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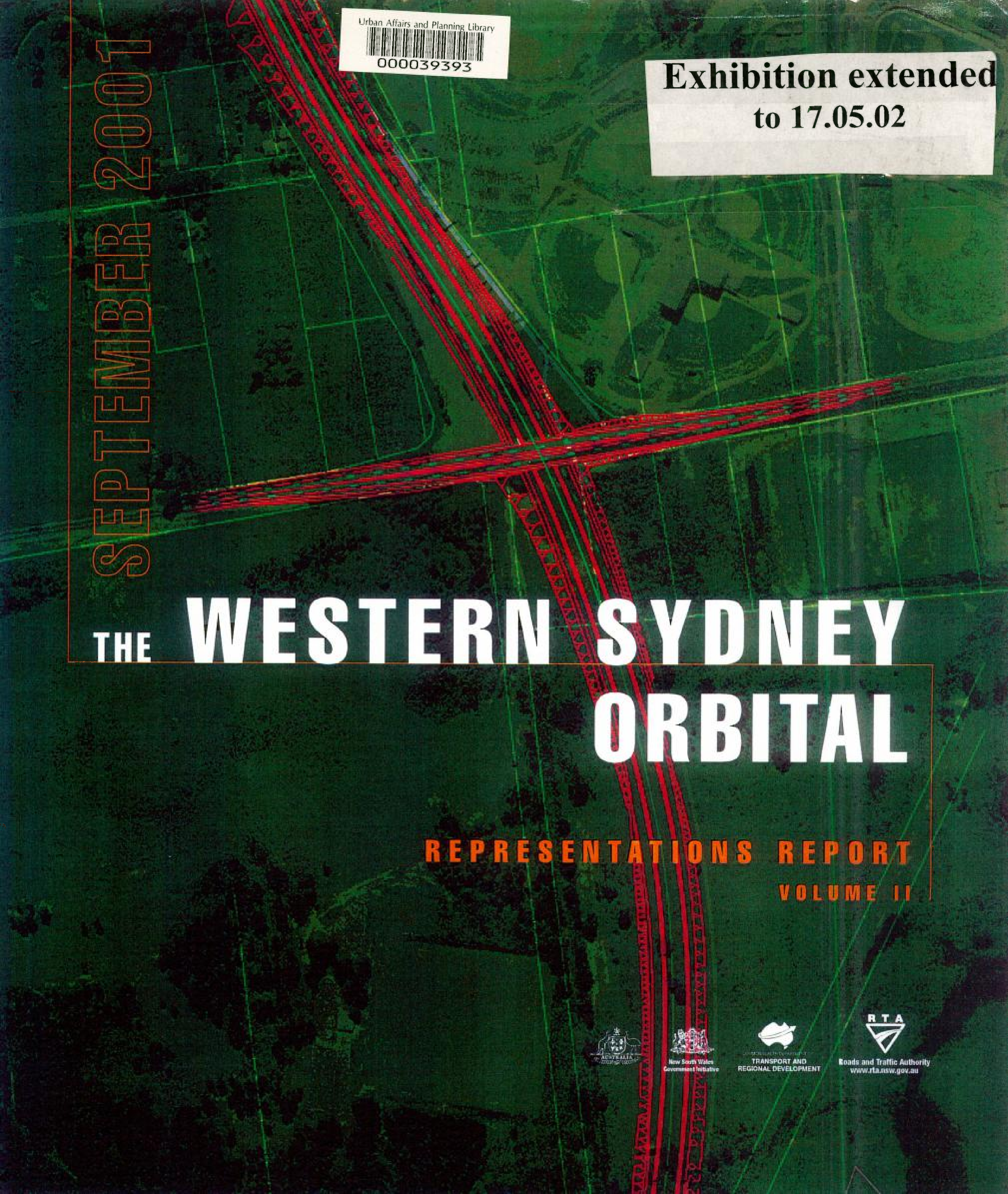
SEPTEMBER 2001

THE WESTERN SYDNEY ORBITAL

REPRESENTATIONS REPORT

VOLUME II



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APPENDIX EIGHT

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Indigenous Heritage Assessment for the Western Sydney Orbital Representations Report.

Addendum to the Western Sydney Orbital EIS and Working Paper 7

Commissioned by Sinclair Knight Merz on behalf of the RTA
May, 2001.

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Executive summary.

Following the release of the EIS document for the Western Sydney Orbital (WSO), Robynne Mills was commissioned by the RTA to respond to indigenous heritage issues raised in submissions.

Public authority and community submissions on indigenous heritage issues were received from:

- National Parks and Wildlife Service
- Environment Australia
- Department of Land and Water Conservation
- Blacktown and District Environmental Group
- Department of Urban Affairs and Planning.

Issues raised by the NPWS and the methodology used by the consultant to address NPWS requirements include:

- Ongoing consultation with NPWS representatives
- Broad based Aboriginal community consultation
- The review and upgrade of the EIS Heritage working Papers into one cohesive heritage document
- Updated details of sites identified in the EIS studies so that current details of site location, extent, condition etc can be considered in the assessment of site significance and statements of impact.
- A contextual framework for all statements of scientific significance
- Issues associated with Plumpton Ridge which have been assessed as having high/rare archaeological and cultural significance.

This report sets out details of all WSO heritage works completed and currently in progress and presents management recommendations for all sites identified within the impact area of the WSO. The report also details all tasks to be completed post Representations Report.

1. Introduction and Background

The heritage assessment for the proposed WSO alignment was conducted in 1995/6. The route was assessed in two sections.

The southern section of the proposed alignment from Prestons to Elizabeth Drive, Cecil Hills which is within the Gandangara LALC area, was assessed for the EIS by Helen Brayshaw of Brayshaw, Heritage Consultants and Jamie Thomas, Barry Gunther and John Griffiths of the Gandangara Local Aboriginal Land Council (LALC).

The northern section from Elizabeth Drive to Old Windsor Road, which is in the Deerubbin LALC area, was surveyed for the EIS by Robynne Mills and Jim Kelton, Archaeological and Heritage Services. The Darug (now Deerubbin) LALC was represented in the field by Tony Condak and Luke Hickey. Consultation was also undertaken with the Darug Link (now the Darug Tribal Aboriginal Corporation) and a field inspection was undertaken with Mr Colin Gale. The Darug Custodial Aboriginal Corporation were not invited to participate in the survey, but were provided with details of the survey results.

Neville Baker, Australian Museum Business Services (AMBS) undertook preliminary testing at Plumpton Ridge for Mills and Kelton, Archaeological and Heritage Services for the purpose of the EIS. The results of this testing program were presented in EIS Working Paper 7

The working papers for the northern and southern sections of the alignment were presented to NPWS on behalf of the RTA by SKM (northern sector) and PPK (southern sector). The National Parks and Wildlife Service (NPWS) Sydney Zone archaeologist, Phil Hunt reviewed the working papers and provided comments to the consultant and the RTA. Responses to these comments were prepared by Mills and Brayshaw and incorporated into the final Working Paper 7 as presented in the EIS.

When funds were made available for the commencement of the WSO Project, the EIS containing the two separate heritage Working Papers was placed on public exhibition. This occurred from January 2001. During this exhibition period, the Heritage Working Papers as presented in the EIS document were reviewed by the NPWS, other statutory bodies and the public.

At the close of the public viewing period, community and public authority responses to the EIS Indigenous Heritage Working Papers had been received from:

- National Parks and Wildlife Service
- Environment Australia
- Department of Land and Water Conservation
- Blacktown and District Environmental Group
- Department of Urban Affairs and Planning)

The RTA commissioned Robynne Mills to prepare responses to all indigenous heritage representations received. The responses to all groups are addressed in the body of the Representations Report in Chapter 3. Responses to issues of concern raised by NPWS are expanded upon in Sections 3 and 4 of this report.

2. Structure of the Heritage Assessment for the WSO Project.

Some WSO heritage assessment tasks identified in this report have been completed, some are currently in progress and others including finalisation of Aboriginal Community statements, sub-surface testing programs and geological investigations at Plumpton Ridge are yet to be undertaken. All tasks identified in this report will be completed prior to the submission of any Consent to Destroy Permit Applications.

2.1 Works completed for the Representations Report

Works completed during the preparation of the Representations Report period include:

- Amalgamation of the results of the two 1995 heritage reports into one cohesive report
- Field reassessment of sites identified in 1995 surveys to identify any changes to the assessments (eg damage, failure to relocate items etc)
- Preparation of accurately surveyed maps presenting the location of all sites relative to the WSO alignment.
- Identification of the degree of potential impact to sites and PADs from the proposed WSO.
- Further consultation has been undertaken with all Aboriginal Groups identified by NPWS including Deerubbin LALC, Darug Tribal Aboriginal Corporation, Darug Custodian Aboriginal Corporation, Gandangara LALC and Tribal Elders. This consultation included a briefing session at the RTA Offices in Blacktown chaired by Suzanne Malligan, RTA Aboriginal Liaison Officer. At this briefing all groups were provided with maps of the sites and WSO alignment for presentation to groups.
- Representatives of all Aboriginal groups were taken on an inspection of all recorded sites and PADs along the WSO corridor and asked to comment on management options for all sites and PAD areas within the impact area of the WSO.
- Review of statements of scientific significance and management options prepared in the EIS.
- Clarification of the high scientific and cultural significance status assigned to Plumpton Ridge in the preliminary sub-surface testing program conducted for the EIS. Additionally, it has been identified that further investigations are required at Plumpton Ridge to determine the locations and extent of intact silcrete deposits within the ridgeline and to ensure thata representative sample of intact silcrete is retained outside the WSO impact area for future scientific investigation and cultural requirements. Dr Peter Mitchell has been engaged to conduct the geological assessment of silcrete deposits at Plumpton Ridge.

2.2 Works to be completed Post Representations Report

WSO heritage issues and tasks which have been identified in this report and are currently in progress or remain to be completed are summarized below and fully documented in Sections 7 and 8 of this report.

- Sub-surface testing of all PAD areas to determine whether or not they contain cultural heritage material and if so, identification of appropriate management options for these sites. This testing program will be carried out by the archaeologist and representatives of the Aboriginal Community.
- Further review of scientific and cultural/social statements of significance for all sites presented in the EIS to include a contextual overview in those statements once sub-surface testing is completed.

- Review of management options for all sites as presented in the EIS document, in light of sub-surface testing results and provision of Aboriginal Community consensus on management options (where possible). These options may include recommendation for avoidance by bridging sites, realignment of structures, monitoring, offset areas and/or applications for Consent to Destroy Permits with salvage if appropriate.
- Further research at Plumpton Ridge has been identified as necessary as the silcrete deposits have been identified as having high scientific and cultural significance (see section 5.5 of this report). These investigations will be designed to ensure that retention of a representative sample of the ridge is retained as a management option for future scientific/cultural investigations.

3. Issues raised by the NPWS in response to Heritage Working Paper 7

The NPWS response to the assessment of Aboriginal heritage is summarized below.
The NPWS considers that the Aboriginal heritage assessment component of the EIS was not sufficient to adequately assess the impacts of the proposal. The NPWS stated in their submission.

The following information is essential to the NPWS processing any Section 90 Consents to Destroy Applications and undertaking its statutory role as joint determining authority for the EIS.

1. Overall assessment of the impact of the proposal on Aboriginal Heritage
The Aboriginal heritage impacts are currently assessed separately for the northern and southern portions of the proposal. The NPWS considers that such a disjointed assessment provides the public, the proponent and the determining or approval bodies with limited information on the total impacts of the proposal. It is advised that the RTA identify and consider the impact of the proposal in light of the following:

- *The number of sites to be impacted over the entire length of the proposal*
- *The proportion of sites in the region which will be impacted by the proposal and*
- *The significance of the sites remaining compared to the significance of the sites to be destroyed.*

2. A statement of significance must be supplied for each site that may be impacted by the proposal. The contents of these statements should be discussed with the NPWS.

3. A detailed account of the extent of the impact that the proposal is expected to have on each site

4. Consultation with all Aboriginal groups that currently have an interest in the area, including the Deerubbin LALC, Gandangara LALC, Darug Tribal Aboriginal Corporation and Darug Custodian Aboriginal Corporation.

5. The EIS should be able to demonstrate that the recommendations of all Aboriginal Groups have been considered and incorporated into the proposal.

NPWS suggest that the RTA and its consultants should urgently meet with the NPWS to discuss the Section 90 Consent to Destroy Application process and receive a more detailed overview of the further information that is required.

4. Actions taken to address NPWS Requirements

- Sinclair Knight Merz on behalf of the RTA has commissioned Robynne Mills, Archaeological and Heritage Services, to review and where necessary update the 1995 WSO Heritage Working Papers for the northern and southern sections of the WSO. The results and management recommendations from these two reports have been amalgamated into one coherent assessment (Table 3, Maps 1 to 9, Appendix 5).

- Since the 1995 heritage studies were conducted, the RTA has appointed an Aboriginal Liaison Officer, Ms Suzanne Malligan, to assist in the consultation process between the RTA, heritage consultants and Aboriginal Communities. Ms Malligan has played a key role in the consultation process and will continue to be involved in the ongoing Aboriginal community consultation process.

- The consultant met with the WSO team at the RTA Blacktown Office in May 2001. At this meeting comments received to the EIS Heritage Working Papers were given to the consultant for review and a strategy for dealing with these responses was discussed.

4.1 Meeting with NPWS

The consultant and Ms Lisa Brown, RTA Environmental Officer for the WSO Project met with NPWS Archaeologist, Kathryn Przywolnik and Teresa Gay, Manager, Central Aboriginal Heritage Unit, at the NPWS Office in Hurstville on 27th April, 2001. Details of this meeting are presented as Appendix 2 of this report. As a result of this meeting, the consultant and NPWS agreed that the Consent to Destroy process would best be achieved if a methodology was adopted which addressed six main objectives.

4.2 Identified Project Aims and Objectives.

1. Ongoing consultation with the NPWS Central Aboriginal Heritage Unit over the duration of the project.
2. Broad Aboriginal Community consultation to ensure that all interested Aboriginal community members have an opportunity to participate in discussions about the WSO alignment and identify all sites in the impact areas which are of cultural heritage significance to the community (NB not necessarily prehistoric sites but also sites of cultural/social significance).
3. The review of the two heritage working papers presented in the EIS and the presentation of one list of all heritage sites and PADs which will be impacted by the proposed WSO.
4. Details of all sites and PADs identified in the 1995 surveys to be updated so that current details of site location, extent, condition etc can be considered in the assessment of site significance and statements of impact.
5. Statements of contextual significance will be required to accompany all applications for Consent to Destroy Permits, in the format required by NPWS (ie a contextual framework which provides details of the proportion of sites in the region which will be impacted by the proposal and which identifies the significance of the sites remaining compared to the significance of the sites to be destroyed). NPWS would assist by providing database information and information on conservation areas.
6. Particular issues related to the scientific and social significance of Plumpton Ridge to be identified and management options pursued to ensure that a representative sample of Plumpton Ridge is retained for cultural land scientific protection. Resolution of acceptable arrangements may be essential to the consideration by NPWS of RTA Consent to Destroy Permit Applications.

5. Methodology to achieve the objectives of the Project

Set out below is a summary of aims and methods employed for the Reps Report to address the stated objectives of the project and recommendations for additional works required to be conducted in the next stage of the investigation to ensure that all stated objectives are met and all Permit Applications meet NPWS requirements.

5.1 Objective: Ongoing consultation with the NPWS

5.1.1 Methodology:

Meetings have been held with RTA's Aboriginal Liaison Officer, the consultant and/or the RTA WSO project team and NPWS to ensure that the methodology implemented by the consultant is in line with NPWS expectations. All Consent to Destroy Permit Applications presented to the Service by the RTA would conform to NPWS requirements and expecxtations.

5.2 Objective: Broad based Aboriginal Community consultation

5.2.1 Methodology

- All groups identified by the NPWS were contacted by phone, fax/letter and informed that funding for the WSO supplementary archaeological investigations had commenced and that preliminary studies would be undertaken prior to works commencing (see Appendix 3)
- All groups were invited to attend a meeting at the RTA Office in Blacktown at which details of the proposed investigations were outlined.
- Groups notified were: Deerubbin LALC, Darug Tribal Aboriginal Corporation, Darug Custodian Aboriginal Corporation, Gandangara LALC and Tribal Elders
- A meeting with Aboriginal community groups was held on Monday 2nd July, 2001
- Those who attended the meeting were:

  Steve Randall, Deerubbin LALC
  Colin Gale, Darug Tribal Aboriginal Corporation
  Edna Watson and John Gallard, Darug Custodian Aboriginal Corporation
  Gabrielle Fletcher, Gandangara LALC
  Kathryn Przywolnik, NPWS Central Aboriginal Heritage Unit
  Elise Stocker, NPWS Conservation and Planning Unit
  Lisa Brown, RTA Environmental Officer for the WSP Peoject
  Suzanne Malligan, RTA Aboriginal Liaison Officer
  Robynne Mills, Heritage Consultant.

At that meeting all participants were supplied with the following information (see Appendix 4)

- Written details of the history of the project, details of the original survey and the names of community representatives who had participated in the survey
- A work plan for the next stage of the investigations.
- A map of the locations of the sites identified in the previous survey and the names assigned to each site and PAD
- A UBD map of the alignment along with a request was also provided to each group and a request made for the representatives to seek comments from their community members about any areas along the route, which may be important to the local community. It was stressed that these areas need not be physical remains but could include dreaming sites, spiritual sites, walking tracks and sites of more recent cultural/social importance (such as

the Native Institute, houses of important community members or where important events had taken place, early leases, burials, missions). The purpose of providing this information was to ensure that places of importance to the local community are identified, protected and considered in the management recommendations for the WSO project.

A site visit to the WSO alignment was arranged for community representatives, the RTA Aboriginal Liaison Officer and the Consultant.
Site visits were conducted

- Wednesday 18th July with the Darug Tribal Aboriginal Corporation and the Darug Custodian Aboriginal Corporation
- Thursday 19th July with the Gandangara LALC,
- Friday 20th July with the Deerubbin LALC.

There has been on-going discussions with the community groups to obtain correspondence relating to the impact of the WSO proposal on cultural heritage sites. A detailed response has been received from the Darug Tribal Aboriginal Corporation and responses from other Aboriginal community groups are being sought. These responses will be considered in the preparation of preliminary research permits for sub-surface testing and Consent to Destroy Permit Applications.

5.3 Objective: Review of the two Heritage Working Papers and amalgamation of site and PAD details to a sequential list. Update of site and PAD details (Map 1, Table 1).

5.3.1 Methodology

- The RTA has prepared aerial photographs on which the latest WSO alignment has been plotted.
- Consultants (Brayshaw and Mills) were engaged to accompany an RTA surveyor into the field to identify the exact locations and extent of sites and PADs which were identified in the 1995 assessments. The dimensions of all sites and PADs were plotted on the aerial photographs.
- The RTA commissioned Robynne Mills to update the heritage information for the WSO Project. As part of this update, the consultant visited all sites and PADs along the full extent of the alignment and updated the information about these sites, including current condition, impacts since 1995 identification, extent of PADs and management recommendations. The updated information is contained in Table 3, Maps 1 to 9 and Appendix 5.
- Mills produced a sequential list of sites and PADs for the whole WSO alignment. All site and PAD names now have a common prefix of WSO.

It is now possible to identify the exact location and extent of all sites and PADs along the full length of the WSO and relate the sites and PADs to an annotated list of sites which provides summary details of previous names of sites in Working Paper 7, LALC area, contents, description, degree of impact, assessed scientific significance, management recommendations and permit requirements. This information is contained in Table 3.

5.4 Objective: Preparation of statements of significance for all impacted sites in the format required by NPWS (ie a contextual framework).

5.4.1 Methodology

Sites for which the RTA will need to prepare applications for Consent to Destroy Permits are identified on the aerial photographs and in Table 2 Appendix 5. The limited easement width in the northern section of alignment and the fact that houses have been built to the easement boundary means that there is little room for movement to avoid sites and therefore avoidance of all sites is not an available option in the north. In the southern section, there was a little more room available for site avoidance to be considered as an option.

Statements of scientific significance have been prepared for all sites listed in the Heritage Working Papers presented in the EIS Document, however these significance statements are not currently presented in a contextual framework as requested by NPWS and can only be updated once the sub-surface testing is undertaken for the next stage of the investigations. The preparation of this contextual framework is yet to be undertaken but will be submitted to NPWS for any applications for Consent to Destroy.

5.5 Objective: The high scientific and cultural significance of Plumpton Ridge has been identified by the consultant and representatives of the Aboriginal Community. NPWS has stated that mitigation and management options should be presented for Plumpton Ridge and that options may include conservation areas.

5.5.1 Methodology

To date there has been no statement of cultural/social significance prepared by the Aboriginal community for Plumpton Ridge and its surrounding area. However, community representatives have indicated verbally that they have concerns about the overall impacts on the Ridge. Cultural assessments are being sought from the community and will be presented as part of the Plumpton Ridge assessment. Correspondence has been received from the Darug Tribal Aboriginal Corporation for this report and responses from the other community groups will be pursued for consideration in future statements about cultural heritage aspects of Plumpton Ridge.

Evidence of quarrying of silcrete cobbles contained in the Plumpton Ridge gravels, and reduction sequences for its distribution across the Cumberland Plain are topics of scientific research and debate. For some members of the scientific community including Dallas & Witter (1983), Hiscock and Mitchell (1993) and McDonald (1984) the whole ridge has been identified as a quarry source from which much of the high quality silcrete found in sites across the Cumberland Plain has originated. For others, including Baker (1996), the claim that the entire Ridge is a site is not justified and it is only within the red ridge gravels which occur in isolated areas of the ridge that there is potential for archaeological evidence to occur. The availability and maintenance of research data from the Ridge is essential to this academic debate and is important for current and future scientific research. The research potential of the remaining intact section of the ridge line is further increased by the fact that the section of the Ridge to the north of the WSO easement, identified by NPWS as a heritage site with restricted landuse constraints, has been heavily compromised by a breach of the National Parks and Wildlife Act for which the land owner was convicted of impact to a known relic.

The limited research which was undertaken as part of the 1995 heritage investigations is reported in full in the EIS document and is summarised below.

- Dr Peter Mitchell, a geomorphologist, visited Plumpton Ridge with the Consultant and Deerubbin LALC representatives and identified areas of the Ridge where silcrete cobbles were present within the ridge gravels. Mitchell explained that the silcrete cobbles are present on the Ridge and low spur crest as "lenses" rather than a "discrete layer".

- Neville Baker (AMBS) undertook limited sub-surface testing of two areas within the impact area of the WSO. One site (WSO-OS-19 formerly PT1) was located to the east of Pace Farm, off the heavily impacted ridge crest and the second WSO-OS-13 (PT 2) to the west of Symonds Road at the base of the ridge. Baker concluded that Transect WSO-OS-13 "had no research potential as artefacts were extremely sparse, the ridge gravel layer thin and inconsistent and the areas apparently subject to greater recent disturbance closer to the road."(Baker 1996 p27).

  Baker makes the following comments on the excavation of WSO-OS-19 (Transect PT1). "This transect crosses both shale soils and ridge gravel soils. Artefacts were found to occur only in association with the ridge gravels. No evidence is expected away from these silcrete lenses, although fragments of silcrete gravel may occur on the shale based soils due to colluvial movement. Baker extrapolates that evidence from PT1 confirms a likely localised archaeological site size of 60m x 60m. Baker concludes that present evidence of reduction at Plumpton Ridge does not support large scale or systematic exploitation of the Ridge silcrete. More extensive flaking debris would be expected, including abundant rejected cobbles with flaking scars. This point requires testing through further excavation at WSO-OS-19.

  Baker further concluded that the investigations suggest that reduction sites occur at various locations in association with Plumpton Ridge and that these sites should be separately identified and managed. Baker recommended that conservation of this highly significant site (WSO-OS-19) was not a viable option due to continued disturbance. He concluded that a comprehensive salvage/excavation program should be undertaken to mitigate the loss of this evidence.

5.5.2 Need for additional Investigations at Plumpton Ridge

Further research at Plumpton Ridge has been identified as necessary as the silcrete deposits have been identified as having high scientific and cultural significance. These investigations would be undertaken on properties where access is available for research and would be designed to ensure that a representative sample of the ridge is retained for future scientific investigation. In order to ensure that a representative sample is retained, the following investigations will be conducted.

- An assessment of the location of all silcrete outcrops in the broader Plumpton Ridge area by geomorphologist, Dr Peter Mitchell
- Identification of all areas where intact silcrete deposits remain
- Identification by RTA surveyors of those areas which will be impacted by the WSO
- Identification of areas of intact silcrete deposit within the broader Plumpton Ridge area, which could be retained and protected for future scientific and cultural research.
- Review of potential conservation areas by representatives of the archaeological and Aboriginal communities to determine if the identified area will meet research and community needs.

- Archaeologically sensitive sections of the Ridge which are to be impacted by WSO construction, would be fully assessed by a sub-surface testing and salvage program approved by the NPWS. The information on the Ridge would be presented to NPWS as part of the contextual significance information for a Consent to Destroy Application once sub-surface testing is complete.

It should be pointed out that the sample tested by Baker during the EIS investigations was extremely small and possibly unrepresentative of the total Ridge area. The consultant recommends that a more extensive testing program be conducted across the whole WSO impact area at Plumpton Ridge prior to any lodgement of a Consent to Destroy Application.

6. Post Representations Report Investigations.

It is advised that the following outstanding investigations, to fulfill the NPWS objectives, will be undertaken after the Representations Report is submitted to DUAP for determination. The RTA's aim is to complete the following tasks prior to the determination of the Minister for Urban Affairs and Planning. .

6.1 Consultation

Ongoing consultation will be conducted with:

- the NPWS and
- Aboriginal groups and LALCs as identified in section 4.2.1 of this report, for the purpose of the Preliminary Research Permits and Consent to Destroy Applications..

6.2 Upgrading of the contextual component of the Scientific Statements of Significance for all sites and obtaining cultural/social statements for sites from Aboriginal Community groups and LALCs.

In order to prepare the contextual component of scientific statements of significance an assessment of the proportion of sites in the region that will be impacted by the WSO proposal will be identified from:

- a search of the NPWS database for the Cumberland Plain Region.
- the mapping of relevant site locations to determine site distribution
- identification of the proportion of known sites in the region which will be impacted by the proposal.
- obtaining site details including size, artefact assemblage, landform unit, context, integrity, identified research potential, significance assessment.
- size, contents, assessed significance
- determining where possible the degree of security these "other"sites have from future development (ie a location of a conservation or protected area, and any other mitigation options). The NPWS would assist in the provision of that information. The above information would be used to obtain contextual information on sites to be impacted by the WSO.

Once the Aboriginal community groups and LALCs have had an opportunity to assess the sites and PAD areas affected by the WSO and discuss the cultural/social significance of those sites, the participating groups will be asked to provide the RTA with comments on social/cultural significance and management recommendations for these sites. The fulfilment of this objective will be dependent on the ongoing consultation with all members of the various Aboriginal Groups through the RTA's Aboriginal Liaison Officer and the consultant.

6.3 Preparation of Preliminary Research Permit Applications by the consultant for all PAD testing programs.

The RTA will commission a sub-surface testing program at each PAD site to determine if cultural heritage material is present. If cultural heritage material is present in any PADs, a full assessment of the scientific and cultural significance of these sites would be prepared and mitigation and management options presented for these sites (see Table 2, Appendix 5). Application for sub-surface testing of all PADs will require:

- Application to NPWS for a Preliminary Research Permit (PRP) which sets out the methodology for the sub-surface testing program
- Consultation with the LALCs and identified groups
- Issue of a Permit by NPWS

Discussions have been held by the consultant with NPWS Archaeologist, Kathryn Przywolnik to determine the format in which applications for Preliminary Research Permits will be structured. The following details will be provided by the consultant to NPWS for each PAD area: landform unit, presence or absence of associated artefacts, potential extent of PAD, potential sensitivity of the PAD based on the site prediction model and sampling strategy for sub-surface testing program. Sketches for all PADs indicating the exact location of the PAD and the area over which testing will be conducted will provided. The subsurface testing program will include auger sampling with the option for expanding the test area by hand excavation if cultural material is identified. NPWS have alerted the consultant to the need to ensure that there is no impact to threatened species from the sub-surface testing program. Research Permit applications will be submitted for all PADs by the end of August, 2001. NPWS advise that the issue of preliminary research permits may take a minimum of 8 weeks.

6.4 Preparation of Consent to Destroy Permit Applications for the RTA.

Should all other options for mitigation and management options for sites be exhausted, the RTA is required to make application to the NPWS for a Consent to Destroy Permit for each site which will be impacted by the proposed WSO road construction works. Sites for which such applications are proposed are set out in Section 7 of this report.

Should the RTA apply for a Consent to Destroy Permit for Plumpton Ridge (including sites WSO-OS-13 (PT2), WSO-OS-19 (PT1), all mitigation and management recommendations set out in Section 5.5 of this report should have been completed and the results presented with the Permit Application.

In order for these Permit applications to be considered by the NPWS, the following documentation would be provided to NPWS

- A statement of scientific significance in the format required by the Service (ie a contextual framework) will be prepared for each Consent tot Destroy Application.
- A statement of cultural/social significance from the Aboriginal Community
- Completion and lodgment of the Consent to Destroy Application form.

7. Recommendations.

Recommendations for individual sites are set out below.

Abbreviations used in site notation:

WSO: Western Sydney Orbital
OS: Open stone camp site with stone artefacts present
ST: Scarred tree
IF: Isolated artefact
PAD: Area of Potential Archaeological Deposit.
R: Cecil Hills Realignment Route

Table 3: Management Recommendations

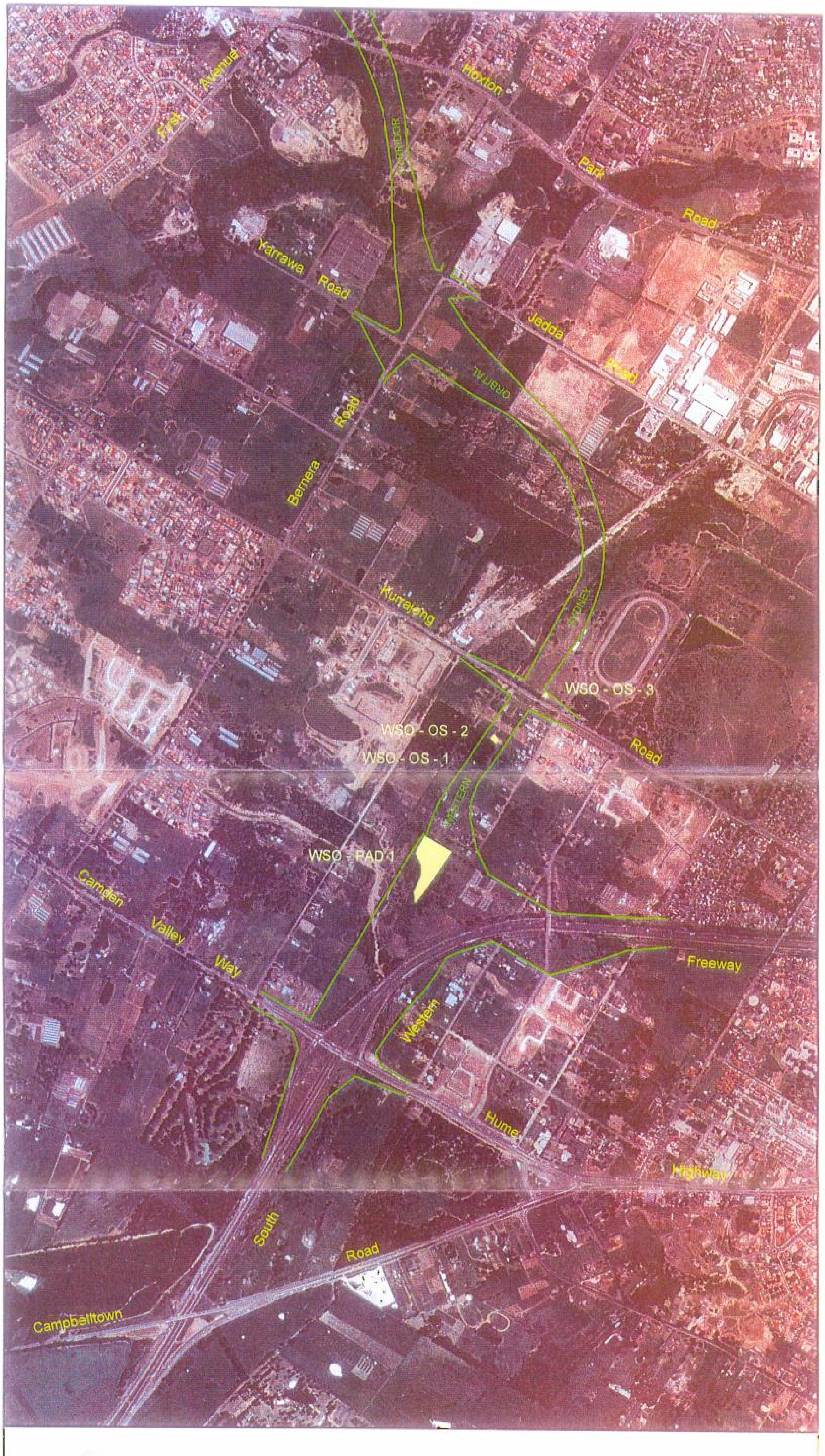
The significance statements used in this table are based on those developed for the EIS. A full statement of significance will be prepared for each site and presented in the format required by NPWS as discussed in Section 5.4 of this report.

Item Number (Previous site name)	Previous Site Name	Level of Significance	Extent of Impact	Recommendation for action	Permits
WSO-PAD 1	P-PAD 1	To be determined	Direct	Community Consultation Sub-surface testing	NPWS Research Permit
WSO-OS-1	MC-11	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Consent to Destroy Application
WSO-OS-2	P-CP-15	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Consent to Destroy Application
WSO-OS-3	P-CP-16	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Consent to Destroy Application
WSO-PAD 2	P-PAD 2	To be determined	Direct	Community Consultation Sub-surface testing	NPWS Preliminary Research Permit
WSO-OS-4	P-CP-5	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Research Permit
WSO-OS-5	P-CP-6	Low	Possible indirect	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Consent to Destroy Application
WSO-PAD 3	R: PAD 1	To be determined	Direct	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Consent to Destroy Application
WSO-PAD 4	R: PAD 2	To be determined	Direct	Community Consultation Sub-surface testing	NPWS Research Permit
WSO-PAD 5	Brayshaw PAD 3	To be determined	Direct	Nil	NPWS Research Permit
WSO-OS-6	P-CP-14	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Consent to Destroy Application
WSO-OS-7	SO-OS-1	To be determined	Direct	Community Consultation Sub-surface testing and salvage	Avoidance by Bridging. NPWS Research Permit
WSO-PAD 7	SO-PAD 1	To be determined	Direct	Community Consultation Subsurface testing	NPWS Research Permit

WSO-ST-1	SO-ST-1		Direct	Additional investigation by tree surgeon to determine the nature of the scar	To be determined
WSO-OS-8	SO-OS-2	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Research Permit
WSO-OS-9	SO-OS-3	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement. Collection of artefacts	NPWS Consent to Destroy Application
WSO-PAD 8	PAD ass. with OS-3	To be determined	Direct	Community Consultation Subsurface testing	NPWS Research Permit
WSO-ST-2	SO-ST-2		Direct	Additional investigation by tree surgeon to determine the nature of the scar	To be determined
WSO-OS-10	SO-OS-4	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Consent to Destroy Application
WSO-OS-11	SO-OS-5		Direct	Community Consultation. Preparation of contextual framework for Significance Statement. Collection of artefacts	NPWS Consent to Destroy Application
WSO-PAD 9	OS-PAD 4 Associated with OS-5	To be determined	Direct	Community Consultation Subsurface testing	NPWS Research Permit
WSO-ST-3	SO-ST-3		Direct	Additional investigation by tree surgeon to determine the nature of the scar	To be determined
WSO-PAD 10	OS-PAD 3	Potentially high	Direct	Community Consultation Subsurface testing	NPWS Research Permit
WSO-OS-12	SO-OS-7	Low	Direct	Community Consultation No further work	NPWS Consent to Destroy Application
WSO-ST-4	SO-ST-4		Direct	Additional investigation by tree surgeon to determine the nature of the scar	To be determined
WSO-PAD 11	Plumpton Ridge	Extremely high	Direct	Community Consultation for impact area. Formulation of mitigation/management strategies For Baker Site PT1	NPWS Research Permit NPWS Consent to Destroy Application
WSO-OS-13	PT 2 Symonds Road	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Consent to Destroy Application
WSO-PAD 12		Potentially high	Direct	Community Consultation, Subsurface testing	NPWS Research Permit
WSO-PAD 13		Potentially high	Direct	Community Consultation, Subsurface testing	NPWS Research Permit
WSO-PAD 14		Potentially high	Direct	Community Consultation, Subsurface testing	NPWS Research Permit
WSO-PAD 15		Potentially high	Direct	Community Consultation, Subsurface testing	NPWS Research Permit
WSO-OS-14	SO-OS-9	Low	Direct	Community Consultation. Preparation of contextual framework	NPWS Consent to Destroy Application

WSO-OS-15	SO-OS-10	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement	NPWS Consent to Destroy Application
WSO-OS-16	SO-OS-11	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement Salvage	NPWS Consent to Destroy Application
WSO-PAD 16	SO-OS-11	Potentially High	Direct	Community Consultation, Sub-surface testing	NPWS Research Permit
WSO-OS-17	SO-OS-12	Low	Direct	Community Consultation. Preparation of contextual framework for Significance Statement Salvage	NPWS Consent to Destroy Application
WSO-ST-5	SO-ST-5		Direct	Additional investigation by tree surgeon to determine the nature of the scar	To be determined
WSO-OS-18	SO-OS-13	Moderate/ High	Direct	Community Consultation. Preparation of contextual framework for Significance Statement Salvage Artefact collection	NPWS Consent to Destroy Application
WSO-PAD 17	SO-OS-13	To be determined	Direct	Community Consultation, Sub-surface testing	NPWS Research Permit
WSO-ST-6	SO-ST-6	Low	Direct	Additional investigation by tree surgeon to determine the nature of the scar	To be determined
WSO-PAD 18		To be determined	Direct	Community Consultation, Further assessment	NPWS Research Permit
WSO-OSW-19	PT 1 Plumpton Ridge	High	Direct	Community Consultation, Further assessment	Research Program to be formulated including a geological and heritage assessment
WSO-IF-1	P-IF-3	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-2	P-IF-4	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-3	P-IF-5	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-4	P-IF-6	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-5	P-IF-9	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-6	P-IF-10	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-7	P-IF-11	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-8	SO-IF-1	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-9	SO-IF-2	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-10	SO-IF-3	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-11	SO-IF-4	Low	Direct	No further work	NPWS Consent to Destroy Application
WSO-IF-12	SO-IF-5	Low	Direct	No further work	NPWS Consent to Destroy Application

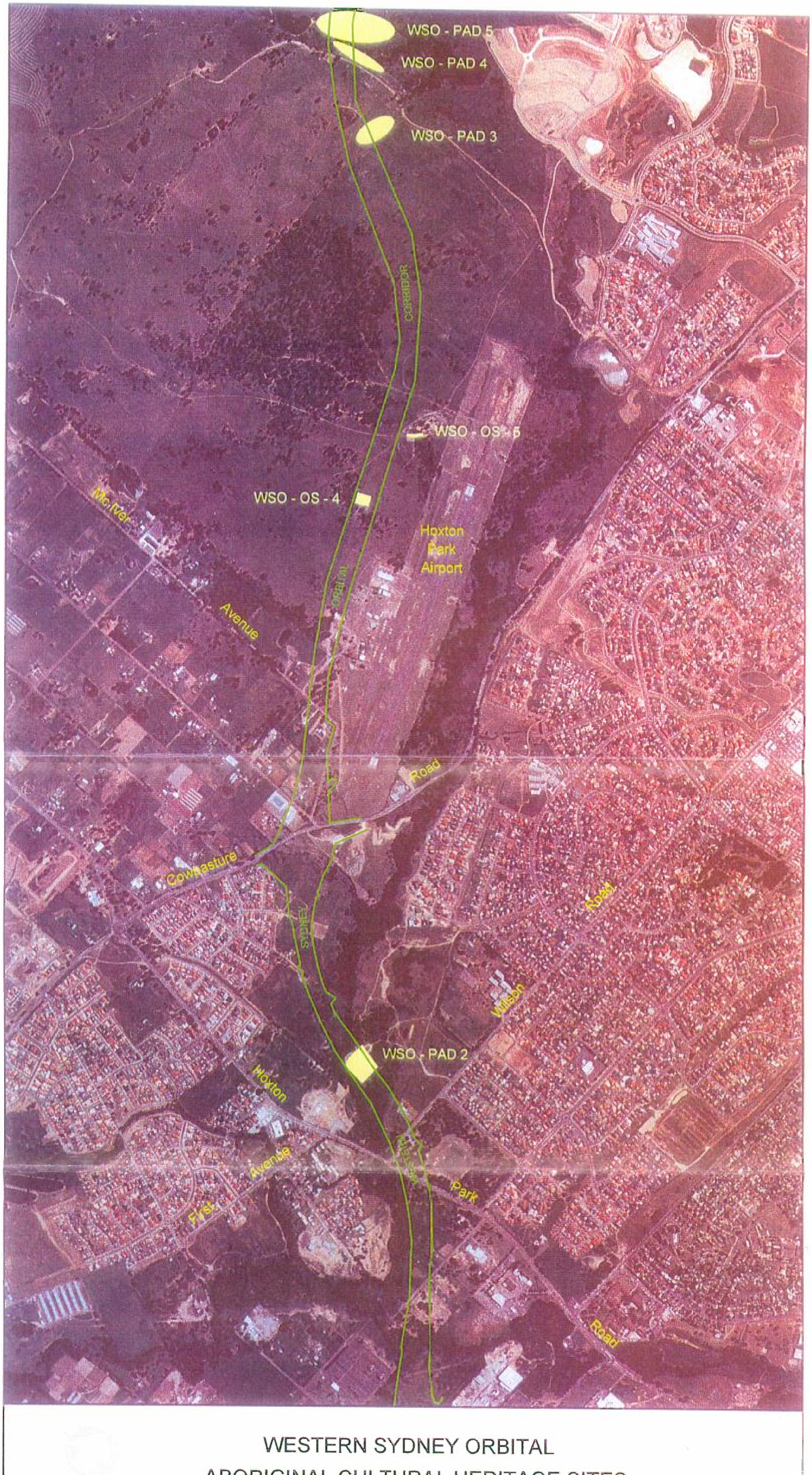
Appendix 1: Maps



WESTERN SYDNEY ORBITAL

ABORIGINAL CULTURAL HERITAGE SITES

Figure 1



WESTERN SYDNEY ORBITAL

ABORIGINAL CULTURAL HERITAGE SITES

Figure 2

WESTERN SYDNEY ORBITAL

ABORIGINAL CULTURAL HERITAGE SITES

Figure 3

WESTERN SYDNEY ORBITAL

ABORIGINAL CULTURAL HERITAGE SITES

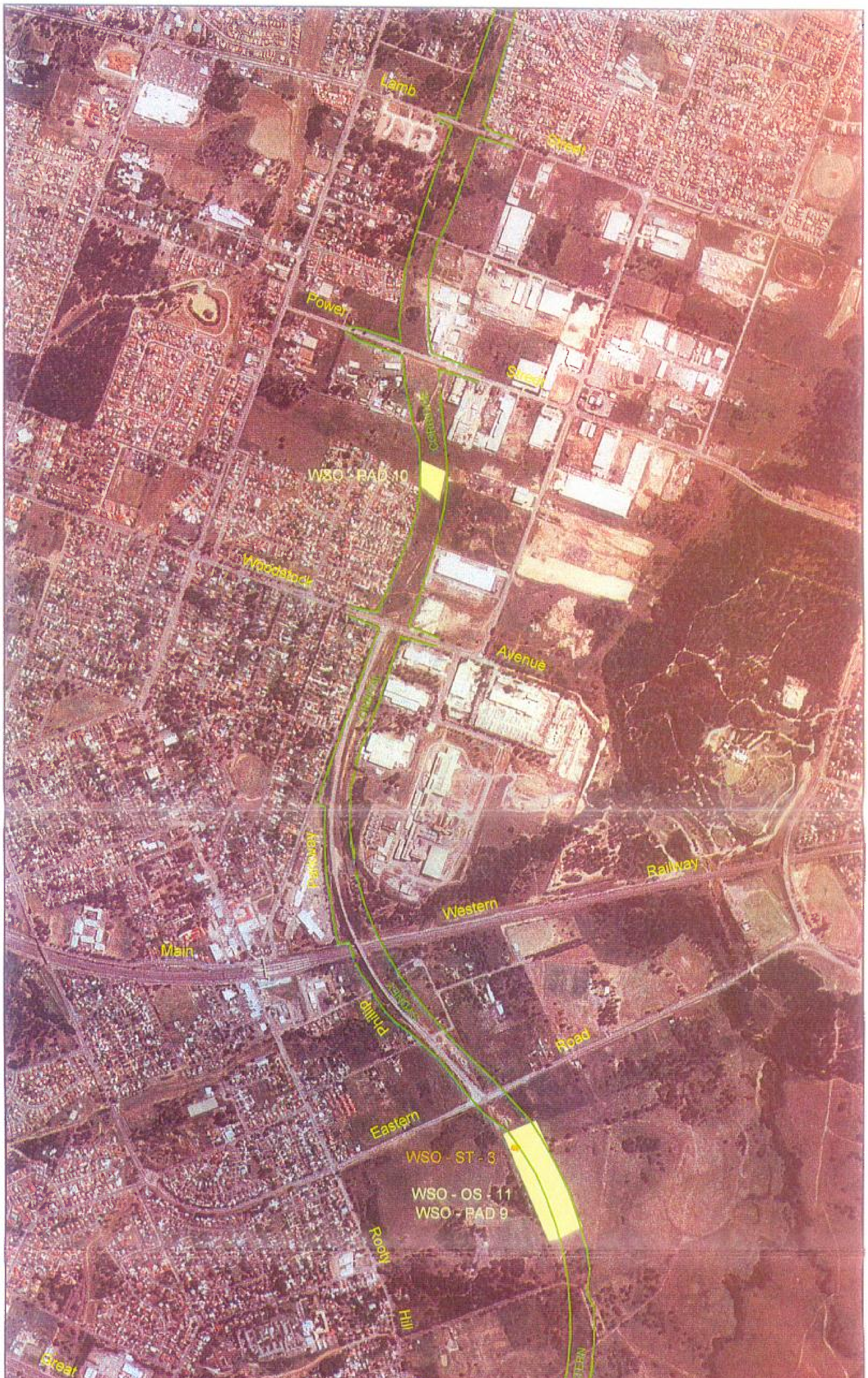
0 250 500

Figure 4

WESTERN SYDNEY ORBITAL

ABORIGINAL CULTURAL HERITAGE SITES

Figure 5

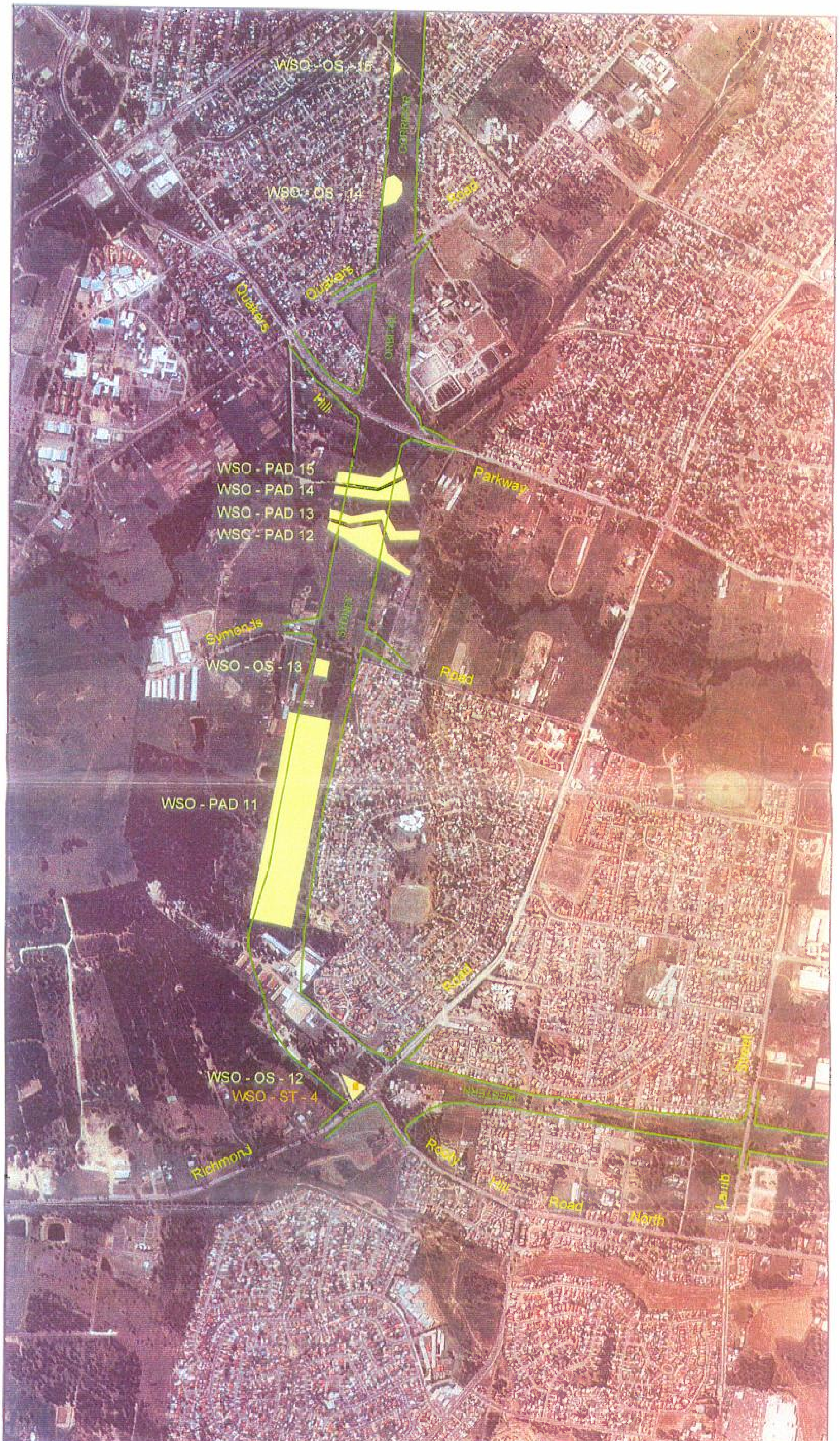


WESTERN SYDNEY ORBITAL

ABORIGINAL CULTURAL HERITAGE SITES

0 250 500m

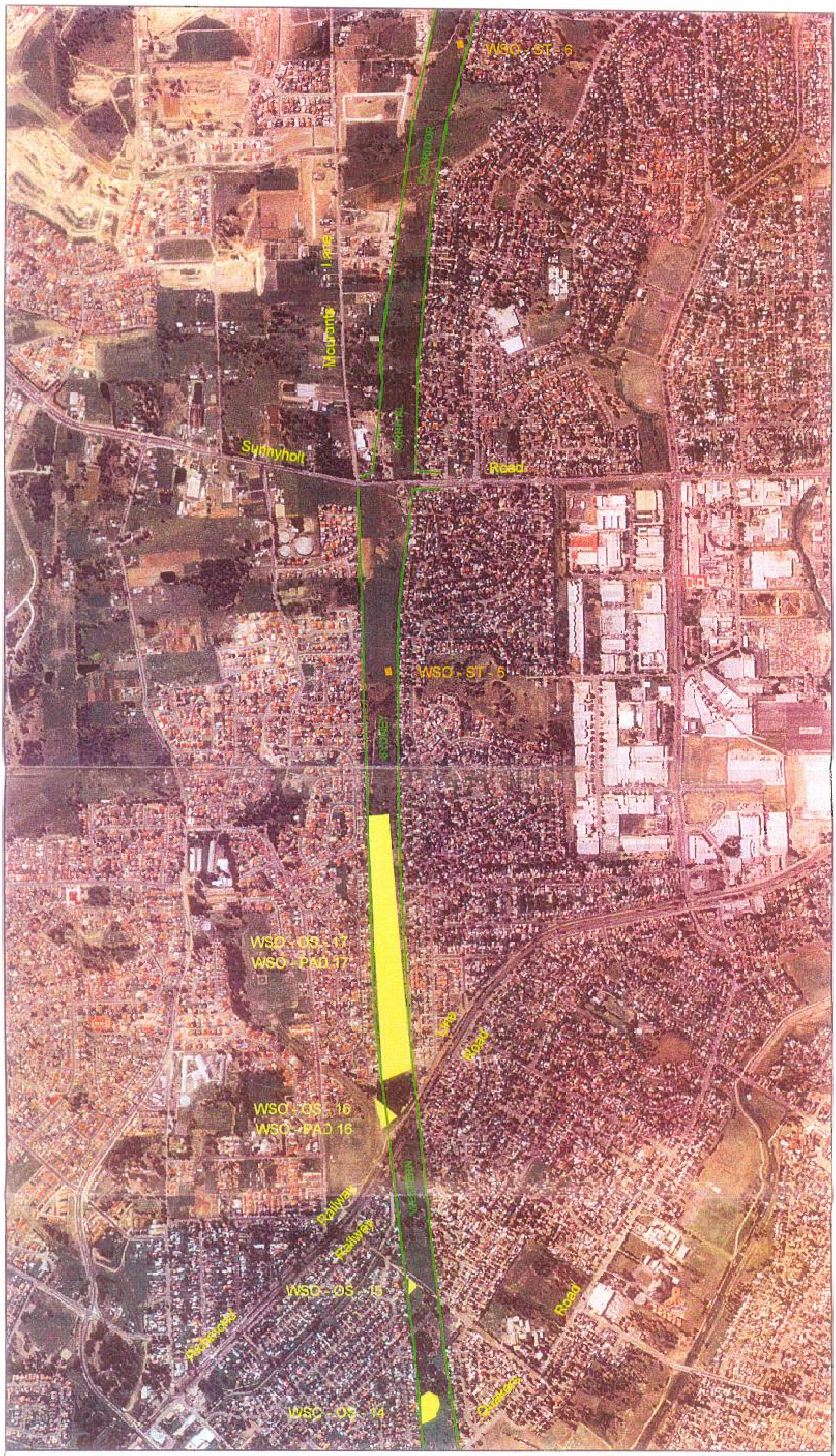
Figure 6



WESTERN SYDNEY ORBITAL
ABORIGINAL CULTURAL HERITAGE SITES

0 250 500m

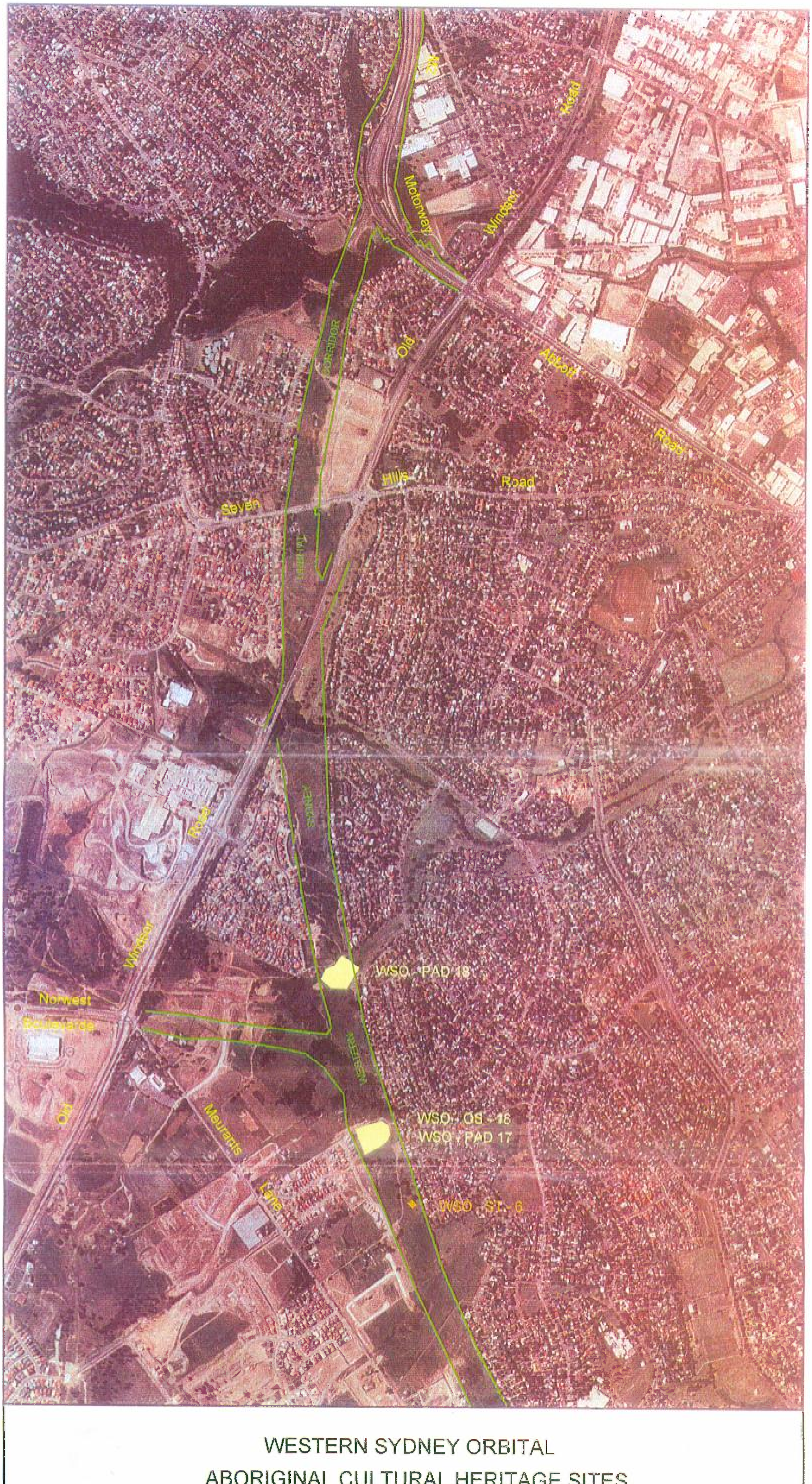
Figure 7



WESTERN SYDNEY ORBITAL

ABORIGINAL CULTURAL HERITAGE SITES

Figure 8



WESTERN SYDNEY ORBITAL

ABORIGINAL CULTURAL HERITAGE SITES

Figure 9

Appendix 2:

Details of Meeting with NPWS 27th April, 2001

Robynne Mills Archaeological and Heritage Services
60 Watkin Street
Newtown 2042
Ph: (02) 95171413
Fax: (02) 95179860
Email: robynnemills@ozemail.com.au

Summary of Discussion at meeting with NPWS Re Western Sydney Orbital

Date: 27th April, 2001

Present: Kathryn Przywoln, NPWS Sydney Zone Archaeologist
Teresa Gay, NPWS Manager Central Aboriginal Heritage Unit
Lisa Brown, RTA Project Coordinator for the Western Sydney Orbital Project
Robynne Mills, Archaeological Consultant

Aim of the meeting:

Meeting and introduction of personnel from NPWS, RTA and the Heritage Consultant involved in the indigenous heritage assessment of the Western Sydney Orbital project.

General discussion of the project to date and a brief summation of heritage work conducted for the EIS and responses from NPWS archaeologist to those reports prior to the EIS. (NB NPWS archaeologist who dealt with the heritage works prior to EIS has now left the Service)

Discussion of NPWS response to the EIS heritage documents and the implications of those comments for the implementation of the EIS heritage management recommendations.

Discussion focused on:

- Comments prepared by former NPWS archaeologist, Phil Hunt and presented to the RTA (March 2001 Appendix 1)
- Current NPWS Requirements for the implementation of heritage management/mitigation measures presented at the meeting by current Kathryn Przywoln are summarised in the table below.

Issues identified by NPWS

No	Issue	Tasks	Result	Time Frame
1	Need for continuous consultation between the consultant and NPWS to ensure that all NPWS requirements are adequately met at each stage of the heritage assessment	A monthly meeting at NPWS Hurstville Office and on site if required of the NPWS Archaeologist, NPWS Aboriginal Heritage Manager, RTA Aboriginal Liaison Officer and other RTA personnel as required. The consultant will report the minutes of these meeting to the RTA Project Manager, Lisa Brown.	• Continuous assessment of the project by NPWS • Report of progress of the heritage assessment • Setting of goals for each stage of the works program • Immediate identification of any heritage issues	From 27th April on a monthly basis or more frequently if required.
2	NPWS require a complete, sequential list of sites and PADs within the Western Sydney Orbital route alignment and a map showing their exact locations.	RTA should instruct surveyors to identify and plot sites and PADs assisted by archaeologists who identified the sites during EIS investigations (Mills and Brayshaw).	Map of route alignment with the locations of all sites and PADs identified	28-4-01 in progress
3	Need to assess the cultural heritage significance of the sites within and adjacent to the Western Sydney Orbital alignment and identify Aboriginal community views on management of their cultural heritage.	Contact with identified Aboriginal Groups will be initiated through RTA Liaison officer and NPWS Aboriginal Sites Officer. Groups identified include: Deerubbin LALC Darug Tribal Aboriginal Corporation Darug Custodian Aboriginal Corporation Gandangarra LALC and Tribal Elders. This should not be regarded as an exclusive list. Consultation may identify other groups and individuals who have an interest in the issues (eg identified elders, State LALC, AIATSIC etc).	• Production of statement of Cultural Heritage significance for the sites within Western Sydney • Identification of sites and areas of high cultural significance to the Aboriginal community. Assessment of community views on management and interpretation of their cultural heritage. • Colin Gale informed the consultant that the Darug Tribal Corporation had commissioned work on the recent history of the Darug Clan.	To commence ASAP To be co-ordinated by Suzanne Malligan Meeting at NPWS to determine procedures for consultation and recording of information.

3 (cont)	NPWS have requested that maps of the area be produced for Aboriginal Community groups and individuals to identify areas of cultural significance for them	RTA to provide maps of area through Suzanne Malligan		
4	Need for an update of information about sites and PADs identified in EIS assessments	Consultant to prepare the following information for all sites: • Location of site in relation to impact • Degree of impact • Reassessment of current site condition	Detailed up to date information regarding the sites and PADs within the impact area and the degree of impact to these sites from the proposed development.	To commence week commencing 15[th] May
5	Need to establishment the status of all PAD areas identified within the impact area of the development. If subsurface testing identifies these PADs as sites, then significance statements for these sites will need to be prepared.	RTA will be required to conduct a sub-surface testing program at each PAD site to determine if cultural heritage material is present. This will require; • Application to NPWS for a Preliminary Research Permit (PRP) which sets out the methodology for the sub-surface testing program • Consultation with the Deerubbin LALC • Issue of a Permit by NPWS NB Issue of such permits can take up to 6 weeks.	All PADs will be identified either as sites or removed from the list of sensitive archaeological areas.	To commence as soon as the mapping of sites and PADs is completed.

6	Expansion of Statements of significance for all sites to include a contextual framework which will indicate the location and distribution of similar sites in the area and identify those sites and site complexes which are within recognised conservation areas. Where it is established that there are rare sites of high archaeological/cultural heritage (eg Plumpton ridge) which have no representative examples in adequately controlled conservation areas, then the establishment of such a conservation area may be essential to the consideration by NPWS of RTA Consent to Destroy Permits for such sites.	The Consultant will: • Provide RTA with AMG co-ordinates for all sites in the vicinity of the Orbital from NPWS Data base • Current conservation areas will be identified with assistance of NPWS and mapped. It is assumed that these areas will contain sites of high archaeological /cultural significance. • Comparative data for identified sites will be retrieved from NPWS Reports where possible.	Provide NPWS with a visual, contextual database which identifies the archaeological/ cultural significance of sites within the alignment. Mapping will also identify sites of high scientific/cultural significance in the vicinity of the alignment where sites could be conserved or have already been conserved (eg Western Sydney Park, Olympic Equestrian Centre, ADI site, Native Institute, Nurragingy Reserve) **This information will assist NPWS in their assessment of Consent to Destroy Applications.**	To commence as soon as the mapping of sites and PADs is completed
7	Application by RTA for Consent to Destroy Permits for sites which will be directly impacted by the proposed road alignment	• Preparation of the Consent to Destroy Applications by the consultant • Statement from LALC and other identified Aboriginal Groups • Presentation of necessary support documentation to a NPWS including a report and research design	Consideration of Consent to Destroy Applications by NPWS	Permit Applications can be lodged only after all NPWS requirements as set out above have been completed and presented to NPWS in a documented report.

Appendix 3:

Correspondence with Aboriginal LALCs and community groups

FAX

Robynne Mills Archaeological and Heritage Services
60 Watkin Street
Newtown 2042
Ph: (02) 95171413
Fax: (02) 95179860
Email: robynnemills@ozemail.com.au
****

To: Darug Custodian Aboriginal Corporation
Attention: Mrs Edna Watson
Date: 11th June, 2001
Fax No:
Number of Pages:
****

Dear Mrs Watson,

As you will be aware from the News, the RTA have been funded to undertake the construction of the Western Sydney Orbital. Road. It is over two years since the original investigations were conducted for this project.

Suzanne Malligan, RTA Aboriginal Liaison Officer has arranged a meeting to outline the Western Sydney Orbital project to date and discuss the next stage of the heritage assessment.

Meeting Details
Date: 2nd July, 2001
Location: Level 3, Flushcombe Road, Blacktown
Time: 10AM.

If you have any questions about the meeting Suzanne can be contacted on her mobile: 0413368261 or you can ring me on 95171413. Hope to see you on the 2nd July.

Regards,

Robynne Mills.

FAX

Robynne Mills Archaeological and Heritage Services
60 Watkin Street
Newtown 2042
Ph: (02) 95171413
Fax: (02) 95179860
Email: robynnemills@ozemail.com.au
****

To: Darug Tribal Aboriginal Corporation
Attention: Mr Colin Gale
Date: 11th June, 2001
Fax No:
Number of Pages:
****

Dear Mr Gale,

As you will be aware from the News, the RTA have been funded to undertake the construction of the Western Sydney Orbital. It is over two years since you and I undertook an examination of the proposed alignment. Suzanne Malligan from the RTA is to involved in this project and will be contacting you behalf of the RTA.

I would very much like to arrange a meeting with you to discuss the project and determine the issues of concern to your organisation so that these issues can be integrated in the development of a management plan for the project. I think a good start to the project would be a reassessment of the alignment from Elizabeth Drive north to Richmond Road and east to Old Windsor Road. On that walk through we can identify the sites and PAD areas which were identified in the original survey, determine the condition of the sites and PADs and develop a strategy for the additional assessment works required to assess both the scientific and cultural significance of the sites. I know that one of your major concerns were the development of a history of the Darug People and issues associated with Plumpton Ridge.

It is also understood that a large area of Plumpton ridge outside the impact of the proposed roadway is available for Conservation. Maps etc of this area will be available for our consideration. A review of this area can also be undertaken as part of the survey.

Suzanne Malligan, RTA Aboriginal Liaison Officer has arranged a meeting to outline the Western Sydney Orbital project to date and discuss the next stage of the heritage assessment.
Meeting Details
Date: 2nd July, 2001
Location: Level 3, Flushcombe Road, Blacktown
Time: 10AM.
If you have any questions about the meeting Suzanne can be contacted on her mobile: 0413368261 or you can ring me on 95171413. Hope to see you on the 2nd July.

Regards,

FAX

Robynne Mills Archaeological and Heritage Services
60 Watkin Street
Newtown 2042
Ph: (02) 95171413
Fax: (02) 95179860
Email: robynnemills@ozemail.com.au
****

To: Deerubbin LALC
Attention: Kevin and Steve
Date: 11th June, 2001
Fax No: 98322496
Number of Pages:
****

Kevin and Steve,

As you will be aware from the News, the RTA have been funded to undertake the construction of the Western Sydney Orbital. It is over two years since Kevin Kondak, Luke Hickey, Jim Kelton and myself undertook the survey of the alignment. There are many issues to be discussed prior to the next stage of the heritage assessment.

Suzanne Malligan, RTA Aboriginal Liaison Officer has arranged a meeting to outline the Western Sydney Orbital project to date and discuss the next stage of the heritage assessment.

Meeting Details
Date: 2nd July, 2001
Location: Level 3, Flushcombe Road, Blacktown
Time: 10AM.

If you have any questions about the meeting Suzanne can be contacted on her mobile: 0413368261 or you can ring me on 95171413. Hope to see you on the 2nd July.

Regards,

Robynne Mills.

FAX

Robynne Mills Archaeological and Heritage Services
60 Watkin Street
Newtown 2042
Ph: (02) 95171413
Fax: (02) 95179860
Email: robynnemills@ozemail.com.au
****

To: Gandangarra LALC
Attention: Gabrielle Fletcher
Date: 11th June, 2001
Fax No: 96022741
Number of Pages:
****

Gabrielle,

As you aware from our survey of the realignment of the Western Orbital Alignment (WSO) at Cecil Hills, the News, the RTA have been funded to undertake the construction of the Western Sydney Orbital. It is over two years since your organisation conducted a survey of the alignment from Prestons to Cecil Hills with archaeologist, Helen Brayshaw.

This note is to inform the LALC that myself and Jim Kelton have been commissioned by the RTA to conduct the archaeological assessment of the whole WSO alignment. Suzanne Malligan the Aboriginal Liaison Officer appointed to the project. Unfortunately she has relocated to Nowra but will still be involved in the project.

Suzanne Malligan, RTA Aboriginal Liaison Officer has arranged a meeting to outline the Western Sydney Orbital project to date and discuss the next stage of the heritage assessment.

Meeting Details
Date: 2nd July, 2001
Location: Level 3, Flushcombe Road, Blacktown
Time: 10AM.

If you have any questions about the meeting Suzanne can be contacted on her mobile: 0413368261 or you can ring me on 95171413. Hope to see you on the 2nd July.

Regards,

Robynne Mills.

Appendix 4:

Details of meeting with Aboriginal LALCs and Community Representatives

Meeting of RTA Project Team, National Parks and Wildlife Service (NPWS) Aboriginal Heritage Officers, Local Aboriginal Land Council (LALC) and Aboriginal Community Representatives to discuss the Western Sydney Orbital Project (WSO).

1. Aim of this meeting

This meeting has been called by the RTA Aboriginal Liaison Officer, Ms Suzanne Malligan. The aim of this meeting is to:

- bring together and introduce representatives of the RTA, NPWS, Aboriginal LALCs, Community Representatives and the archaeological consultants
- summarize details of Aboriginal heritage surveys previously undertaken for the Project
- review the heritage issues identified in the previous surveys and management recommendations proposed
- identify tasks which will be required to be undertaken in the next stage of the heritage assessment for the proposed WSO to meet the requirements of the National Parks and Wildlife Act.

2. Outline of the Project to Date

- In 1995/6 archaeological surveys of the proposed WSO alignment were conducted. The southern section of the alignment within the Gandangarra LALC area was assessed by Helen Brayshaw, Heritage Consultants and Jamie Thomas, Barry Gunther and John Griffiths of the Gandangarra LALC. The survey of the alignment north from Elizabeth Drive, was conducted by Robynne Mills and Jim Kelton Archaeological and Heritage Services. The Darug (now Deerubbin) LALC was represented in the field by Tony Condak and Luke Hickey The Darug Link (now the Darug Tribal Aboriginal Corporation) was represented in the field by Mr Colin Gale and the Darug Custodial Aboriginal Corporation was provided with details of the survey results. Preliminary subsurface testing at Plumpton Ridge was undertaken for Mills and Kelton, Archaeological and Heritage Services by Neville Baker (AMBS). The results of these assessments were presented in the Environmental Impact Assessment (EIS) for the Project in October 2000

- Earlier this year funding was made available to the RTA for the project to go ahead.

- A review of the EIS heritage documents was conducted by the NPWS. As a result of this review the Service has identified indigenous heritage issues to be addressed prior to any works being undertaken on the construction of the roadway.

- In response to NPWS requirements the following issues have been addressed by the RTA
    - Mills and Kelton, Archaeological and Heritage Services have been engaged to conduct the indigenous heritage assessment of the WSO alignment from Prestons to Baulkham Hills.
    - All sites and areas of potential archaeological deposit (PADs) recorded in the Brayshaw and Mills/Kelton surveys have been assessed to determined the degree of impact. All sites and PADs which will be directly impacted by the WSO have been identified for further assessment.
    - All locations have been given site names, commencing with the prefix WSO and are numbered sequentially from south to north-east.

- The alignment of the WSO identified on the displayed map is complete with one exception. The exception is the final alignment of the road through Plumpton Ridge. RTA is currently considering moving the alignment 50m to the north to avoid the Pace Chicken Farm. A full heritage assessment of this change to the alignment will be undertaken by Mills and Kelton.

3. Work Plan for the Assessment of the Western Sydney Orbital Alignment.

- As there has been a considerable time lag between the 1994/5 assessments and Government approval for the project, it is proposed that there should be a walk over the route by the RTA Liaison Officer, Suzanne Malligan, archaeologists Mills and Kelton, the LALC and other interested Aboriginal groups. At this walk over, the locations of and proposed impacts to the sites and PADs should be identified to Aboriginal groups.

- At the conclusion of the walk over, all participating Aboriginal groups will be asked to discuss the importance of the identified sites to their respective groups.. A request will also be made to each group to identify any other areas within the WSO Alignment which may have particular importance to their groups. These sites may not necessarily be prehistoric sites but may relate to more recent times eg Native Institute, missions, community halls. Land Grants etc).

- Sub-surface testing of all PAD areas will be required to determine whether or not these PADs contain sites.

- Statements of significance will be prepared for all sites. NPWS have indicated that these statements should include:
    - a statement of scientific significance
    - a statement of cultural significance from the LALC and interested Aboriginal groups
    - the identification of the locations of similar site types within conservation areas in the Western Sydney area.
    - **NB.** It should be noted that the corridor for the proposed WSO easement is very constrained by residential development and there is little room to avoid identified sites, therefore it is likely that the RTA will be applying to NPWS for Consent to Destroy Permits for all sites within the easement. Obviously the conditions of such Permits would be subject to NPWS consultation with LALCs and other interested Aboriginal Groups.

- **Plumpton Ridge** was identified in the original heritage assessment as an area of high scientific and cultural significance and a recommendation for avoidance was made. Avoidance is not an option. The RTA has however identified areas within the ridge which could be contained within a NPWS conservation area. The area currently identified for conservation contains sensitive sections of ridge line identified by archaeologists, Mills, Kelton, Corkill and Baker, geologist, Dr Peter Mitchell and representatives of the Darug LALC and Darug Tribal Aboriginal Corporation. However to determine the potential scientific and cultural significance of the proposed conservation area, it would be necessary to conduct further investigations of the area. These investigations would include:

- Discussions and field assessment with NPWS representatives and members of the scientific community with expertise in the identification of silcrete deposits within the Plumpton Ridge area. These discussions would determine the potential of the proposed conservation area for future research on scientific questions associated with Plumpton Ridge and procurement sites (quarries) in general.
- Consultation with the LALC and identified Aboriginal community representatives to determine the value and relevance of the creation of a conservation area for the Aboriginal Community.

4. Contact Personnel for the Project

RTA

Ms Suzanne Malligan
RTA Aboriginal Liaison Officer
Mobile: 0413368261

Ms Lisa Brown
RTA Blacktown Office
PH: 98310066

NPWS

Kathryn Przywoln
Sydney Zone Archaeologist
Ph: 95856677

Teresa Gay
NPWS Manager,
Central Aboriginal Heritage Unit.
95856444

Archaeological Consultants

Robynne Mills
Jim Kelton
Ph: 95171413
Mobile: 0429602191

Appendix 5:

Table 2: List of all sites and PADs within the WSO impact area.

Complete list of Indigenous Heritage Items which are in the immediate vicinity and within the alignment of the Western Sydney Orbital.

NB Each site has been given a site name with the prefix (WSO). The site numbers are sequential from Prestons to Baulkham Hills.
This site name replaces all previous site names used in the EIS documentation for these sites (see attached map).

Abbreviations used in site notation:
WSO: Western Sydney Orbital
OS: Open stone camp site with stone artefacts present
ST: Scarred tree
IF: Isolated artefact
PAD: Area of Potential Archaeological Deposit.
R: Cecil Hills Realignment Route

Item Number (Previous site name)	Previous Site Name	Comments from reassessment of the alignment April 2001	LALC Area	Contents Description	Level of Significance	Extent of Impact	Recommendation for action	Permits
WSO-PAD 1	P-PAD 1	Sensitive landform unit	Gandangarra		To be determined	Direct	Community Consultation Sub-surface testing	NPWS Research Permit
WSO-OS-1	MC-11	Recorded by McDonald	Gandangarra	3 artefacts	Low	Direct	Community Consultation No further work	NPWS Consent to Destroy Application
WSO-OS-2	P-CP-15	Spoil mixed and deflated. No PAD identified.	Gandangarra	4 artefacts	Low	Direct	Community Consultation No further work	NPWS Consent to Destroy Application
WSO-OS-3	P-CP-16	A soil horizon deflated. No PAD identified	Gandangarra	3 artefacts	Low	Direct	Community Consultation No further work	NPWS Consent to Destroy Application

WSO-OS-8	SO-OS-2	Heavily disturbed topsoil removed by grading	Deerubbin	10 artefacts	Low	Direct	Community Consultation No further work	NPWS Research Permit
WSO-OS-9	SO-OS-3	Heavily disturbed area used as RAAF camp. PAD areas identified	Deerubbin	6 artefacts	Low	Direct	Community Consultation Collection of artefacts	NPWS Consent to Destroy Application
WSO-PAD 8	PAD associated with OS-3	Sensitive Landform but heavily disturbed	Deerubbin		To be determined			
WSO-ST-2	SO-ST-2	Scar in very poor condition	Deerubbin			Direct		
WSO-OS-10	SO-OS-4	Area heavily disturbed previous road works, gas pipeline installation	Deerubbin	4 artefacts	Low	Direct	Community Consultation No further work	NPWS Consent to Destroy Application
WSO-OS-11	SO-OS-5	PAD identified	Deerubbin	13 artefacts		Direct	Community Consultation Collection of artefacts	NPWS Consent to Destroy Application
WSO-PAD 9	OS-PAD 4 Associated with OS-5	With SO-OS-5	Deerubbin		To be determined	Direct	Community Consultation Subsurface testing	NPWS Research Permit
WSO-ST-3	SO-ST-3	Scar and tree healthy	Deerubbin	1 scar		Direct	Community Consultation Further detailed assessment	

WSO-OS-14	SO-OS-9	Heavily disturbed	Deerubbin	9 artefacts	Low	Direct	Community Consultation No further work	NPWS Consent to Destroy Application
WSO-OS-15	SO-OS-10	Heavily disturbed	Deerubbin	7 artefacts	Low	Direct	Community Consultation No further work	NPWS Consent to Destroy Application
WSO-OS-16	SO-OS-11	A soil horizon intact	Deerubbin	12 artefacts		Direct	Community Consultation Salvage	NPWS Consent to Destroy Application
WSO-PAD 16	SO-OS-11	PAD area intact		Nil	Potentially High	Direct	Community Consultation Sub-surface testing	NPWS Research Permit
WSO-OS-17	SO-OS-12	Heavily disturbed but some limited areas of sub-soil intact	Deerubbin	11 artefacts	Low	Direct	Community Consultation No further work	NPWS Consent to Destroy Application
WSO-ST-5	SO-ST-5	Tree dead	Deerubbin	1 scar		Direct	Community Consultation Further assessment	
WSO-OS-18	SO-OS-13	Heavily disturbed by adjacent residential development. PAD present	Deerubbin	30 artefacts	Moderate/High	Direct	Community Consultation Artefact collection	NPWS Consent to Destroy Application
WSO-PAD 17	SO-OS-13	Limited intact A-horizon soils associated with SO-OS-13	Deerubbin	Nil	To be determined	Direct	Community Consultation Sub-surface testing	NPWS Research Permit
WSO-ST-6	SO-ST-6	Tree felled	Deerubbin		Low	Direct	Community Consultation Further assessment	NPWS Consent to Destroy Application
WSO-PAD 18		Creek Terrace, opposite Edna Place	Deerubbin		To be determined	Direct	Community Consultation Further assessment	NPWS Research Permit

Non-Indigenous Heritage Assessment for the Western Sydney Orbital Representations Report.

Addendum to the Western Sydney Orbital EIS and Working Paper 7

Commissioned by Sinclair Knight Merz on behalf of the RTA
July, 2001.

Robynne Mills Archaeological and Heritage Services
60 Watkin Street
Newtown

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Fax 02 95179860
Email: robynnemills@ozemail.com.au

Table of Contents

Appendices

Executive Summary.

Following the release of the EIS document for the Western Sydney Orbital (WSO), all indigenous and non-indigenous heritage responses were referred to Robynne Mills (Archaeological Heritage Services) for action. Casey & Lowe Associates were sub-contracted by Robynne Mills to undertake the additional non-indigenous heritage investigations.

The following report is a record of all works undertaken by Mills and Casey & Lowe, Archaeological and Heritage Consultants, to address the concerns of respondents to the EIS and it's Working Paper 7. Working Paper 7 addresses in detail the investigations undertaken for the initial study.

RTA Responses to all representations, with some input from Robynne Mills, have been included in the body of the Representations Report. This report forms an addendum to the representations report and provides detailed information to support the RTA's responses to representations. This report particularly focuses on issues raised by the NSW Heritage Council, which is the State Consent Authority for non-indigenous heritage.

As part of their involvement in this project, Casey & Lowe undertook a heritage assessment of the southern section of the WSO alignment, Prestons to Cecil Hills (Casey & Lowe 2001). The results of this assessment are presented as Appendix 3 of this report. A total of five (5) sites were identified in that survey. They include:

- Hoxton Park Airport,
- Farm buildings/archaeological site,
- Upper Canal System: Cecil Hills Tunnel and vent,
- Site of outbuildings off Jedda Road, Prestons, and
- Site next to the Spanish Mission House Bernera Road, Prestons.

This report presents management recommendations for all sites identified within the WSO impact area. It also outlines the requirements and process for seeking excavation permits after the Representations Report is submitted for determination.

1. Introduction and Background

The heritage assessment for the Western Sydney Orbital (WSO) Environmental Impact Statement (EIS) was conducted in 1995/6. The route was assessed in two sections.

The southern section of the proposed alignment from Prestons to Elizabeth Drive, Cecil Hills, was originally assessed by Helen Brayshaw Heritage Consultants. The northern section from Elizabeth Drive to Old Windsor Road was surveyed by Robynne Mills and Jim Kelton, Archaeological and Heritage Services.

The working papers for the northern and southern sections of the alignment were presented to the NSW Heritage Council on behalf of the RTA by SKM (northern sector) and PPK (the southern sector) in 2000.

When funds were made available for the commencement of the WSO Project, the EIS and Working Paper 7 were placed on public exhibition, in January 2001. During this exhibition period, the Heritage Working Papers, as presented in the EIS document, were reviewed by the Heritage Council, other Statutory bodies and the public.

At the close of the public viewing period, public authority and community group responses to the EIS Non-indigenous Heritage Working Paper had been received from:

- NSW Heritage Council (Reece McDougall)
- Heritage Office (Susan McDonald)
- Department of Urban Affairs and Planning (Mark Hather)
- Hoxton Park Airport Ltd (Kim Ellis)
- Environment Australia (Gerry Morvell)
- Mark Pearce, representing Pearce's Cemetery
- Sydney Water (Gordon Cameron)
- Fairfield City Council (Mayor Robert Watkins)
- Blacktown City Council General Manager (Ian Reynolds)
- Blacktown and District Environment Group (BDEG)

The RTA then commissioned SKM, who commissioned Robynne Mills, to prepare responses and specialist studies to address all indigenous and non-indigenous heritage issues raised in the EIS review. In order to compile meaningful responses to the representations and adequately address deficiencies in the EIS, it was necessary to undertake some additional research, surveys and consultation. The general responses are contained in the body of the Representations Report (chapter 3). The technical details of the additional work are contained in this report and support the responses in chapter 3 of the Representations Report.

2. Consultation

Lisa Brown of the RTA spoke with Natalie Vinton and Stuart Read of the NSW Heritage Office to discuss requirements for this report. An 'in-principle' approach was verbally agreed to and advice on information sources was provided by the Heritage Office. Discussions were also held with DUAP and the Heritage Office to determine the consent and approvals process. An overview of the project was presented to Natalie Vinton and Gary Pringle in early August 2001 to clarify the process.

Consultation was undertaken with the following Council representatives to ensure that all LEP details in this Representations Report are current:

Liverpool City Council: Joanne Tapp / Graham Brooks (98219222)
Fairfield City Council: Nathan Burbridge (97250222)
Blacktown City Council: Sue Galt (98396000)
Baulkham Hills Shire Council: Erin Trenear (98430265)

Jon Breen (Sydney Water Archives), Sian Waythe (Sydney Catchment Authority) and Denis Gojak (DUAP) were also contacted to provide details on various heritage items requiring further investigation.

Curtilage information for heritage items was also obtained from the above Council officers, Denis Gojak and Stuart Read.

Documentation used in this assessment:

Australian Heritage Commission Register and State Heritage Register
National Trust from Published List in Book form (1995) and Mara Barnes, Site Registrar
LEP Documents from Local Councils current at 31st May, 2001.
Local Council Heritage Studies
Draft Colonial Landscapes of the Cumberland Plain and Camden NSW, Morris and Britton.

A site visit and consultation was undertaken with the Sydney Catchment Authority (SCA) in late July for the purpose of the Cecil Hills Tunnel assessment and section 60 application (Appendix 4). The measures for mitigating the impacts on the Cecil Hills Tunnel were designed in consultation with, and approved by, SCA.

3. Assessment of the southern section of the alignment (Prestons to Cecil Hills)

3.1 Methodology:

In their representation to the EIS, the NSW Heritage Council expressed concern that there had been no adequate heritage assessment of the southern section of the WSO alignment from Prestons to Cecil Hills. In response to this concern a heritage assessment of this section of the alignment was conducted by Casey & Lowe in June, 2001. That assessment identified five (5) items of potential heritage significance that would be impacted by the proposal. The full report is presented in Appendix 3.

Table 2: Sites identified in Southern Section of the Alignment

Item Number	Description	Location
WSO-E-1	Site next to Spanish Mission House. Potential sub-surface remains	Southwest cnr of Bernera Road and Jedda Road, Prestons.
WSO-E-2	Site of outbuildings	Off Jedda Road, Prestons
WSO-E-3	Hoxton Park Airport	Cowpasture Rd Hoxton Park
WSO-E-4 *(CH-E-1)*	Farm buildings archaeological site	West of Kensington Crescent, Cecil Hills
WSO-E-5	Upper Canal System: Cecil Hills Tunnel and vent.	Junction of Elizabeth Drive/Wallgrove Road

4. Update of the Original Heritage Assessment

4.1 Methodology

4.1.1 Survey

Consultants (Mills and Casey & Lowe) accompanied an RTA surveyor into the field to identify the exact locations and extent of sites identified in the 1995 assessments. The locations and dimensions of all sites, including those identified in Casey & Lowe's survey of the southern section of the WSO alignment were plotted on a map of the latest proposed WSO alignment.

As a result of this survey, Mills produced a sequential list of sites for the whole WSO alignment. All site names now have the common prefix 'WSO' and are as far as possible in sequential order (Table 2 Appendix 2). The exact location and extent of all sites along the length of the WSO have been identified and related to an annotated list of sites which provides summary details of the previous name of sites in Working Paper 7, a description of each item, assessment of impact, levels of significance, management recommendations and Permit requirements.

4.1.2 Section 60 Application

A Statement of Heritage Impact and section 60 application were undertaken for the Cecil Hills Tunnel, which is part of the Upper Canal System which is listed on the State Heritage Register. Although the item would not be physically impacted, the context of that item in the landscape would be altered by the proposal. A full Statement of Heritage Impact and Statement of Significance for that item is provided at Appendix 4.

4.1.3 Colonial Landscapes

The Heritage Office also provided the RTA with a list of 'Colonial Landscapes' that may be affected by the proposed WSO (letter dated 03/04/01). The locations and curtilages of these items were examined, and the potential physical and visual impact was assessed (Appendix 5).

It was determined that none of the Colonial Landscapes put forward by the Heritage Office were directly physically impacted by the WSO. One landscape, Pearce's Cemetery, was potentially impacted visually by the bisecting of its physical context from Bella Vista by the proposed alignment of the WSO. . The details of the visual impact assessment and mitigation measures are contained at Appendix 5.

4.1.4 Statements of Significance

The initial assessment of signifcance of sites identified during the survey of sites used a basic premise for assessing the level of significance of each site. The nature of the sites, such as outbuildings and late nineteenth-century house/farm fit into local categories of significance because there are typically a representative number of these types of sites within any local area. The detailed assessment of these sites for the purpose of the excavation permits would be designed to refine the assessment of significance of these sites. A more detailed level of significance would be undertaken after the Representations Report is submitted to DUAP, but prior to determination by the Minister, for the purpose of any excavation permits. While it is agreed that Heritage Studies do not necessarily identify many archaeological sites they do frequently identify sites of State significance, such as Bernera. The Heritage Study histories provided at Appendix 3 of this report and in Working Paper 7 were also used as the basis for the historical background for each area and the determination of the significance rating of each item.

5. Post-Representations Report Requirements

From the additional research, field work, consultation and assessment, it has been determined that all of the sites listed below will be impacted by the proposed Western Sydney Orbital to varying extents. Levels of significance and details of impacts and mitigation measures are provided in Appendix 2. The majority of these sites will be subject to s.140 excavation permits, except the Cecil Hills Tunnel, for which a s.60 application has been lodged with the NSW Heritage Office.

1. WSO-E-1 Site of Outbuildings
2. WSO-E-2 Site next to the Spanish Mission House. Potential sub-surface remains.
3. WSO-E-3- Hoxton Park Airport
4. WSO-E-4 Farm Buildings archaeological site
5. WSO-E-5 Upper Canal System (Cecil Hills Tunnel)
6. WSO-E-10 Warragamba Pipeline
7. WSO-E-11 World War 2 RAAF Base
8. WSO-E-12 Remains of Coleman's Inn
9. WSO-E-13 Brick-lined well
10. WSO-E-14 Isolated European Burial
11. WSO-E-19 House, Meurants Lane Lot 606, DP1015876
12. WSO E-20 Old Windsor Road
13. WSO-E-21 Pearce's Cemetery (visual impact only)

Part VI Division 9 of the *Heritage Act 1977* provides for the issue of 'excavation permits' in respect of 'relics' in accordance with section 140. The RTA is not required to obtain s.140 permits until after Ministerial approval is given for the project to proceed, however it is the intention of the RTA that excavation permits would be sought **prior to determination** of the project but **after** the Representations Report is **submitted** for determination. This would mean that any refusal of s.140 applications, or approval of s.140 applications with conditions, could be taken into consideration by the Planning Minister in making a determination on the proposal. It is anticipated that there would be a minimum of 4 months between submitting the Representations Report for determination and the time when a determination is made. The information for the s.140 consents would be compiled in that time period and submitted to the Heritage Office.

For the s.140 applications, Statements of Heritage Impact and Heritage Significance would be provided in accordance with the NSW Heritage Office Guidelines. The Statements of Heritage Significance and Statements of Heritage Impact would formalise and expand upon the information provided in the EIS Working Paper 7 and this report and would be presented to the Heritage Office in seeking excavation permits for any affected "relics".

Appendix 1: Maps

Appendix 2:

List of all sites within the WSO impact area

Details of all sites within and immediately adjacent to the WSO Alignment

Item Number (Previous site name)	Description	Location	LGA	Register Listing (AHC, SHR, NT, LEP, SW)	Extent of Impact	Stage 2 Requirements
WSO-E-1	Site of outbuildings	Off Jedda Road, opposite Joadja Rd, Prestons	Liverpool	Nil	Direct	s. 140 application
WSO-E-2	Site next to Spanish Mission House. Potential subsurface remains	Southwest corner of Bernera Road and Jedda Road,l Prestons	Liverpool	Nil	Direct	s. 140 application
WSO-E-3	Hoxton Park Airport	Cowpastures Rd Hoxton Park	Liverpool	AHC	Direct to Western Boundary. Acquisition of 4355 square metres.	s.140 application
WSO-E-4 *(CH-E-1)*	Farm buildings archaeological site	West of Kensington Crescent, Cecil Hills	Liverpool	Nil	Direct	s. 140 application
WSO-E-5	Upper Canal System: Cecil Hills Tunnel	Junction of Elizabeth Drive/Wallgrove Road	Liverpool	SHR NT, LEP, SW	Direct	s. 60 application
WSO-E-6	City Farm	East of Trigon Road, Abbotsbury	Fairfield	LEP	Nil	Nil.
WSO-E-7	Relics of early Homestead	Elizabeth Drive Abbotsbury	Fairfield	LEP	Nil	Nil.
WSO-E-8	Remnants of Abbotsbury House	Southdown Road Horsley Park	Fairfield	LEP	Nil	Nil.

WSO-E-9 *(SO-E-1)*	Timber barn	Redmayne Rd, Horsley Park	Fairfield	Nil	Nil	Nil.
WSO-E-10	Warragamba Pipeline	North of Chandos Street	Blacktown	SCA s.170 register	Direct	s. 140 application
WSO-E-11 *(SO-E-9)*	World War 2 RAAF Base	Wallgrove Road, eastern side South of M4 Motorway	Blacktown	Nil	Direct	s. 140 application
WSO-E-12	Remains of Coleman's Inn	South-eastern corner of Great Western Highway and Wallgrove Rd	Blacktown	Nil	Direct	s. 140 application
WSO-E-13 *(SO-E-7)*	Brick lined well and house foundations	East of Church Street Doonside	Blacktown	SHR Part of Bungarribee Farm	Direct	s. 140 application
WSO-E-14	Native Institute	Cnr Rooty Hill Road North and Richmond Road	Blacktown	AHC, SHR, LEP	Immediately adjacent to alignment, although not directly impacted.	Nil.
WSO-E-15 *(SO-E-2)*	Isolated European Burial	East of Symonds Road, Dean Park, 30m west of Eastern Creek	Blacktown	Nil	Direct	s. 140 application Department of Health, Coroner Advise Local Council
WSO-E-16 *(SO-E-3)* **demolished**	Timber barn and battery chicken shed	100m east of Eastern Creek	Blacktown	Nil	Nil	Nil.
WSO-E-17 *(SO-E-10)*	Exeter Farm, otherwise known as Meurants Cottage	Lot 50 DP 792657 Meurants Lane	Blacktown	SHR LEP	Nil	Plan of Management to be reviewed by SHO.

WSO-E-18 *(SO-E-4)*	Potential archaeological site	In the vicinity of scarred tree WSO-ST-6 (access Lady Penrhyn Park	Blacktown	Nil	Nil	Nil
WSO-E-19 *(SO-E-11)*	House	Meurants Lane, part of Lot 6 DP 878474	Blacktown	LEP	Immediately adjacent to off ramp to Meurants lane exit.	Nil
WSO-E-20 *(SO-E-8)*	Old Windsor Road	Seven Hills Road to Windsor Road	Blacktown	AHC	Direct	s. 140 application
	Old Windsor Road	1.5km south from Meurants Lane		NT	Direct	s.140 application
	Old Windsor Road	1.5km south from Meurants Lane		LEP Blacktown	Direct	s.140 application
	Old Windsor Road post and rail fencing	Eastern side of Windsor Road	Baulkham Hills	LEP	Direct in vicinity of Meurants Lane Junction	s.140 application
WSO-E-21 *(SO-E-5)*	Pearce's Cemetery	Lot 100 DP 707538, Seven Hills Road, Baulkham Hills	Baulkham Hills	SHR LEP	Immediately Adjacent (Curtilage, Visual, vibration impact). GPR testing to be undertaken.	Plan of Management incorporating a Landscape Plan. To be reviewed by SHO.
WSO-E-22 *(SO-E-6)* **Demolished**	Single room dairy and beehive cistern	Adjacent to water tower west of Toongabbie Creek, Baulkham Hills	Baulkham Hills	Nil	Nil	Nil

Appendix 3:

Report on the heritage survey of the southern section of the WSO from Prestons to Cecil Hills.

NON-INDIGENOUS HERITAGE

ARCHAEOLOGICAL SURVEY

Southern Section

Western Sydney Orbital

(Prestons to Cecil Park)

For

Robynne Mills & Associates

on behalf of

NSW Roads & Traffic Authority

July 2001

CASEY & LOWE ASSOCIATES
Archaeology & Heritage

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EXECUTIVE SUMMARY

RESULTS

The southern section of the WSO contains a series of known and potential heritage sites or relics. These are:

Item Number (Previous site name)	Description	Location	LGA	Register Listing (AHC, SHR, NT, LEP, SW)	Level of Significance	Impact
WSO-E-1	Site next to Spanish Mission House. Potential subsurface remains.	Southwest cnr of Bernera Road and Jedda Road, Prestons.	Liverpool	Nil	To be determined but probably **Local**	direct
WSO-E-2	Site of outbuildings	off Jedda Road, opposite Joadja Road, Prestons	Liverpool	Nil	To be determined but probably **Local**	direct
WSO-E-3	Hoxton Park Airport	Cowpastures Rd Hoxton Park	Liverpool	AHC	Potentially National Estate	taxiways
WSO-E-4 *(CH-E-1)*	Farm buildings archaeological site	West of Kensington Crescent, Cecil Hills	Liverpool	Nil	To be determined but probably **Local**	direct
WSO-E-5	Upper Canal System: Cecil Hills Tunnel	Junction of Elizabeth Drive/Wallgrove Road	Liverpool	SHR, NT, LEP, SW	State	above position of tunnel, buries shaft

RECOMMENDATIONS

1. All of the identified heritage sites within the southern area of the proposed WSO alignment, excepting the Cecil Hills tunnel, require detailed assessments of heritage significance and an analysis of impacts from the WSO alignment as the next stage of the heritage process. The sites requiring archaeological assessments are:
    - WSO-E-1 - Site next to Spanish Mission House
    - WSO-E-2 - Site of outbuildings
    - Potential subsurface remains WSO-E-3 - Hoxton Park Airport
    - WSO-E-4 - Farm buildings archaeological site.
2. These sites need to be assessed in accordance with the NSW Heritage Office *Archaeological Assessment Guidelines*. These assessments may make recommendations for archaeological work which may include: testing, recording, archaeological investigation (excavation), monitoring, avoidance of a site or other appropriate recommendations.
3. The Cecil Hill Tunnel, which is on the SHR, requires investigation to establish the depth of the tunnel within the study area, near the intersection with Elizabeth Drive and Wallgrove Road, and the impact on the shaft which it is proposed to bury. An understanding of engineering issues in relation to the roadworks can only be determined once the successful contractor identifies appropriate methodology. Details of potential impacts from construction works need to be established, such as, vibrations and other impacts. If there are any potential issues from construction works these need to be mitigated. RTA has advised that 'The successful Contractor will be advised to ensure that he protects from damage the tunnel and vent'.

STATUTORY REQUIREMENTS AND APPROVALS

Item Number (Previous site name)	Description	Register Listing (AHC, SHR, NT, LEP, SW)	Statutory Requirements	Approval	Level of Significance
WSO-E-1	Site next to Spanish Mission House. Potential subsurface remains.	Nil	Relic provisions of NSW *Heritage Act*	s. 140 approval - NSW HO	To be determined but probably **Local**
WSO-E-2	Site of outbuildings	Nil	Relic provisions of NSW *Heritage Act*	s. 140 approval - NSW HO	To be determined but probably **Local**
WSO-E-3	Hoxton Park Airport	AHC	Federal agency referral to AHC. Relic provisions of NSW *Heritage Act*	s. 140 approval NSW HO	Potentially National Estate
WSO-E-4 *(CH-E-1)*	Farm buildings archaeological site	Nil	Relic provisions of NSW *Heritage Act*	s. 140 approval NSW HO	To be determined but probably **Local**
WSO-E-5	Upper Canal System: Cecil Hills Tunnel	SHR NT, LEP, SW	SHR register LEP	s. 60 approval NSW HO. LEP approval Liverpool Council	State

CONTENTS

1.0 Introduction

1.1 Background

Casey & Lowe Associates were commissioned by Robynne Mills & Associates on behalf of the Roads and Traffic Authority (RTA) to undertake the non-indigenous archaeology component for the Representations Report of the Western Sydney Orbital (WSO) project. This report was written to cover the survey of non-indigenous sites in the southern part of the WSO route. The NSW Heritage Office in their representation to the EIS specifically noted that there had not been a non-indigenous heritage assessment of the southern section of the study area. However a brief non-indigenous heritage assessment of the southern section was undertaken by Helen Brayshaw Heritage Consultants. This report expands on that assessment. The non-indigenous heritage in the northern part of the WSO route was surveyed by Robynne Mills and the report was included in Working Paper No. 7 of the EIS. The WSO project is funded by both State and Federal governments and is therefore subject to both State and Federal heritage legislation.

1.2 Study Area

The study area is the southern part of the route of the proposed WSO, extending from Bringelly Road, Prestons to Elizabeth Drive, Cecil Hills (Figs 1.1, 1.2).

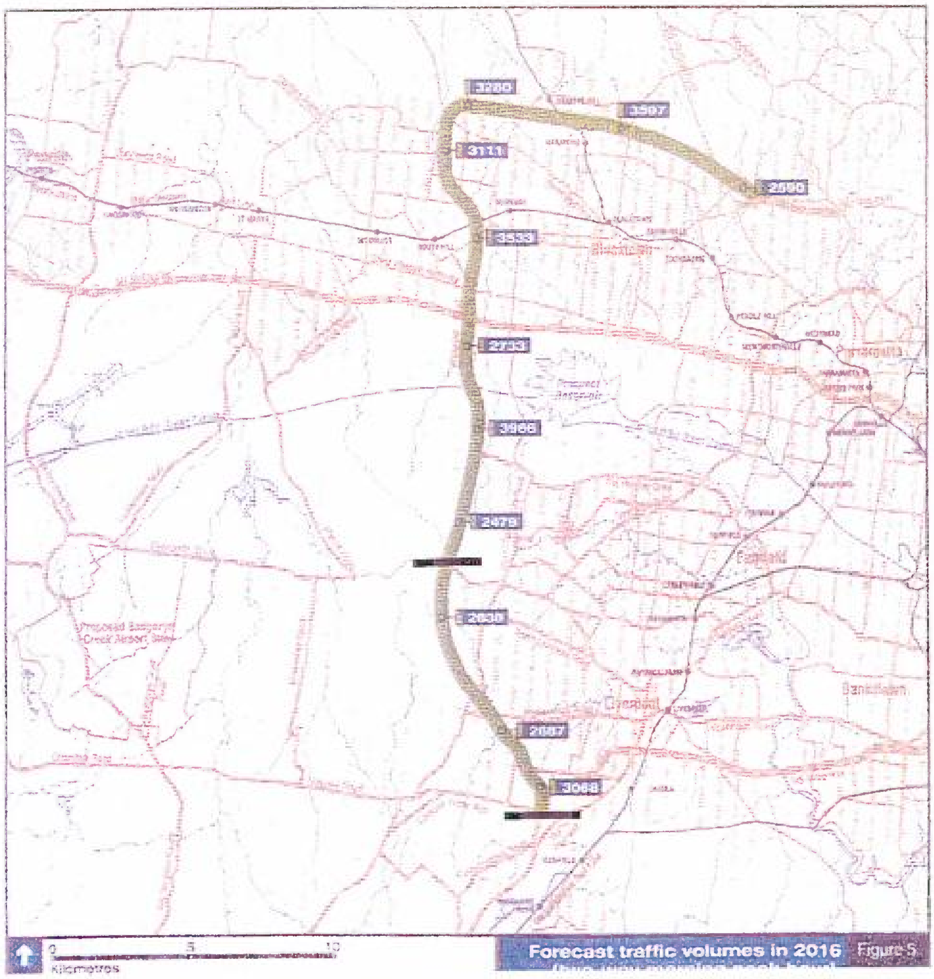


Figure 1.1: Location plan showing entire route of the proposed Western Sydney Orbital. The boundaries of the study area for this report, the southern section of the WSO, are marked with thick black lines. The map is taken from EIS summary document.

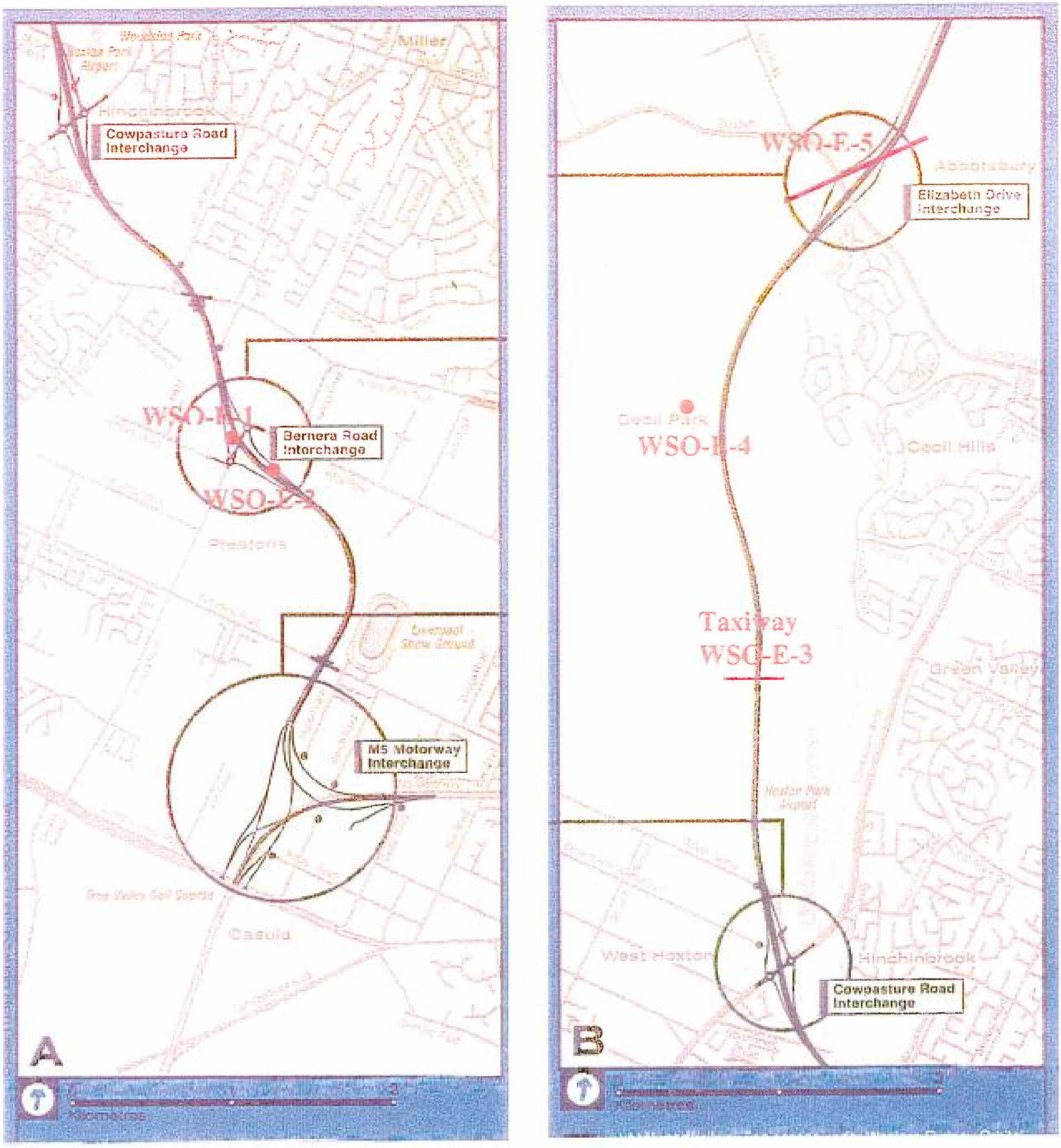


Figure 1.2: Study area plans showing the proposed route of the WSO. The route at Cecil Hills has been altered to move it further to the west (approx. 400 m) away from housing (not shown). Maps taken from EIS summary document.

1.3 Methodology

In June 2001 Robynne Mills did a search of all relevant heritage registers for non-indigenous buildings and sites within the study area and spoke to the Liverpool heritage planner, Liverpool local studies librarian, a local councillor at Liverpool and a member of the local historical society to identify potential known sites within the study area. In addition, Mary Casey obtained copies of 1947 and 1951 aerial photos of the study area to use as a base for identifying potential historic sites that may be within the study area for which there are no longer extant structures (Figs. 2.2-2.6). A review of the Liverpool Heritage Study was also undertaken to determine if there were other potential sites not gazetted on the LEP.

This process allowed for the identification of potential sites as a predictive model for the field survey. The field survey included the proposed realignment of the WSO at Cecil Hills. All sites identified through this process were inspected and the general vicinity of the study area was inspected. An RTA surveyor assisted in the field to identify the route of the WSO and survey the potential sites.

During the field survey four additional sites were identified, two at Prestons, one near Hoxton Park Airport and another at Cecil Hills on the proposed realignment (identified by Robynne Mills). In addition a number of other sites, indicated by various sources as being near the proposed route, were found to be outside the area of the proposed WSO route and would therefore not be impacted by the proposal. In addition a draft report on the *Colonial Landscapes of the Cumberland Plan and Camden* was used to identify if there were extant houses or sites of houses with significant cultural landscapes that may be impacted by the proposed route of the WSO.[1]

A field survey is the first stage in the process of identifying and assessing potential non-indigenous archaeological sites within the corridor of impact from the proposed development. At the pre-determination stage an assessment is required to provide detailed historical background, the archaeological potential and heritage significance of identified sites as well as proposed development impacts and opportunities for mitigation.

1.4 Statutory Constraints

1.4.1 NSW *Heritage Act* 1977 (amended)

1.4.1.1 State Heritage Register

The listing of a site on the State Heritage Register (SHR) offers a place, building, work, relic, moveable object, precinct, or land additional protection under the Heritage Act. A listing on the SHR replaces the older form of protection under a Permanent Conservation Order (PCO). Under Section 57 of the *Heritage Act* 1977 (amended):

Division 2 - Controlled Activities

> *(1) When an interim heritage order or listing on the State Heritage Register applies to a place, building, work, relic, moveable object, precinct, or land, a person must not do any of the following things except in pursuance of an approval granted by the approval body under Subdivision 1 of Division 3:*
>
> *(a) demolish the building or work,*
>
> *(b) damage or despoil the place, precinct or land, or any part of the place, precinct or land,*
>
> *(c) move, damage or destroy the relic or moveable object,*
>
> *(d) excavate any land for the purpose of exposing or moving the relic,*
>
> *(e) carry out any development in relation to the land on which the building, work or relic is situated, the land that comprises the place, or land within the precinct,*
>
> *(f) alter the building, work, relic or moveable object,*
>
> *(g) display any notice or advertisement on the place, building, work, relic, moveable object or land, or in the precinct,*
>
> *(h) damage or destroy any tree of other vegetation on or remove any tree*

[1] Morris and Britton 2000.

or other vegetation from the place, precinct or land

(2) *The Minister on the recommendation of the Heritage Council, may, by order published in the Gazette, grant an exemption from subsection (1) or such of the provisions of the subsection as are specific in the order in respect of the engaging in or carrying out of such activity or class of activities by such a person or class of persons in such circumstances as may be so specified.*

The Minister's power under this subsection extends to apply in respect of interim heritage orders made by councils.

(3) *A council may, by order published in the Gazette, grant an exemption from subsection (1) or such of the provisions of that subsection as are specified in the order in respect of the engaging in or carrying out of such activity or class of activities by such a person or class of persons in such circumstances as may be so specified. Such an exemption has effect only in respect of an interim heritage order made by the council concerned.*

Division 3 – Application for Approval

Section 60
This is the section of the Heritage Act under which an application for approval is made to the Heritage Council to undertake works on a place, building, work, relic, moveable object, precinct, or land where their item is listed on the SHR. These applications typically go to the Heritage Council for approval.

1.4.1.2 Division 9: Section 139, 140-146 - Relics Provisions - Excavation Permit
The main legislative constraint on archaeological remains is the relics provisions of the *Heritage Act* 1977.

According to Section 139:

1. *A person must not disturb or excavate any land knowing or having reasonable cause to suspect that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, moved, damaged or destroyed unless the disturbance or excavation is carried out in accordance with an excavation permit.*
2. *A person must not disturb or excavate any land on which the person has discovered or exposed a relic except in accordance with an excavation permit.*

A 'relic' is an item of 'environmental heritage' defined by the *Heritage Act 1977* (amended) as:

those places, buildings, works, relics, moveable objects, and precincts, of State or local heritage significance (part 1, Section 4).

A relic as further defined by the Act is:

..any deposit, object or material evidence -
(a) which relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement; and
(b) which is 50 or more years old (Part 1, Section 4)

Any item identified as an historical archaeological site or relic cannot be impacted upon without an **excavation permit**. An excavation permit forms an approval from the Heritage Council for permission to 'disturb' a relic.

An application for an excavation permit must be made to the Heritage Council of NSW (Section 60 for items on the State Heritage Register). This will usually take four weeks to be processed. The application for a permit must nominate a qualified archaeologist to manage the disturbance of the relics. There is a processing fee of $100 attached to each excavation permit.

1.4.1.3 Section 170 Register, NSW *Heritage Act* 1977 (amended)

A section 170 register is a listing of properties owned by a Government instrumentality.

1.4.2 Environmental Protection Act - Local Environmental Plans

A number of sites identified as being in the current study area are listed on local LEPs. The current study area is completely within Liverpool City Council area. The gazettal of an item on a LEP requires that a proponent seek approval from council for undertaking of works or alterations to an item.

1.4.3 Australian Heritage Commission Act

Where a site has been placed on the Register of the Australia Heritage Commission or has an interim listing on the Register certain protections are put in place which involve protection of sites in the case of impact by projects that involve Federal funding. Under

> *Section 30 of the Australian Heritage Commission Act imposes several obligations on Commonwealth Ministers, departments, authorities and companies owned by the Commonwealth to protect places in the Register of the National Estate. It comes into force when a place is either in the Register of the National Estate, or is on the Interim List of the Register.*
>
> *Commonwealth agencies have two general conservation obligations as well as a referral obligation. In addition, agencies are generally obliged to assist the Commission. The following summaries are provided for reference, however, agencies should be aware of the specific wording of these obligations in the Act.*
>
> ***Conservation Obligation 1***
>
> *Commonwealth agencies, including Ministers, departments and authorities, must not take any action that has an adverse effect on any part of the National Estate unless there is no feasible and prudent alternative. The decision whether an action can be taken or not is a decision for the agency, not the Commission. (Refer to subsection 30(1) or 30(2))*
>
> ***Conservation Obligation 2***
>
> *If a Commonwealth agency finds that it must take an action which will have an adverse effect on part of the National Estate, because there is no feasible and prudent alternative, then the agency must take all reasonable measures to minimise the adverse effect. (Refer to subsection 30(1) or 30(2))*[2]

[2] Extract from AHC web page http://www.ahc.gov.au/heritage/protection/obligations.html

Referral Obligation

Before a Commonwealth agency takes any action that might affect to a significant extent a place which is part of the national estate, it must advise the Commission and give the Commission a reasonable opportunity to consider and comment on it. The Commission's role is to provide expert advice, it does not take the decision-making role away from the agency. (Refer to subsection 30(3))

An important aspect of this legislation is that it does not give the Commission a formal 'watchdog' role. Rather, it confers the responsibility for complying with this legislation on the various Commonwealth Ministers, departments and authorities whose actions affect the National Estate.

It is not the Commission which decides whether or not the Commonwealth Government will proceed with an action which will adversely affect a place in the Register. It is up to the Commonwealth Government, or the Government agency responsible for the proposed action to take this decision. The interpretation of 'feasible and prudent alternative', for example, is up to the Government proponent to determine, not the Commission. The Commission is only obliged to provide full advice on the impact of the proposed action on the national estate values of the place concerned.

Advice provided by the Commission to Commonwealth Ministers and bodies under section 30, is based on the statements of significance. These are statements which are prepared for each place in the Register and which explain the significant national estate values of each place.

1.5 Limitations

There were no real limitations on the production of this survey report.

1.6 Author Identification

This report was written by Mary Casey and reviewed by Tony Lowe of Casey & Lowe. Part of this work is based on previous surveying and reporting undertaken by Robynne Mills.

1.7 Acknowledgements

Robynne Mills, Greg Mills
RTA: Lisa Brown, Lindsay King, Stuart Amery, Walter Prolov
Liverpool Local Studies Librarian: John Johnson
Australian Heritage Commission: Richard Morrison
HLA-Envirosciences: Iain Stuart
Bankstown Airport: Janine Stablum
Sydney Water: Jon Breen
NSW Heritage Office: Stuart Reid

1.8 Terminology

Archaeological Assessment
A study undertaken to establish the archaeological significance (research potential) of a particular site and to identify appropriate management actions.

Archaeological Potential
Archaeological potential is here used and defined as a site's potential to contain archaeological relics which fall under the provisions of the *Heritage Act* 1977 (amended). This potential is identified through historical research and by judging whether current building or other activities have removed all evidence of known previous land use.

Archaeological Investigation or Excavation
The manual excavation of an archaeological site. This type of excavation on historic sites usually involves the stratigraphic excavation of open areas.

Archaeological Monitoring
Archaeological monitoring is recommended for those areas where the impact of the works is not considered to mean the destruction of significant archaeological fabric. Nevertheless the disturbance of features both suspected and unsuspected is possible. In order to provide for the proper assessment and recording of these features an archaeologist should inspect the works site at intervals they consider to be adequate and to be 'at call' in case the contractor uncovers remains that should be assessed by the archaeologist.

It is not anticipated that monitoring will impact on the planned works or unduly hold up the contractors' work schedules. If recording of features is necessary it would be carried out as quickly as possible so that any time delays are minimised.

Monitoring is a regular archaeological practice used on many building and development sites.

Excavation Permit
A permit to disturb or excavate a relic issued by the Heritage Council of New South Wales under Section 60 or Section 140 of the NSW *Heritage Act* 1977.

Archaeological Site
A place that contains evidence of past human activity. Below ground sites include building foundations, occupation deposits, features and artefacts. Above ground archaeological sites include buildings, works, industrial structures and relics that are intact or ruined.

Historical Archaeology
Historical Archaeology (in NSW) is the study of the physical remains of the past, in association with historical documents, since the European occupation of NSW in 1788. As well as identifying these remains the study of this material can help elucidate the processes, historical and otherwise, which have created our present surroundings. It includes an examination of how the late eighteenth- and nineteenth-century arrivals lived and coped with a new and alien environment, what they ate, where and how they lived, the consumer items they used and their trade relations, and how gender and cultural groups interacted. The material remains studied include:

* Archaeological Sites:
  - below ground: these contains relics which include building foundations, occupation deposits, rubbish pits, cesspits, wells, other features, and artefacts.
  - above ground: buildings, works, industrial structures and relics that are intact or ruined.

* Cultural Landscapes
* Maritime Sites:
  - shipwrecks
  - structures associated with maritime activities.

Research Design
A set of questions which can be investigated using archaeological evidence and a methodology for addressing them. A research design is intended to ensure that archaeological investigations focus on genuine research needs. It is an important tool that ensures that when archaeological resources are destroyed by excavation, their information content can be preserved and can contribute to current and relevant knowledge.

Relic
A relic as further defined by the NSW *Heritage Act* 1977 (amended) is:

> *..any deposit, object or material evidence -*
> *(a) which relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement; and*
> *(b) which is 50 or more years old* (Part 1, Section 4)

Research Potential
The ability of a site or feature to yield information through archaeological investigation. The significance of archaeological sites is assessed according to their ability to contribute information to substantive research questions.

Sampling
Sampling of the archaeological resource is an excavation strategy that is adopted when there is a large area that contains a similar resource and it is not considered warranted to fully excavate everything as the sample can be extrapolated to stand for the whole of the resource. The sample taken should be considered representative of the whole related resource and should be chosen only after detailed consideration of the various alternatives.

Testing
The usual intention behind archaeological testing is to have a look in the ground to confirm the archaeological potential of the site identified in the archaeological assessment. It can be an integral part of the process of confirming the presence or absence of the archaeological resources. It is important to have a testing strategy that addresses the predictive model rather than just looks for structures.

1.9 List of Illustrations

Section 2.0

Figures

Photos

2.0 Archaeological Survey

2.1 Historical Background

The study area between Camden Valley Way, Prestons and Elizabeth Drive, Abbotsbury was once part of a number of early estates. The southern end of the proposed WSO passes through what were Church and School Lands and the Bernera Estate. The site of the Bernera homestead is listed on the Liverpool LEP and is a considerable distance to the southwest of the proposed alignment of the WSO through the estate (Figure 2.3). Bernera Estate was originally 1000 acres of land granted to Dr Donald Macleod.[3] He sold it to Alan McPherson who built a timber house c. 1856-57. This house was destroyed in 1986. Bernera Estate was subdivided in 1889 when Hardie and Gorman auctioned the blocks of land (Fig. 2.7). The WSO goes through lots 4, 5, 17 and 23 of the Bernera Estate, either side of the junction of Bernera Road and Jedda Road (formerly Wonga Street). There will be no impact on the site of Bernear homestead by the proposed WSO route.

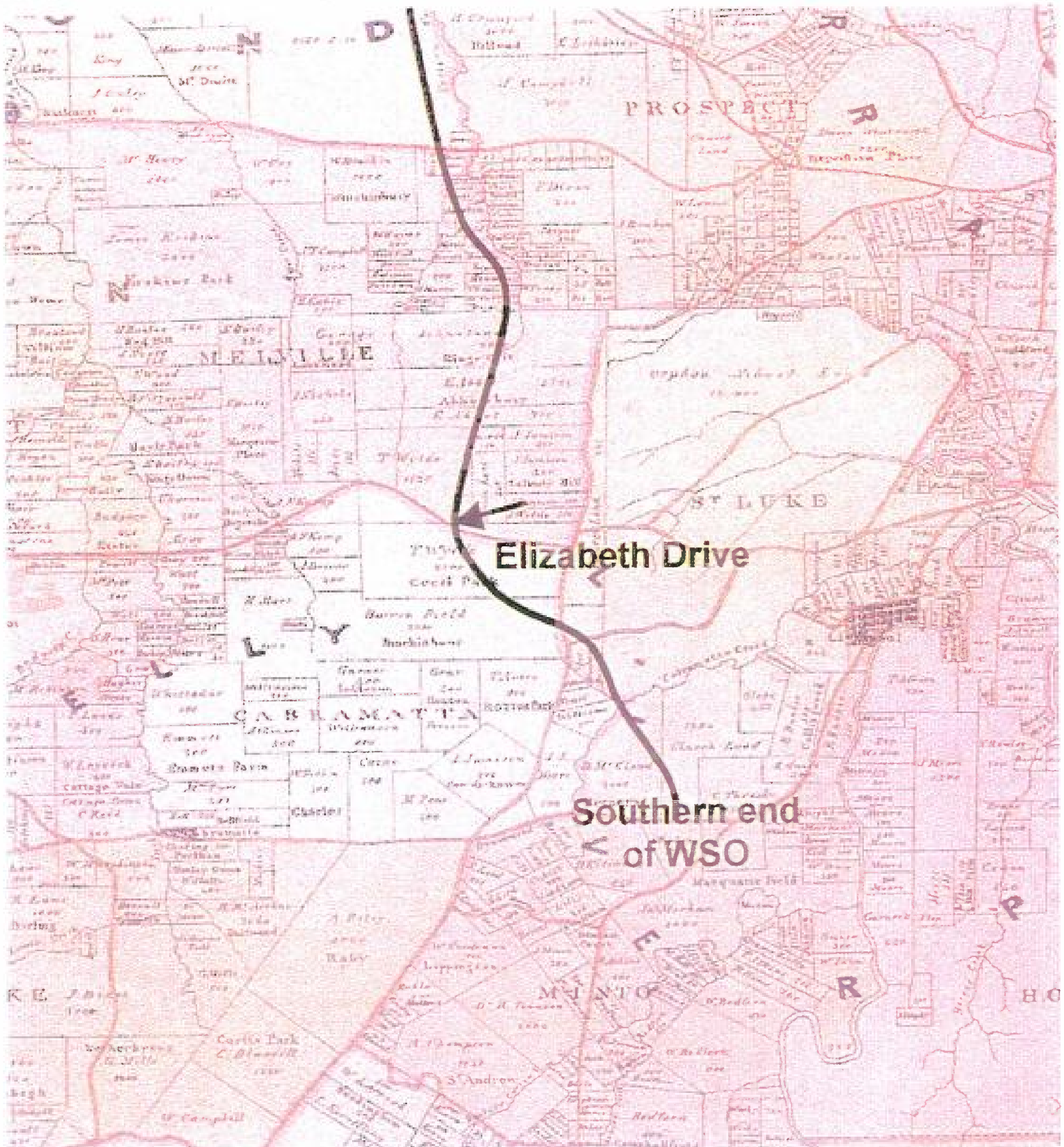


Figure 2.1: Plan showing early land grants in the Liverpool district and approximate position of proposed WSO alignment. WSO alignment based on the EIS 'Summary' document. *County of Cumberland*, 1894, ML MSS. Taken from Keating 1996.

[3] Keating 1996:22.

Figure 2.2: Aerial photo of southern end of southern alignment of Western Sydney Orbital, sheet 1. LPI, January 1947.

joins/overlaps Figure 2.3

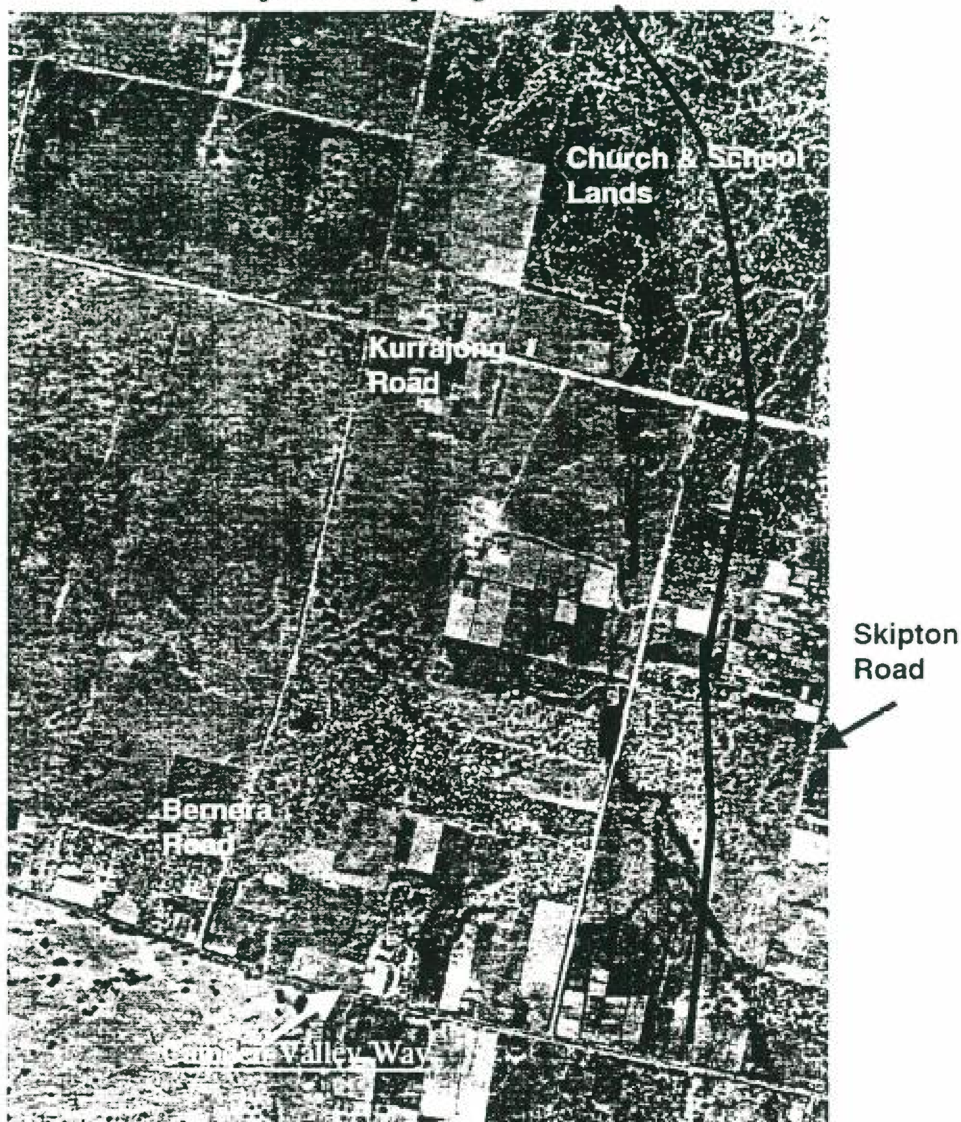


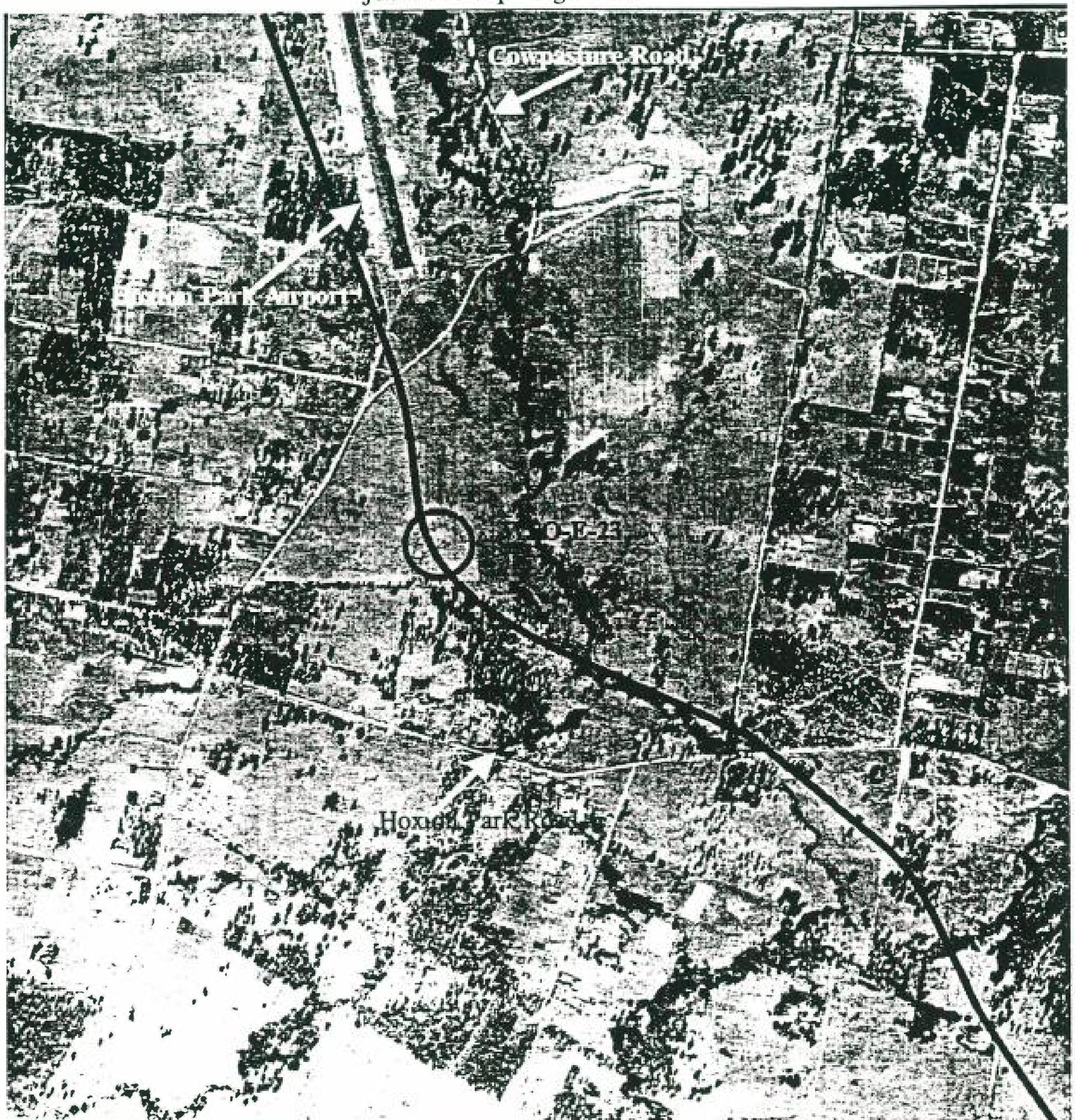
Figure 2.3: Aerial photo of southern part of southern alignment of Western Sydney Orbital. Sheet. LPI, January 1947.

joins/overlaps Figure 2.4

joins/overlaps Figure 2.2

Figure 2.4: Aerial photo of middle end of southern alignment of Western Sydney Orbital, sheet 3. LPI, May 1951.

joins/overlaps Figure 2.5



joins/overlaps Figure 2.3

Figure 2.5: Aerial photo of northern end of southern alignment of Western Sydney Orbital, sheet 4. LPI, May 1951.

joins/overlaps Figure 2.6

joins/overlaps Figure 2.4

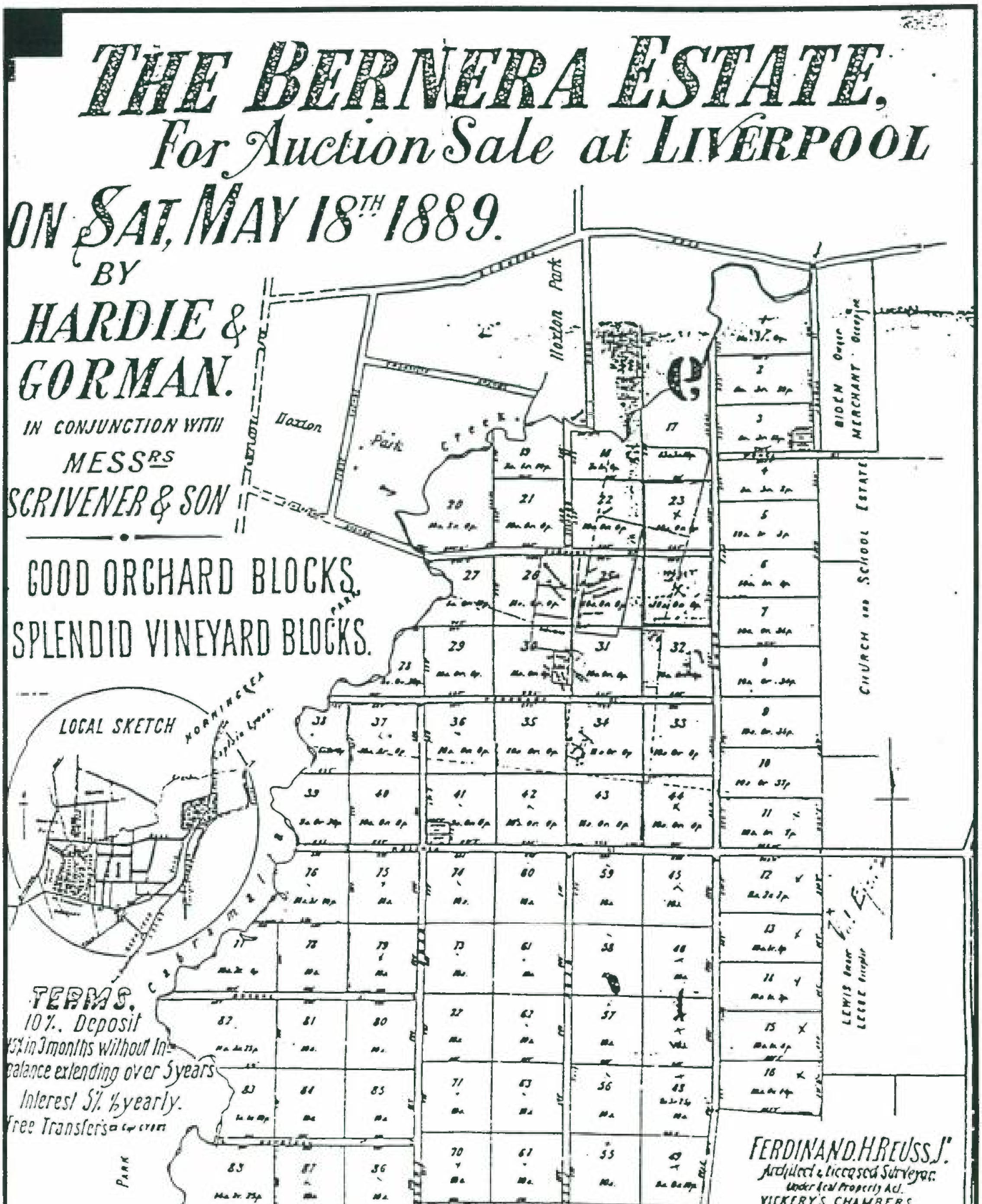


Figure 2.7: Bernera Estate plan as subdivided in 1889. ML. Subdivision Plans, Liverpool, L/10/4.

The Morris and Britton report on the *Colonial Landscapes of the Cumberland Plain and Camden, NSW*, identified the presence of the site of the Bernera homestead at Prestons but noted that since the fire in 1986 the 'local area has recently developed for suburban housing and the former Bernera is now only an archaeological site'.[4] No other houses, landscapes or sites mentioned in this report are adjacent to the current study area.

The 1947 aerial photos show the Church and School Lands as being generally undeveloped in 1947 indicating that some areas had been cleared very little or that there was considerable regrowth on lands no longer intensively used for grazing or farming (Fig. 2.2, 2.3).

The proposed WSO then passes through the southwest corner of School and Orphan lands, into a small property once owned by Drummond. It then passes through the northeastern part of the Hoxton Park Estate which was subdivided in 1887 and in 1906 was described as 'thickly timbered. Small holdings, a few occupied, the others are covered with thick timber & scrub'.[5] It crosses over the line of Cowpasture Road, an early road in the district. It next passed through a larger estate granted to Barron Field called 'Hinchinbrook' (Fig. 2.1). To the north was 'Cecil Hills', the early estate of Sir John Wylde, Judge Advocate, which has extant original buildings (Fig. 2.6).[6] This house and outbuildings are located on Sandringham Drive, Cecil Hills and are considerably to the east of the proposed realignment of the WSO in this area and are therefore not affected by the WSO.

Elizabeth Drive, which is the northern boundary of the current study area, is within the former boundary of the Cecil Hills Farm grant. The Cecil Hills grant was made in 1817 and was taken up in 1818. The house is thought to have been built c. 1824. The Wylde's ran cattle on the property and sold beef to the government stores. Judge Advocate John Wylde was recognised as one of the largest landholders in the colony in the 1820s. The family retained ownership until 189? when the Perpetual Trustee sold the property. The Crown compulsorily purchased this property in 1972.[7] Only parts of this grant have been subdivided. The 1947 aerial photos show that this area was uncultivated grazing land with some fenced yards with some house and outbuilding groups at some distance from the study area (Fig. 2.5, 2.6). One of the yard areas (WSO-E-2) will be affected by the proposed route of the WSO.

The Hoxton Park Airport, which was initially used as a WWII airstrip, is to the west of Cowpasture Road (Fig. 2.4, 2.5, 2.8). It appears to be mostly within the two early grants to Barron Field and Judge Wylde. The southern end is probably within the Hoxton Park Estate.[8] While it has been reported that the airstrip had 'revetments' these actually consist only of gravel road taxiways.[9] The aim of the taxiways was to allow for the planes to be quickly scattered, in the case of a Japanese attack, into the adjacent tree cover (now Landcom land). An aerial photo (Fig. 2.5) shows the position of the main taxiway from the airport to the revetments and indicates the location of proposed impacts from the WSO alignment.

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[4] Morris and Britton 2000:113.
[5] Quoted in Kass 1992:3.19.
[6] Keating 1996:22.
[7] Heritage Office Register listing, web page.
[8] Mitchell Library, Liverpool subdivision plan L 10/34.
[9] Iain Stuart, pers. comm.

2.2 Review of Historical Aerial Photos

The study area was generally undeveloped by 1947 and 1950. The aerial photos are reviewed from south to the north.

Figure 2.2 (1947) shows the general vicinity of the WSO route was undeveloped although there were houses on Skipton road to the east of the alignment. The route generally goes along the rear of these properties.

Figure 2.3 (1947) indicates two possible sites (WSO-E-2 & 1) within the vicinity of Bernera Road and Joadja Road which are in the path of the proposed alignment. Again the surrounding countryside is mostly grazing land with some rural houses and outbuildings. The site of Bernera is visible to the southeast of the WSO alignment with its layout of intact houses.

Figure 2.4 (1951) this sheet shows that the area to the south of Hoxton Park Airport is mostly grazing land with limited cultivation. There appears to be only one house on this sheet close to the proposed alignment of the WSO, near the end of Government Road (WSO-E-23).

Figure 2.5 (1951) this sheet shows the general deforested appearance of grazing land surrounding Hoxton Park Airport. At the west of the northern end of the airport is the gravel road or taxiway going into the forested area which contained the taxiways. To the northwest of the airport was an area with pens or animal yards adjacent to a dirt road. These yards were probably associated with a house to the southwest. The yards area is directly impacted by the proposed WSO.

Figure 2.6 (1947) on this sheet the areas are more deforested with tracks and creek lines to the south of Elizabeth Drive. The City Farm (WSO-E-6) (indicated) is considerably to the west of the proposed WSO alignment and therefore outside its corridor of impact.

2.3 Archaeological Sites

A number of potential sites were identified within the general area of impact from the WSO. Of the sites in this list only some of them are within the corridor of the proposed WSO.

Item Number (Previous site name)	Description	Location	LGA	Register Listing (AHC, SHR, NT, LEP, SW)	Level of Significance	Proposed WSO Impact
WSO-E-1	Site next to Spanish Mission House. Potential subsurface remains.	Southwest cnr of Bernera Road and Jedda Road, Prestons.	Liverpool	Nil	To be determined but probably **Local**	Direct
WSO-E-2	Site of outbuildings	Jedda Road, opposite Joadja Road, Prestons	Liverpool	Nil	To be determined but probably **Local**	Direct
WSO-E-3	Hoxton Park Airport	Cowpastures Rd Hoxton Park	Liverpool	AHC	Potentially National Estate	Limited impact on taxiway only
WSO-E-4 *(CH-E-1)*	Farm buildings archaeological site	West of Kensington Crescent, Cecil Hills	Liverpool	Nil	To be determined	Direct
WSO-E-5	Upper Canal System: Cecil Hills Tunnel	Junction of Elizabeth Drive/Wallgrove Road	Liverpool	SHR NT, LEP, SW	State	36 m above tunnel, encloses shaft
WSO-E-6	City Farm	East of Trigon Road, Abbotsbury	Fairfield	LEP	Regional Status in LEP following changes to NSW *Heritage Act* is **Local**	No impact
WSO-E-7	Relics of early Homestead	Elizabeth Drive Abbotsbury	Fairfield	LEP	Regional Status in LEP, following changes to NSW *Heritage Act* is **Local**	No Impact
WSO-E-23	Site of house and outbuildings	End of Government Road.	Liverpool	Nil	To be determined but probably **Local**	None

2.3.1 WSO-E-3 Hoxton Park Airport

The airport was initially an airstrip that was used during WW II. The plans and aerial photographs of the airport indicate that the most extensive part of the remains of the revetment are within Landcom land and not within the area of impact from the WSO which is further to the east. The impact from the WSO will be on the remnant taxiway leading to the taxiways in the forested area (Figs 2.5, 2.8, Photos 2.1, 2.2). There may also be some impact near the southwestern boundary of the airport but this has to be refined during the detailed assessment process. There was another taxiway in this area which now is a bitumen taxiway and is within the current road alignments outside the airport boundary (Fig. 2.8).

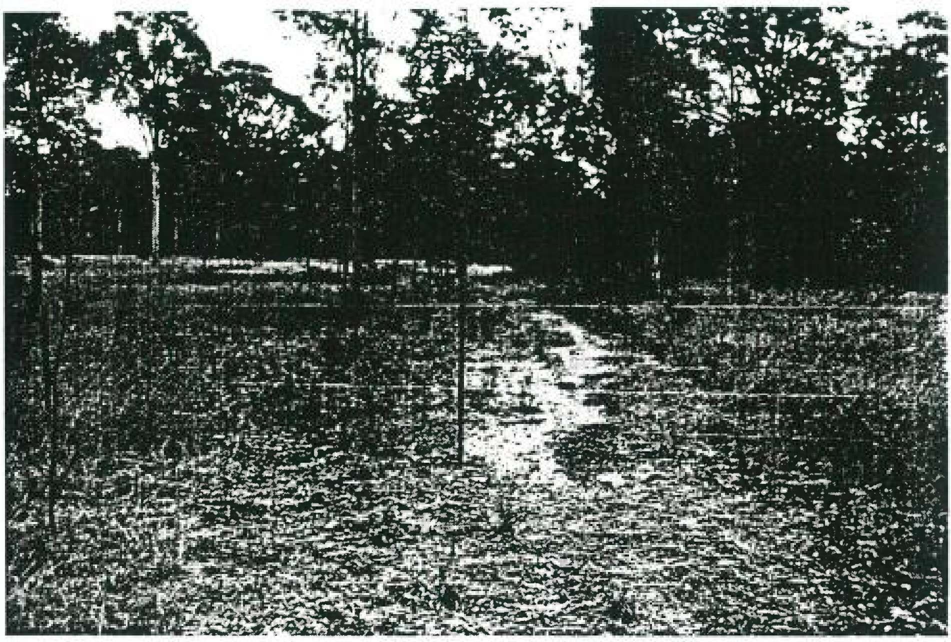

Photo 2.1: View to west into Landcom land showing the boundary between Landcom land and the proposed WSO route land. The gravel road is the taxiway.

Photo 2.2: View to east showing the alignment of the taxiway as overgrown and not particularly distinct. The proposed WSO alignment goes through this area.

A recent heritage report has been written on Hoxton Park Airport by HLA Envirosciences. Permission to obtain this report has been requested from the owner but it has not yet been made available. This report was only finalised at the end of June 2001 and was written as part of addressing the issues regarding a nomination of the airport to the National Estate. This site is currently on the interim register of the National Estate and is therefore protected under Section 30 of the Australian Heritage Commission Act. This requires the appropriate Federal Government agency to refer the matter to the Australian Heritage Commission for advice on the heritage issues affecting this site.

Hoxton Park RAAF Landing Ground 1942

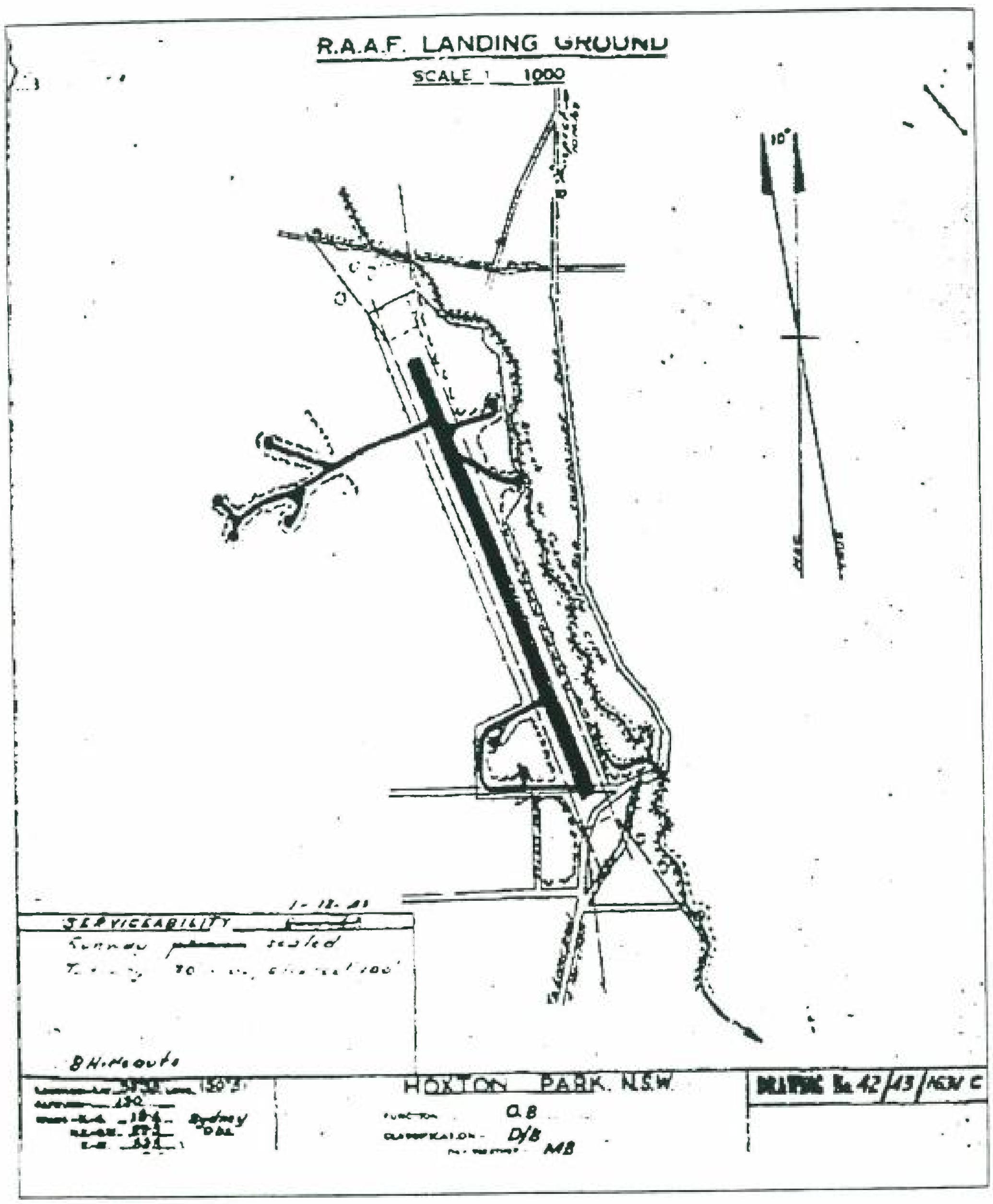

Figure 2.8: Plan of Hoxton Park Airport in 1942. Provided from application for listing on the National Estate.

2.3.2 WSO-E-4 Farm buildings - archaeological site

This area contains the remains of a series of fenced yards that are partly burned and extend for some distance (Photo 2.3). The extant evidence for this site mostly consists of extensive remains of timber-fenced yards and some loose masonry. Some of the posts have adze marks perhaps indicating an early date. These yards were probably associated with the house to the west which is outside the proposed area of impact (Fig. 2.5). Further research is required to identify and deal with the nature of this site and its significance during the assessment process.

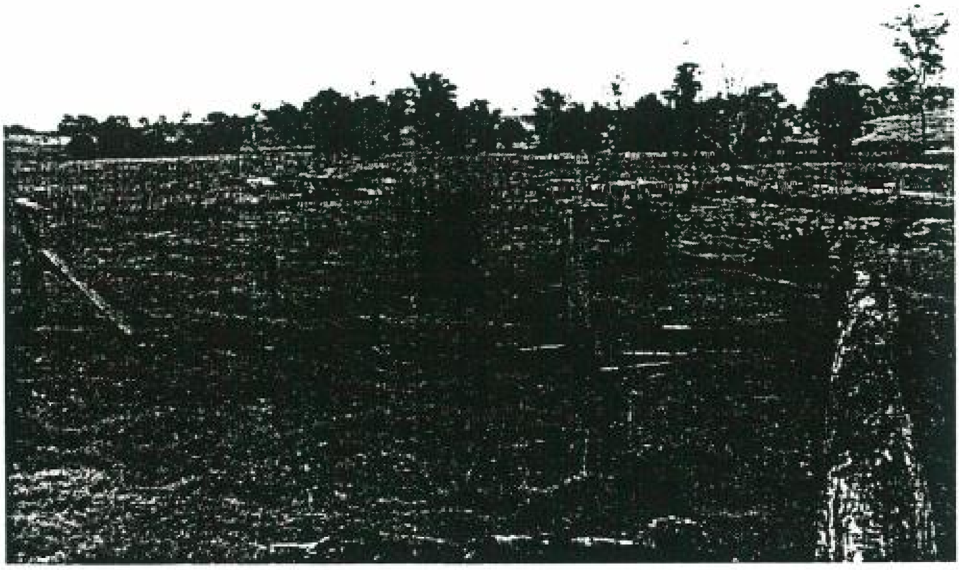

Photo 2.3: View to northwest showing remains of fenced yards.

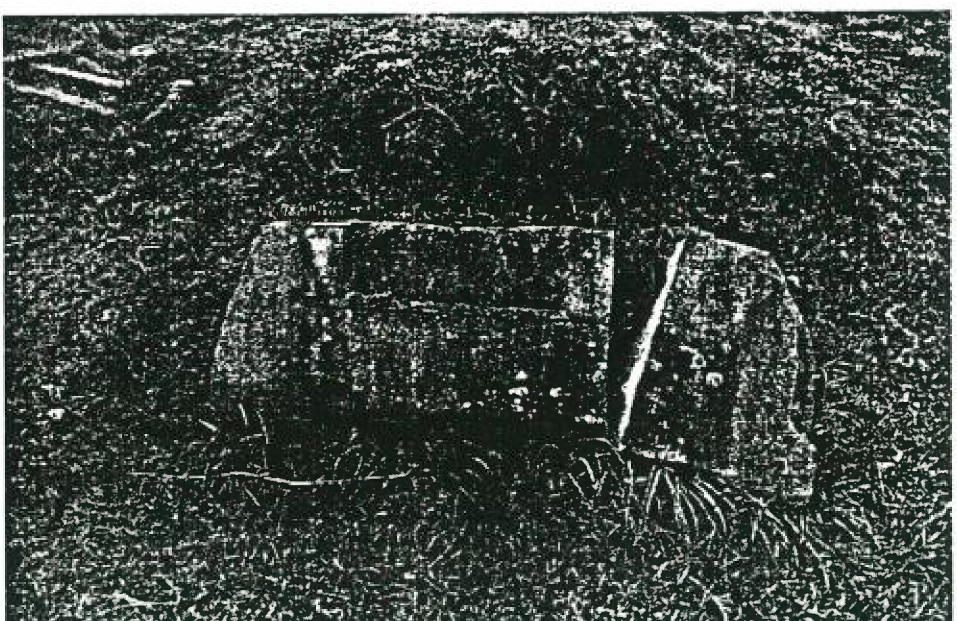

Photo 2.4: Large block of sandstone found adjacent to the yards.

2.3.3 WSO-E-5 Upper Canal System – Cecil Hills Tunnel

The Cecil Hills Tunnel is an integral part of the nineteenth-century Upper Canal System which provides water to Sydney. It is managed by the Sydney Catchment Authority. The upper canal is a 36-mile (57 km) conduit of tunnels, open canals and aqueducts. Work on the scheme commenced in 1880 and was completed in 1888.[10] The tunnel was excavated in the 1880s as part of a system of tunnels and canals that transfers water from the Upper Nepean to Prospect Reservoir. A total of seven shafts were sunk to allow for driving the tunnel both directions from the shafts. Shaft no. 4, adjacent to Elizabeth Drive and Wallgrove Road, is approximately 110 feet (33.8 m) deep (Fig. 4). The top of the shaft is covered with a circular sandstock brick structure with hard cement mortar and capped with rough-faced and margined sandstone blocks and a steel lid (Figs 5, 6). The shaft and tunnel are both brick lined.[11] The shaft structure is 1.8 m by 1.8 m. The top of the tunnel is approximately 33.8 m deep where the proposed line of the WSO intersects with the line of the Cecil Hills Tunnel.

Other tunnels in the Upper Canal system include Trafalgar Tunnel, Weston Tunnel, Calmsleys Tunnel, Devils Back Tunnel, Molles Main Tunnel, Badgally Tunnel, Mt Annan Tunnel, and Sugarloaf Tunnel. All of these tunnels have shafts. No details are available on the number of shafts within the tunnel system. The shafts were used to excavate the tunnels, to remove stone from the tunnel cuttings and to provide air to the system. They still operate this way today. No specific details are available on the shafts within the tunnel component of the system from the overall heritage study completed in 1992.[12] According to comments from SCA workers all other shaft covers are pyramidal sandstone block structures.

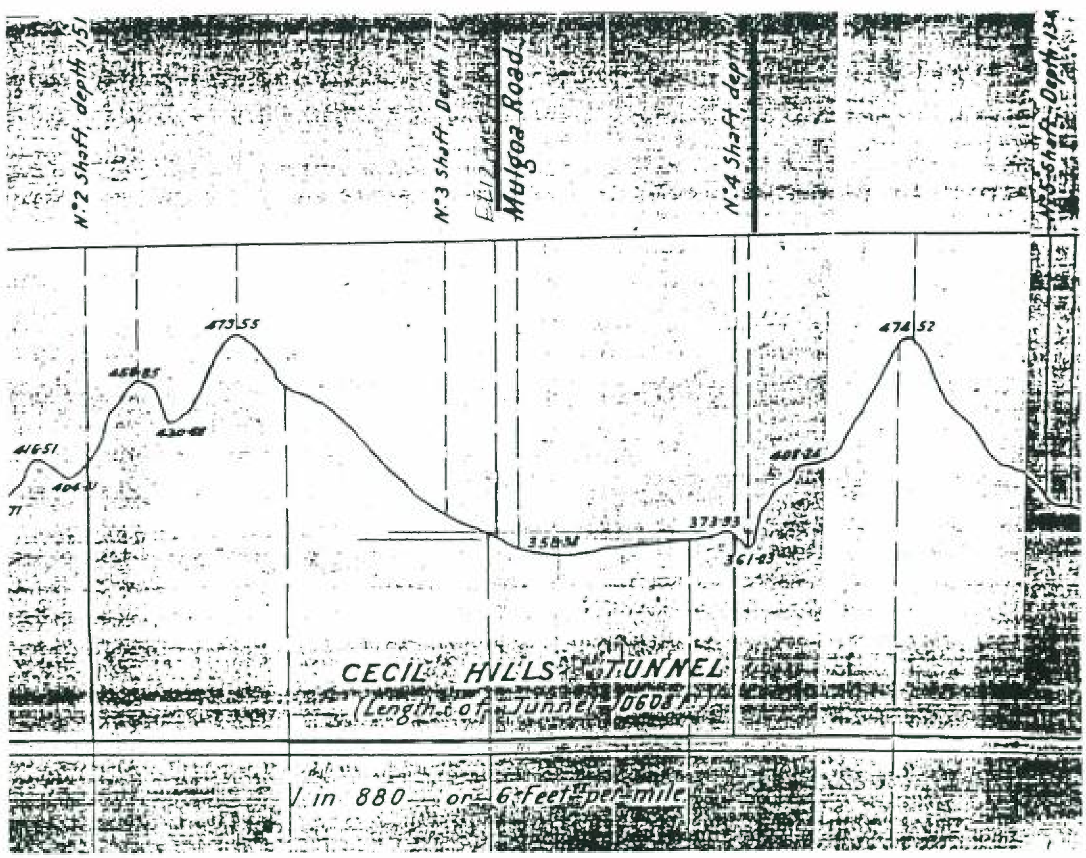

Figure 2.9: Section through Cecil Hills tunnel showing the position of Elizabeth Drive. Shaft no. 3 is 126 feet (39 m) deep near the proposed alignment of WSO not far from Elizabeth Drive.

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[10] Aird 1961:16-17.
[11] Inventory Form from Heritage Study, Sian Waythe (SCA) pers. comm.
[12] Sian Waythe, SCA pers. comm.

2.3.4 WSO-E-2 Site of Outbuildings

The aerial photograph showed that there were a group of outbuildings in this area that were probably associated with a house on Jedda Road, opposite Joadja Road (Fig. 2.3). These outbuildings were on a property that was part of the subdivision of the 'Church and School Estate' (Fig. 2.7). These buildings appear to be twentieth century. Modern works on this property show that there has been considerable build up of fill levels in this area which will have buried any potential archaeological remains (Photos 2.5, 2.6). Additional research is required to identify the nature of the archaeological potential of this site and its heritage significance as part of the detailed assessment of the site.

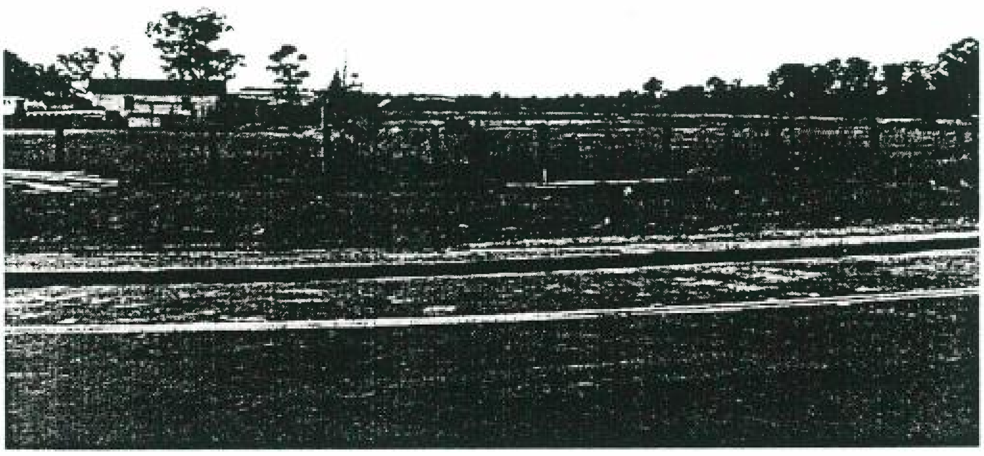

Photo 2.5: View to southeast from Bernera Road near corner with Jedda Road. Piles of fill in background have raised the original levels in this area.

Photo 2.6: This area includes the site of WSO-E-2 - farm outbuildings and extensive layers of fill imported into this area.

2.3.5 WSO-E-1 Site next to Spanish Mission House - subsurface remains

The 1947 aerial (Fig. 2.3) shows an extensive group of buildings in this area which may be associated with the derelict remains of a fibro Spanish Mission style house c. 1930s (Photo 2.7) or with another house which according to initial research was owned and occupied by a Mr Sharpe. No remains survive of the buildings that were adjacent to the derelict house. The area is currently covered by blackberries and extensive sapling regrowth (Fig. 2.8). Any buildings in this area would post-date the 1889 subdivision. Additional research is required to identify the nature of the archaeological potential of this site and its heritage significance. This will be undertaken as part of the detailed assessment stage.

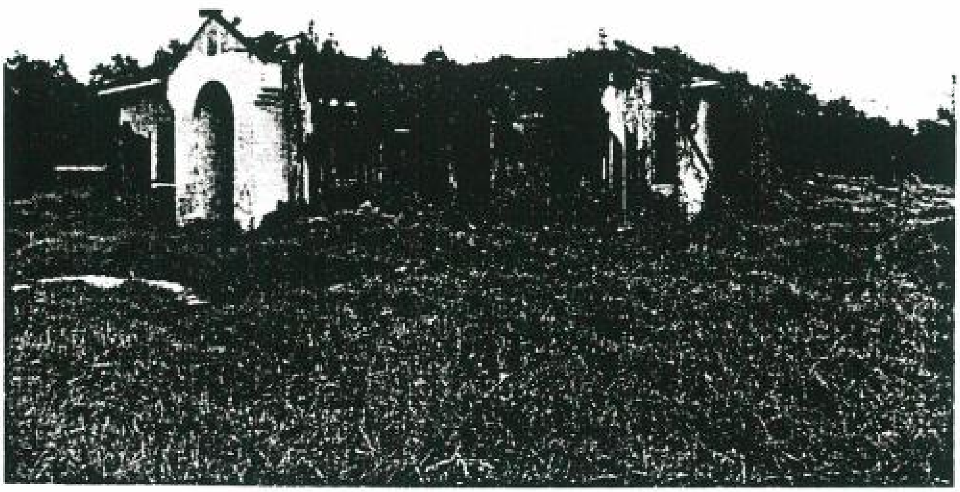

Photo 2.7: Ruined fibro Spanish Mission style house on western corner of Bernera and Jedda Roads, Prestons.

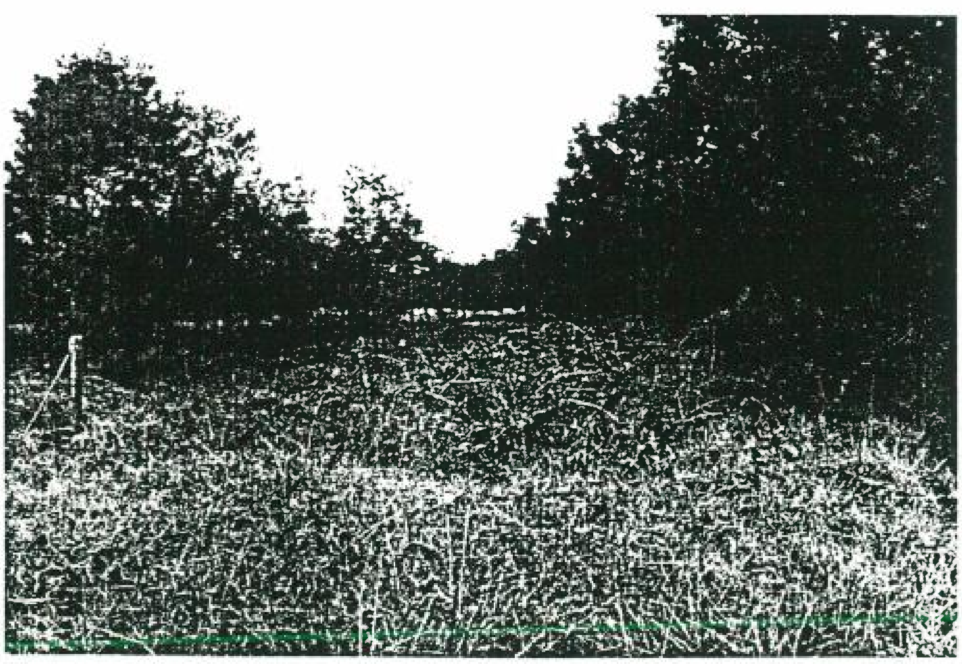

Photo 2.8: Land to south of house that was shown occupied by a group of buildings on the 1947 aerial. It is now covered with blackberry bushes and extensive saplings. The proposed WSO route goes through this area.

2.3.6 WSO-E-23 Site of house and outbuildings

Figure 2.4 shows a single house and outbuildings previously located at the eastern end of Government Road. The location of this house, when compared to the modern house near this area (Fig. 2.10), appears to be further to the west in the vicinity of the new housing estate. It is therefore considerably outside the proposed alignment of the WSO. Based on our current understanding no further work is required on this site as there are to be no impacts from the proposed alignment of the WSO.

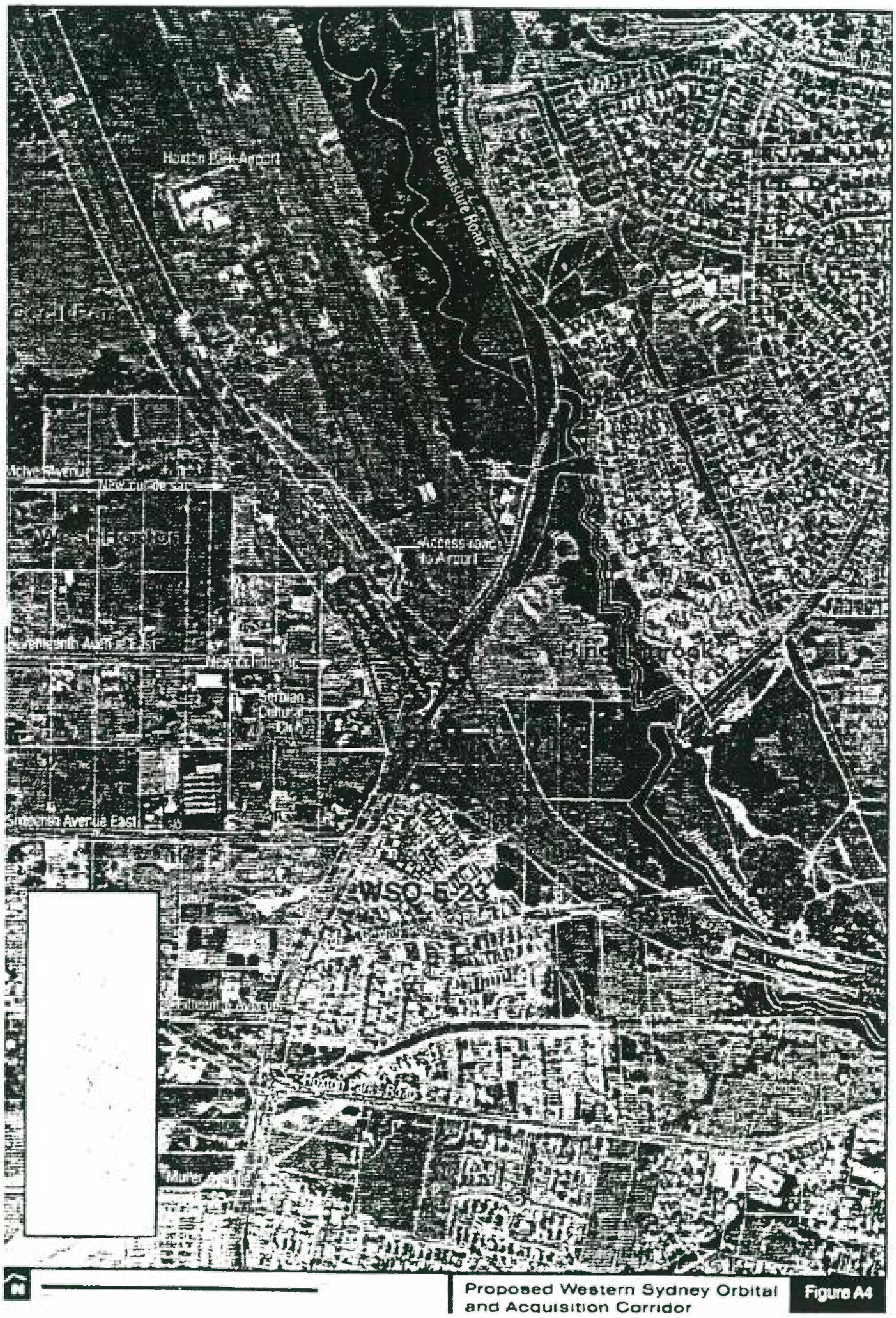

Figure 2.10: Recent aerial photo overlaid with proposed route of WSO. The probable location of the house and outbuildings (WSO-E-23) is indicated on this aerial by a black dot. It is on the edge of the new housing estate and appears to be outside the boundary of the WSO alignment.

2.3.7 Cowpasture Road

Mary Casey and Tony Lowe inspected the length of Cowpasture Road that will be affected by the proposed line of the WSO. All culverts were modern concrete and there was no evidence for earlier road elements (Photo 2.9). The visual significance of this section of Cowpasture Road has been assessed by Warwick Mayne-Wilson.

Photo 2.9: Main concrete culvert on Cowpasture Road where the road will be altered by the proposed WSO.

3.0 Heritage Significance

3.1 Heritage Significance

No detailed significance assessment of sites within the study area has been undertaken as part of this survey report. Where there are stated or known levels of heritage significance these are listed below. Three of the identified potential archaeological sites are indicated as likely to have a local level of heritage significance. This is based on the later nineteenth or early twentieth-century date for their construction and occupation and the indication that these are generally representative of types of sites known to be typical of the local area and land uses. These sites will be assessed in more detail, as part of an archaeological assessment. This process requires further historical research to be undertaken which allows for a better understanding of the nature and significance of the sites and allows for the making of more detailed recommendations.

Interim National Estate

- WSO-E-3 - Hoxton Park Airport

State Significance

- WSO-E-5 - Upper Canal System: Cecil Hills Tunnel

Probably of Local Significance

- WSO-E-1 - Site next to Spanish Mission House. Potential subsurface remains.
- WSO-E-2 - Site of outbuildings
- WSO-E-4 - Farm buildings archaeological site

4.0 Results and Recommendations

4.1 Results

The southern section of the WSO contains a series of known and potential heritage sites and relics. These are:

Item Number (Previous site name)	Description	Location	LGA	Register Listing (AHC, SHR, NT, LEP, SW)	Level of Significance	Impact
WSO-E-1	Site next to Spanish Mission House. Potential subsurface remains.	Southwest cnr of Bernera Road and Jedda Road, Prestons.	Liverpool	Nil	To be determined but probably **Local**	direct
WSO-E-2	Site of outbuildings	off Jedda Road, opposite Joadja Road, Prestons	Liverpool	Nil	To be determined but probably **Local**	direct
WSO-E-3	Hoxton Park Airport	Cowpastures Rd Hoxton Park	Liverpool	AHC	Potentially National Estate	taxiways
WSO-E-4 *(CH-E-1)*	Farm buildings archaeological site	West of Kensington Crescent, Cecil Hills	Liverpool	Nil	To be determined but probably **Local**	direct
WSO-E-5	Upper Canal System: Cecil Hills Tunnel	Junction of Elizabeth Drive/Wallgrove Road	Liverpool	SHR, NT, LEP, SW	State	above position of tunnel, buries shaft

All these sites have a minimum level of protection under the relics provisions of the Heritage Act while some have a further level of protection, such as being listed on a LEP or on the State Heritage Register.

4.2 Recommendations

1. All of the identified heritage sites within the southern area of the proposed WSO alignment, excepting the Cecil Hills tunnel, require detailed assessments of heritage significance and an analysis of impacts from the WSO alignment as the next stage of the heritage process. The sites requiring archaeological assessments are:
    - WSO-E-1 - Site next to Spanish Mission House. Potential subsurface remains.
    - WSO-E-2 - Site of outbuildings
    - WSO-E-3 - Hoxton Park Airport
    - WSO-E-4 - Farm buildings archaeological site
2. These sites need to be assessed in accordance with the NSW Heritage Office *Archaeological Assessment Guidelines*. These assessments may make recommendations for further archaeological work which may include: testing, recording, archaeological investigation (excavation), monitoring, avoidance of a site or other appropriate recommendations.
3. The Cecil Hill Tunnel, which is on the SHR, requires investigation to establish the depth of the tunnel within the study area, near the intersection with Elizabeth Drive and Wallgrove Road, and the impact on the shaft which it is proposed to bury. An understanding of engineering issues in relation to the roadworks can only be determined once the successful contractor identifies appropriate methodology. Details of potential impacts from construction works need to be established, such as, vibrations and other impacts. If there are any potential issues from construction works these need to be mitigated. RTA has advised that 'The successful Contractor will be advised to ensure that he protects from damage the tunnel and vent'.

5.0 Statutory Requirements and Approvals

5.1 Summary List of Statutory Requirements and Approvals

All items included in this list are protected under the NSW *Heritage Act* 1977 (amended):

Item Number (Previous site name)	Description	Register Listing (AHC, SHR, NT, LEP, SW)	Statutory Requirements	Approval	Level of Significance
WSO-E-1	Site next to Spanish Mission House. Potential subsurface remains.	Nil	Relic provisions of NSW *Heritage Act*	s. 140 approval - NSW HO	To be determined but probably **Local**
WSO-E-2	Site of outbuildings	Nil	Relic provisions of NSW *Heritage Act*	s. 140 approval - NSW HO	To be determined but probably **Local**
WSO-E-3	Hoxton Park Airport	AHC	Federal agency referral to AHC. Relic provisions of NSW *Heritage Act*	s. 140 approval NSW HO	Potentially National Estate
WSO-E-4 *(CH-E-1)*	Farm buildings archaeological site	Nil	Relic provisions of NSW *Heritage Act*	s. 140 approval NSW HO	To be determined but probably **Local**
WSO-E-5	Upper Canal System: Cecil Hills Tunnel	SHR NT, LEP, SW	SHR register LEP	s. 60 approval NSW HO, LEP approval Liverpool Council	State

6.0 Bibliography

Aird, W. V. 1961 *The water supply, sewerage and drainage of Sydney*, Halstead Press, Sydney.

Bickford, A. & S. Sullivan, 1984 "Assessing the research significance of historic sites", in Sullivan, S. & S. Bowdler (eds), *Site Surveys and Significance Assessment in Australian Archaeology*, Dept. of Prehistory, Research School of Pacific Studies, ANU, Canberra.

Kass, T. 1992 'Thematic History' in Neustein *et al Liverpool Heritage Study*1992:3.4 -3.48.

Keating, C. 1996 *On the Frontier. A Social History of Liverpool*, Hale & Iremonger, Sydney.

Morris, Colleen and Geoffrey Britton, 2000 *Colonial Landscapes of the Cumberland Plain and Camden*, for the National Trust of Australia (NSW), draft.

Neustein & Associates with Somerville, Rod Howard, Terry Kass, Edward Higginbotham, Siobhan Lavelle, Anne Marie Clements and D. Taylor 1992 *Liverpool Heritage Study* for Liverpool City Council.

NSW Heritage Office August 2000 *Assessing Heritage Significance.*

NSW Heritage Office & DUAP 1996 *Archaeological Assessment Guidelines.*

NSW Department of Planning/Heritage Council of NSW 1994 *Manual for the Use of Historical Themes and Evaluation Criteria*

Appendix 4:
Cecil Hills Tunnel Statement of Heritage Impact for a s.60 Application.

RTA

www.rta.nsw.gov.au

Roads and Traffic Authority
ABN 64 480 155 255

Environmental Services Branch

Level 3, 83 Flushcombe Road
Blacktown NSW 2148
Telephone (02) 9672 253
Facsimile (02) 9831 0184
PO Box 558
Blacktown NSW 2148
DX 8120 Blacktown

Mr Gary Pringle
NSW Heritage Office
Level 11
2-10 Wentworth Street
PARRAMATTA 2124

Regarding: Cecil Hills Tunnel

08/08/01

Dear ~~Mr Pringle~~ Gary,

Thank you very much for meeting with us earlier this week. Further to your enquiries at that meeting, and you letter of 09/08/01, please find additional information below to assist you in processing the Section 60 application for the Cecil Hills Tunnel, lodged 03/08/01, along with a cheque for $400; being the prescribed fee.

Justification for Proposal:

The original proposal was to retain the Cecil Hills Tunnel vent to the east of the road. The relocation now places the vent in the median of the road. Although there will be no physical damage to the vent, its visual context on the landscape (which has been assessed as significant) will be altered.

A relocation of the WSO southbound ramp to Elizabeth Drive and the Elizabeth Drive to WSO southbound ramp westwards is required to reduce the footprint of the WSO. The purpose of the proposed relocation is to protect an area of nationally threatened bushland (Cumberland Plain Woodland) and a future area of Western Sydney Regional Park.

Potential Damage of Item by Concrete Footpath:

Further to our discussion regarding damage to the vent by the proposed concrete footpath around the base of the item at the current ground level, we have consulted one of our advising civil engineers for the project, who has provided the following information:

1. *Potential for damage to vent structure due to expansion/contraction of the concrete:*
This would be extremely unlikely as the concrete will be 4m below final ground level and not in direct sunlight. However to overcome the potential for damage the concrete would be fully jointed and an expansion joint material placed for the full depth of the slab around the entire circumference of the brick structure.

2. *Potential for damage due to chemical attack by concrete:*
This scenario is extremely unlikely to impossible. The mortar bonding the bricks currently is cement based and there are no signs of chemical damage. Therefore concrete (also cement based) would not cause any damage.

3. Damage during placement of the concrete surround slab:
As required with all work in the vicinity, the appropriate precautions would be taken to prevent damage. In this instance, plastic covers would be used to cover the vent structure to prevent concrete splashing onto the surface of the bricks. Once the footpath is laid, the plastic cover would be removed.

In order to prevent potential damage to the vent structure, it would be possible to leave the concrete footpath out altogether. This is not recommended as the ground around the structure would possibly become damp and muddy as grass is unlikely to grow, making access difficult and possibly causing damage to the bricks due to permanent soaking.

***Expansion of the Statement of Significance*:**

Please find attached a revised edition of the Statement of Heritage Impact relating to the Cecil Hills Tunnel. The revised edition was undertaken by Casey & Lowe Associates and contains an expansion to the statement of significance and more detailed information on the material, visual and contextual impacts.

The RTA's own investigations into the Upper Canal have been assisted by the SCA. The SCA advises that there is no map evidence in their archives which details the exact number of shafts that exist along the Upper Canal. A field survey conducted by the SCA for the purpose of this heritage assessment located 10 tunnels along the entire Upper Canal and noted that Shaft 4 was the only shaft on the Cecil Hills Tunnel. The remaining 10 tunnels are all located on SCA owned land, most of which is surrounded by private property. Additionally, Shaft 4 is the only known vent structure on the Upper Canal that is built from sandstock brick.

Given the above information, the contextual representativeness of Shaft 4 is highly significant. Hence, the RTA would take all necessary measures to maintain access to Shaft 4 and to protect it from any damage during construction. The measures outlined in Attachment 2 of our application would achieve that objective.

We trust this is now sufficient information for you to process the Section 60 application. Please do not hesitate to contact me if you require further clarification.

Yours sincerely,

Geoff Cahill
Manager, Environmental Services
Client Services Directorate

Statement of Heritage Impact
Proposed Western Sydney Orbital
Cecil Hills Tunnel and Shaft

Statement of Heritage Impact for:
Proposed line of Western Sydney Orbital which would place Shaft 4 of the Cecil Hills Tunnel within the median strip of the proposed new road near the corner of Elizabeth Drive and Wallgrove Road (Figs 1, 2). This property is owned and managed by the Sydney Catchment Authority.

Date prepared:
2 August 2001, amended 8 August 2001.

Heritage Listings:
Cecil Hills Tunnel is listed on the State Heritage Register (gazetted 18 November 1999, no. 1373). It is listed on the Liverpool Heritage LEP, by the National Trust (NSW) and is on the Sydney Catchment Authority's s.170 register.

Statement Prepared by:
This Statement of Heritage Impact was prepared by Mary Casey and reviewed by Tony Lowe of Casey & Lowe Associates for the NSW Roads and Traffic Authority (RTA). Warwick Mayne-Wilson of Mayne-Wilson & Associates has provided advice on visual assessment and impact.

Background
The Cecil Hills Tunnel is an integral part of the nineteenth-century Upper Canal System which provides water to Sydney. It is managed by the Sydney Catchment Authority. The upper canal is a 36-mile (57 km) conduit of tunnels, open canals and aqueducts. Work on the scheme commenced in 1880 and was completed in 1888.[1] The tunnel was excavated in the 1880s as part of a system of tunnels and canals that transfers water from the Upper Nepean to Prospect Reservoir. A total of seven shafts were sunk to allow for driving the tunnel both directions from the shafts. Shaft no. 4, adjacent to Elizabeth Drive and Wallgrove Road, is approximately 110 feet (33.8 m) deep (Fig. 4). The top of the shaft is covered with a circular sandstock brick structure with hard cement mortar and capped with rough-faced and margined sandstone blocks and a steel lid (Figs 5, 6). The shaft and tunnel are both brick lined.[2] The shaft structure is 1.8 m by 1.8 m. The top of the tunnel is approximately 33.8 m deep where the proposed line of the WSO intersects with the line of the Cecil Hills Tunnel.

Other tunnels in the Upper Canal system include Trafalgar Tunnel, Weston Tunnel, Calmsleys Tunnel, Devils Back Tunnel, Molles Main Tunnel, Badgally Tunnel, Mt Annan Tunnel, and Sugarloaf Tunnel. All of these tunnels have shafts. No details are available on the number of shafts within the tunnel system. The shafts were used to excavate the tunnels, to remove stone from the tunnel cuttings and to provide air to the system. They still operate this way today. No specific details are available on the shafts within the tunnel component of the system from the overall heritage study completed in 1992.[3]

[1] Aird 1961:16-17.
[2] Inventory Form from Heritage Study, Sian Waythe (SCA) pers. comm.
[3] Sian Waythe, SCA pers. comm.

Significance of Item
The *Heritage Study of the Upper Canal, Prospect Reservoir, & Lower Canal (Upper Nepean Scheme)*, 1992 by Higginbotham *et al.*, identified the Cecil Hills Tunnel, as part of the Upper Canal as having a state level of significance. While there was no detailed statement of significance for the Cecil Hills Tunnel it was identified as having historic, interpretative, integrity, representative and technical significance (See attachment - Inventory Form). The tunnel was listed as part of the upper canal on the State Heritage Register.

Statement of Significance
The s. 170 register statement of significance is for the Upper Nepean Scheme, of which Cecil Hills Tunnel is a part. The following statement is taken from the s. 170 register inventory form.

The Upper Nepean Scheme is significant because:

1. It has functioned as a unique part of the main water supply for Sydney for over 100 years, and apart from development in supply and improvements has changed little in its basic principles since the day it was completed, except for the decommissioning of the Lower Canal in the 1990s.
2. It provides detailed and varied evidence of engineering construction techniques prior to the revolution inspired by reinforced concrete construction. Although concrete was later used to improve the durability of the Sydney, much of the earlier technology is still evident along the Canal.
3. It also provides extensive evidence of the evolution of engineering practice, such as the replacement of timber flumes by wrought iron flumes to be followed by concrete flumes. The early utilisation of concrete for many engineering purposes in the System, also demonstrates the growing emergence of an engineering technology based on man-made materials.
4. The Upper Nepean Scheme made the big advance from depending on local water sources to harvesting water in upland catchment areas, storing it in major dams and transporting it to the city by means of canals and pipelines.
5. In its scope and execution it is a unique and excellent example of the ingenuity of late nineteenth century hydraulic engineering in Australia, illustrating the techniques of canal building (often at extremely small grades), the progressive improvements in both pipe manufacture and pipeline construction, and the construction, even by present day standards, of a large earth fill and rock dam. Of particular note is the way in which it was designed to supply a large area of Sydney by gravity.
6. Now, over 100 years later, its components are still par of Sydney's main water supply System, an in most cases operate in essentially the same was as was originally envisaged, except for the decommissioning of the Lower Canal in the 1990s.
7. Of the way in which the initial Scheme completed in 1888 lent itself to progressive development over a period of over 100 years to meet Sydney's increasing water supply needs.
8. Many of the original control installations such as the "stoney gates", s top logs, penstocks and gate valves, are still in service and continue to illustrate the technology of the time.
9. The scheme possesses many elements of infrastructure which are of world and national renown in technological and engineering terms.

Significance under previous criteria (s. 170 register extracted from Higginbotham *et al.* 1992):

Historical Significance:
The Upper Nepean Scheme has functioned as part of the main water supply system for Sydney for over 100 years, and apart from development in supply and improvements has

changed little in its basic principles since the day it was completed, except for the decommissioning of the lower Canal in the 1990s.

Now, over 100 years later, the components of the Upper Nepean Scheme are still part of Sydney's main water supply System, and in most cases operate in essentially the same way as was originally envisaged, except for the decommissioning of the Lower Canal in the 1990s.

Aesthetic Significance
The Upper Nepean Scheme is an excellent example of the ingenuity of the late nineteenth century hydraulic engineering, illustrating the techniques of canal building (0ften at extremely small grades), the progressive improvements in both pipe manufacture and pipeline construction, and the construction, even by present day standards, of a large earth fill and rock dam. Of particular note is the way in which it was designed to supply a large area of Sydney by gravity.

Technical/Research
The Upper Nepean Scheme provides detailed and varied evidence of engineering construction techniques prior to the revolution inspired by reinforced concrete construction. Although concrete was later used to improve the durability of the Sydney, much of the earlier technology is still evident along the Canal.

It also provides extensive evidence of the evolution of engineering practice, such as the replacement of timber flumes by wrought iron flumes to be followed by concrete flumes. The early utilisation of concrete for many engineering purposes in the System, also demonstrates the growing emergence of an engineering technology based on man-made materials.

The Upper Nepean Scheme made the big advance from depending on local water sources to harvesting water in upland catchment areas, storing it in major dams and transporting it to the city by means of canals and pipelines.

Now, over 100 years later, the components of the Upper Nepean Scheme are still part of Sydney's main water supply System, and in most cases operate in essentially the same way as was originally envisaged, except for the decommissioning of the Lower Canal in the 1990s.

It is highly significant that the initial Scheme, completed in 1888, lent itself to progressive development over a period of over 100 years to meet Sydney's increasing water supply needs.

Rare

Many of the original control installations such as the "stoney gates", s top logs, penstocks and gate valves, are still in service and continue to illustrate the technology of the time.

Representativeness

Although many of the features of the Upper Nepean Scheme are used elsewhere in the SWC system, nonetheless many of the structural elements are unique to the Upper Nepean Scheme.

Integrity/Intactness

Apart from the decommissioning of the Lower Canal, which still remains a distinct entity, the whole of the Upper Nepean Scheme remains largely intact and preforms the same functions as originally intended.

There is no detailed statement of significance for the Cecil Hills Tunnel and no detailed mention of the shafts.

Comments on Visual Issues[4]

Figure 8 is a photo looking north from the junction of Elizabeth Drive and Wallgrove Road. The shaft is not visible at this point although it is only about 200 m to the north. It is scarcely a noticeable element in the landscape.

This raises the issue as to whether a purely functional item such as a brick airshaft that is related to an underground tunnel warrants either a curtilage or consideration of view corridors or catchments to it. Certainly, no consideration would have been to views from it in any direction when the shaft was built, as this was quite irrelevant. Nor, of course, did it have any visual or functional relationship with Cecil Hills farm.

It is clear that the proposed line of the WSO would be running directly over the shaft. It is for others to decide how it should be best treated in that event. However, there would be no *visual* loss to the community, or its ability to be aware of, or to interpret, the tunnel if the shaft were to be covered over by the WSO. A tunnel, by its nature, is underground, and this one makes no contribution to visual landscape character.

Other shafts along the Cecil Hills Tunnel

The other shafts along the Cecil Hills Tunnel are built in large sandstone blocks in a pyramidal form.[5] This is the only shaft of this form among the approximate 20 shafts in all the tunnels.[6] In my view because this shaft was so close to a roadway (Elizabeth Drive) it was built so it would not be particularly visible and therefore not be subject to vandalism.

Proposed Impact

As the tunnel is about 33.8 m deep where it passes underneath the proposed alignment of the WSO at the junction of Elizabeth Drive and Wallgrove Road there will be no impact on the tunnel (Fig. 4). It is proposed that the above-ground shaft structure will be enclosed by the proposed WSO alignment. Appropriate measures, based on engineering advice, will be put in place to protect the tunnel and shaft and shaft structure and to mitigate impacts.

Methodology for Mitigating Impacts

The following methodology was produced by Australian Water Technologies (AWT), and the NSW Roads and Traffic Authority (RTA) in consultation with Sydney Catchment Authority (SCA).

The proposed works around the shaft and surface structure:

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[4] Comments in this section are from Warwick Mayne-Wilson.

[5] Sian Wyeth and Byron Grant, SCA staff pers. comm.

[6] Byron Grant pers. comm. The SCA does not have details on shaft numbers or their configuration. They are in the process of surveying the top of the Cecil Hills Tunnel to confirm the number of shafts and the configuration of the shaft capping structures. There are currently access problems to doing this.

- The structure will be positioned in the median of the Western Sydney Orbital between the main southbound and northbound carriageways.
- The concept design surface level is planned to be raised by approximately 4m at the location of the surface structure.
- No damage or alteration to the structure will be acceptable.
- The brick surface structure shall be protected from damage by a surrounding reinforced concrete protective structure. The protective structure shall be constructed so as to provide clear access, at the existing ground surface level around the entire circumference of the brick surface structure, of no less than 1 metre wide between the two structures.
- In order to prevent surface water runoff from entering the new protective structure and the access shaft, the new protective structure shall be constructed so that it extends by approximately 0.5 metres above the future median invert level. Surface water shall be diverted around the protective structure by localised shaping and bunding of the fill in the median.
- Access to the Upper Canal access shaft and surface structure shall be provided via the median of the Western Sydney Orbital. Flexible unbound pavement areas shall be constructed adjacent to both the northbound and southbound carriageways either side of the new protective structure in the median. These pavements shall allow SCA vehicles such as trucks and cranes (50T crane) to park next to the protective structure for maintenance and SCA access purposes. The pavements shall be weather proof, however they need not be sealed.
- The new protective structure shall be provided with a removable steel lid, which shall be fitted such that a gap of 20mm is made between the under side of its edge and the protective structure.
- Within the protective structure, just below the steel lid, a removable mesh screen shall be provided as a secondary measure to prevent falls or objects being dropped into the access shaft.
- At the base of the protective structure (and the access shaft surface structure), the surrounding ground shall be paved with a 75mm thick unreinforced concrete slab. The slab shall be constructed so that water is directed away from the brick surface structure towards a subsoil drainage pipe, which drains to the outside of the Western Sydney Orbital embankment.

Access into the protective structure for SCA personnel shall be achieved by the provision of an extendable steel ladder bolted to the inside face of the protective structure. A platform to allow access to the top of the brick surface structure shall be installed approximately halfway down the inside face of the protective structure.

The proposal impacts on the heritage significance of the item in the following way:
The proposed methodology outlined above retains the physical fabric and integrity of the item. While the proposed methodology will surround the item it will still provide access both inside and outside of the item. According to the visual assessment there will be no visual loss to the community if the shaft structure is no longer visible. In general the impact on the item is limited to burying it within the road but all other components of the system will still operate - it will provide air and access to the tunnel. There will be no loss of access to an operating part of the Upper Canal system. Therefore the proposed Western Sydney Orbital will have no material effect on the state significance of the Cecil Hills Tunnel or the Upper Canal or the Upper Nepean Scheme.

Impacts on the item would be mitigated by:
- Retaining any fill away from the sides of the structure.

- Putting protective measures in place during construction to ensure the structure is not accidentally damaged.
- Acceptable levels of vibration being established that will not cause damage to the visible structure, as well as the integrity of the shaft itself and the tunnel.

List of figures:

Attachments:

- Inventory Form, *Heritage Study of the Upper Canal, Prospect Reservoir, & Lower Canal (Upper Nepean Scheme)* 1992.
- Section 170 register listing, Sydney Catchment Authority

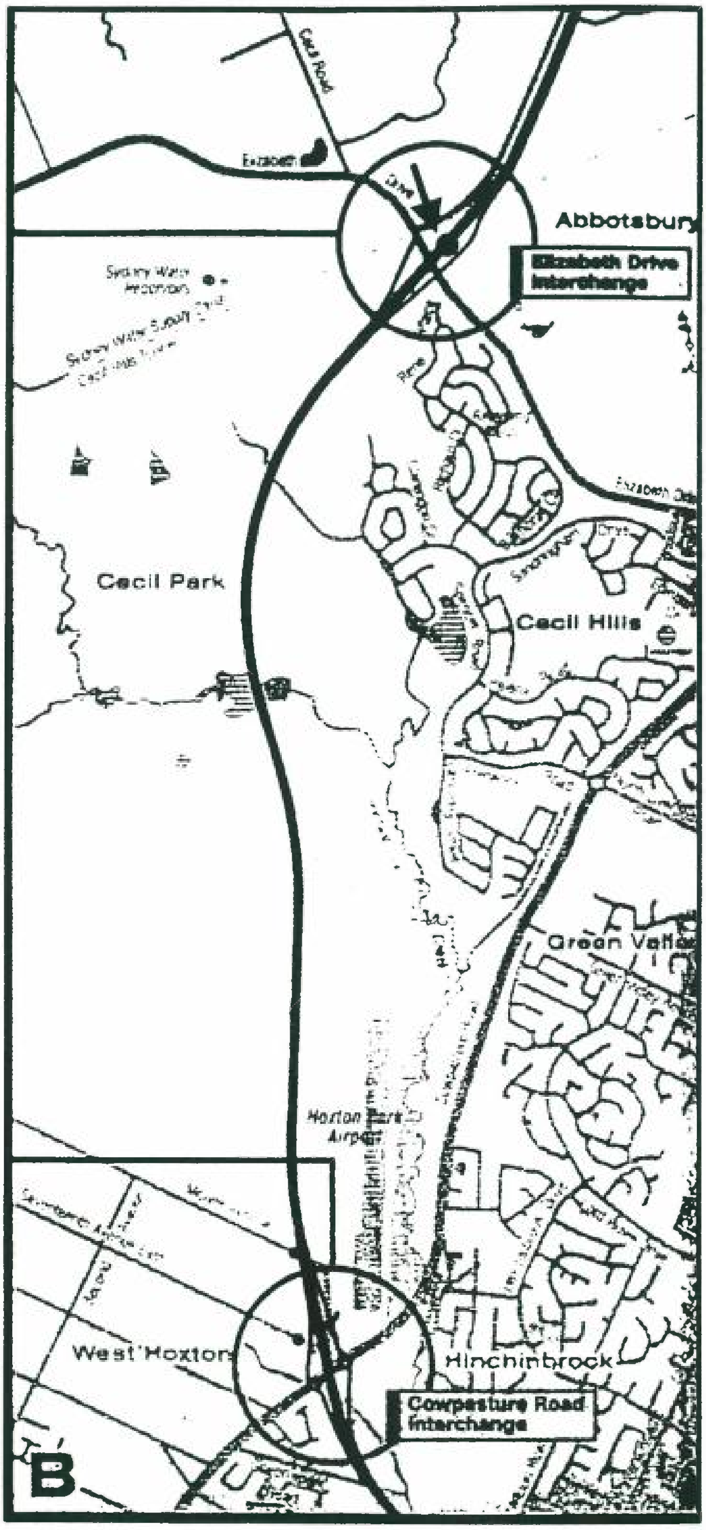


Figure 1: Location plan.

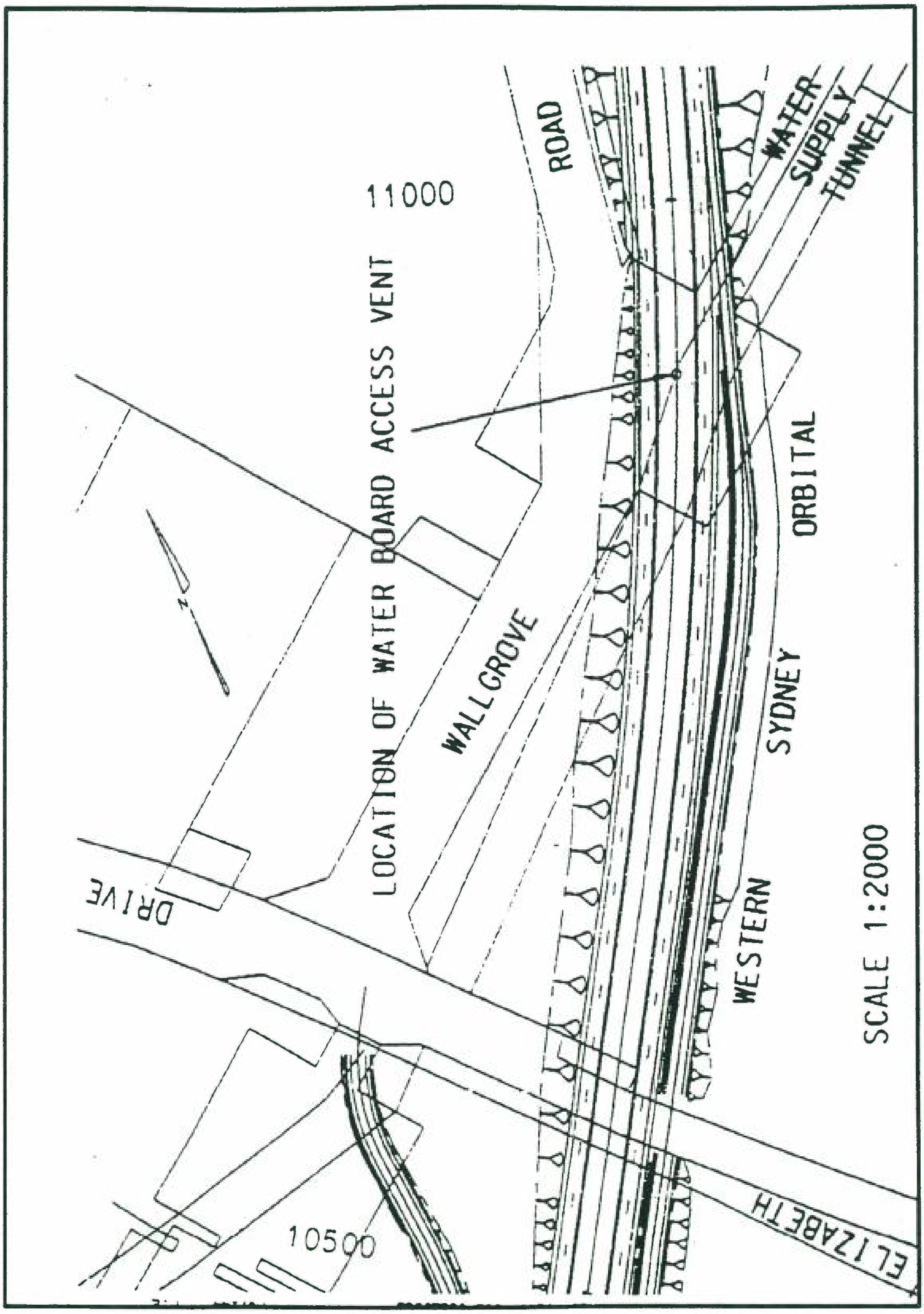


Figure 2: Plan showing the proposed line of the WSO and the position of the vent.

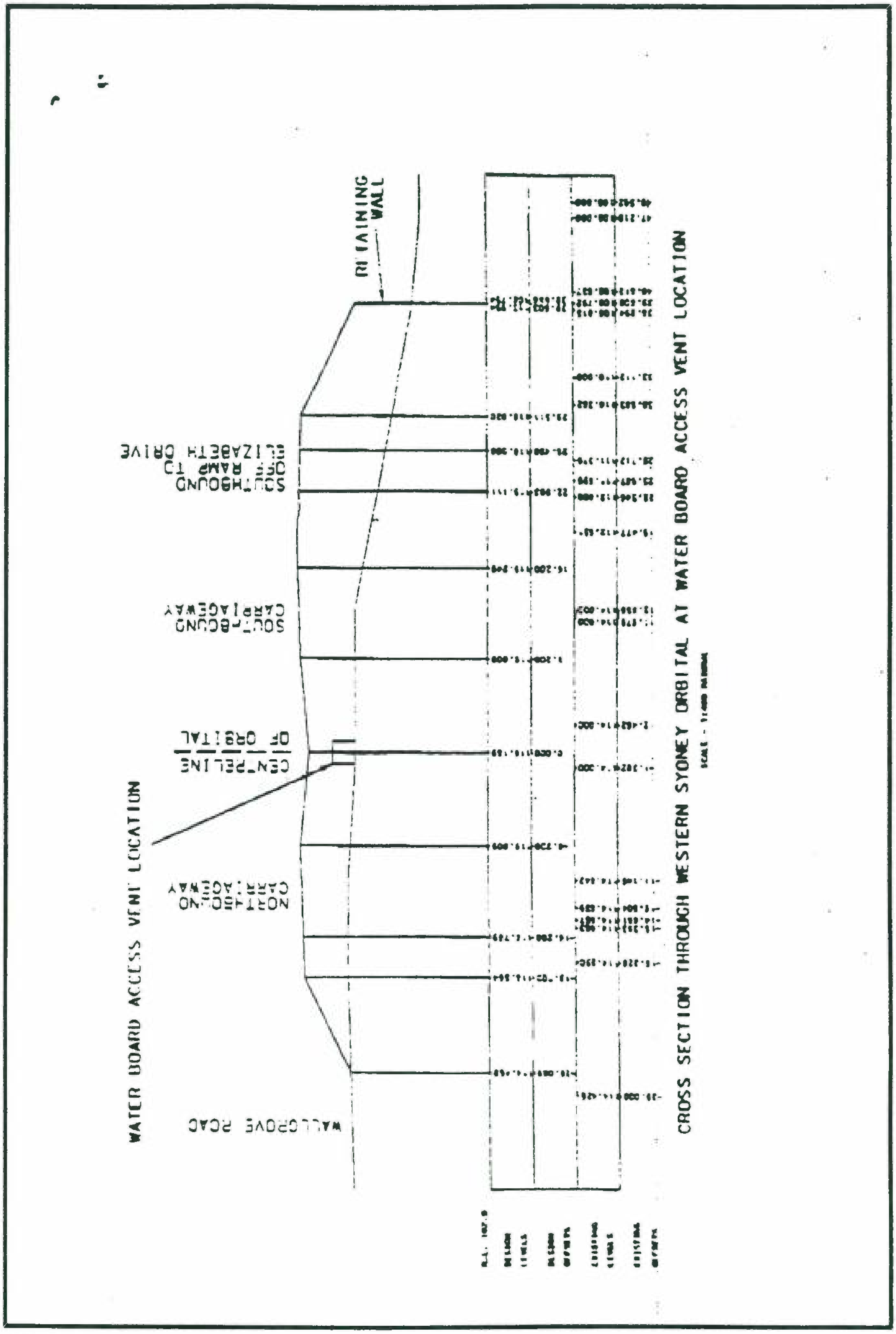


Figure 3: Section through the proposed WSO showing the position of the vent.

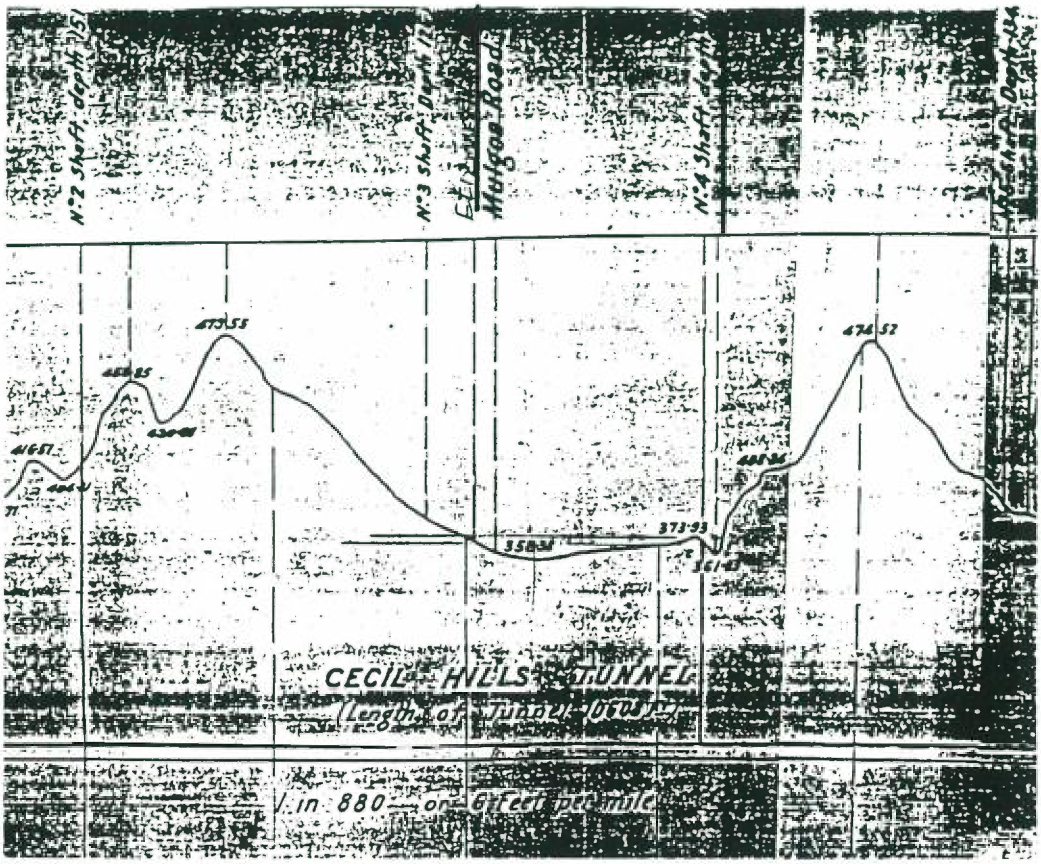


Figure 4: Historic section through Cecil Hills Tunnel showing the shaft and depth of tunnel.

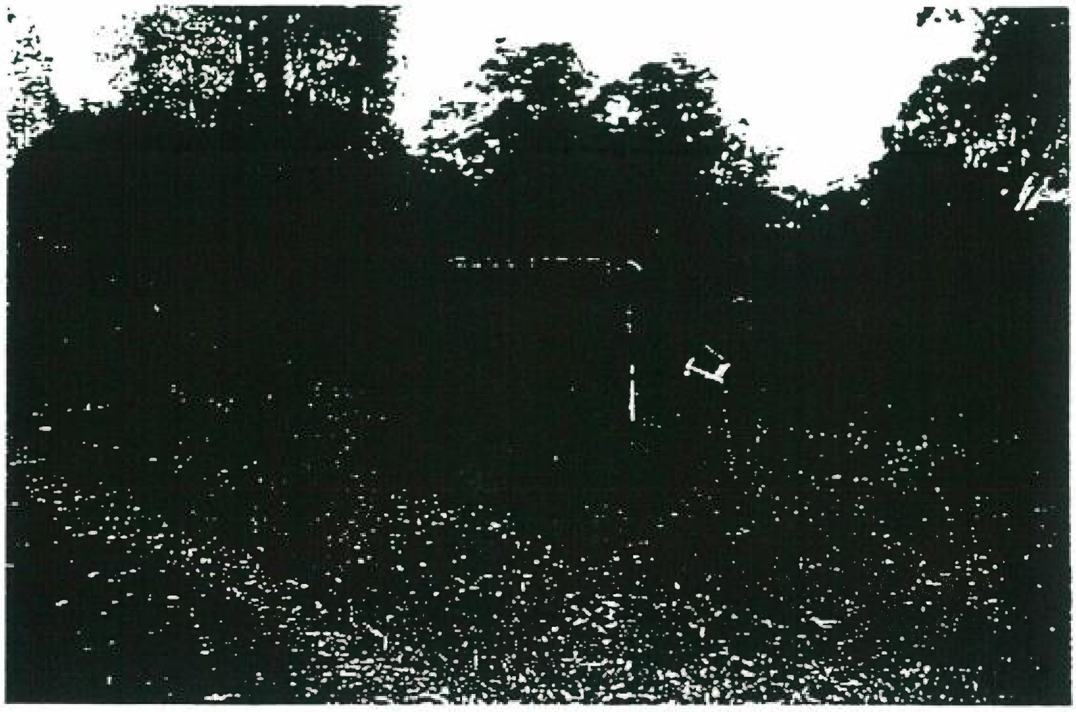


Figure 5: Photo of above-ground shaft structure adjacent to Wallgrove Road and Elizabeth Drive.

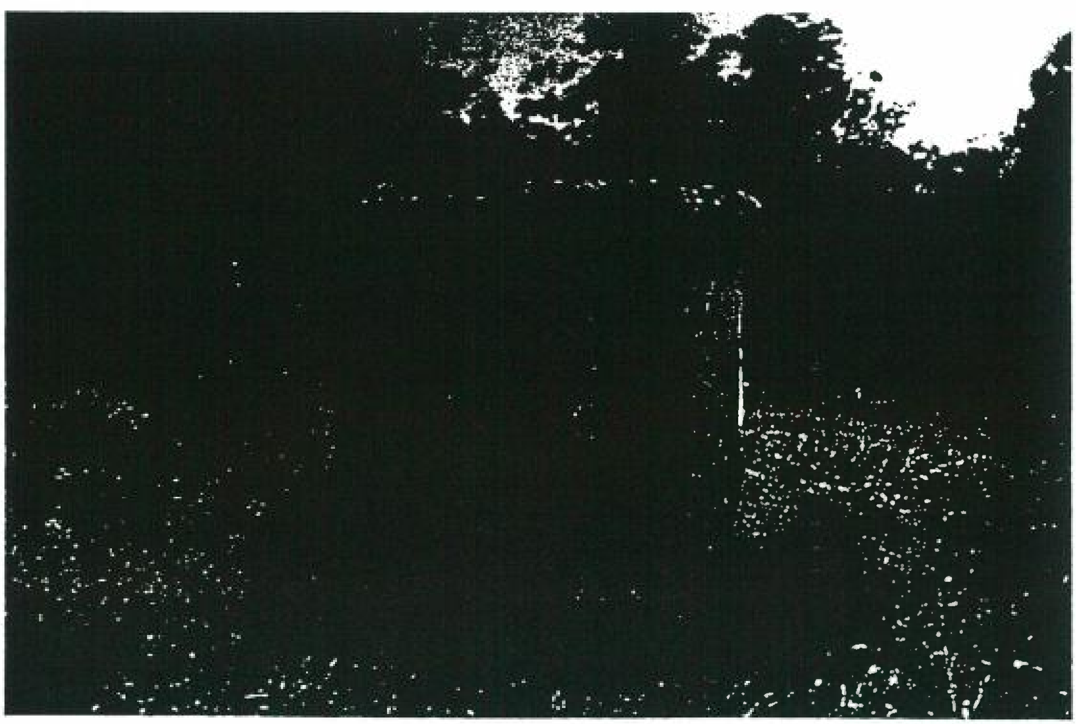


Figure 6: Shaft structure.

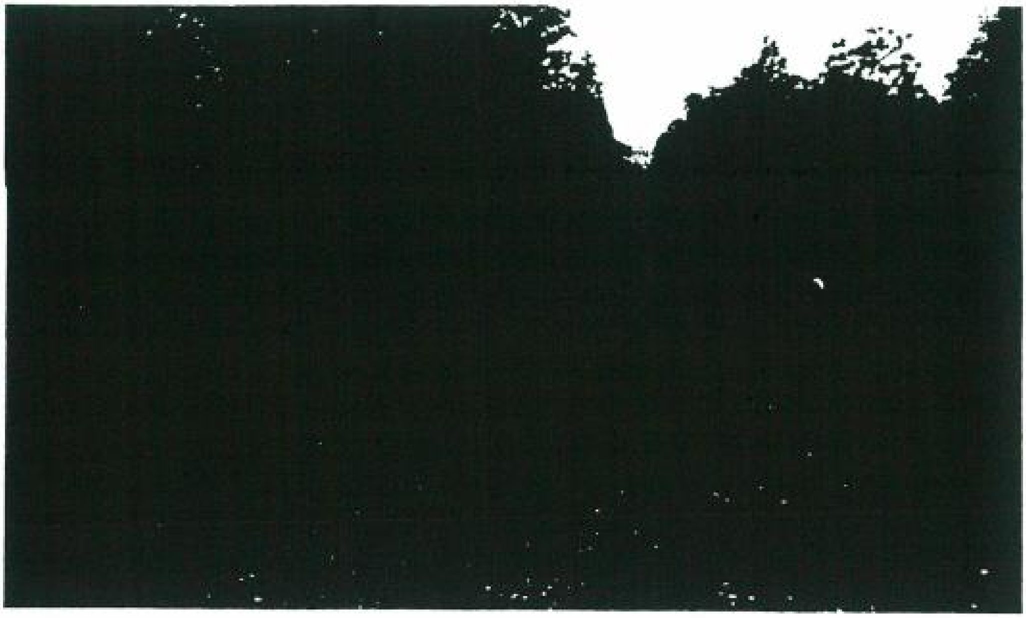


Figure 7: View of shaft structure from a distance of about 20 m. The mown strip is to the right of the shaft. The white vent is the gas pipeline.

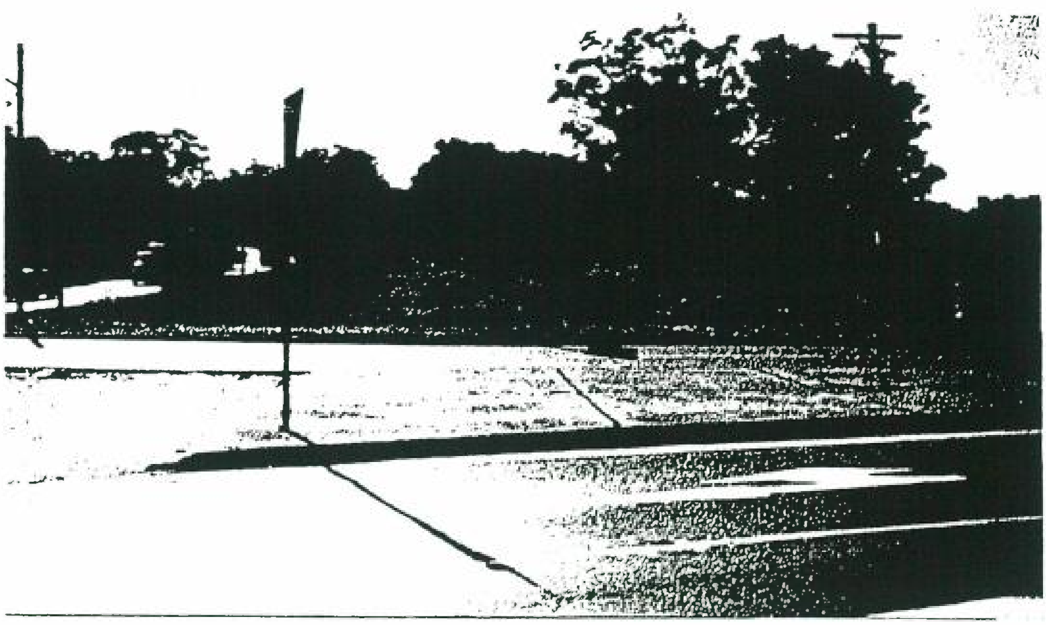


Figure 8: View to the north from the intersection of Elizabeth Drive and Wallgrove Road. The shaft cover is not visible at this point. Photo by Warwick Mayne-Wilson.

Inventory form

Locality Upper Canal **Section no.** 10 **Inventory no.** 21 **Photograph**

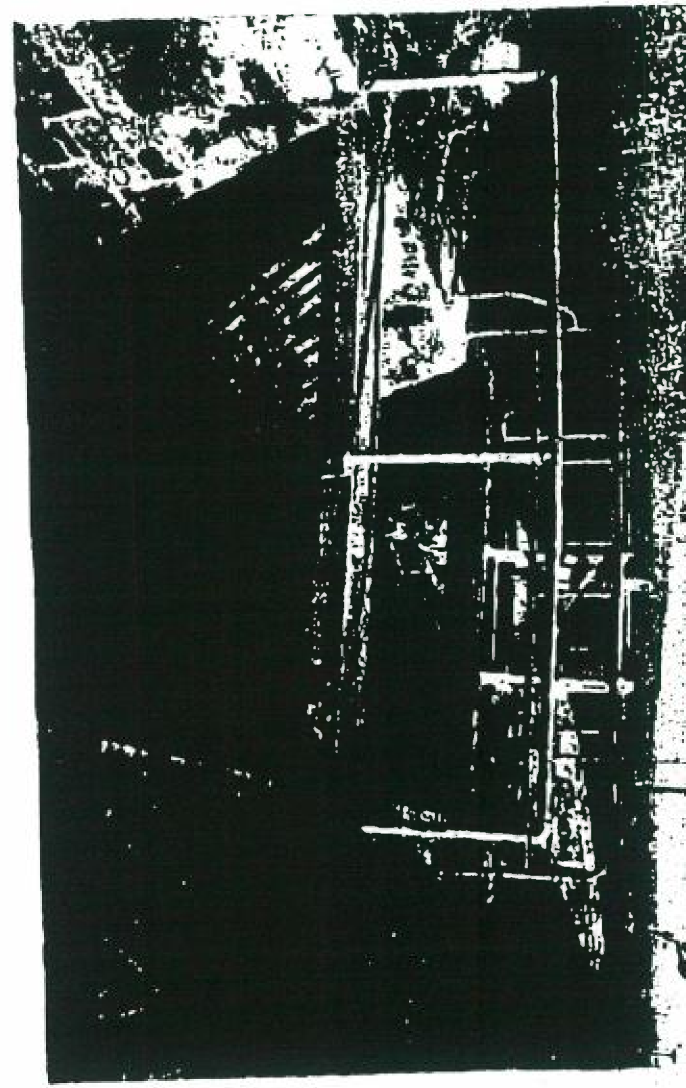
Precinct no. **Precinct name**

Item name Cecil Hills Tunnel

Item type Tunnel **Type no** 2

No of extant examples 10 **Date from** 1888 **Date to**

Location Commencing at approximately 34 5/8 miles



Item description The Cecil Hills Tunnel is a brick-lined tunnel driven through (largely) shale formation. It has an oval cross-section and is 10,608 feet long (approximately 3210 metres), 9 1/2 feet wide (2.8 m), and 7 1/2 feet high (2.3m) with a 7 foot depth of water. It commences at about 34 5/8 miles and ends at about 36 5/8 miles. It has a gradient of 6 feet per mile. The tunnel has 7 air shafts, some of which have been filled. The southern portal of the tunnel has a 3-ring brick arch forming the tunnel inlet with a headwall of English bond brickwork. The headwall has a decorative rendered string-course and coping. A marble plaque on the headwall reads:" CECIL HILLS / TUNNEL / 11 465 FEET ". At the approach to the tunnel , about 82 yards (75 metres) south of the inlet, there are two steel and concrete docks across the canal which support a large iron "trash rack" (c 1920s) and a hand operated winch and chain which raises the rack enabling easier removal of debri. A covered way adjoins the northern end of the tunnel, commencing at about 36 5/8 miles and continuing to approximately 36 3/4 miles. The covered way is 10 feet 3 inches wide (3.1 m) and 8 feet 3inches (2.45 m) high, with a gradient of 4 feet per mile, total length 845 feet (256 metres).The north portal of the covered way has a 3 ring brick arch with English bond brick headwall and a concrete coping. The boundary between Sections 10 and 11 is positioned just beyond the end of the the tunnel covered way.

Level of significance State **Nature and degree of significance** Historic
Interpretive
Integrity
Representative
Technical

Recommendations This item or group of items should be conserved. A conservation plan should be prepared prior to disturbance.

References Water Board, Official Handbook 1913

Roll 9 **Negative** 3.4.5

Recorded by S. Lavelle **Date entered** 8/8/91

Water Board, 1991

Item Name: **Upper Nepean Scheme.**

Location: **From Pheasant's Nest to Pipe Head, Guildford.**

Address: From Pheasant's Nest to Pipe Head **Corner:**

State:

Suburb / Nearest Town: Guildford.

Other/Former Names:

Group ID:

Area/Group/Complex: Upper Nepean Scheme.

Local Govt Area:

Local Government Area:	DUAP Region:	Historic region:
Wollondilly	Illawarra & Macarthur	Sydney
Campbelltown	Illawarra & Macarthur	Sydney
Camden	Illawarra & Macarthur	Sydney
Liverpool City	Sydney West	Sydney
Fairfield City	Sydney West	Sydney
Blacktown City	Sydney West	Sydney
Holroyd	Sydney West	Sydney

Property Identifier:

Boundary:

Item Type: Built **Group:** Utilities - Water **Category:** Water Supply Canal

Owner: Sydney Water

Owner Codes: Water **Code 2:** Upper Nepean Sche **Code 3:** Other

Current Use: Water supply canal and associated works.

Former Uses: Water supply canal and associated works.

Assessed Significance: **State** **Endorsed Significance:**

Statement of Significance: The following statement of significance is for the Upper Nepean Scheme as a whole. The significance of individual items within the Scheme is entered onto each inventory form in the Upper Nepean Scheme Heritage Study.

The Upper Nepean Scheme is significant because:

1. It has functioned as a unique part of the main water supply system for Sydney for over 100 years, and apart from development in supply and improvements has changed little in its basic principles since the day it was completed, except for the decommissioning of the Lower Canal in the 1990s.

2. It provides detailed and varied evidence of engineering construction techniques prior to the revolution inspired by reinforced concrete construction. Although concrete was later used to improve the durability of the System, much of the earlier technology is still evident along the Canal.

3. It also provides extensive evidence of the evolution of engineering practice, such as the

Item Name: **Upper Nepean Scheme.**

Location: **From Pheasant's Nest to Pipe Head, Guildford.**

replacement of timber flumes by wrought iron flumes to be followed by concrete flumes. The early utilisation of concrete for many engineering purposes in the System, also demonstrates the growing emergence of an engineering technology based upon man-made materials.

4. The Upper Nepean Scheme made the big advance from depending on local water sources to harvesting water in upland catchment areas, storing it in major dams and transporting it to the city by means of major canals and pipelines.

5. In its scope and execution it is a unique and excellent example of the ingenuity of late nineteenth century hydraulic engineering in Australia, illustrating the techniques of canal building (often at extremely small grades), the progressive improvements in both pipe manufacture and pipeline construction, and the construction, even by present day standards, of a large earth fill and rock dam. Of particular note is the way in which it was designed to supply a large area of Sydney by gravity.

6. Now, over 100 years later, its components are still part of Sydney's main water supply System, and in most cases operate in essentially the same way as was originally envisaged, except for the decommissioning of the Lower Canal in the 1990s.

7. Of the way in which the Initial Scheme completed in 1888 lent itself to progressive development over a period of over 100 years to meet Sydney's increasing water supply needs.

8. Many of the original control installations such as the "stoney gates", stop logs, penstocks and gate valves, are still in service and continue to illustrate the technology of the time.

9. The scheme possesses many elements of infrastructure which are of world and national renown in technological and engineering terms.

The listing includes the canal and all associated structures, together with landscaping and plantings, unless specifically excluded, to the property boundary.

Historical Notes or Provenance: History of the Upper Nepean Scheme.

In 1867, the growth of Sydney coupled with recurring dry seasons, brought into sharp focus the pressing need for a water supply which was larger and more reliable than the existing Botany Swamps source. This lead the Governor (Sir John Young) to appoint a special Commission to investigate how an adequate long term supply might be achieved.

The Commission reported in 1869 and recommended the Upper Nepean Scheme whereby water from the head waters of the Upper Nepean River and its tributaries, the Avon, Cordeaux and Cataract Rivers would be conveyed by canal, tunnel, pipe and aqueduct to a storage reservoir to be built at Prospect. From there another canal would carry the water to a basin at Guildford from where it would be piped to a smaller service reservoir at Potts Hill for distribution to Sydney.

After a lapse of six years during which no decision was made, and a number of alternative proposals were circulated, the government decided to engage an eminent English civil

Item Name: Upper Nepean Scheme.

Location: From Pheasant's Nest to Pipe Head, Guildford.

engineer, W. Clark, M. I. C. E., to review the various proposals. Clark arrived in November 1876 and, in May 1877, after reviewing eight schemes, strongly endorsed the Upper Nepean Scheme.

An Appropriation Act was passed in July and work commenced in 1880. Construction was carried out by contractors under the direction of the Harbours and Rivers Branch of the Public Works Department. The head of that branch was Edward Orpen Moriarty, who contributed a great deal to public engineering works of the time. He was responsible for the both the design and execution of the works and had a number of site engineers under him. His signature appears on most of the plans of the Scheme.

When the Scheme had initially been proposed in 1869, Moriarty had then drawn up plans for parts of the System, such as weirs and aqueducts. Between 1869 and when work actually commenced in the 1880s, alterations had been made to the initial plans. In 1869, Moriarty had proposed to bridge the creeks, which the Upper Canal would cross by means of aqueducts with approaches built on top of dry rubble stone walls. When the Scheme was finally under construction in 1884, he drew up new plans to cross these creeks with wrought iron inverted syphons.

Work proceeded as rapidly as possible once contracts were let, but by June 1885, because of continued dry seasons, there were only about ten days supply remaining in the Botany Swamps. In response to urgent demands for relief, the government of the day accepted an offer made by the Sydney engineering firm of Hudson Brothers (later to be incorporated as Clyde Engineering) to provide a temporary supply by bridging the gaps in the Upper Canal where creeks remained to be crossed, and, also, carrying the water from Pipe Head by elevated temporary fluming to the Botany Swamps.

Matters proceeded rapidly and, when a bond to commence the work was signed on 3 September 1885, work was already underway. Maximum use was made of the firm's workshops at Redfern and Granville to fabricate the various components, including the manufacture of 1200 cast iron pipes. Many of these 36 inch diameter pipes were laid to operate as inverted syphons, supported on timber trestles above flood level, over the creeks intersecting the route of the Upper Canal.

Although the correspondence was minuted, "There are no plans", some plans of the temporary inverted syphons exist in the Water Board Design Branch Plans Room.

Hudson's temporary Scheme delivered its first water in January 1886 and functioned until the Upper Nepean Scheme was commissioned in 1888, after which it was dismantled and sold.

Construction and Operation of the System.

The great merit of the Upper Nepean Scheme is that it was, and still is, a gravity one. Water harvested in the Southern Highlands, when diverted by the Pheasants Nest and Broughtons Pass weirs, flowed all the way down the Upper Canal into Prospect Reservoir, thence along the Lower Canal to Pipe Head, then by pipe to Potts Hill Reservoir and again by pipe to Crown Street Reservoir from where it was reticulated to the major portion of the city and

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suburbs of the time, all by gravity. Even more remarkable is that there still exists an area of Sydney, known as the "gravitation zone" which receives its water by gravity via Prospect Reservoir, the Lower Canal, Pipe Head, Potts Hill. The Lower Canal has been taken out of service, with water from Prospect Reservoir being piped to Pipe Head.

The Upper Canal was built of a variety of materials with section profiles depending upon the nature of the country through which it was passing. Where the ground was soft, the Canal was V shaped and the sides were pitched with shale or sandstone slabs. In other sections, a U shape was utilised and here the sides were walled with sandstone masonry, or, if cut into solid rock left unlined. Where the canal had to go under a hill, tunnels were excavated. These were left unlined if cut through in solid rock, or lined with brick or stone, if cut through softer material. Where the canal crossed creeks or large depressions, such as Elladale, Simpson's, Ousedale, Mullaly, Woodhouse, Nepean's and Leaf's Creeks, the water was carried across in wrought iron invertec syphons resting upon stone piers.

To supply water for towns along the route, such as Camden, Campbelltown, Ingleburn and Liverpool, offtakes were built at suitable points along the Canal, where stop logs were used to divert water. At the Liverpool Offtake, a small storage dam was built in the 1890s, for use when the canal was emptied for cleaning or repairs.

In addition, stopboards or bulk-heads permitted the closing of sections of the Canal for cleaning and repairs. So that stormwater, polluted with animal and other wastes, did not find its way into the Canal, and so pollute Sydney's drinking water, a series of flumes carried stormwater over the canal. At first many of these flumes were built of timber, but gradually they were replaced by wrought iron and even later, by concrete flumes. Bridges carried major roads such as the Camden Road over the canal. In addition, "occupation bridges" allowed property owners access between their holdings.

After travelling a total of 39 3/4 miles (64 kilometres) from Pheasant's Nest, the water entered the Trafalgar Tunnel, where it passed over a measuring or gauging weir and then along the inlet race into Prospect Reservoir. Prospect Reservoir was built in the 1880s as the major storage dam for Sydney's water supply. It is an earth dam with a crest length of 7300 feet (approximately 1.37 miles or 2.2 kilometres) consisting essentially of a puddled clay core with shoulders of selected earth placed in layers 12 inches thick and compacted by rolling. The upstream face of the dam wall is pitched with locally quarried diorite blocks 18 inches thick as protection against wave action. The maximum height of the dam is 86 feet (26.2 metres). A brick and stone outlet tower draws water from the dam and feeds it through pipes laid in a brick-lined tunnel under the wall to the Valve House, which controls the discharge of water into the Lower Canal. When the Upper Nepean Scheme was completed in 1888, Prospect was Sydney's only storage dam and its level fell drastically during dry seasons when the flow of the diverted rivers often almost ceased completely. In 1902, pumps were used to take water from the Upper Canal directly to the Lower Canal because the level of Prospect Reservoir had fallen below gravitation level.

The Lower Canal was constructed in similar fashion to the Upper Canal although most of it was built as a V section open cutting lined with stone pitchers. Below Prospect Hill, it entered what was called the "covered way". In 1903, the covered way collapsed when the Canal was emptied and it was rebuilt in concrete.

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The Lower Canal terminated at Pipe Head Basin, initially built simply as the point at which the water was let into a 72 inch pipe feeding the Reservoir at Potts Hill. At Potts Hill, the water was screened to remove dirt, vegetable matter and other unwanted debris. From Potts Hill, the water was then piped under gravity pressure to consumers in the various parts of Sydney.

The water supply was managed by a Resident Engineer, housed at Veteran Hall at Prospect Reservoir until 1912, when the construction of an additional Reservoir at Potts Hill meant that he needed to be housed at that site for better supervision. In 1933, the position of Resident Engineer to control Head Works, was created, and the incumbent was housed at Pipe Head.

By 1898, a telephone line was in operation along the whole length of Upper Canal. In that year, the existing line was duplicated. That line was an integral element in controlling the System. Maintenance men were positioned along the Upper Canal, at Prospect, and at Pipe Head. At the weirs and at Prospect Reservoir, there were valve controllers responsible for the discharge of water along the System.

Care and maintenance of the Upper Canal in particular, was in the hands of Inspector's and maintenance men. They were housed along the Canal in cottages, owned and maintained by the Board. Initially, the men walked or used horses to patrol the length of Canal assigned to them. By the late 1890s, a gradual process of adding roadways along the Canals was under way. The larger creeks were not finally bridged until 1935-6, although one of the early photographs shows a stone embanked roadway across the bed and up the sides of one of the gullies crossed by the Upper Canal.

During the cooler months when the demand for water was lower and requirements could be supplied from water impounded at Prospect, repairs and maintenance were carried out on the Upper Canal. The sides were regularly cleaned, and, by the 1900s, some lengths were being relined.

More extensive work, was either contracted out, or completed by the Board, utilising day labour.

Progressive Development of the Upper Nepean Scheme after 1888.

An outstanding feature of the Upper Nepean Scheme as originally envisaged and constructed was its potential for progressive development. Initially, it was a "run of rivers" scheme, because there was virtually no storage behind the Pheasants Nest and Broughtons Pass weirs. Immediately after its completion in 1888, drought and population growth necessitated its further development and this was implemented over a period of nearly fifty years by the construction of major storage dams on the Cataract, Cordeaux, Avon and Nepean Rivers as follows:-

* Cataract Dam, built 1907, height 183 feet (55.7 metres), storage 94,300 ML. First large cyclopean masonry dam in Australia.

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* Cordeaux Dam, built 1926, height 191 feet (58.2 metres), storage 50,600 ML. Curved concrete faced cyclopean sandstone.
* Avon Dam, built 1927, height 237 feet (72.2 metres), storage 146,700 ML. Curved, concrete faced, cyclopean sandstone.
* Nepean Dam, built 1935, height 266 feet (81.1 metres), storage 52,000 ML. Curved, concrete faced cyclopean sandstone.

The provision of these major storage dams changed the role of Prospect Reservoir from being Sydney's first storage reservoir to that of being a vital service reservoir to cover the daily fluctuations of demand in the distribution System.

The Upper and Lower Canals continued their role as the main arteries of the System, but upgrading was necessary. The Upper Canal needed only minor work to bring its capacity up to 150 million gallons per day, which applies to this day, but more extensive works were needed to improve the Lower Canal structure and increase its capacity. The capacity of the System downstream of Pipe Head was amplified by the progressive provision of additional 72 inch diameter steel mains, and, in more recent years, by their boosting with electric and diesel pumping stations. An additional major service reservoir was built at Potts Hill between 1913 and 1923.

The work on the Upper Canal consisted mainly of improving its flow characteristics by concreting rough spots on the bottom and sides, and replacing some stone pitching by concrete. By-passes were also provided around the wrought iron inverted syphons crossing the creeks to enable their internal maintenance when demand conditions permitted. Work to improve the capacity of the Lower Canal commenced in 1902. Initially, a length of 1909 lineal feet was reconstructed in concrete, and 846 lineal feet in Monier plates, i. e. pre-cast concrete slabs. An inquiry judged the Monier plates to be the better solution for upgrading the canal, and by 1912, the remaining walls of its whole 5 mile length had been raised 2 feet and lined by this method. The Lower Canal, as reconstructed, had its capacity increased from 50 to 93 million gallons per day whilst subsequent minor improvements and operating procedures have lead to its maximum current day capacity being 100 million gallons per day.

A feature of the Lower Canal was the Boothtown aqueduct of 22 brick arches, each 30 feet span, which carried the canal over a valley. From 1892 onwards, it suffered a series of structural failures to the brick sides of the water channel, until, in 1907, it had to be replaced by a reinforced concrete inverted syphon, 10 feet 6 inches in diameter, located in an earth bank beside the old aqueduct. This was the largest continuous concrete work of its kind constructed in Australia up to that time. It was fitted with the more modern "stoney gates", which were also used to replace the earlier "butterfly" gates to Broughton's Pass in 1912.

As previously mentioned, Prospect Reservoir was completed in 1888, but in 1898, its storage level was raised by 1 foot 3 inches to give it greater operating capacity. The Prospect earthen bank, with its clay core, suffered a series of slumps in 1893, 1898, 1899, 1902. Various remedial measures were carried out, and these included:-

i) the driving of tunnels into the downstream toe to relieve soakage water and their later conversion to permanent rubble drains.
ii) the placing of 12,000 cubic yards of blue metal spawls on the upstream slope at the slump

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areas to stabilise the toe of the bank
iii) Renewal of parts of the leaking clay puddle core
iv) Later extensive re-making of the puddle core down to a depth of 40 feet and further weighting of the toe of the embankment

By 1905, the situation was stabilised, and the technique developed of keeping the clay puddle core suitably moist by means of surface drains to stop its alternate shrinking and expanding with consequential leakage and earth movements.

Although no serious trouble was experienced from then on, in 1980, the Board completed a major strengthening of the dam by greatly increasing the volume of the downstream side of the embankment and providing improved drainage facilities in the light of modern knowledge of the stability of earth dams. This work did not alter the length or height of the wall, or the top water level, but only the volume and slope of the downstream side.

Since 1930, two major electric pumping stations have been built on the eastern shore of the Prospect Reservoir-
One to pump water to the adjacent service reservoirs (one an elevated structure) on Prospect Hill to serve the Blacktown and adjoining areas to the north.
One to pump water to a major service reservoir at Thornleigh for the Upper North Shore, thus supplementing the Ryde Pumping Station which was commissioned in 1892, and has received its suction water from Pipe Head since 1903 (prior to that from Potts Hill). There is also another electric pumping station on the south side of the Prospect Reservoir.

As the ever increasing demand for water was met by the construction of the major storage dams previously mentioned, the provision of additional conduits to carry it to the city was also necessary. Particularly deficient was the System between Prospect Reservoir and Pipe Head where the amplified Lower Canal could carry only 100 million gallons per day as compared with the 150 million gallons per day the Upper Canal could carry to Prospect from the dams.

In 1926, a scheme was considered whereby a pressure tunnel would be built between Cecil Hills on the Upper Canal to link up with another pressure tunnel then under construction between Potts Hill and Sydney, thus by-passing Prospect, the Lower Canal, Pipe Head and Potts Hill. This would have been extremely expensive, and, in the event, a 54 inch diameter woodstave main was constructed from the Upper Canal not far from where it entered Prospect Reservoir to the Pipe Head basin and then on to Potts Hill. It was completed in 1927 and could deliver 50 million gallons per day to Pipe Head and Potts Hill or 33 million gallons per day to Potts Hill alone. Later in 1937, it was replaced by a 72 inch (1,800 mm) diameter steel main laid between the Upper Canal from just before its discharge into Prospect Reservoir, and Pipe Head. This main could also be fed directly from Prospect Reservoir. It had a capacity of 34 million gallons per day under Upper Canal head and 45 million gallons per day (later 60 million gallons per day) under Prospect head. Still later, in 1958, when Warragamba water became progressively available to Prospect Reservoir, an 84 inch (2,100 mm) diameter steel pipeline was commissioned between Prospect and Pipe Head with a capacity of 90 million gallons per day.

In more recent years, pumping stations have been constructed to boost the flow through

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these conduits, and in 1986, the position was as follows:-

Lower Canal, 100 million gallons per day, boosted not applicable
72 inch pipeline, 60 million gallons per day, boosted 120 million gallons per day
84 inch pipeline, 90 million gallons per day, boosted 180 million gallons per day.

Thus, it can be seen that the Lower Canal accounted for 40% of the unboosted capacity between Prospect and Pipe Head and 25% of the total boosted capacity, despite being 103 years old. The Lower Canal has now been made redundant by the construction of another pipeline between Prospect reservoir and Pipe Head.

Until 1913, screening of the water was carried out in a large circular screening chamber at Potts Hill, so that, with the changeover of the Ryde Pumping Station suction offtake to Pipe Head in 1903, screens had to be provided there also.

Between 1913 and 1925, three screening basins each 250 feet long by 40 feet wide were constructed at Pipe Head and became a key installation in the System. The entry of water to each chamber was controlled by a "stoney gate".

Each screen was approximately 14 feet (4.3 metres) by 3 feet 3 inches (99 centimetres) and consisted of copper mesh. Initially, a mesh of 625 per square inch was used, then this was later changed to 36 per square inch, but later again to a fine mesh. Of the individual screens, some 600 all told, about 400 were individually lifted by small mobile cranes for regular cleaning, whilst the remainder were cleaned in situ. The cranes were originally powered by crude oil engines, but were converted to electricity in 1917, and two are still in regular use.

In the 1970s, two of the main screening basins were dismantled and replaced by a set of four modern rotary drum screens, known as microstrainers. These have a mesh of 120 X 120, i.e. 14,400 minute holes per square inch.

Pipe Head is now the headquarters for the whole Headworks system of catchment areas, major dams including Warragamba, canals, pipelines and pumping stations. The Resident Engineer no longer lives there but the cottage has been converted to office space. There is a large main office building, workshops and an impressively instrumented supervisory control centre located beside the end of the Lower Canal.

A chlorination plant was installed at Broughtons Pass in 1948 for disinfecting the flow into the Upper Canal after periods of heavy rain. In June 1960, following the installation of a more modern plant, continuous chlorination was implemented to operate under all flow conditions.

National Themes:

State Themes: Utilities

Events

Persons

Technology

Item Name: **Upper Nepean Scheme.**

Location: **From Pheasant's Nest to Pipe Head, Guildford.**

Study Themes:

Designer:

Maker / Builder:

Year Started: **Year Completed:** 1888 **Circa:** No

Physical Description: This is the main listing for the Upper Nepean Scheme. For description of the Upper Nepean Scheme, see above historical description and individual listings for:
The Upper Canal,
Prospect Reservoir,
Pipe Head,
Water supply pipelines,
Veteran Hall.

The Lower Canal is no longer in Sydney Water ownership and is therefore excluded from the listing, although it is still a tangible and integral component of the scheme.

The Upper Nepean Scheme includes, among other items, the Upper Canal, Prospect Reservoir and the Lower Canal. Each of these elements was originally divided up into one or more maintenance sections. The use of the term 'section' therefore usually refers to a maintenance section. These sections were used as the basic framework for the Listings.

There are 11 maintenance sections on the Upper Canal, numbered 1 to 11 from Broughton's Pass in a northerly direction. The north end of the Upper Canal and the western end or commencement of the Lower Canal fall within the maintenance section for Prospect Reservoir. The Lower Canal forms one maintenance section and finishes at Pipe Head, itself forming another maintenance section.

Within each section, there are a variable number of precincts. A precinct was allocated when there was a concentration of items in close (geographical) proximity, for example, Broughton's Pass Precinct within Section 1 of the Upper Canal. A precinct is however an artificial division created for the purpose of the site survey, and does not have any historical meaning.

The Upper Canal commences by tunnel from Pheasant's Nest Weir on the Nepean River. In all historical documentation, measurement along the Upper Nepean Scheme commences at Pheasant's Nest.

Physical Condition: The Upper Nepean Scheme as a whole is in a fair condition.

Modification Dates: See individual listings.

Recommended Management: Manage the place and its components in accordance with the NSW Heritage Office Management Principles and Guidelines for NSW Agencies.

Undertake a Conservation Management Plan for the place and its components prior to

Item Name: **Upper Nepean Scheme.**

Location: **From Pheasant's Nest to Pipe Head, Guildford.**

undertaking any works to the place, which affect significance. The Upper Nepean Scheme Heritage Study should be used as a basis for all future work.

Undertake a Statement of Heritage Impact prior to works which affect the place and/or its components.

Involvement of experienced heritage practitioners is needed in the preparation and execution of works to the place.

Further Comments: See other listings for Upper Nepean Scheme.

Historical Significance: The Upper Nepean Scheme has functioned as part of the main water supply system for Sydney for over 100 years, and apart from development in supply and improvements has changed little in its basic principles since the day it was completed, except for the decommissioning of the Lower Canal in the 1990s.

Now, over 100 years later,the components of the Upper Nepean Scheme are still part of Sydney's main water supply System, and in most cases operate in essentially the same way as was originally envisaged, except for the decommissioning of the Lower Canal in the 1990s.

Aesthetic Significance: The Upper Nepean Scheme is an excellent example of the ingenuity of late nineteenth century hydraulic engineering, illustrating the techniques of canal building (often at extremely small grades), the progressive improvements in both pipe manufacture and pipeline construction, and the construction even by present day standards, of a large earth fill and rock dam. Of particular note is the way in which it was designed to supply a large area of Sydney by gravity.

Social Significance:

Technical / Research: The Upper Nepean Scheme provides detailed and varied evidence of engineering construction techniques prior to the revolution inspired by reinforced concrete construction. Although concrete was later used to improve the durability of the System, much of the earlier technology is still evident along the Canal.

It also provides extensive evidence of the evolution of engineering practice, such as the replacement of timber flumes by wrought iron flumes to be followed by concrete flumes. The early utilisation of concrete for many engineering purposes in the System, also demonstrates the growing emergence of an engineering technology based upon man-made materials.

The Upper Nepean Scheme made the big advance from depending on local water sources to harvesting water in upland catchment areas, storing it in major dams and transporting it to the city by means of major canals and pipelines.

Now, over 100 years later, its components are still part of Sydney's main water supply System, and in most cases operate in essentially the same way as was originally envisaged, except for the decommissioning of the Lower Canal in the 1990s.

It is highly significant that the initial Scheme, completed in 1888, lent itself to progressive

Appendix 5:
Visual Impact Assessment.

ASSESSMENT OF VISUAL AND LANDSCAPE IMPACTS
of the
PROPOSED WESTERN SYDNEY ORBITAL
on
HERITAGE ITEMS AND PLACES EN ROUTE

Prepared on behalf of Casey & Lowe, Archaeologists

for

The NSW Roads & Traffic Authority

by

Mayne-Wilson & Associates
Paddington NSW 2021

August 2001

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1.0 Introduction

The NSW Roads and Traffic Authority (RTA) requires an assessment of the likely impact of the proposed Western Sydney Orbital (WSO) on a number of properties listed on the State Heritage Registers or included in the Colonial Landscapes of the Cumberland Plain Report (CLCPR) that were thought to be in the vicinity of the WSO. If there were any perceived impacts, the RTA would also require appropriate recommendations to mitigate these impacts. Casey & Lowe, Archaeologists, were engaged by the RTA to assess such impacts, but with regard to the assessment of possible *visual* impacts, Casey & Lowe sought approval to engage heritage landscape architects, Mayne-Wilson & Associates (MWA) to undertake that task as sub-consultants. MWA had undertaken several visual impact assessments on other projects, including for Sydney City Council, the Sydney Ports Authority, and Baulkham Hills Council, and worked in association with Casey & Lowe on the latter and other earlier projects.

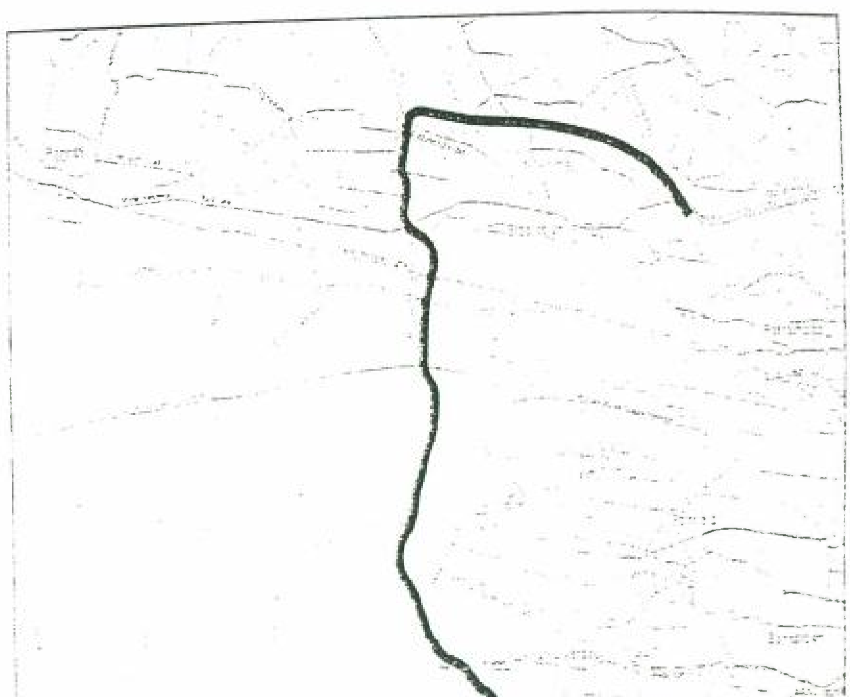
A list of properties that may be affected – see table attached at Appendix A - was provided to MWA (but please note the numbering of items has been changed.) This was supplemented by additional advice and documentation received from the Heritage Office through Mary Casey.

1.1 Aim

The purpose of this report is to identify any likely adverse visual impacts on those heritage properties that are within the vicinity of the proposed WSO, and to provide advice on how any identified impacts may be mitigated.

1.2 The Study Area

The study area comprised the entire route of the proposed WSO, from the junction of the M5 Motorway and Camden Valley Way near Casula through to the M2 Motorway near West Baulkham Hills – see location map below.



1.3 Report Structure

This report traces the route of the WSO from south to north, recording and assessing those heritage properties which were nearby and visible from the proposed Orbital route and considered warranting a visual impact assessment. Each such item, but not including archaeological items which are being assessed separately, is listed in the sequence shown on the aerial photographic sheets contained in Appendix A, titled "European Heritage Sites". Also inspected were other sites nominated by the Heritage Office which appear in the State Heritage Register or in the Colonial Landscapes Report. The location of the item is stated, an indication of its heritage significance provided, a photograph of its relationship to the proposed WSO also provided, and an assessment made of any likely adverse visual impact. This is summarised in a table at the end of the report. Recommendations are made in a few cases of those measures which it would be desirable to take in order to mitigate adverse impacts.

1.4 Methodology

The consultants first familiarised themselves with the background documentation provided. On examining the range of properties the Heritage Office asked to be studied, it was evident that some of them such as *Horsley*, the Veterans Hall and Greystanes at Prospect, St Bartholemews's Church, Prospect, the Minchinbury site, the site of Bungarribee homestead, *Clydesdale* on Richmond Road, and *Bella Vista* were of such a distance from the WSO, with other existing main roads between them and the WSO, that they could not be said to be adversely affected by it. They were therefore excluded from the survey. The consultants commenced their serial site inspections at Bernera Road, Prestons. They stopped at each site, photographed it, and recorded any perceived adverse visual impacts immediately evident. Properties which contained only archaeological elements which were not visible, or only slightly visible above ground were not included, because they did not give rise to visual issues and would be assessed by Casey & Lowe for their archaeological significance anyway.
Following the site visits, the visible, physical evidence was compared against the written documentation that had been provided, to ensure that no important aspect of significance had been overlooked, and that the level of significance was taken into full account. In cases where a perceived adverse impact was identified, comments were made as to its extent and seriousness, and recommendations put forward at the end of the relevant item to mitigate them.

1.5 Authorship

This report was written by Warwick Mayne- Wilson, principal of Mayne-Wilson & Associates, with the assistance of his deputy, Ari Anderson, landscape architect.

1.6 Report Limitations

In some cases, although an inventory sheet had been provided, it only contained the name and location of the place and a very brief statement of significance. In other cases, such as Coleman's Inn, the RAAF Base east of Wallgrove Road, various barns and outbuildings, and Cowpasture Road or Windsor Road, no inventory sheet or background information was provided because the studies had not been undertaken and written up, thus rendering a heritage impact assessment particularly difficult. As it was not this consultant's task to undertake a heritage study for such items, the lack of reliable and detailed heritage information must be considered a significant limitation on an ability to assess any adverse impacts on them. This consultant has been advised that further assessments will be undertaken on a number of these properties, but not when and by whom. It is presumably up to the relevant State and local heritage authorities to commission such studies in the near future.

1.7 Acknowledgements

The author wishes to acknowledge the assistance and advice provided by Mary Casey, Denis Gojak, and Hazel McGann.

2.0 The Survey of Possible Affected Sites

Bernera, Yarrunga Rd., Hoxton Park
Comment: Because the "The Colonial Landscapes of the Cumberland Plain" Report (CLCP) stated that:

- *Bernera* homestead had been burned down
- the principal trees had been removed
- was now only an archaeological site
- was surrounded by recent development, and
- was several hundred metres distant from the proposed WSO –

this consultant concluded that there was little point in inspecting this site.

Impact: The question of an adverse visual impact created by the WSO does not arise in this case.

Sites WSO – E – 1 & 2
As these are essentially archaeological sites, they are being assessed separately by Mary Casey.

Site WSO - E – 3 Hoxton Park Airport
Comment: It appears from figure A4 of the Summary EIS that the proposed route of the WSO will touching only the western boundary of the airport where there is at present a small commercial soil storage business and, beyond it, some regenerating vegetation.

Impact: The routeing of the WSO to the west of the airport and the general visual compatibility of flat airport surfaces and a flat (or gently rising) expressway, all on a horizontal rather than vertical plane, do not appear to create a significant adverse visual impact, one way or the other. There is no issue of visual corridor or catchment in this instance, because the airport lies between low hills on the west and a forested creek on the east, and its siting was deliberately chosen to be as inconspicuous as possible during wartime. In sum, the landscape character of the precinct (see MWA Figs. 1 & 2) will be little changed or affected by the insertion of the WSO.

MWA Fig. 1 View along the western boundary of Hoxton Park Airport. The eastern edge of the WSO would run approximately along the line of the fence to the left of the photograph and would not intrude on sight-lines down the length of the airport. Photo: MWA, 2001.

MWA Fig. 2 This view looks to the north-west from the entrance into the soil company site on the western edge of the airport. The WSO would run through the middle of this photograph, covering the works site and causing the removal of the vegetation at left. Although this vegetation has some visual amenity it has no heritage value and its removal would have a neutral impact on the airport's heritage. Photo: MWA. 2001.

Cowpasture Road at Hoxton Park

This section of the road over which the WSO will cross is an unremarkable stretch, having been built on flat, quasi-marshy land to the west of Hinchinbrook Creek. There are no known historic structures or elements on this segment of the road.

Impacts: Although there will be approaches to, and exits from, the WSO which are adjacent to or leading off or onto the Cowpastures Road, these will sever only a small section of a visually uninteresting and unimportant stretch of this road. The changes would not affect its ability to be interpreted in future as an important historic route into the Cowpastures district of the Cumberland Plain.

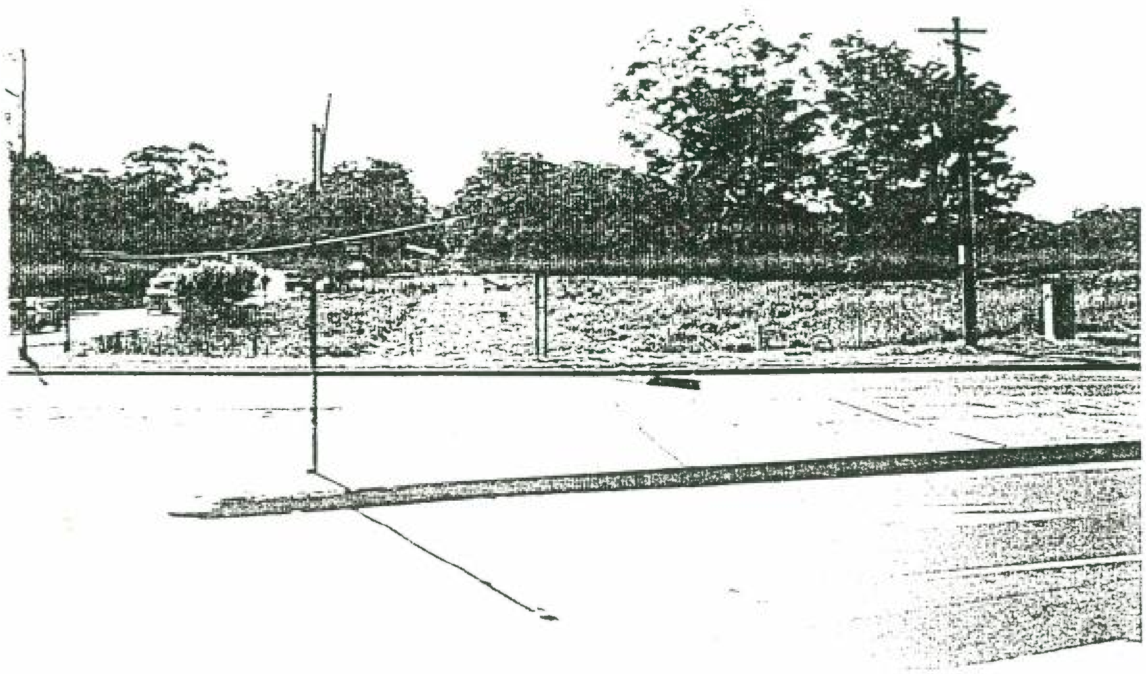
Site WSO - E – 5 Upper Canal System of the Cecil Hills Tunnel

Comment: Because it is underground, the existing water tunnel to the north of the junction of Elizabeth Drive and Wallgrove Road is not visible, as seen in MWA Fig. 3 (although it is apparent to the south of it). The documentation provided to the consultant did not draw attention to the presence of a brick air shaft cover along the route of the tunnel, so this was not noted. In visual terms, however, it is scarcely a noticeable element in the landscape, being less than 2m. high and some distance from the road.

This raises the issue as to whether a purely functional item such as a brick airshaft that is related to an underground tunnel warrants either a curtilage or consideration of view corridors or catchments *to* it. Certainly, no consideration would have been given to views *from* it in any direction when the shaft was built, as this was irrelevant. Nor did it have any visual or functional relationship with Cecil Hills Farm.

A curtilage would only be relevant if the shaft were to be retained and deliberately interpreted by signage. Even then, it would only warrant a curtilage to the width of the tunnel, and about 15m. in each longitudinal direction from it.

Impact: From fig. A6 of the aerial photographs, it is clear that the WSO would run directly over the tunnel and the air shaft. Archaeologist Mary Casey has advised separately how it should be best treated in that event. However, there would be no *visual* loss (i.e. significant adverse visual impact) to the community, or people's ability to be aware of, or to interpret, the pipeline tunnel if the shaft were to be removed or covered over by the WSO. A tunnel, by its nature, is underground, and this one makes no contribution to visual landscape character. Being covered by the WSO will not therefore create an adverse visual impact, since it has no visibility to lose.



MWA Fig. 3 The mown grass strip at the centre of the view indicates the route of the water and gas pipelines to the north of Elizabeth Drive. The WSO would run about 50m to the right of Wallgrove Road, at left, and cover the grasslands up to the group of Eucalypts (centre & right). However, as Wallgrove Road already exists as a main road, and as the pipeline system is underground, the construction of the orbital would not detract from any current appreciation of the pipeline tunnel. Photo: MWA, 2001.

Site WSO - E – 6 City Farm (east of Trigon Road)

Comment: Although the consultant drove along Elizabeth Drive and identified, in general terms, the location of City Farm, he considered it too far distant, and too separated visually by rolling terrain (the Cecil Hills, see MWA Fig. 4) and dense stands of vegetation to have any visual relationship with the proposed WSO.

Impact: Because Wallgrove Road is not visible at all from City Farm, it is not considered likely that the WSO, which follows its alignment, would also be visible, even if the WSO is raised by a few metres. The visual impact would therefore be nil.

Site WSO - E – 7 Relics of early homestead.

Comment: The location of this site was not precisely marked on the aerial photograph (fig. 3) to allow identification from Elizabeth Drive. However, it was considered, like the previous item, to be too distant, and separated visually by rolling terrain (the Cecil Hills, see MWA Fig. 5) and dense stands of vegetation, to have any visual relationship with the proposed WSO. It did not appear to have any visual relationship even with Elizabeth Drive, either. While it may have done so in the 19th century, because of the rigorous clearing of all farmland by the early settlers, natural bushland regeneration has mostly screened off Elizabeth Drive.

Impact: Because it is difficult to believe that the relics of the early homestead would be visible from Wallgrove Road, it was considered unlikely that the WSO, which follows the Wallgrove Rd. alignment would, in turn, be visible from it. While it is noted that a small embankment is proposed in the gully for the feeder road going off the WSO on the eastern side, it would still seem that the density of the intervening vegetation would provide such screening as to cause that feeder road or the WSO to have little if any adverse impact.

Site WSO - E – 8 Remnants of Abbotsbury House

Comment: The location of this site was not precisely marked on the aerial photograph (fig. 4) to be able to identify it from either Wallgrove Road or Saxony Road. The remnants themselves were not readily identifiable even from Saxony Road (although a trained archaeologist may be able to recognise them if the precise location was made available).

Impact: It was considered that the remnants were likely to be too distant, and separated visually by the ridge crest, with falling land to the east, as well as scattered stands of vegetation, to have any visual relationship with the proposed WSO.

Horsley House

Comment: The closest boundary of this item is nearly a kilometre from the route of the WSO and the intervening land contains recent residential development and scattered vegetation. The CLCP Report does not identify an important visual catchment to Wallgrove Road, nor a curtilage that would extend much beyond the present estate. It would be extremely difficult to discern *Horsley House* from either Wallgrove Road or the new WSO, and vice versa.

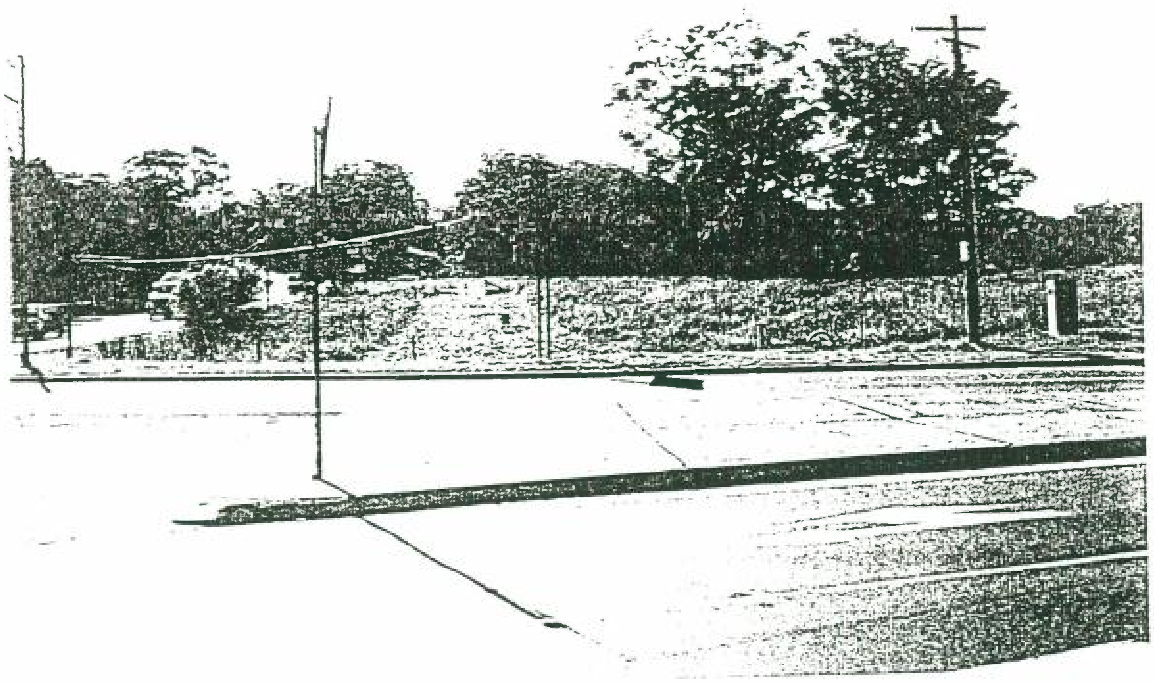
Impact: *Horsley House* is too distant, and its visual catchment too interrupted, for there to be any visual impact of the proposed WSO upon views out from or to it. Moreover, as the Horsley Road interchange will be to the east of Wallgrove Road, on the eastern shoulder of a ridge and therefore at a level slightly lower than Wallgrove Road, there is even less likelihood of the WSO creating an adverse visual impact on Horsley House

Site WSO - E – 9 Timber Barn, Redmayne Road

Comment: The information provided was too little to identify which particular shed along this road was the one that may have heritage significance, and with which SHR item (if any) it may have been associated. There were several sheds, but none which appeared so significant as to warrant a special impact study.

Impact: While Redmayne Road is a pleasant country lane rather than a road, it appears to have no special landscape values and its heritage value is not known to this author. Its crossing by the WSO will truncate it and close it off from the west.

MWA Fig. 4 & 5 The ridge in the background of this view, behind which Fairfield City Farm lies, has a major gully on its south-western side. This gully, the regenerated vegetation, and the ridge in the distance severely restrict views to the east from the WSO's crossing of Elizabeth Drive and Wallgrove Road. The City Farm itself cannot be seen from this location, nor can the relics of an early homestead on Elizabeth Drive. Therefore, the proposed orbital road would not detract from views of these features from this zone. Photo: MWA, 2001.



Site WSO - E – 10 The Wollondilly to Prospect Pipeline

Comment: Although the proposed WSO would pass directly over this pipeline, it is below Wallgrove Road at this point and encased in concrete anyway. As MWA Figs. 6 & 7 show, there would still be views available out to the west, and also to the east, from the WSO and Wallgrove Road after the WSO was built which would enable the pipeline to be quite visible and easily interpreted for what it is.

Impact: The visual impact of the WSO on an essentially underground item which has no visual catchment and minimal landmark character at this point would be negligible.

Site WSO - E – 11 World War II RAAF base.

Comment: It was not possible to enter this site from Wallgrove Road, but in any case it is such a sprawling, amphorphous one that without a prior and detailed heritage study (which has not yet been prepared), it would be impossible to pinpoint what particular heritage item or value might be adversely impacted. There is no doubt that the WSO would pass directly over the western border area of this base, and from the aerial photograph (fig. 5) would pass several hundred metres to the west of what appear to be former RAAF base buildings. The WSO would be just above natural ground level along this stretch, and considerably elevated in the north-west corner, at the interchange with the M4 motorway. However, there is an amount of regenerating vegetation in the western sector of the Base, and this would partly screen the visibility of the WSO. The undulating ground also contributes to this. It appears unlikely that the Base buildings would have been sited to exploit a visual catchment, and even less likely that this would still be available today.

Impact: There will undoubtedly be an impact on the Base site, but on the face of it, the principal buildings appear sufficiently distant for the WSO not to make a noticeable impact. Whether it might impact on hidden revetments or Base huts and dwellings is not possible to say without more data. However, such an impact would be more of archaeological significance than visual. It is noted that this site will be the focus of further heritage assessment for the purpose of an excavation permit

Site of Bungarribee Homestead

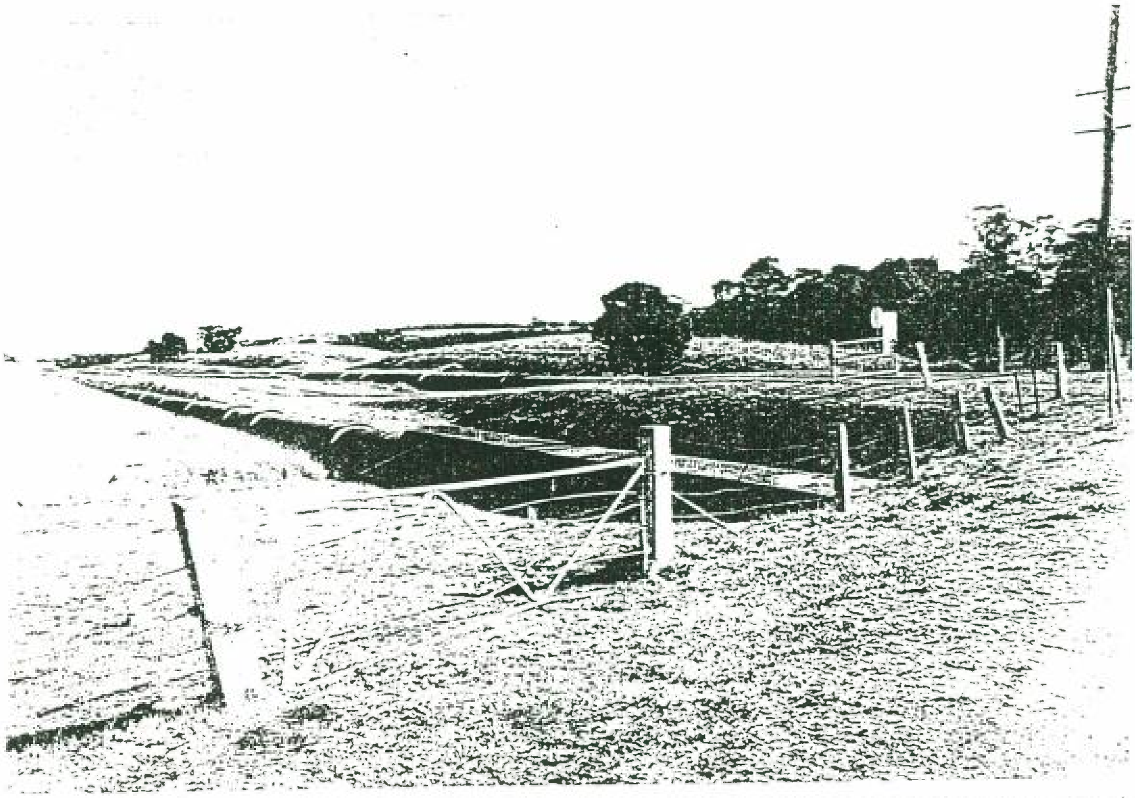
Comment: As the homestead site is more than a kilometre to the east of the route of the WSO – even of Bungarribee Creek, an eastern tributary of Eastern Creek, and is only an archaeological site, it was not considered likely to warrant a visual impact assessment, and was therefore not visited. The archaeological items in the vicinity of Church Road are not part of the Bungarribee homestead site, but possibly related to another, lesser dwelling on that estate. A separate report on these is being prepared by Mary Casey.

Impact: None.

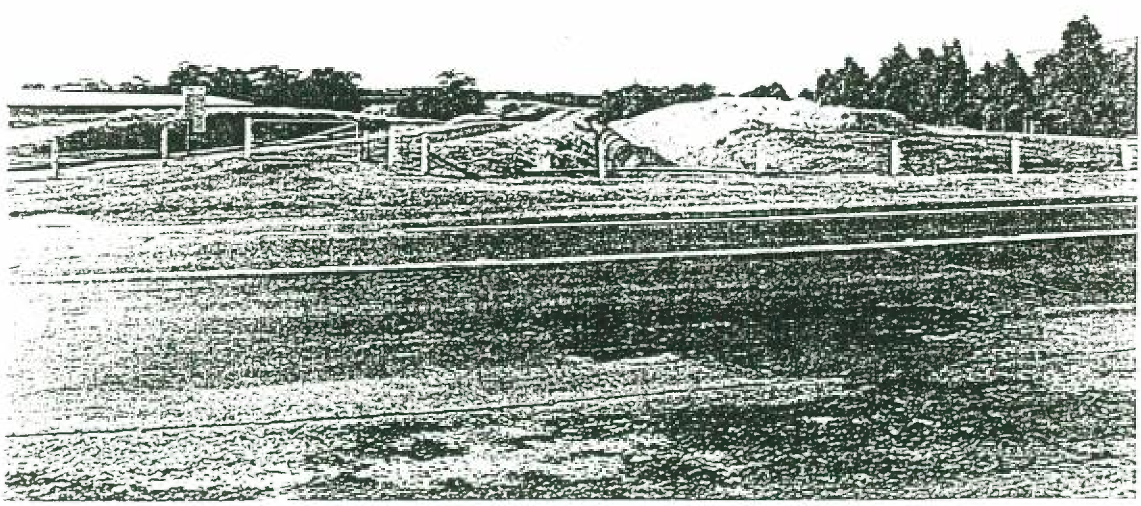
Minchinbury site

Comment: This site was considered to be too far (at least 2kms) to the west of the WSO route to warrant investigation.

Impact: None.



MWA Fig. 6 Looking west along the Prospect Pipeline from its intersection with Wallgrove Road. The proposed orbital road would be located on the eastern side of Wallgrove Road, and therefore none of the pipeline visible in this photograph would be concealed from Wallgrove Road or from the WSO, thereby retaining its visibility and people's ability to understand and interpret it. Photo: MWA, 2001.



MWA Fig. 7 Looking east across Wallgrove Road along the Prospect Pipeline. The WSO would span the pipeline on the far edge of Wallgrove Road, but would conceal only a narrow portion of it. No significant loss of views to the line would be incurred should the road development proceed. Photo: MWA, 2001.

Site WSO - E – 12 Remains of Coleman's Inn, Great Western Highway
Comment: This item was difficult to identify, but some experts suspect it is contained within the cottage appearing in MWA Fig. 8. Further research is being undertaken by Carol Liston, who advised this consultant that in the 19th century the whole stretch of the Great Western Highway between Wallgrove Road and Eastern Creek once comprised the hamlet of Eastern Creek, but that most buildings, including another inn and the tollgate, had disappeared with the widening of the highway in the 1960s. According to fig.A12 of the Summary EIS, the inn would be within the WSO road reserve but possibly just to the western edge of the western embankment that would allow the WSO to fly over the Great Western Highway.

Impact: There is little doubt that the remnants of the inn would be adversely affected, not only visually but physically as well. It is noted that this site will be the subject of further assessment, and that other sites (if only archaeological ones) may be identified in this precinct as having heritage significance.

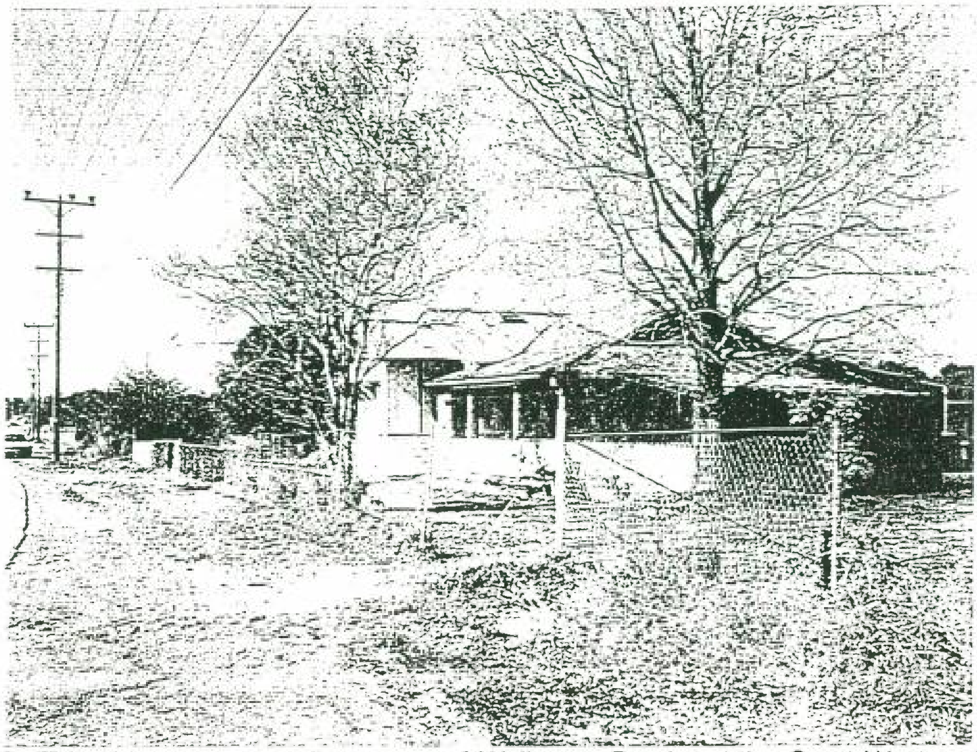
Recommendation: In the event that Coleman's Inn and/or other heritage items (principally footings or the existing buildings on the corner of the highway and Pike's lane - see MWA Fig. 9 - or opposite on the northern side of the highway) are found to have heritage significance, it may be advisable to shift the route of the WSO a little to the east or west to avoid having such a direct impact on them, and to ameliorate some of its potentially overwhelming presence.

Site WSO - E – 13 Archaeological site, east of Church St., Doonside
Comment: As it is an archaeological site, any impacts will be covered by the archaeological consultants; however, no visual issues appear to arise, since this was not the site of *Bungarribee* homestead.

Impact: None that is relevant to a visual/landscape impact study.

Site WSO - E – 14 Native Institute, near cnr of Rooty Hill Rd. North and Richmond Rd.
Comment: Although primarily an archaeological site, a few remains are visible above ground. However, in the absence of a detailed heritage/archaeological report, their significance was difficult to interpret. They were, however, photographed (see MWA Fig. 10) from various angles, in their generous, open field/reserve setting. From fig. A16 in the Summary EIS, it appears that the main WSO carriageways will pass about 200m. to the east of the site, and it would be screened from it by a belt of trees just east of Rooty Hill Road North. In addition, some road upgrading directly adjacent to the curtilage would occur at the Rooty Hill/Richmond Road intersection, all within the existing road reserve.

Impact: It is noted that an embankment will be built to lift the WSO over Richmond Rd., and that this may increase its visibility. However, the relevance of a visual impact assessment of the WSO to archaeological remains which are over 100m distant from it, and particularly when screened by intervening vegetation, has been questioned earlier in this report. It is doubtful, under these circumstances, that one could say the WSO would have an adverse impact on the heritage values of the Native Institute or its ability to be understood or interpreted in its setting. No intrusion into the eastern edge of the Institute reserve land will occur when the feeder roads are constructed, because the area will be securely fenced off and no machinery will be allowed in.



MWA Fig. 8 This old cottage near the corner of Wallgrove Road and the Great Western Highway is thought to encompass some of the fabric of Coleman's Inn, and is currently being assessed for its heritage value. It lies just on the western edge of the proposed WSO. As the cottage is already heritage listed, and as that listing would be strengthened if the current study confirms the presence and importance of the remains of Coleman's Inn, a case would exist for shifting the WSO 50m to the east. Even so, the visual impact of the WSO on the former Inn would be considerable, if inescapable. Photo: MWA, 2001.

MWA Fig. 9 The old dwelling and outbuildings to the east of the presumed site of Coleman's Inn and on the eastern side of Pike's Lane, which may have heritage significance and/or an association with the Coleman or Dean families. MWA 2001

MWA Fig. 10 This un-mown patch and trees may represent the 'Native Institute' or ground within the reserve recognised as having importance for the Aboriginal community. More detailed information on the site would have to be provided to understand the exact importance of Aboriginal associations with this pocket of land. Being 100m further to the east, the proposed WSO itself is unlikely to have any greater visual impact on this site than that caused by the existing roads and surrounding development.
Photo: MWA, 2001.

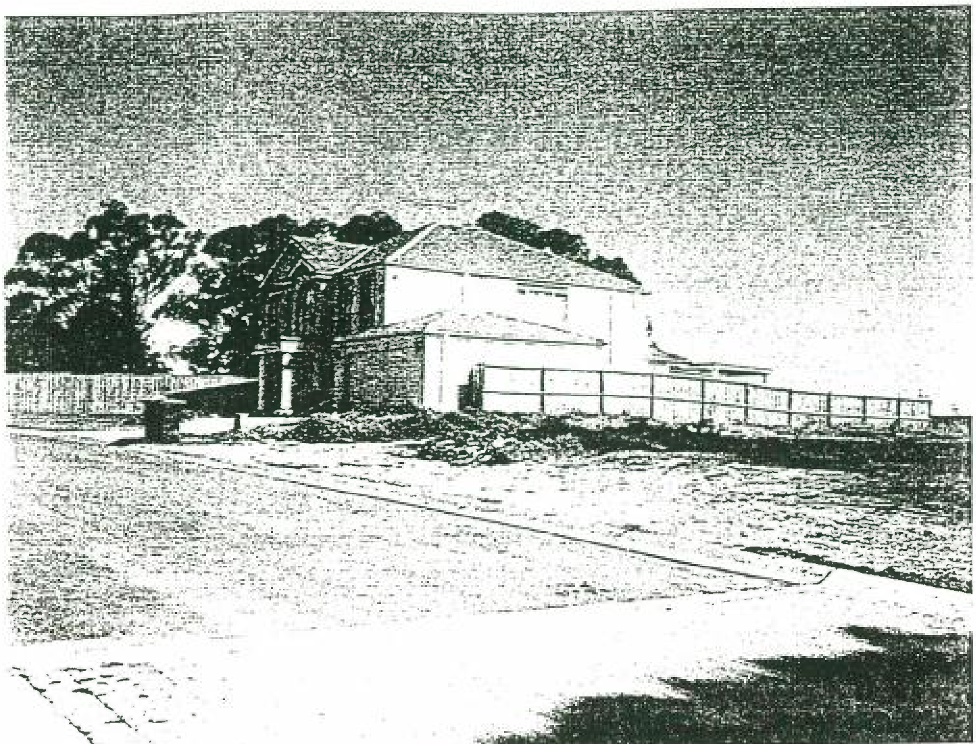
Clysdale Homestead, Marden Park (off Richmond Rd.)
Comment: As this homestead is about 7kms. distant from the WSO, no assessment was considered necessary.

Site WSO - E – 17 Exeter/Meurant's Farm
Comment: This homestead was difficult to find, because it is now surrounded by large, two storey modern houses, some of which are still being completed. Most unfortunately, it has a minimal curtilage, which excluded nearly all its relevant outbuildings, thereby rendering it difficult – and in future almost impossible - to interpret as an important early farm. The proposed WSO will be passing within 40m. of it, but fortunately to its rear. However, a large modern two storey dwelling (see MWA Fig. 11) is located between it and the boundary of the WSO, which is further screened off by a high, timber paling fence.
Finally, the WSO will pass through a cutting at this stage, so its visibility would be reduced to zero. (However, there would be aural impacts.)

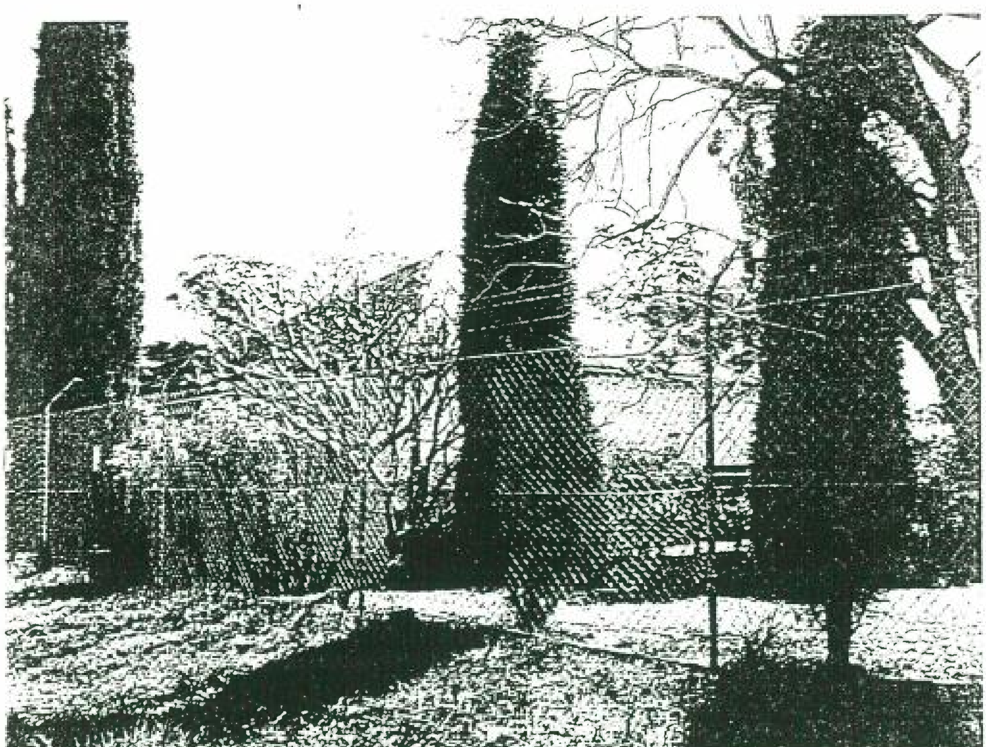
Impact: Because of all the intervening elements, there will be no direct visual impact of the WSO on *Exeter/Meurant's Farm*, or at least on the remnant homestead. Nor will the homestead be visible from the WSO.

Site WSO - E – 19 House at end of Meurant's Lane.
Comment: Insufficient information was available to understand why this item was listed in the Blacktown LEP. The off-ramp from the WSO that crosses Old Windsor Rd. near this property will be more than 100m distant from it, and will be going through a cut anyway. Fig. A22 of the Summary EIS indicates that Meurant's Lane will be closed off at this point.

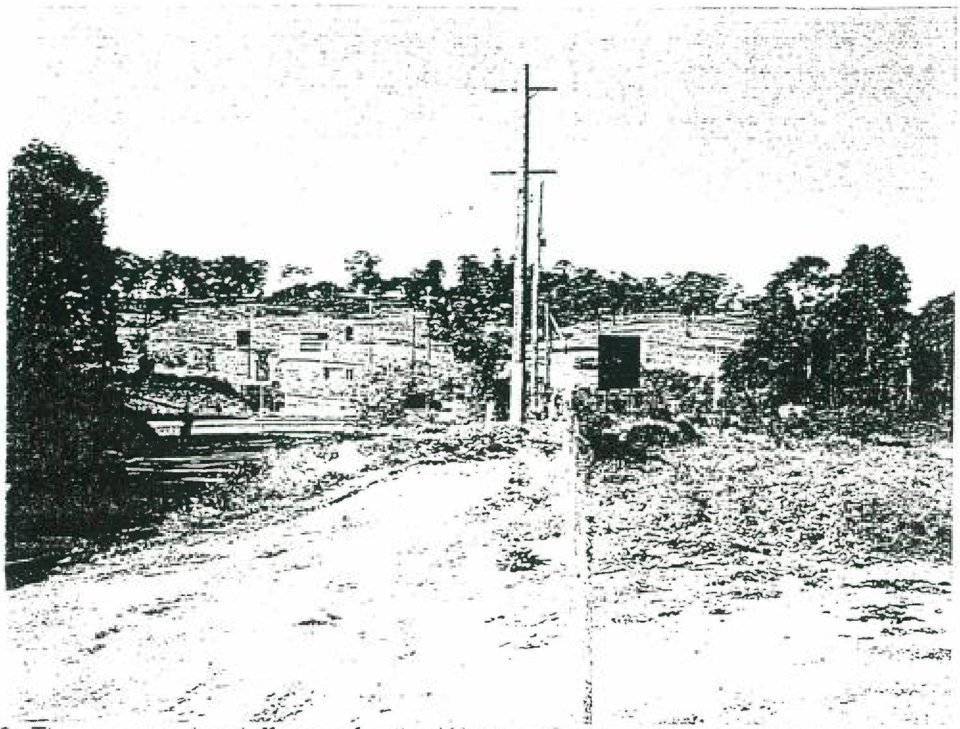
Impact: Since the WSO will be below natural ground level in the vicinity of the house (see MWA Figs. 12 & 13), and since the house addresses Meurant's Lane and not Old Windor Road (which is about 50m. distant, in a cutting), the visual impact of the WSO on the house will be negligible.



MWA Fig. 11 This house, part of the recent subdivisions around Exeter Farm, lies to the immediate north of the Western Sydney Orbital Corridor, which would extend along the far side of the timber paling fence in the background of this photograph. Whilst this house and others on its alignment adjoining the WSOC will be significantly affected by its construction, Exeter Farm, lying approximately 75 metres down slope will not suffer any direct visual impact from the proposed WSO development. Photo: MWA, 2001.



MWA Fig. 12 This house at the eastern end of Meurants Lane will be unaffected by the proposed WSOC. An on/off ramp servicing the Western Sydney Orbital will extend across the open land to the house's south, joining into Old Windsor Road at Norwest Boulevarde, but as the house is built on the crest of a hill, and the proposed ramp for the orbital will lie on lower ground to the south, the house will retain its present visual catchment virtually intact Photo: MWA, 2001.



MWA Fig. 13 The proposed on/off ramp for the Western Sydney Orbital at Norwest Boulevarde will join into Old Windsor Road near the black sign in the middle-ground of the photograph. Being lower and more distant, this ramp will not significantly increase visual impacts on the house at the end of Meurants Lane, which is already bounded on its immediate south by busy Meurants Lane. In fact, the latter is to be closed off at this point, and no traffic will pass by the house then. Photo: MWA, 2001.

Bella Vista homestead

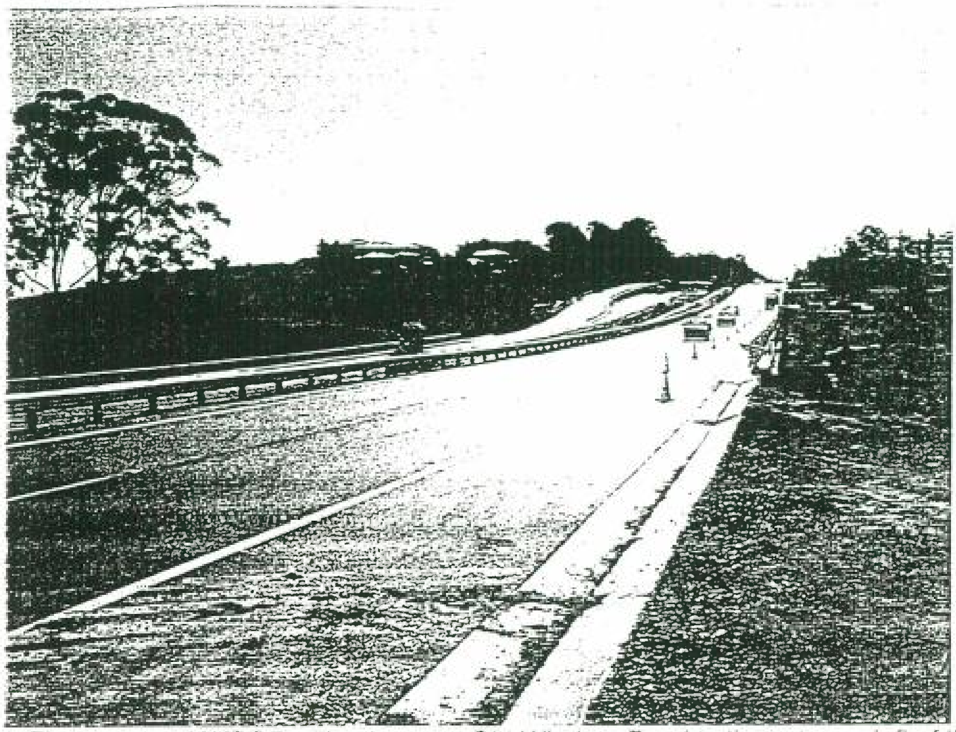
Comment: While *Bella Vista* may be only about 100m (as the crow flies) from the WSO off-ramp that crosses Old Windsor Road near Meurant's Lane, the modest roadworks associated with that ramp are not likely to be visible from *Bella Vista*. This is particularly because of the rolling nature of the topography and the density of existing vegetation in this corner of the estate (just south of Norwest Boulevard. It is noted that one of the former entry drives to *Bella Vista* off Old Windsor Road was opposite Meurant's Lane, but that the new Norwest Boulevard is now the dominant feature and entrance road into the industrial precinct to the north-west of the homestead.

Impact: There is perceived to be no visual impact on *Bella Vista* of the WSO or its off-ramp, which will merge into Norwest Boulevard. Any impact which the construction of that Boulevard and the new Hardwarehouse had on the homestead would have been greater than that which the proposed off-ramp is likely to create. Neither the present nor proposed extended curtilage for *Bella Vista* would be adversely affected by the WSO, and this includes also the visual catchment from it.

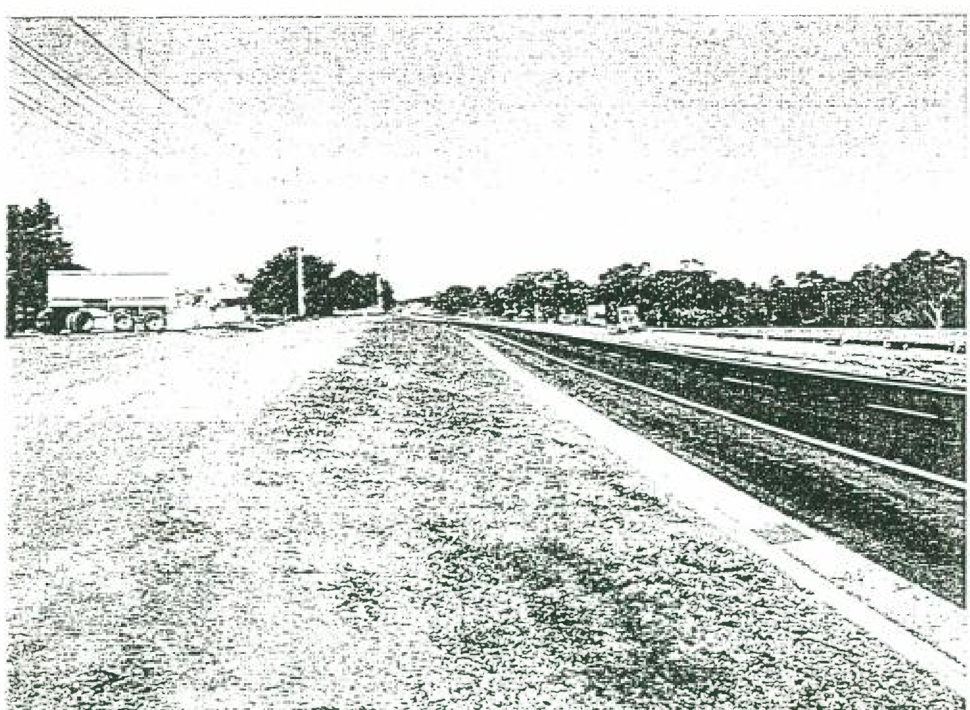
Site WSO - E – 20 Old Windsor Road

Comment: Whatever historic elements may have existed along the section of Old Windsor Road affected by the WSO have been swept away by the recent road works which have turned it into a modern dual carriageway (see MWA Figs. 14 & 15). It is no longer an old country road, and there are no historic road elements at the point at which the WSO crosses it (just north of the intersection of Old Windsor Road and Seven Hills Road).

Impact: While visually the WSO will become the dominant element in the landscape, the latter has been so developed anyway that the new expressway will not be out of character in this particular modern setting.



MWA Fig. 14 The proposed WSOC will cut across Old Windsor Road to the extreme left of this location. As Old Windsor Road has been developed into a major arterial road link, removing all reference to its historic form and heritage features, it cannot be considered as an item which would lose its visual qualities or heritage values as a result of the proposed cross-over by the proposed WSO. Photo: MWA, 2001.



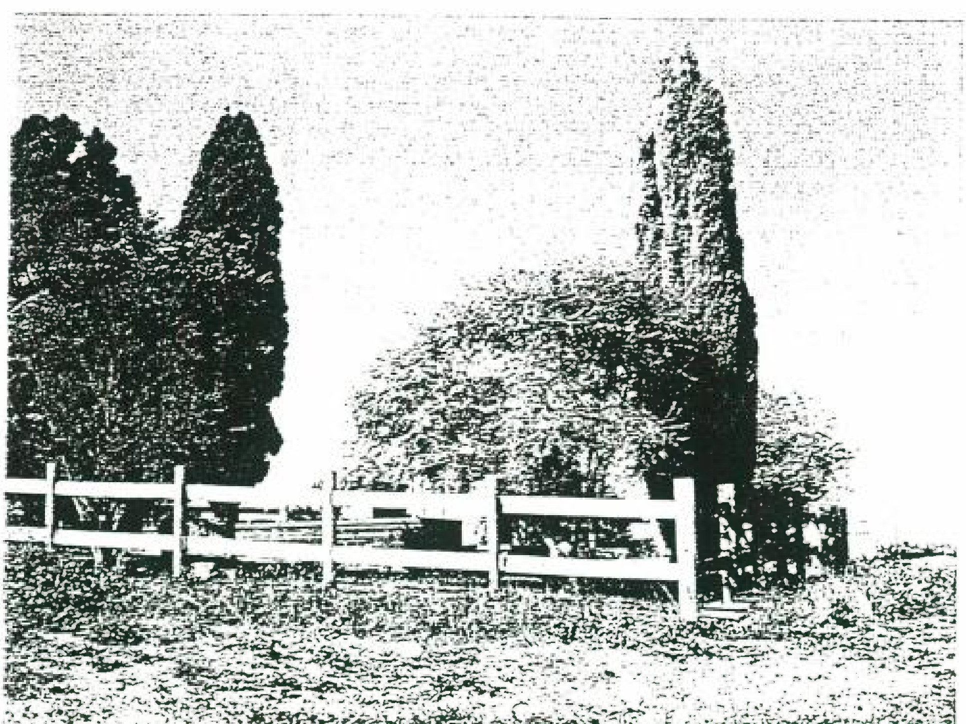
MWA Fig. 15 After the proposed WSOC cuts across Old Windsor Road, it would extend up the ridge-line through the residences at the far left background of this photograph. The orbital road would not interfere with any significant visual attributes or features of the existing arterial road, most of those being lost with its recent re-development. Photo: MWA, 2001.

Site WSO - E – 21 Pearce Family Cemetery

Comment: This cemetery (seen in MWA Figs. 16 & 17) is, according to the CLCP report, important in the history of *Bella Vista,* and one of its authors' recommendations was to "ensure the conservation area supporting the SHR listing for *Bella Vista* includes the Pearce family cemetery on Seven Hills Road". This arises from the fact that *Bella Vista* was owned by the Pearce family from 1842 through until 1950. Figure A23 of the Summary EIS shows the WSO cutting through land immediately to the east of the cemetery. It is understood that a 10m. wide buffer between the boundary of the cemetery and the top edge of the cutting has been proposed, but that a larger buffer would be preferred.

Impact: There is no doubt that the WSO would separate, both visually and physically, the Pearce family cemetery from the original *Bella Vista* estate. This would be unfortunate, in that it would isolate the cemetery on a traffic island and greatly weaken the understanding and interpretation of the very important association of the Pearce family with the *Bella Vista* estate. However, because the WSO would be below the present natural ground level of the cemetery, it would be less intrusive visually than it was at or above ground level. This is fortunate in that the plantings within and adjacent to the cemetery will retain their landmark quality.

Recommendation: That the route of the orbital be adjusted so that it would pass to the *west,* not to the east, of the cemetery, so that the latter would not be visually and physically separated from the *Bella Vista* estate. Also, that there be as much land as possible, not less than 10m. between the western post and rail fence of the cemetery and the top edge of the cutting for the WSO, and that the edge of that cutting be planted with dense shrubs not to exceed 2m., some of which would trail downwards over the edge. It is important that any new plantings do not compete with the tall, vertical cypresses present within the cemetery which provide its landmark quality.



MWA Fig. 16 Pearce's family cemetery, near the junction of Seven Hills Road and Old Windsor Road is likely to be affected significantly by the proposed WSO development. As this cemetery marks the burial place of the early owners of the *Bella Vista* estate, the orbital corridor should be constructed to the right of the post and rail fence at the right of this picture, so as not to separate the cemetery from the land of the original Bella Vista estate. Photo: MWA, 2001.

MWA Fig. 17 Beyond the view through the centre of the cemetery lies the corridor reserved for the remainder of the WSO. It indicates how the cemetery lies virtually directly in the centre of the route, creating problems for road designers, and a challenges for a skillful design that preserves the landmark and social values of this important family resting place. Photo: MWA, 2001.

Concluding remarks

It was found there were very few visual and/or landscape impacts of the proposed WSO on the great majority of listed heritage items assessed by this consultant. The assessment mostly excluded purely archaeological items, because they had no visual presence in the landscape and are being assessed separately by Mary Casey anyway.

Of the items studied by this consultant, the Pearce family cemetery at Baulkham Hills will be the most adversely affected, and it is recommended that the alignment of the WSOC be adjusted so that it runs to the west, not to the east of the cemetery. The principal reason for this is that the cemetery would otherwise be separated from the family's *Bella Vista* estate and left stranded on a traffic island surrounded by the WSO, Old Windsor Road, and Seven Hills Road. In this situation it would be difficult to find parking and to gain access to the cemetery. Ameliorative landscaping would not solve this problem.

Other items which will be adversely affected are Coleman's Inn (in the former hamlet of Eastern Creek) and possibly elements of the former RAAF base just to the south of it. The seriousness of these possible impacts has yet to be determined, because formal heritage studies have not been undertaken on these sites. It is recommended that these be commissioned as soon as possible.

This consultant was not requested to assess the effects of the WSO on the landscape and scenic values on the Telstra site and Huntingwood Extension west of Blacktown and incorporating a length of Eastern Creek. It may be desirable that be carried out in a supplementary study.

Item Number	Description	Location	LGA	Listed	Extent of Visual Impact
(un-numbered)	Bernera homestead site	Yarrunga Road, Hoxton Park	Liverpool	CLCP Rpt	No visual impact on item as item burned down and principal trees removed
WSO-E-3	Hoxton Park Airport (AHC listing)	Cowpasture Road Hoxton Park	Liverpool	AHC	Negligible impact due to compatibility of land uses
WSO-E-5	Upper Canal System: Cecil Hills Tunnel	Junction of Elizabeth Drive and Wallgrove Road	Liverpool	SHR, NT LEP	No visual impact on tunnel due to it being underground Loss of vent hardly noticeable
WSO-E-6	City Farm	East of Trigon Road, Abbotsbury	Fairfield	LEP	No visual impact on item due to intervening landform and regenerated vegetation.
WSO-E-7	Relics of early homested	Elizabeth Drive, Abbotsbury	Fairfield	LEP	No visual impact on item due to intervening landform
WSO-E-8	Remnants of Abbotsbury House	Southdown Road, Horsley Park	Fairfield	LEP	No visual impact on item due to distance from WSO
(un-numbered)	Horsley House	Horsley Drive/Jamieson Close		CLCP Rpt	No visual impact on item due to distance from WSO
WSO-E-9	Timber barn (insufficient info. to identify)	Redmayne Road, Horsley Park	Fairfield	No	Relevant one not identified so not possible to assess impact
WSO-E-10	The Wollondilly to Prospect Pipeline	North of Chandos Street	Blacktown	SCA S.170 register	Negligible visual impact on item because partly underground at this point. Pipes still visible to east and west.
WSO-E-11	WWII RAAF Base Insufficient info. to determine if significant items present on Base's western edge because heritage study not yet undertaken	Eastern side of Wallgrove Road south of the M4 Motorway	Blacktown	Not yet	Full visual impact not yet known but existing structures too far east to be seen due to undulating landform & intervening trees.

(un-numbered)	Site of Bungarribee Homestead	Doonside Road, Doonside	Blacktown	SHR CLCP Rpt	No visual impact on item because too far east from WSO
(un-numbered)	Minchinbury site	Great Western Highway corner of Barossa Drive	Blacktown	SHR	No visual impact on item as too far distant from WSO
WSO-E-12	Remains of Coleman's Inn	South-eastern corner of Wallgrove Rd. and GW Highway	Blacktown	Not yet but now being studied	Moderate to high visual impact on item. RTA is proposing direct demolition.
WSO-E-14	Native Institute (archaeological site only)	North-west corner of Rooty Hill Road North and Richmond Road	Blacktown	AHC, SHR	No visual impact on items which are archaeological .
(un-numbered)	Clydesdale homestead	Marsden Park (off Richmond Road)	Blacktown	SHR	No visual impact on item due to distance (7kms) from WSO
WSO-E-17	Exeter Farm (Meurants Cottage)	Meurants Lane	Blacktown	SHR, LEP	No direct visual impact on item because WSO 50m behind it, in cutting, & new housing in between
WSO-E-19	House at the end of Meurants Lane	Lot 6 DP878474	Blacktown	LEP	Negligible visual impact on item No action required.
(un-numbered)	Bella Vista homestead	Old Windsor Road, Kellyville	Baulkham Hills	SHR, CLCP Rpt	No visual impact as item too far from WSO & screened by trees
WSO-E-20	Old Windsor Road	From its junction with Meurants Lane up to Seven Hills Road	Blacktown/ Baulkham Hills	AHC, NT LEP	Will be visual impact but not necessarily adverse as all heritage aspects now gone.
WSO-E-21	Pearce family cemetery	Lot 100 DP707538 Seven Hills Road, Baulkham Hills	Baulkham Hills	SHR, LEP	Moderate to high visual impact on item. Realignment of WSOC recommended, as item otherwise isolated (on traffic island) from family's Bella Vista estate Landscaping not a solution

APPENDIX A

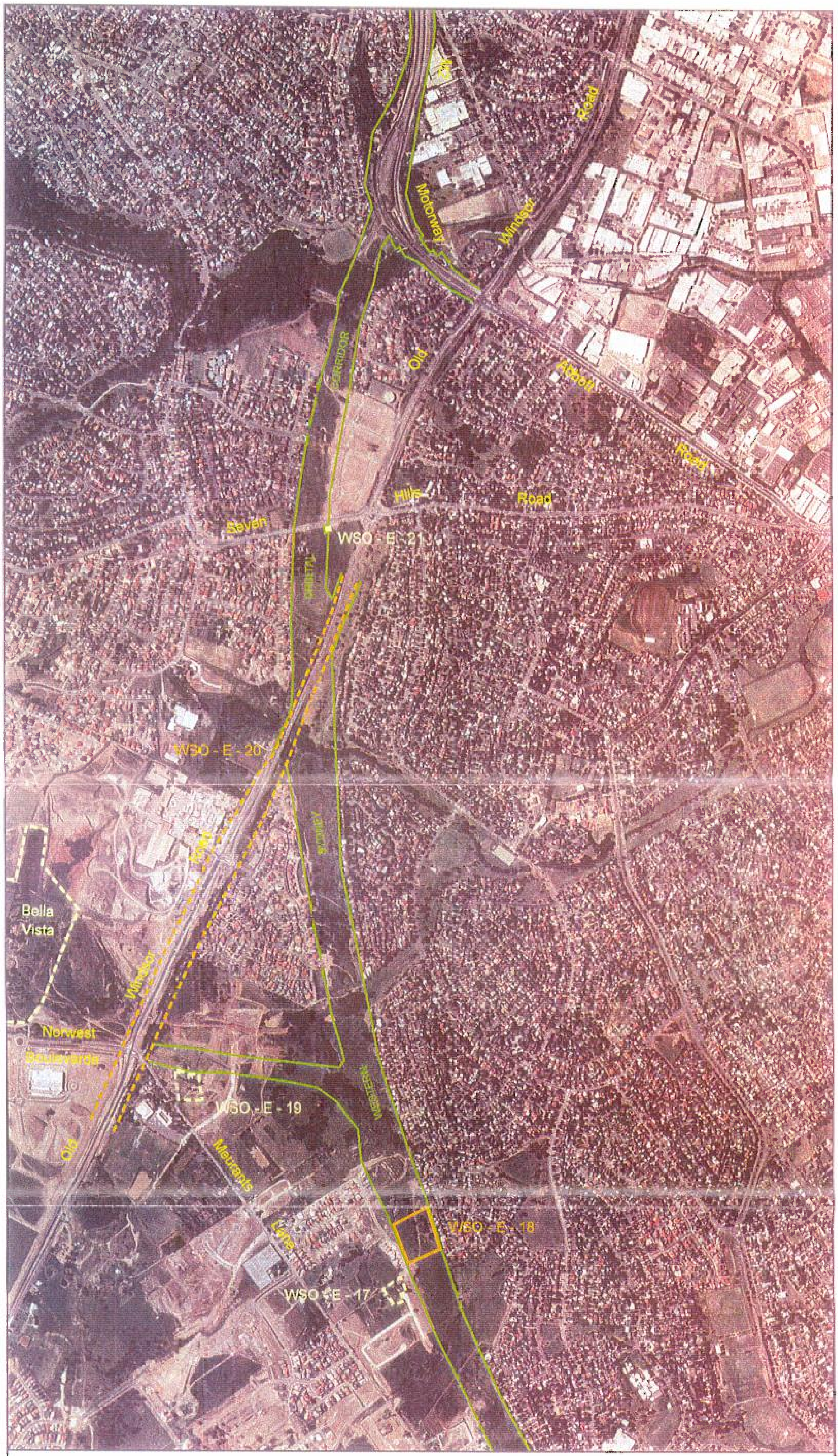
List of properties provided to MWA from Casey & Lowe and the Heritage Office

Table 2: Details of all sites within and immediately adjacent to the WSO Alignment

Item Number (Previous site name)	Description	Location	LGA	Register Listing (AHC, SHR, NT, LEP, SW)	Extent of Impact	Stage 2 Heritage Assessment Requirements
WSO E 1	Hoxton Park Airport	Cowpastures Rd Hoxton Park	Liverpoo l	AHC	Direct to Western Boundary	Detailed significance assessment and analysis of impacts
WSO E 2 (*CH E 1*)	Farm buildings archaeological site	West of Kensington Crescent, Cecil Hills	Liverpoo l	Nil	Direct	Detailed significance assessment and analysis of impacts
WSO E 3	Upper Canal System Cecil Hills Tunnel	Junction of Elizabeth Drive/Wallgrove Road	Liverpoo l	SHR NT, LEP, SW	Direct	Investigation of impacts
WSO E 4	City Farm	East of Trigon Road, Abbotsbury	Fairfield	LEP	Item immediately adjacent to alignment	Determination of impact
WSO E 5	Relics of early Homestead	Elizabeth Drive Abbotsbury	Fairfield	LEP	Item immediately adjacent to alignment. Curtilage not known.	Determination of impact
WSO E 6	Remnants of Abbotsbury House	Southdown Road Horsley Park	Fairfield	LEP	Item immediately adjacent to alignment. Curtilage not known	Determination of impact

WSO-E-7 *(SO-E-1)*	Timber barn	Redmayne Rd, Horsley Park	Fairfield	Nil	Nil	Determination of impact
WSO-E-8	Wollondilly to Prospect Pipeline. Construction date 1968. Later addition to the Upper canal system.	North of Chandos Street	Blacktown	SHR	Direct	Investigation of impacts to SHR listed item
WSO-E-9 *(SO-E-9)*	World War 2 RAAF Base	Wallgrove Road, eastern side South of M4 Motorway	Blacktown	Nil	Direct	Detailed significance assessment and analysis of impacts
WSO-E-10	Remains of Coleman's Inn	South eastern corner of Great Western Highway and Wallgrove Rd	Blacktown	Nil	Direct	Detailed significance assessment and analysis of impacts
WSO-E-11 *(SO-E-7)*	Brick lined well and house foundations	East of Church Street Doonside	Blacktown	SHR Part of Bungarribe e Farm	Direct	Assessment of DUAP excavation results and Management recommendations for the site.
WSO-E-12	Native Institute	Cnr Rooty Hill Road North and Richmond Road	Blacktown	AHC, SHR, LEP	Direct	Investigation of impacts to SHR listed item
WSO-E-13 *(SO-E-2)*	Isolated European Burial	East of Symonds Road, Dean Park, 30m west of Eastern Creek	Blacktown	Nil	Direct	Detailed significance assessment and analysis of impacts
WSO-E-14 *(SO-E-3)* **demolished**	Timber barn and battery chicken shed	100m east of Eastern Creek	Blacktown	Nil	Nil	Nil
WSO-E-15 *(SO-E-10)*	Exeter Farm, otherwise known as Meurants Cottage	Lot 50 DP 792657 Meurants Lane	Blacktown	SHR LEP	Nil	Nil

WSO-E-16 *(SO-E-4)*	Potential archaeological site	In the vicinity of scarred tree WSO-ST-6 (access Lady Penhyn Park	Blacktown	Nil	Nil	Nil
WSO-E-17 *(SO-E-11)*	House	Meurants Lane, part of Lot 6 DP 878474	Blacktown	LEP	Immediately adjacent to off ramp to Meurants lane exit.	Determination of impact
WSO-E-18 *(SO-E-8)*	Old Windsor Road	Seven Hills Road to Windsor Road	Blacktown	AHC	Direct	Determination of impact
	Old Windsor Road	1.5km south from Meurants Lane		NT	Direct	Determination of impact
	Old Windsor Road	1.5km south from Meurants Lane		LEP Blacktown	Direct	Determination of impact
	Old Windsor Road post and rail fencing	Eastern side of Windsor Road	Baulkham Hills	LEP	Direct in vicinity of Meurants Lane Junction	Determination of impact
WSO-E-19 *(SO-E-5)*	Pearces Cemetery	Lot 100 DP 707538, Seven Hills Road, Baulkham Hills	Baulkham Hills	SHR LEP	Immediately Adjacent (Curtilage, Visual, vibration impact)	Determination of impact
WSO-E-20 *(SO-E-6)* **Demolished**	Single room dairy and beehive cistern	Adjacent to water tower west of Toongabbie Creek, Baulkham Hills	Baulkham Hills	Nil	Nil	Nil
WSO-E-21	Site of outbuildings	Off Jedda Road, opposite Joadja Rd, Prestons	Liverpool	Nil	Direct	Detailed significance assessment and analysis of impacts
WSO-E-22	Site next to Spanish Mission House, Potential subsurface remains	Southwest corner of Bernera Road and Jedda Road,I Prestons	Liverpool	Nil	Direct	Detailed significance assessment and analysis of impacts

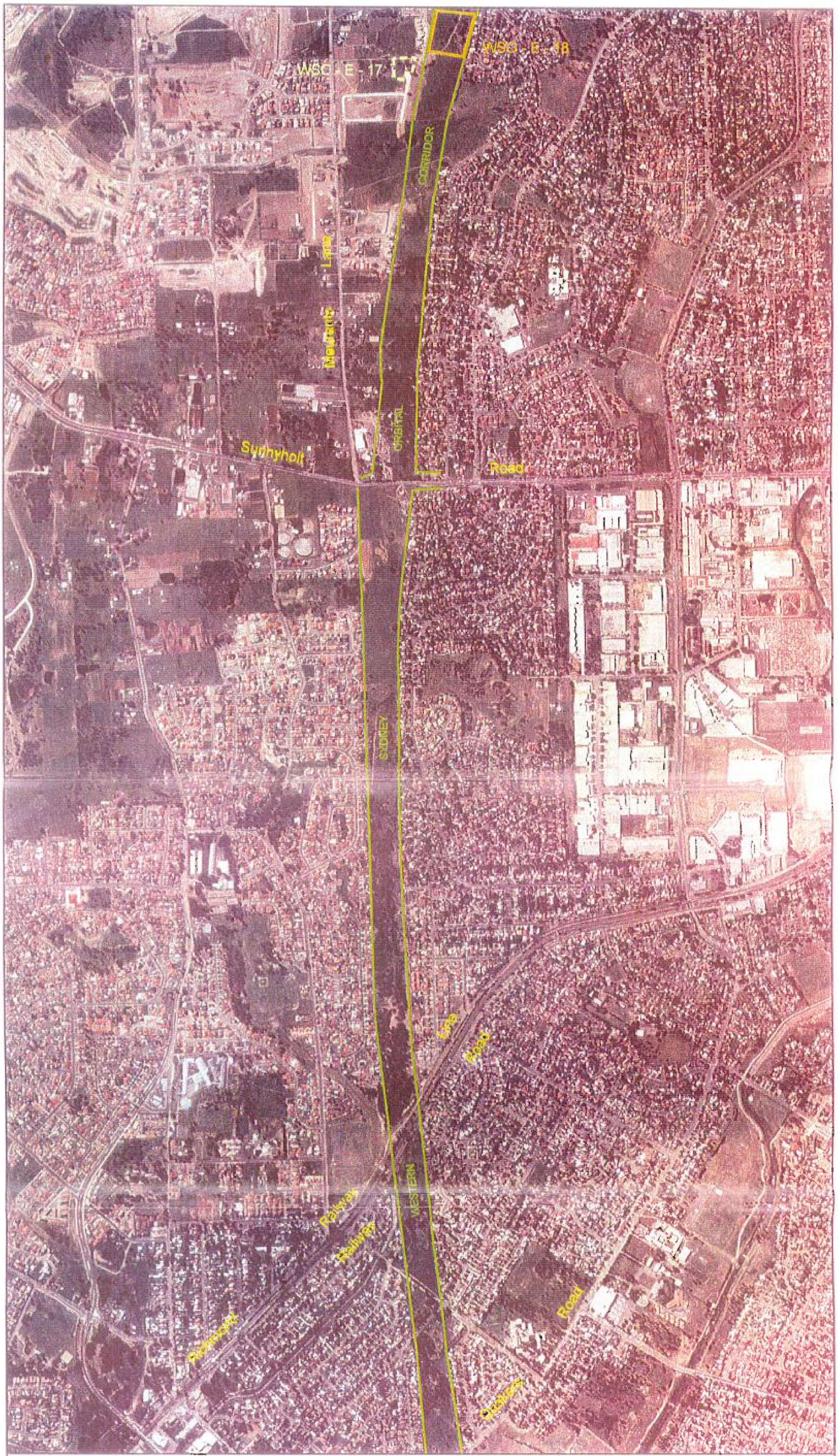


WESTERN SYDNEY ORBITAL
EUROPEAN HERITAGE SITES

0 250 500m

defined curtilage
property boundary
extent of cemetery
extent of potential relic

Figure 9

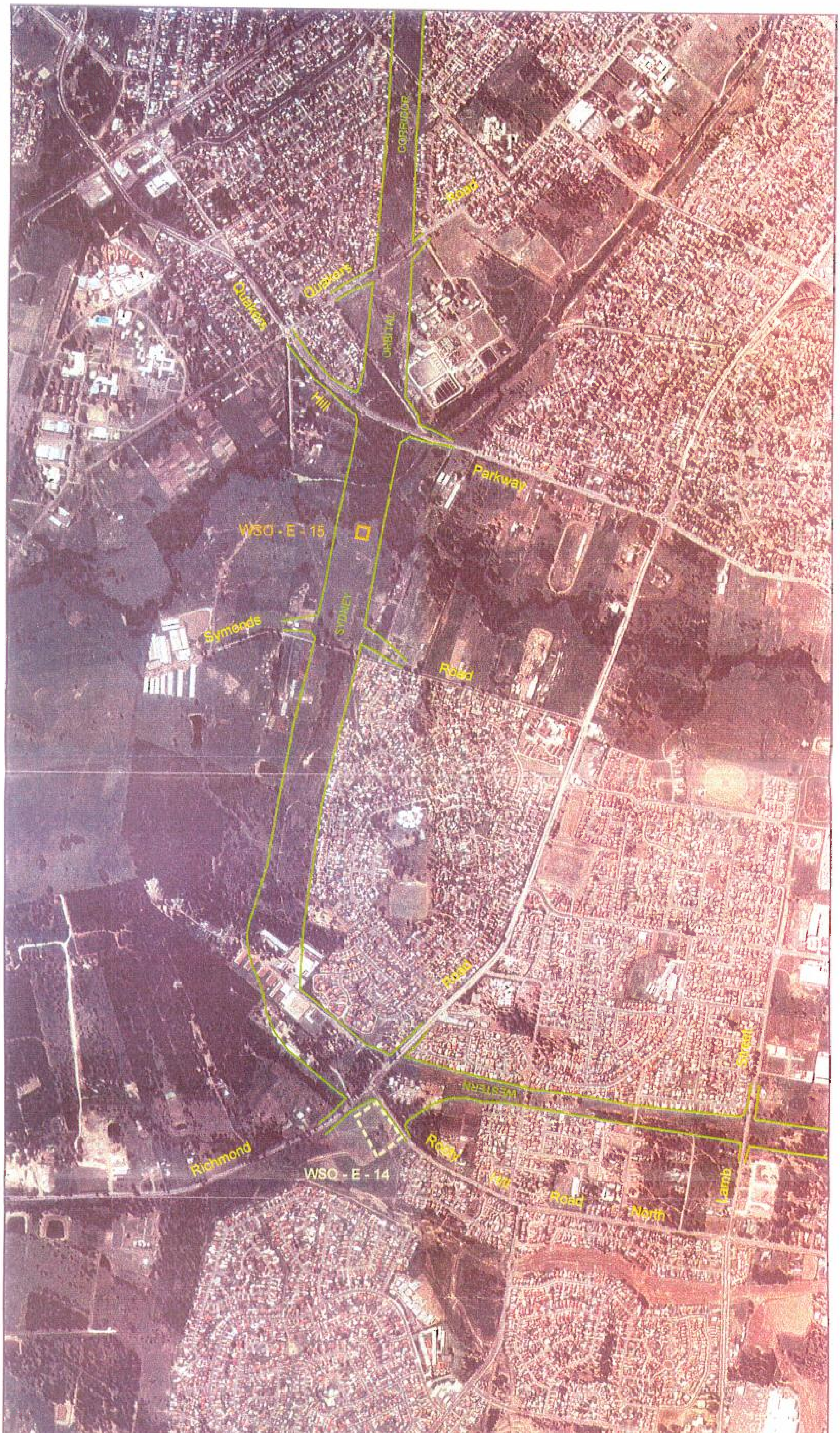


WESTERN SYDNEY ORBITAL
EUROPEAN HERITAGE SITES

0 250 500m

defined curtilage
property boundary
visible extent of relic
extent of potential relic

Figure 8

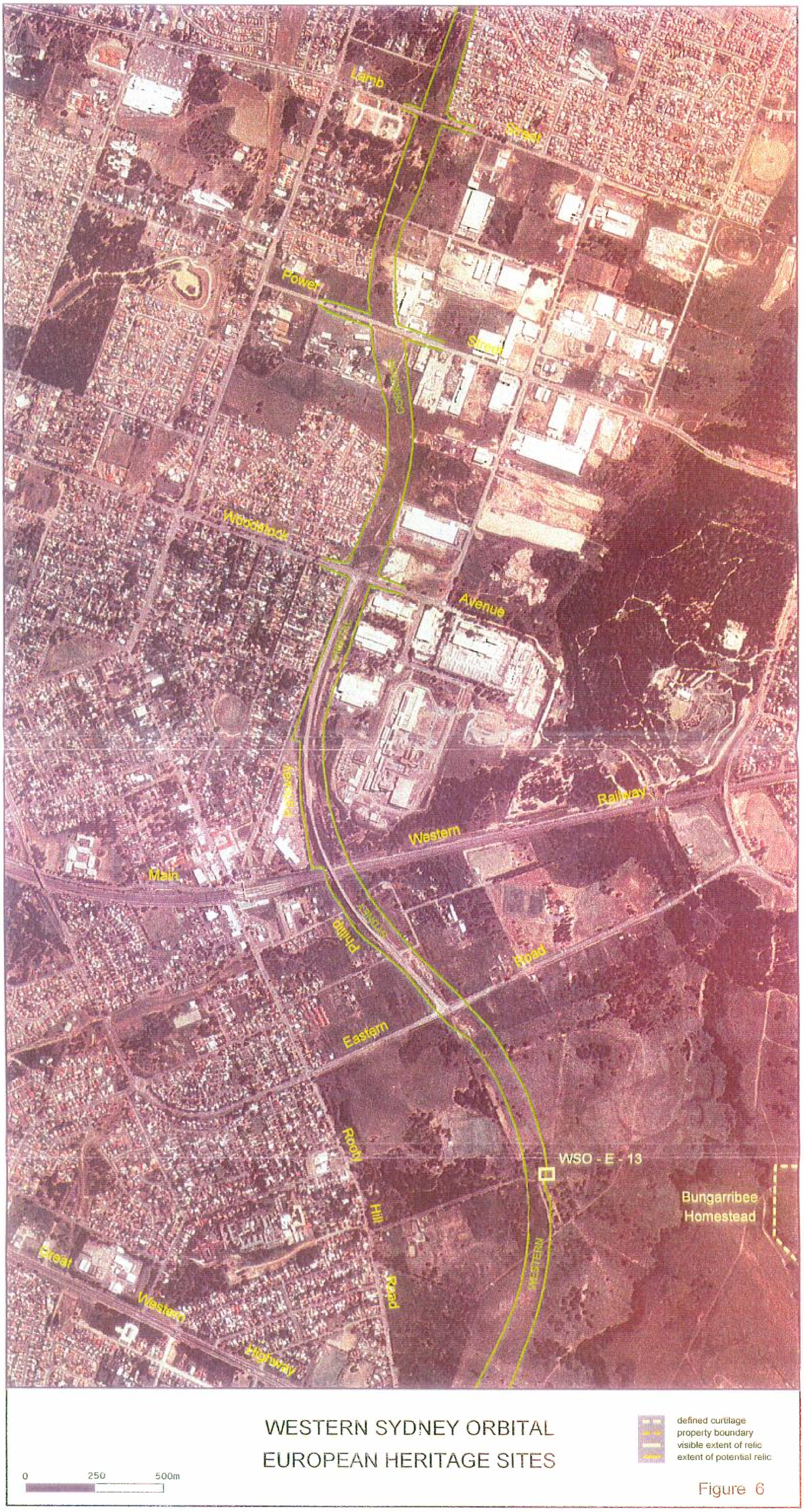


WESTERN SYDNEY ORBITAL
EUROPEAN HERITAGE SITES

0 250 500m

defined curtilage
property boundary
visible extent of relic
extent of potential relic

Figure 7



WESTERN SYDNEY ORBITAL
EUROPEAN HERITAGE SITES

Figure 6

0 250 500m

WESTERN SYDNEY ORBITAL
EUROPEAN HERITAGE SITES

defined curtilage
property boundary
visible extent of relic
extent of potential relic

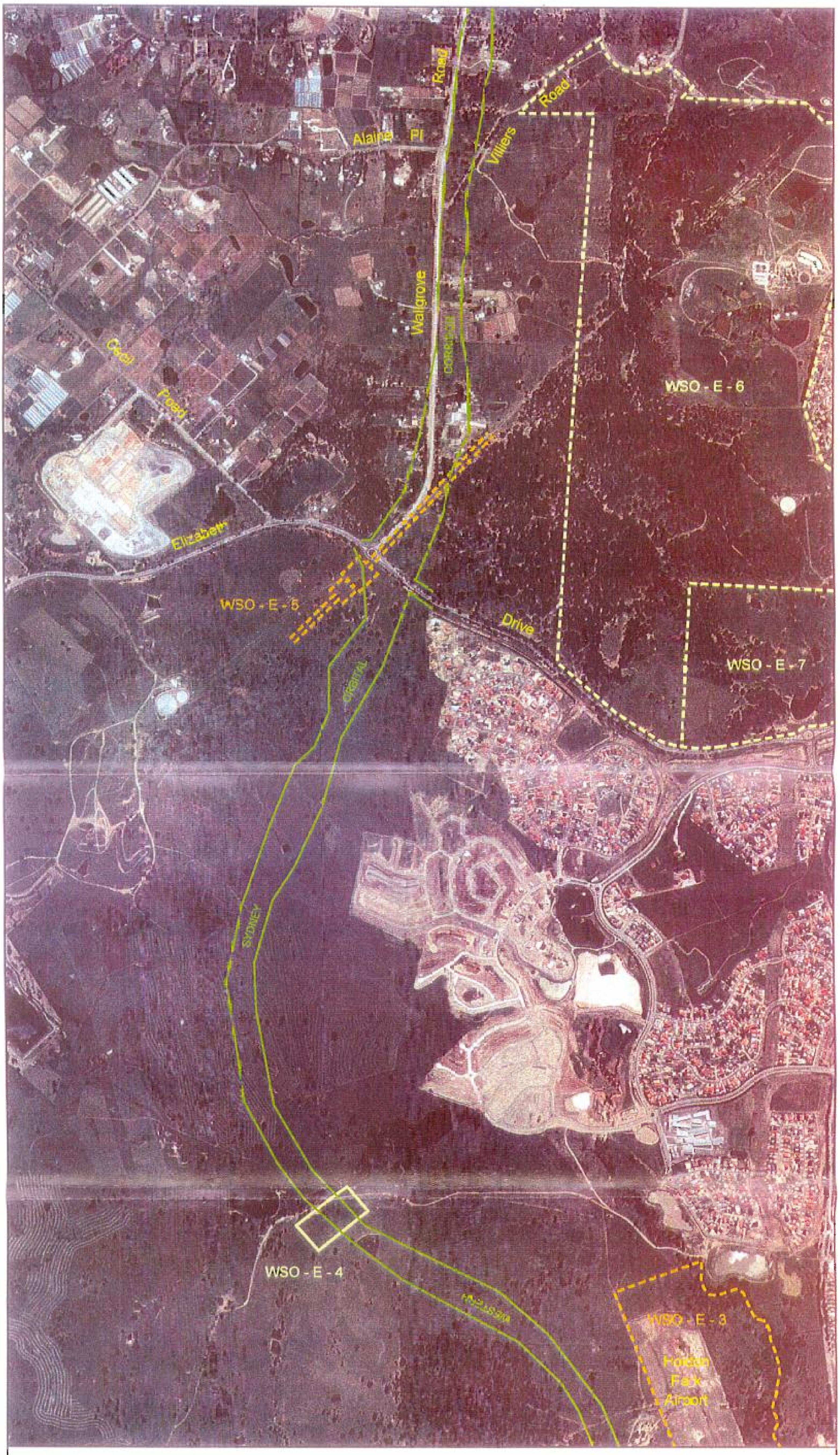
Figure 5

WESTERN SYDNEY ORBITAL
EUROPEAN HERITAGE SITES

0 250 500

defined curtilage
property boundary
visible extent of relic
extent of potential relic

Figure 4



WESTERN SYDNEY ORBITAL
EUROPEAN HERITAGE SITES

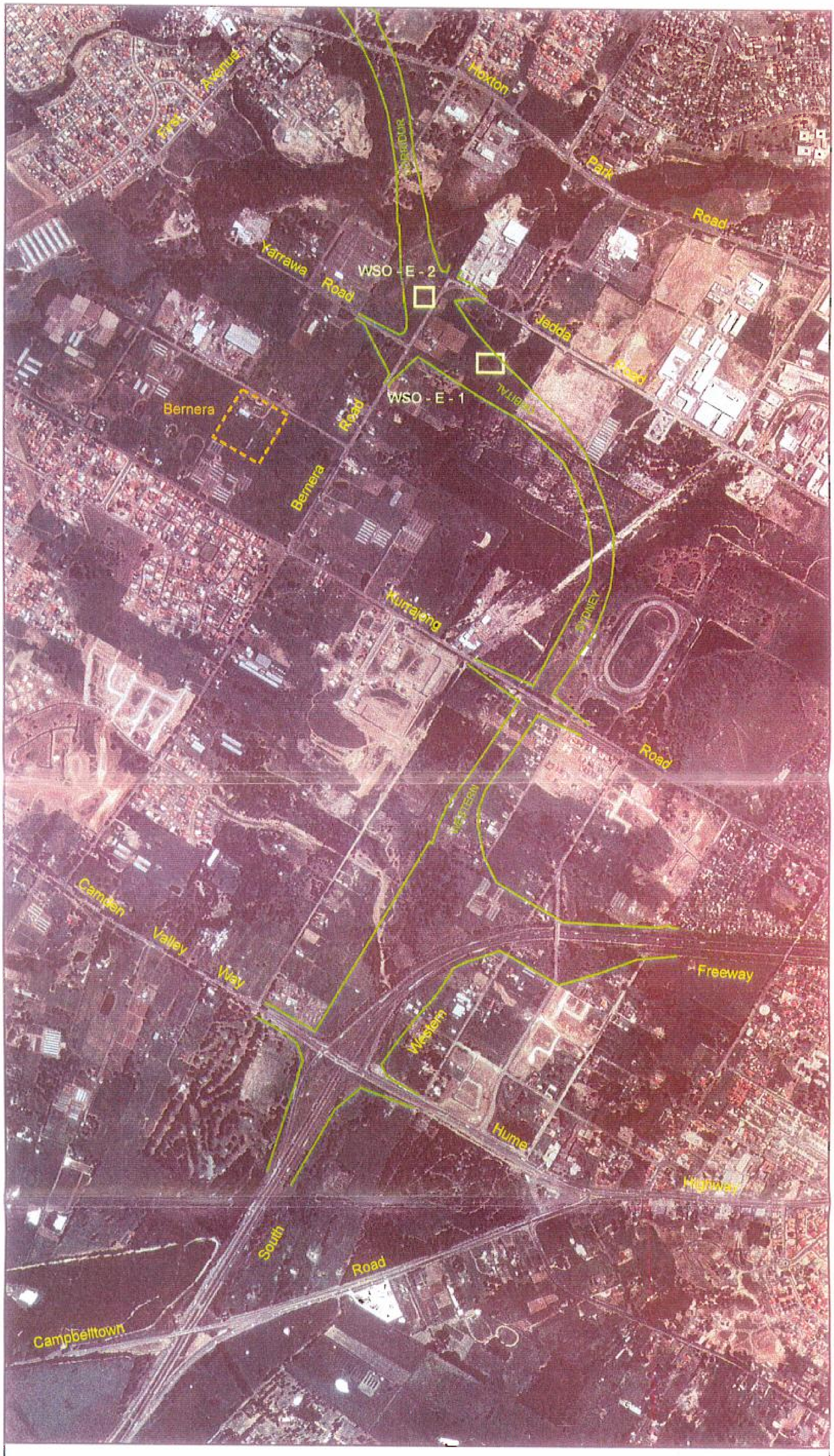
defined curtilage
property boundary
visible extent of relic
extent of potential relic

0 250 500m

Figure 3

WESTERN SYDNEY ORBITAL
EUROPEAN HERITAGE SITES

Figure 2



WESTERN SYDNEY ORBITAL
EUROPEAN HERITAGE SITES

0 250 500m

defined curtilage
property boundary
visible extent of relic
extent of potential relic

Figure 1

MODIFICATIONS REPORT

NON-INDIGENOUS HERITAGE

WESTERN SYDNEY ORBITAL

For

Robynne Mills & Associates

on behalf of

NSW Roads & Traffic Authority

August 2001

CASEY & LOWE ASSOCIATES

Archaeology & Heritage

420 Marrickville Road, Marrickville NSW 2204 • Tel: (02) 9568 5375

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EXECUTIVE SUMMARY

Results

The analysis for potential archaeological sites, the location of known heritage items and the field survey of all modifications indicates that the proposed modifications for the WSO will generally have no impact on archaeological sites or heritage items. Only five of the modifications require further assessment and most of these were already to be undertaken because of impacts from the proposed WSO. Modification 9 required a statement of heritage impact, which has already been written, and a s. 60 application approved by the NSW Heritage Council with conditions. Modifications requiring further work are:

- Modification 6: archaeological assessment of Hoxton Park Airport (WSO-E-3)
- Modification 8: archaeological assessment of site WSO-E-4
- Modification 13: Statement of Heritage Impact and s. 140 application (WSO-E-5)
- Modification 17: archaeological assessment of Wallgrove homestead and tannery (WSO-E-24).
- Modification 18: archaeological assessment for site WSO-E-13 and need to cordon off and protect site B5.

No detailed statements of significance can be written for these sites before the archaeological assessments and/or Statement of Heritage Impacts are written. All potential archaeological sites and relics are subject to the relics provisions of the NSW *Heritage Act* 1977 (amended).

The area of Modification 17 and the area to the east and also the area to the north of the M4 within the alignment of the proposed WSO may contain a site not previously identified, Wallgrove homestead and tannery (WSO-E-24). This area needs to be assessed to see if any remains survive in the area of the WSO alignment and if the modifications affect this potential site. The construction of the M4 may have affected the archaeological potential of this site.

Any change of design in relation to Modification 22 and 24 needs to avoid the site of the Native Institute.

Recommendations

1. Archaeological assessments need to be undertaken on the identified sites as soon as possible to understand the constraints of the sites and their heritage significance. The assessment of site of the possible European burials (WSO-E-15) needs to include the potential site of Symmonds' house.
2. There can be no impacts on potential sites without excavation permits (s. 140 application) being approved by the NSW Heritage Council.
3. In the area of Modification 18, site B5 should be identified and protected during construction works. It should be fenced around with coloured bunting and signs put up identifying the position of the site. The site should be located on design drawings so that the contractors are aware of the site at all times.
4. If there are further modifications or changes to the current design of WSO they will need to be assessed to determine if there are any further heritage issues.
5. If there is redesign to Modification 22 and 24 they should continue to avoid the Native Institute site.

CONTENTS

EXECUTIVE SUMMARY

1.0 Introduction

1.1 Background

This report on modifications is additional to the survey reports written for the Western Sydney Orbital EIS. The areas covered by the modifications are those where the works are outside the line of the EIS study area. Some of the modifications are minor works to link regional and state roads into the WSO and mainly involve upgrading roads by widening them within existing corridors. In a few cases some land will be acquired for widening. Mary Casey and Tony Lowe undertook the field survey of all the modifications on Wednesday 3 August 2001.

1.2 Study Area

While 30 modifications have been identified many of these are within the EIS boundary. Only modifications in areas outside the EIS boundary are the subject of this study. Therefore a total of 14 modifications are the subject of this report. The original modification number has been retained to maintain the overall numbering system. The majority of modifications are widening of existing roads while some of them involving the sideways shifting of the proposed route of WSO.

1.3 Methodology

The methodology used in this report is one where areas of archaeological potential are identified by using historic plans and aerial photographs and the potential is then assessed in the field. In addition heritage registers and lists of sites identified by earlier reports were reviewed. The histories from the Liverpool, Fairfield and Blacktown heritage studies were used as well as the Casey & Lowe report *Southern Section, Western Sydney Orbital, Non-Indigenous Heritage Survey*, July 2001. In addition where other heritage reports were available they were used to assist with the identification of sites.

1.4 Statutory Constraints

1.4.1 NSW *Heritage Act* 1977 (amended)

1.4.1.1 Division 9: Section 139, 140-146 - Relics Provisions - Excavation Permit

The main legislative constraint on archaeological remains is the relics provisions of the *Heritage Act* 1977.

According to Section 139:

1. *A person must not disturb or excavate any land knowing or having reasonable cause to suspect that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, moved, damaged or destroyed unless the disturbance or excavation is carried out in accordance with an excavation permit.*
2. *A person must not disturb or excavate any land on which the person has discovered or exposed a relic except in accordance with an excavation permit.*

A 'relic' is an item of 'environmental heritage' defined by the *Heritage Act 1977* (amended) as:

> *those places, buildings, works, relics, moveable objects, and precincts, of State or local heritage significance* (part 1, Section 4).

A relic as further defined by the Act is:

..any deposit. object or material evidence -
(a) which relates to the settlement of the area that comprises New South Wales. not being Aboriginal settlement: and
(b) which is 50 or more years old (Part 1. Section 4)

Any item identified as an historical archaeological site or relic cannot be impacted upon without an **excavation permit**. An excavation permit forms an approval from the Heritage Council for permission to 'disturb' a relic.

An application for an excavation permit must be made to the Heritage Council of NSW (Section 60 for items on the State Heritage Register). This will usually take four weeks to be processed. The application for a permit must nominate a qualified archaeologist to manage the disturbance of the relics. There is a processing fee of $100 attached to each excavation permit.

Section 140
An application can be made to the Heritage Council for a permit. It must be made on the correct form and a fee paid.

Section 146
A person discovering a relic must notify the Heritage Council of the location of the relic unless they have reasonable grounds for believing that the Heritage Council are aware of the relic. Furnish the Heritage Council with information concerning the relic.

1.4.1.2 Section 170 Register, NSW *Heritage Act* 1977 (amended)
A section 170 register is a listing of properties owned by a Government instrumentality.

1.4.2 Environmental Protection Act - Local Environmental Plans
A number of sites identified as being in the current study area are listed on local LEPs. The gazettal of an item on a LEP usually requires that a proponent seek approval from council for undertaking of works or alterations to an item.

1.4.3 Australian Heritage Commission Act
Where a site has been placed on the Register of the Australia Heritage Commission or has an interim listing on the Register certain protections are put in place which involve protection of sites in the case of impact by projects that involve Federal funding. Under

> *Section 30 of the Australian Heritage Commission Act imposes several obligations on Commonwealth Ministers. departments. authorities and companies owned by the Commonwealth to protect places in the Register of the National Estate. It comes into force when a place is either in the Register of the National Estate. or is on the Interim List of the Register.*
>
> *Commonwealth agencies have two general conservation obligations as well as a referral obligation. In addition. agencies are generally obliged to assist the Commission. The following summaries are provided for reference. however. agencies should be aware of the specific wording of these obligations in the Act.*
>
> ***Conservation Obligation 1***

Commonwealth agencies, including Ministers, departments and authorities, must not take any action that has an adverse effect on any part of the National Estate unless there is no feasible and prudent alternative. The decision whether an action can be taken or not is a decision for the agency, not the Commission. (Refer to subsection 30(1) or 30(2))

Conservation Obligation 2

If a Commonwealth agency finds that it must take an action which will have an adverse effect on part of the National Estate, because there is no feasible and prudent alternative, then the agency must take all reasonable measures to minimise the adverse effect. (Refer to subsection 30(1) or 30(2))[1]

Referral Obligation

Before a Commonwealth agency takes any action that might affect to a significant extent a place which is part of the national estate, it must advise the Commission and give the Commission a reasonable opportunity to consider and comment on it. The Commission's role is to provide expert advice, it does not take the decision-making role away from the agency. (Refer to subsection 30(3))

An important aspect of this legislation is that it does not give the Commission a formal 'watchdog' role. Rather, it confers the responsibility for complying with this legislation on the various Commonwealth Ministers, departments and authorities whose actions affect the National Estate.

It is not the Commission which decides whether or not the Commonwealth Government will proceed with an action which will adversely affect a place in the Register. It is up to the Commonwealth Government, or the Government agency responsible for the proposed action to take this decision. The interpretation of 'feasible and prudent alternative', for example, is up to the Government proponent to determine, not the Commission. The Commission is only obliged to provide full advice on the impact of the proposed action on the national estate values of the place concerned.

Advice provided by the Commission to Commonwealth Ministers and bodies under section 30, is based on the statements of significance. These are statements which are prepared for each place in the Register and which explain the significant national estate values of each place.

1.5 Limitations

There were no real limitations on the production of this survey report.

1.6 Author Identification

This report was written by Mary Casey and reviewed by Tony Lowe of Casey & Lowe.

1.7 Acknowledgements

Robynne Mills
RTA: Lisa Brown
Blacktown Council: Sue Galt

[1] Extract from AHC web page http://www.ahc.gov.au/heritage/protection/obligations.html

1.8 Abbreviations

DCP Development Control Plan
LEP Local Environmental Plan
LPI Land and Property Information
RTA Road and Traffic Authority

1.9 Terminology

Archaeological Assessment
A study undertaken to establish the archaeological significance (research potential) of a particular site and to identify appropriate management actions.

Archaeological Potential
Archaeological potential is here used and defined as a site's potential to contain archaeological relics which fall under the provisions of the *Heritage Act* 1977 (amended). This potential is identified through historical research and by judging whether current building or other activities have removed all evidence of known previous land use.

Archaeological Investigation or Excavation
The manual excavation of an archaeological site. This type of excavation on historic sites usually involves the stratigraphic excavation of open areas.

Archaeological Monitoring
Archaeological monitoring is recommended for those areas where the impact of the works is not considered to mean the destruction of significant archaeological fabric. Nevertheless the disturbance of features both suspected and unsuspected is possible. In order to provide for the proper assessment and recording of these features an archaeologist should inspect the works site at intervals they consider to be adequate and to be 'at call' in case the contractor uncovers remains that should be assessed by the archaeologist.

It is not anticipated that monitoring will impact on the planned works or unduly hold up the contractors' work schedules. If recording of features is necessary it would be carried out as quickly as possible so that any time delays are minimised.

Monitoring is a regular archaeological practice used on many building and development sites.

Excavation Permit
A permit to disturb or excavate a relic issued by the Heritage Council of New South Wales under Section 60 or Section 140 of the NSW *Heritage Act* 1977.

Archaeological Site
A place that contains evidence of past human activity. Below ground sites include building foundations, occupation deposits, features and artefacts. Above ground archaeological sites include buildings, works, industrial structures and relics that are intact or ruined.

Historical Archaeology
Historical Archaeology (in NSW) is the study of the physical remains of the past, in association with historical documents, since the European occupation of NSW in 1788. As well as identifying these remains the study of this material can help elucidate the processes, historical and otherwise, which have created our present surroundings. It includes an examination of how the late eighteenth- and nineteenth-century arrivals lived and coped with a new and alien environment, what they ate, where and how they lived, the consumer items they used and their trade relations, and how gender and cultural groups interacted. The material remains studied include:

- Archaeological Sites:
  - below ground: these contains relics which include building foundations, occupation deposits, rubbish pits, cesspits, wells, other features, and artefacts.
  - above ground: buildings, works, industrial structures and relics that are intact or ruined.
- Cultural Landscapes
- Maritime Sites:
  - shipwrecks
  - structures associated with maritime activities.

Research Design
A set of questions which can be investigated using archaeological evidence and a methodology for addressing them. A research design is intended to ensure that archaeological investigations focus on genuine research needs. It is an important tool that ensures that when archaeological resources are destroyed by excavation, their information content can be preserved and can contribute to current and relevant knowledge.

Relic
A relic as further defined by the NSW *Heritage Act* 1977 (amended) is:

> *..any deposit, object or material evidence -*
> *(a) which relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement: and*
> *(b) which is 50 or more years old* (Part 1, Section 4)

Research Potential
The ability of a site or feature to yield information through archaeological investigation. The significance of archaeological sites is assessed according to their ability to contribute information to substantive research questions.

Sampling
Sampling of the archaeological resource is an excavation strategy that is adopted when there is a large area that contains a similar resource and it is not considered warranted to fully excavate everything as the sample can be extrapolated to stand for the whole of the resource. The sample taken should be considered representative of the whole related resource and should be chosen only after detailed consideration of the various alternatives.

Testing
The usual intention behind archaeological testing is to have a look in the ground to confirm the archaeological potential of the site identified in the archaeological assessment. It can be an integral part of the process of confirming the absence or presence and extent of the archaeological resources. It is important to have a testing strategy that addresses the predictive model rather than just looks for structures.

1.10 List of Illustrations

Figure 2.15: Subdivision plan of Duggan Farms Estate, Quakers Hill. This shows the land to the east of the railway line and west of Sunnyholt Road as being relatively undeveloped prior to subdivision this post-1915 subdivision. The thick black line indicates the approximate position of the WSO where it meets the intersection of Sunnyholt Road and Meurants Lane. ML SP Quakers Hill Q1/7.

<u>Section 3</u>

Figure 3.1: View to north along Beech Road through modern housing estate. This road will be widened to 4/5 lanes. Modification 1. 1 August 2001.

Figure 3.2: View to south along Bernera Road, Prestons. The road will be widened along the western side where a strip of land will be acquired. Modification 3. 1 August 2001.

Figure 3.3: View to east along Jedda Road, Prestons. Land acquisition along northern side. Modification 4. 1 August 2001.

Figure 3.4: View to east across southern part of Hoxton Park Airport. Modification 6. 1 August 2001.

Figure 3.5: View to west along McIver Avenue. Modification 7. 1 August 2001.

Figure 3.6: View to east over the Sydney Water Supply pipelines that cross Wallgrove Road. Modification 11. 12 June 2001.

Photo 3.7: Person standing on doorstep at site B5, OTC property, Eastern Creek. This site dates to post-1917. This site is outside the line of construction and should be fenced off during construction works. Modification 18. 14 August 2001.

Photo 3.8: View over site B7 which has been remediated. Dates to post-1917. Modification 18. 14 August 2001.

Photo 3.9: General area of site B8 as shown on aerial. No remains survive in this area. Modification 18. 14 August 2001.

Photo 3.10: Yard area adjacent to where the house had been at site B8. This site dates to post-1917. Modification 18. 14 August 2001.

Figure 3.11: View to northwest over the site of the Native Institute. Near Modification 22 and 24. 1 August 2001.

Figure 3.12: Location of Native Institute site adjacent to Rooty Hill Road North. Modification 22.

Figure 3.13: View to north along entry road into sand and gravel place. Modification 23. 1 August 2001.

<u>Section 4</u>

Figure 4.1: View to west along proposed extension of Northwest Boulevard. Heritage item, a weatherboard house, is visible on the right in the background. 1 August 2001.

2.0 Historical Background

2.1 Methodology

As part of determining the location of potential non-indigenous archaeological sites within the corridor of the modifications a search of relevant parish, subdivision and other historic plans was undertaken as well as a review of relevant heritage studies and their histories. While a search of heritage registers rarely identifies archaeological sites it does provide a backbone of the development of the general area by indicating where important extant houses and their associated estates were established. The histories from the heritage studies assists in this process by usually identifying sites of significant homesteads that had been demolished. In the case of this project some of this initial work was undertaken for the EIS. In addition a search of Mitchell Library subdivision plans provided important additional information on the process of subdivision along the route of the proposed WSO and its modifications.

2.2 Heritage Themes

The thematic histories from the Liverpool, Fairfield and Blacktown heritage studies identified a number of themes that related to the development of areas through which the WSO route passes:

- Settlement
- Transport and urbanisation
- Exploitation of natural resources
- Farming activities
- Rural industry
- Subdivision and urban growth
- Regional functions

These themes are variously named in the three histories as they were written prior to the formalising of the state heritage themes.

2.3 Liverpool Section - Historical Background

The Liverpool section of the study area has been dealt with in some detail in the Casey & Lowe's most recent survey report on the Prestons to Cecil Hills Part of the route - *Non-Indigenous Heritage. Archaeological Survey. Southern Section Western Sydney Orbital*, July 2001. The following section is extracted from that report.

The study area between Camden Valley Way, Prestons and Elizabeth Drive, Abbotsbury was once part of a number of early estates (Fig. 2.1). At its southern end the proposed WSO passes through what were Church and School Lands and the Bernera Estate. The site of the Bernera homestead is listed on the Liverpool Local Environmental Plan (LEP) and the State Heritage Register (SHR) and is a considerable distance to the southwest of the proposed alignment of the WSO through the estate. Bernera Estate was originally 1000 acres of land granted to Dr Donald Macleod.[2] He sold it to Alan McPherson who built a timber house c. 1856-57. This house was destroyed in 1986. Bernera Estate was subdivided in 1889 when Hardie and Gorman auctioned the blocks of land (Fig. 2.2). The WSO goes through lots 4, 5, 17 and 23 of the Bernera Estate, either side of the junction of Bernera Road and Jedda Road (formerly Wonga Street). Jedda and Joadja Roads were aligned as part of the 1889 subdivision of Bernera Estate. There will be no impact on the site of Bernera homestead by the proposed modifications to the WSO route, either visual or physical.

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[2] Keating 1996:22.

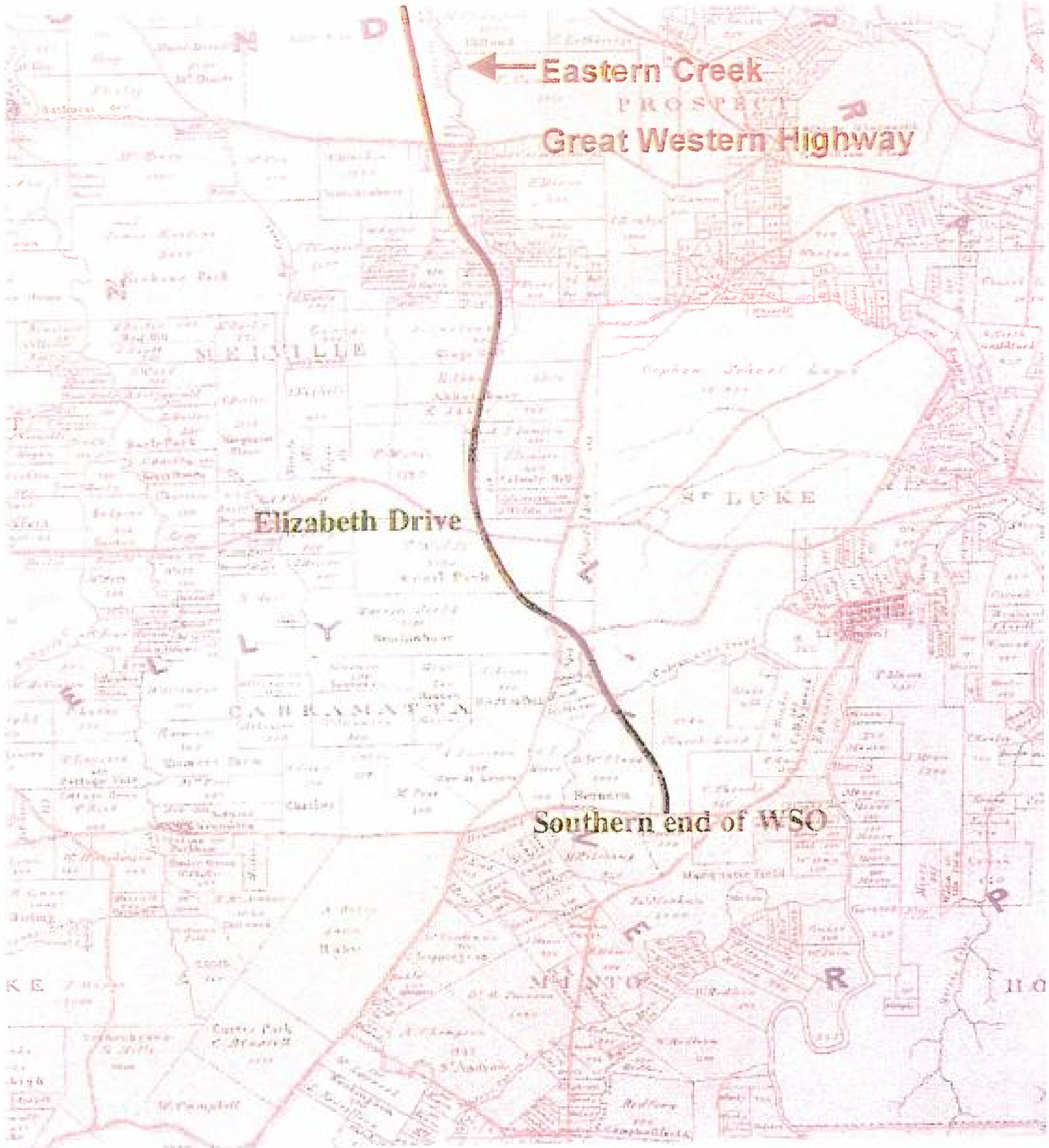

Figure 2.1: Plan showing early land grants in Liverpool and Fairfield districts and approximate position of proposed WSO alignment. WSO alignment based on the EIS 'Summary' document. *County of Cumberland*, 1894, ML MSS. Taken from Keating 1996.

The Morris and Britton report on the *Colonial Landscapes of the Cumberland Plain and Camden, NSW*, identified the presence of the site of the Bernera homestead at Prestons but noted that since the fire in 1986 the 'local area has recently developed for suburban housing and the former Bernera is now only an archaeological site'.[3] No other houses, landscapes or sites mentioned in the Colonial Landscapes report are particularly close to the proposed route of the WSO or its modifications.

The 1947 aerial photos show the Church and School Lands at the southern end as being generally undeveloped in 1947, indicating that some areas had been cleared very little or that there was considerable regrowth on lands no longer intensively used for grazing or farming (Aerials 1, 2). The proposed WSO then passes through the southwest corner of School and Orphan lands, into a small property once owned by Drummond (Fig. 2.1). It then passes through the northeastern part

[3] Morris and Britton 2000:113.

of the Hoxton Park Estate which was subdivided in 1887 and in 1906 was described as 'thickly timbered. Small holdings, a few occupied, the others are covered with thick timber & scrub'.[4] It crosses over the line of Cowpasture Road, an early road in the district which was a major route between Camden and Parramatta and was frequently used by cattle drovers.[5] It opened as a track in 1806 from the settlement at Prospect Hills to the Cowpastures.[6] William Roberts undertook some road construction on a number of early roads using convict gangs and built a series of bridges on roads including Liverpool Road (Great Western Highway) and Dog Trap Road (Woodville Road) as well as Cowpasture Road. No early roadworks survive within the study area.

The next stage of the proposed WSO next passes through a larger estate granted to Barron Field called 'Hinchinbrook' (Fig. 2.1). To the north was 'Cecil Hills farm', the early estate of Sir John Wylde, Judge Advocate, which has extant original buildings including a homestead and outbuildings (Aerial 5).[7] This house and outbuildings are located on Sandringham Drive, Cecil Hills and are considerably to the east of the proposed realignment of the WSO in this area and are therefore not affected by the WSO.

Elizabeth Drive, which is the northern boundary of the current study area, is within the former boundary of the Cecil Hills Farm grant. The Cecil Hills grant was made in 1817 and was taken up in 1818. The house is thought to have been built c. 1824. The Wylde family ran cattle on the property and sold beef to the government stores. Judge Advocate John Wylde was recognised as one of the largest landholders in the colony in the 1820s. The family retained ownership until 1892 when the Perpetual Trustee sold the property. The Crown compulsorily purchased this property in 1972.[8] Only parts of the grant have been subdivided. The 1947 aerial photos show that this area was uncultivated grazing land with some fenced yards with a house and outbuilding group at some distance from the study area (Aerial 5). An area of ruined yards (WSO-E-4) will be affected by modification 8 of the proposed route of the WSO.

The Hoxton Park Airport, which was initially used as a WWII airstrip, is to the west of Cowpasture Road (Fig. 2.4, 2.5, 2.8). It appears to be mostly within the two early grants to Barron Field and Judge Wylde. The southern end is probably within the Hoxton Park Estate.[9] While it has been reported that the airstrip had 'revetments' these actually consist only of gravel road taxiways.[10] The aim of the taxiways was to allow for the planes to be quickly scattered, in the case of a Japanese attack, into the adjacent tree cover (now Landcom land). An aerial photo (Aerial 4) shows the position of the main taxiway from the airport to the revetments and indicates the location of proposed impacts from the WSO alignment. Modification 6 will impinge into the southern area of the airport. All Commonwealth-owned land associated with Hoxton Park Airport is the subject of an interim listing on the National Estate.

[4] Quoted in Kass 1992:3.19.
[5] Kass 'Thematic history', Fairfield Heritage Study, p. 5.
[6] Keating 1996:15.
[7] Keating 1996:22.
[8] Heritage Office Register listing, web page.
[9] Mitchell Library, Liverpool subdivision plan L 10/34.
[10] Iain Stuart, pers. comm.

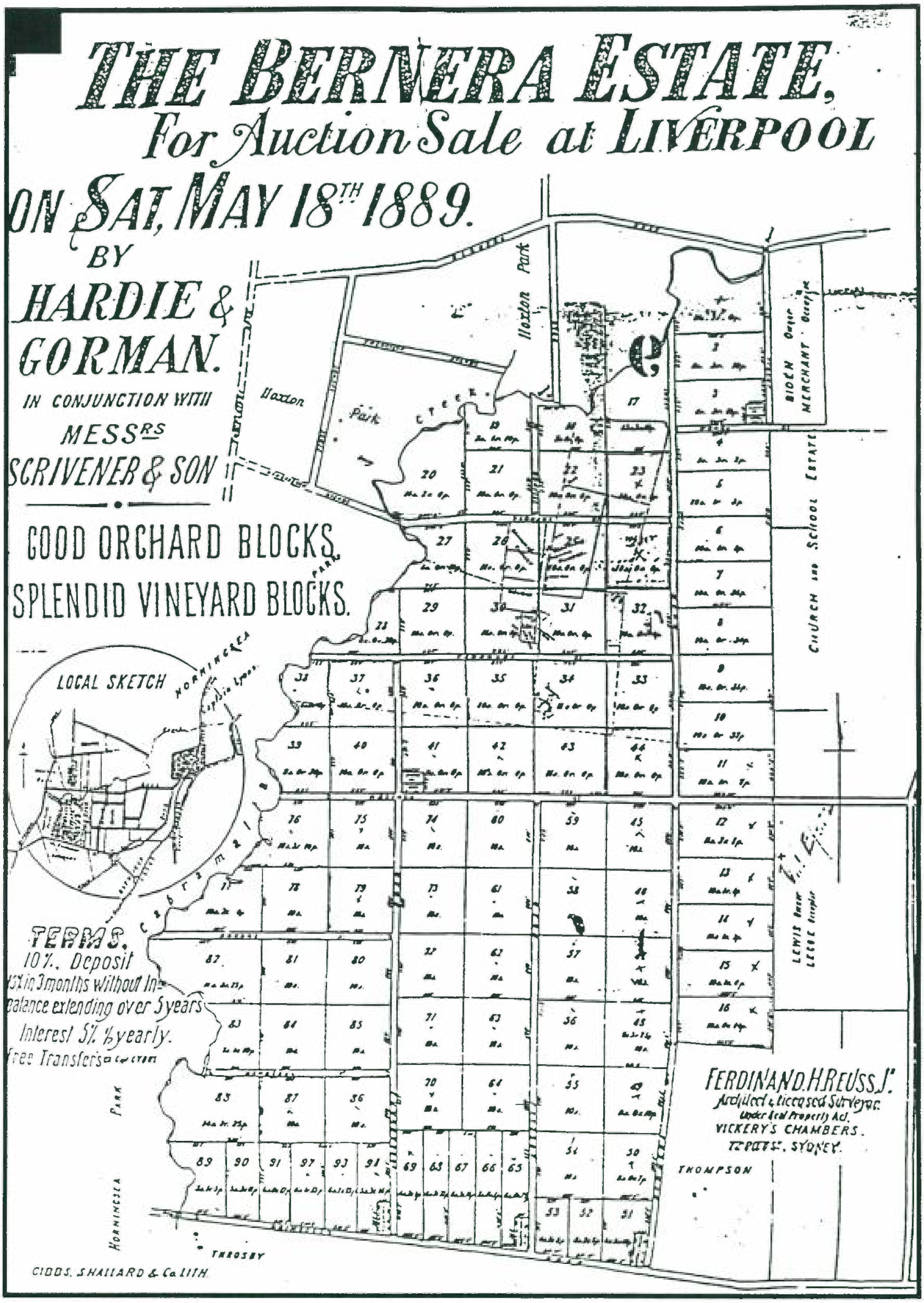

Figure 2.2: Bernera Estate plan as subdivided in 1889. ML, Subdivision Plans, Liverpool, L/10/4.

2.4 Fairfield Section - Historical Background

The section of the study area north of Elizabeth Drive, Cecil Hills and south of the Warragamba Pipelines is in Fairfield City Council area. The majority of this area to the east of Wallgrove Road became part of the Abbotsbury Estate and later it was owned by the residents of Horsley Park. The southern section immediately north of Elizabeth Drive was part of two small grants, one owned by Simeon Lord and the other owned by Joseph Sherred (Fig. 2.1). The next two grants were those owned by Edward Abbott, one of which was called 'Abbotsbury'. It then crosses through a larger grant given to George Johnson called 'Kings Gift'. This area is now part of the Horsley Park Equestrian Centre which was the subject of a detailed archaeological assessment in 1996 prior to the development of the Olympic Equestrian Centre.[11]

Abbotsbury land was granted to Edward Abbott in 1806 and appears to have been managed as a grazing property. It was sold in 1810 to William Browne. Browne's family are living on the property, apparently in a cottage, by 1815. A house and outbuildings were erected on the property. Browne sold his property in 1831. There were a succession of owners until the 1840s. The owners of Horsley park, the Johnson-Weston family eventually purchased this property. It appears that the house probably fell into disuse by the 1910s.[12] Figure 2.3 shows the position of archaeological remains associated with Abbotsbury. None of these sites are effected by the proposed WSO or its modifications.

George Johnson's grant to the north 'Kings Gift' appears to have been used for grazing and possibly farming. This 2000 acre grant was given to George Johnson in 1805 in recognition of his important role in quelling the Irish convict uprising at Vinegar Hill in 1804. By 1828 the property had huts and stockyards and was owned by Johnson's son David. The house built on this land was Horsley house which is to the west of Wallgrove Road approximately 800 metres from the line of the proposed WSO (Aerial 7). Chandos Road is on the northern boundary of Johnson's original grant.

After leaving 'Kings Gift' the route of the WSO passes through a number of smaller grants (Fig. 2.1). The aerial shows a patchwork of properties to the east of the proposed WSO with much of the land to the west being relatively undeveloped (Aerial 8). In 1947 the land to the south of the Warragamba pipelines was generally undeveloped although it had been cleared. There appears to have been little development of the area around the pipelines prior to their construction.

2.5 Blacktown Section - Historical Background

The area to the north of the pipelines and north of Reedy Creek was a WWII RAAF base where the people operating Hoxton Park airport lived. The radio station of the airport operated out of this base (Aerial 9). The land to the south of the Great Western Highway was part of an early grant to William Dean. The house thought by some to be Coleman's Inn is situated on land granted to Dean. The land to the north of the Great Western Highway was once part of the Rooty Hill Stock Farm (Fig. 2.4). This stock farm was declared by Governor King in 1803 and was one of a series of government farms and public commons established by King. They were used for breeding animals for distribution to new settlers to start their farms. Grimes suggested that the land west from Prospect to South Creek was government reserve, totalling as much as 58,000 acres. By 1803 this area became known as Rooty Hill stock farm.[13]

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[11] Higginbotham 1996 *Historical and archaeological assessment of the proposed Sydney International Equestrian Centre, Horsley Park, NSW*, for the Olympic Co-Ordination Authority.

[12] Higginbotham 1996:5-9.

[13] Liston, thematic history, *Blacktown Heritage Study* 1996:3.

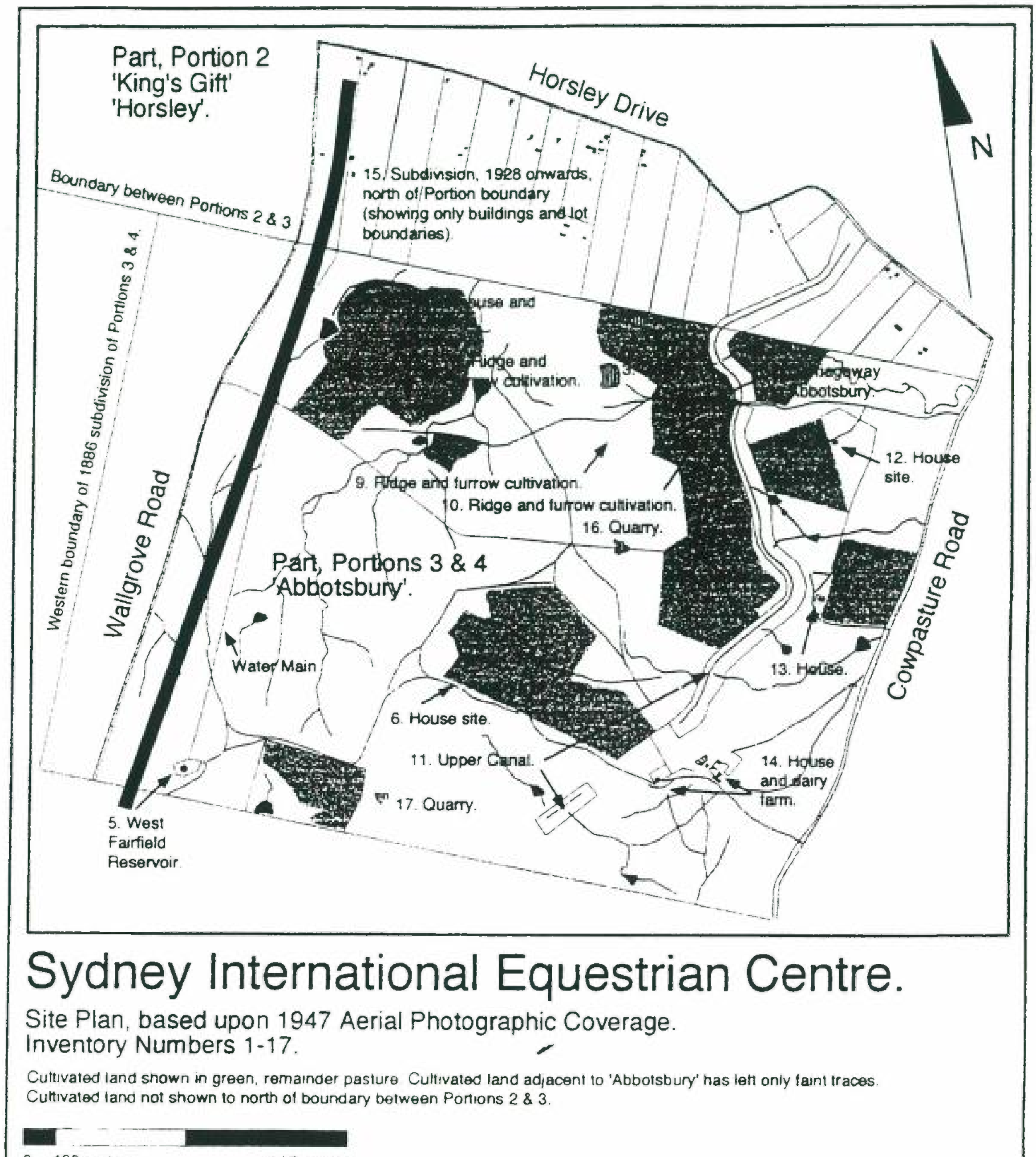

Figure 2.3: Plan of sites identified at the Horsley Park Equestrian Centre. The proposed line of the WSO is to the east of the Wallgrove Road and west of the water main. There will be no impact from the modifications on identified archaeological sites. Taken from Edward Higginbotham & Associates 1996.

Governor Macquarie was ordered to discontinue the use of government farming and granted portions of the stock farm to Lieutenant-Colonel Maurice O'Connell (2,500) acres in 1810. The stockyard was reorganised in 1813. A residence was built at the Rooty Hill stock farm in 1815. The line of Rooty Hill Road linked the stock farm and the cottage to the Great Western Highway (Liverpool Road). Remains associated with stock farm survive in Dunsmore Street, Rooty Hill (Aerial 11).

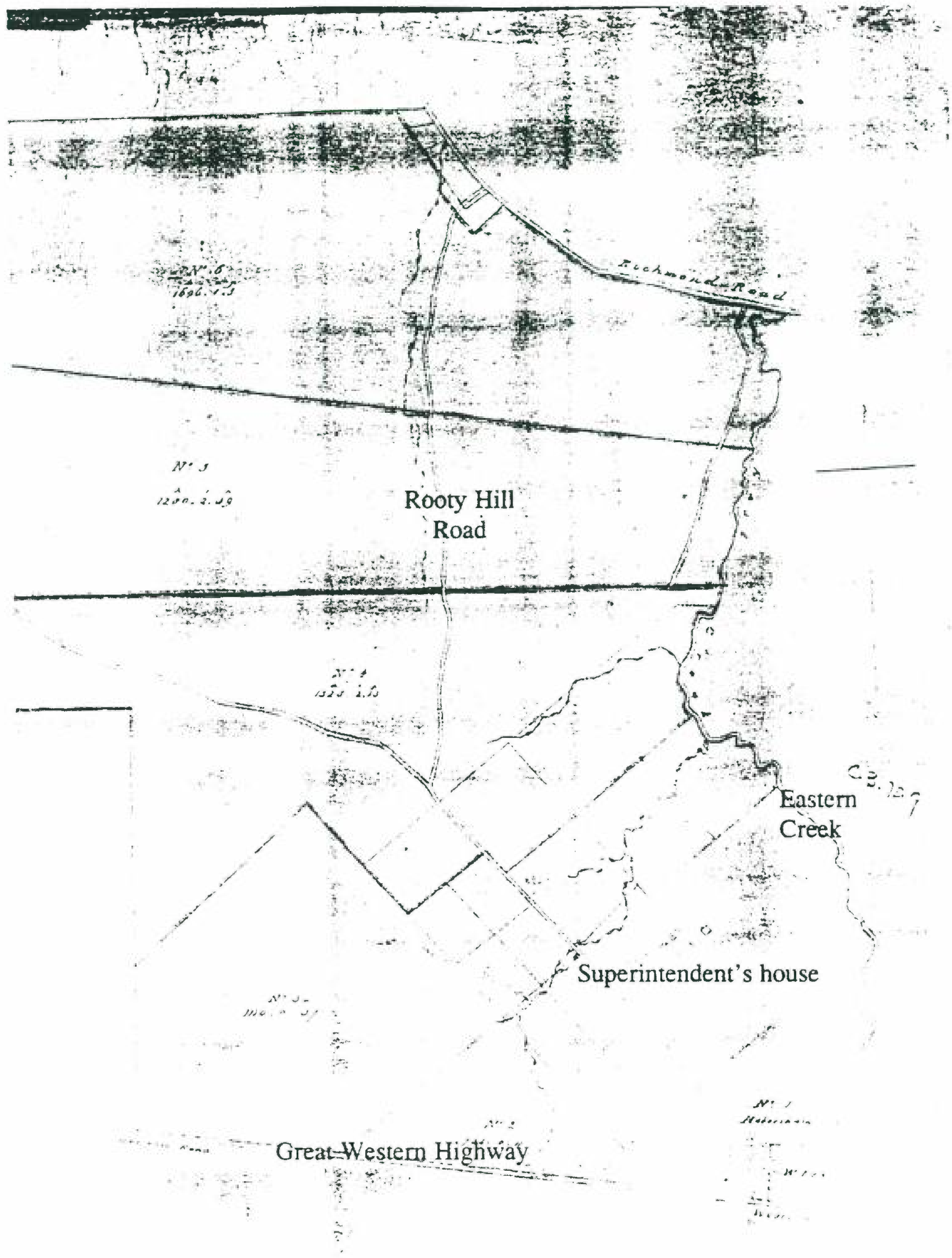

Figure 2.4: *Plan of Rooty Hill Stock Farm/Church and School Estate.* Position of the Superintendent's house is shown in the lower section of the map, c. 1831. SR Map 1811.

By the 1820s further grants of land reduced the size of the stock farm. Its eastern boundary had become Eastern Creek. Figure 2.4 shows the stock farm in c. 1831 when its boundaries were Eastern Creek, the Western Road and Richmond Road. Richmond Road was made by William Cox as the second road to the Hawkesbury in 1819.[14] In 1829 the remnants of Rooty Hill Stock Farm were transferred to the Church and School Corporation but because it did not use the land successfully the corporation was abolished in 1832. The government eventually sold the land.[15]

[14] Liston 1986:16.
[15] Liston 1986:5.

The lands at Rooty Hill were leased as grazing land and were offered for sale in 1865. Much of the land that makes up Rooty Hill was acquired by Charles McKay of Minchinbury, up to the railway line. Walter Lamb of Woodstock acquired extensive land to the north of the railway up to Richmond Road.

Land on the Highway (Western Road) had been granted to William Dean a convict who arrived in 1799 (Fig. 2.4). Dean had grants on either side of the Western Road which he was given in January 1817.[16] It was here that a small settlement node was established with Dean's inn, a post office, a blacksmith's shop and public school (Fig. 2.5, 2.6). The inn building was to the east of Eastern Creek, while the house at 587 Great Western Highway (WSO-E-12) was Mr Coleman's house. The inn was variously called the Bush Inn, Corporation Inn (1832) and Red Lion. The William and Elizabeth Dean moved into 'Hillborough' though to be an old convict barrack in 1846.[17] To the south, near modifications 17 and where the proposed WSO orbital links into the M4, was the site of Wallgrove Homestead (WSO-E-24) which had a tannery and orchard (Fig. 2.5). This was probably the Wallgrove Estate purchased by John Shand of Rooty Hill, gentleman and tanner, from Charles Roberts in 1866. Shand retained ownership for most of the nineteenth-century. No physical evidence for this site survives above ground. This is a purely sub-surface archaeological site. This site is not visible on the 1951 aerial photo (Aerial 9). It is also possible that remains associated with this site were destroyed when the M4 when through. The subdivision to the south of the Wallgrove Homestead (Fig. 2.5) eventually became the RAAF base (WSO-E-11) (Aerial 9). This camp was established by the Australian Army during World War 2 and continued to operate until the 1970s. Sections of the bases were used in 1949 for post-war immigrant accommodation.[18]

An archaeological assessment of the OTC site, which includes the site of Bungarribee, identified a series of sites (Fig. 2.7). Two of these are adjacent to the line of the WSO and Modification 18 which shifts the alignment approximately 40 m to the west near Belmore Road and Curry Street. Details of impacts on sites are discussed in Section 3. All sites adjacent to or in the alignment of the proposed WSO and Modification 18 appear to date after the 1917 subdivision.

The next subdivision plan immediately to the north of Figure 2.6 shows the position of the Rooty Hill Stock farm building to the west of the Phillip Parkway (Fig. 2.8). When this area was subdivided there it was generally undeveloped aside from the Rooty Hill 'homestead' which was the superintendent's house built under Macquarie's direction and another cottage to the east. The proposed line of WSO affects none of these sites or items. The focus of later nineteenth-century settlement at Rooty Hill was on Rooty Hill Road near the railway line and station. This subdivision was part of 'Smith's Eastern Creek farms'.

Further to the north was Walter Lamb's estate Woodstock. As noted above Lamb purchased part of the Rooty Hill Stock Farm following its sale in 1865. He built a homestead with dairies further to the north (Fig. 2.9). Woodstock House is still extant and is item 55 on the draft Blacktown DCP plan (Appendix 2). The subdivision of Lamb's estate was into small orchard allotments. Within two yeas the area was a highly productive with 100 acres of peaches, apricots, pears, quince, plums, apples, oranges and lemons and a nursery of young trees.[19] Lamb was an extremely successful businessman and Member of the Legislative Council. The line of WSO is to the west of the main group of buildings associated with his Woodstock Estate (Fig. 2.9).

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[16] Austral Archaeology *An archaeological and heritage impact assessment of the Telstra OTC site, Great Western Highway, Doonside*. nd:29.

[17] Liston 1986:17.

[18] Liston 1986:39.

[19] Liston 1986:30.

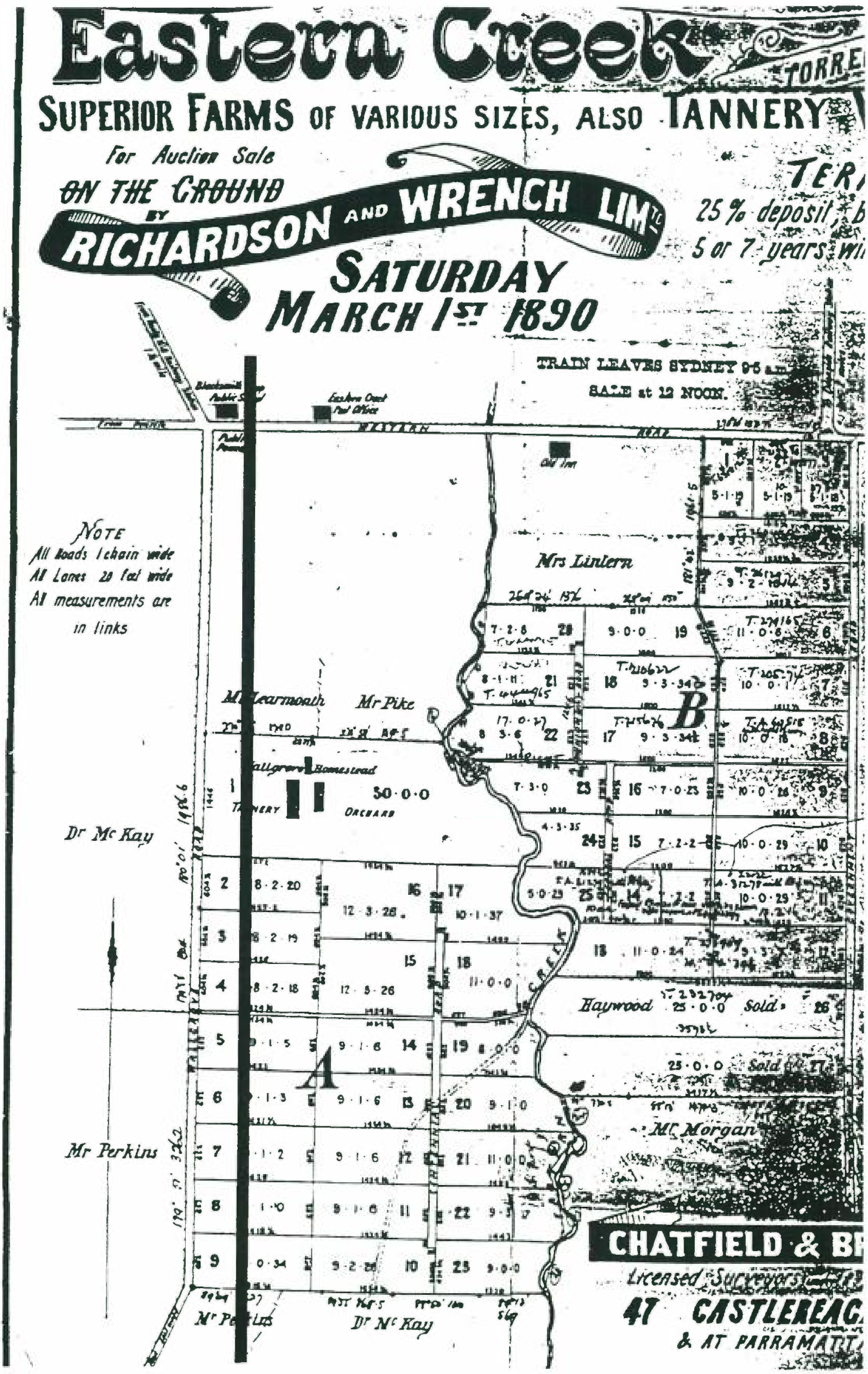

Figure 2.5: Subdivision plan showing buildings on the Western Road and to the south, including Wallgrove Homestead, tannery and orchard, 1890. The thick black line is the approximate position of the WSO. ML SP Rooty Hill R13.1/22.

Figure 2.6: This shows a group of buildings aligned either side of the Great Western Road. The land in the OTC property to the north of the Highway has just been subdivided and is up for sale. This dates most of the remains in the western part of the Bungaribee property to after 1917. This is not an accurate plan. Thick black line shows approximate position of proposed WSO. ML SP Rooty Hill R13.1/19.

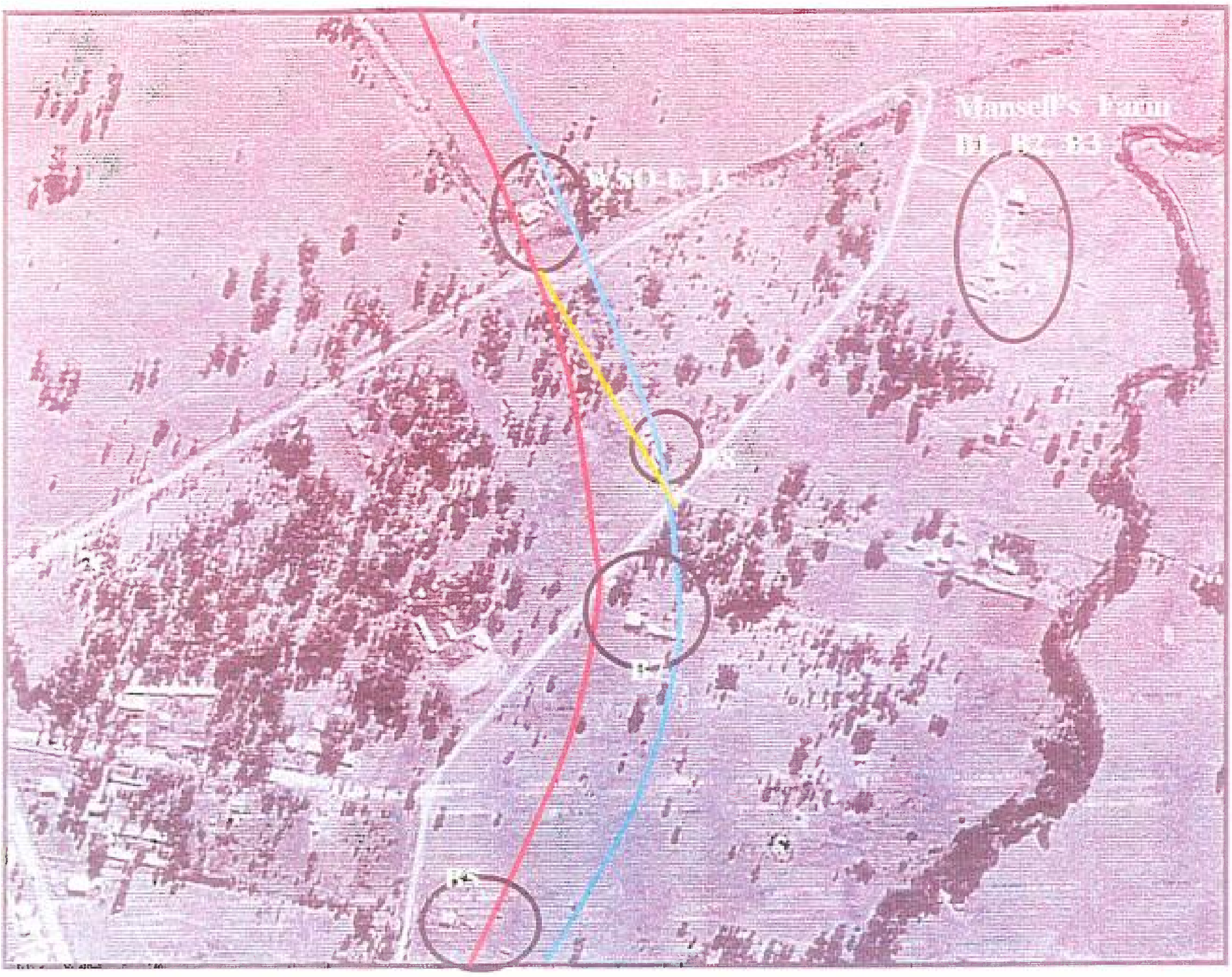

Figure 2.7: Detail from 1951 aerial showing the various sites identified in the western part of the Bungarribee. Site B1-3 and B5 were identified by Austral Archaeology. The red line indicates the approximate position of the new western side of Modification 18.

Modification 22, the widening of Rooty Hill Road North along the western side of the road, does not affect the site of any remains associated with this property. As Figures 2.8, 2.9 and Appendix 2 shows the main extant buildings listed on the LEP are to the south of the modification. The western side of Rooty Hill Road was generally undeveloped aside from the township at Plumpton (Fig. 2.8, 2.9).

In 1814 Governor Macquarie assisted missionary William Shelley in establishing a native institue at Parramatta to teach Aboriginal children European customs and farming.[20] In May 1816 Macquarie granted land to Colebe and Nurragingy, two local Aborigines, to the north of Richmond Road, near Bells Creek. The details are sketchy but they both appear to have had 15 acres (6 ha) each (Fig. 2.13). In 1819 a log house was built for Nurragingy (Creek Jemmy) on the grant. The native institute was moved to the south of Richmond Road and west of Rooty Hill Road North in 1823, on land opposite the grants to Colebe and Nurragingy.[21] By 1821 five couples were living there and in mid-1822 Dr John Harris called this area Black Town.[22] The native institute operated until it was abandoned in 1833 and the land was sold in 1834 to William Bell. The mission house was used as an inn until it was purchased by Sydney Burdekin for a country residence and renamed 'Lloydhurst (Fig. 2.11). The building burnt down in 1924. In 1917 there were Aboriginal families living in bark huts on the Colebe and Nurragingy grants.[23]

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[20] Liston 1986:12.
[21] Brooks & Kohen 1991:37-39.
[22] Liston 1986:13.
[23] Liston 1986:14.

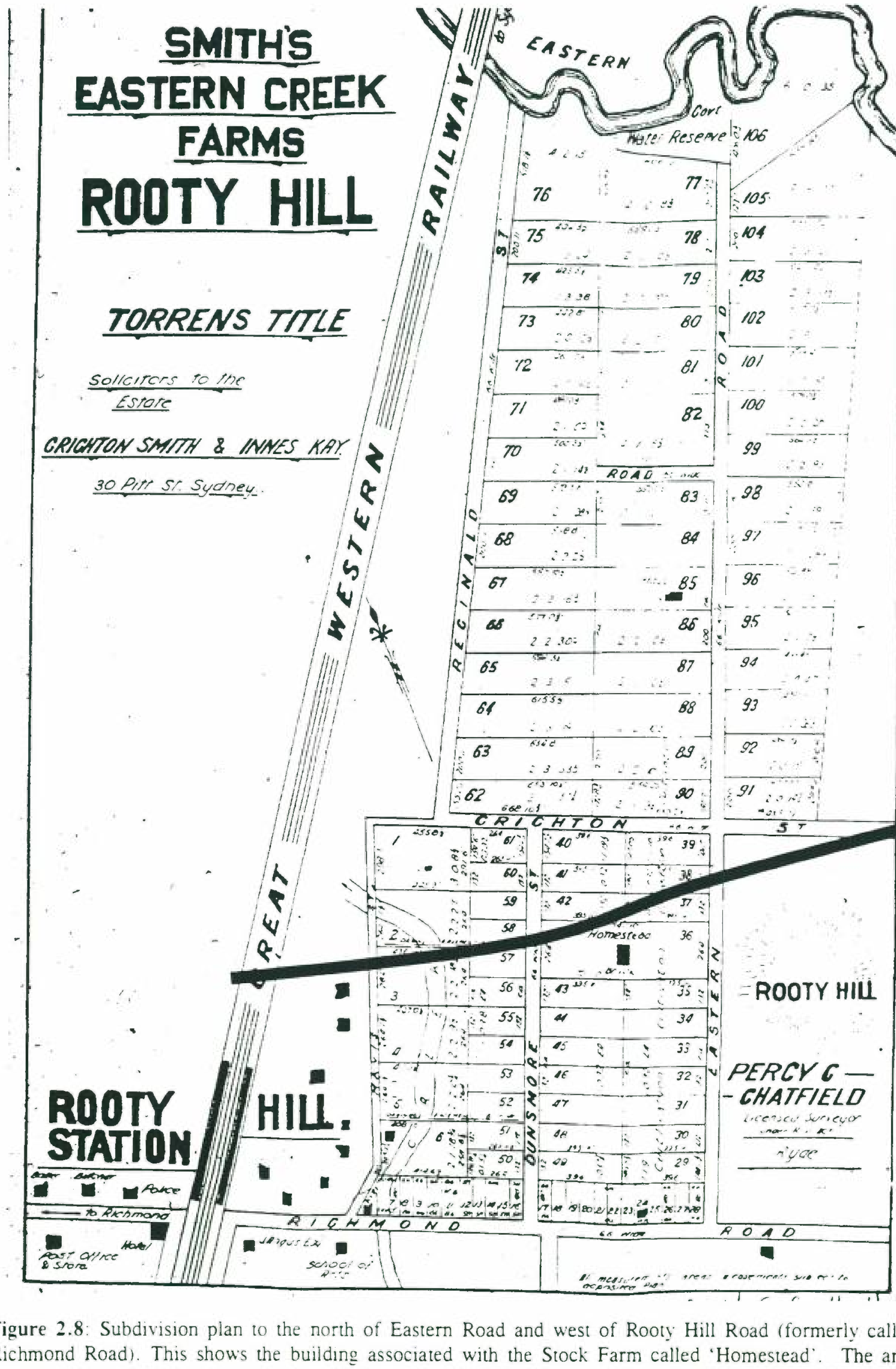

Figure 2.8: Subdivision plan to the north of Eastern Road and west of Rooty Hill Road (formerly called Richmond Road). This shows the building associated with the Stock Farm called 'Homestead'. The area proposed for subdivision is marked cultivation. The WSO in this area involves adding lanes to the eastern side of the already built Phillip Parkway. Thick black line shows approximate position of proposed WSO. No date. ML SP Rooty Hill R13.1/35a.

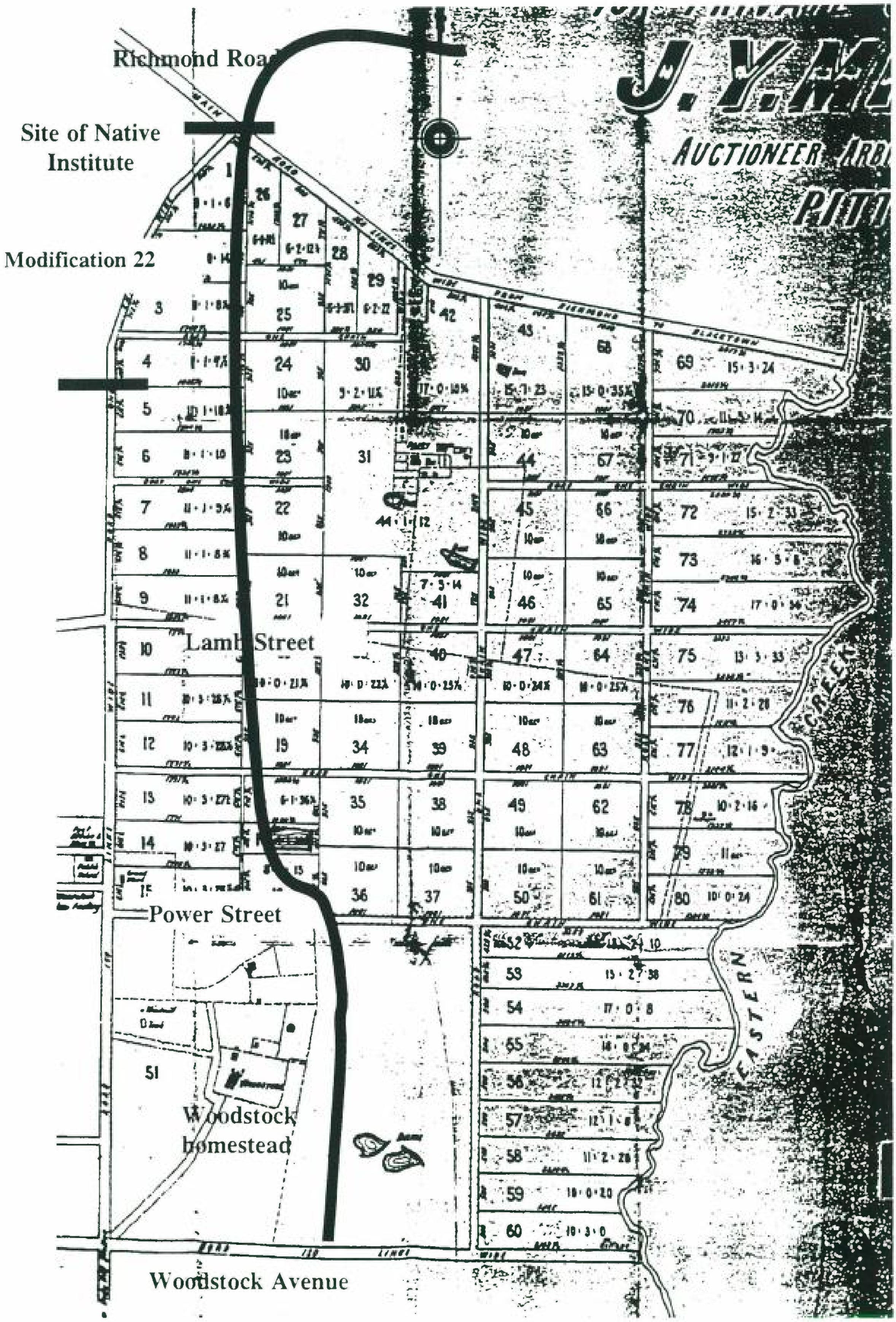

Figure 2.9: The thick black line is the approximate position of the alignment of the WSO and the lines across Rooty Hill Road North show the length of Modification 22 along Rooty Hill Road North. *Woodstock Homestead Farm Subdivision, 10 acres farm and orchard blocks Rooty Hill*, ML SP Rooty Hill R13.1/4.

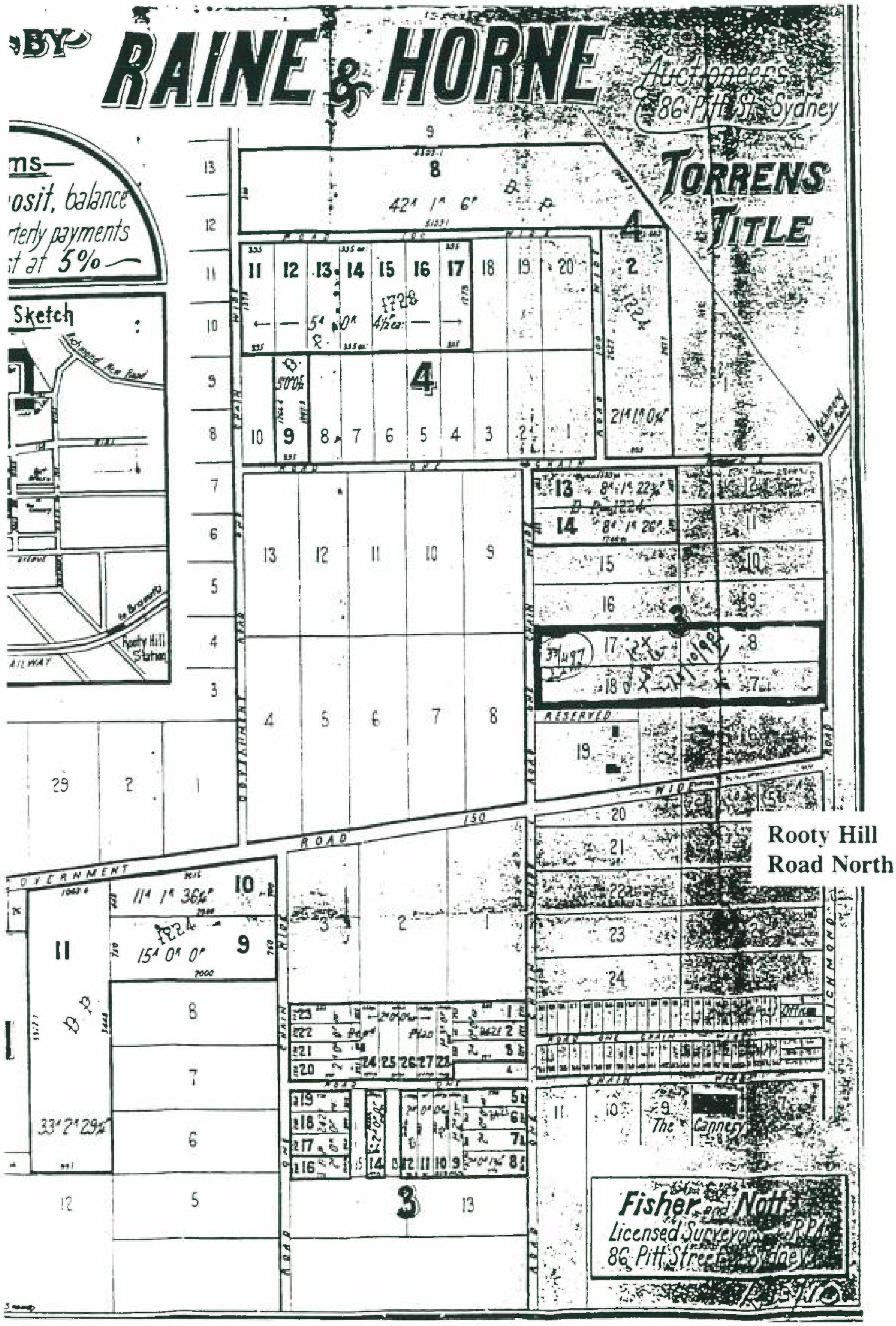

Figure 2.10: Subdivision plan of the western side of Rooty Hill Road North, Plumpton, May1901. There was only two buildings near Rooty Hill Road, the 'cannery' and the Post Office. ML SP Rooty Hill R13.1/10.

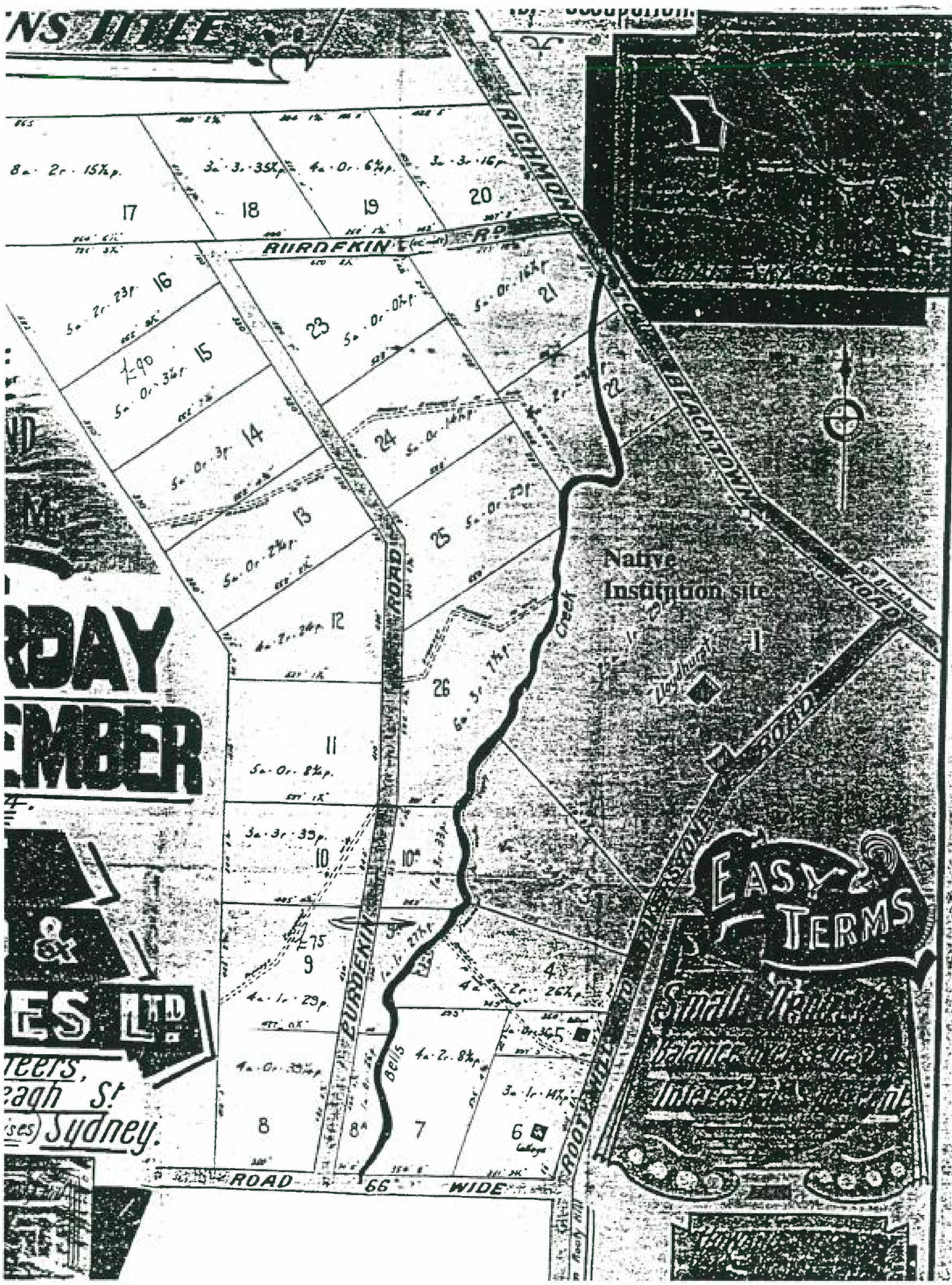

Figure 2.11: Subdivision plan of Plumpton showing the location of 'Lloydhurst' the main building in the Native Institute, 1914. Aside from Lloydhurst there were only two other buildings in this part of Plumpton in 1914. ML SP Rooty Hill R13.1.70.

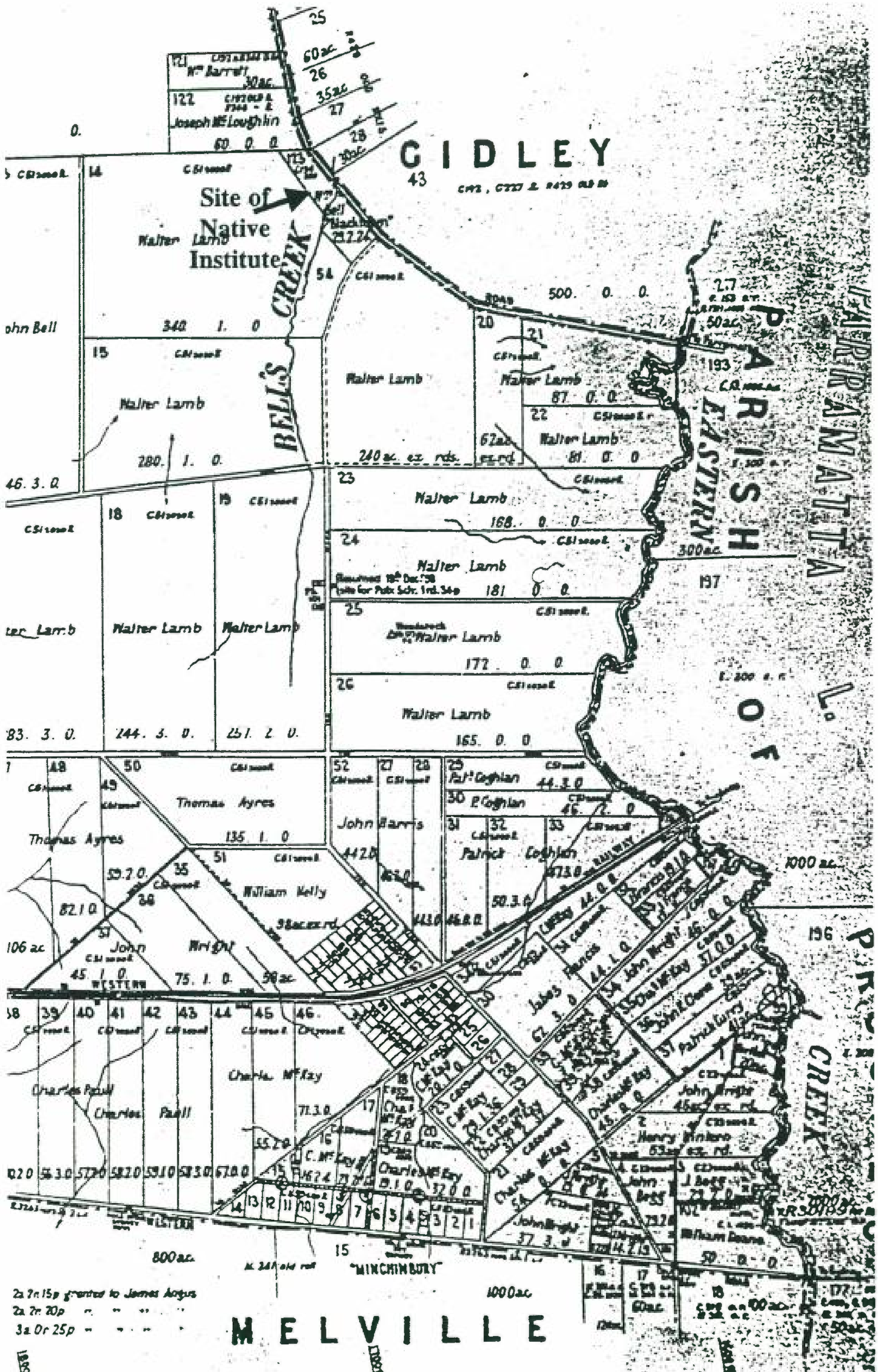

Figure 2.12: Detail from parish map, Parish of Rooty Hill. This shows that Walter Lamb owned most of the land either side of Rooty Hill Road to the north of Woodstock Avenue. ML Parish of Rooty Hill, 1903.

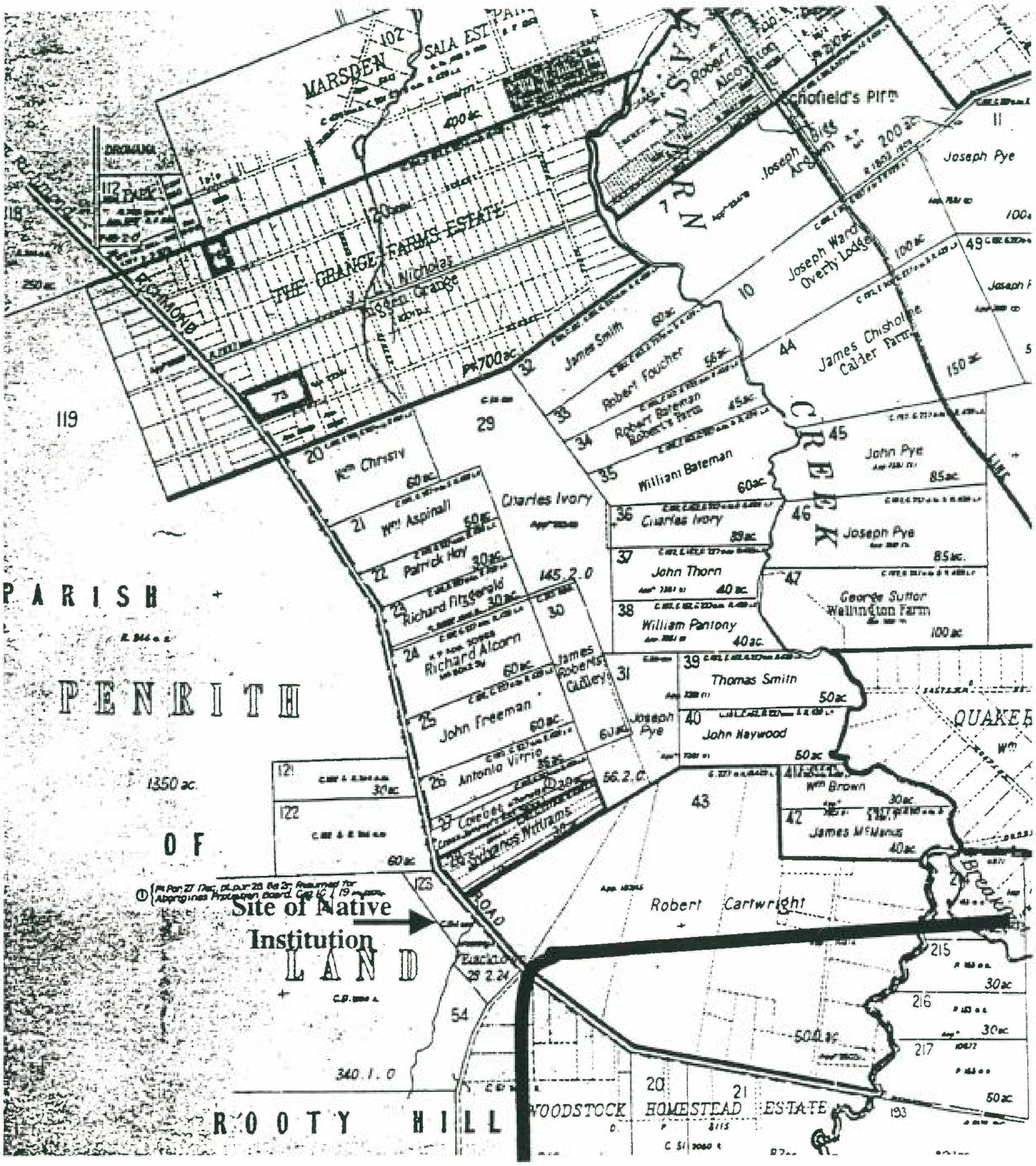

Figure 2.13: Detail from Parish of Gidley showing the ownership of land to the north of Richmond Road. Colebee and Creek Jemmy's names were listed on Lot 27, on 30 acres. These were two Aborigines who were given grants by Governor Macquarie in 1816. Land noted as being owned by Robert Cartwright was being held in trust for grants to future settlers from the native institute. The thick black line shows approximate position of WSO. Parish Map of Gidley, 1924, ML.

The land on the northern side of Richmond Road, 500 acres that Robert Cartwright held in trust for future distribution was sold in 1829 to William Hall. Hall had been appointed in 1826 to run the second attempt at the native school. The children were taught reading, writing, religion, carpentry (boys) and needlework (girls). The school now included some Maori children. After the closure of the native institute in 1833 Hall settled on the 500 acre grant and built a home 'Upperby' and established a school for white children which operated until 1875 when Rooty Hill Public School was established.[1]

The development of the 500 acres had not been researched in detail but the 1947 aerial shows the area as being relatively undeveloped (Aerial 12). Much of this area is now the site of a modern housing estate except the northern part which the WSO will pass through. There may be a house site to the west of Symmonds Road, in the vicinity of the possible European burial site (WSO-E15) which may be the reason for the burials in this apparently isolated location. This house is also shown on a subdivision plan for the adjoining estate (Fig. 2.14). The area of Modification 23, the shifting of the alignment of the proposed WSO to the west when it crosses to the northern side of Richmond Road, is mostly within the 500 acres held in trust by Cartwright and then sold to Hall. Modification 24, the widening of Richmond Road to the west of Rooty Hill Road North, should have no impact on any European sites as this area was shown to be undeveloped (Fig. 2.11, Aerial 12). The lack of development in this general area is because it is a ridgeline with outcrops of silcrete. The silcrete was an important source of materials for stone tool making and trade for the local Aborigines.

The area to the west of Eastern Creek and east of the railway line was relatively undeveloped prior to subdivision (Fig. 2.14). The 1947 aerial suggests that this subdivision was not particularly successful as there was limited development of the rear of the properties near Breakfast Creek (Aerial 12). The area to the east of the railway line and west of Sunnyholt Road was also slow to subdivide and develop. A subdivision plan post-dating 1915 shows limited subdivision south of Pye Street (Fig. 2.15). This plan shows that the subdivisions and building were mostly focused on the area to the north of Pye Street.

The area to the east of Sunnyholt Road and south of Meurants Lane was relatively undeveloped other than for a few early farms. Exeter Farm, an extant farmhouse, was built on land granted to Daniel Bryan/Brien by Governor Macquarie in 1821. It is possible that the house was built prior to the 1821 grant.[2] Bryan was an emancipist settler as was Ferdinand Meurant who also received a land grant from Governor Macquarie. Exeter Farm is outside the line of the WSO and is now surrounded by a recent housing development (Aerial 14). Another house (WSO-E-19)near the corner of Meurants Lane and Old Windsor Road is located on a property adjacent to Modification 27, the extension of Norwest Boulevard up to Old Windsor Road but not through the remnant cutting of the Old Windsor Road. The line of the proposed WSO then crosses over Old Windsor Road to the south of the creek line in an area where the road was realigned more than fifteen years ago.

[1] Liston 1986:13-14.

[2] Heritage Office Web site entry for Exeter Farm based on Rosemary Annable's history.

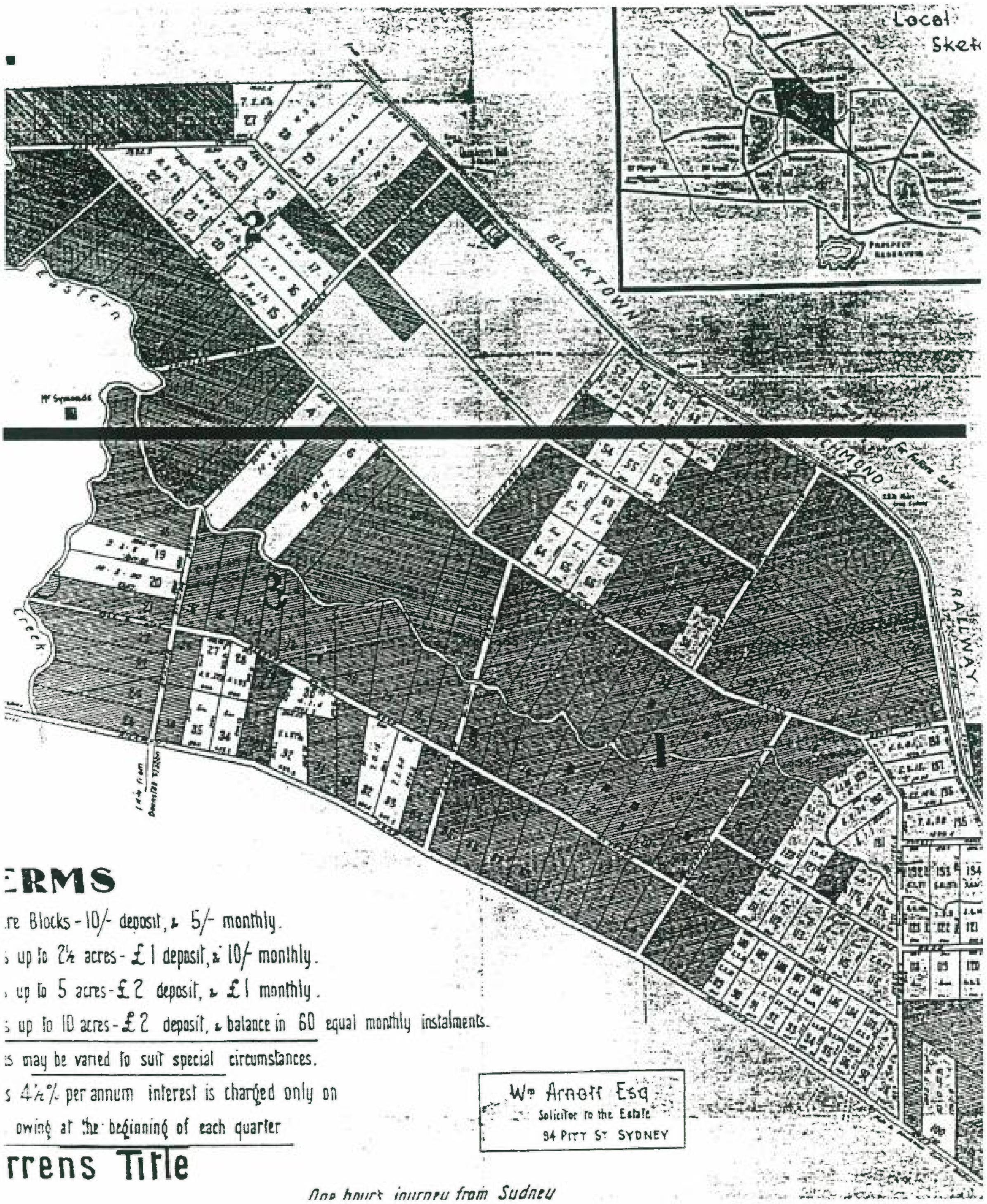

Figure 2.14: Subdivision plan of Quaker's Hill Estate. This shows the land to the east of Eastern Creek and west of the railway Line as relatively undeveloped prior to subdivision. It also identifies the house to the west of Eastern Creek as Mr Symmonds'. The thick black line indicates the approximate position of the WSO. ML SP Quakers Hill Q1/1.

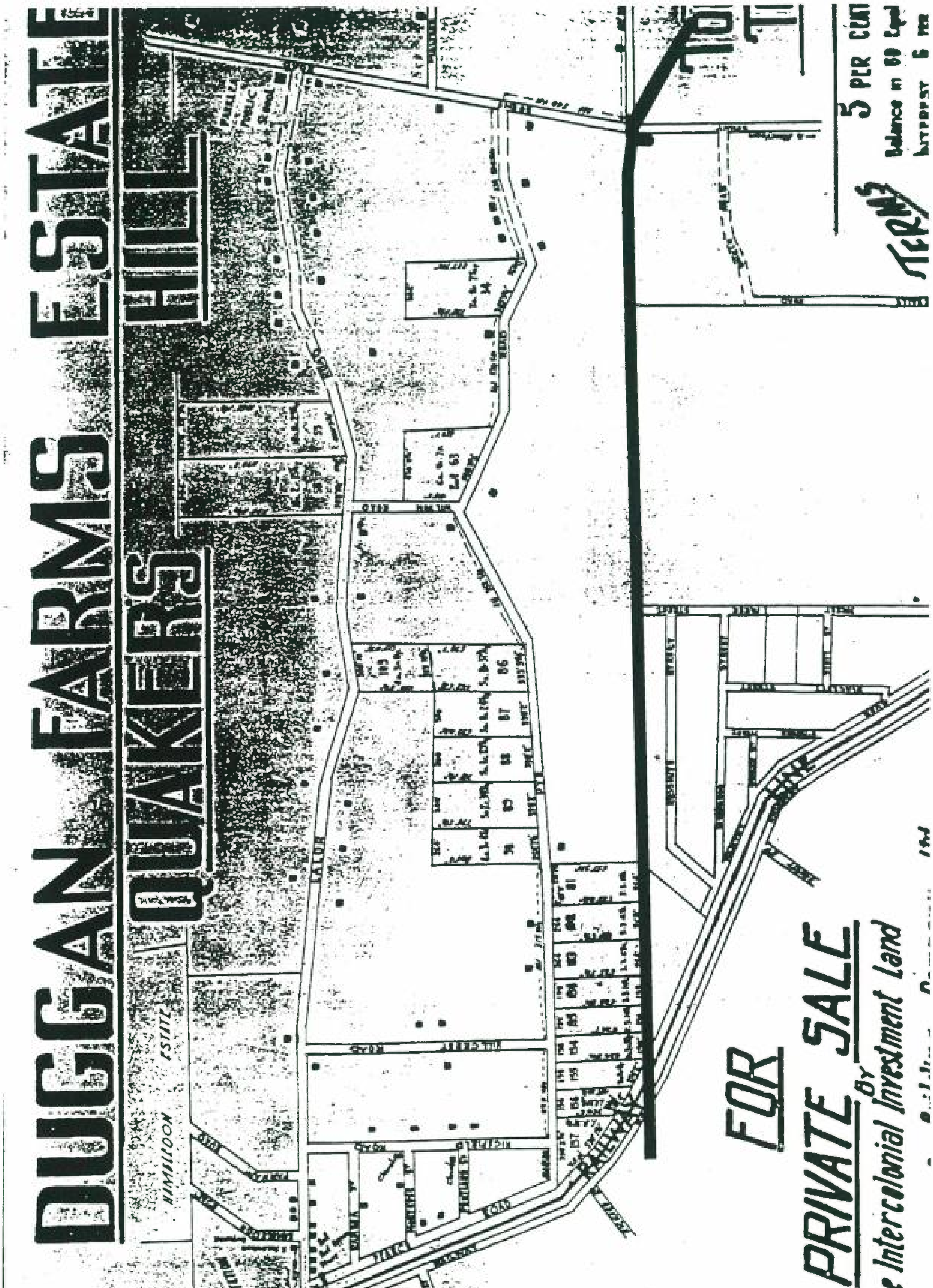

Figure 2.15: Subdivision plan of Duggan Farms Estate, Quakers Hill. This shows the land to the east of the railway line and west of Sunnyholt Road as being relatively undeveloped prior to subdivision this post-1915 subdivision. The thick black line indicates the approximate position of the WSO where it meets the intersection of Sunnyholt Road and Meurants Lane. ML SP Quakers Hill Q1/7

3.0 Review of Modifications

3.1 Modifications

Aerial photos are included in Appendix 1.

1. Upgrade Beech Road at Casula

This road is through a modern housing estate. The aerial photo shows this road was extant in 1947. It was initially part of the Church & School Estate. This road is considered to have no archaeological potential (Fig. 3.1). No further heritage input is required.

3. Upgrade Bernera Road at Prestons

This area has modern fencing and 1930s and 1950s housing (Figure 3.2). Bernera Road was aligned as part of the 1889 subdivision of the Bernera Estate. Aerial photos and historic plans indicate that there were no buildings or sites on Bernera Road other than those already identified as being impacted by WSO (WSO-E-2) (Fig. 2.2; Appendix 1, Aerial 2). There will be no visual or physical impact on curtilage of the site Bernera (SHR). No further heritage input is required.

4. Upgrade Jedda Road and Joadja Road at Prestons

Road widening with some land acquisition. This area is either vacant land or recent housing and fencing. Aerial photos show that the area to the north of Jedda and west of Joadja Road was forest in 1947 (Aerial 2). To the east was a house that was set some distance back off the road. These two roads were set out c. 1889 as part of the subdivision of the Bernera estate (Fig 2.2). No further heritage input required.

6. Relocate Access to Hoxton Park Airport

This modification affects the southern part of the airport (Fig. 3.4). It is site WSO-E-3. Impact from the modifications is limited. Access road is further within the airport. Issues with Hoxton Park Airport identified in previous report (*Non-Indigenous Survey*, Casey & Lowe July 2001). This site requires an assessment.

7. Upgrade McIver Avenue at West Hoxton

This is a dirt road littered with rubbish that is to be sealed (Fig. 3.5). The sealing of this road has no heritage impact. No further heritage input is required.

8. Relocate WSO Westwards at Cecil Hills

Reporting on this modification included in Casey & Lowe July 2001 *Non-Indigenous Heritage, Archaeological Survey. Southern Sections of Western Sydney Orbital (Prestons to Cecil Park)*. Site WSO-E-4. This site requires an archaeological assessment and a s. 140 application.

9. Relocate WSO Ramps at Elizabeth Drive

The modifications in this area which affect the shaft of the Cecil Hills Tunnel, Upper Canal has been the subject of a Statement of Heritage Impact, *Statement of Heritage Impact Proposed Western Sydney Orbital Cecil Hills Tunnel and Shaft* by Casey & Lowe Associates, August 2001. A s. 60 application was lodged for this works as the Upper Canal is an item on the SHR. The NSW Heritage Council has given approval for this work to go ahead with conditions.

Figure 3.1: View to north along Beech Road through modern housing estate. This road will be widened to 4/5 lanes. Modification 1. 1 August 2001.

Figure 3.2: View to south along Bernera Road, Prestons. The road will be widened along the western side where a strip of land will be acquired. Modification 3. 1 August 2001.

Figure 3.3: View to east along Jedda Road, Prestons. Land acquisition along northern side. Modification 4. 1 August 2001.

Figure 3.4: View to east across southern part of Hoxton Park Airport. Modification 6. 1 August 2001.

Figure 3.5: View to west along McIver Avenue. Modification 7. 1 August 2001.

Figure 3.6: View to east over the Sydney Water Supply pipelines that cross Wallgrove Road. Modification 13. 12 June 2001.

11. Access to Sydney International Equestrian Centre from Saxony Road
This area was assessed by Edward Higginbotham & Associates as part of the development of the site for the Olympic Equestrian Centre. The western part of the site between Wallgrove Road and the water main contained no identified sites (Fig. 2.3).[3] Therefore there will be no impact on heritage items by this modification. No further heritage input is required.

13. Raise and Relocate WSO Westwards at Water Supply Pipelines and Provide New Access to Nearby Properties
Main result of modification is a new access road into the chicken farm to the north of the Water Supply Line (Fig. 3.6). The 1947 aerial photo shows this area under cultivation and there appears to be no likelihood for archaeological sites. In addition the construction of the pipelines will have destroyed any sites in most of the area of impact. This modification will involve construction over the top of these pipelines. This site will require a Statement of Heritage Impact and s. 140 application as the pipelines are subject to the relics provisions of the NSW *Heritage Act* 1977.

17. Reconfigure WSO and Great Western Highway Interchange
This area is in the vicinity of the Wallgrove Estate, homestead and tannery which requires an archaeological assessment. The modification places the western boundary closer to Wallgrove Road. This general area requires assessment.

18. Relocate WSO North of Great Western Highway
This section of the proposed WSO and its modification is cutting through the western side of the Bungaribee property. The modification places the western boundary of the WSO closer to Belmore Road and Curry Street than previously identified. Additional field survey in consultation with Denis Gojak DUAP (14/8/2001) has clarified the position of a number of sites identified by Austral Archaeology as being located on this property and within the vicinity of the proposed WSO.[4]

A site called B4 which was identified as a well could not be relocated. It is likely that this site was wrongly located and is site WSO-E-13, a remediated well site. Another site B5 is to the west of the corridor of impact (Figs. 2.7, 3.7) and should be able to be retained. These remains from a twentieth-century house are considered to have a low level of heritage significance. This site will need to be located and fenced during construction works but will not require any further works or permits.

Another potential site (B7) was identified but it appears already to have been the subject of remediation, for the removal of asbestos products. This site appears to have no or little archaeological potential remaining aside from a scatter of machine-made bricks (Fig. 3.8). This site would have related to a house site on the aerial photo (Fig. 2.7). No substantive remains associated with this house survive. This site requires no further assessment or approvals.

Another site to the north was also inspected (B8) but it was considered that there were no remains at this site, either above ground or sub-surface, other than some modern yard fencing (Figs 3.9, 3.10). This site requires no further assessment or approvals.

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[3] Edward Higginbotham & Associates Pty Ltd 1996 *Historial and Archaeological Assessment of the Proposed Sydney International Equestrian Centre, Horsley Park, NSW.*
[4] Austral Archaeology nd. *An Archaeological and Heritage Impact Assessment of the Telstra OTC Site, Great Western Highway, Doonside,* for Australian Site Assessment on behalf of Telstra OTC.

The only site requiring approvals in this area is WSO-E-11 which is the location of a well which requires a s. 140 approval.

21. Upgrade Power Street West of WSO
A twentieth-century road with modern fencing and a recent subdivision to the north. Part of backyards of new houses facing Power Street to be acquired for road widening. The New Tribes Mission Bible College contains an older residence which the Council is considering listing. This house is up away from Power Street.[5] The road widening should not affect any potential heritage significance of this item. Analysis in Section 2 shows that this area was part of Walter Lamb's Woodstock Estate and the impacts are at some distance from the extant buildings and associated potential archaeological sites (Fig. 2.9).

22. Upgrade Rooty Hill Road North from South of Luxford Road to Richmond Road
The northern part of this work is adjacent to the site of the Native Institute (Figs 3.11, 3.12). The current modifications have been designed to have no impact on the site of the Native Institute. The widening of the Richmond Road will take place on the eastern side of the road, away from the Native Institute site. Road widening on the side adjacent to the Native Institute is within the existing road reserve and does not extend into the curtilage of the site.

A review of all LEP sites on Rooty Hill Road was undertaken but there were no heritage items or sites within the corridor of impact other than the Native Institute Site (H50) which is also listed on the SHR. LEP items outside the corridor of impact from road widening are:

- Headmaster's Residence, 321 Rooty Hill Road and Cannery Road, Plumpton, (**H56**)
- Plumpton Public School, 327 Rooty Hill Road North, Plumpton (**H56**)
- House, 'Lozells', Cannery Road (**H54**)
- House, par of lot 31, DP 709050, Rooty Hill Road North (**H57**)
- 'Alroy', Rooty Hill Road North, Plumpton (south of Jersey Road) (**H58**)
- House, 'Woodstock', Hobson and Dexter Places (**H55**)
- School of Arts, corner Rooty Hill Road South
- Belvedere, 116 Rooty Hill Road.
- Imperial Hotel, 1 Rooty Hill Road North, Rooty Hill (SHR item)

See Appendix 2 for location of closest items and the positions of modifications.

[5] Sue Galt, Blacktown Council.

Photo 3.7: Person standing on doorstep at site B5, OTC property, Eastern Creek. This site dates to post-1917. This site is outside the line of construction and should be fenced off during construction works. Modification 18. 14 August 2001.

Photo 3.8: View over site B7 which has been remediated. Dates to post-1917. Modification 18. 14 August 2001.

Photo 3.9: General area of site B8 as shown on aerial. No remains survive in this area. Modification 18. 14 August 2001.

Photo 3.10: Yard area adjacent to where the house had been at site B8. This site dates to post-1917. Modification 18. 14 August, 2001.

Figure 3.11: View to northwest over the site of the Native Institute. Near Modification 22 and 24. 14 August 2001.

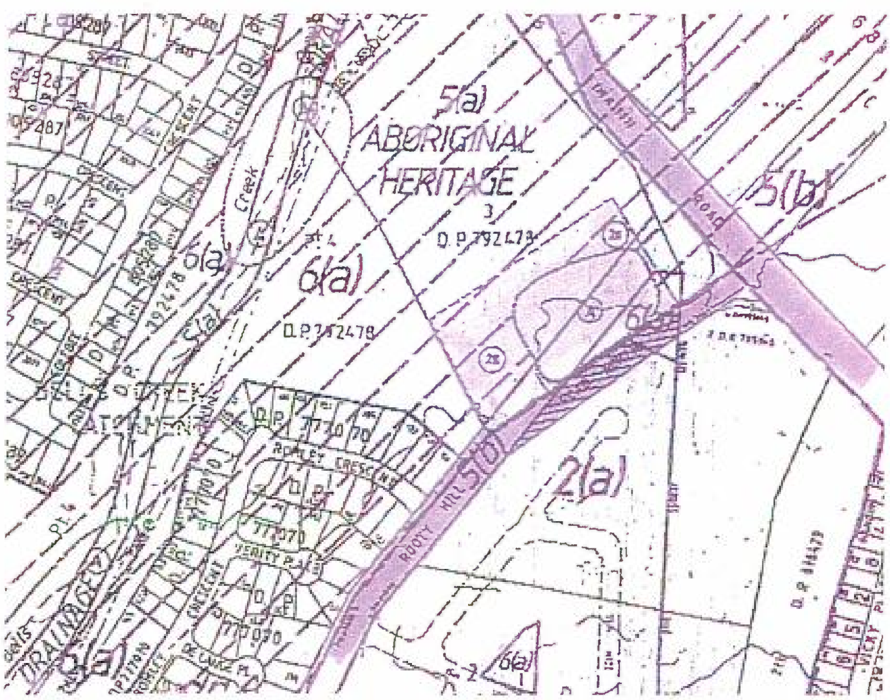


Figure 3.12: Location of Native Institute site adjacent to Rooty Hill Road North. Modification 22.

Figure 3.13: View to north along entry road into sand and gravel place. Modification 23. 1 August 2001.

The extant 'Woodstock' house which is to the south of the road widening and is site 55 on the map in Appendix 2. This property was owned by Walter Lamb of Woodstock who had extensive holdings on either side of Rooty Hill Road North (Fig. 2.12). Analysis in Section 2 suggests that there should be no heritage or archaeological issues associated with the widening of Rooty Hill North Road. As long as the widening is kept to the eastern side of Rooty Hill Road no further heritage input is required.

23. Relocate WSO West and North of Richmond Road Interchange

Much of this area is currently occupied by a sand and gravel supplier and also contains a modern house and swimming pool and an egg farm. The southwestern part of the area is relatively undeveloped (Fig. 3.13). None of the standing structures are heritage issues. The 1947 aerial photos shows the area as being lightly forested and undeveloped (Appendix 1, Aerial 7). This is one of the few modifications not associated with an existing line of road.

The area to the north of Richmond Road that is affected by this modification was part of 500 acres given to Robert Cartwright in trust for distribution to Aborigines attending the Native Institute. All indigenous archaeological sites, both pre- and post-1788, are being dealt with by Robynne Mills. There is a possible non-indigenous site near the location of the possible European burial WSO-E-15. This site is already to be the subject of an assessment which will need to incorporate the possibility of a house site within the general area.

There are no European heritage issues associated with this modification.

24. Upgrade Richmond Road from WSO to north of Bells Creek

Modern roadway to be widened and land to be acquired along northern side. The site of the Native Institute is adjacent to the southwestern side of Richmond Road (Fig. 3.11, 3.12). There will be no impact on the curtilage of the SHR location of the Native Institute site. All culverts along this section of roadway are modern. Analysis in Section 2 indicates that there is little likelihood of potential archaeological sites in this area.

4.0 Other Areas

4.1 Northwest Boulevard

This assessment and survey was of an extension of Northwest Boulevard rather than a modification. This section of road has already been partly graded. It is adjacent to a Blacktown LEP item, a house (WSO-E-19) (Fig. 4.1) and is some distance from Exeter Cottage (WSO-E-17), Meurants Lane, a SHR item. It will have no impact on either of these items. This section of the extension of Northwest Boulevard does not extend into Old Windsor Road which is a LEP item, a item on the register of the National Estate, listed by the National Trust and protected under the relics provision of the NSW *Heritage Act* 1977 (amended). This extension is not associated with an existing line of road. This work does not include the penetration of Norwest Boulevard through to Old Windsor Road which would involve making further openings through the early cutting.

Figure 4.1: View to west along proposed extension of Northwest Boulevard. A heritage item, a weatherboard house, is visible on the right in the background. 1 August 2001.

5.0 Summary of Impacts from Modifications

This assessment of the modifications suggest that they will generally have limited impact on archaeological sites or heritage items other than impacts already identified in the representations report.

5.1 Summary

Only modifications 6, 8, 14, 17 and 18 require further heritage input. All these sites, except modification 17, were previously identified as requiring further work. Modification 9 has already been the subject of a s. 60 application and approval has been given for this modification.

- **Modification 6** needs to be assessed as part of the assessment to be undertaken for Hoxton Park Airport, WSO-E-3.
- **Modification 8** requires an archaeological assessment and a s. 140 application for WSO-E-4.
- **Modification 14** requires a Statement of Heritage Impact and a s. 140 application because of the alterations associated with the pipelines which are relics under the NSW Heritage Ace 1977 (amended).
- **Modification 17** may affect the site of Wallgrove homestead and tannery. This area requires assessment. This is a newly identified potential archaeological site.
- **Modification 18** will impact on WSO-E-13, the site of a well that has been remediated by Telstra. The impact on the well requires an assessment and a s. 140 application. Site B5 will need to be protected during site works.

Modification	Site #	Listing	No Further Work Required	Further Work Required	Approval Required
1. Upgrade Beech Road at Casula.		No	X		
3. Upgrade Bernera Road at Prestons.		No	X		
4. Upgrade Jedda Road and Joadja Road at Prestons.		No	X		
6. Relocate Access to Hoxton Park Airport.	WSO-E-3	AHC		X	s. 140
7. Upgrade McIver Avenue at West Hoxton.		NO	X		
8. Relocate WSO Westwards at Cecil Hills.	WSO-E-4	NO		X	s. 140
9. Relocate WSO Ramps at Elizabeth Drive	WSO-E-5	SHR	X		approval given
11. Access to Sydney International Equestrian Centre from Saxony Road.		NO	X		
14. Raise and Relocate WSO Westwards at Water Supply Pipelines and Provide New Access to Nearby Properties.		NO		X	SHI s. 140
17. Reconfigure WSO and Great Western Highway Interchange.				X	AA
18. Relocate WSO North of Great Western Highway.	WSO-E-13	NO		X	s. 140
21. Upgrade Power Street West of WSO.		NO	X		

Modification	Site #	Listing	No Further Work Required	Further Work Required	Approval Required
22. Upgrade Rooty Hill Road North from South of Luxford Road to Richmond Road.		SHR, LEP AHC Native Institute site is close. No impact.	X		
23. Relocate WSO West and North of Richmond Road Interchange.		NO	X		
24. Upgrade Richmond Road from WSO to north of Bells Creek.		NO	X		

6.0 Heritage Items and Registers

A review of various registers was undertaken for the EIS and additional work was undertaken for this modifications report. All listed items affected by the modifications or nearby are listed below. Lists of heritage items from the Australian Heritage Commission web site and the Heritage Office web site are included in Appendix 3:

6.1 National Estate

The following lists are taken from the Australian Heritage Commission web page:

6.1.1 Baulkham Hill Council Area

Name of Item	Listing	Impact
Bella Vista Complex	Registered	Nearby, no impact from extension of Norwest Boulevard
Pearce Family Graves	Indicative place	Nearby, no impact from extension of Norwest Boulevard
Old Windsor Road, Seven Hills Road to Windsor Road	Registered	Extension ends just before it meets Old Windsor Road

6.1.2 Blacktown City Council Area

The following items within Blacktown City Council are near the modifications but are not affected by current designs:

Name of Item	Listing	Impact
Old Windsor Road, Seven Hills Road to Windsor Road	Registered	Extension ends just before it meets Old Windsor Road
Indigenous Place, Oakhurst (appears to be the Native Institute Site)	Registered	Nearby, no impact from modifications 22 and 24

6.1.3 Fairfield City Council Area

The following items within Fairfield City Council are at some distance from the modifications and are not affected by current designs:

Name of Item	Listing	Impact
Horsley Garden	Registered	Some distance away, no impact from modifications
Horsley homestead, outbuildings and surrounds	Registered	Some distance away, no impact from modifications

6.1.4 Liverpool City Council Area

Of the following items within Liverpool City Council area only one is affected by the modifications the other two are nearby:

Name of Item	Listing	Impact
Bernera including Site and Knoll	Registered	Nearby, no impact from modifications
Hoxton Park Airport	Interim List	Some limited impact
Ingleburn Army Camp	Indicative Place	Some distance away, no impact from modifications

N.B: The listing for Bernera refers to the importance of the vernacular architecture suggesting that the date of this listing was prior to 1986 when the house was burnt down.

6.2 State Heritage Inventory

6.2.1 Baulkham Hills Council Area

The following list is based on information contained on the Heritage Office web page and obtained from Baulkham Hills Council. None of these sites are affected by the modifications.

Name of Item	Listing	Impact
Bella Vista Complex	SHR	Nearby, no impact from extension of Norwest Boulevard
Pearce family Cemetery	SHR	Nearby, no impact from extension of Norwest Boulevard
Old Windsor Road post & rail fencing	LEP	Proposed extension of Norwest Boulevard ends before it meets Old Windsor Road

6.2.2 Blacktown City Council Area

The following list is based on information contained on the Heritage Office web page and obtained from Blacktown City Council, and their draft DCP. Many of these items are located on the draft DCP plan in Appendix 2. None of these sites or items is impacted by current designs.

Name of Item	Listing	Impact
Bungarribee Archaeological Complex	SHR	No impact, at some distance from modifications.
Exeter farm	SHR	Nearby, no impact from modifications
Government Depot Site	SHR	Nearby, no impact from modifications
Imperial Hotel	SHR	At some distance from modification, no impact
Native Institute Site	SHR LEP	Adjacent to modification, no impact in current design
Upper Canal System - Cecil Hills Tunnel	SHR LEP	Impact on shaft from Modification 9, s.60 approved
Headmaster's Residence, 321 Rooty Hill Road and Cannery Road, Plumpton, (H56)	LEP	Nearby, no impact from modifications
House, 'Lozells', Cannery Road (H54)	LEP	Nearby, no impact from modifications
House, 'Woodstock', Hobson and Dexter Places (H55)	LEP	Nearby, no impact from modifications
Plumpton Public School, 327 Rooty Hill Road North, Plumpton (H56)	LEP	Nearby, no impact from modifications
House, part of lot 31, DP 709050, Rooty Hill Road North (H57)	LEP	Nearby, no impact from modifications
'Alroy', Rooty Hill Road North, Plumpton (south of Jersey Road) (H58)	LEP	Nearby, no impact from modifications
Old Windsor Road	LEP	Proposed extension of Norwest Boulevard ends before it meets Old Windsor Road

6.2.3 Fairfield City Council Area

The following list is based on information contained on the Heritage Office web page. None of the items or sites below is affected by the modifications.

Name of Item	Listing	Impact
Horsley House homestead	SHR	Some distance away, no impact from modifications
City Farm, Abbotsbury	LEP	Nearby, no impact from modifications
Relics of early homestead & vegetation.	LEP	Nearby, no impact from modifications

Elizabeth Drive		
Remnants of Abbotsbury House	LEP	Nearby, no impact from modifications

6.2.4 Liverpool City Council Area

The following items within Liverpool City are nearby to the modifications but are not affected:

Name of Item	Listing	Impact
Bernera site	SHR LEP	Nearby, no impact from modifications
Cecil Hills Farm	SHR	Nearby, no impact from modifications
Horningsea Park Group	SHR LEP	Some distance away, no impact from modifications
Ingleburn Army Camp	LEP	Nearby, no impact from modifications
Sydney Water Supply – Upper Canal	SHR LEP	Impact on shaft from Modification 9, s.60 approved

6.3 National Trust Listings

The following lists are taken from the National Trust Register (1993), the EIS and the Representations report:

6.3.1 Baulkham Hill Council Area

None of the listed sites or items will be affected by the modifications:

Name of Item	Impact
Old Windsor Road	Proposed extension of Norwest Boulevard ends before it meets Old Windsor Road
Bella Vista Complex	Nearby, no impact from extension of Norwest Boulevard
Pearce Family Cemetery	Nearby, no impact from extension of Norwest Boulevard

6.3.2 Blacktown City Council Area

The following items within Blacktown City Council area have been registered by the National Trust. None of these items are affected by the modifications based on current designs:

Name of Item	Impact
Bungarribee Coach House (demolished)	At some distance from the archaeological site, no impact from modifications
Imperial Hotel	At some distance, no impact from modifications
Upper Canal System	Impact on shaft from Modification 9, s.60 approved
House, 'Woodstock', Hobson and Dexter Places (H55)	Nearby, no impact from modifications
House, part of lot 31, DP 709050, Rooty Hill Road North (H57)	Nearby, no impact from modifications
'Alroy', Rooty Hill Road North, Plumpton (south of Jersey Road) (H58)	Nearby, no impact from modifications
Old Windsor Road, 1.5km south from Meurants Lane	Proposed extension of Norwest Boulevard ends before it meets Old Windsor Road

6.3.3 Fairfield City Council Area

The following item within Fairfield City Council is at some distance (800 m) from the modification and is not affected:

Name of Item	Impact
Horsley Park	At some distance, no impact from modifications

6.3.4 Liverpool City Council Area

The following items within Liverpool City Council area are nearby to the modifications but are not affected:

Name of Item	Impact
Bernera site	Nearby, no impact from modifications
Cecil Park, Elizabeth Drive	Nearby, no impact from modifications
Horningsea Park Group	Some distance away, no impact from modifications
Sydney Water Supply – Upper Canal, Cecil Hills	Impact on shaft from Modification 9, s.60 approved

6.4 Summary of Heritage Items Listed on Registers

Hoxton Park Airport is the only identified site which will be impacted by the modifications. The Native Institute site is very close to Modification 22 and 24 any redesign in this area needs to avoid this important site.

Name of Item	Listing	Impact
Baulkham Hills Council area		
Bella Vista Complex	SHR AHC NT	Nearby, no impact from extension of Norwest Boulevard
Pearce family Cemetery	SHR AHC	Nearby, no impact from extension of Norwest Boulevard
Old Windsor Road post & rail fencing	LEP	Nearby, no impact from extension of Norwest Boulevard
Old Windsor Road, Seven Hills Road to Windsor Road	AHC	Nearby, no impact from extension of Norwest Boulevard
Blacktown City Council area		
Bungarribee Coach House (demolished)	NT	At some distance from site, no impact from modifications
Bungarribee Archaeological Complex	SHR	No impact, at some distance from modifications
Exeter farm	SHR	Nearby, no impact from modifications
Government Depot Site	SHR	Nearby, no impact from modifications
Imperial Hotel	SHR NT	At some distance from site, no impact from modifications
Native Institute Site	SHR LEP AHC	Adjacent to modification, no impact in current design
Upper Canal System	SHR LEP NT	Impact on shaft from Modification 9, s.60 approved
Headmaster's Residence, 321 Rooty Hill Road and Cannery Road, Plumpton, (H56)	LEP	Nearby, no impact from modifications
House, 'Lozells', Cannery Road (H54)	LEP	Nearby, no impact from modifications

House, 'Woodstock', Hobson and Dexter Places (H55)	LEP NT	Nearby, no impact from modifications
Plumpton Public School, 327 Rooty Hill Road North, Plumpton (H56)	LEP	Nearby, no impact from modifications
House, par of lot 31, DP 709050, Rooty Hill Road North (H57)	LEP NT	Nearby, no impact from modifications
'Alroy', Rooty Hill Road North, Plumpton (south of Jersey Road) (H58)	LEP NT	Nearby, no impact from modifications
Old Windsor Road, from Seven Hills Road to Windsor Road	AHC	Nearby, no impact from extension of Norwest Boulevard
Old Windsor Road, 1.5km south from Meurants Lane	LEP NT	Nearby, no impact from extension of Norwest Boulevard
Fairfield City Council Area		
Horsley House homestead	SHR AHC NT	Nearby, no impact from modifications
City Farm, Abbotsbury	LEP	Nearby, no impact from modifications
Relics of early homestead & vegetation, Elizabeth Drive	LEP	Nearby, no impact from modifications
Remnants of Abbotsbury House	LEP	Nearby, no impact from modifications
Liverpool City Council area		
Bernera site	SHR LEP AHC NT	Nearby, no impact from modifications
Cecil Hills Farm	SHR NT	Nearby, no impact from modifications
Horningsea Park Group	SHR LEP NT	Some distance away, no impact from modifications
Ingleburn Army Camp	LEP AHC	Nearby, no impact from modifications
Hoxton Park Airport	AHC	Some limited impact
Sydney Water Supply – Upper Canal	SHR LEP NT	Impact on shaft from Modification 9, s.60 approved

7.0 Results and Recommendations

7.1 Results

The analysis for potential archaeological sites, the location of known heritage items and the field survey of all modifications indicates that the proposed modifications for the WSO will generally have no impact on archaeological sites or heritage items. Only five of the modifications require further assessment and most of these were already to be undertaken because of impacts from the proposed WSO. Modification 9 required a statement of heritage impact, which has already been written, and a s. 60 application approved by the NSW Heritage Council with conditions. Modifications requiring further work are:

- Modification 6: archaeological assessment of Hoxton Park Airport (WSO-E-3)
- Modification 8: archaeological assessment of site WSO-E-4
- Modification 13: Statement of Heritage Impact and s. 140 application (WSO-E-5)
- Modification 17: archaeological assessment of Wallgrove homestead and tannery (WSO-E-24).
- Modification 18: archaeological assessment for site WSO-E-13 and need to cordon off and protect site B5.

No detailed statements of significance can be written for these sites before the archaeological assessments and/or Statement of Heritage Impacts are written. All potential archaeological sites and relics are subject to the relics provisions of the NSW *Heritage Act* 1977 (amended).

The area of Modification 17 and the area to the east and also the area to the north of the M4 within the alignment of the proposed WSO may contain a site not previously identified, Wallgrove homestead and tannery (WSO-E-24). This area needs to be assessed to see if any remains survive in the area of the WSO alignment and if the modifications affect this potential site. The construction of the M4 may have affected the archaeological potential of this site.

Any change of design in relation to Modification 22 and 24 needs to avoid the site of the Native Institute.

7.2 Recommendations

1. Archaeological assessments need to be undertaken on the identified sites as soon as possible to understand the constraints of the sites and their heritage significance. The assessment of site of the possible European burials (WSO-E-15) needs to include the potential site of Symmonds' house.
2. There can be no impacts on potential sites without excavation permits (s. 140 application) being approved by the NSW Heritage Council.
3. In the area of Modification 18, site B5 should be identified and protected during construction works. It should be fenced around with coloured bunting and signs put up identifying the position of the site. The site should be located on design drawings so that the contractors are aware of the site at all times.
4. If there are further modifications or changes to the current design of WSO they will need to be assessed to determine if there are any further heritage issues.
5. If there is redesign to Modification 22 and 24 they should continue to avoid the Native Institute site.

8.0 Bibliography

Austral Archaeology *An archaeological and heritage impact assessment of the Telstra OTC site. Great Western Highway, Doonside*. nd:29.

Brook, J. and Kohen J. L. 1991 *The Parramatta Native Institution and the Black Town: A history*. NSW University Press, Kensington.

Casey & Lowe Associates July 2001 *Non-indigenous Heritage Archaeological Survey. Southern Section Western Sydney Orbital, Prestons to Cecil Park*. for Robynne Mills & Associates on behalf of the NSW Roads and Traffic Authority.

Casey & Lowe Associates August 2001 *Statement of Heritage Impact. Cecil Hills Tunnel and Shaft*. for Robynne Mills & Associates on behalf of the NSW Roads and Traffic Authority.

Edward Higginbotham & Associates Pty Ltd 1996 *Historial and Archaeological Assessment of the Proposed Sydney International Equestrian Centre. Horsley Park. NSW*.

Kass, Terry 1992 'Thematic History' in Neustein *et al. Liverpool Heritage Study* 1992:3.4 -3.48.

Kass, Terry 'Thematic history', *Fairfield Heritage Study*.

Keating, Christopher 1996 *On the Frontier. A Social History of Liverpool*. Hale & Iremonger, Sydney.

Liston, Carol 1986 'Thematic History', *Blacktown Heritage Study*.

Morris, Colleen and Geoffrey Britton, 2000 *Colonial Landscapes of the Cumberland Plain and Camden*, for the National Trust of Australia (NSW), draft.

Neustein & Associates with Somerville, Rod Howard, Terry Kass, Edward Higginbotham, Siobhan Lavelle, Anne Marie Clements and D. Taylor 1992 *Liverpool Heritage Study* for Liverpool City Council.

NSW Heritage Office August 2000 *Assessing Heritage Significance*.

NSW Heritage Office & DUAP 1996 *Archaeological Assessment Guidelines*.

NSW Department of Planning/Heritage Council of NSW 1994 *Manual for the Use of Historical Themes and Evaluation Criteria*.

Maps

Mitchell Library

Parish of Rooty Hill, 1903.

Parish Map of Gidley, 1924.

County of Cumberland, 1894, ML MSS.

Subdivision Plans

SP Quakers Hill Q1/1.

SP Quakers Hill Q1/7.

SP Liverpool, L/10/4.

SP Rooty Hill R13.1/22.

SP Rooty Hill R13.1/19

SP Rooty Hill R13.1/35a.

SP Rooty Hill R13.1/4.

SP Rooty Hill R13.1/10.

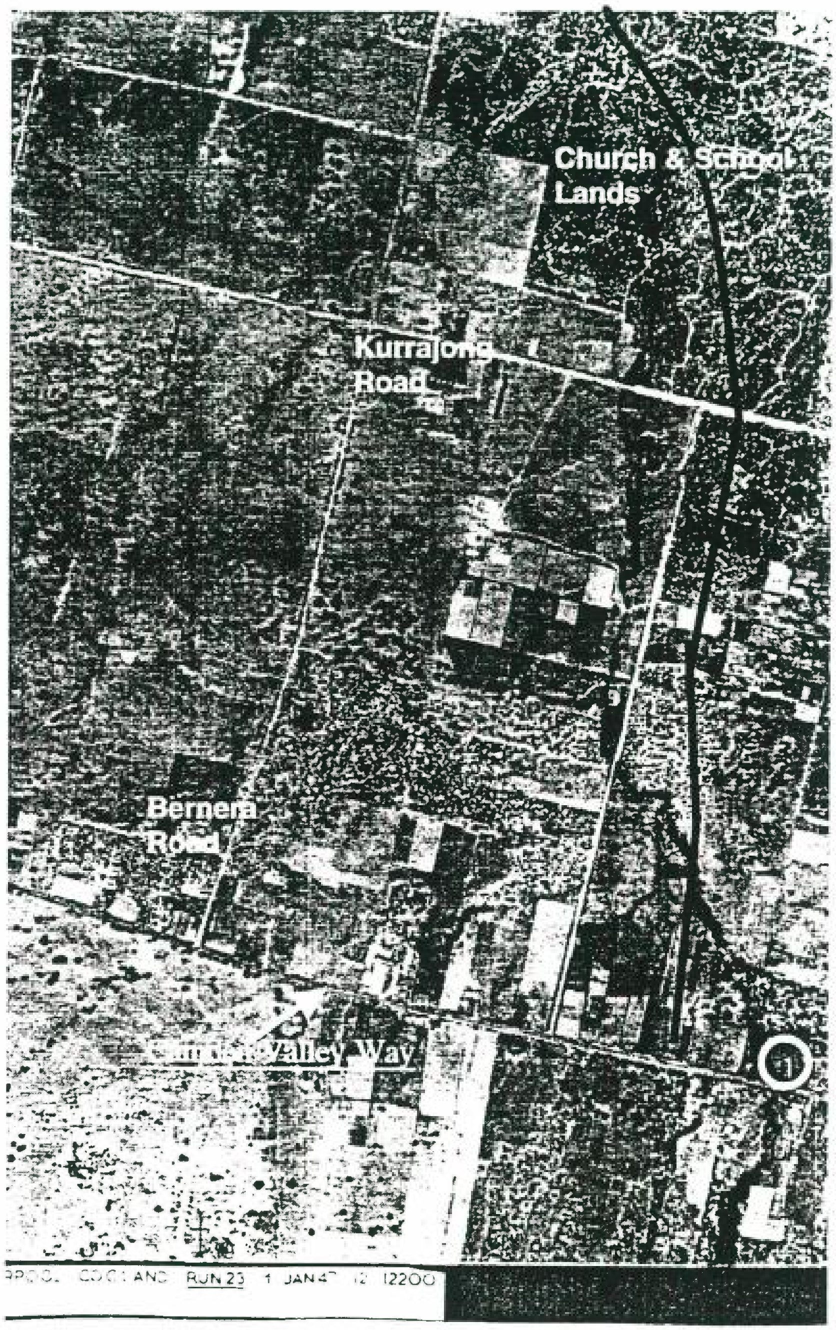
SP Rooty Hill R13.1/70.

State Records

SR Map 1811.

Appendix 1: Historic Aerial Photos

Aerial 1: Aerial Photo January 1947. WSO route from south to north. Land Property Information. Shows approximate position of Modification 1.



Aerial 2: Aerial photo shows position of modifications 3 and 4. The thick dark line is the approximate position of the proposed Western Sydney Orbital. Shows approximate position of Modifications 3 and 4. LPI. January 1947.

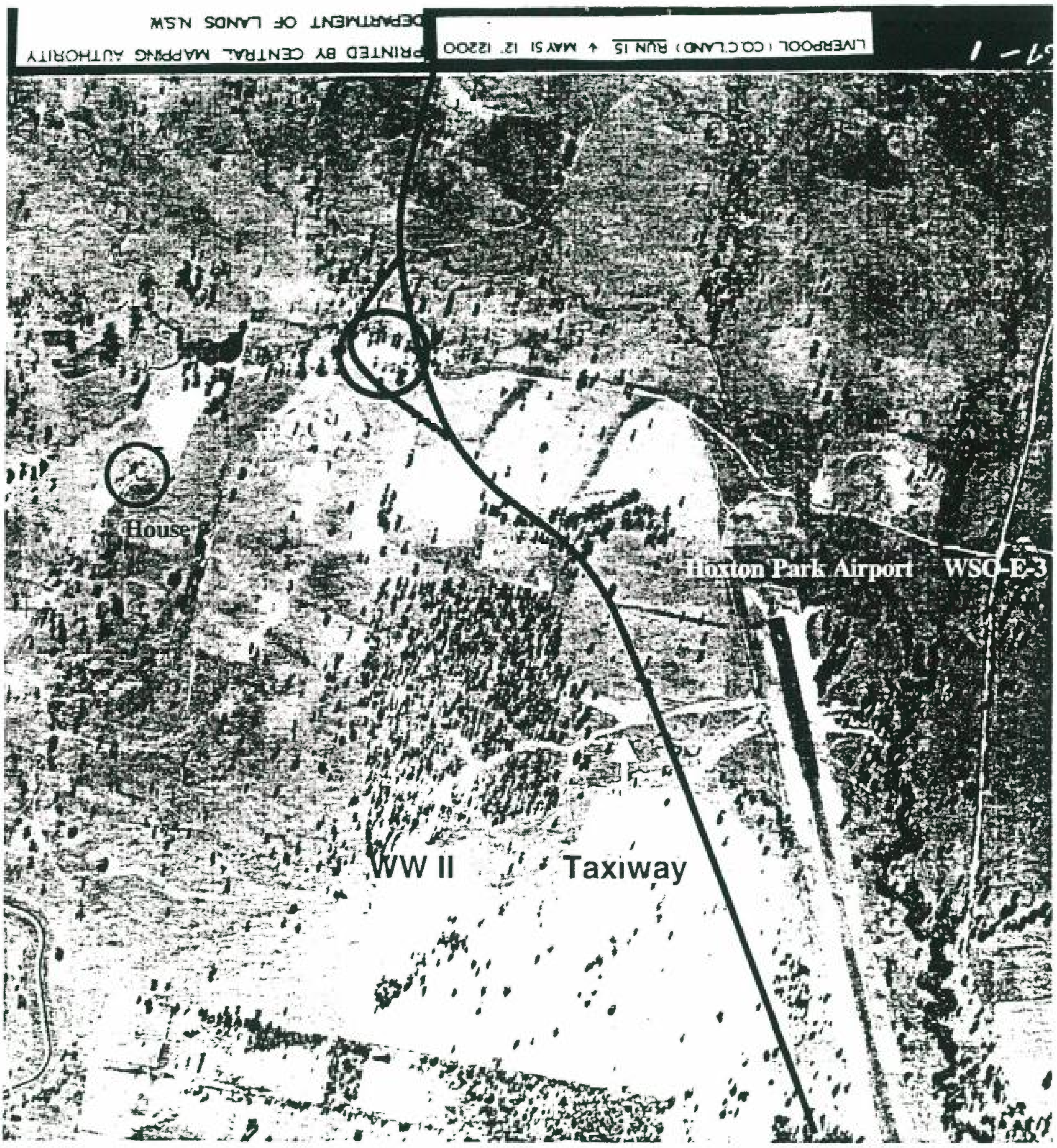
joins/overlaps Aerial 3

joins/overlaps Aerial 1

Aerial 3: Aerial photo of proposed Western Sydney Orbital adjacent to Hoxton Park Airport, sheet 3, LPI, May 1951. Shows position of modifications 6 and 7.

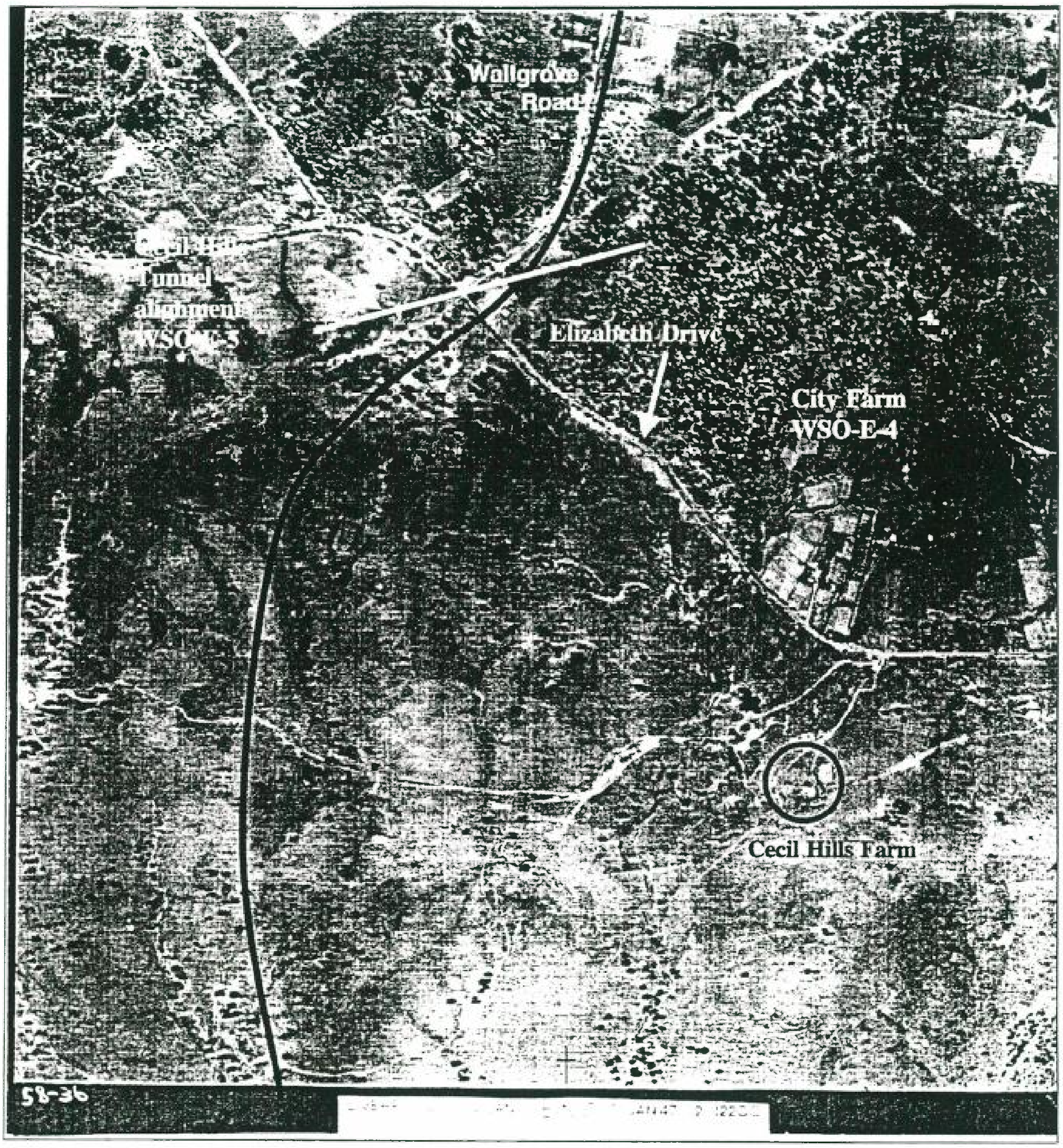
Aerial 4: Aerial photo of proposed alignment of the Western Sydney Orbital and the position of modification no. 8. LPI, May 1951.

joins/overlaps Aerial 5



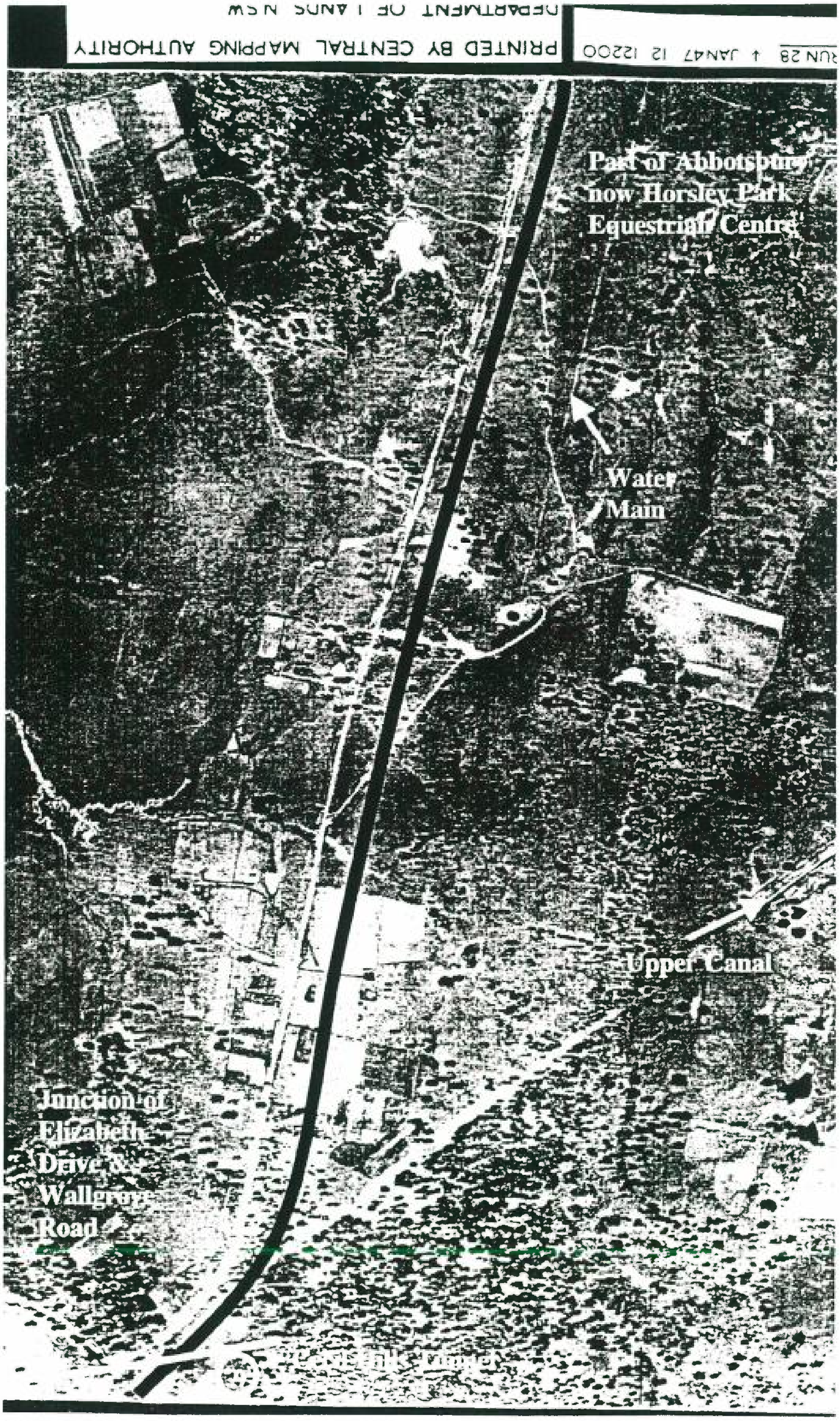
joins/overlaps Aerial 3

Aerial 5: Aerial photo near intersection of Elizabeth Drive and Wallgrove Road. LPI. January 1947.



joins/overlaps Aerial 4

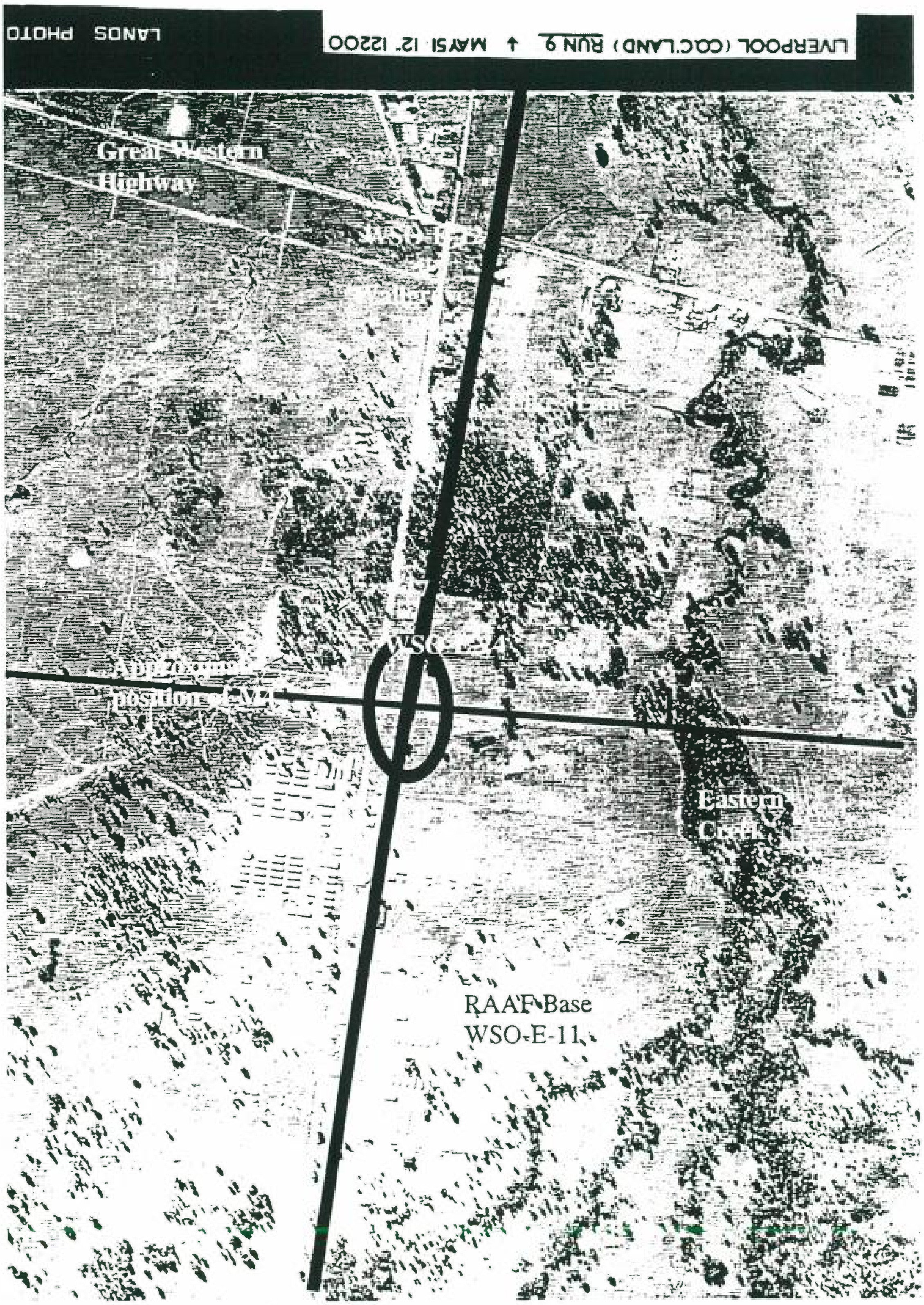
Aerial 6: Aerial photo of alignment of Western Sydney Orbital north from Elizabeth Drive. Modification 9 is the enclosing of shaft 4 of the Cecil Hills Tunnel. Upper canal with the structure of the WSO. Access to the shaft will be maintained. LPI. January 1947.



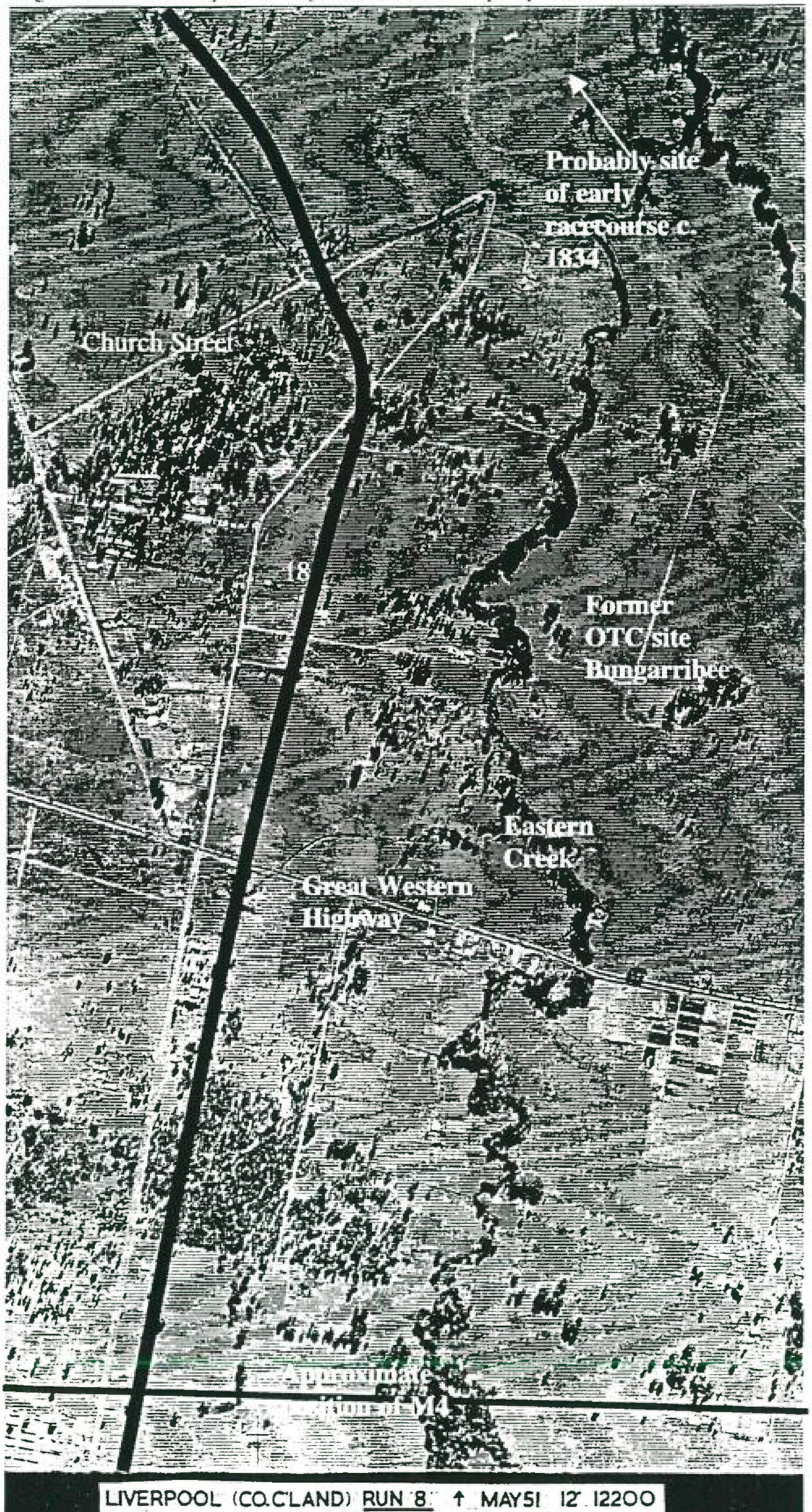
Aerial 7: Northern section of Horsley Park Equestrian Centre and the approximate location of Modification 11. January 1947. Land Property Information.

Aerial 8: Area between Horsley Park Road and Warragamba pipelines. January 1947. Land Property Information. Modification 13.

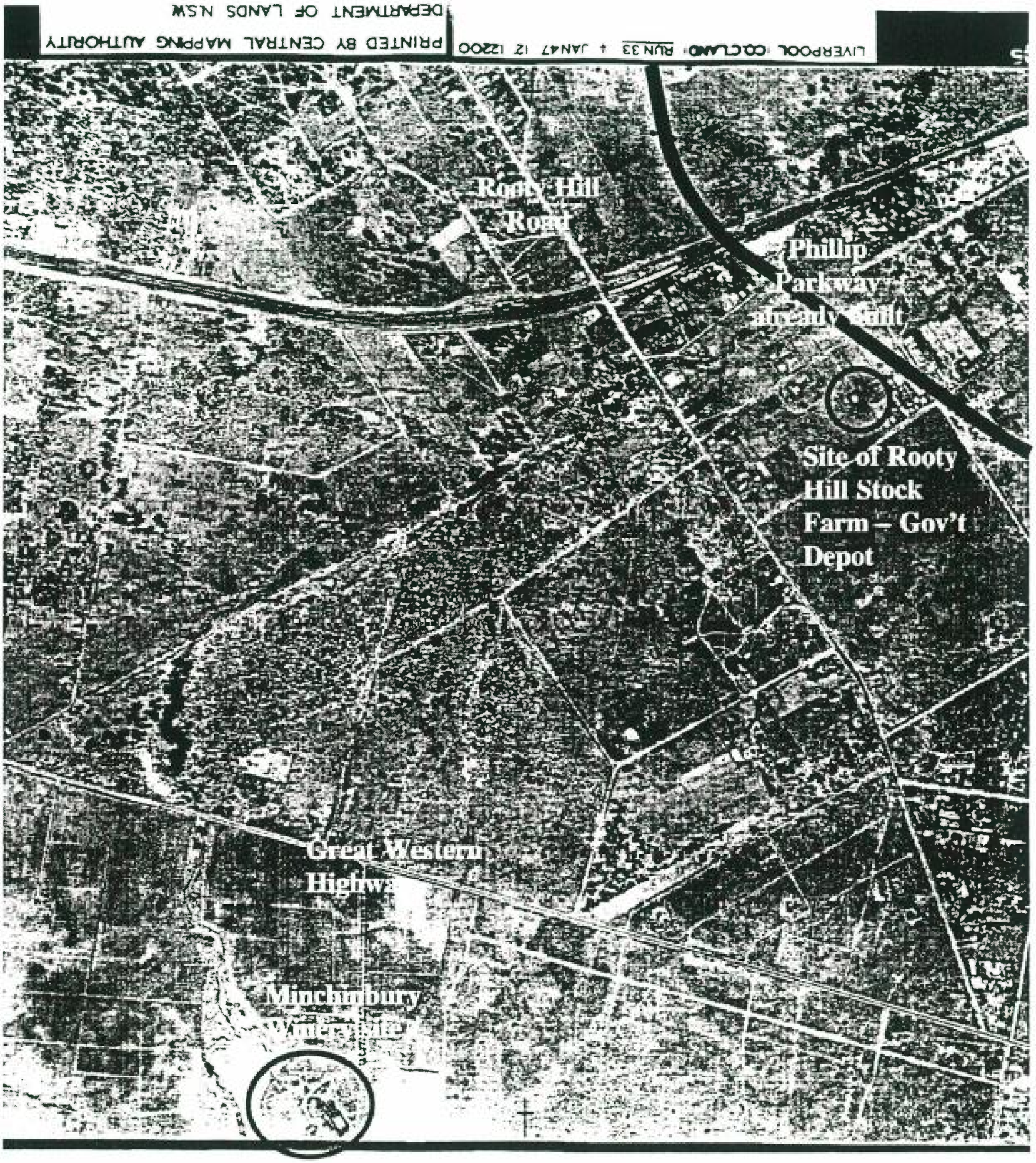
Aerial 9: The area to the east of Wallgrove Road, at the junction of the Great Western Highway, had a small settlement with blacksmiths shop, at least one inn, possibly two, a post office and houses. Modification 16 is immediately north of the M4. May 1951, Land Property Information.



Aerial 10: Proposed alignment through former OTC site, Bungarribee. Modification 18. For details see figure 2.7. Aerial photo May 1951, Land Property Information.



Aerial 11: Proposed alignment through part of Rooty Hill. WSO is to the east of Phillip Parkway. Aerial photo January 1947. Land Property Information.

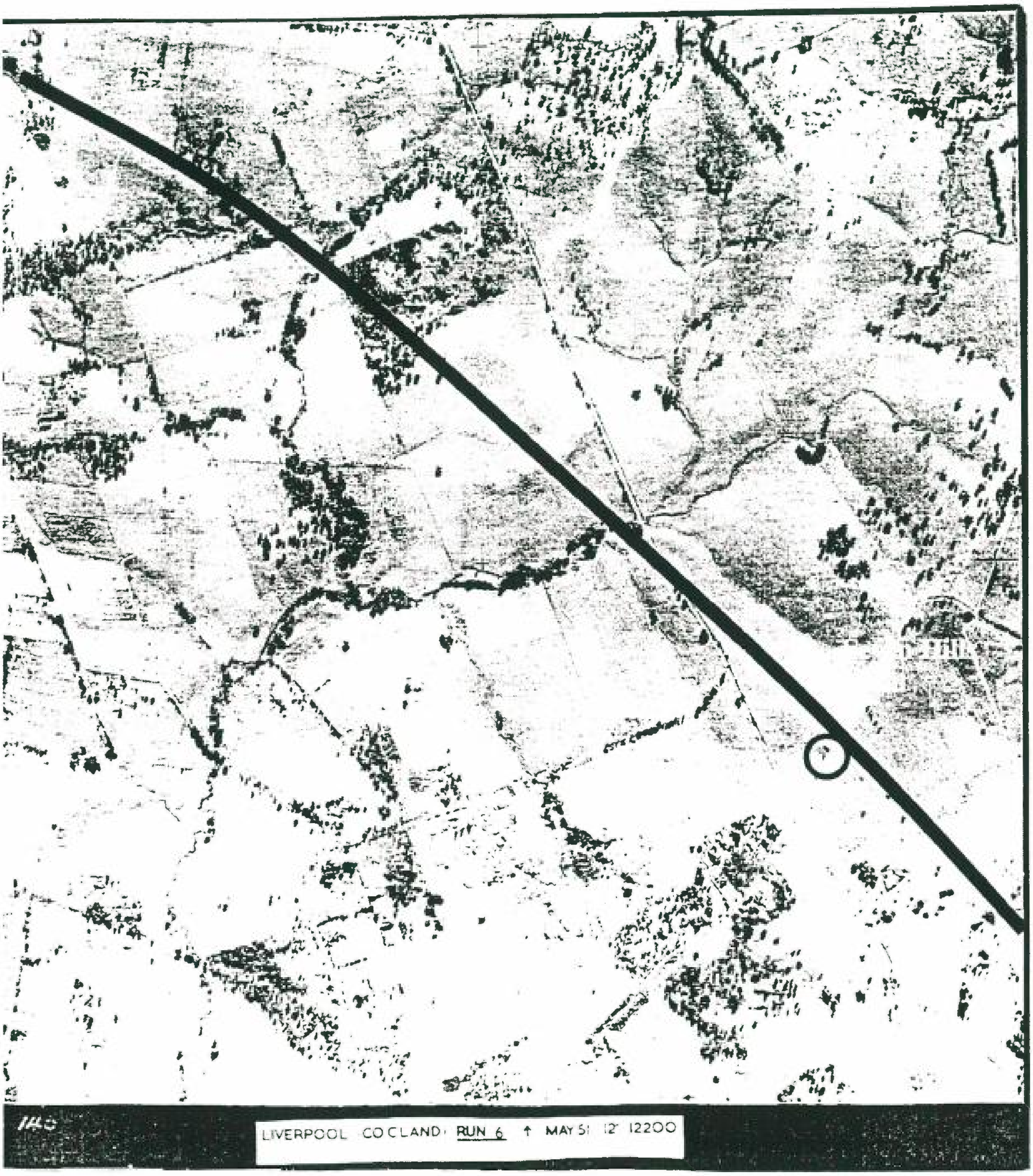


Aerial 12: January 1947. Land and Property Information. Approximate position of proposed WSO and Modification 23 near Richmond Road.

Aerial 13: January 1947, Land and Property Information. Approximate position of proposed WSO as it crosses over Sunnyholt Road and is south of Meurants Lane.

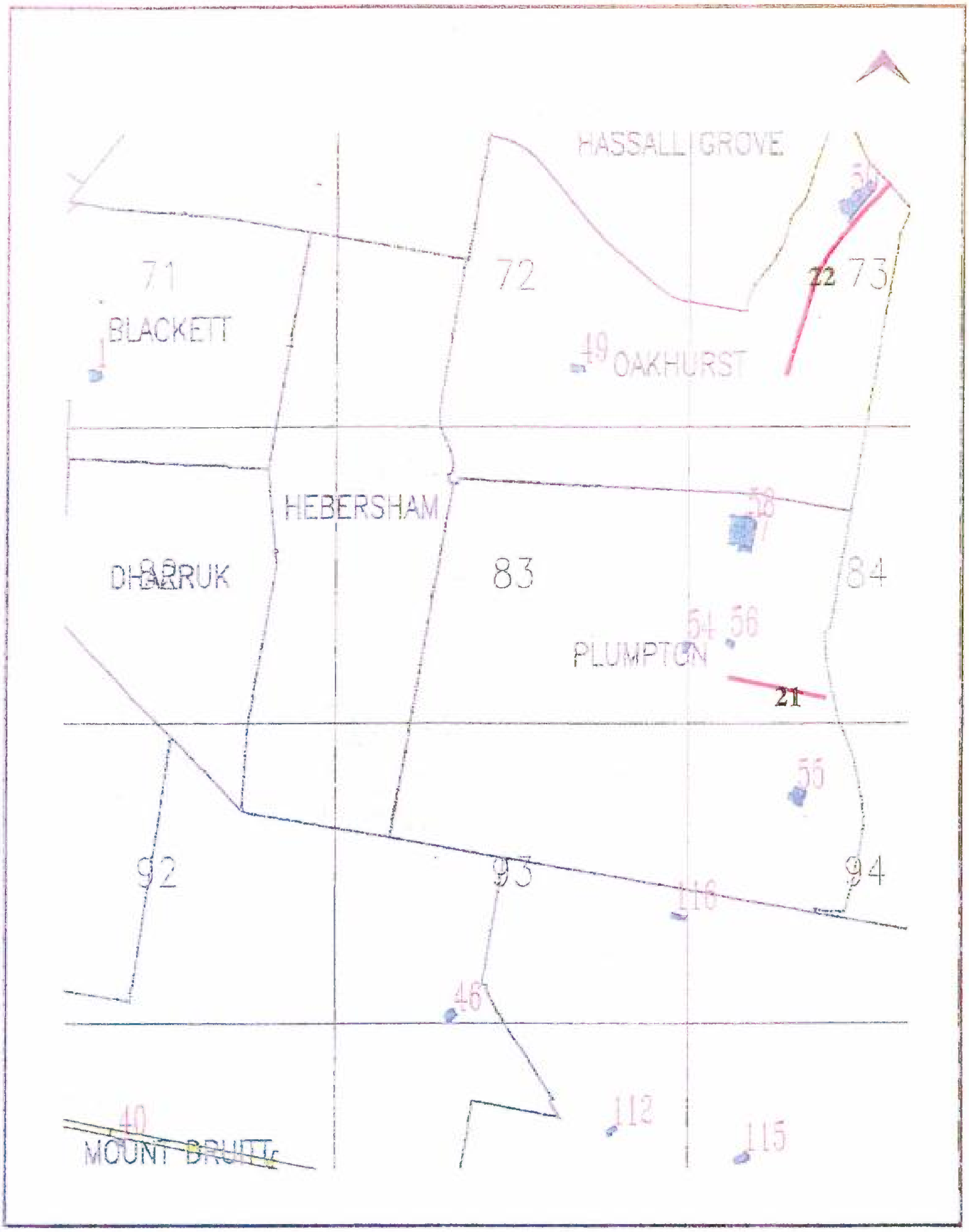
Aerial 14: January 1947. Land and Property Information. Approximate position of proposed WSO to the south of Meurants Lane and as it crosses over Old Windsor Road. Shows position of extension of Norwest Boulevard.

Aerial 15: January 1947. Land and Property Information. Approximate position of proposed WSO and modification 23 near Richmond Road.



Appendix 2: Location plans from Blacktown draft DCP showing the location of heritage items

Suburb Index Sheet



Plan from Blacktown draft DCP showing the approximate position of modifications 21 and 22 in relation to a range of environmental heritage items on Rooty Hill North Road, Plumpton.

Appendix 3: Heritage Listings in Baulkham Hills, Blacktown, Fairfield and Liverpool Council areas

AUSTRALIAN HERITAGE COMMISSION

Register of the National Estate Database

[RNE search | AHC Home | Disclaimer | ©]

Found 21 records:

- **Bents Basin State Recreation Area and Adjacent Areas**, Bents Basin Rd, Greendale, [Liverpool City], NSW (Registered)
- **Bernera including Site and Knoll**, Yarrunga St, Prestons, [Liverpool City], NSW (Registered)
- **Bringelly Radio Receiving Station Complex**, Badgerys Creek Rd, Bringelly, [Liverpool City], NSW (Indicative Place)
- **Church of the Holy Innocents**, Church St, Rossmore, [Liverpool City], NSW (Registered)
- **Collingwood**, Birkdale Cr, Liverpool, [Liverpool City], NSW (Registered)
- **Cubbitch Barta National Estate Area**, Old Illawarra Rd, Holsworthy, [Liverpool City], NSW (Registered)
- **Denham Court and St Marys Anglican Chapel**, Campbelltown Rd, Denham Court, [Liverpool City], NSW (Registered)
- **Glenfield Farm**, Leacocks La, Casula, [Liverpool City], NSW (Registered)
- **Horningsea Park**, Horningsea Park Dr, Horningsea Park, [Liverpool City], NSW (Registered)
- **Hoxton Park Airport**, Cowpasture Rd, Cecil Park, [Liverpool City], NSW (Interim List)
- **Ingleburn Army Camp**, Campbelltown Rd, Ingleburn Village, [Liverpool City], NSW (Indicative Place)
- **Kelvin, Outbuildings and Curtilage**, The Retreat, Bringelly Village, [Liverpool City], NSW (Registered)
- **Kemps Creek Natural Area**, Exeter Rd, Cecil Park, [Liverpool City], NSW (Registered)
- **Kitchener House**, 208 Moorebank Av, Moorebank, [Liverpool City], NSW (Identified Place)
- **Liverpool Courthouse (former)**, 251 Bigge St, Liverpool, [Liverpool City], NSW (Registered)
- **Liverpool Dam**, Heathcote Rd, Liverpool, [Liverpool City], NSW (Registered)
- **Liverpool Fire Station**, 70-78 Terminus St, Liverpool, [Liverpool City], NSW (Indicative Place)
- **Liverpool Hospital (former)**, College St, Liverpool, [Liverpool City], NSW (Registered)
- **Old Army / Internment Camp Group Holsworthy**, Artillery Rd, Holsworthy, [Liverpool City], NSW (Registered)
- **St Lukes Anglican Church**, 156 Northumberland St, Liverpool, [Liverpool City], NSW (Registered)
- **Voyager Point**, Sirius Rd, Voyager Point, [Liverpool City], NSW (Registered)

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 25/7/2001

RNEDB URL : http://www.erin.gov.au/heritage/register/easydatabase/database.html

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AUSTRALIAN HERITAGE COMMISSION

Register of the National Estate Database

[RNE search | AHC Home | Disclaimer | ©]

Bernera including Site and Knoll, Prestons NSW

Class: Historic
Legal Status: Registered (21/10/1980)

Database Number: 003290
File Number: 1/15/023/0002

Statement of Significance : Of the numerous early homesteads surviving in the former County of Cumberland, none is more strongly representative of the Australian vernacular style. Bernera's fine architectural quality and history make it a building of great value. Built around 1850 by Alan McPherson who arrived in New South Wales and became the first Collector of Internal Revenue.

(The Commission is in the process of developing and/or upgrading official statements for places listed prior to 1991. The above data was mainly provided by the nominator and has not yet been revised by the Commission.)

Description : A timber verandahed homestead strongly vernacular in character. The walls are weatherboard externally and inside are lined with sawn planks finished with wallpaper. The plan form is sophisticated, the entrance side balanced by two wings which form a forecourt. Garden elevation of five bays with shuttered French doors opening onto the deep timber floored verandah. Four panelled doors. Site is important and the knoll included in listing.

Condition and Integrity :

Location : Yarrunga Street, Prestons.

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 19/8/2001
RNEDB URL : http://www.ahc.gov.au/heritage/register/easydatabase/database.html

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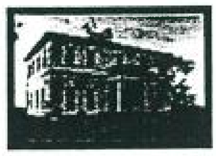
Register of the National Estate Database

Horningsea Park, Horningsea Park NSW



Class: Historic
Legal Status: Registered (21/03/1978)

Database Number: 003296
File Number: 1/15/023/0008

Statement of Significance : A fine early Georgian homestead built c 1830-39. Designed by its owner Joshua John Moore to replace his Cumberland Cottage which stood on the 500 acres of Horningsea Park granted to him in 1819. Moore was Registrar of The Governor's Court and one of the four trustees of St Luke's, Liverpool. An historic property, which has an important link with the establishment of settlement in the Canberra District and later associations with the conqueror of Mount Kosciusko. it is threatened with demolition.

(The Commission is in the process of developing and/or upgrading official statements for places listed prior to 1991. The above data was mainly provided by the nominator and has not yet been revised by the Commission.)

Description : This two storey stuccoed stone and rubble homestead was designed by its owner Lieutenant Joshua John Moore and built c 1830-39. The central door with its semi circular fanlight is flanked by paired French windows which are repeated on the side elevations. All the windows were shuttered. The interior contains elegant cedar joinery a courtyard at the rear is enclosed by projecting wings. Fine trees have survived from the original garden.

Condition and Integrity :

Location : Including trees and remaining portions of original land grant, Horningsea Park Drive, Horningsea Park.

Bibliography:
Trust listing records Moore. J.J. Pioneer of Canberra and Peninsular War Veteran. Measured drawings by W. Hardy Wilson in National Library.

Report produced : 19/8/2001
RNEDB URL : http://www.ahc.gov.au/heritage/register/easydatabase/database.html

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Register of the National Estate Database

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Hoxton Park Airport, Cecil Park NSW

Class: Historic
Legal Status: Interim List (27/03/2001)

Database Number: 102082
File Number: 1/15/023/0018

Statement of Significance : Hoxton Park Airport (1942-43) is historically significant for its direct association with defence plans during the Second World War. The airport was constructed as part of a group of airfields to be used as aircraft dispersal fields in the event of Japanese air attack on the Sydney area. (Criterion A.4)

The airport, retaining its airstrip (with some of its wartime surface visible), a remnant taxiway bridge and part of an associated taxiway, reflects important features of these dispersal airfields, and is particularly important for being a rare surviving airfield of this type. (Criteria B.2 and D.2)

Hoxton Park contains remnants of Cumberland Plain Woodland, a vegetation community listed as endangered at Commonwealth and state level. Less than six per cent of this woodland type remains in western Sydney and any remnant is regarded as significant. Alluvial Woodland is listed as an endangered ecological community at state level and is present along the edge of Hinchinbrook Creek, forming part of a corridor of natural vegetation running through a heavily modified environment. (Criterion B.1)

Description : History

The airport was developed by the Royal Australian Air Force in 1942-43 as one of a series of aircraft dispersal airfields on the perimeter of Sydney. The airfield was built in case of Japanese air attack, and reflects Australian fears of Japanese offensive operations against Sydney at that stage of the Pacific War. Also, RAAF pilots trained at Hoxton Park under the Empire Air Training Scheme. Hoxton Park was built as a satellite dispersal field for Bankstown airfield (Bankstown operates today) and was one of a collection of dispersal airfields built at the time, the others including Menangle, Bargo, Cordeaux, The Oaks, Wallgrove, Fleurs, St Marys, Castlereagh, Pitt Town, and Ettalong. All of these other airfields are gone and the land has been used for other purposes.

After World War Two Hoxton Park Airport was leased to the Hardy Rubber company for use as a tyre test track. Plans were made to convert it into a speedway but lobbying by aviation bodies saw it revert back to the airport it is today. The Federal Airports Corporation (FAC) managed and operated the site from 1988 to 1998, when on 2 July 1998 Hoxton Park Airport Limited assumed the management and operation from the FAC.

Today, the airport is used for light aircraft flying training and private flying. It is operational 24 hours per day and is one of the busiest uncontrolled airfields in Australia. As the airport is not operational for passenger traffic it does not have terminal facilities.

Description

Hoxton Park Airport is an active general aviation airport in Sydney's west. It covers 85 hectares and is 13kms west of Bankstown airport and 8kms from Liverpool. The physical structures include a single runway, taxiways, hangars and other aviation related buildings.The one sealed runway is 1,098 metres in length in the 16/34 direction.

At the northern end of the runway (beyond the length currently used by aircraft) there are present two earlier forms of sealing, one bitumen and the other gravel, hence reflecting the form of surface dating from the Second World War. Also, there is the entrance to a wartime taxiway leading off to the north-west, and also a surviving bridge which takes the taxiway across a drainage gully. Beyond the perimeter of the airport fence (and beyond the area of this listing) the taxiway continues to a stand of eucalypts which formerly was the site of wartime revetments used to disperse and hide aircraft in case of attack.

Hoxton Park Airport has approximately 35 hectares of remnant vegetation, mainly comprised of Alluvial Woodland, a component of Sydney Coastal River-Flat Forest and Shale Plains Woodland, a component of Cumberland Plain Woodland. Most of this vegetation lies to the east of the airfield along Hinchinbrook Creek. Cumberland Plain Woodland is a vegetation community listed as endangered at Commonwealth and state levels. Less than six per cent of Cumberland Plain Woodland remains in western Sydney and any remnant is regarded as significant. Alluvial Woodland is listed as an endangered ecological community at state level and is present along the edge of Hinchinbrook Creek. The soils consist of Quaternary alluvium derived from Wianamatta Shales and Hawkesbury Sandstone on flat to gently sloping alluvial plains.

Sixty-eight fauna species have been recorded from the place including 52 birds, four mammals, four frogs and eight reptiles. Species recorded include the whistling tree frog (LITORIA VERREAUXII), black-bellied marsh snake (HEMIAPSIS SIGNATA), sugar glider (PETAURUS BREVICEPS) and yellow-faced honeyeater (LICHENSTOMUS CHRYSOPS). The common scaly-foot (PYGOPUS LEPIDOPODUS) is a legless lizard found at Hoxton Park regarded as the most primitive member of its group.

Condition and Integrity : The airport is a relatively intact example of a wartime defence facility.
The northern end of the runway is disused and has grass growing on it in places. The original taxiway bridge to the revetments is present.

The airport is under threat of closure due to Badgery's Creek Airport developments and adjacent land is at risk of subdivision for housing. The revetment taxiway beyond the perimeter fence is threatened by the proposed Western Sydney orbital road and wildlife habitats are also similarly threatened. The Eucalyptus forest may be protected by the Government instrumentality Landcom. (December 2000)

Location : About 88ha, at Cecil Park, being an area bounded by a line commencing at the intersection of McIver Avenue and Cowpasture Road, then northerly via the western side of Cowpasture Road to Hinchinbrook Creek, then northerly via the central thread of Hinchinbrook Creek to its intersection with the northern boundary of Lot 1 DP546264, then westerly and southerly via the boundary of Lot 1 DP546264 to its intersection with McIver Avenue, then south easterly via the northern side of McIver Avenue to the point of commencement.

Bibliography:
Hoxton Park Airport Limited - Preliminary Draft Environmental HPAL, Feb 1999.

Sydney Airports Corporation Limited Annual Report, 1999.

Greening Australia, information from Mr Richard Davis.

National Archives of Australia; CRSA9716 Box 30 File 384 'Hoxton Park-RAAF Directorate of Works and Buildings-Engineer Intelligence Section-correspondence and other related information on aerodrome 8 December 1943-20 March 1953'. Also, files Series A705 item 171/26/54 parts 1 and 2, and item 171/106/717.

NSW National Parks and Wildlife Service. Native Vegetation of the Cumberland Plain. NSW Government, Sydney 2000.

NSW National Parks and Wildlife Service. NSW Wildlife Atlas Data. NSW Government, Sydney 1998.

Sydney Basin Visual Pilot Guide and Visual Terminal Chart Civil Aviation Safety Authority, June 1999.

Road Transport Authority - Preliminary Brochure on Western Sydney Orbital Road.

Royal Australian Air Force Executive Officer, Historical Records (Air Force), information, 2000.

Report produced : 25/7/2001
RNEDB URL : http://www.ahc.gov.au/heritage/register/easydatabase/database.html

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AUSTRALIAN HERITAGE COMMISSION

Register of the National Estate Database

Ingleburn Army Camp, Ingleburn Village NSW

Class: Historic
Legal Status: Indicative Place

Database Number: 101050
File Number: 1/15/010/0042

Nominator's Statement of Significance :

Description :

Condition and Integrity :

Location : About 300ha, between Zouch Road and the South Western Freeway (Hume Highway), Ingleburn Village and Edmondson Park.

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 19/8/2001
RNEDB URL : http://www.ahc.gov.au/heritage/register/easydatabase/database.html

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Register of the National Estate Database

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Found 6 records:

- **Fairfield Fire Station**, 3 Williams St, Fairfield, [Fairfield City], NSW (Indicative Place)
- **Horsley Garden**, The Horsley Dr, Horsley Park, [Fairfield City], NSW (Registered)
- **Horsley Homestead, Outbuildings and Surrounds**, The Horsley Dr, Horsley Park, [Fairfield City], NSW (Registered)
- **Lansdowne Bridge**, Hume Hwy, Lansvale, [Fairfield City], NSW (Registered)
- **Prospect Reservoir Area**, Prospect, [Fairfield City], NSW (Indicative Place)
- **The Homestead**, Brown Rd, Bonnyrigg Heights, [Fairfield City], NSW (Registered)

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 25/7/2001
RNEDB URL : http://www.erin.gov.au/heritage/register/easydatabase/database.html

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Register of the National Estate Database

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Horsley Garden, Horsley Park NSW

Class: Historic
Legal Status: Registered (21/03/1978)

Database Number: 003012
File Number: 1/14/014/0001

Statement of Significance : Horsley Garden is significant for demonstrating the mid-nineteenth century estate garden style, reflecting the nineteenth century Australian landscape movement and the influence of contemporary horticultural societies. It is a rare survival of this garden style. Significant features are as follows: the use of an elevated site, taking advantage of views over the surrounding countryside; a gently sweeping carriage drive; a central carriage loop with quatre-foil shrubbery; and extensive plantings of highly ornamental trees such as bunya bunyas and stone pines (Criterion 3.2). The garden is aesthetically important for the visual drama of large scale plantings of trees with interesting form creating contrasts with the gentle curves of the drive and carriage loop (Criterion 5.2).

Description : The garden is the setting for Horsley Homestead, erected in 1832 by the Johnston family. The approach is by a gently curving carriage drive through a formal avenue of ARAUCARIA bidwilli and PINUS picea. On the crest of a hill, the property entrance is marked by groupings of PLUMBAGO and sweet bays and a pair of Moreton Bay figs. Close to the house, the drive forks to form a petal shaped carriage loop, which further divides to create a smaller, circular loop. There is a large quatre-foil shrubbery in front of the house. Behind the house is a later tennis court and remnant flower beds. The western property boundary is marked by a row of ARAUCARIA bidwilli. On the northern slope there are extensive remains of orchard terracing and a second drive.

Condition and Integrity : Development of the surrounding land has the potential to impact on the garden setting. There is an intrusive chicken shed located beneath the house.

Location : The Horsley Drive, Horsley Park.

Bibliography:
W. HARDY WILSON. OLD COLONIAL ARCHITECTURE IN NEW SOUTH WALES AND TASMANIA. SYDNEY 1923.
COW PASTURE ROAD, SYDNEY 1920.

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 19/8/2001
RNEDB URL : http://www.ahc.gov.au/heritage/register/easydatabase/database.html

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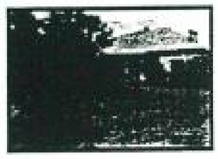
Horsley Homestead, Outbuildings and Surrounds, Horsley Park NSW



Class: Historic
Legal Status: Registered (21/03/1978)

Database Number: 003011
File Number: 1/14/014/0001

Statement of Significance : The Horsley complex is historically significant as an unusually intact example of a self contained country estate of the early nineteenth century and for its associations with the prominent early Johnston family. It has architectural significance for demonstrating many of the characteristic features of Old Colonial Regency style and the links with the architecture of British India of the same period. The garden is historically significant in its own right.

Description : The single storey house is a direct copy of an Indian Bungalow, built of rendered brick, with a hipped, corrugated iron roof. It has a central front verandah, supported by three pairs of Tuscan columns. The use of folding casement doors, of sixteen panes and, having adjustable louvre shutters, indicate its British India design origins. The internal joinery is of a high standard, featuring many pairs of four paned, double cedar doors. Numerous outbuildings are grouped along the continuation of the carriage drive to the rear of the main residence. The garden provides an appropriate period setting for the house and is significant in its own right.

Condition and Integrity : The entrance drive is now seldom used and the carriage loop is grassed over. The integrity of the garden is damaged by an unsympathetic chicken shed, sited beneath the house and destroying the view from the entrance gates over the paddock and up to the house.

Location : The Horsley Drive, Horsley Park.

Bibliography:
HOUSES OF AUSTRALIA AND TASMANIA, 1948; W.HARDY WILSON, OLD COLONIAL ARCHITECTURE OF NEW SOUTH WALES AND TASMANIA, SYDNEY 1923.

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

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Found 13 records:

- Grantham Poultry Research Station (former), Seven Hills Rd Sth, Seven Hills, [Blacktown City], NSW (Registered)
- Indigenous Place, Colebee, [Blacktown City], NSW (Indicative Place)
- Indigenous Place, Oakhurst, [Blacktown City], NSW (Registered)
- Indigenous Place, Kellyville, [Blacktown City], NSW (Indicative Place)
- Old Boiler House, Blacktown Rd, Blacktown, [Blacktown City], NSW (Indicative Place)
- Old Windsor Road Section, Old Windsor Rd, Kellyville, [Blacktown City], NSW (Registered)
- Prospect Reservoir Area, Prospect, [Blacktown City], NSW (Indicative Place)
- Rouse Hill House Garden, Windsor Rd, Rouse Hill, [Blacktown City], NSW (Registered)
- Rouse Hill House including Stables and Outbuildings, Windsor Rd, Rouse Hill, [Blacktown City], NSW (Registered)
- Shale Woodland Llandilo, Stony Creek Rd, Shanes Park, [Blacktown City], NSW (Registered)
- Site of Veteran Hall, Reservoir Rd, Prospect, [Blacktown City], NSW (Registered)
- St Bartholomews Anglican Church (former), Prospect Hwy, Prospect, [Blacktown City], NSW (Registered)
- Western Sydney Shale Woodland St Marys, Forrester Rd, St Marys, [Blacktown City], NSW (Registered)

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 25/7/2001
RNEDB URL : http://www.erin.gov.au/heritage/register/easydatabase/database.html

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Register of the National Estate Database

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Old Windsor Road Section, Kellyville NSW

Class: Historic
Legal Status: Registered (21/03/1978)

Database Number: 002963
File Number: 1/14/004/0001

Statement of Significance : A length of historical road containing landscape elements typical of the early nineteenth century.

(The Commission is in the process of developing and/or upgrading official statements for places listed prior to 1991. The above data was mainly provided by the nominator and has not yet been revised nor reconsidered by the Commission).

Description : Until the early 1980s, a gravel road with ditches at sides, defined by earth banks, hedgerows and remaining lengths of post and rail fences. It appears to be a portion of the vehicle road put through from Toongabbie to South Creek, Windsor by Governor Hunter's instructions in 1797. The road was improved in 1812 and ran from Parramatta to South Creek Windsor.

Condition and Integrity : Now sealed and duplicated for most of its length.

Location : The whole of Old Windsor Road Reserve from its intersection with Seven Hills Road to its intersection with the new Windsor Road at Kellyville.

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 25/7/2001
RNEDB URL : http://www.ahc.gov.au/heritage/register/easydatabase/database.html

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AUSTRALIAN HERITAGE COMMISSION

Register of the National Estate Database

Indigenous Place, Colebee NSW

Class: Indigenous
Legal Status: Indicative Place

Database Number: 018986
File Number: 1/14/005/0009

Nominator's Statement of Significance :

Description :

Condition and Integrity :

Location :

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 19/8/2001
RNEDB URL : http://www.ahc.gov.au/heritage/register/easydatabase/database.html

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Indigenous Place, Oakhurst NSW

Class: Indigenous
Legal Status: Registered (30/06/1992)

Database Number: 015905
File Number: 1/14/005/0004

Nominator's Statement of Significance :

Description :

Condition and Integrity :

Location :

Bibliography:
Bickford, A. (1981) The archaeological investigation of the Native Institution Blacktown, NSW.

Brook, J. (1983) Blacktown, a name of character : a history of the Aboriginal settlement of Blacktown. Blacktown and District Historical Society, Blacktown.

Kohen, J. (1986) An archaeological study of Aboriginal sites within the City of Blacktown. A National Estate Grant Program Report.

The place is also listed on the NSW National Parks and Wildlife Service Aboriginal Sites Register (No 45-5-398).

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

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Indigenous Place, Kellyville NSW

Class: Indigenous
Legal Status: Indicative Place

Database Number: 016089
File Number: 1/14/005/0005

Nominator's Statement of Significance :

Description :

Condition and Integrity :

Location :

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 19/8/2001
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Found 25 records:

- **Arndells Windmill Complex**, Wisemans Ferry Rd, Cattai, [Baulkham Hills Shire], NSW (Indicative Place)
- **Bella Vista Complex**, Elizabeth Macarthur Dr, Bella Vista, [Baulkham Hills Shire], NSW (Registered)
- **Burnside Homes**, Pennant Hills Rd, North Parramatta, [Baulkham Hills Shire], NSW (Registered)
- **Cad Die and Curtilage**, Cattai Rd, Cattai, [Baulkham Hills Shire], NSW (Registered)
- **Castle Hill House**, 215-219 Old Northern Rd, Castle Hill, [Baulkham Hills Shire], NSW (Indicative Place)
- **Castle Hill Public School and Residence (former)**, 266 Old Northern Rd, Castle Hill, [Baulkham Hills Shire], NSW (Registered)
- **Castle Hill Settlement Site**, Old Castle Hill Rd, Castle Hill, [Baulkham Hills Shire], NSW (Registered)
- **Chelsea Farm**, 8-10 Englart Pl, Baulkham Hills, [Baulkham Hills Shire], NSW (Registered)
- **Elwatan**, Castle Hill Rd, Castle Hill, [Baulkham Hills Shire], NSW (Indicative Place)
- **Felton Mathew Marked Tree**, Floyd Rd, South Maroota, [Baulkham Hills Shire], NSW (Registered)
- **Glenhope and Grounds**, 113 Castle Hill Rd, West Pennant Hills, [Baulkham Hills Shire], NSW (Registered)
- **Glenroy**, 756 Old Northern Rd, Middle Dural, [Baulkham Hills Shire], NSW (Rejected Place)
- **Gowan Brae Group**, Pennant Hills Rd, North Parramatta, [Baulkham Hills Shire], NSW (Registered)
- **Gowan Brae House**, Pennant Hills Rd, North Parramatta, [Baulkham Hills Shire], NSW (Registered)
- **Joyce Farmhouse**, 15 Valerie Av, Baulkham Hills, [Baulkham Hills Shire], NSW (Indicative Place)
- **Kings School Chapel**, Pennant Hills Rd, North Parramatta, [Baulkham Hills Shire], NSW (Registered)
- **Methodist Church (former)**, Mud Island Rd, Sackville North, [Baulkham Hills Shire], NSW (Indicative Place)
- **Old Windsor Road Section**, Old Windsor Rd, Kellyville, [Baulkham Hills Shire], NSW (Registered)
- **Pearce Family Graves**, Seven Hills Rd, Bella Vista, [Baulkham Hills Shire], NSW (Indicative Place)
- **St Michaels Catholic Church (former)**, Windsor Rd, Baulkham Hills, [Baulkham Hills Shire], NSW (Registered)
- **St Pauls Anglican Church (former)**, 225 Old Northern Rd, Castle Hill, [Baulkham Hills Shire], NSW (Indicative Place)
- **Sydney Woollen Mills**, Windsor Rd, Northmead, [Baulkham Hills Shire], NSW (Indicative Place)
- **The Old Parsonage**, 210 Old Northern Rd, Castle Hill, [Baulkham Hills Shire], NSW (Indicative Place)
- **The Pines - House, Outbuildings and Pine Trees**, 656 Old Northern Rd, Dural, [Baulkham Hills Shire], NSW (Registered)

- **Wisemans Ferry Settlement Site**, Great North Rd, Wisemans Ferry, {Baulkham Hills Shire}, NSW (Indicative Place)

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 25/7/2001
RNEDB URL : http://www.erin.gov.au/heritage/register/easydatabase/database.html

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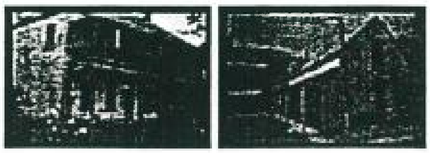
Bella Vista Complex, Bella Vista NSW



Class: Historic
Legal Status: Registered (28/09/1982)

Database Number: 002971
File Number: 1/14/004/0006

Statement of Significance : The core of the Seven Hills Farm, which is important for its historic associations with the establishment of the wool industry in Australia. The buildings are associated with the development of the property for fruit growing by the Pearce family for over 100 years (Criterion A.4). The associations with Elizabeth Macarthur, who raised Merino sheep on the property between 1801-20, are particularly strong (Criterion H.1). The complex of homestead and outbuildings represents the once prolific agricultural enterprises of the Cumberland Plain and show the growth and development of a nineteenth century farming establishment (Criterion D.2). The former entrance avenue of Bunya Bunya pines is a local landmark and an important element of the cultural landscape of the property (Criterion E.1).

Description : The complex comprises main homestead, built between 1850-72, which is of two storeys, a single story kitchen block built about 1830 as an earlier house, Fitzgerald Cottage with attached coach house farmstore, barn, stables, slab building (labourers' dormitory), shed, stalls, milking shed, wells, fences and avenue of Bunya pines.

Condition and Integrity : Main house originally single storey built 1850, extended 1860 to two storey and further side extension added 1872. Kitchen 1830, other buildings may be older.

Location : About 7ha, off Elizabeth Macarthur Drive and Old Windsor Road, south of its intersection with Norwest Drive, Bella Vista, comprising: homestead, associated farm outbuildings, avenue of Bunya pines and surrounds, being that area defined in proposed Permanent Conservation Order No 52 under the New South Wales Heritage Act 1977.

Report produced : 19/8/2001
RNEDB URL : http://www.ahc.gov.au/heritage/register/easydatabase/database.html

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Pearce Family Graves, Bella Vista NSW

Class: Historic
Legal Status: Indicative Place

Database Number: 002977
File Number: 1/14/004/0012

Nominator's Statement of Significance : National Trust Recorded earliest grave, 1832.

Description :

Condition and Integrity :

Location : Seven Hills Road, near corner Old Windsor Road, Bella Vista

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 19/8/2001
RNEDB URL : http://www.ahc.gov.au/heritage/register/easydatabase/database.html

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Old Windsor Road Section, Kellyville NSW

Class: Historic
Legal Status: Registered (21/03/1978)

Database Number: 002963
File Number: 1/14/004/0001

Statement of Significance : A length of historical road containing landscape elements typical of the early nineteenth century.

(The Commission is in the process of developing and/or upgrading official statements for places listed prior to 1991. The above data was mainly provided by the nominator and has not yet been revised nor reconsidered by the Commission).

Description : Until the early 1980s, a gravel road with ditches at sides, defined by earth banks, hedgerows and remaining lengths of post and rail fences. It appears to be a portion of the vehicle road put through from Toongabbie to South Creek, Windsor by Governor Hunter's instructions in 1797. The road was improved in 1812 and ran from Parramatta to South Creek Windsor.

Condition and Integrity : Now sealed and duplicated for most of its length.

Location : The whole of Old Windsor Road Reserve from its intersection with Seven Hills Road to its intersection with the new Windsor Road at Kellyville.

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

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Heritage Listings BACK

State Heritage Inventory Search Results

Statutory Listed Items

Information and items listed in the State Heritage Inventory come from a number of sources. This means that currently there may be several entries for the same heritage item in the database.

Your search results have been divided into two sections.

The first section contains items listed on the State Heritage Register, covered by an Interim Heritage Order or protected under section 130 of the NSW Heritage Act. This information is provided by the NSW Heritage Office.

Additional information on some of these items, provided by Local Councils & Shires and State Government Agencies, may also be found in the second section.

Item Name	Address	Suburb	LGA	State Heritage Register
Bella Vista, outbuildings and Bunya Bunya Pines	Old Windsor Road	Kellyville	Baulkham Hills	Yes
Box Hill House	10 Terry Road	Baulkham Hills	Baulkham Hills	Yes
Box Hill Inn	Windsor Road	Box Hill	Baulkham Hills	Yes
Cattai Estate		Cattai National Park	Baulkham Hills	Yes
Former Third Government Farm	Gilbert Road	Castle Hill	Baulkham Hills	Yes
Great Drain and two house sites	off Wisemans Ferry Road	Maroota South	Baulkham Hills	Yes
Hunting Lodge (former)	The Water Lane	Rouse Hill	Blacktown City	Yes
McCall Garden Colony	10 Terry Road	Box Hill	Baulkham Hills	Yes
Pearce Family Cemetery	Seven Hills Road	Baulkham Hills	Baulkham Hills	Yes
Royal Oak Inn	Windsor Road	Rouse Hill	Baulkham Hills	Yes
St Paul's Anglican Church	221 Old Northern Road	Castle Hill	Baulkham Hills	Yes

Item Name	Address	Suburb	LGA	Information Source
Aberdoon	Mile End Road	Rouse Hill	Baulkham Hills	GAZ
Allens House	548 Old Northern Road	Round Corner	Baulkham Hills	GAZ
Alliance Church	Windsor Road	Baulkham Hills	Baulkham Hills	GAZ
Balcombe Heights Community Buildings	Seven Hills Road	Baulkham Hills	Baulkham Hills	GAZ
Barn	80 Pitt Town Road	Kenthurst	Baulkham Hills	GAZ
Baulkham Hills Public	[illegible]	Baulkham	Baulkham	[illegible]

School	5-13 Russell Street	Hills	Hills	GAZ
Bellerive	177 Old Northern Road	Castle Hill	Baulkham Hills	GAZ
Brewongle Field Studies Centre	Sackville Maroota Road	Sackville North	Baulkham Hills	GAZ
Brick Cottage	100 Windsor Road	Kellyville	Baulkham Hills	GAZ
Browns Cemetery	River Road	Lower Portland	Baulkham Hills	GAZ
Bungool	Wisemans Ferry Road	Cattai	Baulkham Hills	GAZ
Cable Ferry - Sackville	Sackville - Maroota Road	Sackville	Baulkham Hills	GAZ
Cable Ferry - Webbs Creek	River Road	Wisemans Ferry	Baulkham Hills	GAZ
Cable Ferry - Wisemans Ferry	Old Northern Road	Wisemans Ferry	Baulkham Hills	GAZ
Caddie House (Cattai State Recreation Area)	Wisemans Ferry Road	Cattai	Baulkham Hills	GAZ
Caprera House	65 Caprera Road	Northmead	Baulkham Hills	GAZ
Castle Hill Public School	266 Old Northern Road	Castle Hill	Baulkham Hills	GAZ
Cemetery	Mile End Road	Rouse Hill	Baulkham Hills	GAZ
Chelsea Farm	8-10 Englart Place	Baulkham Hills	Baulkham Hills	GAZ
Christ Church Anglican Church	Windsor Road	Rouse Hill	Baulkham Hills	GAZ
Convict Station	Old Northern Road	Wisemans Ferry	Baulkham Hills	GAZ
Creasy's	11-13 Old Northern Road	Baulkham Hills	Baulkham Hills	GAZ
Darcey Hey	215-219 Old Northern Road	Castle Hill	Baulkham Hills	GAZ
Dargle house	River Road	Lower Portland	Baulkham Hills	GAZ
Divine Word Missionaries (former)	Windsor Road	Kellyville	Baulkham Hills	GAZ
Dunrath	139 Castle Hill Road	West Pennant Hills	Baulkham Hills	GAZ
Durham Park	174-176 Old Northern Road	Castle Hill	Baulkham Hills	GAZ
Eurambie Park	View Street	West Pennant Hills	Baulkham Hills	GAZ
Fairholme	157 Castle Hill Road	West Pennant Hills	Baulkham Hills	GAZ
Garthowen	14 Garthowen Crescent	Castle Hill	Baulkham Hills	GAZ
Gate	153 Castle Hill Road	West Pennant Hills	Baulkham Hills	GAZ
Glenhope and Grounds	113 Castle Hill Road	West Pennant Hills	Baulkham Hills	GAZ
Government Farm Site	Old Northern Road	Castle Hill	Baulkham Hills	GAZ

Gowan Brae Group	Pennant Hills Road	North Parramatta	Baulkham Hills	GAZ
Havilah House & stables	25 Bevan Place	Carlingford	Baulkham Hills	GAZ
Hope Farm and Mill Ruins	Wisemans Ferry Road	Cattai	Baulkham Hills	GAZ
House	428 Old Northern Road	Glenhaven	Baulkham Hills	GAZ
House	37,60,66,67 Old Northern Road	Baulkham Hills	Baulkham Hills	GAZ
House	Annangrove Road	Annangrove	Baulkham Hills	GAZ
House	7 Blue Gum Road	Annangrove	Baulkham Hills	GAZ
House	489 Boundary Road	Maraylya	Baulkham Hills	GAZ
House	4 Mary Street	Northmead	Baulkham Hills	GAZ
House	31 Kenthurst Road	Kenthurst	Baulkham Hills	GAZ
House	21 Junction Road	Baulkham Hills	Baulkham Hills	GAZ
House	11 Hession Road	Nelson	Baulkham Hills	GAZ
House	Green Road	Kellyville	Baulkham Hills	GAZ
House	44 Annangrove Road	Annangrove	Baulkham Hills	GAZ
House	221 Annangrove Road	Annangrove	Baulkham Hills	GAZ
House	74 Showground Road	Castle Hill	Baulkham Hills	GAZ
House	245 Windsor Road	Baulkham Hills	Baulkham Hills	GAZ
House	175 Windsor Road	Northmead	Baulkham Hills	GAZ
House	41 Windsor Road	Kellyville	Baulkham Hills	GAZ
House	342 Old Northern Road	Castle Hill	Baulkham Hills	GAZ
House	145 Windsor Road	Baulkham Hills	Baulkham Hills	GAZ
House	243 Windsor Road	Baulkham Hills	Baulkham Hills	GAZ
House	244 Old Northern Road	Castle Hill	Baulkham Hills	GAZ
House	181 Windsor Road	Northmead	Baulkham Hills	GAZ
House	183-185 Windsor Road	Northmead	Baulkham Hills	GAZ
House	187 Windsor Road	Northmead	Baulkham Hills	GAZ
House	227 Windsor Road	Northmead	Baulkham Hills	LGOV
House and Barn	554 Nelson Road	Nelson	Baulkham Hills	GAZ
House and barn	79 Pitt Town Road	Kenthurst	Baulkham Hills	GAZ
Hunting Lodge (former)	The Water Lane	Rouse Hill	Baulkham Hills	GAZ

Item	95 Cattai Ridge Road	Glenorie	Baulkham Hills	GAZ
Item	Sackville Maroota Road	Sackville North	Baulkham Hills	GAZ
Johnstons house	Wisemans Ferry Road	Cattai	Baulkham Hills	GAZ
Joyce Farmhouse	15 Valerie Avenue	Baulkham Hills	Baulkham Hills	GAZ
Kenthurst Literary Institute	131 Kenthurst Road	Kenthurst	Baulkham Hills	GAZ
Marklye	18 Nelson Road	Box Hill	Baulkham Hills	GAZ
Merrymount	Wisemans Ferry Road	Cattai	Baulkham Hills	GAZ
Mill Ruins	Wisemans Ferry Road	Cattai	Baulkham Hills	GAZ
Montrose	Wisemans Ferry Road	Cattai	Baulkham Hills	GAZ
Mungerie	Windsor Road	Rouse Hill	Baulkham Hills	GAZ
Peacocks	River Road	Lower Portland	Baulkham Hills	GAZ
Pine Ridge	151 Castle Hill Road	West Pennant Hills	Baulkham Hills	GAZ
Police Station & Residence	Old Northern Road	Wisemans Ferry	Baulkham Hills	GAZ
Post Office & Residence	Old Northern Road	Wisemans Ferry	Baulkham Hills	GAZ
Public School	5-13 Russell Street	Baulkham Hills	Baulkham Hills	GAZ
Pye's Cottage	11 Pye Road	Northmead	Baulkham Hills	GAZ
Rockcliff	224 North Rocks Road	North Rocks	Baulkham Hills	GAZ
Rose Park	Post Office Road	Cattai	Baulkham Hills	GAZ
Rosenfels	23 Glenhaven Road	Glenhaven	Baulkham Hills	GAZ
Roughley House The Pines	656 Old Northern Road	Dural	Baulkham Hills	GAZ
Rouse Hill Public School	Windsor Road	Rouse Hill	Baulkham Hills	GAZ
Rumery Homestead	13 Windsor Road	Box Hill	Baulkham Hills	GAZ
Slab Hut	Mile End Road	Rouse Hill	Baulkham Hills	GAZ
Speedwell	68 Pitt Town Road	Kenthurst	Baulkham Hills	GAZ
St Gabriel's	190 Old Northern Road	Castle Hill	Baulkham Hills	GAZ
St Madeleine Sophie Barat Roman Catholic Church (former)	Kenthurst Road	Kenthurst	Baulkham Hills	GAZ
St Mary's Magdalene Anglican Church	River Road	Wisemans Ferry	Baulkham Hills	GAZ
St Michael's Roman Catholic Church (former)	Windsor Road	Baulkham Hills	Baulkham Hills	GAZ
St Paul's Cemetery	245 Old Northern Road	Castle Hill	Baulkham Hills	GAZ

Stonehouse Grove	Wisemans Ferry Road	Cattai	Baulkham Hills	GAZ
Stoneleigh	570 Pennant Hills Road	West Pennant Hills	Baulkham Hills	GAZ
Terry Mount house	Wisemans Ferry Road	Cattai	Baulkham Hills	GAZ
The Parsonage	210 Old Northern Road	Castle Hill	Baulkham Hills	GAZ
The Parsonage	Mud Island Road	Sackville	Baulkham Hills	GAZ
The Pines - House, outbuildings & pine trees	153 Windsor Road	Northmead	Baulkham Hills	GAZ
Thornbury lodge	38 Seven Hills Road	Baulkham Hills	Baulkham Hills	GAZ
Uniting Church	River Road	Lower Portland	Baulkham Hills	GAZ
Uniting Church and Cemetery	Mud Island Road	Sackville	Baulkham Hills	GAZ
Wansbrough House	226-230 Old Northern Road	Castle Hill	Baulkham Hills	GAZ
Wellgate	Withers Road	Kellyville	Baulkham Hills	GAZ
William Daley's Grave	Post Office Road	Cattai	Baulkham Hills	GAZ

There were 115 records matching your search criteria.

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Statutory Listed Items

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Item Name	Address	Suburb	LGA	State Heritage Register
Bungarribee Homestead Complex - Archaeological Site	Doonside Road	Doonside	Blacktown City	Yes
Clydesdale - Grand House, Barn & Cottage	Richmond Road	Marsden Park	Blacktown City	Yes
Dayton House	37-39 Roger Place	Seven Hills	Blacktown City	Yes
Exeter Farm	Meurants Lane	Parklea	Blacktown City	Yes
Government Depot Site (former)	Dunsmore Street	Rooty Hill	Blacktown City	Yes
Grantham Poultry Research Station (former)	71 Seven Hills Road	Seven Hills	Blacktown City	Yes
Hunting Lodge (former)	The Water Lane	Rouse Hill	Blacktown City	Yes
Imperial Hotel	Rooty Hill Road	Rooty Hill	Blacktown City	Yes
Merriville House & Gardens	Vinegar Hill Road	Kellyville	Blacktown City	Yes
Mount Druitt Railway Station group	Great Western Railway	Mount Druitt	Blacktown City	Yes
Neoblie	Great Western Hwy	Mount Druitt	Blacktown City	Yes
Prospect Post Office (former)	23 Tarlington Place	Prospect	Blacktown City	Yes
Prospect Reservoir & surrounding area	Reservoir Road	Prospect	Blacktown City	Yes
Prospect Reservoir Valve House	East Of Reservoir	Prospect	Blacktown City	Yes
Riverstone Railway Station and yard group	Blacktown-Richmond railway	Riverstone	Blacktown City	Yes
Rouse Hill House	Windsor Road	Rouse Hill	Blacktown City	Yes
Royal Cricketers Arms Inn	385 Reservoir Road	Prospect	Blacktown City	Yes
Seven Hills rail underbidge	Great Western Railway	Seven Hills	Blacktown City	Yes

Seven Hills Railway Station group	Great Western Railway	Seven Hills	Blacktown City	Yes
St Andrew's Anglican Church, Hall & Rectory	313 Seven Hills Road North	Seven Hills	Blacktown City	Yes
St Bartholomew's Anglican Church & Cemetery	Ponds Road	Prospect	Blacktown City	Yes
The Manse	The Avenue	Mount Druitt	Blacktown City	Yes
Upper Canal System	From Prospect to Wollondilly		Wollondilly	Yes
Veteran Hall - House Remains	Great Western Highway	Prospect	Blacktown City	Yes

Item Name	Address	Suburb	LGA	Information Source
Battle of Vinegar Hill Memorial Site	Windsor Road	Kellyville	Blacktown City	GAZ
Burn's House	Mount Druitt Road	Mount Druitt	Blacktown City	GAZ
Colyton Public School	Nelson Street	Mount Druitt	Blacktown City	GAZ
Community Services Geriatric Day Care Centre	Luxford Road	Mount Druitt	Blacktown City	GAZ
Cottage	Garfield Road West	Marsden Park	Blacktown City	GAZ
Cottage	Rooty Hill Rd Nth	Plumpton	Blacktown City	GAZ
Cottage	Garfield Road East	Riverstone	Blacktown City	GAZ
Farmhouse	Seven Hills Rd Sth	Seven Hills	Blacktown City	GAZ
Farmhouse	Riverstone Road	Riverstone	Blacktown City	GAZ
Gate Keepers Lodge	Mount Druitt Road	Mount Druitt	Blacktown City	GAZ
Glenwood Park Dairy	Sunnyholt Road	Parklea	Blacktown City	GAZ
Headmaster's Residence	Rooty Hill Road North	Plumpton	Blacktown City	GAZ
Hebe Farm	Bridge Street	Riverstone	Blacktown City	GAZ
House	Redgate Farm Road	Riverstone	Blacktown City	GAZ
House	First Avenue	Seven Hills	Blacktown City	GAZ
House	Tarlington Place	Prospect	Blacktown City	GAZ
House	Ropes Creek Road	Mount Druitt	Blacktown City	GAZ
House	Riverstone Road	Riverstone	Blacktown City	GAZ
House	Bourke Street	Riverstone	Blacktown City	GAZ
House Alroy	Rooty Hill Rd North	Plumpton	Blacktown City	GAZ
House Belvedere	Rooty Hill Rd South	Rooty Hill	Blacktown City	GAZ
House Ellalong	Lindsay Place	Doonside	Blacktown City	GAZ

House in grounds of item		Seven Hills	Blacktown City	GAZ
House Nu Welwyn	Clarke Street	Riverstone	Blacktown City	GAZ
House The Oaks	Hanna Place	Oakhurst	Blacktown City	GAZ
House Watts Cottage	Watt Street	Rooty Hill	Blacktown City	GAZ
House Woodstock	Hobson Place	Plumpton	Blacktown City	GAZ
Item	Old Western Road	Prospect	Blacktown City	GAZ
Item	Old Western Road	Prospect	Blacktown City	GAZ
Item	Flushcombe Road	Prospect	Blacktown City	GAZ
Item	Augusta Street	Prospect	Blacktown City	GAZ
Item	Great Western Hwy	Eastern Creek	Blacktown City	GAZ
Item 1368 House south of Cook & Rooty Hill Road Nth		Plumpton	Blacktown City	GAZ
Malmo	Luxford Road	Mount Druitt	Blacktown City	GAZ
Masonic Hall	Garfield Road East	Riverstone	Blacktown City	GAZ
Meadows Public School incl Original Building	Fuller Street	Seven Hills	Blacktown City	GAZ
Minchinbury Cellars & Row of Olive Trees	Great Western Hwy	Minchinbury	Blacktown City	GAZ
Mount Druitt Child Care Centre	Luxford Road	Mount Druitt	Blacktown City	GAZ
Mount Druitt Hall	Mount Druitt Road	Mount Druitt	Blacktown City	GAZ
Mount Druitt Youth Resource Centre	Mt Druitt Place	Blacktown	Blacktown City	GAZ
Native Institution Centre - Blacktown Site	Richmond Road	Plumpton	Blacktown City	GAZ
New Tribes Mission	Rooty Hill Road Nth	Plumpton	Blacktown City	GAZ
Original School Buildings Primary School	Flushcombe Road	Blacktown	Blacktown City	GAZ
Plumpton Public School	Rooty Hill Rd North	Plumpton	Blacktown City	GAZ
Redgate	Farm Road	Riverstone	Blacktown City	GAZ
Riverstone Railway Station Group	Riverstone Parade	Riverstone	Blacktown City	GAZ
Rosebank	Garfield Road East	Riverstone	Blacktown City	GAZ
Rouse Hill House Garden	Windsor Road	Rouse Hill	Blacktown City	GAZ
School of Arts	Rooty Hill Road South	Rooty Hill	Blacktown City	GAZ
Shop	Garfield Road West	Riverstone	Blacktown City	GAZ
Slab cottage between Grange & Richmond	South Street	Marsden Park	Blacktown City	GAZ
St Andrew's Uniting Church	Richmond Road	Marsden Park	Blacktown City	GAZ

St Anthony's Roman Catholic Church	Bowmans Road	Kings Park	Blacktown City	GAZ
Stationmaster's residence	Mount Druitt Road	Mount Druitt	Blacktown City	GAZ
Sydney Water Supply Upper Canal	Reservoir Road	Prospect	Blacktown City	GAZ
Unnamed farmhouse	Seven Hills Rd Sth	Seven Hills	Blacktown City	GAZ
Veteran Hall remains & site	Reservoir Road	Prospect	Blacktown City	GAZ

There were 81 records matching your search criteria.

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Item Name	Address	Suburb	LGA	State Heritage Register
Bonnyrigg House	Cartwright Street	Bonnyrigg	Fairfield City	Yes
Fairfield Railway Station group	Great Southern Railway	Fairfield	Fairfield City	Yes
Horsley House Homestead	52-58 Jamieson Close	Horsley Park	Fairfield City	Yes
Land Next to Male Orphan School	Lot 1 Cartwright St	Bonnyrigg	Fairfield City	Yes
Lansdowne Bridge	Hume Highway-SH No 2	Lansvale	Fairfield City	Yes
Villawood Railway Station group	Regents Park-Cabramatta railway	Villawood	Fairfield City	Yes

Item Name	Address	Suburb	LGA	Information Source
Bandstand Cabravale Park	Railway Parade	Cabramatta	Fairfield City	GAZ
Blands Oak Oakdene Park	Bland Street	Fairfield	Fairfield City	GAZ
Bossley Park Public School	Marconi Road	Bossley Park	Fairfield City	GAZ
Brick Federation House	716 The Horsley Drive	Smithfield	Fairfield City	GAZ
Brick Railway Building	Railway Parade	Cabramatta	Fairfield City	GAZ
Bridge	Cross Street	Guildford	Fairfield City	GAZ
Bunya Pine Tree nth-west corner	The Horsley Drive	Horsley Park	Fairfield City	GAZ
Bunya Pines ridgetop	Victoria Street	Cabramatta West	Fairfield City	GAZ
Cabramatta Civic Hall	165-178 Railway Parade	Canley Vale	Fairfield City	GAZ
Carramar Station	Wattle Avenue	Carramar	Fairfield City	GAZ
Christ Church Anglican Church and Trees	130 Orchardleigh Street	Old Guildford	Fairfield City	GAZ

Church	Justin Street	Smithfield	Fairfield City	GAZ
Church	136 John Street	Cabramatta	Fairfield City	GAZ
Church	7 Bowden Street	Cabramatta West	Fairfield City	GAZ
Church	103 Cabramatta Road East	Cabramatta	Fairfield City	GAZ
City Farm	Darling Street	Abbotsbury	Fairfield City	GAZ
Corner Shop	2 Canley Vale Road	Canley Vale	Fairfield City	GAZ
Crane	The Crescent	Fairfield	Fairfield City	GAZ
Ettinger House	214 Sackville Street	Canley Vale	Fairfield City	GAZ
Fairfield Showground, grandstand & trees	Smithfield Road	Prairiewood	Fairfield City	GAZ
Fairfield Station	The Crescent	Fairfield	Fairfield City	GAZ
Federation Cottage	26,28,30 Frederick Street	Fairfield	Fairfield City	GAZ
Federation Cottage	2 Kay Street	Guildford	Fairfield City	GAZ
Federation Cottage	23 Lawson Street	Fairfield	Fairfield City	GAZ
Federation Cottage	16 North Street	Fairfield	Fairfield City	GAZ
Federation House	59 Hamilton Road	Fairfield	Fairfield City	GAZ
Federation House	9 Hawkesbury Street	Fairfield West	Fairfield City	GAZ
Federation House	7 Haughton Street	Fairfield	Fairfield City	GAZ
Federation House	63 Hamilton Road	Fairfield	Fairfield City	GAZ
Federation House	40 Frederick Street	Fairfield	Fairfield City	GAZ
Federation House	18 Cunninghame Street	Fairfield	Fairfield City	GAZ
Federation House	322 Canley Vale Road	Canley Heights	Fairfield City	GAZ
Federation House	87 Thorney Road	Fairfield West	Fairfield City	GAZ
Federation House	91 Corinda Street	St Johns Park	Fairfield City	GAZ
Federation House and garden	13 Prout Street	Cabramatta	Fairfield City	GAZ
Federation Worker's Cottage	132 Broomfield Street	Cabramatta	Fairfield City	GAZ
Federation Worker's Cottage	62 Campbell Street	Fairfield	Fairfield City	GAZ
Fire Station	1-3 William Street	Fairfield	Fairfield City	GAZ
Forest of Spotted Gums	Chandos Road	Horsley Park	Fairfield City	GAZ
Georgian House	43 Stimson Street	Guildford	Fairfield City	GAZ
Georgian House	10 Rosedale Street	Canley Heights	Fairfield City	GAZ

-		Heights	City	
Georgian House	24 Shackel Avenue	Old Guildford	Fairfield City	GAZ
Hoop Pine	Alick Street	Cabramatta West	Fairfield City	GAZ
Hoop Pines	Trivett Street	Wetherill Park	Fairfield City	GAZ
Horse Water Trough opposite Hughes Street	Railway Parade	Cabramatta	Fairfield City	GAZ
House	5 Waratah Street	Old Guildford	Fairfield City	GAZ
Indigenous Flora	Moonlight Street	Prairiewood	Fairfield City	GAZ
Inter-War Bungalow	11 Hunter Street	Fairfield	Fairfield City	GAZ
Inter-War Bungalow	452 The Horsley Drive	Fairfield	Fairfield City	GAZ
Inter-War Bungalow	118 Nelson Street	Fairfield	Fairfield City	GAZ
Inter-War Bungalow	10 Riverview Road	Fairfield	Fairfield City	GAZ
Inter-War House	16 Granville Street	Fairfield	Fairfield City	GAZ
Inter-War House	43 Myddleton Avenue	Fairfield	Fairfield City	GAZ
Inter-War Houses	Artie Street	Fairfield	Fairfield City	GAZ
Inter-War Spanish Mission House	Warana Road	Cecil Park	Fairfield City	GAZ
Kaluna Cellars	Kaluna Avenue	Smithfield	Fairfield City	GAZ
Male Orphan School Bonnyrigg House	Cartwright Street	Bonnyrigg	Fairfield City	GAZ
Mid Victorian Church	704 The Horsley Drive	Smithfield	Fairfield City	GAZ
Milestone Lansdowne Road & Hollywood Drive Sth	Hume Highway	Lansvale	Fairfield City	GAZ
Museum Collection	632 The Horsley Drive	Smithfield	Fairfield City	GAZ
Oak and Peppercorn Tree	275 River Avenue	Carramar	Fairfield City	GAZ
Oak tree	12 Bowden Street	Cabramatta West	Fairfield City	GAZ
Oak Tree nature strip	1 Matthews Street	Fairfield	Fairfield City	GAZ
Pailau Gateway south end	Park Road	Cabramatta	Fairfield City	GAZ
Public School	Smart Street	Fairfield	Fairfield City	GAZ
Railway Bridge	Sandal Crescent	Carramar	Fairfield City	GAZ
Railway Viaduct	Fairfield Street	Fairfield	Fairfield City	GAZ
Railway Viaduct Cabramatta Creek	Railway Parade	Cabramatta	Fairfield City	GAZ
Railway Viaduct Stuart & Canley Vale Road	Railway Parade	Canley Vale	Fairfield City	GAZ
Red Gums Cabramatta Golf Course	Cabramatta Road West	Cabramatta West	Fairfield City	GAZ
Relics of early homestead &	Elizabeth Drive	Abbotsbury	Fairfield	GAZ

exotic vegetation	Elizabeth Drive	Abbotsbury	City	GAZ
Remnants of Abbotsbury House relic	Southdown Road	Horsley Park	Fairfield City	GAZ
School	Cabramatta Road East	Cabramatta	Fairfield City	GAZ
School of Arts	19 Harris Street	Fairfield	Fairfield City	GAZ
Site of Toll House and Gates	Hume Highway	Lansvale	Fairfield City	GAZ
Slab Cottage	76 Chifley Street	Smithfield	Fairfield City	HGA
Slab Hut - Museum	632 The Horsley Drive	Smithfield	Fairfield City	GAZ
Smithfield Cemetery	Dublin Street	Smithfield	Fairfield City	GAZ
Stone Pine Tree	320 Canley Vale Road	Canley Heights	Fairfield City	GAZ
Uniting Church & Hall	21-25 Harris Street	Fairfield	Fairfield City	GAZ
Uniting Church Cemetery	711 The Horsley Drive	Smithfield	Fairfield City	GAZ
Victorian Church	269 Canley Vale Road	Canley Heights	Fairfield City	GAZ
Victorian Cottage	542 The Horsley Drive	Fairfield	Fairfield City	GAZ
Victorian Cottage	65 Sackville Street	Canley Vale	Fairfield City	GAZ
Victorian House	1 Kay Street	Guildford	Fairfield City	GAZ
Victorian House	1 Matthews Street	Fairfield	Fairfield City	GAZ
Victorian House	63 Station Street	Fairfield	Fairfield City	GAZ
Victorian House	1 Stuart Street	Canley Vale	Fairfield City	GAZ
Victorian House	63 Wolseley Street	Fairfield	Fairfield City	GAZ
Victorian House	11 Melbourne Road	St Johns Park	Fairfield City	GAZ
Victorian House	161 Polding Street	Fairfield	Fairfield City	GAZ
Victorian Museum Building	632 The Horsley Drive	Smithfield	Fairfield City	GAZ
Victorian/Federation Cottage	94 Canley Vale Road	Canley Vale	Fairfield City	GAZ
Victorian/Georgian Cottage	45 Chifley Street	Smithfield	Fairfield City	GAZ
Victorian/Georgian House	8 Megan Avenue	Smithfield	Fairfield City	GAZ
Villawood Railway Station	Villawood Road	Villawood	Fairfield City	GAZ
Von Heiden Gardens	Haughton Street	Fairfield	Fairfield City	GAZ
Westacott Victorian Cottage	110 Railway Parade	Canley Vale	Fairfield City	GAZ

There were 104 records matching your search criteria.

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WESTERN SYDNEY ORBITAL EIS: ABORIGINAL ARCHAEOLOGICAL INVESTIGATIONS, HOXTON PARK - HORSLEY PARK: A SUPPLEMENTARY REPORT

A report to
NSW Roads & Traffic Authority

Report prepared for:
Robynne Mills Archaeological & Heritage Services
60 Watkins Street
Newtown NSW 2042

A report by
Central West Archaeological & Heritage Services Pty Ltd
92 Darling Street, Cowra NSW 2794
&
Lot 4, Powerline Road, McPhersons Plains
Via Tumbaruma NSW 2653

September 2001

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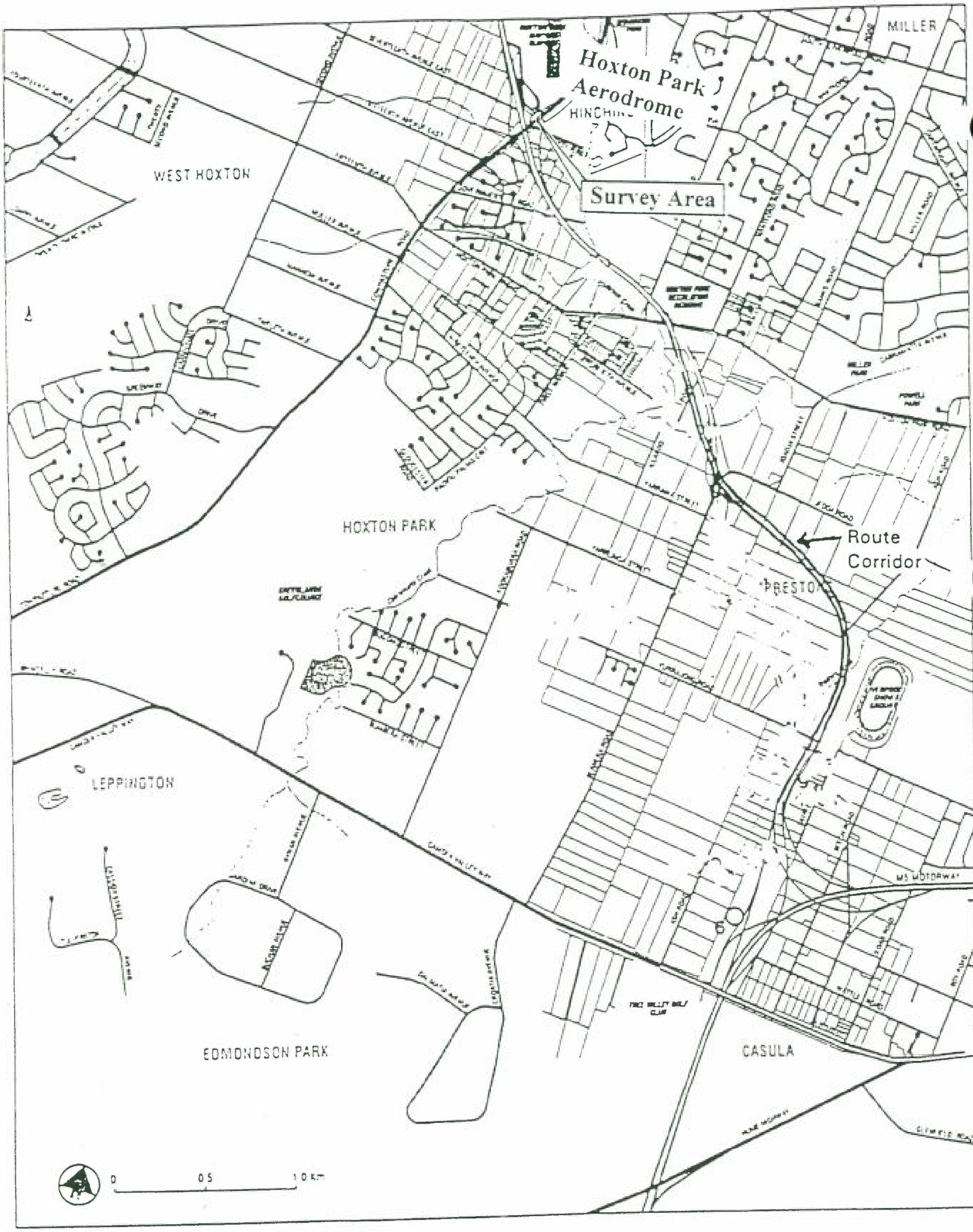


Legend:

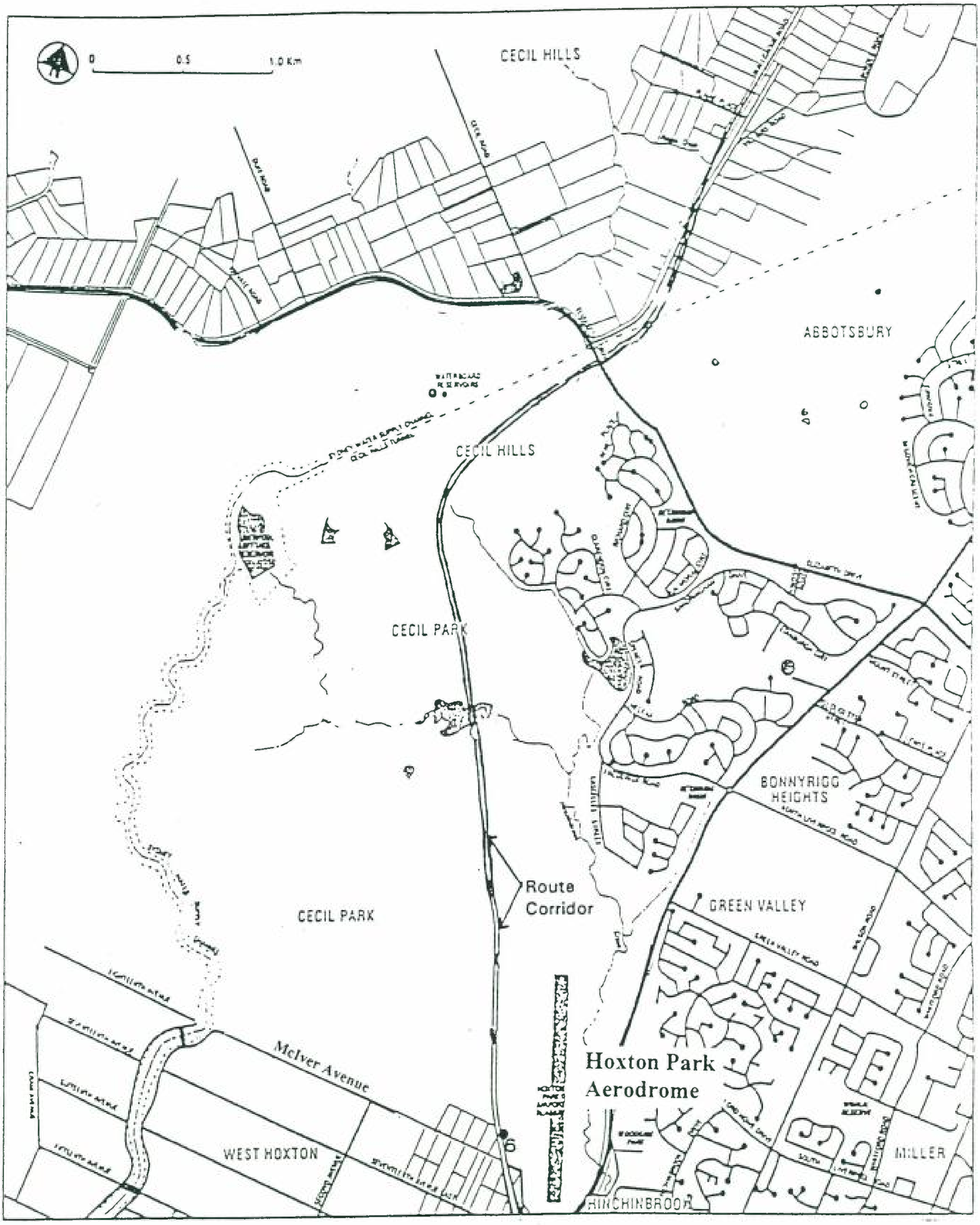
Survey Area

Proposed Orbital Route

Figure 1a

Survey Area Locality Map Hoxton Park Aerodrome

(Map: Brayshaw & White 1999)



Legend:

Survey Area

Proposed Orbital Route

Figure 1b

Survey Area Locality Map
McIver Avenue (Hoxton Park)
(Map: Brayshaw & White 1999)

Legend:

Survey Area

Proposed Orbital Route

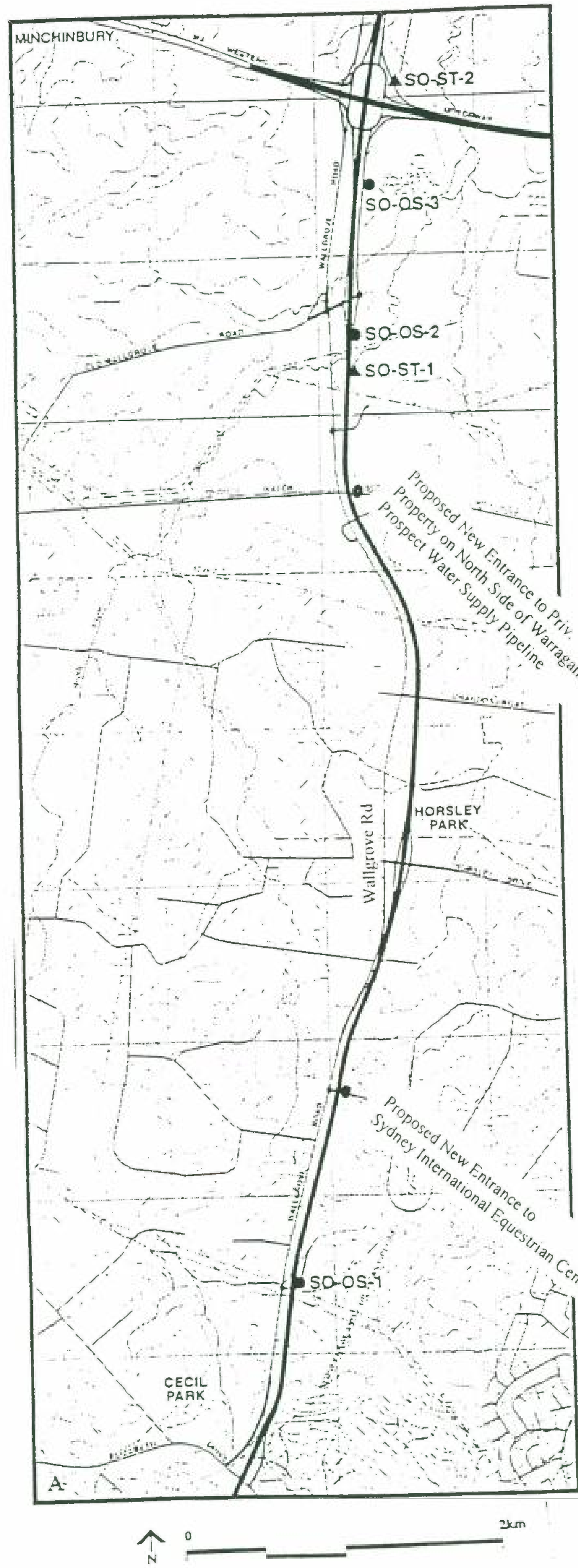


Figure 1c

Survey Area Locality Map
Sydney Equestrian Centre -
Warragamba - Prospect Water Supply Pipeline
(Map: Mills 1996)

WESTERN SYDNEY ORBITAL EIS: ABORIGINAL ARCHAEOLOGICAL INVESTIGATIONS - HOXTON PARK TO HORSLEY PARK: A SUPPLEMENTARY REPORT

1.0 INTRODUCTION

The Roads and Traffic Authority (RTA) proposes to construct a new arterial road, known as the Western Sydney Orbital ('the orbital'), which will skirt Sydney's western suburbs from Prestons in the south to Baulkham Hills in the north (**Figure 1**).

The proposal was the subject of an environmental impact statement (EIS) produced for the RTA by Sinclair Knight Merz Pty Ltd and PPK Environment & Infrastructure Pty Ltd. The EIS was released in January 2001. Mills (1996,2001) and Brayshaw & White (1999) were commissioned to conduct, as components of the EIS, specialist Aboriginal archaeological heritage assessments over two separate sections, covering the entire proposed route.

However, since completion of the EIS the RTA has identified a number of modifications to the original (2001) orbital design. The proposed modifications occur within three separate geographic precincts along the orbital route. The following report is an archaeological assessment of the first of the three precincts.

Robynne Mills Archaeological & Heritage Services, Newtown, was commissioned by the RTA to conduct an Aboriginal archaeological heritage impact assessment of the four proposed orbital modifications situated within the first RTA identified precinct, between Hoxton Park and Horsley Park. The field survey of the proposed changes to the original design was conducted by Robynne Mills and Jim Kelton on 20th - 21st August 2001.

The following report is intended as an addendum to the comprehensive archaeological studies "Archaeological Survey of the Proposed Western Sydney Orbital from West Baulkham Hills to Cecil Park" (Mills 1996), "A Heritage Study For The Proposed Realignment of The Western Sydney Orbital Route at Cecil Hills" (Mills 2001) and "Western Sydney Orbital EIS Prestons to Cecil Park Aboriginal Archaeology" (Brayshaw & White 1999). The current report should be read in conjunction with and reference to the Mills' and Brayshaw & White reports.

This report provides, in summary form, details of the local environment and the known archaeology of the survey area, as well as documenting survey methods and results.

The locations of the identified changes to the orbital plan will be referred to in the report as the *'survey area'* whilst the broader area including and immediately surrounding the survey area, within approximately 2km radius, will be referred to as the '*study area*'.

The proposed modifications to the orbital have the potential to disturb or destroy Aboriginal archaeological relics and sites located within the identified survey area, as any earthworks or clearing of old-growth native timber associated with the proposed development has the potential to disturb archaeological deposits occurring as surface or sub-surface deposits.

1.1 Associated Orbital Reports

This report is a supplementary report on a number of proposed modifications to the recently released orbital EIS, and it is intended that it be read as an addendum to the two previous archaeological reports (i.e. Mills 1996,2001 and Brayshaw & White 1999). The reports by Mills and Brayshaw & White are comprehensive in the detail they provide on the archaeological and environmental backgrounds of their relevant study areas (i.e. sections of the proposed orbital to which they apply). For this reason, and because the proposed modifications are relatively minor in nature and either overlap previously surveyed areas or are located immediately adjacent to previously surveyed sections, the consultant has decided not to reproduce the extensive details of environment and archaeological background. Instead, summary descriptive tables of specific supplementary report survey area locations are provided and, where appropriate, these will be accompanied by references to specific sections of the Mills and Brayshaw & White reports.

Locations identified in the report by RTA numbers 3 and 4 occur within Brayshaw & White's (1999) survey area and the consultant recommends that reference should be made to the relevant sections of the Brayshaw & White report for more comprehensive details on the environmental context and known archaeology of each locality. Similarly, reference should be made to the relevant sections of Mills' (1996) report to obtain the same levels of detail in relation to RTA location numbers 8 and 11.

1.2 Client's Brief

The RTA brief to the consultants was in table form and identified 4 separate modifications to the original orbital route between Hoxton Park in the south and Horsley Park in the north, requiring assessment for their potential to contain Aboriginal archaeological relics. The report writing brief required that the consultant's report include the location, identification and significance assessment of any Aboriginal archaeological relics detected within the bounds of the proposed orbital modifications (*'relics'* as defined in the NPW Act 1974). The consultant's report was also to include appropriate management strategies for all additional Aboriginal relics identified during the field survey.

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Executive Summary
The Roads and Traffic Authority (RTA) has identified a number of modifications it wishes to implement to the originally identified route of the Western Sydney Orbital ('the orbital'). This report covers all proposed modifications requiring archaeological assessment located between Hoxton Park Aerodrome and the northern side of the Warragamba - Prospect Water Supply Pipeline on Wallgrove Road, Horsley Park (see **Figure 1**).

Mills (1996,2001) and Brayshaw & White (1999) were commissioned by the RTA to conduct independent specialist archaeological studies of the original orbital proposal to assess the potential for the proposed development to impact Aboriginal archaeological heritage. Mills' (1996,2001) study areas were along the proposed orbital route north of Elizabeth Drive, Cecil Hills, to the junction with the M5 motorway at Baulkham Hills. The section of the route assessed by Brayshaw & White (1999) was from south of the Elizabeth Drive - Wallgrove Road intersection, Cecil Hills, to the M5 motorway at Prestons.

Jim Kelton of Central West Archaeological & Heritage Services Pty Ltd was engaged by Robynne Mills Archaeological & Heritage Services Pty Ltd to produce the archaeological report on the proposed orbital alignment modifications and assist in the supplementary field survey of the proposed modifications. This report is intended as an addendum to the Mills (1996) and Brayshaw & White (1999) reports.

Field Survey
The supplementary archaeological field survey for the Western Sydney Orbital project was carried out by consulting archaeologists Robynne Mills and Jim Kelton over two days, 20th - 21st August 2001. Coverage was on-foot and intensive over all identified locations.

Aboriginal Community Consultation & Involvement
All relevant local Aboriginal groups have been consulted with regard to the original EIS proposal and the proposed modifications to that proposal. Following discussions with the RTA's Aboriginal Liaison Officer, Ms Suzanne Malligan, it was agreed that Deerubbin and Gandangara Local Aboriginal Land Councils would be the primary contact groups for the supplementary field investigations.

Whilst Deerubbin LALC was able to provide a field survey representative (Mr Steven Randall) during the supplementary field survey within that LALC's area of administration, due to prior commitments Gandangara LALC was unable to provide a representative. It was agreed with Gandangara LALC that, as an alternative, they would be provided, as would all other relevant Aboriginal groups, with copies of the results of the supplementary field survey for comment.

There have been no concerns raised by Aboriginal groups in relation to the proposed modifications to the orbital design (Mills, pers. coms. 12/9/2001).

Field Survey Results

Almost all of the identified supplementary survey areas were located within existing highly disturbed road easements / corridors. Those which weren't located within existing road corridors occurred over highly disturbed locations situated immediately adjacent to road corridors (see **Figure 1**). Whilst several of the identified locations occur upon landforms considered to be archaeologically sensitive, disturbance has been so great at these locations than any archaeological potential has long since been obliterated by past road construction and urban development (see **Section 4**).

There were no Aboriginal relics ('sites') identified during the field survey within the areas affected by the proposed design modifications and, although a number of Aboriginal sites have been recorded during previous investigations in the vicinity of the current survey area, one of which is located within 250m of the proposed modifications, none of the sites are threatened with development related impact (see **Section 4** and **Figure 2**).

Conclusions

Based upon the results of the supplementary field survey, the searches of the NPWS Aboriginal site database and following consultation with the relevant Aboriginal organisations the consultants believe that, from an Aboriginal heritage perspective, there should be no reason why the proposed modifications to the planned orbital alignment should not proceed.

1.3 Aims of the Investigation

The aim of the study was to assess the potential impact upon Aboriginal archaeological relics (including individual isolated artefacts, collections of artefacts and places of significance, generally referred to as 'sites') of the modifications to the original orbital proposal. An assessment of site significance and the development of management recommendations was to be carried out based upon the results of the field survey, supplemented by the results of searches of the relevant indigenous and non-indigenous heritage databases. The field investigation focused upon the location and documentation of archaeological relics, as well as determining the potential for additional relics to occur (i.e. as undetected surface or sub-surface deposits). All work was to be conducted under NPWS field survey guidelines and within the provisions of the NSW NPW Act (1974). Because the report is supplementary to and intended as an addendum to the Mills (1996,2001) and Brayshaw & White (1999) reports it will not follow exactly the NPWS report writing guidelines. However, the guidelines have still been used as a basis for the report format.

1.4 Aboriginal Community Consultation (see Appendix 1)

The survey area occurs within the Deerubbin and Gandangara Local Aboriginal Land Council (LALC) areas of administration. In addition, two other Aboriginal organisations have indicated that they have an interest in the management of Aboriginal heritage within the vicinity of the Deerubbin LALC section of the survey area. They consist of Darug Tribal Aboriginal Corporation and Darug Custodian Aboriginal Corporation. All groups were consulted with prior to and upon completion of the field survey.

All relevant Aboriginal groups were consulted with extensively by Mills (1996:6) and Brayshaw & White (1999:25) during the initial field surveys along the original proposed orbital route. The proposed modifications to the orbital alignment are extremely limited in their total area and generally occur within very close proximity to the originally surveyed orbital route. Therefore it is not expected that there would be any significant changes in the views of the relevant Aboriginal groups towards the proposed modifications. However, as a matter of courtesy Aboriginal community consultation still occurred in relation to the proposed modifications regardless of their limited scale.

Following discussions with Ms Suzanne Malligan, the appointed RTA Aboriginal Liaison Officer (Mills, pers. coms. 2001), it was agreed that Deerubbin and Gandangara LALCs would be the primary contact groups for the field survey and that each organisation would be invited to provide representation during the field survey within their respective land council boundaries. Deerubbin LALC was represented in the field during the field survey by Mr Steven Randall. Gandangara LALC was unable to provide a representative to attend the field survey due to prior commitments but indicated (Fletcher, pers. coms. 2001) that it was happy to be informed of the field survey results, once completed. The LALC requested that it be given the opportunity to comment upon the field results and the proposed changes to the original orbital design (should they feel it was appropriate to do so). All interested Aboriginal groups have been notified of the results of the survey.

The Deerubbin and Gandangara LALCs were also requested to provide details of the locations of any sites or other 'places of significance' in the survey area or within the immediate vicinity which may be known to the local Aboriginal community. This request was made so that sites or places of significance known to the local community but which may not occur on the NPWS Aboriginal site database could be accommodated within an appropriate management framework. The LALCs were also asked to be prepared to submit a site significance statement (Mills, pers. coms. 2001), in the event that Aboriginal sites should be found.

Discussions carried out in the field with the Deerubbin LALC representative, Steve Randall, indicated that he could see no problems with the proposed orbital modifications proceeding providing that no Aboriginal site or PAD area was threatened with development related impact (Randall, pers. coms. 21/8/2001).

Whilst an assurance has been received from the LALC that a copy of Deerubbin LALC's 'statement of involvement' in the field survey would be forthcoming, at the time of the submission of this report it had not been received. A copy of the LALC statement will be forwarded, upon receipt, to the RTA for inclusion in **Appendix 1**.

Subsequent discussion with a representative of Gandangara LALC over the results of the field survey has indicted that the LALC has no concerns over the proposed modifications proceeding (Mills, pers. coms. 12/9/2001). Copies of relevant sections of the draft report were sent to the LALCs and other interested Aboriginal groups for comment and a copy of this final report will be sent to each organisation for their records.

2.0 THE MODIFICATIONS

The RTA brief finally identified four minor modifications to the orbital design requiring archaeological assessment within the Hoxton Park - Horsley Park study area precinct (see **Figure 1**). Although not previously assessed, the identified locations are directly associated with the orbital and are located either partially within or immediately adjacent to the original archaeologically assessed orbital corridor.

The following table is a summary description of the proposed EIS modifications.

Table 1
Proposed EIS Modifications Requiring Archaeological Assessment

RTA Proposal No. / Location	Map Ref. / Approx. AMG Co-ords	Description of Proposal	LALC Area of Administration	Approx. Survey Area / Dimensions (excluding existing road surfaces & shoulders)
3. Hoxton Park Aerodrome	Liverpool 9030-11-S, 1:25 000 topo 301400E 6243100N	Relocate access to Hoxton Park Aerodrome	Gandangara LALC	0.05ha (50m x 10m)
4. McIver Ave, West Hoxton	Liverpool 9030-11-S, 1:25 000 topo 301000E 6245020N	Upgrade unformed section of McIver Ave at West Hoxton	Gandangara LALC	0.4ha (400m x 10m)
8. Sydney International Equestrian Centre, Sunset Hills	Prospect 9030-11-N, 1:25 000 topo 301000E 6251700N	Provide access to Sydney International Equestrian Centre from Saxony Road	Deerubbin LALC	1.12ha Comprising a narrow section parallel with orbital (on east side) est. 735m long < 25m wide and intersection on opposite, western side of orbital
11. Warragamba - Prospect Water Supply Pipeline, Wallgrove Rd, Horsley Park	Prospect 9030-11-N, 1:25 000 topo 301100E 6255350N	Raise & relocate orbital westwards at water supply pipelines & provide new access to nearby properties	Deerubbin LALC	0.69ha 3 connecting short sections totalling approx. 860m (averaging est. 10m width)
Total Survey Area				**2.26ha**

NSW Central Mapping Authority (Dept of Land & Water Conservation) 1:25.000 scale topographic map sheets used during the field survey consist of:

- Prospect 9030-11-N; and
- Liverpool 9030-11-S.

Additional maps were reproduced from the original Mills (1996) and Brayshaw & White (1999) reports.

2.1 Potential Impacts Upon The Archaeological Record

It is anticipated that the proposed modifications to the orbital EIS will involve but will not be limited to earthworks and vegetation clearing which will result in surface and sub-surface disturbance and the potential loss of remaining old-growth eucalyptus trees. As a result of these impacts, there is a potential to disturb previously undetected and often relatively unobtrusive surface and sub-surface archaeological deposits. The threat of development related impact to previously undetected Aboriginal relics from the proposed orbital modifications is considered in **Section 4** of the report.

Where suitable landforms occur, open campsites and scarred / carved tree sites are the main site types predicted to occur over the areas affected by the proposed modifications to the original proposal. Isolated artefact find sites may also be affected (see **Section 4.2**). However, due to the paucity of archaeologically sensitive landforms within the survey area, the potential for impact upon the archaeological record is considerably reduced. Where old-growth trees occur within the survey area, inspection for evidence of past Aboriginal scarring will determine the existence of such sites and the potential for impact.

3.0 ENVIRONMENTAL CONTEXT

For a more detailed and comprehensive description of the current survey area landscape reference should be made to Mills (1996:13-14) and Brayshaw & White (1999:5-14).

In the very broadest terms it is sufficient to say that the entire survey area occurs within a typical, although highly disturbed, Cumberland Plain soil and vegetative landscape. Landform descriptions in this report are based upon definitions provided in McDonald, et. al.(1998).

Generally, almost the entire survey area has been heavily disturbed as a consequence of past road and highway construction and their associated earthworks (e.g. see **Plates 1-6**), as well as by the considerable effects of urban development (e.g. **Plates 8-10**). In the few instances where the survey area occurs over normally archaeologically sensitive landform units such as the alluvial banks of perennial and ephemeral creeks, their associated terraces, and adjacent level plains, past disturbance was found to have been so great that any archaeological potential appears to have been totally obliterated (e.g. **Plate 3**).

The dominant survey area micro-landform units consist of undulating low hill slopes, rises and crests (> 80% of the survey area) (e.g. see **Plates 3&7**) followed by highly disturbed level plains (e.g. **Plate 1**). Alluvial creek banks and their associated terraces are relatively uncommon throughout the survey area, comprising less than 1% of the survey area (i.e. the only survey area creekline is a highly disturbed and poorly defined spring-fed creek adjacent to McIver Avenue, Hoxton Park) (see **Plate 3**).

The entire study area has been heavily impacted by the effects of European settlement and related land management practices including agriculture (e.g. **Plate 7**), rural housing, semi-rural housing (e.g. **Plate 5**), road construction and related drainage works (see **Plates 2-4**), above and below ground water supply pipeline construction and underground telecommunication cable laying.

Virtually the entire survey area has been cleared of all old-growth native timber (see **Plates 1,6&7**), although patches of regrowth eucalyptus trees were found along the road verges within the road corridor along the McIver Avenue - Hoxton Park Aerodrome section of the survey area (e.g. **Plates 2-5**).

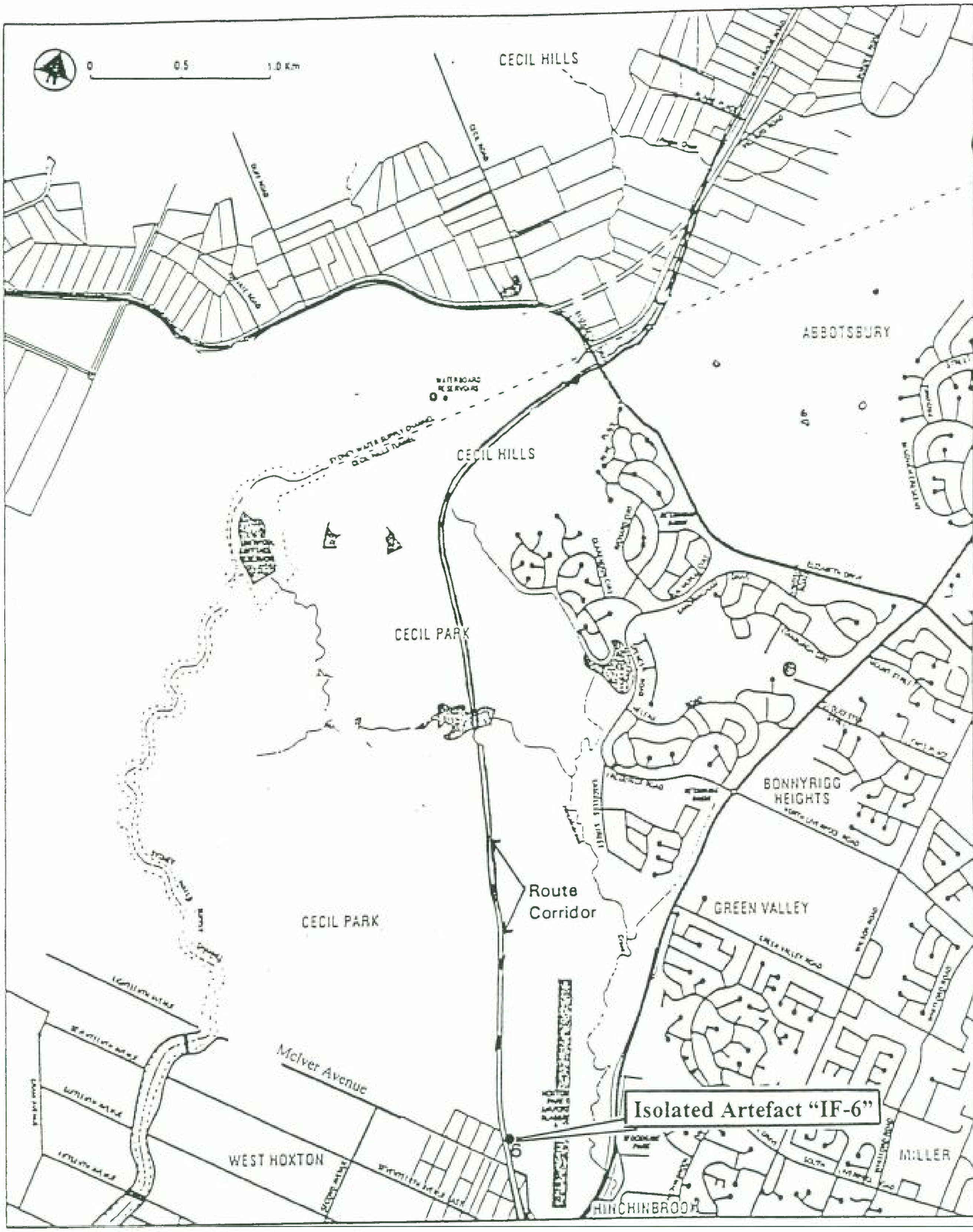
Table 2 identifies prevailing survey area landform, vegetation and surface visibility characteristics, etc. at the time of the field survey for all surveyed locations. The reader is reminded that more comprehensive detail on specific locations can be obtained from Mills (1996:13) and Brayshaw & White (1999:5).

Table 2
Survey Area Landscape Summary: Hoxton Park - Horsley Park
(refer to Mills 1996 and Brayshaw & White's 1999 report for more comprehensive detail)

RTA Proposal No. / Location	Map Ref. & Approx. AMG Co-ords	Proposed Modification	Proposed Modification Survey Area / Dimensions (approx.)	Landform / Micro-landform Unit	Geology	Vegetation	Surface Visibility (est.) (excluding existing road surfaces)	Surface Condition
3. Hoxton Park Aerodrome	Liverpool 9030-11-S, 1:25 000 topo 301400E 6243100N	Airport access to aerodrome to be configured off Cowpasture Road (partially within airport)	0.05ha (50m x 10m)	Level plain - colluvial terrace approx. 400m west of Hinchinbrook Creek	Bringelly Shales of the Wianamatta Group (Brayshaw & White 1999:5): Podsolic loam soils	Cleared of all native timber & extensively modified / replaced native understorey shrub/ grass species	100% along cleared road edges. < 20% along corridor & airport grounds - dense introduced grass cover	100% highly disturbed by airport earthworks - levelling & related topsoil removal
4. McIver Ave, West Hoxton	Liverpool 9030-11-S, 1:25 000 topo 301000E 6245020N	Upgrading unformed road to 2 sealed lanes to provide new access to properties at eastern end of McIver Ave	0.4ha (400m x 10m)	Slopes of a gently undulating - undulating rise > 600m west of Hinchinbrook Creek	As above	Partially cleared - road edges contain scattered, mainly regrowth grey box (Euc. sp.)	100% along road edges, av. < 50% along timbered verges between fenceline and road edges	30% of road verges suffered topsoil removed. Est 40%- 60% patches of bare earth along timbered verges

Table 2 (cont'd)
Survey Area Landscape Summary: Hoxton Park - Horsley Park
(refer to Mills' 1996 report for more comprehensive detail)

RTA Proposal No. / Location	Map Ref. & Approx. AMG Co-ords	Proposed Modification	Proposed Modification Survey Area / Dimensions (approx.)	Landform /Micro-landform Unit	Geology	Vegetation	Surface Visibility (est.) (excluding existing road surfaces)	Surface Condition
8. Sydney International Equestrian Centre, Sunset Hills	Prospect 9030-11-N, 1:25 000 topo 301000E 6251700N	Construct a new vehicle access to Sydney International Equestrian Centre via Saxony Rd. New internal access road to parallel orbital alignment	1.12ha Comprising a narrow section parallel with orbital (on eastern side)	Slopes & crests of undulating-rolling hills: nearest reliable natural water supply > 1km north (upper catchment of Eastern Creek0	Bringelly Shales of the Wianamatta Group Luddenham Soil Landscape - Podsolic loam soils	Cleared of all native timber & extensively modified / replaced native understorey with exotic shrub/ grass species	Av. < 20% over undulating hills where dense grass cover occurs	> 90% highly disturbed by intensive market gardening practices: remainder impacted by fencing and formed / graded vehicle access tracks
11. Warragamba - Prospect Water Supply Pipeline, Wallgrove Rd, Horsley Park	Prospect 9030-11-N, 1:25 000 topo 301100E 6255350N	Raise & relocate orbital westwards at water supply pipelines & provide new access to nearby properties	0.69ha 3 connecting short sections totalling approx. 860m (averaging est. 10m width)	Upper slopes & crests of undulating low hills: nearest water is Reedy Creek, est. 900m west	As above	As above	Av. est. 30% along road edges: < 10% either side of pipeline in vicinity of poultry farm complex	> 75% of surface highly disturbed by past road and water supply pipeline construction as well as poultry farm shed / complex construction



Legend:

Survey Area

Proposed Orbital Route

Figure 2

Known Aboriginal Site Locations Within 200m of McIver Ave (& Hoxton Parl Aerodrome) Survey Areas

(Map: Brayshaw & White 1999)

4.0 KNOWN ARCHAEOLOGY & PREDICTIVE MODELS

A comprehensive archaeological background for the study area, including the results of searches of the NPWS Aboriginal site database and report archives, is provided in the reports by Mills (1996,1998,2001) and Brayshaw & White (1999).

4.1 Heritage Database Searches

An updated search of the NPWS Aboriginal site database (supported by those conducted previously by Mills (1996,1998,2001) and Brayshaw & White (1999), confirmed that there are no known Aboriginal sites located within a 100m radius of the proposed modifications to the orbital alignment (see **Appendix 2**).

4.1.1 NPWS Report Archival Searches

Searches of the NPWS report archives and consultation with the relevant consultants have confirmed that two previous archaeological surveys have been conducted in the immediate vicinity of, and in at least one instance overlaps, sections of the current survey areas. The reports are by Mills (1996,2001) and Brayshaw & White (1999) who conducted the original orbital studies.

The closest known Aboriginal site to the current survey area is:

Isolated Artefact 'IF-6' (NPWS # 45-5-2474) (see Figure 2):
An isolated artefact recorded by Brayshaw & White (1999) during their investigation of the orbital route between Prestons and Cecil Park. The site was given the field name 'IF-6'.

According to Brayshaw & White's report (1999:35) the artefact was located in the grounds of Hoxton Park Aerodrome, approximately 250m north-east of the proposed upgrade of McIver Avenue (and approximately 30m north-east of the proposed orbital alignment), at approximate AMG co-ordinates 301260E 6245160N. As such, the site is not threatened with development related impact.

4.2 Aboriginal Site Prediction, Archaeological Sensitivity and Potential

Archaeological sensitivity is defined as the likelihood of an area of land to contain archaeological sites and does not necessarily reflect what is observed on the surface of an area at a given time. It is generally based upon an assessment of study area landforms and the known distribution of sites on landforms within a particular geographic region. ***Archaeological potential***, whilst related to archaeological sensitivity, should not be confused with sensitivity. The archaeological potential of a specific area of land, comprising a part of a particular study area landform or the entire study area / survey area landform, refers to the potential for sites to remain, bearing in mind the landform's archaeological sensitivity assessment. An area's assessed archaeological potential allows for a number of factors to be considered which relate to the preservation of sites. These may include 'natural' geomorphological processes such as erosion etc., as well as the effects of surface and sub-surface disturbance. Surface and sub-surface disturbance resulting mainly from non-Aboriginal occupation and settlement may contribute significantly to a reduced level of archaeological potential over an area, whilst not reducing the area's generally assessed level of sensitivity.

A summary of landform based archaeological sensitivity and potential is provided in **Table 3** in the report using a scale of High, Moderate or Low.

4.3 Archaeological Sensitivity Assessment

A range of Aboriginal archaeological sites have been recorded in the Cumberland Plain study area, and with a knowledge of these site types and their distribution across the landscape it is possible to develop a model of archaeological sensitivity for the survey area.

It is believed that the distribution of sites within the study area and environs will be subject to the same patterns and selection criteria which Mills (1996:14) and Brayshaw & White (1999:16) have identified in their predictive models for the Cumberland Plain study area (with reference also to previously developed models by Kohen (1986), Smith (1989a&b), McDonald (1992), Rich & McDonald (1995) and Mills (2001). Reference should be made to the above mentioned reports. **Table 3** is a summary of survey area sensitivity / potential assessment. Reference should be made to Mills (1996) and Brayshaw & White (1999) reports for assessment of study area landform sensitivity.

4.4 Aboriginal Site Prediction

Prior to commencement of the current field survey, a desk top assessment of the survey area landforms indicated that the site types which were most likely to occur within the survey area would be strongly influenced by the availability of water and the prevailing study area topography.

Based upon the above and upon site prediction models produced (and earlier models referred to) in Mills (1996,2001) and Brayshaw & White (1999) it was anticipated that the potential distribution of Aboriginal sites within the survey area would be dominated by campsites (i.e. open campsite-stone artefact scatters) of varying size and complexity. The greatest potential was considered to occur in close proximity to survey area creeklines.

Whilst Aboriginal scarred tree sites have been found over most Cumberland Plain micro-landform units where suitable old-growth native timber occurs, given the largely cleared nature of the survey area the potential for such sites to occur was considered to be extremely limited. The only survey area location which contained any old-growth native timber at all, and these occurred very sparsely (the location was dominated by regrowth vegetation), were along the verges of McIver Avenue, Hoxton Park (in the vicinity of Hoxton Park Aerodrome).

The potential for the occurrence of other less common Aboriginal site types within the survey area is more than adequately covered in the Mills (1996,2001) and Brayshaw & White (1999) reports.

Table 3
Survey Area Archaeological Sensitivity & Potential Assessment

RTA Proposal No. & Location	Current Vegetation & Micro-landform Units	Archaeological Sensitivity	Archaeological Potential
3. Hoxton Park Aerodrome	Cleared, level floodplain terrace approx. 400m west of Hinchinbrook Creek	Floodplain: Low due to vulnerability to flooding from Hinchinbrook Ck	Low: Due to past aerodrome construction / levelling & past vulnerability to flooding (prior to drainage works)
4. McIver Ave, West Hoxton	Regrowth timber: slopes of a gently undulating - undulating rise > 600m west of Hinchinbrook Creek Tributary of Hinchinbrook Ck: Creek & creek banks of a poorly defined, highly disturbed spring-fed creek passes alongside the location's eastern boundary	Slopes: Moderate Creek Banks: More elevated banks less vulnerable to flooding considered to be highly sensitive	Low: Any potential has been almost totally obliterated along the road edges / verges due to past road construction and drainage works
8. Sydney International Equestrian Centre, Sunset Hills	Cleared slopes & crests of undulating-rolling hills: nearest reliable natural water supply > 1km north (upper catchment of Eastern Creek)	Slopes & Crests: Moderate	Low: Due to history of intensive agriculture / horticulture, i.e. market gardening.
11. Warragamba - Prospect Water Supply Pipeline, Wallgrove Rd, Horsley Park	Cleared upper slopes & crests of undulating low hills: nearest water is Reedy Creek, est. 900m west	Slopes & Crests: Moderate	Low: Due to location's highly disturbed state, i.e. history of intensive horticulture, road & pipeline construction as well as poultry farm construction.

5.0 FIELD SURVEY METHODOLOGY & COVERAGE

All identified locations were inspected during the field survey for the presence of surface archaeological deposits. Each was also assessed for the potential to contain undetected sub-surface archaeological deposits (see **Table 3**).

5.1 Surface Visibility

The term 'surface visibility' in this report refers to the level of visible bare earth over a given area, and is expressed as a percentage of the total area. Impediments on the surface may obstruct surface visibility and therefore the observation of archaeological material. The main factor to affect surface visibility is vegetative cover, although features such as rock outcrops and other natural or man - made obstructions on the landscape can also affect surface visibility.

Surface visibility can be expressed as a percentage of the surface which is visible (Bonhomme 1986:11). **Table 4** is used in the report to provide a basis for surface visibility assessment.

Surface visibility during the current survey was generally moderate - high. The generally high level of surface visibility was due primarily to high levels of surface disturbance along all survey area road corridors, combined with generally sparse understorey (seasonal grass cover) at the time of the field survey. Highest levels of surface visibility occurred along the exposed road edges and verges (averaging 70% - 100%) (e.g. see **Plates 4&6**). Surface visibility encountered over survey area hillslopes and crests adjacent to existing road corridors (e.g. in the vicinity of the Western Sydney Regional Park & Equestrian Centre and at Hoxton Park Aerodrome) varied considerably but was estimated to range between 5% - 30%, depending upon grass cover at the time (e.g. see **Plates 1&7**).

Table 4
Guide to Surface Visibility Assessment

a.	Nil soil visibility	0 - 5%
b.	Occasional glimpses of sand / soil	5 - 20%
c.	Frequent patches of bare ground	20 - 50%
d.	Approx. 50% bare surface	50 - 75%
e.	> 75% bare surface	75 - 100%

Table 5
Summary of Survey Area Surface Visibility

RTA Proposal No. / Location	Total Area	Est. Average Surface Visibility (%)	Comments
3. Hoxton Park Aerodrome	0.05ha	<20%	Up to 20% vis. across cleared grass surface within aerodrome grounds. Higher (to 100%) where proposed works meet existing road surfaces
4. McIver Ave, West Hoxton	0.4ha	75%	Up to 100% along formed road edges, averaging between 50%-80% along adjacent road verges (in road corridor)
8. Sydney International Equestrian Centre, Sunset Hills	1.12ha	<20%	Very low where dense grass cover occurs particularly along furrowed (disused market garden) surfaces
11. Warragamba - Prospect Water Supply Pipeline, Wallgrove Rd, Horsley Park	0.69ha	<30%	Higher, to 50%, along existing highly disturbed road/pipeline surfaces. Grass cover impeded visibility elsewhere

5.2 Coverage

Coverage of the survey area was 'total'. Intensive on-foot coverage occurred over the surface of all identified locations of proposed orbital design modifications. The surface of each location within Deerubbin LALC area was inspected by three 'walkers' skilled in the identification of Aboriginal archaeological relics. In the case of locations within Gandangarra LALC two walkers conducted the inspections.

Where proposed modifications were lineal in their nature a system of parallel transect coverage was employed. The distance between transects varied considerably (2m-5m), depending upon factors such as surface visibility, obstructions across the surface, topography, and archaeological sensitivity and potential assessment. This level of assessment was complemented by the on-foot inspection of all locations between transects where surface visibility was higher and thus conducive to surface inspection for the presence of relics. At other locations where the area identified for modification was more limited, on-foot coverage was again total, but not necessarily lineal.

Due to the considerable variability of surface visibility across the survey area surface and at specific survey area locations it was not possible to accurately calculate effective coverage. Any determination of the effectiveness of survey area coverage can be made by reference to and with the assistance of the surface visibility figures in **Table 5**.

6.0 DEFINITION OF SITES AND ESTABLISHING SITE BOUNDARIES

Flood (1989:286) defined an Aboriginal site as *"...a place where past human activity is identifiable"*. Based on the discussion of site prediction in **Section 4**, it can be seen that site types vary considerably in form and function, generally in response to a variety of cultural complexities and environmental influences. These factors affected the development of sites and the activities of the people in pre - historic times. A site can be evidence of a complex of cultural activities, e.g. a large open scatter site (of stone artefacts, cooking fire hearths etc.), or a mound site. Alternatively, a site might be representative of a single, isolated occupation incident, for example a scarred tree, a small camp site - artefact scatter, or an isolated burial site.

For the purpose of surface archaeological surveys, for obvious reasons, site boundaries are most frequently determined by the presence of Aboriginal cultural material. NPWS report writing guidelines indicate that a site may be determined by the presence of two artefacts located within 50 metres of each other. However, in contrast to the above definition by Flood, Witter (pers.coms.1996) describes a cultural site as *"... a place identified as such by an observer (including someone listening to oral accounts) ... a site should be a unit of management"*. A general interpretation of the above is that whilst an archaeological '*site*' may be a place where physical evidence of past Aboriginal occupation has occurred, e.g. open campsites or stone arrangements, other site types may be determined by the presence of a single artefact (i.e. a scarred tree site) or even by the presence of a recognised significant area, based perhaps upon anecdotal information, often occurring with no visible artefacts (e.g. places of ceremonial or religious significance such as natural geological formations).

The extent of a site, particularly in the case of open campsites and similar artefact scatters, is often difficult to assess due to the effects of the geomorphic processes which may have impacted upon a particular area and therefore upon its archaeological deposits. However, surface deposits of archaeological material are considered to be good indicators of the archaeological sensitivity of a specific location, and in western regions of the state surface deposits tend to be reliable guides to a particular area's archaeological potential.

It should be acknowledged that environmental impact assessment related surface studies do have their limitations, and where the archaeologist believes that there is a potential for sub - surface archaeological deposits to exist, the issue should be raised and steps taken to accommodate that potential within a management framework. That framework might include a recommendation for further more extensive archaeological investigations or else simply take into account the likelihood of sub - surface deposits during the development of management recommendations. Inevitably, NPWS will determine what further management will be required under the Act, perhaps bearing in mind the consultant's findings and recommendations and also following consultation with the relevant local Aboriginal organisation.

7.0 SURVEY RESULTS

The field survey was carried out on 20th -21st August 2001 by Robynne Mills and Jim Kelton of Robynne Mills Archaeological & Heritage Services, Newtown. Mr Steven Randall, Deerubbin LALC, assisted. No Aboriginal sites were found at any of the identified survey area locations and, based upon observations made during the field survey, the potential for relics to occur as either undetected surface or sub-surface deposits is assessed to be very low to non-existent.

Given the assessed generally low-moderate level of archaeological sensitivity attributed to the majority of the survey area and the assessed low level of archaeological potential (resulting primarily from generally high levels of surface and sub-surface disturbance across virtually the entire survey area), the above result is not surprising.

8.0 CONCLUSIONS

Based upon the results of the field survey, the results of the NPWS site database search and following consultation with the relevant Aboriginal representative bodies it is concluded that there can be no Aboriginal archaeological impediments to the proposed modifications to the orbital design.

9.0 RECOMMENDATIONS

9.1 There should be no requirement for further archaeological assessment at the identified locations associated with the proposed Western Sydney Orbital modifications and from an Aboriginal archaeological perspective there should be no impediments to the proposed modifications to the Western Sydney Orbital proposal.

This recommendation is based upon the results of the field survey during which no Aboriginal sites were found and due to the fact that the survey area was found to be generally low in archaeological sensitivity and / or potential.

9.2 Any additional development related impact outside the bounds of the identified four locations (2.26ha survey area covered during the current investigation), e.g. works / office sites, machinery storage compounds, gravel dump sites and other roadwork related infrastructure, including the construction of new roads or the upgrading of existing roads, water pipelines, electricity cables, etc, not assessed during the current or previous investigations should be subject to additional archaeological heritage impact assessment.

9.3 In the unlikely event that unrecorded Aboriginal relics or material suspected of being Aboriginal relics are discovered during development related earthworks it is recommended that work should cease and that NPWS should be contacted immediately for further directions.

10.0 LEGAL OBLIGATIONS

The RTA is reminded of their obligations under the NSW NPW Act 1974, where it is stated that all Aboriginal relics (sites and objects), other than those made for sale, are protected. Aboriginal archaeological sites are a non renewable resource, valued for the information they can provide on the lifestyles of Aboriginal people in the past, and are also valued by some Aboriginal communities who have maintained cultural links with specific sites in their 'country'.

It is illegal to disturb, damage or destroy or allow disturbance to, destruction or removal of a site / relic without the prior consent of the Director of NSW NPWS. Any such disturbance requires a permit from the Director. The Act requires that relics recovered under such a permit come under the custody of the Australian Museum in Sydney.

REFERENCES

Bell, D., & Wakelin-King, Z. (1985). *Living Monuments : Aboriginal Carved Trees of NSW*. Australian Natural History 4 (7):302-305.

Bonhomme, T. (1986) *An Archaeological Survey of Proposed Pipeline Route Between Young and Lithgow* Unpublished Report to the Pipeline Authority, Canberra

Brayshaw, H. & White, E. (1999). *Western Sydney Orbital EIS Prestons To Cecil Park Aboriginal Archaeology*. Unpublished report to PPK Environment & Infrastructure Pty Ltd and the RTA.

Flood, J. (1989). *Archaeology of The Dreamtime*. Collins. Sydney.

Koettig, J. (1984). *Prehistoric settlement in the western Cumberland Plain. resources, environment and technology*. Unpublished PhD thesis, Macquarie University.

McCarthy, F.D. (1976). *Australian Aboriginal Stone Implements*. The Australian Museum Trust. Sydney.

McDonald, J. (1992a). *Archaeological investigation of Project 12603 Cowpasture Road, Hoxton Park, NSW*. Unpublished report to Dept. of Housing.

McDonald, J. (1992b). *Archaeological survey of the proposed 33kV transmission line between Bringelly and Rossmore, NSW*. Unpublished report to Prospect Electricity .

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J and Hopkins, M.S. (1998). *Australian Soil and Land Survey Field Handbook*. (second edition). CSIRO. Canberra.

Mills, R. (1996). *Archaeological Survey of the Proposed Western Sydney Orbital from West Baulkham Hills to Cecil Park*. Unpublished report to Sinclair Knight Merz Pty Ltd and the RTA.

Mills, R. (1998). *An Aboriginal Heritage Study Of A Proposed Residential Development At Old Windsor Road and Meurants Lane, Parklea*. Unpublished report to NPWS.

Mills, R. (2001). *A Heritage Study For The Proposed Realignment of The Western Sydney Orbital Route at Cecil Hills*. Unpublished report to the RTA.

NSW National Parks & Wildlife Service. (1997). *Standards Manual For Archaeological Practice in Aboriginal Cultural Heritage Management. Draft No. 2.* NSW National Parks & Wildlife Service. Sydney.

Pearson, M. (1981). *Seen Through Different Eyes: Changing Land Use and Settlement Patterns in The Upper Macquarie River Region of NSW From Prehistoric Times to 1860.* Unpublished Ph.D. Thesis. Dept. Prehistory and Anthropology, ANU. Canberra.

Read, P. (1988). *A Hundred Years War*. ANU Press. Canberra.

Rich, E. & McDonald, J. (1995). *Archaeological salvage of site WH3 [45-5-965]: Project 12603, Cowpasture Road, West Hoxton, NSW.* Unpublished report to Lean Lackenby and Hayward on behalf of Landcom, Parramatta.

Smith, L. (1989a). *Site survey and site analysis on the northern Cumberland Plain Stage 1.* Unpublished report to NPWS.

Smith, L. (1989b). *Liverpool Release Areas: archaeological survey and planning study.* Unpublished report to Liverpool City Council.

Tindale, N. (1974). *Tribal Boundaries in Aboriginal Australia.* Aust. Institute of Aboriginal Studies. Four Map series 1:2,500,000.

White, I. (1976). *Dimensions of Wiradjuri.* Unpublished Thesis, Dept. Prehistory and Anthropology, ANU. Canberra.

Witter, D. (1980). 'Draft Research Design and Interim Report on the Development of a Predictive Approach to the Distribution of Archaeological Sites in Australia'. NPWS.

Witter, D. (1992). *Regions and Resources.* Unpublished PhD thesis. Dept. Prehistory and Anthropology, ANU. Canberra.

Witter, D. (1995). *Guidelines: Minimum Requirements and Standards for Archaeological Survey Methodology and Significance Assessment To Be Used For Cultural Resource Impact Statements.* Unpublished NPWS Document.

Personal Communications:

Fletcher, G. Gandangara Local Aboriginal Land Council. 18th August 2001.

Mills, R. Robynne Mills Archaeological & Heritage Services, Newtown. 20th August 2001.

Mills, R. Robynne Mills Archaeological & Heritage Services, Newtown, 12th September 2001.

Randall, S. Deerubbin Local Aboriginal Land Council. 20th August 2001.

Witter, D. NSW National Parks and Wildlife Service archaeologist 16th May 1996

GLOSSARY OF TERMS

Apron	The area at the front of a rock shelter occupation or art site, often found to be archaeologically sensitive
Artefact	Any object made by human agency.
Assemblage	A range of artefacts found in close association with each other.
Backed blade	stone artefact, blade shaped, with one margin deliberately trimmed to provide an edge where pressure could be applied to the opposite, cutting edge.
Basalt	A fine grained often porphyritic, darkly coloured, igneous rock.
Blade	Parallel sided flake, approximately twice as long as wide.
Bora ground	A ceremonial ground generally consisting of one or two earth - banked circles, and often connected by a pathway'.
Chert	A fine grained crystalline aggregate of silica.
Compaction	A term used to identify the possible accumulation of once stratified archaeological deposits, the evidence of isolated occupation events (often isolated in time and place), into one large deposit at a single level, with no stratigraphy present (due to the effects of erosion etc.)
Conchoidal fracture	Shell-like, bulbed and curved rippled zone resulting from fracture of certain rock types.
Core	A slab of stone from which flakes of stone have been removed.
Core tool	A core with evidence of trimming and / or use - wear indicating its use as an implement.
Debitage	Discarded flaked stone material, often showing no evidence of flaking, but associated with the flaking operation.
Drip-line	An impact zone across the front of a rock shelter site entrance where water run-off from the surface above accumulates on the site 'apron' before draining away.

Glossary of Terms (Cont'd)

Flake	A piece of stone detached from another stone; usually removed from the core using another stone.
Geomorphology	Study of the form of the earth's surface.
Hammerstone	Stone implement used to produce other stone tools and grind plant materials.
Hearth	Site of a campfire. Usually indicated by presence of charcoal, burnt earth, discolouration, organic material, or stone.
Holocene	Comparatively recent geological time, over past 10,000 years.
Jasper	An impure opaque silica, commonly red in colour due to the presence of iron oxides in silica.
Midden	An Aboriginal refuse site
Millstone	Stone artefact used for grinding seeds, fruits, foodstuffs and sometimes bone and ochre.
Open campsite	A surface scatter of artefacts, usually stone.
PAD	An area assessed to have the potential to contain unrecorded relatively undisturbed sub-surface archaeological deposits.
Pleistocene	Glacial epoch preceding Holocene, to approximately 2 million years.
Quartz	A rock material consisting of crystalline silica SiO_2, usually white in colour.
Quartzite	Metamorphosed sandstone.
Retouch	Trimming of an artefact, usually stone, after it was detached from its core.
Sandstone	Compacted and cemented sedimentary rocks consisting essentially of rounded grains of sand.
Silcrete	A poorly defined metamorphic (?) rock of generally fine grained silicous nature occurring as a silica replacement.
Scraper	Stone tool manufactured from a flake and often with one or more working edges.

Glossary of Terms (Cont'd)

Stratigraphy	Superimposed layering of deposits, with older material overlain by later deposits.
Striking platform	Area on a core where a flake is detached. The detached flake carries a section of the core's striking platform on the butt end.
Use wear	Worn or smooth area produced on the working edge of an implement resulting from the use of the implement.

PLATES

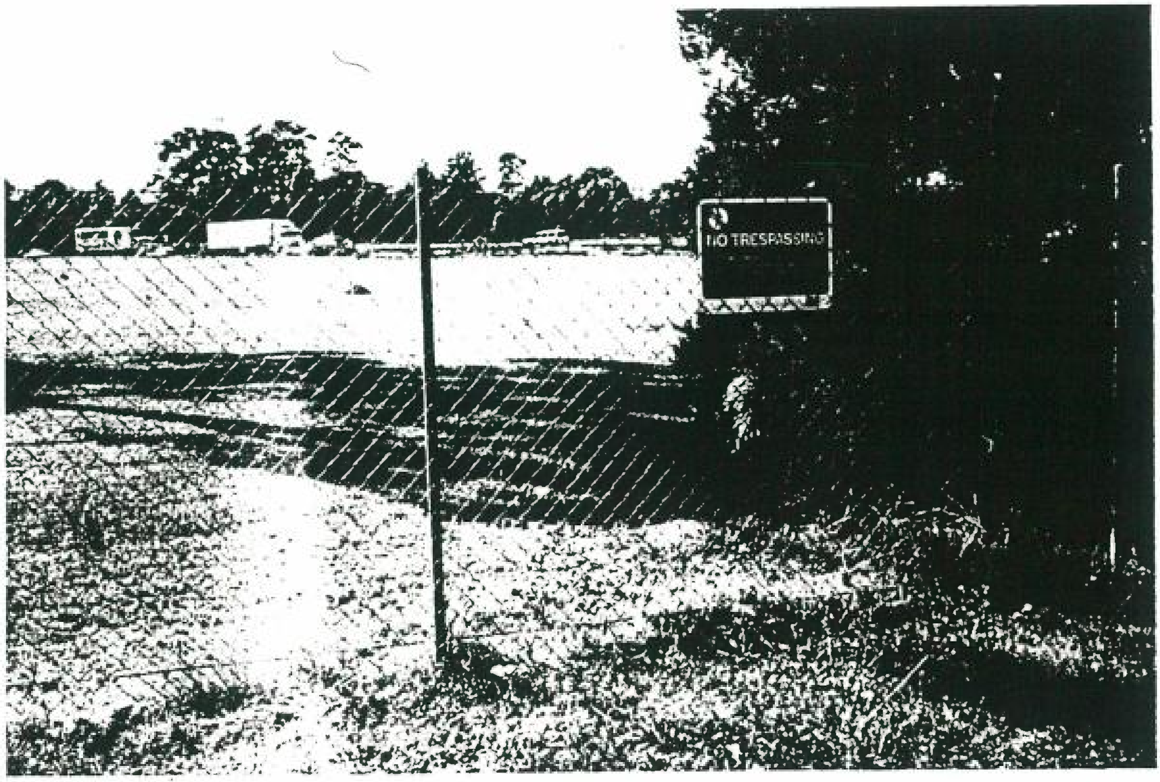


Plate 1: Photo showing the typically highly disturbed landscape at the site of the proposed orbital design modification at Hoxton Park Aerodrome looking east from the existing airport access road towards Cowpasture Road across the aerodrome's cleared surface.

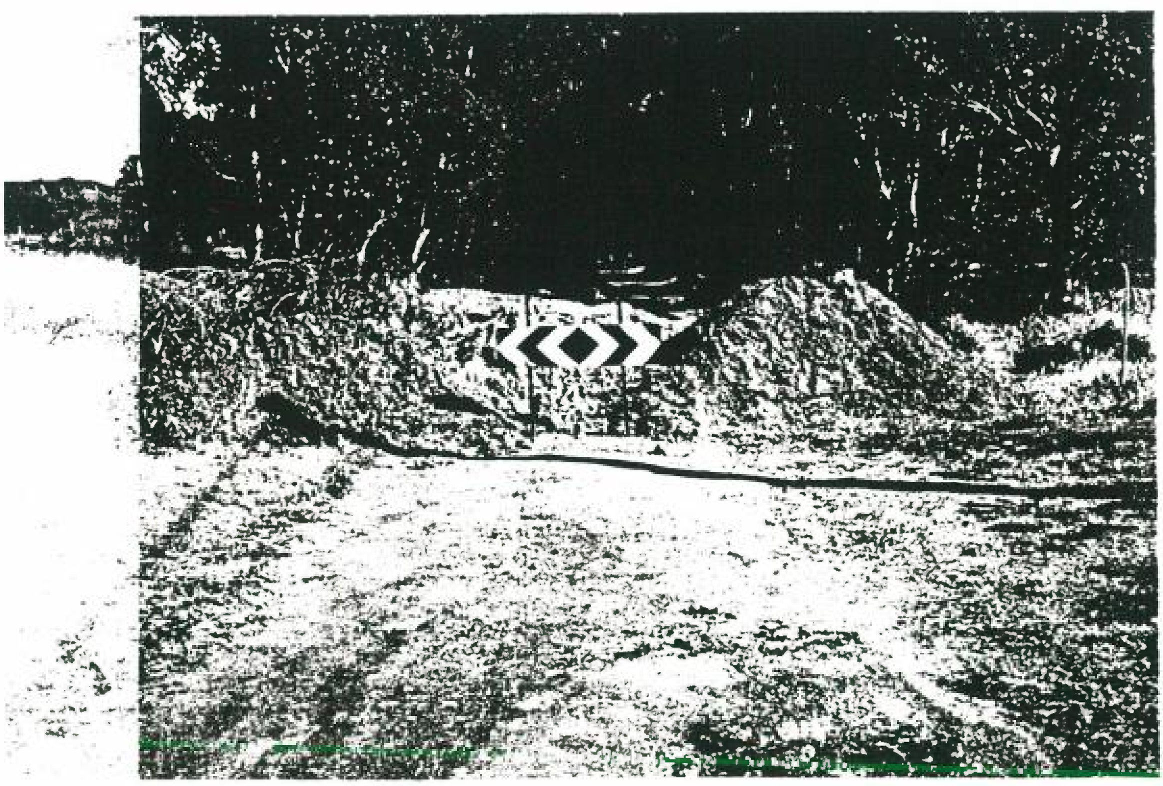


Plate 2: A view of the typically highly disturbed eastern end of McIver Ave in the vicinity of Hoxton Park Aerodrome looking west along McIver Ave.

Plate 3: A view of the eastern end of the McIver Ave survey area and the adjacent highly disturbed spring-fed creekline tributary of Hinchinbrood Creek along the road's north-eastern edge (right side of photo).

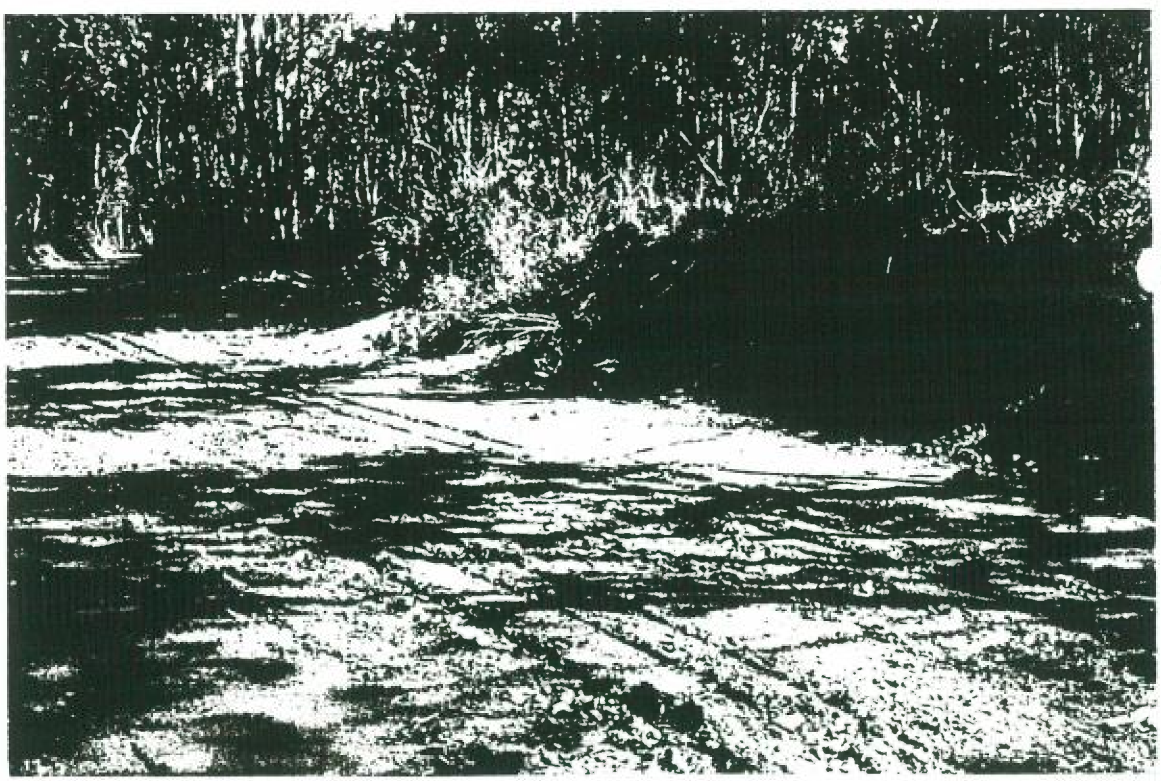


Plate 4: Photo example of the high level of disturbance along the McIver Ave survey area (mid-way along the northern side of the road looking north-west).

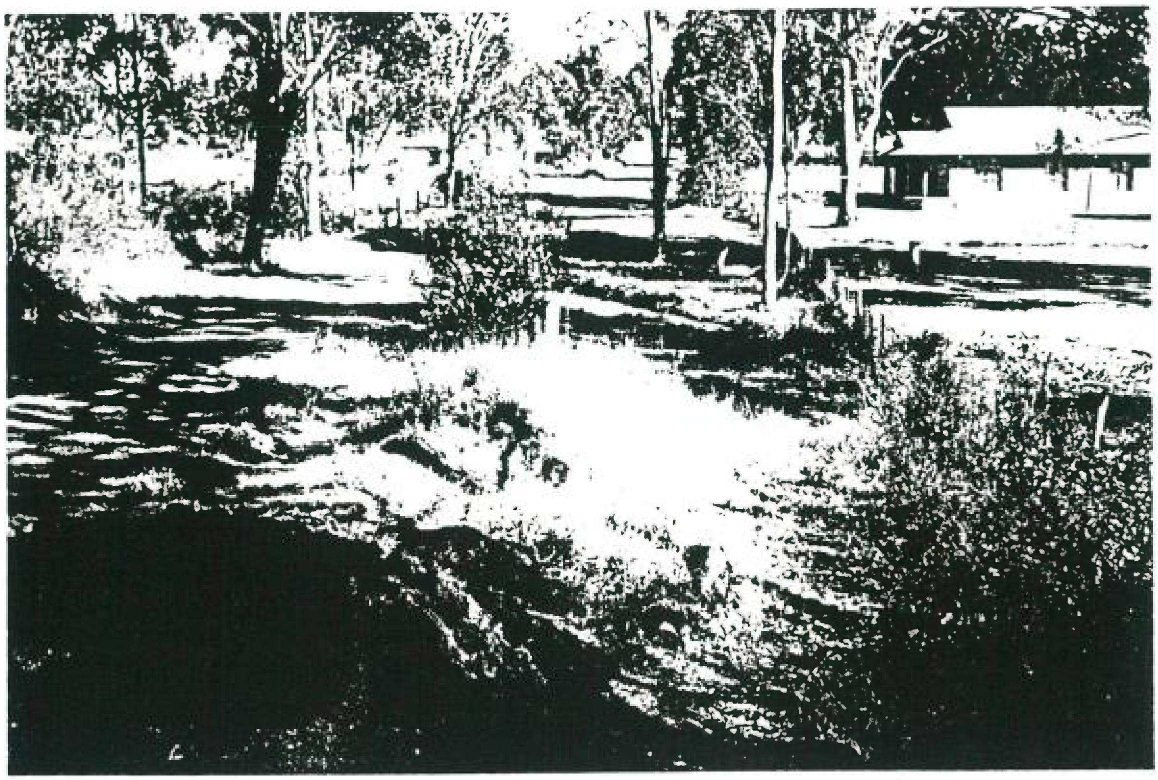


Plate 5: Photo of the highly disturbed western end of the McIver Ave section of the survey area looking west along the formed section of the road.

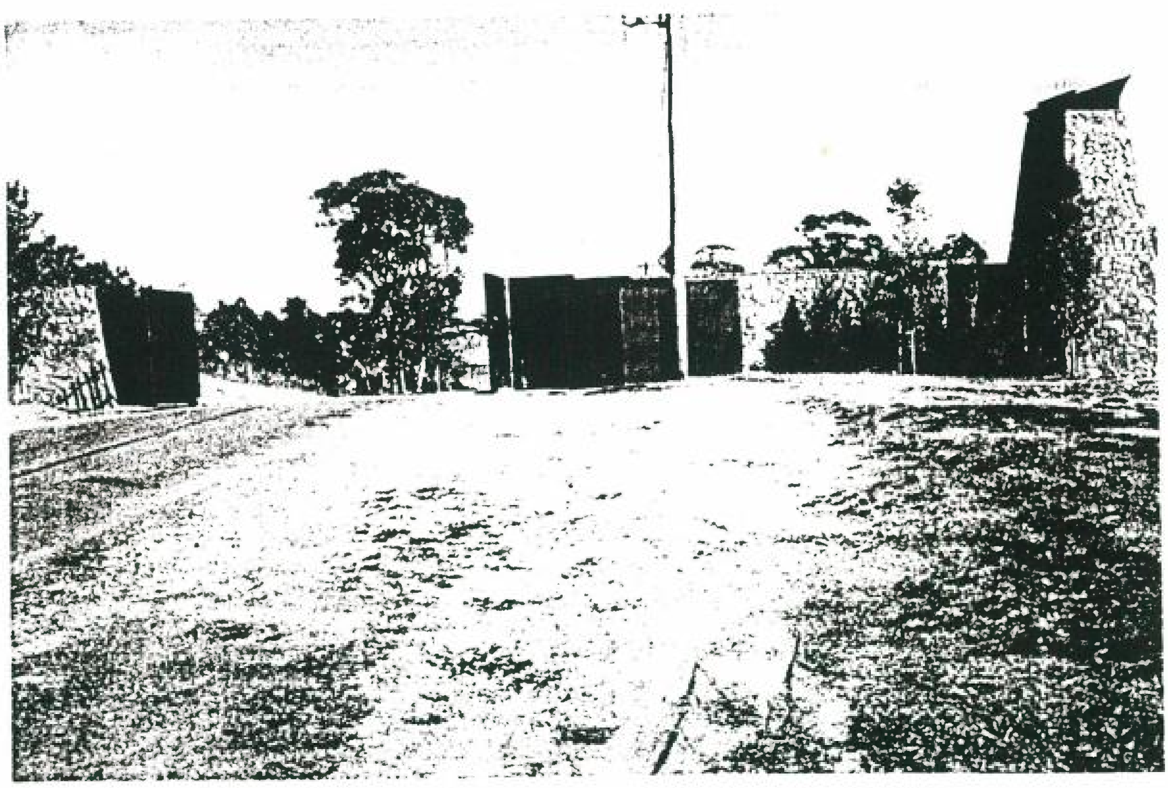


Plate 6: View of the western approach to the proposed new access from the orbital to the Sydney International Equestrian Centre, Horsley Park (at the location of the existing entrance to the Western Sydney Regional Park) looking east from Wallgrove Rd.

Plate 7: Photo of the proposed new route to the Sydney International Equestrian Centre over abandoned market gardens looking north along the eastern edge of the previously surveyed orbital route.

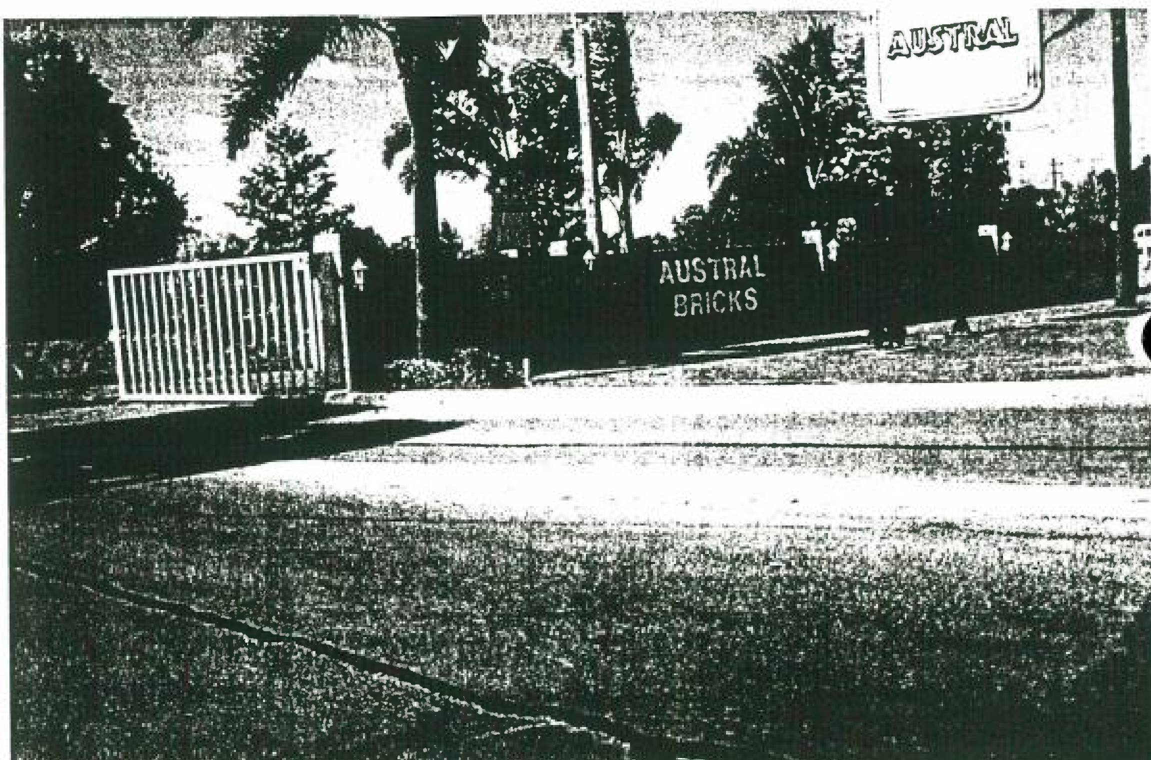


Plate 8: Photo of the existing Austral Brick entrance - proposed new entrance of the orbital for private property located on the opposite, northern side of the Warragamba - Prospect Water Supply Pipeline on the eastern side of Wallgrove Rd, Horsley Park, looking east from Wallgrove Rd.

Plate 9: A photo of the typically highly disturbed landscape at the southern end of the proposed new private property access off Wallgrove Rd / the orbital looking east along the Austral Brick access road.

Plate 10: View of the highly disturbed surface of the route of the proposed modification (new access road) over the Warragamba - Prospect Water Supply Pipeline, Horsley Park, looking north towards the Pace poultry farm.

Plate 11: Photo example of the extent of the disturbance of the route of the proposed new vehicle access on the northern side of the Warragamba - Prospect Water Supply Pipeline at Horsley Park looking north along the eastern side of the poultry farm shed complex.

APPENDICES

APPENDIX 1

COPY OF STATEMENT OF INVOLVEMENT
IN THE FIELD SURVEY BY DEERUBBIN LALC
(WHERE PROVIDED)

APPENDIX 2

COPY OF NPWS SITE DATA-BASE SEARCH PRINT-OUT FOR THE SURVEY AREA

Aboriginal Heritage Information Management System

National Park and Wildlife Services, NSW

List of Sites (Partial)

AHIMS # 4802

Grid Reference Type = AMG Zone = 56 Easting From = 301000 Easting to = 302000 Northing From = 6244500 Northing to = 6245500

Site id	AMG / GDA	Zone	Easting	Northing	Access Restrictions			Further Site Information Contact	Report ID
					Gender	General	Location		
45-5-2474	AMG	56	301260	6245160	None	—	15-6	(Brayshaw 1999)	
45-5-0769	AMG	56	301840	6244700	None				1727
45-5-0770	AMG	56	301840	6244540	None				1727
45-5-0771	AMG	56	302000	6244700	None				1727
45-5-0774	AMG	56	301430	6245400	None				1727

Hoxton Park / Airport.

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Site Number	Location and Sitename		Amg E	Amg N	Date Recorded	Recorder	Assoc Report	Sitetype	
45-1-0220	IF 2		301560	6263220	28OCT1992	Crew, D	C-2440	Isolated find	
45-1-0221	IF 1		301560	6263220	27OCT1992	Crew, D	C-2440	Isolated find	
45-1-0222	Site 13		302150	6263030	28OCT1992	Crew, D	C-2440	Open camp site	
45-1-0223	Site 12		301940	6263660	28OCT1992	Crew, D.	C-2440	Open camp site	
45-1-0224	Site 11		302330	6263660	28OCT1992	Crew, D	C-2440	Open camp site	
45-1-0225	Site 10		302180	6263890	28OCT1992	Crew, D	C-2440	Open camp site	
45-1-0226	Site 9		302130	6264010	28OCT1992	Crew, D	C-2440	Open camp site	
45-1-0227	Site 8		302050	6264100	28OCT1992	Crew, D	C-2440	Open camp site	
45-1-0228	Site 7		302210	6264110	28OCT1992	Crew, D	C-2440	Open camp site	
45-1-0229	Site 6		302380	6264150	28OCT1992	Crew, D	C-2440	Open camp site	
45-1-0230	Site 5		302230	6264230	28OCT1992	Crew, D	C-2440	Open camp site	
45-1-0231	Site 4		301900	6264020	27OCT1992	Crew	C-2440	Open camp site	
45-1-0232	Site 2		301800	6263850	27OCT1992	Crew	c-2440	Open camp site	
45-1-0233	Site 1		301880	6263660	27OCT1992	Crew	c-2440	Open camp site	
45-5-0132	Castle Hill		313050	6266532		Taplin		Axe grinding groo	
45-5-0133	Castle Hill		312953	6266605		Taplin		Shelter c deposit	Shelter c art
45-5-0135	Kellyville		310915	6265137		Taplin		Shelter c deposit	Axe grinding groo
45-5-0136	Stanhope	Kellyville	308631	6268002		Taplin		Shelter c deposit	
45-5-0223	Eastern Creek	Doonside	301800	6262700				Open camp site	Scarred tree
45-5-0224	Kerry Road	Blacktown	304500	6261100	14AUG1979	Kohen, J.		Open camp site	
45-5-0245	Eastern Creek	Plumpton	301410	6265120	1980	Kohen,	C-156,	Open camp site	Quarry
45-5-0246	Glengarry		299100	6265550	00FEB1980	Haglund	C-367	Open camp site	
45-5-0247	Eastern Creek	Owen Street	301600	6264400	00FEB1980	Haglund	C-367	Open camp site	
45-5-0248	Plumpton	Cook Rd	300000	6264670	00AUG1983	Happ	C-367,	Open camp site	
45-5-0249	Wallgrove	Wallgrove Road	300900	6257100	1980	Haglund		Open camp site	
45-5-0251	Cook Road	Plumpton	299825	6264650	1980	Haglund	C-367	Open camp site	
45-5-0252	Rooty Hill Road	Plumpton	300549	6265010	1980	Haglund	C-367	Open camp site	
45-5-0253	Eastern Creek	Symonds Rd	301720	6265140	1980	Haglund	C-157,	Open camp site	
45-5-0255	Bells Creek	Cannery Road	299358	6260413	1980	Haglund		Open camp site	
45-5-0256	Wallgrove		301834	6260095	1980	Haglund		Open camp site	
45-5-0271	Doonside 8	Doonside	303105	6262620	00FEB1985	J.L.Kohen		Open camp site	
45-5-0274	Bosley Park		302028	6250129	1981	Hanrahan		Open camp site	
45-5-0297	Doonside 6	Doonside	303102	6262609	00FEB1985	J.L.Kohen		Open camp site	Scarred tree
45-5-0348	Grantham Creek	Grantham Poultr	308320	6259710	20OCT1991	Guilder, M.		Open camp site	
45-5-0349	Plumpton	Hassall Open Si	299110	6264510	1982	Dallas	C-242,	Open camp site	
45-5-0355	Plumpton	Owen Street	301650	6264320	1982	Haglund	C-359,	Open camp site	
45-5-0357	QH 1	Quakers Hill	306360	6266390	00MAR1982	Dallas, M.	C-260	Open camp site	
45-5-0358	QH 2	Quakers Hill	305780	6266410	11JUL1985	J.McDonald	C-260	Open camp site	
45-5-0364	Plumpton		299000	6265510	1982	Dallas,_M.	C-261	Open camp site	
45-5-0398	Blacktown Nativ		300075	6265915	00AUG1981	Bickford	C-77	Contact, Mission	
45-5-0419	Bells Creek_4	4, B & C	300080	6264930	00AUG1983	Happ	C-413	Open camp site	
45-5-0420	Bells Creek 2		300070	6264930	00AUG1983	Happ	C-413	Open camp site	
45-5-0421	Bells Creek_3		300090	6264940	00AUG1983	Happ	C-413	Open camp site	
45-5-0422	Blacktown	Plumpton	300660	6265230	00FEB1984	McDonald	C-755	Open camp site	
45-5-0429	Second Ponds Cr	HC 7400	306100	6267800	21OCT1984	Basic Aborigina	C-823,	Open camp site	
45-5-0435	Eastern Creek	W6	299290	6257880	1983	McIntyre		Open camp site	
45-5-0436	Eastern Creek	W3	300740	6258050	1983	McIntyre		Open camp site	
45-5-0437	Eastern Creek	W4	299260	6257680	1983	McIntyre		Open camp site	
45-5-0438	Eastern Creek	W2	300900	6257650	1983	McIntyre		Open camp site	
45-5-0439	Eastern Creek	W1	300750	6256650	1983	McIntyre		Open camp site	
45-5-0440	Eastern Creek	W5	299760	6259120	1983	McIntyre		Open camp site	
45-5-0441	Bells Creek_1		300100	6264780	00AUG1983	Happ	C-413	Open camp site	
45-5-0445	Woodstock open	Plumpton	300560	6262450	1983	Dallas		Open camp site	
45-5-0451	Bungarribee 1	Blacktown	303640	6260350	00FEB1985	J.L.Kohen		Open camp site	
45-5-0452	Bungarribee 9	Blacktown	302690	6259970	00FEB1985	J.L.Kohen		Open camp site	
45-5-0453	Bungarribee 12	Blacktown	302680	6258870	00FEB1985	J.Kohen		Open camp site	
45-5-0454	Bungarribee13	D.T.C.Doonside	302590	6258990	01FEB1985	J Kohen		Open camp site	

45-5-0456	South East Plum		300990	6262050	29APR1985	Kohen J.L.		Open camp site
45-5-0457	Bungarribee 4	Blacktown	303540	6260490	00FEB1985	J.L.Kohen		Open camp site

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Site Number	Location and Sitename		Amg E	Amg N	Date Recorded	Recorder	Assoc Report	Sitetype
45-5-0458	Bungarribee 5	Blacktown	303620	6260600	00FEB1985	J.L.Kohen		Open camp site
45-5-0459	Bungarribee 8	Blacktown	303650	6259360	00FEB1985	J.L.Kohen		Open camp site
45-5-0460	Bungarribee 7	Blacktown	302550	6260440	00FEB1985	J.L.Kohen		Open camp site
45-5-0461	Bungarribee 6	Blacktown	303300	6262240	00FEB1985	J.L.Kohen		Open camp site
45-5-0462	Bungarribee 21	Blacktown	301850	6259330	00FEB1985	J.Kohen		Open camp site
45-5-0463	Bungarribee 20	Blacktown	302010	6259520	00FEB1985	J.Kohen		Open camp site
45-5-0464	Bungarribee19	Blacktown	301820	6259500	00FEB1985	J.Kohen		Open camp site
45-5-0465	Bungarribee18	Blacktown	302320	6258930	00FEB1985	J.Kohen		Open camp site
45-5-0466	Doonside 4	Doonside	301210	6261100	00FEB1985	J.Kohen		Open camp site
45-5-0467	Bungarribee 17	Blacktown	302010	6259610	00FEB1985	J.Kohen		Open camp site
45-5-0468	Bungarribee16	C.T.C.Doonside	302100	6260050	00FEB1985	J.Kohen		Open camp site
45-5-0469	Bungarribee 14	C.T.C.Doonside	302750	6258500	00FEB1985	J.Kohen		Open camp site
45-5-0470	Doonside 5	Services Corrid	302150	6261090	00FEB1985	J.Kohen		Open camp site
45-5-0472	South Blacktown	Blacktown	302910	6259710	29APR1985	Kohen J.L.		Open camp site
45-5-0473	South Blacktown	Blacktown	303370	6257780	29APR1985	Kohen J.L.		Open camp site
45-5-0474	Southeast Plump		301150	6262030	29APR1985	Kohen J.L.		Open camp site
45-5-0475	Southeast Plump		301300	6262390	29APR1985	Kohen.J.L.		Open camp site
45-5-0476	South Blacktown	Blacktown	303380	6258180	29APR1985	Kohen J.L.		Open camp site
45-5-0477	South Blacktown	Blacktown	304050	6258890	29APR1985	Kohen.J.L.		Open camp site
45-5-0478	South Blacktown	Blacktown	304630	6259610	29APR1985	Kohen.J.L.		Open camp site
45-5-0483	Southeast Plump	Rooty Hill	300850	6262100	29APR1985	Kohen J.L.		Open camp site
45-5-0485	Bells Creek B	Rooty Hill	300050	6265900	10MAY1985	Kohen,J.L.	C-1006	Open camp site
45-5-0486	Bells Creek A	Rooty Hill	300180	6265200	10MAY1985	Kohen J.L.	C-1006	Open camp site
45-5-0487	Southeast Plump	Rooty Hill	301530	6263660	29APR1985	Kohen J.L.		Open camp site
45-5-0488	Bells Creek D	Rooty Hill	299710	6262680	10MAY1985	Kohen J.L.		Open camp site
45-5-0489	Bungarribee.	Bungarribee Hil	303640	6260350	00FEB1985	Kohen J.		Open camp site
45-5-0490	Quakers Hill.	Pye Road Carrie	305960	6265340	05JUL1985	McDonald J.	C-874	Open camp site
45-5-0492	Bella Vista 1	Baulkham Hills	310030	6264790	13NOV1985	Brayshaw H	C-945_	Open camp site
45-5-0497	Eastern Creek 3	Schofields Aero	303000	6266920	00FEB1985	Kohen J.L	C-521	Open camp site
45-5-0498	Eastern Creek 5	Schofields Aero	302300	6267600	00FEB1985	Kohen J.L	C-521	Open camp site
45-5-0503	Eastern Creek 6	Schofields Aero	303000	6267500	00FEB1985	Kohen J	C-521	Open camp site
45-5-0527	PR2	Prospect	301750	6263300	21MAY1986	Smith L		Open camp site
45-5-0543	SA 6	Riverstone	301290	6266490	00OCT1986	M'Donald J	C-1018	Open camp site
45-5-0544	SA 8	Riverstone	301900	6266860	00OCT1986	McDonald J	C-1018	Open camp site
45-5-0545	SA 9	Riverstone	301770	6266930	00OCT1986	McDonald J	C-1018	Open camp site
45-5-0546	SA 10	Riverstone	301850	6266960	00OCT1986	McDonald, J.	C-1018	Open camp site
45-5-0547	SA 11	Riverstone	301840	6267020	00OCT1984	McDonald, J.	C-1018	Open camp site
45-5-0548	SA 12	Riverstone	301650	6267050	00OCT1986	McDonald, J.	C-1018	Open camp site
45-5-0549	SA 2	Riverstone	301270	6266750	00OCT1986	McDonald, J.	C-1018	Open camp site
45-5-0550	SA 3	Riverstone	301290	6266670	00OCT1986	McDonald. J.	C-1018	Open camp site
45-5-0551	SA 4	Riverstone	301290	6266650	00OCT1986	McDonald, J.	C-1018	Open camp site
45-5-0552	SA 5	Riverstone	301600	6266500	00OCT1986	McDonald, J.	C-1018	Open camp site
45-5-0553	SA 7	Riverstone	301330	6266380	00OCT1986	McDonald, J.	C-1018	Open camp site
45-5-0554	SA 1	Riverstone	301240	6266500	00OCT1986	McDonald, J.	C-1018	Open camp site
45-5-0555	PR1	Plumpton Road N	301250	6263310	21MAY1986	Smith, L.	C-1021	Open camp site
45-5-0558	Blacktown South	Eastern Creek	300120	6256880	00JUN1986	Kohen, J. L.	C-1007	Open camp site
45-5-0588	Blacktown South	Eastern Creek	300130	6256700	00JUN1986	Kohen, J.L.		Open camp site
45-5-0594	LR 1	Hassell:Fracing	299960	6264570	00FEB1985	Dallas, M.	C-996	Open camp site
45-5-0595	LR 2	Hassell	299840	6264140	22FEB1985	Dallas, M.	C-996	Open camp site
45-5-0637	Lamb Street 1		301720	6265610	30JAN1987	Haglund.L	C-1247	Open camp site
45-5-0694	MG 55	Marayong_NR	305060	6264500	00APR1988	Smith, L.J.	C-1380	Open camp site
45-5-0695	MG 56	Marayong NR	304930	6264230	00APR1988	Smith, L.J.	C-1380	Open camp site
45-5-0696	MG 57	Marayong Park	305230	6264860	00APR1988	Smith, L.J.	C-1380	Open camp site
45-5-0741	WDD1		301340	6255920	11APR1989	M. Koetteg	?	Open camp site
45-5-0742	WDD 2		302020	6255670	11APR1989	M. Koetteg	C-1530	Open camp site
45-5-0743	WDD3		301650	6255750	11APR1989	M. Kotteg	C-1530	Open camp site
45-5-0744	WDD5		302070	6255560	11APR1989	M. Koetteg	?	Open camp site
45-5-0745	WDD 6		302220	6255400	11APR1989	M. Koetteg	C-1530	Open camp site

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	Site Number	Location and Sitename		Amg E	Amg N	Date Recorded	Recorder	Assoc Report	Sitetype	
	5-5-0751	E11		302230	6257550	25NOV1989	Rich E. Smith	C-1646	Open camp site	
	45-5-0752	E10		302330	6257400	25NOV1989	Rich E. Smith	C-1646	Open camp site	
	45-5-0753	E9		302200	6257100	14NOV1989	Crew D. Rich E	C-1814	Open camp site	
	45-5-0754	E8		302300	6257080	14NOV1989	Crew D. Rich E	C-1814	Open camp site	
	45-5-0755	E7		302750	6257200	14NOV1989	Crew D. Rich E	C-1644	Open camp site	
	45-5-0756	E6		302070	6257330	13NOV1989	Crew D. Rich E	C-1644	Open camp site	
	45-5-0757	E5		302350	6257250	13NOV1989	Crew D. Rich E	C-1644	Open camp site	
	45-5-0758	E4		302500	6257150	13NOV1989	Crew D. Rich E	C-1644	Open camp site	
	45-5-0759	E3		302550	6257150	13NOV1989	Crew D. Rich E	C-1644	Open camp site	
	45-5-0760	E2		302540	6257520	13NOV1989	Crew D. Rich E	C-1644	Open camp site	
	45-5-0761	E1		302540	6257520	13NOV1989	Crew D. Rich E	C-1644	Open camp site	
	45-5-0765	PR 1		303350	6254070	12JAN1990	Smith, L.	c-1723	Open camp site	
	45-5-0766	PR 2		303500	6254000	12JAN1990	Rich, E.	c-1723	Open camp site	Contact, Mission
	45-5-0767	PR 3		303550	6254150	12JAN1990	Rich, E.	c-1723	Open camp site	Contact, Mission
	45-5-0768	PR 4		304400	6254200	12JAN1990	Rich, E	c-1723	Open camp site	
	45-5-0791	Toongabbie cree		311410	6260170	00OCT1989	Attenbrow, V.		Open camp site	
	45-5-0800	Scarred Tree	Prospect Reserv	304525	6253950	00AUG1990	Comber, J.	C-1557	Scarred tree	
	45-5-0801	KPB1	Prospect Reserv	304600	6254100	00AUG1990	Comber, J.	C-1957	Open camp site	
	45-5-0802	PB2	Prospect Reserv	305025	6254075	00AUG1990	Comber, J.	C-1957	Open camp site	
	45-5-0803	PB3	Prospect Reserv	305350	6254100	00AUG1990	Comber, J.	C-1857	Open camp site	
	45-5-0804	PB4	Prospect Reserv	306025	6254150	00AUG1990	Comber, J.	C-1857	Open camp site	
	45-5-0805	PA1	Prospect Reserv	305200	6254360	15NOV1990	Comber, J.	C-1919	Open camp site	
	45-5-0806	PA2	Prospect Reserv	305210	6254750	15NOV1990	Comber, J.	C-1919	Open camp site	
	45-5-0824	Moxhams Road Ca		313800	6259810	20JUN1991	Guider, M	none	Shelter c art	
x x	45-5-0826	Schofields 1		301800	6267100	02SEP1989	Nicholson, A.	C-2081	Open camp site	
x x	45-5-0827	Schofields 2		301100	6267200	02SEP1989	Nicholson, A.	C-2081	Open camp site	
x x	45-5-0828	Schofields 3		301600	6267200	02SEP1989	Nicholson, A.	C-2081	Open camp site	
x x	45-5-0829	Schofields 4		301700	6267100	02SEP1989	Nicholson, A.	C-2081	Open camp site	
x x	45-5-0830	Schofields 5		301500	6267200	02SEP1989	Nicholson, A.	C-2081	Open camp site	
x x	45-5-0831	Schofields 6		301400	6267200	02SEP1989	Nicholson, A.	C-2081	Open camp site	
x x	45-5-0832	Schofields 7		301300	6267200	02SEP1989	Nicholson, A.	C-2081	Open camp site	
	45-5-0835	Toongabbie Cave	Old Toongabbie	312210	6259450	14SEP1991	Guider, M.	?	Shelter c deposit	
	45-5-0839	Greystanes Cree	Toongabbie	308810	6258350	23OCT1991	Guilder, M.	none	Open camp site	
	45-5-0840	Greystanes Cree	Toongabbie	309750	6258130	23OCT1991	Guilder, M.	none	Open camp site	
	45-5-0841	Toongabbie Cree	Winston Hills	311890	6259660	15SEP1991	Guilder, M.	none	Axe grinding groo	
	45-5-0842	Toongabbie Cree	Old Toongabbie	313550	6259390	21SEP1991	Guilder, M.	none	Open camp site	
	45-5-0843	Finalysons Cree	Wentworthville	313040	6257910	25OCT1991	Guilder, M.	none	Axe grinding groo	
	45-5-0866	TPP 1	Prospect Reserv	302950	6255150	27NOV1991	Donlon, D.	C-2246	Open camp site	
	45-5-0867	TPP2	Prospect Reserv	303530	6254150	27NOV1991	Donlon, D.	C-2246	Scarred tree	
	45-5-0868	PP1	Prospect Reserv	306000	6254450	09AUG1991	Comber, J.	C-2225	Open camp site	
	45-5-0869	PP2	Prospect Reserv	305900	6254250	08AUG1991	Comber, J.	C-2225	Open camp site	
	45-5-0870	Prospect Lagoon	Prospect Reserv	304500	6253850	02OCT1991	Donlon, D.	C-2225	Open camp site	
	45-5-0871	Toongabbie CK 1	Baulkham Hills	311390	6262450	01JAN1992	Guider, M.	NONE	Axe grinding groo	
	45-5-0872	PB 1		301600	6262850	20OCT1992	McDonald		Open camp site	
	45-5-0873	PB 2		301560	6262820	20OCT1992	McDonald	?	Open camp site	
	45-5-0884	Murragingy 1		301920	6262410	06NOV1992	McDonald	?	Open camp site	
	45-5-0885	Murragingy 2		302080	6262400	06NOV1992	McDonald	?	Open camp site	
x	45-5-0910	PK/CD 1	Rouse Hill	308190	6267200	25FEB1993	McDonald,J.	c-2499	Open camp site	
x	45-5-0911	PK/CD 2	Rouse Hill	307860	6266930	25FEB1993	McDonald,J.	c-2499	Open camp site	
x	45-5-0912	PK/CD 3	Rouse Hill	308230	6265530	00MAR1993	McDONALD, J.	C-2499	Open camp site	
x	45-5-0913	PK/CD4	Rouse Hill	308720	6265900	25FEB1993	McDonald, J.	c-2499	Open camp site	
x	45-5-0914	PK/CD 5	Rouse Hill	308820	6265700	11MAR1993	McDonald,J.	c-2499	Open camp site	
x	45-5-0916	PK/CD 6	Rouse Hill	308290	6265590	11MAR1993	McDONALD,J.	C-2499	Open camp site	
	45-5-0920	Abbotsbury 1		303150	6251700	00JUN1993	Navin, K.	C-	Open camp site	
	45-5-0921	Abbotsbury 2		302960	6251700	00JUN1993	Navin, K.		Open camp site	
x	45-5-0929	PK/PC 5	Rouse Hill	307200	6267050	00AUG1993	McDonald,J.	c-2654	Open camp site	
	45-5-0930	RH/SC3	Rouse Hill	311700	6268270	24FEB1993	McDonald,J	?	Axe grinding groo	
	45-5-0933	RH/CD_9	Rouse Hill	305200	6268420	00JUN1993	McDonald,J.	C-	Open camp site	
x	45-5-0935	Powers Lane 1		309610	6264050	29JUL1993	Byrne, D.	?	Open camp site	
	45-5-0936	Powers Lane 2		309640	6263750	29JUL1993	Byrne, D.	?	Open camp site	

45-5-0937	Powers Lane 3		309440	6263790	29JUL1993	Byrne, D.	?	Open camp site
45-5-0939	PK/PC 4	Rouse Hill	307460	6266960	00APR1993	McDonald, J.	c-2654	Open camp site
45-5-0940	PK/CD7	Rouse Hill	308410	6266920	01APR1993	McDonald, J.	c-2656	Open camp site
45-5-0949	Abbotsbury 4		302600	6250700	00JUL1993	Rich, E	c-2620	Open camp site
45-5-0961	OWR 6	Rouse Hill	308090	6265560	00NOV1992	Corkhill, T		Open camp site
45-5-0962	OWR 7	Rouse Hill	309550	6264950	00NOV1992	Corkhill		Open camp site
45-5-0963	OWR 8	Rouse Hill	309700	6264510	00NOV1992	Corkhill, T	?	Open camp site
45-5-0970	Toongabbie Ck 1		311110	6261770	04FEB1994	Edgar, J.	c-3832	Open camp site
45-5-0973	Powers Lane 4	PL-4	309850	6264400	01NOV1993	Byrne,D & Konde	?	Open camp site
45-5-0980	Abbotsbury 4		302600	6250700	00JUL1994	Navin, K.	c-2950	Open camp site
45-5-0983	OWR IF2		305900	6266560	00DEC1994	Corkill, T.	?	Open camp site
45-5-0994	Station Road 1	ST1	302960	6265110	23FEB1995	Byrne,D	?	Open camp site
45-5-2281	bc1	Rouse Hill	305500	6265820	00MAY1989	dallas,m	c-1567	Open camp site
45-5-2282	bc2	PK/PC 5	307550	6266800	00MAY1989	McDonald	c-1567	Open camp site
45-5-2283	bc3	Rouse Hill	307140	6268500	00MAY1989	Mcdonald	c-1567	Scarred tree
45-5-2289	Unregistered to	Rouse Hill	310500	6262300	00JUL1989	dallas,m	?	Axe grinding groo Shelter c art
45-5-2292	PH/DC1	Rouse Hill	307400	6262300	21APR1993	Brayshaw,H	c-2544	Open camp site
45-5-2293	PK/PC1	Rouse Hill	307110	6266550	21APR1993	Brayshaw,H	c-2544	Open camp site
45-5-2294	PK/PC2	Rouse Hill	307660	6266730	21APR1993	Brayshaw,H	c-2544	Open camp site
45-5-2295	Toongabbie 1		312890	6259630	14AUG1993	McDonald, J.	?	Axe grinding groo
45-5-2296	Toongabbie 2		313300	6259360	14AUG1993	McDonald, J.	?	Shelter c deposit
45-5-2297	Toongabbie 3		313100	6259450	14AUG1993	McDonald, J.	?	Midden
52-2-1673	Westacott. No.9		313990	6260150	30JAN1982	Bluff, W.	nil	Rock engraving (0

APPENDIX NINE

ENVIRONMENTAL NOISE AND VIBRATION IMPACT ASSESSMENT UPDATE

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WESTERN SYDNEY ORBITAL

ENVIRONMENTAL NOISE & VIBRATION IMPACT ASSESSMENT UPDATE

T440-12F05 (REV9) WSO ASSESSMENT UPDATE

15 August 2001

Prepared for:

Roads & Traffic Authority
Environmental Services, Sydney Client Services
Level 3, 83 Flushcombe Road
Blacktown
c/- PPK Environment & Infrastructure

TABLE OF CONTENTS

1. INTRODUCTION

Project Description

This report presents an update of the results of an environmental noise and vibration impact assessment undertaken for the proposed Western Sydney Orbital (WSO) between the M5 Motorway at Prestons and the M2 Motorway at West Baulkham Hills, Sydney. The proposal is to construct and operate a four lane divided carriageway road that provides a direct link from the M5 Motorway at the Camden Valley Way interchange to the M2 Motorway at West Baulkham Hills.

EIS Description

The WSO Environmental Impact Statement dated October 2000, presented a separate noise study for each of the two sections forming the proposal:

- **South Section:** M5 Motorway at the Camden Valley Way interchange at Prestons to Elizabeth Drive at Cecil Park – undertaken by PPK Environment & Infrastructure Pty Ltd with sub-consultants Renzo Tonin & Associates Pty Ltd (Working Paper ref: T440-08F03 (rev2) Noise Working Paper – No Toll, No Airport, dated 31 December 1999)

- **North Section:** Elizabeth Drive, Cecil Park to M2 Motorway at West Baulkham Hills – undertaken by Sinclair Knight Merz Pty Ltd with sub-consultants Wilkinson Murray Pty Ltd (Working Paper ref: 95147-4, Version B, dated July 2000)

New Consistent Approach

This report brings together the environmental noise and vibration impact assessments conducted separately for each section, and provides a consistent approach to the whole WSO route.

This report is prepared mostly from data and information obtained from the previous assessments after validation and verification of noise monitoring and modelling results so to ensure that a uniform methodology for the whole WSO route is maintained.

This report does not repeat bulk data and detail information, which essentially remain unchanged from the earlier studies, unless that information is required to present a complete picture of the impacts that can be expected from the proposed roadway.

The WSO is proposed to be a tolled motorway. As a tolled motorway, traffic volumes are expected to be lower than if non-tolled, and subsequently noise emissions are also expected to be lower. Noise from the proposed road is calculated for the year of opening 2006 and the ultimate development of the road in the year 2016, using the high traffic volumes forecasted for a non-tolled motorway scenario. Note that as the predicted noise levels are based on the higher non-tolled traffic volumes, the overall assessment of noise from the WSO is conservative.

Predicted noise levels are assessed in terms of the relevant noise goals set by the Environment Protection Authority (EPA) in their "Environmental Noise Criteria for Road Traffic Noise" released in May 1999. Similarly, construction noise and vibration impacts are assessed in terms of the guidelines set out in the EPA's "Environmental Noise Control Manual", 1994.

Impacts are assessed at noise sensitive land use developments such as residential areas, proposed and existing educational institutions, hospital wards, places of worship, recreational areas, parks and reserves. Impacts are assessed on both existing developments and proposed developments based on the most recent zoning information available.

Traffic noise from the road is assessed by grouping residential areas along the route into Noise Catchment Areas. In each Noise Catchment Area (NCA), the number of houses where the EPA criteria are exceeded is counted. This identifies areas of significant noise impact. Appropriate noise mitigation is discussed for each NCA.

Nominal noise and vibration mitigation measures are presented for the construction and operational phases of the project taking into consideration the existing environment and the feasibility of available measures to provide the required attenuation for affected premises to achieve the EPA's noise and vibration goals.

Each chapter of this report defines and explains the noise terms that are relevant to its content. In addition, a general glossary of environmental noise terms is provided at the end of this report.

Road Alignment Modifications & Additions

Since the EIS was produced, the proposed WSO alignment has been modified in certain areas and the project now includes some additional roads which require noise and vibration assessment. To assess noise impacts at additional roads to the project, ambient noise monitoring and concurrent traffic volume counts have been conducted along these roads. Noise and vibration impacts in these areas are presented herein but are assessed as part of a separate report.

2. EXISTING ACOUSTIC ENVIRONMENT

2.1. NOISE SURVEY METHODOLOGY

Description of Monitoring Methodology

Measurement of the existing noise environment is required because the perception of a new noise source, such as noise associated with the construction of the proposed road or traffic noise from the proposed road once it is operational, will depend on how audible it is compared with existing noise. The purpose of ambient monitoring is therefore to:

- Measure existing background noise levels at locations potentially affected by construction noise for residences close to the proposed roadway.

- Measure existing traffic noise exposure and use this as a base measure to compare predicted traffic noise levels and determine the potential change in traffic noise along the proposed route.

Ambient noise levels were measured at several locations along the proposed route generally using long-term unattended monitoring methods backed up with some short-term attended monitoring. The locations were selected to provide a cross-section of the various acoustic environments to be found along the proposed route. The location of monitoring relative to a proposal does not necessarily need to be determined by proximity, but simply be representative of the surrounding ambient road traffic noise environment. This is especially the case where existing road traffic noise is insignificant close to a proposal, as is the case for many areas along this route, especially where they are undeveloped.

Long-term Noise Monitoring at 40 Locations

Long-term noise monitoring was conducted at a total of 40 locations over several days during separate periods between 1995 and 1998. The monitoring periods are defined below:

- 9 to 17 August 1995 - Locations 1, 2 and 6
- 20 September to 28 November 1995 – Locations 11 to 40
- 13 to 20 November 1995 - Locations 3, 4 and 5
- 4 to 8 September 1998 - Location 7
- 3 to 11 December 1998 - Locations 8, 9 and 10.

See ***Figures 2.1*** to ***2.3***, which show the noise monitoring locations.

The monitoring sites selected are therefore considered representative of the surrounding noise sensitive receivers likely to be impacted by the proposal and are generally in reasonable proximity to the WSO route. The surrounding existing and future road noise environment can alternatively be characterised by using noise modelling. Future traffic noise levels from existing roads adjoining and surrounding the WSO are presented at multiple points along the route in ***Section 5*** of this report both in tabular format for critical receiver locations within defined Noise Catchment Areas and contour map format for the general study area.

Additional Noise Monitoring not Required

From the above and given that traffic noise is compared and assessed herein to the 'base criteria' for the 'new freeway or arterial road corridor' category in the EPA's "Environmental Criteria for Road Traffic Noise", no further noise monitoring is considered necessary at this stage of the project. Furthermore, the RTA, through their selected contractor, is expected to conduct additional ambient and background noise monitoring at potentially sensitive locations along the route prior to commencement of construction.

Consistent Monitoring Methodology

The methodology used for each of the southern and the northern sections of the road is described in Section 2.1 and 2.2 of the Renzo Tonin & Associates report and in Section 3.1 and 3.2 of the Wilkinson Murray report, respectively. The noise monitoring undertaken for both the southern and the northern sections of the project are considered generally consistent in methodology and in equipment used. For example, all long-term noise monitoring was undertaken using environmental noise loggers which comply with Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" and are designated as Type 2 instruments suitable for field use. All loggers were calibrated prior and subsequent to each measurement and no significant drift in calibration was observed on any noise logger.

Environmental Noise Loggers

Where differences in the methodologies exist, these are accounted for in the presentation of monitored noise results within each report. For example, the effect of monitoring noise in a free-field environment as opposed to 1 metre from a facade and monitoring noise either closer or further away from a road than where the nearest facade is located, is accounted for with the application of the necessary noise corrections.

Noise data acquired during days that may have experienced adverse weather conditions were compared to that acquired on finer days, and where the data was found to be affected by adverse weather conditions it was discarded from further analysis.

Noise Monitoring Descriptors

Noise loggers determine L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels of the existing noise environment. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1%, 10% and 90% of the sample time respectively. The L_{A1} is indicative of maximum noise levels due to individual noise events such as the occasional passby of a heavy vehicle. The L_{A90} level is normally taken as the background noise level. The L_{Aeq} level is the equivalent continuous sound level and contains the same sound energy over the sampling period as the actual noise environment with its fluctuating sound levels. While the L_{A10} has in the past been used as a descriptor for traffic noise, the L_{Aeq} is now the standard descriptor for traffic noise, as it takes into account both the level of noise and the number of noise events. The L_{Aeq} is shown in technical literature to best correlate with human annoyance scales.

Noise monitoring data acquired by Wilkinson Murray along the northern-section, were re-processed using Renzo Tonin & Associates computer programs, which strictly follow the EPA's noise analysis requirements, for verification purposes. Where noise monitoring results were found to differ significantly from those reported by Wilkinson Murray, these were replaced with the new results to provide a consistent approach over the entire route.

Table 2.1.1 below describes the long-term noise monitoring locations and surrounding areas.

RENZO TONIN & ASSOCIATES PTY LTD

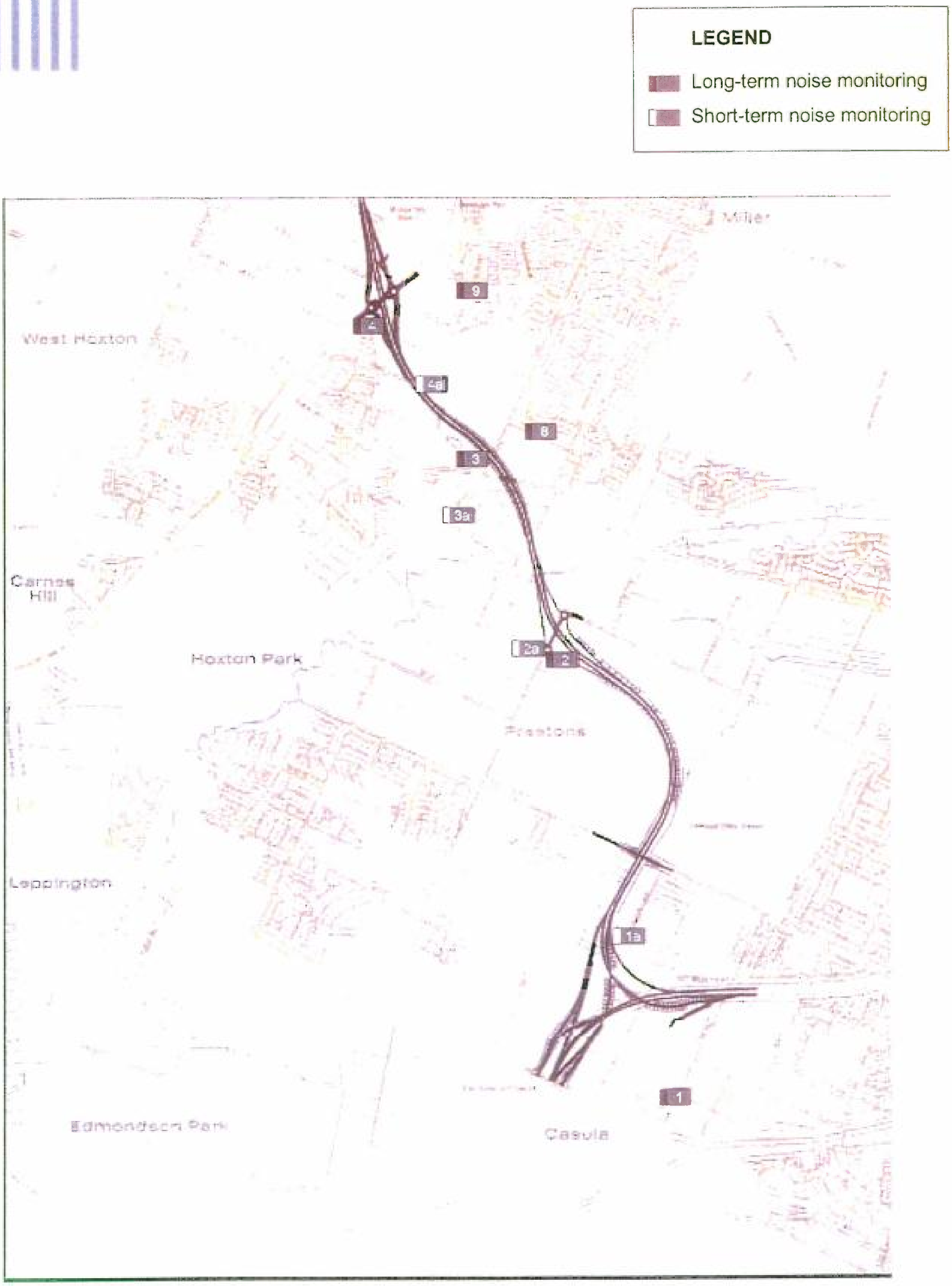


Figure 2.1 - Noise monitoring locations

LEGEND

Long-term noise monitoring

Short-term noise monitoring

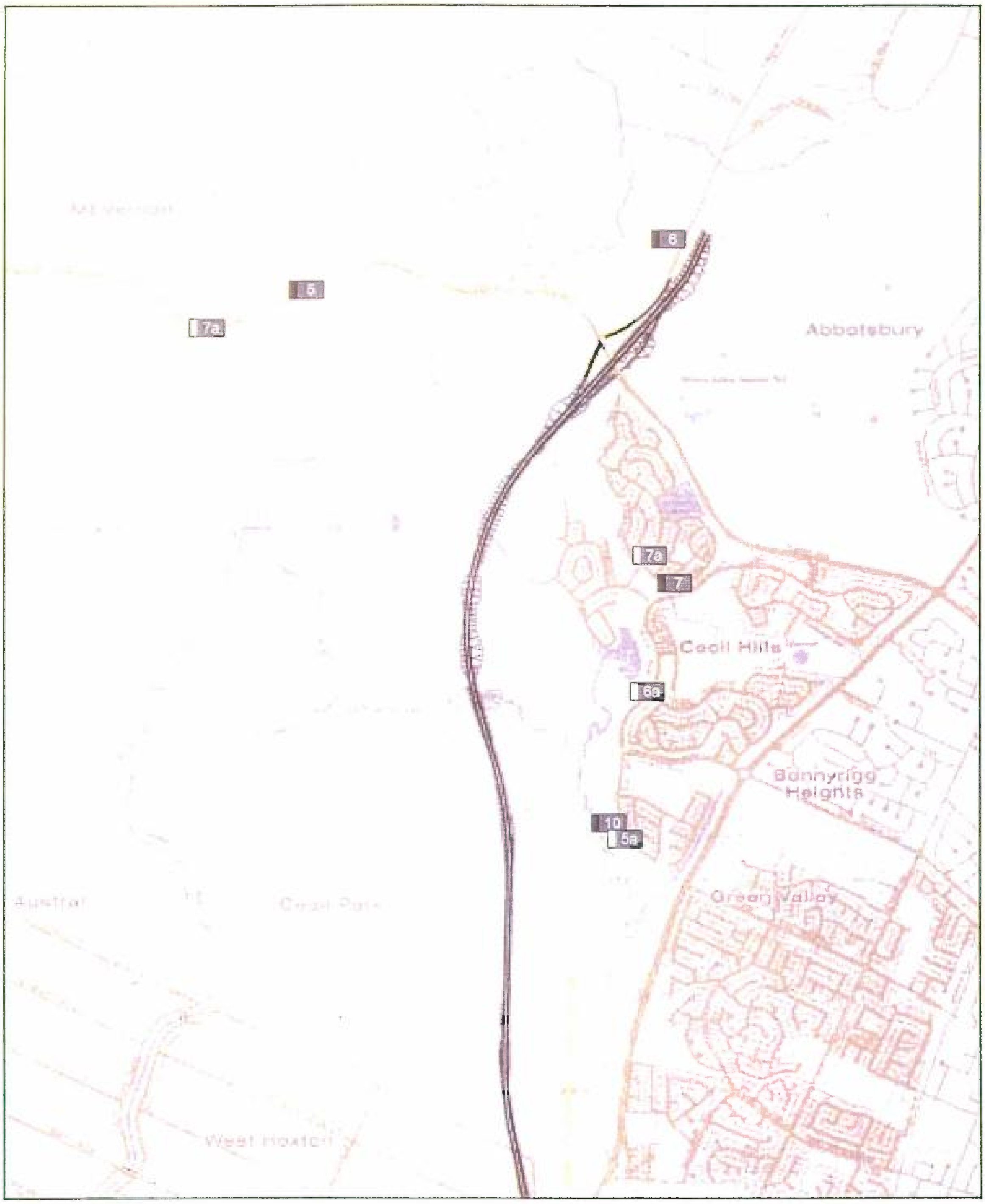


Figure 2.2 - Noise monitoring locations

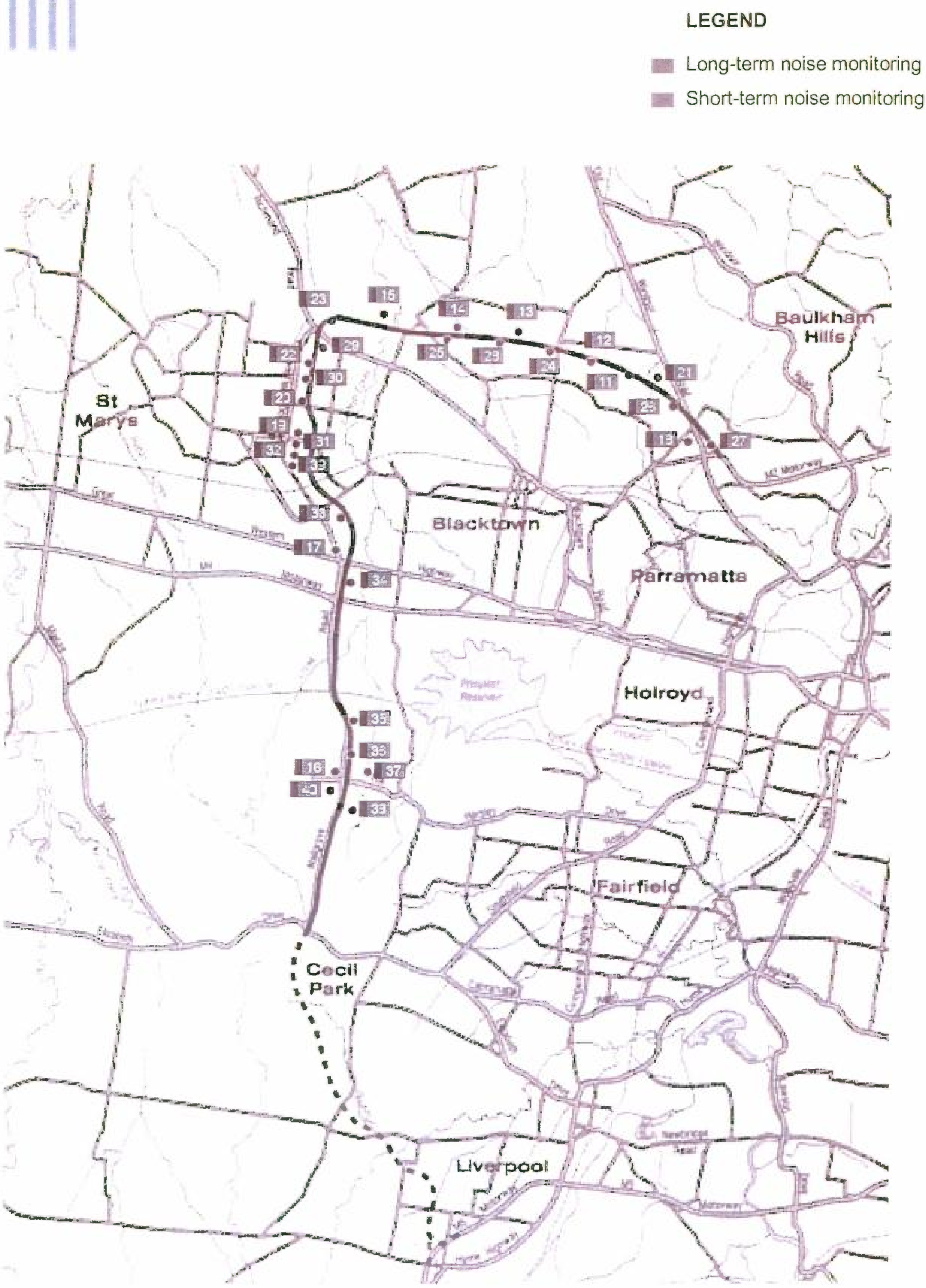


Figure 2.3 - Noise monitoring locations

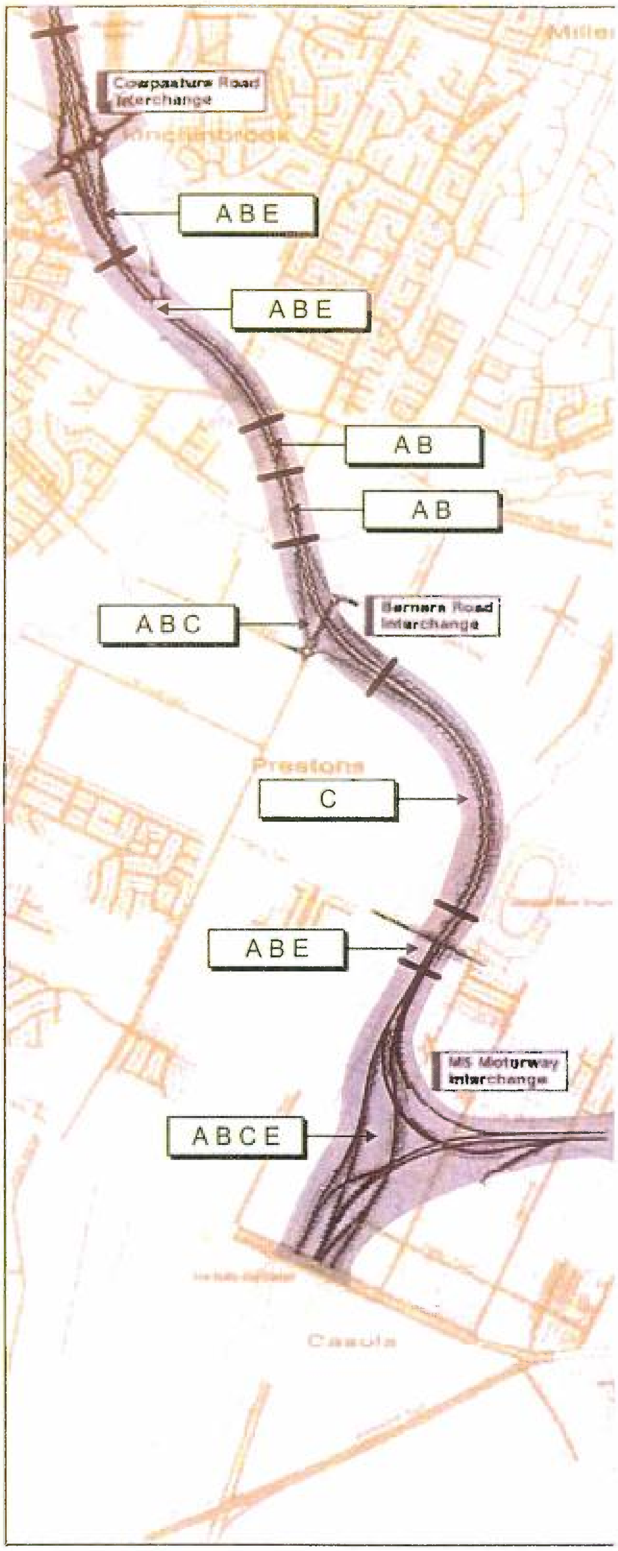


Figure 3.7.2(a) - Construction activities

TABLE 2.1.1 LONG-TERM NOISE MONITORING LOCATIONS ALONG THE WSO		
Location	**Address**	**Monitoring Period**
1	Wattle and Beech Roads, Casula	9/8/1995 to 17/8/1995
2	Bernera Road and Yarrawa Street, Prestons	9/8/1995 to 17/8/1995
3	Hoxton Park Road, Hoxton Park	13/11/1995 to 20/11/1995
4	Cowpasture Road, Hinchinbrook	13/11/1995 to 20/11/1995
5	Elizabeth Drive, Cecil Hills	13/11/1995 to 20/11/1995
6	87-95 Wallgrove Road, Cecil Hills	9/8/1995 to 17/8/1995
7	85 Balmoral Circuit, Cecil Hills	4/9/98 to 8/9/98
8	25 Topnot Avenue, Hoxton Park	3/12/1998 to 11/12/1998
9	11 Linne Place, Hinchinbrook	3/12/1998 to 8/12/1998
10	20 Lascelles Street, Cecil Hills	3/12/1998 to 11/12/1998
11	44 Sporing Avenue, Kings Langley	27/9/1995 to 3/10/1995
12	64 Shanke Crescent, Kings Langley	27/9/1995 to 3/10/1995
13	28 Sampson Crescent, Kings Park	27/9/1995 to 3/10/1995
14	4 Foster Place, Quakers Hill	27/9/1995 to 3/10/1995
15	112 Symonds Road, Dean Park	27/9/1995 to 3/10/1995
16	Horsley Park Public School – inside classroom on Western side of site with windows facing Wallgrove Rd	4/10/1995 to 9/10/1995
17	Eastern Creek Public School – inside classroom on Eastern boundary, adjoining Rooty Hill Road South	4/10/1995 to 9/10/1995
18	Seven Hills North Public School – outside classroom on Eastern side of grounds facing Old Windsor Road	20/11/1995 to 28/11/1995
19	9 Gilpin Place, Blacktown	4/10/1995 to 9/10/1995
20	12 Lambert Avenue, Blacktown	4/10/1995 to 8/10/1995
21	Lot 228 Fernview Place, Kellyville	4/10/1995 to 8/10/1995
22	19 Natalie Place, Oakhurst	4/10/1995 to 8/10/1995
23	14 Durward Street, Dean Park	10/10/1995 to 15/10/1995
24	21 Wellesley Crescent, Kings Park	10/10/1995 to 15/10/1995
25	23 Chaplin Crescent, Quakers Hill	10/10/1995 to 15/10/1995
26	10 Mercury Place, Kings Langley	16/10/1995 to 19/10/1995
27	1/57 Valerie Avenue, Winston Hills	19/10/1995 to 23/10/1995
28	146 Donohue Street, Kings Park	16/10/1995 to 19/10/1995

TABLE 2.1.1 LONG-TERM NOISE MONITORING LOCATIONS ALONG THE WSO		
Location	**Address**	**Monitoring Period**
29	17 Vicky Place, Oakhurst	19/10/1995 to 23/10/1995
30	23 Shaughnessy Street, Oakhurst	19/10/1995 to 23/10/1995
31	1/132 Station Street, Rooty Hill	16/10/1995 to 19/10/1995
32	68 Station Street, Rooty Hill	16/10/1995 to 19/10/1995
33	5 Church Street, Rooty Hill	16/10/1995 to 19/10/1995
34	41 Pikes Lane, Eastern Creek	16/10/1995 to 19/10/1995
35	700-714 Wallgrove Road, Horsley Park	16/10/1995 to 19/10/1995
36	285-309 Wallgrove Road, Horsley Park	16/10/1995 to 19/10/1995
37	Lot 99 The Horsley Drive, Horsley Park	23/10/1995 to 27/10/1995
38	8 Southdown Road, Abbotsbury	16/10/1995 to 19/10/1995
39	24 Station Street, Rooty Hill	20/11/1995 to 28/11/1995
40	529-543 Wallgrove Road, Horsley Park	16/10/1995 to 19/10/1995

2.2. EXISTING AMBIENT & BACKGROUND NOISE LEVELS

Areas of most impact

The areas along the proposed route that would potentially be most affected by WSO traffic noise, are those currently removed from busy roads, have quiet existing ambient noise levels and are located adjacent to the proposed route.

As the existing noise environment varies from one point to another along the length of the proposal, the proposed road has been dissected into sections and the existing noise environment has been broadly established for each section.

Areas with high noise levels were affected mostly by traffic noise and to a lesser extent non-traffic noise (other general noise from surrounding sources). Conversely, in areas with low noise levels, the component of non-traffic noise is significant, however traffic noise is still the main noise contributor for those areas.

Tables 2.3, 2.4 and 2.5 of the Renzo Tonin & Associates working paper present the actual monitoring results for each monitoring location for the southern section of the route, while Table 3.3 of the Wilkinson Murray working paper presents the actual monitoring results for each monitoring location for the northern section of the route. It is noted that Table 26.2 of the EIS incorrectly repeats the $L_{Aeq,15hr}$ results in place of the $L_{Aeq,9hr}$ results and the L_{A90} results, therefore only Table 3.3 of the working paper should be referred to for the noise monitoring results as processed by Wilkinson Murray for the northern section.

Existing traffic and background noise long-term noise monitoring locations

Table 2.2.1 below, presents the results of long-term noise monitoring undertaken by both Renzo Tonin & Associates and Wilkinson Murray. For the purpose of consistency, the noise data from all Wilkinson Murray locations, except for those indicated, were re-processed by Renzo Tonin & Associates using computer programs, which follow the EPA's present data analysis requirements.

Short-term noise monitoring results are not presented herein as these are presented in the Renzo Tonin & Associates Working Paper No 5 (Ref: T440-08F03(rev2)).

TABLE 2.2.1 - LONG-TERM NOISE MONITORING RESULTS

Location	Description	$L_{Aeq,15hr}$ dB(A)	$L_{Aeq,9hr}$ dB(A)	L_{A90} , dB(A)		
				Day	Eve	Night
1	Wattle and Beech Roads, Casula	60	58	45	51	46
2	Bernera Rd & Yarrawa St, Prestons	67	63	48	50	42
3	Hoxton Park Road, Hoxton Park	74	69	60	52	37
4	Cowpasture Road, Hinchinbrook	75	70	58	50	34
5	Elizabeth Drive, Cecil Hills	71	67	53	46	37
6	87-95 Wallgrove Road, Cecil Hills	70	66	49	44	36
7	85 Balmoral Circuit, Cecil Hills	56	50	42	38	33
8	25 Topnot Avenue, Hoxton Park	56	50	45	43	37
9	11 Linne Place, Hinchinbrook	57	47	41	40	33
10	20 Lascelles Street, Cecil Hills	57	47	36	36	30
11	44 Sporing Avenue	49	45	38	40	33
12	64 Shanke Crescent	52	44	36	35	31
13	28 Sampson Crescent	49	41	39	36	30
14	4 Foster Place	51	45	38	44	39
15	112 Symonds Road	52	50	39	45	40
16 *	Horsley Park Public School	$L_{Aeq\,1hr}$ = 51[4]	n/a	45	n/a	n/a
17 *	Eastern Creek Public School	$L_{Aeq\,1hr}$ = 55[4]	n/a	43	n/a	n/a
18 *	Seven Hills North Public School	$L_{Aeq\,1hr}$ = 43[4]	n/a	50	n/a	n/a
19	9 Gilpin Place	55	48	39	38	36
20	12 Lambert Avenue	51	46	44	38	33
21	Lot 228 Fernview Place	55	45	40	40	35
22	19 Natalie Place	50	45	37	38	31
23	14 Durward Street	55	47	37	39	33
24	21 Wellesley Crescent	48	45	37	41	32
25	23 Chaplin Crescent	67	60	35	39	32

TABLE 2.2.1 - LONG-TERM NOISE MONITORING RESULTS						
Location	Description	$L_{Aeq,15hr}$ dB(A)	$L_{Aeq,9hr}$ dB(A)	L_{A90}, dB(A)		
				Day	Eve	Night
26	10 Mercury Place	53	50	45	44	34
27	1/57 Valerie Avenue	52	43	42	38	33
28	146 Donohue Street	51	45	37	35	30
29	17 Vicky Place	52	47	47	38	36
30	23 Shaughnessy Street	50	46	42	43	35
31	1/132 Station Street	59	57	48	44	40
32	68 Station Street	61	55	44	41	38
33	5 Church Street	49	49	40	42	38
34	41 Pikes Lane	54	55	45	48	44
35	700-714 Wallgrove Rd	64	62	54	50	34
36	285-309 Wallgrove Rd	59	57	51	49	38
37	Lot 99 The Horsley Drive	58	56	47	46	35
38	8 Southdown Road	50	46	39	36	30
39 *	24 Station Street	58	52	44	-	-
40	529 543 Wallgrove Rd	63	60	50	44	36

Notes:
1. Locations 1-10 monitored by Renzo Tonin & Associates
2. Locations 11-40 monitored by Wilkinson Murray
3 All results presented above were processed by Renzo Tonin & Associates except at the locations marked with * which are as presented in the Wilkinson Murray working paper
4. Indoor noise levels with windows open

Existing traffic and background noise in sections and NCAs along route

Table 2.2.2 below, presents a guide to the representative traffic noise levels and background noise levels established for each section along the proposed route. It is noted that areas located near busy arterial and local roads were found to have significantly greater noise levels than those presented here. Conversely, areas further away from busy arterial and local roads, were found to have significantly lower noise levels than those presented here.

It is further noted that the noise levels presented in ***Table 2.2.2*** have not necessarily been acquired from the nearest or most affected premises along the proposed route, but rather from a representative location for each section along the proposed route. Noise levels are expected to vary widely within each section, as noted above, therefore the levels presented in the table should only be used for guidance purposes. Noise monitoring is recommended later in this report within each noise catchment area.

With the available data, to determine existing noise levels along the proposed road corridor, the following steps were taken:

- Primarily, the data obtained from long-term noise monitoring from nearby locations was used to establish, in a broad sense, each sections ambient noise levels along the route.

- Where data available from long-term noise monitoring was found to be insufficient or unrepresentative for the majority of the area, reference was made to additional noise data. Additional noise data was obtained by correlating short-term and long-term noise monitoring results where a distinct, repeatable noise pattern was evident in each period of interest.

- Where ambient noise levels were found to be controlled by one particular road, noise levels were also corrected for distance, where necessary, in order to better represent the ambient noise environment for each section.

- As traffic noise is assessed at 1 metre from building facades, a 2.5dB(A) facade correction was applied to all measurement results that were acquired in the free field. This correction accounts for the effect of sound reflections from facades and is recommended in the EPA's 'Environmental Criteria for Road Traffic Noise' and Australian Standard 1055.1-1997 'Acoustics – Description and measurement of environmental noise – Part 1: General Procedures'.

The L_{90} noise levels presented in ***Table 2.2.2*** are considered to be conservatively low levels, because these were measured as early as 1995 when less development existed in the area. This will result in the setting of more stringent construction noise criteria, which subsequently leads to a conservative construction noise assessment.

TABLE 2.2.2 - EXISTING TRAFFIC & BACKGROUND NOISE LEVELS ESTABLISHED FOR EACH SECTION OF THE PROPOSED ROAD, dB(A)

Road Section Description	Road Chainage Range	NCA's within Road Chainage Range	Traffic Noise Levels		L_{90} Background Noise Levels		
			$L_{eq,15\,hr}$	$L_{eq,9\,hr}$	Day	Eve.	Night
M5 Motorway to north of Kurrajong Rd (north of Sule College)	S 0 – S 1,500	E1, E2, E3, E4, W1, W2	55	52	43	48	44
North of Sule College to Illaroo Rd	S 1,500 – S 3,000	E5, E6, W3, W4, W5, W6	58	55	39	41	33
Illaroo Rd to Hinchinbrook Creek	S 3,000 – S 4,000	E6, E7, E8, W7	56	50	45	43	37
Hinchinbrook Creek to mid-way of Hoxton Park Airport runway	S 4,000 – S 6,000	E8, E9, E10, E11, W8, W9, W10, W11, W12, W13, W14	59	49	41	40	33
Mid-way of Hoxton Park Airport runway to Chainage 8000	S 6,000 – S 8,000	E12, E12A, E13, W14	59	49	36	36	30
Chainage 8,000 to Elizabeth Drive	S 8,000 – S 9,500	E13, E14, E15, E16	56	50	42	38	33
Elizabeth Drive to end of interchange with Orbital	S 9,500 – S 10,500	E16, E17, E18	67	63	51	44	35
Elizabeth Dr – The Horsley Drive	N 2,500 – N 6,000	1E, 1W	63	60	50	44	36
The Horsley Drive – Old Wallgrove Rd Interchange	N 6,000 – N 10,000	2E, 2W	59	57	51	49	38
Old Wallgrove Rd – M4 Interchange	N 10,000 – N 11,000	3	54	55	45	48	44
M4 Interchange – Great Western Hwy Interchange (east)	N 11,000 – N 12,000	4	54	55	45	48	44

TABLE 2.2.2 - EXISTING TRAFFIC & BACKGROUND NOISE LEVELS ESTABLISHED FOR EACH SECTION OF THE PROPOSED ROAD, dB(A)							
Road Section Description	Road Chainage Range	NCA's within Road Chainage Range	Traffic Noise Levels		L_{90} Background Noise Levels		
			$L_{eq,15\,hr}$	$L_{eq,9\,hr}$	Day	Eve.	Night
M4 Interchange – Great Western Hwy Interchange (west)	N 11,000 – N 12,000	5	54	55	45	48	44
Great Western Hwy Interchange – Eastern Rd Overpass	N 12,000 – N 14,000	6	49	49	40	42	38
Eastern Rd – Main Western Railway	N 14,000 – N 14,500	7	49	49	40	42	38
Railway – Woodstock Av	N 14,500 – N 15,500	8	58	52	44	-	-
Woodstock Av – Power St Interchange	N 15,500 – N 16,500	9	55	48	39	38	36
Power St Interchange – Lamb St	N 16,500 – N 17,500	10	51	46	44	38	33
Lamb St – Florence St (west)	N 17,500 – N 18,000	11	50	46	42	43	35
Lamb St – Florence St (east)	N 17,500 – N 18,000	12	50	46	42	43	35
Florence St – Richmond Rd Interchange (east)	N 18,000 – N 18,500	13	50	45	37	38	31
Florence St – Richmond Rd Interchange (west)	N 18,000 – N 18,500	14	50	45	37	38	31
Richmond Rd Interchange – Symonds Rd	N 18,500 – N 20,500	15S, 15N	55	47	37	39	33
Symonds Rd - Quakers Hill Parkway	N 20,500 – N 21,500		52	50	39	45	40
Quakers Hill Parkway – Quakers Rd	N 21,500 – N 22,000	16	52	50	39	45	40
Quakers Rd – Richmond Railway (north)	N 22,000 – N 23,000	17	51	45	38	44	39
Quakers Rd – Richmond Railway (south)	N 22,000 – N 23,000	18	51	45	38	44	39
Richmond Railway – Sunnyholt Rd (north)	N 23,000 – N 25,500	19	49	41	39	36	30
Richmond Railway – Sunnyholt Rd (south)	N 23,000 – N 25,500	20	48	45	37	41	32
Sunnyholt Rd – Old Windsor Rd Interchange (north)	N 25,500 – N 29,500	21	55	45	40	40	35
Sunnyholt Rd – Old Windsor Rd Interchange (south)	N 25,500 – N 29,500	22	53	50	45	44	34
Old Windsor Rd – Abbott Rd Interchange (north)	N 29,500 – N 31,000	23	52	43	42	38	33
Old Windsor Rd – Abbott Rd Interchange (south)	N 29,500 – N 31,000	24	52	43	42	38	33

Source: Renzo Tonin and Associates.

Note: S – WSO Section South of Elizabeth Drive

N – WSO Section North of Elizabeth Street

3. ENVIRONMENTAL IMPACTS DURING CONSTRUCTION

3.1 INTRODUCTION

During the construction of the WSO, residential and commercial receivers adjacent to the site may be potentially affected by construction noise and/or vibration impacts, particularly when works are being undertaken immediately adjacent to the relevant receiver locations.

In general, construction works would be undertaken only during daytime hours. However, some construction works may need to be carried out during the evening and night time periods.

The nearest and potentially most affected residential and commercial occupancies have been identified for the entire WSO route. This section of the report identifies the potential noise and vibration impact of construction activities on the residential and commercial receivers and outlines management strategies to control these impacts.

The scope of the construction activities covered in this assessment is summarised in ***Table 3.1*** below.

TABLE 3.1 - PROPOSED ACTIVITIES & EQUIPMENT

Activity	Proposed Equipment
Bridgeworks	➢ Piling Drilling Rig ➢ Concrete Pump ➢ Concrete Truck ➢ Delivery Truck ➢ Dump Truck ➢ Crane ➢ Assorted pneumatic jack hammers ➢ Excavator ➢ Concrete Vibrator
Bridge Approach Works	➢ Excavator ➢ Dump Truck ➢ Delivery Truck ➢ Concrete Truck ➢ Roller ➢ Grader ➢ Backhoe ➢ Concrete Paver ➢ Asphalt Paver
	➢ Scraper ➢ Dump Truck ➢ Vibratory Roller ➢ Spreader ➢ Dozer

TABLE 3.1 - PROPOSED ACTIVITIES & EQUIPMENT	
Activity	**Proposed Equipment**
Embankment Construction	➢ Excavator ➢ Concrete Truck ➢ Delivery Truck ➢ Concrete Paver ➢ Asphalt Paver ➢ Roller
Bulk Excavation	➢ Line Drilling ➢ Dozer ➢ Excavator ➢ Scraper ➢ Dump Truck ➢ Grader ➢ Concrete Paver ➢ Asphalt Paver ➢ Roller
Noise Wall Construction	➢ Delivery Truck ➢ Concrete Truck ➢ Excavator ➢ Drilling Rig ➢ Crane

3.2 METHOD USED TO ASSESS IMPACTS

Detailed information regarding construction programs, plant types and numbers, construction methods, etc is not available at the concept design stage. However, various plant and construction duration have been estimated to assess construction noise impacts.

Potential noise impacts during construction are usually assessed by comparing the noise emitted by construction machinery calculated at the boundary of the nearest residence, with existing background noise levels measured in the absence of the construction noise. Sound power levels and sound pressure levels at standard distances of machinery can be used to determine the noise levels resulting from the operation of a number of machines at each receiver point of interest.

3.3 CONSTRUCTION NOISE CRITERIA

Noise level objectives for scheduled activities, such as construction of the proposed roadway, are subject to licensed approvals from the EPA. Once a roadway is designated as a scheduled premise or activity under the *Protection of the Environment Operations Act 1997*, the EPA's criteria apply. These guidelines are contained in Chapter 171 of the EPA's *Environmental Noise Control Manual (1994)*.

3.3.1 Residential Receivers

Residential Construction Criteria

The EPA guidelines for construction plant noise sets out three categories for assessment criteria depending on the period of noise exposure. These are:

- **Short-term** - 4 weeks or less. The L_{10} level of construction noise should not exceed the L_{90} background noise level by more than 20dB(A).
- **Medium-term** - greater than 4 weeks but less than 26 weeks. The L_{10} level of construction noise should not exceed the L_{90} background noise level by more than 10dB(A).
- **Long-term** - greater than 26 weeks. The L_{10} level of construction noise should not exceed the L_{90} background noise level by more than 5dB(A).

Construction hours

Also, construction is limited to between the hours of 7am and 6pm Monday to Friday, and between 7am and 1pm Saturday, if construction noise is inaudible at residential premises, otherwise 8am to 1pm Saturday. No construction work is to take place on Sundays or Public Holidays.

Work outside normal hours would only be carried out in special circumstances and only upon gaining approval from the EPA and liaising with councils and the local community. However, it is envisaged that there will be times when the road contractor will require to work after hours, especially when work is carried out near busy adjoining roads, interchanges and when constructing ramps, overpasses and underpasses, so to minimise interference to drivers.

It is understood that approval of out-of-hours work will be the exception rather than the rule and that judgement will be made on the merits of each application on a case-by-case basis, given that most construction noise complaints occur during night-time works. It is also understood that the EPA reserves the right to impose additional noise controls and a restriction in working hours where noise and vibration levels are shown to be clearly unacceptable, as part of the licence conditions.

Table 3.3.1 indicates the construction noise criteria under the EPA's guidelines for each section of the proposed road.

TABLE 3.3.1 L_{10} CONSTRUCTION NOISE CRITERIA FOR EACH SECTION OF THE PROPOSED ROAD, dB(A)

Chainage	NCA's within Road Chainage Range	Established L_{90} Background Noise Level			Duration Less Than 4 Weeks L_{10}			Duration 4 to 26 Weeks L_{10}			Duration More Than 26 weeks L_{10}		
		Day	Eve	Night	Day	Eve	Night	Day	Eve	Night	Day	Eve	Night
S 0 – S 1,500	E1, E2, E3, E4, W1, W2	43	48	44	63	68	64	53	58	54	**48**	**53**	**49**
S 1,500 – S 3,000	E5, E6, W3, W4, W5, W6	39	41	33	59	61	53	49	51	43	**44**	**46**	**38**
S 3,000 – S 4,000	E6, E7, E8, W7	45	43	37	65	63	57	55	53	47	**50**	**48**	**42**
S 4,000 – S 6,000	E8, E9, E10, E11, W8, W9, W10, W11, W12, W13, W14	41	40	33	61	60	53	51	50	43	**46**	**45**	**38**

TABLE 3.3.1 L_{10} CONSTRUCTION NOISE CRITERIA FOR EACH SECTION OF THE PROPOSED ROAD, dB(A)

Chainage	NCA's within Road Chainage Range	Established L_{90} Background Noise Level			Duration Less Than 4 Weeks L_{10}			Duration 4 to 26 Weeks L_{10}			Duration More Than 26 weeks L_{10}		
		Day	Eve	Night	Day	Eve	Night	Day	Eve	Night	Day	Eve	Night
S 6,000 – S 8,000	E12, E12A, E13, W14	36	36	30	56	56	50	46	46	40	**41**	**41**	**35**
S 8,000 – S 9,500	E13, E14, E15, E16	42	38	33	62	58	53	52	48	43	**47**	**43**	**38**
S 9,500 – S 10,500	E16, E17, E18	51	44	35	71	64	55	61	54	45	**56**	**49**	**40**
N 2,500 – N 6,000	1E, 1W	48	44	36	68	64	56	58	54	46	**53**	**49**	**41**
N 6,000 – N 10,000	2E, 2W	50	49	38	70	69	58	60	59	48	**55**	**54**	**43**
N 10,000 – N 11,000	3	45	48	44	65	68	64	55	58	54	**50**	**53**	**49**
N 11,000 – N 12,000	4, 5	45	48	44	65	68	64	55	58	54	**50**	**53**	**49**
N 12,000 – N 14,000	6	40	42	38	60	62	58	50	52	48	**45**	**47**	**43**
N 14,000 – N 14,500	7	40	42	38	60	62	58	50	52	48	**45**	**47**	**43**
N 14,500 – N 15,500	8	44	-	-	64	-	-	54	-	-	**49**	-	-
N 15,500 – N 16,500	9	37	38	36	57	58	56	47	48	46	**42**	**43**	**41**
N 16,500 – N 17,500	10	36	38	33	56	58	53	46	48	43	**41**	**43**	**38**
N 17,500 – N 18,000	11, 12	38	43	35	58	63	55	48	53	45	**43**	**48**	**40**
N 18,000 – N 18,500	13, 14	37	38	31	57	58	51	47	48	41	**42**	**43**	**36**
N 18,500 – N 20,500	15S, 15N	36	39	33	56	59	53	46	49	43	**41**	**44**	**38**
N 20,500 – N 21,500	-	37	45	40	57	65	60	47	55	50	**42**	**50**	**45**
N 21,500 – N 22,000	16	37	45	40	57	65	60	47	55	50	**42**	**50**	**45**
N 22,000 – N 23,000	17, 18	37	44	39	57	64	59	47	54	49	**42**	**49**	**44**
N 23,000 – N 25,500	19, 20	39	36	30	59	56	50	49	46	40	**44**	**41**	**35**
N 25,500 – N 29,500	21, 22	40	40	35	60	60	55	50	50	45	**45**	**45**	**40**
N 29,500 – N 31,000	23, 24	42	38	33	62	58	53	52	48	43	**47**	**43**	**38**

Note: Given that construction is likely to continue for a period greater than 26 weeks at any one location, and consistent with a conservative assessment, comparisons between predicted noise levels and the construction noise criteria should be made against the bold values in ***Table 3.3.1*** above as these are the more stringent of the criteria.

Although the total duration of the project works will be in excess of 26 weeks, the short term noise limits (for work periods less than 4 weeks and less than 26 weeks), represent a practical compromise that could be negotiated between the project and the community. That is the duration of each of the EPA's noise level objectives refer to the cumulative periods of noise exposure at any noise receiver adjacent to the construction site, not to the duration of the overall construction project. For example, for dwellings adjacent to ramps and interchanges, but further removed from the WSO carriageways, may expect that the higher noise level limit of background noise + 20dB(A) should apply for only 4 weeks. The road contractor should therefore plan their work so that higher noise level activities be confined to as short a period as possible after implementing the construction noise mitigation measures implemented in ***Section 3.8*** of this report.

The noise generated by construction plant and activities will vary for each receiver location as construction progresses along the proposal corridor. For most of the construction period, equipment will not be operating immediately adjacent to any single receiver. Therefore, it is appropriate to assess construction noise levels against the short-term and medium-term guidelines indicated above.

3.3.2 Educational Facilities and Places of Worship

Guidance is obtained from noise levels recommended in AS 2107-1987 "Acoustics - Recommended Design Sound Levels and Reverberation Times for Building Interiors" to adequately limit regenerated noise. AS2107 refers to steady ambient noise in rooms. Noise levels from short-term construction however, may exceed the recommended levels without causing disturbance, provided the margins above the steady ambient noise levels are not excessive.

Given that construction will occur for a significant period of time and assuming the worst-case that noise from construction activities are fairly steady in level, then the recommended maximum internal noise levels as stated in AS2107, are used to set internal noise criteria suitable for this impact study. Subsequently, using a typical noise loss of 10dB(A) through an open window sets outdoor noise limits.

Therefore, the following noise criteria are recommended:

- **Educational Buildings: Teaching Spaces:**

  Indoor = 45dB(A); Outdoor = 55dB(A)

- **Places of Worship:**

  Indoor = 40dB(A); Outdoor = 50dB(A)

3.3.3 Commercial and Industrial Premises

The noise criteria for commercial and industrial premises may be up to 5dB(A) and 10dB(A) higher, respectively, than those set for residential receivers in ***Table 3.3.1***.

3.3.4 Sleep Arousal

See ***Section 2*** for the sleep arousal criteria applicable to construction activities along the entire WSO route.

3.3.5 Truck Noise Assessment Criteria

No specific criteria for construction traffic

The EPA does not currently recommend noise goals for vehicular sources in relation to construction projects once the vehicles have left the construction site precinct. That is, when construction vehicles move onto public roads, the vehicle noise may be perceived as part of the general road traffic. Given the long-term nature of the construction activities which are likely to take place during the construction of the WSO, guidance may be obtained from the EPA's "Environmental Criteria for Road Traffic Noise" for assessing WSO related construction road traffic noise.

Note that this report does not assess the noise impact associated with road traffic noise due to construction vehicles, as the number of construction vehicles is not known at this stage of the project. The relevant Criteria for arterial and collector roads are detailed in ***Table 3.3.2***.

TABLE 3.3.2 EPA'S POLICY – ENVIRONMENTAL CRITERIA FOR ROAD TRAFFIC NOISE			
Type of Development	**Criteria**		
	Day, dB(A)	**Night, dB(A)**	**Where Criteria are Already Exceeded**
7. Land use developments with potential to create additional traffic on existing freeways/arterials	$L_{Aeq(15hr)}$60	$L_{Aeq(9hr)}$55	Where feasible, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB
8. Land use developments with potential to create additional traffic on collector road	$L_{Aeq(1hr)}$60	$L_{Aeq(1hr)}$55	Where feasible and reasonable, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating time of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB

3.4 VIBRATION CRITERIA

Categories of vibration

The effects of ground vibration on buildings near road and bridge construction may be summarised into the following three categories:

1. Disturbance to building occupants - Vibration in which the occupants or users of the building are inconvenienced or possibly disturbed,

2. Effects on building contents - Vibration where the building contents may be affected, and,

3. Effects on building structures - Vibration in which the integrity of the building or structure itself may be prejudiced.

Disturbance criteria is most stringent

In general, vibration criteria for human disturbance (1) are more stringent than vibration criteria for effects on building contents (2) and building structural damage (3). Hence, compliance with the more stringent limits dictated by Category 1, would ensure that compliance is also achieved for the other two categories.

3.4.1 Disturbance to building occupants - human comfort

Chapter 174 of the EPA's ENCM presents vibration level limits based on Australian Standard AS 2670.2-1990 "Evaluation of human exposure to whole body vibration – Continuous and shock induced vibration in buildings". It states that for human comfort, vibration from activities such as construction work shall not exceed a prescribed curve of vibration limits expressed in terms of velocity units over a range of frequencies. The set levels aim to protect human comfort (ie Category 1). These vibration limits are well below the levels needed to cause structural damage to buildings and are therefore considered suitable for use in the assessment.

Vibration is assessed in terms of "continuous" or "intermittent / impulsive" vibration criteria. Continuous vibration is vibration that is present at a reasonably steady level for long periods of time, for example vibration from vibratory rollers and compactors. Intermittent or impulsive vibration results from sources such as rock breaking, piling or blasting. Continuous vibration limits are generally more stringent than intermittent / impulsive vibration limits, mainly due to the issue of duration.

The EPA guidelines also require restricting vibration generating activities to within normal construction hours if vibration levels exceed the "continuous" vibration limits. That is, if vibration is not perceivable or within "continuous" vibration limits, then no time restriction should apply.

Based on Chapter 174-2 of the EPA's ENCM, the following ***Table 3.4.1*** presents 'root-mean-squared' (rms) vibration limits presented in terms of velocity levels at one-third octave band frequencies applicable between 8Hz and 80Hz (which is the frequency range of interest for construction) determined for normal construction activities to protect human comfort.

TABLE 3.4.1 – EPA VIBRATION LIMITS TO PROTECT HUMAN COMFORT (RMS)

Place	Time	Continuous	Intermittent or Impulsive
Residential	Daytime	0.2mm/s	6.0mm/s
	Night time	0.14mm/s	2.0mm/s
Office	Daytime	0.4mm/s	12.7mm/s
	Night time	0.4mm/s	12.7mm/s
Workshops	Daytime	0.8mm/s	12.7mm/s
	Night time	0.8mm/s	12.7mm/s

Furthermore, British Standard BS 6472:1992 also provides guidance on potential vibration disturbance to occupants or users of a building.

Table 3.4.2 below summarises peak vibration levels associated with a low probability of adverse comment.

TABLE 3.4.2 BS 6472 VIBRATION CRITERIA FOR HUMAN COMFORT (PEAK)

Type of Space Occupancy	Time of Day	Vibration Levels in mm/s over the Frequency Range 8Hz to 80Hz			
		Continuous Vibration (16h Day, 8h Night)		Impulsive Vibration Excitation (up to 3 Occurrences per Day)	
		Vertical	Horizontal	Vertical	Horizontal
Critical working areas (eg some hospital operating theatres, precision laboratories)	Day	0.14	0.4	0.14	0.4
	Night	0.14	0.4	0.14	0.4
Residential	Day	0.3 to 0.6	0.8 to 1.6	8.4 to 12.6	24 to 36
	Night	0.2	0.6	2.8	8
Offices	Day	0.6	1.6	18	51
	Night	0.6	1.6	18	51
Workshops	Day	1.2	3.2	18	51
	Night	1.2	3.2	18	51

BS 6472 also contains a method to calculate vibration dose information. This allows intermittent vibration to be appropriately assessed.

3.4.2 Effects on building contents

The typical frequency range of road and bridge construction induced ground vibration is approximately 8 Hz to 100 Hz. Over this range the threshold of visible movement of building contents such as plants, pictures, blinds etc is approximately 0.5 mm/s. At vibration levels higher than 0.9 mm/s, audible rattling of loose objects such as crockery can be expected.

3.4.3 Effects on building structures

German Standard DIN 4150 - Part 3:1986 provides guideline levels of vibration velocity for evaluating the effects of vibration in structures. This Standard gives the maximum levels measured in any direction at the foundation or in the plane of the uppermost floor. These values are summarised in ***Table 3.4.3*** below and are generally recognised to be conservative.

TABLE 3.4.3 DIN 4150 STRUCTURAL DAMAGE CRITERIA - SAFE LIMITS FOR BUILDING VIBRATION (RMS)

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

These levels are safe limits up to which no damage due to vibration effects has been observed for the particular class of building. Damage is defined as minor non-structural effects such as cracking in cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls.

3.5 BLASTING CRITERIA

As stated in the EIS noise working papers, blasting is not expected to be undertaken as part of this project. This was re-confirmed with the RTA recently. However, for the sake of completeness, blasting limits and general advice is provided herein to ensure all items are addressed in this study.

Blasting produces ground-borne vibration and air blast over pressure, both of which can cause discomfort and at higher levels, damage to property.

It is important that the blast charge configuration be selected to ensure that EPA goals are not exceeded. Before blasting can commence at any site, critical locations should be identified and appropriate measures taken to limit over-pressure and vibration to acceptable levels. Blasts should be monitored initially at these locations to ensure that predicted over pressure and vibration levels are not exceeded.

The recommended goals for blasting are based on EPA guidelines. These state: "Blasting operations should in most cases be confined to the periods Mondays to Saturdays, 9 am to 3 pm. Blasting outside of those times should be approved only where blasting during the preferred times is clearly impracticable, and should then be limited in number. Blasting at night should be avoided unless it is absolutely necessary."

The following ***Table 3.5.1*** shows the limiting blast over-pressure and ground vibration for the control of blasting impact on critical premises.

TABLE 3.5.1 LIMITING CRITERIA FOR THE CONTROL OF BLASTING IMPACT AT CRITICAL PREMISES

Day	Time of Blasting	Blast Over Pressure Level, dB (linear)	Ground Vibration, peak particle velocity, (mm/sec)
Monday to Saturday	9am-3pm	115	5
Monday to Saturday	6am-9am, 3pm-8pm	105	2
Sunday, Public Holiday	6am-8pm	95	1
Any day	8pm-6am	95	1

In addition, any exceedence above a blast over-pressure of 115dB (linear) should be limited to not more than 5% of the total number of blasts. On these infrequent occasions a maximum limit of 120dB (linear) should not be exceeded at any time.

Ground vibrations above 5 mm/sec should also be limited to not more than 5% of the total number of blasts. On these infrequent occasions a maximum limit of 10 mm/sec should not be exceeded at any time.

3.6 REGENERATED NOISE CRITERIA

Regenerated noise, also termed structure-borne noise, can occur inside residences as a result of a building structure being excited by vibration transferred to it via the ground. This is normally only considered and assessed during the evening and night-time period, and not during daytime as is the plan for construction works here. Therefore, although regenerated noise may occur from time to time due to the planned works, it is the intrusion of airborne noise that is likely to dominate the overall perceived noise indoors. During daytime, therefore only tactile vibration limits would apply in accordance with the EPA's human comfort criteria.

In case construction is necessary on a rare occasion during the evening and night-time, guidance is obtained from noise levels recommended in AS 2107-1987 "Acoustics - Recommended Design Sound Levels and Reverberation Times for Building Interiors" to adequately limit regenerated noise. AS2107 refers to steady ambient noise in rooms. Noise levels from short-term construction however, may exceed the recommended levels without causing disturbance, provided the margins above the steady ambient noise levels are not excessive.

Suitable evening and night-time regenerated noise criteria for residential receivers are therefore 35-40 dB(A) for bedrooms and 40-45 dB(A) for general living areas. These limits would only apply during evening and night-time when background noise levels are quietest and people's repose is potentially affected.

3.7 IMPACTS DURING CONSTRUCTION

3.7.1 General Noise Impacts

The noise generated by construction equipment will rise and fall as construction progresses along the WSO route. The equipment may therefore be assumed to have a moving acoustic centre, which for most of the construction period will not be immediately adjacent to a single residence. Construction plant noise levels from the operation of a number of machines are predicted at the nearest affected residence (NAR) in each noise catchment area from the centre of the road works.

The EPA recommend that all possible steps should be taken to silence construction site equipment so as to minimise the impact of construction noise.

Construction would be undertaken in stages, namely earthworks, construction of bridges and elevated road structures and laying of the road surface. In general, the extent of noise impact to residents would depend on the type of operation being undertaken. This can be divided into a number of activities, outlined below:

Construction of Bridges and Elevated Road Structures

Construction of bridges would commence with foundations. Bored or driven piles could be used depending on the location. Bridge decks over existing roads would generally be precast concrete or steel beams supporting a cast in-situ concrete deck. Otherwise, bridges would be concrete cast in-situ.

Earthworks for Road Sections In Cut or On Fill

Both minor and major excavation and filling would be required. Fill would mainly be supplied from cutting spoil. Transportation routes for fill would be selected to minimise the use of public roads wherever possible. A temporary haul road along the route would be established at the beginning of the construction period to assist in this. Equipment used would be bulldozers, scrapers, excavators, graders, rollers, compressors and compacters. It is expected that mechanical ripping will be sufficient to form all cuts along the Western Sydney Orbital alignment so that blasting will not be required. The construction of the entire alignment will take some years, therefore construction is likely to take place in several campaigns.

Laying of Pavement

The pavement surface would be applied by specialist machines. Open Graded Asphaltic Concrete is required to provide an additional 2 to 3 dB(A) reduction in traffic noise levels required primarily for the educational institutions located along the route.

Of these three stages, the highest construction noise levels would be generated during excavation and earthworks stages.

Major equipment to be used would include bulldozers, scrapers, graders, excavators, rollers, vibratory rollers, piling rigs, compressors and paving machines. Typical noise emission levels for this road construction equipment are shown in ***Table 3.7.1***.

Table 3.7.1 presents typical sound power levels obtained from AS2436 – 1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites", BS5228 – 1 1984 "Noise Control on Construction and Open Sites", and from Renzo Tonin & Associates' data library.

Table 3.7.1 SOUND POWER LEVELS FOR PROPOSED CONSTRUCTION EQUIPMENT

Activity	Proposed Equipment	SWL re: 1pW, dB(A)		
		Range	Max (L_1)	Typical (L_{10})
Bridgeworks	Piling Drilling Rig	112-124	124	114
	Concrete Pump	100-109	109	107
	Concrete Truck	108-110	110	110
	Delivery Truck	102-113	113	108
	Dump Truck	102-113	113	108
	Crane	110-115	115	113
	Assorted pneumatic jackhammers	110-115	115	113
	Excavator	105-115	115	112
	Concrete Vibrator	101-105	105	105
Bridge Approach Works	Excavator	105-115	115	112
	Dump Truck	102-113	113	108
	Delivery Truck	102-113	113	108
	Concrete Truck	108-110	110	110
	Roller	100-113	113	107
	Grader	105-115	115	110
	Backhoe	110-115	115	111
	Concrete Paver	110-114	114	112
	Asphalt Paver	110-114	114	114

Table 3.7.1 SOUND POWER LEVELS FOR PROPOSED CONSTRUCTION EQUIPMENT				
Activity	Proposed Equipment	SWL re: 1pW, dB(A)		
		Range	Max (L_1)	Typical (L_{10})
Embankment Construction	Scraper	110-115	115	113
	Dump Truck	102-113	113	108
	Vibratory Roller	108-110	110	109
	Spreader	95-98	98	98
	Dozer	105-118	118	112
	Excavator	105-115	115	112
	Concrete Truck	108-110	110	110
	Delivery Truck	102-113	113	108
	Concrete Paver	110-114	114	112
	Asphalt Paver	110-114	114	114
	Roller	100-113	113	107
Bulk Excavation	Line Drilling	112-124	124	114
	Dozer	105-118	118	112
	Excavator	105-115	115	112
	Scraper	110-115	115	113
	Dump Truck	102-113	113	108
	Grader	105-115	115	110
	Concrete Paver	110-114	114	112
	Asphalt Paver	110-114	114	114
	Roller	100-113	113	107
Noise Wall Construction	Delivery Truck	102-113	113	108
	Concrete Truck	108-110	110	110
	Excavator	105-115	115	112
	Drilling Rig	112-124	124	114
	Crane	110-115	115	113

Note: The sound power data within the column marked "Typical" has been used in this study to calculate typical noise levels at the nominated assessment locations.

Noise data sources The sound power levels for the majority of activities presented in the above table are based on maximum levels given in Table D2 of Australian Standard 2436 - 1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites", British Standard BS5228 – 1984 " Noise Control on Construction and Open Sites", information from past projects and information held in our library files.

Given that at any one time there may be up to four (4) pieces of construction plant working simultaneously whilst carrying each construction activity, the cumulative sound power noise level for each construction activity is given in ***Table 3.7.2***.

TABLE 3.7.2 L_{10} SOUND POWER LEVELS FOR A COMBINATION OF PROPOSED CONSTRUCTION EQUIPMENT		
Activity	**Label**	**Cumulative L_{10} SWL re: 1pW, dB(A) (4 Items of plant)**
Bridgeworks	A	119
Bridge Approach Works	B	118
Embankment Construction	C	119
Bulk Excavation	D	119
Noise Wall Construction	E	119

Cumulative construction noise

A sensitivity analysis was undertaken to determine the effect of increasing the number of construction plant items operating in each construction activity, and it is found that the first additional plant item would increase total noise levels by 1-2dB(A) and each successive plant item added has a lesser and lesser effect on total noise levels. This occurs because noise, measured in decibels adds in a logarithmic manner, where the first few noise sources have a greater effect than do successive noise sources.

The various construction activities as shown in ***Table 3.7.2*** will be carried out along the entire WSO route as outlined in ***the Figures 3.7.2a, 3.7.2b, 3.7.2c, 3.7.2d*** and ***3.7.2e***.

Table 3.7.3 presents typical L_{max} sound power levels from the loudest plant items likely to be used at night, as obtained for each activity type from ***Table 3.7.1***. These exclude the piling / drilling rig as this plant will rarely be used and where used will only be used during daytime.

TABLE 3.7.3 L_1 SOUND POWER LEVEL FOR EACH PROPOSED CONSTRUCTION ACTIVITY		
Activity	Label	SWL L_1, dB(A) re:1pW ,dB(A) (Loudest item of plant)*
Bridgeworks	A	115
Bridge Approach Works	B	115
Embankment Construction	C	118
Bulk Excavation	D	118
Noise Wall Construction	E	115

*Note: The Piling Drilling Rig is not included in the sleep disturbance assessment

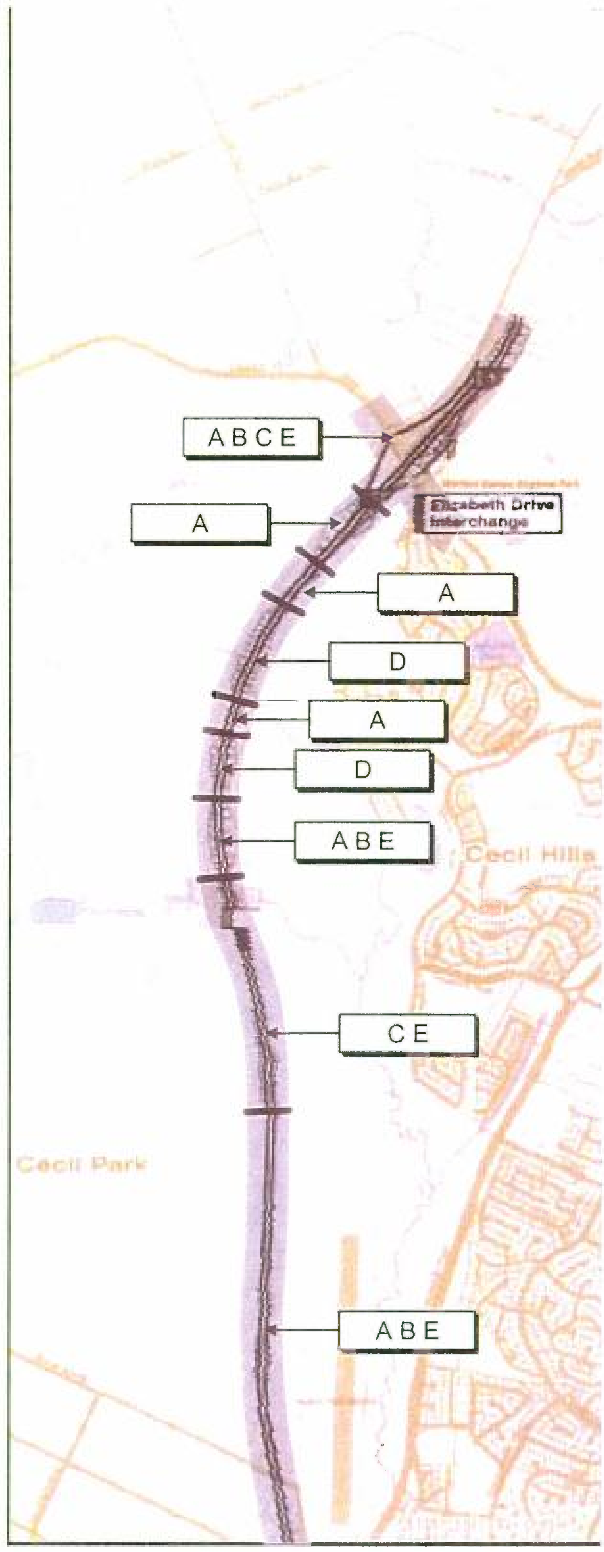


Figure 3.7.2(b) - Construction activities

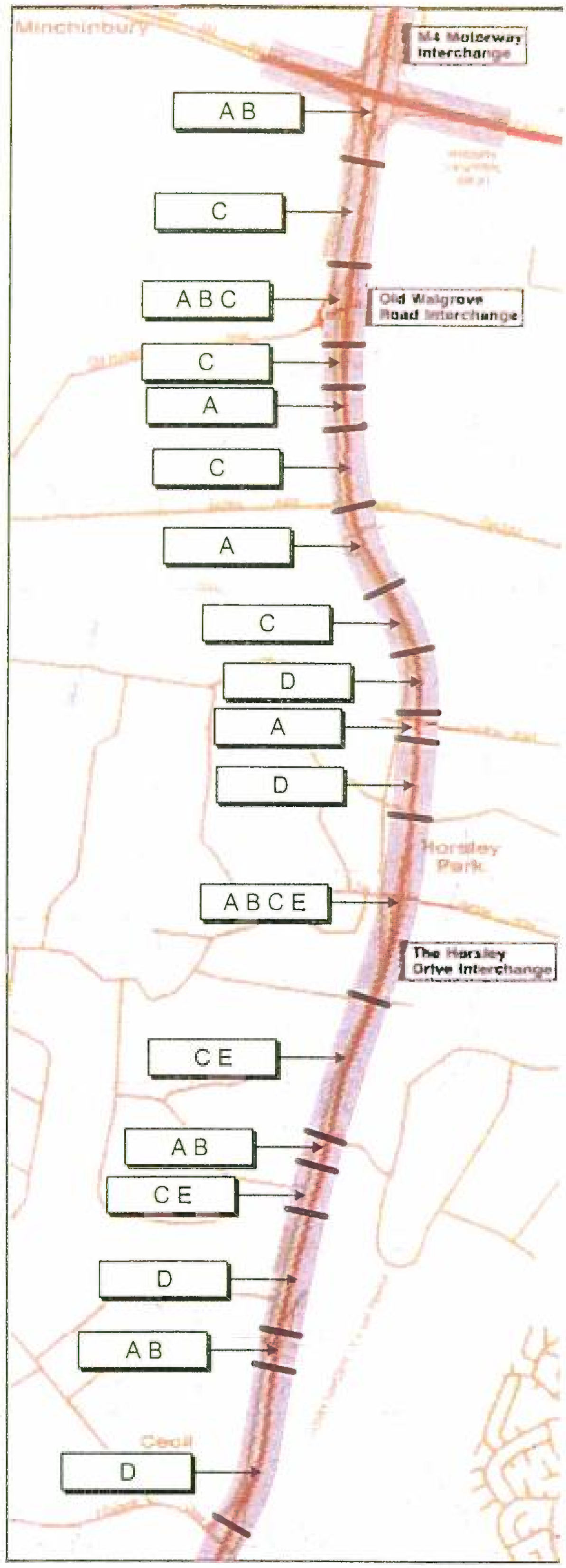


Figure 3.7.2(c) - Construction activities

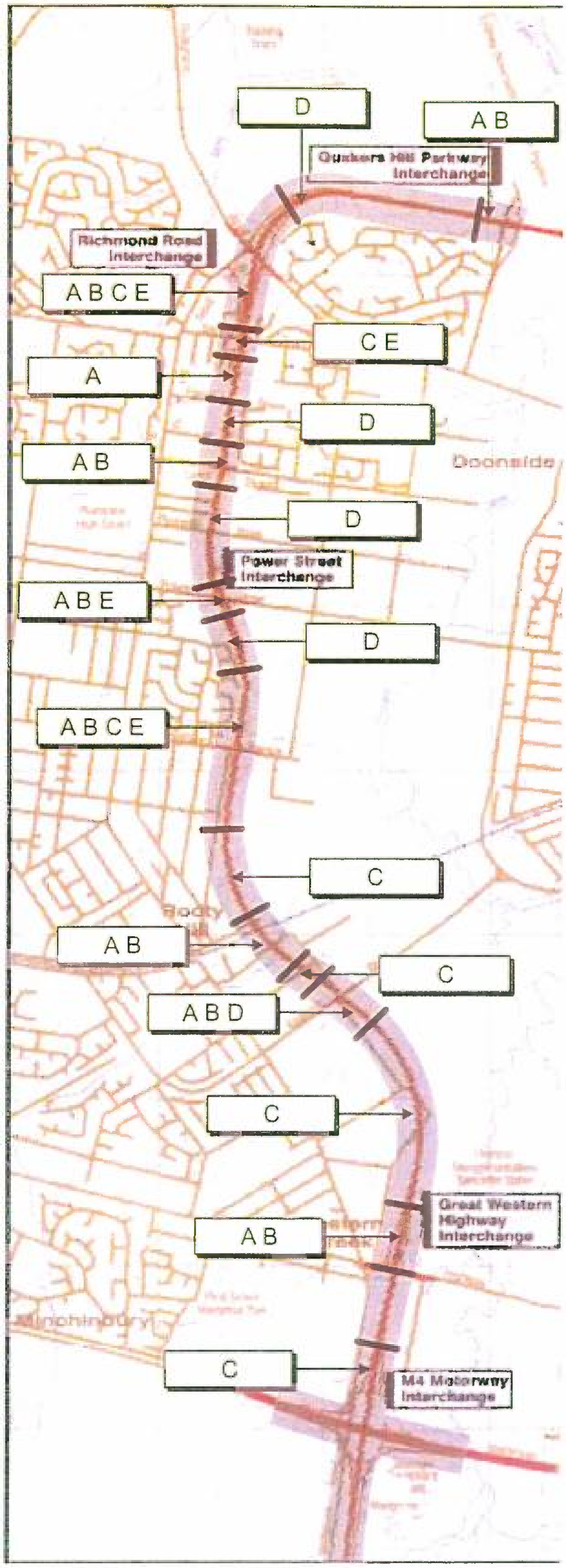
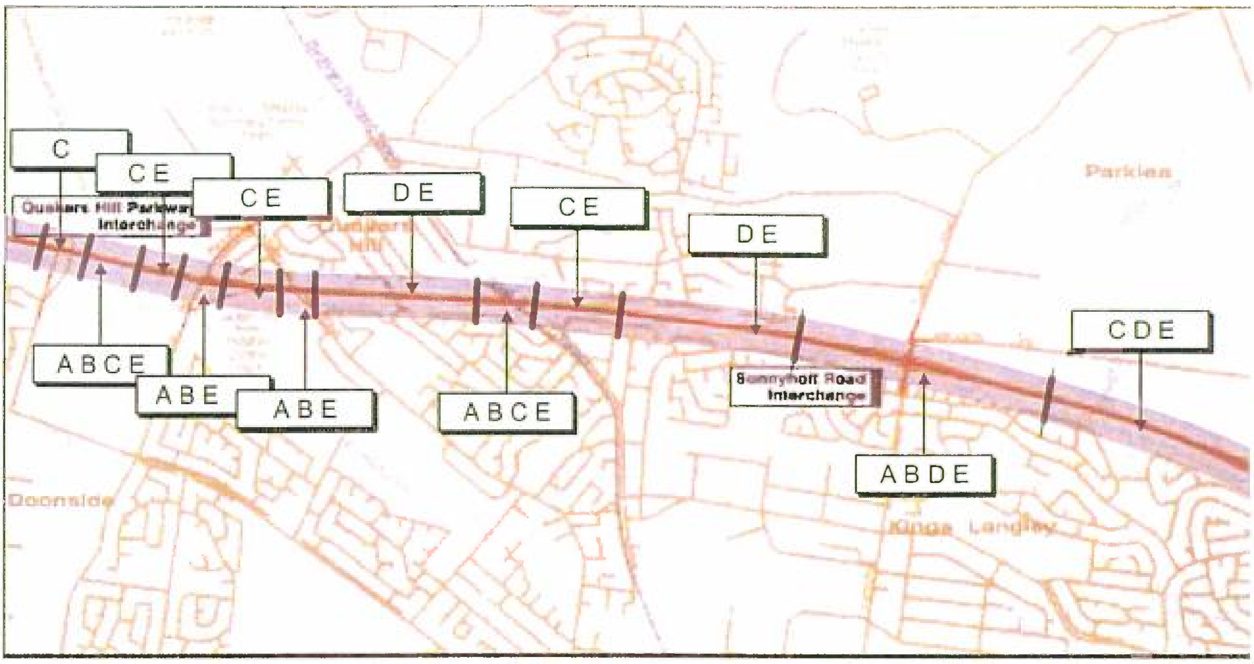


Figure 3.7.2(d) - Construction activities



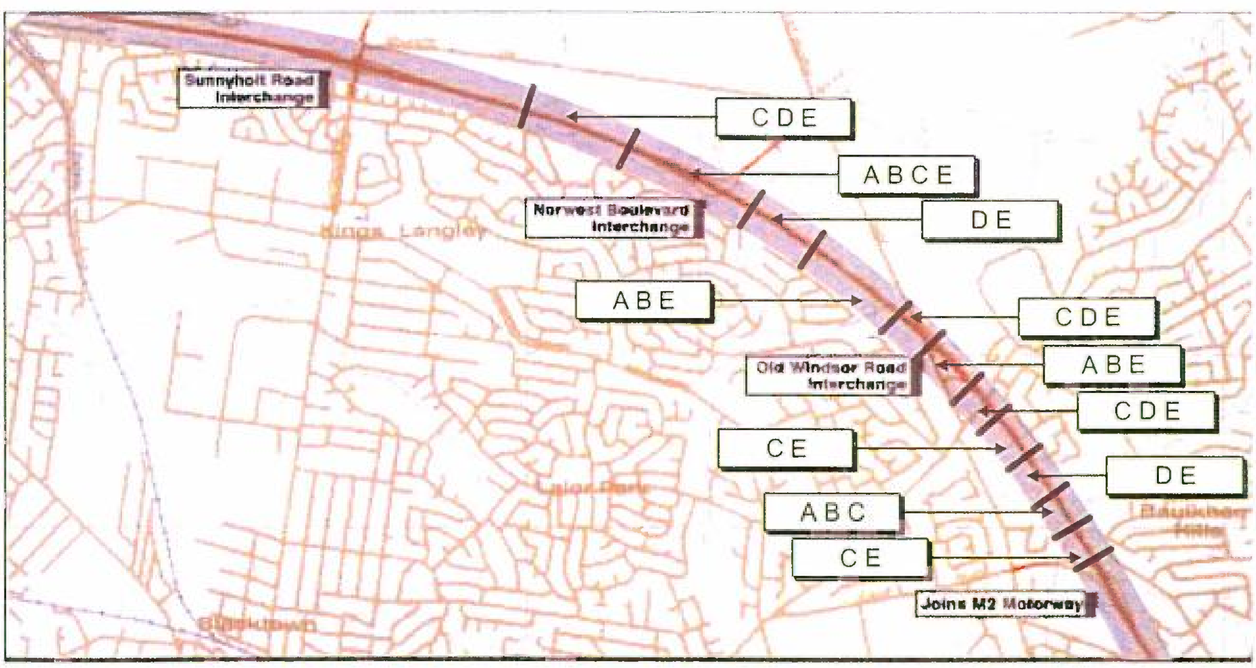


Figure 3.7.2(e) - Construction activities

Loudest cumulative sources used

Table 3.7.4 shows the calculated noise levels at the nearest affected educational institution and places of worship along the WSO route. The predicted noise level due to construction activities at each receptor is calculated assuming a cumulative sound power level due to the loudest construction activities of 119dB(A) re: 1pW being carried out opposite each receptor.

Acoustic allowances

Noise attenuation due to distance between the road corridor and the potentially affected receiver has been taken into account, as well as a nominal loss of 10dB(A) for any shielding effects from intervening topography, cuttings, buildings and other plant and excess attenuation due to ground and air absorption effects. The nominal acoustic loss referred to here is considered conservative, given that for most cases the distances between the road corridor and the receivers is very large (see ***Figure 3.7.1***).

Similarly a nominal noise reduction of 10dB(A) is applied for construction noise calculations which include noise treatment (see ***Section 3.8***).

TABLE 3.7.4 CALCULATED CONSTRUCTION NOISE LEVELS WITHOUT TREATMENT AT THE NEAREST AFFECTED EDUCATIONAL INSTITUTIONS AND PLACES OF WORSHIP, dB(A)

NEAREST SCHOOL	Approx. Distance to WSO (m)	Noise at Receiver Without Noise Treatment L_{10}, dB(A)	Noise at Receiver With Noise Treatment L_{10}, dB(A)	Exceedance over Outdoor Noise Limits, dB(A)
Existing Educational Institutions				
Casula High School	1500	37	27	-
Prestons Public School	1100	40	30	-
Lurnea High School	1600	37	27	-
Sule College	200	55	45	-
Lurnea Public School	1500	37	27	-
Miller TAFE College	600	45	35	-
Miller High School	1200	39	29	-
Hoxton Park Public School	100	61	51	-
Catholic Hoxton Park/Hinchinbrook Good Shepherd School	300	51	41	-
Hoxton Park High School	350	50	40	-
Liverpool Handicapped Centre and Sheltered Workshop	700	44	34	-
Hinchinbrook Public School	700	44	34	-
Cecil Hills High School	650	45	35	-
Horsley Park Public School	130	59	49	-
Eastern Creek Public School	230	54	44	-
Seven Hills North Public School	200	55	45	-
Marion Primary School, Horsley Park	200	55	45	-
Plumpton Primary School	500	47	37	-
Plumpton High School	800	43	33	-
William Dean Primary School, Dean Park	230	54	44	-
Glendenning Primary School	370	50	40	-

TABLE 3.7.3 CALCULATED CONSTRUCTION NOISE LEVELS AT THE NEAREST AFFECTED RECEIVER IN EACH NOISE CATCHMENT, dB(A)					
Chainage	**NCA**	**NAR**	**Approx. Distance to WSO (m)**	**Noise Level at NAR Without Noise Treatment L_{10}, dB(A)**	**Noise Level at NAR With Noise Treatment L_{10}, dB(A)**
30150	23a	Ampitheatre Circuit, East of Old Windsor Rd	60	70	60
30950	23b	Baulkham Hills Rd (west)	42	74	64
30150	24	Valerie Ave, north of Seven Hills Reservoir	60	70	60
Southern Section – Prestons To Cecil Park					
	E1	West end of Wattle Rd (sth side)	60	70	60
	E2	north end of Maple Rd (West side)	80	68	58
	E3	Western side of Skipton Lane	70	69	59
700	E4	Western side of Skipton Lane	80	68	58
2400	E5	Cnr Jedda Rd & Bernerra Rd	100	66	56
3100	E6	East of Illaroo Rd	30	76	66
3650	E7	East of Wilson Road	40	74	64
na	E8	na	na	n/a	
na	E9	na	na	55	45
4950	E10	West of Hinchenbrook Dr	180	61	51
5350	E11	West of Hinchenbrook Dr	350	55	45
na	E12	na	na	n/a	n/a
na	E13	na	na	n/a	n/a
na	E14	na	na	n/a	n/a
na	E15	na	na	n/a	n/a
na	E16	na	na	n/a	n/a
na	E17	na	na	n/a	n/a
na	E18	na	na	n/a	n/a
500	W1	Eastern side of Ash Road	170	61	51
1050	W2	Sule College, nth of Kurrajong Rd	260	58	48
2300	W3	Cnr Bernerra Rd (West) & Yarrawa St	120	64	54
2300	W4	Bernerra Rd Prestons (west side)	350	55	45
2400	W5	Bernerra Rd Prestons (east side)	420	54	44
2500	W6	Yarrawa St Prestons (south side)	330	56	46
3450	W7	North of Twentieth Ave, Hoxton Park	200	60	50
4300	W8	Southern side of Government Rd	100	66	56
4600	W9	East of Cowpasture Rd	100	66	56
4500	W10	Cnr Cowpasture Rd & Government Rd	425	53	43
4550	W11	Cnr Cowpasture Rd & Fifteenth Ave	510	52	42
4750	W12	Western side of Cowpasture Rd	100	66	56
5300	W13	North side of McIver Ave	70	69	59

- Both sound power and sound pressure levels given in the table are average-maximum which approximately equates to L_{A10} noise levels.

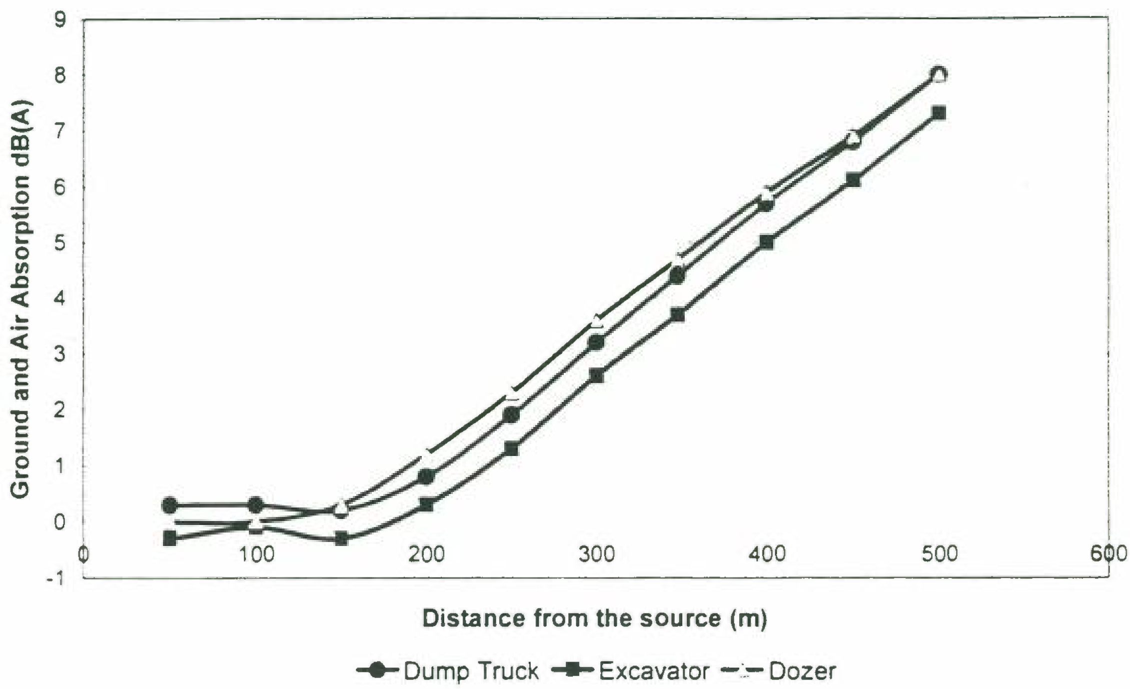
- The sound pressure level refers to the audible noise and is directly related to the distance of the receptor from the noise source. In this instance the noise levels at the receptor are based on the perpendicular distance from the boundary of the receptor to the centre of the constructed road.

TABLE 3.7.3 CALCULATED CONSTRUCTION NOISE LEVELS AT THE NEAREST AFFECTED RECEIVER IN EACH NOISE CATCHMENT, dB(A)

Chainage	NCA	NAR	Approx. Distance to WSO (m)	Noise Level at NAR Without Noise Treatment L_{10}, dB(A)	Noise Level at NAR With Noise Treatment L_{10}, dB(A)
Northern Section – Cecil Park To West Baulkham Hills					
3000	1E	Wallgrove Rd, sth of Alaine St	85	67	57
5400	1W	Wallgrove Rd, sth Cobham St	88	67	57
7150	2E	Redmayne Rd (sth), east Wallgrove Rd	68	69	59
7150	2W-a	Wallgrove Rd (east), sth of Chandos St	43	73	63
6200	2W-b	Wallgrove Rd (east), nth Horsley Dr	179	61	51
	3	No Houses			
11500	4	Pikes Ln (east side), sth Gt Western Hwy	196	60	50
11850	5	Wallgrove Rd, sth Gt Western Hwy	136	63	53
13150	6	Church St (end of), east Rooty Hill Rd	103	66	56
14200	7E	End Dunsmore St (east)	68	69	59
14150	7W	Dunsmore St (nth side), last house before WSO	55	71	61
15500	8	Station Street (west), south of Woodstock	34	75	65
16000	9	Polonia Ave, Chainage 16000	55	71	61
17350	10E	Farmhouse south of Lamb St	119	65	55
17000	10W	Plumpton Road (West)	55	71	61
17600	11	End of Shaughnessy St	98	66	56
17600	12	Woodley Cres, Oakhurst (opposite 11)	47	73	63
18200	13	End of Simms Road	34	75	65
18200	14	End of Ansley Ave	34	75	65
20300	15N	End of Symonds Road	94	67	57
19350	15S	Nathan Cres, opposite Brook Street	102	66	56
21500	16	Station Road (north) Last hse before bush	51	72	62
22250	17	Rowntree Street (Sth), opposite Caton Pl	40	74	64
22750	18	Molong St (North) opposite Marx Pl	77	68	58
23750	19	Sherridon Crs (Sth) opposite Parnell Ave	51	72	62
24250	20	Timor Place/ Donahue St	60	70	60
28000	21E	End of Powers Lane	111	65	55
26100	21W	Old farmouse on Meurants Lane (sth)	98	66	56
26100	22	Battleaxe on cnr of Shanke Cres (nth)	64	70	60

To allow for acoustic losses due to ground and air absorption, generic ground and air absorption losses were modelled over flat ground with typical plant operating, using ENM noise modelling software. ***Figure 3.7.1*** below shows the ground and air absorption losses calculated for various distances from the operation of a dump truck, a bulldozer and an excavator.

Figure 3.7.1 – Losses due to Ground and Air Absorption at Various Distances with Various Plant Operating



Loudest cumulative sources used

Table 3.7.3 shows the calculated noise levels at the Nearest Affected Residences (NARs) in each noise catchment area along the WSO route. The predicted noise level due to construction activities at each NAR is calculated assuming a cumulative sound power level due to the loudest construction activities of 119dB(A) re: 1pW being carried out adjacent to each noise catchment area.

Acoustic allowances

Noise attenuation due to the distance between the road corridor and the NAR has been taken into account. A nominal loss of 5dB(A) for any shielding effects from intervening topography, cuttings, buildings and other plant and excess attenuation due to ground and air absorption effects (see ***Figure 3.7.1***) has also been taken into account. Similarly a nominal noise reduction of 10dB(A) is applied for construction noise calculations which include noise treatment (see ***Section 3.8***).

The levels calculated in ***Table 3.7.3*** and ***Table 3.7.4*** should be interpreted as follows:

- The sound power level refers to the actual power of the sound emitted from the plant equipment and does not take into account distance from the source.

TABLE 3.7.4 CALCULATED CONSTRUCTION NOISE LEVELS WITHOUT TREATMENT AT THE NEAREST AFFECTED EDUCATIONAL INSTITUTIONS AND PLACES OF WORSHIP, dB(A)				
NEAREST SCHOOL	**Approx. Distance to WSO (m)**	**Noise at Receiver Without Noise Treatment L_{10}, dB(A)**	**Noise at Receiver With Noise Treatment L_{10}, dB(A)**	**Exceedance over Outdoor Noise Limits, dB(A)**
St Francis of Assissi Catholic Primary, Glendenning	250	53	43	-
Quakers Hill High	480	47	37	-
Quakers Hill East Primary	1500	37	27	-
Quakers Hill Public	160	57	47	-
Kings Langley Primary	350	50	40	-
Matthew Pierce Primary		53	43	-
New Tribes Bible College	50	67	57	2dB(A)
Holy Family High	650	45	35	-
Marayong Heights Primary	700	44	34	-
Uni. West. Syd. (Inst. or TAFE)	700	44	34	-
Barnier Primary	1500	37	27	-
Clare Catholic High	700	44	34	-
Proposed Educational Institutions				
Hoxton Park Catholic School	50	67	57	2dB(A)
Carnes Hill Primary School	1500	37	27	-
Bumbera Street Primary School	2500	33	23	-
Horningsea High School	3000	31	21	-
Prestons West Primary School	400	49	39	-
Prestons Public School	-	-	-	-
Places of Worship				
Hoxton Park Christian Life Centre	70	64	54	yes by 4dB(A)
Seventh Day Adventist	400	49	39	no
Catholic Hoxton Park/Hinchinbrook Good Sheperd Church	400	49	39	-
Horsley Park Catholic Church	300	51	41	-
(Rooty Hill Presbyterian Church)		closed	closed	

Worst-case scenario

Comparing the results of ***Table 3.7.3*** to the construction noise criteria presented in ***Section 3.3***, it is evident that noise levels from some plant and construction activity will exceed the set criteria by varying degrees, but these noise levels would be temporary. For example, if construction noise is audible for more than 26 weeks at the NAR in the E6 noise catchment area (the worst affected of all catchment areas), the construction noise calculated in ***Table 3.7.3*** of 66dB(A) with noise treatment, exceeds the construction noise criteria of 50dB(A) by up to 16dB(A).

Similarly, the results of ***Table 3.7.4*** show that noise levels from some plant and construction activity will exceed the set criteria by varying degrees, but these noise levels would be temporary. For example, if construction noise is audible for more than 26 weeks at the New Tribes Bible College located at chainage 16600 (the worst affected educational facility), the construction noise calculated in ***Table 3.7.3*** of 57dB(A) with noise treatment, exceeds the construction noise criteria of 50dB(A) by up to 7dB(A).

Residences, educational institutions and places of worship located adjacent to areas of the proposal that require extensive filling or cutting may be exposed to construction noise for extended periods of time. Receptors located adjacent to cut sections of the proposed roadway however, may also benefit from shielding provided by the cut itself as road works progress deeper into the ground.

There are no legal requirements for silencing plant equipment. However, there is an applicable Australian Standard (AS2436 – 1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites") which recommends typical plant noise levels.

The actual construction noise level would depend on the location of the receptor, the type and duration of operation being undertaken. Construction noise levels may exceed the relevant noise objectives when noisy plant operates for long periods near receptors. This indicates that mitigative measures may be required in these specific instances.

To minimise temporary noise impacts during construction, the noise mitigation measures described in ***Section 3.8*** would be implemented where and when necessary. It is recommended that residents, educational institutions and places of worship, be informed that construction is to take place and is likely to generate relatively high noise levels at times. Traffic noise barriers would be built as soon as possible during the construction period to assist in mitigating any potential construction noise impacts. All construction work would be licensed by the EPA and its approval would be sought prior to construction.

3.7.2 Sleep Disturbance

Table 3.7.5 shows the calculated $L_{1(60\ sec)}$ noise levels at the NARs in each noise catchment area along the WSO route. The predicted noise level outside the bedroom window at each NAR is the sleep arousal assessment due to construction activities, calculated using the loudest construction item in each activity for each noise catchment area.

Acoustic calculation allowances

Noise attenuation due to distance between the road corridor and each NAR has been taken into account, as well as an assumed nominal loss of 5dB(A) for any shielding effects from intervening topography, cuttings, buildings and other plant, and excess attenuation due to ground and air absorption effects. Similarly a nominal noise reduction of 10dB(A) is applied for construction noise calculations which include noise treatment (see ***Section 3.8***).

TABLE 3.7.5 CALCULATED CONSTRUCTION NOISE LEVELS [$L_{1(60\,sec)}$, dB(A)] OUTSIDE THE BEDROOM WINDOW OF THE NEAREST AFFECTED RECEIVER IN EACH NOISE CATCHMENT							
Chainage	NCA	NAR	Approx. Distance to WSO, (m)	Noise Level at NAR Without Noise Treatment L_1, dB(A)	Noise Level at NAR With Noise Treatment L_1, dB(A)	Sleep Arousal Criterion at Each NAR L_1, dB(A)	Exceedance over Noise Criterion, dB(A)
Northern Section – Cecil Park To West Baulkham Hills							
3000	1E	Wallgrove Rd, sth of Alaine St	85	66	56	51	5dB(A)
5400	1W	Wallgrove Rd, sth Cobham St	88	66	56	51	5dB(A)
7150	2E	Redmayne Rd (sth), east Wallgrove Rd	68	68	58	53	5dB(A)
7150	2W-a	Wallgrove Rd (east), sth of Chandos St	43	72	62	53	9dB(A)
6200	2W-b	Wallgrove Rd (east), nth Horsley Dr	179	60	50	53	-
	3	No Houses	n/a	-	-	-	-
11500	4	Pikes Ln (east side), sth Gt Western Hwy	196	59	49	59	-
11850	5	Wallgrove Rd, sth Gt Western Hwy	136	62	52	59	-
13150	6	Church St (end of), east Rooty Hill Rd	103	65	55	53	2dB(A)
14200	7E	End Dunsmore St (east)	68	68	58	53	5dB(A)
14150	7W	Dunsmore St (nth side), last house before WSO	55	70	60	53	7dB(A)
15500	8	Station Street (west), south of Woodstock	34	74	64	51	13dB(A)
16000	9	Polonia Ave, Chainage 16000	55	70	60	51	9dB(A)
17350	10E	Farmhouse south of Lamb St	119	64	54	48	6dB(A)
17000	10W	Plumpton Road (West)	55	70	60	48	12dB(A)
17600	11	End of Shaughnessy St	98	65	55	50	5dB(A)
17600	12	Woodley Cres, Oakhurst (opposite 11)	47	72	62	50	12dB(A)
18200	13	End of Simms Road	34	74	64	46	18dB(A)
18200	14	End of Ansley Ave	34	74	64	46	18dB(A)
20300	15N	End of Symonds Road	94	66	56	48	8dB(A)
19350	15S	Nathan Cres, opposite Brook Street	102	65	55	48	7dB(A)
21500	16	Station Road (north) Last hse before bush	51	71	61	55	6dB(A)
22250	17	Rowntree Street (Sth), opposite Caton Pl	40	73	63	54	9dB(A)
22750	18	Molong St (North) opposite Marx Pl	77	67	57	54	3dB(A)
23750	19	Sherridon Crs (Sth) opposite Parnell Ave	51	71	61	54	7dB(A)
24250	20	Timor Place/ Donahue St	60	69	59	45	14dB(A)
28000	21E	End of Powers Lane	111	64	54	50	4dB(A)

TABLE 3.7.5 CALCULATED CONSTRUCTION NOISE LEVELS [$L_{1(60 sec)}$, dB(A)] OUTSIDE THE BEDROOM WINDOW OF THE NEAREST AFFECTED RECEIVER IN EACH NOISE CATCHMENT							
Chainage	**NCA**	**NAR**	**Approx. Distance to WSO, (m)**	**Noise Level at NAR Without Noise Treatment L_1, dB(A)**	**Noise Level at NAR With Noise Treatment L_1, dB(A)**	**Sleep Arousal Criterion at Each NAR L_1, dB(A)**	**Exceedance over Noise Criterion, dB(A)**
26100	21W	Old farmouse on Meurants Lane (sth)	98	65	55	50	5dB(A)
26100	22	Battleaxe on cnr of Shanke Cres (nth)	64	69	59	50	9dB(A)
30150	23a	Ampitheatre Circuit, East of Old Windsor Rd	60	69	59	48	11dB(A)
30950	23b	Baulkham Hills Rd (west)	42	73	63	48	15dB(A)
30150	24	Valerie Ave, north of Seven Hills Reservoir	60	69	59	48	11dB(A)
Southern Section – Prestons To Cecil Park							
	E1	West end of Wattle Rd (sth side)	60	69	59	59	-
	E2	north end of Maple Rd (West side)	80	67	57	59	-
	E3	Western side of Skipton Lane	70	68	58	59	-
700	E4	Western side of Skipton Lane	80	67	57	59	-
2400	E5	Cnr Jedda Rd & Bernerra Rd	100	65	55	48	7dB(A)
3100	E6	East of Illaroo Rd	30	75	65	52	13dB(A)
3650	E7	East of Wilson Road	40	73	63	52	11dB(A)
na	E8	na	na	-	-	-	-
na	E9	na	na	-	-	-	-
4950	E10	West of Hinchenbrook Dr	180	60	50	48	2dB(A)
5350	E11	West of Hinchenbrook Dr	350	54	44	48	-
na	E12	na	na	-	-	-	-
na	E13	na	na	-	-	-	-
na	E14	na	na	-	-	-	-
na	E15	na	na	-	-	-	-
na	E16	na	na	-	-	-	-
na	E17	na	na	-	-	-	-
na	E18	na	na	-	-	-	-
500	W1	Eastern side of Ash Road	170	60	50	59	-
1050	W2	Sule College, nth of Kurrajong Rd	260	54	44	59	-
2300	W3	Cnr Bernerra Rd (West) & Yarrawa St	120	63	53	48	5dB(A)
2300	W4	Bernerra Rd Prestons (west side)	350	54	44	48	-
2400	W5	Bernerra Rd Prestons (east side)	420	53	43	48	-
2500	W6	Yarrawa St Prestons (south side)	330	55	45	48	-
3450	W7	North of Twentieth Ave, Hoxton Park	200	59	49	52	-

TABLE 3.7.5 CALCULATED CONSTRUCTION NOISE LEVELS [$L_{1(60\,sec)}$, dB(A)] OUTSIDE THE BEDROOM WINDOW OF THE NEAREST AFFECTED RECEIVER IN EACH NOISE CATCHMENT							
Chainage	**NCA**	**NAR**	**Approx. Distance to WSO, (m)**	**Noise Level at NAR Without Noise Treatment L_1, dB(A)**	**Noise Level at NAR With Noise Treatment L_1, dB(A)**	**Sleep Arousal Criterion at Each NAR L_1, dB(A)**	**Exceedance over Noise Criterion, dB(A)**
4300	W8	Southern side of Government Rd	100	65	55	48	7dB(A)
4600	W9	East of Cowpasture Rd	100	65	55	48	7dB(A)
4500	W10	Cnr Cowpasture Rd & Government Rd	425	52	42	48	-
4550	W11	Cnr Cowpasture Rd & Fifteenth Ave	510	51	41	48	-
4750	W12	Western side of Cowpasture Rd	100	65	55	48	7dB(A)
5300	W13	North side of McIver Ave	70	68	58	48	10dB(A)

3.7.3 Vibration Impacts

Equipment such as vibrating rollers also have the potential to cause vibration disturbance. However, for this project, the separation between the works and nearby residences is expected to be sufficient to prevent nuisance from vibration at all locations.

Negligible vibration impacts expected

With respect to annoyance to residents the typical distances to residences from the bridgeworks are far enough that no impact would be expected. During the earthworks phase, vibratory rolling and some piling (in limited areas) would be required but typical distances to all of the residences from the WSO are far enough that this activity would be unlikely to result in significant annoyance. At residences within approximately 50 metres vibration may be perceptible, however the duration of this activity would be short and negligible impact would be expected.

With respect to vibration annoyance to educational institutions and places of worship, the typical distances to these receptors from the bridgeworks are far enough that no impact would be expected. During the earthworks phase, vibratory rolling and some impact piling (in limited areas) would be required but typical distances to all of the receptors from the WSO are far enough that this activity would be unlikely to result in significant annoyance. Given that all educational institutions and places of worship are more than approximately 50 metres away from the construction works, it is unlikely that vibration will be perceptible.

These vibration generating activities may cause some annoyance, however, they are only temporary and residents, educational institutions and places of worship should be informed in advance to allay any fears about potential building damage. This should form part of the community consultation program.

3.7.4 Blasting Impacts

Although blasting is not expected to be used on this project, if it were to be carried out, blast charge and blast configuration would need to be selected to ensure that EPA goals are not exceeded. Before blasting can commence at a site, critical affected locations would be identified and appropriate measures taken to limit over-pressure and vibration to acceptable levels. Blasts would be monitored initially at these locations to ensure that predicted overpressure and vibration levels are not exceeded.

3.7.5 Transportation Noise

Spoil transportation routes would generally avoid populated or noise sensitive sites. Use of selected streets would minimise noise impacts such that an increase in noise on roads already carrying considerable traffic would be less noticeable. The use of the road corridor as a temporary haul route would also be beneficial to the local community. Furthermore, spoil haulage off the site would only occur during daytime hours.

Temporary treatment, in the form of noise barriers protecting a number of school classroom windows may also be required if classroom noise levels are to exceed the EPA's noise criteria for classrooms, described in ***Section 3.8***. This would depend on the number of truck movements and is a matter for detailed design.

3.7.6 Mobile Concrete Batching Plant Noise

It is unlikely that a concrete batching plant would be established on the site. Concrete would be transported by agitator to the site. Mitigative measures as outlined in ***Section 3.8*** would therefore be applicable to both of these pieces of equipment.

Should a mobile concrete batching plant be required, a review of environmental factors would be prepared to examine the impacts of the plant on the environment.

3.8 CONSTRUCTION NOISE MITIGATION

3.8.1 General Construction

It is difficult to control noise from construction sites due to the variations in the duration, type of noise generated and also the location of residences. The EPA specifies conditions on the construction work to ensure that the most appropriate available techniques are used and the proposed equipment meets modern noise emission standards.

Implementation of noise control measures, such as those suggested in Australian Standard 2436-1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites", are expected to reduce construction noise levels to acceptable levels. Reference to Australian Standard 2436-1981, Appendix E, Table E1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table E2 in Appendix E presents typical examples of noise reductions achievable after treatment of various noise sources. Table E3 in Appendix E presents the relative effectiveness of various forms of noise control treatment.

Table 3.8.1 below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

TABLE 3.8.1 RELATIVE EFFECTIVENESS OF VARIOUS FORMS OF NOISE CONTROL, dB(A)					
Noise Control Method	**Practical Examples**	**Typical noise reduction possible in practice**		**Maximum noise reduction possible in practice**	
		AS 2436	**Renzo Tonin & Assoc.**	**AS 2436**	**Renzo Tonin & Assoc.**
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	7 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 30	10 to 20	50	30
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	15 to 25	15 to 25	60	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436, in this study.

Table 3.8.2 below identifies possible noise control measures that are applicable on the construction plant likely to be used on site.

TABLE 3.8.2 – NOISE CONTROL MEASURES FOR LIKELY CONSTRUCTION PLANT				
Plant Description	**Screening**	**Acoustic Enclosures**	**Silencing**	**Alternative Process**
Mobile Crane	✔	✔	✔	x
Pneumatic Hand Tools (general)	✔	✔	✔	✔
Dump Trucks	✔	x	✔	x
Concrete Truck	✔	x	✔	x
Welders	✔	✔	x	x
Concrete Pump	✔	✔	✔	✔
Truck (> 20 tonne)	✔	x	✔	x
Concrete Vibrator	✔	x	x	x
Silenced Air Compressor	✔	✔	✔	✔
Jack hammers	✔	x	✔	x
Excavator (30 tonne)	✔	x	✔	x
Bulldozer	✔	x	✔	x
Excavator (25 tonne)	✔	x	✔	x
Light commercial vehicles (eg 4WD)	✔	x	x	x
Roller	✔	x	✔	x
Grader	✔	x	✔	x
Backhoe	✔	x	✔	x
Concrete paver	✔	x	✔	x
Asphalt Paver	✔	x	✔	x
Scraper	✔	x	✔	x
Vibratory Roller	✔	x	✔	x

TABLE 3.8.2 – NOISE CONTROL MEASURES FOR LIKELY CONSTRUCTION PLANT				
Plant Description	**Screening**	**Acoustic Enclosures**	**Silencing**	**Alternative Process**
Piling Drilling Rig	✔	✔	x	x
Spreader	✔	x	✔	x

To ensure efficient noise attenuation performance is achieved using any of the methods listed above, it is recommended acoustic engineers work closely with the construction contractors and carry out preliminary testing prior to commencement of construction work.

The successful contractor would be required to develop a plan to monitor, assess and control potential noise/vibration impacts on a stage by stage basis as each phase of the works is defined and implemented. This would form part of an environmental management plan.

Construction Noise Management Plan

The following environmental management measures would be taken to minimise temporary noise impacts during construction:

- The contractor(s) would prepare a detailed construction noise assessment report showing predicted noise levels at critical locations and the mitigative measures proposed. The construction methods and noise control measures would be the most appropriate available and the proposed equipment would meet relevant standards. The report would demonstrate the contractor's intention to minimise noise impact wherever practicable.

- Construction noise would conform to EPA requirements. All plant and equipment would be required to comply with the limits set out in the Protection of the Environment Operations Act 1997. The use of alternative quieter construction technologies is preferred over noisy methods.

- Community Liaison - Leaflets and information would be distributed prior to the commencement of construction work informing potentially affected residents of the type, expected noise emissions, times and duration of any construction work. Any community queries, concerns or complaints regarding noise and vibration would also be addressed.

- Silenced Equipment - The quietest construction equipment would be selected and where possible residential class mufflers would be used. Noise from loud plant would also be silenced to residential standards and their operators would be instructed to operate the equipment in the quietest way possible. Noise control kits would be fitted to noisy mobile equipment and shrouds provided around stationary plant.

- Equipment Maintenance and Operation - All plant and equipment would be inspected to ensure that it is in ideal running order, regularly maintained and free of defective components to minimise noise emissions.

- Noise Monitoring - Noise compliance tests for all major equipment used on site would also be undertaken. Noise monitoring is to be conducted, where required, at all critical or sensitive areas (eg residences, schools etc). The noise and vibration levels of all items of plant and equipment are to be tested for compliance with limits set in the environmental management plan immediately after the item is brought to site and prior to its regular use. Plant noise levels should also be re-checked at regular intervals over the period of construction in order to ensure that there is no critical degradation in the silencing equipment on any plant items. Additionally, regular monitoring of overall noise and vibration from potentially critical construction works would be conducted to assist in identifying and controlling emissions from particularly noisy or vibrating plant.

- Equipment Location - Noisy plant and equipment would be located as far as possible from noise sensitive areas, optimising attenuation effects from topography, natural and purpose built barriers and materials stockpiles.

- Project Planning and Erection of Barriers - Construction would be programmed so that noise barriers or mounding required to control traffic noise are built as soon as possible. Temporary noise barriers would be erected if necessary.

- Working Hours Restriction - The hours of operation of particularly noisy equipment would be restricted. Work outside normal hours would only be carried out in special circumstances and after liaison with Councils, the EPA and the local community.

- Access Roads - Site access roads would be selected as far as possible from noise sensitive areas, minimising any vehicle movements outside construction hours. A temporary haul road would be established along the route of the project.

Complaints handling protocol

In addition to the noise mitigation measures outlined above, a management procedure would need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.

Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the community should be adequately trained and experienced in such matters.

Where noise level exceedances cannot be avoided, then consideration should be given to implementing time restrictions and/or providing periods of repose for residents.

The above measures would be incorporated into the environmental management plan. As part of the environmental management plan, the successful contractor would conduct additional ambient noise monitoring, wherever required, for the purpose of gaining approval from the EPA for the construction of the roadway. Therefore, prior to the contractor submitting an application to the EPA to carry out construction work, they would need to conduct noise monitoring at the exact location of residences where noise impact is likely to be of concern. This would ensure accurate L_{A90} background noise levels are determined at the relevant critical assessment points. From this data, relevant construction noise limits can be determined for noise control and compliance check purposes.

Furthermore, the EPA may monitor noise or request that construction noise be monitored to ensure that levels comply with its guidelines, approvals and licences.

3.8.2 Barriers

The construction of temporary noise barriers can be from any durable material with sufficient mass to prevent direct noise transmission eg. plywood, steel, fibrous-cement or polycarbonate, selected to withstand the weather elements. Plywood 15-20mm thick is often adequate for use as a noise screen. Noise screens must also have no clearance gaps underneath them.

In addition to the above, a noise screen design should give regard to the following:

- The extent of noise reduction required of the noise screen as a whole as perceived from any potentially affected receiver sites.
- Any penetrations through the fabric of the noise screen should be sealed air tight.
- All joints between noise screen panels should be overlapped or sealed air tight.

3.8.3 Acoustic Treatment of Residences

If, after implementing all practicable noise control measures on plant and on site and after managing the site in a way that noise from the site is reduced to the lowest practical limit, it is determined that additional acoustic treatment is needed, negotiations with residents at each receiver is needed to assist with determining the best method of acoustic treatment. Additional acoustic treatments may include closing or upgrading windows with provision of alternative temporary or permanent ventilation.

3.8.4 Guidelines for Piling Activities

No piling at night

Whilst the contractor may not use any percussive piling as such, but rather a pile-drilling rig, the following recommendations are included should the contractor do so.

Piling activities should not be conducted outside of the daytime construction period as the noise emissions from piling activities are much higher than that of other activities carried out on site. Piling has the potential to cause sleep disturbance at the NAR's.

Whilst Chapter 171 of the EPA's ENCM provides guidelines on typical construction activities, there are no specific guidelines for assessing noise from piling activities. General guidance is provided by the EPA that the acceptability of a given noise not only depends on its level but also on its character and the character of the background sound in the area.

Due to the impulsive nature of piling noise and its intermittency, piling noise often does not register on the standard L_{10} noise level scale. This is the case when piling is carried out using a slow strike rate. The resulting problem is that very high levels of noise can be emitted from piling without adequate limits applied to protect the amenity of nearby residents. Complaints regarding construction noise may arise as a result if this.

In addition, to protect the noise amenity of the area, assessment of piling noise can be based on the average maximum noise level from this type of event, denoted by the L_{avmax}. An appropriate limit, keeping in mind the nature and quality of the noise and its duration is that the L_{avmax} should not exceed the background L_{90} noise level by more than 15dB(A). The EPA in Chapter 19 of their ENCM recommend such a limit, assessable immediately outside a residence, for preventing sleep arousal from short-duration high-level noises occurring during night-time. Therefore, applying such a limit during daytime and at the residential property boundary provides for a conservative assessment.

It is therefore recommended that piling activities be carefully managed. Public consultation regarding the proposed activities should be carried out prior to the commencement of any piling works, informing in particular of the total duration of piling activities and of respite times, when there is no piling activity on site. A complaints-phone-line should be established for residents to inform the site of unsatisfactorily high noise levels.

3.8.5 Blasting

Although blasting is not expected to be required, if it were to be carried out the following applies.

To ensure that the EPA's over-pressure and vibration limits are complied with, the following recommendations would be provided:

- noise and vibration predictions would be required once the proposed charge and blast configuration information becomes available in order to establish buffer zones around blast sites,
- blast charges and blast configurations would be selected to ensure that EPA goals are not exceeded,
- dilapidation surveys would be conducted on all buildings located within the buffer zones prior to commencement and after completion of all blasting activities at each site,
- the blasting contractor would conduct and monitor one or more trial blasts to obtain appropriate propagation characteristics at each blast site,
- methods would be implemented to control noise and vibration from blasts as described in Chapter 154 of the EPA's "Environmental Noise Control Manual", as deemed necessary, and

- blasts would be monitored at all critical sites to ensure compliance with the set limits.

3.8.6 Construction Vibration Management

Construction Vibration Management Plan

The following in-principle vibration control measures are provided to minimise vibration impact from construction activities to the nominated occupancies and to meet the EPA's human comfort vibration limits:

- The proper implementation of this vibration management plan is required to avoid adverse vibration disturbance to affected occupancies. Consultation with property owners/residents is recommended and should be aimed at providing a communication path directly to the contractor.

- A management procedure will be implemented to deal with vibration complaints. Each complaint will be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures shall be put in place to mitigate future occurrences.

- Where vibration is found to be excessive, management measures shall be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller plant, establishment of safe buffer zones and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

- Carry out vibration testing of actual equipment on site to determine acceptable buffer distances to commercial and residential occupancies.

- Carry out additional vibration monitoring when construction activities are at the nearest point to the nominated occupancies. This monitoring may signal to the contractor by way of a buzzer or flashing light etc, when levels approach/exceed the recommended limits in nearby occupancies.

- Before, during and after the construction stages we recommend preparation of a dilapidation report on the state of the existing buildings nearest to the road corridor.

3.9 CONCLUSION

The noise impact from the proposal has been assessed against the EPA's 'Environmental Noise Control Manual'. All areas likely to be impacted upon by the construction of the proposed WSO have been identified, including residences, educational institutions and places of worship.

To meet the EPA's noise objectives at all critical locations noise control measures are suggested for consideration by the community and the EPA. The use of suitably designed mitigative measures such as temporary or permanent noise barriers would ensure compliance with the EPA's construction noise level objectives where practical and feasible. Other temporary or permanent acoustic treatments could be applied directly to residential or educational buildings, where the cost of noise mitigation using noise barriers is high compared to the number of buildings likely to benefit from the noise control measures, or if the use of barriers is inappropriate for visual or other reasons. For areas with isolated residences or with isolated schools, building treatments could be applied to achieve the required noise objectives. The final choice of noise mitigation measures however, would be the subject of community consultation.

It is our opinion that the roadway can be constructed in such a manner that, with the necessary acoustic controls, will ensure minimal impacts to the local community. We conclude that with the appropriate mitigation measures in place, noise and vibration impact from the construction of the roadway can be contained to levels that comply with the EPA's primary objectives.

4. ROAD TRAFFIC NOISE CRITERIA

EPA's Traffic Noise Policy

In May 1999, the Environment Protection Authority released their new policy on traffic noise entitled "Environmental Criteria for Road Traffic Noise". This new policy has been agreed to by NSW Government bodies, including the Roads and Traffic Authority, (Ref: EPA's "Guide to the Draft Environmental Criteria for Road Traffic Noise", June 1998) and as such the criteria is sometimes referred to as the "NSW Government Environmental Criteria for Road Traffic Noise". This new EPA policy has replaced the draft EPA policy dated June 1998 and all previous traffic noise policies.

4.1 RESIDENTIAL LAND USE DEVELOPMENT AREAS

4.1.1 New Road Corridor

L_{eq} Noise Level Criteria

The EPA's noise goals use the following traffic noise descriptors for the noise assessment of new roads in residential areas:

- $L_{Aeq,\ 15hour}$ - 15 hour daytime (7am-10pm) equivalent continuous noise level
- $L_{Aeq,\ 9hour}$ - 9 hour night-time (10pm-7am) equivalent continuous noise level

Relevant to this proposal, is Category 1 of the traffic noise policy which states the following road traffic noise criteria for proposed road or residential land use developments:

TABLE 4.1.1 EPA'S ROAD TRAFFIC NOISE CRITERIA FOR PROPOSED ROAD OR RESIDENTIAL LAND USE DEVELOPMENTS

Type of Development	Criteria		
	Day, dB(A)	Night, dB(A)	Where Criteria are Already Exceeded
1. New freeway or arterial road corridor	$L_{eq(15hr)}$ 55	$L_{eq(9hr)}$ 50	The new road should be designed so as not to increase existing noise levels by more than 0.5dB. Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In some instances this may be achievable only through long-term strategies such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage.

Source: Table 1, EPA's "Environmental Criteria for Road Traffic Noise" (May 1999).

The noise guidelines for residential areas apply externally 1 metre from a facade that is most exposed to traffic noise, and at a height of 1.5 metres above the floor level. The residential noise criteria include a 2.5dB(A) allowance for noise reflected from the facade.

The noise criteria specified in Table 1 of the EPA's new traffic noise policy states:

"Specified noise values refer to noise from traffic on roads, road bridges and freeways, and do not include ambient noise from other sources. However, they rely on all traffic noise at the receiver location - not only noise due to the project under consideration."

'Allowance' criteria only applies after all other measures have been exhausted

Further to the traffic noise criteria presented above, where the criteria cannot be achieved, then traffic noise control measures implemented shall approach these criteria as far as is reasonable and feasible while taking into account cost effectiveness. That is, the +0.5dB(A) allowance is only assigned where all feasible and reasonable mitigation measures have been used.

The EPA policy states that noise impact be assessed immediately after opening of the road, being the year 2006, and for 10 years after opening of the road, being the year 2016 (Ref: Appendix C1, p31, EPA's "Environmental Criteria for Road Traffic Noise", May 1999).

The highest traffic volumes for the year 2016 are used here resulting in conservatively high noise level predictions for the purpose of assessing impact and subsequently more stringent noise attenuation requirements.

4.1.2 Existing Roads

For areas along existing roads removed far enough from the proposal that noise emission from the proposal does not itself directly contribute to the traffic noise levels, any change in traffic noise impact should be compared to the EPA's noise goals as set for redeveloped roads.

Even though many existing roads within the study area will not be redeveloped, many of them may experience increases (or decreases) in traffic volumes and changes to traffic mix as a result of the proposal. Relevant to this aspect of the assessment are Categories 3, 6 and 12 of the EPA's traffic noise policy which sets 'base' noise criteria relevant to residential noise receivers along freeway / arterial, collector and local roads, respectively. These are summarised in ***Table 4.1.2*** below.

TABLE 4.1.2 EPA'S ROAD TRAFFIC NOISE CRITERIA FOR REDEVELOPMENT OF ROADS

Type of Development	Criteria		
	Day, dB(A)	Night, dB(A)	Where Criteria are Already Exceeded
3. Redevelopment of existing freeway/arterial road	$L_{Aeq(15hr)}$60	$L_{Aeq(9hr)}$55	In all cases, the redevelopment should be designed so as not to increase in existing noise levels of more than 2 dB Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In many instances this may be achievable only through medium-term and long-term strategies, such as regulation of exhaust noise from in-service vehicles; limitations on exhaust brake use; restricted access for sensitive areas or during sensitive times to low-noise vehicles; improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle standards and regulations of in-service vehicles; and alternative methods of freight haulage
6. Redevelopment of existing collector road	$L_{Aeq(1hr)}$60	$L_{Aeq(1hr)}$55	
12. Redevelopment of existing local roads	$L_{Aeq(1hr)}$55	$L_{Aeq(1hr)}$50	

Source: Table 1, EPA's "Environmental Criteria for Road Traffic Noise" (May 1999).

Importantly, where the 'base' traffic noise criteria is exceeded along existing roads, the EPA's traffic noise policy considers noise increases of more than

2dB(A) over existing levels to be significant. In such circumstances, where feasible and reasonable, noise levels from existing roads should be reduced to meet the 'base' noise criteria.

Renzo Tonin & Associates do not agree with Wilkinson Murray's interpretation of the WSO as affecting existing roads in a manner described as a 'new development which has the potential to change traffic flows on surrounding roads' (p.41 of Working Paper). This implies the use of Category 7 of Table 1 in the EPA's ECRTN, which does not apply to this project.

4.1.3 Maximum Night Time Noise Levels - Sleep Arousal Criteria

No specific limits, but broad assessment required

The EPA's policy on traffic noise does not specify a night-time L_{max} noise limit or noise goal. This is because research conducted to date in this field has not been definitive and the relationship between maximum noise levels, sleep disturbance and subsequent health effects is not currently well defined. According to the policy however, the likely maximum or peak noise levels from new freeway or arterial roads are to be broadly assessed and reported for the night-time period, which is generally considered by the EPA as being 10pm to 7am.

The EPA's $L_{eq,\ 9\ hour}$ noise goal, described above, partially assists with the control of overall noise at night. Therefore it could be argued that the night-time $L_{eq,\ 9\ hour}$ noise goal partially takes into consideration the issue of sleep preservation.

The EPA's "Environmental Noise Control Manual" (Chapter 19), provides general noise guidelines for assessing sleep arousal resulting from short duration high level noises which occur at night (10pm to 7am). These guidelines, however, do not necessarily apply directly to traffic noise.

The EPA's general sleep arousal goal is as follows:

"Noise controls should be applied with the general intent to protect people from sleep arousal. To achieve this, the L_1 level of any specific noise source should not exceed the background noise level (L_{90}) by more than 15dB(A) when measured outside the bedroom window."

According to the above and given a typical measured background noise level (L_{90}) of say 35dB(A) measured at night [see **Section 2** of this report], the noise criterion outside the bedroom window would be:

$L_1 \leq L_{90}$ 35dB(A) + 15dB(A) = **50dB(A) ... outside**

Importantly, existing noise levels measured along the proposed route indicate that in many instances, L_1 noise levels would currently exceed the L_{90} noise levels by more than 15dB(A), even before the road is built.

L90 Background + 5dB(A) is too stringent

We are in general agreement with this guideline, however, recent research shows that low-level noises, even though they exceed the background by more than 15dB(A) do not necessarily cause sleep arousal [see Carter et al, Acoustics Australia vol 20 No 2 August 1992 pp49-55]. It is noted that the EPA's ENCM guideline was written in 1985 and there has been new research carried out since then on sleep disturbance, as set out in Appendix B of the "Environmental Criteria for Road Traffic Noise" (ECRTN). The

EPA's sleep arousal criterion is currently being reviewed as the general opinion is that this criterion is conservatively low.

We therefore obtain guidance from recent work produced by Griefahn [Acoustics Australia vol 20 No 2 August 1992 pp43-47]. Griefahn has developed a dose/response curve from recent research relating noise induced awakenings with the number of short noise events which occur during a night.

For intermittent or short-duration noise events, Griefahn shows that there are zero awakenings amongst 90% of the exposed population (including the aged) if maximum noise levels inside bedrooms are at:

- 59.4dB(A) for 2 noise events per night
- 54.1dB(A) for 10 noise events per night, and
- 53.6dB(A) for 30 noise events per night.

Griefahn also notes that at an absolute level of 53.2dB(A) measured indoors, there are zero awakenings in 90% of the population. This level "represents the upper risk which must not be exceeded in order to avoid long-term effects on health".

A level of 53.2dB(A) measured indoors corresponds to a conservative level of 65dB(A) measured outside the bedroom window assuming windows are open for ventilation. Therefore, we adopt as a criterion which will ensure that 90% of the population (including the aged) are protected in their sleep an emergence level (L_{avmax} or L_1) of 65dB(A). This criteria applies to short-duration noises which occur at night such as doors closing, car engines revving, tyre screeching and people noise.

For continuous, steady or quasi-steady noise, recent evidence suggests an L_{eq} of 40dB(A) be used as an upper limit for assessment of sleep arousal inside bedrooms. This criteria can also be expressed in terms of noise levels outside. Research conducted by Carter et al (1992) found the attenuation through a slightly open window when measured at the centre (bed position) of a bedroom is in the order of 13 to 20dB(A) when measured in L_{eq}. Using a typical noise reduction of 15 dB(A), then the maximum allowable L_{eq} noise levels outside is 55dB(A) to avoid sleep awakenings during the night for 90% of the population including the aged. The EPA's ECRTN policy for new freeways or arterial roads, is therefore more stringent than this as it recommends a night-time L_{eq} noise level of 50dB(A) expressed in terms of $L_{Aeq,9hour}$.

Furthermore, Figure 2.1 of the EPA's ECRTN (produced by Bullen et al. 1996), reproduced below as ***Figure 4.1***, synthesises a number of studies that have been conducted into sleep disturbance due to noise expressed in terms of maximum internal levels for intermittent and short-duration noise events from a range of different noise sources.

Figure 4.1 Awakenings Due To Noise (compiled from various studies)

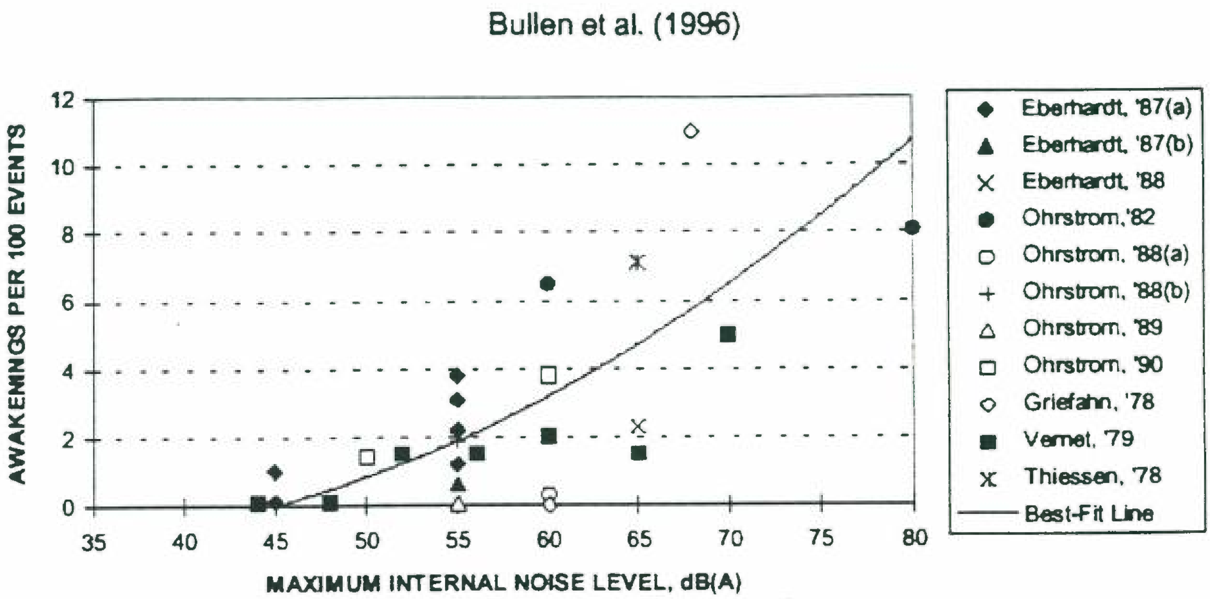


Figure 2.1 demonstrates the problems in using the ENCM's "background + 15dB(A)" criterion to predict awakenings from noise. That is, if according to the ENCM, the outdoor sleep arousal criterion were to be $L_{1,outdoor} \leq 50dB(A)$, then this translates to an indoor noise criterion of approximately $L_{1,indoor} \leq 35dB(A)$, after applying an outdoor-to-indoor correction of 15dB(A) (see Carter et al, 1992). Similarly, should an outdoor-to-indoor correction of only 10dB(A) be applied, then the indoor noise criterion would be $L_{1,indoor} \leq 40dB(A)$. According to ***Figure 4.1***, both of these indoor noise criteria are significantly below the lowest level required to cause a single awakening, demonstrating how the ENCM's "background + 15dB(A)" criterion is overly conservative.

4.2 SENSITIVE LAND USE DEVELOPMENTS

The Environment Protection Authority's traffic noise policy also sets guidelines for the assessment of traffic noise on sensitive land use developments.

TABLE 4.1.2 EPA'S ROAD TRAFFIC NOISE CRITERIA FOR SENSITIVE LAND USE DEVELOPMENTS

Type of Development	Criteria		
	$L_{eq(1hr)}$,dB(A)		Noise Mitigation Measures
	Day	Night	
1. Proposed school classrooms	40 [1]	-	To achieve internal noise criteria in the short-term, the most practicable mitigation measures are often related to building or facade treatments. In the medium to longer term, strategies such as regulation of exhaust noise from in-service vehicles, limitations on exhaust brake use, and restricting access for sensitive areas or during sensitive to low noise vehicles can be applied to mitigate noise impacts across the road system. Other measures include improved planning, design and construction of sensitive land use developments; reduced new vehicle emission standards; greater use of public transport; and alternative methods of freight haulage. These medium- to long-term strategies apply equally to mitigating internal and external noise levels. Where existing levels of traffic noise exceed the criteria, all feasible and reasonable noise control measures should be evaluated and applied. Where this has been done and the internal or external criteria (as appropriate) cannot be achieved, the proposed road or land use development should be designed so as not to increase existing road traffic noise levels by more than 0.5dB(A) for new roads and 2dB(A) for redeveloped roads or land use development with potential to create additional traffic.
2. Existing school classroom	45 [1]	-	
3. Hospital wards	35 [1]	35 [1]	
4. Places of worship	40 [1]	40 [1]	
5. Active recreation (eg golf courses)	$L_{eq(15hr)}$= 60 [2]	-	
6. Passive recreation and school playgrounds	$L_{eq(15hr)}$= 55 [2]	-	

Source: EPA's "Environmental Criteria for Road Traffic Noise" (May 1999).

Note: 1. Internal noise criteria
2. External noise criteria
\- no criteria specified in the EPA policy.

Further to the EPA criteria set out above, it is appropriate to assess noise impact upon commercial and industrial developments on the basis of the recommended noise levels set out in Australian Standard 2107 – 1987 "Acoustics – Recommended design sound levels and reverberation times for building interiors".

4.2.1 Educational Institutions

The $L_{eq(1hr)}$ guidelines for schools are relevant between 8.30am and 3.30pm with the assessment point being inside the classroom with the windows open. To meet a level of 40-45dB(A) internally, the external noise level should not exceed 55dB(A). Where current ambient noise levels inside existing classrooms exceed 45dB(A), then the permitted increase in ambient noise level is 0.5dB(A) for new roads and 2dB(A) for redeveloped roads.

Existing schools

Existing educational institutions, which could potentially be affected by the proposed road, are:

- Casula High School - Myall Road, Casula;
- Prestons Public School - Kurrajong Road and Box Road, Prestons;

- Lurnea High School - Hillview Parade, Lurnea;
- Sule College - Kurrajong Road, Prestons;
- Lurnea Public School - West Street and Reilly Street, Lurnea;
- Miller TAFE College - Hoxton Park Road and Banks Road, Miller;
- Miller High School - Cabramatta Avenue, Miller;
- Hoxton Park Public School - Hoxton Park Road and First Avenue, Hoxton Park;
- Hoxton Park Catholic School - Hoxton Park Road, Hoxton Park
- Catholic Hoxton Park / Hinchinbrook Good Shepherd School – 20 Twentieth Avenue, Hoxton Park;
- Hoxton Park High School - Wilson Road, Hoxton Park;
- Liverpool Handicapped Centre and Sheltered Workshop - Cowpasture Road and Fifteenth Avenue, Hoxton Park;
- Hinchinbrook Public School - Hinchinbrook Drive and Keppel Circuit, Hinchinbrook;
- Cecil Hills High School - Leopold Place, Cecil Hills;
- Horsley Park Public School – The Horsley Drive & Wallworth Road, Horsley Park;
- Eastern Creek Public School – Rooty Hill Road, South, Eastern Creek;
- Seven Hills North Public School – Seven Hills Road & Windsor Road, Seven Hills;
- Marion Primary School, Horsley Park – The Horsley Drive & Felton Street, Horsley Park;
- Plumpton Primary School – Bottles Road, Plumpton;
- Plumpton High School – Bottles Road & Hyatts Road, Plumpton;
- William Dean Primary School - Yarramundi Drive, Dean Park;
- Glendenning Primary School – Armitage Drive, Glendenning;
- St Francis of Assissi Catholic Primary Glendenning – Richmond Road & Stone Street, Glendenning;
- Quakers Hill High – Lalor Road & Summerfield Avenue, Quakers Hill;
- Quakers Hill Parish Primary – Farnham Road and Barnier Road, Quakers Hill;
- Quakers Hill Public – Quakers Hill Road & Medlow Drive, Quakers Hill;
- Kings Langley Primary – Isaac Smith Parade & Pont Place, Kings Langley;
- Matthew Pearce Primary – Astoria Park Road, Baulkham Hills;
- New Tribes Bible College - Power Street & Rooty Hill Road, Plumpton;
- Holy Family High – Quakers Hill Rd & Benalla Court, Quakers Hill;
- Marayong Heights Primary – Shedworth Street, Marayong;
- University of Western Sydney (Western Sydney Institute of TAFE & Terra Sancta College) – Quakers Hill Road, Quakers Hill;
- Barnier Primary – Barnier Road and Farnham Road, Quakers Hill; and
- Clare Cath High – Buckwell Drive, Hassall Grove.

Future schools

Proposed educational institutions which could potentially be affected by the proposed road are:

- Carnes Hill Primary School – Cowpasture Road and Twelfth Avenue, Hoxton Park;
- Bumbera Street Primary School – Bumbera Street, Prestons;
- Horningsea High School – west of Bumbera Street, Prestons;
- Prestons West Primary School – near Skipton Lane, Prestons West; and
- Prestons Public School - Dalmeny Drive, Prestons

4.2.2 Places of Worship

Existing places of worship, which could potentially be affected by the proposed road, are:

- Hoxton Park Christian Life Centre - Illaroo Road and Hoxton Park Road, Hoxton Park;
- Seventh Day Adventist - Hoxton Park Road, Hoxton Park;
- Catholic Hoxton Park / Hinchinbrook Good Shepherd Church – 20 Twentieth Avenue, Hoxton Park;
- Horsley Park Catholic Church; and
- Rooty Hill Presbyterian Church.

There are no proposed places of worship along the Orbital route that could be affected by the road.

4.2.3 Recreational Areas: Parks and Reserves

Major existing recreational areas, which could potentially be affected by the proposed road, are:

- Liverpool Showground - Kurrajong Road, Prestons;
- Miller Park, Powell Oval - Hoxton Park Road, Miller;
- Hoxton Park Recreation Reserve - Hoxton Park Road, Hoxton Park;
- Serbian Cultural Club - 256 Cowpasture Road, Hoxton Park (to be acquired by RTA);
- Sydney International Shooting Range – Cecil Hills, Hoxton Park Corridor
- Western Sydney Regional Park, Cecil Park
- Fairfield City Farm (Mountain Bike Track), Darling Street, Abbottsbury
- Sydney International Equestrian Centre, The Horsley Park Dr, Horsley Park
- Horsley Park, Horsley Dr & Arindle Rd, Horsely Park
- Australia's Wonderland, Wallgrove Rd, Minchinbury
- Eastern Creek Raceway, Ferrers Rd, Eastern Creek
- Pinegrove Memorial Park (Lawn Cemetery), Kington St, Minchinbury
- Cawarra Reserve, Cawarra Street, Minchinbury
- Morreau Reserve, Cnr Eastern Rd & Rooty Hill Rd, Rooty Hill
- Harry Dennison Park, Rooty Hill
- Aquilina Reserve, Reginald Street, Rooty Hill
- Narragundy Reserve, Knox Road Doonside
- Blacktown Pioneer Soccer Field' Blacktown
- Sanford Street Reserve, Glendenning
- Yarramundi Dr Reserve, Yarramundi Drive, Dean Park
- Anthea Place Reserve, Anthea Place, Dean Park
- Symmond Road Reserve, Dean Park
- Wright Reserve, Pye Road, Kings Park
- Corbin Reserve, Kings Park
- Qua-Mara Pony Club, Quakers Hill
- Melrose Park, Melrose Ave, Quakers Hill
- Faukland Cres Reserve, Faukland Cres, Kings Park
- Glenwood Park, Glenwood Park Dr, Glenwood (under development)
- Reserve (sth of Meurants), Meurants Rd, Glenwood (under development)
- Discovery Park, Kings Langley
- Lady Penrhyn Reserve, Hartam Street & Rosina St Kings Park

- Edna Street Reserve, Kings Langley
- Troubador Park, Kings Langley
- Solar Ave Reserve, West Baulkham Hills
- Sierra Reserve, West Baulkham Hills
- Col Sutton Park, West Baulkham Hills

5. TRAFFIC NOISE PREDICTION METHODOLOGY

5.1 TRAFFIC NOISE MODEL

Noise levels along the proposed Western Sydney Orbital were modelled and noise predictions have been calculated for the first year of the road opening, year 2006, and ten years after opening, year 2016.

CORTN model

Noise predictions are based on a method developed by the United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)" known as the CORTN (1988) method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board and as a result it is recognised and accepted by the Environment Protection Authority. The model predicts noise levels for steady flowing traffic and a modified method has been developed which enables an accurate prediction of noise from high truck exhausts to be taken into account.

The method predicts the $L_{10,\ 1hour}$ noise levels, and a correction of -3dB(A) is applied to obtain the $L_{eq,\ 1\ hour}$ noise levels for every hour in a 24 hour day. The $L_{eq(1\ hour)}$ noise levels for the time period 7.00am to 10.00pm are then collated and logarithmically averaged to derive the daily $L_{eq(15\ hour)}$ noise level. Similarly, the $L_{eq(1\ hour)}$ noise levels for the time period 10.00pm to 7.00am are collated and logarithmically averaged to derive the night time $L_{eq(9\ hour)}$ noise level.

Model inputs

The noise prediction model takes into account:

- traffic volume and heavy vehicle forecasts;
- vehicle speed;
- road gradient;
- location of the noise sources on the road lanes travelling in each direction;
- different source heights for cars and trucks (3 source heights for trucks)
- the differing source heights of cars and trucks;
- relative levels and angles of view of the road from the receiver's position;
- intervening ground type between the road and the noise receivers
- attenuation from barriers (natural and purpose built) and cuttings;
- reflections from barriers, cuttings, roadside structures etc;
- the noise reduction from the use of an open-graded asphaltic concrete road surface along the WSO; and
- correction for shielding due to any intervening buildings between the road and receivers.

Details of assumptions used in the model for noise contour predictions are given in ***Appendix B*** to this report.

Traffic volumes used in the predictions were based on modelled traffic volumes for a non-tolled WSO. While the use of non-tolled traffic volumes provides an overestimate of traffic noise for the WSO, it simultaneously underestimates traffic volumes and hence traffic noise from roads such as Wallgrove Road, where traffic volumes may be higher under the tolled WSO scenario.

To predict traffic noise levels and generate noise contours for the proposed road, the following traffic volumes, composition and vehicle speeds were used for the year 2016 as presented in ***Table 5.1*** below.

TABLE 5.1 PREDICTED TRAFFIC VOLUMES FOR THE PROPOSED WSO (YEAR 2016)

Road Section	Vehicle Speed (km/hr)	15 hours (7am to 10pm)		9 hours (10pm to 7am)	
		Total Volume	% Heavy Vehicles	Total Volume	% Heavy Vehicles
Western Sydney Orbital (WSO) – Main Carriageways					
WSO - north of Camden Valley Way	90	46,003	11	7,826	11
WSO - north of Bernera Rd	90	42,614	11	7,248	11
WSO - north of Cowpasture Rd	90	44,065	11	7,495	11
WSO - north of Elizabeth Dr	90	44,335	11	7,541	11
WSO - north of Elizabeth Dr	110	46100	8	8660	8
WSO - north of The Horsely Dr	110	57100	7	11810	7
WSO - north of Old Wallgrove Rd	110	37800	7	7830	7
WSO - north of M4 Motorway	110	45800	6	9430	6
WSO - north of Great Western Hwy	110	51500	6	10600	6
WSO - north of Power St	90	47100	4	9700	4
WSO - east of Richmond Rd	90	49400	6	8290	6
WSO - east of Quakers Hill Parkway	90	58500	5	9830	5
WSO - east of Sunnyholt Rd	90	58300	6	8540	6
WSO - east of Norwest Blvd	90	30800	7	4510	7
WSO - east of Old Windsor Rd	90	36000	8	5220	8
WSO Ramps					
Northbound WSO Ramp from Camden Valley Way	60	5535	11	942	11
Southbound WSO Ramp onto Camden Valley Way	60	5535	11	942	11
Eastbound WSO Ramp onto M5	60	6542	11	1113	11
Westbound WSO Ramp from M5	60	6542	11	1113	11
Northbound M5 Ramp from Camden Valley Way	60	10756	11	1830	11
Southbound M5 Ramp onto Camden Valley Way	60	10756	11	1830	11
Northbound WSO Ramp from M5	60	9308	11	1583	11
Southbound WSO Ramp onto M5	60	9308	11	1583	11
Eastbound WSO Ramp onto Bernera Rd	60	4090	11	696	11
Westbound WSO Ramp from Bernera Rd	60	4090	11	696	11
Eastbound WSO Ramp from Bernera Rd	60	5526	11	940	11
Westbound WSO Ramp onto Bernera Rd	60	5526	11	940	11
Westbound WSO Ramp from Cowpasture Rd	60	4746	11	807	11
Eastbound WSO Ramp from Cowpasture Rd	60	4746	11	807	11
Westbound WSO Ramp onto Cowpasture Rd	60	4054	11	690	11
Eastbound WSO Ramp onto Cowpasture Rd	60	4054	11	690	11
Northbound WSO Ramp onto Elizabeth Drive	60	1450	11	247	11
Southbound WSO Ramp from Elizabeth Drive	60	1450	11	247	11
Southbound WSO Ramp onto Elizabeth Drive	60	3174	11	540	11
Northbound WSO Ramp Elizabeth Dr	80	4250	10%	750	10%
Northbound WSO Ramp off Elizabeth Dr	80	9435	9%	1665	9%
Southbound WSO Ramp onto Elizabeth Dr	80	5780	8%	1020	8%

TABLE 5.1 PREDICTED TRAFFIC VOLUMES FOR THE PROPOSED WSO (YEAR 2016)					
Road Section	Vehicle Speed (km/hr)	15 hours (7am to 10pm)		9 hours (10pm to 7am)	
		Total Volume	% Heavy Vehicles	Total Volume	% Heavy Vehicles
Southbound WSO Ramp Elizabeth Dr	80	6545	10%	1155	10%
Northbound WSO Ramp onto The Horsley Dr	80	4675	10%	825	10%
Northbound WSO Ramp off The Horsley Dr	80	6035	9%	1065	9%
Southbound WSO Ramp onto The Horsley Dr	80	7650	8%	1350	8%
Southbound WSO Ramp off The Horsley Dr	80	1785	10%	315	10%
Northbound WSO Ramp to M4 Motorway	80	8755	11%	1545	11%
Northbound WSO Ramp from M4 Motorway	80	6715	8%	1185	8%
Southbound WSO Ramp onto M4 Motorway	80	13600	7%	2400	7%
Southbound WSO Ramp off M4 Motorway	80	5780	12%	1020	12%
Northbound WSO Ramp onto Gt Western Hwy	80	4845	12%	855	12%
Northbound WSO Ramp from Gt Western Hwy	80	1530	12%	270	12%
Southbound WSO Ramp onto Gt Western Hwy	80	4590	13%	810	13%
Southbound WSO Ramp from Gt Western Hwy	80	5865	12%	1035	12%
Northbound WSO Ramp onto Power St	80	6545	12%	1155	12%
Northbound WSO Ramp from Power St	80	7055	12%	1245	12%
Southbound WSO Ramp onto Power St	80	18615	9%	3285	9%
Southbound WSO Ramp from Power St	80	6290	12%	1110	12%
Northbound WSO Ramp onto Richmond Rd	80	16575	9%	2925	9%
Eastbound WSO Ramp from Richmond Rd	80	25160	11%	4440	11%
Southbound WSO Ramp from Richmond Rd	80	8925	10%	1575	10%
Westbound WSO Ramp to Richmond Rd	80	8330	9%	1470	9%
Eastbound WSO Ramp from Station Rd	80	7140	11%	1260	11%
Westbound WSO Ramp to Station Rd	80	15130	9%	2670	9%
Eastbound WSO Ramp to Sunnyholt Rd	80	6120	14%	1080	14%
Eastbound WSO Ramp from Sunnyholt Rd	80	12750	10%	2250	10%
Westbound WSO Ramp to Sunnyholt Rd	80	11475	7%	2025	7%
Westbound WSO Ramp from Sunnyholt Rd	80	11220	10%	1980	10%
Eastbound WSO Ramp onto Norwest Blvd	80	7735	9%	1365	9%
Eastbound WSO Ramp from Norwest Blvd	80	0	0%	0	0%
Westbound WSO Ramp onto Norwest Blvd	80	11560	9%	2040	9%
Westbound WSO Ramp from Norwest Blvd	80	19720	8%	3480	8%
Eastbound WSO Ramp off Old Windsor Rd	80	17340	8%	3060	8%
Westbound WSO Ramp onto Old Windsor Rd	80	0	0%	0	0%
Eastbound WSO Ramp onto Seven Hills Rd	80	0	0%	0	0%
Eastbound WSO Ramp of Seven Hills Rd	80	8585	10%	1515	10%
Westbound WSO Ramp onto Seven Hills Rd	80	20400	10%	3600	10%
Westbound WSO Ramp off Seven Hills Rd	80	13685	9%	2415	9%
Adjoining Roads					
The Horsley Dr (west of Wallgrove Rd)	60	39107	8%	6901	8%

TABLE 5.1 PREDICTED TRAFFIC VOLUMES FOR THE PROPOSED WSO (YEAR 2016)					
Road Section	**Vehicle Speed (km/hr)**	**15 hours (7am to 10pm)**		**9 hours (10pm to 7am)**	
		Total Volume	**% Heavy Vehicles**	**Total Volume**	**% Heavy Vehicles**
The Horsley Dr (west of Ferres Rd)	60	24184	8%	4268	8%
M4 Motorway (east of Erskine Park Rd)	100	103234	7%	18218	7%
M4 Motorway (at Horsely Rd underpass)	100	98695	7%	17417	7%
Gt Western Hwy (east of Carlisle Ave)	80	32640	6%	5760	6%
Gt Western Hwy (east of Rooty Hill Rd)	80	38464	6%	6788	6%
Gt Western Hwy (east of east of WSO)	80	40810	6%	7202	6%
Power St (east of Rooty Hill Rd)	60	25796	6%	4552	6%
Power St (east of Glendenning Rd)	60	26296	6%	4640	6%
Richmond Rd (east of Rooty Hill Rd)	60	15300	6%	2700	6%
Richmond Rd (east of Knox Rd)	60	19727	6%	3481	6%
Sunnyholt Rd (south of WSO)	60	35537	6%	6271	6%
Sunnyholt Rd (north of WSO)	60	23297	6%	8222	6%
Norwest Blvd	60	22205	7%	3919	7%
Old Windsor Rd (south of Abbott Rd)	60	47889	8%	8451	8%
Seven Hills Rd (west of Old Windsor Rd)	60	25388	8%	4480	8%
Seven Hills Rd (east of Old Windsor Rd)	60	18911	8%	3337	8%
Abbott Rd (west of Old Windsor Rd)	60	29478	8%	4422	8%
Quakers Rd (north of WSO)	60	12934	6%	2282	6%
Quakers Rd (north of Station Rd)	60	33170	6%	5854	6%
Quakers Rd Bypass (north of Douglas Rd)	60	11791	6%	2081	6%
Quakers Rd Bypass (east of Hambledon Rd)	60	9007	6%	1589	6%
Quakers Hill Pky (west of Sunnyholt Rd)	60	15494	6%	2734	6%
Eastern Rd (east of Rooty Hill Rd)	60	8354	6%	1474	6%
Woodstock Ave (west of Rooty Hill Rd)	60	14474	6%	2554	6%
Wallgrove Rd (north of Elizabeth Dr)	90	2897	8%	511	8%
Wallgrove Rd (north of Horsely Dr)	90	1510	7%	266	7%
Wallgrove Rd (south of M4))	90	1652	6%	292	6%

Source: EIS - PPK and Sinclair Knight Merz in their 'Transport Modelling Update (1999)'
Wilkinson Murray Traffic Flow Data used in EIS (North Section)

Noise due to speed changes

Noise modelling of the southern section of the WSO was carried using a speed limit of 90km/hr as advised by the RTA, based on AUSTROAD's Guide to Traffic Engineering Practice Part 2 "Roadway Capacity". It is understood that this speed is based on the speed of 85 percent of vehicles using the roadway. To adjust predicted noise levels to a speed of 100km/hr or 110km/hr, add 0.8dB(A) or 1.6dB(A) respectively to the modelled noise levels.

Further to the validation studies that have been conducted by the Australian Road Research Board on the CORTN procedure, Renzo Tonin & Associates' have also conducted a validation of their CORTN model by comparing modelled traffic noise levels to measured L_{eq} noise levels acquired from existing roads along the WSO corridor and at other sites too.

The validation results of the model for this project specifically are presented below, whilst the validation of the model for other past projects are presented in ***Appendix C*** of this report. A close correlation was found between the modelled and measured noise results, which supports the suitability of the model for this road project.

5.2 TRAFFIC NOISE MODEL VALIDATION

This section of the report presents validation results from past projects using the CORTN 88 model that was used on the southern section of the WSO EIS and on all subsequent works carried out as part of this report.

Comparisons of calculated noise levels versus measured $L_{Aeq,15\ hour}$, $L_{Aeq,9hour}$ and $L_{Aeq,24hour}$ noise levels from 8/5/96 to 14/5/96, were performed at:

North Section

- Location 25: 700-714 Wallgrove Rd, Horsley Park - 1m from ground floor facade facing proposed WSO
- Location 30: 529-543 Wallgrove Rd, Horsley Park - 1m from ground floor facade facing proposed WSO

South Section

- Location 3: Hoxton Park Road, Hoxton Park - 3m up power pole, ~3m from kerb and opposite Hoxton Park Primary School
- Location 4: Cowpasture Road, Hinchinbrook - 3m high up power pole, 3m from kerb and 25-30m from nearest residence, 18m from boundary
- Location 5: Elizabeth Drive, Cecil Hills - Adjacent power pole, ~5m from kerb and 50m from nearest residence
- Location 6: 87-95 Wallgrove Road, Cecil Hills - Front yard of residence, ~10m from kerb and 20m from nearest residence.

Traffic volumes, compositions and vehicle speeds were not measured simultaneously with the noise logging, but were taken from RTA's historical data ('Traffic Volume Data for the Sydney Region 1996') and through site observations. This data is summarised in ***Table 5.2.1*** below.

TABLE 5.2.1 – TRAFFIC MODEL DATA USED FOR VALIDATION TESTING

EIS Monitoring Location	Existing Road	1996 Traffic Volumes				% HV	V Speed
		Stn	15hr	9hr	24hr		
Northern Section							
25. 700-714 Wallgrove Rd, Horsley Park	Wallgrove Rd	71.04	23566	4379	27184	11	90
30. 529-543 Wallgrove Rd, Horsley Park	Wallgrove Rd	65.01	-	-	15121	11	90
Southern Section							
3. Hoxton Park Rd, Hoxton Park	Hoxton Park Rd	64.09	-	-	22876	11	60
4. Cowpasture Rd, Hinchinbrook	Cowpasture Rd	64.05	-	-	19933	11	60

TABLE 5.2.1 – TRAFFIC MODEL DATA USED FOR VALIDATION TESTING							
EIS Monitoring Location	Existing Road	1996 Traffic Volumes				% HV	V Speed
		Stn	15hr	9hr	24hr		
5. Elizabeth Dr, Cecil Hills	Elizabeth Dr	64.02	16876	3013	19755	11	60
6. 87-95 Wallgrove Rd, Cecil Hills	Wallgrove Rd	65.01	-	-	15121	11	90
Additional Noise Monitoring							
A. Beech Rd, Casula, between Camden Valley Way & Proposed WSO	Beech Rd	-	5304	714	-	18	70
Bernera Rd, Prestons, between proposed WSO & 150m south of Yarrunga St	Bernera Rd	-	12354	2180	-	11	74
Power St, Glendenning, between proposed WSO & Rooty Hill Rd	Power St	-	2729	444	-	7	76
Rooty Hill Rd Nth, Oakhurst, between 150m sth of Luxford Rd & Richmond Rd	Rooty Hill Rd	-	18721	2944	-	18	66

At locations where 15 hour and 9 hour traffic volume data was not available, $L_{Aeq,24hour}$ noise levels only were calculated, based on the AADT (24 hour).

Table 5.2.2 below presents the results of the validation testing.

TABLE 5.2.2 – MODELLED -V- MEASURED NOISE LEVELS									
EIS Monitoring Location	Modelled Noise Level			Measured Noise Level			Difference (Mod - Meas)		
	15hr	9hr	24hr	15hr	9hr	24hr	15hr	9hr	24hr
Northern Section									
25. 700-714 Wallgrove Rd, Horsley Park	65.4	60.3	63.9	64	62	63.4	1.4	-1.7	0.6
30. 529-543 Wallgrove Rd, Horsley Park	-	-	63.0	63.0	60	62.1	-	-	0.9
Southern Section									
3. Hoxton Park Rd, Hoxton Park	-	-	71.2	74.3	69.0	73.0	-	-	-1.8
4. Cowpasture Rd, Hinchinbrook	-	-	70.6	74.7	70.4	73.5	-	-	-2.9
5. Elizabeth Dr, Cecil Hills	70.4	65.4	68.3	71.3	66.6	70.1	-0.9	-1.2	-1.7
6. 87-95 Wallgrove Rd, Cecil Hills	-	-	66.2	69.6	66.1	68.6	-	-	-2.3
Additional Noise Monitoring									
A. Beech Rd, Casula, between Camden Valley Way & Proposed WSO	61	55	-	58	56	-	3	-1	-
Bernera Rd, Prestons, between proposed WSO & 150m south of Yarrunga St	63	57	-	63	58	-	0	-1	-
Power St, Glendenning, between proposed WSO & Rooty Hill Rd	59	56	-	58	55	-	1	1	-
Rooty Hill Rd Nth, Oakhurst, between 150m sth of Luxford Rd & Richmond Rd	71	66	-	69	65	-	2	1	-

The tabulated results indicate that modelled noise levels are generally less than the measured noise levels. As a general rule, the CORTN noise model tends to over-predict traffic noise levels. However in this case there are a number of uncertainties which may be responsible for the slight under-prediction which is evident, and these are listed below:

- Traffic noise levels measured in 1995 do not exclude influences from other noise sources, therefore monitored noise levels would generally be higher than the traffic noise levels alone.

- Traffic volume data is based on 1996 traffic volumes at the nearest, most relevant traffic monitoring station listed in the RTA's 'Traffic Volume Data for the Sydney Region 1996'. For more accurate validation, traffic counts should be concurrent with the noise monitoring period.

- The percentage heavy vehicle data used in most of the validation modelling was assumed at 11%, based on the values used for the WSO traffic noise predictions. This may not be the case at these validation test locations.

- All monitoring locations were re-visited to check the distances between the monitoring locations and the existing road. While evidence of possible road realignment or changes to the surrounding environment since 1995 was checked during the field trip, this is difficult to determine accurately. This may have resulted in changes to distances between the existing road and the monitor locations, which would thus slightly influence the modelled noise results.

Acceptable level of accuracy

The CORTN noise model used by Renzo Tonin & Associates in the WSO EIS and subsequent work carried out for this report has been validated against noise logger data measured along for existing roads along the northern and southern sections of the route. The results generally found that the model validates within ± 3dB(A) of the measured road traffic noise levels.

Validation of the CORTN noise model as part of past projects also shows that the model has good correlation with actual road traffic noise levels and, has a statement of acceptance from the EPA (see ***Appendix C***).

5.3 NORTH SECTION EIS NOISE MODEL VERIFICATION

This section of the report presents verification of the noise model used for the North Section EIS against the CORTN 88 model, which was used to model traffic noise for the South Section.

The noise level at the nearest affected residence (NAR) in each Noise Catchment Area (NCA) was determined from the noise contour maps provided in the EIS Working Paper No 5. These noise levels were then compared with the noise levels modelled at each NAR using CORTN. Care was taken to ensure that the CORTN input data was the same as was used in the EIS. For example, adjoining roads were not modelled for the EIS North Section, therefore they were omitted from the input data into the CORTN model.

The results of the verification are summarised in ***Table 5.3.1*** below.

TABLE 5.3.1 – EIS NOISE LEVELS -V- CORTN NOISE LEVELS (NORTH SECTION)								
NCA	Loc'n wrt WSO	Nearest Affected Residence (NAR)	EIS Noise Level		CORTN Noise Level		Difference (EIS-CORTN)	
			Day	Night	Day	Night	Day	Night
1E	east	Wallgrove Rd, sth of Alaine St	55	50	58	53	-3	-3
1W	west	Wallgrove Rd, sth Cobham St	60	55	61	56	-1	-1
2E	east	Redmayne Rd (sth), east of Wallgrove Rd	63	58	60	55	3	3
2W-a	west	Wallgrove Rd (east), sth of Chandos St	55	50	58	52	-3	-2
2W-b	west	Wallgrove Rd (east), nth of Horsley Dr	58	53	60	55	-2	-2
3	No Houses							
4	east	Pikes Ln (east side), sth Grt Western Hwy	60	55	57	52	3	3
5	west	Wallgrove Rd, sth of Grt Western Hwy	61	52	58	54	3	-2
6	west	Church St (end of), east of Rooty Hill Rd	59	56	61	57	-2	-1
7E	east	End of Dunsmore St (east), opp. 7W	63	58	62	58	1	0
7W	west	Dunsmore St (nth side), last house before WSO	63	58	64	59	-1	-1
8	west	Station Street (west), south of Woodstock	65	60	68	63	-3	-3
9	west	Polonia Ave, Chainage 16000	65	60	68	63	-3	-3
10E	east	Farmhouse south of Lamb St	58	53	59	54	-1	-1
10W	west	Plumpton Road (West)	62	57	64	59	-2	-2
11	west	End of Shaughnessy St	57	51	54	50	3	1
12	east	Woodley Cres, Oakhurst (opposite 11)	60	55	62	57	-2	-2
13	east	End of Simms Road	65	60	65	60	0	0
14	west	End of Ansley Ave	63	60	63	58	0	2
15N	north	End of Symonds Road	55	48	55	49	0	-1
15S	south	Nathan Cres, opposite Brook Street	55	47	57	52	-2	-5
16	north	Station Road (north) Last hse before bush	65	60	65	59	0	1
17	north	Rowntree Street (Sth), opposite Caton Pl	60	55	62	55	-2	0
18	south	Molong St (North) opposite Marx Pl	60	55	63	57	-3	-2
19	north	Sherridon Crs (Sth) opposite Parnell Ave	62	56	65	59	-3	-3
20	south	Timor Place/ Donahue St	60	54	63	57	-3	-3
21	north	End of Powers Lane	57	51	60	54	-3	-3
22	south	Battleaxe on cnr of Shanke Cres (nth)	59	53	56	50	3	3
23a	north east	Ampitheatre Circuit, East of Ol Windsor Rd	60	54	60	54	0	0
23b	north east	Baulkham Hills Rd (west)	63	57	66	59	-3	-2
24	south west	Valerie Ave, north of Seven Hills Reservoir	58	52	61	55	-3	-3

Good correlation The verification results tabulated above show that the two methods of noise modelling compare within ± 3dB(A) except at one location. This is within the expected accuracy for noise modelling.

Therefore, instead of re-modelling the entire north section, the noise contours predicted in the EIS are modified herein to incorporate noise levels from interchanges, major adjoining roads and major cross roads.

5.4 NIGHT-TIME MAXIMUM NOISE PREDICTIONS

A brief literature survey indicates there are no commercially available computer programs capable of predicting the L_{max} noise levels resulting specifically from traffic. As such, the RTA is currently conducting a study to investigate the development of a method for predicting or calculating L_{max} (or peak) traffic noise levels from proposed roadways.

However, as the Environment Protection Authority's policy requests a broad assessment of L_{max} noise levels along new roadways, two different techniques have been developed by Renzo Tonin & Associates and used in this study to predict the L_{max} noise levels likely to be experienced within representative residential areas adjacent to the proposed road:

Technique 1: Analyse and compare the night-time $L_{eq,9\ hour}$ and L_{max} noise data available from our library files which has been measured along existing motorways, to derive a typical correction for the difference between the $L_{eq,9hour}$ and L_{max} noise levels resulting from traffic flows. Invariably, these factors are dependent on a number of road and traffic parameters, therefore distance attenuation, ground effects and noise barrier effects were investigated to develop noise conversion factors, suitable for each selected assessment point along the proposed road. The assessment of L_{max} noise levels was conducted at critical points selected as being potentially worst affected along the roadway.

Technique 2: Obtain L_{max} sound power levels of trucks on Australian roads driving under a number of different conditions and speeds and use the Environmental Noise Model (ENM) computer model, to predict the L_{max} noise level range applicable at each selected residential assessment point. The computer model accounts for attenuation between the noise source and the receptor points due to topographic shielding, road-side barriers, distance attenuation and ground effects. The assessment of L_{max} noise levels is conducted at the points selected as potentially most affected along the proposed road.

6. TRAFFIC NOISE IMPACTS

In order to assess the proposal against the Environment Protection Authority's noise goals, daytime $L_{eq(15\ hour)}$ and night-time $L_{eq(9\ hour)}$, noise contours were generated for the year 2016. Noise levels were computed using the traffic noise model for the year 2006, however noise contours were not generated for that year as the noise results are only marginally different to the year 2016 results (for example see Table 4.4 of the Renzo Tonin & Associates working paper). Therefore, only the higher impact, year 2016 noise contours, are presented showing the combined noise emissions of the proposed road and the adjoining feeder roads.

Noise contour maps

The noise contour maps presented for daytime $L_{eq(15hour)}$ and night-time $L_{eq(9hour)}$, generally remain unchanged from those presented in the Renzo Tonin & Associates working paper for the section south of Elizabeth Drive Cecil Hills, with the exception of ***Figures 12.6f*** and ***12.7f***, where a major change in road alignment is proposed.

Therefore, ***Figures 26.3a to 26.3q*** in ***Appendix D*** show the predicted daytime noise level contours for the year 2016 without noise abatement measures for the northern route extending from Cecil Hills to the M2 Motorway. ***Figures 26.4a to 26.4q*** in ***Appendix D*** show the predicted night-time noise level contours for the year 2016, also without noise abatement measures. All noise contours and noise levels predicted herein do not include noise losses due to any noise abatement measures other than from features integral to the 'base' design of the roadway eg. road alignment, road cuttings, road embankments, low road gradients, open-graded asphaltic concrete on main carriage ways and other such base design features as described below in more detail:

Road design features which assist in noise reduction

Road Alignment:

The alignment of the route has been planned so as to minimise impact (with respect to both its siting and noise resulting from conveyed traffic flows) upon developed and urbanised areas.

The alignment of the route has, where appropriate, been selected so as to take advantage of the acoustic opportunities provided by naturally occurring buffer zones and vegetation between the proposed roadway and adjacent residences. This is exemplified by the fact that the proposed route has now undergone a major re-alignment westwards to be further removed from the new residential development areas at Cecil Hills.

Road Cuttings:

The benefit of the road being in a cutting at some locations, is clearly demonstrated in the noise contour figures, where traffic noise levels rapidly attenuate due to the natural barrier effects. For example this occurs from Hoxton Park Airport to Wallgrove Road.

Road Embankments:

There is a perception that elevated roadways "amplify" noise. In fact, this is not the case. Noise propagates from elevated roads differently to roads at-grade. Road height affects how noise spreads beside the road and not the amount of noise generated.

Spread of noise from a road is largely dependent on two factors:

- Distance from the road, and
- Acoustic shielding (from noise walls or mounds, from intervening buildings or natural land contours). Shielding can produce attenuation equivalent to more than a doubling of the distance between a receiver and the road. Shielding is more effective than distance in reducing traffic noise for receivers set back from the road.

Locations under elevated roads are within "shadow" zones created by shielding from the road structure. Further away, and at higher levels benefits from shielding are lost, so noise levels are higher. For example, there is more noise 100 metres from the road than directly under the road.

Noise spread from a road "at-grade" or in a cutting is attenuated by the combined effect of distance and shielding from intervening buildings. Beyond the first few rows of buildings, traffic noise may not be noticed above ambient noise from traffic on other roads in the vicinity.

If an elevated road is higher than the surrounding residences, significant separation may be necessary before other traffic noise sources mask noise from the road, however noise would be audible over a wider area.

Adding roadside barriers extends the "shadow" zone and significantly reduces noise levels at shielded locations. Barriers also reduce the differences between at-grade and elevated roads.

The road is largely on embankments from the M5 Motorway to the Hoxton Park Airport.

Low Road Gradient:

The proposed road has been designed in-keeping with a low road gradient objective. A low road gradient was maintained wherever possible.

Steep road gradients require vehicle engines to work harder while the vehicle travels up hill, than what they would when vehicles travel on flatter roads. An increase in road gradient from 0° to 10° from the horizontal plane can raise noise emission levels by approximately 3dB(A).

Low-Noise Road Surface:

The noise loss resulting from the use of open-graded asphaltic concrete is conservatively taken to be in the order of 2-3dB(A) in noise prediction calculations. The actual degree of noise loss achieved in practice is dependent on the actual road surface mix used and the way it is applied.

Predicted Change in Noise Impact from Year 2006 to Year 2016:

Table 4.4 of the Renzo Tonin & Associates working paper presents the net change in traffic noise levels expected between the first year of opening (year 2006) of the proposed southern section of the WSO and ten years after opening (year 2016). The table includes these results for the proposed road, its ramps and adjoining roads separately.

Traffic noise change

Table 6.0 below presents the net change in traffic noise levels expected between the first year of opening (year 2006) of the proposed northern section of the WSO and ten years after opening (year 2016). The table includes these results for the proposed road, its ramps and adjoining roads separately. Traffic volume data was supplied by Wilkinson Murray.

TABLE 6.0 - PREDICTED NOISE CHANGE FROM YEAR 2006 TO YEAR 2016 FOR NORTHERN SECTION

Roadway	Forecast Traffic Volumes		Predicted Change in
	2006	2016	Noise Levels
Western Sydney Orbital (WSO) Motorway			
WSO - north of Elizabeth Dr	43900	57000	1.1
WSO - north of Abbotsbury Rd	43900	57000	1.1
WSO - north of The Horsley Dr	62600	74000	0.7
WSO - north of M4 Interchange	47500	62700	1.2
WSO - north of Great Western Hwy Interchange	46400	55200	0.8
WSO - north of Eastern Rd	46700	55800	0.8
WSO - north of Woodstock Rd	46700	55800	0.8
WSO - north of Power St	47500	62100	1.2
WSO - east of Richmond Rd Interchange	56800	67600	0.8
WSO - east of Station St	73600	86800	0.7
WSO - east of Sunnyholt Rd	62400	80600	1.1
WSO - east of Norwest Blvd	50200	61000	0.8
WSO - east of Old Windsor Rd	60600	76500	1.0
WSO - east of Seven Hills Rd	60600	76500	1.0
WSO Ramps			
Northbound WSO Ramp to Elizabeth Dr	4100	5000	0.9
Northbound WSO Ramp from Elizabeth Dr	7400	11100	1.8
Southbound WSO Ramp to Elizabeth Dr	3800	6800	2.5
Southbound WSO Ramp from Elizabeth Dr	6100	7700	1.0
Northbound WSO Ramp to The Horsley Dr	5800	5500	-0.2
Northbound WSO Ramp from The Horsley Dr	7300	7100	-0.1
Southbound WSO Ramp to The Horsley Dr	9700	9000	-0.3
Southbound WSO Ramp from The Horsley Dr	1900	2100	0.4
Northbound off ramp to M4 Motorway	9000	10300	0.6
Northbound on ramp from M4 Motorway	5000	7900	2.0
Southbound off ramp to M4 Motorway	8400	16000	2.8
Southbound on ramp from M4 Motorway	6700	6800	0.1
Northbound off ramp to Great Western Hwy	5700	8700	1.8
Northbound on ramp from Great Western Hwy	1800	1800	0.0
Southbound off ramp to Great Western Hwy	5400	5400	0.0

TABLE 6.0 - PREDICTED NOISE CHANGE FROM YEAR 2006 TO YEAR 2016 FOR NORTHERN SECTION			
Roadway	**Forecast Traffic Volumes**		**Predicted Change in**
	2006	**2016**	**Noise Levels**
Southbound on ramp from Great Western Hwy	6900	9300	1.3
Northbound off ramp to Power St	7200	7700	0.3
Northbound on ramp from Power St	7600	8300	0.4
Southbound off ramp to Power St	14200	21900	1.9
Southbound on ramp from Power St	7000	7400	0.2
Northbound off ramp to Richmond Rd (west)	13200	19500	1.7
Eastbound on ramp from Richmond Rd (west)	26200	29600	0.5
Westbound off ramp from Ricmond Rd (east)	7000	9800	1.5
Southbound on ramp from Richmond Rd (east)	12400	16100	1.1
Eastbound on ramp from Station Rd	7300	8400	0.6
Westbound off ramp to Station Rd	12400	17800	1.6
Eastbound off ramp to Sunnyholt Rd	8200	7200	-0.6
Eastbound on ramp from Sunnyholt Rd	12100	15000	0.9
Westbound off ramp to Sunnyholt Rd	7700	13500	2.4
Westbound on ramp from Sunnyholt Rd	10200	13200	1.1
Eastbound off ramp to Norwest Blvd	6300	9100	1.6
Eastbound on ramp from Norwest Blvd	0	0	0.0
Westbound off ramp to Norwest Blvd	8900	13600	1.8
Westbound on ramp to Norwest Blvd	13400	23200	2.4
Eastbound on ramp from Old Windsor Rd	13000	20400	2.0
Westbound off ramp to Old Windsor Rd	0	0	0.0
Eastbound off ramp to Seven Hills Rd	0	0	0.0
Eastbound on ramp from Seven Hills Rd	8200	10100	0.9
Westbound off ramp to Seven Hills Rd	19000	24000	1.0
Westbound on ramp from Seven Hills Rd	10300	16100	1.9
Existing Roads			
Wallgrove Rd - north of Elizabeth Dr	14800	19400	1.2
Wallgrove Rd - north of Abbotsbury Dr	21800	28000	1.1
Wallgrove Rd - north of The Horsley Dr	14300	19000	1.2
Wallgrove Rd - north of Old Wallgrove Rd	16900	24000	1.5
Wallgrove Rd - north of WSO Interchange	38200	45600	0.8
Wallgrove Rd - north of M4 Ramps South	32200	38500	0.8
Wallgrove Rd - north of M4 ramp north	31000	34200	0.4
Wallgrove Rd - north of Great Western Hwy	26300	30300	0.6
Rooty Hill Rd South - north of Great Western Hwy	29900	37300	1.0
Eastern Rd - north of Rooty Hill Rd South	20300	23700	0.7
Woodstock Ave - b/w Phillip Pwy & Rooty Hill Rd Nth	5900	10600	2.5
Rooty Hill Rd Nth - north of Woodstock Ave	15800	18500	0.7

TABLE 6.0 - PREDICTED NOISE CHANGE FROM YEAR 2006 TO YEAR 2016 FOR NORTHERN SECTION			
Roadway	**Forecast Traffic Volumes**		**Predicted Change in**
	2006	**2016**	**Noise Levels**
Rooty Hill Rd Nth - north of Power St	11200	13300	0.7
Rooty Hill Rd Nth - north of Jersey Rd	16400	20500	1.0
Rooty Hill Rd Nth - north of Luxford Rd	20900	26800	1.1
Richmond Rd - East of Rooty Hill Rd Nth	26300	32700	0.9
Richmond Rd - East of Station Rd	26500	33200	1.0
Station Rd - East of Richmond Rd	34900	48200	1.4
Quakers Rd - East of Station Rd	52500	69000	1.2
Quakers Hill Bypass - Douglas Rd to Hambledon Rd	14300	27200	2.8
Quakers Hill Bypass - Hambledon Rd to Lalor Rd	9500	18200	2.8
Douglas Rd - Quakers Rd to Eastern Rd	52500	69000	1.2
Douglas Rd - Eastern Rd to Pearce Rd	11800	17400	1.7
Lalor Rd - Pearce Rd to Hambledon Rd	10400	14900	1.6
Lalor Rd - Hambledon Rd to Sunnyholt Rd	23200	30200	1.1
Sunnyholt Rd - Lalor Rd to Stanhope Pwy	42900	57400	1.3
Sunnyholt Rd - Stanhope Pwy to Old Windsor Rd	57600	82000	1.5
Sunnyholt Rd - WSO Interchange to James Cook Dr	42500	56400	1.2
Old Windsor Rd - Sunnyholt Rd to Windsor Rd	44600	58400	1.2
Old Windsor Rd - Sunnyholt Rd to Meurants Ln	49800	69600	1.5
Sunnyholt Rd - Lalor Rd to Wilson Rd	53400	70800	1.2
Sunnyholt Rd - James Cook Dr to Vardys Rd	40400	54300	1.3
Sunnyholt Rd - Vardys Rd to Turner St	37000	47800	1.1
Sunnyholt Rd - Turner St to Sackville St	32500	42900	1.2
Old Windsor Rd - Norwest Nlvd to Seven Hills Rd	52000	70100	1.3
Norwest Blvd - Old Windsor Rd to WSO	24600	38200	1.9
Old Windsor Rd - Meurants Ln to Seven Hills Rd	45800	58300	1.0
Old Windsor Rd - Seven Hills Rd to Abbott Rd	42200	45700	0.3
Seven Hills Rd - Old Windsor Rd to Merindah Rd	29200	36100	0.9
Seven Hills Rd - Old Windsor Rd to Joseph Banks Dr	37600	49400	1.2
Seven Hills Rd - Joseph Banks Dr to Johnson Ave	27300	42200	1.9
Abbott Rd - Old Windsor Rd to Johnson Ave	25800	26400	0.1

Source: Wilkinson Murray Traffic Flow Data used in EIS (North Section)

Overview of Road Traffic Noise Impacts from the Entire Route

In summary, the findings from the entire route (both southern and northern sections) are that from year 2006 to year 2016 the following shall occur:

- Increase in noise emissions from the main carriageways of the WSO by up to 1.2dB(A);

- Increase in noise emissions from most ramps by up to 2.8dB(A). Some ramps noise emissions decrease by up to -0.6dB(A); and

- Generally an increase in noise emissions from all roads adjoining the motorway by up to 2.8dB(A), with some decreasing by up to 1.5dB(A).

Comparison of With and Without the WSO

Predicted traffic noise levels on roads surrounding the southern section of the WSO, both with and without development of the WSO have been assessed for the years 2006 and 2016. These results are presented in Tables 4.5 & 4.6 of the Renzo Tonin & Associates working paper.

Year 2006 Comparison for Southern Section

In summary, the findings show for the year 2006 that traffic volumes, and in turn noise emissions, on most roads surrounding the proposed WSO will decrease in level with the WSO constructed. The decreases in noise emission levels range from zero at Camden Valley Way, south of Denham Court Road, Denham Court to 5.9dB(A) at Wallgrove Road, north of Elizabeth Drive, Cecil Park. A few surrounding roads are expected to increase in noise level by up to 2.7dB(A).

Year 2016 Comparison for Southern Section

Similarly, for the year 2016 traffic volumes, and in turn noise emissions, on most roads surrounding the proposed WSO will also decrease in level with the WSO constructed. The decreases in noise emission levels range from zero at Camden Valley Way, south of Denham Court Road, Denham Court and Fifteenth Avenue, west of Cowpasture Road, West Hoxton to 7.5dB(A) at Wallgrove Road, north of Elizabeth Drive, Cecil Park. A few surrounding roads are expected to increase in noise level by up to 2.4dB(A).

Year 2016 Comparison for Northern Section

Section 15.7 of the Wilkinson Murray working paper assesses the noise impact of with and without the development of the WSO for the year 2016. For a non-tolled WSO all roads, except Mimosa Road, south of The Horsley Drive Bossley Park, should experience a decrease in traffic flow and therefore a decrease in noise level. The predicted increase in noise level on Mimosa Street is +0.3dB(A), based on a non-tolled WSO. (See **Section 5.3** regarding North Section model validation)

That is, traffic volumes for the year 2016 and subsequently noise levels along most of the roads adjoining the proposal would decrease if the proposed road were built. Noise levels along most major adjoining roads would also decrease by the first year of opening of the proposed road.

Noise Model Sensitivity Analysis

An analysis of the sensitivity of the traffic noise model with regard to changes to certain input parameters such as traffic volume, vehicle speed and percentage heavy vehicles, was undertaken, and the results are summarised below.

The inputs were selected to cover the maximum possible range of scenarios that could occur for the project. The inputs were changed in the CORTN noise model and the dB(A) change in noise levels were established. The results are presented in ***Table 6.1*** below.

TABLE 6.1 – SENSITIVITY ANALYSIS OF TRAFFIC NOISE MODEL	
Physical Change to Existing Parameter	**Change in Traffic Noise Levels**
± 2% Heavy Vehicles	± 0.5 dB(A)
± 10% Traffic Volume	± 0.5 dB(A)
± 10km/hr Vehicle Speed	± 0.8 dB(A)
± 20km/hr Vehicle Speed	± 1.6 dB(A)

This shows that of all the three parameters modified to test the sensitivity of the noise model, the vehicle speed parameter produces the greatest noise change, showing more than a 1dB(A) change in noise level for a change of 20km/h in vehicle speed.

6.1 RESIDENTIAL AREAS

6.1.1 L_{eq} Noise Assessment

South 33 NCAs + North 29 NCAs = Total 62 NCAs

To determine the degree of impact upon residences along the proposed road during its operational phase, the route was sub-divided into a number of sections or receptor areas, identified as Noise Catchment Areas (NCAs). Each NCA was selected on the basis of having similar topographical features and similar noise contour patterns. For the southern section, a total of 33 NCAs were selected: 19 NCA's on the east-side and 14 NCA's on the west-side of the proposed roadway. For the northern section a total of 24 NCA's were identified. For this update, some of the northern section NCA's were split into two catchments where it was considered necessary so that a total of 29 NCA's were assessed.

The number of dwellings counted as being noise affected are those which fall within the boundaries of the nominated Noise Catchment Areas (NCA), as defined in ***Figures 12.8a – 12.8f***.

No. of dwellings affected

For each NCA, predicted traffic noise levels, number of dwellings exceeding the 'base criteria' and noise mitigation options were provided in Table 4.7 of the Working Paper (Table 12.10, Vol.2 of the EIS) for the southern section and Tables 6.1 and 6.2 of the Working Paper (Table 26.6 & 26.7, Vol.3 of the EIS) for the northern section. By comparing the data and information presented in the Working Paper tables to those in the EIS tables, it appears that the EIS tables contain a number of typographical errors. Notwithstanding this, the results of these tables have been re-worked and re-represented below in this report.

Table 6.1.1 provides the predicted traffic noise levels calculated at residences within each NCA. The number of dwellings that are expected to be exposed to traffic noise levels greater than $L_{eq,\ 15hr}$ = 55dB(A) during daytime and $L_{eq,\ 9hr}$ = 50dB(A) during night-time for the year 2016 are also provided. House counts are based on aerial photography provided by the RTA (dated April 2000). Estimates of total future housing are shown in brackets and are based on the SKM report 'Review and Update of Zoning and Land Use May 2001'.

As there is only a marginal increase in predicted traffic noise levels from year 2006 to year 2016, the predicted noise levels and number of dwellings counted for both years are very similar, so only the results of year 2016 are presented. The counts include dwellings that are currently exposed to traffic noise levels that are much greater than the aforementioned EPA's 'base' criteria levels, hence the counts are high. This is consistent with a conservative assessment of impact.

Additional to the noise abatement measures which form an integral part of the design of the proposed roadway (eg. cuttings, embankments, low road gradients, 'low noise' pavement surface), ***Table 6.1.1*** nominates the most preferred noise mitigation measures, from a practical and feasible perspective, for each NCA. Comments in support of the selected measures are also provided.

The provision of treatment would be 'unreasonable' where the noise level at the affected location is within 2dB(A) of the base criteria and/ or within 2dB(A) of the existing noise level as this is considered to be an insignificant change. This is particularly relevant where all remaining traffic management and road design opportunities for reducing road traffic noise have been exhausted.

The number of dwellings affected for the Southern Section, presented in ***Table 6.1.1*** below, were determined from the noise contour maps generated for the EIS, which used a vehicle speed of 90km/h. As noted in ***Table 6.1*** above, to increase the vehicle speed to 110km/h, for example, would result in a traffic noise level increase of approximately 1.6dB(A). This shift in noise contours will not significantly alter the number of dwellings affected, as presented below.

The number of dwellings affected for the Northern Section were based on the revised noise contours presented in ***Appendix D***. The vehicle speed used for the Northern Section was the posted speed limit of 110km/h between Elizabeth Drive and Woodstock Road and 90km/h between Woodstock Rd and the M2 Motorway.

TABLE 6.1.1 PREDICTED NOISE LEVELS FOR YEAR 2016, NUMBER OF DWELLINGS EXPOSED TO NOISE LEVELS EXCEEDING EPA'S 'BASE' TRAFFIC NOISE GOALS, PROPOSED NOISE MITIGATION OPTIONS AND COMMENTS

NCA	Predicted Traffic Noise Levels at Residences (2016), dB(A)		Number of Affected Residences Exceeding:				Proposed Noise Mitigation Options	Comments
			Daytime [$L_{eq,15hr}$ = 55dB(A)]		Night, [$L_{eq,9hr}$ = 50dB(A)]			
			Noise Exceedance		Noise Exceedance			
	$L_{eq,15hr}$	$L_{eq,9hr}$	1–5dB(A)	6–10dB(A)	1–5dB(A)	6–10dB(A)		
E1	55-62	50-57	36 (~85)	24 (~75)	36 (~85)	24 (~75)	Roadside Noise Barriers	Building treatment would not be cost-effective due to many residences
E2	54-63	49-58	24 (~150)	3 (~70)	24 (~150)	3 (~70)	Roadside Noise Barriers	
E3	52-65	47-60	14 (~70)	6 (~70)	14 (~70)	6 (~70)	Roadside Noise Barriers	
E4	52-59	47-54	9 (~40)	3 (~20)	9 (~40)	3 (~20)	Roadside Noise Barriers	
E5	62-65	57-60	0	2	0	2	Building treatment	Noise barriers would not

TABLE 6.1.1 PREDICTED NOISE LEVELS FOR YEAR 2016, NUMBER OF DWELLINGS EXPOSED TO NOISE LEVELS EXCEEDING EPA'S 'BASE' TRAFFIC NOISE GOALS, PROPOSED NOISE MITIGATION OPTIONS AND COMMENTS

NCA	Predicted Traffic Noise Levels at Residences (2016), dB(A)		Number of Affected Residences Exceeding: Daytime [$L_{eq,15hr}$ = 55dB(A)] Noise Exceedance		Night, [$L_{eq,9hr}$ = 50dB(A)] Noise Exceedance		Proposed Noise Mitigation Options	Comments
	$L_{eq,15hr}$	$L_{eq,9hr}$	1–5dB(A)	6–10dB(A)	1–5dB(A)	6–10dB(A)		
E6	49-56	<45-51	2 (~30)	0	2 (~30)	0	Building treatment[1]	be cost-effective due to few residences
E7	49-65	45-60	0 (~25)	1	0 (~25)	1	Building treatment[1]	
E8	no houses	no houses	0 (~30)	0	0 (~30)	0	No treatment necessary[1]	-
E9	49-53	<45-48	0	0	0	0	No treatment necessary	-
E10	46-58	<45-53	30	0	30	0	Roadside Noise Barriers	Building treatment would not
E11	48-65	<45-60	37	36	37	36	Roadside Noise Barriers	be cost-effective due to many residences
E12A	<50-65	<45-60	0 (~200)	0 (~80)	0 (~200)	0 (~80)	No treatment necessary[1]	-
E12	<50	<45	0	0	0	0	No treatment necessary	-
E13	<55	<50	0	0	0	0	No treatment necessary	-
E14	<50-55	<45-50	0	0	0	0	No treatment necessary	-
E15	50-55	<45-55	0	0	0	0	No treatment necessary	-
E16	<55-57	<45-55	0	0	0	0	No treatment necessary	-
E17	<55-60	<45-55	7	3	7	3	Roadside Noise Barriers	Elizabeth Drive Only. Building treatment would not
E18	<55-60	<45-55	23	0	20	12	Roadside Noise Barriers	be cost-effective due to many residences
W1	51-54	46-49	0 (50)	0	0 (50)	0	Roadside Noise Barriers	Building treatment would not
W2	46-47	<45	0 (70)	0	0 (70)	0	Roadside Noise Barriers	be cost-effective due to many residences
W3	59-61	54-56	0	3	0	3	Building treatment	Noise barriers would not
W4	56-60	51-55	2	1	2	1	Building treatment	be cost-effective due to
W5	48-60	<45-55	4	1	4	1	Building treatment	few residences
W6	49-52	<45-47	0	0	0	0	No treatment necessary	-
W7	47-53	<45-48	0	0	0	0	No treatment necessary	-
W8	45-53	<45-48	0 (~30)	0	0 (~30)	0	No treatment necessary[1]	-
W9	48-59	<45-54	36 (~46)	0	36 (~46)	0	Roadside Noise Barriers	Building treatment would not be cost-effective due
W10	47-65	<45-60	16	13	16	13	Roadside Noise Barriers	to many residences

TABLE 6.1.1 PREDICTED NOISE LEVELS FOR YEAR 2016, NUMBER OF DWELLINGS EXPOSED TO NOISE LEVELS EXCEEDING EPA'S 'BASE' TRAFFIC NOISE GOALS, PROPOSED NOISE MITIGATION OPTIONS AND COMMENTS

NCA	Predicted Traffic Noise Levels at Residences (2016), dB(A)		Number of Affected Residences Exceeding:				Proposed Noise Mitigation Options	Comments
			Daytime [$L_{eq,16hr}$ = 55dB(A)] Noise Exceedance		Night, [$L_{eq,9hr}$ = 50dB(A)] Noise Exceedance			
	$L_{eq,16hr}$	$L_{eq,9hr}$	1–5dB(A)	6–10dB(A)	1–5dB(A)	6–10dB(A)		
W11	48-63	<45-58	2 (~50)	1	2 (~50)	1	Building treatment[1]	Noise barriers would not be cost-effective due to few residences
W12	48-59	<45-54	3 (~50)	0	3 (~50)	0	Building treatment[1]	
W13	48-61	<45-56	0 (~50)	1	0 (~50)	1	Building treatment[1]	
W14	50-65	<45-60	0 (~220)	0 (~200)	0 (~220)	0 (~200)	No treatment necessary[1]	-
1E	<45-65	<45-60	1	2	2	1	Building treatment	Noise barriers would not be cost-effective due to few residences
1W	<45-65	<45-60	27	12	23	16	Building treatment	
2E	<45-65	<45-60	3	5	3	2	Building treatment	
2W	<45-65	<45-60	10	6	10	3	Building treatment	
3	<50-65	<45-60	0	0	0	0	Building treatment	
4	<55-65	<50-60	6	5	6	5	Building treatment	
5	<55-65	<50-60	2	2	2	2	Building treatment	
6	<45-65	<45-60	0	0	0	0	No treatment necessary	-
7E	<50-65	<45-60	0	0	0	0	No treatment necessary	-
7W	<50-65	<45-60	17	3	15	2	Building treatment	Noise barriers would not be cost-effective due to few residences
8	<55-65	<45-60	25	61	23	57	Roadside Noise Barriers	Building treatment would not be cost-effective due to many residences
9	<45-65	<45-60	41	43	25	37	Roadside Noise Barriers	
10E	<45-65	<45-60	1	0	1	0	Building treatment	Noise barriers would not be cost-effective due to few residences
10W	<45-65	<45-60	27	16	30	25	Roadside Noise Barriers	Building treatment would not be cost-effective due to many residences
11	<50-65	<45-60	15	10	15	7	Roadside Noise Barriers	
12	<45-65	<45-60	5	20	5	23	Roadside Noise Barriers	
13	<45-65	<45-60	40	80	42	68	Roadside Noise Barriers	
14	<50-65	<45-60	90	50	95	52	Roadside Noise Barriers	

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TABLE 6.1.1 PREDICTED NOISE LEVELS FOR YEAR 2016, NUMBER OF DWELLINGS EXPOSED TO NOISE LEVELS EXCEEDING EPA'S 'BASE' TRAFFIC NOISE GOALS, PROPOSED NOISE MITIGATION OPTIONS AND COMMENTS								
NCA	Predicted Traffic Noise Levels at Residences (2016), dB(A)		Number of Affected Residences Exceeding:				Proposed Noise Mitigation Options	Comments
			Daytime [$L_{eq,15hr}$ = 55dB(A)] Noise Exceedance		Night, [$L_{eq,9hr}$ = 50dB(A)] Noise Exceedance			
	$L_{eq,15hr}$	$L_{eq,9hr}$	1–5dB(A)	6–10dB(A)	1–5dB(A)	6–10dB(A)		
15N	<50-65	<45-60	1	1	1	1	Building treatment	Noise barriers would not be cost-effective due to few residences
15S	<45-65	<45-60	96	54	85	44	Roadside Noise Barriers	
16	<60-65	<45-60	28	30	30	28	Roadside Noise Barriers	Building treatment would not be cost-effective due to many residences
17	<50-65	<45-60	108	82	102	79	Roadside Noise Barriers	
18	<45-65	<45-60	167	51	146	64	Roadside Noise Barriers	
19	<45-65	<45-60	180	90	180	90	Roadside Noise Barriers	
20	<45-65	<45-60	290	78	290	78	Roadside Noise Barriers	
21	<55-65	<45-60	455	385	445	385	Roadside Noise Barriers	Building treatment would not be cost-effective due to many residences
22	<45-65	<45-60	205	110	194	110	Roadside Noise Barriers	
23a	<50-65	<45-60	19	11	19	11	Roadside Noise Barriers	
23b	<50-65	<45-60	27	5	23	5	Roadside Noise Barriers	
24	<50-65	<45-60	160	160	160	160	Roadside Noise Barriers	

Notes:

1. Numbers appearing in brackets (x) represent estimated number of houses potentially affected by the WSO in areas zoned for residential development. The number of affected residences is based on an estimated maximum number of dwellings within each land parcel. However, it is noted that the responsibility for noise mitigation to future residences in these areas is likely to rest with the developer as directed by local council (see respective comments). Whether the responsibility rests with the developer or the RTA , is likely to depend on the timing of developer approvals with respect to the timing of construction approval for the WSO. Treatment may be needed for vacant land that has been subdivided or is the subject of subdivision approval to allow noise sensitive development.
2. All NCAs have had the number of residences counted from aerial photographs taken in February 1998 along the proposed corridor.

It is noted that the predicted traffic noise levels in ***Table 6.1.1*** represent the range of noise levels calculated from the least affected to the most affected residences in each NCA.

The most 'cost-effective' noise mitigation measures nominated in ***Table 6.1.1*** were determined by comparing all available options and selecting the least costly option that would achieve noise compliance with the project's 'base' noise objectives.

6.1.2 Maximum Night Time Noise Assessment

In executing the two analysis techniques described above, three representative receiver sites for each of the northern and southern sections of the motorway were identified for inclusion on the basis of their proximity to the proposed roadway. The location of the representative subject residences is detailed in ***Table 6.1.2.1*** below.

TABLE 6.1.2.1 LOCATION OF RESIDENCES INCLUDED IN THE ANALYSIS OF MAXIMUM NIGHT TIME NOISE LEVELS

Residence Location	Approximate Road Chainage	Comments
Southern Section		
East side Illaroo Rd, Hoxton Park	3000	Single residence 50m east of WSO
West side Illaroo Rd, Hoxton Park	3200	Single residence 75m east of WSO
McIver Ave, West Hoxton	5300	Single residence 50m west of WSO
Northern Section		
Station Street, Rooty Hill	15500	Row of residences 34m west of WSO
Armitage Drive, Glendenning	18200	Row of residences 34m east of WSO
Rowntree Street, Quakers Hill	22250	Row of residences 40m north of WSO

In each instance, the predicted maximum L_{max} night time noise level impinging on each residence as a result of traffic flows on the proposed roadway was determined using each of the techniques described in ***Section 5.4*** above.

The results of the analysis are summarised in ***Table 6.1.2.2*** below. The table describes a range of results obtained using Technique 1 as opposed to the single values obtained using Technique 2. This occurs as a direct result of the variation found in the long-term monitoring data from which the results have been derived. By way of example, it was found that the typical differential between the $L_{eq,9hour}$ and L_{max} noise descriptors for all monitoring locations 50m removed from the considered roadway was between 11 to 14 dB(A). This variation or range was carried through the analysis to better represent the empirically derived results.

In contrast, given that available data allowed for the representation of the maximum sound power level of truck pass-bys (the loudest type of vehicle expected to use the proposed roadway) by a single number, the results of the Technique 2 analysis are presented as a singular value. Acoustic data for truck pass-by was derived from Australian Design Rule 28/01 "External Noise of Motor Vehicles" issued by the Federal Department of Transport and Communications, 1992.

Significantly, the noise limits set by the Australian Design Rule apply only to new vehicles and not older vehicles, which have experienced typical wear. Furthermore, the measurement procedure used in testing such a vehicle's noise compliance is conducted under controlled conditions on a flat road at a maximum speed of approximately 50km/h. Hence, the sound power levels used as the basis of the Technique 2 calculations are considered lower than the levels likely to be experienced given actual traffic conditions.

TABLE 6.1.2.2 ANALYSIS OF PREDICTED MAXIMUM NIGHT TIME NOISE LEVELS RESULTING FROM TRAFFIC FLOWS ON PROPOSED ROADWAY			
Residence Location	**Approximate Roadway Chainage**	**Predicted Maximum Noise Level L_{max}, dB(A)**	
		Technique 1	**Technique 2**
Southern Section			
East side Illaroo Rd, Hoxton Park	3000	62 – 65	53
West side Illaroo Rd, Hoxton Park	3200	59 – 61	49
McIver Ave, West Hoxton	5300	60 – 63	60
Northern Section			
Station Street, Rooty Hill	15500	71 – 74	72
Armitage Drive, Glendenning	18200	76 – 79	72
Rowntree Street, Quakers Hill	22250	69 - 72	66

Although the two estimation techniques used are fundamentally different, both sets of results generally indicate that the maximum L_{max} noise levels resulting from night-time traffic flows on the proposed road are not likely to exceed the previously described maximum noise level assessment goals, once some form of noise mitigation (eg noise barriers, mounds or building treatment to dwellings) is implemented for the purpose of complying with the L_{eq} criteria. Without noise abatement measures though, residences located close to the proposed road (ie. within approximately 100m) may be exposed to maximum noise levels that have the potential for sleep arousal at night.

It is noted that large variations in these noise estimates may occur given the influence of several variable factors specific to a given site. For example, the presence of a gradient in a road's profile will generally require that heavy vehicles use, on the one hand, low gears to negotiate the climb up the slope, and on the other, their engine compression (auxiliary) brakes to retard their acceleration down the incline. In each case, the resulting L_{max} noise levels generated by the vehicle can be significantly different, and more likely greater, than accounted for in the Australian Design Rule.

6.2 EDUCATIONAL INSTITUTIONS

Table 6.2 below presents the predicted $L_{eq(1\ hour)}$ external results for schools in the vicinity of the proposed WSO.

All schools, with the exception of the schools listed below, potentially affected by the proposal would achieve compliance with the EPA's $L_{eq(1\ hour)}$ 55dB(A) external playground noise criterion, which in turn achieves compliance with the $L_{eq(1\ hour)}$ 40-45dB(A) internal noise criteria between 8.30am and 3.30pm.

Schools where the $L_{eq(1\ hour)}$ 55dB(A) external playground criterion is exceeded include:

- Hoxton Park Catholic School;
- Horsley Park Public School;

- Eastern Creek Public School;
- Seven Hills North Public School;
- Marion Primary School, Horsley Park;
- Plumpton Primary School;
- St Francis of Assissi Catholic Primary Glendenning;
- Quakers Hill Public;
- New Tribes Bible College;
- Holy Family High.

The internal noise level criterion will be complied with at all schools with the windows kept open, except for those schools listed above. Of these ten schools, exceedances are only expected with windows closed at Horsley Park Public School, Seven Hills North Public School, Marion Primary School, Horsley Park and New Tribes Bible College. These schools may require upgraded glazing to meet the criterion in the classrooms. At all ten schoc mechanical ventilation or airconditioning may be required if the windows are to be kept closed for control of noise in affected rooms. These rooms would need to be identified by a more detailed assessment than is included here.

As Hoxton Park Catholic School is a proposed educational institution, noise mitigation can be integrated into its building design to ensure noise compliance with the EPA's noise objectives is achieved.

TABLE 6.2 PREDICTED PEAK HOUR $L_{EQ\,(1\,HOUR)}$ EXTERNAL NOISE LEVELS FOR YEAR 2016 AT EXISTING AND PROPOSED EDUCATIONAL INSTITUTIONS ALONG THE PROPOSED ROUTE

No.	Educational Institution	Address	Approx. Distance to WSO	External Noise Level $L_{eq,1hour}$	Internal Noise Level (open windows) $L_{eq,1hour}$	Internal Noise Level (closed windows) $L_{eq,1hour}$
		Existing Educational Institutions				
1	Casula High School	Myall Road, Casula	1500m	<45	35	25
2	Prestons Public School	Kurrajong Road and Box Road, Prestons	1100m	<45	35	25
3	Lurnea High School	Hillview Parade, Lurnea	1600m	<45	35	25
4	Sule College	Kurrajong Road, Prestons	≥200m	<55	45	35
5	Lurnea Public School	West Street and Reilly Street, Lurnea:	1500m	<45	35	25
6	Miller TAFE College	Hoxton Park Rd and Banks Rd, Miller	600m	<50	40	30
7	Miller High School	Cabramatta Avenue, Miller	1200m	<45	35	25
8	Hoxton Park Public School	Hoxton Park Road and First Avenue, Hoxton Park	100m	55	45	35
9	Catholic Hoxton Park / Hinchinbrook Good Shepherd School	20 Twentieth Avenue, Hoxton Park	300m	<55	45	35

TABLE 6.2 PREDICTED PEAK HOUR $L_{EQ\ (1\ HOUR)}$ EXTERNAL NOISE LEVELS FOR YEAR 2016 AT EXISTING AND PROPOSED EDUCATIONAL INSTITUTIONS ALONG THE PROPOSED ROUTE

No.	Educational Institution	Address	Approx. Distance to WSO	External Noise Level $L_{eq,1hour}$	Internal Noise Level (open windows) $L_{eq,1hour}$	Internal Noise Level (closed windows) $L_{eq,1hour}$
10	Hoxton Park High School	Wilson Road, Hoxton Park	350m	<55	45	35
11	Hoxton Park Catholic School	Hoxton Park Road, Hoxton Park	50m	60	50	40
12	Liverpool Handicapped Centre and Sheltered Workshop	Cowpasture Road and Fifteenth Avenue, Hoxton Park	700m	<50	40	30
13	Hinchinbrook Public School	Hinchinbrook Drive and Keppel Circuit, Hinchinbrook	700m	<50	40	30
14	Cecil Hills High School	Leopold Place, Cecil Hills	650m	<50	40	30
15	Horsley Park Public School	The Horsley Drive & Wallworth Road, Horsley Park	130m	67	57	47
16	Eastern Creek Public School	Rooty Hill Road, South, Eastern Creek	230m	63	53	43
17	Seven Hills North Public School	Seven Hills Road & Windsor Road, Seven Hills	200m	68	58	48
18	Marion Primary School, Horsley Park	The Horsley Drive & Felton Street, Horsley Park	200m	66	56	46
19	Plumpton Primary School	Bottles Road, Plumpton	500m	62	52	42
20	Plumpton High School	Bottles Road & Hyatts Road, Plumpton	800m	<45	35	25
21	William Dean Primary School, Dean Park	Yarramundi Drive, Dean Park	230m	48	38	28
22	Glendenning Primary School	Armitage Drive, Glendenning	370m	<45	35	25
23	St Francis of Assissi Catholic Primary Glendenning	Richmond Road & Stone Street, Glendenning	250m	63	53	43
24	Quakers Hill High	Lalor Road & Summerfield Avenue, Quakers Hill	480m	55	45	35
25	Quakers Hill Parish Primary	Farnham Road & Barnier Road, Quakers Hill	1500m	<45	<35	<25
26	Quakers Hill Public	Quakers Road & Medlow Drive, Quakers Hill	160m	64	54	44
27	Kings Langley Primary	Isaac Smith Parade & Pont Place, Kings Langley	350m	45	35	25
28	Matthew Pearce Primary	Astoria Park Road, Baulkham Hills	260m	48	38	28
29	New Tribes Bible College	Power Street & Rooty Hill Road, Plumpton	50m	69	59	49
30	Holy Family High	Quakers Hill Rd & Benalla Court, Quakers Hill	650m	63	53	43
31	Marayong Heights Primary	Shedworth Street, Marayong	700m	<45	<35	<25

TABLE 6.2 PREDICTED PEAK HOUR $L_{EQ\ (1\ HOUR)}$ EXTERNAL NOISE LEVELS FOR YEAR 2016 AT EXISTING AND PROPOSED EDUCATIONAL INSTITUTIONS ALONG THE PROPOSED ROUTE						
No.	**Educational Institution**	**Address**	**Approx. Distance to WSO**	**External Noise Level $L_{eq,1hour}$**	**Internal Noise Level (open windows) $L_{eq,1hour}$**	**Internal Noise Level (closed windows) $L_{eq,1hour}$**
32	Uni. of West. Sydney (Western Syd. Inst. of TAFE & Terra Sancta College)	Quakers Hill Road, Quakers Hill	700m	52	42	32
33	Bamier Primary	Bamier Road & Farnham Road, Quakers Hill	1500m	<45	<35	<25
34	Clare Cath High	Buckwell Drive, Hassall Grove	700m	<45	<35	<25
			Proposed Educational Institutions			
35	Carnes Hill Primary School	Cowpasture Road and Twelfth Avenue, Hoxton Park	1500m	<45	35	25
36	Bumbera Street Primary School	Bumbera Street, Prestons	2500m	<45	35	25
37	Horningsea High School	500m west of Bumbera Street, Prestons	3000m	<45	35	25
38	Prestons West Primary School	Near Skipton Lane, Prestons West	400m	<50	40	30
39	Prestons Public School	Dalmeny Drive, Prestons	600m	<45	35	25

The noise levels presented in ***Table 6.2*** above include noise contributions from adjoining and surrounding roads as well as WSO road traffic noise. In some cases, the contribution from the WSO is significantly less than from other roads.

6.3 PLACES OF WORSHIP

For places of worship, the Environment Protection Authority requires that the noise impact of road projects be assessed against an internal goal of $L_{eq,1\ hr}$ = 40dB(A). An internal noise level of 40dB(A) approximates to a noise level of 50dB(A) outside the building.

TABLE 6.3 - PREDICTED $L_{eq\ (1\ hour)}$ NOISE LEVELS FOR YEAR 2016 AT PLACES OF WORSHIP ALONG THE ROUTE			
No.	**Place of Worship**	**Address**	**Predicted External $L_{eq,1hour}$ (Peak Hour)**
1	Hoxton Park Christian Life Centre	Illaroo Road and Hoxton Park Road, Hoxton Park	52dB(A)
2	Seventh Day Adventist	Hoxton Park Road, Hoxton Park	<50dB(A)
3	Catholic Hoxton Park / Hinchinbrook Good Shepherd Church	20 Twentieth Avenue, Hoxton Park	<50dB(A)
4	Horsley Park Catholic Church	The Horsley Drive, Horsley Park	62dB(A)
5	Rooty Hill Presbyterian Church	Rooty Hill Road South, Rooty Hill	56dB(A)

Of the places of worship listed in ***Table 6.3*** above, which are potentially affected by the proposal, the following places of worship may experience noise levels in excess of the Environment Protection Authority's traffic noise goals:

- Hoxton Park Christian Life Centre;
- Horsley Park Catholic Church;
- Rooty Hill Presbyterian Church

Noise monitoring and modelling conducted for these places of worship indicates that ambient noise levels are controlled by traffic along Hoxton Park Road, The Horsely Drive and Rooty Hill Road South respectively and are already in excess of 50dB(A) outside the buildings. At the Hoxton Park Christian Life Centre and the Rooty Hill Presbyterian Church, noise from Hoxton Park Road and Rooty Hill Road South controls the local noise environment. The erection of tall noise barriers along the WSO would provide no net improvement to ambient noise levels.

Noise measurements should be undertaken within the Horsley Park Catholic Church to determine appropriate noise mitigation to be applied. The appropriate hour to assess the $L_{Aeq,1hr}$ may be specific to each church. The above levels assume the churches are used on weekdays, which is likely. Sunday morning levels might be 1-2 dB(A) less than the predicted level.

All other places of worship are not expected to be adversely affected by the proposal.

6.4 RECREATIONAL AREAS: PARKS AND RESERVES

Noise impact to recreational areas was adequately assessed as part of the EIS, however the assessment of recreational areas as buffer zones for residential areas was considered inadequate.

Therefore assessment of potentially affected recreational areas has been carried out to determine the feasibility of acoustic treatment. The assessment is based on the type of use, frequency of use and the likelihood that predicted traffic noise levels will impact on recreational activities. Proposed parks or proposed changes to parks and recreational areas have also been considered in this assessment

Table 6.4.1 presents the predicted traffic noise level exposure of recreational areas identified along the proposed route.

TABLE 6.4.1 - PREDICTED $L_{eq\ (1\ hour)}$ NOISE LEVELS FOR YEAR 2016 AT RECREATIONAL AREA ALONG THE ROUTE

Recreational Area	Address	Use: Active/ Passive	Frequency of Use	Criteria $L_{Aeq,15hr}$, dB(A)	Predicted $L_{eq,15hr}$, dB(A)	Comment
Southern Section						
Liverpool Showground	Kurrajong Rd Prestons	Passive		55	60+	Privately owned. Owners approaching RTA for acquisition

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TABLE 6.4.1 - PREDICTED $L_{eq\ (1\ hour)}$ NOISE LEVELS FOR YEAR 2016 AT RECREATIONAL AREA ALONG THE ROUTE						
Recreational Area	**Address**	**Use: Active/ Passive**	**Frequency of Use**	**Criteria $L_{Aeq,15hr}$, dB(A)**	**Predicted $L_{eq,15hr}$, dB(A)**	**Comment**
Miller Park, Powel Oval	Hoxton Park Rd Miller	Active	Cricket & BMX track. Not used every day	60	<50	Complies
Hoxton Par Recreation Reserve	Hoxton Park Rd Hoxton Park	Active	Soccer/ Cricket 7 days	60	50-60+	Part to be acquired by RTA. <10% of remainder exceeds criteria
Serbian Cultura Club	256 Cowpasture Rd Hoxton Park	-	Privately owned. Owners approaching RTA for acquisition	55	60	To be acquired by the RTA
Sydney International Shooting Range	Cecil Hills, Hoxto Park Corridor	Active		60	<50	Complies
Freodore D Reserve	Feodore Dr, Ceci Park	Passive	Local usage; no plans for development in near future	55	<50	Complies
Northern Section						
Western Sydney Regional Park	Cecil Park	Passive	Public open space for recreation at social and informal level	55	<60	<10% exceeds criteria. Park designed to accommodate WSO.
Fairfield City Farm (Mountain Bike Track)	Darling Street Abbottsbury	Active	Horse riding & bike riding training + competitions; Eastern side used for activities. Western side facing WSO for grazing	60	<55	Complies. Noise contribution mostly Elizabeth Dr.
Sydney International Equestrian Centre	The Horsley Par Dr, Horsley Park	Active	Training & competitions. Usage expected to increas with new marketing strategy.	60	57-65	<5% affected by WSO alone. Horsley Dr contributes to total noise
Horsley Park	Horsley Dr & Arindl Rd, Horsely Park	Active	Winter - 7 days per week for soccer training + games; Summer picnic ground used each weekend	60	<60	Complies. Noise contribution mostly The Horsley Dr.
Australia's Wonderland	Wallgrove Rd Minchinbury	Active	7 days per week	60	<50-60	Complies
Eastern Creek Raceway	Ferrers Rd, Easter Creek	Active	Up to 7 days per week	60	<55	Complies
Pinegrove Memorial Park (Lawn Cemetery)	Kington St Minchinbury	Passive	7 days per week	55	<55-58	150m strip west of Wallgrove Rd potentially affected. Noise contribution from WSO & Wallgrove Rd
Cawarra Reserve	Cawarra Street Minchinbury	Active	Sports field. All weekend + during week for training + school use	60	50-60	Complies.
The Rooty Hill	Cnr Eastern Rd Rooty Hill Rd, Root Hill	Passive	Concerts/ fireworks 1-2 times per year	55	50-55	Complies
Morreau Reserve		Active	Sports field. All weekend + during week for training + school use	60	50-60	Complies.
Harry Dennison Park	Rooty Hill	Active	Sports field. All weekend + during week for training + school use	60	55	Complies
Aquilina Reserve	Reginald Street	Active	Athletics track used 7 days	60	55-58	Complies

TABLE 6.4.1 - PREDICTED $L_{eq\ (1\ hour)}$ NOISE LEVELS FOR YEAR 2016 AT RECREATIONAL AREA ALONG THE ROUTE						
Recreational Area	**Address**	**Use: Active/ Passive**	**Frequency of Use**	**Criteria $L_{Aeq,15hr}$, dB(A)**	**Predicted $L_{eq,15hr}$, dB(A)**	**Comment**
	Rooty Hill		by schools + Western Sydney Academy of Sport etc			
Narragundy Reserve	Knox Rd Doonside	Passive	Picnic grounds in constant use + wedding reception centre (run privately, leased from Council) used most weekends	55	<50	Complies
Blacktown Pionee Soccer Field	Blacktown	Active	Sports field. All weekend + during week for training + school use	60	46-48	Complies
Sanford Street Reserve	Glendenning	Passive	Local park with playground equipment used by local residents	55	50	Complies
Yarramundi Dr Reserve	Yarramundi Drive Dean Park	Active	Cricket ground. Generally used on weekends	60	50-55	Complies
Anthea Place Reserve	Anthea Place, Dea Park	Passive	Local park with playground equipment used by local residents	55	55	Complies
Symmond Road Reserve	Dean Park	Passive	Local park with playground equipment used by local residents	55	<55	Complies
Wright Reserve	Pye Rd, Kings Park	Active	Sports field. All weekend + during week for training + school use	60	55-60	Complies
Corbin Reserve	Kings Park	Active	Sports field. All weekend + during week for training + school use	60	<55	Complies
Melrose Park	Melrose Ave Quakers Hill	Active	Sports field. All weekend + during week for training + school use	60	<55	Complies
Faukland Cres Reserve	Faukland Cres Kings Park	Passive	Local park with playground equipment used by local residents	55	<50	Complies
Glenwood Park	Glenwood Park Dr Glenwood	Active	(To be developed) Sports field. All weekend + during week for training + school use	60	45-50	Complies
Reserve (sth of Meurants)	Meurants Rd Glenwood	Active	(To be developed) Sports field. All weekend + during week for training + school use	60	55-65	<10% exceeds criteria. Barriers used to reduce traffic noise at residences would also reduce noise levels at park
Valentine Park	Cnr Meurants Ln Old Windsor Rd Glenwood	Active	Sports field. All weekend + during week for training + school use	60	55-65	<10% exceeds. Exceedance contributed to mostly by Old Windsor Rd and Norwest Bld
Discovery Park	Kings Langley	Passive	Local park with playground equipment used by local residents	55	<50	Complies
Lady Penrhyn Reserve	Hartam Street Rosina St King Park	Passive	Local park with playground equipment used by local residents	55	50-65	<10% exceeds criteria. Barriers used to reduce traffic noise at residences would also reduce noise

TABLE 6.4.1 - PREDICTED $L_{eq\ (1\ hour)}$ NOISE LEVELS FOR YEAR 2016 AT RECREATIONAL AREA ALONG THE ROUTE						
Recreational Area	**Address**	**Use: Active/ Passive**	**Frequency of Use**	**Criteria $L_{Aeq,15hr}$, dB(A)**	**Predicted $L_{eq,15hr}$, dB(A)**	**Comment**
						levels at park
Edna Street Reserve	Kings Langley	Passive	Local park with playground equipment used by local residents	55	48-60	<10% exceeds criteria. Barriers used to reduce traffic noise at residences would also reduce noise levels at park
Troubador Park	Kings Langley	Passive	Local park with playground equipment used by local residents	55	60-65	Old Windsor Rd contributes to exceedance
Solar Ave Reserve	Solar Ave, Wes Baulkham Hills	Passive	Local park with playground equipment used by local residents. Usage likely to increase with planned improvements	55	50-55	Complies.
Sierra Reserve	Sierra Pl, Wes Baulkham Hills	Mixed Active + Passive	Cyclepath & bush track. Usage likely to increase with planned improvements	55	>60	M2 contributes to exceedance
Col Sutton Park	Baulkham Hills Rd West Baulkham Hills	Passive	Cyclepath & bush track. Usage likely to increase with planned improvements	55	>60	M2 contributes to exceedance

The table above summarises the parks and recreational areas that may experience noise levels in excess of the Environment Protection Authority's active or passive recreational area traffic noise objectives.

Generally these facilities are located amongst residences. Recreational land areas and parks are often used to provide noise buffer zones to protect residential areas. Parks that may experience an exceedance of the EPA's criteria have been further assessed in terms of their level of use and the type of use in order to determine the feasibility of providing acoustic treatment to achieve the EPA's criteria.

All other recreational areas are located further away from the proposed road and would comply with the project's respective passive or active noise criteria.

6.5 COMMERCIAL & INDUSTRIAL PREMISES

Generally, commercial and industrial properties are located amongst residential areas. These include the Hoxton Park and Hinchinbrook areas. Noise calculations indicate that noise levels at commercial and industrial properties would generally comply with the recommended interior noise levels of Australian Standard AS2107 -1987 "Acoustics-Recommended design sound levels and reverberation times for building interiors" assuming standard commercial building construction. Mitigative treatments proposed to achieve the Environment Protection Authority's traffic noise criteria for schools and residential properties may further reduce noise emissions to commercial properties, further ensuring noise compliance with the set objectives for such premises.

Typical construction materials and building methods adopted in high density urban and city areas may be applied to construct quality office space and hotels in the future to ensure that any potential noise impacts are ameliorated.

7. PROJECT MODIFICATIONS

7.1. RELEVANT PROJECT MODIFICATIONS

This information included in this assessment update is based on the following project modifications, considered to potentially change the noise impact of the WSO, as assessed in the EIS. Other project modifications do not require quantitative noise assessment. The project modifications have been considered when generating noise contour maps and tabled data for this report.

- Beech Road upgrade from 2 to 4 lanes from WSO ramp to Camden Valley Way at Casula. 1x traffic signals and 1x roundabout.

- Bernera Road upgrading 400 metres from WSO to Yarrunga Street at Prestons. West side strip acquisition for future Transitway.

- WSO/Cowpasture Road interchange - Cowpasture Road widened on east side within road reserve (N and S of WSO) to allow for future six lanes.

- Move horizontal alignment of the WSO at Cecil Hills up to 250 metres westwards.

- Vertical alignment of the WSO at The Horsley Drive - lifted 2 to 3 metres to provide vertical clearance over The Horsley Drive.

- WSO/M4 EIS Interchange at Eastern Creek replaced with new interchange to improve traffic capacity, safety performance and more logical directional movement for road users.

- WSO/Power Street interchange. South-facing ramps deleted at Power Street and moved to Woodstock Avenue. Grade separation at Woodstock Avenue will become a partial interchange. WSO graded to go over Woodstock Avenue to reduce impacts on private properties in Woodstock Avenue and Station Street.

- Widen Power Street from 2 to 4 lanes west of WSO to Rooty Hill Road.

- Widen Rooty Hill Road North from 2 to 4 lanes between Luxford Road and Richmond Road.

- Richmond Road upgrade to 4 lane dual carriageway from WSO to Bells Creek.

- Assess section Norwest Blvd - from Greenhill Drive to Old Windsor Road.

Therefore, noise impacts as a result of these additions and modifications to the project have been assessed in other sections of this report. Revised noise contour maps for the northern section appear in ***Appendix D***. Revised noise contour maps for the southern section appear ***in Appendix E***.

7.2. ADDITIONAL NOISE MONITORING

Additional noise monitoring was carried out at six locations over a 7 day period in June 2001. The six locations were selected based on the proposed modifications listed above, and the anticipated change in noise impact. Noise monitoring was used as the base for traffic noise modelling of the proposed modifications.

Traffic counting was carried out simultaneously with noise monitoring to enable the noise model to be validated.

Noise monitoring and traffic counting was undertaken at the following locations:

- Beech Road, Casula - Between Camden Valley Way & proposed WSO
- Benera Road, Prestons - Between proposed WSO & 150m south of Yarrunga St
- Power Street, Glendenning - Between proposed WSO & Rooty Hill Rd
- Rooty Hill Road North - Between 150m south of Luxford Rd & Richmond Rd
- Richmond Road, Marsden Park - Between 150m north of Bells Creek & WSO
- Greenhill Drive, Glenmore Park - Between 150m north of Bells Creek & WSO

As noted above, traffic volume data was measured during the noise monitoring. This data, along with predicted traffic volumes for 2006 and 2016 were used in the noise modelling at each location. This data is summarised in ***Table 7.2.1***.

TABLE 7.2.1 ADDITIONAL NOISE MONITORING TRAFFIC VOLUME SUMMARY

Road	AADT		
	Measured	Estimated	
	2001	2006	2016
Beech Road	6020	24120	26124
Bernerra Road	14534	7560	10464
Norwest Boulevarde	-	16823	26124
Power Street	3169	22860	30348
Richmond Road	21010	32484	36192
Rooty Hill Road	9571	33192	34272

Noise modelling was carried out to determine the change in noise levels at the six locations identified above where road modifications have occurred. Nominal barrier heights were also predicted for each location, based on

2016 traffic volumes. The results are presented in ***Table 7.2.2*** below. The results of noise monitoring appear in ***Appendix F***.

TABLE 7.2.2 EXISTING AND PREDICTED NOISE LEVELS AT ADDITIONAL MONITORING LOCATIONS							
Address	**Traffic Noise Level, dB(A)**						**2016 Barrier Height1 to Achieve ECRTN 'Base Criteria'2, m**
	2001 Measured		**2006 Predicted**		**2016 Predicted**		
	$L_{Aeq,15h}$	$L_{Aeq,9h}$	$L_{Aeq,15h}$	$L_{Aeq,9h}$	$L_{Aeq,15h}$	$L_{Aeq,9h}$	
Beech Rd Casula	58	56	66	60	66	61	3.5
Bernera Rd Prestons	63	58	60	46	61	46	2
Power St Glendenning	58	55	68	63	69	64	5.5
Rooty Hill Rd Nth Oakhurst	69	65	73	68	73	68	5
Richmond Rd Marsden Park	56*	50*	57	52	57	52	1
Norwest Bld Bella Vista	58	48	~63	~57	~65	~59	3.5

Note: *Noise logger experienced a technical fault, therefore noise levels predicted based on traffic count data on Richmond Road, measured 17.06 to 23.06.2001

7.3. SUMMARY OF NOISE IMPACTS FROM PROJECT MODIFICATIONS

The results of a comparison of noise impact of the WSO at the EIS stage against the WSO at the re-assessment stage, with and without the project modifications are summarised in ***Table 7.3.1*** below.

TABLE 7.3.1 – COMPARISON OF NOISE IMPACT WITH & WITHOUT PROPOSED PROJECT MODIFICATIONS								
Modification and catchment area	**Year 2016, Daytime $L_{eq(15hr)}$**				**Year 2016, Night time Leq(9hr)**			
	Before Modification (EIS Stage)		**After Modification (Re-assessment)**		**Before Modification (EIS Stage)**		**After Modification (Re-assessment)**	
	$L_{eq(15hr)}$ Noise level	**No of dwellings exceeding criteria**	**$L_{eq(15hr)}$ Noise level**	**No of dwellings exceeding criteria**	**$L_{eq(9hr)}$ Noise level**	**No of dwellings exceeding criteria**	**$L_{eq(9hr)}$ Noise level**	**No of dwellings exceeding criteria**
WSO realignment at Cecil Hills								
E12A	New catchment - did not exist at EIS stage		<50-65	0	New catchment - did not exist at EIS stage		<45-60	0
E12	52-63	31	<50	0	47-58	31	<45	0
E13	45-62	4	<55	0	<45-57	4	<50	0
E14	49-58	7	<50-55	0	<45-53	7	<45-50	0
E15	50-51	0	50-55	0	45-46	0	<45-55	0
E16	50-51	0	<55-57	0	45-47	0	<45-55	0
E17	49-63	8	<55-60	10	<45-58	8	<45-55	10
E18	46-59	18	<55-60	23	<45-54	18	<45-55	32
New M4 interchange design								
3	not shown in EIS	0	<50-65	0	not shown in EIS	0	<45-60	0
4	not shown in EIS	4	<55-65	11	not shown in EIS	4	<50-60	11
5	not shown in EIS	1	<55-65	4	not shown in EIS	1	<50-60	4
Include traffic noise from Horsely Dr								

TABLE 7.3.1 – COMPARISON OF NOISE IMPACT WITH & WITHOUT PROPOSED PROJECT MODIFICATIONS								
Modification and catchment area	**Year 2016, Daytime $L_{eq(15hr)}$**				**Year 2016, Night time Leq(9hr)**			
	Before Modification (EIS Stage)		**After Modification (Re-assessment)**		**Before Modification (EIS Stage)**		**After Modification (Re-assessment)**	
	$L_{eq(15hr)}$ Noise level	**No of dwellings exceeding criteria**	**$L_{eq(15hr)}$ Noise level**	**No of dwellings exceeding criteria**	**$L_{eq(9hr)}$ Noise level**	**No of dwellings exceeding criteria**	**$L_{eq(9hr)}$ Noise level**	**No of dwellings exceeding criteria**
2	not shown in EIS	5	<45-65		not shown in EIS	5	<45-60	
Include traffic noise from Woodstock Ave								
8	not shown in EIS	35	<55-65	86	not shown in EIS	35	<45-60	80
9	Not shown in EIS	42	<45-65	84	not shown in EIS	41	<45-60	62

Notes:

- Data taken from EIS and Renzo Tonin and Associates 'WSO Assessment Update' document
- Increase in numbers of affected dwellings in the Northern Section is due to the inclusion of noise from adjoining roads as part of the Assessment Update
- Increase in numbers of affected dwellings in the Southern Section at Cecil Hills is due to new housing development areas

More information on the impacts and mitigation measures associated with these modifications are provided in a separate review of environmental factors report.

8. TRAFFIC NOISE MITIGATION MEASURES

8.1 NOISE BARRIERS OR MOUNDS

Nominal barriers to achieve EPA's 'base' criteria

This section of the report presents nominal barrier heights for each noise catchment area to provide an indication of the heights required to achieve compliance with the EPA's ECRTN 'base' criteria. The following points outline the procedure for calculating barrier heights.

- The nearest affected residence (NAR) was determined for each noise catchment area (NCA).
- Use of the CORTN traffic noise model to establish traffic noise levels from the proposed WSO and its ramps, and adjoining roads at each NAR without barriers.
- Compare modelled noise level at each NAR with the EIS noise contours for verification.
- Increase barrier heights by 0.5m increments above the WSO road surface level until the ECRTN 'Base Criteria' of $L_{Aeq,15hour}$ = 55dB(A) and $L_{Aeq,9hour}$ = 50dB(A) achieved.

Estimated barrier heights were calculated using a speed limit of either 90km/hr and 110km/hr, as detailed in the table below. It should be noted that noise modelling for the southern section was based on a vehicle speed limit of 90km per hour, based on AUSTROAD's Guide to Traffic Engineering Practice Part 2 "Roadway Capacity", as was advised for the EIS. To correct for a speed limit of 100km/hr or 110km/hr add 0.8dB(A) or 1.6dB(A) respectively to the modelled noise level. In general, a change in vehicle speed from 90km/h to 110km/h would increase the nominal barrier height by approximately 0.5m.

Road traffic noise levels were predicted with Open-Graded Asphaltic Concrete (OGAC) on the WSO route only. Ramps and existing/adjoining roads were modelled with standard Dense-Graded Asphaltic Concrete (DGAC) pavement.

The results of the modelling are presented in ***Table 8.1*** following. These results provide nominal barrier heights on the assumption that barriers are the only viable option in all cases. This of course is not the case in every noise catchment area, however is presented here for the purpose of providing input information into future cost-effectiveness and feasibility analysis.

Cost analysis and re-modelling is necessary before establishing barriers

The barrier heights shown are only nominal and aim at achieving the strictest EPA 'base' noise criteria. Therefore these barriers must not be constructed without undertaking a cost effectiveness / feasibility study and without undertaking noise re-modelling as part of the detail design phase of the project.

Furthermore, consultation should occur with the relevant regulatory authorities and community prior to establishing the final noise barrier design.

TABLE 8.1 PREDICTED NOISE LEVELS AT THE NEAREST AFFECTED RESIDENCE (NAR) FOR YEAR 2016 AND REQUIRED BARRIER HEIGHTS TO ACHIEVE ECRTN CRITERIA

NCA	Predicted Contribution Traffic Noise Levels at NAR (2016), dB(A)				Predicted Traffic Noise Levels at NAR (2016), dB(A)		Barrier Height to achieve ECTRN 'Base' Criteria with WSO at 90km/hr, m			Barrier Height* to achieve ECTRN 'Base' Criteria with WSO at 110km/hr, m			Comment regarding barrier locations (ramps & adjoining roads)
	WSO + Ramps		Adjoining Roads										
	Leq,15hr	Leq,9hr	Leq,15hr	Leq,9hr	Leq,15hr	Leq,9hr	WSO	Ramp	Adj Rd	WSO	Ramp	Adj Rd	
	South Section												
E1	55	50	64	59	64	59	-	1; 2	5	-	1; 2	6	N-bnd ramp Camden Valley Way to M5; S-bnd ramp WSO to Camden Valley Way; M5 Mway
E2	56	51	67	62	67	62	-	2	7	-	2	8.5	N-bnd ramp Camden Valley Way to M5; S-bnd ramp WSO toM5; W-bnd ramp M5 to WSO; M5 Mway
E3	61	56	-	-	61	56	-	1.5; 2; 3	-	-	-	-	S-bnd ramp WSO to M5; E-bnd ramp WSO to M5; W-bnd ramp M5 to WSO
E4	58	54	-	-	58	54	1.5	-	-	2.0	-	-	-
E5	63	57	64	60	66	60	5.0	4	4	7.0	4	4	Except Westbound WSO ramp to Bernerra Rd; Bernerra & Jedda Rds
E6	57	52	-	-	57	52	0.8	-	-	1.2	-	-	-
E7	64	59	-	-	64	59	3.4	-	-	4.2	-	-	-
E8	60	54	-	-	60	54	1.8	-	-	2.4	-	-	Proposed new residential area
E9	46	40	37	31	46	41	-	-	-	-	-	-	-
E10	46	41	56	51	57	52	-	-	1.0	-	-	1.0	Cowpasture Rd
E11	45	40	64	59	64	59	-	-	3.2	-	-	3.3	Cowpasture Rd
E12	57	51	-	-	57	51	1	-	-	1.5	-	-	-
E13	52	46	-	-	52	46	-	-	-	-	-	-	-
E14	55	49	-	-	55	49	-	-	-	1	-	-	-
E15	54	48	-	-	54	48	-	-	-	1	-	-	-
E16	55	50	-	-	55	50	-	-	-	1	-	-	-
E17	57	52	55	50	59	54	2	-	1.5	3	-	1.5	Elizabeth Dr
E18	53	48	53	48	56	51	1	-	1	1	-	1	Elizabeth Dr
W1	52	47	-	-	52	47	-	-	-	-	-	-	-

TABLE 8.1 PREDICTED NOISE LEVELS AT THE NEAREST AFFECTED RESIDENCE (NAR) FOR YEAR 2016 AND REQUIRED BARRIER HEIGHTS TO ACHIEVE ECRTN CRITERIA

NCA	Predicted Contribution Traffic Noise Levels at NAR (2016), dB(A)				Predicted Traffic Noise Levels at NAR (2016), dB(A)		Barrier Height to achieve ECTRN 'Base' Criteria with WSO at 90km/hr, m			Barrier Height* to achieve ECTRN 'Base' Criteria with WSO at 110km/hr, m			Comment regarding barrier locations (ramps & adjoining roads)
	WSO + Ramps		Adjoining Roads										
	Leq,15hr	Leq,9hr	Leq,15hr	Leq,9hr	Leq,15hr	Leq,9hr	WSO	Ramp	Adj Rd	WSO	Ramp	Adj Rd	
W2	54	48			54	48	-	-	-	-	-	-	Proposed new residential area
W3	59	50	58	53	62	55	3.5	2.0	3.0	4.0	2.0	3.0	Westbound WSO ramp onto Bernerra Rd; Bernerra Rd
W4	51	42	60	55	61	55	1.0	-	2.1	1.5	-	2.1	Bernerra Rd
W5	50	40	60	55	61	55	1.0	-	2.0	1.5	-	2.0	Bernerra Rd
W6	51	46	-	-	51	46	-	-	-	-	-	-	-
W7	54	49	-	-	54	49	-	-	-	0.4	-	-	-
W8	55	49	-	-	55	49	-	-	-	0.8	-	-	-
W9	58	53	53	48	60	54	3.5	-	2.0	4.0	-	2.0	Cowpasture Road
W10	47	41	60	55	61	55	-	-	2.8	-	-	2.8	Cowpasture Road
W11	48	42	64	59	64	59	1.0	-	3.2	2.0	-	3.2	Cowpasture Road
W12	55	49	56	53	58	54	1.0	1.0	1.5	1.2	1.2	1.5	Westbound WSO ramp from Cowpasture Rd; Cowpasture Rd
W13	60	55	-	-	60	55	2.2	-	-	3.0	-	-	-
North Section													
1E	57	51	-	-	57	51	Noise monitoring undertaken only for 110km/h			2.5	-	-	
1W	61	56	-	-	62	57				2.5	-	2.5	Wallgrove Road
2E	60	55	<45	<40	60	55				7.0	2	-	Southbound Horsley Dr Off Ramp
2W	60	55	57	52	62	57				4.0	-	3	Wallgrove Road
4	58	60	47	50	58	61				2.0	1	-	Southbound M4 off ramp
5	59	55	55	50	61	56				3.5	1.5	1 & 2	Sthbound M4 off ramp; Grt Western Hwy & Wallgrove Rd respectively
6	61	57	-	-	61	57				2.5	-	-	
7E	62	58	<45	<40	62	58				3.0	-	-	
7W	64	59	<45	<40	64	59				3.5	-	-	
8	64	59	<50	<45	64	59				3	-	-	

TABLE 8.1 PREDICTED NOISE LEVELS AT THE NEAREST AFFECTED RESIDENCE (NAR) FOR YEAR 2016 AND REQUIRED BARRIER HEIGHTS TO ACHIEVE ECRTN CRITERIA

NCA	Predicted Contribution Traffic Noise Levels at NAR (2016), dB(A)				Predicted Traffic Noise Levels at NAR (2016), dB(A)		Barrier Height to achieve ECTRN 'Base' Criteria with WSO at 90km/hr, m			Barrier Height* to achieve ECTRN 'Base' Criteria with WSO at 110km/hr, m			Comment regarding barrier locations (ramps & adjoining roads)
	WSO + Ramps		Adjoining Roads										
	Leq,15hr	Leq,9hr	Leq,15hr	Leq,9hr	Leq,15hr	Leq,9hr	WSO	Ramp	Adj Rd	WSO	Ramp	Adj Rd	
9	66	61	-	-	68	63				5	-	-	
10E	59	54	<45	<40	59	54	3	-	-				
10W	64	59	<45	<40	64	59	5	-	-				
11	54	50	<45	<40	54	50	2	-	-				
12	62	57	<45	<40	62	57	4	-	-				
13	65	60	-	-	65	60	3.5	-	-				
14	63	58	-	-	63	58	2.5	-	-				
15N	55	49	-	-	55	49	-	-	-				
15S	56	50	-	-	56	50	1.0	-	-				
16	64	59	50	45	64	50	4.0	4 & 1.5	-	Noise monitoring undertaken only for 90km/h			On ramp and off ramp respectively
17	60	54	-	-	60	54	6.0	-	-				
18	63	57	-	-	63	57	4.0	-	-				
19	65	59	-	-	65	59	4.0	-	-				
20	62	57	-	-	62	57	4.5	-	-				
21	60	54	<45	<40	60	54	3.0	-	-				
22	56	50			56	50	2.0	-	-				
23W	60	54	-	-	60	54	5.5	-	-				
23E	65	59	55	49	66	60	5.5	-	2.0				Abbott Rd
24	61	55	-	-	61	55	6.0	-	-				

Note: Predicted total traffic noise levels are compared and assessed against the EPA's ECRTN 'Base' Criteria: $L_{Aeq,15hour}$ = 55dB(A) and $L_{Aeq,9hour}$ = 50dB(A)

*Barrier Height refers to height above **road surface level**

The nominal barrier heights have been determined using the ECRTN 'base' criteria. Barrier requirements may significantly change from those presented above should the 'allowance' criteria be used, as is permitted in the ECRTN.

Use of 'allowance' criteria, where 'base' criteria can't be met, will reduce lengths and heights of barriers

'Allowance' criteria can only accurately be set for this project, after undertaking further noise monitoring, which the RTA has committed to prior to the commencement of construction and preferably when a cost-effectiveness analysis is undertaken to select the most appropriate noise mitigation designs. Use of the 'allowance' criteria may provide a reduction of barrier design heights, and possibly an elimination of noise barriers in some locations, such as where the 'base criteria' may be marginally exceeded. This will be particularly apparent along sections of the route currently impacted by road traffic noise. In these locations, provision of a barrier along the WSO while reducing traffic noise from the WSO, may not reduce the total noise at the affected receiver due to noise contributions from other existing roads, such as Wallgrove Road.

9. CONCLUSION

The noise impact from the proposal has been assessed against the Environment Protection Authority's new traffic noise goals. All areas likely to be impacted upon by the proposed Orbital have been identified, including residences, educational institutions, places of worship, recreational areas, parks, reserves and commercial/industrial areas.

Predicted traffic noise levels on roads surrounding the proposed Westem Sydney Orbital both with and without the development of the proposal have been assessed. The results show that noise levels along most major surrounding roads would decrease if the Western Sydney Orbital from Prestons to Cecil Park was built.

To meet the EPA's noise objectives at all critical locations preferred noise control measures are suggested for consideration by the community, local council and the Environment Protection Authority as part of the proposal. The use of suitably designed mitigative measures such as noise barriers or mounding would ensure compliance with the EPA's daytime and night-time noise level objectives where practical and feasible. Other acoustic treatments could be applied directly to residential or educational buildings where the cost of noise mitigation using noise barriers is high compared to the number of buildings likely to benefit from the noise control measures, or if the use of barriers is inappropriate for visual or other reasons. For areas with isolated residences or with isolated schools, building treatments could be applied to achieve the required noise objectives. The final choice of noise mitigation measures however, would be the subject of community consultation, local council consultation, urban design and the DUAP approval.

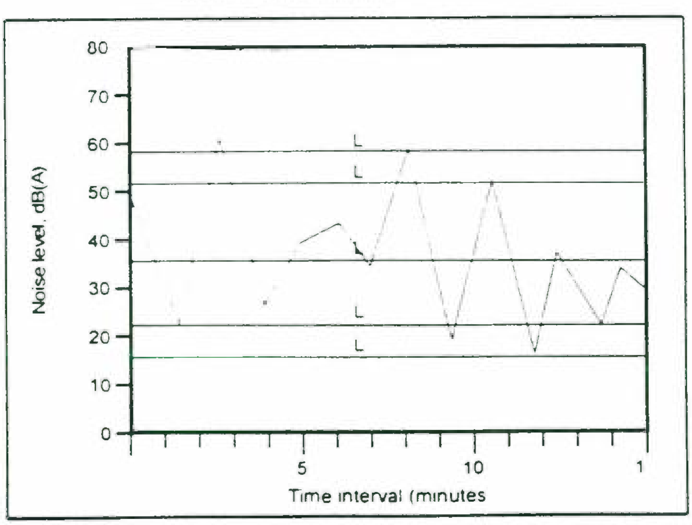
It is our opinion that the roadway can be constructed in such a manner that, with the necessary acoustic controls, will ensure minimal impacts to the local community. We conclude that with the appropriate mitigation measures in place, noise and vibration impact from the construction and the operation of the roadway can be contained to levels that comply with the EPA's primary objectives.

APPENDIX A – GLOSSARY OF ENVIRONMENTAL NOISE TERMS

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Acoustic Barrier	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc used to reduce noise, without eliminating it.
Air-borne Noise	This refers to noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise and receiver.
Ambient Sound	The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.
Assessment Period	The period in a day over which assessments are made.
Assessment Point	A point at which noise measurements are taken or estimated.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Background Noise	Background noise is the term used to describe the noise measured in the absence of the noise under investigation. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L_{90} noise level (see below).
Barrier	See "acoustic barrier", a solid object used to attenuate sound.
Character, acoustic	The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictate a sound's character.
Decibel [dB]	The level of noise is measured objectively using a Sound Level Meter. This instrument has been specifically developed to mimic the operation of the human ear. The human ear responds to minute pressure variations in the air. These pressure variations can be likened to the ripples on the surface of water but of course cannot be seen. The pressure variations in the air cause the eardrum to vibrate and this is heard as sound in the brain. The stronger the pressure variations, the louder the sound is heard. The range of pressure variations associated with everyday living may span over a range of a million to one. On the top range may be the sound of a jet engine and on the bottom of the range may be the sound of a pin dropping. Instead of expressing pressure in units ranging from a million to one it is found convenient to condense this range to a scale 0 to 120 and give it the units of decibels. The following are examples of the decibel readings of every day sounds; 0dB the faintest sound we can hear 30dB a quiet library or in a quiet location in the country 45dB typical office space. Ambience in the city at night 60dB Martin Place at lunch time 70dB the sound of a car passing on the street

	80dB loud music played at home 90dB the sound of a truck passing on the street 100dB the sound of a rock band 115dB limit of sound permitted in industry 120dB deafening
dB(A): A-weighted decibels	The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
Diffraction	The distortion around solid obstacles of waves travelling past.
Fluctuating Noise	Noise that varies continuously and to an appreciable extent over the period of observation. It can also include intermittent noise. As a guide, when the level varies noticeably by more than 5 dB over a period of less than one minute, the noise is considered to be fluctuating.
Frequency	Frequency is synonymous to *pitch*. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Heavy Vehicle	Heavy vehicles are assumed to be buses, rigid trucks and semi trailer trucks with a tare weight greater than 3 tonnes. Also heavy vehicles can be defined in terms of length as buses, or trucks with a length exceeding 5.25 metres.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.



REPORT: T440-12F05 (REV9) WSO ASSESSMENT UPDATE.DOC

Lnn Noise Descriptors	Because noise varies with time, a single noise value cannot adequately define the noise ambient. For this reason, the acoustic environment is described using a number of noise level descriptors as follows;
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
$L_{10(1hr)}$	The L_{10} level measured over a 1 hour period.
$L_{10(18hr)}$	The arithmetic average of the $L_{10(1hr)}$ levels for the 18 hour period between 6am and 12 midnight on a normal working day. It was a common traffic noise descriptor. For traffic noise it is usually about 3dB(A) higher than L_{eq} (24 hours).
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
L_{eq}	Equivalent sound pressure level – the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{eq(1hr)}$	The L_{eq} noise level for a specific one-hour period.
$L_{eq(8hr)}$	The continuous noise level during any one hour period between 10pm and 6am.
$L_{eq(9hr)}$	The L_{eq} noise level for the period 10pm to 7am.
$L_{eq(15hr)}$	The L_{eq} noise level for the period 7am to 10pm.
$L_{eq\ (24hr)}$	The equivalent continuous noise level during a 24 hour period, usually from midnight to midnight.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on. That is, the sound of 85 dB is 400% times the loudness of a sound of 65 dB.
Low-frequency noise	Containing major components within the low frequency range (20Hz – 250Hz) of the frequency spectrum.
Microphone	An electro acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
Nature, acoustic	The innate or essential quality of the noise. That which makes one noise distinguishable from another (e.g. the spoken voice from the sound of a dog barking, a telephone ringing from the sound of a gun).
Noise	Sound which a listener does not wish to hear.
Noise Monitor	See "sound level meter".
Quality, acoustic	An attribute, characteristic or property of the noise, its duration, its time-varying characteristics or its frequency content. Examples are the "screech" of screaming, the "rumble" of an airconditioner, the "dripping" of a tap.

Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound Absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
STC	Sound Transmission Class. This is a measure of the extent of sound reduction of noise going through a building element, presented as a rating or class. It denotes the sound attenuation properties of walls, floors and ceilings used to construct building spaces. The higher the STC the better the sound reducing performance of the construction.
Structure-borne noise	This refers to noise which is generated by vibrations induced in the ground and/or structure. These vibrations excite walls and slabs in buildings and cause them to radiate noise. This type of noise can not be attenuated by barriers or walls but requires the interposition of a resilient (neoprene, springs etc.) break between the source and the receiver.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B – CORTN TRAFFIC NOISE PREDICTION MODEL INPUTS

B1 – Traffic forecasts and speeds

The most recent traffic forecast files were supplied by Sinclair Knight Merz in 1999. Traffic volumes were determined from high demand scenario traffic flows during peak hour traffic and converted to Average Annual Daily Traffic (AADT) 24hr volumes, 15hr volumes and 9hr volumes for use in the CORTN88 computer model. The traffic forecasts used were those for the modelled years of 2006, the year of opening, and year 2016, 10 years after opening the road. These are presented in ***Table 5.1*** of this report.

B2 - Percentage (%) heavy vehicles

For the southern section, the percentage of heavy vehicles is generally 11% for the main carriageways and vary for the adjoining roads. For the northern section, the percentage of heavy vehicles varies along the WSO route. These are presented in ***Table 5.1*** of this report.

B3 - Road gradient

The road gradient was determined from road long sections of the proposed WSO route provided by the RTA.

B4 - Road surface treatment

Recent research has indicated that significant noise reductions may be gained by the use of open graded asphaltic concrete (OGAC) compared to standard road surfaces such as dense graded asphaltic concrete (DGAC). Generally, the use of OGAC results in a noise reduction of approximately 2 to 3 dB(A). A correction factor of 2.5dB(A) has been taken in the model to account for the use of OGAC along the Motorway carriageways only. OGAC not used on ramps.

B5 - Traffic source locations

The location of the noise source line was calculated as per CORTN, at a distance of 3.5m in from the edge of the nearest traffic lane. Each dual carriageway (ie north bound and south bound) are considered as a separate noise source lines and assumed to carry even traffic flows in both directions. The distance between north and south bound source lines is 21m, determined from typical cross sections supplied by the RTA (Road Design Services - Road Technology Branch).

B6 – Traffic source heights

The effectiveness of roadside barriers is dependent on the relative heights of the source, barrier and receiver. Therefore, if there is a barrier present, the height of the source is an important factor in determining receiver noise levels.

CORTN88 assumes that the acoustic centre of all vehicles is 0.5m from the ground. While this is a reasonable approximation for a car, it is too low for a heavy vehicle, and results in an over estimation of the attenuation due to barriers.

The major noise source from a typical heavy vehicle is the engine, the acoustic centre of which is at approximately 1.5m from the road surface level. Noise from the truck exhaust is at 3.6m from the ground.

In calculating the effect of a barrier, the total traffic noise level was partitioned into three parts as shown in Table B6 below. The effect of the barrier on each component was calculated separately. Barrier calculations were also performed separately for traffic at the centre of each carriageway (ie source line), and the resulting noise levels added to give the total noise level in the presence of the barrier.

Table B6 lists the height of the acoustic centre above the road pavement nominated by CORTN88 for traffic noise sources - ie cars and trucks.

Table A6 Heights of Traffic Noise Sources above Road Pavement Level

Vehicle Type	Source Height (m)
Cars	0.5
Truck Engines	1.5
Truck Exhausts	3.6

B7 - Ground reference levels (RL's) and separation distances of the noise source (ie traffic) to the receiver

Ground reference levels (RLs) and separation distances of the noise source to the receivers were determined from RTA drawings and additional information from PPK and SKM. Road RLs were determined from design plans and cross sections of the proposed roadway and interchange ramps.

In addition, noise levels were predicted at 1m from building facades and 1.5m above the ground floor level. The height of this point above actual ground level was typically 2m for a single storey dwelling representative of the majority of residences in the surrounding area. Double storey dwellings would experience similar noise levels as single storey dwellings, except where shielding occurs from barriers or other intervening structures.

B8 - Ground type between the source and receivers

A combination of both hard and soft ground, as determined suitable, was used along the proposed route. This is only applicable in highly developed areas and provides a conservatively higher estimate of traffic noise to receivers located over grassed or rural areas.

B9 - Angles of view from the road to receivers

Receiver relative levels and likely angles of view to the proposed road were obtained from 1:4000 orthophoto and topographical maps. The road relative levels along the route were determined from long sections of the proposed road provided by the Roads and Traffic Authority.

B10 - Attenuation from noise barriers

Based on the standard CORTN88 method.

B11 - Reflections from noise barriers

Acoustically absorptive finishes have been assumed on the faces of noise barriers. These have been taken as having finishes which will achieve a Noise Reduction Coefficient (NRC) of at least 0.5.

B12 - Modified CORTN88 for Australian Conditions

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 levels predicted by the CORTN88 method. This indicated that for sites where a correction for facade reflection is applicable (as in the case for predictions in this report), a correction of -1.7 dB(A) should be applied to CORTN88 results to provide the best estimate of noise levels under Australian conditions. This correction has been applied to calculated noise levels in this report.

APPENDIX C – CORTN MODEL VALIDATION: PAST PROJECTS

1. M4 MOTORWAY (WEST) VIADUCT

Project: T587 - M4 Motorway (West) Via-duct,
James Ruse Drive ramp to Church Street

Date: 27 May 1996

Locations: Comparisons of modelled noise levels versus 24 hour and 8 hour Leq noise levels (measured from 8/5/96 to 14/5/96) were performed at:

- Location A: 26 Prince Street, 70m from M4 road (using long term noise monitoring techniques)
- Location B: 10 Dalley Street, 15m from M4 road (using long term noise monitoring techniques)
- Location C: 49 kemp Street, 50m from M4 road (using long term noise monitoring techniques)
- Location 11: St Olivers School (cnr Wigram & Allen Street), 200m from M4 road [using short term noise measurements and correlation to nearby long term noise monitor (Loc. B)]
- Location 8: 27 Richie Street, 90m from M4 road [using short term noise measurements and correlation to nearby long term noise monitor (Loc. B)]
- Location 19: 30 Kemp Street, 200m from M4 road [using short term noise measurements and correlation to nearby long term noise monitor (Loc. C)].

Noise modelling includes traffic volumes from actual traffic counts, as they were performed simultaneously with the noise monitoring. The noise modelling performed herein includes the noise shielding effect of low height barriers.

Results:

Table C.1 – Modelled -v- Measured Noise Levels

Location	Modelled	Measured	Difference	Modelled	Measured	Difference
	$L_{Aeq,\ 24\ hour}$			$L_{Aeq,\ 8\ hour}$		
A	63.6	62.2	+1.4	59.1	58.6	+0.5
B	65.0	64.8	+0.2	60.6	60.8	-0.2
C	65.4	63.8	+1.6	60.9	59.3	+1.6
11	57.3	53.8*	+3.5	52.8	49.8*	+3.0
8	59.1	56.3*	+2.8	54.7	52.3*	+2.4
19	55.2	54.4*	+0.8	50.7	49.9*	+0.8

These noise levels are obtained by correlating short-term 15 minute noise measurements to long-term noise logger results to determine $L_{Aeq,\ 24\ hour}$ and $L_{Aeq,\ 8\ hour}$ levels

2. ST MARY'S ADI SITE - SINGLE AND MULTIPLE SEGMENTS

Project: TA119 – ADI Site, St Marys,

Date: October 1999

Location: Logger Location 3 - The Northern Road, north of Sherringham Road

22m from kerbside to logger, 70km/h traffic speed, traffic volumes estimated at 18,594 (15hr) and 3,469 (9hr) with 8% heavy vehicles.

Traffic volumes, composition and vehicle speed were not measured simultaneously with the noise logging, but estimated from RTA's historical data and through site observations.

Table C.2 – Modelled -v- Measured Noise Levels

Segment Description	Measured	Modelled	Difference
Leq 15hr – Day			
1 segment of 160°	63	69.4	6.4
2 segments of 80°	63	67.8	4.8
4 segments of 40°	63	67.5	4.5
Leq 9hr – Night			
1 segment of 160°	59	62.3	3.3
2 segments of 80°	59	60.7	1.7
4 segments of 40°	59	60.5	1.5

Comments:
The table above shows the CORTN modelled results converging with the measured noise levels more and more as the number of segments used are increased. This shows how breaking up a segment into multiple sub-segments improves the accuracy of the calculations. This approach tends to show lower noise levels than assuming a single segment approach.

Furthermore, it is demonstrated again that the CORTN noise model used, tends to predict higher traffic noise levels than those measured in the field, providing a conservative approach to traffic noise impact studies.

3. RTA Noise Abatement Program – Exmoor Place, Blairmount

Project: TA360 – RTA Noise Abatement Program,

7 Exmoor Place, Blairmount

Date: 23 October 2000

Locations: Comparisons of modelled noise levels versus measured $L_{Aeq,15\ hour}$ and $L_{Aeq,9hour}$ noise levels on 23 October 2000 at 7 Exmoor Place, Blairmount, 1m from the most exposed facade to the Hume Highway.

Traffic volumes, composition and vehicle speed were not measured simultaneously with the noise logging, but estimated from RTA's historical data and through site observations.

Results:

Table C.3 - Modelled -v- Measured Noise Levels

Location	Modelled	Measured	Difference	Modelled	Measured	Difference
	$L_{Aeq,\ 15\ hour}$			$L_{Aeq,\ 9\ hour}$		
1	66.9	66	+0.9	63.0	65	-2.0

4. EPA STATEMENT: ACCURACY & VALIDITY OF THE TRAFFIC NOISE PREDICTIONS FOR THE M5 EAST PROJECT-1997

As part of the EPA's response to the M5 East EIS (Original 1994 EIS and the 1996 EIS Supplement), the EPA made the following statement regarding the accuracy and the validity of the traffic noise predictions performed using Renzo Tonin & Associates' CORTN noise model:

" Based on calculations performed at four reference points along the road alignment, there was reasonable agreement between the noise predictions presented in the EIS and levels calculated by the EPA. The calculated noise levels were within ± 1 dB(A) for two of the reference points and ± 3 dB(A) for the other two reference points. These differences are considered to be attributed to the slightly different calculation methodologies used to predict the traffic noise levels and are considered acceptable."

APPENDIX D – REVISED NOISE CONTOURS (NORTHERN SECTION)

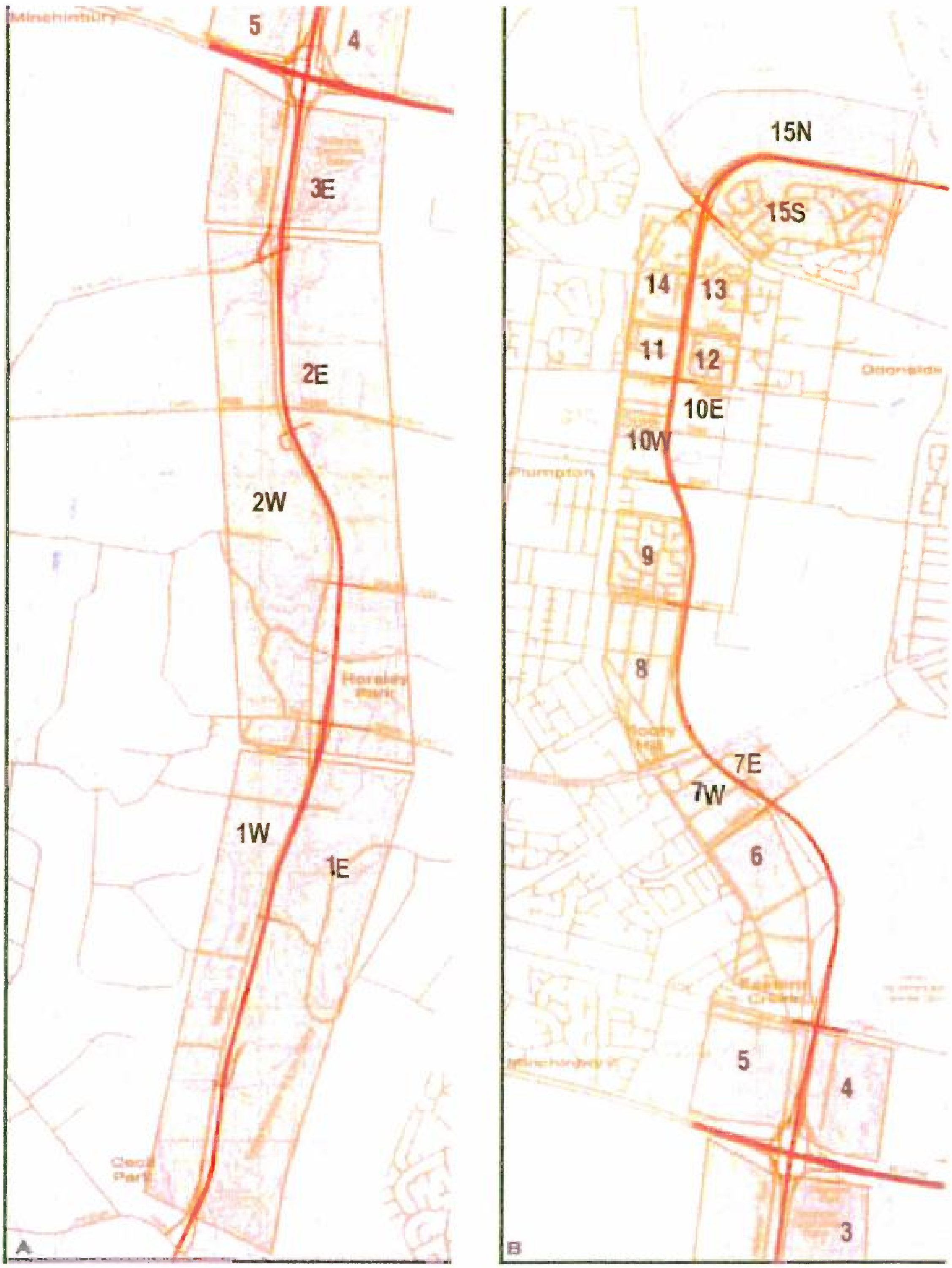
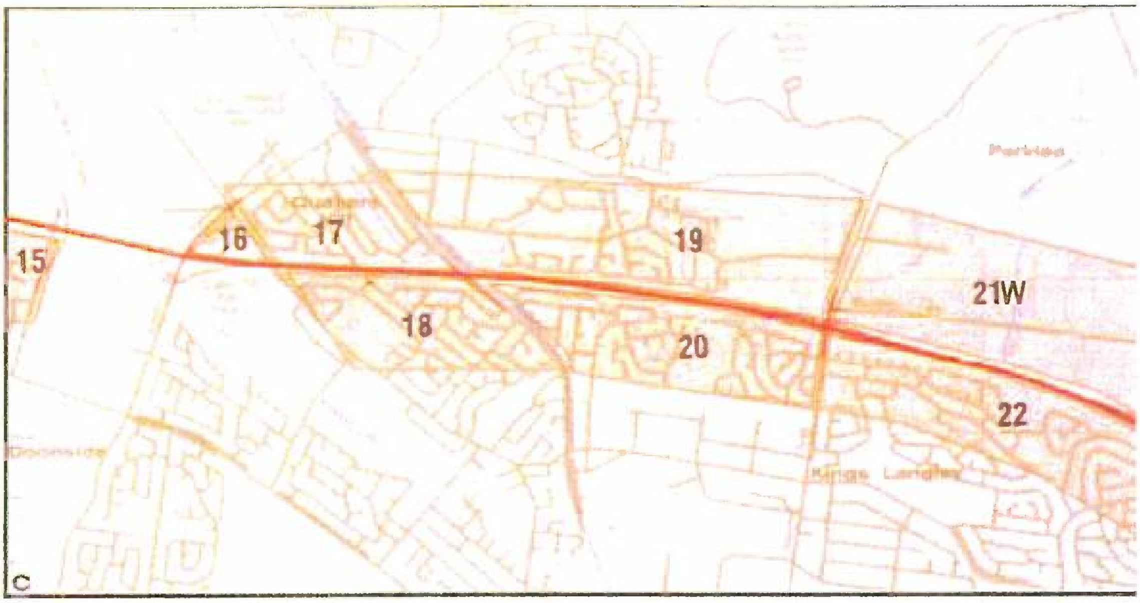


Figure 26.2 - Noise Catchment Areas



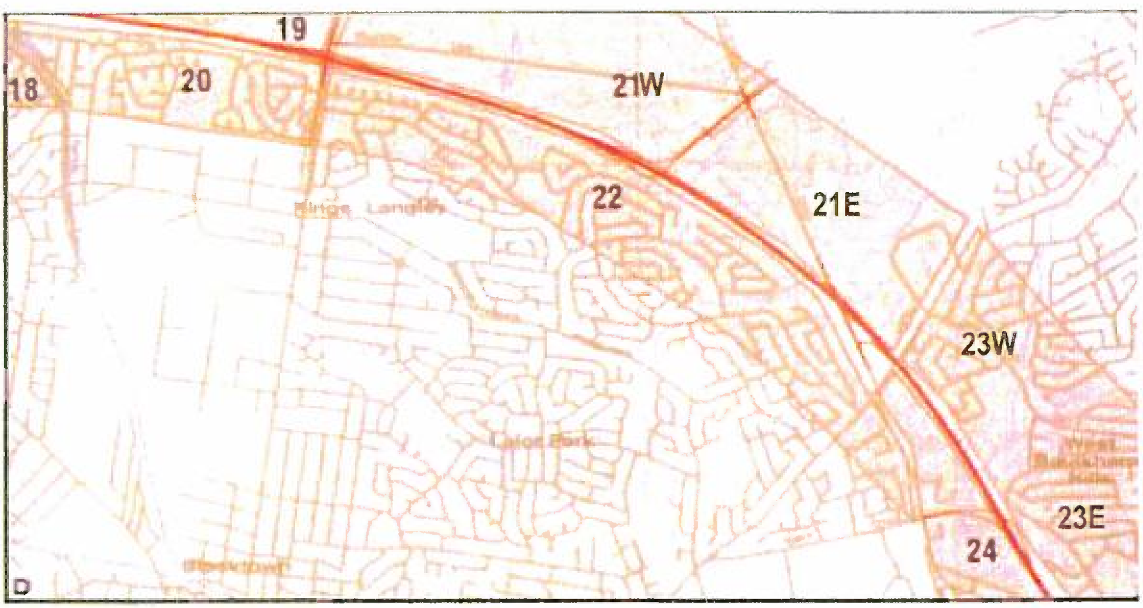
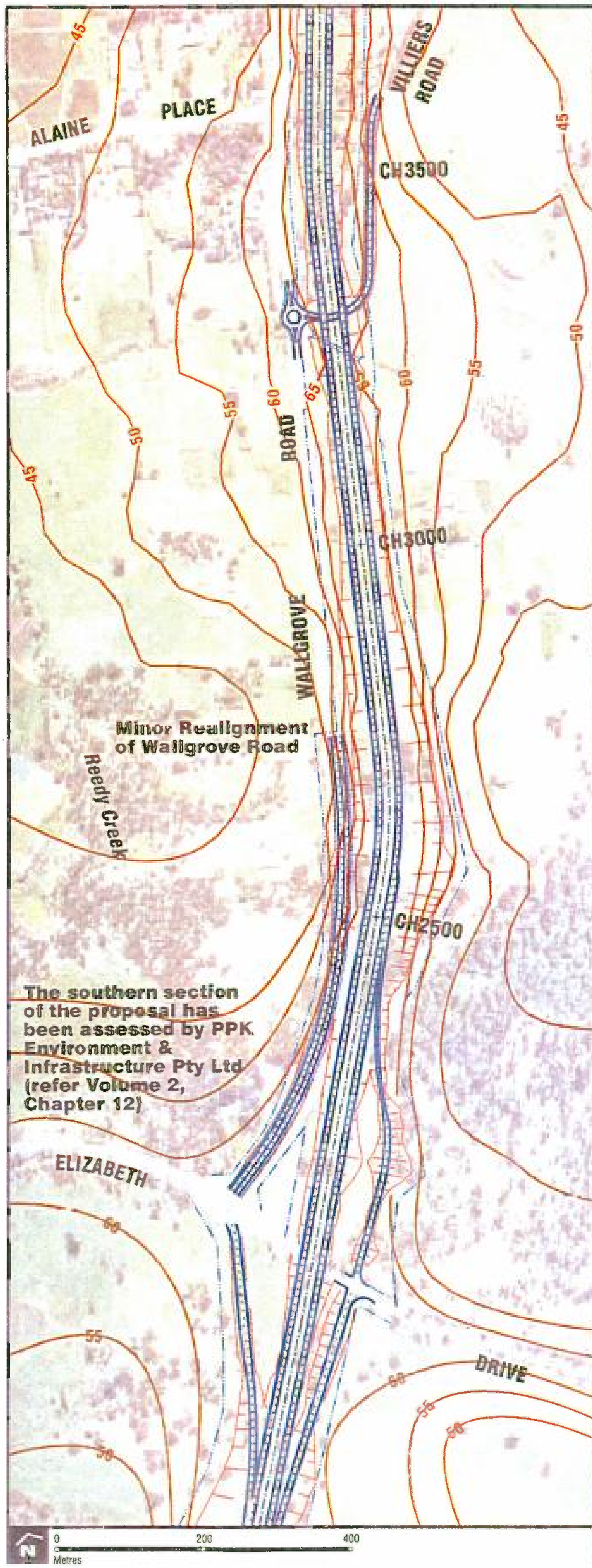
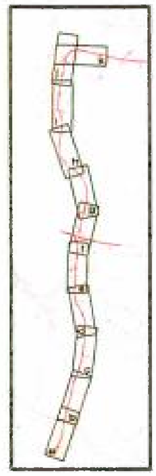


Figure 26.2 - Noise Catchment Areas

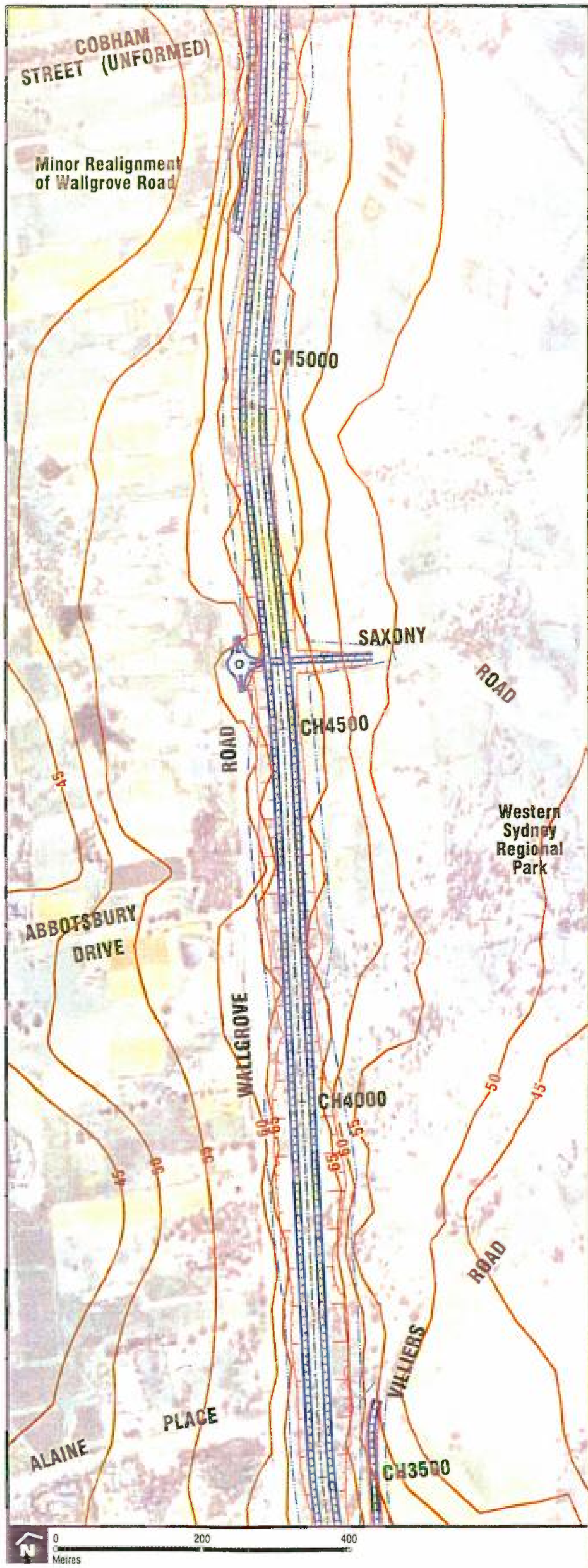


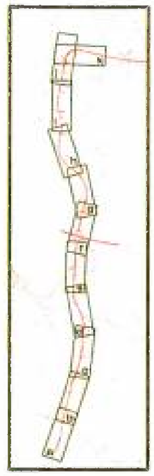


Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Day-time L_{Aeq} noise level (dBA)

Day-time Noise Contours (Year 2016)

Figure 26.3a

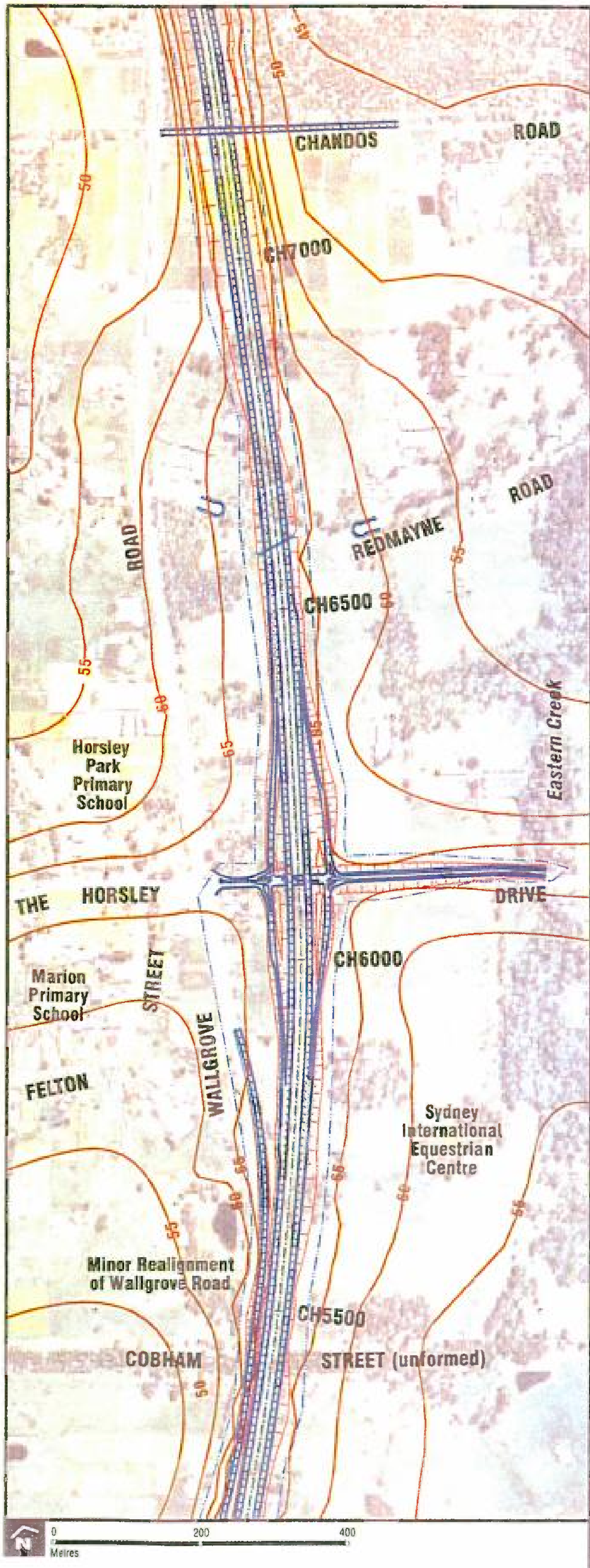


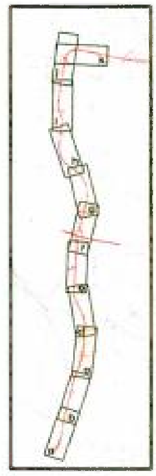


Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Day-time LAeq noise level (dBA)

Day-time Noise Contours (Year 2016)

Figure 26.3b

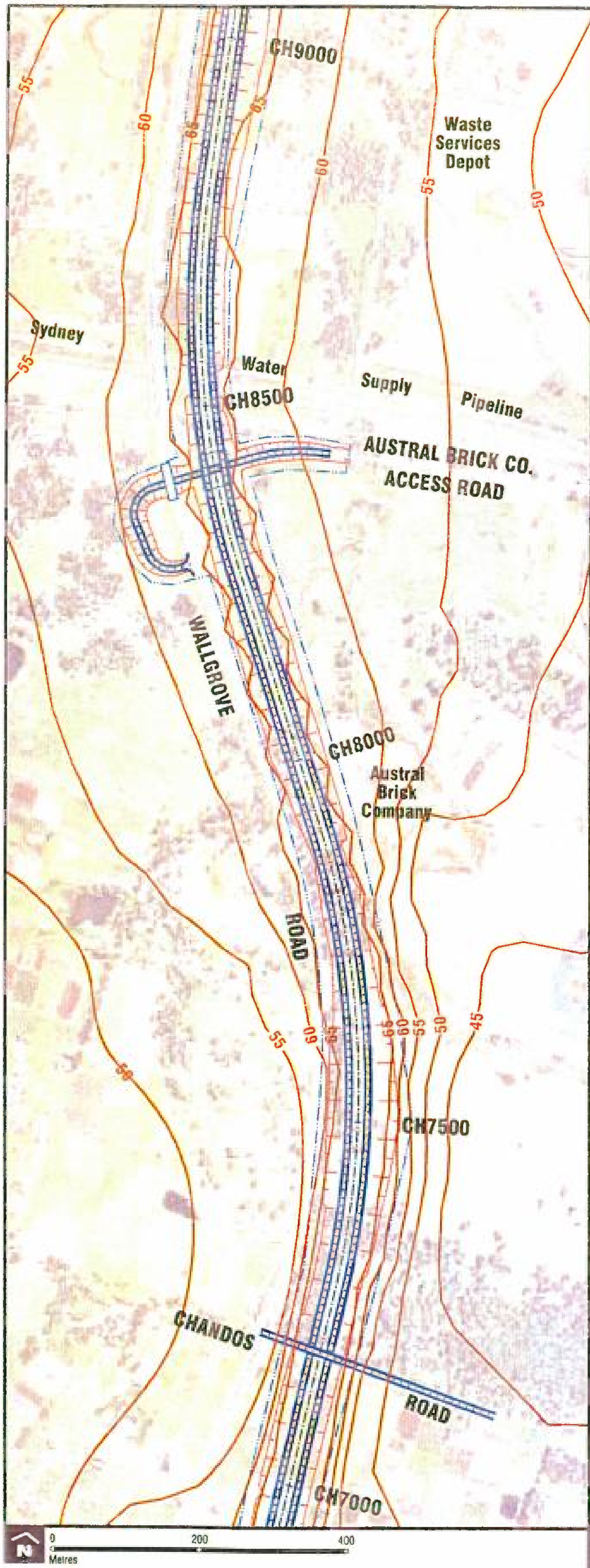


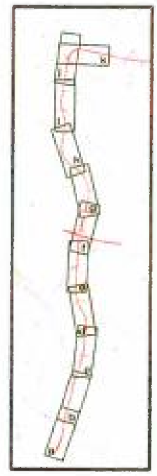


Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Day-time LAeq noise level (dBA)

Day-time Noise Contours
(Year 2016)

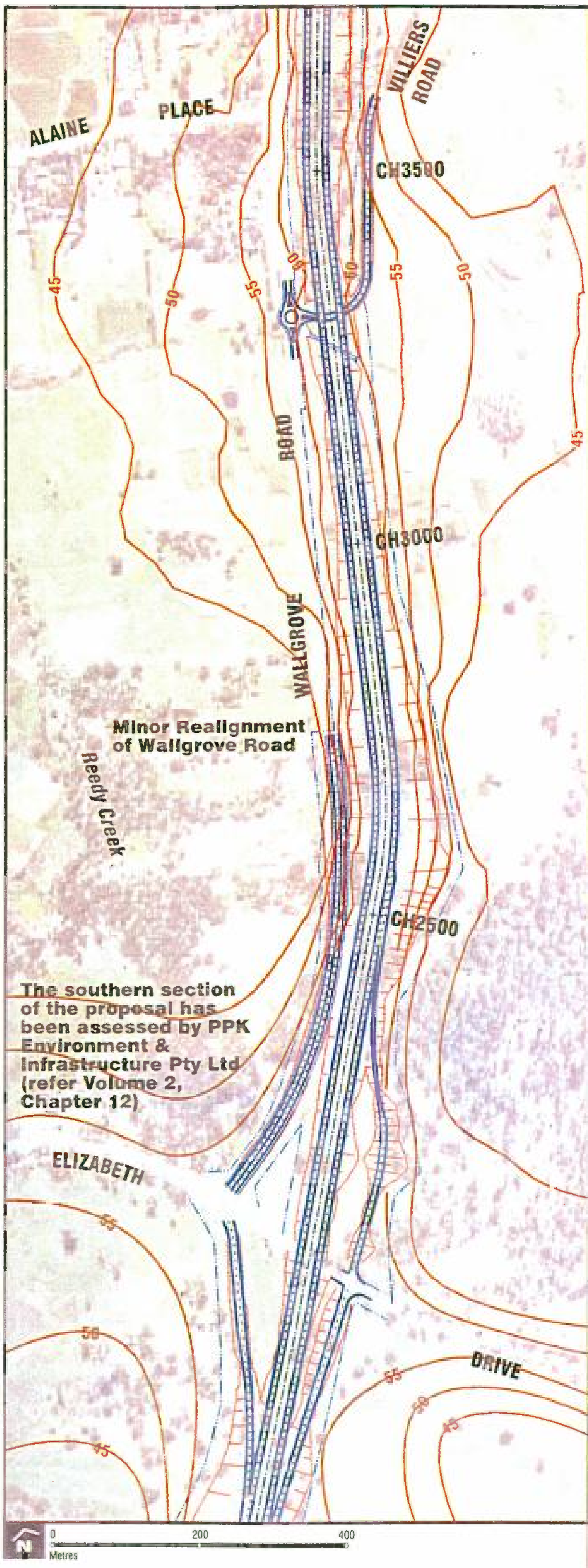
Figure 26.3c

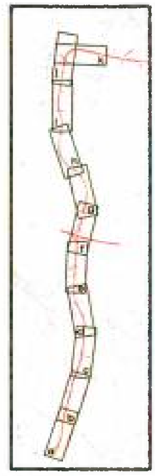




Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Day-time L_{Aeq} noise level (dBA)

Day-time Noise Contours (Year 2016) Figure 26.3d

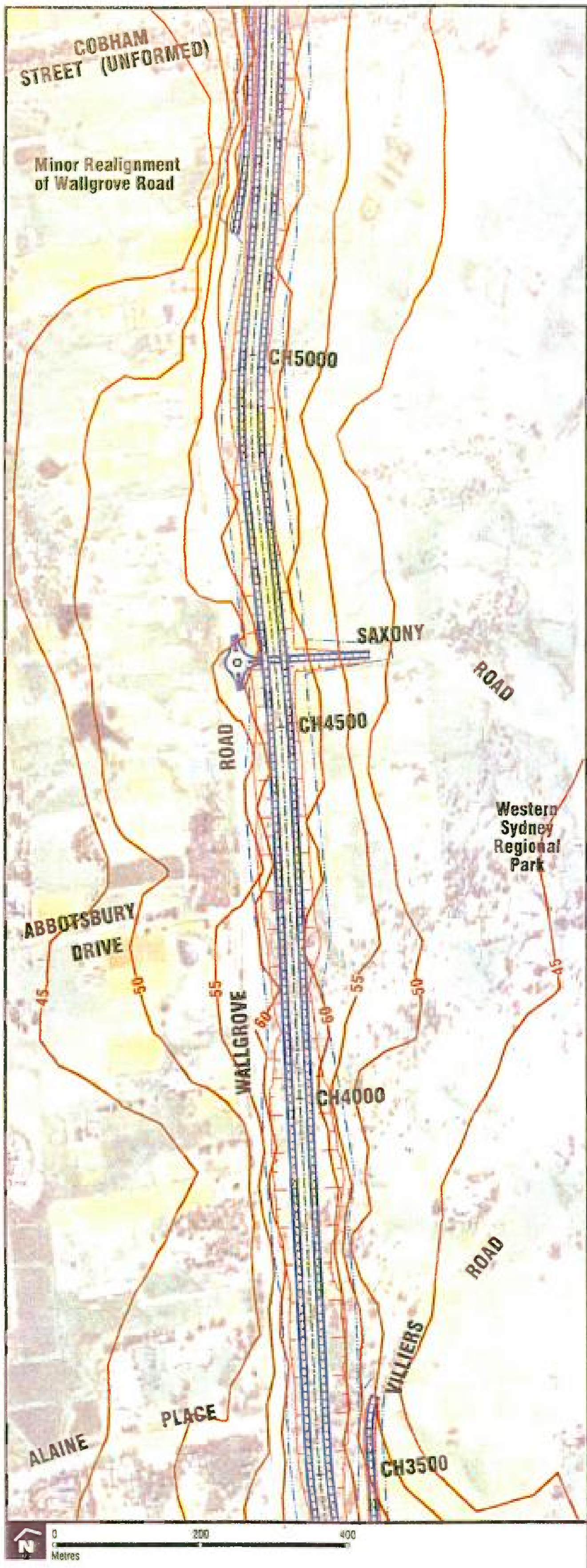


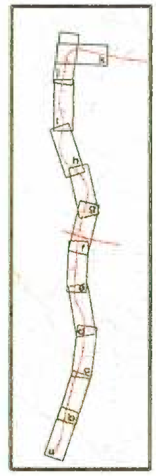


Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Night-time L_{Aeq} noise level (dBA)

Night-time Noise Contours (Year 2016)

Figure 26.4a





Proposed Road Corridor Boundary

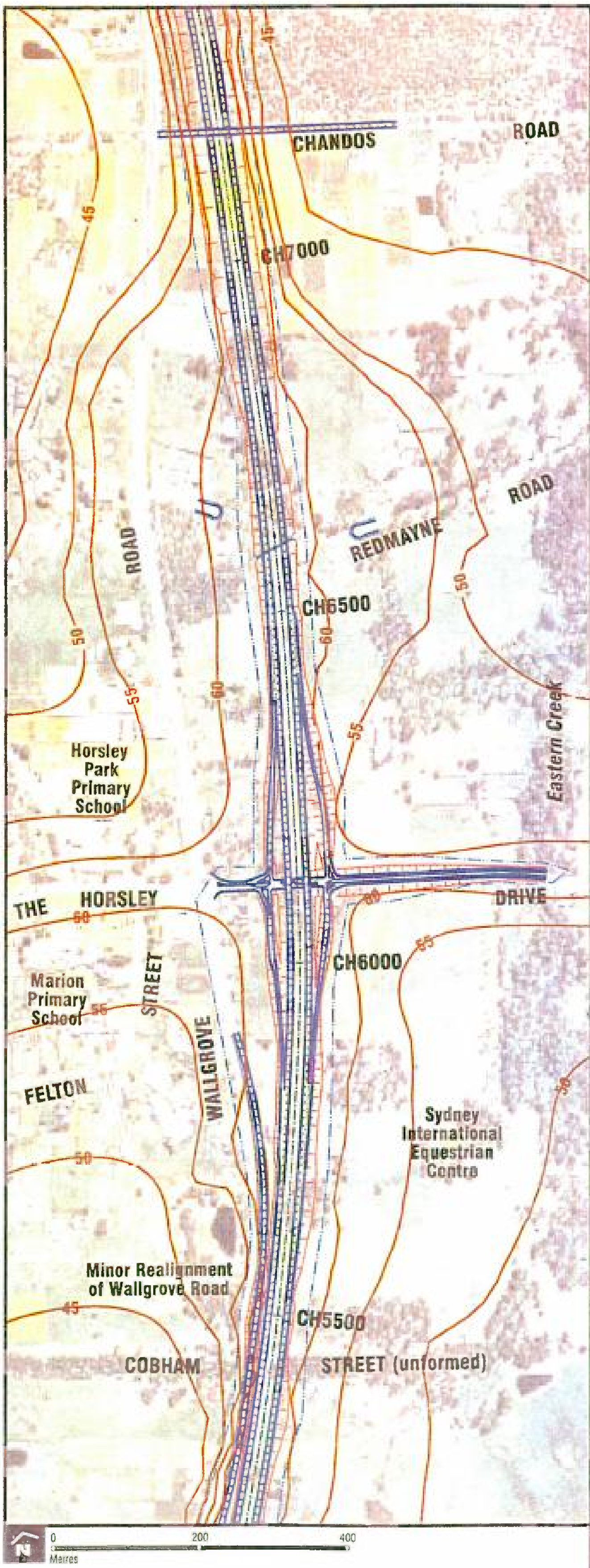
Cut

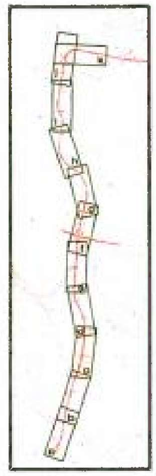
Fill

Bridges or Viaducts

Night-time LAeq noise level (dBA)

Night-time Noise Contours (Year 2016) Figure 26.4b

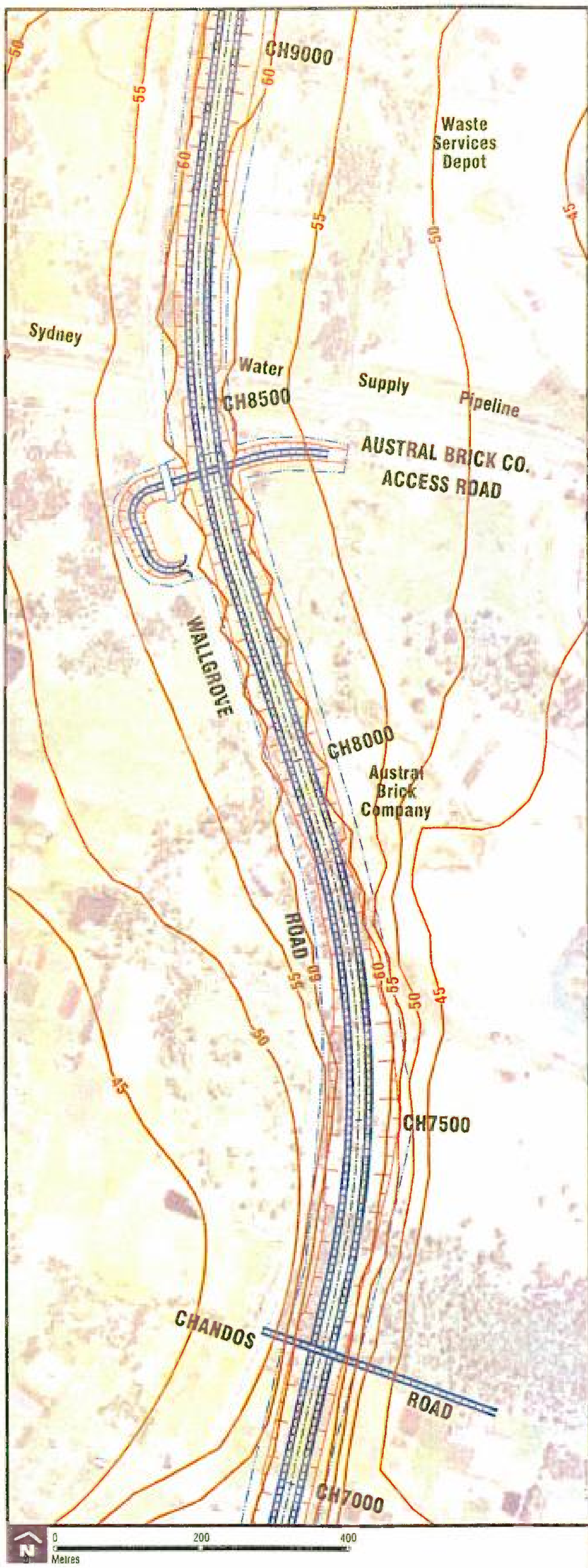


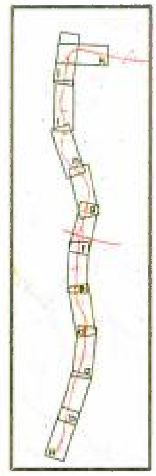


Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Night-time L_{Aeq} noise level (dBA)

Night-time Noise Contours (Year 2016)

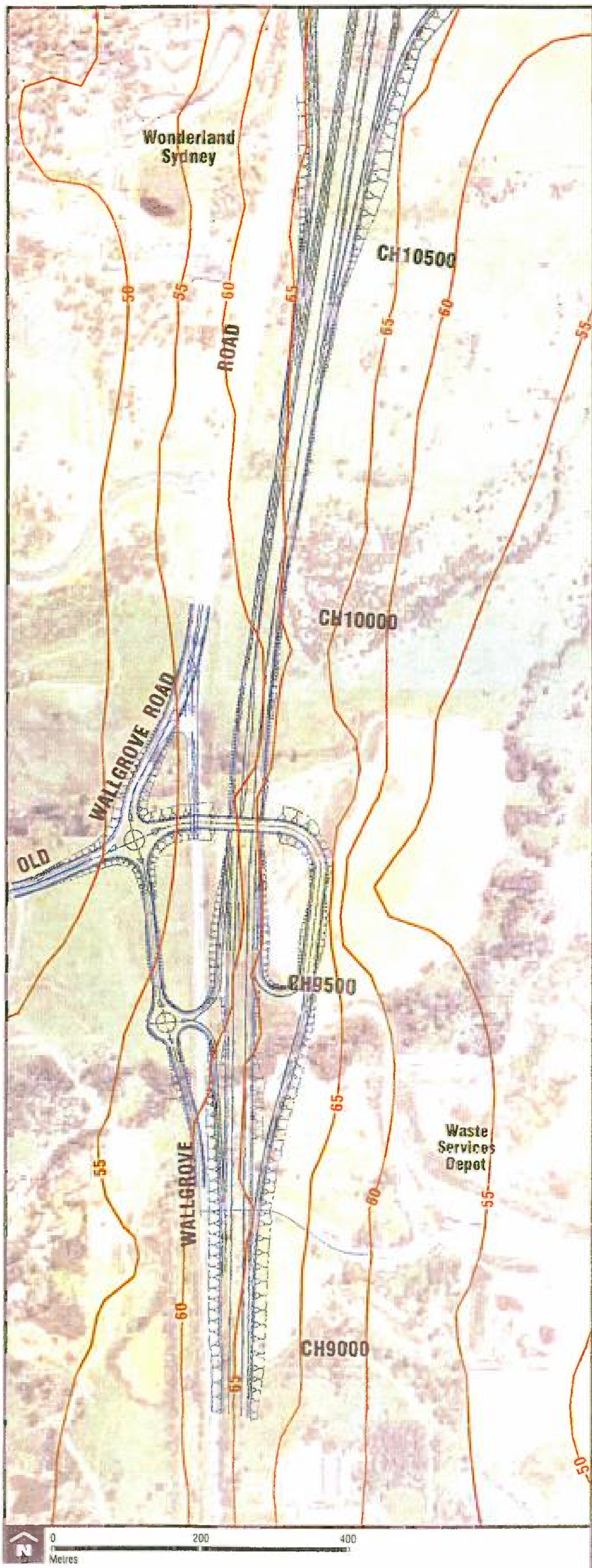
Figure 26.4c

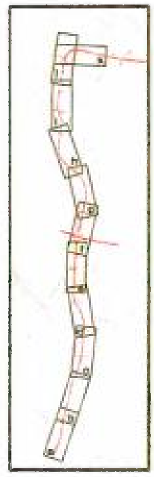




Night-time Noise Contours (Year 2016)

Figure 26.4d

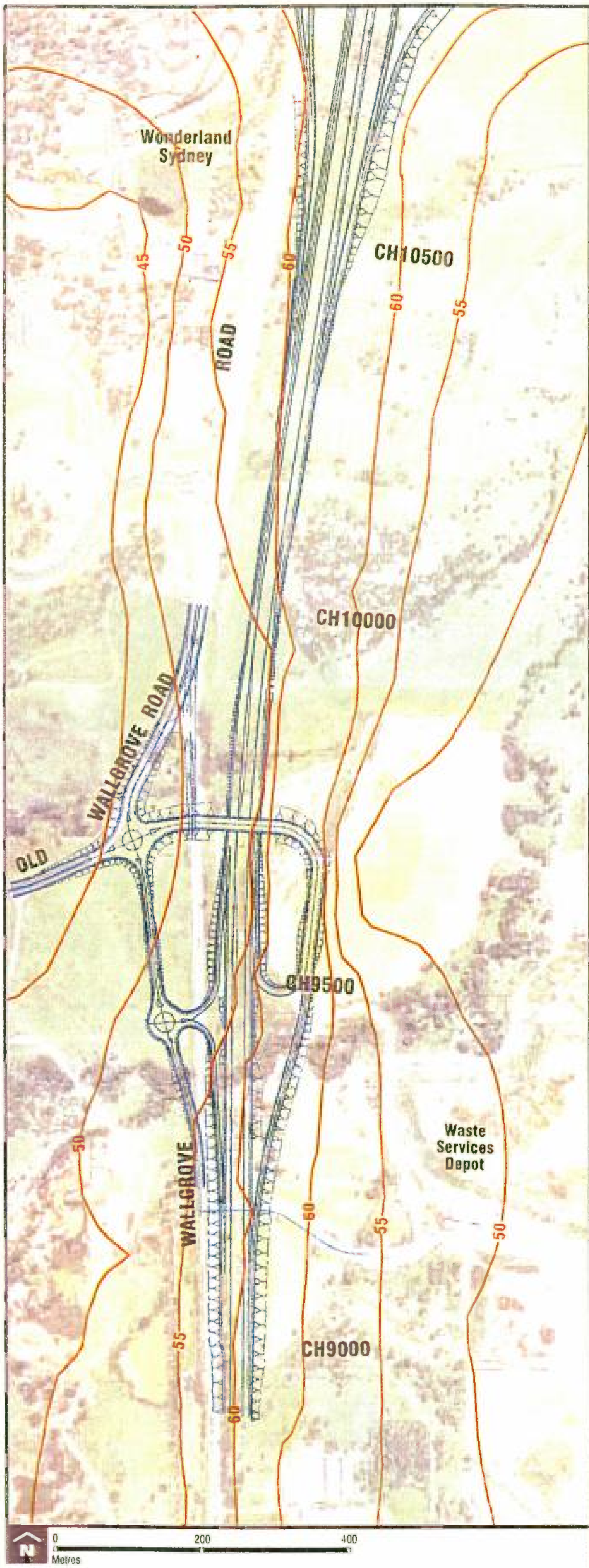


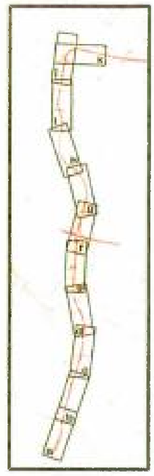


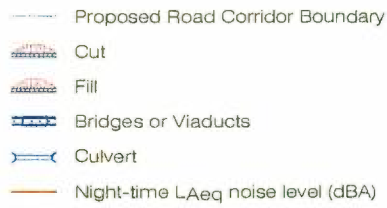
- Proposed Road Corridor Boundary
- Cut
- Fill
- Bridges or Viaducts
- Culvert
- Day-time L_{Aeq} noise level (dBA)

Day-time Noise Contours (Year 2016)

Figure 26.3e

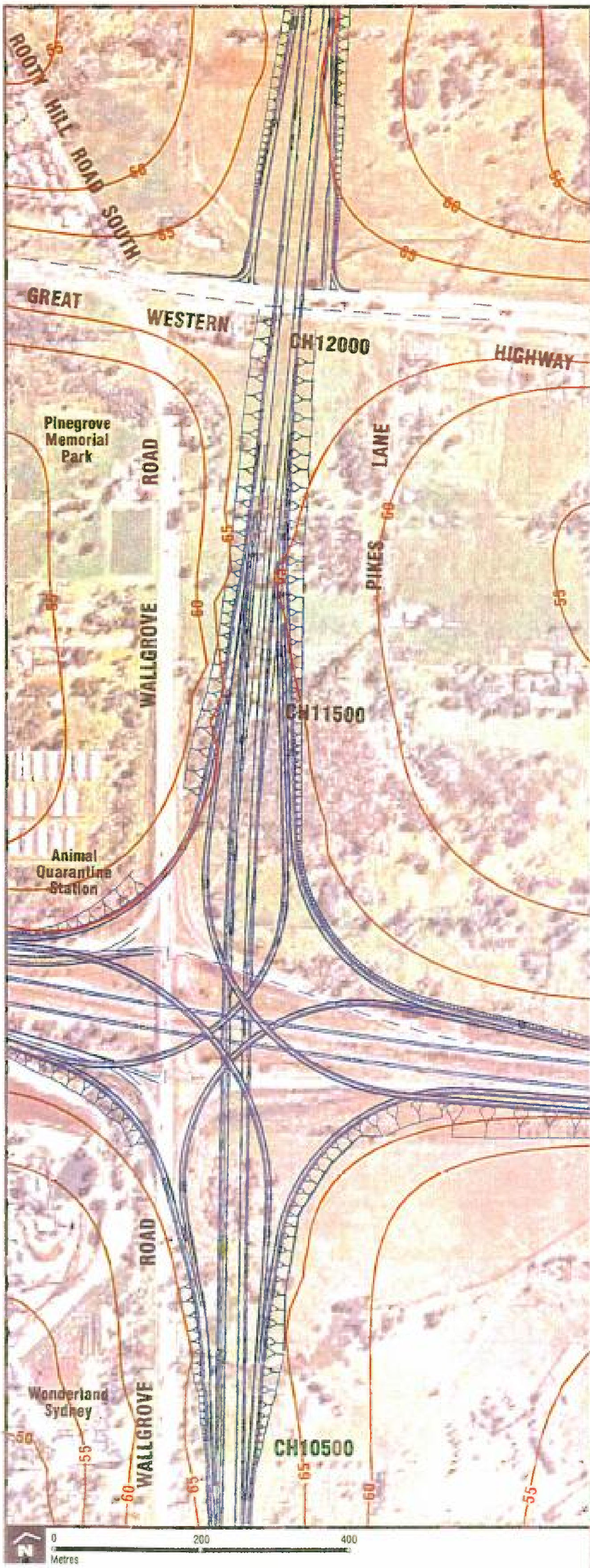


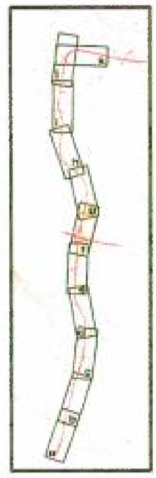




Night-time Noise Contours (Year 2016)

Figure 26.4e





Proposed Road Corridor Boundary

Cut

Fill

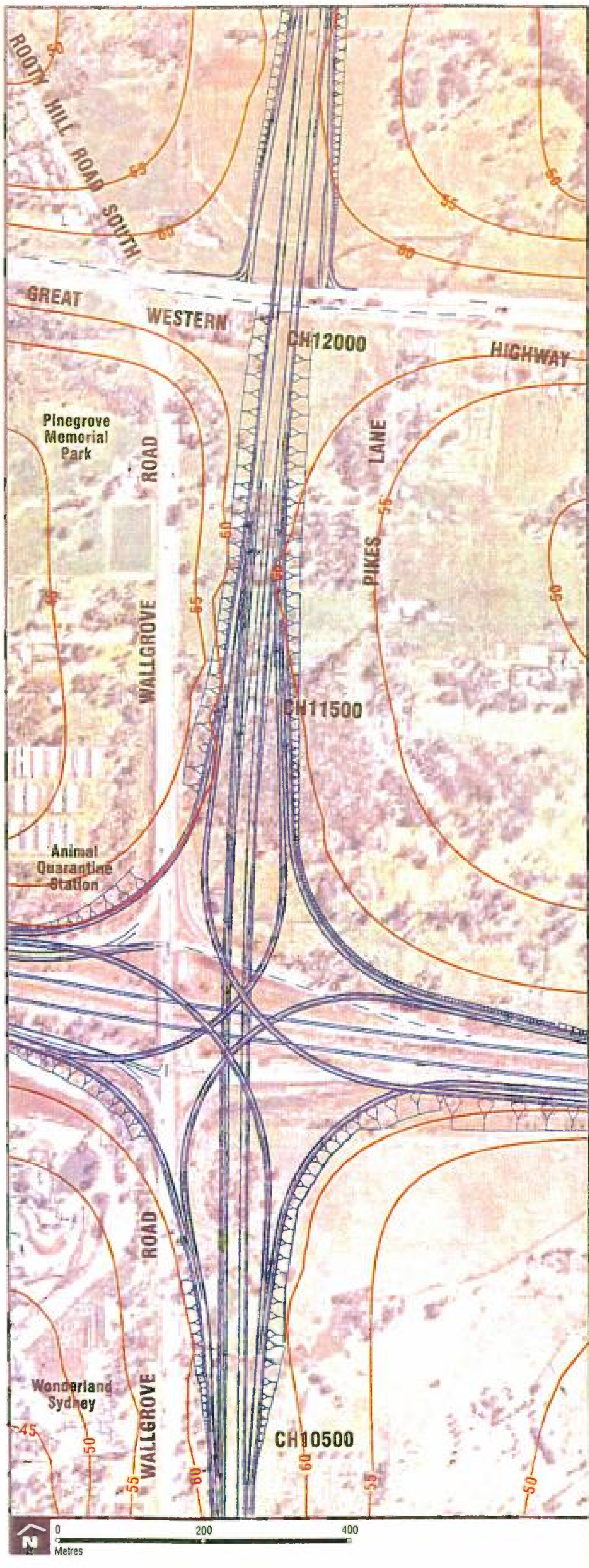
Bridges or Viaducts

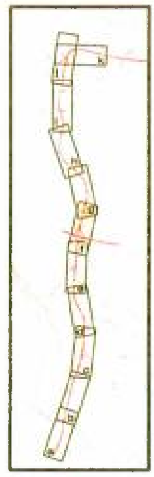
Culvert

Day-time L_{Aeq} noise level (dBA)

Day-time Noise Contours (Year 2016)

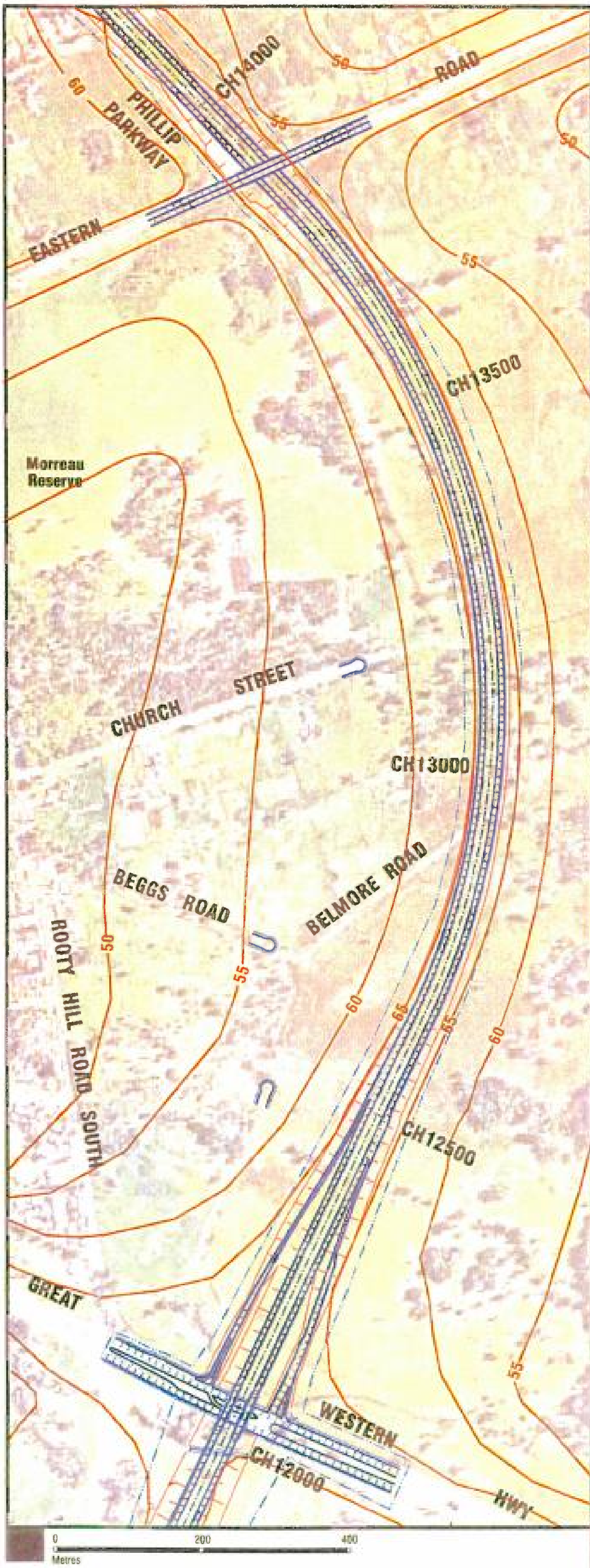
Figure 26.3f

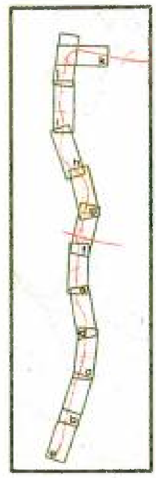




Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Night-time LAeq noise level (dBA)

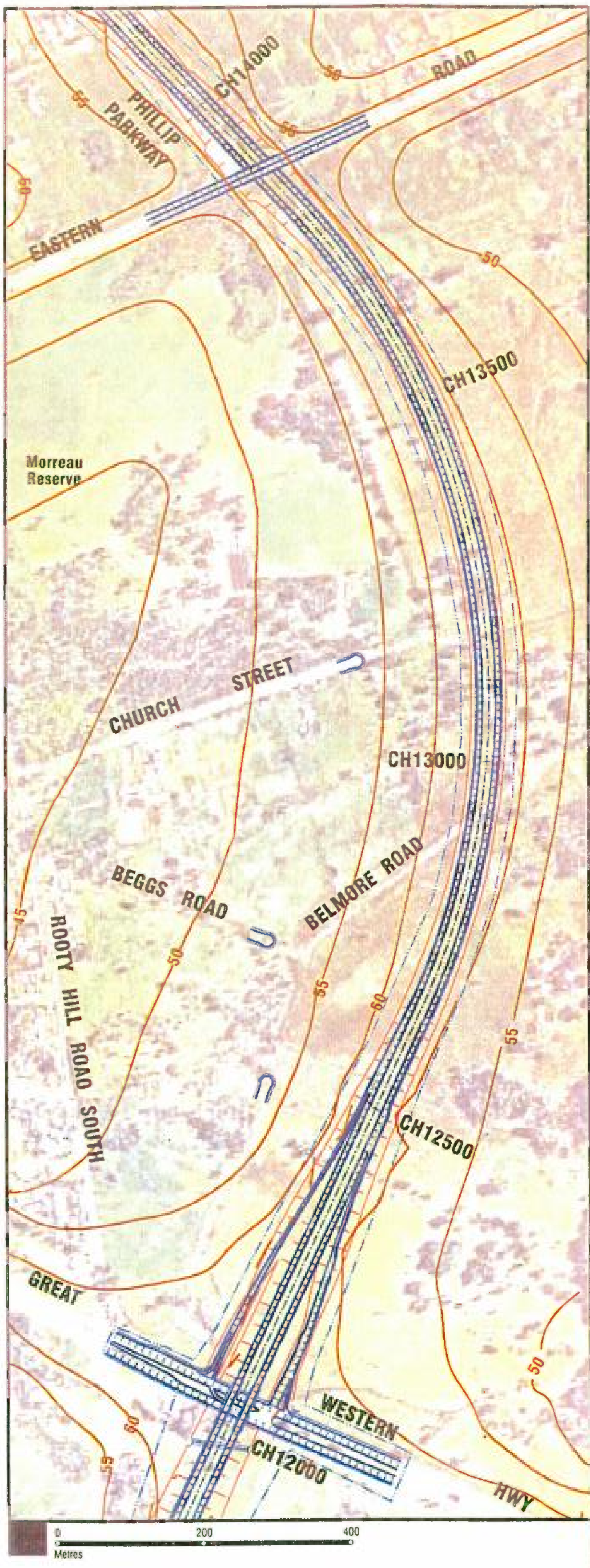
Night-time Noise Contours (Year 2016) Figure 26.4f

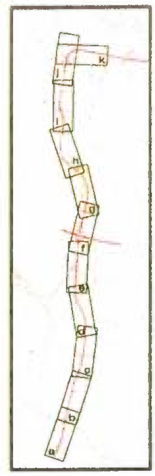




Day-time Noise Contours (Year 2016)

Figure 26.3g

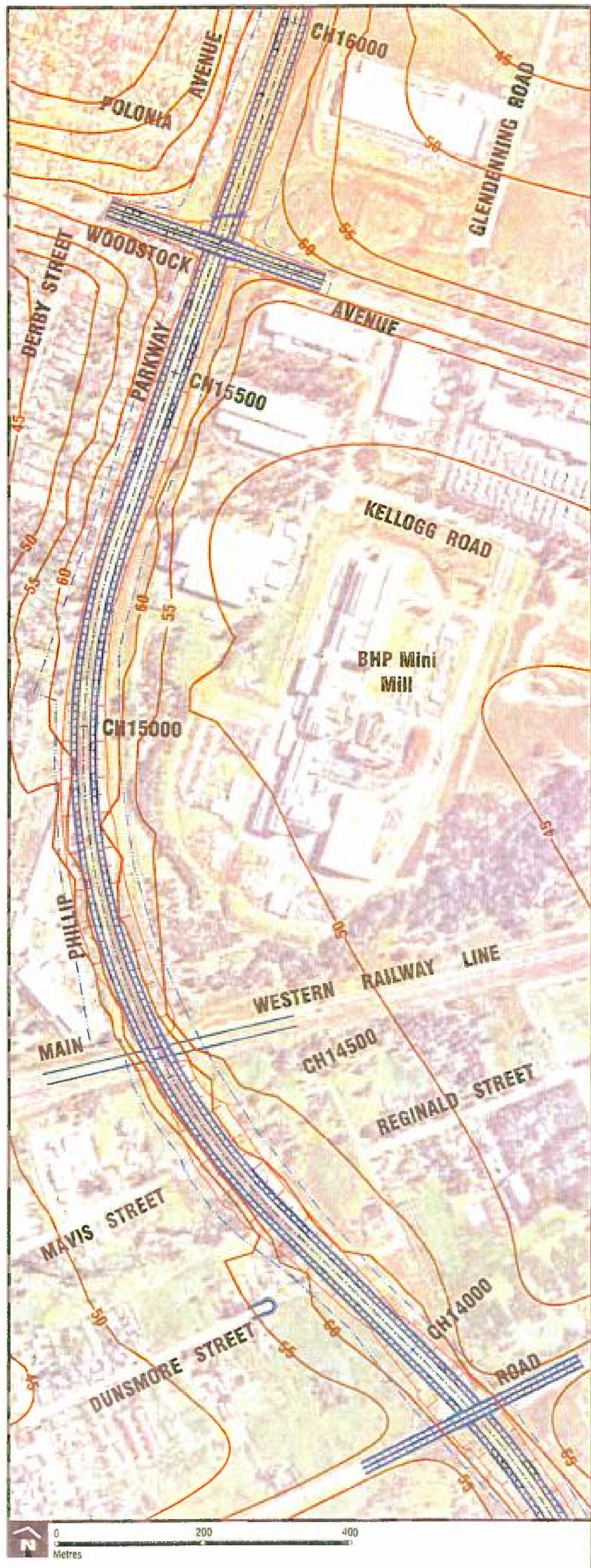


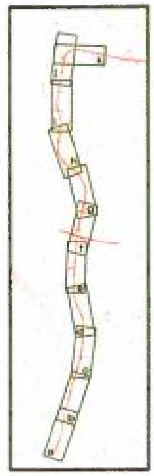


Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Night-time L_{Aeq} noise level (dBA)

Night-time Noise Contours (Year 2016)

Figure 26.4g





Proposed Road Corridor Boundary

Cut

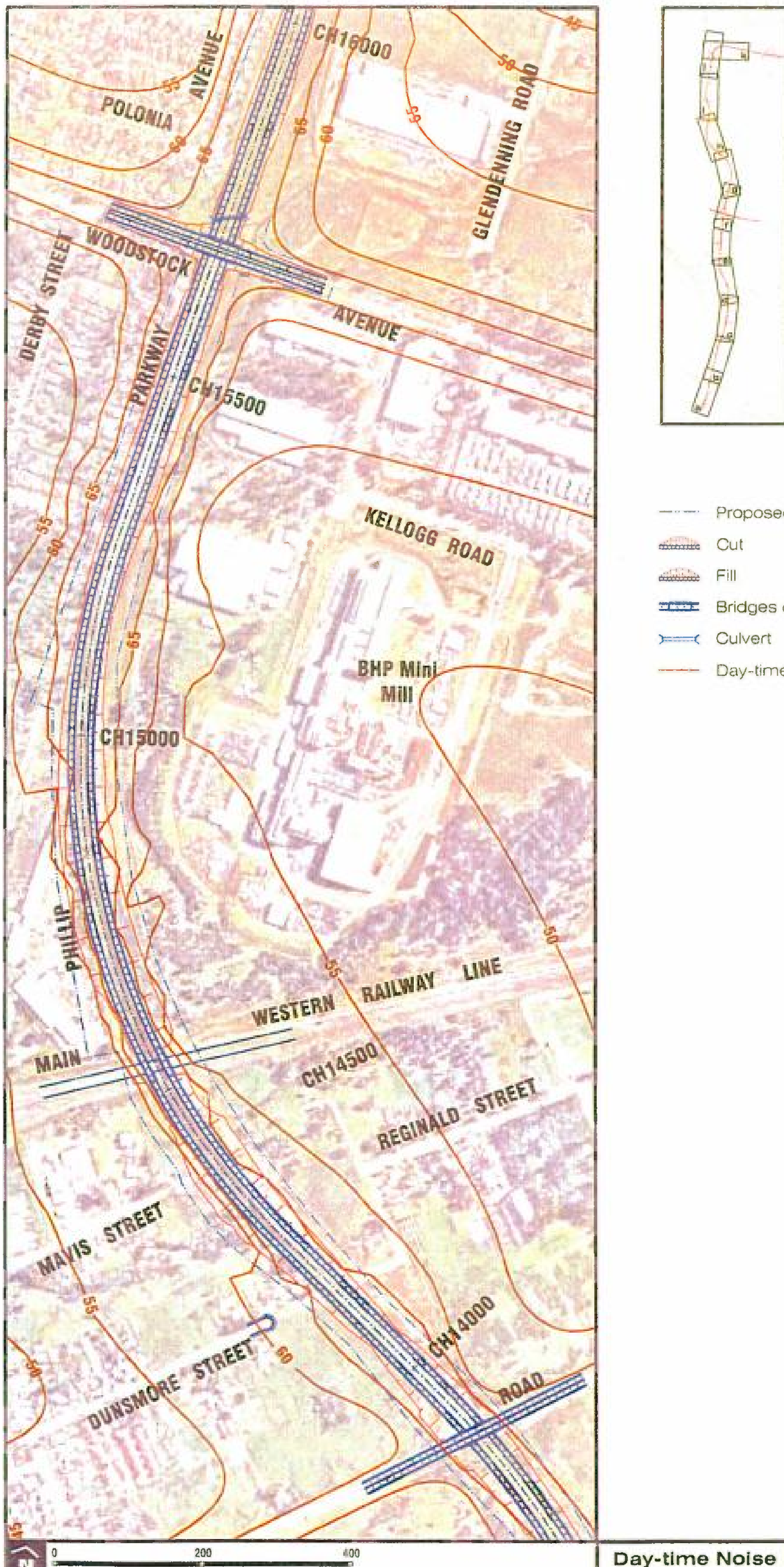
Fill

Bridges or Viaducts

Culvert

Night-time L_{Aeq} noise level (dBA)

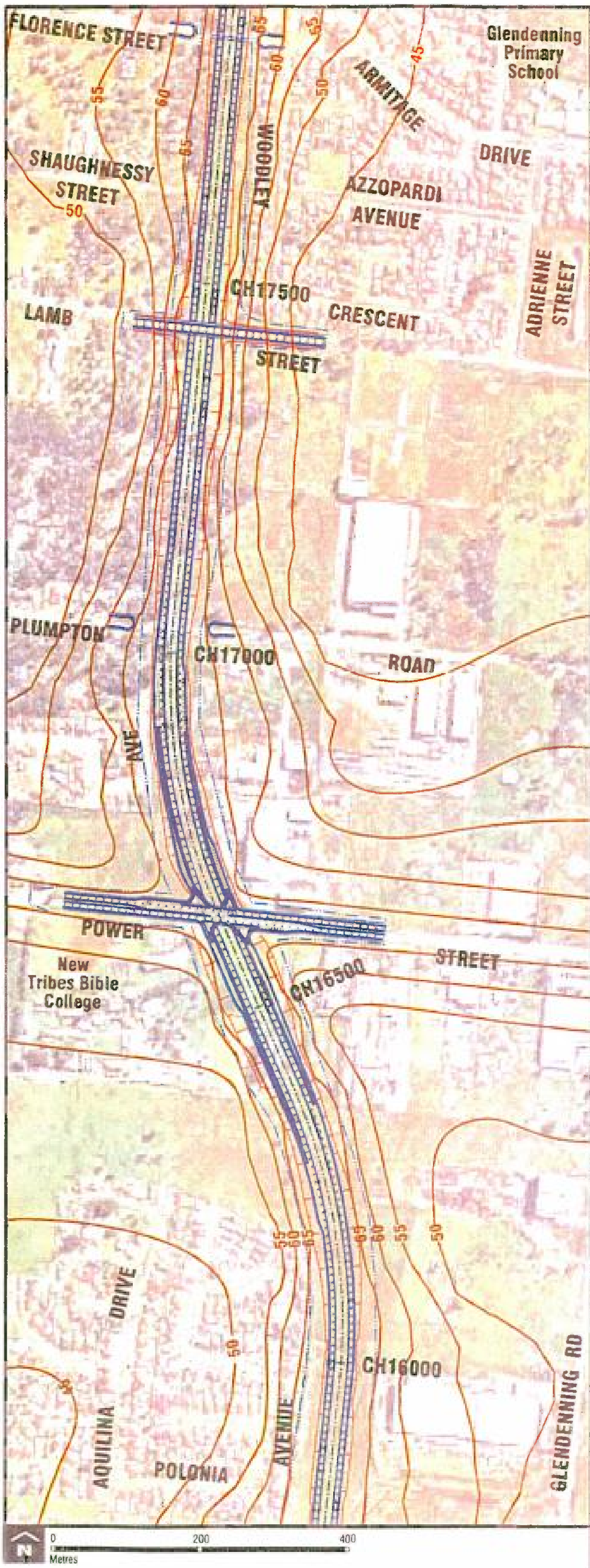
Night-time Noise Contours (Year 2016) Figure 26.4h

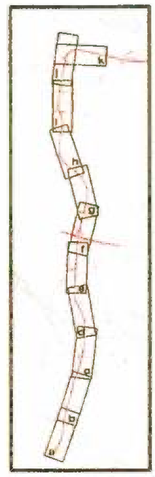


Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Day-time LAeq noise level (dBA)

Day-time Noise Contours (Year 2016)

Figure 26.3h

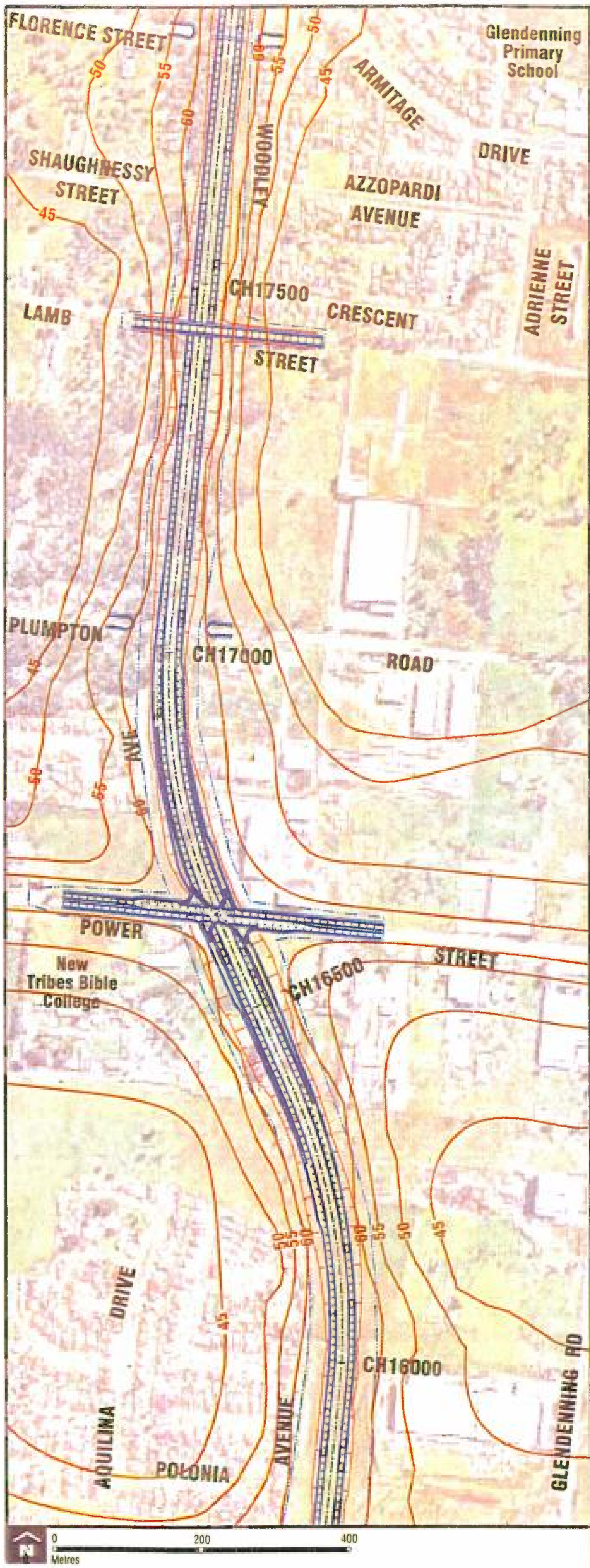


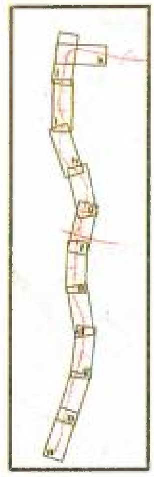


Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Day-time LAeq noise level (dBA)

Day-time Noise Contours (Year 2016)

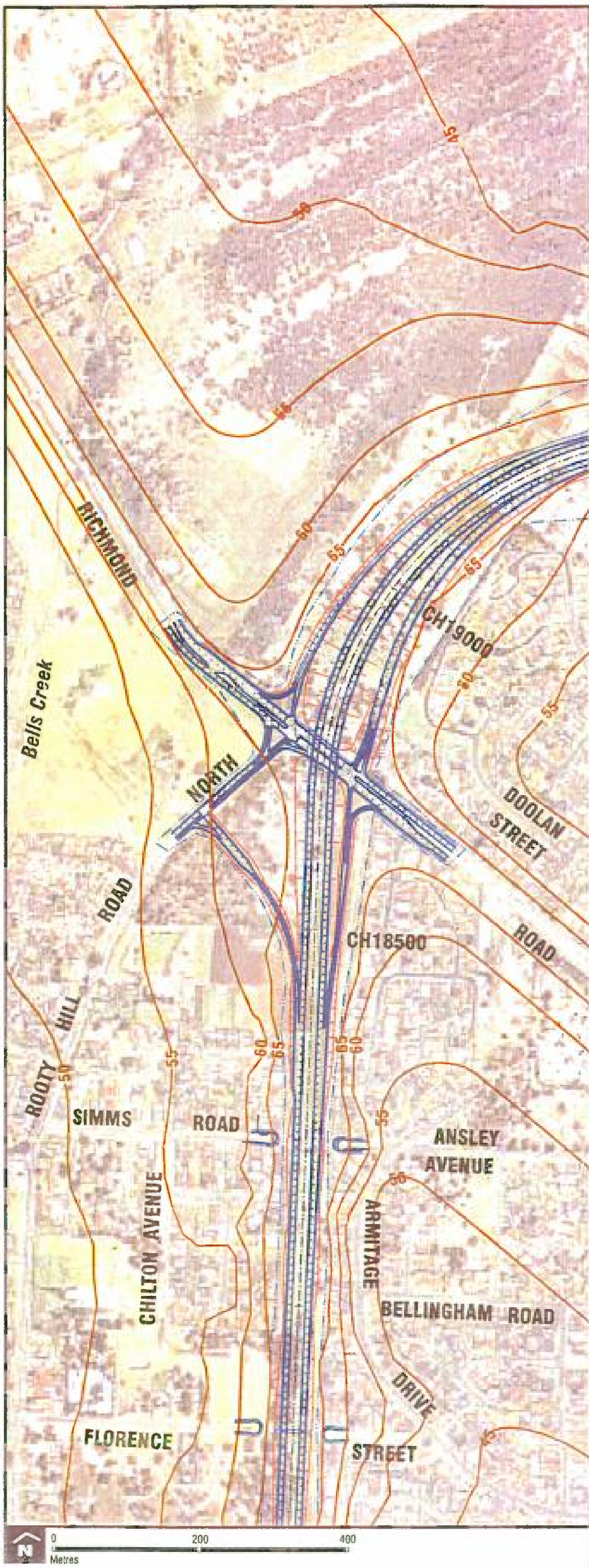
Figure 26.3i

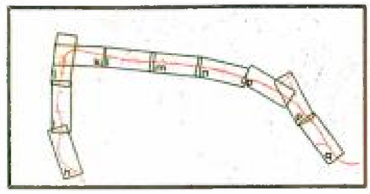




Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Night-time LAeq noise level (dBA)

Night-time Noise Contours (Year 2016) Figure 26.4i

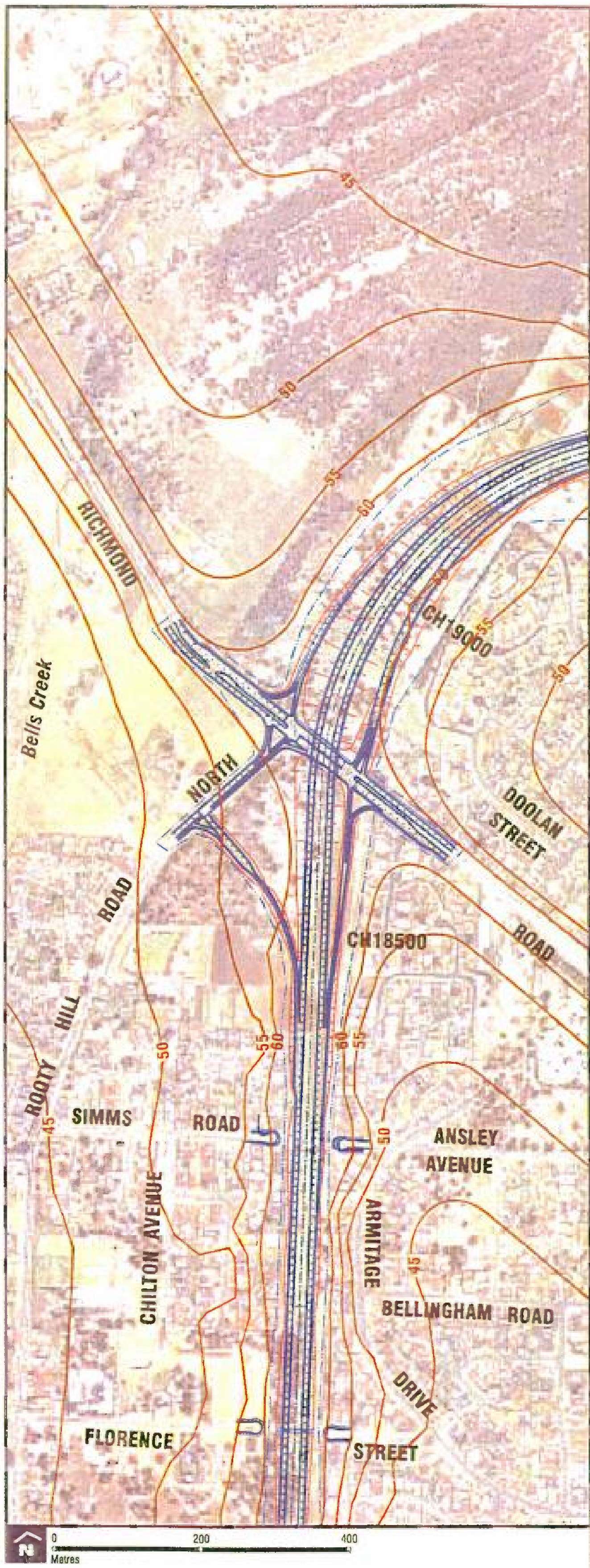


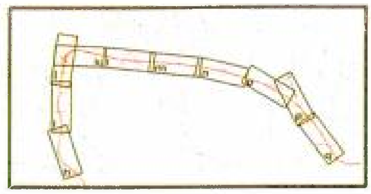


- Proposed Road Corridor Boundary
- Cut
- Fill
- Bridges or Viaducts
- Culvert
- Day-time LAeq noise level (dBA)

Day-time Noise Contours (Year 2016)

Figure 26.3j





Proposed Road Corridor Boundary

Cut

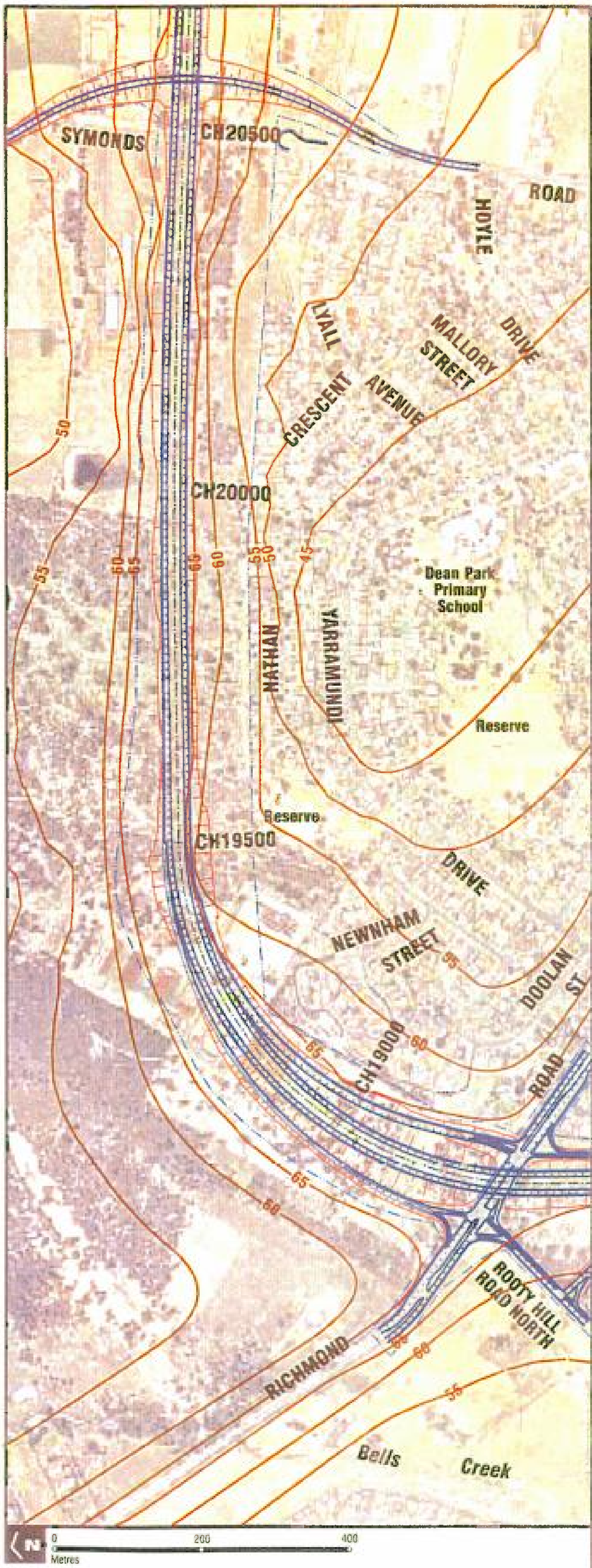
Fill

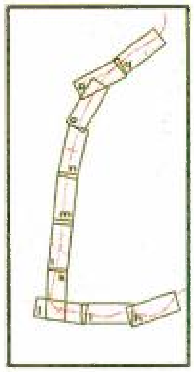
Bridges or Viaducts

Culvert

Night-time LAeq noise level (dBA)

Night-time Noise Contours (Year 2016) Figure 26.4j

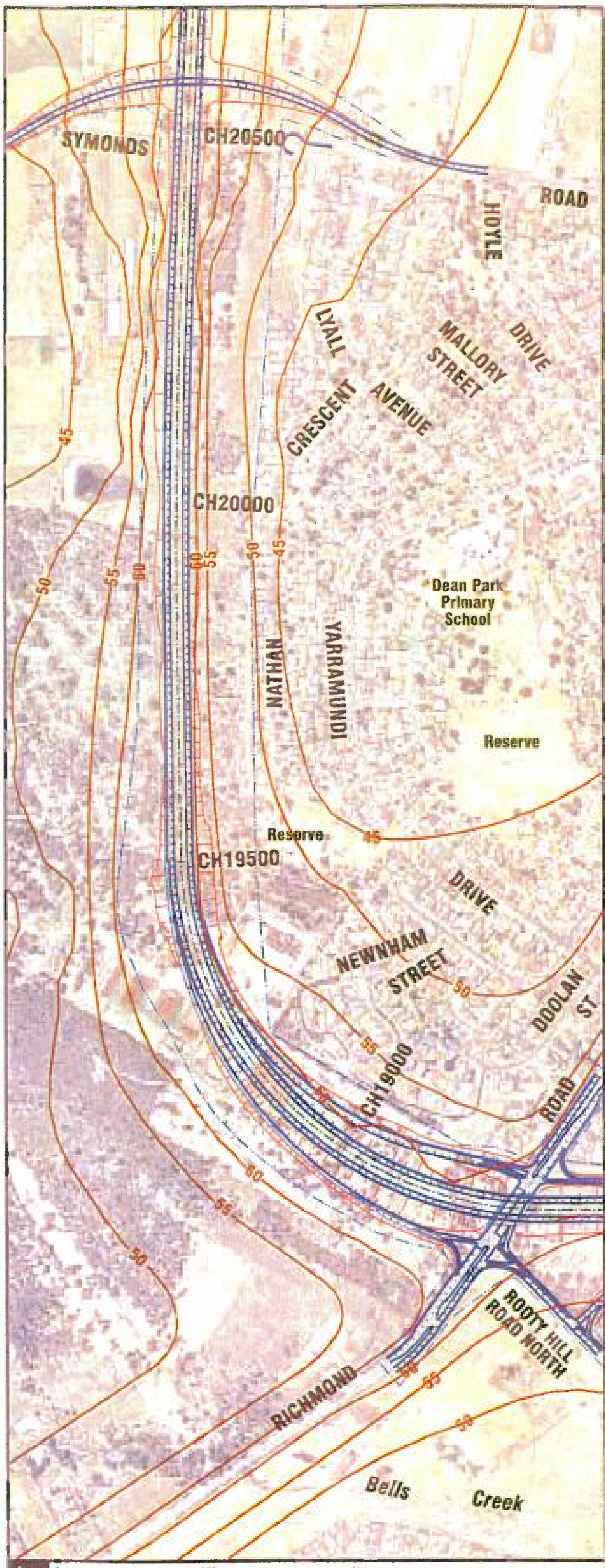


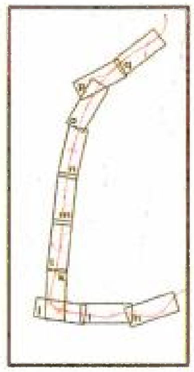


Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Day-time LAeq noise level (dBA)

Day-time Noise Contours (Year 2016)

Figure 26.3k





Proposed Road Corridor Boundary

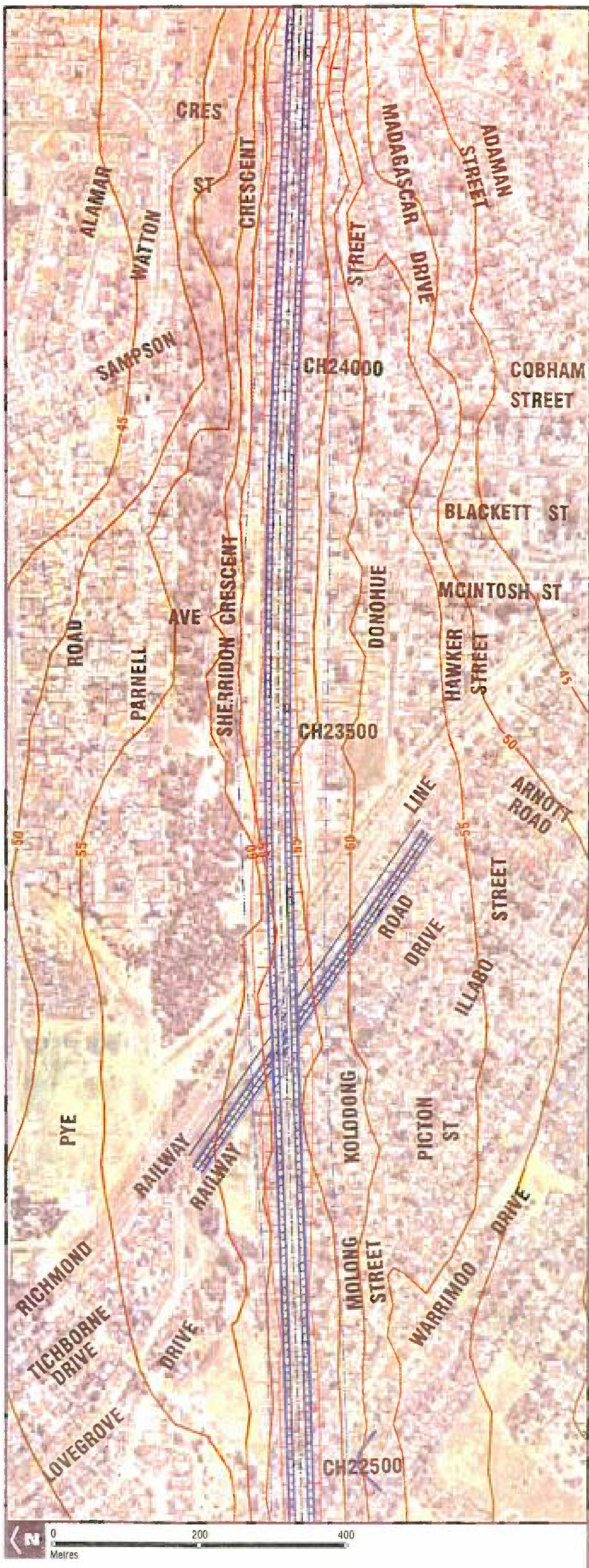
Cut

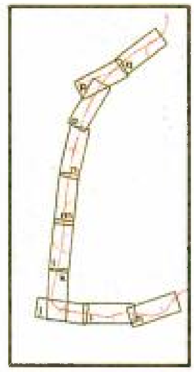
Fill

Bridges or Viaducts

Night-time L_{Aeq} noise level (dBA)

Night-time Noise Contours (Year 2016) Figure 26.4k





Proposed Road Corridor Boundary

Cut

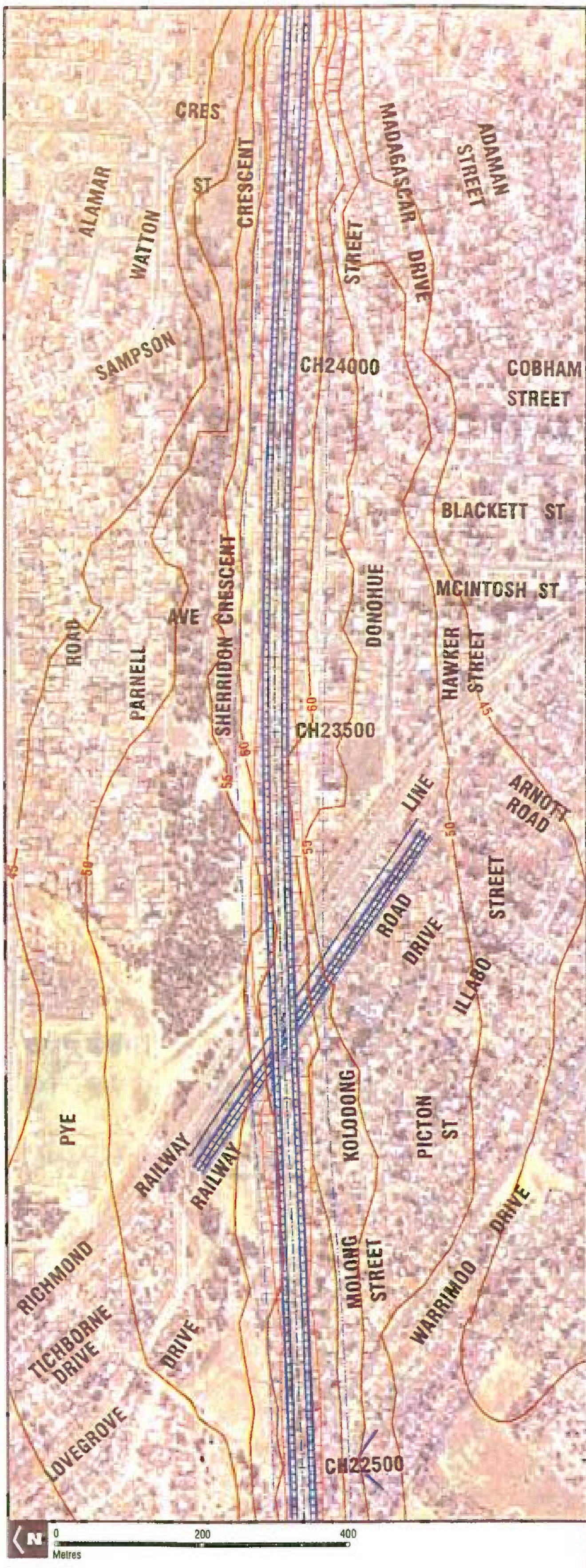
Fill

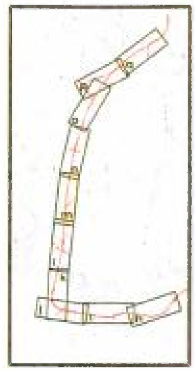
Bridges or Viaducts

Day-time LAeq noise level (dBA)

Day-time Noise Contours (Year 2016)

Figure 26.3m





Proposed Road Corridor Boundary

Cut

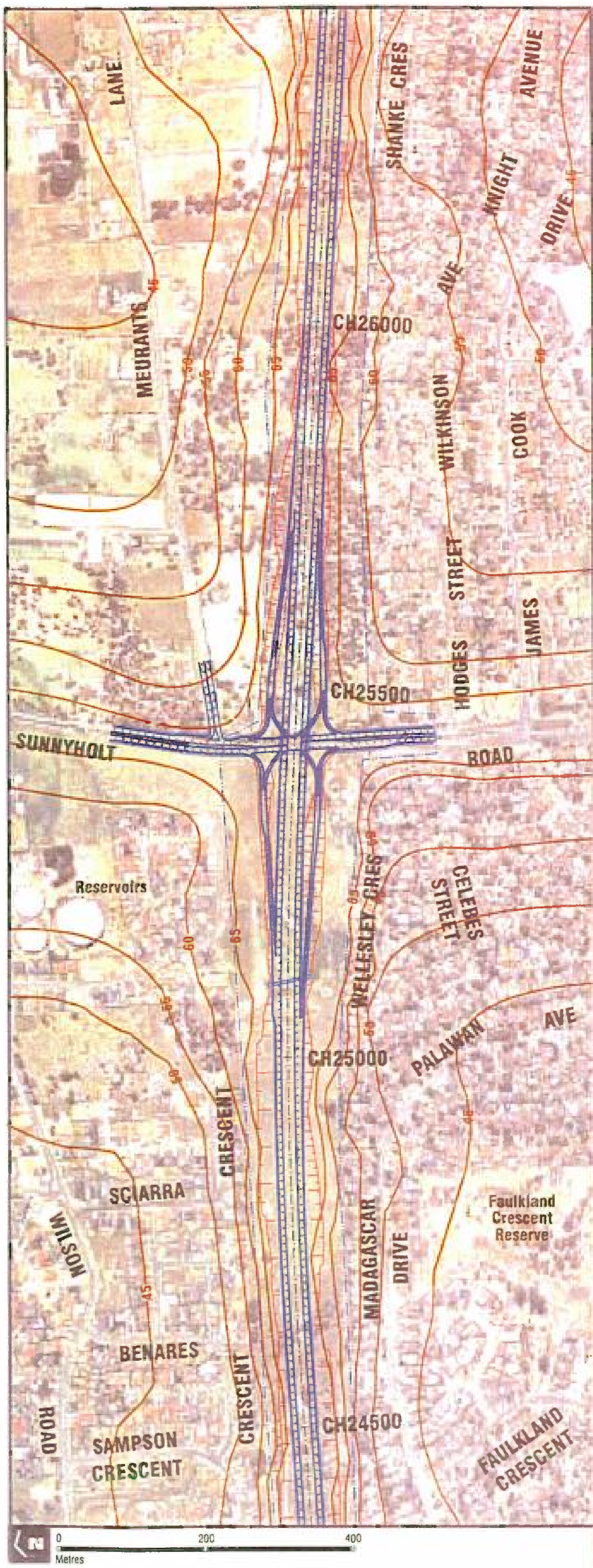
Fill

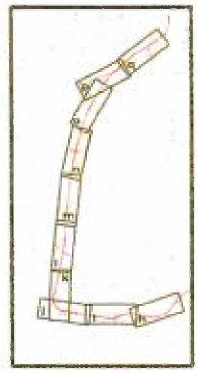
Bridges or Viaducts

Night-time LAeq noise level (dBA)

Night-time Noise Contours (Year 2016)

Figure 26.4m





Proposed Road Corridor Boundary

Cut

Fill

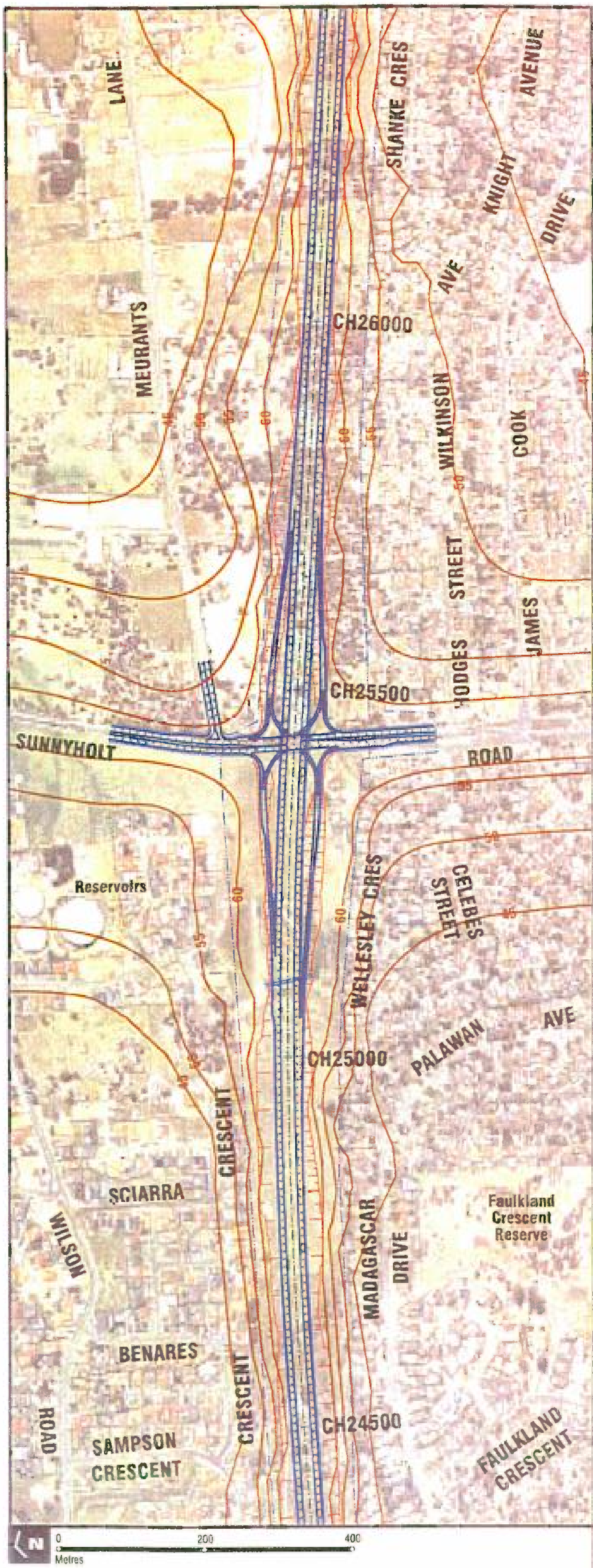
Bridges or Viaducts

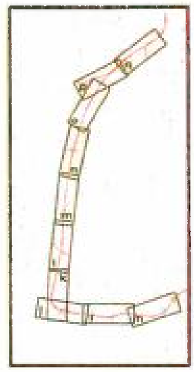
Culvert

Day-time L_{Aeq} noise level (dBA)

Day-time Noise Contours (Year 2016)

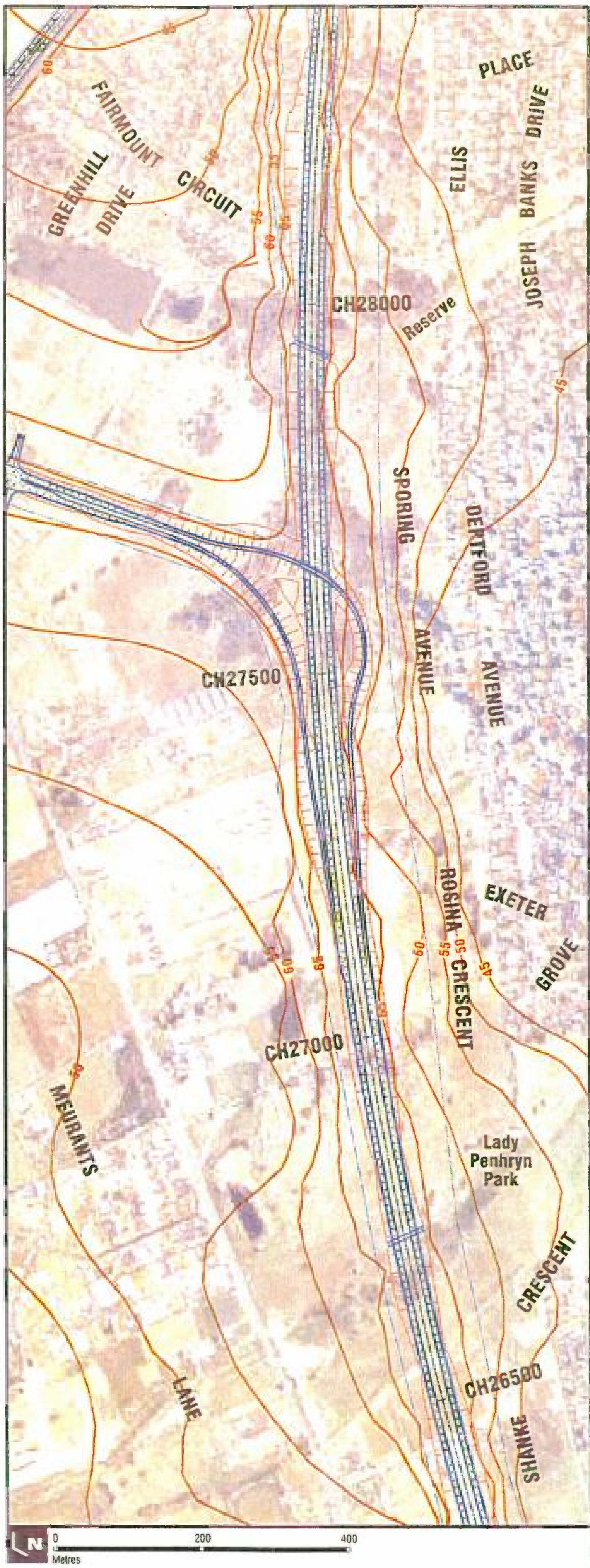
Figure 26.3n

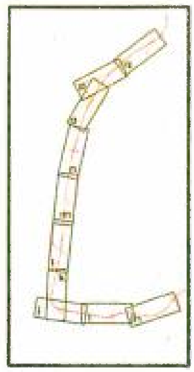




Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Night-time L_{Aeq} noise level (dBA)

Night-time Noise Contours (Year 2016) Figure 26.4n





Proposed Road Corridor Boundary

Cut

Fill

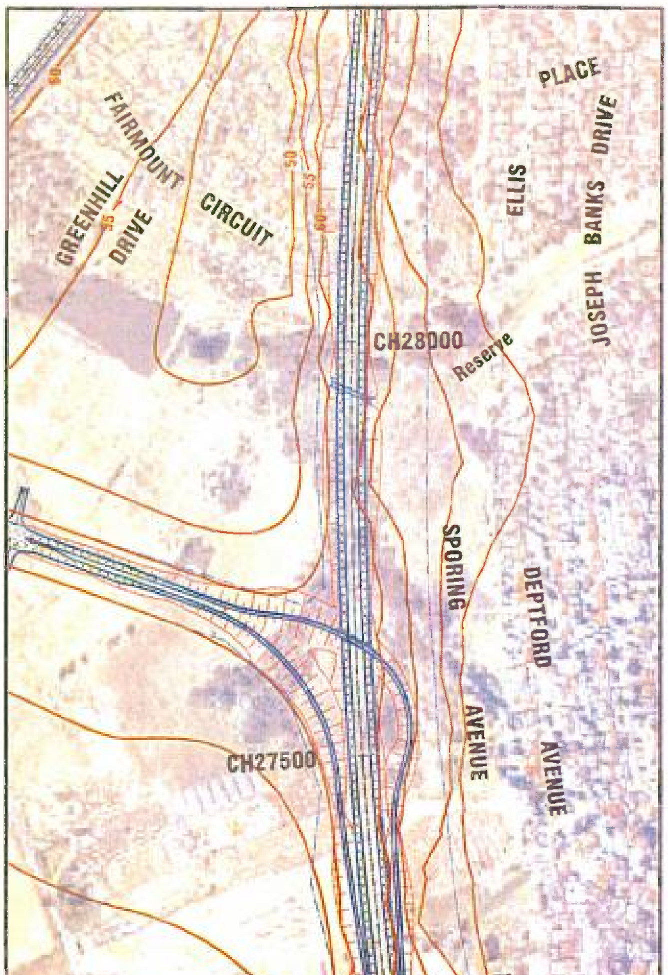
Bridges or Viaducts

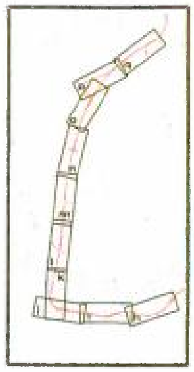
Culvert

Day-time LAeq noise level (dBA)

Day-time Noise Contours (Year 2016)

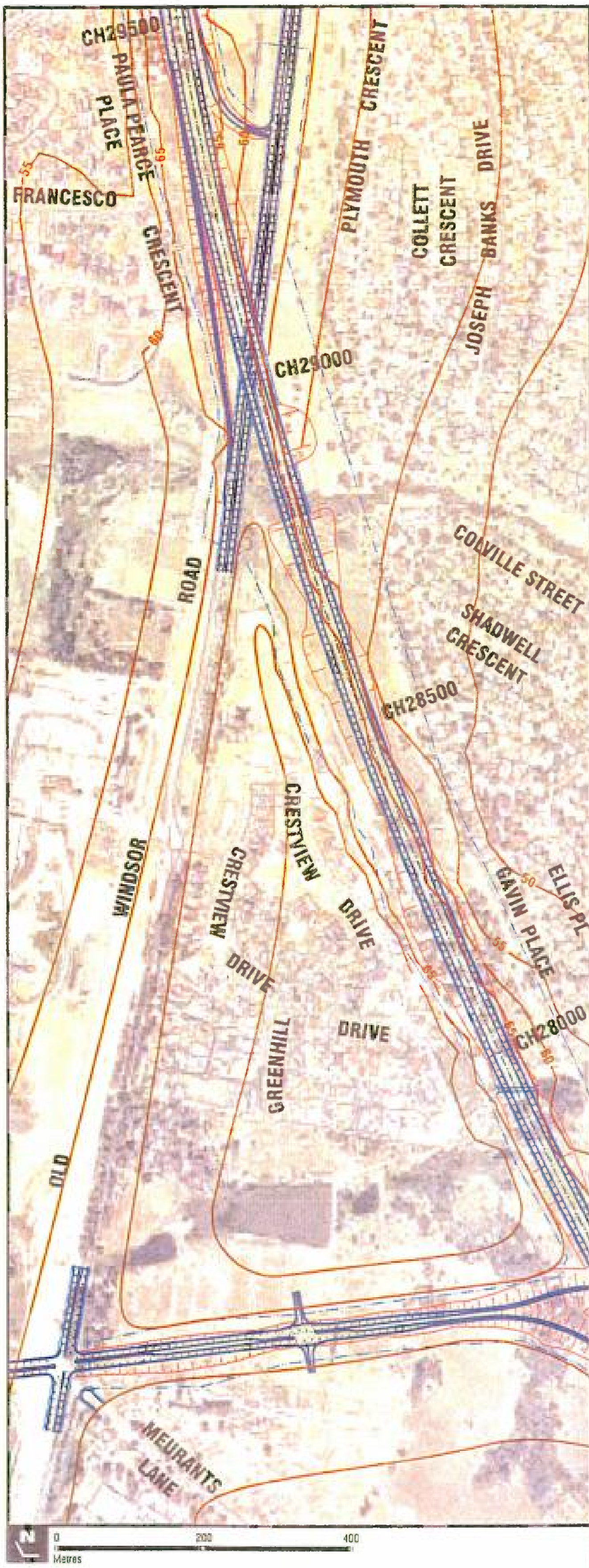
Figure 26.3o

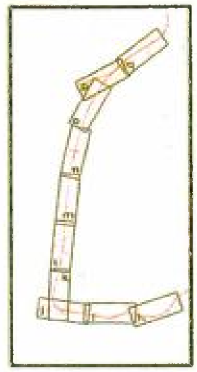




- Proposed Road Corridor Boundary
- Cut
- Fill
- Bridges or Viaducts
- Culvert
- Night-time LAeq noise level (dBA)

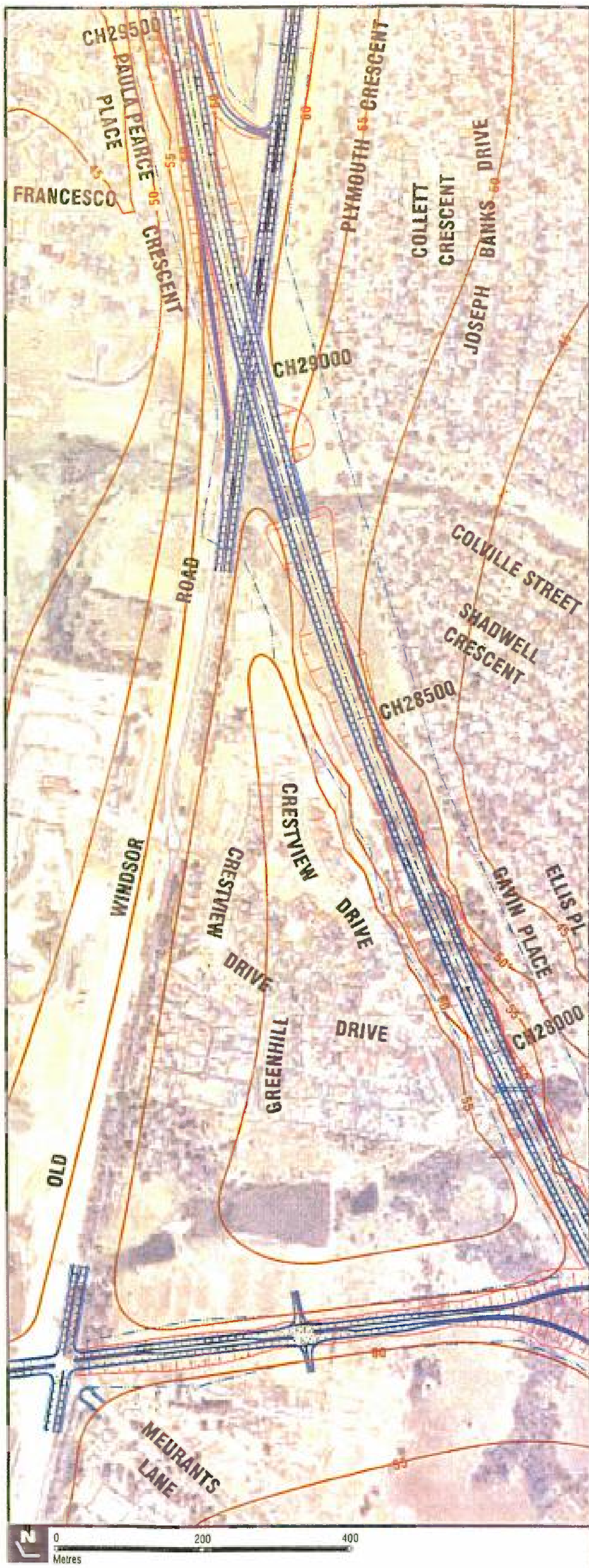
Night-time Noise Contours (Year 2016) Figure 26.4o

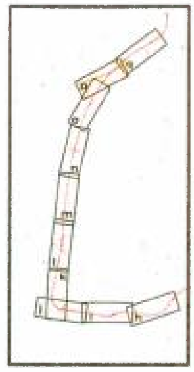




— · — Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Culvert
Day-time L_{Aeq} noise level (dBA)

Day-time Noise Contours (Year 2016) Figure 26.3p





Proposed Road Corridor Boundary

Cut

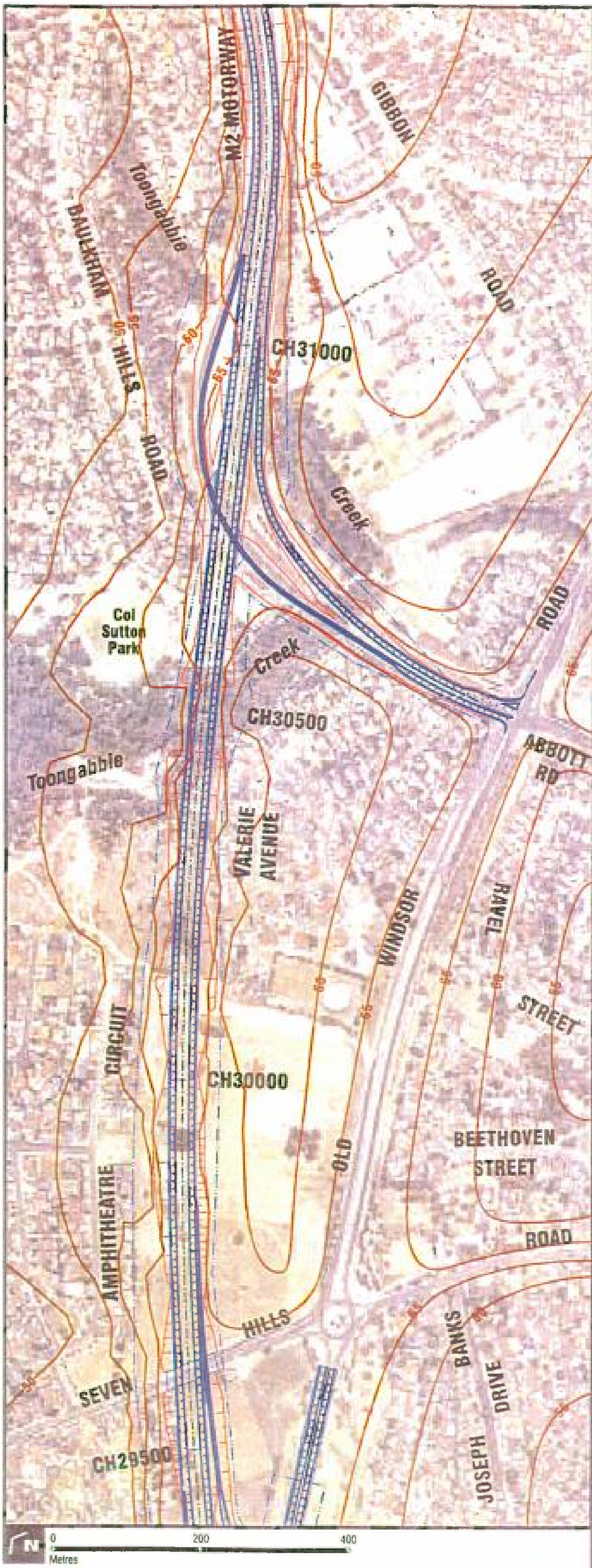
Fill

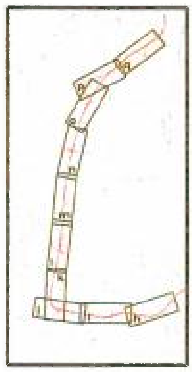
Bridges or Viaducts

Culvert

Night-time L_{Aeq} noise level (dBA)

Night-time Noise Contours (Year 2016) Figure 26.4p

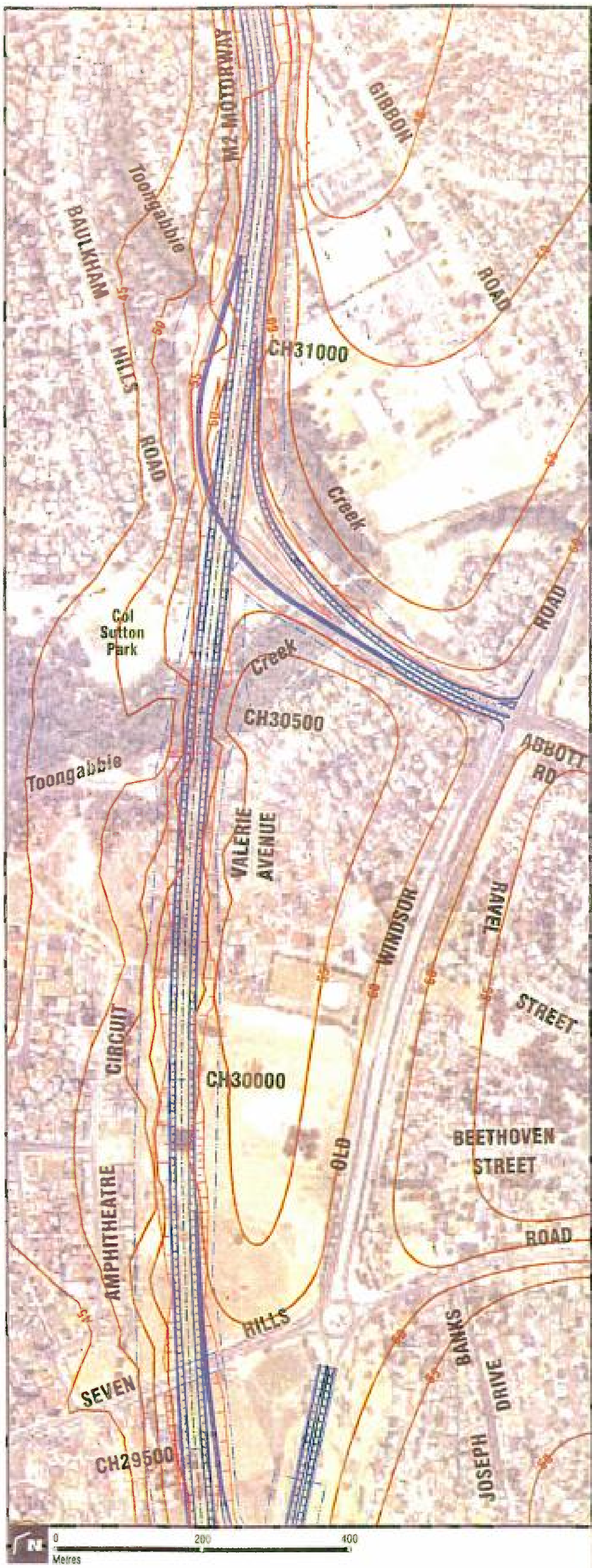


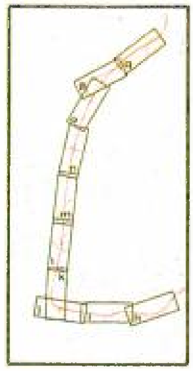


Proposed Road Corridor Boundary
Cut
Fill
Bridges or Viaducts
Day-time LAeq noise level (dBA)

Day-time Noise Contours (Year 2016)

Figure 26.3q





Proposed Road Corridor Boundary

Cut

Fill

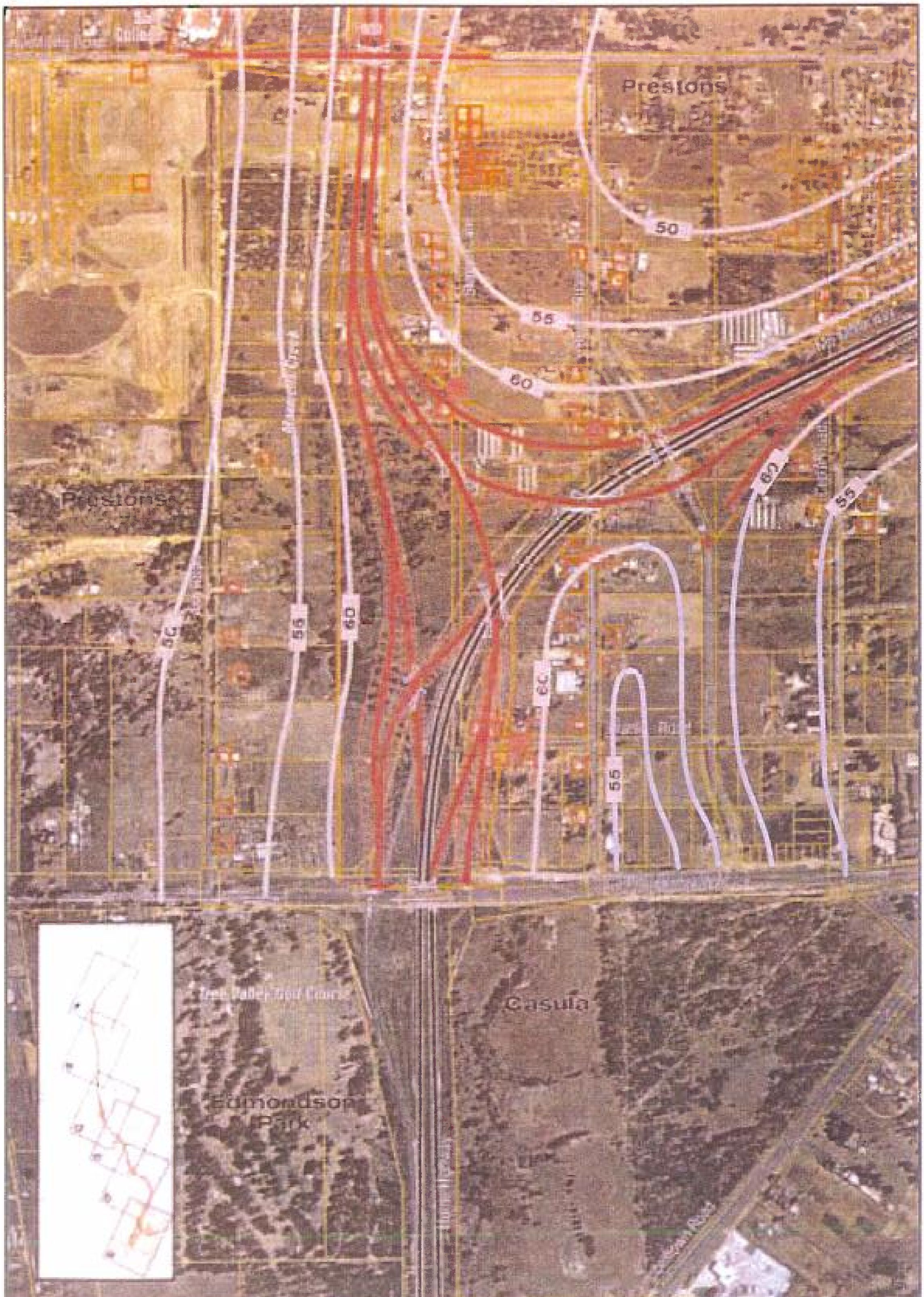
Bridges or Viaducts

Night-time LAeq noise level (dBA)

Night-time Noise Contours (Year 2016)

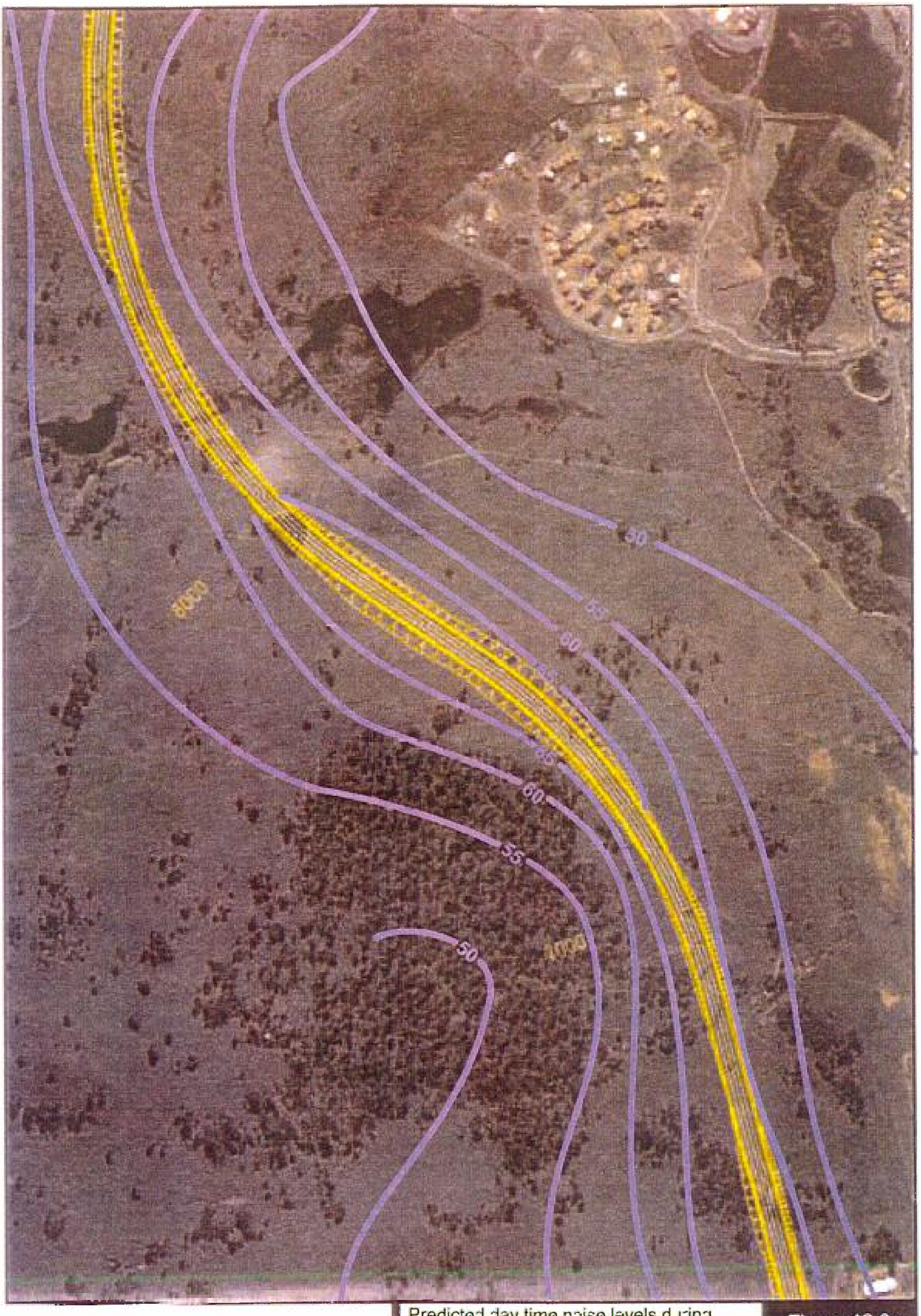
Figure 26.4q

APPENDIX E – REVISED NOISE CONTOURS (SOUTHERN SECTION)



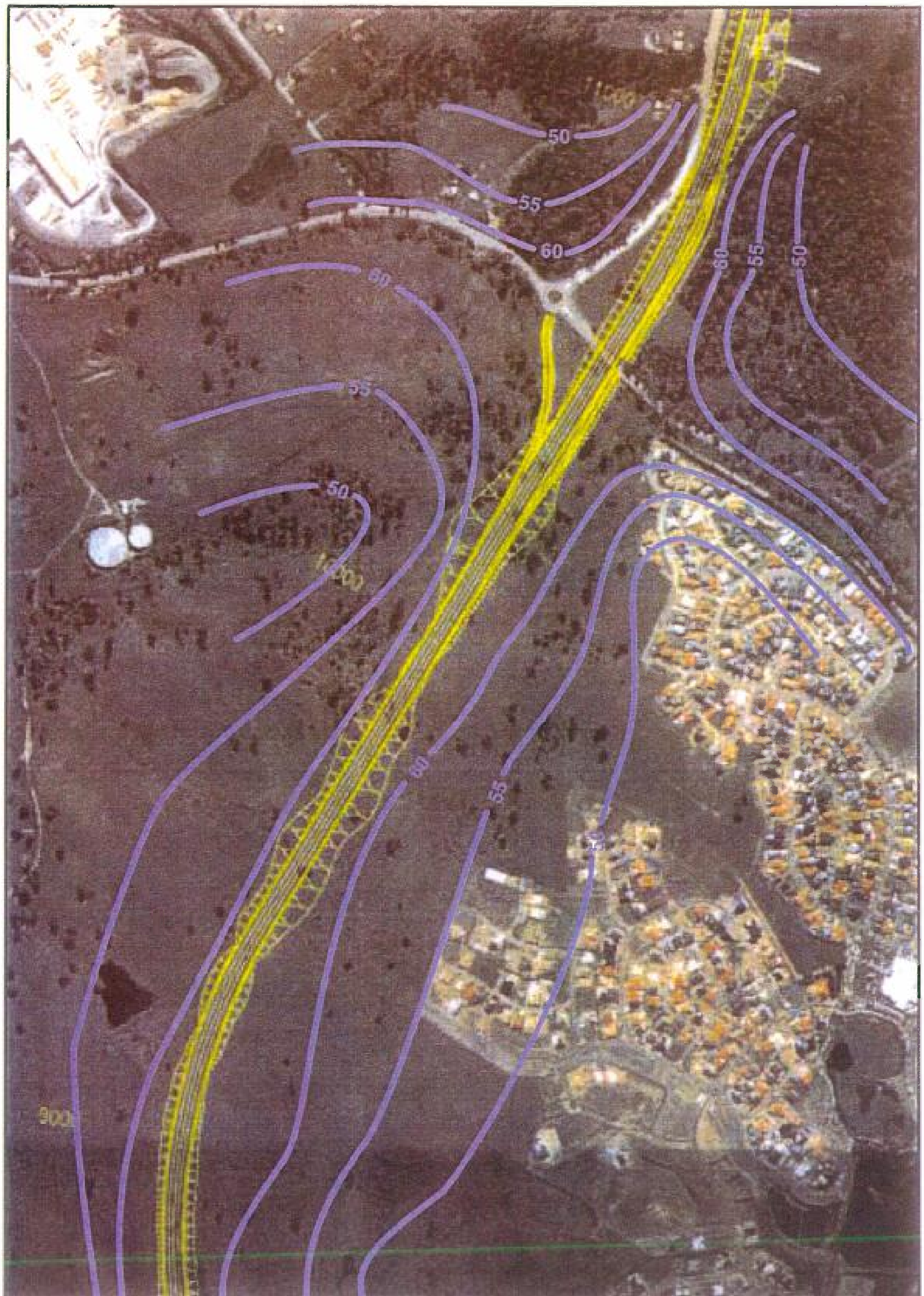
Predicted day time noise levels during operation of the proposal (Year 2016)

Figure 12.6a



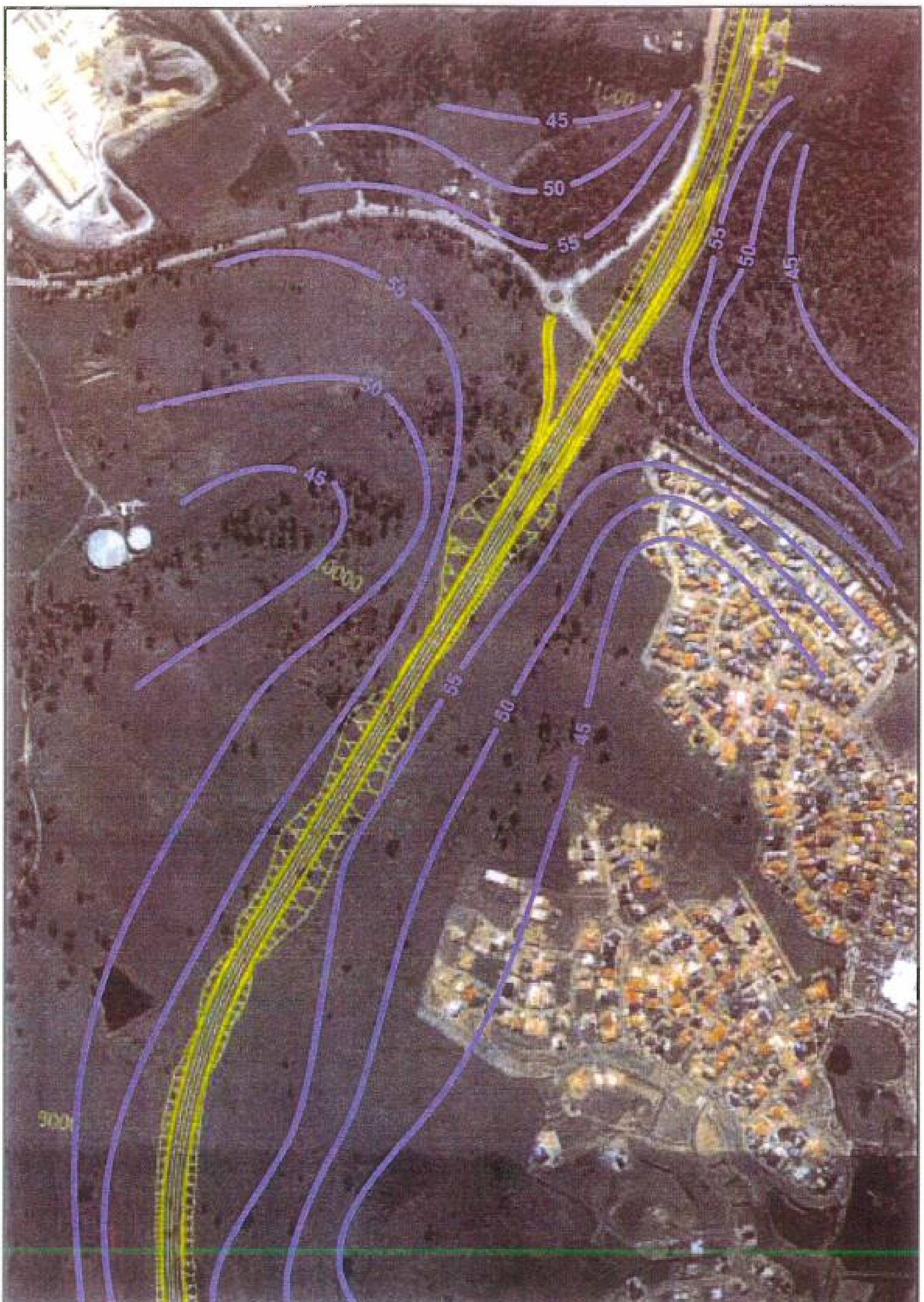
Predicted day time noise levels during operation of the proposal (Year 2016)

Figure 12.6e



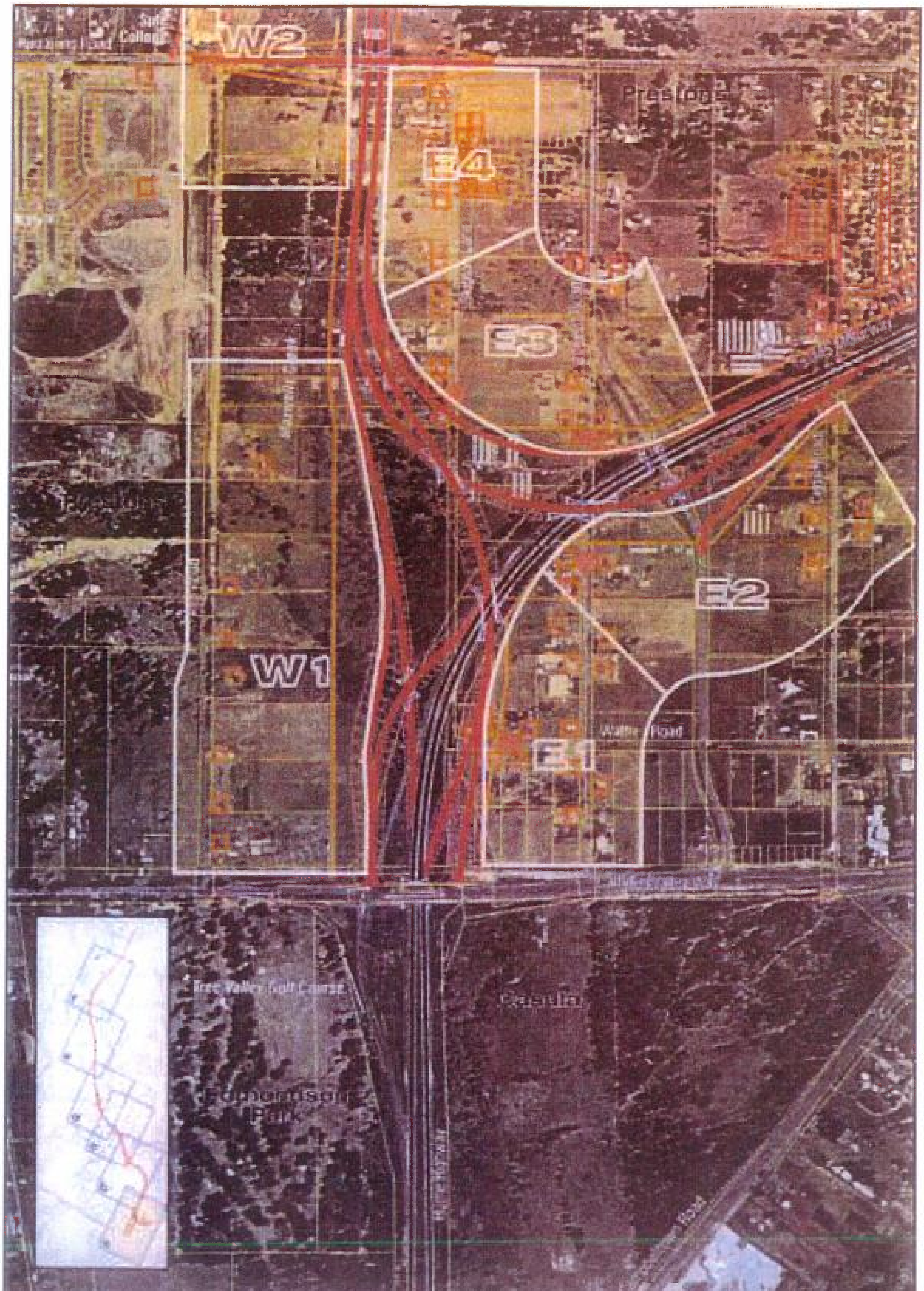
Predicted day time noise levels during operation of the proposal (Year 2016)

Figure 12.6f



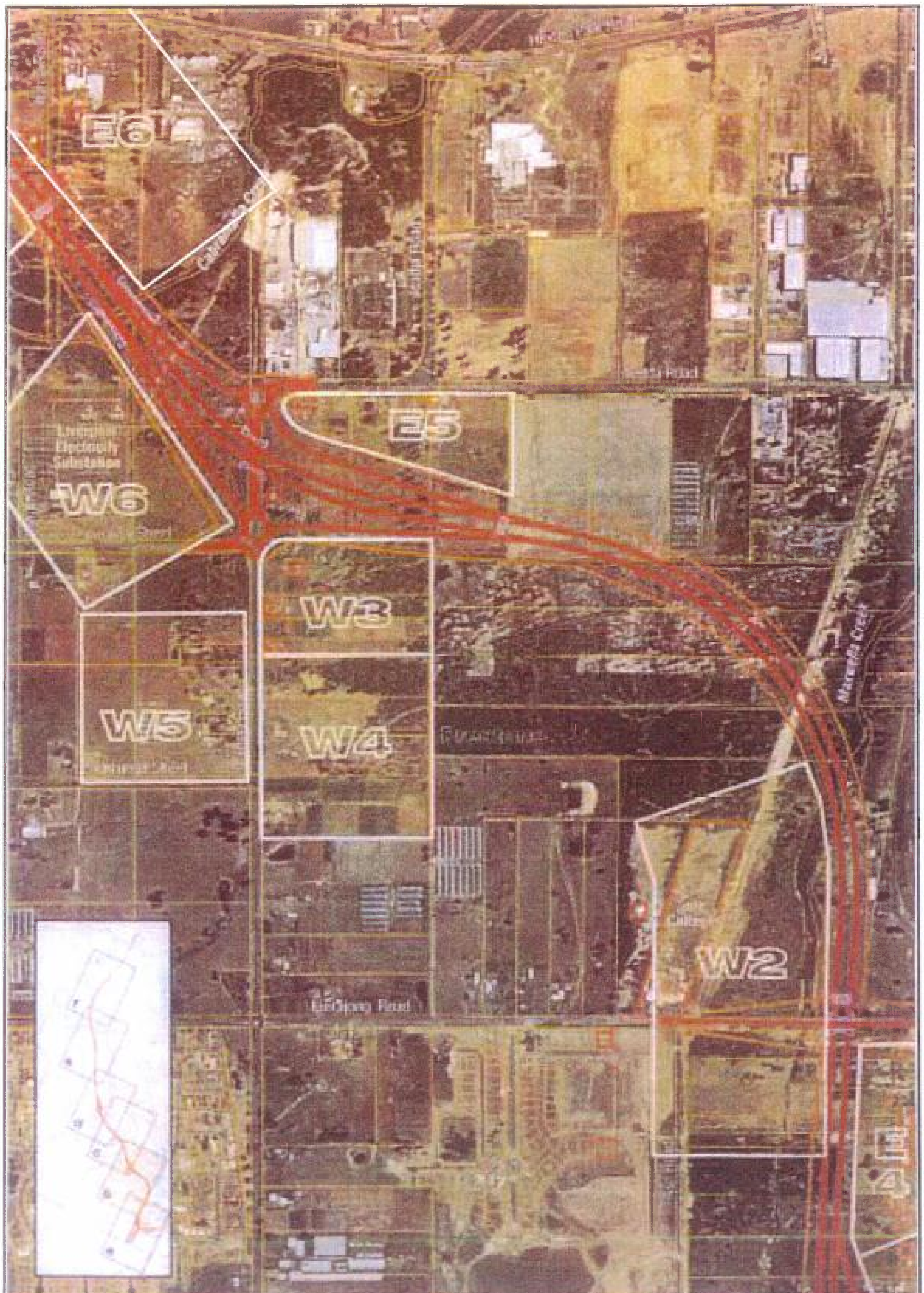
Predicted night time noise levels during operation of the proposal (Year 2016)

Figure 12.7f



Noise Catchment Areas

Figure 12.8a

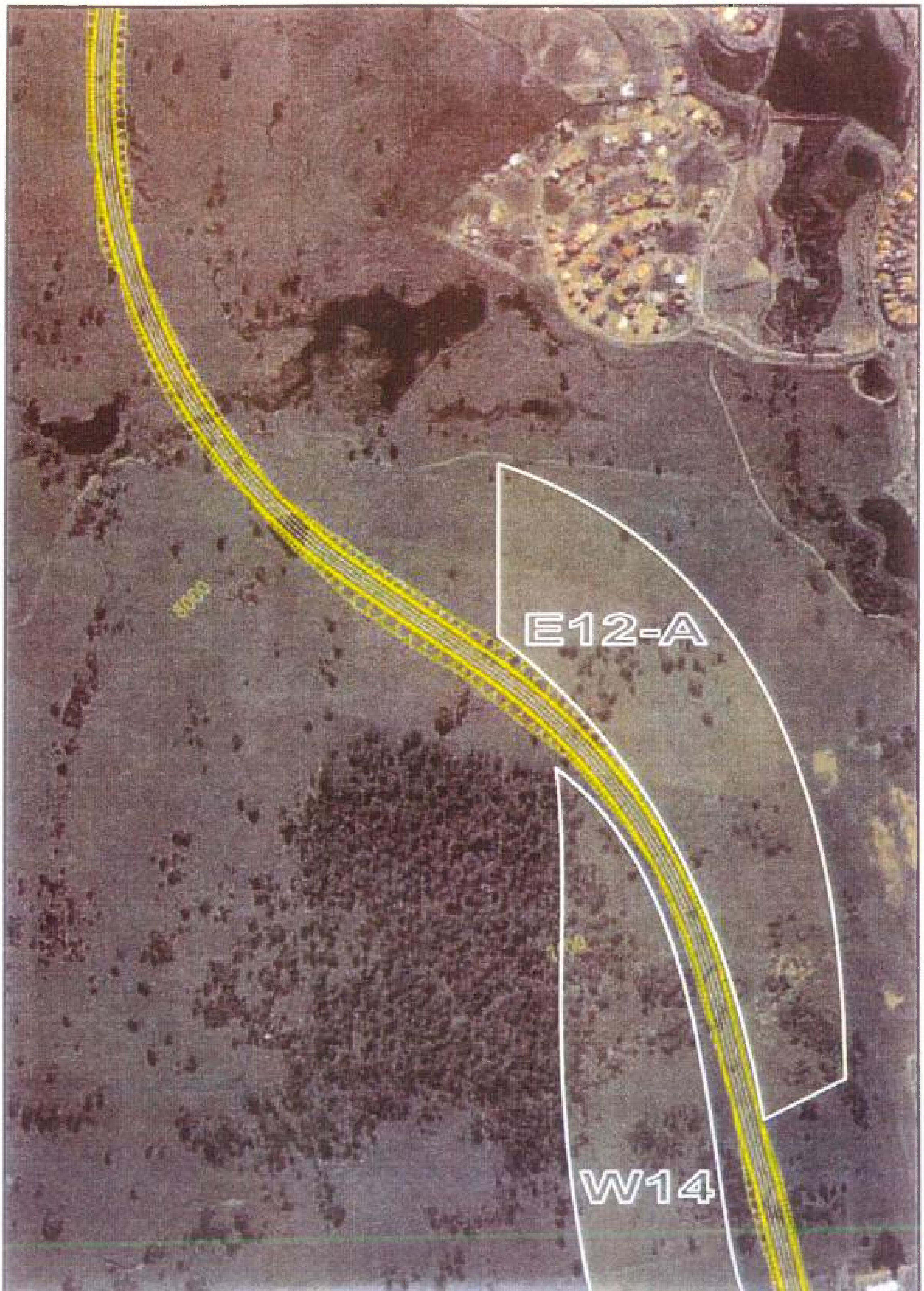


Noise Catchment Areas

Figure 12.8b

Noise Catchment Areas

Figure 12.8d



Noise Catchment areas

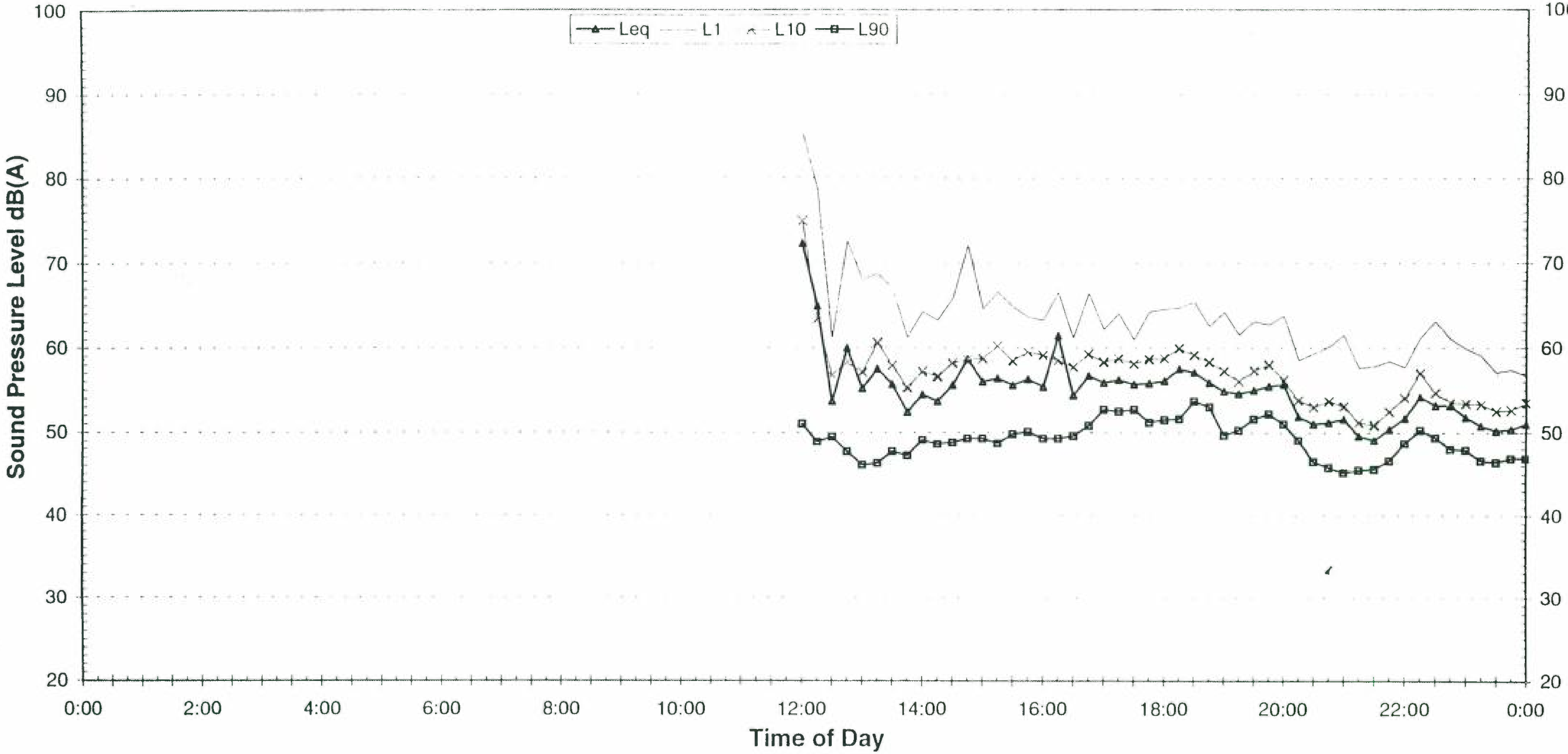
Figure 12.8e

APPENDIX F – ADDITIONAL NOISE MONITORING LOGGER GRAPHS

EXISTING AMBIENT NOISE LEVELS

Location 1 - Cnr Wattle Street & Beech Road, Casula

Tuesday, 12 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	47.7	45.5	39.9
Leq (see note 3)	58.4	51.6	49.6

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.

2. "Night" relates to period from 10pm on this graph to 7am on the following graph.

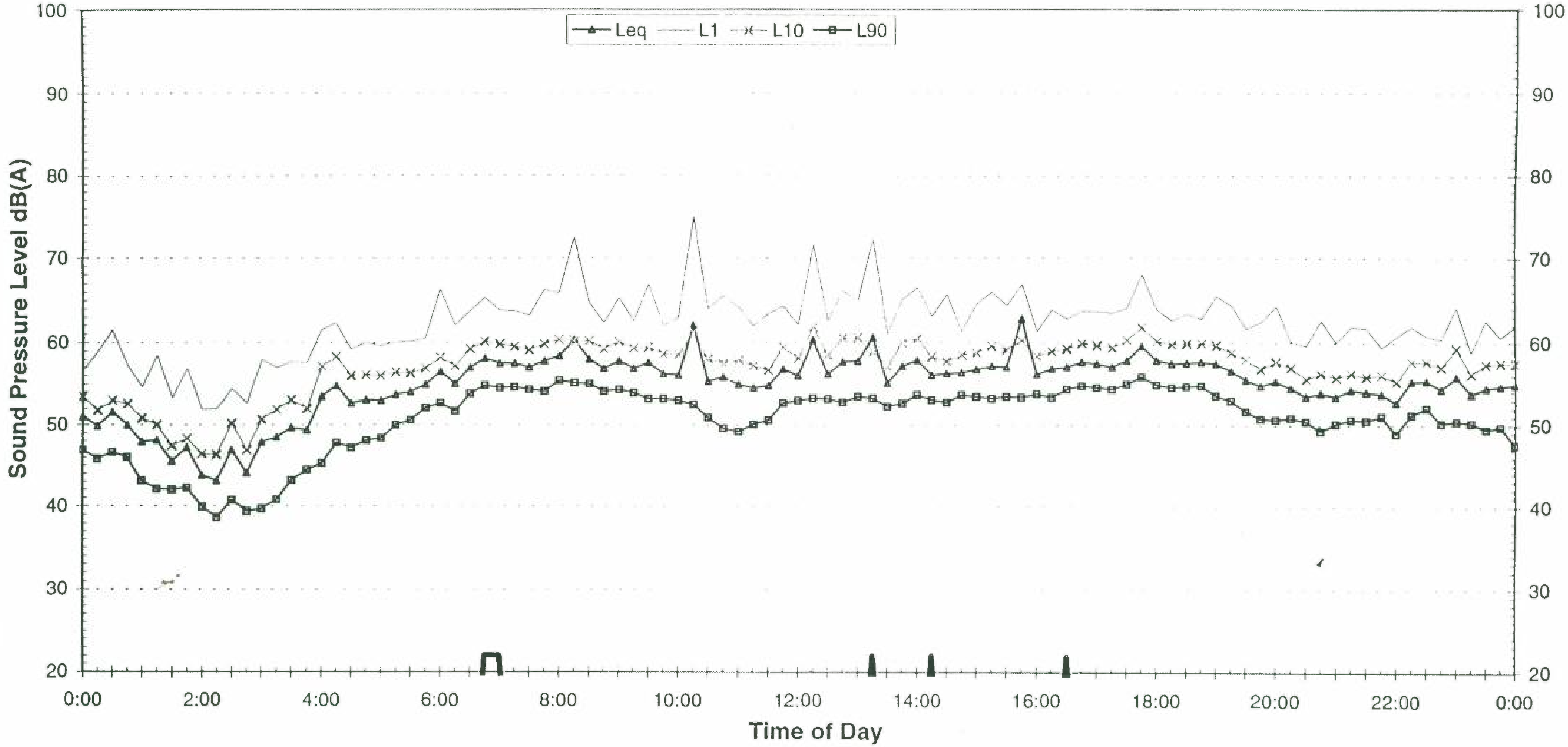
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	59.3	52.1
Leq 1hr upper 10 percentile	71.9	56.1
Leq 1hr lower 10 percentile	50.4	45.9

Rev 9 Data File Beechrd.dat

TA999-01S01 (rev 0)

EXISTING AMBIENT NOISE LEVELS
Location 1 - Cnr Wattle Street & Beech Road, Casula
Wednesday, 13 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	50.9	49.3	46.2
Leq (see note 3)	55.2	53.0	53.6

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.

2. "Night" relates to period from 10pm on this graph to 7am on the following graph.

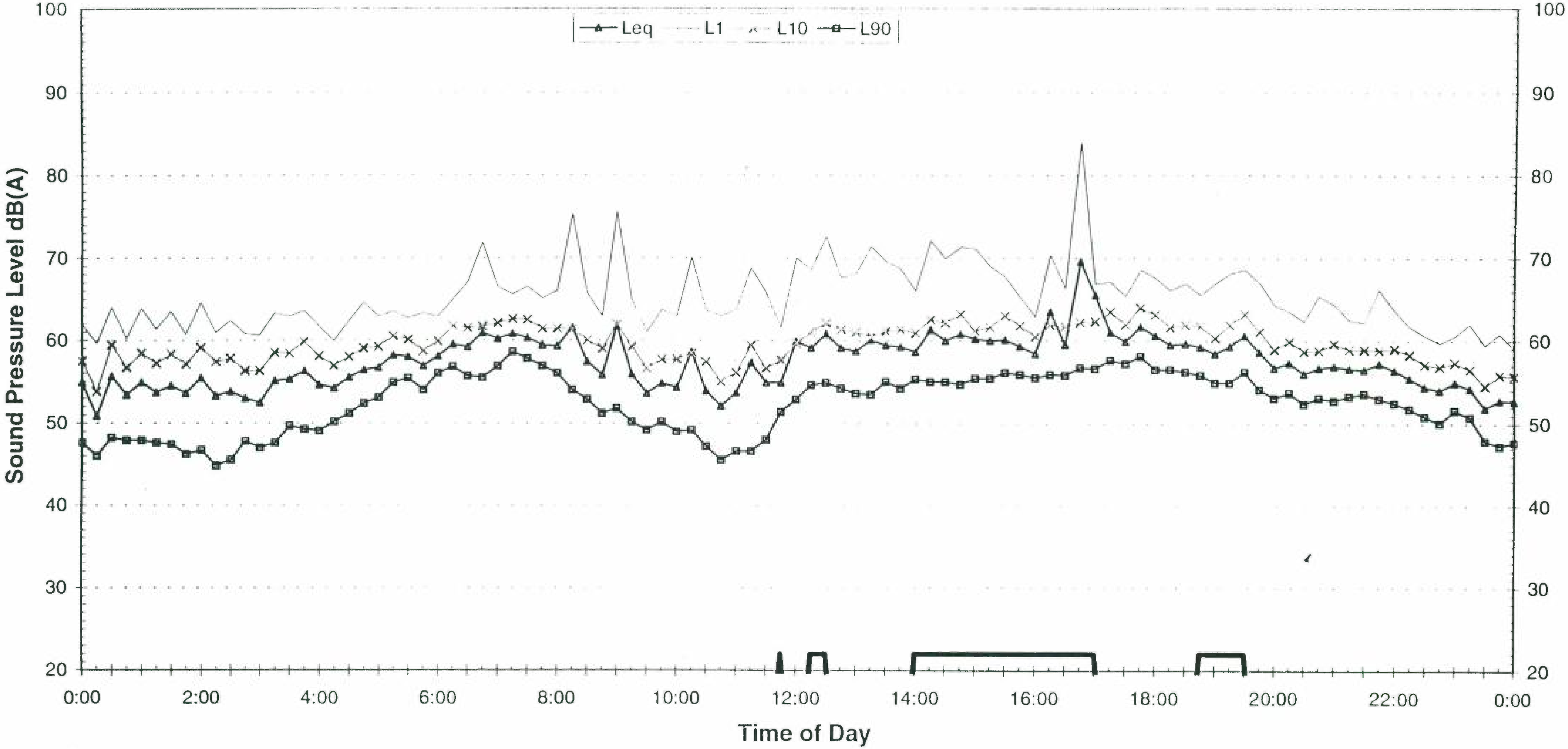
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	57.2	56.1
Leq 1hr upper 10 percentile	58.9	60.0
Leq 1hr lower 10 percentile	53.8	53.2

EXISTING AMBIENT NOISE LEVELS

Location 1 - Cnr Wattle Street & Beech Road, Casula

Thursday, 14 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	47.2	52.5	45.7
Leq (see note 3)	56.3	55.0	54.1

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.

2. "Night" relates to period from 10pm on this graph to 7am on the following graph.

3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	58.5	56.6
Leq 1hr upper 10 percentile	60.7	62.0
Leq 1hr lower 10 percentile	54.9	51.0

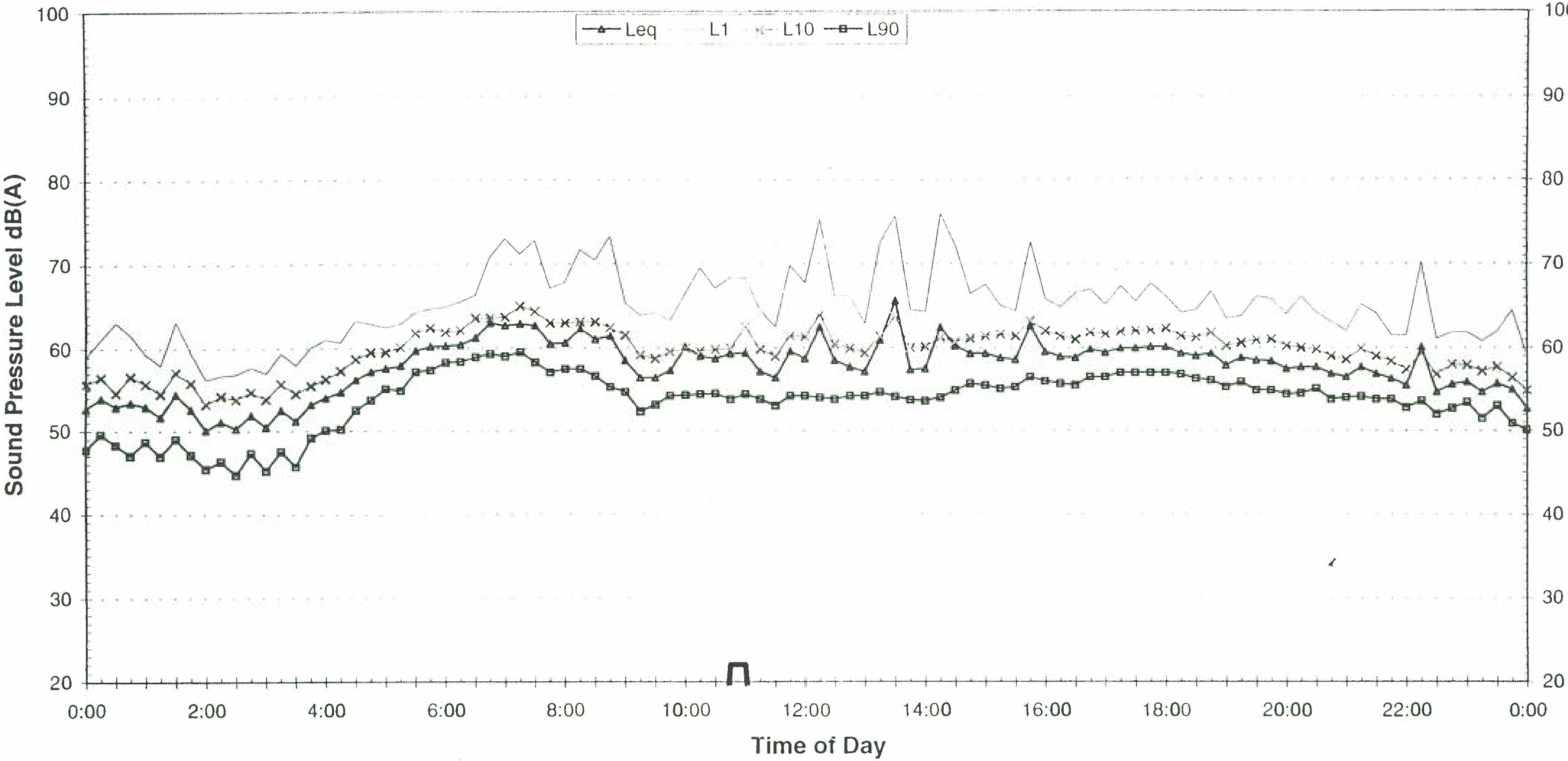
Rev 9 Data File Beechrd.dat

TA999-01S01 (rev 0)

EXISTING AMBIENT NOISE LEVELS

Location 1 - Cnr Wattle Street & Beech Road, Casula

Friday, 15 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	53.7	53.8	46.5
Leq (see note 3)	57.6	55.4	52.4

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.

2. "Night" relates to period from 10pm on this graph to 7am on the following graph.

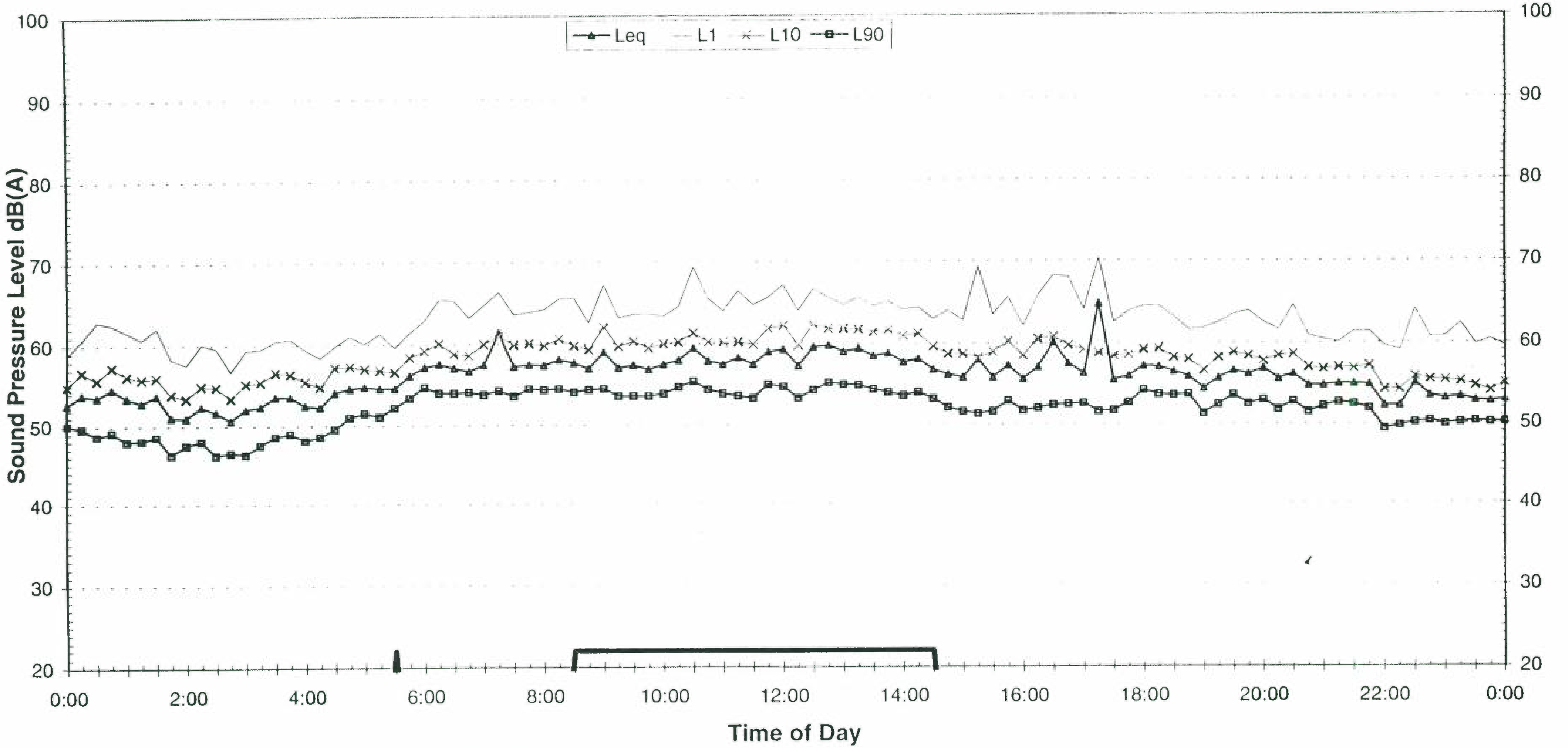
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	59.6	54.9
Leq 1hr upper 10 percentile	61.8	57.2
Leq 1hr lower 10 percentile	57.0	51.8

EXISTING AMBIENT NOISE LEVELS

Location 1 - Cnr Wattle Street & Beech Road, Casula

Saturday, 16 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	51.6	51.3	43.5
Leq (see note 3)	55.9	53.1	49.4

NOTES:

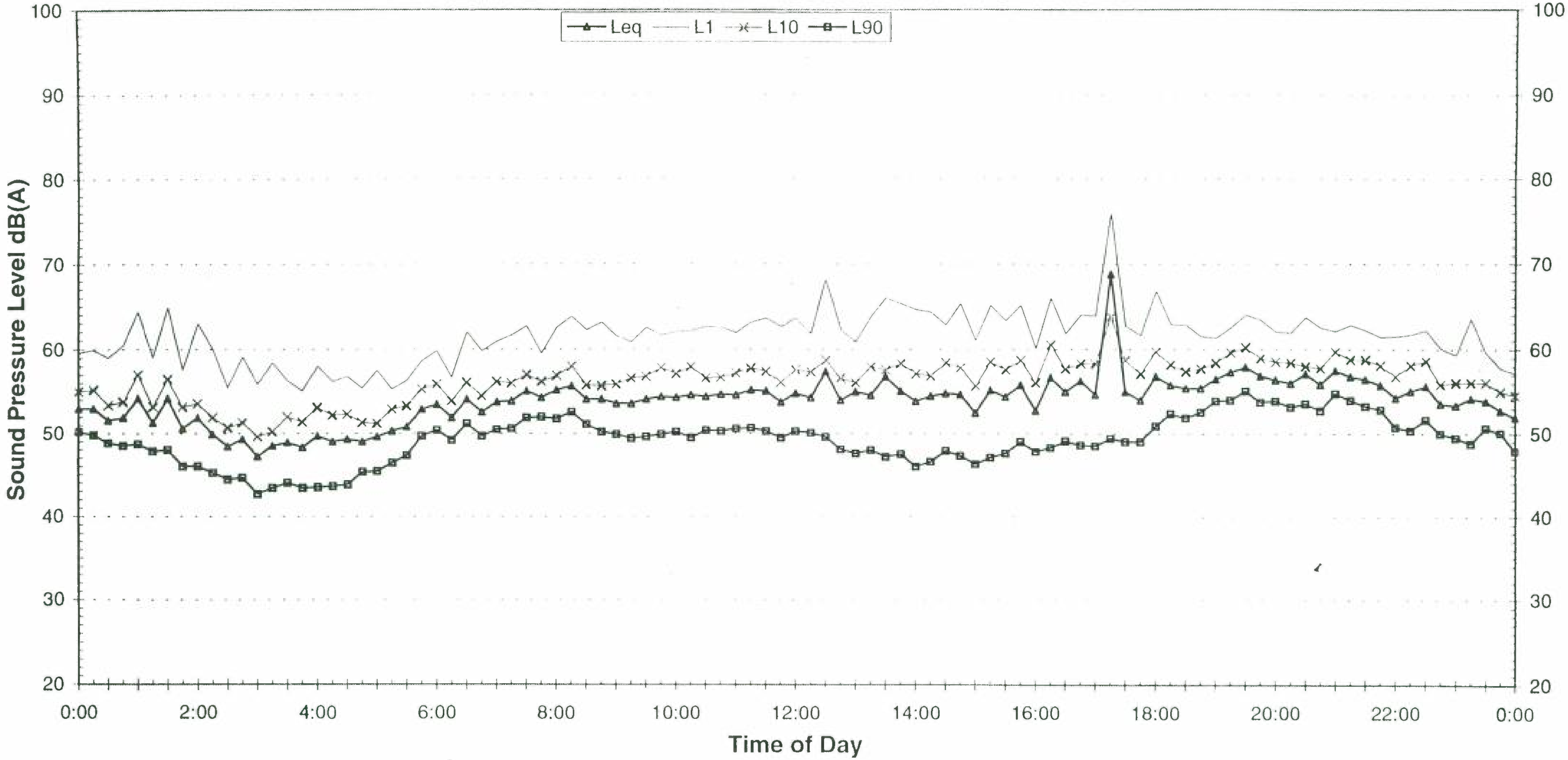
1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured 1m from facade; tabulated results free-field corrected*

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	57.4	51.9
Leq 1hr upper 10 percentile	60.3	53.6
Leq 1hr lower 10 percentile	54.4	48.8

EXISTING AMBIENT NOISE LEVELS

Location 1 - Cnr Wattle Street & Beech Road, Casula

Sunday, 17 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	47.2	51.9	45.0
Leq (see note 3)	54.2	53.9	53.7

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	56.7	56.2
Leq 1hr upper 10 percentile	61.3	60.9
Leq 1hr lower 10 percentile	54.2	50.9

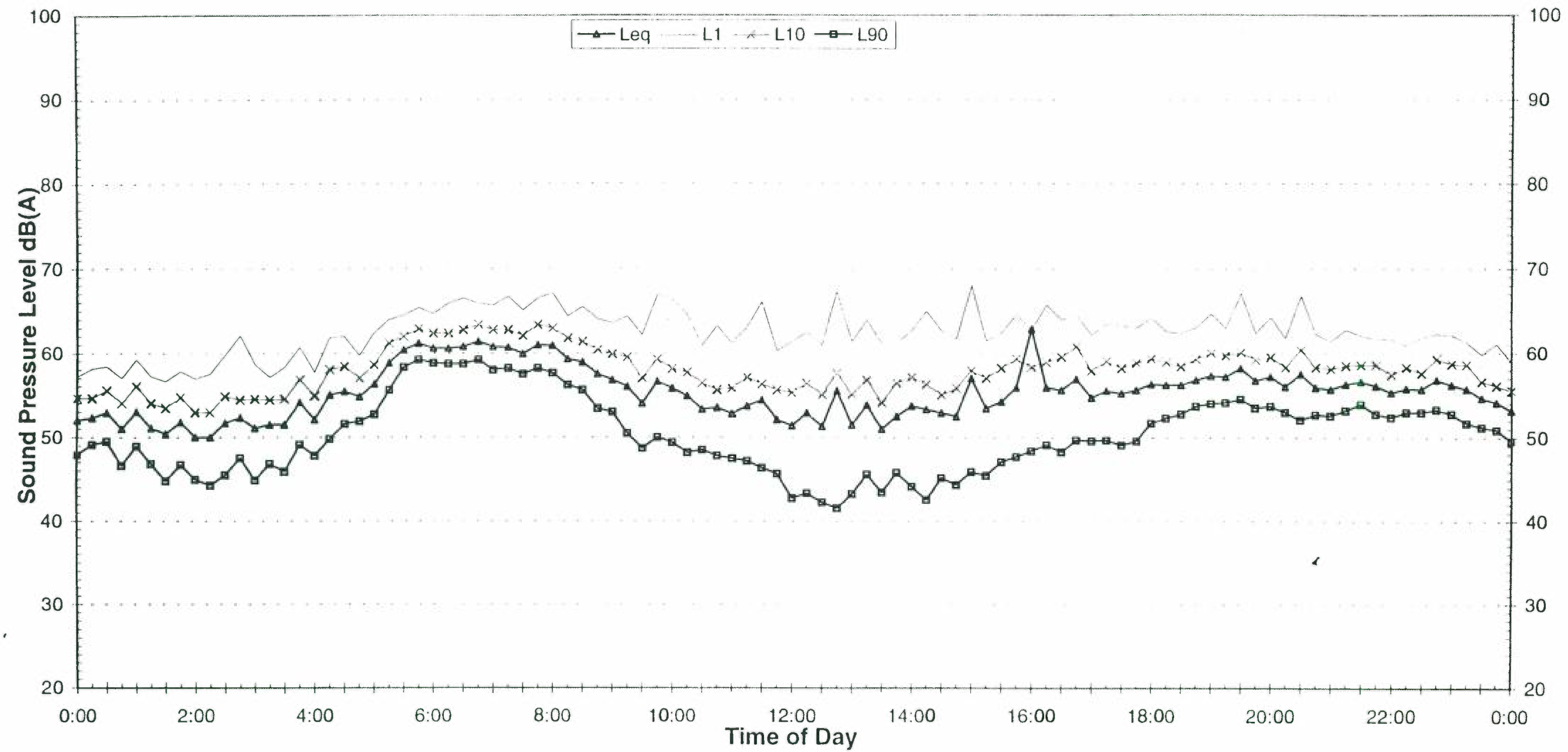
Rev 9 Data File Beechrd.dat

TA999-01S01 (rev 0)

EXISTING AMBIENT NOISE LEVELS

Location 1 - Cnr Wattle Street & Beech Road, Casula

Monday, 18 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	43.3	52.3	46.9
Leq (see note 3)	53.9	54.1	53.6

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade: tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	56.4	56.1
Leq 1hr upper 10 percentile	59.7	60.3
Leq 1hr lower 10 percentile	53.0	51.9

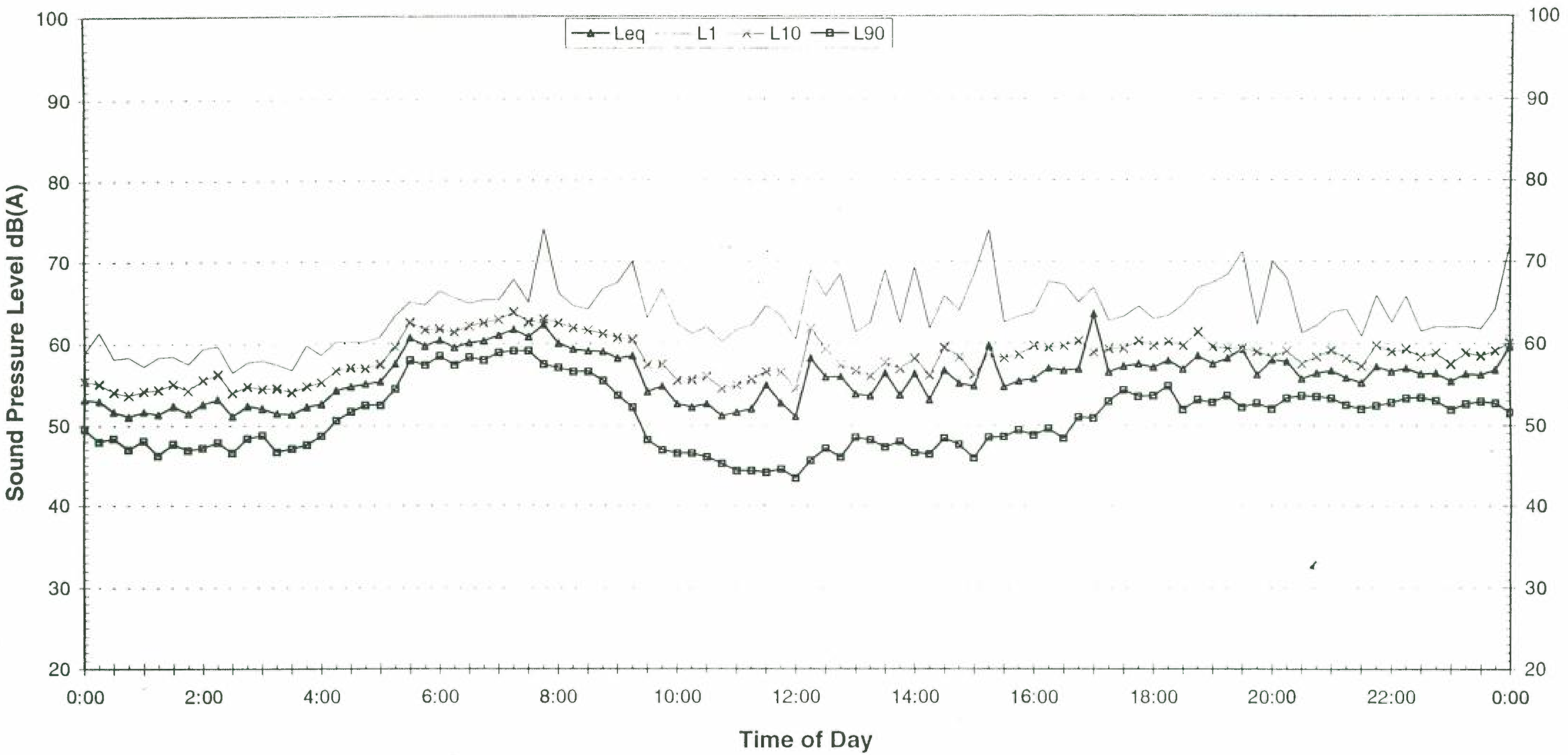
Rev 9 Data File Beechrd.dat

TA999-01S01 (rev 0)

EXISTING AMBIENT NOISE LEVELS

Location 1 - Cnr Wattle Street & Beech Road, Casula

Tuesday, 19 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	44.5	52.0	47.6
Leq (see note 3)	54.8	54.8	56.4

NOTES:

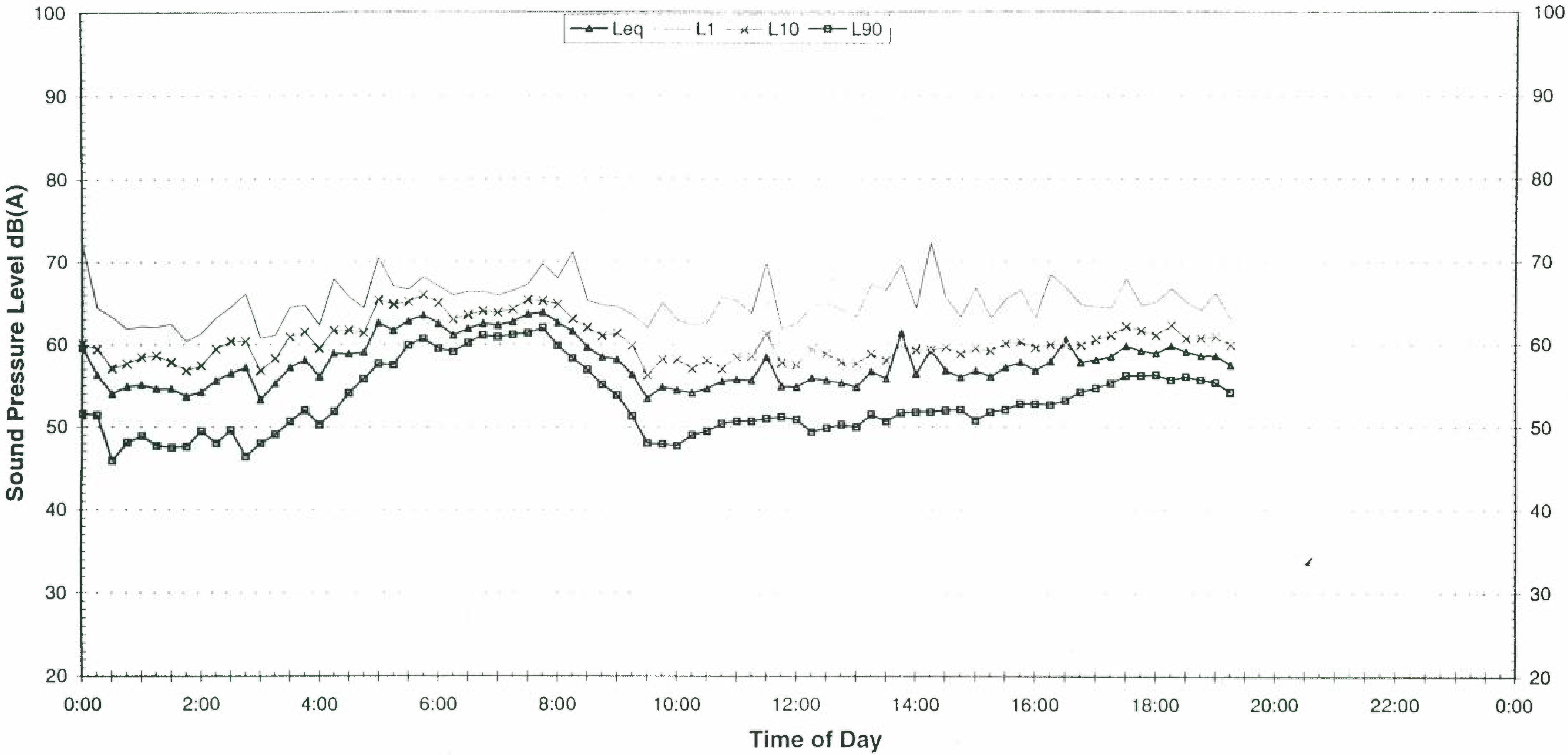
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	57.3	58.9
Leq 1hr upper 10 percentile	60.6	62.7
Leq 1hr lower 10 percentile	52.5	54.3

EXISTING AMBIENT NOISE LEVELS

Location 1 - Cnr Wattle Street & Beech Road, Casula

Wednesday, 20 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	49.4	54.2	-
Leq (see note 3)	55.9	56.3	-

NOTES:

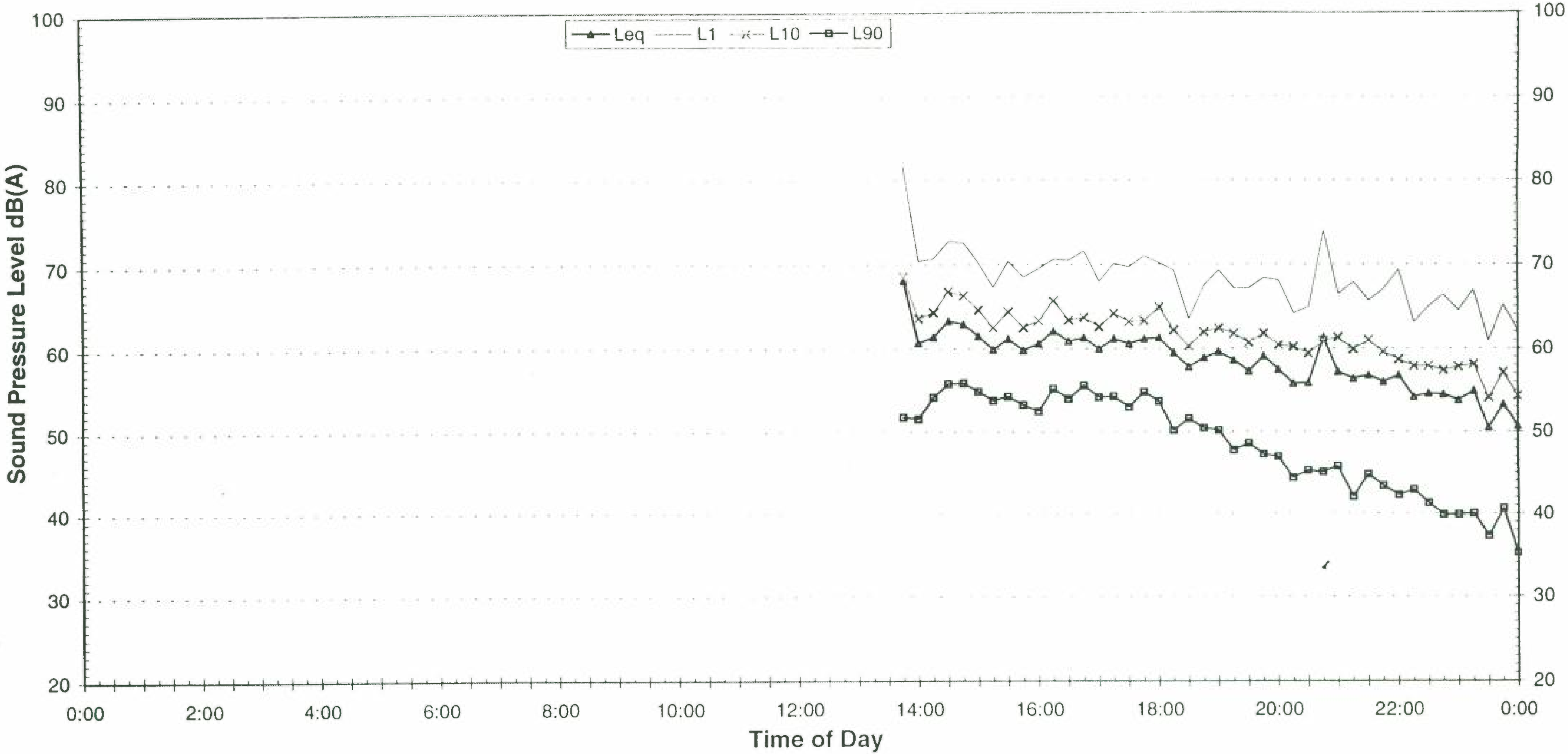
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.

2. "Night" relates to period from 10pm on this graph to 7am on the following graph.

3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	58.5	-
Leq 1hr upper 10 percentile	62.4	-
Leq 1hr lower 10 percentile	54.9	-

EXISTING AMBIENT NOISE LEVELS
Location 2 - Bernera Road, Prestons
Tuesday, 26 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	51.8	42.3	34.0
Leq (see note 3)	59.6	55.6	53.6

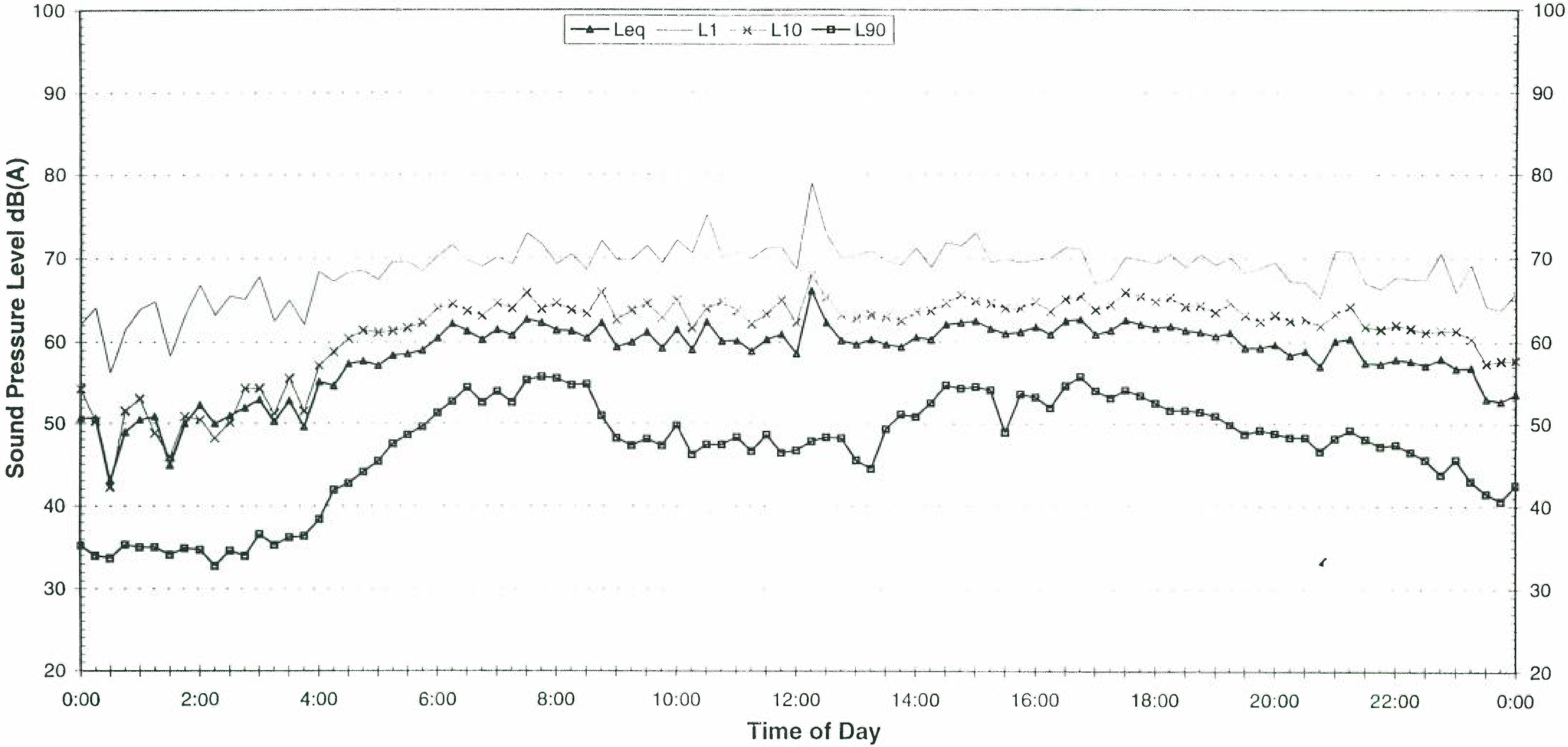
NOTES:
1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured 1m from facade; tabulated results free-field corrected*

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	60.7	56.1
Leq 1hr upper 10 percentile	65.8	61.4
Leq 1hr lower 10 percentile	56.5	49.1

EXISTING AMBIENT NOISE LEVELS

Location 2 - Bernera Road, Prestons

Wednesday, 27 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	46.6	47.2	39.5
Leq (see note 3)	58.9	57.3	56.2

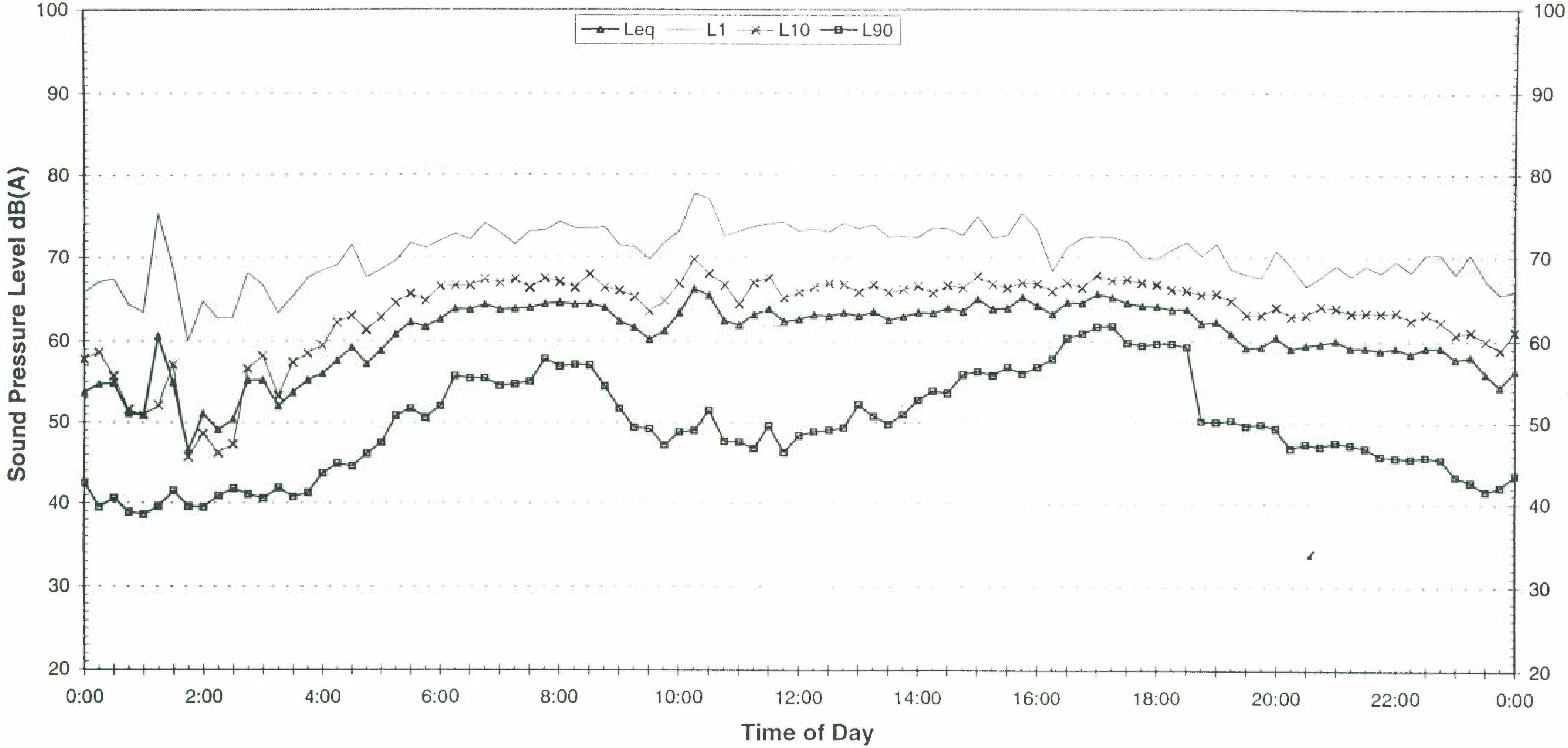
NOTES:
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	61.0	58.7
Leq 1hr upper 10 percentile	62.4	63.9
Leq 1hr lower 10 percentile	58.6	53.3

EXISTING AMBIENT NOISE LEVELS

Location 2 - Bernera Road, Prestons

Thursday, 28 June 2001



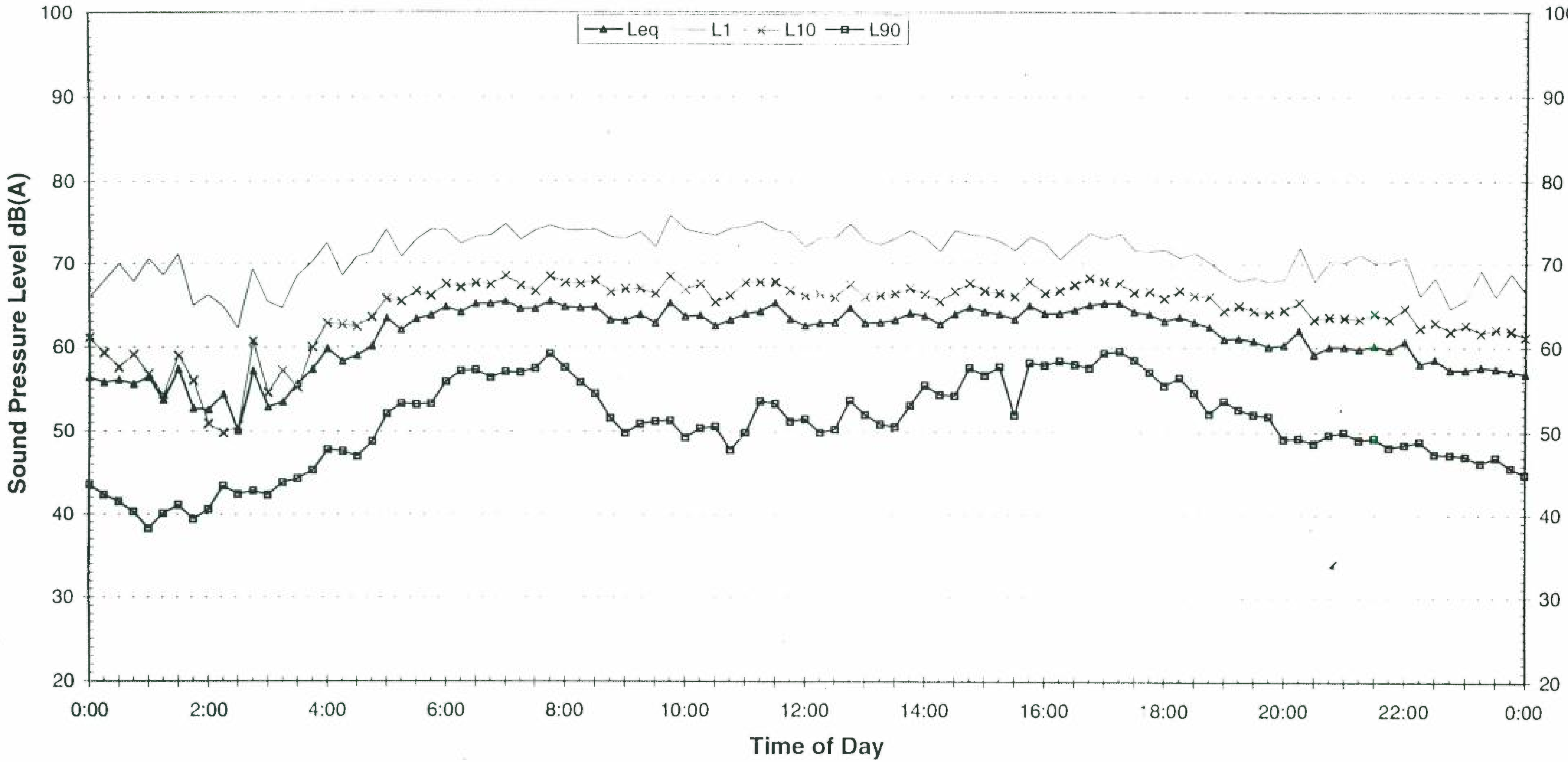
EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	47.7	45.9	40.3
Leq (see note 3)	61.3	58.3	57.6

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	63.1	60.1
Leq 1hr upper 10 percentile	64.5	65.0
Leq 1hr lower 10 percentile	59.4	54.4

EXISTING AMBIENT NOISE LEVELS
Location 2 - Bernera Road, Prestons
Friday, 29 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	49.9	48.5	39.9
Leq (see note 3)	61.5	58.6	56.2

NOTES:

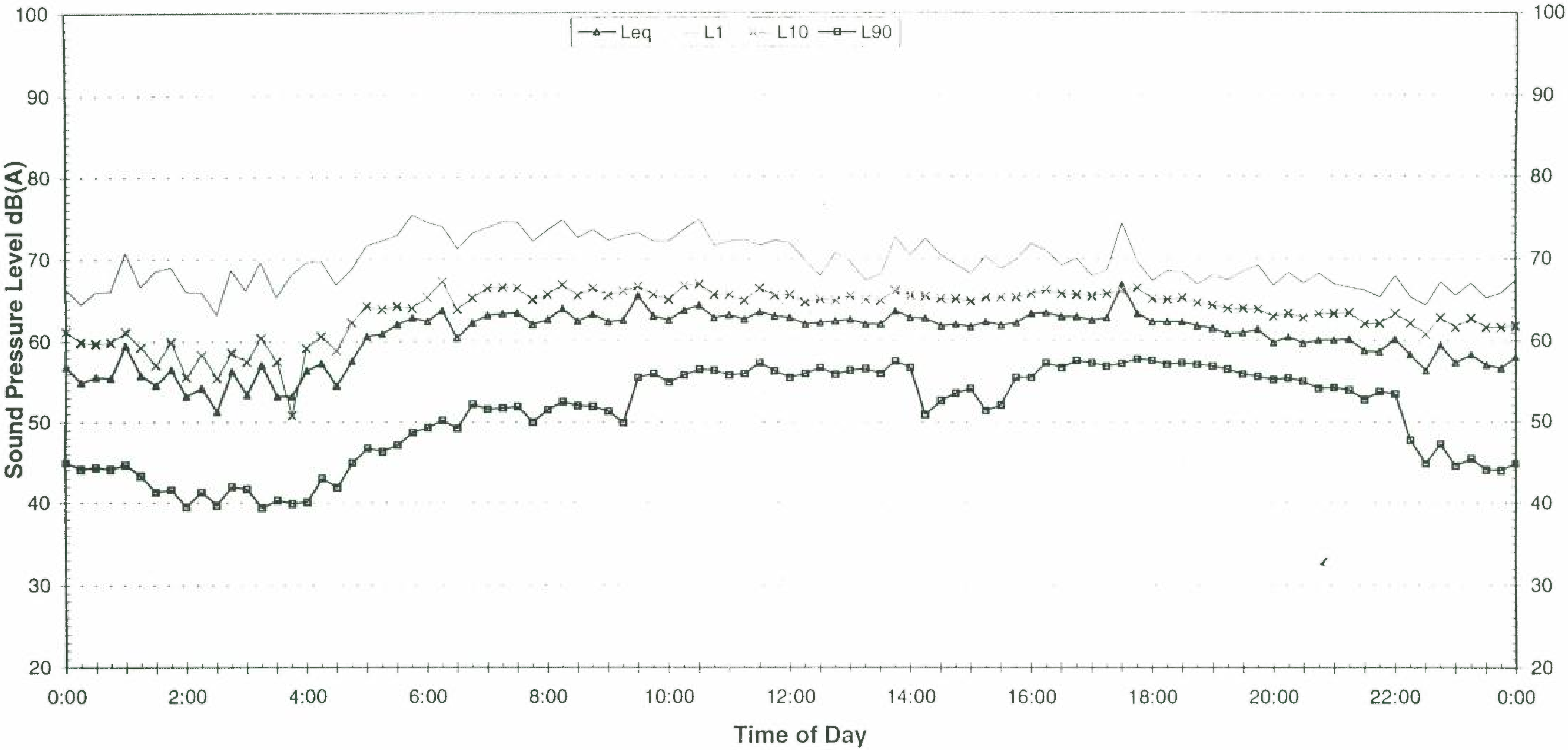
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade: tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	63.4	58.7
Leq 1hr upper 10 percentile	64.7	62.5
Leq 1hr lower 10 percentile	60.3	54.2

EXISTING AMBIENT NOISE LEVELS

Location 2 - Bernera Road, Prestons

Saturday, 30 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	51.4	53.4	39.5
Leq (see note 3)	60.5	58.2	53.8

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.

2. "Night" relates to period from 10pm on this graph to 7am on the following graph.

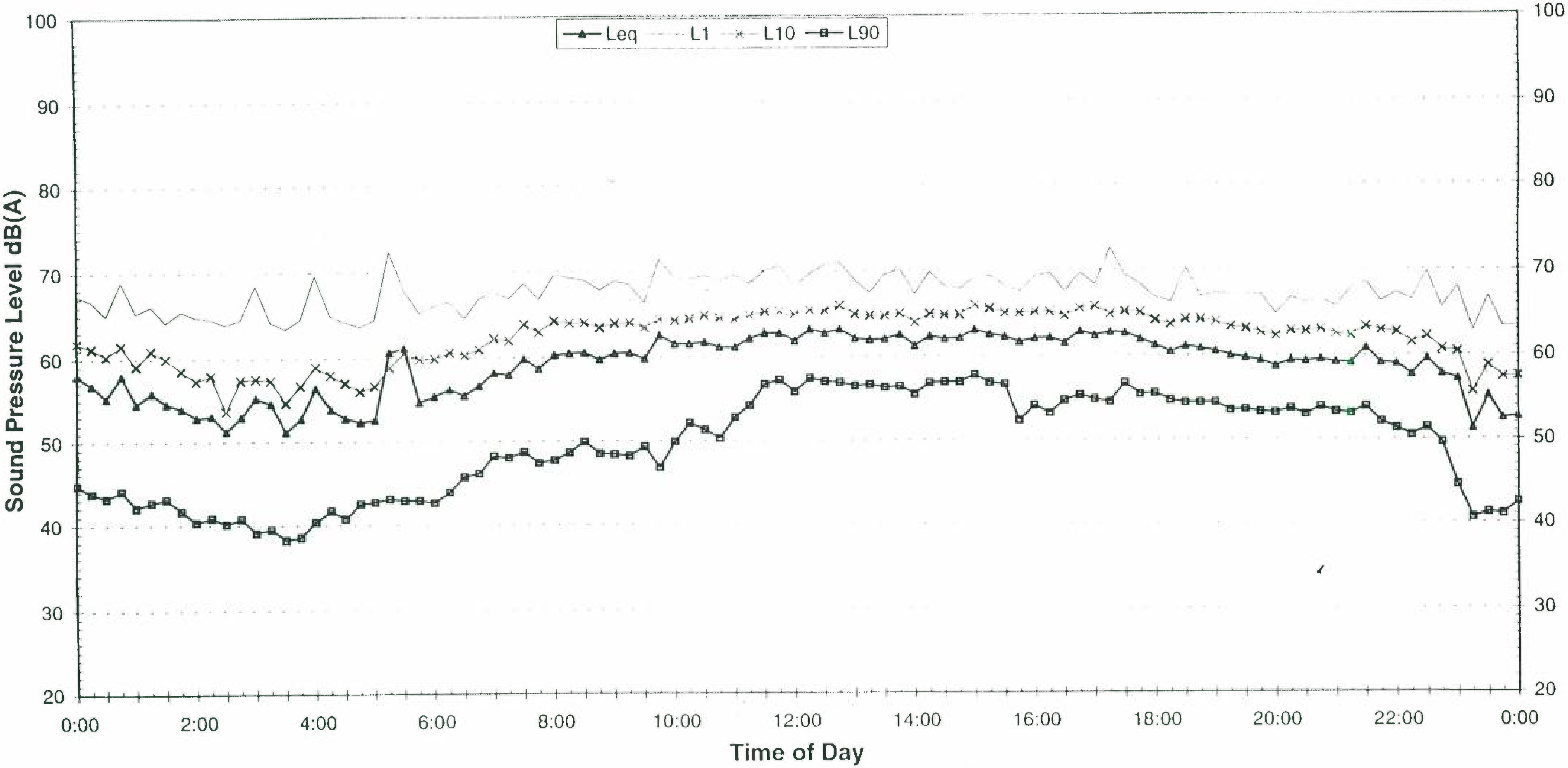
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	62.5	56.3
Leq 1hr upper 10 percentile	63.9	58.9
Leq 1hr lower 10 percentile	59.8	52.9

EXISTING AMBIENT NOISE LEVELS

Location 2 - Bernera Road, Prestons

Sunday, 1 July 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	48.2	52.1	39.3
Leq (see note 3)	59.2	57.3	56.4

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.

2. "Night" relates to period from 10pm on this graph to 7am on the following graph.

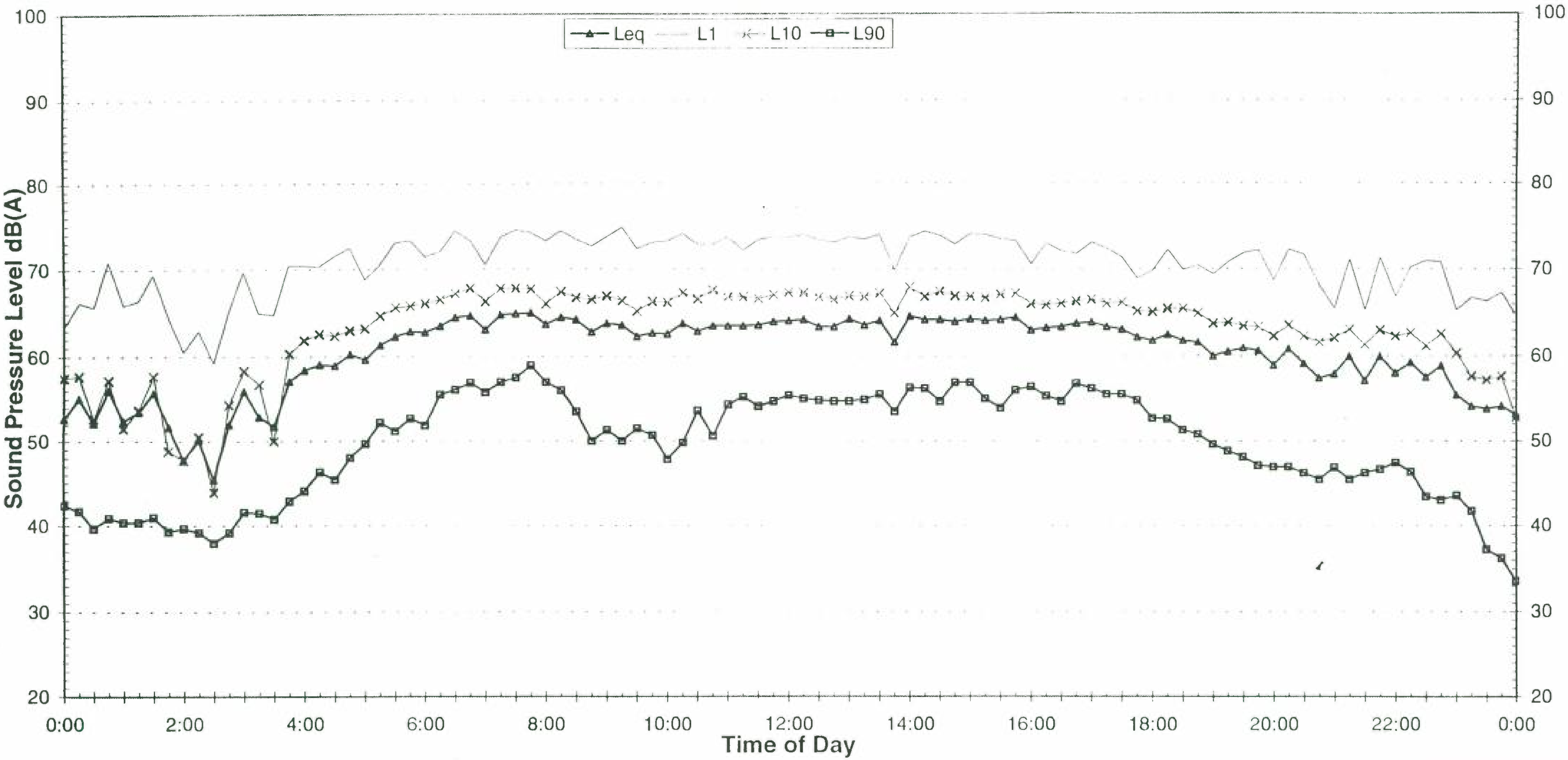
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	61.3	58.9
Leq 1hr upper 10 percentile	62.6	64.0
Leq 1hr lower 10 percentile	59.3	52.3

EXISTING AMBIENT NOISE LEVELS

Location 2 - Bernera Road, Prestons

Monday, 2 July 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	50.6	45.4	35.1
Leq (see note 3)	61.2	57.6	56.7

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.

2. "Night" relates to period from 10pm on this graph to 7am on the following graph.

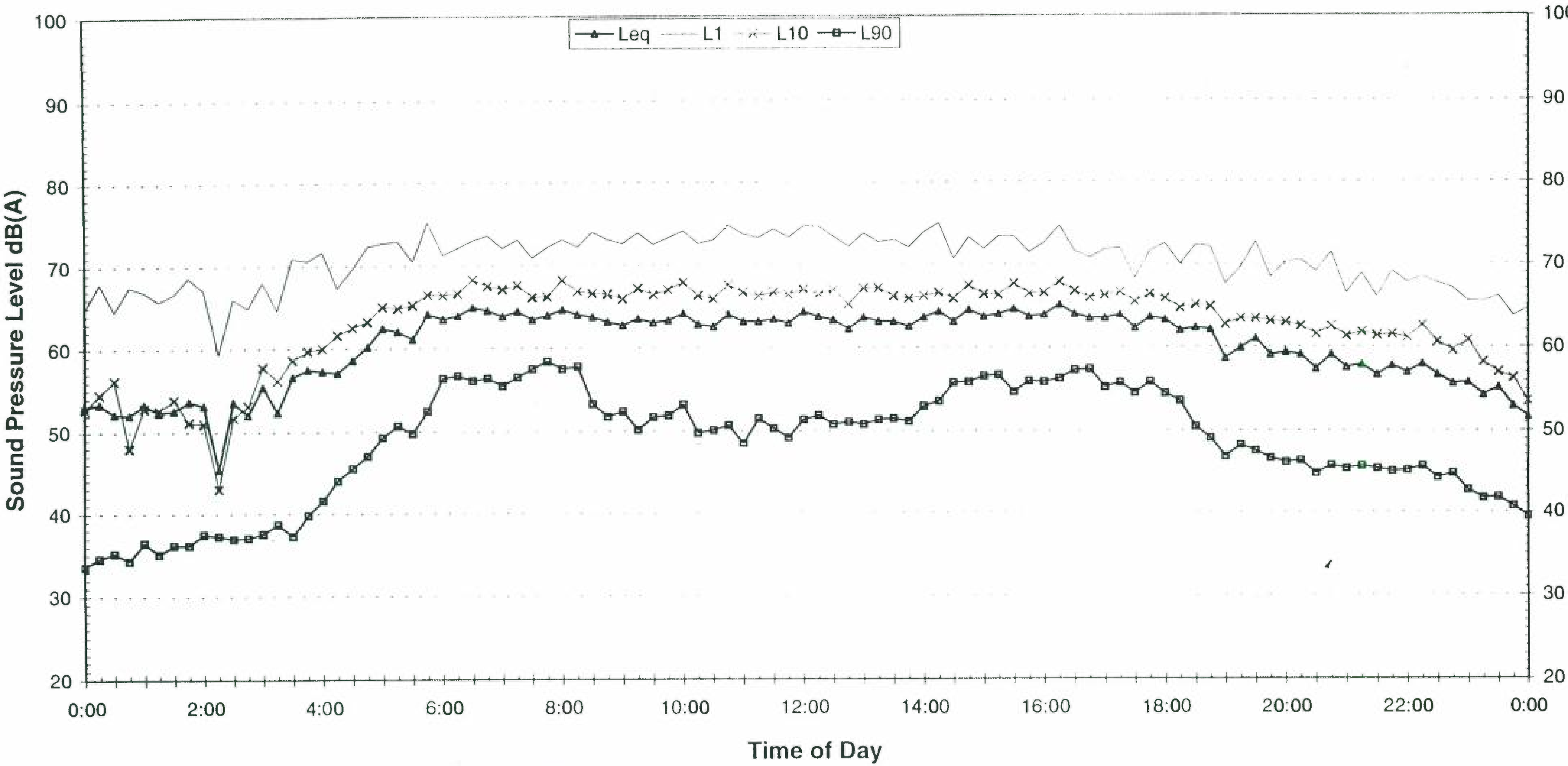
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	63.0	59.2
Leq 1hr upper 10 percentile	64.4	64.3
Leq 1hr lower 10 percentile	58.9	52.8

EXISTING AMBIENT NOISE LEVELS

Location 2 - Bernera Road, Prestons

Tuesday, 3 July 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	50.2	45.0	38.7
Leq (see note 3)	61.1	57.1	56.8

NOTES:

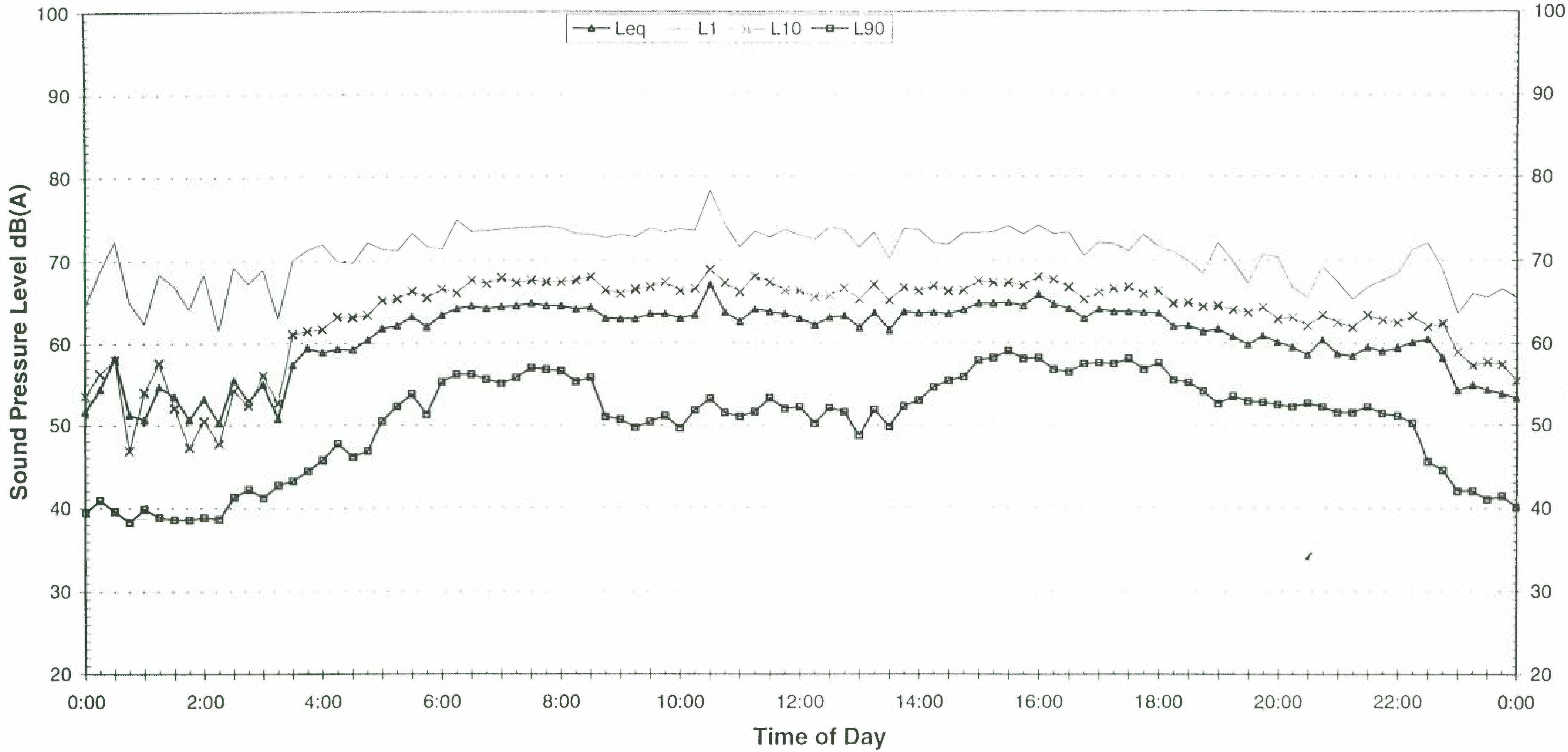
1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured 1m from facade; tabulated results free-field corrected*

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	62.8	59.3
Leq 1hr upper 10 percentile	64.1	64.3
Leq 1hr lower 10 percentile	57.9	53.3

EXISTING AMBIENT NOISE LEVELS

Location 2 - Bernera Road, Prestons

Wednesday, 4 July 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	50.2	51.4	39.6
Leq (see note 3)	61.4	57.8	57.2

NOTES:

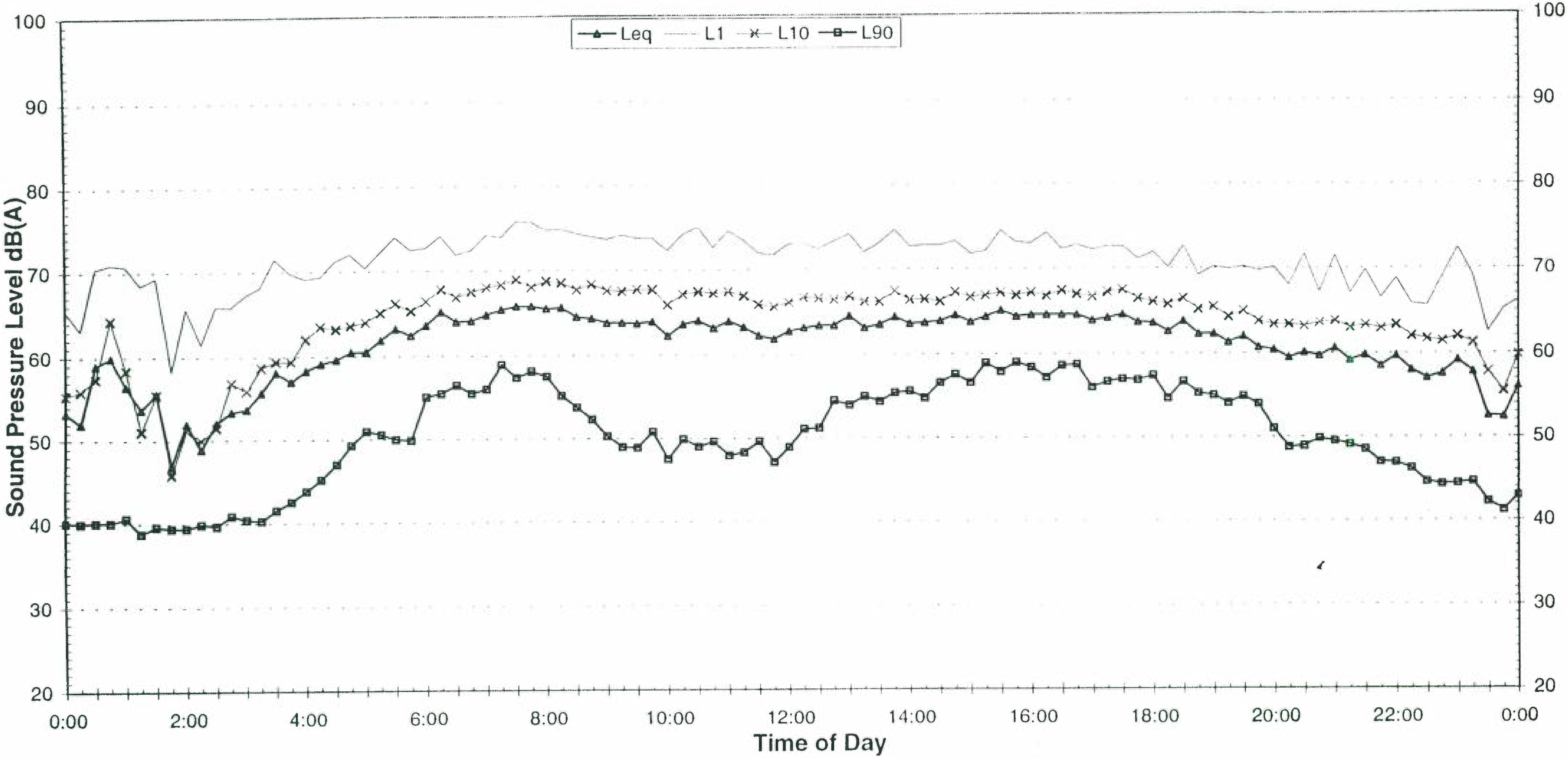
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	63.2	59.7
Leq 1hr upper 10 percentile	64.8	64.6
Leq 1hr lower 10 percentile	59.2	52.4

EXISTING AMBIENT NOISE LEVELS

Location 2 - Bernera Road, Prestons

Thursday, 5 July 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	48.9	47.0	41.2
Leq (see note 3)	61.6	58.5	54.4

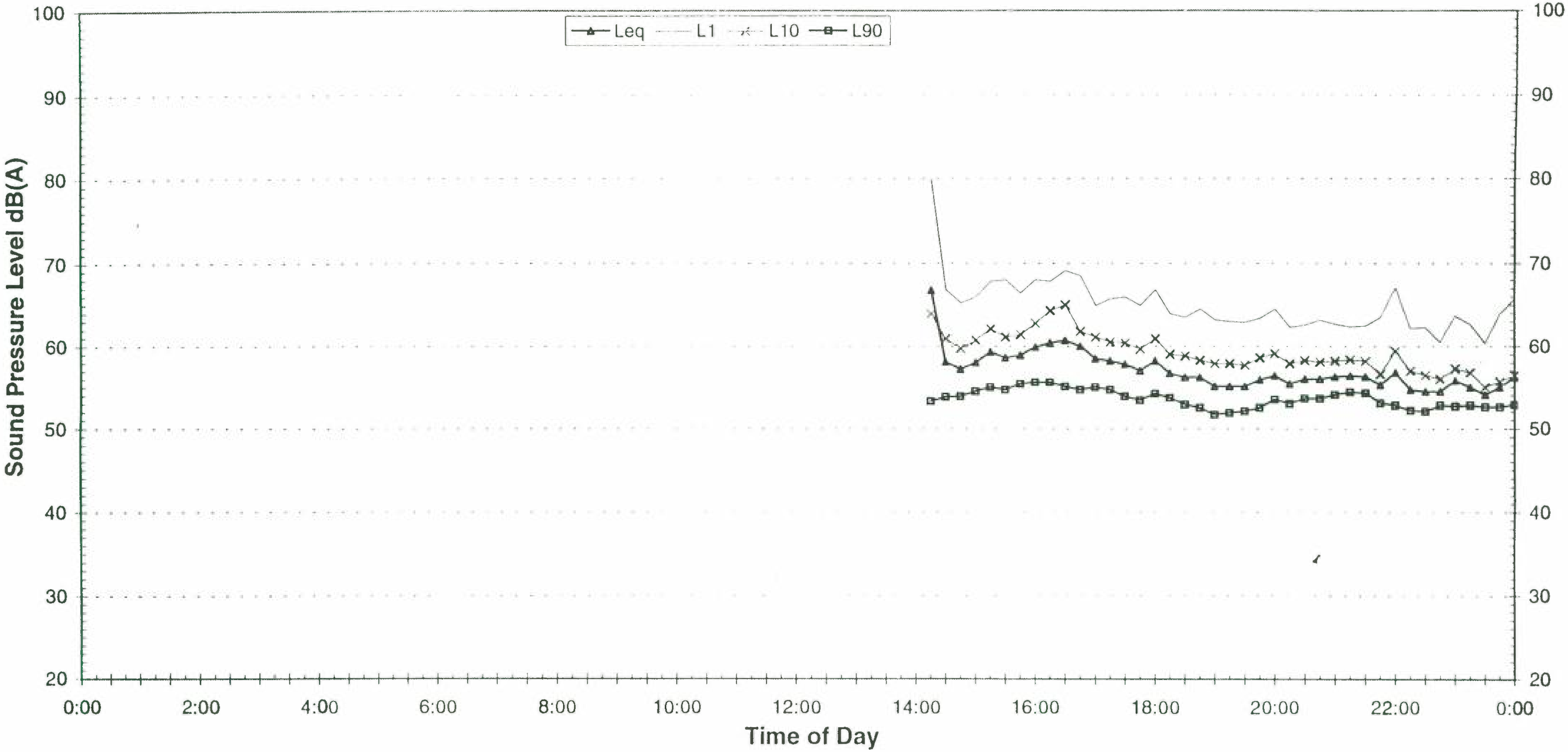
NOTES:
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	63.5	56.9
Leq 1hr upper 10 percentile	65.2	58.0
Leq 1hr lower 10 percentile	59.7	55.3

EXISTING AMBIENT NOISE LEVELS

Location 3 - New Tribes Bible College, Power Street, Glendenning

Tuesday, 12 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	53.4	51.9	51.9
Leq (see note 3)	57.6	53.5	53.1

NOTES:

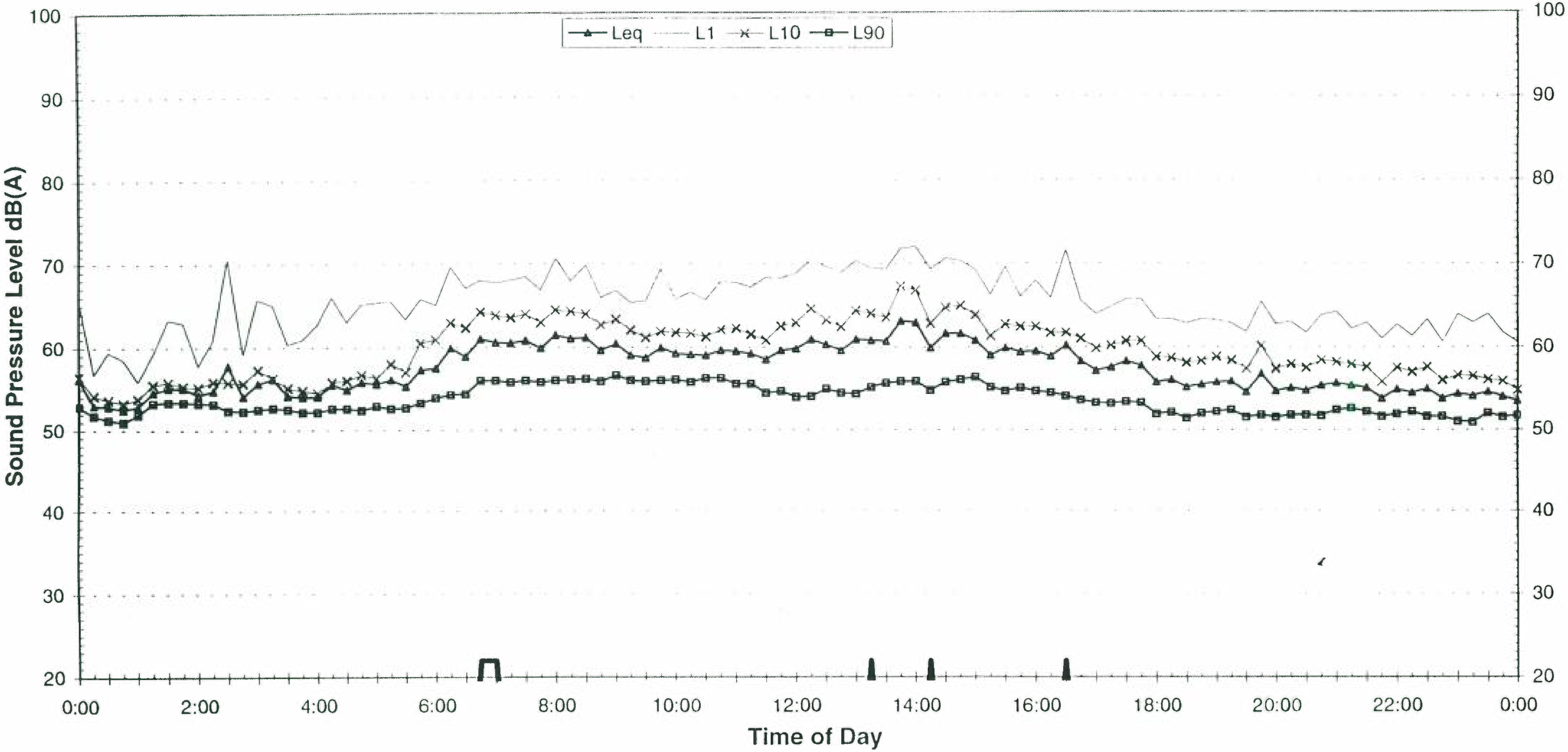
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	58.5	55.6
Leq 1hr upper 10 percentile	62.1	59.4
Leq 1hr lower 10 percentile	55.7	52.8

EXISTING AMBIENT NOISE LEVELS

Location 3 - New Tribes Bible College, Power Street, Glendenning

Wednesday, 13 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	53.4	51.5	51.1
Leq (see note 3)	57.5	52.9	53.3

NOTES:
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	59.1	55.8
Leq 1hr upper 10 percentile	61.9	60.6
Leq 1hr lower 10 percentile	55.1	52.7

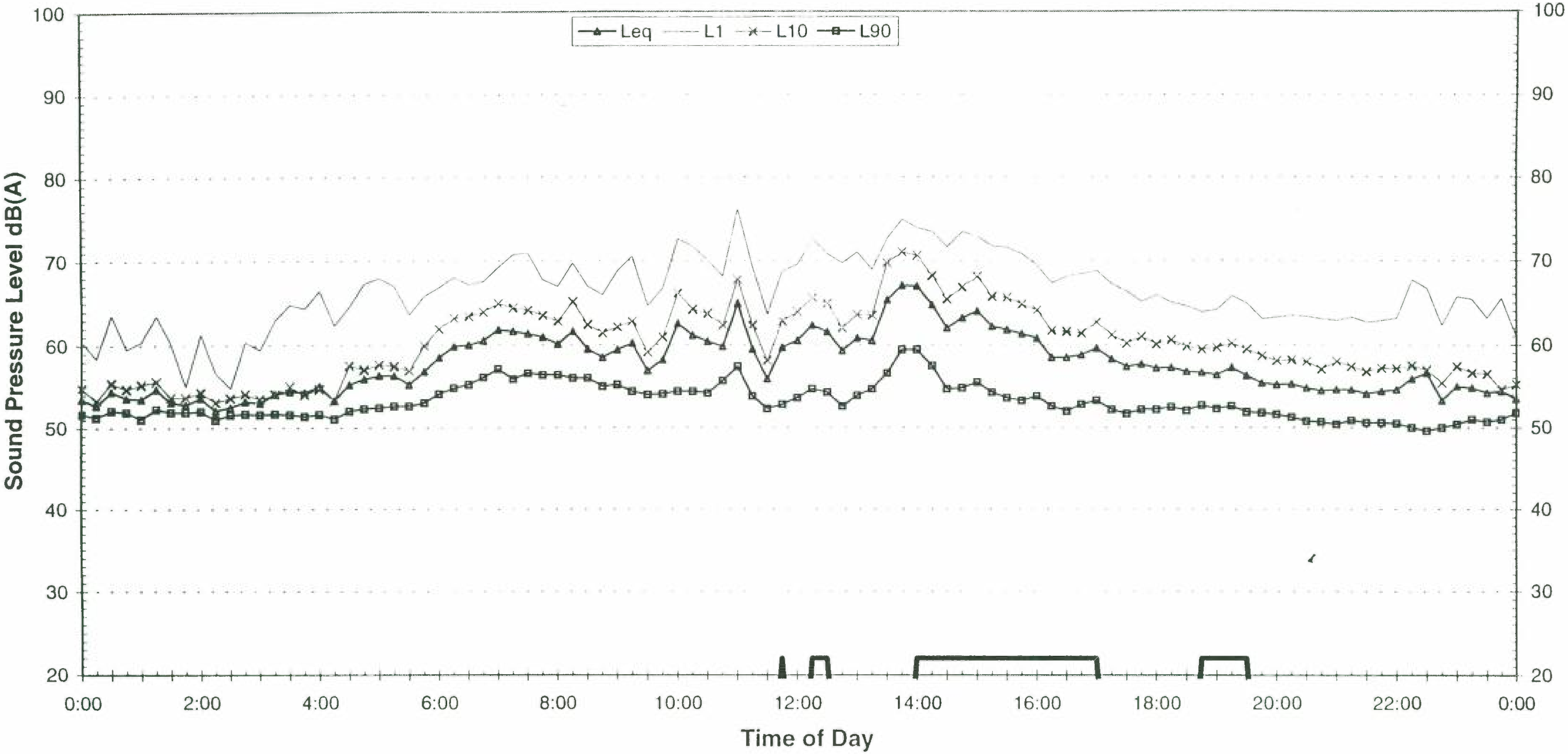
Rev 9 Data File 20.dat

T440-12S03 Power St (rev0)

EXISTING AMBIENT NOISE LEVELS

Location 3 - New Tribes Bible College, Power Street, Glendenning

Thursday, 14 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	52.2	50.5	50.1
Leq (see note 3)	58.6	52.7	53.6

NOTES:

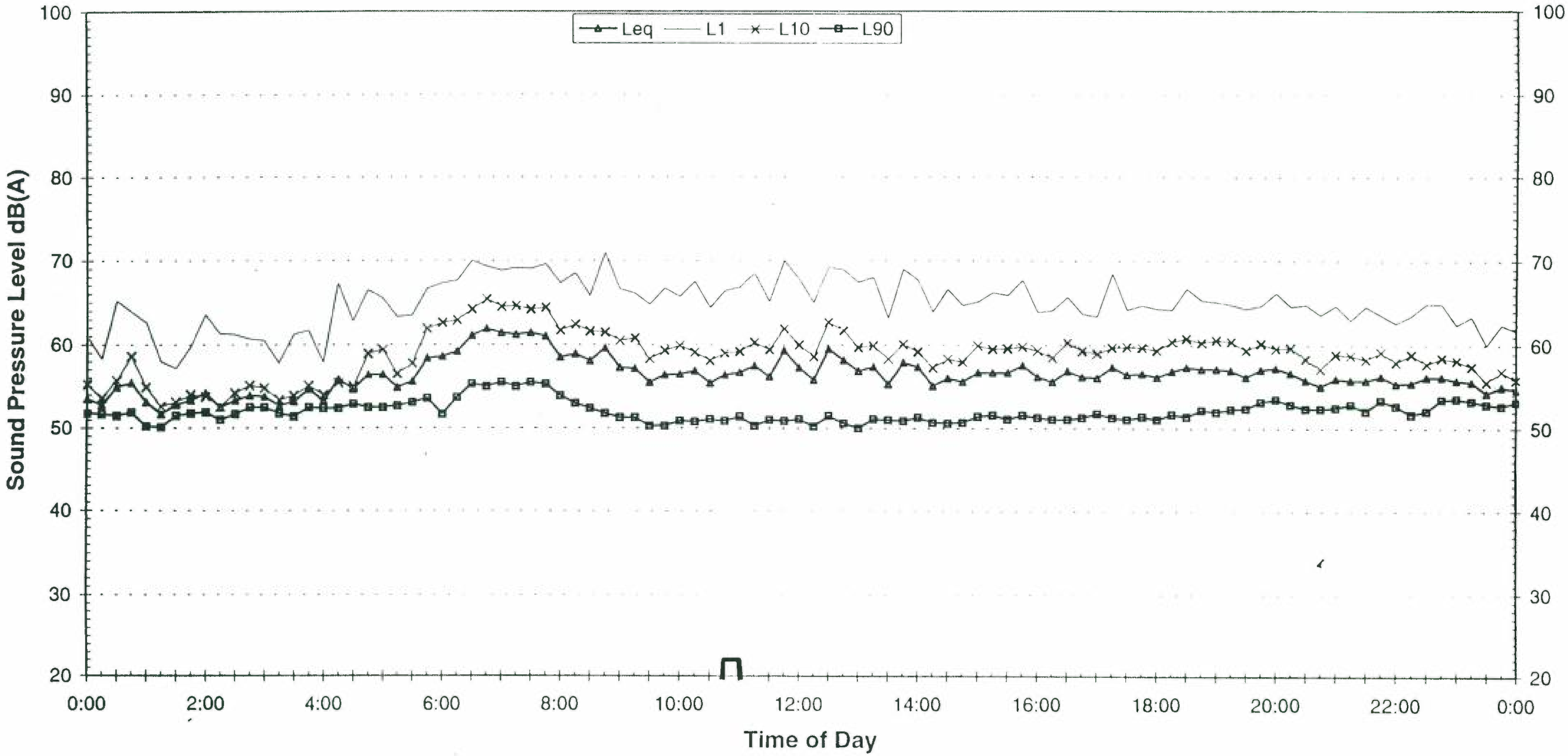
1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured 1m from facade; tabulated results free-field corrected*

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	60.0	56.1
Leq 1hr upper 10 percentile	64.6	61.0
Leq 1hr lower 10 percentile	54.5	53.1

EXISTING AMBIENT NOISE LEVELS

Location 3 - New Tribes Bible College, Power Street, Glendenning

Friday, 15 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	50.3	51.7	49.4
Leq (see note 3)	55.1	54.0	52.1

NOTES:

1. *Bars denote periods adversely affectec by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured 1m from facade; tabulated results free-field corrected*

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	57.3	54.6
Leq 1hr upper 10 percentile	59.7	55.9
Leq 1hr lower 10 percentile	55.9	51.7

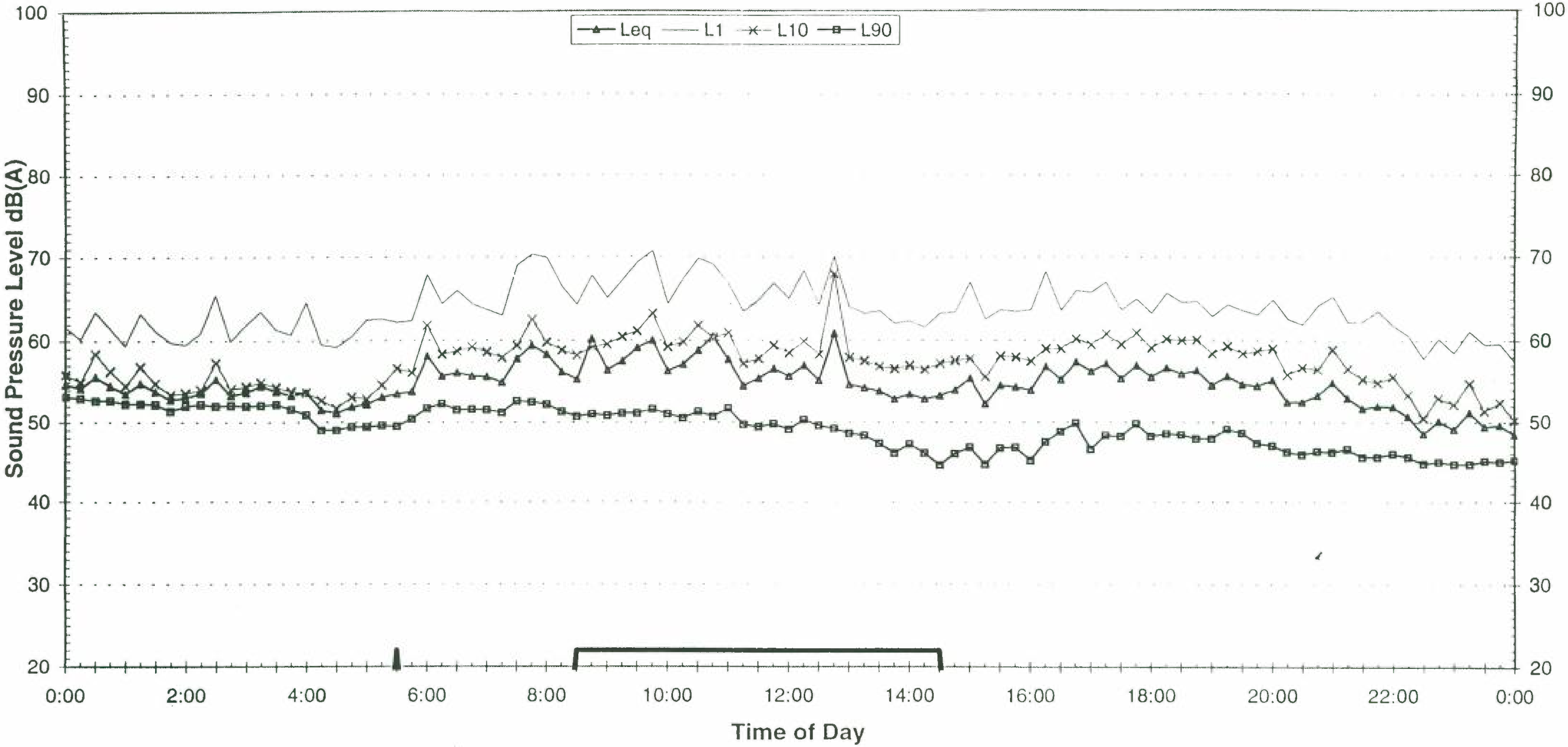
Rev 9 Data File 20.dat

T440-12S03 Power St (rev0)

EXISTING AMBIENT NOISE LEVEL

Location 3 - New Tribes Bible College, Power Street, Glendenning

Saturday, 16 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	45.2	45.6	43.3
Leq (see note 3)	53.7	51.9	46.1

NOTES:

1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured 1m from facade; tabulated results free-field corrected*

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	55.5	48.6
Leq 1hr upper 10 percentile	57.9	50.0
Leq 1hr lower 10 percentile	52.2	46.4

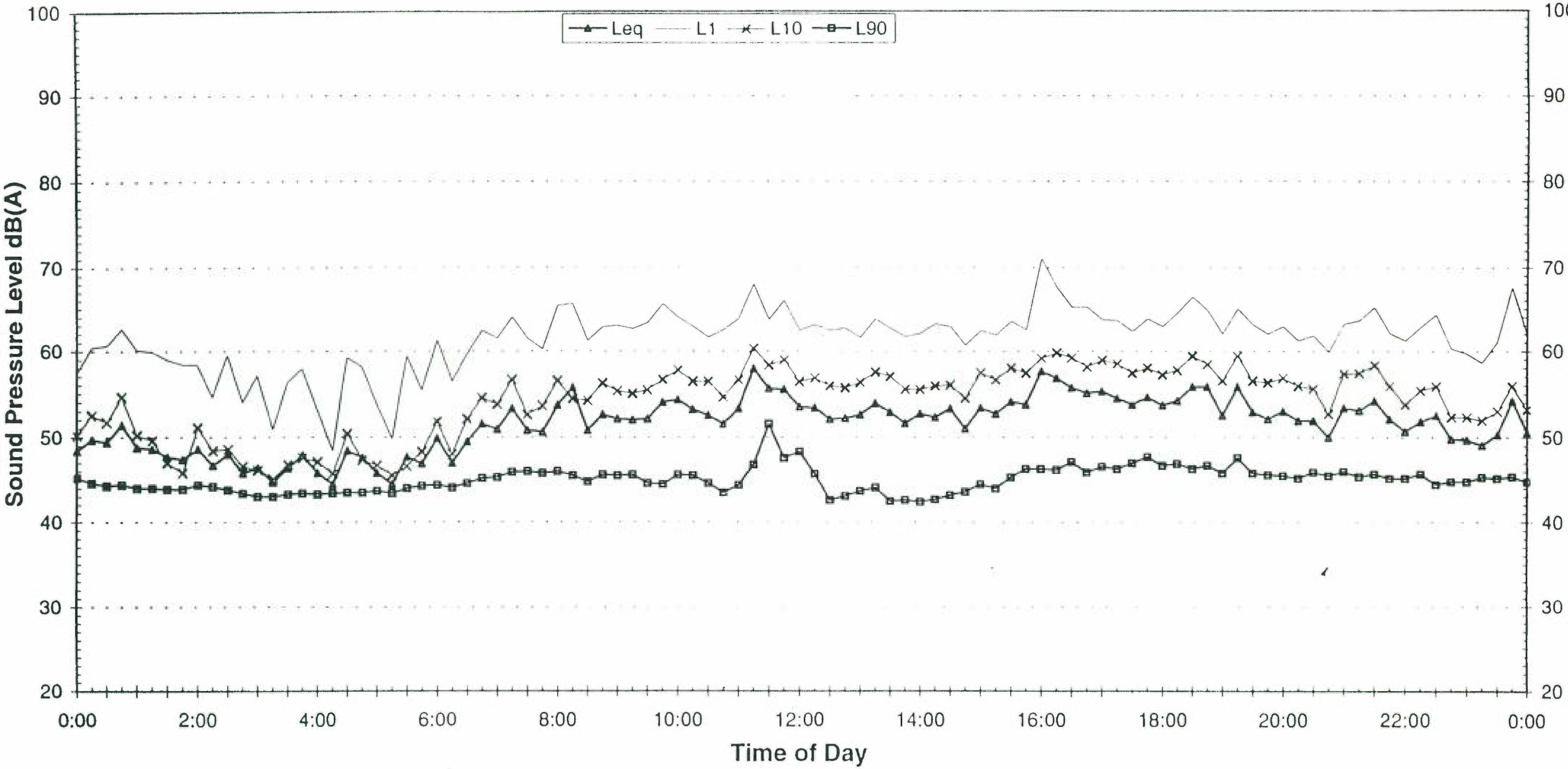
Rev 9 Data File 20.dat

T440-12S03 Power St (rev0)

EXISTING AMBIENT NOISE LEVELS

Location 3 - New Tribes Bible College, Power Street, Glendenning

Sunday, 17 June 2001

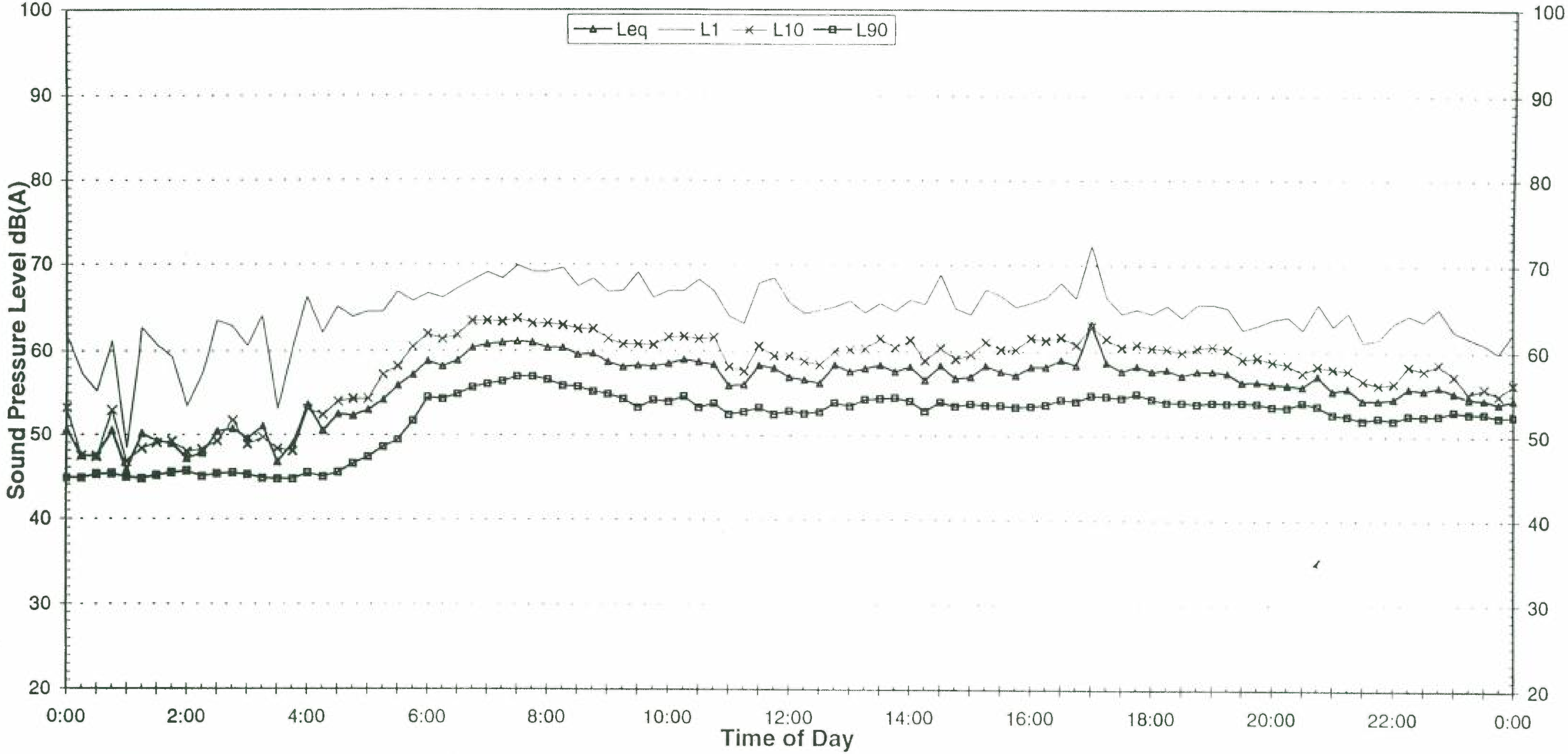


EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	42.7	45.2	44.7
Leq (see note 3)	51.4	50.9	51.4

NOTES:
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on .his graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	53.7	53.9
Leq 1hr upper 10 percentile	55.8	59.7
Leq 1hr lower 10 percentile	52.1	48.1

EXISTING AMBIENT NOISE LEVELS
Location 3 - New Tribes Bible College, Power Street, Glendenning
Monday, 18 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	52.8	51.9	51.1
Leq (see note 3)	56.1	53.9	53.1

NOTES:
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	58.2	55.6
Leq 1hr upper 10 percentile	60.6	60.0
Leq 1hr lower 10 percentile	55.5	52.8

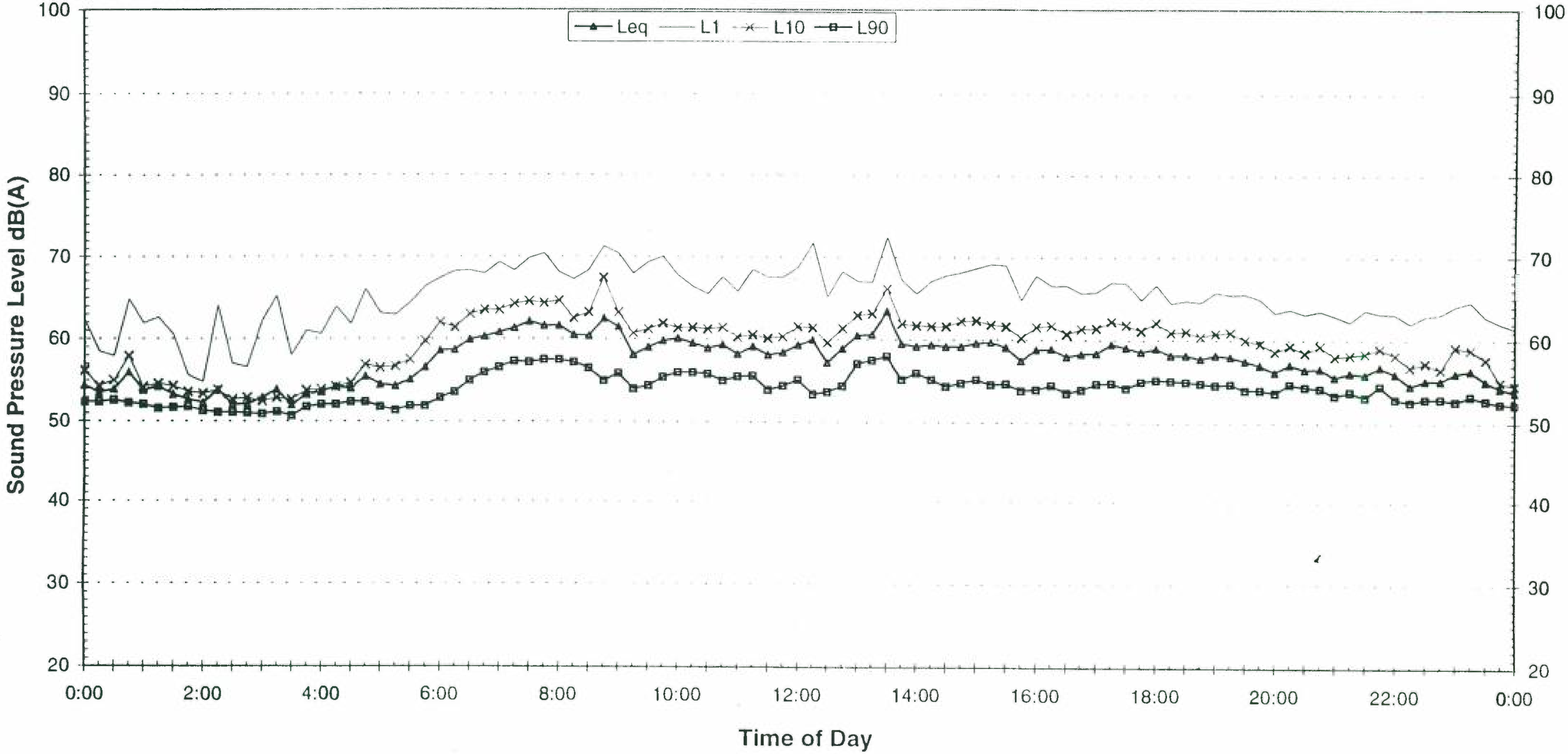
Rev 9 Data File 20.dat

T440-12S03 Power St (rev0)

EXISTING AMBIENT NOISE LEVELS

Location 3 - New Tribes Bible College, Power Street, Glendenning

Tuesday, 19 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	53.9	53.2	52.0
Leq (see note 3)	57.3	54.6	53.8

NOTES:
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	59.2	56.3
Leq 1hr upper 10 percentile	61.5	61.0
Leq 1hr lower 10 percentile	56.4	53.6

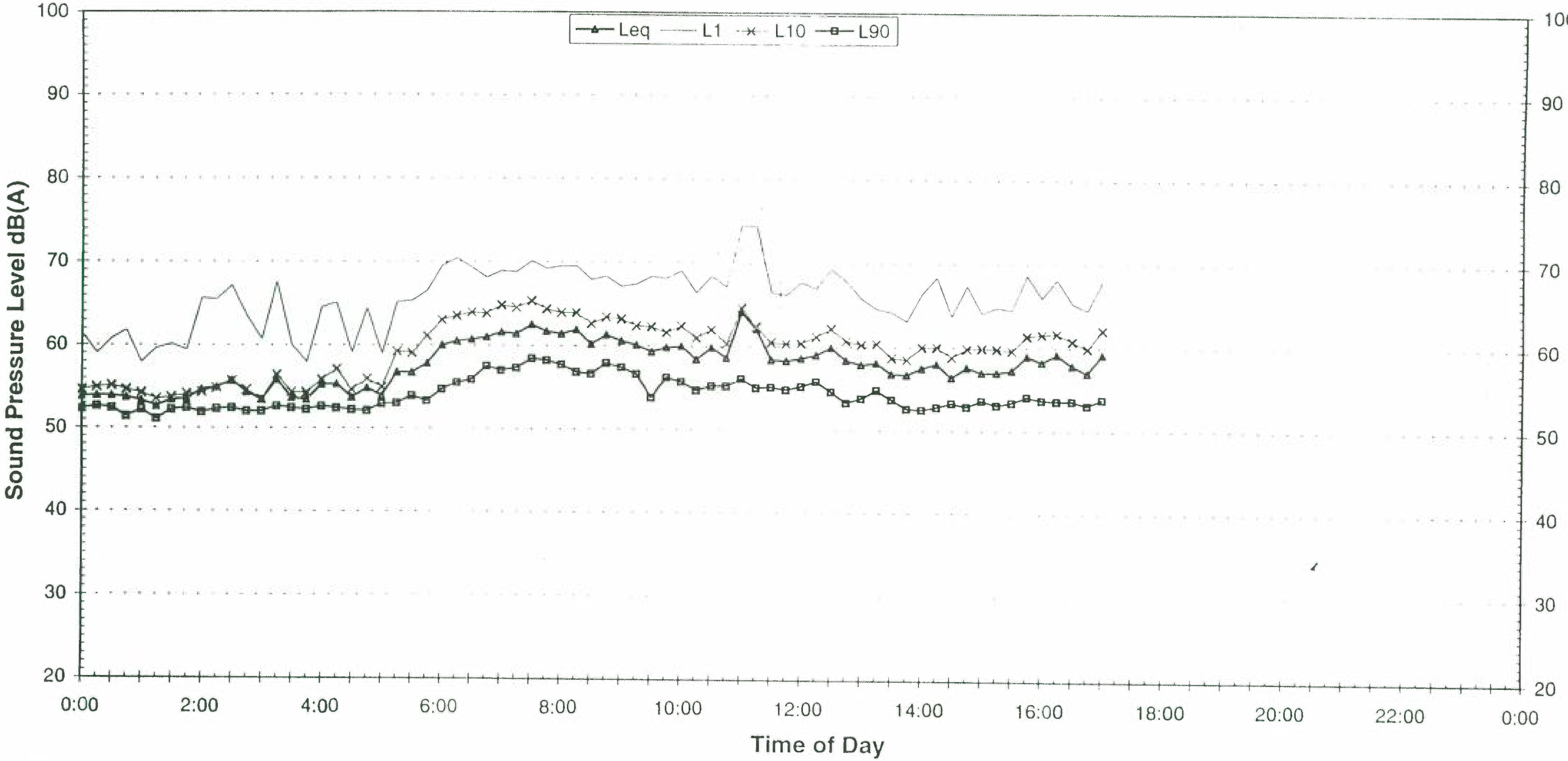
Rev 9 Data File 20.dat

T440-12S03 Power St (rev0)

EXISTING AMBIENT NOISE LEVEL

Location 3 - New Tribes Bible College, Power Street, Glendenning

Wednesday, 20 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	53.0	-	-
Leq (see note 3)	57.1	-	-

NOTES:
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade, tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	59.6	-
Leq 1hr upper 10 percentile	61.8	-
Leq 1hr lower 10 percentile	57.3	-

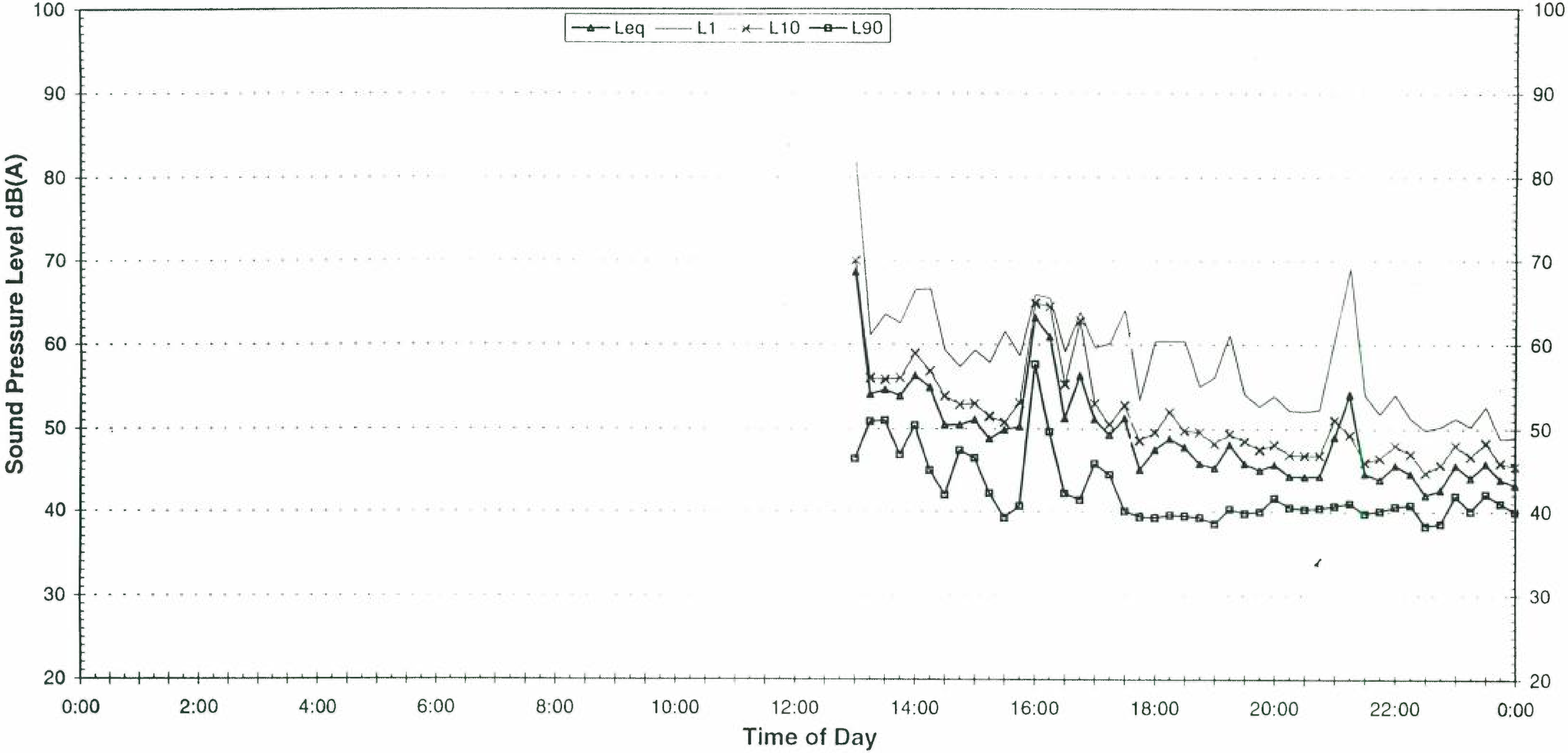
Rev 9   Data File   20.dat

T440-12S03 Power St (rev0)

EXISTING AMBIENT NOISE LEVELS

Location 2 - 57 Greenhill Drive, Glenmore

Friday, 15 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	40.1	39.3	33.0
Leq	58.2	47.4	42.5

NOTES:
1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured in free-field; tabulated results facade corrected*

EPA Traffic Noise Policy (1m from facade)		
(see note 3) Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	58.5	45.0
Leq 1hr upper 10 percentile	71.1	47.9
Leq 1hr lower 10 percentile	48.5	39.1

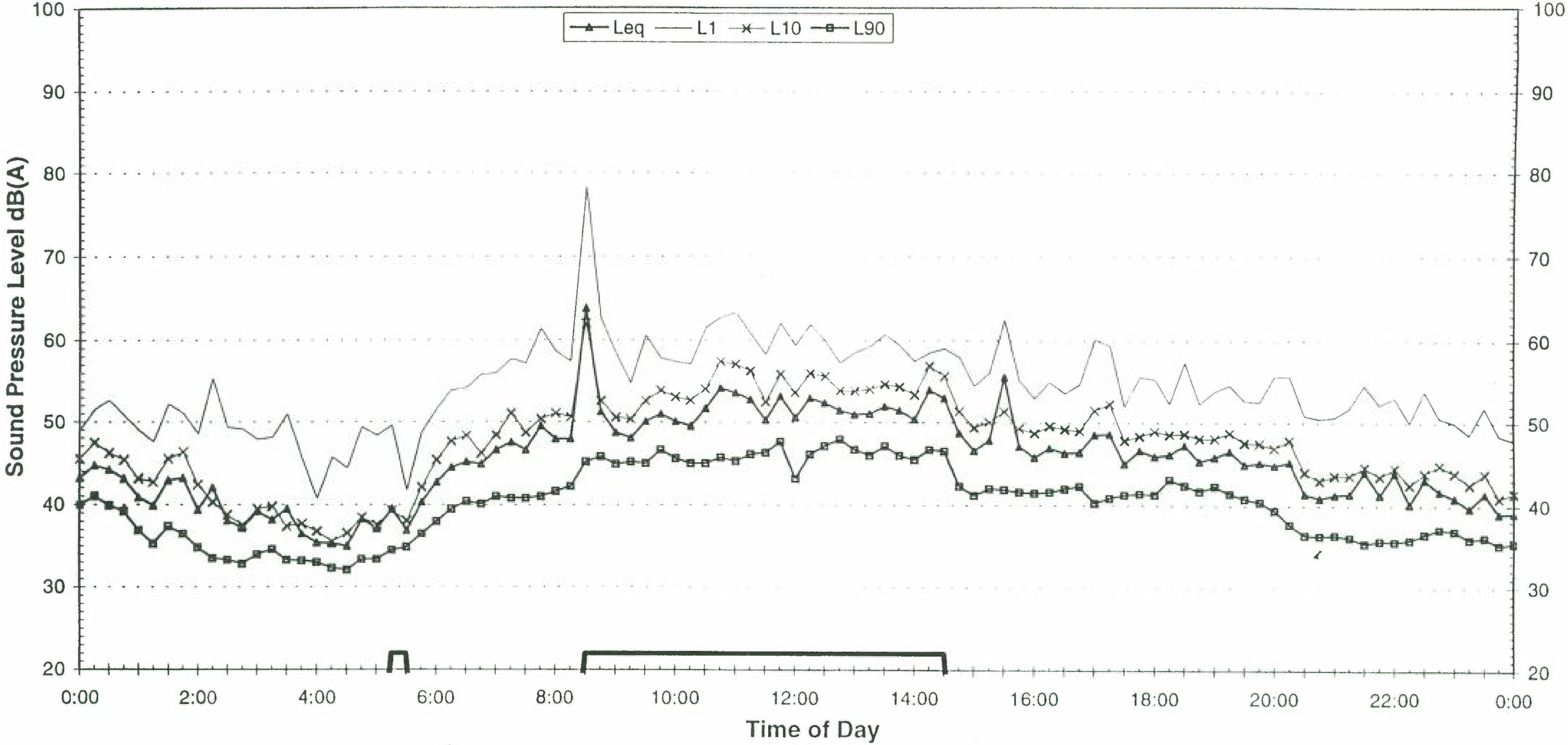
Rev 9 Data File WSO-092.dat

TA440-12S02 (rev 0)

EXIS[illegible]G AMBIENT NOISE LEVEL

Location 2 - 57 Greenhill Drive, Glenmore

Saturday, 16 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	40.8	35.6	31.3
Leq	48.5	44.5	38.6

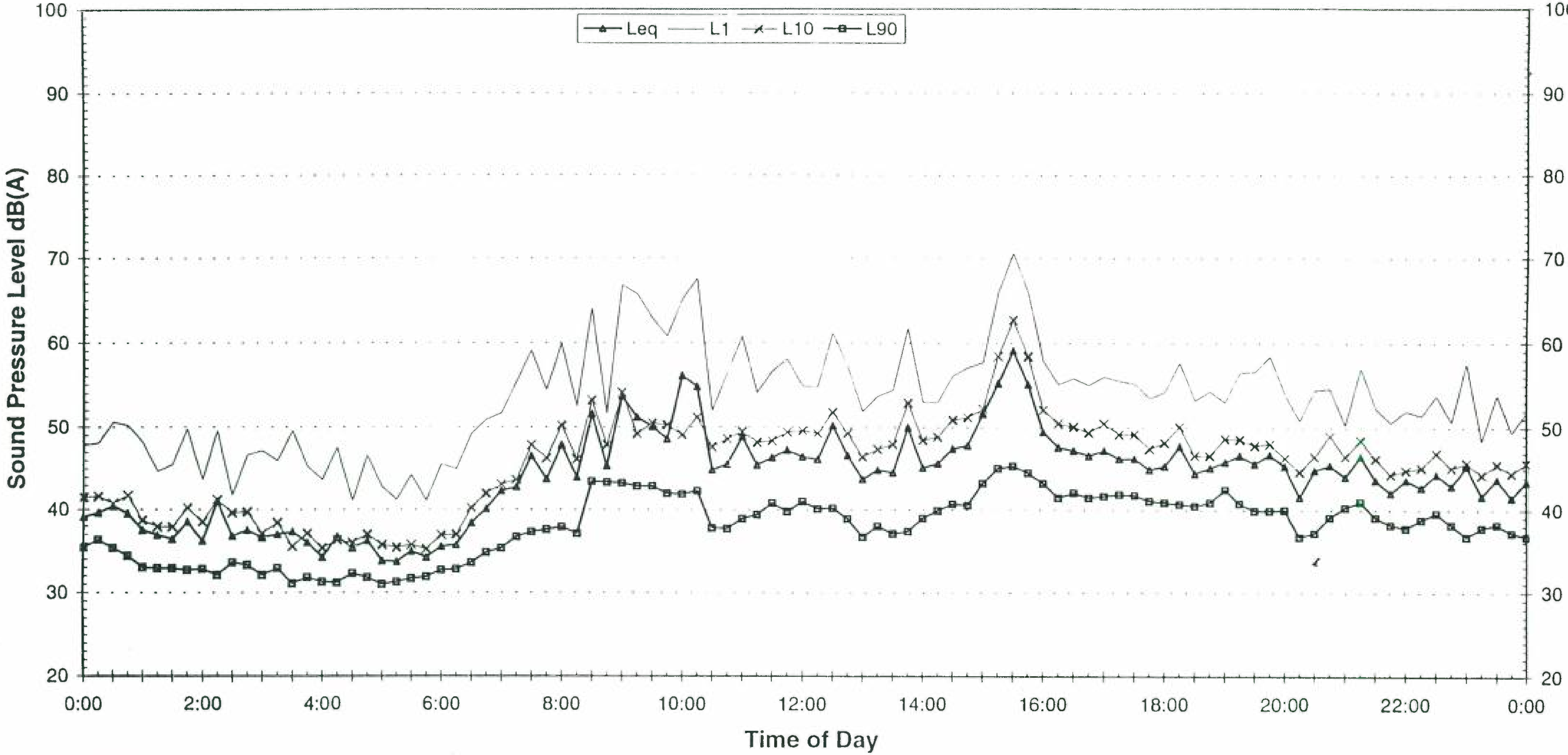
NOTES:
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured in free-field; tabulated results facade corrected

EPA Traffic Noise Policy (1m from facade) (see note 3)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	49.6	41.1
Leq 1hr upper 10 percentile	53.6	44.1
Leq 1hr lower 10 percentile	45.1	37.1

Rev 9 Data File WSO-092.dat

TA440-12S02 (rev 0)

EXISTING AMBIENT NOISE LEVELS
Location 2 - 57 Greenhill Drive, Glenmore
Sunday, 17 June 2001

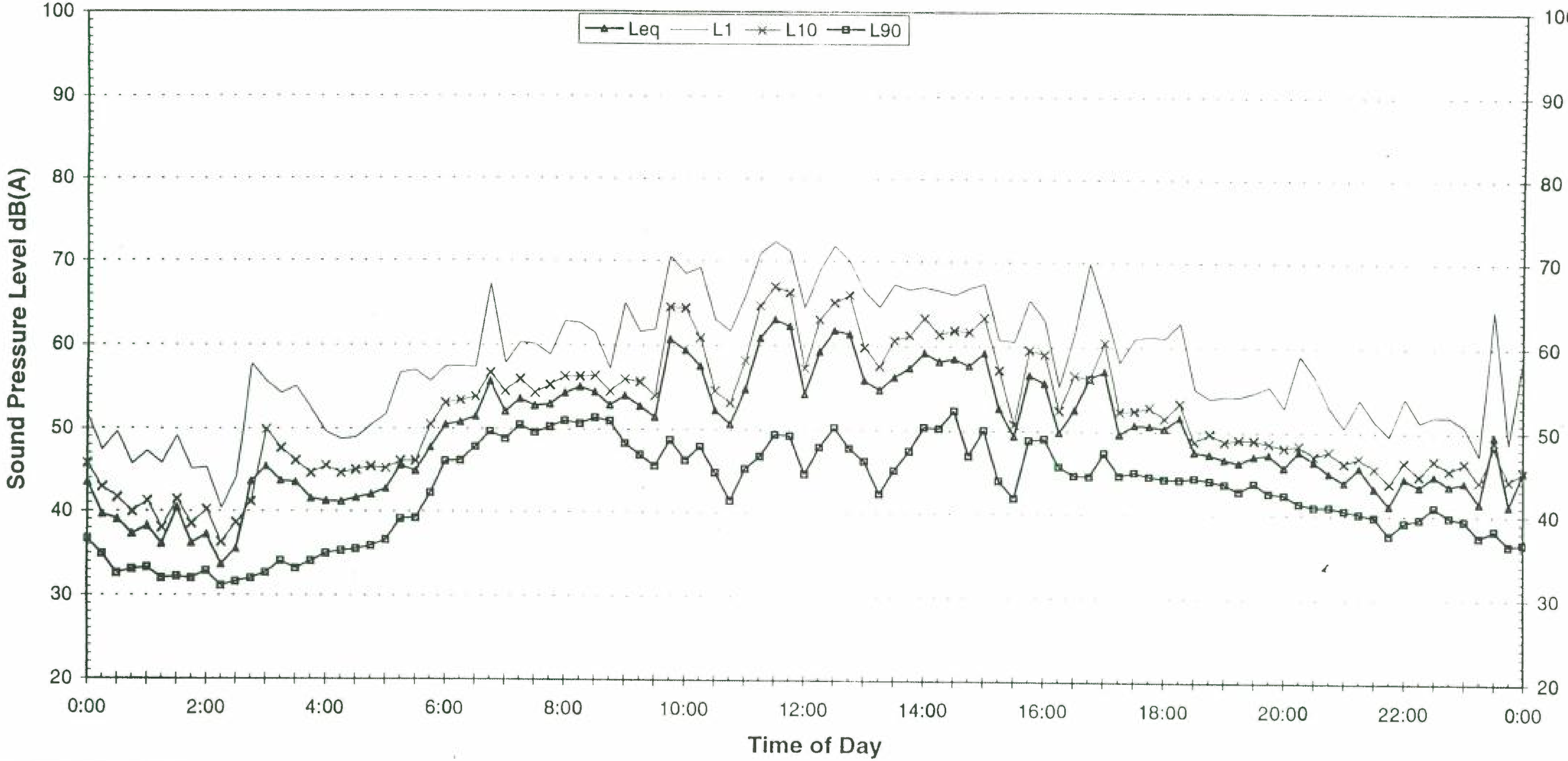


EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	37.3	37.2	32.0
Leq	50.2	45.3	46.1

NOTES:
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured in free-field; tabulated results facade corrected

EPA Traffic Noise Policy (1m from facade)		
(see note 3) Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	51.8	48.6
Leq 1hr upper 10 percentile	57.0	55.4
Leq 1hr lower 10 percentile	46.8	40.4

EXISTING AMBIENT NOISE LEVEL
Location 2 - 57 Greenhill Drive, Glenmore
Monday, 18 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	**44.3**	39.2	32.0
Leq	57.1	46.7	45.9

NOTES:

1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured in free-field; tabulated results facade corrected*

EPA Traffic Noise Policy (1m from facade) (see note 3)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	58.4	48.4
Leq 1hr upper 10 percentile	61.3	54.9
Leq 1hr lower 10 percentile	47.6	39.1

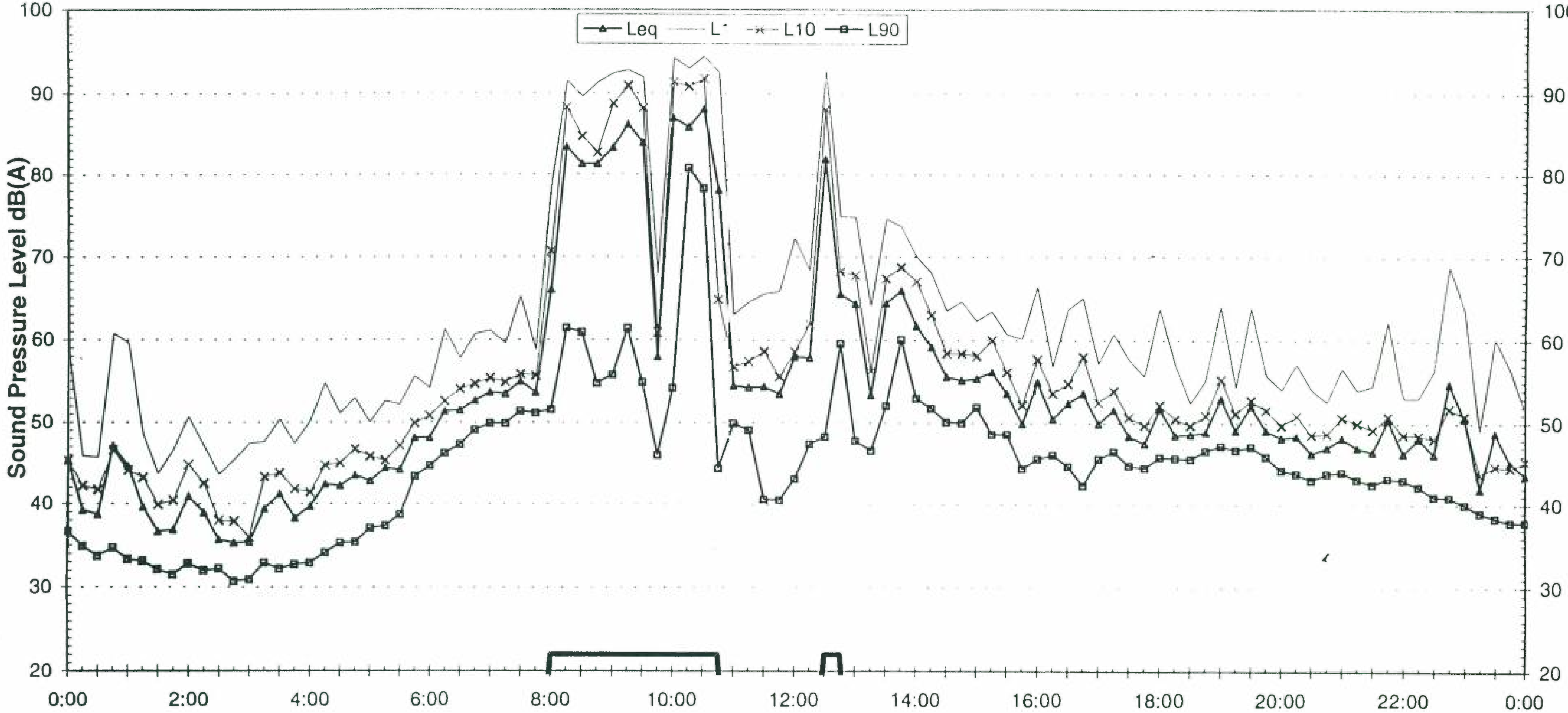
Rev 9 Data File WSO-092.dat

TA440-12S02 (rev 0)

EXISTING AMBIENT NOISE LEVELS

Location 2 - 57 Greenhill Drive, Glenmore

Tuesday, 19 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	42.7	43.0	34.2
Leq	57.8	49.1	47.6

NOTES:

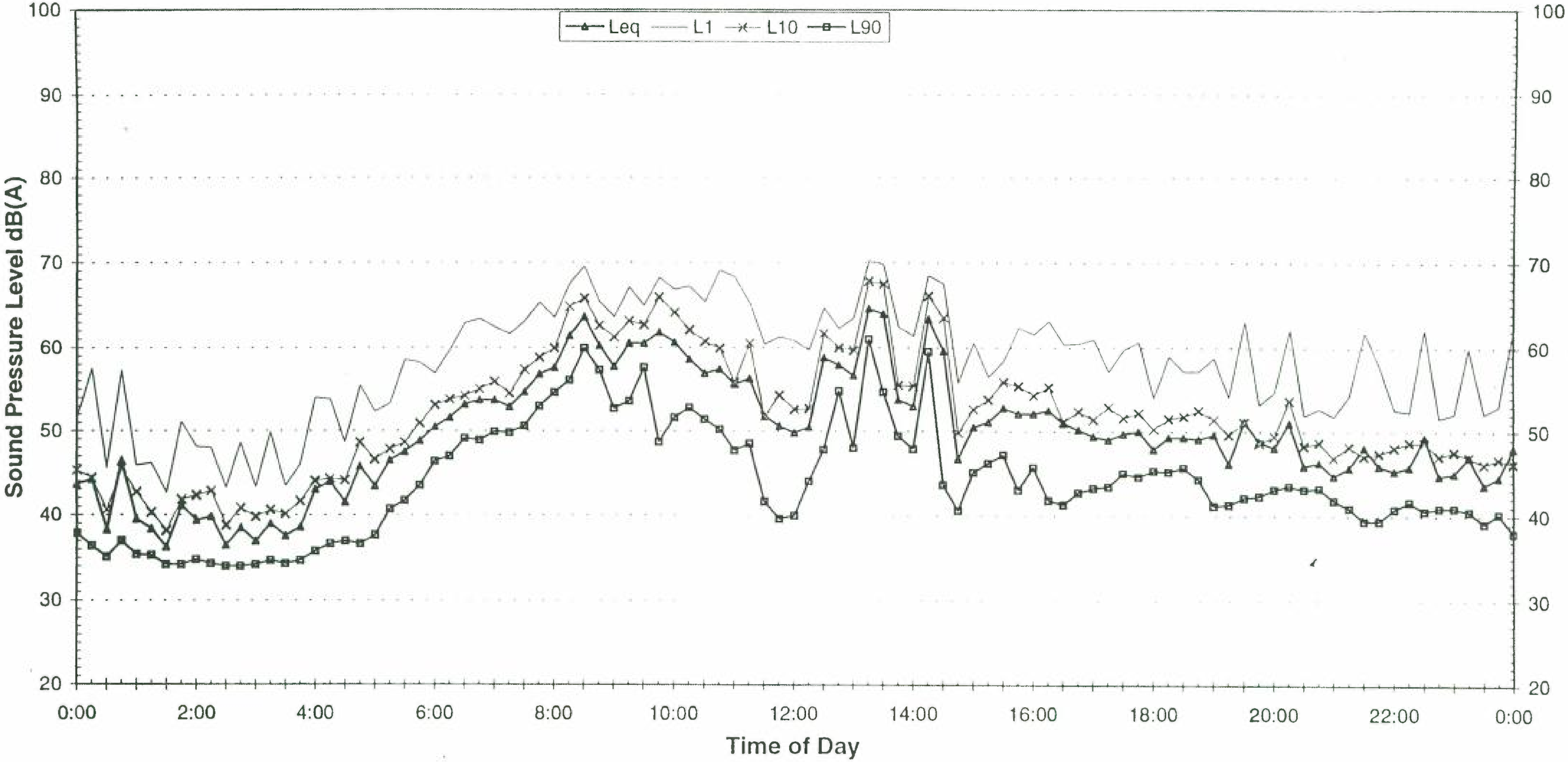
1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured in free-field; tabulated results facade corrected*

EPA Traffic Noise Policy (1m from facade) (see note 3)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	58.7	50.1
Leq 1hr upper 10 percentile	65.4	55.6
Leq 1hr lower 10 percentile	50.2	40.6

Rev 9 Data File WSO-092.dat

TA440-12S02 (rev 0)

EXIS[illegible]G AMBIENT NOISE LEVEL
Location 2 - 57 Greenhill Drive, Glenmore
Wednesday, 20 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	41.6	39.4	34.4
Leq	57.9	48.2	46.4

NOTES:

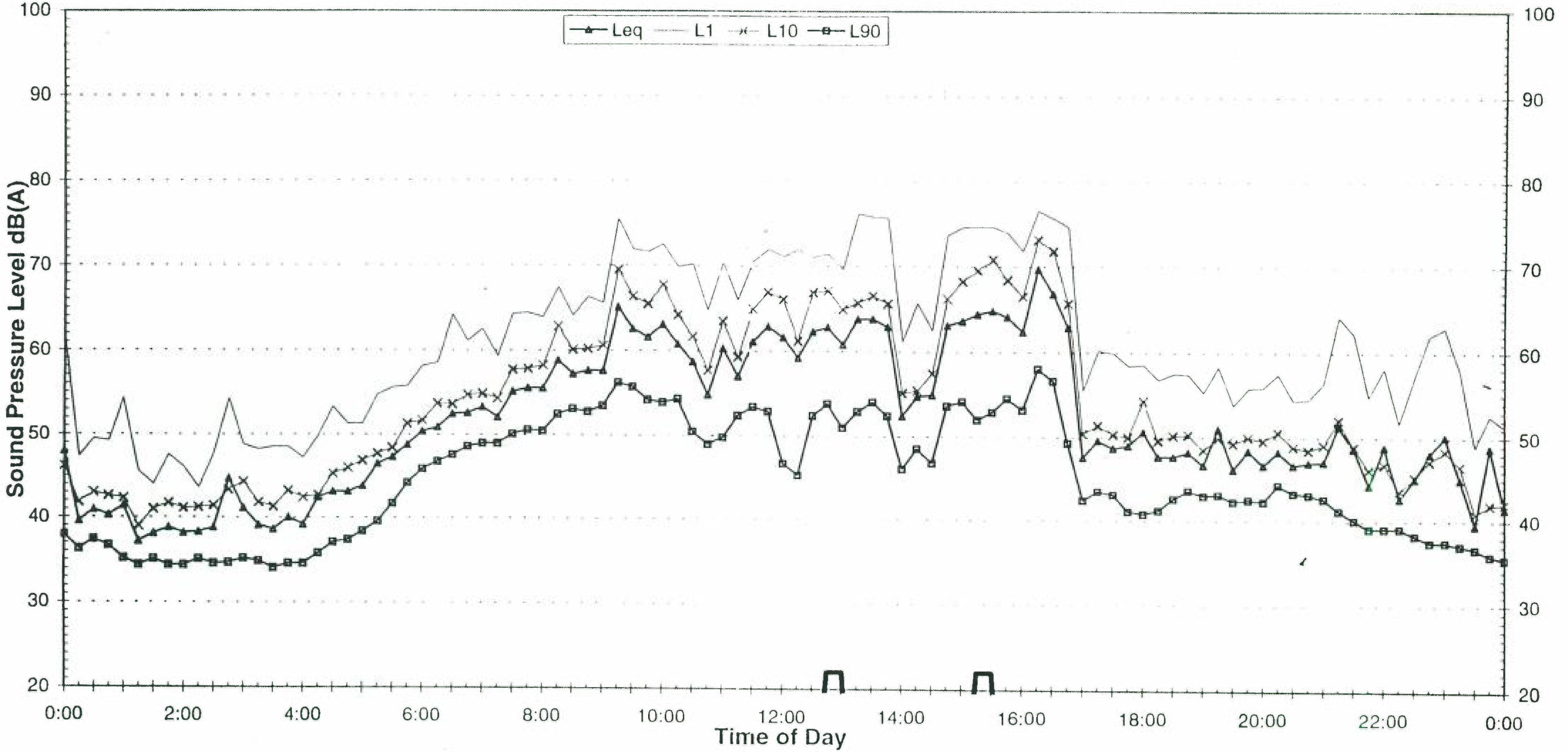
1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured in free-field; tabulated results facade corrected*

EPA Traffic Noise Policy (1m from facade) (see note 3)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	59.2	48.9
Leq 1hr upper 10 percentile	63.9	54.9
Leq 1hr lower 10 percentile	49.6	40.6

EXISTING AMBIENT NOISE LEVELS

Location 2 - 57 Greenhill Drive, Glenmore

Thursday, 21 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	43.3	39.1	34.3
Leq	61.5	48.1	47.1

NOTES:

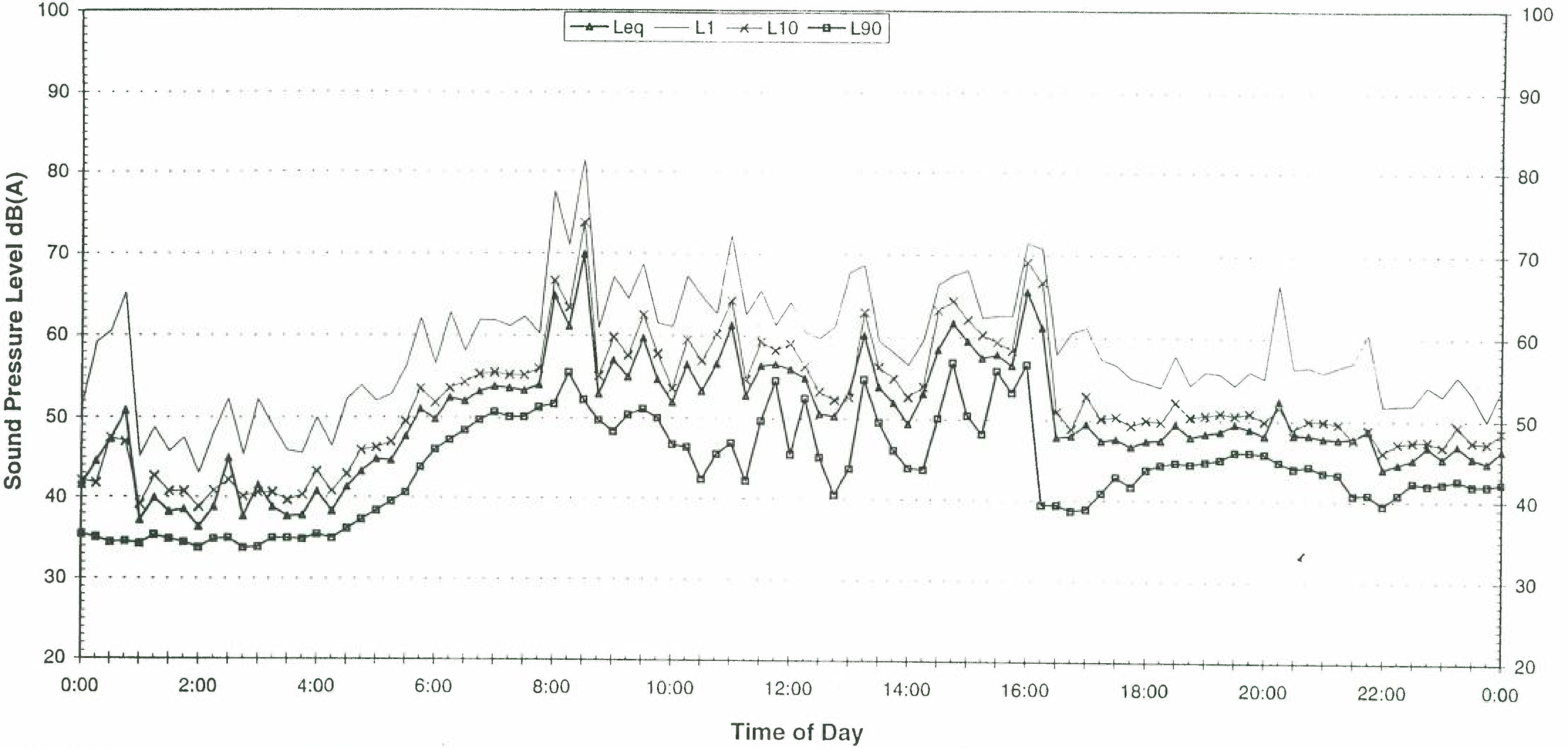
1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on th s graph to 7am on the following graph.*
3. *Graphed data measured in free-field; tabulated results facade corrected*

EPA Traffic Noise Policy (1m from facade) (see note 3)		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	62.6	49.6
Leq 1hr upper 10 percentile	67.4	55.4
Leq 1hr lower 10 percentile	50.0	40.9

Rev 9   Data File   WSO-092.dat

TA440-12S02 (rev 0)

EXISTING AMBIENT NOISE LEVEL
Location 2 - 57 Greenhill Drive, Glenmore
Friday, 22 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night² 10pm-7am
L90	40.5	40.7	35.4
Leq	58.8	48.6	44.6

NOTES:

1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured in free-field; tabulated results facade corrected*

EPA Traffic Noise Policy (1m from facade) (see note 3)		
Descriptor	Day 7am-10pm	Night² 10pm-7am
Leq 15 hr and Leq 9 hr	60.2	47.1
Leq 1hr upper 10 percentile	65.8	50.8
Leq 1hr lower 10 percentile	49.8	43.3

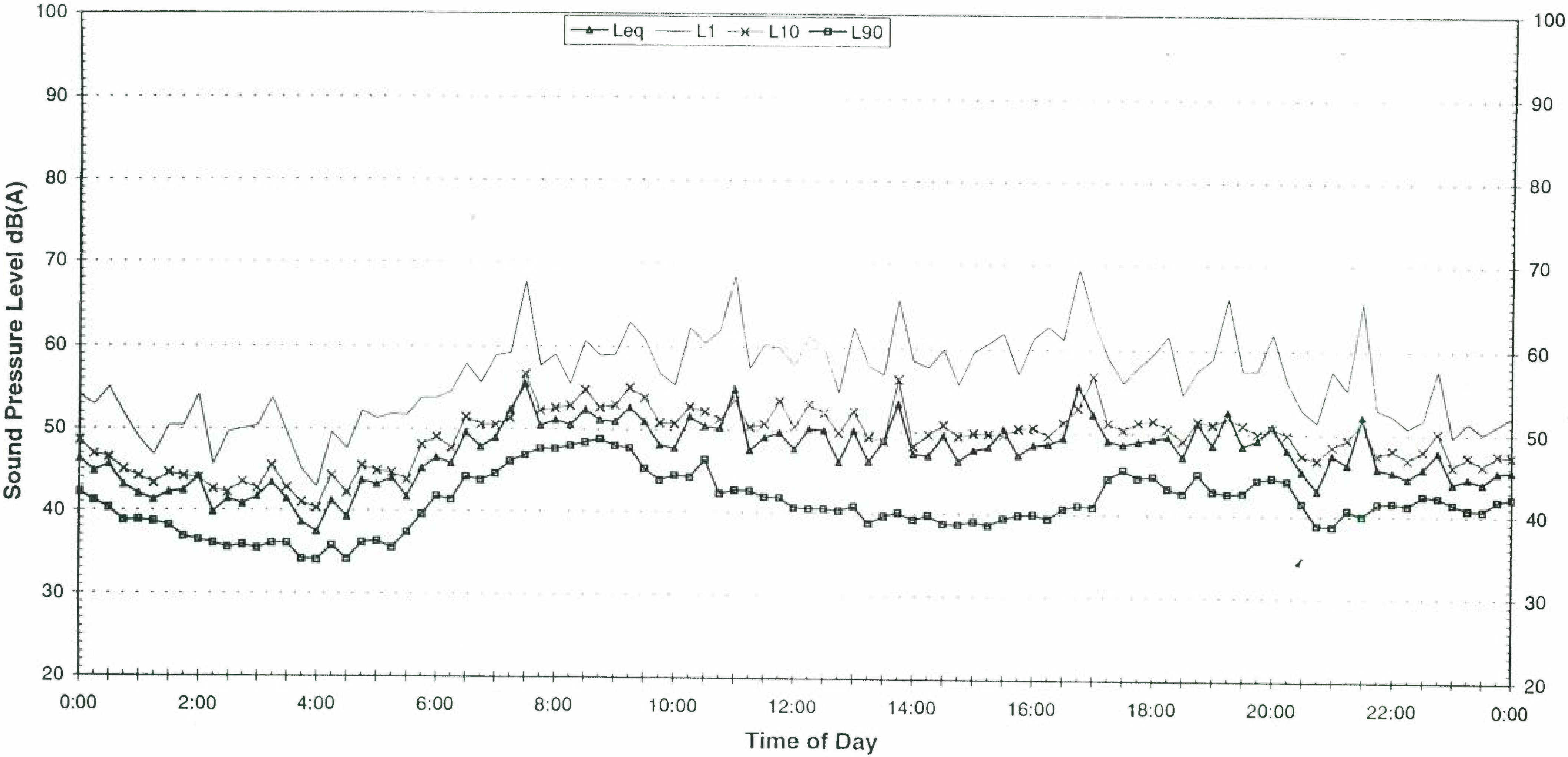
Rev 9 Data File WSO-092.dat

TA440-12S02 (rev 0)

EXISTING AMBIENT NOISE LEVELS

Location 2 - 57 Greenhill Drive, Glenmore

Saturday, 23 June 2001



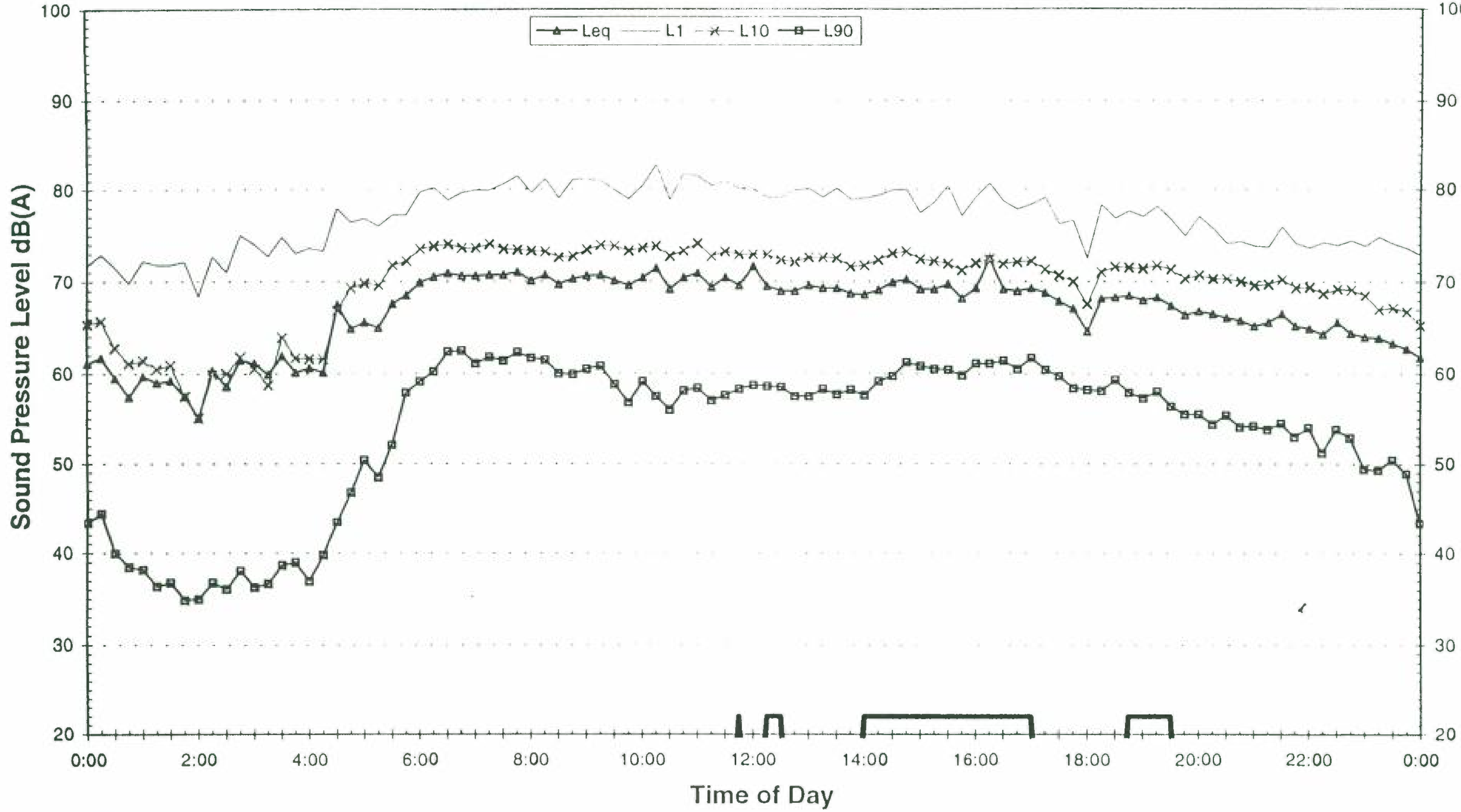
EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	39.1	38.8	34.1
Leq	50.6	49.0	43.5

NOTES:

1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured in free-field; tabulated results facade corrected*

EPA Traffic Noise Policy (1m from facade) (see note 3) Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	52.7	46.0
Leq 1hr upper 10 percentile	55.2	48.3
Leq 1hr lower 10 percentile	49.7	41.2

EXISTING AMBIENT NOISE LEVELS
Location 5 - Cnr Rooty Hill Rd & Romey Cres, Rooty Hill
Thursday, 14 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night² 10pm-7am
L90	57.5	53.8	39.0
Leq (see note	67.4	63.9	63.1

NOTES:

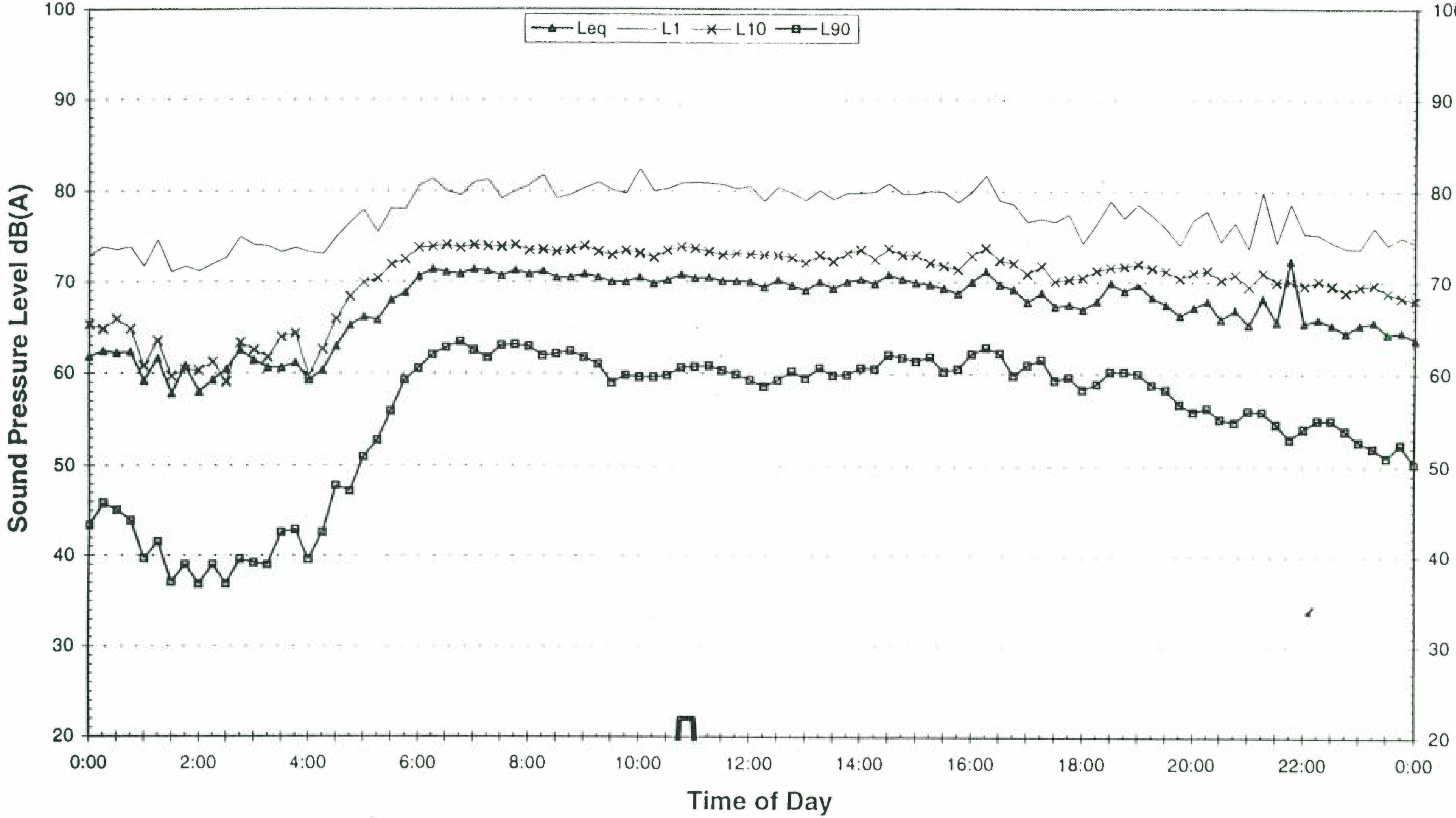
1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured 1m from facade; tabulated results free-field corrected*

EPA Traffic Noise Policy (1m from facade		
Descriptor	Day 7am-10pm	Night² 10pm-7am
Leq 15 hr and Leq 9 hr	69.1	65.6
Leq 1hr upper 10 percenti	70.6	71.2
Leq 1hr lower 10 percentil	65.7	59.9

EXISTING AMBIENT NOISE LEVELS

Location 5 - Cnr Rooty Hill Rd & Romey Cres, Rooty Hill

Friday, 15 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	59.3	54.1	41.5
Leq (see note	67.5	65.7	61.6

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	69.5	64.1
Leq 1hr upper 10 percenti	70.9	68.1
Leq 1hr lower 10 percenti	67.0	59.8

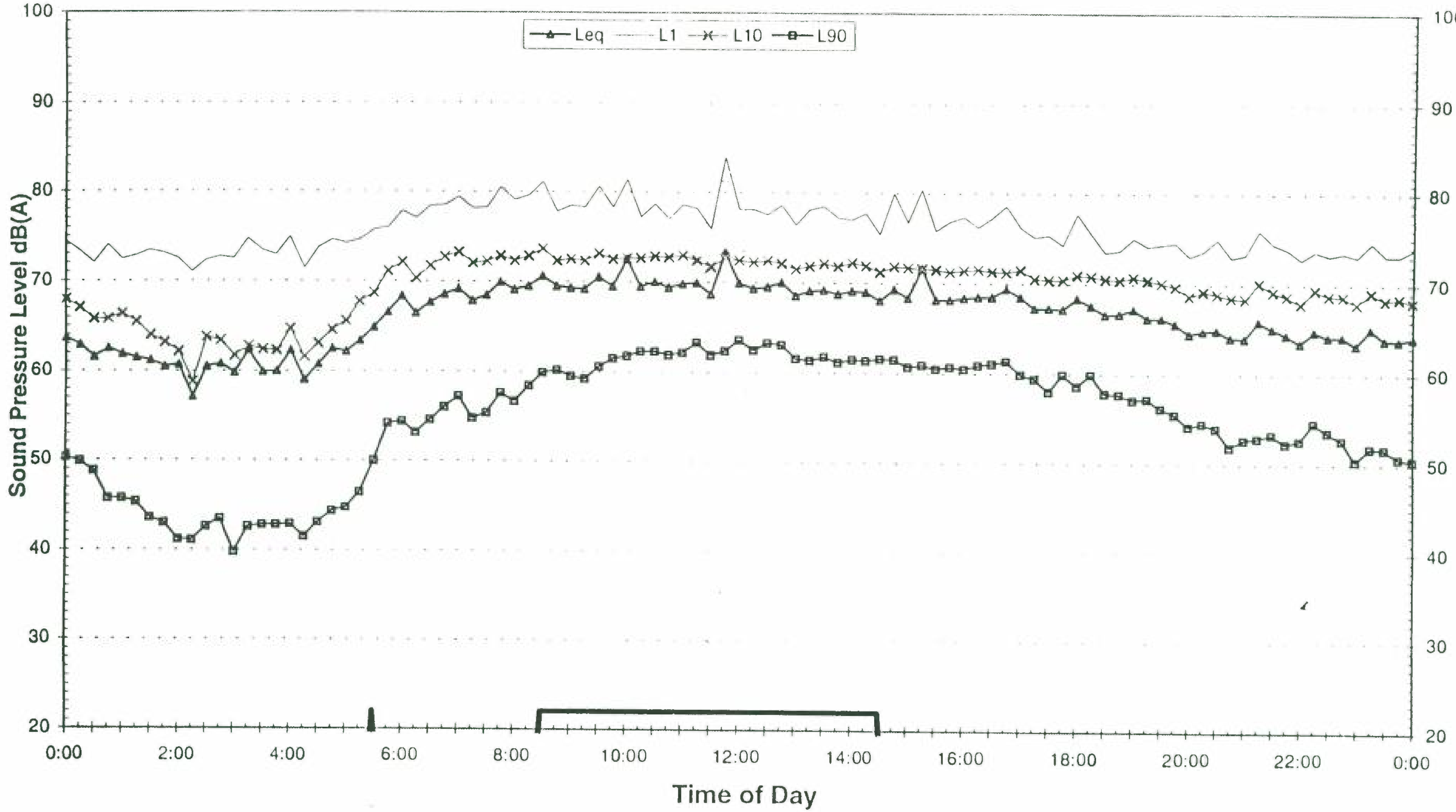
Rev 9 Data File 2romeycr.dat

T440-12S05 Rooty Hill Rd (rev 0)

EXI[illegible]NG AMBIENT NOISE LEVE[illegible]

Location 5 - Cnr Rooty Hill Rd & Romey Cres, Rooty Hill

Saturday, 16 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	55.4	52.3	37.7
Leq (see note	66.3	63.1	59.9

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

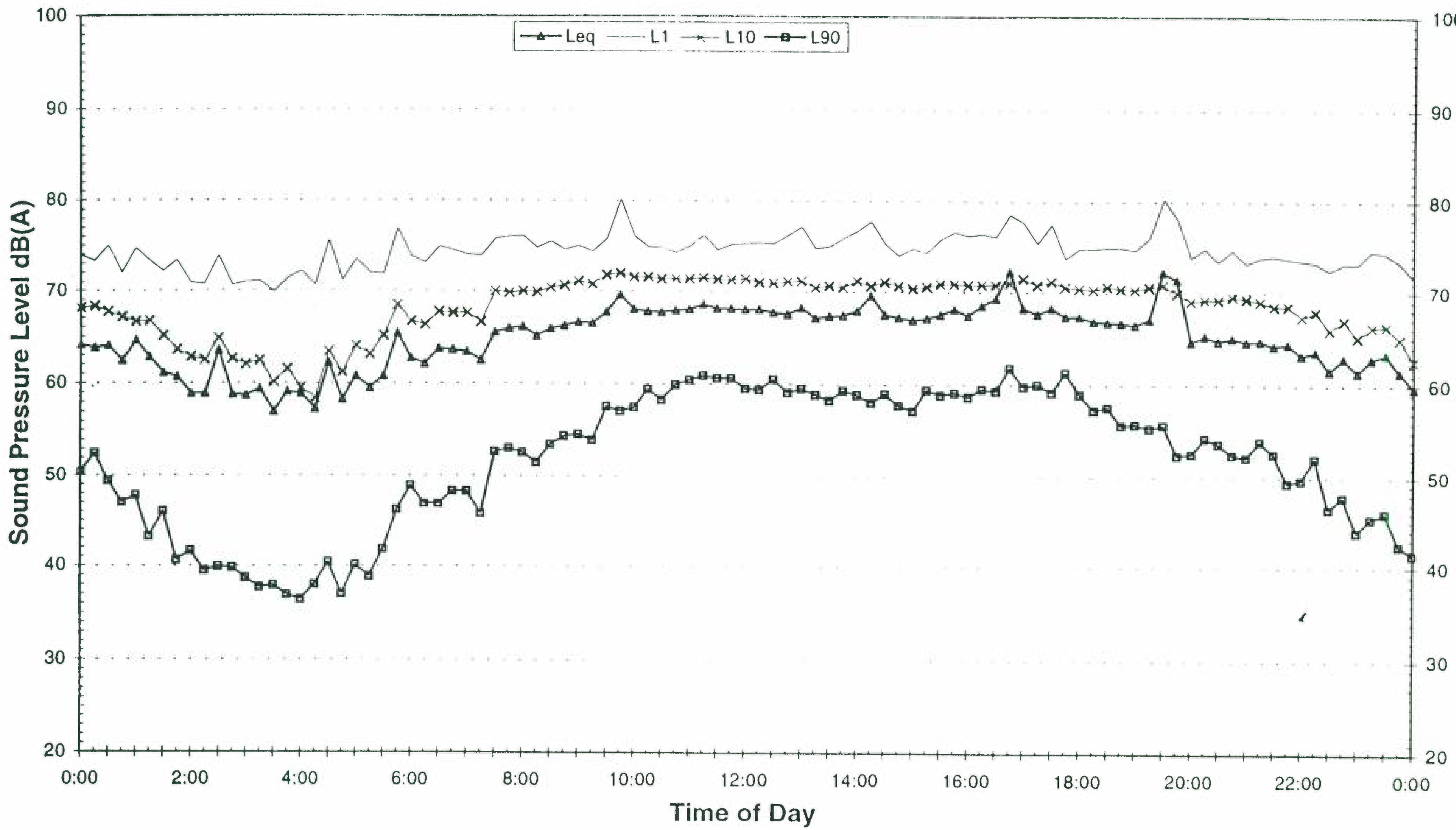
EPA Traffic Noise Policy (1m from facade		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	67.6	62.4
Leq 1hr upper 10 percenti	69.5	64.3
Leq 1hr lower 10 percenti	64.5	58.7

Rev 9 Data File 2romeycr.dat T440-12S05 Rooty Hill Rd (rev 0)

EXISTING AMBIENT NOISE LEVELS

Location 5 - Cnr Rooty Hill Rd & Romey Cres, Rooty Hill

Sunday, 17 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	53.1	49.7	37.6
Leq (see note	65.3	64.5	62.4

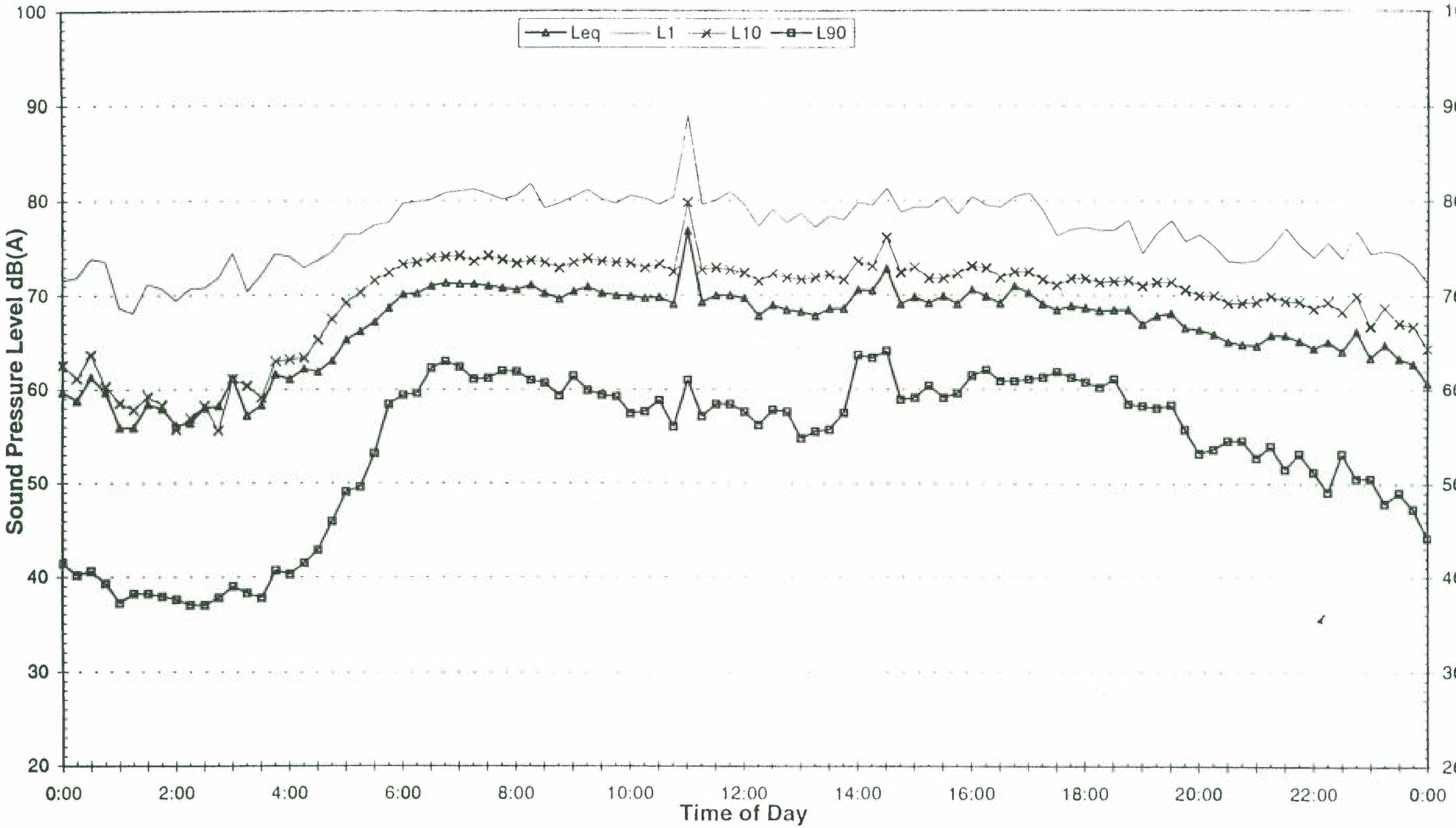
NOTES:
1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured 1m from facade; tabulated results free-field corrected*

EPA Traffic Noise Policy (1m from facade		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	67.6	64.9
Leq 1hr upper 10 percenti	69.9	70.9
Leq 1hr lower 10 percentil	64.5	57.2

Rev 9 Data File 2romeycr.dat

T440-12S05 Rooty Hill Rd (rev 0)

EXISTING AMBIENT NOISE LEVELS
Location 5 - Cnr Rooty Hill Rd & Romey Cres, Rooty Hill
Monday, 18 June 2001



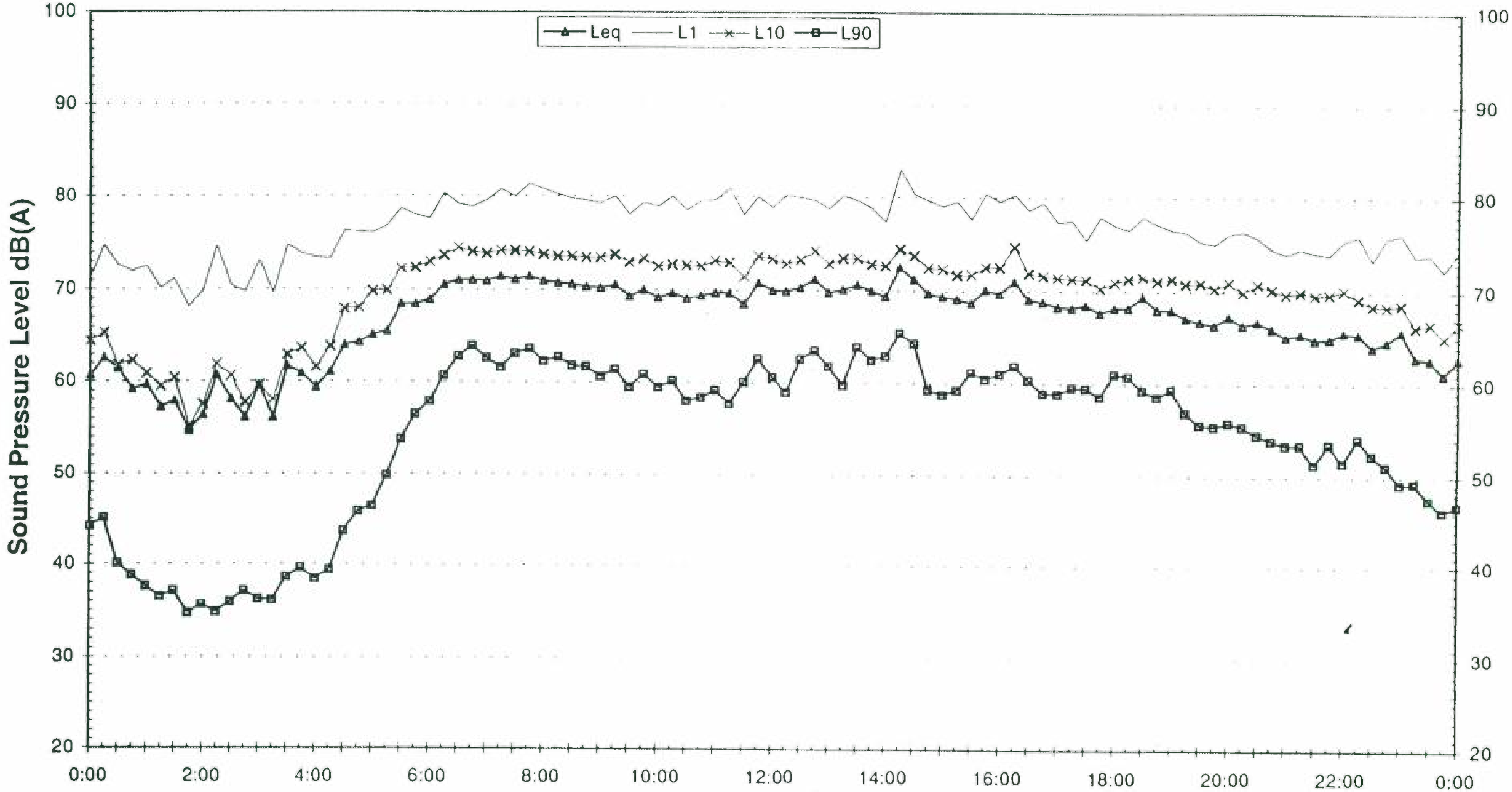
EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	56.2	51.5	35.9
Leq (see note	67.7	64.2	62.7

NOTES:

1. *Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.*
2. *"Night" relates to period from 10pm on this graph to 7am on the following graph.*
3. *Graphed data measured 1m from facade; tabulated results free-field corrected*

EPA Traffic Noise Policy (1m from facade		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	69.5	65.2
Leq 1hr upper 10 percenti	71.9	70.9
Leq 1hr lower 10 percenti	65.2	56.7

EXISTING AMBIENT NOISE LEVELS
Location 5 - Cnr Rooty Hill Rd & Romey Cres, Rooty Hill
Tuesday, 19 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	58.8	51.6	37.2
Leq (see note	67.5	64.3	62.9

NOTES:
1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	69.3	65.4
Leq 1hr upper 10 percenti	71.0	71.1
Leq 1hr lower 10 percenti	65.7	57.7

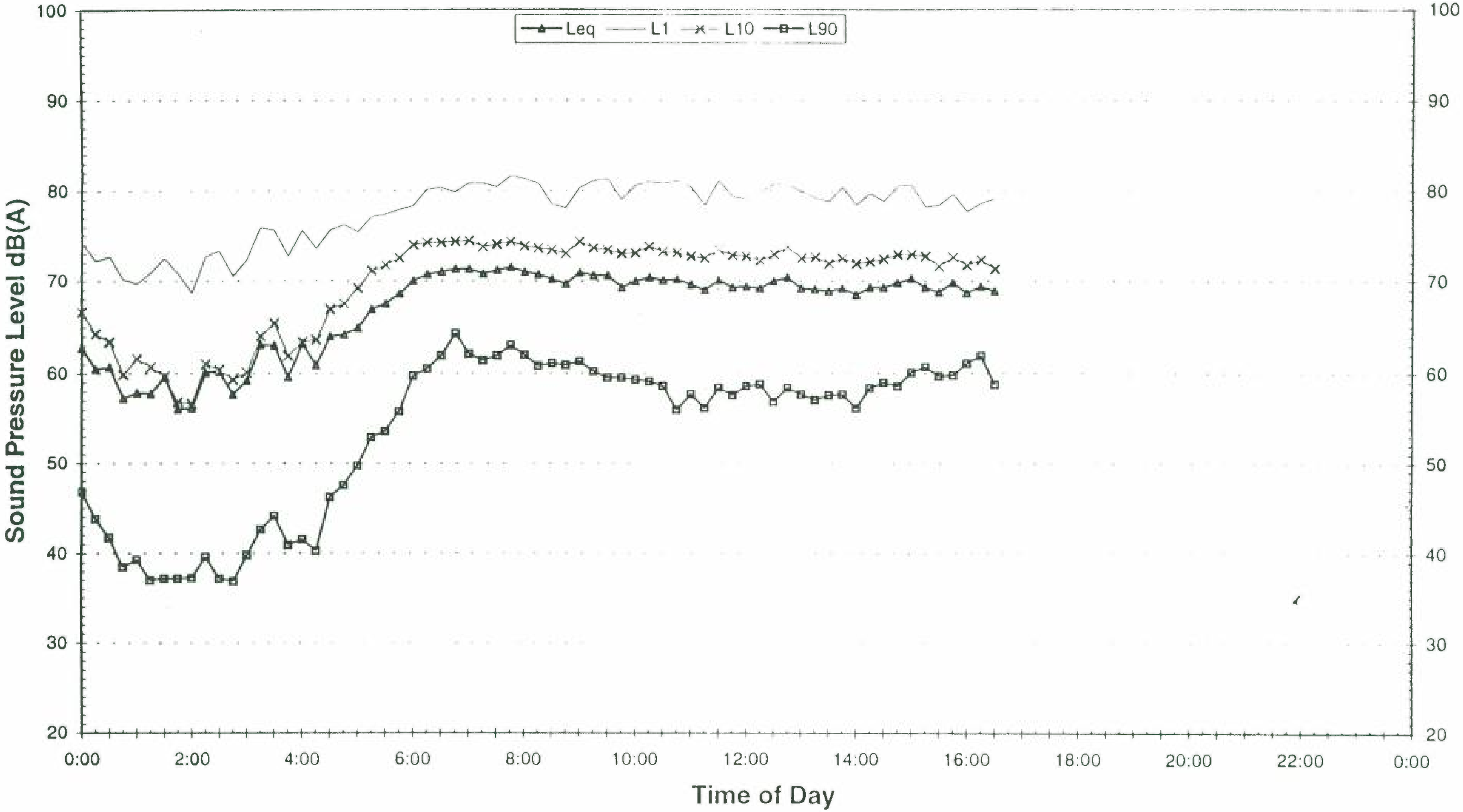
Rev 9 Data File 2romeycr.dat

T440-12S05 Rooty Hill Rd (rev 0)

EXI[illegible]G AMBIENT NOISE LEVEL[illegible]

Location 5 - Cnr Rooty Hill Rd & Romey Cres, Rooty Hill

Wednesday, 20 June 2001



EPA Industrial Noise Policy (Free Field)			
Descriptor	Day 7am-6pm	Evening 6pm-10pm	Night[2] 10pm-7am
L90	56.9	-	-
Leq (see note	67.4	-	-

NOTES:

1. Bars denote periods adversely affected by rain, wind or extraneous noise - data in these periods excluded from calculations.
2. "Night" relates to period from 10pm on this graph to 7am on the following graph.
3. Graphed data measured 1m from facade; tabulated results free-field corrected

EPA Traffic Noise Policy (1m from facade		
Descriptor	Day 7am-10pm	Night[2] 10pm-7am
Leq 15 hr and Leq 9 hr	69.9	-
Leq 1hr upper 10 percent	71.1	-
Leq 1hr lower 10 percent	68.9	-

APPENDIX TEN

AIR QUALITY ASSESSMENT

AIR QUALITY ASSESSMENT
WESTERN SYDNEY ORBITAL – REPRESENTATIONS REPORT

20 July 2001

Prepared for
Roads & Traffic Authority of NSW

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all figures at end

1 INTRODUCTION

1.1 Preamble

This report has been prepared by Holmes Air Sciences for the Roads and Traffic Authority (RTA). Its purpose is to consolidate the air quality assessment reports which were prepared for the Western Sydney Orbital (WSO) Environmental Impact Statement (EIS). This report includes the findings of the study for the northern section between Elizabeth Drive and Baulkham Hills and the southern section from Prestons to Cecil Park. It takes account of changes in land use identified through the WSO Representations Report – Land Use Update and Proposed Infrastructure Modifications as well as the proposed modifications to the project.

1.2 Overview

The report provides information on the following aspects of air quality assessments:

- Existing air quality in the vicinity of the route;
- Emissions from various segments of the roadway involved in the development;
- Estimation of kerb side concentrations of roadway air emissions; and
- The contribution of the roadway emissions to regional air quality.

The assessment of the impacts of motor vehicle emissions is based on the use of a computer model to determine the dispersion of emissions and to predict ground-level concentrations of the various exhaust components in the area close to the road. It has been assumed that in the first year of assessment (2006) 95% of motor vehicles would be powered with unleaded petrol and therefore the impact of lead emissions has been assessed. By 2016 it is likely that effectively all motor vehicles will be powered with unleaded petrol or diesel and thus the primary pollutants of concern will be carbon monoxide, hydrocarbons, nitrogen oxides and particulate matter.

Monitoring of carbon monoxide, nitrogen oxides and nitrogen dioxide, ozone, particulate matter and lead have been carried out by Stephenson & Associates at the sites shown in **Figure 1**. Details of this study are contained in a separate report (**Coffey & Partners, 1995**). Also included in the current report is a summary of data collected at the EPA monitoring sites in Western Sydney.

2 DESCRIPTION OF THE PROJECT

The proposed route of the Western Sydney Orbital is shown in **Figure 1** and this assessment has been carried out for the Orbital operating as a tollway. Cross-sections of this route are shown in **Figure 2**. The assessment of air quality impacts for this report has been undertaken for the tolled WSO from Cecil Park to West Baulkham Hills. Potential air quality impacts have been assessed along the proposed route and on other roadways affected by the project. Although this assessment is for a tollway, the traffic volumes are based on the Orbital being untolled. However, volumes would be expected to be lower if the Orbital is tolled and so this provides a worst-case assessment of the Orbital itself. Other peripheral roads may experience increases in traffic if the project proceeds, since vehicles will use these roads to access or exit from the Orbital. A number of these roads have been assessed individually for the "build" and "no build" cases and the results of this modelling are discussed in **Section 8.2**. In this case traffic for the tolled option was used.

3 AIR QUALITY CRITERIA

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

The National Environment Protection Council of Australia (NEPC) has determined a new set of air quality goals for adoption at a national level, which are part of the National Environment Protection Measures (NEPM). In its publication "Action for Air" (**EPA, 1998**), the NSW EPA has proposed new air quality goals for particulate matter and nitrogen dioxide, some of which are consistent with the NEPM standards.

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

3.1 Carbon monoxide

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

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

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

3.2 Oxides of nitrogen

Nitrogen oxides (NO_x) emitted by motor vehicles are comprised mainly of nitric oxide (nitric oxide, approximately 95% at the point of emission) and nitrogen dioxide (NO_2, approximately 5% at the point of emission). Nitric oxide is much less harmful to humans than nitrogen dioxide and is not generally considered a pollutant with health impacts at the concentrations normally found in urban environments. Concern with nitric oxide relates to its transformation to nitrogen dioxide and its role in the formation of photochemical smog. Nitrogen dioxide has been reported to have an effect on respiratory function although the evidence concerning effects has been mixed and conflicting. The EPA has not set any air quality goals for nitric oxide, however it has set 1-hour and annual average goals for nitrogen dioxide. It has adopted the NEPM standard of 0.12 ppm or 245 $\mu g/m^3$. It has also adopted the WHO 1-hour goal of 0.11ppm or 200 $\mu g/m^3$ as a long term reporting goal.

Table 1 – NSW Air Quality Goals		
Pollutant	Goal	Agency
Carbon monoxide	87 ppm or 108 mg/m^3 (15-minute maximum) 25 ppm or 31 mg/m^3 (1-hour maximum) 9 ppm or 10 mg/m^3 (8-hour maximum)	WHO WHO NHMRC NEPM
Nitrogen dioxide	16 pphm or 320 $\mu g/m^3$ (1-hour maximum) 5 pphm or 103 $\mu g/m^3$ (annual mean) 12 pphm or 245 $\mu g/m^3$ (1-hour maximum) 11pphm or 200 $\mu g/m^3$ (1-hour maximum) 3 pphm or 60 $\mu g/m^3$ (annual mean)	NHMRC US EPA NEPM, NSW EPA WHO, NSW EPA long term reporting goal NEPM, NSW EPA
Total suspended particulate matter (TSP)	90 $\mu g/m^3$ (annual mean)	NHMRC
Particulate matter < 10 μm (PM_{10})	50 $\mu g/m^3$ (annual mean) 30 $\mu g/m^3$ (annual mean) 150 $\mu g/m^3$ (24-hour maximum) 50 $\mu g/m^3$ (24-hour maximum)	US EPA NSW EPA US EPA NEPM, NSW EPA
Lead	1.5 $\mu g/m^3$ (90-day average) 0.5 $\mu g/m^3$ (annual average)	NHMRC NEPM
Ozone	10 pphm or 200 $\mu g/m^3$ (1-hour maximum) 8 pphm or 150 $\mu g/m^3$ (4-hour maximum) 8 pphm or 150 $\mu g/m^3$ (1-hour maximum) 6 pphm or 120 $\mu g/m^3$ (4-hour average)	NHMRC, NEPM, NSW EPA NSW EPA long term reporting goal
Sulphur dioxide	25 pphm or 700 $\mu g/m^3$ (10-minute maximum) 20 pphm or 570 $\mu g/m^3$ (1-hour maximum) 8 pphm or 225 $\mu g/m^3$ (1 day) 2 pphm or 60 $\mu g/m^3$ (annual mean)	NHMRC NEPM NEPM NHMRC and NEPM

ppm - part per million
pphm – parts per hundred million
$\mu g/m^3$ – micrograms per cubic metre
mg/m^3 – milligrams per cubic metre

3.3 Hydrocarbons

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

There is growing concern about the amount of benzene released in motor vehicle emissions, especially in Europe where fuel has a higher benzene and aromatic content than in Australia. At present NSW has no ambient air quality goals for benzene. Many in the scientific community hold the view that there is no safe limit for benzene. The WHO specifies a risk factor for developing leukaemia of between 4.4×10^{-6} – 7.5×10^{-6} for a lifetime exposure to 1 $\mu g/m^3$ (**WHO, 1995**). The United Kingdom has an annual average ambient benzene goal of 5 parts per billion (ppb) or 16 $\mu g/m^3$ to be achieved by 2005. The 5 ppb goal is based on the "No Observable Adverse Effect Level" from the findings of the UK Expert Panel on Air Quality Standards that the risk of leukaemia in workers would not be detectable when the average working lifetime exposure to benzene was less than 500 ppb. Two safety factors of 10 were then applied to derive the goal of 5 ppb.

3.4 Particulate matter

The presence of particulate matter in the atmosphere can have an adverse effect on health and amenity. The health effects of particles are largely related to the extent to which they can penetrate the respiratory tract. Larger particles, that is those greater than 10 µm, generally adhere to the mucus in the nose, mouth, pharynx and larger bronchi and from there are removed by either swallowing or expectorating. Finer particles can enter bronchial and pulmonary regions of the respiratory tract, with increased deposition during mouth breathing which increases during exercise. The very fine particles can be deposited in the pulmonary region and it is these which are of particular concern.

The health effects of particulate matter are further complicated by the chemical nature of the particles and by the possibility of synergistic effects with other air pollutants such as sulphur dioxide.

Much of the recent concern over the health effects of fine particulate matter is based on investigations carried out in the US, with the view to quantifying the health risks associated with both long-term and short-term exposure to airborne particulate matter. The study is colloquially referred to as "The Six Cities Study" from the original work by **Dockery et al. (1993)**, which determined a relationship between fine particulate matter (defined as particles smaller than 2.5 µm in diameter) in the air and mortality in six US cities.

The basic findings of the Six Cities Study is that there is an increase in mortality with increasing concentrations of fine particulate matter. The conclusions appear to be robust and have been supported by subsequent studies and as far as can be determined are not confounded by other known variables. The mechanism is still unknown but is being actively researched.

These findings have not yet been fully evaluated by the scientific community. New Australian standards determined by NEPC include a goal for PM_{10} but not for $PM_{2.5}$. The US EPA has not changed its PM_{10} (particles less than 10 µm in diameter) goal but has introduced new goals for fine particles ($PM_{2.5}$) with a 24-hour limit of 65 $\mu g/m^3$ and an annual limit of 15 $\mu g/m^3$. The NSW EPA has historically noted the US EPA 24-hour air quality standard of 150 $\mu g/m^3$ and annual average standard of 50 $\mu g/m^3$ for PM_{10}. It now adopts the NEPM 24-hour standard of 50 $\mu g/m^3$, and references a new annual average of 30 $\mu g/m^3$ as a long-term reporting goal.

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

3.5 *Ozone*

Ozone is a powerful oxidant, formed in the atmosphere in the presence of sunlight, nitrogen oxides and reactive hydrocarbons. It is not a primary emission from motor vehicles but a regional pollutant, being a major component of photochemical smog. Because of its highly reactive nature, ozone can combine with virtually all classes of biologically active molecules including enzymes, proteins and lipids. Cellular membranes are a target for ozone which has also been reported to have an irritant effect on the respiratory system. The air quality goal has been revised downwards from 257 $\mu g/m^3$ (12 pphm) to 200 $\mu g/m^3$ (10 pphm) for a 1-hour maximum. In addition the EPA now notes a four hour ozone goal of 8 pphm or 170 $\mu g/m^3$. The revision of the goal to a more stringent standard may result in additional exceedances of the goal without changes to air quality.

3.6 *Sulphur dioxide*

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

Lead has not been considered in this report as it has been largely removed from petrol on sale in NSW. Lead levels in Sydney suburbs have declined significantly since the introduction of unleaded petrol and are now almost below the level of detection at the EPA monitoring sites (see **Figure 3**).

4 DISPERSION METEOROLOGY

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

4.1 *Meteorology*

4.1.1 *Meteorology of the Sydney Basin*

Before discussing the local meteorology in the vicinity of WSO, it is useful to consider the meteorology of the Sydney Basin as it relates to air pollution issues.

Sydney has been developed in a coastal bowl shaped area bounded by high ground to the north, west and south and open to the sea to the east. The bowl is subdivided by minor, but meteorologically important topographical features, into three distinct areas referred to by **Hyde and Johnson (1990)** as the Parramatta River Valley (bounded by the triangle extending from Botany Bay in the South to Parramatta in the west, to Manly in the east), the Liverpool Basin (defined by the triangular region running from Sutherland in the south, to Hoxton Park in the West and Toongabbie in the north) and the Hawkesbury Basin (defined by an approximately rectangular area running from Camden in the south to Blaxlands Ridge in the north). This topographical environment is important in determining the movement of air within the Sydney area, particularly at night.

The topography affects the movement of air in two ways. Firstly wind is deflected by terrain features which steer, or channel the wind. The more stable the atmosphere the greater the effect. The terrain structure can also affect the movement of air by generating so-called katabatic, or drainage flows. These are generally generated at night when the wind is light and the skies are clear. Under these conditions the ground will cool by radiating heat to space. The cooled ground will then chill the air close to it making that air denser than the air further from the ground. If the ground is sloping then the air close to the ground will be denser than the nearby air at the same height above sea level, but a different height above the ground. The result will be that the dense air close to the surface will begin to drift down the slope.

Because the drainage flows are comprised of stable air which suppresses vertical movement they can flow as discrete entities, one sheet of air flowing at a different speed and in a different direction over the other.

A conceptual model for the drainage flow in the Sydney basin has been developed over the past decade by Hyde and is discussed in detail in the evaluation of air quality issues in the south-west region of Sydney (**Hyde and Johnson, 1990**). The basic components of the model involve nighttime drainage flows which move from the high ground to the north, west and south of Sydney, and daytime seabreezes which return the polluted air which has drained out over the sea.

Night-time

At night, the sheets of air move downward from the high ground, travel initially from the south in a northward direction and fill up the Sydney basin, or the western portion of the Sydney basin, and cause air to flow out towards the east and out to the sea. Similarly, air from the west would undertake the same sort of movement as would air from the northern high ground in the Sydney basin. Thus the ultimate movement of air is from the high ground into the basin, and then out to sea.

Hyde has also identified an interesting phenomena in which air in the Hawkesbury Basin flows into the Parramatta Basin over the low point in the ridge that separates the two basins at Blacktown. Hyde refers to this as spillover.

Day-time

During the day the sun warms the land and a sea breeze is developed. Air which has flowed out of the basin at night on to the sea is then returned into the basin and is transported generally towards the west and the south. The significance of this effect for the air quality in the Sydney Basin, is that pollutants which are produced in the eastern and northern regions of Sydney may be transported to the south and west. If this pattern is repeated over several days, it can result in a significant recirculation of pollutants.

This model for air movement within the Sydney Airshed is particularly relevant to the formation of photochemical smog which is discussed in **Section 4.2.2**. It should be noted however that this pattern of air movement does not occur every day. On many occasions synoptic winds prevent the formation of drainage flows and the movement of air will be determined by synoptic scale driving forces. The model is relevant to still conditions when air quality is often at poorer levels, but of course not all such conditions lead to exceedances of air quality goals.

4.1.2 Rainfall, temperature and humidity

Table 2 presents the temperature, humidity and rainfall data for Seven Hills (**Bureau of Meteorology, 1988**). Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean and median monthly rainfall and the average number of raindays per month.

From temperature data recorded over 11 years, the annual average maximum and minimum temperatures experienced were 23.4°C and 11.3°C. January was the hottest month with average maximum temperatures of 28.3°C. July was the coldest month, with an average minimum temperature of 4.6°C.

The annual average humidity reading from 11 years of data collected at 9 am was 71%. The month with the highest humidity on average was June with an average of 82%. 3 pm readings were not recorded. Rainfall data collected over 37 years show that January and March were the wettest months, with mean rainfall readings of 112 mm and 114 mm, respectively. The average number of raindays for these months was 10 and 11, respectively. The average annual rainfall was 932 mm and the average number of raindays was 109.

Table 3 presents the temperature, humidity and rainfall data for Liverpool (**Bureau of Meteorology internet site, 1996**). Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean and median monthly rainfall and the average number of raindays per month.

From temperature data recorded over 32 years, the annual average maximum and minimum temperatures experienced are 23.1°C and 11.5°C. On average, January is the hottest month with an average maximum temperature of 28.1°C. July is the coldest month, with an average minimum temperature of 4.6°C.

The annual average humidity reading from 32 years of data collected at 9 am is 73%, and at 3 pm is 51%. The month with the highest humidity on average is June with a 9 am average of 82%, and the lowest is September with a 3 pm average of 44%.

Rainfall data collected over 33 years show that March is the wettest month, with an average rainfall of 105 mm over 11 days. The average annual rainfall is 871 mm with an average of 107 raindays.

Table 2 – Temperature, humidity and rainfall data for Seven Hills Experimental Farm
(Station number 067083 Latitude 33 Deg 47 Min S Longitude 150 Deg 56 Min E Elevation 55 m)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Temperatures (C) and Relative Humidity (%) (17 years of record)													
Dry-bulb	22.5	22.2	20.7	17.7	13.4	10.6	9.7	12.0	15.3	18.4	20.2	22.0	17.1
Wet-bulb	18.7	19.1	17.7	15.2	11.4	9.2	7.9	9.2	11.8	14.7	16.2	18.1	14.1
Humidity	68	73	73	75	77	82	77	67	63	65	64	67	71
Daily Maximum Temperature (C) (21 Years of record)													
Mean	28.3	28.1	27.0	24.3	20.2	17.5	17.6	18.8	21.5	24.0	25.8	28.2	23.4
86 Percentile	33.9	32.7	31.3	28.5	23.3	20.0	20.2	21.9	26.2	29.5	31.8	34.2	
14 Percentile	23.0	23.3	22.5	20.5	16.7	15.3	15.3	15.7	17.2	19.2	20.3	22.8	
Daily Minimum Temperature (C) (21 Years of record)													
Mean	16.9	17.1	15.3	12.2	8.3	6.4	4.6	6.2	8.2	11.6	13.5	15.7	11.3
86 Percentile	20.0	19.7	18.3	15.6	11.8	10.4	8.0	9.7	11.8	15.0	16.2	18.6	
14 Percentile	13.9	14.4	12.2	8.7	4.4	2.5	1.3	2.8	4.8	8.1	10.2	12.5	
Rainfall (mm) (99 Years of record)													
Mean	112	107	114	60	69	95	43	59	43	78	80	72	932
Median	82	94	99	38	36	58	31	36	36	56	65	49	913
Raindays (Number) (99 Years of record)													
Mean	10	11	11	8	8	9	7	8	8	11	9	9	109

Source : Bureau of Meteorology (1988)

Table 3 – Temperature, humidity and rainfall data for Liverpool Council
(Station number 067035 Latitude 33 Deg 55 Min S Longitude 150 Deg 55 Min E Elevation 21.0m)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Temperatures (C) and Relative Humidity (%) (32 years of record)													
Dry-bulb	21.8	21.3	20.2	17.2	13.1	10.0	8.8	11.0	14.5	17.7	19.2	21.1	16.3
Wet-bulb	18.7	18.8	17.7	14.7	11.3	8.6	7.[illegible]	8.7	11.2	14.0	15.6	17.4	13.6
Humidity	73	77	76	76	81	82	77	72	66	65	67	68	73
3 pm Mean Temperatures (C) and Mean Relative Humidity (%) (32 Years of record)													
Dry-bulb	26.6	26.3	25.0	22.8	19.5	16.9	16.5	17.9	20.0	22.0	23.8	25.7	21.9
Wet-bulb	20.2	20.5	19.2	16.9	14.5	12.4	11.2	12.0	13.4	15.5	17.4	18.9	16.0
Humidity	53	56	55	52	55	55	49	45	44	48	49	50	51
Daily Maximum Temperature (C) (32 Years of record)													
Mean	28.1	27.7	26.2	23.9	20.5	17.7	17.3	18.9	21.4	23.6	25.3	27.4	23.1
Daily Minimum Temperature (C) (32 Years of record)													
Mean	17.6	17.5	15.7	12.5	9.2	6.3	4.6	5.8	8.1	11.4	13.8	16.1	11.5
Rainfall (mm) (33 Years of record)													
Mean	95	96	105	86	70	76	37	55	45	61	78	68	871
Median	87	75	86	55	63	48	24	26	39	46	66	65	873
Raindays (Number) (33 Years of record)													
Mean	11	10	11	8	9	9	7	7	8	9	10	9	107

4.1.3 *Wind data for the project area*

The terrain along the WSO route varies from the elevated terrain of the Blacktown Ridge in the Cecil Park area, to the relatively flat area north west of Blacktown, and then east to higher ground near Baulkham Hills.

The closest meteorological monitoring stations with data which can be considered as representative of the meteorological conditions along the route are at Fleurs (collected in 1980) and Blacktown (collected in 1984) and West Hoxton (collected in 1980-81). The locations of the monitoring sites are shown in **Figure 1**. **Figures 4a** (Fleurs), **4b** (Blacktown) and **4c** (West Hoxton) present seasonal and annual wind rose diagrams compiled from these data which were collected by Macquarie University using Lambecht model 1482 wind recorders (installed at 10 m above local ground level).

On an annual basis, the most frequent winds at Fleurs are from the southeast sector. This pattern persists in autumn and spring, although in spring there is also a strong westerly component. In summer, westerlies comprise a much smaller percentage of winds, while in winter, winds are predominantly from the south to west-southwest.

Blacktown experiences winds predominantly from the northwestern and southeastern quadrants on an annual basis. This is the trend for each season except winter. During winter the winds from the southeast die down but the majority of winds still come from the northwest.

West Hoxton experiences winds predominantly from the southwest clockwise to the northwest and from the east clockwise to the south-southeast. Winds from the north to east-northeast are infrequent. This pattern persists in spring and autumn, while in winter the winds shift to the west. In summer the winds are predominantly from the east to south-southeast.

4.1.4 *Atmospheric stability*

To use the wind data to assess dispersion it is necessary also to have available data on atmospheric stability. This is a measure of the capacity of the atmosphere to disperse pollutants. In the Pasquill-Gifford stability class assignment there are six stability classes, A through to F. Class A relates to unstable conditions such as might be found on a sunny day with light winds. In such conditions plumes will spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances. The intermediate classes B, C, D and E relate to intermediate dispersion conditions. **Table 4** shows the frequency of the occurrence of stability classes at Fleurs, Blacktown and West Hoxton.

Table 4 – Percentage frequency of occurrence of stability classes at Fleurs, Blacktown and West Hoxton			
Stability class	Percentage frequency of occurrence		
	Fleurs	Blacktown	West Hoxton
A	11.6	3.5	2.5
B	7.3	18.1	15.3
C	12.4	15.3	17.4
D	36.5	13.0	15.9
E	16.6	7.4	8.1
F	15.7	40.6	40.8
Total	**100**	**100**	**100**
Average wind speed m/s	**2.91**	**7.9**	**2.25**

4.2 Air quality issues

4.2.1 Regional air quality

The NSW government has completed a major study of air pollution in the Sydney airshed and the Newcastle and Illawarra regions, known as the *Metropolitan Air Quality Study* (referred to as MAQS). The data collection aspects of the study were completed in 1995 and the findings were released on 17 July, 1995.

The Metropolitan Air Quality Study upgraded and extended the Environment Protection Authority's air quality monitoring network over a wider area. It has also further refined the understanding of the present chemistry and air movements in the Sydney airshed and has updated the emissions inventories. Some aspects of this are discussed in the following sections. However, future air quality projections would need to take account of improved emissions controls or changes in population growth and employment patterns which are emerging. On the basis of the Metropolitan Air Quality Study findings the EPA has developed a 25 year air quality management plan which is summarised in its publication *Action for Air* (**EPA, 1998**). This document sets out the EPA's priorities for maintaining and improving air quality in the greater metropolitan area. The plan presents an integrated "whole of government" approach which incorporates commitment from the RTA and the NRMA through its Clean Air 2000 program which aims to reduce congestion and emission by the year 2000 through driver education.

The Action for Air plan includes the following actions:

- Adoption of new ambient air quality goals, drawing in part from those developed at a federal level by the National Environment Protection Council (NEPC) which were discussed in **Section 3.** They have been adopted by the EPA for use in NSW.
- Reducing emissions from motor vehicles as high priority and this will be undertaken by improved transport options including new rail links, encouraging cycling and walking as well as integrating the planning of freight movement.
- Heavy duty diesel vehicles have been identified as a major source of oxides of nitrogen and particulate emissions and these will be targeted by promoting the use of cleaner fuels and alternative technologies for trucks and buses.

4.2.2 *Vehicle emissions and photochemical smog*

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

In the past the State Pollution Control Commission (**SPCC, 1983**) (now EPA) has acted to control smog by reducing the amount of hydrocarbons emitted into the Sydney air, mainly through the use of catalytic converters on motor cars using unleaded petrol and by other controls on stationary sources. This has led to a substantial reduction in hydrocarbon emissions from individual vehicles. Total hydrocarbon emissions in the Sydney area are estimated to have declined by 20.8% from 1976 to 1992 despite an increase of about 49% in vehicle kilometres travelled (VKT) over the same period (source: data taken from **Eiser and Koo, 1984** and **Carnovale et. al, 1997**).

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

The significance (to the formation of photochemical smog) of the change in hydrocarbons relative to emissions of oxides of nitrogen is as follows. The rate at which photochemical smog forms depends on the ratio of hydrocarbon to oxides of nitrogen. If the ratio favours nitrogen oxides, then the process by which ozone or smog is produced is delayed in onset until all the nitrogen oxides are consumed. The reaction then proceeds and the photochemical smog is formed. In simple terms, oxides of nitrogen determines how much ozone can form, while hydrocarbons determine the timing or how quickly it will form. The amount of ozone that is formed also depends on the temperature and the accumulated sunlight, and the concentration that occurs depends on the dilution that takes place as the reacting components are carried downwind.

4.2.3 *Conversion of nitric oxide to nitrogen dioxide*

As discussed previously there are no ambient air quality goals for nitric oxide, the major nitrogen oxide emission from motor vehicles. Nitric oxide is however converted to nitrogen dioxide and its rate of conversion is dependent on the presence of oxidising agents. The issue here is the rate at which nitric oxide converts to the more harmful nitrogen dioxide. An analysis of the EPA's nitrogen oxides monitoring data reveals that the percentage of nitrogen dioxide in the air is inversely proportional to the total oxides of nitrogen concentration. **Figure 5** presents a plot of the mean percentage nitrogen dioxide (calculated from the mean nitrogen dioxide concentration and the mean total oxides of nitrogen concentration in ppm) against the mean nitrogen oxide concentration recorded at five sites in Sydney, namely Earlwood, Eagle Vale, Lidcombe, Kensington and Rozelle, from 1988 to 1992.

The trend in the graph shows an inverse correlation between total oxides of nitrogen concentration and percentage of nitrogen dioxide. Average percentages of nitrogen dioxide in the EPA monitoring data range from 5 to 50% with a mean value of about 30%.

Monitoring data collected by the RTA in Sydney (**RTA, 1997**) indicate that close to the roadways, nitrogen dioxide would make up from 5 to 20% by weight of the total oxides of nitrogen. A conservative value of 15% by weight at 0 - 10 m from the kerb has been used in the impact assessment presented in **Section 8**.

4.3 Existing air quality

4.3.1 Monitoring data collected for the project

Local air quality with respect to carbon monoxide, nitrogen oxides, ozone, sulphur dioxide and particulate matter including lead has been monitored at sites chosen to represent existing concentrations currently experienced close to the route. The locations of these sites are shown in **Figure 1** (**Coffey and Partners, 1995**). These monitoring data give an indication of the likely background levels in the study area.

The most comprehensive monitoring was carried out at the following three sites; Arnott's Distribution Centre on Horsley Road, Eastern Creek (site A1); Peck's Australia Pty Ltd employee carpark, Rooty Hill (site A2); and Prospect Electricity Substation at Wallgrove Road, Horsley Park (site A4). Data consisted of continuous measurements on oxides of nitrogen, nitrogen dioxide, ozone and sulphur dioxide over a three week period. At Sites A1 and A2 this was from October 21 to November 15, and from November 15 to December 8 1994 at site A4. Particulate matter samples were collected every second day over a four week period and analysed for TSP, PM_{10} and lead. Grab samples were taken on either side of the road at other indicated sites (B1 to B7) and analysed for carbon monoxide.

Table 5 summarises the results of the monitoring study. The site identifications are as in the report by **Coffey & Partners** (**1995**). Monitored levels for all pollutants except PM_{10} were well below their respective historical and newly adopted air quality goals. It should be noted that the lead levels were averaged over a four week period, however the ambient lead goal refers to a three month averaging period. The PM_{10} goal now adopted by the NSW EPA has been reduced to 50 $\mu g/m^3$ which, as shown in **Table 5**, is exceeded at least once at each "A" site. This goal is allowed to be exceeded on 5 occasions per year, however it is not possible to determine from 3 weeks of data how many times per year 50 $\mu g/m^3$ is exceeded.

Monitoring was carried out in late spring/early summer when the worst-case dispersion conditions (inversions) are unlikely to prevail for extended periods. However the high level of ultraviolet radiation which occurs in summer provides the most favourable conditions for ozone formation. Therefore while the frequency with which high levels of most roadway pollutants occur is likely to be less in summer, the highest levels of the secondary pollutant ozone would be expected to occur during this period.

Table 5 – Summary of pollutant levels at monitoring sites along the proposed route

Site Number and Location[1]	CO (mg/m^3) average range	CO (mg/m^3) average range	O_3 ($\mu g/m^3$)	NO_2 ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	TSP ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	Lead in TSP ($\mu g/m^3$)	Lead in PM_{10} ($\mu g/m^3$)
	1-hour	8-hour	1-hour			24-hour average mean (maximum)			
A1 (Eastern Creek)	–	1.15	98	–	79	45.3 (84.7)	30.0 (54.4)	0.16 (0.29)	0.15 (0.28)
A2 (Rooty Hill)	–	–	98	–	26	60.8 (123.3)	35.4 (65.7)	0.15 (0.28)	0.12 (0.27)
A3 (Hoxton Park Road, Hoxton Park)	NDA[2]	–	33 (154)	30 (90)	7 (81)	59.1 (103.1)	33.4 (68)	0.07 (0.12)	0.06 (0.10)
A4 (Hoxton Park)	–	2.3	78	45	Below level of detection	38.6 (51.8)	31.7 (57.0)	0.05 (0.08)	0.06 (0.09)
B1 (Kings Park)	0.4 – 8.3	1.9 – 9.5	–	–	–	–	–	–	–
B2 (Quakers Hill)	1.6 – 4.5	2.1 – 6.8	–	–	–	–	–	–	–
B3 (Hassel Grove)	3.3 – 8.0	3.3 – 5.1	–	–	–	–	–	–	–
B4 (Eastern Creek)	0.8 – 4.9	4.0 – 6.6	–	–	–	–	–	–	–
B5 (Horsley Park, north)	0.5 – 3.3	2.9 – 6.9	–	–	–	–	–	–	–
B6 (Horsley Park, south)	1.0 – 4.8	2.1 – 5.9	–	–	–	–	–	–	–

Site Number and Location[1]	CO (mg/m^3) average range	CO (mg/m^3) average range	O_3 (µg/m^3)	NO_2 (µg/m^3)	SO_2 (µg/m^3)	TSP (µg/m^3)	PM_{10} (µg/m^3)	Lead in TSP (µg/m^3)	Lead in PM_{10} (µg/m^3)
B7 (Cecil Park)	1.0 – 5.9	3.4 – 6.5	–	–	–	–	–	–	–
B8 (17th Avenue West Hoxton)	0.6-2.8	2.0-7.8							
B9 (Hoxton Park Road Hinchinbrook)	1.5-4.1	2.6-5.9							
B10 (Kurrajong Road Prestons)	1.0-14.8	1.9-4.5							

Note 1: Site identifications A1 to A4, and B1 to B10 refer to the site numbering used in Coffey & Partners (1995)

4.3.2 EPA monitoring data

In addition to the project-specific monitoring data, data which are generally representative of air quality in Western Sydney are collected by the NSW EPA at the sites shown in **Figure 1**. The NSW EPA has expanded its air monitoring network in the outer regions of Sydney in recognition of the fact that under particular meteorological conditions, air pollution can be transported from the eastern parts of the Sydney to the west and the southwest.

Table 6 summarises the EPA's air quality monitoring data collected from 1993 to 1998. These data are presented in more detail in **Attachment A**. Shaded areas show exceedances of the goal.

Table 6 - Summary of EPA air quality monitoring data

Ozone data 1993 – 1998						
	Maximum 1-hour value (pphm)					
	Goal/standard - 10 pphm					
	1993	1994	1995	1996	1997	1998
Blacktown	12.5	11.4	5.9	8.2	14.9	10.9
Bringelly	9.6	13.0	8.1	9.8	13.5	11.3
Liverpool	10.1	11.3	7.9	9.2	15.1	13.0
St Marys	12.5	12.7	6.8	8.7	12.4	12.2
Westmead	11.4	9.8	7.4	7.4	13.1	14.5
	Annual Average (pphm)					
	Goal/standard – none					
	1993	1994	1995	1996	1997	1998
Blacktown	0.5	0.5	0.5	0.6	0.7	0.6
Bringelly	0.6	0.8	0.7	0.7	0.8	0.7
Liverpool	0.4	0.4	0.4	0.4	0.5	0.5
St Marys	0.5	0.7	0.7	0.7	0.8	0.9
Westmead	0.7	0.4	0.4	0.4	0.5	0.6
Nitrogen dioxide data 1993 – 1998						
	Maximum 1-hour value (pphm)					
	Goal/standard – 12 pphm					
	1993	1994	1995	1996	1997	1998
Blacktown	10.4	8.1	6.3	5.9	9.7	6.0
Bringelly	4.6	5.8	5.2	4.3	6.0	5.0
Liverpool	12.3	9.3	8.8	5.4	6.0	6.3
St Marys	8.4	7.8	5.6	3.8	7.2	4.3
Westmead	7.8	9.3	8.3	5.5	11.3	5.9
	Annual Average (pphm)					
	Goal/standard –3 pphm					
	1993	1994	1995	1996	1997	1998
Blacktown	1.4	1.3	1.3	1.1	1.3	1.3
Bringelly	0.4	0.7	0.6	0.4	0.5	0.5
Liverpool	1.2	1.3	1.2	1.0	1.1	1.1
St Marys	0.7	0.8	0.8	0.7	0.6	0.6
Westmead	1.4	1.5	1.3	1.0	1.3	1.3

Table 6 - Summary of EPA air quality monitoring data (Cont.)						
NO_x data 1993 –1998						
	Maximum 1-hour value (pphm)					
	Goal/standard – none					
	1993	1994	1995	1996	1997	1998
Blacktown	52.3	44.8	42.9	35.7	50.9	42.7
Bringelly	10.5	26.9	8.8	21.3	10.6	8.3
Liverpool	42.9	70.6	59.9	56.1	56.8	53.7
St Marys	34.5	40	34.2	51.8	25.7	29.9
Westmead	44.6	74	51.5	38.4	54.3	37.6
	Annual Average (pphm)					
	Goal/standard – none					
	1993	1994	1995	1996	1997	1998
Blacktown	2.8	2.1	2.1	1.9	2.1	2.1
Bringelly	1.3	1.0	0.8	0.8	0.7	0.8
Liverpool	2.2	2.6	2.4	2.2	2.5	2.1
St Marys	1.4	1.3	1.3	1.1	1.0	1.1
Westmead	2.8	2.9	2.6	2.3	2.7	2.5
PM_{10} data 1993 – 1998						
	Maximum 24-hour value ($\mu g/m^3$)					
	Goal/standard – 50 $\mu g/m^3$					
	1993	1994	1995	1996	1997	1998
Blacktown	120	126	40	31	44	66
Bringelly	45	191	*	*	*	*
Liverpool	*	*	*	*	*	*
St Marys	*	*	*	*	*	*
Westmead	*	*	*	*	*	*
	Annual Average ($\mu g/m^3$)					
	Goal/standard – 30 $\mu g/m^3$					
	1993	1994	1995	1996	1997	1998
Blacktown	22	25	19	18	19	21
Bringelly	19	*	*	*	*	*
Liverpool	*	*	*	*	*	*
St Marys	*	*	*	*	*	*
Westmead	*	*	*	*	*	*
TEOM PM_{10} data 1993 – 1998						
	Maximum 1-hour value ($\mu g/m^3$)					
	Goal/standard – none					
	1993	1994	1995	1996	1997	1998
Blacktown	*	*	*	132	176	230
Bringelly	*	119	93	249	142	149
Liverpool	*	114	95	132	203	193
St Marys	*	*	*	122	232	158
Westmead	*	*	*	252	203	190

Table 6 – Summary of EPA air quality monitoring data (Cont.)						
	Annual Average (µg/m³)					
	Goal/standard – 30 µg/m³					
	1993	1994	1995	1996	1997	1998
Blacktown	12	15	13	12	16	15
Bringelly	13	15	12	11	13	14
Liverpool	14	17	14	13	15	14
St Marys	11	15	12	10	10	13
Westmead	*	20	16	15	18	17
Sulfur dioxide data 1993 – 1998						
	Maximum 1-hour value (pphm)					
	Goal/standard – 20 pphm					
	1993	1994	1995	1996	1997	1998
Blacktown	2.8	*	*	2	1.8	2
Bringelly	2	*	*	0.9	1.2	1.3
Liverpool	*	*	*	*	*	*
St Marys	*	*	*	*	*	*
Westmead	*	*	*	*	*	*
	Annual Average (pphm)					
	Goal/standard – 2 pphm					
	1993	1994	1995	1996	1997	1998
Blacktown	0.2	*	*	0.1	0.1	0.1
Bringelly	0.1	*	*	0.1	0.1	0.1
Liverpool	*	*	*	*	*	*
St Marys	*	*	*	*	*	*
Westmead	*	*	*	*	*	*
Carbon monoxide data 1993 – 1998						
	Maximum 1-hour value (ppm)					
	Goal/standard – 25 ppm					
	1993	1994	1995	1996	1997	1998
Blacktown	*	8.7	7.1	5.7	6.7	7
Bringelly	*	*	*	*	*	*
Liverpool	*	8.5	9.3	7.3	9	8.3
St Marys	5.8	0.7	*	*	*	*
Westmead	*	*	5.8	7	4.8	*
	Annual Average (ppm)					
	Goal/standard – none					
	1993	1994	1995	1996	1997	1998
Blacktown	*	0.4	0.4	0.3	0.4	0.5
Bringelly	*	*	*	*	*	*
Liverpool	*	0.5	0.5	0.5	0.5	0.4
St Marys	1.1	0.2	*	*	*	*
Westmead	*	*	*	0.4	0.3	0.3

The data indicate that air quality in the area has not changed substantially over the six-year monitoring period, despite the growth in the areas and apart from ozone, the reported levels are generally within the goals.

Ozone levels are very dependent on meteorology and the summers of 1993/1994 and 1997/1998 were "high ozone" summers with exceedances across Sydney, not just in the western region.

5 METHODS FOR ASSESSING IMPACTS

The Caline4 dispersion model has been used to estimate the concentration of oxides of nitrogen, carbon monoxide and hydrocarbons that are likely to be produced in the vicinity of the route. This model is an upgrade of Caline3, the most recent US EPA approved model, and is a steady state Gaussian model which can determine concentrations at receptor locations downwind of "at grade", "fill", "bridges" and "cut section" highways located in relatively uncomplicated terrain. The model is applicable for any wind direction, highway orientation and receptor location and has been validated in a study undertaken in Sydney by **Williams et al. (1994)** for the RTA.

An initial assessment for particulate matter was carried out using Caline4, however, another model was used for further assessment. This model is part of a package (Breeze Roads) which incorporates Caline4 as well as Cal3qhc, a modified version of Caline3, and is able to make predictions for averaging periods longer than the 1-hour time periods that Caline4 uses. This is important for particulate matter since the air quality goals are for 24-hour and annual time periods.

Two different approaches have been taken for this assessment, depending on the pollutant being assessed and the model being used. Both approaches are outlined below:

Initial assessment

All pollutants were assessed using Caline4 under worst-case conditions. These worst-case conditions comprise peak hour traffic flows combined with the poorest dispersion conditions (stable atmosphere and light winds). Traffic flow was assumed to be constant (at peak levels) along each section of the route, and the worst-case wind angle was determined to give the highest concentrations at the roadside receptors.

Particulate matter assessment

Once the most affected sections were determined using Caline4, a further assessment was carried out for those sections using longer averaging periods to more accurately assess particulate matter. This was done using the Cal3qhc model in the Breeze Roads package. Variations in traffic volumes throughout the day were taken into account, and representative hourly meteorological data were used. The model is able to estimate 24-hour and annual average concentrations at each receptor, to compare with the relevant air quality goals.

This further analysis was carried out only for particulate matter and only for the worst affected sections in 2016. On a pro rata basis, concentrations at all other sections will be lower than for the worst affected section.

6 METHODS FOR ESTIMATING EMISSIONS

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

An estimation of these emissions has been made by Pengilley (1989) and US EPA emission factors (US EPA, 1985). These data have been used in previous roadway studies, however a comprehensive emissions inventory which relates vehicle emissions to different travel conditions in NSW has now been prepared for the Metropolitan Air Quality Study (MAQS) (Carnovale et. al 1997). These emission rates have been combined with traffic flow data to determine air quality impacts of the project in 2006 and 2016. **Attachment B** provides a detailed description of the calculation of vehicle emissions for both years. Morning peak values have been used as these were generally higher than evening peaks along all sections of the proposed Orbital.

6.1 Carbon monoxide

The way in which vehicle emissions vary with speed is fundamental to the understanding of the analysis presented in this report. The relationship between speed and carbon monoxide emission is shown in **Figure 6** where the estimated carbon monoxide emission rates in the years 1988 and 2000 are presented for light duty petrol vehicles (hot start). It is assumed that approximately 30% and 96% of cars are fitted with catalytic converters in 1988 and 2006 respectively. At present about 70% of the fleet are fitted with catalytic converters and so the year 2006 assumption of 96% would be an overestimate. For cars without catalytic converters, there is a marked decrease of emissions with speed. Fitting cars with catalytic converters reduces the overall emissions and again the same pattern of decreasing emission rate with speed is observed.

The emissions of carbon monoxide from vehicles were determined for previous studies from these relationships (**Nigel Holmes & Associates, 1992, 1994**). The emissions inventory prepared for MAQS takes a different approach. Although similar principles apply in terms of the relationship between speed and emissions, the roads are divided into different categories and emissions from the mix of traffic on that type of road is determined. The categories are as follows:

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

Emission rates for different vehicle categories and different roadway classifications have been determined. Details of these are presented in **Attachment B**. For this assessment it has been assumed that travel on the WSO equates to freeway travel conditions.

6.2 Oxides of nitrogen

Oxides of nitrogen emissions show a different trend with speed from carbon monoxide and this is illustrated in **Figure 7**. As in the case of carbon monoxide, catalytic converters reduce the overall oxides of nitrogen emission rate, however the trend with increasing speed is reversed, that is oxides of nitrogen increases with increasing speed, although the effect is more gradual.

As for carbon monoxide, while the same trend remains, these emission factors have been replaced by those determined for MAQS (see **Attachment B**).

6.3 Hydrocarbons

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

6.4 Particulate matter

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

7 ESTIMATED EMISSIONS

Emission rates during peak hour for different sections of the route are estimated from the total traffic volume and the emission rate per vehicle. The estimated morning peak hour traffic flows in 2006 and 2016 are summarised in **Table 7**. Details of assumptions relating to the percentages of heavy vehicles and diesel-fuelled vehicles are presented in **Attachment B**. Note that the data for the Orbital relate to the untolled option and are therefore conservative.

Table 7 – Estimated peak hour (AM) traffic for 2006 and 2016 (traffic data for untolled option)				
Roadway Section	**Estimated Traffic Volumes – 1 hour Peak**			
WSO route	**2006**		**2016**	
Southern Section	**NB**	**SB**	**NB**	**SB**
North of Camden Valley Way	2695	1188	2947	1413
North of Bernera Road	2306	1163	2696	1343
North of Cowpasture Road	2855	996	2989	1187
South of Elizabeth Drive	2855	996	2989	1187
Elizabeth Drive to The Horsley Drive	2290	1210	2920	1330
The Horsley Drive to Old Wallgrove Road	2400	2220	3350	2650
Old Wallgrove Road to M4	1880	790	3040	1040
M4 to Great Western Highway	1660	2190	2290	2600
Great Western Highway to Power Street	1760	2590	2500	3210
Power Street to Richmond Road	1740	2260	2260	2880
Northern Section	**EB**	**WB**	**EB**	**WB**
Richmond Road to Quakers Hill Parkway	2360	1370	2890	2000
Quakers Hill Parkway to Sunnyholt Road	3070	1580	3600	2200
Sunnyholt Road to Norwest Blvd	2360	860	3610	1720
Norwest Blvd to Old Windsor Road	1850	630	2070	780
Old Windsor Road to Abbott Road	2170	760	2390	920
Elizabeth Drive				
	EB	**WB**	**EB**	**WB**
East of Mamre Road	950	286	1096	361
West of Cabramatta Road	925	138	1065	151

Source : Sinclair Knight Merz and PPK Environment & Infrastructure
Note : For volumes less than 1000, these numbers have been rounded to the nearest 10 and for those greater than 1000 they have been rounded to the nearest 100.

Emission estimates for the proposed road are presented in detail in **Attachment B** and are summarised in **Table 7** and **Table 8**. Emissions were calculated for peak hour traffic in 2006 and 2016 for eleven sections along the proposed WSO route.

The mix of older and newer vehicles has been taken into account when determining emission rates for the light duty vehicle fleet. Information has been taken from the MAQS emissions inventory for different years, and a new emission rate calculated from a combination of emissions from older vehicles and emissions from newer vehicles. This process is discussed further in **Attachment B**.

Table 8 – Estimated peak hour traffic emissions for 2006 (kg/km/hour)					
Roadway Section	Direction of traffic flow	Carbon Monoxide	Nitrogen Oxides	Hydrocarbons	Particulate Matter
WSO route					
North of Camden Valley Way	Northbound	25.24	8.11	2.37	0.38
	Southbound	11.13	3.58	1.05	0.17
North of Bernera Road	Northbound	21.59	6.94	2.03	0.33
	Southbound	10.89	3.5	1.02	0.16
North of Cowpasture Road	Northbound	26.73	8.59	2.51	0.4
	Southbound	9.33	3.01	0.88	0.14
South of Elizabeth Drive	Northbound	26.73	8.59	2.51	0.4
	Southbound	9.33	3.01	0.88	0.14
Elizabeth Drive to	Northbound	20.04	4.79	1.65	0.16
The Horsley Drive	Southbound	11.13	3.34	1.01	0.15
The Horsley Drive to	Northbound	21.05	5.09	1.74	0.17
Old Wallgrove Road	Southbound	19.71	5.07	1.67	0.19
Old Wallgrove Road to M4	Northbound	16.51	4.01	1.37	0.14
	Southbound	6.90	1.64	0.57	0.05
M4 to Great Western	Northbound	14.48	3.40	1.18	0.11
Highway	Southbound	19.20	4.63	1.58	0.16
Great Western Highway to	Northbound	15.32	3.56	1.25	0.11
Power Street	Southbound	22.56	5.26	1.84	0.17
Power Street to	Northbound	14.98	3.27	1.19	0.09
Richmond Road	Southbound	19.53	4.35	1.56	0.13
Richmond Road to	Eastbound	20.37	4.51	1.62	0.13
Quakers Hill Parkway	Westbound	12.13	3.08	1.02	0.11
Quakers Hill Parkway to	Eastbound	26.43	5.76	2.09	0.16
Sunnyholt Road	Westbound	13.98	3.54	1.18	0.13
Sunnyholt Road to	Eastbound	20.37	4.51	1.62	0.13
Norwest Blvd	Westbound	7.84	2.27	0.70	0.10
Norwest Blvd to	Eastbound	15.99	3.57	1.28	0.11
Old Windsor Road	Westbound	5.82	1.78	0.53	0.08
Old Windsor Road to	Eastbound	18.86	4.34	1.53	0.14
Abbott Road	Westbound	7.17	2.37	0.68	0.11
Elizabeth Drive					
East of Mamre Creek	Northbound	8.9	2.87	0.84	0.14
	Southbound	2.67	0.86	0.25	0.04
West of Cabramatta Road	Northbound	8.67	2.79	0.81	0.13
	Southbound	1.29	0.41	0.12	0.02

Table 9 – Estimated peak hour traffic emissions for 2016 (kg/km/hour)					
Roadway Section		Carbon Monoxide	Nitrogen Oxides	Hydrocarbons	Particulate Matter
WSO route					
North of Camden Valley Way	Northbound	25.4	8.69	2.41	0.42
	Southbound	12.17	4.16	1.15	0.20
North of Bernera Road	Northbound	23.24	7.96	2.21	0.38
	Southbound	11.58	3.97	1.1	0.19
North of Cowpasture Road	Northbound	25.76	8.82	2.45	0.42
	Southbound	10.42	3.51	0.97	0.17
South of Elizabeth Drive	Northbound	25.76	8.82	2.45	0.42
	Southbound	10.24	3.51	0.97	0.17
Elizabeth Drive to	Northbound	23.25	5.98	1.92	0.21
The Horsley Drive	Southbound	11.31	3.71	1.05	0.17
The Horsley Drive to	Northbound	26.79	7.02	2.23	0.25
Old Wallgrove Road	Southbound	21.49	5.97	1.84	0.23
Old Wallgrove Road to M4	Northbound	24.35	6.42	2.03	0.23
	Southbound	8.25	2.09	0.68	0.07
M4 to Great Western	Northbound	18.19	4.64	1.49	0.16
Highway	Southbound	20.64	5.24	1.69	0.18
Great Western Highway to	Northbound	19.88	5.08	1.63	0.18
Power Street	Southbound	25.35	6.29	2.06	0.21
Power Street to	Northbound	17.68	4.20	1.41	0.13
Richmond Road	Southbound	22.56	5.40	1.80	0.17
Richmond Road to	Eastbound	22.74	5.54	1.83	0.18
Quakers Hill Parkway	Westbound	16.09	4.33	1.35	0.16
Quakers Hill Parkway to	Eastbound	28.21	6.75	2.25	0.21
Sunnyholt Road	Westbound	17.61	4.63	1.47	0.17
Sunnyholt Road to	Eastbound	28.38	6.89	2.28	0.22
Norwest Blvd	Westbound	14.16	4.17	1.24	0.17
Norwest Blvd to	Eastbound	16.34	4.04	1.32	0.13
Old Windsor Road	Westbound	6.67	2.23	0.62	0.10
Old Windsor Road to	Eastbound	18.95	4.79	1.55	0.16
Abbott Road	Westbound	8.01	2.83	0.77	0.14
Elizabeth Drive					
East of Mamre Creek	Northbound	9.45	3.24	0.9	0.16
	Southbound	3.11	1.07	0.3	0.05
West of Cabramatta Road	Northbound	9.18	3.14	0.87	0.15
	Southbound	1.31	0.45	0.12	0.02

8 PREDICTION AND ASSESSMENT OF IMPACTS

8.1 Operational impacts

This section assesses the air quality impacts of the project by comparing the predicted ground-level concentrations of roadway emissions with air quality goals or other air quality criteria where specified goals are not available.

Table 10 and **Table 11** present the maximum predicted 1-hour average increase in ground-level concentrations of carbon monoxide, hydrocarbons, nitrogen oxides, nitrogen dioxide, particulate matter and lead at various distances from the proposed kerb. They do not include background levels. The model has been set to find the worst case wind angle assuming a wind speed of 1.0 m/s. It has also been assumed that F-class stability[1] conditions occur.

8.1.1 Carbon monoxide

It can be seen from **Table 10** and **Table 11** that the highest predicted increase in 1-hour carbon monoxide concentration 10 m from the proposed roadway is 2.9 mg/m^3 in 2006, occurring between the Horsley Drive and Old Wallgrove Road. This increases slightly to 3.3 mg/m^3 in 2016. All predicted concentrations are well below the EPA's 1-hour goal of 31 mg/m^3. The next highest predicted 1-hour carbon monoxide concentration 10 m from the roadside is 2.8 mg/m^3 in 2006 on the sections north of Camden Valley Way, north of Cowpasture Road and south of Elizabeth Drive. Concentrations at 30 – 50 m from the roadway, where most of the nearby residences are located are about half this value. The maximum 1-hour background measured along the route was 14.8 mg/m^3 at Kurrajong Road.

If the maximum measured level is added to the predicted levels due to roadway emissions, the maximum total carbon monoxide level is 17.6 mg/m^3 which is less than 60% of the 1-hour air quality goal. Adding the maximum measured level to the maximum predicted level is a very conservative approach and involves an element of double counting. This is because the monitored levels were measured close to existing roadways and are not a true reflection of "background concentration" in the absence of roadways.

The maximum 8-hour level measured along the route was 7.8 mg/m^3 at Seventeenth Avenue, West Hoxton. Adding this to the maximum predicted 1-hour value gives a level of 10.7 mg/m^3 however comparing the 1-hour prediction with the 8-hour goal is a very conservative approach as it assumes that the worst-case dispersion conditions and peak hour emissions would occur for eight hours continuously. Roadside monitoring conducted by the RTA (**RTA, 1997**) indicates that peak values are substantially more than the 8-hour values. Although there will be heavy traffic along the route for times outside peak hour, these are not substantial contributors to carbon monoxide levels which are generally dominated by passenger vehicles in contrast to oxides of nitrogen and particulate matter which are dominated by emissions from heavy duty diesel vehicles.

[1] In dispersion modelling stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford stability class assignment scheme there are six stability classes, A through to F. Class A relates to unstable conditions, such as might be found on a sunny day with light winds. In such conditions plumes will spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances.

Table 10 – Predicted increase in 1-hour average ground level concentrations of vehicle emission in 2006					
Roadway Section	Distance from the kerb (m)	Carbon Monoxide (mg/m^3)	Nitrogen Dioxide* ($\mu g/m^3$)	Hydrocarbons (mg/m^3)	Particulate Matter ($\mu g/m^3$)
WSO route					
North of Camden Valley Way	0	5.5	178	0.52	85
	10	2.8	135	0.26	43
	20	2.2	141	0.21	34
	30	1.9	119	0.17	28
	50	1.5	96	0.14	23
North of Bernera Road	0	4.9	159	0.46	76
	10	2.6	123	0.24	39
	20	2.0	129	0.19	31
	30	1.7	110	0.16	26
	50	1.4	88	0.13	21
North of Cowpasture Road	0	5.6	181	0.53	87
	10	2.8	134	0.26	43
	20	2.2	138	0.20	33
	30	1.8	118	0.17	28
	50	1.5	94	0.14	22
South of Elizabeth Drive	0	5.6	181	0.53	87
	10	2.8	134	0.26	43
	20	2.2	138	0.20	33
	30	1.8	118	0.17	28
	50	1.5	94	0.14	22
Elizabeth Drive to The Horsley Drive	0	5.2	137	0.43	45
	10	2.5	101	0.21	23
	20	1.9	106	0.16	18
	30	1.6	91	0.14	16
	50	1.3	74	0.12	13
The Horsley Drive to Old Wallgrove Road	0	5.8	151	0.48	51
	10	2.9	116	0.24	27
	20	2.3	123	0.20	21
	30	2.0	106	0.16	18
	50	1.6	86	0.14	15
Old WallgroveRoad to M4 Motorway	0	4.2	109	0.35	36
	10	2.0	77	0.16	17
	20	1.5	79	0.13	13
	30	1.3	66	0.10	10
	50	1.0	54	0.08	9.2
M4 Motorway to Great Western Highway	0	5.2	133	0.43	40
	10	2.6	100	0.21	21
	20	2.0	103	0.16	16
	30	1.7	89	0.14	14
	50	1.4	71	0.12	10
Great Western Highway to Power Street	0	5.9	146	0.47	41
	10	2.9	107	0.23	21
	20	2.2	111	0.18	16
	30	1.9	93	0.15	14
	50	1.5	76	0.13	12
Power Street to Richmond Road	0	5.2	124	0.41	35
	10	2.6	92	0.21	17
	20	2.0	96	0.16	14
	30	1.7	84	0.14	12
	50	1.4	66	0.12	9.2
Richmond Road to Quakers Hill Parkway	0	5.3	128	0.43	37
	10	2.5	94	0.20	18
	20	2.0	98	0.15	15
	30	1.7	84	0.13	13
	50	1.3	66	0.10	10

Table 10 – Predicted increase in 1-hour average ground level concentrations of vehicle emission in 2006 (Cont.)

Quakers Hill Parkway to Sunnyholt Road	0	6.4	154	0.52	45
	10	2.9	109	0.24	22
	20	2.3	113	0.18	17
	30	2.0	96	0.16	15
	50	1.6	76	0.13	12
Sunnyholt Road to Norwest Blvd	0	5.0	123	0.40	36
	10	2.3	89	0.20	18
	20	1.8	91	0.15	14
	30	1.5	76	0.13	13
	50	1.2	62	0.10	9.2
Norwest Blvd to Old Windsor Road	0	4.0	101	0.33	30
	10	1.9	74	0.16	15
	20	1.5	76	0.13	12
	30	1.2	64	0.10	10
	50	1.0	52	0.08	8.1
Old Windsor Road to Abbott Road	0	4.7	122	0.39	38
	10	2.2	89	0.18	20
	20	1.7	91	0.14	16
	30	1.4	79	0.13	14
	50	1.1	62	0.09	10
Elizabeth Drive					
East of Mamre Road	0	2.5	81	0.24	38
	10	1.2	57	0.11	18
	20	0.9	57	0.08	14
	30	0.7	48	0.07	11
	50	0.6	38	0.06	9
West of Cabramatta Road	0	2.3	75	0.22	36
	10	1.1	51	0.10	16
	20	0.8	51	0.07	12
	30	0.7	42	0.06	10
	50	0.5	33	0.05	8

* *Assumed to be 10% by weight of total nitrogen oxides at kerbside, 15% at 10m and 20% at 20m, 30m and 50m*

Table 11 – Predicted increase in 1-hour average ground level concentrations of vehicle emission in 2016

Roadway Section	Distance from the kerb (m)	Carbon Monoxide (mg/m^3)	Nitrogen Dioxide ($\mu g/m^3$)	Hydrocarbons (mg/m^3)	Particulate Matter ($\mu g/m^3$)
WSO route					
North of Camden Valley Way	0	5.5	189	0.53	92
	10	2.8	143	0.27	47
	20	2.2	149	0.21	36
	30	1.9	127	0.18	31
	50	1.5	102	0.14	25
North of Bernera Road	0	5.2	177	0.49	86
	10	2.6	136	0.25	44
	20	2.1	142	0.20	35
	30	1.8	120	0.17	29
	50	1.4	98	0.14	24
North of Cowpasture Road	0	5.5	187	0.52	91
	10	2.7	139	0.26	45
	20	2.1	144	0.20	35
	30	1.8	122	0.17	30
	50	1.4	98	0.14	24
South of Elizabeth Drive	0	5.5	187	0.52	91
	10	2.7	139	0.26	45
	20	2.1	144	0.20	35
	30	1.8	122	0.17	30
	50	1.4	98	0.14	24
Elizabeth Drive to The Horsley Drive	0	5.6	149	0.47	51
	10	2.6	105	0.22	28
	20	2.0	111	0.17	22
	30	1.7	93	0.15	18
	50	1.4	76	0.12	15
The Horsley Drive to Old Wallgrove Road	0	6.8	191	0.56	66
	10	3.3	140	0.28	32
	20	2.5	145	0.22	25
	30	2.2	125	0.18	22
	50	1.8	101	0.15	17
Old WallgroveRoad to M4 Motorway	0	5.7	160	0.47	53
	10	2.5	107	0.21	23
	20	1.9	108	0.16	17
	30	1.6	91	0.14	14
	50	1.3	74	0.10	12
M4 Motorway to Great Western Highway	0	5.5	150	0.45	48
	10	2.8	113	0.23	24
	20	2.2	118	0.18	28
	30	1.9	101	0.15	16
	50	1.5	84	0.13	13
Great Western Highway to Power Street	0	6.4	171	0.52	52
	10	3.1	125	0.25	25
	20	2.4	130	0.20	20
	30	2.1	111	0.17	17
	50	1.7	91	0.14	14
Power Street to Richmond Road	0	5.8	149	0.47	41
	10	2.9	109	0.23	21
	20	2.2	113	0.18	16
	30	1.9	98	0.15	14
	50	1.6	79	0.13	12

Table 11 – Predicted increase in 1-hour average ground level concentrations of vehicle emission in 2016 (Cont.)					
Richmond Road to Quakers Hill Parkway	0	5.8	154	0.47	48
	10	2.8	113	0.23	24
	20	2.2	119	0.18	20
	30	1.9	101	0.15	16
	50	1.5	81	0.13	14
Quakers Hill Parkway to Sunnyholt Road	0	6.8	176	0.54	51
	10	3.2	125	0.25	25
	20	2.4	130	0.20	20
	30	2.1	111	0.17	16
	50	1.7	89	0.14	14
Sunnyholt Road to Norwest Blvd	0	6.7	178	0.54	56
	10	3.0	124	0.25	28
	20	2.3	128	0.20	22
	30	2.0	108	0.10	18
	50	1.6	89	0.13	15
Norwest Blvd to Old Windsor Road	0	4.1	113	0.35	37
	10	1.9	83	0.16	18
	20	1.5	86	0.13	15
	30	1.3	74	0.10	13
	50	1.0	59	0.08	10
Old Windsor Road to Abbott Road	0	4.7	134	0.39	46
	10	2.2	98	0.18	23
	20	1.7	101	0.15	18
	30	1.4	86	0.13	16
	50	1.2	69	0.10	13
Elizabeth Drive					
East of Mamre Road	0	2.6	91	0.25	44
	10	1.2	63	0.12	21
	20	0.9	64	0.09	16
	30	0.8	54	0.07	13
	50	0.6	43	0.06	10
West of Cabramatta Road	0	2.4	84	0.23	41
	10	1.1	56	0.10	18
	20	0.8	56	0.08	14
	30	0.7	46	0.06	11
	50	0.5	36	0.05	9

** Assumed to be 10% by weight of total nitrogen oxides at kerbside, 15% at 10m and 20% at 20m, 30m and 50m*

8.1.2 Nitrogen dioxide

Estimating nitrogen dioxide concentrations is more complicated than estimating carbon monoxide concentrations. As discussed previously, nitrogen oxides are initially emitted as a mixture of nitric oxide and other oxides of nitrogen, which are oxidised to nitrogen dioxide. At the point of emission the mixture is generally about 5% nitrogen dioxide by mass. However, while the maximum concentrations of total oxides of nitrogen generally occur during peak hour, this is not necessarily the case for nitrogen dioxide. An extensive monitoring program undertaken by the RTA (**RTA, 1997**) indicates that during peak hour the percentage nitrogen dioxide at 10 m from the roadway edge is likely to be about 5%. The conversion rate from nitric oxide to nitrogen dioxide at other times of the day may be significantly higher than this although the total oxides of nitrogen levels may be significantly lower than peak hour levels. It is necessary therefore to assume some intermediate value for a worst-case assessment.

Data from the RTA program indicates that at 10 m from the roadway a conversion rate of 15% by weight is still conservative but more realistic than the 20% assumed in previous EIS studies. At distances of 30 - 60 m from the kerbside the 20% conversion rate appears to be appropriate.

There are no monitoring data for the kerbside location in the present study, but it is considered that a 15% conversion rate at 10 m is likely to still be conservative. Conversion rates of 10% and 15% have been used at 0 m and 10 m respectively, while a rate of 20% has been assumed for the remaining distances of 20 m, 30 m and 50 m.

Taking this into consideration, the highest predicted increase in 1-hour nitrogen dioxide concentration 10 m from the proposed roadways in 2006 is 135 $\mu g/m^3$ north of Camden Valley Way in 2006 and 143 $\mu g/m^3$ in the same section in 2016. This is below the NEPM goal of 245 $\mu g/m^3$. The concentrations at 50 m from the roadway edge are substantially lower (102 $\mu g/m^3$). When added to the measured 1-hour average nitrogen dioxide concentration of 45 $\mu g/m^3$ (**Table 5**) the levels remain below the NEPM goal, and also the long term reporting goal of 200 $\mu g/m^3$.

It should be noted that predictions do not take into account fully the benefits of three way catalytic converters which are fitted to all new (fuel injected) petrol fuelled passenger vehicles in Australia and which substantially reduce oxides of nitrogen emissions. Nor (more significantly) do they take account of controls on diesel vehicles which are being implemented through new design rule ADR-70. Heavy vehicles comprise a significant proportion of vehicles in this assessment, so any advances in technology which will help reduce emissions from diesel vehicles will significantly reduce roadside oxides of nitrogen levels.

The NEPM standard for nitrogen dioxide adopted by the NSW EPA, would currently be difficult to achieve in many areas of Australia, most notably in the vicinity of a busy road carrying a high percentage of diesel vehicles. The approach adopted by NEPC is that compliance with standard will be achieved over a ten year time frame through a raft of measures including source control. These controls are to be left to individual jurisdictions to determine and implement. This approach is reflected in the NSW EPA Air Quality Management Plan (**NSW EPA, 1998**) which targets diesel emissions and heavy industry.

It is therefore likely that by 2016 the fleet emissions will be substantially lower than those assumed in the modelling presented in this report. It is expected that despite the projected traffic growth, pollutant levels will not exceed acceptable levels. It should also be noted that the traffic numbers assumed in the modelling represent peak traffic on the worst day rather than the average peak traffic levels.

8.1.3 Hydrocarbons

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

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

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

From **Tables 10** and **11** the predicted maximum 1-hour increase in total hydrocarbons is of the order of 0.27 mg at 10 m the kerb. Assuming a 5% benzene composition in the exhaust, the benzene concentration at 10 m from the kerb would be approximately 0.014 mg/m^3 or 14 µg/m^3 1-hour average under unfavourable dispersion and with a peak traffic flow. This is just below the UK goal of 16 µg/m^3. However it must be emphasised that this is a worst-case 1-hour prediction. The long-term concentrations would be substantially less than the short-term peaks as they are averaged over conditions which include much lower traffic flows and much better atmospheric dispersion. Concentrations would of course, be substantially lower at the locations of residences and other sensitive receptors such as schools.

For example, the closest approach which the roadway makes to the grounds of Sule College is approximately 100 m. At this distance maximum level 1-hour levels of benzene due to roadway emissions would be approximately 5 mg/m^3 and long-term levels would be substantially less, therefore constituting a very low level of risk.

The current understanding of long-term health risks is that they are a function of average lifetime exposure levels. For example, as discussed in **Section 3.3**, WHO estimated that the risk of developing leukaemia with a lifetime exposure to ambient concentrations of 1 µg/m^3 of benzene is 4.4×10^{-6} - 7.5×10^{-6}. This is referred to as a unit risk estimate.

Levels of benzene can range from 3 µg/m^3 in a rural environment to up to a 160 µg/m^3 in an urban environment, higher close to service stations and storage tanks with typical levels of about 20 µg/m^3 in residential areas.

8.1.4 Particulate matter

A preliminary assessment of PM_{10} concentrations has been undertaken using the Caline4 model. These predicted levels however are for 1-hour averaging periods while the air quality goal refers to a 24-hour period. Comparing these is therefore a conservative approach, (therefore an over prediction) as the maximum predicted 1-hour average will always be higher than the predicted 24-hour average. The relationship between the predicted 1-hour maximum and the 24-hour average will obviously vary with meteorology and daily traffic flow. An empirical averaging time correct factor of 0.24 has been suggested by **Katestone Scientific (1995)** to convert 1-hour predictions to 24-hour averages. This factor however, is not site specific and while it provides a reasonable estimate of the relationship between the 1-hour peak and the 24-hour average it cannot be regarded as rigorous.

To provide a more realistic estimate of the 24-hour average, taking account of the variation in traffic flow and meteorological conditions throughout the day, a different model, Cal3qhc, has been used which is able to calculate both 24-hour and annual average concentrations for particulate matter. This model is part of the package known as Breeze Roads described in **Section 5**. Cal3qhc was used to assess the 24-hour and annual average PM_{10} concentrations for the section of road between The Horsley Drive and Old Wallgrove Road for 2016 and the section of road south of Elizabeth Drive. These sections were chosen because they were shown in **Table 11** to be the sections resulting the highest roadside concentrations of particulate matter for the northern and southern sections of the route. The results of this additional modelling are listed in **Table 12.**

Table 12 – Predicted increase in 24-hour and annual average PM_{10} concentrations in 2016 due to WSO				
Distance from the kerb (m)	24-hour average ($\mu g/m^3$)		Annual average ($\mu g/m^3$)	
	Between Horsley Drive and Old Wallgrove Road	South of Elizabeth Drive	Between Horsley Drive and Old Wallgrove Road	South of Elizabeth Drive
0	22.9	12.5	6.3	4.8
10	13.8	7.3	3.3	2.8
20	11.0	5.6	2.6	2.1
30	9.3	4.7	2.2	1.8
50	7.2	3.7	1.7	1.4

At distances from the road where people would spend a substantial amount of time (30 – 50 metres) the predicted maximum 24-hour increase is less than 10 $\mu g/m^3$ and the annual average increase is approximately 1 – 2 $\mu g/m^3$. Background levels measured for the project were near existing roadways and were on occasion greater then the goal of 50 $\mu g/m^3$. Adding the maximum predicted to the maximum measured would also lead to an exceedance of the goal. However, the predictions do not take account of the newly introduced controls on diesel emissions, which should have a significant effect on the heavy-duty fleet by 2016. This would affect both emissions from the roadway and background levels. It must also be remembered that the background level was measured close to existing roadways and includes emissions from traffic already in the area and there is therefore an element of double counting when adding these to predicted concentrations. Further, the EPA PM_{10} goal is a regional target and will not be met everywhere in Sydney, particularly next to busy roads until the new emission control measures and management strategies outlined in Action for Air are fully implemented.

8.2 Peripheral Roads

The aim of this report is to assess the likely air quality impacts for the proposed roadway. However, there will be some peripheral roads associated with the project that may experience changes in traffic if the proposal proceeds. For example, those roads near interchanges may experience increases in traffic as vehicles enter or leave the Orbital via these roads. A brief modelling exercise was carried out for a number of these roads which may be affected. These roads and the estimated traffic volumes for the "No build" and "Build" scenarios are listed in **Table 13**. The resulting roadside concentrations at 10 m from the roadway are listed in **Table 14** and **Table 15**.

Note that those sections which are shaded in these two tables represent those side roads which show a 10% (approximately) or more increase for one or more of the pollutants when the Orbital is operational under a tolled system. As will be shown in the tables it does not necessarily mean that the predicted concentrations are high, just that the increase is more than 10% with respect to the "no build" case when the Orbital is operational. Note as discussed that the predictions relate to traffic data

Table 13 – Estimated peak hour (AM) traffic for the "No build" and "Build" scenarios				
Roadway	No Build		Build	
	NB/EB	SB/WB	NB/EB	SB/WB
2006				
Bernera Rd, South of Jedda Rd	366	243	572	152
Jedda Rd, North of Bernera Rd	366	243	640	282
The Horsley Dr, West of Ferres Rd	740	740	903	903
Wallgrove Rd, North of Elizabeth Dr	1132	395	361	44
Wallgrove Rd, South of the M4	1340	1340	129	128
Humphries Rd, East of Canley Vale Road	300	340	340	330
Lalor Road, East of Hambledon Road	330	390	150	560
Mamre Road, North of Elizabeth Drive	180	550	530	670
Mamre Road, North of Luddenham Road	450	460	730	570
Mimosa Road, South of The Horsley Drive	1200	270	950	100
The Horsley Drive, East of Gipps Road	190	400	450	280
The Horsley Drive, East of Smithfield Road	450	760	690	750
Woodstock Avenue, West of Rooty Hill Road	640	470	640	490
2016				
Bernera Rd, South of Jedda Rd	547	340	796	288
Camden Valley Way, East of the M5	1732	554	1606	1100
Camden Valley Way, West of the Hume Hwy	1272	1154	1289	1515
Jedda Rd, North of Bernera Rd	547	340	874	487
Kurrajong Rd, East of Bernera Rd	388	606	389	657
Kurrajong Rd, East of Wonga Rd	388	774	374	1020
The Horsley Dr, West of Ferres Rd	787	787	1186	1185
Wallgrove Rd, North of Elizabeth Dr	1185	376	244	41
Wallgrove Rd, South of the M4	1392	1392	81	81
Humphries Rd, East of Canley Vale Road	350	370	480	370
Lalor Road, East of Hambledon Road	230	300	180	490
Mamre Road, North of Elizabeth Drive	220	610	370	700
Mamre Road, North of Luddenham Road	510	510	590	600
Mimosa Road, South of The Horsley Drive	1100	360	1300	410
The Horsley Drive, East of Gipps Road	300	510	390	460
The Horsley Drive, East of Smithfield Road	550	900	580	830
Woodstock Avenue, West of Rooty Hill Road	740	540	800	620

Table 14 – Predicted increase in 1-hour average ground level concentrations of vehicle emission in 2006 at 10 m from the kerb

Roadway	Carbon Monoxide (mg/m^3)		Nitrogen Dioxide* ($\mu g/m^3$)		Hydrocarbons (mg/m^3)		Particulate Matter ($\mu g/m^3$)	
	No build	Build	No build	Build	No build	Build	No build	Build
Bernera Rd, South of Jedda Rd	0.7	0.8	32	37	0.06	0.07	10	11
Jedda Rd, North of Bernera Rd	0.7	1.0	32	46	0.06	0.09	10	14
The Horsley Dr, West of Ferres Rd	1.4	1.7	64	75	0.13	0.15	18	22
Wallgrove Rd, North of Elizabeth Dr	1.6	0.5	93	30	0.17	0.05	33	11
Wallgrove Rd, South of the M4	2.5	0.4	146	21	0.26	0.04	51	7
Humphries Rd, East of Canley Vale Road	0.7	0.7	30	31	0.06	0.06	6.8	7.5
Lalor Road, East of Hambledon Road	0.8	0.8	31	33	0.06	0.07	7.2	7.8
Mamre Road, North of Elizabeth Drive	0.8	1.2	37	52	0.07	0.10	9.2	12.9
Mamre Road, North of Luddenham Road	1.0	1.3	46	61	0.09	0.12	12.8	16.7
Mimosa Road, South of The Horsley Drive	1.5	1.1	66	46	0.13	0.09	17.5	11.7
The Horsley Drive, East of Gipps Road	0.7	0.8	42	41	0.07	0.08	13.8	11.6
The Horsley Drive, East of Smithfield Road	1.3	1.5	76	83	0.13	0.14	24.3	25.6
Woodstock Avenue, West of Rooty Hill Road	1.1	1.2	57	57	0.11	0.11	16.0	16.3

* *Assumed to be 15% by weight of total nitrogen oxides at 10m from the kerb.*

Table 15 – Predicted increase in 1-hour average ground level concentrations of vehicle emission in 2016 at 10 m from the kerb								
Roadway	Carbon Monoxide (mg/m^3)		Nitrogen Dioxide* ($\mu g/m^3$)		Hydrocarbons (mg/m^3)		Particulate Matter ($\mu g/m^3$)	
	No build	Build	No build	Build	No build	Build	No build	Build
Bernera Rd, South of Jedda Rd	0.9	1.0	43	52	0.08	0.10	13	16
Camden Valley Way, East of the M5	2.0	2.2	98	111	0.18	0.21	30	34
Camden Valley Way, West of the Hume Hwy	2.0	2.2	100	111	0.19	0.21	31	35
Jedda Rd, North of Bernera Rd	0.9	1.3	43	62	0.08	0.12	13	19
Kurrajong Rd, East of Bernera Rd	0.9	1.0	41	43	0.08	0.09	13	13
Kurrajong Rd, East of Wonga Rd	1.1	1.2	47	55	0.09	0.11	15	17
The Horsley Dr, West of Ferres Rd	1.4	1.9	66	93	0.13	0.18	19	27
Wallgrove Rd, North of Elizabeth Dr	1.5	0.4	94	23	0.16	0.04	34	8
Wallgrove Rd, South of the M4	2.4	0.2	148	14	0.25	0.02	53	5
Humphries Rd, East of Canley Vale Road	0.7	0.8	31	37	0.06	0.07	7.5	9.4
Lalor Road, East of Hambledon Road	0.5	0.7	24	30	0.05	0.06	5.6	7.2
Mamre Road, North of Elizabeth Drive	0.8	1.0	42	52	0.08	0.09	12.4	14.8
Mamre Road, North of Luddenham Road	1.0	1.1	50	57	0.09	0.10	14.0	16.1
Mimosa Road, South of The Horsley Drive	1.3	1.5	63	72	0.12	0.13	16.6	18.9
The Horsley Drive, East of Gipps Road	0.8	0.8	46	46	0.08	0.08	14.1	13.8
The Horsley Drive, East of Smithfield Road	1.4	1.3	76	72	0.13	0.13	22.9	22.0
Woodstock Avenue, West of Rooty Hill Road	1.2	1.3	61	66	0.11	0.12	17.4	19.1

* *Assumed to be 15% by weight of total nitrogen oxides at 10m from the kerb.*

The predicted concentrations due to roadway emissions in the vicinity of these roads is generally fairly low compared to the levels predicted in the vicinity of the Orbital, with the highest levels along sections of the Camden Valley Way and The Horsley Drive. The predicted increases for the "build" case over the "no-build" case are generally fairly small and would be unlikely to result in exceedances of air quality goals.

8.3 *Construction Impacts*

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

Estimates of dust emissions from construction operations can be made using emission factors developed by the **SPCC (1983)** (now EPA) and the **US EPA (1981, 1985)**. These emission factors relate the amount of dust generated by different types of equipment and operations associated with construction work. The most likely equipment to be used in the project includes bulldozers, backhoes, rollers, scrapers, excavators, pavers, concrete trucks, mobile cranes, truck-mounted boring rig, jackhammers and haul trucks. The major sources of dust would be the bulldozers, excavators, scrapers and wind erosion. An estimate of the amount of dust generated by each operation per day is summarised below. [The details of construction activities are not known at this stage, and so the following is given as an example of activities that are likely to take place].

- Three bulldozers, assuming ten-hours of operation per day generating dust at the rate of 2.75 kg/h, would give a total of 82.5 kg/day.
- Dust from loading of material by excavator to trucks assuming dust is generated at the rate of 0.01 kg/t and that 50 x 15 cubic metre trucks loads are removed in a ten-hour day, making a total of approximately 750 m^3 or approximately 1125 t of material removed per day gives a total dust generation of 11.25 kg/day.
- Scrapers generate dust at a rate of between 3 to 9 kg/kilometre of travel depending on soil silt content, soil moisture and the weight of the scraper. Watering the travelling surface would reduce this emission by between 50 and 80%. A scraper working for ten hours could be expected to travel approximately 70 to 100 km. Taking account of laden and unladen trips and 50% dust control the scraper would be expected to generate up to 300 kg of dust in a working day. With intensive watering of the travelling surface this could be reduced to 120 kg/day per scraper. A total of three scrapers would give 360 kg/day.
- Dust from trucks travelling on the unsealed road surface assuming a 400 m round trip distance, five movements per hour and 2 kg of dust/vehicle/km (after taking account of dust suppression by watering of the trafficked areas) would generate 40 kg during a ten-hour working shift.
- Dust from wind erosion from an exposed area of 200 m long by 30 m wide (the exposed area would be greater than this but the area which could contribute significant amounts of dust to a particular residence would be unlikely to be larger) assuming an erosion rate of 0.4 kg/ha/hour gives a total of 2.4 kg in ten hours.
-

Thus, for this example, the total dust generated in a ten-hour working day would be expected to be approximately 500 kg for a 200 m section of the roadway. (As noted above the working area and associated dust emissions would be greater than this, but for any given near road receptor, the most significant impacts would be from a fairly restricted section of the road). On a hot, dry, windy day the amount of dust from wind erosion could be much higher, and would have to be controlled using water sprays. It is possible that under some extreme wind conditions, construction activities would have to be stopped.

The appropriate air quality goal for determining impacts from construction work is the US EPA 24-hour goal for PM_{10} of 150 $\mu g/m^3$ (formerly noted by the NSW EPA). This is approximately equivalent to the former EPA 24-hour goal of 260 $\mu g/m^3$ for total suspended particulate matter (TSP). It is still useful to refer to this goal as many historical measurements are for TSP. The US EPA PM_{10} goal is considered to be appropriate in this instance as the emitted dust is of crustal origin and is likely to contain only a small fraction of $PM_{2.5}$ which is the particulate fraction of concern. When assessing particulate emissions from combustion processes (such as roadway emissions) which have a high $PM_{2.5}$ content, the more stringent PM_{10} goal of 50 µg/m^3 is appropriate.

Previous dispersion modelling studies (**Stephenson, 1991**) indicate that high levels of dust generation associated with road construction work, can result in short-term dust impacts. That is exceedances of the 24-hour air quality goal for TSP, out to 600 m or more under "worst-case" dispersion conditions and out to 300 m for typical conditions.

In addition to the goals for ambient dust concentrations it is appropriate to consider goals for dust deposition during the construction period. The EPA consider that residential areas begin to experience dust related nuisance impacts when annual average dust (insoluble solids) deposition levels exceed 4 g/m^2/month, and that dust impacts would be at unacceptable levels when they reached 10 g/m^2/month (**SPCC 1983**). In the early 1990s the EPA (**Dean et al., 1990**) refined these criteria. They are now expressed in terms of an acceptable increase in dust deposition over the existing background. For example, in residential areas with annual average deposition levels of between 0 and 2 g/m^2/month, an increase of up to 2 g/m^2/month would be permitted before it is considered that a significant degradation of air quality has occurred. **Table 16** shows the maximum acceptable increase in dust deposition over the existing dust levels.

Dust levels in the area are likely to be of the order of 1-2 g/m^2/month. Therefore an increase of 2 g/m^2/month could occur before there was a perceptible degradation in air quality.

Table 16 – EPA criteria for dust fallout

Existing dust fallout level (g/m^2/month)	Maximum acceptable increase over existing fallout levels (g/m^2/month)	
	Residential	Other
2	2	2
3	1	2
4	0	1

As construction is likely to continue over several years, it is important that exposed areas be stabilised as quickly as possible and that appropriate dust suppression methods be used to keep dust impacts to a minimum. It is recommended that monitoring be carried out during the construction phase of the project to assess compliance with goals for dust concentration and deposition rates.

Exhaust emissions from construction equipment is not likely to be a significant issue as the equipment will be largely spread out and not operating at all hours. They are likely to be considerably less than those from the vehicle fleet using the proposed roadway on completion.

A further issue during construction is that dust sensitive industries located close to sites of construction should be identified and mitigative measures put into place. Industries which are dust sensitive include food preparation/processing industries (including abattoirs), manufacturing/processing industries such as electronic parts, pharmaceuticals and spray painting. This list is not exhaustive, but is indicative of the type of industry which may be affected. During the construction period any such industry would need to be identified and appropriately consulted.

8.4 *Greenhouse issues*

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

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

Australia is signatory to the "International Frame-work Convention on Climate Change" (Rio Convention), which commits Australia to programs of monitoring and reporting on greenhouse gas emissions. A target of the Rio Convention is that signatory countries should attempt to reduce greenhouse gas emissions to the levels that applied in 1990. At the Kyoto meeting the convention agreed that Australia would be allowed to reduce their emissions to 8% above the 1990 level, between 2008 and 2012.

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

Approximately 14% of NSW's total carbon dioxide emissions are estimated to come from the transport sector (**EPA, 1995**). At a broad level, the RTA has been involved in and implemented several strategic initiatives to address the issue of road transport related greenhouse gas emissions. These are:

- National Greenhouse Response Strategy

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

- RTA Greenhouse Reduction Plan

    The RTA has prepared a plan at a strategic level to address and provide policy in relation to greenhouse gas emissions resulting from its activities. A greenhouse emissions inventory of RTA activities has been carried out (**Beer et al., 1996**) and the findings incorporated into the RTA Greenhouse Inventory.

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

The RTA also continues to engage in other strategies to encourage the tightening of vehicle emissions standards. These include;

- working with the EPA to implement the State's Motor Vehicle Maintenance Program for lowering emissions, and on the introduction of vehicle emissions testing;
- enhancing the State's vehicle emissions enforcement resources; and,
- continuing its role on MVEC (Motor Vehicle Environment Committee) to encourage the early implementation of more stringent Australian Design Rules, including the revision of ADR-37/0X to tighten current light vehicle emission standards. A revision of ADR-70, is also in progress. This will also contribute to controlling emissions from diesel vehicles, which will be particularly important for oxides of nitrogen and particulate matter emissions (**RTA, 1995**).

In terms of the construction of the proposed additional lanes on the roadway, the new route is likely to result in better traffic flow and hence better fuel economy and therefore reduced greenhouse gas emissions.

An estimate of greenhouse emissions for the project has been undertaken. An estimate for the fuel used for the construction phase of the project and the fuel saved at various stages of the project is presented in **Table 17**. Also presented are associated emissions of carbon dioxide.

Table 17 - Estimate of fuel savings and greenhouse emissions for the project

	Fuel used/saved	CO_2 emitted/saved
Construction phase	70 Ml used	190 Mt emitted
2006 with WSO built	133 Ml saved	359 Mt saved
2016 with WSO built	152 Ml saved	414 Mt saved

On this basis, in the first year of opening (2006), there will be a net saving of fuel of 63 Ml and greenhouse emissions of 169 Mt compared to the no build case. In subsequent years there will also be net benefits.

8.5 *Regional air quality impacts*

While the cumulative effect on air quality in the Sydney airshed of the entire network of roads is clearly significant, the impact of a single roadway will be small. It is nevertheless useful to estimate the contribution of the Western Sydney Orbital to regional air quality.

The Metropolitan Air Quality Study has developed a detailed emissions inventory for the Sydney region and a methodology for estimating future emissions. With this information it is possible to estimate the effect of the proposed Western Sydney Orbital on emissions into the Sydney airshed. The effect of the proposed road on regional vehicle emissions has been assessed by calculating the total vehicle kilometres travelled for the Sydney network with and without its construction. Account has been taken of different emission rates from roadways under different travel conditions, that is freeway, arterial and residential.

Table 18 presents the calculated total motor vehicles emissions into the Sydney airshed, with and without the proposed Western Sydney Orbital. The emissions are the product of the vehicle kilometres travelled and the emission rates estimated for different classes of roads in Sydney. The calculations presented are for the tolled option.

Table 18 – Total annual motor vehicle emissions from the Sydney network 2006 with and without the proposed Western Sydney Orbital (Tonnes)

Emission	Without Orbital	With Orbital	Percentage difference
CO_2	122,666	12,307	2.8%↓
CO	378.72	376.81	0.5%↓
NO_x	68.33	68.46	0.2%↑
HC	26.97	26.79	0.7%↓
PM_{10}	4.21	4.16	1.2%↓

The differences in emissions with and without the road are small. The increase in vehicle kilometres travelled for freeway travel is offset by the decreased travel time and associated emissions under these conditions, apart from emissions of NO_x which increase with speed. There is a 1.2 percent decrease in particulate matter (PM_{10}) with the proposed road built and a 0.2 percent increase in nitrogen oxides.

8.6 Mitigation measures

The Western Sydney Orbital will provide a general benefit to the region and the whole of the Sydney network in terms of fuel consumed and hours of travel. The project however comprises a major roadway which will be built where there was previously no road therefore close to WSO there will inevitably be levels of pollution which were not experienced before. However, the modelling indicates that the air quality will be acceptable at all sensitive receptors along the route and the design will be such as to minimise the impact of the road. Mitigative measures which are incorporated into the roadway design include the following.

- Electronic tolling which reduces emissions by reducing stop/start conditions;
- Well designed off-ramps and intersections to minimise queuing.

In addition, a set back distance from the roadway of 30 m is recommended for any future development. This will help to reduce the impact of roadway emissions. The roadway will also be designed so that public transport options are not excluded.

8.7 Implication of changes to land use and WSO modifications

Since the EIS was exhibited there have been a number of design modifications proposed . In addition an update of land use has been provided as part of the Representations Report. These have been reviewed and it is considered that none of these will have any substantial impact on the air quality assessment. The assessment has been carried out so that pollutant levels at specific distances from the roadway have been calculated, therefore any chang any changes to the conclusions of the report that, at specified distances from the roadway, air quality will be at acceptable levels.

The most significant change in the roadway is to the horizontal alignment at Cecil Hills of up to 250 m westwards. This will move the roadway to a substantial distance from the existing residential developments. However there is likely to be future development closer to the roadway and as noted in the mitigative measures a set back distance of 30 m to any new residential development is recommended.

9 CONCLUSIONS

The results of the air quality assessment undertaken for this EIS conclude that:

1. Due to the present emission controls on motor vehicles and the projected traffic conditions for the years 2006 and 2016, the EPA's carbon monoxide 1-hour or 8-hour goals are not expected to exceeded for any section of the proposed route.
2. The historical PM_{10} annual and 24-hour maximum air quality goals are not predicted to be exceeded by the project. However, the short-term NEPM goal adopted by the NSW EPA may be exceeded at the kerb under worst-case conditions when maximum background levels are taken into consideration.
3. The predicted increases in concentration of nitrogen dioxide indicate that the NEPM newly adopted EPA goals (both short-term and long-term reporting) would not be exceeded at 10 m from the kerb along any section of the route.
4. Predicted concentrations of benzene (and other pollutants) are not at levels which, from current understanding, should pose health effects. However, it is recognised that there may be no safe level for exposure to benzene and it is prudent to minimise risk.
5. There are a number of side roads which are predicted to experience increases in ground-level concentrations of pollutants if the building of the Orbital proceeds. These roadways have generally lower emissions than the Orbital, and the increases are not expected to increase concentrations to levels which would cause exceedances of the relevant air quality goals.

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

For this project, no exceedances of air quality goals are predicted at nearby sensitive receptors. However the general issue of controls on nitrogen oxides and particulate emissions is being addressed by the Air Quality Management Plan for the Sydney region which is summarised in the "Action for Air" document recently released by the EPA. General compliance in the Sydney airshed with the new more stringent goals for these pollutants, will be reliant in part upon implementing controls on diesel emissions.

10 REFERENCES

Australian Bureau of Statistics (ABS) (1992)
"Australia's Environment Issues and Facts" AGPS, Canberra

Beer T, Galbally I and Howden M (1994)
"Greenhouse Gas Inventory Victoria" prepared by the Environment Protection Authority Victoria, March 1994 ISBN 0 7306 2829 9.

Bureau of Meteorology (1988)
"Climatic Averages Australia", Australian Government Publishing Service Canberra., ISBN 0 644 06943 0.

Carnovale F, Tilly K, Stuart A, Carvalho C, Summers M and Eriksen P (1997)
"Metropolitan Air Quality Study – Air Emissions Inventory" prepared by the Environment Protection Authority of Victoria, 1997

Coffey & Partners (1995)
"Air Quality Monitoring Proposed Highway Link Prestons to West Baulkham Hills".

Dean M, Holmes N and Mitchell P (1990)
"Air Pollution from Surface Coal Mining Community Perception, Measurement and Modelling", Proceedings of the International Clean Air Conference 1990, Aukland, New Zealand, March 25-30, p 215-222.

Dockery D W, Pope C A, Xu X, Spengler J D, Ware J H, Fay M E, Ferris B G and Speizer F E (1993)
"An association between air pollution and mortality in six US cities" The New England Journal of Medicine, **329**, 1753-1759.

Eiser C R and Koo F(1984)
"Emission Trends for Hydrocarbons and Nitrogen Oxides from Stationary Sources in Sydney" Proceedings of the Eighth International Clean Air Conference, Melbourne, 8-11 May.

EPA (1995)
"NSW Greenhouse Gas Inventory Report - Estimate for 1990 and 2000" prepared by the NSW EPA ISBN 0 7310 3770 7.

EPA (1998)
"Action for Air", the NSW Government's 25-Year Air Quality Management Plan

Hyde R and Johnson G M (1990)
"Pilot Study: Evaluation of air quality issues for the development of the Macarthur South and South Creek Valley regions of Sydney".

Katestone Scientific (1995)
"Road Traffic Pollution at Facilities Housing Sensitive Receptors- Design Criteria" prepared for the Brisbane City Council by Katestone Scientific, September 1995.

Nelson P F and Quigley S M (1982)
"Atmospheric Hydrocarbons in Sydney: Compositions of the Sources" In "The Urban Atmosphere Sydney a Case Study" Edited by Carras J.N. and Johnson G.M., Proceedings of a Conference organised by CSIRO.

Nigel Holmes & Associates (1992)
"Air Quality Assessment, M5 Casula Link" working paper prepared for Stephenson & Associates, 1992

Nigel Holmes & Associates (1994)
"Air Quality Assessment, Proposed Motorway Billinudgel to Chinderah" working paper prepared for Sinclair Knight, 1994

Pengilley M (1989)
"Motor Vehicle Emission Factors for 1988 and 2000" State Pollution Control Commission, Noise and Transport Branch, GPO Box 4036, Sydney.

RTA (1995)
"RTA's Plan for Reducing Vehicle Emissions" RTA, The Environment and Community Impact Branch. ISBN 0 7310 49381.

RTA (1997)
"RTA Air Quality Monitoring Program" prepared for the RTA by Holmes Air Sciences, January 1997.

SPPC (1983)
"Pollution Control in NSW: A Progress Report", Supplement of 1982, 1983 Annual Report.

Stephenson (1991)
"Air Quality Study, North West Transport Links, Environmental Impact Statement" Stephenson & Associates, August 1991.

US EPA (1981)
"Improved Emission Factors for Fugitive Dust from Western Surface Coal Mining Sources", US EPA, Office of Research and Development, Cincinnati, Ohio.

US EPA (1985)
"Complication of Air Pollutant Emission Factors", AP-42, Forth Edition United States Environmental Protection Agency, Office of Air and Radiation Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.

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

VEPA (1986)
"The Ausplume Gaussian Plume Dispersion Model", Environment Protection Authority, Olderfleet Buildings, 477 Collins Street, Melbourne Victoria 3000, Publication Number 264.

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

WHO (1995)
"Updating and Revision of Air Quality Guidelines for Europe". Report on a WHO Working Group on Volatile Organic Compounds, Brussels, Belgium 1-6 October 1995."

Williams D J, Carras J N, Shenouda D, Drummond M S and Lange A L (1994)
"Traffic generated pollution near roads and highways: models and measurements" prepared by CSIRO Division of Coal and Energy Technology for the RTA, March 1994 Investigation Report CET/IR238.

ATTACHMENT A
EPA MONITORING DATA

BLACKTOWN	O_3 (pphm)		NO_2 (pphm)		NOx (pphm)		NO (pphm)		PM_{10} ($\mu g/m^3$)		TEOM-PM_{10} ($\mu g/m^3$)		SO2 (pphm)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)						NEPM Standard 50 μg/m3 (24hr max)				NHMRC Goal 20 pphm (1hr max)		WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-93	0.8	10.4	0.9	4.5	1.3	10.3	0.3	6.1	21	28	*	*	0.1	1.4	0.1	2.1
Feb-93	0.8	12.5	1.1	5	1.7	18.4	0.4	15	17	25	*	*	0.1	1.7	0.5	3.7
Mar-93	0.4	7.8	1.1	6	2	16.7	0.6	14.1	20	37	*	*	0.1	1.1	0.4	2.9
Apr-93	0.4	4.6	1.8	10.4	3.8	44.3	1.5	38.8	19	25	*	*	0.1	2.8	0.6	5.3
May-93	0.2	3.2	2.1	6.4	5.2	48.2	2.3	41.8	25	30	7.4	*	0.2	1.3	*	*
Jun-93	0.2	2.2	1.9	9	4.6	52.3	2.2	44.7	24	45	11.8	*	0.7	1.6	*	*
Jul-93	0.2	2.3	2.1	7	5.8	49.4	3.1	44.9	30	48	12.8	*	0.4	1.8	*	*
Aug-93	0.4	3.2	1.5	6.3	2.8	39.9	1	35.5	14	20	12.2	*	*	*	*	*
Sep-93	0.5	4.6	1.4	4.2	2.3	19.2	0.7	16.2	34	120	12	*	*	*	*	*
Oct-93	0.7	5.5	1.2	3.8	1.6	14.6	0.4	12.1	19	32	13	*	*	*	*	*
Nov-93	0.7	6.7	1	5	1.5	12.9	0.4	10.6	16	24	14	*	*	*	*	*
Dec-93	0.7	6.4	0.9	5.4	1.3	16.8	0.4	15.1	28	46	15	*	*	*	*	*
Annual Ave	**0.5**		**1.4**		**2.8**		**1.1**		**22.3**		**12.3**		**0.2**		**0.4**	
Maximum		**12.5**		**10.4**		**52.3**		**44.9**		**120.0**		**0.0**		**2.8**		**5.3**
Jan-94	0.8	8.8	0.9	5.7	1.2	14.3	0.3	11.7	33	126	22.4	*	*	*	*	*
Feb-94	0.6	11.4	1.1	4.2	1.7	17.3	0.4	16.1	15	17	15.4	*	*	*	0.3	2.9
Mar-94	0.3	5	1.1	3.2	2	22.1	0.7	21.3	13	16	11.6	*	*	*	0.3	3.7
Apr-94	0.3	4.7	1.1	4.7	2.1	18	0.7	16.2	35	106	17	*	*	*	0.5	3.2
May-94	0.4	4.8	1.3	8.1	2.5	44.8	0.8	39.2	33	74	19	*	*	*	0.5	8.7
Jun-94	0.3	2.4	1.6	5.2	3.4	31.1	1.3	27.4	28	54	12	*	*	*	0.7	5.5
Jul-94	0.3	2.6	1.6	5.8	3.4	36.1	1.4	31.8	29	41	12	*	*	*	0.6	5.8
Aug-94	0.6	4.1	1.6	6.7	2.5	37.3	0.7	32.6	29	34	17	*	*	*	0.4	5.8
Sep-94	0.7	5.6	1.3	6.9	2	30.6	0.5	26.6	20	26	14	*	*	*	0.4	4.9
Oct-94	0.7	6.3	1.4	8.1	2	26.9	0.5	20.3	20	26	14	*	*	*	0.3	3.8
Nov-94	1	9.4	1	5.3	1.3	16.6	0.3	11.8	23	43	12	*	*	*	0.3	2.8
Dec-94	0.7	7.2	1	4.4	1.3	11.1	0.3	9.1	18	28	18	*	*	*	0.3	2
Annual Ave	**0.6**		**1.3**		**2.1**		**0.7**		**24.7**		**15.4**				**0.4**	
Maximum		**11.4**		**8.1**		**44.8**		**39.2**		**126.0**						**8.7**

BLACKTOWN cont'd	O$_3$ (pphm)		NO$_2$ (pphm)		NOx (pphm)		NO (pphm)		PM$_{10}$ (µg/m^3)		TEOM-PM$_{10}$ (µg/m^3)		SO2 (pphm)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)						NEPM Standard 50 µg/m3 (24hr max)				NHMRC Goal 20 pphm (1hr max)		WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-95	0.5	5.4	1	4.5	1.3	18.1	0.4	16.1	14	18	11	*	*	*	0.4	4.2
Feb-95	0.5	5.5	1	4.9	1.6	21.9	0.5	19	22	28	13	*	*	*	0.3	3.1
Mar-95	0.5	5.5	1.3	5.9	1.7	19.7	0.2	3	23	29	12	*	*	*	0.4	3.3
Apr-95	0.4	4.1	1.4	4.4	2.3	18.9	0.7	16.4	22	31	14	*	*	*	0.4	3.3
May-95	0.3	2.5	1.4	4.9	2.8	33.8	0.9	29.7	13	20	10	*	*	*	0.5	5.5
Jun-95	0.4	2.3	1.5	5.2	3.2	33.9	1.2	31.4	23	34	9	*	*	*	0.5	6.3
Jul-95	0.4	2.7	1.3	4.6	2.8	42.9	1.2	38.7	20	36	13	*	*	*	0.5	7.1
Aug-95	0.5	4.7	1.5	5.6	2.7	26.9	0.9	24	33	40	20	*	*	*	0.4	4.9
Sep-95	0.6	3.7	1.4	4.2	2.1	17	0.5	14.9	14	16	11	*	*	*	0.3	3
Oct-95	0.7	5.3	1.3	6.3	1.9	21.6	0.4	17.1	13	19	13	*	*	*	0.3	2.8
Nov-95	0.8	5.9	1.2	4.9	1.6	15.4	0.3	12.6	18	27	10	*	*	*	0.3	2.5
Dec-95	0.8	5.3	1	5.5	1.5	11.6	0.3	9.4	18	21	14	*	*	*	0.3	1.6
Annual Ave	**0.5**		**1.3**		**2.1**		**0.6**		**19.4**		**12.5**	*			**0.4**	
Maximum		**5.9**		**6.3**		**42.9**		**38.7**		**40.0**		**0.0**				**7.1**
Jan-96	0.5	8.2	0.9	4.9	1.2	18.9	0.3	17.3	16.0	23.0	11.0	101.0	*	*	0.3	2.3
Feb-96	0.5	7.5	1.0	5.2	1.6	21.3	0.5	19.5	19.0	25.0	14.0	54.0	*	*	0.3	3.3
Mar-96	0.4	5.1	1.1	3.9	2.1	25.8	0.7	24.4	17.0	25.0	13.0	128.0	*	*	0.3	3.8
Apr-96	0.4	4.4	1.3	5.9	2.3	26.5	0.7	23.8	18.0	25.0	13.0	64.0	*	*	0.4	3.5
May-96	0.3	1.5	*	*	*	*	*	*	14.0	19.0	13.0	132.0	*	*	0.3	2.5
Jun-96	0.3	2.3	1.4	4.1	3.3	35.7	1.3	32.7	22.0	31.0	12.0	72.0	*	*	0.6	5.7
Jul-96	0.4	2.5	1.3	4.2	3.1	34.8	1.4	31.1	19.0	30.0	12.0	65.0	0.1	2.0	0.4	5.6
Aug-96	0.6	2.8	1.1	4.7	1.8	26.9	0.6	23.1	14.0	17.0	10.0	78.0	0.1	0.9	0.3	5.1
Sep-96	0.9	4.5	1.1	4.7	1.6	20.8	0.4	17.0	15.0	25.0	10.0	52.0	0.1	1.2	0.3	2.6
Oct-96	0.9	5.7	1.2	5.1	1.8	19.3	0.4	16.3	17.0	23.0	13.0	43.0	0.1	1.2	0.2	2.5
Nov-96	1.1	6.4	0.9	4.4	1.2	20.2	0.3	16.6	18.0	30.0	12.0	86.0	0.1	0.7	0.2	2.6
Dec-96	0.9	6.6	1.0	3.8	1.3	10.4	0.3	8.5	21.0	28.0	15.0	81.0	0.1	0.9	0.3	1.5
Annual Ave	**0.6**		**1.1**		**1.9**		**0.6**		**17.5**		**12.3**		**0.1**		**0.3**	
Maximum		**8.2**		**5.9**		**35.7**		**32.7**		**31.0**		**132.0**		**2.0**		**5.7**

BLACKTOWN cont'd																
	O_3 (pphm)		NO_2 (pphm)		NO_x (pphm)		NO (pphm)		PM_{10} (µg/m^3)		TEOM-PM_{10} (µg/m^3)		SO_2 (pphm)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)						NEPM Standard 50 µg/m3 (24hr max)				NHMRC Goal 20 pphm (1hr max)		WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-97	0.6	10.1	0.9	4.0	1.5	14.5	0.4	13.1	18.0	25.0	13.0	65.0	0.1	1.0	0.3	1.9
Feb-97	0.7	10.5	1.1	4.0	1.6	15.6	0.4	14.2	13.0	22.0	13.0	53.0	0.1	1.1	0.3	1.9
Mar-97	0.7	7.2	1.2	3.8	1.8	24.2	0.4	21.8	15.0	24.0	17.0	106.0	0.1	1.2	0.4	3.7
Apr-97	1.0	5.7	*	*	*	*	*	*	27.0	31.0	23.0	165.0	0.2	1.6	0.6	5.4
May-97	0.4	2.8	1.3	5.5	2.4	30.3	0.8	25.6	21.0	34.0	*	*	0.2	1.4	0.4	4.3
Jun-97	0.4	2.6	1.6	6.5	3.4	50.9	1.2	45.4	22.0	35.0	*	*	0.2	1.5	0.5	6.7
Jul-97	0.4	2.6	1.3	3.8	2.4	29.2	0.7	26.5	15.0	27.0	13.0	48.0	0.1	1.8	0.4	4.6
Aug-97	0.6	4.9	1.7	5.5	2.9	18.1	1.0	16.6	18.0	44.0	14.0	135.0	0.1	0.6	0.5	3.5
Sep-97	0.6	4.7	1.3	4.0	2.2	25.2	0.6	21.8	15.0	20.0	10.0	116.0	0.1	0.9	0.4	3.1
Oct-97	1.0	6.8	1.2	4.7	1.8	17.0	0.4	14.7	15.0	17.0	17.0	65.0	0.2	1.0	0.3	2.0
Nov-97	1.1	14.9	1.3	5.2	1.6	15.4	0.3	13.3	20.0	29.0	20.0	151.0	0.1	1.0	0.4	2.3
Dec-97	1.1	8.7	1.0	9.7	1.3	19.2	0.3	13.8	31.0	41.0	23.0	176.0	0.2	1.8	0.5	3.3
Annual Ave	**0.7**		**1.3**		**2.1**		**0.6**		**19.2**		**16.3**		**0.1**		**0.4**	
Maximum		**14.9**		**9.7**		**50.9**		**45.4**		**44.0**		**176.0**		**1.8**		**6.7**
Jan-98	0.8	10.9	1.0	3.4	1.2	13.1	0.3	11.7	16.0	19.0	16.0	97.0	*	*	0.3	1.6
Feb-98	1.0	10.9	1.2	5.6	1.7	20.4	0.4	17.2	26.0	35.0	18.0	149.0	*	*	0.4	2.8
Mar-98	0.7	8.4	1.3	6.0	1.9	24.3	0.4	19.9	31.0	66.0	18.0	230.0	0.1	2.0	0.5	3.7
Apr-98	0.5	5.5	1.5	5.2	2.5	24.0	0.8	19.5	14.0	23.0	13.0	72.0	0.2	1.3	0.4	3.1
May-98	0.3	2.7	1.5	4.6	3.0	42.7	1.0	38.1	21.0	35.0	13.0	82.0	0.1	0.8	0.8	7.0
Jun-98	0.4	2.4	1.3	4.7	2.5	40.6	0.8	36.0	16.0	28.0	10.0	58.0	0.1	1.1	0.7	6.1
"Annual" Ave	**0.6**		**1.3**		**2.1**		**0.6**		**20.7**		**14.7**		**0.1**		**0.5**	
Maximum		**10.9**		**6.0**		**42.7**		**38.1**		**66.0**		**230.0**		**2.0**		**7.0**

BRINGELLY																
	O_3 (pphm)		NO_2 (pphm)		NO_x (pphm)		NO (pphm)		TEOM-PM_{10} (μg/m3)		SO_2 (pphm)		PM_{10} (μg/m^3)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)								NHMRC Goal 20 pphm (1hr max)		NEPM Standard 50 μg/m3 (24hr max)		WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-93	0.7	9.4	*	*	*	*	*	*	*	*	0.1	2	22	27	*	*
Feb-93	0.6	9.6	*	*	*	*	*	*	*	*	0.1	2	18	21	*	*
Mar-93	0.4	5.3	0.4	2.9	1.9	4.9	1.4	3.8	*	*	0.1	2	17	32	0.3	1.2
Apr-93	0.5	4.9	0.3	3.2	1.9	6.3	1.3	5.6	14.6	*	0.1	1.5	24	31	0.5	1.4
May-93	0.4	3.7	0.3	2.8	2.2	8.3	1.8	8.3	14.6	*	0.1	1	21	23	0.3	1.3
Jun-93	0.4	2.7	0.2	2.5	1.7	9.3	0.9	8.8	12.3	*	0.2	1.3	18	45	*	*
Jul-93	0.3	2.9	0.6	2.6	1.7	10.5	0.7	10.1	11.7	*	0.2	0.4	22	39	*	*
Aug-93	0.6	3.9	0.5	3.9	1	8.2	0.3	6.4	11.9	*	0.2	1.3	18	28	*	*
Sep-93	0.8	5.2	0.7	4.6	0.7	8.7	0.2	7.4	9.9	*	*	*	10	21	*	*
Oct-93	0.9	5.9	0.6	3.1	0.7	4.3	0.2	0.5	12	*	*	*	17	18	*	*
Nov-93	0.9	7.3	0.4	2.7	0.6	4.5	0.2	2.7	13	*	*	*	15	20	*	*
Dec-93	0.9	8.2	0.4	3.3	0.6	5.6	0.3	4.5	15	*	*	*	24	41	*	*
Annual Ave	**0.6**		**0.4**		**1.3**		**0.7**		**12.8**		**0.1**		**18.8**		**0.4**	
Maximum		**9.6**		**4.6**		**10.5**		**10.1**		**0.0**		**2.0**		**45.0**		**1.4**
Jan-94	0.9	13	0.5	4.3	0.6	5.2	0.2	3.1	20	*	*	*	69	191	*	*
Feb-94	0.8	11.8	1.4	5.8	2.1	9.2	0.5	7.6	15.9	*	*	*	*	*	*	*
Mar-94	0.6	6.7	0.9	2.5	0.8	5.5	0.3	5	11.1	*	*	*	*	*	*	*
Apr-94	0.5	5.3	0.6	4.8	1.1	8	0.4	5.7	15	*	*	*	*	*	*	*
May-94	0.6	4.1	0.6	4.4	1	9.5	0.4	6.9	17	*	*	*	*	*	*	*
Jun-94	0.4	3	0.6	3.8	1	10.7	0.5	9.5	10	*	*	*	*	*	*	*
Jul-94	0.4	3.2	0.6	3.3	1.2	8.8	0.6	6.9	13	77	*	*	*	*	*	*
Aug-94	0.7	4.1	0.6	4	0.9	7.6	0.3	5.6	13	75	*	*	*	*	*	*
Sep-94	0.8	5.5	0.5	4.2	0.7	8	0.3	5	13	77	*	*	*	*	*	*
Oct-94	1	7.5	0.6	5	0.7	26.9	0.2	3.6	17	76	*	*	*	*	*	*
Nov-94	1.2	11.2	0.5	4.3	0.8	16.6	0.3	5	19	119	*	*	*	*	*	*
Dec-94	1.1	10.3	0.5	3.4	0.7	11.1	0.2	3.4	17	60	*	*	*	*	*	*
Annual Ave	**0.8**		**0.7**		**1.0**		**0.4**		**15.1**				**69.0**			
Maximum		**13.0**		**5.8**		**26.9**		**9.5**		**119.0**				**191.0**		

BRINGELLY cont'd																
	O_3 (pphm)		NO_2 pphm)		NO_x (pphm)		NO (pphm)		TEOM-PM_{10} (µg/m3)		SO_2 (pphm)		PM_{10} (µg/m^3)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)								NHMRC Goal 20 pphm (1hr max)		NEPM Standard 50 µg/m3 (24hr max)		WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-95	0.7	8.1	0.6	2.4	0.8	3.3	0.2	2.9	14	48	*	*	*	*	*	*
Feb-95	0.7	8.1	0.4	4	0.7	4.6	0.2	3	15	54	*	*	*	*	*	*
Mar-95	0.8	7.2	0.4	5.2	0.6	6.6	0.2	3	14	75	*	*	*	*	*	*
Apr-95	0.6	5.1	0.6	4.4	0.8	5.8	0.3	4.1	13	59	*	*	*	*	*	*
May-95	0.5	2.8	0.5	4.2	0.7	8.8	0.3	7.6	8	41	*	*	*	*	*	*
Jun-95	0.5	2.7	0.4	2.8	0.8	8.2	0.4	7.1	9	56	*	*	*	*	*	*
Jul-95	0.5	3.1	0.4	2.7	0.7	8.8	0.4	7.5	11	66	*	*	*	*	*	*
Aug-95	0.5	5.1	1.1	3.9	1.4	6.5	0.3	3.9	15	93	*	*	*	*	*	*
Sep-95	0.8	4.3	0.7	4.3	0.9	6.5	0.3	5	10	77	*	*	*	*	*	*
Oct-95	0.9	6.1	0.6	4.9	0.8	5.9	0.3	0.8	12	54	*	*	*	*	*	*
Nov-95	1	7.1	*	*	*	*	*	*	10	58	*	*	*	*	*	*
Dec-95	0.9	5.8	0.9	2.5	1.1	3	0.2	1.6.	12	35	*	*	*	*	*	*
Annual Ave	**0.7**		**0.6**		**0.8**		**0.3**		**11.9**							
Maximum		**8.1**		**5.2**		**8.8**		**7.6**		**93.0**						
Jan-96	0.7	9.7	*	*	1.1	21.3	0.1	9.7	8	210	*	*	*	*	*	*
Feb-96	0.7	9.8	0.3	2.7	0.5	3.9	0.2	3.4	11	249	*	*	*	*	*	*
Mar-96	0.6	4.9	0.4	3.8	0.8	4.4	0.3	4	14	89	*	*	*	*	*	*
Apr-96	0.6	4.5	0.5	3.2	0.8	7.1	0.3	5	12	127	0.1	0.2	*	*	*	*
May-96	0.5	3.4	0.5	2.5	0.9	7.6	0.4	6.7	11	72	0.1	0.3	*	*	*	*
Jun-96	0.4	2.8	0.5	2.1	1.1	6.2	0.5	5.7	9	60	0.1	0.4	*	*	*	*
Jul-96	0.4	2.8	0.4	2.5	0.8	6.9	0.4	5.6	9	78	0.1	0.4	*	*	*	*
Aug-96	0.7	3.3	0.4	2	0.6	5	0.3	4.1	9	62	0.1	0.9	*	*	*	*
Sep-96	0.9	5.3	0.5	3.5	0.8	5.2	0.3	4.2	10	54	0.1	0.8	*	*	*	*
Oct-96	0.9	6.2	0.5	3.7	0.7	4.4	0.2	2.2	12	61	0.1	0.6	*	*	*	*
Nov-96	1.1	8.3	0.3	4.3	0.5	4.8	0.2	2.2	12	78	0.1	0.5	*	*	*	*
Dec-96	1.1	8.9	0.5	2.4	0.6	3.3	0.2	2.3	15	93	0.1	0.9	*	*	*	*
Annual Ave	**0.7**		**0.4**		**0.8**		**0.3**		**11.0**		**0.1**					
Maximum		**9.8**		**4.3**		**21.3**		**9.7**		**249.0**		**0.9**				

BRINGELLY cont'd																
	O_3 (pphm)		NO_2 (pphm)		NOx (pphm)		NO (pphm)		TEOM-PM_{10} (µg/m3)		SO_2 (pphm)		PM_{10} (µg/m^3)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)								NHMRC Goal 20 pphm (1hr max)		NEPM Standard 50 µg/m3 (24hr max)		WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-97	0.7	11.5	0.4	2.9	0.6	4.2	0.2	3.7	12	67	0.1	0.7	*	*	*	*
Feb-97	0.8	10.1	0.4	2.8	0.5	3.2	0.2	2.6	12	57	0.1	1.2	*	*	*	*
Mar-97	0.8	8.1	0.4	2.4	0.6	4.4	0.2	3.5	14	92	0.1	0.5	*	*	*	*
Apr-97	1	5.2	0.6	6	0.9	7.8	0.3	4.7	20	116	0.1	1.1	*	*	*	*
May-97	0.5	3.2	0.4	4.1	0.8	10.6	0.4	7.6	9	46	0.1	0.7	*	*	*	*
Jun-97	0.6	2.9	0.3	2.8	0.6	9.4	0.3	8.1	12	130	0.1	0.4	*	*	*	*
Jul-97	0.7	3	0.5	2.9	0.8	7.7	0.4	6.2	7	89	0.1	0.8	*	*	*	*
Aug-97	0.8	5.5	0.4	3.1	0.6	6.7	0.3	5	10	112	0.1	0.6	*	*	*	*
Sep-97	0.7	6.3	0.5	3.3	0.7	7.1	0.2	4.2	8	121	0.1	0.6	*	*	*	*
Oct-97	1	7.4	0.5	3.4	0.7	4.4	0.2	2.3	16	72	0.1	0.8	*	*	*	*
Nov-97	1.2	13.5	0.6	2.6	0.7	4.4	0.2	3.3	16	104	0.1	0.5	*	*	*	*
Dec-97	1.1	11.4	0.6	4.2	0.8	4.8	0.2	3.2	20	142	0.1	0.8	*	*	*	*
Annual Ave	**0.8**		**0.5**		**0.7**		**0.3**		**13.0**		**0.1**					
Maximum		**13.5**		**6.0**		**10.6**		**8.1**		**142.0**		**1.2**				
Jan-98	0.8	9.7	0.6	2.3	0.8	4.1	0.2	2.9	15	101	0.1	0.7	*	*	*	*
Feb-98	0.9	11.3	0.6	3.2	0.7	5.1	0.2	3.1	17	89	0.1	0.9	*	*	*	*
Mar-98	0.8	10.0	0.6	5	0.9	5.1	0.2	3.5	17	87	0.1	0.8	*	*	*	*
Apr-98	*	*	0.6	2.8	0.9	5.6	0.3	5	11	149	0.1	1.3	*	*	*	*
May-98	0.6	3.0	0.5	3.2	0.8	8.3	0.3	7	11	89	0.1	0.4	*	*	*	*
Jun-98	0.6	2.7	0.3	2.5	0.6	7.6	0.3	6.7	10	104	0.1	0.4	*	*	*	*
Annual Ave	**0.7**		**0.5**		**0.8**		**0.3**		**13.5**		**0.1**					
Maximum		**11.3**		**5.0**		**8.3**		**7.0**		**149.0**		**1.3**				

LIVERPOOL														
	O_3 (pphm)		NO_2 (pphm)		NOx (pphm)		NO (pphm)		TEOM-PM_{10} (µg/m3)		TEOM-$PM_{2.5}$ (µg/m3)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		**NHMRC Goal** 16 pphm (1 hr max)										**WHO Goal** 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-93	0.7	10.1	1.1	7	1.4	10.8	0.3	8.9	*	*	*	*	*	*
Feb-93	0.7	8.5	1.3	6.4	1.6	17.6	0.4	14.4	*	*	*	*	*	*
Mar-93	0.4	5.4	1.2	3.7	1.7	21.8	0.6	18.9	*	*	*	*	*	*
Apr-93	0.4	4.7	1.6	7.7	2.5	22.1	0.8	17.4	*	*	*	*	*	*
May-93	0.4	6.4	1.7	6	3.8	42.9	1.5	37.1	*	*	*	*	*	*
Jun-93	0.2	1.8	1.3	6.1	2.5	36.9	0.9	30.8	*	*	*	*	*	*
Jul-93	0.1	1.1	1.4	8	3.5	31	1.5	26	15.1	*	*	*	*	*
Aug-93	0.2	2.1	1.1	4.8	2	26.8	0.6	22.5	14.2	*	*	*	*	*
Sep-93	0.3	4.5	1.2	5.5	2.4	24.7	0.9	23.2	13.2	*	*	*	*	*
Oct-93	0.3	3.3	1	3.7	1.7	19.9	0.6	16.8	14	*	*	*	*	*
Nov-93	0.3	5.9	0.7	4.1	1.3	12.6	0.4	11.7	14	*	*	*	*	*
Dec-93	0.4	7.5	1.3	12.3	2.3	20.4	0.7	13.6	16	*	*	*	*	*
Annual Ave	**0.4**		**1.2**		**2.2**		**0.8**		**14.4**					
Maximum		**10.1**		**12.3**		**42.9**		**37.1**						
Jan-94	0.6	11.3	0.8	4.5	1.4	18.1	0.5	16.1	20.6	*	*	*	*	*
Feb-94	0.4	9.5	1.2	5.9	2	20.1	0.6	0.6	16.7	*	*	*	0.4	2.1
Mar-94	0.3	4.8	1	4.1	2.2	18.4	0.9	0.9	11.3	*	*	*	0.4	2.9
Apr-94	0.3	5.3	1.1	6.3	2.8	34.4	1	30.8	18	*	*	*	0.5	6.4
May-94	0.3	4	1.7	9.3	3.9	53.4	1.4	47.8	20	*	*	*	0.5	7.3
Jun-94	0.2	2.2	1.8	9.1	4.5	49.6	1.8	46	17	*	*	*	0.7	7.1
Jul-94	0.3	2.6	1.9	6.7	4.8	70.6	2	65.2	16	95	*	*	0.8	8.5
Aug-94	0.4	4.4	1.7	7.3	2.9	46.2	0.8	41.2	16	73	*	*	0.4	6.6
Sep-94	0.5	4.6	1.1	6.4	1.9	30.4	0.7	27.5	15	70	*	*	0.4	5
Oct-94	0.4	8.3	1.2	6	2.1	21.4	0.7	18.9	16	69	*	*	0.5	3.4
Nov-94	0.7	7.7	1	4.6	1.4	16.9	0.3	12.3	19	114	*	*	0.4	2.6
Dec-94	0.5	7.2	0.9	4.7	1.4	18	0.3	15.4	17	62	*	*	0.4	1.7
Annual Ave	**0.4**		**1.3**		**2.6**		**0.9**		**16.9**				**0.5**	
Maximum		**11.3**		**9.3**		**70.6**		**65.2**		**114.0**				**8.5**

LIVERPOOL cont'd														
	O_3 (pphm)		NO_2 (pphm)		NOx (pphm)		NO (pphm)		TEOM-PM_{10} (µg/m3)		TEOM-$PM_{2.5}$ (µg/m3)		CO (ppm)	
	NHMRC Goal **10 pphm (1 hr max)**		**NHMRC Goal** **16 pphm (1 hr max)**										**WHO Goal** **25 ppm (1hr max)**	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-95	0.3	7.8	1	3.9	1.6	16	0.4	13.2	13	39	*	*	0.3	2.5
Feb-95	0.4	7.9	1.1	4.7	2.1	23.2	0.6	21.6	16	51	*	*	0.6	2.3
Mar-95	0.4	6.1	1	5.7	1.9	22.8	0.6	19.1	16	69	*	*	0.3	3.6
Apr-95	0.3	4.6	1.1	4.2	2.3	33	0.9	30.4	15	66	*	*	0.4	3.9
May-95	0.2	2	1.4	4.4	3	40	1.1	37.2	10	51	*	*	0.5	6.3
Jun-95	0.2	2.1	1.4	4.7	3.5	59.9	1.5	55.9	11	86	*	*	0.7	9.3
Jul-95	0.3	2.4	1.2	5.5	3.2	57.5	1.4	53.1	13	79	*	*	0.7	8.3
Aug-95	0.4	4.9	1.4	7.2	3.3	51.2	1.3	47.4	21	95	*	*	0.7	7.3
Sep-95	0.5	3.7	1.1	4.7	2.2	52.5	0.7	49.2	12	50	*	*	0.5	7.6
Oct-95	0.5	5	1.2	6.1	2.1	27.1	0.7	24.7	15	55	*	*	0.4	3.5
Nov-95	0.5	7	1.3	8.8	2	32.7	0.5	29.6	14	52	*	*	0.5	4.5
Dec-95	0.6	5.4	0.9	3.7	1.4	17.6	0.3	16.5	15	44	*	*	0.3	1.8
Annual Ave	**0.4**		**1.2**		**2.4**		**0.8**		**14.3**				**0.5**	
Maximum		**7.9**		**8.8**		**59.9**		**55.9**		**95.0**				**9.3**
Jan-96	0.4	8.7	1	4.3	1.6	14.7	0.4	13	11	102	*	*	0.4	2.2
Feb-96	0.4	9.2	0.9	4.2	1.7	19	0.5	17.5	*	*	*	*	0.3	3.3
Mar-96	0.3	4.7	1	3.9	2.3	19.6	0.9	18.4	*	*	*	*	0.4	3.3
Apr-96	0.3	4.7	1	5.4	2.4	32	1	30	*	*	*	*	0.4	4.1
May-96	0.2	2.8	1.2	4.7	3.3	56.1	1.4	53.3	21	103	*	*	0.6	7.3
Jun-96	0.2	2.2	1.1	3.8	3.3	46.5	1.6	43.8	12	69	*	*	0.5	5.5
Jul-96	0.3	2.2	1.1	4	3	44.4	1.5	41.7	12	132	*	*	1.1	5.7
Aug-96	0.4	2.7	0.8	2.9	2.1	31.9	0.8	29.9	11	84	*	*	0.5	3.5
Sep-96	0.5	4	0.8	4.6	1.5	38.7	0.5	40	11	94	*	*	0.4	3.7
Oct-96	0.5	5.1	1	4.9	1.9	23.9	0.6	21.5	13	72	*	*	0.4	3.2
Nov-96	0.6	6.9	0.7	3.9	1.3	29.7	0.4	28.2	12	108	*	*	*	*
Dec-96	0.6	7	0.8	3.4	1.4	19	0.4	18.1	16	100	*	*	0.3	2.5
Annual Ave	**0.4**		**1.0**		**2.2**		**0.8**		**13.2**				**0.5**	
Maximum		**9.2**		**5.4**		**56.1**		**53.3**		**132.0**				**7.3**

LIVERPOOL cont'd														
	O_3 (pphm)		NO_2 (pphm)		NO_x (pphm)		NO (pphm)		TEOM-PM_{10} (µg/m3)		TEOM-$PM_{2.5}$ (µg/m3)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)										WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-97	0.4	9.3	0.8	3.7	1.6	18.5	0.5	16.5	12	56	*	*	0.3	2.4
Feb-97	0.4	8.9	0.8	3.6	1.4	18.5	0.4	16.4	18	47	*	*	0.3	2.4
Mar-97	0.4	9.4	1	3.8	1.8	21.8	0.5	20.4	16	82	*	*	0.4	2.3
Apr-97	0.4	5.5	1.3	6	3.7	30	1.2	22.2	21	113	*	*	0.5	4.7
May-97	0.3	2.4	1.2	4.2	3.5	33.2	1.1	27	11	71	*	*	0.5	6.1
Jun-97	0.2	2.2	1.3	4	4.8	56.8	1.8	51.4	14	157	*	*	0.8	9
Jul-97	0.3	2.3	1.4	3.7	3.4	31.1	1.4	28.3	11	133	*	*	0.8	5.1
Aug-97	0.5	5	1.1	5.7	2.1	39.9	0.7	37	13	141	*	*	0.5	5.4
Sep-97	0.4	4.4	1.3	4.8	2.5	21.9	0.8	19.1	10	60	*	*	0.4	2.9
Oct-97	0.7	8.3	1.2	5.5	1.9	23	0.5	20.6	16	77	*	*	*	*
Nov-97	0.8	15.1	1	5.1	1.5	27.9	0.3	24.2	17	199	*	*	*	*
Dec-97	0.8	6.7	1	5.5	1.4	19.4	0.3	17.8	21	203	*	*	0.2	1.5
Annual Ave	**0.5**		**1.1**		**2.5**		**0.8**		**15.0**				**0.5**	
Maximum		**15.1**		**6.0**		**56.8**		**51.4**		**203.0**				**9.0**
Jan-98	0.6	9.2	0.9	4.2	1.1	18.4	0.2	17	16	106	*	*	0.3	2.0
Feb-98	0.6	13.0	1.1	4.5	1.9	23.5	0.5	20.8	18	146	11	43	0.4	2.8
Mar-98	0.5	12.4	1.1	5.5	1.9	21.3	0.5	19.5	18	127	8	48	0.4	3.2
Apr-98	0.4	5.8	1.2	6.3	2.3	32.2	0.8	27.7	13	176	7	42	0.4	4.4
May-98	0.3	2.5	1.1	3.4	2.5	51.7	1.1	48.7	11	193	7	58	0.4	6.3
Jun-98	0.3	2.3	1.1	2.9	3	53.7	1.2	51.4	9	107	6	58	0.6	8.3
Annual Ave	**0.5**		**1.1**		**2.1**		**0.7**		**14.2**		**7.8**		**0.4**	
Maximum		**13.0**		**6.3**		**53.7**		**51.4**		**193.0**		**58.0**		**8.3**

ST MARYS												
	O_3 (pphm)		NO_2 (pphm)		NO_x (pphm)		NO (pphm)		TEOM-PM_{10} ($\mu g/m^3$)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)								WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-93	0.9	12.5	0.4	3.3	0.5	4.9	0.1	2.6	*	*	*	*
Feb-93	0.7	12.2	0.7	3	1.2	11.8	0.3	9.4	*	*	0.5	1.3
Mar-93	0.5	8	0.6	3.4	1.1	15	0.4	13.4	*	*	1.2	3.2
Apr-93	0.4	5.9	0.8	8.3	1.6	19.1	0.6	17.1	*	*	3.6	5.8
May-93	0.2	3.4	0.7	4.3	2	28.5	1	25.8	*	*	1.3	5.8
Jun-93	0.3	2.5	0.7	8.4	1.9	34.5	1	30.4	13	*	0.1	4.2
Jul-93	0.2	2.8	0.8	5.2	2.3	19.3	1.1	17.2	9.3	*	1.4	3.5
Aug-93	0.4	3.4	0.9	4.9	1.9	23.5	0.7	21.1	10.6	*	1.6	3.8
Sep-93	0.5	5	0.6	4.3	1	17.7	0.4	15.3	8.6	*	0.7	4
Oct-93	0.8	6.5	0.7	3.8	1.1	18.9	0.3	15	*	*	0.8	2.9
Nov-93	0.8	8.8	0.7	3.3	1	11.4	0.3	9.1	13	*	0.3	1.8
Dec-93	0.8	6.9	0.6	5.3	0.9	14.1	0.3	10.4	13	*	0.2	2.4
Annual Ave	**0.5**		**0.7**		**1.4**		**0.5**		**11.3**		**1.1**	
Maximum		**12.5**		**8.4**		**34.5**		**30.4**				**5.8**
Jan-94	0.9	12	0.6	5.1	0.9	7.7	0.2	6.1	17.2	*	0.2	0.7
Feb-94	0.7	11.1	0.7	4.2	1.1	8.8	0.3	8.1	11.6	*	*	*
Mar-94	0.6	6.6	0.6	3.2	1	15.4	0.4	14.4	9.8	*	*	*
Apr-94	0.5	5.5	1	4.9	1.5	17.1	0.4	14.8	16	*	*	
May-94	0.5	4.4	0.8	5	1.8	31.6	0.8	28.3	17	*	*	
Jun-94	0.4	3	0.8	5.6	1.8	40	0.9	40	13	*	*	
Jul-94	1	5	1	5.1	2.3	33.8	1	32.6	12	*	*	
Aug-94	1	5	0.9	4.9	1.4	22	0.5	18.9	16	*	*	
Sep-94	1	5	0.6	4.5	1	25.4	0.4	22.3	14	*	*	
Oct-94	0.9	6.6	0.8	7.8	1.1	18.7	0.4	16.4	17	*	*	
Nov-94	1.1	11	0.8	4.2	1.3	13.9	0.4	12.1	15	*	*	
Dec-94	0.1	12.7	0.7	4.3	0.9	5.8	0.2	4.7	18	*	*	
Annual Ave	**0.7**		**0.8**		**1.3**		**0.5**		**14.7**		**0.2**	
Maximum		**12.7**		**7.8**		**40.0**		**40.0**				**0.7**

ST MARYS cont'd												
	O_3 (pphm)		NO_2 (pphm)		NO_x (pphm)		NO (pphm)		TEOM-PM_{10} (μg/m³)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)								WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-95	0.6	6.5	0.7	2.9	1	6.1	0.3	5.5	12	*	*	*
Feb-95	0.7	6.8	0.8	3.4	1	9	0.3	5.6	15	*	*	*
Mar-95	0.7	6	1	5.6	1.4	10.5	0.3	8.9	14	*	*	*
Apr-95	0.5	4.5	1	4.3	1.4	16.9	0.4	14.9	13	*	*	*
May-95	0.5	2.7	0.7	3.2	1.2	18.2	0.5	17	8	*	*	*
Jun-95	0.4	2.8	0.8	3.6	1.6	33.9	0.7	32.2	10	*	*	*
Jul-95	0.5	3.3	0.9	4.2	1.8	31.5	0.9	29.4	12	*	*	*
Aug-95	0.5	5.1	1.1	4.6	2	34.2	0.7	31.3	17	*	*	*
Sep-95	0.7	4.2	0.7	4.1	1	13.6	0.4	12.2	10	*	*	*
Oct-95	0.8	6	0.7	4.1	1	10.9	0.3	8.9	*	*	*	*
Nov-95	1	6.4	0.7	4.4	1	13	0.2	8.9	*	*	*	*
Dec-95	1	5.6	0.6	3.9	0.7	7.7	0.2	5.9	*	*	*	*
Annual Ave	**0.7**		**0.8**		**1.3**		**0.4**		**12.3**			
Maximum		**6.8**		**5.6**		**34.2**		**32.2**				
Jan-96	0.8	8.7	0.6	2.8	0.7	24.0	0.2	19.5	*	*	*	*
Feb-96	0.7	8.2	0.9	3.8	1.2	51.8	0.3	42.9	*	*	*	*
Mar-96	0.5	5.1	0.7	3.5	1.1	15.1	0.3	15.1	*	*	*	*
Apr-96	0.5	4.7	0.7	3.8	1.2	17.5	0.5	15.9	*	*	*	*
May-96	0.4	2.9	0.9	3.6	1.7	27.6	0.6	26.4	14.0	59.0	*	*
Jun-96	0.3	2.8	0.8	3.0	2.1	21.0	1.0	19.3	6.0	54.0	*	*
Jul-96	0.3	3.0	*	*	*	*	*	*	8.0	63.0	*	*
Aug-96	0.6	3.3	0.5	2.8	0.9	18.6	0.4	16.2	9.0	113.0	*	*
Sep-96	0.8	4.8	0.5	3.4	0.8	26.6	0.3	25.0	8.0	70.0	*	*
Oct-96	0.9	5.5	0.6	3.5	0.8	10.5	0.2	8.4	11.0	91.0	*	*
Nov-96	1.2	8.3	0.4	3.8	0.5	14.0	0.2	11.3	11.0	107.0	*	*
Dec-96	1.0	6.2	0.6	3.8	0.7	6.5	0.2	4.6	14.0	122.0	*	*
Annual Ave	**0.7**		**0.7**		**1.1**		**0.4**		**10.1**			
Maximum		**8.7**		**3.8**		**51.8**		**42.9**		**122.0**		

ST MARYS cont'd												
	O_3 (pphm)		NO_2 (pphm)		NOx (pphm)		NO (pphm)		TEOM-PM_{10} ($\mu g/m^3$)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)								WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-97	0.6	9.6	0.5	2.9	0.7	7.2	0.2	5.0	10.0	71.0	*	*
Feb-97	0.9	8.9	1.0	2.9	1.7	11.2	0.4	9.4	11.0	50.0	*	*
Mar-97	0.8	7.3	0.6	4.3	0.8	13.7	0.2	11.4	11.0	130.0	*	*
Apr 97	0.6	5.0	0.7	5.4	1.1	19.2	0.3	17.5	17.0	101.0	*	*
May-97	0.4	3.3	0.6	4.3	1.1	19.8	0.5	18.8	8.0	70.0	*	*
Jun-97	0.4	2.6	0.5	4.7	1.3	24.6	0.7	24.6	10.0	84.0	*	*
Jul-97	0.5	2.9	0.4	3.6	0.6	25.7	0.3	22.1	8.0	64.0	*	*
Aug-97	*	*	0.7	4.5	1.3	22.3	0.6	18.8	11.0	171.0	*	*
Sep-97	0.8	5.7	*	*	*	*	*	*	6.0	232.0	*	*
Oct-97	0.9	7.1	0.7	4.0	1.0	18.0	0.3	15.6	11.0	83.0	*	*
Nov-97	1.2	11.7	0.7	4.2	0.9	11.5	0.2	9.6	9.0	72.0	*	*
Dec-97	1.2	12.4	0.6	7.2	0.8	10.7	0.2	8.0	10.0	158.0	*	*
Annual Ave	**0.8**		**0.6**		**1.0**		**0.4**		**10.2**			
Maximum		**12.4**		**7.2**		**25.7**		**24.6**		**232.0**		
Jan-98	1.5	12.2	0.7	3.2	0.9	10.0	0.2	8.4	15.0	85.0	*	*
Feb-98	1.4	7.6	*	*	*	*	*	*	18.0	85.0	*	*
Mar-98	0.9	9.7	*	*	*	*	*	*	17.0	158.0	*	*
Apr-98	0.6	6.0	0.6	4.3	1.2	12.7	0.4	11.6	12.0	90.0	*	*
May-98	0.5	3.0	0.5	3.5	1.0	26.2	0.5	25.0	9.0	51.0	*	*
Jun-98	0.5	2.6	0.5	2.8	1.1	29.9	0.6	28.8	8.0	46.0	*	*
"Annual" Ave	**0.9**		**0.6**		**1.1**		**0.4**		**13.2**			
Maximum		**12.2**		**4.3**		**29.9**		**28.8**		**158.0**		

WESTMEAD														
	O_3 (pphm)		NO_2 (pphm)		NOx (pphm)		NO (pphm)		TEOM-PM_{10} (µg/m^3)		TEOM-$PM_{2.5}$ (µg/m^3)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		NHMRC Goal 16 pphm (1 hr max)										WHO Goal 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-93	1	11.4	*	*	*	*	*	*	*	*	*	*	*	*
Feb-93	0.9	9.4	0.5	7.8	0.4	24.8	0.2	18	*	*	*	*	*	*
Mar-93	0.6	6.9	1.5	4.1	2.6	24	0.6	21.2	*	*	*	*	*	*
Apr-93	0.6	4.4	1.9	7.3	3.2	32.5	0.9	28.6	*	*	*	*	*	*
May-93	0.5	3.6	1.7	4.9	4.1	34.3	1.6	32.1	*	*	*	*	*	*
Jun-93	0.5	2.3	1.6	4	3.2	44.6	1.2	40.8	*	*	*	*	*	*
Jul-93	0.4	2.2	1.7	5.5	4.6	43.9	2.1	39.9	*	*	*	*	*	*
Aug-93	0.6	4	1.7	6.5	2.9	40.8	1	35.8	*	*	*	*	*	*
Sep-93	0.6	3.9	1.6	5	3.6	37.4	1.7	33.6	22.1	*	*	*	*	*
Oct-93	0.7	4.6	1.3	4.2	2.7	19.9	1.2	17.6	14	*	*	*	*	*
Nov-93	*	*	1.3	5.5	2.5	21.3	0.9	19.4	16	*	*	*	*	*
Dec-93	0.8	5.8	0.7	4.6	1	18.8	0.3	17	16	*	*	*	*	*
Annual Ave	**0.7**		**1.4**		**2.8**		**1.1**		**17.0**					
Maximum		**11.4**		**7.8**		**44.6**		**40.8**						
Jan-94	0.7	9	1.1	5.3	1.6	33.5	0.4	30.6	19.4	*	*	*	*	*
Feb-94	0.4	9.8	1.3	5.7	2.1	36.4	0.4	32.5	15.4	*	*	*	*	*
Mar-94	0.3	5	1.6	5.7	3	28.9	1	25.7	13.8	*	*	*	*	*
Apr-94	0.3	4.9	1.9	6.4	3.3	34	1	30.4	21	*	*	*	*	*
May-94	0.3	3.9	1.6	9.3	3.6	42.7	1.4	37.3	24	*	*	*	*	*
Jun-94	0.2	2	1.8	6.8	4.5	74	1.6	68.4	16	*	*	*	*	*
Jul-94	0.2	2.5	1.7	4.9	5.6	45.6	2.1	43.8	21	*	*	*	*	*
Aug-94	0.4	3.7	1.9	5.9	3.6	35.6	1	30.6	20	*	*	*	*	*
Sep-94	0.5	4.5	1.6	9.3	2.7	42.9	0.8	37.7	18	*	*	*	*	*
Oct-94	0.6	6.1	1.3	8.3	2.2	19.2	0.6	15	25	*	*	*	*	*
Nov-94	0.8	9.1	1	4.5	1.4	26.4	0.3	22.1	23	*	*	*	*	*
Dec-94	0.6	8	1.1	4.8	1.5	20.4	0.3	17	21	*	*	*	*	*
Annual Ave	**0.4**		**1.5**		**2.9**		**0.9**		**19.8**					
Maximum		**9.8**		**9.3**		**74.0**		**68.4**						

WESTMEAD cont'd														
	O_3 (pphm)		NO_2 (pphm)		NOx (pphm)		NO (pphm)		TEOM-PM_{10} (µg/m^3)		TEOM-$PM_{2.5}$ (µg/m^3)		CO (ppm)	
	NHMRC Goal 10 pphm (1 hr max)		**NHMRC Goal** 16 pphm (1 hr max)										**WHO Goal** 25 ppm (1hr max)	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-95	0.5	7.4	*	*	*	*	*	*	15	*	*	*	*	*
Feb-95	0.5	5.9	1.2	6.4	1.8	29.6	0.6	26.9	19	*	*	*	*	*
Mar-95	0.5	6.3	1.4	6.2	1.9	21.6	0.5	18.8	20	*	*	*	*	*
Apr-95	0.3	4.4	1.5	4.3	3.1	26.8	1	24.3	18	*	*	*	*	*
May-95	0.2	2.4	1.5	4.3	3.9	36.3	1.4	33.6	16	*	*	*	*	*
Jun-95	0.2	3.7	1.4	4.1	4.3	51.5	1.7	47.5	16	*	*	*	*	*
Jul-95	0.3	2.7	1.3	3.3	2.9	27.4	1	25.2	17	*	*	*	*	*
Aug-95	0.4	4.9	1.5	8.3	3.3	39.6	1.1	34.1	*	*	*	*	*	*
Sep-95	0.4	3.3	1.4	4.1	2.5	26	0.7	24.4	13	*	*	*	*	*
Oct-95	0.6	5.2	1.3	4.4	2.1	18.9	0.5	16.3	15	*	*	*	*	*
Nov-95	0.6	4.8	1.3	7.5	1.9	24.8	0.4	19.1	14	*	*	*	*	*
Dec-95	0.6	4.6	0.9	7.4	1.4	19.7	0.3	17.7	15	*	*	*	*	*
Annual Ave	**0.4**		**1.3**		**2.6**		**0.8**		**16.2**					
Maximum		**7.4**		**8.3**		**51.5**		**47.5**						
Jan-96	0.4	5.8	1.1	4.3	1.6	21.3	0.4	18.6	14.0	55.0	*	*	*	*
Feb-96	0.3	4.4	0.8	3.5	1.6	27.7	0.6	26.5	17.0	252.0	*	*	*	*
Mar-96	0.2	2.5	0.8	3.8	2.0	28.6	1.0	27.3	16.0	89.0	*	*	0.4	4.0
Apr-96	0.2	3.1	1.0	4.6	2.2	23.2	1.0	19.8	17.0	82.0	*	*	0.5	4.4
May-96	0.1	1.1	0.9	3.0	3.3	36.1	0.1	34.4	15.0	75.0	*	*	0.6	5.8
Jun-96	0.1	1.5	1.2	3.3	4.2	35.6	2.4	33.8	15.0	55.0	*	*	0.6	5.5
Jul-96	0.2	1.5	1.3	4.6	4.1	38.4	2.2	35.9	15.0	71.0	*	*	0.6	5.3
Aug-96	0.3	2.8	*	*	*	*	*	*	13.0	79.0	*	*	0.4	4.4
Sep-96	0.7	4.9	1.1	5.5	1.8	26.7	0.4	22.8	13.0	74.0	*	*	0.2	3.4
Oct-96	0.7	5.5	1.1	4.2	1.8	22.3	0.5	18.1	15.0	63.0	*	*	0.2	3.0
Nov-96	0.6	7.4	1.0	4.5	1.5	23.0	0.3	19.9	15.0	98.0	*	*	0.2	2.8
Dec-96	0.9	7.2	1.0	4.7	1.3	17.9	0.3	15.2	17.0	180.0	*	*	0.2	2.7
Annual Ave	**0.4**		**1.0**		**2.3**		**0.8**		**15.2**				**0.4**	
Maximum		**7.4**		**5.5**		**38.4**		**35.9**		**252.0**				**5.8**

WESTMEAD cont'd														
	O_3 (pphm)		NO_2 (pphm)		NOx (pphm)		NO (pphm)		TEOM-PM_{10} (µg/m³)		TEOM-$PM_{2.5}$ (µg/m³)		CO (ppm)	
	NHMRC Goal **10 pphm (1 hr max)**		**NHMRC Goal** **16 pphm (1 hr max)**										**WHO Goal** **25 ppm (1hr max)**	
	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average	Max
Jan-97	0.4	9.3	1.0	4.4	1.8	18.7	0.5	17.0	14.0	53.0	*	*	0.2	2.7
Feb-97	0.3	9.8	1.0	3.7	1.7	16.4	0.4	14.9	16.0	52.0	*	*	0.2	2.5
Mar-97	0.2	2.7	1.1	4.7	1.8	28.0	0.5	25.9	19.0	118.0	*	*	0.2	3.4
Apr-97	0.2	1.6	1.6	6.4	3.5	28.6	1.2	25.9	24.0	92.0	*	*	0.4	3.7
May-97	0.2	2.6	1.4	4.7	3.6	30.5	1.3	27.1	14.0	64.0	*	*	0.3	3.9
Jun-97	0.3	2.8	1.5	5.3	4.7	54.3	2.1	51.2	18.0	104.0	*	*	0.6	7.0
Jul-97	0.3	2.7	1.5	4.0	4.1	33.0	1.8	30.6	13.0	72.0	*	*	0.4	4.7
Aug-97	0.5	5.3	1.3	4.5	2.9	35.5	1.0	32.1	17.0	109.0	*	*	0.3	3.9
Sep-97	0.5	4.8	1.2	4.1	2.5	27.0	0.8	24.1	14.0	68.0	*	*	0.2	2.6
Oct-97	0.9	9.9	1.1	4.7	1.9	22.4	0.5	20.0	18.0	78.0	*	*	0.2	2.4
Nov-97	1.0	13.1	1.2	5.6	1.9	20.0	0.4	17.1	22.0	127.0	*	*	0.2	2.8
Dec-97	1.1	7.9	1.1	11.3	1.5	21.2	0.3	16.7	23.0	203.0	*	*	0.2	2.7
Annual Ave	**0.5**		**1.3**		**2.7**		**0.9**		**17.7**				**0.3**	
Maximum		**13.1**		**11.3**		**54.3**		**51.2**		**203.0**				**7.0**
Jan-98	0.9	10.7	1.0	4.1	1.2	19.4	0.3	17.0	19.0	95.0	*	*	0.2	2.1
Feb-98	0.9	14.5	1.2	5.4	1.6	25.0	0.4	21.9	20.0	165.0	13.0	40.0	0.2	3.2
Mar-98	0.7	11.6	1.3	5.9	1.7	29.7	0.4	25.1	20.0	110.0	9.0	88.0	0.2	4.0
Apr-98	0.4	5.5	1.4	5.0	2.7	28.5	0.9	25.7	15.0	190.0	9.0	36.0	0.3	3.4
May-98	0.3	2.7	1.5	3.9	4.5	36.3	2.1	33.4	15.0	71.0	9.0	40.0	0.4	4.8
Jun-98	0.3	2.2	1.4	3.8	3.4	37.6	1.3	34.7	14.0	97.0	8.0	41.0	0.4	4.5
"Annual" Ave	**0.6**		**1.3**		**2.5**		**0.9**		**17.2**		**9.6**		**0.3**	
Maximum		**14.5**		**5.9**		**37.6**		**34.7**		**190.0**		**88.0**		**4.8**

ATTACHMENT B
EMISSIONS CALCULATIONS

VEHICLE EMISSIONS FACTORS

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

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

These classes of vehicles account for more than 99% of all vehicle kilometres travelled on Sydney's roads (**Pengilley 1989**). The following assumptions were made regarding the vehicles in 2006 and 2016:

- 95% of light duty passenger vehicles were using catalytic converters in 2006
- 100% of petrol vehicles were using catalytic converters as emission control in 2016
- Of the heavy vehicles category, 90% are considered to be HDDV and 10% are considered to be HDPV.

The emissions of CO, oxides of nitrogen, HC and particulate matter were taken from estimates in the Sydney Metropolitan Air Quality Study (MAQS) (**Carnovale & Tilly, 1995**). It was assumed that traffic on the Western Sydney Orbital Route was in freeway/highway travel mode. It was also assumed that the deterioration of catalytic converters was as in the 1992 MAQS estimates of passenger vehicle emission rates.

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

Calculation of vehicle emission rates

Details of emission calculations for the route sections at peak hour for 2006 and 2016 are presented in the following tables.

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

Calculating emission rates for light duty petrol vehicles

The total emissions from the light duty fleet should take into account emissions from pre-1985 and post-1985 vehicles. This has been done for the year 2006 when an estimated 95% of the light duty petrol fleet are assumed to be fitted with catalytic converters. The MAQS emissions inventory provides emission rates for both these types of vehicle, and these values have been used in determining the fleet emission rate. Table A1 below, shows the varying emission rates for freeway conditions, such as have been assumed for this study.

Table A1 – Vehicle emission rates for the light duty fleet, estimated for 2006 – g/km*

	1976 – 1985	Post-1985	2006**
CO	24.29	7.57	8.41
NO_x	2.95	1.51	1.58
HC	2.05	0.56	0.63

* *Adapted from Table 4.15 in the Metropolitan Air Quality Study Emissions Inventory*
** *Calculated by adding 5% of the 1976 to 1985 emissions to 95% of the post-1985 emissions*

Estimated emissions for the proposed roadway in 2006 and 2016

Section	North of Camden Valley Way			Northbound		2006	AM				
Freeway		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot PM10	tot Pb
total no	2695.00										
total heavy	296.00										
LDPV	2399.00	8.41	1.58	0.63	0.021	0.001	20175.59	3790.42	1511.37	50.38	2.6389
HDDV	266.40	7.11	15.72	2.58	1.150		1894.10	4187.81	687.31	306.36	
HDPV	29.60	107.09	4.59	5.82	0.008	0.032	3169.86	135.86	172.27	0.24	0.9531
Brake & Tyre					0.009					24.26	
Total kg/km/h							25.24	8.11	2.37	0.38	0.0036
g/v-mi							14.98	4.82	1.41	0.23	0.0021
Section	North of Camden Valley Way			Southbound		2006	AM				
Freeway		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot PM10	tot Pb
total no	1188.00										
total heavy	131.00										
LDPV	1057.00	8.41	1.58	0.63	0.021	0.001	8889.37	1670.06	665.91	22.20	1.1627
HDDV	117.90	7.11	15.72	2.58	1.150		838.27	1853.39	304.18	135.59	
HDPV	13.10	107.09	4.59	5.82	0.008	0.032	1402.88	60.13	76.24	0.11	0.4218
Brake & Tyre					0.009					10.69	
Total kg/km/h							11.13	3.58	1.05	0.17	0.0016
g/v-mi							14.99	4.83	1.41	0.23	0.0021
Section	North of Bernera Road			Northbound		2006	AM				
Freeway		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot PM10	tot Pb
total no	2306.00										
total heavy	253.00										
LDPV	2053.00	8.41	1.58	0.63	0.021	0.001	17265.73	3243.74	1293.39	43.11	2.2583
HDDV	227.70	7.11	15.72	2.58	1.150		1618.95	3579.44	587.47	261.86	
HDPV	25.30	107.09	4.59	5.82	0.008	0.032	2709.38	116.13	147.25	0.20	0.8147
Brake & Tyre					0.009					20.75	
Total kg/km/h							21.59	6.94	2.03	0.33	0.0031
g/v-mi							14.98	4.81	1.41	0.23	0.0021
Section	North of Bernera Road			Southbound		2006	AM				
Freeway		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot PM10	tot Pb
total no	1163.00										
total heavy	128.00										
LDPV	1035.00	8.41	1.58	0.63	0.021	0.001	8704.35	1635.30	652.05	21.74	1.1385
HDDV	115.20	7.11	15.72	2.58	1.150		819.07	1810.94	297.22	132.48	
HDPV	12.80	107.09	4.59	5.82	0.008	0.032	1370.75	58.75	74.50	0.10	0.4122
Brake & Tyre					0.009					10.47	
Total kg/km/h							10.89	3.50	1.02	0.16	0.0016
g/v-mi							14.99	4.82	1.41	0.23	0.0021

Estimated emissions for the proposed roadway in 2006 and 2016

Section	North of Cowpasture Road				Northbound		2006	AM				
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		2855.00									PM10	
total heavy		313.00										
LDPV		2542.00	8.41	1.58	0.63	0.021	0.001	21378.22	4016.36	1601.46	53.38	2.7962
HDDV		281.70	7.11	15.72	2.58	1.150		2002.89	4428.32	726.79	323.96	
HDPV		31.30	107.09	4.59	5.82	0.008	0.032	3351.92	143.67	182.17	0.25	1.0079
Brake & Tyre						0.009					25.70	
Total kg/km/h								26.73	8.59	2.51	0.40	0.0038
g/v-mi								14.98	4.81	1.41	0.23	0.0021
Section	North of Cowpasture Road				Southbound		2006	AM				
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		996.00									PM10	
total heavy		110.00										
LDPV		886.00	8.41	1.58	0.63	0.021	0.001	7451.26	1399.88	558.18	18.61	0.974[illegible]
HDDV		99.00	7.11	15.72	2.58	1.150		703.89	1556.28	255.42	113.85	
HDPV		11.00	107.09	4.59	5.82	0.008	0.032	1177.99	50.49	64.02	0.09	0.3542
Brake & Tyre						0.009					8.96	
Total kg/km/h								9.33	3.01	0.88	0.14	0.0013
g/v-mi								14.99	4.83	1.41	0.23	0.0021
Section	South of Elizabeth Drive				Northbound		2006	AM				
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		2855.00									PM10	
total heavy		313.00										
LDPV		2542.00	8.41	1.58	0.63	0.021	0.001	21378.22	4016.36	1601.46	53.38	2.7962
HDDV		281.70	7.11	15.72	2.58	1.150		2002.89	4428.32	726.79	323.96	
HDPV		31.30	107.09	4.59	5.82	0.008	0.032	3351.92	143.67	182.17	0.25	1.0079
Brake & Tyre						0.009					25.70	
Total kg/km/h								26.73	8.59	2.51	0.40	0.0038
g/v-mi								14.98	4.81	1.41	0.23	0.0021
Section	South of Elizabeth Drive				Southbound		2006	AM				
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		996.00									PM10	
total heavy		110.00										
LDPV		886.00	8.41	1.58	0.63	0.021	0.001	7451.26	1399.88	558.18	18.61	0.9746
HDDV		99.00	7.11	15.72	2.58	1.150		703.89	1556.28	255.42	113.85	
HDPV		11.00	107.09	4.59	5.82	0.008	0.032	1177.99	50.49	64.02	0.09	0.3542
Brake & Tyre						0.009					8.96	
Total kg/km/h								9.33	3.01	0.88	0.14	0.0013
g/v-mi								14.99	4.83	1.41	0.23	0.0021

Estimated emissions for the proposed roadway in 2006 and 2016

Section	Elizabeth Dr E of Mamre Rd				Eastbound		2006	AM				
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		950.00									PM10	
total heavy		105.00										
LDPV		845.00	8.41	1.58	0.63	0.021	0.001	7106.45	1335.10	532.35	17.75	0.9295
HDDV		94.50	7.11	15.72	2.58	1.150		671.90	1485.54	243.81	108.68	
HDPV		10.50	107.09	4.59	5.82	0.008	0.032	1124.45	48.20	61.11	0.09	0.3381
Brake & Tyre						0.009					8.55	
Total kg/km/h								8.90	2.87	0.84	0.14	0.0013
g/v-mi								14.99	4.83	1.41	0.23	0.0021
Section	Elizabeth Dr E of Mamre Rd				Westbound		2006	AM				
Freeway			Emission rate g/km/vehicle				M	Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		286.00									PM10	
total heavy		31.00										
LDPV		255.00	8.41	1.58	0.63	0.021	0.001	2144.55	402.90	160.65	5.36	0.2805
HDDV		27.90	7.11	15.72	2.58	1.150		198.37	438.59	71.98	32.09	
HDPV		3.10	107.09	4.59	5.82	0.008	0.032	331.98	14.23	18.04	0.03	0.0998
Brake & Tyre						0.009					2.57	
Total kg/km/h								2.67	0.86	0.25	0.04	0.0004
g/v-mi								14.96	4.79	1.40	0.22	0.0021
Section	Elizabeth Dr W of Cabramata Rd				Eastbound		2006	AM				
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		925.00									PM10	
total heavy		105.00										
LDPV		820.00	8.41	1.58	0.63	0.021	0.001	6896.20	1295.60	516.60	17.22	0.9020
HDDV		94.50	7.11	15.72	2.58	1.150		671.90	1485.54	243.81	108.68	
HDPV		10.50	107.09	4.59	5.82	0.008	0.032	1124.45	48.20	61.11	0.09	0.3381
Brake & Tyre						0.009					8.33	
Total kg/km/h								8.69	2.83	0.82	0.13	0.0012
g/v-mi								15.04	4.89	1.42	0.23	0.0021
Section	Elizabeth Dr W of Cabramata Rd				Westbound		2006	AM				
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		138.00									PM10	
total heavy		15.00										
LDPV		123.00	8.41	1.58	0.63	0.021	0.001	1034.43	194.34	77.49	2.58	0.1353
HDDV		13.50	7.11	15.72	2.58	1.150		95.99	212.22	34.83	15.53	
HDPV		1.50	107.09	4.59	5.82	0.008	0.032	160.64	6.89	8.73	0.01	0.0483
Brake & Tyre						0.009					1.24	
Total kg/km/h								1.29	0.41	0.12	0.02	0.0002
g/v-mi								14.97	4.79	1.40	0.22	0.0021

Estimated emissions for the proposed roadway in 2006 and 2016

Section	North of Camden Valley Way			Northbound		2016	AM			
Freeway		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot PM10
total no	2947.00									
total heavy	324.00									
LDPV	2623.00	7.57	1.51	0.56	0.021		19856.11	3960.73	1468.88	55.08
HDDV	291.60	7.11	15.72	2.58	1.150		2073.28	4583.95	752.33	335.34
HDPV	32.40	107.09	4.59	5.82	0.008		3469.72	148.72	188.57	0.26
Brake & Tyre					0.009					26.52
Total kg/km/h							25.40	8.69	2.41	0.42
g/v-mi							13.79	4.72	1.31	0.23
Section	North of Camden Valley Way			Southbound		2016	AM			
Freeway		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot PM10
total no	1413.00									
total heavy	155.00									
LDPV	1258.00	7.57	1.51	0.56	0.021		9523.06	1899.58	704.48	26.42
HDDV	139.50	7.11	15.72	2.58	1.150		991.85	2192.94	359.91	160.43
HDPV	15.50	107.09	4.59	5.82	0.008		1659.90	71.15	90.21	0.13
Brake & Tyre					0.009					12.72
Total kg/km/h							12.17	4.16	1.15	0.20
g/v-mi							13.79	4.71	1.31	0.23
Section	North of Bernera Road			Northbound		2016	AM			
Freeway		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot PM10
total no	2696.00									
total heavy	297.00									
LDPV	2399.00	7.57	1.51	0.56	0.021		18160.43	3622.49	1343.44	50.38
HDDV	267.30	7.11	15.72	2.58	1.150		1900.50	4201.96	689.63	307.40
HDPV	29.70	107.09	4.59	5.82	0.008		3180.57	136.32	172.85	0.24
Brake & Tyre					0.009					24.26
Total kg/km/h							23.24	7.96	2.21	0.38
g/v-mi							13.79	4.72	1.31	0.23
Section	North of Bernera Road			Southbound		2016	AM			
Freeway		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot PM10
total no	1343.00									
total heavy	148.00									
LDPV	1195.00	7.57	1.51	0.56	0.021		9046.15	1804.45	669.20	25.10
HDDV	133.20	7.11	15.72	2.58	1.150		947.05	2093.90	343.66	153.18
HDPV	14.80	107.09	4.59	5.82	0.008		1584.93	67.93	86.14	0.12
Brake & Tyre					0.009					12.09
Total kg/km/h							11.58	3.97	1.10	0.19
g/v-mi							13.79	4.73	1.31	0.23

Estimated emissions for the proposed roadway in 2006 and 2016

Section	North of Cowpasture Road				Northbound		2016	AM			
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		2989.00									PM10
total heavy		329.00									
LDPV		2660.00	7.57	1.51	0.56	0.021		20136.20	4016.60	1489.60	55.86
HDDV		296.10	7.11	15.72	2.58	1.150		2105.27	4654.69	763.94	340.52
HDPV		32.90	107.09	4.59	5.82	0.008		3523.26	151.01	191.48	0.27
Brake & Tyre						0.009					26.90
Total kg/km/h								25.76	8.82	2.45	0.42
g/v-mi								13.79	4.72	1.31	0.23
Section	North of Cowpasture Road				Southbound		2016	AM			
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		1187.00									PM10
tal heavy		131.00									
DPV		1056.00	7.57	1.51	0.56	0.021		7993.92	1594.56	591.36	22.18
HDDV		117.90	7.11	15.72	2.58	1.150		838.27	1853.39	304.18	135.59
HDPV		13.10	107.09	4.59	5.82	0.008		1402.88	60.13	76.24	0.11
Brake & Tyre						0.009					10.68
Total kg/km/h								10.24	3.51	0.97	0.17
g/v-mi								13.80	4.73	1.31	0.23
Section	South of Elizabeth Drive				Northbound		2016	AM			
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		2989.00									PM10
total heavy		329.00									
LDPV		2660.00	7.57	1.51	0.56	0.021		20136.20	4016.60	1489.60	55.86
HDDV		296.10	7.11	15.72	2.58	1.150		2105.27	4654.69	763.94	340.52
HDPV		32.90	107.09	4.59	5.82	0.008		3523.26	151.01	191.48	0.27
Brake & Tyre						0.009					26.90
Total kg/km/h								25.76	8.82	2.45	0.42
g/v-mi								13.79	4.72	1.31	0.23
ction	South of Elizabeth Drive				Southbound		2016	AM			
reeway			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		1187.00									PM10
total heavy		131.00									
LDPV		1056.00	7.57	1.51	0.56	0.021		7993.92	1594.56	591.36	22.18
HDDV		117.90	7.11	15.72	2.58	1.150		838.27	1853.39	304.18	135.59
HDPV		13.10	107.09	4.59	5.82	0.008		1402.88	60.13	76.24	0.11
Brake & Tyre						0.009					10.68
Total kg/km/h								10.24	3.51	0.97	0.17
g/v-mi								13.80	4.73	1.31	0.23

Estimated emissions for the proposed roadway in 2006 and 2016

Section	Elizabeth Dr E of Mamre Rd				Eastbound		2016	AM			
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		1096.00									PM10
total heavy		121.00									
LDPV		975.00	7.57	1.51	0.56	0.021		7380.75	1472.25	546.00	20.48
HDDV		108.90	7.11	15.72	2.58	1.150		774.28	1711.91	280.96	125.24
HDPV		12.10	107.09	4.59	5.82	0.008		1295.79	55.54	70.42	0.10
Brake & Tyre						0.009					9.86
Total kg/km/h								9.45	3.24	0.90	0.16
g/v-mi								13.80	4.73	1.31	0.23
Section	Elizabeth Dr E of Mamre Rd				Westbound		2016	AM			
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		361.00									PM10
total heavy		40.00									
LDPV		321.00	7.57	1.51	0.56	0.021		2429.97	484.71	179.76	6.74
HDDV		36.00	7.11	15.72	2.58	1.150		255.96	565.92	92.88	41.40
HDPV		4.00	107.09	4.59	5.82	0.008		428.36	18.36	23.28	0.03
Brake & Tyre						0.009					3.25
Total kg/km/h								3.11	1.07	0.30	0.05
g/v-mi								13.80	4.74	1.31	0.23
Section	Elizabeth Dr W of Cabramata Rd				Eastbound		2016	AM			
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		1065.00									PM10
total heavy		117.00									
LDPV		948.00	7.57	1.51	0.56	0.021		7176.36	1431.48	530.88	19.91
HDDV		105.30	7.11	15.72	2.58	1.150		748.68	1655.32	271.67	121.10
HDPV		11.70	107.09	4.59	5.82	0.008		1252.95	53.70	68.09	0.09
Brake & Tyre						0.009					9.59
Total kg/km/h								9.18	3.14	0.87	0.15
g/v-mi								13.79	4.72	1.31	0.23
Section	Elizabeth Dr W of Cabramata Rd				Westbound		2016	AM			
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		151.00									PM10
total heavy		17.00									
LDPV		134.00	7.57	1.51	0.56	0.021		1014.38	202.34	75.04	2.81
HDDV		15.30	7.11	15.72	2.58	1.150		108.78	240.52	39.47	17.60
HDPV		1.70	107.09	4.59	5.82	0.008		182.05	7.80	9.89	0.01
Brake & Tyre						0.009					1.36
Total kg/km/h								1.31	0.45	0.12	0.02
g/v-mi								13.83	4.78	1.32	0.23

Estimated emissions for 2006

Section	Elizabeth Dr to The Horsley Dr			Northbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	2290.00									PM10	
total heavy	90.00										
LDPV	2200.00	8.41	1.58	0.63	0.021	0.001	18502.00	3476.00	1386.00	46.20	2.4200
HDDV	81.00	7.11	15.72	2.58	1.150		575.91	1273.32	208.98	93.15	
HDPV	9.00	107.09	4.59	5.82	0.008	0.032	963.81	41.31	52.38	0.07	0.2898
Brake & Tyre					0.009					20.61	
Total kg/km/h							20.04	4.79	1.65	0.16	0.0027
g/v-mi							14.00	3.35	1.15	0.11	0.0019
Section	Elizabeth Dr to The Horsley Dr			Southbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	1210.00									PM10	
total heavy	110.00										
LDPV	1100.00	8.41	1.58	0.63	0.021	0.001	9251.00	1738.00	693.00	23.10	1.2100
HDDV	99.00	7.11	15.72	2.58	1.150		703.89	1556.28	255.42	113.85	
HDPV	11.00	107.09	4.59	5.82	0.008	0.032	1177.99	50.49	64.02	0.09	0.3542
Brake & Tyre					0.009					10.89	
Total kg/km/h							11.13	3.34	1.01	0.15	0.0016
g/v-mi							14.72	4.42	1.34	0.20	0.0021
Section	The Horsley Dr to Old Wallgrove			Northbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	2400.00									PM10	
total heavy	100.00										
LDPV	2300.00	8.41	1.58	0.63	0.021	0.001	19343.00	3634.00	1449.00	48.30	2.5300
HDDV	90.00	7.11	15.72	2.58	1.150		639.90	1414.80	232.20	103.50	
HDPV	10.00	107.09	4.59	5.82	0.008	0.032	1070.90	45.90	58.20	0.08	0.3220
Brake & Tyre					0.009					21.60	
Total kg/km/h							21.05	5.09	1.74	0.17	0.0029
g/v-mi							14.04	3.40	1.16	0.12	0.0019
Section	The Horsley Dr to Old Wallgrove			Southbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	2220.00									PM10	
total heavy	120.00										
LDPV	2100.00	8.41	1.58	0.63	0.021	0.001	17661.00	3318.00	1323.00	44.10	2.3100
HDDV	108.00	7.11	15.72	2.58	1.150		767.88	1697.76	278.64	124.20	
HDPV	12.00	107.09	4.59	5.82	0.008	0.032	1285.08	55.08	69.84	0.10	0.3864
Brake & Tyre					0.009					19.98	
Total kg/km/h							19.71	5.07	1.67	0.19	0.0027
g/v-mi							14.21	3.65	1.20	0.14	0.0019
Section	Old Wallgrove Rd to M4			Northbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	1880.00									PM10	
total heavy	80.00										
LDPV	1800.00	8.41	1.58	0.63	0.021	0.001	15138.00	2844.00	1134.00	37.80	1.9800
HDDV	72.00	7.11	15.72	2.58	1.150		511.92	1131.84	185.76	82.80	
HDPV	8.00	107.09	4.59	5.82	0.008	0.032	856.72	36.72	46.56	0.06	0.2576
Brake & Tyre					0.009					16.92	
Total kg/km/h							16.51	4.01	1.37	0.14	0.0022
g/v-mi							14.05	3.41	1.16	0.12	0.0019
Section	Old Wallgrove Rd to M4			Southbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	790.00									PM10	
total heavy	30.00										
LDPV	760.00	8.41	1.58	0.63	0.021	0.001	6391.60	1200.80	478.80	15.96	0.8360
HDDV	27.00	7.11	15.72	2.58	1.150		191.97	424.44	69.66	31.05	
HDPV	3.00	107.09	4.59	5.82	0.008	0.032	321.27	13.77	17.46	0.02	0.0966
Brake & Tyre					0.009					7.11	
Total kg/km/h							6.90	1.64	0.57	0.05	0.0009
g/v-mi							13.98	3.32	1.15	0.11	0.0019

Estimated emissions for 2006

Section	M4 to GWH			Northbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	1660.00									PM10	
total heavy	60.00										
LDPV	1600.00	8.41	1.58	0.63	0.021	0.001	13456.00	2528.00	1008.00	33.60	1.7600
HDDV	54.00	7.11	15.72	2.58	1.150		383.94	848.88	139.32	62.10	
HDPV	6.00	107.09	4.59	5.82	0.008	0.032	642.54	27.54	34.92	0.05	0.1932
Brake & Tyre					0.009					14.94	
Total kg/km/h							14.48	3.40	1.18	0.11	0.0020
g/v-mi							13.96	3.28	1.14	0.11	0.0019
Section	M4 to GWH			Southbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	2190.00									PM10	
total heavy	90.00										
LDPV	2100.00	8.41	1.58	0.63	0.021	0.001	17661.00	3318.00	1323.00	44.10	2.3100
HDDV	81.00	7.11	15.72	2.58	1.150		575.91	1273.32	208.98	93.15	
HDPV	9.00	107.09	4.59	5.82	0.008	0.032	963.81	41.31	52.38	0.07	0.2898
Brake & Tyre					0.009					19.71	
Total kg/km/h							19.20	4.63	1.58	0.16	0.0026
g/v-mi							14.03	3.38	1.16	0.11	0.0019
Section	GWH to Power Street			Northbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	1760.00									PM10	
total heavy	60.00										
LDPV	1700.00	8.41	1.58	0.63	0.021	0.001	14297.00	2686.00	1071.00	35.70	1.8700
HDDV	54.00	7.11	15.72	2.58	1.150		383.94	848.88	139.32	62.10	
HDPV	6.00	107.09	4.59	5.82	0.008	0.032	642.54	27.54	34.92	0.05	0.1932
Brake & Tyre					0.009					15.84	
Total kg/km/h							15.32	3.56	1.25	0.11	0.0021
g/v-mi							13.93	3.24	1.13	0.10	0.0019
Section	GWH to Power Street			Southbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	2590.00									PM10	
total heavy	90.00										
LDPV	2500.00	8.41	1.58	0.63	0.021	0.001	21025.00	3950.00	1575.00	52.50	2.7500
HDDV	81.00	7.11	15.72	2.58	1.150		575.91	1273.32	208.98	93.15	
HDPV	9.00	107.09	4.59	5.82	0.008	0.032	963.81	41.31	52.38	0.07	0.2898
Brake & Tyre					0.009					23.31	
Total kg/km/h							22.56	5.26	1.84	0.17	0.0030
g/v-mi							13.94	3.25	1.13	0.10	0.0019
Section	Power St to Richmond Rd			Northbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	1740.00									PM10	
total heavy	40.00										
LDPV	1700.00	8.41	1.58	0.63	0.021	0.001	14297.00	2686.00	1071.00	35.70	1.8700
HDDV	36.00	7.11	15.72	2.58	1.150		255.96	565.92	92.88	41.40	
HDPV	4.00	107.09	4.59	5.82	0.008	0.032	428.36	18.36	23.28	0.03	0.1288
Brake & Tyre					0.009					15.66	
Total kg/km/h							14.98	3.27	1.19	0.09	0.0020
g/v-mi							13.78	3.01	1.09	0.09	0.0018
Section	Power St to Richmond Rd			Southbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	2260.00									PM10	
total heavy	60.00										
LDPV	2200.00	8.41	1.58	0.63	0.021	0.001	18502.00	3476.00	1386.00	46.20	2.4200
HDDV	54.00	7.11	15.72	2.58	1.150		383.94	848.88	139.32	62.10	
HDPV	6.00	107.09	4.59	5.82	0.008	0.032	642.54	27.54	34.92	0.05	0.1932
Brake & Tyre					0.009					20.34	
Total kg/km/h							19.53	4.35	1.56	0.13	0.0026
g/v-mi							13.83	3.08	1.10	0.09	0.0019

Section	Richmond Rd to Quakers Hill Pwy			Eastbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	2360.00									PM10	
total heavy	60.00										
LDPV	2300.00	8.41	1.58	0.63	0.021	0.001	19343.00	3634.00	1449.00	48.30	2.5300
HDDV	54.00	7.11	15.72	2.58	1.150		383.94	848.88	139.32	62.10	
HDPV	6.00	107.09	4.59	5.82	0.008	0.032	642.54	27.54	34.92	0.05	0.1932
Brake & Tyre					0.009					21.24	
Total kg/km/h							20.37	4.51	1.62	0.13	0.0027
g/v-mi							13.81	3.06	1.10	0.09	0.0018
Section	Richmond Rd to Quakers Hill Pwy			Westbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	1370.00									PM10	
total heavy	70.00										
LDPV	1300.00	8.41	1.58	0.63	0.021	0.001	10933.00	2054.00	819.00	27.30	1.4300
HDDV	63.00	7.11	15.72	2.58	1.150		447.93	990.36	162.54	72.45	
HDPV	7.00	107.09	4.59	5.82	0.008	0.032	749.63	32.13	40.74	0.06	0.2254
Brake & Tyre					0.009					12.33	
Total kg/km/h							12.13	3.08	1.02	0.11	0.0017
g/v-mi							14.17	3.59	1.19	0.13	0.0019
Section	Quakers Hill Pwy to Sunnyholt Rd			Eastbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	3070.00									PM10	
total heavy	70.00										
LDPV	3000.00	8.41	1.58	0.63	0.021	0.001	25230.00	4740.00	1890.00	63.00	3.3000
HDDV	63.00	7.11	15.72	2.58	1.150		447.93	990.36	162.54	72.45	
HDPV	7.00	107.09	4.59	5.82	0.008	0.032	749.63	32.13	40.74	0.06	0.2254
Brake & Tyre					0.009					27.63	
Total kg/km/h							26.43	5.76	2.09	0.16	0.0035
g/v-mi							13.77	3.00	1.09	0.09	0.0018
Section	Quakers Hill Pwy to Sunnyholt Rd			Westbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	1580.00									PM10	
total heavy	80.00										
LDPV	1500.00	8.41	1.58	0.63	0.021	0.001	12615.00	2370.00	945.00	31.50	1.6500
HDDV	72.00	7.11	15.72	2.58	1.150		511.92	1131.84	185.76	82.80	
HDPV	8.00	107.09	4.59	5.82	0.008	0.032	856.72	36.72	46.56	0.06	0.2576
Brake & Tyre					0.009					14.22	
Total kg/km/h							13.98	3.54	1.18	0.13	0.0019
g/v-mi							14.16	3.58	1.19	0.13	0.0019
Section	Sunnyholt Rd to Norwest Blvd			Eastbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	2360.00									PM10	
total heavy	60.00										
LDPV	2300.00	8.41	1.58	0.63	0.021	0.001	19343.00	3634.00	1449.00	48.30	2.5300
HDDV	54.00	7.11	15.72	2.58	1.150		383.94	848.88	139.32	62.10	
HDPV	6.00	107.09	4.59	5.82	0.008	0.032	642.54	27.54	34.92	0.05	0.1932
Brake & Tyre					0.009					21.24	
Total kg/km/h							20.37	4.51	1.62	0.13	0.0027
g/v-mi							13.81	3.06	1.10	0.09	0.0018
Section	Sunnyholt Rd to Norwest Blvd			Westbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	860.00									PM10	
total heavy	70.00										
LDPV	790.00	8.41	1.58	0.63	0.021	0.001	6643.90	1248.20	497.70	16.59	0.8690
HDDV	63.00	7.11	15.72	2.58	1.150		447.93	990.36	162.54	72.45	
HDPV	7.00	107.09	4.59	5.82	0.008	0.032	749.63	32.13	40.74	0.06	0.2254
Brake & Tyre					0.009					7.74	
Total kg/km/h							7.84	2.27	0.70	0.10	0.0011
g/v-mi							14.59	4.22	1.30	0.18	0.0020

Estimated emissions for 2006

Section	Norwest Blvd to Old Windsor Rd			Eastbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	1850.00									PM10	
total heavy	50.00										
LDPV	1800.00	8.41	1.58	0.63	0.021	0.001	15138.00	2844.00	1134.00	37.80	1.9800
HDDV	45.00	7.11	15.72	2.58	1.150		319.95	707.40	116.10	51.75	
HDPV	5.00	107.09	4.59	5.82	0.008	0.032	535.45	22.95	29.10	0.04	0.1610
Brake & Tyre					0.009					16.65	
Total kg/km/h							15.99	3.57	1.28	0.11	0.0021
g/v-mi							13.83	3.09	1.11	0.09	0.0019
Section	Norwest Blvd to Old Windsor Rd			Westbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	630.00									PM10	
total heavy	60.00										
LDPV	570.00	8.41	1.58	0.63	0.021	0.001	4793.70	900.60	359.10	11.97	0.6270
HDDV	54.00	7.11	15.72	2.58	1.150		383.94	848.88	139.32	62.10	
HDPV	6.00	107.09	4.59	5.82	0.008	0.032	642.54	27.54	34.92	0.05	0.1932
Brake & Tyre					0.009					5.67	
Total kg/km/h							5.82	1.78	0.53	0.08	0.0008
g/v-mi							14.78	4.51	1.35	0.20	0.0021
Section	Old Windsor Rd to Abbott Rd			Eastbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	2170.00									PM10	
total heavy	70.00										
LDPV	2100.00	8.41	1.58	0.63	0.021	0.001	17661.00	3318.00	1323.00	44.10	2.3100
HDDV	63.00	7.11	15.72	2.58	1.150		447.93	990.36	162.54	72.45	
HDPV	7.00	107.09	4.59	5.82	0.008	0.032	749.63	32.13	40.74	0.06	0.2254
Brake & Tyre					0.009					19.53	
Total kg/km/h							18.86	4.34	1.53	0.14	0.0025
g/v-mi							13.90	3.20	1.13	0.10	0.0019
Section	Old Windsor Rd to Abbott Rd			Westbound		2006	AM				
		Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle	Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no	760.00									PM10	
total heavy	90.00										
LDPV	670.00	8.41	1.58	0.63	0.021	0.001	5634.70	1058.60	422.10	14.07	0.7370
HDDV	81.00	7.11	15.72	2.58	1.150		575.91	1273.32	208.98	93.15	
HDPV	9.00	107.09	4.59	5.82	0.008	0.032	963.81	41.31	52.38	0.07	0.2898
Brake & Tyre					0.009					6.84	
Total kg/km/h							7.17	2.37	0.68	0.11	0.0010
g/v-mi							15.10	5.00	1.44	0.24	0.0022

Estimated emissions for 2016

Section	Elizabeth Dr to The Horsley Dr			Northbound		2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	2920.00									PM10
total heavy	120.00									
LDPV	2800.00	7.57	1.51	0.56	0.021		21196.00	4228.00	1568.00	58.80
HDDV	108.00	7.11	15.72	2.58	1.150		767.88	1697.76	278.64	124.20
HDPV	12.00	107.09	4.59	5.82	0.008		1285.08	55.08	69.84	0.10
Brake & Tyre					0.009					26.28
Total kg/km/h							23.25	5.98	1.92	0.21
g/v-mi							12.74	3.28	1.05	0.11
Section	Elizabeth Dr to The Horsley Dr			Southbound		2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	1330.00									PM10
total heavy	130.00									
LDPV	1200.00	7.57	1.51	0.56	0.021		9084.00	1812.00	672.00	25.20
HDDV	117.00	7.11	15.72	2.58	1.150		831.87	1839.24	301.86	134.55
HDPV	13.00	107.09	4.59	5.82	0.008		1392.17	59.67	75.66	0.11
Brake & Tyre					0.009					11.97
Total kg/km/h							11.31	3.71	1.05	0.17
g/v-mi							13.60	4.46	1.26	0.21
Section	The Horsley Dr to Old Wallgrove			Northbound		2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	3350.00									PM10
total heavy	150.00									
LDPV	3200.00	7.57	1.51	0.56	0.021		24224.00	4832.00	1792.00	67.20
HDDV	135.00	7.11	15.72	2.58	1.150		959.85	2122.20	348.30	155.25
HDPV	15.00	107.09	4.59	5.82	0.008		1606.35	68.85	87.30	0.12
Brake & Tyre					0.009					30.15
Total kg/km/h							26.79	7.02	2.23	0.25
g/v-mi							12.80	3.35	1.06	0.12
Section	The Horsley Dr to Old Wallgrove			Southbound		2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	2650.00									PM10
total heavy	150.00									
LDPV	2500.00	7.57	1.51	0.56	0.021		18925.00	3775.00	1400.00	52.50
HDDV	135.00	7.11	15.72	2.58	1.150		959.85	2122.20	348.30	155.25
HDPV	15.00	107.09	4.59	5.82	0.008		1606.35	68.85	87.30	0.12
Brake & Tyre					0.009					23.85
Total kg/km/h							21.49	5.97	1.84	0.23
g/v-mi							12.98	3.60	1.11	0.14
Section	Old Wallgrove Rd to M4			Northbound		2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	3040.00									PM10
total heavy	140.00									
LDPV	2900.00	7.57	1.51	0.56	0.021		21953.00	4379.00	1624.00	60.90
HDDV	126.00	7.11	15.72	2.58	1.150		895.86	1980.72	325.08	144.90
HDPV	14.00	107.09	4.59	5.82	0.008		1499.26	64.26	81.48	0.11
Brake & Tyre					0.009					27.36
Total kg/km/h							24.35	6.42	2.03	0.23
g/v-mi							12.81	3.38	1.07	0.12
Section	Old Wallgrove Rd to M4			Southbound		2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	1040.00									PM10
total heavy	40.00									
LDPV	1000.00	7.57	1.51	0.56	0.021		7570.00	1510.00	560.00	21.00
HDDV	36.00	7.11	15.72	2.58	1.150		255.96	565.92	92.88	41.40
HDPV	4.00	107.09	4.59	5.82	0.008		428.36	18.36	23.28	0.03
Brake & Tyre					0.009					9.36
Total kg/km/h							8.25	2.09	0.68	0.07
g/v-mi							12.70	3.22	1.04	0.11

Estimated emissions for 2016

Section	M4 to GWH				Northbound		2016	AM			
			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		2290.00									PM10
total heavy		90.00									
LDPV		2200.00	7.57	1.51	0.56	0.021		16654.00	3322.00	1232.00	46.20
HDDV		81.00	7.11	15.72	2.58	1.150		575.91	1273.32	208.98	93.15
HDPV		9.00	107.09	4.59	5.82	0.008		963.81	41.31	52.38	0.07
Brake & Tyre						0.009					20.61
Total kg/km/h								18.19	4.64	1.49	0.16
g/v-mi								12.71	3.24	1.04	0.11
Section	M4 to GWH				Southbound		2016	AM			
			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		2600.00									PM10
total heavy		100.00									
LDPV		2500.00	7.57	1.51	0.56	0.021		18925.00	3775.00	1400.00	52.50
HDDV		90.00	7.11	15.72	2.58	1.150		639.90	1414.80	232.20	103.50
HDPV		10.00	107.09	4.59	5.82	0.008		1070.90	45.90	58.20	0.08
Brake & Tyre						0.009					23.40
Total kg/km/h								20.64	5.24	1.69	0.18
g/v-mi								12.70	3.22	1.04	0.11
Section	GWH to Power Street				Northbound		2016	AM			
			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		2500.00									PM10
total heavy		100.00									
LDPV		2400.00	7.57	1.51	0.56	0.021		18168.00	3624.00	1344.00	50.40
HDDV		90.00	7.11	15.72	2.58	1.150		639.90	1414.80	232.20	103.50
HDPV		10.00	107.09	4.59	5.82	0.008		1070.90	45.90	58.20	0.08
Brake & Tyre						0.009					22.50
Total kg/km/h								19.88	5.08	1.63	0.18
g/v-mi								12.72	3.25	1.05	0.11
Section	GWH to Power Street				Southbound		2016	AM			
			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		3210.00									PM10
total heavy		110.00									
LDPV		3100.00	7.57	1.51	0.56	0.021		23467.00	4681.00	1736.00	65.10
HDDV		99.00	7.11	15.72	2.58	1.150		703.89	1556.28	255.42	113.85
HDPV		11.00	107.09	4.59	5.82	0.008		1177.99	50.49	64.02	0.09
Brake & Tyre						0.009					28.89
Total kg/km/h								25.35	6.29	2.06	0.21
g/v-mi								12.63	3.13	1.02	0.10
Section	Power St to Richmond Rd				Northbound		2016	AM			
			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		2260.00									PM10
total heavy		60.00									
LDPV		2200.00	7.57	1.51	0.56	0.021		16654.00	3322.00	1232.00	46.20
HDDV		54.00	7.11	15.72	2.58	1.150		383.94	848.88	139.32	62.10
HDPV		6.00	107.09	4.59	5.82	0.008		642.54	27.54	34.92	0.05
Brake & Tyre						0.009					20.34
Total kg/km/h								17.68	4.20	1.41	0.13
g/v-mi								12.52	2.97	1.00	0.09
Section	Power St to Richmond Rd				Southbound		2016	AM			
			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		2880.00									PM10
total heavy		80.00									
LDPV		2800.00	7.57	1.51	0.56	0.021		21196.00	4228.00	1568.00	58.80
HDDV		72.00	7.11	15.72	2.58	1.150		511.92	1131.84	185.76	82.80
HDPV		8.00	107.09	4.59	5.82	0.008		856.72	36.72	46.56	0.06
Brake & Tyre						0.009					25.92
Total kg/km/h								22.56	5.40	1.80	0.17
g/v-mi								12.54	3.00	1.00	0.09

Estimated emissions for 2016

Section	Richmond Rd to Quakers Hill Pwy		Eastbound			2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	2890.00									PM10
total heavy	90.00									
LDPV	2800.00	7.57	1.51	0.56	0.021		21196.00	4228.00	1568.00	58.80
HDDV	81.00	7.11	15.72	2.58	1.150		575.91	1273.32	208.98	93.15
HDPV	9.00	107.09	4.59	5.82	0.008		963.81	41.31	52.38	0.07
Brake & Tyre					0.009					26.01
Total kg/km/h							22.74	5.54	1.83	0.18
g/v-mi							12.59	3.07	1.01	0.10
Section	Richmond Rd to Quakers Hill Pwy		Westbound			2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	2000.00									PM10
total heavy	100.00									
LDPV	1900.00	7.57	1.51	0.56	0.021		14383.00	2869.00	1064.00	39.90
HDDV	90.00	7.11	15.72	2.58	1.150		639.90	1414.80	232.20	103.50
HDPV	10.00	107.09	4.59	5.82	0.008		1070.90	45.90	58.20	0.08
Brake & Tyre					0.009					18.00
Total kg/km/h							16.09	4.33	1.35	0.16
g/v-mi							12.88	3.46	1.08	0.13
Section	Quakers Hill Pwy to Sunnyholt Rd		Eastbound			2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	3600.00									PM10
total heavy	100.00									
LDPV	3500.00	7.57	1.51	0.56	0.021		26495.00	5285.00	1960.00	73.50
HDDV	90.00	7.11	15.72	2.58	1.150		639.90	1414.80	232.20	103.50
HDPV	10.00	107.09	4.59	5.82	0.008		1070.90	45.90	58.20	0.08
Brake & Tyre					0.009					32.40
Total kg/km/h							28.21	6.75	2.25	0.21
g/v-mi							12.54	3.00	1.00	0.09
Section	Quakers Hill Pwy to Sunnyholt Rd		Westbound			2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	2200.00									PM10
total heavy	100.00									
LDPV	2100.00	7.57	1.51	0.56	0.021		15897.00	3171.00	1176.00	44.10
HDDV	90.00	7.11	15.72	2.58	1.150		639.90	1414.80	232.20	103.50
HDPV	10.00	107.09	4.59	5.82	0.008		1070.90	45.90	58.20	0.08
Brake & Tyre					0.009					19.80
Total kg/km/h							17.61	4.63	1.47	0.17
g/v-mi							12.81	3.37	1.07	0.12
Section	Sunnyholt Rd to Norwest Blvd		Eastbound			2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	3610.00									PM10
total heavy	110.00									
LDPV	3500.00	7.57	1.51	0.56	0.021		26495.00	5285.00	1960.00	73.50
HDDV	99.00	7.11	15.72	2.58	1.150		703.89	1556.28	255.42	113.85
HDPV	11.00	107.09	4.59	5.82	0.008		1177.99	50.49	64.02	0.09
Brake & Tyre					0.009					32.49
Total kg/km/h							28.38	6.89	2.28	0.22
g/v-mi							12.58	3.05	1.01	0.10
Section	Sunnyholt Rd to Norwest Blvd		Westbound			2016	AM			
		Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no	1720.00									PM10
total heavy	120.00									
LDPV	1600.00	7.57	1.51	0.56	0.021		12112.00	2416.00	896.00	33.60
HDDV	108.00	7.11	15.72	2.58	1.150		767.88	1697.76	278.64	124.20
HDPV	12.00	107.09	4.59	5.82	0.008		1285.08	55.08	69.84	0.10
Brake & Tyre					0.009					15.48
Total kg/km/h							14.16	4.17	1.24	0.17
g/v-mi							13.18	3.88	1.16	0.16

Estimated emissions for 2016

Section	Norwest Blvd to Old Windsor Rd				Eastbound		2016	AM			
			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		2070.00									PM10
total heavy		70.00									
LDPV		2000.00	7.57	1.51	0.56	0.021		15140.00	3020.00	1120.00	42.00
HDDV		63.00	7.11	15.72	2.58	1.150		447.93	990.36	162.54	72.45
HDPV		7.00	107.09	4.59	5.82	0.008		749.63	32.13	40.74	0.06
Brake & Tyre						0.009					18.63
Total kg/km/h								16.34	4.04	1.32	0.13
g/v-mi								12.63	3.12	1.02	0.10
Section	Norwest Blvd to Old Windsor Rd				Westbound		2016	AM			
			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		780.00									PM10
total heavy		80.00									
LDPV		700.00	7.57	1.51	0.56	0.021		5299.00	1057.00	392.00	14.70
HDDV		72.00	7.11	15.72	2.58	1.150		511.92	1131.84	185.76	82.80
HDPV		8.00	107.09	4.59	5.82	0.008		856.72	36.72	46.56	0.06
Brake & Tyre						0.009					7.02
Total kg/km/h								6.67	2.23	0.62	0.10
g/v-mi								13.68	4.57	1.28	0.21
Section	Old Windsor Rd to Abbott Rd				Eastbound		2016	AM			
			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		2390.00									PM10
total heavy		90.00									
LDPV		2300.00	7.57	1.51	0.56	0.021		17411.00	3473.00	1288.00	48.30
HDDV		81.00	7.11	15.72	2.58	1.150		575.91	1273.32	208.98	93.15
HDPV		9.00	107.09	4.59	5.82	0.008		963.81	41.31	52.38	0.07
Brake & Tyre						0.009					21.51
Total kg/km/h								18.95	4.79	1.55	0.16
g/v-mi								12.69	3.21	1.04	0.11
Section	Old Windsor Rd to Abbott Rd				Westbound		2016	AM			
			Emission rate g/km/vehicle					Total emissions g/km/h			
Vehicle		Number	CO	NOx	HC	PM10		totCO	tot NOx	tot HC	tot
total no		920.00									PM10
total heavy		110.00									
LDPV		810.00	7.57	1.51	0.56	0.021		6131.70	1223.10	453.60	17.01
HDDV		99.00	7.11	15.72	2.58	1.150		703.89	1556.28	255.42	113.85
HDPV		11.00	107.09	4.59	5.82	0.008		1177.99	50.49	64.02	0.09
Brake & Tyre						0.009					8.28
Total kg/km/h								8.01	2.83	0.77	0.14
g/v-mi								13.94	4.92	1.34	0.24

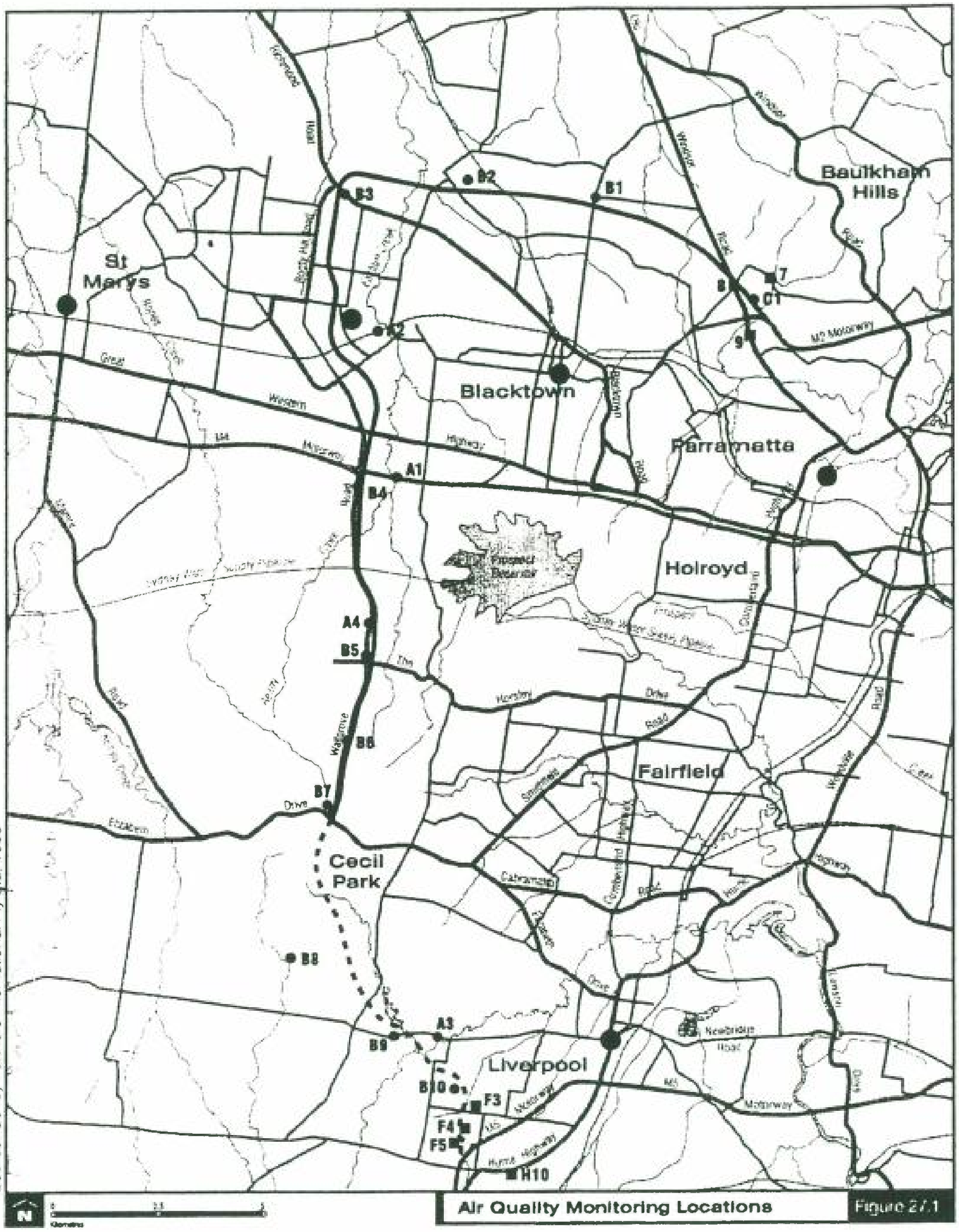
ATTACHMENT C
HYDROCARBON ANALYSIS OF VEHICLE EXHAUST, PETROL AND PETROL VAPOUR

HYDROCARBON COMPOSITION OF VEHICLE EXHAUST, PETROL AND PETROL VAPOUR

Hydrocarbon	Exhaust Average	Exhaust SD	Petrol Average	Petrol SD	Petrol Vapour
ethane	1.4	0.5			
ethylene	11.2	3.2			
acetylene	8.7	2.7			
propane	0.1	0.1	0.1	0.1	1.5
propylene	5.0	1.6			
methylacetylene	0.4	0.3			
n-butane	2.1	0.6	2.9	0.4	18.7
i-butane	1.0	0.3	1.2	0.3	11.1
1-butene	0.9	0.3	0.2	0.1	1.6
i-butene	1.4	0.6			
trans-2-butene	0.6	0.4	0.6	0.1	3.7
cis-2-butene	0.5	0.2	0.5	0.1	2.9
n-pentane	3.0	0.7	6.0	0.6	10.7
i-pentane	4.8	0.9	10.6	0.5	25.4
cyclopentane	0.4	0.1	0.5	0.1	0.6
1-pentene	0.2	0.1	0.3	0.1	0.7
trans-2-pentene	0.3	0.2	0.8	0.1	1.5
cis-2-pentene	0.3	0.2	0.5	0.1	0.9
2-methyl-1-butene	0.3	0.2	0.6	0.1	1.3
2-methyl-2-butene	0.5	0.2	1.6	0.2	2.6
n-hexane	1.9	0.4	3.5	0.3	1.9
2-methylpentane	2.3	0.4	4.9	0.2	3.5
3-methylpentane	1.6	0.3	3.2	0.1	2.2
2,2-dimethylbutane	0.3	0.2	0.5	0.1	0.6
2,3-dimethylbutane	0.6	0.1	1.3	0.1	1.1
methylcyclopentane	1.0	0.2	1.9	0.1	0.9
cyclohexane	0.6	0.2	0.8	0.1	0.3
1-hexene	0.3	0.2	0.4	0.1	0.3
other C_6 olefins	0.7	0.2	1.6	0.1	1.0
benzene	5.0	0.7	2.6	0.2	0.9
n-heptane	0.8	0.2	1.6	0.1	0.3
2-methylhexane	1.5	0.3	2.9	0.1	0.7
3-methylhexane	1.2	0.3	2.3	0.1	0.5
2,4-dimethylpentane	0.3	0.1	0.7	0.1	0.2
methylcyclohexane	0.6	0.2	1.1	0.2	0.2
other C_7 cycloalkanes	0.3	0.2	0.6	0.1	0.1
toluene	10.2	0.9	9.6	0.6	1.0
n-octane	0.4	0.1	0.7	0.1	
2,2,4-trimethylpentane	1.0	0.4	2.1	0.5	0.4
other C_8 alkanes	3.2	0.7	7.1	0.6	0.6
ethylbenzene	1.9	0.2	1.6	0.1	0.1
m, p-xylenes	6.5	0.9	6.5	0.4	0.2
o-xylene	2.5	0.4	2.3	0.2	0.1
n-nonane	0.2	0.1	0.3	0.1	
other C_9 alkanes	1.7	0.4	2.1	0.3	
n-propylbenzene	0.4	0.1	0.4	0.1	
i-propylbenzene	0.2	0.1	0.2	0.1	
1,2,4-trimethylbenzene	1.9	0.3	1.8	0.2	
1,3,5-trimethylbenzene	0.7	0.1	0.7	0.1	
m, p-ethyltoluenes	2.0	0.3	1.8	0.2	
o-ethyltoluene	0.6	0.2	0.5	0.1	
n-decane	0.4	0.1	0.4	0.1	
other C_{10} alkanes & aromatics	0.9	0.4	1.2	0.3	
C_{11} and C_{12} alkanes & aromatics	3.6	1.1	4.2	0.7	
	100.40		99.80		100.30

Source: **Nelson & Quigley (1982)**

FIGURES



Source Coffey Partners International Pty Ltd. 1995

Proposed Western Sydney Orbital

- Cecil Park to West Baulkham Hills
- Cecil Park to Prestons
- EPA Monitoring Site

Monitoring Sites

- Current Study
- Previous Study

FIGURE 1

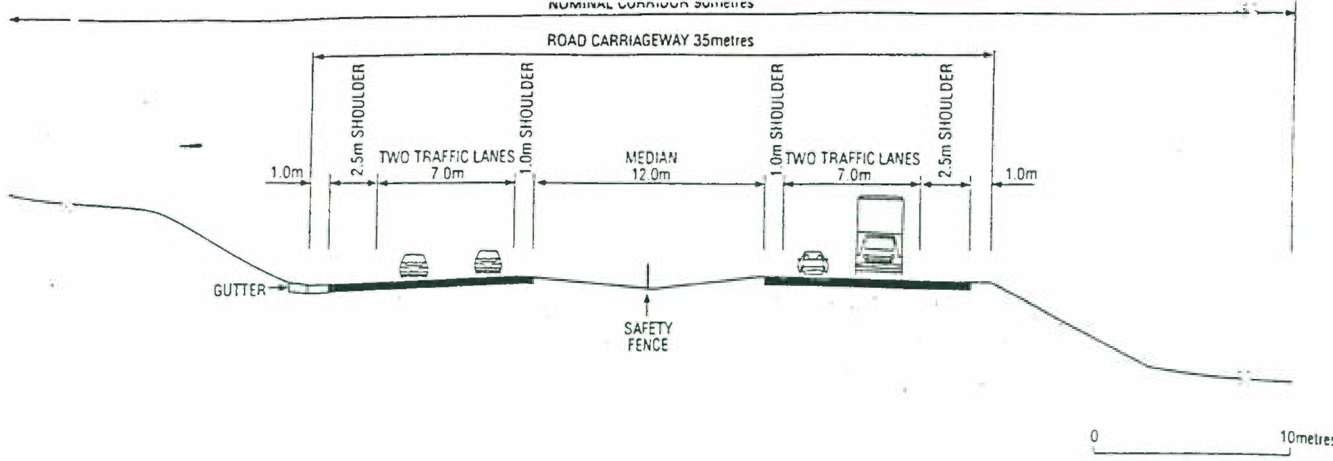


Figure 6.1
Western Sydney Orbital, Prestons to Cecil Park
Typical Cross Section

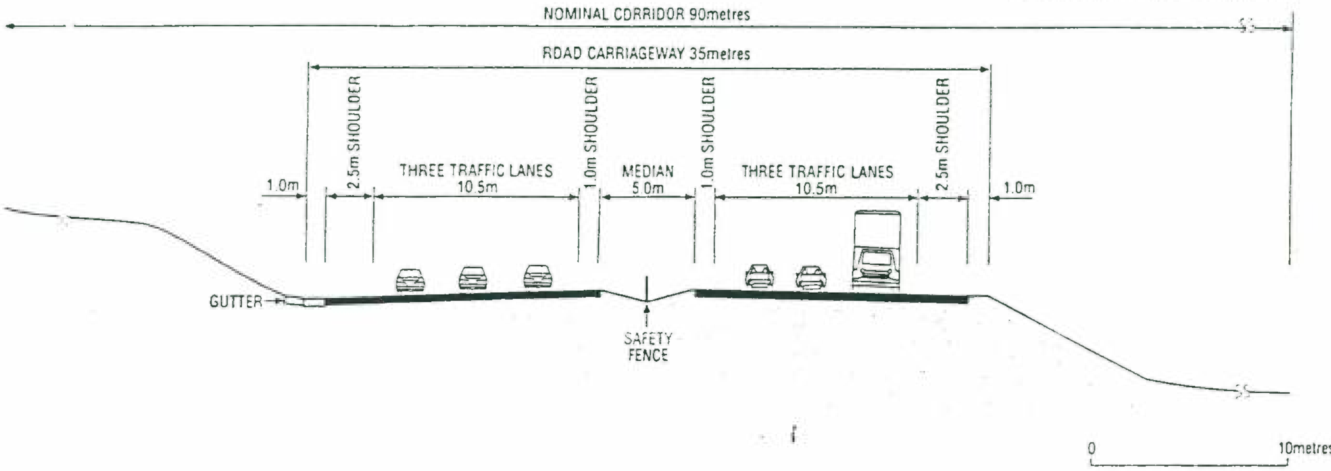


Figure 6.2
Possible Future Six Lane
Cross Section

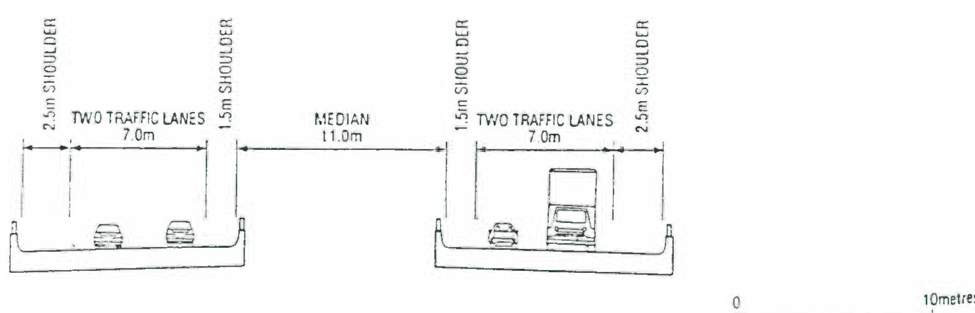


Figure 6.3
Typical Cross Section on Bridge

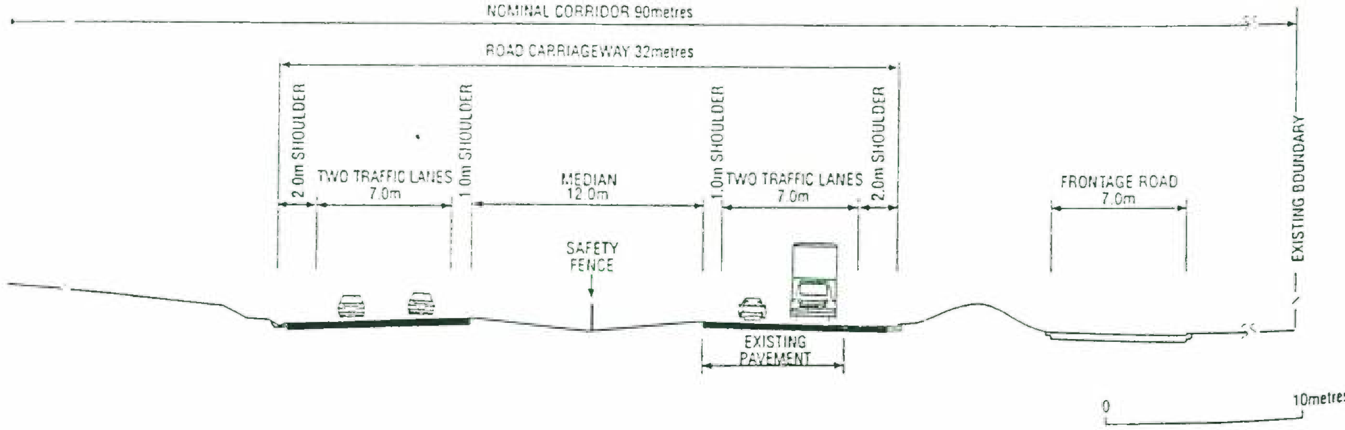
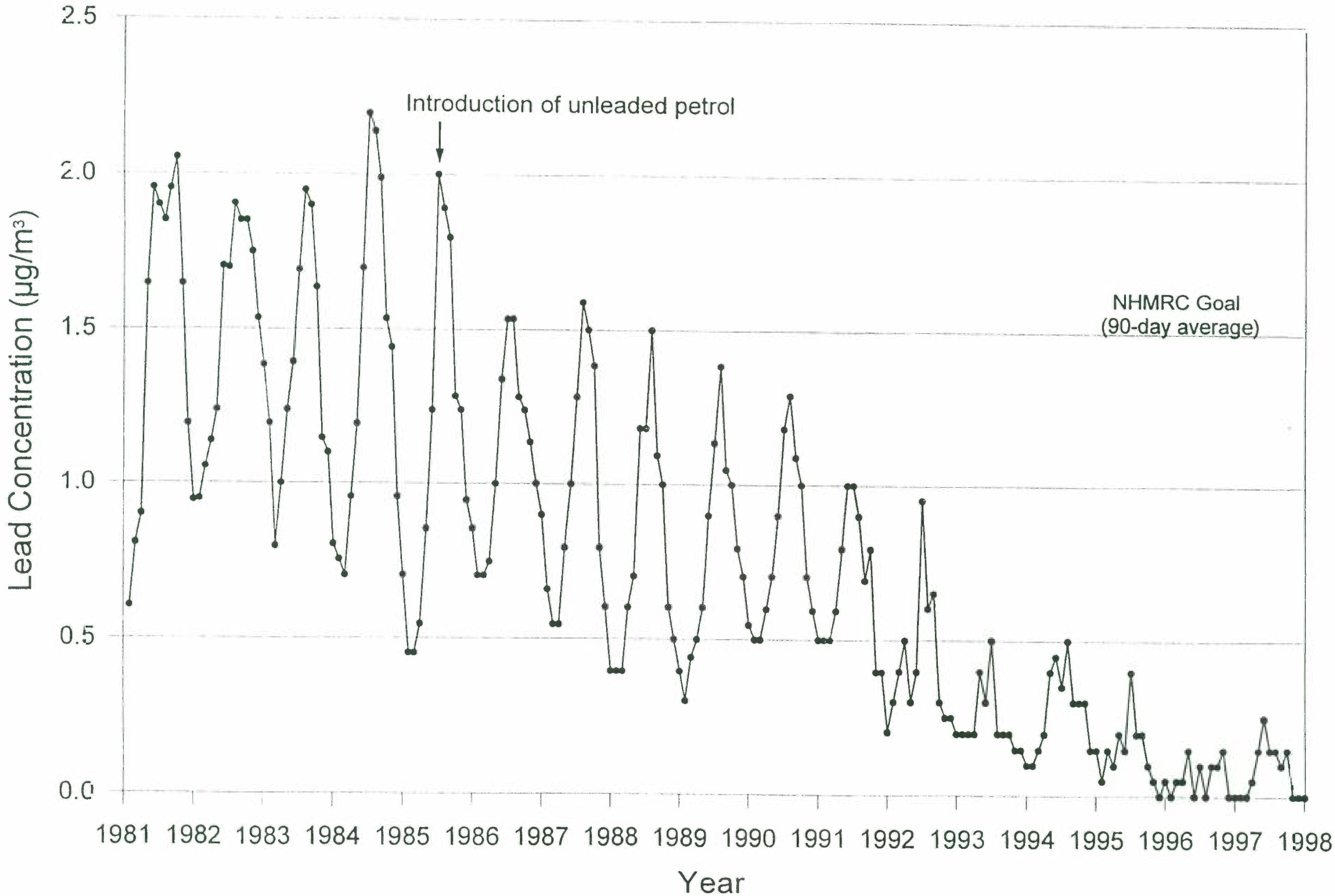


Figure 6.4
Typical Elizabeth Drive Cross Section
(Approximate chainage 1,750)

CROSS SECTION OF THE PROPOSED ROUTE

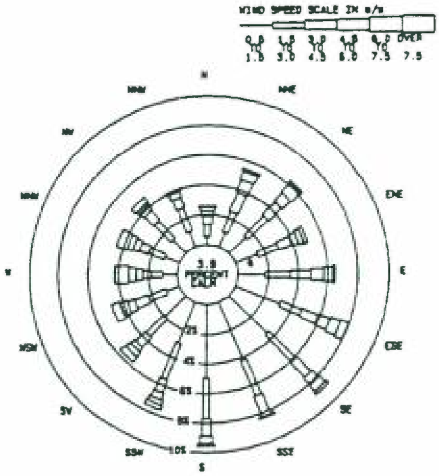
FIGURE 2

LEAD LEVELS - SYDNEY SUBURBS

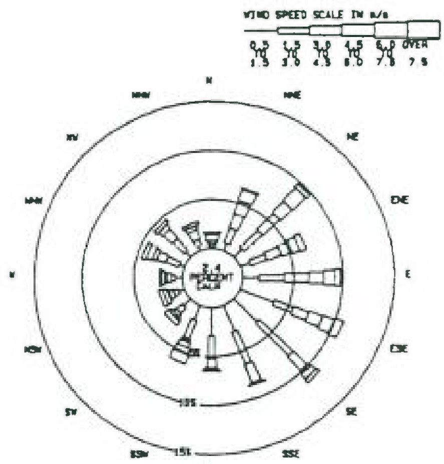


JRE 3

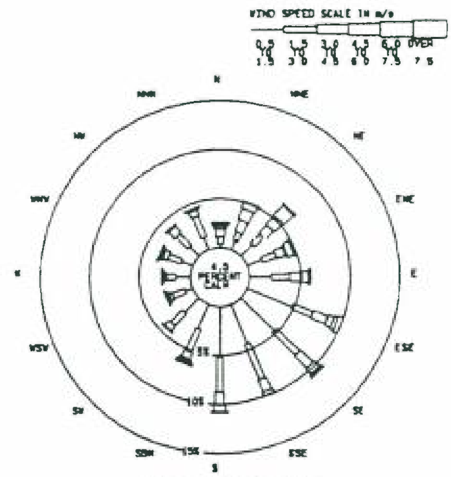
Annual and seasonal windroses for Fleurs 1980



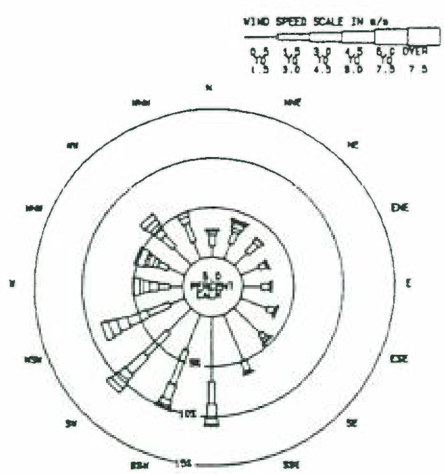
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Annual - 1980



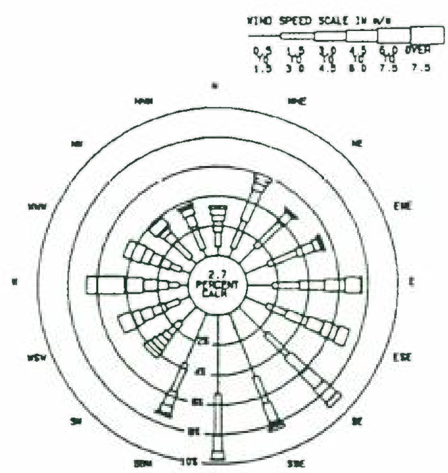
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Summer - 1980



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Autumn - 1980



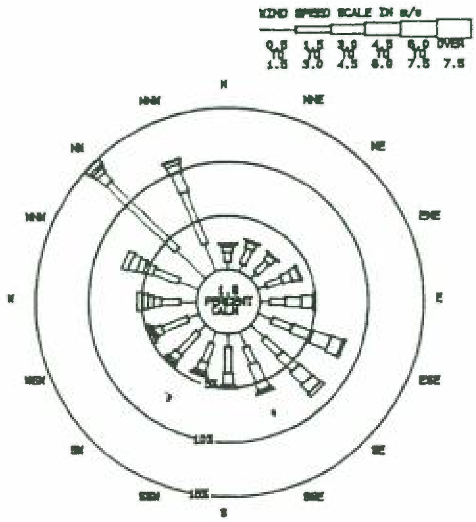
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Winter - 1980



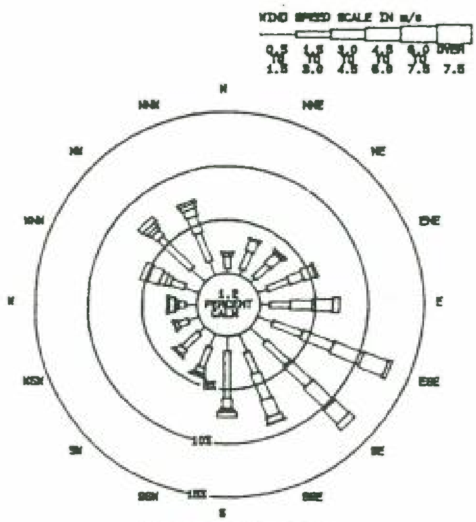
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Spring - 1980

FIGURE 4a

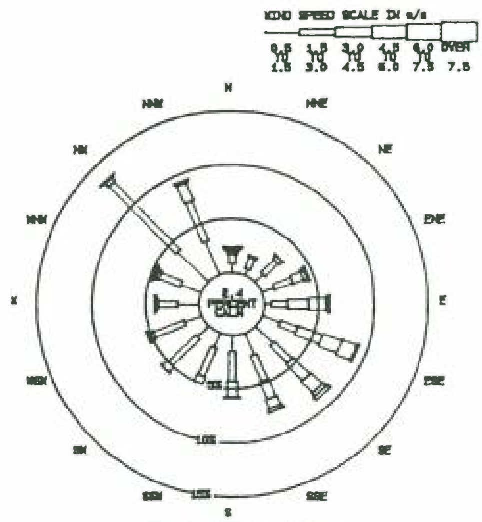
Annual and seasonal windroses for Blacktown 1984



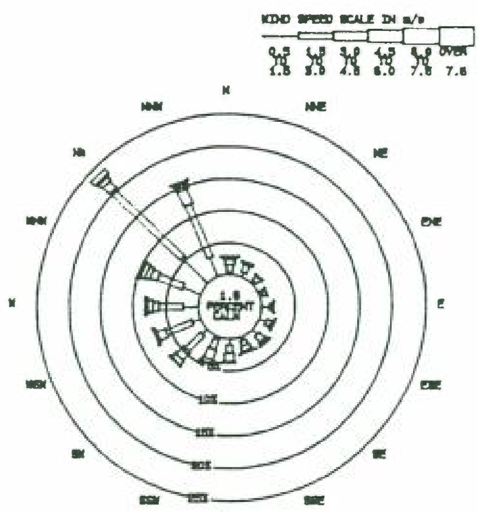
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Blacktown 1984 - Annual



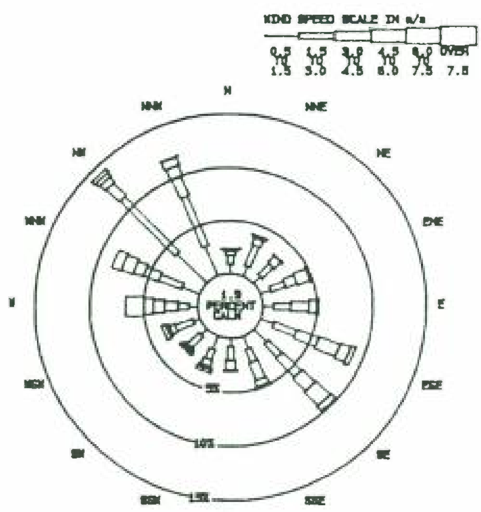
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Blacktown 1984 - Summer



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



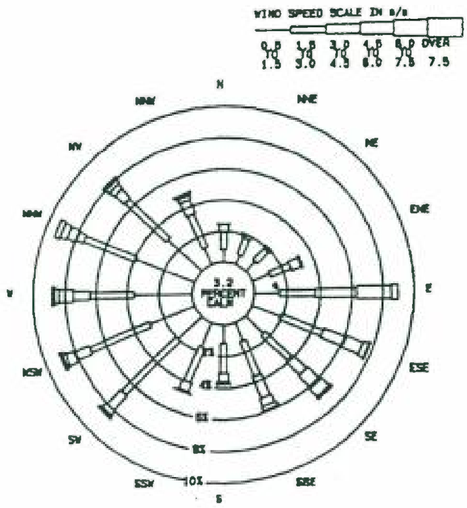
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Blacktown 1984 - Winter



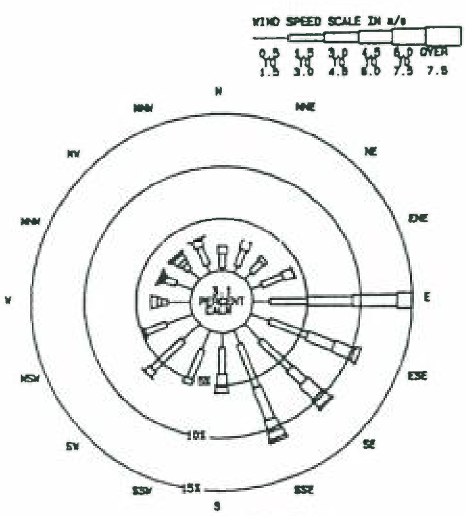
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Blacktown 1984 - Spring

FIGURE 4b

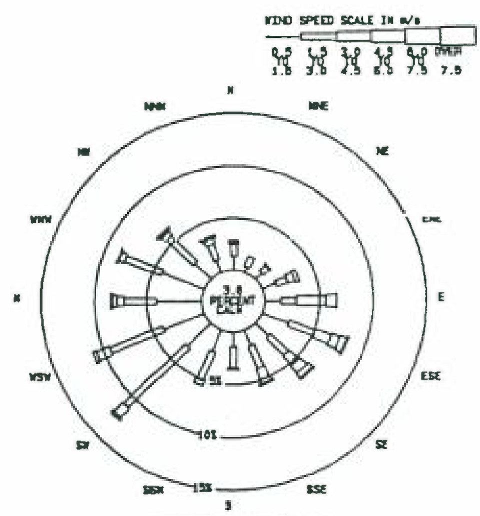
Annual and seasonal windroses for West Hoxton 1980/1981



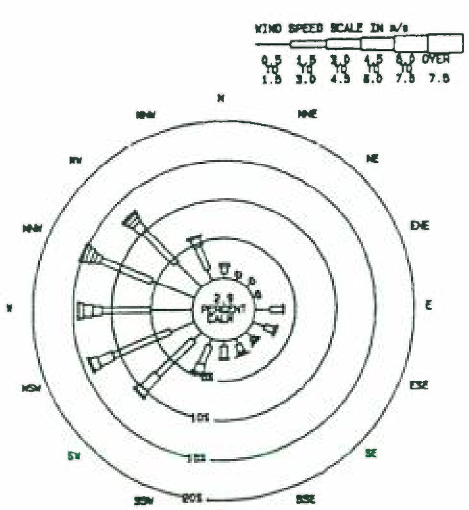
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
West Hoxton 1980/1981 Annual



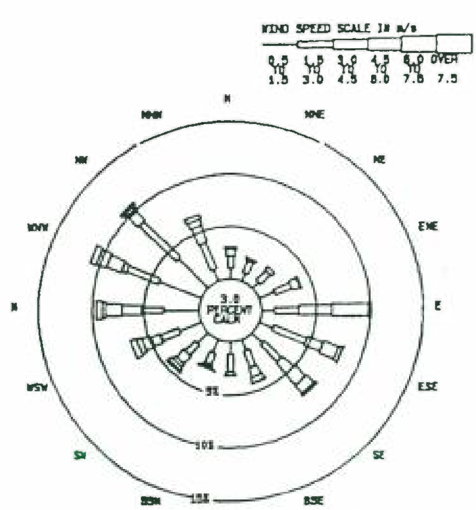
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
West Hoxton 1980/1981 Summer



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
West Hoxton 1980/1981 Autumn



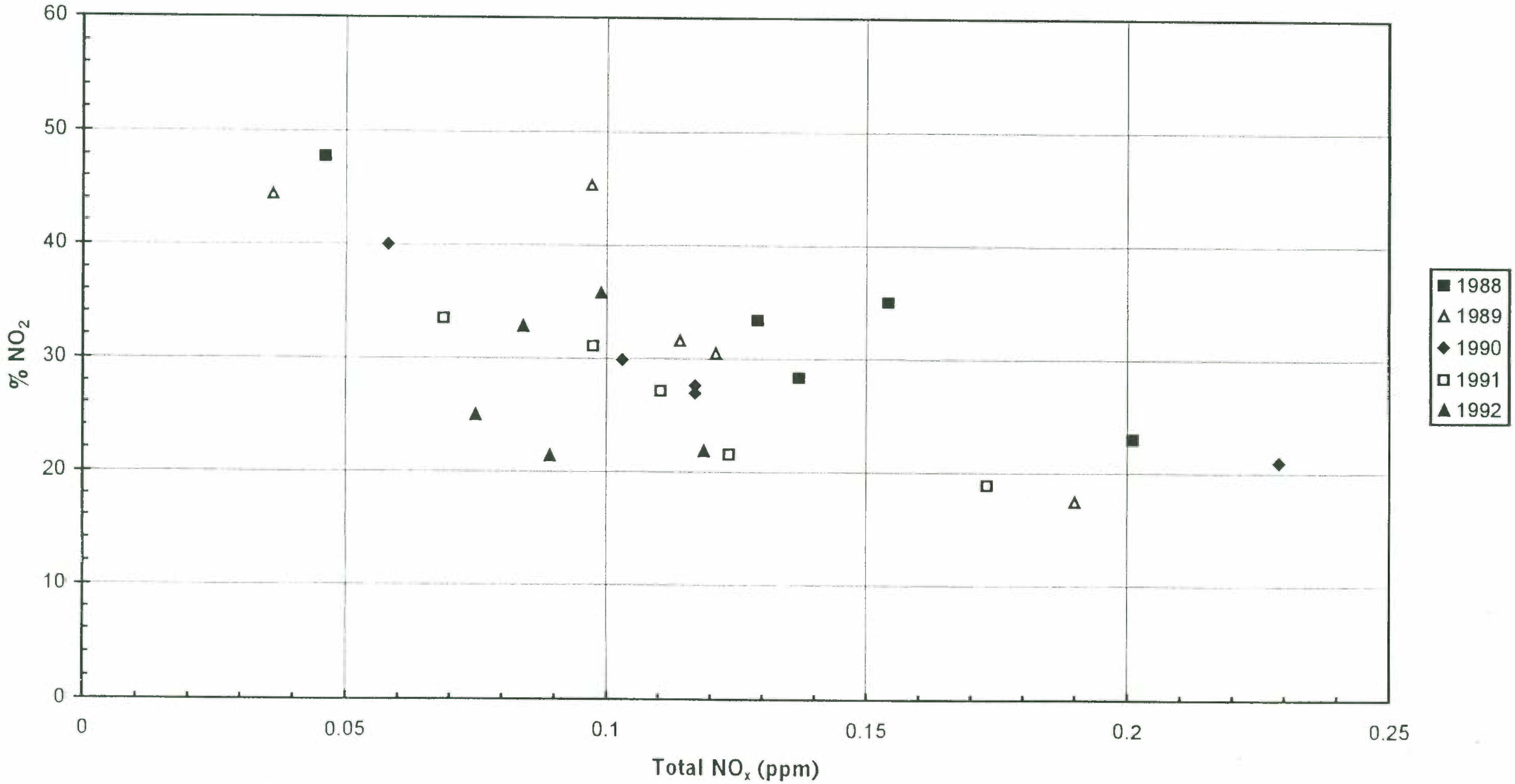
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
West Hoxton 1980/1981 Winter



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
West Hoxton 1980/1981 Spring

FIGURE 4c

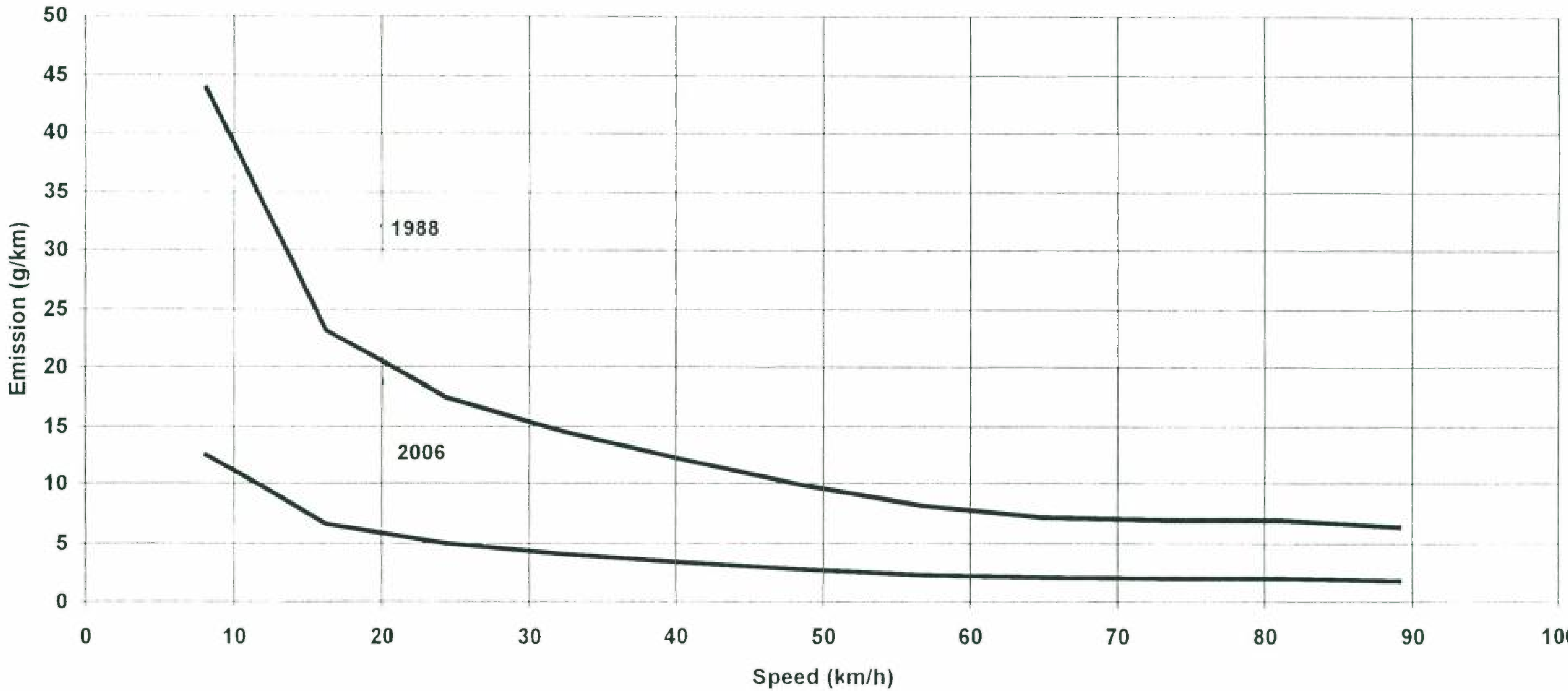
Correlation between % NO_2 and total NO_x
EPA monitoring data



Based on NSW EPA monitoring data 1988-1992

FIGURE 5

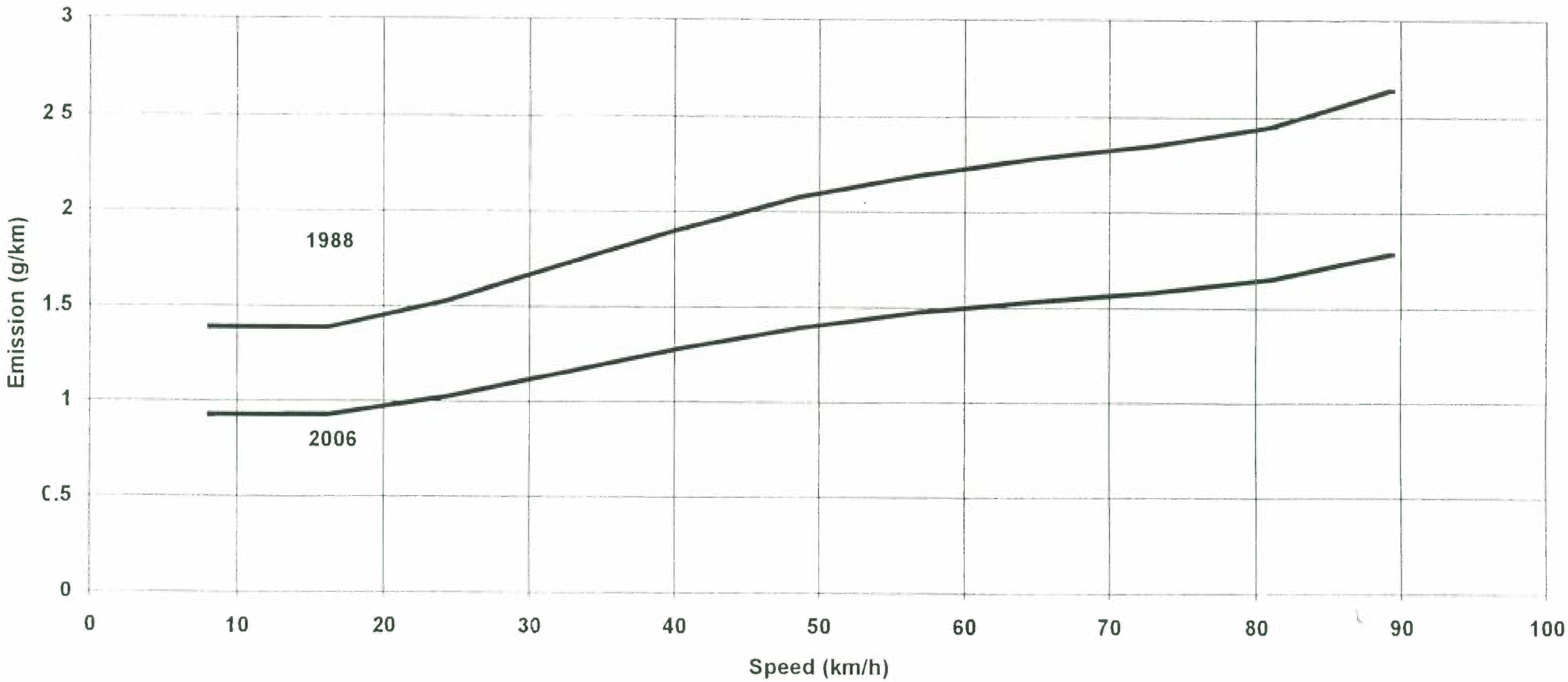
EMISSION RATE OF CO vs SPEED FOR LIGHT DUTY PETROL VEHICLES - YEARS 1988 AND 2006



Based on Pengilley (1989) and US EPA (1985)

FIGURE 6

EMISSION RATE OF NO_x vs SPEED FOR LIGHT DUTY PETROL VEHICLES - YEARS 1988 AND 2006



Based on Pengilley (1989) and US EPA (1985)

FIGURE 7

APPENDIX ELEVEN

PRELIMINARY STUDY FOR GROUNDWATER SALINITY

DAVIES GEOTECHNICAL PTY LTD
CONSULTING ENGINEERS A.B.N. 44 070 628 787

REPORT ON

PRELIMINARY STUDY

for

GROUNDWATER SALINITY

WESTERN SYDNEY ORBITAL PROJECT

Submitted to:

Hyder Consulting (Australia) Pty Ltd

(Attention: Mr B Lyall)

On behalf of the
Roads & Traffic Authority, NSW

3 July 2001 report ref: R/01-019.B

Distribution:

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1.0 INTRODUCTION

This report presents the results of a preliminary study into saline groundwater conditions along the route of the proposed Western Sydney Orbital (WSO) motorway project. The study was requested following public exhibition of, and responses to, the Environmental Impact Statement (EIS), prepared for the WSO project.

The study was commissioned by Hyder Consulting (Australia) Pty Ltd on 23 May 2001, on behalf of the Roads & Traffic Authority of NSW (RTA). The work was carried out in accordance with a proposal by Davies Geotechnical Pty Ltd dated 3 May 2001, reference P/01-0408.A, and a draft scope of work dated 24 April 2001.

The preliminary study comprises a desktop appraisal of the issues raised by the responses to the EIS, and is to assist the preparation of responses to the public submissions.

The study is based on Information regarding the proposed motorway, provided for the purposes of the study, as detailed in the following report.

The report presents the methodology and results of the preliminary study, and provides discussion and recommendations for further actions in regard to possible impacts and management of potential salinity problems.

2.0 BACKGROUND

The Western Sydney Orbital motorway is to be some 39 kilometres long, extending from the Hume Highway/M5 Motorway at Prestons in the south, to the M2 Motorway at West Baulkham Hills in the north. The route alignment is shown on the figures attached to this report, which are reproduced from the EIS document.

The EIS for the Western Sydney Orbital (reference 1) was prepared in October 2000 and was subsequently exhibited. Submissions were received from Government Authorities, concerning the effects of the proposed roadworks on the groundwater table and on groundwater quality.

In particular, the possibilities that saline groundwater may be intercepted by road cuttings, and consequently may enter the hydrologic regime and adversely effect the surface water quality downstream of the motorway, were flagged by Blacktown and Fairfield Councils as possible impacts of the WSO construction. The submissions on this issue by both councils are attached in Appendix A.

Saline groundwater conditions are recognised in the areas of the Western Sydney Region which will be traversed by the proposed motorway route.

Also, previous land uses in rural areas of Fairfield Council, predominantly piggeries and poultry farming, were flagged as potentially providing contamination to surface waters through infiltration and seepage emerging in the road cuttings.

The preliminary study undertaken addresses these issues and provides recommendations for actions considered suitable for further assessment of potential impacts and for managing any adverse impacts during the construction stage and operational life of the motorway.

3.0 STUDY METHOD

The preliminary study has been carried out as a desktop study using the data and information sources referred to in Section 4.0 below, and as referred to elsewhere in the report.

Personal contact has been made with several practitioners in the groundwater and hydrogeology fields to establish the availability of data and information relevant to the saline groundwater problem of the Western Sydney Region.

The data base resources of the Department of Land and Water Conservation (DLWC) have been used to provide data on groundwater and soils.

Reference is also made to a number of publications on the geology, soils and groundwater of the Western Sydney Region.

The distribution of underlying geology and surface soils along the motorway route has been determined and grouped into sections based on route kilometrage. The frequency and depths of cuttings along the route has also been determined. These factors are considered important in an assessment of the likelihood of encountering groundwater and saline conditions.

Mr Nik Kontos of Sydney Groundwater Company Pty Ltd provided assistance with the data gathering and with personal contacts, specifically for this study. A summary report prepared by Sydney Groundwater Company is provided in Appendix B herewith. Information from that report is utilised in the main report following.

4.0 AVAILABLE DATA

The following components of the EIS were used for data sources in the study undertaken:-

i) (Volume 2) Chapter 18: Geology and Soils (Southern Section)
ii) (Volume 2) Chapter 19: Water Quality and Hydrology (Southern Section)
iii) (Volume 3) Chapter 32: Geology and Soils (Northern Section)
iv) (Volume 3) Chapter 33: Water Quality and Hydrology (Northern Section)
v) Working Paper Nine: Geotechnical Assessment (Northern Section)
vi) Working Paper Ten: Water Quantity and Water Quality Assessment (Northern Section)
vii) (Volume 2) Appendix J: Soil Profile Reports
viii) Plans and Longitudinal Sections of the proposed WSO route (1:10,000 horizontal scale and 1:1,000 vertical scale).
ix) Submission from Blacktown Council
x) Submission from Fairfield Council

Reference was made during the study to various other volumes and sections in the EIS document for background and general information on the concept design for the motorway and surface water drainage.

Plans contained in the EIS document, showing the motorway route, have been used for presentation of the outcomes of the preliminary study, on the Figures attached to this report.

In addition to the above data, various other sources of information on the geology, soils and groundwater within and adjacent to the WSO motorway corridor were researched from readily available resources and publications in the public domain.

Personal contact has been made with several practitioners in the groundwater and hydrogeology fields to establish the availability of data and information relevant to the saline groundwater problem.

All additional sources of information and data are referenced where appropriate throughout the following report.

5.0 ROUTE GEOLOGY AND SOILS

The Penrith 1:100 000 Geological Series Sheet (reference 2) indicates that the motorway route traverses bedrock of the Triassic Age Wianamatta Group, predominantly comprising Bringelly Shale (Rwb), Ashfield Shale (Rwa) and Minchinbury Sandstone (Rwm). The Ashfield Shale and Minchinbury Sandstone are older rocks, geologically underlying the Bringelly Shale, and are encountered only at the eastern end of the route near West Baulkham Hills, comprising approximately 12% of the route.

These rocks comprise mainly shale, siltsone, carbonaceous claystone, claystone, laminite and fine to medium grained lithic sandstone.

The motorway route traverses four predominant soil profiles, listed below, as described by Bannerman & Hazelton (reference 3). Summary descriptions of these soil profiles are provided in Chapters 18 and 32 of the EIS and in Working Paper Nine. Appendix C herewith provides an extract from Chapter 18 for reference. The four predominant soil profiles are:-

- Blacktown (bt) - residual (light to medium and heavy clays)
- Luddenham (lu) - erosional (medium to heavy clays)
- Picton (pn) - colluvial (light to medium, stoney clays)
- South Creek (sc) - fluvial (clay to sandy clay loams and light to medium clays)

Table A provides a summary of the route sections based on the distribution of bedrock and soil profile types, determined from this study. Figures 18.1a, 18.1b, and 32.1A – 32.1D, attached herewith, show the route alignment, geological boundaries and soils mapping.

6.0 EXISTING SURFACE WATER SALINITY

Water quality data from monitoring of surface waters along the motorway route is presented in Chapter 19 and Working Paper Ten of the EIS document. The data includes conductivity test results (Chapter 19 only), which are a measure of salinity, for a number of the principal waterways. Mean/median and maximum values of the conductivity data presented are summarised as follows:-

	Mean/Median (mS/m)	Maximum (mS/m)
Upper Maxwells Creek	121	526
Upper Cabramatta Creek	185	446
Hinchinbrook Creek	152	517
Ropes Creek	62.5	168
South Creek	122	429

No conductivity or salinity data were presented in the EIS for the remaining waterways draining the motorway route. These comprise Reedy Creek, Eastern Creek, Breakfast Creek, Caddies Creek, Toongabbie Creek and a number of minor named and unnamed creeks.

Recommended goal maximum values for conductivity are stated to be 150mS/m (1500μS/cm) based on ANZECC guidelines. This is approximately equivalent to total dissolved salts (TDS, or "salinity") of 900mg/l.

Normally accepted ranges in salinity concentrations are as follows:-

	TDS (mg/l)
Fresh	< 1,000
Low salinity (brackish)	1,000 – 3,000
Saline	>3,000

The data available in the EIS document indicate that the mean/median values for conductivity in the monitored surface waters are close to the recommended goal maximum value of 150mS/m, and that the maximum recorded values exceed the recommended goal maximum by a factor of over 3 times. On the basis of the above ranges for salinity classification, these surface waters would be classed as fresh (on average), with variations to the upper limit of brackish, bordering on saline.

7.0 GROUNDWATER AND SOIL SALINITY

No data are provided in the EIS to assess groundwater salinity (as distinct from surface water salinity), relevant to the route corridor. For this study, reliance is placed on limited data available in published literature for the Western Sydney Region, and in the DLWC Bore Master Database (refer discussion below).

D. Woolley (in reference 4) provides commentary on available data from water bores in the Penrith 1:100 000 Sheet area. As at 1991, eleven (11) bores were available in the Wianamatta Group stratigraphic unit. Woolley summarises the data as follows:

> *"There are not many bores in the Wianamatta Group within the map area; most of them yield saline water, which is also hard. Salinity information from shallow wells and bores, compiled by Old (1942) and supplemented by data from more recent bores, shows that the water is generally too saline even for stock watering, the recorded saline content ranging up to 31,750mg/l (total salts). Water from elevated marginal areas of outcrop is usually less saline and is suitable for stock whilst that in the lower lying poorly drained strata near the centre of the Cumberland Basin is more saline."*

By contrast, the data provided by Woolley from 66 bores in the Hawkesbury Sandstone, which is a source of groundwater within the map area, and elsewhere in the Sydney region, indicates salinity ranging from 200 to 1200mg/l (total salts), depending on proximity to the recharge area.

Data was obtained during this study from the DLWC archive of drilling and water bore records, for a nominated corridor 8km wide along the motorway route alignment. The information (provided in Appendix D herewith) indicates that groundwater quality data within the 8km wide corridor is limited to a single bore (DLWC Bore No. GW026226). This bore is located in the Glendenning area, within a few hundred metres from the WSO route, and was tested in 1966. The bore showed saline groundwater (electrical conductivity (EC) measured at 7,529 μS/cm) to be present in fractured shale at a depth of 8.2 metres (refer to Table 1, Appendix D).

The DLWC plan provided in Appendix D shows the bore locations relative to the motorway route corridor.

With respect to water table depth (refer to Table 2, Appendix D), out of a total of 21 registered bores identified within 4km either side of the WSO route, 13 bores showed standing water level (SWL) measured at within 10m below ground level (11 bores had SWL's within 5m below ground level, and 2 bores had SWL's between 5m and 10m below ground level). Of the remaining 8 bores, 4 bores showed SWL's less than 20m below ground level, while 4 bores had no records available.

Mr Dan McKibbin of DLWC (pers. comm.) explained that groundwater data for this area is limited due to the low well yield (<1 litre/second) and high salinity characteristics (EC up to 15,000 μS/cm) of the Bringelly Shale aquifer.

Information provided (pers. comm.) by the University of NSW, Sydney University and the University of Technology, Sydney (UTS) suggests that, although significant groundwater research has been conducted in areas of dryland salinity, very little work has been carried out on the hydrochemistry of groundwater in the Bringelly Shale.

Dr Michael Knight of UTS indicated that a research paper produced in the 1940's provided a groundwater salinity contour map for the Western Sydney area. Dr Knight referred to Dr Bruce Sutton of the Department. of Crop Sciences, Faculty of Agriculture, University of Sydney, as a possible source of access to this paper and the groundwater salinity map. Dr Sutton has not been contactable up to the time of preparing this report.

Mr Neville Pervan of the DLWC (pers. comm.) explained that the 1988/89 Series of Soil Landscape Maps provided little data that could be used for the WSO project with regards to soil salinity. Although a survey designed to produce a "Hazard Map" on soil salinity is scheduled to commence in 2002, no data has been gathered to date. The current DLWC NSW Soil Data System database is understood to have a field for salinity, but no data.

Mr Pervan was able to say that it is known that salt is stored in most Wianamatta Group shales and clays. However, experience has shown that the salt will only mobilise under prolonged wet conditions.

Limited comment is provided on soil salinity by several sources available for this study. Atkinson, Tille and Morse in reference 4 (Table 9 - Soils of the Penrith 1:100 000 Sheet), state that saline scalding is possible in the downstream areas of the quaternary sediments found in the Qal and Qpn geological units. This is possibly not relevant to the motorway as the route crosses predominantly upstream sediments in these geological units. Bannerman & Hazelton (reference 3) note that limitations apply to the subsoils of the Blacktown and South Creek soil profiles due to salinity (localised occurrence and widespread occurrence, respectively). The limited data in the soil profile reports provided in Appendix J of the EIS, from testing carried out for the motorway project in the southern section (M5 to Elizabeth Drive), states that no salting was evident.

No other references to soil salinity were found in the data available for the preliminary study.

8.0 IMPACTS OF PROPOSED MOTORWAY CONSTRUCTION ON WATER QUALITY

8.1 Groundwater and Soil Salinity

Discussion is provided in the EIS, in Chapter 19 (Section 19.4.2) and Chapter 33 (Section 33.3), on potential impacts on water quality downstream of the motorway. These sections of the EIS do not recognise groundwater as a potential source of contamination for the surface waters along the motorway. Working Paper Ten (Section 3.3) briefly mentions crop tolerance to sodium and salinity as a factor in protection of water supply for irrigation.

However, groundwater could be encountered in the proposed road cuttings, as the depths to the ground water levels (refer to discussion in Section 7.0 above) are less than the depths of the typical medium-sized cuts and deeper cuts, and salinity is known to be present in the groundwater.

It is possible that soil salinity may become an issue of environmental concern under poor drainage conditions. Indications are that, where the water table is very shallow and close to the ground surface (such conditions are known to exist in parts of the St Mary's, Mt Druit and Rickaby's Creek areas, and are anticipated in areas of the South Creek soil profile encountered by the proposed motorway), saline groundwater is more likely to occur due the mobilisation of salts from the Wianamatta shale and clay units. However, in these areas of the route, the road is to be either at present surface level, or will be elevated on embankments above the natural surface. In these circumstances, the natural groundwater would not be artificially redirected to surface waters via the road drainage system.

The proposed cut depths (refer to Table A) are frequently in excess of 10m along the motorway. This would result in a likelihood of intersecting the deeper natural groundwater table in the Bringelly Shale and Ashfield Shale bedrock. Strong seepages or flows into cuttings or excavations in the shale bedrock are not usual, and are not anticipated from the motorway cut batters, or from below the road pavement. However, persistent seepages are quite likely. Any seepage from the ground into the cuts will become surface water at the base of the batters, and will be captured by the road drainage system and fed into treatment ponds, along with other surface water from the cuttings.

Based on the information available, it is anticipated that seepages into the road cuttings from the permanent groundwater table in the Bringelly Shale and Ashfield Shale, where encountered, would most likely be saline or partly saline. On the other hand, seepages from intermittent and/or perched water tables are less likely to be saline due to reduced mobilisation of salt from the bedrock or soil layers by this transient groundwater movement.

The occurrence and intensity of potential seepages from the natural groundwater table along the motorway cannot be reliably predicted at this time, due to the lack of groundwater data specific to the immediate vicinity of the road corridor. Recommendations are provided below (Section 10.0) for further investigation and monitoring to enable relevant data to be obtained.

Notwithstanding the anticipated likelihood of saline groundwater being encountered in the road cuttings, it is considered that the quantities of groundwater are likely to be small, and manageable.

8.2 Other Groundwater Contamination

It has been suggested in the public submissions to the EIS that previous rural land use (piggeries and poultry farming) in areas along the motorway may result in contamination of the groundwater, thereby impacting on the surface water quality. For this to occur discrete pathways are required for surface water infiltration from contaminated land to make its way through the soil profile and into the groundwater regime, thence into the cuttings excavated for the motorway.

Chapter 19 (Sections 19.3.1 and 19.3.2) of the EIS makes reference to potential contamination of the surface waters of Maxwells Creek and Cabramatta Creek from livestock and poultry farming activities.

The soils identified in the cut areas of the motorway comprise light, medium and heavy plastic clays. Such soil profiles generally retard the vertical infiltration of water. As a consequence, it is considered that there is a low likelihood that pollutants from these sources would significantly contaminate the natural groundwater table in the bedrock. Further investigation of possible source areas of such contamination would be required to validate this opinion.

Where perched water exists in the soil profile adjacent to the motorway cuttings, it is possible for this water to be intercepted by the cutting at a high elevation on the cut batter. If the products of rural land use contaminate this perched water, the contamination may be transferred to the surface waters through the road drainage system.

The occurrence and intensity of potential seepages from perched water tables along the motorway cannot be reliably predicted due to the lack of groundwater data specific to the immediate vicinity of the road corridor. However, it is noted that the test pits excavated for the geotechnical investigation of the northern section of the motorway (refer to Working Paper Nine) did not encounter any groundwater to 3m depth.

9.0 TREATMENT OF THE PROBLEM

The potential problem of groundwater salinity that could be encountered by excavation of the WSO motorway cuttings is considered most likely to be of proportions that are manageable within the normal range of water quality treatment facilities usually incorporated in the design and construction of such infrastructure.

Treatment requirements will depend on the flow volumes of seepage water into the cuttings, and the concentrations of salinity encountered. The quantities of groundwater seeping into the cuts are anticipated to be small.

A possible scenario for the motorway design is that the net impact on surface water quality, from intercepting only small to negligible quantities of saline or partly saline groundwater seepage in the motorway cuts, may itself be of negligible proportions, and could be tolerated without requirements for even rudimentary treatment. This would depend on approval from regulatory authorities, and would be subject to verification by investigation and monitoring as discussed in Section 10.0, below.

Seepage from groundwater into the cuttings would be influenced by seasonal variations in the level of the groundwater table. Natural evaporation at certain times of the year will account for some loss of seepage water from the cutting batter faces before it enters the surface water regime, thus diminishing the volumes of seepage at the cut floor. This factor should be taken into account in the assessment of seepage quantities requiring to be added to the surface water drainage system.

Depending on the quantities involved, treatment options to reduce or eliminate the salinity of surface waters to be discharged to watercourses could include any one, or a combination of, the following:-

- separation and evaporation,
- dilution.
- macrophyte treatment (species suitable for salt separation),
- filtration in a suitable medium.

Separation and evaporation would involve the interception and direction of saline groundwater seepage to discrete ponds for storage and evaporation. This treatment would result in total removal of the potential for saline water to be discharged to the natural watercourses.

Dilution would involve temporary storage of the saline groundwater from the cuttings, with either controlled discharge to surface waters, or flushing from the road drainage system at times of storm events. The rate of discharge would be regulated according to the salinity levels of the intercepted groundwater, the salinity of the receiving waters arriving at the motorway, and permissible levels for salinity of the waterways downstream of the motorway.

Macrophyte treatment may be feasible, but would depend on a suitable species being available for introduction to the normal water quality treatment pond or wetland treatment system. Further research is required into this possible treatment method.

Filtration, chemical alteration, electrolyte and other molecular-level treatments of the saline water are likely to be costly and requiring sophisticated maintenance, rendering them inappropriate for economical use on the motorway.

10.0 FURTHER INVESTIGATION AND MONITORING

Although the potential for salinity problems due to groundwater interception by the motorway cuttings is recognised, the requirement for preventative or treatment strategies, for protection of the quality of the receiving waters, is dependent on the extent of the problem.

At the present time, adequate information is not available for design-level assessment of the following issues:-

- accurate definition of the locations along the motorway where salinity may be expected due to interception of the groundwater table by the road cuttings,

- reliable assessment of the quantities of groundwater intercepted as cutting seepage,

- reliable assessment of the salinity levels of groundwater seepage into the cuts.

It is recommended that further information should be gathered for design purposes by investigation and monitoring of groundwater in the areas of the proposed cuts. It should be possible for such investigation and monitoring to be carried out as part of the normal detailed geotechnical investigations for the road design.

In addition, further baseline monitoring and ongoing monitoring is recommended for collection of data on salinity of the surface waters likely to be affected by the motorway. Such data is not evident in the EIS.

As a minimum, investigations for the groundwater salinity issue should include at least:-

- boreholes to 5m below the proposed base of cuts, in all cuts deeper than, say, 5m;

- installation of groundwater sampling and monitoring wells in the boreholes;
- sampling of the groundwater for salinity and general groundwater chemistry;
- regular monitoring of the groundwater levels;
- assessment of the results of the testing and monitoring by an experienced hydrogeologist.

Any current geotechnical investigations (eg test pitting, shallow or deep boreholes) for the motorway project could be modified to include testing of retrieved samples for soil salinity. If any representative soil samples are available from the previous investigations (eg as reported in Working Paper Nine and Appendix J), they may be tested for salinity.

Prior to designing or implementing a groundwater investigation and monitoring programme, further research is warranted to establish the extent and nature of any data held in files and reports of private geotechnical and geological consultants, resulting from discrete investigations carried out in the geological domain of Western Sydney, relevant to the motorway route.

Information may be available from past ground investigations or monitoring at specific excavation sites near the motorway route, or elsewhere within the Wianamatta Shales of the Western Sydney Region, or the greater Sydney Region. For example, a number of shale quarries are present in this area, one operated by Austral Brickworks is located less than 1km to the east of the motorway at Horsley Park. The Eastern Creek Waste Depot, adjacent to the motorway route, may be another possible source of relevant groundwater and soils data.

Where a significant potential problem of groundwater is indicated from the investigations, resulting from the level of the groundwater, or potential seepage/flow quantities, or the salinity levels encountered, the investigations may need to be extended (eg, pump tests) to assess data for determination of anticipated flow rates into the cutting(s).

Design and implementation of the groundwater investigation and monitoring programme should be under the control of an experienced hydrogeologist or geotechnical engineer.

In the event that significant potential contamination of surfacer waters is anticipated from the above investigations, due to saline groundwater, preliminary strategies should be developed at an early stage of the motorway design for treatment options. Development of treatment strategies would likely require further investigations into treatment methods, and the likelihood of acceptance by regulatory authorities.

Collection and chemical testing of seepage water from the cuttings during construction and after completion of the works is recommended, for assessment of salinity concentrations in the groundwater and the surface waters in the road drainage system in the cuttings. Implementation of treatment strategies appropriate to the level of salinity and the quantities of seepage water could then be reviewed.

It is also recommended that appropriate investigations should be carried out to assess any potential contamination of groundwater due to past and present rural land use along the motorway corridor. The needs of such investigations may be incorporated into the general and specific groundwater investigations referred to above.

Relevant results of all investigations as recommended above should be supplied to DLWC for inclusion in the Bore Master Database and the NSW Soil Data System database.

11.0 SUMMARY/CONCLUSIONS/RECOMMENDATIONS

The conclusions and recommendations from the preliminary study undertaken, and reported above, are summarised as follows:-

- There is recognised potential for saline groundwater to be encountered in the motorway cuttings of the proposed Western Sydney Orbital road project. This conclusion is based on readily available published information and experience of groundwater practitioners.

- Normal experience in deep road cuts in shale rock of the Wianamatta Group in the Sydney Region indicates that cutting seepages would generally be of low intensity, in terms of flow rate and nuisance.

- Provision is normally made in road cutting design and pavement design for interception of seepage water and its direction into the road drainage system. As a result there is potential for saline groundwater to contaminate the receiving waters along the proposed motorway route.

- Data available at the present time for the motorway project is not adequate for design of treatment options for saline groundwater. Further investigations and monitoring are required, and are recommended, for determining the extent and degree of potential saline groundwater problems, on a cut-by-cut basis.

- Treatment options for saline groundwater require further preliminary assessment in the event that they would be required, based on the results of the further investigations.

- The recommended groundwater investigations and monitoring can be undertaken in accordance with normal practice, as part of the detailed investigation programme for the motorway design. The investigations and monitoring should be controlled by a suitably experienced hydrogeologist or geotechnical engineer.

The preliminary study reported above is based on limited information provided for the purposes stated in Sections 1.0, 2.0 and 3.0 of the report. The overall outcome of the preliminary study recommends that further investigations are warranted into the potential problems associated with interception of saline groundwater by the proposed motorway cuttings.

The opinions, conclusions and recommendations of the preliminary study may be reviewed in the light of any new information from the further investigations.

DAVIES GEOTECHNICAL Pty Ltd

REFERENCES

1. Environmental Impact Statement. *Proposed Western Sydney Orbital*. PPK Environment & Infrastructure Pty Ltd / Sinclair Knight Merz, October 2000.
2. Geol. Sur. NSW, Dept Min Resources 1991. *Geological Series Sheet 9030 (Penrith) 1:100,000*
3. Bannerman S M and Hazelton PA. 1990. *Soil Landscapes of the Penrith 1:100,000 Sheet.* Soil Conservation Service of NSW, Sydney
4. Jones, D.C. and Clark, N.R. (Eds) 1991. *Geology of the Penrith 1:100 000 Sheet 9030*. Geol. Sur. NSW, pages 119 - 121.

TABLE A
WESTERN SYDNEY ORBITAL PROJECT
SUMMARY OF SOILS, GEOLOGY AND PROPOSED CUTTINGS

Section No.	Chainage	Geology	Soil Landscape Association				No. of Cuts	Cut Depth Range	Comments
			bt	lu	Sc	pn			
S1	0 to 700	Qpn			•		Nil		
S2	700 to 1100	Rwb	•				Nil		
S3	1100 to 5200	Qpn	(•)		•		Nil		Intermittent Rwb
S4	5200 to 7600	Rwb	•		(•)		2	5m to 9m	Intermittent Qpn (2 narrow zones, 100 – 150m wide)
S5	7600 to 8800	Rwb		•			1	22m	
S6	8800 to 9300	Rwb				•	1	18m	
S7	9300 to 9700	Rwb		•			Nil		
N1	2000 to 7400	Rwb		•			3	9m to 28m	Note change in chainage datum
N2	7400 to 9000	Rwb	•				1	17m	
N3	9000 to 9400	Qal			•		Nil		
N4	9400 to 10500	Rwb	•				1	9m	
N5	10500 to 13500	Qal			•		Nil		
N6	13500 to 14100	Rwb	•				1	10m	
N7	14100 to 15000	Qal			•		Nil		
N8	15000 to 20700	Rwb	•				6	2m to 15m	
N9	20700 to 21400	Qal			•		Nil		
N10	21400 to 24100	Rwb	•				2	2m to 9m	
N11	24100 to 25000	Rwb		•			1	11m	
N12	25000 to 26000	Rwb	•				1	12m	
N13	26000 to 27400	Rwb		•			3	2m to 9m	
N14	27400 to 32400	Rwa		•			7	2m to 14m	End of WSO at CH32400

Notes
1. Sections identified as Southern (S), M5 Motorway to Elizabeth Drive, and Northern (N), Elizabeth Drive to M2 Motorway at West Baulkham Hills.
2. Chainages for soil boundaries are approximate only, based on published mapping from EIS document (as referenced in report). Subject to verification by further investigation and field mapping
3. Only significant soil landscape associations included (bp and disturbed terrain are not relevant to study)
4. Cut occurrences and depths are based on the current design longitudinal section provided for this study.

APPENDIX A

Submissions by Blacktown Council and Fairfield Council
(6 pages)

Blacktown City Council.

10. Water Quality and Hydrology

10.1 Introduction

This section reviews the potential water quality and flooding impacts associated with construction and operation of the Western Sydney Orbital (WSO) as described in the Water Quality and Hydrology chapter of the EIS and the background working paper entitled Water Quantity and Water Quality Assessment.

10.2 Summary of Chapter 33: Water Quality and Hydrology

This chapter of the EIS provides a description of the current conditions of the waterways, reviews previous studies, assesses environmental values and recommends a series of mitigation measures and environmental safeguards.

10.3 Operation and Monitoring

The following are general comments with regard to issues relating to the construction, operation and monitoring of water quality devices:

- An allowance of 10 – 20% is made in the volume calculations of the proposed wetlands for capture of sediment. A more appropriate figure would be in the order of 20 –30%.
- The effect on storage volume with major retardation basins on the Toongabbie Creek system should be reduced to an absolute minimum. Embankments are to be avoided (within storage areas) and roadway support structures for bridges, etc designed to have a minimal effect on storage volumes.
- Stormwater interceptor devices should be located at all points of discharge from the roadway to proposed wetlands. This is only recommended on those smaller drainage systems not discharging through a wetland.
- A schedule of macrophytes proposed for the constructed wetlands should be provided, with consideration given to local provenance and maintenance of the plant species.
- An Emergency Plan in respect of accidental chemical/toxic spillage(s) should be prepared and submitted to the State Emergency Service, Police Department, Fire Brigades, Environment Protection Authority and Council for comment and approval.
- The design and location of all first flush tanks should be furnished with the Emergency Plan.
- Baseline data for water quality at stormwater discharge points should be established prior to construction activities commencing. This should be established for a period of 12 months. Following construction, water quality must continue to be monitored on a minimum monthly basis, to ensure stormwater management practices are effective in maintaining existing water quality baseline data and aid in the assessment of maintenance standards.

10.4 Maintenance

The following are general comments with regard to maintenance of the water quality devices.

- A management plan should be prepared for the post construction phase of the wetlands and water quality devices to address maintenance and operational issues.
- Estimated costs and frequency of maintenance, including inspection and cleaning, for each of the combined stormwater treatment measures (eg constructed wetlands and oil/sediment separators) should be prepared and be based on the recommendations of the Sinclair Knight Mertz report.
- Alternatives to reno-mattresses in the constructed wetlands design should be considered as these are subjected to vandalism and nuisance weeds that are difficult to manage.
- The EIS does not confirm who is to be the Authority responsible for the maintenance of the stormwater treatment measures.

10.5 Salinity

As previously stated in the Soils and Geology section of this submission, the EIS should consider the potential impacts to surrounding developments and waterways, as well as to the road surface itself, from salinity.

<u>SUMMARY:</u>

The proposal needs to ensure that hydrology and water quality is not adversely affected. In this regard, several additional matters need to be considered or incorporated into an Environmental Management Plan.

Fairfield City Council

11.1 INTRODUCTION

The following comments apply to Working Paper Ten of the Western Sydney Orbital EIS (Water quantity and water quality assessment), and to Volume Three of the EIS (Impacts of the Western Sydney Orbital from Cecil Park to West Baulkham Hills).

The proposed Orbital will generally traverse rural areas of the Fairfield City LGA. The proposal has potential impacts from a drainage and floodplain perspective.

Impacts, which warrant particular consideration, include the following:

- Flood Liable Land
- Noise walls
- Water quality
- Sediment and erosion control
- On Site Detention (OSD)
- Development Control Plan (DCP)
- Local Environment Plan
- Liverpool District Stormwater Management Plan (SMP)
- RTA's Stormwater Management Plan
- Native Vegetation Conservation Act
- Public safety and emergency services and rescue
- Referrals

11.2 FLOOD ISSUES

11.2.1 Flood Liable Land

Existing flood studies are available for Ropes, Reedy, and Eastern Creek giving details of a 100-year flood event. This information does not seem to have been used in the EIS for Fairfield LGA. The EIS refers to the Eastern Creek and Reedy Creek in some detail downstream of Fairfield's boundary at the water supply pipeline and upstream of Elizabeth Drive in Liverpool's area.

Working Paper 10, Page 30 says: "*The proposed WSO will be constructed lower than the existing creek invert levels at crossing No. 26w to crossing no. 29w inclusive*". All these crossing are to be combined into one crossing at No. 30w, where a single cross drainage line under the roadway will be constructed.'

Considerable detail provided as to the increase and/or decrease of the flood levels with respect to the construction of the remaining link of the Western Sydney Orbital However, the interception and diversion of flows will increase the existing upstream catchment area draining to Crossing No. 30w from approximately 27ha to approximately 50ha.

The EIS states that this is approximately an increase in area of 86%. This percentage increase does not seem to be correct and there may be an error in either the areas stated or the percentage increase. This will increase stormwater discharges along the creek for a distance of approximately 150m downstream of the road where the confluence of all the creeks occurs at present. The impact of this should be considered in detail at the design stage.

...unications to: ... (02) 9725 4559 ... Wakeley NSW 2176
City Council, PO Box 21, Fairfield NSW 2165

__Recommendation 63:__ Potential drainage and flood flows at Crossing No. 30w have not been adequately considered in the Orbital EIS. It is essential that this impact be fully defined and resolved. More info.

The EIS states that flood levels will increase by up to 6.6m along the eastern route option in the vicinity of Crossing No. 30e, increasing the land inundated by 8ha. More in

The EIS states that the flood levels will increase up to 6m along the western route at Crossing No. 24w, increasing the land inundated by 1.5ha. Even though this is in Liverpool LGA, the stormwater flows across Elizabeth Drive into Fairfield's area. There does not seem to be any strategy to mitigate the impact of this increase in flood level.

__Recommendation 64:__ Stormwater and flood flows from Crossing No. 24w have the potential for serious impact on the Fairfield LGA. This matter has not been adequately dealt with in the Orbital EIS, and requires further attention.

Sufficient space should be provided within the proposed road reserves for stormwater quality and quantity facilities such as detention basins, sedimentation basins and water quality ponds.

Basin 22 is a proposed detention basin in Liverpool LGA on Cabramatta Creek. This basin has the potential to reduce downstream peak levels for the 100-year flood event. This would provide significant benefits to property owners in Lower Cabramatta Creek in Fairfield City Council's area, potentially reducing flood level by up to 0.3m.

11.2.2 Noise Walls

Noise walls have the potential to impact upon both the local drainage and flooding patterns. Noise walls constructed across overland flow paths or within a 100-year flood plain should be designed to allow the safe passage of these flows with appropriate mitigating measures to ensure that there is no adverse impact.

__Recommendation 65:__ Particular care will be required with the design of noise walls to allow safe passage of extreme flood and drainage flows.

11.2.3 Sediment and Erosion Control

Detailed sediment and erosion control plans will be required. Council's Environmental Services should be consulted.

__Recommendation 66:__ The RTA to consult with the Environmental Services group at Fairfield City Council in relation to the development and implementation of detailed sediment and erosion control plans for the Orbital.

11.2.4 Probable Maximum Flood

The impact of the Probable Maximum Flood should also be considered.

11.2.5 Emergency Service Implications

In the interest of public safety in areas that are presently affected by flooding, the SES evacuation plan should be updated to reflect the change in traffic conditions with the construction of the remaining link of the WSO.

__Recommendation 67:__ The RTA ensure that the current SES evacuation plan be updated in accordance with changed circumstances and traffic conditions caused by the Orbital.

…3 WATER QUALITY

Volume 3, Page 33.4 - The EIS stated that there is little water quality information for Ropes Creek, Reedy Creek and Caddies Creek. This issue should be reviewed by Fairfield City Council's Environmental Branch. Other issues that need to be considered are the impact on the water table level and salinity.

> *Recommendation 68: The RTA ensure that the impact of the proposed Orbital on the level of the regional water table, and on salinity, be fully defined and resolved.*

Some areas of the City are affected by acid sulphate soils however, the mapping of these areas is not very comprehensive. Advice should be sought from the Department of Land and Water Conservation.

> *Recommendation 69: The RTA ensure that the impact of the proposed Orbital on acid sulphate soils within the Fairfield LGA be appropriately considered.*

11.4 REGULATORY & PLANNING CONSIDERATIONS

11.4.1 On Site Detention Policy (OSD)

The reduction of minimum lot sizes from 2ha to 1 ha in the rural area of the Fairfield LGA was considered by Council to be of concern in terms of the capacity of the existing drainage system to accommodate increased stormwater runoff. The capacity of the existing drainage system, which comprises earth table drains and open watercourses, was clearly seen to be inadequate given the anticipated level of future development. Council's response to the problem was to introduce an on-site detention (OSD) policy. The Western Sydney Orbital Development will increase the impervious area, thus causing an increase in runoff. OSD will be required to limit the discharge in a controlled fashion. A number of permanent wetlands/detention basins are proposed and the design of these should be examined in detail at the design stage.

11.4.2 Existing DCP & LEP

Fairfield City Council's DCP and LEP for the rural area set out guidelines for the management of both stormwater and flood flows. These guidelines require that all development within the Fairfield LGA must provide for resultant increases in storm-water run-off by construction of an appropriate on-site detention system in accordance with Council's On-Site Detention Handbook.

Under existing DCP and LEP guidelines, flood liable land is defined as land within the 100-year Average Recurrence Interval as shown on the DCP Map. No building is to be erected and no work carried out on flood-liable land unless in accordance with Councils Flood Plain Management Policy. In assessing a proposal to erect a building or carry out work on flood- liable land, Council will take into consideration the:

- effect on flood behaviour
- potential increase flood hazard or flood damage to property
- potential to increase erosion, siltation or destruction of the riverbank
- vegetation in the area;
- effect on the water table
- effect on bank stability
- safety of users or occupiers of the proposed development in time of flood
- capacity of the floodway; and
- potential to increase the risk to life and personal safety of emergency services and rescue personnel

11.4.3 Liverpool District Stormwater Management Plan (SMP)

The stormwater management plan addresses 'environmental protection' issues as defined in the Protection of the Environment Administration Act 1991. This includes stormwater quality, river flow, riparian vegetation and aquatic habitat management. The plan is not intended as a flood management plan and issues relating solely to flooding should not affect the primary purpose of the plan, which is to improve the standard of stormwater quality.

11.4.4 RTA's Stormwater Management Plan (SMP)

The RTA's Stormwater Management Plan should also be consulted and questions raised with regards to this document fielded by the Roads and Traffic Authority.

11.4.5 Native Vegetation Conservation Act 1997

Cabramatta Creek is a prescribed stream and any work that is situated within 20 metres of the bed or bank of any part of a river or lake requires a permit from DLWC

11.5 REFERRAL & CONSULTATION

With this type of proposal the following authorities, trusts and legislation should be consulted.

- DLWC
- Fisheries
- Georges River REP
- Native Vegetation Act for Cabramatta Creek
- Hawkesbury Nepean Trust
- Threatened Species Conservation Act 1995.

KEY ISSUES – WATER, DRAINAGE & FLOODING

Flood Liable Land

- 100-year flood event studies are available for Ropes, Ready and Eastern Creek, but do not appear to have been used in those aspects of the EIS that have immediate impact on the Fairfield Local Government Area. This information should be taken into account.

Flood Management

- Inadequate provision appears to have been made for mitigating the impacts on Fairfield of flood events originating in the Liverpool LGA, and flowing across Elizabeth Drive. This should be rectified.

Stormwater Management

- Insufficient space appears to have been allowed within the proposed road reserves for stormwater quality and quantity facilities such as detention basins, sedimentation basins and water quality ponds. This deficiency should be addressed.

Impact of Noise Walls

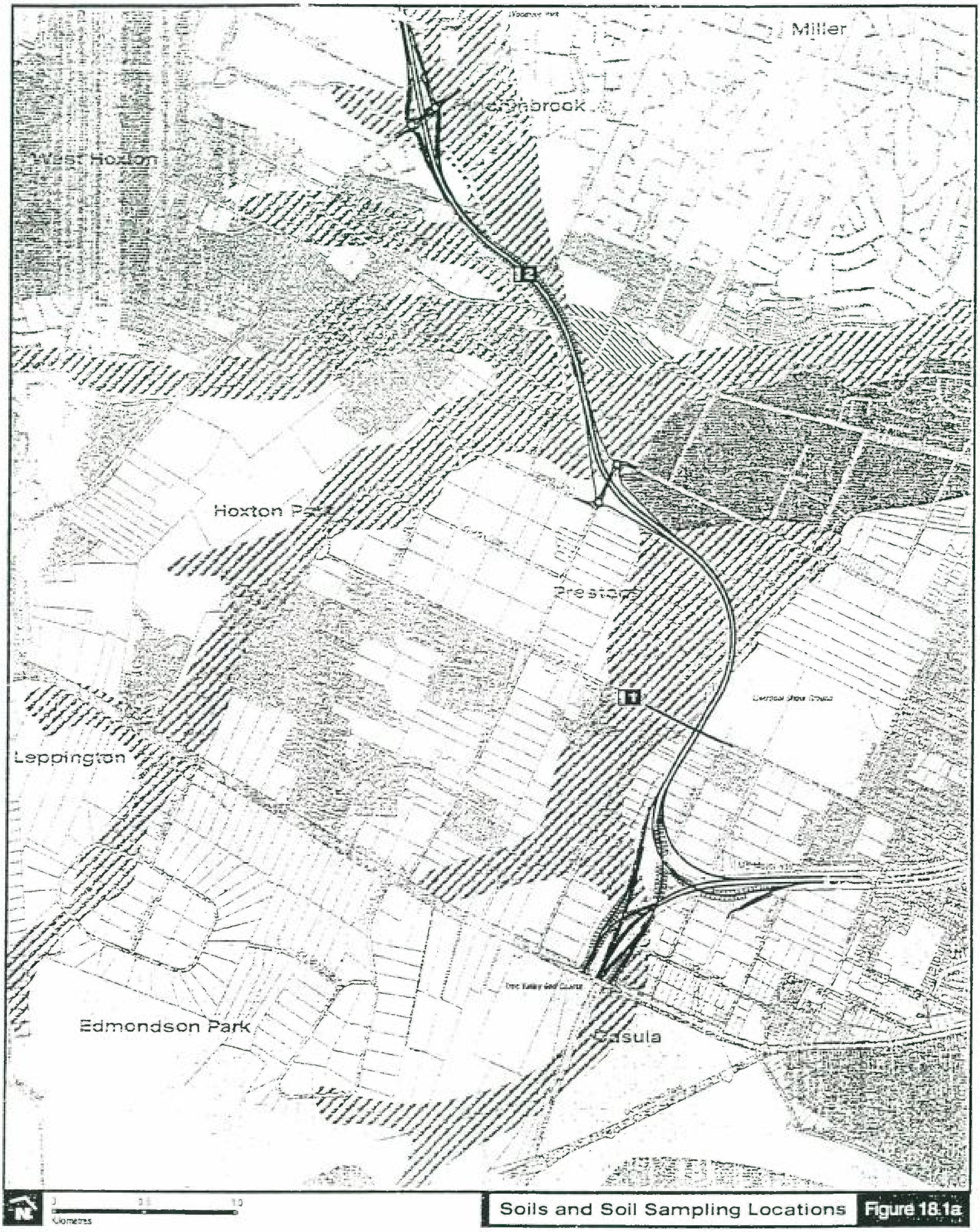
- Anti-noise walls to be constructed across overland flow paths, or within 100-year flood plain areas, should be designed to allow the safe passage of these flows with appropriate mitigating measures to avoid adverse impact.

Sediment and Erosion Control Plans

- Consultation with Council's Environmental Services Division will be required to ensure that appropriately detailed sediment and erosion control plans are developed and implemented.

FIGURES

Figure 18.1a
Figure 18.1b
Figures 32.1A – 32.1D

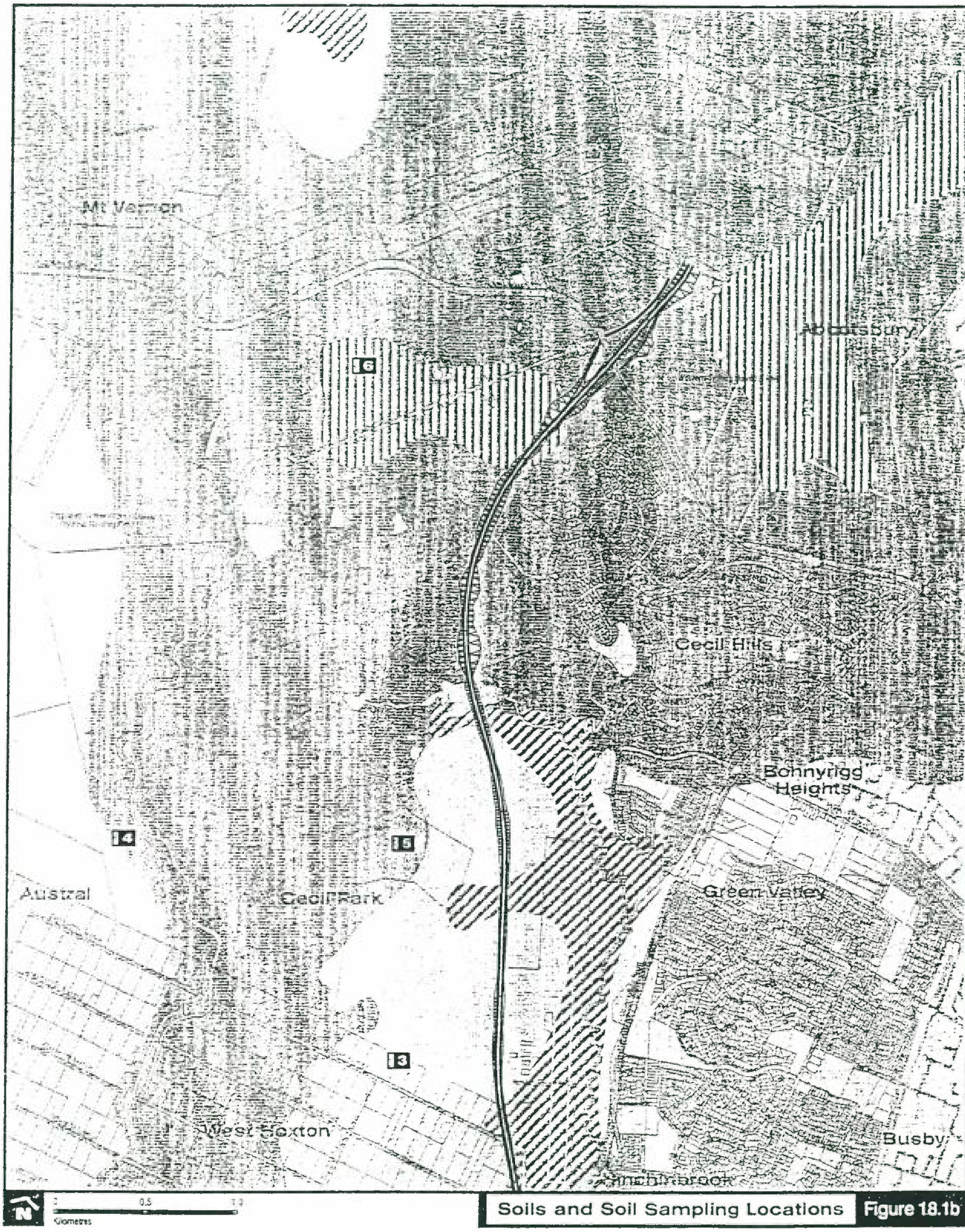


Soils and Soil Sampling Locations **Figure 18.1a**

Soil Landscape Units

- Blacktown residual
- Luddenham erosional
- Berkshire Park fluvial
- South Creek fluvial
- Disturbed terrain

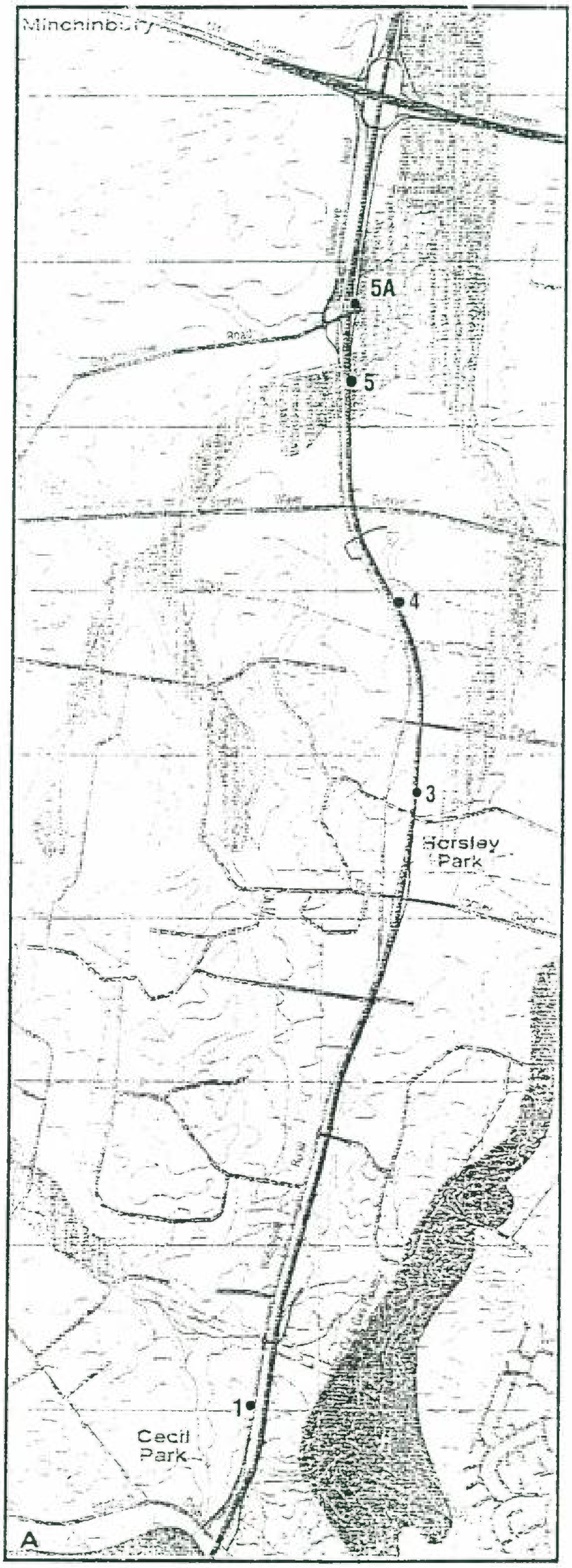
1 Soil sampling location

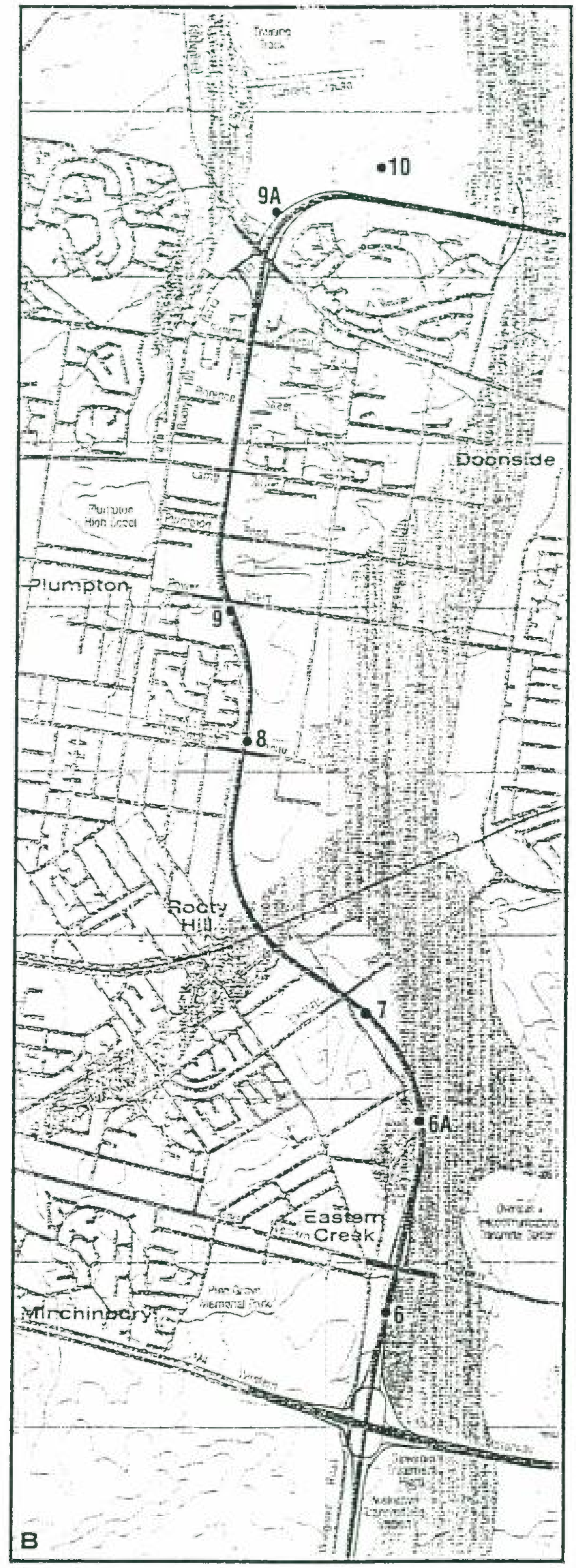


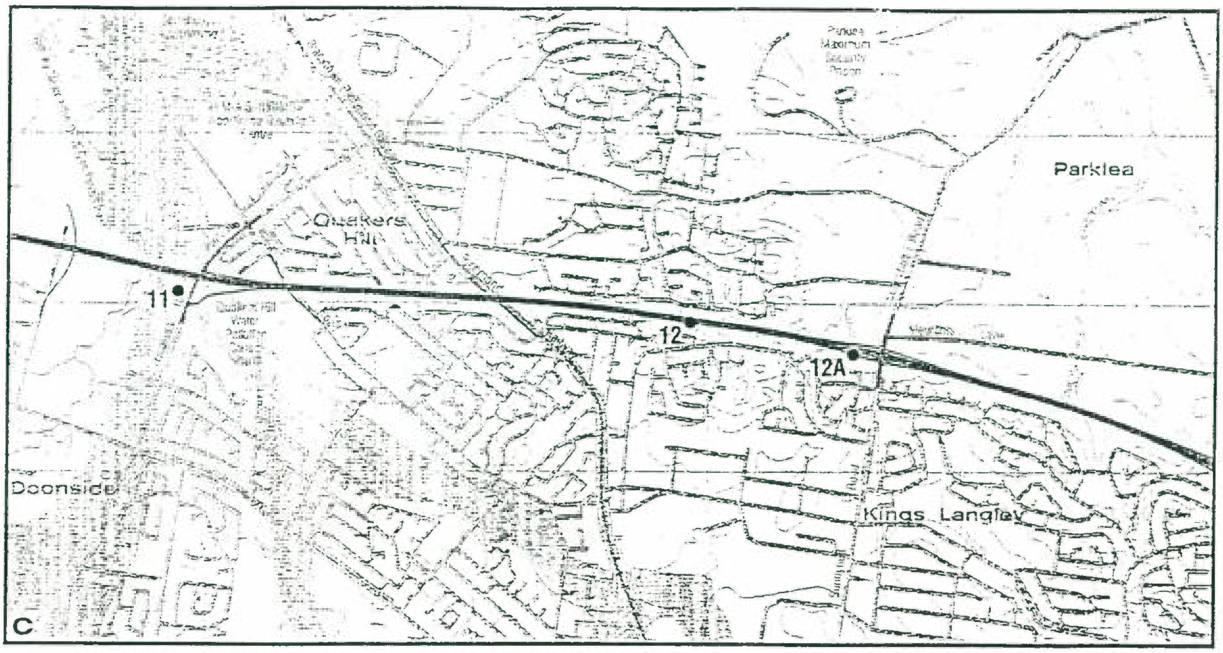
Soils and Soil Sampling Locations Figure 18.1b

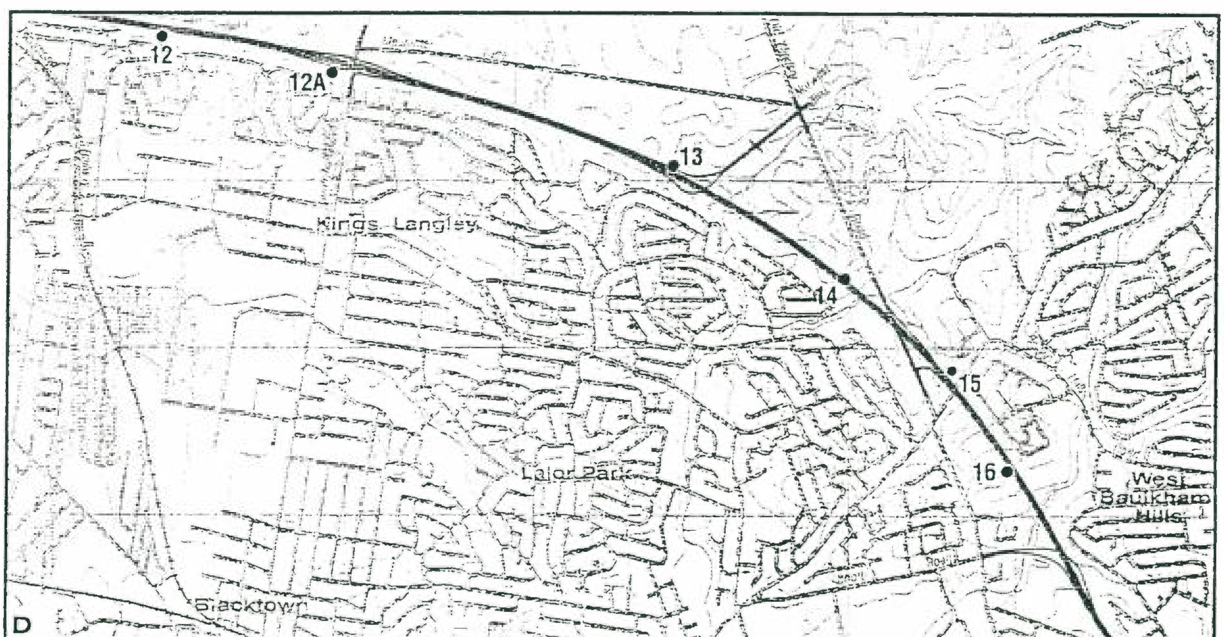
Soil Landscape Units

- Blacktown residual
- Picton colluvial
- Luddenham erosional
- South Creek fluvial
- 1 Soil sampling location


Minchinbury
5A
5
4
3
Horsley Park
1
Cecil Park
A


10
9A
Doonside
Plumpton
9
8
Rocky Hill
7
6A
Eastern Creek
Minchinbury
6
B





Geology and Soils Figure 32.1

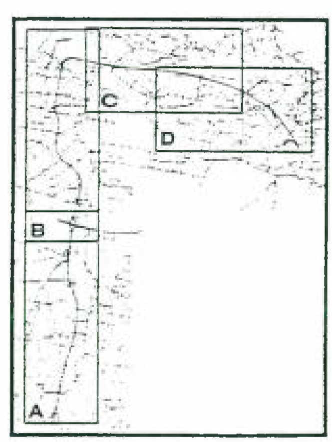
lu: Luddenham Grouping
- Podzolic soils or massive earthy clays
- High soil erosion hazard
- Impermeable highly plastic subsoil
- Moderately reactive

sc: South Creek Grouping
- Often very deep layered sediments
- Erosion hazard
- Frequent flooding

bt: Blacktown Grouping
- Podzolic soils
- Moderately reactive
- Highly plastic subsoil
- Poor soil drainage

pn: Picton Grouping
- Podzolic soils
- High soil erosion hazard
- Slope failure by slumping hazard
- Impermeable and highly plastic soils

● Test Pit Site



APPENDIX B

Summary Report by Sydney Groundwater Company Pty Ltd
Dated 29 June 2001 (2 pages)

SYDNEY GROUNDWATER COMPANY PTY LTD A.B.N. 94 082 966 943
Environmental Investigation & Monitoring Specialists
Level 1, 35 The Seven Ways Rockdale NSW 2216
PO Box 75 Kogarah NSW 1485 AUSTRALIA
Tel: 02-9567-4700 Fax: 02-9567-6955 Mobile: 0419-875-252
E-mail: sydgro@zip.com.au

SYDNEY GROUNDWATER

FACSIMILE ☒ Urgent ☐ Please Reply ☐ For Your Info

Attention:	Mr Warwick Davies	Fax No. 02 9481-8912
Organisation:	Davies Geotechnical Pty Ltd	Your Ref: 01-019
From:	Nik Kontos	Our Ref:
Date:	29 June, 2001	Total Pages: 2
Subject:	Western Sydney Orbital – Preliminary Desk Study for the Assessment of Groundwater and Soil Salinity Conditions with Respect to Potential Impacts to Surface Water Quality.	

1.0 Introduction

Sydney Groundwater Company Pty Ltd (SGC) was engaged by Davies Geotechnical (Consulting Engineers) to conduct a review of available data on groundwater conditions along the proposed Western Sydney Orbital (WSO) transport route.

With reference to your facsimile dated 12 June, 2001 it is understood that the purpose of the study is to respond to concerns raised by Blacktown and Fairfield Councils with respect to groundwater and surface water impacts resulting from the construction of the WSO. It is further understood that the findings of this desk study will be incorporated into the RTA's response to public submissions regarding the environmental effects of the WSO.

The comments and recommendations presented herein are based on a review of the following data:

- PPK Environment & Infrastructure / Sinclair Knight Merz, Chapters 18, 19, 32 and 33, Western Sydney Orbital Environmental Impact Statement;
- Geological Map, 1:100,000 Geological Series Sheet 9030 Penrith Sheet, Geological Survey of New South Wales, Department of Minerals and Energy, DMR (1991);
- Telephone Conversation with Mr Dan McKibbin (Regional Hydrogeologist, Sydney South Coast Region), Department of Land and Water Conservation;
- Groundwater quality, aquifer descriptions and drilling records for registered Water Bores within 4km of the WSO route, Bore Master Database, Department of Land and Water Conservation;
- Telephone Conversation with Dr Michael Knight (Director/Professor, National Centre for Groundwater Management, Univ. Technology Sydney); and
- Telephone Conversation with Mr Neville Pervan (Salinity Officer, Department of Land and Water Conservation).

2.0 Hydrogeological Data

A review of the available geological mapping data indicated that the WSO route is predominantly aligned over areas underlain by shale and sandstone units of the Bringelly Shale Formation, which is part of the Wianamatta Group. The DLWC archive of drilling and water bore records indicated that groundwater quality data is limited to a single bore (DLWC Bore No. GW026226) located within a few hundred metres from the WSO route in the Glendenning area, which was tested in 1966 (presumably after the time of bore installation) and showed saline groundwater (electrical conductivity measured at 7,529 μS/cm) to be present in fractured shale at a depth of 8.2 metres (Ref. Table 1, submitted previously).

With respect to water table depth (Ref. Table 2, submitted previously), out of a total of 21 registered bores identified within 4km of the WSO route: 13 bores showed Standing Water Level (SWL) measured at within 10m below ground level (11 bores had SWLs within 5m BGL, and 2 bores had SWLs between 5m - 10m BGL). Of the remaining 8 bores, 4 bores showed SWLs less than 20m BGL, while 4 bores had no records available.

Mr Dan McKibbin of DLWC explained that groundwater data for this area is limited due to the low well yield (< 1 litre/second) and high salinity characteristics (EC up to 15,000 μS/cm) of the Bringelly Shale aquifer.

3.0 Other Groundwater Data

The information provided by UNSW, Sydney and UTS suggested that although significant groundwater research has been conducted in areas of dryland salinity, very little work has been on the hydrochemistry of groundwater in the Bringelly Shale aquifer. Dr Michael Knight of UTS indicated that a research paper produced in the 1940's provided a groundwater salinity contour map for the Western Sydney area. Dr Knight referred us to Dr Bruce Sutton of Dept. of Crop Sciences, Faculty of Agriculture, University of Sydney (Tel 9351 – 2050) who may be able to provide access to this paper and the groundwater salinity map; unfortunately, Dr Sutton has not been contactable to date.

4.0 Soil Salinity Data

Mr Neville Pervan of the DLWC explained that the 1988/89 Series of Soil Landscape Maps provided little data that could be used for this WSO project with regards to soil salinity, although a survey designed to produce a "Hazard Map" on soil salinity is scheduled to commence in 2002. Mr Pervan was able to say that it is known that salt is stored in most Wianamatta Group shales and clays; however, experience has shown that the salt will only mobilise under prolonged wet conditions.

It is implied therefore that soil salinity may only become an issue of environmental concern under poor drainage conditions. Mr Pervan indicated that where the water table is very shallow and close to the ground surface (such conditions are known to exist in parts of the St Mary's, Mt Druit and Rickaby's Creek areas), saline groundwater is more likely to occur due the mobilisation of salts from the Wianamatta shale and clay units.

5.0 Conclusions and Recommendations

With regards to groundwater conditions, the limited information obtained to date suggests that saline soils and groundwater are present at depths within 10m below ground level along the proposed WSO route. Given the limited time frame however, we have yct to access a groundwater salinity interpretation map for the area, that may allow salinity levels to be better quantified for the proposed WSO route.

Given the limited data available, it would be prudent to conduct targetted field investigations involving drilling, groundwater monitoring bore installation, soil and groundwater sampling and analysis, and data interpretation along the WSO route. This would provide more definitive information regarding the status of soil and groundwater conditions, which may be used to formulate an appropriate soils, drainage and groundwater management program that would be part of the WSO development plan.

Nik Kontos, *SGC Principal Environmental Hydrogeologist*

APPENDIX C

Summary Descriptions of Soil Groups
(1 page)

Table 18.1

Characteristics of Soil Landscape Units

Soil Landscape Unit	Topography	Local Relief	Slopes	Soil Types	Dominant Soil Material	Soil Depths	Existing Erosion	Erosion Hazard
Picton Colluvial Soil Landscape Unit	Steep low hills	90 to 300 metres	Greater than 20%	Red and brown podzolic soils on upper slopes; brown and yellow podzolic soils on colluvial material; and yellow podzolic soils on lower slopes and in drainage lines	Clay loam A Horizon, light to medium clay B Horizon, stony in parts	0.5 to 2 metres	Slumps and sheet erosion, minor gully erosion	High to very high, potential for mass movement when saturated
Luddenham Erosional Soil Landscape Unit	Undulating to rolling low hills	50 to 80 metres	5 to 20%	Dark podzolic and massive earthy clays on crests, red podzolic soils on upper slopes, yellow podzolic and prairie soils on lower slopes and in drainage lines	Loam/clay loam A Horizon, light to medium clay B Horizon	Less than 1.5 metres	Minor gully and moderate sheet erosion	Moderate to very high
Blacktown Residual Soil Landscape Unit	Gently undulating rises	Less than 30 metres	Less than 5%	Red and brown podzolic soils on crests, yellow podzolic soils on slopes and in drainage lines	Loam/clay loam A Horizon; light mottled clay B Horizon	Less than 1 metre	Minor sheet and gully erosion	Slight to moderate for non-concentrated flows
South Creek Fluvial Soil Landscape Unit	Flat to gently sloping alluvial plain	Less than 10 metres	Less than 5%	Red and yellow podzolic soils on terraces. Structured plastic clays or structured loams in and adjacent to drainage lines	Loam/clay loam A Horizon, light to medium clay B Horizon	Often very deep (>2 metres)	Stream bank and sheet erosion of floodplain	Potentially very high to extreme
Berkshire Park Fluvial Soil Landscape Unit	Flat terrace tops dissected by small drainage channels and narrow drainage lines	20 metres	Less than 5%	Solods, red and yellow podzolic on terraces; chocolate soils, structured plastic clays and adjacent to drainage lines	Sandy loams and apedal sandy clay loams in topsoil and A horizon; brown sandy clay and high chroma clay in B Horizon	less than 4.5 metres	Confined to areas for sand or used as unsealed roads. Sheet and rill erosion as well as some wind erosion	Low to moderate for non-concentrated flows; high for concentrated flows

Source: Bannerman and Hazelton 1990

APPENDIX D

DLWC Bore Master Database Information
(31 pages)

Bores around Western Sydney Orbital

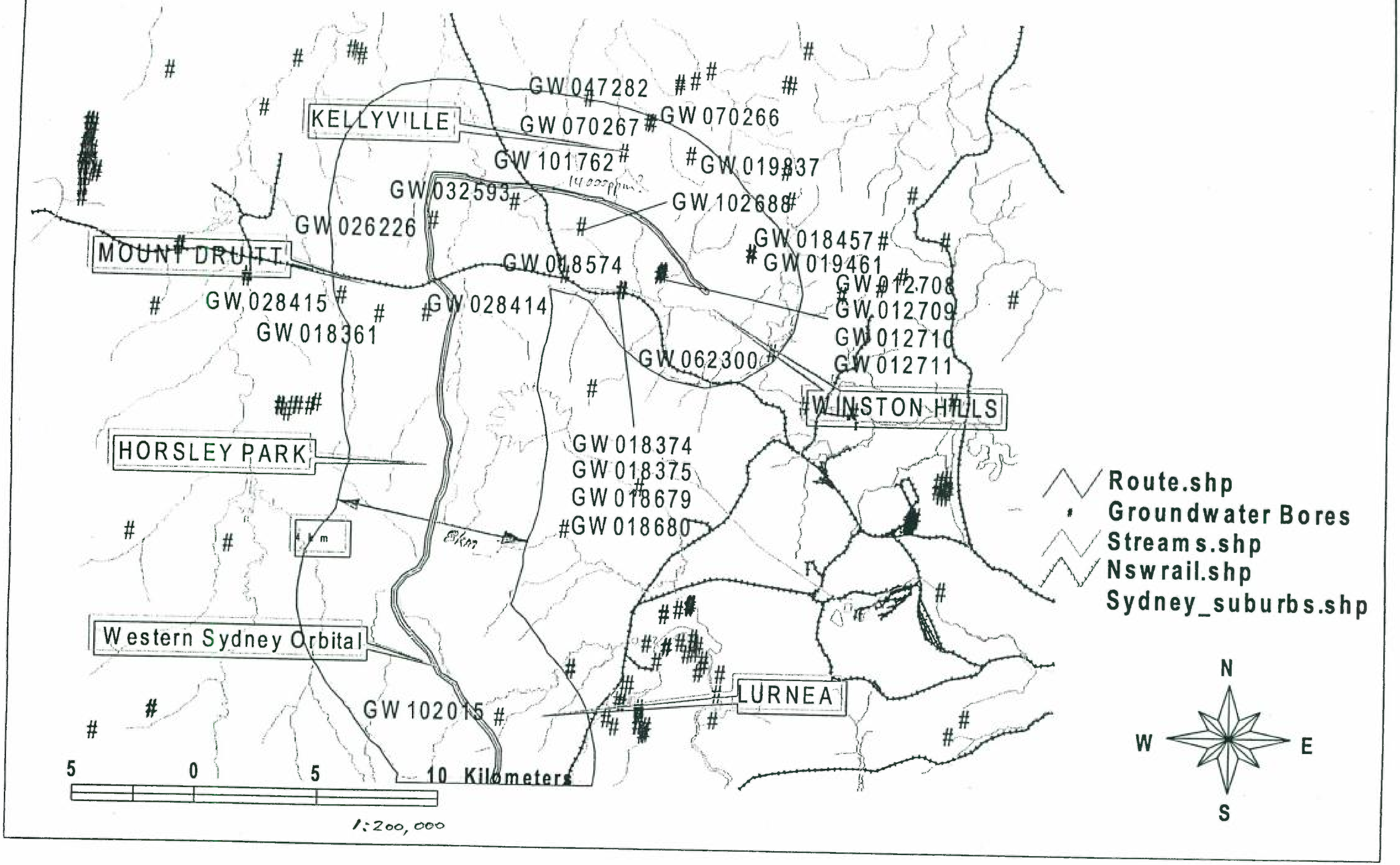


Table 1. Groundwater Quality Data (Source DLWC Boremaster Database)

Station No.	Collect Date	Determinand	Result	Units
GW026226	7-Feb-66	pH	7.5	pH
GW026226	7-Feb-66	Alkalinity as Bicarbonate (HCO3)	748.0684	mg/L
GW026226	7-Feb-66	Calcium as Ca - total	260.2795	mg/L
GW026226	7-Feb-66	Electrical Conductivity @25 C	7529	uS/cm
GW062300	4-Jul-88	Zinc as Zn - total	0.5	mg/L
GW062300	4-Jul-88	Manganese as Mn - total	0.5	mg/L
GW062300	4-Jul-88	Iron as Fe - total	18	mg/L
GW062300	4-Jul-88	Sodium as Na - soluble	77.9997	mg/L
GW062300	4-Jul-88	pH	6	pH
GW062300	4-Jul-88	Chloride as Cl	150.0016	mg/L
GW062300	4-Jul-88	Copper as Cu - total	ND	mg/L
GW062300	4-Jul-88	Calcium as Ca - total	12	mg/L
GW062300	4-Jul-88	Electrical Conductivity @25 C	600	uS/cm
GW062300	4-Jul-88	Potassium as K - soluble	3.4	mg/L
GW062300	4-Jul-88	Magnesium as Mg - total	12	mg/L
GW062300	4-Jul-88	Zinc as Zn - total	0.03	mg/L
GW062300	4-Jul-88	Manganese as Mn - total	0.5	mg/L
GW062300	4-Jul-88	Iron as Fe - total	17	mg/L
GW062300	4-Jul-88	Magnesium as Mg - total	22	mg/L
GW062300	4-Jul-88	pH	6	pH
GW062300	4-Jul-88	Electrical Conductivity @25 C	1060	uS/cm
GW062300	4-Jul-88	Potassium as K - soluble	4.3	mg/L
GW062300	4-Jul-88	Sodium as Na - soluble	140.0008	mg/L
GW062300	4-Jul-88	Calcium as Ca - total	31.0001	mg/L
GW062300	4-Jul-88	Copper as Cu - total	0.1	mg/L
GW062300	4-Jul-88	Chloride as Cl	269.9994	mg/L
GW062300	5-Jul-88	Magnesium as Mg - total	31.6	mg/L
GW062300	5-Jul-88	pH	6.15	pH
GW062300	5-Jul-88	Chloride as Cl	351.9987	mg/L
GW062300	5-Jul-88	Nitrate as N	0.11	mg/L
GW062300	5-Jul-88	Potassium as K - soluble	4.4998	mg/L
GW062300	5-Jul-88	Sodium as Na - soluble	172.2991	mg/L
GW062300	5-Jul-88	Sulphate as SO4	10.2001	mg/L
GW062300	5-Jul-88	Boron as B - total	0.11	mg/L
GW062300	5-Jul-88	Fluoride as F - soluble	0.23	mg/L
GW062300	5-Jul-88	Iron as Fe - total	1.27	mg/L
GW062300	5-Jul-88	Manganese as Mn - total	0.46	mg/L
GW062300	5-Jul-88	Silica as SiO2 - reactive	9.7	mg/L
GW062300	5-Jul-88	Zinc as Zn - total	0.08	mg/L
GW062300	5-Jul-88	Alkalinity as Bicarbonate (HCO3)	137.8984	mg/L
GW062300	5-Jul-88	Calcium as Ca - total	45.3	mg/L

Table 2. Water Bearing Zone Summary (Source DLWC Boremaster Database)

Bore ID.	FROM (m)	TO (m)	AQUIFER	SWL (m)	YIELD (L/s)	SALINITY	SALINITY DESCRIPTION
GW018374	5.7	5.7	(Unknown)		0		Salty
GW018374	11.8	12.1	(Unknown)	2.7			Brackish
GW018374	61.5	61.8	(Unknown)	1.2			Brackish
GW018375	27.4	27.4	Fractured				Salty
GW018375	61.8	61.8	(Unknown)				Salty
GW018457	19.8	52.4	Fractured	1.2	0.315		Salty
GW018574	124.9	127.3	Consolidated	12.8	0.149		(Unknown)
GW018574	134.1	135.9	Consolidated	11.5	0.229		Brackish
GW018679	21.3	21.3	Fractured				Salty
GW018679	61.2	61.2	Consolidated				Salty
GW018680	6.4	6.4	Fractured				Salty
GW018680	21.9	21.9	Fractured				Salty
GW018680	61.2	79.7	(Unknown)	1.8			Salty
GW019461	19.8	52.4	Fractured	1.2	10.104		Salty
GW026226	8.2	8.2	Fractured	1			invalid code
GW028414	5.9	5.9	Fractured	3.9			(Unknown)
GW028415	3	4.8	Unconsolidated				(Unknown)
GW028415	7.4	7.4	Fractured				(Unknown)
GW032593	7.6	7.6	Fractured		0.353		Salty
GW047282	28.6	29	Fractured	28.6	0.075		(Unknown)
GW062300	26.1	26.8	Consolidated	18	0.3		Fresh
GW062300	63.5	63.8	Consolidated	6	0.95		Fresh
GW070266	35	36	Consolidated	8	0.03		S.Salty
GW070266	64	65	Consolidated	8	0.16		S.Salty
GW070267	51.5	52.5	Consolidated	28.4	0.33		Good
GW070267	64.7	65.7	Consolidated	28.4	0.22		Good
GW101762	53	57		8.92	0.858		Good
GW102688	2	5		2.5			
GW102708	1.4	2.2		1.374			
GW102709	1.2	2.4		1.185			
GW102710	1.4	2.2		1.387			
GW102711	1.2	2.5		2.114			

Table 3. **Bore Construction Summary (Source: DLWC Boremaster Database)**

Bore ID.	WORK_STATUS	OWNER TYPE	Drilling Method	Date Completed	Bore Depth (m)	Depth Drilled (m)	SWL (m)	DDN (m)	SALINITY	Water Description	Well Yield
GW018361	(Unknown)	Private	Cable Tool		217.9	217.9				(Unknown)	
GW018374	Supply Obta ned	Private	Cable Tool	1/6/60	85	85				(Unknown)	
GW018375	Supply Obta ned	Private	Cable Tool	1/8/60	76.2	76.2				Salty	
GW018457	(Unknown)	Private	Cable Tool	1/10/59	52.4	52.4				Salty	
GW018574	(Unknown)	Private	Cable Tool	1/10/61	135.9	135.9				(Unknown)	
GW018679	Supply Obta ned	Private	Cable Tool	1/8/60	76.2	76.2				Salty	
GW018680	Supply Obta ned	Private	Cable Tool	1/7/60	79.8	79.8				Salty	
GW019461	(Unknown)	Private	Cable Tool	1/10/59	52.4	52.4				Salty	
GW019837	(Unknown)	Private	(Unknown)	1/10/62	48.7	48.8				V.Salty	
GW026226	Supply Obtained	Private	Cable Tool	1/1/66	8.5	8.5				invalid code	
GW028414	Supply Obtained	Private	Rotary	1/3/66	6	6.1				(Unknown)	
GW028415	Supply Obtained	Private	(Unknown)	1/3/66	0	7.6				Brackish	
GW032593	(Unknown)	Private	Cable Tool	1/2/70	11.8	11.9				>14000 ppm	
GW047282	(Unknown)	Private	Cable Tool	1/2/79	152	152				(Unknown)	
GW062300	(Unknown)	Other Govt	Cable Tool	1/7/88	100	100				Fresh	
GW070266		Private	Rotary Air	4/7/92	105	0				Salty	
GW070267		Private	Rotary	27/06/1992	84	0				Good	
GW101762			Rotary Air	4/12/95	83	83	8.92			Good	0.858
GW102015				1/3/96	9		3	3		Brackish	0
GW102688			Rotary	10/6/99	5	5.55					
GW102708				9/4/99	4	4	1.374		280		
GW102709				9/11/99	4	4	1.185		54		
GW102710				9/11/99	4	4	1.287		270		
GW102711				9/11/99	4	4	2.114		270		

Date/Time :14-Jun-2001 8:34 AM
User :GUEST
Report :RMGW001D.QRP
Executable :S:\G5\PROD\GROUND.EXE
Exe Date :15-Dec-1999
System :Groundwater
Database :Dlwcp

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW018361 *Converted From HYDSYS*

License :

Work Type : Bore open thru rock
Work Status : (Unknown)
Construct. Method : Cable Tool
Owner Type : Private

Authorised Purpose(s)

Intended Purpose(s)
WASTE DISPOSAL

Commenced Date :
Completion Date : 01-Jan-1961
Final Depth : 217.90 m
Drilled Depth : 217.90 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : (Unknown)
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	ROOTY HILL	161
Licensed :			

Region : 10 - SYDNEY SOUTH COAST
River Basin : 212 - HAWKESBURY RIVER
Area / District :

CMA Map : 9030-2N PROSPECT
Grid Zone : 56/1
Scale : 1:25,000

Elevation :
Elevation Source : (Unknown)

Northing : 6259575
Easting : 300510

Latitude (S) : 33° 47' 6"
Longitude (E) : 150° 50' 43"

GS Map : 0056D4
AMG Zone : 56
Coordinate Source : GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	12.10	203			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

(No Water Bearing Zone Details Found)

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	14.02	14.02	Topsoil Clay	Topsoil	
14.02	16.45	2.43	Basalt	Basalt	
16.45	45.72	29.27	Shale Grey	Shale	
45.72	60.96	15.24	Shale Light Grey	Shale	
60.96	61.56	0.60	Shale Grey	Shale	
61.56	64.00	2.44	Basalt	Basalt	
64.00	72.54	8.54	Shale Black	Shale	
72.54	92.04	19.50	Shale Grey	Shale	
92.04	99.06	7.02	Sandstone	Sandstone	
99.06	137.16	38.10	Shale Grey	Shale	
137.16	150.87	13.71	Shale Grey	Shale	
150.87	194.46	43.59	Sandstone White	Sandstone	
194.46	195.68	1.22	Shale Grey	Shale	
195.68	217.62	21.94	Sandstone White	Sandstone	
217.62	217.93	0.31	Shale Grey	Shale	

Remarks

*** End of GW018361 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW018374

Converted From HYDSYS

License :

Work Type : Bore open thru rock
Work Status : Supply Obtained
Construct. Method : Cable Tool
Owner Type : Private

Authorised Purpose(s)

Intended Purpose(s)
WASTE DISPOSAL

Commenced Date :
Completion Date : 01-Jun-1960

Final Depth : 85.00 m
Drilled Depth : 85.00 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : (Unknown)
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	PROSPECT	111
Licensed :			

Region : 10 - SYDNEY SOUTH COAST
River Basin : 213 - SYDNEY COAST - GEORGES RIVER
Area / District :

CMA Map : 9030-2N PROSPECT
Grid Zone : 56/1 **Scale :** 1:25,000

Elevation :
Elevation Source : (Unknown)

Northing : 6260705
Easting : 308515

Latitude (S) : 33° 46' 35"
Longitude (E) : 150° 55' 55"

GS Map : 0056D4 **AMG Zone :** 56

Coordinate Source : GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	10.10	152			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
5.70	5.70	0.00	(Unknown)			0.00			Salty
11.80	12.10	0.30	(Unknown)	2.70					Brackish
61.50	61.80	0.30	(Unknown)	1.20					Brackish

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.04	3.04	Made Ground	Made Ground	
3.04	6.10	3.06	Shale Clay Ironstone Water Supply	Shale	
6.10	8.83	2.73	Shale	Shale	
8.83	9.44	0.61	Shale	Shale	
8.83	9.44	0.61	Some Bands	Invalid Code	
9.44	39.62	30.18	Shale Some Hard Some Soft Water Supply	Shale	
9.44	39.62	30.18	Some Gravel		
39.62	43.28	3.66	Shale Clay	Shale	
43.28	46.32	3.04	Shale Clay	Shale	
43.28	46.32	3.04	Sandstone Some	Sandstone	
46.32	50.29	3.97	Sandstone	Sandstone	
46.32	50.29	3.97	Clay Bands	Clay	
50.29	50.90	0.61	Sandstone White	Sandstone	
50.29	50.90	0.61	Clay Bands	Clay	
50.90	53.03	2.13	Sandstone Hard	Sandstone	
53.03	77.72	24.69	Sandstone White Water Supply	Sandstone	
53.03	77.72	24.69	Clay Some Bands	Clay	
77.72	85.03	7.31	Sandstone	Sandstone	
77.72	85.03	7.31	Clay Bands	Clay	

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW018374 *Converted From HYDSYS*

Remarks

RECHARGE TEST CAPACITY 0.91 L/S

***** End of GW018374 *****

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

Converted From HYDSYS

GW018375

License :

Work Type : Bore open thru rock
Work Status : Supply Obtained
Construct. Method Cable Tool
:
Owner Type : Private

Authorised Purpose(s)

Intended Purpose(s)
WASTE DISPOSAL

Commenced Date :
Completion Date :01-Aug-1960

Final Depth : 76.20 m
Drilled Depth : 76.20 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : Salty
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	PROSPECT	111
Licensed :			

Region :10 - SYDNEY SOUTH COAST
River Basin :213 - SYDNEY COAST - GEORGES RIVER
Area / District :

CMA Map :9030-2N PROSPECT
Grid Zone :56/1 **Scale :**1:25,000

Elevation :
Elevation Source :(Unknown)

Northing :6260705
Easting :308550

Latitude (S) :33° 46' 35"
Longitude (E) :150° 55' 57"

GS Map :0056D4 **AMG Zone :**56

Coordinate Source :GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	(Unknown)	-0.60	17.50	152			(Unknown)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
27.40	27.40	0.00	Fractured						Salty
61.80	61.80	0.00	(Unknown)						Salty

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	6.40	6.40	Clay	Clay	
6.40	26.82	20.42	Shale Hard	Shale	
26.82	44.19	17.37	Shale Water Supply	Shale	
44.19	45.72	1.53	Sandstone Shale	Sandstone	
45.72	76.20	30.48	Sandstone Water Supply	Sandstone	
45.72	76.20	30.48	Clay Bands	Clay	

Remarks

RECHARGE TEST CAPACITY 1.01 L/S

*** End of GW018375 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

Converted From HYDS

GW018457

License :

Work Type :Bore open thru rock
Work Status :(Unknown)
Construct. Method :Cable Tool
Owner Type :Private

Authorised Purpose(s)

Intended Purpose(s)
WASTE DISPOSAL

Commenced Date :
Completion Date :01-Oct-1959

Final Depth : 52.40 m
Drilled Depth : 52.40 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : Salty
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	CASTLE HILL	114
Licensed :			

Region :10 - SYDNEY SOUTH COAST
River Basin :213 - SYDNEY COAST - GEORGES RIVER
Area / District :

CMA Map :9030-2N PROSPECT
Grid Zone :56/1 Scale :1:25,000

Elevation :
Elevation Source :(Unknown)

Northing :6262270
Easting :313920

Latitude (S) :33° 45' 48"
Longitude (E) :150° 59' 27"

GS Map :0056D4 AMG Zone :56 Coordinate Source :GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	6.00	152			(Unknown)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
19.80	52.40	32.60	Fractured	1.20		0.32			Salty

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	19.81	19.81	Shale Sandy	Shale	
19.81	52.42	32.61	Shale Water Supply	Shale	

Remarks

SITE SEVEN HILLS/WINDSOR RD 2153

*** End of GW018457 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW018574 *Converted From HYDSYS*

License :

Work Type : Bore open thru rock		**Authorised Purpose(s)**	**Intended Purpose(s)** WASTE DISPOSAL
Work Status : (Unknown)			
Construct. Method : Cable Tool			
Owner Type : Private			
Commenced Date :	**Final Depth :** 135.90 m		
Completion Date : 01-Oct-1961	**Drilled Depth :** 135.90 m		

Contractor Name :
Driller :

Property :	**Standing Water Level :**	
GWMA :	**Salinity :**	(Unknown)
GW Zone :	**Yield :**	

Site Details

Site Chosen By	**County**	**Parish**	**Portion/Lot DP**
	Form A : CUMBERLAND	PROSPECT	196
	Licensed :		

Region : 10 - SYDNEY SOUTH COAST	**CMA Map :** 9030-2N	PROSPECT
River Basin : 212 - HAWKESBURY RIVER	**Grid Zone :** 56/1	**Scale :** 1:25,000
Area / District :		
Elevation :	**Northing :** 6261275	**Latitude (S) :** 33° 46' 15"
Elevation Source : (Unknown)	**Easting :** 306150	**Longitude (E) :** 150° 54' 24"
GS Map : 0056D4 **AMG Zone :** 56	**Coordinate Source :** GD.,ACC.MAP	

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OO-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	(Unknown)	0.00	5.40	203			(Unknown)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
124.90	127.30	2.40	Consolidated	12.80		0.15			(Unknown)
134.10	135.90	1.80	Consolidated	11.50		0.23			Brackish

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	7.92	7.92	Clay Grey Sticky	Clay	
7.92	45.11	37.19	Shale	Shale	
45.11	55.47	10.36	Sandstone	Sandstone	
45.11	55.47	10.36	Shale Seams	Shale	
55.47	68.58	13.11	Shale	Shale	
68.58	80.77	12.19	Sandstone Shale	Sandstone	
68.58	80.77	12.19	Clay Seams	Clay	
80.77	124.96	44.19	Shale	Shale	
124.96	127.40	2.44	Sandstone Water Supply	Sandstone	
127.40	134.11	6.71	Shale	Shale	
134.11	135.94	1.83	Sandstone Water Supply	Sandstone	

Remarks

SITED KILDARE ST. BLACKTOWN RECHARGE TEST CAPACITY 0.230 L/S

*** End of GW018574 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

Converted From HYDS

GW018679

License :

Work Type :Bore open thru rock
Work Status :Supply Obtained
Construct. Method :Cable Tool
Owner Type :Private

Authorised Purpose(s)

Intended Purpose(s)
WASTE DISPOSAL

Commenced Date :
Completion Date :01-Aug-1960

Final Depth : 76.20 m
Drilled Depth : 76.20 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : Salty
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	PROSPECT	111
Licensed :			

Region :10 - SYDNEY SOUTH COAST
River Basin :213 - SYDNEY COAST - GEORGES RIVER
Area / District :

CMA Map :9030-2N PROSPECT
Grid Zone :56/1 Scale :1:25,000

Elevation :
Elevation Source :(Unknown)

Northing :6260675
Easting :308515

Latitude (S) :33° 46' 36"
Longitude (E) :150° 55' 55"

GS Map :0056D4 AMG Zone :56 Coordinate Source :GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	(Unknown)	-0.90	17.70	152			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
21.30	21.30	0.00	Fractured						Salty
61.20	61.20	0.00	Consolidated						Salty

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	4.57	4.57	Clay	Clay	
4.57	21.33	16.76	Shale Grey Very Hard	Shale	
4.57	21.33	16.76	Aquifer Nominal	Aquifer	
21.33	43.89	22.56	Shale Grey	Shale	
43.89	47.54	3.65	Sandstone Shale Mixed	Sandstone	
47.54	50.59	3.05	Sandstone	Sandstone	
47.54	50.59	3.05	Clay Bands	Clay	
50.59	76.20	25.61	Sandstone Water Supply	Sandstone	

Remarks

RECHARGE TEST CAPACITY 1.26 L/S

***** End of GW018679 *****

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW018680 *Converted From HYDSYS*

License :

Work Type : Bore open thru rock
Work Status : Supply Obtained
Construct. Method : Cable Tool
Owner Type : Private

Authorised Purpose(s)

Intended Purpose(s)
WASTE DISPOSAL

Commenced Date :
Completion Date : 01-Jul-1960

Final Depth : 79.80 m
Drilled Depth : 79.80 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : Salty
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	PROSPECT	111
Licensed :			

Region : 10 - SYDNEY SOUTH COAST
River Basin : 213 - SYDNEY COAST - GEORGES RIVER
Area / District :

CMA Map : 9030-2N PROSPECT
Grid Zone : 56/1 **Scale :** 1:25,000

Elevation :
Elevation Source : (Unknown)

Northing : 6260675
Easting : 308555

Latitude (S) : 33° 46' 36"
Longitude (E) : 150° 55' 57"

GS Map : 0056D4 **AMG Zone :** 56 **Coordinate Source :** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	(Unknown)	-0.90	18.10	152			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
6.40	6.40	0.00	Fractured						Salty
21.90	21.90	0.00	Fractured						Salty
61.20	79.70	18.50	(Unknown)	1.80					Salty

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	5.48	5.48	Clay	Clay	
5.48	45.11	39.63	Shale Some Hard Some Soft Water Supply	Shale	
45.11	49.98	4.87	Sandstone	Sandstone	
45.11	49.98	4.87	Clay Bands	Clay	
49.98	79.85	29.87	Sandstone White Water Supply	Sandstone	
49.98	79.85	29.87	Clay Bands	Clay	

Remarks

RECHARGE TEST CAPACITY 0.91 L/S

*** End of GW018680 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

;W019461 *Converted From HYDSYS*

License :

Work Type : Bore open thru rock
Work Status :(Unknown)
Construct. Method Cable Tool
:
Owner Type : Private

Authorised Purpose(s)

Intended Purpose(s)
WASTE DISPOSAL

Commenced Date : **Final Depth :** 52.40 m
Completion Date :01-Oct-1959 **Drilled Depth :** 52.40 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : Salty
Yield :

;ite ;...ils

.ite Chosen By

County **Form A :**CUMBERLAND **Licensed :**
Parish CASTLE HILL
Portion/Lot DP 114

Region :10 - SYDNEY SOUTH COAST
River Basin :213 - SYDNEY COAST - GEORGES RIVER
Area / District :

CMA Map :9030-2N PROSPECT
Grid Zone :56/1 **Scale :**1:25,000

Elevation :
Elevation Source :(Unknown)

Northing :6262300
Easting :313875

Latitude (S) :33° 45' 47"
Longitude (E) :150° 59' 25"

GS Map :0056D4 **AMG Zone :**56 **Coordinate Source :**GD.,ACC.MAP

;onstruction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	6.00	152			(Unknown)

Nater Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
19.80	52.40	32.60	Fractured	1.20		10.10			Salty

D... ers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	19.81	19.81	Shale Sandy	Shale	
19.81	52.42	32.61	Shale Water Supply	Shale	

Remarks

SITE SEVEN HILLS/WINDSOR RD 2153

*** End of GW019461 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW019837 *Converted From HYDSYS*

License :

Authorised Purpose(s)

Intended Purpose(s)
IRRIGATION

Work Type : Bore open thru rock
Work Status : (Unknown)
Construct. Method : (Unknown)
Owner Type : Private

Commenced Date :
Completion Date : 01-Oct-1962
Final Depth : 48.70 m
Drilled Depth : 48.80 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : V.Salty
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	CASTLE HILL	55
Licensed :			

Region : 10 - SYDNEY SOUTH COAST
River Basin : 212 - HAWKESBURY RIVER
Area / District :

CMA Map : 9030-1S RIVERSTONE
Grid Zone : 56/1 **Scale :** 1:25,000

Elevation :
Elevation Source : (Unknown)

Northing : 6266250
Easting : 311300

Latitude (S) : 33° 43' 37"
Longitude (E) : 150° 57' 48"

GS Map : 0056D3 **AMG Zone :** 56 **Coordinate Source :** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	5.10	152			Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

(No Water Bearing Zone Details Found)

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.91	0.91	Topsoil	Topsoil	
0.91	4.57	3.66	Clay	Clay	
4.57	5.48	0.91	Clay Grey	Clay	
5.48	7.01	1.53	Shale	Shale	
7.01	20.11	13.10	Sandstone	Sandstone	
20.11	20.72	0.61	Shale	Shale	
20.72	30.78	10.06	Sandstone	Sandstone	
30.78	32.30	1.52	Clay	Clay	
32.30	39.01	6.71	Sandstone	Sandstone	
39.01	39.92	0.91	Clay	Invalid Code	
39.92	43.28	3.36	Sandstone	Sandstone	
43.28	44.50	1.22	Clay Ironstone Gravel	Clay	
44.50	48.76	4.26	Sandstone	Sandstone	

Remarks

*** End of GW019837 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW026226

Converted From HYDSYS

License :

Work Type : Bore
Work Status : Supply Obtained
Construct. Method : Cable Tool
Owner Type : Private

Authorised Purpose(s)

Intended Purpose(s)
GENERAL USE

Commenced Date :
Completion Date : 01-Jan-1966

Final Depth : 8.50 m
Drilled Depth : 8.50 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : invalid code
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	ROOTY HILL	24
Licensed :			

Region : 10 - SYDNEY SOUTH COAST
River Basin : 212 - HAWKESBURY RIVER
Area / District :

CMA Map : 9030-2N PROSPECT
Grid Zone : 56/1 **Scale :** 1:25,000

Elevation :
Elevation Source : (Unknown)

Northing : 6263340
Easting : 300655

Latitude (S) : 33° 45' 4"
Longitude (E) : 150° 50' 52"

GS Map : 0056D4 **AMG Zone :** 56

Coordinate Source : GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	Nil	0.00	0.00	0			(Unknown)
1	1	Casing	Drilled	0.00	8.50	101			(Unknown)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
8.20	8.20	0.00	Fractured	1.00					invalid code

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.13	2.13	Clay Red	Clay	
2.13	2.43	0.30	Shale	Shale	
2.43	7.92	5.49	Clay Green	Clay	
7.92	8.53	0.61	Shale	Shale	

Remarks

*** End of GW026226 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW028414 *Converted From HYDSYS*

License :

Work Type :Well
Work Status :Supply Obtained
Construct. Method :Rotary
Owner Type :Private

Authorised Purpose(s):

Intended Purpose(s): IRRIGATION

Commenced Date :
Completion Date :01-Mar-1966

Final Depth : 6.00 m
Drilled Depth : 6.10 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : (Unknown)
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	MELVILLE	14
Licensed :			

Region :10 - SYDNEY SOUTH COAST
River Basin :212 - HAWKESBURY RIVER
Area / District :

CMA Map :9030-2N PROSPECT
Grid Zone :56/1 Scale :1:25,000

Elevation :
Elevation Source :(Unknown)

Northing :6259470
Easting :298550

Latitude (S) :33° 47' 8"
Longitude (E) :150° 49' 27"

GS Map :0056D4 AMG Zone :56

Coordinate Source :GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	Concrete Cylnder	0.00	0.00	1219			(Unknown)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
5.90	5.90	0.00	Fractured	3.90					(Unknown)

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.66	3.66	Clay	Clay	
3.66	6.10	2.44	Shale Soft Broken	Shale	
6.10	6.11	0.01	Shale Grey Hard	Shale	

Remarks

*** End of GW028414 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW028415 *Converted From HYDSYS*

License :

Authorised Purpose(s)

Intended Purpose(s) IRRIGATION

Work Type : Well
Work Status : Supply Obtained
Construct. Method : (Unknown)
Owner Type : Private

Commenced Date :
Completion Date : 01-Mar-1966
Final Depth : 0.00
Drilled Depth : 7.60 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : Brackish
Yield :

Site Details

Site Chosen By

County Form A : CUMBERLAND
Licensed :
Parish ROOTY HILL
Portion/Lot DP 106

Region : 10 - SYDNEY SOUTH COAST
River Basin : 212 - HAWKESBURY RIVER
Area / District :

CMA Map : 9030-2N PROSPECT
Grid Zone : 56/1
Scale : 1:25,000

Elevation :
Elevation Source : (Unknown)

Northing : 6260200
Easting : 296985
Latitude (S) : 33° 46' 44"
Longitude (E) : 150° 48' 27"

GS Map : 0056D4 **AMG Zone :** 56 **Coordinate Source :** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1		Backfill	Backfill	0.00	7.60	1066			
1	1	Casing	Concrete Cylnder	-0.90	-0.90	1066			(Unknown)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
3.00	4.80	1.80	Unconsolidated						(Unknown)
7.40	7.40	0.00	Fractured						(Unknown)

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.61	0.61	Loam Sandy	Loam	
0.61	3.05	2.44	Clay	Clay	
3.05	4.88	1.83	Gravel Clayey Sandy	Gravel	
4.88	7.62	2.74	Shale Soft Broken Water Supply	Shale	
7.62	7.64	0.02	Shale Grey Hard	Shale	

Remarks

*** End of GW028415 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW032593 *Converted From HYDS*

License :

Work Type : Bore
Work Status :(Unknown)
Construct. Method : Cable Tool
Owner Type : Private

Authorised Purpose(s)

Intended Purpose(s) GENERAL USE

Commenced Date :
Completion Date :01-Feb-1970

Final Depth : 11.80 m
Drilled Depth : 11.90 m

Contractor Name :
Driller :

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : Over 14000 ppm
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	PROSPECT	141
Licensed :			

Region :10 - SYDNEY SOUTH COAST
River Basin :212 - HAWKESBURY RIVER
Area / District :

CMA Map :9030-1S RIVERSTONE
Grid Zone :56/1 **Scale :**1:25,000

Elevation :
Elevation Source :(Unknown)

Northing :6264210
Easting :303985

Latitude (S) :33° 44' 38"
Longitude (E) :150° 53' 2"

GS Map :0056D3 **AMG Zone :**56 **Coordinate Source :**GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details

(No Construction Details Found)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
7.60	7.60	0.00	Fractured			0.35			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	6.09	6.09	Clay	Clay	
6.09	11.88	5.79	Shale Black Water Supply	Shale	

Remarks

*** End of GW032593 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW047282 *Converted From HYDSYS*

License :10BL107370

Authorised Purpose(s)
DOMESTIC
IRRIGATION
STOCK

Intended Purpose(s)
IRRIGATION

Work Type : Bore
Work Status :(Unknown)
Construct. Method : Cable Tool
Owner Type : Private

Commenced Date :
Completion Date :01-Feb-1979
Final Depth : 152.00 m
Drilled Depth : 152.00 m

Contractor Name :
Driller :1435 ISELT, John Hans

Property :
GWMA : -
GW Zone : -

Standing Water Level :
Salinity : (Unknown)
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	GIDLEY	12
Licensed :	CUMBERLAND	GIDLEY	NOT AVAILABLE

Region :10 - SYDNEY SOUTH COAST
River Basin :212 - HAWKESBURY RIVER
Area / District :

CMA Map :9030-1S RIVERSTONE
Grid Zone :56/1 **Scale :**1:25,000

Elevation :
Elevation Source :(Unknown)

Northing :6268600
Easting :306975
Latitude (S) :33° 42' 18"
Longitude (E) :150° 55' 2"

GS Map :0056D3 **AMG Zone :**56 **Coordinate Source :**GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details

(No Construction Details Found)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
28.60	29.00	0.40	Fractured	28.60		0.08			(Unknown)

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.40	0.40	Topsoil Dark	Topsoil	
0.40	1.20	0.80	Clay	Clay	
1.20	6.80	5.60	Shale Clay	Shale	
6.80	60.30	53.50	Shale Water Supply	Shale	
60.30	61.00	0.70	Shale Sandstone	Shale	
61.00	83.80	22.80	Sandstone Grey	Sandstone	
83.80	84.20	0.40	Shale Clay	Shale	
84.20	137.00	52.80	Sandstone Grey Silty	Sandstone	
137.00	138.60	1.60	Shale Clay	Shale	
138.60	152.00	13.40	Sandstone Grey Silty	Sandstone	

Remarks

*** End of GW047282 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

Converted From HYDSY

GW062300

License :10BL137938

Work Type :Bore
Work Status :(Unknown)
Construct. Method :Cable Tool
Owner Type :Other Govt

Authorised Purpose(s)	Intended Purpose(s)
INDUSTRIAL	INDUSTRIAL

Commenced Date :
Completion Date :01-Jul-1988

Final Depth : 100.00 m
Drilled Depth : 100.00 m

Contractor Name :
Driller :1435 ISELT, John Hans

Property : - N/A
GWMA : -
GW Zone : -

Standing Water Level :
Salinity : Fresh
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	FIELD OF MARS	L1 DP734689 (99999)
Licensed :	CUMBERLAND	GIDLEY	NOT AVAILABLE

Region :10 - SYDNEY SOUTH COAST
River Basin :213 - SYDNEY COAST - GEORGES RIVER
Area / District :

CMA Map :9030-2N PROSPECT
Grid Zone :56/1 Scale :1:25,000

Elevation :
Elevation Source :(Unknown)

Northing :6258238
Easting :314817

Latitude (S) :33° 47' 59"
Longitude (E) :150° 59' 58"

GS Map :0056D4 AMG Zone :56 Coordinate Source :GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	P.V.C.	-0.30	13.70	168			Cemented
1	1	Casing	Pressure Cemented Casing	0.00	13.70	168			(Unknown)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
26.10	26.80	0.70	Consolidated	18.00		0.30			Fresh
63.50	63.80	0.30	Consolidated	6.00		0.95			Fresh

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.40	0.40	Topsoil	Topsoil	
0.40	5.60	5.20	Sandstone Some Layers	Sandstone	
0.40	5.60	5.20	Shale Clay	Shale	
5.60	9.50	3.90	Sandstone Yellow	Sandstone	
9.50	12.10	2.60	Shale	Shale	
12.10	26.80	14.70	Sandstone Grey Water Supply	Sandstone	
26.80	37.70	10.90	Sandstone Grey Some Shale	Sandstone	
37.70	38.10	0.40	Shale	Shale	
38.10	100.00	61.90	Sandstone Grey Water Supply	Sandstone	

Remarks

BORE IS NOT USED AS IRON REMOVAL IS UNECONOMIC -'89

*** End of GW062300 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW070266

Converted From HYDSYS

License :

Authorised Purpose(s)

Intended Purpose(s)
DOMESTIC

Work Type : Bore open thru rock
Work Status :
Construct. Method : Rotary Air
Owner Type : Private

Commenced Date :
Completion Date : 04-Jul-1992
Final Depth : 105.00 m
Drilled Depth : 0.00

Contractor Name :
Driller : 1556 ORCHARD, Rodney Ronald

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : Salty
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	CASTLE HILL	47
Licensed :			

Region : 10 - SYDNEY SOUTH COAST
River Basin : 212 - HAWKESBURY RIVER
Area / District :

CMA Map : 9030-1S RIVERSTONE
Grid Zone : 56/1 **Scale :** 1:25,000

Elevation : 0.00
Elevation Source :

Northing : 6267581
Easting : 309623

Latitude (S) : 33° 42' 53"
Longitude (E) : 150° 56' 44"

GS Map : 0056D3 **AMG Zone :** 56

Coordinate Source :

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	Steel	-0.30	10.00	165			Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
35.00	36.00	1.00	Consolidated	8.00		0.03			S.Salty
64.00	65.00	1.00	Consolidated	8.00		0.16			S.Salty

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.62	2.62	TOPSOIL		
2.62	9.50	6.88	CLAY		
9.50	18.00	8.50	SHALE		
18.00	104.00	86.00	SANDSTONE		
104.00	105.00	1.00	CLAY		

Remarks

*** End of GW070266 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW070267 *Converted From HYDS*

License :

Work Type :Bore open thru rock
Work Status :
Construct. MethodRotary
:
Owner Type :Private

Authorised Purpose(s)

Intended Purpose(s)
DOMESTIC

Commenced Date :
Completion Date :27-Jun-1992

Final Depth : 84.00 m
Drilled Depth : 0.00

Contractor Name :
Driller :1556 ORCHARD, Rodney Ronald

Property :
GWMA :
GW Zone :

Standing Water Level :
Salinity : Good
Yield :

Site Details

Site Chosen By

County	Parish	Portion/Lot DP
Form A :CUMBERLAND	CASTLE HILL	47
Licensed :		

Region :10 - SYDNEY SOUTH COAST
River Basin :212 - HAWKESBURY RIVER
Area / District :

CMA Map :9030-1S RIVERSTONE
Grid Zone :56/1 Scale :1:25,000

Elevation : 0.00
Elevation Source :

Northing :6267587
Easting :309480

Latitude (S) :33° 42' 52"
Longitude (E) :150° 56' 38"

GS Map :0056D3 AMG Zone :56 Coordinate Source :

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1	1	Casing	Steel	-0.50	8.00	165			Driven into Hole

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
51.50	52.50	1.00	Consolidated	28.40		0.33			Good
64.70	65.70	1.00	Consolidated	28.40		0.22			Good

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.20	0.20	TOPSOIL		
0.20	1.40	1.20	CLAY		
1.40	3.00	1.60	CLAY		
3.00	3.90	0.90	SANDSTONE		
3.90	4.20	0.30	SHALE		
4.20	81.50	77.30	SANDSTONE		
81.50	84.00	2.50	CLAY		

Remarks

*** End of GW070267 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW101762

License :10BL157341

Work Type :Bore
Work Status :
Construct. MethodRotary Air
:
Owner Type :

Authorised Purpose(s)
DOMESTIC
STOCK

Intended Purpose(s)
DOMESTIC

Commenced Date :
Completion Date :04-Dec-1995

Final Depth : 83.00 m
Drilled Depth : 83.00 m

Contractor Name :DALTON WATER DRILLING SERVICES
Driller :1523 DALTON, John Micheal

Property : - N/A
GWMA : -
GW Zone : -

Standing Water Level : 8.92 m
Salinity : Good
Yield : 0.86 L/s

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	GIDLEY	LOT1 DP841334
Licensed :	CUMBERLAND	GIDLEY	LOT1 DP841334

Region :10 - SYDNEY SOUTH COAST
River Basin :
Area / District :

CMA Map :
Grid Zone :
Scale :

Elevation :
Elevation Source :

Northing :
Easting :

Latitude (S) :
Longitude (E) :

GS Map :
AMG Zone :
Coordinate Source :

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1		Hole	Hole	0.00	83.00	160			Rotary Air
1	1	Casing	PVC Class 9	0.00	83.00	160			Glued; Seated on Bottom

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
53.00	57.00	4.00		8.92		0.86	83.00	1.50	Good

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.50	2.50	Red and Black Clay	Clay	
2.50	6.00	3.50	Soft Shale	Shale	
6.00	38.00	32.00	Blue Shale	Shale	
38.00	83.00	45.00	White Sandstone	Sandstone	

Remarks

*** End of GW101762 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW102015

License :10BL157409

Work Type :Bore
Work Status :
Construct. Method :
Owner Type :

Authorised Purpose(s)	Intended Purpose(s)
DEWATERING (GROUNDWATER)	DEWATERING (GROUNDWATER)

Commenced Date :
Completion Date :01-Mar-1996

Final Depth : 9.00 m
Drilled Depth :

Contractor Name :
Driller :

Property : - N/A
GWMA : -
GW Zone : -

Standing Water Level : 3.00 m
Salinity : Brackish
Yield : 0.00

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :			
Licensed :	CUMBERLAND	ST LUKE	LOT1 DP24184

Region :10 - SYDNEY SOUTH COAST
River Basin :
Area / District :

CMA Map :
Grid Zone :
Scale :

Elevation :
Elevation Source :

Northing :
Easting :

Latitude (S) :
Longitude (E) :

GS Map :
AMG Zone :
Coordinate Source :

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details

(No Construction Details Found)

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

(No Water Bearing Zone Details Found)

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments

Remarks

Form A Remarks:
L-shaped pit with measurements 20 m. by 9 m. along one branch and 20 m. by 3 m. along the other.
Sealed off from aquifer and not pumped from.
DETAILS OBTAINED BY PHONE

*** End of GW102015 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW102688

License :10BL159263

Work Type :Bore
Work Status :
Construct. MethodRotary
:
Owner Type :

Authorised Purpose(s)
MONITORING BORE

Intended Purpose(s)
MONITORING BORE

Commenced Date :
Completion Date :10-Jun-1999

Final Depth : 5.00 m
Drilled Depth : 5.55 m

Contractor Name :MACQUARIE DRILLING
Driller :1712 HOWE, Steve Robert

Property : - N/A
GWMA : -
GW Zone : -

Standing Water Level :
Salinity :
Yield :

Site Details

Site Chosen By
Geologist

	County	Parish	Portion/Lot DP
Form A	CUMBERLAND	PROSPECT	LOT23 DP571630
Licensed	CUMBERLAND	PROSPECT	LOT23 DP571630

Region :10 - SYDNEY SOUTH COAST
River Basin :
Area / District :

CMA Map :
Grid Zone :
Scale :

Elevation :
Elevation Source :

Northing :
Easting :

Latitude (S) :
Longitude (E) :

GS Map :
AMG Zone :
Coordinate Source :

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1		Hole	Hole	0.00	5.55	125			
1	1	Casing	PVC Class 18	0.00	1.00	50			C: 0-.7m; Screwed
1	1	Opening	Slots	0.00	1.00	50			PVC Class 18; SL: 1mm
1	1	Opening	Screen	1.00	5.00	50			PVC Class 18; A: .4mm; Screwed
1		Annulus	(Unknown)	0.70	5.00				Graded; GS: 0-2mm; Q: 4300m³

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
2.00	5.00	3.00		2.50					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	SAND FILL MINOR CLAY	Sand Drift	
1.00	4.50	3.50	CLAY SILTY/SANDY	Clay Bands	
4.50	5.55	1.05	SHALE WEATHERED	Shale	

Remarks

Form A Remarks:
THREE MONITOR WELLS ON SERVICE STATION SITE LOCATED AT THE CORNER OF SUNNYHOLT ROAD AND FORGE STREET (BLAWCKTOWN).CONSTRUCTION DERTAILS FOR 3 WELLS ARE SAME.

*** End of GW102688 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW102708

License :10BL159453

Work Type :Bore
Work Status :
Construct. Method :
Owner Type :

Authorised Purpose(s): MONITORING BORE
Intended Purpose(s): MONITORING BORE

Commenced Date :
Completion Date :09-Apr-1999

Final Depth : 4.00 m
Drilled Depth : 4.00 m

Contractor Name :McDERMOTT DRILLING
Driller :

Property : - N/A
GWMA : -
GW Zone : -

Standing Water Level : 1.37 m
Salinity : 280.00 mg/L
Yield :

Site Details

Site Chosen By: Hydrogeologist

	County	Parish	Portion/Lot DP
Form A	CUMBERLAND	PROSPECT	LOT2 DP233147
Licensed	CUMBERLAND	PROSPECT	LOT2 DP233147

Region :10 - SYDNEY SOUTH COAST
River Basin :
Area / District :

CMA Map :
Grid Zone :
Scale :

Elevation :
Elevation Source :

Northing :
Easting :

Latitude (S) :
Longitude (E) :

GS Map :
AMG Zone :
Coordinate Source :

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1		Hole	Hole	0.00	4.00	120			Auger
1	1	Casing	PVC Class 18	0.00	1.00	60			C: 0-.6m; Screwed; Seated on Bottom; Casing Shoe
1	1	Opening	Slots - Horizontal	1.00	4.00	60			PVC Class 18; Sawn; SL: 30mm; A: .5mm
1		Annulus	(Unknown)	0.90	4.00				Graded; GS: 0-2mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
1.40	2.20	0.80		1.37					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.20	0.20	CONCRETE	Concretionary	
0.20	4.00	3.80	CLAY SILTY	Clay Bands	

Remarks

*** End of GW102708 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW102709

License :10BL159453

	Authorised Purpose(s)	Intended Purpose(s)
Work Type :Bore	MONITORING BORE	MONITORING BORE
Work Status :		
Construct. Method :		
Owner Type :		

Commenced Date : Final Depth : 4.00 m
Completion Date :09-Nov-1999 Drilled Depth : 4.00 m

Contractor Name :McDERMOTT DRILLING
Driller :

Property : - N/A Standing Water Level : 1.19 m
GWMA : - Salinity : 54.00 mg/L
GW Zone : - Yield :

Site Details

Site Chosen By	County	Parish	Portion/Lot DP
Form A	CUMBERLAND	PROSPECT	LOT2 DP233147
Licensed	CUMBERLAND	PROSPECT	LOT2 DP233147

Region :10 - SYDNEY SOUTH COAST CMA Map :
River Basin : Grid Zone : Scale :
Area / District :

Elevation : Northing : Latitude (S) :
Elevation Source : Easting : Longitude (E) :

GS Map : AMG Zone : Coordinate Source :

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1		Hole	Hole	0.00	4.00	120			Auger
1	1	Casing	PVC Class 18	0.00	1.00	60			C: 0-.5m; Screwed; Seated on Bottom; Cap; Casing Shoe
1	1	Opening	Slots - Horizontal	0.00	4.00	60			PVC Class 18; Sawn; SL: 30mm; A: .5mm
1		Annulus	(Unknown)	0.80	4.00				Graded; GS: 0-2mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
1.20	2.40	1.20		1.19					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.05	0.05	ASPHALT	Ash	
0.05	0.20	0.15	ROCK CRUSHED	Rock Bars	
0.20	4.00	3.80	CLAY SILTY	Clay Bands	

Remarks

*** End of GW102709 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW102710

License :10BL159453

Work Type :Bore
Work Status :
Construct. Method :
Owner Type :

Authorised Purpose(s)	Intended Purpose(s)
MONITORING BORE	MONITORING BORE

Commenced Date :
Completion Date :09-Nov-1999

Final Depth : 4.00 m
Drilled Depth : 4.00 m

Contractor Name :McDERMOTT DRILLING
Driller :

Property : - N/A
GWMA : -
GW Zone : -

Standing Water Level : 1.29 m
Salinity : 270.00 mg/L
Yield :

Site Details

Site Chosen By

	County	Parish	Portion/Lot DP
Form A :	CUMBERLAND	PROSPECT	LOT2 DP233147
Licensed :	CUMBERLAND	PROSPECT	LOT2 DP233147

Region :10 - SYDNEY SOUTH COAST
River Basin :
Area / District :

CMA Map :
Grid Zone :
Scale :

Elevation :
Elevation Source :

Northing :
Easting :

Latitude (S) :
Longitude (E) :

GS Map :
AMG Zone :
Coordinate Source :

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1		Hole	Hole	0.00	4.00	120			Auger
1	1	Casing	PVC Class 18	0.00	1.00	60			C: 0-.6m; Screwed; Seated on Bottom; Cap; Casing Shoe
1	1	Opening	Slots - Horizontal	1.00	4.00	60			PVC Class 18; Sawn; SL: 30mm; A: .5mm
1		Annulus	(Unknown)	0.90	4.00				Graded; GS: 0-2mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
1.40	2.20	0.80		1.39					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	GRAVEL CLAYEY	Gravel	
1.00	4.00	3.00	CLAY SILTY	Clay Bands	

Remarks

*** End of GW102710 ***

DEPARTMENT OF LAND & WATER CONSERVATION
Work Summary

GW102711

License :10BL159453

Work Type :Bore
Work Status :
Construct. Method :
Owner Type :

Authorised Purpose(s)	Intended Purpose(s)
MONITORING BORE	MONITORING BORE

Commenced Date :
Completion Date :09-Nov-1999

Final Depth : 4.00 m
Drilled Depth : 4.00 m

Contractor Name :McDERMOTT DRILLING
Driller :

Property : - N/A
GWMA : -
GW Zone : -

Standing Water Level : 2.11 m
Salinity : 270.00 mg/L
Yield :

Site Details

Site Chosen By
Hydrogeologist

	County	Parish	Portion/Lot DP
Form A	CUMBERLAND	PROSPECT	LOT2 DP233147
Licensed	CUMBERLAND	PROSPECT	LOT2 DP233147

Region :10 - SYDNEY SOUTH COAST
River Basin :
Area / District :

CMA Map :
Grid Zone :
Scale :

Elevation :
Elevation Source :

Northing :
Easting :

Latitude (S) :
Longitude (E) :

GS Map :
AMG Zone :
Coordinate Source :

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

H	P	Component	Type	From (m)	To (m)	OD (mm)	ID (mm)	Interval	Details
1		Hole	Hole	0.00	4.00	120			Auger
1	1	Casing	PVC Class 18	0.00	1.00	60			C: 0-.4m; Screwed; Seated on Bottom; Casing Shoe
1	1	Opening	Slots - Horizontal	1.00	4.00	60			PVC Class 18; Sawn; SL: 30mm; A: .5mm
1		Annulus	(Unknown)	0.80	4.00				Graded; GS: 0-2mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
1.20	2.50	1.30		2.11					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	4.00	4.00	SILTY CLAY	Silty Clay	

Remarks

*** End of GW102711 ***

*** End of Report ***