Before an Independent Hearings Panel
appointed by Christchurch City Council

under: the Resource Management Act 1991

in the matter of: the hearing of submissions on Plan Change 14 (Housing and Business Choice) to the Christchurch District Plan

and: **Christchurch International Airport Limited**
Submitter 852

Statement of Evidence of Christopher Day (acoustics)

Dated: 20 September 2023

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STATEMENT OF EVIDENCE OF CHRISTOPHER DAY

1 My full name is Christopher William Day.

2 I have worked in the field of acoustics, noise measurement and control for the past 50 years in England, Australia and New Zealand, specialising in transportation noise and acoustics for the performing arts. My firm is one of the largest acoustic engineering consultancies worldwide, working on major projects in over 15 countries. We employ approximately 100 professional staff throughout New Zealand, Australia, Hong Kong and France.

3 I have the qualification of Bachelor of Engineering (Mechanical) from Monash University in Melbourne, Australia. My work over the last 45 years has included noise control engineering and town planning work for various major corporations and city councils within New Zealand, and I have been engaged on numerous occasions as an expert witness before the Environment Court.

4 I have had significant involvement in matters relating to airport noise at all three major airports in New Zealand: Auckland, Wellington and Christchurch, as well as most of the regional airports, including Rotorua, Whangarei, Dunedin, Invercargill, Queenstown, Wanaka, Ardmore, Hamilton, Tauranga, Nelson, Napier, Omaka, Paraparaumu, Gisborne, Masterton and Taupo.

5 Marshall Day Acoustics has been engaged by Christchurch International Airport Limited (CIAL) since 1992 to advise on various noise issues including:

5.1 preparation of the original noise contours (1994) to form the basis of the airport noise provisions in the Canterbury Regional Policy Statement (*CRPS*) and the Christchurch, Waimakariri and Selwyn District Plans;

5.2 preparation of the 2007 remodelled contours and associated hearings;

5.3 preparation of the 2023 remodelled noise contours; and

5.4 providing noise evidence on a number of specific land use consent applications and plan changes.

CODE OF CONDUCT

6 Although this is not an Environment Court hearing, I note that in preparing my evidence I have reviewed the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023. I have complied with it in preparing my evidence on technical matters. I confirm that the technical matters on which I give evidence are within my area of expertise, except where relying on

the opinion or evidence of other witnesses. I have not omitted to consider material facts known to me that might alter or detract from my opinions expressed.

SCOPE OF EVIDENCE

7 My colleague **Ms Laurel Smith** has presented evidence on the background to the New Zealand Standard on airport noise and how it has been implemented at Christchurch. Ms Smith has also explained how the updated noise contours have been prepared. I have been asked to specifically comment on the suitability of the 50 dB L_{dn} airport noise contour as the basis for land use planning controls around Christchurch International Airport (*Christchurch Airport* or *the Airport*). This is in relation to the intensification of residential activity proposed to be enabled by Plan Change 14 to the Christchurch District Plan.

8 My evidence will address:

8.1 Introduction;

8.2 Historical land use planning around Christchurch Airport;

8.3 New Zealand Standard NZS 6805;

8.4 Community response to noise;

8.5 Planning constraints at other airports;

8.6 General District Plan noise limits;

8.7 Complaints;

8.8 Sound insulation;

8.9 Reverse sensitivity effects at other airports; and

8.10 Reduction in aircraft noise emissions.

9 In my **Appendix 1**, I include a Glossary of Terminology.

SUMMARY AND CONCLUSIONS

10 It is my opinion that the existing approach of using the 50 dB L_{dn} contour for the commencement of land use planning controls is the appropriate approach to be used at Christchurch. There are a number of key arguments to support this recommendation;

- A Noise Exposure Line and a 50 dB L_{dn} contour has historically been used at Christchurch since 1975

- The use of 50 dB L_{dn} contour has previously been debated in several hearings and in all cases the use of the 50 dB L_{dn} contour was reconfirmed as appropriate for Christchurch

- NZS 6805 recommends that existing noise controls should not be downgraded

- World-wide, community annoyance from aircraft noise has approximately doubled since these controls were first introduced and NZS 6805:1992 was written

- The WHO recommended a level of 40 dB L_{night} to avoid adverse effects on sleep and this contour for Christchurch is roughly the same size and shape as the 50 dB L_{dn} contour

- Planning controls at other New Zealand airports vary depending on the circumstances – some are less stringent than Christchurch and one is more restrictive

- District Plan noise limits for general noise sources (non airport) are set at around 50 dB L_{dn}

- Airports generally experience significant complaint from residents located outside 55 dB L_{dn}

- Providing sound insulation to affected dwellings does not solve all the annoyance issues from aircraft noise

- Reverse sensitivity is a very real affect for airports worldwide. Costly operational constraints have been implemented at many airports

- Noise reductions due to aircraft technology appear to have plateaued and only minor gains appear likely in the future

- From a noise perspective, it is my opinion that 50 dB L_{dn} should be retained as the commencement of planning restrictions around Christchurch Airport

11 Each of these issues is discussed in this evidence.

INTRODUCTION

12 The objective of my evidence is to discuss at what noise level should planning restrictions commence for Christchurch Airport. Community response to noise is clearly a 'grey scale' – annoyance does not start and stop at a specific noise level or boundary line on a map. However, to implement planning controls, a specific noise level does need to be decided upon.

13 It is a long-established concept that aviation noise can have an adverse effect on people and communities.

14 World-wide, the lack of appropriate land use planning around airports has historically caused significant numbers of people to be exposed to airport noise and subsequent community action has initiated operational constraints on airports. The fore-fathers in Greater Christchurch however have managed to avoid this situation by farsighted planning of the Christchurch Airport location including a 'buffer' protecting the Airport.

15 The noise levels experienced around Christchurch Airport are not sufficiently high to create physiological damage such as hearing loss but there are nevertheless adverse effects caused by noise. These adverse effects include annoyance, speech interference, sleep disturbance and potentially health effects associated with annoyance.

16 However, at what level of noise do these effects commence? There is no doubt there are adverse effects from aircraft noise at 50 dB L_{dn}. While the adverse effects are less than, for example, they are at 65 dB L_{dn}, they are nevertheless real. If land is available elsewhere in the Christchurch region for new residential development (or intensification), I would not recommend from an acoustics perspective, to allow new noise sensitive activities inside the 50 L_{dn} Air Noise Contour if it can be avoided. I accept noise effects are just one input to the decision-making process on land use restrictions.

17 A number of factors confirm there are adverse effects from aircraft noise inside the 50 L_{dn} Air Noise Contour and that this is not a desirable noise environment in which to locate new residential development, and these are discussed in my evidence.

18 Recent overseas studies have shown that between 50 dB and 55 dB L_{dn}, 18% to 33% of people were found to be highly annoyed by aircraft noise. If noise sensitive activities such as residential development, hospitals and education facilities are allowed to locate in this area (50 dB to 55 dB L_{dn}), the number of people adversely affected by aircraft noise would increase.

19 The World Health Organisation (*WHO*) 2018 Study[1] (section 3.3) states "aircraft noise above 45 dB L_{den} [2] is associated with adverse health effects".

20 In addition, specifying sound insulation to be fitted to buildings in these noise environments will not eliminate all the adverse effects of

[1] Environmental Noise Guidelines for the European Region (WHO 2018)

[2] L_{den} is a very similar measure to L_{dn} with an evening penalty of 5 dB added to the L_{Aeq} . In practice, the L_{den} value is very close to the L_{dn} value - within 1 dB or so.

noise, due to open windows and an unsatisfactory outdoor noise environment.

HISTORICAL LAND USE PLANNING AROUND CHRISTCHURCH AIRPORT

1975 Waimairi District Plan

21 Christchurch has been extremely fortunate in the management of aircraft noise for two main reasons. Firstly, the main Christchurch Airport runway was aligned roughly north/south with the city located to the east. As airport noise contours are long and narrow, the city is relatively unaffected by aircraft noise while maintaining close access to the Airport. Secondly, the authorities have managed to maintain a 'greenbelt' ensuring that new residential development does not come too close to the Airport.

22 Christchurch City has been extremely progressive in introducing airport noise planning at an early stage. In 1975 the Waimairi Council introduced Plan Change 10 which included a "calculated noise control line and endeavoured to control possible conflict between airport related activities and residents in the vicinity by making dwelling–houses (including the rebuilding of existing dwelling houses), a conditional use with requirements for noise insulation".

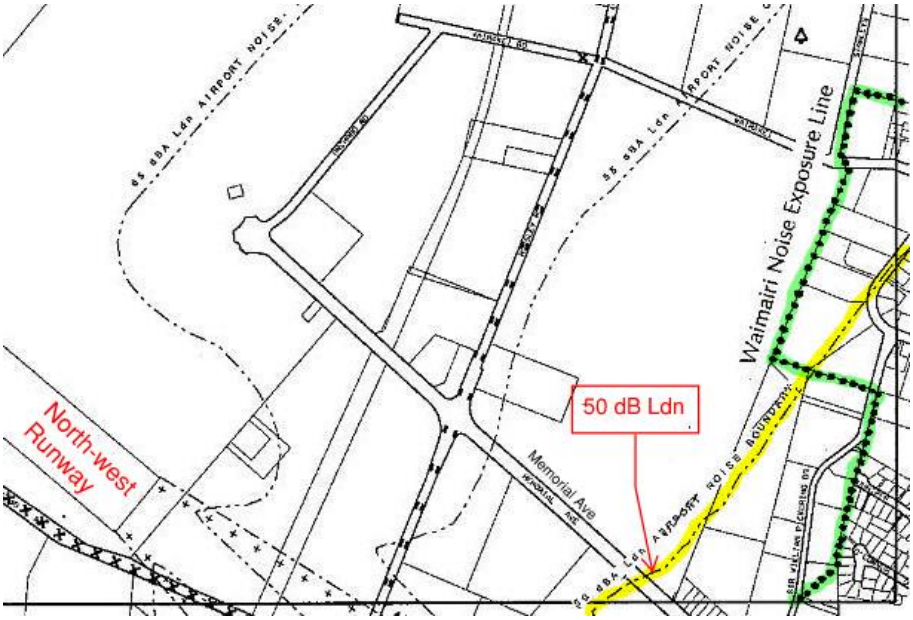
23 A copy of the Waimairi District Planning Scheme 1989 Section Twelve - Part One: "Christchurch International Airport Noise Exposure Line" (*NEL*) is attached as **Appendix 2** with an excerpt below at **Figure 1**.

24 The planning scheme clearly states the objectives of the NEL; "The controls associated with the noise exposure line are provided both to protect residents living in the vicinity of the airport from airport related noise and also to protect the airport from complaints about noise from residents which if sustained could lead to constraints upon airport operations".

25 The location of the NEL at that time was based on a 50 dB Day-Night Level (L_{dn}) contour produced by the Department of Scientific Research.

26 **Appendix 3** shows a copy of two City Plan Maps 23B and 24B from the Christchurch City Plan (which was made operative in 1995). These maps (and the **Figure 1** excerpt) show the location of the NEL and the 50 dB L_{dn} Airport Noise Boundary in the City Plan near Memorial Drive. The NEL wanders either side of the 1995 City Plan L_{dn} 50 dB contour but is mostly outside it.

Figure 1 – 1975 Noise Exposure Line versus 50 dB L_{dn} Airport Noise Boundary 1995 CCP



27 It may appear anomalous that the 50 dB contour in 1975 is in roughly the same place as it is 20 years later. The reason for this is that the reduction in aircraft noise due to technological advances in aircraft design has roughly matched the growth in aircraft movements. This reduction in aircraft noise emissions is discussed further in paragraphs 108 onwards of my evidence below. In 1975 there were a smaller number of noisier aircraft. These advances in aircraft technology have enabled airports to grow significantly without noticeably increasing the overall noise exposure for the community.

28 In 1993, work began to develop airport noise boundaries based on the New Zealand Standard NZS 6805:1992 *Airport Noise Management and Land Use Planning* (*NZS 6802* or *the Standard*) approach. These boundaries were eventually introduced into the Christchurch District Plan in 2001.

29 The noise boundaries were updated in 2008 and referenced in the CRPS. Subsequently these updated noise boundaries were implemented in the Selwyn, Waimakariri and Christchurch District Plans. These contours are sometimes referred to as the 'Expert Panel' or as the Operative Noise Contours.

Planning Hearings Debating 50 dB L_{dn}

30 Since 1994 there have been several hearings (Council and Environment Court) that have debated whether a 50 dB L_{dn} contour is appropriate for Christchurch Airport. These cases will be

discussed in detail in CIAL's legal submissions, however the overall summary is that many overseas and local noise experts presented evidence as to the suitability of the 50 dB L_{dn} contour and in all cases the use of the 50 dB L_{dn} contour for the Outer Control Boundary (*OCB*) was reconfirmed as appropriate for Christchurch.

31 I have seen no new information that supports changing this approach. To the contrary, in this evidence, I provide the results of new research that strengthens the argument that the 50 dB L_{dn} approach should be retained.

NEW ZEALAND STANDARD NZS 6805

32 A description of NZS 6805 is included in the evidence of **Ms Smith**. The Standard generally lays out a process for using 55 dB L_{dn} as the minimum/outer level of protection but there are a number of specific clauses in the Standard that in my opinion support the use of 50 dB L_{dn}.

Clause 1.1.4 'Do not downgrade existing noise controls'

33 Clause 1.1.4 of NZS 6805 states that "This Standard shall not be used as a mechanism for downgrading existing or future noise controls…"

34 The Christchurch City Plan has had a 50 dB L_{dn} airport noise contour in place since 1975 as described above. If the District Plan now adopted the 55 dB L_{dn} contour as the commencement of land use controls (i.e. a position closer to the Airport than the historical line), this would be a significant 'downgrading of the previously existing controls' and thus contrary to the recommendations in the Standard.

Clause 1.4.3.8 'Minimum Standard of Protection'

35 It is understood the NZS 6805 is very much recommending a minimum level of protection with its use of 55 dB L_{dn} as the OCB. The Standard states in clause 1.4.3.8 that the local authority may show "the contours in a position further from, or closer to the airport, if it considers it more reasonable to do so in the special circumstances of the case".

36 Christchurch Airport is a unique situation where the Council and CIAL have diligently maintained a 'buffer' around the Airport through the implementation of appropriate land use planning over a significant period of time. Many other New Zealand airports have not been as fortunate due to severe shortages of residential land. In these situations, the local authorities have tended to implement less stringent land use planning rules during the adoption of NZS 6805 into their district plans as in most cases the Standard arrived too late (1992) to prevent residential encroachment.

37 Auckland is an example of this less stringent approach due to the current and future shortage of residential land in the Manukau area. However, Queenstown, which also has a shortage of residential land, has adopted a more protective approach with new residential development between the OCB and Air Noise Boundary (*ANB*) listed as a prohibited activity in rural zones.

38 I understand, based on the evidence of CIAL's other experts and on the Council's section 42A reports and evidence, that the Christchurch area does not have an overriding need to site residential development in areas affected by airport noise. In my view, such land should be used for non-noise sensitive users or uses which require low population densities thus keeping the number of people impacted by aircraft noise to a minimum. I understand that there are many areas away from the Airport not affected by aircraft noise that can more appropriately be used for residential development.

39 The Standard clearly envisages that a better standard of protection than the 'minimum standard' may be implemented somewhere in New Zealand – otherwise it would not have these words in clause 1.4.3.8 of the Standard. It is difficult to imagine a more appropriate location than Christchurch with its national significance in the transportation network, as outlined by **Ms Natalie Hampson** and **Mr Darryl Millar**, and its already well established 'buffer', to implement "contours in a position further from the airport".

The 50 dB L_{dn} Planning Controls are not particularly arduous

40 As discussed earlier, the adverse effects of noise gradually increase with increasing noise level. The NZS 6805 suggested land use planning controls thus become more stringent as the noise level increases. Christchurch follows this approach with very moderate land use controls between the 50 dB to 60 dB L_{dn} noise contours. In simple terms new noise sensitive activities are to be discouraged and rural land should not be altered to residential land.

COMMUNITY RESPONSE TO NOISE

41 A large number of overseas studies have been carried out over time to investigate community response to environmental noise. The general approach of these studies is to question residents (verbally or in writing) as to their level of annoyance to a particular noise source. The noise level at the respondent's location is then determined by either measuring it or by using calculated noise contours.

42 'Noise levels' are normally measured/calculated as L_{dn} – the Day/Night Level which involves a summation of the noise energy over 24 hours with a 10 dB penalty for noise at night. Analysis of these widely varying results allows a 'dose-response curve'

(regression analysis) to be prepared showing the percentage of people highly annoyed versus the level of noise they are exposed to.

43 In the 1970s, the Schultz[3] curve was developed from a number of studies in general transportation noise (included air, road and rail). The Schultz results were used during the preparation of NZS 6805.

44 Subsequently, Miedema and Oudshoorn carried out comprehensive amalgamation of the various transportation noise studies (including aircraft) in 2001[4] and the dose-response curve from this study has been used internationally and in New Zealand since then.

45 In 2002, Taylor Baines & Associates and Marshall Day Acoustics conducted a noise annoyance survey in Christchurch. The study was conducted to investigate how the Christchurch community responded to environmental noise when compared to the previous overseas studies (Schultz and Miedema).

46 More recently, there have been a number of international studies that have been undertaken in the last 5 years. Marshall Day Acoustics has completed a literature review of 45 of the latest studies. The full report is available separately and a summary of the 14 most significant studies is included below.

47 Each study included analysis of a number of different airports. Of the 14 studies:

47.1 6 reported an increase in noise annoyance over time (FAA, Guski x3, WHO, Janssen and Vos);

47.2 1 reported a decrease (Vietnam);

47.3 4 reported no change (Gjestland x 2, Fidell, Gelderblom); and

47.4 3 did not report on a change (NZTA, Brink, Gjestland 2021).

48 The two largest studies in this set of studies, were the 2017 Guski Study[5] adopted by the WHO in 2018 and the Federal Aviation Administration (*FAA*) study[6] in the US in 2021.

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[3] Schultz, T. (1978). *Synthesis of social surveys on noise annoyance*. The Journal of the Acoustical Society of America 64 (2): 377-405.

[4] Miedema, H, & Oudshoorn, C. (2001). *Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals.* Environmental Health Perspectives, 109(4)

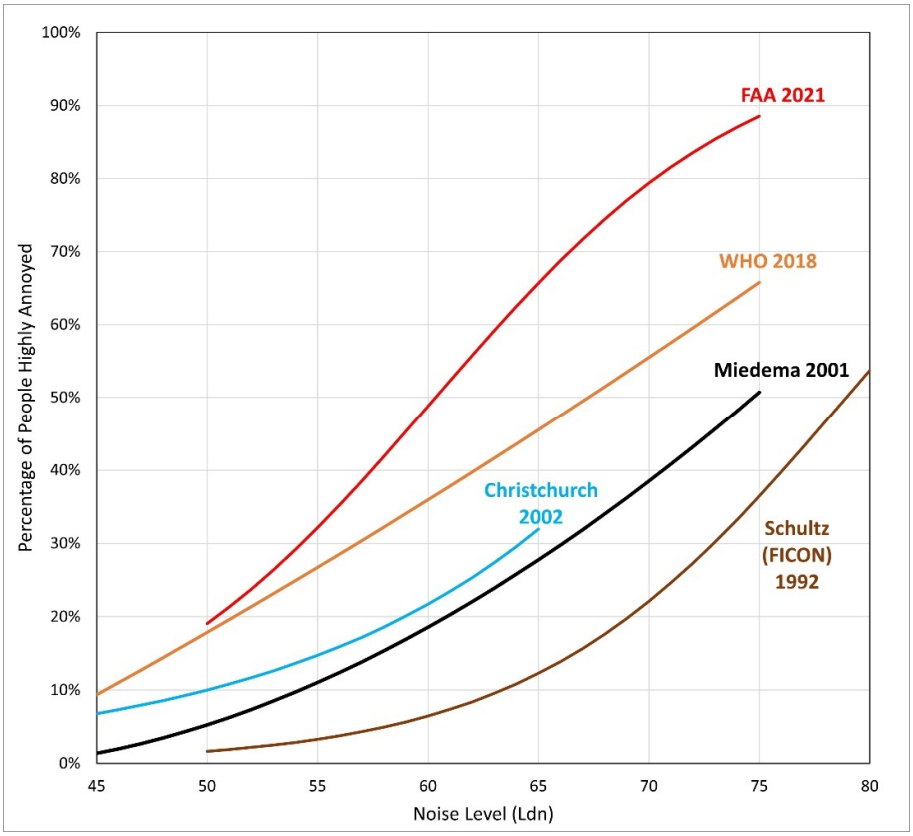
[5] Guski, R., Schreckenberg, D., & Schuemer, R. (2017). *WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Annoyance.* International Journal of Environmental Research and Public Health, 14(12), 1539

[6] U.S Department of Transportation (FAA). (2021). *Analysis of the Neighbourhood Environmental Survey.* National Technical Information Service

49 Both of these studies show a significantly higher level of annoyance than the Miedema 2001 dose-response curve. The dose response curves from these studies are shown below in **Figure 2** along with the Miedema and 2002 Christchurch study for comparison.

50 A 'dose-response curve' is the graphed results of the percentage of people highly annoyed versus the noise level (L_{dn}/L_{den}) they experience.

Figure 2: Community Response to Aircraft Noise



51 The clear conclusion from these recent studies and **Figure 2**, is that community annoyance from aircraft noise is significantly higher today than the results 20 to 40 years ago – which were used to develop the recommendations in NZS 6805 and adopted as the basis for airport controls in previous Christchurch District Plans.

52 Based on these results, in my view it would not seem sensible to relax the planning controls to enable residential intensification in closer proximity to the Airport when the level of annoyance is trending the other way.

WHO Night Noise

53 The WHO have developed a criterion L_{night} to evaluate the effects of noise on sleep disturbance at night. This criterion is discussed in detail in the Assessment of Noise Effects and in the evidence of my colleague **Ms Smith**.

54 In summary, the 2018 WHO Guidelines recommended a level of 40 dB L_{night} to avoid adverse effects on sleep based on a predicted 11% of people being highly sleep disturbed at this level. While this level of protection is not achievable at most overseas airports, it does provide a useful objective for a more 'rural' airport.

55 **Ms Smith's** Figure 5 shows that the 40 dB L_{night} contours, are a similar shape but slightly larger than the 50 dB L_{dn} outer envelope contour. It does not seem sensible, in my view, to deliberately intensify residential development in a noise environment that the WHO Guidelines describe as causing "adverse effects on sleep".

PLANNING CONTROLS AT OTHER AIRPORTS

56 In past debates, it has often been promoted by potential land developers, that 'other airports do not use 50 dB for planning controls so why should Christchurch'. In my opinion this argument has little weight – the fact that other airports have not been able to implement adequate planning controls is no reason to allow large numbers of people to be exposed to the adverse effects of aircraft noise in Christchurch. Other territorial authorities would be delighted to have the low numbers of people adversely affected by aircraft noise that there are in Christchurch. Other airport authorities would be delighted to have the lack of operational restrictions that Christchurch enjoys due to the foresight of Christchurch planners.

57 Each airport has individual historic circumstances that give rise to their particular land use planning controls. As outlined above, in many cases 'the horse had already bolted' at the time airport planning regimes were introduced. For example, when NZS 6805 was implemented at Wellington Airport in the 1990s there were already houses existing right beside the runway and over 600 houses inside the future 65 dB L_{dn} Air Noise Boundary and many thousands inside 55 dB L_{dn}. This is discussed in more detail below.

58 The next sections of my evidence examine the three other 'main' New Zealand airports.

Auckland International Airport

59 The noise contours for Auckland International Airport have been based on the noise levels expected from future growth scenarios in 30 to 40 years' time.

60 Auckland Airport is moderately well laid out geographically for the avoidance of aircraft noise effects, in that half the noise contours (the western end) lie over the Manukau Harbour. However, the other half of the contours lie over significant areas of residential land. The size of these contours is such that a large number of residents are exposed to moderate to high levels of aircraft noise – there are 379 houses in the High Aircraft Noise Area (*HANA*) (inside the future 65 dB L_{dn}).

61 There is an Aircraft Noise Notification Area (*ANNA*) between 55 dB and 60 dB L_{dn} with no planning controls. The land use planning rules at Auckland commence inside 60 dB L_{dn}.

62 Between 60 dB and 65 dB L_{dn} (an area known as the Moderate Aircraft Noise Area (*MANA*)) noise sensitive activities are a discretionary activity and there are density controls. Inside the 65 dB L_{dn} (HANA) noise sensitive activities are a prohibited activity.

63 The reason for these relatively moderate land use controls is that there has been a severe shortage of residential land in Auckland and there are significant areas for new development in these moderate noise areas 55 to 65 dB L_{dn} (the ANNA and MANA).

64 A community liaison group meets on a quarterly basis and provides an opportunity for the community to interact with Auckland International Airport Limited (*AIAL*) and Airways on noise issues. The majority of noise complaints at Auckland come from the relatively low aircraft noise areas – 45 to 55 dB L_{dn}.

65 In 2013, AIAL was involved in a high profile and very expensive exchange with disgruntled residents following the introduction of a new Required Navigation Performance (*RNP*) arrival procedure – a computer controlled shortened approach path designed to reduce fuel burn and air emissions. The residents were exposed to relatively low levels of aircraft noise (45 to 50 dB L_{dn}) but were extremely agitated by the change.

Wellington International Airport

66 Wellington International Airport was built in 1959 in the middle of an existing residential area. Since then, it has been compromised in terms of a curfew on airport operations and there are a significant number of people exposed to aircraft noise (660 houses inside the ANB – approximately 1,800 people).

67 NZS 6805 was implemented for Wellington International Airport in the 1990s but with a considerably 'watered down' version of the Standard's land use planning recommendations. The ANB is based on the 65 dB L_{dn} noise contour from a projected capacity scenario.

68 New noise sensitive activities inside the ANB are not 'prohibited' as recommended by the Standard – they are permitted in residential zones and restricted discretionary in other zones. There is no OCB included in the Wellington District Plan and thus no land use controls in the moderate noise areas. The approach taken by the decision makers in Wellington was that 'the horse had already bolted' so what's a few more houses.

69 Consequently, there have been further increases in the number of people exposed to aircraft noise over the years. Wellington International Airport is an excellent example of how bad land use planning has caused a significant number of people to be exposed to the adverse effects of airport noise and for consequential restrictions on airport operations.

Queenstown Airport

70 The geographical layout at Queenstown Airport is well suited to the avoidance of aircraft noise except for a small pocket of historically residential land at the Frankton end of the runway.

71 The Queenstown noise boundaries are largely consistent with NZS 6805, in that an ANB based on the 65 dB L_{dn} contour, and an OCB based on the 55 dB L_{dn} contour have been adopted based on a future growth scenario. There are approximately 70 houses inside the ANB at Queenstown.

72 New residential activity is prohibited inside both the ANB (65 dB L_{dn}) and OCB (55 dB L_{dn}) for rural and commercial zones around the airport. However, new noise sensitive activities are not prohibited by the Queenstown Lakes District Plan within the residentially zoned land in the ANB, but new and altered noise sensitive activities are required to be acoustically insulated.

73 Due to the close proximity of houses to the runway, night operations are not permitted between 10pm and 6am. Noise is further restricted at Queenstown Airport for practical reasons as the runway and surrounding topography cannot accommodate larger wide-bodied aircraft.

74 The noise contours for Queenstown Airport have been based on 'projected growth' rather than 'ultimate capacity' since initial implementation in 1994. In practice, the actual growth rates have turned out to be much higher than anticipated in the projections and this has resulted in the contours needing to be expanded through district plan changes. Expanded noise contours were notified in PC35 in 2010 and implemented in 2013 after a protracted series of Environment Court hearings.

75 In 2018 the noise contours at Queenstown Airport were again approaching the noise boundaries in the District Plan. An updated

forecast and noise study projected a 5 dB expansion of the contours was required to accommodate the anticipated growth. This was put to the community in a series of public consultation meetings and met with significant resistance from existing residents.

76 Some affected residents were of the view, "enough is enough, we don't want higher levels of airport noise". There was also a political faction that was of the opinion that 'Queenstown should not grow any further' and they saw the airport noise contours as a tool that could be used to restrict growth in the region. There was also a business faction that was in support of the projected growth.

77 The Queenstown Airport Corporation withdrew the plan change and currently have no plans to take the plan change any further and are thus constrained to the 2013 PC35 boundaries.

GENERAL DISTRICT PLAN NOISE LIMITS

78 Because other airports have generally not used 50 dB L_{dn} as the onset of land use planning controls, 50 dB L_{dn} may be seen by some as unusual or 'highly conservative'. By way of comparison, however, the operative Christchurch District Plan sets the residential zone noise limits as 50 dB L_{Aeq} daytime and 40 dB L_{Aeq} night-time. Without going into the technical explanation, these controls are effectively the same as 50 dB L_{dn}. Most other district councils including Waimakariri and Selwyn Districts, set similar noise limits. This gives an indication of what local Councils view as a reasonable 'receiving noise level' for the protection for residential amenity in the wider Christchurch context.

79 On this basis, as it is reasonable that residential uses should be protected to a level of 50 dB L_{dn} from general noise sources, it is therefore equally reasonable that residential uses should not be allowed to establish next to an existing noisy activity (such as an airport) at levels higher than 50 dB L_{dn}.

80 It is understood that in the CRPS and in the Christchurch, Waimakariri and Selwyn District Plans the following activities (broadly) have been classified as 'sensitive activities to aircraft noise' - residential activities, education activities including pre-schools, visitors accommodation and health care facilities.

81 In my opinion, it is reasonable that all these noise sensitive land uses should be protected to a level of 50 dB L_{dn} from general noise sources as they are in the general district plan noise rules. It is therefore equally reasonable that these same uses should not be allowed to establish next to an existing noisy activity at levels higher than 50 dB L_{dn}.

COMPLAINTS

82 It is common at hearings or in planning processes for questions to arise which seek to either draw conclusions based on the number of complaints received – ("But there aren't many complaints at the moment") or to introduce anecdotal evidence from a particular individual experience ("I live in this area and the planes don't bother me").

83 There are several reasons for the lack of complaints about aircraft operational noise from Christchurch Airport. Firstly, the historic land use planning has meant that there are relatively few people exposed to aircraft noise in Christchurch. Secondly, people do not complain if they assume their complaints are likely to have no effect. If the airport is operating in its normal mode and they are annoyed, they know nothing can be done about the noise. The Taylor Baines study shows that of the relatively few people exposed to current levels of aircraft noise at Christchurch, there are a number who are 'highly annoyed' but are not complaining during normal airport operations.

84 However, when an airport changes an operation (flight paths or runway length) then significant complaints can arise. The 2013 trial in Auckland of alternative arrival procedures caused the number of complaints to jump from 2 per month to around 500 per month. These complaints came from a relatively low aircraft noise area.

85 The comments that "I live in this area and the planes don't bother me", overlook the fact that the noise contours (and thus land use planning) are based on future noise levels – not current noise levels. The number of annual aircraft movements in the updated Air Noise Contours (235,000 mpa), are over double the 'pre-covid' movements (76,000 mpa).

SOUND INSULATION

86 Some advocates for residential development in areas affected by aircraft noise have suggested that sound insulation fitted to proposed dwellings is sufficient on its own to avoid the adverse effects of noise and to protect the interests of the Airport. The argument is understood to be, that sound insulation provides sufficient mitigation, regardless of the population density of the land involved. In my opinion, this assertion, that sound insulation is all that is required to prevent reverse sensitivity effects, is incorrect for several reasons.

87 Firstly, the level of sound insulation required in the 50 to 60 dB L_{dn} area is provided by a standard house. No additional construction techniques or materials are required in this area. However, 18% to 37% (WHO graph) of the population is still typically highly annoyed by aircraft noise in this environment, even though they have the opportunity to close their windows and achieve 'WHO satisfactory

noise levels' inside. This is why sound insulation, on its own, is insufficient and land use controls in the form of density restrictions are the only real form of mitigation available in this case.

88 Secondly, houses exposed to aircraft noise, need to operate with their windows closed to reduce internal noise levels – this becomes particularly desirable at night. Three scenarios are then likely:

- the windows are kept closed resulting in an unsatisfactory level of fresh air; or
- a ventilation system or air-conditioning system is installed to improve air quality at significant cost; or
- the windows are left open resulting in an unsatisfactory noise environment.

89 Each of these scenarios is likely to result in annoyance and possible complaints from the residents. It is interesting to note that residents involved in the Auckland Airport mediation forum were shocked to learn that they would have to shut their windows to achieve an acceptable internal noise environment and they did not like the concept of mechanical ventilation.

90 In this respect, sound insulation also does not solve the problem for hospitals and education facilities as they are heavily reliant on open windows.

91 The third difficulty with sound insulation is that it does not deal with the outdoor noise environment. New Zealanders in general, enjoy an 'outdoor' type of lifestyle that includes barbecues and gardening. This is particularly the case in rural and urban fringe areas where people have more outdoor space and an expectation of enjoying it. Again, an unsatisfactory external noise environment is a potential source of residential complaint with demands to reduce noise, affecting airport operations. There has been a history in New Zealand of people moving into lifestyle blocks and complaining about noise from already existing activities within the rural zone e.g. bird scarers in vineyards. Minimising the number of people affected by airport noise by restricting residential development is the most effective form of mitigation available in this case.

92 The Standard refers to sound insulation as a fallback mitigation measure. In my opinion the Standard prefers to 'avoid' the effects of airport noise, ahead of mitigation. Table 2 in the Standard states that new residential inside the OCB "should be prohibited unless a district plan permits such uses, subject to a requirement to incorporate appropriate acoustic insulation."

93 In my opinion, the issues set out above, highlight why partial mitigation through sound insulation is a much less desirable option

to avoiding the effects of airport noise through appropriate land use controls.

REVERSE SENSITIVITY EFFECTS

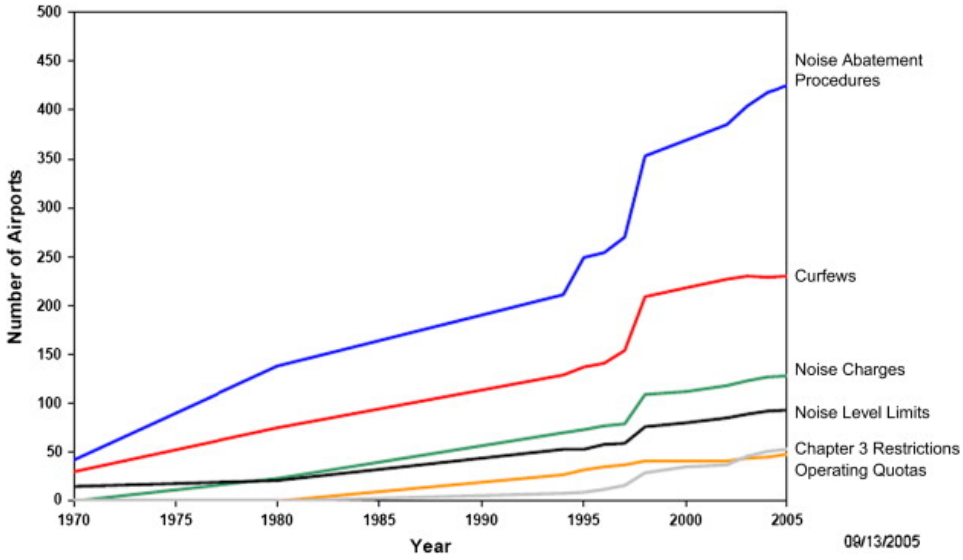
94 At previous hearings some submitters have suggested that reverse sensitivity effects due to aircraft noise are not a real effect and do not need to be considered at New Zealand airports. I disagree with this opinion – as have the decision makers at previous airport noise hearings.

95 As I have outlined above, it is true that Christchurch Airport has not experienced significant levels of complaint in the past but that is primarily due to the foresighted planning that has resulted in relatively few people inside the noise contours. Having said that, there have been a few instances where difficulties have occurred at Christchurch due to community action resulting from noise.

96 For example, maintenance on the main runway is required every year or so. To allow this to happen, the main runway is closed at night and all aircraft use the cross-wind runway at night. This has caused a number of complaints with pressure to modify the activity. In another example, works and activity associated with an extension to the cross-wind runway for safety reasons in 2015 were subject to community action trying to stop the works. Ms Hayman discusses the level of complaints at Christchurch in her evidence.

97 Overseas however, there is a very different picture to Christchurch's low level of complaint activity. Overseas, there has not been a lot of success in keeping people away from airport noise affected areas and there are many millions of people living within the airport noise contours. The result of this incompatibility is that a large number of airports world-wide have had operational restrictions due to noise effects forced upon them. **Figure 3** below shows the significant growth in airport noise restrictions over time.

Figure 3: Growth in Airport Noise Restrictions (Boeing)



98 This increase in restrictions has occurred during a period when noise levels from aircraft have reduced significantly. I will discuss this further in my evidence to come.

99 I would now like to give a very small selection of airports that have had their operations significantly affected by community pressure due to aircraft noise effects.

Wellington International Airport

100 When Wellington Airport was originally built, there were a large number of houses very close on both sides of the runway. This resulted in a curfew being put in place at Wellington that prevents landings and take-offs between 11pm and 6am (there are subtle variations within this concept).

101 In the 1980s community action groups were influential in Air New Zealand changing their fleet to quieter aircraft – first to the B737 Hushkit and later the B737-300.

102 My colleague **Ms Smith** has been involved with hearings to expand the Wellington terminal building and noise due to taxiing and auxiliary power unit equipment has been of significant concern to residents close to the eastern side of the airport. This incompatibility has caused restrictions to be implemented for the expanded activities.

Amsterdam Schiphol Airport

103 Schiphol Airport is Europe's third busiest airport on passenger numbers and has had significant noise issues for a long period of

time. There are large numbers of people living inside the noise contours. This incompatibility has caused serious constraints on the airport due to noise. 4 out of the 6 runways at Schiphol have curfews applying and overall noise limits have been in place for a long time.

104 In 2023 a significant study was commissioned by the *Ministerie van Infrastructuur en Waterstaat*[7]. The study included significant consultation with the Schiphol Environmental Council (a combination of various resident action groups), the government and the aviation sector. The Notification Document[8] provides a comprehensive description of the consultation process and details a set of noise objectives and subsequent actions to be implemented.

105 The Noise Objectives are expressed in terms of percentage reductions in the number of people inside the noise contours relative to a 2024 projected baseline operation (Table 1 below). The 'Chosen Measures' are a combination of noise abatement measures that were able to be agreed upon as follows. Each of the measures is providing constraints on either the airlines or the airport operations with large cost implications.

1. The use of quieter aircraft at nighttime.
2. A reduction in the use of secondary runways.
3. A cap of 28,700 annual movements at night (down from 32,000).
4. A cap of 452,500 annual movements (down from 500,000+).

106 The results of these chosen measures along with the objectives is shown in Table 1 below.

Table 1 Schiphol Airport – Noise Reduction Objectives and Chosen Measures

Indicator	Objective (by 2024)	Chosen Measures
The number of houses within the 58 dB(A) L_{den} contour	Reduce by 20%	16% Reduction
The number of highly annoyed people within the 48 dB(A) L_{den} contour	Reduce by 20%	15% Reduction

[7] Ministry of Infrastructure and Water Management

[8] European Commission Notification - Balanced Approach procedure for Schiphol (September 2023)

107 It is interesting to note that the assessment uses the L_{den} 48 dB contour (and 58 dB). L_{den} is a very similar measure to L_{dn} with the only difference being an evening penalty of 5 dB to the L_{Aeq} (1900 to 2300 hrs - see Appendix A). In practice, the L_{den} value is very close to the L_{dn} value - within 1 dB or so. Thus 48 dB L_{den} is very close to the L_{dn} 50 dB that has been used at Christchurch since 1998.

108 It is important to note that the costly operational constraints (chosen measures) are being put in place to reduce the number of houses inside the noise contours. In Christchurch there is the opportunity to avoid the Schiphol predicament by maintaining the low number of houses/people affected by aircraft noise, through sensible land use planning and continuing to avoid houses being built inside the noise contours.

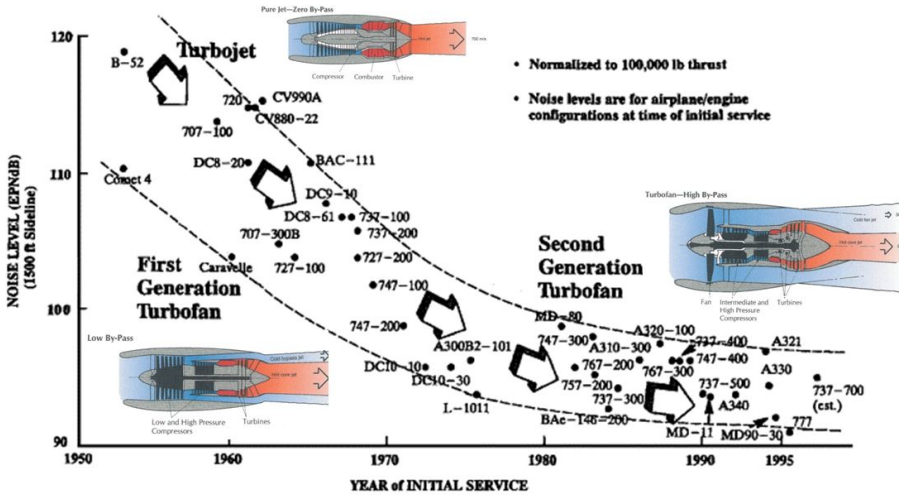
109 These examples highlight but a few of the reverse sensitivity effects that continue to impact airports where residential activity has been allowed to establish inside the noise contours. However, in my opinion, it is not just the reverse sensitivity effects on airports that need to be considered - there are undeniable adverse effects on residents from aircraft noise that should be avoided by responsible land use planning as part of a social responsibility to protect the residents.

REDUCTION IN AIRCRAFT NOISE EMISSIONS

110 At previous hearings, some parties have suggested that as aircraft are getting quieter, airport noise contours should be much smaller than predicted based on growth of current aircraft types.

111 It is worth noting that the airline industry as a whole, has spent billions of dollars mitigating noise from aircraft through the development of 'quiet technology' engines over the last 60 years. **Figure 4** below, shows the reduction in noise level for the different aircraft types over time.

Figure 4 – Progress in Aircraft Noise Reduction (Source: Boeing)



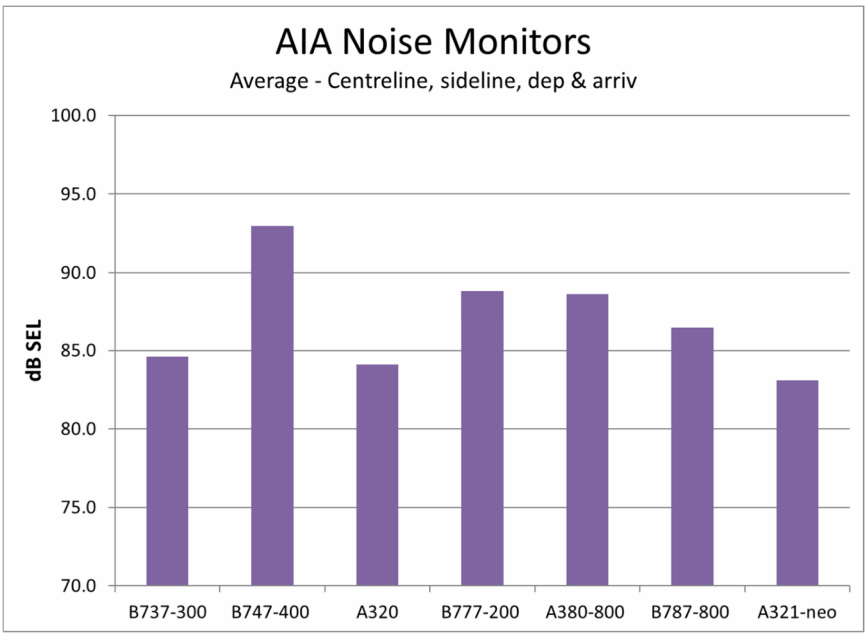
112 The obvious trend from this graph is that noise reductions are 'bottoming out' – no further large reductions in noise are looking likely.

113 There are rumours about Electric Aircraft (*EA*) solving the noise problems at airports. In my opinion this is unlikely for several reasons. Firstly, EA are only viable for short haul regional flights which make up a small percentage of the overall airport noise output.

114 Secondly, very little data is available on how quiet these aircraft are or will be. The proposed electric aircraft are propellor driven. In general, aircraft noise on approach is driven by 'airframe noise' – noise generated by airflow over aircraft elements such as landing gear, propellors and control flaps – very little noise is generated by the engine on low load. Thus, landing noise for EA is unlikely to be much quieter but take-off noise may be a bit quieter for regional aircraft. This would be of benefit to regional airports but have little significance at Christchurch.

115 Analysis of the ongoing noise monitoring at Auckland International Airport shows that the modern aircraft are not as quiet as had been anticipated. **Figure 5** below shows the average Sound Exposure Level (*SEL*) from the analysis of a large number of aircraft movements at 3 permanent monitoring locations at Auckland International Airport.

Figure 5 – Noise monitoring at Auckland International Airport



Note: Sound Exposure Level (SEL) is a measure of the 'noise energy' from individual aircraft flyovers

116 **Figure 5** shows the modern B787 Dreamliner is slightly noisier than the older (and smaller) B737 and A320 by approximately 2dB – contrary to the historic trend. The new A321-neo is 1 dB quieter than the earlier A320. To put this in perspective, a 1 to 2 dB change is not perceptible, 3 dB is just perceptible and a 5 dB change is noticeable.

117 These newer aircraft do carry more passengers for similar noise output but the Auckland measurements confirm the noise levels from modern aircraft are not very different to 1990s aircraft ie. the 'curve' shown in Figure 4 above has flattened out over the last 30 years.

118 It is interesting to note that despite the very significant aircraft noise reduction achieved over 60 years, that during this time there has been the significant increase in the noise restrictions placed on airports and flight procedures as shown in **Figure 3** above. In addition, there has been a significant increase in the number of people annoyed by aircraft noise as shown in **Figure 2** (WHO & FAA).

119 Over time, the increase in airport noise due to growth in airport operations has generally outstripped or matched the noise reduction achieved by the aircraft manufacturing industry.

Christopher Day
20 September 2023

APPENDIX A GLOSSARY OF TERMINOLOGY

Term and Abbreviation	Meaning
Air Noise Boundary (*ANB*)	Noise control boundary used to control aircraft noise and land use with a limit of 65 dB L_{dn}.
Outer Control Boundary (*OCB*)	Noise control boundary used to control aircraft noise and land use with a limit of 55 dB L_{dn}.
Decibel (*dB*)	The unit of sound level. Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 □Pa i.e. dB = 20 x log(P/Pr)
A-weighting	The process by which noise levels are corrected to account for the non-linear frequency response of the human ear.
$L_{Aeq(t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
L_{Amax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
L_{dn}	L_{dn} is a measure of the cumulative noise exposure over time. It is defined as the A-weighted day night noise level which is calculated from the 24 hour L_{Aeq} with a 10 dB penalty applied to the night-time (2200-0700 hours) L_{Aeq}.
L_{den}	L_{den} is also a measure of the cumulative noise exposure over time. It is defined as the A-weighted day-evening-night noise level which is calculated from the 24 hour L_{Aeq} with a 10 dB penalty applied to the night-time noise (2300-0700 hours) and 5 dB during the evening (1900-2300 hours).

Term and Abbreviation	Meaning
Sound Exposure Level (*SEL* or L_{AE})	The sound level of one second duration which has the same amount of sound energy as the actual noise event measured. Usually used to measure the sound energy of a particular event, such as a train pass-by or an aircraft flyover.
NZS 6805:1992	New Zealand Standard NZS 6805:1992 "*Airport Noise Management and Land Use Planning*"
Auxiliary Power Unit (*APU*)	Component of an aircraft used to generate power for essential systems when main engines are not operating.
Ground Power Unit (*GPU*)	Land based power supply for aircraft essential systems while parked and not running the APU.
Noise dose-response curve	A dose–response relationship is the magnitude of the response (in this case annoyance) of a person to a certain dose of a stimulus or stressor (in this case noise). Dose–response relationships can be described by dose–response curves. Dose-response curves are created by graphing the magnitude of the response (level of annoyance) for each individual against the dose (noise level) and performing a statistical analysis (regression analysis or curve fit) on this data to create a single dose-response curve for the population.

APPENDIX 2 WAIMAIRI DISTRICT PLAN 1988

SPECIAL PROVISIONS

PART ONE: CHRISTCHURCH INTERNATIONAL AIRPORT NOISE EXPOSURE LINE

INTRODUCTION

The Christchurch International Airport, although in Paparua County is located close to the Waimairi boundary. The airport, as well as being a considerable traffic generator and a local employment source, places restraints on activities in the District because of height and safety requirements and the noise associated with aircraft operations. The height and safety requirements are catered for in the Scheme by designation .

In 1975 the Council introduced Change No. 10 to the previous Scheme. That Change rezoned to Rural A, land within a calculated noise control line, and endeavoured to control possible conflict between Airport related activities and residents in the vicinity by making dwelling-houses including the rebuilding of existing dwellinghouses, a conditional use with requirements for noise insulation. Following a reappraisal of the controls proposed by Change No. 10 in 1980, revised provisions were introduced as part of a major review of rural zoning. (Change No.27)

The noise exposure line provisions in this Scheme are similar to those included in Change No. 27 except that the line has been adjusted in some places and also now includes some properties within the urban area previously excluded (Change No. 27 dealt only with the Rural area.) It is also noted that with extensions being carried out to the main runway there may be changes in aircraft noise patterns. Any necessary further revision of the noise exposure line will be introduced by variation or change to the scheme.

The controls associated with the noise exposure line are provided both to protect residents living in the vicinity of the airport from airport related noise and also to protect the airport from complaints about noise from residents which if sustained could lead to constraints upon airport operations (eg. night time curfews). The importance and economic benefit of Christchurch International Airport, not only to Waimairi District but to the Canterbury Region and beyond, is recognised by the Scheme.

SPECIAL PROVISIONS

Refer to definitions of RESIDENTIAL BUILDING, HABITABLE ROOM - SECTION THREE - DEFINITIONS.

The Airport noise exposure requirements of this Scheme are based on revised noise control lines which relate to actual flight paths and a larger number of recorded noise levels rather than the largely theoretical model on which the previous Rural A boundary had been based. The basic measure now used is the Day-Night Level (LDN). The contour line at which it is considered sound attenuation requirements should be imposed for residential buildings is the 50 LDN line, the location of which was determined by the Department of Scientific and Industrial Research and reported to the Christchurch Airport Authority in "Christchurch International Airport Noise" - July 10, 1978. The "The Christchurch International Airport Noise Exposure Line " is shown on the planning maps and generally follows the D.S.I.R. line with some adjustment for property boundaries and also takes into account the north west (29 - 11) runway, which was not subject to D.S.I.R. measurement. Although this runway is used less frequently than the main runway (20 - 02) (i.e. 5 - 8% of occasions per year) there is nevertheless a significant noise problem of ground testing of engines. This suggests the need for insulation of residential buildings in the vicinity.

It is not intended that the controls within the noise exposure line should be applied in an arbitrary manner. There will be circumstances varying for each site which will greatly affect the extent of external noise levels due to such things as local characteristics, angle of incidence of aircraft and tree planting. The noise exposure line will therefore be used as a basis for determining those sites in the District where it is expected that noise insulation will be required. By taking noise level readings at each proposed site, their amount of attenuation required can be determined and techniques for achieving it (eg. orientation of the building, internal layout, materials to be used, form and standard of construction), recommended. It is intended through these means that the indoor design sound level (i.e. the maximum noise level from an aircraft flyover, heard inside the building) should not exceed 55 dBA for habitable rooms other than kitchens and 65 dBA for other rooms in respect of normal aircraft movements to and from the Christchurch Airport. These levels, which are those recommended by the Standards Association of Australia (AS 2021 - 1977) are considered to be the maximum noise levels which will be judged by the average listener as not excessively intrusive or annoying. Because of the variability of the subjective responses to aircraft noise, however, these figures may not provide sufficiently low interior noise levels for occupants who have a particular sensitivity to aircraft noise.

1. SPECIAL PROVISIONS: AIRPORT NOISE EXPOSURE AREA

1.1 PRE-CONDITION

This ordinance shall apply to every site located between the Christchurch International Airport Noise Exposure Line, as notated on the planning map and the boundary of the District with that of the Paparua and Eyre Counties to the west.

1.2 REQUIREMENTS FOR RESIDENTIAL BUILDINGS

1.2.1 In addition to any requirements of the zone in which the site is located, building design, construction and insulation of residential buildings shall be such that the maximum indoor design sound level due to aircraft noise for habitable rooms other than kitchens shall not exceed 55 dBA and for other rooms 65 dBA. The New Zealand Standard N.Z.S.6801:1977 ("Methods of Measuring Noise") and N.Z.S. 6802 ("Assessment of Noise in the Environment") shall be followed in regard to noise measurement, correction, interpretation and assessment.

1.2.2 Prior to any consent being given to erect the residential building, noise level measurements shall be monitored at the site by the Council to determine the attenuation required. The applicant shall submit calculations and design details prepared by a Registered Engineer with expertise in acoustics as to how the required attenuation is to be achieved, including such of the following matters as are considered necessary by the Registered Engineer in the circumstances.

(a) Orientation of the building.

(b) Internal room layout of the building and location of windows and external doors.

(c) Materials to be used in construction, including their accoustic ratings.

(d) Form of construction.

(e) Maximum window area to exterior wall area ratios.

(f) Installation of fixed-closed windows and/or double glazing.

1.2.3 Where the circumstances indicate that close supervision of the erection of the building is required in order to achieve the necessary insulation, a registered Clerk of Works or similar approved person shall supervise the erection and issue of a Certificate of Compliance that the conditions of the Council relating to noise attenuation have been satisfied.

APPENDIX 3 1975 NOISE EXPOSURE LINE RELATIVE TO THE 50 DB LDN OUTER CONTROL BOUNDARY (1995)