR LIGHT DUTY PETROL VEHICLES - YEARS 1988 AND 2000

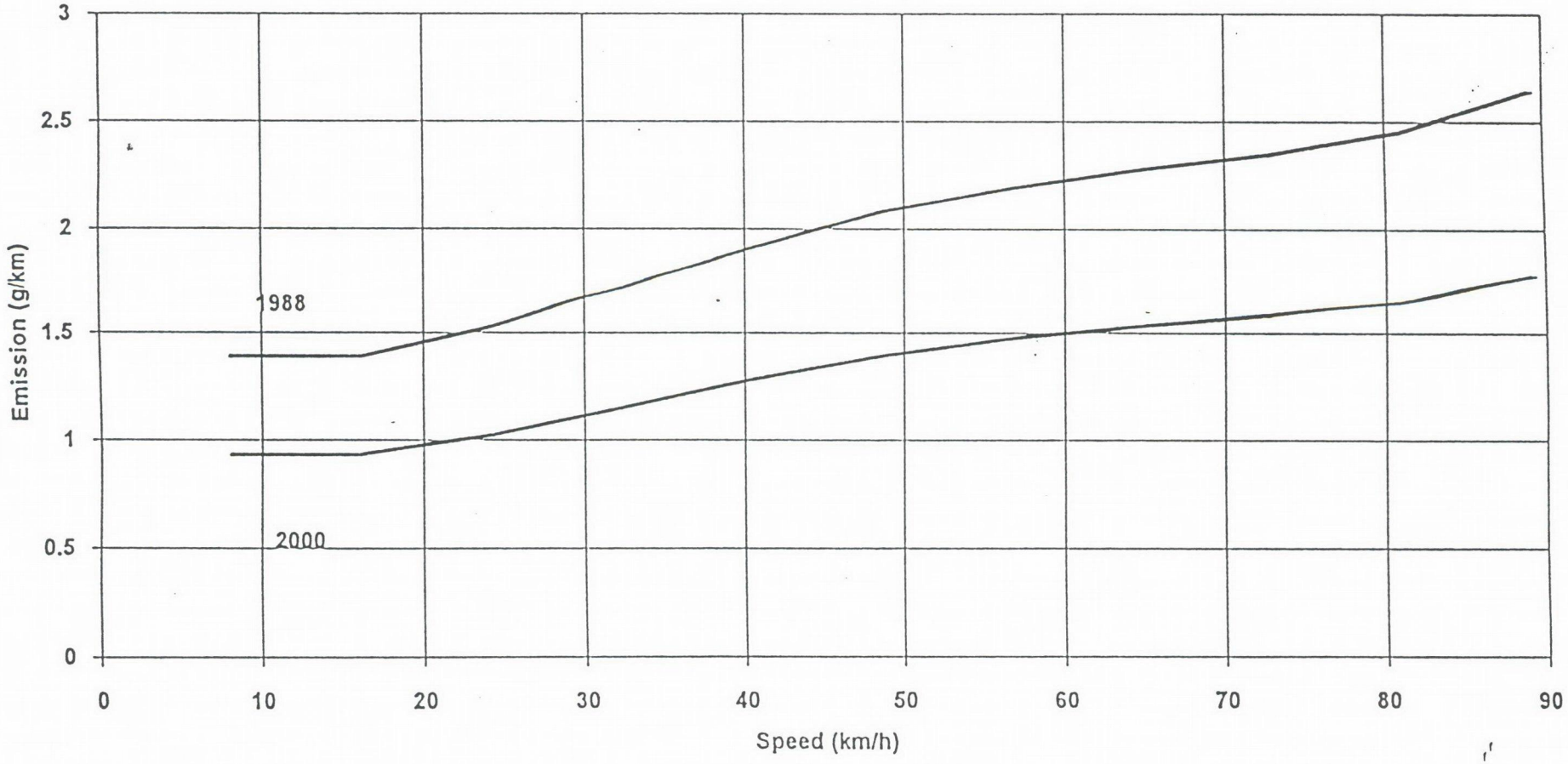


FIGURE 7

ATTACHMENT 2

FLORA ASSESSMENT

November 1995, Lesryk Environmental Consultants

1.0 FLORA SURVEY

1.1.1 Introduction

This flora survey has been carried out at the request of Environmental Planning Pty Ltd in order to describe the current status of the indigenous vegetation growing on and adjacent to the proposed construction area. The value of the vegetation in the national and regional context is considered in relation to vegetation types and individual plant species occurring in the study area.

General studies of the region have been carried out by Benson (1992), Benson & Howell (1990) and Benson & MacDougall (1991). More detailed studies of the area include a study of the Eastern Creek/ Prospect/ Horsley Park Corridor (Perkins 1992; QEM 1993), Elizabeth Drive and Western Sydney Orbital (Gunninah 1995a), ADI Site, St Marys (Gunninah 1995b), CAA Site, Llandilo (Mills 1991) and of Hoxton Park (Mount King Ecological Surveys 1990). These references were checked for descriptions of similar vegetation types, and for recordings of rare or endangered plant species.

1.1.2 Geology and Soils

Four Soil Landscape Groupings occur in the study area; Luddenham, Richmond, South Creek , and Blacktown (Hazelton Bannerman & Tille 1989). Soils derived from the Luddenham Group occur on both sides of the existing road alignment between Penrith South and Werrington. One stand of shale/gravel Transition Forest is recorded on the eastern limits of this soil type, to the north of the study area (Benson 1992). Soils derived from the Richmond Group occur on both sides of the Nepean River. No stands of vegetation are recorded by Benson (1992) in this section of the study area; original vegetation probably consisted of low open woodland (Hazelton *et al.* 1989). Soils of the South Creek group occur along the catchments of Eastern, Ropes and South Creeks, with soils derived from the Blacktown Group, occurring between these catchments.

Benson (1992) has recorded the occurrence of one stand of Map Unit 9d Shale/Gravel transition Forest and up to nine stands of Map Unit 10c Grey Box Woodland within 2km of the study area. Two stands of Map Unit 10d Grey Box-Ironbark Woodland are also recorded in the area; a small stand between the Western Freeway and the Great Western highway and a large continuous stand occurring along the northern margins of Prospect Reservoir.

1.2 METHODS

1.2.1 Identification and naming of species and families

Plant identifications were made according to recent nomenclature in Harden (1990, 1991, 1992 & 1993).

1.2.2 Classification of communities

Stands of vegetation are described with reference to vegetation descriptions by Benson (1992).

1.2.3 Conservation significance of plant species

The scientific and conservation significance of individual species and vegetation types was established with reference to Briggs & Leigh (in prep.) in the national context. Conservation significance of plant species and vegetation types was established in the regional context according to Benson & McDougall (1991) and Benson (1992).

1.2.4 Field Survey Strategy

A general survey (York *et al* 1991) was carried out by Claire Aston on 28/10/95 in order to inventory a majority of the plant species occurring in the road reserve. Stands of more-or-less intact native vegetation occurring within 100m of the proposed alignment were sampled. Recent plantings in the road reserve were not inventoried, as it is assumed that records are available for these plantings. A list of plant species recorded is included as Appendix 1. Plant species considered to have regional conservation significance (Benson & McDougall 1991) are indicated in this list.

1.3 VEGETATION ON THE STUDY AREA

Vegetation in the road reserve consists mostly of mown grasses, although in some areas small shrubs and herbs are also present. Trees and shrubs have been planted in some sections of the road reserve, and appear to receive occasional maintenance.

Adjacent native vegetation consists mostly of regrowth, and ranges from grassland to woodland or forest. In most woodland or forest stands understorey is either disturbed or in an early stage of revegetation. Apparent disturbance factors include fires, grazing, clearing and dumping.

Representative stands of five vegetation stands described by Benson (1992) occur in the study area, with a sixth vegetation description being used for areas of mown grassland or horticultural plantings.

1.3.1. Grey Box Woodland

Structure
Trees to 20 m, generally occurring as regrowth vegetation with the result that over-mature trees are rare and stands are often uniform in age. Understorey shrubs are generally sparsely distributed or absent.

Occurrence
Small stands occur near Eastern Creek and the Archbold flyover.

Floristics
Grey box *Eucalyptus moluccana* is usually the most common species, although forest redgum *E. tereticornis* is occasionally co-dominant. Common shrub species include paper daisy *Ozothamnus diosmifolius, Daviesia ulicifolia, Dillwynia juniperina,* blackthorn *Bursaria spinosa* and Parramatta green wattle *Acacia parramattensis*. Herb and grass species include violet leafed goodenia *Goodenia hederacea, Einadia hastata, Entolasia marginata* and kangaroo grass *Themeda australis*.

1.3.2. Grey Box - Ironbark Woodland

Structure
Trees to 20m. Over-mature trees are usually absent. Shrub understorey is occasionally dense but more typically sparse.

Occurrence
This vegetation type occurs as disjunct regenerating stands between Eastern Creek and Ropes Creek, as well as near South Creek, Mamre Road and Kent Road.

Floristics
Species composition of the tree canopy is variable; possibly as a result of disturbance history and stage of regeneration. Common species are Grey box *Eucalyptus moluccana*, forest redgum *E. tereticornis* and narrow-leaved ironbark *E. crebra*. Common understorey shrubs are Parramatta green wattle *Acacia parramattensis*, blackthorn *Bursaria spinosa* and *Pultenaea villosa*.

1.3.3. Shale/Gravel Transition Forest

Structure
Trees to 20m, generally with tall, straight trunks and narrow canopies. Shrub and small tree understorey to 4m is patchy, being occasionally dense, but more typically sparse.

Occurrence
Several stands occur to the west of Ropes Creek.

Floristics
Greybox *E. moluccana* broad-leaved ironbark *E. fibrosa* and narrow-leaved ironbark *E. crebra* are the most common canopy species, with occasional occurrences of thin-leaved stringybark *E. eugenioides*. Common shrub species include *Daviesia ulicifolia, Dillwynia juniperina*, native olive *Notelaea longifolia* and blackthorn *Bursaria spinosa*.

1.3.4. Freshwater Reed Swamp

Structure
Sedges and rushes to 1.4m. Structure and floristics are variable, depending on factors such as location, water quality, current use and disturbance history.

Occurrence
Margins of creek lines; Eastern Creek, Ropes Creek and South Creek.

Floristics
No species are consistently common throughout the study area: In larger water bodies cumbungi *Typha orientalis* and *Phragmites australis* are often common around the margins. Rushes *Juncus usitatus* and sedges *Cyperus* spp and *Bolboschoenus* spp occur along drainage lines. Aquatic species include water peppers *Persicaria* spp, *Ludwigia peploides* subsp *montevidensis* and water ribbons *Triglochin procera*.

1.3.5. River-flat forest

Structure
Trees to 20m, often closely spaced, but usually occurring as a narrow band adjacent to cleared fields. Understorey may be heavily grazed or, if not grazed, heavily infested with introduced herb and climber species.

Occurrence
Along the banks of Eastern Creek Ropes Creek and South Creek.

Floristics
The vegetation is variable, but generally contains components of map unit 9F - River-flat Forest: Swamp oak *Casuarina glauca* tends to form monotypic stands in some areas, particularly if the understorey is heavily grazed. Rough-barked apple *Angophora floribunda* and forest redgum *Eucalyptus tereticornis* are common in some sections while paperbark species *Melaleuca linariifolia, M. decora* and *M. styphelioides* are also common occurrences.

1.3.6. Grassland / horticultural

This vegetation description applies to road reserves, median strips and agricultural land which is occasionally mown, grazed or maintained. This vegetation includes grasses and ground covers, isolated stands of trees and shrubs, and planted areas.

1.4 VALUE OF THE VEGETATION IN THE STUDY AREA

1.4.1 Plant species

Benson (1992) list plant species of national or regional conservation that have been recorded in the Penrith 1:100 000 map sheet area. None of these species were recorded in the study area, although one species of national conservation significance listed by Briggs and Leigh (in prep.) was recorded in the Shale/gravel Transition Forest near Ropes Creek. Up to 40 individuals of *Dillwynia tenuifolia* were recorded in the road reserve, in an area apparently burnt several years ago. This species has a conservation rating of 2VCi, and is endemic to the Castlereagh Woodlands of Western Sydney (Benson & McDougall 1991). Mills (1991) recorded two occurrences of this species near the study area at St Marys.

Other species of conservation significance for which specific searches were made included: *Pimelea spicata, Pultenaea parviflora, Acacia pubescens* and *Dodonaea falcata.* The occurrences of individuals or populations of these species have been recorded in the studies cited above, although in most cases the recorded occurrences are more than 2km from the study area. *Grevillea juniperina* was also recorded in the same site as the population of *Dillwynia tenuifolia*. Although this species is not listed as having national significance by Briggs & Leigh (in prep.), it is recognised as a separate form, having light yellow flowers, and is considered to be endangered by housing development (Benson & MacDougall 1991).

Benson & McDougall (1991) list species occurring in Western Sydney which are considered vulnerable in the regional context. 17 species were recorded in the study area, although in most cases these species were recorded in vegetation adjacent to the road reserve.

1.4.2 Plant communities

Large continuous stands of native vegetation are not common in Western Sydney, and in most cases existing stands are not conserved (Benson & Howell 1990, Benson & MacDougall 1991). Stands of Grey box Woodland, Grey Box - Ironbark Woodland, Shale/Gravel Transition Forest and River Flat Forest that occur in the study area are often fragments of similar, adjacent vegetation stands, and as such they may represent possible corridors for native bird species so should be retained where possible.

1.5 RECOMMENDATIONS

The number of mature trees requiring removal should be limited to the minimum necessary to accommodate construction operations.

The alignment should be designed to minimise the loss of existing native vegetation. The alignment should skirt existing stands rather than cause fragmentation by passing through the stand. Where the fragmentation of an existing stand of native vegetation cannot be avoided roadside planting should be carried out as soon as possible, in order to reduce edge effects.

The section of road reserve containing the vulnerable plant species *Dillwynia tenuifolia* and *Grevillea juniperina* should not be disturbed by clearing, construction, parking or stockpiling. The shrub species occurring in this area should not be mown.

Roadside planting should be designed to supplement existing native stands occurring adjacent to the easement. All roadside planting should consist of native species, propagated from locally collected seed or other propagules.

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Appendix 1: Flora species recorded on the study site for the proposed upgrading of M4.

Source
1 Grey Box Woodland
2. Grey Box - Ironbark Woodland
3. Shale/Gravel Transition Forest
4. Freshwater Reed Swamps
5. River-flat Forest
6. Grassland/Horticultural
* = *introduced species; # = species of conservation significance*

	PLANT SPECIES		1	2	3	4	5	6
FILICOPSIDA								
Dennstaedtiaeae	*Pteridium esculentum*							1
Sinopteridaceae	*Cheilanthes sieberi*		1	1	1		1	
MAGNOLIOPSIDA - DICOTYLEDONS								
Acanthaceae	*Brunoniella australis*		1	1	1		1	
Amaranthaceae	*Amaranthus retroflexus*	*	1		1			
Apiaceae	*Centella asiatica*			1	1			
	Foeniculum vulgare	*					1	1
	Poranthera microphylla						1	
Asclepiadaceae	*Araujia sericiflora*	*					1	1
	Gomphocarpus fruticosus	*						1
Asteraceae	*Ageratina adenophora*	*					1	
	Arctotheca calendula	*						1
	Aster subulatus	*					1	
	Bidens pilosa	*	1		1			1
	Brachycome angustifolia var. *angustifolia*						1	
	Calotis cuneifolia			1				
	Cassinia arcuata	#	1				1	
	Chrysocephalum apiculatum	#	1					1
	Cirsium vulgare	*	1		1		1	1
	Cichorium inytbus	*						1
	Conyza albida	*	1		1			1
	Conyza bonariensis	*	1					
	Coreopsis lanceolata	*						1
	Cotula coronopifolia					1		
	Delairea odorata	*			1			
	Eclipta platyglossa					1		
	Gnaphalium sphaericum		1					
	Hypochoeris radicata	*	1		1		1	1
	Lagenifera stipitata		1					
	Olearia microphylla			1				
	Ozothamnus diosmifolius		1				1	
	Pseudognaphalium luteoalbum		1	1			1	1

	Senecio hispidulus var. *hispidulus*	#			1			
	Senecio madascariensis	*	1	1	1		1	1
	Sonchus oleraceus	*	1	1				
Basellaceae	*Anredera cordifolia*	*					1	
Boraginaceae	*Echium vulgare*	*						1
Brassicaceae	*Brassica oleracea*	*						1
	Rorippa palustris					1		
Campanulaceae	*Wahlenbergia communis*						1	
	Wahlenbergia gracilis		1					
	Wahlenbergia stricta subsp. *stricta*						1	1
Casuarinaceae	*Allocasuarina littoralis*						1	1
	Casuarina cunninghamiana							1
	Casuarina glauca						1	
Cassythaceae	*Cassytha glabella*		1		1			
Chenopodiaceae	*Chenopodium album*	*					1	
	Einadia hastata		1				1	
	Einadia nutans subsp *nutans*						1	
Clusiaceae	*Hypericum gramineum*			1			1	1
Convolvulaceae	*Convolvulus erubescens*						1	
	Dichondra repens		1	1			1	
	Ipomoea indica	*					1	
	Polymeria calycina	#	1					
Crassulaceae	*Kalanchoe tubiflora*	*		1				
Dilleniaceae	*Hibbertia aspera*		1	1	1			
	Hibbertia pedunculata	#					1	
Epacridaceae	*Astroloma humifusum*		1					
	Leucopogon juniperinus		1		1			
	Lissanthe strigosa			1	1			
Euphorbiaceae	*Ricinocarpus pinifolus*	*	1					
Fabaceae: Caesalpinioideae	*Senna pendula* var. *glabrata*		1	1				1
Fabaceae: Faboideae	*Bossiaea heterophylla*		1					
	Chorizema parviflorum						1	
	Daviesia ulicifolia		1				1	
	Desmodium varians		1		1			
	Dillwynia juniperina		1		1			
	Dillwynia tenuifolia	#					1	
	Glycine clandestina species complex		1					1
	Glycine microphylla	#					1	
	Glycine tabacina species complex						1	1
	Hardenbergia violacea		1	1			1	
	Melilotus officinalis	*	1					1
	Pultenaea villosa		1	1			1	

	Trifolium dubium	*	1					1
	Trifolium repens	*						1
	Vicia sativa	*					1	1
Fabaceae: Mimosoideae	*Acacia decurrens*	*	1					
	Acacia falcata				1			
	Acacia floribunda							1
	Acacia longifolia							1
	Acacia parramattensis		1	1	1		1	1
	Acacia ulicifolia		1		1			
Fumariaceae	*Fumaria muralis*	*						1
Gentianaceae	*Centaurium minus*	*						1
Goodeniaceae	*Goodenia hederacea* var. *hederacea*		1				1	
	Scaevola albida						1	
Lamiaceae	*Ajuga australis*				1			
	Prostanthera scutellarioides						1	
	Scutellaria humilis		1					
Lauraceae	*Cinnamomum camphora*	*		1				1
Linaceae	*Linum marginale*		1		1			
Loranthaceae	*Amyema pendulum* subsp. *pendulum*		1		1			
Malaceae	*Cotoneaster pannosus*	*						1
	Pyracantha fortuneana	*		1				
Malvaceae	*Modiola caroliniana*	*	1		1			1
Meliaceae	*Melia azedarach*				1		1	1
Myoporaceae	*Myoporum debile*				1			
Myrtaceae	*Angophora floribunda*						1	
	Angophora subvelutina (?)	#					1	
	Eucalyptus amplifolia (?)	#					1	
	Eucalyptus crebra			1	1		1	
	Eucalyptus eugenioides				1			
	Eucalyptus fibrosa				1		1	
	Eucalyptus moluccana		1	1	1		1	
	Eucalyptus tereticornis		1	1	1		1	
	Kunzea ambigua		1				1	
	Melaleuca decora				1		1	
	Melaleuca linariifolia						1	
	Melaleuca nodosa				1		1	
	Melaleuca styphelioides						1	
	Melaleuca thymifolia				1			
Oleaceae	*Ligustrum lucidum*	*	1				1	1
	Ligustrum sinense	*			1		1	
	Notelaea longifolia forma *longifolia*						1	
	Olea europaea subsp. *africana*	*	1				1	

Onagraceae	*Epilobium billardierianum* subsp. *cinereum*	#				1		
	Ludwigia peploides subsp. *montevidensis*					1		
Oxalidaceae	*Oxalis corniculata*				1			
	Oxalis perennans		1		1			1
Pittosporaceae	*Billardiera scandens*		1					
	Bursaria spinosa var. *spinosa*		1	1	1		1	
Plantaginaceae	*Plantago gaudichaudii*						1	
	Plantago lanceolata	*	1		1		1	1
Polygonaceae	*Acetosa sagittata*	*				1		
	Persicaria decipiens					1		
	Rumex crispus	*				1	1	
Primulaceae	*Anagallis arvensis*	*	1		1			
Proteaceae	*Grevillea juniperina*	#					1	
	Hakea sericea				1			
Ranunculaceae	*Clematis aristata*		1				1	
	Clematis glycinoides				1			
	Ranunculus lappaceus					1		
	Ranunculus plebeius					1		
Rubiaceae	*Asperula conferta*						1	
	Opercularia diphylla			1				
	Pomax umbellata						1	
Rosaceae	*Rubus fruticosus* species-aggregate	*					1	1
Salicaceae	*Populus nigra 'Italica'*	*						1
	Salix alba	*						1
	Salix babylonica	*						1
Santalaceae	*Exocarpos cupressiformis*				1			
Sapindaceae	*Cardiospermum grandiflorum*	*						1
	Dodonaea triquetra		1		1			
Scrophulariaceae	*Verbascum thapsus*	*						1
Solanaceae	*Cestrum parqui*	*					1	
	Solanum pseudocapsicum	*					1	
Thymeliaceae	*Pimelea linifolia* subsp.*linifolia*		1		1		1	
Verbenaceae	*Verbena bonariensis*	*	1		1			1
	Verbena rigida	*			1			
MAGNOLIOPSIDA - MONOCOTYLEDONS								
Anthericaceae	*Laxmannia gracilis*			1				
	Tricoryne elatior				1			
Asparagaceae	*Myrsiphyllum asparagoides*	*					1	
	Protosparagus densiflorus	*					1	
Commelinaceae	*Tradescantia albiflora*	*		1			1	

Cyperaceae	*Bolboschoenus caldwelii*	#				1		
	Bolboschoenus fluviatilis	#				1		
	Carex appressa					1		
	Cyperus eragrostis	*				1		
	Schoenoplectus validus					1		
Juncaceae	*Juncus usitatus*					1		
Juncaginaceae	*Triglochin procera*					1		
Lomandraceae	*Lomandra filiformis* subsp. *coriacea*		1				1	
	Lomandra longifolia		1	1			1	
	Lomandra multiflora						1	
Phormiaceae	*Dianella revoluta*		1	1			1	
Poaceae	*Andropogon virginicus*	*	1					1
	Aristidia ramosa		1		1			
	Aristidia vagans		1					
	Avena fatua	*						1
	Axonopus affinis	*						1
	Bothriochloa macra		1	1	1		1	
	Briza maxima	*						1
	Briza minor	*					1	1
	Chloris gayana	*					1	1
	Cymbopogon refractus	#	1		1			
	Cynodon dactylon		1	1	1		1	1
	Dichelachne micrantha		1				1	
	Echinopogon caespitosus var. *caespitosus*		1	1	1			
	Entolasia stricta		1		1			
	Eragrostis brownii		1					1
	Imperata cylindrica var. *major*		1	1	1			1
	Lolium perenne	*						1
	Microlaena stipoides var. *stipoides*		1	1	1		1	
	Paspalum dilatatum	*	1	1			1	1
	Paspalum distichum	#				1		
	Pennisetum clandestinum	*	1	1		1	1	1
	Phalaris minor	*				1		
	Phragmites australis					1		
	Poa annua	*	1					1
	Poa sieberiana	#	1		1			
	Setaria gracilis	*						1
	Sporobolus indicus var. *capensis*	*						1
	Stenotaphrum secundatum	*	1	1	1		1	1
	Themeda australis		1	1	1		1	1
Pontederiaceae	*Eichhornia crassipes*	*				1		
Potamogetonaceae	*Potamogeton tricarinatus*	#				1		
Typhaceae	*Typha orientalis*					1		

ATTACHMENT 3

FAUNA ASSESSMENT

November 1995, Lesryk Environmental Consultants

1.0 FAUNA ASSESSMENT

1.1.1 Introduction

This report describes a limited fauna assessment within and adjacent to, two section of the M4 Motorway: from Church Street, Parramatta to Coleman Street, Mays Hill, and from Prospect to Lapstone west of Sydney (the study area). The study has been carried out at the request of Environmental Planning Pty Ltd as part of a Review of Environmental Factors for the proposed upgrading of the existing Motorway from four lanes to six.

The report provides an assessment of the potential impacts of the proposed development on the ecology of the study area and those habitats located adjacent to it. The survey focused on those habitats and vegetation communities along the road median, the area in which the majority of construction activity is expected to take place. No road construction is expected to be undertaken within the road verges to the north and south of the Motorway. If these areas are to be impacted upon supplementary fauna and flora work would be necessary.

The assessment is based on a brief field survey of the proposed development area, as well as the adjacent vegetation communities. A literature review of previous studies carried out in the region was also undertaken. The aims of the report are to:

- Identify the existing environment and describe the site which is likely to be affected by the proposed development;
- Outline the likely interactions between the proposed development and the environment, and discuss whether these interactions would impact significantly on the environment;
- Identify any flora and fauna species of conservation significance that may be affected by the proposed development;
- Identify any significant indigenous plant communities or fauna habitats that may be adversely affected by the proposed development;
- Consider the likely significance of potential impacts of the proposed development on rare and endangered fauna and their habitats under Section 4A of the *Environmental Planning and Assessment Act 1979*, as required under the *Endangered Fauna (Interim Protection) Act 1991*.
- Determine any ameliorative measures that may be considered necessary.

1.2 METHODS

A limited survey of the Motorway and adjacent habitats was carried out by Deryk Engel on the 28 October 1995. The weather during this time was fine and warm.

Techniques employed for this investigation included habitat assessment, litter searches, direct observation and identification of indirect fauna evidence. Searches were undertaken throughout all areas likely to be affected by the proposal, as well as through the adjacent vegetated and wetland areas.

Searches concentrated on areas of bushland which occur both within, or close to, the Motorway, as well as those drainage lines which the Motorway crosses. The survey essentially assessed the health of these vegetation communities, and their suitability to provide habitat for species of conservation significance. Given the brief nature of the survey, the precautionary principle has been applied. It

has also been assumed that the proposed upgrade would be undertaken within the existing median and that the vegetated communities outside of these areas would not be impacted upon (Environmental Planning pers.comm.).

Nomenclature

The naming of reptiles and amphibians follows that used in Cogger (1992). Simpson and Day (1993) was used for the naming of birds observed. Strahan (1992) is used for the nomenclature of mammals and Triggs (1989) used to identify scats, tracks and markings.

A review of past studies undertaken in the area, and consultation of both the National Parks & Wildlife Service 1:100,000 Atlas, and Australian Museum databases, was carried out to identify other fauna species recorded or expected in the region.

1.3 HABITAT TYPES AVAILABLE FOR NATIVE FAUNA SPECIES

The study area contains several habitat types available for native fauna. These are:

Parramatta to Mays Hill

- **Medium density landscape planting's** consisting of a mixture of exotic and native shrub species. Few mature trees. Ground cover composed of maintained lawns. No water bodies or continuous stands of vegetation occur, surrounding land use dominated by residential, industrial and open space. Central median, combination of maintained lawns and concrete barriers.

Prospect to Lapstone

- **Isolated stands of semi-mature trees**, 15-20 metres in height with no suitable nesting hollows or understorey. Ground cover varies with degree of maintenance. Area appears to be regularly burnt. Vegetated stands are isolated with the main fauna corridors occurring along the drainage lines. Leaf litter and ground debris present. Medium density maintained grass cover with sparse distribution of horticultural planting's. Wind blown and dumped rubbish, broken plastic and glass parts from car accidents is common along Motorway.

- **Casuarina lined water courses** with sparse to medium distribution of emergent eucalypts to 15 metres. Several suitable nesting hollows. Medium density of casuarina, acacia and shrub undergrowth to 3 metres, ground cover dense layer of exotic and native grass'. Creek lines with combination of native aquatic vegetation and dense weeds. Weed infestation occurring along drainage line. Dams with aquatic vegetation and some adjacent woodland. Several small wetlands occur outside of road corridor.

- **Grazed pastures**, consisting of exotic weed and grass species. Some isolated shrubs and trees.

Of those habitats identified within the study area, none are considered pristine, all being impacted upon by past and present agricultural practices, road and noise attenuation works, surrounding residential development, mining and industrial activities. At a regional level, none of those habitats

observed during the current survey are considered unique. All habitat types are well represented throughout the region, in some cases in a more extensive and pristine condition. The modification of the habitats observed within the road median would not result in the depletion of any of these resources from the region.

Even though they are highly disturbed and impacted upon, at a local level, the remnant woodland communities adjacent to the road shoulders are considered of importance. These areas were noted to support a number of fauna species which would not be seen in the adjacent residential and/or agricultural areas. The loss of these communities from the study area would see the displacement and/or local extinction of a number of these species. It is noted that the majority of these areas occur on private land, their conservation and protection therefore not considered as being secure. Both the terrestrial and aquatic habitats observed are highly disturbed, either by weed infestation, previous clearing and/or agricultural activities. All habitat types, whether highly or mildly disturbed, can be found throughout the region..

The proposed construction works are to take place in areas essentially devoid of natural vegetation. As such there would be no impact on vegetation communities of either local or regional conservation significance. Of those habitats observed within the vicinity of the road reserve, the vegetation communities adjacent to the road shoulder and outside of the Motorway corridor are more comprehensive and important to wildlife conservation.

1.4 FIELD SURVEY RESULTS

During the investigation of the proposal and its surrounding areas, 3 mammals, 43 birds, 4 reptiles and 1 frog were identified (Appendix 1). Of those animals recorded by the completion of the field work, none are considered of conservation concern as defined by inclusion on Schedule 12 of the *National Parks & Wildlife Act 1974* (as amended). Furthermore, none are considered to reach their distribution limit in the vicinity of the study site or be of local significance with respect to species conservation. Previous studies and fauna surveys in the region have identified a further 67 birds, 11 native and 6 introduced mammals, 22 reptiles and 14 amphibian species recorded in the vicinity of the proposal (Appendix 1). Of those species recorded in the region during previous studies, five, the Green and Golden Bell Frog (*Litoria aurea*), Australasian Bittern (*Botaurus poicilopiilus*), Swift Parrot (*Lathamus discolor*), Superb Parrot (*Polytelis swainsonii*) and Regent Honeyeater (*Xanthomyza phrygia*) are of national conservation significance.

1.4.1 Mammal Species

During the daytime search one native mammal, the Common Brushtail Possum (*Trichosurus vulpecula*) and two introduced species, the fox (*Vulpes vulpes*) and rabbit (*Oryctolagus cuniculus*), were recorded as inhabiting or using the habitats found along the M4 Motorway. The presence of these species was indicated through the observation of distinctive scratchings on a number of smooth barked trees, tracks and scats respectively.

A review of databases and previous fauna studies undertaken in the area have identified an additional 11 native mammals occurring in the region of the proposal (Appendix 1). All of those species previously recorded are considered common to abundant where suitable habitat is provided. No habitat significant to any terrestrial mammal species of conservation significance is located in the study area. Therefore it is highly unlikely that any terrestrial species of conservation significance would be adversely affected.

Based on distribution patterns, several microchiropteran species of conservation significance may occur in the vicinity of the proposed development (Hall and Richards 1979, Parnaby 1992, Strahan 1992). During previous surveys, none of these species have been recorded in the vicinity of the Motorway. The main threat to the survival of these species has been attributed to the loss of either large trees with suitable roosting hollows, or riparian vegetation (Hall and Richards 1979, Reardon and Flavel 1987, Strahan 1992). Neither of these necessary habitat requirements are located within the road median but, several suitable stands of woodland and riparian vegetation do occur within the road corridor. The loss of these may have an adverse impact on several of these species of conservation significance. Given the construction of the additional lanes within the median, no impact on this genera is expected.

The presence of two introduced species, the fox (*Vulpes vulpes*) and rabbit (*Oryctolagus cuniculus*) was indicated through the identification of distinctive tracks and scats respectively. Each of these species is commonly encountered in semi-rural areas. Other introduced species likely to be found within the study area identified in Appendix 1. The presence of introduced species is known to cause a dramatic reduction of native wildlife numbers, especially in areas where there is little protection offered by vegetation (Paton 1991, Beeh 1992, Tiggelen 1992). Their presence in the area is expected to already had a significant impact on native species diversity and abundance.

1.4.2 Avian Species

Of the 43 bird species recorded within the M4 Motorway corridor, all are "common-to-abundant" within their relative habitats. None of those species recorded during the current survey, or expected to occur within the area, reach their distributional limits in the vicinity of the site. All these species are typical of the aquatic and terrestrial habitats found throughout the region.

No bird species of conservation significance rely on habitats similar to those identified within the study area. Several species of national conservation significance have been recorded in the vicinity of the Motorway (NPWS 1995, Australian Museum 1995) (Appendix 1). These species may, at some stage during foraging or migration, use the woodlands adjacent to the Motorway to shelter and/or feed in. As such the impact of the proposed development on these species has been assessed using the "seven point test" of significance listed under Section 4A of the *Environmental Planning & Assessment Act 1979*. It is possible that these endangered birds may move through the construction area, but those habitats expected to be modified are not considered to be important wildlife corridors or necessary for the conservation of these genera. The loss of several grasslands areas and communities of horticultural planting's is not considered to be significant for any avian species be they endangered or common to abundant. Adjacent woodlands are expected to be more significant for any endangered bird species in the area. Construction work is not expected to impact on these sites.

1.4.3 Reptile Species

Four reptile species, the Eastern Water Skink (*Eulamprus quoyii*), Grass Skink (*Lampropholis delicata*), Garden Skink (*Lampropholis guichenoti*) and Red-bellied Black Snake (*Pseudechis porphyriacus*) were recorded during the field survey. Most of the reptiles were either observed basking on ground debris or located under leaf litter. The recording of *P.porphyriacus* came from a road kill in the vicinity of Eastern Creek. In addition to the reptiles identified, an additional 22 species have been recorded in the region (Appendix 1). None of those species previously recorded, or expected based on their distribution patterns (Cogger 1992), are considered of conservation significance as listed on Schedule 12 of the *National Parks and Wildlife Act 1974*.

Due to the proposed construction of the additional lanes within the present road median none of those reptile species recorded or considered likely to occur are expected to be adversely affected by the proposed works. Some reptile habitat along the median would be lost, but this impact is not expected to be significant. It is acknowledged that some individuals of commonly occurring species may die due to car strike, but this is not expected to cause the local extinction of any species. Given the existing condition of the road, these species are already at risk from car strike. The increase in road width is expected to increase this threat, thereby reducing existing population numbers. This is not considered to cause the local extinction of any reptile species.

1.4.4 Amphibian Species

The existence of artificial dams, vegetated drainage lines and wetlands in the vicinity of the Motorway provides ideal habitat for those amphibian species found, or expected, to occur in the study area. Such habitats were noted to be highly disturbed by weed infestation or impacted upon by residential development or domestic livestock. It is expected that such disturbances are likely to have affected all but the most tolerant of amphibian species, such as the Common Eastern Froglet (*Crinia signifera*) which was recorded during the study. No water bodies occur within the road median and none are expected to be directly impacted upon.

An additional 14 amphibian species have been recorded in the vicinity of the proposal (Appendix 1). Of these one, the Green and Golden Bell Frog (*Litoria aurea*), is considered of conservation significance as listed on Schedule 12 of the *National Parks and Wildlife Act 1974*. The record of this species comes from north of the Motorway, along Ropes Creek (NPWS 1995, A.White, Biosphere Environmental Consultants, pers.comm). Within the road median no habitat suitable for this species occurs, though suitable habitat does occur both along and adjacent to the Motorway corridor. The impact of the proposed development on this species has been assessed using the "seven point test" of significance listed under Section 4A of the *Environmental Planning & Assessment Act 1979*.

1.5 ASSESSMENT OF SIGNIFICANCE

The potential impacts of the proposed development on Schedule 12 species which may occur, or utilise those habitats identified within the survey boundaries, are considered using the "seven point test" of significance listed under Section 4A of the *Environmental Planning & Assessment Act 1979*. These criteria are designed to determine "whether there is likely to be a significant impact on the environment of protected fauna", and consequently, whether a Fauna Impact Statement is required. The following seven point tests are carried out assuming that these species may occur on site, due to the occurrence of habitats that occur within survey boundaries and which are known regionally to be significant for these species.

1.5.1 GREEN AND GOLDEN BELL FROG *LITORIA AUREA*

HABITAT REQUIREMENTS AND DISTRIBUTION

Distributed from eastern and south-eastern New South Wales and far eastern Victoria, the Green and Golden Bell Frog (*Litoria aurea*) has been recorded within the ropes Creek region (NPWS 1995). Listed under Part 1 of Schedule 12 of the National Parks & Wildlife Act 1974 as being threatened, this carnivorous species is known to inhabit ephemeral water bodies with fluctuating water levels. Requirements within these water bodies include a lack of well developed emergent vegetation, with waters free of chemical contamination and no introduced fish species (White in press). One finding of recent research is that *L.aurea* can inhabit a variety of habitats, many of which are highly physically disturbed and have undergone major alterations (White in press). Nonetheless, *L.aurea* has several habitat requirements including the presence of diurnal shelter and basking sites, refuge sites for hibernation over winter, feeding areas, aquatic breeding and spawning areas and absence of exotic fish such as Mosquito fish (*Gambusia sp.*) (White in press, Cogger 1992, Robinson 1993).

During the present survey no habitat significant for the conservation of this species was observed within the road median. No drainage lines are expected to be impacted upon and no wetlands are to be filled in. No isolation of aquatic habitats would occur, all drainage lines and water bodies being maintained in their current location.

SEVEN POINT TEST

(a) *"...the extent of modification or removal of habitat, in relation to the same habitat type in the locality..."*

No water bodies with the necessary requirements for this species were within the road median. Therefore no areas suitable for the conservation of this species would be modified or removed as a result of the present proposal. Habitats both within the road corridor and adjacent wetland areas are expected to be more significant for this species, if it occurs in the vicinity of the Motorway. If these areas are to be impacted upon, additional work would be require to determine the presence and absence of this species. If this species is recorded in the vicinity of the Motorway, and there is a potential for the population to be adversely impacted upon, a Fauna Impact Statement would be required.

(b) *"...the sensitivity of the species of fauna to removal or modification of its habitat..."*

This species is highly sensitive to the removal or modification of its habitat.

(c) *"...the time required to regenerate critical habitat, namely, the whole or any part of the habitat which is essential for the survival of that species of fauna..."*

It is considered that no habitat critical to the survival of this species occurs within the proposal boundaries.

(d) *"...the effect on the ability of the fauna to recover, including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development or activities..."*

It is considered that no habitats necessary for the survival of this species occurs within the proposal boundaries, or in adjacent habitats.

(e) *"...any proposal to ameliorate the impact..."*

Even though no impacts were identified which would result in this species becoming adversely affected, it is recommended that suitable measures be take to ensure that no polluted runoff be discharged directly into any water bodies. All runoff from exposed work surfaces should be filtered, either through sediment fencing or settling ponds, prior to entering into the existing drainage system. These filtering structures should be maintained throughout the construction process and should not be removed until all exposed surfaces are stabilised. Permanent settling ponds should be located in area away from drainage lines, wetlands and woodland areas and should be planted with a range of terrestrial and aquatic species. Such planting's would supplement existing vegetation communities. Efforts should also be made to link such water bodies, thereby providing a valuable fauna corridor.

(f) *"...whether the land is currently being assessed for wilderness by the Director of National Parks & Wildlife under the Wilderness Act 1987..."*

The subject land is not currently being assessed by the Director of National Parks and Wildlife under the Wilderness Act 1987.

(g) *"...any adverse effect on the survival of that species of protected fauna or of populations of that fauna..."*

There would be no adverse effect on this species of protected fauna or on populations of *L.aurea.*

EXPECTED IMPACT ON SPECIES DUE TO CURRENT PROPOSAL

The present proposal is unlikely to have a significant impact on this species.

1.5.2 AUSTRALASIAN BITTERN *BOTAURUS POICILOPIILUS*

HABITAT REQUIREMENTS AND DISTRIBUTION

The present distribution of *B.poiciloptilus* includes south-eastern Queensland, New South Wales, Victoria and south-east South Australia, including the Adelaide plain (Garnett 1992, Garnett 1993). Populations are also known from south-west Australia, from Moora to Mt Arid, Tasmania and New Zealand (Garnett 1992, Garnett 1993). *B.poiciloptilus* prefers shallow, vegetated freshwater or brackish swamps, usually dominated by tall, dense reed beds of Cumbungi (*Typha sp*), rushes (*Juncus sp*) and reeds (*Phragmites sp*) (Garnett 1992, Garnett 1993, Smith et al 1995). Nests are formed on platforms of these reeds and rushes, usually built over water in dense cover (Frith 1970, Smith et al 1995). When not breeding, *B.poiciloptilus* is a solitary creature (Kingsford 1991). Hunting at night, *B.poiciloptilus* feeds on aquatic invertebrates, small fish and frogs, usually caught in the shallow water or wet mud (Frith 1970, Garnett 1993, Smith et al 1995). Throughout its range, the decline of this species has been attributed mainly to the drainage of wetlands for agricultural purposes, though overgrazing of wetlands by livestock, hydrological modifications of wetlands, pollution of wetlands and predation by foxes and feral cats are also other factors (Garnett 1993, Smith et al 1995).

During the present survey no habitat significant for the conservation of this species was observed within the road median. No vegetated drainage lines are expected to be impacted upon and no wetlands are to be filled in. No isolation of aquatic habitats would occur, all drainage lines and water bodies being maintained in their current location.

SEVEN POINT TEST

(a) *"...the extent of modification or removal of habitat, in relation to the same habitat type in the locality..."*

It is considered that no habitat potentially significant for this species would be modified by the proposed development. Only one area of potential habitat was observed within the boundaries of the site, this being along the drainage line to the north of the Council dam. Due to the flood prone nature of this drainage line, it is unlikely that this would be developed or impacted upon. Given it small size and the surrounding land uses, this area is not considered as a significant habitat for this species, though it may occasionally be used for foraging or roosting purposes. At a regional level, this habitat is not considered unique, with similar aquatic vegetation communities being observed in a number of the drainage lines, creek and river systems in the region.

(b) *"...the sensitivity of the species of fauna to removal or modification of its habitat..."*

This species is sensitive to the drainage of wetlands for agricultural purposes, overgrazing of wetlands by livestock, hydrological modifications of wetlands, pollution of wetlands and predation by foxes and feral cats.

(c) *"...the time required to regenerate critical habitat, namely, the whole or any part of the habitat which is essential for the survival of that species of fauna..."*

It is considered that no habitat critical to the survival of this species occurs within the boundaries of the proposed development.

(d) *"...the effect on the ability of the fauna to recover, including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development or activities..."*

No habitats identified during the survey are considered to be critical to the survival of this species. Adjacent habitats are expected to contain more extensive shelter and food resources than those to be modified.

(e) *"...any proposal to ameliorate the impact..."*

Even though no impacts were identified which would result in this species becoming adversely affected, it is recommended that suitable measures be take to ensure that no polluted runoff be discharged directly into any water bodies. All runoff from exposed work surfaces should be filtered, either through sediment fencing or settling ponds, prior to entering into the existing drainage system. These filtering structures should be maintained throughout the construction process and should not be removed until all exposed surfaces are stabilised. Permanent settling ponds should be located in area away from drainage lines, wetlands and woodland areas and should be planted with aquatic species which may at some stage be used by *B.poiciloptilus*.

(f) *"...whether the land is currently being assessed for wilderness by the Director of National Parks & Wildlife under the Wilderness Act 1987..."*

The subject land is not currently being assessed by the Director of National Parks and Wildlife under the Wilderness Act 1987.

(g) *"...any adverse effect on the survival of that species of protected fauna or of populations of that fauna..."*

There would be no adverse effect on the survival of this species of protected fauna or on populations of *B.poiciloptilus*.

EXPECTED IMPACT ON SPECIES DUE TO CURRENT PROPOSAL

The proposed development is not expected to have an impact on this species.

1.5.3 SWIFT PARROT *LATHAMUS DISCOLOR*

HABITAT REQUIREMENTS AND DISTRIBUTION

Distributed from Tasmania, Victoria, central and eastern New South Wales through to south-eastern Queensland, the Swift Parrot over-winters on the mainland and breeds in Tasmania (Frith 1977, Lendon 1979, Garnett 1992). *L.discolor* inhabits eucalypt forests, feeds on eucalypt nectar and breeds in the hollows of mature and senescent trees (Garnett 1993). When over-wintering on the mainland, this species is dependent on winter-flowering eucalypt species, communities of which it will often return to regularly (Garnett 1992). Such species include the Red Ironbark (*Eucalyptus sideroxylon*), Yellow Gum (*E. leucoxylon*), White Box (*E. albens*), Swamp Gum (*E. ovata*) and Manna Gum (*E. vimialis*) (Garnett 1992). It should be noted that none of these eucalypt species occur within the boundaries of the proposed development site, nor in the vicinity of the site (NPWS unpubl).

The clearance of winter-flowering eucalypt species, as well as suitable breeding trees in Tasmania, for agricultural, commercial and forestry purposes is attributed to the species decline (Garnett 1992, Garnett 1993).

During the flora survey, no stands of any winter-flowering eucalypt species were observed in either the road median or in the vicinity of the Motorway.

SEVEN POINT TEST

(a) *"...the extent of modification or removal of habitat, in relation to the same habitat type in the locality..."*

No habitat necessary for the survival of *L.discolor* is likely to be modified, or removed, due to the proposed development. During the field survey, no winter-flowing eucalypt species were observed on which *L.discolor* may feed. Those eucalypts recorded all flower during the summer months (Beadle et al 1986, Leonard 1993), a period when this species is in Tasmania breeding.

(b) *"...the sensitivity of the species of fauna to removal or modification of its habitat..."*

This species is highly sensitive to the removal or modification of its habitat.

(c) *"...the time required to regenerate critical habitat, namely, the whole or any part of the habitat which is essential for the survival of that species of fauna..."*

It is considered that no habitat critical to the survival of this species occurs within the boundaries of the proposed development.

(d) *"...the effect on the ability of the fauna to recover, including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development or activities..."*

No habitats identified during the survey are considered to be critical to the survival of this species. No impacts on *L.discolor* are expected from which this species would need to recover.

(e) *"...any proposal to ameliorate the impact..."*

No impacts were identified which would result in this species becoming adversely affected, therefore no ameliorative measures are proposed..

(f) *"...whether the land is currently being assessed for wilderness by the Director of National Parks & Wildlife under the Wilderness Act 1987..."*

The subject land is not currently being assessed by the Director of National Parks and Wildlife under the Wilderness Act 1987.

(g) *"...any adverse effect on the survival of that species of protected fauna or of populations of that fauna..."*

There would be no adverse effect on the survival of this species of protected fauna or on populations of *L.discolor* as a result of the proposed development.

EXPECTED IMPACT ON SPECIES DUE TO CURRENT PROPOSAL

The proposed development is unlikely to have an impact on this species.

1.5.4 REGENT HONEYEATER *XANTHOMYZA PHRYGIA*

HABITAT REQUIREMENTS AND DISTRIBUTION

The principle habitat of the Regent Honeyeater is temperate eucalypt woodland and open forest with stands of over mature, dominant trees. These trees are used as central places for nesting and feeding territories (Garnett 1993). This species feeds primarily on four eucalypt species (Red Ironbark *Eucalyptus sideroxylon*, White Box *E. albens*, Yellow Box *E. melliodora* and Yellow Gum *E. leucoxylon*) as well as heavy infestations of mistletoe (Garnett 1992, Garnett 1993). Distributed from southern Queensland through central Victoria to South Australia, the western slopes of the Great Dividing Range, New South Wales, appears to be this species current stronghold (Ford et al 1993).

Land clearance, habitat fragmentation and a lack of regeneration as a result of grazing by domestic stock and rabbits, have been attributed to the decline of this species (Garnett 1993, Ford et al 1993). Additional threats include competition with other honeyeaters, such as the Noisy Miner (*Manorina melanocephala*), Red Wattlebird (*Anthochaera carunculata*) and Noisy Friarbird (*Philemon corniculatus*) (Garnett 1993, Ford et al 1993). Fragmentation of habitats as a result of current agricultural practices is likely to have favoured these more aggressive honeyeater species, which compete with *X. phrygia* for available resources (Ford et al 1993).

During the field survey, none of *X. phrygia* known feed trees were observed within the study boundaries. Likewise, no mistletoe infestations and stands of over mature, dominant trees were noted.

SEVEN POINT TEST

(a) *"...the extent of modification or removal of habitat, in relation to the same habitat type in the locality..."*

No habitat necessary for the survival of *X .phrygia* is likely to be modified, or removed, due to the proposed development. *X. phrygia* is a forest and woodland species, dependant on preferred feed trees, mistletoe infestations and stands of over mature trees. Given the lack of any of these resources in the survey boundaries, and the presence of other aggressive honeyeater species, those woodland communities observed within the study boundary are not considered significant for this species. Retention of roadside woodland strips and corridors would provide for the movement of any individuals which may traverse the survey area.

(b) *"...the sensitivity of the species of fauna to removal or modification of its habitat..."*

The loss of suitable eucalypt woodlands, and competition for available resources, is likely to impact on this species. It is expected that, if individuals of this species do visit the area, trees outside of the proposed development would provide for *X. phrygia*'s feeding and sheltering needs.

(c) *"...the time required to regenerate critical habitat, namely, the whole or any part of the habitat which is essential for the survival of that species of fauna..."*

It is considered that no habitat critical to the survival of this species occurs within the boundaries of the proposed development.

(d) *"...the effect on the ability of the fauna to recover, including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development or activities..."*

No habitats identified during the survey are considered to be critical to the survival of this species. No impacts on *X. phrygia* are expected from which this species would need to recover.

(e) *"...any proposal to ameliorate the impact..."*

No habitats identified during the survey are considered to be critical to the survival of this species. No impacts on *X. phrygia* are expected from which this species would need to recover.

(f) *"...whether the land is currently being assessed for wilderness by the Director of National Parks & Wildlife under the Wilderness Act 1987..."*

The subject land is not currently being assessed by the Director of National Parks and Wildlife under the Wilderness Act 1987.

(g) *"...any adverse effect on the survival of that species of protected fauna or of populations of that fauna..."*

There would be no adverse effect on the survival of this species of protected fauna or on populations of *X. phrygia.*

EXPECTED IMPACT ON SPECIES DUE TO CURRENT PROPOSAL

The proposed development is unlikely to have an impact on *X. phrygia.*

1.5.5 SUPERB PARROT *POLYTELLIS SWAINSONII*

HABITAT REQUIREMENTS AND DISTRIBUTION

On the western slopes of the Great Dividing Range, the Superb Parrot forages and nests within box woodland, principally that dominated by yellow box (*Eucalyptus melliodora*) (Garnett 1992). Fidelity to nesting sites is high, with foraging areas being up to 10 kilometres from nesting locations. Foraging pattern usually follow wooded corridors and rarely cross extensive open ground (Garnett 1992, Garnett 1993). Part of the *P.swainsonii* population is known to migrate northwards for the winter (Webster 1988, Garnett 1993) Distributed from northern central New South Wales through to northern Victoria, breeding appears to be confined to the southern part of its range (Garnett 1993). Particular breeding areas include the watercourses of the Murrumbidgee, Edward and Murray Rivers and the area between Canberra and Cootamundra (Webster 1988, Garnett 1993).

This species faces decline due to clearance for agriculture, degradation of habitat by stock and loss of habitat through attrition or felling for firewood (Garnett 1992, Garnett 1993).

During the field survey, none of *P.swainsonii*'s known feed trees were observed within the study boundaries. Likewise no significant wooded corridors line the Motorway, the majority of woodland patches being isolated by open ground resulting from agricultural and residential activities.

SEVEN POINT TEST

(a) *"...the extent of modification or removal of habitat, in relation to the same habitat type in the locality..."*

No habitat necessary for the survival of *P.swainsonii* is likely to be modified, or removed, due to the proposed development. During the field survey, no stands of yellow box (*Eucalyptus melliodora*) were observed and no significant wooded corridors are to be impacted upon.

(b) *"...the sensitivity of the species of fauna to removal or modification of its habitat..."*

The loss of suitable eucalypt woodlands, is likely to impact on this species.

(c) *"...the time required to regenerate critical habitat, namely, the whole or any part of the habitat which is essential for the survival of that species of fauna..."*

It is considered that no habitat critical to the survival of this species occurs within the boundaries of the proposed development.

(d) *"...the effect on the ability of the fauna to recover, including interactions between the subject land and adjacent habitat that may influence the population beyond the area proposed for development or activities..."*

No habitats identified during the survey are considered to be critical to the survival of this species. No impacts on *P.swainsonii* are expected from which this species would need to recover.

(e) *"...any proposal to ameliorate the impact..."*

No habitats identified during the survey are considered to be critical to the survival of this species. No impacts on *P.swainsonii* are expected from which this species would need to recover.

(f) *"...whether the land is currently being assessed for wilderness by the Director of National Parks & Wildlife under the Wilderness Act 1987..."*

The subject land is not currently being assessed by the Director of National Parks and Wildlife under the Wilderness Act 1987.

(g) *"...any adverse effect on the survival of that species of protected fauna or of populations of that fauna..."*

There would be no adverse effect on the survival of this species of protected fauna or on populations of *P.swainsonii*.

EXPECTED IMPACT ON SPECIES DUE TO CURRENT PROPOSAL

The proposed development is unlikely to have an impact on this species.

1.6 DISCUSSION

Residential development, agricultural practices and past road works have resulted in habitat fragmentation and land clearing in the vicinity of the M4 Motorway. The only significant wildlife corridors which occur in the vicinity of this site are those that follow the drainage lines flowing north towards the Hawkesbury-Nepean River. These corridors are not considered to be well developed but are expected to be important for migratory fauna species. The isolated, cleared and heavily developed nature of the proposal site is expected to have adversely impacted on all but a few tolerant and widespread species. These species are generally tolerant of moderate levels of disturbance and would be common in the rural areas surrounding the proposal. Given the nature of the study area, it is expected that those native fauna species in the vicinity of the proposed construction are under pressure from the existing road infrastructure, predation, competition for resources from introduced animals (including domestic livestock), habitat clearing and residential runoff/pollution.

Given the isolated and cleared nature of the vegetation along the median and the lack of any stands of bushland between the east and west bound lanes, the habitats in this area are not considered to be of significance to any native species. Widening of the road is expected to result in an increase in car strike mortalities, the existing vegetation along the median presently providing some form of protection for fauna species. The impact of this is not expected to result in the local extinction of any of these fauna species. Vegetation communities to the north and south of the Motorway are considered to be more significant for these species, due to the lack of any other significant stands in the region. Though isolated, and in some cases quite sparse, these communities do provide habitat for a range of fauna species, and may be utilised by a number of migratory birds and microchiropteran (small bat) species of conservation significance. The loss of these communities is expected to have a significant impact on both common to abundant and endangered species, resulting in their local extinction. If these communities are to be impacted upon, additional fauna work is recommended to determine the fauna assemblages present and their conservation status.

Within the boundaries of the proposal, no habitats were identified which would be of importance to the conservation of any endangered or "common-to-abundant" fauna species. No habitats of significance were observed which would be adversely impacted by the present proposal. Those habitats recorded are similar to communities found throughout the region and in similar rural environments. Of those habitats observed in the vicinity of the proposal, the vegetation communities along the Motorway may provide suitable sheltering and foraging resources for a number of common fauna species.

Based on the field survey of those habitats present and a literature review of previous studies, none of the species of national conservation significance known, or likely to occur within the study area are expected to be adversely impacted by the present proposal. The construction of two additional lanes is not expected to have a significant impact on the environment of protected fauna. Therefore it is not considered that a Fauna Impact Statement be carried out for the construction of two additional lanes within the median of the M4 Motorway.

1.7 RECOMMENDATIONS

Access should be maintained under bridge supports for aquatic species and any fauna likely to be moving along the creek line. Green and Golden Bell Frogs will not move through dark tunnels, therefore measures should be taken to ensure that a cave type environment is not created. Suitable example to follow are the bridges crossing Eastern and Ropes Creek. This will ensure that no barriers to amphibian migrations are created.

All site offices and work compounds should be located in areas already disturbed. These areas should be located away from any water bodies, drainage lines and woodland communities.

All contaminants should be collected and removed from the construction area.

To minimise the possibility of sediment laden runoff entering the creek systems during construction, it is recommended that erosion and sedimentation controls be erected prior to, and during construction. These structures should not be removed until the proposed development is completed and no runoff is expected.

Permanent settling ponds should be located in area away from drainage lines, wetlands and woodland areas and should be planted with a range of locally occurring terrestrial and aquatic species. Such planting's should supplement existing vegetation communities. Efforts should also be made to link such water bodies, thereby providing a valuable fauna corridor.

Newly exposed surfaces should be mulched and replanted as soon as possible in order to reduce the potential for erosion.

If vegetation communities to the south and north of the Motorway are to be cleared or impacted upon, it is recommended that these be assessed for endangered species. Additional fauna work should target habitat necessary for microchiropterans, the Green and Golden Bell Frog and the Australasian Bittern.

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Appendix 1: Species recorded, or known to occur, in the vicinity of the M4, Parramatta to Lapstone

Source

1 = Species Recorded During Present Study
2 = Engel (1995)
3 = Gunninah (1995a)
4 = NPWS (1995)
5 = Australian Museum (1995)
6 = Gunninah (1995b)
* = *Schedule 12 Species; # = Introduced Species*

BIRDS			
Australasian (little) Grebe	*Tachybaptus novaehollandiae*		3
Australian Pelican	*Pelecanus conspicillatus*	1	
Pied Cormorant	*Phalacrocorax varius*		3,5
Little Pied Cormorant	*Phalacrocorax melanoleucos*	1	5
Great (Black) Cormorant	*Phalacrocorax carbo*	1	4
Rufous Night Heron	*Nycticorax caledonicus*		5
Australasian Bittern *	*Botaurus poicilopiilus*		4
White-faced Heron	*Ardea novaehollandiae*	1	3
Cattle Egret	*Ardea ibis*	1	3
Little Bittern	*Ixobrychus minutus*		5
Pacific Black Duck	*Anas superciliosa*	1	2,3
Chestnut Teal	*Anas castanea*	1	4
Maned (Wood) Duck	*Chenonetta jubata*	1	2,3
Black-shouldered Kite	*Elanus notatus*	1	2,3
Brown Goshawk	*Accipiter fasciatus*		5
Peregrine Falcon	*Falco peregrinus*	1	3
Brown Quail	*Coturnix australis*		3
Painted Button-quail	*Turnix varia*		5
Dusky Moorhen	*Gallinula tenebrosa*		3,4
Purple Swamphen	*Porphyrio porphyrio*		3
Eurasian Coot	*Fulica atra*		3
Masked Lapwing (Plover)	*Vanellus miles*	1	2,3,5
Feral Pigeon #	*Columba livia*	1	3
Spotted Turtle-Dove #	*Streptopelia chinensis*	1	2,3,4
Crested Pigeon	*Geophaps' lophotes*	1	3
King Parrot	*Alisterus scapularis*		4
Superb Parrot *	*Polytelis swainsonii*		4
Galah	*Cacatua roseicapilla*	1	2,3
Long-billed Corella	*Cacatua tenuirostris*		3
Sulphur-crested Cockatoo	*Cacatua galerita*	1	2,3
Rainbow Lorikeet	*Trichoglossus haematodus*		3
Swift Parrot *	*Lathamus discolor*		4,5
Eastern Rosella	*Platycercus eximius*	1	3
Crimson Rosella	*Platycercus elegans*		3

Red-rumped Parrot	*Psephotus haematonotus*	1	2,3
Pallid Cuckoo	*Cuculus pallidus*		5
Fan-tailed Cuckoo	*Cuculus flabelliformis*		3
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*		5
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*		5
Common Koel	*Eudynamys scolopacea*		5
Southern Boobook	*Ninox novaeseelandiae*		5
Barn Owl	*Tyto alba*		5
Sacred Kingfisher	*Halcyon sancta*	1	4,5
Kookaburra	*Dacelo novaeguineae*	1	2,3,4,5
Tawny Frogmouth	*Podargus strigoides*		3,5
Welcome Swallow	*Hirundo neoxena*	1	2,3,5
Tree Martin	*Hirundo nigricans*	1	3
Fairy Martin	*Hirundo ariel*		2
Richard's Pipit	*Anthus novaeseelandiae*		2,3,5
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	1	2,3,5
Cicadabird	*Coracina tenuirostris*		3
Red-whiskered Bulbul #	*Pycnonotus jocosus*		2,3
Blackbird #	*Turdus merula*		4
Rose Robin	*Petroica rosea*		5
Scarlet Robin	*Petroica multicolor*		5
Eastern Yellow Robin	*Eopsaltria australis*	1	3,5
Jacky Winter	*Microeca leucophaea*		5
Crested Shrike-tit	*Falcunculus frontatus*		2,5
Golden Whistler	*Pachycephala pectoralis*		5
Rufous Whistler	*Pachycephala rufiventris*		3,5
Grey Shrike-thrush	*Colluricincla harmonica*	1	3,5
Restless Flycatcher	*Myiagra inquieta*		2,3,5
Grey Fantail	*Rhipidura fuliginosa*	1	3,5
Willie Wagtail	*Rhipidura leucophrys*	1	2,3,5
Clamorous Reed-warbler	*Acrocephalus stentoreus*	1	2,3
Golden-headed Cisticola	*Cisticola exilis*		5
Superb Fairy-wren	*Malurus cyaneus*	1	2,3,5
Origma (Rock Warbler)	*Origma solitaria*		5
White-browed Scrubwren	*Sericornis frontalis*		3,4
Speckled Warbler	*Sericornis sagittatus*		5
Brown Thornbill	*Acanthiza pusilla*		3
Buff-rumped Thornbill	*Acanthiza reguloides*		5
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*		5
Yellow (Little) Thornbill	*Acanthiza nana*	1	3,5
Varied Sittella	*Daphoenositta chrysoptera*		5
White-throated Treecreeper	*Cormobates leucophaea*		3,4
Brown Treecreeper	*Climacteris picumnus*		5
Red Wattlebird	*Anthochaera carunculata*	1	3
Brush Wattlebird	*Anthochaera chrysoptera*	1	2,3,4

Regent Honeyeater *	*Xanthomyza phrygia*		4
Noisy Friarbird	*Philemon corniculatus*		3
Noisy Miner	*Manorina melanocephala*	1	3
Yellow-faced Honeyeater	*Lichenostomus chrysops*		3,5
White-eared Honeyeater	*Lichenostomus leucotis*		5
Yellow-tufted Honeyeater	*Lichenostomus melanops*		5
White-plumed Honeyeater	*Lichenostomus penicillatus*	1	2,3,4
White-naped Honeyeater	*Melithreptus lunatus*		5
Black-chinned Honeyeater	*Melithreptus gularis*		5
Eastern Spinebill	*Acanthorhynchus tenuirostris*		3
White-fronted Chat	*Ephthianura albifrons*		5
Spotted Pardalote	*Pardalotus punctatus*		2,3,5
Striated Pardalote	*Pardalotus striatus*		4
Silvereye	*Zosterops lateralis*	1	2,3,5
House Sparrow #	*Passer domesticus*	1	2,3,4,5
European Goldfinch #	*Carduelis carduelis*		3
Red-browed Firetail	*Neochmia temporalis*	1	3,4,5
Zebra Finch	*Taeniopygia guttata*		5
Double-barred Finch	*Taeniopygia bichenovii*		3
Common Mynah #	*Acridotheres tristis*	1	2,3,4
Common Starling #	*Sturnus vulgaris*	1	2,3,4
Olive-backed Oriole	*Oriolus sagittatus*		3,5
Spangled Drongo	*Dicrurus bracteatus*		5
Australian Magpie-lark	*Grallina cyanoeuca*	1	2,3,5
Dusky Woodswallow	*Artamus cyanopterus*		5
Masked Woodswallow	*Artamus leucorhynchus*		5
White-browed Woodswallow	*Artamus superciliosus*		5
Grey Butcherbird	*Cracticus torquatus*	1	3,5
Australian Magpie	*Gymnorhina tibicen*		2,3,5
Pied Currawong	*Strepera graculina*	1	2,3
Australian Raven	*Corvus coronoides*	1	2,3

MAMMALS			
Lesser Long-eared Bat	*Nyctophilus geoffroyi*		5,6
Chocolate Wattled Bat	*Chalinolobus morio*		6
Little Forest Eptesicus	*Eptesicus vulturnus*		6
Greater Broad-nosed Bat	*Nycticeius ruepellii*		6
Grey-headed Flying Fox	*Pteropus poliocephalus*		3,4,5
Echidna	*Tachyglossus aculeatus*		6
Sugar Glider	*Petaurus breviceps*		3,6
Eastern Pygmy Possum	*Acrobates pygmaeus*		5
Common Brushtail Possum	*Trichosurus vulpecula*	1	3,6
Common Ringtail Possum	*Pseudocheirus peregrinus*		3,5,6
Long-nosed Bandicoot	*Perameles nasuta*		3,4,5
Water Rat	*Hydromys chrysogaster*		5
House Mouse #	*Mus musculus*		6
Black Rat #	*Rattus rattus*		2,6
Fox #	*Vulpes vulpes*	1	3,6
Cat #	*Felis catus*		3,6
Dog #	*Canis familiaris*		3
Rabbit #	*Oryctolagus cuniculus*	1	3,6
Hare #	*Lepus capensis*		3,6
Fallow Deer #	*Dama dama*		3

REPTILES			
Eastern Long-necked Tortoise	*Chelodina longicollis*		5,6
Lesueur's Velvet Gecko	*Oedura lesueurii*		5
Thick-tailed Gecko	*Underwoodisaurus milli*		5
Stone Gecko	*Diplodactylus vittatus*		4,5,6
Burton's Snake-Lizard	*Lialis burtonis*		5
Common Scaly-Foot	*Pygopus lepidopodus*		5,6
Blind or Worm Snake	*Ramphotyphlops nigrescens*		5,6
Eastern Water Dragon	*Physignathus lesueurii*		5,6
Bearded Dragon	*Pogona barbatus*		6
Jacky Lizard	*Amphibolurus muricatus*		3,6
Three-toed Skink	*Saiphos equalis*		5
Weasel Skink	*Saproscincus mustelinus*		5
Striped Skink	*Ctenotus robustus*		4,6
Eastern Water Sknik	*Eulamprus quoyii*	1	3,5,6
"No Common Name"	*Eulamprus tenuis*		5
Grass Skink	*Lampropholis delicata*	1	3,6
Garden Skink	*Lampropholis guichenoti*	1	3,6
Common Death Adder	*Acanthophis antarcticus*		6
Yellow-faced Whip Snake	*Demansia psammophis*		5
Red-naped Snake	*Furina diadema*		5,6
Red-bellied Black Snake	*Pseudechis porphyriacus*	1	3,5,6

Reptiles Contd			
Eastern Brown Snake	*Pseudonaja textilis*		3,6
Bandy-Bandy	*Vermicella annulata*		5,6
Bearded Dragon	*Pogona barbata*		3,5
Eastern Blue-tongued	*Tiliqua scincoides*		3,5,6
Lace Monitor	*Varanus varius*		3,6

FROGS			
Common Eastern Froglet	*Crinia signifera*	1	3,6
Green & Golden Bell Frog *	*Litoria aurea*		4,5
Bleating Tree Frog	*Litoria dentata*		3,5,6
Eastern Dwarf Tree Frog	*Litoria fallax*		3,5,6
Broad-palmed Frog	*Litoria latopalmata*		6
Person's Tree Frog	*Litoria personii*		6
Large-eyed Tree Frog	*Litoria tyleri*		6
Leseur's Tree Frog	*Litoria lesueuri*		3,6
Peron's Tree Frog	*Litoria peronii*		3,4,5
Green Tree Frog	*Litoria caerulea*		3,5,6
Leaf Green Tree Frog	*Litoria phyllochroa*		5,6
Brown Toadlet	*Pseudophryne bibronii*		5,6
Eastern Banjo Frog	*Limnodynastes dumerilli*		6
Spotted Grass Frog	*Limnodynastes tasmaniensis*		5
Brown-striped Frog	*Limnodynastes peronii*		3,5,6

ATTACHMENT 4

M4 UPGRADING PROJECT - TRAFFIC NOISE ASSESSMENT REPORT, CHURCH STREET, PARRAMATTA TO COLEMAN STREET, MAYS HILL

October 1995, ERM Mitchell McCotter Pty Ltd

MITCHELL
ERM McCOTTER

ERM Mitchell McCotter Pty Ltd. A.C.N. 002 773 248. A member of the Environmental Resources Management Group.

26 October, 1995

Roads and Traffic Authority
PO Box 558
BLACKTOWN NSW 2148

Our Ref: 95232L3

Attention: Mr Bernie Chellingworth

Dear Sir

RE: M4 MOTORWAY UPGRADING - CHURCH STREET TO COLEMAN STREET

This report provides a noise assessment for the M4 Motorway Upgrading, for the section between Church Street and Coleman Street. It is proposed to widen the motorway by one lane each way. Where required, control measures are recommended to reduce noise levels at the closest residences to the motorway to comply with the RTA's Interim Traffic Noise Policy, as applied for the M4 Motorway.

Traffic Noise Criteria

i Residential Receivers

The criteria specified by the RTA to assess the impact of traffic noise at potentially affected residences along the M4 Motorway are more stringent than those specified in the RTA's Interim Traffic Noise Policy for residences with a high existing noise environment. The criteria are defined in terms of the descriptors $L_{eq(24hr)}$ and $L_{eq(8hr)}$ and are summarised in *Table 1.* These represent the total noise energy at a receiver location, measured over a 24-hour period and over the eight hour period from 10:00 pm to 6:00 am, respectively.

Level 1, 24 Falcon Street, CROWS NEST NSW 2065. PO Box 943 CROWS NEST NSW 2065 Australia
Telephone (02) 9906 1666 Facsimile (02) 9906 5375 DX 9507 CROWS NEST

Table 1 M4 MOTORWAY RESIDENTIAL TRAFFIC NOISE CRITERIA

Noise Descriptor	Existing Ambient Noise Level, dB(A)	Adopted Noise Criterion, dB(A)
Daytime (24 hr) $L_{eq(24hr)}$	< 48 ≥ 48	Ambient + 12 60
Night-time (10 pm - 6 am) $L_{eq(8hr)}$	< 43 ≥ 43	Ambient + 12 55

For the level of traffic noise at residences to be considered acceptable, the relevant criteria in terms of $L_{eq(24hr)}$ and $L_{eq(8hr)}$ should both be met. Previous measurements at residences adjacent to the M4 Motorway have indicated that the night-time criterion is the governing criterion. As such, the following assessment at the closest receivers will be conducted for the night time $L_{eq(8hr)}$ noise level.

From previous measurements the existing $L_{eq(8hr)}$ noise levels at residences adjacent to the M4 Motorway are greater than 43 dB(A). According to the RTA guidelines shown in *Table 1*, the base level objective is 55 dB(A) $L_{eq(8hr)}$. The assessment locations are at 1 metre from the building facade and 1.5 m above ground level.

ii Parramatta West Public School

For classrooms in educational institutions, the RTA in its Interim Traffic Noise Policy specifies that the internal $L_{eq(1hr)}$ noise level should not exceed 45 dB(A) between the hours from 8:30 am to 3:30 pm. With windows open, this corresponds approximately to 55 dB(A) measured at 1 metre outside the facade. This criterion is adopted for the assessment of Parramatta West Public School at the closest building to the motorway.

The criteria apply for the projected traffic flow in the year 2005, that is, 10 years after the upgrade of the Motorway.

Calculation Methodology

A computer model containing relevant data such as barrier heights, traffic lanes and cuttings was established for the section of the M4 Motorway, slightly west of Church Street to Coleman Street. Information such as traffic volumes, proportion of heavy vehicles and mean traffic speeds was also incorporated into the model.

Noise levels at each receiver location were calculated using an in-house computer program which implements the CORTN traffic noise prediction model.

The model involves dividing each traffic lane into 100 metre sections and calculating noise levels from each road section to each receiver. Where required, barrier heights were incorporated into the calculation procedure to achieve the relevant noise criteria.

Source heights of 0.5 m, 1.5 m and 3.6 m were used for cars, heavy vehicles and heavy vehicle exhausts respectively. For heavy vehicles, noise levels contributed from the exhausts are approximately 8 dB lower than those from the engines.

Correction for facade effects, adjusted to Australian conditions as described in the RTA's Interim Traffic Noise Guidelines, was incorporated in the model.

The predicted noise levels using CORTN procedure are in terms of $L_{10(18hr)}$ and $L_{10(1hr)}$ noise levels. These may be converted to $L_{eq(24hr)}$ and $L_{eq(1hr)}$ noise levels by subtracting 3.5 dB and 3 dB from the calculated $L_{10(18hr)}$ and $L_{10(1hr)}$ noise levels respectively. Since previous noise measurements at residences adjacent to this section of the M4 Motorway indicated that the night-time $L_{eq(8hr)}$ noise levels are approximately 4 dB below the $L_{eq(24hr)}$ noise levels. The $L_{eq(8hr)}$ noise levels may therefore be obtained by subtracting 4 dB from the $L_{eq(24hr)}$ noise levels.

Receiver locations were obtained from 1:4000 orthophoto maps and aerial photographs provided by the RTA. A site survey was conducted to identify the existence of the receivers and to determine ground floor heights.

Design parameters used in the calculations are:

- **Traffic Speed:**
  30 km/hr where traffic volumes are more 2000 vehicles per lane per hour; and
  90 km/hr where traffic volumes are less than 2000 vehicles per lane per hour.

- **Traffic Volumes:**
  Night-time projected traffic volumes and proportion of heavy vehicles for the year 2005 for road section between Church Street and Coleman Street are shown in *Table 2* below. These were projected with an annual growth rate of 2 per cent based on the data recorded in September 1995 by the RTA. It is assumed that the proportions of heavy vehicles in future are similar to the existing situation.

Table 2 PREDICTED AVERAGE WEEKDAY DAILY TRAFFIC VOLUMES FOR THE YEAR 2005: CHURCH STREET TO COLEMAN STREET

Direction	Average Weekday Daily Traffic Volume	Percentage of Heavy Vehicle
Eastbound (Coleman to Church Street)	72550	4%
Westbound (Church Street to Coleman Street)	73167	5%
Entry Ramp (near Church Street)	23825	5%
Exit Ramp (near Church Street)	23746	5%

Results

i Residences Adjacent to Meehan Street, East of Inkerman Street

The existing $L_{eq(8hr)}$ noise levels at residences adjacent to Meehan Street (near the Nissan Car Dealership) were measured to be between 59 and 61 dB(A). The predicted $L_{eq(8hr)}$ noise levels at these residences in the year 2005 are 62 dB(A). The main contribution is due to traffic on the via-duct as noise from traffic on the entry and exit ramps near Church Street is significantly reduced by the existing barriers along the motorway between the Nissan Car Dealership and Inkerman Street.

Calculations showed that predicted $L_{eq(8hr)}$ noise levels at residences adjacent to Meehan Street (near the Nissan Car Dealership) in the year 2005 would still be well above the criterion of 55 dB(A) even if the existing barrier heights were raised to 6 metres. In addition, calculations were performed with a 6 metre high barrier along the boundary of 10 Meehan Street/Nissan Car Dealership and a 6 metre high barrier along the motorway between Inkerman Street and Church Street. The predicted $L_{eq(8hr)}$ noise level was found to be 59 dB(A) which is 4 dB above the criterion of 55 dB(A).

If a 2 m high barrier on the approach of the via-duct is constructed in addition to the existing barriers along the motorway, the predicted $L_{eq(8hr)}$ noise levels at most residences adjacent to Meehan Street would be reduced to the objective level. The predicted $L_{eq(8hr)}$ noise levels are above the criterion at about six residences west of the Nissan Car Dealership if this option is implemented. The predicted $L_{eq(8hr)}$ noise levels are up to 59 dB(A) at these residences.

ii Other Residences Between Church Street and Coleman Street

Table 4 shows the required barrier heights along the remaining sections of the M4 Motorway between Church Street and Coleman Street to ensure that the predicted $L_{eq(8hr)}$ noise levels at the closest residences are within the criterion of 55 dB(A).

Table 4 LOCATIONS AND HEIGHTS OF BARRIERS REQUIRED

Location *(see sketches attached)*		Height (m)
Inkerman Street - Denison Street	North Side	4.0
Denison Street - Crown Street	North Side	4.0
Crown Street - Tiara Place	North Side	5.0
Pitt Street - Franklin Street	North Side	1.5
Patricia Street - Bernard Street	North Side	1.5
Fox Street - Pitt Street	South Side	3.5
Rickard Street - Morgan Street	South Side	2.0
Morgan Street - Davidson Street	South Side	1.5
Davidson Street - Coleman Street	South Side	3.5

It can be seen from *Table 4* that barriers between Crown Street and Tiara Place are higher than 4 metres.

iii Parramatta West Public School

A traffic volume of 11145 vehicles during the peak hour was used to predict noise levels at the school from the motorway. This was projected using data recorded by the RTA with annual growth rate as discussed above. It should be noted that traffic flow on the M4 Motorway during school hours (8:30 am - 3:30 pm) peaks between 2:30 pm and 3:30 pm. Mean traffic speed and proportion of heavy vehicles used were as described in *Table 2*. The predicted $L_{eq(1hr)}$ noise level at the closest building facade of the school during the peak hour is approximately 66 dB(A). For the $L_{eq(1hr)}$ noise level at the building facade to be within 55 dB(A), a 4.5 metre high barrier should be constructed on the northern side of the M4 Motorway between Franklin Street and Burnett Street.

Barriers may be constructed in the form of earth mounds, fences or a combination of these so as to achieve the specified heights where space for earth mounds is insufficient. Where relevant, the barriers should be positioned at the top of the cutting or embankment.

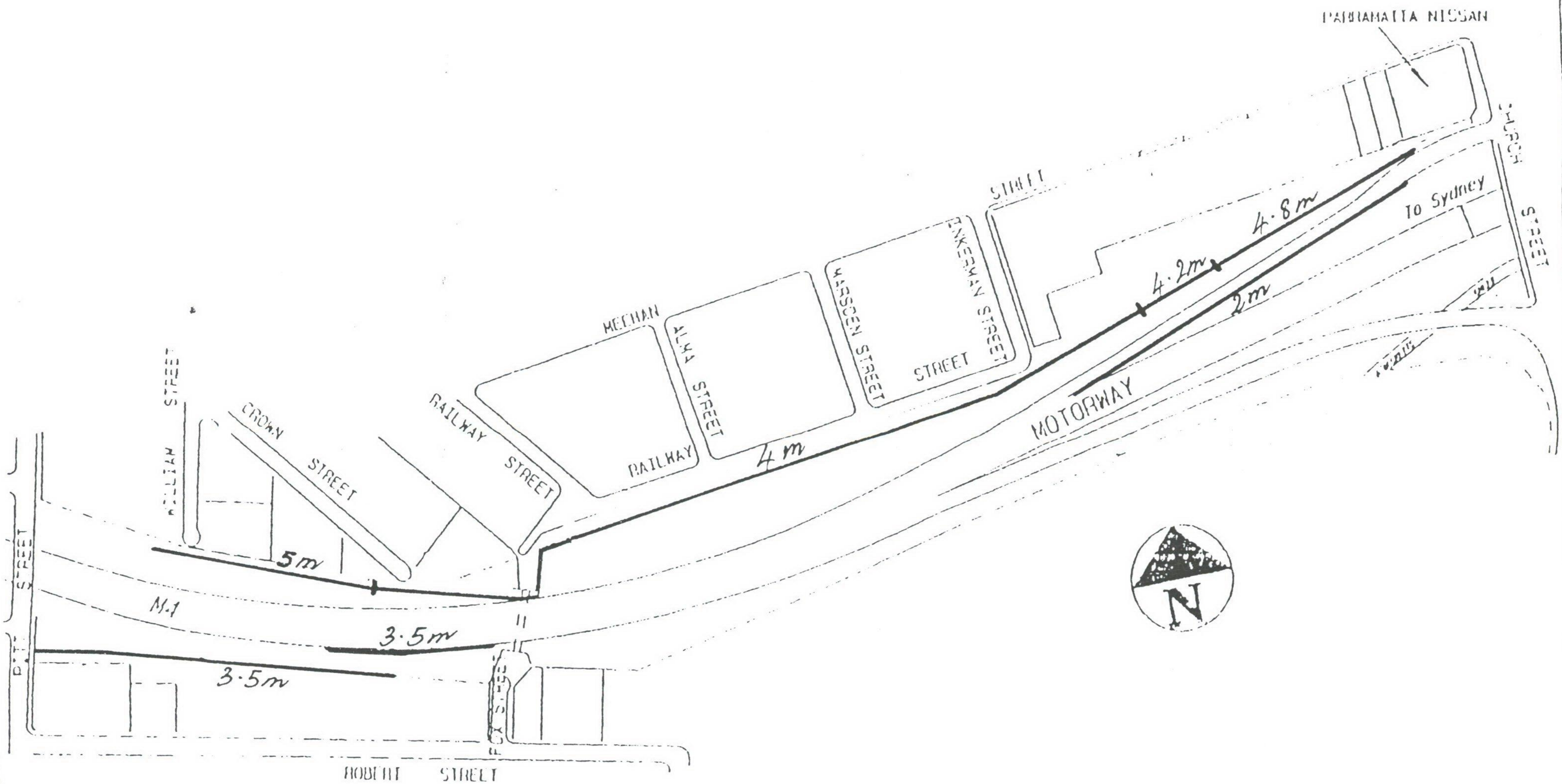
Conclusion

In conclusion, if the above recommendations are implemented, traffic noise levels at most residences along the M4 Motorway between Church Street and Coleman Street would comply with the proposed M4 Motorway RTA guidelines. It is expected that the predicted $L_{eq(8hr)}$ noise levels would not comply with the relevant criteria at about six residences nearest to the Nissan Car Dealership.

Yours sincerely
for ERM Mitchell McCotter Pty Ltd

Dan Dang
Acoustic Engineer

Project Director Quality Assurance Check
John Wassermann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RAILWAY
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3·5m
PITT STREET
ROBERT STREET
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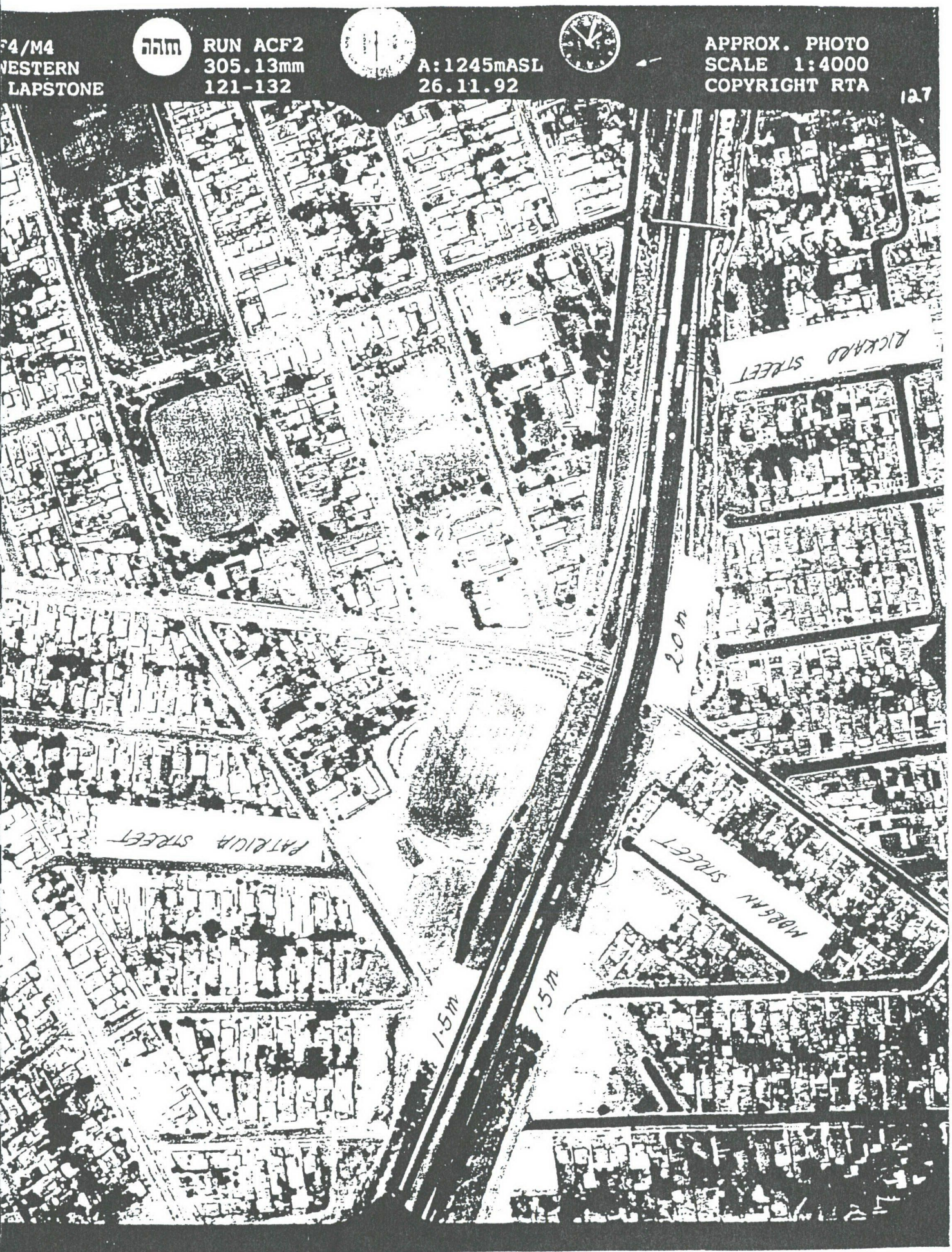
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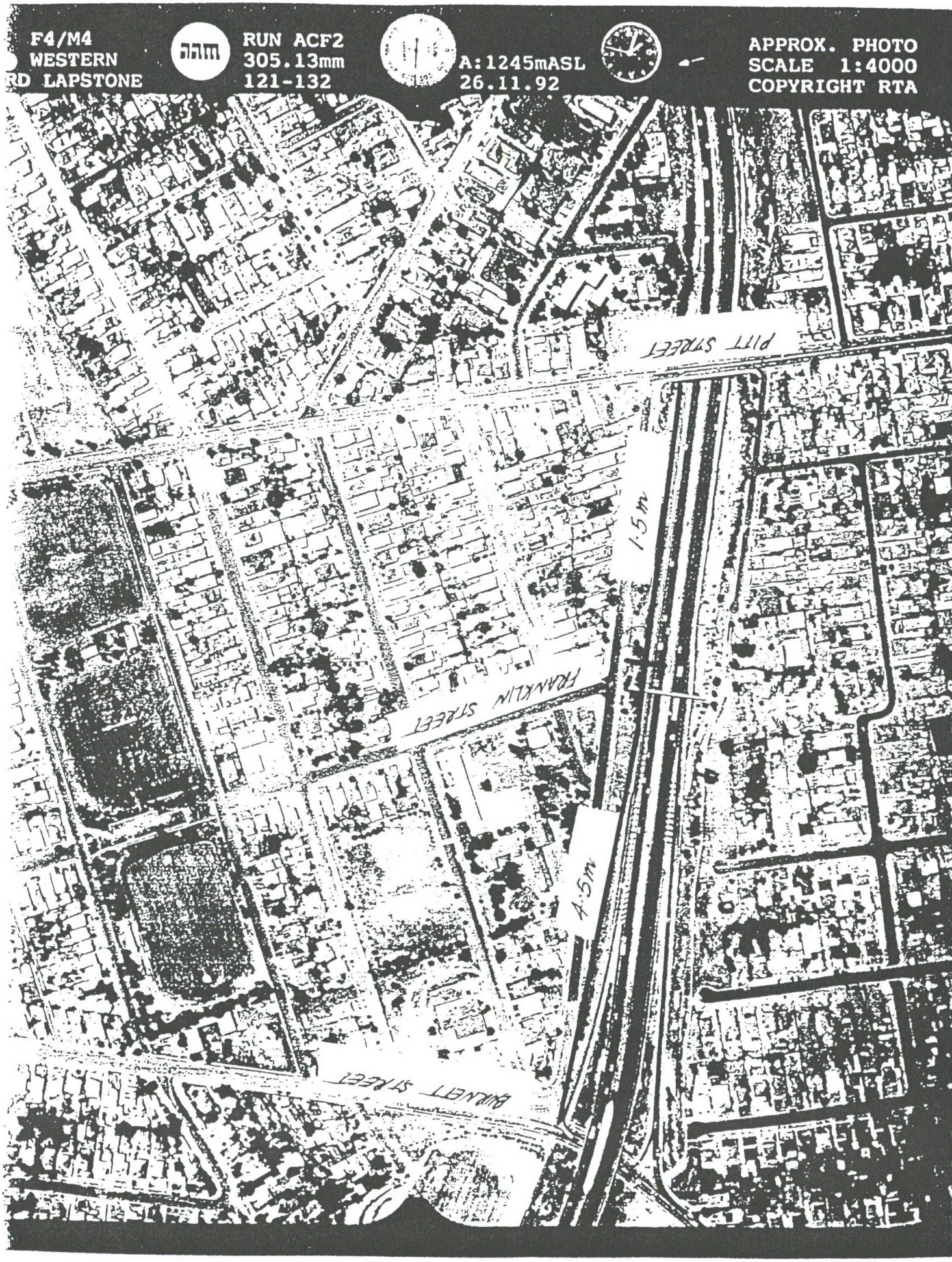
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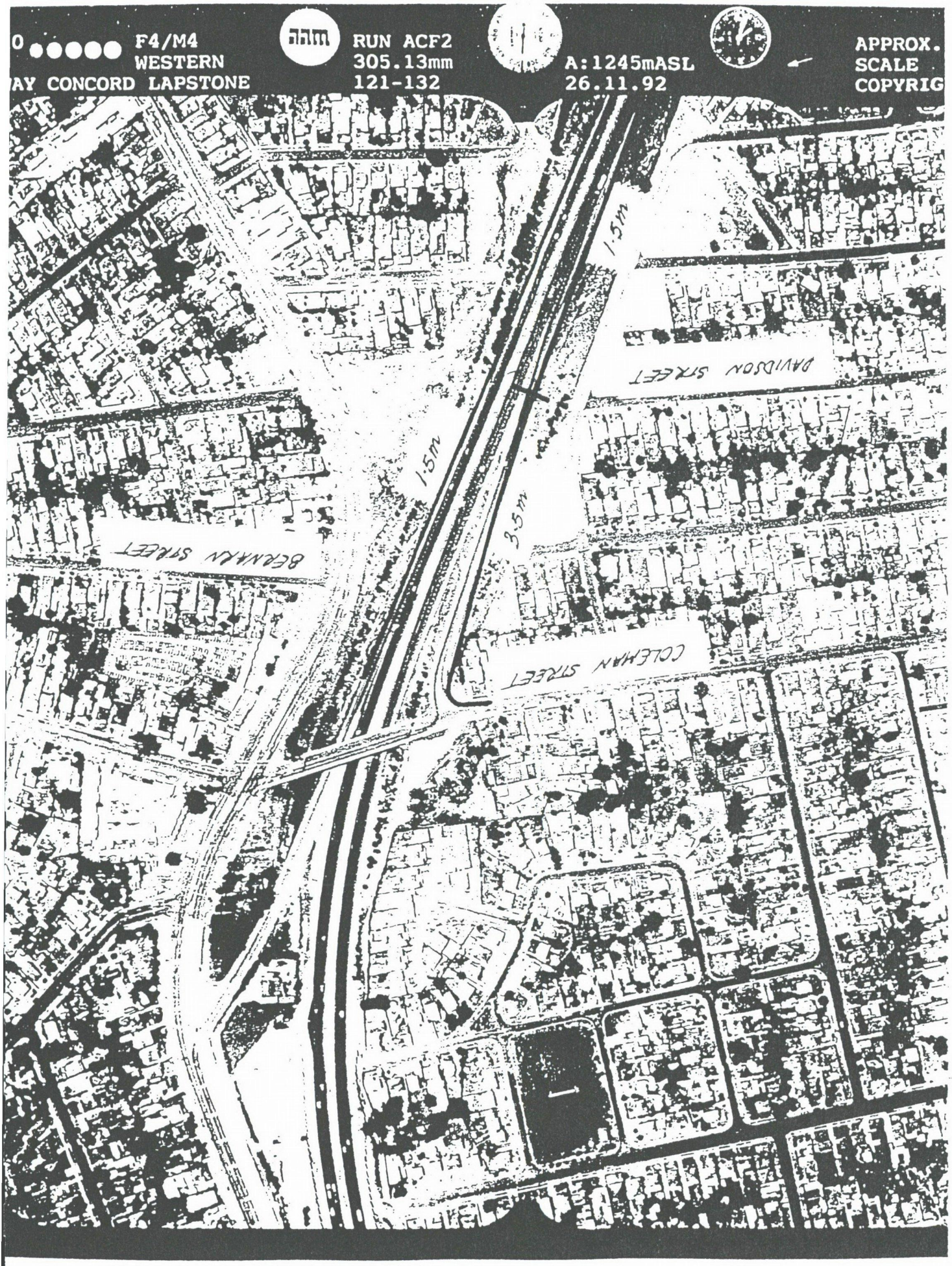
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COLEMAN STREET
BERMAN STREET

ATTACHMENT 5

M4 UPGRADING PROJECT - PROSPECT TO EMU PLAINS TRAFFIC NOISE ASSESSMENT REPORT

October 1995, Wilkinson Murray Pty Limited

M4 UPGRADING PROJECT –

PROSPECT TO EMU PLAINS

TRAFFIC NOISE ASSESSMENT REPORT

Report No 95212

October 1995

Prepared for

Roads & Traffic Authority
Private Ventures
83 Flushcombe Road
BLACKTOWN NSW 2148

Prepared by

Wilkinson Murray Pty Limited
123 Willoughby Road
CROWS NEST NSW 2065
Telephone (02) 437 4611
Fax: (02) 437 4393

TABLE OF CONTENTS

1. INTRODUCTION

Wilkinson Murray was requested by the Roads & Traffic Authority (RTA) to assess the impact of road traffic noise along certain sections of the M4 between Prospect and Russell Street, Emu Plains and to advise on noise control measures.

There have been some complaints regarding road traffic noise associated with the motorway along this section. In addition to this, the RTA has requested proposals from the private sector to design and construct upgrading works on this section of the M4. The upgrading works would include the construction of additional lanes and the provision of noise barriers to meet the objective set out in the RTA's Interim Traffic Noise Policy, 1992.

This report provides existing noise levels at relevant locations and design of acoustic barriers to meet the noise objectives for future traffic.

2. SITE DESCRIPTION

For convenience and for the purpose of this report the M4 has been split into four different sections, as shown in the table below and Figures 1.1 to 1.4

* Section 1 from Wallgrove Road to Archbold Road. (Minchinbury).
* Section 2 from Roper Road to Mamre Road. (Colyton/St. Clair).
* Section 3 from the Northern Road to Mulgoa Road. (Jamisontown/Penrith).
* Section 4 from Mulgoa Road to Russell Street. (Jamisontown/Regentville).

The sections of motorway between Prospect and Russell Street not included in the above four sections do not have residences in the vicinity of the road and have not been discussed further in this report.

3. EXISTING NOISE ENVIRONMENT

3.1 Measurement Procedure

Measurements of the existing noise environment were made during the week starting Monday 18 September until Friday 22 September, 1995 and then again from Monday 9 October until Friday 13 October, 1995. The reason for the two week gap in the middle was to avoid the School Holidays where traffic flows are usually less and, therefore, the traffic noise may not be representative. All measurements were taken at 1 m from the facade at the following locations:

* 33 Farrington Street
* 7 Rutherglen Place
* 7 Tod Place
* 13 Orchard Road
* 14 Caines Crescent
* 22 Oliver Crescent
* 24 Buckland Road
* 69 Clyburn Avenue
* 24 Jeanette Street
* 49 Moolana Parade
* 2 Mensa Place
* 110 Nepean Street
* 44 Factory Road
* 13 Cornell Street

These are shown in Figures 1.1 to 1.4.

The noise monitoring equipment used for these measurements consisted of Environmental Noise Loggers set to A-Weighted, Fast response continuously monitoring over 15 minute sampling periods. This equipment is capable of remotely monitoring and storing noise level descriptors for later detailed analysis. The equipment was calibrated before and after the survey and no significant drift occurred.

The logger determines L_{A1}, L_{A10}, L_{A90} and L_{Aeq} levels of the existing noise environment. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1%, 10% and 90% of the sample time respectively. The L_{A1} is indicative of maximum noise levels due to individual noise events such as the occasional passby of a heavy vehicle. The L_{A90} level is normally taken as the background noise level. The L_{Aeq} level is the Equivalent Continuous Sound Level and has the same sound energy over the sampling period as the actual noise environment with its fluctuating sound levels. Whilst the L_{A10} has in the past been used as a descriptor for traffic noise, the L_{Aeq} is now the standard descriptor for traffic noise.

3.2 Measurement Results

The 24 hour L_{Aeq} and 8 hour night time L_{Aeq} levels have been calculated from the recorded data and are summarised in the Table 1. A full graphical representation of the statistical noise data is given in Appendix A.

TABLE 1 : MEASUREMENT RESULTS

Area	Location	L_{Aeq} 24 hr (00.00–24.00) dBA	L_{Aeq} 8 hr (10pm–6 am) dBA	Date of Measurement (1995)	Approx. Distance from Traffic (m)
1 Minchinbury	Farrington St	58 57	56 55	21/9 22/9	70
	Rutherglen Pl	59 59	57 58	21/9 22/9	75
	Tod Place	60 60	59 58	21/9 22/9	70
2 Colyton/ St. Clair	Orchard Rd	64 62	60 60	18/9 18/9	45
	Caines Cr	63 61	60 59	18/9 19/9	60
	Oliver Cr	63 63	59 59	18/9 19/9	45
	Buckland Rd	60 60	60 58	21/9 22/9	90
3 Jamisontown/ Penrith	Clyburn Av	61 60	58 57	18/9 19/9	45
	Jeanette St	61 61	55 55	21/9 22/9	130
	Moolana Prd	63 64	60 61	12/10 13/10	65
	Mensa Place	61 64	60 60	12/10 13/10	40
4 Jamisontown/ Regentville	Nepean St	59 60	55 57	18/9 19/9	50
	Factory Rd	57 56	54 56	21/9 22/9	125
	Cornell St	59 59	54 54	18/9 19/9	60

NOTE: All levels rounded to the nearest whole decibel.

4. NOISE LEVEL CRITERIA

The criteria used to assess noise levels are based on the RTA 1992 Interim Traffic Noise Policy (INTP) objectives for roadworks which is summarised in Table 2 below.

TABLE 2 : RTA INTERIM NOISE LEVEL OBJECTIVES

Assessment Site Category	Descriptor	Base Objective	Lower Noise Areas
Buildings of a residential nature including residences, hospitals, motels and caravan parks	"Daytime" (24 hour) L_{Aeq}(24 hour)	60 dBA	Ambient + 12 dBA (where L_{Aeq} < 48 dBA)
	Night-time (10 pm - 6 am) L_{Aeq} (8 hour)	55 dBA	Ambient + 12 dBA (where L_{Aeq} < 43 dBA)
Classrooms in educational institutions	8.30 am - 3.00 pm L_{Aeq} (1 hour) internal	45 dBA	45 dBA
Community facilities, eg places of worship, passive urban parks and noise sensitive facilities (eg libraries)	Consideration will be given to ambient noise conditions, extent and type of use to determine whether noise reduction strategies are needed.		

Notes: 1) These ambient levels refer to the existing noise climate as opposed to the noise climate 10 years into the future if the proposed scheme was not completed.

2) The criteria related to limitation of increase in traffic noise from ambient levels in higher noise areas are not to be adopted in this case.

In view of the fact that the M4 currently exists, the base noise level objectives in Column 3 are the appropriate objectives in this case. In particular, the measured noise levels are to be compared with:

* L_{Aeq} (24 hour) 60 dBA
* L_{Aeq} (8 hour) 55 dBA

5. ASSESSMENT OF FUTURE NOISE LEVELS

Future noise levels for the Year 2005 have been determined and these have been compared with the base noise level objectives.

RTA have advised that a 2% per annum traffic growth should be assumed at least to the Year 2005. On this basis, the growth in traffic from 1995 to 2005 will be 22%.

Using standard noise level/traffic flow relationships (for example, CORTN)* the increase in L_{Aeq} road traffic noise between 1995 and 2005 has been estimated as 0.9 dBA. This increase has been rounded to the nearest whole number, 1 dBA.

Table 3 shows the future noise levels, determined by adding 1 dBA to the measured levels in Table 1, and the amount by which the base noise level will be exceeded.

* Calculation of Road Traffic Noise U.K. Department of Transport (1988).

TABLE 3 : CRITERION EXCEEDANCE

Area	Location	L_{Aeq} 24 hr (00.00–24.00) dBA		L_{Aeq} 8 hr (10pm–6 am) dBA	
		2005	Criterion Exceeded by	2005	Criterion Exceeded by
1 Minchinbury	Farrington St	59 58	–	57 56	2
	Rutherglen Pl	60 60	–	58 59	4
	Tod Place	61 61	1	60 59	5
2 Colyton/ St. Clair	Orchard Rd	65 63	5	61 61	6
	Caines Cr	64 62	4	61 60	6
	Oliver Cr	64 64	4	60 60	5
	Buckland Rd	61 61	1	61 59	6
3 Jamisontown/ Penrith	Clyburn Av	62 61	2	59 58	4
	Jeanette St	62 62	2	56 56	1
	Moolana Prd	64 65	5	61 62	7
	Mensa Place	62 65	5	61 61	6
4 Jamisontown/ Regentville	Nepean St	60 61	1	56 58	3
	Factory Rd	58 57	–	55 57	2
	Cornell St	60 60	–	55 55	–

NOTES: All levels rounded to the nearest whole decibel.

6. NOISE CONTROL MEASURES

It can be seen from Table 3 that the road traffic noise levels in the Year 2005 will exceed the base level objective by up to 7 dBA. The objectives will be exceeded in most areas, over the 24 hour period and the 8 hour night-time period. The night-timeperiod, generally, has a greater exceedance level.

The levels and exceedances given in Table 3 are the highest numbers for the residential areas in question. Noise levels and exceedances at other houses are either equal to or less than those shown in the Table.

The heights of the recommended roadside noise barriers, designed to reduce the noise levels to meet the criteria at all residences have been calculated using the `CORTN' method and are shown in Table 4 below:

TABLE 4 : BARRIER HEIGHTS TO MEET NOISE LEVEL OBJECTIVES

Area	Location	Recommended Barrier Height (m)	Predicted Noise Reduction (dB)	Approx. Distance from Traffic (m)
1 Minchinbury	Farrington St	2	4	70
	Rutherglen Pl	3	4	75
	Tod Place	3.5	4	70
2 Colyton/ St. Clair	Orchard Rd	4	6	45
	Caines Cr	4	6	60
	Oliver Cr	4.5	5	45
	Buckland Rd	4.5	5	90
3 Jamisontown/ Penrith	Clyburn Av	3	4	45
	Jeanette St	1.5	2	130
	Moolana Prd	3.5	7	65
	Mensa Place	3.0	6	40
	Timaru	3	6	35 to 60
4 Jamisontown/ Regentville	Nepean St	1	3	50
	Factory Rd	1	2	125
	Cornell St	0	0	60

NOTE: All levels rounded to the nearest whole decibel.

For practicality and efficiency reasons, the barriers should be installed at the side of the motorway, as close as practicable to the traffic. In most cases, they can be constructed as landscaped earth mounds, but this will not be possible where the road is on fill or on a bridge. These situations occur on, and on the entries to, the Regentville Bridge and also at sections of motorway passing over creeks and gullies.

Where space is not available for earth mounds, barriers in the form of a wall should be erected. These can be constructed of well sealed timber of thickness approximately 30 mm, concrete or lightweight concrete panels or specially designed acoustic panels.

In some cases, the barriers required are already provided by existing topography and, further barrier construction or full height barrier construction is not required.

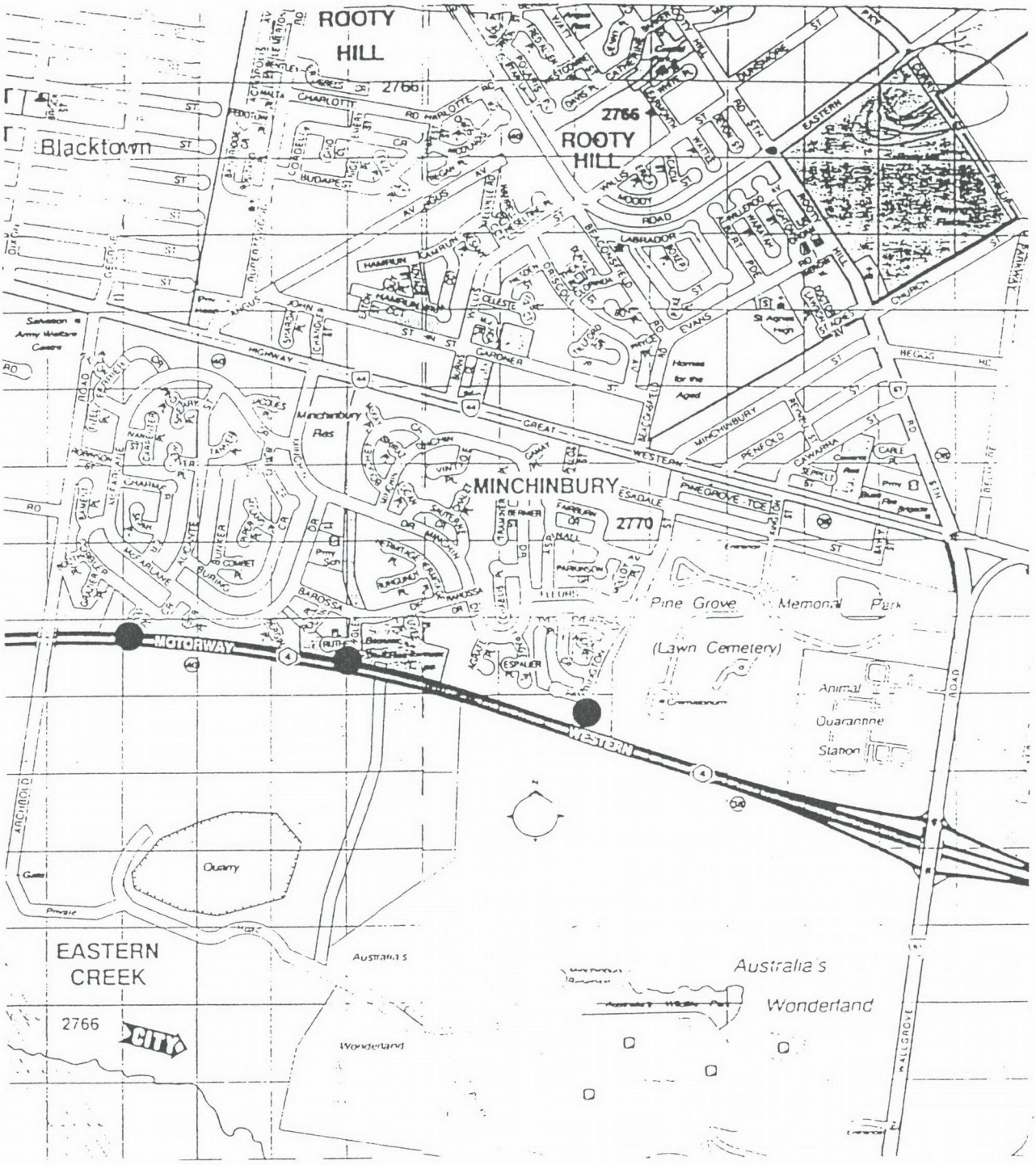
Taking all of these factors into account, an outline of the barrier construction requirements are shown in Figures 2.1 to 2.4.

7. CONCLUSIONS

Noise levels from road traffic affecting residential areas along the M4 including areas; Minchinbury, Colyton/St Clair, Jamisontown/Penrith and Jamisontown/Regentville will exceed the base level noise objectives by up to 7 dBA in 2005.

Acoustic barriers (mainly earth mound) of various heights are suggested to reduce the noise levels to meet the goals.

Revisions	Date	Status	Prepared by:	Checked by:
0	25 October, 1995	Draft	K. Scannell	B.J. Murray
1	31 October, 1995	Final		



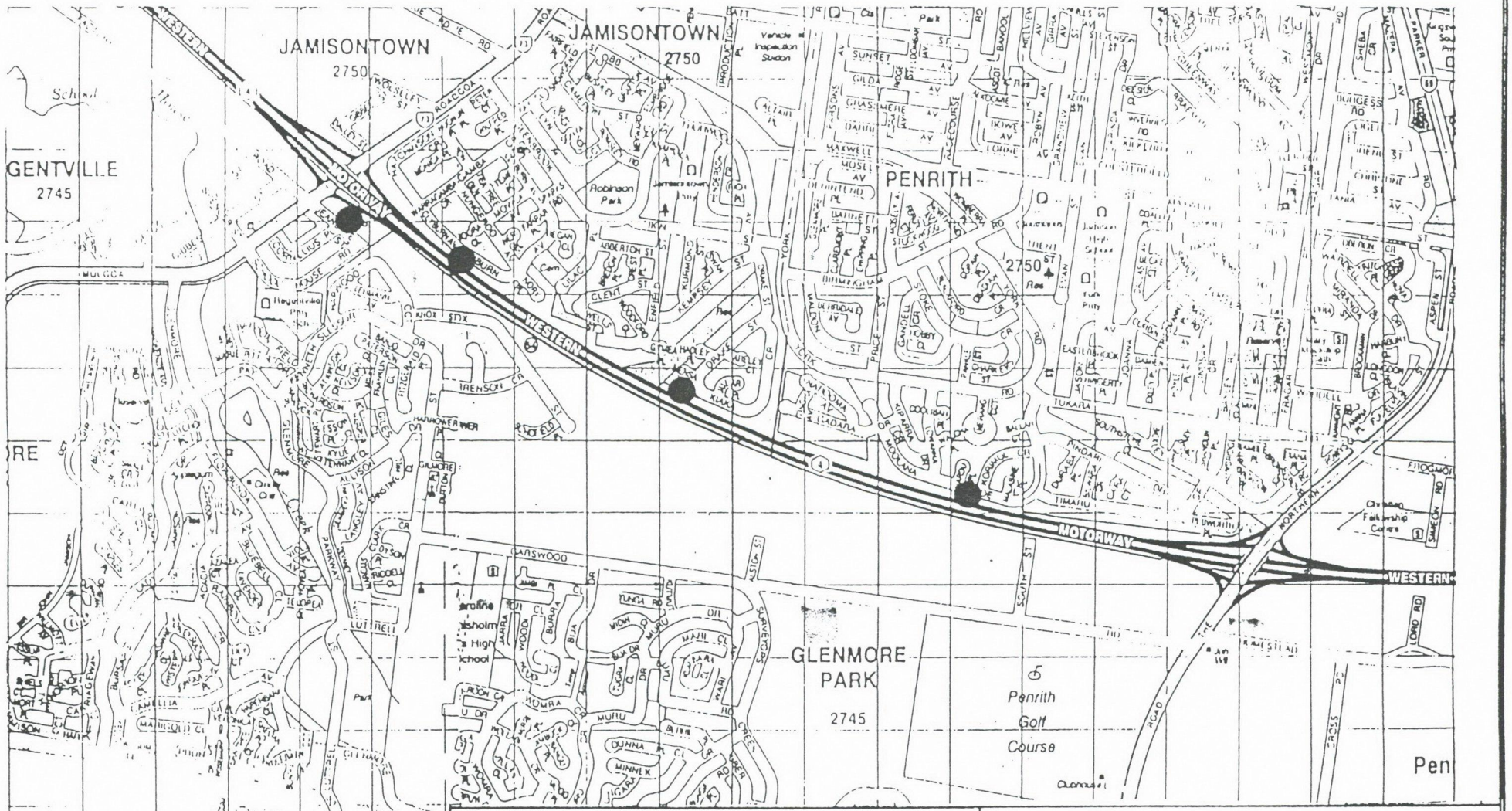
● measurement locations

WILKINSON MURRAY PTY LTD
Level 1, 123–125 Willoughby Road
Crows Nest NSW 2065

Telephone (02) 437 4611
Facsimile (02) 437 4393

MEASUREMENT LOCATIONS
SECTION 1

REPORT NO 95212 FIGURE 1.1



● measurement locations

WILKINSON MURRAY PTY LTD
Level 1, 123–125 Willoughby Road
CROWS NEST NSW 2065

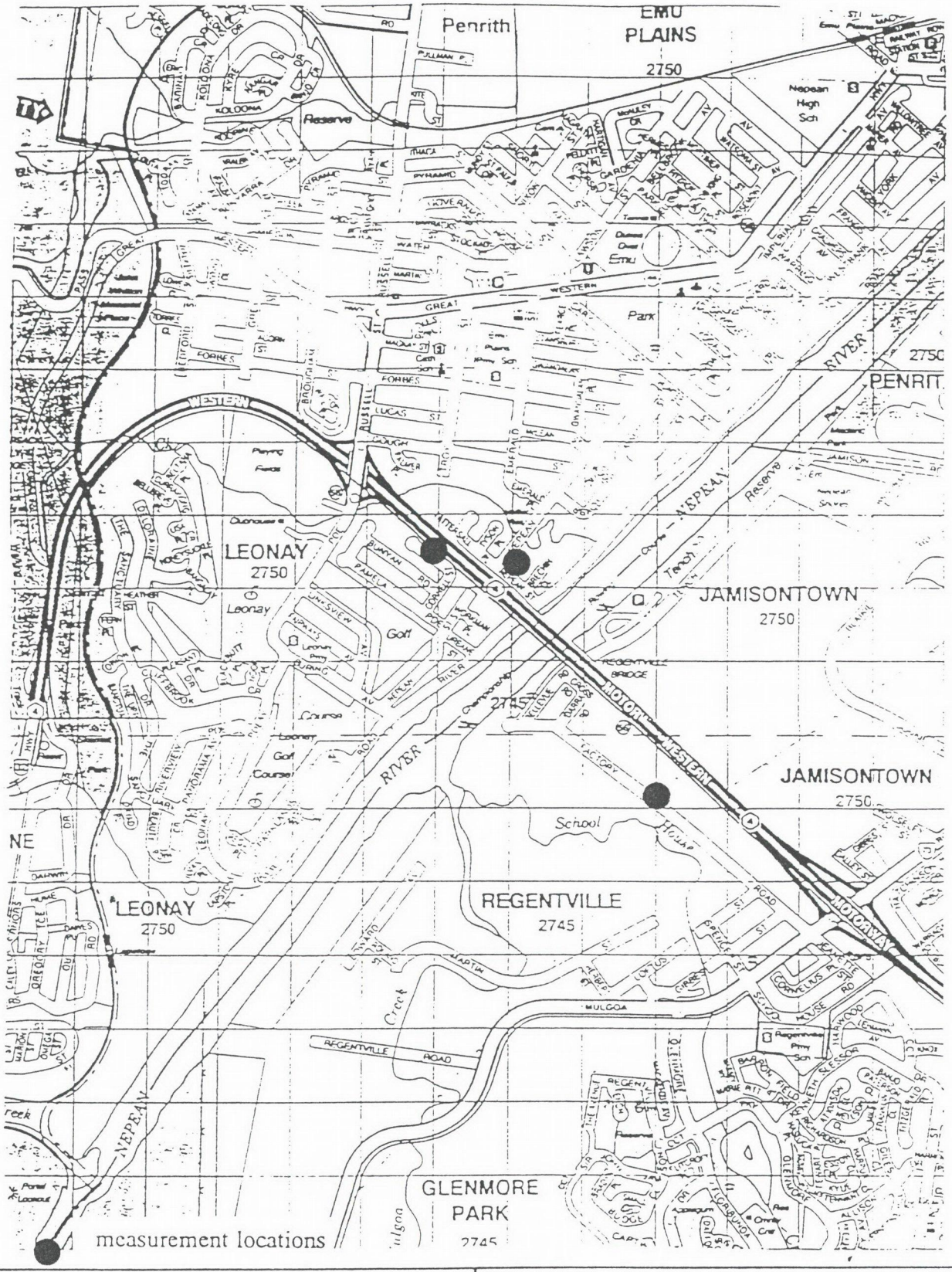
Telephone (02) 437 4611
(02) 437 493

MEASUREMENT LOCATIONS SECTION 3

REPORT NO. 95212 FIGURE 1.3

● measurement locations

WILKINSON MURRAY PTY LTD Level 1, 123-125 Willoughby Road Crows Nest NSW 2065 Telephone (02) 437 4611 Facsimile (02) 437 4393	MEASUREMENT LOCATIONS SECTION 2 REPORT NO 95212 FIGURE 1.2



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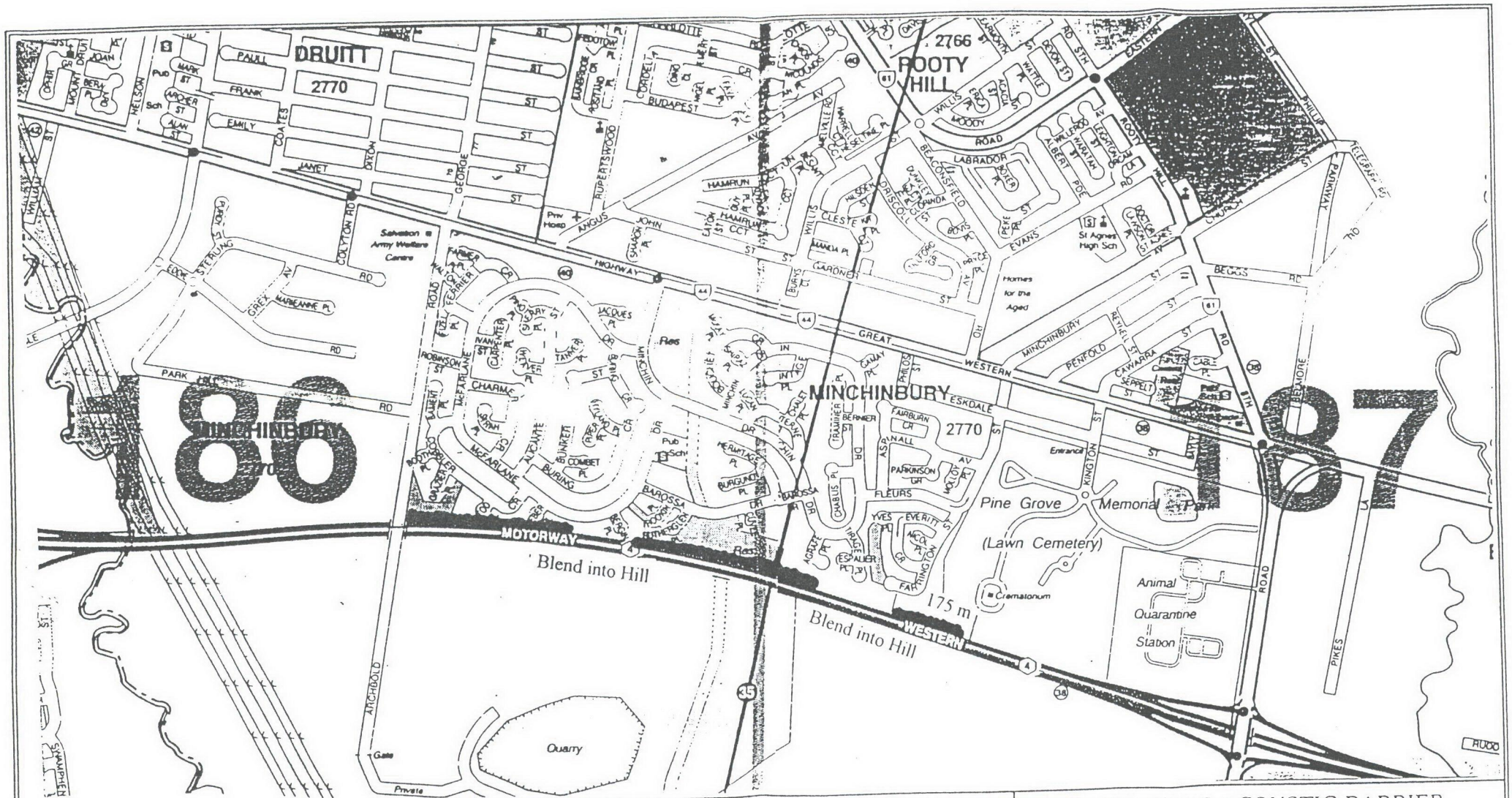
Crows Nest NSW 2065

Telephone (02) 437 4611
Facsimile (02) 437 4393

MEASUREMENT LOCATIONS
SECTION 4

REPORT NO 95212 FIGURE 1.4



Acoustic barriers

WILKINSON MURRAY PTY LTD
Level 1, 123–125 Willoughby Road
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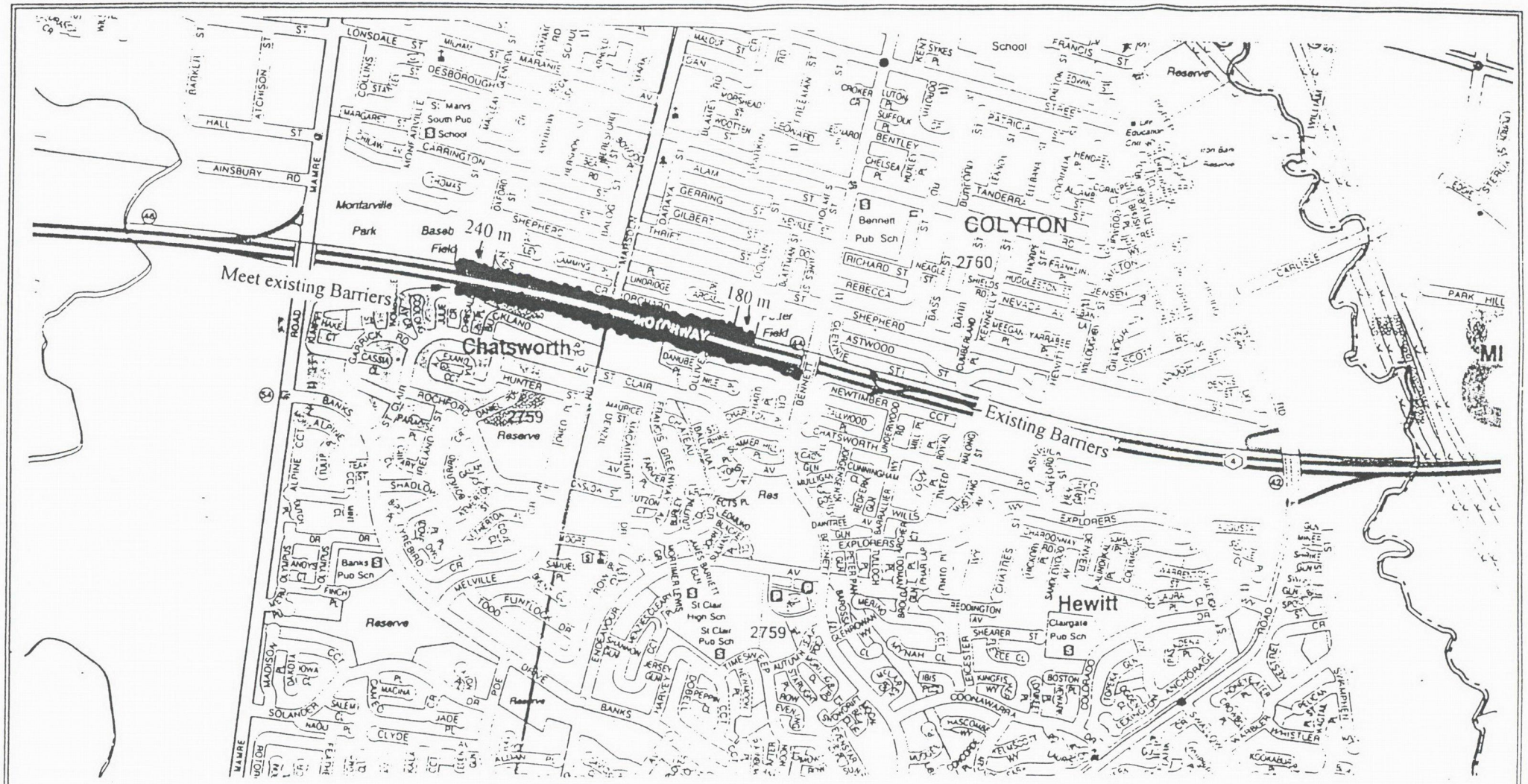
Facsimile (02) 437 493

OUTLINE OF ACOUSTIC BARRIER POSITIONS

REPORT NO. 95212 FIGURE 2.1



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Telephone (02) 437 4611
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OUTLINE OF ACOUSTIC BARRIER POSITIONS

REPORT NO. 95212 FIGURE 2.2

WILKINSON MURRAY PTY LTD
Level 1, 123-125 Willoughby Road
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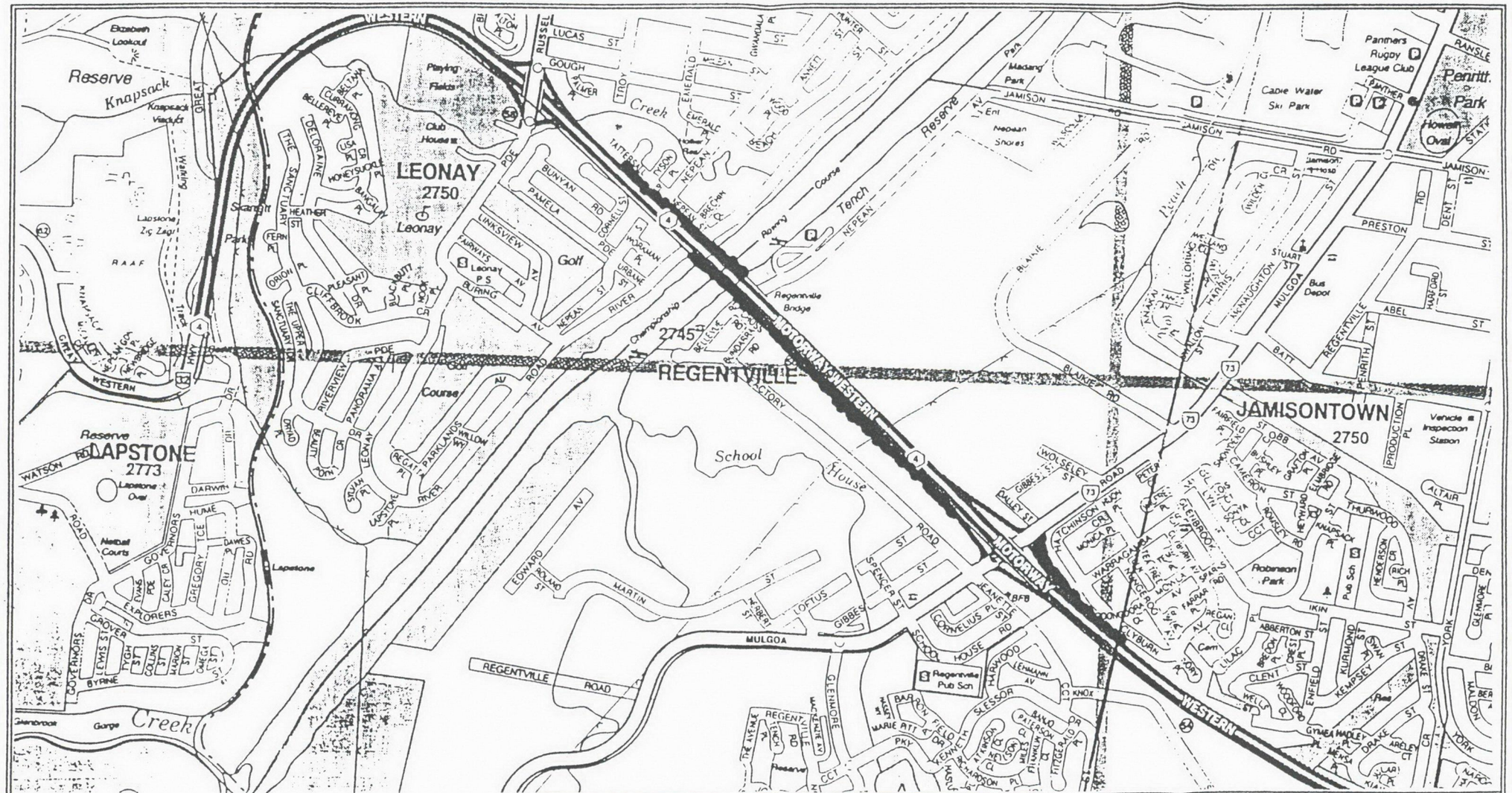
Telephone (02) 437 4611
Facsimile (02) 437 493

OUTLINE OF ACOUSTIC BARRIER POSITIONS

REPORT NO. 95212 FIGURE 2.3



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CROWS NEST NSW 2065

Telephone (02) 437 4611
Facsimile (02) 437 493

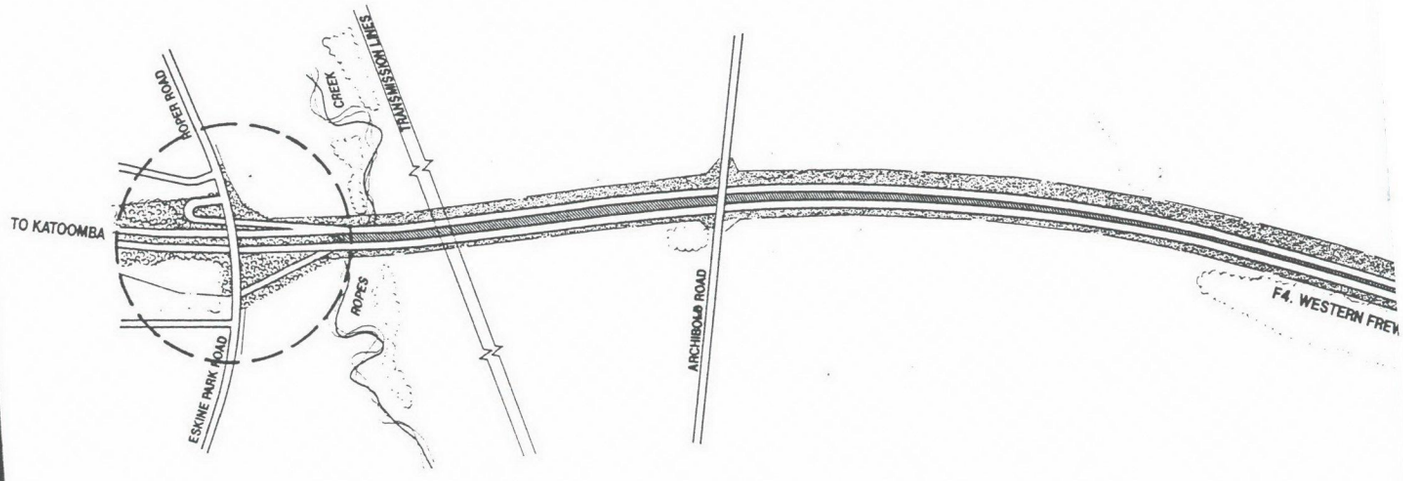
OUTLINE OF ACOUSTIC BARRIER POSITIONS

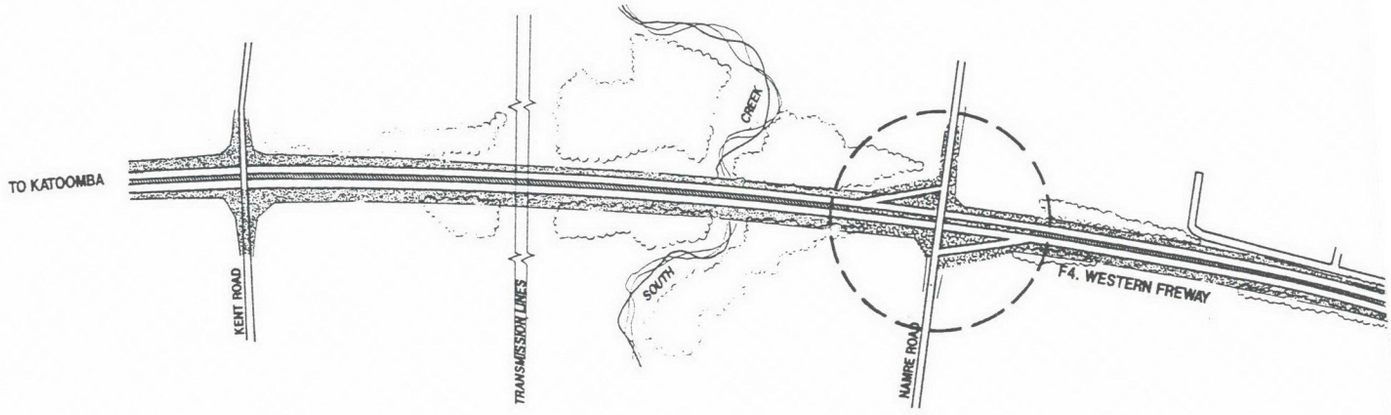
REPORT NO. 95212 FIGURE 2.4

ATTACHMENT 6

LANDSCAPE CONCEPT PLANS

Drawing Number 6004.358.LP 0030 (Sheets 1 and 2)



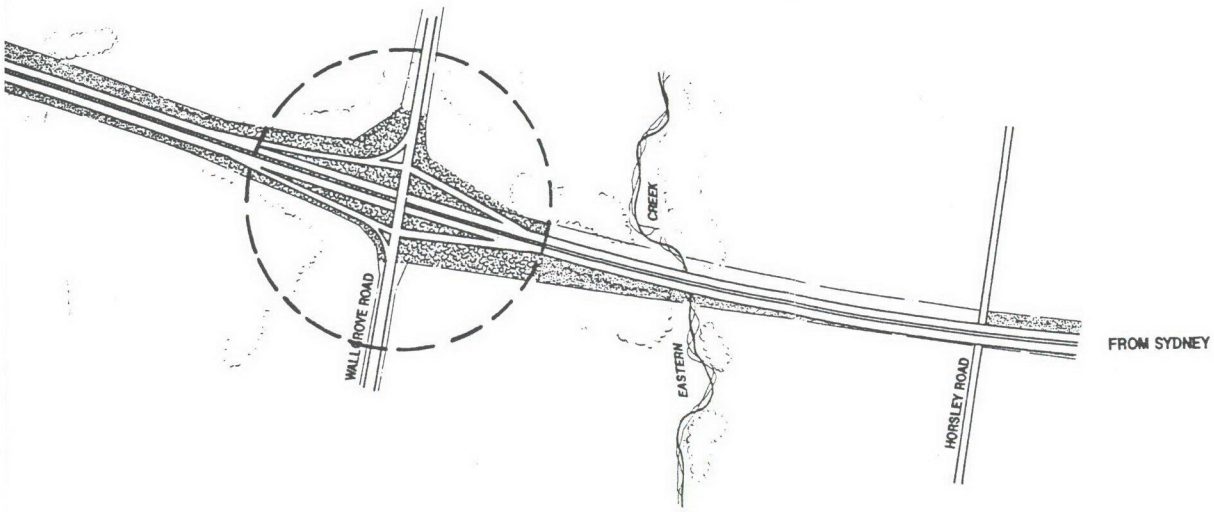


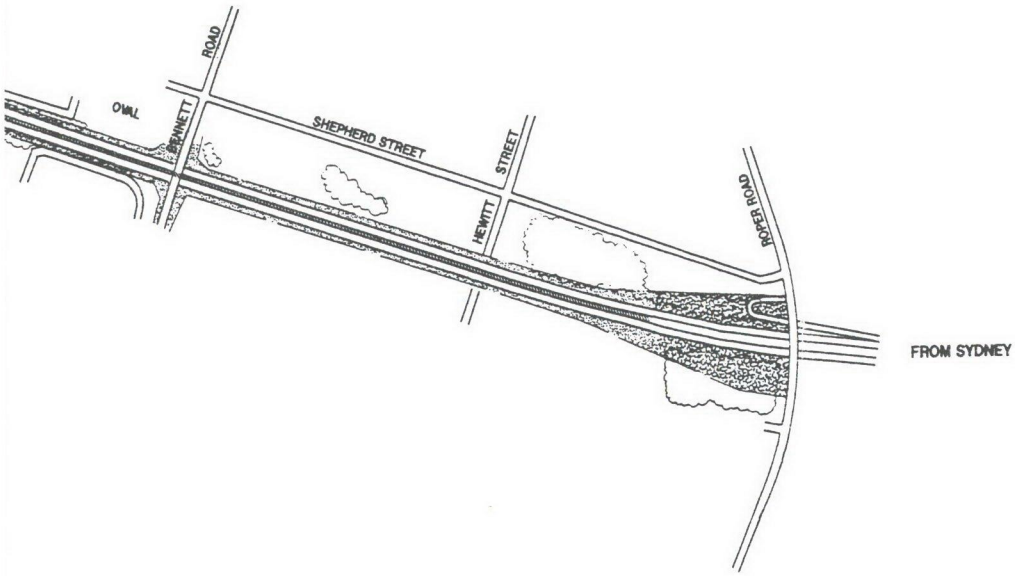
Existing vegetation

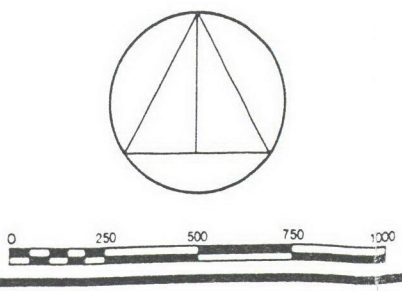
Mass tree planting with local tree species at close spacings, i.e 3.0m x 3.0m with shrubs interplanted over the area to be native seeded. Tree planting shall be at a minimum eight (8) rows, 5.0m in from carriageway.
Direct native seeding, principally with local species of Acacia, Eucalyptus and Casuarina, shall be 5.0m in from carriageway and extend to the boundary fence, after appropriate site treatment , including mowing and weed spraying.
All cut embankments shall be direct seeded by hand.

Mass shrub planting along median with local species at close spacings i.e 2.0m x 2.0m over the area to be native seeded.
Shrub planting shall be 2.0m in from carriageway.
Native seeding shall be with Acacia , Bursaria and Melaleuca species, 2.0m in from carriageway.

Formal nodal tree and shrub planting's to visually enhance the interchange along the freeway. Super-advanced size trees and colourful native shrubs are to be used where appropriate.
Species to be selected and planting designed in a manner which reinforces visual identity and creates a locally unique node.







ECOLOGICAL LANDSCAPE
Road Technology Branch

RTA TECHNOLOGY

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				Date	OCT '95
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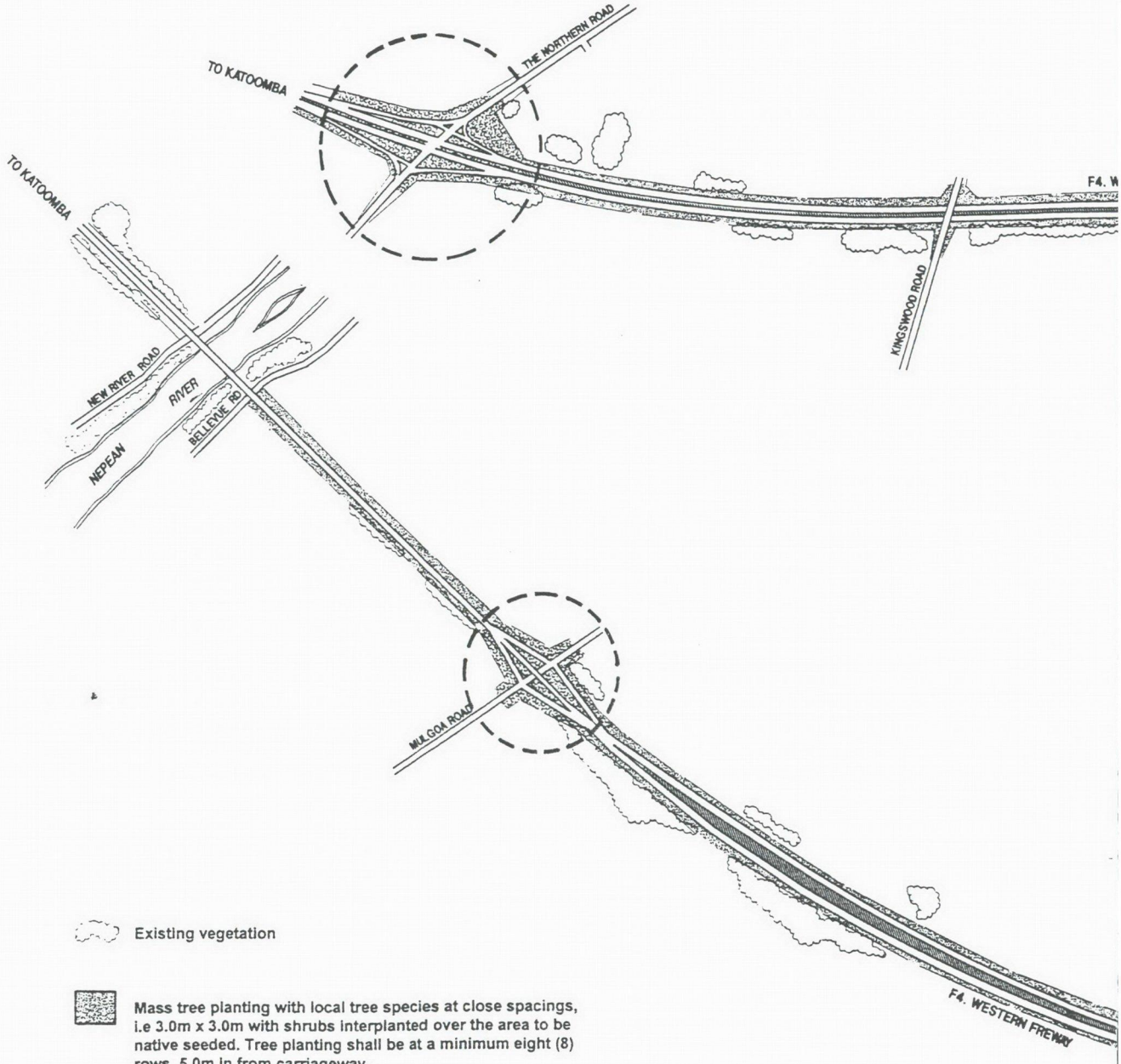

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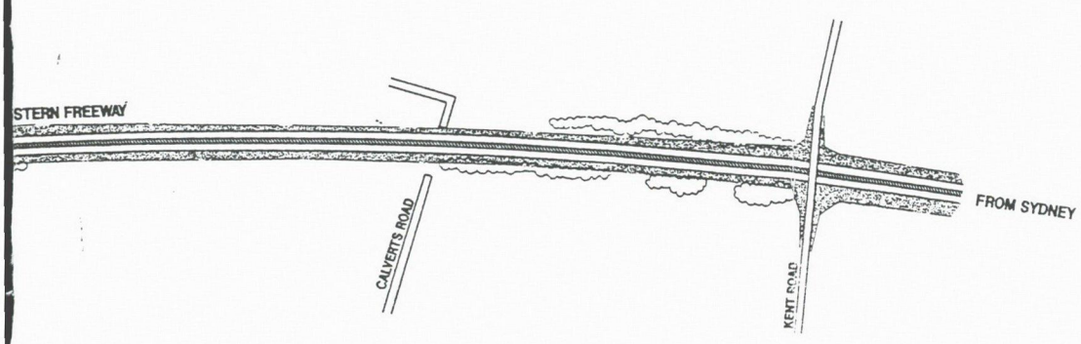

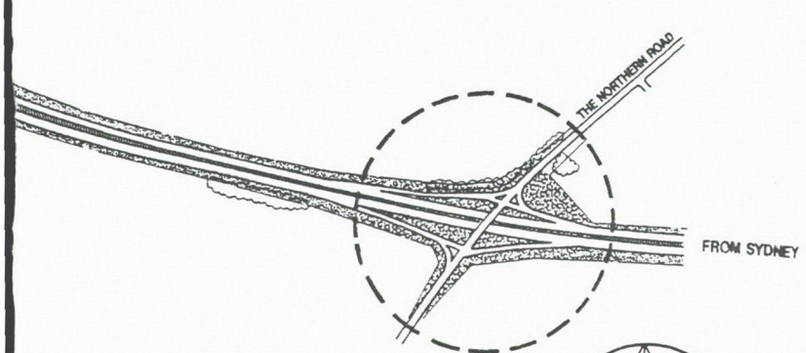

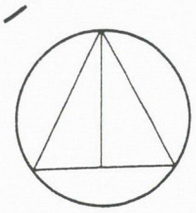

ECOLOGICAL LANDSCAPE
Road Technology Branch

RTA TECHNOLOGY

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