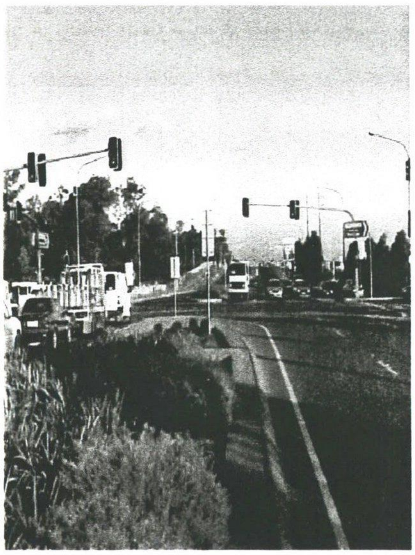
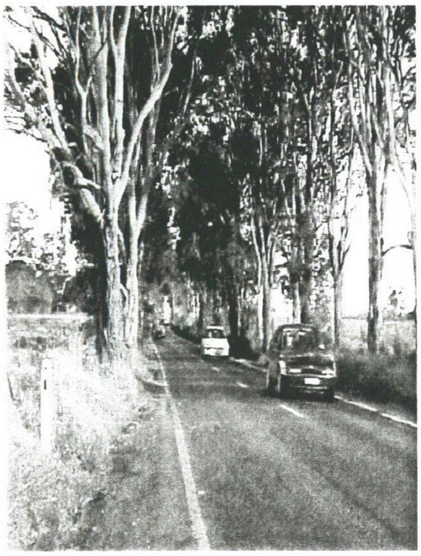
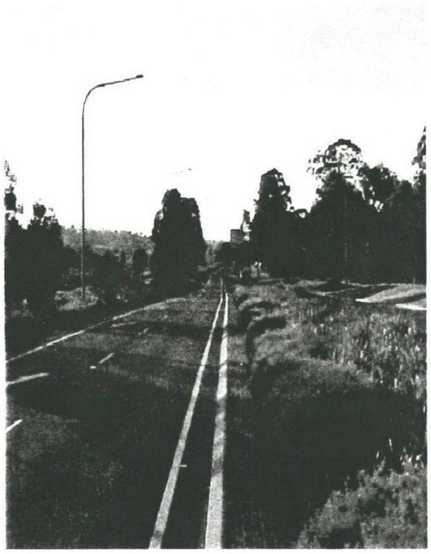
RTA

Review of Environmental Factors Old Windsor Road/Windsor Road

Proposed Upgrade between Sunnyholt Road and Merriville Road, Kellyville

Vol 2: Appendices

Hyder

Review of Environmental Factors
Old Windsor Road/Windsor Road

Author:	Katrina van Lint	K. van Lint	**Date:**	14 June 2001
Checker:	John Ridley	J Ridley	**Report no:**	NT00EFE2 - REF
Approver:	Tim Rodham	Tim Rodham		
RTA Approver:			**Date:**	

Disclaimer
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OLD WINDSOR ROAD
SUNNYHOLT ROAD TO MERRIVILLE ROAD, KELLYVILLE
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26 SEPTEMBER 2000

1. EXECUTIVE SUMMARY

The Roads and Traffic Authority (RTA) have recently commissioned Hyder Consulting to provide Concept and Detailed Design Services for the reconstruction of Old Windsor Road/Windsor Road between Sunnyholt Road and Merriville Road, Kellyville.

It is the policy of the RTA to subject every major project to a Value Management workshop in order to ensure an optimum solution is obtained with the participation of all key stakeholders.

A Value Management workshop addressing this project has already been undertaken, but a number of changes have taken place since it was held in 1995.

This workshop addressed the current concept design.

Brian Dawson, Principal of Value Systems facilitated the 1 day workshop, which was held at the offices of Integral Energy, Huntingwood on 26 September 2000.

This document reports on the processes undertaken and the outcomes agreed:

Workshop processes:

- Information and background regarding the concept design was presented by the RTA and the design team.
- The objectives for the project were identified and agreed.
- The workshop objectives were agreed.
- Assumptions underlying the project were identified during a brainstorming session, which generated 31 items. These were examined by the team and identified as follows:
    - Addressed as part of the design development process,
    - Discussions with relevant parties in progress
    - Examine at this workshop – critical issue

This resulted in the examination of 10 critical issues. Each was discussed in a structured format, leading to an agreed outcome and action plan.

Outcome of the Workshop

The Value Management workshop provided an opportunity for the RTA and the design team to receive valuable feed-back from stakeholders. There was discussion from all sides and all issues addressed resulted in a consensus.

At the conclusion of the workshop, the participants agreed that the workshop objectives set at the commencement of the workshop had been met.

2. OBJECTIVES

To ensure there is common understanding of the objectives and direction of the project, the Value Management Workshop Team identified the following:
(Note: Not in any particular order or priority).

2.1 PROJECT OBJECTIVES

1. To ***minimise impact*** on utilities and existing businesses
2. To ***minimise disruption*** during construction
3. To provide a multi-modal ***transport system*** to cater for current and future needs.
4. To achieve ***agreed milestones***.
5. To ensure the ***safety*** of all users, including safe connections between modes and to the community.
6. To ***integrate the access*** corridor with the surrounding development and between modes.
7. To improve ***traffic efficiency***.
8. To ***minimise impact*** and where possible, enhance the natural and built ***environment.***
9. To provide all of the above within ***budget***, both capital and operational.

2.2 WORKSHOP OBJECTIVES

1. To present the current concept design to stakeholders.
2. To identify issues and concerns of stakeholders.
3. To examine and action these concerns.
4. To achieve an in-principle agreement to the concept.

3. ASSUMPTIONS

The following assumptions were generated by the Workshop Team. Each assumption was addressed and identified as follows:

A	=	This item will be addressed as part of design development
B	=	To be addressed here
C	=	Discussions in progress

Ref	Assumption	Ranking
1.	That there will be adequate bus facilities for local and regional services	B
2.	That the road will operate at a good level of service from completion date	A
3.	Communications during construction between all parties will be implemented	A
4.	A transitway will be built in accordance with the government program	B
5.	A corridor bicycle lane will be provided	A
6.	A consistent dual carriageway will be provided	A
7.	Safe access will be provided	A
8.	Where the present concept is 4 lanes, there is sufficient space to widen to 6 later	B
9.	Allowance will be made for future development in the area	B
10.	Assets will be protected during construction, including gas, water, communication, electricity, etc	C
11.	The project will be completed on time	A
12.	There will be crossing facilities linking communities	B
13.	Vehicular access to current properties will be left in / left out only and future access will be via local road network	A
14.	Selection of planting will take into consideration utilities above and below ground	A
15.	Landscaping will take into account safety issues for all road users	A
16.	An acceptable landscape concept is implemented	A
17.	The location allowed for the transitway is appropriate	C

Ref	Assumption	Ranking
18.	Future requirements for utilities will be allowed for in the design	C
19.	The road will be designed for 90 KPH	A
20.	Drainage will meet environmental and safety requirements (to specified criteria)	A
21.	Flood mitigation is appropriate (to specified criteria)	A
22.	Existing overhead utilities remain so, unless requested otherwise	B
23.	Pavement will be designed to cater for heavy vehicles	A
24.	Pavement will be designed to miminise road noise	B
25.	Noise mitigation measures are not visually intrusive	B
26.	Intersection analysis for Sunnyholt Road / Old Windsor Road will be included in the REF	B
27.	Where services are to be relocated, landscape opportunities should be maximised	A
28.	The project will be suitably sign posted	A
29.	Noise mitigation will only consider the existing built environment	B
30.	Heritage items will be protected	A
31.	Traffic signals will be coordinated	A

4. ISSUES AND CONCERNS

Assumptions identified as B – to be addressed in this workshop were discussed in a structured format. Following summarises the outcomes.

4.1 BUS FACILITIES *(Ref #1)*

Action	By	When
Meeting regarding positioning / access etc requirements for bus facilities to be arranged by Hyder to include RTA / bus company / Council	TR	6/10

4.2 TRANSITWAY *(Ref #4)*

The current strategic concept will be considered in the development of the design.

4.3 UTILITY ACCESS / PROTECTION / FUTURE REQUIREMENTS *(Ref # 8, 10 & 18)*

Action	By	When
Concept design will be forwarded to utility authorities for review and comment	PL	29/9

4.4 FUTURE WIDENING *(Ref #9)*

Meeting between RTA / Hyder to address this

4.5 FUTURE DEVELOPMENT IN THE AREA – 6 LANES IN THE FUTURE? *(Ref # 3, 9, & 26)*

Action	By	When
Extend the traffic modelling to 2016 to identify possible future upgrades and report to Baulkham Hills and Blacktown Councils, including intersection analysis in Sunnyholt Road / Old Windsor Road	PL	26/10

4.6 CROSSING FACILITIES LINKING COMMUNITIES *(Ref # 12)*

Action	By	When
• The only facilities to cross Old Windsor Road is at traffic signals • Blacktown and Baulkham Hills Councils will supply information to RTA for consideration on the location of the proposed cycleway and greenway link	CH AL	26/9

4.7 NOISE MITIGATION *(Ref # 21, 24, 25 & 29)*

- RTA policy is not to allow for noise mitigation measures for buildings yet to be built.
- On the western side, there are many utilities, making building of mounding impracticable within the road corridor.
- Solutions can be negotiated with developments adjacent to the corridor.
- On the eastern side, options will be investigated as part of design development.

Action	By	When
A meeting between Mirvac and the RTA is to be held to discuss noise mitigation.	SMC	6/10

4.8 OVERHEAD FACILITIES *(Ref # 23)*

Current facilities to remain overhead unless funded by other than the RTA

APPENDIX 1 - LIST OF PARTICIPANTS
STUDY - OLD WINDSOR ROAD/SUNNYHOLT ROAD TO MERRIVILLE ROAD, KELLYVILLE – VALUE MANAGEMENT WORKSHOP
DATE - 26 SEPTEMBER 2000

Name	Title	Organisation	Telephone No	Facsimile No
Brian Dawson	Facilitator	Value Systems	9415 6510	9415 6151
Jim Johnson	Client Representative	RTA	9831 0986	9831 0159
Bob Cochrane	Network Development Manager	RTA	9831 0954	9831 0155
Jamie Robinson	Project Management Services	RTA	9507 2597	9831 0070
Peter Letts	Project Manager	RTA	9831 0068	9831 0070
Ray Finn	Licensee	McDonald's Rouse Hill	9629 5722	9629 5733
Stuart McCowan	Senior Development Manager	Landcom	9841 8674	9841 8777
Bruce McBride	Project Coordinator	Optus	9837 9082	9837 9060
Derek Burrows	Environmental Consultant	Hyder	9433 6293	9433 6001
Maureen King	Representative	Stanhope Gardens Residents	9836 0159	-
Kim Ferguson	Kellyville Community Development Worker	Hills Community Aid & Information Service	9686 3124	9686 3100
Lyn Cole	President	Beaumont Hills Residents Assoc	9629 2850	9629 2860
Trevor Jennings	Planning Manager	Busways	9497 1878	9418 4488
Craig Hazell	Senior Traffic Engineer	Blacktown Council	9839 6017	9672 3381
Chrissy Chadwick	Stragetic Planner	Blacktown Council	9839 6220	9831 1961
Colin Tull	Project Director	Hyder	9433 6000	9433 6001
Tim Rodham	Project Leader	Hyder	9433 6000	9433 6001
John Holland	Landscape Architect	Edaw	9906 6899	9906 4380
Chris Garde	Project Manager	Integral Energy	9353 5642	9853 5655
Pat Kenny	Program Manager	RTA	9218 6257	9218 6167
Dennis Woodbridge	Project Services	RTA	9831 0074	9831 0070
Bernie Chellingworth	Project Manager (Transitways Concept Design)	RTA	9831 0924	9831 0070

Name	Title	Organisation	Telephone No	Facsimile No
Raeburn Chapman	A/Snr Manager, Urban Design	RTA	9218 6686	9218 6167
Anssa Levy	Transport Planner/Analyst	Baulkham Hills Shire Council	9853 1910	9843 0339
Neil Morrison	Land Services Officer	AGL	8977 6537	8977 6819
Peter Graham	Officer – Network Proetection	Telstra	9204 0910	9204 9011
Otre Massa	Manager	Telstra	9204 0880	9204 9011

APPENDIX 2
OLD WINDSOR ROAD – SUNNYHOLT ROAD TO MERRIVILE ROAD, KELLYVILLE

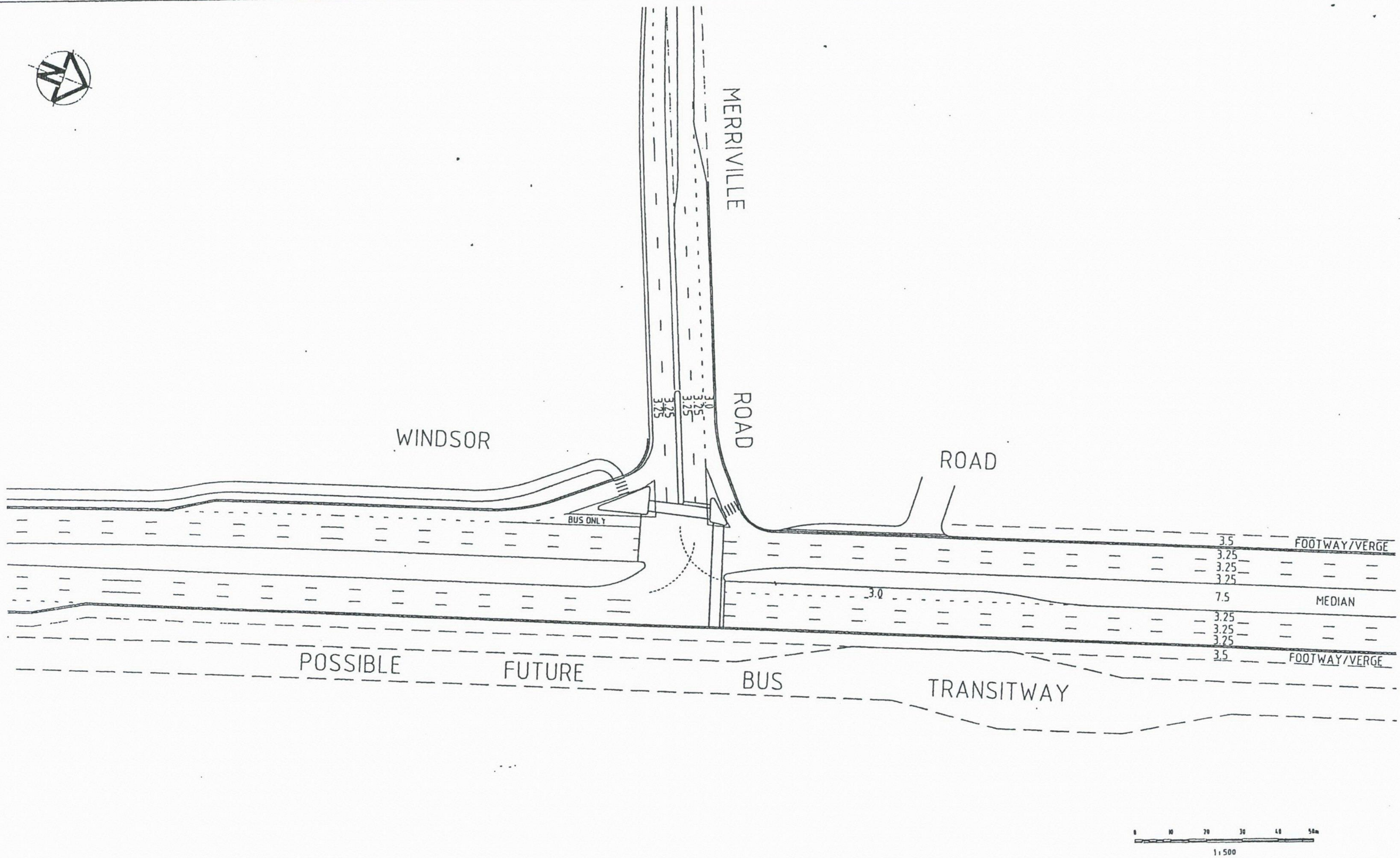
VALUE MANAGEMENT WORKSHOP

26 SEPTEMBER 2000

AGENDA

9.00 am	Assemble and Introduction
9.30 am	Value Management Overview
9.40 am	Project Information – Overview • Strategic Network Planning – RTA • Current Status of Project – RTA • Concept Design Presentation – Hyder • Urban Design Considerations – Edaw • Environmental Issues - Hyder
10.50 am	Objectives • Project Objectives agreed • Value Management Workshop Objectives agreed
11.30 am	Assumptions • Brainstorming of Assumptions • Assumptions assessed for risk to identify critical issues
12.30 pm	*Lunch*
1.30 am	Critical Issues • Issues addressed in structured format • Action agreed
4.00 pm	Summary of Workshop and Action Plan
4.30 pm	*Adjourn*

Please note: Lunch, Morning & Afternoon Tea will be served



Client
RTA

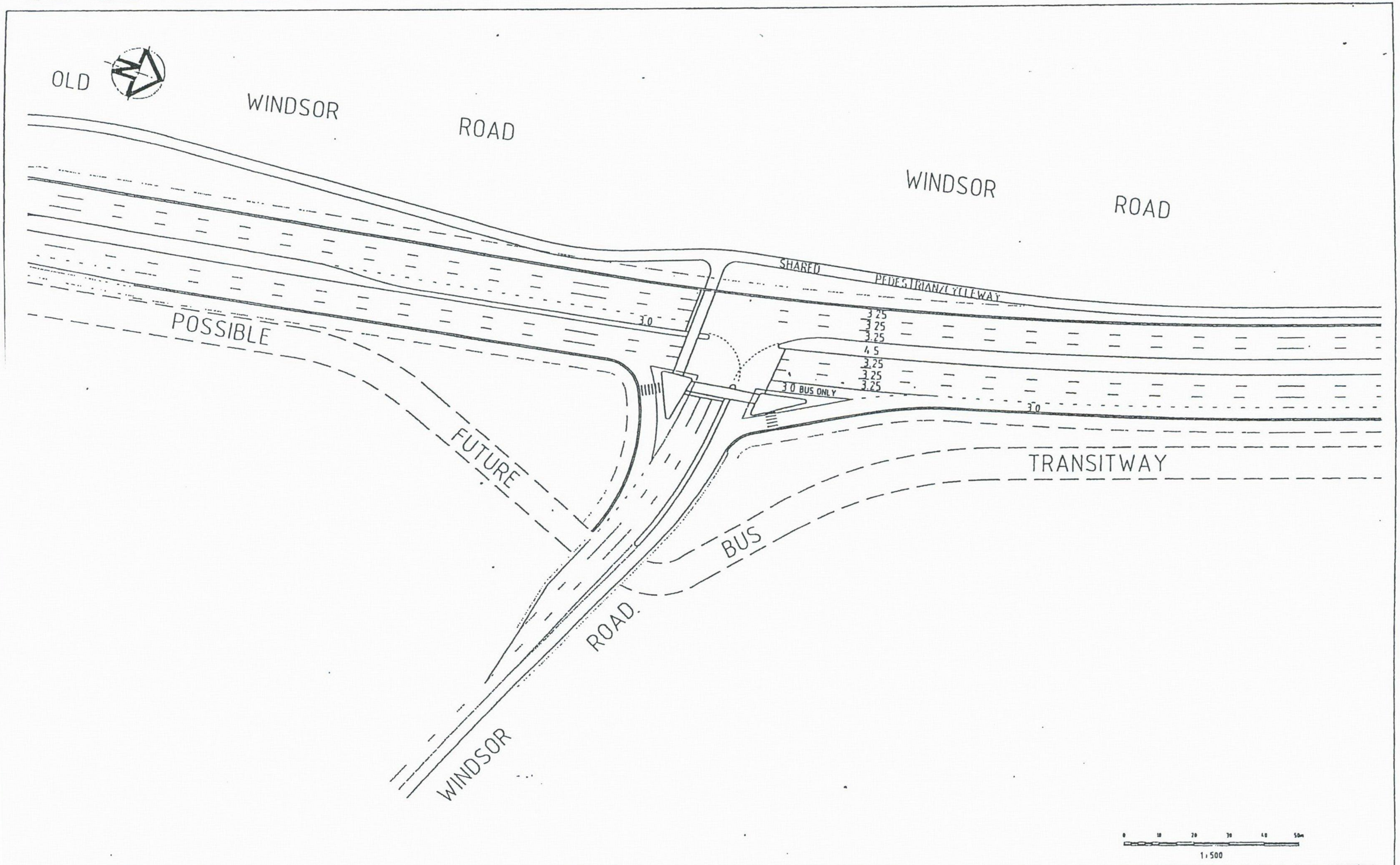
Project
OLD WINDSOR ROAD
UPGRADE

Title
INTERSECTION AT

Hyder

HYDER CONSULTING (AUSTRALIA) PTY LTD
Level 13
601 Pacific Highway
St Leonards, NSW, 2065
ACN 000 579 846

Tel. +61 (0)2 9433 6000



ISSUED FOR INFORMATION	DRV			25/09/03

Client: RTA	Project: OLD WINDSOR ROAD UPGRADE	Title: INTERSECTION AT WINDSOR ROAD	Hyder

Status: | Scale (A3): 1:500 | Datum:

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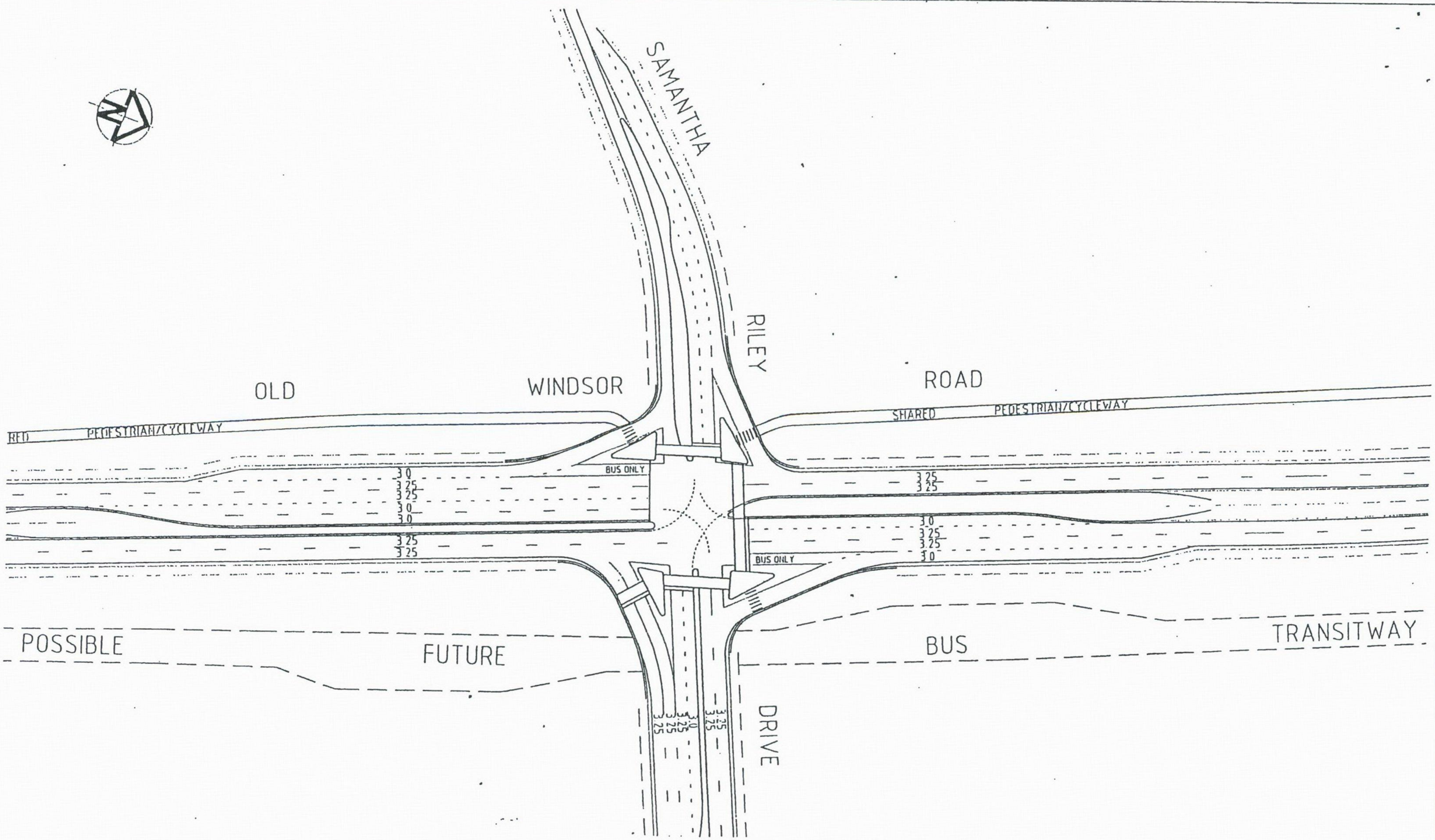

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Issue	Description	Drwn	Chk	Appd	Date
P1	ISSUED FOR INFORMATION	DRV			25/09/00

Status: PRELIMINARY ONLY

Client: RTA

Scale (A1): 1:500

Datum:

Drawn:

Designed:

Project: OLD WINDSOR ROAD UPGRADE

Title: INTERSECTION AT PROPOSED SAMANTHA RILEY DRIVE

Hyder

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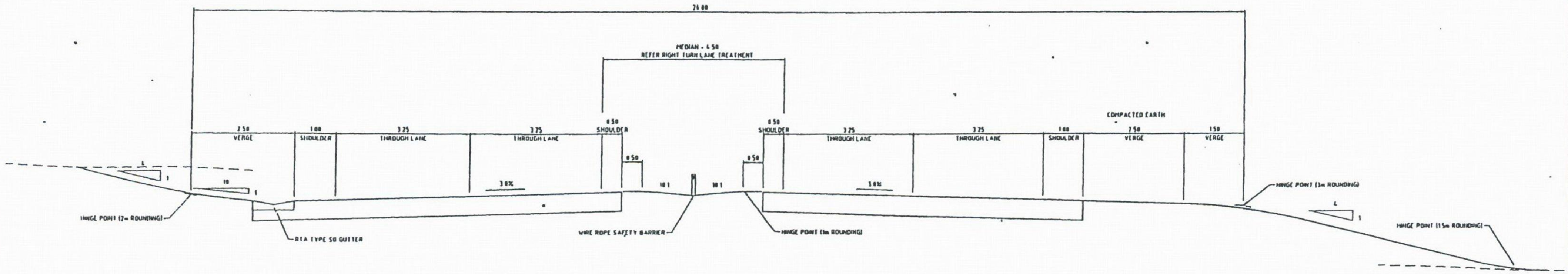
Level 13
601 Pacific Highway
St Leonards NSW 2065
ACN 065 579 846

Project Code:

Drawing No:

Issue:



OLD WINDSOR ROAD TYPICAL SECTION - NARROW MEDIAN

INFORMATION	DRY		25/09/00

Status: PRELIMINARY ONLY

Client: RTA

Scale (A1): 1:50

Datum

Project: OLD WINDSOR ROAD UPGRADE

Title: INTERSECTION AT TYPICAL CROSS SECTION

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Project Code | Drawing No | Issue

Appendix B: Air Quality Assessment Report

AIR QUALITY ASSESSMENT:
OLD WINDSOR ROAD UPGRADE

Prepared
for
Connell Wagner Pty Ltd

by

Nigel Holmes & Associates
2B 14 Glen Street
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Phone (02) 874-8644

15 November 1995

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TABLES

FIGURES all figures at end

1.0 INTRODUCTION

This report has been prepared by Nigel Holmes & Associates for Connell Wagner Pty Ltd who are acting for the Roads and Traffic Authority of New South Wales (RTA). Its purpose is to assess the air quality impacts of the proposed upgrading of Old Windsor Road between Seven Hills Road and Windsor Road at Kellyville (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;
- Kerbside concentrations of roadway air emissions; and
- Existing air quality in the vicinity of the route.

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 later years of assessment (2006 and 2011) motor vehicles will be powered almost exclusively with unleaded petrol or diesel and thus the primary pollutants of concern will be carbon monoxide, hydrocarbons, nitrogen oxides and particulate matter. The issue of lead impacts in 1996 has also been assessed where it has been assumed that approximately 65% of vehicles would be using unleaded petrol.

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.

2.0 DESCRIPTION OF THE DEVELOPMENT

The RTA proposes to upgrade a 6.5 km section of Old Windsor Road between Seven Hills Road and Windsor Road at Kellyville, with the new road generally following the existing route of Old Windsor Road. The current concept involves the provision of a four lane divided carriageway to replace the existing undivided two lane road. A six lane divided carriageway is ultimately planned.

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 humans 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 4×10^{-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 absorbed 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 been considered in this report for 1996 only 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 the air have been reduced by a factor of two in suburban Sydney (see Figure 2).

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 NH&MRC has recently determined a new ozone goal of 0.1 ppm for one hour averaging period and 0.08 ppm for a four hour averaging period. This goal has not yet been adopted by the NSW EPA but is expected to be in the near future.

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 the Metropolitan Air Quality Study (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 (**Carnovale and Tilly, 1995**). 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 Blacktown

The closest meteorological monitoring station with data which can be considered as representative of the study area is at Blacktown. **Figure 3** presents the seasonal and annual wind rose diagrams compiled from data collected in 1980 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 NW and NNW followed by winds from the ESE and SE. A similar pattern is seen in spring and autumn. In winter the winds are predominantly from the NW and NNW, while in summer the winds from the SE and ESE are dominant.

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 readings. No data are available for 3 pm . 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.

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 - no data available													
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

From temperature data recorded over 11 years, the annual average maximum and minimum temperatures experienced were 23.4°C and 11.3°C. In summer, the average maximum temperatures recorded were 28.2°C for the month of December and 28.3 and 28.1°C for January and February. July was 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 9 am humidity on average were May, June and July with average readings of 77%, 82% and 77% respectively. The annual average humidity at 3 pm was not available. Rainfall data collected over 37 years show that March and January were the wettest months, with mean rainfall readings of 114 mm and 112 mm, respectively. The average number of raindays for these months was 10. July and September were the driest months with average rainfall of 43 mm and an average of 7 and 8 raindays respectively. The average annual rainfall was 932 mm and the average number of raindays was 109.

4.3.1 Vehicle emissions and photochemical smog

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.

In the past the State Pollution Control Commission (SPCC, 1983) (now EPA) 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. Total hydrocarbon emissions in the Sydney area are estimated to have declined by 20.8% from 1976 to 1992 despite an increase of about 49% in vehicle kilometres travelled (VKT) over the same period (source: data taken from Eiser and Koo, 1984 and Carnovale and Tilly, 1995).

However, at the same time as hydrocarbon emissions have declined, emissions of nitrogen oxides from motor vehicles have substantially increased. According to the 1992 MAQS estimate the increase has been 68.7% over 1976 levels. At least part of this is due to increases in diesel-powered vehicles emissions which were estimated to comprise about 40% of mobile source emissions in 1992.

The significance to the formation of photochemical smog of the change in the balance of hydrocarbons to oxides of nitrogen, that is the hydrocarbon:NO_x ratio is as follows. The rate at which photochemical smog forms depends on the ratio of hydrocarbon to NO_x. If the ratio favours nitrogen oxides, then the process by which ozone or smog is produced is delayed in onset until all the nitrogen oxide is consumed. The reaction then proceeds and the photochemical smog is formed. The amount that is formed depends on the temperature and the integrated sunlight, and the concentration that occurs depends on the dilution that takes place as the reacting components are carried downwind.

Part of the aim of the 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.

4.3.2. Existing air quality

Local air quality with respect to carbon monoxide and nitrogen oxides was measured in 1991 on Old Windsor Road to the south of Seven Hills Road roundabout as part of the air quality assessment for the M2 Motorway project (**Stephenson & Associates, 1991**). In addition more comprehensive monitoring has been carried out by the EPA at Flushcombe Road, Blacktown commencing in October 1992. While not completely representative of the project site these data give some indication of air quality in the area, particularly close to moderately busy roads. The location of the monitoring sites are shown in **Figure 1** and a summary of the EPA data is presented in **Appendix A**.

Monitoring data from the Old Windsor Road site consisted of grab samples collected on both sides of the road either during am or pm peak hour traffic on six separate days. Carbon monoxide levels ranged from 3.1 to 17 mg/m^3 and total nitrogen oxides ranged from 62 to 290 μg/m^3.

Data from the EPA monitor is patchy and no complete year of data is available. However the recorded data indicates that carbon monoxide and nitrogen dioxide levels were all well below their respective air quality goals. Levels of PM_{10} complied with 24 and annual average goal. Higher than usual levels were recorded in 1994 during the time of the Sydney bushfires in January and during a dust storm in April. Ozone levels were generally in compliance with air quality goals although one exceedance was recorded in February 1993.

A further issue relating to nitrogen oxides emissions is the rate at which nitric oxide converts to nitrogen dioxide. Analysis of the EPA's nitrogen oxides monitoring data reveals that the percentage of NO_2 in the air is inversely proportional to the total NO_x concentration. **Figure 4** presents a plot of the mean percentage NO_2 (calculated from the mean NO_2 concentration and the mean total NO_x concentration in ppm) against the mean nitrogen oxide concentration recorded at five sites in Sydney, namely Earlwood, Eagle Vale, Lidcombe, Kensington and Rozelle, from 1988 to 1992.

The trend in the graph shows an inverse correlation between total nitric oxide concentration and percentage of nitrogen dioxide. For example the Earlwood site has the highest concentration of nitrogen oxides and the lowest proportion of NO_2. The converse is true of the Eagle Vale site which has the lowest total NO_x and the highest percentage NO_2). Average percentages of NO_2 in the EPA monitoring data range from 5 to 50% with a mean value of about 30%.

Monitoring data collected at other monitoring sites in Sydney (Stephenson & Associates, 1992) show similar trends and indicate that close to the source, NO_2 would make up from

15-20% by weight of the total NO_x. A conservative value of 20% by weight has been used in the impact assessment presented in Section 8.0.

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 EIS nor indeed necessary to do so for an extended road such as the Old Windsor Road upgrade. 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 Connell Wagner to determine air quality impacts of the proposed upgrade in 1996, 2006 and 2011. Appendix B provides a detailed description of the calculation of vehicle emissions for 2016. 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 5 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 over 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. These relationships have been used in previous roadway studies.

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. These have been based on actual measurements of Australian motor vehicles under test drive conditions. Details of these are presented in **Appendix B**. it should be noted, however that these emission rates do not take account of grade, and may not properly account for acceleration/deceleration conditions which occur at intersections and toll plazas. For this assessment it has been assumed that travel on Old Windsor Road equates to arterial road conditions.

6.2 Oxides of nitrogen

Oxides of nitrogen emissions show a different trend with speed from carbon monoxide and this is illustrated in **Figure 6**. 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 rates 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 and lead

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.

It has been assumed that in 1996, 65% of motor vehicles will be powered with unleaded petrol, the amount of lead in leaded petrol would be 200 mg/l, the average petrol consumption would be 11.8 l/100 km (ABS, 1990) and that 70% of lead in petrol is emitted in vehicle exhausts. It has also been assumed that unleaded petrol contains 2.5 mg/l of lead. On this basis the emission rate for lead in 1996 was estimate to be 5.91 mg/vehicle kilometre. It was assumed that in 2006 and 2011 the emission rate for lead was negligible.

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 the years 1996, 2006 and 2011 is summarised in Table 3.

TABLE 3 - ESTIMATED PEAK HOUR (AM) TRAFFIC FLOW ALONG OLD WINDSOR ROAD

ROAD SECTION	1996		2006		2011	
	North bound	South bound	North bound	South bound	North bound	South bound
North of Sunnyholt Road	506	1368	1064	2564	1256	2701
North of Meurants Lane	537	1594	674	2818	642	3184
North of Seven Hills Road	636	2015	869	3396	828	3837

Emission estimates for the proposed road are presented in detail in **Appendix B** and are summarised in **Table 4**. Emissions were calculated for am peak hour traffic for 1996, 2006 and 2011.

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

Road Section	Year	Total emissions			
		CO	NO_x	PM_{10}	Hydrocarbons
North of Sunnyholt Road	1996	33.32	3.23	0.14	2.55
	2006	29.62	6.34	0.51	2.33
	2011	32.30	6.91	0.55	2.54
North of Meurants Lane	1996	37.87	3.68	0.16	2.89
	2006	28.51	6.10	0.48	2.24
	2011	31.24	6.68	0.53	2.45
North of Seven Hills Road	1996	47.11	4.58	0.2	3.59
	2006	34.82	7.45	0.59	2.74
	2011	38.09	8.15	0.65	2.99

8.0 PREDICTION OF AIR QUALITY EFFECTS AND ASSESSMENT OF IMPACTS

This section assesses the air quality impacts of the proposed development 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.

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.

Carbon monoxide

It can be seen from Table 5 that in 1996 the highest predicted 1-hour carbon monoxide concentration at 10 m from the roadside is 4.4 mg/m³ along the section of the route north of Seven Hills Road. As more cars fitted with catalytic converters enter the market, the average fleet emissions of carbon monoxide decrease and despite the increase in traffic, the predicted roadside carbon monoxide levels in 2006 and 2011 are below the maximum levels predicted in 1996. The predicted levels in 1996 are still well below the EPA's 1-hour goal of 31 mg/m³. The average "background" level along the route is likely to be of the order of 3 mg/m³, however even if the maximum level of 17 mg/m³ measured at Old Windsor Road in 1991 (which included emissions from peak flow traffic) were added to the predicted carbon monoxide level the values would still be below the air quality goal.

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

Roadway Section	Year	Carbon monoxide (mg/m³)	Nitrogen oxides (µg/m³)	Nitrogen dioxide* (µg/m³)	Hydrocarbons (mg/m³)	PM_{10} (µg/m³)
North of Sunnyholt Road	1996	3.2	309	62	0.24	13
	2006	2.7	577	115	0.22	46
	2011	2.9	630	126	0.23	50
North of Meurants Lane	1996	3.6	350	70	0.28	15
	2006	2.6	555	111	0.21	44
	2011	2.9	609	122	0.22	48
North of Seven Hills Road	1996	4.4	436	87	0.34	19
	2006	3.1	679	136	0.25	54
	2011	3.4	736	147	0.27	59

Nitrogen dioxide

Estimating nitrogen dioxide concentrations is more complicated than estimating carbon monoxide concentrations. As discussed in Section 4.3.2 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 µg/m³ (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 147 $\mu g/m^3$ in 2011. This is well below the EPA goal of 328 $\mu g/m^3$. Likely maximum background concentrations of nitrogen dioxide in this type of environments are likely to be of the order of 60 $\mu g/m^3$ (**Stephenson & Associates 1992, Rust PPK 1995**). Adding this to the maximum predicted levels would not result in exceedances of the air quality goals.

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 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 in 1996 is 0.34 mg/m^3 at 10 m from the kerb. In later years, despite the increase in traffic, the predicted hydrocarbon concentrations decrease, due to the increased proportion of the fleet fitted with catalytic converters. Assuming a 5% benzene composition in the exhaust the benzene concentration at 10 m from the kerb would be approximately 0.017 mg/m^3 or 17 $\mu g/m^3$ (1-hour average), under unfavourable dispersion and with peak traffic flows, which is similar to the proposed United Kingdom goal of 15 $\mu g/m^3$. Concentrations would of course be lower at the locations of residences and much lower at other times of the day and under more favourable dispersion conditions. The annual average would therefore be substantially lower than the predicted peak value. It is nevertheless recognised that there may be no safe limit for 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 and lead

The predicted levels of PM_{10} are for 1-hour averaging periods however the air quality goal refers to a 24-hour period. Monitoring results also refer to a 24-hour period. The approach adopted in this study has been to add predicted 1-hour levels to the average PM^{10} levels from EPA data. This is a conservative 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 60 $\mu g/m^3$ 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 $\mu g/m^3$ (24-hour average) or the 50 $\mu g/m^3$ annual average goal to be exceeded. Similarly the NH&MRC 90 $\mu g/m^3$ (annual average) TSP goal is unlikely to be exceeded.

Average background PM_{10} levels are likely to be in the range 20-30 $\mu g/m^3$. The maximum 24-hour average PM_{10} level at Blacktown was 126 $\mu g/m^3$ in January 1994 however this was at the time of the Sydney bushfires. Adding an average level of 30 $\mu g/m^3$ to the predicted 1-hour level of 59 $\mu g/m^3$ in 2011 along the section North of Seven Hills Road gives a conservative estimate of 89 $\mu g/m^3$ for the 24-hour PM_{10} kerbside concentration, which is nevertheless still below the 24-hour air quality goal.

Lead impacts have been assessed in 1996 only and only for the section of the route which carries the most traffic. It should be noted that the lead goal applies to a 90 day averaging period and the predicted level if for a "worst-case' one hour period, corresponding to peak hour traffic and the poorest dispersion conditions. The predicted level will be much greater than the 90 day average. The predicted 1-hour lead level north of Sunnyholt Road is 1.5 $\mu g/m^3$ which is the same as the 90-day goal. Therefore it is very unlikely that the road will result in exceedance of the lead 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

VEPA (1991)
"Air Emissions Inventory Port Phillip Control Region: Planning for the Future".

WHO (1987)
"Air Quality Guidelines for Europe". World Health Regional Office for Europe, WHO Regional Publication European Series: No. 23, ISBN 92-890-1114-9.

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APPENDIX A
EXISTING MONITORING DATA

SUMMARY OF EPA BLACKTOWN MONITORING DATA

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
NO_x (pphm)														
1992	Monthly average										1.0	1.0	1.2	1.1
	maximum										11.9	11.4	11.5	11.9
1993	Monthly average	1.3	1.7	2.0										1.7
	maximum	10.3	18.4	16.7										18.4
1994	Monthly average	1.2	1.7	2.0	2.1	2.5	3.4							2.2
	maximum	14.3	17.3	22.1	18.0	44.8	31.1							44.8
NO_2 (pphm)														
1992	Monthly average										0.7	0.7	0.8	0.7
	maximum										3.0	5.0	2.6	5.0
1993	Monthly average	0.9	1.1	1.1	1.8	2.1	1.9							1.5
	maximum	4.5	5.0	6.0	10.4	6.4	9.0							10.4
1994	Monthly average	0.9	1.1	1.1	1.1	1.3	1.6							1.2
	maximum	5.7	4.2	3.2	4.7	8.1	5.2							8.1

SUMMARY OF EPA BLACKTOWN MONITORING DATA

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ozone (pphm)														
1992	Monthly average										0.7	0.3		0.5
	maximum										4.5	3.6		4.5
1993	Monthly average	0.8	0.8	0.4	0.4	0.2	0.2							0.5
	maximum	10.4	12.5	7.8	4.6	3.2	2.2							12.5
1994	Monthly average	0.8	0.6	0.3	0.3	0.4	0.3							0.5
	maximum	8.8	11.4	5	4.7	4.8	2.4							11.4
PM_{10} ($\mu g/m^3$)														
1992	Monthly average											11	12	11.5
	maximum											16	16	16
1993	Monthly average	21	17.	20	19	25	24							21
	maximum	28	25	37	25	30	45							45
1994	Monthly average	33	15	13	35	33	28							26.2
	maximum	126	17	16	106	74	54							126
CO (ppm)														
1992	Monthly average										0.8	0.4	0.3	0.5
	maximum										2.7	1.9	1.4	2.7
1993	Monthly average	0.1	0.5	0.4	0.6									0.4
	maximum	2.1	3.7	2.9	5.3									5.3
1994	Monthly average		0.3	0.3	0.5	0.5	0.7							0.5
	maximum		2.9	3.7	3.2	8.7	5.5							8.7

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 1996, 2006 and 2011 are presented in the following tables.

Emission rates for CO, NO_x, hydrocarbons (HC) and PM_{10} 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).

	Motor vehicle emissions with deterioration in 1996 g/km				
	pre 1976	1976-1985	post 1985	fleet 1996	
proportion	0.03	0.31	0.66		
HC					
Freeway	3.08	2.05	0.82	1.27	
Arterial	3.48	2.32	0.77	1.33	
Congested	4.48	3.02	0.86	1.64	
Residential	4.01	2.69	1.07	1.66	
NOx					
Freeway	3.25	2.95	1.75	2.17	
Arterial	1.73	2.01	1.3	1.53	
Congested	2.43	2.44	1.38	1.74	
Residential	2.27	2.35	1.44	1.75	
CO					
Freeway	32.66	24.29	11.95	16.40	
Arterial	38.05	28.12	11.96	17.75	
Congested	46.26	33.98	12.73	20.32	
Residential	45.81	33.67	16.48	22.69	

Exhaust emissions for arterial roads					
Category	Fuel	Emission rate	VKT	Composite	Emission
		g/km	% fleet	g/km	% Fleet
HC					
Passenger vehicles	Petrol	1.33	75.4	1.00	70.15
Passenger vehicles	Diesel	0.5	2	0.01	0.70
Passenger vehicles	LPG	0.94	2.3	0.02	1.51
Light commercial	Petrol	1.33	10.3	0.14	9.58
Light commercial	Diesel	0.5	2.8	0.01	0.98
Light commercial	LPG	0.94	0.3	0.00	0.20
Heavy duty vehicles	Petrol	6.3	0.5	0.03	2.20
Heavy duty vehicles	Diesel	2.8	5.4	0.15	10.58
Heavy duty vehicles	LPG	3.78	0.1	0.00	0.26
Motor cycles	Petrol	6.08	0.9	0.05	3.83
		total	100	1.43	100.00
NOx					
Passenger vehicles	Petrol	1.53	75.4	1.15	49.73
Passenger vehicles	Diesel	1.01	2	0.02	0.87
Passenger vehicles	LPG	1.93	2.3	0.04	1.91
Light commercial	Petrol	1.76	10.3	0.18	7.81
Light commercial	Diesel	1.16	2.8	0.03	1.40
Light commercial	LPG	2.21	0.3	0.01	0.29
Heavy duty vehicles	Petrol	4.59	0.5	0.02	0.99
Heavy duty vehicles	Diesel	15.72	5.4	0.85	36.59
Heavy duty vehicles	LPG	5.74	0.1	0.01	0.25
Motor cycles	Petrol	0.39	0.9	0.00	0.15
		total	100	2.32	100.00
CO					
Passenger vehicles	Petrol	17.75	75.4	13.38	79.82
Passenger vehicles	Diesel	1.08	2	0.02	0.13
Passenger vehicles	LPG	8.66	2.3	0.20	1.19
Light commercial	Petrol	17.75	10.3	1.83	10.90
Light commercial	Diesel	1.08	2.8	0.03	0.18
Light commercial	LPG	8.66	0.3	0.03	0.15
Heavy duty vehicles	Petrol	120.62	0.5	0.60	3.60
Heavy duty vehicles	Diesel	8.01	5.4	0.43	2.58
Heavy duty vehicles	LPG	54.28	0.1	0.05	0.32
Motor cycles	Petrol	20.88	0.9	0.19	1.12
			100	16.77	100.00

Old Windsor Road Upgrade Emissions

Section	North of Sunnyholt road					1996				
Arterial	Northbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		506.00								PM10
total heavy		7.59								
LDPV		498.41	17.75	1.53	1.33	0.037	8846.78	762.57	662.89	18.44
HDDV		6.83	8.01	15.72	2.80	2.090	54.72	107.38	19.13	14.28
HDPV		0.76	120.62	4.59	6.30	0.147	91.55	3.48	4.78	0.11
Brake & Tyre						0.009				4.55
Total kg/km/hr							8.99	0.87	0.69	0.04
g/v-mi							28.44	2.76	2.17	0.12
Section	North of Sunnyholt Road					1996				
Arterial	Southbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		1368.00								PM10
total heavy		20.52								
LDPV		1347.48	17.75	1.53	1.33	0.037	23917.77	2061.64	1792.15	49.86
HDDV		18.47	8.01	15.72	2.80	2.090	147.93	290.32	51.71	38.60
HDPV		2.05	120.62	4.59	6.30	0.147	247.51	9.42	12.93	0.30
Brake & Tyre						0.009				12.31
Total kg/km/hr							24.31	2.36	1.86	0.10
g/v-mi							28.44	2.76	2.17	0.12
Section	North of Meurants Lane					1996				
Arterial	Northbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		537.00								PM10
total heavy		8.06								
LDPV		528.95	17.75	1.53	1.33	0.037	9388.77	809.29	703.50	19.57
HDDV		7.25	8.01	15.72	2.80	2.090	58.07	113.96	20.30	15.15
HDPV		0.81	120.62	4.59	6.30	0.147	97.16	3.70	5.07	0.12
Brake & Tyre						0.009				4.83
Total kg/km/hr							9.54	0.93	0.73	0.04
g/v-mi							28.44	2.76	2.17	0.12
Section	North of Meurants Lane					1996				
Arterial	Southbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		1594.00								PM10
total heavy		23.91								
LDPV		1570.09	17.75	1.53	1.33	0.037	27869.10	2402.24	2088.22	58.09
HDDV		21.52	8.01	15.72	2.80	2.090	172.37	338.28	60.25	44.97
HDPV		2.39	120.62	4.59	6.30	0.147	288.40	10.97	15.06	0.35
Brake & Tyre						0.009				14.35
Total kg/km/hr							28.33	2.75	2.16	0.12
g/v-mi							28.44	2.76	2.17	0.12

Old Windsor Road Upgrade Emissions

Section	North of Seven Hills Road					1996				
Arterial	Northbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		636.00								PM10
total heavy		9.54								
LDPV		626.46	17.75	1.53	1.33	0.037	11119.67	958.48	833.19	23.18
HDDV		8.59	8.01	15.72	2.80	2.090	68.77	134.97	24.04	17.94
HDPV		0.95	120.62	4.59	6.30	0.147	115.07	4.38	6.01	0.14
Brake & Tyre						0.009				5.72
Total kg/km/hr							11.30	1.10	0.86	0.05
g/v-mi							28.44	2.76	2.17	0.12
Section	North of Seven Hills Road					1996				
Arterial	Southbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		2015.00								PM10
total heavy		30.23								
LDPV		1984.78	17.75	1.53	1.33	0.037	35229.76	3036.71	2639.75	73.44
HDDV		27.20	8.01	15.72	2.80	2.090	217.89	427.62	76.17	56.85
HDPV		3.02	120.62	4.59	6.30	0.147	364.57	13.87	19.04	0.44
Brake & Tyre						0.009				18.14
Total kg/km/hr							35.81	3.48	2.73	0.15
g/v-mi							28.44	2.76	2.17	0.12
Section	North of Sunnyholt road					2006				
Arterial	Northbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		1064.00								PM10
total heavy		53.20								
LDPV		1010.80	7.58	1.07	0.51	0.037	7661.86	1081.56	515.51	37.40
HDDV		47.88	8.01	15.72	2.80	2.090	383.52	752.67	134.06	100.07
HDPV		5.32	120.62	4.59	6.30	0.147	641.70	24.42	33.52	0.78
Brake & Tyre						0.009				9.58
Total kg/km/hr							8.69	1.86	0.68	0.15
g/v-mi							13.06	2.79	1.03	0.22
Section	North of Sunnyholt road					2006				
Speed l/h	Southbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		2564.00								PM10
total heavy		128.20								
LDPV		2435.80	7.58	1.07	0.51	0.037	18463.36	2606.31	1242.26	90.12
HDDV		115.38	8.01	15.72	2.80	2.090	924.19	1813.77	323.06	241.14
HDPV		12.82	120.62	4.59	6.30	0.147	1546.35	58.84	80.77	1.88
Brake & Tyre						0.009				23.08
Total kg/km/hr							20.93	4.48	1.65	0.36
g/v-mi							13.06	2.79	1.03	0.22

Old Windsor Road Upgrade Emissions

Section	North of Meurants Lane					2006				
Arterial	Northbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		674.00								PM10
total heavy		33.70								
LDPV		640.30	7.58	1.07	0.51	0.037	4853.47	685.12	326.55	23.69
HDDV		30.33	8.01	15.72	2.80	2.090	242.94	476.79	84.92	63.39
HDPV		3.37	120.62	4.59	6.30	0.147	406.49	15.47	21.23	0.50
Brake & Tyre						0.009				6.07
Total kg/km/hr							5.50	1.18	0.43	0.09
g/v-mi							13.06	2.79	1.03	0.22
Section	North of Meurants Lane					2006				
Arterial	Southbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		2818.00								PM10
total heavy		140.90								
LDPV		2677.10	7.58	1.07	0.51	0.037	20292.42	2864.50	1365.32	99.05
HDDV		126.81	8.01	15.72	2.80	2.090	1015.75	1993.45	355.07	265.03
HDPV		14.09	120.62	4.59	6.30	0.147	1699.54	64.67	88.77	2.07
Brake & Tyre						0.009				25.36
Total kg/km/hr							23.01	4.92	1.81	0.39
g/v-mi							13.06	2.79	1.03	0.22
Section	North of Seven Hills Road					2006				
Arterial	Northbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		869.00								PM10
total heavy		43.45								
LDPV		825.55	7.58	1.07	0.51	0.037	6257.67	883.34	421.03	30.55
HDDV		39.11	8.01	15.72	2.80	2.090	313.23	614.73	109.49	81.73
HDPV		4.35	120.62	4.59	6.30	0.147	524.09	19.94	27.37	0.64
Brake & Tyre						0.009				7.82
Total kg/km/hr							7.09	1.52	0.56	0.12
g/v-mi							13.06	2.79	1.03	0.22
Section	North of Seven Hills Road					2006				
Arterial	Southbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		3396.00								PM10
total heavy		169.80								
LDPV		3226.20	7.58	1.07	0.51	0.037	24454.60	3452.03	1645.36	119.37
HDDV		152.82	8.01	15.72	2.80	2.090	1224.09	2402.33	427.90	319.39
HDPV		16.98	120.62	4.59	6.30	0.147	2048.13	77.94	106.97	2.50
Brake & Tyre						0.009				30.56
Total kg/km/hr							27.73	5.93	2.18	0.47
g/v-mi							13.06	2.79	1.03	0.22

Old Windsor Road Upgrade Emissions

Section	North of Sunnyholt road					2011				
Arterial	Northbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		1256.00								PM10
total heavy		62.80								
LDPV		1193.20	7.58	1.07	0.51	0.037	9044.46	1276.72	608.53	44.15
HDDV		56.52	8.01	15.72	2.80	2.090	452.73	888.49	158.26	118.13
HDPV		6.28	120.62	4.59	6.30	0.147	757.49	28.83	39.56	0.92
Brake & Tyre						0.009				11.30
Total kg/km/hr							10.25	2.19	0.81	0.17
g/v-mi							13.06	2.79	1.03	0.22
Section	North of Sunnyholt road					2011				
Arterial	Southbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		2701.00								PM10
total heavy		135.05								
LDPV		2565.95	7.58	1.07	0.51	0.037	19449.90	2745.57	1308.63	94.94
HDDV		121.55	8.01	15.72	2.80	2.090	973.58	1910.69	340.33	254.03
HDPV		13.51	120.62	4.59	6.30	0.147	1628.97	61.99	85.08	1.99
Brake & Tyre						0.009				24.31
Total kg/km/hr							22.05	4.72	1.73	0.38
g/v-mi							13.06	2.79	1.03	0.22
Section	North of Meurants Lane					2011				
Arterial	Northbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		642.00								PM10
total heavy		32.10								
LDPV		609.90	7.58	1.07	0.51	0.037	4623.04	652.59	311.05	22.57
HDDV		28.89	8.01	15.72	2.80	2.090	231.41	454.15	80.89	60.38
HDPV		3.21	120.62	4.59	6.30	0.147	387.19	14.73	20.22	0.47
Brake & Tyre						0.009				5.78
Total kg/km/hr							5.24	1.12	0.41	0.09
g/v-mi							13.06	2.79	1.03	0.22
Section	North of Meurants Lane					2011				
Arterial	Southbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		3184.00								PM10
total heavy		159.20								
LDPV		3024.80	7.58	1.07	0.51	0.037	22927.98	3236.54	1542.65	111.92
HDDV		143.28	8.01	15.72	2.80	2.090	1147.67	2252.36	401.18	299.46
HDPV		15.92	120.62	4.59	6.30	0.147	1920.27	73.07	100.30	2.34
Brake & Tyre						0.009				28.66
Total kg/km/hr							26.00	5.56	2.04	0.44
g/v-mi							13.06	2.79	1.03	0.22

Old Windsor Road Upgrade Emissions

Section	North of Seven Hills Road					2011				
Arterial	Northbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		828.00								PM10
total heavy		41.40								
LDPV		786.60	7.58	1.07	0.51	0.037	5962.43	841.66	401.17	29.10
HDDV		37.26	8.01	15.72	2.80	2.090	298.45	585.73	104.33	77.87
HDPV		4.14	120.62	4.59	6.30	0.147	499.37	19.00	26.08	0.61
Brake & Tyre						0.009				7.45
Total kg/km/hr							6.76	1.45	0.53	0.12
g/v-mi							13.06	2.79	1.03	0.22
Section	North of Seven Hills Road					2011				
Arterial	Southbound		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no		3837.00								PM10
total heavy		191.85								
LDPV		3645.15	7.58	1.07	0.51	0.037	27630.24	3900.31	1859.03	134.87
HDDV		172.67	8.01	15.72	2.80	2.090	1383.05	2714.29	483.46	360.87
HDPV		19.19	120.62	4.59	6.30	0.147	2314.09	88.06	120.87	2.82
Brake & Tyre						0.009				34.53
Total kg/km/hr							31.33	6.70	2.46	0.53
g/v-mi							13.06	2.79	1.03	0.22

APPENDIX C
HYDROCARBON ANALYSIS OF VEHICLE EXHAUST, PETROL AND PETROL VAPOUR

HYDROCARBON COMPOSITION OF VEHICLE EXHAUST, PETROL AND PETROL VAPOUR

Hydrocarbon	Exhaust Average	Exhaust SD	Petrol Average	Petrol SD	Petrol Vapour
ethane	1.4	0.5			
ethylene	11.2	3.2			
acetylene	8.7	2.7			
propane	0.1	0.1	0.1	0.1	1.5
propylene	5.0	1.6			
methylacetylene	0.4	0.3			
n-butane	2.1	0.6	2.9	0.4	18.7
i-butane	1.0	0.3	1.2	0.3	11.1
1-butene	0.9	0.3	0.2	0.1	1.6
i-butene	1.4	0.6			
trans-2-butene	0.6	0.4	0.6	0.1	3.7
cis-2-butene	0.5	0.2	0.5	0.1	2.9
n-pentane	3.0	0.7	6.0	0.6	10.7
i-pentane	4.8	0.9	10.6	0.5	25.4
cyclopentane	0.4	0.1	0.5	0.1	0.6
1-pentene	0.2	0.1	0.3	0.1	0.7
trans-2-pentene	0.3	0.2	0.8	0.1	1.5
cis-2-pentene	0.3	0.2	0.5	0.1	0.9
2-methyl-1-butene	0.3	0.2	0.6	0.1	1.3
2-methyl-2-butene	0.5	0.2	1.6	0.2	2.6
n-hexane	1.9	0.4	3.5	0.3	1.9
2-methylpentane	2.3	0.4	4.9	0.2	3.5
3-methylpentane	1.6	0.3	3.2	0.1	2.2
2,2-dimethylbutane	0.3	0.2	0.5	0.1	0.6
2,3-dimethylbutane	0.6	0.1	1.3	0.1	1.1
methylcyclopentane	1.0	0.2	1.9	0.1	0.9
cyclohexane	0.6	0.2	0.8	0.1	0.3
1-hexene	0.3	0.2	0.4	0.1	0.3
other C_6 olefins	0.7	0.2	1.6	0.1	- 1.0
benzene	5.0	0.7	2.6	0.2	0.9

Hydrocarbon	Exhaust Average	SD	Petrol Average	SD	Petrol Vapour
n-heptane	0.8	0.2	1.6	0.1	0.3
2-methylhexane	1.5	0.3	2.9	0.1	0.7
3-methylhexane	1.2	0.3	2.3	0.1	0.5
2,4-dimethylpentane	0.3	0.1	0.7	0.1	0.2
methylcyclohexane	0.6	0.2	1.1	0.2	0.2
other C_7 cycloalkanes	0.3	0.2	0.6	0.1	0.1
toluene	10.2	0.9	9.6	0.6	1.0
n-octane	0.4	0.1	0.7	0.1	
2,2,4-trimethylpentane	1.0	0.4	2.1	0.5	0.4
other C_8 alkanes	3.2	0.7	7.1	0.6	0.6
ethylbenzene	1.9	0.2	1.6	0.1	0.1
m, p-xylenes	6.5	0.9	6.5	0.4	0.2
o-xylene	2.5	0.4	2.3	0.2	0.1
n-nonane	0.2	0.1	0.3	0.1	
other C_9 alkanes	1.7	0.4	2.1	0.3	
n-propylbenzene	0.4	0.1	0.4	0.1	
i-propylbenzene	0.2	0.1	0.2	0.1	
1,2,4-trimethylbenzene	1.9	0.3	1.8	0.2	
1,3,5-trimethylbenzene	0.7	0.1	0.7	0.1	
m, p-ethyltoluenes	2.0	0.3	1.8	0.2	
o-ethyltoluene	0.6	0.2	0.5	0.1	
n-decane	0.4	0.1	0.4	0.1	
other C_{10} alkanes & aromatics	0.9	0.4	1.2	0.3	
C_{11} and C_{12} alkanes & aromatics	3.6	1.1	4.2	0.7	
	100.40		99.80		100.30

Source: Nelson & Quigley (1982)

Hydrocarbon	Exhaust Average	Exhaust SD	Petrol Average	Petrol SD	Petrol Vapour
n-heptane	0.8	0.2	1.6	0.1	0.3
2-methylhexane	1.5	0.3	2.9	0.1	0.7
3-methylhexane	1.2	0.3	2.3	0.1	0.5
2,4-dimethylpentane	0.3	0.1	0.7	0.1	0.2
methylcyclohexane	0.6	0.2	1.1	0.2	0.2
other C_7 cycloalkanes	0.3	0.2	0.6	0.1	0.1
toluene	10.2	0.9	9.6	0.6	1.0
n-octane	0.4	0.1	0.7	0.1	
2,2,4-trimethylpentane	1.0	0.4	2.1	0.5	0.4
other C_8 alkanes	3.2	0.7	7.1	0.6	0.6
ethylbenzene	1.9	0.2	1.6	0.1	0.1
m, p-xylenes	6.5	0.9	6.5	0.4	0.2
o-xylene	2.5	0.4	2.3	0.2	0.1
n-nonane	0.2	0.1	0.3	0.1	
other C_9 alkanes	1.7	0.4	2.1	0.3	
n-propylbenzene	0.4	0.1	0.4	0.1	
i-propylbenzene	0.2	0.1	0.2	0.1	
1,2,4-trimethylbenzene	1.9	0.3	1.8	0.2	
1,3,5-trimethylbenzene	0.7	0.1	0.7	0.1	
m, p-ethyltoluenes	2.0	0.3	1.8	0.2	
o-ethyltoluene	0.6	0.2	0.5	0.1	
n-decane	0.4	0.1	0.4	0.1	
other C_{10} alkanes & aromatics	0.9	0.4	1.2	0.3	
C_{11} and C_{12} alkanes & aromatics	3.6	1.1	4.2	0.7	
	100.40		99.80		100.30

Source: Nelson & Quigley (1982)

FIGURES

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

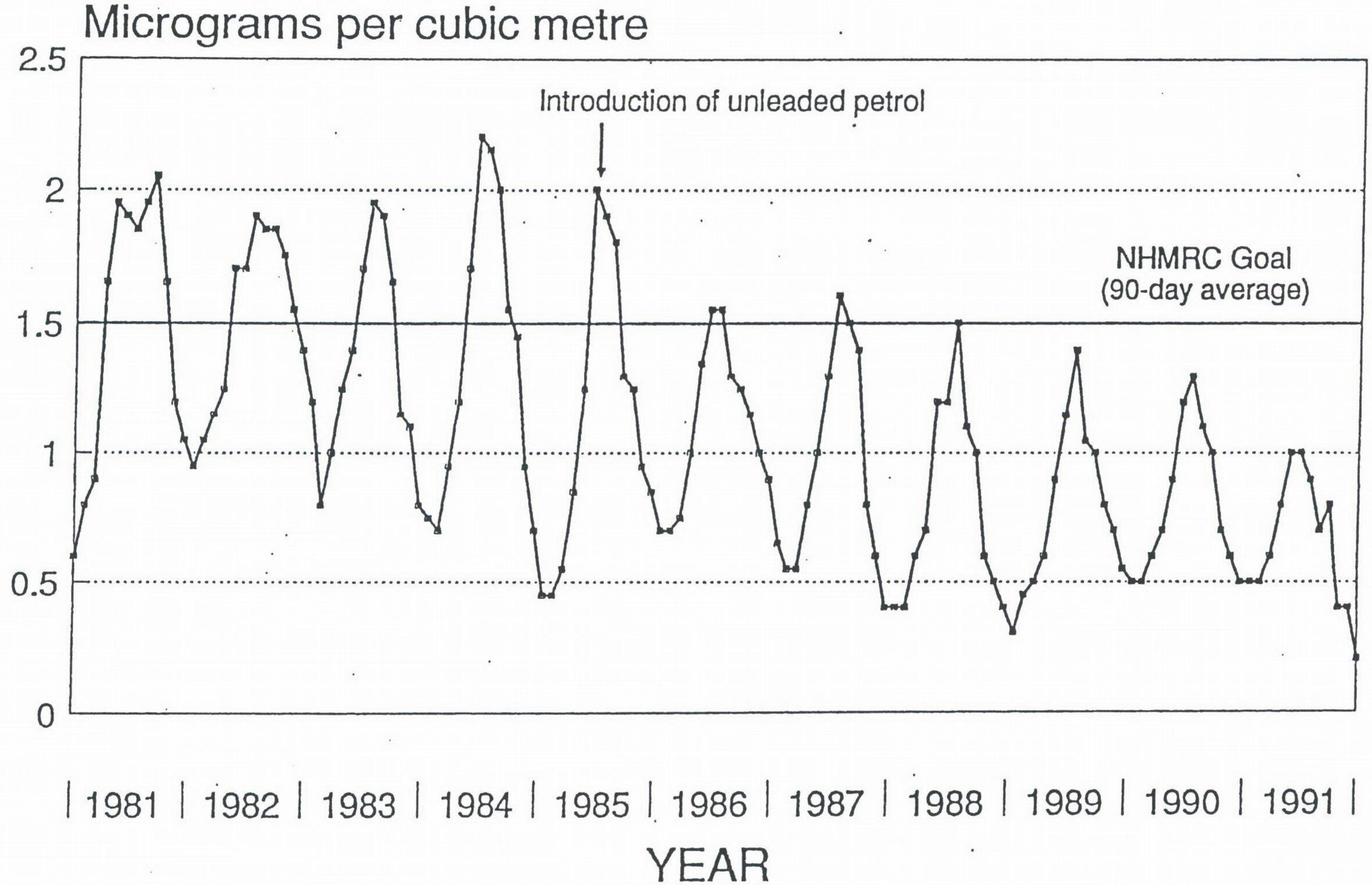
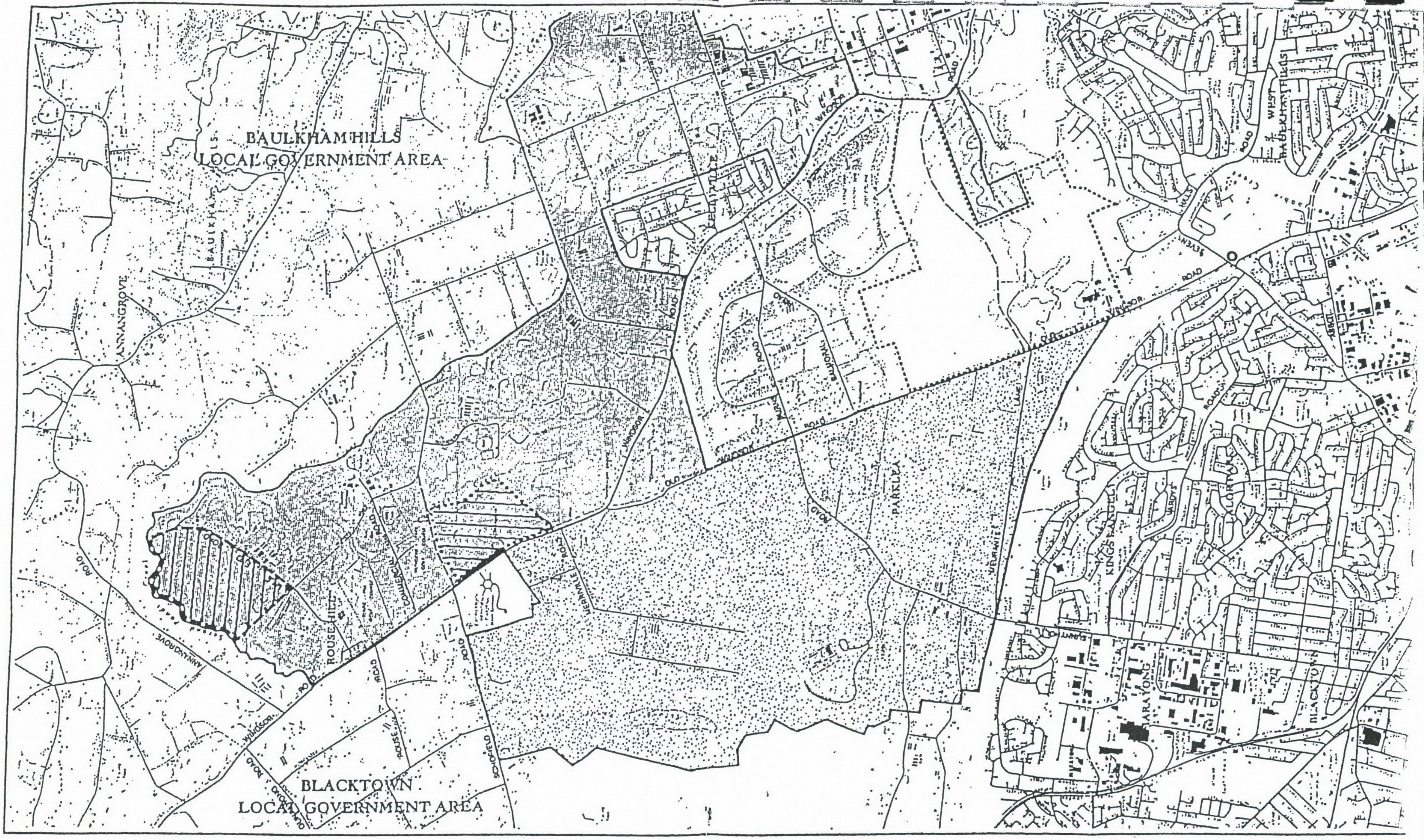


FIGURE 3



STAGE ONE RELEASE

PARKLEA RELEASE AREA

KELLYVILLE/ROUSE HILL RELEASE AREA

MUNGERIE PARK COMMERCIAL CENTRE

PROPOSED LIGHT INDUSTRIAL AREA

PROPOSED ROAD

PROPOSED CASTLEREAGH MOTOR WAY

LOCATION OF ROADWAY AND MONITORING SITES

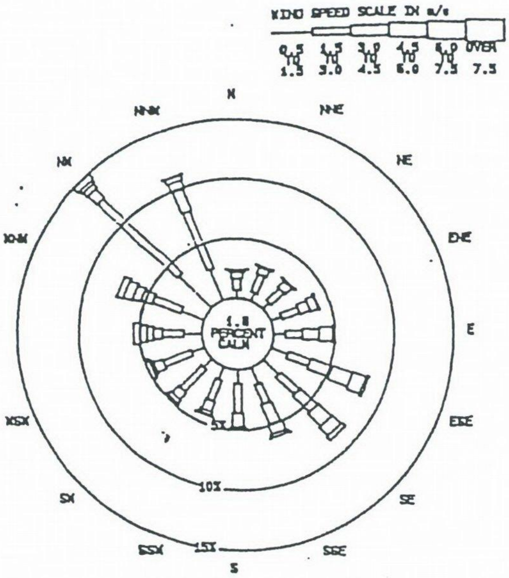
o Monitoring sites

0 1 2

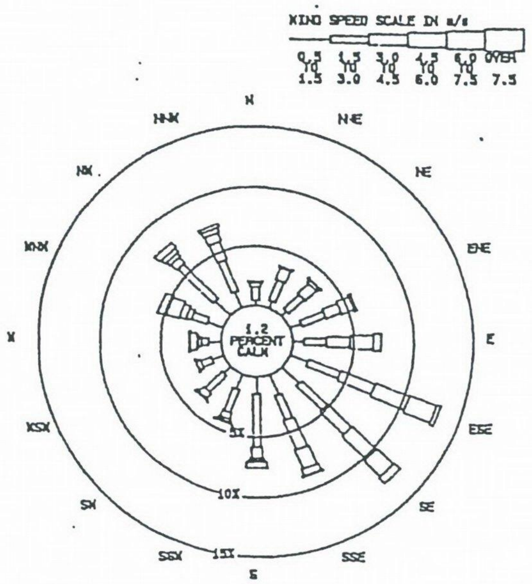
THE NORTH WEST SECTOR
- STAGE ONE RELEASE

FIGURE 1

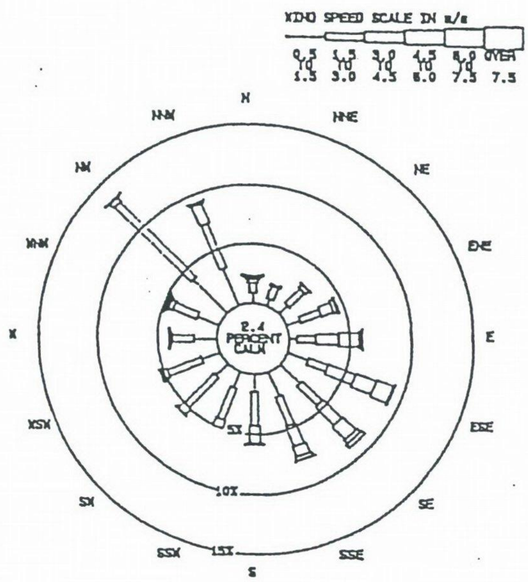
SEASONAL AND ANNUAL WINDROSES BLACKTOWN



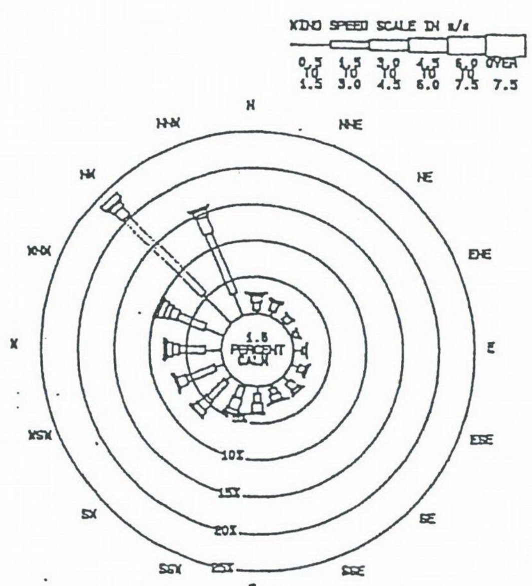
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Blacktown 1984 - Annual



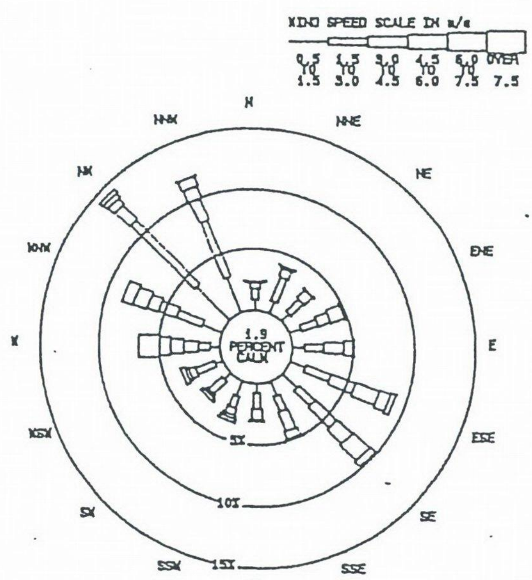
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Blacktown 1984 - Summer



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Blacktown 1984 - Autumn



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Blacktown 1984 - Winter



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Blacktown 1984 - Spring

FIGURE 3

Correlation between % NO2 and total NOx
EPA monitoring data

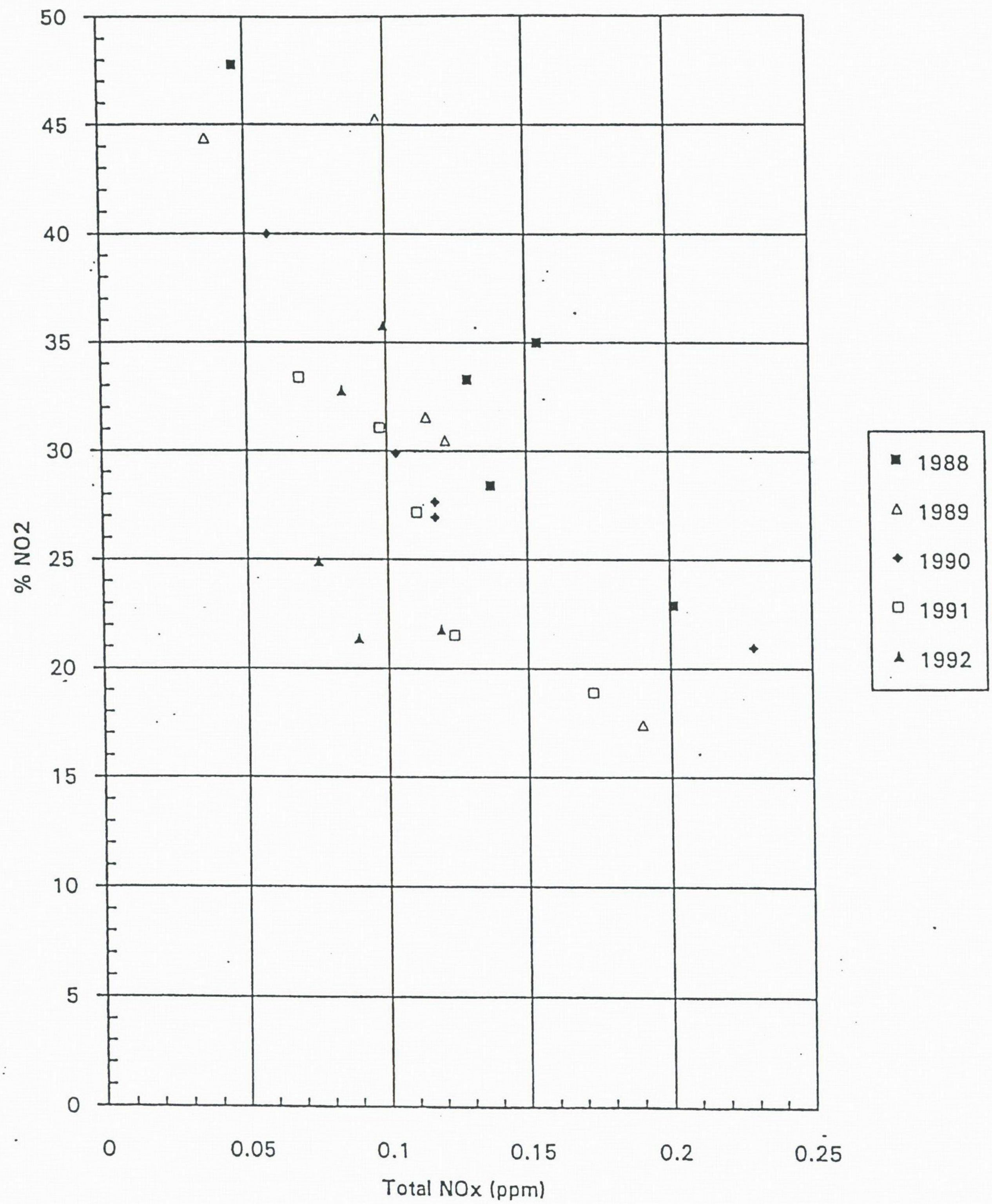


FIGURE 4

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

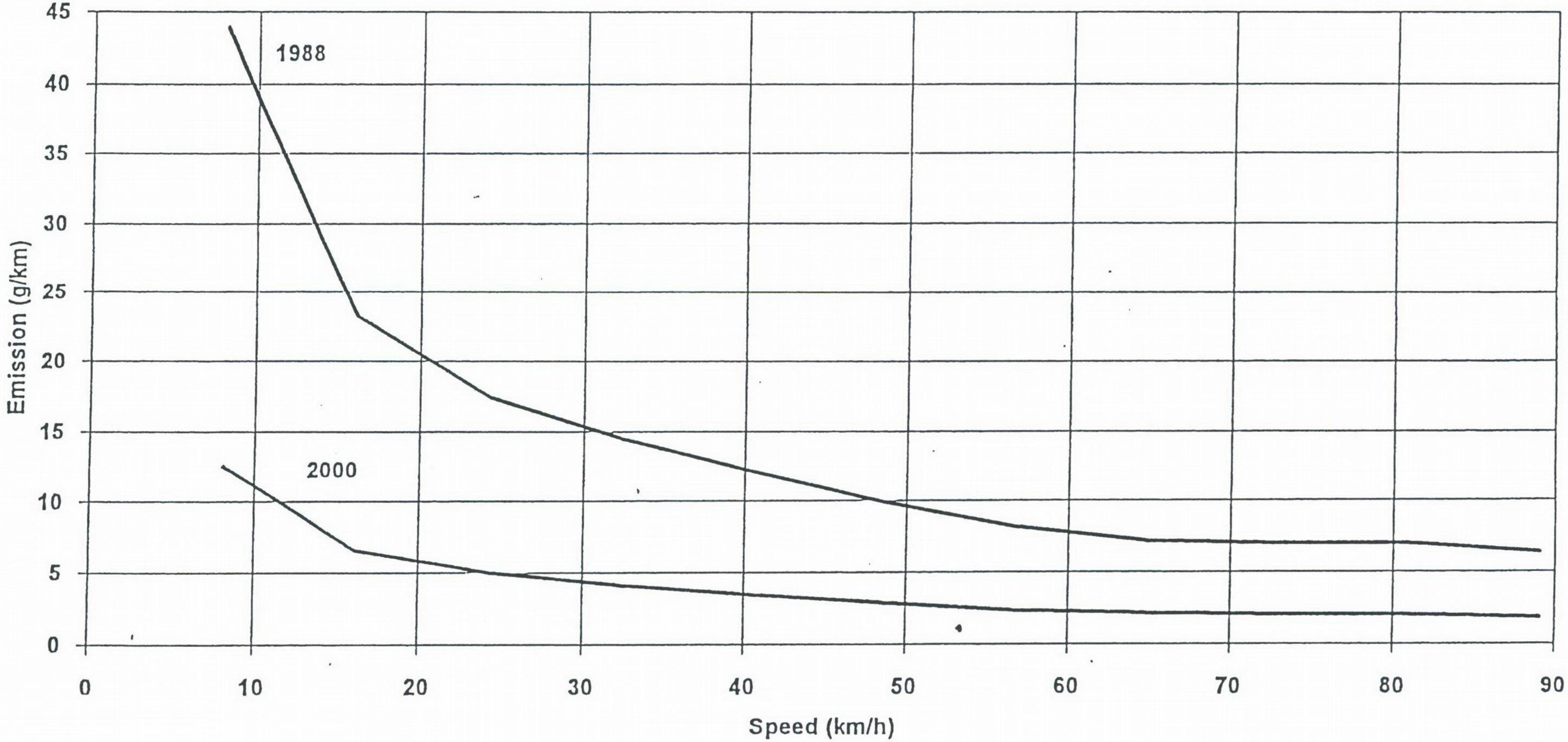


FIGURE 5

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

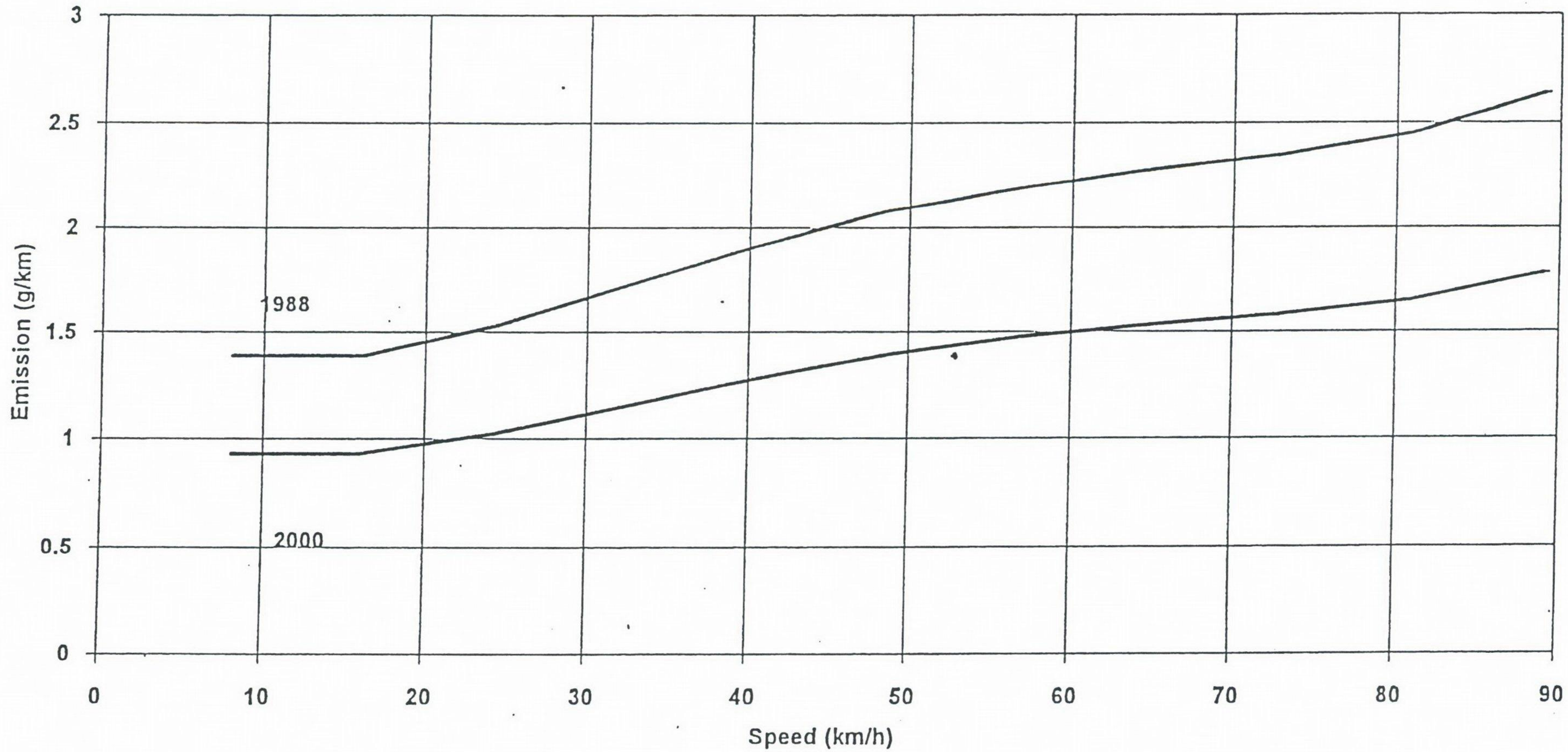


FIGURE 6

Appendix C: Flora and Fauna Assessment Report

FAUNA AND FLORA ASSESSMENT IN RELATION TO,

THE PROPOSED UPGRADING AND REALIGNMENT OF,

OLD WINDSOR ROAD BETWEEN

MERRIVILLE AND SUNNYHOLT ROADS,

YARRANDALE.

November 2000

Report prepared for the NSW Roads and Traffic Authority.

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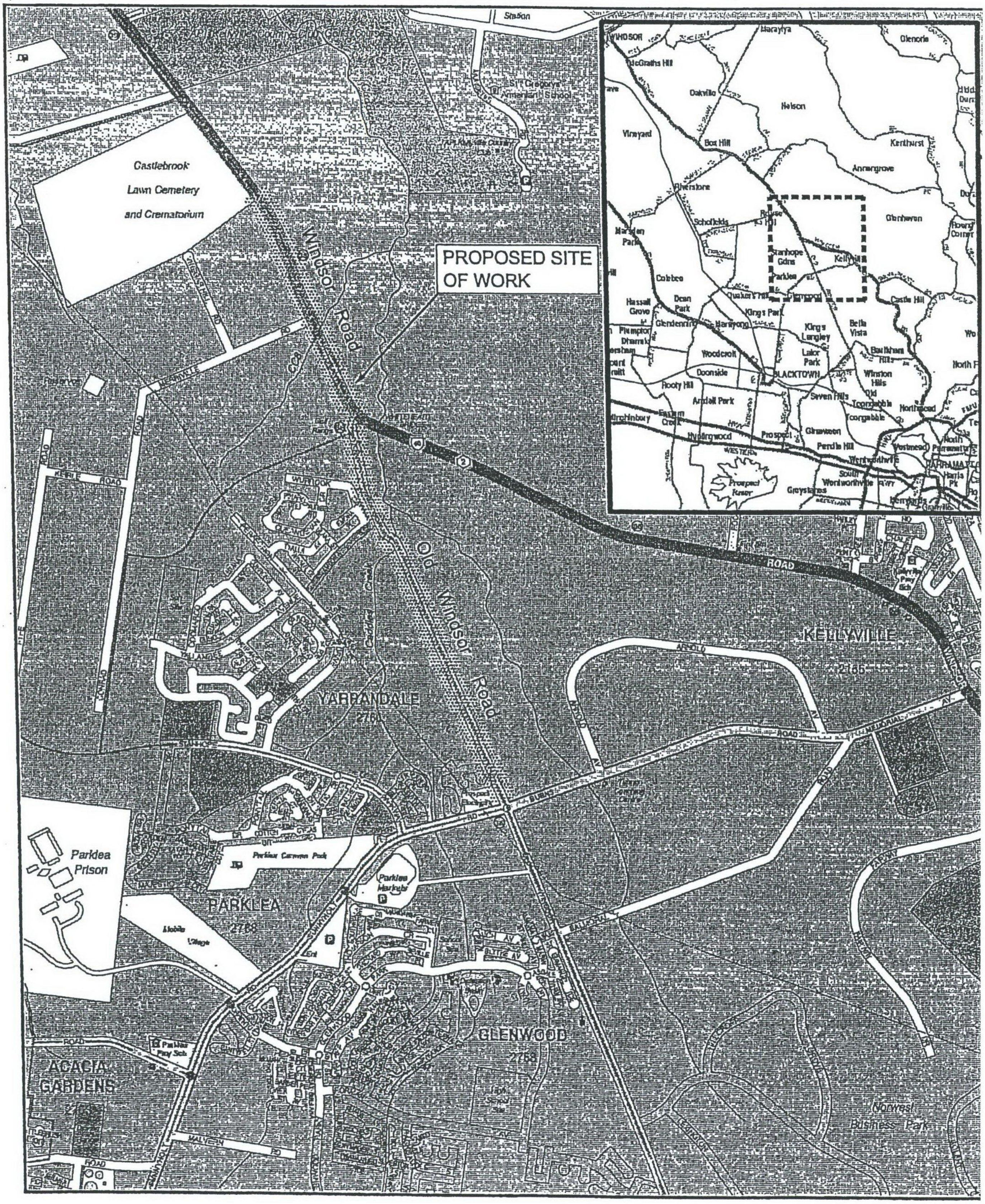
PART A INTRODUCTION AND ENVIRONMENTAL SETTING

1.0 INTRODUCTION

At the request of Hyder Consulting Australia, on behalf of the NSW Roads and Traffic Authority, a fauna and flora survey of Old Windsor Road, between Merriville and Sunnyholt Roads, Yarrandale, NSW, has been carried out. The survey has been conducted as the Roads and Traffic Authority wishes to upgrade and realign this section of road, thereby improving sight distances, road conditions and driver safety. The survey follows on from one originally conducted by Connell Wagner during July 1995. At the time the Connell Wagner report was produced, the assessment criteria and legislative obligations of proposals were different to those currently applied and therefore the initial report required reviewing and updating. The initial report also required updating as the scope of the project has been changed, the current proposal covering a smaller area and different alignment to that initially proposed. The present survey has therefore been carried out to determine the current assemblages of native species present, or potentially occurring within, and adjacent to, the proposed road works, their conservation status at a local, regional and State level, and the implications of this to the undertaking of the proposal. The present survey gives consideration to the current legislative obligations of proposed developments, particularly with reference to the *Threatened Species Conservation Act 1995*, Section 5A of the *Environmental Planning and Assessment Act 1979* and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*.

While conducting the field surveys, the current diversity and structure of the vegetation communities and fauna habitats present were identified, and consideration given to the role these would play in meeting the life cycle requirements of native species, particularly those which are threatened as listed under the Schedules to the *Threatened Species Conservation Act 1995*. In considering the value of the vegetation communities and fauna habitats to meet the needs of native species, an assessment of the impacts associated with the removal of these, as a result of the undertaking of the proposed upgrade and realignment, was undertaken.

The upgrade and realignment of Old Windsor Road is proposed to be undertaken between the intersections of Merriville Road and Sunnyholt Road, Yarrandale (Figure 1). The works would also include the provision of a four ways intersection as part of the development of the future road network of the surrounding area. Unless specific sections or areas are referred to, the proposed route will be hereafter be referred to as the study area or the proposed works. The study area is defined as the boundaries of the revised road alignment, this being indicated in Figure 1. The proposed upgrade is to be 4 lanes wide, the lanes being divided by a small medium strip. Curb and guttering would also be provided, as would sealed shoulders. The proposed easement would also provide opportunities for construction of an 8 metre wide bus transitway at a later stage. The future bus transitway does not form a component of the present proposal, but is proposed to occur within the study area at some stage. It has been assumed that, when adopted, the proposed bus transitway would occupy the existing alignment (and therefore infrastructure) of Old Windsor Road. Culverts across those drainage lines which traverse under the existing road network have already been constructed. These culverts either occur in association with the existing road network or within the proposed new alignment. The culverts are large concrete box structures, approximately 2 metres wide, 0.5 metres high and 60 metres long. Wooded bollards occur on their downstream sides. The road would have a sealed, bitumen surface. Within the study area, Old Windsor Road is currently single laned with unformed, dirt shoulders, though two lanes do occur in the vicinity of the intersections.



LEGEND

PROPOSED SITE

CREEKS

MAIN ROADS

SECONDARY ROADS

0 0.5

Figure 1

Regional Location and Study Ar

2.0 ENVIRONMENTAL SETTING

The study area is located to the east of Yarrandale, approximately 8 kilometres north east of the Blacktown Central Business District. The proposed upgrade and realignment is approximately 2 kilometres long and between 45 and 60 metres wide. The majority of the study area is highly disturbed, and essentially cleared. The area is generally vegetated by disturbed grasslands, though a small area of natural bushland is present within the study area near the Old Windsor and Windsor Roads intersection. This stand is currently degraded by the invasion of exotic plants, rubbish dumping, recreational use and the proximity of urban and rural areas.

Two creek lines, these being Caddies Creek and a unnamed drainage channel which flows into Caddies Creek, occur within and adjacent to the study area. These have an urban-rural catchment and both supported water at the time of the field investigation. Within the study area, the creeks are fed by a series of road verges which collect and channel water off Old Windsor Road. Besides the two main creek lines, most of the drainage lines appear to be ephemeral, though, at the time of field investigations, some standing water was present in a number of these. Caddies Creek and the unnamed drainage channel have both been modified through the in-channel construction of culverts. The unnamed drainage channel has also been significantly modified through the placement of a gravel filter and rock mattress, the contouring and shaping of the channel banks and the compaction of the soil substrate. At the time of the field survey, it was not established whether the unnamed drainage channel followed the original creek alignment or whether this had been altered. Within the study area, no aquatic vegetation is present in the unnamed drainage channel, though some occurs within Caddies Creek. Aquatic vegetation is also present within several of the road verge storm water runoff diversion channels.

The study area is bound to the east and west by residential developments and disturbed grasslands. To the south and south east, residential and commercial developments also occur. A transmission easement is present to the west of the proposed road alignment, this easement being regularly maintained and cleared. Further to the north, east, south and west, residential developments are present, these including houses, maintained lawns, foot paths, gardens and other urban infrastructures. Also present are rural areas with associated paddocks, sheds and farm infrastructures.

The study area experiences warm summers, with an average annual maximum temperature of 23^{0}C and an average annual minimum temperature of 11^{0}C. The study area has an average annual rainfall of 943 mm, with the rainfall being mainly experienced between summer and autumn (Weather Station 067026 Collins St, Seven Hills).

The study area generally occurs on a low lying section of the Cumberland Plain, the topography of the area being typical of the gently undulating rises on Wianamatta Shales. The topography in the study area is flat to gently sloping, with a local relief of less than 10 metres. The underlying geology is composed of the Ashfield Shales, Bringelly Shales and Minchinbury Sandstones. Rocks of these materials usually produce clayey soils of the Blacktown Group (Bannerman and Hazelton 1990). Soils derived from this unit are usually Brown or Red podzolic soils that are shallow to moderately deep, and, where runoff flows are concentrated, of moderate erodibility (Bannerman and Hazelton 1990). Around the Caddies Creek area, the soils change to Quaternary alluviums derived from the Wianamatta Group of shales and the Hawkesbury Sandstones. The soils are often very deeply layered sediments over bedrock. Natural elevations within the study area ranges from 45 metres Above Sea Level (ASL) to 65 metres ASL.

Conservation reserves in the vicinity of the study area are limited to a number of small, isolated Council maintained reserves and parks.

The study area is in the Central Coast botanical division (Harden 1990-93).

PART B FLORA ASSESSMENT

3.0 BACKGROUND

A previous survey by Connell Wagner Pty. Ltd. (1995) provided a description of the vegetation along Old Windsor Road between Sunnyholt Road and Merriville Road and a plant species list based on a general survey and two 10 metre by 10 metre sampling plots. That survey was undertaken prior to the implementation of the NSW *Threatened Species Conservation Act 1995*, and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The present study verified the occurrence of plant species previously recorded along the survey corridor and identified any unrecorded species. The assessment of the conservation significance of plant species, populations and communities was updated to the requirements of the *Threatened Species Conservation Act 1995*, the *Environment Protection and Biodiversity Conservation Act 1999* and local conservation significance.

4.0 METHODOLOGY

A one day general walking survey was undertaken by John Speight on 6 September 2000 using the Random Meander Method described by Cropper (1993). This method is the most suitable for covering large areas and for locating rare species that may occur in the survey site. The method involves walking randomly across the survey area while sampling all of the various habitats until no new species have been recorded for at least thirty minutes. During the field survey, particular attention was paid to areas where native tree and shrub cover remains, and where mechanical disturbance and weed infestation was lowest.

A further inspection was undertaken on 12 October 2000 to assess the likely impacts of the proposed Sam Riley Drive on the existing Old Windsor Road intersection.

The occurrence of previously recorded species were ascertained during the current survey and any other species identified were recorded. By the completion of the survey approximately six (6) hours of active searching had been undertaken.

The study area boundaries are shown on Figure 2 and included the areas directly affected by the proposed works, including the Sam Riley Drive intersection and up to 10 metres beyond the boundaries of the road formation.

5.0 RESULTS

5.1 Plant Communities

All of the vegetation within the study area has been modified and degraded by land clearing for farming, road construction and more recently, residential housing developments. These modifications range from total vegetation clearing and topsoil stripping for urban developments, to native vegetation cover clearing and the sowing of pasture grasses for improved grazing for livestock, to partial clearing with subsequent regrowth of native vegetation. The majority of the study area consists of weed dominated old grazing pastures or recently cleared areas. Some stands of native vegetation remain, notably a narrow linear band of Forest Red Gum - Rough-barked Apple Open Forest along Old Windsor Road between the southern side of Caddies Creek and Sunnyholt Road. This vegetation would not be directly affected by the proposed works.

Five vegetation community types can be recognised in the study area. These are mapped on Figure 2. They are:


Grey Box - Forest Red Gum woodland
Forest Wood Gum - rough barked Apple Woodland
Narrow Leaved Ironbark woodland
Swamp Oak open woodland
WINDSOR ROAD
MERRIVILLE ROAD
Strangers Creek
WINDSOR ROAD
Caddies Creek
Elizabeth Macarther Creek
OLD WINDSOR ROAD
SUNNYHOLT ROAD
BURNS ROAD
0
0.25

Figure 2

1. Exotic Grassland.
2. Grey Box - Forest Red Gum Woodland (*Cumberland Plains Woodland*).
3. Swamp Oak Open Woodland (*Sydney Coastal Riverflat Forest*).
4. Forest Red Gum - Rough-barked Apple Woodland.
5. Narrow-leaved Ironbark Open Woodland (*Castlereagh Ironbark Woodland*).

These vegetation stands are described below.

1. Exotic Grassland

Occurrence
The exotic grassland community occurs across the majority of the study area, in all of the parts not covered by the other the vegetation communities identified. Large continuous areas occur to the west of the existing Old Windsor Road between Caddies Creek and Sunnyholt Road.

Structure
Grasses and herbs to 07 metres high. The grassland comprises mostly exotic grasses, herbs and forbs, with some native grasses and herbs. The native shrub Parramatta Green Wattle *Acacia parramattensis* occurs scattered across the grassland areas.

Common Species (* = exotic species)
Grasses:
Tussock Grass *Poa labillardieri*, Wallaby Grass *Danthonia tenior*, Couch *Cynodon dactylon*, Narrowleaf Carpet Grass *Axonopus affinis**, Perennial Rye Grass *Lolium perrene**, Rhodes Grass *Chloris gayana**, Kikuyu *Pennisetum clandestinum**, Phalaris *Phalaris aquatica**, Summer Grass *Digitaria sanguinalis**, Pigeon Grass *Setaria viridis**, and Paspalum *Paspalum dilatatum**.

Herbs and Twiners:
Saloop *Einadia hastata*, Blackberry *Rubus fruiticosus**, Fireweed *Senecio madagascariensis**, Love Creeper *Glycine clandestina*, Hardenbergia *Hardenbergia violacea*, Spear Thistle *Circium vulgare**, Field Bindweed *Convovulus arvensis**, Paddy's Lucerne *Sida rhombifolia**, White Clover *Trifolium repens**, Paddy's Lucerne *Sida rhombifolia**, Onion Grass *Romulea rosea* var. *australis**, Verbena *Verbena bonariensis** and Common Vetch *Vicia sativa* ssp. *angustifolia**.

2. Grey Box - Forest Red Gum Woodland.

This community type forms one of the vegetation communities (Grey Box Woodland) of the Cumberland Plain Woodland complex, which is listed as an Endangered Ecological Communities under Schedule 1 (Part 3) of the *Threatened Species Conservation Act 1995*, and also by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Occurrence
Three small stands of this community type occurs at the northern end of the proposal corridor between the intersection of Windsor Road and Merriville Road (Figure 2). The largest stand is approximately 800m^2 (40m X 20m) in area. A linear stand of single tree width also occurs along both sides of a section of Old Windsor Road in the area of the proposed Sam Riley Drive intersection (see Figure 2).

Structure
Trees to 20 metres high with a sparse to medium density canopy. The understorey varies from a grassy cover dominated by exotic grasses and herbs, to an open understorey of native grasses, herbs and shrubs. The shrub layer height varies in height between 1 and 3 metres. The exotic Kikuyu and Buffalo grasses are common

and rubbish, building rubble and excavated earth dumping has affected all of the stands.

Common Species (* = exotic species)
Trees:
Grey Box *Eucalyptus moluccana* and Forest Red Gum *E. tereticornis*. Some Small-leaved Privet *Ligustrum sinense** and Large-leaved Privet *Ligustrum lucidum**.

Shrubs:
Blackthorn *Bursaria spinosa*, Parramatta Green Wattle *Acacia parramattensis*, African Olive *Olea europaea* ssp. *africanus**, and *Dillwynia sieberi*.

Groundcovers and Climbers:
Flax Lily *Dianella longifolia* var. *longifolia*, *Centella asiatica*, Half-berried Salt Bush *Atriplex semibaccata*, Fuzzweed *Vittadinia pustulata*, Poison Rock Fern *Cheilanthes sieberi*, Wallaby Grass *Danthonia linkii*, Saloop *Einadia hastata*, Old Man's Beard *Clematis glycinoides*, Hardenbergia *Hardenbergia violacea*, Paddy's Lucerne *Sida rhombifolia**, Kikuyu *Pennisetum clandestinum**, and Buffalo Grass *Stenotaphrum secundatum**.

3. Swamp Oak Open Woodland.

This very degraded stand of riverbank vegetation is a remnant of the same vegetation type that occurs upstream along Caddies Creek to the west of the study area. It represents a degraded remnant of one of the community types that forms the Sydney Coastal River-flat Forest complex which is listed as an Endangered Ecological Community under Schedule 1 (Part 3) of the *Threatened Species Conservation Act 1995*.

Occurrence
A very small stand of this community type occurs at the existing Old Windsor Road crossing of Caddies Creek. It consists of several trees and shrubs, and associated sedges and reeds. Areas immediately upstream and downstream of the crossing have been cleared of native vegetation. The community grades into the Forest Red Gum - Rough-barked Apple Woodland to the south along Old Windsor Road.

Structure
Trees to about 15 metres high with a sparse canopy. The understorey consists of sedges and reeds in standing water and creek margins, and exotic grasses on the banks, where Kikuyu and Phalaris are common.

Common Species (* = exotic species)
Trees:
Swamp Oak *Casuarina glauca* and Small-leaved Privet *Ligustrum sinense**.

Shrubs:
Parramatta Green Wattle *Acacia parramattensis*, White Feather Honeymyrtle *Melaleuca decora*, and African Olive *Olea europaea* ssp. *africanus**.

Sedges, Reeds and Water Plants
Cumbungi *Typha orientalis*, *Juncus usitatus*, *Cyperus eragrostis**, *Cyperus congestus**, Spotted Knotweed *Persicaria decipiens*, Curled Dock *Rumex crispus**, Marsh Daisy *Cotula coronopifolia**,

Groundcovers and Climbers:
Kikuyu *Pennisetum clandestinum**, Phalaris *Phalaris aquatica** and Buffalo Grass *Stenotaphrum secundatum**.

4. Forest Red Gum - Rough-barked Apple Woodland.

This vegetation represents another of the community types that forms the Sydney Coastal River-flat Forest complex which is listed as an Endangered Ecological Community under Schedule 1 (Part 3) of the *Threatened Species Conservation Act 1995*.

Occurrence
A stand of this community type forms a narrow linear woodland on both sides of Old Windsor Road, south from Caddies Creek for about 200 metres. The stand is only up to two metres wide.

Structure
Trees to 15 metres high with a medium density canopy. The understorey consists of a grassy cover dominated by exotic grasses and herbs, with scattered native shrubs grasses and herbs.

Common Species (* = exotic species)
Trees:
Rough-barked Apple *Angophora floribunda*, Forest Red Gum *E. tereticornis*, Small-leaved Privet *Ligustrum sinense**, and Large-leaved Privet *Ligustrum lucidum**.

Shrubs:
Blackthorn *Bursaria spinosa*, Parramatta Green Wattle *Acacia parramattensis*, African Olive *Olea europaea* ssp. *africanus**, and White Feather Honeymyrtle *Melaleuca decora*.

Groundcovers and Climbers:
Flax Lily *Dianella longifolia* var. *longifolia*, *Centella asiatica*, Poison Rock Fern *Cheilanthes sieberi,* Wallaby Grass *Danthonia linkii*, Saloop *Einadia hastata*, Old Man's Beard *Clematis glycinoides*, Hardenbergia *Hardenbergia violacea*, Blackberry *Rubus fruiticosus**, Kikuyu *Pennisetum clandestinum**, Phalaris *Phalaris aquatica*,* and Japanese Honeysuckle *Lonicera japonica**.

5. Narrow-leaved Ironbark Open Woodland (*Castlereagh Ironbark Woodland*).

Occurrence
A stand of this community type occurs on the eastern side of Old Windsor Road north from the intersection with Sunnyholt Road.

Structure
Trees to 12 metres high with an open canopy. The understorey consists of a grassy cover dominated by exotic grasses and herbs, with scattered native shrubs grasses and herbs.

Common Species (* = exotic species)
Trees:
Narrow-leaved Ironbark *Eucalyptus crebra* and Forest Red Gum *E. tereticornis*.

Shrubs:
Blackthorn *Bursaria spinosa*, Parramatta Green Wattle *Acacia parramattensis* and African Olive *Olea europaea* ssp. *africanus**.

Groundcovers and Climbers:
Flax Lily *Dianella longifolia* var. *longifolia*, *Centella asiatica*, Poison Rock Fern *Cheilanthes sieberi,* Wallaby Grass *Danthonia linkii*, Saloop *Einadia hastata*, Hardenbergia *Hardenbergia violacea,* Kikuyu *Pennisetum clandestinum** and Kangaroo Grass *Themeda australis*.

5.2 Plant Species

A list of plants identified during the current survey is provided in Appendix 1. No species of national conservation significance, as listed by the NSW *Threatened Species Conservation Act 1995* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, were located during the survey of the study area.

One individual of a species listed on Schedule 2 Part 2 (Vulnerable species) of the *Threatened Species Conservation Act 1995*; *Grevillea juniperina*, was located in weed infested bushland at the intersection of Windsor Road and Old Windsor Road during the previous survey by Connell Wagner (1995). That individual could not be relocated during the current survey. The report by Connell Wagner noted that the individual had red flowers rather than the light yellow flowers of the endemic form and may have been a cultivar.

The National Parks and Wildlife Service's Wildlife database lists 5 plant species of national conservation significance known to occur in the district (7 x 7 Km search area). These are *Pimelea spicata*, *Darwinia biflora*, *Epacris purpurascens* var. *purpurascens*, Pendant Beard-heath *Leucopogon fletcheri* ssp. *fletcheri* and *Eucalyptus* sp. Cattai. The conservation status of these species is given in Table 1. Only one of these species (*Pimelea spicata*) grows in the clay soil habitats that occur at the study site and therefore could potentially occur in the study area. The other species occur on sandstone or shale/sandstone transition habitats. The unclassified taxon *Eucalyptus* sp. Cattai occurs as an emergent in scrub, heath and low woodland on sandy soils, in the area between Colo Heights, north of Richmond to Castle Hill, south of the study site. The soils of the study area would not support this species. None of these species were recorded in the study area.

TABLE 1: Plant species of conservation significance potentially occurring within the study area.

SPECIES / (Family)	Conservation Status		Growth Form / Habitat
	ROTAP#	TSC Act Schedule	
Pimelea spicata (Thymelaceae)	3ECi	S1	Herb. Grassy understoreys of open forests on clay soils.
Darwinia biflora (Myrtaceae)	2VCa	S2	Small shrub. Sandstone woodlands and heath on ridges.
Epacris purpurascens var. *purpurascens* (Epacridaceae)	2KC-	S2	Small shrub. Poorly drained clay soils on sandstone or shale.
Leucopogon fletcheri ssp. *fletcheri* (Epacridaceae)	2RC-	S1	Open dry heath on sandstone.
Eucalyptus sp. Cattai (Myrtcaeae)		S1	Small tree. Emergent in scrub, heath and low woodland on sandy soils. Generally on ridgetops.

An explanation of the ROTAP codes is provided in Appendix 2.

Five species considered to be of conservation concern in Western Sydney (NPWS 1997) occur in the study area. These are listed below.

- Fuzzweed *Vittadinia pustulata*
- Wallaby Grass *Danthonia linkii*
- *Glycine microphylla*
- Tussock Grass *Poa labillardieri*
- Swamp Dock *Rumex brownii*

Several individuals of *Vittadinia pustulata* occur in the larger Grey Box Woodland stand on the western side of Old Windsor Road, north of the Windsor Road intersection. While Wallaby Grass, Tussock Grass, Swamp Dock and *Glycine microphylla* occur scattered throughout the study area.

6.0 DISCUSSION

6.1 Conservation Status of the Vegetation

Two of the vegetation communities in the study area are remnants of Endangered Ecological Communities listed under the NSW *Threatened Species Conservation Act 1995*, and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. These are the Grey Box - Forest Red Gum Woodland remnants which are listed by both the NSW and Commonwealth legislation, and the Swamp Oak Woodland and the Forest Red Gum - Rough-barked Apple Woodland, which are listed under the NSW legislation.

No plant species listed under the Schedules to the NSW *Threatened Species Conservation Act 1995*, or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* occur in the study area. Five species considered vulnerable in Western Sydney occur in the study area, but most species occur scattered through the road corridor. Only the Fuzweed *Vittadinia pustulata* occurs in discrete areas within the Grey Box Woodland stands. It would be difficult to retain or protect any of these species potentially affected by the proposal and all of the species occur in larger native vegetation remnants within the locality, including the Forest Red Gum - Rough-barked Apple Woodland stand adjacent to Old Windsor Road that is to be retained.

All of the woodland remnants are small and highly degraded, particularly the Grey Box Woodland remnants at the northern end of the proposal (north of the Windsor Road intersection) and the Swamp Oak Woodland remnant at Caddies Creek. The Swamp Oak woodland occurs on the eastern side of Old Windsor Road and would not be directly affected by the construction work, although increases in sediment into the creek may adversely affect sedges and reeds. As previously mentioned, the Grey Box woodland stands are degraded by rubbish and rubble dumping, and significant weed invasion. Given the likely continuation of these impacts as urbanisation continues and their small size, these stands are unlikely to have long-term viability. Weed species will continue to smother native groundcover species and new weeds are likely to be introduced by soil and rubbish dumping.

While the loss of five mature trees at the proposed Sam Riley Drive intersection would not constitute a significant effect on the botanical conservation and ecological values of the site or the district (see eight-part test below), their loss to the heritage and landscape values of the Old Windsor Road vegetation corridor needs to be assessed.

6.2 Likely Impacts of The Road Proposal

The construction of a road along the proposed alignment would remove the small stands of Grey Box Woodland (approximately $800m^2$) and large areas of the exotic grassland. Four large Forest Red Gum and one large Grey Box would also be removed from the roadside vegetation corridor of Old Windsor Road for the construction of the Sam Riley Drive intersection. A small area of the Narrow-leaved Ironbark Open Woodland would also be removed near the intersection of Sunnyholt Road.

Direct impacts of the Construction of the road would be the total clearing of the vegetation in the corridor and the stripping of topsoil. Some indirect impacts on vegetation outside the construction zone could also occur, including sedimentation of Caddies Creek and the trampling of adjacent vegetation by construction machinery and personnel. These indirect impacts could be easily controlled by providing effective erosion and sediment controls and fencing areas of sensitive vegetation that are to be retained. The majority of the road corridor has already been disturbed by past land uses, and extensive drainage works have recently been completed at Caddies Creek and the small creek near Merrivale Road, in the areas to be used for the roadway.

6.3 Eight Part Test

An eight part test as required under Section 5A of the *Environmental Planning and Assessment Act 1979* has been undertaken below. These criteria are designed to determine whether there is likely to be a significant effect on threatened species, populations or ecological communities, and consequently whether a Species Impact Statement is required to be prepared. The Eight Part Test has been carried out for the Grey Box Woodland community remnants that would be removed for the construction of the proposal.

(a) *"...in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction..."*

No threatened plant species listed on Schedules 1 or 2 of the *Threatened Species Conservation Act 1995* occur in the survey area.

(b) *"...whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised..."*

No populations of a threatened plant species listed on Schedules 1 or 2 of the *Threatened Species Conservation Act 1995* occur in the survey area.

(c) *"...in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed..."*

Stands of the endangered Grey Box Woodland community occur in the area between the Windsor Road intersection and Merriville Road, and at the location of the proposed Sam Riley Drive intersection would be removed for the work.

(d) *"...whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community..."*

The remnant stands to the north of the Windsor Road intersection are already isolated by about one hundred metres from more continuous stands of the vegetation. The linear stand of vegetation along Old Windsor Road, while continuous from Sunnyholt Road to Caddies Creek, is also unconnected to other areas of native vegetation. The removal of five trees from the Sam Riley Drive intersection site would not result in the isolation of the trees on either side of the road in terms of pollination and seed dispersal of the Grey Box or Forest Red Gum trees that constitute the Endangered Ecological Community. All pollination and seed dispersal mechanisms, apart from arboreal mammals such as possums, would still be able to operate over the 50 metre gap created between trees on either side of the new road.

(e) *"...whether critical habitat will be affected..."*

No habitat critical to the survival of a threatened species, population or community of plants would be affected by works. No critical plant habitat is listed in the Schedules to the *Threatened Species Conservation Act 1995.*

(f) *"...whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region..."*

The Grey Box Woodland community is not considered to be adequately represented in any of the nature conservation reserves in the region. However, the stands of this community type to be removed are small, degraded and isolated and are likely to continue to decline in health and species richness unless protection and restoration measures are implemented, given the rapid urbanisation of the area.

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

At the time of report preparation clearing for roadworks was not listed under Schedule 3 Key Threatening Processes of the *Threatened Species Conservation Act 1995*.

(h) *"...whether any threatened species, populations or ecological community is at the limit of its known distribution..."*

The study area is within the central distribution range of the Grey Box Woodland.

6.4 Expected Impact On Threatened Flora

The proposed removal of the stands of Grey Box Woodland for the construction of the new road alignment would not result in a significant reduction in the area of Grey Box Woodland remaining in the Sydney region. The stands are small with a large edge to area ratio which leaves them vulnerable to degrading processes. The stands have been, and continue to be degraded by weeds, rubbish dumping and trampling by pedestrians and vehicles. Unless active management of the stands are undertaken, they will continue to decline in vigour and species diversity and richness. Given the small total size of all of the stands, and their poor condition, the preparation of a flora Species Impact Statement for the proposed development is not considered necessary.

PART C FAUNA ASSESSMENT

7.0 LITERATURE REVIEW

As part of the overall fauna assessment, a review of previous studies and known databases was undertaken to identify the diversity of fauna species known for, or potentially occurring in, the study region. These species are ones which may utilise the study area on occasion but were not observed, recorded or indicated during the current investigation. The undertaking of a literature search also ensures that the results from surveys conducted during different climatic, seasonal and date periods are also considered and drawn upon as required. This approach therefore increases the probability of considering all known and likely native species, particularly those of conservation concern. The identification of known, or potentially occurring, native species within the Blacktown and Baulkham Hills Local Government Areas, particularly those listed under the Schedules to the *Threatened Species Conservation Act 1995*, also permits the tailoring of the field strategy to the detection of these species, and the selection of the most appropriate survey methods.

In documenting the potential for threatened species to occur within, or adjacent to the study area, only those animals which would occur within, or utilise those habitats present, were targeted, as these would be the animals most likely to be affected by the proposed road works if they were to proceed.

The studies and reports referred to included, but are not limited to:

- the National Parks and Wildlife Service's Atlas of New South Wales Wildlife (NPWS 2000);
- the initial flora and fauna working paper produced for the project area (Connell Wagner 1995);
- a flora and fauna management plan prepared for the proposed Mungerie Park town centre (Urban Bushland Management Consultants 1999);
- a flora and fauna survey undertaken for proposed roadworks at Riverstone (LandScope Environmental Consultants 1999);
- the flora and fauna report prepared for the abandoned waste transfer station, Withers Road, Kellyville (Gunninah Environmental Consultants 1998);
- a flora and fauna assessment prepared in relation to the proposed subdivision of Lot 50, Meurants Lane, Kings Ridge (LesryK Environmental Consultants 1997a);
- a flora and fauna report prepared in relation to the proposed residential re-zoning of Lots 311 and 312, DP 706399, Bingara Crescent and Lots 17 and 18, DP 225564 and Lot 161 DP 810009 Windsor Road, Baulkham Hills (LesryK Environmental Consultants 1997b);
- a flora and fauna assessment for a proposed residential subdivision, Stage 9 Duncraig Estate, Kellyville (LesryK Environmental Consultants 1996); and
- Blacktown and Baulkham Hill Councils' *State Of The Environment Reports 1999.*

Other reports referred to and drawn upon are provided in the Bibliography section of this report.

Field guides and standard texts used were:

- Cogger (1992) – reptiles and frogs;
- Simpson and Day (1996) – birds;
- Strahan (1995) – mammals; and
- Triggs (1996) – identification of scats, tracks and markings.

The naming of native species recorded or known for the region follows those presented in these documents.

The conservation significance of animals observed is made with reference to the *Threatened Species Conservation Act 1995*, while their regional and local status was determined through reference to the National Park's *Urban Bushland Biodiversity Survey* (NPWS 1997) and both Blacktown and Baulkham Hill Councils' *State Of The Environment Reports 1999.*

8.0 FIELD SURVEY METHODS

A survey of the entire study area, and those habitats which occur adjacent to it, was carried out by Mishy Mckensy $_{(B.Sc.)}$ on 6 September 2000. The weather conditions experienced during the field surveys were clear skies, warm temperatures and slight breezes. By the completion of the study, a total of 2 hours of field investigation had been accumulated, this consisting entirely of diurnal work, the survey being carried out between the midday and afternoon period.

During the field survey, no limitations to the success of the study were encountered. During the field survey the climatic conditions experienced were conducive to the detection of the majority of native species present, while access to all parts of the study area permitted the documentation and targeting of various habitat types.

Based on the outcomes of the literature review process, particularly the identification of potentially occurring threatened species, combined with the identification of the habitats present within the study site, the fauna survey techniques selected to identify the diversity of native and introduced species present within, and adjacent to, the study area, and to determine the presence or absence of Scheduled animals, were:

- Direct observation of fauna species;
- Litter and ground debris searches for reptiles, frogs and threatened snails;
- Bird watching;
- The identification of indirect evidence, such as tracks, scratchings and scats;
- Analysis of any carnivore scats which contained bone or hair material; and
- Call identification during both the day and night time surveys.

Where required, further explanation of these methods is provided in Section 8.1.

In relation to those invertebrates which occur within the study area, only the presence of the Large Land Snail *Meriodolum corneovirens*, a species listed under Schedule 1 of the *Threatened Species Conservation Act 1995*, was targeted. While conducting the field investigations, no other invertebrates were collected or identified.

8.1 Survey Methods

The daytime field survey strategy employed for the study involved traversing the entire road corridor, and the adjacent habitats, by foot following the 'Random Meander Method' described in Cropper (1993) which has been adapted to be suitable for fauna surveys. Where sites of potential conservation significance were identified, including drainage lines and remnant vegetation, they were searched in greater detail. By undertaking an assessment using this strategy, all fauna habitats present within and adjacent to the study area were identified and surveyed, and the majority of resident fauna species recorded. Visibility to all fauna habitats present was high and access to all sections of the road corridor was good to above average.

During the daytime searches, rocks and other suitable ground debris material was turned and leaf litter accumulations were investigated. These habitat features were surveyed to identify any snails, reptiles or frogs.

During the present study, no live trapping was conducted. This technique was not undertaken due to the results of the literature review process, the lack of suitable habitat within the study area, the proximity of urban areas, and therefore the potential for theft or tampering with the traps (and any captured animals) and the author's knowledge of the species most likely to be present in the study area based on the results of past studies.

While undertaking the field survey, efforts were made to document the diversity, structure and value of the habitats present within, and adjacent to, the study area for those protected, as defined under the *National Parks and Wildlife Act 1974*, and threatened species, as indicated by the Schedules to the *Threatened Species Conservation Act 1995* observed, or expected to occur based on past studies and known distribution patterns. This involved assessing the structure of the vegetation associations and fauna habitats present and determining their significance to native species, particularly those of conservation concern. While conducting the habitat assessments, efforts were made to identify features such as known feed trees, mature trees with hollows, connectivity with other woodland areas, suitable aquatic environments, caves or cave substitutes and other habitat features important to the life cycle requirements of threatened animals known or likely to occur in the study region.

9.0 HABITAT TYPES AVAILABLE FOR NATIVE FAUNA SPECIES

For simplicity, due to the length of the study area, the proposed route has been divided into three sections. These sections are arbitrary and have been selected for ease of reference, the sections generally relating to physical features such as drainage lines or intersections. The locations of the boundaries of the fauna habitats, in relation to these reference points, are approximations, but do provide an indication of the quality and value of the habitats present within each section and throughout the whole road corridor. Within each section, Old Windsor Road is a sealed, one laned road with unsealed or partially sealed shoulders of varying widths. Within the existing road corridor, power lines, lighting and their associated easements are present, as are road signages and unformed parking areas. Wind blown rubbish and dumped construction and building waste are present at various locations. The character of the existing Old Windsor Road is typical of those arterial roads found in the semi-rural areas of the north western residential release areas.

In summary, five (5) habitats were recorded during the field investigation these being:

- disturbed grasslands;
- remnant woodland;
- aquatic environments;
- exotic shrubland; and
- disturbed environments.

The habitats recorded during the present survey appear to correspond to the ones recorded in the area during the Connell Wagner (1995) study, though the encroachment and expansion of residential developments has had some detrimental impacts on their quality and value.

9.1 Section 1: Merriville Road to Old Windsor Road

Three habitat types, these being a disturbed grassland, a remnant woodland and aquatic environment, were observed within this section of the study area, with the disturbed grassland dominating the site. Descriptions of each of these follows.

The disturbed grasslands consist of either cleared land or a low to medium density layer of exotic grasses and weeds to 0.3 metres in height. Within the grasslands, a few regenerating native trees, and both native and exotic shrubs 2 metres high, are present. Along the roadside, occasional clumps of mature trees to 16 metres do occur. Three of the trees present within this section support hollows 0.1 to 300 millimetres in diameter, these being suitable for the life cycle needs of those hollow dependant native species known or potentially occurring in this area. The disturbed grasslands are associated with new residential estates proposed to occur on both sides of the road in this section, the estates resulting in the contouring and levelling of the area. Currently fencing, guttering, and the internal road network are being constructed within these new release areas.

Two small patches of remnant woodland, approximately 20 by 40 metres and 10 by 15 metres respectively are present within the southern western portion of this section. The trees are generally between 8 and 10 metres high. No tree hollows were observed in any of the eucalypts which occur within these woodland areas. The understorey is composed of saplings and shrubs 2.5 metres high, these occurring as either isolated individuals or small dense clumps. Ground cover plants are sparse and composed of exotic and native grasses, forbs, weeds and seedlings. Leaf litter is sparse to moderate, with most of the ground debris consisting of urban refuse, construction rubble and some branches.

The aquatic environments consist of a number of modified drainage lines. These drainage lines vary according to time since the earth works were carried out, the function and location of the channel. The main drainage line in this section occurs to the south of Merriville Road. Recent large-scale earthworks have been undertaken along this channel. The contoured banks consisting of bare earth, the channel being composed of medium sized sandstone rocks. Within the study area, no floating or emergent vegetation was present. At the time of the field investigation, the unnamed drainage channel was not flowing but did support a series of isolated pools. Numerous culverts and other drainage structures have been constructed within and over this drainage line. A roadside drainage line occurs to the immediate south west of Merriville Road. This channel was 1 metre wide and forty metres long, and was vegetated by a dense stand of Typha, the Typha being associated with moister areas. No floating aquatic vegetation was observed. Water was not flowing along the drainage line. The bed was composed of dirt.

All habitats have been significantly disturbed by the proximity of nearby residential areas and the associated construction activities. The woodland areas are isolated remnants, currently not connected to any significant stands of native vegetation.

New residential areas, noise barriers, disturbed grasslands, houses, a takeaway food outlet, petroleum station, nursery and the existing road bound this section.

9.1.1 Value of habitats observed and expected impacts on native species if removed.

Due to their isolated, cleared and degraded condition, the habitats present within this section of the proposed alignment are considered to be of limited to no value. The habitats present would not be of any significant value for the life cycle requirements of any native species, particularly any listed under the Schedules to the *Threatened Species Conservation Act 1995*. No native species would be disturbed or affected as a result of the further disturbance and modification of these habitat types, such that they would be placed at risk of extinction.

9.2 Section 2: Old Windsor Road to Caddies Creek

Three habitat types, these being disturbed grasslands, an exotic shrubland and an aquatic environment, were observed within this section. Descriptions of each of these follows.

The disturbed grasslands consist of a medium to high density layer of exotic and native grasses and weeds 0.05 to 0.5 metres in height. Within the grasslands no regenerating native trees and shrubs are present. Along the roadside two linear stands of mature trees, 12 metres in height do occur, with approximately 10 individuals in each stand. These occur in the south west portion of this section. These trees appear to be suffering from dieback. None of the trees present within this section of the study area support hollows suitable for the life cycle needs of any hollow dependant native species. The disturbed grasslands are associated with pasture lands which occur on both sides of the road, and a golf driving range. Associated with the golf driving range and Telstra building are established gardens of introduced trees, palms and shrubs, as well as maintained grasslands.

The disturbed grassland dominates the study area.

A small exotic shrubland of the introduced wattles, *Acacia sp.*, approximately 30 by 30 metres in size, is present within the north eastern portion of this Section. The shrubs are generally between 1 and 2.5 metres high. The groundcover is composed of seedlings and exotic grasses, 0.5 metres high, these occurring as a medium to dense layer. Leaf litter is sparse, with most of the ground debris consisting of urban refuse.

Caddies Creek is the main drainage line in this section. The southern part of the creek from Old Windsor Road has been extensively altered recently for the construction of a new culvert, this occurring adjacent to a new subdivision. On the northern side of Old Windsor Road, the creek drains into a pool before continuing along its natural alignment. Some emergent vegetation was present within this drainage line, this vegetation encompassing a small area of dense Typha. The channel bed is composed of mud and dirt. A small stand of Casuarina's occurs either side of the existing Old Windsor Road bridge. These trees are to a height of 12 metres. At the time of the field investigations the creek was not flowing. Caddies Creek is dammed 2.5 kilometres upstream of the study area.

All habitats have been significantly disturbed by the proximity of nearby new residential areas, and their associated construction activities. The presence of farming properties and the agricultural history of the region has also had a detrimental impact.

New residential areas, disturbed grasslands, a golf driving range, and a Telstra building bound the edges of this section.

9.2.1 Value of habitats observed and expected impacts on native species if removed.

Caddies Creek would be utilised by a number of protected native species, these including frogs, reptiles and birds. The sections downstream of the proposed road works are considered to be of most value for native animals, due to the presence of stands of riparian vegetation. This area occurs beyond the boundaries of the proposed road works and will not be removed or significantly impacted upon by the proposal providing that the recommendations provided in Section 14.0 are followed. No Scheduled species are considered to occur within, or rely upon, the sections of Caddies Creek which occur within, or in close proximity to, the study area.

The grassland and exotic shrubland are considered to be of limited to no value due to their isolated, cleared and degraded condition. They would not be of any significant value for the life cycle requirements of any native species, particularly any listed under the Schedules to the *Threatened Species Conservation Act 1995*. No native species would be disturbed or affected as a result of the further disturbance and modification of this habitat type, such that they would be placed at risk of extinction.

9.3 Section 3: Caddies Creek to Sunnyholt Road

Disturbed grasslands dominate this section of the study area. These consist of a medium to high density layer of exotic and native grasses and weeds, 0.5 metres in height. Within the grasslands a small number of isolated native trees and shrubs are present

A linear stand of eucalypts occurs within the existing road reserve, on both sides of the road. The trees occur to a height of 16 metres and several support hollows suitable for the life cycle needs of several hollow dependant native species. The linear stand of trees occurs within the northern third of this section, and is a band width of approximately 10 metres. The canopies of these trees are interconnected, though these stands are isolated from any other wooded areas. Some of these trees appear to be suffering from dieback. Where present, shrubs occur to a height of 1.5 metres.

Remnant woodland occurs on the eastern side of Old Windsor Road, north of Sunnyholt Road. This area supports trees, 12 metres high with a semi-continuous canopy. The understorey is composed of isolated native shrubs to 2 metres, with the groundcover being dominated by exotic grasses and herbs.

In relation to the single line of trees, it is noted that these have been identified as having heritage significance (Hyder Consulting, pers.comm.). Although this is the case, the proposed road works would result in the removal of several of these. The loss of several trees, in relation to the extent of vegetation remaining within, and adjacent to the study area, is not considered to significantly reduce the amount of available foraging and sheltering resources.

9.3.1 Value of habitats observed and expected impacts on native species if removed.

The grasslands and associated native vegetation are considered to be of little to no value due to their isolated, cleared and degraded condition. They would not be of any significant value for the life cycle requirements of any native species, particularly any listed under the Schedules to the *Threatened Species Conservation Act 1995*. No native species would be disturbed or affected as a result of the further disturbance and modification of this habitat type, such that they would be placed at risk of extinction.

10.0 WILDLIFE CORRIDORS AND VEGETATION LINKS

For the majority of native species the site is considered to be highly isolated and not connected to any nearby woodland areas. Surrounding landuses, which include road networks, housing and industrial developments and farming properties, have fragmented any fauna corridors which would have initially been present in this area for these species. These land uses have also presented a physical barrier to the movement patterns of these species, thereby isolating habitat areas. For these species, no fauna movement or dispersal corridors are considered to be present and therefore none would be further affected by the undertaking of the proposed works.

Short narrow vegetation links do occur along Caddies Creek to the east and west of the study area. The connectivity of the vegetation along this drainage line would not be further affected as a result of the undertaking of the development. Within and in close proximity to the study area, the value of this creekline has been reduced and compromised due to the construction of a series of culverts, and the residential expansion which has occurred within this north western sector.

As such the proposed works would not affect any locally or regionally important fauna dispersal or movement corridors.

11.0 RESULTS

11.1 Species Recorded During The Current Field Survey

During the investigation of the study area, twenty (20) native birds, one (1) reptile, one (1) frog and one (1) native snail were recorded (Appendix 3). A range of exotic and introduced species were also recorded within, and adjacent to, the site (Appendix 3). The native species recorded are all characteristic of the habitats present, confirming the observations made in the field and assisting in the determination of likely threatened species. The species recorded are all regularly observed in the regions farmlands, pasture grasslands, woodlands, urban areas and the ecotones between these habitat types. The species recorded would all be considered woodland associated and dependant animals, thereby indicating the diversity of threatened species which may occur.

In regards to the detection of those species recorded:-

- All birds were observed within, or flying over, the site, or identified from their distinct calls;
- The Common Eastern Froglet (*Crinia signifera*) was identified by it's distinctive call, these calls emanating from Caddies Creek;
- The Grass Skink (*Lampropholis delicata*) was observed during the leaf litter searches; and
- The Large Land Snail (*Meriodolum corneovirens*) and Garden Snail (*Helix aspera*) were both recorded during the ground debris and leaf litter searches.

Of those animals recorded by the completion of the field survey, one, the Large Land Snail is considered to be of conservation concern as defined by inclusion on Schedule 1 of the *Threatened Species Conservation Act 1995*. This snail was recorded on the northern side of Old Windsor Road, near Merriville Road, this species being identified through the collection of one empty shell which was found while searching underneath some urban refuse. This refuse was present within an area vegetated by several shrubs. These shrubs are isolated from any other wooded stands due to the presence of Old Windsor Road to the south, recently cleared paddocks to the north and dense grasses within the road reserve. While conducting the field survey, no living individuals of this species were found, and no additional discarded shells recorded.

The Large Land Snail is currently restricted to the Cumberland Plains region of western Sydney. It is closely associated with the Cumberland Plains Forest Community, particularly those areas with Wianamatta Shale based soils. It typically occurs in eucalypt woodland under logs and other debris and amongst leaf and bark accumulations around bases of trees, where possible it will burrow into loose soil. It's current known distribution is in an area roughly bounded by Cattai (to the north), Camden (to the south), Prospect Reservoir (to the east) and Mulgoa (to the west). Very little is currently known about the biology and life history of the species, however, it is hermaphroditic. The species can be common when suitable habitat is present but, given the relatively rapid development of Western Sydney in the last few decades, the snails distribution has been severely fragmented.

The observation of a Large Land Snail shell would suggest that a population of these animals would have been present in this area at some stage. The lack of recordings of any living individuals, or other discarded shells, and the extent of clearing undertaken to the north of the study area, would suggest that the species and its habitat, are now locally extinct. As mentioned, during the field survey, no living individuals of this species were found, and therefore the local population cannot be considered viable.

The remainder of the native species recorded are protected, as defined by the *National Parks and Wildlife Act 1974*, but considered to be common to abundant throughout this region. These animals would be considered edge and/or generalist species (Catteral, Green and Jones 1991), species which are regularly encountered within the surrounding woodland, semi-rural and urban areas or within the interfaces of these habitats. None of the species recorded would be affected by the proposed road works such that a viable local population of that species would be placed at risk of extinction.

None of the species or fauna habitats recorded are listed under the Schedules to the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*. Similarly, none of the fauna habitats present are covered by the matters of consideration present within this piece of legislation.

11.2 Species Recorded During Previous Studies

Fauna surveys undertaken within the region over the last five years have identified twenty seven (27) native mammals, and an additional, eighty six (86) native birds, twenty seven (27) reptiles and eleven (11) amphibians (Appendix 3). Of these species recorded, six (6) are listed under the Schedules of the *Threatened Species Conservation Act 1995* (Table 2) and twenty two (22) are considered to be of local or regional conservation significance (Table 3). For reference, the Scheduled species are identified in Table 2, this table also providing:

- the habitat requirements of these species;
- a likely location of these animals if present within the subject site; and
- a consideration of likely impacts associated with the undertaking of the proposal on the local and regional occurrence of these species.

Based on the habitat requirements of those threatened species previously recorded in the study region, the results of the field survey and the determination of the diversity of fauna habitats available for native species, none of the species listed in Table 2 are considered to occur as a resident population within, or be significantly reliant upon, the study area. The further disturbance and modification of the study area will not significantly affect the presence of any threatened species or their habitats such that they would be displaced or made locally extinct. As such, none of the threatened fauna previously recorded in the study region would be affected by the proposed road works.

TABLE 2: Scheduled fauna species known to occur within the study region.

* - habitat requirements were generally extracted from Frith (1997), Churchill (1998), Cogger (1992), Ehmann (1997), Strahan (1995) and NPWS (1999), with other references used being identified in the bibliography.

Species	Habitat Requirements*	Likelihood Of Occurrence and Likely Impacts
BIRDS		
Swift Parrot *Lathamus discolor*	The Swift Parrot breeds in Tasmania but migrates to mainland Australia (February-April) to feed during winter. On the mainland, this species occurs in wide variety of habitats, depending on the availability of winter flowering eucalypt species.	**Likelihood Of Occurrence** Moderate. Possibly foraging and moving over study area. **Likely Impacts** Low. The removal of a number of semi-mature and mature trees will not have a significant impact on the possible occurrence of this species during its over-wintering periods.
Powerful Owl *Ninox strenua*	The Powerful Owl favours wet to dry eucalypt forests with a dense understorey. Nesting in large hollows, nearly always in the trunk or top of a mature eucalypt. When not breeding, this bird will roost during the day within the shelter provided by a dense understorey, such as a bushy eucalypt or vine forest, usually clutching the remains of the previous evenings meal.	**Likelihood Of Occurrence** Low. No habitats suitable for this species present within the study area. **Likely Impacts** Low. Species not considered to occur within or rely upon the study area.
Barking Owl *Ninox connivens*	Inhabits the timbered hills, forests and savanna woodlands of coastal and sub-coastal eastern and northern Australia. Hunts within the woodlands, picking arboreal and small ground dwelling mammals from the air. Usually always found in pairs occupying a range of between 30 and 200 hectares year round. Within their territories, numerous roosts may be used during the day.	**Likelihood Of Occurrence** Low. No habitats suitable for this species present within the study area. **Likely Impacts** Low. Species not considered to occur within or rely upon the study area.
MAMMALS		
Common Bentwing-bat *Miniopterus schreibersii*	This species is the dominant cave-dwelling bat in south-eastern Australia. Occurs in a variety of habitats and roosts in caves, storm water channels, mines and houses. Feeds on insects caught on the wing from within eucalypt woodlands and forests.	**Likelihood Of Occurrence** Moderate. May traverse and forage over study area. **Likely Impacts** Low. No caves or suitable cave substitutes were observed and none are to be disturbed or removed. No significant impacts would arise to the occurrence of this species as no significant roosting, sheltering or breeding resources are to be removed or modified.
Eastern Freetail-bat *Mormopterus norfolkensis*	Confined to the east of the Great Dividing Range, this species is known to predominantly roost during the day in tree hollows. Emerging after dusk to feed on flying insects, the Eastern Freetail-bat hawks through the forest canopy, or in clearings at its edge.	**Likelihood Of Occurrence** Moderate. May traverse across and forage over study area and roost in tree hollows. **Likely Impacts** Low. The removal of a number of semi-mature trees, and five hollow bearing trees will not have a significant impact on the possible occurrence of this species, given the amount of more suitable habitat that is to be preserved in both the heritage and surrounding areas.

Species	Habitat Requirements*	Likelihood Of Occurrence and Likely Impacts
AMPHIBIANS		
Green and Golden Bell Frog *Litoria aurea*	Large open water bodies which have been recently disturbed and are either clear or support colonising aquatic plants (*Typha* or *Eleocharis*) on the banks, free of detergents and pesticides. Water may be turbid and contain some pollutants. Requires the presence of diurnal shelter, basking sites and refuge sites for hibernation over winter, feeding areas, aquatic breeding and spawning areas and an absence of exotic fish, such as Mosquito fish.	**Likelihood Of Occurrence** Low. No wetlands or suitable aquatic environments present within or in close proximity to the study area. **Likely Impacts** None. No individuals or populations of this species were found and no individuals were heard calling.

11.2.1 Species Of Regional Conservation Significance

Twenty two (22) fauna species of regional conservation significance have been recorded during previous surveys undertaken in the region. These species along with an indication of their preferred habitats are provided in the Table 3.

TABLE 3: Regionally significant fauna species known to occur within the study region.

* - as identified within the following documents Frith (1997), Cogger (1992), Ehmann (1997) and Strahan (1995).

Species	Documented Habitat Association*
BIRDS	
Brown Quail *Coturnix ypsilophora*	Prefers dense tall pockets of tussock and sedgeland often around swamps, creeks and lakes. Sometimes found in crop and grasslands. Usually nest in tall grass. Feed on seed and insects.
Wedge-tailed Eagle *Aquila audax*	Occurs in most habitats across Australia. Utilises both wooded and forested areas. Feeds on both hunted prey and carrion. Adults mate permanently and hold a steady home range.
Little Eagle *Hieraaetus morphnoides*	Found across most of mainland Australia usually in wooded country. This species generally hunts for live prey, although will occasionally eat carrion. Pairs usually mate for life.
Peregrine Falcon *Falco peregrinus*	Found throughout Australia, particularly near water courses, cliffs and timbered country, though rarely common anywhere. A swift hunting bird that preys on birds and small mammals. Peregrines mate for life and usually occupy a home range of about 20 – 50 square kilometres throughout the year.
Common Bronzewing *Phaps chalcoptera*	Inhabits open woodland and scrub. This species does not live permanently in cleared areas. They will fly over open areas. Usually walk around foraging on the ground.
White-throated Needletail *Hirundapus caudacutus*	Breeding in northern Asia, this species arrives in Australia in October, making their way down the east coast,. Most commonly associated with the eastern highlands, coastal plains and the hinterlands of arid inland Australia. Feeds on insects. Spends most of time in the air.
Fork-tailed Swift *Apus pacificus*	Breeding in north-eastern Eurasia, this species arrives in mid-October. Spending all day and most of the night in the air. Forage for flying insects.
Brown Treecreeper *Climacteris picumnus*	Found in Eucalypt woodland. They keep to open woodland with much fallen timber. This species forages on tree trunks for insects, particularly ants.
Buff-rumped Thornbill *Acanthiza reguloides*	Most commonly associated with dry open eucalypt forests and heath woodlands of the east coast and nearby ranges. Spends much time on the ground, among leaf litter and on rough barked trees gleaning and poking for insects and seeds.
Yellow-rumped Thornbill *Acanthiza chrysorrhoa*	A widespread species that occurs throughout most open woodlands and scrubs. This species shelters, nests and breeds in bushes and spends much of the day foraging on the ground for insects, spiders, caterpillars and the occasional seeds.
Scarlet Robin *Petroica multicolor*	Occurs in scrubby Eucalypt forest and woodland. Established adult pairs stay near territory year round. This species feeds on insects.
Jacky Winter *Microeca fascinans*	Prefers the edge of dry eucalypt forest, woodland and grazing areas. This species hawks for insects from set perches. Established pairs keep the same territory (10-15 hectares) year round.

Species	Documented Habitat Association*
Restless Flycatcher *Myiagra inquieta*	Occupies open eucalypt woodland. Catches insects on the wing. It prefers to forage in the mid strata of woodland.
MAMMALS	
Short-beaked Echidna *Tachyglossus aculeatus*	Most habitats. Usually feeds in the evening and at dusk on ants and termites. Shelters under thick bush, or occasionally in rabbit or wombat burrows.
Long-nosed Bandicoot *Perameles nasuta*	A night forager of arthropods and succulent plant roots. In the day the bandicoot rests in one of a number of simple, inconspicuous nests on the ground. Habitats range from rainforest to woodland.
Sugar Glider *Petaurus breviceps*	Common in sclerophyll forest and grassy woodland. The Sugar Glider can glide for distances up to 50 metres. Sugar Gliders feed on gummy exudates of eucalypts and acacias as well as pollen, nectar and insects. Nesting occurs in leaf-lined tree hollows. Lives in family groups.
REPTILES	
Lesueur's Velvet Gecko *Oedura lesueurii*	Found in dry sclerophyll forest and heath with rock outcrops. It is a nocturnal terrestrial species that is usually found under exfoliations and in rock crevices. It feeds on small insects,
Burton's Snake Lizard *Lialis burtonis*	This species is found over a great variety of habitats. It generally avoids the heat of the day, being most active in the late afternoon, or on warm overcast days. It feeds on small skinks.
Common Scaly Foot *Pygopus lepidopodus*	A legless lizard that is diurnal and terrestrial. Found under rocks, logs, other ground debris and in low shrubs. It is found in a variety of habitats including woodland. It feeds on invertebrates.
Bearded Dragon *Pogona barbata*	Dry sclerophyll forest and open woodland. It is a diurnal and semi-arboreal species. It often seen on stumps and logs. It is territorial and often hibernates in sealed burrows. It feeds on insects, and small lizards and snakes.
Lace Monitor *Varanus varius*	This reptile is diurnal and arboreal. It occurs in a variety of habitats ranging from coastal rainforest to savanna woodland. It feeds on reptiles, birds, small mammals and carrion. Foraging usually occurs in the afternoon.
Red-naped Snake *Furina diadema*	A small nocturnal snake. It is usually found in woodland or grassland under rocks, logs and the bark of dead trees. It feeds on small skinks and possibly certain species of soft insects.
Black-bellied Swamp Snake *Hemiaspis signata*	Occurs in moist areas adjacent to swamps, lagoons and creeks. It is a terrestrial species that may be diurnal or semi-nocturnal. It feeds on frogs, skinks and skink eggs.
Eastern Tiger Snake *Notechis scutatus*	Found in dry sclerophyll forest, grasslands, swampy areas. It is terrestrial, usually diurnal and occasionally arboreal. It feeds on frogs, lizards, young birds and mice.
FROGS	
Brown Toadlet *Pseudophryne bibronii*	Found in forest, heath or grassland, usually singly (except when breeding). Lays eggs in damp leaf mould or in burrows under rocks and logs. Call throughout the year from burrows in damp soil, from within damp leaf litter, under rocks or within grass clumps.
Smooth Toadlet *Uperoleia laevigata*	Dry forest and woodland in grassy areas which can be covered by water after rain. Males call from the ground or low vegetation near temporarily flooded grasslands.
Green Tree Frog *Litoria caerulea*	Found throughout the coast of northern Australia to the drier interior of north western WA, NT, Qld, SA and NSW. Can be found throughout a variety of habitats including amongst urban areas.

The regionally significant species listed in Table 3 all have specific habitat requirements, no major components of which were observed in the study area. The needs of these species are all considered to be better catered for by both the vegetation within the heritage area (which is to be largely preserved) and along Caddies Creek, these areas being of greater size and structure than the habitats which are to be removed or disturbed. It is not considered that any of the regionally significant animals would rely solely on the study area and, as such, the proposed upgrading and realignment of the road is not considered to have an adverse cumulative impact on the occurrence of these species. Several of these species may traverse over and forage through the study area on occasions, however the proposed road alignment will not further affect the local and regional occurrence of these species.

12.0 ECOLOGICAL ASSESSMENT

The potential for the proposed development to have an adverse impact on native species of conservation significance which have been previously recorded in this region are considered using the eight part test as listed under Section 5A of the *Environmental Planning and Assessment Act 1979*. These criteria are designed to determine "whether there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitats", and consequently, whether a Species Impact Statement is required.

The assessment of significance has been undertaken giving consideration to the value of the habitats to be removed or disturbed, particularly in meeting the life cycle needs of those threatened species previously recorded in the region. The assessment considers the quality of the environments present and determines whether the removal of these would significantly affect a threatened species, population or ecological community. This approach has also been undertaken as a) no viable local populations of any Scheduled species had been recorded for the site and b) no significant habitats suitable for the life cycle requirements of woodland associated Scheduled species are present within the study area. This approach is in line with the National Parks' information circular and guidelines on the eight part test (NPWS 1996).

12.1 The Eight Part Test

(a) *"...in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction..."*

The habitats present within, and in close proximity to, the proposed road works are not considered critical for the life cycle needs of any of the threatened fauna species previously recorded for the region. The realignment and upgrading of Old Windsor Road would not result in the removal of any habitats which are important for any threatened species. No significant areas which support trees with hollows, known feed trees, wetlands, drainage lines, caves or suitable cave substitutes or woodland stands would be removed, and no fauna corridors would be fragmented. The habitats present are not considered essential for any species listed under the Schedules of the *Threatened Species Conservation Act 1995*, and as such, the undertaking of the works are not considered to disrupt the life cycle of any threatened fauna species, such that the viability of a local population of that species is likely to be placed at risk of extinction.

(b) *"...whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised..."*

There are no listed endangered populations on the site or within the sphere of influence of the proposed road works. No endangered fauna populations listed under the Schedules to the *Threatened Species Conservation Act 1995* occur within either the Blacktown or Baulkham Hills Local Government Areas.

(c) *"...in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed..."*

The habitats within the boundaries of the proposed road works are not considered significant for any threatened species, their populations or ecological communities. The habitats which would be removed as a result of the proposal are all highly disturbed and modified and would not be considered a significant regional resource. The further disturbance of the habitats present would not have an impact on or compromise the regional distribution of any areas of habitat known to be occupied or relied upon by threatened species.

(d) *"...whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community..."*

The proposed road works would not isolate any currently interconnecting or proximate areas of habitat for any threatened species, populations or ecological communities. No fauna dispersal, movement or migratory corridors would be affected by the proposal.

(e) *"...whether critical habitat will be affected..."*

No habitats considered critical to the life cycle needs of those threatened fauna species previously recorded in the region occur within, or in close proximity to, the boundaries of the study area. The area is not listed as critical habitat under Part 3 Division 1 of the *Threatened Species Conservation Act 1995*. There is no critical habitat within the sphere of influence of the proposed road works.

(f) *"...whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region..."*

None of the threatened fauna species previously recorded for the region are considered to be adequately represented in the regions conservation reserve system. Although this is the case, it is not expected that any threatened species would significantly rely upon those habitat present within the study area such that their removal would compromise the viability of any resident local populations.

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

The activities associated with the proposed road works have not been listed as a threatening process under Schedule 3 of the *Threatened Species Conservation Act 1995*. Currently seven threatening processes for mainland New South Wales are listed under the *Threatened Species Conservation Act 1995*, these being predation by the introduced Plague Minnow *Gambusia holbrooki*, predation by the European Red Fox *Vulpes vulpes*, predation by the Feral Cat Catus *Felis catus*, invasion by *Chrysanthemoides monilifera*, high frequency fires, anthropogenic climate change and bushrock removal. None of these threatening processes are directly or indirectly applicable to the current proposal. The current proposal would not result in the removal of any habitat areas important to the life cycle requirements of any native species.

(h) *"...whether any threatened species, populations or ecological community is at the limit of its known distribution..."*

None of the threatened fauna species previously recorded are known to reach the limit of their distribution in the vicinity of the study area.

12.2 Expected Impact On The Habitats Of Threatened Species Due To The Undertaking of the Proposal

The realignment and upgrading of Old Windsor Road between Merriville and Sunnyholt Roads, Yarrandale is not considered to disturb, remove, modify or fragment any habitats critical to the life cycle requirements of any woodland associated and dependant threatened fauna species. No habitats were observed within the boundaries of the study area which would be considered significant for the conservation of these animals. No fauna corridors would be disturbed, and no significant areas of local or regional habitat would be removed or isolated. As such, the expected impacts associated with the works on species of conservation concern are considered to be minimal, and therefore, the preparation of a Species Impact Statement is not considered necessary.

PART D CONCLUSIONS AND RECOMMENDATIONS

13.0 CONCLUSIONS

The current report has updated the initial study prepared for the study area by Connell Wagner in 1995, bringing it in line with current legislative requirements for developments.

Three small stands of the endangered ecological community Grey Box Woodland would be removed for the proposal, but this was assessed as not being a significant impact due the existing poor condition of the stands.

One threatened fauna species was identified during the present field survey, this being the Large Land Snail (*Meriodolum corneovirens*). This species was recorded through the collection of a single empty shell. During the field survey, no living individuals of this animals were recorded, and no additional discarded shells found. The extent of habitat clearance and disturbance which has occurred within and adjacent to the study area is considered to have affected the viability of a local population of the species at this location. The viability of the former local populations which would have once occurred is considered to have been compromised due to the removal, disturbance and fragmentation of its habitat areas, and the direct destruction of individuals. As such, it is not considered that any viable local populations currently occur within, or adjacent to the study area. Therefore, no local populations of this species would be significantly affected such that they would be placed at risk of extinction.

Five habitat types available for use by native fauna species were recorded within the study area. These habitats were: a disturbed grasslands, a remnant woodland, an exotic shrubland, aquatic and disturbed environments, of which the disturbed grasslands and environments dominate the proposed development area. The further disturbance of these habitat types would not result in the displacement or disturbance of any native fauna species, such that they are placed at risk of local or regional extinction. As such, it is not considered that the realignment and upgrading of Old Windsor Road between Merriville and Sunnyholt Roads, Yarrandale, NSW would have a significant effect on any potentially occurring threatened fauna species, populations or ecological communities, or their habitats, and therefore the preparation of a Species Impact Statement for threatened fauna is not considered necessary.

The works will not result in the fragmentation or isolated of any important habitat areas, nor will it affect any locally or regionally significant fauna corridors.

The proposed road works would not have a direct or indirect impact on the habitats of any common to abundant or regionally significant fauna species. Therefore no native fauna would be affected by works such that a viable population of that species would be displaced or placed at risk of extinction.

14.0 RECOMMENDATIONS

- The linear stand of Forest Red Gum - Rough-barked Apple Woodland along Old Windsor Road, south of Caddies Creek, should be protected from accidental damage during construction by fencing the boundary between the vegetation and the construction zone.

- To preserve the value of those drainage lines which occur within, and adjacent to, the study area, it is recommended that:
  - appropriate erosion and sedimentation fencing be erected between the construction sites and adjacent areas, particularly sites downslope of any work locations;

- regular inspection of erosion and sedimentation structures be undertaken to ensure their adequacy, maintenance and effectiveness. Where these are identified as being inadequate or in need or repair, this should be undertaken immediately;
- areas outside of the construction zone should be fenced off (either with Paraweb or Cyclone Fencing) to ensure vehicles and machinery are do not enter or park in these sites. The location of fenced off areas should be noted on any construction plans produced for the project;
- disturbed areas near the two major drainage lines be rehabilitated first; and
- appropriate landscaping of areas under, and in close proximity to, the bridges be carried out. Landscape features should include the provision of shrubs, ground cover plants and natural ground debris such as rocks and logs.

- Effective erosion and sediment structures that are <u>regularly maintained</u> until exposed soils are stabilised should be constructed between all construction areas and those drainage lines which occur within and adjacent to the study area. An Erosion and Sedimentation Management Plan should be prepared. This plan should include the use of hay bales, filter and sedimentation fencing, and should address treatments between all construction sites and drainage lines.

- During construction activities, construction vehicles should be restricted in their movements to the existing road network and areas already disturbed.

- Vehicles and machinery should not be parked or stored in the vicinity of trees or any areas of natural vegetation to be retained, nor in the proximity of any drainage lines. These areas should be avoided to prevent compaction of the soil, sedimentation of drainage lines and ring barking of the trees. Areas of natural vegetation in close proximity to the work areas should be fenced off or distinctively marked to prevent vehicles or machinery being stored or entering these sites.

- Cleared native vegetation should be mulched and used in any rehabilitation works undertaken after construction.

- Seed bearing weeds and any exotic plants which are removed should be taken to an approved Council waste facility.

- Any hollow bearing trees requiring removal should be checked for the presence of bird nestlings and arboreal animals such as possums before felling or pushing. Animals found to be occupying trees should be safely removed before clearing of the trees. Removed animals should be relocated locally into the woodland habitats which occur downstream of the study area, adjacent to Caddies Creek.

- Tree hollows should be checked for animals after felling or pushing, and injured animals should be taken to a local vet, or the local wildlife rescue service should be notified.

- Where possible, hollows should be cut out of felled trees, modified and placed in adjacent bushland to provide supplementary habitat for displaced species by a qualified ecologist.

- Where it is not possible to use any naturally occurring hollows, commercially available substitutes should be used. These substitutes would be used in instances where the naturally occurring hollows are damaged during the tree felling process.

- Established hollows should be monitored for a period of twelve months to ensure they do not benefit exotic species.

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

- It is recommended that revegetation of areas within the road corridor be undertaken where possible. These measures would increase the habitat value of the road corridor, as well as providing a high quality aesthetic environment. Rehabilitation measures should include:

- The planting of a range of locally occurring native shrubs, trees and ground cover plants,
- The provision of a vegetation strip as wide as possible,
- The incorporation of existing natural vegetation where possible,
- The maintenance of plantings for a minimum of twelve months, and
- The management of exotic weeds species.

It is noted that, where understorey shrubs occur, the diversity of birds increases by 20 to 30 percent, with the presence of these birds having beneficial impacts on the survival of other plants through their concentration of foraging activities on lerps and other insects (Birds Australia 2000). It is also noted that where stumps, logs and ground debris are provided in an area that the diversity of bark-foraging bird increases by 7% for every fallen tree or log (Birds Australia 2000). As such, the inclusion of, for example, ten logs/dead trees within landscaping works would increase the bird diversity by 70%.

- Revegetation works should be undertaken by appropriate personnel.

- No water discharges should be permitted to flow directly into Caddies Creek or any of the other drainage lines without first being filtered.

- Any site offices or work compounds should be located away from existing drainage lines, and in areas already cleared on native vegetation.

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

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APPENDIX 1. PLANT SPECIES LIST Old Windsor Road, Yarrandale.

Species occurring in the area surveyed along the proposed widening corridor and the proposed realignment corridor of Old Windsor Road, Yarrandale New South Wales.

Key:

VC Very commonly occurring.
C Commonly occurring.
U Uncommonly occurring.

* Introduced species.
Plant species of conservation significance are printed in **bold** type.

FAMILY	GENUS SPECIES	
FILICOPSIDA		
Schizaeaceae	*Cheilanthes seiberi*	C
MAGNOLIOPSIDA - MAGNOLIIDAE		
Apiaceae	*Foeniculum vulgare* *	VC
Asclepiadaceae	*Araujia hortorum* *	U
Asteraceae	*Cirsium vulgare**	VC
	Cotula coronopifolia *	U
	Crysocephalum apiculatum	C
	*Hypochaeris radicata**	C
	Lactuca serriola *	U
	*Senecio madagascariensis**	C
	Silybum marianum *	U
	Soliva pterosperma *	C
	Sonchus oleraceaus *	VC
	Taraxacum officinale *	VC
	Vittadinia pustulata	U
Brassicaceae	*Capsella bursapastoris* *	VC
Caprifoliaceae	*Lonicera japonica* *	C
Carophyllaceae	*Cerastium glomeratum* *	VC
	Polycarpon tetraphyllum *	C
	Stellaria media *	C
Casuarinaceae	*Casuarina glauca*	U
Campanulaceae	*Wahlenbergia gracilis*	C
Chenopodiaceae	*Atriplex semibaccata*	U
	Einadia hastata	U
Convovulaceae	*Convovulus arvensis* *	C
	Dichondra repens	VC
Euphorbiaceae	*Ricinus communis* *	U
Fabaceae: Caesalpinioideae	*Genista monspessulana* *	VC
Fabaceae: Faboideae	*Dillwynia sieberi*	U
	Glycine clandestina	C
	Glycine microphylla	U
	Hardenbergia violaceae	C
	Medicago sp.	C
	Trifolium repens *	VC
	Vicia sativa ssp. *angustifolia* *	C
Fabaceae: Mimosoideae	*Acacia falcata*	U
	Acacia parramattensis	C
	Acacia salicina	U
Goodeniaceae	*Goodenia bellidifolia*	U
	Goodenia hederacea var. *hederacea*	U
Malvaceae	*Sida rhombifolia* *	C
Myrtaceae	*Angophora floribunda*	U
	Callistemon citrinus (planted)	U
	Corymbia maculata (planted)	U
	Eucalyptus crebra	U
	Eucalyptus moluccana	U
	Eucalyptus tereticornis	U
	Melaleuca decora	U
Oleaceae	*Ligustrum lucidum* *	U

	Ligustrum sinense *	U
	Olea europaea ssp. *africanus* *	U
Oxalidaceae	*Oxalis corniculata* *	VC
Pittosporaceae	*Bursaria spinosa* var. *spinosa*	U
	Pittosporum undulatum	U
Phytolaccaceae	*Phytolacca octandra* *	U
Plantaginaceae	*Plantago lanceolata* *	VC
	Plantago gaudichaudii	U
Polygonaceae	*Persicaria decipiens*	C
	Rumex brownii	C
	Rumex crispus *	VC
Primulaceae	*Anagallis arvensis* *	C
	Ranunculus inundatus	C
Ranunculaceae	*Clematis glycinoides*	U
Rosaceae	*Rubus fruiticosus* species aggregate*	C
Solanaceae	*Solanum nigrum* *	VC
	Solanum mauritianum *	C
Verbenaceae	*Phyla nodiflora* *	C
	Verbena bonariensis *	VC
	Verbena brasiliensis *	C
MAGNOLIOPSIDA - LILIIDAE		
Cyperaceae	*Cyperus brevifolius*	C
	Cyperus congestus *	C
	*Cyperus eragrostis**	C
	Cyperus polystachyos	C
	Cyperus rotundus *	C
Juncacae	*Juncus subsecundus*	C
	Juncus usitatus	C
Lomandraceae	*Lomandra glauca*	U
Phormiaceae	*Dianella longifolia* var. *longifolia*	U
Poaceae	*Anropogon virginicus* *	C
	Aristida ramosa	U
	Avena fatua *	C
	Axonopus affinis *	C
	Briza maxima *	C
	Briza minor *	C
	Bromus catharticus *	C
	Chloris gayana *	C
	*Cynodon dactylon**	VC
	Danthonia tenior	C
	Dichelachne micrantha	C
	Digitaria sanguinalis *	C
	Eichonopogon caespitosus	U
	Impertata cylindrica	U
	Lolium perrene *	C
	Paspalum dilatatum *	VC
	Paspalum distichum	U
	Pennisetum clandestinum *	VC
	Phalaris aquatica *	VC
	Poa annua *	C
	Poa labillardieri	U
	Setaria spp.*	C
	Sporobolus africanus *	C
	Themeda australis	U
Typhaceae	*Typha orientalis*	U

APPENDIX 2. Explanation of ROTAP Codes.

Example: ***Rarus planticus*** **3ECi+**

3 **Distribution Category for the species or taxon (can be 1,2 or 3).**

1 = Known from one collection only.

2 = Geographic range <100 kilometres.

3 = Geographic range >100 kilometres.

E **The Conservation Code (can be X, E, V, R, or K).**

X = **Presumed Extinct.** The taxon has not been collected or otherwise verified over the past 50 years despite thorough searching, or all known wild populations have been destroyed more recently.

E = **Endangered.** The taxon is in serious risk of disappearing from the wild within 10-20 years if present landuse and other threats continue.

V = **Vulnerable.** The taxon is not presently endangered but is at risk of disappearing from the wild over a longer period (20-50 years) through continued depletion, or occurs on land whose future use is likely to change and threaten its survival.

R = **Rare.** A taxon which, while rare in Australia and hence usually the world is not currently threatened by ant identifiable factor.

K = **Poorly Known.** The taxon is suspected but not definitely known to belong to one of the above categories.

C = **Reserved.** The taxon has at least one population within a national park or other proclaimed conservation reserve.

i+ **Size Of Reserved Population (can be a, i, + or -)**

a = indicates that 1,000 plants or more are known to occur within a conservation reserve(s).

i = indicates that less than 1,000 plants are known to occur within a conservation reserve(s).

+ = indicates that although recorded from within a reserve the population size is unknown.

- = indicates that the taxon also has a natural distribution outside Australia.

APPENDIX 3. Fauna Observed, Or Known To Occur Within The Region.

Source of Records

1 = Species recorded during present survey
2 = National Parks and Wildlife Service (2000)
3 = Connell Wagner (1995)
4 = LandScope Environmental Consultants (1999)
5 = Urban Bushland Management Consultants (1999)
6 = Gunninah Environmental Consultants (1998)
7 = LesryK Environmental Consultants (1997a)
8 = LesryK Environmental Consultants (1997b)
9 = LesryK Environmental Consultants (1996)

Key:

x – species identified as potentially occurring.
- indicates species listed under the *Threatened Species Conservation Act 1995.*
• - indicates species of regional conservation significance (NPWS 1997).
* - indicates introduced species.

Common Name	Scientific Name	1	2	3	4	5	6	7	8	9
BIRDS										
• Brown Quail	*Coturnix ypsilophora*		x							
Australian Pelican	*Pelecanus conspicillatus*							x		
Pied Cormorant	*Phalacrocorax varius*							x		
Great Cormorant	*Phalacrocorax carbo*						x			
Little Black Cormorant	*Phalacrocorax sulcirostris*		x			x	x			
Australasian Grebe	*Tachybaptus novaehollandiae*			x				x		
Plumed Whistling-duck	*Dendrocygna eytoni*		x							
Pacific Black Duck	*Anas superciliosa*			x		x		x	x	x
* Mallard	*Anas platyrhynchos*			x						
Grey Teal	*Anas gracilis*			x						
Chestnut Teal	*Anas castanea*	x				x	x	x		
Australian Wood Duck	*Chenonetta jubata*	x		x		x	x			
Dusky Moorhen	*Gallinula tenebrosa*			x		x	x	x		
Purple Swamphen	*Porphyrio porphyrio*			x		x		x		
Eurasian Coot	*Fulica atra*							x		
White-faced Heron	*Egretta novaehollandiae*	x		x		x		x		
Cattle Egret	*Ardea ibis*			x				x		
Australian White (Sacred) Ibis	*Threskiornis molluca*			x						
Straw-necked Ibis	*Threskiornis spinicollis*			x				x		
Masked Lapwing	*Vanellus miles*	x		x		x	x	x		
Black-shouldered Kite	*Elanus axillaris*	x						x	x	
Black Kite	*Milvus migrans*		x							
• Wedge-tailed Eagle	*Aquila audax*		x							
• Little Eagle	*Hieraaetus morphnoides*			x						
Australian Hobby	*Falco longipennis*			x						
Brown Falcon	*Falco berigora*					x				
* Rock Dove	*Columba livia*	x		x			x	x	x	
* Spotted Turtle-dove	*Streptopelia chinensis*	x	x	x	x	x	x	x	x	
• Common Bronzewing	*Phaps chalcoptera*						x			
Crested Pigeon	*Ocyphaps lophotes*	x		x	x	x	x			
Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*			x		x				x
Galah	*Eolophus roseicpilla*	x		x		x	x			x

Little Corella	*Cacatua sanguinea*		x	x						
Sulphur-crested Cockatoo	*Cacctua galerita*	x		x	x		x			x
Rainbow Lorikeet	*Trichoglossus haematodus*	x	x	x		x	x		x	
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*						x			
Little Lorikeet	*Glossopsitta pusilla*			x						
# Swift Parrot	*Lathamus discolor*		x							
Crimson Rosella	*Platycercus elegans*			x		x	x			x
Eastern Rosella	*Platycercus eximius*	x	x	x		x	x	x		x
Red-rumped Parrot	*Psephotus haematonotus*	x		x		x	x	x	x	
Fan-tailed Cuckoo	*Cuculus flabelliformis*			x						
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*		x							
# Powerful Owl	*Nonox strenua*						x			
Southern Boobook	*Ninox novaeseelandiae*			x						x
# Barking Owl	*Ninox connivens*		x							
Barn Owl	*Tyto alba*		x							
Tawny Frogmouth	*Podargus strigoides*			x	x	x				
• White-throated Needletail	*Hirundapus caudacutus*			x						
• Fork-tailed Swift	*Apus affinis*		x							
Laughing Kookaburra	*Dacelo naxaeguineae*			x		x	x			
Forest Kingfisher	*Todiramphus macleayii*						x			
Sacred Kingfisher	*Todiramphus sanctus*			x		x	x			
Varied Sittella	*Daphoenositta chrysoptera*		x	x			x			
White-throated Treecreeper	*Cormobates leucophaeus*			x			x			x
• Brown Treecreeper	*Climacteris picumnus*				x		x			
Superb Fairy-wren	*Malurus cyaneus*	x	x	x	x	x	x	x	x	x
Variegated Fairy-wren	*Malurus lamberti*			x						
Spotted Pardalote	*Pardalotus punctatus*		x		x	x	x			x
Striated Pardalote	*Pardalotus striatus*		x	x						x
White-browed Scrubwren	*Sericornis frontalis*			x						x
Weebill	*Smicrornis brevirostris*		x	x						
White-throated Gerygone	*Gerygone olivacea*					x				
Brown Thornbill	*Acanthiza pusilla*			x		x				
Yellow Thornbill	*Acanthiza nana*		x	x	x	x	x			
Striated Thornbill	*Acanthiza lineata*			x	x					
• Buff-rumped Thornbill	*Acanthiza reguloides*		x							
• Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*				x					
Red Wattlebird	*Anthochaera carunculata*			x						
Little (Brush) Wattlebird	*Anthochaera chrysoptera*						x			x
Noisy Friarbird	*Philemon corniculatus*						x			
Noisy Miner	*Manorina melanocephala*	x	x	x	x	x		x	x	x
Yellow-faced Honeyeater	*Lichenostomus chrysops*		x	x			x	x	x	x
White-eared Honeyeater	*Lichenostomus leucotis*		x							
Yellow-tufted Honeyeater	*Lichenostomus melanops*						x			
White-plumed Honeyeater	*Lichenostomus pencillatus*			x	x				x	
White-cheeked Honeyeater	*Phylidonyris nigra*			x			x			
New Holland Honeyeater	*Phylidonryis novaehollandiae*									x
Eastern Spinebill	*Acanthorhynchus tenuirostris*		x	x			x			
Eastern Whipbird	*Psophodes olivaceus*		x	x			x			x
Rose Robin	*Petroica rosea*		x				x			
• Scarlet Robin	*Petroica multicolor*			x						
Eastern Yellow Robin	*Eopsaltria australis*			x			x			
• Jacky Winter	*Microeca fascinans*			x			x			

Grey Shrike-thrush	*Colluricincla harmonica*		x	x		x	x			x
Golden Whistler	*Pachycephala pectoralis*		x	x						x
Rufous Whistler	*Pachycephala rufiventris*			x			x			x
Grey Fantail	*Rhipidura fuliginosa*		x	x	x	x	x			x
Rufous Fantail	*Rhipidura rufifrons*			x	x	x				
Willie Wagtail	*Rhipidura leucophrys*	x	x	x	x	x	x	x	x	
Leaden Flycatcher	*Myiagra rubecula*			x						
Satin Flycatcher	*Myiagra cyanoleuca*						x			
• Restless Flycatcher	*Myiagra inquieta*						x			
Black-faced Monarch	*Monarcha melanopsis*			x			x			
Magpie Lark	*Grallina cyanoleuca*	x	x	x	x	x	x	x	x	x
Olive-backed Oriole	*Oriolus sagittatus*			x		x	x			
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	x		x	x	x	x		x	x
Dusky Woodswallow	*Artamus cyanopterus*		x	x						
Grey Butcherbird	*Cracticus torquatus*		x	x		x	x			
Australian Magpie	*Gymnorhina tibicen*	x		x	x	x	x	x	x	
Pied Currawong	*Strepera graculina*			x						x
Australian Raven	*Corvus coronoides*	x	x	x	x	x	x	x	x	x
Welcome Swallow	*Hirundo neoxena*	x		x	x	x	x	x	x	
Fairy Martin	*Hirundo ariel*			x		x				
Richard's Pipit	*Anthus naovaeseelandiae*					x		x		
Golden-headed Cisticola	*Cisticola exilis*			x		x				
* House Sparrow	*Passer domesticus*	x		x	x	x	x	x	x	
Double-barred Finch	*Taeniopygia bichenovii*		x		x				x	
Red-browed Finch	*Neochmia temporalis*	x	x	x	x	x	x	x	x	
* Nutmeg Mannikin	*Lonchura puntulata*			x	x			x	x	
Silvereye	*Zosterops lateralis*		x	x	x		x		x	
* Red-whiskered Bulbul	*Pycnonotus jocosus*		x	x			x			
* Common Blackbird	*Turdus merula*			x		x	x		x	x
* Common Starling	*Sturnus vulgaris*	x	x	x	x	x	x	x	x	
* Common Myna	*Acridotheres tristis*	x	x	x	x	x	x	x	x	x
MAMMALS										
• Short-beaked Echidna	*Tachyglossus aculeatus*			x						
• Long-nosed Bandicoot	*Perameles nasuta*			x						
• Sugar Glider	*Petaurus breviceps*			x						x
Common Ringtail Possum	*Pseudocheirus peregrinus*		x	x		x	x			
Common Brushtail Possum	*Trichosurus vulpecula*		x	x	x	x	x			
Grey-headed Flying Fox	*Pteropus poliocephalus*		x	x						
Gould's Wattled Bat	*Chalinolobus gouldii*				x	x				
Chocolate Wattled Bat	*Chalinolobus morio*					x				
# Common Bentwing-bat	*Miniopterus schreibersii*		x							
Long-eared Bat	*Nyctophilus sp.*				x					
Eastern Broad-nosed Bat	*Scotorepens orion*				x	x				
# Eastern Freetail-bat	*Mormopterus norfolkensis*		x							
Freetail Bat	*Mormopterus* sp.1					x				
White-striped Freetail-bat	*Nyctinomus australis*		x		x		x			
Bush Rat	*Rattus fuscipes*			x						
* House Mouse	*Mus musculus*			x	x					
* Black Rat	*Rattus rattus*		x	x			x			
* Fox	*Vulpes vulpes*			x		x	x	x		x
* Dog	*Canis familiaris*	x		x	x		x			x
* Feral Cat	*Felis catus*			x	x		x			
* Rabbit	*Oryctolagus cuniculus*	x		x		x	x	x	x	x
REPTILES										
Eastern Snake-necked Turtle	*Chelodina longicollis*			x		x				
Wood Gecko	*Diplodactylus vittatus*		x	x			x			

• Lesueur's Velvet Gecko	*Oedura lesueurii*			x						
• Burton's Snake-lizard	*Lialis burtonis*			x						
• Common Scaly-foot	*Pygopus lepidopodus*			x						
Jacky Lizard	*Amphibolurus muricatus*			x			x			
Eastern Water Dragon	*Physignathus lesueurii*						x			
• Bearded Dragon	*Pogona barbata*			x		x				
• Lace Monitor	*Varanus varius*			x						
Wall Skink	*Cryptoblepharus virgatus*			x						
Striped Skink	*Ctenotus robustus*		x	x						
Copper-tailed Skink	*Ctenotus taeniolatus*			x			x			x
Cunningham's Skink	*Egernia cunninghami*			x						
White's Skink	*Egernia whitii*			x						
Yellow-bellied Skink	*Eulamprus tenuis*			x						
Eastern Water Skink	*Eulamprus quoyii*			x			x			
Grass Skink	*Lampropholis delicata*	x		x	x		x	x	x	
Garden Skink	*Lampropholis guichenoti*			x	x		x			x
Weasel Skink	*Saproscincus mustelinus*			x						
Eastern Blue-tongued	*Tiliqua scincoides*			x	x					
Three-toed Skink	*Saiphos equalis*			x						
Blind or Worm Snake	*Ramphotyphlops nigrescens*			x						
• Red-naped Snake	*Furina diadema*		x							
• Black-bellied Swamp Snake	*Hemiaspis signata*			x						
• Eastern Tiger Snake	*Notechis scutatus*			x						
Red-bellied Black Snake	*Pseudechis porphyriacus*			x	x		x			
Eastern Brown Snake	*Pseudonaja textilis*			x						
Bandy Bandy	*Vermicella annulata*		x	x						
AMPHIBIANS										
Common Eastern Froglet	*Crinia signifera*	x	x	x	x	x	x	x	x	x
Striped Marsh Frog	*Limnodynastes peronii*			x			x	x		x
Spotted Grass Frog	*Limnodynastes tasmaniensis*			x						
• Brown Toadlet	*Pseudophryne bibronii*			x						
• Smooth Toadlet	*Uperoleia laevigata*			x						
# Green and Golden Bell Frog	*Litoria aurea*			x						
• Green Tree Frog	*Litoria caerulea*			x						
Bleating Tree Frog	*Litoria dentata*			x			x			
Eastern Dwarf Tree Frog	*Litoria fallax*					x	x			x
Rocket Frog	*Litoria nasuta*						x			
Peron's Tree Frog	*Litoria peronii*				x	x	x			
Verreaux's Tree Frog	*Litoria verreauxii*		x	x				x		
* Cane Toad	*Bufo marinus*		x							
INVERTEBRATES										
* Garden Snail	*Helix aspera*	x			x					
# Large Land Snail	*Meriodolum corneovirens*	x	x		x					

Appendix D: Non-Indigenous Heritage Assessment Report

Old Windsor Road REF Sunnyholt Road to Merriville Road

Investigation of the Potential Impacts of Proposed Upgrading on items of Non Indigenous (European) Heritage

Prepared September 2000
for Hyder Consulting (Australia) Pty Ltd

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Contents

1 Introduction

Outside Sydney and Parramatta, the Old Windsor Road (OWR) is the oldest roadway in NSW with its original alignment and cuttings dating between 1794 and 1812 and has had continual use as a transport corridor since its construction.

The road retains elements of its original appearance, configuration and scenic vistas, and has the ability to evoke images of past transport modes.

The road has historical significance, as it was the first route linking the town of Parramatta with the then new settlement of Windsor. It was the beginning of the expansion into the pastoral lands and a new era of expansion for the colony. The road has associative significance with important figures of the first one hundred years of white settlement of Australia.

Constructed by 'ticket of leave' convicts it was integral to the development of farming in this district of the Cumberland Plains and along the Hawkesbury River, and to the provision of food to the growing colonial population.

The section of OWR between Sunnyholt Road and Merriville Road has historic, archaeological, aesthetic, educational, associative and social significance. It is part of a unique remnant of an eighteenth and early nineteenth century road. It is associated with the early development of the colony of NSW, and has a high degree of physical integrity. The road is considered to be of national significance.

The heritage significance of the OWR has been the subject of a number of studies including a Review of Environmental Factors for the proposed upgrading of Old Windsor Road between Seven Hills Road to Windsor Road (Connell Wagner Pty Ltd 1995) which includes the majority of this study area. Other studies include the Environmental Overview (Mitchell McCotter, 1992), the OWR Heritage Study (HTL, 1994) and a European Heritage Sites survey conducted by the RTA Heritage Group in August 2000 (RTA, 2000). This report is a rewrite of the Connell Wagner REF heritage study and incorporates much of the text and results of that report which was prepared by Katherine Kiernan and Lester Tropman.

1.1 Proposal Justification

The proposed upgrading of the OWR is justified in terms of the strategic planning goals established for the region, the need to cater for forecast traffic volumes and a requirement to improve the poor travel and safety conditions along the route at present.

The study falls within the NW sector, which was first identified as being suitable for further development in the 1968 Sydney Region Outline Plan. Strategic documents that followed, such as Sydney's Future and the 'Cities for the 21st Century', reinforced the role of the NW Sector in providing for Sydney's growing population.

The 1989 Regional Environmental Plan for the Rouse Hill Development Area, the first area in the Sector to be developed, included a study of the arterial road network that would be required to serve the future population. The OWR was identified as being one of the major north-south links to serve passenger and freight transport. The OWR was considered suitable as it provides links to Blacktown, via Sunnyholt Road, and Parramatta, via Windsor Road, both of which are being developed as regional employment centres. The OWR also provides access to the M2 Motorway.

A traffic study in 1995 (Masson and Wilson, 1995) used population and land use forecasts to model future traffic conditions along the OWR with and without upgrading. The study found that should the upgrading of the OWR not occur, traffic volumes would increase to a point where in 2006, traffic flows would be over twice the capacity of the road and in excess of the capacity of key intersections. Upgrading as proposed would mean that this section of the OWR would operate at less than 100% capacity into the next decade.

The proposal can be justified on the basis that:

- It satisfies the required road function objectives in terms of traffic volumes, intersection performance and road safety;
- It has flexibility in the design for the possible future provision of a dedicated public transport artery (Bus Transit Way);
- It preserves the heritage significance of the study area through strategies outlined in the Conservation Management Plan; and
- It is consistent with the existing planning strategies for the RHDA and NW Sector.

1.2 Existing Conditions

The OWR is recognised as a significant part of Australia's heritage by virtue of its inclusion in the Register of the National Estate, which is held by the Australian Heritage Commission. There are presently no statutory protection measures covering the OWR although some associated heritage items are listed on the RTA section 170 Heritage Conservation register, the National Trust of Australia (NSW) and in the local environmental plans of Blacktown and Parramatta councils.

1.2.1 The Heritage Resource

There are a number of components that comprise the heritage resource of the OWR. The location of these components is shown in Figure 6.5. Each component is described below.

Roadway Function

One of the most significant attributes of the OWR is its continuity of use as a roadway and transportation corridor since its opening in the late 1700s.

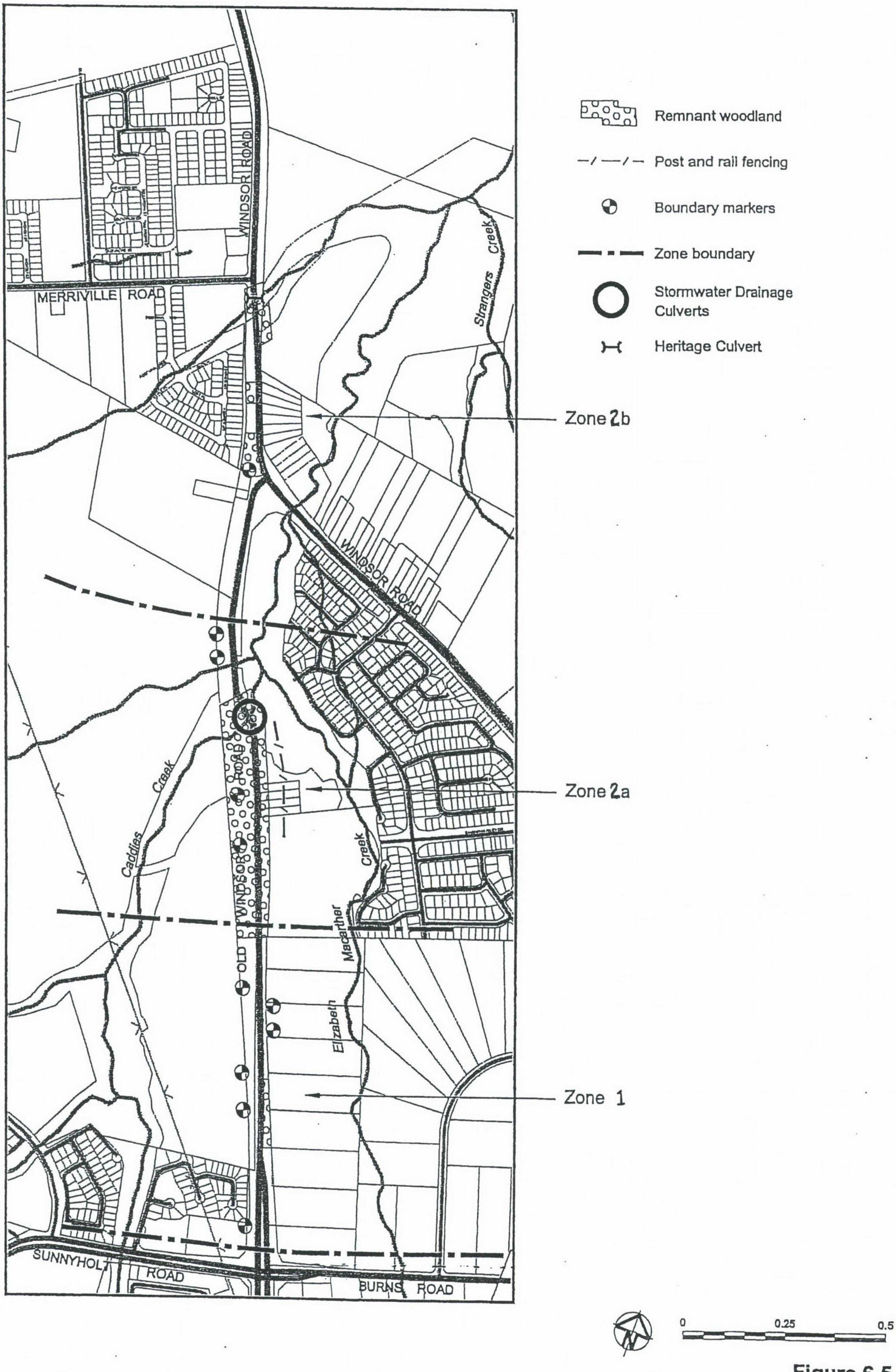

Figure 6.5
Location of Heritage Components and Landscape Zones

Landscape Character

There are different landscape character zones along the length of the study section of the OWR that contribute to the heritage significance of the road. These can be perceived visually by their spatial qualities, for example whether the road appears enclosed by threes, cuttings and fences, or whether the road is passing through an open stretch of rolling grassland.

The existing landscape character and its attributes has been assessed and discussed in previous studies (Mitchell McCotter, 1992). From the perspective of special qualities, the whole length falls into two zones with unique landscape characteristics. These zones are shown in figure 6.5 and include:

Zone 1 Sunnyholt Road to the end of housing on the eastern side of the OWR.

Zone 2 2a – end of housing on the east to Windsor Road

2b – Windsor Road intersection to Merriville Road.

Zone 1 has the road traversing open, gently undulating grassland. There are scattered remnant tree stands and sweeping views, which are being lost with the rapid encroachment of housing and industrial development. The current road pavement is on top of the earlier unsealed pavement, and it is this route and the remnant fences and archaeological sites existing in the road reserve, which are the critical heritage components in this zone.

Zone 2a is partially enclosed, with remnant trees and fences close to the road. The pavement is on top of the original alignment and lower than the surrounding land. Because of these components, and the surrounding pastoral land, this Zone also currently has the "old country lane" ambiance. Adjacent to the road reserve, the creek and its flood plain have casuarinas which create a distinctive setting, critical to this ambience, and to the overall landscape.

Zone 2b has had numerous route changes over time, and is lacking any substantial vegetation.

Oldest Road Remnants

The construction of roads in Australia commenced in 1788 following the landing of the First Fleet. In that year the first road at Sydney Cove was built and the following year a track to Parramatta was cut through the bush. This way was improved in 1794 when the road was continued on to the Hawkesbury River near Windsor. The OWR was therefore the second major road to be constructed in Australia.

Little emphasis would have been given in 1794 to the form of road construction or drainage. It was not until 1811 that the reconstruction of the road from Parramatta to Windsor specified a higher crown with drainage ditches and a set road width. But as this part of the road was effectively bypassed for Sydney traffic in 1813 it was probably not upgraded at this time. More likely it was reconstructed under Governor Druitt between 1817 and 1822 (HTL, 1994).

To the south of the survey area are the last remnants of the oldest remaining road built in Australia. There are two lengths of the earliest formation of the OWR, adjacent to the western side of the existing road. With the construction of the entry road for the Kings Ridge housing estate opposite Norbrik, the two sections were contiguous. The current proposal would not affect these remains.

This section between the Norbrik entry road and Meurants Lane also contains the majority of the heritage components such as cuttings, boundary markers, the one remaining original culvert and much of the post and rail fencing. Associated with these features is much of the remnant vegetation. None of these items would be affected by this proposal.

Within the study area there are eleven boundary markers and one section of post and rail fencing see figure 6.5 for locations.

Boundary Markers

Eleven of the original boundary markers have been identified between Sunnyholt Road and Merriville Road. They have not been dated by previous studies however it is likely they are circa 1800. More of these stones probably exist under the surface.

These stones are significant as markers of the location of the OWR, and as items of historical value. It is important that these blocks remain in their original locations.

Post and Rail Fencing

Fencing in the district started with the government stockyard, located on the OWR north of Meurants Lane in the current location of the Soccer Federation playing fields. This fencing was noted as existing in 1800. As settlement occurred with land grants in the vicinity dating from 1803, the roads were enclosed with post and rail fences, which would have confined stock within paddocks as well as separating travelling stock on the roads.

The ready availability of timber from the local trees, which proved well suited to fencing, meant that land owners continued the building and necessary maintenance of the fence with local wood. This form of fencing with either two or three rails continued in use well into the 1900s despite the availability of fencing wire from the 1860s.

The current condition of the remnant section of fence to the south of Caddies Creek is fragile with a rapid loss of fabric through removal and decay. There are few if any examples of contiguous post and rail fences today, due to road widening, changes in agricultural practices and decay. The remnant section of post and rail fences are possibly the most powerful reminder of the history of the roadway.

2 Strategies for Heritage Management

The choice of the preferred alignment was in part guided by the need to preserve the heritage components discussed above. To further mitigate impacts of the proposal, a range of conservation management strategies have been developed as part of the proposal to maintain and enhance the heritage resource. These strategies and the resultant impacts of the Proposal on the heritage resource are discussed below.

2.1 Roadway Function

It is important that the transportation corridor function of the road is continued. The Proposal would maintain the function of the road by upgrading the carriageway and through partial deviation to avoid the heritage resource, particularly the remnant fence line.

The upgrading of the road's construction standard to carry increased volume of traffic and different modes of traffic is consistent with the evolution of this road. The past practice has been a combination of upgrading the existing pavement and a construction of a new carriageway parallel to the existing road. This has provided a collage of road technologies that is a visible and accessible historic and educational resource.

A repeat of the pattern of partial deviation of the road pavement would be the most contextually appropriate and sympathetic solution to the need to upgrade the standard of the road.

2.2 Landscape Character

The landscape character of the road would be managed through the implementation of landscape strategies for each of the zones. The proposed strategies for each of the zones are as follows:

Zone 1 – Given the changes of land use in this zone, verges should be planted to screen out the visual intrusion from the roadway, and provide a setting appropriate to the functions required. A prime consideration should be the function of continuing the 'old country lane' corridor found to the south with Zone 2. New plantings should reflect the endemic species of this site.

Zone 2a – Conservation of this landscape character is dependant on the views and vistas beyond the roadway. Unimpeded visual connection with the Casuarina flood plain is important. Planting on the western verge should screen out any visual intrusion from changed landuse, to retain this zones 'old country lane' ambience. New plantings should reflect the endemic species of this site.

Zone 2b – Opportunities to restore trees to the road verges exist within this zone.

2.3 Current Roadway

The aim of conserving this section of the existing road is to retain the roadway as a functioning road and to conserve the associated components.

The existing section of road is unsuitable for the requirements of an arterial road. As discussed the partial deviation of the road to a new alignment is an appropriate evolution. This section of road would retain its function as a roadway by the proposed integration of a dedicated public transport way along the old alignment. In this way the significance of the current roadway is preserved. Any signage or lighting would be sympathetic in design to the character of the road.

2.4 Boundary Markers

The conservation of these sandstone blocks requires them to remain in situ maintaining the visibility while ensuring their exposed surfaces are not damaged. This has implications for maintenance of the general area. For example, the discrete and limited use of herbicide to kill the grass surrounding the boundary markers should be undertaken. This should be followed by hand mowing rather than tractor mowing to avoid the possibility of physical damage. During construction, para-web fencing would mark the location of the boundary markers and works would be designed to avoid any impact.

2.5 Remnant Vegetation

Much of the remnant vegetation is not within the road reserve and is therefore beyond the study boundaries. Within the road reserve, conservation of the oldest remnant trees would require the minimum of disturbance and compaction to the root zone, and maintenance of the sources and amount, of water they currently receive. Conservation of the understorey plant species also requires a minimum of disturbance, including mowing. Fire and the further invasion of weeds are the other great threats to the viability of these remnants and maintenance programs would address these issues.

2.6 Post and Rail Fences

The retention and maintenance of as much of the existing fabric as possible is desirable. Where possible, the restoration and reconstruction of sections of the fence, in its original alignment, to enhance the educational, interpretative and visual appreciation of the old roadway would be undertaken.

These fences would be conserved through the repair and replacement of timber sections and the removal of old debris and vegetative regeneration that would cause further deterioration of the fences. Any salvaged fence timbers would be utilised in the maintenance and restoration of existing sections.

Fire, decay and pilfering are the greatest risks to the fences and management and maintenance of the verges would specifically address these issues.

3 Heritage Management

To minimise the impact of the Proposal on the heritage resource through the effective conservation of the components, the responsibilities for the implementation of the management strategies need to be clearly defined.

The OWR at this location is the common boundary of Baulkham Hill Shire Council to the east and Blacktown City Council to the west. The stewardship of the land reserve between the road boundaries and the heritage elements contained within it would lie with the respective councils. The RTA only accepts responsibility for the road pavement and for that part of the adjacent reserve needed for protection of the permanent asset.

Discussions held with Blacktown and Baulkham Hills councils in 1995 during the preparation for the REF for the Proposed upgrading of the OWR between Seven Hills Road to Windsor Road (Connell Wagner, 1995), indicated that they were willing in principle to assume ongoing responsibility for their relevant areas. This was subject to the RTA conducting initial conservation works. It is not known if this is still the position.

The responsible stewardship of these road verges would entail works beyond those required for regular road verges. These works can be divided into two stages, initial conservation tasks, including remedial works and ongoing conservation tasks, including appropriate maintenance.

As part of the RTA's construction phase to upgrade the OWR, the verges and the sections of road made redundant by the deviated alignment would be rendered safe, functional and able to be maintained. Many of the initial conservation tasks could be implemented in this phase. The following is a list of works, which could be undertaken during the initial conservation works:

Vegetation management, including tree removal, chipping and mulching, herbicide spraying, limited bushland regeneration;

Road repairs including drainage improvement;

Fence reconstruction in selected locations using available stock;

Exposure/reset of boundary stones;

Design and construction of a visitor/interpretative facility highlighting the heritage features of interest.

Works that would be carried out by the relevant Council, as part of the ongoing maintenance of the area would include the following;

Vegetation management, including weed spraying, mowing, supplementary planting;

Fire management;

Maintenance of any visitor facilities; and

maintenance of the road asset.

There are many opportunities for funding of heritage conservation works and operations. Heritage grants from the NSW Heritage Council can be applied for on an annual basis, for a wide range of projects. Priorities for funding are determined annually. Similarly, grants can be sought from the Australian Heritage Commission, under their National Estates Grants Program. Though the priorities are also set annually, grants can be obtained for a program of works to be implemented over a maximum of three years.

Other funding sources would be from Australian Federal Government initiatives such as the Landcare movement.

4 Historical Archaeology

Two historical archaeological surveys have been carried out in the study area, Brayshaw McDonald in 1993 and RTA in August 2000. The Brayshaw McDonald study identified and assessed items of historical archaeological significance within the current study area as part of a wider study for the Rouse Hill development.

This study identified the section of post and rail fencing discussed previously and a dwelling located half way between Sunnyholt Road and Windsor Road. The site is described below:

House Site (RH/35) - This site is located on the eastern side of OWR approximately midway between Sunnyholt Road and Windsor Road. Several elements that formed part of the original timber house are still intact. Round timber posts protruding approximately 15 cm out of the ground delineate a building with a detached kitchen. An earthen mound runs along the side of the building, with two dry pressed brick cisterns to the south and south east and several sandstone blocks and a stone mantelpiece near the kitchen are intact. There is a single oleander tree in the former garden. The site has been assessed as having considerable significance.

There would be no direct impact on this site by the Proposal. If any other items of historical archaeology significance were unearthed during construction, advice would be sought from the NSW Heritage Council.

5 .Conclusion

The OWR is of national significance and the Proposal and accompanying conservation management strategies have been developed to minimise adverse impacts. There would be no impact on any sites of archaeological significance.

6 References

Heritage Office and Heritage Council of New South Wales 1996a *Altering Heritage Assets*, Heritage Council Policy No. 2, Crown Copyright

Heritage Office and Heritage Council of New South Wales 1996b *Statements of heritage Impact,* Crown Copyright

Appendix E: Indigenous Heritage Assessment Report

Report produced for HYDER CONSULTING

REPORT ON ABORIGINAL HERITAGE ASSESSMENT
SUNNYHOLT ROAD TO MERRIVILLE ROAD, NSW
OLD WINDSOR ROAD UPGRADE

Report prepared by DARWALA-LIA
March, 2001

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1:0 EXECUTIVE SUMMARY

The Aboriginal heritage assessments for the upgrade of Old Windsor Road has been ongoing for the last decade, with the last Review of Environmental Factors completed in 1995. Design changes have been made to the section of upgrade between Sunnyholt Road and Merriville Road, which require a separate heritage assessment.

The fieldwork was completed on Sunday 10th of September, 2000 with the Darug Custodian Aboriginal Corporation. The low level of ground visibility meant that visual identification of Aboriginal sites and places were not possible, and therefore no 'new' sites and places were recorded. However, from previous surveys Aboriginal artefacts have been found at the junction of Old Windsor Road and Windsor Road, although these have been subject to a Consent to Destroy.

Recommendations include the need for a final consultation with Ms Sue Malligan of the RTA Blacktown, to ensure that all Aboriginal organisations have been made fully aware of the report findings.

2:0 INTRODUCTION

This report has been commissioned by Hyder Consulting, on behalf of the RTA, to conduct an Aboriginal archaeological assessment of the Old Windsor Road upgrade, between Sunnyholt Road and Merriville Road. The existing Old Windsor Road has only two lanes, and needs to be upgraded to a dual carriageway to cope with the increase in traffic and housing developments. The aims and requirements of this project, then, are to:

- review the NSW National Parks and Wildlife Service Site Register and relevant literature
- consult with the relevant Aboriginal agencies
- conduct a field survey to relocate previously recorded sites, and to record and register other Aboriginal heritage site and places
- make recommendations about the impact of the proposal on Aboriginal sites
- make recommendations regarding the monitoring of earth works or construction of the proposal.

3:0 LOCATION

Old Windsor Road is in western Sydney, where the north end starts from Kellyville (turning off Windsor Road) and finishes south at Old Toongabbie (joining into the Cumberland Highway).

The upgrade of Old Windsor Road has been ongoing for some years now, where this latest Aboriginal heritage assessment is concerned only with one portion of the Road. Design changes have been made to the section of upgrade between

Sunnyholt Road and Merriville Road including the turn-off from Windsor Road Into Old Windsor Road, and this portion is found at the north end of Old Windsor Road.

4:0 CONSULTATION

The official and endorsed policy from the NSW National Parks and Wildlife Service requires from the archaeological community that a representative from a Local Aboriginal Land Council (LALC), such as a Sites Officer, be present during a survey (NSW NPWS Standards & Guidelines Kit, 1997:1-2). This requirement recognises that Aboriginal people are the rightful owners of Aboriginal heritage, and should have decision-making power as to the protection and preservation of that heritage.

The National Native Title Tribunal is another agency, which deals with Native Title Claims across Australia, and information can be found about other Aboriginal people who should be consulted with. Some Native Title Claimants are members of LALCs, however many Claimants form their own organisations, either to prevent a conflict of interest or because of frustrations felt with the LALC. Therefore, the LALC may not be the only stakeholder to conduct consultation with.

The proposed Old Windsor Road upgrade is located within the boundaries of the Deerubbin Local Aboriginal Land Council, as well as within two separate Native Title Claims. The Native Title groups are the Darug Tribal Aboriginal Corporation (DCAC) and the Darug Custodian Aboriginal Corporation (DTAC).

At the commencement of the project, a letter was written and faxed, as well as telephone messages, to all Aboriginal groups that were to be consulted with. At the time only one group was able to accompany Darwala-Lia on the field survey, being the Darug Custodian Aboriginal Corporation. The other two groups have subsequently inspected the proposed route with Sue Malligan, Aboriginal Liaison Officer with the RTA Blacktown.

In this case, Darwala-Lia has not sufficiently completed consultation with the other Aboriginal groups, this being the Deerubbin LALC and the Darug Tribal Aboriginal Corporation. This gap has now been filled by Ms Malligan, and her responses were made to Hyder Consulting for the first draft of this report.

5:0 GEOGRAPHIC SETTING

The proposed road upgrade of Old Windsor Road is located on the western border of the Cumberland Plain. The Cumberland Plain is characterised by the Wianamatta Shale, found across the entire area, where the wind and water erosion of the shale creates clay soils with a thin layer of topsoil. The study area is also located within a transition zone between the Wianamatta Shales and the Hawkesbury Sandstone (AMBS, 1997), and is rich in diverse resources for Aboriginal use. The landscape then, appears as a series of rolling hills intersecting with waterways.

The immediate geography of the Old Windsor Road upgrade has a series of three broad landscape components, these being Caddies Creek and adjacent banks, the hilltop of Sunnyholt Road, and the ridgeline/slopes between the two. These landscapes are all considered important to an Aboriginal lifestyle, and are archaeologically quite sensitive. The hilltop view from Sunnyholt Road, south-west to the north-west, looks across a valley to the next ridge, and sweeps over the descending flats to Caddies Creek at the north-west. Therefore, the lookout positions on hilltops, the campground 'fingers' off slopes and ridgelines, and the rich soils of creek banks are all considered prime locations where Aboriginal occupational material is likely to be found.

The majority of artefacts found on the Cumberland Plain are made from silcrete, particularly from the St Marys formation, which caps ridges and low spurs on parts of the north western Cumberland Plain (AMBS, 1997:37). One raw material source has been identified at Riverstone, where silcrete cobbles and an *in situ* artefact manufacturing place are in close proximity (Darwala-Lia, 1999:37-41). Riverstone is no more than a few hours slow walk from Kellyville, and therefore must be considered as a likely source for stone tools.

6:0 VISIBILITY AND DISTURBANCE LEVELS

Visibility is an extremely important factor in any archaeological survey. The need to rely on visual assessments to determine the extent of Aboriginal occupation is fraught with difficulties.

The land to the western side of Old Windsor Road has been used for cattle grazing, a lawn cemetery and crematorium and a maximum security prison, and of Sunnyholt Road a new housing development is being planned and landscaped. This portion is mainly ploughed paddocks, however an existing wetlands section of Caddies Creek has been retained and conserved at Samantha Riley Drive, no doubt as part of that new housing development. The eastern side of Old Windsor Road mainly comprises private homes on large houseblocks, and still retains some remnant trees and water plants and animals on the slopes and flats of Caddies Creek.

In all areas of the proposed Old Windsor Road upgrade visibility was restricted to less than 5%. Surface visibility was decreased by the great amount of ground cover, mainly by grass species, but in other areas a dirt access road had been created into Samantha Riley Drive. The road dirt has been imported and covers the grass, except where the culvert has been newly constructed over Caddies Creek into Samantha Riley Drive.

It is more than likely that sites, such as isolated artefacts, were missed by visual assessment. It should never be mistaken that because Aboriginal sites and places are not found, such as artefact scatters, that no sites or places exist or have existed. In areas of low visibility, then, monitoring of the construction works then becomes important.

7:0 REVIEW OF PREVIOUS ARCHAEOLOGICAL RESEARCH

The NSW National Parks and Wildlife Service (NPWS) holds the majority of the records regarding Aboriginal sites and places, both Site Cards and corresponding report. A review of the Site Register and reports show that the general category of recorded Aboriginal sites and places for western Sydney are stone tools, either as a scatter or open site or as an isolated artefact. Over the last decade, the greater parts of western Sydney have been redeveloped – from paddocks to housing estates – and a disproportionate number of archaeological surveys have been conducted.

Large-scale excavations and surveys have been conducted at Rouse Hill (McDonald & Rich, 1993), Riverstone (Darwala-Lia, 1999) and Mungerie Town Park, Kellyville (AMBS, 2000), as well as numerous and smaller infrastructure assessments, where thousands of artefacts are catalogued. From these works, the number of recorded Aboriginal sites and places, such as artefact scatters, has dramatically increased, but so has the range of models of human occupation and movement.

A previous review, by Connell Wagner (1995), of Aboriginal heritage assessments for the immediate area of Old Windsor Road was undertaken for the RTA upgrade. Several staged projects to identify and record Aboriginal heritage places, including the major excavations of a knapping floor near Norwest Boulevard, have resulted in all sites being destroyed through NPWS Permits (Connell Wagner, 1995:132). Of the actual survey portion between Sunnyholt Road and Merriville Road, two artefact scatters were recorded at the west-side junction of Old Windsor Road and Windsor Road, and the east-side of Old

Windsor Road, near Caddies Creek. These artefact scatters have also been destroyed, although the present survey did try to relocate the places they were taken from.

In regards to further archaeological work, Connell Wagner's recommendations are that a:

> *Daruk LALC representative would be present during the proposed roadworks when there is removal or disturbance to the topsoil layers of the soil within the proposed road route. If any relics were found during construction advice would be sought from the Daruk LALC site officer and if necessary work would stop and NPWS would be contacted (1995:132).*

It is unsure whether the recommendations from the Deerubbin (Daruk) LALC were made after the Consent to Destroy permits were granted and the excavations undertaken.

Other studies undertaken closer to area for this survey, have investigated the area of Caddies Creek and the Mungerie Town Park, located east of the Cranebrook Cemetery and south of the Kellyville Golf Course. On the east side of Caddies Creek, a series of over 150 axe-grinding grooves are found on sandstone platforms (AMBS, 1998). This is the closest source of sandstone within a 5km westerly radius, and is an extremely rare place of Aboriginal heritage. To manufacture a basalt river pebble into an axe head by grinding it on sandstone takes time, knowledge and a high level of social organisation to extract and process the raw materials.

In expanding the models of occupation of this immediate area, the Australian Museum Business Services (AMBS) undertook a six week excavation programme on the western side of Caddies Creek, and in view of the axe-grinding grooves. The excavation area, known as Mungerie Town Park, revealed that Aboriginal occupational evidence extended upwards of 300m from the creek bank (AMBS, 2000). Furthermore, two separate artefact scatters identified from the initial test pitting proved to be either end of a larger occupational area, where complete knapping floors, a localised new type of artefact ('Mungerie Points') and a sample of over five thousand artefacts were part of the site complex (Ibid:ii).

The excavations resulted in the identification of a very localised, but overlapping pattern of Aboriginal occupation, as well as influencing the future methodology of excavations by highlighting the importance of distinguishing between artefact identification and artefact distribution. Indeed, the very good analysis of excavated material by AMBS showed that while Aboriginal activities and occupation occurred across all areas of the creek slope and banks, the area within 120m of the water was extensively reused and revisited (AMBS, 2000:ii).

The implications for further Aboriginal heritage work are concerned with going beyond describing and classifying artefacts, and assessing significance on the basis of ground disturbance or lack of 'educational' or 'scientific' significance. Instead, archaeologists should now analyse artefacts in the context of where they lay in the landscape, and whether they are an indication of a complex or suite of activities that occur in the area.

8:0 PREDICTIVE SITE MODELLING

The survey is to follow a 2.5km proposed roadway, which mostly parallels Old Windsor Road, and is not considered large-scale fieldwork. The area, however, does contain an entire sample landscape of hilltops, slopes and creek banks. Whilst the survey area is in close proximity to Caddies Creek and Mungerie Town Park, it does not contain the same types of resources, such as the sandstone platforms, or appear to have the same conditions, such as topsoil depths and low disturbance rates. However, the models presented by AMBS regarding the activities taking place at Mungerie Town Park can be used and expanded on.

The Aboriginal occupation places associated with the axe-grinding grooves, such as the Mungerie Town Park evidence, represent the campsites and activities of people while they are manufacturing axe heads, and perhaps sharpening spears and other implements, on the sandstone. In this manner, the Mungerie sites and places are a 'core' or 'centre' of activities, where Aboriginal people would then hunt and gather outside of this area.

A survey by Darwala-Lia (1999) at Riverstone showed a similar pattern, where a higher concentrate of sites and places centred around the raw material source. Aboriginal sites and places then decreased in number and size away from the core areas, representing either day camps, where food is prepared or stone tools are worked on, or short term, resource-targetted occupations. In this manner, the sites and places that have been previously recorded near the junction of Old Windsor Road and Windsor Road, whilst being 'sites' in their own right, are probably part of a larger complex of sites and places associated with Mungerie Town Park.

Therefore, the survey for Aboriginal heritage along Old Windsor Road should focus on areas that are likely to serve as day camps, or overnight campsites; directions most likely to be taken in getting to and from Mungerie; and the resources that are likely to be used along the way.

9:0 SURVEY METHODOLOGY AND RESULTS

The fieldwork survey was completed on Sunday 10th September, 2000, where John Gallard of DCAC accompanied Darwala-Lia. The survey began at Sunnyholt Road, and followed the proposed road upgrade to Merrlville Road. A slow walking pace was adopted and areas where some clear ground was visible were thoroughly searched. One section of the survey that was concentrated on was the landscape between the culvert on Samantha Riley Drive and the junction of Old Windsor and Windsor Roads, where the road is closest to Caddies Creek. This section is close to fresh water, still has resources such as ducks, other birds and lizards, as well as providing good land areas for camping.

Unfortunately, the low level of visibility prevented identification of any Aboriginal sites and places. One small section, just below the culvert, had some stone material on the access road surface, but this appeared to have been brought in with the dirt. However, the stone is in close association with Caddies Creek (no more than 20m from water) and therefore may be redeposited with the culvert works nearby.

As stated before, it is not assumed that because Aboriginal sites were not seen, that they are not there. Ground visibility was not possible as the grass cover was absolute, however the different landscape components each represent an ideal location for Aboriginal occupation and should therefore be thought of as a site or place in themselves. The potential then, for occupational material such as artefacts, to be found subsurface is quite high. The sites and places that have been recorded and destroyed is evidence that Aboriginal activities were occurring in this area, thus both the potential to have missed visual identification and for subsurface artefacts is high.

Indeed, from nearby salvage excavations at Rouse Hill, conducted by McDonald and Rich (1993), found that 13 out of 15 (87%) test pits contained *in situ* archaeological deposits. These areas were chosen on the basis of potential for Aboriginal sites and places, and not all were identified by surface artefacts or other sites (1993:103).

10:0 RECOMMENDATIONS

These recommendation are made on the basis of:

- Legal requirements under terms of the National Parks and Wildlife act,1974 (as amended) whereby it is illegal to destroy, deface or damage or knowingly permit the destruction, defacement to damages to an Aboriginal place is guilty under this act unless written permission is granted by the Director-General;
- Consultation with the Darug Custodian Aboriginal Corporation and Ms Sue Malligan, from RTA Blacktown, on behalf of the Deerubbin LALC and Darug Tribal Aboriginal Corporation;
- The results of the background review and fieldwork assessment; and
- The nature of the development within the study area.

The specific recommendations for the archaeological concerns regarding the upgrading of Old Windsor Road are:

- that all spoil heaps, storage sheds and equipment/office space are set back a distance of at least 10m from the west side of Caddles Creek, at the junction of Old Windsor Road and Windsor Road.

- that any further consultation includes Ms Sue Malligan, RTA Blacktown, who works with all three Aboriginal groups. Ms Malligan should accompany the archaeologist if any further works are required, so that she may consult with all or any of the organisations regarding their needs and recommendations. A final consultation with Ms Malligan is recommended to ensure that all Aboriginal organisations have been consulted with, either by Darwala-Lia or her/self.

- that part of Ms Malligan's duties are to ensure that contractors are aware of their requirements to protect Aboriginal heritage. Ms Malligan works with the Aboriginal groups to ensure that appropriate protocols and work methodologies are Incorporated into the construction process.

- If any artefacts are found or identified by either the DCAC monitor or by the contracted crew during the construction works, then the NSW National Parks and Wildlife Service must be notified.

- If during any time of the construction, human remains are unearthed, then works should be stop immediately in that area. The local National Parks and Wildlife Service office should be contacted about the discovery.

- It is recommended that no further archaeological assessment is required, unless Aboriginal sites or places are found during monitoring and that the DCAC or NPWS suggests the need for further analysis.

11:0 REFERENCES

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Suzanne Malligan
Environmental Services Branch (ESB)
Roads & Traffic Authority (RTA)
83 Flushcombe Road,
Blacktown NSW 2148

REF: ACHA:786

12 March, 2001

SUBJECT: ABORIGINAL CULTURAL HERITAGE ASSESSMENT
PROPOSED ROAD UPGRADE: OLD WINDSOR ROAD,
FROM SUNNYHOLT ROAD, TO MERRIVALE ROAD,
KELLYVILLE

Dear Ms Malligan

As you are aware, a representative of Deerubbin Local Aboriginal Land Council (DLALC) undertook an Aboriginal cultural heritage assessment of the proposed road upgrade along Old Windsor Road, between Sunnyholt Road and Merrivale Roads Kellyville on 4 December, 2000.

DLALC has no objection to the development. However, DLALC would require, as a condition, that the removal of topsoil be monitored by an appropriately qualified Aboriginal representative of the DLALC.

Should you wish to discuss this project, please feel free to contact me on (02) 9832 2457.

Yours Sincerely

(Kevin Cavanagh
Executive Officer)

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Appendix F: Traffic Noise and Vibration Assessment Report

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ACOUSTICS

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Consulting Acoustical & Vibration Engineers

NOISE AND VIBRATION ASSESSMENT
OLD WINDSOR ROAD/WINDOR ROAD UPGRADE
SUNNYHOLT ROAD TO MERRIVILLE ROAD

31.5140.R1:DD17
Rev 01

Prepared for: Hyder Consulting Pty Ltd
Level 13, 601 Pacific Highway
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Prepared by: Atkins Acoustics and Associates Pty Ltd.
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May 2001

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1.0 INTRODUCTION

The NSW Road and Traffic Authority (RTA) proposes to upgrade Old Windsor Road between Sunnyholt Road and Merriville Road to four lanes. Atkins Acoustics was commissioned by Hyder Consulting Pty Ltd on behalf of the RTA to conduct an assessment of traffic noise from the upgraded road and construction noise and vibration.

The extent of this assessment is limited to existing developed residential receivers. It is understood that vacant land adjacent to the roads has been proposed for future development, which could include residential and educational uses. Atkins Acoustics was advised by the RTA that control measures will be imposed on the future development of this land.

This report provides results and findings of the noise assessment and recommendations for possible control measures to reduce the noise and vibration impacts. The findings from the study have been prepared for the particular investigation described and no part should be used in any other context or for any other purpose.

2.0 METHODOLOGY

The methodology adopted for the assessment presented in this report is as follows:

- measurement of existing traffic noise levels;
- establishment of operational noise assessment goals, using the NSW EPA's Environmental Criteria for Road Traffic Noise (ECRTN, May 1999);
- establishment of assessment goals for construction noise, in accordance with the EPA's Environmental Noise Control Manual (ENCM, 1994);
- establishment of assessment goals for vibration impacts from construction equipment, using the EPA (ENCM, 1994) and relevant International Standards;
- prediction of existing traffic noise levels and comparison with the measured levels to validate the prediction model;
- prediction and assessment of future road traffic noise levels from the proposal;
- prediction and assessment of noise and vibration from construction activities; and
- where required, recommendation of possible measures to reduce road traffic noise.

3.0 DESCRIPTION OF THE PROPOSAL

The proposed upgrading of Old Windsor Road between Sunnyholt Road and Merriville Road is approximately 3km long. The surrounding topography of the area is relatively flat.

Noise emissions from the proposal are due to the change to existing road alignment, increased traffic speed and the projected traffic growth over a ten (10) year period and short-term road construction. Construction activities will require excavation, earthworks, formation and compaction of road base and construction of asphalt road pavement.

There are relatively few residential dwellings adjacent to Windsor Road and Old Windsor Road in the study area (Sunnyholt Road and Merriville Road). The existing dwellings are located in excess of 40m from the road, except for two houses adjacent to Windsor where they are approximately 20m from the road.

4.0 EXISTING AMBIENT NOISE LEVELS

The existing traffic noise was monitored from 29 January to 14 February 2001 at two receiver locations within the study area. Instrumentation used consisted of environmental noise data loggers. The loggers were set to A-weighting, fast response and programmed to calculate and record statistical noise levels at every 15-minute interval. The instrumentation was calibrated before and after the measurement periods with a Bruel & Kjaer sound level calibrator Type 4230, drift in calibration was within ±0.5dB(A).

Table 1 provides details of the noise monitoring locations and date of monitoring. Detailed results of the noise measurements at 15-minute interval are given in Appendix 1.

Table 2 provides results of the measured $L_{Aeq,15hr}$ and $L_{Aeq,9hr}$ noise levels. These measured levels were used to validate the noise prediction model and establish goals for the assessment of traffic noise. Extraneous noise data was extracted from the analysis of the measured $L_{Aeq,15hr}$ and $L_{Aeq,9hr}$ noise levels.

Table 1 Noise Monitoring Locations

Monitoring Location	Distance from Road m	Date of Monitoring	Noise Source
117 Windsor Road	50	29 January – 10 February, 2001	Traffic on Windsor Road
Lot 31 Old Windsor Road	40	29 January – 14 February, 2001	Traffic on Old Windsor Road

Table 2 *Measured $L_{Aeq,15hr}$ and $L_{Aeq,9hr}$ Noise Levels*
dB(A) re 20×10^{-6} Pa

Date of Monitoring	Existing $L_{Aeq,15hr}$ and $L_{Aeq,9hr}$ Road Traffic Noise Level			
	117 Windsor Road		Lot 31 Old Windsor Road	
	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Monday 29 January 2001		58.5		50.9
Tuesday 30 January 2001	62.6	60.4	57.3	54.2[1]
Wednesday 31 January 2001	64.2	61.4	57.0	56.0[1]
Thursday 1 February 2001	62.5	61.1	56.7	52.4
Friday 2 February 2001	61.2	59.0	55.7	51.3
Saturday 3 February 2001	59.7	57.0	54.4	50.2
Sunday 4 February 2001	59.3	59.0	54.5	50.6
Monday 5 February 2001	63.1	59.7	57.0	52.5
Tuesday 6 February 2001	63.4	59.4	57.4	52.3
Wednesday 7 February 2001	62.0	59.4	55.3	52.2
Thursday 8 February 2001	61.5	59.8	54.7	52.1
Friday 9 February 2001	62.0	58.2	55.0	51.6
Saturday 10 February 2001			55.1	50.2
Sunday 11 February 2001			55.2	50.6
Monday 12 February 2001			54.3	50.9
Tuesday 13 February 2001			54.9	50.8
Logarithmic Average	**63**	**60**	**56**	**52**

Note 1 data was discarded in the analysis

5.0 NOISE ASSESSMENT GOALS

5.1 Continuous Traffic Flow

Goals for assessment of traffic noise are specified in the NSW EPA's Environmental Criteria for Road Traffic Noise (May 1999). For the redevelopment of existing highway/freeways/arterial roads, the following base line traffic noise goals apply to residential receivers.

- daytime $L_{Aeq,15hr}$ traffic noise levels between the hours from 7:00am and 10:00pm at 1m from the facade of any residential premises should be limited to 60 dB(A);

- night-time $L_{Aeq,9hr}$ traffic noise levels between the hours from 10:00pm and 7:00am at 1m from the facade of any residential premises should be limited to 55 dB(A);

Where the existing traffic noise levels exceed the base line goals, the RTA recommends that road redevelopment and projected 10 year traffic growth should not increase the pre-construction traffic noise levels by more than 2 dB(A).

5.2 Intermittent Traffic Flow

Maximum noise levels from vehicle pass-bys during night-time have the potential to cause sleep disturbance to nearby residents. Although assessment goals are not specified, the EPA requires impacts of L_{Amax} noise levels from vehicle pass-bys to be assessed at the potentially affected residences.

Based on research the RTA has developed the following protocol provides a protocol for assessment of sleep disturbance:

- maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions. These equate to external L_{Amax} noise levels of 60-65 dB(A) with bedroom windows open to normal extent for adequate ventilation;

- one or two noise events per night with maximum internal noise levels of 65-70 dB(A) are unlikely to affect health and well-being significantly. These equate to external L_{Amax} noise levels of 75-80 dB(A) with bedroom windows open to provide adequate ventilation;

- where the L_{Amax} exceed the $L_{Aeq,9hr}$ noise level by 15 dB(A) or higher, sleep disturbance impacts may be significant.

6.0 NOISE PREDICTION MODEL

The CORTN traffic noise prediction model was adopted for the prediction of traffic noise. CORTN has been shown to be relatively reliable, and validated under Australian conditions (*R E Saunders, S E Samuels, A Hall, A Leach (1983), "An Evaluation of the UK DoE Traffic Noise Prediction Method"*).

CORTN predicts traffic noise in terms of $L_{A10,1hr}$ and $L_{A10,18hr}$ levels. With the application of relevant correction factors, conversions to the L_{Aeq} noise levels can be performed with reasonable accuracy (*Technical Note No. 1 - Some Simple Transformations for Road Traffic Noise Scales, A L Brown, School of Australian Environmental Studies, Griffith University, Nathan, Queensland*).

Modifications to the CORTN noise prediction model were made to represent the source heights for passenger cars, heavy vehicles and heavy vehicle exhausts which are 0.5m, 1.5m and 3.6m above the ground level respectively. For heavy vehicles, noise levels contributed from the exhausts were 8 dB lower than those from the engines (*Transportation Noise Reference Book, Paul Nelson, 1987*).

The CORTN model calculates the noise levels at 10m from the nearside road edge and applies a series of corrections. These corrections account for change in traffic speed, road gradient, road surface, distance of propagation, ground type, angle of view, facade refection and screening effects from buildings, barriers, cuttings and embankments.

The road alignment details were provided by Hyder Consulting Pty Ltd. Residential receiver locations were identified from orthophoto maps and site inspections. The coordinates of the receivers were obtained from orthophoto maps.

7.0 TRAFFIC DATA

7.1 Existing Traffic Conditions

Existing traffic volumes on Windsor Road and Old Windsor Road were monitored by Northern Transport Planning from 29 January to 14 February 2001. The monitoring locations were in the vicinity of residences 117 Windsor Road and 31 Old Windsor Road. *Table 3* presents a summary of the average weekday data during the monitoring period.

Table 3 Existing Daytime and Night-time Traffic Conditions (Year 2001)

Traffic Data	Windsor Road		Old Windsor Road	
	North Bound	South Bound	North Bound	South Bound
	Daytime (7:00am - 10:00pm)			
Total daytime traffic volume	14,385	12,641	6,415	5,705
Number of heavy vehicles	1,226	869	241	184
Percentage of heavy vehicles (%)	8.4	6.9	3.8	3.2
Average traffic speed (km/hr)	63	63	68	68
	Night-time (10:00pm - 7:00am)			
Total daytime traffic volume	2,312	3,945	1,130	1,820
Number of heavy vehicles	197	461	36	79
Percentage of heavy vehicles (%)	8.4	11.6	3.2	4.5
Average traffic speed (km/hr)	70	69	73	71

7.2 Forecast Future Traffic Conditions

Projected daytime and night-time traffic volumes and proportions of heavy vehicles for the year 2011, ie. 10 years after the envisage road opening, were provided by Hyder Consulting Pty Ltd and are summarised in *Table 4* below.

Table 4 *Forecast Traffic Conditions*
Year 2011

Forecast Traffic Condition	Windsor Road		Old Windsor Road	
	Daytime	Night-time	Daytime	Night-time
Total number of vehicles	53,340	13,329	33,360	8,334
Percentage of heavy vehicles (%)	8	10	8	10
Average traffic speed (km/hr)	65	70	70	70

8.0 VALIDATION OF NOISE PREDICTION MODEL

Table 5 presents the predicted and measured traffic noise levels at the reference monitoring locations. It can be seen from the results in *Table 5* that the predicted noise levels are 1-2 dB(A) higher than those measured. Given the small differences between the predicted and measured levels, no corrections were applied to the prediction model. From the validation assessment, it is considered that the CORTN model provides reliable prediction of road traffic noise levels.

Table 5 ***Predicted and Measured Traffic Noise Levels***
dB(A) re 20 × 10⁻⁶ Pa

Receiver Location	$L_{Aeq,15hr}$ Traffic Noise Level		$L_{Aeq,9hr}$ Traffic Noise Level	
	Measured	Calculated	Measured	Calculated
117 Windsor Road	63	64	60	62
Lot 31 Old Windsor Road	56	58	52	54

9.0 PREDICTED TRAFFIC NOISE LEVELS

The L_{Amax}, $L_{Aeq,15hr}$ and $L_{Aeq,9hr}$ traffic noise levels from the existing and upgraded Windsor Road and Old Windsor Road (between Sunnyholt Road to Merriville Road) are presented in *Table 6*.

Table 6 ***Predicted Road Traffic Noise Levels***
dB(A) re 20 × 10⁻⁶ Pa

Receiver Location	Existing (Year 2001)			Forecast (Year 2011)		
	L_{Amax}	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	L_{Amax}	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Receivers adjacent to Windsor Road						
117 WR[1]	67	64[3]	62[3]	67	66	63
115 WR	78	70	68	75	70	68
114 WR	75	69	66	72	69	66
Receivers adjacent to Old Windsor Road						
Lot 31 OWR[2]	69	58[3]	54[3]	65	64	60
Lot 30 OWR	67	57	54	64	63	60
Lot 29 OWR	68	59	55	65	64	61
Lot 28 OWR	69	60	57	66	65	62
Lot 27 OWR	68	60	57	67	65	62
Lot 26 OWR	68	60	57	68	66	62
Lot 25 OWR	68	58	54	69	66	62

Notes 1. *WR denotes Windsor Road*
2. *OWR denotes Old Windsor Road*
3. *The calculated noise levels are 1-2 dB(A) higher than those measured (ref: Chapter 8)*

Although traffic volumes in Year 2011 will increase, it can be seen from the results in *Table 6* that the pre-construction traffic noise at residences 115 and 114 Windsor Road will not increase. This is due to the fact that the upgraded road will be further from these residences. For residence 117 Windsor Road, the increase in daytime ($L_{Aeq,15hr}$) and night-time ($L_{Aeq,9hr}$) noise levels are 2 dB(A) and 1 dB(A) respectively.

The predicted changes in traffic noise levels at residences adjacent to Windsor Road are within 2 dB(A) which satisfy the EPA (ERCTN) assessment goals. Accordingly, provision of additional noise mitigation measures for these residences have not been considered.

For receivers adjacent to Old Windsor Road, the predicted Year 2011 traffic noise levels will exceed the base line and project assessment goals by more than 2 dB(A) (*ref: Table 6*). Hence, noise mitigation measures have been considered to reduce the traffic noise at these residences to within the recommended assessment goals.

The predicted L_{Amax} traffic noise levels are also presented in *Table 6*. It should be noted that the predicted levels are due to single pass-by events only. It can be seen that the L_{Amax} traffic noise levels satisfy the $L_{Aeq,9hr}$ plus 15 dB(A) and within the RTA's protocol for the assessment of sleep disturbance.

10.0 NOISE CONTROL OPTIONS

The following section of the report presents preliminary options of types of noise controls that may be appropriate, providing they are shown to be practical with regard to their effectiveness, secondary impacts such as loss of views, loss of access to properties and cost implications. It should be noted that recommendations are preliminary and that any controls should be selected in consultation with council and individual land owners.

10.1 Road Side Acoustic Barriers

Barriers could be constructed to reduce traffic noise at residences adjacent Old Windsor Road. The barriers could be constructed in the form of concrete panels, masonry walls, earth mounds or similar constructions. Noise reduction achieved by acoustics barriers depends on the locations and heights of the source, receivers and barriers.

Table 7 presents barrier heights and locations required to reduce traffic noise levels to at residences adjacent to Old Windsor Road to within the assessment goals. *Table 8* presents the predicted $L_{Aeq,15hr}$ and $L_{Aeq,9hr}$ road traffic noise levels for Year 2011 at the affected receivers with the recommended barriers.

Table 7 Recommended Barrier Height and Location

Chainage (m)	Barrier Length (m)	Barrier Height (m)	Location
0 – 100	100	2.0	Eastern boundary
100 – 220	120	2.5	Eastern boundary
220 – 460	240	1.5	Eastern boundary
460 – 640	180	2.0	Eastern boundary
640 – 750	110	2.5	Eastern boundary
750 – 800	50	2.0	Eastern boundary

Table 8 ***Predicted Traffic Noise Levels with Recommended Barriers***
dB(A) re 20 × 10⁻⁶ Pa

Receiver Location	Assessment Goal		Predicted Traffic Noise Level		Compliance	
	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Lot 31 OWR[1]	60	56	60	56	Yes	Yes
Lot 30 OWR	59	56	59	56	Yes	Yes
Lot 29 OWR	61	57	60	57	Yes	Yes
Lot 28 OWR	62	59	61	58	Yes	Yes
Lot 27 OWR	62	59	61	58	Yes	Yes
Lot 26 OWR	62	59	62	58	Yes	Yes
Lot 25 OWR	60	56	60	56	Yes	Yes

Note 1. OWR denotes Old Windsor Road

10.2 Treatment to Individual Dwellings

Treatment to individual properties or dwellings could include boundary barriers, external court yard walls, closing exposed door and window openings, upgrading exposed building facade/glazing, sealing off openings and provisions for ventilated exposed rooms.

Noise reductions achieved from a typical building facade with an open window are in the order of 10 dB(A). With closed windows, the noise reduction is in the order of 20-25 dB(A). It should be noted that treatments to dwellings provide no benefit to the outdoor acoustic amenity.

To satisfy the ECRTN internal night-time noise goals (35 - 40 dB(A)), the recommended treatments to the dwellings may include upgrading glazing, doors, etc. and provisions for alternative mechanical ventilation.

10.3 Future Planning

The local council has a role in ensuring road traffic noise is considered when determining rezoning and development applications under the provisions of the Environmental Planning and Assessment Act, 1979. It is recommended that the local council consider planning strategies for future land zoning and development adjacent to Old Windsor Road and Windsor Road.

10.4 Future Development in Traffic Noise Control

As part of the government long-term plan to reduce road traffic noise, strategies that are being considered include controlling noise emissions from individual vehicles, developing programs to monitor and control noise vehicles, controlling noise from trucks and engine brakes and reducing traffic speed. The effective implementation of these plans will assist in further reductions to road traffic noise.

11.0 CONSTRUCTION NOISE AND VIBRATION

11.1 Overview

Details of construction program and activities will be determined when a contractor is engaged. At this time, it is envisaged that the construction activities would be based on established road design and construction procedures. To evaluate the likely level of noise and vibration emitted from the envisaged construction activities, the following construction phases and plant schedules have been considered.

11.1.1 Preliminary Site Works

Preliminary site works would involve relocation of services and adjustments to access roads. It is envisaged that trucks, graders and excavators would be used to excavate and transport materials during the preliminary site works.

11.1.2 Earthworks

The envisaged construction activities during the main earthworks phase of the project will involve excavation, filling and compaction. During this phase of the project, dozers, scrapers, excavators, graders and compactors would be used to excavate, transport, spread, level and compact the material to form the road.

11.1.3 Sub-base Preparation

Following the earthworks, the road sub-base would be prepared by a fleet of trucks and concrete laying machines.

11.1.4 Road Surfacing

Laying of asphalt pavement would be carried out by an asphalt paving machine, asphalt trucks and rollers.

11.1.5 Construction Compounds

The location of construction compound sites for the establishment of material, plant and stockpile sites would be identified and carried out by the construction contractor. These areas are normally located within the road reservation, or by prior agreement with individual property owner on private property.

11.1.6 Construction Schedule

Table 9 presents a summary of the likely construction plant and construction schedules.

Table 9 Operations and Equipment Required

Operation	Plant Type	Quantity
Preliminary Site Works	Grader	1
	Excavator	1
	25T trucks	2
Earthworks	25T trucks	3
	Excavator	1
	Scrapers	2
	Dozers	1
	Compactors	2
Sub-base Preparation	Concrete trucks	3
	Concrete Paving Machine	1
	Trucks	3
Road Paving	Asphalt trucks	3
	Rollers	2
	Asphalt Paving Machine	1
Construction	Cranes	2
	Trucks	2
	Generator	2

11.2 Construction Hours

To minimise noise impacts, the construction activities would generally be restricted to between 7:00am and 6:00pm, Monday to Friday, and 8.00am to 1.00pm on Saturday.

With prior approval from the EPA and Council and notification to residents, construction outside these hours could be undertaken provided the construction noise did not give rise to an unreasonable nuisance or disturbance to the occupiers of nearby residential dwellings.

11.3 Assessment Goals

11.3.1 Goals for Noise Assessment

Goals for assessment of construction noise are recommended in the EPA's Environmental Noise Control Manual (1994). These are dependent on the duration of the activities and are as follows:

- for construction periods limited to four weeks, the $L_{A10,15min}$ construction noise should not exceed the L_{A90} background by more than 20 dB(A);
- for construction periods between four weeks and 26 weeks, the $L_{A10,15min}$ construction noise should not exceed the L_{A90} background by more than 10 dB(A); and
- for construction periods longer than 26 weeks, long-term noise goals apply. That is, the $L_{A10,15min}$ construction noise should not exceed the L_{A90} background by more than 5 dB(A).

It is anticipated that construction would only take place during daytime and be completed within 26 weeks near any receiver. Goals for assessment of construction noise established from measured background L_{A90} noise levels (*ref* Appendix 1) are summarised in *Table 10* below.

Table 10 *Goals for Assessment of Construction Noise*
dB(A) re 20 × 10⁻⁶ Pa

Assessment Location	Background L_{A90} Noise Level	$L_{A10,15min}$ Noise Goal	
		Short-term	Medium-term
Receivers adjacent to Old Windsor Road	44 – 52	64 – 72	54 – 62
Receivers adjacent to Windsor Road	52 – 61	72 – 81	62 - 71

11.3.2 Goals for Vibration Assessment

i Annoyance

The EPA, ENCM (Chapter 174) recommends goals in terms of potential disturbance to the occupants of buildings. In accordance with the EPA, *Table 11* presents a summary of vibration levels for the assessment.

Table 11 *Vibration Levels for Assessment of Human Comfort*

Type of Occupancy	Time	Vibration Level (mm/s)	
		Continuous Vibration	Intermittent Vibration
Residential	Day	0.2 – 0.6	8 – 12
	Night	0.2	2

ii Perception

Table 12 presents a summary of vibration levels referenced to degrees of perception and potential reactions. These may be used to evaluate human response to vibration levels.

Table 12 ***Human Perception to Vibration***
Ref: German Standard DIN 4150 (1986)

Vibration Level mm/s	Likely Perception
0.15	Perception Threshold
0.35	Barely Noticeable
1.0	Noticeable
2.2	Easily Noticeable
6.0	Strongly Noticeable
14.0	Very Strongly Noticeable

iii *Structural Damage*

German Standard DIN4150 Part3:1986 provides guidelines for evaluating the effects of vibration on building structures. The values recommended in the standard are summarised in *Table 13*. These are the maximum vibration levels measured in any direction at the building foundation.

Table 13 ***Safety Limits for Structural Damage***

Type of Structure	Vibration Level (mm/s)			
	< 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15

Ref: German Standard DIN4150

As the buildings in the vicinity of the proposal are residential structures, DIN4150 recommends a maximum vibration level of 5mm/s to avoid possible structural damage. It should be noted that the standard states that this level is a "safe limit" up to which no damage due to vibration effects has been observed for the particular class of building. "Damage" is defined by DIN4150 to include minor non-structural superficial cracking in cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls.

iv Building Contents

The threshold for visible movement of susceptible building contents (eg. plants, hanging pictures, etc.) is approximately 0.5mm/s. Audible rattling of loose objects (eg. crockery) generally does not occur until levels of about 0.9mm/s.

11.4 Noise and Vibration from Construction Equipment

11.4.1 Noise from Construction Equipment

Sound power levels of equipment for the envisaged construction activities are summarised in *Table 14*. These are established from data presented in the Australian Standard AS2436-1981 and previous studies conducted by Atkins Acoustics.

Table 14 Construction Plant and Sound Power Levels
dB(A) re 20 × 10^{-6} Pa

Plant Description	Plant Type	Sound Power Level
Dozer	Caterpillar D7, D9	113
Front End Loader	Wheeled	110
Scraper	Caterpillar 651	110
Grader	Caterpillar 16	110
Compactor	Caterpillar 825	110
Vibratory Roller	10-12 tonne	110
Water Cart		106
Excavator	Kato 750	107
Truck		106
Crane	Truck mounted	110
Compressor	600 CFM	100
Backhoe		108
Grader	Caterpillar	106
Tip Truck		106
Concrete/Asphalt Paver		115
Concrete/Asphalt Truck		108
Concrete/Asphalt Pump		109
Concrete/Asphalt Vibrators		105

11.4.2 Vibration from Construction Equipment

Table 15 provides typical ground vibration levels generated by construction equipment.

Table 15 ***Vibration Levels from Construction Equipment***

Plant Description	Vibration Level (mm/s)	
	5m	20m
Dozer	2	0.2
Vibrating Compactor	20	2
Roller	8	1

11.5 Predicted Noise and Vibration Impacts

11.5.1 Noise Impacts from Construction Equipment

Table 16 provides a summary of predicted noise levels from each construction phase at various distances from the equipment. The predicted noise levels represent those under worst case scenario, ie. when all plant items during each construction phase operate simultaneously.

Table 16 ***Predicted Noise Levels from Construction Activities***
dB(A) re 20×10^{-6} ***Pa***

Construction Phase	Predicted Noise Levels at Various Distances			
	20m	30m	50m	100m
Preliminary site works	80	76	72	66
Earthworks	85	81	77	71
Sub-base preparation	84	80	76	70
Road paving	83	79	75	69

Site inspections identified there are two (2) houses within 20m (adjacent to Windsor Road) and other houses are within 50m from the envisage construction activities.

It can be seen from *Table 16* that the predicted noise levels exceed the assessment goals for medium term construction activities near receivers within 50m from the site. The short term goals are also exceeded at some stages of the construction activities.

11.5.2 Vibration Impacts from Construction Equipment

Table 17 provides a summary of predicted vibration levels that could be generated from various plant equipment.

Table 17 Typical Plant Vibration Levels

Plant Description	Vibration Level (mm/s)	
	20m	40m
Dozer	0.2	0.02
Compactor	2	0.3
Roller	1	0.1

It can be seen from the results in *Table 17* that vibration levels generated by construction plant are unlikely to exceed the "safe limit" of 5mm/s for structural damage to residential buildings and satisfy the EPA goals.

11.6 Recommendation

To minimise noise and vibration impacts from construction activities, an Environment Management Plan (EMP) should be prepared to address noise and vibration issues. As part of the EMP, the following should be considered:

- establishment of a construction noise and vibration control plan;
- selection of plant and equipment on acoustic performance, where practical;
- implementation of a monitoring program to ensure that construction noise and vibration are controlled and that best possible practices are implemented; and

- implementation of an information program to inform local residents of the construction program and time periods when noise and vibration levels could exceed the recommended assessment guidelines.

12.0 SUMMARY

This report presents the results and findings of noise and vibration assessments for the proposed upgrading of Old Windsor Road and Windsor Road between Sunnyholt Road and Merriville Road.

Site investigations and noise monitoring were conducted to quantify the existing ambient noise levels and establish goals for assessment of future traffic noise impacts, construction noise impacts and validation of the noise prediction model.

The EPA's Environmental Criteria for Road Traffic Noise recommends base line and allowance goals for assessing of road traffic noise. For the redevelopment of arterial road, the RTA recommends that the existing traffic noise levels should not be increased by more than 2 dB(A).

Possible sleep disturbance impacts were also assessed in accordance with the RTA's protocol.

Where the predicted traffic noise levels exceed the allowance goals, possible control measures have been recommended to reduce the traffic noise levels. The types of control measures depend on the feasibility and practicality.

As part of the NSW Government long term plan to reduce road traffic noise, strategies that are being considered include controlling noise emissions from individual vehicles, developing programs to monitor and control noisy vehicles, and the control of noise from trucks and engine brakes. The progressive and effective implementation of these plans will assist in further reductions to road traffic noise from the proposal.

With regard to future planning the local Council has a role in ensuring that road traffic noise is considered when determining rezoning development and building applications under the provisions of the Environmental Planning and Assessment Act, 1979, and Local Government Act, 1993. It is recommended that the local Council consider planning strategies for any future residential development adjacent to Windsor Road and Old Windsor Road.

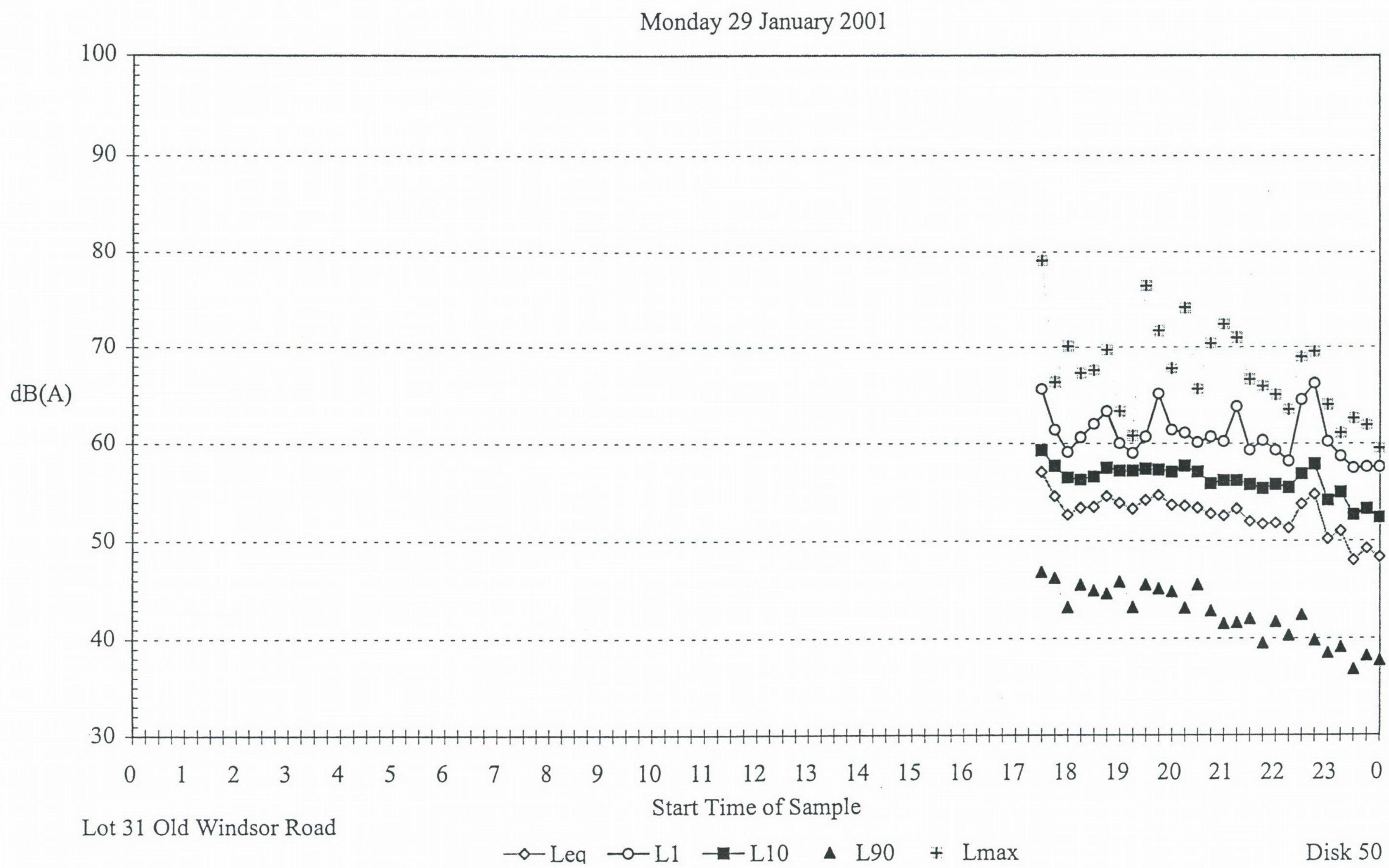
Assessment of construction noise has been based on normal road design and construction procedures, ie. site preparation, sub-base preparation and the laying of a asphalt pavement and guidelines in the EPA's Environmental Noise Control Manual and other relevant standards.

The assessment has shown that during the construction there would be localised adverse noise impacts where road construction activities take place near residential receivers. Noise and vibration impacts from these activities can be minimised through planning, programming and consultation with the occupiers of the affected properties.

It is recommended that following the opening of the road, post construction noise monitoring be undertaken to confirm compliance with the project assessment goals. To ensure that construction noise and vibration impacts are minimised during the road construction, it is recommended that as part of the construction contractors undertakings, an Environmental Management Plan be prepared to address and control construction noise and vibration.

APPENDIX 1: NOISE MONITORING RESULTS

Ambient Sound Pressure Levels



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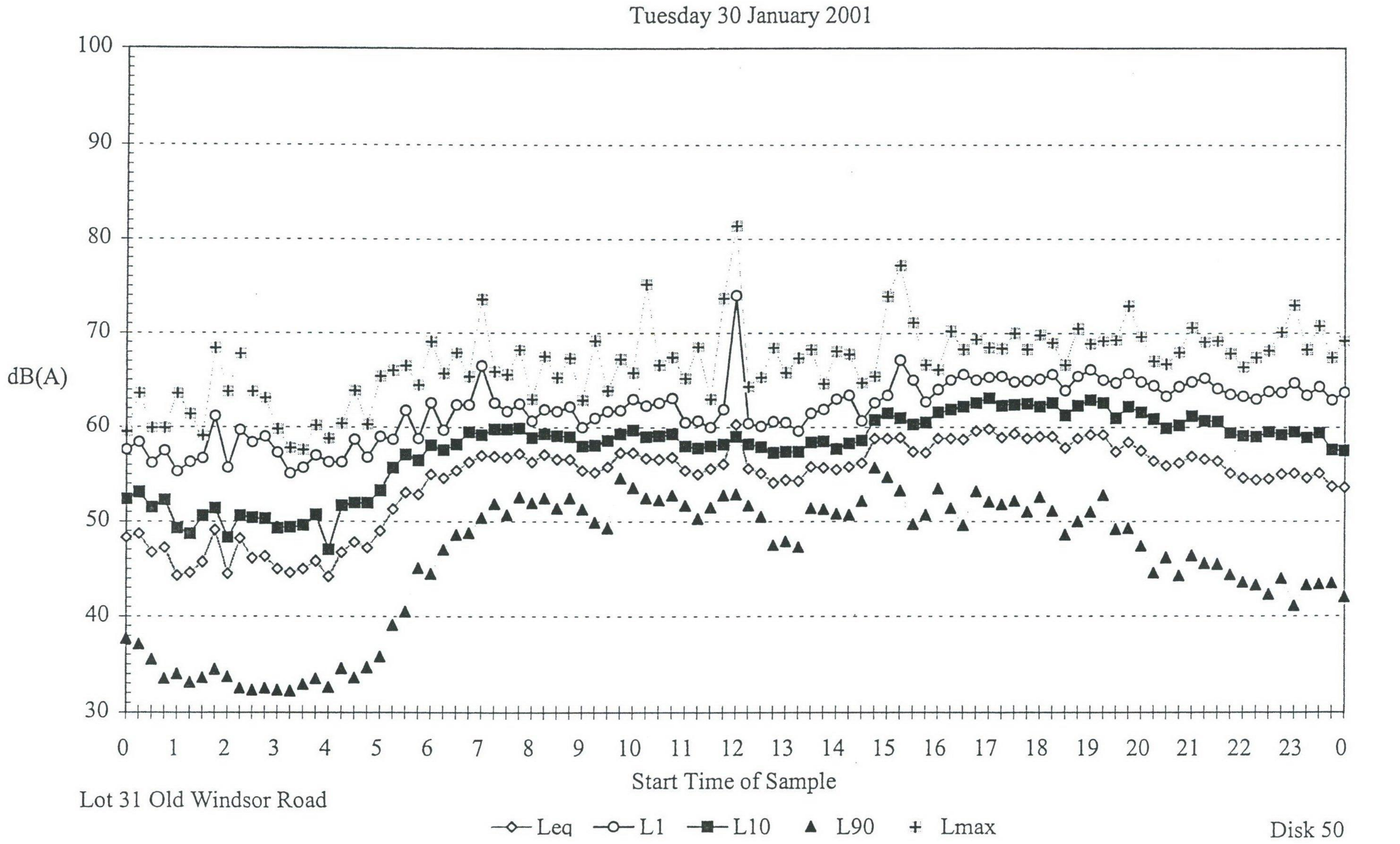

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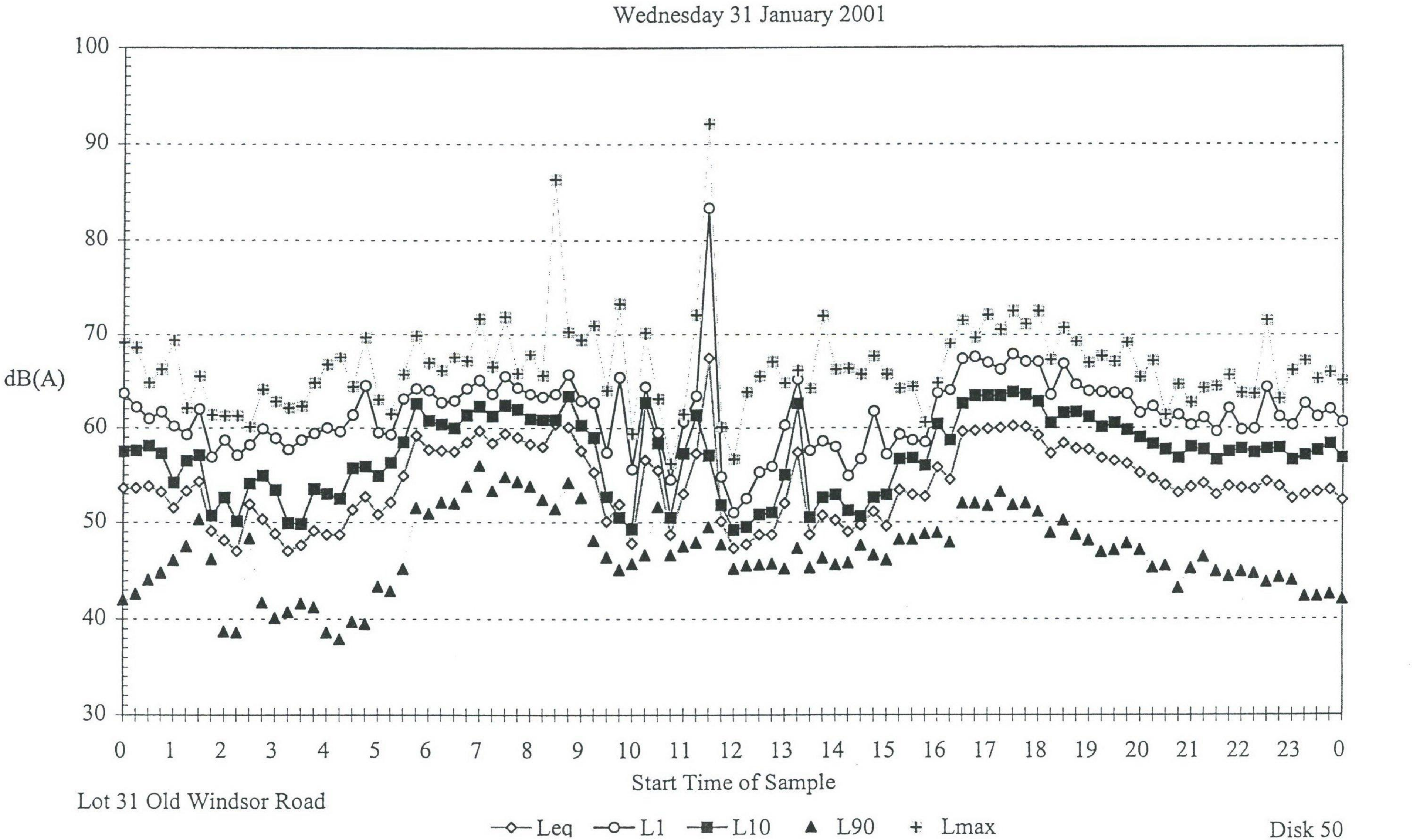

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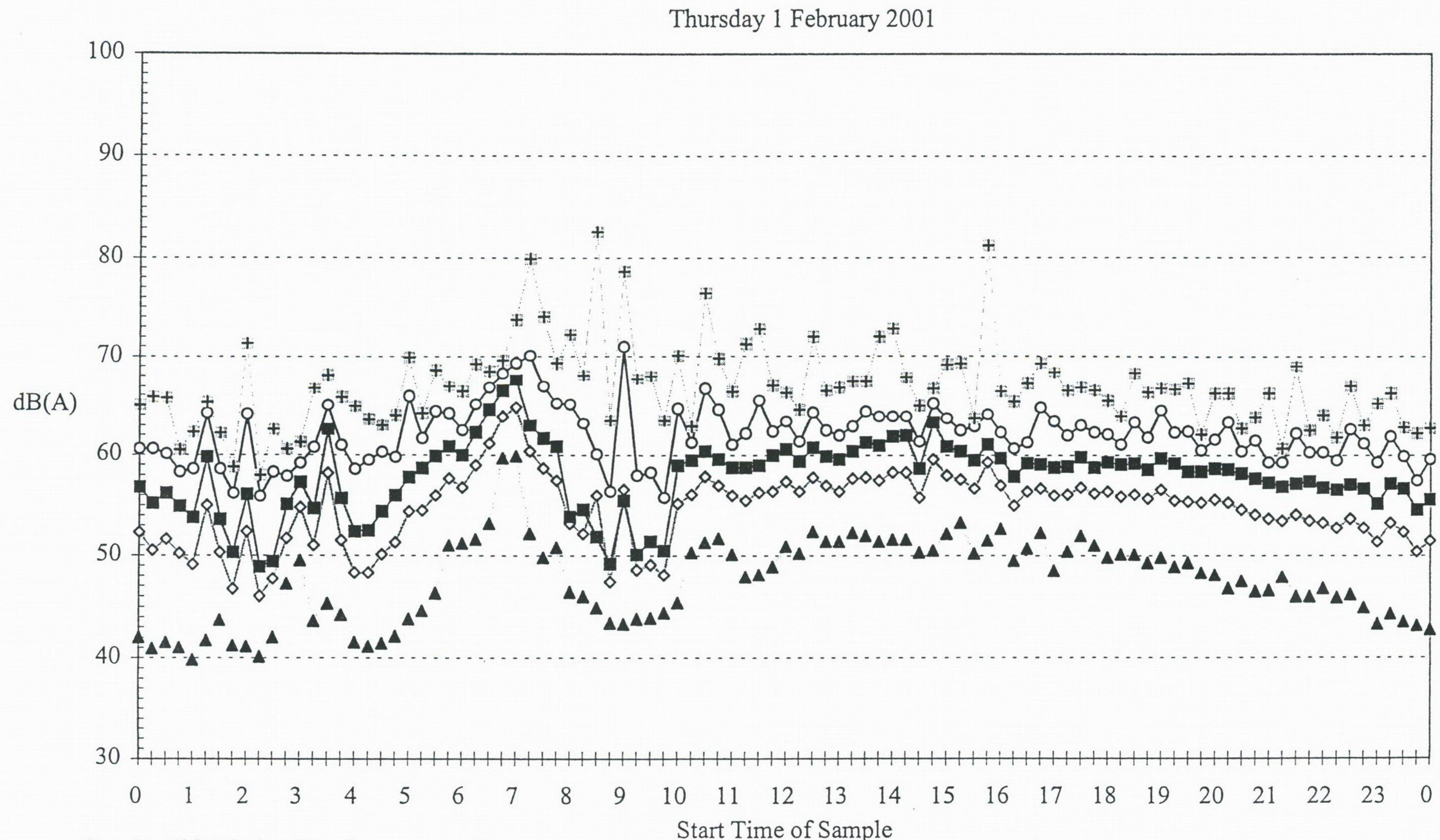

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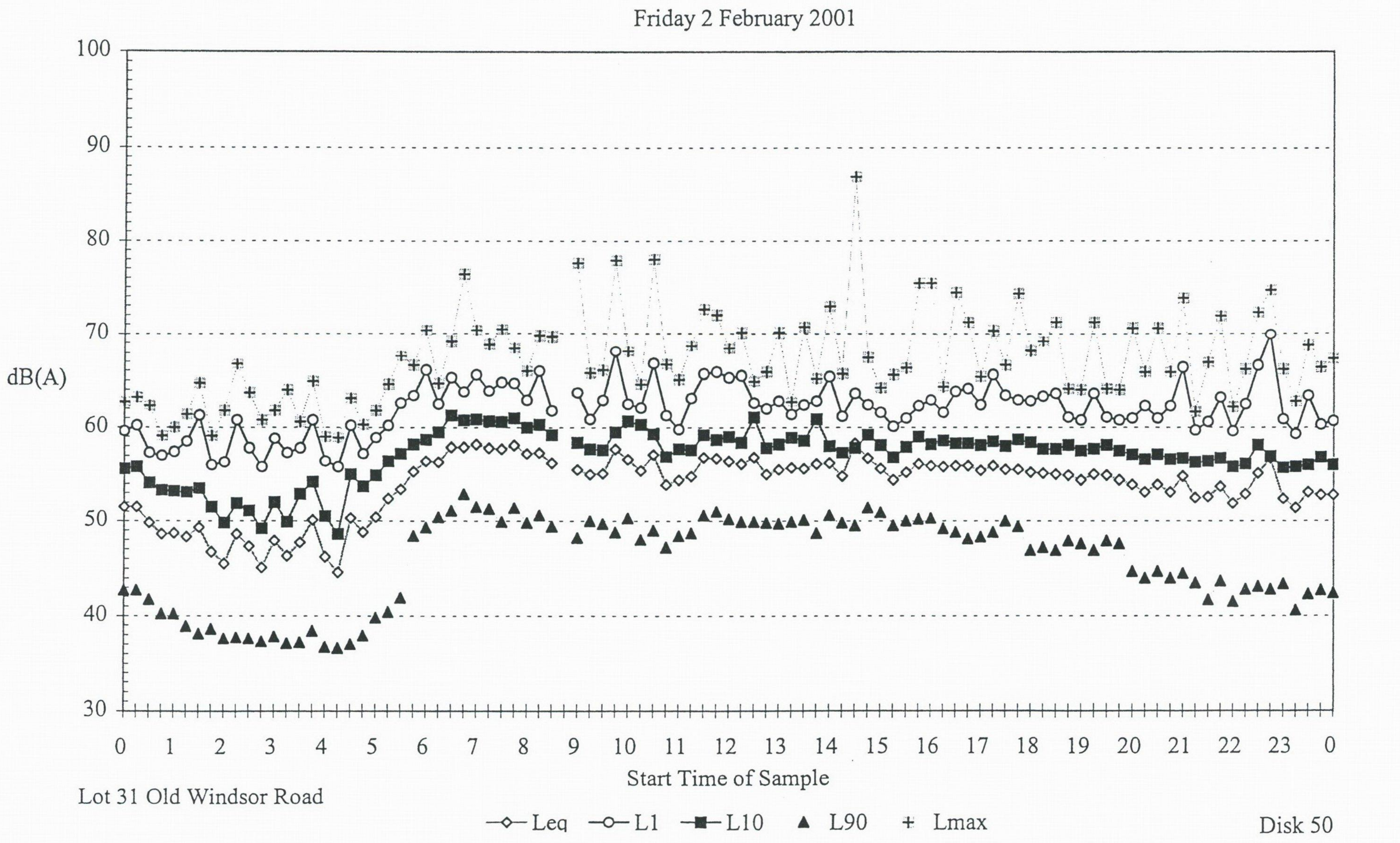

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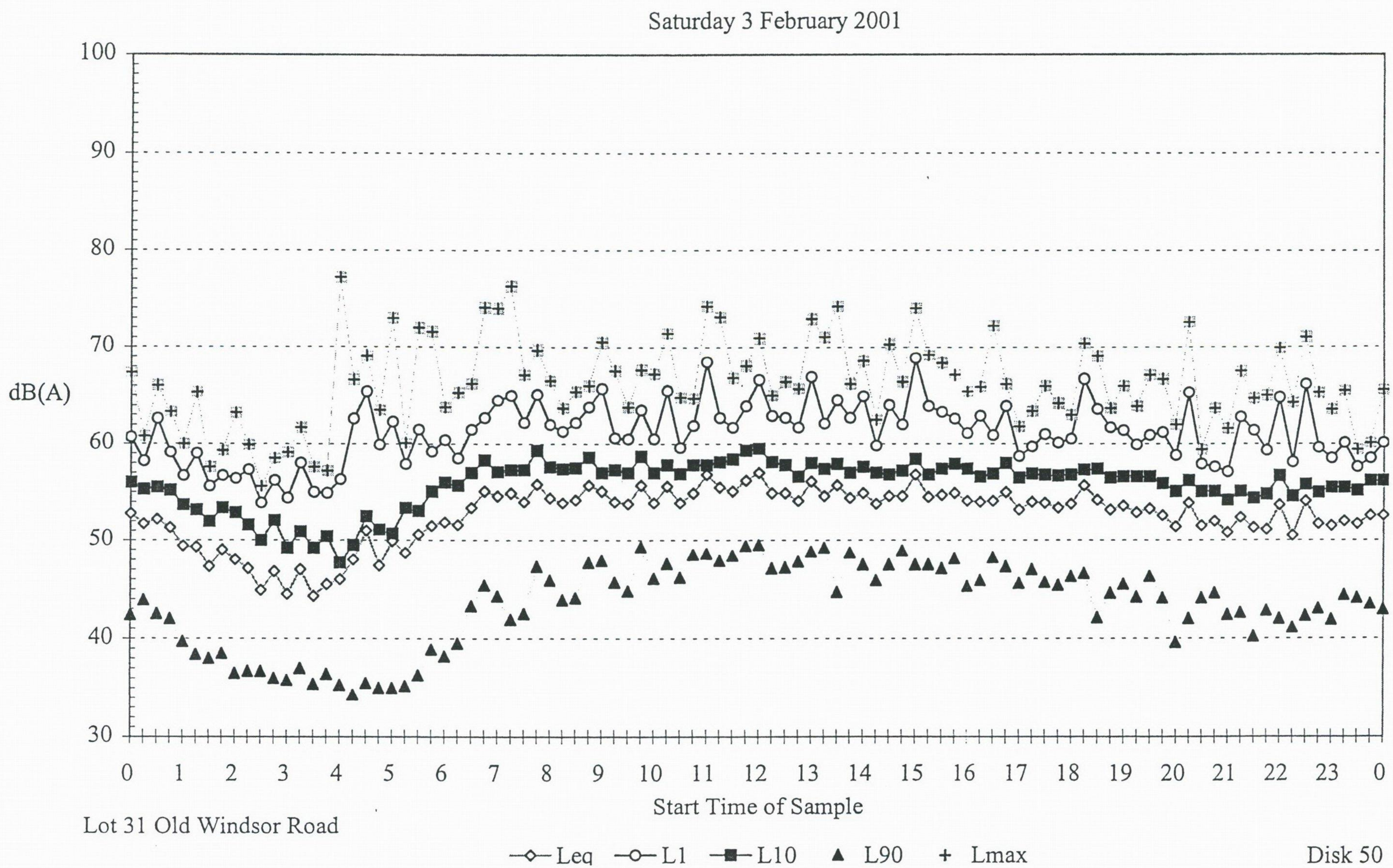

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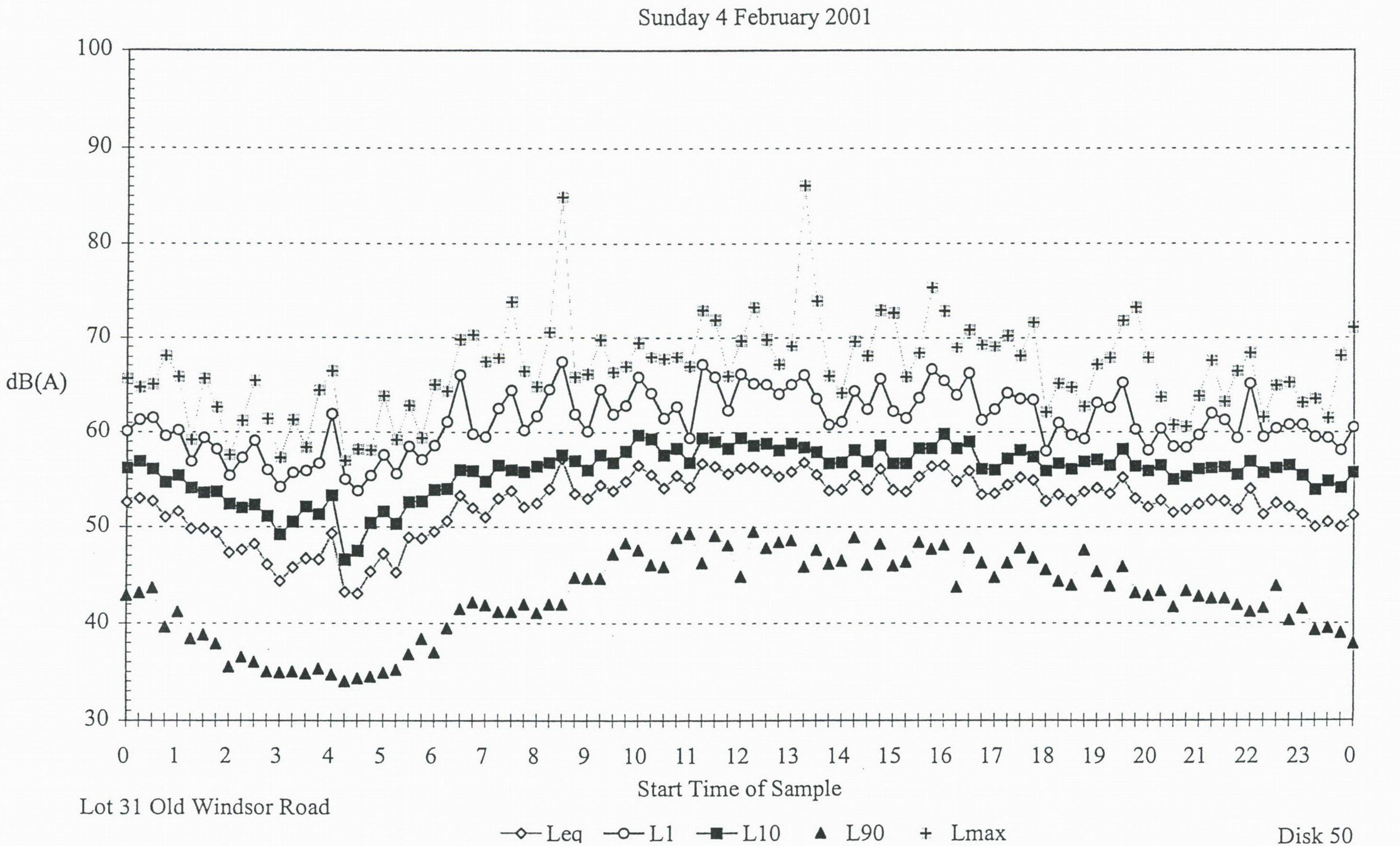

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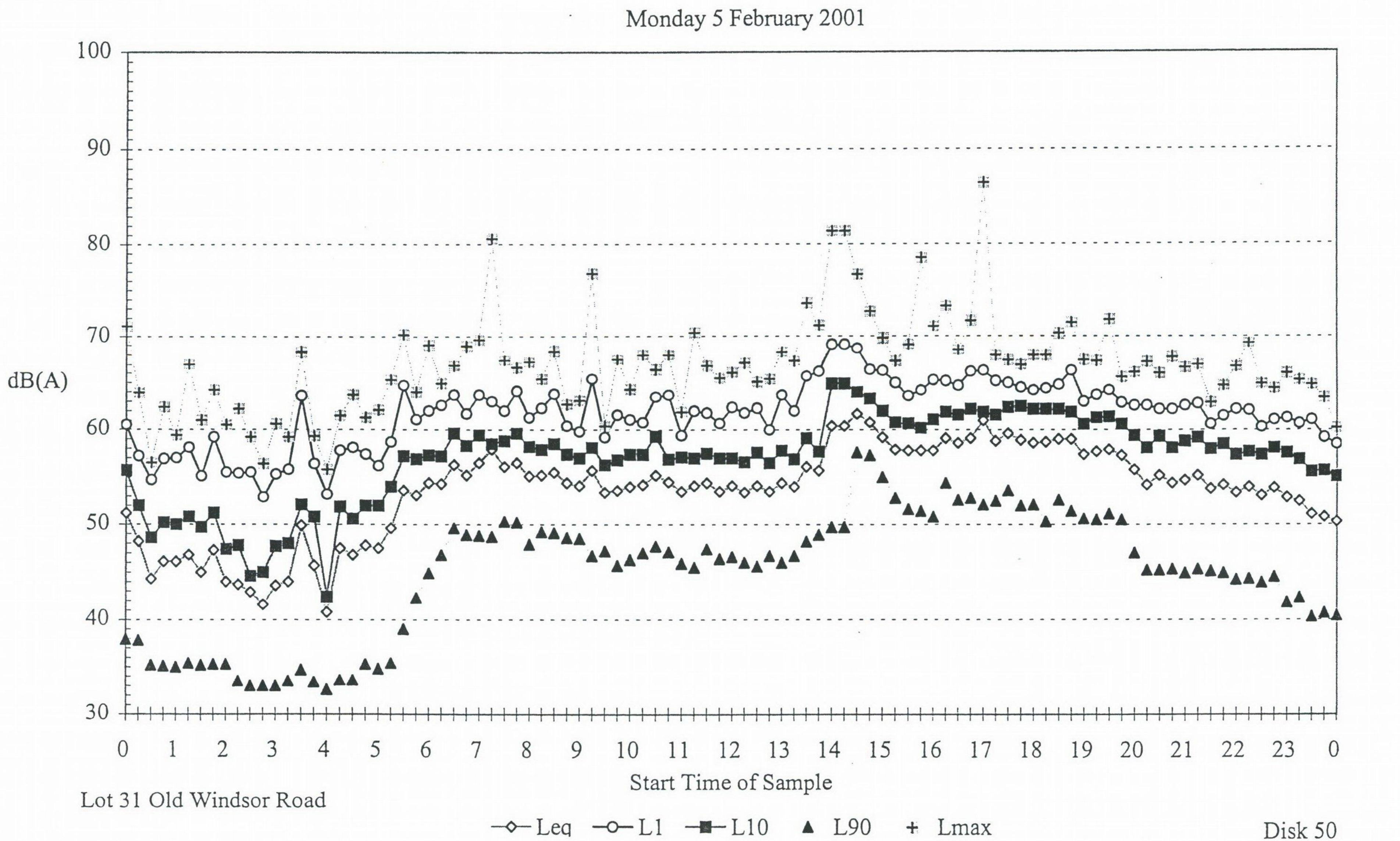

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Ambient Sound Pressure Levels

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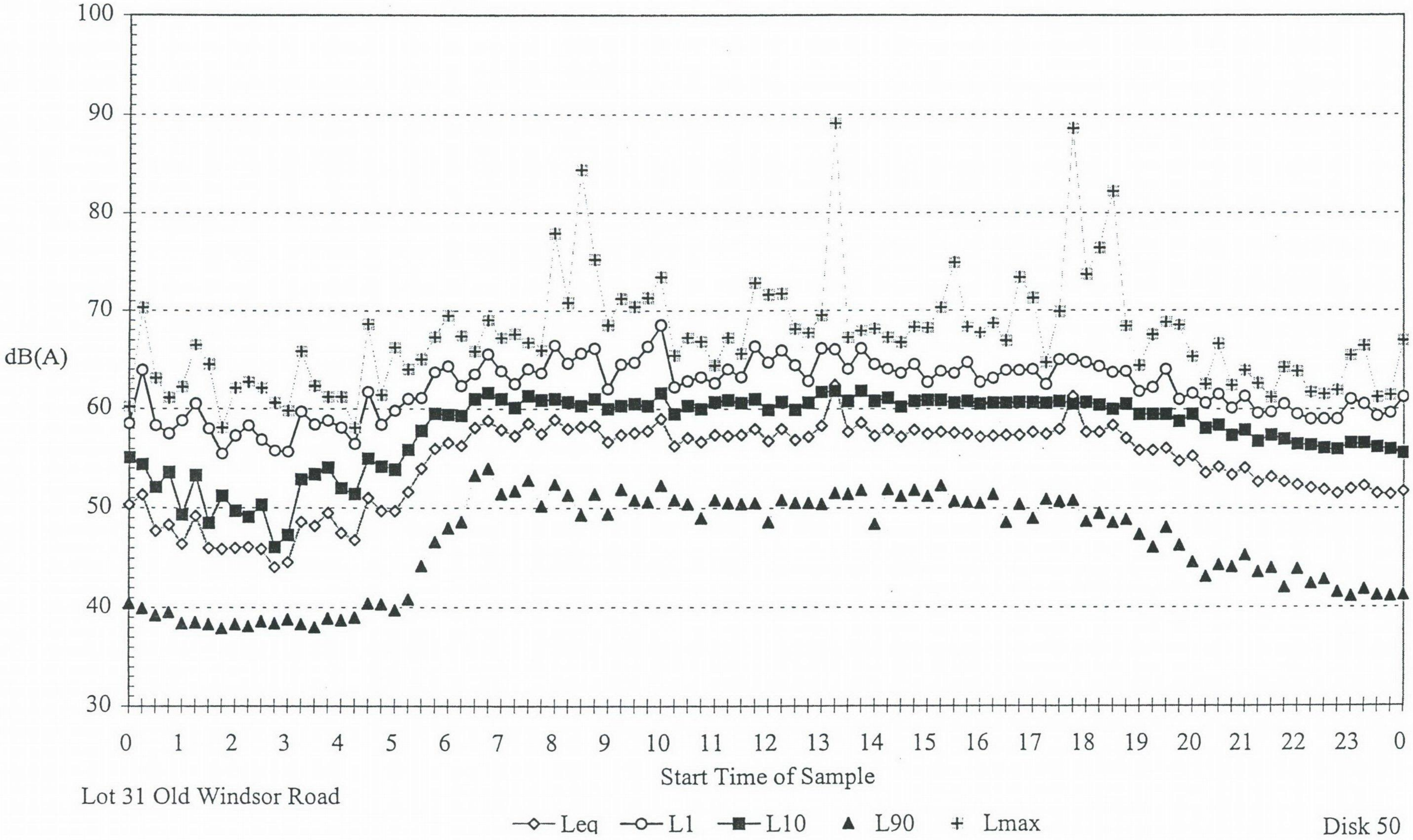

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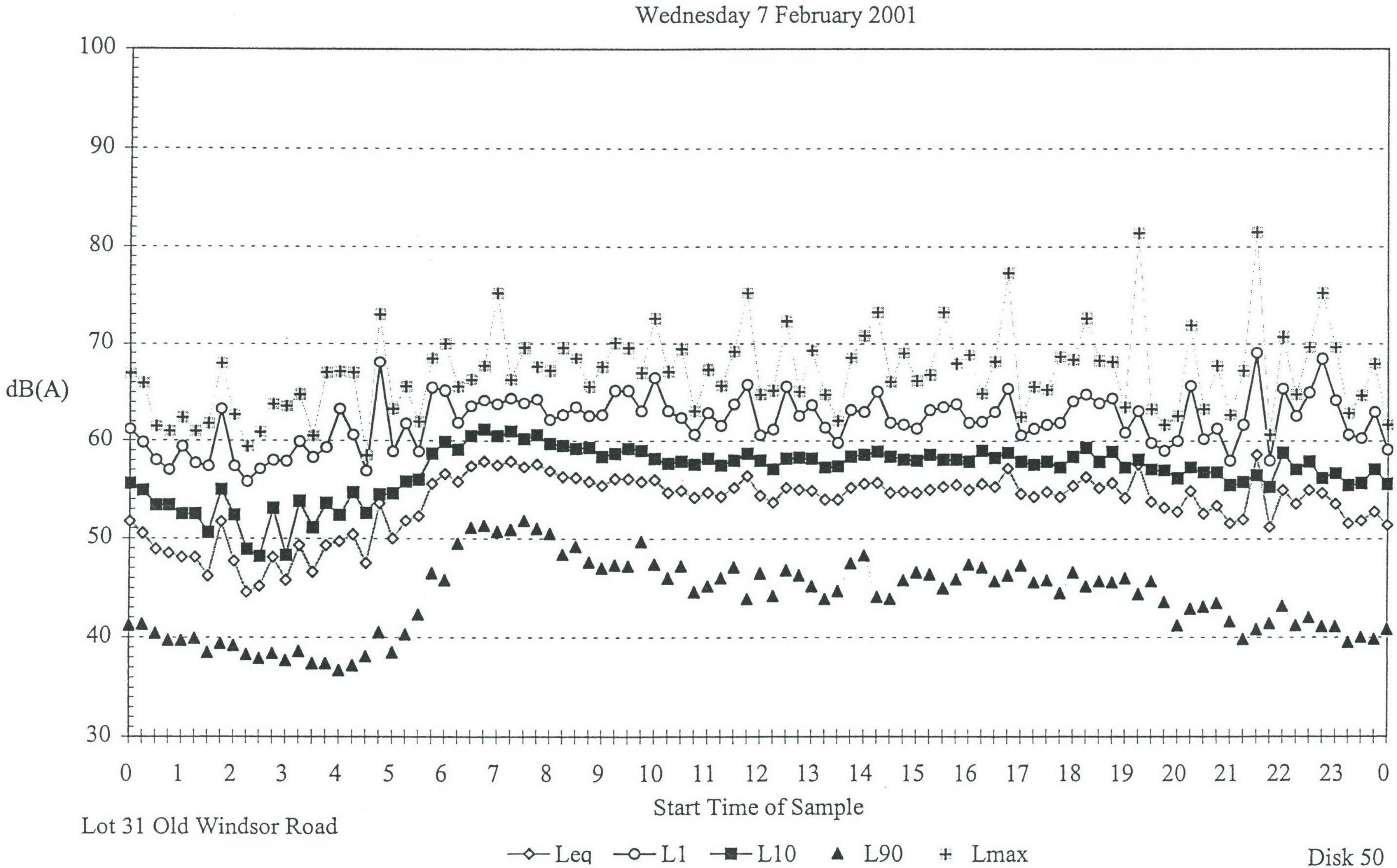

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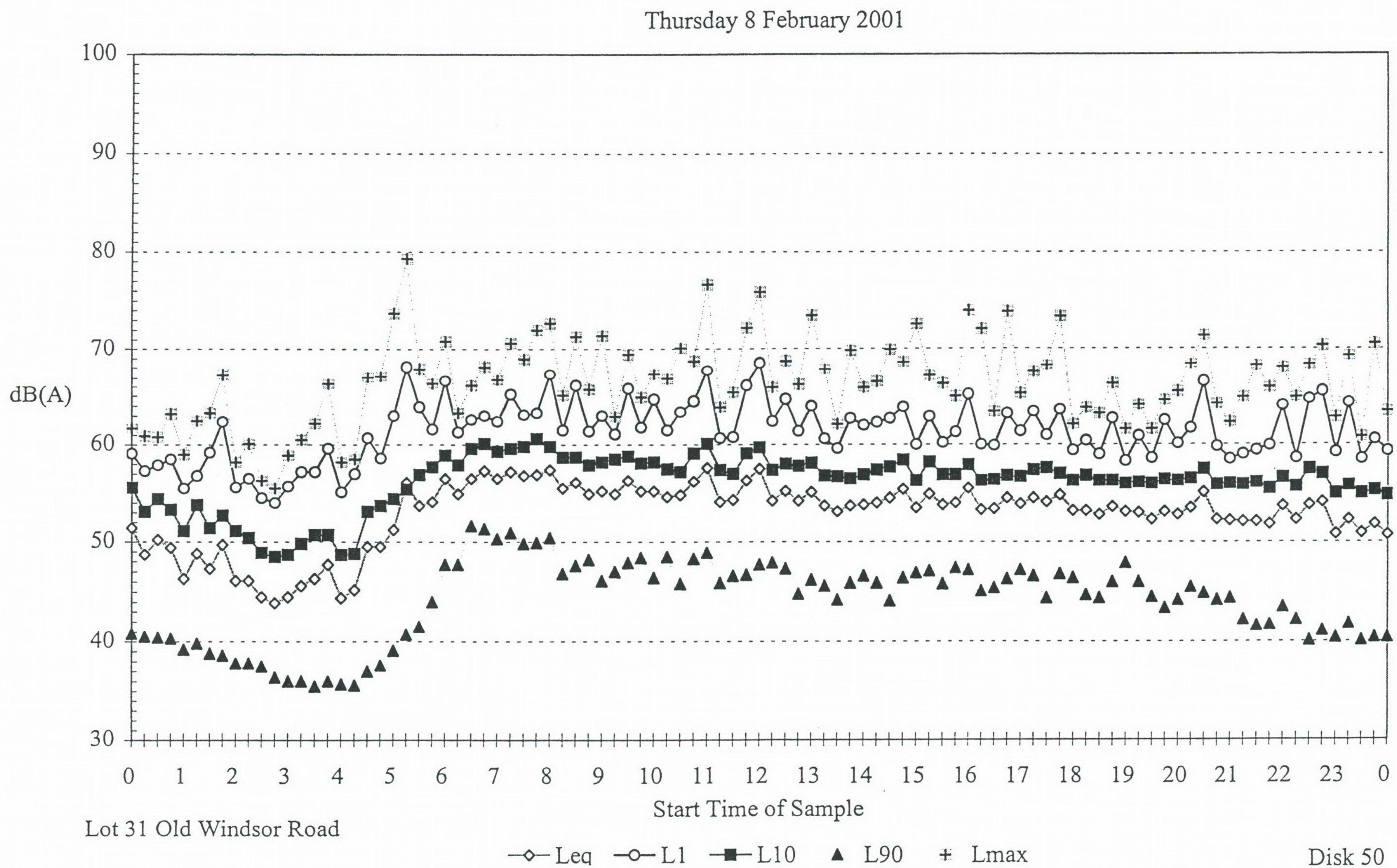
Ambient Sound Pressure Levels

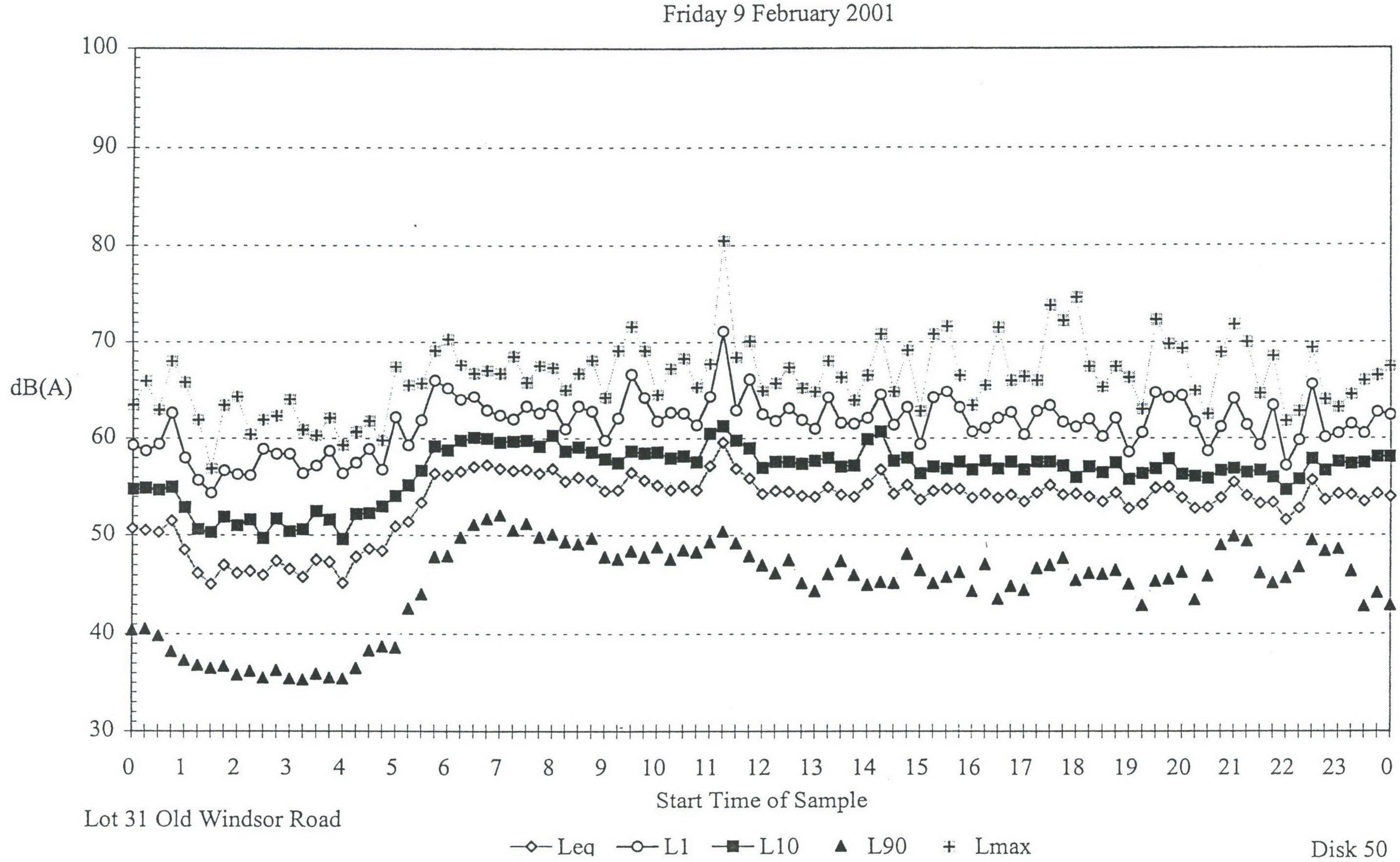


Lot 31 Old Windsor Road

Disk 50

5140r1b_1.xls

Ambient Sound Pressure Levels



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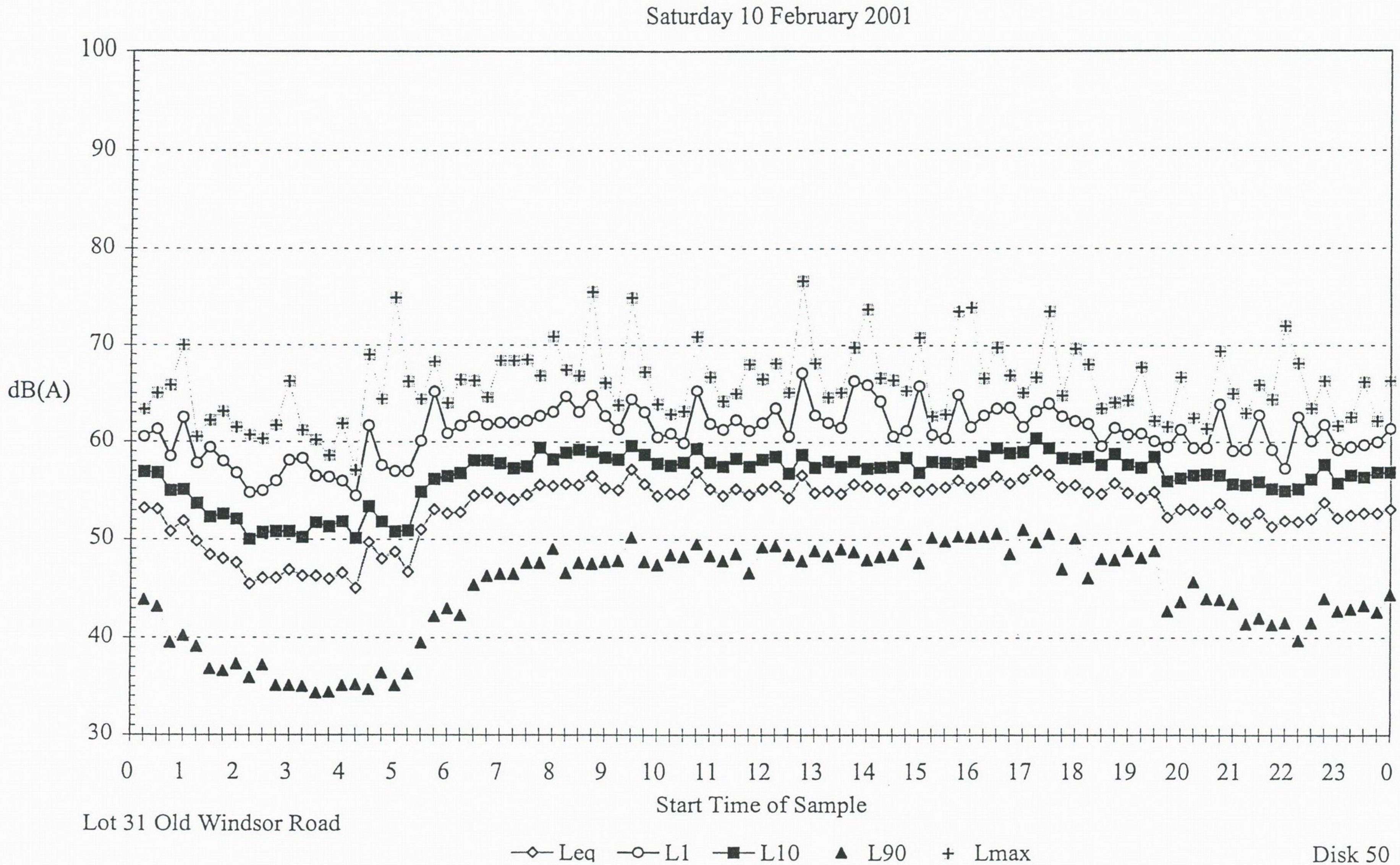

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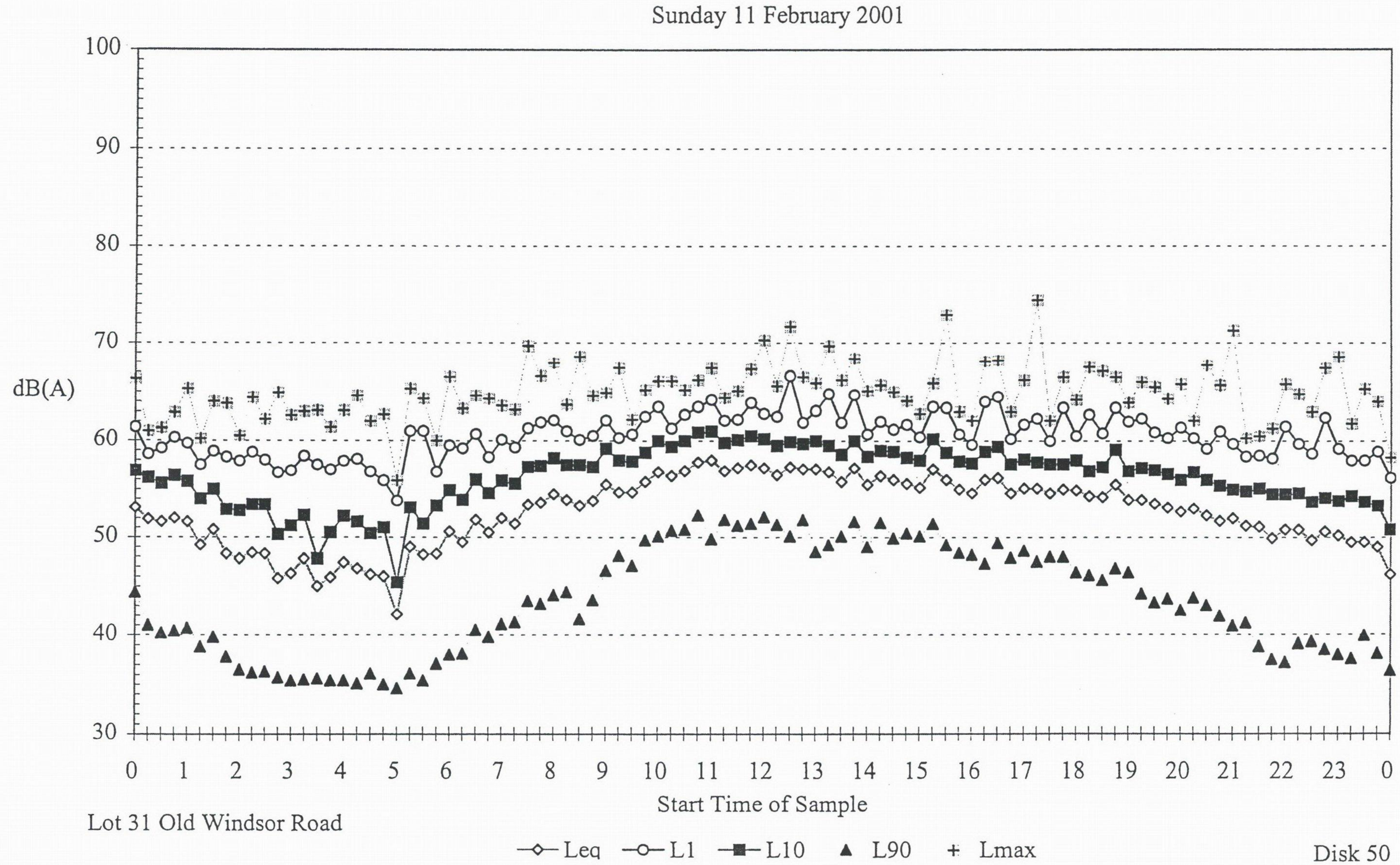

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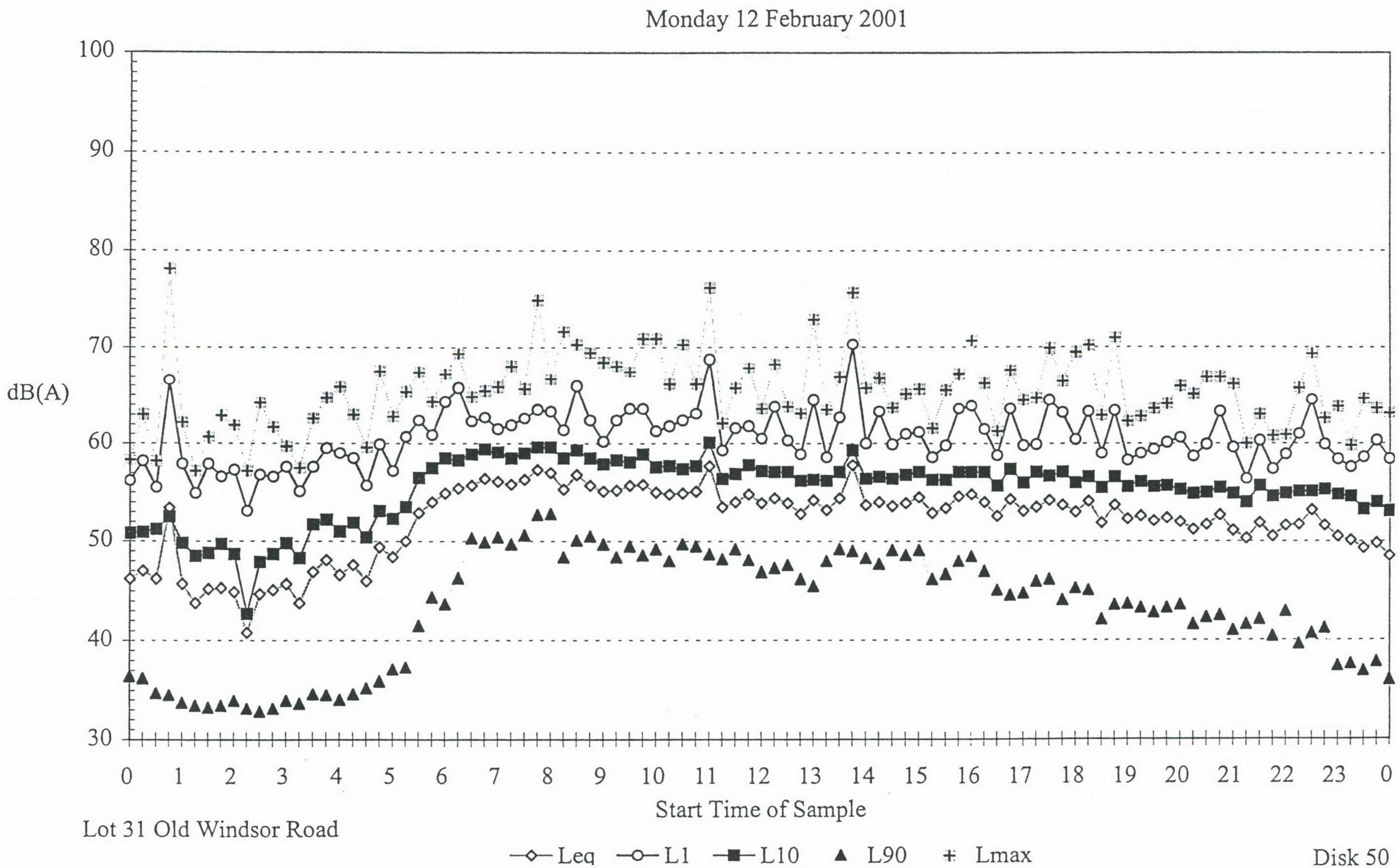

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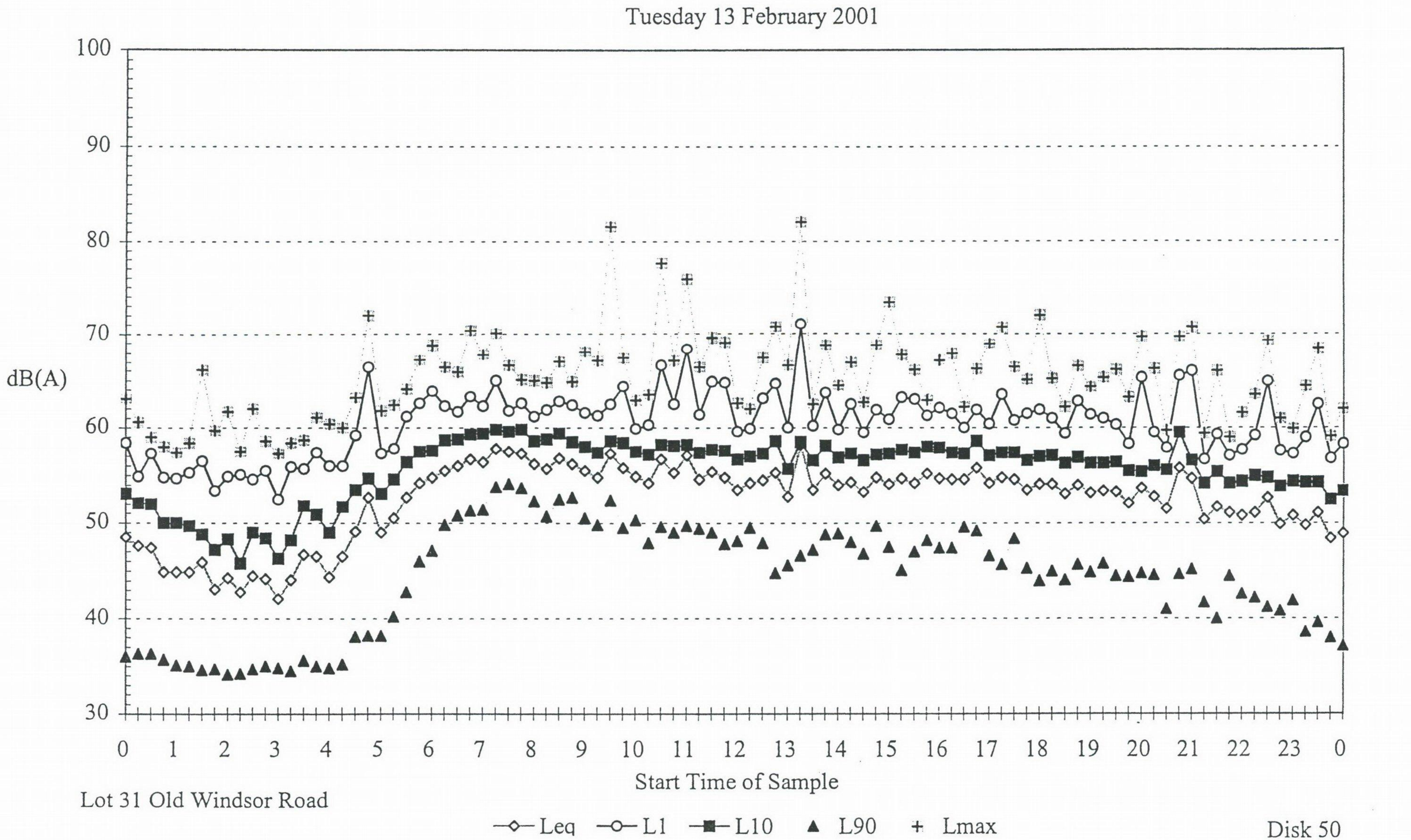

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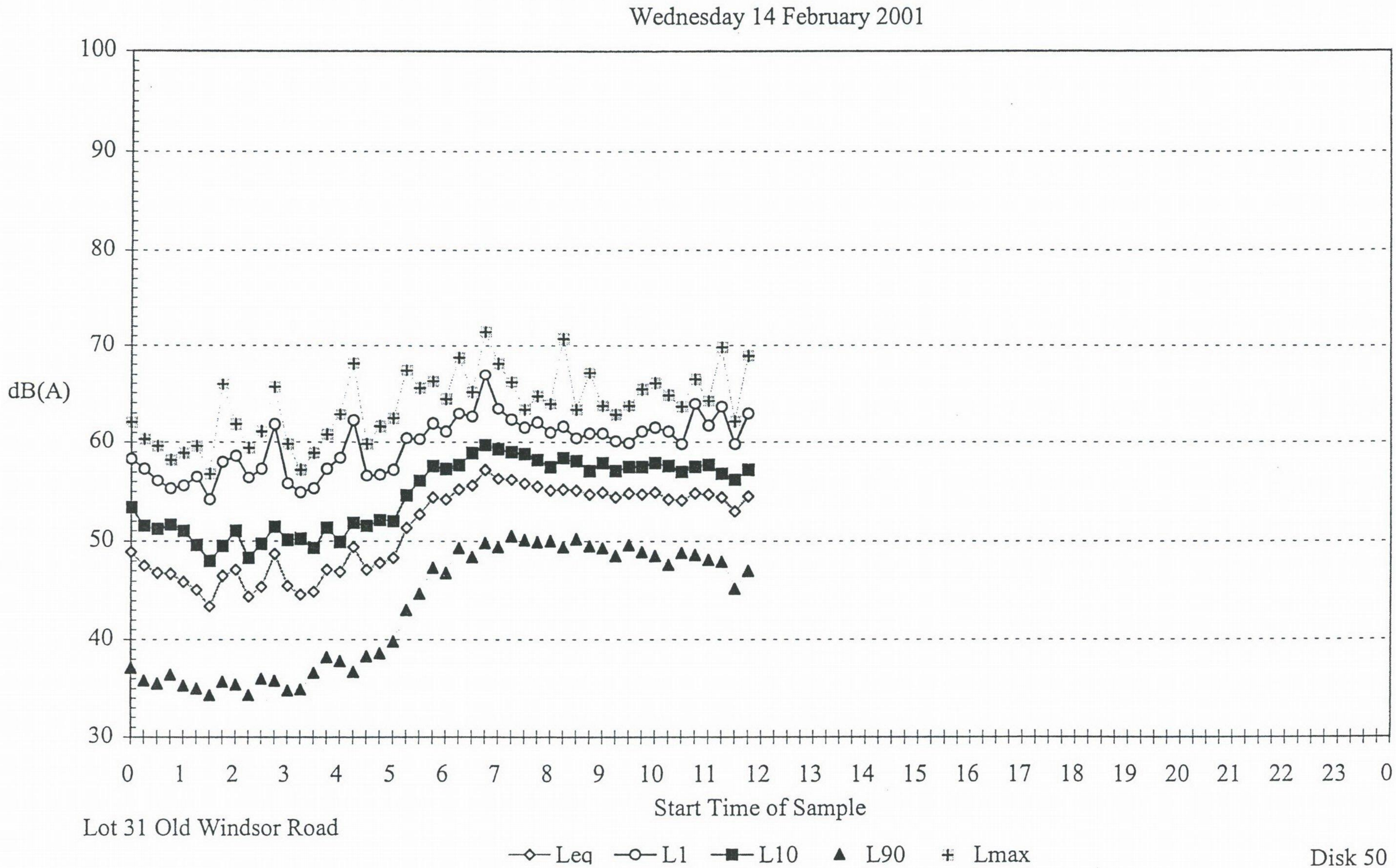

Lot 31 Old Windsor Road

Disk 50

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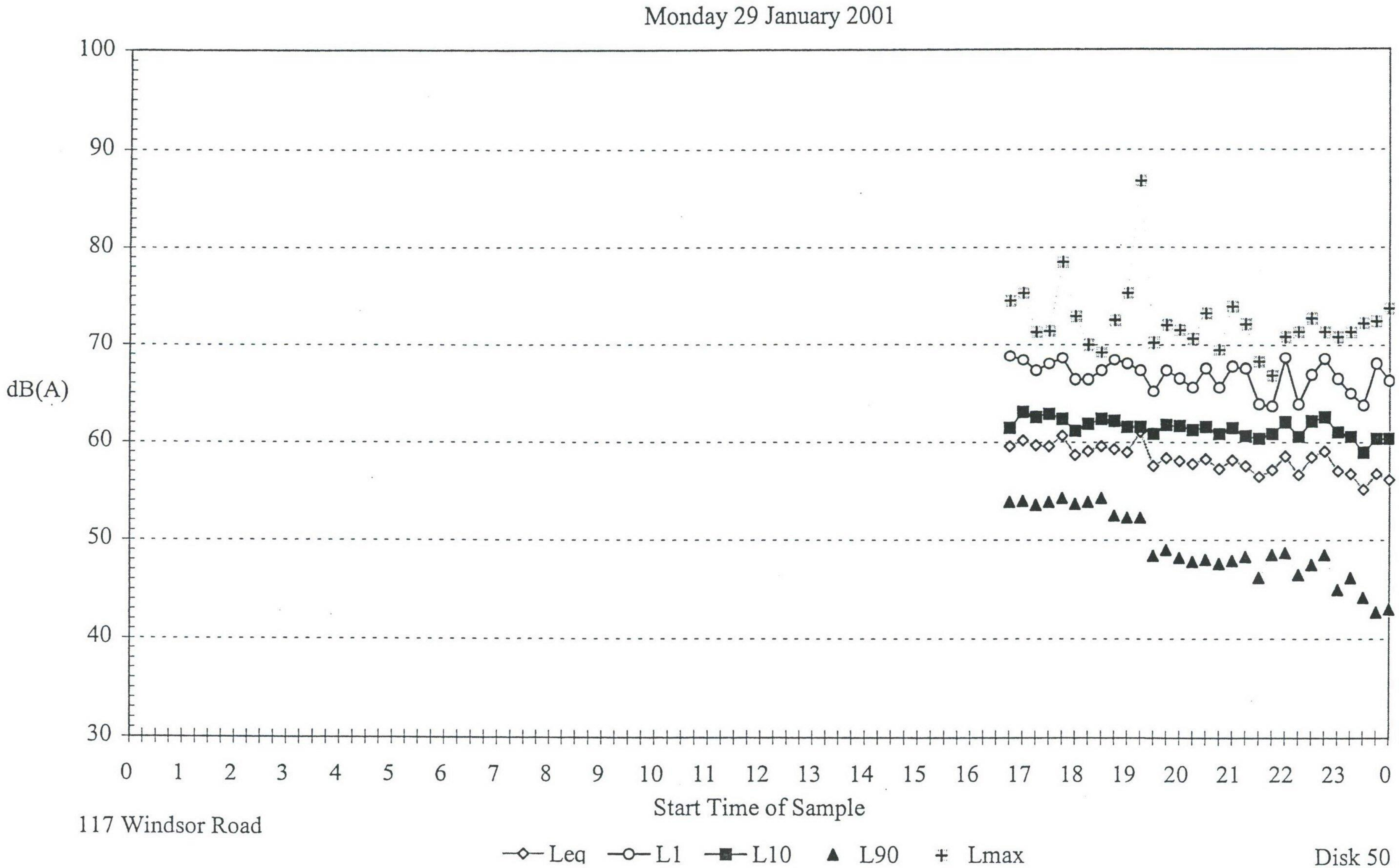
Ambient Sound Pressure Levels



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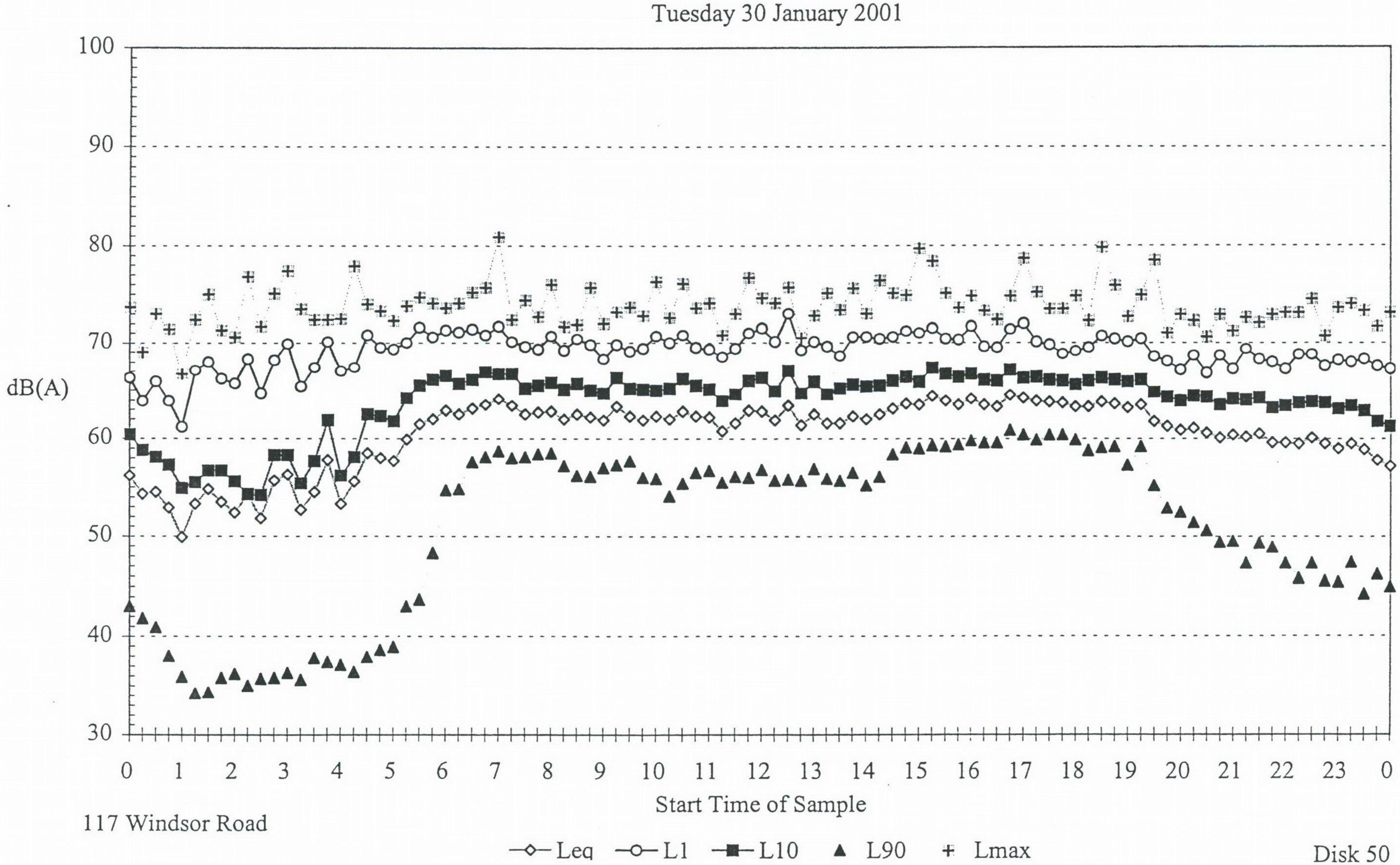

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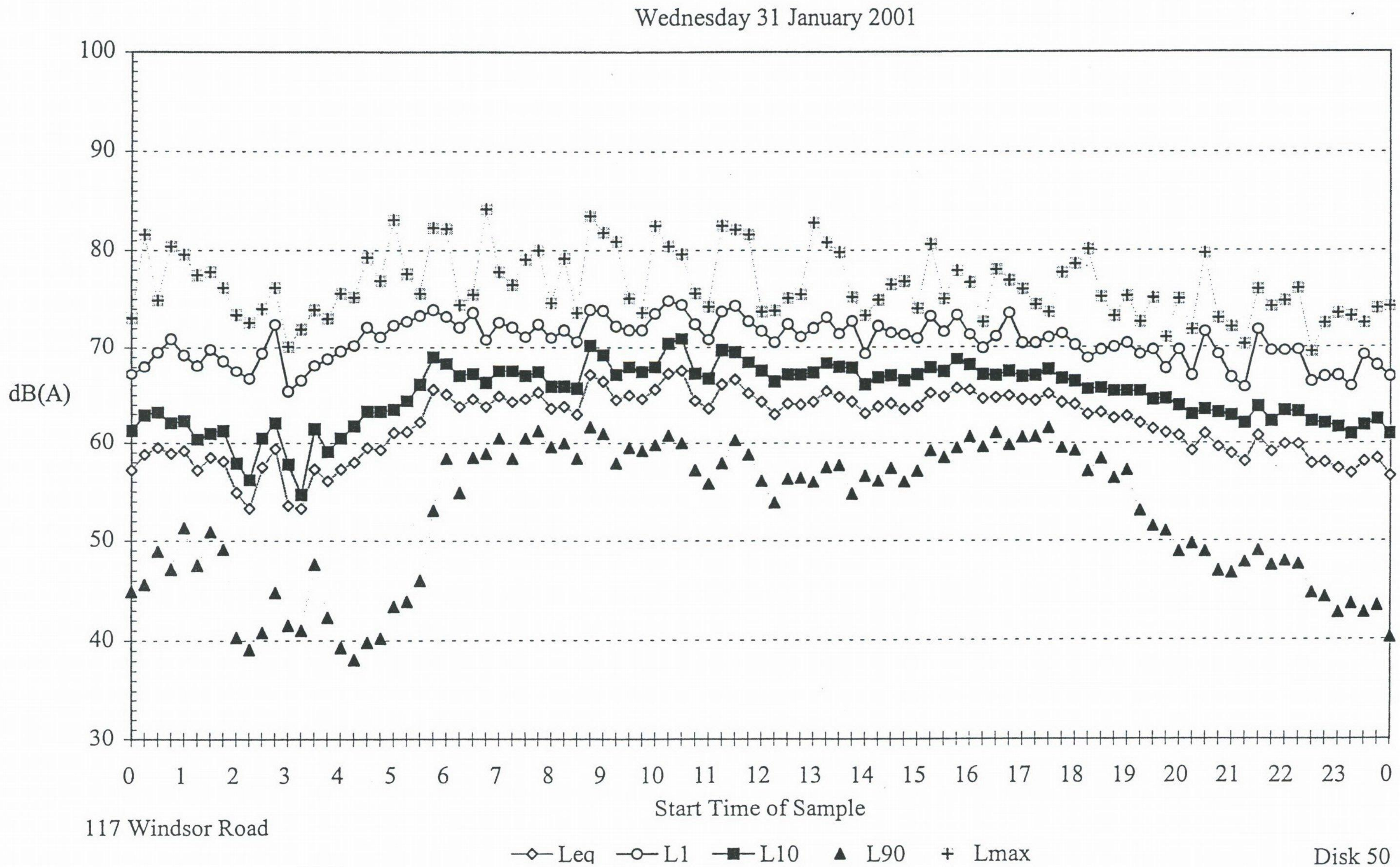

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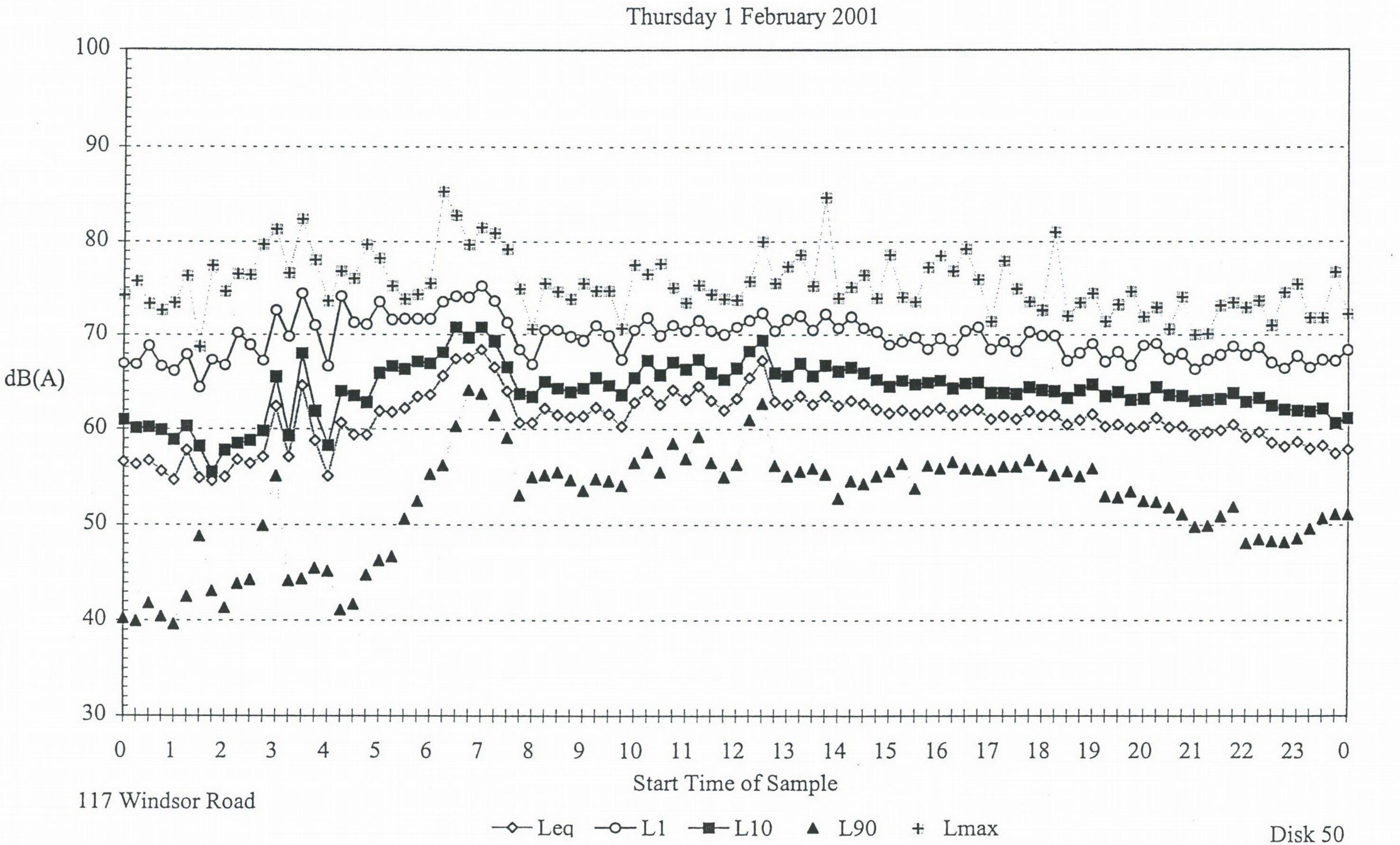

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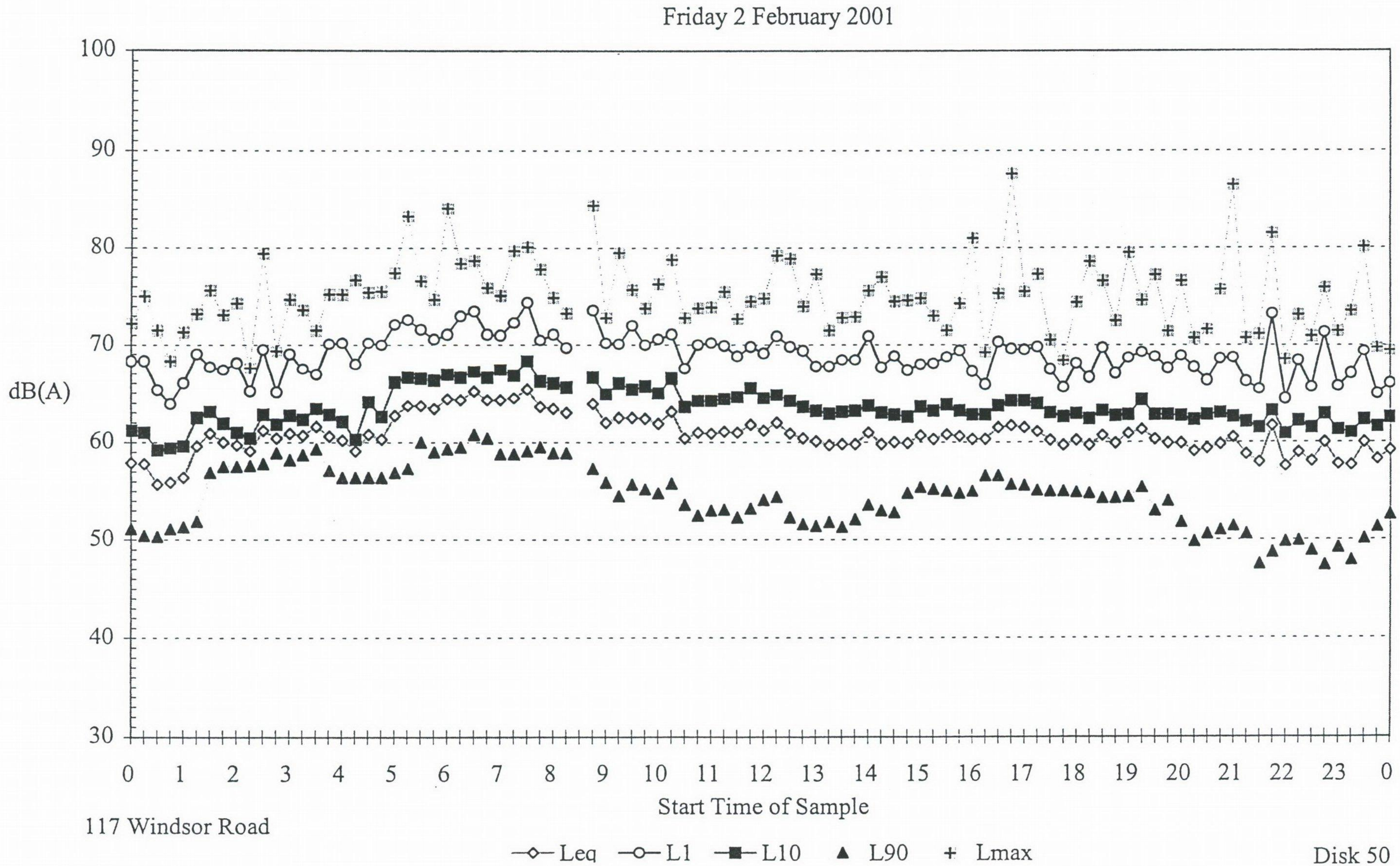

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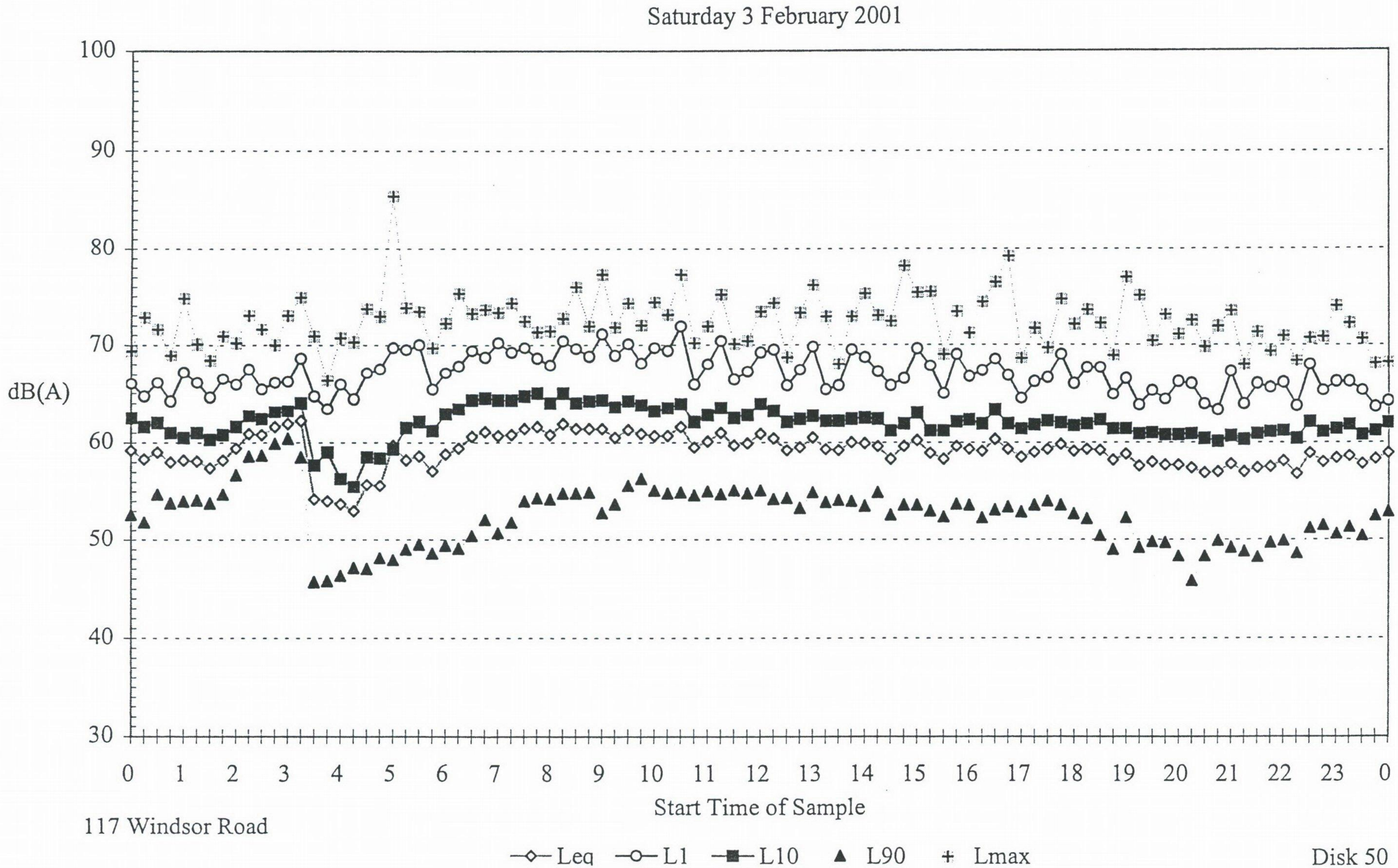

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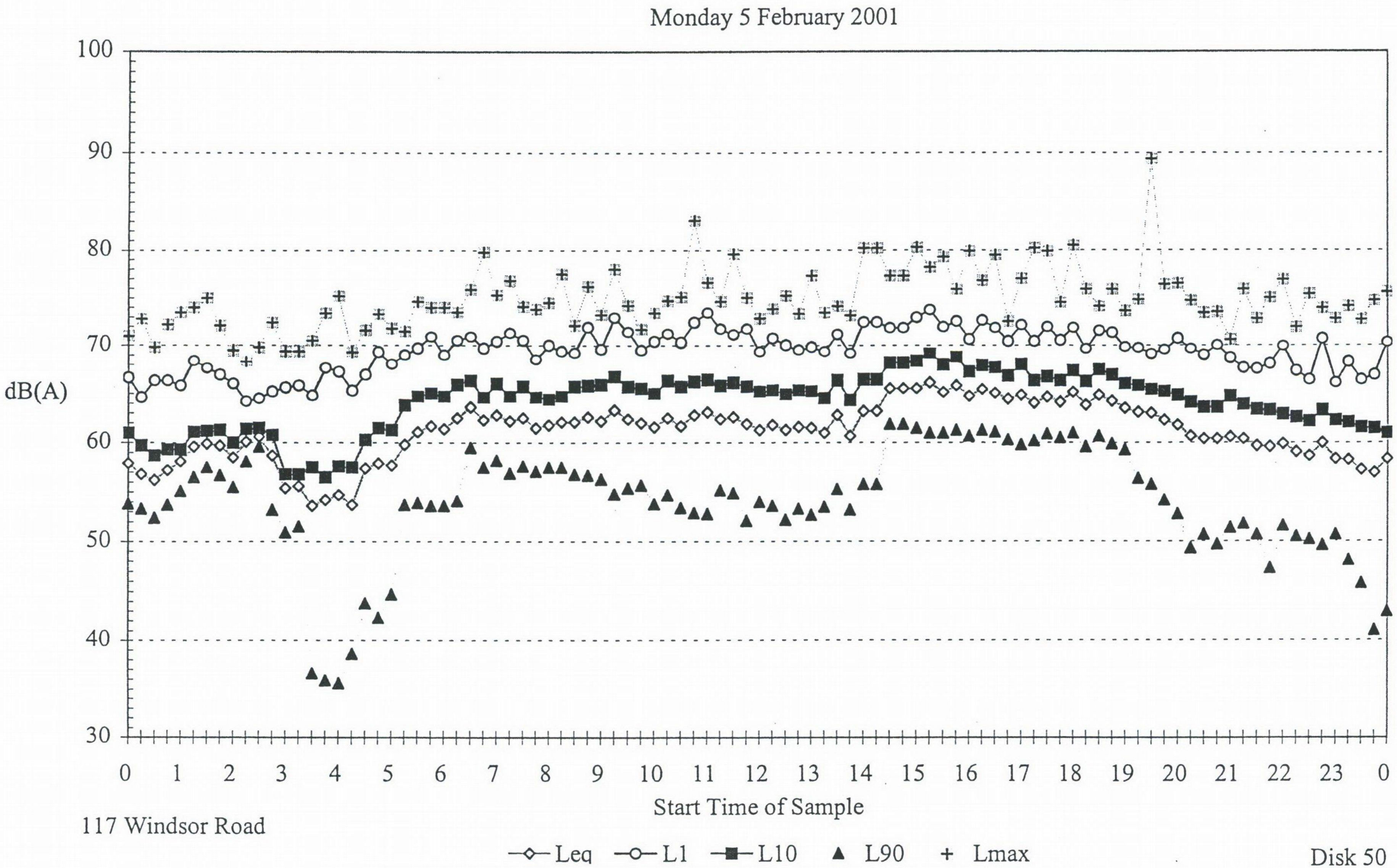
Ambient Sound Pressure Levels

5140r3b.xls

Ambient Sound Pressure Levels

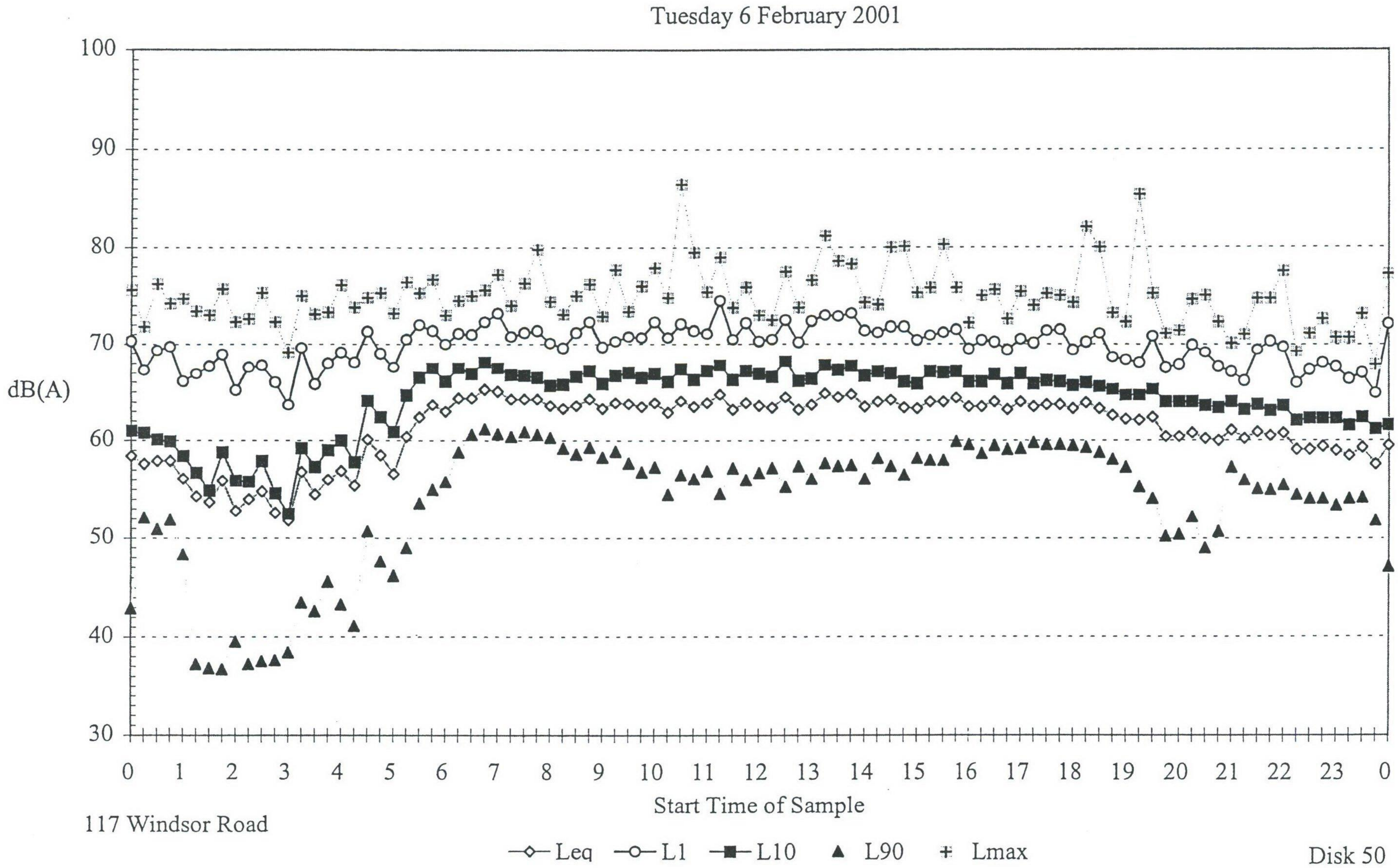


117 Windsor Road

Disk 50

5140r3b.xls

Ambient Sound Pressure Levels



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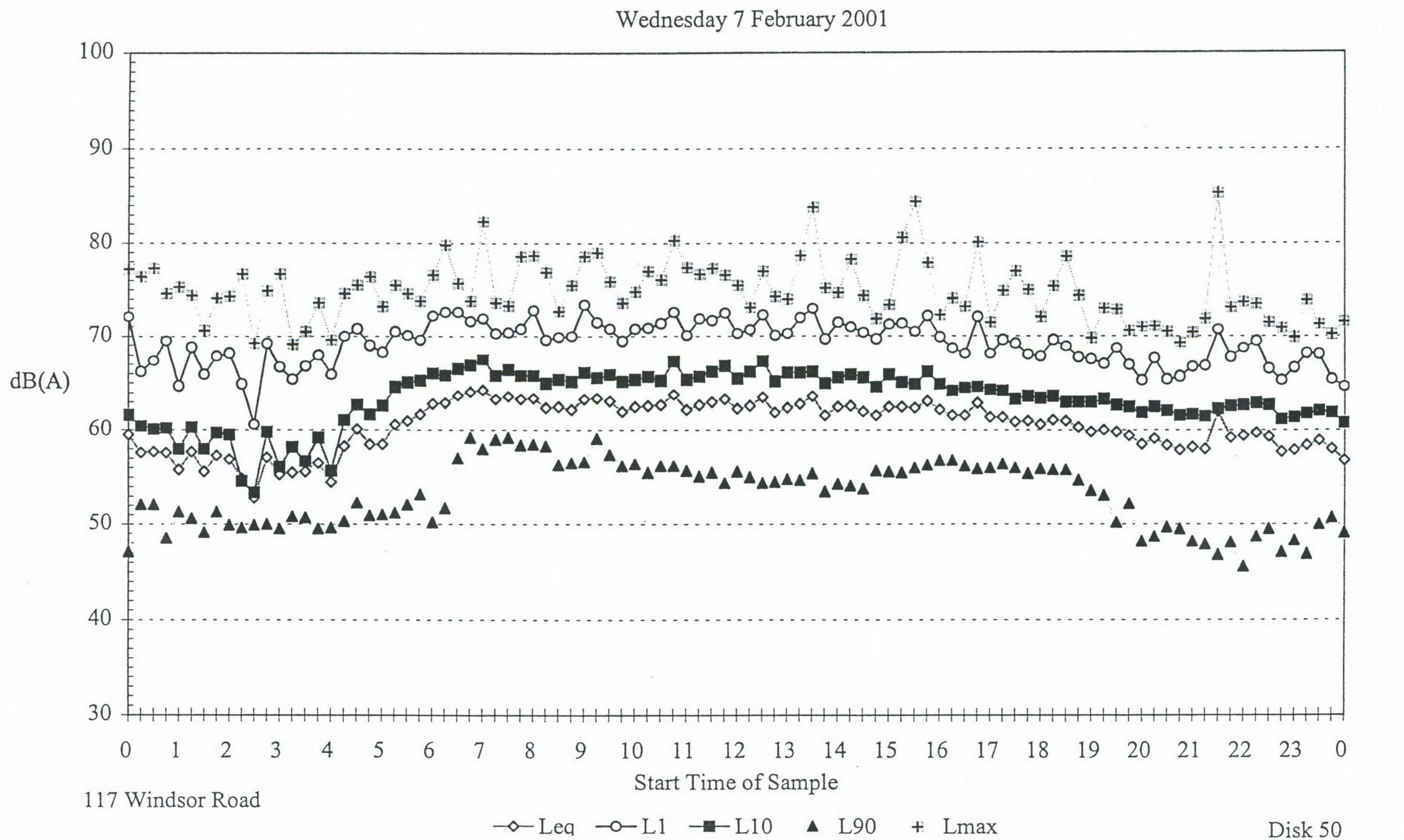
Ambient Sound Pressure Levels



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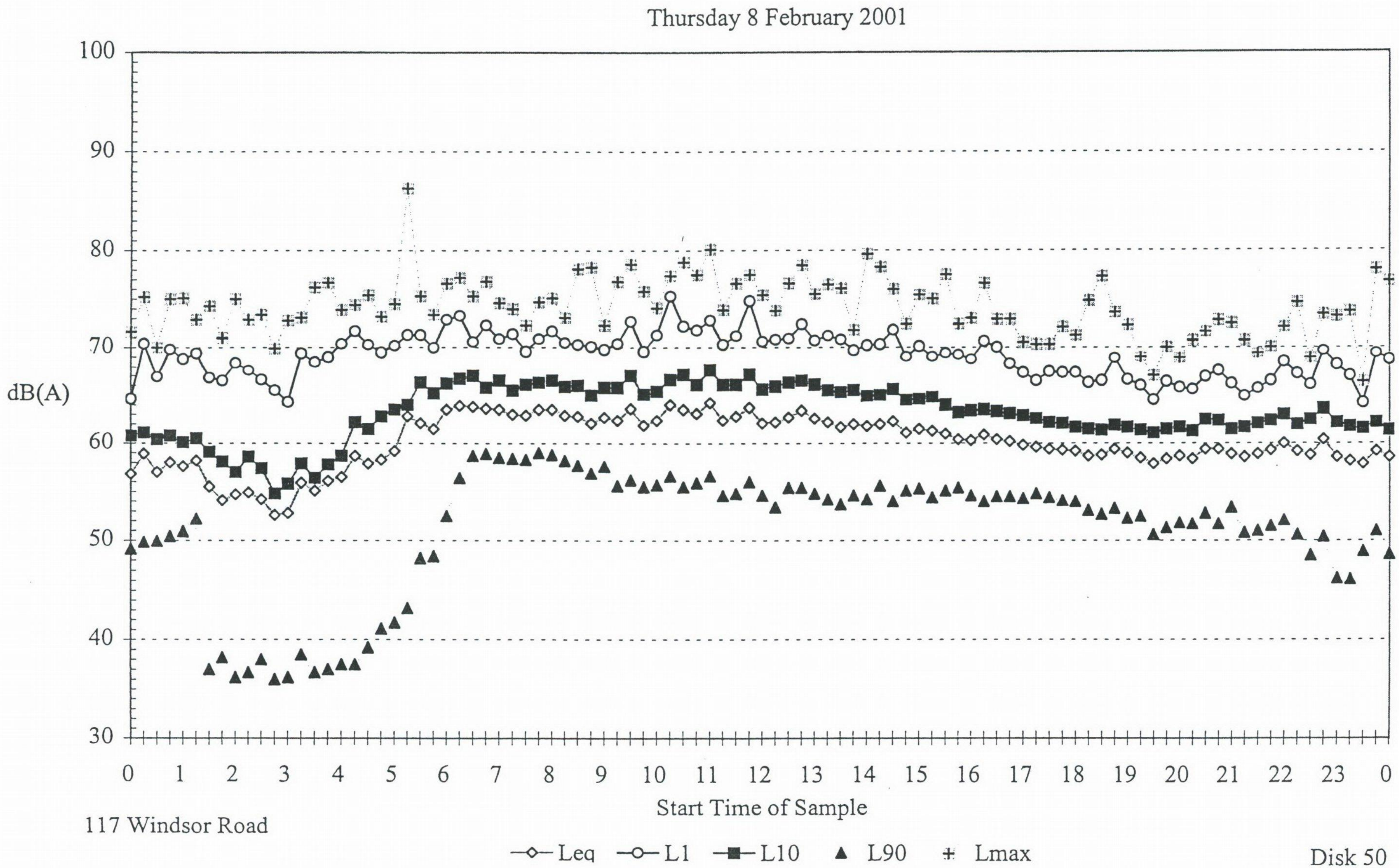
Ambient Sound Pressure Levels



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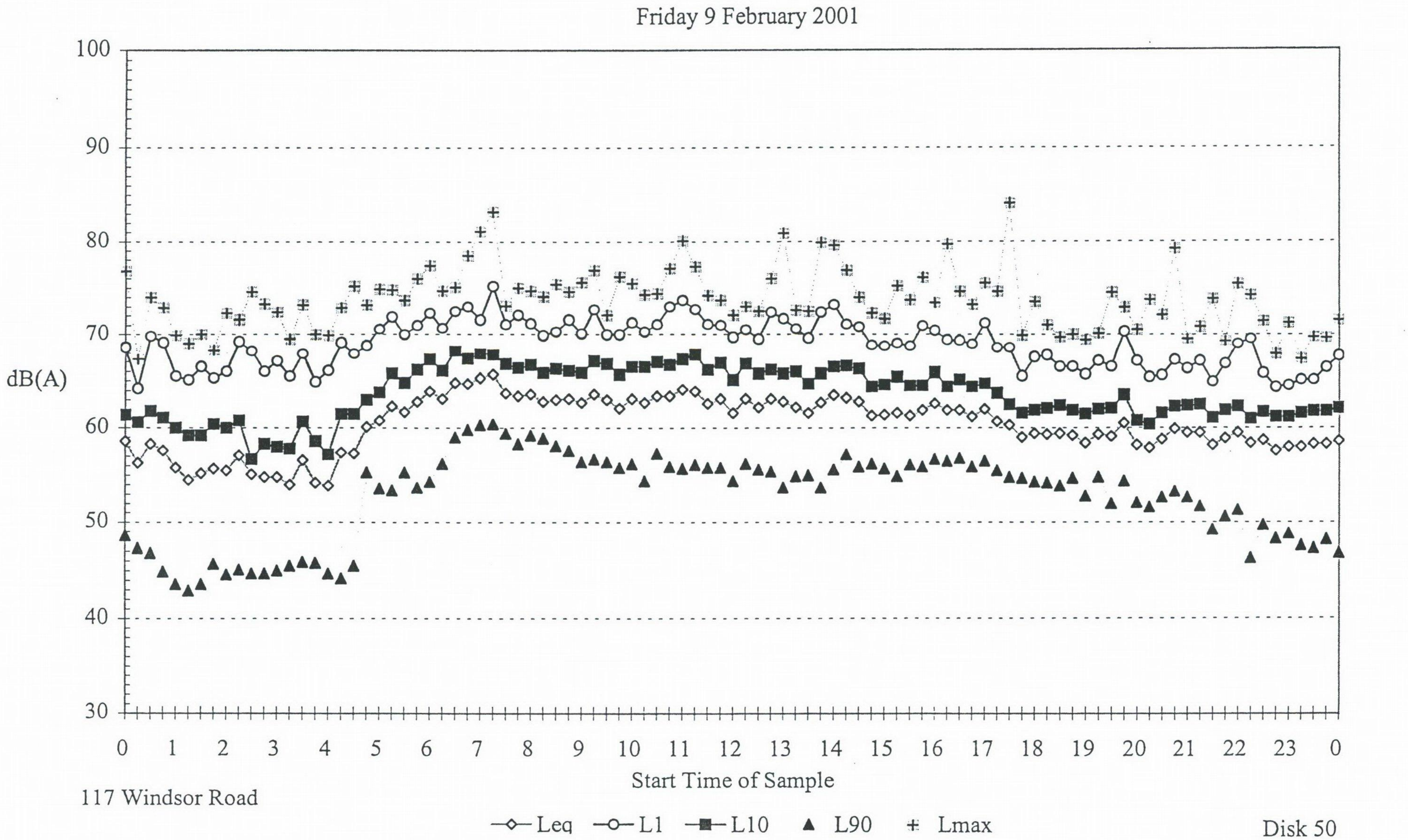
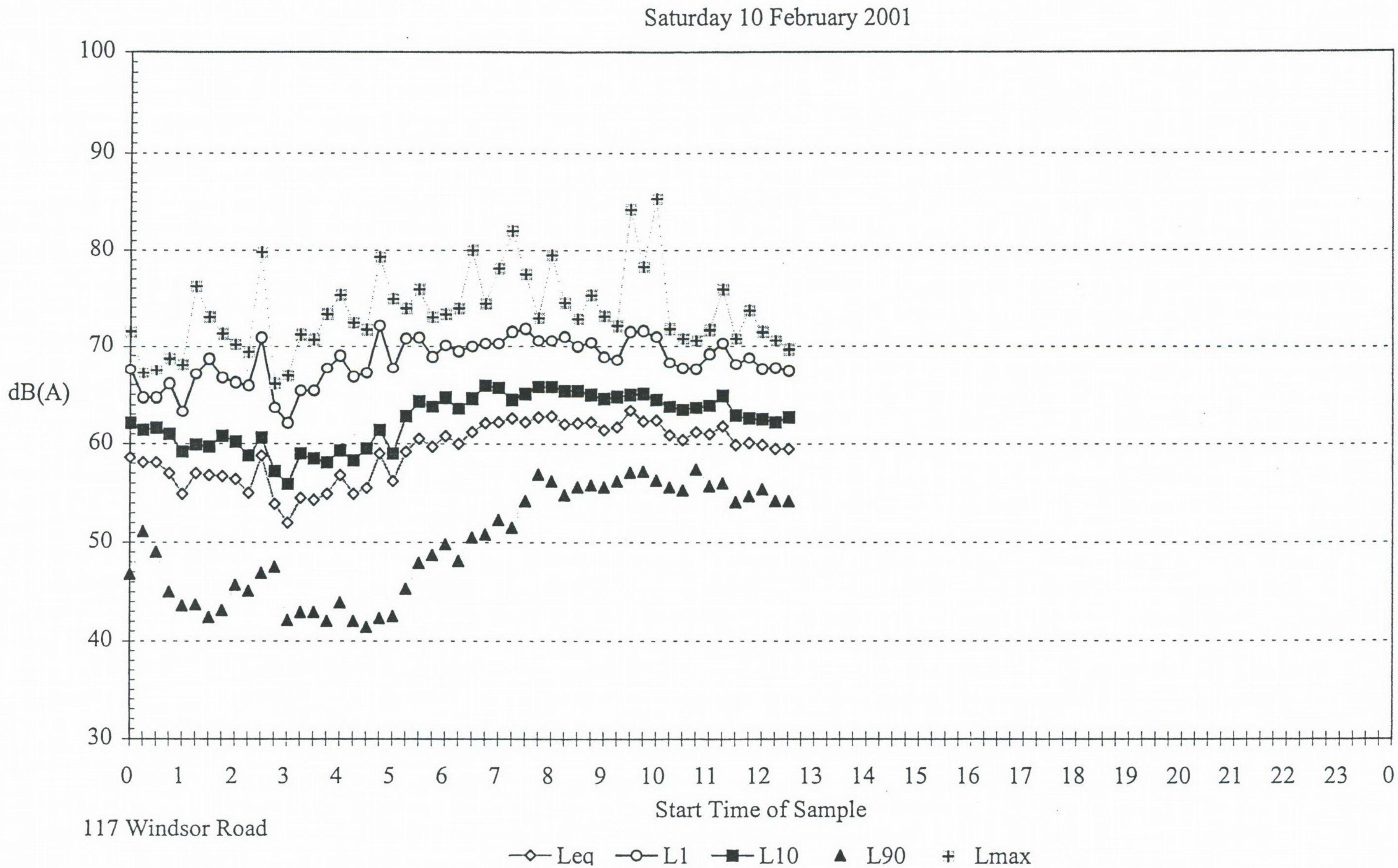
Ambient Sound Pressure Levels



5140r3b.xls

Ambient Sound Pressure Levels



5140r3b.xls

Appendix G: Cost Benefit Assessment

OWR/WR Upgrade Analysis

Economic Appraisal

The economic performance of the proposal was assessed to determine net road user benefits in accordance with the procedures set out in the RTA's Economic Analysis Manual.

Total capital costs for the project have been estimated at $31 million, which include construction costs, property acquisition, alterations to utilities, and includes allowances for items such as noise mitigation, landscaping, flora and fauna impact management treatments, erosion control and water pollution treatments during construction. Of this, $5.25 million has already been spent, and as a sunk cost has not been included in the analysis. Accordingly, only the remaining capital costs of $25.75 million have been included in the analysis.

The recurrent operation and maintenance (O&M) costs over the thirty-year project life have also been included. The RTA advises that they do not presently have the data to distinguish the maintenance costs for a new carriageway compared with an old carriageway approaching the end of its economic life. For simplicity, a flat rate of $10,400 per kilometre of carriageway per annum has been applied to the base case and the project case, based on estimates of total O&M costs provided by the RTA.

On the road user benefit side, estimates have been made of the three principal components of this benefit, namely:

- Travel time savings;
- Vehicle operating cost savings; and
- Accident cost savings.

Estimates for each component have been derived from network modelling statistics produced using the NETANAL transportation modelling system, undertaken by Transport and Traffic Planning Associates Pty Ltd. The dollar value of the benefits produced are based on the savings produced by the project relative to the base case in each year of the 30-year project life.

Standard discounted cash flow techniques were used to convert all cash flows over the project life to present values, and from these key indicators such as Benefit Cost Ratio (BCR), Net Present Value (NPV) and First Year Rate of Return (FYRR) were calculated, as summarised in Table 1. Complete spreadsheets for the road user benefit cost assessment are attached at Appendix A.

Table 1– Summary of Key Economic Indicators

INDICATOR	BCR	FYRR (%)	NPV ($million)
Median Case (7%)	2.0	46%	24
4% Discount Rate	2.5	44%	38
10% Discount Rate	1.7	47%	15
O&M Cost + 10%	2.0	46%	24
O&M Cost - 10%	2.0	46%	24
Construction + 10%	1.7	40%	20
Construction - 10%	2.4	54%	28

The principle outcome of the analysis is that the project produces benefits in excess of the remaining capital and O&M costs under all scenarios. However, the extent to which the BCR exceeds the RTA's corporate BCR target of 2.0 for new network development projects is sensitive to factors such as the discount rate and the capital costs. For example, under the 'median' scenario using a discount rate of 7%, the BCR is 2.0, but this rises to 2.5 when the discount rate is reduced to 4%. Maintaining a discount rate of 7%, the capital costs would need to drop by 10% to produce a BCR in excess of 2.0.

In summary, the project appears to be robust in terms of its economic efficiency with a BCR greater than 1.0 in all scenarios. However, the project appears to be marginal in terms of meeting the RTA's economic performance requirements.

Appendix A – Cost Assessment

PROJECT NAME: OLD WINDSOR ROAD WIDENING

Discount Rate 4%

DATE: 06/07/01

JOB NO: NS00625

GENERAL PARAMETER VALUES

EXPANSION FACTOR	1500
DISCOUNT RATE	4%
COST PARAMETERS	
VEHICLE OPERATING COST PER KM	$ 0.13
VALUE OF TIME PER VEH-HR	$ 13.52
ACCIDENT COSTS PER VEH-KM x 10^6	$ 42,500

PROJECT COST

	OPTION 1	OPTION 2	OPTION 3
COST ($M)	25.75	29.6	21.9

MAINTENANCE COST

	BASE	OPTION 1	OPTION 2	OPTION 3
COST ($M)	0.13	0.27	0.27	0.27

OUTPUT FROM NETANAL

	BASE		OPTION 1		OPTION 2		OPTION 3	
	2000	2011	2000	2011	2000	2011	2000	2011
TOTAL VEH-KM	11087177	12982537	11086508	12982524	11086508	12982524	11086508	12982524
TOTAL VEH-HRS	346727	433385	346190	433277	346190	433277	346190	433277
SPEED								

RESULTS OF ECONOMIC ANALYSIS

	30 YEARS			20 YEARS			10 YEARS			FYRR (%)	NET PRESENT VALUE
	BENEFIT ($M)	NPV ($M)	BCR	BENEFIT ($M)	NPV ($M)	BCR	BENEFIT ($M)	NPV ($M)	BCR		
OPTION 1	62.44	37.76	2.53	55.41	30.73	2.24	45.01	20.32	1.82	44%	24.68
OPTION 2	62.44	34.05	2.20	55.41	27.03	1.95	45.01	16.62	1.59	38%	28.38
OPTION 3	62.44	41.46	2.98	55.41	34.43	2.64	45.01	24.03	2.15	52%	20.98

OPTION 2 AND 3 TEST THE SENSITIVITY OF THE ANALYSIS BY CHANGING THE PROJECT COST. 15% IS ADDED FOR OPTION 2 AND 15% IS DEDUCTED FOR OPTION 3.

TWO-HOURLY COSTS ($M)

	BASE		OPTION 1		OPTION 2		OPTION 3	
	2000	2011	2000	2011	2000	2011	2000	2011
VEHICLE DISTANCE	1.4413	1.6877	1.4412	1.6877	1.4412	1.6877	1.4412	1.6877
VEHICLE TIME	4.6877	5.8594	4.6805	5.8579	4.6805	5.8579	4.6805	5.8579
ACCIDENTS	0.4712	0.5518	0.4712	0.5518	0.4712	0.5518	0.4712	0.5518
TOTAL ($M)	6.6003	8.0989	6.5929	8.0974	6.5929	8.0974	6.5929	8.0974
ANNUAL COSTS ($M)	9900.43	12148.28	9889.37	12146.09	9889.37	12146.09	9889.37	12146.09

BENEFIT YEARLY CASH FLOWS

YEAR	BASE		OPTION 1		OPTION 2		OPTION 3	
		DISCOUNTED		DISCOUNTED		DISCOUNTED		DISCOUNTED
2001	0	0	0	0	0		0	
2002	0	0	0	0	0		0	
2003	0	0	0	0	0		0	
2004	9901	8802	9890	8792	9890	8792	9890	8792
2005	10182	8703	10172	8695	10172	8695	10172	8695
2006	10463	8600	10454	8593	10454	8593	10454	8593
2007	10744	8491	10737	8485	10737	8485	10737	8485
2008	11025	8378	11019	8374	11019	8374	11019	8374
2009	11306	8261	11301	8258	11301	8258	11301	8258
2010	11587	8141	11584	8139	11584	8139	11584	8139
2011	11868	8018	11866	8016	11866	8016	11866	8016
2012	12148	7891	12146	7890	12146	7890	12146	7890
2013	12148	7588	12146	7587	12146	7587	12146	7587
2014	12148	7296	12146	7295	12146	7295	12146	7295
2015	12148	7015	12146	7014	12146	7014	12146	7014
2016	12148	6746	12146	6744	12146	6744	12146	6744
2017	12148	6486	12146	6485	12146	6485	12146	6485
2018	12148	6237	12146	6236	12146	6236	12146	6236
2019	12148	5997	12146	5996	12146	5996	12146	5996
2020	12148	5766	12146	5765	12146	5765	12146	5765
2021	12148	5544	12146	5543	12146	5543	12146	5543
2022	12148	5331	12146	5330	12146	5330	12146	5330
2023	12148	5126	12146	5125	12146	5125	12146	5125
2024	12148	4929	12146	4928	12146	4928	12146	4928
2025	12148	4739	12146	4739	12146	4739	12146	4739
2026	12148	4557	12146	4556	12146	4556	12146	4556
2027	12148	4382	12146	4381	12146	4381	12146	4381
2028	12148	4213	12146	4213	12146	4213	12146	4213
2029	12148	4051	12146	4051	12146	4051	12146	4051
2030	12148	3895	12146	3895	12146	3895	12146	3895
2031	12148	3746	12146	3745	12146	3745	12146	3745
2032	12148	3602	12146	3601	12146	3601	12146	3601
2033	12148	3463	12146	3462	12146	3462	12146	3462
2034	12148	3330	12146	3329	12146	3329	12146	3329
10 YEAR TOTAL		82873		82828		82828		82828
20 YEAR TOTAL		144417		144362		144362		144362
30 YEAR TOTAL		185995		185932		185932		185932

BENEFIT ($M)

10 YEARS				45		45		45
20 YEARS				55		55		55
30 YEARS				62		62		62

PROJECT YEARLY CASH FLOWS

	OPTION 1		OPTION 2		OPTION 3	
		DISCOUNTED		DISCOUNTED		DISCOUNTED
2001	3.25	3.25	3.74	3.74	2.76	2.76
2002	17.00	16.35	19.55	18.80	14.45	13.89
2003	5.50	5.09	6.33	5.85	4.68	4.32

COST BENEFIT ANALYSIS

PROJECT NAME: OLD WINDSOR ROAD WIDENING

Discount Rate 7%

DATE: 06/07/01

JOB NO: NS00625

GENERAL PARAMETER VALUES

EXPANSION FACTOR	1500
DISCOUNT RATE	7%
COST PARAMETERS	
VEHICLE OPERATING COST PER KM	$ 0.13
VALUE OF TIME PER VEH-HR	$ 13.52
ACCIDENT COSTS PER VEH-KM x 10^6	$ 42,500

PROJECT COST

	OPTION 1	OPTION 2	OPTION 3
COST ($M)	25.75	29.6	21.9

MAINTENANCE COST

	BASE	OPTION 1	OPTION 2	OPTION 3
COST ($M)	0.13	0.27	0.27	0.27

OUTPUT FROM NETANAL

	BASE		OPTION 1		OPTION 2		OPTION 3	
	2000	2011	2000	2011	2000	2011	2000	2011
TOTAL VEH-KM	11087177	12982537	11086508	12982524	11086508	12982524	11086508	12982524
TOTAL VEH-HRS	346727	433385	346190	433277	346190	433277	346190	433277
SPEED								

RESULTS OF ECONOMIC ANALYSIS

	30 YEARS			20 YEARS			10 YEARS			FYRR (%)	NET PRESENT VALUE
	BENEFIT ($M)	NPV ($M)	BCR	BENEFIT ($M)	NPV ($M)	BCR	BENEFIT ($M)	NPV ($M)	BCR		
OPTION 1	48.03	24.08	2.01	44.77	20.83	1.87	38.37	14.42	1.60	46%	23.94
OPTION 2	48.03	20.49	1.74	44.77	17.24	1.63	38.37	10.83	1.39	40%	27.53
OPTION 3	48.03	27.68	2.36	44.77	24.42	2.20	38.37	18.02	1.89	54%	20.35

OPTION 2 AND 3 TEST THE SENSITIVITY OF THE ANALYSIS BY CHANGING THE PROJECT COST. 15% IS ADDED FOR OPTION 2 AND 15% IS DEDUCTED FOR OPTION 3.

COST BENEFIT ANALYSIS

TWO-HOURLY COSTS ($M)

	BASE		OPTION 1		OPTION 2		OPTION 3	
	2000	2011	2000	2011	2000	2011	2000	2011
VEHICLE DISTANCE	1.4413	1.6877	1.4412	1.6877	1.4412	1.6877	1.4412	1.6877
VEHICLE TIME	4.6877	5.8594	4.6805	5.8579	4.6805	5.8579	4.6805	5.8579
ACCIDENTS	0.4712	0.5518	0.4712	0.5518	0.4712	0.5518	0.4712	0.5518
TOTAL ($M)	6.6003	8.0989	6.5929	8.0974	6.5929	8.0974	6.5929	8.0974
ANNUAL COSTS ($M)	9900.43	12148.28	9889.37	12146.09	9889.37	12146.09	9889.37	12146.09

BENEFIT YEARLY CASH FLOWS

YEAR	BASE		OPTION 1		OPTION 2		OPTION 3	
		DISCOUNTED		DISCOUNTED		DISCOUNTED		DISCOUNTED
2001	0	0	0	0	0		0	
2002	0	0	0	0	0		0	
2003	0	0	0	0	0		0	
2004	9901	8082	9890	8073	9890	8073	9890	8073
2005	10182	7768	10172	7760	10172	7760	10172	7760
2006	10463	7460	10454	7454	10454	7454	10454	7454
2007	10744	7159	10737	7154	10737	7154	10737	7154
2008	11025	6866	11019	6862	11019	6862	11019	6862
2009	11306	6580	11301	6578	11301	6578	11301	6578
2010	11587	6303	11584	6301	11584	6301	11584	6301
2011	11868	6033	11866	6032	11866	6032	11866	6032
2012	12148	5772	12146	5771	12146	5771	12146	5771
2013	12148	5394	12146	5393	12146	5393	12146	5393
2014	12148	5041	12146	5040	12146	5040	12146	5040
2015	12148	4711	12146	4711	12146	4711	12146	4711
2016	12148	4403	12146	4402	12146	4402	12146	4402
2017	12148	4115	12146	4114	12146	4114	12146	4114
2018	12148	3846	12146	3845	12146	3845	12146	3845
2019	12148	3594	12146	3594	12146	3594	12146	3594
2020	12148	3359	12146	3359	12146	3359	12146	3359
2021	12148	3139	12146	3139	12146	3139	12146	3139
2022	12148	2934	12146	2934	12146	2934	12146	2934
2023	12148	2742	12146	2742	12146	2742	12146	2742
2024	12148	2563	12146	2562	12146	2562	12146	2562
2025	12148	2395	12146	2395	12146	2395	12146	2395
2026	12148	2238	12146	2238	12146	2238	12146	2238
2027	12148	2092	12146	2092	12146	2092	12146	2092
2028	12148	1955	12146	1955	12146	1955	12146	1955
2029	12148	1827	12146	1827	12146	1827	12146	1827
2030	12148	1708	12146	1707	12146	1707	12146	1707
2031	12148	1596	12146	1596	12146	1596	12146	1596
2032	12148	1491	12146	1491	12146	1491	12146	1491
2033	12148	1394	12146	1394	12146	1394	12146	1394
2034	12148	1303	12146	1303	12146	1303	12146	1303
10 YEAR TOTAL		67416		67378		67378		67378
20 YEAR TOTAL		105301		105257		105257		105257
30 YEAR TOTAL		124560		124512		124512		124512

BENEFIT ($M)

10 YEARS				38		38		38
20 YEARS				45		45		45
30 YEARS				48		48		48

PROJECT YEARLY CASH FLOWS

	OPTION 1		OPTION 2		OPTION 3	
		DISCOUNTED		DISCOUNTED		DISCOUNTED
2001	3.25	3.25	3.74	3.74	2.76	2.76
2002	17.00	15.89	19.55	18.27	14.45	13.50
2003	5.50	4.80	6.33	5.52	4.68	4.08

PROJECT NAME: OLD WINDSOR ROAD WIDENING
Discount Rate 10%

DATE: 06/07/01
JOB NO: NS00625

GENERAL PARAMETER VALUES

EXPANSION FACTOR	1500
DISCOUNT RATE	10%
COST PARAMETERS	
VEHICLE OPERATING COST PER KM	$ 0.13
VALUE OF TIME PER VEH-HR	$ 13.52
ACCIDENT COSTS PER VEH-KM x 10^6	$ 42,500

PROJECT COST

	OPTION 1	OPTION 2	OPTION 3
COST ($M)	25.75	29.6	21.9

MAINTENANCE COST

	BASE	OPTION 1	OPTION 2	OPTION 3
COST ($M)	0.13	0.27	0.27	0.27

OUTPUT FROM NETANAL

	BASE		OPTION 1		OPTION 2		OPTION 3	
	2000	2011	2000	2011	2000	2011	2000	2011
TOTAL VEH-KM	11087177	12982537	11086508	12982524	11086508	12982524	11086508	12982524
TOTAL VEH-HRS	346727	433385	346190	433277	346190	433277	346190	433277
SPEED								

RESULTS OF ECONOMIC ANALYSIS

	30 YEARS			20 YEARS			10 YEARS			FYRR (%)	NET PRESENT VALUE
	BENEFIT ($M)	NPV ($M)	BCR	BENEFIT ($M)	NPV ($M)	BCR	BENEFIT ($M)	NPV ($M)	BCR		
OPTION 1	38.57	15.32	1.66	37.01	13.76	1.59	32.99	9.74	1.42	47%	23.25
OPTION 2	38.57	11.83	1.44	37.01	10.28	1.38	32.99	6.26	1.23	41%	26.74
OPTION 3	38.57	18.80	1.95	37.01	17.25	1.87	32.99	13.23	1.67	55%	19.76

OPTION 2 AND 3 TEST THE SENSITIVITY OF THE ANALYSIS BY CHANGING THE PROJECT COST. 15% IS ADDED FOR OPTION 2 AND 15% IS DEDUCTED FOR OPTION 3.

TWO-HOURLY COSTS ($M)

	BASE		OPTION 1		OPTION 2		OPTION 3	
	2000	2011	2000	2011	2000	2011	2000	2011
VEHICLE DISTANCE	1.4413	1.6877	1.4412	1.6877	1.4412	1.6877	1.4412	1.6877
VEHICLE TIME	4.6877	5.8594	4.6805	5.8579	4.6805	5.8579	4.6805	5.8579
ACCIDENTS	0.4712	0.5518	0.4712	0.5518	0.4712	0.5518	0.4712	0.5518
TOTAL ($M)	6.6003	8.0989	6.5929	8.0974	6.5929	8.0974	6.5929	8.0974
ANNUAL COSTS ($M)	9900.43	12148.28	9889.37	12146.09	9889.37	12146.09	9889.37	12146.09

BENEFIT YEARLY CASH FLOWS

YEAR	BASE		OPTION 1		OPTION 2		OPTION 3	
		DISCOUNTED		DISCOUNTED		DISCOUNTED		DISCOUNTED
2001	0	0	0	0	0		0	
2002	0	0	0	0	0		0	
2003	0	0	0	0	0		0	
2004	9901	7438	9890	7430	9890	7430	9890	7430
2005	10182	6954	10172	6948	10172	6948	10172	6948
2006	10463	6497	10454	6491	10454	6491	10454	6491
2007	10744	6065	10737	6061	10737	6061	10737	6061
2008	11025	5658	11019	5655	11019	5655	11019	5655
2009	11306	5274	11301	5272	11301	5272	11301	5272
2010	11587	4914	11584	4913	11584	4913	11584	4913
2011	11868	4576	11866	4575	11866	4575	11866	4575
2012	12148	4258	12146	4257	12146	4257	12146	4257
2013	12148	3871	12146	3870	12146	3870	12146	3870
2014	12148	3519	12146	3518	12146	3518	12146	3518
2015	12148	3199	12146	3199	12146	3199	12146	3199
2016	12148	2908	12146	2908	12146	2908	12146	2908
2017	12148	2644	12146	2643	12146	2643	12146	2643
2018	12148	2403	12146	2403	12146	2403	12146	2403
2019	12148	2185	12146	2185	12146	2185	12146	2185
2020	12148	1986	12146	1986	12146	1986	12146	1986
2021	12148	1806	12146	1805	12146	1805	12146	1805
2022	12148	1642	12146	1641	12146	1641	12146	1641
2023	12148	1492	12146	1492	12146	1492	12146	1492
2024	12148	1357	12146	1356	12146	1356	12146	1356
2025	12148	1233	12146	1233	12146	1233	12146	1233
2026	12148	1121	12146	1121	12146	1121	12146	1121
2027	12148	1019	12146	1019	12146	1019	12146	1019
2028	12148	927	12146	926	12146	926	12146	926
2029	12148	842	12146	842	12146	842	12146	842
2030	12148	766	12146	766	12146	766	12146	766
2031	12148	696	12146	696	12146	696	12146	696
2032	12148	633	12146	633	12146	633	12146	633
2033	12148	575	12146	575	12146	575	12146	575
2034	12148	523	12146	523	12146	523	12146	523
10 YEAR TOTAL		55505		55472		55472		55472
20 YEAR TOTAL		79289		79252		79252		79252
30 YEAR TOTAL		88459		88421		88421		88421

BENEFIT ($M)

10 YEARS				33		33		33
20 YEARS				37		37		37
30 YEARS				39		39		39

PROJECT YEARLY CASH FLOWS

	OPTION 1		OPTION 2		OPTION 3	
		DISCOUNTED		DISCOUNTED		DISCOUNTED
2001	3.25	3.25	3.74	3.74	2.76	2.76
2002	17.00	15.45	19.55	17.77	14.45	13.14
2003	5.50	4.55	6.33	5.23	4.68	3.86

PROJECT NAME: OLD WINDSOR ROAD WIDENING

O&M Cost + 10%

DATE: 06/07/01

JOB NO: NS00625

GENERAL PARAMETER VALUES

EXPANSION FACTOR	1500
DISCOUNT RATE	7%
COST PARAMETERS	
VEHICLE OPERATING COST PER KM	$ 0.13
VALUE OF TIME PER VEH-HR	$ 13.52
ACCIDENT COSTS PER VEH-KM x 10^6	$ 42,500

PROJECT COST

	OPTION 1	OPTION 2	OPTION 3
COST ($M)	25.75	29.6	21.9

MAINTENANCE COST

	BASE	OPTION 1	OPTION 2	OPTION 3
COST ($M)	0.14	0.27	0.27	0.27

OUTPUT FROM NETANAL

	BASE		OPTION 1		OPTION 2		OPTION 3	
	2000	2011	2000	2011	2000	2011	2000	2011
TOTAL VEH-KM	11087177	12982537	11086508	12982524	11086508	12982524	11086508	12982524
TOTAL VEH-HRS	346727	433385	346190	433277	346190	433277	346190	433277
SPEED								

RESULTS OF ECONOMIC ANALYSIS

	30 YEARS			20 YEARS			10 YEARS			FYRR (%)	NET PRESENT VALUE
	BENEFIT ($M)	NPV ($M)	BCR	BENEFIT ($M)	NPV ($M)	BCR	BENEFIT ($M)	NPV ($M)	BCR		
OPTION 1	48.30	24.36	2.02	45.03	21.09	1.88	38.59	14.65	1.61	46%	23.94
OPTION 2	48.30	20.77	1.75	45.03	17.49	1.64	38.59	11.06	1.40	40%	27.53
OPTION 3	48.30	27.95	2.37	45.03	24.68	2.21	38.59	18.24	1.90	54%	20.35

OPTION 2 AND 3 TEST THE SENSITIVITY OF THE ANALYSIS BY CHANGING THE PROJECT COST. 15% IS ADDED FOR OPTION 2 AND 15% IS DEDUCTED FOR OPTION 3.

TWO-HOURLY COSTS ($M)

	BASE		OPTION 1		OPTION 2		OPTION 3	
	2000	2011	2000	2011	2000	2011	2000	2011
VEHICLE DISTANCE	1.4413	1.6877	1.4412	1.6877	1.4412	1.6877	1.4412	1.6877
VEHICLE TIME	4.6877	5.8594	4.6805	5.8579	4.6805	5.8579	4.6805	5.8579
ACCIDENTS	0.4712	0.5518	0.4712	0.5518	0.4712	0.5518	0.4712	0.5518
TOTAL ($M)	6.6003	8.0989	6.5929	8.0974	6.5929	8.0974	6.5929	8.0974
ANNUAL COSTS ($M)	9900.43	12148.28	9889.37	12146.09	9889.37	12146.09	9889.37	12146.09

BENEFIT YEARLY CASH FLOWS

YEAR	BASE		OPTION 1		OPTION 2		OPTION 3	
		DISCOUNTED		DISCOUNTED		DISCOUNTED		DISCOUNTED
2001	0	0	0	0	0		0	
2002	0	0	0	0	0		0	
2003	0	0	0	0	0		0	
2004	9901	8082	9890	8073	9890	8073	9890	8073
2005	10182	7768	10172	7760	10172	7760	10172	7760
2006	10463	7460	10454	7454	10454	7454	10454	7454
2007	10744	7159	10737	7154	10737	7154	10737	7154
2008	11025	6866	11019	6862	11019	6862	11019	6862
2009	11306	6580	11301	6578	11301	6578	11301	6578
2010	11587	6303	11584	6301	11584	6301	11584	6301
2011	11868	6033	11866	6032	11866	6032	11866	6032
2012	12148	5772	12146	5771	12146	5771	12146	5771
2013	12148	5394	12146	5393	12146	5393	12146	5393
2014	12148	5041	12146	5040	12146	5040	12146	5040
2015	12148	4711	12146	4711	12146	4711	12146	4711
2016	12148	4403	12146	4402	12146	4402	12146	4402
2017	12148	4115	12146	4114	12146	4114	12146	4114
2018	12148	3846	12146	3845	12146	3845	12146	3845
2019	12148	3594	12146	3594	12146	3594	12146	3594
2020	12148	3359	12146	3359	12146	3359	12146	3359
2021	12148	3139	12146	3139	12146	3139	12146	3139
2022	12148	2934	12146	2934	12146	2934	12146	2934
2023	12148	2742	12146	2742	12146	2742	12146	2742
2024	12148	2563	12146	2562	12146	2562	12146	2562
2025	12148	2395	12146	2395	12146	2395	12146	2395
2026	12148	2238	12146	2238	12146	2238	12146	2238
2027	12148	2092	12146	2092	12146	2092	12146	2092
2028	12148	1955	12146	1955	12146	1955	12146	1955
2029	12148	1827	12146	1827	12146	1827	12146	1827
2030	12148	1708	12146	1707	12146	1707	12146	1707
2031	12148	1596	12146	1596	12146	1596	12146	1596
2032	12148	1491	12146	1491	12146	1491	12146	1491
2033	12148	1394	12146	1394	12146	1394	12146	1394
2034	12148	1303	12146	1303	12146	1303	12146	1303
10 YEAR TOTAL		67416		67378		67378		67378
20 YEAR TOTAL		105302		105257		105257		105257
30 YEAR TOTAL		124561		124512		124512		124512

BENEFIT ($M)

10 YEARS				39		39		39
20 YEARS				45		45		45
30 YEARS				48		48		48

PROJECT YEARLY CASH FLOWS

	OPTION 1		OPTION 2		OPTION 3	
		DISCOUNTED		DISCOUNTED		DISCOUNTED
2001	3.25	3.25	3.74	3.74	2.76	2.76
2002	17.00	15.89	19.55	18.27	14.45	13.50
2003	5.50	4.80	6.33	5.52	4.68	4.08

PROJECT NAME: OLD WINDSOR ROAD WIDENING

O&M Cost - 10%

DATE: 06/07/01

JOB NO: NS00625

GENERAL PARAMETER VALUES

EXPANSION FACTOR	1500
DISCOUNT RATE	7%
COST PARAMETERS	
VEHICLE OPERATING COST PER KM	$ 0.13
VALUE OF TIME PER VEH-HR	$ 13.52
ACCIDENT COSTS PER VEH-KM x 10^6	$ 42,500

PROJECT COST

	OPTION 1	OPTION 2	OPTION 3
COST ($M)	25.75	29.6	21.9

MAINTENANCE COST

	BASE	OPTION 1	OPTION 2	OPTION 3
COST ($M)	0.12	0.27	0.27	0.27

OUTPUT FROM NETANAL

	BASE		OPTION 1		OPTION 2		OPTION 3	
	2000	2011	2000	2011	2000	2011	2000	2011
TOTAL VEH-KM	11087177	12982537	11086508	12982524	11086508	12982524	11086508	12982524
TOTAL VEH-HRS	346727	433385	346190	433277	346190	433277	346190	433277
SPEED								

RESULTS OF ECONOMIC ANALYSIS

	30 YEARS			20 YEARS			10 YEARS			FYRR (%)	NET PRESENT VALUE
	BENEFIT ($M)	NPV ($M)	BCR	BENEFIT ($M)	NPV ($M)	BCR	BENEFIT ($M)	NPV ($M)	BCR		
OPTION 1	47.75	23.81	1.99	44.51	20.57	1.86	38.14	14.20	1.59	46%	23.94
OPTION 2	47.75	20.22	1.73	44.51	16.98	1.62	38.14	10.61	1.39	40%	27.53
OPTION 3	47.75	27.40	2.35	44.51	24.16	2.19	38.14	17.79	1.87	54%	20.35

OPTION 2 AND 3 TEST THE SENSITIVITY OF THE ANALYSIS BY CHANGING THE PROJECT COST. 15% IS ADDED FOR OPTION 2 AND 15% IS DEDUCTED FOR OPTION 3.

TWO-HOURLY COSTS ($M)

	BASE		OPTION 1		OPTION 2		OPTION 3	
	2000	2011	2000	2011	2000	2011	2000	2011
VEHICLE DISTANCE	1.4413	1.6877	1.4412	1.6877	1.4412	1.6877	1.4412	1.6877
VEHICLE TIME	4.6877	5.8594	4.6805	5.8579	4.6805	5.8579	4.6805	5.8579
ACCIDENTS	0.4712	0.5518	0.4712	0.5518	0.4712	0.5518	0.4712	0.5518
TOTAL ($M)	6.6003	8.0989	6.5929	8.0974	6.5929	8.0974	6.5929	8.0974
ANNUAL COSTS ($M)	9900.43	12148.28	9889.37	12146.09	9889.37	12146.09	9889.37	12146.09

BENEFIT YEARLY CASH FLOWS

YEAR	BASE		OPTION 1		OPTION 2		OPTION 3	
		DISCOUNTED		DISCOUNTED		DISCOUNTED		DISCOUNTED
2001	0	0	0	0	0		0	
2002	0	0	0	0	0		0	
2003	0	0	0	0	0		0	
2004	9901	8082	9890	8073	9890	8073	9890	8073
2005	10182	7768	10172	7760	10172	7760	10172	7760
2006	10463	7460	10454	7454	10454	7454	10454	7454
2007	10744	7159	10737	7154	10737	7154	10737	7154
2008	11025	6866	11019	6862	11019	6862	11019	6862
2009	11306	6580	11301	6578	11301	6578	11301	6578
2010	11587	6303	11584	6301	11584	6301	11584	6301
2011	11868	6033	11866	6032	11866	6032	11866	6032
2012	12148	5772	12146	5771	12146	5771	12146	5771
2013	12148	5394	12146	5393	12146	5393	12146	5393
2014	12148	5041	12146	5040	12146	5040	12146	5040
2015	12148	4711	12146	4711	12146	4711	12146	4711
2016	12148	4403	12146	4402	12146	4402	12146	4402
2017	12148	4115	12146	4114	12146	4114	12146	4114
2018	12148	3846	12146	3845	12146	3845	12146	3845
2019	12148	3594	12146	3594	12146	3594	12146	3594
2020	12148	3359	12146	3359	12146	3359	12146	3359
2021	12148	3139	12146	3139	12146	3139	12146	3139
2022	12148	2934	12146	2934	12146	2934	12146	2934
2023	12148	2742	12146	2742	12146	2742	12146	2742
2024	12148	2563	12146	2562	12146	2562	12146	2562
2025	12148	2395	12146	2395	12146	2395	12146	2395
2026	12148	2238	12146	2238	12146	2238	12146	2238
2027	12148	2092	12146	2092	12146	2092	12146	2092
2028	12148	1955	12146	1955	12146	1955	12146	1955
2029	12148	1827	12146	1827	12146	1827	12146	1827
2030	12148	1708	12146	1707	12146	1707	12146	1707
2031	12148	1596	12146	1596	12146	1596	12146	1596
2032	12148	1491	12146	1491	12146	1491	12146	1491
2033	12148	1394	12146	1394	12146	1394	12146	1394
2034	12148	1303	12146	1303	12146	1303	12146	1303
10 YEAR TOTAL		67416		67378		67378		67378
20 YEAR TOTAL		105301		105257		105257		105257
30 YEAR TOTAL		124560		124512		124512		124512

BENEFIT ($M)

10 YEARS				38		38		38
20 YEARS				45		45		45
30 YEARS				48		48		48

PROJECT YEARLY CASH FLOWS

	OPTION 1		OPTION 2		OPTION 3	
		DISCOUNTED		DISCOUNTED		DISCOUNTED
2001	3.25	3.25	3.74	3.74	2.76	2.76
2002	17.00	15.89	19.55	18.27	14.45	13.50
2003	5.50	4.80	6.33	5.52	4.68	4.08

Table: Summary of Key Economic Indicators

INDICATOR	BCR	FYRR (%)	NPV ($million)
Median Case (7%)	2.0	46%	24
4% Discount Rate	2.5	44%	38
10% Discount Rate	1.7	47%	15
O&M Cost + 10%	2.0	46%	24
O&M Cost - 10%	2.0	46%	24
Construction + 10%	1.7	40%	20
Construction - 10%	2.4	54%	28