COMMONWEALTH DEPARTMENT OF
TRANSPORT AND REGIONAL DEVELOPMENT

Noise

Volume 1: Main Report

Proposal for a Second Sydney Airport
at Badgerys Creek or Holsworthy Military Area

3

Technical Paper

PPK
Environment & Infrastructure

Prepared for:

COMMONWEALTH DEPARTMENT OF
TRANSPORT AND REGIONAL DEVELOPMENT

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Proposal for a Second Sydney Airport
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Explanatory Statement

This technical paper is not part of the Draft Environmental Impact Statement (EIS) referred to in paragraph 6 of the Administrative Procedures made under the Environment Protection (Impact of Proposals) Act 1974.

The Commonwealth Government is proposing to construct and operate a second major airport for Sydney at Badgerys Creek. This technical paper contains information relating to the Badgerys Creek airport options which was used to assist the preparation of the Draft EIS.

The technical paper also assesses the impacts of developing a major airport at the Holsworthy Military Area. On 3 September 1997, the Government eliminated the Holsworthy Military Area as a potential site for Sydney's second major airport. As a consequence, information in this technical paper relating to the Holsworthy Military Area is presented for information purposes only.

Limitations Statement

This technical paper has been prepared in accordance with the scope of work set out in the contract between Rust PPK Pty Ltd and the Commonwealth Department of Transport and Regional Development (DoTRD) and completed by PPK Environment and Infrastructure Pty Ltd (PPK). In preparing this technical paper, PPK has relied upon data, surveys, analyses, designs, plans and other information provided by DoTRD and other individuals and organisations, most of which are referenced in this technical paper. Except as otherwise stated in this technical paper, PPK has not verified the accuracy or completeness of such data, surveys, analyses, designs, plans and other information.

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Acknowledgments

Data used to develop the figures contained in this document have been obtained and reproduced by permission of the Australian Bureau of Statistics, NSW Department of Land and Water Conservation, NSW National Parks and Wildlife Service (issued 14 January 1997), NSW Department of Urban Affairs and Planning and Sydney Water. The document is predominantly based on 1996 and 1997 data.

To ensure clarity on some of the figures, names of some suburbs have been deleted from inner western, eastern, south-eastern and north-eastern areas of Sydney. On other figures, only 'Primary' and 'Secondary' centres identified by the Department of Urban Affairs and Planning's Metropolitan Strategy, in addition to Camden, Fairfield and Sutherland, have been shown.

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Introduction

1 INTRODUCTION

1.1 INTRODUCTION

This technical paper addresses the potential noise impacts identified as part of the previously proposed development of the Second Sydney Airport at either Badgerys Creek or Holsworthy Military Area. It contains information used to prepare the Draft Environmental Impact Statement (EIS) which addresses the overall environmental impacts of the Badgerys Creek airport options.

This technical paper is made up of three volumes. The first contains the main report and Appendices A and B. The second volume contains the technical review of the potential health effects of aircraft noise. Volume 3 contains the detailed noise results for the Community Assessment Areas and Sub-Community Assessment Areas.

1.2 A BRIEF HISTORY

The question of where, when and how a second major airport may be developed for Sydney has been the subject of investigation for more than 50 years. The investigations and the associated decisions are closely related to the history of the development of Sydney's existing major airport, located at Mascot.

The site of Sydney Airport was first used for aviation in 1919. It was acquired by the Commonwealth Government in 1921, and was declared an International Aerodrome in 1935. In 1940 the first terminal building and control tower were opened.

In 1945 the airport had three relatively short runways. A major expansion began in 1947, and by 1954 the current east-west runway was opened. The north-south runway was first opened in 1954 and was extended to its current length in 1972. The present international terminal was opened in 1970.

Planning and investigations for a site for a second Sydney airport first started in 1946. A large number of possible sites both within and outside the Sydney Basin have been investigated.

The *Second Sydney Airport Site Selection Program Draft Environmental Impact Statement* (Kinhill Stearns, 1985) re-examined all possible locations for the second airport and chose 10 for preliminary evaluation. Two sites, Badgerys Creek and Wilton, were examined in detail and an EIS was prepared. In February 1986 the then Commonwealth Government announced that Badgerys Creek had been selected as the site for Sydney's second major airport.

The Badgerys Creek site, which is about 46 kilometres west of Sydney's Central Business District and is 1,700 hectares in area, was acquired by the

Commonwealth between 1986 and 1991. A total of $155 million has been spent on property acquisition and preparatory works.

Since 1986, planning for Sydney's second airport has been closely linked to the development of the third runway at Sydney Airport. In 1989 the Government announced its intention to construct a third runway. An EIS was undertaken and the decision to construct the runway was made in December 1991.

At the same time as investigations were being carried out on the third runway, detailed planning proceeded for the staged development of the second airport at Badgerys Creek. In 1991 it was announced that initial development at Badgerys Creek would be as a general aviation airport with an 1,800 metre runway.

The third runway at Sydney Airport was opened in November 1994. In March 1995, in response to public concern over the high levels of aircraft noise, the Commonwealth Senate established a committee in March 1995 to examine the problems of noise generated by aircraft using Sydney Airport and explore possible solutions. The committee's report, *Falling on Deaf Ears?*, containing several recommendations, was tabled in parliament in November 1995 (Senate Select Committee on Aircraft Noise, 1995).

During 1994 and 1995 the Government announced details of its proposed development of Badgerys Creek, and of funding commitments designed to ensure the new airport would be operational in time for the 2000 Olympics. This development included a 2,900 metre runway for use by major aircraft.

The decision to accelerate the development of the new airport triggered the environmental assessment procedures in the *Environment Protection (Impact of Proposals) Act 1974*. In January 1996 it was announced that an EIS would be prepared for the construction and operation of the new airport.

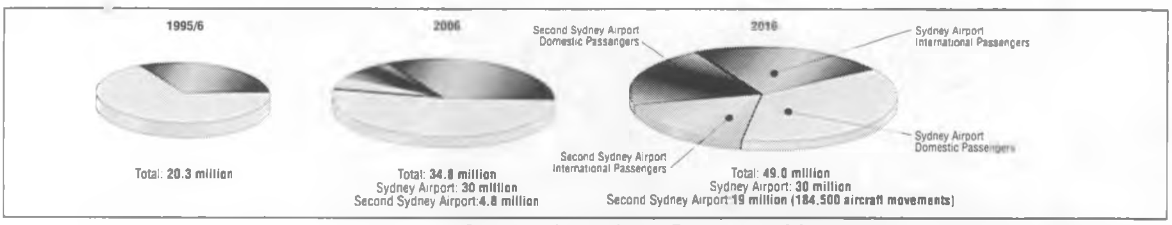
In May 1996, the present Commonwealth Government decided to broaden the environmental assessment process. It put forward a new proposal involving the consideration of 'the construction and operation of a second major international/domestic airport for Sydney at either Badgerys Creek or Holsworthy on a site large enough for future expansion of the airport if required' (Department of Transport and Regional Development, 1996). A major airport was defined as one 'capable of handling up to about 360,000 aircraft movements and 30 million passengers per year' (Department of Transport and Regional Development, 1996).

The Government also indicated that 'Badgerys Creek at this time remains the preferred site for Sydney's second major airport, subject to the favourable outcome of the EIS, while Holsworthy is an option to be considered as an alternative' (Minister for Transport and Regional Development, 1996). The two sites considered in this technical paper are shown in *Figure 1.1*.

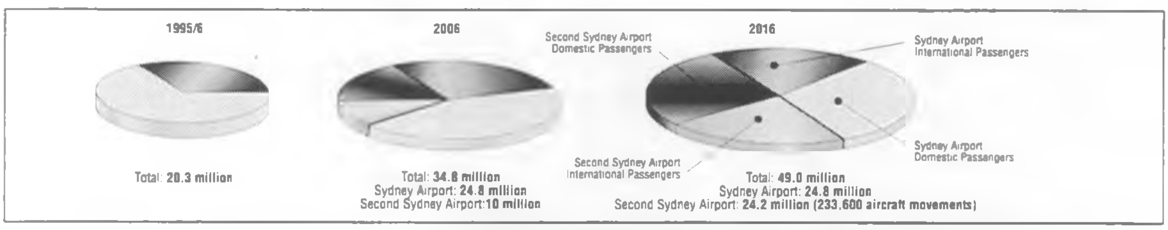
Following the substantial completion of a Draft EIS on the Badgerys Creek and Holsworthy airport options, the Government eliminated the Holsworthy Military Area as a potential site for Sydney's second major airport. The environmental assessment showed that the Badgerys Creek site was significantly superior to the Holsworthy Military Area. As a result a Draft EIS

Figure 1.1
Potential Airport Sites Considered in the Draft EIS

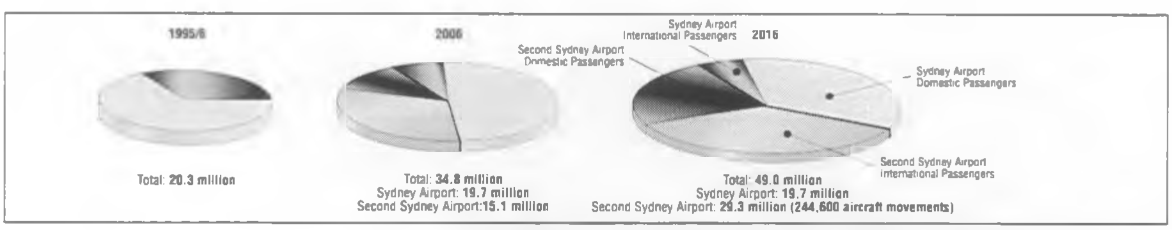
TN
0Km 10Km 20Km



Assumptions about Passenger Movements for Air Traffic Forecast 1



Assumptions about Passenger Movements for Air Traffic Forecast 2



Assumptions about Passenger Movements for Air Traffic Forecast 3

Figure 1.2
Summary of Passenger Movement Forecasts Used for Environmental Assessment

was prepared which examines only the Badgerys Creek site. While this technical paper examines both the Badgerys Creek and Holsworthy airport options, only the parts of the assessment relating to the Badgerys Creek airport options were used to assist the preparation of the Draft EIS.

1.3 THE PROPOSAL

The Commonwealth Government proposes the development of a second airport for Sydney capable of handling up to 30 million domestic and international passengers a year. By comparison, Sydney Airport will handle about 20 million passengers in 1997. The *Second Sydney Airport Site Selection Program Draft Environmental Impact Statement* anticipated Sydney's second airport would accommodate about 13 million passengers each year (Kinhill Stearns, 1985).

In the Government's view, Sydney needs a second major airport to handle the growing demand for air travel and to control the level of noise experienced by Sydney residents (Coalition of Liberal and National Parties, 1996).

Government policy (Coalition of Liberal and National Parties, 1996) indicates:

- an intention that Sydney's second airport will be more than just an overflow airport and will, in time, play a major role in serving Sydney's air transport needs; and
- a goal of reducing the noise and pollution generated by Sydney Airport as much as possible and that the Government would take steps to ensure that the noise burden around Sydney Airport is shared in a safe and equitable way.

Certain assumptions are made on how the Second Sydney Airport would operate, and in the master plans which set out the broad framework for future physical development of the airport. These assumptions are based on an operational limit of 30 million passengers a year. The main features include parallel runways, a cross wind runway and the provision of the majority of facilities between the parallel runways.

Consideration has also been given to how the airport might be expanded in the future and the subsequent environmental implications. Such an expansion could not proceed, however, unless a further detailed environmental assessment and decision making process were undertaken by the Government.

Five airport options are considered in this Technical Paper, as well as the implications of not proceeding with the proposal. Three of the airport options are located at Badgerys Creek and two are located within the Holsworthy Military Area. The environmental assessment of all five airport options assisted the Government in making its decision to eliminate the Holsworthy Military Area from further consideration. The environmental assessment of the Badgerys Creek airport options was also used to assist in the preparation of the Draft EIS which examines only those three options. Generally, the airport options are:

- Badgerys Creek Option A develops the site in a form generally consistent with the planning undertaken since 1986. The airport would be developed within land presently owned by the Commonwealth with two parallel runways constructed on an approximate north-east to south-west alignment;
- Badgerys Creek Option B would adopt an identical runway alignment to Option A, but provides an expanded land area and also a cross wind runway;
- Badgerys Creek Option C would provide two main parallel runways on an approximate north to south alignment in addition to a cross wind runway. Again the land area required would be significantly expanded from that which is presently owned by the Commonwealth;
- Holsworthy Option A would be located centrally within the Holsworthy Military Area and would have two main parallel runways on an approximate north to south alignment and a cross wind runway; and
- Holsworthy Option B would be located in the south of the Holsworthy Military Area and would have two main parallel runways on an approximate south-east to north-west alignment and a cross wind runway.

To ensure that the likely range of impacts are identified, a number of assumptions have been made about how the different airport options would be developed and operate. These relate to the number and types of aircraft that may operate from the airport, the flight paths used and the direction of take offs and landings.

It is clear that the number of flights into and out of the proposed airport would depend partly on the types of aircraft using it and the associated numbers of passengers in each aircraft. The proposal put forward by the Government anticipates a major airport handling 30 million passengers and up to 360,000 aircraft movements per year.

Air traffic forecasts have been developed based on an examination of the number and type of aircraft liable to be using the airport as it approaches the proposed operating level of 30 million passengers per year. This examination has shown that if the airport accommodated about 245,000 aircraft movements each year, the number of air passengers would approach 30 million. This assumes a relatively high percentage of international flights being directed to the Second Sydney Airport. Therefore it is appropriate for this environmental assessment to examine the airport operating at a level of 245,000 aircraft movements per year, rather than the 360,000 originally anticipated by the Government. It has been assumed that this level of operation could be reached by about 2016.

1.4 AIR TRAFFIC FORECASTS

Cities around the world which have developed second major airports have responded to their particular needs in different ways. For example, the original airport in Dallas, United States, is now used for short range traffic that does not connect with other flights. Second airports in New York and Washington serve as hubs for particular airlines. In Taipei, Taiwan, smaller domestic aircraft use the downtown airport and larger international flights use a newer airport 40 kilometres from the city.

It is clear that each metropolitan area around the world has unique characteristics and the development of multi-airport systems respond to particular local circumstances. The precise role and consequential staging of development of the Second Sydney Airport would be the subject of future Government decisions. To assist in developing a realistic assessment of the potential impacts of the Second Sydney Airport, three sets of air traffic forecasts for the airport were developed. Each forecast assumes a major airport would be developed, however, this may be achieved at different rates of growth.

The three potential air traffic scenarios considered for the Second Sydney Airport are shown in *Figure 1.2*. They are:

- *Air Traffic Forecast 1* where the Second Sydney Airport would provide only for demand which cannot be met by Sydney Airport. This is an overflow forecast, but would nevertheless result in a significant amount of air traffic at the Second Sydney Airport. The proportion of international and domestic air traffic is assumed to be similar at both airports;
- *Air Traffic Forecast 2* where the Second Sydney Airport would be developed to cater for 10 million passengers a year by 2006, with all further growth after this being directed to the second airport rather than Sydney Airport. The proportion of international and domestic traffic is also assumed to be similar at both airports; and
- *Air Traffic Forecast 3* which is similar to Forecast 2 but with more international flights being directed to the Second Sydney Airport. This would result in the larger and comparatively noisier aircraft being directed to the second airport. It would accommodate about 29.3 million passengers by 2016.

1.5 OPERATION OF THE AIRPORT OPTIONS

At any airport, aircraft operations are allocated to runways (which implies both the physical runway and the direction in which it is used) according to a combination of wind conditions and airport operating policy. The allocation is normally performed by Air Traffic Control personnel.

Standard airport operating procedures indicate that a runway may not be selected for either approach or departure if the wind has a downwind component greater than five knots, or a cross wind component greater than

25 knots. If the runway is wet, it would not normally be selected if there is any downwind component. This applies to all aircraft types, although larger aircraft would be capable of tolerating relatively higher wind speeds. Wind conditions at the airport site therefore limit the times when particular runways may be selected. However, there would be a substantial proportion of the time, under low wind conditions, when the choice of runways would be determined by airport operating policy.

For the environmental assessment, the maximum and minimum likely usage for each runway and runway direction was estimated and the noise impact of each case calculated. The actual impact would then lie between these values and would depend on the operating policy which is applicable at the time.

The three airport operation scenarios were adopted for the environmental assessment, namely:

- *Airport Operation 1* shown in *Figure 1.3*. Aircraft movements would occur on the parallel runways in one specified direction (arbitrarily chosen to be the direction closest to north), unless this is not possible due to meteorological conditions. That is, take offs would occur to the north from the parallel runways and aircraft landing would approach from the south, travelling in a northerly direction. Second priority is given to operations in the other direction on the parallel runways, with operations on the cross wind runway occurring only when required because of meteorological conditions;
- *Airport Operation 2* shown in *Figure 1.4*. As for Operation 1, but with the preferred direction of movements on the parallel runways reversed, that is to the south; and
- *Airport Operation 3*. Deliberate implementation of a *noise sharing* policy under which seven percent of movements are directed to occur on the cross wind runway (equal numbers in each direction) with the remainder distributed equally between the two parallel runway directions.

Since a cross wind runway is not proposed at Badgerys Creek Option A, only Operations 1 and 2 were considered for that option.

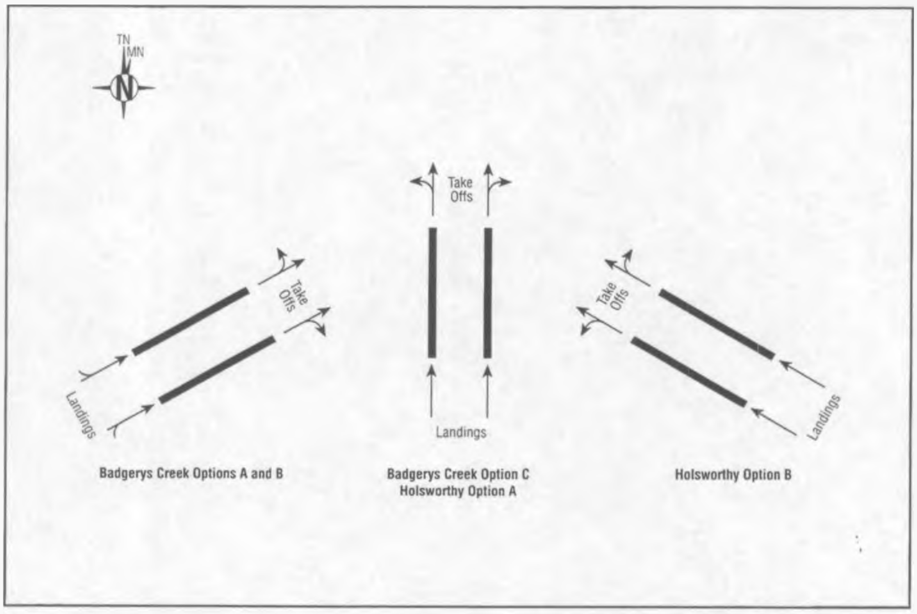


Figure 1.3

Predominant Directions of Movement of Aircraft for Airport Operation 1

Note: Cross wind runway used only when required because of meteorological conditions

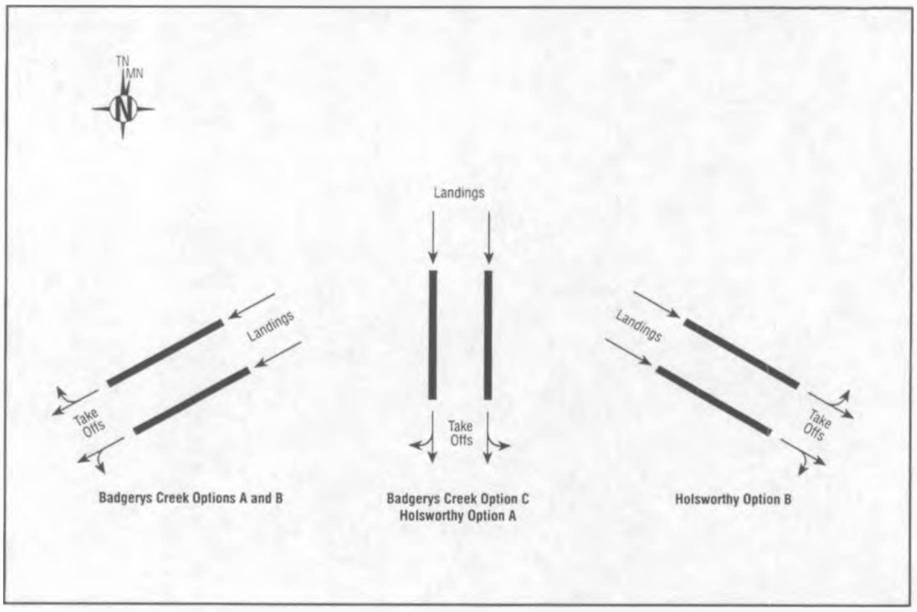


Figure 1.4

Predominant Directions of Movement of Aircraft for Airport Operation 2

Note: Cross wind runway used only when required because of meteorological conditions

Part B
Existing Noise Environment

3 EXISTING NOISE ENVIRONMENT

This chapter describes the existing noise environment surrounding and up to approximately 20 kilometres from the proposed airport sites. The existing noise environment has been monitored for the purpose of assessing noise impacts associated with the proposed Second Sydney Airport, including construction noise, ground running noise and the noise of aircraft overflights.

3.1 MEASUREMENT LOCATIONS AND TIMES

The region surrounding the proposed airport sites was split into a number of distinct areas, termed Community Assessment Areas. These were selected to reflect both the type of area, for example, semi-rural, suburban and the likely exposure to noise based on their position with respect to the proposed Second Sydney Airport sites and orientation of the runways.

The 108 Community Assessment Areas and the corresponding noise measurement locations are shown in *Figure 3.1*.

Noise measurements have been made at 137 locations within the Community Assessment Areas throughout the region from Bellambi in the south-east to Springwood in the north-west; from Tahmoor in the south-west to Kings Langley in the north-east; and from Woronora in the east to Warragamba in the west.

In general, within each Community Assessment Area a measurement point typical of the quietest location was selected by avoiding locations near major roads and industrial areas. However, in some areas where there is a distinct variation in the existing noise environment an attempt has been made to present the range of noise levels by measuring at more than one point.

The noise measurement survey was conducted over a period of approximately three months from mid October 1996 to mid January 1997, which included 15 separate monitoring periods as shown in *Table 3.1*.

TABLE 3.1 NOISE MONITORING PERIODS

Period 1	15.10.96 to 21.10.96	Period 9	27.11.96 to 2.12.96
Period 2	21.10.96 to 25.10.96	Period 10	2.12.96 to 6.12.96
Period 3	25.10.96 to 31.10.96	Period 11	6.12.96 to 12.12.96
Period 4	31.10.96 to 5.11.96	Period 12	12.12.96 to 17.12.96
Period 5	5.11.96 to 12.11.96	Period 13	17.12.96 to 21.12.96
Period 6	12.11.96 to 17.11.96	Period 14	8.1.97 to 13.1.97
Period 7	17.11.96 to 21.11.96	Period 15	13.1.97 to 20.1.97
Period 8	21.11.96 to 27.11.96		

As can be seen from *Table 3.1*, measurements were made over a period of at least five days at each location. General weather information was recorded from various meteorological stations in the areas including Lucas Heights, Bankstown, Penrith, Appin, Badgerys Creek and Tahmoor to determine whether weather conditions were suitable for measurement. For those locations and periods when the weather was considered to be intermittently unsuitable, the measurement period was increased to up to seven days. This ensured that at least three full days of non-weather affected results were obtained within each Community Assessment Area.

3.2 MEASUREMENT PROCEDURE

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

The logger determines L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels of the ambient noise. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for one percent, 10 percent and 90 percent 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_{A10} is the descriptor used to assess annoyance from typical noise sources and the L_{A90} level is normally taken as the background noise level. The L_{Aeq} level is the Equivalent Continuous Sound Level and has the same sound energy over the sampling period as the actual noise environment with its fluctuating sound levels.

3.3 MEASUREMENT RESULTS

In deciding on those periods of each day for which noise measurement results would be determined, careful consideration was given to the potential impact of noise generated by the airport and its associated operations at different times of the day. Historically the 24 hour day has been split into day, evening and night, which generally represents the working day, relaxing during the evening and sleeping at night. The historical time periods generally used are summarised as follows:

- Daytime 7.00 am - 7.00 pm;
- Evening 7.00 pm - 10.00 pm; and
- Nighttime 10.00 pm - 7.00 am.

It is clear that at both 7.00 am and 10.00 pm there is not a sudden change in the existing noise environment or people's activities. Given the current operations at Sydney Airport and its curfew on jet aircraft between 11.00 pm and 6.00 am, it is appropriate that the 6.00 am - 7.00 am period be assessed separately from the rest of the night and likewise the 10.00 pm - 11.00 pm period. These periods have therefore also been addressed separately giving

Community Assessment Area

Noise measurement location

Urban Areas (indicated by local roads)

TN MN N

0Km 10Km 20Km

Figure 3.1
Community Assessment Areas and Noise Measurement Locations

the following time periods for analysis of the existing noise environment for this study:

- Early morning 6.00 am - 7.00 am;
- Daytime 7.00 am - 7.00 pm;
- Evening 7.00 pm - 10.00 pm;
- Late evening 10.00 pm - 11.00 pm; and
- Nighttime 10.00 pm - 6.00 am and 10.00 pm - 7.00 am.

To keep the assessment relatively concise, the summary of survey results has been based on two noise descriptors; L_{Aeq} and L_{A90}. The L_{Aeq} is a measure of the average noise level and is widely used internationally to assess potential noise impact. L_{Aeq} noise levels can be predicted for future airport operations and this descriptor is therefore a useful parameter for comparing future noise levels against existing noise levels.

The L_{A90} is termed the background noise level and is the noise level exceeded for 90 percent of the time. This is an effective measure of how quiet an area can be.

For the nighttime period, the L_{A90} results are given for the standard nighttime period of 10.00 pm to 7.00 am. However, the L_{aeq} results are given for the eight hour nighttime period of 10.00 pm to 6.00 am since this period is required for calculation of the sleep disturbance index introduced later in this technical paper.

A summary of the results of the noise survey is given in *Table 3.2*. The exact location where the noise measurements within each Community Assessment Area were carried out can be seen in this table.

Since most of the Community Assessment Areas are in rural or low density population areas and the measurement location has been selected in the quieter part of each Community Assessment Area, the appropriate NSW Environment Protection Authority recommendations for comparison purposes are those for rural and residential areas. These recommendations suggest acceptable background levels (L_{A90})of 45 dBA during daytime and 35 dBA during the night.

Most background levels measured during the day were less than 40 dBA with all but one location being less then 45 dBA. During the night, most background levels were less than the recommended 35 dBA.

There are no clear recommendations for acceptable L_{Aeq} levels. It is probably more appropriate to assess these levels by comparing them with the background noise levels measured during the same period. During daytime, the L_{Aeq} levels are in general terms about 15 dBA above the background noise levels. This is fairly typical of residential areas where passing traffic (mainly road traffic) tends to elevate the L_{Aeq} above the background level. However, during the night it is anticipated that there would be less traffic to affect the L_{Aeq}. The analysis of nighttime L_{Aeq} values shows a larger spread than for daytime, but in very general terms the nighttime L_{Aeq} levels are in the vicinity of 10 dBA above the background level. This is again generally consistent with residential areas.

Overall, the whole area surveyed is typical of quiet rural and residential areas.

TABLE 3.2 NOISE MEASUREMENT RESULTS

CAA[1]	Location	Measured Noise Levels (dBA)									
		L_{Aeq}					L_{A90}				
		7 am to 7 pm	7 pm to 10 pm	10 pm to 6 am	6 am to 7 am	10 pm to 11 pm	7 am to 7 pm	7 pm to 10 pm	10 pm to 7 am	6 am to 7 am	10 pm to 11 pm
1	21 Arafura Ave, Mount Pleasant	50	50	43	46	41	32	30	26	30	28
2	231 Seventh Ave, Llandillo	49	46	46	48	43	37	36	30	37	32
3	14 Willow Road, St Marys North	49	42	42	48	37	35	36	29	36	33
4	60 Tarawa Road, Lethbridge Park	51	50	40	45	44	35	38	32	35	36
5	24 Adrienne Road, Glendenning	52	49	43	45	44	34	38	33	35	36
6	39 Birdwood Ave, Doonside	52	51	47	50	44	43	41	37	44	39
7	11 Finn Place, Maryong	48	47	41	47	42	38	37	36	42	36
8	66 Joseph Street, Blacktown	50	48	44	45	44	36	37	35	38	37
9	6 Catherine Crescent, Rooty Hill	46	43	40	40	41	36	37	30	35	35
10	58 Fuller Street, Mount Druitt	56	59	56	48	47	39	39	33	40	37
10	192 McFarlane Drive, Minchinbury	48	45	42	44	41	37	39	30	39	36
11	1 Arnold Avenue, St Marys	47	41	41	43	39	34	34	27	34	31
12	3 Loxwood Avenue, Cambridge Park	54	48	36	47	36	35	33	25	35	30
13	20 Treetops Ave, Penrith	49	46	42	43	41	34	35	28	32	36
14	18 McAuley Cres., Emu Plains	56	46	58	50	42	36	31	28	37	29
15	1209 Mulgoa Road, Mulgoa	53	44	45	49	40	36	34	26	37	28
15	5 Bulu Drive, Glenmore Park	51	42	41	47	35	33	32	27	33	29
16	18 Claremont Road, RAAF Base	46	43	41	51	45	37	35	27	45	38
17	130 Gates Road, Luddenham	50	41	42	40	34	29	31	26	29	30
17	"Roseland Lodge", Badgerys Creek	49	46	47	52	44	38	36	31	46	33
18	68 Homestead Road, Orchard Hills	44	44	40	41	43	34	36	33	37	40
19	8 Vivaldi Crescent, Claremont Meadows	53	49	47	47	41	35	37	33	39	35
19	55 Manning Street, Kingswood	53	47	39	41	39	38	37	36	38	37
20	28 Pine Creek Circuit, St Clair	51	41	44	51	35	33	31	27	34	28
21	Lot 8, Ferrer Road, Eastern Creek	57	55	53	55	52	44	38	35	42	36

TABLE 3.2 CONTINUED

CAA[1]	Location	Measured Noise Levels (dBA)									
		L_{Aeq}					L_{A90}				
		7 am to 7 pm	7 pm to 10 pm	10 pm to 6 am	6 am to 7 am	10 pm to 11 pm	7 am to 7 pm	7 pm to 10 pm	10 pm to 7 am	6 am to 7 am	10 pm to 11 pm
22	67-71 Felton Street, Horsley Park	54	50	48	55	42	42	36			
22	Lot 7 Chandos Road, Horsley Park	56	45	53	56	41	39	34	29	41	34
22	6 Hopkins Street, Wetherill Park	57	52	42	42	44	38	38	31	35	34
23	5A Evans Street, Fairfield Heights	52	47	45	49	42	38	37	30	36	37
24	15 Allambie Road, Edensor Park	53	49	45	53	46	40	39	33	38	37
25	93/108 Goodrich Road, Cecil Park	55	43	54	52	35	37	31	31	36	31
26	114 Mount Vernon Road, Mount Vernon	52	44	51	52	36	38	32	28	39	31
27	55 Clifton Avenue, Kemps Creek	52	44	46	50	39	36	34	30	35	33
28	50B Ramsay Road, Kemps Creek	46	43	38	45	37	36	34	30	38	32
28	616 Devonshire Road, Kemps Creek	49	49	46	50	44	37	37	32	44	34
29	175 Sixteenth Ave, West Hoxton	53	46	43	49	39	36	35	29	39	31
29	12 Margaret Way, Cecil Hills	53	56	57	62	49	40	42	33	43	40
30	51 Marriott Road, Bonnyrigg	51	47	43	49	41	39	39	32	41	36
31	113 McBurney Road, Cabramatta	52	46	50	52	41	38	37	32	34	36
32	62 Bungara Road, Chipping Norton	54	50	48	50	45	44	39	38	43	38
33	4 Phillis Street, Mount Pritchard	50	45	44	47	41	39	36	31	38	35
34	4 Lyndley Street, Busby	50	49	41	43	42	40	37	34	36	36
35	Lot 56, First Ave, Hoxton Park	52	45	42	49	37	36	34	29	35	29
36	275 Twelfth Avenue, Austral	49	44	44	48	41	37	36	35	39	35
37	27 Emmetts Farm Road, Rossmore	48	43	40	46	38	34	33	29	37	30
38	61 Kelvin Park Road, Bringelly	48	44	43	46	36	36	35	34	39	35
38	Lot 3, Lawson Road, Badgerys Creek	53	47	47	48	39	38	32	28	38	30
39	43 Blaxland Ave, Luddenham	56	45	52	56	37	41	35	28	43	30
39	38 Greendale Road, Wallacia	55	54	48	54	50	37	35	30	38	32
40	27 Third Street, Warragamba	44	43	37	42	35	33	32	30	32	31
40	112 Ridgehaven Road, Silverdale	47	45	43	46	41	38	37	36	38	36

TABLE 3.2 CONTINUED

CAA[1]	Location	Measured Noise Levels (dBA)									
		L_{Aeq}					L_{A90}				
		7 am to 7 pm	7 pm to 10 pm	10 pm to 6 am	6 am to 7 am	10 pm to 11 pm	7 am to 7 pm	7 pm to 10 pm	10 pm to 7 am	6 am to 7 am	10 pm to 11 pm
41	9 Barrington Drive, Silverdale	41	39	39	39	38	30	34	31	30	32
42	495 Wolstenholme Ave, Greendale	49	43	43	46	34	31	33	27	31	29
42	Lot 10, Greendale Road, Greendale	48	51	46	50	46	35	41	28	38	39
43	15 Colonel Pye Drive, Cobbitty	51	45	47	48	44	33	39	28	33	36
44	438 Catherine Fields Rd, Catherine Field	48	48	43	46	46	34	37	31	35	40
44	72 Robinson Road, Bringelly	52	49	48	53	42	39	38	33	42	36
45	18 Phillip Road, Leppington	49	40	47	50	35	35	32	28	34	30
46	75 Jardine Drive, Edmondson Park	51	45	43	47	38	36	38	29	37	35
46	10 Blaxland Rd, Ingleburn Military Camp	49	40	42	47	33	36	33	29	37	29
47	92 Skipton Lane, Prestons	51	51	47	51	44	38	42	37	39	41
48	39 Gill Avenue, Liverpool	54	47	44	47	39	37	35	29	36	34
48	8 Roberts Road, Casula	52	44	43	48	40	40	34	34	41	34
49	15 Murray Court, Wattle Grove	51	49	45	48	47	43	41	33	38	38
49	11 Curtis Crescent, Moorebank	52	46	44	50	40	38	34	31	47	33
49	46 Market Street, Moorebank	50	48	45	48	42	40	36	33	39	35
50	69 Raleigh Road, Milperra	54	46	38	45	42	38	37	31	38	33
51	69 Ardath Avenue, Panania	56	47	48	51	37	39	32	28	39	30
52	East Hills Barracks, Voyager Point	50	45	43	46	42	37	36	32	38	33
52	32 Riverview Rd, Pleasure Point	51	46	42	45	40	40	34	26	40	33
52	84 George Crescent, Sandy Point	48	44	40	45	39	37	36	30	40	35
53	43 Stewart Street, Hammondville	54	47	46	49	42	40	39	36	40	37
53	21 Fitzgerald Ave, Hammondville	54	51	48	51	46	45	41	32	42	38
54	Illawarra Road, Holsworthy Barracks	46	41	40	44	38	35	30	30	34	30
55	13 Hyde Park Court, Wattle Grove	58	42	40	46	35	33	31	26	33	28
55	33 Salamaua Cres. Holsworthy	51	46	43	50	42	41	38	36	42	37
55	29 Birdwood Avenue, Holsworthy	52	44	46	50	42	39	36	30	36	33

TABLE 3.2 CONTINUED

CAA[1]	Location	Measured Noise Levels (dBA)									
		LAeq					LA90				
		7 am to 7 pm	7 pm to 10 pm	10 pm to 6 am	6 am to 7 am	10 pm to 11 pm	7 am to 7 pm	7 pm to 10 pm	10 pm to 7 am	6 am to 7 am	10 pm to 11 pm
56	School of Military Engineering	49	45	46	48	47	40	36	34	38	37
57	98 Belmont Road, Glenfield	50	45	43	47	40	35	35	32	37	34
58	28 Mimmulos Place, Macquarie Fields	48	42	40	43	39	33	26	23	32	25
59	12 Kingdon Pde, Long Point	46	38	37	43	34	30	27	26	30	27
60	22 Maserati Drive, Ingleburn	54	46	51	52	43	44	37	28	46	35
61	15 St James Road, Varroville	47	46	38	46	44	34	40	31	37	35
62	220 Chittick Lane, Cobbitty	51	40	45	47	39	34	33	28	36	35
63	176 Terry Road, Theresa Park	46	44	36	41	34	31	32	31	32	33
64	75 Pine Ridge Crescent, Weromba	45	47	38	43	38	32	37	31	32	36
65	110 Eagle Creek Road, Weromba	47	43	42	44	38	33	38	31	34	36
66	70 Silverwood Road, Brownlow Hill	43	41	36	44	38	32	33	31	34	31
67	9 William Avenue, Camden	53	46	46	49	40	38	36	30	37	36
67	309 Ellis Lane, Camden	54	40	48	49	31	36	29	27	38	28
68	68 Valley View Drive, Narellan	47	43	36	42	38	39	37	34	36	35
68	16 Charles Place, Mount Annan	44	40	33	38	37	31	29	26	29	30
69	4 Gladiator Street, Raby	50	46	39	42	37	35	37	29	32	32
70	49 Chardonnay Ave, Eschol Park	47	47	40	37	38	33	34	31	32	33
71	21 Rutherglenn Drive, St Andrews	50	48	46	52	49	38	43	40	48	45
72	82 Gurnsey Ave, Minto	56	47	45	50	41	42	34	29	41	31
73	13 Morton Road, Minto Heights	45	40	38	43	33	34	29	28	34	28
74	79 Old Kent Road, Kentlyn	46	40	44	48	35	34	30	26	33	30
75	19 Taburie Street, Lumeah	46	40	41	46	35	36	31	26	35	30
75	15 Kelburn Place, Airds	49	42	42	48	39	34	31	23	33	27
75	64 Palmer Cres. St Helens Park	51	48	42	48	41	39	39	36	41	38
76	72 Queenscliff Drive, Woodbine	49	42	40	43	37	38	36	30	37	33
77	13 Gidley Crescent, Claymore	57	55	47	46	49	42	45	36	41	41

TABLE 3.2 CONTINUED

CAA[1]	Location	Measured Noise Levels (dBA)									
		LAeq					LA90				
		7 am to 7 pm	7 pm to 10 pm	10 pm to 6 am	6 am to 7 am	10 pm to 11 pm	7 am to 7 pm	7 pm to 10 pm	10 pm to 7 am	6 am to 7 am	10 pm to 11 pm
78	91 Cummins Road, Menangle Park	48	41	44	45	39	35	32	28	35	30
79	27 Phelps Crescent, Bradbury	51	47	43	49	41	41	37	31	44	35
80	25 Trotwood Avenue, Ambarvale	55	49	47	49	44	42	42	34	41	37
81	31 Amberfoyle Road, Wedderburn	45	41	35	44	40	30	33	30	32	34
81	104 Katanna Road, Wedderburn	46	40	35	45	36	31	30	26	34	32
82	Holsworthy Military Area	No measurement taken									
83	14 Caley Place, Lucas Heights	48	39	38	43	29	33	28	26	34	26
83	41 Thomas Mitchell Dr, Lucas Heights	55	50	43	43	33	34	31	31	33	31
83	33 Barnes Cres. Menai	52	45	41	47	34	35	31	30	35	30
84	50 Scarborough Street, Bundeena	52	51	45	48	46	37	35	32	36	31
85	3 McKell Avenue, Waterfall	51	42	46	49	41	37	31	28	35	30
86	23 Chullora Crescent, Engadine	52	42	45	53	39	41	36	39	43	36
87	1239 Princes Highway, Engadine	50	47	46	51	41	40	36	28	40	32
87	23 Abbott Road, Heathcote	49	42	44	50	34	35	32	28	35	28
88	55 Yanagang Road, Waterfall	46	41	38	39	38	30	33	29	31	31
89	Garrawarra Centre for the Aged	51	48	45	49	45	42	38	36	40	38
90	16 Plateau Road, Stanwell Tops	43	38	37	42	30	32	28	26	32	27
90	1A Walker Street, Helensburgh	54	39	39	47	32	33	27	27	35	27
91	280 Appin Road, Appin	47	46	44	50	46	36	35	33	42	36
92	9 King Street, Appin	48	44	40	46	42	38	38	31	40	37
93	Mount Gilead, Appin Road	49	46	43	50	41	36	33	32	37	31
94	120 Quirkes Lane, Camden	43	41	38	40	39	29	27	27	30	25
95	35 Durham Street, Douglas Park	50	45	42	47	40	40	34	28	35	33
96	225 Calf Farm Road, Mount Hunter	42	42	43	43	42	29	32	29	30	40

TABLE 3.2 CONTINUED

CAA[1]	Location	Measured Noise Levels (dBA)									
		L_{Aeq}					L_{A90}				
		7 am to 7 pm	7 pm to 10 pm	10 pm to 6 am	6 am to 7 am	10 pm to 11 pm	7 am to 7 pm	7 pm to 10 pm	10 pm to 7 am	6 am to 7 am	10 pm to 11 pm
97	184 Glendiver Road, The Oaks	42	38	35	39	31	30	30	27	31	30
98	28 William Street, The Oaks	57	51	56	55	45	39	35	28	41	28
99	63 Rita Street, Thirlmere	47	40	41	46	38	34	28	28	33	29
100	1 Camden Street, Wilton	50	42	41	43	34	34	29	26	32	28
101	7 Antill Street, Picton	43	39	36	39	30	32	29	27	32	27
102	31 Progress Street, Tahmoor	47	45	44	45	35	35	33	33	36	33
103	84 Darkes Forest Road, Darkes Forest	49	35	41	49	32	34	27	27	32	27
104	14 Cliff Street, Coledale	59	54	51	51	50	45	46	44	45	45
105	8 Stanhope Street, Woonona	54	46	47	51	40	43	36	36	41	36
106	63 Russell Street, Balgownie	47	45	44	45	35	35	33	33	36	33
107	63 Norton Avenue, Springwood	41	39	37	41	28	29	27	25	29	26
108	36 Ravine Avenue, Blaxland	44	44	39	45	38	34	32	28	37	31

Note: 1. Community Assessment Area (refer *Figure 3.1*).

Part C

Aircraft Overflight Noise

4 METHODOLOGY TO ASSESS AIRCRAFT OVERFLIGHT NOISE

This chapter discusses the methodology for determining the impact of aircraft overflight noise from each of the five airport options.

4.1 SYDNEY AIRPORT THIRD RUNWAY EXPERIENCE

In November 1994, the Third Runway at Sydney Airport was officially opened. Following this, there was a significant amount of community reaction and protests about the impacts of noise resulting from the opening.

In March 1995, the Senate Select Committee on Aircraft Noise in Sydney was established to inquire into a number of issues associated with the noise impact at Sydney Airport and discrepancies between predicted and actual noise impact. This Committee issued a report (Senate Select Committee on Aircraft Noise, 1995) in November 1995 which identified several issues of concern arising from the *Proposed Third Runway at Sydney (Kingsford Smith) Airport Draft Environmental Impact Statement* (Kinhill, 1990). These issues included:

- inadequate attention given to potential impacts on residential areas affected by low or moderate levels of aircraft noise;
- incorrect predictions of the level of use of each of the runways; and
- insufficient emphasis on the greater reaction to aircraft noise of those communities which would be newly affected, compared with those communities which were previously affected by aircraft noise.

The principle which formed the basis of the decision to approve the third runway was questioned by the Committee. The principle assumed that the impacts of noise should be concentrated over fewer people. That principle has been reassessed by the present Commonwealth Government which has recently been investigating ways of sharing the noise across larger areas of Sydney. Details of its current policy on noise sharing at Sydney Airport are included in the *Sydney Airport Long Term Operating Plan - Proponents Statement* (Department of Transport and Regional Development, 1997) which has been released to the public.

The noise assessment reported in this Technical Paper for the proposed Second Sydney Airport is different from the assessment carried out for the third runway at Sydney Airport. The objective of this assessment is to establish a much clearer understanding of the potential effects of aircraft noise and more accurately and fully quantify the degree of impact.

4.2 NOISE AND NOISE LEVELS

Most noise in the community is measured in decibels (dB). The ear responds to pressure fluctuations in the air and the pressure fluctuations detected by the ear range from approximately 0.00002 pascals to approximately 600 pascals, a large range that is difficult to use in practical situations. For this reason, the decibel scale was introduced relying on a logarithmic function. It is an unusual scale whereby noise levels do not appear to relate to the loudness of a noise. For example, if a noise is increased by 10 dB, say from 60 dB to 70 dB, then the noise appears to be approximately twice as loud. Equally, two noise sources each of which generates a noise level of 60 dB at a particular point do not result in a total level of 120 dB, but a total level of 63 dB.

Because the ear responds to different tones of noise (frequencies) in different ways, the A-weighted decibel (dBA) has been developed. The dBA measure gives a close mathematical representation to the perceived loudness of any noise. Some typical noise levels are shown in *Figure 4.1*. Since the noise level generally falls off with increasing distance from any noise source, the figure also shows a distance from the noise source at which the particular level would be heard.

The dBA scale is suited to the measurement of steady (non-varying) noise. However, most noise environments within the community involve noise levels which continuously vary in response to the changing situation within the environment, such as motor vehicles passing, aircraft flying overhead, people talking and wind in the trees. For this reason, noise descriptors have been developed to allow interpretation of such typical noise environments. These generally involve statistical descriptors for continuously varying noise environments and noise energy based descriptors, particularly for noise environments involving intermittent noise events.

4.3 AIRCRAFT OVERFLIGHT NOISE DESCRIPTORS

Environments around airports which are affected by aircraft noise experience a series of relatively high noise levels generated as aircraft fly overhead, separated by significant periods of lower ambient noise levels. Suitable aircraft noise descriptors therefore need to take into account this specific noise environment.

In Australia, aircraft noise impact is mostly measured using the Australian Noise Exposure Concept (ANEC) or Forecast (ANEF) measure. Whilst this measure has been used for the assessment of the five options for the Second Sydney Airport, the L_{Aeq} level and the maximum noise levels from individual events have also been used.

4.3.1 ANEC AND L_{AEQ}

ANEC levels are commonly applied to potential future airports or airport operations, with the word *concept* referring to the levels of noise exposure which would occur if particular future scenarios eventuated. The measure is

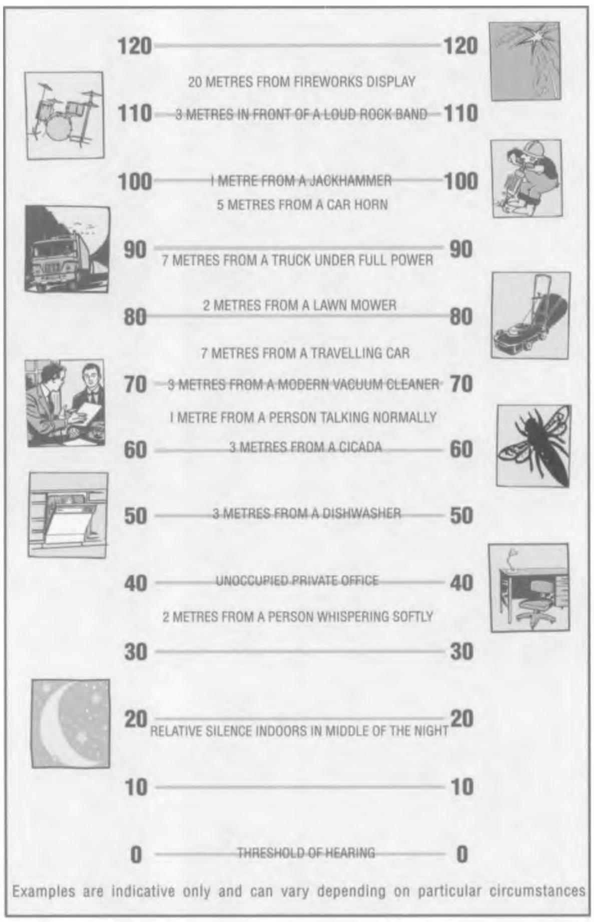


Figure 4.1

Typical Noise Levels [dBA]

more widely known as ANEF (Australian Noise Exposure Forecast) which is formulated in the same way, but which relates to forecast future airport operations. In addition, ANEI (Australian Noise Exposure Index) is used to describe historical situations, such as the noise impact that occurred during the 1996 calendar year. The discussion in this Technical Paper refers to the word *concept* and *ANEC* to avoid confusion, except where there is a specific need to differentiate between concept, forecast and index.

The Noise Exposure Concept (NEC) system was first developed by the Federal Aviation Administration in the United States of America. The descriptor is a measure of total noise exposure which is calculated from the noise level of each type of aircraft movement, the number of such movements, the tonal quality of the noise and the duration of the noise during each movement. In addition, a 10 dB weighting factor (penalty) is applied to the nighttime period between 10.00 pm and 7.00 am to account for the increased sensitivity to noise during this nighttime period. Taking into account the different duration of the daytime and night time periods, this weighting amounts to considering each night time aircraft movement as equivalent to 16.7 daytime movements.

In 1992, the National Acoustic Laboratories published a report giving the results of a survey of community reaction to aircraft noise within Australia (Hede and Bullen, 1982). This report found that Australians were more sensitive to aircraft noise during the evening period (7.00 pm - 10.00 pm) than during the daytime and that their sensitivity to noise during the nighttime period was not as great as was assumed in the NEC formulation. Accordingly, the formulation was modified for Australia resulting in ANEC.

ANEC is the same as NEC, excepting that, instead of the original nighttime weighting factor, a 6 dB evening and nighttime (7.00 pm - 7.00 am) weighting factor is applied, effectively making one evening nighttime movement equivalent to approximately four daytime movements.

To determine ANEC, noise levels are measured using the Effective Perceived Noise Level (EPNL), the units of EPNL being EPNdB. The ANEC formulation is as follows:

$$\text{ANEC} = 10\log\left\{\sum_{i,j}\left(N_{i,j}+4N^{1}_{i,j}\right)10^{EPNL_{i,j}/10}\right\}-88$$

Where:

- $EPNL_{i,j}$ is the energy-mean value of EPNL for aircraft of type i performing operation j;
- N_{ij} is the average number of such aircraft operating per day during the times 7.00 am to 7.00 pm; and
- N^1_{ij} is the average number operating between 7.00 pm and 7.00 am.

In accordance with Environment Australia guidelines, aircraft noise exposure has also been determined in this Technical Paper using the L_{Aeq} descriptor. L_{Aeq} is the Equivalent Continuous Sound Level and is a measure of the steady continuous noise which contains the same sound energy over the measurement period as the varying noise environment in question. It is measured in dBA.

At individual locations, L_{Aeq} noise levels are calculated separately for various time periods. These time periods are 24 hours and 10.00 pm to 6.00 am.

4.3.2 MAXIMUM NOISE LEVELS

Another useful way of describing aircraft noise is to refer to the maximum noise level of the particular aircraft overflight. This is the highest level that occurs as the aircraft flies over and it is commonly measured in dBA.

High maximum noise levels from aircraft flying low over residential communities can cause a number of impacts including disruption to normal conversation, interference with television viewing, general annoyance or disturbance to sleep during nighttime. Knowledge of the maximum noise levels that might occur in particular communities and the number of times these levels might occur will allow estimates of conversation and sleep interference to be made.

In this Technical Paper, areas around each airport option have been divided into a number of Community Assessment Areas and the maximum noise levels from the expected aircraft movements over each area have been estimated. The number of maximum noise level events exceeding 60 dBA, 70 dBA, 80 dBA and 90 dBA has been estimated. These numbers have been estimated separately for a typical 24 hour period and for the nighttime period (in this case defined as eight hours from 10.00 pm to 6.00 am). In addition, the number of maximum noise level events exceeding 65 dBA has been estimated for the core school period of 9.00 am to 3.00 pm.

4.4 AIR TRAFFIC FORECASTS

Aircraft noise levels have been calculated for each airport option for two key years; 2006 and 2016. Although the time for the opening of the airport is not known, 2006 has been taken to represent a time not long after opening of the airport when only one of the parallel runways would be constructed and in operation. The year 2016 represents a point where both parallel runways would be in operation as well as the cross wind runway (where appropriate) and the airport would be carrying a substantial amount of air traffic.

The role of the Second Sydney Airport in satisfying the overall airport needs within the Sydney basin has not been determined as part of the brief for this study. Hence, three possible scenarios are considered for the role of the airport, namely:

- *Air Traffic Forecast 1* where the Second Sydney Airport would provide only for demand which cannot be met by Sydney Airport;
- *Air Traffic Forecast 2* where the Second Sydney Airport would be developed to cater for 10 million passengers per annum by 2006, with

all further growth after this time being directed to the Second Airport rather than Sydney Airport; and

- *Air Traffic Forecast 3* which would be similar to Air Traffic Forecast 2, but with more international flights being directed to the Second Sydney Airport. This would also result in the larger and relatively noisy aircraft being directed to the Second Sydney Airport.

Air traffic movement forecasts for each of these cases were provided by the Second Sydney Airport Planners (1997a and 1997b), as shown in *Table 4.1*. The first column in this table shows the forecast (as discussed above) and the year (either 2006 or 2016).

The breakdown of these forecasts by aircraft type is shown in *Table 4.2*. Aircraft are grouped by the code designation used in the INM computer model which was used for noise prediction. In some cases, similar aircraft types have been grouped under a single code and the description provided relates to the most common aircraft type in the group.

TABLE 4.1 RANGE OF AIR TRAFFIC FORECASTS AT SECOND SYDNEY AIRPORT

Forecast/	International Movements		Domestic Movements		Total Movements
Year	Day	Night	Day	Night	Day and Night
1-2006	7,840	2,626	38,035	14,788	63,289
1-2016	32,009	10,723	105,669	36,179	184,580
2-2006	16,129	5,453	71,688	23,906	117,073
2-2016	39,344	13,092	136,128	43,872	232,436
3-2006	45,079	15,068	52,284	17,911	130,225
3-2016	65,300	21,663	119,303	38,489	244,730

Source: Second Sydney Airport Planners, 1997a.

TABLE 4.2 FORECASTS OF AIRCRAFT MOVEMENTS PER YEAR BY AIRCRAFT TYPE

INM	Description	Forecast/Year					
Code		1	1	2	2	3	3
		2006	2016	2006	2016	2006	2016
707320	Boeing Stratolifter 717	4	6	4	7	6	8
737300	Boeing 737-300	7,924	27,250	16,497	35,731	12,314	31,349
737400	Boeing 737-400	4,450	16,583	9,286	21,706	7,392	19,490
74720A	Boeing 747-100/ 200/300	2,626	8,893	5,432	10,903	15,078	17,926
747400	Boeing 747-400	2,977	13,374	6,261	16,563	16,855	26,074
747SP	Boeing 747SP-B5	197	133	402	188	1,126	287
757RR	Boeing 757-2T7	105	326	218	403	571	639
767CF6	Boeing 767-238ER	7,058	23,147	14,664	29,465	19,124	32,791
A300	Airbus A300	1,551	5,054	3,233	6,601	2,766	6,042
A310	Airbus A310-324	278	956	584	1,239	601	1,252
A320	Airbus A320-210	2,324	9,770	4,848	12,829	3,377	11,055
A7D	Aermacchi MB326	5	8	5	8	5	8
B747+	New Large Aircraft	1,578	9,967	3,134	12,294	8,950	20,260
BAE146	BAE146-200 F28-400	221	624	466	818	325	705

TABLE 4.2 CONTINUED

INM Code	Description	Forecast/Year					
		1 2006	1 2016	2 2006	2 2016	3 2006	3 2016
BAE300	BAE 146-300A	1,088	3,026	2,296	3,972	1,578	3,411
BEC58P	Piper PA-31	5,625	6,229	5,487	6,079	5,487	6,084
C130	C130 Hercules	23	25	23	25	23	25
CIT3	Cessna CIT3	17	49	28	58	66	92
CL600	CL600-1A11 NL60	115	151	126	160	153	186
CL601	CL-601 Challenger	1	2	2	2	2	3
CNA441	Rockwell 690-A	473	550	473	523	473	523
CNA500	Cessna 500	57	61	57	61	57	61
CONCRD	Concord		3	3	4	3	5
DC1010	Douglas DC10-10	194	786	399	761	1,060	1,661
DC3	Douglas DC-3	17	18	17	18	17	18
DC6	Douglas DC-4	5	6	6	7	6	6
DC870	Airbus A340	118	933	431	1,179	565	1,175
DHC6	BAe31	7,296	19,867	15,147	26,195	10,518	22,544
DHC8	De Haviland HC8	3,906	10,972	8,239	14,407	5,666	12,369
DHC830	Fokker F50	1,360	3,828	2,872	5,026	1,975	4,315
GASEPF	Piper PA-28	158	176	160	176	160	177
GASEPV	Beech 36	225	245	227	245	227	247
GIV	Dissault Falcon 900	449	649	566	672	621	723
HEL	Generic Helicopter	1,743	1,932	1,743	1,933	1,743	1,933
L1011	Lockheed 1011-1		2	2	2	2	4
L188	P3-Orion	3	3	3	3	3	3
LEAR35	Swearlngen SA227	2,682	2,788	2,308	2,606	2,373	2,671
MD11GE	McDonnell MD-11	242	1,910	507	2,516	664	2,498
MU3001	Cessna C 550	55	60	55	60	55	60
SF340	Saab SF340A	6,139	14,218	10,965	16,993	8,355	16,078

Source: Second Sydney Airport Planners, 1997a.

To allocate the forecast aircraft movements to individual flight paths, it is necessary to know the direction of origin or destination of aircraft movements to and from the airport. This information is provided in *Table 4.3*.

Further, for noise calculation purposes, the stage length (distance of first leg of flight) of each take off is required so that the rate of climb of the aircraft can be estimated. This information is provided in *Table 4.4*.

TABLE 4.3 PERCENTAGE OF AIRCRAFT MOVEMENTS BY ORIGIN/DESTINATION[1]

Forecast/ Year	Sector of Origin or Destination				
	East	North	North-West	South[2]	West
1-2006	6.5%	33.4%	12.5%	27.9%	19.8%
1-2016	8.7%	32.0%	11.5%	28.5%	19.3%
2-2006	7.0%	33.8%	11.2%	29.4%	18.6%
2-2016	8.5%	32.8%	10.9%	29.1%	18.7%
3-2006	17.0%	24.6%	15.5%	22.9%	20.1%
3-2016	13.0%	28.4%	13.0%	25.8%	19.8%

Source: Second Sydney Airport Planners, 1997a.

Note:
1. Percentages may not add to 100 due to rounding.
2. A small number of movements designated as the south-west sector in the Second Sydney Airport Planners files were re-designated as south.

TABLE 4.4 PERCENTAGE OF AIRCRAFT MOVEMENTS BY STAGE LENGTH

Forecast/Year	Stage Length						
	1	2	3	4	5	6	7
International							
1-2006	3.2%	1.2%	3.9%	1.3%	1.6%	3.6%	1.7%
1-2016	4.5%	1.7%	5.5%	1.7%	2.1%	5.1%	2.5%
2-2006	3.6%	1.5%	4.7%	1.4%	2.0%	3.8%	1.5%
2-2016	4.4%	1.6%	5.3%	1.8%	2.1%	5.1%	2.4%
3-2006	8.9%	3.8%	11.7%	3.5%	5.3%	9.1%	3.8%
3-2016	6.9%	2.6%	8.4%	2.7%	3.4%	7.9%	3.7%
Domestic							
1-2006	73.7%	5.5%	2.1%	2.2%	0.0%	0.0%	0.0%
1-2016	65.2%	6.3%	2.5%	2.8%	0.0%	0.0%	0.0%
2-2006	71.3%	5.6%	2.2%	2.5%	0.0%	0.0%	0.0%
2-2016	65.8%	6.2%	2.5%	2.9%	0.0%	0.0%	0.0%
3-2006	47.4%	3.6%	1.4%	1.5%	0.0%	0.0%	0.0%
3-2016	54.9%	5.1%	2.1%	2.4%	0.0%	0.0%	0.0%

Source: Second Sydney Airport Planners, 1997a.

4.5 AIRPORT OPERATION

At any airport, aircraft operations are allocated to runways (which implies both the physical runway and the direction in which it is used) according to a combination of wind conditions and airport operating policy. The allocation is normally performed by air traffic control personnel.

Standard airport operating procedures (Airservices Australia, 1997) indicate that a runway may not be selected for either approach or departure if the wind has a downwind component greater than five knots or a cross wind component greater than 25 knots. If the runway is wet, it should not be selected if there is any downwind component. This applies to all aircraft types, although larger aircraft would be capable of tolerating higher wind speeds. Wind conditions at the airport site therefore limit the times when particular runways may be selected. However, there would be a substantial proportion of the time, under low wind conditions, when the choice of runways would be determined by airport operating policy.

In practice, an airport operating policy is determined for an airport and this requires the use of particular runways and runway directions where, given wind conditions, these are available for use. At other times when they are not available for use, then alternative runways and runway directions are used, consistent with wind conditions. For parallel runways with a cross wind runway, the operating policy normally requires use of the parallel runways with landing and take off operations in one preferred direction. Under wind conditions when this operating procedure is not available, then the first alternative is to use the parallel runways with landing and take off operations in the opposite direction. When neither of these operating procedures are available, then the cross wind runway is used.

The approach used in this analysis is to estimate the maximum and minimum likely usage for each runway and runway direction and to calculate noise impact in each case. The actual impact would then lie between these values and would depend on the operating policy which is applied at the time.

The three airport operation scenarios modelled are as follows:

- *Airport Operation 1.* Aircraft movements would occur on the parallel runway in one specified direction (arbitrarily chosen to be the direction closest to north), unless this is impossible due to meteorological conditions. That is, take offs would occur to the north from the parallel runways and aircraft landing would approach from the south, travelling in a northerly direction. Second priority is given to operations in the other direction on the parallel runways, with operations on the cross wind runway occurring only when required because of meteorological conditions;
- *Airport Operation 2.* As for Operation 1, but with the preferred direction of movements on the parallel runways reversed, that is, to the south; and
- *Airport Operation 3.* Deliberate implementation of a 'noise sharing' policy under which seven percent of movements are directed to occur on the cross wind runway (with equal numbers in each direction) with the remainder distributed equally between the two parallel runway directions.

The three airport operation scenarios are shown in *Figures 1.3* and *1.4* in *Chapter 1*.

For Badgerys Creek Option A and for all airports in the year 2006, only Operations 1 and 2 are considered, as there would be no cross wind runway.

For Operations 1 and 2, data on wind speed and direction, and rainfall for the airport sites are used to determine the proportion of time when aircraft could operate on the parallel runways in one specified direction. If this direction is not possible, movements are assumed to occur in the opposite direction on the parallel runways, and if this is also not possible due to a high cross wind component, use of the cross wind runway is assumed (if it exists).

For Operation 3, it is assumed that movements on the cross wind runway are deliberately increased through airport operating policy. In this case, the maximum usage of the cross wind runway is determined not by wind conditions but by the capacity of the single, short runway. Information from Airservices Australia indicates that at most approximately seven percent of all movements could be directed to the cross wind runway without severe impacts on airport capacity. Hence, for Operation 3, seven percent of all movements are assumed to occur on the cross wind runway, with equal distribution in each direction. In this scenario, movements on the parallel runways are also assumed to be equally distributed in each direction.

From the above discussion, airport usage has been modelled to occur in at most four modes. At any time, all operations are assumed to occur in one of the four possible runway directions. In practice, it is likely that other operating modes would be used. For example, at certain times it may be possible for departures to occur on one parallel runway and arrivals in the opposite direction on the other runway. In addition, light aircraft may be able to operate on the cross wind runway while larger aircraft use the parallel runways. Modelling of such complex usage patterns is not possible within the scope of this analysis. However, it is likely that these alternative operating modes would be introduced at least in part as noise abatement measures. Hence, once again the present analysis provides a conservative indication of the likely level of noise impact. This impact could then be reduced through fine tuning the airport operating conditions.

The remainder of this section describes the procedures used to calculate maximum and minimum runway allocations under Airport Operations 1 and 2 using available wind and rainfall data.

Having established the maximum and minimum runway use, the allocation of aircraft take off and landing movements to individual flight paths is required to allow the noise calculation to proceed.

4.5.1 METEOROLOGICAL DATA

Meteorological data relevant to the proposed airport sites and recommendations for its use, were supplied by Macquarie Research and are described in *Technical Paper No. 5*. In view of the limited meteorological data available, best estimates have been made of the most appropriate data and its use.

For the Badgerys Creek site, two years of wind data are available from Macquarie University, covering the period 1 April 1990 to 31 March 1992. The data are in the form of hourly average wind speed and direction. Rainfall data for this period were taken from three separate sources, in order of priority:

- Australian Water Technology's West Hoxton monitoring station;
- Australian Water Technology's Warragamba Dam station; and

- Bankstown Airport.

The first two data sets consist of two minute rainfall data. Where any rain was recorded in a given hour, this information was added to the wind data file. However, these data sets include large sections of missing data, and for these periods Bankstown Airport data were used. The Bankstown Airport data give only total rainfall since the last measurement, recorded daily at 0600, 0800, 1200 and 1500 hours eastern standard time. Where rainfall was recorded, it was therefore necessary to estimate the period of the rainfall and record this in the appropriate hours in the wind data file.

For the Holsworthy airport options, 15 minute average wind speed, wind direction and rainfall data are available from a monitoring station at Lucas Heights, for the period 19 October 1992 to 31 October 1996. Wind speeds were recorded at two heights, 10 metres and 49 metres. On advice from Macquarie Research, data recorded at 10 metres were used for modelling runway allocations at both the Holsworthy A and B airport options. However, the terrain near the monitoring station is relatively rough, and resulting wind speeds are expected to be lower than would be recorded at a cleared airport site. Macquarie Research has advised that for these sites the recorded wind speeds should be increased by 20 percent to account for this effect.

Both the above meteorological datasets contain missing data. The proportion of missing data is summarised in *Table 4.5* by month. The Badgerys Creek dataset contains a large proportion of missing data, particularly for the months of December and January. The Holsworthy dataset has fewer missing data, with the exception of a relatively large 'hole' in October. The dataset was extended to cover a period slightly over four years in order to include more data for October.

TABLE 4.5 PERCENTAGE OF METEOROLOGICAL DATA MISSING

Month	Percentage of Data Missing	
	Badgerys Creek	Holsworthy
January	54.4%	4.8%
February	0.0%	0.0%
March	2.8%	7.8%
April	0.0%	7.2%
May	0.0%	12.4%
June	0.0%	6.2%
July	29.5%	0.0%
August	12.2%	0.1%
September	35.8%	0.0%
October	0.0%	29.1%
November	0.6%	7.8%
December	41.7%	8.8%

4.5.2 MODELLING OF RUNWAY ALLOCATION

Runway allocations for each airport were calculated for Airport Operations 1 and 2, based on the above meteorological data sets. The following procedure was used:

- calculate the "preferred" runway direction (as close as possible to north for Operation 1; as close as possible to south for Operation 2), based on the orientation of the parallel runways for the airport in question;
- for each time in the meteorological data set, calculate the tailwind and crosswind components in the preferred direction, from the wind speed and direction;
- operation in the preferred direction is considered possible if the tailwind is less than five knots and the crosswind less than 25 knots, unless rain was recorded in the time period, in which case operation is possible only if the tailwind is less than 0.5 knots;
- if operation in the preferred direction is not possible, the opposite direction is allocated, unless this is also not possible. In this case, the cross wind runway is allocated (if it exists for the airport configuration considered). In such cases, the direction in which the cross wind runway is used will always be determined by the wind;
- one additional feature of the model is a 'time lag' for switching back to the preferred runway. If operations are allocated to a non-preferred runway, and allocation to the preferred runway then becomes possible, the preferred runway is not allocated immediately (assuming that operation on the non-preferred runway also remains possible). Allocation remains on the non-preferred runway for a time period which was set at one hour, before switching to the preferred runway. This models actual airport usage, in that controllers do not change runway allocations until they have some confidence that weather conditions will allow the new allocation to remain for a reasonable period of time; and
- in rare instances of very high wind, no runway may be able to be allocated. In these cases the airport is designated as unusable.

Results of the above analysis were recorded as a time series, allowing analysis of runway allocations by month, time of day and other variables.

As indicated in *Section 4.5.1* the available wind data included average wind speeds as opposed to maximum speeds or gust speeds. Accordingly, the runway allocations were based on average wind speeds rather than gusts which are often used by air traffic controllers at airports. Notwithstanding this, the validation of the runway allocation model discussed below indicates that use of average speeds in the model results in relatively accurate estimates of runway use. In any event, information regarding wind gusts was not available for an alternative analysis based on gusts.

4.5.3 VALIDATION OF RUNWAY ALLOCATION MODEL

The above procedure was validated using data from Sydney Airport covering the period May 1995 to November 1996. Half hour average wind speed and direction and rainfall data, recorded at the airport were available for this period. The model described above was used to predict maximum and minimum possible usage of the parallel runways in the southerly direction. The minimum possible usage should correspond to the actual usage under the airport operating policy applying at the time. The minimum possible usage indicates the usage that must apply as a result of meteorological conditions, irrespective of the operating policy which requires a preference for operations to the south.

Calculations were performed with various values for the 'time lag' before changing to the preferred runway, as described above. *Figure 4.2* shows the calculated maximum and minimum possible usage of the parallel runways in the northerly direction (heading 340°).

Figure 4.2 also shows actual usage of the northerly direction at Sydney Airport over the period May 1995 to March 1996. During this period, operational procedures at the airport corresponded closely with the assumptions using in modelling - first priority was given to operations in the southerly direction, second to the northerly direction, and the cross wind runway was used only when required due to meteorological conditions. (usage during this period was in fact 1.5 percent of all movements).

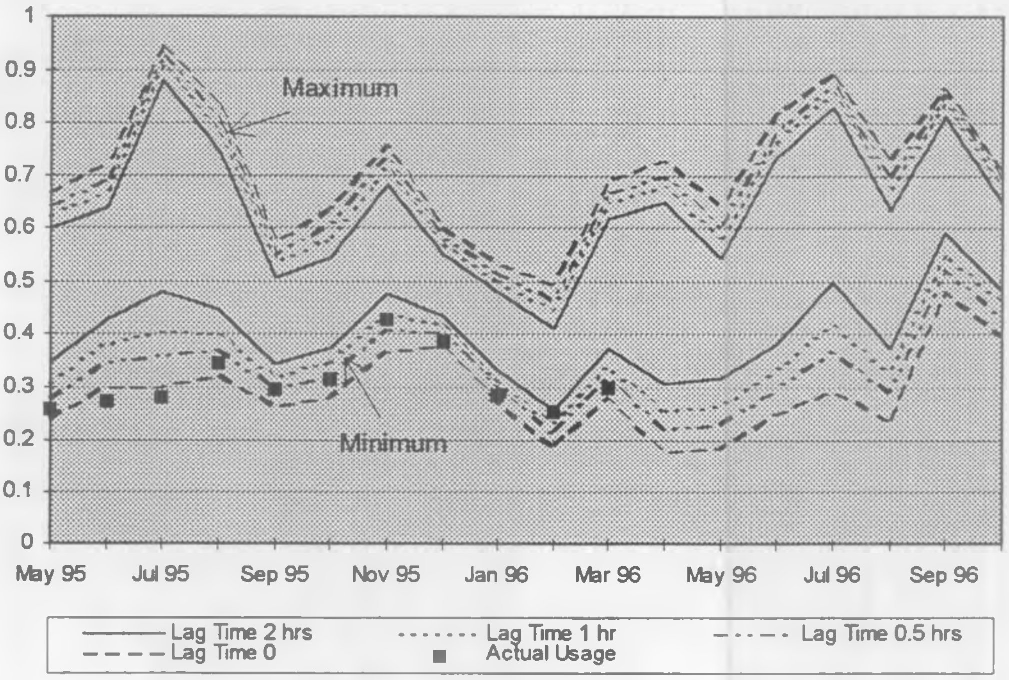
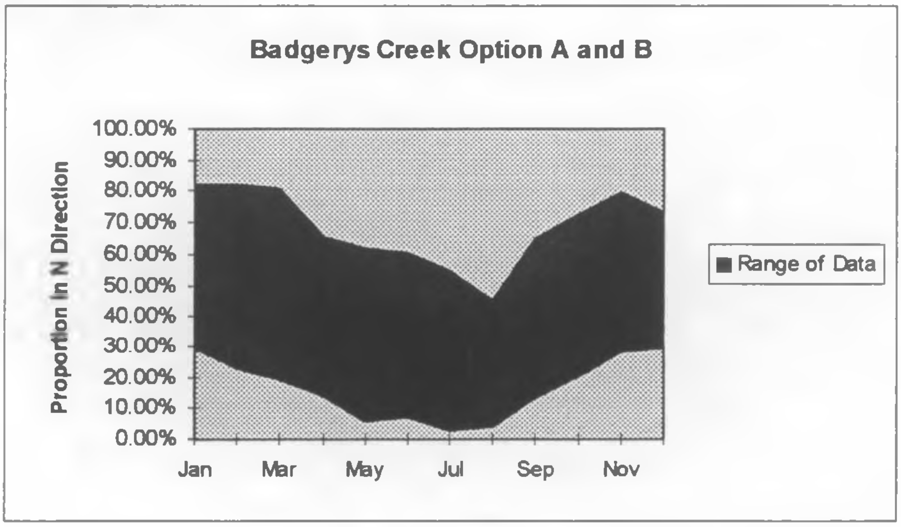


FIGURE 4.2 CALCULATED MAXIMUM AND MINIMUM POSSIBLE USAGE OF PARALLEL RUNWAYS AT SYDNEY AIRPORT IN NORTHERLY (34) DIRECTION

Apart from the months of June and July 1995, when usage of the northerly direction was lower than the minimum predicted by the model, actual usage is predicted comparatively well, with lag times of between half and one hour giving the best prediction. As noted above, in calculations for the proposed Second Sydney Airport, a lag time of one hour was assumed.

4.5.4 CALCULATED ALLOCATIONS

Based on the above analysis, runway allocations for Airport Operations 1 and 2 were calculated for each of the five Second Sydney Airport options. To indicate the range of results, *Figures 4.3* and *4.4* show the possible allocations in the 'north' direction - heading 05 at Badgerys Creek Options A and B, 36 at Badgerys Creek Option C, 34 at Holsworthy Option A and 29 at Holsworthy Option B - for each month of the year. *Figures 4.5* and *4.6* show the possible allocations for each hour of the day. The figures show the calculated proportion of movements in this direction under Operations 1 and 2, representing maximum and minimum movements in this direction respectively.



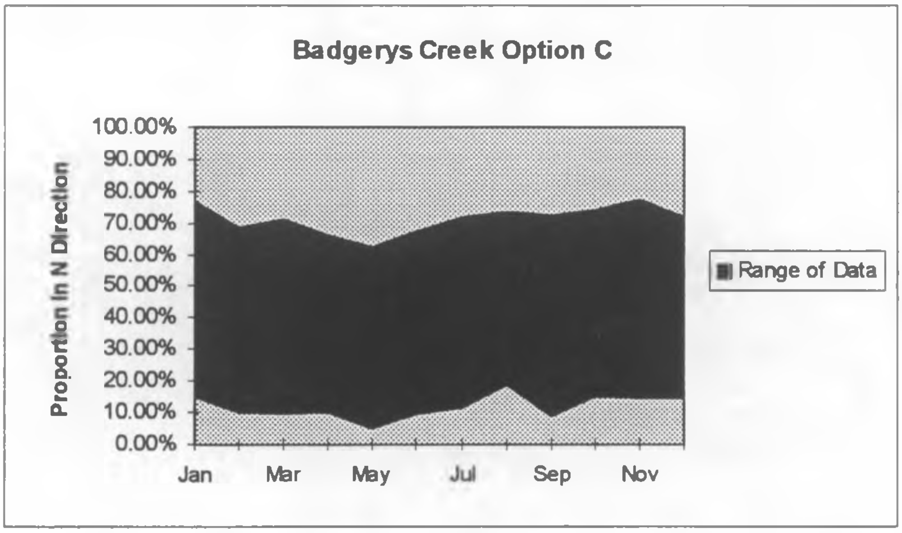
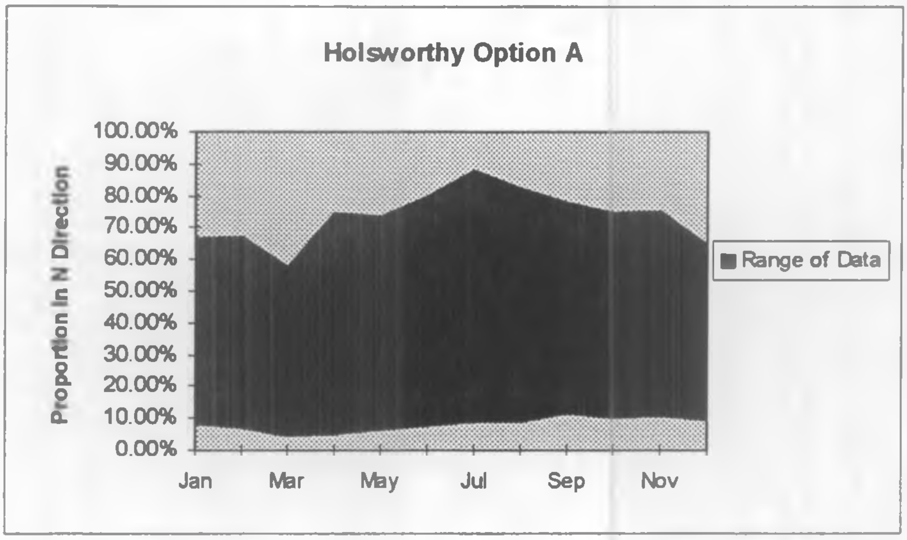


FIGURE 4.3 RANGE OF POSSIBLE RUNWAY ALLOCATIONS FOR BADGERYS CREEK AIRPORT OPTIONS EACH MONTH



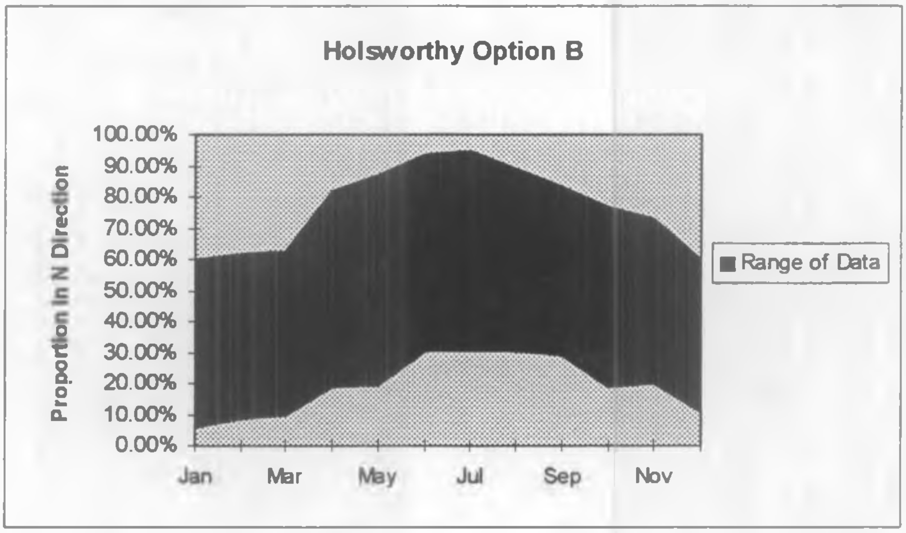
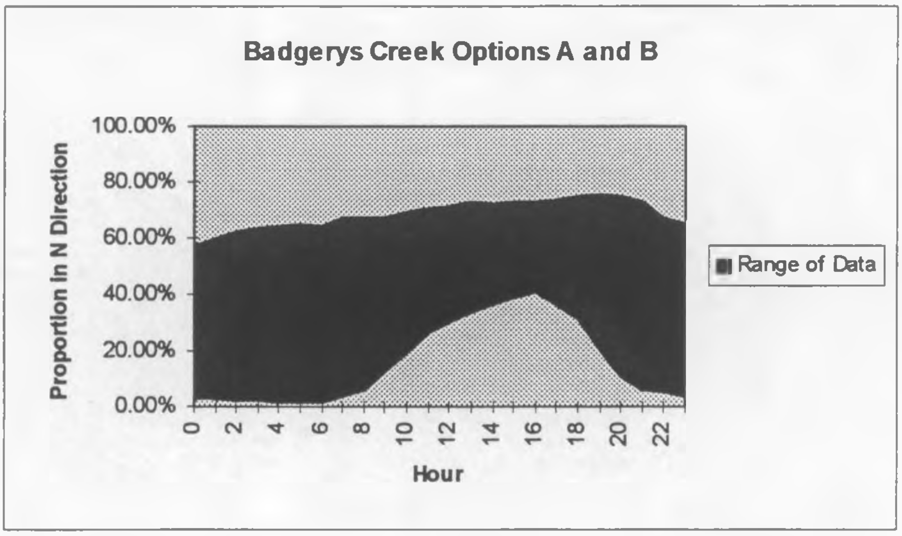


FIGURE 4.4 RANGE OF POSSIBLE RUNWAY ALLOCATIONS FOR HOLSWORTHY AIRPORT OPTIONS EACH MONTH



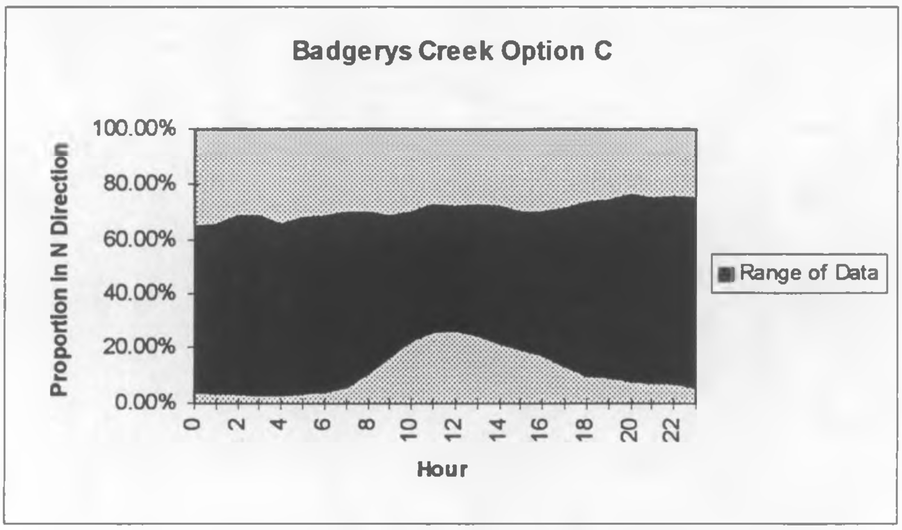
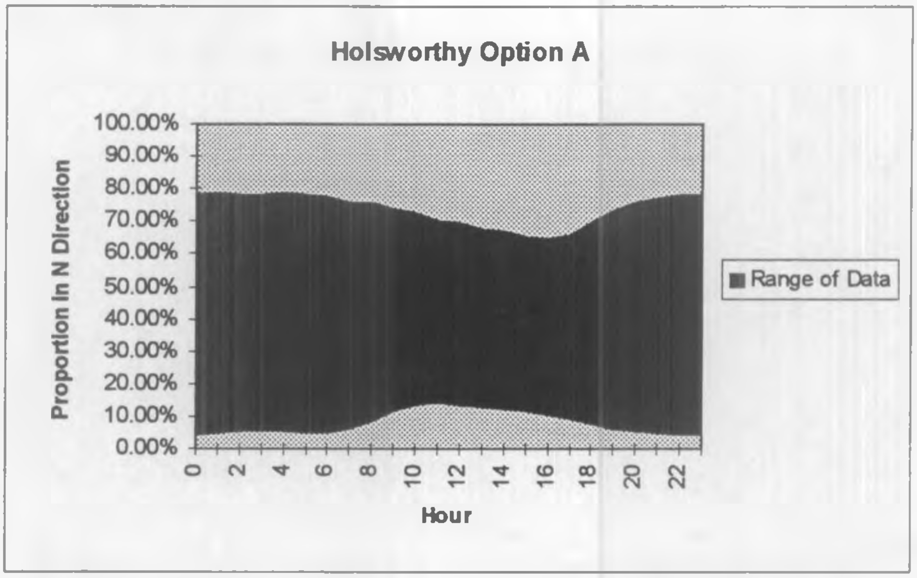


FIGURE 4.5 RANGE OF POSSIBLE RUNWAY ALLOCATIONS FOR BADGERYS CREEK AIRPORT OPTIONS EACH HOUR



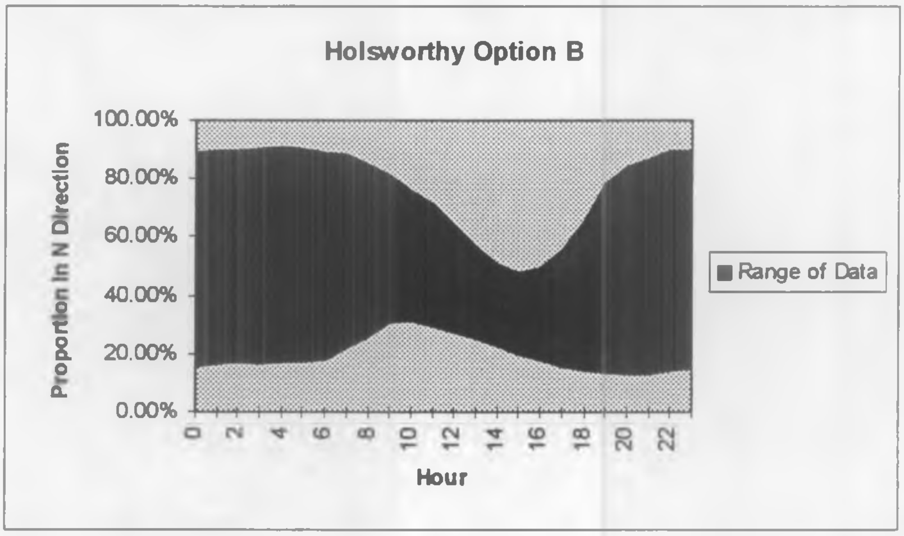


FIGURE 4.6 RANGE OF POSSIBLE RUNWAY ALLOCATIONS FOR HOLSWORTHY AIRPORT OPTIONS BY HOUR

It is notable from *Figures 4.3* and *4.4* that the range of possible runway allocations at all airports is significantly wider than at Sydney Airport. In particular, based on the available meteorological data, it would be possible to provide a significantly greater concentration of movements in a single preferred runway direction, particularly one with a general southerly orientation, than is possible at Sydney Airport. This is due to the generally lower wind speeds assumed at these sites, which is illustrated in *Figure 4.7*.

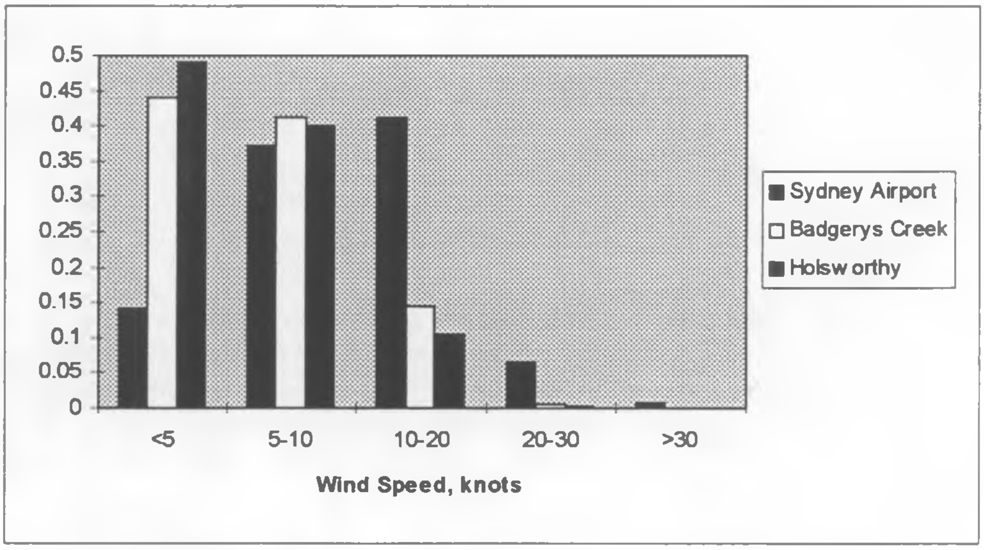


FIGURE 4.7 PROPORTION OF RECORDED WIND SPEEDS IN VARIOUS RANGES

The final allocations of aircraft to runways are shown in *Table 4.6* for Airport Operations 1 and 2. Allocations are shown separately for the 'day' and 'night' periods as used in the calculation of ANEC values, namely 7.00 am - 7.00 pm and 7.00 pm - 7.00 am respectively.

TABLE 4.6 ALLOCATION OF AIRCRAFT OPERATIONS TO RUNWAY DIRECTIONS

Airport Option	Runway Direction	Airport Operation 1 (Prefer North Direction) Day	Airport Operation 1 (Prefer North Direction) Night	Airport Operation 2 (Prefer South Direction) Day	Airport Operation 2 (Prefer South Direction) Night
Badgerys Creek A	North (05)	70.9%	66.0%	26.2%	5.0%
	South (23)	29.1%	34.0%	73.8%	95.0%
Badgerys Creek B	North (05)	70.9%	66.0%	26.2%	5.0%
	South (23)	29.1%	34.0%	73.8%	95.0%
	Cross (15)	0.0%	0.0%	0.0%	0.0%
	Cross (33)	0.0%	0.0%	0.0%	0.0%
Badgerys Creek C	North (36)	70.8%	70.3%	17.9%	5.3%
	South (18)	29.0%	29.7%	82.0%	94.7%
	Cross (09)	0.0%	0.0%	0.0%	0.0%
	Cross (27)	0.2%	0.0%	0.2%	0.0%
Holsworthy A	North (34)	69.8%	77.5%	11.2%	5.1%
	South (16)	30.2%	22.5%	88.7%	94.9%
	Cross (09)	0.0%	0.0%	0.0%	0.0%
	Cross (27)	0.0%	0.0%	0.0%	0.0%
Holsworthy B	North (29)	66.1%	88.2%	23.5%	15.5%
	South (11)	33.9%	11.8%	76.4%	84.5%
	Cross (17)	0.0%	0.0%	0.0%	0.0%
	Cross (35)	0.0%	0.0%	0.0%	0.0%

In all cases, for Airport Operation 3 ('noise sharing'), the allocated proportions were 46.5 percent in each of the parallel runway directions and 3.5 percent in each of the cross wind runway directions for both day and night.

It can be seen from *Table 4.6* that due to the relatively low wind speeds (compared with Sydney Airport), it would be very rare for usage of the cross wind runway to be dictated by wind conditions. The proportion of time when any airport would be unusable due to wind conditions was negligible in all case.

4.5.5 ALLOCATION OF FLIGHT PATHS

Airservices Australia in association with the Second Sydney Airport Planners have undertaken a preliminary analysis of the airspace requirements for each of the Second Sydney Airport options and the interaction with other airports, particularly Sydney Airport (Second Sydney Airport Planners, 1997a). Accordingly, they have identified a series of flight zones around each airport option for all runway uses considered.

Within each flight zone, a series of flight paths have been identified as being the most likely paths to be followed by aircraft with origins or destinations in each sector. For each runway direction, at least one 'arrival' path and one 'departure' path was allocated for aircraft arriving from or departing to each geographical sector. In some cases, the same track was used for a number of sectors. In many cases, two alternative paths were defined for the same sector, with a proportion of operations assigned to each path. In particular, for departures, where the major path is curved, a small proportion of operations were also assigned to a straight path to cater for traffic situations under which a straight out departure would be required.

The definition of flight paths was made by the Second Sydney Airport Planners, after consultation with Airservices Australia. For initial modelling, paths were defined primarily by operational constraints, rather than complete optimisation for noise control. Possibilities for achieving noise mitigation through alterations to flight paths are discussed below.

The basic flight paths used in noise level calculations are shown in *Figures 4.8* to *4.25*. The allocation of aircraft movements to these paths are provided in *Appendix A*. Note that the paths shown are for the master plan (2016 case). For the 2006 case, there are of course no paths from the cross wind runway, and paths from the second parallel runway were transposed so that operations were all on the same runway. The proportional allocation of operations to these tracks was not altered.

The flight paths shown in *Figures 4.8* to *4.25* represent the likely dispersion of aircraft due to wind, differences in aircraft climb rates (which result in differences in the point at which a turn may be executed) and other factors.

In all noise calculations, each of the paths shown in *Figures 4.8* to *4.25* was modelled as five separate paths - a central path, and two paths dispersed on each side of it. The additional paths were dispersed at angles of 1.5 and 3 degrees for arrival paths, and 4.5 and 9 degrees for departure paths. Operations on the nominal paths were allocated 40 percent to the central path, 20 percent to each of the closer dispersed paths and 10 percent to each of the wider dispersed paths.

Urban Areas (indicated by local roads)
Preliminary Landing Flight Paths
Preliminary Take Off Flight Paths
Flight Zones
Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 9-30

Figure 4.8

Preliminary Flight Paths for Badgerys Creek Option A: Landings From the South-West and Take Offs to the North-East

TN MN N

0Km 10Km

Urban Areas (indicated by local roads)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 26-68

TN MN N

0Km 10Km

Figure 4.9

Preliminary Flight Paths for Badgerys Creek Option A: Landings From the North-East and Take Offs to the South-West

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

Urban Areas (indicated by local roads)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 9-30

Figure 4.10

Preliminary Flight Paths for Badgerys Creek Option B: Landings From the South-West and Take Offs to the North-East

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

TN MN N

0Km 10Km

Urban Areas (indicated by local roads)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 51-132

Figure 4.11

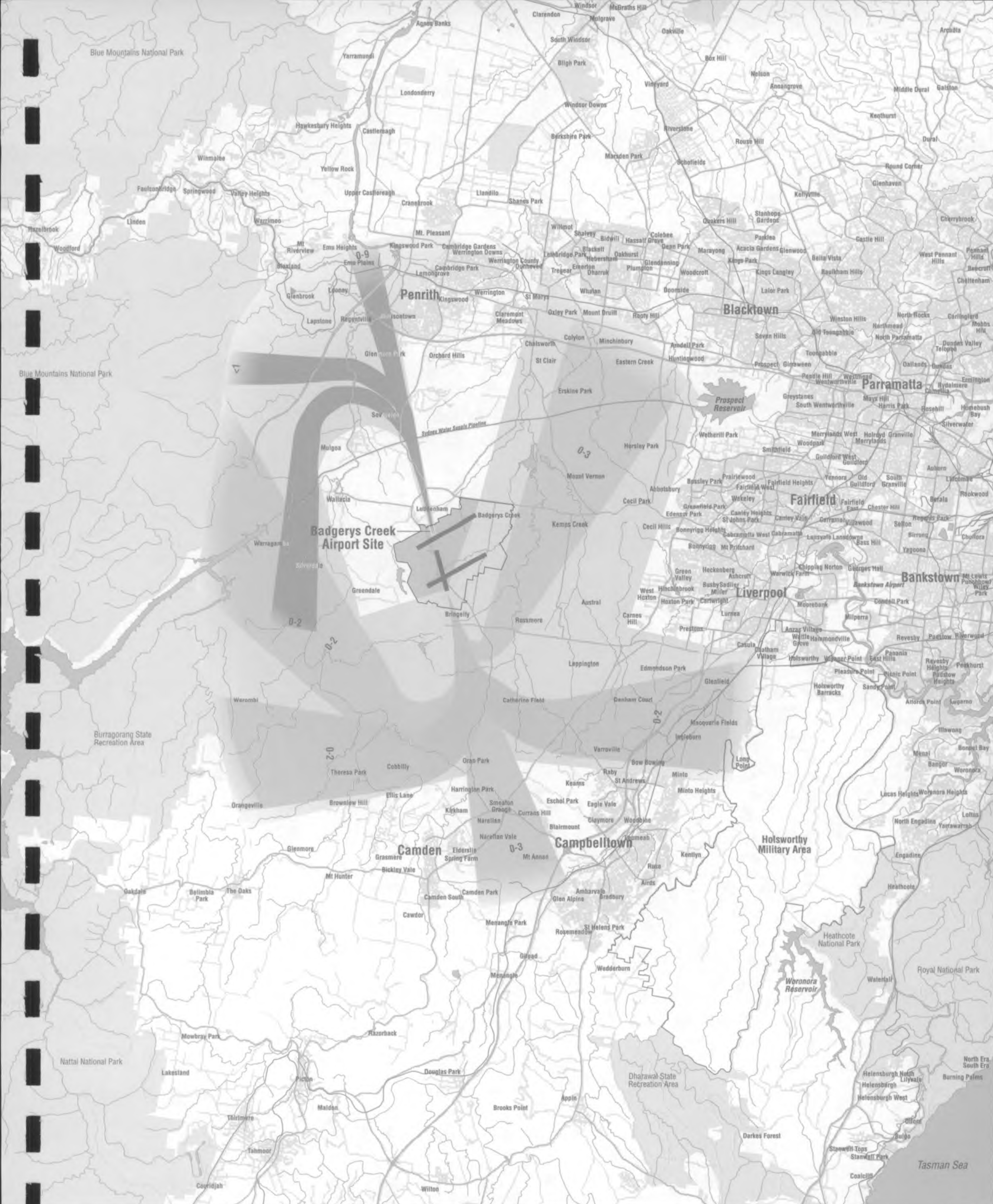
Preliminary Flight Paths for Badgerys Creek Option B: Landings From the North-East and Take Offs to the South-West

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

TN MN N

0Km 10Km



Urban Areas (indicated by local roads)	
Preliminary Landing Flight Paths	
Preliminary Take Off Flight Paths	
Flight Zones	
Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 (< 1 means less than one on average)	0-3

Figure 4.12

Preliminary Flight Paths for Badgerys Creek Option B: Landings From the North and Take Offs to the South

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

TN MN

0Km 10Km

Urban Areas (indicated in local roads)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 (<1 means less than one on average) 0-0

Figure 4 .13

Preliminary Flight Paths for Badgerys Creek Option B: Landings From the South and Take Offs to the North

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

TN MN N

0Km 10Km

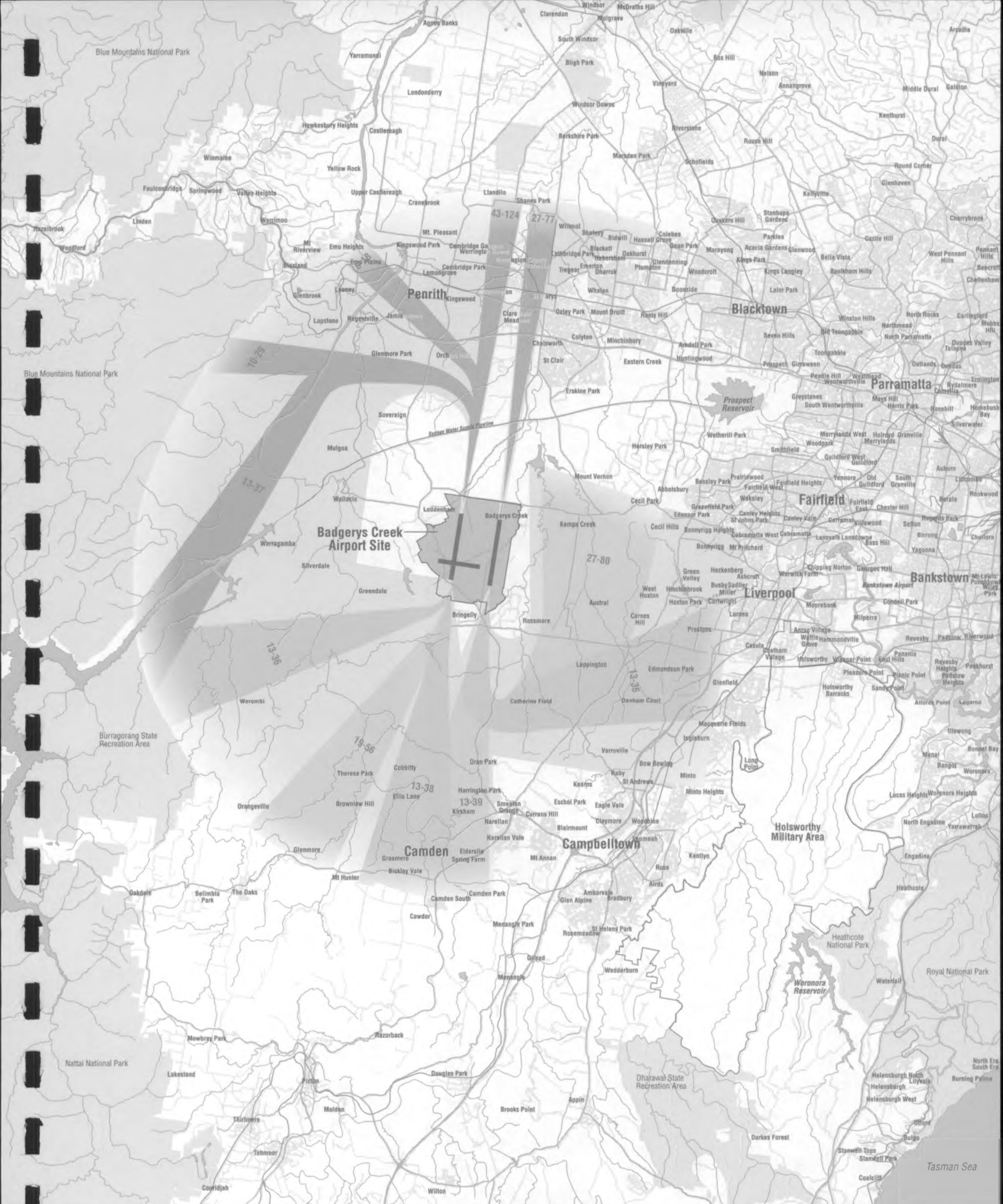
Urban Areas (indicated by local roads)
Preliminary Landing Flight Paths
Preliminary Take Off Flight Paths
Flight Zones
Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 10-49

Figure 4.14

Preliminary Flight Paths for Badgerys Creek Option C: Landings From the South and Take Offs to the North

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.



Urban Areas (indicated by local roads)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

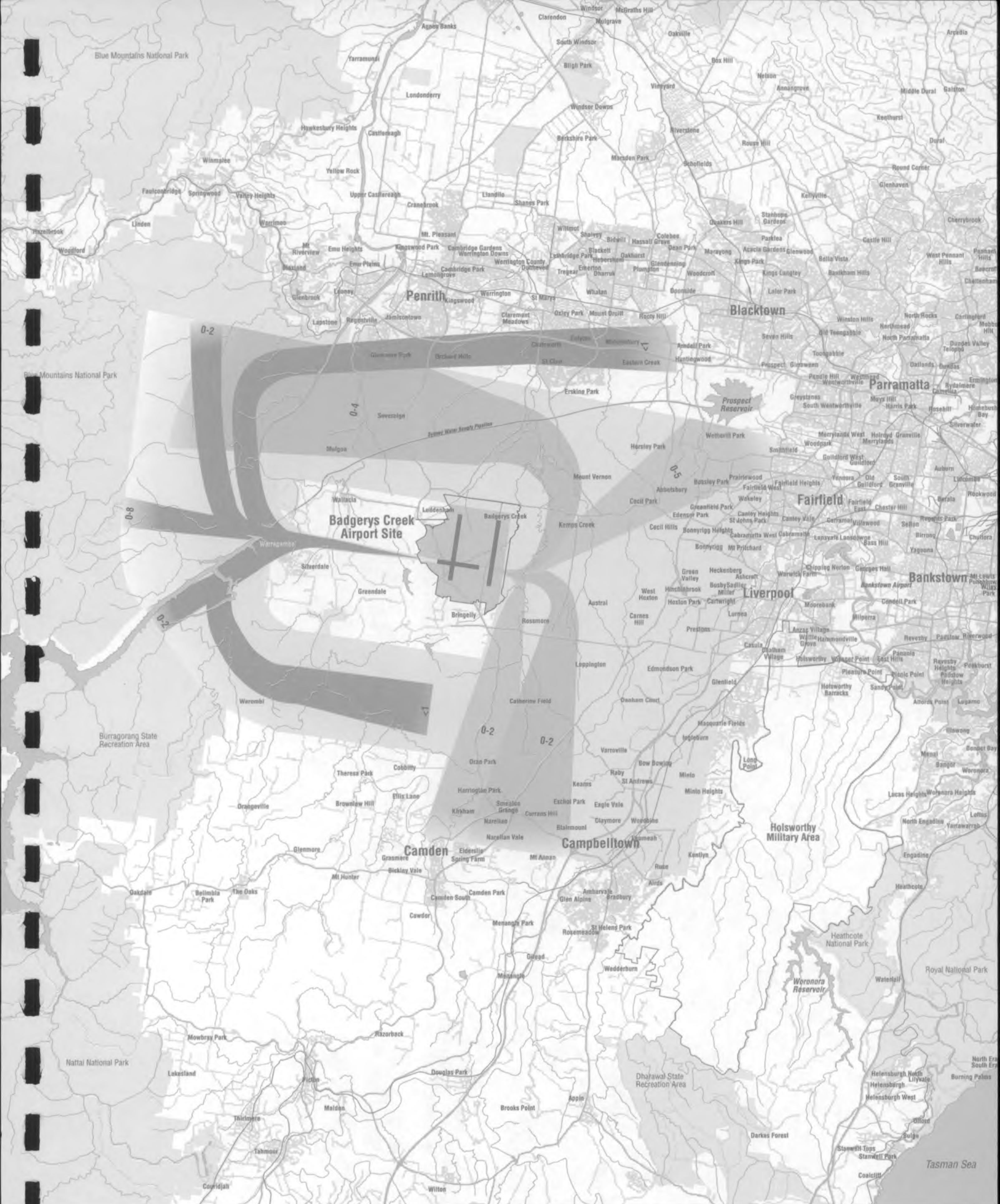
Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 13-36

Figure 4.15

Preliminary Flight Paths for Badgerys Creek Option C: Landings From the North and Take Offs to the South

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.



Urban Areas (indicated by local roads)
Preliminary Landing Flight Paths
Preliminary Take Off Flight Paths
Flight Zones
Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 (<1 means less than one on average) 0-2

Figure 4.16

Preliminary Flight Paths for Badgerys Creek Option C: Landings From the West and Take Offs to the East

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

TN MN N

0Km 10Km

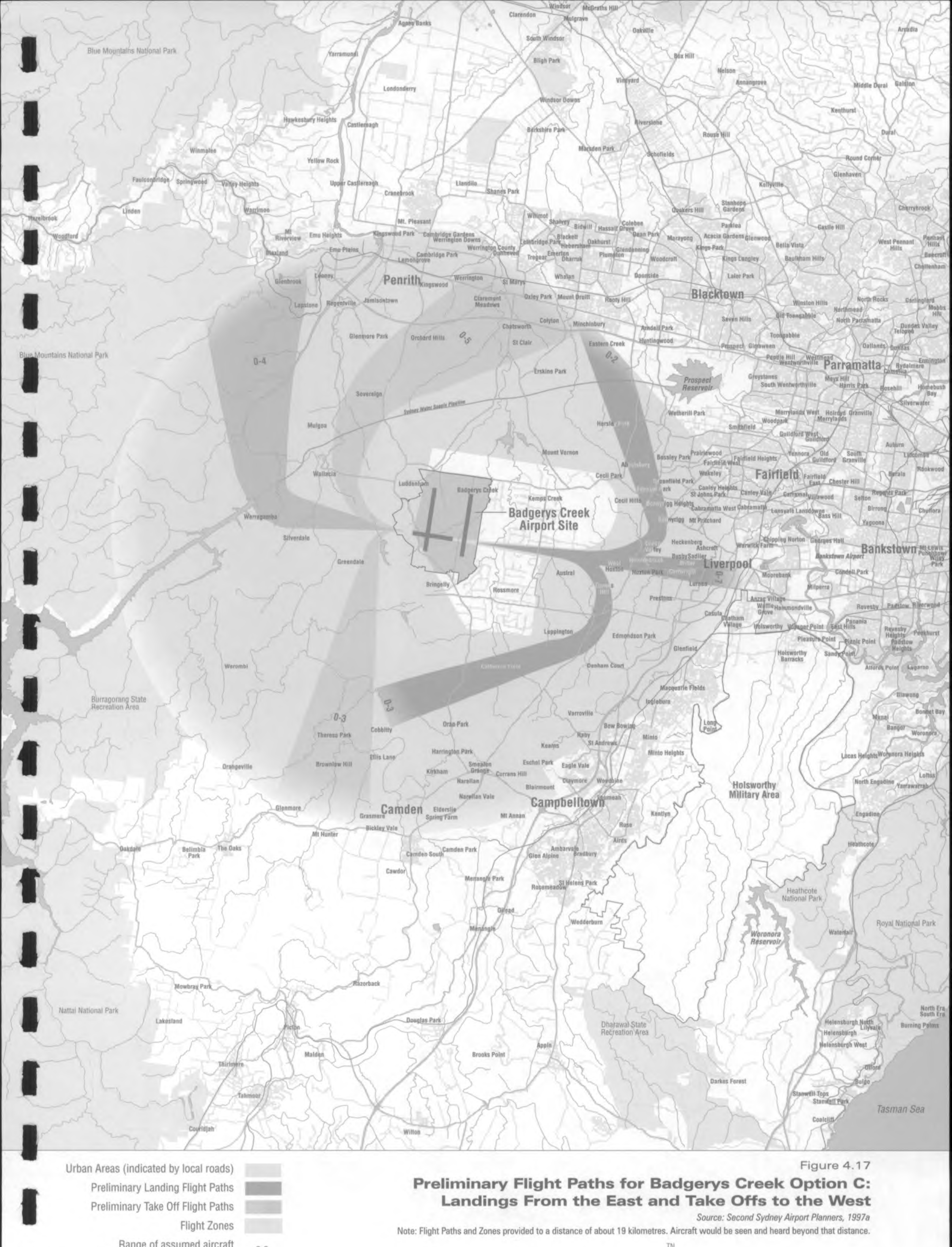


Figure 4.17

Preliminary Flight Paths for Badgerys Creek Option C: Landings From the East and Take Offs to the West

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

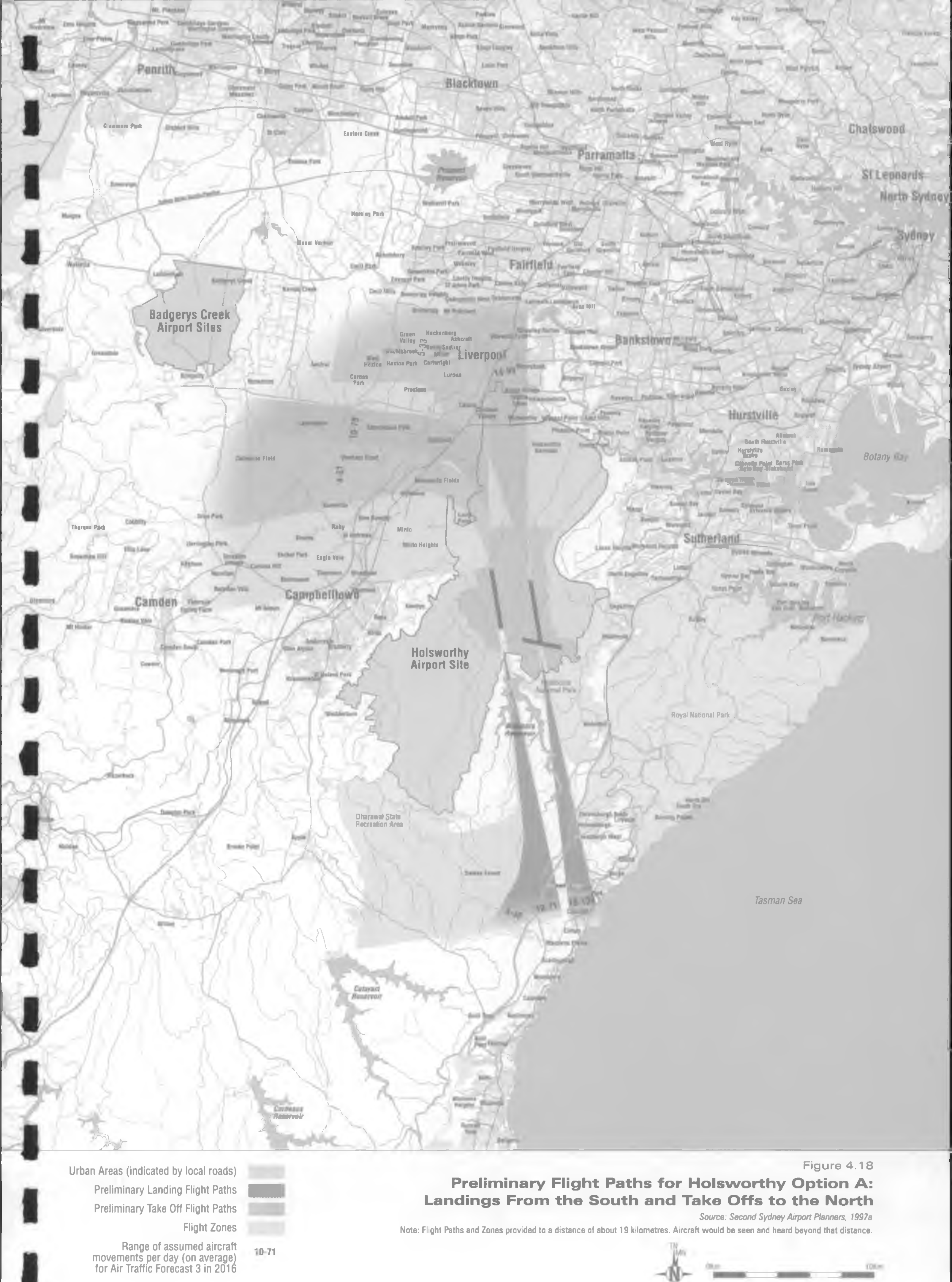


Figure 4.18

Preliminary Flight Paths for Holsworthy Option A: Landings From the South and Take Offs to the North

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

Urban Areas (indicated by local roads)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 30-85

Figure 4.19

Preliminary Flight Paths for Holsworthy Option A: Landings From the North and Take Offs to the South

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

Urban Areas (indicated by local roads)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 0-3

0Km — 10Km

Figure 4.20

Preliminary Flight Paths for Holsworthy Option A: Landings From the West and Take Offs to the East

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

Urban Areas (indicated by local roads)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 0-0

Figure 4.21

Preliminary Flight Paths for Holsworthy Option A: Landings From the East and Take Offs to the West

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

0km 10km

Urban Areas (indicated by local road)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

Range of assumed aircraft movements perday (on average) for Air Traffic Forecast 3 in 2016 — 24-67

Figure 4.22

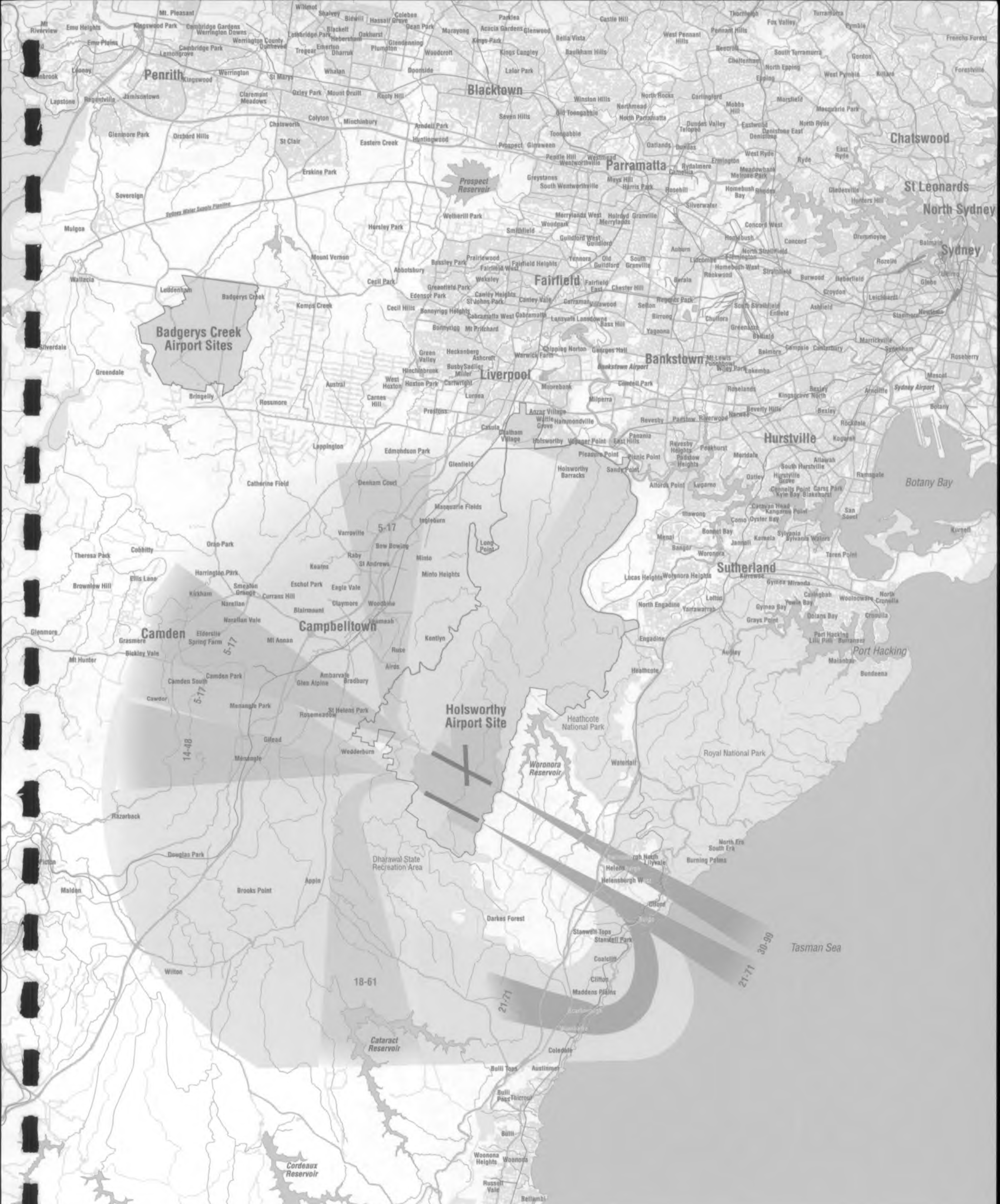
Preliminary Flight Paths for Holsworthy Option B: Landings From the West and Take Offs to the East

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

TN MN

0Km 10Km



Urban Areas (indicated by local roads)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 18-61

Figure 4.23

Preliminary Flight Paths for Holsworthy Option B: Landings From the East and Take Offs to the West

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

Urban Areas (indicated by local roads)

Preliminary Landing Flight Paths

Preliminary Take Off Flight Paths

Flight Zones

Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 0-7

Figure 4.24

Preliminary Flight Paths for Holsworthy Option B: Landings From the South and Take Offs to the North

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

TN MN

0Km 10Km

Urban Areas (indicated by local roads)
Preliminary Landing Flight Paths
Preliminary Take Off Flight Paths
Flight Zones
Range of assumed aircraft movements per day (on average) for Air Traffic Forecast 3 in 2016 — 0-5

Figure 4.25
Preliminary Flight Paths for Holsworthy Option B: Landings From the North and Take Offs to the South

Source: Second Sydney Airport Planners, 1997a

Note: Flight Paths and Zones provided to a distance of about 19 kilometres. Aircraft would be seen and heard beyond that distance.

TN MN N
0Km 10Km

To allow some compression of data processing time, all operations for aircraft types with total movements of less than one per day were allocated to the central paths. This had a negligible impact on overall noise exposure measures.

4.6 NOISE MODELLING

4.6.1 ASSUMPTIONS IN MODELLING

Calculations of aircraft overflight noise were carried out using the Integrated Noise Model (INM) which has been developed by the US Federal Aviation Administration. Version 5.01 of the program was used, which represents the latest version which was available in a fully tested form at the time of performing the calculations.

The INM Model simulates typical aircraft operations and calculates noise levels in the surrounding area. It has the ability to determine aircraft climb rates, thrust and flap settings and noise generation during specific operations. From this, it is able to calculate a range of noise descriptors suitable for assessment of aircraft overflight noise.

This model includes the most recently available information on noise levels from current aircraft types. This is obtained from detailed test data, generally gathered during aircraft noise certification trials. Noise levels can be calculated for individual aircraft operations on arrival, and on departure for a number of stage lengths (distance to be travelled in the first leg). These noise levels depend on aircraft operational parameters such thrust and flap settings. In keeping with the general nature of the noise assessment process, standard values (that is, the default values specified in the INM model) were used for these parameters in all calculations. In Australia, any variation which may be specified to these operating parameters at a specific airport is most likely to be associated with noise abatement procedures, and hence the procedure adopted provides a conservatively high estimate of likely noise exposure.

One important class of aircraft specified in air traffic forecasts has been labelled 'New Large Aircraft', and represents aircraft which are currently under development by both Boeing and Airbus Industries. Noise level test data for these aircraft are obviously not available. Current information from the manufacturers indicates that noise levels from both aircraft should be within those of current generation 747 400 aircraft on both approach and departure. However, as a conservative measure, in calculations the noise level from new large aircraft was set at two dBA higher than that from a 747 400 aircraft.

In recent years there has been a marked decline in the operation of older, noisy aircraft in Australia. This reflects increased regulation of aircraft noise in Australia through the *Air Navigation (Aircraft Noise) Regulations* and a move towards greater use of aircraft which comply with the latest, more stringent International Civil Aviation Organisation noise standards. Engine manufacturers are continuing to develop quieter engines to maintain compliance with the increasingly strict international aircraft noise standards.

Other operational parameters assumed in calculations are a temperature of 20 C, atmospheric pressure 760 mmHg and mean headwind eight knots. The effect of changes in these parameters on calculated noise levels, for typical aircraft types and receiver locations, was investigated and is summarised in *Table 4.12*. The results relate to noise levels from 747 400 and 737 400 aircraft on departure (stage 7) at receiver locations 5,000 metres from start of roll and either directly beneath the flight path of 500 metres to the side.

TABLE 4.12 EFFECT OF CHANGES IN ASSUMED OPERATIONAL PARAMETERS

Change to Operational Parameters	Maximum Change in Calculated Noise Level	
	Beneath Flight Path	**Side of Flight Path**
Reduce Temperature, 20°C to 10°C	+ 0.5 dB	+ 0.9 dB
Increase Atmospheric Pressure, 760 mmHg to 773 mmHg	-0.6 dB	-0.3 dB
Reduce Average Headwind, 8 kts to 0 kts	+0.8 dB	+0.5 dB

The values adopted for temperature and pressure are considered reasonable as average values for the airport sites considered. The mean headwind, which affects the assumed flight profile, is generally calculated to be approximately eight knots for non-preferred runways, but lower for preferred runways. This therefore results in some under prediction of noise levels at points close to preferred runways. However, the variations shown in *Table 4.12* are relatively minor, and are within the tolerance of overall model predictions.

The INM model does not allow for calculation of the effect of atmospheric conditions such as wind and temperature inversions on sound propagation. These factors are known to have a strong influence on noise generated at ground level. However, for sources which are significantly elevated, such as an aircraft in flight, their influence on sound propagation is much lower, and has not been as thoroughly studied. In many cases, the major impact of adverse wind and temperature gradient conditions on noise from ground level sources comes through removal of the effect of intervening barriers. This can result in very significant enhancement of noise at the receiver location. However, this effect is obviously not relevant for noise from a source such as an aircraft in flight. Standard noise prediction programs which calculate the effect of meteorological conditions on sound propagation, such as ENM and SoundPlan, have not been validated in modelling an elevated source, and are generally based on data from sources close to the ground.

The INM model does take into account the elevation of noise receivers in the calculation by the incorporation of topography of the area surrounding the airport.

Some indication of the total likely variation in noise levels from individual aircraft - including variation due to meteorological effects as well as other factors - can be gained from noise monitoring results obtained from

Airservices Australia's Noise and Flight Path Monitoring System. These are described in the following section.

4.6.2 VALIDATION OF INM PREDICTIONS

Apart from the rigorous test data on which INM noise level calculations are based, validation of some of the noise level predictions for individual aircraft operations has been provided over a number of years by Airservices Australia's Noise and Flight Path Monitoring System, which continuously records maximum A-weighted noise levels from aircraft operations around a number of airports in Australia.

A report by Airservices Australia (1996b) addresses the accuracy of INM by comparing predicted noise levels with noise levels measured around Sydney Airport. Measured noise levels were obtained at ten sites over periods of 12 hours at eight sites and seven hours at the remaining two. Maximum noise levels were recorded for aircraft arrivals and departures, broken down by aircraft type. Mean values of these maximum levels were then compared with predictions produced by the INM model.

Figure 4.26 shows a comparison between measured and predicted noise levels from arrivals and departures of B747, B767/A300 and B737/A320 aircraft. The figure indicates a very close relationship for locations where the predicted noise level from the overflight exceeds approximately 65 dBA. The maximum difference between predicted and measured levels for these cases is 2.8 dBA with all other differences less than two dBA. These are the most important noise events from the point of view of noise assessment.

For lower predicted noise levels (below approximately 60 dBA), there is a marked tendency for the measured levels to exceed the predictions made using INM. Reasons for this may include a possible systematic under prediction by INM in locations where the aircraft is at a low angle to the horizon as seen from the receiver. This is the case for most locations where the predicted level is low. Alternatively, some measured maximum noise levels may have been influenced by other noise where the measured level was relatively low.

It can be concluded that, at least for aircraft noise events with maximum noise levels exceeding 60 to 65 dBA, INM provides a prediction of the mean maximum noise level which is generally accurate to within approximately two dB. This is considered acceptable for the purposes of this noise assessment.

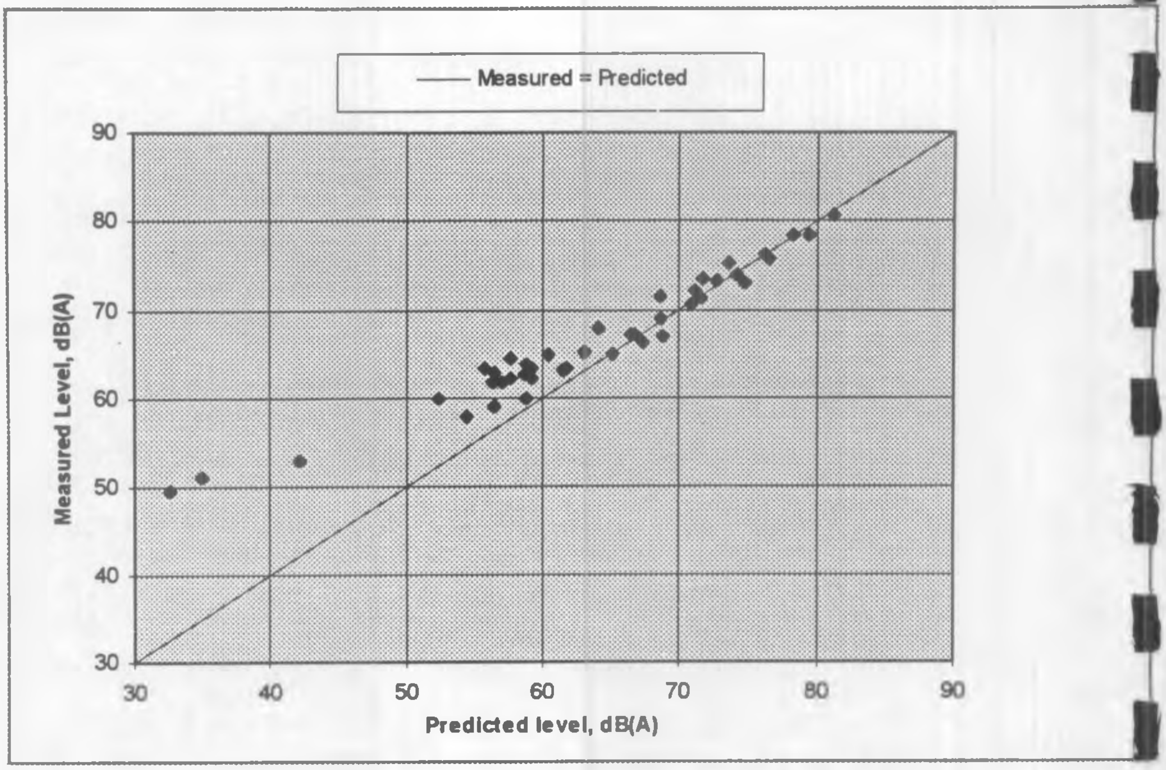


FIGURE 4.26 COMPARISON BETWEEN MEASURED AND PREDICTED MAXIMUM NOISE LEVELS FROM AIRCRAFT FLYOVERS

5 AIRCRAFT OVERFLIGHT NOISE IMPACTS

This chapter presents the results of noise calculations and assesses the potential impacts of aircraft overflight noise for each of the five airport options.

5.1 MODELLING PROCEDURES AND RESULTS

Two types of aircraft noise calculations were performed as part of this study - noise contour calculations and calculations for Community Assessment Areas. These are described below.

5.1.1 NOISE CONTOUR CALCULATIONS

Two types of noise contours were generated in this study - ANEC and maximum dBA. The first of these is intended to provide information relevant to land use planning, and also detailed information on the likely spatial distribution of noise in areas relatively close to the airport sites. The second is intended to indicate the spatial spread of lower level noise impacts and is specifically the area over which the predicted maximum noise level from a 747 400 aircraft, performing any operation on any flight track, exceeds 70 dBA.

To take account of the height of the ground in the area surrounding each airport, it was necessary to conduct specific calculations of ANEC levels, using INM, at a grid of points with a grid spacing of 200 metres, covering an area of at least 20 kilometres x 10 kilometres surrounding each airport option. This area was extended as required to include the relevant contours. Ground heights at each point were provided by PPK. From these data, noise level contours were calculated using the SURFER surface generation program.

For each airport, ANEC contours were calculated for two years - 2006 and 2016 - for each of the three air traffic forecasts and each of the two or three airport operation scenarios. This gives six sets of ANEC contours at each airport for 2006, and nine at each airport except Badgerys Creek Option A for 2016. These are presented as a range of possible locations for each contour line. The precise location of the contour would depend on Government policy regarding the transfer of operations to Second Sydney Airport and regarding runway usage at the airport.

The maximum modelled extent of the ANEC contours calculated for 2006 and 2016 are shown in *Figures 5.1* to *5.10*. These contours show the outside extent of the range of ANEC levels which result from the three forecasts and three airport operations analysed. They have been derived by firstly plotting the noise contours for all forecasts and all airport operations, as shown in *Figures 5.11* to *5.20*.

Figures 5.21 and *5.22* provide examples of the extent of single event contours for a straight approach and departure for Boeing 747-400, 747-300 and 737-300 aircraft. Contours showing the maximum extent of the 70 dBA noise level for the 747-400 aircraft using all the predicted flight paths are shown in *Figures 5.23* to *5.27*. These contours represent the maximum noise level from a 747 400 aircraft on departure (with maximum stage length) using any departure track, or on arrival using any arrival track. They provide information on the noise level from a relatively noisy event, but take no account of how often these would occur. For example, in areas adjacent to cross wind runways the number of such events would be much lower than in areas adjacent to the main parallel runways.

5.1.2 CALCULATIONS FOR COMMUNITY ASSESSMENT AREAS

Noise level contours, as described above, can provide general information on the spatial extent of certain types of noise impact. However, some types of information, such as the number of noise events exceeding certain thresholds during certain times of the day, are difficult to convey in this way. In addition, contours become less meaningful at large distances from the airport where the distance between two adjacent contours may be very large.

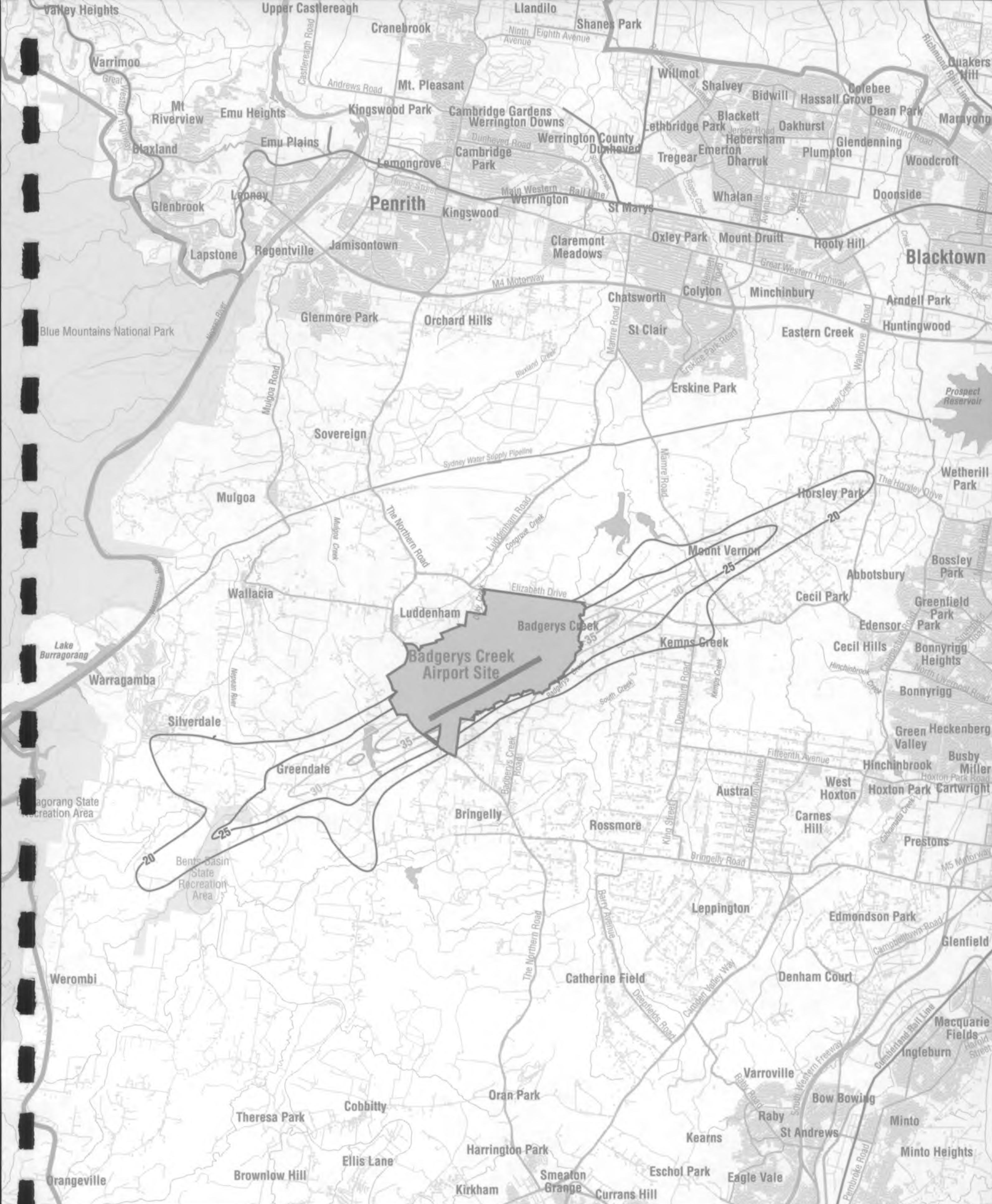
To provide more directly meaningful information on the likely pattern of noise exposure at specific locations, detailed noise level calculations were undertaken for 108 Community Assessment Areas. These areas have also been used for definition of demographic population characteristics and assessment of existing noise exposure (see below). They are shown in *Figure 3.1*. Community Assessment Areas cover a much broader geographical area around each airport than the ANEC noise level contours described above.

Close to each airport option where aircraft overflight noise levels change quickly with distance, it has been necessary to subdivide the Community Assessment Areas into Sub-Community Assessment Areas. In view of the different locations of the airport options and the different orientations of runways, a different subdivision is required for each airport option. These Sub-Community Assessment Areas are shown in *Volumes 3* to *8* of this Technical Paper.

Locations and ground heights for each of the areas were provided by PPK. In this case, INM was used to calculate and save noise levels at each Community Assessment Area for each aircraft type performing each operation on each track. This allows great flexibility in performing further calculations to define measures of noise exposure at each point.

The noise exposure descriptors calculated are:

- ANEC;
- L_{Aeq} levels for two time periods - 24 hours and sleep period (10.00 pm - 6.00 am);
- the average number of noise events per day exceeding 60, 70, 80 and 90 dBA;
- the average number of noise events during the sleep period (10.00 pm - 6.00 am) exceeding 60, 70, 80 and 90 dBA;



Indicates Density of Dwellings in 1996

Extent of Dwelling Data

Figure 5.1

Modelled Maximum 2006 ANEC Contours for Badgerys Creek Option A

Indicates Density of Dwellings in 1996

Extent of Dwelling Data

Figure 5.2

Modelled Maximum 2016 ANEC Contours for Badgerys Creek Option A

TN MN N

0Km 5Km

Indicates Density of Dwellings in 1996

Extent of Dwelling Data

Figure 5.3

Modelled Maximum 2006 ANEC Contours for Badgerys Creek Option B

Indicates Density of Dwellings in 1996

Extent of Dwelling Data

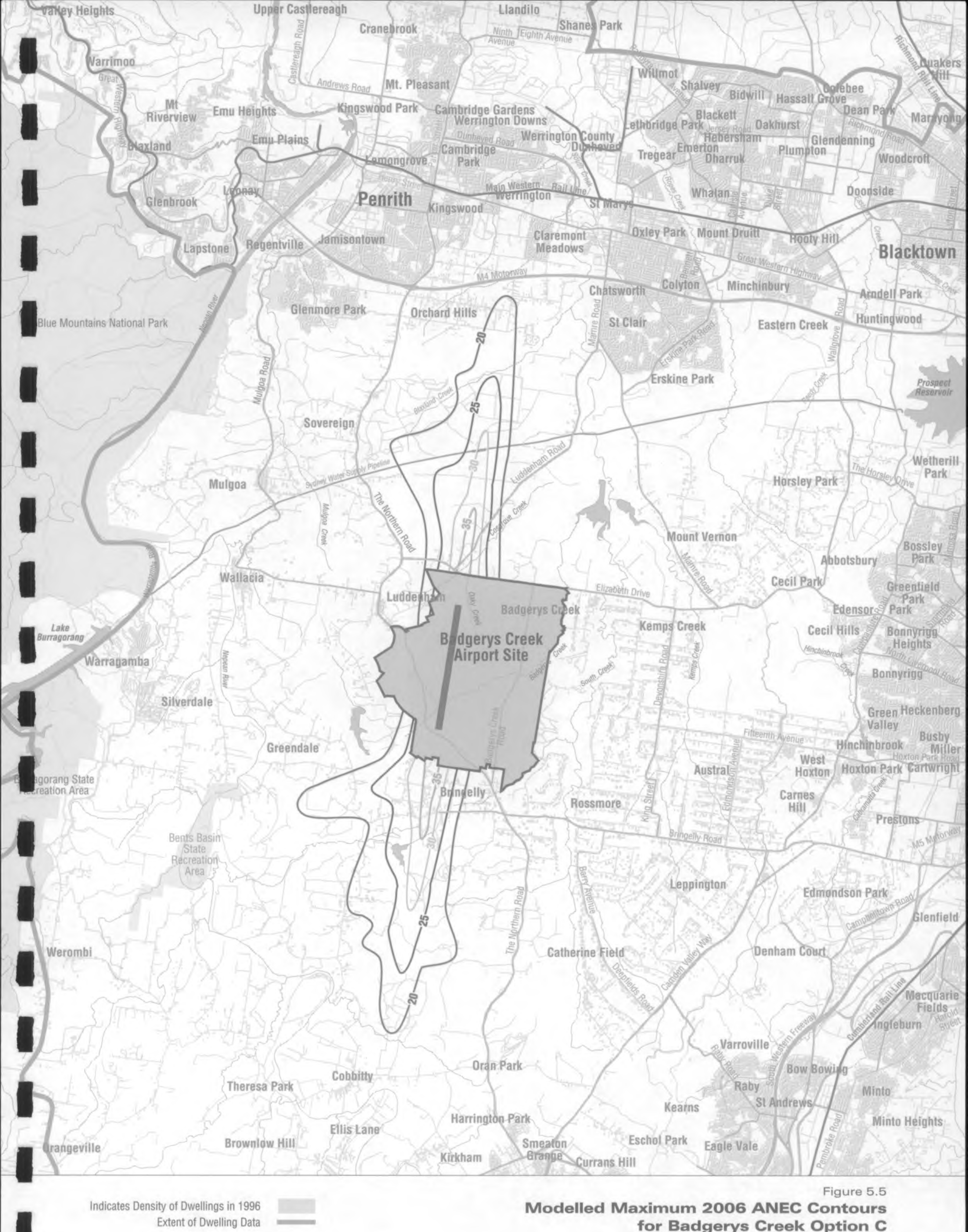
Figure 5.4

Modelled Maximum 2016 ANEC Contours for Badgerys Creek Option B

TN MN

N

0Km 5Km



Indicates Density of Dwellings in 1996

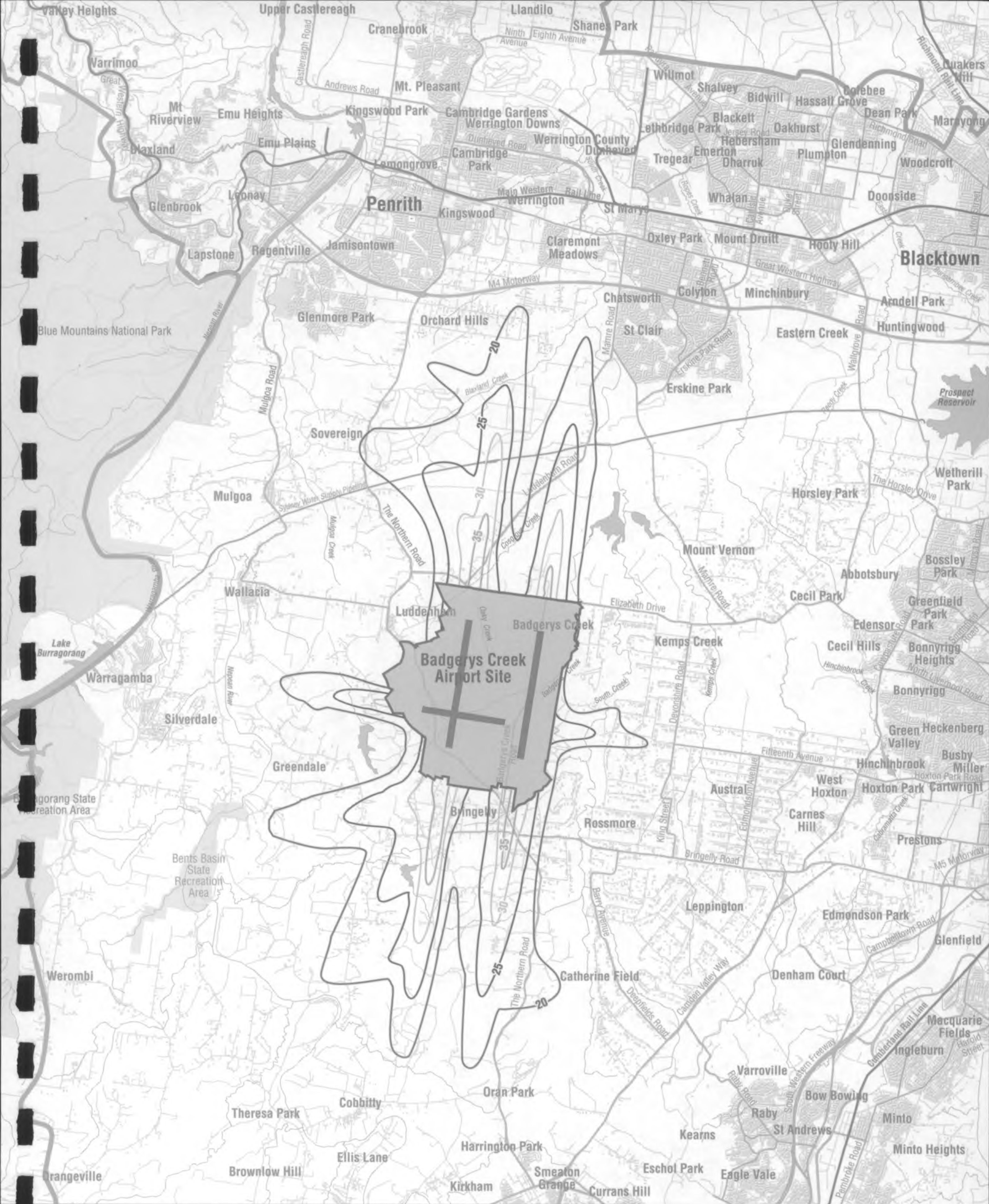
Extent of Dwelling Data

Figure 5.5

Modelled Maximum 2006 ANEC Contours for Badgerys Creek Option C

TN MN N

0Km 5Km



Indicates Density of Dwellings in 1996

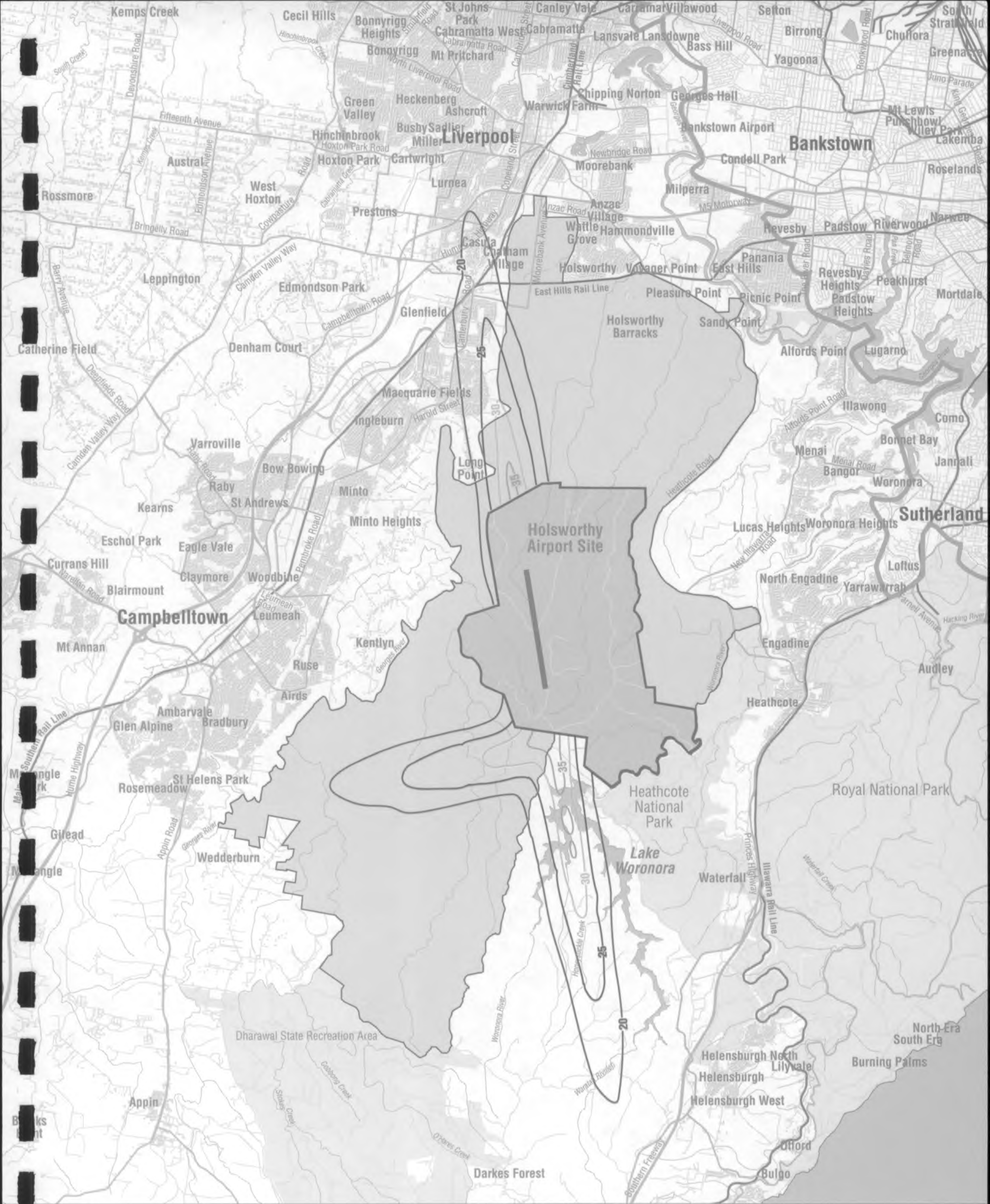
Extent of Dwelling Data

Figure 5.6

Modelled Maximum 2016 ANEC Contours for Badgerys Creek Option C

TN MN N

0Km 5Km



Indicates Density of Dwellings in 1996

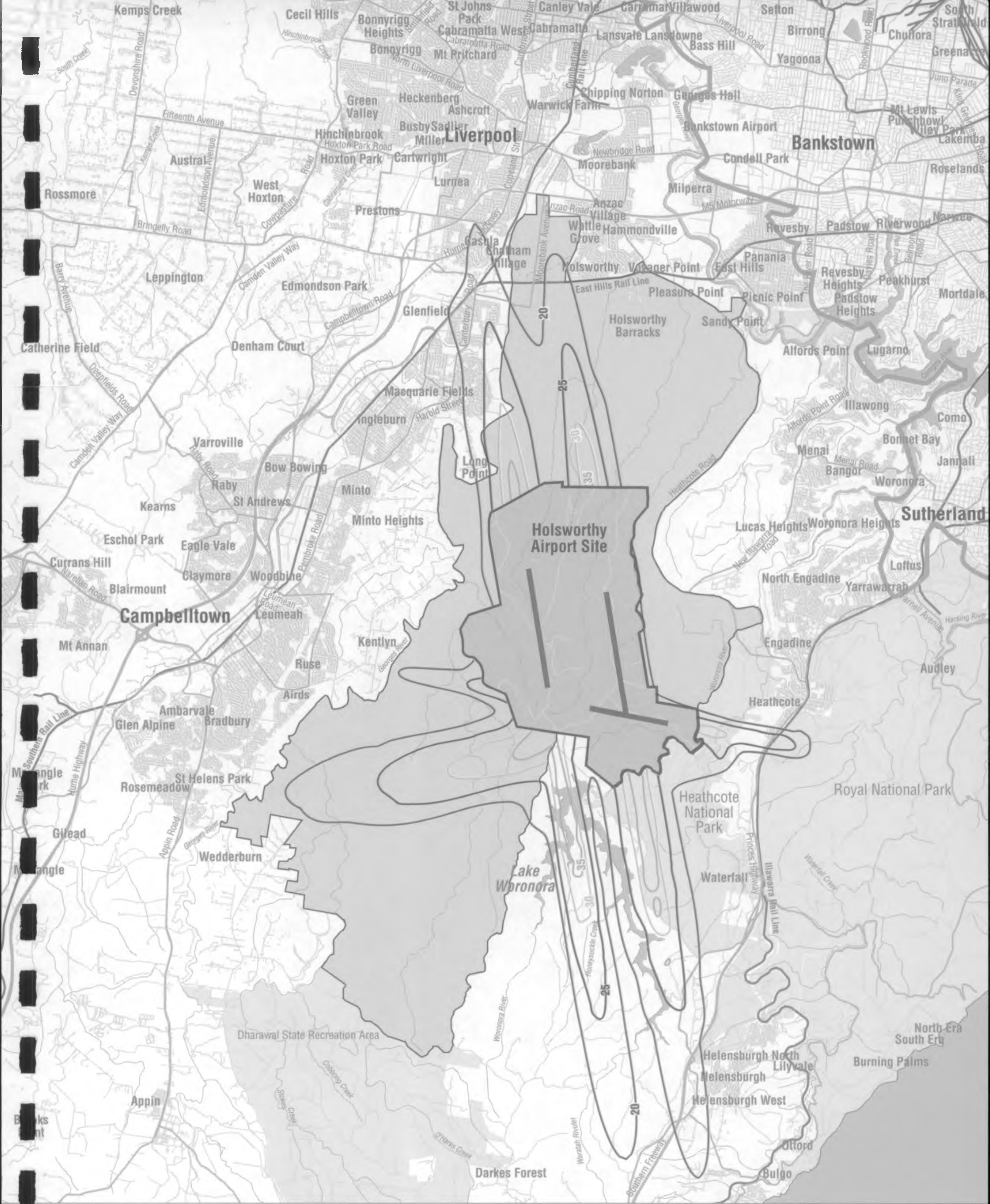
Extent of Dwelling Data

Figure 5.7

Modelled Maximum 2006 ANEC Contours for Holsworthy Option A

TN MN N

0Km 5km



Indicates Density of Dwellings in 1996

Extent of Dwelling Data

Figure 5.8

Modelled Maximum 2016 ANEC Contours for Holsworthy Option A

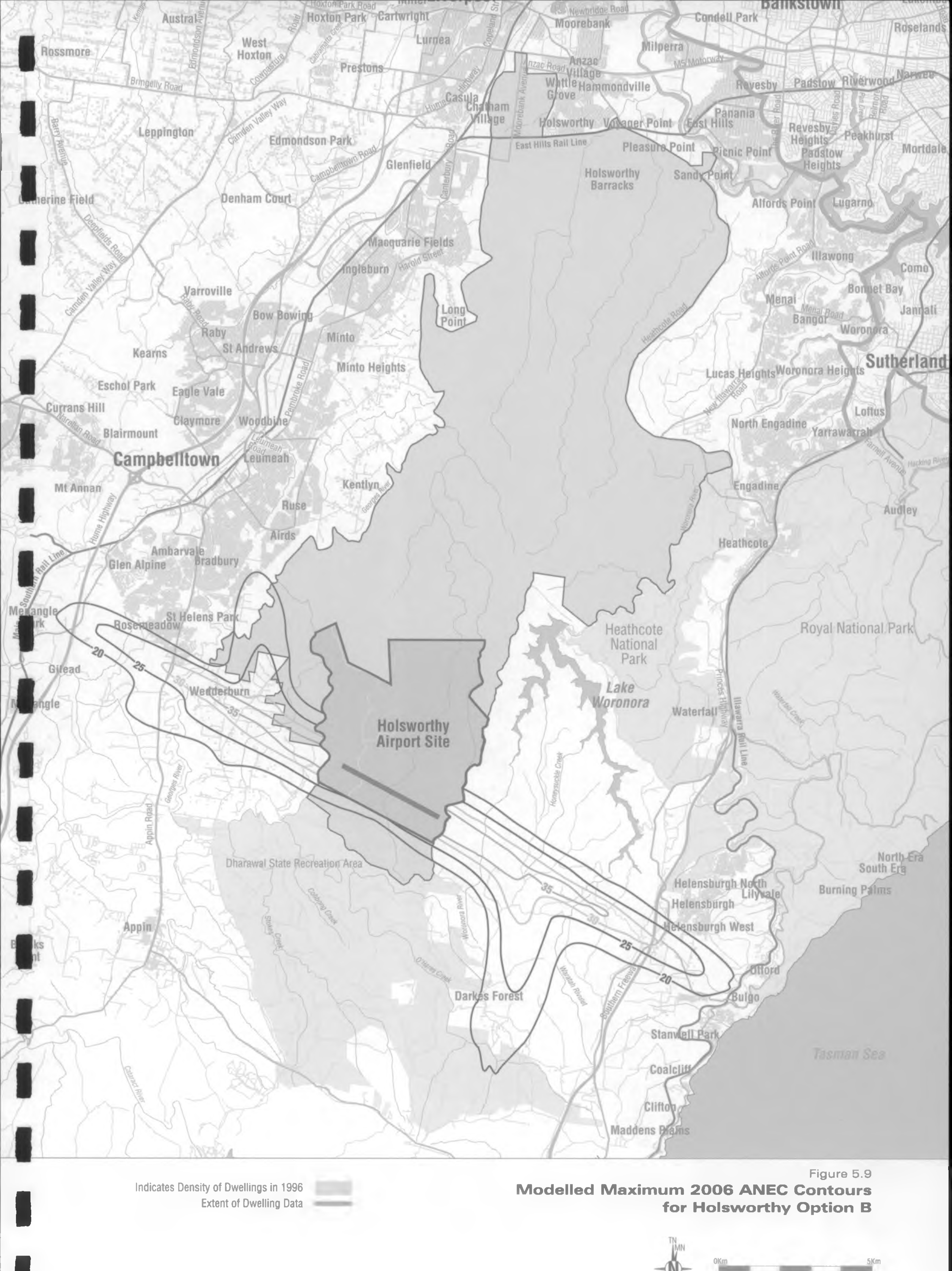
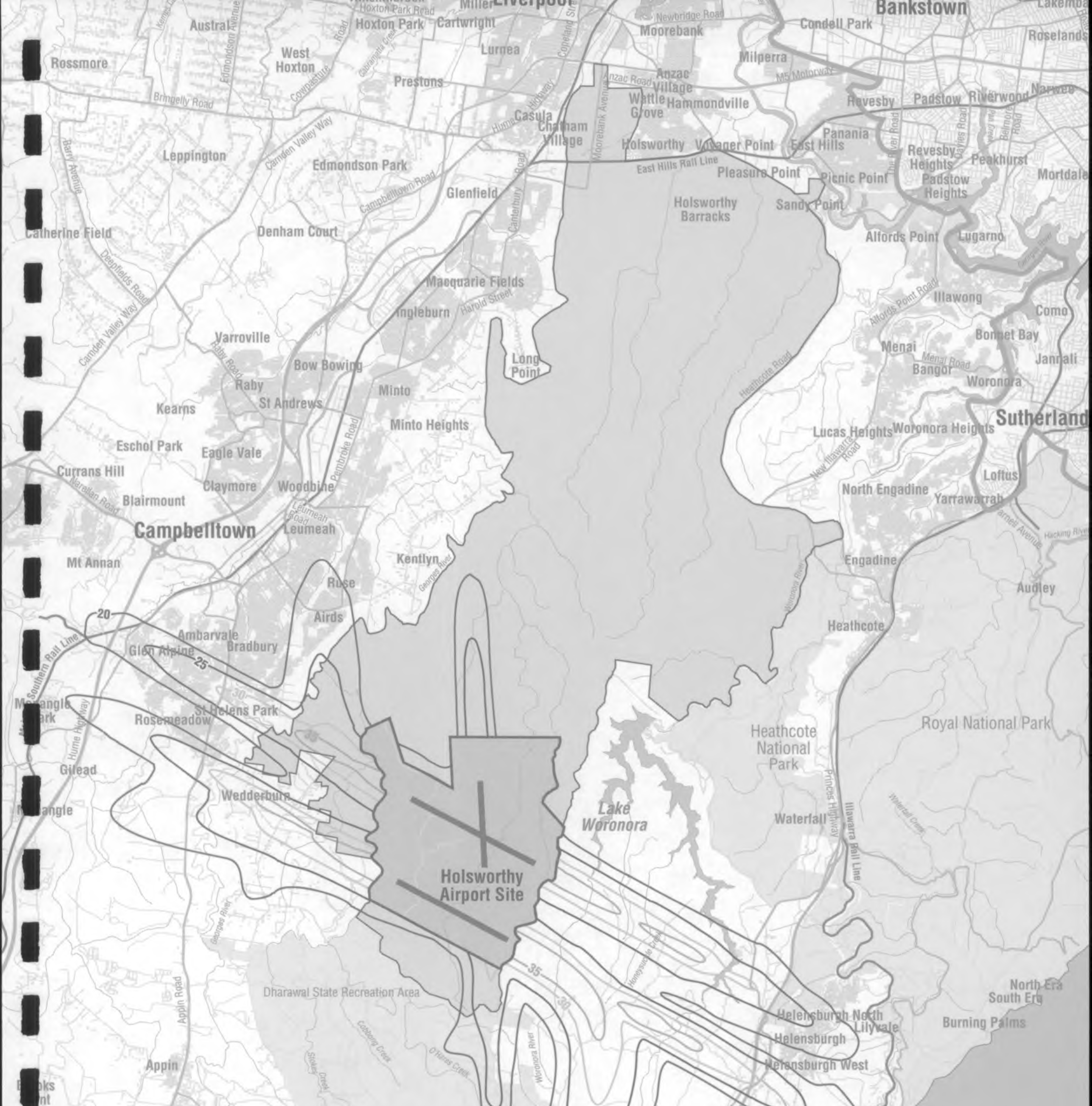


Figure 5.9

Modelled Maximum 2006 ANEC Contours for Holsworthy Option B



Indicates Density of Dwellings in 1996

Extent of Dwelling Data

Figure 5.10

Modelled Maximum 2016 ANEC Contours for Holsworthy Option B

TN MN N

0Km 5Km

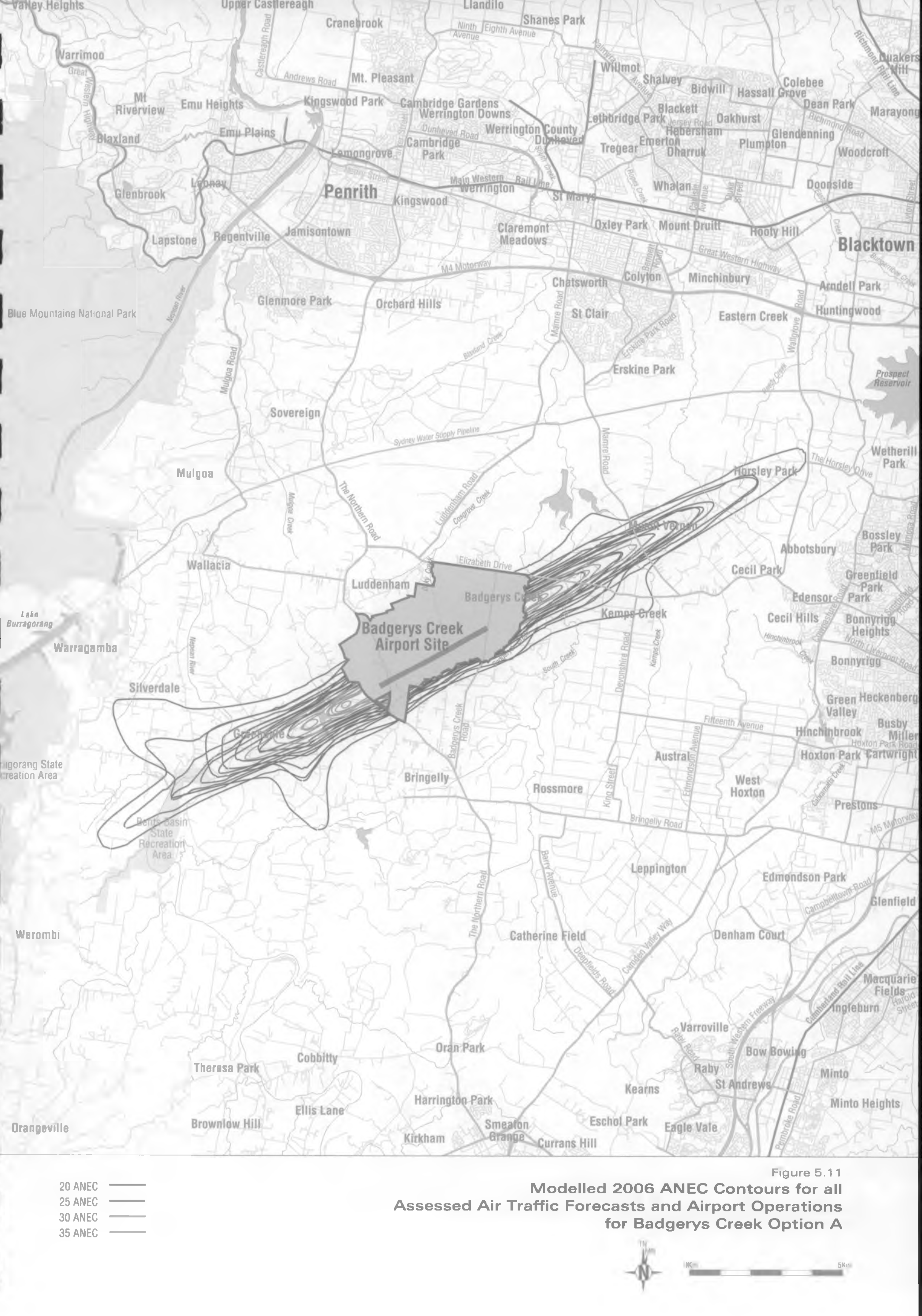


Figure 5.11
Modelled 2006 ANEC Contours for all Assessed Air Traffic Forecasts and Airport Operations for Badgerys Creek Option A

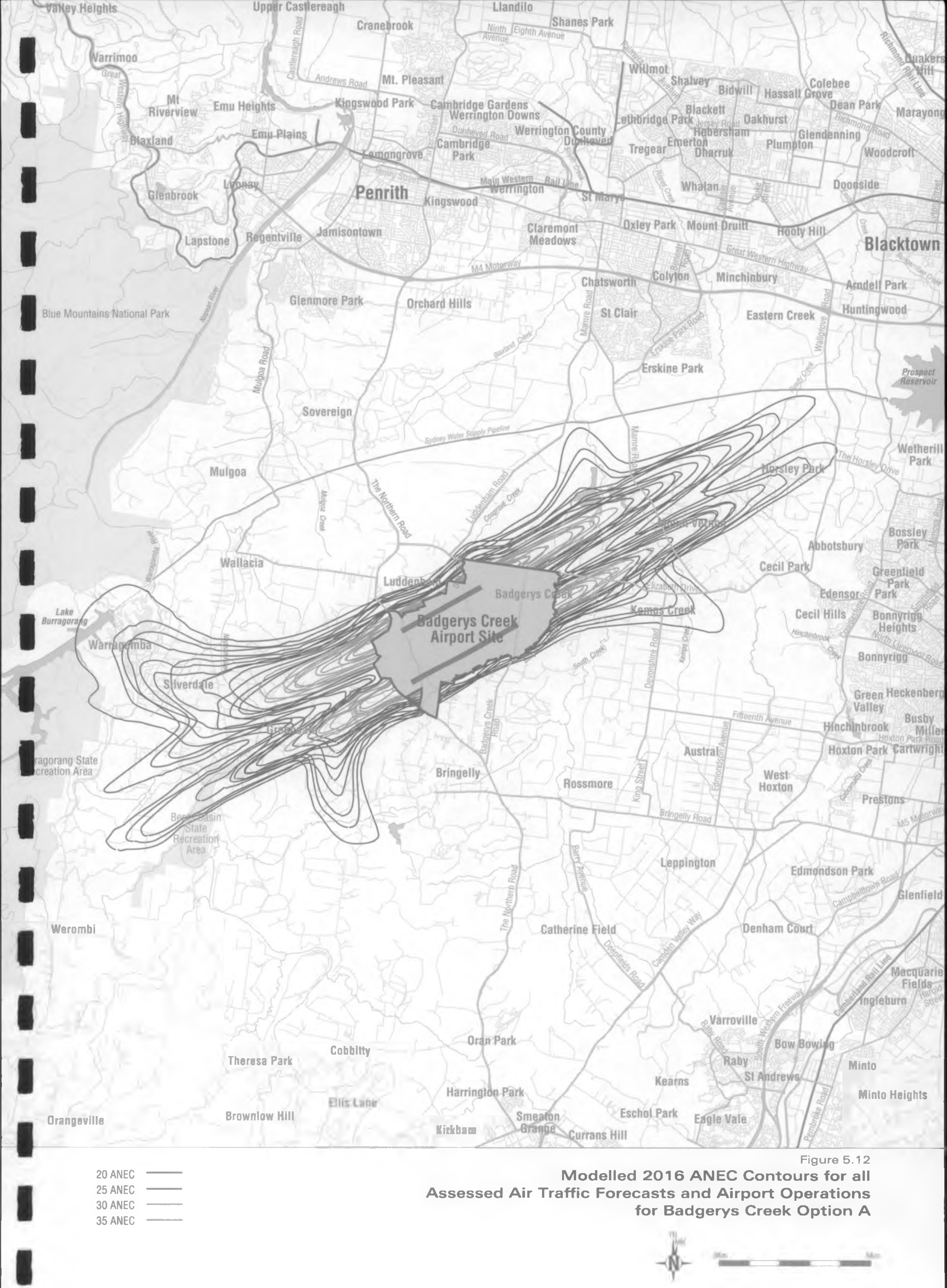


Figure 5.12

Modelled 2016 ANEC Contours for all Assessed Air Traffic Forecasts and Airport Operations for Badgerys Creek Option A

20 ANEC
25 ANEC
30 ANEC
35 ANEC

Figure 5.13

Modelled 2006 ANEC Contours for all Assessed Air Traffic Forecasts and Airport Operations for Badgerys Creek Option B

Indicates Density of Dwellings in 1996
Extent of Dwelling Data
20 ANEC
25 ANEC
30 ANEC
35 ANEC

Figure 5.14

Modelled 2016 ANEC Contours for all Assessed Air Traffic Forecasts and Airport Operations for Badgerys Creek Option B

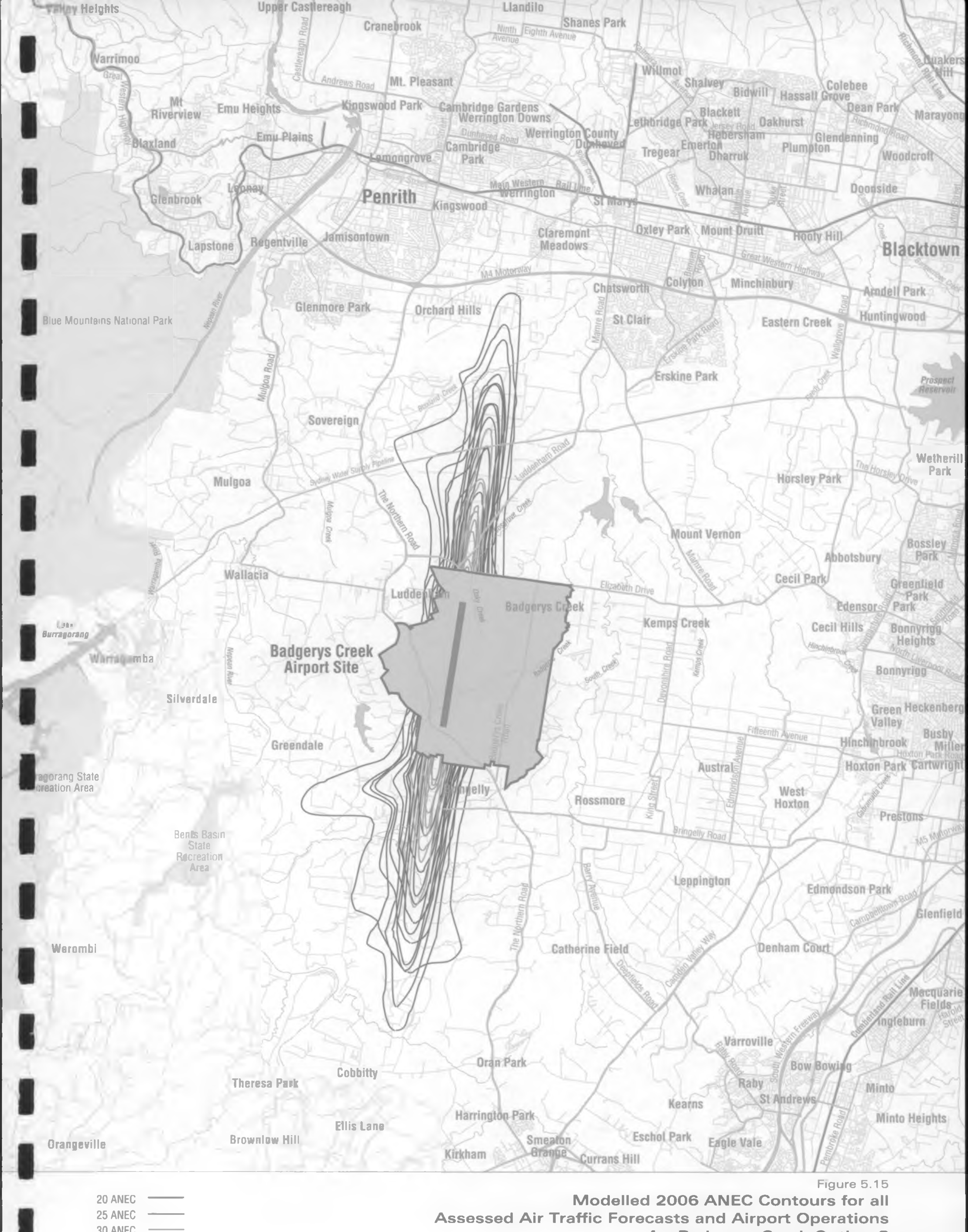
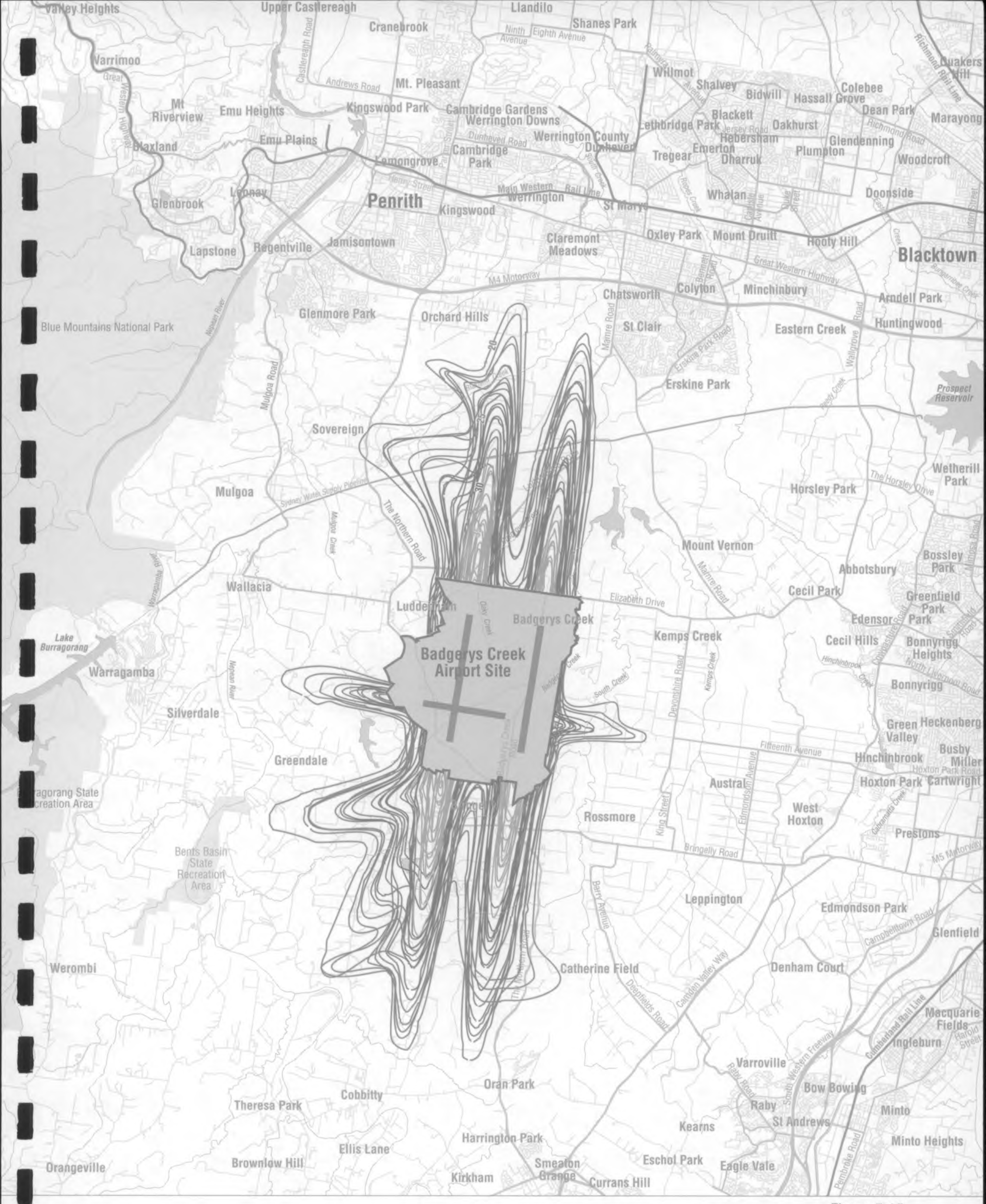


Figure 5.15
Modelled 2006 ANEC Contours for all Assessed Air Traffic Forecasts and Airport Operations for Badgerys Creek Option C



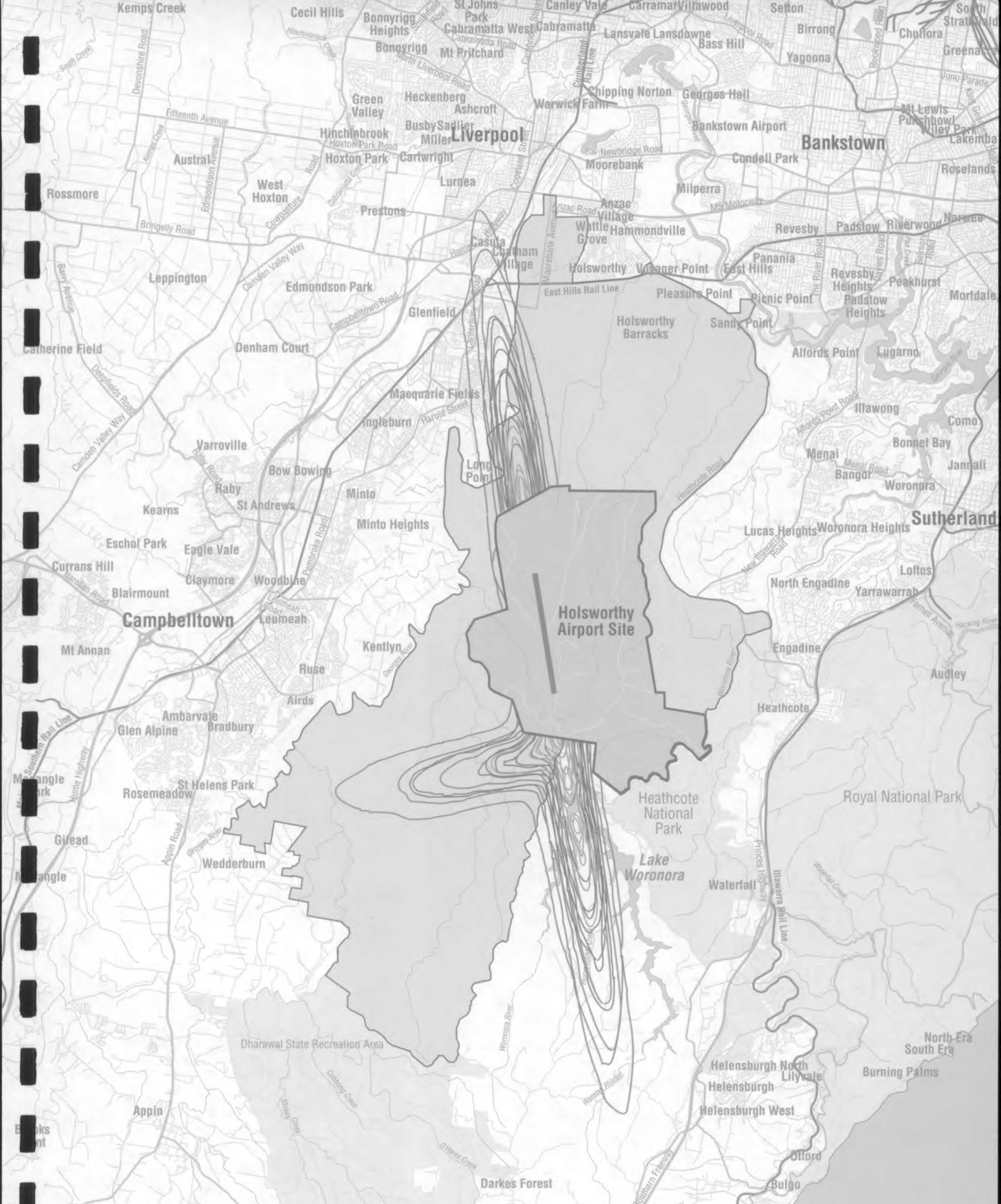
20 ANEC
25 ANEC
30 ANEC
35 ANEC

Figure 5.16

Modelled 2016 ANEC Contours for all Assessed Air Traffic Forecasts and Airport Operations for Badgerys Creek Option C

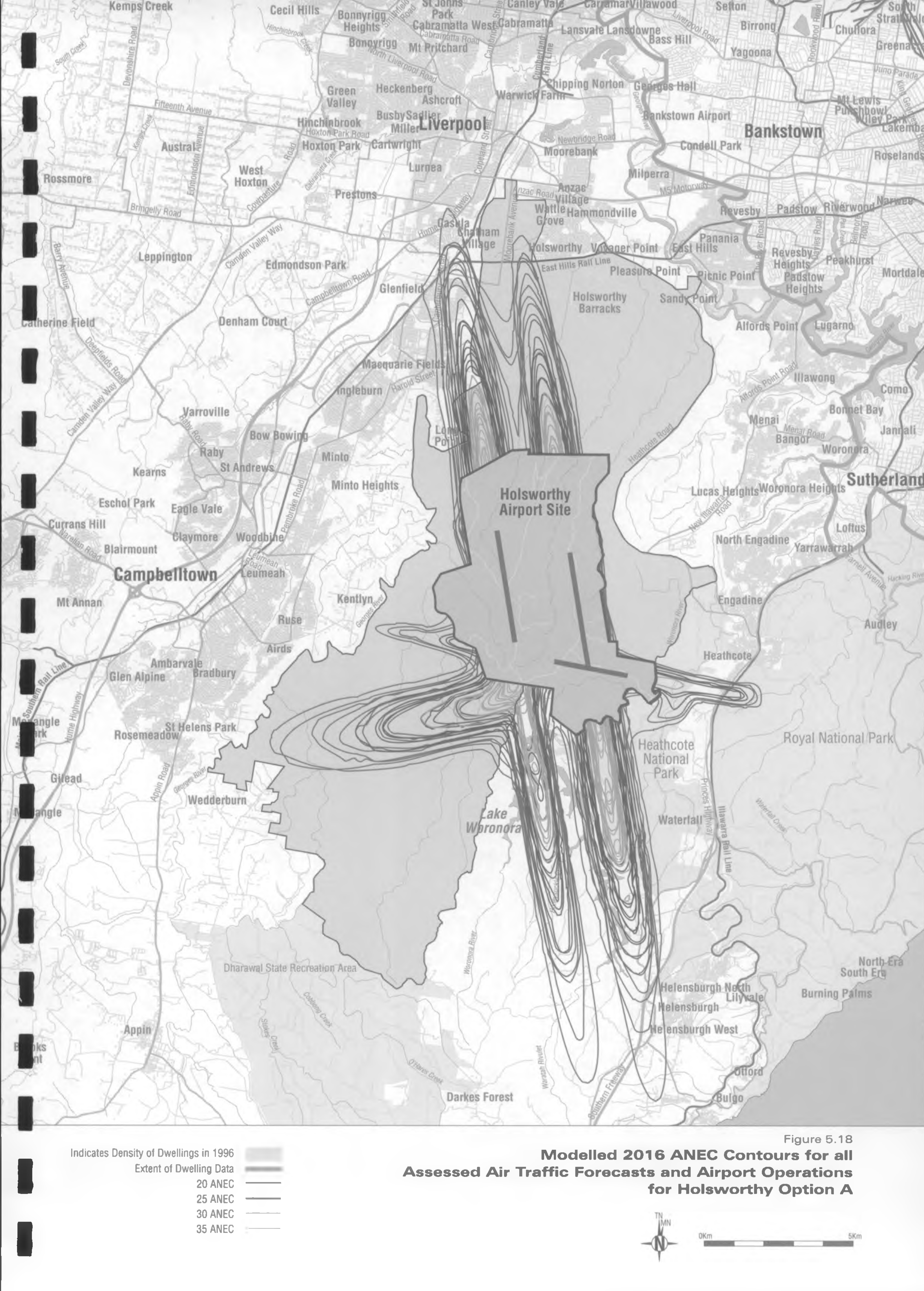
TN MN N

0Km 5Km



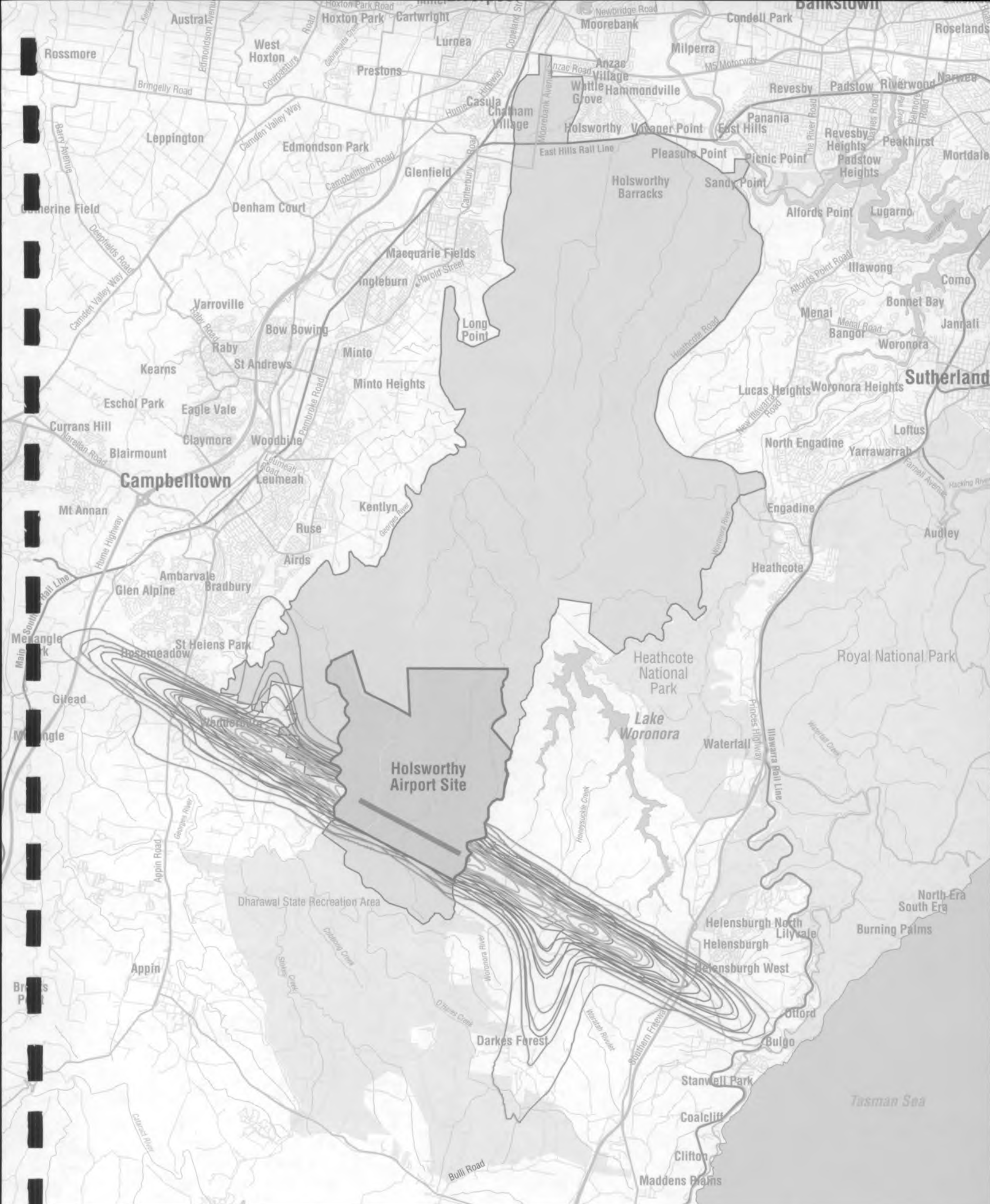
20 ANEC
25 ANEC
30 ANEC
35 ANEC

Figure 5.17
Modelled 2006 ANEC Contours for all Assessed Air Traffic Forecasts and Airport Operations for Holsworthy Option A



Indicates Density of Dwellings in 1996
Extent of Dwelling Data
20 ANEC
25 ANEC
30 ANEC
35 ANEC

Figure 5.18
Modelled 2016 ANEC Contours for all Assessed Air Traffic Forecasts and Airport Operations for Holsworthy Option A



20 ANEC
25 ANEC
30 ANEC
35 ANEC

Figure 5.19
Modelled 2006 ANEC Contours for all Assessed Air Traffic Forecasts and Airport Operations for Holsworthy Option B

TN MN N

0Km 5Km

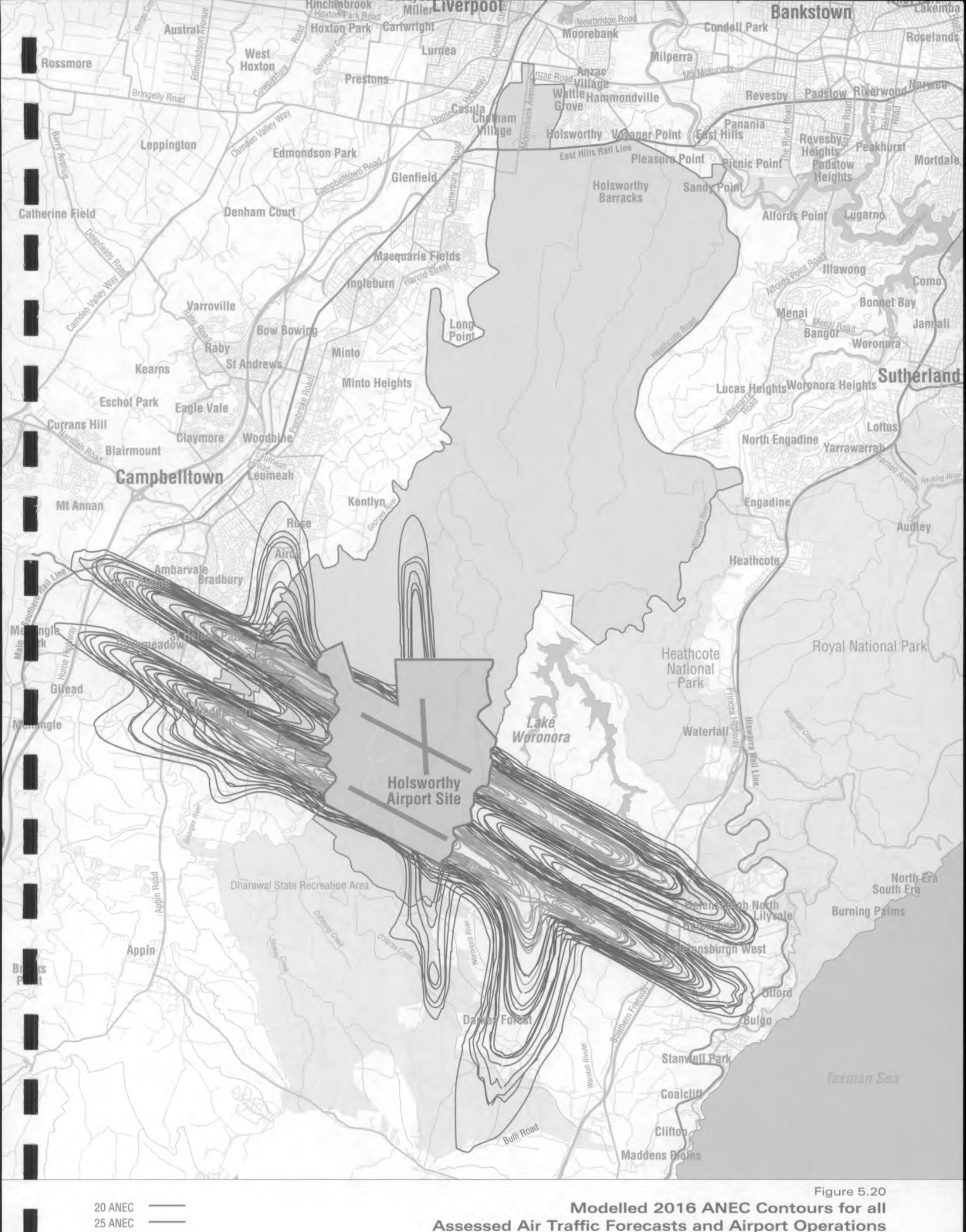


Figure 5.20
Modelled 2016 ANEC Contours for all Assessed Air Traffic Forecasts and Airport Operations for Holsworthy Option B

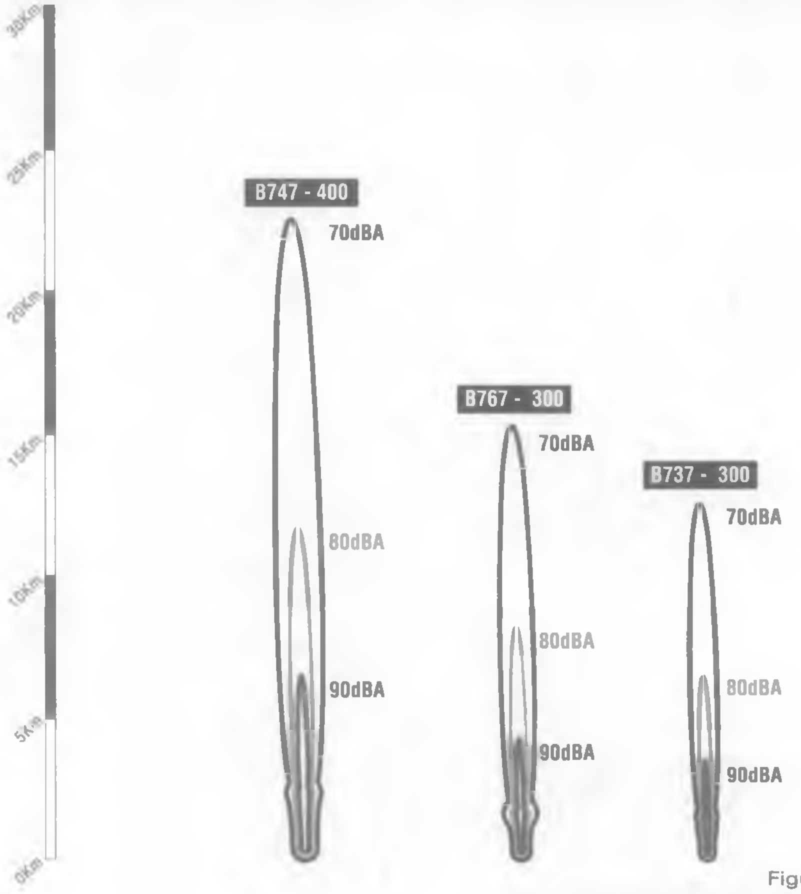


Figure 5.21

Single Noise Event Arrival Contours for some Typical Aircraft

Source: Department of Transport and Regional Development

Note: Modelling assumptions based on the Sydney Airport Long Term Operating Plan ANEC assumptions

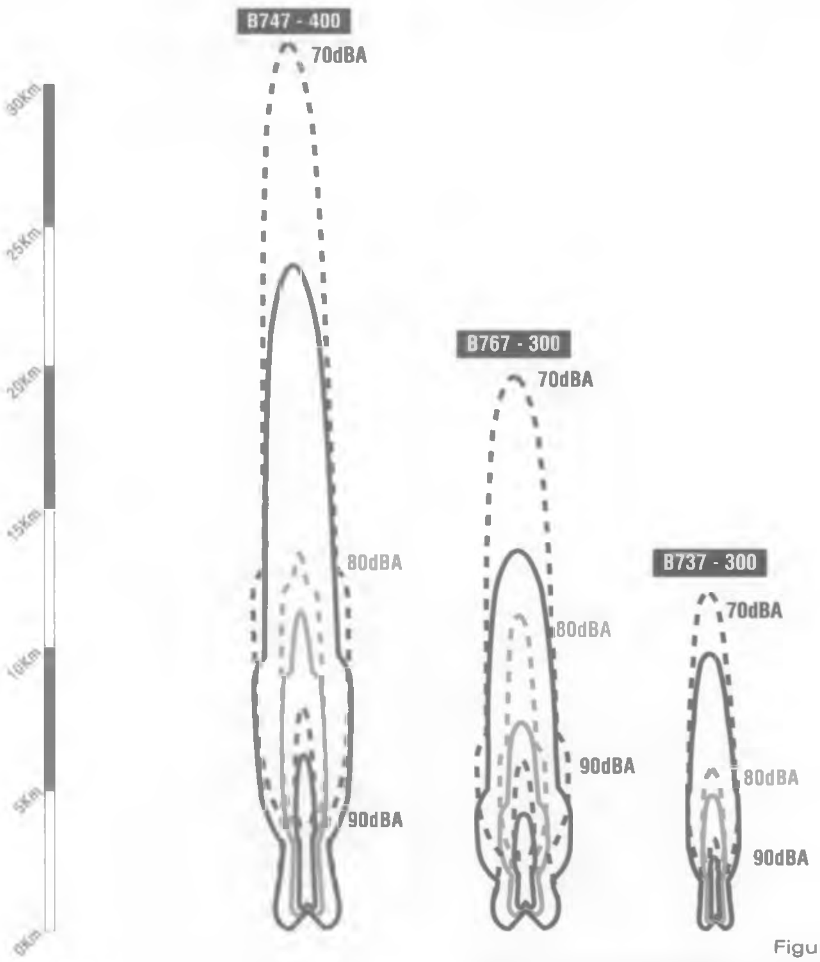


Figure 5.22

Single Noise Event Departure Contours for some Typical Aircraft

Source: Department of Transport and Regional Development

Note: Modelling assumptions based on the Sydney Airport Long Term Operating Plan ANEC assumptions

2006
2016
Urban Areas (indicated by local roads)

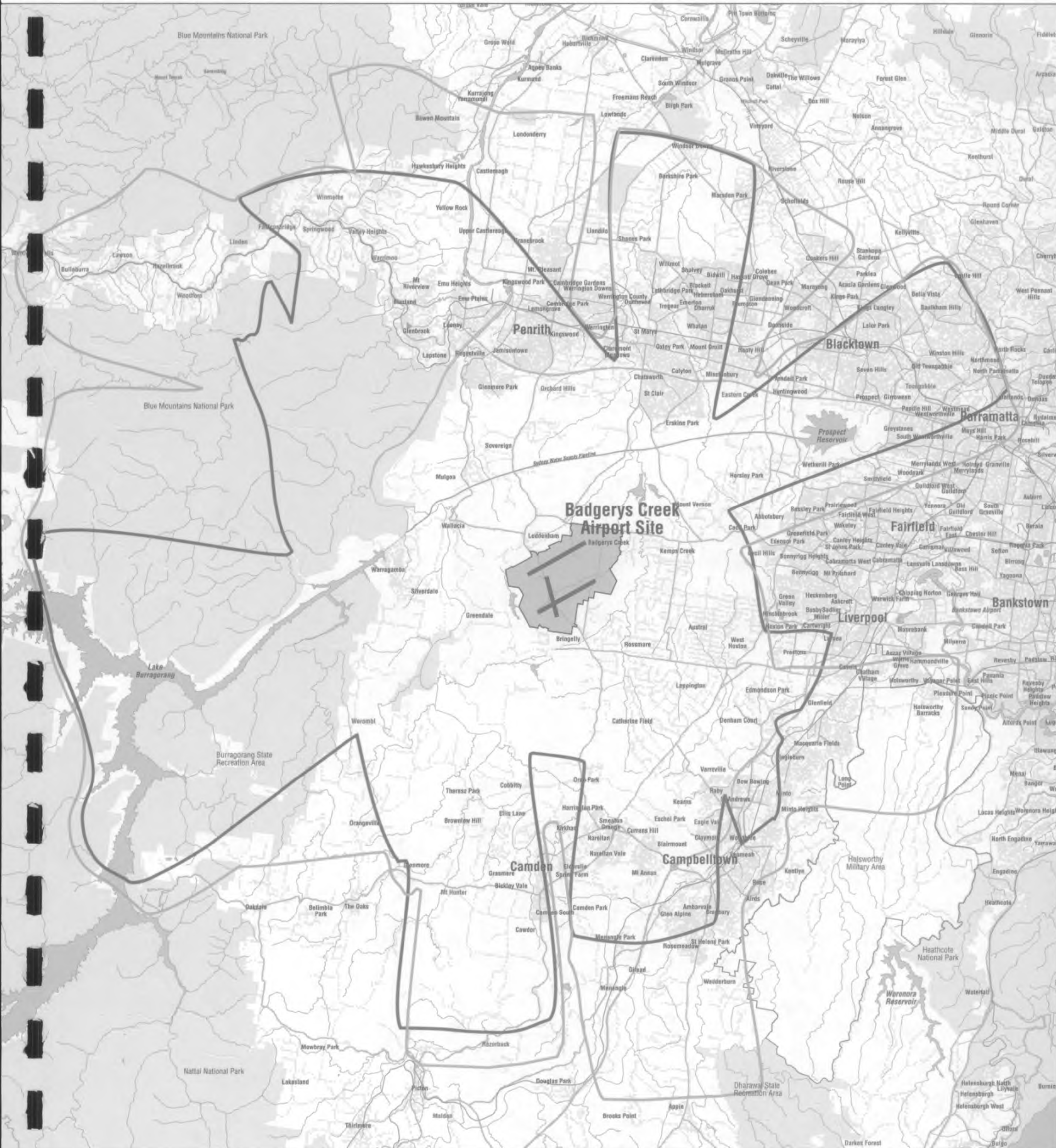
Figure 5.23

70 dBA Contour (747-400)for Badgerys Creek Option A

Note: Shows an amalgamation of 70dBA contours that would be generated by a 747-400 aircraft in 2006 and 2016 on all of the defined flight paths. Only a small part of the area shown would be affected by a single movement of a 747-400 aircraft movement. Some areas within this contour would rarely experience this level of noise.

TN

0Km 10Km 20Km



2006
2016
Urban Areas (indicated by local roads)

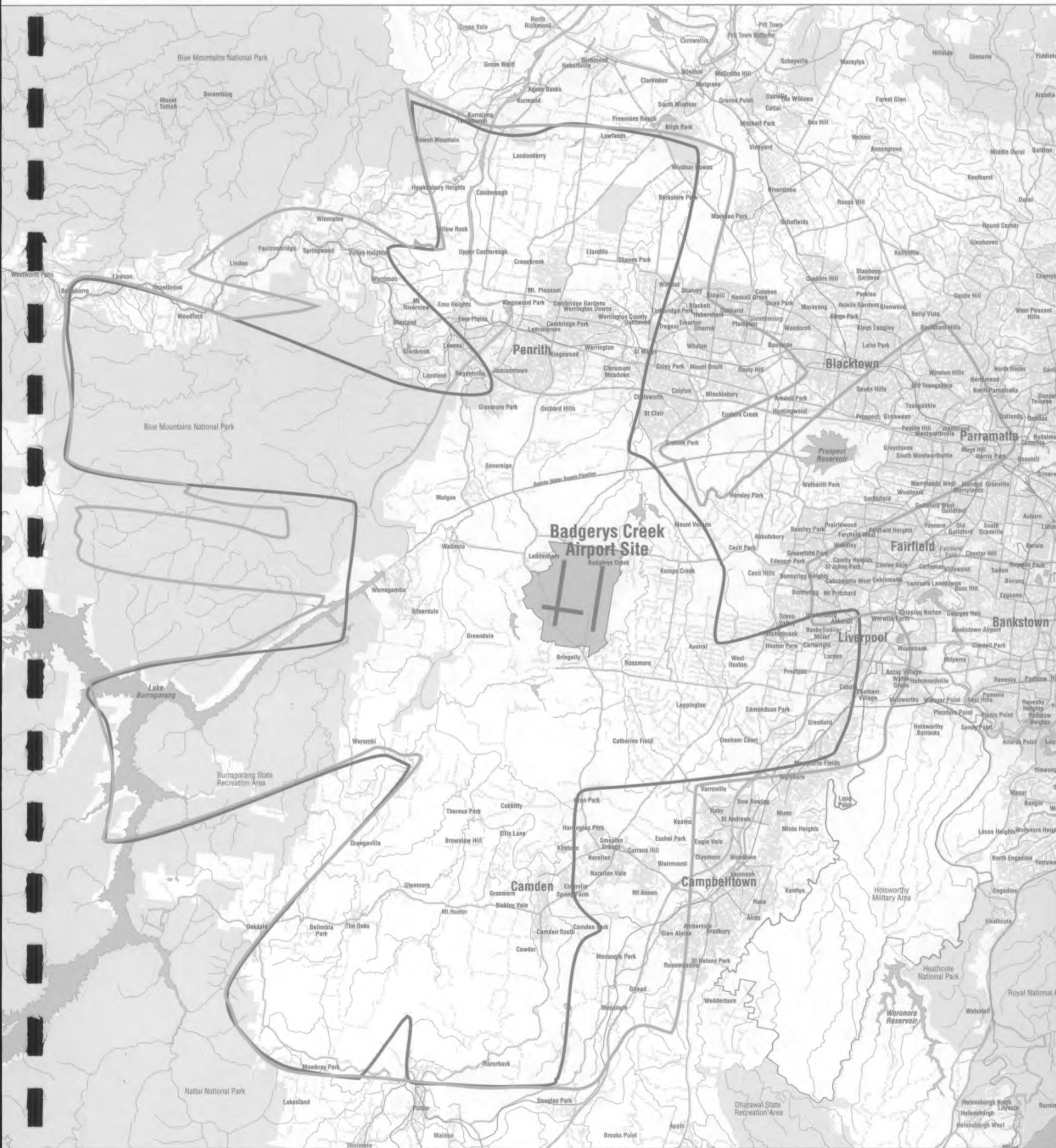
Figure 5.24

70 dBA Contour (747-400) for Badgerys Creek Option B

Note: Shows an amalgamation of 70dBA contours that would be generated by a 747-400 aircraft in 2006 and 2016 on all of the defined flight paths. Only a small part of the area shown would be affected by a single movement of a 747-400 aircraft movement. Some areas within this contour would rarely experience this level of noise.

TN

0Km 10Km 20Km



2006
2016
Urban Areas (indicated by local roads)

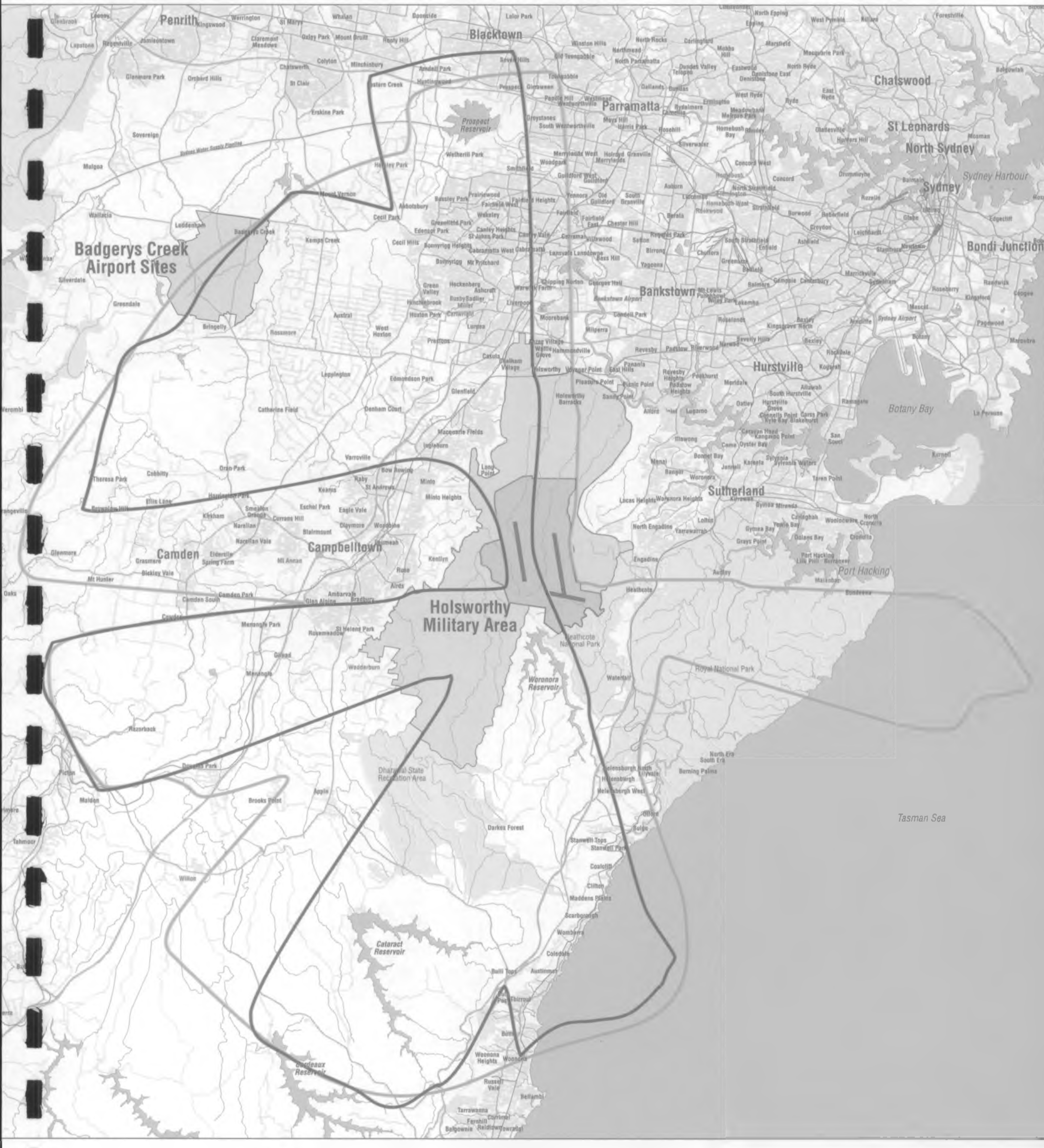
Figure 5.25

70 dBA Contour (747-400) for Badgerys Creek Option C

Note: Shows an amalgamation of 70dBA contours that would be generated by a 747-400 aircraft in 2006 and 2016 on all of the defined flight paths. Only a small part of the area shown would be affected by a single movement of a 747-400 aircraft movement. Some areas within this contour would rarely experience this level of noise.

TN

0Km 10Km 20Km



2006

2016

Urban Areas (indicated by local roads)

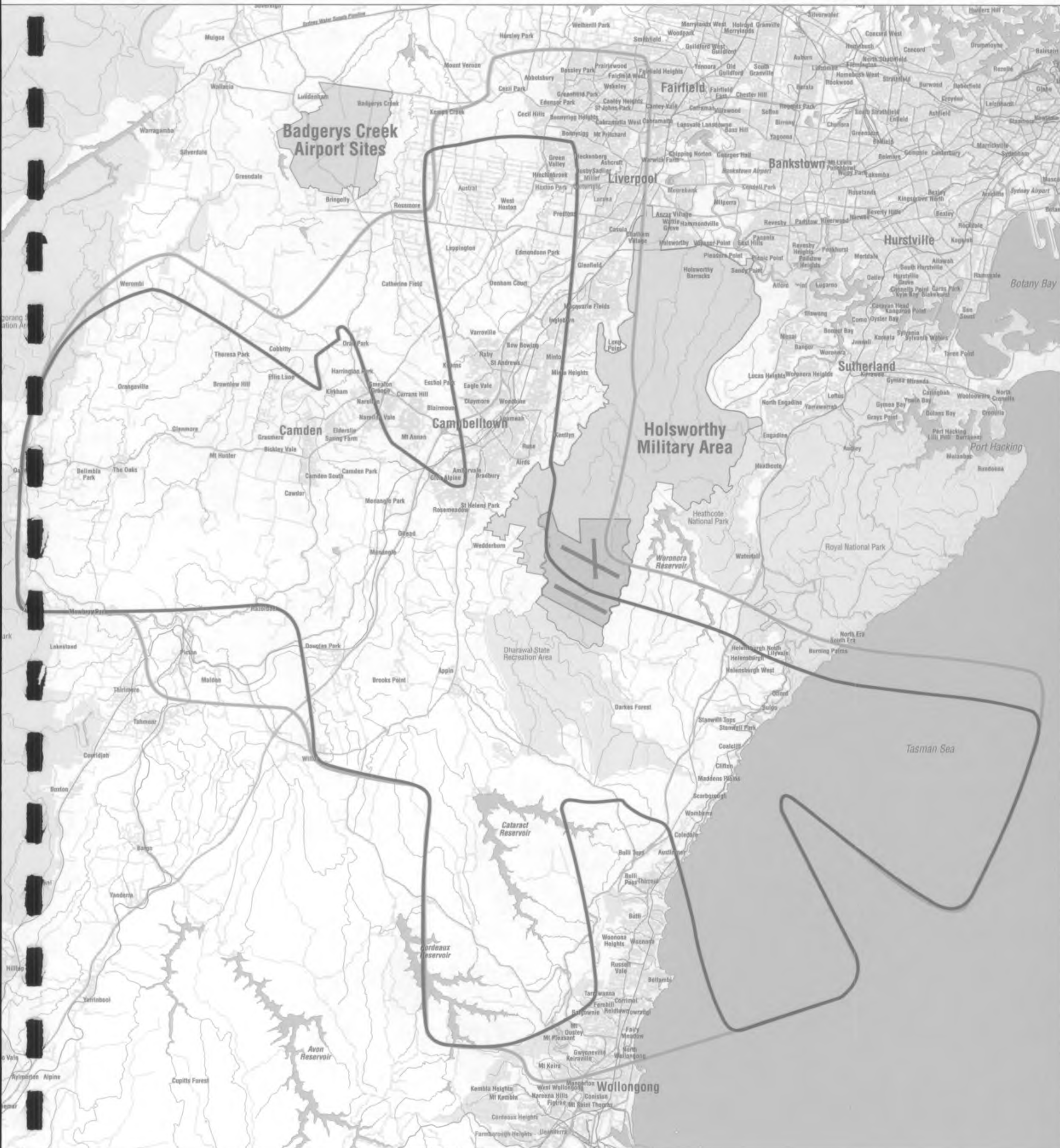
Figure 5.26

70 dBA Contour (747-400) for Holsworthy Option A

Note: Shows an amalgamation of 70dBA contours that would be generated by a 747-400 aircraft in 2006 and 2016 on all of the defined flight paths. Only a small part of the area shown would be affected by a single movement of a 747-400 aircraft movement. Some areas within this contour would rarely experience this level of noise.

TN

0Km 10Km 20Km



2006
2016
Urban Areas (indicated by local roads)

Figure 5.27

70 dBA Contour (747-400) for Holsworthy Option B

Note: Shows an amalgamation of 70dBA contours that would be generated by a 747-400 aircraft in 2006 and 2016 on all of the defined flight paths. Only a small part of the area shown would be affected by a single movement of a 747-400 aircraft movement. Some areas within this contour would rarely experience this level of noise.

TN

N

0Km 10Km 20Km

- the average number of noise events during school hours (9.00 am - 3.00 pm) exceeding a conversation disturbance criterion of 65 dBA; and
- the value of the Sleep Disturbance Index, a measure of likely interference with sleep, which is described below.

Calculations for the various time periods relied on information from the Second Sydney Airport Planners, on expected numbers of movements during these periods. In the case of operations during the sleep period, initial calculations were based on numbers of operations produced under the assumption that there would be no curfew at the Second Sydney Airport. Introduction of a curfew is discussed below as a possible noise mitigation measure.

As for noise level contours, in each case there would be a range of possible values for the noise descriptor, depending on the air traffic forecast and airport operation scenario. These in turn depend on Government policy regarding the transfer of operations to the Second Sydney Airport and regarding runway usage at the airport.

Results of these calculations for each Community Assessment Area are presented in *Volumes 3* to *8* of this Technical Paper. These results should be interpreted as approximate because many details regarding air traffic and operations at the proposed Second Sydney Airport are not known at this stage. Further to this, noise level estimates in the outer areas, less than approximately 20 ANEC, are subject to some uncertainties as a result of uncertainties regarding aircraft performance and noise propagation under varying weather conditions.

5.2 ASSESSMENT OF AIRCRAFT OVERFLIGHT NOISE

The relationship between the response of a community affected by aircraft noise and the noise itself is complex. The noise is intermittent in nature and the amount of noise can vary from day to day, depending upon airport runway use. Further to this, social surveys have found a large variation in individual response to noise, some people being highly sensitive to noise whilst others are relatively insensitive (Hede and Bullen, 1992; Conner and Patterson, 1972).

The main purpose of the following discussion is to describe impacts on the community resulting from aircraft noise, where possible in quantitative terms, allowing interpretation of the aircraft overflight noise levels discussed above, and considering the overall impact of overflight noise.

More detail regarding the effect of aircraft overflight noise on residential communities, and in particular the potential for health effects is provided in *Volume 2* of this Technical Paper.

5.2.1 SLEEP DISTURBANCE

Apart from the consideration of the benefits of a nighttime curfew in *Section 5.5* of this Technical Paper, assessment of noise impacts is based on the assumption that the Second Sydney Airport would operate on a 24 hour basis. However, based on studies of other curfew free airports conducted by the Second Sydney Airport Planners (1997b), nighttime movements are predicted to be significantly less frequent than daytime movements, due to lower demand. These forecasts have been incorporated into calculated nighttime noise levels as described in *Section 5.1*.

Because of the significant community concern regarding disturbance to sleep and potential related health effects, any effect that aircraft noise may have upon quality of sleep is an important factor in the assessment of the noise impact.

Common descriptors of aircraft noise based on the equal energy principle, such as ANEC and L_{Aeq}, have been found to correlate relatively poorly with sleep disturbance. A significant amount of research into noise induced sleep disturbance over recent years has identified the following factors as contributing to the degree of disturbance:

- maximum noise levels of individual noise events;
- number of noise events;
- the 'emergence' of the maximum noise levels above the general ambient noise; and
- the duration of the individual noise events.

The sleep disturbance caused by noise is discussed in more detail in *Volume 2* of this Technical Paper.

An assessment methodology for sleep disturbance due to intermittent noise has been proposed by Griefahn (1992), based on research data on numbers of awakenings due to various types of noise. However, this has the drawback that it applies only to a series of events all having the same noise level.

A method for the assessment of sleep disturbance using a descriptor termed Sleep Disturbance Index has recently been developed by Bullen, Hede and Williams (1996). The Sleep Disturbance Index is numerically equivalent to the estimated average number of noise induced awakenings during one night. The method assumes, at least for low numbers of events, that the number of noise induced awakenings is proportional to the number of noise events.

Bullen, Hede and Williams (1996) summarise previous research into sleep disturbance to produce the graph shown in *Figure 5.28*. This shows the relationship between the maximum noise level of a noise event, measured within the bedroom, and the expected number of awakenings per 100 such events during the sleeping period.

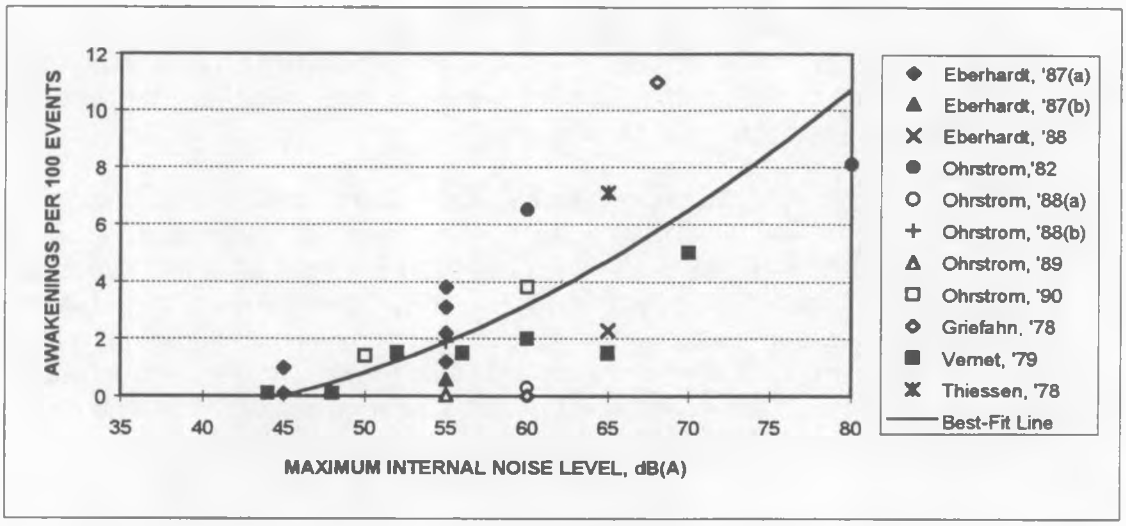


FIGURE 5.28 PROBABILITY OF AWAKENING - RESULTS OF 11 STUDIES
Source: Bullen, Hede and Williams (1996)

These data are combined with results related to the 'emergence' of noise events from the ambient noise level to give an estimate of the mean number of awakenings resulting from an arbitrary set of noise events in a given existing environment. The Sleep Disturbance Index can thus be used quite generally to describe the level of sleep disturbance due to intermittent nighttime noise.

In this analysis, it is assumed that dwellings would have external bedroom windows open at night. Under these circumstances, internal noise levels within the bedroom can be expected to be approximately 10 dB below external levels.

Although the Sleep Disturbance Index provides a method of comparing the level of sleep disturbance at various locations and for various airport operational conditions, there are as yet no firm guidelines or criteria for direct assessment of acceptability. The impacts of aircraft overflight noise on sleeping patterns, however, need to be considered in the context of current understanding of sleeping patterns which indicate that, on average, people have about 1.5 awakenings each night for reasons unrelated to noise (Bullen, Hede and Williams, 1996).

Volumes 3 to *8* of this Technical Paper, which gives the results of noise calculations for the Community Assessment Areas, provides the Sleep Disturbance Indices calculated at all locations. Again, these indices are given as a range.

5.2.2 CONVERSATION DISTURBANCE

Aircraft overflight noise has the potential to disturb aural communication within residential areas, within schools, within churches, within commercial buildings and in some public buildings where communication is important. Most of this communication occurs within the building, but some occurs in outdoor areas, such as residential backyards and at outdoor sporting facilities.

Within the domestic environment, the disturbance could take the form of interference with conversation, television viewing, radio listening or telephone conversation. Such interference can be addressed by considering the likely disturbance to conversation.

A number of laboratory studies have been carried out into speech interference by intruding noise. The results of these studies are best summarised in *Figure 5.29* which has been extracted from the *Handbook of Noise Control* (Webster, 1979). This figure shows the degree of communication possible during a range of levels of intruding noise for different voice efforts (from a normal voice through to a shout). In addition, the figure also shows the effect of the natural raising of the normal voice in the presence of an intruding noise.

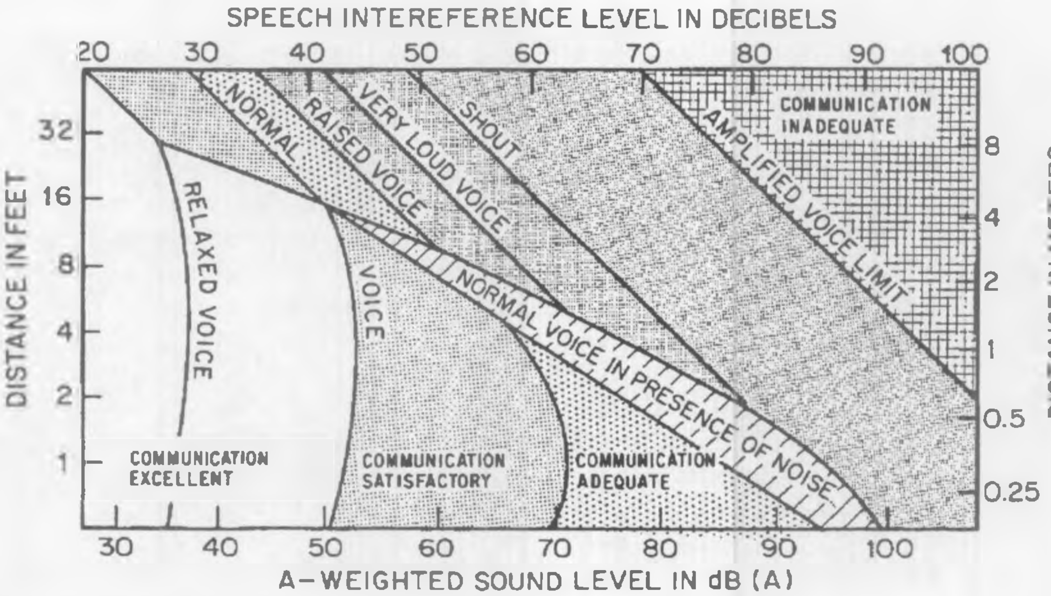


FIGURE 5.29 SPEECH INTERFERENCE BY INTRUDING NOISE

Note: Permissible distance between a talker and listener, not facing each other, for various voice levels. The distance is plotted as a function of the A-weighted sound level (along the lower horizontal axis) and the speech interference level (along the upper horizontal axis). If the talker and listener are facing each other, a background noise level of 5 dB greater than that indicated is permissible.

In particular, analysis of the figure reveals that a normal voice (inside) provides satisfactory communication at a distance of two metres with an intruding background noise level of 60 dBA. A raised voice will provide the same standard in the same background noise at a distance of four metres. Since a television is commonly set to a level similar to a raised voice and a radio is often set to a level of a raised voice or higher, 60 dBA represents the level at which intruding aircraft noise begins to cause significant disturbance to aural communication in domestic situations.

For indoor communication in domestic situations with windows open, the 60 dBA internal level is equivalent to an outdoor level of approximately 70 dBA. Of course, for outdoor communication the external level of 60 dBA is the relevant level. The degree of disturbance to aural communication from aircraft overflights would depend upon the number of times and the duration, for which aircraft noise levels exceed 70 dBA outside for indoor communication and 60 dBA outside for outdoor communication. Since each overflight produces near maximum noise levels for a few seconds, depending upon the height and speed of the aircraft, the number of aircraft movements with maximum levels exceeding these values would generally indicate the degree of disturbance.

Although these levels have been determined for domestic situations, they are generally applicable to other situations such as commercial premises and libraries where windows are left open. For those buildings, mainly commercial buildings and public buildings, where windows are kept or fixed closed, higher external noise levels are appropriate for the assessment of communication disturbance.

For some more acoustically sensitive buildings, lower noise level thresholds from aircraft overflights are appropriate for assessment of communication disturbance. In classrooms and churches, speakers normally use a raised voice and the following maximum aircraft noise levels would just allow communication over the distances indicated:

- classrooms - eight metres 55 dBA; and
- churches - 20 metres 50 dBA.

These levels represent appropriate communication disturbance thresholds for people with normal hearing.

Aircraft noise levels at which communication would become difficult are summarised in *Table 5.1*.

TABLE 5.1 MAXIMUM NOISE LEVELS USED FOR ASSESSMENT OF DISTURBANCE TO COMMUNICATION

Building Space and Activity	External Noise Level Criterion to Ensure Acceptable Communication
Residence, inside	70 dBA
Residence, outside	60 dBA
Commercial Building, Public Building, etc - open windows	70 dBA
Commercial Building, Public Building, etc. - closed windows	80 dBA[1]
School Classroom	65 dBA
Church	60 dBA

Note: 1: Approximate - depends on glazing type.

The internal noise levels discussed above for residences, classrooms and churches are the same as those recommended in *Australian Standard 2021-1994* for normal domestic areas within houses, teaching areas within schools and churches. The levels recommended in the Australian Standard for commercial buildings - 55 dBA for a private office and 65 dBA for an open office - are generally consistent with the 60 dBA internal noise level suggested as a commercial noise level threshold.

The number of events above a range of maximum dBA levels provided in the Community Assessment Areas results in *Volumes 3* to *8* can assist in the interpretation of the degree of communication disturbance. The number of events exceeding the levels in *Table 5.1* give an indication of the overall disturbance.

5.2.3 ANNOYANCE

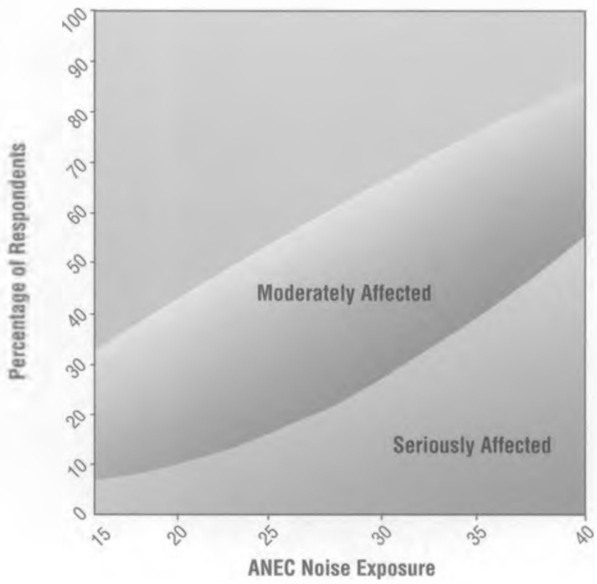
The effect of aircraft overflight noise can, in part, be measured by the degree of annoyance caused within residential communities. This is generally assessed using social survey techniques, by asking respondents to rate how much they are 'annoyed' or 'affected' by aircraft noise in their area. In such studies, it is consistently found that there is a high degree of individual variation in residents' reaction to aircraft noise for the same noise level. For this reason, results are generally quoted in terms of the proportion of people experiencing a particular level of reaction.

The National Acoustic Laboratories (Hede and Bullen, 1982) carried out a major survey of community reaction around Australian airports. The survey was conducted within communities affected by noise from Sydney Airport, Richmond RAAF Base, Adelaide Airport, Perth Airport and Melbourne Airport. The two major results from the study were:

- in assessing annoyance due to aircraft noise, 'equal energy' units (such as ANEF and L_{Aeq}) provide the most appropriate single measurement units. It was recommended that the weighting used for nighttime noise events in the then current NEF unit be reduced, and extended to cover evening and nighttime, resulting in the formulation of the unit known as ANEF; and
- the relationship between ANEF levels and the proportion of people who could be described as 'seriously affected' and 'moderately affected' by aircraft noise is as shown in *Figure 5.30* (from *Australian Standard 2021-1994*).

Around major airports the majority of the population perceive noise as disturbing at least some daily activities. Although large individual variation in reaction exists, relationships between the level of aircraft noise and people's reactions have been studied and conclusions drawn. The most accepted conclusions are based on the results of two major Australian studies of aircraft noise (Hede and Bullen, 1982; and Bullen, Job and Burgess, 1985). These studies led to the development of Australian Standard 2021-1994, from which the relationship shown in *Figure 5.30*, between ANEC levels and the proportion of people who could be described as 'serious affected' and 'moderately affected', is described.

Figure 5.30 has been developed from surveys of people living around existing Australian airports. It shows that people react differently to different levels of noise. For example, about 10 percent of respondents to the survey indicated they regarded themselves as being seriously affected and about 45



The above figure indicates the relationship between levels of community response to aircraft noise and the ANEC measure. People react differently to different levels of noise. In a study undertaken by the National Acoustic Laboratories approximately 10% of people regarded themselves as being seriously affected by noise and 45% regarded themselves as being moderately affected at a noise exposure of 20 ANEC. At 25 ANEC almost 20% of respondents were seriously affected and over 55% regarded themselves as moderately affected.

Figure 5.30

General Reactions to Aircraft Noise

Source: Australian Standard 2021

percent considered themselves moderately affected by noise exposure of 20ANEC. At 25 ANEC almost 20 percent considered themselves seriously affected and over 55 percent regarded themselves as moderately affected.

Although 20 ANEC is the lowest level generally plotted on contour maps, *Figure 5.30* shows that noise levels below this still have a significant effect on residential communities.

The likelihood of a negative reaction to aircraft noise is increased for people who have a negative attitude to the noise source (aircraft, the airport or airport authorities); for individuals who are fearful of the health and/or safety impacts of aircraft noise; for noise-sensitive individuals; and for those who view the noise as uncontrollable. Australian data suggests that older residents are less likely than younger residents to report negative reactions to the noise, although the effect of age is quite small.

Low frequency aircraft noise, particularly at high levels, can cause minor vibration of building components due to the resonant interaction with those components. Whilst the perception of this vibration is different from that of noise, the relationship shown in *Figure 5.30* accounts, in general, for this effect.

While adaptation to noise might be expected to occur, evidence suggests that only some responses to noise adapt with time. The orienting response and some sleep disturbances apparently adapt. However, many sleep effects and reaction (annoyance, etc) do not appear to adapt.

Evidence exists (Geoplan, 1992; Griffiths and Raw, 1986 and Brown, 1987) that communities with previous exposure to noise are likely to demonstrate lower reaction from a particular noise level than other communities without pre-exposure. The difference may well result from the fact that, over a period of time, residents who are more sensitive to noise tend to move out. The overall result is that the communities in the noise affected areas are generally less sensitive to noise than those who choose to live in the quieter areas.

The studies noted above have estimated that there is a difference in sensitivity to noise between pre-exposed communities and newly exposed communities. The general findings are that this difference can be accounted for by a noise level difference in the vicinity of eight decibels. In the case of aircraft noise, this can be interpreted as a noise level difference in the vicinity of eight ANEC points.

Figure 5.31 demonstrates the likely relationship between ANEC and the percentage of people who may regard themselves as being seriously and moderately affected within those areas around a Second Sydney Airport where there would be an abrupt change in the noise environment. This figure has been prepared by adjusting *Figure 5.30* by eight ANEC points.

It cannot be assumed that the opening of a Second Sydney Airport would result in an abrupt change to the noise environment, since the number of aircraft movements at the airport is likely to increase gradually over a period of time. Nevertheless, the airport would result in a significant change in the noise environment over the medium term.

Following the opening of a Second Sydney Airport, it is likely that community reaction would fall somewhere between *Figure 5.30* and *Figure 5.31*. The research is unclear as to the time required for full adaptation of a community and therefore the time at which the community reaction would be generally in accordance with *Figure 5.30* is not fully known. When the second parallel runway and cross runway are constructed and commence operation, further communities would be newly affected by noise and, in this case, the buildup of noise would be faster than that following the opening of the first runway. Again, these newly affected communities are likely to demonstrate a reaction somewhere between *Figure 5.30* and *Figure 5.31*, ultimately changing to somewhere around that shown in *Figure 5.30* after time for adaptation.

Table 5.2 summarises the percentage of respondents that would be likely to be seriously and moderately affected by aircraft noise at a level of 20 ANEC around the proposed Second Sydney Airport. The percentage figures in this table have been extracted from *Figures 5.30* and *5.31*. They indicate the expected sensitivities of the surrounding populations to noise given the likely change in sensitivity with time as the population adjusts to noise exposure.

TABLE 5.2 LIKELY REACTION TO AIRCRAFT NOISE AT 20 ANEC

	Percentage of Population Moderately Affected	**Percentage of Population Seriously Affected**
2006	67%	28%
2016[1]	45%	12%

Note: 1. These percentages apply to communities affected by the first parallel runway.

5.2.4 EFFECTS OF AIRCRAFT NOISE ON WILDLIFE

There is limited knowledge regarding the effects of noise on wildlife in view of the diverse reaction across the different species that may be encountered and the different levels and character of noise likely to be experienced. A book edited by Fletcher and Busnell (1978) is one of the most relevant documents regarding this subject. The book is based on a 1971 Symposium of the *Effects of Noise on Wildlife and Other Animals* for the US Environment Protection Agency. The book is in fact a compilation of several papers.

It is very difficult to speak in general terms regarding noise effects on animals. There are numerous species of birds, insects, mammals and others and these vary greatly in psychology, habitat and behavioural patterns. Throughout this diverse group, the most important effect of noise would be masking of communication signals. However, interference with mating is also a major issue, depending upon whether the prime reliance is on hearing, as opposed to sight and scent.

In interpreting the effect of human made noise upon wildlife, it should not be assumed that the natural environment is silent. For example, near a large waterfall a continuous loud noise is produced. Social noises are often very loud for species which live in dense and large colonies, for example, Sulphur Crested Cockatoos. Further, there are many examples in the literature of the adaptation of animals to high noise levels. Some examples are:

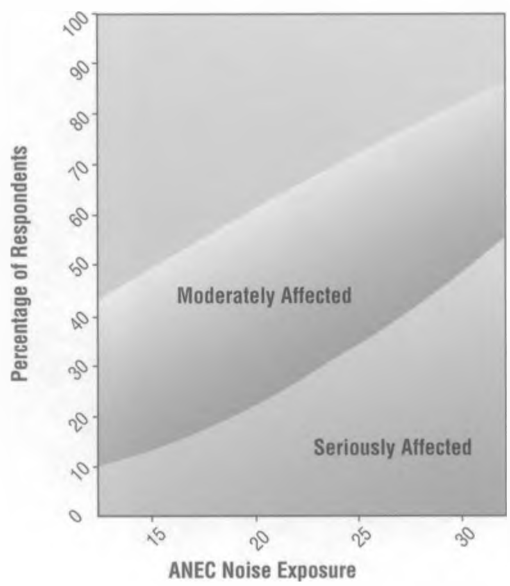


Figure 5.31
Reaction to Aircraft Noise in Newly Exposed Areas

- dolphins are often considered to be attracted to ships, including warships sailing at full speed;
- birds quickly adapt to explosive devices designed to frighten them from orchards and airport runways; and
- rats and mice often live in noisy subways and manufacturing plants.

A report to the US Congress prepared by the United States Department of Agriculture, Forest Service (1992) reports a literature search into the effects of aircraft overflights on wildlife. The findings of this literature search are summarised below.

The findings include the conclusion that invertebrates, fish, reptiles and amphibians are likely to be affected by aircraft noise to a minimal degree. However, few studies have been carried out relevant to this topic.

In respect of birds, some studies have reported effects on egg laying and reproduction due to human intrusion. Some birds have been found to avoid unpredictable noise, but appear to return after the noise has ceased. Overall, there appears to be little evidence that aircraft noise can affect bird reproduction.

Noise has been found to have some effect on some mammals. Rodents found at airports appear not to demonstrate any significant effect from high levels of noise, but have exhibited stress in laboratory tests involving high noise levels, although not necessarily effects on reproduction.

Carnivores are well known to respond intelligently to human intrusion, but the effect of aircraft noise on these animals is not properly understood. There is no evidence that the sleep of carnivores is disturbed by aircraft noise.

There have been a number of studies carried out into the effect of aircraft noise on large herbivores, including domestic animals. Although these studies have shown that these animals respond to aircraft noise, there is no evidence of an effect upon reproduction. Aircraft overflights at distances of 50 to 100 metres have resulted in response in these large animals, but the response falls off quickly with increasing distance.

Overall, studies have found that human intrusion and habitat destruction has had a profound impact on animals. It is therefore commonly assumed that aircraft overflights are equally damaging. However, the literature suggests that animals respond differently to aircraft overflights. Whilst overflights can be startling, animals often adapt to them very well under most circumstances.

None of the findings regarding wildlife reported here involve quantified noise levels. It can therefore be assumed that there is no known relationship between noise levels and wildlife behaviour.

In regard to domestic animals and birds, the research leads to the same conclusion that there is no known relationship between noise levels and behaviour. At high noise levels there is anecdotal evidence that horses may be affected and the same applies to domestic birds such as chickens and turkeys.

5.2.5 EFFECT OF AIRCRAFT NOISE ON ENJOYMENT OF NATURAL AREAS

The western and southern regions of Sydney contain and are adjoined by significant areas of natural bushland. They include national parks, state recreation areas and Sydney Water's protected catchment areas as shown in *Figure 5.32*. Noise from aircraft overflights associated with the proposed Second Sydney Airport has the potential to affect people who seek to enjoy the natural characteristics of these areas, although it is noted that access to Sydney Water's protected catchment areas is generally restricted.

The natural areas in question are visited, at least from time to time, by people primarily for the purpose of bush walking. Although it is unlikely that there would be many people within each area at any time, the people in question are endeavouring to engage in an experience which is close to nature and are likely to be more sensitive to noise than residents in normal domestic situations.

For the purposes of this environmental assessment, natural areas are those areas where nature predominates and there are few signs of human activity. In general, this implies that significant amounts of aircraft noise are not compatible with natural areas. For wilderness areas, the principle of 'natural quiet' has been advocated, particularly within the United States.

There is limited information regarding the impacts of aircraft overflight noise on visitors to wilderness areas. The most meaningful information is included in a report to the US Congress prepared by the United States Department of Agriculture Forest Service (1992). This report is a culmination of a number of investigations into a range of issues associated with aircraft overflights of wilderness areas, including noise impact.

United States Department of Agriculture Forest Service (1992) refers to a number of noise surveys carried out within wilderness areas and a number of social surveys to determine the response of visitors to aircraft noise. It reports the inferred relationship between percentage of visitors highly annoyed and the aircraft noise exposure in three of the wilderness areas studied. This information is then compared with recognised dose response relationships for residential exposure. A number of conclusions are drawn, the most relevant being:

- three of the most mentioned reasons for visiting natural areas (selected from a list of possible reasons) were experiencing peace and quiet, viewing scenic vistas without hearing sounds of civilisation and hearing the sounds of nature;
- for the same level of aircraft noise exposure, the prevalence of annoyance amongst respondents was greater than that of residential populations; and
- a theory based interpretation of the reactions of respondents to aircraft noise exposure suggests that people are approximately 10 dB less tolerant of noise in natural settings than in residential settings.

In relation to aircraft noise descriptors, the third conclusion does not automatically lead to a clear interpretation. It is likely that respondents in

Figure 5.32

Natural Areas Surrounding Airport Options

Source: National Parks and Wildlife Service and Sydney Water

wilderness setting are 10 dB less tolerant of noise than those pre-exposed populations whose response is indicated in *Figure 5.30*. This is roughly equivalent to the response indicated by *Figure 5.31* for previously unexposed populations.

5.2.6 EFFECTS OF NOISE ON HEARING

Relatively high noise levels can cause hearing loss after an extended period of exposure. This is particularly relevant in the work place where some work personnel are exposed to high noise levels for much of their working day.

Australian Standard 1269-1989 provides information which allows an assessment of the effects of noise exposure over a period of time on hearing performance. A constant level or an L_{Aeq} of 80 dBA during eight hours of each working day over a lifetime, is likely to result in a hearing impairment of approximately 2 dB in five percent of the population. This hearing impairment is measured at 4 kHz, which is one of the main frequencies affected by noise induced hearing loss. Tinnitus is unlikely to occur as a result of residential aircraft noise exposure.

The level of 80 dBA during an eight-hour day is equivalent (in terms of hearing loss prediction) to a level of 75 dBA over a 24 hour day. It would therefore follow that, to substantially avoid hearing loss in the population, an overall $L_{Aeq,\ 24\ hour}$ level less than 75 dBA would be required.

In some cases, levels of noise experienced in the home may add to those experienced in the workplace. The worst case would be represented by a worker in a noisy night shift occupation, who would also experience daytime aircraft noise at home. In this case, to avoid additive effects, exposure in the home may need to be limited to an $L_{Aeq,\ 24\ hour}$ level of 70 dBA.

This is generally consistent with the US Environmental Protection Agency's recommendation of 70 dBA $L_{Aeq,\ 24\ hour}$ as a maximum to avoid hearing loss within the community.

The $L_{Aeq,\ 24\ hour}$ levels predicted in this Technical Paper from a Second Sydney Airport can be compared with this level for assessment purposes.

5.2.7 URBAN LAND USE COMPATIBILITY

For the purpose of minimising the effect of aircraft overflight noise on future development in the vicinity of airports, it is important to avoid locating noise sensitive developments in noise affected areas. In Australia, planning decisions to implement this principle are generally guided by recommendations in *Australian Standard 2021-1994*.

Areas which are considered 'acceptable', 'conditional' and 'unacceptable' for various land uses are defined by this Standard in terms of the ANEF level for the site, which in the current study is estimated by the ANEC level for a particular scenario. Areas designated as 'conditional' are considered acceptable provided that internal noise levels within building spaces are controlled to within designated criteria through the use of acoustic treatment.

Areas designated as 'acceptable', 'conditional' and 'unacceptable' for various building types under this Standard are shown in *Table 5.3*.

TABLE 5.3 BUILDING SITE ACCEPTABILITY BASED ON ANEC ZONES[1]

Building Type	ANEC Zone of Site		
	Acceptable	Conditional	Unacceptable
House, home unit, flat, caravan park	<20 ANEC[2]	20 -25 ANEC[3]	>25 ANEC
Hotel, motel, hostel	<25 ANEC	25-30 ANEC	>30 ANEC
School, university	<20ANEC[2]	20-25 ANEC[3]	>25 ANEC
Hospital, nursing home	<20ANEC[2]	20-25 ANEC	>25 ANEC
Public building	<20ANEC[2]	20-30 ANEC	>30 ANEC
Commercial building	<25ANEC[1]	25-35 ANEC	>35 ANEC
Light industrial	<30ANEC	30-40 ANEC	>40 ANEC
Other industrial	Acceptable in all ANEC zones		

Source: Australian Standard 2021 - 1994.

Notes:
1. There will be cases where a building of a particular type will contain spaces used for activities which would generally be found in a different type of building (for example, an office in an industrial building). In these cases *Table 3.7* of AS2021-1994 should be used to determine site acceptability, internal design noise levels within the specific spaces should be separately determined.
2. The actual location of the 20 ANEC contour is difficult to define accurately, mainly because of variation in aircraft flight paths.
3. Within 20 ANEC to 25 ANEC, some people may find that the land is not compatible with residential or educational uses. Land use authorities may consider that the incorporation of noise control features in the construction of residences or schools is appropriate.

5.2.8 CUMULATIVE NOISE IMPACTS

As described in *Chapter 3*, the existing noise environment in areas likely to be affected by an airport at any of the proposed locations is typical of quiet rural or residential areas. The measured L_{90} background noise levels are typically less than 40 dBA during the daytime and less than 35 dBA at night. In such an environment, aircraft noise events at levels more than approximately 5 dB above the background level would often be audible. An event with a maximum level of 60 dBA would generally be the predominant source of external noise while it was present, although other intermittent sources such as local traffic may have similar or higher maximum levels.

Two alternative hypotheses have been put forward regarding the relationship between reaction to an intermittent noise source and the level of ambient noise:

- that intermittent noise will be more annoying in a quieter environment, because it will be more noticeable; and
- that it will be more annoying in a noisy environment, because residents will already be sensitised by the existing noise.

Research evidence (for example, Taylor et al, 1980; Fields and Walker, 1982) suggests that reaction to aircraft noise does not depend strongly on the level of ambient noise in the area, indicating either that neither of the above effects has an important influence on reaction, or that the two effects tend to cancel each other out.

In terms of cumulative noise impact assessment, this indicates that the level of noise from other sources has only a minor influence, if any, on reaction to aircraft noise, which can best be assessed through indices reflecting the contribution of aircraft noise alone. This is the approach which has generally been taken in this assessment, although levels of existing noise are listed for each Community Assessment Area for comparison with predicted levels of aircraft noise.

The above discussion also applies to assessment of noise from engine ground running and other sources associated with the proposed airport. Research results (Taylor, 1982) indicate that reaction to noise from a number of individual and distinct sources is best assessed by considering each source in turn, rather than by attempting to assess *overall* reaction to the total noise environment. This is supported by data from the NAL study of reaction to aircraft noise in Australia (Hede and Bullen, 1982) which indicates that there are grounds for assessing airport generated noise and flyover noise by separate measures, as is done for aircraft and traffic noise. This procedure is followed in this assessment, in that the level of noise from ground operations is discussed in terms of descriptors recommended by the NSW Environment Protection Authority for general non-transport noise sources, while noise from overflights is described as discussed above.

In some potentially affected areas, aircraft noise associated with operations at Sydney, Bankstown and other airports is currently a noticeable part of the environment. In these cases, the total aircraft noise impact after development of a Second Sydney Airport may be somewhat higher than predicted for the second airport alone, due to the presence of additional noise from these other airports.

However, the pattern of noise exposure from aircraft associated with Sydney Airport has recently altered significantly with the introduction of revised operating procedures and could alter further in the near future. The introduction of a Second Sydney Airport would result in further changes to the pattern of usage at all nearby airports. In this context, it has not been possible to estimate in detail the likely contribution of noise from other airports to total aircraft noise exposure in the areas considered in this study.

Based on distance from the airport and the aircraft types typically operating, the maximum noise level from any overflights associated with other airports would generally be below 70 dBA in the areas considered in this study (with the exception of areas very close to Bankstown, Hoxton Park and other general aviation airfields). Hence, estimates of numbers of events with noise levels exceeding 70 dBA would be largely unaffected by this additional noise. Estimates of ANEC levels are also expected to be unaffected in areas with ANEC values of 20 and above. In other areas, it is possible that the total aircraft noise level may be somewhat higher than estimated for Second Sydney Airport alone. The size of this effect in individual areas cannot be calculated in detail at this point.

5.2.9 ALTERNATIVE NOISE EXPOSURE INDICES

Apart from the measures of aircraft noise exposure described above, a number of alternative measures are used or have been proposed for use in the assessment of various types of noise impacts. Some of the most important are described below.

DNL

This index (also known as L_{dn}) is a variant on the equivalent continuous noise level L_{Aeq}, incorporating a weighting of 10 dB for noise which occurs during the period 10 pm to 7 am. It is widely used in the United States where it is used for assessment of all types of community noise. The index was originally formulated on the basis that it could be used to set consistent noise level criteria for different forms of transport noise. However, later studies showed that reaction to different noise sources differed for the same DNL value, and hence the index lost much of its appeal. In the present assessment, it is not considered that this index would give information on likely noise reaction that is not provided by ANEC and L_{Aeq} levels, which are provided for each Community Assessment Area.

NNI

This index is similar to equal energy indices such as ANEC and L_{Aeq}, but depends more strongly on the number of noise events per day. It was formulated on the basis of early studies around Heathrow Airport, but further studies have indicated that it has no advantage over L_{Aeq} in terms of its ability to predict noise reaction. It was used largely in the United Kingdom, but is being replaced by other measures, notably DNL.

Other Equal-Energy and Related Measures

Many individual countries have, like Australia, developed measures of aircraft noise which are similar to the basic L_{Aeq} noise exposure index, but with differences reflecting the results of studies conducted in each country. Examples are the German Storindex Q; the Kosten unit, used in the Netherlands; and WECPNL, which is used in a number of countries including Japan and Italy. These measures are generally unfamiliar in Australia, and do not appear to offer any benefits over ANEC or L_{Aeq} in terms of understanding noise reaction. They largely provide alternative methods of describing the same fundamental property of the noise exposure, namely the total noise energy received (hence the term *equal energy* units).

TA(X)

This unit represents the average time, in minutes per day or minutes per hour, during which the level of aircraft noise exceeds a particular value X dBA. It is very similar to NA(X) - the number of noise events per day with maximum levels exceeding X dBA, which is reported in this study for each Community Assessment Area - but also takes account of the duration of the exceedance. Both these units are related largely to communication disturbance, and are often presented in addition to equal energy units to gain a more comprehensive understanding of aircraft noise impacts. However, often values of TA(X) can be misleading for the general public in terms of understanding the implications of aircraft noise. For example, the effect of an average of two minutes per hour with disturbed communication may be difficult to understand, but when expressed as 12 events per hour lasting ten seconds each, the extent of disturbance becomes clearer. In general, experience indicates that the total time during which communication is disrupted is not as important as the number of individual events during which this occurs. For this reason, and to avoid presentation of even larger amounts of data which could cause more confusion than enlightenment, it was decided to present this information only in terms of NA(X).

Other Measures of Sleep Disturbance

Apart from the Sleep Disturbance Index (SDI), it is considered that no other formal indices have been proposed for quantitative description of the level of sleep disturbance due to intermittent noise. However, acceptability criteria and methods of determining compliance, have been proposed, based on various properties of the noise. As mentioned in *Section 5.2.1*, these include a proposal by Griefahn (1992) based on the number and maximum noise level of a series of noise events. Under this, sleep disturbance would exceed the criterion if, for example, there were more than ten events per night with internal noise levels exceeding 54 dBA (equivalent to an SDI of approximately 0.17). However, the method cannot be directly applied to events with differing noise levels, and gives only a criterion of acceptability rather than a quantitative comparison of options. Similarly, the NSW Environment Protection Authority recommend that to protect against sleep disturbance the L_1 noise level from a source should not exceed the L_{90} background noise level by more than 15 dB. Given the measured night-time background noise levels in the areas in question, this criterion would be exceeded over most of the study area for all airport options, and would in many cases already be exceeded by noise from existing airports. As in the case of Griefahn's proposed criterion, it does not allow for quantitative comparison of options in terms of varying levels of sleep disturbance. For these reasons, the Sleep Disturbance Index has been used in this assessment as the primary unit to indicate the likely level of sleep disturbance associated with the various airport options.

5.3 AIRCRAFT OVERFLIGHT NOISE IMPACT ON PEOPLE NEAR SECOND SYDNEY AIRPORT OPTIONS

5.3.1 OVERVIEW

The anticipated aircraft overflight noise impacts associated with the five airport options are described in detail in *Volume 2* of this technical paper where noise level predictions are provided for each Community Assessment Area. Reference should be made to these predictions to determine the nature and level of potential noise impacts on individual communities.

The general comments in *Sections 5.3.4* and *5.3.5* on potential noise impacts from each airport option are based on the highest level of air traffic forecast (Air Traffic Forecast 3) of 15 million passengers by 2006 and 30 million passengers by 2016 unless otherwise stated. The affected populations referred to in the comments are those applying at the time, that is, in 2006 and 2016. For each airport option, restrictions have been assumed on population growth in noise affected areas within the 25 ANEC contour and the populations quoted reflect these restrictions.

5.3.2 DAILY AND SEASONAL VARIATION IN NOISE LEVELS

The impacts described in the following sections and in the data sheets in *Volumes 3* to *8* of this Technical Paper represent annual average noise impacts. These impacts may vary significantly from day to day, depending on a number of factors as described below.

Runway Usage Patterns

As discussed in *Section 4.5*, runway usage at any of the proposed airport sites would depend to some extent on meteorological conditions, which vary on hourly, daily and seasonal time frames. On the shortest time scale, there may be periods of up to one day when landings and take offs would be forced to occur in one direction, which may not be the preferred direction of operation at the airport. Where the enforced direction of operation is on the parallel runways, the effect would be to replace landings over any location with take offs, or vice versa. The effect of this in terms of noise levels would depend very much on the location. However, an indication of the size of the expected daily variation in noise levels can be gained from the range of values for each noise descriptor quoted in the data sheets in *Volume 2*. This range generally represents the difference in average noise levels between a *prefer north* and a *prefer south* airport operating policy. Hence, a large range of values would indicate the likelihood of a large daily variation in noise levels at the location in question.

When meteorological conditions force the use of a cross wind runway, the pattern of noise exposure around the airport would change significantly, with noise exposure in some areas increasing dramatically. Based on available meteorological data, it appears that for any of the airport sites there would be very few times (possibly two days per year) when wind conditions would force the use of the cross wind runway. Hence, these unpredictable events, while creating significant new noise exposure for residents near the cross wind runway, would not be a frequent occurrence. For Airport Operation 3 it is assumed that use of the cross wind runway may be deliberately increased through airport operating policy. In this case, the times when this runway would be used could be expected to be more predictable, for example, between certain hours of the day and when wind conditions permit. Under these circumstances daily variation from the annual average values quoted in these areas would be much lower.

The proportion of time when certain runway directions would be available for selection varies according to time of day and seasonal factors. For each airport option, this variation is illustrated in *Figures 4.4* to *4.7*. These figures also illustrate the wide range of choice in runway usage which is available through airport operating policy. For example, for Badgerys Creek Options A or B, during the summer months the proportion of operations in the *northerly* direction could vary between approximately 30 percent and 80 percent depending on operating policy, while during the winter months it could vary between approximately five percent and 50 percent. In this context, the influence of daily and seasonal meteorological factors is seen as being secondary to the influence of airport operating policy in determining the distribution of runway usage.

Variation in Actual Aircraft Locations

It is well known that aircraft may depart from their nominal flight track on approach or (especially) departure for a number of reasons, including the influence of wind. In calculations, this has been modelled by allowing for a spread of actual flight tracks, centred on the nominal track, as described in *Section 4.6*. On some days, there is likely to be a concentration of actual tracks to one side or the other of this range of possible tracks, resulting in higher or lower noise exposure at points on the ground for that day. Calculations indicate that for the modelled track dispersion, this effect could result in changes in the noise level from individual aircraft of up to approximately 4 dBA, but at most locations this difference would be substantially lower.

Variation in Individual Aircraft Noise Levels

Noise emission levels from aircraft may also vary depending on parameters such as thrust and flap settings, and due to meteorological conditions affecting sound propagation. These effects are discussed in *Section 4.6*. Based on the measurements described there, the standard deviation in noise levels from individual operations by larger jet aircraft can be expected to be between 2 and 5 dBA, depending on the location and type of operation.

5.3.3 EFFECTS ON SENSITIVE POPULATION GROUPS

The description of noise impacts for each airport option, as set out below, is expressed largely in terms of noise descriptors which are related to the level of noise impact for the majority of residents. Specific impacts relevant to educational facilities are also discussed. However, there are other minority groups within the population, notably shift workers, hospital patients and in some cases the aged for whom other noise descriptors would be required to provide a comprehensive assessment of likely noise impacts from each airport option.

The impact of aircraft noise in general on these groups is described in detail in *Volume 2* of this Technical Paper. However, it is not possible within the scope of this assessment of specific airport options to present details of the impact of aircraft noise from each option on each of these groups. In general, options which affect relatively large numbers of residents and schools could also be expected to affect relatively large numbers of shift workers and other minority groups.

Locations of specific noise sensitive facilities such as hospitals, child care centres, etc. would need to be taken into account in the detailed design of noise mitigation measures for any of the airport options which may be selected for development (see *Section 5.5*).

5.3.4 BADGERYS CREEK AIRPORT OPTIONS

Badgerys Creek Option A

Noise exposure for this airport site is characterised by the existence of some residences with relatively high noise exposure, but minimisation of the number exposed to low or moderate levels, compared with other sites.

Between 100 and 200 residents are predicted to experience noise levels in excess of 30 ANEC. These are located in Badgerys Creek to the north-east of the airport, and scattered around in Greendale and Silverdale to the south-west. For Air Traffic Forecast 1, these people would experience approximately 50 to 70 aircraft overflights a day in 2006 with noise levels exceeding 70 dBA, rising to over 100 per day in 2016. For Air Traffic Forecasts 2 and 3 they would experience over 100 such overflights a day from 2006.

Up to three existing schools would be exposed to more than 50 aircraft overflights a day during school hours which exceed 65 dBA. As described above, this is the level at which it is considered that communication with a class may be interrupted.

Up to approximately 1,000 residents would be exposed to nighttime noise levels giving a Sleep Disturbance Index exceeding 0.5. This represents an average of approximately one awakening every two nights, for a typical sleeper. These residents would be located over a wider area, including the western side of Horsley Park, Mount Vernon, Kemps Creek and part of Cecil Park.

Impacts at a somewhat lower level (ANEC greater than 20) would affect up to approximately 7,000 people in 2016. Most of these are located to the west of the airport in the general area of Silverdale and Warragamba. In 2016, residents in these locations would experience up to 80 overflights a day with noise levels exceeding 70 dBA, and nighttime noise would generate a Sleep Disturbance Index approaching 0.5. These values would depend on the airport operating mode ultimately adopted.

At a still lower noise level (ANEC greater than 15), between approximately 11,000 and 15,000 people are predicted to be impacted in 2016. A large number of these people would live in new residences located in the growth areas of Cecil Park, Cecil Hills and proposed urban village developments to the south near the proposed rail line. The Cecil Hills urban release area, containing an estimated 15,000 residents in 2016, would experience an average of up to 10 overflights a day with levels exceeding 70 dBA, and a Sleep Disturbance Index of up to 0.1. Schools would experience an average of up to 11 overflights a school day greater than 65 dBA.

Some departures to the south would be over proposed urban village developments to the south of the airport, estimated to contain approximately 10,000 residents in 2016. Here, residents would be exposed to an average of up to five overflights a day above 70 dBA.

For this airport option, no existing large, densely populated residential areas are predicted to experience noise levels above 10 ANEC. The areas of this type with greatest exposure would be Hoxton Park to the south-east, and Penrith, Kingswood and Jamisontown to the north-west. In both cases, the predicted average number of overflights greater than 70 dBA is only four to five.

There is potential for this airport option to impact the natural areas within the Blue Mountains National Park. In view of the elevation of the Park relative to the airport site, it is anticipated that up to approximately 25 movements per day could exceed 70 dBA with up to about five overflights a day exceeding 80 dBA in some areas. However, the level of impact would depend upon the airport operation ultimately adopted.

A somewhat similar noise impact is likely to occur in the natural areas south of Lake Burragorang. In this area up to about 15 aircraft overflights a day may exceed 70 dBA with about two overflights exceeding 80 dBA.

Badgerys Creek Option B

The pattern of noise exposure for the Badgerys Creek Option B would be similar to Badgerys Creek Option A. There is a tendency for the population exposed to any given noise level to be lower for Badgerys Creek Option B. This is due to detailed differences in the assumed flight paths, but adjustments to these paths could make the populations affected more closely aligned.

Numbers of residences exposed to high noise levels are similar to those for Badgerys Creek Option A. Predicted noise impacts in Silverdale and Warragamba are lower than for the Badgerys Creek Option A. This results from the differences in the flight paths adopted for each option and the threshold of the northern runway being approximately 500 metres further to the south west for the Badgerys Creek Option B master plan. The resulting noise level from individual operations over Silverdale is approximately 5 dBA lower.

Considering areas with lower exposure, the number of residences exposed to noise equivalent to 10 to 20 ANEC for 2016 and the number that would be exposed to more than 10 overflights a day greater than 70 dBA, is lower than for Badgerys Creek Option A. This is also because of a relatively minor change in flight paths and differences in the locations of the thresholds of runways which means that predicted noise levels in some urban areas would be lower. For example the noise levels from individual movements within the urban release areas west of Liverpool would be approximately 5 dBA lower.

The above changes emphasise the importance of assessing the implications of aircraft flight path options in detail in order to minimise the impact of lower level noise on areas at some distance from the airport. This could only occur if the airport proposal was approved and detailed operational plans for the airport were developed.

The impact of noise from this option in the Blue Mountains National Park and in the natural area south of Lake Burragorang would be similar to that described for Badgerys Creek Option A.

Badgerys Creek Option C

Badgerys Creek Option C is characterised by a similar extent of noise impact to the Badgerys Creek Options A and B for higher levels of noise impact, but with potentially large numbers of people affected at lower levels of impact.

At the highest level of impact of more than 30 ANEC, affected residences are generally to the south of the airport site, including Bringelly and scattered residences along Greendale Road. Bringelly itself would have lower exposure (less than 10 ANEC) in 2006, but this would increase dramatically after the opening of the second parallel runway. Residents would then experience approximately 140 overflights a day with noise levels greater than 70 dBA, and would have a Sleep Disturbance Index of approximately 0.9 (an average of about one awakening every night).

Within the 20 ANEC contour, the affected residences are in small villages or are isolated residences, with the total number within the contour being lower than for either Badgerys Creek Option A or Option B, for the equivalent airport operation type.

Considering impacts in terms of the number of movements per day reveals a strong dependence on the air traffic operating mode. Arrivals from the north on the two parallel runways would pass close to St Clair, and to sections of Chatsworth and Claremont Meadows south of the Great Western Highway. For 2006, only areas in south Claremont Meadows would be directly overflown. This area is already heavily populated, and is projected to expand considerably in the future. If a southerly traffic flow is preferred, people living in this area would experience up to approximately 20 to 40 overflights a day greater than 70 dBA, and noise at night would generate a Sleep Disturbance Index of up to approximately 0.2 (an average of one awakening every five nights). The estimated 15 schools in the area would experience an average of up to approximately 30 overflights a school day greater than 65 dBA in 2016.

At lower levels of exposure (ANEC greater than 10), a greater population may be affected. Residents in Penrith and Kingswood would experience up to approximately 10 aircraft overflights a day greater than 70 dBA, with a Sleep Disturbance Index of up to 0.04 (an average of one awakening every 25 nights).

Most potentially affected residents to the south of the airport are located relatively close to the site.

Because of the alignment of the parallel runways associated with this option, it is expected to cause less noise impact in the natural areas than Badgerys Creek Options A and B. In the Blue Mountains National Park, up to a possible maximum of about eight overflights a day could exceed 70 dBA with no overflights above 80 dBA. South of Lake Burragorang, there could be up to about seven overflights a day exceeding 70 dBA with none exceeding 80 dBA. However, again the impact from this option upon the natural areas would depend on the way the airport would operate.

5.3.5 HOLSWORTHY AIRPORT OPTIONS

Holsworthy Option A

Noise exposure from Holsworthy Option A would be characterised by high levels of noise exposure (greater than 30 ANEC) confined to within the Holsworthy Military Area or uninhabited areas in both 2006 and 2016. The number of people experiencing high levels of sleep disturbance would also be very low.

Large numbers of people, however, would be affected by more moderate levels of exposure. The number of people that may experience noise levels equivalent to 20 ANEC range from 8,500 to 15,000 in 2016, compared with a maximum of approximately 7,000 for any of the Badgerys Creek options. These people would be located almost entirely in the suburbs of Glenfield, Casula, Macquarie Fields and Chatham Village. The number of people affected by high noise levels from individual operations is similar. For example, the number of people that would experience more than 50 overflights a day at greater than 70 dBA ranges from 9,500 to 22,000. These people are located in the same suburbs, and in some cases include areas in the southern part of Lurnea.

At lower levels of exposure, the number of people affected by the operation of Holsworthy Option A would be much higher than for any other option. Areas experiencing at least 20 overflights a day over 70 dBA, and Sleep Disturbance Index exceeding 0.2 (one awakening every five nights), extend to the north of Liverpool, and take in large, densely-populated suburban areas in Lurnea, Ashcroft, Mt Pritchard, Busby, Sadlier, Miller, Heckenberg and surrounding areas.

At levels of noise exposure equivalent to 10 to 20 ANEC or more than 10 overflights a day greater than 70 dBA, the number of people that would be affected would be generally at least ten times higher than for the Badgerys Creek Options A or B.

The number of schools affected by noise from Holsworthy Option A follows the pattern of residential exposure, with few schools affected by very high individual noise levels but large numbers affected by mid range levels (at least 20 overflights a day during school hours greater than 65 dBA). The most affected schools would be located in Glenfield, Casula, Lurnea, Liverpool, Busby, Sadlier, Miller and Ashcroft.

Use of the cross wind runway would result in a noise exposure of up to 30 ANEC for a small number of residences to the south of Heathcote, as well as for residences in Kentlyn and Minto Heights, and to a lesser extent Ruse and Minto.

To the south of the airport, the most affected population centre is Helensburgh, where ANEC levels in 2016 would range from 14 to 16.

One feature of this airport option is that there is little difference between the number of people affected to a moderate extent in years 2006 and 2016. This is because the major noise impacts are associated with the western parallel runway, which is the runway proposed to be constructed first. After this, growth in total numbers of operations between 2006 and 2016 is counteracted by displacement of some operations to the eastern runway.

Significant noise levels would be experienced within the Holsworthy Military Area. ANEC levels are expected to vary between zero (between flight paths) and 40 (near the ends of the runways), but large tracts of land, particularly towards the north, east and south would experience noise levels below ANEC 20 in 2016. In relation to individual overflights, in some areas no overflights exceeding 70 dBA are expected particularly along the eastern edge. In other areas near the ends of runways, up to approximately 170 overflights a day above 70 dBA would be expected, 140 overflights above 80 dBA and over 80 overflights above 90 dBA. Such noise levels near runways would have the potential to interfere with military training. Nevertheless, large parts of the Military Area would be affected by less than 20 overflights a day exceeding 70 dBA.

This airport option would result in a very limited noise impact on the Defence facilities at Holsworthy Barracks. There would be between zero and one aircraft overflight a day over 70 dBA and no overflights exceeding this noise level.

Depending upon the mode of operation of Holsworthy Option A, some impact could occur within the Royal National Park. Although much of the Park would be affected to only a small degree, a wide band extending east-west across the middle of the Park may be affected by up to 14 aircraft overflights exceeding 70 dBA in any one day, 12 overflights exceeding 80 dBA and eight overflights exceeding 90 dBA. Such levels may interfere with the enjoyment of this Park.

Holsworthy Option B

The most significant noise impacts caused by Holsworthy Option B would occur in the area of St Helens Park and Wedderburn to the west of the airport site. Some residents would experience ANEC levels of up to 41 and up to 150 overflights a day with noise levels greater than 70 dBA. Further away, large areas of Ambarvale, Rosemeadow and Bradbury would also be affected by a significant number of overflights over 70 dBA and overall up to 5,500 people would be exposed to more than 100 overflights per day with noise levels greater than 70 dBA in 2016. This would be much higher than any other airport option. Up to 7,000 people in these areas would have a Sleep Disturbance Index value of greater than 0.5, representing an average of one awakening every two nights. Again, the noise impact associated with this option would depend upon the ultimate airport operation.

At mid range levels of noise impact (ANEC greater than 20), the areas affected include large sections of Rosemeadow, Ambarvale, Bradbury and St Helens Park. Because of the high population density in these areas, the number of people affected to this extent would be relatively large.

Flight paths to the east pass over Helensburgh, Stanwell Tops and Stanwell Park, Helensburgh West, Helensburgh North, Bulgo and Otford. The most affected population centre to the east is Helensburgh. In 2016 the estimated ANEC for Helensburgh is 23 to 24, with 50 to 70 overflights a day greater than 70 dBA. The Sleep Disturbance Index is 0.3 to 0.4, representing an average awakening of about once every three nights.

The number of schools likely to be affected by high range noise levels (more than 20 events per school day greater than 65 dBA) is very low in 2006, but higher in 2016. The schools likely to be affected are largely located in the Airds and Leumeah areas.

Significant noise levels would be experienced within the Holsworthy Military Area, particularly in the south. ANEC levels are expected to vary between zero in the north and 40 near the ends of the runways. In the latter areas, up to approximately 170 overflights a day above 70 dBA would be expected, 140 overflights above 80 dBA and over 80 overflights above 90 dBA. The noise levels near runways therefore have the potential to interfere with military training.

Apart from approximately one quarter of the training area in the south, the Military Area would be subjected to noise levels below ANEC 20. Most of the area would therefore be available for Military training with minor noise impact. This option would also have very little effect upon the Defence facilities at Holsworthy Barracks.

The effect of Holsworthy Option B on the Royal National Park would be negligible with no more than one movement per day exceeding 70 dBA at the most affected location. Only the very southern tip of the Park would be affected to this limited degree.

5.3.6 NOISE INDUCED VIBRATION

At high noise levels, the low frequency components of aircraft noise can result in vibration of loose elements in buildings, notably windows. This effect is distinct from that of wake vortices, which result from aerodynamic turbulence caused by the aircraft as it passes through the air, and in some instances have been known to dislodge loose roof tiles. Even at the highest expected noise levels, the levels of vibration due to low frequency noise are well below those which may cause structural damage to buildings. However, they can result in secondary radiation of noise from loose windows and other building elements.

With typical light building structures, noise induced vibration may begin to occur where the maximum external noise level reaches approximately 90 dBA. The effect is more common for take offs than for landings, since the noise spectrum from a take off close to the airport has stronger low frequency components.

Table 5.4 shows the predicted number of residents who may experience some noise induced vibration due to operations at each of the airport sites. This has been calculated as the number of residents experiencing an average of at least one overflight per 30 days with maximum noise level exceeding

90 dBA. The range of values shown is for the range of airport operations under Air Traffic Forecast 3 for year 2016.

TABLE 5.4 NUMBERS OF RESIDENTS WHO MAY EXPERIENCE NOISE INDUCED VIBRATION OF BUILDING ELEMENTS DUE TO AIRCRAFT OVERFLIGHTS

Airport Option	Predicted Number of Residents Experiencing at Least One Event Per 30 Days with Maximum Noise Level Exceeding 90 dBA
Badgerys Creek Option A	700 to 1,000
Badgerys Creek Option B	500 to 2,500
Badgerys Creek Option C	6,000 to 8,000
Holsworthy Option A	<100 to 800
Holsworthy Option B	4,500 to 5,500

In all cases, the higher values for numbers of residents affected are for Airport Operation 3, where some residents close to the cross wind runway would also experience events with high individual noise levels.

5.4 AIRCRAFT OVERFLIGHT NOISE IMPACT ON WILDLIFE NEAR SECOND SYDNEY AIRPORT OPTIONS

As indicated in *Section 5.2.4* the effect of aircraft noise levels on wildlife varies greatly depending upon the species in question. Further, little is known about the extent of noise that is likely to affect individual species.

5.4.1 BADGERYS CREEK OPTIONS

Noise associated with the Badgerys Creek options has the potential to affect wildlife in the Blue Mountains National Park and the natural areas south of Lake Burragorang. However, in these areas the noise levels would generally be relatively low and overflights would be infrequent.

Options A and B may generate up to about 25 aircraft overflights a day exceeding 70 dBA and up to about five overflights a day exceeding 80 dBA in some areas of the Blue Mountains National Park. South of Lake Burragorang, fewer overflights would occur, with up to about 15 exceeding 70 dBA and one or two exceeding 80 dBA. It is unlikely that this frequency of noise events at the levels indicated would have a significant effect upon wildlife in these areas.

Option C would have a lower effect than the first two options. Within both natural areas it is expected that there would be no overflights above 80 dBA and up to seven or eight overflights a day exceeding 70 dBA. This level of noise is unlikely to have an effect upon wildlife in these areas.

Although the likely effect of aircraft noise on domestic animals and birds is not clearly understood, there is potential for animals, such as horses and chickens to be affected by aircraft noise under the flight paths. This is particularly so in areas close to the airport boundary.

5.4.2 HOLSWORTHY OPTIONS

Noise within the Holsworthy Military Area resulting from Holsworthy Options A and B would have the greatest potential to affect wildlife. Both options would generate noise levels close to the airport which have the potential to interfere with some species. Near the ends of runways, ANEC levels up to 40 and up to 170 aircraft overflights a day above 70 dBA may be expected. At higher noise levels, more than 80 overflights over 90 dBA could also be expected.

On the other hand, large tracts of land would remain substantially unaffected by aircraft noise. In the case of Option B, in the vicinity of three quarters of the Military Area would remain largely unaffected. In the case of Option A, something in the vicinity of one third to one half of the area would remain unaffected by aircraft noise, but this area would be made up of three or four separate sections of the Military Area.

Noise levels affecting wildlife within the Wedderburn area, including koalas, and within the water catchment area to the east would be lower than those within the Holsworthy Military Area. The Wedderburn area is likely to be most affected by Holsworthy Option B, whilst the water catchment area could be affected by either of the Holsworthy options.

In the Wedderburn area, Option B is likely to result in up to 110 overflights on an average day exceeding 70 dBA with up to 90 overflights over 80 dBA. The extent of disturbance to wildlife from this noise environment cannot be accurately determined.

In the water catchment area, up to 140 aircraft overflights on an average day over 70 dBA are likely to occur as a result of Option B and up to 80 overflights a day over 70 dBA would occur as a result of Option A. Again, it is not possible to determine the degree of disturbance to wildlife that would result from these noise environments.

To a lesser extent, noise associated with the Holsworthy options also has the potential to affect wildlife in the Royal National Park, Heathcote National Park and the Woronora catchment area. However, Option B would affect only the southern tip of the Royal National Park and Option A would affect an east-west strip across the centre of this Park. The effect in these zones is also quite limited. In the case of Option A, only a few overflights exceeding 90 dBA would be expected in any average day with possibly up to about 14 exceeding 70 dBA for the Royal National Park. In the case of Option B, no more than one overflight a day exceeding 70 dBA would be expected. Given the degree of human intrusion within these two parks, it is anticipated that aircraft noise would have minor consequences upon wildlife.

Although the likely effect of aircraft noise on domestic animals, particularly horses and domestic birds, such as chickens, is not clearly understood, there is potential for animals and birds to be affected by aircraft noise under the flight paths. This is particularly so in areas under the flight paths and also close to the Holsworthy Military Area.

5.5 ENVIRONMENTAL MANAGEMENT

The environmental noise impact associated with aircraft overflight can be reduced in a number of ways. Environmental management options and factors which may influence the ultimate adoption of these options are described below.

5.5.1 NIGHTTIME CURFEW

It is common for nighttime curfews to be implemented at airports which are surrounded by noise sensitive land uses, particularly residential uses. At Sydney Airport, an aircraft curfew applies between the hours of 11.00 pm and 6.00 am and this has the effect of limiting the number of aircraft movements during this period and restricting the runways that these aircraft can use. Such a curfew at the Second Sydney Airport could have the effect of reducing the number of nighttime movements, particularly of jet aircraft, and reducing the impact of these movements by specific nighttime noise abatement procedures.

In regard to the reduction of aircraft movements, a curfew could have the effect of moving many of the aircraft operations forecast to occur during the curfew period to the shoulder nighttime periods of 10.00 pm to 11.00 pm and 6.00 am and 7.00 am.

During the evening/nighttime period as defined by the ANEC system (7.00 pm to 7.00 am) there would be no decrease in the number of movements and the ANEC levels discussed above would not change. In the case of the Sleep Disturbance Index, the nighttime period has been defined as 10.00 pm to 6.00 am and a curfew could therefore result in reduced nighttime movements as a result of the transfer of movements into the 6.00 am to 7.00 am period. Notwithstanding this, the Sleep Disturbance Index values calculated would reduce only slightly.

The ANEC and Sleep Disturbance Index assessments do not, however, fully reflect the potential benefits of a nighttime curfew. Although there would likely be an increased frequency of aircraft flights during the shoulder periods of 10.00 pm to 11.00 pm and 6.00 am to 7.00 am, there could be limited aircraft movements during the central nighttime period 11.00 pm to 6.00 am. Furthermore, the reduced frequency of movements during the nighttime period, may allow more flexibility to direct these movements onto noise abatement flight paths which would generally not be over residential areas.

Overall, a nighttime curfew including restrictions on flight paths used during specific hours could be expected to result in some benefits to noise affected residential areas at all airport options, especially those that would experience a Sleep Disturbance Index of greater than 0.5. The extent of these benefits cannot be determined precisely without detailed modelling of the noise abatement flight paths and procedures which would apply. Such modelling should form part of the detailed analysis which would be required to produce an operating plan for the selected airport site.

5.5.2 SELECTING PREFERRED OPERATIONS AND FLIGHT PATHS

This section discusses the potential benefits of selecting a preferred type of airport operation and use of flight paths to minimise overall noise impacts.

The noise impacts discussed in *Section 5.3* are based on analysis of three airport operational modes: preferred operations to the north, preferred operations to the south and spreading of the noise. The choice of which operational mode is to be implemented at the airport would affect the overall noise impact.

The environmental assessment is also based on the assumed flight paths without detailed consideration being given to their noise impact. The use of noise abatement flight paths or the avoidance of some flight paths over residential areas can reduce the overall noise impact.

More flexibility in regard to runway use and flight path use would exist during periods when the airport is less busy. At nighttime, when aircraft movements at the airport are expected to be relatively infrequent, greater opportunities to select the airport mode and to use low noise impact flight paths would exist. Further, during the night wind speeds are generally lower and this results in more flexibility as to runway use. It is possible at airports with wide spaced parallel runways (as proposed for the Second Sydney Airport options) to have 'nose to nose' operations during the nighttime period, that is landing from one direction with takeoff in the opposite direction from the other runway. This operating procedure does, however, have a lower margin of safety than more conventional methods of traffic management.

Badgerys Creek Option A

In view of the scattered nature of residences around the Badgerys Creek site, the opportunities to reduce the overall noise impact by selected airport operations and flight paths are quite limited. There is a marginal benefit of the preferred north operation over the preferred south operation as a result of the reduced noise impact that would occur over Warragamba and Silverdale.

In regard to individual flight paths, aircraft taking off to the south and then turning north to travel either north or east are likely to fly over the residential areas of Warragamba and Silverdale. Where practicable, reduced noise impacts could result from ensuring these aircraft travel out past these two areas before turning north.

There is a high probability that aircraft taking off to the north and heading south would fly over the growth areas around Cecil Park and Cecil Hills and those taking off to the south and heading south would fly over the growth areas to the south near the proposed rail route. Although the noise impact on these areas would be relatively low, there would be some benefit in specifically modifying takeoff flight paths to avoid these areas.

Badgerys Creek Option B

As for Badgerys Creek Option A, only limited reductions in noise impact can be gained by the use of selected runway directions and flight paths. Overall, the comments above for Option A also apply to Option B.

Badgerys Creek Option C

The highest impact from Badgerys Creek Option C would occur to the south in the area around Bringelly. However, a mid range degree of noise impact is likely to occur to the north around St Clair, Chatsworth and Claremont Meadows, particularly as a result of landings over these areas during operations to the south. Introducing a system of preferring takeoffs to the north (Airport Operation 1) would significantly reduce the noise impact in these areas.

However, preferring takeoff to the north would increase the low degree of noise impact in the Penrith and Kingswood areas. These impacts could then be reduced by ensuring that takeoff flight paths to the north avoid heavily populated areas.

Overall, there is a potential for significant noise impact reductions for Badgerys Creek Option C by preferring takeoffs to the north utilising noise abatement flight paths. The opportunity for this is obviously much greater during the nighttime period. During this period, it may even be possible to direct takeoffs to the south and also receive landings from the south.

Holsworthy Option A

The most significant noise impacts from Option A would occur on densely populated suburbs to the north and north-west of the airport site. The construction of the western parallel runway as the first stage of the airport development would result in the immediate introduction of significant noise exposure to areas such as Macquarie Fields and Glenfield. The adoption of the easterly parallel runway as the first stage would reduce these noise impacts.

The most useful noise mitigation measure would involve the selection of appropriate airport operation modes. Airport Operation 1, preferred northerly movements, would be preferable to Airport Operation 2, preferred southerly movements, as it would minimise high level noise impacts over areas such as Mt Pritchard, Lurnea, Glenfield, Ashcroft and Casula.

A further possibility to reduce noise impacts would be the use of a mode of operation in which all landings occur from the south on the western parallel runway, with all takeoffs to the north on the eastern parallel runway. When operation in the opposite direction is required, landings would be on the eastern parallel runway and takeoffs on the western parallel runway. Although noise impacts for this type of operation have not been investigated in detail, it offers the possibility of a significant reduction in total noise impact.

Wherever possible, and particularly at night, all landings and takeoffs would best operate to the south.

Notwithstanding the possibility of these mitigation measures having a significant reduction in noise impacts, the total number of people impacted by low to moderate levels of aircraft noise for Option A would still likely be higher than for any of the Badgerys Creek options.

Holsworthy Option B

The relatively high noise impact found for this airport option is a result of the orientation of the runways, resulting in high level noise events over the densely populated suburbs of Rosemeadow, Bradbury and Ambarvale, as well as Helensburgh in the east. For approaches from the north-west, the alignment also directly affects Camden, Elderslie, Spring Farm, Camden Park, Glen Alpine and Menangle Park. If site conditions and air traffic control requirements were to allow a reorientation of the main runways approximately 10 degrees counter clockwise, overall noise impacts would be dramatically reduced. Such a reorientation does not, however, appear to be feasible in engineering and airspace management terms.

In the absence of such a realignment, preferring takeoff to the south (Airport Operation 2) would give the lowest noise impact. At night, it may be possible to substantially reduce the noise impact by taking off to the south and landing from the south.

Where take offs to the north occur, flight paths could be adjusted to minimise the noise impact. There would be an advantage in aircraft taking off to the north on the right hand runway (northern runway) maintaining runway heading for at least eight kilometres before tracking north approximately over the South Western Freeway. This flight path would result in some noise exposure in areas to the west of Rosemeadow, and in Elderslie, Narellan, Menangle Park and Mount Annan. However, it would avoid a significantly greater noise impact in the heavily populated areas of Airds, Leumeah, Minto and Ruse. This flight path would also reduce the number of schools adversely affected by noise.

5.5.3 ACQUISITION AND ACOUSTICAL TREATMENT

The Sydney Airport Noise Amelioration Program involves:

- voluntary acquisition of residential properties and a church within the 40 ANEF contour;
- assistance for the insulation of residences within the 30 ANEF contour; and
- insulation of public buildings (that is, schools, colleges, child care centres, hospitals, nursing homes and churches) within the 25 ANEF contour.

Existing Commonwealth Government policy for the originally proposed Badgerys Creek airport allowed the voluntary acquisition of residential properties within the 35 ANEC contour.

Preliminary estimates of the costs of acquiring residential properties within the 35 ANEC contour for the proposed Second Sydney Airport are:

- $6 to $11 million for Badgerys Creek Option A;
- zero for Badgerys Creek Option B;
- $12 to $27 million for Badgerys Creek Option C;
- zero for Holsworthy Option A; and
- zero to $2 million for Holsworthy Option B.

Beyond acquisition within the 35 ANEC contour, consideration could also be given to acoustical treatment of residences within the 30 or 25 ANEC contours. Treatment could be designed in accordance with the recommendations in Australian Standard 2021, but the actual extent of treatment would depend upon the detailed interpretation of this standard. Based on the findings of a pilot program of noise insulation around Sydney Airport, the treatment is likely to involve double glazing of windows, upgrading of doors, acoustical treatment within ceiling spaces and air conditioning.

Whilst the treatment of residences around Sydney Airport has had regard to the recommendations in Australian Standard 2021, it has been determined on a practical basis. For this treatment, the average cost per residence north of the airport has been $37,500 and to the west of the airport $41,000 (pers. communication, Works Australia, 1997). Allowing for the larger residences and the large area of glazing expected in areas surrounding the Second Sydney Airport options, the estimate per house in these areas is $50,000.

The preliminary cost estimates for the acoustical treatment policy are provided in *Table 5.4*.

TABLE 5.4 APPROXIMATE COST ESTIMATES FOR ACOUSTICAL TREATMENT OF RESIDENCES

Airport Option	**Total Cost Estimate[1] ($ million)**	
	Within ANEC 30-35[2]	**Within ANEC 25-35[2]**
Badgerys Creek Option A	3	12 to 19
Badgerys Creek Option B	1 to 3	7 to 9
Badgerys Creek Option C	2 to 5	6 to 12
Holsworthy Option A	0	7 to 12
Holsworthy Option B	2 to 14	26 to 91

Notes 1. Factored up to $50,000 based on average costs of insulating a dwelling of $37,500 and $41,000 derived from Works Australia.

2. Residences located in areas above 35 ANEC are assumed to be acquired.

It should not be assumed that acoustical treatment to residences would eliminate the noise impact from aircraft overflights on the occupants of those residences. Treatment to bedrooms is likely to substantially eliminate sleep disturbance due to aircraft flights at night. However, during the day the acoustical treatment would benefit the occupants only when they are indoors and all doors and windows are closed. In view of the common lifestyle in areas potentially affected by noise, a number of domestic activities occur outside the residence and the acoustical treatment would have no effect on noise impacts during these activities. Further, the doors and windows need to be closed to provide the benefits from the acoustical treatment and this has an effect of restricting the existing lifestyle.

Consideration could also be given to the acquisition and/or acoustical treatment of other noise sensitive buildings, such as educational buildings (schools) and health care buildings (hospitals). As stated previously, insulation of these types of public buildings is being undertaken for Sydney Airport within the 25 ANEF contour.

Although consideration could be given to the acoustical treatment of other buildings such as hotels/motels and commercial buildings, such treatment appears to be outside of the Government's responsibility. These types of buildings were not treated as part of the Sydney Airport Noise Amelioration Program.

Generally speaking, noise sensitive buildings would require double glazing, roof/ceiling upgrade and air conditioning to meet the requirements of Australian Standard 2021. The cost per building varies significantly depending upon the building size and design.

5.5.4 LAND USE PLANNING

So as to avoid increase in the impact of aircraft overflight noise with time as a result of new noise sensitive development, a restriction could be placed on new development in accordance with the land use compatibility table included in Australian Standard 2021. This Table is included as *Table 5.5*.

TABLE 5.5 BUILDING SITE ACCEPTABILITY BASED ON ANEC ZONES[1]

Building Type	**ANEC Zone of Site**		
	Acceptable	**Conditional**	**Unacceptable**
House, home unit, flat, caravan park	<20 ANEC[2]	20-25 ANEC[3]	>25 ANEC
Hotel, motel, hostel	<25 ANEC	25-30 ANEC	>30 ANEC
School, university	<20 ANEC[2]	25-25 ANEC[3]	>25 ANEC
Hospital, nursing home	<20 ANEC[2]	20-25 ANEC	>25 ANEC
Public building	<20 ANEC[2]	20-30 ANEC	>30 ANEC
Commercial building	<25 ANEC[2]	25-35 ANEC	>35 ANEC
Light industrial	<30 ANEC	30-40 ANEC	>40 ANEC
Other industrial	Acceptable in all ANEC zones		

Source: Australian Standard 2021 - 1994.

Notes: 1. There will be cases where a building of a particular type will contain spaces used for activities which would generally be found in a different type of building (for example, an office in an industrial building). In these cases *Table 3.7* (in AS2021) should be used to determine site acceptability, internal design noise levels within the specific spaces should be separately determined.

2. The actual location of the 20 ANEC contour is difficult to define accurately, mainly because of variation in aircraft flight paths.

3. Within 20 ANEC to 25 ANEC, some people may find that the land is not compatible with residential or educational uses. Land use authorities may consider that the incorporation of noise control features in the construction of residences or schools is appropriate.

Although such a restriction would substantially limit the increase in noise impact over time, it would still allow some increase in the lower noise impact zones.

5.5.5 OTHER NOISE MANAGEMENT METHODS

In view of the house price devaluation discussed in detail in *Technical Paper No. 4*, consideration could be given to compensating land holders in noise affected zones. This type of compensation was considered by the *Draft Noise Management Plan for Sydney Airport* (Mitchell McCotter and Associates, 1994). It was found to present a number of implementation problems and does not form part of current Government policy.

Also, because the opening of a Second Sydney Airport is likely to generate a significant community reaction, consideration could be given to an appropriate community liaison program. In general terms this would involve providing advice to the public as to the progress of the airport and the opening date and also the telephone number for the Noise Enquiry Unit. This Unit could operate like the existing unit at Sydney Airport and could respond to the particular complaints.

Other noise management methods placing limitations on how aircraft may operate could also be considered, but most have safety implications, are unlikely to prove practicable and would not be measures that should be designed into a new international airport.

5.5.6 NOISE MONITORING

A noise and flight path monitoring system could be installed at a Second Sydney Airport. Similar to Sydney Airport, this could consist of a central control station and a number of monitoring terminals around the airport. Surveillance radars could also be used as part of the system to acquire flight track information on aircraft using the airport.

Using this system, the following would be determined:

- contribution of individual aircraft to total noise exposure;
- assessment of the effects of any noise abatement or other procedures;
- compliance with those procedures; and
- validation of noise levels assumed in computed calculations of noise exposure levels.

Monitoring using this system could also provide statistics on runway and flight path utilisation, operating times, aircraft types and comparative noise levels.

Direct assessment of the impact of aircraft noise on communities could also be carried out through the use of social surveys. A well designed study indicating the extent of reaction before and after a significant increase in noise levels would provide valuable information regarding the extent of impacts in the specific affected communities, and also more generally applicable information on noise reaction.

Part D

Other Noise Impacts

6 GROUND OPERATION NOISE

Significant noise can be generated at an operational airport as a result of ground activities such as ground running of aircraft, taxiing and reverse thrust.

Reverse thrust during landing, whilst generating relatively high noise emission levels, is of a short duration during a high proportion of jet landings. On the other hand, whilst noise during taxiing can be continuous or nearly continuous, the levels from this activity are substantially below takeoff, reverse thrust and ground running noise levels.

Noise associated with ground running is likely to have the greatest impact of all of the operational noises generated within the airport. This is because aircraft are often 'runup', for some period of time on full power, for maintenance purposes, and this activity can occur during either daytime or nighttime.

For a future airport such as the Second Sydney Airport, details as to the amount of ground running are not available and the amount of time that ground running would occur would depend upon future policies regarding maintenance of aircraft. Notwithstanding this, it is expected that, for maintenance purposes, aircraft could be runup from time to time during the daytime or nighttime. Although much of the runup would occur with the engine at idle, there would be short periods of time when the engine is run on low power and occasionally for very short periods of time the engine would be run on high power. Since engines idling and on low power are not likely to have a noise impact at a significant distance from the airport, consideration is given here to assessment of noise associated with high powered runup.

6.1 RUNUP NOISE CRITERIA

For continuous noise, the NSW Environment Protection Authority generally recommends a noise criterion of five dBA over the background (L_{A90}) noise level. However, the acceptable noise level should be increased where the noise is not continuous throughout the day.

It is likely that high powered runup would occur for approximately five minutes per day, possibly during the daytime and also possibly during the nighttime. However, the orientation of the aircraft would vary from time to time and the higher noise levels expected at any one location would occur during approximately 25 percent of this time. As a maximum, therefore, it is anticipated that runup noise would be significant for just over one minute during any day and one minute during any night. For this duration of intermittent noise, the NSW Environment Protection Authority recommends that the acceptable level be increased by 20 dBA during daytime and 10 dBA during nighttime. Accordingly, the noise criteria set for assessment of runup noise are:

- 25 dBA above background noise levels during the day; and
- 15 dBA above background noise levels during the night.

The background noise levels at nighttime within areas potentially affected by runup noise mostly fall in the range 30 to 35 dBA, but are sometimes below and sometimes above this range. Based on an assumed nighttime background noise level of 35 dBA, the nighttime noise criterion for aircraft runup at high power would be 50 dBA. In view of the likely increase in background noise levels in the general vicinity of a developed Second Sydney Airport, the 50 dBA criterion is considered appropriate for all areas potentially affected.

6.1.1 CALCULATION OF RUNUP NOISE

Runup noise levels surrounding the Second Sydney Airport sites have been calculated using the Environmental Noise Model, ENM. This model allows for the noise emission level associated with typical ground running, attenuation with distance, shielding by natural topography, the effect of air absorption and ground effects and the effects related to meteorological conditions.

The noise emission level used for the calculations was a sound power level of 153 dBA for a typical Boeing 747 aircraft under high power runup conditions. Although the noise emission from the aircraft is directional (different levels being emitted at the different directions around the aircraft), no allowance has been made for directionality. Since aircraft running up are commonly operated with the nose facing the wind, there is no fixed orientation of the aircraft. Accordingly, a conservative assumption that the aircraft noise emission is not directional has been made. A sound power level of 153 dBA applying to all direction from the aircraft has been assumed.

Noise calculations have been performed for two relatively common meteorological conditions:

- neutral conditions (strictly isothermal atmospheric conditions involving temperature constant with height), and
- a temperature inversion of three degrees Celsius per 100 metres. This occurs when the temperature increases uniformly by three degrees Celsius above ground temperature up to a height of about 100 metres.

Specific runup bay locations have not been identified at this stage for the airport options. The assumption has been made that the runup bays would be near the area allocated for maintenance. Since Badgerys Creek Options A, B and C involve maintenance areas in similar positions, only one runup bay location assumption has been necessary for these three options. For the Holsworthy options a runup bay location has been identified for each of Options A and B.

6.2 CALCULATION RESULTS

The noise contours calculated are shown in *Figures 6.1* to 6.6. Contours are shown for both neutral conditions and temperature inversion conditions.

The two sets of contours cover the range of noise levels from average to high, but do not show lower noise levels that might occur during temperature lapse conditions and up wind.

In view of the probabilities of light wind conditions and temperature inversion conditions (refer *Technical Paper No. 5*), the contours for neutral conditions are considered appropriate for daytime runup and the contours for temperature inversion conditions are considered appropriate for nighttime runup. The effect at nighttime is therefore likely to be substantially greater than the effect at daytime and the impact of runup noise extends for a substantial distance from the airport during the night time period.

6.3 ASSESSMENT OF IMPACTS

On the assumption that high power runup would occur during the nighttime period, the contours for temperature inversion conditions are the most appropriate to consider. These cover a greater area than the contours for neutral atmospheric conditions as a result of the focusing effects of the temperature inversion.

The 50 dBA noise contour on *Figures* 6.2, *6.4* and 6.6 represents the outer extent of potential noise impact from nighttime ground running. For all airport options this contour extends over a wide area.

In the case of the Badgerys Creek options, the noise impact would extend over much of the rural land, rural residential land and associated villages surrounding the sites.

The impact associated with Holsworthy Option A would extend to the west into the edge of the Campbelltown local government area and surrounding area and to Sutherland in the east. To the north, the impact is expected to be limited to within the Holsworthy Military Area and the impact to the south and south-east would extend to the escarpment near the coast.

The impact associated with Holsworthy Option B would also extend west into the edge of the Campbelltown local government area and surrounding area and to the north-east in to the Royal National Park. Directly north, the impact is expected to be limited to within the Holsworthy Military Area, but the impact would extend significantly to the south and south-east towards the coast.

The actual impact of run-up noise in areas within the 50 dBA contour, but under proposed flight paths, is likely to be lower than indicated above. The occasional night time run-up would generate noise levels for a few minutes which are lower than intermittent levels which would occur from aircraft overflights. In view of the lack of certainty of night time flight paths on the assumption that some noise abatement procedures may be implemented during that period, it is not possible to quantify the run-up noise impact in these areas.

6.4 ENVIRONMENTAL MANAGEMENT

6.4.1 AIRCRAFT ORIENTATION

During aircraft runup, it is common practice to orientate the aircraft to point into the wind. This limits the flexibility of aircraft orientation during much of the time.

During still or light breeze conditions, however, it may be possible to orientate the aircraft in a specific direction to minimise the noise impact and this would often occur during the night-time period. In the case of the Badgerys Creek sites, benefits could be gained by pointing the aircraft to the east, while for both Holsworthy sites, the greatest benefits could be gained by pointing the aircraft to the north.

The benefits of specific orientation of this type are likely to be greater for the Holsworthy sites than for the Badgerys Creek sites.

6.4.2 NIGHTTIME CURFEW FOR RUNUP

Aircraft are runup mostly after routine maintenance on the engines, but are also runup from time to time as a result of unscheduled maintenance. Accordingly, it may be possible to limit routine maintenance runup to daytime to avoid the more sensitive nighttime period and also to reduce the probability of noise focusing as a result of temperature inversions.

Notwithstanding such a control, there may still be the need for the occasional runup at night as a result of unscheduled maintenance associated with early morning scheduled aircraft takeoff.

Limiting most high power runup activity to daytime would have a substantial effect upon the impact of ground running noise upon the surrounding area. The benefit derived would be similar for all airport options.

6.4.3 NOISE SHIELDING

The noise contours reported for ground running assume no shielding by the airport development. In practice, some of the buildings proposed, including maintenance hangars and passenger terminals, would shield ground running noise in some directions. In view of the present conceptual nature of the proposed airport options, potential shielding from the airport development has not been included in the calculations.

Apart from shielding resulting from other development at the airport, it may also be practicable to provide specific noise shielding around the runup bay. This could be in the form of earth bunding or a specific noise barrier. Shielding of about 10 metres high would provide about 10 dBA noise reduction in the surrounding area, depending upon such factors as the meteorological conditions at the time and the degree of shielding currently being provided by surrounding topography.

A 10 dBA reduction in the surrounding area would bring the 50 dBA contours shown in *Figures 6.1* to 6.6 into the approximate location of the 60 dBA contours. The benefit of this form of noise control would therefore be substantial.

In practice, noise shielding would be best provided by proposed buildings and specially constructed barriers to reduce noise propagation to those areas around the airport between proposed flight paths. Future knowledge of night time flight paths would be required to allow an integrated design of noise shielding.

6.4.4 SUMMARY OF POTENTIAL GROUND OPERATION NOISE IMPACTS

The environmental management measures outlined above would reduce the spread of ground operation noise from all airport options. The ground running curfew and the noise shielding would affect all sites to the same degree, whilst restrictions on aircraft orientation would benefit the Holsworthy sites to a slightly greater degree than the Badgerys Creek sites.

Despite the potential for the reduction of ground operation noise, the noise impacts have been summarised on the assumption that no relevant environmental management measures are implemented. The approximate populations likely to be affected by ground running noise have been estimated using the noise contours shown in *Figures 6.1* to 6.6 in 2016. These numbers are shown in *Table* 6.2.

TABLE 6.2 GROUND OPERATION NOISE IMPACTS IN 2016

Noise Indicator dBA	Badgerys Creek Options A, B and C	Holsworthy Option A	Holsworthy Option B
	Population[1]	Population[1]	Population[1]
Neutral Conditions			
50-55	600-1,000	0	0
Over 55	700-1,500	0	0
Temperature Inversion Conditions			
50-55	10,000-12,000	69,000[2, 3]	27,000 [2]
Over 55	5,500-9,000[2]	1,000	<100

Notes:
1. Population projection for 2016.
2. Figures above 5,000 rounded to nearest 1,000.
3. Approximately 9,000 of this population has been estimated from 1991 census data.

The results show that the impact of ground running noise at both Badgerys Creek and Holsworthy is likely to be substantial for temperature inversion conditions. The impact for all three Badgerys Creek options would be significantly less than the impact for both Holsworthy options. In view of the more remote location of the Holsworthy Option B site, its impact is significantly less than that for Holsworthy Option A.

The total impact of ground running noise as indicated in the contours and *Table 6.2* probably represents an overestimate of the true impact. Jet aircraft demonstrate directional noise characteristics whereby more noise is emitted towards the rear of the aircraft during runup than towards the sides and front. Accordingly, under normal runup conditions, the noise contours would be expected to extend significantly further in one quadrant than in the other three quadrants. However, the orientation of the aircraft during runup depends upon the wind direction and is expected to vary from day to day because of wind variations. Accordingly, the contours have been drawn to indicate the greatest extent of noise impact that would occur from time to time, assuming that the maximum noise level is emitted from the aircraft in all directions simultaneously. The contours shown therefore represent the overall extent of the possible impact during the long term, rather than the extent of the impact on any particular occasion.

Overall, the three methods to control the spread of ground operation noise outlined in *Section 6.4* or any combinations of these would not change the relative impacts of the airport sites. The impact for all Badgerys Creek options would be similar and would be less than those for the Holsworthy options. Holsworthy Option A impact would have a greater impact than Holsworthy Option B.

Ground operation noise is likely to affect some areas which would also be affected by aircraft overflight noise. The cumulative effect of these two noise levels is therefore of interest. It is considered that at the ground operation noise levels likely to result from a developed airport, aircraft overflight noise is very likely to substantially dominate the noise environment. In this case, the cumulative effect of ground operation noise when added to overflight noise would be negligible. The final relationship between these two types of noise would however depend upon the management of noise ultimately adopted for the chosen airport option.

7 CONSTRUCTION NOISE

During construction of any future airport, construction noise has the potential to affect the surrounding area. The noisiest stage of construction is the earthworks which, particularly in the case of the Holsworthy sites, would be substantial.

7.1 PROPOSED CONSTRUCTION

At the Badgerys Creek site, it is anticipated that the site earthworks would be carried out during daytime hours only and for a period in the vicinity of two years for Stage 1 development and three years for the master plan. The work is likely to involve a number of scrapers and trucks moving earth around the site, supported by loaders, dozers and compactors.

The earthworks required for both Holsworthy sites is substantially greater. For Holsworthy Option A, it is anticipated that the earthworks would last in the vicinity of 3 to 5 years for Stage 1 and 5 to 6 years for the master plan, based on operations of 20 hours per day. This could therefore involve nighttime operations. The construction operation is expected to be similar to a mining operation involving a large number of off road haul trucks backed by a significant number of loaders, dozers and compactors. It is also anticipated that blasting would need to be carried out.

For Holsworthy Option B, it has been estimated that the earthworks would last for 3 to 5 years for Stage 1 and 5 to 6 years for the master plan, based on operations occurring for 20 hours a day. A similar, but larger fleet of equipment would be required for this option. Again, it is anticipated that blasting would be required.

7.2 CONSTRUCTION NOISE CRITERIA

The NSW Environment Protection Authority recommends maximum construction noise levels for construction sites. These recommendations take into account the duration of the construction activity and assume that construction is carried out generally during daytime hours.

The time restrictions recommended are:

- Monday to Friday 7.00 am to 6.00 pm; and
- Saturday 7.00 am to 1.00 pm, if inaudible on residential premises, otherwise 8.00 am to 1.00 pm.

Based on these times, the following levels are recommended:

- construction period of four weeks and under:

  The L_{A10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background (L_{A90}) level by more than 20 dBA.

- construction period greater than four weeks and not exceeding 26 weeks:

  The L_{A10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background (L_{A90}) level by more than 10 dBA.

Although not stated by the NSW Environment Protection Authority, it is interpreted that criteria for long term noise exposure are appropriate for hours outside those recommended, and for construction periods in excess of 26 weeks. This latter situation would apply for all Second Sydney Airport site options, and the first situation is also likely to apply at Holsworthy. Accordingly, the long term criterion of five dBA above the background (L_{A90}) noise level is appropriate for the assessment of the Second Sydney Airport construction noise.

During the daytime period, the measured background noise levels in the vicinity of the Badgerys Creek site generally fall in the range 35 to 40 dBA. Assuming the upper end of this range, specifically allowing for the temporary nature of construction noise results in possible increase in a construction noise criterion of 45 dBA.

Around the Holsworthy sites, the typical nighttime background noise level is 30 to 35 dBA and, on the assumption of a 35 dBA background noise level, the appropriate criterion is 40 dBA. The assumed background noise levels are considered consistent with the long term background noise levels, since background noise levels in the area are likely to increase as a result of developing the Second Sydney Airport. The construction noise criteria are therefore as shown summarised in *Table 7.1*.

TABLE 7.1 CONSTRUCTION NOISE CRITERIA

Airport Option	Criterion
Badgerys Creek Option A	45 dBA
Badgerys Creek Option B	45 dBA
Badgerys Creek Option C	45 dBA
Holsworthy Option A	40 dBA
Holsworthy Option B	40 dBA

7.3 CONSTRUCTION NOISE CALCULATIONS

Construction noise levels surrounding the Second Sydney Airport sites were calculated using the Environmental Noise Model (ENM). This model allows for the noise emission level associated with individual items of construction equipment, attenuation with distance, shielding by natural topography, the effect of air absorption and ground effects and the effects related to meteorological conditions.

For each airport site a construction scenario has been developed for the construction of Stage 1 from information obtained from the Second Sydney Airport Planners (1997a). Individual items of plant have been assigned locations and noise emission levels.

One scenario has been developed for the three Badgerys Creek options. Loaders and dozers have been assumed to be working on the higher ground to the western end of the airport with scrapers and dozers moving this material towards the east to construct the landform on which the first parallel runway, tarmacs and buildings would be constructed.

One scenario has been prepared for each of Holsworthy Options A and B. In each case, the rugged topography means that material would be moved around the Stage 1 area for the purposes of levelling the site. Loaders and dozers have been assumed to be removing and loading material on the high ground with large off-road haul trucks moving this material to place fill in the low areas. It has also bee assumed that drills would be operating on the high areas for the purpose of blasting.

The noise calculations have been carried out for two relatively common meteorological conditions:

- neutral conditions; and
- a temperature inversion of three degrees Celsius per 100 metres.

The neutral conditions are relatively common during daytime whereas the temperature inversion conditions are relatively common at night. The former conditions have therefore been assumed for daytime calculations applying to the construction of the Badgerys Creek options. The latter conditions have been applied to possible nighttime construction which would occur at both Holsworthy sites. Although wind, particularly low velocity wind, can affect the spread of noise from construction sites, the increase downwind is similar to that which would occur during a temperature inversion condition. Accordingly, the calculations for temperature inversion conditions tend to provide a good indication of maximum levels that might occur downwind during a light breeze.

The method of blasting would need to be designed at some future time but assumptions have been made to estimate the likely vibration and airblast levels that would result from blasting. It has been assumed that blasting would involve five metre benches with holes of 125 millimetres diameter. The burden has been assumed to be 4.5 metres and, based on the use of ANFO (Ammonium Nitrate Fuel Oil) explosive, a charge of 44 kilograms has been assumed per hole.

Vibration and airblast levels have been predicted using scaled depth and scaled distance techniques developed by Duvall and Devine (1977). Scaled distance curves have been prepared for blasting in Sydney sandstone over a number of years using the techniques and these have been used in this case.

7.4 CONSTRUCTION NOISE IMPACTS

Construction noise contours are shown in *Figures 7.1* to *7.3*. *Figure 7.1* applies to all Badgerys Creek options and is based on neutral conditions, consistent with the proposed daytime construction. *Figures 7.2* and *7.3* apply to the Holsworthy options and are based on temperature inversion conditions, consistent with the proposed nighttime construction.

The construction noise contours shown in the figures result from the main earthworks associated with levelling of the site for Stage 1 and construction of the first runway. There would be times when earthworks and other construction of a less significant nature would be carried out closer to the boundary of each site and this work could generate higher noise levels in some areas from time to time. For this less significant construction work, the duration of construction would be limited and higher noise criteria would therefore be appropriate. Accordingly, the contours shown in *Figures 7.1* to *7.3*, generally speaking, indicate the extent of the construction noise impact.

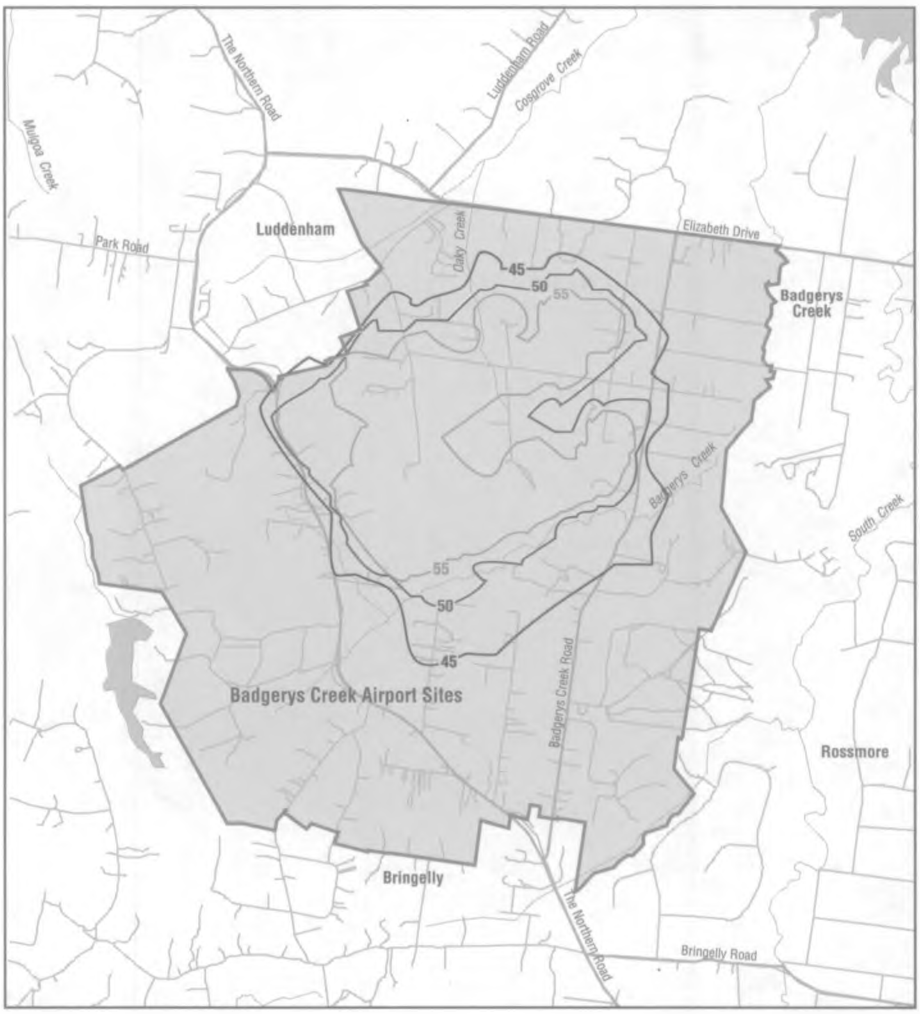
The results shown for the Badgerys Creek sites are for the construction of Stage 1 of Badgerys Creek Option A. The noise contours for construction of Options B and C would be similar, with a slight increase in noise level to the south, largely within the airport boundaries. During construction of the master plan at Badgerys Creek, additional noise would be generated to the north for Options A and B and to the south-east for Option C.

The contours shown for Holsworthy Option A are for Stage 1 construction. For the master plan construction, higher noise levels would be expected to the east with the contours being contained fully within the Holsworthy Military Area.

Since preparation of the noise contours for Holsworthy Option a, a material borrow area has been identified to the west of the airport site for Stage 1 construction and, if used, this would have the effect of increasing noise levels to the west of the airport. Again, the contours would still remain within the Holsworthy Military Area.

The master plan construction at Holsworthy Option B would be inclined to increase the noise levels to the north of the airport site, but wholly within the Holsworthy Military Area.

The likely extent of impact from construction at Badgerys Creek is indicated by the 45 dBA contour shown in *Figure 7.1*. Since this contour only marginally extends beyond the airport boundaries, the impact of construction noise at Badgerys Creek is expected to be minimal. This results from the fact that construction activities are currently proposed only during daytime.



Noise contour measured in dBA — 45 —

Boundary of Options A, B and C

Figure 7.1
Construction Noise Contours for Badgerys Creek Options A, B and C (Neutral Conditions)

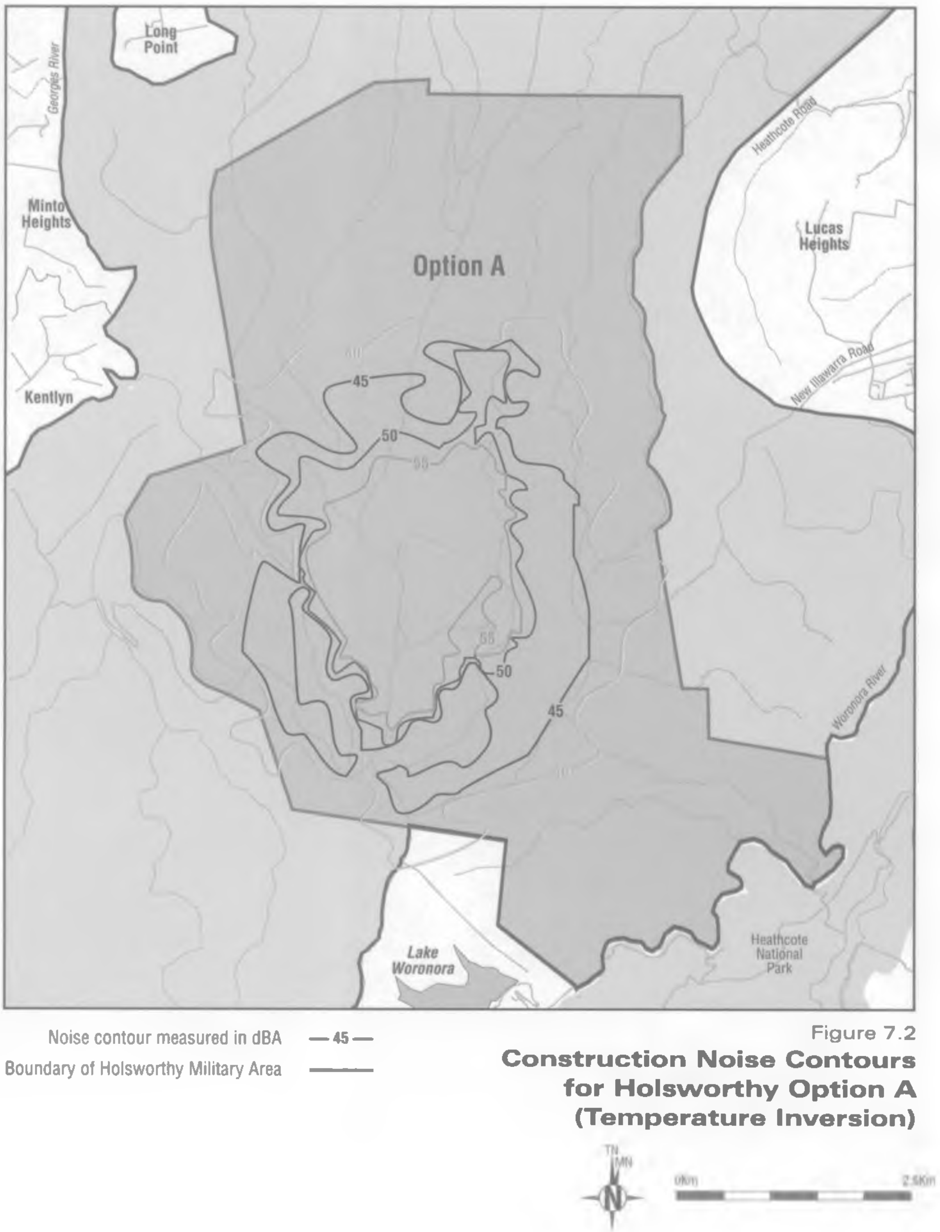
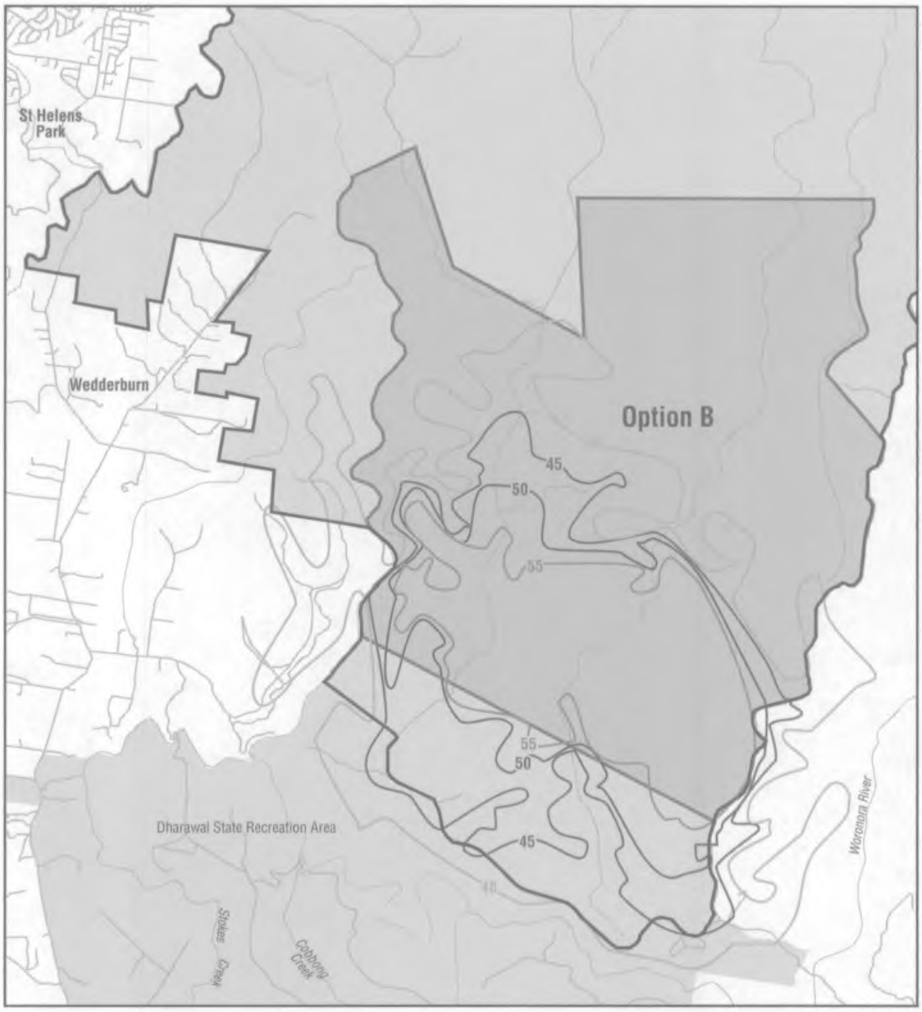


Figure 7.2
Construction Noise Contours for Holsworthy Option A (Temperature Inversion)



Noise contour measured in dBA 45

Boundary of Holsworthy Military Area

Figure 7.3

Construction Noise Contours for Holsworthy Option B (Temperature Inversion)

The extent of impact of construction noise associated with both Holsworthy options is indicated by the 40 dBA contour shown in *Figures 7.2* and *7.3*. The 40 dBA contour does not extend far beyond the Holsworthy Military Area resulting in a relatively minor impact from construction noise at these sites, despite the fact that construction would be carried out during the night.

7.5 IMPACTS OF BLASTING

Blasting for the removal of rock would generate groundborne vibration as well as airblast overpressure which would be transmitted through the air. Both of these phenomena can cause discomfort to residents and, at higher levels, damage to buildings.

7.5.1 VIBRATION AND AIR BLAST CRITERIA

The NSW Environment Protection Authority recommends maximum vibration and airblast levels to avoid discomfort to residents. If these criteria are achieved, then the risk of building damage is minimal.

The Environment Protection Authority criteria are shown in *Table 7.2*.

TABLE 7.2 ENVIRONMENT PROTECTION AUTHORITY LIMITING CRITERIA FOR THE CONTROL OF BLASTING IMPACT AT RESIDENCES.

Time of Blasting	Blast Over-pressure Level (dB(linear))	Ground Vibration, Peak Particle Velocity (mm/sec)
Monday - Saturday 9 am - 3 pm	115	5
Monday - Saturday 6 am - 9 am and 3 pm - 8 pm	105	2
Sunday, Public Holiday, 6 am - 8 pm	95	1
Any day 8 pm - 6 am		

7.5.2 BLAST ASSESSMENT

Based on the assumed blast design, the following distances would be required to meet the criteria shown in *Table 7.2* for the 9.00 am - 3.00 pm period, if one hole were blasted per delay:

- Vibration 280 metres
- Airblast 350 metres

Since these distances from likely blasting would still be within the Holsworthy Military Area, it is concluded that blasting can be conducted without exceeding NSW Environment Protection Authority criteria at residential locations.

Since the propagation of airblast from a bench blast is directional, further control of airblast can involve the use of specific bench orientations in areas in the vicinity of residential development. It is therefore concluded that the vibration and airblast criteria can be complied with, with the implementation of special blast designs, for blasting during early morning, daytime and early evening periods.

7.6 MANAGEMENT OF CONSTRUCTION NOISE

Construction noise at all proposed airport sites is expected to be minor. Construction noise control is therefore not proposed at any site at this stage. More detailed construction modelling would be undertaken when detailed construction plans are available during the detailed design phase. Monitoring of noise levels would be undertaken during construction, and if necessary, appropriate action would be taken to ensure that the criteria are not exceeded at nearby residences.

8 NOISE ASSOCIATED WITH OFF AIRPORT SITE INFRASTRUCTURE

A preliminary assessment of potential noise impacts associated with the off airport site road and rail proposals is provided in *Appendix B*. The infrastructure that would be built as part of the Second Sydney Airport proposal would be subject to separate environmental assessment processes under NSW legislation and has therefore not been addressed in detail in this Technical Paper.

Part E

Comparison of Options and Conclusions

9 COMPARISON OF AIRPORT OPTIONS - AIRCRAFT OVERFLIGHT NOISE

The noise impacts likely to result from development of the five airport options have been determined and assessed. The most important of these results from aircraft overflights associated with landings and takeoffs at the airport.

Table 9.1 summarises the impact of aircraft overflight noise from all airport options on populations in 2006 and 2016. *Table 9.2* summarises potential impacts on the predicted numbers of educational facilities in 2006 and 2016. *Table* 9.3 summarises potential impacts on predicted numbers of noise sensitive facilities in 2006 and 2016. These tables assume that none of the management measures discussed in *Section 5.5* are implemented.

The tables have been prepared on the basis of Air Traffic Forecast 3 which represents the highest level of aircraft movements. The results are provided in the form of a range resulting from the three airport operational scenarios analysed.

In *Table 9.3* there is no clear cut method for describing noise impact, as this would depend on the exact times of use, building construction and other parameters. The numbers of facilities impacted have been addressed in general terms by counting the number of facilities with noise exposure exceeding certain ANEC levels. ANEC levels have, in the past, been used to define areas of eligibility for insulation of schools and other facilities.

These tables reveal that all airport options would cause a significant aircraft overflight noise impact. Some sleep disturbance is likely to result around each airport option, particularly if a nighttime curfew is not implemented. Nevertheless, the extent of sleep disturbance is limited by the fact that the frequency of aircraft movements expected during the nighttime sleeping period is quite limited.

Conversation disturbance is likely to be one of the greatest impacts of all airport options. This is likely to occur within residences, educational institutions, churches, public buildings and some commercial buildings and noise affected zones. Annoyance from aircraft overflight noise is also likely for affected residents. The degree of annoyance is likely to be more significant shortly after the opening of the airport, despite the fact that only one runway would operate at that time. This is because of the sensitivity of the existing populations to aircraft noise. The effects of aircraft noise upon affected populations are discussed in detail in *Chapter 13*. The relationship between community annoyance and ANEC level is discussed and it should be noted that the population affected in the year 2006 is likely to be approximately eight dB more sensitive than the population affected in the year 2016.

The number of noise events exceeding 70 dBA over a 24 hour period tends to indicate the degree of disruption to normal domestic communication. At noise levels below 70 dBA, communication is unlikely to be interrupted, whilst above 70 dBA some interruption is likely to occur. The same comment applies in regard to the number of events exceeding 65 dBA at schools.

The effect of aircraft noise on wildlife and domestic animals and birds is less clear, but some effect is likely to result from all of the options. Equally, all options are likely to cause some effects upon users of natural areas and parks in the vicinity.

The impacts of the airport options vary depending on which noise indicator is examined. While impacts of the Badgerys Creek airport options would be similar across most indicators, it can be concluded that the Holsworthy airport options would generally affect more people than the Badgerys Creek airport options.

The impacts indicated in *Tables 9.1, 9.2* and *9.3* are the average annual impacts. During some days, the noise impact may be greater than this average depending on wind and operating conditions at the airport.

To allow a visual comparison of the five airport options, the affected populations are shown in the form of histograms in *Figures 9.1* and *9.2*.

TABLE 9.1 CUMULATIVE AIRCRAFT OVERFLIGHT NOISE IMPACTS[1, 2] ON ESTIMATED POPULATIONS IN 2006 AND 2016

Noise Indicator	Badgerys Creek Option A	Badgerys Creek Option B	Badgerys Creek Option C	Holsworthy Option A	Holsworthy Option B
	Population[3, 4]	Population[3, 4]	Population[3, 4]	Population[3, 4]	Population[3, 4]
People that may experience the following ANEC levels in 2006[5]:					
greater than 30	100-200	<100	<100	<100	<100
greater than 25	500	100-200	100-300	600-800	300-400
greater than 20	1,500-2,000	600-3,000	300-600	11,000-14,000	1,000-2,000
greater than 15	4,000-5,000	4,000	1,500-24,000	38,000-46,000	9,500-23,000
People that may experience, on average, the following number of noise events per day over 70 dBA in 2006:					
greater than 100 events	400-1,000	<100-200	<100	700-9,500	<100-1,500
greater than 50 events	1,500	400-800	200-300	16,000-32,000	1,500-4,500
greater than 20 events	3,000-3,500	2,500-4,000	400-23,000	46,000-56,000	7,000-8,000
greater than 10 events	5,500-6,500	5,000-5,500	24,000-38,000	88,000-108,000	17,000-55,000
People that may, on average, be awoken the following times in 2006[6]:					
once a night	<100	<100	<100	<100	<100-100
once every 2 nights	300-600	<100-100	<100-200	<100-1,500	<100-700
once every 5 nights	1,500	600-3,000	200-400	16,000-32,000	1,500-4,500

Noise Indicator	Badgerys Creek Option A	Badgerys Creek Option B	Badgerys Creek Option C	Holsworthy Option A	Holsworthy Option B
	Population[3,4]	Population[3,4]	Population[3,4]	Population[3,4]	Population[3,4]
People that may experience the following ANEC levels in 2016[5]:					
greater than 30	200	<100-200	<100-300	<100	<100-900
greater than 25	700-1,000	500-800	200-700	400-600	1,500-7,000
greater than 20	4,500-7,000	3,500-5,000	200-1,500	8,500-15,000	18,000-22,000
greater than 15	11,000-15,000	13,000-15,000	9,000-11,000	66,000-74,000	43,000-74,000
People that may experience, on average, the following number of noise events per day over 70 dBA in 2016:					
greater than 100 events	500-1,000	200-700	300-400	800-1,500	<100-5,500
greater than 50 events	2,500-5,000	2,000-4,500	800-1,000	9,500-22,000	10,000-17,000
greater than 20 events	8,000-9,500	6,000-7,000	3,000-17,000	54,000-96,000	30,000-63,000
greater than 10 events	14,000-25,000	12,000-14,000	46,000-49,000	153,000-162,000	57,000-89,000
People who may, on average, be awoken the following times in 2016[6]:					
once a night	<100	<100	<100-100	<100	<100
once every 2 nights	500-1,000	300-800	400-600	800-1,500	500-7,000
once every 5 nights	6,000-8,000	3,500-6,000	1,500-17,000	36,000-66,000	20,000-47,000

Notes:

1. Based on Air Traffic Forecast 3.
2. The noise impacts provided in this table are for standard airport operational conditions which have not been optimised with the objective of reducing noise impacts. Optimising runway use and flight paths would likely significantly reduce the numbers of people affected.
3. Population estimates for 2006 and 2016. Estimates of population affected by noise vary because of the different assumptions made about how the airport may operate.
4. There are limitations in the accuracy of predicting future populations and predicting future aircraft noise levels. Estimates of population greater than 10,000 have been rounded to the nearest 1000; estimates of population between 1,000 and 10,000 have been rounded to the nearest 500; and estimates of population less than 1,000 have been rounded to the nearest 100. Estimates of population less than 100 are provided as <100, meaning less than 100.
5. Impacts of levels of ANEC assume all residential properties within the 35 ANEC contour would be acquired.
6. Worst case situation as it does not assume any of the noise management measures that would be available to minimise noise at night

TABLE 9.2 CUMULATIVE AIRCRAFT OVERFLIGHT NOISE IMPACTS ON ESTIMATED EDUCATIONAL FACILITIES IN 2006 AND 2016[1]

Noise Indicator	Badgerys Creek Option A	Badgerys Creek Option B	Badgerys Creek Option C	Holsworthy Option A	Holsworthy Option B
	Educational[2] Facilities	Educational[2] Facilities	Educational[2] Facilities	Educational[2] Facilities	Educational[2] Facilities
Educational facilities that may experience, on average, the following number of noise events over 65 dBA[3] between 9am to 3pm in 2006:					
greater than 100 events	0	0	0	0	0
greater than 50 events	1	2	0	1-8	0
greater than 20 events	1-2	2-4	0-7	16-37	0-2
greater than 10 events	4	6-7	7-22	45-49	9-26
Educational facilities that may experience, on average, the following number of noise events over 65 dBA[3] between 9am to 3pm in 2016:					
greater than 100 events	0	0	0	0-2	0
greater than 50 events	2-3	1-2	1	3-6	0-3
greater than 20 events	6	4-7	3-22	30-43	14-27
greater than 10 events	6-13	10-16	28-40	66-68	29-42

Notes:
1. Based on Air Traffic Forecast 3.
2. Estimates of number of educational facilities in 2006 and 2016.
3. 65 dBA is the level at which communication within education buildings would be disturbed with external windows open.

TABLE 9.3 CUMULATIVE AIRCRAFT OVERFLIGHT NOISE IMPACTS ON OTHER NOISE SENSITIVE FACILITIES IN 2006 AND 2016[1]

Type of Facility	Year	ANEC	Badgerys Creek Option A	Badgerys Creek Option B	Badgerys Creek Option C	Holsworthy Option A	Holsworthy Option B
Hospitals	2006[2]	greater than 30	0	0	0	0	0
		greater than 25	0	0	0	0	0
		greater than 20	0	0	0	0	0
		greater than 15	0	0	0	0-1	0
	2016[2]	greater than 30	0	0	0	0	0
		greater than 25	0	0	0	0	0
		greater than 20	0	0	0	0	0
		greater than 15	0	0	0-1	2	0
Aged Care	2006[2]	greater than 30	0	0	0	0	0-1
		greater than 25	0	0	0	0	1
		greater than 20	0	0	0	2-3	1
		greater than 15	0	0	0	3	1-2
	2016[2]	greater than 30	0	0	0	0	0-1
		greater than 25	0	0	0	0	1
		greater than 20	0	0	0	3-4	1
		greater than 15	0	0-1	0	4-9	1-3

Notes:
1. Based on Air Traffic Forecast 3.
2. Estimates of number of facilities in 2006 and 2016.

Other studies, notably the *Environmental Impact Statement for the Third Runway at Sydney (Kingsford Smith) Airport* (Kinhill, 1990), have made use of information on predicted numbers of people in ANEC zones, together

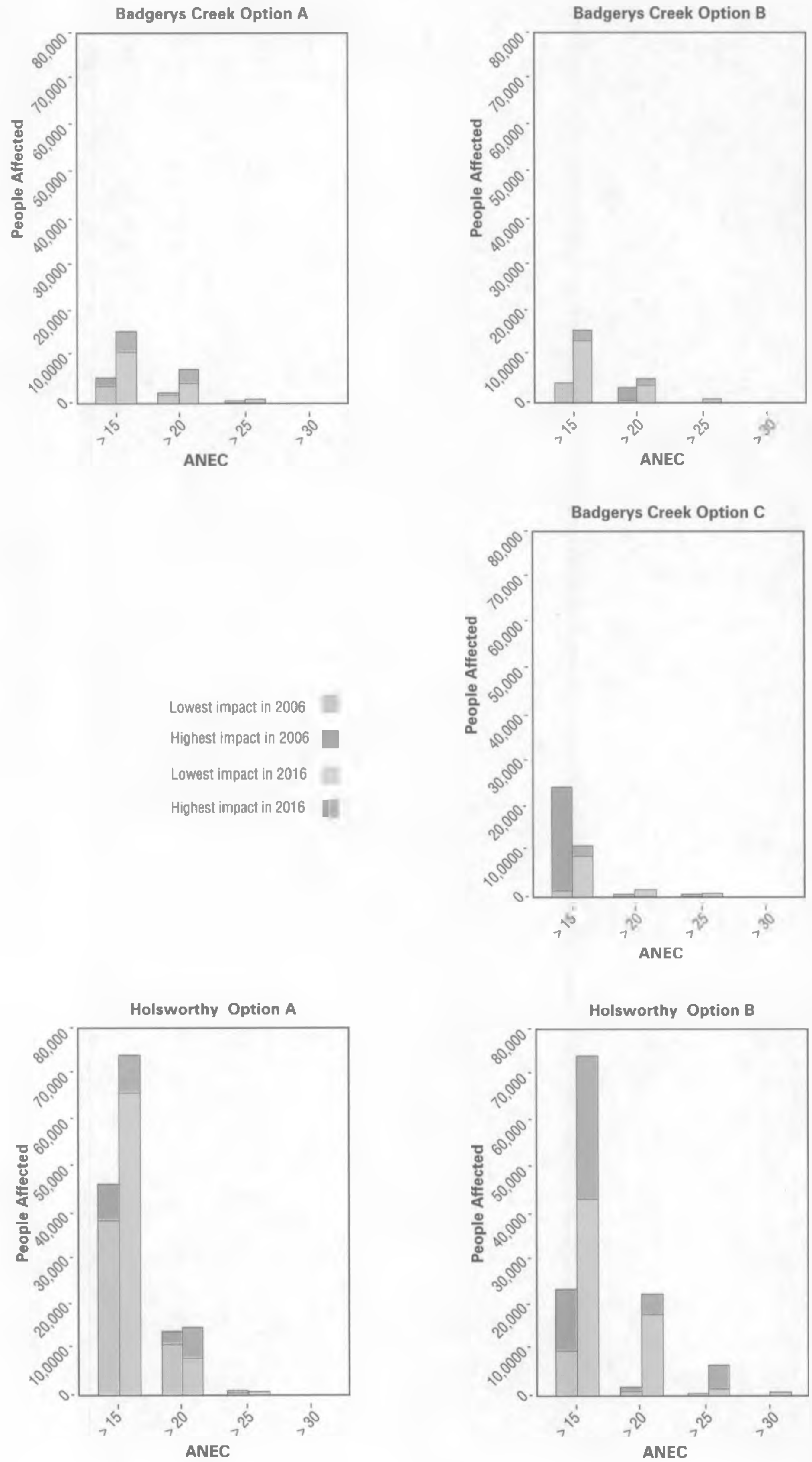


Figure 9.1

Range of Populations Affected by ANEC Noise Levels

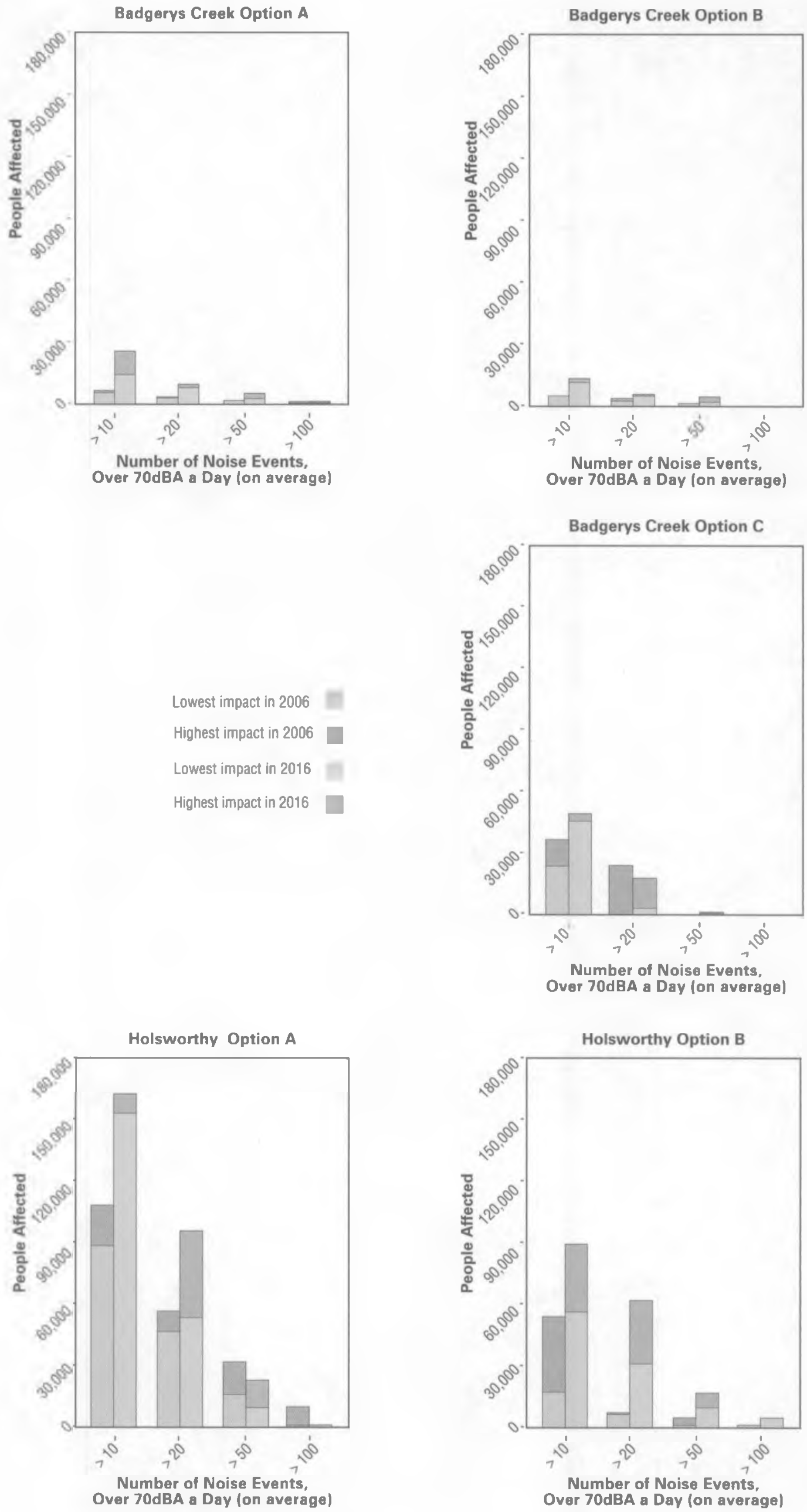


Figure 9.2
Range of Populations Affected by Noise Events Greater than 70 dBA

with data such as that shown in *Figures 5.28* and *5.29*, to calculate total numbers of people predicted to be *seriously affected* and *moderately affected* by aircraft noise under various scenarios. However, for the present study the more comprehensive assessment provided by *Tables 9.1*, *9.2* and 9.3 is preferred, for the following reasons:

- for all airport options, a large number of people would be affected by relatively low levels of aircraft overflight noise (less than 15 ANEC). The reaction of people in these areas cannot be reliably predicted and hence to attempt to calculate the proportion of people seriously and moderately affected would be misleading;
- the impact of noise from a newly introduced source is not well understood, although it is known to be higher than that from a source which has been in an area for some time; and
- even where relatively accurate estimates of numbers of people affected can be obtained, an approach which simply ranks options according to these estimates does not provide sufficient information to assess possibilities for noise mitigation through changes to flight paths or operating procedures, programs for acquisition or insulation of buildings or land use planning.

10 CONCLUSIONS

10.1 AIRCRAFT OVERFLIGHT NOISE

The results of aircraft overflight noise have been provided as a range to allow for uncertainties regarding the exact number of aircraft movements, runway operations and flight paths at the airport.

The results of the assessment lead to the following conclusions:

- all airport options would result in a significant noise impact. Significant numbers of people are likely to be annoyed by aircraft noise, to have their sleep disturbed and to have their conversation disturbed. High predicted noise levels close to the two Holsworthy options are likely to have some effect on wildlife, and domestic animals and birds close to all airport sites could be affected;
- Badgerys Creek Options A and B would result in a significantly lower noise impact than the other options;
- the impact of Badgerys Creek Option C and of Holsworthy Option B would be of the same order;
- the impact of Holsworthy Option A would be substantially above all other options; and
- although management of the noise impacts (noise abatement procedures and a nighttime curfew) is possible, this would not significantly change the ranking between the options.

10.2 GROUND OPERATION NOISE

Noise levels associated with nighttime ground running of aircraft engines have been estimated and assessed.

Providing some reasonable degree of control is implemented (such as noise shielding walls or bunds) the impact of noise associated with ground running at Holsworthy Options A and B would be limited. For the Badgerys Creek options, a more significant impact would result but this impact would be substantially less than that associated with aircraft overflights.

10.3 CONSTRUCTION NOISE

The noise associated with construction of the Second Sydney Airport has also been estimated and assessed.

In view of the separation between airport runways and nearby populated areas, it is unlikely that construction noise would have an impact on surrounding communities. This is despite the fact that it has been assumed that construction at both the Holsworthy options would be carried out during nighttime as well as daytime.

10.4 NOISE CONSEQUENCES OF ULTIMATE AIRPORT DEVELOPMENT

Development of the Second Sydney Airport beyond the master plan capable of handling 30 million passengers per annum to the ultimate airport development of handling 60 million passengers per annum is likely to increase the noise impact upon the surrounding communities.

Development of the conceptual plans would involve the construction of two additional parallel runways outside of those proposed for the master plans. This would have the effect of widening the area of noise impact parallel with the parallel runways so that additional communities would be affected. Those communities at the ends of the master plan parallel runways are not likely to experience an increase in the noise impact since the additional aircraft movements are likely to be accommodated on the new runways.

Overall, whilst an increase in the overall noise impact is expected, the amount of increase would depend upon operational procedures adopted at the airport, the aircraft types that would be flying at the time and the noise levels of those aircraft types.

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Appendices

Appendix A

Allocation of Aircraft Movements to Basic Flight Paths

TABLE A1 ALLOCATION OF AIRCRAFT MOVEMENTS TO BASIC FLIGHT PATHS - BADGERYS CREEK OPTION A

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
Arrivals	A12	North (05)	N	50.00%
	A13	North (05)	NW	50.00%
	A14	North (05)	N	50.00%
			W	50.00%
			NW	50.00%
	A15	North (05)	S	50.00%
			E	50.00%
			W	50.00%
	A16	North (05)	S	25.00%
	A17	North (05)	E	50.00%
	A18	South (23)	E	50.00%
			N	50.00%
			W	50.00%
			S	50.00%
			NW	50.00%
	A19	South (23)	E	50.00%
			N	50.00%
			S	50.00%
			NW	50.00%
			W	50.00%
	A24	North (05)	S	25.00%
Departures	D01	North (05)	NW	98.50%
	D02	North (05)	N	98.50%
	D03	North (05)	NW	1.50%
			N	1.50%
			E	100.00%
	D04	North (05)	S	49.25%
	D05	North (05)	W	98.50%
	D06	South (23)	E	49.25%
	D07	South (23)	N	98.50%
	D08	South (23)	NW	98.50%
	D09	South (23)	W	98.50%
	D10	South (23)	S	98.50%
	D11	South (23)	E	49.25%
	D20	North (05)	W	1.50%
			S	1.50%
	D21	North (05)	S	49.25%
	D22	South (23)	N	1.50%
			W	1.50%
			E	0.75%
			NW	1.50%
	D23	South (23)	E	0.75%
			S	1.50%

TABLE A2 ALLOCATION OF AIRCRAFT MOVEMENTS TO BASIC FLIGHT PATHS - BADGERYS CREEK OPTION B

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
Arrivals	A17	Cross (33)	E	50.00%
	A22	North (05)	N	50.00%
	A23	North (05)	NW	50.00%
	A24	North (05)	N	50.00%
			NW	50.00%
			W	50.00%
	A25	North (05)	E	50.00%
			S	50.00%
			W	50.00%
	A26	North (05)	S	50.00%
	A27	North (05)	E	50.00%
	A28	South (23)	N	50.00%
			E	50.00%
			S	50.00%
			W	50.00%
			NW	50.00%
	A29	South (23)	W	50.00%
			N	50.00%
			E	50.00%
			NW	50.00%
			S	50.00%
	A30	Cross (15)	S	50.00%
			N	100.00%
			E	100.00%
			W	50.00%
			NW	100.00%
	A31	Cross (15)	W	50.00%
	A32	Cross (15)	S	50.00%
	A33	Cross (33)	E	50.00%
			S	100.00%
			W	50.00%
			N	50.00%
			NW	50.00%
	A35	Cross (33)	N	50.00%
	A36	Cross (33)	W	50.00%
			NW	50.00%
Departures	D01	North (05)	NW	98.50%
	D02	North (05)	N	98.50%
	D03	North (05)	N	1.50%
			E	100.00%
			NW	1.50%
	D04	North (05)	S	49.25%
	D05	North (05)	W	98.50%
	D06	South (23)	E	49.25%
	D07	South (23)	N	98.50%
	D08	South (23)	NW	98.50%
	D09	South (23)	W	98.50%

TABLE A2 CONTINUED

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
	D10	South (23)	S	98.50%
	D11	South (23)	E	49.25%
	D12	Cross (15)	N	98.50%
	D13	Cross (15)	E	98.50%
	D14	Cross (15)	NW	1.50%
			W	1.50%
			N	1.50%
			E	1.50%
			S	100.00%
	D15	Cross (15)	W	98.50%
	D16	Cross (15)	NW	98.50%
	D18	Cross (33)	N	98.50%
	D19	Cross (33)	NW	98.50%
	D20	Cross (33)	W	98.50%
	D21	Cross (33)	S	98.50%
	D37	Cross (33)	N	1.50%
			W	1.50%
			S	1.50%
			NW	1.50%
			E	1.50%
	D38	Cross (33)	E	98.50%
	D39	North (05)	S	1.50%
			W	1.50%
	D40	North (05)	S	49.25%
	D41	South (23)	W	1.50%
			E	0.75%
			N	1.50%
			NW	1.50%
	D42	South (23)	S	1.50%
			E	0.75%

TABLE A3 ALLOCATION OF AIRCRAFT MOVEMENTS TO BASIC FLIGHT PATHS - BADGERYS CREEK OPTION C

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
Arrivals	A16	North (36)	N	50.00%
			E	50.00%
	A17	North (36)	NW	50.00%
			W	50.00%
			S	100.00%
	A18	North (36)	W	50.00%
	A19	North (36)	NW	50.00%
	A20	South (18)	N	50.00%
			E	100.00%
	A21	South (18)	NW	50.00%
			N	50.00%
			S	50.00%

TABLE A3 CONTINUED

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
			W	50.00%
	A22	South (18)	NW	50.00%
	A23	South (18)	W	50.00%
	A24	South (18)	S	50.00%
	A25	Cross (09)	E	25.00%
	A26	Cross (09)	N	50.00%
	A27	Cross (09)	NW	100.00%
			W	100.00%
			S	50.00%
			E	50.00%
			N	50.00%
	A28	Cross (09)	S	50.00%
	A29	Cross (09)	E	25.00%
	A30	Cross (27)	NW	50.00%
			N	50.00%
	A31	Cross (27)	NW	50.00%
			E	100.00%
			S	50.00%
			N	50.00%
			W	50.00%
	A32	Cross (27)	W	50.00%
			S	50.00%
	A33	North (36)	N	50.00%
			E	50.00%
Departures	D01	North (36)	E	100.00%
			N	100.00%
	D02	North (36)	NW	98.50%
	D03	North (36)	W	98.50%
	D04	North (36)	S	98.50%
	D05	South (18)	N	98.50%
	D06	South (18)	E	98.50%
	D07	South (18)	E	1.50%
			S	50.00%
			N	1.50%
	D08	South (18)	W	1.50%
			NW	1.50%
			S	50.00%
	D09	South (18)	NW	98.50%
	D10	Cross (09)	NW	100.00%
			W	100.00%
	D11	Cross (09)	E	100.00%
			N	100.00%
	D12	Cross (09)	S	50.00%
	D13	Cross (27)	E	98.50%
			N	98.50%
	D14	Cross (27)	NW	100.00%
			W	100.00%
			S	1.50%

TABLE A3 CONTINUED

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
			N	1.50%
			E	1.50%
	D15	Cross (27)	S	98.50%
	D34	Cross (09)	S	50.00%
	D35	South (18)	W	98.50%
	D36	North (36)	W	1.50%
			S	1.50%
			NW	1.50%

TABLE A4 ALLOCATION OF AIRCRAFT MOVEMENTS TO BASIS FLIGHT PATHS - HOLSWORTHY OPTION A

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
Arrivals	A14	North (34)	E	100.00%
			S	50.00%
			N	100.00%
	A15	North (34)	S	50.00%
			NW	50.00%
			W	50.00%
	A16	South (16)	N	50.00%
			S	100.00%
			E	100.00%
	A17	South (16)	N	50.00%
			NW	50.00%
			W	50.00%
			S	100.00%
	A18	Cross (09)	W	100.00%
			S	100.00%
			E	50.00%
			NW	50.00%
			N	50.00%
	A19	Cross (27)	N	100.00%
			W	100.00%
			S	100.00%
			E	100.00%
			NW	100.00%
	A20	South (16)	NW	50.00%
			W	50.00%
	A21	North (34)	NW	50.00%
			W	50.00%
	A22	Cross (09)	NW	50.00%
			N	50.00%
			E	50.00%
Departures	D01	North (34)	N	100.00%
			E	100.00%
	D02	North (34)	S	1.50%
			W	1.50%

TABLE A4 CONTINUED

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
			NW	100.00%
	D03	North (34)	S	49.25%
	D04	South (16)	N	100.00%
			E	100.00%
	D05	South (16)	NW	98.50%
			W	98.50%
	D06	South (16)	S	49.25%
	D07	Cross (09)	NW	98.50%
			W	98.50%
			N	98.50%
	D08	Cross (09)	NW	1.50%
			W	1.50%
			S	1.50%
			E	100.00%
			N	1.50%
	D09	Cross (09)	S	98.50%
	D10	Cross (27)	E	98.50%
			N	98.50%
	D11	Cross (27)	W	98.50%
			NW	98.50%
	D12	Cross (27)	S	98.50%
	D13	North (34)	W	49.25%
			S	49.25%
			W	49.25%
	D23	South (16)	NW	1.50%
			W	1.50%
			S	1.50%
	D24	South (16)	S	49.25%
	D25	Cross (27)	W	1.50%
			NW	1.50%
			N	1.50%
			E	1.50%
			S	1.50%

TABLE A5 ALLOCATION OF AIRCRAFT MOVEMENTS TO BASIC FLIGHT PATHS - HOLSWORTHY OPTION B

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
Arrivals	A13	North (29)	N	100.00%
			E	100.00%
	A14	North (29)	NW	50.00%
			W	50.00%
			S	50.00%
	A15	North (29)	NW	50.00%
			S	50.00%
			W	50.00%
	A16	South (11)	N	50.00%

TABLE A5 CONTINUED

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
			NW	50.00%
			W	50.00%
	A17	South (11)	S	50.00%
			E	50.00%
	A18	South (11)	S	50.00%
			E	50.00%
	A19	Cross (17)	E	100.00%
			NW	100.00%
			S	100.00%
			N	100.00%
			W	100.00%
	A20	Cross (35)	S	100.00%
			NW	50.00%
			W	50.00%
			N	50.00%
			E	50.00%
			W	50.00%
			W	50.00%
	A21	Cross (35)	NW	50.00%
			W	50.00%
			N	50.00%
	A22	South (11)	NW	50.00%
			W	50.00%
			N	50.00%
	A23	Cross (35)	E	50.00%
Departures	D01	North (29)	N	98.50%
			E	98.50%
	D02	North (29)	W	98.50%
	D03	North (29)	S	98.50%
	D04	South (11)	N	100.00%
			E	100.00%
	D05	South (11)	S	98.50%
	D06	South (11)	W	98.50%
			NW	98.50%
	D07	Cross (17)	N	98.50%
	D08	Cross (17)	NW	98.50%
			W	98.50%
	D09	Cross (17)	S	98.50%
			E	98.50%
	D10	Cross (35)	E	100.00%
			S	1.50%
			W	1.50%
			NW	1.50%
			N	100.00%
	D11	Cross (35)	W	98.50%
			NW	98.50%
	D12	Cross (35)	S	98.50%
	D24	South (11)	W	1.50%

TABLE A5 CONTINUED

Operation	Path Identifier	Runway Direction	Destination/ Origin	Percentage of Specified Operations Using Path
			S	1.50%
			NW	1.50%
	D25	Cross (17)	W	1.50%
			S	1.50%
			E	1.50%
			N	1.50%
			NW	1.50%
	D26	North (29)	NW	50.00%
			E	1.50%
			N	1.50%
	D27	North (29)	NW	50.00%
			W	1.50%
			S	1.50%

Appendix B

Preliminary Noise Assessment of Off Airport Site Road and Rail Infrastructure Proposals

Appendix B: Preliminary Noise Assessment of Off Airport Site Road and Rail Infrastructure Proposals

A preliminary assessment of the potential noise impacts of proposed off airport site road and rail infrastructure has been undertaken.

1. Noise Criteria

Different noise criteria have been used for new access corridors and where the proposal is for upgrading of existing roads or rail lines.

Road Noise Criteria

EPA has recently revised its road traffic noise policy and early information regarding the revised policy indicates the following noise criteria for new roads:

$L_{Aeq,15hr}$ 55 dBA (7.00 am - 10.00 pm)
$L_{Aeq,9hr}$ 50 dBA (10.00 pm - 7.00 am)

In view of the lack of nighttime traffic data, the 15 hour daytime criterion only has been adopted for this assessment.

In the case of existing roads, the criterion adopted is a maximum L_{Aeq} noise level increase of 2 dBA. Such an increase is considered barely noticeable on an existing road.

Rail Noise Criteria

EPA has published rail noise criteria which apply to new rail links and these are:

$L_{Aeq,24hr}$ 55 dBA
L_{Amax} 80 dBA

The $L_{Aeq,\ 24\ hour}$ criterion has been adopted for this assessment since it includes both train noise level and number of movements.

In the case of existing rail lines, the criterion adopted is an increase in $L_{Aeq,24hr}$ levels of 2 dBA. This increase is also considered barely noticeable.

2. Ambient Noise Levels

Ambient noise levels have been measured over 4-7 day periods (average 5) along existing roads and rail lines in the vicinity of the airport options and also near proposed upgrades or extensions to these. The results of measurements are shown in *Table B1*.

TABLE B1 MEASURED $L_{AEQ,(15 HR)}$, $L_{AEQ,(9 HR)}$ AND $L_{AEQ,24 HR}$, AT MEASUREMENT POSITIONS NEAR SECOND SYDNEY AIRPORT TRANSPORT LINKS

Location	Suburb	$L_{Aeq,15 hr}$ dBA	$L_{Aeq,9 hr}$ dBA	$L_{Aeq,24 hr}$ dBA
Bina Road (Army)	Holsworthy 2173	48	43	47
12 Kingdom Parade	Long Point 2564	46	40	44
13 Hyde Park Court	Wattle Grove 2173	57	43	56
33 Barnes Crescent	Menai 2234	57	53	55
31 Aberfoyle Road	Wedderburn 2173	46	40	45
64 Parma Crescent	St Helens Park 2560	62	45	58
72 Robinson Road	Bringelly 2171	53	51	52
"Mount Gilead", Appin Road	Gilead 2560	49	48	49
2680 Elizabeth Drive	Badgerys Creek	57	54	56
1798 Elizabeth Drive	Badgerys Creek	62	57	61
770 Bringelly Road	Bringelly	59	55	58
145 Badgerys Creek Road	Bringelly	53	48	52
46 Findley Road	Greendale	57	54	55
17 Glenfield Road	Glenfield	63	59	62
16 Goodenough Street	Glenfield	56	51	54
23 Haultain Street	Minto	50	42	47
126 Fairview Avenue	Engadine	49	44	48

$L_{Aeq,24 hr}$ levels at the three locations selected for measurement of ambient noise levels near proposed rail links (Bina Road, Holsworthy; 31 Aberfoyle Road, Wedderburn and 72 Robinson Road, Bringelly) are less than the 55 dBA criterion. The $L_{Aeq,15 hour}$ at 12 Kingdom Parade, Long Point, which is near one of the proposed access roads, is also less than the criterion of 55 dBA.

All of the remaining locations are on existing roads which have the potential to be affected by the airport options. The $L_{Aeq,15 hr}$ levels measured are mostly above the 55 dBA criterion with the exception of 145 Badgerys Creek Road, Bringelly and 23 Haultain Street, Minto.

3. Road Noise Assessment

Road noise levels have been calculated using the AADT forecasts and assuming 2.5% of the traffic is heavy vehicles and 85% of the AADT flow occurs during the 15 hour daytime period. Noise calculations have used the CORTN procedure, developed by the UK Department of Environment.

Badgerys Creek Options

For all three Badgerys Creek options, the proposed road traffic routes and road traffic forecasts are the same. For most roads in the vicinity of these airport options, the increases in $L_{Aeq,15 hr}$ levels would be less than the criterion of 2 dBA in 2016. Those roads where more than a 2 dBA increase has been estimated are shown in *Table B2*. At these locations, a road traffic noise impact would occur at adjacent residential locations as a result of the Badgerys Creek airport options. However, the increases expected could be reduced to a maximum of 2 dBA or totally eliminated by the use of open graded asphalt or by the erection of roadside barriers in front of residential locations.

TABLE B2 $L_{Aeq,15\,hr}$ NOISE LEVEL INCREASES DUE TO BADGERYS CREEK AIRPORT OPTIONS

		Forecast Noise Level Change (dBA)	
		1996-2016 Without Airport	1996-2016 With Airport
Bringelly Road	East of Northern Road	1	7
Bringelly Road	East of Kings Street	0	6
Bringelly Road	West of Kings Street	1	7
Bringelly Road	East of Cowpasture Road	-5	6
Bringelly Road	West of Cowpasture Road	4	2
Camden Valley Way	South of Bringelly Road	0	2
Denham Court Road	East of Camden Valley Hwy	-	2
Devonshire Road	Elizabeth Drive	1	3
Elizabeth Drive	West of Wallgrove Road	1	3
Elizabeth Drive	West of Badgerys Creek Road	2	6
Elizabeth Drive	West of Devonshire Road	2	5
Elizabeth Drive	West of Mamre Road	2	4
15th Avenue	West of Cowpasture Road	-	3
Luddenham Road	North of Elizabeth Drive	4	11
Mamre Road	South of M4	-	4
The Northern Road	North of Elizabeth Drive	2	2
The Northern Road	North of Bringelly	-	4

Table B2 shows the base noise level increase (or decrease) which results from natural traffic growth in the absence of the Badgerys Creek airport options. It also shows the increase over and above this due to the airport being developed in 2016.

Holsworthy Option A

Most of the roads in the vicinity of a Holsworthy A option would experience road traffic noise increases of less than 2 dBA as a result of developing the airport. However, some roads would experience increases above 2 dBA as indicated in *Table B3*.

TABLE B3 $L_{Aeq,15hr}$ NOISE LEVEL INCREASES DUE TO HOLSWORTHY OPTION A

		Forecast Noise Level Change (dBA)				
		1996-2016 Without Airport	2016 N1	2016 N2	2016 N3	2016 N4
Anzac Road	West of Heathcote Road	-1	2	1	2	0
Cambridge Road	West of Moorebank	-	4	4	2	0
Moorebank Avenue	North of Cambridge Avenue	1	6	4	3	0
Moorebank Avenue	South of M5	-	4	3	2	0
Campbelltown Road	North of Glenfield Road	2	0	0	2	1
Glenfield Road	East Old Glenfield Road	0	0	-1	6	1
Old Illawarra Road	North of Bangor Bypass	4	0	1	0	2

Since the proposed alternative access roads to this airport option are partly outside the Holsworthy Military Area, there is potential for noise associated with them to affect residences in the vicinity. The $L_{Aeq,15hr}$ levels have been estimated at two typical distances from the road, assuming relatively flat ground. The estimated levels are shown in *Table B4*.

TABLE B4 $L_{AEQ,15HR}$ NOISE LEVELS ADJACENT TO HOLSWORTHY OPTION A ACCESS ROADS IN 2016

Access Option	$L_{Aeq,15hr}$ Noise Levels (dBA)							
	Alternative 1/2 (North of Airport)		Alternative 2 (East of Freeway)		Alternative 3 (East of Airport)		Alternative 4 (West of Airport)	
	20 m	100 m	20 m	100 m	20 m	100 m	20 m	100 m
N1	78	70	74	67	-	-	-	-
N2	76	69	74	67	76	69	-	-
N3	76	69	-	-	75	67	73	66
N4	-	-	-	-	-	-	73	66

At both distances estimated traffic noise levels are likely to exceed Environment Protection Authority recommended levels without the implementation of noise control measures.

Holsworthy Option B

The increases in $L_{Aeq,15hr}$ noise levels on most of the roads surrounding Holsworthy Option B are expected to be less than the 2 dBA criterion. However, in some cases, as shown in *Table B5*, the increases would be more.

TABLE B5 NOISE LEVEL INCREASES DUE TO HOLSWORTHY OPTION B

Road	Section	Forecast Noise Level Change (dBA)		
		1996-2016 Without Airport	2016 S2	2016 S3
Appin Road	South of Copperfield Road	3	4	2
Atchison Road	North of Saywell Road	-	2	1
Blaxland Road	East of Narellan Road	-3	4	1
Cambridge Avenue	West of Moorebank Avenue	-	2	0
Camden Valley Way	South of Denham Court Road	-2	3	0
Campbelltown Road	South of Denham Court Road	4	3	1
Campbelltown Road	South of Ben Lomond Road	3	2	1
Campbelltown Road	South of Williamson Road	2	2	1
Harold Street	South of Victoria Street	0	3	0
Moorebank Avenue	North of Cambridge Avenue	1	2	0
South Western Freeway	North of Narellan Road	-	3	2
South Western Freeway	North of Link 6	-	5	4
The Northern Road	Atlowes Creek	0	3	1
Williamson Road	South of Books Street	-2	3	-1
New Illawarra Road	North of Heathcote Road	3	0	2

The proposed access road to this option runs from the South Western Freeway to the western edge of the airport, crossing Appin Road. The $L_{Aeq,15hr}$ noise levels expected at two typical distances, based on flat ground, are shown in *Table B6* for the Year 2016.

TABLE B6 $L_{Aeq,15hr}$ NOISE LEVELS ADJACENT TO HOLSWORTHY OPTION B ACCESS ROAD IN 2016

Access Option	$L_{Aeq,15hr}$ Noise Levels (dBA)			
	Alternative 6 (West of Appin Road)		Alternative 6 (East of Appin Road)	
	20 m	100 m	20 m	100 m
S2	76	68	78	70
S3	73	66	74	67

This table shows that the noise levels anticipated at both distances would exceed the Environment Protection Authority recommended level without noise control measures.

4. Railway Noise Assessment

Apart from the additional proposed rail track, the existing rail network would be utilised for access to the airport for the Holsworthy options. This would generally involve an increase in rail movements and therefore an increase in noise level adjacent to the rail line. The forecast increases in the $L_{Aeq,24hr}$ noise levels adjacent to existing lines by the year 2016 are shown in *Table B7*.

TABLE B7 CHANGE IN $L_{Aeq,24hr}$ NOISE LEVELS ADJACENT TO RAIL LINES IN 2016

Rail Link	Forecast Noise Level Change (dBA)			
	1996-2016 Base	Badgerys Creek 2016	Holsworthy Option A 2016	Holsworthy Option B 2016
Holsworthy Station to City	1	6	6	6
Cumberland Line	0	0	1	1
Glenfield to Holsworthy	1	1	1	1
Campbelltown to Glenfield	0	-2	-2	-2
Macarthur to Campbelltown	2	-2	-2	-2

For all of these rail links, except Holsworthy Station to the Sydney central business district, the increases would be less than the 2 dBA criterion for all airport options. For Holsworthy Station to the Sydney central business district, increases are all the same and are significant for all three airport sites.

For the proposed new rail link to each of the airport sites, the anticipated rail movements are the same. Consequently, the $L_{Aeq,24hr}$ noise levels expected at typical distances from this line, assuming flat ground, are the same for all airport options. These are shown in *Table B8*.

TABLE B8 $L_{Aeq,24hr}$ NOISE LEVELS FROM NEW RAIL ACCESS LINKS FOR ALL AIRPORT OPTIONS IN 2016

Airport Option	$L_{Aeq,24hr}$ Noise Levels (dBA)	
	20 m	100 m
All Options	60	52

The levels in *Table B8* are based on passenger train movements, but any additional freight movements are not expected to increase the estimated levels. Freight movements up to 10 per day would not change the $L_{Aeq,24hr}$ levels quoted in the table.

Although the rail noise criterion would be met at 100 metres, it would be exceeded at 20 metres. Further calculations show that the criterion would be met at a distance of approximately 50 metres.

5. Conclusion

Road traffic to all the Second Sydney airport options would use existing roads (upgraded as required) and also newly constructed access roads. Significant noise level increases would occur on some existing roads as a result of each of the airport options. However, the higher increases could be reduced to the 2 dBA criterion or be eliminated mostly by the use of open graded asphalt road paving, but in some cases also with the use of roadside noise barriers.

In regard to both Holsworthy Options A and B, the new access roads required would be partly outside of the Holsworthy Military Area. The noise levels expected at both 20 metres and 100 metres from these roads (without specific noise control measures) would exceed the EPA recommended criterion. However, it may be possible to align these roads to avoid being near existing residences. Where noise levels still exceed the EPA criterion, reductions could be achieved by the use of open graded asphalt as the road paving and/or road side noise barriers.

Transport links to the proposed airport option by rail would also utilise the existing rail network, but some new access links would need to be constructed. On the existing network, noise level increases would be expected to be unnoticeable, except for the main line from Holsworthy Station to the Sydney central business district. On this line, the overall increase in noise level would be expected to be approximately 6 dBA for all airport options. Such an increase would be expected to cause a noise impact upon adjacent residents.

For those sections of the proposed new rail lines outside of the airport boundaries and outside of the Holsworthy Military Area, the noise levels are expected to comply with the Environment Protection Authority criterion at 50 metres. It may be possible to construct these new rail links following an alignment which is not closer than 50 metres from any residence. If further noise control is required, then this can be provided by the use of noise barriers at the side of the rail line.