



Discussion Paper

Expanding Ways
to Describe
and Assess
Aircraft Noise



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Feedback

Comments on the ideas put forward in this paper would be valued. These may be sent to

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Foreword

This document has been prepared to promote debate on the development and use of more transparent approaches to describing and assessing aircraft noise around Australian airports.

The paper is primarily targeted at those persons who are directly involved in generating, or making formal decisions based on, aircraft noise exposure information - airport operators, airlines, noise consultants and officials of government aviation, environment, transport and planning agencies. The broad aim is to advance the way in which aircraft noise exposure information is conveyed to the non-expert as a basis for informed dialogue between airports and surrounding communities.

The concepts described in this paper have been developed over the past three years as a result of the special circumstances surrounding Sydney Airport and are the outcome of the Sydney community's response to the conventional approach to providing information on aircraft noise.

The 1995 Senate Select Committee on Aircraft Noise in Sydney identified many deficiencies in the way in which aircraft noise information had been conveyed to the public through the reliance on the Australian Noise Exposure Forecast (ANEF) System in the Environmental Impact Statement (EIS) for the Third Runway at Sydney Airport.

In response to the Committee's recommendations a number of new approaches to conveying information on aircraft noise have been developed in recent years. These approaches are based on describing aircraft noise in a way that is understandable to a non-expert rather than in the terms in which noise 'experts' communicate with each other.

As the paper broadly addresses issues raised by the Senate Select Committee much of the information included relates to Sydney Airport. However, the approaches canvassed have broad applicability and the paper includes a number of examples of information on aircraft noise exposure patterns at other Australian airports using the 'new' metrics.

These supplementary approaches have essentially only been made possible by the advent in recent years of inexpensive and powerful computing hardware and associated software – databases, geographic information systems, satellite images, etc. Technological advances will undoubtedly continue to play an important role in expanding the way in which information on aircraft noise can be presented and disseminated.

The concepts put forward for discussion in this paper have been developed by officers of the Department of Transport and Regional Services and do not necessarily reflect the views of the Commonwealth Government.

Synopsis

THE PROBLEM AND OUR PROPOSED RESPONSE

Over the past twenty years the Australian Noise Exposure Forecast (ANEF) system has been used in four key ways. It is used to delineate where, and what type of, development can take place around airports; to determine which buildings are eligible for insulation around Sydney Airport; for technical assessments of airport operating options in Environmental Impact Statement (EIS) processes; and as a tool for providing information to the public on noise exposure patterns around airports.

It has been, and continues to be, successfully used in the first three of these roles. However, the Department considers that there are significant limitations in using the ANEF as a way to describe aircraft noise exposure to the layperson.

While the populations with the highest aircraft noise burdens live within the 20 ANEF contour, the majority of noise complaints that are received are now coming from persons living outside the 20 ANEF contour. Traditionally the residents of these areas have been given little information on aircraft noise through the ANEF system other than that the area is considered 'acceptable' for new housing. This type of approach has at best proven unhelpful and at worst has sent completely the wrong message. Some people living outside the 20 ANEF contour have been given an expectation of receiving little or indeed no aircraft noise and, as a consequence, find the levels of noise actually experienced to be 'unacceptable'.

In simple terms people want to be told about aircraft noise exposure in their own language - where the flight paths are, how many movements, what time of the day, etc - but the official response has been to provide information in the form of a single figure ANEF value. Not unnaturally there has frequently been a breakdown in communication between the 'noise expert' and the community which we consider has been at the expense of both parties.

This paper describes approaches that the Department of Transport and Regional Services has developed in an effort to address these communication problems. The proposed solutions are simple - no doubt some will characterise them as simplistic. In essence the Department is trying to encourage airports/acoustical professionals/planners to use the same terminology that non-experts use when talking to each other. This has led to the development of descriptors based on treating aircraft noise as a series of single events rather than through cumulating and computing average noise energy which is the basis of the ANEF.

It is argued in the paper that these descriptors enable us to move beyond the conventional thinking on aircraft noise where on one side of the line the noise is described as being 'acceptable' while on the other it is termed 'unacceptable'.

The descriptors enable people to 'visualise' what aircraft noise will be like. Armed with this information they are in a much better position to make a decision whether they are likely to find future noise 'acceptable'. For example, a noise sensitive person will be greatly advantaged when deciding on whether to make a house move if they have access to this type of information rather than simply knowing that the area is exposed to say less than 20 ANEF.

The same principle applies to situations where an airport is proposing to introduce changes such as a new runway which would, if approved, result in major changes to the aircraft noise exposure patterns over neighbouring communities. Providing 'real' aircraft noise information for all of the areas likely to be subject to changes in aircraft noise enables the community to actively and meaningfully participate in any public consultation process. It also gives the decision makers a much clearer picture of what the outcomes will be if they approve the project. In effect it enables a community to decide on what it believes are 'acceptable' operating and flight path arrangements for its airport.

The broad thesis being proposed by the Department is that it would be to the advantage of all parties - airports, industry and the community - if we moved beyond using the ANEF system as an information tool (but retain it for its other uses) and commenced producing 'real' aircraft noise information on a regular basis. To this end it is suggested that Australian Standard AS2021 needs to be enhanced to provide a basis for the provision of better information to address the aircraft noise issues that are now arising at a number of Australian airports.

This paper is not an attempt to replace the ANEF system as a planning tool. The ANEF system continues to be the most technically complete means of portraying aircraft noise exposure and the Department is not proposing any changes to the land use planning principles and restrictions embodied in Australian Standard AS2021.

Index

1. Introduction	1
1.1 Describing aircraft noise in ‘everyday’ terms	1
1.2 Conventional information – ANEF contours	1
1.3 The role of the ANEF	2
1.4 The Sydney Airport experience	4
1.5 Broad issues	5
1.5.1 <i>The average day</i>	5
1.5.2 <i>Sensitive times</i>	5
1.5.3 <i>Extent of coverage</i>	6
1.6 Assessing the total noise load generated by airports	6
1.7 Drawing the information together	6
2. Primary Information – Flight Paths and Movement Numbers	7
2.1 Flight path maps	7
2.2 Runway end movement information	7
2.3 Flight path movements charts	8
2.4 The average day	8
2.5 Sensitive times	14
2.6 Extent of coverage	16
2.7 Discussion	16
2.7.1 <i>Limitations</i>	16
3. Respite – Monitoring and Reporting Breaks from Aircraft Noise	19
3.1 Background	19
3.2 The average day	20
3.3 Sensitive times	20
3.4 Extent of coverage	22
3.5 Discussion	22
4. The N70 – Combining Movement Numbers and Noise Levels	23
4.1 Background	23
4.2 The average day	25
4.3 Sensitive times	25
4.4 Extent of coverage	35
4.5 Discussion	37

5.	The Person-Events Index – Assessing the Total Noise Load of Airports	40
5.1	Background	40
5.2	The Person-Events Index (PEI)	41
5.3	The Average Individual Exposure (AIE)	41
5.4	Worked Example – Sydney Airport	42
5.5	Discussion	43
6.	Discussion	45
6.1	Rethinking the concept of ‘acceptable’ – Enabling the individual to decide on ‘acceptability’	45
6.2	Using information as a tool to improve compatibility between communities and airports	46
6.3	Targeting the noise sensitive individual	48
6.4	Using relational indicators in noise forecasts	49
7.	A Way Ahead – A Suggested Initial Approach	53
7.1	Broad principles	53
7.2	Regular publication of area wide relational noise information	54
7.3	Review and revision of Australian Standard AS2021	55
7.4	Further studies	55
	7.4.1 <i>N70 verification study</i>	55
	7.4.2 <i>Development of other relational noise indicators</i>	56
	7.4.3 <i>The Internet</i>	56
	REFERENCES	57
	APPENDIX A	
	The Australian Noise Exposure Forecast (ANEF) System	59
A.1	Genesis	60
A.2	Relationship to other indicators	60
A.3	Land use compatibility advice	60
A.4	Terminology	60
	APPENDIX B	
	Derivation of Noise Indices	63
B.1	Flight path movements charts	64
B.2	Respite charts	64
B.3	N70 contours	64
	B.3.1 <i>Computation of N70 contours</i>	64
	B.3.2 <i>Computation of the number of persons within the N70 contours</i>	65
	B.3.3 <i>Accuracy of N70 contours</i>	65
	APPENDIX C	
	PEI Computations	67
C.1	Detailed computations for the ‘Worked Example’	68
C.2	Using the PEI to analyse partial noise loads	71



Introduction

1.1 Describing aircraft noise in 'everyday' terms

Most people who are affected by aircraft noise do not have a technical background and when talking about aircraft noise use 'everyday' terminology. For example, they make statements like 'Three noisy planes flew over my house in the last half hour.' They do not use, and do not want to use, complicated technical terms when discussing aircraft noise.

Experience has shown that members of the public are interested in being provided aircraft noise information in a form that they can readily relate to. The following are some of the typical questions that are asked. Where will the flight paths be? How many aircraft will use the flight paths? At what time will I get the noise – during the day, early mornings, evenings or weekends? What will it be like on the 'bad' days? Will I get more noise in summer? Will the largest and noisiest aircraft fly over my area? Will I get take-offs or landings over my house? When will I get a break from the noise?

Despite these simple questions, it has been conventional until recently for relevant authorities to only provide complicated answers.

1.2 Conventional information – ANEF contours

In Australia the conventional approach to providing information on aircraft noise has been to publish Australian Noise Exposure Forecast (ANEF) contours. These contours show the amount of total noise energy received by locations on the ground near an airport on an annual average day. Australian Standard AS2021 'Aircraft noise intrusion – building siting and construction' uses ANEF values to determine land use compatibility. For example, the standard states that areas with an aircraft noise exposure level of less than 20 ANEF are 'acceptable' for residential development [ref 1]. **Appendix A** contains a brief description of the ANEF system.

The production of ANEFs is required at leased Commonwealth airports as part of the airport master planning process established under the *Airports Act 1996*.

To illustrate the way the ANEF system has been used as an information tool it is useful to examine the type of advice that has conventionally been given to a person who is considering moving into a new area and is interested in learning about aircraft noise exposure.

This person has generally been given advice by aviation and/or local government authorities along the following lines

'There is an Australian Standard which sets criteria for the siting of houses to protect occupiers from aircraft noise. Under the Standard sites which have an Australian Noise Exposure Forecast (ANEF) value less than 20 ANEF are acceptable for housing. The house you are looking at has a noise exposure of less than 20 ANEF and therefore it is in an area which the Standard says is acceptable.'

Depending on the circumstances this advice may also have been tempered by additional words such as *'you will be able to hear aircraft noise at the house and if you are very sensitive to aircraft noise you may find that it affects you.'*

This approach is illustrated by a 1985 letter from the then Department of Transport to a member of the public which was reported to the 1995 Senate Select Committee on Aircraft Noise in Sydney in which a person was told that *'...[the house] is situated outside the 20 ANEI [(ANEF)] contour. Aircraft noise is therefore objectively assessed as being insignificant and the area suitable for residential use.'* [ref 2].

At best this advice is not very enlightening - being told that the noise exposure at a house site is less than 20 ANEF does not give the person any sense of what the noise will be like. The advice has only told the person that an Australian Standard (based on 'expert' analysis of data on community reaction) has decided that he/she would not be too upset by aircraft noise if he/she were to move into the house. Indeed, on one interpretation, the person concerned could conclude that no aircraft noise would be heard. Given the statement in an 'official' letter that *'...noise [outside the 20 ANEF contour] is ...insignificant...'*, it is not surprising that people would form the view that aircraft noise would only be a problem 'inside' the contours.

Unfortunately experience in recent years has demonstrated that the aircraft noise problem is not confined to areas inside the noise contours. In fact most complaints about aircraft noise at Australian airports come from people who live outside the published ANEF noise contours (ie the 20 ANEF). This is illustrated in **Figure 1.1**. At Sydney Airport during 1998 approximately 90% of the complaints came from residents of areas outside the 20 ANEF (ANEI) contour.

1.3 The role of the ANEF

The ANEF system was developed and adopted in the early 1980s. Over a period of years the use of ANEF contours as an aircraft noise information tool grew to the point where these contours effectively excluded all other ways of describing aircraft noise exposure patterns. This is despite the fact that ANEF contours were not developed, or initially intended to be used, as a way to describe noise impacts to the non-expert. The ANEF system is primarily a land use planning system.

In recent years there has been much public criticism of using ANEF contour information to describe aircraft noise exposure. Clearly, as described in the previous section, there are

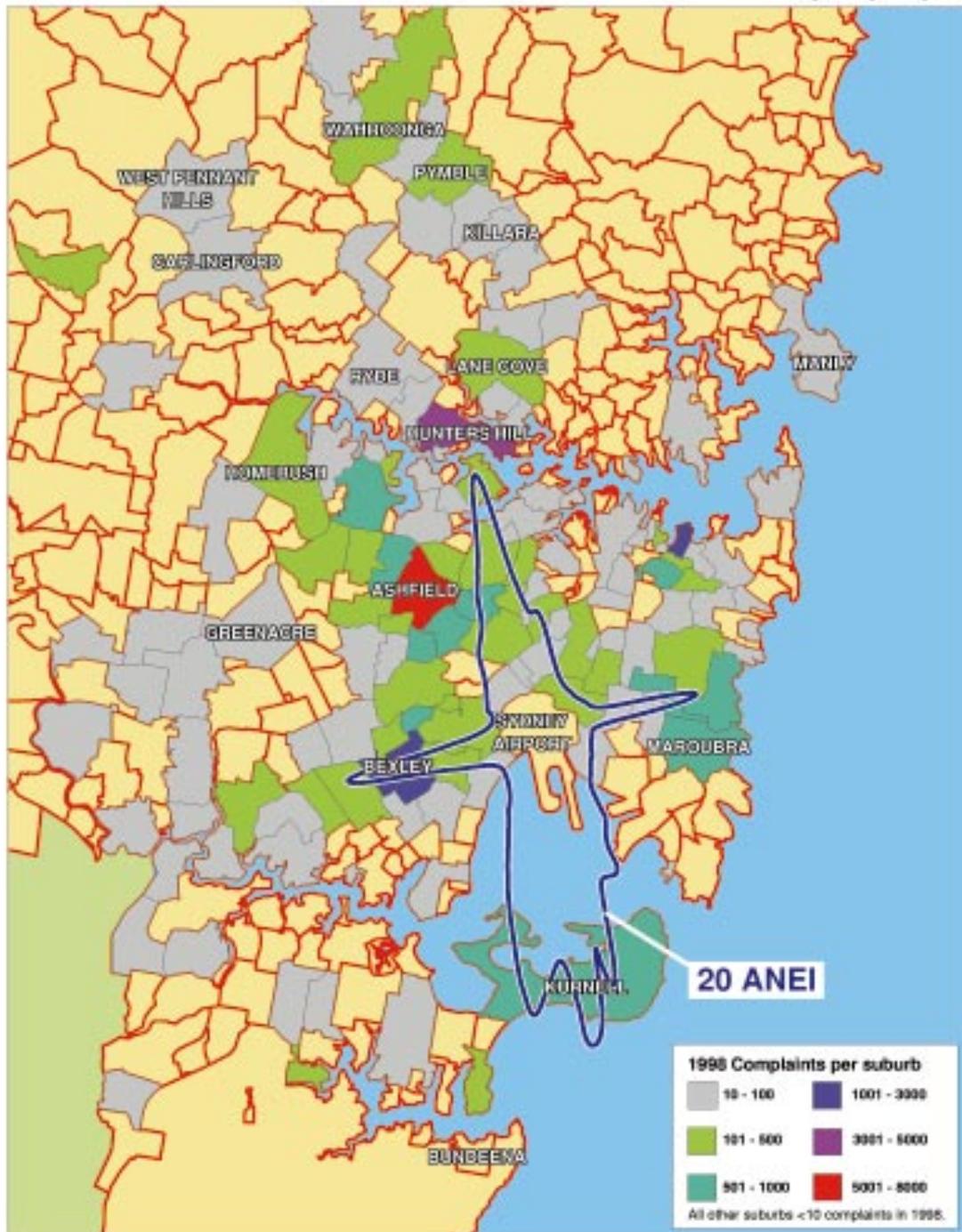


Figure 1.1 1998 Aircraft noise complaints vs 1998 20 ANEI contour

shortcomings in the way the contours have been used in the past to provide community information and strategies to address these are a major thrust of this paper. However, this does not mean that the ANEF system has no place or that it should be discarded. Rather its role needs to be more clearly defined and its strengths and weaknesses recognised.

An ANEF at a particular point on the ground is computed by summing up the noise energy received at that point on an average day. The contour maps are based on the ANEF being

computed across a grid with the contour lines joining those grid points with equal ANEF value. Technically this is a more complete way to portray the noise exposure at a point on the ground than the 'user friendly' indices discussed in this paper.

The underlying approach of the ANEF system - forecasting and reporting aircraft noise exposure through summing total noise energy - is common to that contained in the aircraft noise indices used by most overseas countries.

The study that led to the establishment of the ANEF system showed that, when compared to other noise metrics, the ANEF most closely relates community reaction to noise exposure [ref 3]. Given this, and the fact that it is more technically complete than other metrics (ie it computes total noise dose), it is the most valid way to define land use acceptability for areas around an airport. This of course was the reason the ANEF was established. The above arguments also directly support the ANEF as being the most appropriate metric to use when determining eligibility for insulation under the Sydney Airport Noise Insulation Program.

Given that the ANEF is the most technically complete way of portraying noise exposure patterns there is clear logic in it being used as the basic technical assessment tool in environmental assessments for a project (in particular in Environmental Impact Statements). However, because such assessments often serve a dual role of technical analysis and dissemination of information, and because the decision makers on the project will almost certainly not be noise experts, it is considered imperative that ANEF information in an environmental assessment be **supplemented** by other approaches.

1.4 The Sydney Airport experience

In November 1994 the third runway opened at Sydney Airport. The resultant changes in noise exposure patterns, which concentrated noise on suburbs to the north of the Airport, triggered a public outcry which ultimately led to the establishment of the Senate Select Committee on Aircraft Noise in Sydney.

The Select Committee's report was particularly critical of the way in which the noise impacts had been portrayed in the project's Environmental Impact Statement (EIS) [ref 4]. As was standard practice at the time, the EIS had used ANEF information as the prime tool for describing the changes in noise exposure. For a range of reasons a large number of people considered that they had been misled by the way this information had been presented.

In response to the Select Committee's recommendations major changes have now been made to the way in which aircraft noise is described and discussed with the community in Sydney. The conventional approach involving noise experts trying to find easy ways to explain to non-experts what their metrics (such as the ANEF) mean has largely been superseded. The new approaches are based on describing, as far as possible, aircraft noise in a way which a person uses when holding an 'everyday' conversation or making a telephone complaint. These are described and discussed in **Chapters 2, 3 and 4.**

These changes have largely evolved over the past three years during the process of developing and implementing the 'Sydney Airport Long Term Operating Plan' (LTOP). This Plan also arose out of the Select Committee's recommendations and is designed to remove the concentration of noise over suburbs to the north of Sydney Airport through a 'noise sharing' approach.

1.5 Broad issues

There are a number of broad issues which overlay the specific problems generated by describing noise to the community simply in terms of an ANEF number.

These have been grouped under the headings of 'The Average Day', 'Sensitive Times' and 'Extent of Coverage' and are areas of difficulty when using any noise metric.

These issues receive specific attention in **Chapters 2, 3 and 4.**

1.5.1 The average day

Conventional aircraft noise metrics reduce information on noise exposure to that on an annual average day since this has proven to be the most convenient way to condense the information to a digestible amount. However, aircraft noise exposure for many areas around an airport varies very widely from hour to hour, day to day and season to season and hence an average day is rarely a typical day. Aircraft noise often has 'flood' or 'famine' qualities.

This means that the information that is given to the public very often doesn't relate closely to a person's actual experience.

The problems generated by reducing noise information to the annual average day were specifically addressed in the report of the Senate Select Committee. A quote from the report encapsulates the issue

'An average figure for levels of intrusive noise is meaningless; it is usually the peaks which draw the most hostile response. So too an averaging of noise energy received over a year, which will simply mask periods where the intensity is very high...' [ref 5]

1.5.2 Sensitive times

It is generally recognised that at certain times of the day (or the week) an aircraft noise event will have a greater impact. Social surveys and noise complaint patterns indicate that for most people the most noise sensitive times are night-time, evenings and early mornings and weekends.

The ANEF system allows for this to some extent by including a four times weighting for movements between 7pm and 7am. Other systems used overseas have different weightings for different time periods (eg the DNL used in the US weights movements between 10pm and 7am by 10 times). By way of contrast the Leq used in several countries has no weighting for sensitive times.

The differences in the hours and magnitude of the 'sensitive times' weightings is one of the major differences between individual international noise metrics and clearly therefore it is a difficult area on which to reach agreement or to prove that there is a 'right' answer.

1.5.3 Extent of coverage

It was shown in **Section 1.2** that under the conventional ANEF approach no aircraft noise information is given to residents of areas outside the 20 ANEF other than that the area is suitable for residential use. The lack of specific information on aircraft noise exposure patterns for these residents was a major area of criticism raised by the Senate Select Committee. The two paragraphs below highlight this point and the position adopted by the Committee.

'The adoption of land use planning criteria to confine noise impact [the 20 ANEF] meant that residents from as far afield as Ku-ring-gai, Summer Hill, Haberfield, Kurnell and Bundeena were led to believe that they would not be affected by aircraft noise. These residents were effectively disenfranchised by this approach. They took no active part in the EIA process because they felt themselves unaffected.' [ref 6]

'It is essential that information concerning noise impact at levels below 20 ANEF be provided to affected communities.' [ref 7]

The indicators in this paper have therefore placed emphasis on giving information on noise exposure as far away as possible from an airport recognising that the information will be less reliable for areas distant from an airport.

1.6 Assessing the total noise load generated by airports

It is frequently necessary for an assessment to be made of the overall changes in noise exposure resulting from, for example, the construction of a new runway or the restructuring of the airspace arrangements at an airport.

Decisions are commonly based on analyses which compare the number of persons within particular noise exposure zones for a number of options. However, analysis of this type of information is not straightforward. In order to address some of the problems identified with current approaches a simplified additional Index – the Person-Events Index – has been developed. This is discussed in **Chapter 5**.

This Index is intended to **supplement** and not replace existing assessment methods.

1.7 Drawing the information together

Some implications of adopting the noise indicators presented in the core of the paper are discussed in **Chapters 6**. This leads in **Chapter 7** to the Department's suggested approach for furthering the use of these indicators.

Primary Information

FLIGHT PATHS AND MOVEMENT NUMBERS

The first information which is sought by a member of the public when looking into aircraft noise for the first time (eg when deciding whether to buy a new house in a certain area) is generally the location of the flight paths. If there are no flight paths near the area the person is interested in then aircraft noise is generally no longer an issue for that person. However, if flight path maps indicate that there will be aircraft overflights of the area then the person invariably asks how many aircraft movements will there be on the flight paths.

2.1 Flight path maps

Historic flight path information is frequently sought by members of the public from the Airservices Australia Noise and Flight Path Monitoring Systems (NFPMS), which are in place at most of the major Australian airports. This information is made freely available and is used as a key indicator in all airport monitoring reports.

The issue of presenting information on future flight paths, for example in an EIS, is more problematic. In the initial phase of developing the Sydney Airport Long Term Operating Plan (LTOP) a large number of detailed flight path maps were provided to the community. These maps proved very useful as they gave persons a long way away from the Airport an indication where the aircraft were likely to be. However, they did have weaknesses.

While the NFPMS maps show the spread of the flight paths the representation of flight paths in the LTOP report by relatively narrow lines gave the impression to some people that aircraft fly on 'rail lines' in the sky. There are other shortcomings which apply equally to both the NFPMS maps and the LTOP maps. For example, the maps do not indicate how often the flight paths have been, or would be, used, and how high and loud aircraft were, or would be, at a particular point. They can also give the impression that aircraft will only be audible in areas immediately under, or very close to, the lines.

2.2 Runway end movement information

At Sydney the most basic form of 'noise' information is presented simply in terms of the number of movements (and/or percentages of total traffic) over the four geographic quadrants – north, south, east and west.

Clearly a statement such as '25% of the movements during May were to the north of the Airport' leaves out a large amount of detail (eg whether the movements were landings or take-offs, which flight paths were used, etc). Nevertheless, this information does enable a person to gain a broad appreciation of the distribution of noise in areas close to the airport.

Despite its shortcomings, this very simple way of describing 'noise' has received very wide usage in Sydney over the past three years.

2.3 Flight path movements charts

In order to address some of the key weaknesses in the types of information discussed in the previous Sections flight path movements charts of the type at **Figure 2.1** have been developed. These essentially answer the two basic questions - where do the aircraft fly and how many overflights are there. These only include information on *jet* aircraft, which are the overwhelming source of public complaint, primarily in order to maximise the clarity of the charts.

These charts are simple to derive and are based on airport NFPMS flight path maps and on aircraft movements information contained in an airport's Avcharges database. This is explained in **Appendix B**. The charts shown in this Chapter report on what has happened. Producing charts to indicate future noise exposure patterns is discussed in **Section 6.4**.

Examples of flight path movements charts for Coolangatta, Perth and Brisbane are shown in **Figures 2.2, 2.3** and **2.4**. These reveal some interesting differences between the nature of the noise exposure at different airports. For example, at Sydney almost all of the areas that receive a high average daily number of overflights per year still have a very significant number of days with no movements (see most of the flight paths in **Figure 2.1**). By comparison at Perth, areas which have a relatively low average number of daily overflights have a much smaller number of days with no overflights (see almost all the flight paths in **Figure 2.3**). On the other hand a 'bad' day at Sydney tends to be much worse than one at Perth.

2.4 The average day

While the first question on the number of overflights a person may ask is usually couched in average terms – how many flights will there be a day? – this quickly evolves into questions on the hour to hour, day to day and season to season variations. As indicated in the Introduction (**Section 1.5**) providing 'average day' information using any aircraft noise indicator has the potential to be misleading due to the generally wide temporal variations in aircraft overflights at a given location.

In order to address the average day issue the boxes on the charts include, for each flight path, some simple statistical information on the variations in movements over the time period for which the chart applies. Specifically the boxes show the range in the number of daily movements (ie the 'quietest' and 'busiest' days) for the period and also specify how many days there were when there were no movements. The boxes also give an indication of the proportion of the total jet movements along each of the flight paths to show the extent to which the movements are shared between the flight paths (this is a particularly important issue for Sydney Airport under its 'noise sharing' regime).

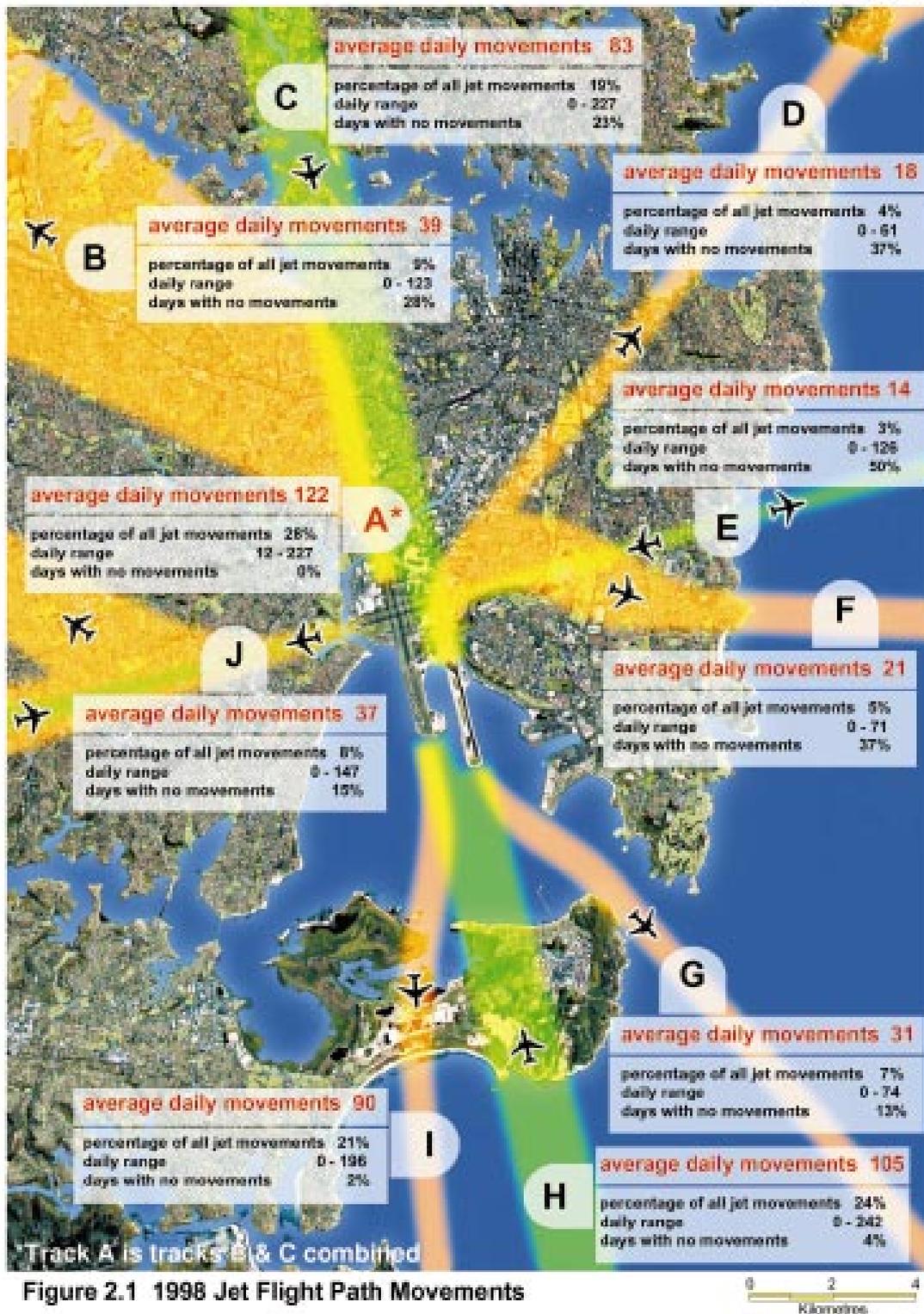


Figure 2.1 1998 Jet Flight Path Movements

Coolangatta Airport



Figure 2.2 Jul - Dec 1998 Jet Flight Path Movements

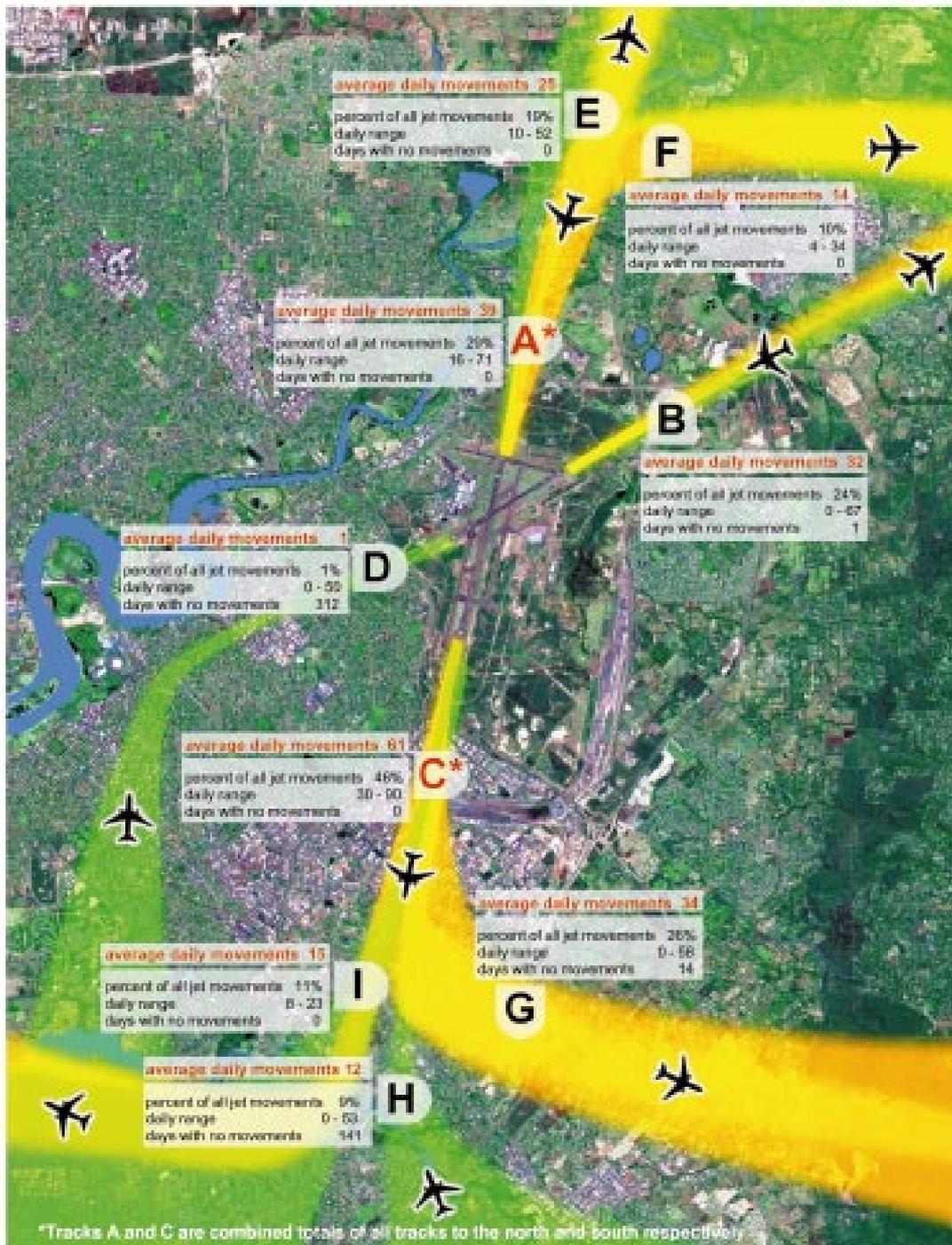
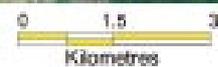


Figure 2.3 1998 Jet Flight Path Movements Chart



Brisbane Airport



Figure 2.4 1998 Jet Flight Path Movements

The information in the boxes has evolved in response to the most frequent questions raised by the Sydney community. Clearly it would be very simple to use alternative statistical descriptors such as the mode or the number of days when the activity is below a specified threshold level if these more closely responded to the questions being raised by communities at other airports.

Alternatively flight path movements charts could be produced daily and the statistics could relate to the hour by hour variations in movements (eg the charts could show the quietest and busiest hours and the number of hours with no movements).

Figure 2.5 is another simple statistical representation derived from the Sydney Airport Avcharges database which has been prepared in response to questions on the number of overflights on the average day over a specific area. This shows that under the parallel runway regime (1995) there were typically around 200 jet overflights a day over areas to the north of the Airport. Under the noise sharing regime (1998) there is much greater variability in the number of overflights and on the most common day the activity levels are approximately half of those under the parallel runway regime.

Sydney Airport

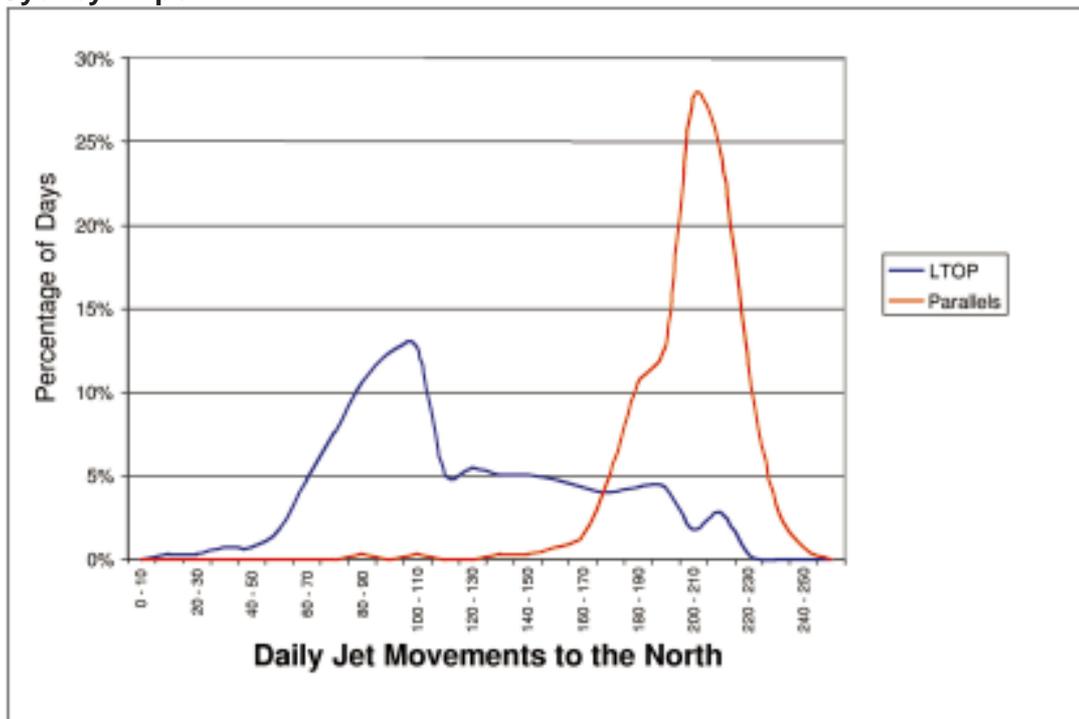


Figure 2.5 Daily number of Jet movements to the North comparison between LTOP and Parallel runway operations

The average day question can also be addressed by producing the charts on a more frequent basis. This approach means that shorter term variations are less likely to be 'buried' by a mass of other information. **Figure 2.1** shows the chart for a year; similar charts are produced on a monthly basis for Sydney Airport as part of its ongoing environmental reporting. Shorter term charts could be produced if they were considered necessary.

Information on very short term fluctuations (eg hour to hour) in the patterns of aircraft movements, which forms part of this issue, has been treated separately and captured under the topic of 'respite'. This is discussed in detail in **Chapter 3**.

2.5

Sensitive times

As indicated in the Introduction (**subsection 1.5.2**) a key issue is the reporting of, or making allowance for, movements which occur at noise sensitive times particularly evening, night, early morning and weekends. The standard charts at **Figures 2.1-2.4** do not include any weighting or explicit information on what happened at the noise sensitive times.

There would appear to be two broad approaches which could be adopted to address this question. The first would be to adopt some form of weighting system, similar to that used in many standard cumulative noise indices (eg ANEF, Ldn), where movements at sensitive times are taken to be x times worse than those at other times. If it were possible to agree on a suitable weighting factor or factors it would be simple to produce a weighted chart. However, experience would suggest that any factors chosen would be the subject of debate and criticism.

The second approach is to produce a separate chart specifically for the sensitive times. This latter approach is preferred since it overcomes the problem of gaining agreement on what is the appropriate weighting factor; instead it simply factually reports the movements. It is also preferred as it is a much more transparent approach and does not 'hide' (by swamping with other movements) the fact that there may be significant aircraft activity over certain areas at sensitive times. Nevertheless, a balance has to be struck and it is recognised that producing a multiplicity of charts for separate time periods can be confusing.

Figure 2.6 is an example of a 'sensitive times' jet flight path movements chart for Sydney Airport (sensitive times have been defined as 6am-7am & 8pm-11pm on weekdays and 6am to 11pm on weekends – see **Section 3.3**). Comparison between this figure and **Figure 2.1** shows, for example, that while areas north of the Parramatta River (flight path C) are exposed to more than twice the number of total overflights, the west (flight path J) has a greater average daily exposure to overflights at sensitive times.

Sydney Airport

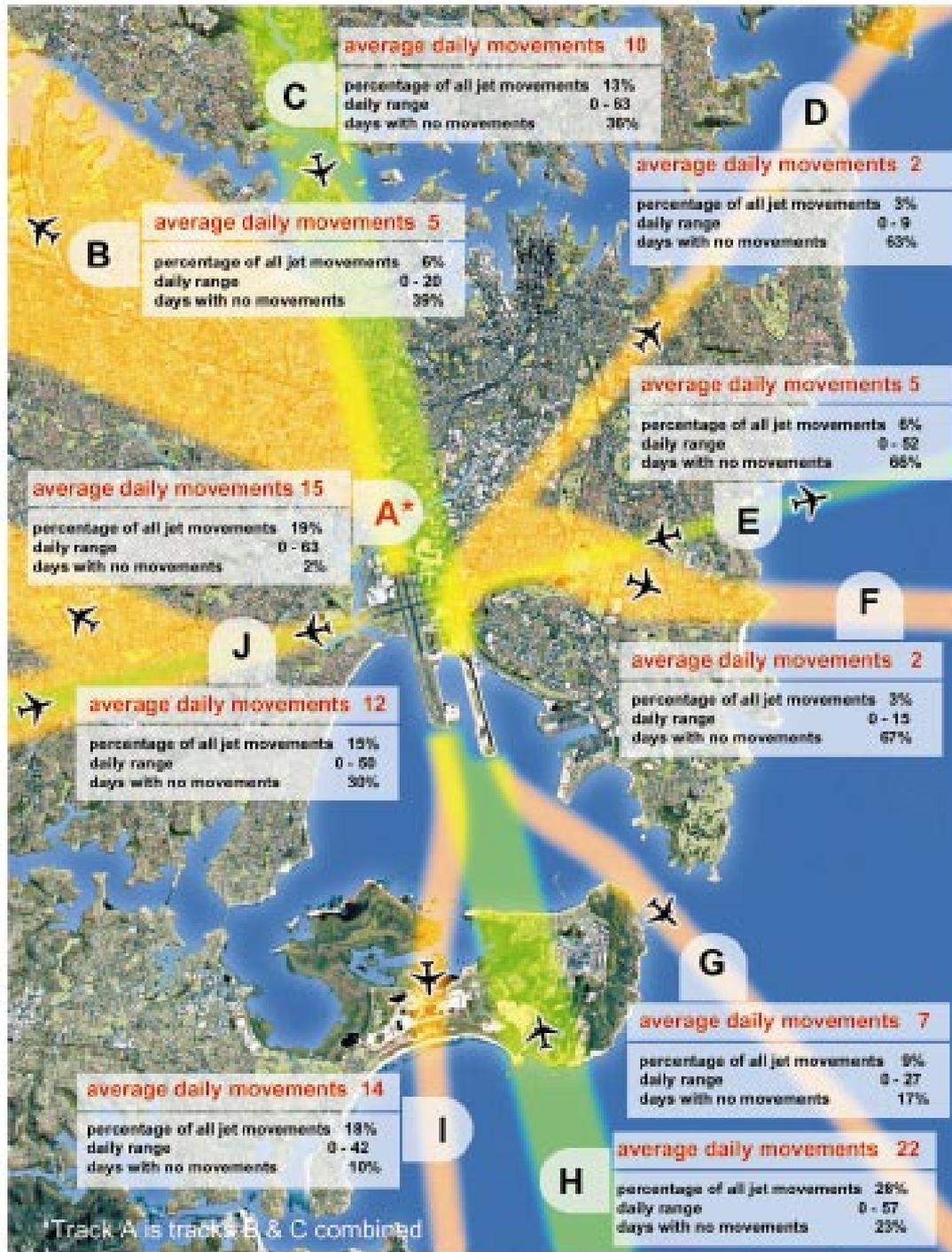


Figure 2.6 1998 Sensitive Hours Jet Flight Path Movements



As indicated in **sub-section 1.5.3** a very major issue has been how to appropriately and accurately present information on aircraft noise for those areas which lie outside the conventional noise contours.

Putting aside the question of comprehensibility, the most obvious response to this issue would have been to produce conventional noise contours to a lower noise exposure level. The standard outer contour on ANEF maps is the 20 ANEF. Many requests have therefore been made to report out to the 15 ANEF (for example see [ref 8]). However, this approach has largely not been successful as an information tool because the 15 ANEF generally does not extend far beyond the 20 ANEF (for example see [ref 9]).

It has been found that one of the key reasons for the acceptance of the flight path movements charts has been that they give information on aircraft movements for areas at some distance outside the 20 ANEF contour. This point is illustrated in **Figure 2.7**.

The Sydney Airport flight path movements charts have been in use for approximately two years and have received wide acceptance as a simple tool for reporting on the Airport's aircraft noise exposure patterns. They are used in the Airport's monthly operational reports and have appeared in a number of Sydney newspapers.

The charts are now being produced for other airports in response to requests from airports and community representatives. It is too early to gauge how useful they will be at these airports where the flight path and aircraft movement patterns have different characteristics to Sydney. However, the initial response has been very positive across a wide range of interested parties from community representatives to State planning and transport officials.

In broad terms the charts have been very useful in broadening knowledge about the temporal and spatial variations in aircraft movement patterns particularly the extent and frequency of day to day variations. The topic of hour to hour variations in movements is examined in **Chapter 3** under the heading of 'respite'.

2.7.1 Limitations

Despite the acceptance they have received the charts clearly have their shortcomings.

While the charts considerably expand the areas for which aircraft noise information is available they are not totally comprehensive – aircraft noise complaints still come from residents of areas which lie outside the areas covered by the charts. Further expanding the areas covered by the charts creates computational and presentational difficulties. Nevertheless, the potential for doing this is now being examined.

Sydney Airport

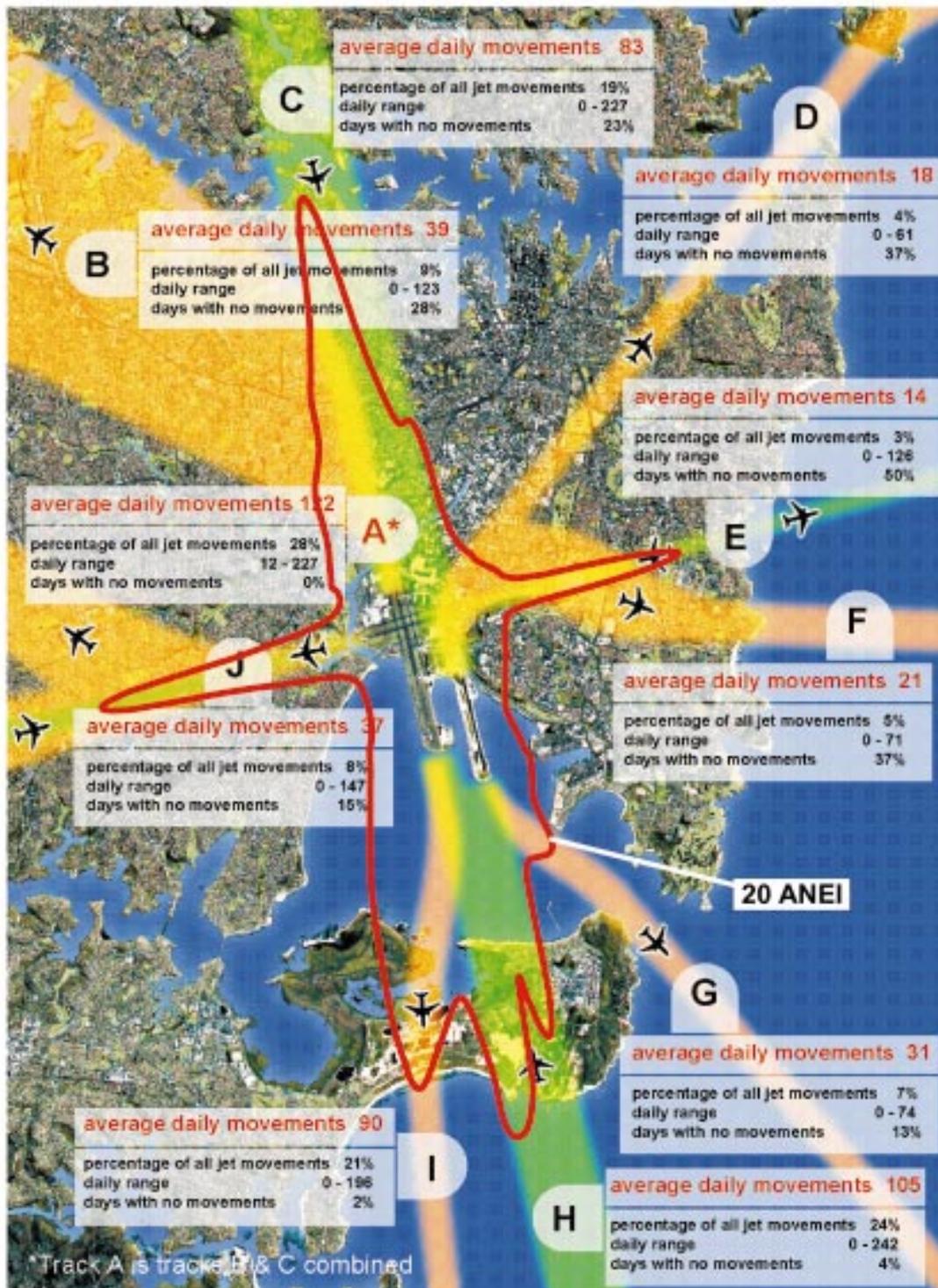


Figure 2.7 Comparison of 1998 Flight Path Movements and 1998 ANEI 20 Contour

The charts only represent a surrogate for noise and are not based on any actual noise measurements – a long haul B747 is given the same value as a small business jet, while an aircraft movement a long way from the Airport has the same value as one close to the Airport. Another weakness is that the visual impression can be given that in the areas where the aircraft are dispersed there is more noise than in those where the flight paths are concentrated even when this is clearly not the case (eg compare flight paths B & C in **Figure 2.1**) – there is a natural tendency for the person's attention to be drawn to the graphic image rather than the numerical information.

There is the potential for the latter problem to be addressed by more sophisticated graphics. The issue of the lack of actual noise information underpinning the charts has not proven to be as great a problem as might first be thought. Most individuals have a 'calibrated ear' and broadly know the range of noise levels which aircraft produce when operating in the vicinity of their home. For many people therefore the question of interest is not how many dB(A) a particular flight generates but what can be done to reduce the number of overflights, particularly at the noise sensitive times.

The absence of noise information only becomes an important issue when the flight path movement charts are used to compare the noise exposure at two different locations. Understandably any such comparisons based solely on the number of overflights have been challenged as being too simplistic and metrics based on noise levels need to be used (see **Chapter 4**).



Respite

MONITORING AND REPORTING BREAKS FROM AIRCRAFT NOISE

3.1 Background

'...now it is just constant, it just never goes away; plane after plane after plane, after plane, after plane...'

'...a level of volume which may be tolerable in isolation, may become intolerable when it is recurrent – a similar effect to a dripping tap;'

The above quotes are taken from the report of the Senate Select Committee on Aircraft Noise in Sydney and illustrate the respite issue [ref 10]. When the new runway opened at Sydney Airport the noise was concentrated over suburbs to the north of the Airport. The total number of movements to the north of the Airport on a typical day rose from around 160 to around 370. For many people the prime issue became not so much how many movements, or how much noise, they received in total but whether they were able to get a break from the noise.

The question of providing this break or 'respite' from noise therefore became an important part of the discussions during the development of the Long Term Operating Plan (LTOP) for Sydney Airport. Airservices Australia devised a means of providing the respite through a system of rotating the operational runways throughout the day which has been introduced under LTOP. This is of course not possible or suitable for all airports to do. However, the monitoring and reporting of respite presented a particular challenge for the noise professionals involved in the process as their training and experience had revolved around the monitoring and reporting of noise, not the absence of noise.

Extensive debate took place on how best to define 'respite'. Is it a period when aircraft noise is below a certain threshold level, say 70 dB(A)? Does a period of say 30 minutes without aircraft noise constitute respite? Perhaps it can be defined as say a four hour period when there are no more than four events louder than 70 dB(A)?

A number of different ways of defining and reporting respite were trialed over an approximate two year period. Computational and definitional difficulties led to the exclusion of approaches using a particular dB(A) threshold value. Attention was therefore focussed on methods using the base flight path map from the jet flight path movements charts (see **Chapter 2**) and analysis of temporal movement patterns using the Avcharges database.

The first promising approach was based on defining respite as any period where the gap between aircraft overflights on a particular flight path exceeded 30 mins. The **total** number of minutes in these separate periods was summed to give the total amount of respite say for one day on a particular flight path. For example, if there were a jet movement at 10.00am and another at 10.29am on a particular flight path no respite would be recorded. If the movements were at 10.00am and 10.40am then 40 minutes of respite would be registered. Despite its prima facie attractions this approach was abandoned for comprehensibility reasons – when it was trialed the output created confusion and a simpler approach was adopted.

The current approach which is used in the monthly monitoring reports for Sydney Airport is illustrated by the respite chart in **Figure 3.1**. This is based on computing the number of whole clock hours (eg 7am to 8am) when there are no movements on the particular flight paths and reporting these as a percentage of the sum of all the clock hours in the period in question. For example, if there were no movements on a particular flight path during 50 clock hours in a 100 clock hour period then it would be reported as ‘Respite Hours 50%’.

Details on the computation of the respite charts is given in **Appendix B**.

3.2 The average day

The approach to addressing the average day issue is somewhat different to that adopted in the jet flight path movements charts since the respite charts are focussed on reporting hour to hour variations rather than day to day variations in noise. The respite charts report respite during four discrete periods; three noise sensitive periods (see the next Section) and ‘daytime’ (7am to 8pm) on weekdays.

Similar to the jet flight path movements charts the respite charts are produced on a monthly basis for the Sydney Airport Operational reports and also on an annual basis. The computation of the charts is simple and charts could be produced for shorter periods if more information were required on short term variations in respite.

3.3 Sensitive times

Information on respite during the sensitive hours is shown on the respite charts. For the purposes of the charts the sensitive times are defined as

Morning Respite	6am to 7am on weekdays
Evening Respite	8pm to 11pm on weekdays
Weekend Respite	6am to 11pm on Saturdays and Sundays

These time periods were selected following an extended period trialing the information with representatives of the Sydney community. There is a strictly enforced curfew at Sydney Airport and therefore reporting on respite during the period 11pm to 6am period has not been a key issue at Sydney. However, at other airports which may have a number of movements over

Sydney Airport

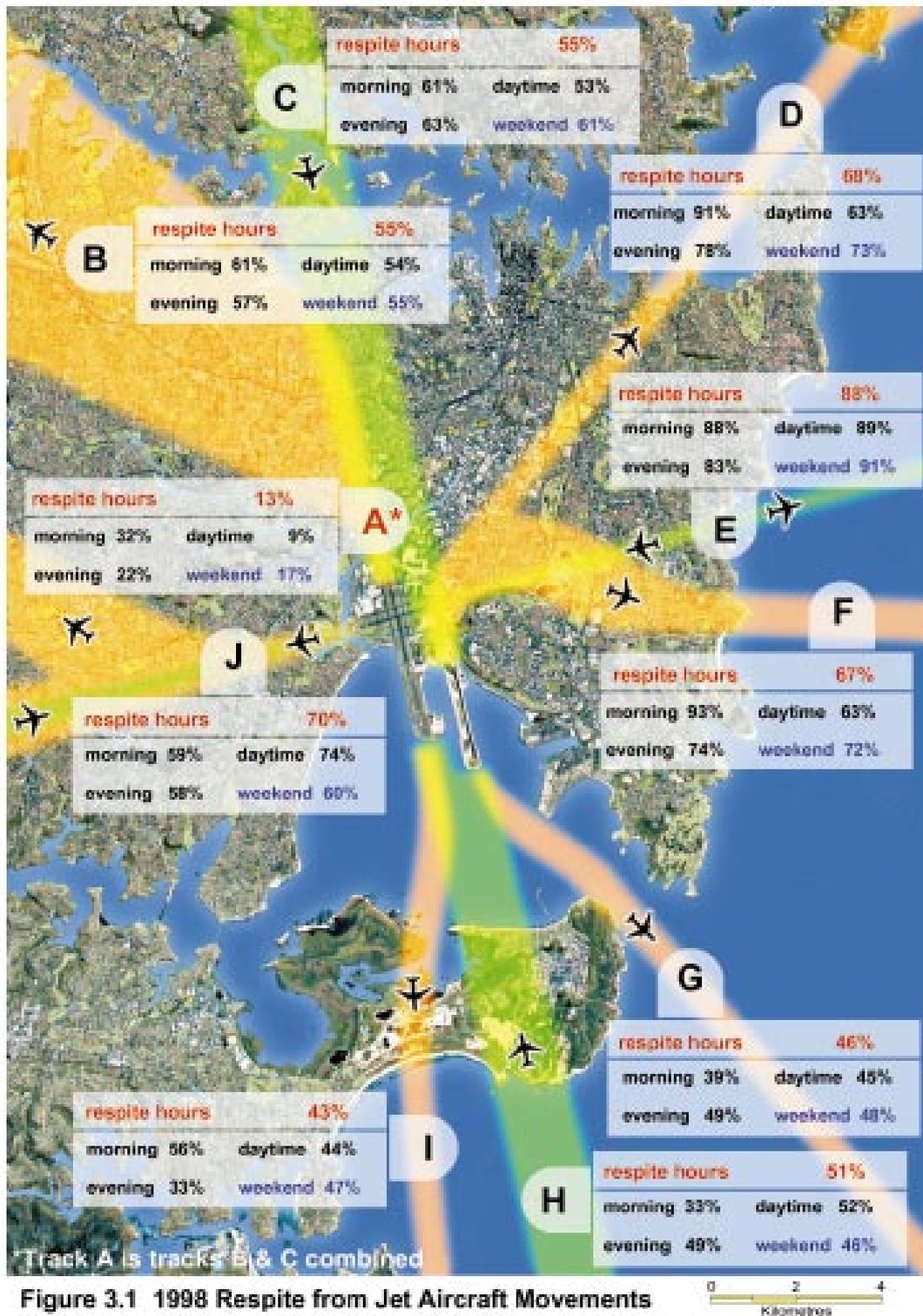


Figure 3.1 1998 Respite from Jet Aircraft Movements

suburbs during the night it would very likely be useful to examine and report on respite during this period.

It would of course be theoretically possible to derive some form of weighting for each of the specified sensitive time periods and then produce a figure for the weighted average for each of the flight paths. However, similar to the approach spelt out in **Section 2.5** the preferred and most robust approach is considered to be one based on reporting the actual respite for each of the designated sensitive periods.

3.4 **Extent of coverage**

The comments under **Section 2.6** equally apply to the respite chart – the charts provide aircraft noise information over a much greater area than the conventional ANEF approach.

3.5 **Discussion**

The reporting of respite has proved to be a difficult concept and while the respite charts have received some broad acceptance they have not proved as successful as the jet flight path movements charts.

A particular criticism in Sydney has been that computing respite on the individual flight paths does not give an accurate picture as in a number of areas noise is audible (though not necessarily at a high level) from more than one of the flight paths. Therefore it is claimed that the respite on one flight path is disturbed by movements on another flight path. This is a valid comment for certain limited areas which are close to more than one flight path. However, no practical suggestions on how this weakness can be overcome have been put forward and for most parts of Sydney the charts give a very good indication of the extent to which respite is being achieved.

Basing respite simply on clock hours is also somewhat a weakness as it only allows the counting of respite in one hour units. This has the tendency to lead to an understatement of the respite. For example, if there were one movement at 12.05pm and one movement at 1.55pm no respite would be recorded for that two hour period. This would be despite the fact that for virtually all that period (110 minutes) there were no movements.

With the phase out of the older noisier ICAO Chapter 2 aircraft the current worldwide trend is for aircraft noise problems to increasingly focus on the high numbers of noise events (rather than individual 'noisy' aircraft). Given this, it is inevitable that community pressures to get a 'break' from aircraft noise (and the need to quantify this respite) are not going to disappear. The area of monitoring and reporting of respite is not well established and clearly further development work is required on the concepts trialed at Sydney if mature approaches are to be arrived at.

The N70

COMBINING MOVEMENT NUMBERS AND NOISE LEVELS

4.1 Background

During the development of the Sydney Airport Long Term Operating Plan (LTOP) extended debate took place with community representatives on ways to provide information on aircraft noise levels (as distinct from the number of movements) in a way that could be easily understood.

Interest was initially focussed on providing information on the dB(A) level of single aircraft movements as this is most basic way to report the noise. Single event contours superimposed on flight paths enable a person to readily see the noise level in the vicinity of their home for a single event for a certain aircraft type. The contours allow the person to readily compare the noise levels generated by different aircraft types and say landings versus take-offs.

A large number of single event contours were produced for a range of flight paths and aircraft types and were provided to the community as part of the LTOP consultation process. However, single event maps by themselves can be misleading because they do not contain information on the number of times the noise events will occur.

Figure 4.1 is one of a suite of single event contours produced for a particular individual and shows an example of an early attempt to combine single event contours with information on the number of noise events. The Figure gives information on single event noise levels and on movement numbers for one flight path at Sydney Airport. A number of similar figures were produced for different aircraft types for the same flight path. While this approach proved very useful for the individual for whom the information was produced, it could not be used to provide a large number of people with specific information of the single event noise levels at their homes due to the multiplicity of flight paths and aircraft types that would have been involved.

In order to overcome these problems 'Number Above' contours began to be produced by the Department. These contour maps in effect combine information on single event noise levels with aircraft movement numbers.

Contour maps showing the number of events louder than 70 dB(A) have been adopted as the normal presentation. The level of 70 dB(A) has been chosen because this is equivalent to the single event level of 60 dB(A) specified in Australian Standard AS2021 as the indoor design

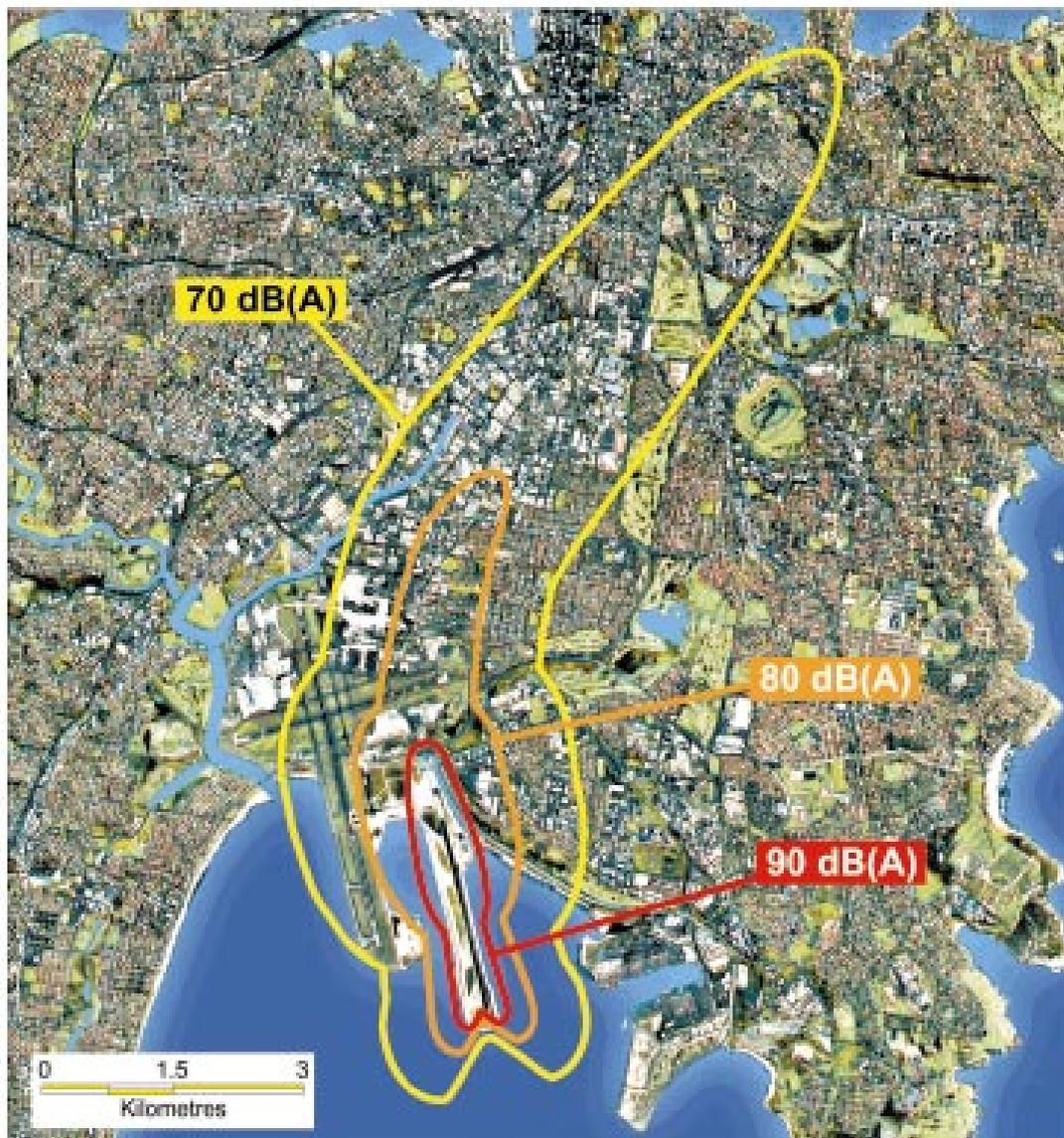


Figure 4.1 An example chart combining information on single event noise levels and flight path movements

Noise Contours

The diagram shows single event noise contours for a **Boeing 767-300** departing from runway 34R on the NE track.

Movement Numbers

It is projected that there will be 2.5 movements a day by **Boeing 767-300** aircraft on the NE track.

* Similar charts can be produced for each separate aircraft type operating on this flight path.

sound level for normal domestic areas in dwellings [ref 11]. [An external single event noise will be attenuated by approximately 10 dB(A) by the fabric of a house with open windows.] An internal noise level of 60 dB(A) is the sound pressure level of a noise event that is likely to interfere with conversation or with listening to the radio or the television.

An N70 map for the annual average day at Sydney Airport in 1998 is shown in **Figure 4.2**. Following the adoption of the N70 for Sydney Airport it was used as an important indicator (along with the ANEF and other location specific noise information) in the Environmental Impact Statement for the Second Sydney Airport. **Figures 4.3 to 4.7** respectively show comparable N70 maps for Canberra, Coolangatta, Perth, Brisbane and Adelaide airports.

It can be seen from the Figures that at Sydney there are a significant number of persons exposed to between 100 and 200 events per day louder than 70 dB(A). At Perth and Adelaide there are populations exposed to between 50 and 100 events per day. At the other airports the highest impacts on residential areas are essentially in the 20 to 50 events per day range. The numbers of persons within the 10 events/day N70 contour for the largest Australian airports are shown in **Table 5.2**.

Number Above maps have also been published for other noise levels. For example, the Proponent's Statement for LTOP showed an N80 map for Sydney Airport [ref 12]. The EIS for the Second Sydney Airport showed a number of N60 maps [ref 13].

The N70 contours have been produced using the United States Federal Aviation Administration's (FAA) Integrated Noise Model (INM) – details of the methodology used to derive the contours and discussion on their accuracy is contained in **Appendix B**.

4.2 The average day

Worst day N70s can be produced in order to address the 'average day problem'. These have been produced for Sydney Airport and used in the consultative process on the implementation of LTOP. These N70s are shown at **Figures 4.8 & 4.9**. These show, respectively, the distribution of noise events on a sample day when the Airport was in a northerly flow (Mode 9) and in a southerly flow (Mode 10) for more than 15 hours. They very clearly illustrate that the noise exposure patterns on the average day (**Figure 4.2**) are very different to those experienced on the bad day. They also show that a 'bad' day for some areas is a 'good' day for other areas.

A detailed analysis showing the type of information that can be extracted from the 'worst day' N70s is given in **Appendix C**.

4.3 Sensitive times

Consistent with the approach adopted in the previous chapters it is considered that the best way to represent the N70 levels during the sensitive hours is to produce separate contours for this time period. **Figure 4.10** is a 'sensitive times' N70 which shows the number of events above 70 dB(A) during the early morning and evening periods (6am to 7am and 8pm to 11pm) on the average day during 1998 at Sydney Airport.

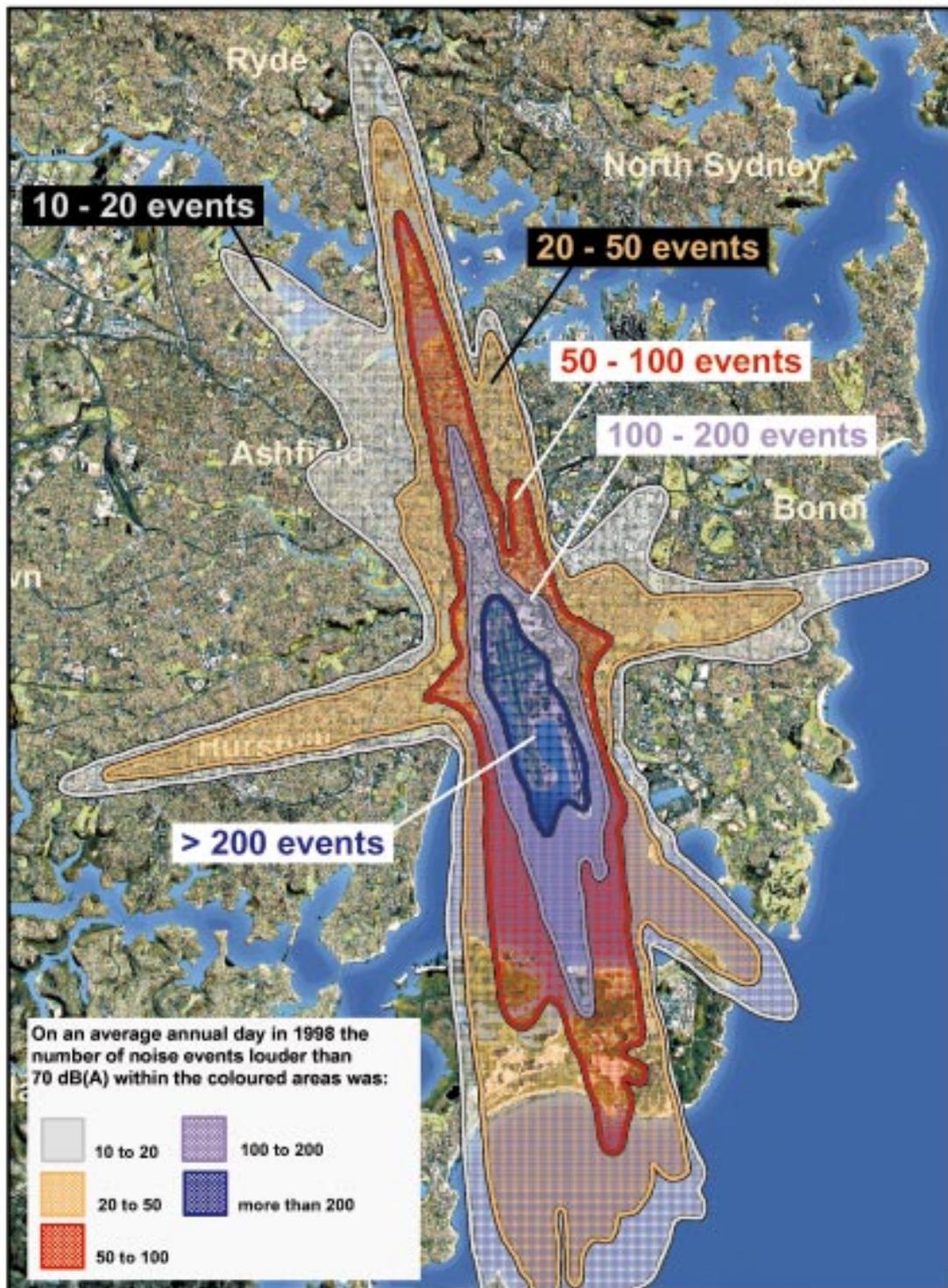


Figure 4.2 1998 N70 - Average Day

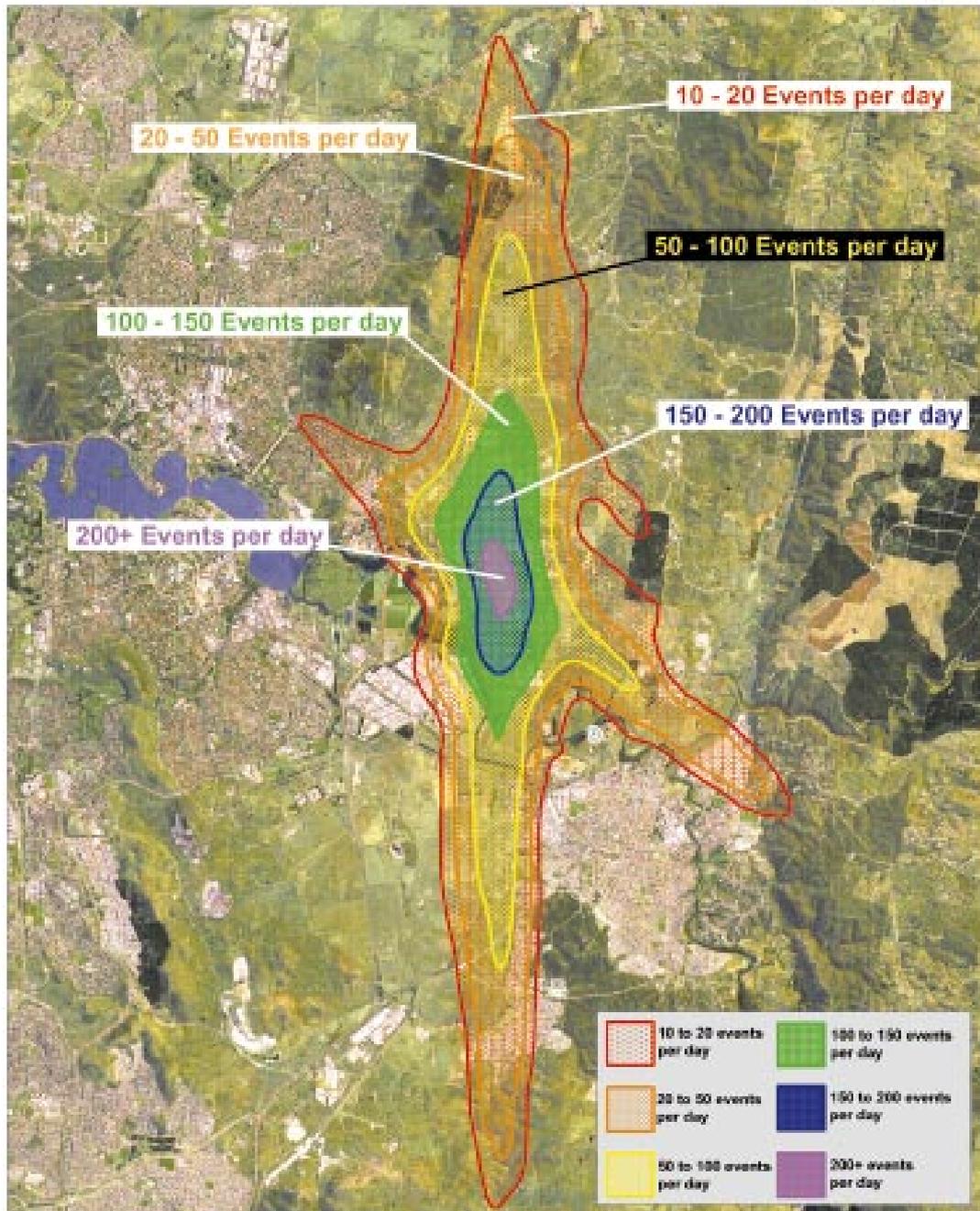


Figure 4.3 1998 Indicative N70 - Average Day

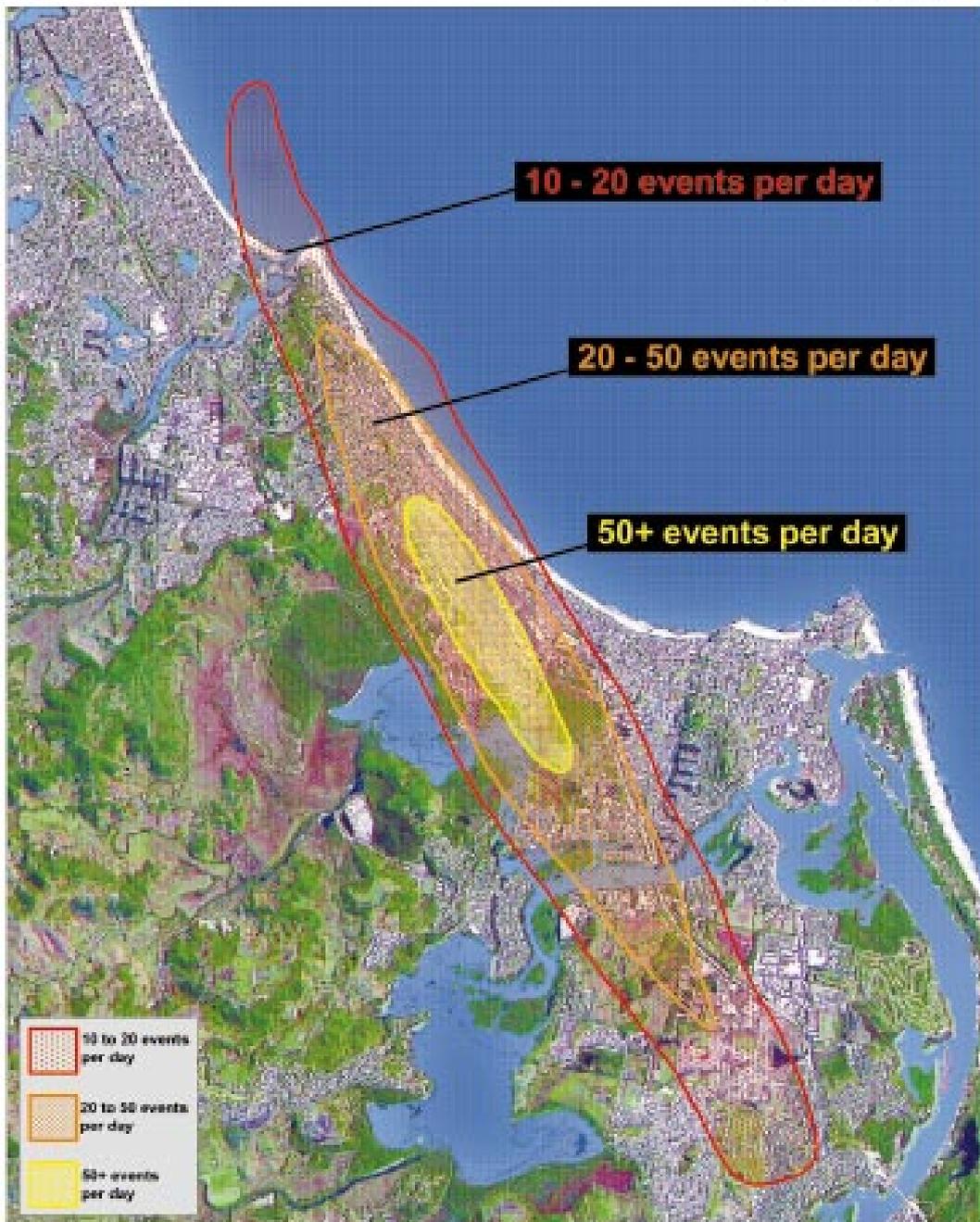


Figure 4.4 1998 N70 - Average Day

0 1.5 3
Kilometres

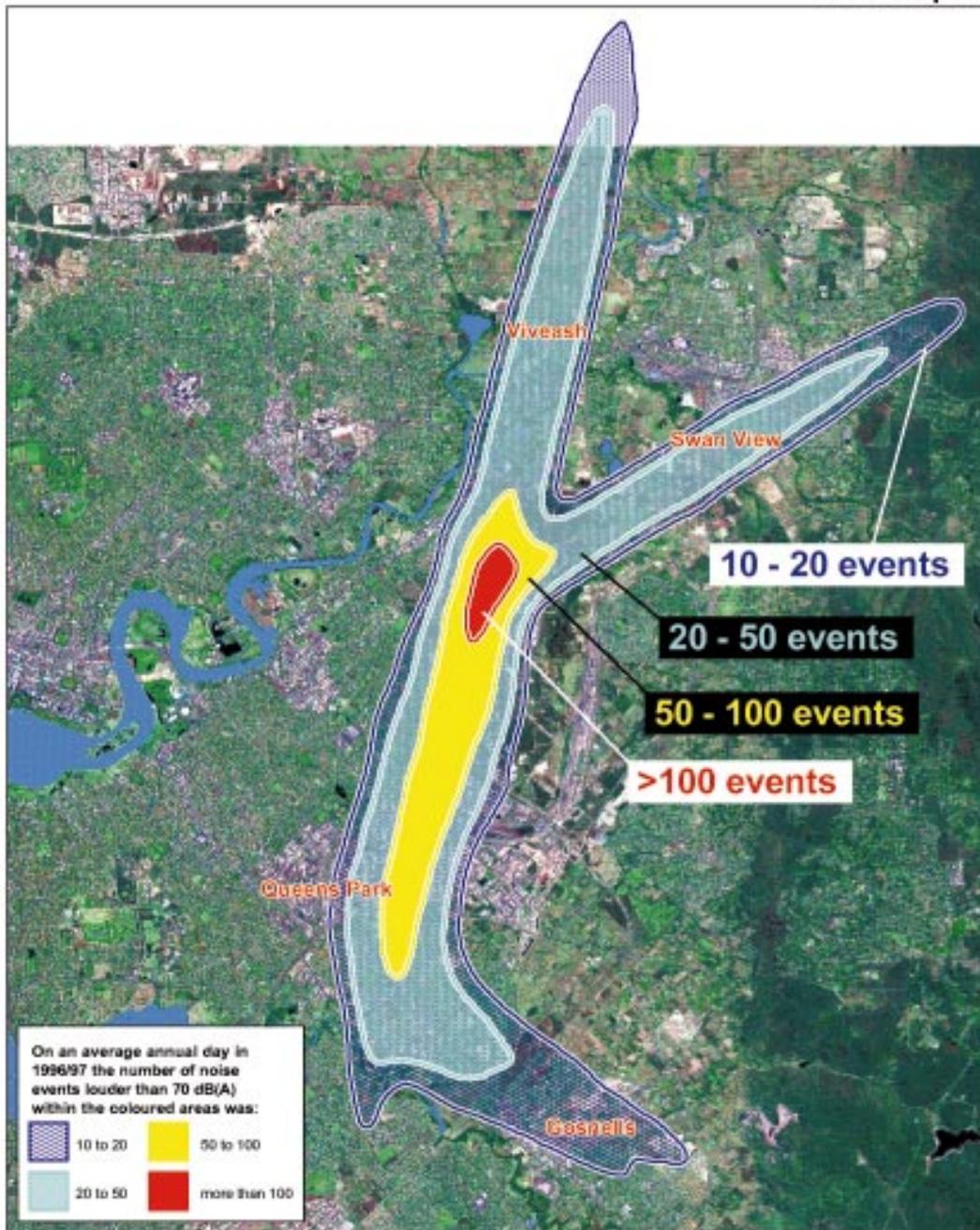


Figure 4.5 1996/97 Indicative N70 - Average Day

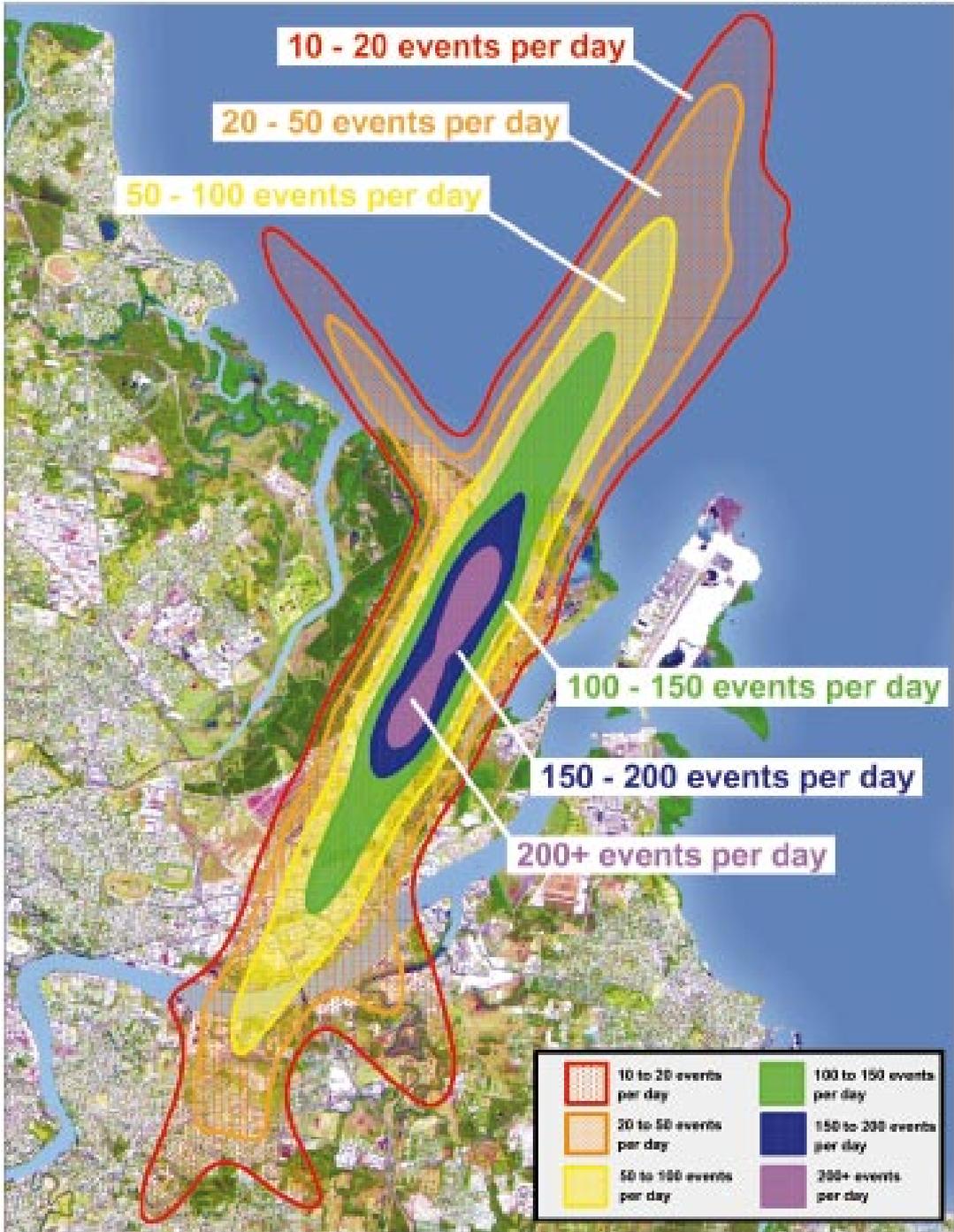


Figure 4.6 1998 N70 - Average Day

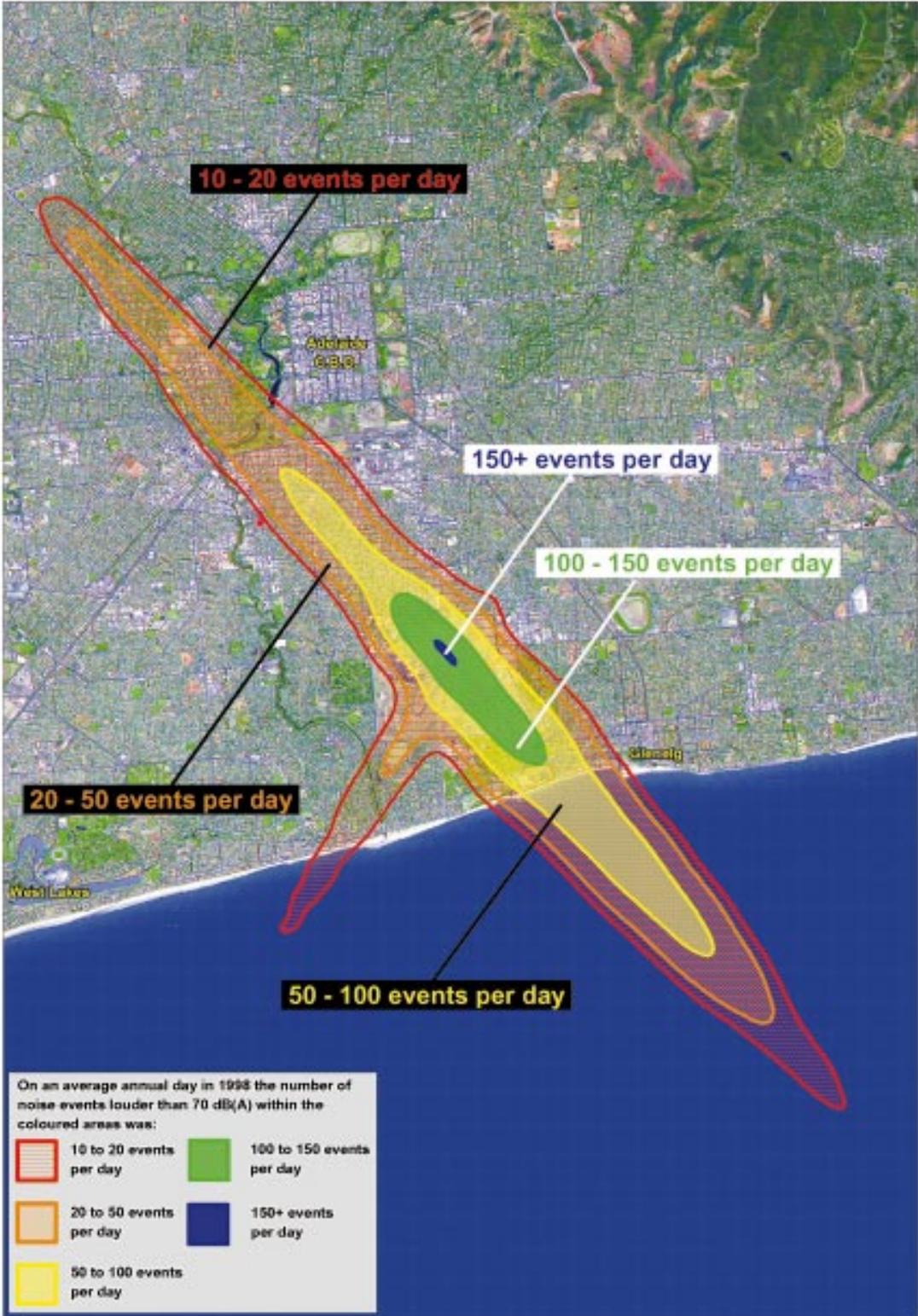


Figure 4.7 1998 N70 - Average Day

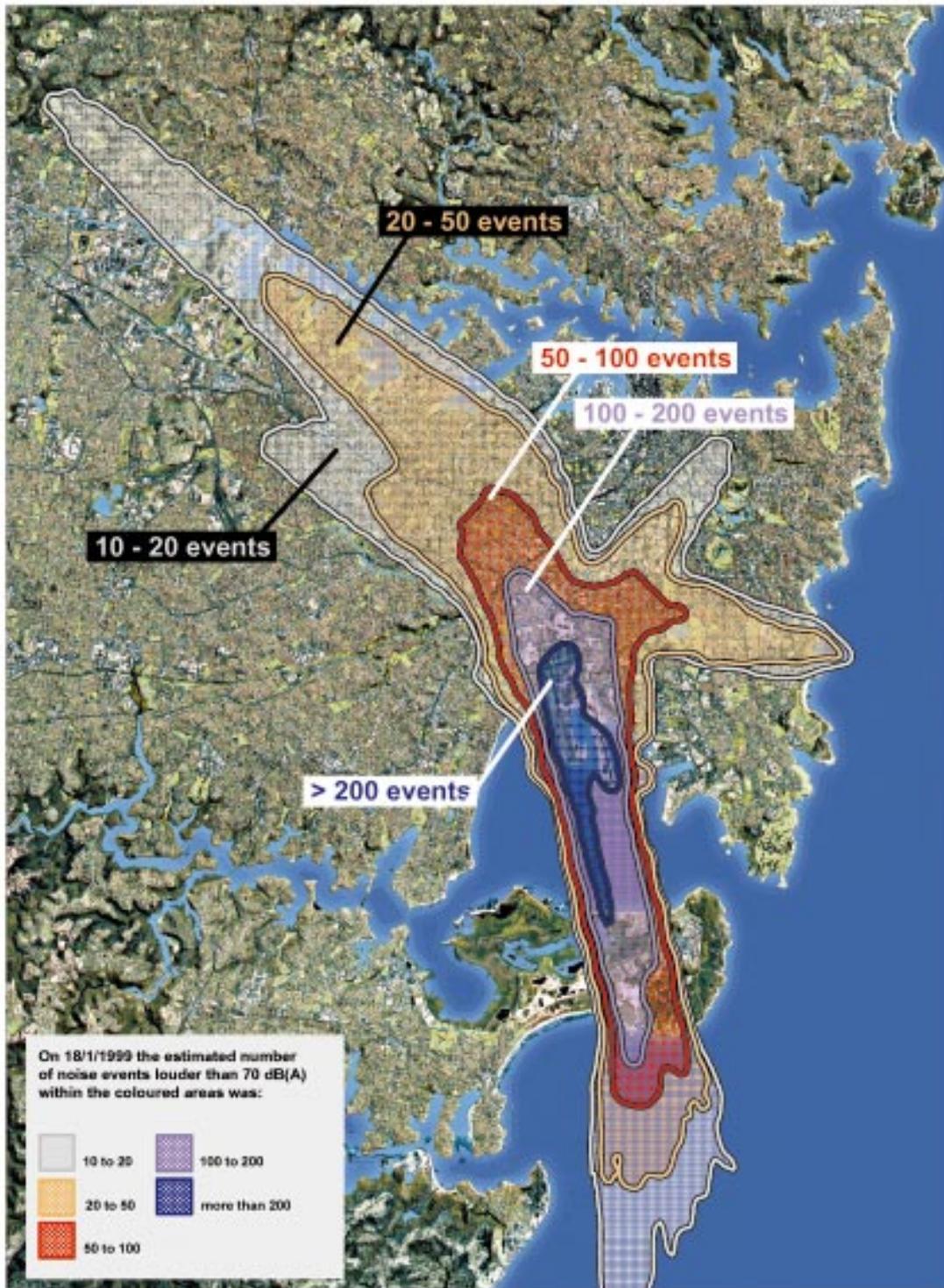


Figure 4.8 1999 N70 - Typical Northerly flow Day

0 3 6
Kilometres

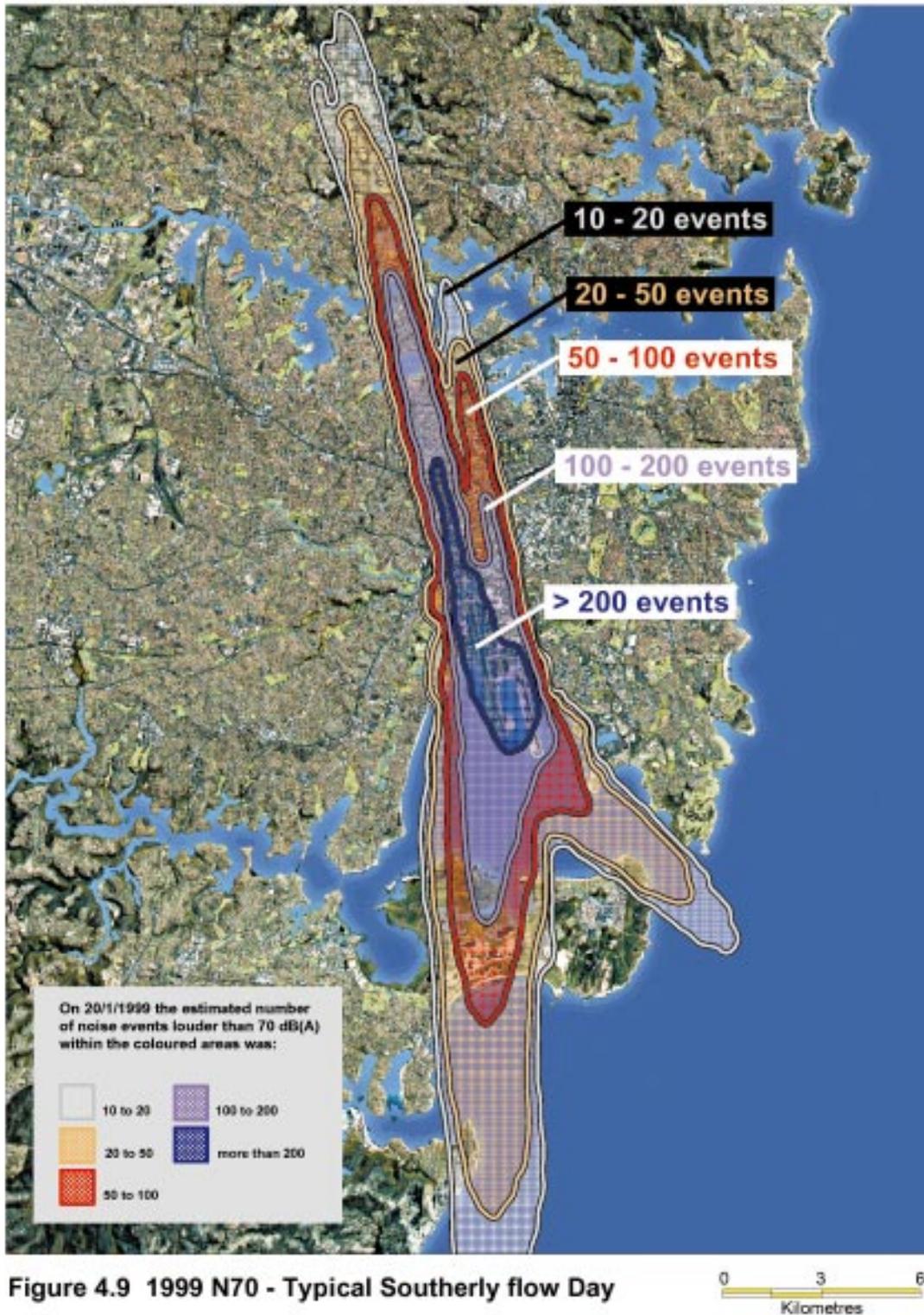


Figure 4.9 1999 N70 - Typical Southerly flow Day



Figure 4.10 1998 Sensitive Times N70 - Average Day

As indicated in **Section 4.1** a number of N60 contours for the period 10pm to 6am were shown in the EIS for the Second Sydney Airport to represent night-time noise exposure patterns. The level of 60 dB(A) was chosen because an external single event noise level of 60 dB(A) equates to the sleep disturbance level of 50 dB(A) specified in AS2021.

While not the preferred approach it would be possible to produce a weighted N70 which combines information on sensitive and other times. The most obvious way to produce this would be to assign a weighting to the number of events at the sensitive times – for example, a movement between 7pm and 7am could be taken to be equivalent to four movements during the day and be factored into the N70. This would be analogous to the weighting in the ANEF system.

However, a more robust approach to producing a weighted N70 could be to expand the concept used in the Second Sydney Airport EIS and base the weighting factors on the indoor design sound levels in AS2021. For example, a ‘number of events grid’ could be computed based on

- the number of events above 70 dB(A) for the period 7am to 7pm (normal domestic - eg conversation, watching TV, etc)
- the number of events above 65 dB(A) for the period 7pm to 10pm (a combination of normal domestic plus quiet relaxing – eg reading, studying, etc)
- the number of events above 60 dB(A) for the period 10pm to 7am (sleeping).

Such a grid has been computed for Sydney Airport using the 1998 data and the resulting contours are shown in **Figure 4.11**. When this figure is compared with the unweighted N70 for the same period (**Figure 4.2**) it can be seen that the greatest change is in the outer contours (as would be expected since these areas will be subject to the greatest relative change in the number of noise events).

4.4 Extent of coverage

A practice has evolved in relation to Sydney Airport and in the EIS for the Second Sydney Airport, of reporting N70s down to the 10 events per day exceeding 70 dB(A) level.

This extends the noise contours considerably further than the 20 ANEF which is the usual extent of ANEF reporting. At Sydney Airport the 20 ANEF approximates to 40 events a day louder than 70 dB(A) (this is not necessarily the same at other airports).

Extending noise contours produced by the INM out to this level raises significant questions about the accuracy of the information at the lower noise levels. To place this issue in context, Airservices puts a caveat on its ANEF maps about the accuracy of its 20 ANEF contour due to uncertainties in the location of flight paths at that distance from an airport. The accuracy of the N70 contours is discussed in **Appendix B**.

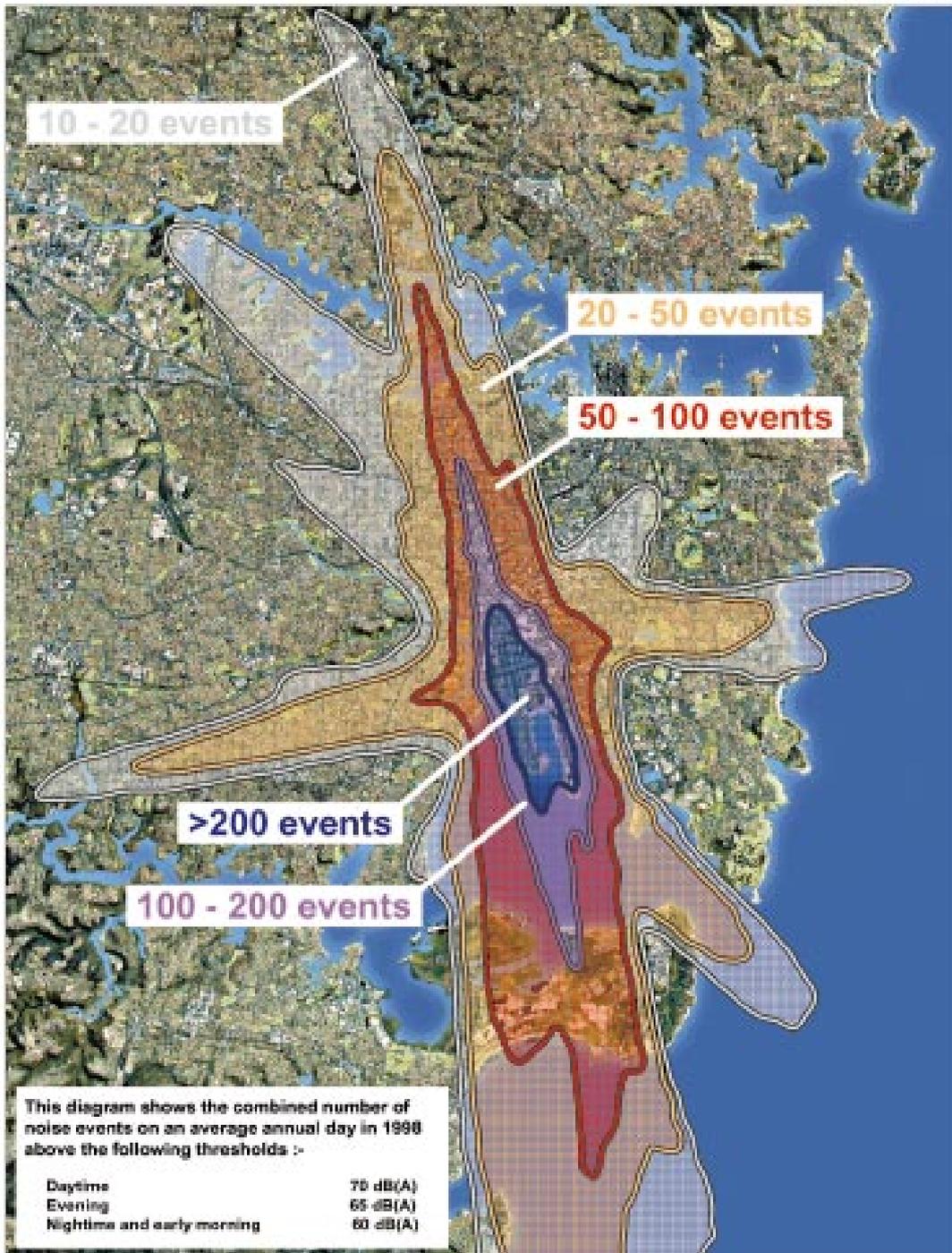


Figure 4.11: Number of events contours weighted for sensitive times

4.5 Discussion

The N70 is not a new concept. It was one of indicators examined by the National Acoustic Laboratories (NAL) in its 1982 study [ref 14]. Intuitively it is very easy to conceptualise noise impact using an N70 because it reports aircraft noise in the way that a person perceives it – as a series of noise events some of which are perceptibly intrusive.

The N70 was also used to a limited degree in the EIS for the third runway at Sydney Airport [ref 15]. This EIS showed the N70 value at 15 selected sites rather than using contour maps showing N70 values for the broad Sydney area. This limited use of the N70 in that EIS may be related, at least in part, to the fact that the INM does not provide for direct computation of N70 contours and the publication of these contours is a relatively new innovation in Australia.

N70 contours were first included by the Department in the LTOP Proponent's Statement [ref 16]. They were subsequently used in the EIS for the Second Sydney Airport. It is interesting to note that the media, when reporting on the forecast noise exposure patterns in the EIS, tended to express these using the N70 information rather than the ANEF data which appears to support the thesis that non-experts more readily relate to N70 information.

The N70 is particularly attractive to the layperson in that it is an arithmetic indicator. *All other things being equal*, if the number of movements over an area doubles the N70 doubles – a very different outcome to logarithmic indicators such as the ANEF which are very insensitive to change. This relative insensitivity of the ANEF is well illustrated by computations in the EIS for the Second Sydney Airport which show the changes in exposed population at Sydney Airport resulting from traffic growth using both the N70 and the ANEF [ref 17].

The N70 is also a very useful metric as it permits *measured* noise levels to be very neatly summarised for any given period. **Figure 4.12** is an example of a measured N70 for Sydney Airport prepared for a one month period. It is common for members of the public to distrust, rightly or wrongly, any form of noise information produced by a computer model and to place much more faith in measured noise levels. Therefore the type of presentation in **Figure 4.12** is a very useful addition to an Airport's information suite.

The information in the Figure is very easily obtained from information gathered by the Airport's Noise and Flight Path Monitoring System. It can be seen that the Figure shows the N70 at the noise monitoring terminals for the average day and also for four separate time slots including sensitive times (these time slots are the same as those defined in **Chapter 3**). Noise levels can vary quite markedly even at relatively short distances from the terminals, particularly for landings which have a very narrow 'noise footprint'. Therefore, while the approach is useful, the information given by the type of presentation shown in **Figure 4.12** needs to be treated with some caution.

It is not uncommon for a person who is not familiar with aircraft noise or the dB(A) scale to ask how 70 dB(A) compares with the level of noise generated by common everyday events.



Events louder than 70 dB(A) on an average day in July 1999*
**as measured at the noise monitoring terminals around Sydney Airport*

Croydon Morning 0.3 Daytime 15 Evening 1 Weekend 14	Leichhardt Morning 4 Daytime 88 Evening 12 Weekend 117	Annandale Morning 1 Daytime 47 Evening 5 Weekend 47	Paddington Morning 0.1 Daytime 12 Evening 0.4 Weekend 7
Earwood Morning 1 Daytime 10 Evening 2 Weekend 15	Sydenham Morning 6 Daytime 120 Evening 13 Weekend 112	St Peters Morning 2 Daytime 73 Evening 7 Weekend 69	Coogee Morning 1 Daytime 39 Evening 8 Weekend 26
Penshurst Morning 1 Daytime 15 Evening 5 Weekend 34	Bexley Morning 5 Daytime 36 Evening 11 Weekend 69	Botany Morning 1 Daytime 35 Evening 2 Weekend 25	Eastlakes Morning 1 Daytime 44 Evening 5 Weekend 18
	Kurnell Morning 1 Daytime 35 Evening 5 Weekend 30	La Perouse Morning 0.1 Daytime 4 Evening 1 Weekend 6	

Figure 4.12 Measured N70 from Noise Monitoring Terminal Data

A person will generally be exposed to a very high number of noise events louder than 70 dB(A) on a normal day – from cars, domestic appliances, music, shouts, articles being banged or dropped, etc. However, a statement such as ‘when we move the flight path over your home the sound pressure level at your house from an aircraft will only be the same as that from a car passing down the road’ is likely to prove very misleading. While the sound pressure levels may be the same the person’s perceptions of the two events will almost certainly be very different. Experience has shown that using a ‘noise thermometer’ to place aircraft noise levels in context is likely to be counterproductive. Undoubtedly the best approach, if a person shows a strong interest in this topic, is to let the person form their own view by directing them to a place where the sound pressure level from aircraft overflights can be compared to the reading on a sound level meter and where it can also be compared to other common sources of noise such as road traffic.

It was shown in **Section 1.2** that at Sydney in 1998 approximately 90% of the noise complaints came from areas outside the 20 ANEI. By way of comparison it is estimated that only about 30% of the complaints came from areas outside the 10 events per day louder than 70 dB(A) contour. Some observers have suggested this shows that the N70 may give a better indication of community reaction to aircraft noise than the conventional ANEFs. Clearly this conclusion cannot be validly drawn from this information. In this instance the difference is primarily brought about because the N70 contours have been taken out to a much lower noise level. If ANEF contours were extended (say to the 10 ANEF level) then it would not be unreasonable to expect a similar level of ‘complaint capture’. It is also important to not lose sight of the fact that there is often a very poor correlation between underlying ‘community reaction’ and the level of aircraft noise complaints.

One apparent weakness with the N70 is that it, for example, registers a noise event at 70 dB(A) to be the same as one at 90 dB(A). There are arguments that this is not important since the N70 is based on the concept that once a certain noise threshold is reached the event becomes intrusive and the actual level of the noise is not necessarily important. For example, a sleeping person may have the same reaction whether they are exposed to a noise event at 70 dB(A) or 80 dB(A) – they are likely to wake up.

This issue can be addressed by the production of ‘Number Above’ contours for other noise levels (eg 80, 90 dB(A)). The production of these additional contours works well when a ‘one-off’ detailed examination of noise exposure patterns is being carried out. However, producing such additional contours for regular public reporting would not necessarily assist in understanding of the noise exposure patterns due to the multiplicity of charts that would be produced.



The Person-Events Index

ASSESSING THE TOTAL NOISE LOAD OF AIRPORTS

5.1 Background

The conventional method of assessing the noise loads generated by competing airport development or operating options (eg new runway and/or flight path configurations), for example in an EIS process, is to compute and compare the number of persons living within specified noise exposure zones.

In some cases comparisons of population distributions across noise zones give a clear picture of overall noise exposure trends or differences. However, in many cases the conclusions are not clear-cut and decision-makers are faced with a dilemma when considering options. Which imposes the greatest noise load? Option A where there is a small number of persons exposed to a high noise load or Option B where there is a large number of persons exposed to a low noise load.

Option A type approaches are superficially attractive since they involve impacting the least number of people. However, this may not necessarily be the option with the most desirable outcome since the outcome may have been achieved by concentrating the noise on a small number of people rather than by reducing the total noise load. This data interpretation dilemma is only likely to be exacerbated in the future as community pressures force noise reporting to be extended to lower noise levels and the number of noise zones under consideration to be increased.

One common way to rank, or assess changes in, data sets which have subsets which vary independently is to use some form of single figure index which 'summarises' the overall data (eg the Dow Jones Index). In a similar vein an index termed the Person-Events Index (PEI) has been developed by the Department of Transport and Regional Services to summarise population noise exposure data sets.

The index has deliberately been expressed in a form which gives non-experts (eg decision-makers & community representatives) some feel for the magnitude of the noise load.

The index **is not intended to replace** existing noise indicators but to supplement them. An index assists interpretation of data; detailed examination of the base data always needs to be made if definitive conclusions are to be drawn when comparing two noise exposure data sets.

5.2 The Person-Events Index (PEI)

The PEI allows the total noise load generated by an airport to be computed by summing, over the exposed population, the total number of instances where an individual is exposed to an aircraft noise event above a specified noise level over a given time period.

For example, if a departure off a specific runway at an airport by a particular aircraft type leads to 20,000 persons being exposed to a single event noise level greater than 70 dB(A) then the PEI(70) for that event would be 20,000. If there were a further similar event the PEI(70) would double to 40,000 since there would have been that number of instances where a person was exposed to a noise level louder than 70 dB(A). The PEI is therefore expressed by the following formula

$$PEI(x) = \sum P_N N$$

where x = the single event threshold noise level expressed in dB(A)

P_N = the number of persons exposed to N events $> x$ dB(A)

The PEI is summed over the range between N_{min} (a defined cut-off level) and N_{max} (the highest number of noise events louder than x dB(A) persons are exposed to during the period of interest).

By summing all the single events at an airport, say for an average day, a total PEI(70) (or PEI(80), etc) can be developed. The PEI(70) is the total number of instances on the average day where a person is exposed to a noise event greater than 70 dB(A) and is a measure of the total noise load generated by the airport. For example, the worked example in **Section 5.4** shows that for Sydney Airport in the 'noise sharing' configuration the PEI(70) is approximately 6.9 million (when considering the population within the 40 events per day contour).

5.3 The Average Individual Exposure (AIE)

The PEI in itself does not indicate the extent to which the noise has been distributed over the exposed population. For example, a PEI(70) of 2 million for an airport could mean that one person has been exposed to two million events in excess of 70 dB(A) (assuming this were possible), or that two million people have each received one event or it could be arrived at by any other combination of the two factors. A summary of the noise distribution is provided by the Average Individual Exposure (AIE) which is given by the formula

$$AIE = PEI/\text{total exposed population}$$

For example, in the worked example shown in the next section, at Sydney Airport in the 'noise sharing' configuration approximately 100,000 persons are exposed to 40 or more noise events greater than 70 dB(A) on the average day. The PEI(70) = 6.9×10^6 and hence the AIE is $((6.9 \times 10^6)/10^5) = 69$. This shows that for the exposed population under consideration

(ie those persons living within the 40 events per day contour) the average individual exposure is approximately 70 events per day louder than 70 dB(A).

The AIE therefore gives the average individual noise exposure in the number of events greater than the specified noise level over the specified time. When comparing options at a particular airport the AIE indicates the extent to which the noise is concentrated or shared.

5.4 Worked Example – Sydney Airport

Over the past five years there have been three very distinct operating regimes at Sydney Airport. Prior to November 1994 the Airport operated with two crossing runways. During 1995 and the first few months of 1996 the Airport operated almost exclusively on the two north-south parallel runways. Since March 1996 noise sharing arrangements under the Airport's Long Term Operating Plan have been in place. These distinct operating regimes give a good opportunity to demonstrate how the PEI/AIE enables changes in noise exposure patterns to be examined. It also allows a comparison to be made with ANEF data.

Table 5.1 below summarises the noise exposure patterns for the three operating scenarios using the ANEF & PEI/AIE.

Table 5.1: Comparison of Indices

Runway configuration	ANEF		PEI(70) (x10 ⁶)	AIE
	Population >30	Population >20		
Pre-parallels	6,300	97,100	7.0	87
Parallels	11,000	68,600	8.6	122
Noise Sharing	3,700	89,100	6.9	68

- Notes**
- (i) See Appendix C for details of the derivation of the data in the table.
 - (ii) The PEI & AIE in the table are based on the 40 events/day contour as this broadly equates to the 20 ANEF contour at Sydney Airport.

It is very illustrative to compare the information on the pre-parallels and parallels regimes shown in the table. One of the key noise arguments in favour of introducing the parallel runways was that it would lead to a significant reduction in the number of persons within the 20 ANEF contour. This in fact did take place as shown in the Table. However, the table also shows that if the project had been assessed using the PEI a somewhat different picture would have emerged. The Table shows that by going to parallel runways the noise load expressed in PEI in fact increased by more than 20%, rather than decreased as implied by the ANEF. The change in the Average Individual Exposure (AIE) from 87 to 122 gives a very simple indication of the magnitude to which the noise was concentrated on the smaller number of persons exposed.

The table also illustrates that the total noise load of the Airport under the current noise sharing arrangements is similar to that existing under the pre-parallels arrangements but that the noise is significantly less concentrated than under either of the two previous arrangements.

5.5 Discussion

The worked example shows that the PEI assists in the interpretation of noise exposure distributions when considering different operating arrangements at an airport. The index permits a rapid overview to be made of noise exposure information and reveals a somewhat different picture to *prima facie* conclusions based solely on the total numbers of persons exposed.

The EIS for the Second Sydney Airport contains a PEI/AIE analysis which is used to analyse differences in the noise exposure patterns between Sydney Airport and the three options for the proposed new airport [ref 18].

Table 5.2 shows how the PEI/AIE allows a comparison to be made of the total noise loads generated by different airports.

Table 5.2: PEI/AIE Comparison between Australian Airports

Airport	No of persons exposed to > 10 events/day > 70 dB(A)	PEI(70) (x 10 ⁶)	AIE
Adelaide	27,000	1.1	40.8
Brisbane	9,000	0.2	20.9
Coolangatta	13,000	0.4	27.0
Melbourne	NA	NA	NA
Perth	31,000	0.8	26.3
Sydney	270,000	8.7	32.0
Major international airport	190,000	27.0	142.0

Notes

- (1) *The information for the major international airport relates to the number of persons exposed to more than 40 events a day louder than 70 dB(A). The airport asked that it not be identified in this paper.*

It can be seen that the total noise load generated by Sydney Airport, when expressed in PEI, far exceeds that at other Australian airports. To place these figures in context the PEI generated when one B747-200 takes off to the north on the main runway at Sydney Airport is approximately 250,000. This is similar to a whole day's noise load at Brisbane Airport. By the same token the average daily PEI at Sydney is significantly lower than that shown for the major international airport.

While the PEI is high for Sydney by Australian standards the Average Individual Exposure is relatively low and is, in fact, similar to the other Australian airports. This highlights the relevance of the noise sharing policy to the airport which generates by far the largest aggregate noise load of any Australian airport. Nevertheless, sight should not be lost of the fact that there are a significant number of persons exposed to more than 100 events louder than 70 dB(A) on the average day at Sydney. By way of contrast, while the AIE at Adelaide (for persons living within the 10 events/day contour) is higher than that at Sydney, the maximum individual noise load is less than 100 events a day.

Compared to conventional approaches the PEI has advantages in that, because it is not based on the common equal energy indicators, it throws a different light on noise exposure data and presents the 'picture' in a way that can be readily understood by the non-expert. It is arithmetic and therefore shows differences between scenarios much more starkly than logarithmic indices which dampen any differences. It is very easy to carry out computations with the PEI and both the PEI and AIE express the information in a way that can be 'visualised' (ie they refer to a number of noise events).

The PEI is particularly useful for computing partial noise loads. A PEI can be calculated, with relative ease, for one or a small number of movements to give a figure that has some 'meaning'. This allows rapid 'first-cut' comparisons to be made between different airport scenarios (eg comparing noise exposure patterns from different flight paths or different aircraft types on the same flight path). Appendix C includes a PEI/AIE analysis of the two main operating modes at Sydney Airport to illustrate how the index can be used to analyse partial noise loads.

As demonstrated by the worked example, the Average Individual Exposure(AIE) is particularly useful when comparing different operating scenarios at **a particular airport** as it gives a very quick and easily understood indication of the extent to which the airport's noise load is concentrated or spread. As such it acts as a flag to warn when there are unusual aspects to a noise distribution (eg very high concentration) which warrant further examination. The AIE needs to be used with caution when comparing noise exposure patterns **between different airports** and in these circumstances the PEI is a more useful tool.

While noise practitioners are able to accurately interpret noise exposure data, experience has shown that decision-makers and community representatives are strongly attracted to scenarios which result in the least number of people being in the contours. However, it is very easy for the inexperienced eye to be confounded by a situation where the minimisation of persons within noise contours has been achieved by concentrating noise on a relatively small number of people (without any reduction, or even an increase, in the total noise load).

At the very least the PEI is a good device for 'sanity checking' when assessing noise exposure patterns and for assisting decision-makers and community members to understand the implications of noise exposure data.

The use of the 'new' noise indicators described in the earlier Chapters has generated much discussion on some of the broader concepts underlying the conventional approaches to aircraft noise information. These are explored in the following Sections.

6.1

Rethinking the concept of 'acceptable' - Enabling the individual to decide on 'acceptability'

A common reaction when a person is first presented with the noise indicators shown in this paper is for them to ask what is the 'acceptable' number of jet aircraft movements and/or number of events louder than 70 dB(A) on an average day.

This suggests that the person is trying to translate the information into an ANEF type approach where on one side of a line the noise is considered 'acceptable' and on the other side 'unacceptable'. It is considered that it would be helpful if we could now move beyond this 'black and white' approach.

The underlying basis of the ANEF is that it will predict the level of **community** reaction to a certain level of noise dose. While this type of information is useful for establishing broad acceptability standards (eg the land use acceptability advice in AS2021) it does not help the **individual** to gain an understanding of how noise will affect them. This dilemma was shown in the discussion in **Section 1.2** – in most circumstances a person wants to know how the noise will impact on him or her, not what proportion of the total population will consider themselves affected.

This issue was picked up in the Senate Select Committee Report

'The ANEF system...did not provide people potentially exposed to aircraft noise with sufficient information to enable them to judge on a rational basis how they [as individuals] might be affected and hence whether the predicted level of noise would be acceptable to them' [ref 19].

Experience at Sydney, which has led to the development of the indicators described in this paper, has clearly demonstrated that aircraft noise can be described in non technical terms to give individuals enough information to allow them **to make up their own mind** whether the noise is likely to affect them or be 'acceptable' to them.

If a person is told where the flight paths are, how many movements there are, at what time of day, what the bad days will be like, etc it enables the person to form a mental image of what the noise will be like (cf the type of information given to the public cited in **Section 1.2**). Armed with this information the person is then able, for example, to make an informed decision about going to live in a certain area or to decide whether to object to a proposed development at an airport.

Noise indicators based on the type of information which enables a person to form a mental image of the noise may be termed 'relational' indices. That is they describe the noise in a way that the person can relate to. Ideally a relational indicator will be able to be monitored and verified by the individual without any need for special equipment or expertise. Clearly the indicators discussed in **Chapters 2** and **3** are the most pure relational aircraft noise indices – they can be simply observed by a person watching aircraft. The N70 is also relational as it describes aircraft noise in the way a person perceives and talks about noise – as a series of loud noise events. However, it does require the use of a sound level meter (or a computer model) to be calculated.

The ANEF falls at the other end of the spectrum and is clearly 'non-relational'. A person does not perceive, think or talk about aircraft noise by accumulating the amount of noise energy they have received over a year.

6.2 Using information as a tool to improve compatibility between communities and airports

The strategies employed to minimise community exposure to aircraft noise can be broadly placed in two categories. Those strategies directed at reducing the amount of noise emitted over residential areas (eg specified flight paths, curfews, noise certification of aircraft, etc) and those directed at protecting the receiver from the noise (eg land use planning controls to stop residential encroachment toward airports, insulation programs, etc).

The operational controls embodied in the first of these categories are the subject of ongoing development and refinement at most airports. While the strategies in this category have led to very significant reductions in the level of community aircraft noise exposure (cf the exposure levels that would otherwise have occurred) they have not eliminated the aircraft noise problem. Virtually all airports inevitably impose aircraft noise on neighbouring communities.

The ANEF system, which is picked up in Australian Standard AS2021, is directed at the second category through controlling land use around airports. The acceptability criteria for residential development in Australia contained in the Standard are amongst the strictest in the world. **Table 6.1** gives a comparison of the criteria for a number of countries.

Despite the efforts encompassed in this two pronged attack, aircraft noise pressures at some airports are tending to increase, not decrease. A particularly problematic aspect of the issue is that the majority of complaints and pressures to restrict airport operations come from persons living in areas which the ANEF system indicates are suitable for residential development – that is outside the 20 ANEF (see **Figure 1.1**).

Table 6.1: Comparison of Aircraft Noise Based Land Use Planning Controls

Noise Exposure ANEF	Australia	United States	Netherlands	France	Canada	Germany
> 40	No housing	No housing	No housing	No new housing	Housing not recommended	No new housing
30 – 40	No new housing; insulation of existing housing at Sydney	No new housing; insulation of existing housing	No new housing; insulation of existing housing	Limited new housing	Housing not recommended	Limited new housing
25 – 30	No new housing	No restrictions	No new housing	No restrictions	New housing with insulation	Restrictions in some States
20 – 25	New housing with insulation	No restrictions	No new housing	No restrictions	No restrictions	Restrictions in some States
< 20	No restrictions	No restrictions	No restrictions	No restrictions	No restrictions	No restrictions

Many of the people raising this issue live in areas quite distant from an airport and it would clearly be impractical to prohibit residential development over massive urban areas on the grounds of aircraft noise.

Clearly there are people who consider themselves badly affected by noise at levels much lower than 20 ANEF – the level of acceptability for the siting of new housing specified in AS2021. This is not inconsistent with the findings of the NAL study which showed that at the 20 ANEF level 10% of the population considers itself ‘seriously affected’ by aircraft noise [ref 3]. Given this, some airports have been advocating that land use planning restrictions on residential development be extended to the 15 ANEF. This approach may be valid in areas where there is still undeveloped land which can be protected for non noise sensitive uses such as industrial.

The counter argument to this is the fact that there are very large numbers of persons who appear to very happily live in areas exposed to aircraft noise say up to the 25 ANEF level. Therefore extending the boundaries of the controlled areas beyond the 20 ANEF would represent a very broad brush approach to a problem which only affects a section of the population. In these circumstances, it is considered that there is much to be said for continuing to develop and refine *targeted* information tools which will enable *noise sensitive people* to make decisions that enable them to avoid aircraft noise.

6.3 Targeting the noise sensitive individual

The discussion in the previous Section focuses on reducing the level of aircraft noise exposure as a way to reduce community pressures on airports. However, an important strategy that is often overlooked is that of improving information flows so that the reaction to a particular level of noise is reduced.

Experience has shown that the most strident complaints often come from people who believe they have been misled in some way. They may have received advice on aircraft noise directly from the airport or an official body in the form shown in **Section 1.2** or they may have independently examined the ANEF contours published by an airport. In either case they are likely to have been presented with information on future aircraft noise which led them to envisage a certain pattern of noise exposure which did not eventuate.

It is of course more likely that an aircraft noise sensitive person, rather than a noise tolerant person, will seek advice on noise exposure patterns, or examine information published by an airport, before making a house move. They are therefore likely to be particularly focussed on the message given in the information.

The generation of an ‘anti airport’ resident as a result of a perception of misleading information can arise in a number of ways. In particular, from data issued during the environmental assessment process for a new project (eg new runways or flight path arrangements) or from advice given to a person moving into a new house which is in an area where there is existing audible aircraft noise.

The circumstances surrounding the EIS for the third runway at Sydney Airport are a prime example of the first case. Many people claim that they did not object during the EIS process because the ANEF information led them to believe that they would not be affected by the project. This was an important issue raised before the Senate Inquiry [ref 6].

As discussed in **Section 6.1**, if a person is **fully** informed of aircraft noise exposure patterns in a way which they can understand using relational noise indicators (ie numbers/times of overflights, etc) before making a house purchase they can factor this in to their decision making. If they then decide to proceed with the house move, but armed with full information, experience is that they are less likely to become an 'anti airport activist' if they subsequently hear aircraft noise after they have moved in to the new home.

On the other hand, if the person is not informed of audible aircraft noise before the move, and only becomes aware of it after moving into a new home, it can evolve into a major issue for the person. This is particularly likely where they have moved into a house which is a long way from an airport. In these circumstances the person expects to receive no aircraft noise and therefore even very low levels of aircraft noise can become a significant source of annoyance.

6.4

Using relational indicators in noise forecasts

The information in the paper has focussed on reporting historic or current aircraft movement and associated noise exposure patterns. However, some interest has been shown in using relational indicators in noise forecasts to help explain the information in published ANEFs.

The use of the relational indicators has essentially been kept to current data because to date the greatest demand from the public has been for this type of information. People predominantly seek information about aircraft movements they have complained or are concerned about – which in general is in the immediate past. Alternatively they want to know what it would be like in the immediate future if they were to move into an area or if new procedures such as revised flight paths were to be introduced. The question is whether the community would be interested in knowing, for example, how many events there will be louder than 70 dB(A) on an average day in twenty years time.

The ANEF is a land use planning tool. Since its prime purpose is to stop long term residential encroachment on airports it has much longer time horizons than the immediate noise information generally sought by the public. For example the ANEF for Perth Airport has a fifty year horizon. Given this, ANEF contours do not generally portray current or near term noise exposure patterns – they broadly reflect what the noise exposure patterns are likely to be at some time in the future when, for example, one or more new runways may be in operation. Therefore in many cases ANEFs are solely planning lines which, even if they could be understood by the layperson, have little or no relevance to current noise exposure patterns.

Unfortunately, this latter point is often poorly understood and people often erroneously look at the ANEF to gain an insight into current noise exposure patterns. Given this, the preferred approach is not to translate long term ANEFs into relational indicators since this would most

likely only reinforce the current misunderstanding of ANEF information. The preferred approach is to ensure that ANEF contours are treated solely as planning lines and that separate information be produced to describe current noise exposure patterns.

Irrespective of the above, there is no reason why relational indicators cannot be used for short term forecasts. For example, if at an airport there were no plans to build any new runway or change airspace arrangements say within the next five years then it would be quite feasible to produce five year noise exposure forecasts if this type of information were considered useful.

Figures 6.1 and **6.2** are examples of a future notional flight path movements chart and N70 for Coolangatta Airport for a five year horizon. These can be compared with **Figures 2.2** and **4.4**. These are purely illustrative projections based on the current flight path arrangements and origin/destination traffic mix with the movements being assumed to grow at 3% per annum. More refined versions of these figures could be produced if an airport wished to produce a 'forecast' in this form.

Relational indicators can also be successfully used for near term forecasting when comparing operating scenarios in the context of an EIS at an airport (eg when a new runway project is being assessed) where there has been detailed modelling of flight paths and there is confidence in origin/destination traffic forecasts.

By the same token it would be very misleading to use the indicators in circumstances where such detailed flight path modelling has not taken place or there is great uncertainty in traffic forecasts.

Coolangatta Airport



Figure 6.1 2005 Notional Jet Flight Path Movements



Figure 6.2: Notional projection of the number of noise events louder than 70 dB(A) on an average day in 2005.



A Way Ahead

A SUGGESTED INITIAL APPROACH

Where do we go from here? Subject to the discussion generated and feedback received on this paper, the Department is proposing that we now essentially put in place a new aircraft noise information regime in Australia. It is proposed that this regime be based on the principles discussed in **Section 7.1** and that the actions identified in the subsequent Sections be initiated.

7.1 Broad principles

Examination of the issues raised by this paper has led us to conclude that we now need to work toward an aircraft noise information regime based on the following broad principles:

Transparency	- communicating in 'everyday' language
	- using information that can be easily verified by the layperson
Inclusiveness	- not excluding people from information because the 'Standard' indicates noise is not a problem
Empowerment of the individual	- placing the individual in a position where they can form their own view on the acceptability of future noise

There are four key areas that need to be balanced in publishing aircraft noise (and most other) information - completeness, accuracy, comprehensibility and timeliness. In recent years it appears that the emphasis in providing aircraft noise information has been placed almost totally on trying to achieve technical accuracy/completeness (not geographic completeness) at the expense of the other factors.

Unfortunately the drive to get the 'right' answer inevitably leads to more complicated indicators which make them less comprehensible and less accessible to the layperson – this in effect is what appears to have happened as the ANEF has evolved.

It goes without saying that if any information is to be trusted by the community it must be accurate but by the same token it must be comprehensible to the audience it is intended for. ***Information may be totally accurate but it is likely to be very misleading if it cannot be fully understood.***

In our experience public confidence in the 'correctness' of information can be improved if the indicator being used can be monitored by a member of the public, without any special equipment or expertise, to check its accuracy. The relational noise indicators in this paper lend themselves to this type of verification.

While the thrust of this paper has been toward making aircraft noise information more transparent and accessible to the general public, the need to make aircraft noise information comprehensible to decision makers is equally important.

Decisions on the design of airspace arrangements, on the location of airports or the orientation of runways are fundamental to the patterns of community noise exposure. However, the persons charged with responsibilities for these decisions are rarely noise experts and have to largely rely on technical advice. Clearly if the decision maker has information like the relational indicators shown in this paper it enables him/her to gain a real 'feel' for what is the likely outcome of their decision. It places the decision maker in a much better position to ask the 'right' questions of their technical advisers.

7.2

Regular publication of area wide relational noise information

The Department considers that a constructive dialogue between airports and their surrounding communities would be facilitated by airports producing area wide, regular, transparent and widely distributed reports on aircraft operations and noise.

Implementation of this action would, for example, as argued in **Chapter 6**, lead in the long term to a lower number of noise sensitive people moving into areas where there is audible aircraft noise than would otherwise be the case. There would also be much less likelihood of persons feeling misled by airport information.

To date supplementary relational noise indicators such as those shown in this paper have been used on an ad hoc basis in Australia in response to circumstances where the interested parties have demanded information that goes beyond the ANEF.

Many Australian airports continue to only provide information on noise exposure patterns through the publication of ANEF contours. This may be a reflection of the fact that the production of an ANEF is formally required under the provisions of the *Airports Act 1996* and State and Territory planning instruments. However, this requirement relates to the use of the ANEF as a planning tool. In the context of the arguments presented in this paper about the use of the ANEF as an information tool, an ANEF map is particularly deficient in that it provides no information on noise exposure patterns beyond the 20 ANEF. It is considered that this can only work against the long term interests of both the airport and those noise sensitive members of the community.

It is proposed to encourage and assist all airport operators to prepare and make available to as wide an audience as appropriate for each airport the types of information presented in this paper. The Department is happy to make available to all airport operators (and any other

interested party) the routines developed to prepare the noise information described in this paper and to assist those bodies to establish systems for the preparation and publication of regular relational noise information reports.

7.3

Review and revision of Australian Standard AS2021

Australian Standard AS2021 needs to be reviewed and revised to incorporate recommendations for the production of area wide relational aircraft noise information. This would facilitate mandatory publication and dissemination of such information through relevant authorities picking up the Standard.

Australian Standard AS2021 clearly has a key role in the area under discussion in this paper. Unfortunately some of the messages it has conveyed have not been helpful and it is considered important that the Standard now be thoroughly reviewed so that the role of the ANEF as a land use planning system is clarified.

In the first instance it is considered important that the wording 'acceptable' and 'unacceptable' in the Standard be replaced by more objective terms such as 'no building restrictions' or 'building not permitted/recommended'. As discussed at a number of points in this paper, what is considered to be 'acceptable' by the Standard is not necessarily 'acceptable' to the individual.

It is considered essential that in a revised Standard a clear differentiation be made between 'aircraft noise information' and 'land use planning controls'. Ideally the ANEF in future will be treated solely as a (noise based) land use planning line and it will no longer be used as a primary aircraft noise information tool. The best approach to achieve this goal may even ultimately be to produce two Standards – one for land use planning and one for aircraft noise information.

7.4

Further studies

The Department considers that it would be productive to carry out further specific work or studies directed at

- . the verification of N70s
- . the development of further relational noise indicators
- . the use of the Internet for disseminating aircraft noise information.

7.4.1 N70 verification study

The US FAA Integrated Noise Model does not allow direct computation of the N70 and therefore the Department has developed a system for computing these indirectly from the model (see **Appendix B**).

As far as is known no other country is routinely producing and publishing N70 contours. Very importantly a fundamental aim of the published N70s is to give information to communities relatively distant from an airport. Accuracy will drop off with distance from an airport. Given

this it is not clear how much confidence can be placed on the contours and they are normally treated as being 'indicative'.

While informal accuracy checks are very positive (see **Appendix B**) it would be beneficial if an independent study were carried out into the contours to ascertain the level of confidence that can be placed in them.

7.4.2 Development of other relational noise indicators

Clearly this paper does not represent the end of the road - it shows the current state of play. Undoubtedly significant improvements could be made to the presentations in this paper. For example, there are many alternative ways in which the 'average day' and 'sensitive times' shortcomings of the current approaches could be addressed. The graphics in the flight path movements charts could be enhanced to indicate altitude or the density of flight path spreading.

There may therefore be merit in carrying out a special study involving consultation with all interested parties to ascertain whether the current range of relational indicators we have developed can be expanded and to decide on the best way to refine and enhance the indicators now in use.

7.4.3 The Internet

The Internet is largely an untapped tool for promulgating information on aircraft noise in Australia at the present time. There would appear to be a major potential for using the Internet to provide ongoing, current aircraft noise exposure information, using relational noise indicators for all major Australian airports.

By way of example, the Department is now looking at ways to adapt the flight path movement charts shown in **Chapter 2** for the Internet. It is proposed that the charts will include animation and will allow querying of information about movements on each of the flight paths.

Some airports have already moved to establish very good web sites and put relevant operational and noise information on the site for the community to access.

Clearly this is going to be a very fruitful area of further work.

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Appendix A

AUSTRALIAN NOISE EXPOSURE FORECAST
(ANEF) SYSTEM

A.1 Genesis

The ANEF system was developed through a major socio-acoustic survey carried out in the vicinity of a number of Australian airports in 1980 (see the report cited at [ref 3]). Based on the results of this work the system then in use in Australia – the NEF system – was modified to suit Australian conditions and became termed the ANEF system. The ANEF system incorporated a weighting for the period 7pm to 7am (as opposed to the 10pm to 7am period under the NEF system) as the study showed that this gave the best correlation between noise dose and community reaction.

A.2 Relationship to other indicators

The ANEF is an equal energy noise index similar to the Ldn and Leq. ANEF is generally taken to be approximately equivalent to $Leq - 35$. A sample ANEF contour is shown in **Figure A.1**.

A.3 Land use compatibility advice

The ANEF system was developed as a land use planning tool aimed at controlling encroachment on airports by noise sensitive buildings. The system underpins Australian Standard AS2021 '*Acoustics – Aircraft noise intrusion – Building siting and construction*'. The Standard contains advice on the acceptability of building sites based on ANEF zones.

The acceptability criteria vary depending on the type of land use. However, the most crucial criterion for the purposes of this paper specifies that land with an aircraft noise exposure level of less than 20 ANEF is acceptable for the building of new residential dwellings.

The line for acceptability of residential building construction was drawn at 20 ANEF as this corresponded to the 10% 'seriously affected' level in the dose/response relationship established by the 1980 study mentioned in **Section A.1**.

A.4 Terminology

There are three different forms of contour maps recognised under the ANEF system.

ANEFs These are the official forecasts of future noise exposure patterns around an airport and they constitute the contours on which land use planning authorities base their controls.

ANEIs These are contours showing historic noise exposure patterns and are used in environmental reporting and benchmarking.

ANECs These are scenario contours and are used to produce 'what if' contours, for example, in the process of examining flight path options around an airport.

In order to aid clarity the term 'ANEF' is generally used throughout the paper when referring to any of the above three types of contour.

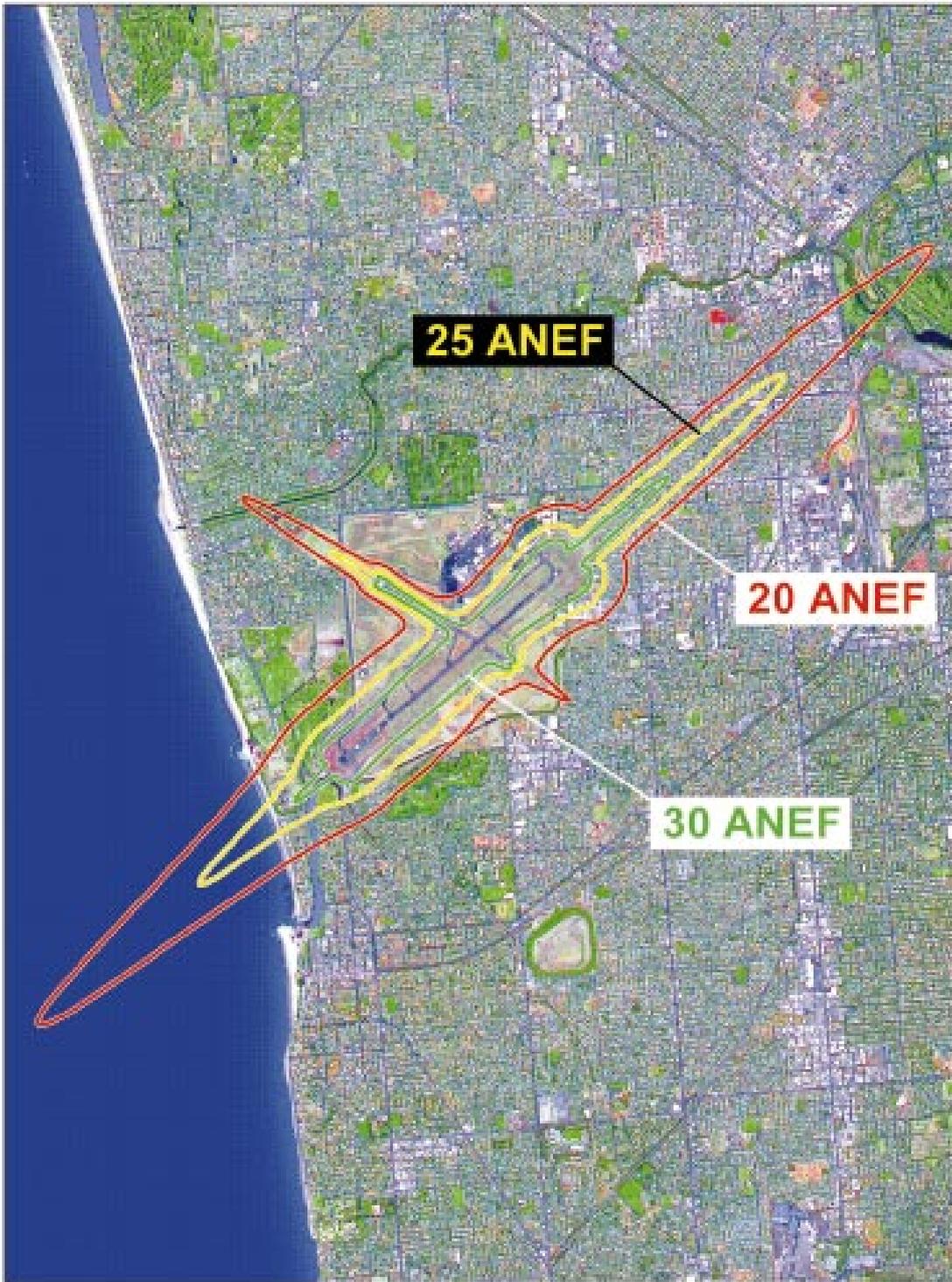


Figure A.1 Illustrative ANEF noise contours





Appendix B

DERIVATION OF NOISE INDICES

B.1 Flight path movements charts

The jet flight path movements charts shown in **Chapter 2** are derived from two sources.

The base flight path 'zones' shown on the charts have been derived from examination of flight path maps covering the period represented on the chart. The flight path maps are produced by the airports' noise and flight path monitoring systems. The 'zones' are designed to give a good indicative representation of the general flight path patterns, say 90% of jet aircraft movements. They do not represent the total spread of aircraft on the particular flight paths.

The number of aircraft movements assigned to each flight path at any airport is derived from that airport's Avcharges database. The Avcharges database is established by Airservices Australia to facilitate charging of airport users. The database contains information on runway use, aircraft type, time of day of operations, destination and origin of aircraft, etc.

For some airports the assignment to flight paths is simply derived from runway use (eg Coolangatta Airport – **Figure 2.2**). At airports where the charts show splits on the approach or departure flight paths (eg Sydney and Perth **Figures 2.1** and **2.3**) assignment is based both on runway use and either on interrogating the database on port of origin and/or destination or by estimating the number of aircraft using each flight path through examination of the flight path maps.

The statistical information in the boxes is simply derived from interrogation of the Avcharges database.

B.2 Respite charts

These charts use the same flight path base map as the flight path movements charts.

Respite is simply derived from interrogation of the Avcharges database. As indicated in **Section 3.1**, respite as shown in **Figure 3.1** is calculated by counting the number of clock hours when there were no jet movements on a particular flight path and reporting this as a percentage of the total number of hours during the period of interest.

B.3 N70 contours

B.3.1 Computation of N70 contours

The N70 contours have been derived using the US Federal Aviation Administration's (FAA) Integrated Noise Model (INM).

N70 contours are not on the menu of INM output metrics. The contours have therefore been produced indirectly from the model by, in essence, computing a detailed grid and summing the number of events within the model which register a non zero time above 70 dB(A). The Department has developed a computer program which carries out this task and produces an N70 grid which enables the contours to be drawn using the INM contouring routine or another contouring program.

Figures 4.8 and 4.9, which show N70s for Sydney Airport on the 18 Jan 1999 and 20 Jan 1999, were derived by manipulating the aircraft type and runway use data in the 1998 ANEI files to correspond with the actual activities that took place on those days. The flight paths were not adjusted from those used in the 1998 ANEI – examination of the flight path maps for those days did not show any significant divergence from the flight paths used for modelling the average day. The mix of aircraft stage lengths for each particular aircraft type for the two days was assumed to same as that for the average day.

Figure 4.10 which shows the N70 for the ‘sensitive times’ was similarly derived by interrogating the Avcharges database for 1998, ascertaining the jet movements during the times selected and using this to replace the data for the average day. The flight paths and stage lengths were treated in a similar manner to that for the other partial N70s.

B.3.2 Computation of the number of persons within the N70 contours

The computations of the PEI/AIE in **Chapter 5** involve the number of persons within specified N70 contours. **Table 5.1** also shows the total number of persons within the 10 events per day louder than 70 dB(A) contour at specified airports.

These computations have been based on the Australian Bureau of Statistics 1996 census data. Each INM grid point is assigned a population based on the population density within the individual census Collection Districts. This enables the total population exposed to any specified N70 level to be computed.

B.3.3 Accuracy of N70 contours

As indicated above the N70 contours have been derived indirectly using information in the INM model. The N70 is therefore not an FAA verified contour. The Proponent’s Statement [ref 20] contains a short discussion on some potential sources of computational error in the contours.

While no formal study has been carried out in Australia to verify the accuracy of the contours, they are checked informally and the work to date indicates that broad confidence can be placed on them as being good indicative contours.

When preparing an N70 an initial informal check of the contours is made which involves ensuring that the N70 values are consistent with the number of operations that took place during the period of interest and with the 70 dB(A) single event contours for the types of aircraft that operated.

An attempt has also been made to verify the INM computed N70 values by comparing them to the measured N70 values recorded at the permanent noise monitoring terminals (NMTs) sited around Sydney Airport. This comparison is shown in **Table B.1**.

It can be seen that at the noise monitoring terminals the agreement between modelled and measured values is broadly of the order of the mean +/- 10%.

The agreement is worst at Annandale but the difference is not biased in one direction – on the Mode 9 day the modelled value is significantly higher than the measured value; this is reversed on the Mode 10 day. It appears that this problem has arisen because Annandale is just on the edge of the 70 dB(A) contour for certain aircraft types. With a threshold type indicator such as the N70, ‘edge effects’ will occur – a reading of 69.9 dB(A) is a ‘no’ while a reading of 70.1 dB(A) is a ‘yes’.

Conceptually it would be expected that, given the number of events involved and the way they have been computed, the N70 for the annual average day would be more accurate than the short term N70s. It would also be expected that, due to the greater variation in the flight paths of departing aircraft, there would be more uncertainty in the N70 values for those areas impacted primarily by noise from departing aircraft (eg to the north-west at Sydney – see **Figure 2.1**) than for those areas impacted by noise from arrivals.

Table B.1: Comparison of modelled and measured N70s – Sydney Airport

Noise Monitoring Terminal (NMT) Location	1998 N70		Mode 10 N70		Mode 9 N70	
	INM	NMT	INM	NMT	INM	NMT
Bexley	45	41	<10	-	8	-
Penshurst	20	26	<10	1	<10	6
Sydenham	128	109	202	210	105	82
Leichhardt	90	85	190	200	39	35
St Peters	58	74	99	128	55	58
Annandale	27	46	45	88	24	9
Eastlakes	40	32	<10	-	45	17
Coogee	21	24	<10	-	<10	1
Botany	15	23	17	28	<10	5
La Perouse	<10	7	<10	4	<10	1
Kurnell	50	52	<10	3	90	70

Notes

- (1) **INM** -N70s *modelled* using the Integrated Noise Model
- (2) **NMT** -N70s *measured* at the Sydney Airport Noise Monitoring Terminals



Appendix C

PEI COMPUTATIONS

Section 5.4 of the paper contains a worked example of a PEI/AIE analysis of different operating configurations at Sydney Airport. The base computations for this example are contained in **Tables C.1** and **C.2**. **Table C.1** shows the number of persons within five N70 bands for the three operating configurations and then shows the computation of the partial PEI (and the AIE used) in each of the bands. **Table C.2** cumulates the information in **Table C.1**.

The analysis in **Table C.2** is particularly useful for examining the distribution of the noise load. For example, the table shows that in the 'noise sharing' scenario very little of the total noise load is in areas where the N70 exceeds 100 events per day. For the noise sharing scenario this figure is about 12% of the total PEI, by way of comparison in the parallels scenario the figure is about 75%. By the same token the Tables show that the number of persons exposed to more than 40 events per day is, as would be expected, greatest under the noise sharing regime.

The N70 computations in the Tables only include areas within the 40 events per day contour as this broadly equates to the 20 ANEF (55 Leq) contour for Sydney and this therefore allows a 'like for like' comparison to be made between the PEI/AIE approach and the ANEF approach in the worked example.

The outer contour on the N70s shown in **Chapter 4** extends to 10 events per day in order to maximise the coverage of the information. It is important that this difference in 'cut-off' level is not overlooked when making comparisons between different PEIs.

The analysis has been based on the N70. If a detailed analysis were being carried out, a similar table would need to be produced for, say the N80 (number of events above 80 dB(A)), to ascertain the consistency of the noise exposure patterns at different single event levels.

In order to address the above issues and ensure clarity when using the PEI and AIE it is more robust to express them in the form PEI(x,y) and AIE(x,y) where 'x' is the dB(A) value and 'y' is the number of events 'cut-off' value.

Table C.1: PEI(70) and AIE Values – Comparison of Operating Arrangements at Sydney Airport

No of Events >70 dB(A)	PRE-PARALLELS			PARALLELS			NOISE SHARING		
	No of persons exposed	No of Person-Events	AIE	No of persons exposed	No of Person-Events	AIE	No of persons exposed	No of Person-Events	AIE
>200	750	187,500	250	10,500	2,625,000	250	100	25,000	250
150 – 200	1,750	306,500	175	10,000	1,750,000	175	700	122,500	175
100 – 150	22,000	2,750,000	125	15,500	1,937,500	125	5,500	687,500	125
50 – 100	42,000	3,150,000	75	25,000	1,875,000	75	58,000	4,350,000	75
40 – 50	14,000	630,000	45	9,500	427,500	45	37,500	1,687,500	45

Notes

(1) The number of person-events for each exposure zone has been calculated by multiplying the population in each zone by the mid-point N70 value for each range. Hence AIE – the average individual exposure – in this case is the mid-point N70. A more accurate approach would be based on assigning census populations to INM grid points for which N70 values have been computed. The information in the Table is only indicative.

Table C.2: Cumulative PEI(70) and AIE Values – Comparison of Operating Arrangements at Sydney Airport

No of Events > 70 dB(A)	PRE-PARALLELS			PARALLELS			NOISE SHARING		
	No of persons exposed	No of Person-Events	AIE	No of persons exposed	No of Person-Events	AIE	No of persons exposed	No of Person-Events	AIE
>200	750	187,500	250	10,500	2,625,000	250	100	25,000	250
>150	2,500	494,000	198	20,500	4,375,000	213	800	147,500	184
>100	24,500	3,244,000	132	36,000	6,312,500	175	6,300	835,000	133
>50	66,500	6,394,000	96	61,000	8,187,500	134	64,300	5,185,000	81
>40	80,500	7,024,000	87	70,500	8,615,000	122	101,800	6,872,500	68

Notes

- (1) The cumulative values for exposed population and number of person-events shown in the Table have been derived from the partial values shown in Table 3A.
- (2) AIE – the average individual exposure - is calculated by dividing the number of person-events by the population exposed.

C.2 Using the PEI to analyse partial noise loads

The PEI is very useful for considering partial noise loads. The PEI can be calculated for just one movement, or a small number of movements, to produce a result that is meaningful. For example, it was shown in **Section 5.5** how the noise load generated by one flight at Sydney can be very easily compared to the total daily noise load generated at other airports.

A good example of examining partial noise loads is to compare the two most commonly used, and highest capacity, runway operating modes at Sydney Airport (Mode 9 – northerly parallel flow & Mode 10 – southerly parallel flow). **Figures 4.8** and **4.9** in **Chapter 4** show the ‘worst day’ N70s for these two modes.

A PEI/AIE analysis has been carried out on the noise distribution for these two ‘worst days’ and the key information is summarised in **Table C.3** along with data for the 1995 and 1998 average days for comparative purposes.

Table C.3 Summary of PEI Analysis for Partial Noise Loads

Exposure for persons within the N70 contours	1998 Average Day (LTOP)	Mode 10 Day (approx 2.5 days/month)	Mode 9 Day (approx 2.5 days/month)	1995 Average Day (parallels)
No of persons exposed to more than 10 events louder than 70 dB(A)	269,500	110,000	332,500	142,500
No of persons exposed to more than 150 events louder than 70 dB(A)	1,100	23,000	800	21,000
No of Person-Events (x 10 ⁶)	8.7	8.6	10.8	9.9
Average number of noise events louder than 70 dB(A) for persons within the 10 events contour	32	79	33	69

Notes

- (1) The figures for the 1995 Average Day (parallel runway regime) are based on an N70 which extends to 10 events/day. The figures shown in **Table 5.1** for the parallel runway regime only extend to the 40 events/day contour to allow comparison with the population within the 20 ANEF.

Comparison of the data in the table for the 'Mode 9 Day' with the 'Mode 10 Day' reveals an excellent example of noise sharing versus noise concentration

- on a Mode 9 day more than 3 times the number of persons are within the 10 events N70 contour
- on a Mode 10 day the average noise load per person is approximately 2.5 that under Mode 9 (79 events cf 33 events).

Tables C.4 and **C.5** contain the detailed PEI/AIE workings and show that the total noise load (expressed as PEI for persons within the 10 events/day contour) generated by Mode 9 is approximately 20% greater than that generated by Mode 10

- on the Mode 9 day less than 10% of the noise load is imposed on areas where there are more than 100 movements
- on the Mode 10 day about 65% of the noise load is on areas where there are more than 100 movements
- the greatest noise load for the Mode 9 day is in the 20 – 50 movements range; for the Mode 10 day it is in the 100 – 200 movements range.

In summary Mode 9 generates a greater total noise load and more people are exposed to noise but the average individual noise load is much lower than under Mode 10.

Table C.3 also shows that under the parallel runway regime the noise exposure regime on an average day was broadly similar to that on a Mode 10 'worst day' which now only occurs on about 2.5 days per month on average.

This example illustrates that the PEI/AIE approach enables the differences between scenarios to be clearly drawn out. If the analysis were based on ANEF information, due to the logarithmic base of the ANEF, the differences between the two modes would not appear to be as stark and the output not as clearly understood given the non-relational nature of the units.

Figures C.1 and **C.2** show continuous functions of the PEI/AIE information in **Tables C.4** and **C.5**.

Table C.4 PEI(70) and AIE Values – Comparison of Sydney Airport LTOP Modes

No of Events >70 dB(A)	1998 AVERAGE DAY				MODE 9 DAY				MODE 10 DAY			
	No of persons exposed	No of Person-Events	% of total PEI	AIE	No of persons exposed	No of Person-Events	% of total PEI	AIE	No of persons exposed	No of Person-Events	% of total PEI	AIE
>200	719	185,242	2.1	258	353	86,565	0.8	245	5,017	1,102,081	12.8	220
100 – 200	9,174	1,062,299	12.2	115	6,044	734,983	6.8	121	28,668	4,344,253	50.6	152
50 – 100	31,504	2,249,297	25.8	71	52,918	3,412,551	31.6	64	25,590	1,854,034	21.6	72
20 – 50	114,238	3,623,798	41.6	32	154,597	4,864,955	45.0	31	29,799	999,318	11.7	34
10 – 20	113,723	1,588,698	18.3	14	118,594	1,707,682	15.8	14	19,841	284,275	3.3	14
TOTAL	269,358	8,709,334	100.0	32	332,506	10,806,736	100.0	33	108,915	8,583,961	100.0	79

Notes

(1) The number of person-events has been obtained by multiplying the number of persons exposed by the number of events above 70 dB(A). It has been calculated by assigning census populations to INM grid points for which N70 values have been computed. The information in the Table is only indicative.

Table C-5 Cumulative PEI(70) and AIE Values – Comparison of Sydney Airport LTOP Modes

No of Events >70 dB(A)	1998 AVERAGE DAY				MODE 9 DAY				MODE 10 DAY			
	No of persons exposed	No of Person-Events	% of total PEI	AIE	No of persons exposed	No of Person-Events	% of total PEI	AIE	No of persons exposed	No of Person-Events	% of total PEI	AIE
>200	719	185,242	2.1	258	353	86,565	0.8	245	5,017	1,102,081	12.8	220
>100	9,893	1,247,541	14.3	126	6,397	821,548	7.6	128	33,685	5,446,334	63.4	161
>50	41,397	3,496,838	40.2	84	59,315	4,234,099	39.2	71	59,275	7,300,368	85.0	123
>20	155,635	7,120,636	81.8	46	213,912	9,099,054	84.2	42	89,074	8,299,686	96.7	93
>10	269,358	8,709,334	100.0	32	332,506	10,806,736	100.0	33	108,915	8,583,961	100.0	79

Notes

(1) The cumulative values for exposed population and number of person-events shown in the Table have been derived from the partial values shown in Table C.4.

AIE – the average individual exposure - is calculated by dividing the number of person-events by the population exposed.

(2) 'Mode 9 Day' and 'Mode 10 Day' refer to a day when these parallel modes were used for more than 15 hours. The data in the table is derived from the movements on sample days - 18 Jan 1999 for the 'Mode 9 Day' and 20 Jan 1999 for the 'Mode 10 Day'.

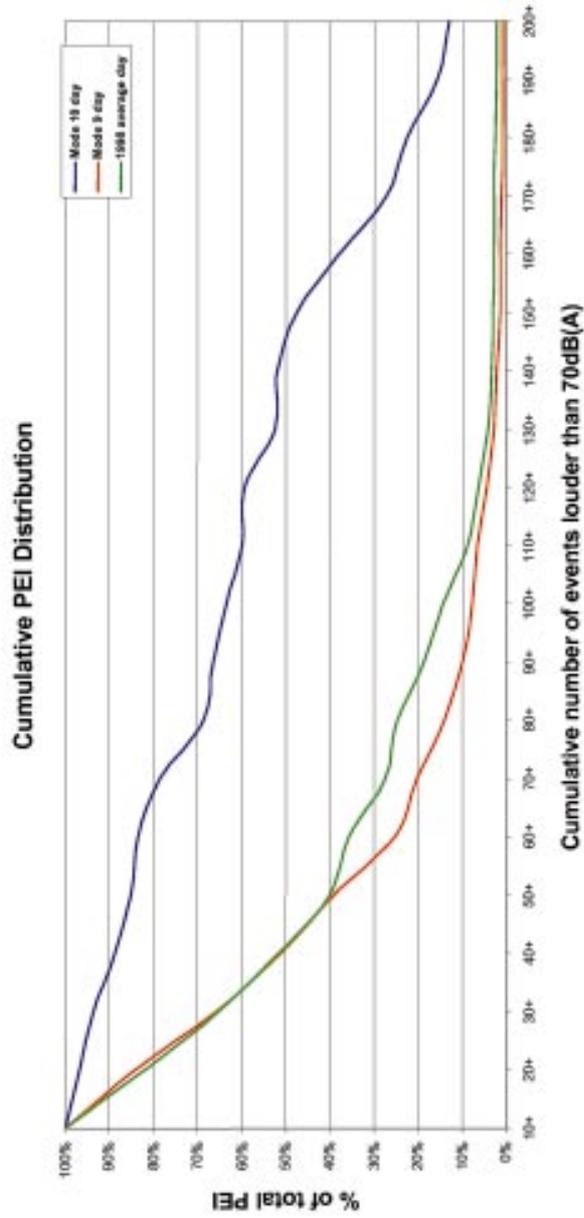


Figure C.1 Runway Mode Comparison - Cumulative PEI Distribution

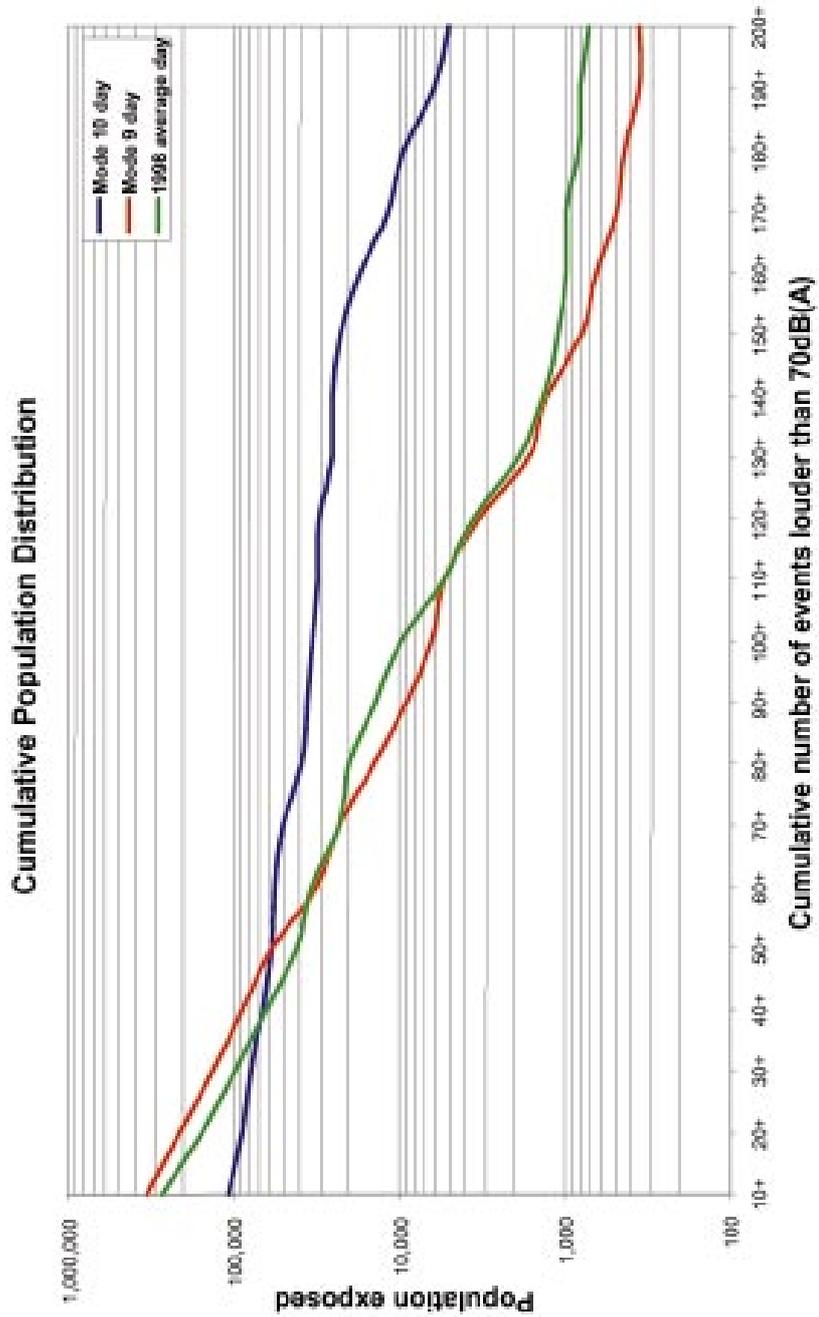


Figure C.2 Runway Mode Comparison - Cumulative Population Distribution

Notes

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