RTA

Roads and Traffic Authority
New South Wales

PENNANT HILLS ROAD

WIDENING AND RECONSTRUCTION BETWEEN BOUNDARY ROAD AND MAHERS ROAD

Volume 2 – Working Papers

Connell Wagner

PENNANT HILLS ROAD

WIDENING AND RECONSTRUCTION
BETWEEN BOUNDARY ROAD AND MAHERS ROAD

Environmental Impact Statement

Volume 2 - Working Papers

Prepared for

ROADS AND TRAFFIC AUTHORITY OF NSW

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PENNANT HILLS ROAD WIDENING

ENVIRONMENTAL IMPACT STATEMENT

VOLUME 2 - WORKING PAPERS

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1. TRAFFIC STUDY

TRAVERS MORGAN

ROADS AND TRAFFIC AUTHORITY

PENNANT HILLS ROAD WIDENING
TRAFFIC STUDY FOR ENVIRONMENTAL IMPACT STATEMENT

TRAVERS MORGAN PTY LTD

REF: 1896

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TRAVERS MORGAN

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CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

In August 1989, TRAVERS MORGAN was appointed by Connell Wagner (NSW) Pty Ltd to undertake the Pennant Hills Road widening (from Boundary Road to Mahers Road) traffic planning study as part of the Review of Environmental Factors (REF) requirements for the road improvement project.

The aim of the study was to provide traffic advice to Connell Wagner during phase 1 (Concept Design) of the project on the following aspects:

i. Collection and analysis of traffic data;

ii. Interpretation of the results of TRANPLAN modelling carried out by the Roads and Traffic Authority (RTA), Sydney Western Region for various design years and network options;

iii. Assessing the original RTA design concept Registration No. 0013 031 CD 002 and other alternatives; and

iv. Recommendations on the preferred design concept.

The traffic planning study was completed in June 1990 and the study report[1] presented to the client.

The REF was placed on public exhibition in June 1990.

However, the RTA has proposed that an Environmental Impact Statement (EIS) be prepared to address any matters raised by the community during the REF as well as the impact on the project of recent findings of the Commission of Inquiry into the Castlereagh (F2) Freeway.

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[1] Pennant Hills Road Widening Traffic Planning by Travers Morgan Pty Ltd, June 1990.

In October 1990, TRAVERS MORGAN was appointed by Connell Wagner (NSW) Pty Ltd to carry out a traffic study for the EIS. The study is to bring forward the traffic analysis work carried out in the previous study for the REF (which assumes the construction of the F2 Freeway from Abbot Street to Delhi Road in North Ryde). It also addresses the impact on the road project of recent findings of the Commission of Inquiry into the Castlereagh (F2) Freeway.

The regional traffic forecasts based on TRANPLAN were provided by RTA (Sydney Western Region).

1.2 REPORT STRUCTURE

The remainder of the report is structured as follows:

* Chapter 2 summarises the traffic planning study for the REF.

* Chapter 3 outlines the recommendation by the Commission of Inquiry on road projects in the F2 Freeway Corridor, the assumptions used by RTA in TRANPLAN modelling with these projects and results of traffic assignments in years 1993, 2001 and 2011.

* Chapter 4 gives details of comparison of performance of the preferred design concept under the two options.

* Chapter 5 discusses the impact of possible network options on the road project and the need for additional road widening reserve for Pennant Hills Road.

* Chapter 6 presents the economic analysis by the SCATES model of future operating costs of road users and the impact of the project on access to properties, intersection operation and public transport services etc.

In addition, Appendix A gives details of traffic assignment results and Appendix B lists SCATES economic assessment outputs.

CHAPTER 2
SUMMARY OF TRAFFIC PLANNING STUDY[1] FOR THE REF

2.1 EXISTING TRAFFIC FLOWS

2.1.1. Existing Traffic Pattern

Pennant Hills Road is an arterial road (Route No. 77) connecting the Sydney-Newcastle Tollway (F3) and Pacific Highway at its northern end with Beecroft Road, Castle Hill Road, Carlingford Road, Marsden Road, James Ruse Drive and, in the future, the proposed Castlereagh (F2)[2] Freeway.

The section of Pennant Hills Road north of Boundary Road was widened to dual-3 lane standards whilst the section south of Boundary Road remains essentially a four-lane undivided road.

About half of the southbound traffic leaves Pennant Hills Road at the northern arm of Beecroft Road whilst a similar but smaller traffic volume joins the southbound flow from Castle Hill Road. Significant traffic flows leave the southbound carriageway of Pennant Hills Road for Hannah Street (490 vehicles/hr) and Copeland Road (130 vehicles/hr) during the AM peak.

In the northbound direction, traffic starts to build up at Copeland Road where about 370 vehicles/hr join the northbound flow on Pennant Hills Road during the AM peak. Further north, another 420 vehicles/hr turn left from Aiken Road into Pennant Hills Road northbound. About 750 vehicles/hr leave Pennant Hills Road via Castle Hill Road and 610 vehicles/hr join it via the latter road. About

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[1] The traffic planning study for the REF was based on the assumption that the Castlereagh (F2) Freeway (from Abbot Street to Epping Road in North Ryde) would be built.

[2] The proposal by the RTA to construct the section of Castlereagh (F2) Freeway from Pennant Hills Road, Beecroft to Epping Road at North Ryde was considered by a Commissioner of Inquiry for Environment and Planning. In July 1990 the Commission of Inquiry recommended against the construction of the freeway as proposed and suggested alternative road projects - see Chapter 3 for details.

710 vehicles/hr enter the northbound traffic stream on Pennant Hills Road from Beecroft Road in the AM peak.

Generally speaking, therefore, the most heavily trafficked sections of Pennant Hills Road lie between Boundary Road and Beecroft Road, and between Castle Hill Road and Copeland Road.

2.1.2. Daily Traffic Volume

The section of Pennant Hills Road between Boundary Road in the north and North Rocks Road in the south is currently carrying an Annual Average Daily Traffic Flow (AADT) of between 38,000 vehicles per day (vpd) at a point just south of Copeland Road to over 58,000 vpd at a point north of Boundary Road.

Castle Hill Road is now carrying about 33,000 vpd at a point near Church Street. Beecroft Road has recorded a flow of about 23,000 vpd west of Pennant Hills Road.

2.1.3. Seasonal and Hourly Variation of Traffic Flow

The AADT on Pennant Hills Road exhibits a seasonal variation pattern which is typical of suburban arterial roads. Figure 1 shows the seasonal variation; the AADT reaches the peak in December but drops significantly in January. The lowest AADT occurs during the winter months of July and August.

Figure 2 shows the weekday hourly variation of traffic volumes on Pennant Hills Road at a point just south of Copeland Road. The southbound flow is predominant during the morning and, in the afternoon the reverse holds for the northbound flow which generally exhibits a gentler peak than the southbound flow. Both Figure 1 and Figure 2 are derived from the Roads and Traffic Authority's publication "Traffic Volume and Supplementary Data for Sydney Region" (DMR).

2.1.4. Intersection Movement Counts

Intersection movement counts were obtained from Roads and Traffic Authority (RTA) records and extracted from West Pennant Hills Traffic Study (1989)

prepared by Transportation Environment Consultants. These are fairly recent movement counts (both AM and PM peaks) at various intersections along Pennant Hills Road. Supplementary intersection movement counts were undertaken where no previous records exist or more up-to-date information is desirable. The results of these counts are summarised in Figure 4.

2.1.5. Bus Routes and Services

Pennant Hills Road and its immediate environs are currently served by an extensive network of STA buses and buses operated by private operators.

Figure 5 shows the detailed routing of buses along Pennant Hills Road and areas on both sides of the road as well as Castle Hill Road. The area on the west side of Pennant Hills Road and Castle Hill Road lies within the jurisdiction of Baulkham Hill Shire Council whereas the area to the east of these roads is part of Hornsby Shire. Figure 5 also indicates the turning and cross movements of buses at all intersections along this section of Pennant Hills Road.

There are eighteen different bus routes operated by six operators (including STA) in the area.

Details of their operation are summarised in Figure 5 and the following table:

TABLE 2.1: DETAILS OF BUS ROUTES AND THEIR OPERATORS ON PENNANT HILLS ROAD

Operator	Route No.	From	To
Harris Park Transport Company	82	Epping Station	Carlingford Square/North Carlingford
	90	Barclay Road	Epping Station via North Rocks
	91	Pennant Hills Station	West Pennant Hills or Old Northern Road
	101	Parramatta Station	Pennant Hills Station
	165	Parramatta Station	Epping Station
	181	Parramatta	Beecroft Station
Hornsby Bus Group	148	Pennant Hills Station	Hornsby
Metrowest Bus Company	150	Eastwood	Carlingford Station
State Transit Authority	501(511)	Ryde	Carlingford
Red Arrow (Westbus Pty Ltd)	630	Epping	Blacktown via Baulkham Hill
Glenorie Bus Company	651	Berrilee	Pennant Hills Station
	652	Glenorie	Pennant Hills Station
	653	Glenhaven	Pennant Hills Station
	654	Castle Hill	Macquarie University via Beecroft Station
	655	Castle Hill	Pennant Hills Station via West Pennant Hills
	657	Annangrove	Pennant Hills Station
	658	Kenthurst	Pennant Hills Station

2.1.6. Truck and Heavy Vehicle Movements

A truck study of the Castlereagh (F2) Freeway corridor was carried out for the RTA by Stapleton and Hallam in February 1990. The main function of the study was to provide a data base on truck and heavy vehicle movements through the corridor.

Counts were undertaken along various screenlines of the corridor and one of these fell on Pennant Hills Road north of Castle Hill Road. The number of trucks and heavy vehicles in the traffic stream is summarised in Table 2.2.

TABLE 2.2: NUMBER OF TRUCKS AND HEAVY VEHICLES ON PENNANT HILLS ROAD NORTH OF CASTLE HILL ROAD FROM 6 AM TO NOON - HOURLY FLOWS (2-WAY)

Period	Car	Lt Truck	Hv Truck	Semi	Bus	Total
6-7 am	2,179	179	46	120	6	2,530
7-8	2,897	120	78	158	28	3,281
8-9	2,697	160	68	158	40	3,123
9-10	2,010	193	90	169	25	2,487
10-11	1,621	196	79	155	11	2,062
11-12 noon	1,511	128	72	144	11	1,866
Total	12,915	976	433	904	121	15,349
Percentage	84.1%	6.4%	2.8%	5.9%	0.8%	100%

Source: Truck Study of the Castlereagh Freeway (F2) Corridor by Stapleton and Hallam.
Note: Car = Car, van and motorbike
Lt Truck = Vehicles with more than 4 wheels but only 2 axles
Hv Truck = Heavy rigid truck with 3 or more axles
Semi = Semi-trailer
Bus = Bus

Overall percentage of heavy vehicles on Pennant Hills Road was 9.5% during the period from 6.00 am to noon.

However, along a screenline of the corridor west of Pennant Hills Road, it was observed that the overall percentage of heavy vehicles during the morning peak two hours period of 7.00to 9.00 am was lower than the 6.00 am to noon period (2.9% versus 4%) but there was a higher concentration of these vehicles on Pennant Hills Road east of James Ruse Drive (6% during AM peak two hours).

In the weekday night time period from 8.00 pm to 2.00 am, the number of trucks and heavy vehicles observed on Pennant Hills Road north of Castle Hill Road is shown on Table 2.3.

TABLE 2.3: NUMBER OF TRUCKS AND HEAVY VEHICLES ON PENNANT HILLS ROAD NORTH OF CASTLE HILL ROAD FROM 8 PM TO 2 AM - HOURLY FLOWS (2-WAY)

Period	Car	Lt Truck	Hv Truck	Semi	Bus	Heavy Veh
8-9 pm	751	21	7	81	2	10.4%
9-10 pm	623	16	7	89	3	13.4%
10-11 pm	516	10	8	47	0	9.5%
11-12 midnight	362	10	2	71	1	16.6%
12-1 am	143	12	2	45	0	23.3%
1-2 am	78	16	3	43	0	32.9%

Source: Truck Study of the Castlereagh Freeway (F2) Corridor by Stapleton and Hallam.

There was a consistent number of heavy vehicles throughout the night time survey period, with the proportional impact increasing early in the morning.

The result of the truck survey reinforces the need to improve the road over the day and not just for peak commuter travel hours.

2.2 EXISTING INTERSECTION OPERATION AND CAPACITY

Although the scope of the road project includes only the section of Pennant Hills Road from Lilla Road in the north to Murray Farm Road in the south, the traffic analysis was extended to cover the section between Boundary Road and North Rocks Road in order to provide a more comprehensive basis of evaluation.

There are at present nine sets of traffic lights along this section of Pennant Hills Road. They are located (from north to south) at:

* Boundary Road
* North arm of Beecroft Road
* South arm of Beecroft Road
* South of Cardinal Avenue (pedestrian crossing only)
* Castle Hill Road
* Aiken Road
* Copeland Road/Eaton Road
* South of Murray Farm Road (pedestrian crossing only)
* North Rocks Road.

SCATES[1] analysis of existing intersection operation and capacity was carried out using intersection movement counts along Pennant Hills Road. These include movements entering and leaving side streets which are not signalised at present.

In order to calibrate SCATES model parameters, the calculated cycle lengths, phase splits, queue lengths etc were compared with the current SCATS (Sydney Co-ordinated Adaptive Traffic Signal System) data at three major intersections.

The calculated degrees of saturation of the signalised intersections along Pennant Hills Road are shown on the following table:

TABLE 2.4: DEGREE OF SATURATION OF EXISTING INTERSECTIONS ON PENNANT HILLS ROAD

	Degree of Saturation			
	AM Peak		PM Peak	
	Coordinated	Isolated	Coordinated	Isolated
Boundary Rd	1.10	1.10	0.97	0.97
N. Arm of Beecroft Rd	0.76	0.82	0.75	0.77
S. Arm of Beecroft Rd	0.89	0.90	0.84	0.90
Castle Hill Rd	0.92	0.92	0.96	0.96
Aiken Rd	1.04	1.04	0.94	0.94
Copeland Rd/Eaton Rd	1.37	1.37	0.92	0.93
North Rocks Rd	1.07	1.07	0.94	0.94

The above table shows that most intersections along Pennant Hills Roads are operating at capacity during peak periods, especially in the AM peak. The most congested intersections are those at Copeland Road/Eaton Road (degree of saturation = 1.37), Boundary Road (degree of saturation = 1.10) and North Rocks Road (degree of saturation = 1.07) with resultant long queues of traffic on their approaches.

2.3 EXISTING PENNANT HILLS ROAD OPERATION AND CAPACITY

[1] SCATES calculates phase splits, cycle lengths, delays, stops, turning bay requirements and fuel consumption as well as operating cost for co-ordinating traffic signal systems.

Pennant Hills Road is currently carrying traffic flows which are well above the design capacity of the road except for the section between Beecroft Road and Castle Hill Road.

Table 2.5 shows the design traffic volumes in passenger car units (p.c.u) per hour for urban roads at different levels of service.

TABLE 2.5: ONE WAY TRAFFIC VOLUMES (PCU/HR) FOR URBAN ROADS AT DIFFERENT LEVELS OF SERVICE

Type of Road	Level of Service*					
	A	B	C	D	E	F
2 Lane Undivided	540	630	720	10	900	FORCED FLOWS
4 Lane Undivided	900	1050	1200	1350	1500	
4 Lane Undivided with Clearways	1080	1260	1440	1620	1800	
4 Lane Divided with Clearways	1140	1330	1520	1710	1900	
6 Lane Undivided	1440	1680	1920	2160	2400	
6 Lane Divided with Clearway	1740	2030	2320	2610	2900	

Source: DMR

Note: * Level of Service:
- A- Free flow (almost no delays)
- B- Stable flow (slight delays)
- C- Stable flow (acceptable delays)
- D- Approaching unstable flow (tolerable delays)
- E- Unstable flow (congestion; intolerable delays)
- F- Forced flow (jammed)

The Service Volumes and Capacity in the above Table can increase by 20 to 40 percent where, amongst other factors, the absence of significant traffic movements entering/crossing the major roadway from minor streets or major developments, and where these movements are restricted by major road priority controls.

By comparison with the above table, the level of service of various sections of Pennant Hills Road is as follows:

Section	Level of Service (AM Peak)
Boundary Road to Beecroft Road	E
Beecroft Road to Castle Hill Road	D
Castle Hill Road to Copeland Road	F
Copeland Road to North Rocks Road	D

It is apparent that the section from Castle Hill Road to Copeland Road is operating under forced flow conditions with long queues of traffic and low travelling speed during peak periods. In the northbound direction, the section between Beecroft Road (northern arm) and Boundary Road is also running to saturation with an unsatisfactory level of service during peak periods.

2.4 TRAFFIC ASSIGNMENTS FOR YEARS 1991, 2001 AND 2011

2.4.1. Historical Growth Trends

Figure 3 shows the historical growth trends of traffic flow on Pennant Hills Road and Castle Hill Road at various strategic locations. An indication of this growth can also be seen in Table 2.6 which compares AADT's in 1985-1987:

TABLE 2.6: AADT GROWTH ON PENNANT HILLS ROAD AND CASTLE HILL ROAD AT VARIOUS LOCATIONS 1985-1987

Location	AADT (VPD)		Annual Growth (%)
	1985	1987	
Pennant Hills Road			
North of Boundary Road	47,996	54,911	7.2
West of Marsden Road	38,436	41,250 (1)	3.7
South of Copeland Road	32,717	35,016	3.5
Castle Hill Road	23,852	32,622	6.5

Source: DMR Traffic Volumes & Supplementary Data 1987
Note: (1) extrapolated

The above annual growth rates reflect significant growth of population and attraction in the Hills District.

2.4.2. Traffic Distribution and Assignment Methodology

A detailed description of the methodology using RTA's TRANPLAN model was given in Travers Morgan's report - Pennant Hills Road Widening Traffic Planning (June 1990).

It was found that the assigned traffic flows[1] in the base year generally matched those actually observed on the road after suitable adjustments were made to a few locations.

2.4.3. Traffic Assignment for Year 1993

TRANPLAN assignments were produced for the following loaded networks:

Network	Description	Triptable	Lodhist
HD93N1	1993 Committed works F2 (Delhi - Abbott) [*tolled*] F4 Missing Link [*tolled*] Silverwater Road extension Pennants Hills Road widening	1991	HD93L1
HD93N6	1993 Committed works As above NO MERELYNNE CONNECTION TO F2	1991	HD93L6
F2E93N4	1993 Committed works F2 (Delhi - Abbott) [*No Toll*] F4 Missing Link [*Tolled*] Silverwater Road extension Pennant Hills Road widening	1991	F2E93L4

The TRANPLAN assignment for Network HD93N1 was adjusted for the corrections required as mentioned in paragraph 2.4.2 and divided by a factor of 1.7 to give an equivalent AM peak hour flow (vph) in year 1993. The result is shown in Diagram 4 of Appendix A (PHR93TML).

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[1] The assignments produced by the TRANPLAN model cover two hours in the AM peak and exclude commercial vehicles. These should be divided by a factor of 1.7 to give an equivalent AM peak hour flow (vph).

Similarly, the results of TRANPLAN assignments for Network HD93N6 and Network F2E93N4, after similar adjustments, are shown in Diagrams 5 and 6 of Appendix A (PHR93TNM & PHR93NTML) respectively.

2.4.4. Traffic Assignment for Year 2001

The trip matrix table for year 2001 was loaded onto the following two road networks:

Network	Description	Triptable	Lodhist
HD01N1	2001 Most likely network F2 (Delhi - Abbott) [*tolled*] F4 Missing Link [*tolled*] Silverwater Road extension Pennants Hills Road widening	2001	HD01l1
F2E01N4	2001 Most likely NETWORK F2 NO TOLL (Delhi - Abbott) Then as in HD01N1	2001	F2E01L4

The TRANPLAN assignment for Network HD01N1 after adjustments is shown on Diagram 7 of Appendix A (PHR01TNL).

Similarly, the results of TRANPLAN assignment for Network F2E01N4, after adjustments, is shown in Diagram 8 of Appendix A (PHR01NTNL).

2.4.5. Traffic Assignments for Year 2011

The trip matrix table for year 2011 was loaded onto the following road networks:

Network	Description	Triptable	Lodhist
HD11N1	2011 Expected Network F2 (Delhi - Abbott) [*tolled*] No F3 - F2 Connection	2011	HD11L1
F2E11N4	2011 Expected Network F2 (Delhi - Abbott) [*No Toll*] No F3 - F2 Connection	2011	F2E11L4
F2E11N6	2011 Expected Network F2 (Delhi - Abbott) [*Tolled*] F3 F2 Connection In	2011	F2E11L6

The TRANPLAN assignment for Network HD11N1 after adjustments is shown on Diagram 9 of Appendix A (PHR11TNL).

Similarly, the results of TRANPLAN assignments for Networks F2E11N4 and F2E11N6, after adjustments, are shown in Diagrams 10 and 11 of Appendix A (PHR11NTNL and PHR11TL) respectively.

2.5 ASSESSMENT OF ORIGINAL RTA DESIGN CONCEPT

Various alternative proposals for Pennant Hills Road widening were assessed by the SCATES model using traffic assignment results in years 1993, 2001 and 2011 and taking the original RTA design concept as a starting point. The original RTA concept utilises the existing road reserve boundary.

Review of Number of Through Lanes and Extent of Widening

Assessments were made of the possibility of reducing the encroachments onto the Observatory Park by deleting one southbound lane on Pennant Hills Road and the effect on traffic conditions by reducing the extent of widening of the road between Beecroft Road (south arm) and Lancaster Avenue from dual three lanes to dual two lanes. The results show that they would either over-tax the road capacity or precipitate in enforced merging and a lowering of level of service.

Review of Extent of Widening

The SCATES analysis shows that it would be desirable to extend the road widening project southwards to include North Rocks Road, or at least carry out substantial improvements at the intersection of North Rocks Road/Pennant Hills Road, in some future stage in view of the congestion anticipated over this section.

Review of Castle Hill Road Improvements

The original design concept shows only one traffic lane in the proposed tunnel from Castle Hill Road to Pennant Hills Road southbound. The TRANPLAN assignments for year 2011, however, predicted a very high flow of about 2,700 vehicles/hr turning right from Castle Hill Road into Pennant Hills Road in the AM peak. In order to cater for this heavy traffic demand, it is considered that a two-lane tunnel would be required.

Review of Intersection Design

The design of all intersections were assessed[1] using the SCATES model. In particular, six alternative traffic arrangements for the closely spaced intersections of Copeland Road/Eaton Road and Aiken Road with Pennant Hills Road, utilising the existing road reserve boundary, were evaluated with regard to their merits of improving traffic flow along Pennant Hills Road and effects on access and traffic detour. The intersection of Cardinal Avenue with Pennant Hills Road was assessed for alternative design concepts relating to access to West Pennant Hills Public School and the shopping centre at Thompsons Corner and the amount of traffic on Cardinal Avenue.

Review of Impact of Widening on Observatory Park

In an attempt to minimise the impact of road widening on the Observatory Park (which was regarded as a landmark with high amenity value during the REF) and the adjacent Mount Benedict Girls' High School, five different traffic

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[1] For details of the assessments, refer to Travers Morgan's report - Pennant Hills Road Widening Traffic Planning

arrangements for the intersection of Pennant Hills Road with the two arms of Beecroft Road were investigated and the results are summarised in Table 2.7. On the basis of this investigation, the existing traffic arrangement was found to have the least impact on the park.

Review of Road Closures

We consider that the proposed road closures shown on the original RTA concept design are generally reasonable for the efficient operation of the improved Pennant Hills Road and its connection to the F2 Freeway.

Review of Bus Stops

The proposed location of bus stops with respect to existing and possible future bus services were reviewed. Some additional bus stops in indented bays were considered necessary to improve passenger comfort, public transport patronage and traffic flow conditions on Pennant Hills Road.

Conclusion of Traffic Assessment

The traffic assessment showed that provided the further improvement options as described in paragraph 2.6 below are adopted, the proposed widening of Pennant Hills Road would provide an effective solution to cater for future traffic demands on this important arterial route.

2.6 RECOMMENDATION ON DESIGN CONCEPT

The following recommendations are made for the preferred design concept assuming that the F2 Freeway from Abbot Street to Epping Road in Lane Cove would be constructed:

TABLE 2.7: INTERSECTIONS OF PENNANT HILLS RD WITH BEECROFT RD COMPARISON OF ALTERNATIVE DESIGNS WITH PREFERRED ARRANGEMENT

ALTERNATIVE CONSIDERED	ENCROACHMENT ONTO OBSERVATORY PARK[1]	ADVANTAGES
1. Preferred Arrangement: E/B flow via north arm of Beecroft Rd, W/B flow via south armof Beecroft Rd.	-	-
2. Alternative One: Two-way traffic on north arm of Beecroft Rd with or without left-turning traffic from Beecroft Rd south arm into Pennant Hills Rd S/B.	More encroachments (about 6.5m) along the north side of park. Land could be returned to park or the reserve near Mount Benedict Girls' High School along the south arm of Beecroft Rd.	Serious overloading of intersection of Pennant Hills Rd with the north arm of Beecroft Rd. Additional[2] set of traffic lights at the intersection of the two arms of Beecroft Rd.
3. Alternative Two: Remove traffic lights[3] and convert the roads around the park into a clockwise rotary system.	More encroachments (about 6.5m) along both the north side and south side of park[4]. Less encroachment onto the western side of park.	Inadequate absorption capacity if the system is treated as a roundabout (give-way) rule applies). Inadequate weaving lengths along all sides of park if the system is treated as a series of weaving sections.
4. Alternative Three: Two-way traffic on both arms of Beecroft Rd (most direct route for all movements).	More encroachments (about 3.2-6.5m) along the north side of park). Some land could be returned to park along the south arm of Beecroft Rd.	Overloading of intersection of Pennant Hills Rd with the north arm of Beecroft Rd. Additional set of traffic lights at intersection of the two arms of Beecroft Rd.
5. Alternative Four: W/B flow via north arm of Beecroft Rd, E/B flow via south arm of Beecroft Rd.	More encroachments (from about 3.2m to nil) along the north side of park and (about 3.2m) along the west side of park. Some land could be returned to park along the south arm of Beecroft Rd.	Overloading of intersection of Pennant Hills Rd with the north arm of Beecroft Rd. Additional set of traffic lights at the intersection of the two arms of Beecroft Rd. School buses on the wrong side of Mount Benedict Girls' High School.

Note: (1) Compared to preferred arrangement
(2) Not required if the south arm of Beecroft Rd is closed to traffic
(3) Traffic lights are still required at intersection of Pennant Hills Rd with the south arm of Beecroft Rd to cater for pedestrians crossing Pennant Hills Rd
(4) Required if the system is treated as a series of weaving sections instead of a roundabout

2.6.1. **Number of Through Lanes**

Pennant Hills Road

We recommend that Pennant Hills Road should be widened to generally dual three lane standards, with the additional provision of exclusive turning lanes where required.

Between Beecroft Road (South Arm) and Lancaster Avenue, the widening could be gradually narrowed down to dual two lanes without unduly restricting the capacity of the route as a whole. However, the additional lanes would improve operating conditions and driving comfort.

Tunnel from Castle Hill Road to Pennant Hills Road

We recommend that a two-lane tunnel should be provided, which could be marked for one-lane only in the first few years after the project is completed.

2.6.2. **Intersection Design**

F2 Freeway/Pennant Hills Road

All movements should be allowed to and from the freeway.

We recommend the following measures should be adopted:

- Provision of a short left-turn slip from the F2 westbound ramp into Pennant Hills Road southbound.
- The pedestrian crossing at the south-western corner be made radial to the kerbline.
- Provision of three lanes from the F2 eastbound ramp turning into Pennant Hills Road northbound.

Without the section of the freeway east of Pennant Hills Road, a different traffic arrangement as described in paragraph 4.1 would be required.

Eaton Road/Copeland Road/Pennant Hills Road

We recommend that all existing movements at Copeland Road should continue with the provision of adequate left-turn and right-turn bays.

The provision of a turning bay on Pennant Hills Road will enable right-turns for northbound traffic to Copeland Road except for the AM peak (7.00 - 10.00 am). During the AM peak, we recommend that this right-turn be banned (buses excepted). However, it may not be necessary to impose the ban on the right-turn into Copeland Road in the first few years after the project is completed.

We recommend that all movements be permitted at Eaton Road, except for the right-turn in.

It is essential that the traffic lights at this intersection be closely coordinated with those at the nearby T-intersection with Aiken Road.

Aiken Road/Pennant Hills Road

We recommend two right-turn lanes into Aiken Road be provided. In addition, road widening within the existing road reserve should be carried out in Aiken Road at the approach to Pennant Hills Road to provide an additional left-turn lane. The right-turn out from Aiken Road should continue to be banned.

Castle Hill Road/Pennant Hills Road

We recommend a 2-lane tunnel be constructed to provide unimpeded right turns from Castle Hill Road to Pennant Hills Road.

A U-turn facility above the tunnel portal at Thompsons Corner should be provided for Castle Hill Road southbound traffic.

We recommend that two lanes under signal control should be provided for the left-turn from Pennant Hills Road northbound into Castle Hill Road.

Cardinal Avenue/Pennant Hills Road

We recommend the installation of traffic lights, establishment of pedestrian crossings, and provision of a turning bay in Pennant Hills Road to enable right-turns for southbound traffic to the western side of Cardinal Avenue. The present right-turn into the eastern arm of Cardinal Avenue from Pennant Hills Road should be banned (buses excepted).

We consider that the cross movements between east and west sides of Cardinal Avenue would not significantly affect the operation of the intersection. The preferred concept design shows these movements being prohibited, and east side becoming left turn out only.

Beecroft Road/Pennant Hills Road

All existing movements at the intersection should remain. We recommend the existing pedestrian crossing be relocated to the south side of the intersection and the Beecroft Road approach be realigned slightly to provide a high entry angle.

Boundary Road/Pennant Hills Road

Our recommendations for this intersection consist of the following:

- All existing movements be retained.
- Provision of two right-turning lanes about 150 metres long from Pennant Hills Road into Boundary Road.
- Provision of five lanes in Boundary Road for as long as possible to allow two right-turn lanes and one left-turn lane out from Boundary Road.

Church Street/Castle Hill Road

We recommend the right-turn from Castle Hill Road into Church Street be banned.

Access from Church Street into Mt Wilberforce Lookout car park should only be provided under signal control.

2.6.3. Road Closures

The following road closures and access arrangements of the roads connecting to Pennant Hills Road are recommended:

- Lilla Road - left in/left out only
- Beecroft Road (both arms) - unchanged
- Loftus Road - left in/left out only
- Hull Road - left in/left out only
- Lancaster Avenue - left in/left out only
- Grace Avenue - closed
- Oratava Avenue - left out only
- Hannah Street - left out only
- Mahers Road - closed when the interchange with F2 is constructed.

2.6.4. Bus Stops

Bus stops at properly designed indented bays are recommended at the following locations:

- **Pennant Hills Road**

  Southbound
  - south of Hull Road
  - south of Cardinal Avenue
  - Thompson's Corner opposite Castle Hill Road
  - north of Copeland Road
  - south of F2 Freeway

  Northbound
  - north of F2 Freeway
  - north of Aiken Road
  - north of Cardinal Avenue
  - south of Hull Road
  - south of Beecroft Road

- **Castle Hill Road**
  - on the southern side near driveway to church

- **Beecroft Road**
  - on the south arm of Beecroft Road near Pennant Hills Road (bus stop only)

CHAPTER 3
EFFECTS OF RECOMMENDATION BY COMMISSION OF INQUIRY FOR THE CASTLEREAGH (F2) FREEWAY ON TRAFFIC PLANNING FOR PENNANT HILLS ROAD WIDENING

3.1 RECOMMENDATION BY COMMISSION OF INQUIRY FOR THE CASTLEREAGH (F2) EXPRESSWAY ON ROAD PROJECTS IN THE PROPOSED EXPRESSWAY CORRIDOR

The proposal by the Roads and Traffic Authority (RTA) to construct the section of Castlereagh (F2) Freeway from Pennant Hills Road, Beecroft to Epping Road at North Ryde was considered by a Commission of Inquiry for Environment and Planning.

In July 1990, the Commission of Inquiry recommended against the construction of the freeway as proposed and suggested the following road projects in the same corridor:

* an Epping Bypass involving a tunnel connecting Carlingford Road to Pembroke Street and then Epping Road;

* the Epping Bypass be supported by a number of road improvements on Epping Road including fly-overs at Vimiera, Balaclava, Herring and Wicks Road;

* widening of Carlingford Road; and

* a fly-over at Carlingford Road and Pennant Hills Road and upgrading of Pennant Hills Road with a fly-over at North Rocks Road to connect to the western arm of the Castlereagh Freeway near the Golf Course at Pennant Hills.

Should the recommendations by the Commission of Inquiry on road projects in the corridor be adopted, they would have a profound effect on the future distribution of traffic in the road network adjacent to Pennant Hills Road and the road itself. Consequently, it was necessary to define more clearly the

assumptions underlying the road network options before carrying out traffic assignments using the TRANPLAN model and evaluation of scenarios based on these options.

3.2 TRANPLAN MODELLING FOR PROJECT ALTERNATIVES - EPPING BYPASS, IMPROVEMENTS ON EPPING AND CARLINGFORD ROADS AND UPGRADING OF PENNANT HILLS ROAD BETWEEN CARLINGFORD AND NORTH ROCKS ROAD

Preliminary engineering assessment of the road projects recommended by the Commission of Inquiry was carried out by the RTA (Sydney Western Region). This resulted in a more clearly defined set of individual road improvement schemes. The schemes incorporated, in certain cases, alternative proposals for upgrading key intersections, with due consideration of engineering factors and environmental constraints, but generally would provide the equivalent level of capacity improvements envisaged by the Commission of Inquiry to the roads involved. The schemes are as follows:

- **Epping Bypass**
  A four-lane two-way tunnel connecting Carlingford Road at its eastern end with Epping Road just to the east of Pembroke Street.

- **Improvements on Epping Road**
  Widening of sections of Epping Road between the proposed tunnel and Delhi Road and grade-separation at Vimiera Road, Balaclava Road, Herring Road and Wicks Road to provide six unimpeded through lanes.

- **Widening of Carlingford Road**
  Widening of Carlingford Road to six lanes and grade-separation at its intersections with Pennant Hills Road, Midson Road and Beecroft Road (Epping Bypass Tunnel).

- **Upgrading of Pennant Hills Road between Carlingford and North Rocks Roads**
  At the intersections of Carlingford Road/Pennant Hills Road and Marsden Road/Pennant Hills Road, a single-lane tunnel would connect the westbound carriageway of Carlingford Road with the southbound

carriageway of Pennant Hills Road west of Marsden Road. Another single-lane tunnel would enable traffic to exit directly from Carlingford Road westbound onto Pennant Hills Road northbound. The two existing sets of traffic lights at the intersection of Carlingford Road/Pennant Hills Road and Marsden Road/Pennant Hills Road would remain to cater for other turning movements.

Moreover, Pennant Hills Road would be widened on its western side to allow a two-lane northbound carriageway from Marsden Road to Moseley Street, segregated from another two lanes for traffic from Marsden and Pennant Hills Roads right-turning into Carlingford Road only. Two lanes would be provided for southbound traffic on Pennant Hills Road plus a single-lane ramp linking Pennant Hills Road directly with Carlingford Road eastbound.

Between Moseley Street and North Rocks Road, Pennant Hills Road would be widened to dual three-lanes. A diamond interchange would be provided at the intersection with North Rocks Road to provide for unimpeded traffic flow along Pennant Hills Road.

A pair of west-facing ramps would be provided to connect the western arm of the F2 Freeway opposite Pennant Hills Golf Course with Pennant Hills Road.

The original proposal for a Castlereagh (F2) Freeway between Pennant Hills Road and Epping Road at North Ryde (hereinafter referred to as the Freeway Option) assumed in the traffic analysis in the REF and the alternative road network incorporating the above improvements (hereinafter referred to as the Epping Bypass Option) is shown on Figure 6.

3.3 NETWORKS AND TRAFFIC ASSIGNMENT FOR YEAR 1993

TRANPLAN assignments were produced by the RTA for the following loaded networks:

YEAR 1993

Network Description	Triptable	LODHIST
1. P + A + E 1993 Committed works F4 Missing Link (tolled) Silverwater Rd extension Only western (from Abbot St to Pennant Hills Rd) arm of F2 in. Pennant Hills Rd widening Epping Bypass Improvements on Epping Rd Widening of Carlingford Rd Grade separation at the intersections of Carlingford Rd/ Pennant Hills Rd and western arm of F2/Pennant Hills Rd	1991	PH93L11
2. A + E Same as 1 but no Pennant Hills Rd widening	1991	PH93L22
3. P + A 1993 committed works F4 Missing Link (tolled) Silverwater Rd extension Only western (from Abbot St to Pennant Hills Rd) arm of F2 in. Pennant Hills Rd widening	1991	PH93L1

The TRANPLAN assignment for Network P+A+E was adjusted for the corrections required as mentioned in paragraph 2.4, and divided by a factor of 1.7 to give an equivalent AM peak hour flow (vph) in year 1993. The result is shown in Diagram 13 of Appendix A (PHR93PAE).

Similarly, the results of TRANPLAN assignments for Network P+A and Network A+E, after similar adjustments, are shown in Diagrams 12 and 14 of Appendix A (PHR93F2W and PHR93AE) respectively.

PHR93AE is the "DO NOTHING" case for Pennant Hills Road widening (from Boundary Road to Mahers Road) under the Epping Bypass Option whilst PHR93F2W was included for comparison purpose only as it included neither the freeway (B+C sections) nor the Epping Bypass.

3.3.1. Effect of Epping Bypass in Year 1993

Under the Epping Bypass Option, traffic flow on Pennant Hills Road southbound at the Boundary Road end would increase from about 3,470 vph to 3,750 vph during the AM peak. For the section between Beecroft Road (south arm) and Castle Hill Road, there would be an increase from about 1,650 vph to 1,920 vph. The traffic flow in the reverse direction would remain generally unchanged.

Between Castle Hill Road and Aiken Road, there would be no significant change in traffic flow volume in the southbound direction although it would increase slightly (60-100 vph) in the northbound direction under the Epping Bypass Option.

From Aiken Road to F2 Freeway, there would be some reduction of traffic flow in both directions, due to change of traffic pattern (eg. more traffic opt to turn into Aiken and Copeland Roads).

As would be expected, under the Epping Bypass Option, a great deal more traffic would be attracted to use the section of Pennant Hills Road between the western arm of the freeway and Carlingford Road (an increase of 40%).

The Average Annual Daily Traffic (AADT)[1] on the section of Pennant Hills Road to be improved as calculated by SCATES would increase from 52,433 pcu's to 59,267 pcu's under the Epping Bypass Option.

Without the freeway (B+C sections), more traffic (about 270 vph) from Ryde, Turramurra, West Pymble and areas further to the east would use Pennant Hills Road via Comenarra Parkway or Pacific Highway to travel to the western arm of the freeway or Aiken Road (thence to West Pennant Hills, Carlingford or Pennant Hills Road west of Marsden Road). Similarly, more traffic (about 270 vph) from Castle Hill Road and Boundary Road would opt to use either Pennant

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[1] This is only an approximate indication since the AADT calculated by SCATES excluded the flow in the tunnel from Castle Hill Road into Pennant Hills Road. The model for the Freeway Option consisted of 10 intersections including North Rocks Road whilst that for the Epping Bypass Option had only 9 intersections.

Hills Road (north of Boundary Road) or Beecroft Road during the AM peak for their eastbound journey instead of travelling down Pennant Hills Road south of Castle Hill Road. Consequently, there would be heavier traffic flow along Pennant Hills Road between Castle Hill Road and the north arm of Beecroft Road.

Compared with the Freeway Option much more traffic would use the side streets (Aiken Road, Copeland Road, North Rocks Road and Midson Road) for both eastbound and westbound trips during the AM peak. For example, the traffic assignment on Copeland Road (eastbound) increased from 350 vehicles/hr (PHR93TML) to 660 vph (PHR93PAE) whilst the usage of the section of the freeway west of Pennant Hills Road would drop from 4,250 vph (2-day) to 3,170 vph (2-way). The increased usage of side streets is concomitant to heavier turning movements at their intersections with Pennant Hills Road.

3.4 NETWORKS AND TRAFFIC ASSIGNMENT FOR YEAR 2001

Only one road network was used with the trip matrix table for year 2001 as follows:

YEAR 2001

Network Description	Triptable	LODHIST
P + A + E 2001 most likely network F4 Missing Link (tolled) Silverwater Rd extension Only western (from Abbot St to Pennant Hills Rd) arm of F2 in. Pennant Hills Rd widening Epping Bypass Improvements on Epping Rd Widening of Carlingford Rd Grade separation at the intersections of Carlingford Rd/ Pennant Hills Rd and western arm of F2/Pennant Hills Rd	2001	PH01L55

The TRANPLAN assignment for Network P+A+E was adjusted for the corrections required as mentioned in paragraph 2.4, and divided by a factor of 1.7 to give an equivalent AM peak hour flow (vph) in year 2001. The result is shown on Diagram 15 of Appendix A (PHR01PAE).

3.4.1. Effect of Epping Bypass in Year 2001

The effect of Epping Bypass on the traffic assignment in year 2001 was similar to those in year 1993. However, there would be more traffic from Castle Hill Road opting to use Beecroft Road via Pennant Hills Road northbound.

3.5 NETWORKS AND TRAFFIC ASSIGNMENT FOR YEAR 2011

The trip matrix table for year 2011 was loaded onto the following road networks:

YEAR 2011

Network Description	Triptable	LODHIST
1 P + A + E 2011 Expected Network Only western (from Abbot St to Pennant Hills Rd) arm of F2 in. Pennant Hills Rd widening Epping Bypass Improvements on Epping Rd Grade separation at the intersections of Carlingford Rd/ Pennant Hills Rd and western arm of F2/Pennant Hills Rd	2011	PH11L66
2. A + E Same as 6 but no Pennant Hills Rd widening	2011	PH11L77

The TRANPLAN assignment for Network P+A+E was adjusted for the corrections required as mentioned in paragraph 2.4, and divided by a factor of 1.7 to give an equivalent AM peak hour flow (vph) in year 2011. The result is shown on Diagram 16 of Appendix A (PHR11PAE).

Similarly, the result of TRANPLAN assignment for Network A+E, after adjustments, is shown in Diagram 17 of Appendix A (PHR11AE).

PHR11AE is the "DO NOTHING" case for Pennant Hills Road widening (from Boundary Road to Mahers Road) under the Epping Bypass scenario.

3.5.1. Effect of Epping Bypass in Year 2011

The effect of Epping Bypass on the traffic assignment in year 2011 was similar to those in years 1993 and 2001.

Traffic flow on Pennant Hills Road southbound at the Boundary Road end would increase from about 4,110 vph to 4,580 vph during the AM peak. For the section between Beecroft Road (south arm) and Castle Hill Road, there would be an increase from about 2,780 vph to 3,030 vph. The traffic flow in the reverse direction would also increase by about 200 to 340 vph.

Between Castle Hill Road and Aiken Road, there would be no significant change in traffic flow volume in the southbound direction although it would increase by about 170 vph in the northbound direction under the Epping Bypass Option.

From Aiken Road to the F2 Freeway, there would be some reduction of traffic flow in both directions, due to change of traffic pattern (as alluded to in paragraph 3.3.1.).

As would be expected, under the Epping Bypass Option, a great deal more traffic would be attracted to use the section of Pennant Hills Road between the western arm of the freeway and Carlingford Road (an increase of 35%), requiring three lanes in either direction over this section.

The AADT[1] on the section of Pennant Hills Road to be improved as calculated by SCATES would increase from 80,611 pcu's to 94,099 pcu's under the Epping Bypass Option.

The increased usage of Beecroft Road in year 2011 is even more pronounced than year 2001 in comparing the two options.

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[1] Please refer to notes under paragraph 3.3.1.

More traffic would use the side streets (Aiken Road, Copeland Road, North Rocks Road and Midson Road) for both eastbound and westbound trips during the AM peak, with the traffic assignments on Copeland Road (eastbound) increased from 442 vph (PHR11TNL) to 998 vph (PHR11PAE). Again, the increased usage of side streets was accompanied by heavier turning movements at their intersections with Pennant Hills Road and diminished use of the western arm of the F2 freeway.

The results of the traffic assignments were input into the SCATES model for further detailed analysis.

CHAPTER 4
COMPARISON OF PERFORMANCE OF PREFERRED DESIGN CONCEPT UNDER THE TWO OPTIONS - F2 FREEWAY AND ROAD PROJECTS RECOMMENDED BY COMMISSION OF INQUIRY

4.1 COMPARISON OF DEGREE OF SATURATION AT INTERSECTIONS

SCATES analysis of forecast traffic demands in years 1993, 2001 and 2011 with the preferred design concept under the two options - F2 Freeway and Epping Bypass indicated the respective degrees of saturation to be expected at intersections along Pennant Hills Road. The results of this analysis are given in Table 4.1.

TABLE 4.1: COMPARISON OF DEGREE OF SATURATION[1] OF INTERSECTIONS ON PENNANT HILLS ROAD IN 1993, 2001 AND 2011 - F2 FREEWAY VERSUS EPPING BYPASS

Intersection with	AM PEAK						PM PEAK					
	F2 Freeway			Epping Bypass			F2 Freeway			Epping Bypass		
	1993	2001	2011	1993	2001	2011	1993	2001	2011	1993	2001	2011
Boundary Rd	0.84	0.99	0.92	0.99	1.22	1.28	0.57	0.89	0.94	0.72	0.99	1.13
N. Arm of Beecroft Rd	0.41	0.81	0.83	0.42	0.75	0.92	0.40	0.66	0.69	0.50	0.75	0.84
S. Arm of Beecroft Rd	0.69	0.93	0.96	0.62	0.82	0.88	0.72	0.97	1.01	0.61	0.85	0.97
Cardinal Ave	0.37	0.56	0.58	0.41	0.63	0.63	0.33	0.57	0.63	0.46	0.63	0.69
Castle Hill Rd	0.52	0.85	0.89	0.32	0.97	0.94	0.62	0.85	0.95	0.55	0.84	1.00
Aiken Rd	0.59	0.85	0.84	0.56	1.12	1.44	0.62	0.67	0.92	0.71	0.75	1.48
Copeland Rd/Eaton Rd	0.98 [2]	1.07	1.08	1.03 [2]	0.87	1.21	0.60	0.75	0.87	0.80	0.62	1.14
F2 Freeway	0.68	0.82	0.83	0.77	0.87	1.10	0.61	0.79	0.80	0.82	0.96	1.06
North Rocks Rd	1.24	1.57	1.76	-	-	-	0.85	1.21	1.48	-	-	-

Note: (1) Coordinated mode

(2) Assume right-turn into Copeland Road permitted in 1993.

In SCATES modelling of the Epping Bypass Option, it was assumed that the following traffic re-arrangements would be incorporated:

. At the intersection with F2 Freeway, three of the four storage lanes on the off ramp from the freeway would be designated for traffic right-turning into Pennant Hills Road southbound, and one lane left-turning into Pennant Hills Road northbound;

- At the intersection with the south arm of Beecroft Road, three of the four storage lanes on Beecroft Road would be designated for traffic right-turning into Pennant Hills Road northbound and one lane left-turning into Pennant Hills Road southbound.

The reduction of degree of saturation at the intersection with Castle Hill Road under the Epping Bypass Option in years 1993 and 2011 was due to the decrease in number of right-turning movements from Pennant Hills Road southbound into Castle Hill Road forecast by TRANPLAN.

There was also a reduction of degree of saturation at the intersection with Copeland Road/Eaton Road in year 2001 compared with the freeway option, due to the decrease of traffic flow along Pennant Hills Road over this section.

Apart from the above cases, under the Epping Bypass Option, there were generally significant increases in degree of saturation at the signalised intersections along Pennant Hills Road. In particular, the following intersections would be seriously overloaded in year 2011 during the AM peak:

Intersection with	**Degree of Saturation**
F2 Freeway	1.10
Copeland Rd/Eaton Rd	1.21
Aiken Road	1.44
Boundary Rd	1.28

The increase in saturation levels at the intersections would lead to much deteriorated operating conditions along Pennant Hills Road.

4.2 COMPARISON OF OPERATIONAL CONDITIONS

4.2.1. Travel Speed

A comparison of travel speed in the southbound direction during the AM peak under the two options is as follows:

Year	Travel Speed (km/hr)	
	Freeway Option[1]	Epping Bypass Option[2]
1993	39	40
2011	38	36

Notes: (1) Average speed from Boundary Road to North Rocks Road (10 intersections)
(2) Average speed from Boundary Road to South of Mahers Road (9 intersections)

The apparent improvement of travel speed under the Epping Bypass Option in 1993 is due to the grade-separation of North Rocks Road intersection assumed in the TRANPLAN model for this option.

Despite the difficulty of carrying out a direct comparison, the SCATES analyses indicated a general lowering of travel speeds within the section of Pennant Hills Road to be improved under the Epping Bypass Option for both years, 1993 and 2011.

4.2.2. Level of Service

The level of service of various sections of Pennant Hills Road in years 1993, 2001 and 2011 were assessed as follows:

Section	Level of Service (AM Peak)[1]					
	Freeway Option			Epping Bypass Option		
	1993	2001	2011	1993	2001	2011
Boundary Rd to Beecroft Rd	C	E	E	D	F	F
Beecroft Rd to Castle Hill Rd	A	D	D	B	E	E
Castle Hill Rd to Copeland Rd	E	F	F	E	F	F
Copeland Rd to F2 Freeway	E	F	F	E	E	F
F2 Freeway to Murray Farm Rd	C	C	D	F	F	F
Murray Farm Rd to North Rocks Rd	E [2]	E [2]	F [2]	F	F	F

Notes: (1) Based on average of northbound and southbound conditions
(2) Assume no improvement to four lane undivided section

It is apparent that the widened Pennant Hills Road with the preferred design concept would operate at much poorer levels of service under the Epping Bypass Option.

Under the Freeway Option, Pennant Hills Road would fare better but still operate at "fair" to "poor" levels of service in year 2011. The section between Castle Hill Road and F2 Freeway would be heavily trafficked, especially in the southbound direction. This is primarily due to the very high traffic growth predicted for the road. Without the widening, the operating conditions would be intolerable.

4.3 ADDITIONAL IMPROVEMENTS REQUIRED FOR PENNANT HILLS ROAD WIDENING UNDER OPTION TWO - PROJECT ALTERNATIVES TO THE FREEWAY

Under the Option Two - project alternatives to the freeway (referred to as the Epping Bypass Option in this report), the intersections controlled by traffic lights along Pennant Hills Road would operate with some reserve capacity (with the exception of Copeland Road/Eaton Road) in 1993, albeit generally with higher degrees of saturation compared with those under the Freeway Option.

In year 2001, two intersections (Boundary Road and Aiken Road) would become oversaturated in the AM peak.

In year 2011, four intersections would be seriously overloaded in both the AM peak and PM peak, as mentioned in paragraph 4.1 above.

To restore the degree of saturation of the intersections during peak commuter travel hours to acceptable levels, a combination of the following measures would be required:

i. To give priority to main traffic streams on Pennant Hills Road and hold traffic queues on side streets as far as possible. This would tend to reduce total delays experienced for the system as a whole provided the queues on side streets would not build up to such an extent that these would lead to undesirable alternative routes or dangerous manoeuvres.

ii. To provide additional capacity at the overloaded intersections. The following improvements were recommended by SCATES analysis:

F2 Freeway
To provide a 380 metres long slip lane for traffic left-turning from Pennant Hills Road northbound into the on-ramp of F2 Freeway; and

To lengthen the two right-turning lanes from Pennant Hills Road southbound into the on-ramp of F2 Freeway by about 55 metres.

Copeland Road/Eaton Road
To introduce the proposed traffic management scheme as mentioned in paragraph 2.6.2 (Q-turn via Aiken Road) in year 1993;

To provide a 325 metres long storage lane for traffic left-turning from Pennant Hills Road southbound into Copeland Road eastbound; and

To lengthen the right-turn bay on Copeland Road from 80 metres to 185 metres and the left-turn bay from 45 metres to 95 metres.

Aiken Road
To provide a 270 metres long storage lane for traffic left-turning from Pennant Hills Road northbound into Aiken Road westbound; and

To lengthen the two right-turning lanes from Pennant Hills Road southbound into Aiken Road by about 95 metres.

Boundary Road
To lengthen the storage lane for traffic left-turning from Pennant Hills Road northbound into Boundary Road, from 170 metres to 420 metres; or

To re-open Wilson Road to allow left-in movement only from Pennant Hills Road.

It should be noted that the extensive improvements recommended by SCATES represent ideal conditions instead of minimum requirements to reduce the degrees of saturation to an acceptable level. Furthermore, the above proposals would have serious repercussions on properties (mainly residential buildings) along Pennant Hills Road in terms of land acquisition and environmental impact. We therefore consider that these should not be introduced as part of the preferred design concept unless absolutely unavoidable.

4.4 PERFORMANCE OF DESIGN CONCEPT WITH ADDITIONAL IMPROVEMENTS UNDER OPTION TWO

If the improvements listed in paragraph 4.3 above (PHR11RWL) were incorporated into the design concept, the degree of saturation of intersections along Pennant Hills Road would be those given in Table 4.2 in year 2011:

TABLE 4.2: DEGREES OF SATURATION OF INTERSECTIONS ON PENNANT HILLS ROAD IN 2011 (WITH ADDITIONAL IMPROVEMENTS)

Intersection with	AM Peak	PM Peak
Boundary Rd	1.00 (1)	1.00 (1)
N. Arm of Beecroft Rd	0.92	0.73
S. Arm of Beecroft Rd	0.88	0.97
Cardinal Ave	0.63	0.69
Castle Hill Rd	0.94	1.00
Aiken Rd	0.80	0.96
Copeland Rd/Eaton Rd	1.05	1.00
F2 Freeway	1.02	0.93

Notes: (1) Assume some traffic leaving Boundary Road would be diverted to other routes

The average traffic speed for the southbound direction in the AM peak would remain at about 36 km/hr although delay on side streets would be much reduced compared to the case without additional improvements.

CHAPTER 5
DISCUSSION OF NETWORK OPTIONS AND PROJECT TIMING

5.1 NETWORK OPTIONS[1]

The possible network options are:

i. P + A + B + C - Pennant Hills Road widening (preferred design concept) plus F2 Freeway from Abbot Street to Epping Road;

ii. P + A + E - Pennant Hills Road widening (preferred design concept), western arm of the freeway plus the Epping Bypass Option;

iii. P + A - Pennant Hills Road widening (preferred design concept), plus western arm of the freeway;

iv. A + B + C - F2 Freeway from Abbot Street to Epping Road; and

v. A + E - Western arm of the freeway plus Epping Bypass Option.

The signalised intersections along Pennant Hills Road from Boundary Road to south of Mahers Road would be significantly overloaded for all three design years 1993, 2001 and 2011 if either network Option (iv) or (v) ie. no widening of Pennant Hills Road is adopted. This would lead to unacceptable delays to all types of vehicles including buses and trucks, and excessive use of local residential streets by through traffic with obvious economic and environmental consequences, especially during the peak commuting hours.

5.2 USEFUL LIFE OF PREFERRED DESIGN CONCEPT

The preferred design concept for Pennant Hills Road widening would operate with satisfactory degrees of saturation in year 1993 if any one of the following network options is adopted:

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[1] Refer to Figure 5 for explanation of P, A, B, C, E.

* P + A + B + C
* P + A + E
* P + A[(1)]

The future growth of traffic demand in the F2 Freeway corridor is such that either the F2 Freeway or the road projects (Epping Bypass) recommended by the Commission of Inquiry will have to be constructed in the near future. Therefore it would be reasonable to assume either one of these options would exist in year 2001 and beyond for the traffic planning of Pennant Hills Road widening.

Should the Freeway Option (P+A+B+C) be adopted, the preferred design concept for Pennant Hills Road widening would generally operate with acceptable travel speeds and degrees of saturation as its signalised intersections in years 2001 and 2011 although the intersection with Copeland Road/Eaton Road would be slightly over-saturated.

SCATES analysis (PHR11SLC) showed that it would be possible to reduce the degree of saturation at the intersection with Copeland Road/Eaton Road to 1.00 in year 2011[(2)] by providing an additional storage lane 170 metres long to traffic left-turning from Pennant Hills Road southbound into Copeland Road and thus achieve more uniform operational conditions along Pennant Hills Road and with less likelihood of traffic queuing back into the tunnel exit near Hannah Street during the AM peak.

Under the Epping Bypass Option (P+A+E), it was shown in Chapter 4 that with the preferred design concept, the following two intersections would be over-saturated in year 2001:

* Aiken Road
* Boundary Road

---

(1) The intersection with Boundary Road would be overloaded but traffic could be diverted to other roads.

(2) The saving of cost to road users is detailed in Chapter 6.

However, lengthening of the two right-turning lanes from Pennant Hills Road southbound into Aiken Road by about 60 metres (PHR01LRA) would significantly reduce the degree of saturation at the intersection with Aiken Road from 1.12 to 0.72 during the AM peak.

The over-saturation of the intersection with Boundary Road may be tolerated by giving priority to traffic (on Pennant Hills Road) and holding any traffic queue on Boundary Road.

Also traffic may use alternative routes such as New Line Road and Castle Hill Road to reach Pennant Hills Road.

Beyond year 2001, the preferred design concept would progressively become seriously overloaded under the Epping Bypass Option.

We therefore conclude that, with suitable adjustments to the widening proposals at Aiken Road the preferred design concept would have a minimum useful life of up to about year 2001 under either scenarios (Freeway Option or Epping Bypass Option).

5.3 ADDITIONAL ROAD WIDENING RESERVES FOR PENNANT HILLS ROAD

It was shown in paragraph 4.4 above that under the Epping Bypass Option it would be possible to restore the degree of saturation at the signalised intersections in year 2011 to a satisfactory level by additional improvements to storage lanes and turning bays.

However, these improvements would require considerable additional land acquisitions and have significant impact on the environment beyond those required for the preferred design concept.

In view of the useful life of the preferred design concept, the need to devise a robust widening scheme pending a final decision on the F2 Freeway and the Epping Bypass Options and to minimise land acquisition and environmental impact, it is recommended that the preferred design concept incorporating possibly adjustment to the road boundary at Aiken Road should be adopted.

Additional road widening reserves would be required to accommodate the improvements to storage lanes and turning bays as detailed in paragraph 4.4.

No land take or demolition of houses is required for the additional road widening reserve at this stage but future developments beside this section of Pennant Hills Road will have to take cognizance of the additional road widening requirements.

5.4 PROJECT TIMING

It is recommended that the preferred design concept should be implemented as soon as possible so that the benefit in terms of saving in travel time and vehicle operating cost and reduction to through traffic on local residential streets could be realised at the earliest possible time. This is the best traffic planning strategy under all scenarios considered.

CHAPTER 6
ECONOMIC ASSESSMENT AND TRAFFIC IMPACT

6.1 ECONOMIC ASSESSMENT USING SCATES

SCATES can be used to evaluate alternative traffic management schemes. For economic evaluation purpose, the relevant outputs are:

* Total Costs to Road Users
* Delay Hours
* Number of Stops
* Mean AADT
* Total Travel Distance
* Fuel Consumption
* Average Cost/Veh-km
* Average Cost/Vehicle.

The current unit costs for road user's time, fuel and stops as well as number of hours in various time periods (AM peak, PM peak, business peak etc) are given in RTA Circular C90/13 to calculate annual vehicle operating costs and travel time costs. Saving in vehicle operating costs and travel time costs can be calculated by subtracting the base case values from the options' values. These savings would be for one year only.

The values produced can be used to calculate a first year rate of return (FYRR). In order to calculate benefits over an evaluation period, it is necessary to run SCATES for a minimum of two future years and interpolate or extrapolate values for other years. These values of savings can then be used to calculate either the Net Present Value (NPV) or Internal Rate of Return (IRR) of the improvement options.

In the case of Pennant Hills Road widening, however, it is likely that a portion of the benefits would accrue to other sections of the whole road network since nearby routes would be congested with traffic diverted from Pennant Hills Road should the widening not be carried out. Such benefits would be included in the economic output summary sheets of the TRANPLAN model.

On the other hand, the SCATES model is very effective in evaluating traffic conditions on Pennant Hills Road itself with and without widening and to assess the benefits due to local traffic improvement measures.

The result of SCATES economic assessment of various options is in Appendix B and summarised as follows:

- The benefit to road users on Pennant Hills Road of the preferred design concept (PHR93PAE) over the Do Nothing Case (PHR93AE), in 1993 was estimated by SCATES at $26.8 million/year in 1990 dollars (undiscounted) under the Epping Bypass Option;

- The benefit of road users on Pennant Hills Road of the preferred design concept (PHR11PAE) over the Do Nothing Case (PHR11AE) in 2011 was estimated by SCATES at $116.1 million/year in 1990 dollars (undiscounted) under the Epping Bypass Option;

- The benefit to road users by providing a 170 metres long storage lane for left-turning traffic from Pennant Hills Road southbound into Copeland Road in years 1993 and 2001 was estimated by SCATES at $0.011 million/year and $0.045 million/year respectively in 1990 dollars (undiscounted), assuming the Q-turn traffic management scheme mentioned in paragraph 4.4 would be introduced;

- The benefit to road users by lengthening the two right-turn lanes by 60 metres from Pennant Hills Road southbound into Aiken Road in year 2001 was estimated by SCATES at $0.024 million/year in 1990 dollars (undiscounted).

6.2 TRAFFIC IMPACT OF WIDENING OF PENNANT HILLS ROAD

6.2.1. Impact of Road Closures on Surrounding Road Network

The effects of the widening of Pennant Hills Road on the surrounding road network fall into two general categories:

A. Side streets which would have to be closed as a result of the road project.

The side streets which would have to be closed at their intersection with Pennant Hills Road include:

- Grace Avenue: to be closed with a circular cul-de-sac near Pennant Hills Road; and
- Mahers Road: to be closed with cul-de-sacs on both sides of Pennant Hills Road when the interchange with F2 freeway is constructed. The road will be re-aligned to the south but run parallel to the proposed F2 Freeway with a reduced width near the interchange of F2 Freeway/Pennant Hills Road.

B. Side streets which would carry additional traffic due to road closures, construction of the median strip and banning of cross and turning movements at road intersections.

The closure of the above streets would cause traffic thereon to be diverted to adjacent roads. However, as both streets to be closed are residential streets carrying virtually no through traffic, their closure would only slightly increase traffic on adjacent roads.

Construction of the median strip on Pennant Hills Road would eliminate all existing right turns to and from properties fronting the road and cause these movements to be diverted to side streets before returning to the opposite side of Pennant Hills Road. The effect on the side streets tends to be well dispersed throughout the area, and any increase in traffic on any individual street as a result would not be significant (less than 15%). The streets which would most frequently be used for such detours include:

- Aiken Road
- Oakes Road
- Eaton Road
- Copeland Road between Pennant Hills Road and Cardinal Avenue
- Boundary Road
- Victoria Road
- the two arms of Beecroft Road
- Cardinal Avenue
- Church Street.

Similarly, the banning of cross and turning movements at signalised road intersections would cause traffic to be diverted into side streets. The streets so affected are the same as those listed above.

6.2.2. Impact on Provision of Turning at Various Junctions

Between Boundary Road and Cardinal Avenue there are no significant changes to the provision of turning at various intersections with the following exceptions:

* at Boundary Road, two right-turning lanes will be provided from Pennant Hills Road southbound into Boundary road and vice versa.

* at Loftus Road, Hull Road and Lancaster Avenue, traffic would be able to turn left-in and left-out only.

* at the intersection of Pennant Hills Road with Cardinal Avenue, the preferred concept design provides a short turning bay for southbound traffic on Pennant Hills Road to turn right into the western section of Cardinal Avenue. Right-turn from Pennant Hills Road northbound into Cardinal Avenue eastbound would be banned (except for buses). Traffic from the western section of Cardinal Avenue will be allowed to turn left or right into Pennant Hills Road but not be allowed to go into the eastern section of Cardinal Avenue. Traffic exiting from the eastern section of Cardinal Avenue will only be allowed to turn left.

Between Cardinal Avenue and Mahers Road, the following changes to turning arrangements are envisaged:

* Major changes are proposed for the intersection at Castle Hill Road. Traffic on Castle Hill Road right-turning into Pennant Hills Road southbound will be directed into a viaduct across and underneath both the north and southbound carriageways of Pennant Hills Road before emerging to the surface and joining Pennant Hills Road at a point about 55 metres north of Hannah Street. Two lanes will be provided for both the right-turn from Pennant Hills Road into Castle Hill Road and the left-turn from Pennant Hills Road northbound into Castle Hill Road. A U-turning facility above the tunnel portal at Castle Hill Road will be provided to minimise detours near Thompsons Corner.

* Grace Avenue and Mahers Road will be closed where they meet Pennant Hills Road.

* Traffic at the intersection with Hannah Street and Oratava Avenue will only be allowed to turn left-out of the side streets.

* No changes are proposed for the existing movements at the intersection with Aiken Road except that two right turning lanes will be provided from Pennant Hills Road southbound into Aiken Road and vice versa.

* No changes to the movements at the intersection with Copeland Road and Eaton Road are proposed except that traffic right-turning from Pennant Hills Road northbound into Copeland Road should not be allowed during the AM peak (7-10 pm) except for buses.

* A new intersection with all movements permitted will be provided at the point where the proposed F2 freeway meets Pennant Hills Road.

On Castle Hill Road, traffic would be banned from turning right into Church Street and the Wilberforce Lookout car park.

6.2.3. Impact on Access

As discussed earlier in paragraph 6.2.1, the construction of the median strip, among other things, will restrict all access to properties fronting Pennant Hills Road to left-in/left-out only, and will in most instances incur additional travel distances to the local residents.

To assess the effects on vehicular access, alternative routes that residents would have to undertake to replace a right turn in/out with a left in/out were determined for residents along sections of Pennant Hills Road and Castle Hill Road.

An analysis of the additional travel distance was undertaken. The results of this analysis are presented in Table 6.1. The table shows that residents along Pennant Hills road would have to travel on average an additional 1.2 kilometres for entry and 1.5 kilometres for exit.

The maximum additional travel distance is 2.3 kilometres which will occur to the Church for exits to the north due to banning of right-turn into Church Street. Other relatively long circuits will affect residents on the west side of Pennant Hills Road between Oratava Street and Castle Hill Road (2.1 kms), between Eaton Road and Mahers Road (2.2 kms), on the east side of Pennant Hills Road between Beecroft Road and Hull Road (2.0 kms), and between Cardinal Avenue and House No. 535 (2.2 kms).

The least impact on access occurs to those residents generally along the west side of Pennant Hills Road between Beecroft Road and Castle Hill Road.

With respect to the local connecting roads, the impact of the median closure would be less significant. Additional travel distances of about 1.3 kilometres would occur to residents on Grace Avenue. Entry/exit to other local roads are not likely to change as residents would generally already undertake circuits to avoid turning right into or out of these local roads, because of the heavy volume of traffic along Pennant Hills Road.

TABLE 6.1: ADDITIONAL TRAVEL DISTANCE REQUIRED FOR VEHICULAR ACCESS TO PROPERTIES DUE TO ELIMINATION OF RIGHT TURN MANOEUVRES

Location	Maximum Travel Distance	
	Entry (km)	Exit (km)
West Side of Pennant Hills Road		
Beecroft Rd to Loftus Rd	0.6	1.4
Loftus Rd to Hull Rd	0.9	1.2
Hull Rd to Cardinal Ave	1.3	1.7
Cardinal Ave to Castle Hill Rd	0.4	0.7
Castle Hill Rd to Oratava St	2.1	1.3
Oratava St to Aiken Rd	1.5	1.2
Aiken Rd to Eaton Rd	1.1	1.7
Eaton Rd to Mahers Rd	2.2	1.9
East Side of Pennant Hills Road		
Beecroft Rd to Hull Rd	1.3	2.0
Hull Rd to Lancaster Ave	0.7	1.7
Lancaster Ave to Cardinal Ave	1.8	1.0
Cardinal Ave to No. 535	0.7	2.0
No. 535 to Hannah St	1.3	1.3
Hannah St to Aiken Rd	1.2	1.4
Aiken Rd to Copeland Rd	1.8	1.4
South Side of Castle Hill Road		
Thompson's Cnr to Park Entrance	0.8	2.3
North Side of Castle Hill Road		
Church St to New Line Road	1.1	0.8*
Average	1.2	1.5

* Assumes a U-turn facility above the tunnel portal at Castle Hill Road

It should be noted, however, that whilst the proposal would represent more circuitous access to properties along Pennant Hills Road, it would offer a significant level of improvement with respect to traffic safety. In addition, it would eliminate interruption to traffic flow which occurs whilst residents wait in the main traffic stream to turn right into their properties. It is also expected that a large proportion of residents would already use the more circuitous routes to achieve safe left in/left out access, and thus may not be affected at all.

6.2.4. Impact on Public Transport

The construction of the median strip and provision of turning at various intersections will have an impact on public transport (bus) services along and on both sides of Pennant Hills Road. Existing bus services are described in detail in Chapter 2.

In future, Route 91 will not be allowed to turn right from Pennant Hills Road southbound into Loftus Road. The alternative route will be via either Boundary Road (existing) or Cardinal Avenue (western arm).

Murray Farm Road is currently frequented by Routes 82 and 181. We consider that there is a strong case for maintaining the left-in/left-out movements for the eastern arm of Murray Farm Road so that bus service could still be carried on the road. However, the cross and right-turning movements of these bus routes at the intersection will have to be transfered to North Rocks Road. It should be noted that Murray Farm Road is outside the scope of the road project.

Buses currently stop on the kerbside lane on both sides of Pennant Hills Road and Castle Hill Road for setting down and picking up passengers. Apart from hindering smooth traffic flow on Pennant Hills Road, the manoeuvre of other traffic in overtaking them constitutes a traffic hazard to pedestrians crossing the road and other motorists as their sight line would be obstructed by buses calling at bus stops.

With the widening scheme for Pennant Hills Road, properly designed indented bays will be provided.

6.2.5. Impact on Pedestrian Movements

The widening of Pennant Hills Road and Castle Hill Road near Thompson's Corner will increase the road widths and hence the distances in crossing the roads. Although pedestrian crossing movements are not heavy, it is of paramount importance from the road safety and general amenity points of view that adequate and proper facilities are provided for pedestrians, many of them are young school children and aged people. To this end, continuous footpaths and verges will be provided on both sides of Pennant Hills Road and Castle Hill Road except for the eastern side of Pennant Hills Road bordering the golf course from Copeland Road to F2 freeway. The combined width of the footpath and verge varies from place to place; however, within the limits of the road project, the combined width generally varies between 3.0 to 3.5 metres, except on the eastern side of Pennant Hills Road between Copeland Road and the F2 Freeway, where only a verge of 2 metres could be provided. Local widening is also provided near bus stops and various locations for sight line and other considerations.

Traffic light controlled pedestrian crossings will be provided at the following signalised intersections across Pennant Hills Road and Castle Hill Road:

* **Pennant Hills Road**
  - F2 Freeway
  - Copeland Road
  - Castle Hill Road[1]
  - Cardinal Avenue
  - South Arm of Beecroft Road[2]
  - Boundary Road

* **Castle Hill Road**
  - Church Street

---

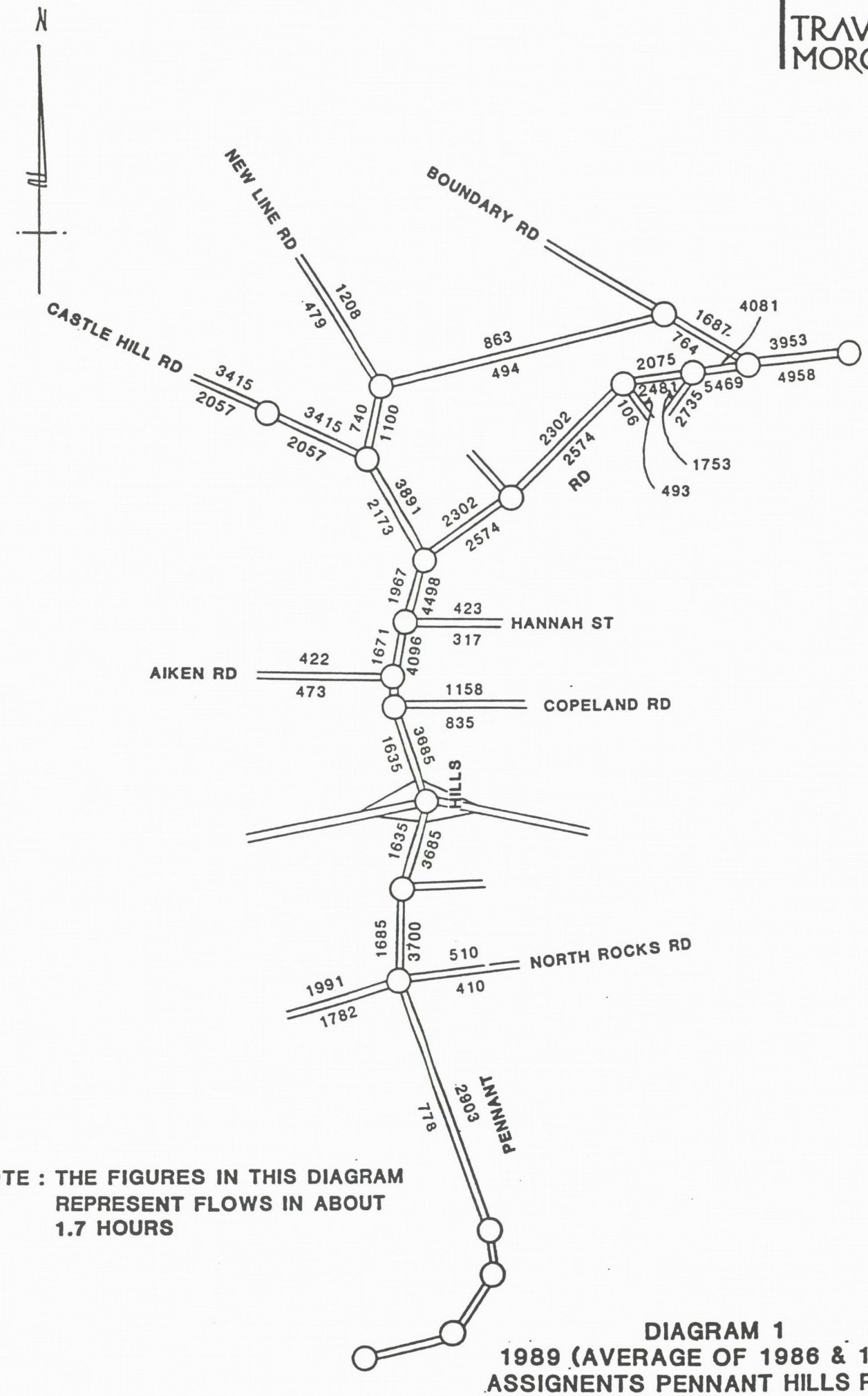
[1] Pedestrians crossing Castle Hill Road near Pennant Hills Road would be provided with safer crossing facilities by putting the left-turn from Pennant Hills Road northbound under traffic light control. In addition, it is understood the RTA is considering the construction of a footbridge across Pennant Hills Road near Castle Hill Road under a separate project.

[2] Pedestrians crossing Pennant Hills Road would be provided with safer and more efficient crossing facilities.

APPENDIX A

TRAFFIC ASSIGNMENT RESULTS

TRAVERS MORGAN



NOTE : THE FIGURES IN THIS DIAGRAM REPRESENT FLOWS IN ABOUT 1.7 HOURS

DIAGRAM 1
1989 (AVERAGE OF 1986 & 1991) ASSIGNENTS PENNANT HILLS ROAD

TRAVERS MORGAN

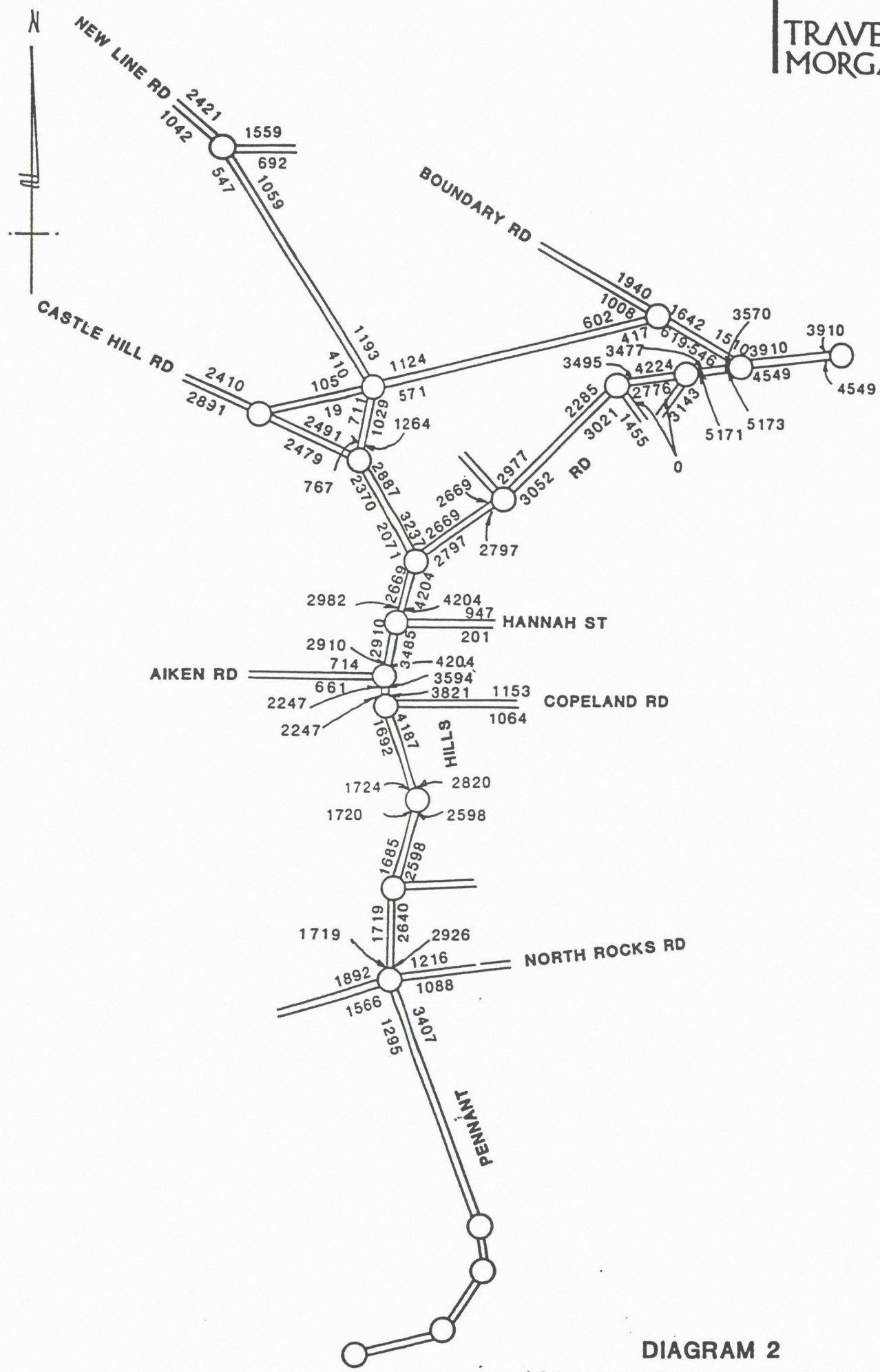


DIAGRAM 2
1989 OBSERVED FLOWS X 1.7

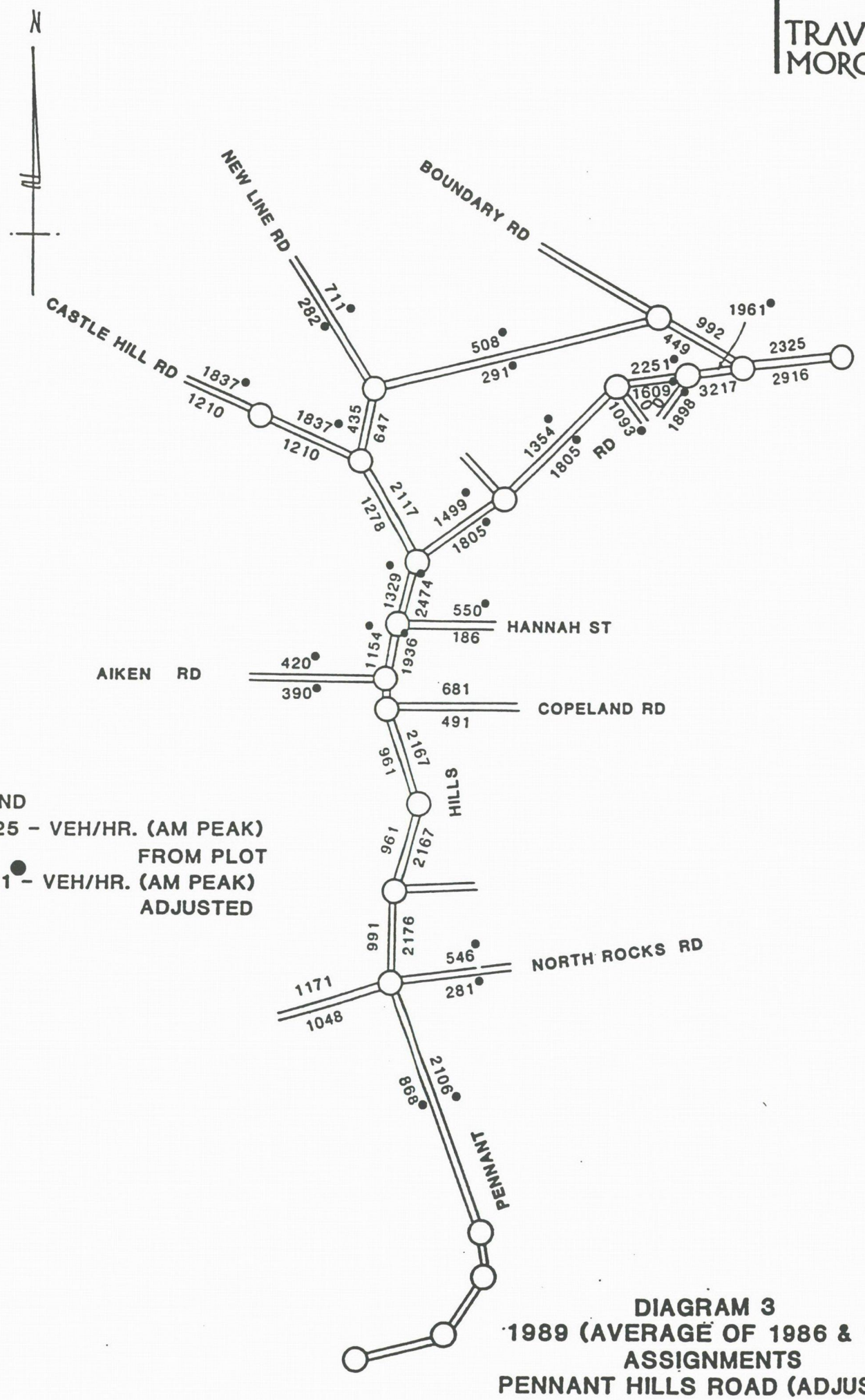


DIAGRAM 3
1989 (AVERAGE OF 1986 & 1991) ASSIGNMENTS
PENNANT HILLS ROAD (ADJUSTED)

LEGEND:

3474 - VEH./HR (AM PEAK) FROM PLOT

3181' - VEH./HR (AM PEAK) ADJUSTED

TRAVERS MORGAN

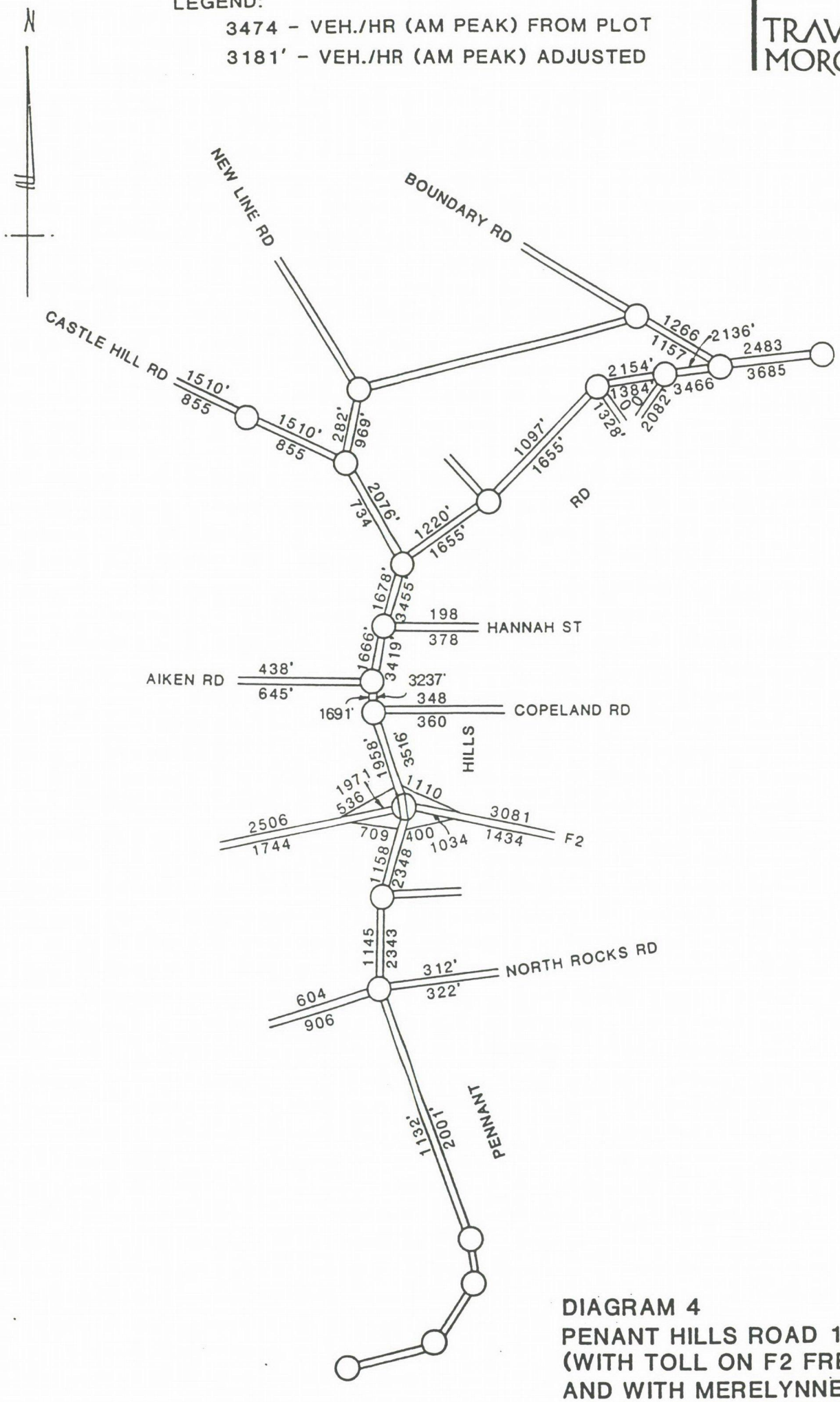


DIAGRAM 4

PENANT HILLS ROAD 1993

(WITH TOLL ON F2 FREEWAY AND WITH MERELYNNE LINK)

ASSIGNMENT - PHR93TML

LEGEND:

3474 - VEH./HR (AM PEAK) FROM PLOT

3181' - VEH./HR (AM PEAK) ADJUSTED

TRAVERS MORGAN

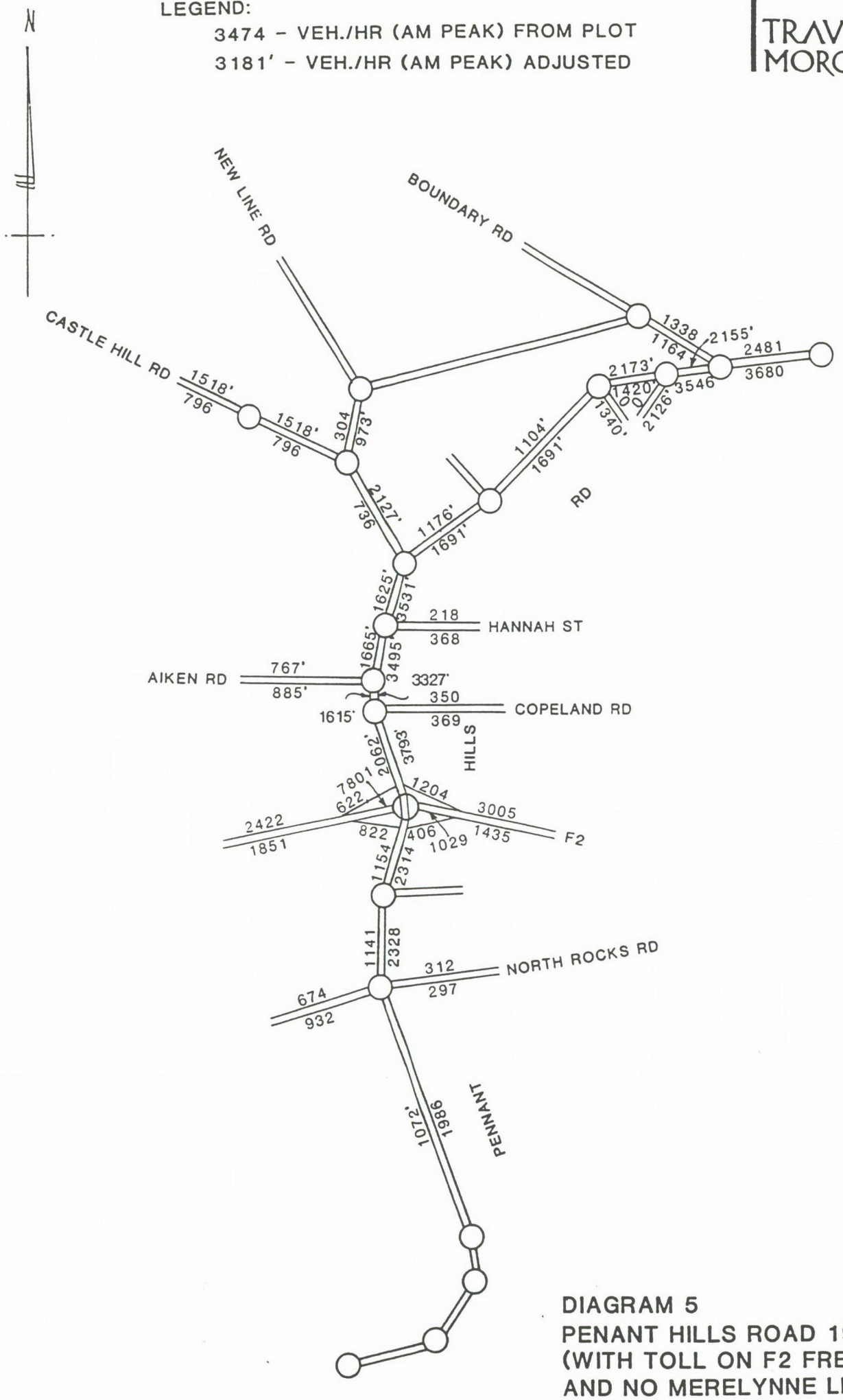


DIAGRAM 5

PENANT HILLS ROAD 1993
(WITH TOLL ON F2 FREEWAY
AND NO MERELYNNE LINK)
ASSIGNMENT - PHR93TNM

LEGEND:

3474 - VEH./HR (AM PEAK) FROM PLOT

3181' - VEH./HR (AM PEAK) ADJUSTED

TRAVERS MORGAN

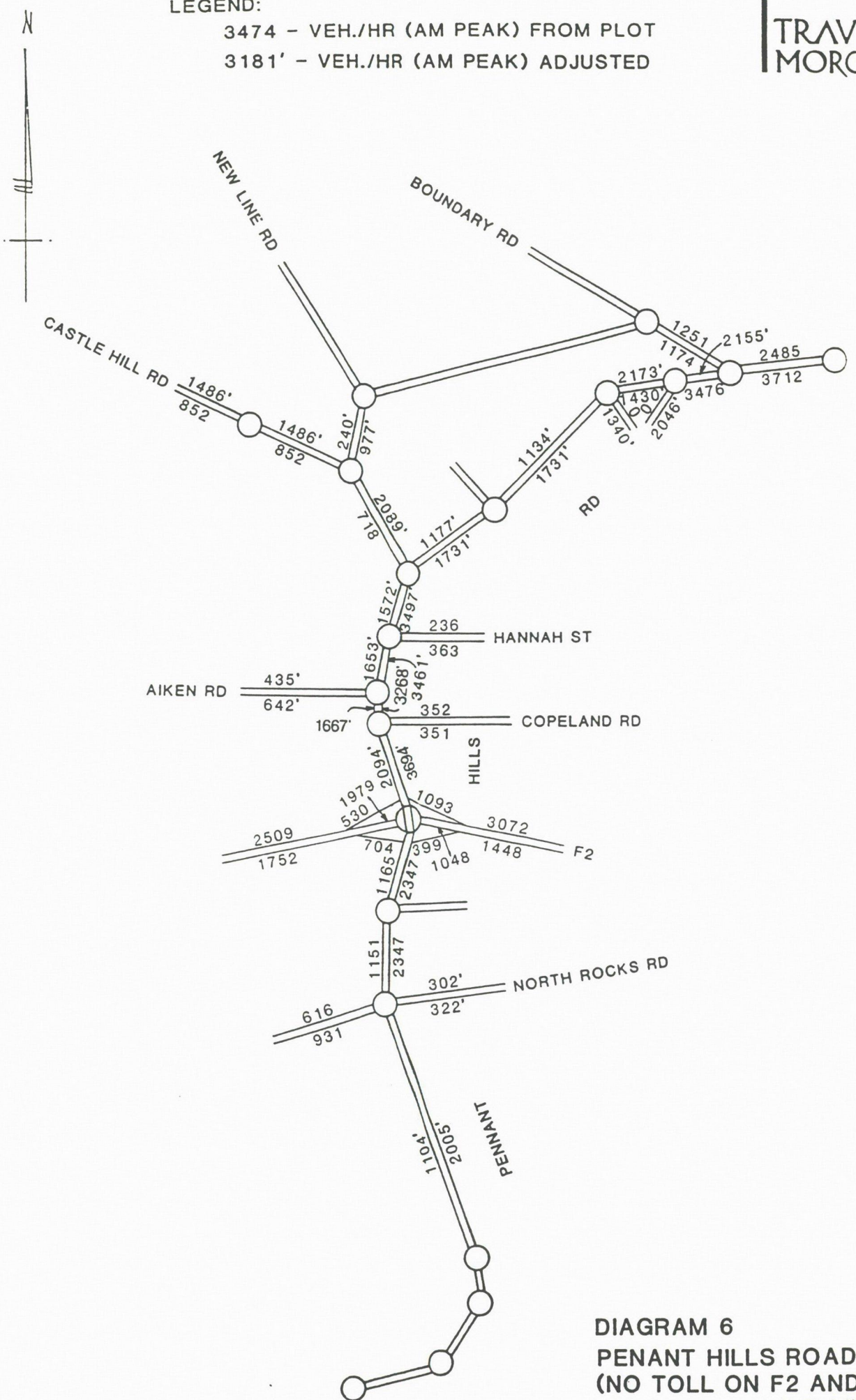


DIAGRAM 6

PENANT HILLS ROAD 1993
(NO TOLL ON F2 AND
WITH MERELYNNE LINK)
ASSIGNMENT - PHR93NTML

LEGEND:

3474 - VEH./HR (AM PEAK) FROM PLOT

3181' - VEH./HR (AM PEAK) ADJUSTED

TRAVERS MORGAN

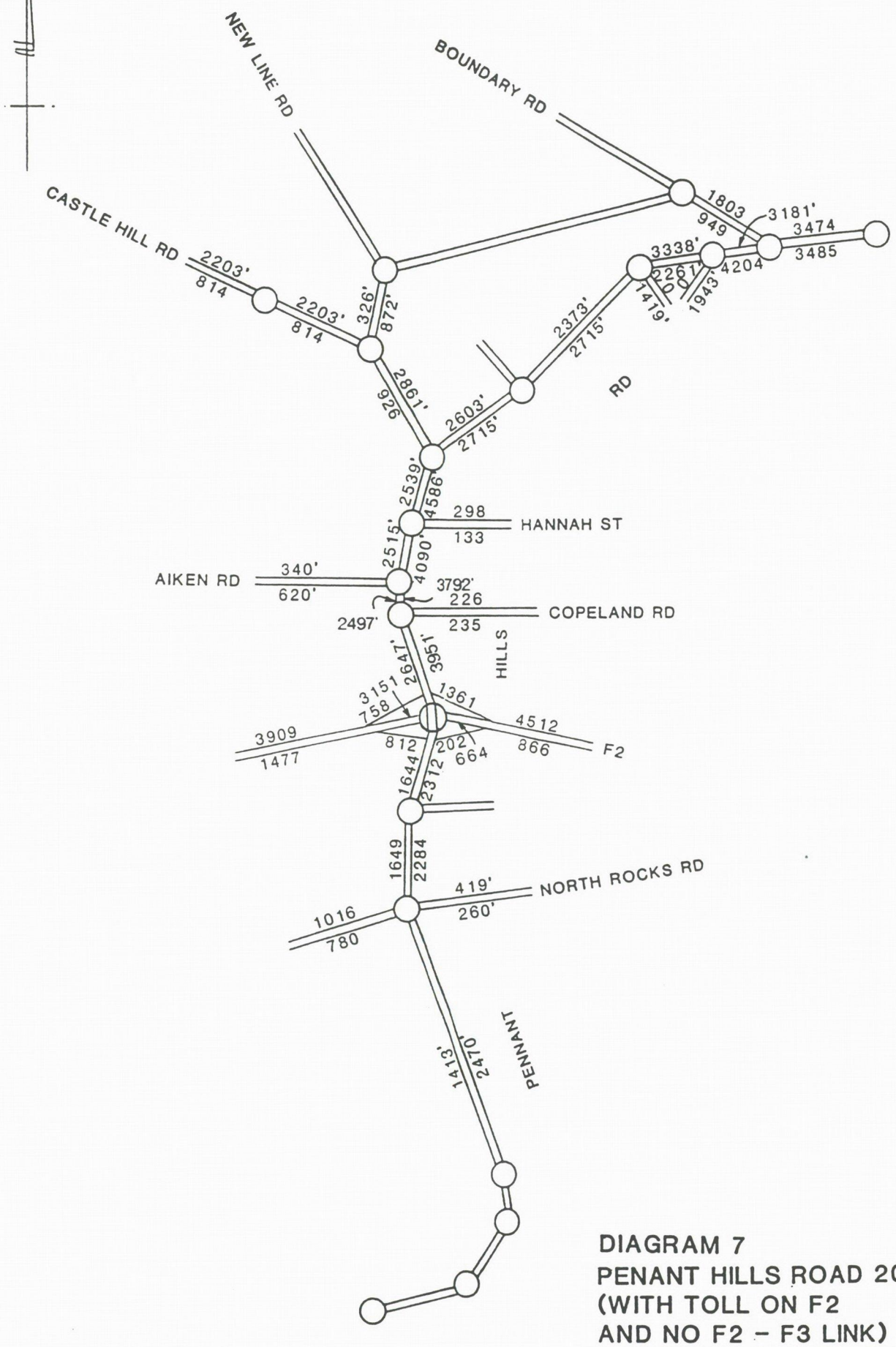


DIAGRAM 7
PENANT HILLS ROAD 2001
(WITH TOLL ON F2
AND NO F2 - F3 LINK)
ASSIGNMENT PHR01TNL

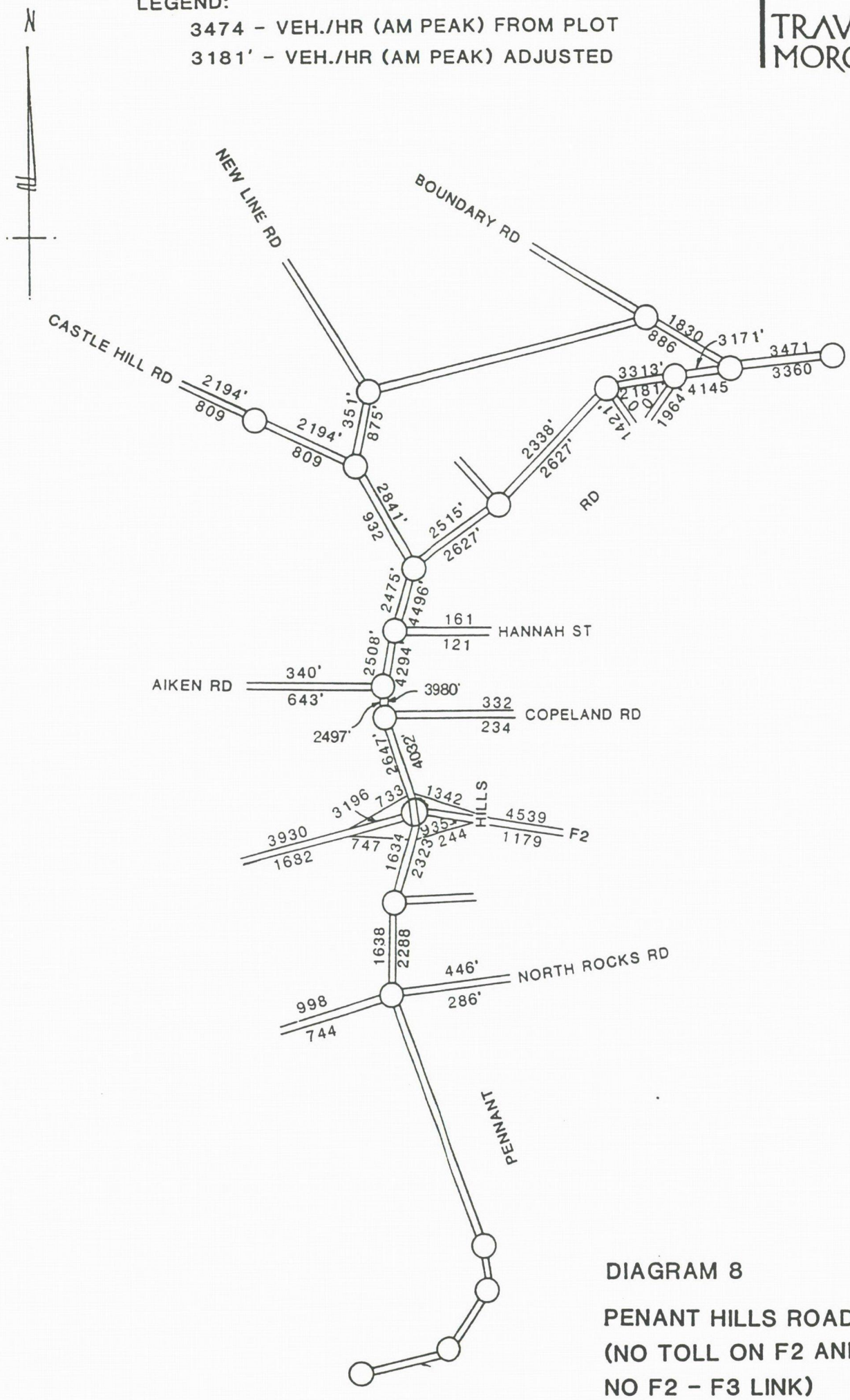


DIAGRAM 8

PENANT HILLS ROAD 2001
(NO TOLL ON F2 AND
NO F2 - F3 LINK)
ASSIGNMENT PHR01NTNL

LEGEND:

3474 - VEH./HR (AM PEAK) FROM PLOT

3181' - VEH./HR (AM PEAK) ADJUSTED

TRAVERS MORGAN

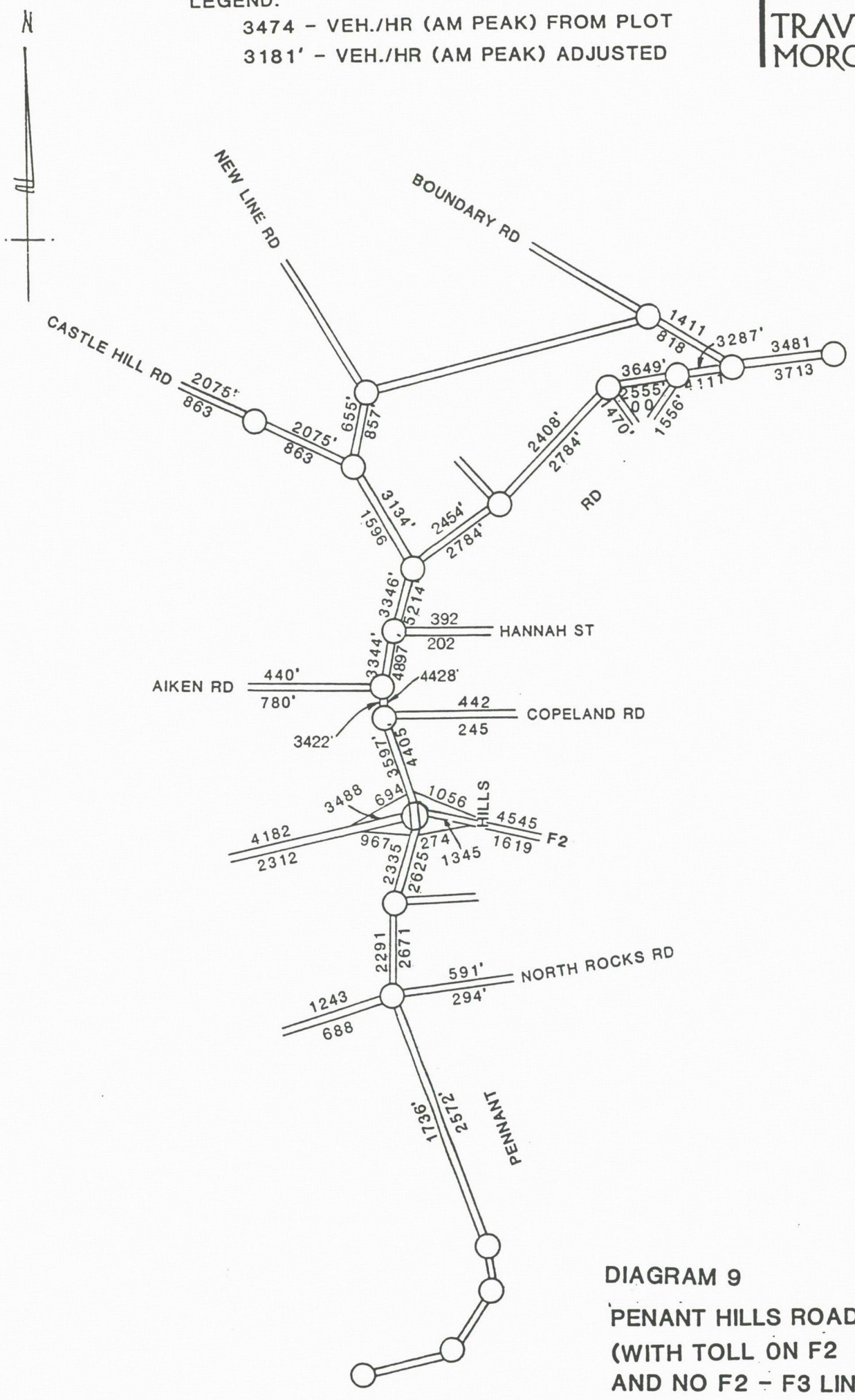


DIAGRAM 9

PENANT HILLS ROAD 2011

(WITH TOLL ON F2

AND NO F2 - F3 LINK)

ASSIGNMENT PHR11TNL

LEGEND:

3474 - VEH./HR (AM PEAK) FROM PLOT

3181' - VEH./HR (AM PEAK) ADJUSTED

TRAVERS MORGAN

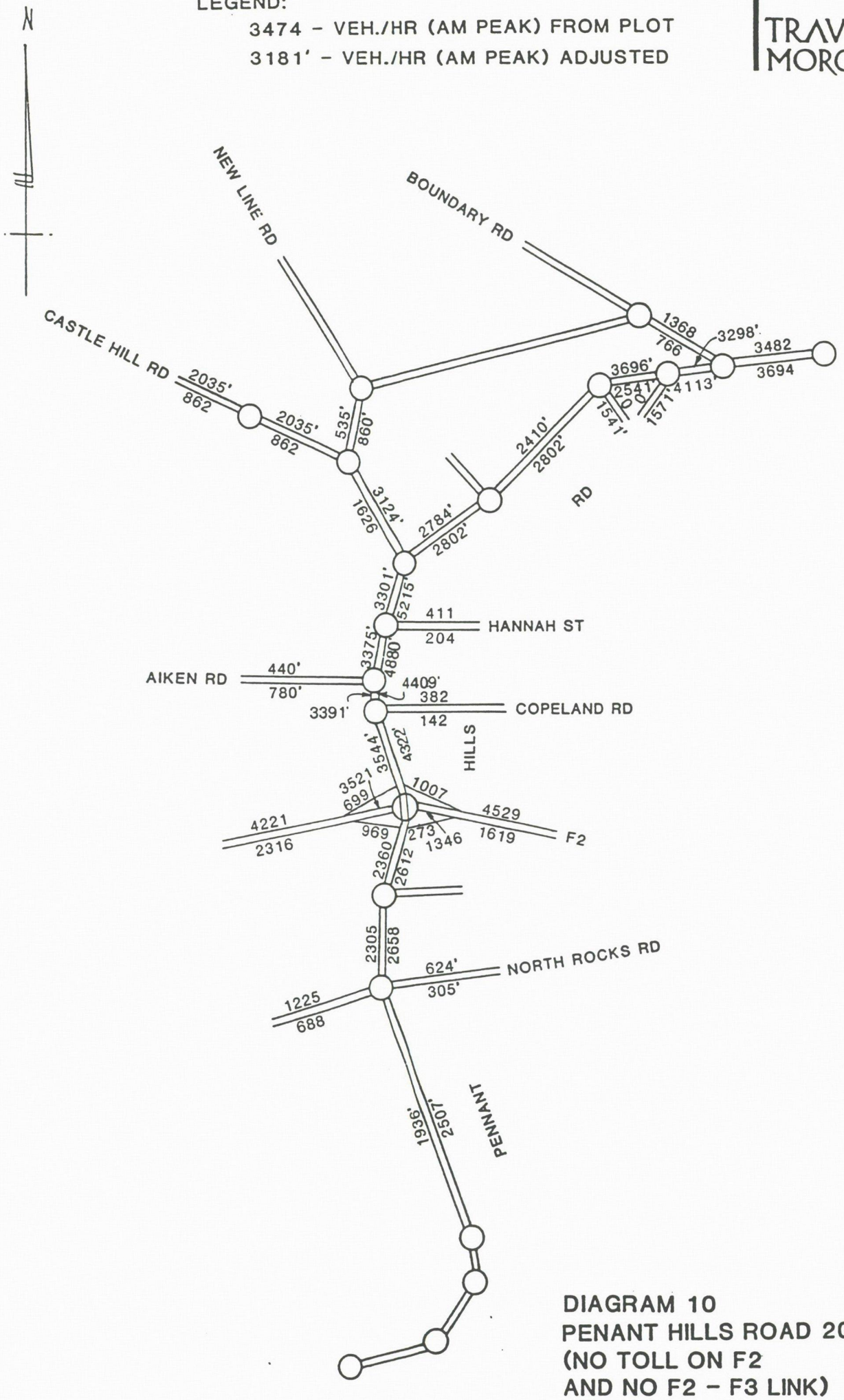


DIAGRAM 10
PENANT HILLS ROAD 2011
(NO TOLL ON F2
AND NO F2 - F3 LINK)
ASSIGNMENT PHR11NTNL

LEGEND:

3474 - VEH./HR (AM PEAK) FROM PLOT

3181' - VEH./HR (AM PEAK) ADJUSTED

TRAVERS MORGAN

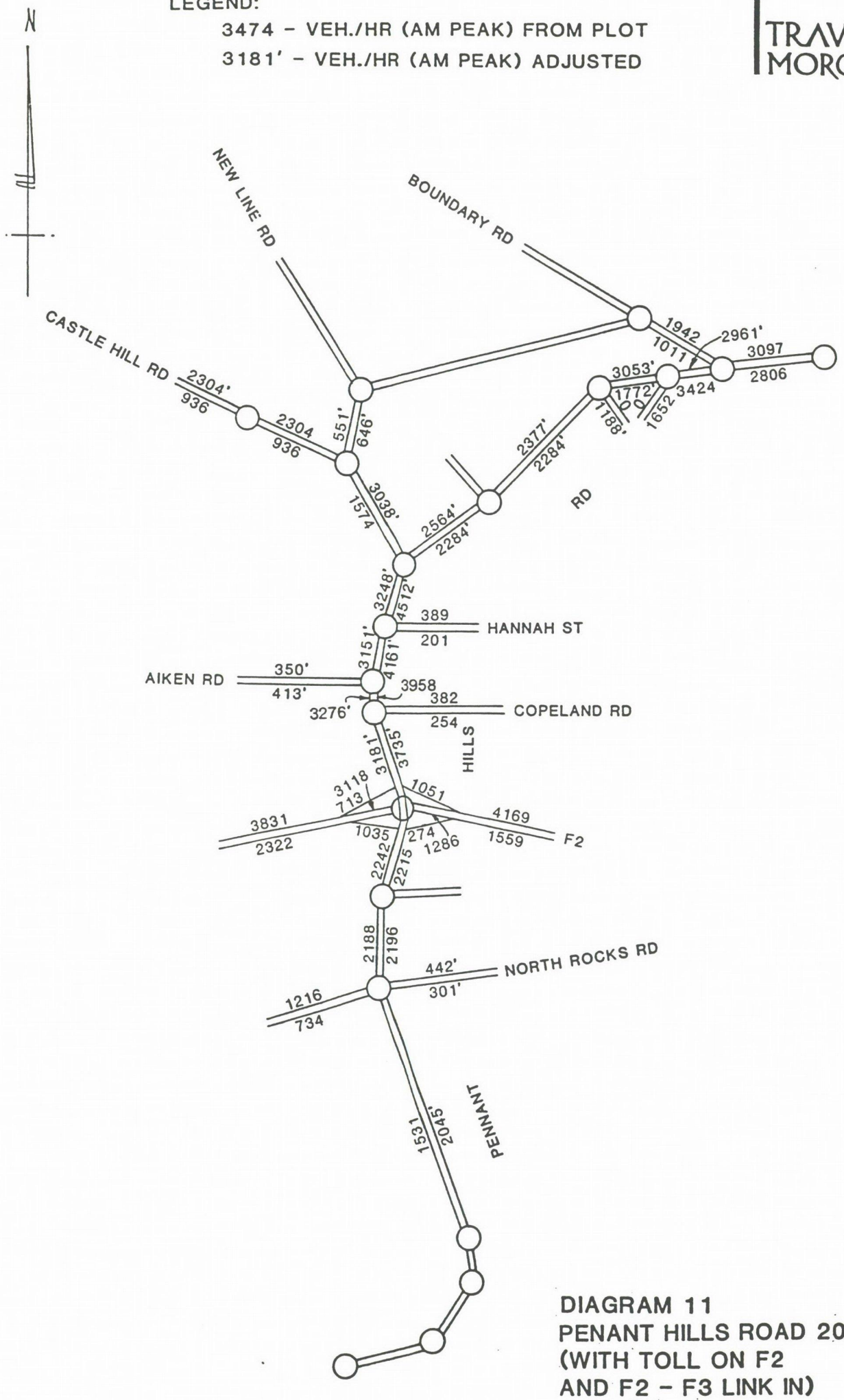
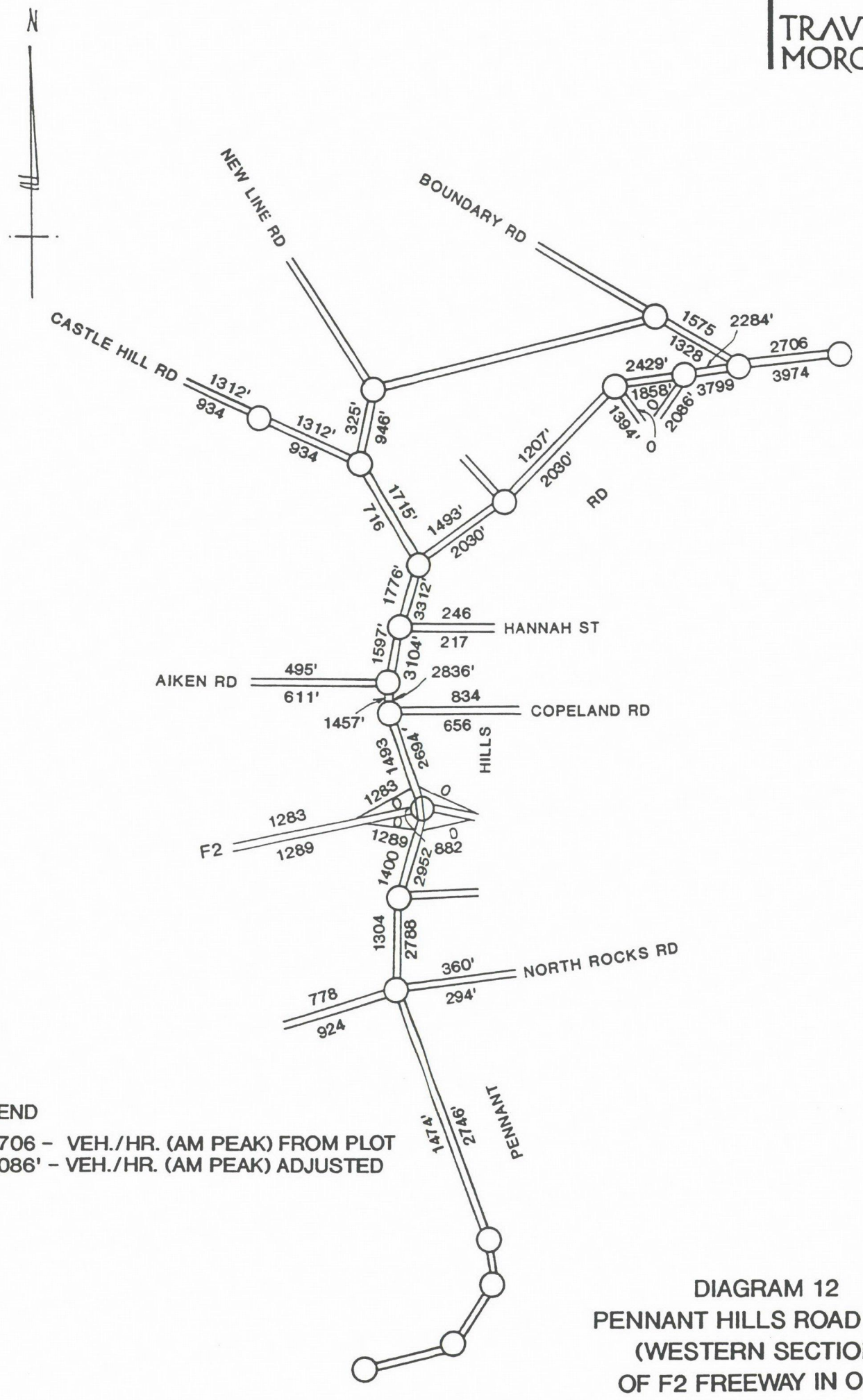
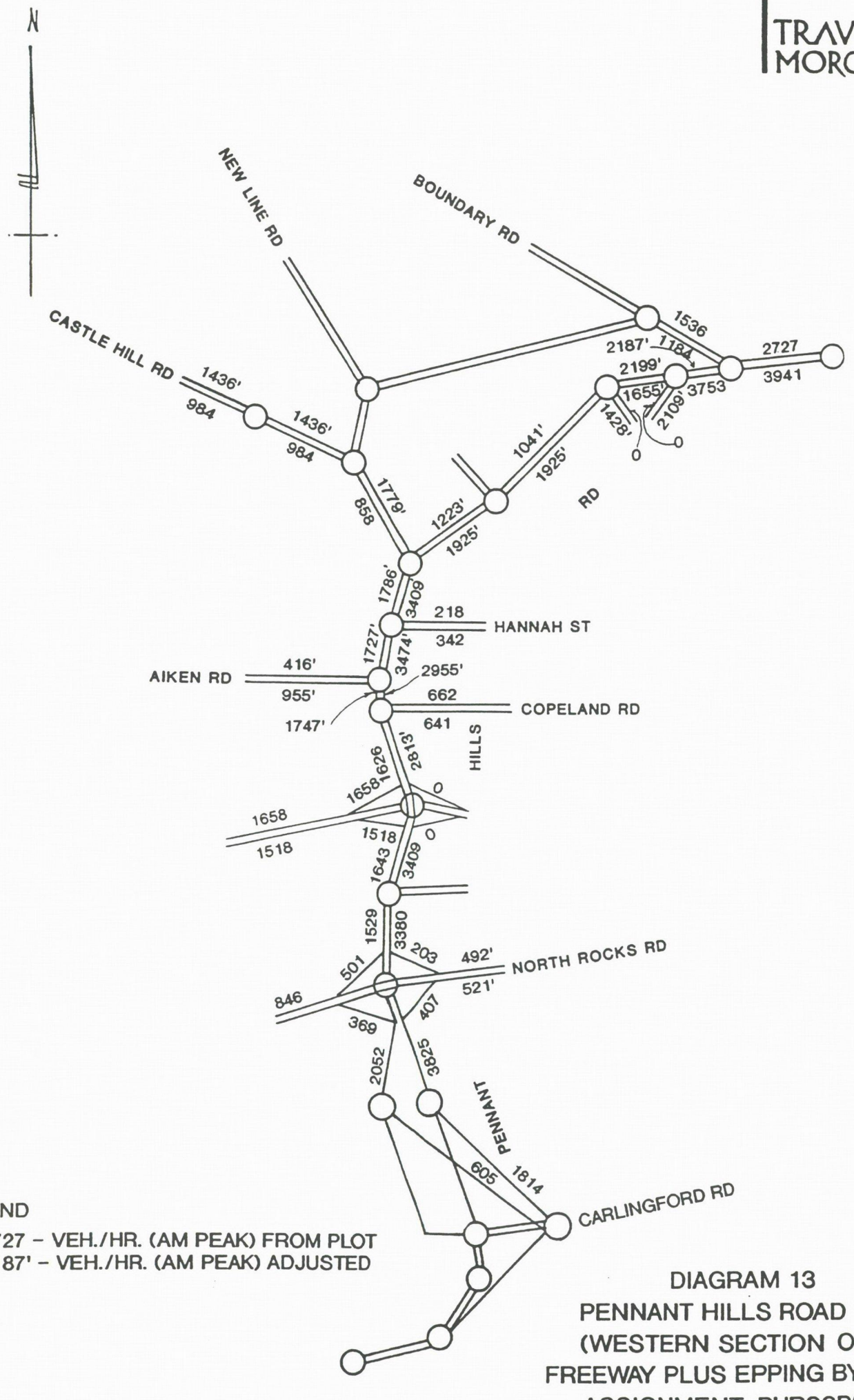
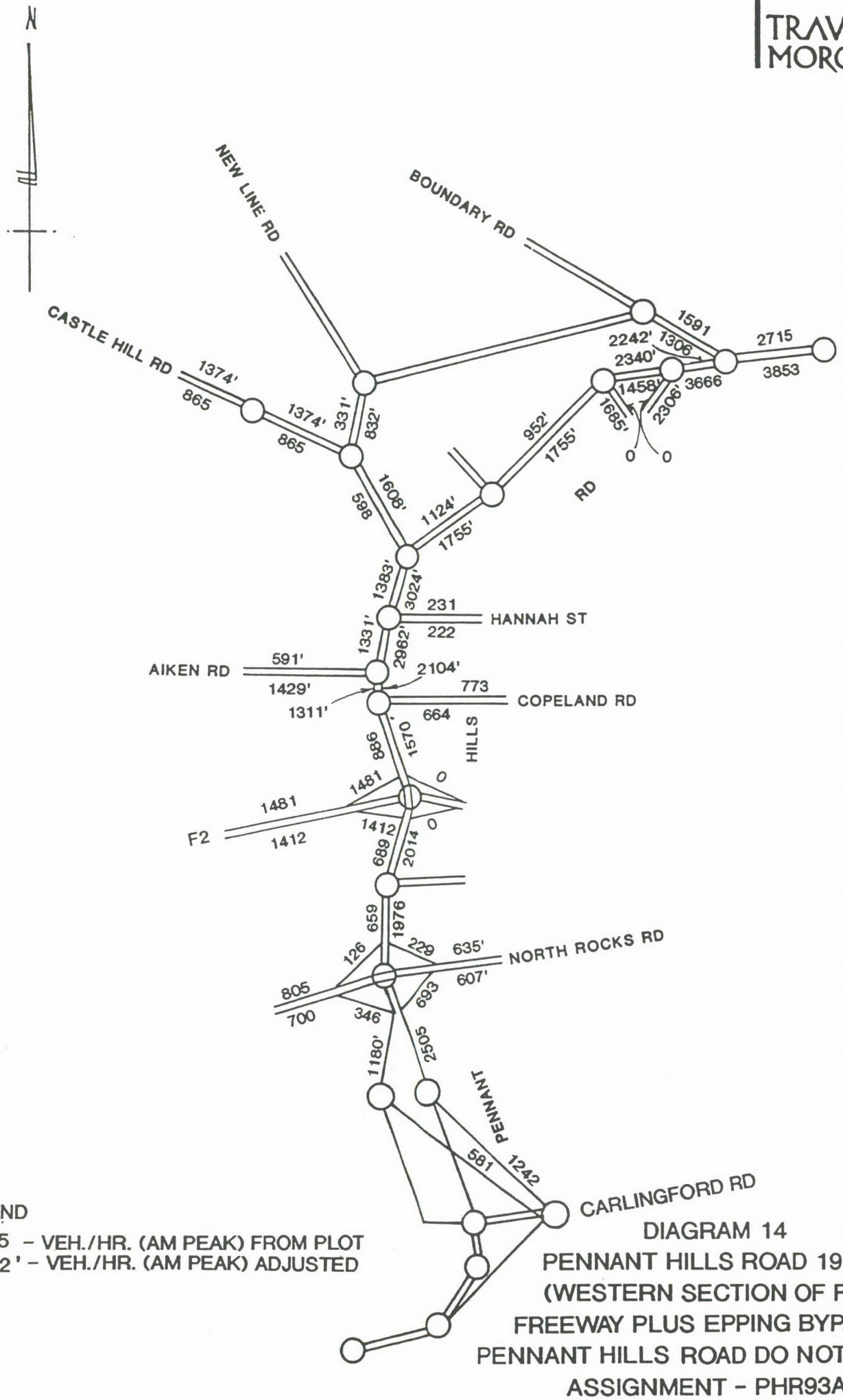


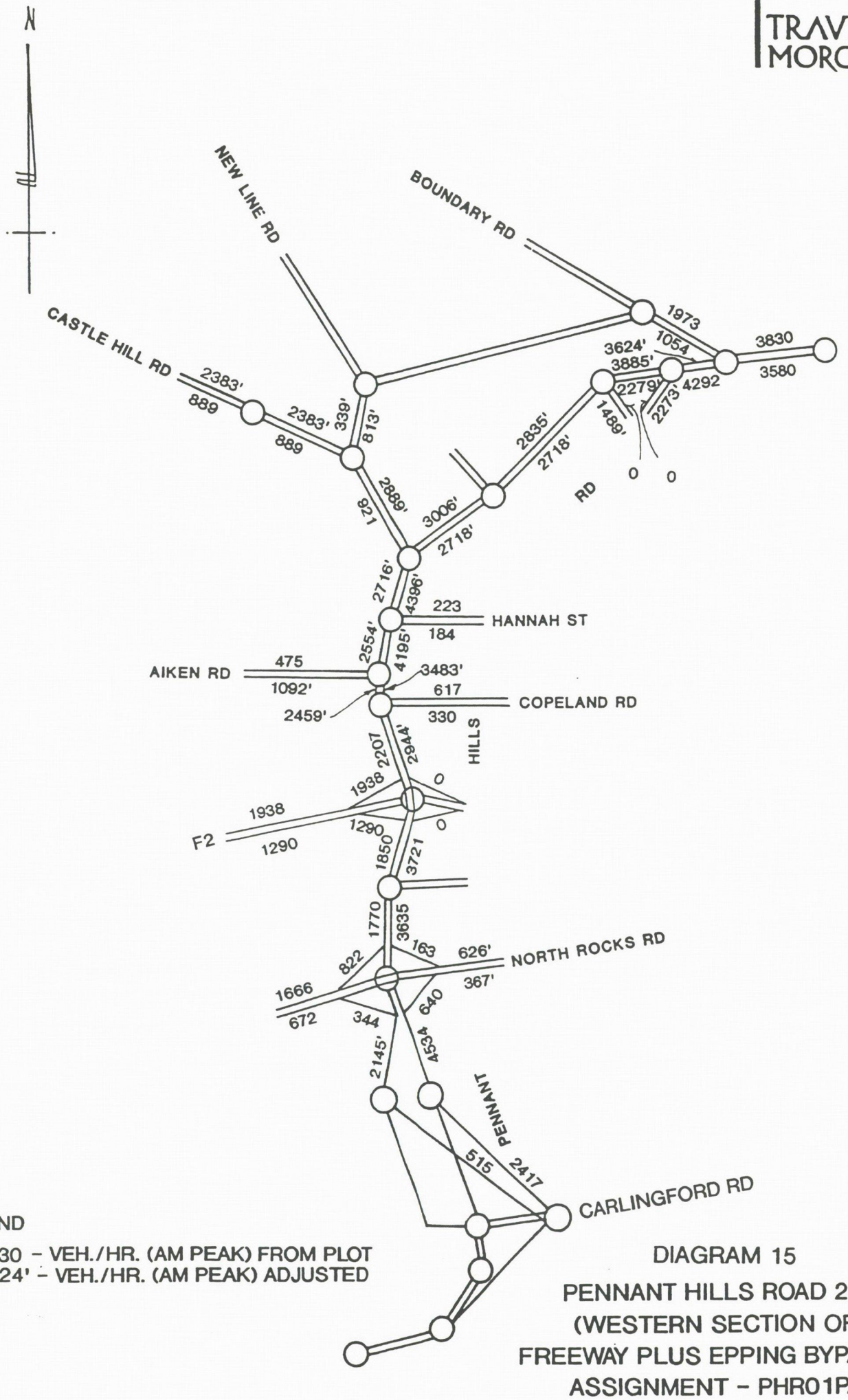
DIAGRAM 11
PENANT HILLS ROAD 2011
(WITH TOLL ON F2
AND F2 - F3 LINK IN)
ASSIGNMENT PHR11TL


N
TRAVERS MORGAN
NEW LINE RD
BOUNDARY RD
CASTLE HILL RD
1312'
934
1312'
934
325'
946'
1575
2284'
1328
2706
3974
2429'
1858'
3799
2086'
1394'
0
1207'
2030'
RD
716'
1715'
1493'
2030'
1776'
3312'
246
217
HANNAH ST
1597'
3104'
AIKEN RD
495'
611'
2836'
834
656
COPELAND RD
1457'
HILLS
1493'
2694'
1283'
1283
1289
F2
1289'
882
1400'
2952'
1304'
2788'
360'
294'
NORTH ROCKS RD
778
924
1474'
2746'
PENNANT
LEGEND
2706 - VEH./HR. (AM PEAK) FROM PLOT
2086' - VEH./HR. (AM PEAK) ADJUSTED
DIAGRAM 12
PENNANT HILLS ROAD 1993
(WESTERN SECTION
OF F2 FREEWAY IN ONLY)
ASSIGNMENT-PHR93F2W


N
TRAVERS MORGAN
NEW LINE RD
BOUNDARY RD
CASTLE HILL RD
1436'
984
1436'
984
1536
2187'
1184
2727
3941
2199'
1655'
3753
2109'
1428'
0
0
1041'
1925'
RD
858
1779'
1223'
1925'
1786'
3409
218
HANNAH ST
342
1727'
3474'
AIKEN RD
416'
955'
2955'
662
COPELAND RD
641
1747'
HILLS
2813'
1626
1658
0
1658
1518
1518
0
1643
3409
1529
3380
203
492'
NORTH ROCKS RD
501
846
521'
407
369
2052
3825
PENNANT
605
1814
CARLINGFORD RD
LEGEND
2727 - VEH./HR. (AM PEAK) FROM PLOT
2187' - VEH./HR. (AM PEAK) ADJUSTED
DIAGRAM 13
PENNANT HILLS ROAD 1993
(WESTERN SECTION OF F2
FREEWAY PLUS EPPING BYPASS)
ASSIGNMENT-PHR93PAE


N
TRAVERS MORGAN
NEW LINE RD
BOUNDARY RD
CASTLE HILL RD
1374'
865
1374'
865
331'
832'
1608'
598
1124'
1755'
952'
1755'
1685'
2306'
1458'
3666
2340'
2242'
1306
1591
2715
3853
0
0
RD
1383'
3024'
231
222
HANNAH ST
1331'
2962'
AIKEN RD
591'
1429'
2104'
1311'
773
664
COPELAND RD
HILLS
886'
1570
1481
1481
1412
1412
0
0
F2
689
2014
659
1976
126
229
635'
607'
NORTH ROCKS RD
805
700
346
693
1180'
2505
PENNANT
581
1242
CARLINGFORD RD
LEGEND
2715 - VEH./HR. (AM PEAK) FROM PLOT
2242' - VEH./HR. (AM PEAK) ADJUSTED
DIAGRAM 14
PENNANT HILLS ROAD 1993
(WESTERN SECTION OF F2
FREEWAY PLUS EPPING BYPASS
PENNANT HILLS ROAD DO NOTHING)
ASSIGNMENT - PHR93AE

TRAVERS MORGAN



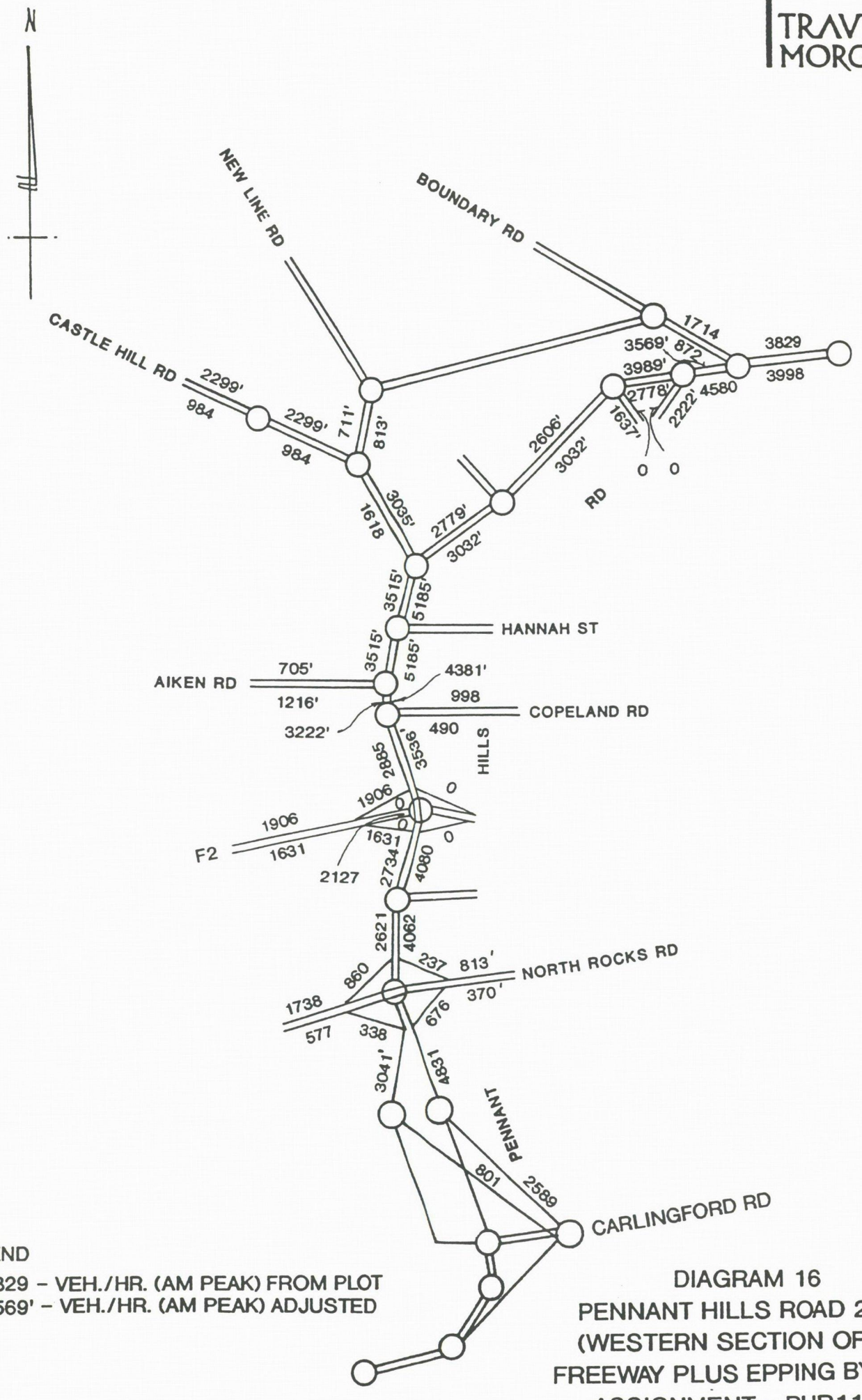
LEGEND

3830 - VEH./HR. (AM PEAK) FROM PLOT
3624' - VEH./HR. (AM PEAK) ADJUSTED

DIAGRAM 15

PENNANT HILLS ROAD 2001
(WESTERN SECTION OF F2
FREEWAY PLUS EPPING BYPASS)
ASSIGNMENT - PHR01PAE

TRAVERS MORGAN

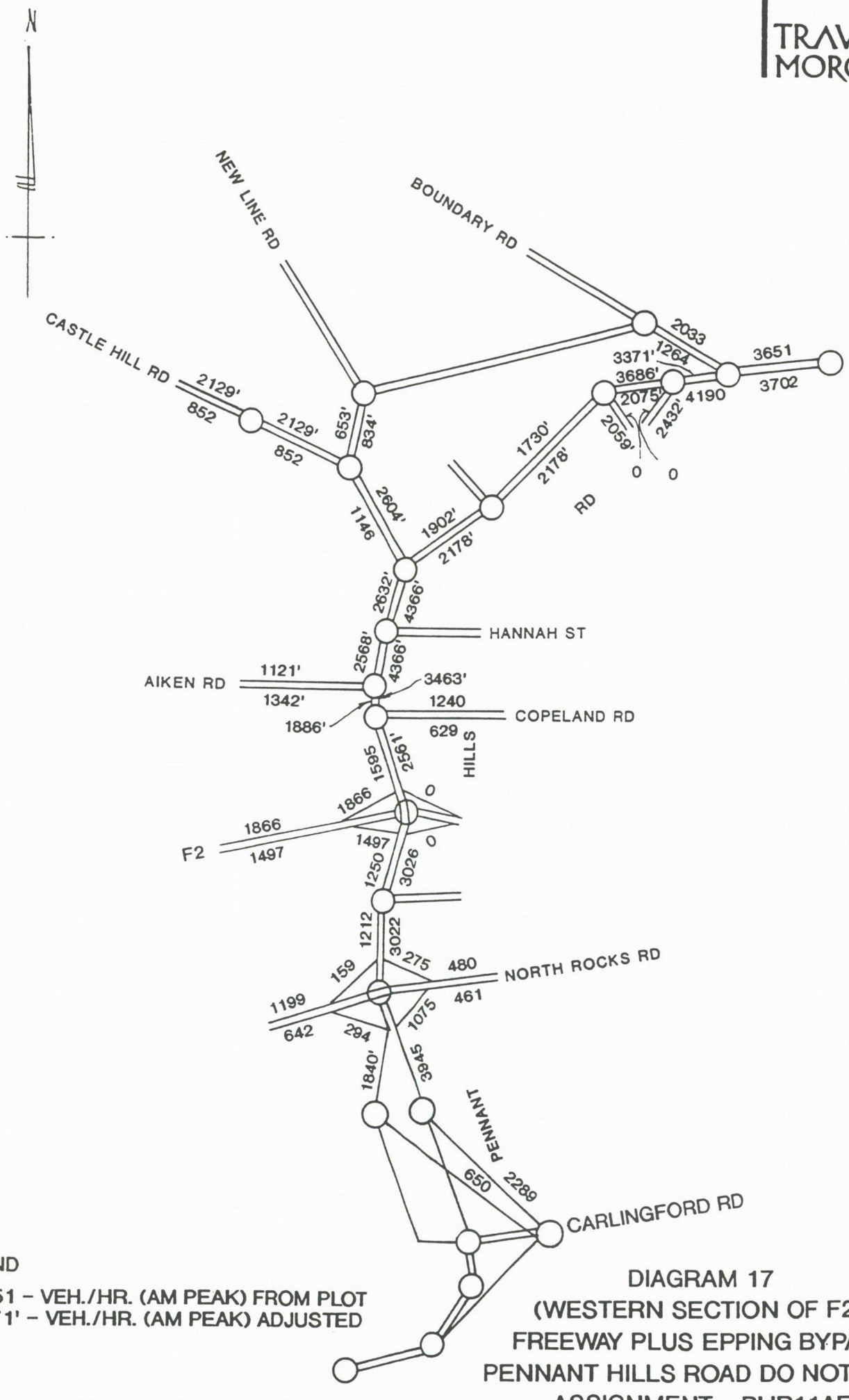


LEGEND

3829 – VEH./HR. (AM PEAK) FROM PLOT
3569' – VEH./HR. (AM PEAK) ADJUSTED

DIAGRAM 16
PENNANT HILLS ROAD 2011
(WESTERN SECTION OF F2
FREEWAY PLUS EPPING BYPASS)
ASSIGNMENT – PHR11PAE

TRAVERS MORGAN



LEGEND

3651 – VEH./HR. (AM PEAK) FROM PLOT
3371' – VEH./HR. (AM PEAK) ADJUSTED

DIAGRAM 17
(WESTERN SECTION OF F2
FREEWAY PLUS EPPING BYPASS,
PENNANT HILLS ROAD DO NOTHING)
ASSIGNMENT – PHR11AE

TRAVERS MORGAN

APPENDIX B

SCATES ECONOMIC ASSESSMENT OUTPUTS

ANNUAL SUMMARY of FILES COMPARED
for SCATS OPERATION.

SCATES Program Version: 4.42 Date: 31-OCT-90
File: PHR93PAE.ALL Time: 10:00:53

RESULTS AS CALCULATED

FILE Name	TOTAL $ Cost Million	DELAY HOURS Million	STOPS Million	Mean AADT	KM Million	FUEL Million LITRES	AVERAGE $Cost/ VEH.Km	AVERAGE $Cost/ VEHICLE
PHR93PAE	18.721	317679	47.293	59267	97.373	10.710	0.519	2.095

COST DATA USED IN ECONOMIC EVALUATION

Traffic Condition Period	Hours/Year	Dollars/Hour
Off Peak	1000	12.770
Medium Off Peak	1050	12.770
Medium Business Hours	1650	16.480
Heavy Business Hours	1800	16.480
Early AM Peak Hour	400	18.000
AM Peak Hour	600	18.000
Early PM Peak Hour	400	18.000
PM Peak Hour	600	18.000
Total Hours Year. (8760)	8100	

Fuel cost/litre.	$ 0.310
Vehicle operating cost/kilometre.	$ 0.100
Vehicle operating cost/hour.	$ 0.301
Vehicle Cost Stop.	$ 0.330
Fuel used/Stop.	0.0400
Kilometres Litre.	11.1111

DESCRIPTION of FILES

FILE
Name

PHR93PAE PENNANT HILLS ROAD

CYCLE LENGTHS USED
PEAK HOUR CYCLE LENGTH OPTIMISATION WAS USED

FILE Name	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
PHR93PAE	32	42	46	90	142	160	50	90

PERCENTAGE OF MAXIMUM PEAK VOLUMES USED IN EACH PERIOD

ANNUAL SUMMARY of FILES COMPARED
for SCATS OPERATION.

SCATES Program Version: 4.42 Date: 31-OCT-90
File: PHR93AE.ALL Time: 10:36:26

RESULTS AS CALCULATED

FILE Name	TOTAL $ Cost Million	DELAY HOURS	STOPS Million	Mean AADT	KM Million	FUEL Million LITRES	AVERAGE $Cost/ VEH.Km	AVERAGE $Cost/ VEHICLE
PHR93AE	72.137	2996491	86.259	45637	67.353	16.704	1.071	4.326

COST DATA USED IN ECONOMIC EVALUATION

Traffic Condition Period	Hours/Year	Dollars/Hour
Off Peak	1000	12.770
Medium Off Peak	1650	12.770
Medium Business Hours	1650	16.480
Heavy Business Hours	1800	16.480
Each AM Peak Hour	400	18.000
AM Peak Hour	600	18.000
Each PM Peak Hour	400	18.000
PM Peak Hour	600	18.000
Total Hours per Year	8100	

Fuel Cost/Litre.	$ 0.810
Vehicle operating cost/Kilometre.	$ 0.100
Vehicle operating cost/Hour.	$ 0.031
Vehicle Cost Ratio.	$ 0.030
Fuel Used/Stop.	0.0400
Kilometres/Litre	11.1111

DESCRIPTION of FILES

FILE Name	
PHR93AE	PENNANT HILLS ROAD

CYCLE LENGTHS USED
PEAK HOUR CYCLE LENGTH OPTIMISATION WAS USED

FILE Name	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
PHR93AE	70	86	114	158	138	160	134	160

PERCENTAGE OF MAXIMUM PEAK VOLUMES USED IN EACH PERIOD

LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
15.0	40.0	68.0	100.0	75.0	100.0	75.0	100.0

ANNUAL SUMMARY of FILES COMPARED
for SCATS OPERATION.

SCATES Program Version: 4.42 Date: 31-OCT-90
File: PHR11PAE.ALL Time: 10:18:38

RESULTS AS CALCULATED

FILE Name	TOTAL $ Cost Million	DELAY HOURS	STOPS Million	Mean AADT	KM Million	FUEL Million LITRES	AVERAGE $Cost/ VEH.Km	AVERAGE $Cost/ VEHICLE
PHR11PAE	103.143	2921730	112.413	96099	138.724	23.994	0.744	3.003

COST DATA USED IN ECONOMIC EVALUATION

Traffic Condition Period	Hours/Year	Dollars/Hour
Off Peak	1000	12.770
Medium Off Peak	1650	12.770
Medium Business Hours	1650	16.480
Heavy Business Hours	1800	16.480
Early AM Peak Hour	400	18.000
AM Peak Hour	600	18.000
Early PM Peak Hour	400	18.000
PM Peak Hour	600	18.000
Total Hours/Year (Tot)	8760	

Fuel Cost $/Litre.	$ 0.700
Vehicle Operating cost/Kilometre.	$ 0.100
Vehicle Operating Cost/Hour.	$ 0.000
Vehicle Cost Gross.	$ 0.000
Fuel Consumption.	0.0400
Kilometres/Litre.	11.1111

DESCRIPTION of FILES

FILE Name	
PHR11PAE	PENNANT HILLS ROAD

CYCLE LENGTHS USED
PEAK HOUR CYCLE LENGTH OPTIMISATION WAS USED

FILE Name	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
PHR11PAE	32	62	110	158	130	160	130	160

PERCENTAGE OF MAXIMUM PEAK VOLUMES USED IN EACH PERIOD

LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
13.3	33.3	45.3	100.0	75.0	100.0	75.0	100.0

ANNUAL SUMMARY of FILES COMPARED
for SCATS OPERATION.

SCATES Program Version: 4.42 Date: 31-OCT-90
File: PHR11AE.ALL Time: 10:52:36

RESULTS AS CALCULATED

FILE Name	TOTAL $ Cost Million	DELAY HOURS Million	STOPS Million	Mean AADT	KM Million	FUEL Million LITRES	AVERAGE $Cost/ VEH.Km	AVERAGE $Cost/ VEHICLE
PHR11AE	119.25512069801	244.555	72507		106.892	48.370	2.051	8.285

COST DATA USED IN ECONOMIC EVALUATION

Traffic Condition Period	Hours/Year	Dollars/Hour
Off Peak	1000	12.770
Medium Off Peak	1650	12.770
Medium Business Hours	1650	16.480
Heavy Business Hours	1800	16.480
Early AM Peak Hour	400	16.000
AM Peak Hour	600	16.000
Early PM Peak Hour	400	16.000
PM Peak Hour	600	16.000
Total Hours Year. (8760)	8760	

Fuel cost/ litre.	$ 0.500
Vehicle operating cost/kilometre	$ 0.100
Vehicle operating cost/hour.	$ 0.000
Vehicle cost/Stop.	$ 0.000
Fuel Used /Km.	0.0400
Kilometres/ litre.	11.1111

DESCRIPTION of FILES

FILE Name	
PHR11AE	PENNANT HILLS ROAD

CYCLE LENGTHS USED
PEAK HOUR CYCLE LENGTH OPTIMISATION WAS USED

FILE Name	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
P-R11AE	34	70	110	158	130	160	130	160

PERCENTAGE OF MAXIMUM PEAK VOLUMES USED IN EACH PERIOD

LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
14.7	38.7	65.3	100.0	75.0	100.0	75.0	100.0

ANNUAL SUMMARY of FILES COMPARED
for SCATS OPERATION.

SCATES Program Version: 4.42 Date: 26-OCT-90
File: PHR93SLC.ALL Time: 13:08:57

RESULTS AS CALCULATED

FILE Name	TOTAL $ Cost Million	DELAY HOURS	STOPS Million	Mean AADT	KM Million	FUEL Million LITRES	AVERAGE $Cost/ VEH.Km	AVERAGE $Cost/ VEHICLE
PHR93SLC	46.134	623617	49.445	52433	81.088	10.772	0.569	2.411

COST DATA USED IN ECONOMIC EVALUATION

Traffic Condition Period	Hours/Year	Dollars/Hour
Off Peak	1000	12.770
Medium Off Peak	1650	12.770
Medium Business Hours	1650	16.400
Peak Business Hours	1200	16.400
Fig AM Peak Hour	400	18.000
Peak Hour	600	18.000
Fig PM Peak Hour	400	18.000
Peak Hour	600	18.000
Total Hours/Year. (8760)	8100	

Fuel cost/litre.	$ 0.510
Vehicle operating cost/kilometre.	$ 0.100
Vehicle operating cost/hour.	$ 0.000
Vehicle Cost/Stop.	$ 0.030
Litres used/Stop.	0.0400
Kilometres/Litre.	11.1111

DESCRIPTION of FILES

File

PHR93SLC PENNANT HILLS ROAD

CYCLE LENGTHS USED
PEAK HOUR CYCLE LENGTH OPTIMISATION WAS USED

	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
93SLC	32	44	78	90	130	160	86	106

PERCENTAGE OF MAXIMUM PEAK VOLUMES USED IN EACH PERIOD

LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
15.0	40.0	75.0	100.0	75.0	100.0	75.0	100.0

ANNUAL SUMMARY of FILES COMPARED
for SCATS OPERATION.

SCATES Program Version: 4.42 Date: 26-OCT-90
File: PHR93RED.ALL Time: 13:38:35

RESULTS AS CALCULATED

FILE Name	TOTAL $ Cost Million	DELAY HOURS	STOPS Million	Mean AADT	KM Million	FUEL Million LITRES	AVERAGE $Cost/ VEH.Km	AVERAGE $Cost/ VEHICLE
PHR93RED	46.145	624352	49.493	52433	81.088	10.776	0.569	2.411

COST DATA USED IN ECONOMIC EVALUATION

Traffic Condition Period	Hours/Year	Dollars/Hour
Off Peak	1000	12.770
Medium Off Peak	1650	12.770
Medium Business Hours	1650	16.480
Heavy Business Hours	1800	16.480
Early AM Peak Hour	400	10.000
AM Peak Hour	600	10.000
Early PM Peak Hour	400	10.000
PM Peak Hour	600	10.000
Total Hours/Year. (8760)	8100	
Fuel cost/litre.		$ 0.310
Vehicle operating cost/kilometre.		$ 0.100
Vehicle operating cost/hour.		$ 0.000
Vehicle cost/Stop.		$ 0.030
Fuel cost/Stop.		0.0400
Kilometres/Litre.		11.1111

DESCRIPTION of FILES

FILE
Name

PHR93RED PENNANT HILLS ROAD

CYCLE LENGTHS USED
PEAK HOUR CYCLE LENGTH OPTIMISATION WAS USED

FILE Name	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
PHR93RED	32	44	78	90	130	160	86	106

PERCENTAGE OF MAXIMUM PEAK VOLUMES USED IN EACH PERIOD

LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
15.0	40.0	75.0	100.0	75.0	100.0	75.0	100.0

ANNUAL SUMMARY of FILES COMPARED
for SCATS OPERATION.

SCATES Program Version: 4.42 Date: 26-OCT-90
File: PHR11SLC.ALL Time: 10:50:34

RESULTS AS CALCULATED

FILE Name	TOTAL $ Cost Million	DELAY HOURS Million	STOPS Million	Mean AADT	KM Million	FUEL Million LITRES	AVERAGE $Cost/ VEH.Km	AVERAGE $Cost/ VEHICLE
PHR11SLC	83.061	1991782	78.126	79390	122.777	18.955	0.677	2.866

COST DATA USED IN ECONOMIC EVALUATION

Traffic Condition Period	Hours/Year	Dollars/Hour
Off Peak	1000	12.770
Medium Off Peak	1650	12.770
Medium Business Hours	1650	16.480
Heavy Business Hours	1800	16.480
Early AM Peak Hour	400	18.000
AM Peak Hour	600	18.000
Early PM Peak Hour	400	18.000
PM Peak Hour	600	18.000
Total Hours/Year. (8760)	8100	
Fuel cost/litre.		$ 0.310
Vehicle operating cost/kilometre.		$ 0.100
Vehicle operating cost/hour.		$ 0.000
Vehicle cost/Stop.		$ 0.030
Fuel use/Stop.		0.0400
Kilometres/Litre.		11.1111

DESCRIPTION of FILES

FILE Name	
PHR11SLC	PENNANT HILLS ROAD

CYCLE LENGTHS USED
PEAK HOUR CYCLE LENGTH OPTIMISATION WAS USED

FILE Name	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
PHR11SLC	32	66	110	160	130	160	130	160

PERCENTAGE OF MAXIMUM PEAK VOLUMES USED IN EACH PERIOD

LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
13.3	36.0	65.3	100.0	75.0	100.0	75.0	100.0

ANNUAL SUMMARY of FILES COMPARED
for SCATS OPERATION.

SCATES Program Version: 4.42 Date: 26-OCT-90
File: PHR11RED.ALL Time: 10:37:45

RESULTS AS CALCULATED

FILE Name	TOTAL $ Cost Million	DELAY HOURS	STOPS Million	Mean AADT	KM Million	FUEL Million LITRES	AVERAGE $Cost/ VEH.Km	AVERAGE $Cost/ VEHICLE
PHR11RED	33.106	1994539	78.085	79390	122.777	18.960	0.677	2.868

COST DATA USED IN ECONOMIC EVALUATION

Traffic Condition Period	Hours/Year	Dollars/Hour
Off Peak	1300	12.770
Medium Off Peak	1650	12.770
Medium Business Hours	1650	16.480
Heavy Business Hours	1800	16.480
Early AM Peak Hour	400	10.000
AM Peak Hour	600	10.000
Early PM Peak Hour	400	10.000
PM Peak Hour	600	10.000
Total Hours/Year. (8760)	8100	

Fuel cost/litre.	$ 0.310
Vehicle operating cost/kilometre.	$ 0.100
Vehicle operating cost/hour.	$ 0.000
Vehicle Cost/Stop.	$ 0.030
Fuel used/Stop.	0.0400
Kilometres/Litre.	11.1111

DESCRIPTION of FILES

FILE Name	
PHR11RED	PENNANT HILLS ROAD

CYCLE LENGTHS USED
PEAK HOUR CYCLE LENGTH OPTIMISATION WAS USED

FILE Name	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
PHR11RED	32	66	110	160	130	160	130	160

PERCENTAGE OF MAXIMUM PEAK VOLUMES USED IN EACH PERIOD

ANNUAL SUMMARY of FILES COMPARED
for SCATS OPERATION.

SCATES Program Version: 4.42 Date: 05-NOV-90
File: PHRO1LRA.ALL Time: 10:20:10

RESULTS AS CALCULATED

FILE Name	TOTAL $ Cost Million	DELAY HOURS	STOPS Million	Mean AADT	KM Million	FUEL Million LITRES	AVERAGE $Cost/ VEH.Km	AVERAGE $Cost/ VEHICLE
PHRO1LRA	74.279	1497428	83.941	79223	116.801	17.544	0.636	2.569

COST DATA USED IN ECONOMIC EVALUATION

Traffic Condition Period	Hours/Year	Dollars/Hour
Off Peak	1000	12.770
Medium Off Peak	1650	12.770
Medium Business Hours	1650	14.480
High Business Hours	1000	16.430
Early AM Peak Hour	400	10.000
AM Peak Hour	600	10.000
Early PM Peak Hour	400	10.000
PM Peak Hour	600	10.000
Total Volume Year (8760)	8100	

Fuel cost/Litre.	$ 0.310
Vehicle operating cost/Kilometre	$ 0.100
Vehicle operating cost/Hour.	$ 0.001
Vehicle Cost/Stop.	$ 0.030
Fuel cost/Litre.	0.0407
Kilometres/Litre.	11.1111

DESCRIPTION of FILES

File
Name

PHRO1LRA PENNANT HILLS ROAD

CYCLE LENGTHS USED
PEAK HOUR CYCLE LENGTH OPTIMISATION WAS USED

FILE Name	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
PHRO1LRA	32	62	114	158	130	160	150	160

PERCENTAGE OF MAXIMUM PEAK VOLUMES USED IN EACH PERIOD

LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
13.3	33.3	68.0	100.0	75.0	100.0	75.0	100.0

Total Operating Cost per Veh.	$	2.81	2.57

ANNUAL SUMMARY of FILES COMPARED
for SCATS OPERATION.

SCATES Program Version: 4.42 Date: 05-NOV-90
File: PHRO1PAE.ALL Time: 09:49:59

RESULTS AS CALCULATED

FILE Name	TOTAL $ Cost Million	DELAY HOURS	STOPS Million	Mean AADT	KM Million	FUEL Million LITRES	AVERAGE $Cost/ VEH.Km	AVERAGE $Cost/ VEHICLE
PHRO1PAE	74.255	1493582	86.346	79228	116.801	17.551	0.636	2.568

COST DATA USED IN ECONOMIC EVALUATION

Traffic Condition Period	Hours/Year	Dollars/Hour
Off Peak	1000	12.770
Medium Off Peak	1690	12.770
Medium Business Hours	1650	16.420
Heavy Business Hours	1300	16.420
Early AM Peak Hour	400	10.000
AM Peak Hour	600	10.000
Early PM Peak Hour	400	10.000
PM Peak Hour	600	10.000
Total Hours/Year. (8760)	8100	
Fuel cost/litre.		$ 0.310
Vehicle operating cost/kilometre.		$ 0.100
Vehicle operating cost/hour.		$ 3.571
Vehicle Cost/Stop.		$ 7.000
Time Used/Stop.		0.0400
Kilometres/Litre.		12.111

DESCRIPTION of FILES

FILE Name	
PHRO1PAE	PENNANT HILLS ROAD

CYCLE LENGTHS USED
PEAK HOUR CYCLE LENGTH OPTIMISATION WAS USED

FILE Name	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
PHRO1PAE	32	62	114	158	130	160	150	160

PERCENTAGE OF MAXIMUM PEAK VOLUMES USED IN EACH PERIOD

	LIGHT OFF	MEDIUM OFF	MEDIUM BUS	PEAK BUS	MEDIUM AM	PEAK AM	MEDIUM PM	PEAK PM
	13.3	33.3	68.0	100.0	75.0	100.0	75.0	100.0

FIGURE 1

PENNANT HILLS ROAD - SOUTH OF COPELAND ROAD

SEASIONAL VARIATION OF TRAFFIC FLOW (AADT)

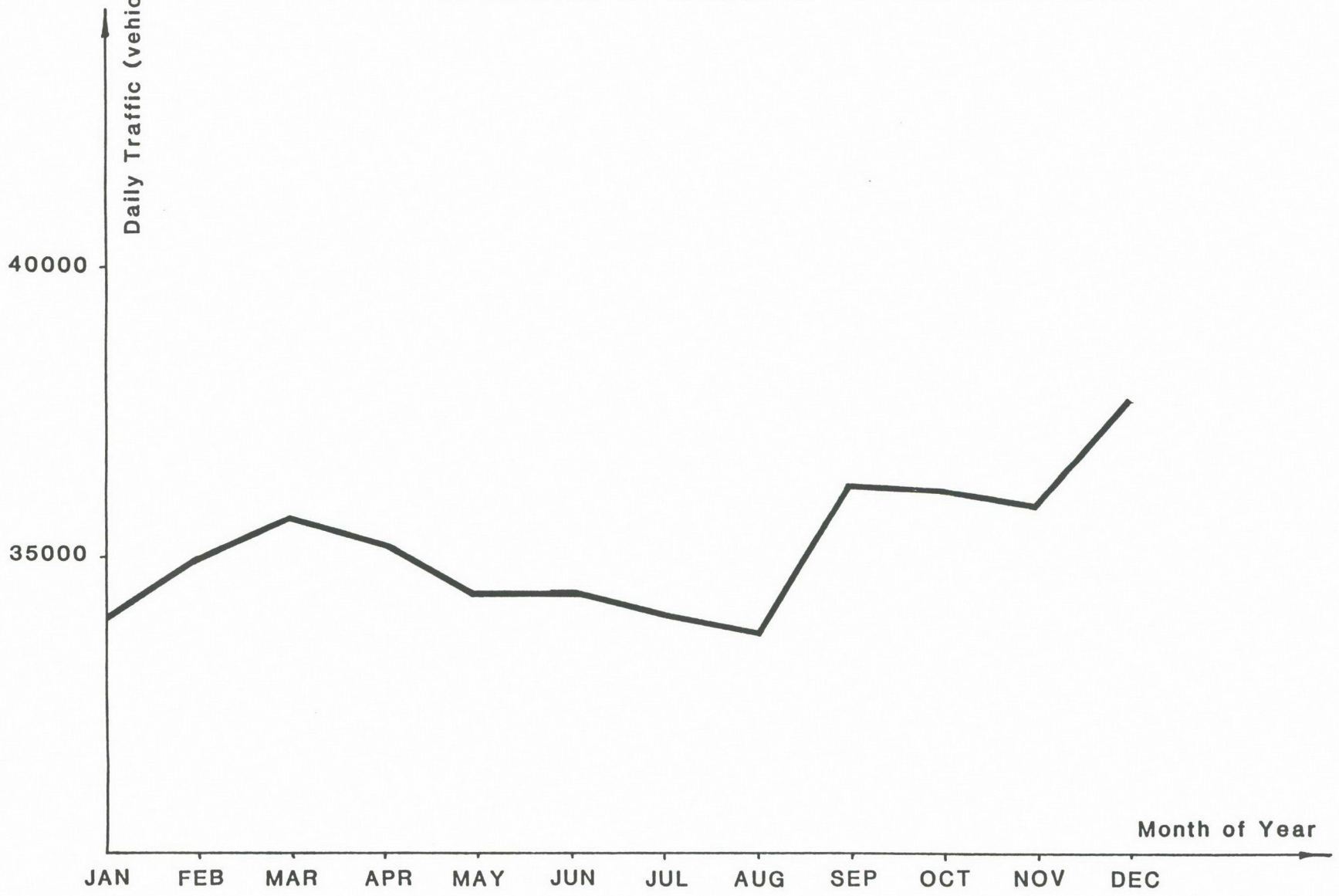


FIGURE 2 : PENNANT HILLS ROAD-SOUTH OF COPELAND ROAD
WEEKDAY HOURLY VARIATION OF TRAFFIC VOLUMES

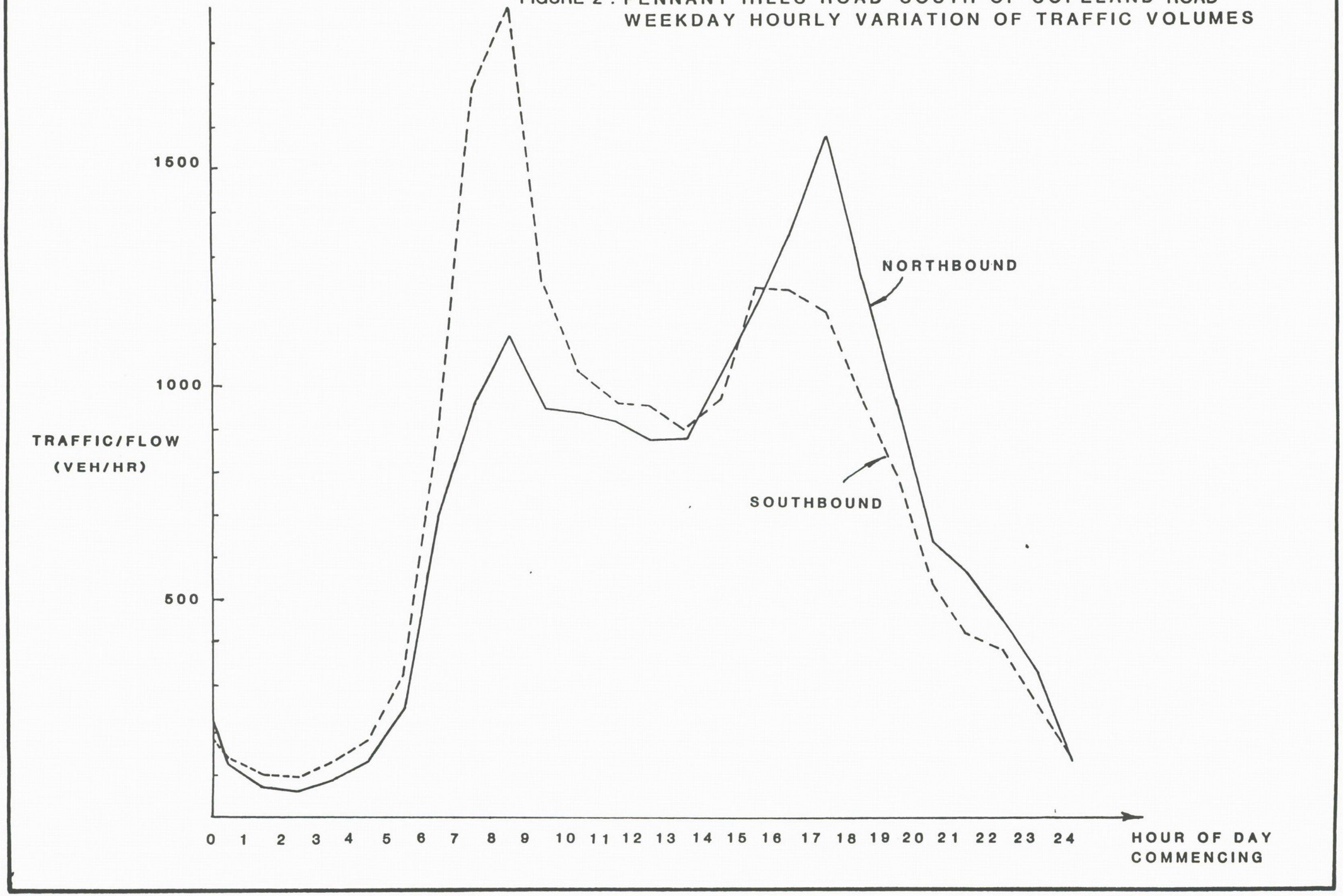
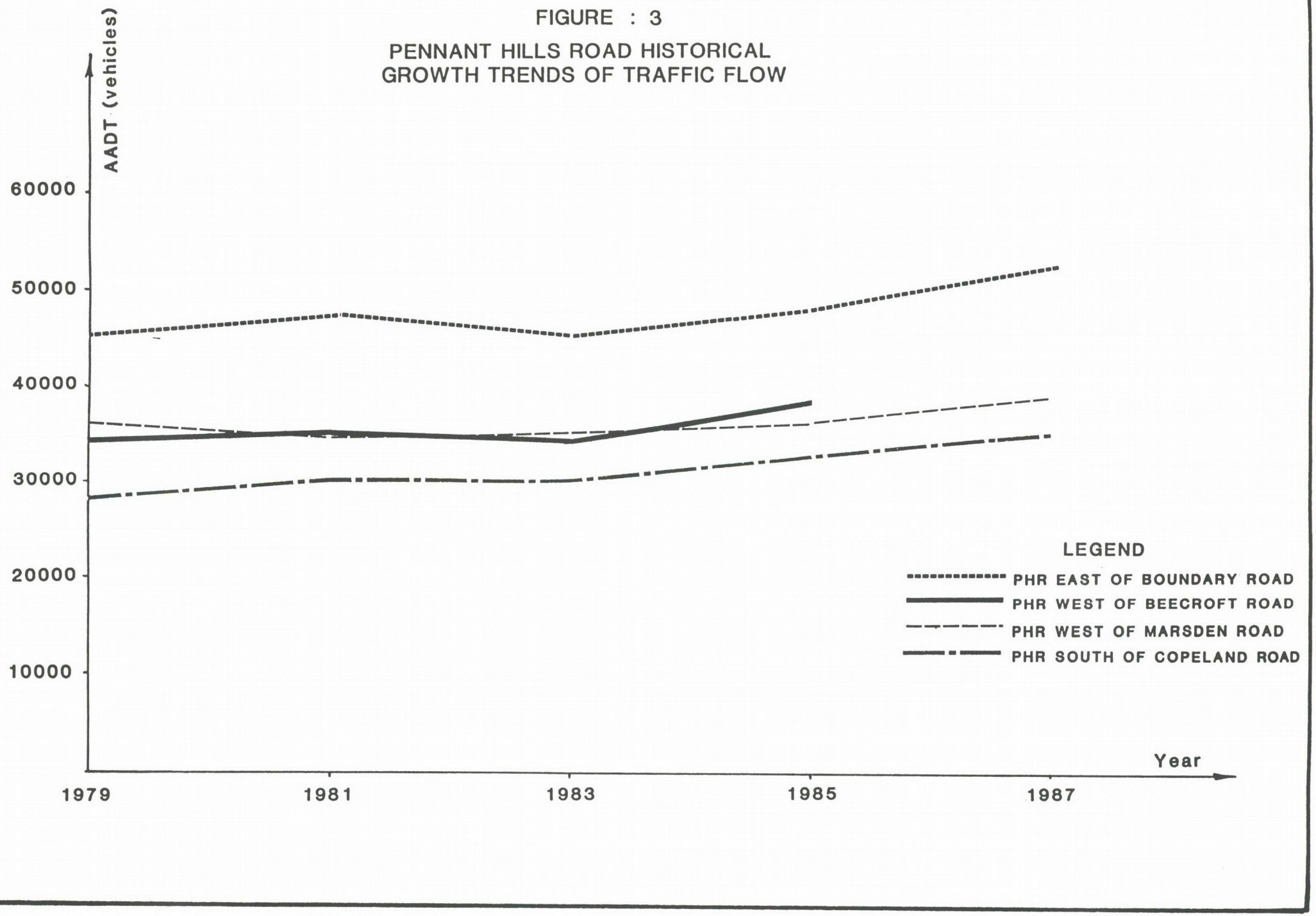


FIGURE : 3

PENNANT HILLS ROAD HISTORICAL
GROWTH TRENDS OF TRAFFIC FLOW



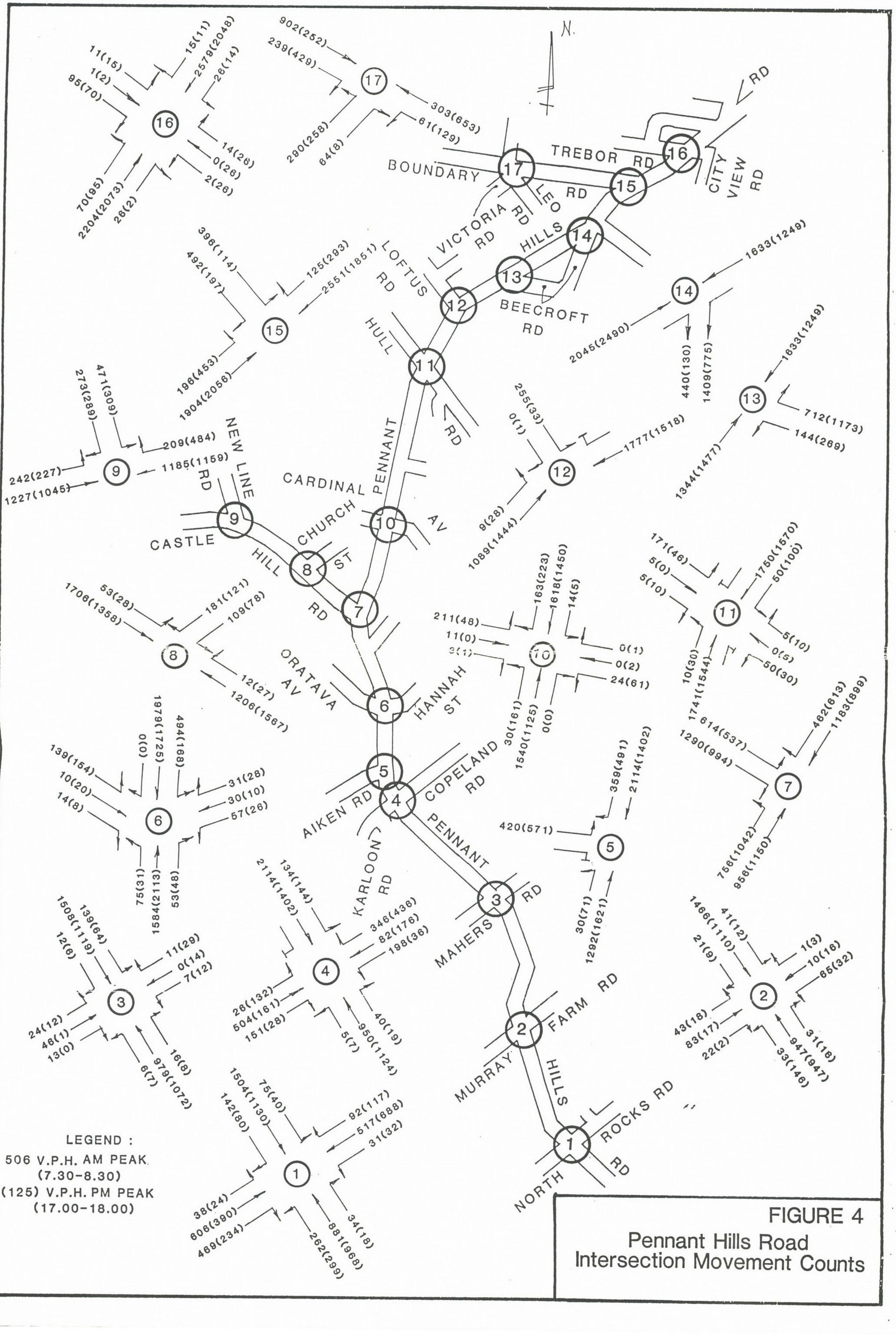


FIGURE 4

Pennant Hills Road
Intersection Movement Counts

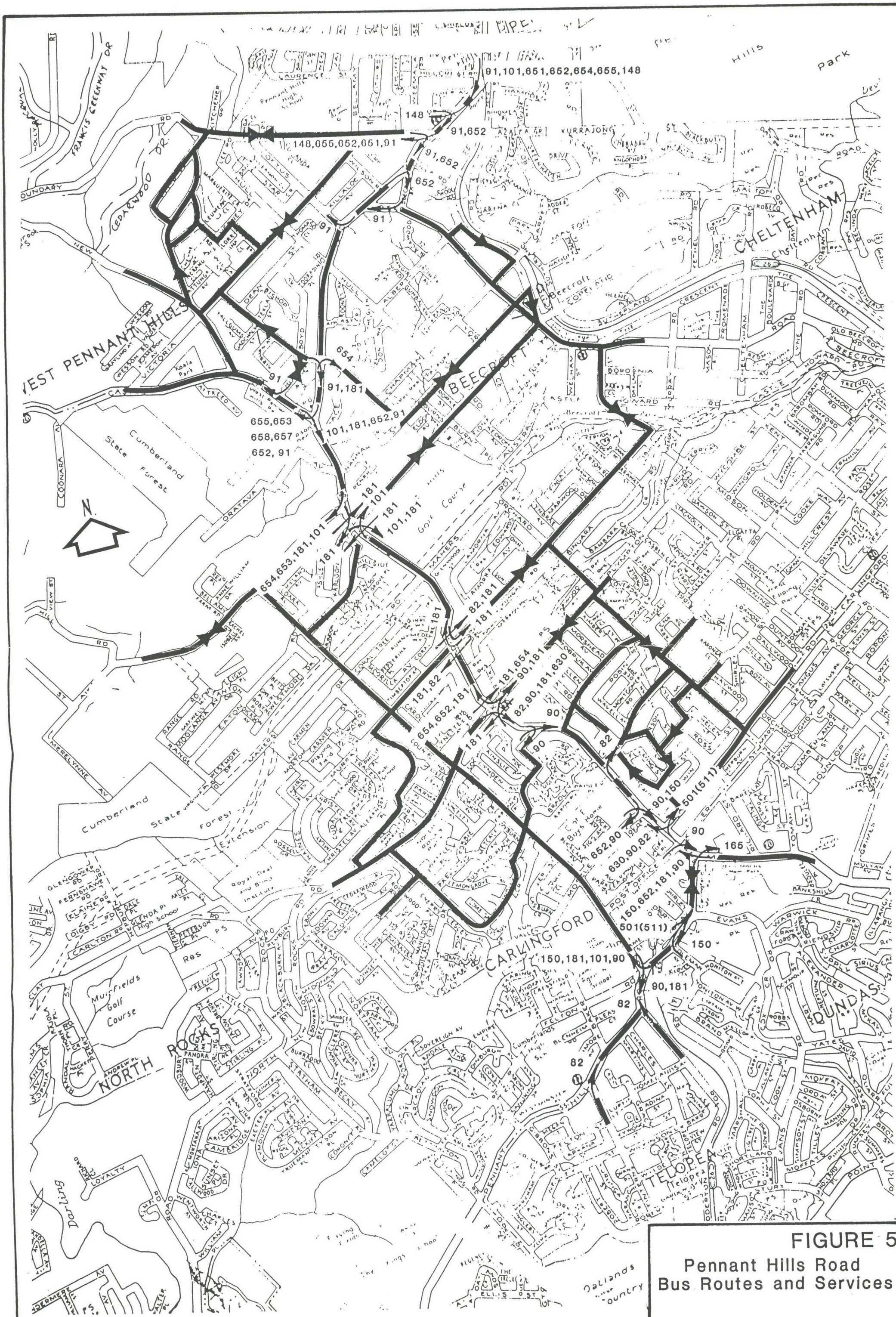
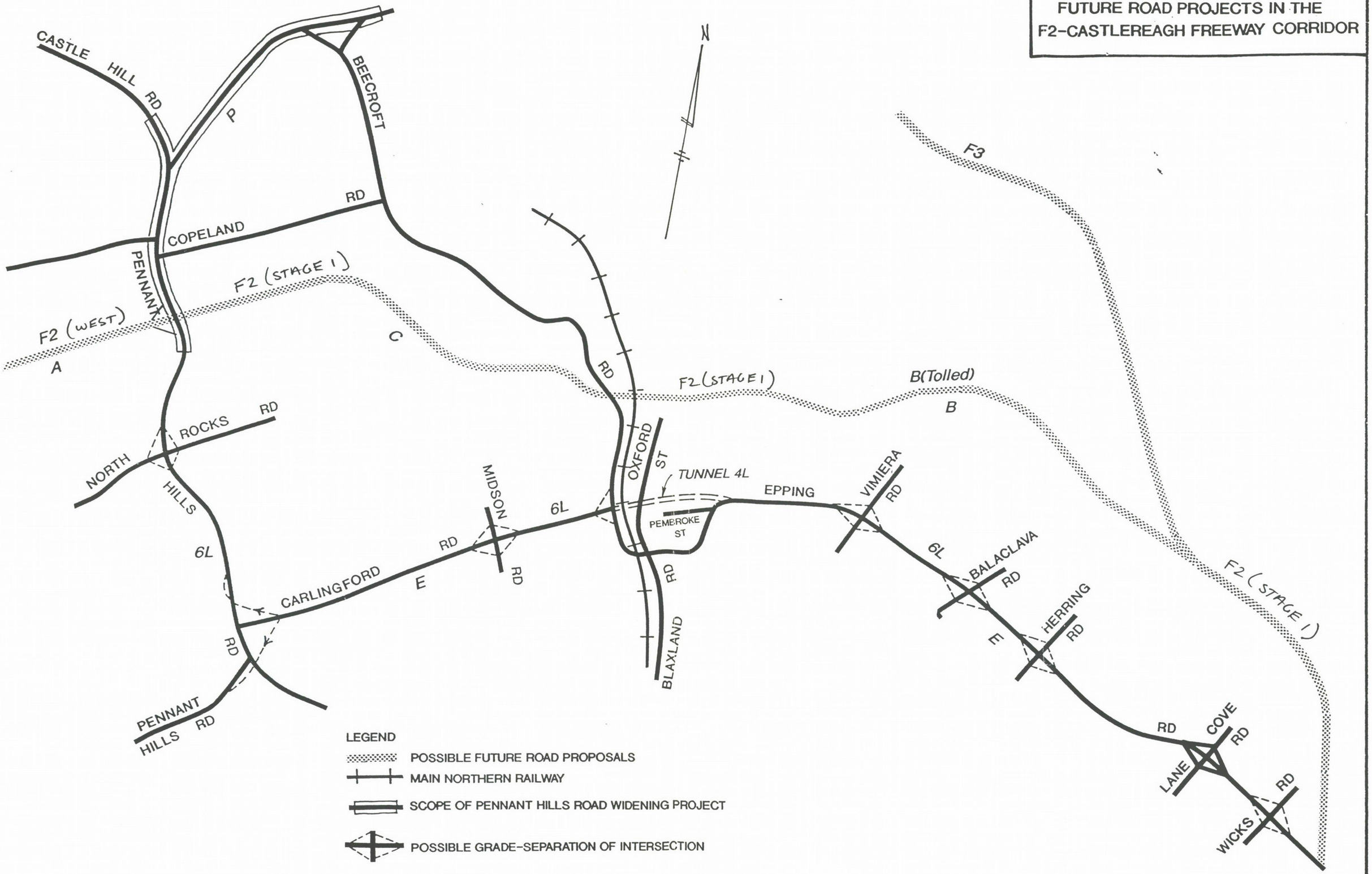


FIGURE 5

Pennant Hills Road
Bus Routes and Services

FIGURE 6
ASSUMPTIONS FOR
FUTURE ROAD PROJECTS IN THE
F2-CASTLEREAGH FREEWAY CORRIDOR



2. ACOUSTIC IMPACT REPORT

JAMES MADDEN COOPER ATKINS

JAMES MADDEN COOPER ATKINS PTY LIMITED.

CONSULTING ACOUSTICAL & VIBRATION ENGINEERS

NOISE INVESTIGATION

PENNANT HILLS ROAD WIDENING

BETWEEN BEECROFT ROAD AND MAHERS ROAD

20.2117.R4:GA16

Prepared for: Connell Wagner (NSW) Pty Limited
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November 1990

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APPENDICES

APPENDIX A: SITE LOCATION
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1.0 INTRODUCTION

The Road Traffic Authority propose to widen and upgrade Pennant Hills Road between Boundary Road and Mahers Road, Beecroft. In addition a section of Castle Hill Road from Thompson Corner to Church Street will also be widened and upgraded. The section of proposed roadworks is shown on Appendix A.

Overall the roadworks involves the widening some 3.3 kilometres of the four lane road to six lanes. The road widening will include property acquisitions and affect some areas of public open space.

This report presents the results and findings of an acoustical assessment of road traffic noise at locations along the subject section of the road for both its operation and construction (Scheme I). Predicted noise levels are also presented for traffic flow increases on the assumption that the F2 freeway is abandoned (Scheme II).

The aims of the investigation were as follows:

1. To determine the existing ambient noise levels on Pennant Hills Road.
2. To calculate the envisaged change in road traffic noise due to the proposed road widening program.
3. To identify the primary areas that are exposed to the road traffic noise.
4. To review and recommend an ameliorative measures for areas.
5. To predict and evaluate noise levels from the envisaged construction program and activities.

2.0 ASSESSMENT CRITERIA FOR TRAFFIC NOISE

There are a number of criterion and policies available for the assessment of road traffic noise.

2.1 Road Traffic Authority Criteria

The current RTA policy in regards to road traffic noise for the planning and design of new works (including road upgrades) is that:

a) The RTA on a project specific basis examines whether it is practical to provide the environmental objective level, where cost affective.

b) For major new road developments the environmental objective level of 63dB(A) at the residential facade (or better where cost effective) has been adopted by the RTA.

c) For existing roads the criteria normally adopted by the RTA is that noise attenuation measures are generally considered to be warranted only when an examination of noise levels reveals that the L_{10} (18 hour) at the residential facade is 68dB(A) or greater and has risen by more than 2dB(A) above the previously existing noise level; or is between 63dB()A and 68dB(A) and has risen above the previously existing noise level by at least 15dB(A).

d) RTA also recommend that where possible disturbance can occur particularly where high traffic volumes or if the numbers of heavy vehicles at night is high than an

appropriate assessment should be made. Their present policy for sleep disturbance assessment is an internal level of 45dB(A) L_{eq} between the 8 hour period from 2200-0600 hours.

e) For the assessment of noise levels in school classrooms the RTA have adopted the New South Wales PWD internal criteria of 45dB(A) L_{eq}.

For the evaluation of the above criterion the following parameters are usually considered.

a) The traffic expected to use the road approximately 10 years after opening.

b) The existing road network plus the proposed facility and any other committed projects (i.e. projects for which the Department has firm proposals and which can be reasonably expected to be completed within the 10year period), having a direct traffic influence on the site in question.

c) An adequate allowance for likely capacity limitation on the approaches, such as an adjoining section not yet improved, traffic signals, etc; and

d) Current rates of growth and traffic flow.

2.2 State Pollution Control Commission

2.2.1 Current Policy

The SPCC currently promotes for planning purposes in situations

where the noise from road traffic is already significant that ameliorative measures should be considered when the L_{10} (18 hours) exceeds 63dB(A).

2.2.2 Proposed Revised Policy

From recent studies and investigations we understand that the SPCC propose to introduce and support a revised descriptor and assessment criteria (TNL55). The TNL criteria is based on an L_{eq} 24 hour measurement which is adjusted by an index weighted towards heavy vehicle movements between 10.00pm and 7.00am.

The general form of the index is given by the equation:

$$TNL = L_{Aeq} \text{ (24 hours)} + (0.1\ (x))$$

Where x = the mean hourly truck count between 10.00pm and 7.00am.

2.3 Project Criteria

For this assessment, road traffic noise levels at residential facades have be assessed in terms of the Road Traffic Authority policy, that is;

" the L_{10} (18 hour) noise at one (1) metre from the facade of a residential dwelling is 68dB(A) or greater and more than 2dB(A) higher than the level prior to construction."

" the sleep disturbance criteria in terms of internal levels of 45dB(A) L_{eq} between the 8 hour period from 2200-0600 hours."

and

" the internal classroom criteria of 45dB(A) L_{eq}."

3.0 PROCEDURE

The findings of this report are based on site visits, inspections, ambient sound pressure level measurements and data provided by the RTA, Connell Wagner Pty Limited and the traffic consultants Travis Morgan.

To determine the existing ambient noise levels, sound pressure level measurements were conducted during the months of October and November 1989 and October 1990. The measurements were conducted on both short term and long term periods (up to 48 hours).

3.1 Instrumentation

The measurement of noise levels was made using the following equipment:

* Bruel & Kjaer Statistical Noise Level Analyser Type 4426, fitted with a 12mm Microphone Type 4165.
* Bruel & Kjaer Precision Sound Level Meter Type 2203 fitted with a 12mm Microphone Type 4165.
* Bruel & Kjaer Level Recorder Type 2317, Serial Number 1134315.
* Cel Instruments Precision Sound Level Meter Type 231 fitted with a 6mm Microphone.
* Onset Laptop Computer Corporation, Data Logger.
* Toshiba Laptop T1000, Computer.

The instruments were checked for calibration prior to and after measurements using a Bruel & Kjaer Sound Level Calibrator Type 4230.

3.2 Noise Level Descriptors

The loudness of fluctuating environmental noise usually is described by reference to the percentile noise level or noise exceedance level.

The most common percentile levels which are commonly referenced and are usually determined by statistical sound level measurement equipment, are the statistical values designated as L_{AN}. The parameters generally regarded as being the most significant amongst these are:

"L_{A1}" which is the A-weighted sound level exceeded for 1% of the time or the peak sound level:
the "L_{A10}" level which is the A-weighted sound level exceeded for 10% of the sample period and which is commonly termed the "average maximum noise level":
the "L_{A90}" level which is the A-weighted sound level exceeded for 90% of the sample period and is commonly termed the "average minimum or background noise level":
and the "L_{Aeq}" level which is the A-weighted energy equivalent continuous (constant) sound level.

3.3 Method for Predicting Traffic Noise Levels

Traffic noise levels are determined in accordance with the L_{A10} (18 hour) descriptor defined in the Australian Standard AS2702 - 1984. The L_{A10} (18 hour) is the arithmetic average of 18 individual L_{A10} values measured between the hours of 6.00am and midnight. The L_{A10} (18 hour) descriptor is used and accepted by the State Pollution Control Commission and the Road Traffic Authority.

Traffic noise levels at each of the reference locations shown in Appendix D were calculated using measured levels combined with adjustments as described in the manual "Calculation of Road Traffic Noise" produced by the UK Department of Environment (CORTN method). The method takes account of vehicle movements and speed, percentage of heavy vehicles, ground cover, topography of the area and both shielding and reflection from barriers.

An Australian Study, published as Australian Road Research Board (ARRB) Research Report No. 122, compared measured noise levels at various locations in Australia with the CORTN predictions and concluded that a facade corrections should be applied to the predictions to provide the best estimate of noise levels under Australian conditions. These corrections have been applied to the calculated levels in this report.

4.0 MEASUREMENT OF EXISTING NOISE LEVELS

For the assessment of existing road traffic noise levels, sound pressure level measurements were made at the following reference locations (Appendix B).

* Location 1 - Pennant Hills Road, boundary of golf course near Mahers Road.

* Location 2 - Front of 660 Pennant Hills Road. Flat topography with a direct line of sight. Facade of house set back approximately 15 metres.

* Location 3 - Front of 612 Pennant Hills Road. Flat topography with a direct line of sight. Facade of house set back approximately 15 metres.

* Location 4 - Front of 602 Pennant Hills Road. The site is slightly elevated with direct line of sight. Facade of house set back approximately 20 metres.

* Location 5 - Front of 596 Pennant Hills Road. The site falls away from road approximately 1.5 metres with a direct line of sight. Facade of house set back approximately 15 metres.

* Location 6 - Front of 541 Pennant Hills Road. Flat topography with a direct line of sight. Facade of house set back approximately 15 metres.

* Location 7 - Near corner of Castle Hill Road. Flat topography, direct line of sight. Facade of house set back approximately 10 metres.

* Location 8 - Front of Church on Castle Hill Road. Flat topography with a direct line of sight. Facade of Church set back approximately 20 metres.

* Location 8a - Inside Church. Windows and doors closed.

* Location 9 - Boundary of West Pennant Hills Public School. Flat topography with a direct line of sight. Facade of school rooms set back approximately 20 metres.

* Location 9a - Inside classroom fronting on to Castle Hill Road. Measurements made during normal school hours.

* Location 10 - Front of 542 West Pennant Hills Road. Flat topography with a direct line of sight. Facade of house set back approximately 12 metres.

* Location 11 - Front of 475 Pennant Hills Road. Flat topography with a direct line of sight. Facade of house set back approximately 15 metres.

* Location 12 - Front of 500 Pennant Hills Road. The site falls away from the road approximately 1.0 metres with a direct line of sight. Facade of house set back approximately 15 metres.

* Location 13 - Front of Novitiate at Mount St. Benedict's Girls High School. The site is on a slight rise from the road with a direct line of sight. Site separated from road by masonry wall approximately 2.5 metres high. Facade of rooms set back approximately 65 metres.

* Location 14 - Front of 476 Pennant Hills Road. Site falls away from road approximately 2 metres with a direct line of sight. Facade of house set back approximately 10 metres.

* Location 15 - Front of Mount St. Benedicts Girls High School. Flat topography, direct line of sight. Facade of class rooms set back approximately 45 metres.

* Location 15a - Inside classroom exposed to traffic noise on Pennant Hills Road. Measurements made during normal school hours.

* Location 16 - Front of 430 Pennant Hills road near Wilson Road. Flat topography with a direct line of sight. Facade of house set back approximately 15 metres.

5.0 EXISTING TRAFFIC NOISE LEVELS

Existing L_{A10} (18 hour), L_{Aeq} (nighttime) and L_{Aeq} (daytime) traffic noise levels have been determined in accordance with descriptors discussed earlier in this report. The noise levels together with traffic counts and heavy vehicle percentages are tabulated in Appendix C and are summarised below in Table I.

TABLE I: EXISTING TRAFFIC NOISE LEVEL

Location	L_{A10} (18 hours)	L_{Aeq} (Night)	Traffic Counts	% Heavy Vehicles
1	78.9	71.4	36306	11.2
2	77.3	70.3	32226	12.9
3	76.4	69.4	32360	12.9
4	75.4	68.4	36006	11.7
5	75.5	68.5	46926	9.1
6	73.8	66.8	41154	10.8
7	73.8	67.8	42774	10.7
8	72.9	-	33222	6.6
8a*	45.2 (L_{Aeq} 0900-1600 hours, internal)			
9	69.9	-	31368	6.1
9a*	54.4(L_{Aeq} 0900-1600 hours, internal)			
10	76.6	69.2	37152	14.0
11	76.5	69.5	37674	14.3
12	75.7	68.7	35940	14.2
13	66.1	-	40884	12.6
14	75.5	68.5	40770	10.5
15	74.9	-	38520	14.1
15a*	52.5(L_{Aeq} 0900-1600 hours, internal)			
16	77.2	68.5	46716	10.8

5.1 Comments on Results and General Discussions

The results of the measurements and our investigations clearly show that properties exposed to Pennant Hills Road are presently subjected to high traffic noise levels.

This situation is unlikely to change with any surface road concept that may be undertaken in the re-development of Pennant Hills Road.

The three major land uses along Pennant Hills Road that are affected by road traffic noise are residential, schools/churches and commercial/shops.

5.1.1 Road Surface

The present road surface is asphalt over concrete. The asphalt surface is in poor condition and in need of resurfacing. The existing surface is affected by a significant number of patches poor construction joints and many other imperfections.

There has been many studies of late into road surfaces in particular asphalt surfaces. The road texture is very important with respect to minimising tire noise, therefore, consideration must be given to select the best possible surface.

5.1.2 Road Gradients

The present road geometry and alignment consists of a number of sections which require extra acceleration of braking by the vehicles.

We recommend that consideration be given to eliminate or reduce the gradients on the various sections on the road.

5.2 Recommendations and Comments

In our opinion there are a number of options or a combination of these options that may be feasible in the redevelopment of this section of Pennant Hills Road, so as to minimise road traffic noise.

The options are:

5.2.1 Underground Road

Consideration should be given to either a tunnel or cut and cover road construction.

With this road design concept as well as reducing noise levels the airspace over the road could be used for commercial or recreation purposes.

5.2.2 Rezoning and Re-development of Land

Road traffic noise in the Hornsby Shire has been recognised for the past 15 years. Council's concern lead to the development of the "Shire of Hornsby Code of Practice for General Sound Insulation for Residential Flat Buildings". The Code has successfully been used for 15 years in reducing road traffic noise.

With the co-operation of Hornsby and Baulkham Hills Councils corridors or pockets of land along Pennant Hills Road could be re-zoned and redeveloped with suitable residential buildings specially designed and constructed to control traffic noise intrusion.

5.2.3 Buffer Zones

The principal envisaged in the provision of buffer zones, is that the existing front row of houses along Pennant Hills Road would be acquired and the land would be used to provide distance separation between other houses and the road traffic.

5.2.4 Noise Control Barriers

The possibility exists for road side barriers to be constructed along Pennant Hills Road, which, if properly designed could significantly reduce the traffic noise impact to the majority of houses.

Noise control barriers with an effective height of between 1.8 - 2.5 metres could be required. They would be constructed in masonry pre-cast panels or concrete block work. The minimum desirable mass per unit area for the barrier is 10kg/m^2.

6.0 PREDICTION OF FUTURE TRAFFIC NOISE LEVELS

For the computation of traffic noise levels at each reference location the following data has been considered:

6.1.1 Traffic Volumes

Traffic volumes are listed in Table II and are based on a data provided by Travis Morgan. Table III, summarises the estimated growth rates and envisaged increase in noise levels when compared to base figures.

Table II: Estimated Traffic Volumes

Location	Scheme 1			Scheme 2		
	Exist.	2001	2010	Exist.	2001	2010
Pennant Hills Road Sth, Castle Hill Rd.	42700	56000	79000	42700	79400	117000
Pennant Hills Road Sth, Beecroft Rd.	38998	51000	64900	38998	58000	75000
Pennant Hills Road Sth, Copeland Rd.	35016	54000	74000	35016	63000	86000
Castle Hill Road Nth, Penn. Hills Rd.	33000	43000	55000	33000	50000	64000

Table II: Estimated % Growth Rate and Noise Increase

Location	Scheme 1		Scheme 2	
	2001	2010	2001	2010
Pennant Hills Road Sth, Castle Hill Rd.	31%(.9dB)	85%(2.5dB)	86%(2.6dB)	174%(5.2dB)
Pennant Hills Road Sth, Beecroft Rd.	31%(.9dB)	66%(2dB)	49%(1.5dB)	92%(2.7dB)
Pennant Hills Road Sth, Copeland Rd.	54%(1.6dB)	111%(3.3dB)	80%(2.4dB)	146%(4.4dB)
Castle Hill Road Nth, Penn. Hills Rd.	30%(.9dB)	66%(2dB)	52%(1.6dB)	94%(2.8dB)

6.1.2 Average Speed

It is understood that as part of the road widening brief it is a requirement that the average traffic speed will be increased from 60kph to 70kph. Based on the existing heavy vehicle composition the increased traffic noise is estimated to be 0.6dB(A). If the average speed increases to 80kph the increase in noise levels would be approximately 1.4dB(A).

6.1.3 Road Gradients

At this time no consideration has been given to any significant changes to the existing road gradients. Therefore no adjustments have been allowed in this assessment.

6.1.4 Road Pavement

Recent investigations have shown that open grade asphalt or similar road surfaces are significantly quieter than standard surfaces (concrete, etc.). The road surface for this assessment has been assumed to be asphalt.

6.1.5 Percentage Heavy Vehicles

The traffic composition was determined whilst the measurements of the existing noise levels were undertaken (Table I). In our calculations of the future traffic noise levels it has been assumed that there will be no significant increase in the existing heavy vehicle percentages.

6.1.6 Acoustic Barriers

To establish the effects of acoustic barriers along the new road alignment two barrier heights have been considered (1.8m and 2.5m). The results of calculated noise levels with the barriers in place are shown in Tables IV and V.

It was assumed that the barriers would be constructed in materials with a minimum mass per unit area of 10kg/m.sq. The barrier should also be detailed to reduce reflected noise and incorporate some absorption properties.

6.1.7 Working Paper

To support the findings of this assessment a working paper was prepared to investigate existing noise levels along a section of Pennant Hills Road that has been widened. The section

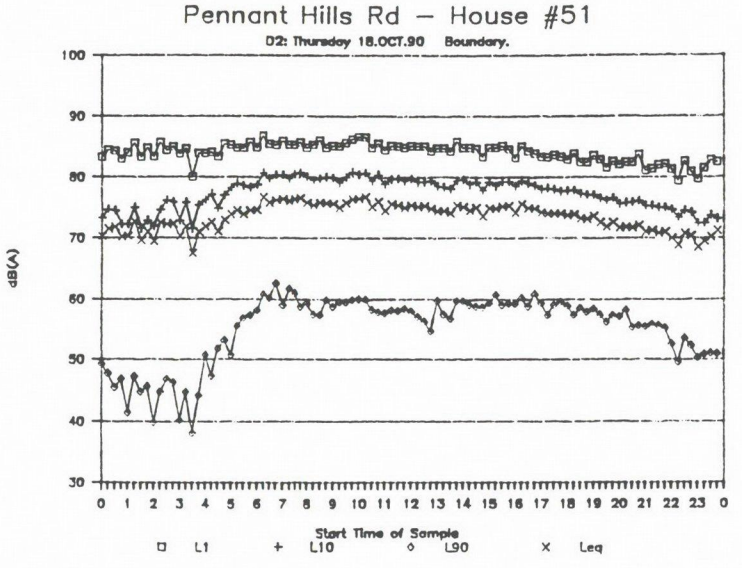
of road that was assessed is between Hewitt Avenue, Wahroonga and Station Street, Thornleigh. The findings of that assessment are summarised in Table III, below. The results of the measured noise levels for 51 Pennant Hills Road, Thornleigh, which are typical for the exposed residential properties in this area are presented in graphical form in Graphics I.

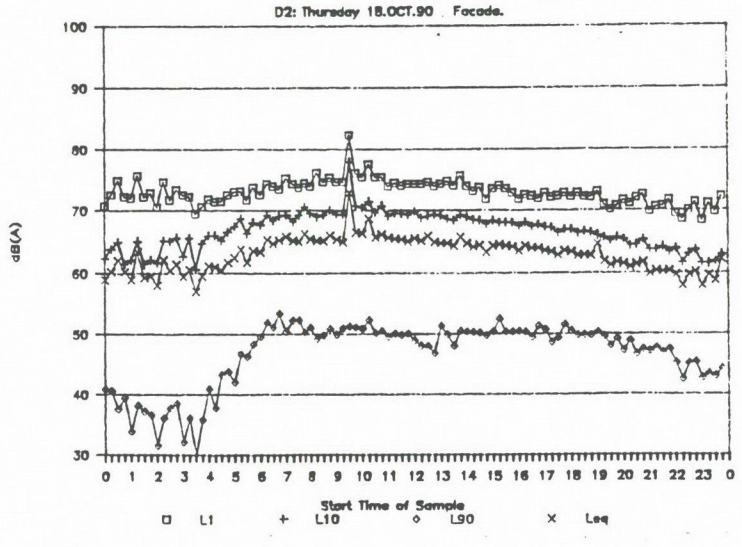
TABLE III: EXISTING TRAFFIC NOISE LEVELS

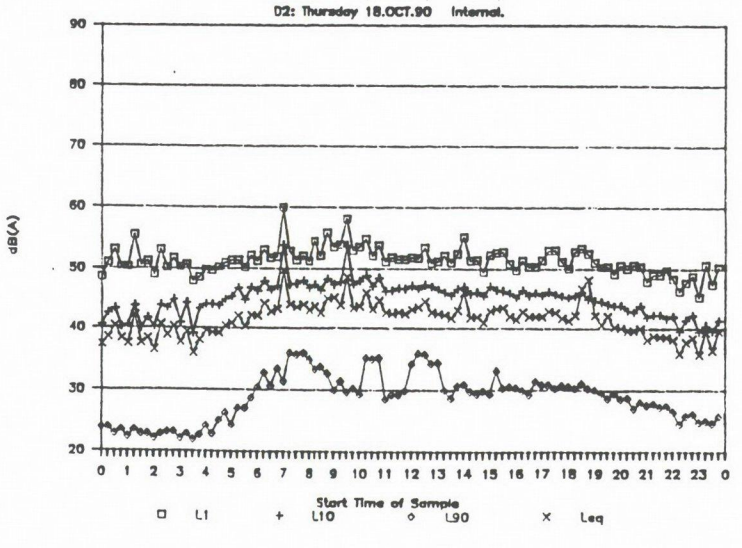
Reference Location	Measurement Position	Sound Pressure Level dB(A) re: $20x10^{-6}$PA	
		L_{A10} (18 hours)	L_{eq} (2200-0600)
49A			
	Facade	70.5	63.7
	Internal	59.0*	48.0
51	Boundary	78.0	71.5
	Facade	67.4	60.7
	Internal	45.5	39.2
69	Boundary	76.6	69.5
	Facade	69.6	62.6
	Internal	55.9	48.8
71	Boundary	78.1	70.6
	Facade	75.6	68.1
	Internal	61.8*	48.4

* Measurements influenced by domestic activities.

GRAPHICS I: NOISE LEVELS AT 51 PENNANT HILLS ROAD.







6.2 Predicted Noise Levels

Tables IV and V, confirm the predicted noise levels at the facades of each reference location. The reference locations have been selected to be representative of houses along Pennant Hills Road, there may be a small number of individual properties that are more or less exposed to the traffic noise, these properties will be identified during the design stage of the project and the noise controls will be evaluated and designed accordingly.

Table IV: Predicted Noise Levels at Facades. Scheme 1.

Location	(Road Widened)				(1.8m Barrier)		(2.5m Barrier)	
	Year 1990		Year 2001		Year 2001		Year 2001	
	L_{A10} (18 Hour)	L_{Aeq} (Night)	L_{A10} (18 Hour)	L_{Aeq} (Night)	L_{A10} (18 Hour)	L_{Aeq} (Night)	L_{A10} (18 Hour)	L_{Aeq} (Night)
Location 1	76.9	69.4	78.5	71.0	67.1	59.6	-	
Location 2	78.9	71.9	80.5	73.5	72.6	65.6	69.1	62.1
Location 3	76.5	69.5	78.1	71.1	71.5	64.5	69.3	62.3
Location 4	75.4	68.4	76.3	69.3	70.0	63.0	67.0	60.0
Location 5	76.3	69.3	77.2	70.1	70.9	63.8	68.0	60.9
Location 6	House to be relocated							
Location 7	73.7	67.7	74.6	68.6	68.5	62.5	64.4	58.4
Location 8	72.9	-	73.8	-	67.0	-	64.5	-
Location 9	69.8	-	70.7	-	64.1	-	61.5	-
Location 10	76.6	69.2	77.5	70.1	70.0	62.6	67.8	60.4
Location 11	76.3	69.3	77.2	70.2	69.1	62.1	66.0	59.0
Location 12	74.9	67.9	75.8	68.8	69.9	62.9	67.0	60.0
Location 13	66.1	-	67.0	-	-	-	-	-
Location 14	74.9	67.9	75.8	68.8	70.4	63.4	67.9	60.9
Location 15	75.4	-	76.3	-	70.9	-	68.4	-
Location 16	77.0	68.3	77.9	69.2	70.9	62.2	68.7	60.0

Table V: Predicted Noise Levels at Facades. Scheme 2.

Location	(Road Widened)				(1.8m Barrier)		(2.5m Barrier)	
	Year 1990		Year 2001		Year 2001		Year 2001	
	L_{A10} (18 Hour)	L_{Aeq} (Night)	L_{A10} (18 Hour)	L_{Aeq} (Night)	L_{A10} (18 Hour)	L_{Aeq} (Night)	L_{A10} (18 Hour)	L_{Aeq} (Night)
Location 1	76.9	69.4	79.3	71.8	67.9	60.4	-	-
Location 2	78.9	71.9	81.3	74.3	73.4	66.4	69.9	62.9
Location 3	76.5	69.5	78.9	71.9	72.3	65.3	70.1	63.1
Location 4	75.4	68.4	78.0	71.0	71.7	64.7	68.7	61.7
Location 5	76.3	69.3	78.9	71.9	72.6	65.6	69.7	62.7
Location 6	House to be relocated							
Location 7	73.7	67.7	76.3	70.3	70.2	64.2	66.1	60.1
Location 8	72.9	-	74.5	-	67.7	-	65.2	-
Location 9	69.8	-	71.4	-	64.8	-	62.2	-
Location 10	76.6	69.2	78.1	70.7	70.6	63.2	68.4	61.0
Location 11	76.3	69.3	77.8	70.8	69.7	62.7	66.6	59.6
Location 12	74.9	67.9	76.4	69.4	70.5	63.5	67.6	60.6
Location 13	66.1	-	67.6	-	-	-	-	-
Location 14	74.9	67.9	76.4	69.4	71.0	64.0	68.5	61.5
Location 15	75.4	-	76.9	-	71.5	-	69.0	-
Location 16	77.0	68.3	78.5	69.8	71.5	62.8	69.3	60.6

6.3 Summary

The findings of our investigations confirm that the existing facade noise levels exceed L_{10} (18 hours) 68 dB(A). The findings also show that with the proposed road widening and existing traffic flows noise levels will marginally increase (by up to 1.6dB(A)) in some areas and decrease in others. With the proposed widened road, the envisaged increase in average

traffic speed to 70kph and allowing for natural traffic growth to the year 2001, overall noise levels will increase by up to 3.2dB(A) for Scheme 1 and 4.0dB(A) for Scheme 2. These increases exceed the RTA assessment criteria. That is;

> "Noise attenuation measures are generally considered to be warranted only when an examination of noise levels reveals that the L_{10} (18 hour) predicted noise level, at a point 1 metre from the nearest facade of adjacent dwellings; is 68dB(A) or greater and has risen by more than 2dB(A) above the previously existing noise level; OR is between 63dB(A) and 68dB(A) and has risen above the previously existing noise level by at least 15dB(A)."

Considering the results and findings of the investigations in terms of the sleep disturbance criteria (45dB(A) L_{eq} between the 8 hour period from 2200-0600 hours) and a typical facade noise reduction of 21dB(A) (windows closed) and 11dB(A) (windows open), the existing and predicted noise levels without road side noise control barriers exceed the RTA assessment criteria.

With respect to the internal measurements at the schools and the church the existing and predicted noise levels without noise control barriers exceed the recommended criteria of L_{eq} 45dB(A).

7.0 CONSTRUCTION NOISE ASSESSMENT

7.1 General

For the major portion of the road widening program, the main construction activities will be based around the removal of the existing carriageway, widening to specified alignments, sub-base preparation, preparation and pouring of concrete base and bitumen sealing.

The only area of variation to the above construction technique will be a cut and cover at the Castle Hill/Pennant Hills Road intersection.

7.2 Construction

The road widening program will be undertaken in several stages, which will be defined in the detail design phase of the Project.

For each stage of the work it is envisaged that dozers, breakers, loaders and trucks will be used to remove the existing road. Trucks, dozers, scrapers and rollers will then be used to prepare a sub-base for paving, concrete mixers will be used to pour concrete, than trucks, bitumen machines and rollers will be used to seal the road.

For the cut and cover section of the road it is understood that there will be no requirements for blasting and that the ripping will be employed to open the road. Therefore, the plant and equipment used will be similar to that used on the main section of the road.

Construction of the road will be restricted to daylight hours, Monday to Saturday.

For the assessment of noise from the various phases of the road construction the following range of sound power levels were allocated to the plant and equipment and used in the calculations. It was also assumed for the purpose of the calculations that the item of plant and equipment were operating at a point in front of the residence at the centre of the road.

Table IV: Typical A-weighted Sound Power Levels

Plant	A-weighted Sound Power Level dB ref. 10^{-12} Watts
Truck	108 to 110
Excavator	108 to 110
Grader	108 to 110
Loader	108 to 110
Concrete Pump	102 to 100
Rock Breaker	110 to 115
Roller	100 to 104
Scraper	108 to 110
Dozer	108 to 115

7.3 Assessment Criteria

The State Pollution Control Commission's Environmental Noise Control Manual (ENCM), Section 171-1, Noise Control Guideline for Construction Site Noise, recommends the following criteria for building sites.

(i) Construction period of 4 weeks and under.

The L_{10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by more than 20dB(A).

(ii) Construction period greater than 4 weeks and not exceeding 26 weeks.

The L_{10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by more than 10dB(A).

Time Restrictions

Monday to Friday, 7am to 6pm.

Saturday, 7am to 1pm if inaudible on residential premises, otherwise 8am to 1pm.

No construction work to take place on Sundays or Public Holidays.

Based on the transit nature of road construction, the variation in activities during the different stages of the work and the assumption that each stage should not exceed a duration of 4

weeks. The most appropriate criteria for the assessment of the construction is that the noise should not exceed the background noise level by more than 20dB(A).

7.4 Background Noise Survey Results

From the results of ambient noise surveys conducted during October and November 1989, the following ranges of background (L_{A90}) noise levels were measured between the hours of 0700 and 1800 hours.

Table V: Measured Background Noise Levels dB(A)

Reference Location	Background S.P.L. L_{A90}
Location 1	57 - 71
Location 2	57 - 66
Location 3	55 - 67
Location 4	61 - 66
Location 5	64 - 70
Location 6	58 - 68
Location 7	63 - 66
Location 8	60 - 64
Location 9	57 - 64
Location 10	62 - 72
Location 11	59 - 69
Location 12	58 - 68
Location 13	63 - 70
Location 14	61 - 69
Location 15	57 - 66
Location 16	67 - 71

Reviewing the above background noise levels we believe that the most appropriate base criteria for the assessment of construction noise is the average of the levels from the above range plus 20dB.

7.5 Predicted Noise Levels at Reference Location

Before any major works are undertaken on Pennant Hills Road, we understand that all property adjustments will be made to the residential properties. As part of these adjustments acoustic barrier to a minimum height of 1800mm will be constructed along the Pennant Hills Road boundaries.

Based on the above assumption and the various construction procedures detailed in the section of the Report, the calculated noise levels from the road construction are summarised below:

Table VI: Calculated L_{Aeq} Noise Levels from Construction Activities dB(A)

Reference Location	Stage I (Excavation)	Stage II (Sub-Base Prep.)	Stage III (Concrete)	Stage IV (Pave)
1 +	67-80	67-80	67-72	67-69
2	60-73	60-73	60-65	60-62
3	60-73	60-73	60-65	60-62
4	60-73	60-73	60-65	60-62
5	59-72	59-72	59-64	59-61
6	56-69	56-69	56-61	56-58
7	57-70	57-70	57-62	57-59

Table VI: Calculated L_{Aeq} Noise Levels from Construction Activities dB(A). Cont'd.

Reference Location	Stage I (Excavation)	Stage II (Sub-Base Prep.)	Stage III (Concrete)	Stage IV (Pave)
8	59-72	59-72	59-64	59-61
9	59-72	59-72	59-64	59-61
10	59-72	59-72	59-64	59-61
11	58-71	58-71	58-63	58-60
12	59-72	59-72	59-64	59-61
13*	51-64	51-64	51-56	51-53
14	58-71	58-71	58-63	58-60
15	59-72	59-72	59-64	59-61
16	59-72	59-72	59-64	59-61

+ No residence at this location (Golf Course)

* Calculation based on existing masonry wall being re-built.

7.6 Summary

Noise levels from construction activities will exceed the recommended criterion at the reference locations if not controlled. To control construction noise its is recommended that before commencing the major activities that acoustic road side barriers be erected.

To comply with the assessment criterion it will be necessary to restrict construction activities to between 7.00am and 6.00pm Monday to Friday and 7.00am to 1.00pm Saturday.

8.0 CONCLUSION

Existing road traffic noise level along Pennant Hills Road between Beecroft Road and Mahers Road have been measured in accordance with the Australian Standard AS2702-1984. The measured levels exceed the criteria normally recommended by the RTA.

With the proposed road widening program, improvements in flow conditions and increases in natural traffic growth, noise level predictions have been made in accordance with the DoE traffic noise model. The calculations have confirmed by the year 2001 the existing noise levels could increase by up to 3.2dB(A) if the F2 Freeway is constructed (Scheme 1) and by 4.0dB(A) if the F2 Freeway (Scheme 2) is abandoned. These increases exceed the current RTA noise assessment criteria.

Considering the findings of this assessment in terms of the sleep disturbance criteria (45dB(A) L_{eq} between the 8 hour period from 2200-0600 hours), the existing and predicted internal noise levels in the residential dwellings exceed the RTA assessment criteria (without road side noise control barriers). With the construction of 1800mm high barriers along the Pennant Hills Road boundary, the nighttime noise criteria with windows closed will be generally satisfied for Scheme 1 and marginally exceeded if the F2 Freeway is abandoned (Scheme 2).

For the purpose of controlling the increase in traffic noise levels at residential properties calculations have been made in terms of effectiveness of acoustic barriers. With the construction of 1800mm high barriers along Pennant Hills Road noise levels can be generally controlled so that the existing levels will not be exceeded, thus satisfying the RTA L_{A10}(18 hour) criteria.

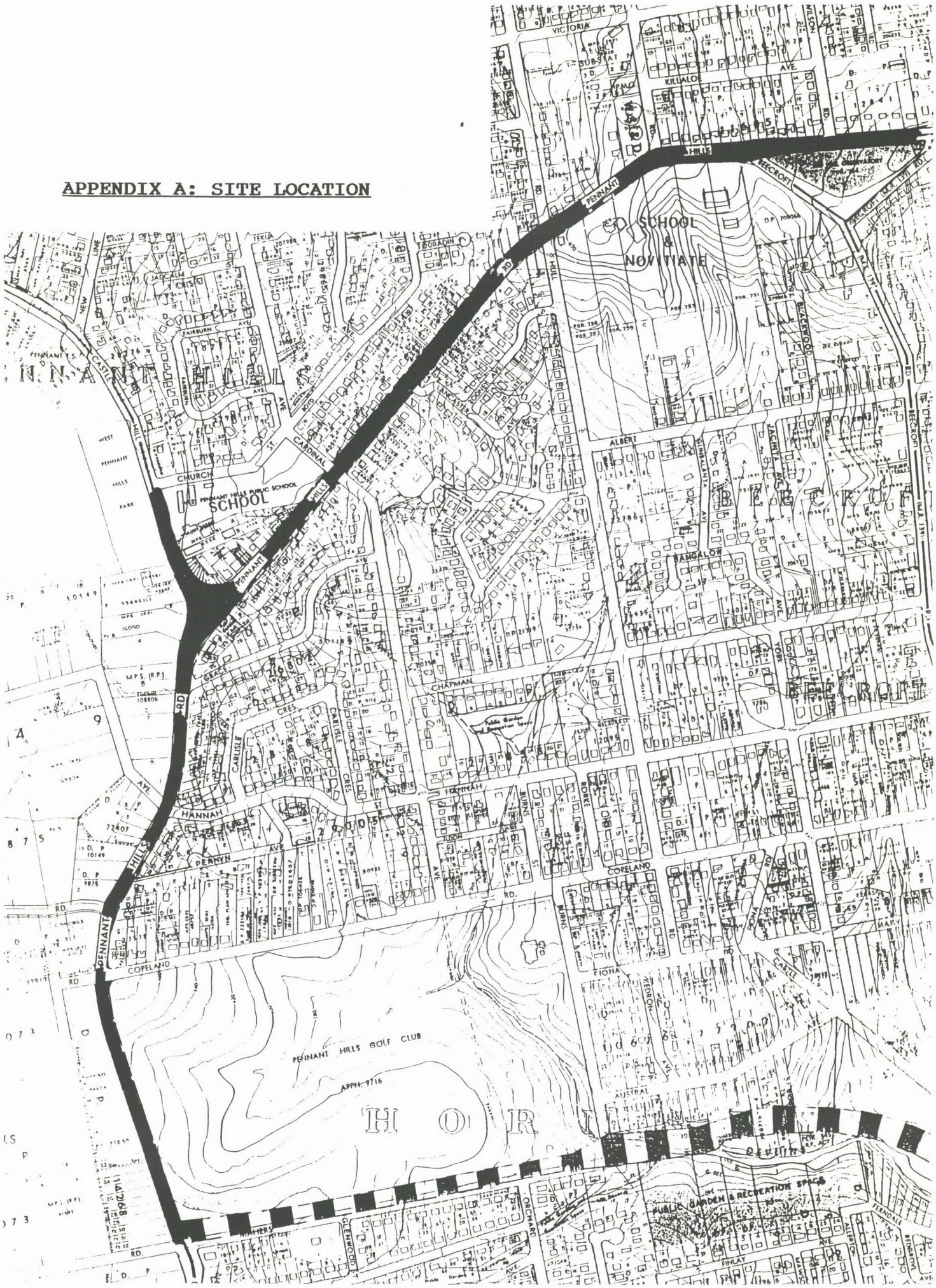
Our investigations have confirmed that in most situations with the construction of the barriers there will be significant reductions in existing road traffic noise levels. If the height of the barriers was increased to 2500mm, additional noise reductions in the order of 3dB(A) could be expected.

As an alternative to constructing acoustic barriers along the full length of Pennant Hills Road, consideration should be given to the re-zoning of a corridor of land for the purpose of constructing residential buildings designed to control traffic noise intrusion. With the co-operation of Hornsby and Baulkham Hills Councils and Government Authorities the Pennant Hills Road corridor could be re-zoned and redeveloped with "quite homes". Thus, achieving a significant improvement in the acoustic amenity for residents, improved visual qualities of the area, improved private vehicle access to and from the road and a considerable cost savings to the Public . Hornsby Council fifteen (15) years ago recognised the problems associated with residential development in close proximity to major roads and adopted a "Code of Practice for General Sound Insulation for Insulation for Residential Flat Buildings". This Code which has been accepted by may Councils in Sydney and extensively used for more than 15 years could be adopted for the Pennant Hills Road corridor.

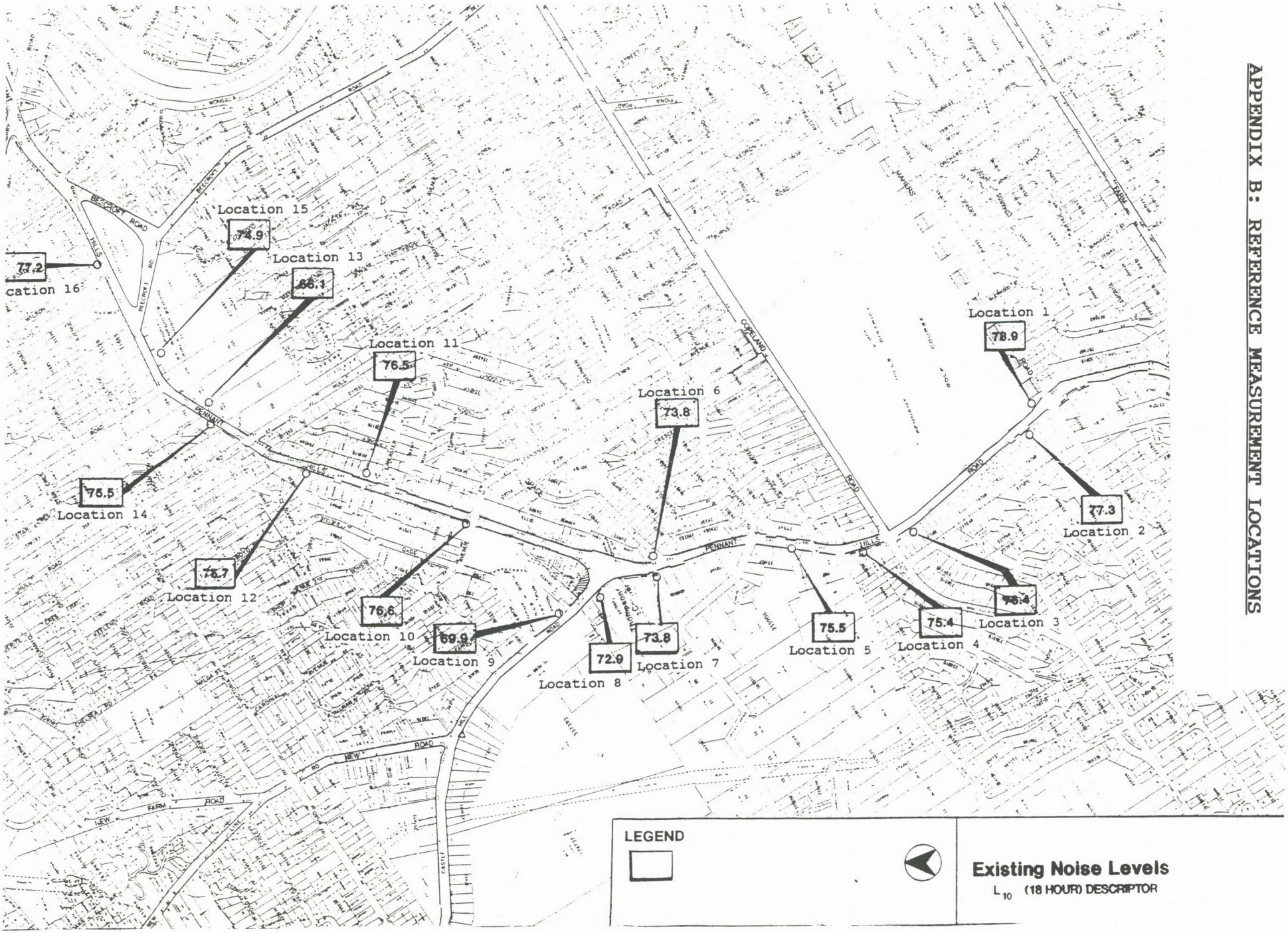
Existing noise levels measured in school classrooms at the Pennant Hill Primary School and St Benedicts and at the Uniting Church on Castle Hill Road exceed the recommended assessment criteria (L_{Aeq} 45dB(A)). These levels will increase with the proposed road widening, thus, as part of the road design it will be necessary to construct acoustic barriers along exposed boundaries of the schools and the church.

For the control of noise from construction activities during the construction of the road, it is recommended that if the 1800mm high acoustic barriers are to be constructed for road traffic noise control, than they should be positioned before the main construction commences. To minimise the potential of noise impact on residents it will be necessary to conduct spot audits on the construction plant and equipment to ensure that all standard mufflers, silencers and noise control devices are fitted and working satisfactorily. Working hours for all construction activities should be restricted construction hours to between 7.00am and 6.00pm Monday to Friday and 7.00am to 1.00pm Saturday.

APPENDIX A: SITE LOCATION



APPENDIX B: REFERENCE MEASUREMENT LOCATIONS



APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 1

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
00.05	52.5	82.8	71.9	65.0	76.0	45	26	Flowing
01.07	47.5	82.0	68.5	60.0	73.0	12	13	Flowing
02.09	37.0	83.0	69.6	51.0	71.5	6	8	Flowing
03.06	46.0	83.3	71.7	61.0	76.5	14	27	Flowing
04.04	47.5	82.5	71.5	62.0	76.0	32	23	Flowing
05.03	56.0	85.3	73.9	66.5	78.0	45	50	Flowing
06.03	57.5	86.3	76.0	73.0	79.5	161	34	Flowing
07.03	57.5	84.8	76.2	74.5	80.0	356	47	Flowing
08.19	71.5	86.3	78.3	80.5	82.5	346	46	Slow Traffic
09.21	69.5	85.0	77.4	76.0	81.0	360	61	Flowing
10.22	59.0	84.5	75.6	73.5	79.5	252	62	Flowing
11.24	61.0	85.0	76.8	75.0	80.0	260	60	Flowing
12.19	59.6	84.5	76.2	74.5	79.3	291	51	Flowing
13.17	60.5	85.5	77.0	75.0	79.0	289	43	Flowing
14.19	59.5	85.0	76.5	74.0	79.5	345	60	Flowing
15.30	62.5	85.5	76.5	75.5	80.0	460	49	Flowing
16.15	62.5	84.0	74.9	73.0	79.0	410	45	Flowing
17.19	64.5	84.3	75.3	73.5	78.5	463	29	Flowing
18.21	59.5	85.3	76.0	73.5	79.5	421	24	Flowing
19.23	61.5	85.3	75.9	73.0	79.5	298	16	Flowing
20.26	60.0	84.0	73.5	70.5	77.0	200	13	Flowing
21.23	60.0	81.8	73.3	71.0	77.5	234	21	Flowing
22.22	50.0	83.3	72.2	66.5	76.0	133	19	Flowing
23.24	49.3	81.0	69.8	62.0	74.0	83	9	Flowing

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 2

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.25	60.0	88.8	78.4	74.47	82.5	290	35	Slow down.
07.29	61.0	87.5	77.7	74.5	81.0	360	29	Slow down.
08.30	66.0	90.8	80.0	75.5	84.0	338	62	Slow down
09.28	58.0	90.3	79.8	76.0	84.0	327	55	Fast traffic
10.25	60.5	89.0	79.2	75.0	83.5	269	65	2 Slow down.
11.20	58.0	90.3	79.6	74.0	83.5	263	59	2 Slow down.
12.19	59.0	89.5	79.5	75.5	83.5	282	57	1 Slow down.
13.42	59.5	87.3	76.9	73.0	81.0	245	60	Slow
14.42	61.5	88.3	77.6	73.0	81.5	260	52	
15.42	65.5	87.3	77.3	73.0	80.5	362	42	
16.42	57.5	87.3	76.4	72.0	80.0	343	47	
17.43	58.2	87.2	76.8	72.0	80.0	339	43	
18.44	58.5	87.3	77.0	72.5	80.0	312	39	
19.42	57.0	84.3	75.6	70.0	77.5	231	8	
20.55	58.5	85.5	72.9	70.0	81.0	151	16	
21.53	55.0	83.3	72.7	66.5	76.5	140	10	
23.04	53.0	83.3	72.2	65.0	76.5	82	9	
23.59	50.5	87.3	74.2	63.0	78.0	81	8	

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 3

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.10	65.5	87.8	79.2	76.5	83.0	212	49	Flowing
07.16	62.5	88.0	79.0	77.0	82.5	381	48	Flowing
08.17	62.5	86.3	77.9	76.0	81.5	359	71	2 Slow down.
09.16	62.5	88.3	78.8	75.0	82.0	275	54	2 Stops
10.11	67.0	89.0	79.2	76.5	84.5	267	64	Flowing
11.07	61.0	88.8	78.5	76.0	82.5	282	53	Flowing
12.06	62.0	89.8	78.9	76.5	82.5	286	54	Flowing
13.27	45.0	85.3	75.5	72.0	80.0	232	43	Flowing
14.24	63.8	85.3	76.0	73.0	80.0	272	57	Flowing
15.28	59.0	85.8	76.1	73.5	79.5	364	41	Flowing
16.25	61.0	85.3	75.3	72.0	79.0	396	45	Flowing
17.27	57.0	82.8	74.5	72.5	78.5	359	29	Flowing
18.32	55.5	84.0	74.8	71.5	79.0	315	30	Flowing
19.28	57.0	83.3	74.3	71.0	78.0	213	15	Flowing
20.40	55.5	83.3	73.5	66.5	77.0	156	13	Flowing
21.38	55.5	84.8	73.5	67.5	77.5	162	8	Flowing
22.37	53.0	84.8	73.1	64.0	76.5	98	16	Flowing
23.02	52.0	83.8	73.0	64.0	76.2	82	9	Flowing

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 4

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.40	65.5	87.3	77.0	74.0	81.0	356	45	6 stops slow traffic.
07.43	65.0	90.8	78.6	71.0	81.5	387	33	4 Stops (More than 1 min each).
08.45	66.5	87.3	77.0	71.5	80.5	290	43	6 long stops very slow traffic.
09.42	65.5	89.8	78.8	73.5	81.5	304	45	5 Stops.
10.40	64.5	89.3	78.5	74.5	82.5	349	59	6 Stop.
11.34	64.0	89.3	78.9	73.0	82.0	301	66	8 Stop.
12.33	65.5	89.8	79.3	73.5	83.0	314	67	5 Stop.
13.55	64.5	90.3	78.6	73.0	82.0	231	55	5 Stops.
14.57	66.5	89.8	75.9	74.5	84.5	332	54	5 Stops.
15.39	62.5	86.8	77.1	72.0	79.0	362	45	6 Stops.
16.55	61.5	87.3	76.1	71.1	79.5	381	34	4 Stops.
17.02	62.5	85.8	75.8	72.5	78.0	350	24	
18.03	61.5	87.3	76.2	76.2	79.0	348	27	5 Stops.
19.00	63.0	84.8	75.3	70.0	77.5	344	22	5 Stops.
19.57	61.0	86.8	75.7	68.5	78.0	217	28	4 Stops.
21.10	60.0	81.3	71.6	68.0	75.0	236	21	5 Stops.
22.07	60.5	87.3	75.5	68.5	78.5	107	25	
23.17	59.0	88.3	76.8	66.5	77.0	89	10	

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 5

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.54	68.5	88.3	78.8	76.0	82.5	499	39	
07.57	69.5	89.3	78.8	77.5	82.0	568	45	
08.59	68.5	89.3	78.5	74.5	82.0	441	57	
09.55	64.5	89.8	79.0	75.5	82.5	407	61	Flowing
10.52	68.0	89.8	79.2	76.0	82.5	407	62	Flowing
11.48	70.5	89.3	79.1	76.0	82.5	348	67	Flowing
12.46	66.5	89.3	80.9	76.0	83.5	360	69	Flowing
13.02	65.5	88.5	78.2	75.5	82.5	374	65	
14.09	64.5	88.3	77.5	74.0	81.0	381	60	Flowing
15.14	67.0	87.8	77.9	74.5	90.0	475	31	Slow down
16.12	67.5	87.3	76.8	73.5	79.5	441	44	Slow down
17.14	67.5	87.2	77.4	73.5	79.0	599	15	
18.15	66.5	84.3	75.8	74.0	78.5	529	16	Slow
19.13	65.5	86.3	76.5	73.0	79.0	432	25	Flowing
20.10	60.5	84.5	74.0	70.0	77.5	247	14	Flowing
21.24	59.0	86.3	74.7	70.5	77.5	285	13	Flowing
22.22	53.5	85.8	74.2	62.0	77.5	142	13	Flowing
23.33	50.0	85.8	72.9	62.5	76.0	94	7	Flowing
23.45	49.5	83.0	71.9	64.0	76.5	82	7	Flowing

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

LOCATION 6

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
6.45	68.5	86.0	75.8	73.5	79.0	622	47	
07.15	68.0	85.3	75.6	73.0	79.5	598	42	Cont. traffic.
08.30	65.0	84.3	75.2	72.5	79.5	415	54	4 stops + slow down.
09.42	64.5	84.8	75.9	72.0	79.5	327	66	2 Stops (20 secs).
10.52	64.0	84.3	75.2	72.5	79.5	324	65	Slow trucks climbing up hill.
11.56	59.0	86.3	75.9	71.0	80.5	296	56	3 slowdown.
12.54	60.0	85.1	75.5	71.0	79.8	284	54	
13.00	62.5	85.3	75.4	71.5	79.5	208	60	2 slowdown.
14.14	60.0	84.3	75.0	72.0	79.0	331	67	Slow Truck climbing hill.
15.13	58.5	83.3	74.2	71.5	78.5	357	64	Slow Truck climbing hill.
16.23	66.5	84.3	75.9	72.5	79.0	455	34	Traffic going north at lights.
17.28	61.5	83.3	73.5	71.0	77.0	531	27	Traffic going north at lights.
18.37	61.5	83.0	73.3	70.5	77.0	480	33	Traffic going north at lights.
19.39	54.5	80.5	70.5	67.5	73.5	287	15	Flowing
20.47	54.5	78.3	69.1	67.0	72.5	218	14	Flowing
21.43	51.0	80.8	70.7	66.5	75.0	157	27	Flowing
22.41	50.0	80.8	69.2	65.0	72.0	154	13	Flowing
23.40	44.5	80.3	67.7	61.0	70.5	70	7	Flowing

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 7

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
00.22	47.0	81.3	68.1	58.5	71.0	33	12	Flowing
01.25	38.5	73.8	61.6	51.5	65.5	12	10	Flowing
02.22	53.0	86.3	73.3	59.5	74.5	13	18	Flowing
03.20	47.5	84.3	71.3	60.5	74.0	14	14	Flowing
04.19	49.0	84.3	71.9	61.0	75.0	26	20	Flowing
05.17	64.0	83.5	72.7	70.0	77.0	44	71	Flowing
06.17	64.0	84.3	73.6	69.5	77.0	309	51	Flowing
07.25	63.5	85.0	74.1	69.0	77.8	556	46	Slow traffic
08.35	66.0	84.0	74.9	71.5	78.5	560	42	Slow traffic
09.35	65.0	85.0	75.1	71.5	79.0	402	68	Slow traffic
10.35	64.5	83.5	74.0	70.0	77.5	340	50	Slow traffic
11.37	64.0	84.0	74.5	69.0	77.0	290	56	Slow Flowing
12.33	65.0	83.8	75.0	69.5	78.1	214	51	Slow Flowing
13.31	64.5	84.0	74.9	70.0	79.5	203	62	Slow Flowing
14.35	64.0	83.5	74.0	68.5	77.9	312	68	Flowing
15.14	65.0	84.0	74.5	69.0	78.0	457	61	Flowing
16.29	66.5	83.5	74.8	71.0	80.0	570	60	Flowing
17.34	65.0	84.3	74.1	70.5	76.5	409	29	Flowing
18.36	64.5	86.8	75.6	71.0	78.0	557	42	Flowing
19.37	62.3	84.0	73.2	68.5	75.5	398	27	Flowing
20.40	59.5	79.5	69.2	67.0	73.0	252	17	Flowing
21.38	58.5	79.0	69.0	66.0	72.5	253	16	Flowing
22.38	57.0	77.0	66.9	64.0	70.3	189	10	Flowing
23.40	49.5	77.0	66.2	59.5	68.0	93	9	Flowing

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 8

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.59	62.3	83.0	72.6	69.5	76.0	429	26	Flowing
07.58	63.0	84.0	72.8	69.5	76.5	405	27	Flowing
08.07	64.0	84.3	73.3	69.5	76.5	411	29	Flowing
09.09	64.0	84.3	74.0	70.0	77.5	301	32	Flowing
10.06	62.0	84.3	73.6	69.0	77.0	268	46	Flowing
11.05	61.5	86.3	74.1	69.0	77.5	253	24	Flowing
12.09	61.5	82.3	72.4	68.5	76.0	289	26	Flowing
13.07	61.5	83.3	73.0	68.5	76.0	243	21	Flowing
14.05	62.0	86.3	75.2	69.5	79.0	403	39	Flowing
15.04	61.0	82.8	72.7	69.5	76.5	314	35	Flowing
16.18	60.5	83.3	73.1	69.5	76.5	353	27	Flowing
17.38	64.0	81.0	72.9	71.5	76.5	465	15	Flowing
18.44	63.0	82.8	72.8	70.0	75.5	387	5	Flowing
19.41	58.5	82.3	71.2	67.5	74.4	243	5	Flowing
20.38	57.0	82.3	71.0	66.0	74.0	138	3	Flowing
21.46	55.5	77.3	68.2	64.5	72.5	122	3	Flowing
22.42	52.5	82.3	69.4	62.0	71.5	87	4	Flowing
23.40	45.0	76.0	65.2	58.0	69.5	59	0	Flowing

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 9

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.10	63.0	81.3	72.1	70.0	75.5	301	27	Flowing
07.11	61.5	82.8	71.8	68.0	75.0	350	23	Traffic backing up frequently.
08.22	61.5	85.3	74.1	68.5	77.0	385	21	" "
09.22	62.5	81.3	72.3	69.5	76.0	321	27	Traffic backing up.
10.20	61.0	83.3	72.8	69.0	76.0	339	18	Flowing
11.18	60.0	82.3	72.2	68.0	75.5	258	37	Flowing
12.23	57.5	83.0	73.0	68.0	76.5	201	32	Flowing
13.21	60.0	83.8	72.5	68.5	75.5	247	24	Flowing
14.20	57.0	81.3	71.0	67.0	75.0	332	28	Flowing
15.17	61.5	80.3	70.6	68.0	74.0	340	21	Flowing
16.34	64.0	81.3	72.6	70.0	76.0	348	23	Traffic backed up Flowing on the other side
17.52	63.5	78.8	71.5	70.5	75.0	460	13	Flowing with slow downs
18.58	59.0	79.8	71.0	69.0	74.5	364	8	Flowing
19.55	53.5	78.3	69.3	66.5	73.0	233	6	Flowing
20.52	52.0	78.3	68.6	63.5	72.5	138	5	Flowing
21.59	52.5	78.3	68.5	64.5	72.5	149	5	Flowing
22.57	45.5	77.3	66.7	59.0	71.0	91	3	Flowing
23.53	40.0	77.3	65.3	52.0	69.5	48	2	Flowing

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 10

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
00.36	45.5	82.3	69.7	56.0	73.0	31	19	Flowing
01.46	43.5	81.0	68.1	52.5	71.0	9	14	Flowing
02.36	42.5	81.8	70.1	54.0	73.0	6	19	Flowing
03.34	46.0	83.3	70.5	54.5	72.5	17	20	Flowing
04.33	49.5	82.8	71.7	59.0	77.0	35	28	Flowing
05.31	59.3	85.3	75.3	70.5	79.5	126	41	Flowing
06.30	69.0	90.0	75.8	74.0	80.0	415	66	Flowing
07.40	69.0	86.0	77.1	74.5	80.5	400	54	Flowing
08.42	72.0	91.0	81.9	77.5	85.0	488	60	Moving Slowly
09.50	66.0	85.0	76.5	74.5	80.5	298	68	Moving Slowly
10.48	67.5	84.5	76.4	74.0	80.5	340	84	Moving Slowly
11.50	66.5	84.3	76.0	73.5	81.0	290	74	Moving Slowly
12.47	64.0	85.1	77.0	74.0	81.5	245	60	Moving Slowly
13.46	65.0	84.5	76.5	75.0	80.5	261	79	Moving Slowly
14.50	66.5	85.0	76.0	74.5	80.8	287	85	Flowing
15.01	68.0	84.9	77.0	75.0	80.2	342	70	Flowing
16.44	67.0	84.8	75.0	72.5	78.0	335	49	Flowing
17.50	66.5	83.3	73.8	72.0	76.0	492	33	Flowing
18.51	62.0	83.3	73.6	72.0	77.0	410	7	Flowing
19.52	58.5	83.8	73.4	69.5	77.0	214	27	Flowing
20.53	58.0	84.5	73.5	68.5	77.5	165	13	Flowing
21.52	54.5	84.0	73.0	68.0	76.5	149	13	Flowing
22.52	52.0	83.0	71.6	65.0	75.5	112	11	Flowing
23.54	50.5	84.0	72.4	64.5	76.0	78	18	Flowing

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 11

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.32	66.0	86.3	77.7	75.5	81.5	365	62	
07.05	67.5	87.3	78.0	75.0	81.0	382	59	
08.13	69.5	88.3	78.3	75.0	81.5	460	65	
09.25	62.5	87.3	77.8	75.0	82.0	319	75	
10.37	62.5	87.3	77.3	74.0	81.0	292	62	
11.40	61.5	86.8	77.8	74.5	81.5	287	75	
12.43	62.0	86.8	77.0	73.5	81.5	254	62	
13.16	62.5	85.9	77.0	74.0	81.0	261	70	
14.00	63.0	85.8	76.8	74.0	81.0	265	91	
14.58	59.0	85.8	76.8	73.5	81.0	287	74	
16.09	61.0	85.8	76.8	74.5	81.0	434	52	
17.14	65.0	85.3	76.4	75.0	80.0	520	39	
18.23	61.5	85.3	76.2	73.9	79.5	366	25	
19.24	56.5	84.8	74.6	71.0	78.5	253	24	
20.32	52.0	85.0	74.0	67.5	78.0	310	23	
21.28	53.5	83.8	73.5	68.0	78.0	127	14	
22.27	52.5	84.3	72.7	66.0	76.5	124	15	
23.25	50.5	82.3	72.5	63.0	76.5	75	11	

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 12

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.05	67.5	86.5	77.6	75.5	80.5	362	51	
07.35	68.0	86.3	77.7	76.0	81.0	448	67	Flowing
08.52	64.5	86.8	77.5	75.5	81.0	382	61	
09.59	58.5	89.3	78.8	75.0	83.0	258	80	1 lane stops for 5 secs.
10.14	61.0	87.9	78.6	74.6	82.5	263	75	
11.09	62.0	87.8	78.6	74.5	81.5	280	73	Flowing
12.12	60.0	86.3	76.9	73.5	80.5	263	62	Flowing
13.18	55.0	85.3	75.5	72.0	79.0	277	60	Flowing
14.30	63.0	87.8	77.5	74.0	81.0	280	73	Flowing
15.40	61.5	86.8	76.5	74.0	79.5	363	58	Flowing
16.43	60.5	85.3	75.8	74.5	79.0	474	47	Flowing
17.49	61.0	86.3	76.1	73.0	78.5	487	18	Flowing
18.57	61.0	87.3	76.7	73.5	79.5	366	26	Flowing
19.54	57.5	85.3	74.1	69.5	77.5	205	21	Trucks Going Fast
21.01	48.5	85.8	73.6	66.5	77.0	159	24	
21.58	53.5	85.8	73.7	66.5	77.5	134	25	
22.57	52.0	84.3	73.4	67.0	76.5	102	23	
23.56	42.5	81.3	68.4	55.0	71.0	34	9	

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 13

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.44	70.8	85.3	77.2	75.8	80.5	501	49	Flowing
07.45	69.0	84.3	76.2	75.0	79.0	492	34	Flowing
07.54	68.0	88.3	78.3	75.5	81.5	410	63	Flowing
09.50	70.0	89.3	80.2	76.5	83.5	490	68	Flowing
10.49	66.5	90.3	79.3	75.5	83.0	269	65	Flowing
11.55	63.5	89.5	79.0	75.0	82.5	240	82	Flowing
12.53	63.0	89.8	79.4	75.5	83.0	319	81	Flowing
13.50	64.5	96.3	80.3	75.0	83.5	421	90	Flowing
14.48	66.0	89.3	78.6	75.5	82.0	361	88	Flowing
15.58	69.5	87.3	78.2	75.5	81.5	391	60	Flowing
16.15	66.4	86.2	77.5	75.0	80.5	405	40	Flowing
17.13	65.5	85.3	76.9	75.0	80.0	476	32	Flowing
18.27	64.0	88.3	77.3	76.5	83.5	420	27	Flowing
19.26	54.5	85.3	75.5	72.0	79.0	264	23	Flowing
20.23	53.0	85.3	74.0	69.0	77.5	168	15	Flowing
21.22	51.5	86.3	73.8	67.0	77.0	153	9	Flowing
22.27	49.5	87.5	74.9	64.5	78.0	97	19	Flowing
23.24	42.0	84.3	72.7	63.0	76.0	73	19	Flowing

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 14

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.27	63.5	88.8	78.1	75.5	81.0	411	49	Flowing
07.25	69.0	84.0	75.4	74.0	78.5	505	32	Flowing
08.37	67.0	85.3	75.6	72.0	78.5	513	57	Flowing
09.37	62.0	85.8	76.6	73.5	80.5	401	52	Flowing
10.35	64.0	86.3	76.8	74.0	80.5	397	66	Flowing
11.40	65.5	87.8	77.5	73.5	81.5	310	49	Flowing
12.38	61.5	87.8	77.6	73.5	81.5	239	50	Flowing
13.36	62.0	88.8	78.1	74.5	81.5	306	70	Flowing
14.34	64.0	89.8	79.1	74.5	82.5	310	58	Flowing
15.41	62.0	86.3	76.4	74.0	79.5	438	62	Flowing
16.54	63.5	88.3	76.0	70.0	80.0	398	60	Slow traffic
17.06	62.5	86.4	75.0	71.5	78.9	415	36	
18.09	61.0	83.3	74.3	72.5	77.5	462	22	
19.12	55.0	85.8	74.9	70.5	77.5	394	20	Flowing
20.09	52.0	85.8	74.3	68.5	78.0	188	21	Flowing
21.07	54.5	88.3	75.5	68.5	77.5	169	23	Flowing
22.14	47.0	80.3	70.3	62.5	74.0	123	6	Flowing
23.11	46.5	84.3	71.9	62.0	74.5	98	15	Flowing

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 15

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
06.17	65.0	89.3	77.5	73.5	80.5	263	54	Flowing
07.54	66.0	88.3	78.3	75.0	81.5	563	63	4 Stops & 1 slowdown.
08.45	63.5	88.0	78.1	74.5	81.5	465	70	
09.11	60.0	88.5	78.2	74.0	82.0	365	83	
10.20	57.0	89.8	78.7	73.0	83.0	282	70	2 Slowdown 1 x stop.
11.25	60.5	88.8	78.4	73.5	82.0	270	89	2 slowdown.
12.24	62.0	87.8	77.2	72.5	80.5	278	75	2 x Stops for few secs.
13.43	59.0	85.8	75.4	71.5	79.5	258	71	2 x stops for lights.
14.45	60.5	85.8	75.8	72.0	80.0	275	65	2 Stops for lights.
15.55	61.0	88.8	78.0	73.0	81.5	421	54	1 x stop at light.
16.59	60.5	86.8	75.6	71.5	78.5	430	53	
17.49	60.0	85.4	75.0	71.5	78.0	429	38	
18.07	59.5	84.8	74.4	71.5	78.0	440	23	3 x Stop at Lights
19.11	58.0	87.8	75.9	70.5	79.0	297	34	No stops
20.17	56.0	84.3	73.7	68.5	77.5	138	19	No stops
21.14	53.0	81.8	71.8	66.0	75.0	161	14	Trucks Going North High speed.
22.12	52.5	84.3	72.5	64.0	75.5	99	14	Trucks going north at high speed.
23.10	49.0	85.3	73.1	63.0	76.0	78	19	" "

APPENDIX C: EXISTING ROAD TRAFFIC NOISE LEVELS

Location 16

TIME	L_{90}	L_1	L_{eq}	L_{50}	L_{10}	CARS	TRUCKS	COMMENTS
00.50	42.5	80.3	68.4	54.5	73.0	28	22	Flowing
01.55	39.3	79.2	66.2	54.0	69.5	23	13	Flowing
02.51	38.5	80.3	67.7	52.5	71.0	10	16	Flowing
03.49	42.5	81.3	68.9	55.5	72.0	20	21	Flowing
04.47	51.5	83.3	71.8	63.5	76.5	28	42	Flowing
05.46	58.5	83.0	73.5	69.0	78.8	121	51	Flowing
06.45	67.0	82.8	74.3	72.5	78.0	596	57	Flowing
07.55	71.5	89.0	80.0	77.5	83.8	500	48	Flowing
08.01	71.5	89.0	81.0	77.8	84.3	492	62	Flowing
09.02	71.5	91.5	82.3	78.0	86.5	490	78	Flowing
10.03	69.3	90.5	79.3	74.5	82.5	372	78	Very Slow
11.06	68.9	91.0	79.0	75.5	79.0	301	52	Very Slow
12.04	69.5	89.0	78.5	74.9	78.5	278	68	Very Slow
13.02	68.5	88.5	77.8	76.0	78.0	258	65	Very Slow
14.05	69.3	89.7	76.9	75.5	82.5	392	56	Flowing
15.45	71.0	88.5	79.1	76.5	83.0	576	86	Flowing
16.01	70.0	88.3	78.5	75.5	82.0	468	48	Flowing
17.01	70.5	84.3	76.7	75.5	79.5	613	31	Flowing
18.04	70.0	86.5	76.9	74.5	80.0	625	49	Flowing
19.06	66.0	88.3	77.8	75.0	80.5	456	55	Flowing
20.10	62.5	88.5	77.5	73.5	80.5	282	30	Flowing
21.08	60.5	87.5	77.0	73.0	79.5	295	16	Flowing
22.06	60.0	87.3	75.9	71.5	78.5	204	13	Flowing
23.05	58.5	85.3	74.3	70.5	77.5	152	19	Flowing

3. VISUAL ASSESSMENT

ENVIRONMENTAL PARTNERSHIP

PENNANT HILLS ROAD
ENVIRONMENTAL IMPACT STATEMENT

WIDENING AND RECONSTRUCTION FROM MAHERS ROAD TO BOUNDARY ROAD

VISUAL ASSESSMENT

ROADS AND TRAFFIC AUTHORITY
SYDNEY WESTERN REGION

NOVEMBER 1990

PENNANT HILLS ROAD
ENVIRONMENTAL IMPACT STATEMENT

WIDENING AND RECONSTRUCTION FROM MAHERS ROAD TO BOUNDARY ROAD

VISUAL ASSESSMENT

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1.0 SUMMARY

This Visual Assessment Report has been prepared to examine and assess the visual impacts of proposed widening and reconstruction of Pennant Hills Road from the Mahers Road in West Pennant Hills to Boundary Road in Beecroft. This report is one working paper for the Environmental Impact Statement of the proposed development.

Scenery or visual character of the landscape is recognised as an important resource in planning and management of the environment. This is particularly evident along the section of Pennant Hills Road being studied, where the landscape is dominated by vegetation and associated qualities, such as shading and screening.

Overall, this section of Pennant Hills Road has a special visual quality, which presents pleasant visual experiences for the road users. This is primarily created by the dominance of tall vegetation, along the road verge and within the private properties, and associated visual benefits. Many specimens have significant individual visual quality.

Thompsons Corner is the only section of low visual quality. It is a wide junction between Castle Hill Road and West Pennant Hills Road, with commercial and retail outlets and no sympathetic landscape treatments. The visual experiences gained along this section are completely different to the rest of Pennant Hills Road.

The widening and reconstruction activities will alter the landscape setting and visual quality of the Road for all viewers. It necessitates the removal of approximately 400 trees along the entire length of the Road. An additional 105 trees are located between the new property boundary and 1.5 metres from the road edge and these may need to be removed but should be retained where possible. The front yards of numerous residential properties will be reduced. In most situations alterations to the fences are required, with removal and relocation of acoustic attenuation fences being necessary. Approximately 16 houses are directly affected and demolition is required. The pleasant driving experiences as well as the screening effects to separate the private properties and the Road will be significantly altered.

Uniform principles have been applied to all landscape treatments along the length of the Road in order to re-establish the ambience created by the existing landscape. It is recognised that the full effect of the existing landscape will be difficult to re-create and will require a substantial time frame. Landscape principles include: retention of as many trees in the road verge as possible; use of plant material that is endemic or representative of the original forest species to the area; planting of trees to be on both the road verge (adjacent to the fences) and within property boundaries; planting of shrubs and groundcover on the road verge; footpath alignments should wind around existing trees in order to avoid their removal; and, upgrading the visual quality in commercial zone at Thompsons Corner to incorporate landscape treatment and enhance user experiences without detracting from the commercial viability of the area. Treatments for each of the nine landscape units have been described and illustrated.

2.0 INTRODUCTION

2.1 PREAMBLE

Pennant Hills Road, between Boundary Road and Mahers Road in West Pennant Hills, is recognised to be inadequate in design and capacity. Average daily traffic loads during morning and evening peak periods are well above its limits, providing a relatively poor level of service. Widening and reconstruction of this portion of Pennant Hills Road was considered to be necessary in order to alleviate the existing heavy traffic congestion and improve road safety as well as fulfil long standing road planning strategies in establishing the route as a main northern link to the metropolitan ring road system.

In May, 1990, a Review of Environmental Factors was prepared to examine the likely impacts of the project on the environment, so the Roads and Traffic Authority (RTA) could fulfil its responsibilities under Part V of the Environmental Planning and Assessment Act, 1979 (EPAA). The report included an assessment of the environmental effects of the landscape, undertaken by Precinct Landscapes. The Review of Environmental Factors went on public exhibition in June, 1990. The response and written submissions indicated general support for the proposal, but some concerns were raised. Loss of trees and the effect on the overall visual environment were addressed in the submissions. In September, 1990, the RTA concluded that the proposed development warranted the preparation of an Environmental Impact Statement (EIS) to assist in the decision making process.

The current investigations are seeking to evaluate the potential visual effects on the study area as a result of the development. These will be included in the EIS for the proposed development.

2.2 STATUTORY REQUIREMENTS

Visual assessment or 'diminution of the aesthetic quality or value' is a factor for consideration, under Clause 56 of the Environmental Planning and Assessment Regulation, 1980 (EPAR). It is also an important component of an Environmental Impact Statement, which requires a full description of the existing environment likely to be affected by the proposal and identification and analysis of the likely environmental interactions and impacts on the environment, in accordance with Clause 57 of the EPAR.

In addition, pursuant to Clause 58 of the EPAR, the Director of the Department of Planning requires photomontages of the proposal from the perspective of roadusers, pedestrians and adjoining residents and an assessment of the visual impacts of the proposal and the measures proposed to mitigate these impacts. The visual assessment should identify visually sensitive areas and landscape concept plans should be provided.

The road is located within two municipalities - Hornsby and Baulkham Hills - and hence the appropriate Local Environmental Plans require consideration. No visual protection zones or zones requiring special visual treatment occur along the length of the alignment.

2.3 OBJECTIVES

This Visual Assessment Report has been prepared to examine and assess the visual effects of the proposed widening and reconstruction of Pennant Hills Road on the landscape.

The objectives of the visual assessment are as follows.

- to describe the visual character of the landscape along the Road, determine its visual catchment and evaluate the visual quality of the environment;

- to prepare a landscape inventory of the features important to the visual character that will be lost in the widening procedures and evaluate the impact on the visual environment;

- to determine the visual sensitivity of the Road in terms of the road users, pedestrians and residents and assess the effects the proposed alterations to the Road on visual sensitivity;

- to recommend landscape treatments to reduce visual degradation from road widening and to reinstate the existing landscape quality.

3.0 VISUAL ENVIRONMENT

3.1 REGIONAL CONTEXT

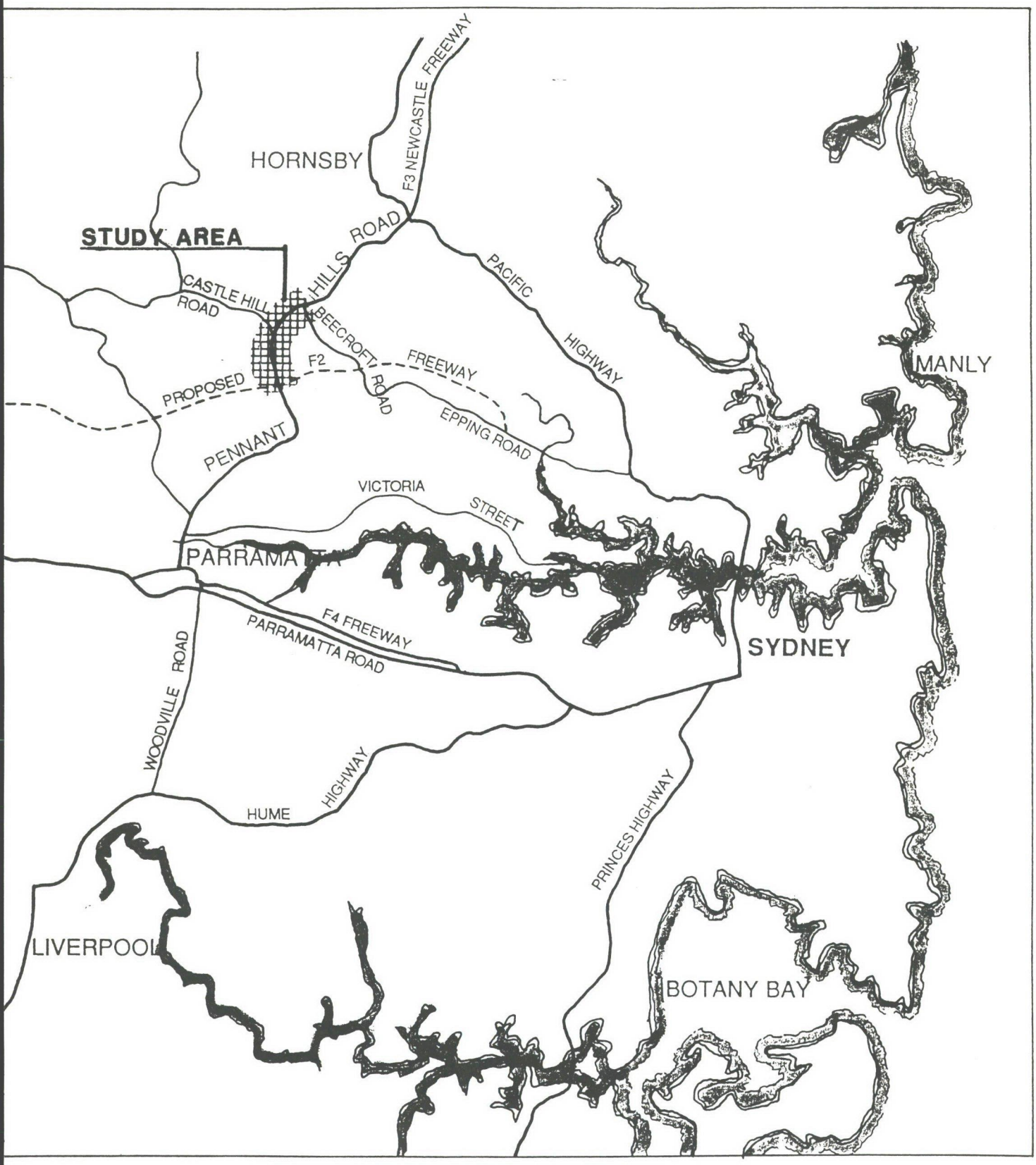
Pennant Hills Road lies within the suburbs of Beecroft and West Pennant Hills, in the north western sections of the Sydney metropolitan area (refer to Figure 3.1). These residential suburbs are recognised for their significant landscape character, particularly due to the remnant native species along road verges and in designated open space areas. Larger pockets of natural bushland in undeveloped gullies reinforce this character.

Pennant Hills Road is an important visual form that gives address to suburbs along its length. The existing size and the presence of vegetation reduces its physical presence and enables the road users to gain a pleasant experience as travelling along it. However, it is a main route and it carries large volumes of traffic, particularly heavy vehicles, at all hours of the day. The traffic creates a strong visual presence and reduces the effects of possible visual experiences from the landscape setting.

3.2 VISUAL CATCHMENT

The section of Pennant Hills Road being studied traverses a local ridgeline, and is heavily enclosed by land use activities and associated landscape treatments. This primarily restricts the visual catchment of the Road to the row of houses and other land uses directly adjacent to the Road.

Glimpses of the wider Sydney Region can be gained through breaks in the tall vegetation or where the orientation of the road affords views (refer to Figures 3.2, 3.3 and 3.4). From Mary Gilmore Park in Thompsons Corner south to Grace Avenue, extensive views of the Sydney City can be gained in the far distance. Views can also be gained of Baulkham Hills from Mount Wilberforce Lookout and Reserve. Some views can be gained west across Mahers Road in the south of the study area.



LOCATION MAP

FIGURE 3.1

ENVIRONMENTAL PARTNERSHIP

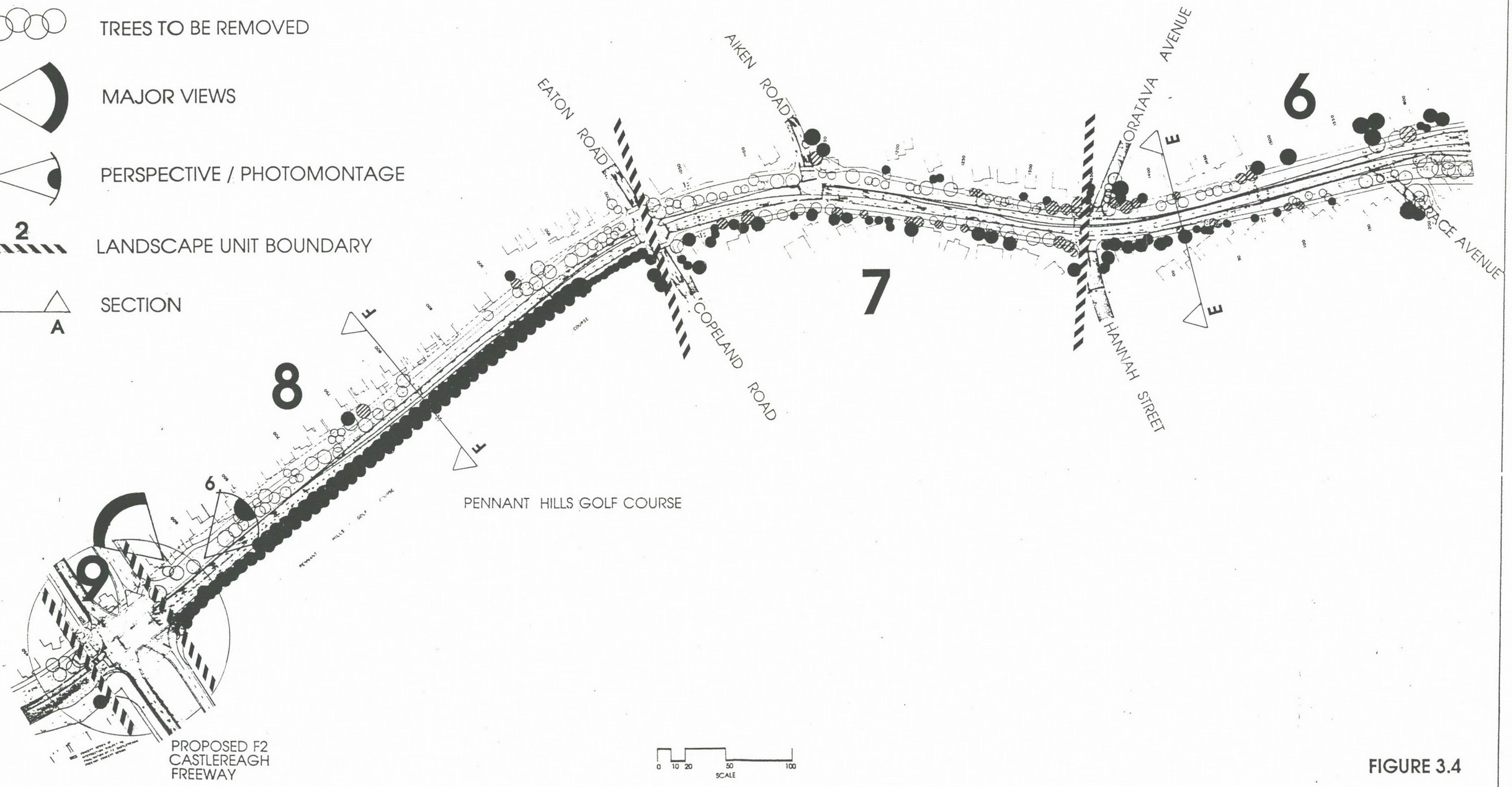
0 1 2 3 4 5 Kms

Scale

ENVIRONMENTAL PARTNERSHIP

KEY

- TREES TO BE RETAINED
- TREES TO BE RETAINED WHERE POSSIBLE
- TREES TO BE REMOVED
- MAJOR VIEWS
- PERSPECTIVE / PHOTOMONTAGE
- 2 — LANDSCAPE UNIT BOUNDARY
- A — SECTION



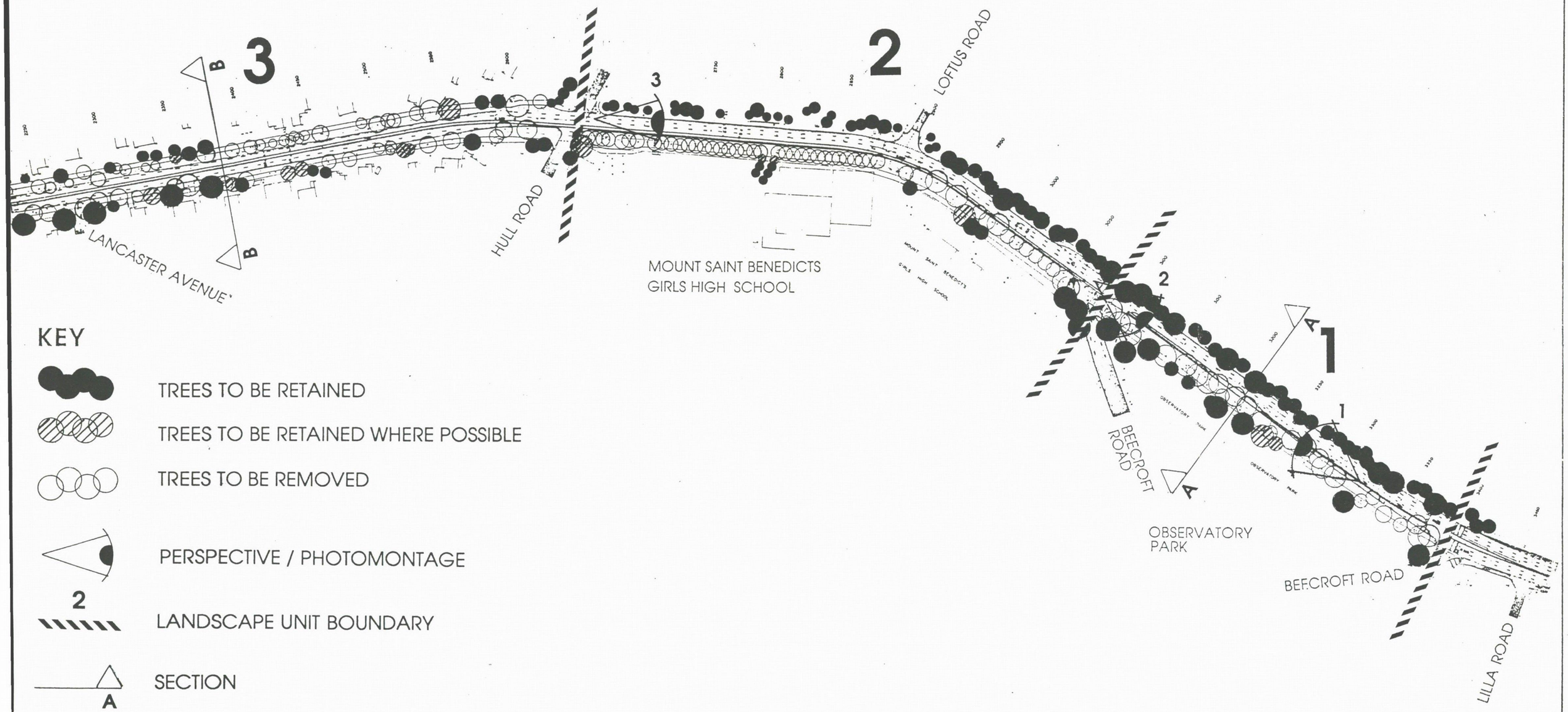
0 10 20 50 100
SCALE

FIGURE 3.4

PENNANT HILLS ROAD WIDENING

VISUAL ENVIRONMENT - LANDSCAPE UNITS 6,7,8 & 9

ENVIRONMENTAL PARTNERSHIP



KEY

- TREES TO BE RETAINED
- TREES TO BE RETAINED WHERE POSSIBLE
- TREES TO BE REMOVED
- PERSPECTIVE / PHOTOMONTAGE
- 2 — LANDSCAPE UNIT BOUNDARY
- A — SECTION

0 10 20 50 100
SCALE

FIGURE 3.2

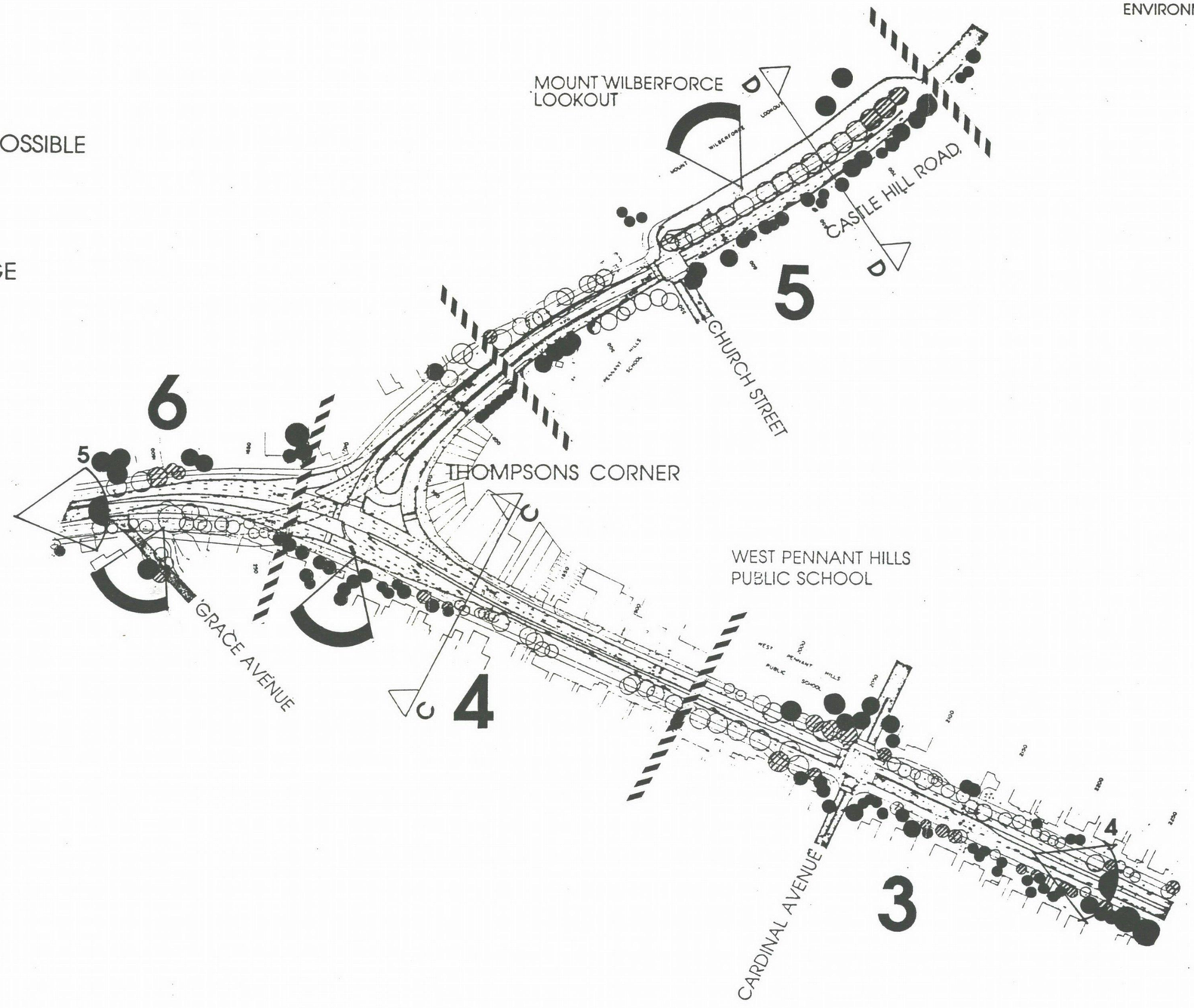
PENNANT HILLS ROAD WIDENING

VISUAL ENVIRONMENT - LANDSCAPE UNITS 1,2 & 3

ENVIRONMENTAL PARTNERSHIP

KEY

- TREES TO BE RETAINED
- TREES TO BE RETAINED WHERE POSSIBLE
- TREES TO BE REMOVED
- PERSPECTIVE / PHOTOMONTAGE
- 2 — LANDSCAPE UNIT BOUNDARY
- SECTION A
- MAJOR VIEWS



0 10 20 50 100
SCALE

FIGURE 3.3

PENNANT HILLS ROAD WIDENING

VISUAL ENVIRONMENT - LANDSCAPE UNITS 3,4,5 & 6

3.3 LOCAL CONTEXT AND LANDSCAPE UNITS

The landscape of Pennant Hills Road between Boundary Road and Mahers Road is characterised by residential and associated land uses with mature native trees along road verges and within properties. Dense understorey growth provides a screen to the residences in many places.

The Road was separated into nine landscape units for analysis (refer to Figures 3.2, 3.3 and 3.4). These units are based on the sectors identified by Precinct Landscapes (1990) but were modified to incorporate land use and land character changes. These are as follows.

3.3.1 Unit 1: Observatory Park

Observatory Park is a significant remnant stand of the eucalyptus forest association that occupied the area prior to urbanisation. These large mature trees provide a pleasant visual experience for both road users and residences. The larger trees arch halfway across the Road. No other elements, such as structures, fences or buildings, dominant the visual environment.

The wooded character of the Park is continued to the northern side of Pennant Hills Road, as the residences are well planted with mature exotics and remnant eucalypts, providing an effective visual screen.

3.3.2 Unit 2: Mount St. Benedict School

The three metre high brick wall and hedge of camphor laurels along Mount Saint Benedict School and the Convent on the south side of the road dominate the visual character of this landscape unit. The gardens within the unit are formally landscaped containing items of significance. At the eastern end of this unit, the camphor laurels are replaced by golden cypresses, which form a thick, tall screen against the road. Sporting fields are present behind the cypress hedge.

The northern side of the road is residential land use, dominated by a mass of medium sized mixed indigenous and exotic shrubs and small trees. These provide some screening to houses.

3.3.3 Unit 3: Hull Road to West Pennant Hills Primary School

This unit is characterised by residential properties both side of the Road. A strong visual character is created by the tall mature eucalypts (predominantly over 30 metres in height). The trees arch over the Road, forming a pleasant visual experience and shading for road users. The understorey of exotic trees and shrubs forms a visual screen separating the roadway from the houses.

Houses and fences tend to be dominated by vegetation, which forms a backdrop to all visual experiences. The colours and hues of all structures are subdued by the shading effects of the tall trees.

The road edge of West Pennant Hills Primary School is consistent with the treed characteristic of this unit. The understorey layer is minimal, with a grassed lawn groundcover beyond the road edge.

3.3.4 Unit 4: Thompsons Corner

Thompsons Corner is an open, stark intersection, dominated by the cluster of shops on the western side of the road. It is typically busy with heavy vehicles frequently utilising the intersection, dominating the visual experiences available. There is no dominant landscape outside the property boundaries. It is generally low in visual character although panoramic views to Sydney can be gained from individual locations within the intersection.

The eastern side of the Road is predominantly residential, with Dame Mary Gilmore Park occupying a small portion. The character of this unit is different as it lacks tall kerbside eucalypts of the previous unit. A mixture of medium sized exotics form an effective screen between the houses and the Road.

The large flag pole within Dame Mary Gilmore Park is a visible landmark across a wide area. No other significant visual features are present in the Park.

A part of Castle Hill Road is included in this unit. This is a combination of residential, retail and the Bethlehem Uniting Church.

3.3.5 Unit 5: Castle Hill Road

This landscape unit is dominated by large native trees and the natural landscape of Mount Wilberforce Reserve. The strong vegetation along the road edge effectively creates a pleasant visual experience for road users and residents.

The streetscape of the southern side of Castle Hill Road is dominated by residential landscape treatments, including small to medium sized ornamental trees and shrubs. West Pennant Hills Public School abutts this Road also. A strong screen of trees and shrubs forms the boundary between the school and the road.

3.3.6 Unit 6: Grace Avenue

This landscape unit is residential with landscaped gardens. It does not have the tall indigenous roadside vegetation of Landscape Units 1 and 3. It has fewer and smaller indigenous trees and a higher proportion of ornamental exotic shrubs and small trees. No arching effect over the road is created.

Walls, fences, buildings and other structures tend to be more visible due to the smaller role of the vegetation in the visual environment.

3.3.7 Unit 7: Oratava Avenue to Copeland Road

The dominant visual character of this landscape unit is the vegetation, represented by a few large eucalypts and a thick understorey of mixed conifers and ornamental trees and shrubs. The understorey effectively screens most of the houses.

The combination of vegetation types and species creates a landscape varied in texture, form and colour. Only a few large trees overhang the Road, therefore the road is open in visual character.

3.3.8 Unit 8: Pennant Hills Golf Course

Pennant Hills Golf Course occupies the full length of the eastern side of the Road. An effective screen composed of mature and semi-mature trees occurs along the inside boundary of the golf course. This has recently been reinforced by plantings of juvenille trees. Species include Eucalypts and Podocarpus.

The western side of the Road is residential land use. The quantity of vegetation is less and the plantings are smaller, exotic trees. The structures, including houses and fences, are visually dominant. These structures are varied in style and scale.

Some clearing and boundary set backs have already taken place in anticipation of the proposed widening of the Road.

3.3.9 Unit 9: Proposed F2 Freeway Interchange

The landscape character of this unit of the eastern side of the Road, occupied by Pennant Hills Golf Course, is similar to Unit 8. The large Eucalypts dominate the setting and screen the Road from activities on the golf course.

The western side of the Road is residential with large Eucalypts along the road verge and within the property boundaries.

3.4 VIEWERS

The limited visual catchment of Pennant Hills Road restricts views primarily to road users. The Road is predominantly utilised, and hence viewed, by motorists, cyclists, pedestrians and residents. All viewers appreciate an attractive landscape setting along the Road,

however, the viewing time and therefore their sensitivity and experiences varies.

Motorists, cyclists and pedestrians are transitory viewers and the effect of changes to their experiences along the 3.3 kilometre stretch of Road will be comparable to the length of the journey undertaken. An attractive road, such as this section of Pennant Hills Road, increases the visual experiences gained on their journey. Pedestrians are the most sensitive out of the transitory viewers as the time taken for them to pass through the study area is the longest.

Residents are most important because they are permanent viewers and the Road forms an major component of all views. It is also the major address to the properties. In many locations, retaining walls, fences and substantial vegetation aims to physically separate and visually screen the Road from the residence. Associated impacts, such as noise and dust, are also reduced by the barriers. However, the tall vegetation along the Road verge and in adjacent properties is important, forming a major component of views from properties.

3.5 SUMMARY: VISUAL QUALITY

The section of Pennant Hills Road between Mahers Road and Boundary Road overall has a special visual quality, which presents pleasant visual experiences for the road users. This is created by the dominance of tall vegetation, along the road verge and within the private properties, and associated visual benefits such as arching and shading. Many specimens have significant individual visual quality.

Thompsons Corner is the only section of low visual quality. It is a wide junction between Castle Hill Road and West Pennant Hills Road, with commercial and retail outlets and no sympathetic landscape treatments. The visual experiences gained along this section are completely different to the rest of Pennant Hills Road.

4.0 METHODOLOGY

4.1 INTRODUCTION

Scenery or the visual character of landscape is widely recognised as a resource that must be taken into account during both planning processes and management programmes. Despite research during the past 25 years, no completely acceptable quantitative method has been devised to assess visual quality of landscapes, as has most other landscape variables such as soils and vegetation. It is possible that this goal is objectively unobtainable because 'perception of beauty depends upon the culturally influenced subjective response of the observer'.

The methodology for this study is subjective, but it is based on the objective methodology of recent Australian and overseas studies used for visual assessment of landscapes.

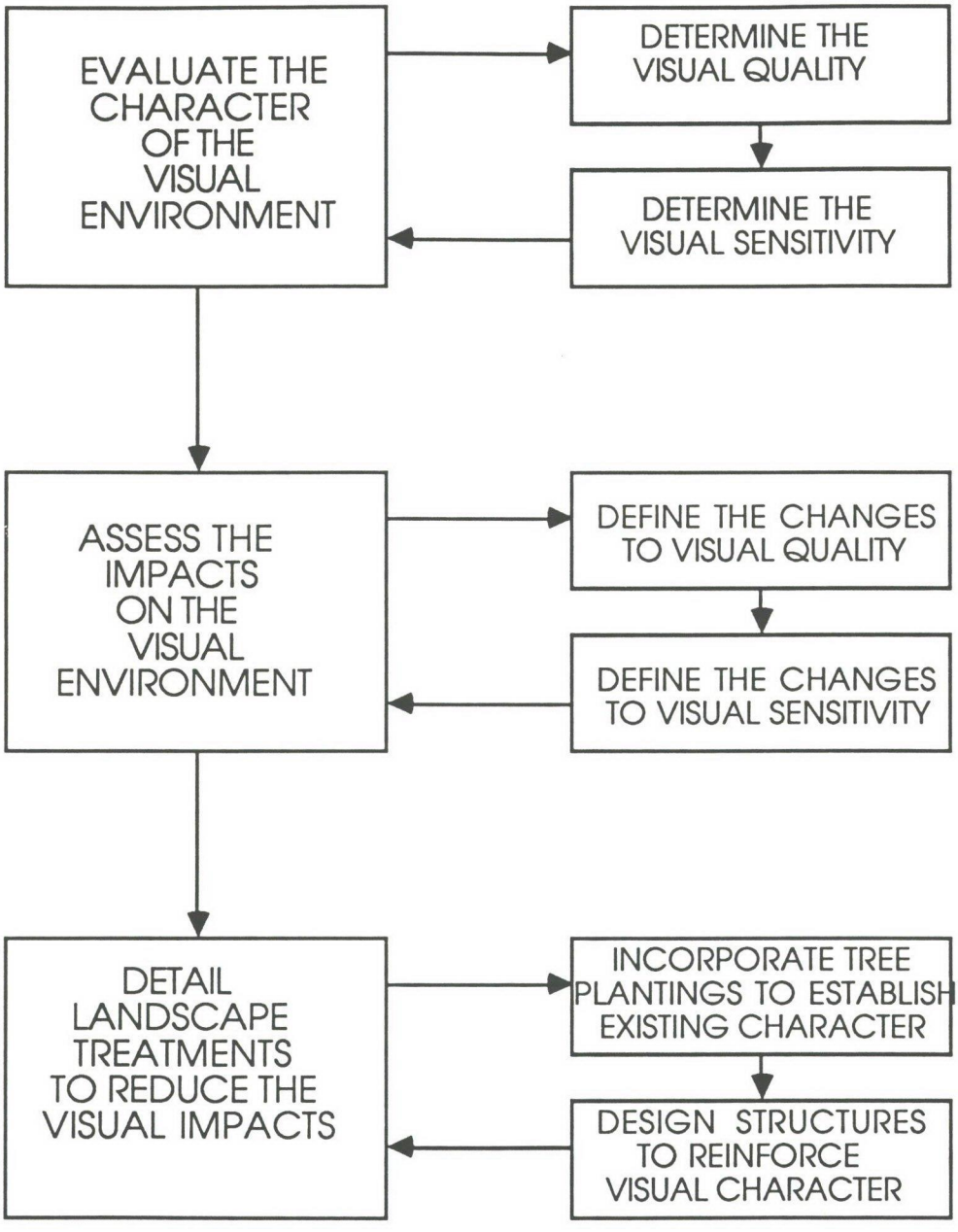
4.2 VISUAL ASSESSMENT PRINCIPLES

The methodology developed for the assessment of the impact on the visual environment of the study area is:

- systematic in approach;
- consistent in application;
- based on professional value judgement;
- based on the United States Forestry Service, Visual Management Systems (1974).

The methodology for the study is outlined in Figure 4.1. The main aim was to evaluate the character of the visual environment, determine and assess the effects of the proposed alignment changes and detail recommendations for landscape treatments. It was considered important to identify the visual resources important to the character of the environment, so these may be preserved if possible.

Figure 4.1 **Methodology for Visual Assessment**



4.3 VISUAL CHARACTER

The character of the visual environment was defined in terms of visual quality and visual sensitivity of the landscape. Visual quality was evaluated through vegetation, houses, fences and other features present along the Road and within its visual catchment. Visual sensitivity of the landscape, a measure of how critically a change will be viewed, was evaluated by analysing the views of people who utilise the Road or reside next to it.

4.4 VISUAL ASSESSMENT

The impacts on the visual environment were assessed by incorporating the necessary changes to the Road on the existing environment and defining the number of trees and structures that would be removed or altered and determining the changes to the landscape. This would also result in changes to the visual experiences gained and hence alter the visual sensitivity.

4.5 LANDSCAPE TREATMENTS

Treatments aiming to recreate the visual character of the existing environment would be recommended. These primarily incorporate tree and shrub planting. The principles and treatments required along the full length of the Road to produce a visual environment with cohesion in character would be outlined. In addition, it is necessary to detail the treatments required in each landscape unit to resolve particular issues and large impacts on the character of the visual environment.

5.0 VISUAL ASSESSMENT

Impacts to the visual character of the study area are assessed and described on two scales: an overview to the full length of the Road corridor and a detailed assessment of each landscape unit.

5.1 THE ROAD CORRIDOR

5.1.1 Visual Catchment

The enclosed nature of the visual resources surrounding the Road confines the visual impacts to this area, however, a large number of people utilise this area and therefore will view the changes. These include residents, road users, pedestrians, school children and visitors to the commercial areas.

In a few places views can be gained through breaks in the landscape canopy and the buildings. For example, at the junction of Grace Avenue and Pennant Hills Road, views can be gained of Sydney city. The city is a far distance view, over 18 kilometres away, and changes to the Road would not be viewed. From this same location views of Ryde and surrounds can be gained in the distance (approximately 8 kilometres). Views of the changes to the Road would be minimal. In addition, the proposed landscape treatments aim to reinstate the existing quantity of vegetation and over time a similar visual character, thereby further reducing changes to these potential viewers. It is during construction activities that views of the alterations would be most visible, but this is temporary.

Views to Baulkham Hills can be gained from Mount Wilberforce Lookout and Reserve. Similarly, the effects from the changes would be temporary and the proposed landscape treatments would provide a screen to the Road.

5.1.2 Road Widening and Reconstruction

The existing Road is four lanes. The primary land uses along its perimeter are residential with open space and schools. A small commercial and retail centre is also present. The proposed activities will widen the Road to six lanes with wide kerbside lanes. This requires alterations to the existing land uses.

The landscape setting and visual quality provided by the combination of large trees, substantial undergrowth and shrubs, which effectively screen the infrastructure beyond, will be altered. The existing road is very busy but the pleasant visual experiences that are created from the vegetation cover allow the density of the traffic to be reduced and allow separation between the residences and the Road.

The proposed six lane road requires the removal of most of the vegetation providing the pleasant driving experiences, which are both visual experiences and microclimatic changes such as shading. These changes will require many years to recover and enable tree growth reach the existing stage. In many cases, the existing trees are well over 100 years old. The pleasant effects created by the canopy on the Road will never reach the full width of the six laned Road.

The commercial and retail centre at Thompsons Corner has the lowest landscape quality along the length of the Road, as the landscape treatments are minimal and will not be altered in the proposed activities.

5.1.3 Vegetation

Assessment of the impact on the vegetation along the length of the Road was primarily in terms of the numbers needed to be removed to incorporate the proposed widening and reconstruction activities. A tree was defined as a single trunked specimen over three metres in height, according to the local councils Tree Preservation Order. The criteria for their removal was dependent on their location. Specimens within 1.5 metres of the new road edge would definitely need to be

removed. Specimens between 1.5 metres and the new property boundary may be able to be retained, depending on their size, location, effect on the root system, potential hazard to traffic safety and role in visual character of the environment. Therefore, these trees were counted separately and numbers indicate the maximum number of specimens that may need to be removed.

Approximately 400 trees would be removed to accommodate the proposed road widening activities along the entire length of the Road. An additional 105 trees are located between the new property boundary and 1.5 metres from the road edge. These may need to be removed but should be retained where possible. The trees to be removed are of all ages, including mature Eucalypts, remnant from the original forest ecosystems and over 100 years old. Trees would be removed from both the existing road verge and within private properties.

The Environmental Impact Statement anticipates the removal of up to 460 trees along the length of the Road. Variation between the numbers of trees to be removed reflects differences in the number of trees that could be retained. These details will be assessed and finalised during the final stages of the project.

The removal of trees will have a dramatic effect on the existing landscape and visual quality of the Road, for all viewers. The arching and shadowing effect created by the trees in various locations will be lost, changing the visual experiences for all road users. It will also reduce the physical and psychological screen between the residences and the Road. In some places, the reduction in space in the front yard is severe and will limit the type and quantity of plant material that can be used.

Auxiliary impacts result from loss of vegetation, such as increased dust reaching the structures and infrastructure. Trees and vegetation effectively trap dust generated by vehicles along the Road. The amount of dust reaching residences, schools and other structures will be increased during construction operations, but will reduce

accordingly as vegetation is reinstated. The RTA has acquired blocks of land where severe impacts on the residents are expected.

5.1.4 Fences

A mosaic of fences exists along the full length of the Road. In many situations, alterations to the fences are required, with removal and relocation being typically necessary.

The large brick wall along the boundary of Mount Saint Benedict Girls School forms a dominant visual resource along the Road. It is an effective visual and sound barrier between the Road and activities within the School and convent. The proposed widening operations requires removal of this wall.

The implementation of acoustic reduction fences is anticipated along the full length of the Road. These will play an important role in visual quality of the landscape. A continuity of the same fences will create a monotonous landscape that lacks the visual quality of the existing landscape.

5.1.5 Buildings

Housing is generally well established, with direct access to the Road. In most situations along the length of the Road, houses will not be altered. However, approximately 16 houses are directly affected and demolition is required.

The commercial and retail centre at Thompsons Corner will not be altered.

The major impact to the visual quality of the landscape as a result of the widening and reconstruction of Pennant Hills Road is generated through exposure of buildings presently screened by vegetation.

5.2 LANDSCAPE UNITS

5.2.1 Unit 1: Observatory Park

Figure 5.1 illustrates the visual impacts as a result of the proposed widening and reconstruction of Pennant Hills Road adjacent to Observatory Park. The existing visual character is illustrated in the photograph and the resultant character is presented in the photomontage.

The roadway will be widened by 13 metres on its southern edge. Observatory Park will lose 31 mature trees, the majority of which are mature Eucalyptus pilularis (Blackbutt) (refer to Figure 5.1). This will reduce the visual experience this Park creates on the environment and the arching effect of the trees over the road. The associated shading effects will be lost. An additional nine Eucalypts within the road verge and may have to be removed.

Changes to Observatory Park will create a significant effect on the existing visual quality of the environment. The Park is a remnant piece of bushland and an important visual resource for road users and residents. The height and maturity of the trees create a significant atmosphere for users of the Park and form an effective barrier between the Park and the Road. In addition, the shading and general appearance of the Road will be altered. No effects from the vegetation along the new edge of the Road would be experienced in the centre lanes of the Road.

Only minor changes to the visual character of the northern side of the Road will result, as no widening is required but the increase in noise warrants the implementation of noise attenuation fences. The existing vegetation will remain. Figure 5.2 is a perspective illustrating the fencing as a result of the proposed activities, viewing east along the Road. Observatory Park is illustrated in the background.

Figure 5.1

Existing and Proposed Landscape Treatment – Landscape Unit 1: View West from Observatory Park

Figure 5.2

Proposed Landscape Treatment – Landscape Unit 1: View East to Observatory Park

5.2.2 Unit 2: Mount St. Benedict School

Widening, to a depth of 10 metres, will occur on the northern side of the road only. Mount Saint Benedict School and Convent occupies this side of the Road. This will result in the removal of the brick wall and a total of 66 trees. An additional seven trees may need to be removed. Therefore, the major visual screen separating the school and convent from the Road will be altered. These features are a important visual resource for school children, teachers and people living in or visiting the convent as well as road users and residents in the properties opposite.

Road widening will also result in reduction in the area of playing fields in the school grounds and will affect the layout and design of the traditional gardens in the convent. Statues as well as the relaxed atmosphere created by the tall mature trees will be affected.

No significant impacts will result on the north side of the Road.

The landscape effect from the proposed activities is demonstrated in Figure 5.3, a perspective of the new landscape.

Figure 5.3

Proposed Landscape Treatment – Landscape Unit 2: View East to Mount St Benedict School

5.2.3 Unit 3: Hull Road to West Pennant Hills Primary School

Figure 5.4 illustrates the visual impacts as a result of the proposed widening and reconstruction of Pennant Hills Road on residential properties in close proximity to Lancaster Avenue. The existing visual character is illustrated in the photograph and the resultant character is presented in the photomontage.

Road widening is on average to 7 metres on either side of the Road in Unit 3. This will result in the loss of a total of 86 trees, approximately 20 of these being large eucalypts. Fifty three of these trees occupy the western side of the Road. The effective screening of the Road to the residences will be significantly altered. Houses will be closer to the Road and the existing screening between the Road and the residence will be reduced. All front yards of the residences will be physically decreased in depth, reducing space and privacy.

There will be an increase in the dominance of fences, houses and other structures in the visual character, through loss of vegetative cover. The arching effect created by the trees on the kerbs will be lost, dramatically changing the visual experiences of the road users and residents. This results in a significant reduction in the existing visual quality.

A further 25 trees lie within the road verge and may have to be removed if the roadworks do not permit the particular location of the tree for safety reasons.

The new roadway will be a wide open space in strong contrast to the narrower road with large trees overhanging the road.

Figure 5.4

Existing and Proposed Landscape Treatment – Landscape Unit 3: View North to Lancaster Avenue

5.2.4 Unit 4: Thompsons Corner

The front yards and screening vegetation will be substantially decreased along the eastern side of the Road. In some cases, minimal front yard will remain, inducing a substantial impact on the privacy and space for landscape treatment. A total of 22 trees will be removed from the eastern side of the Road. The trees and flagpole in Dame Mary Gilmore Park will remain.

Two mature trees will be removed from the western side of Castle Hill Road in this unit, as some widening to the intersection is required. Only four trees exist in this section: one other may have to be removed and the other tree will remain.

There will be no discernible change to the commercial centre. No existing landscape is present of this side of the Road.

The Thompsons Corner landscape unit is presented as a perspective in Figure 5.5, as viewed from Grace Avenue, looking north.

5.2.5 Unit 5: Castle Hill Road

Castle Hill Road will be widened for construction of the underpass at Thompson's Corner. Consequently, alterations to the southern side of Castle Hill Road and east of Church Street will necessitate the removal of 10 trees.

The 11 mature trees along the road edge of Mount Wilberforce Reserve will also be removed, creating a significant impact on the visual character of this landscape unit. The three remaining trees may need to be removed, depending on the effect the proposed activities have on their root systems.

No alterations to the northern side of Castle Hill Road are required. The landscape treatments in front of the residential properties and particularly Pennant Hills Primary School will continue to contribute to the visual quality of the unit and provide an effective screen to activities beyond.

Figure 5.5

Proposed Landscape Treatment – Landscape Unit 4: View North to Thompsons Corner

5.2.6 Unit 6: Grace Avenue

The roadway will be widened on both sides up to 10 metres. This will induce major impacts on several residential properties. Various structures, including one house, will have to be demolished, numerous front yards will be resumed and existing retaining walls will be demolished and new, higher retaining walls built to suit the new road levels. A total of 29 trees will need to be removed and up to a further 12 trees may have to be removed, depending on their exact location within the road verge.

The new road layout will require increased fencing and retaining walls and the houses will be closer to the street alignment. The impact will be exacerbated by the difficulty in re-establishing substantial trees and screen planting in the restricted spaces that will be available.

The road will have a different appearance, with the introduction of new forms such as the tunnel exit point and ramps either side. The road will have an overall width of approximately 35 metres.

5.2.7 Unit 7: Oratava Avenue to Copeland Road

The Road will be widened on both sides by approximately 5 metres. This will result in the loss of 50 trees: 23 on the eastern side and 27 on the western side. An additional 28 trees may have to be removed. This represents a significant impact on the visual quality of the unit and a reduction in the screening effects from the landscape. The depth of the front yard of numerous residences will be significantly reduced.

Acoustic attenuation fences will be constructed to reduce the impacts of noise generated by the Road on residences. The fences will introduce a new visual resource into the existing visual character of the environment.

5.2.8 Unit 8: Pennant Hills Golf Course

Figure 5.6 is a photomontage illustrating the visual impact of the proposed widening operations on the golf course and residences on the eastern side and western side of the Road respectively.

No impact on the visual character of the golf course will result from the widening of the Road. The landscape quality of the vegetation associated with golf course will remain. This is effectively demonstrated in Figure 5.6. The trees along the boundary of the golf course are a significant visual resource and maintaining these has a positive effect on the visual quality.

A total of 45 trees will be removed and 10 trees may be removed from the western side of the Road in front of the residences. The majority of these trees are medium sized exotic species, but they still have a role in the landscape of the unit. Many properties along this side of the Road have been purchased by the RTA.

5.2.9 Unit 9: Proposed F2 Freeway Interchange

Significant alterations to the landscape and visual quality of the unit is required in order to incorporate the proposed F2 Freeway and Interchange. A total of 48 trees will be removed from this small section of Road. In addition, the four houses in this unit will be demolished. They have been acquired by the RTA. The landscape character and quality of this unit will be significant altered to the extent that only remnants of the existing landscape will remain.

Figure 5.6

Existing and Proposed Landscape Treatment – Landscape Unit 8: View North to Pennant Hills Golf Course

6.0 RECOMMENDATIONS

6.1 OVERALL LANDSCAPE TREATMENTS

Uniform principles for all landscape treatments should be applied along the length of the Road in order to create a quality environment that produces pleasant visual experiences for both the residents and the road users. The existing visual quality is primarily high and loss of the high number of trees necessary to incorporate the proposed widening and reconstruction will dramatically affect the quality of the visual environment. The prime aim of landscape treatments should be to re-establish the existing ambience created by the landscape. The full effect of the existing landscape will be difficult to re-create and will require a substantial time frame.

The following principles and guidelines are recommended to be adopted for landscape strategies:

- retention of as many trees in the road verge as possible;
- the use of plant material that is endemic or representative of the original forest species to the area;
- planting of trees to be on both the road verge (adjacent to the fences) and within property boundaries;
- planting of shrubs and groundcover on the road verge;
- planting to incorporate the requirements for driver safety and reduce traffic hazards;
- footpath alignments should wind around existing trees in order to avoid their removal;
- all works to incorporate the needs of residents, the aesthetics of the residence, acoustic reduction and the landscape quality of the Road from the road users perspective;
- upgrade visual quality in commercial zone to incorporate landscape treatment and enhance user experiences without detracting from the commercial viability of the area;
- landscape treatment on footpaths to incorporate pedestrian safety and comfort;
- all transmission and distribution lines to be underground lines;

- road lighting to be set back against property boundaries;
- investigate the use of consolidated blocks of acquired residential land for an open space buffers and compensation for reduced landscape quality. This would be particularly effective in residential areas with limited space for planting.

6.2 LANDSCAPE STRATEGIES FOR LANDSCAPE UNITS

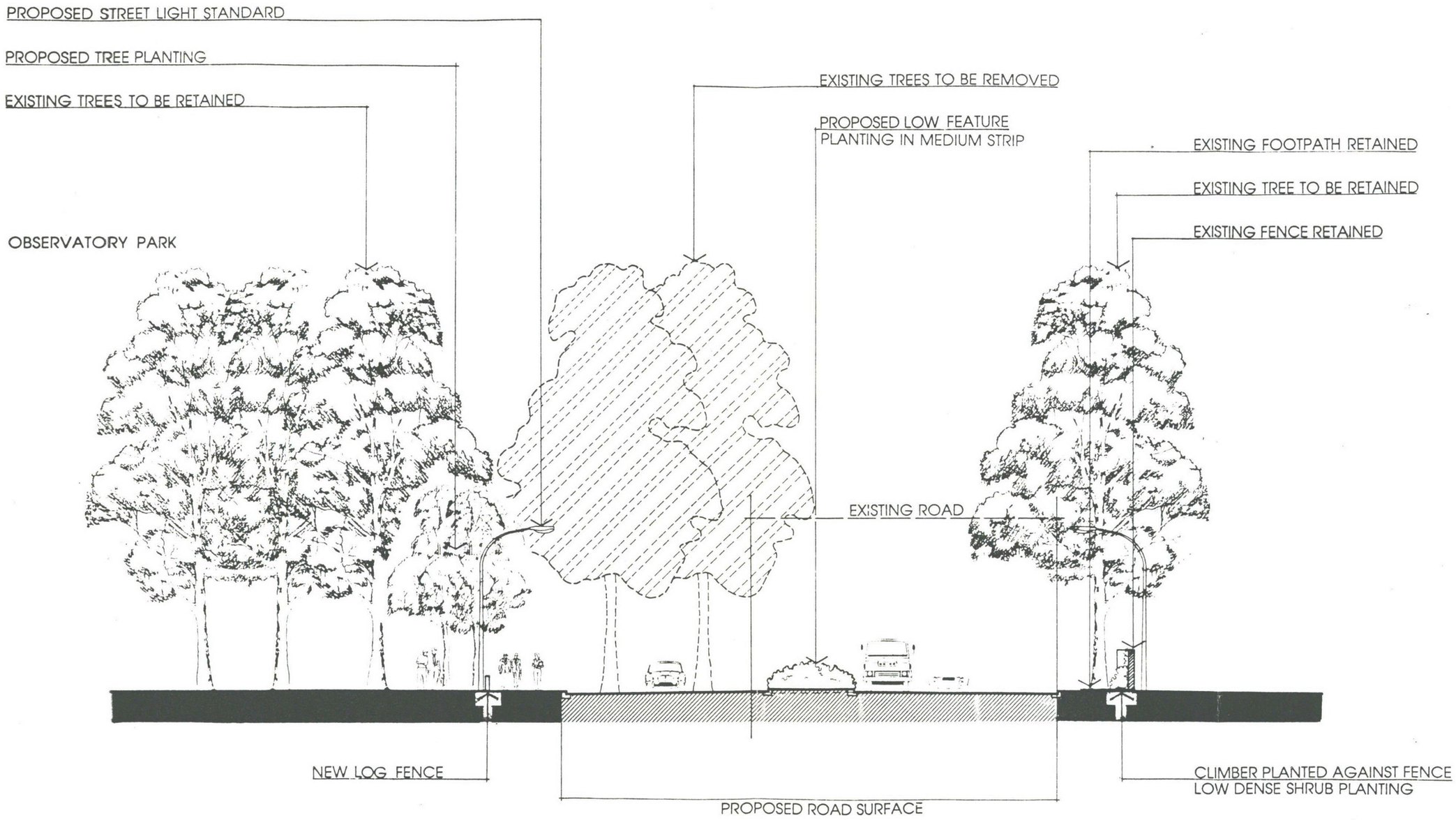
The landscape strategies for each unit are presented in section. Two units are also illustrated in plan view (Unit 2 and Unit 4).

6.2.1 Unit 1: Observatory Park

Refer to Figure 6.1.

Existing trees on the northern side of the Road would be retained. Fences with an acoustic attenuation effect and high visual amenity would be constructed. These would be 1.8 metres high, predominantly brick, stepped, with tall shrubs as infill planting. Understorey species would include Callistemon spp., Melaleuca spp., Leptospermum spp. and large Grevillea spp. Trees would be planted within the road verge, set 3.0 metres from the Road. Recommended species include Eucalyptus pilularis (Blackbutt), E. saligna (Sydney Blue Gum) and Syncarpia glomulifera (Turpentine). A mix of colours and materials used in the acoustic fences would reduce visual monotony and aim to suit the selection of residents.

As many of the existing trees within the Park should be retained and tree canopy should be reinforced with additional planting where possible. Recommended species include Eucalyptus pilularis (Blackbutt), E. saligna (Sydney Blue Gum) and Syncarpia glomulifera (Turpentine). Log fencing should be relocated to the new Park perimeter.



PENNANT HILLS ROAD WIDENING

SECTION A-A - UNIT 1 OBSERVATORY PARK

(LOOKING WEST)

SCALE

0 1 2 3 4 5 10 METRES

FIGURE 6.1

6.2.2 Unit 2: St. Mount Benedict School

Refer to Figures 6.2.

The dominant wall of the school would be reinstated, repeating the existing fence detail. Consideration should be given to stepping the fence to reduce the visual impact of a solid brick wall. Planting should be as outlined in Unit 1, for the residential properties.

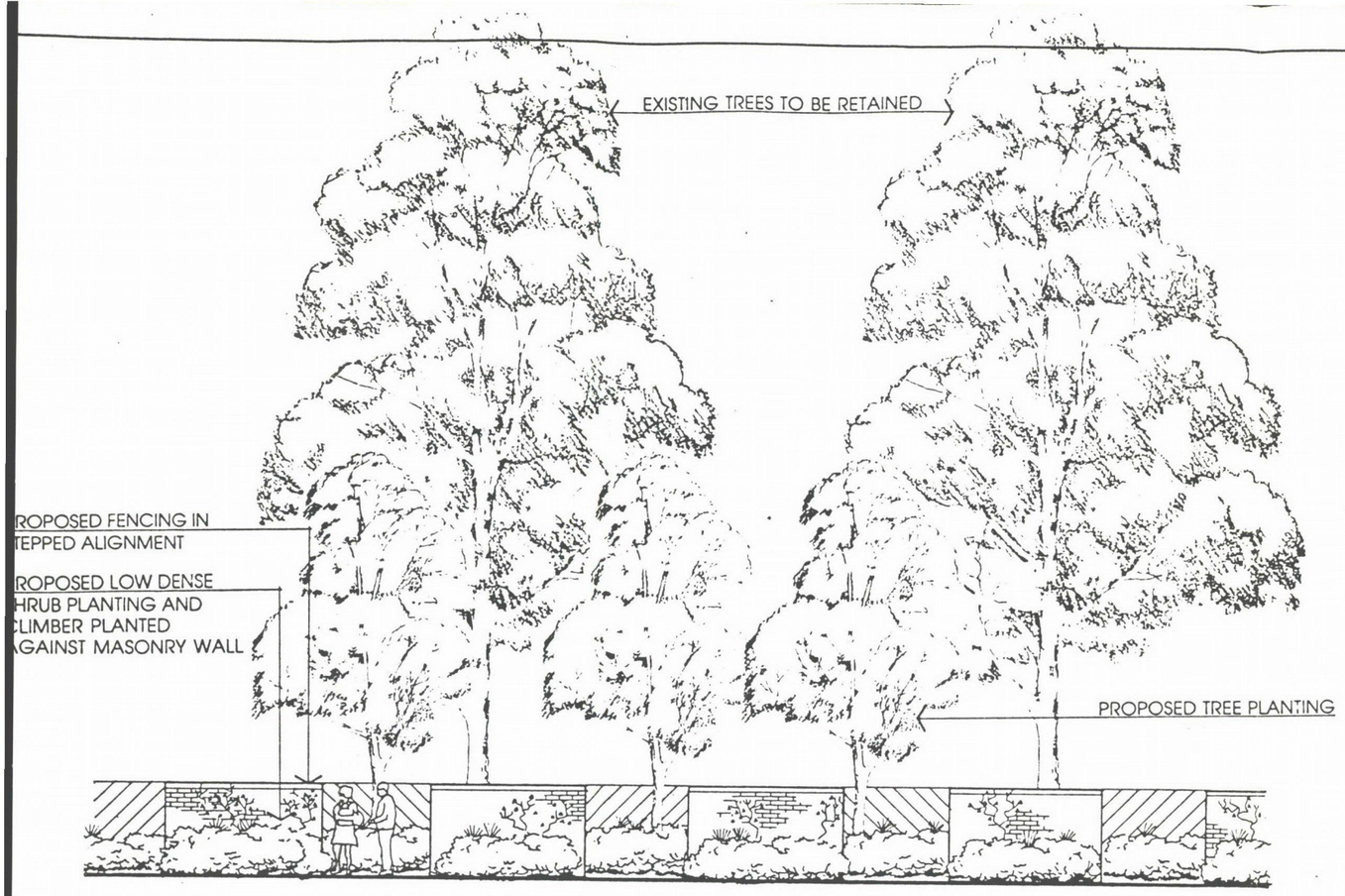
Landscape treatments should be as outlined in Unit 1, for the residential properties. A new footpath should be constructed. Care should be taken to retain as many existing trees as possible and the footpath alignment should wind around these trees to avoid their removal.

6.2.3 Unit 3: Hull Road to West Pennant Hills Primary School

Refer to Figure 6.3.

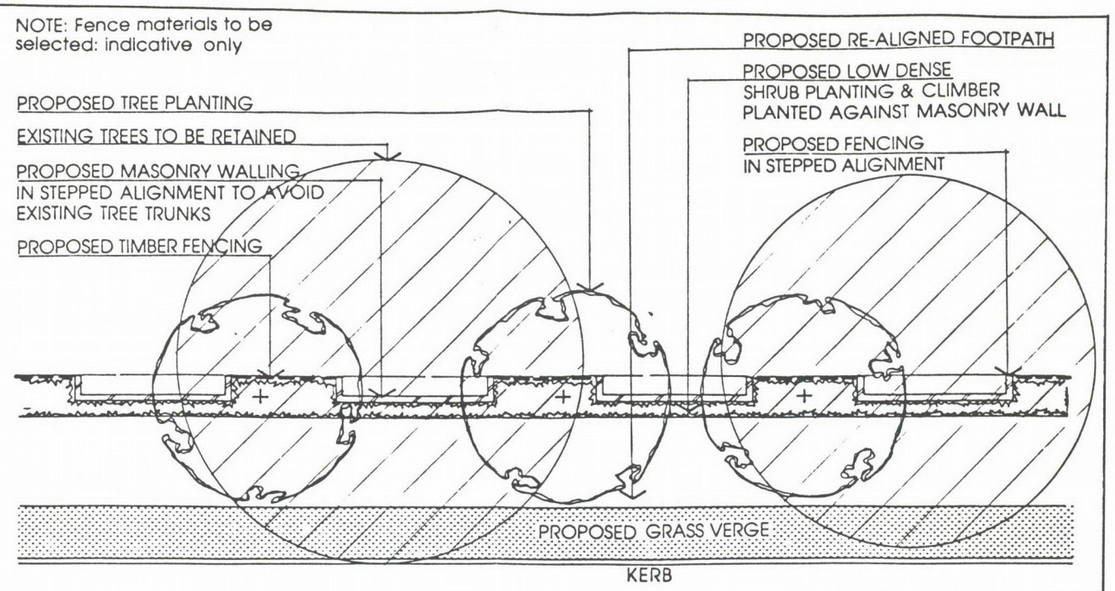
The landscape treatments would be as outlined in Unit 1, for the residential northern side of the Road. The existing footpath should be retained on the western side of the Road and a new footpath constructed on the eastern side of the Road.

Decorative feature median planting, consisting of low shrubs should be included.



TYPICAL ROAD ELEVATION :Typical for all landscape units

0 1 2 3 4 5
SCALE



TYPICAL DETAILED PLAN :Typical for all landscape units

0 1 2 3 4 5
SCALE

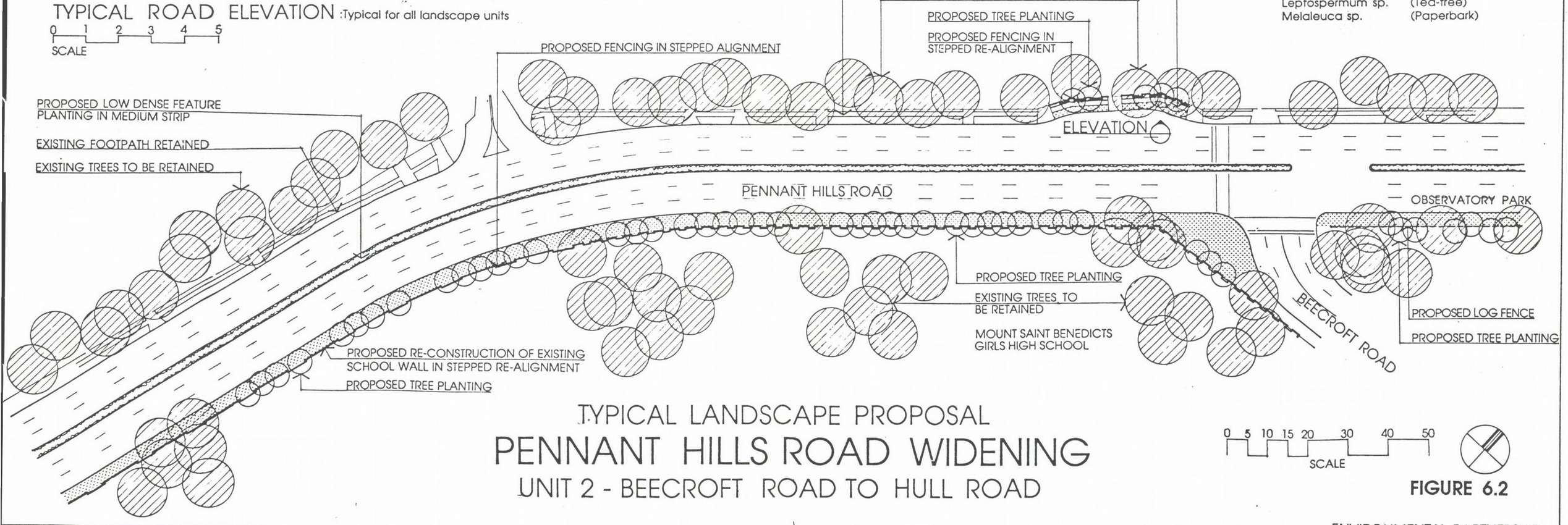
TYPICAL PLANT MATERIALS

TYPICAL TREES

Eucalyptus pilularis	(Blackbutt)
Eucalyptus saligna	(Sydney Blue Gum)
Syncarpia glomulifera	(Turpentine)

TYPICAL SHRUBS

Callistemon sp.	(Bottlebrush)
Grevillea sp.	(Grevillea)
Leptospermum sp.	(Tea-tree)
Melaleuca sp.	(Paperbark)



TYPICAL LANDSCAPE PROPOSAL

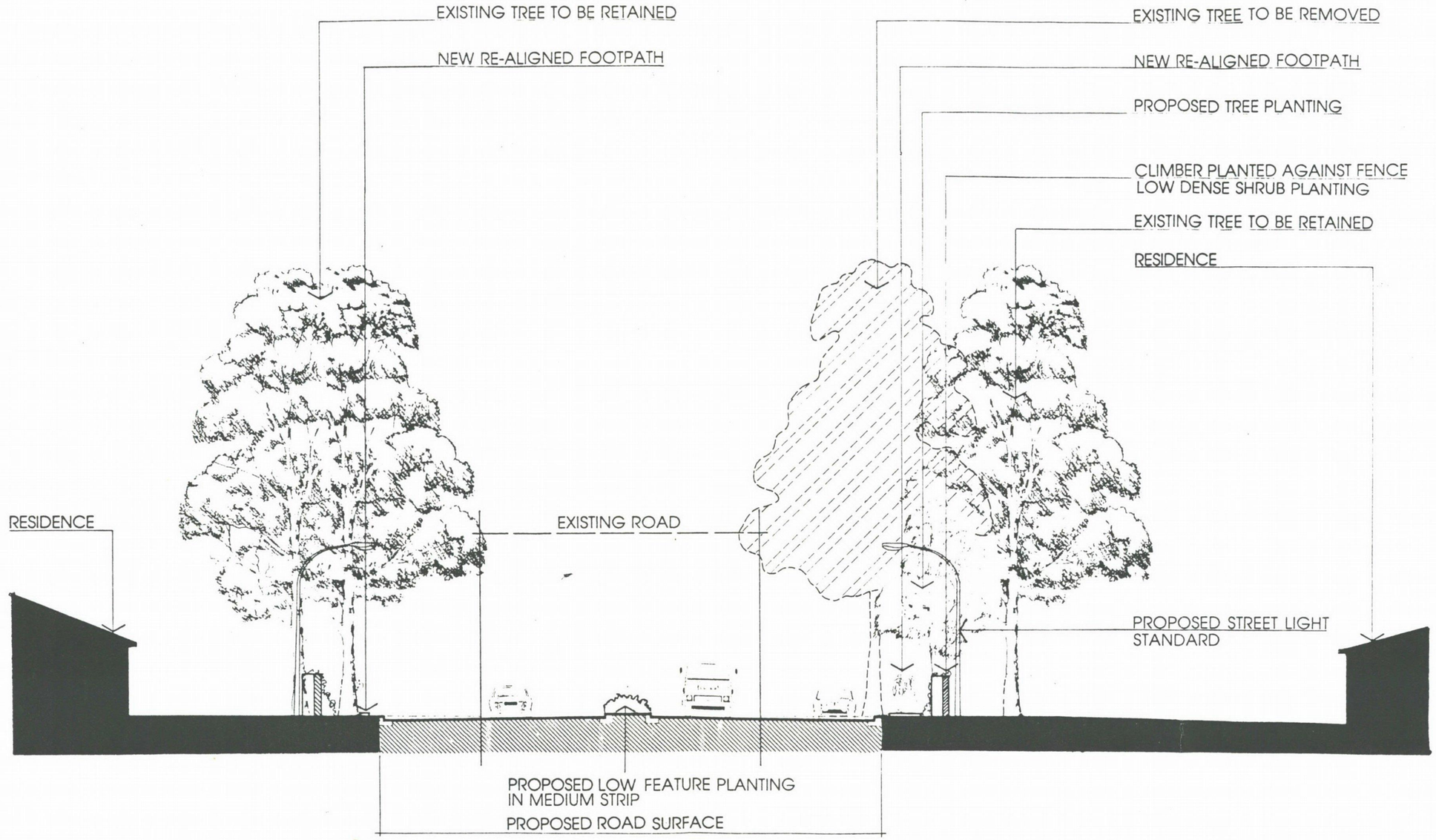
PENNANT HILLS ROAD WIDENING

UNIT 2 - BEECROFT ROAD TO HULL ROAD

0 5 10 15 20 30 40 50
SCALE

FIGURE 6.2

ENVIRONMENTAL PARTNERSHIP



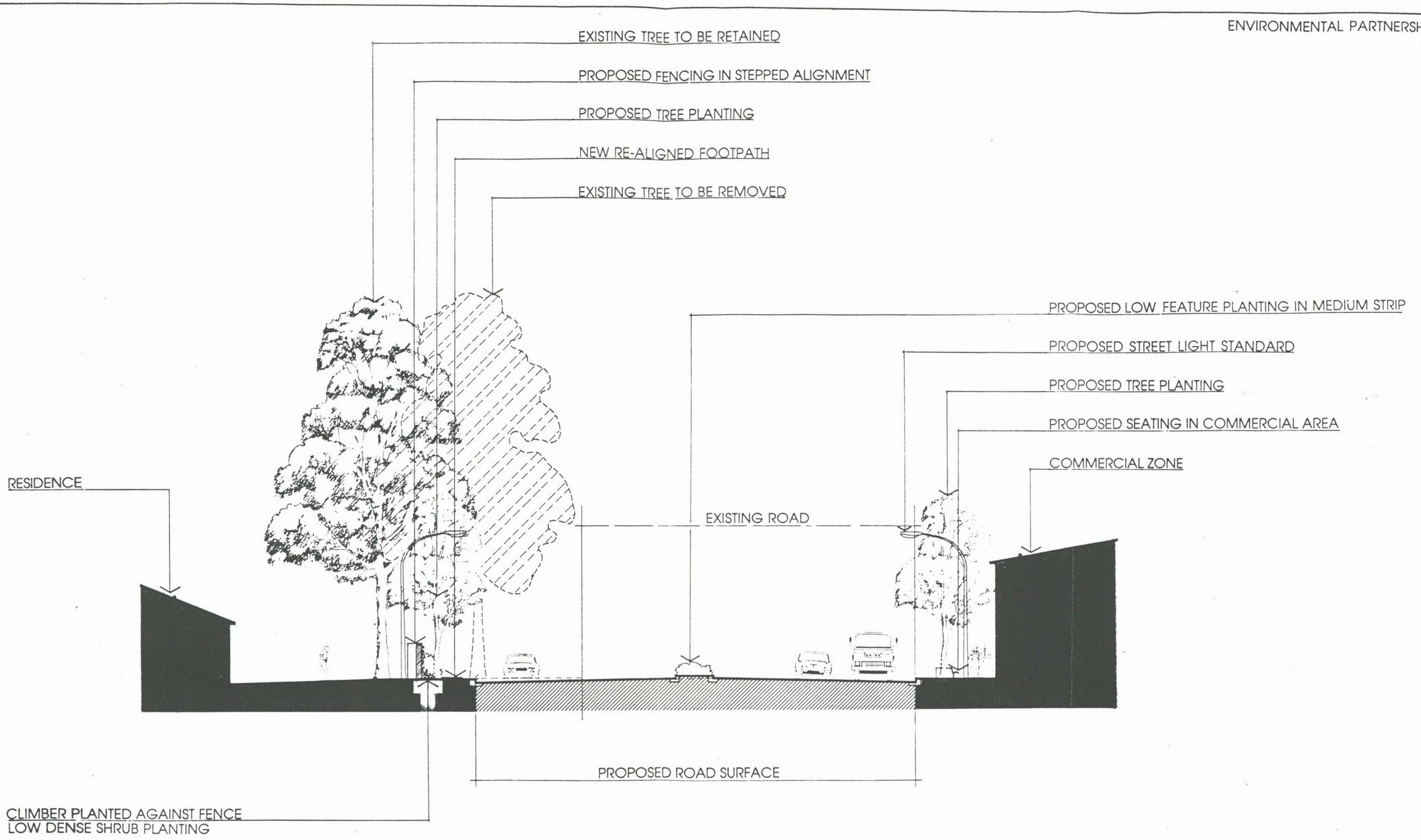
PENNANT HILLS ROAD WIDENING

SECTION B-B (LOOKING SOUTH) - UNIT 3 HULL ROAD TO WEST PENNANT HILLS PRIMARY SCHOOL

FIGURE 6.3

SCALE
0 1 2 3 4 5 10 METRES

ENVIRONMENTAL PARTNERSHIP



PENNANT HILLS ROAD WIDENING

SECTION C-C - UNIT 4 THOMPSONS CORNER

(LOOKING SOUTH)

SCALE

0 1 2 3 4 5 10 METRES

FIGURE 6.4

LEGEND

- EXISTING TREES TO BE RETAINED
- PROPOSED FENCING IN STEPPED ALIGNMENT
- PROPOSED LOW DENSE SHRUB PLANTING AND CLIMBER PLANTED AGAINST MASONRY WALL
- PROPOSED TREE PLANTING
- PROPOSED GRASS VERGE

TYPICAL PLANT MATERIALS

TYPICAL TREES

Eucalyptus pilularis	(Blackbutt)
Eucalyptus saligna	(Sydney Blue Gum)
Syncarpia glomulifera	(Turpentine)
Eucalyptus microcorys	(Tallow-wood)

-in commercial area of Thompsons Corner

TYPICAL SHRUBS

Callistemon sp.	(Bottlebrush)
Grevillea sp.	(Grevillea)
Leptospermum sp.	(Tea-tree)
Melaleuca sp.	(Paperbark)

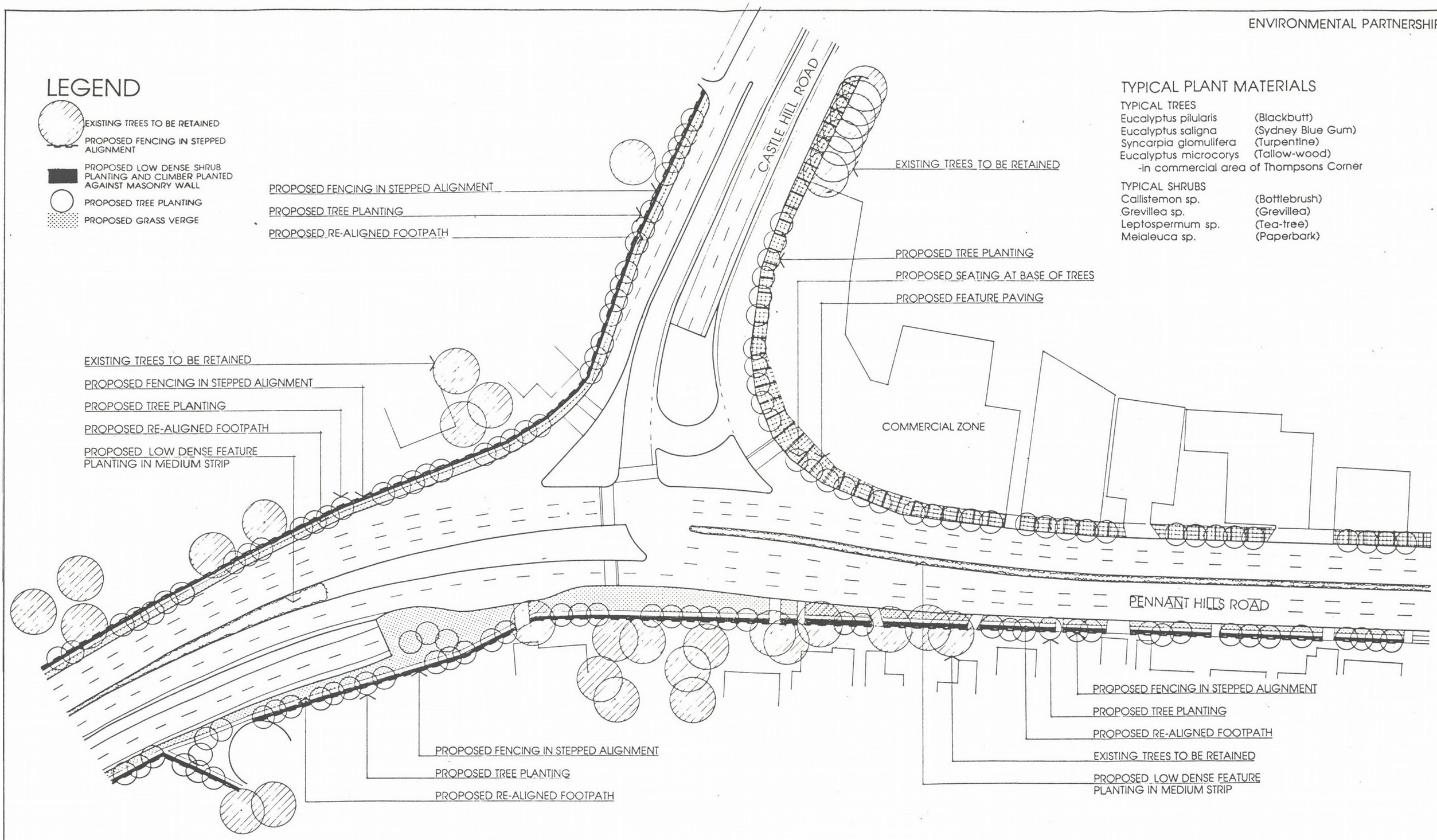
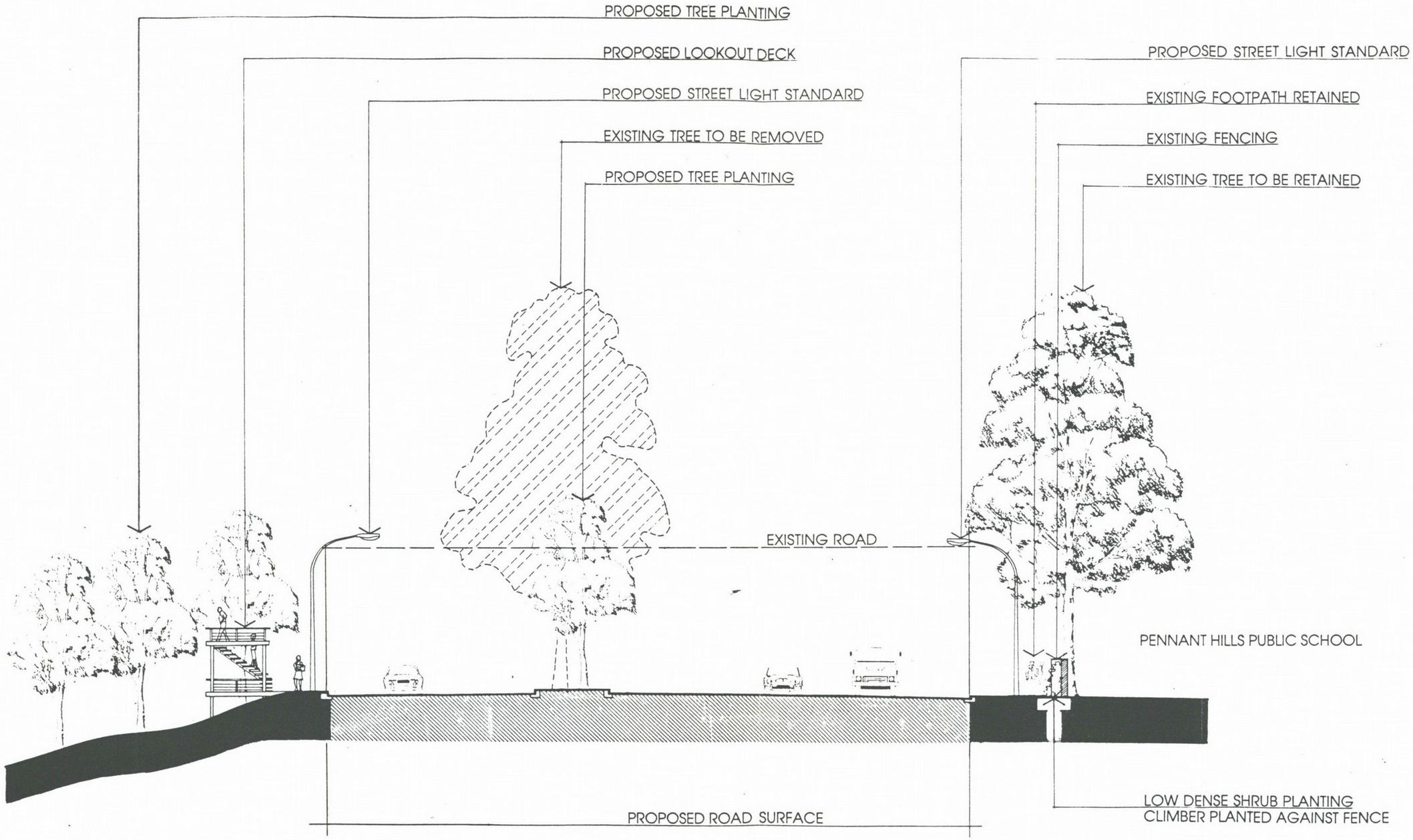


FIGURE 6.5

TYPICAL LANDSCAPE PROPOSAL
PENNANT HILLS ROAD WIDENING
UNIT 4 - THOMPSONS CORNER

0 5 10 15 20 30 40 50
SCALE

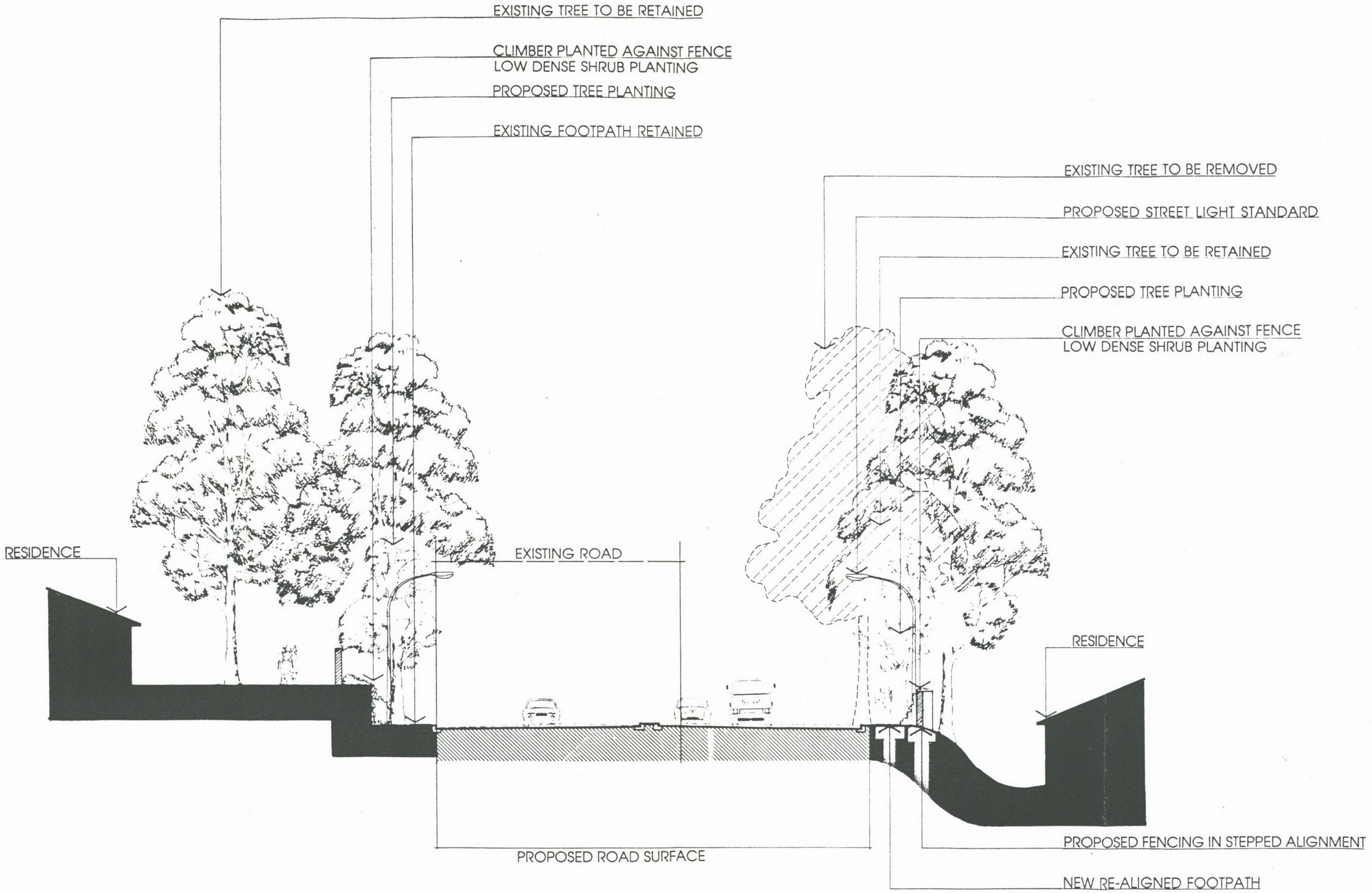


PENNANT HILLS ROAD WIDENING

SECTION D-D - UNIT 5 CASTLE HILL ROAD
(LOOKING NORTH)

SCALE
0 1 2 3 4 5 10 METRES

FIGURE 6.6



PENNANT HILLS ROAD WIDENING

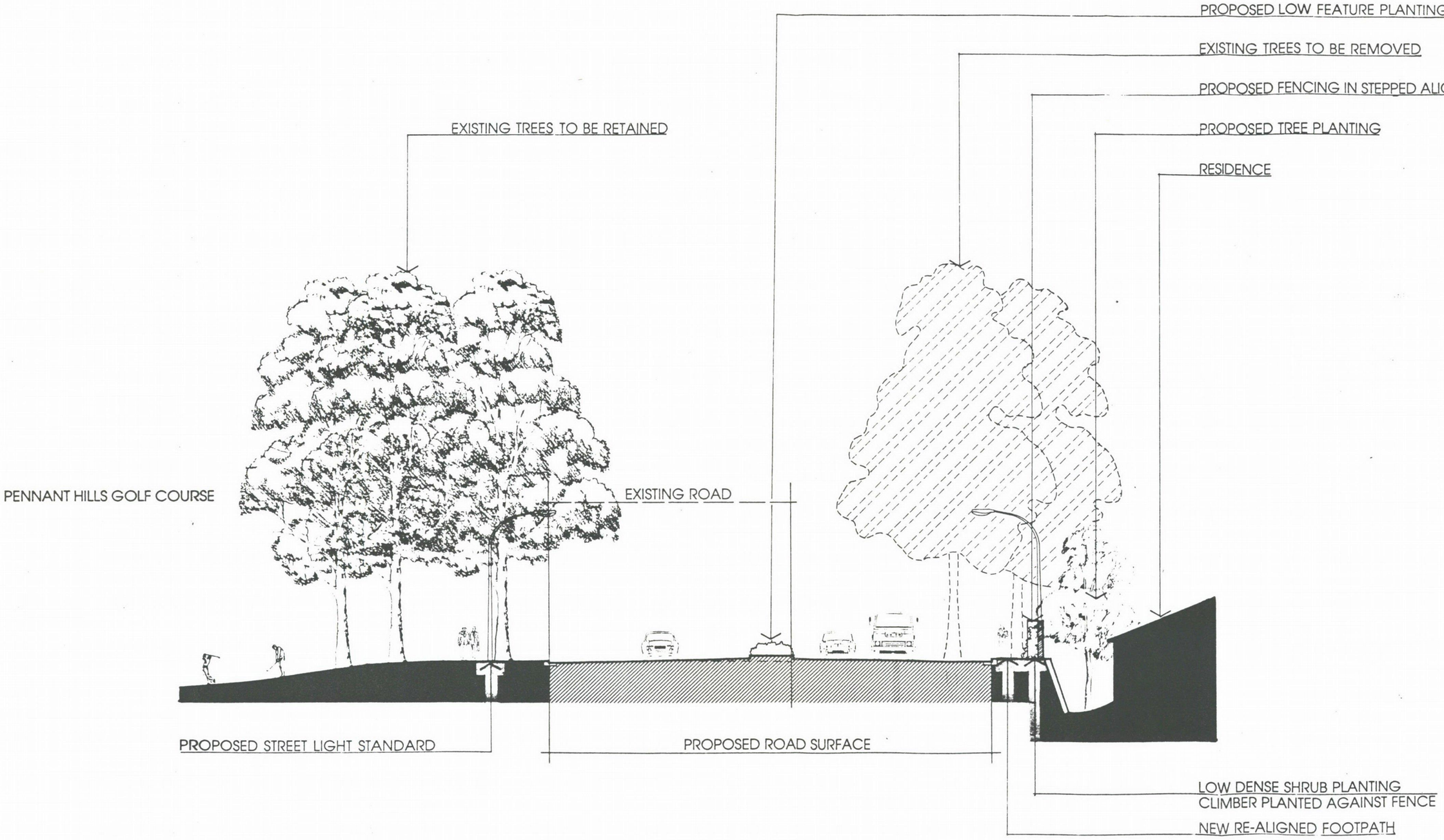
SECTION E-E - UNIT 6 GRACE AVENUE PRECINCT

(LOOKING SOUTH)

SCALE

0 1 2 3 4 5 10 METRES

FIGURE 6.7



PENNANT HILLS ROAD WIDENING

SECTION F-F - UNIT 8 PENNANT HILLS GOLF COURSE
(LOOKING SOUTH)

SCALE
0 1 2 3 4 5 10 METRES

FIGURE 6.8

4. BENEFIT COST ANALYSIS

CONNELL WAGNER

Connell Wagner

ROADS AND TRAFFIC AUTHORITY

PENNANT HILLS ROAD
WIDENING AND RECONSTRUCTION
BETWEEN MAHERS ROAD AND BOUNDARY ROAD

BENEFIT COST ANALYSIS

Prepared by

CONNELL WAGNER (NSW)

NOVEMBER 1990

PENNANT HILLS ROAD WIDENING & RECONSTRUCTION BETWEEN MAHERS ROAD AND BOUNDARY ROAD

BENEFIT COST ANALYSIS

1.0 INTRODUCTION

The Roads and Traffic Authority (RTA) proposes to undertake widening and reconstruction of Pennant Hills Road between Mahers Road and Boundary Road. The project would involve widening from the present four lanes to six lanes to achieve a road standard similar to that recently completed north of Boundary Road. A full description of the proposed works is contained in the environmental impact statement prepared by Connell Wagner.

This report provides an account of the economic evaluation which involved a benefit-cost analysis with respect to a Base Case (Do Nothing) and an Improved Case (the Proposal).

2.0 METHOD

The economic evaluation was carried out using the procedure described in the report - Economic Analysis for Sydney Western Region, Phase 1 Report Procedures (RTA, 1989). This procedure generally adopts the standard values for vehicle operating and time costs used for road projects throughout Australia, as recommended by the National Association of Australian State Road Authorities (NAASRA). As indicated by NAASRA (1989), this method is generally applicable only to national arterial roads of which Pennant Hills Road provides such a function.

The procedure uses information from TRANPLAN, a computer network model which simulates travel patterns for traffic throughout the Sydney Metropolitan region.

The specific outputs used from TRANPLAN are peak two hour vehicle kilometres and peak two hour vehicle hours. Both of these outputs represent the total figures for the whole modelled network.

These outputs are then converted to Road User Costs in order to undertake a conventional method of benefit-cost analysis which employs a discounted cash flow analysis accounting for:

- annual benefits arising from vehicle operating cost savings, travel time savings and accident cost savings;
- annual cost of land acquisition/adjustments, road construction costs and re-adjustment of services.

3.0 ASSUMPTIONS

The conversion of the TRANPLAN outputs to Road User Costs for direct input to the discounted cash flow analysis involved a number of assumptions and parameters. These are described below.

3.1 Modelled Road Network

To determine the annual flows of costs and benefits over the assumed life of the project (i.e. 30 years), TRANPLAN was run for the Do Nothing Case and the Improved Case for the years 1993 and 2011, corresponding to trip tables developed by the Ministry of Transport. Annual Road User Costs up until the year 2019 could then be determined by extrapolation of the changes modelled between 1993 and 2011.

For the 1993 road network it was assumed that all committed road works of the RTA were completed. The major items included the F2 connected from Pennant Hills Road west to Abbott Road, the F4 extension between Prospect and Mays Hill, Silverwater Road extension and Highs Road/Merelynne Road connected to the F2 Freeway.

In addition, these base road networks were tested with the F2 Freeway connected east of Pennant Hills Road to Epping Road (i.e. F2 Stage 1), and alternatively, with the Commission of Inquiry recommendations of widening Epping Road and Carlingford Road (Commissioners of Inquiry for Environment and Planning, 1990).

The 2011 road network essentially included all of the above, plus a number of additional works further afield from the study area. Again, both the F2 (Stage 1 and the alternative Commission of Inquiry recommendations were tested. It is noted that the modelled year 2011 road network used for the economic analysis assumes that there is no F2–F3 connection other than Pennant Hills Road.

3.2 Period Vehicle Kilometres/Vehicle Hours

The TRANPLAN output represents total vehicle kilometres and total vehicle hours only for the peak two hour period. In order for these volumes to be assessed in a discounted cash flow analysis, they need to be annualised. The procedure outlined in the RTA (1989) report is to run TRANPLAN on various increments for the network traffic loadings. This is to enable estimation of the dis-proportionate reduction in vehicle kilometres/vehicle hours that occurs over various periods of the day (i.e. vehicle hours are higher per hour in the peak hour for the same length of road than during other times of the day). From this, vehicle kilometres and vehicle hours can be determined for other periods of the day (i.e. off peak, business peak, peak shoulders, etc).

Following the above procedures for this assessment however, would require nine additional TRANPLAN runs and therefore was considered inappropriate. An alternative method was to select an expansion factor which involves direct factoring of the peak two hour volume to an annual estimate. This is discussed below.

3.3 Expansion Factor

An annual expansion factor was derived from the existing relationship of the two hour peak period with the recorded annual average daily traffic (AADT) for most roads in the Sydney area, which is about 1,600.

It is noted however, that a higher expansion factor could of been used as traffic flow characteristics in the study area (compared to major arterial routes in most central city locations) has a lower proportion of peak period flows relative to daily flows. On this basis, adoption of an expansion factor of 1600 represents a conservative assumption.

3.4 Vehicle Operating Costs

These costs are derived from equations recommended in the RTA 1989 report (subsequently revised in the RTA circular C90/13). The equations however, assume a vehicle composition of 85% cars, 10% light vehicles and 4% heavy vehicles. Pennant Hills Road carries a higher proportion of heavy vehicles (i.e. average approximately 11%) and thus, the equations was modified. The resultant equation used is as follows :

$$VOC = 0.13 \times vkm + 2.94 \times vhrs$$

3.5 Travel Time Costs

Derivation of the average hourly volume of travel time also assumes a significantly lower composition of heavy vehicles than is representative of Pennant Hills Road. The average hourly volume given by the RTA was therefore modified to reflect the higher percentage of heavy vehicles. The resultant equation is :

$$TTC = \$13.77/\text{million vehicle kilometres}$$

3.6 Accident Costs

These costs were derived from the values presented in the RTA Circular No C90/13 and assumes an Undivided Arterial for the Do Nothing Case, and a Divided Arterial for the Improved Case.

It is noted that the average cost per million vehicle kilometres travelled is higher for the Improved Case ($53,176) than the Do Nothing Case ($44,142) by about 8% based on the generally higher cost per accident along divided roads than on undivided roads.

3.7 Cost Estimates

Project costs comprise land acquisitions, property adjustments, public utility alterations, road and tunnel construction, engineering and other costs.

Property and adjustment costs were estimated on current acceptable market values and varied on a pro-rata basis for the area of land affected. Cost estimates for road construction, tunnel construction and public utility alterations were based on similar work undertaken by the RTA and current estimates given by public utility authorities. Table 1 below shows the annual project expenditure for the period of construction.

TABLE 1 : ANNUAL EXPENDITURE ($M)

	89/90	90/91	91/92	92/93	93/94	Total
Property Acquisitions/ Adjustments	11.60	6.90	2.80	1.40	0.00	22.70
Property Disposal	0.00	0.00	0.00	-2.00	-2.00	-4.00
Construction	0.00	0.00	14.40	5.30	12.40	32.10
Utilities	0.00	0.40	3.00	4.00	0.10	7.50
Engineering/Supervision	0.50	0.70	1.60	1.00	0.70	4.50
Totals	12.10	8.00	21.80	9.70	11.20	62.80

Total Expenditure $62.8M.

4.0 RESULTS OF ANALYSIS

The key economic indicators derived from the discounted cash flow analysis for the Do Nothing Case compared with the Improved Case (the Proposal) for a 7% real discount rate and an expansion factor of 1,600 for both road network scenarios, is presented in Table 2 below. The full spread sheet showing the workings of the economic model for the 'worst case' scenario (i.e. lowest benefit-cost ratio) is provided at the end of this report.

TABLE 2 : SUMMARY OF KEY ECONOMIC INDICATORS

Key Economic Indicators	Value With F2	With CI
Benefit/Cost Ratio	3.5	5.4
Nett Present Value ($M)	127.1	227.2
1st Year Rate of Return (%)	19.9	23.7
Internal Rate of Return (%)	19.9	24.7
Payback Period (Years)	9	8

The table indicates that the widening of Pennant Hills Road gives a benefit-cost ratio of at least 3.5, and has a nett present value of at least $127 million. These findings show that the widening and reconstruction of Pennant Hills Road is economic, based on the assumed road network and the benefits and costs that can be readily quantified in dollar values.

It is noted that the benefit-cost ratio is higher with the Commission of Inquiry recommendation. This is because the road network under this scenario would have Pennant Hills Road widened to six lanes from Epping Road to North Rocks Road, and from Boundary Road to Pearces Corner. The subject section of Pennant Hills Road thus acts as a 'missing link' in an otherwise consistent six lane road network. In addition between 15-20% more traffic would use Pennant Hills Road if the Commission of Inquiry recommendations were adopted and thus, benefits accrue to a greater amount of traffic.

4.1 Sensitivity Testing

As noted earlier, there are a number of inputs to the model which have a significant bearing on the key economic indicators. These inputs therefore need to be tested over a range of conditions in order to assess the extent of change in the outcome.

By inspection, it was determined that the most influential variables in the model were the discount rate, the expansion factor, vehicle operating costs and travel time costs.

To test the sensitivity a range of discount rates were tested as well as reducing all the key inputs (i.e. expansion factor, VOC, TTC) by 20%. Results of this testing are shown in Table 3 below.

TABLE 3 : SENSITIVITY OF THE BENEFIT-COST RATIO

	With F2			With CI		
	4%	7%	10%	4%	7%	10%
No Change to Factors	5.2	3.5	2.5	8.3	5.4	3.7
Factors Reduced by 20%	3.3	2.2	1.6	6.6	4.3	3.0

Note:

F2 = F2 Freeway (Stage 1)
CI = Commission of Inquiry recommended corridor.

The testing indicates that the benefit-cost ratio is satisfactory over a range of discount rates and also under the condition of reducing key factors such as expansion factors, vehicle operation costs and travel time costs by 20%. It is noted that this general reduction by 20% was recommended in submissions to the Commission of Inquiry into the F2 Freeway.

REFERENCES

- Commissioners of Inquiry for Environment and Planning (1990), A Proposed Expressway from Pennant Hills Road, Beecroft to Pittwater Road, Ryde known as the F2 Stage 1.

- Department of Environmental and Planning (1988), Sydney into its Third Century. Metropolitan Strategy for the Sydney Region.

- Department of Main Roads (1986), Roads 2000 Plan, Sydney Region.

- Transportation Environment Consultants (1989), West Pennant Hills Traffic Study. Prepared for Hornsby Shire Council.

- State Pollution Control Commission, Environmental Noise Control Manual (Update 1989).

- Department of Main Roads (1987), Road Traffic Noise. Guidelines for Predictions and Measurement of Road Traffic Noise, including Guidelines for the Provision of Noise Attenuation Measures.

- Roads and Traffic Authority (1989), Economic Analysis for Sydney Western Region. Phase 1 Report (Procedures).

- Roads and Traffic Authority (1988), North West Sector Road Needs Study. Analysis of Area Bounded by the Pacific Highway, Pennant Hills Road, Beecroft Road and Epping Road.

- National Association of Australian State Road Authorities (1989), Benefit Cost Analysis of National Arterial Road Projects. NAASRA, Sydney.

A. COMPOSITIONS

	PRIVATE	BUSINESS	COMMERCIAL LIGHT	COMMERCIAL HEAVY
PEAK	0.74	0.05	0.10	0.11
BUSINESS	0.59	0.21	0.09	0.11
OTHER	0.85	0.05	0.07	0.03

B. OCCUPANCY

	PRIVATE	BUSINESS	COMMERCIAL LIGHT	COMMERCIAL HEAVY
PEAK	1.12	1.20	1.44	1.44
BUSINESS	1.50	1.40	1.30	1.10
OTHER	1.97	1.40	1.30	1.10

C. TIME COSTS

	PRIVATE	BUSINESS	COMMERCIAL LIGHT	COMMERCIAL HEAVY
PEAK/BUSI	$6.73	$25.42	$12.28	$12.50
OTHER	$6.73	$6.73	$6.73	$6.73

D. TRAVEL TIME PER VEHICLE

PERIOD			
OP	$12.58	1000	12575.005
MOP	$12.58	1650	20748.758
MBP	$16.38	1650	27025.003
BP	$16.38	1800	29481.822
AMPS	$10.85	400	4340.5376
AMP	$10.85	600	6510.8064
PMPS	$10.85	400	4340.5376
PMP	$10.85	600	6510.8064
	101.3129	8100	111533.27

Average Hourly Value = $13.77

E. VEHICLE OPERATING COSTS PER VEHICLE TYPE

	$/vkms	$/vhrs
VOC=	$0.13	$2.94

F. CONVERSION OF TRANPLAN OUTPUTS TO ROAD USER COSTS

Total Vehicle Kilometers

	1993	2011
Improved	7.427094	11.313842
Unimproved	7.428075	11.314907

Total Vehicle Hours

	1993	2011
Improved	0.197445	0.363939
Unimproved	0.197953	0.364928

Expansion To Annual vkms

Factor= 1600

	1993	2011
Improved	11883.350	18102.147
Unimproved	11884.92	18103.851

Expansion To Annual vhrs

Factor= 1600

	1993	2011
Improved	315.912	582.3024
Unimproved	316.7248	583.8848

VEHICLE OPERATING COSTS

Factors
$0.13 v.km
$2.94 v.hrs

	1993	2011
Improved	2473.6168	4065.2481
Unimproved	2476.2105	4070.1219
Savings($M)	2.59368	4.873776

VEHICLE TRAVEL TIME COSTS

Factor
$13.77

	1993	2011
Improved	4349.9630	8018.0363
Unimproved	4361.1549	8039.8253
Savings($M)	11.191882	21.788920

ACCIDENT COSTS

Factors
Undivided $53,176
Divided $49,142

	1993	2011
Improved	0.3649822	0.5559848
Unimproved	0.3949953	0.6016814
Savings($M)	0.0300130	0.0456966

G. DISCOUNTED CASH FLOW ANALYSIS

PROJECT DESCRIPTION: PENNANT HILLS ROAD WIDENING (Beecroft Rd to F2 Castlereagh Freeway)

PROJECT COSTS	89/90	90/91	91/92	92/93	93/94	94/95	96/97	Total
. Acquisitions/Adjustments	11.60	6.70	2.80	1.40	0.00	0.00	0.00	22.70
. Property Disposal	0.00	0.00	0.00	-2.00	-2.00	0.00	0.00	-4.00
. Construction	0.00	0.00	14.40	5.30	12.40	0.00	0.00	32.10
. Other(utilities)	0.00	0.40	3.00	4.00	0.10	0.00	0.00	7.50
. Engineering&Supervision	0.50	0.70	1.60	1.00	0.70	0.00	0.00	4.50
Total	12.10	8.00	21.80	9.70	11.20	0.00	0.00	62.80

ROAD USER COSTS	Base		Option	
	1993	2011	1993	2011
. Time & Vehicle Operation	6837.365	12109.947	6823.580	12083.285
. Accidents	0.395	0.602	0.365	0.556
Total	6837.760	12110.549	6823.945	12083.841

SUMMARY OF RESULTS

. Discount Rate	7.0%
. Present Value of Costs (million 1989$)	51.48
. Present Value of Benefits (million 1989$)	178.62
. Nett Present Value of Benefits (million 1989$)	127.14
. Benefit/Cost ratio	3.47
. First Year Rate of Return	19.92%
. Internal Rate of Return	19.92%
. Payback Period (years)	9

YEAR	No.	BASE CASE COST					IMPROVED CASE COSTS					ECONOMIC ANALYSIS								
		Const	Maint	Time& VOC	Acc	Total	Const	Maint	Time& VOC	Acc	Total	Const	Maint	Time& VOC	Acc	Total Saving	Total Benefi	Discounting Factor	Const	Benefi
1988/89	0																	1.000		
1989/90	1	0.00	0.0480	6028.85	0.36	6029.21	12.10	0.0100	6017.01	0.33	6017.34	12.10	0.00	0.00	0.00	0.00	0.00	0.935	11.31	0.00
1990/91	2	0.00	0.0496	6287.13	0.37	6287.50	8.00	0.0104	6274.67	0.34	6275.02	8.00	0.00	0.00	0.00	0.00	0.00	0.873	6.99	0.00
1991/92	3	0.00	0.0512	6556.48	0.38	6556.86	21.80	0.0108	6543.37	0.35	6543.73	21.80	0.00	0.00	0.00	0.00	0.00	0.816	17.80	0.00
1992/93	4	0.00	0.0528	6837.37	0.39	6837.76	9.70	0.0112	6823.58	0.36	6823.94	9.70	0.00	0.00	0.00	0.00	0.00	0.763	7.40	0.00
1993/94	5	0.00	0.0544	7130.29	0.41	7130.69	11.20	0.0116	7115.79	0.38	7116.16	11.20	0.00	0.00	0.00	0.00	0.00	0.713	7.99	0.00
1994/95	6	0.00	0.1550	7423.21	0.42	7423.63	0.00	0.0120	7407.99	0.39	7408.38	0.00	0.14	15.22	0.03	15.25	15.39	0.666	0.00	10.26
1995/96	7	0.00	0.0576	7716.13	0.43	7716.56		0.0124	7700.20	0.40	7700.59	0.00	0.05	15.93	0.03	15.96	16.01	0.623	0.00	9.97
1996/97	8	0.00	0.0576	8009.05	0.44	8009.49		0.0128	7992.40	0.41	7992.81	0.00	0.04	16.65	0.03	16.68	16.73	0.582	0.00	9.73
1997/98	9	0.00	0.0576	8301.97	0.45	8302.42		0.0132	8284.61	0.42	8285.03	0.00	0.04	17.36	0.03	17.40	17.44	0.544	0.00	9.49
1998/99	10	0.00	0.0576	8594.89	0.46	8595.36		0.6068	8576.81	0.43	8577.24	0.00	-0.55	18.08	0.04	18.11	17.56	0.508	0.00	8.93
1999/00	11	0.00	1.0576	8887.81	0.48	8888.29		0.0140	8869.02	0.44	8869.46	0.00	1.04	18.79	0.04	18.83	19.87	0.475	0.00	9.44
2000/01	12	0.00	0.0576	9180.74	0.49	9181.22		0.0144	9161.23	0.45	9161.68	0.00	0.04	19.51	0.04	19.55	19.59	0.444	0.00	8.70
2001/02	13	0.00	0.0576	9473.66	0.50	9474.15		0.0148	9453.43	0.46	9453.89	0.00	0.04	20.22	0.04	20.26	20.30	0.415	0.00	8.43
2002/03	14	0.00	0.0576	9766.58	0.51	9767.09		0.0152	9745.64	0.47	9746.11	0.00	0.04	20.94	0.04	20.98	21.02	0.388	0.00	8.15
2003/04	15	0.00	0.0576	10059.50	0.52	10060.02		0.0156	10037.84	0.48	10038.33	0.00	0.04	21.65	0.04	21.69	21.74	0.362	0.00	7.88
2004/05	16	0.00	0.0576	10352.42	0.53	10352.95		0.0160	10330.05	0.49	10330.54	0.00	0.04	22.37	0.04	22.41	22.45	0.339	0.00	7.61
2005/06	17	0.00	0.0576	10645.34	0.54	10645.89		0.0164	10622.26	0.50	10622.76	0.00	0.04	23.09	0.04	23.13	23.17	0.317	0.00	7.33
2006/07	18	0.00	0.0576	10938.26	0.56	10938.82		0.0168	10914.46	0.51	10914.97	0.00	0.04	23.80	0.04	23.84	23.88	0.296	0.00	7.07
2007/08	19	0.00	0.0576	11231.18	0.57	11231.75		0.6086	11206.67	0.52	11207.19	0.00	-0.55	24.52	0.04	24.56	24.01	0.277	0.00	6.64
2008/09	20	0.00	0.0576	11524.10	0.58	11524.68		0.0176	11498.87	0.53	11499.41	0.00	0.04	25.23	0.04	25.28	25.32	0.258	0.00	6.54
2009/10	21	0.00	0.0576	11817.03	0.59	11817.62		0.0180	11791.08	0.55	11791.62	0.00	0.04	25.95	0.04	25.99	26.03	0.242	0.00	6.29
2010/11	22	0.00	0.0576	12109.95	0.60	12110.55		0.0184	12083.28	0.56	12083.84	0.00	0.04	26.66	0.05	26.71	26.75	0.226	0.00	6.04
2011/12	23	0.00	0.0576	12402.87	0.61	12403.48		0.0188	12375.49	0.57	12376.06	0.00	0.04	27.38	0.05	27.42	27.46	0.211	0.00	5.79
2012/13	24	0.00	0.0576	12695.79	0.62	12696.41		0.0192	12667.70	0.58	12668.27	0.00	0.04	28.09	0.05	28.14	28.18	0.197	0.00	5.56
2013/14	25	0.00	0.0576	12988.71	0.64	12989.35		0.0196	12959.90	0.59	12960.49	0.00	0.04	28.81	0.05	28.86	28.90	0.184	0.00	5.32
2014/15	26	0.00	1.0576	13281.63	0.65	13282.28		0.0200	13252.11	0.60	13252.71	0.00	1.04	29.52	0.05	29.57	30.61	0.172	0.00	5.27
2015/16	27	0.00	0.0576	13574.55	0.66	13575.21		0.0204	13544.31	0.61	13544.92	0.00	0.04	30.24	0.05	30.29	30.33	0.161	0.00	4.88
2016/17	28	0.00	0.0576	13867.47	0.67	13868.15		0.6104	13836.52	0.62	13837.14	0.00	-0.55	30.96	0.05	31.01	30.45	0.150	0.00	4.58
2017/18	29	0.00	0.0576	14160.40	0.68	14161.08		0.0212	14128.73	0.63	14129.36	0.00	0.04	31.67	0.05	31.72	31.76	0.141	0.00	4.46
2018/19	30	0.00	0.0576	14453.32	0.69	14454.01		0.0216	14420.93	0.64	14421.57	0.00	0.04	32.39	0.05	32.44	32.47	0.131	0.00	4.27
			3.79				62.80	2.25				62.80	1.34						51.48	178.62

5. RESIDENTIAL ACCESS STUDY

CONNELL WAGNER

Connell Wagner

ROADS AND TRAFFIC AUTHORITY

PENNANT HILLS ROAD
WIDENING AND RECONSTRUCTION
BETWEEN MAHERS ROAD AND BOUNDARY ROAD

REVIEW OF VEHICULAR ACCESS CHANGES FOR RESIDENTIAL PROPERTIES ALONG PENNANT HILLS ROAD AND CASTLE HILL ROAD

Prepared by

CONNELL WAGNER (NSW)

NOVEMBER 1990

PENNANT HILLS ROAD WIDENING & RECONSTRUCTION BETWEEN MAHERS ROAD AND BOUNDARY ROAD

RESIDENTIAL ACCESS STUDY

1.0 INTRODUCTION

This study reviews the impact of the proposed vehicular access to residential properties following the widening and reconstruction of Pennant Hills Road.

The proposed widening incorporates a central median strip in Pennant Hills Road which will prevent all existing right turns to and from residential properties. As such, all access will be restricted to left in/left out only, and will in most instances impose additional travel distances on the local residents.

2.0 RESULTS OF ANALYSIS

To assess the effects on vehicular access, alternative routes that would replace right turns were determined for residents along the affected sections of Pennant Hills Road and Castle Hill Road, and also for access to West Pennant Hills Shopping Centre.

The entry/exit access circuits were plotted on base maps and then measured by direct scaling. These circuits are presented at the back of this report. The measured additional travel distances for entry and exists are shown in Table 1.

The table shows that residents along Pennant Hills Road would have to travel on average, an additional 1.3kms for entry and 1.5kms for exits to and from their homes, where otherwise a direct right hand turn to and from Pennant Hills Road would have been achievable.

The maximum additional travel distance is 2.7kms which occurs to the Church on the south side of Castle Hill Road, between Thompsons Corner and Mt Wilberforce Lookout, and residents on the east side of Pennant Hills Road between Lancaster Avenue and Cardinal Avenue.

With respect to the local connecting roads, the impact of the median close would be less significant. Additional travel distances of about 1.3kms would occur to residents on Grace Avenue however, entry/exits to other local roads are not likely to change as residents would generally already undertake circuits to avoid turning across heavy traffic on Pennant Hills Road.

It should be noted however, that whilst the proposal would represent more circuitous access to properties, it would offer a significant level of improvement with respect to traffic safety. In addition, it would eliminate interruption to traffic flow which occurs whilst residents wait in the main traffic stream to

turn right into their properties. it is also expected that a proportion of residents would have already chosen the more circuitous routes to achieve safe left in/left out access, and thus, may not be effected.

TABLE 1 : ADDITIONAL TRAVEL DISTANCE REQUIRED FOR VEHICULAR ACCESS TO PROPERTIES DUE TO ELIMINATION OF RIGHT TURN MANOEUVRES

Location	Maximum Travel Distance	
	Entry (km)	Exit (km)
West Side of Pennant Hills Road		
o Beecroft Rd to Loftus Rd	0.6	1.4
o Loftus Rd to Hull Rd	0.9	1.2
o Hull Rd to Cardinal Ave	1.3	1.7
o Cardinal Ave to Castle Hill Rd	0.4	0.7
o Castle Hill Rd to Oratava Ave	2.1	1.3
o Oratava Ave to Aiken Rd	1.5	1.2
o Aiken Rd to Eaton Rd	1.1	1.7
o Eaton Rd to Mahers Rd	2.2	1.9
East Side of Pennant Hills Road		
o Beecroft Rd to Hull Rd	1.3	2.0
o Hull Rd to Lancaster Ave	0.7	1.7
o Lancaster Ave to Cardinal Ave	1.8	1.0
o Cardinal Ave to Castle Hill Rd	0.7	2.0
o Castle Hill Rd to End of Tunnel	1.3	1.3
o End of Tunnel to Hannah St	1.2	1.4
o Hannah St to Copeland Rd	1.8	1.4
South Side of Castle Hill Road		
o Thompsons Cnr to Park Entrance	2.7	2.3
North Side of Castle Hill Road		
o Church St to New Line Rd	1.1	0.8 *

* Assumes a U-turn facility above the tunnel at Castle Hill Road.

LEGEND

Access To Residential Properties

Access To Residential Properties

LEGEND

Access To Residential Properties

LEGEND

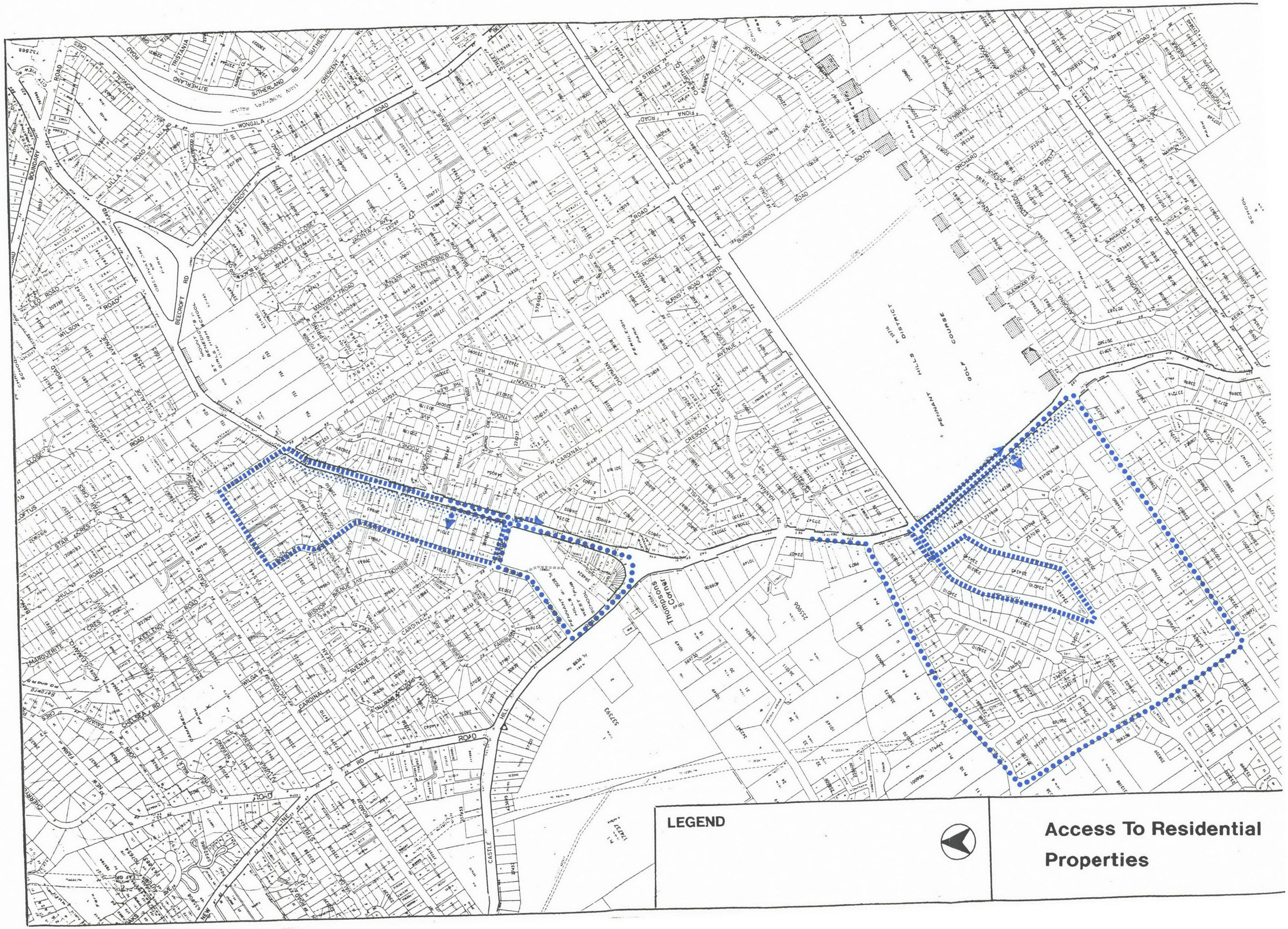
Access To Residential Properties

LEGEND

Access To Residential Properties

LEGEND

Access To Residential Properties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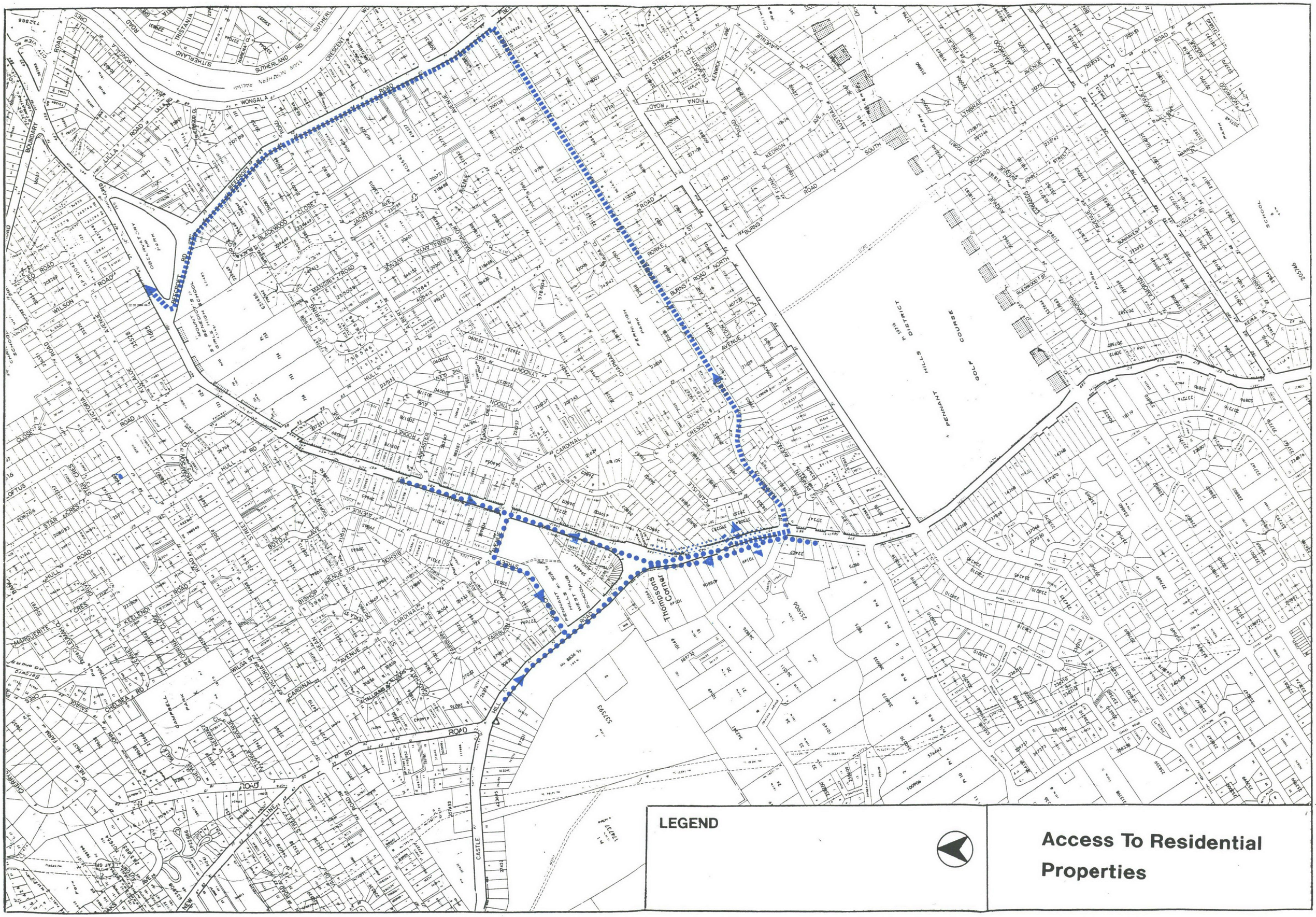
Access To Residential Properties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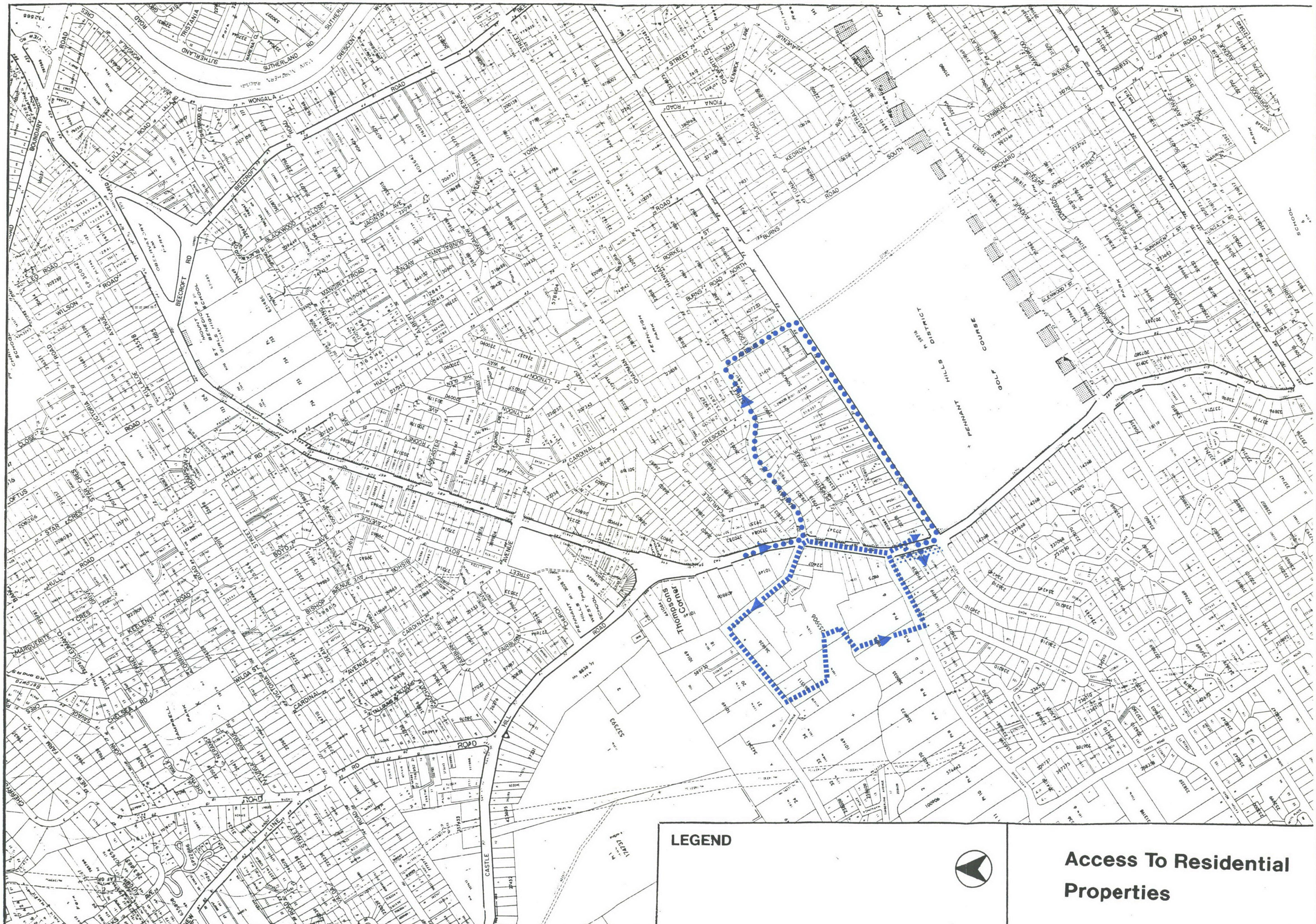
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Access To Residential Properties

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Access To Residential Properties

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Access To Residential Properties

6. ROAD ALIGNMENT ALTERNATIVES

CONNELL WAGNER

Connell Wagner

ROADS AND TRAFFIC AUTHORITY

PENNANT HILLS ROAD
WIDENING AND RECONSTRUCTION
BETWEEN MAHERS ROAD AND BOUNDARY ROAD

ASSESSMENT OF WIDENING OPTIONS

Prepared by

CONNELL WAGNER (NSW)

NOVEMBER 1990

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9.0 SUMMARY ASSESSMENT

SUMMARY

A review of alternate road widening options has been carried out for numerous road sections between Mahers Road and Beecroft Road. The options for each section basically included the concept as adopted in the earlier Review of Environmental Factors (REF) and an alternative to widen wholly on one side of the existing alignment. The side chosen was based on minimal affect to residential properties except in the case of the section between Hull Road and Boundary Road, where the option was to minimise the effects to Observatory Park.

The key findings for each road section are summarised below in terms of a number of key criteria (viz. property effects, cost and tree loss).

Mahers Road to Copeland Road

The option to widen wholly on the western side of Pennant Hills Road would result in :

- Six additional house demolitions (five already owned by the RTA).
- The same total number of residential properties affected, but 16 extra strip acquisitions (10 already owned by the RTA).
- Additional costs of approximately $335,000 allowing for resale of RTA properties and for non-purchase of golf course land. This cost could be substantially offset or even negated if the RTA elected to rezone the residual property on the western side of Pennant Hills Road for higher yielding uses (viz. medium density residential).
- Net saving of about 110 trees mainly in golf course.

On balance, it would seem the streetscape benefits of changing the widening concept are greater than the social and economic disadvantages. The strategy regarding end use of the properties on the western side (i.e. rezoning to medium density) could further improve this position.

Copeland Road to Oratava Avenue

The option to widen wholly on the western side of the road would result in :

- one additional house demolition
- 12 less residential properties affected by strip acquisition, but 10 extra strip are required

- additional costs of approximately $100,000
- saving of about 20 large trees.

The social impact of extra property acquisitions are judged to be more significant than the benefits of tree retention. As such, the alternative offers limited advantages.

Oratava Avenue to Thompsons Corner

As the intersection of Pennant Hills Road and Castle Hill Road is the crux of the project, and the design of the proposed tunnel has been optimised by previous detailed investigation, no suitable options for widening of the southern approach have been identified. Widening wholly on one side in this section would result in significant alteration of the proposed intersection concept.

Thompsons Corner to Cardinal Avenue

The option to widen Pennant Hills Road wholly on the eastern side would result in :

- six additional house demolitions (three owned by the RTA)
- eight less residential properties affected in total, but 13 additional strip acquisitions required of which only five are RTA owned
- additional costs of approximately $600,000
- no saving in the number of large trees lost.

The alternative appears to offer negligible benefits over the existing road widening concept for this section. It is noted that widening wholly on the western side would effect even more properties.

Cardinal Avenue to Hull Road

The option to widen wholly on the western side for this section would result in :

- seven house demolitions (three owned by the RTA) compared to none in the existing concept
- 30 less properties affected by strip acquisition, but 12 additional strip acquisitions required
- additional costs of approximately $1.0 million
- saving of about 16 large trees.

The alternative does not offer significant benefits which out-weigh the disadvantages associated with extra property purchases.

Hull Road to Boundary Road

The option to widen on the western (or northern) side of this road section would result in :

- o six house demolitions (and possibly 13), none of which are owned by the RTA, compared to no demolitions under the proposed concept
- o 23 additional private properties affected by at least strip acquisitions (previously four large properties affected including school, convent and public reserve)
- o additional costs of at least $2.2 million associated with property acquisitions and adjustment
- o loss of about 165 large trees along the western side of the road (which accounts for most of the vegetation on that side of the road) compared to about 120 significant trees in Observatory Park and school grounds.

On balance, the social impacts associated with purchase of properties that are currently unaffected are considered to be more significant than the benefit of saving 40 large mature trees through Observatory Park. It is noted that possible land additions to Observatory Park from the existing Beecroft Road reservation (north and south arm) could be achieved irrespective of where the Pennant Hills Road widening were undertaken. The are of road reserve residue which would be added to the Park is approximately the same as the area which would be lost to widening.

Castle Hill Road - Pennant Hills Road to New Line Road

The design of Thompsons Corner tunnel and minimising the affect to shops, residential properties, Mt Wilberforce Lookout Park and Bethlehem Uniting Church have all been deciding factors in the current road widening concept. No alternative would offer any benefits to that proposed.

Conclusions

Retention of the existing road widening concept appears justified for all sections, with the exception of the southern part between Mahers Road and Copeland Road (i.e. opposite Pennant Hills Golf Course). When deciding on the preferred alignment for this section, it is presumed that the implications for the proposed F2 Freeway Pennant Hill Road interchange will be important. Planning of that arrangement is uncertain due to the F2 Tollway

Inquiry and the concurrent work on the F2 Freeway (west) by others. However, initial examination of the concept to widen wholly to the west does indicate that the standard of design of the interchange would not be compromised.

1.0 INTRODUCTION

This working paper provides an assessment of the possible widening alternatives for Pennant Hills Road. The findings of this assessment will provide the basis for the RTA to make a decision on the preferred arrangement which will then be subject to an Environmental Impact Statement.

The key factors adopted for comparing the merits for the different widening options included impact on properties (viz. house demolitions and strip acquisition effects), difference in costs (viz. acquisitions, adjustments, road construction utilities, etc) and loss of large trees.

The assessment of widening options has been conducted for a number of sections of road between Mahers Road and Boundary Road. These sections were defined basically by apparent changes in land use or development along the route.

2.0 MAHERS ROAD TO COPELAND ROAD

2.1 Present Land Use Status

The western side of Pennant Hills Road is wholly residential, whilst on the eastern side is the Pennant Hills Golf Course. Over 150 replacement trees have been planted in the Golf Course outside the road boundary in expectation of the road widening.

2.2 Options for Widening

Gazetted Road Reserve

The gazetted road reserve would allow widening on both sides of Pennant Hills Road with a variable width strip of up to 10 metres taken along the Golf Course side and a strip of about 3 to 4 metres from the residential side. This option was the subject of a Review of Environmental Factors (REF) which was publicly exhibited in June 1990.

Alternative

The alternative is for road widening entirely on the western side of Pennant Hills Road. This was considered as it would eliminate all affects to Pennant Hills Golf Course, and as almost all the properties on the western side are now owned by the RTA, the social impacts associated with widening on the eastern side only would be significantly reduced.

2.3 Assessment of Options

Impact on Properties

The impact of the options for widening are presented in Table 2.1 below.

TABLE 2.1 : IMPACT ON PROPERTIES

Impact	Existing Reservation	Alternative
Demolitions	5 (5)	11 (10)
Strip Acquisitions	22 (15)	–
Extra Strip Acquisitions/ Whole Purchase	–	16 (10)
Total Properties Affected	27 (18)	27 (19)

Note: ( ) Figures in brackets represent properties already acquired by the RTA.

Table 2.1 indicates that the alternative would affect the same number of properties. An additional six houses would have to be demolished, however the RTA already own all but one of these. The RTA also needs to negotiate for strip acquisition/whole purchase of a further six properties.

Under the option to widen on both sides, the RTA has acquired all properties that would involve house demolition, however still needs to negotiate for strip acquisition of seven properties.

Cost Comparison

To determine any economic benefit of the options a base cost of zero was adopted for the original concept. Hence, an item that saves money will be indicated by a negative value. Table 2.2 summarises the cost comparison. It should be noted that the cost estimates assume that returns from the sale of RTA acquired property would be with unchanged zoning of the land. As such, the estimates do not allow for potentially higher returns that would accrue if rezoning for high and better land use were achieved. For instance, rezoning for medium density residential, which is considered a realistic scenario, would yield improved land values/unit area and could result in substantial reduction of costs incured by acquiring wholly on one side of the road.

TABLE 2.2 : COST OF ALTERNATIVE RELATIVE TO ORIGINAL CONCEPT

Item	Cost ($'000)
Additional Acquisitions	+ 1,025
Property Adjustments	− 75
Utilities	0
Construction	− 150
Acquisitions at Golf Course	− 465
Total Cost	+ 335

Table 2.2 indicates that widening on the western side would only cost about $0.34 million more than the current concept of widening on both sides. This is largely because of the additional full acquisitions required which would more than offset the purchase of the strip along the Golf Course.

It is noted that the costing assumes that the remaining blocks would be sold off individually at reduced market rates. It is likely however, that this residue land could be amalgamated to form a viable parcel which could be rezoned for higher density residential development. In this regard, the deficit of $0.43 million may reduce considerably, making the alternative much more comparable in terms of cost.

It is also noted that widening on one side will improve construction efficiency and costs as it allows for greater flexibility in construction staging, especially with regard to pavement construction and traffic switches.

The existing reservation would require all public utilities in the existing footpath reserve between the kerb line and the property boundary to be relocated to the proposed footpath reserve. On the eastern side of Pennant Hills Road, this was effectively only SCC underground cables and overhead poles. All other utilities are situated on the western side of the road, or under the middle of the road in the case of the water main. These utilities would be relocated to the proposed footpath reserve.

The western option eliminates the need to relocate SCC assets on the eastern side of Pennant Hills Road. However, as part of the general upgrading of services, the SCC intends to lay underground cables and replace their telegraph poles with overhead light masts to match the proposed service on the other sections of the roadway.

On the western side of Pennant Hills Road the utilities would be relocated as required to the new footpath reserve. The extra expense would be minimal since the utilities were to be relocated anyway. Hence, there is no real advantage to be obtained with regard to cost in adopting one option over the other for the public utilities to be relocated.

With respect to the case of construction, widening on one side only is preferable.

Impact on Trees

Table 2.3 below summarises the effect of the road widening options on existing trees.

TABLE 2.3 : IMPACT ON EXISTING TREES

Option	Trees Lost
Widening both sides	121 (east side) 44 (west side) 165 Total
Widening on west side only	55 Total

From the above table it is evident that widening on the western side only would save about 120 trees from the Golf Course whilst removing only an additional 11 trees from the west side. The net saving is therefore about 110 trees.

2.4 Conclusions

The alternative to widen on the western side of the road compares favourably with the existing concept to widen on both sides. About six more houses would have to be demolished, however, all but one house has been acquired by the RTA. This alternative would cost about $0.34 million more. This cost could be reduced if the land is rezoned to medium density residential and thus, return a higher value on the residue land. The alternative also saves about 120 large trees along the Golf Course, whilst only taking an addition 10 trees from the western side. The net saving in trees is about 110.

3.0 COPELAND ROAD TO ORATAVA AVENUE

3.1 Present Land Use Status

The present land use along both sides of this section of Pennant Hills Road is entirely residential.

3.2 Options for Widening

Gazetted Road Reserve

The gazetted road reserve allows for widening on both sides of the road with a variable strip of up to 4 metres taken from existing residential properties frontages. This option was subject to the Review of Environmental Factors (REF) which was publicly exhibited in June 1990.

Alternative

The alternative is for road widening on the western side only of Pennant Hills Road. This would significantly reduce the impact on residents and to trees on the eastern side. Widening on the eastern side was not considered as it would affect more properties.

3.3 Assessment of Options

Impact on Properties

The impact of the options on properties are presented in Table 3.1 below.

TABLE 3.1 : IMPACT ON PROPERTIES

Impact	Existing Reservation	Alternative
Demolitions	3 (0)	4 (0)
Strip Acquisitions	26 (11)	-
Extra Strip Acquisition/ Whole Purchase		14 (4)
Total Properties Affected	29 (11)	18 (4)

Note: ( ) Figures in brackets represent properties already acquired by the RTA.

Table 3.1 indicates that under the option to widen on both sides, (as per the REF) three houses would require demolition, none of which are owned by the RTA. A further 15 strip acquisitions would also require negotiation.

Under the alternative, four houses would require demolition. About 12 less properties would be affected, however the RTA needs to negotiate with 10 property owners for further strip acquisitions or possibly whole property purchase.

In consideration of the number of properties affected, there is probably a marginal advantage in terms of property impact of widening on the western side only (i.e. the alternative).

Cost Comparison

To determine the relative cost of the alternative, a base cost of zero was adopted for the existing road reserve. Table 3.2 summarises the cost comparison. Construction advantages of widening on one side only as discussed in Section 2.3 are also applicable along this section.

TABLE 3.2 : COST OF ALTERNATIVE RELATIVE TO ORIGINAL CONCEPT

Item	Cost ($'000)
Additional Acquisitions	+ 376
Property Adjustments	− 165
Existing Acquisitions	+ 1
Utilities	− 50
Construction	− 60
Total Cost	+ 102

Table 3.2 above indicates that the alternative would represent a slightly higher cost than the concept originally proposed.

Impact on Trees

Table 3.3 below summarises the effect of the road widening options on existing trees.

TABLE 3.3 : IMPACT ON EXISTING TREES

Option	Trees Lost
Widening both sides	39 (east side) 31 (west side) 70 Total
Widening on west side	51 Total

Table 3.3 indicates that widening on the west side only would produce a net saving of about 20 trees. About 30 trees would be saved on the east side, whilst only a further 10 trees would have to be taken for the west side.

3.4 Conclusions

The alternative would provide a marginal saving on tree loss, would significantly reduce impacts on residential properties and would incur a slightly higher cost.

4.0 ORATAVA AVENUE TO THOMPSONS CORNER

This section of Pennant Hills Road has not been subject to the same assessment procedure as undertaken for the rest of the road. No suitable alternatives were found worthy of consideration for this section largely because of design and location of the tunnel beneath Thompsons Corner. Modifications to the tunnel have not been considered as suitable as it has already been designed based on optimal vertical and horizontal geometry, as well as consideration of existing property boundaries, proximity to Thompsons Corner Shopping Centre and construction management staging. Variations to the design and location of the tunnel required by alternative road widening (such as on the western side only), would therefore impose a prohibitively high cost penalty.

5.0 THOMPSONS CORNER TO CARDINAL AVENUE

5.1 Present Land Use Status

The existing land use differs significantly on either side of Pennant Hills Road. The eastern side is entirely residential, whilst the western side comprises of a commercial/business area and a section of West Pennant Hills Public School.

5.2 Options for Widening

Gazetted Road Reserve

The gazetted road reserve permits widening on both side of Pennant Hills Road. This would involve a variable width of strip acquisition of up to 4 metres on either side of the road. The widening would have only a minor direct affect with narrow strip purchases affecting property frontages of the Esso and BP Service Stations, and a car parking area.

Alternative

The alternative is to widen Pennant Hills Road wholly on the eastern side. The western side was not considered as it would have significant impacts on about 60% of the businesses at Thompsons Corner.

5.3 Assessment of Options

Impact on Properties

The impact of the option on properties are summarised in Table 5.1 below.

TABLE 5.1 : IMPACT ON PROPERTIES

Impact	Existing Reservation	Alternative
Demolitions	1 (1)	7 (3)
Strip Acquisitions	27 (12)	-
Extra Strip Acquisitions/ Whole Purchase		13 (5)
Total Properties Affected	28 (13)	20 (8)

Note: ( ) Figures in brackets represent properties already acquired by the RTA.

Table 5.1 indicates that the option to widen on both sides would require demolition of one house, which has already been acquired by the RTA. Strip acquisitions are required from a further 15 properties.

Under the alternative, seven houses would have to be demolished of which three are owned by the RTA. Extra strip acquisitions or whole purchases would also affect a further eight properties.

On balance it is considered that the option to widen on both sides (original concept) would have less impact on existing properties.

Cost Comparison

A cost comparison of the options in terms of property acquisitions is shown in Table 5.2 below.

TABLE 5.2 : COST OF ALTERNATIVE RELATIVE TO ORIGINAL CONCEPT

Item	Cost ($'000)
Additional Acquisitions	+ 1,014
Property Adjustments	- 210
Existing Acquisitions	0
Utilities	- 200
Construction	- 50
Total Cost	+ 554

Table 5.2 above indicates that the alternative would increase the cost of the project by about $0.6 million, largely due to the whole purchases required as opposed to much smaller strip acquisitions needed for the option for widening on both sides.

Impact on Trees

Table 5.3 below summarises the effect on existing trees by the various road widening options.

TABLE 5.3 : IMPACT ON EXISTING TREES

Option	Trees Lost
Widening both sides	31 (east side) 2 (west side) 33 Total
Widening on west side only	34 Total

Table 5.3 indicates that widening on the east side only would affect the same number of trees as the option to widen equally on both sides. In this regard, the alternative offers no particular advantage in terms of reduced impact on trees.

5.4 Conclusions

The alternative offers no advantages over the option to widen on both sides of Pennant Hills Road. The existing concept requires six less house demolitions, involves much narrower strip acquisitions (3-4 metres) to only an additional eight properties, has the same impact on tree loss, and is significantly cheaper ($0.55 million).

6.0 CARDINAL AVENUE TO HULL ROAD

6.1 Present Land Use Status

The existing land use along this section of Pennant Hills Road is completely residential with the exception of a small park just north of Lancaster Avenue. The treescape was noted in the REF as being of particular significance along the section, creating a full enclosure effect along Pennant Hills Road.

6.2 Options for Widening

Gazetted Road Reserve

The gazetted road reserve would allow road widening on either side of Pennant Hills Road, with a variable strip of up to 4 metres taken off the house frontages. This option was subject to the REF.

Alternative

The alternative is to widen Pennant Hill Road on the western side only. This side was chosen because it affected less properties than on the eastern side.

6.3 Assessment of Options

Impact on Properties

The impact of the option on properties is summarised in Table 6.1 below.

TABLE 6.1 : IMPACT ON PROPERTIES

Impact	Existing Reservation	Alternative
Demolitions	0 (0)	7 (3)
Strip Acquisitions	50 (16)	–
Extra Strip Acquisitions/ Whole Purchase		20 (8)
Total Properties Affected	50 (16)	27 (11)

Note: ( ) Figures in brackets represent properties already acquired by the RTA.

Table 6.1 indicates that the alternative would require seven house demolitions, whilst the original concept did not require any.

A further 34 strip acquisitions need to be negotiated under the original concept, however, these are all within the existing road reserve and would generally not affect the viability of the property. Under the alternative a further 12 properties would need to be negotiated, most of which would be whole purchases due to the problems of maintaining access following road widening.

The partial affect to 50 properties (contained within the existing road reserve) has to be compared with the demolition of between 7 and 15 houses (depending on access), and major strip acquisitions to a further 12 properties. On balance it is considered that the alternative does not offer significant advantages over the original concept.

Cost Comparison

A comparison of cost between the existing road reservation and the alternative is shown in Table 6.2 below.

TABLE 6.2 : COST OF ALTERNATIVE RELATIVE TO ORIGINAL CONCEPT

Item	Cost ($'000)
Additional Acquisitions	+ 1,560
Property Adjustments	- 450
Existing Acquisitions	+ 300
Utilities	- 200
Construction	- 150
Total Cost	+ 1,060

Table 6.2 above indicates that the alternative would cost over $1.0 million more than the original concept. This is largely because of the additional house demolitions and major strip acquisitions.

Impact on Trees

Table 6.3 below summarises the effect on existing trees by the various road widening options.

TABLE 6.3 : IMPACT ON EXISTING TREES

Option	Trees Lost
Widening both sides	48 (east side) 46 (west side) 94 Total
Widening on east side only	81 Total
Widening on west side only	78 Total

The table indicates that the option to widen on both sides would save at best 16 trees (i.e. 94–78). Widening on both sides would still preserve at least 30 large trees on the west side and 35 large trees on the east side.

6.4 Conclusions

The alternative does not offer any advantages over the original concept as it provides only a small reduction in trees loss, requires a significant number of additional house demolitions, wider strip acquisitions, and is over $1.0 million more expensive.

7.0 HULL ROAD TO BOUNDARY ROAD

7.1 Existing Land Use Status

The land use along this section of Pennant Hills Road varies markedly on either side. The west side is predominately residential with the exception of the Water Board Reservoir tower located just south of Loftus Street. Adjacent to that there is a small nursing home (Fairholme). On the eastern side is Observatory Park, Ludovic Blackwood Memorial Sanctuary, Mount St Benedict High School and the Sisters of the Good Samaritan Convent.

7.2 Options for Widening

It is noted that this assessment assumes that six lanes would be constructed between Beecroft Road and Cardinal Avenue. The REF indicated the possibility of only four lanes due to the reduced traffic flow along this section. This alternative remains feasible only if a decision is taken to adopt the F2 (Stage 1).

Gazetted Road Reserve

The existing road reserve would permit widening only on the eastern side of Pennant Hills Road. Additional strip acquisition beyond the reservation however, would be required for the proposed indented bus bays north of Cardinal Avenue, south of Hull Road and south of Beecroft Road (south arm).

The strip acquisitions are substantial through this section with up to 10-14 metres being taken along some sections through the School and Convent grounds.

There is no road reserve over the frontage of Observatory Park.

Alternative

The alternative is for widening on the west side only. This is proposed to reduce the potential impacts on trees in Observatory Park and Ludovic Blackwood Memorial Sanctuary, and to limit the disruption to activities in Mount St Benedict High School and the Sisters of the Good Samaritan Convent.

7.3 Assessment of Options

Impacts on Properties

The impact of the options on properties is summarised in Table 7.1 below.

TABLE 7.1 : IMPACT ON PROPERTIES

Impact	Existing Reservation	Alternative
Demolitions	0 (0)	6 (0)
Strip Acquisitions	3 (0)	-
Extra Strip Acquisitions/ Whole Purchases	1 (0)	23 (0)
Total Properties Affected	4 (0)	29 (0)

Note: ( ) Figures in brackets represent properties already acquired by the RTA.

Table 7.1 indicates that under the existing road reservation, major strip acquisitions are required through three properties including the School and the Convent. None of these properties have as yet, been acquired. In addition, a major strip acquisition from Observatory Park would be necessary.

The alternative would require the demolition of at least six properties and perhaps as many as 13, depending upon access arrangements following widening. In total, negotiations with 29 property owners would be required, none of which are presently affected by the existing road reservation.

In consideration of the high number of house demolitions, the alternative produces significant disadvantages in terms of property impacts.

Cost Comparison

A cost comparison of the alternatives are summarised in Table 7.2 below.

TABLE 7.2 : COST OF ALTERNATIVE RELATIVE TO ORIGINAL CONCEPT

Item	Cost ($'000)
Additional Acquisitions	+ 1,995
Property Adjustments	+ 160
Existing Acquisitions	0
Utilities	0
Construction	0
Total Cost	+ 2,155

Table 7.2 above indicates that the alternative is over $2.2 million more expensive than the option to widen on the western side only. This is largely because of the high number of whole purchases and house demolitions required.

Impact on Trees

Table 7.3 below summarises the effect on existing trees by the various road widening options.

TABLE 7.3 : IMPACT ON EXISTING TREES

Option	Trees Lost
Widening on east side only	115
Widening on west side only	165

The 122 trees lost by widening on the eastern side comprise 40 from Observatory Park, seven from Ludovic Blackwood Memorial Sanctuary, 30 from Mount St Benedict High School and 38 from the Sisters of the Good Samaritan Convent.

All the trees from Observatory Park and the Sanctuary and six trees from the School are large mature species, remnants of the unique ridge top Cumberland Forest community. The Parks & Garden Section of Hornsby Shire Council surveyed the condition of the trees affected through Observatory Park and found that eight (19%) were in excellent condition, 22 (55%) in good to fair condition, 9 (23%) in poor condition and one was dead. This indicates that the mature trees in the area are in a generally fair to good in their urban, road side location.

With respect to public use of Observartory Park, it is not generally well utilised as a recreation space. The proximity of busy roads on all sides, its relatively small size and the difficulty of access and parking, does not create a particularly suitable environment to enjoy the normal advantages of a quieter urban parkland setting. Widening through this Park whilst removing about 10% of the park area, is therefore not likely to significantly affect its usage.

The balance of trees (62) on the eastern side comprise of 38 camphor laurels and 24 cyprusses. These are exotic trees, however, have local importance in terms of providing a visual road side screen for the School and Convent.

Widening on the western side would impact on a total of 165 trees. These trees have generally all been planted, however comprise some natives including blue gums, blackbutts and red gums and a larger proportion of exotics, including; camphor laurels, jacarandas, cyprus, oaks and pines. Whilst perhaps not as significant in terms of local ecological importance, these

trees still represent a major visual element along the road side and in this regard, their loss would be as noticeable, if not more, than if trees were removed from the eastern side only.

7.4 Conclusions

The alternative of widening Pennant Hills Road on the western side would require at least 6 house demolitions (possibly 13) and a further 23 strip acquisitions. This compares to strip acquisitions through Observatory Park, the School and the Convent. Widening on the western side would also require the removal of 165 large trees compared to 122 on the eastern side.

While the trees on the western side are of less ecological significance, they represent an equally important landscape/visual element along the road side. Removal of trees through Observatory Park would not affect the existing visual environment along this section of Pennant Hills Road to the same degree, nor significantly affect the public amenity and recreactional use of the Park.

8.0 CASTLE HILL ROAD – PENNANT HILLS ROAD TO NEW LINE ROAD

No alternative was considered for this section of the project as the design was based on optional geometry for the tunnel, as well as consideration of existing property boundaries and proximity to Thompsons Corner Shopping Centre.

It is noted however, that widening wholly on the northern side would affect at least seven shops, and require strip acquisitions from about 10 properties. Widening wholly on the southern side would have a significant affect to Mt Wilberforce Lookout Park, and would have significantly greater impacts on Bethlehem Uniting Church, probably making its operation unviable.

In this regard, no alternatives are considered to provide any substantial benefits to that proposal.

9.0 SUMMARY ASSESSMENT

A summary assessment of widening options along Pennant Hills Road is presented in Table 9.1.

TABLE 9.1 : SUMMARY OF WIDENING ALTERNATIVES

Section	Cost of Alt Relative to REF ($Mill)	Demolition		Property Adjustments		Tree Loss	
		REF	Alt	REF	Alt	REF	Alt
A	+ 0.335	5 (5)	11 (10)	22 (15)	16 (10)	165	55
B	+ 0.102	3 (0)	4 (0)	26 (11)	14 (4)	70	51
C	N/A	1 (1)	N/A	14 (4)	N/A	31	N/A
D	+ 0.554	1 (1)	7 (3)	27 (12)	13 (5)	33	34
E	+ 1.060	0 (0)	7 (3)	50 (16)	20 (8)	94	78
F	+ 2.155	0 (0)	6 (0)	4 (0)	23 (0)	115	165

A = Mahers Road to Copeland Road
B = Copeland Road to Oratava Avenue
C = Oratava Avenue to Thompsons Corner
D = Thompsons Corner to Cardinal Avenue
E = Cardinal Avenue to Hull Road
F = Hull Road to Boundary Road

( ) = Properties already acquired by the RTA.
N/A = No alternative considered (see Section 4.0).