Chapter D3
Health Impact

Summary of key findings:

As with any major transport infrastructure project in a big-city urban environment, some negative health effects, as well as beneficial ones, are expected to occur as a result of Melbourne Airport's Third Runway (M3R). Health effects have been assessed for the following:

Noise

- Impacts due to daytime aircraft noise are expected – particularly annoyance and interference with communication, such as making speech hard to understand. The potential health effects of high levels of annoyance due to daytime aircraft noise are projected to be of a moderate level of severity. Most of this effect will occur in the lower ANEC contour bands due to the higher numbers of people living within them
- Impacts specific to night-time noise are also expected, especially sleep disruption. Although airport operating options and mitigations are available to reduce the overall impacts of sleep disturbance and noise-induced awakenings (compared to not building M3R), overall night noise impacts have been assessed as minor to moderate
- The M3R Build scenario provides a significant benefit over the No Build scenario in permitting alternative runway operation modes. These options will allow significant noise mitigation and noise sharing opportunities that will minimise night-time noise over the Greater Melbourne urban area
- The severity of the potential health effect of myocardial infarction (also known as a heart attack) arising from aircraft noise is projected to be negligible.

Air Quality

- Health risks associated with air quality impacts attributable to aircraft are assessed as minor or negligible for all the air quality indicators that were studied.

Childhood learning

- The severity of the potential health effect on schools, early childcare centres and kindergartens, aged care facilities and libraries from additional N70 overflights due to communication interference is projected to be moderate.
- When comparing the 2046 Build scenario to the No Build scenario, the projected effect on reading comprehension is projected to be negligible.

Employment

- Employment is a key determinant of health. Beneficial effects on health are projected to result from the jobs that will created by M3R
- Additional employment arising from M3R construction is forecast to be 10,700 direct and indirect jobs, 500+ of which are expected to be created in the Melbourne Airport local area each year.
- By comparing the Build and No Build scenarios for 2046, the number of additional jobs arising from operations is ~37,000 direct and indirect jobs. Nine out of 10 jobs are expected to be filled by people who live in Melbourne.

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D3.1 INTRODUCTION

This chapter presents the findings of an assessment of the potential health effects of the Melbourne Airport's Third Runway (M3R) project.

The study independently assessed both the beneficial health impacts and the adverse health impacts of M3R on the airport's local communities. For the potential health effects of adverse significance that were identified, the chapter discusses appropriate measures to prevent, reduce and/or mitigate.

This chapter draws on impacts and benefits described in the MDP chapters **B3: Soils, Groundwater and Waste, B10: Air Quality, C4: Aircraft Noise and Vibration, D2: Economic Impact Assessment** and **D4: Social Impact**. It also refers to other relevant chapters but does not include all their content.

In this assessment:

- Direct effects are those that might arise from people's exposure to noise and air-pollutant emissions from ground-based airport activities, aircraft and associated road traffic
- Indirect effects are related to the employment opportunities offered by the project's construction and operation, and the subsequent employment generated off-airport.

The potential health pathways in this assessment examine the effects arising from changes in air quality, noise and employment.

This assessment was done by Robert Quigley of Quigley and Watts Ltd via AECOM Pty Ltd. The scope, focus and outputs were subject to independent expert peer review by Dr Andrew Buroni and Tara Barratt (RPS Ltd). Spreadsheets showing mortality and hospitalisation rates, and the development of the burden of disease, were produced by independent consultant Dr Matt Soeberg.

D3.2 METHODOLOGY AND ASSUMPTIONS

This assessment followed the approach of the Health Impact Assessment Guidelines (enHealth, 2001) for producing health impact assessments (HIAs) within Australia. The stages of the research and analysis process were:

- Defining and understanding its scope
- Understanding the background and context
- Engaging with key community and health stakeholders
- Assessing potential health impacts
- Considering ways to avoid and mitigate, or enhance, the health impacts.

The above stages were informed by data collected from:

- Site visits to Melbourne Airport and surrounding study areas (see **Section D3.2.2**)
- A review of M3R design and operational phase information
- Literature review of other airport HIAs and studies regarding the potential health effects of airport/aircraft operations on communities
- Mapped information showing the location of various facilities and infrastructure in the study area
- Consultation with health and community stakeholders to inform the scope and focus of this chapter including:
  - Meeting with the Melbourne Airport Community Aviation Consultation Group
  - Interview with the independent Chair of the Community Aviation Consultation Group
  - Interview with Melbourne Airport's Community Engagement Coordinator
  - Interview with Jobs Victoria
- Meetings and discussions with relevant specialists producing the supporting M3R MDP impact assessments.

D3.2.1 M3R scenarios assessed and exposure pathways

The M3R scenarios assessed are consistent with those described in **Chapter A8: Assessment and Approvals Process**. Initial work by the assessors of air quality, noise and economic impacts confirmed that the two scenarios giving most insight into M3R's potential health impacts are:

- M3R construction effects
- The 2046 Build versus No Build scenario for 20 years after opening.

Together, these provide the basis for understanding the worst-case potential health impacts of M3R.

Although scenarios for 2026 and 2031 were assessed, their data is not presented in this chapter because their results were substantially lower than for 2046 and so added little understanding of M3R's potential effects.

As described in **Section D3.2.3** and **Section D3.2.4** (on the air quality and noise assessment methods), health effects have been assessed using a conservative approach. This means that this assessment most likely overestimates the possible effects.

For completeness, and to undertake a sensitivity analysis, where upper and lower confidence intervals exist (e.g. for air quality concentration response functions) potential health effects were calculated using these upper and lower 'bounds'. However, because these calculations do not alter the chapter's conclusions, their findings are not presented here. In statistics, confidence levels refer to the probability that a given parameter will fall between a range of estimates known as an 'upper bound' and a 'lower bound'.

The assessment determines if there are any pathways of exposure between the source of any 'hazards', in this case M3R, and the 'receptors' (the community). This is important, as a hazard by itself does not constitute a risk. It is only when there is a hazard, a receptor and a pathway of exposure that there is any potential for a risk to health.

For example, while air pollution concentrations may be very high near an emitting industrial facility, a health risk will occur only if people ('the receptors') spend time close to ('the pathway') the facility ('the source').

Finally, the concentration and mode of exposure to a specific hazard attributable to M3R, where the evidence base supports such potential effects, is calculated to establish any potential health effects.

D3.2.2 Study areas and populations assessed

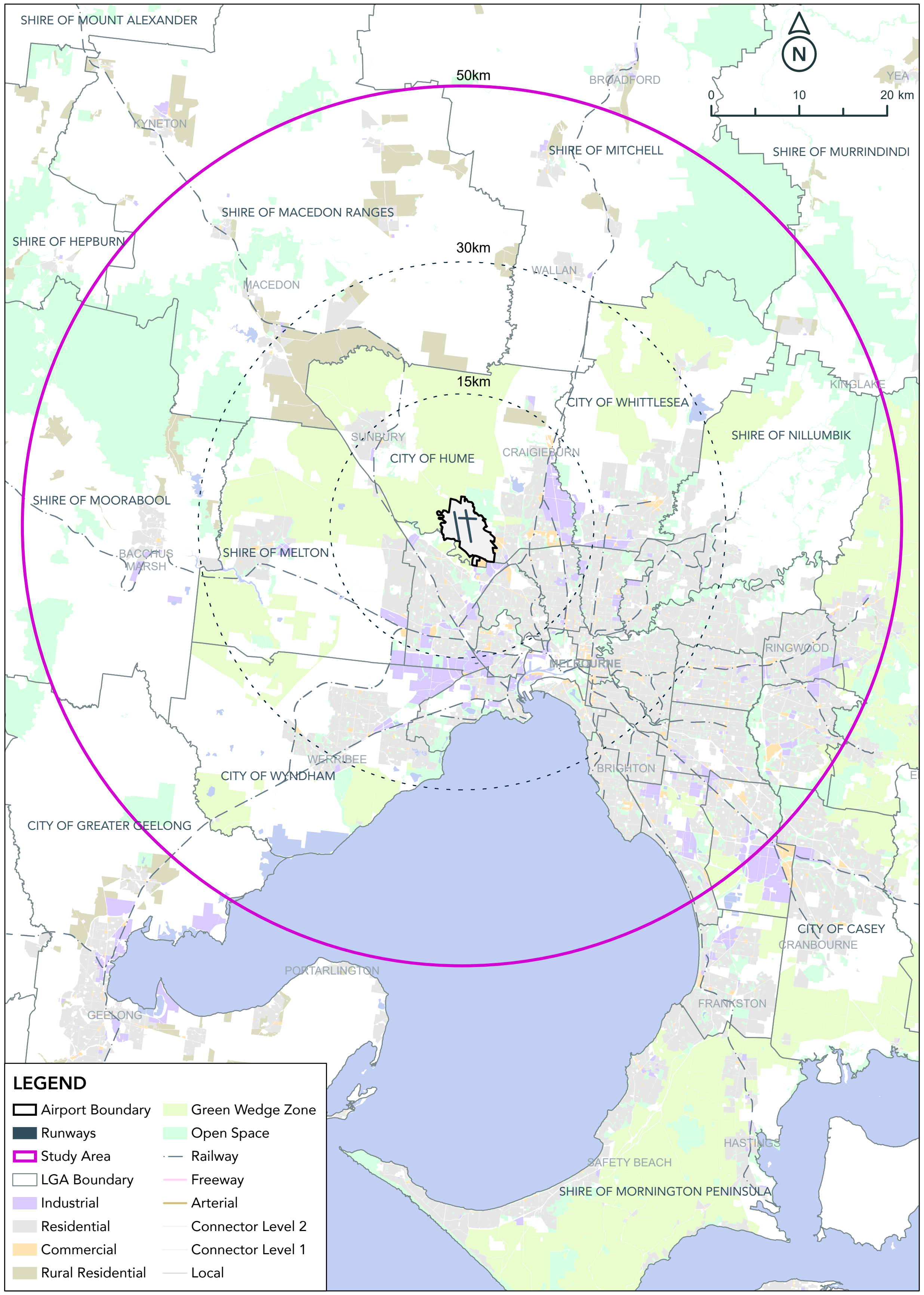
The potential health impacts on the population of two study areas were assessed, for noise and air quality.

Study area one is within a 15 kilometre radius of Melbourne Airport and study area two is located between 15 and 50 kilometres from the airport (see **Figure D3.1**). A third study area, the state of Victoria, was assessed for employment effects.

Exposure has been assessed along this 'environmental pathway' (WHO, 2005):

Source → Emissions → Concentrations → Exposure → Dose → Health effects

Figure D3.1
Health assessment study areas one and two



D3.2.2.1
Study area one

Study area one is the zone within a 15 kilometre radius measured from Melbourne Airport's Aerodrome Reference Point (ARP, i.e. the designated geographical location of an aerodrome) and those areas where 70 decibel noise contours (N70) extend beyond the 15 kilometre radius. It encompasses the existing airport air quality monitoring sites.

Study area one is used as the existing health baseline because data able to detect statistically significant differences in outcomes is available only at the macro Local Government Area (LGA) level. However, because LGAs do not align perfectly with study area one's boundary, a practical 'best fit' approach using health data sets from the six LGAs with most of their area located within study area one was used. These LGAs are:

- Hume
- Melton (most of the Melton township is not within study area one but it is included because a large area of the Melton LGA is)
- Brimbank
- Maribyrnong
- Moonee Valley
- Moreland.

D3.2.2.2
Study area two

Study area two comprises the zone that lies between 15 and 50 kilometres from Melbourne Airport's ARP and is located outside the majority of the N70 contour. This is consistent with the study area defined in **Chapter C4: Aircraft Noise and Vibration**.

D3.2.2.3
Study area three

Study area three is the entire state of Victoria and used only for employment effects.

D3.2.2.4
Sensitive populations and specific populations to assess

For the health pathways scoped into the assessment (noise, air quality, employment) – and where data allowed – impacts upon people who may be sensitive to exposure, and directly affected populations, were assessed. They include:

- School children (particularly the noise impact on reading comprehension)
- Communities with existing high health burdens
- Households directly affected (based on counts of the number of households within noise contours and estimated population)
- Suburbs directly affected (including households and public buildings) for noise
- Suburbs surrounding Melbourne Airport for air quality.

D3.2.3
Air quality assessment method

Airport HIAs typically study air quality health effects (see BAC, 2007; Environmental Resources Management, 2008; RPS, 2013; RPS, 2015; Mott MacDonald, 2014; KR/AF and Arup, 2013; Sunshine Coast Council, 2014; Pacific Environment Ltd, 2015).

The air quality data used to inform this HIA were sourced from **Chapter B10: Air Quality** which includes M3R's operational effects on air quality.

Consideration was given to jet aircraft engines (on the ground and airborne), road vehicles (on the airport and the surrounding road network), Ground Support Equipment (GSE) and aircraft Auxiliary Power Units (APU).

For the purpose of this assessment, air quality data was modelled to show the concentration of air pollutants at the nearest isolated residence/s to M3R. Residents further away are expected to have lesser effects due to the dispersion of any air pollution.

Because all residents in the assessment's calculations were assumed to be exposed to inhalation of the highest concentrations of air pollutants, this exposure pathway is a worst-case assessment and likely overestimates effects. This means that, with more accurate exposure data, any adverse findings would likely be assessed as having a lower significance. This approach is one typically used in international HIAs and for previous Australian airport HIAs.

Impacts on surrounding suburbs were assessed at 'statistical area level 2'. This is the smallest area for the release of Australian Bureau of Statistics (ABS) non-census estimated resident population data. Assessment of these impacts is therefore conservative due to this larger catchment size.

The assessment of health effects is also considered conservative because it does not consider the effects of air quality mitigation discussed in **Chapter B10: Air Quality** (e.g. air quality emission reductions associated with aircraft fleet changes have occurred in the past and are likely to do so in the future).

The air quality assessment results are compared with the legislative standards that are protective of the environment and health (**Section D3.3**). Following this comparison, an appropriate range of quantitative calculations was completed – in addition to the regulatory assessment process – to establish any potential change in hospitalisations or mortality arising from changes in air quality attributable to M3R.

Concentration-Response Functions (CRF) facilitate the quantitative calculation of the potential health effect from air quality and population data. The CRFs selected here draw on the strongest epidemiological data for long-term health effects from the US and Europe.

For short-term health effects, an Australian/New Zealand meta-analysis (EPHC, 2005) is used to provide CRFs. These daily 24-hour CRFs are suggested for use in Australia by a leading group of air quality specialists working on behalf of the Victorian Government's Environment Protection Authority (Jalaludin and Cowie, 2012). They also allow consideration of a range of daily health effects that is substantially wider than previous Australian airport HIAs.

Although National Environment Protection Measure (NEPM) standards apply to one-hour maximum and annual average nitrogen dioxide (NO_2) concentrations for 'burden of disease' (i.e. mortality and hospitalisations) calculations, the relationships are more reliable for 24-hour and annual average concentrations.

To calculate the annual burden of disease for particulate matter less than 10 micrometers (PM_{10}) less than 2.5 micrometers ($PM_{2.5}$) and NO_2, different data are required. An example burden-of-disease calculation is:

Change in rate of events (i.e. mortality or morbidity rate)	=	Change in concentration of pollutant	X	Increase in relative risk (i.e. concentration response function)	X	**Baseline incidence rate**	X	**Number of people exposed**

For the pollutants benzene and formaldehyde, international agencies recommend to different assessments. These have been completed for M3R.

The first is a comparison against the Victorian State Environmental Protection Policy (SEPP) Air Quality Management (AQM) standard for air toxics.

The second is a calculation of lifetime risk of cancer via inhalation of air toxics. It uses unit-risk factors published by international agencies to estimate the increase in risk caused by exposure to one microgram per cubic metre of an air toxic (Office of Environmental Health Hazard Assessment, 2017):

- For benzene, the unit risk factor is 2.9 by 10^{-5} (0.000029) per microgram
- For formaldehyde, the unit risk factor is 6.0 by 10^{-6} (0.000006) per microgram.

For this HIA, the unit risk factor is multiplied by the modelled annual average concentration (from the Build versus No Build scenarios) to determine the increase in lifetime cancer risk attributable to M3R for each population assessed (see **Section D3.6.1.6** for information on possible cancer risks').

D3.2.4 Noise assessment method

The MDP has identified three potential operating strategies for M3R: mixed mode, segregated mode Option 1 and segregated mode Option 2 (see **Chapter C2: Airspace Architecture and Capacity** for details).

Where these operating strategies converge, a 'composite' prediction encapsulating the worst-case of the three has been used (e.g. noise impacts during the day and evening in 2046 with M3R). However, where the operating strategies are predicted to result in divergent outcomes, each operating strategy has been assessed separately (e.g. at night, when segregated modes are predicted to be in operation more frequently).

Noise data and household counts to inform the assessment of health effects have been sourced from **Chapter C4: Aircraft Noise and Vibration**. Some noise assessment levels (e.g. L_{Aeq} and $L_{Aeq\ night}$) and consequent household counts were specifically modelled for this chapter. An appropriate range of quantitative calculations (sourced from the literature review for this chapter and other Australian airport HIAs) was done. The findings expand upon the regulatory assessment process to establish any potential change in health outcomes.

ABS shows an average of 2.7 people per household in the Greater Melbourne area. Where an assessment requires analysis of the number of people affected, this multiplier has been used to convert the estimated numbers of dwellings to estimated numbers of people.

Chapters C4: Aircraft Noise and Vibration and **D4: Social Impact** use noise metrics such as ANEC (24-hour average exposures) and N60 and N70 contours to explain the change in indoor and/or outdoor noise exposure – and the noise-exposure pathway – that may be experienced by people due to M3R.

However, different metrics are sometimes presented in this chapter than those presented in the noise and social chapters. This is because different outcomes are being assessed and these values are important (e.g. health effects may accrue more predominantly from long-term exposure than seasonal or rare events). For example, the noise chapter includes L_{Amax}, N60 and N70; and the social chapter also includes L_{Aeq} and $L_{Aeq,night}$. However, the same underlying datasets, definitions, assumptions (e.g. take-off and landing scenarios) and reference years that were studied apply across all chapters.

D3.2.4.1 Annoyance assessment

Although most community annoyance studies are cross-sectional (i.e. looking at a given population's data at a single point in time) with a consequent limited ability to establish causation (enHealth, 2004), the percentage of people 'highly annoyed' remains a widely accepted health outcome of aircraft noise (enHealth, 2004; World Health Organisation (WHO), 2011, 2018).

Noise annoyance is assessed at the population level by a questionnaire using categories such as 'highly annoyed', 'annoyed', etc. The indicator typically used as a cut-off for investigating potential health effects is 'highly annoyed' (WHO, 2011).

People annoyed by noise experience a range of negative responses including feelings of resentment, displeasure, discomfort, dissatisfaction and offence (UK Civil Aviation Authority, 2016). This wide variation in individual responses prompted the development of population noise-annoyance curves in which aggregated data form consistent relationships.

Overseas, the UK Civil Aviation Authority calculates annoyance using LA_{eq} 16-hour decibel bands (UK Civil Aviation Authority, 2016) while WHO's Environmental Noise Guidelines for Europe (2018) uses the day evening night sound level (L_{den}) decibel bands.

The L_{den} noise metric considers noise across the entire 24-hour day but with penalties (in the form of weighting) to account for increased sensitivity to noise in the evening and night-time periods. Although the concept of L_{den} is similar to ANEC/F it is based on LA_{eq} and uses slightly different time periods and weightings.

In this assessment, the health impacts of annoyance are adequately described and assessed through the ANEC/F and N-above metrics, as is standard practice in Australian airport HIAs. In addition, consideration of discrete night-time noise metrics such as the N60 night and LA_{eq} night provides greater resolution of noise during this noise- sensitive time period – noting that the airport then operates differently by applying Noise Abatement Procedures (NAPs).

To test sensitivity, the LA_{eq} 16-hour decibel bands were compared to ANEC contours with greater numbers of highly annoyed people resulting from noise presented in the ANEC contours. This provided the most conservative measure. Therefore, ANEC contours are also used as the basis for annoyance assessment in this chapter. ANEC contours and the base data for this assessment are also presented in **Chapter C4: Aircraft Noise and Vibration**.

Finally, annoyance is also expected to occur in ANEC contours below 20 – although annoyance in these contours is not typically calculated in Australian settings (BAC, 2007; Sunshine Coast Council, 2014; Pacific Environment Ltd, 2015). This is because exposure prediction at lower sound levels may be significantly inaccurate (Australian Standard AS2021-2015).

Table D3.1 shows the ANEC contours and corresponding percentage of people 'seriously affected' (i.e. highly annoyed) used in this chapter's calculations.

Table D3.1
Percentage of 'highly annoyed' people (Australian Standard AS2021-2015)

ANEC contour (median)	Percentage of seriously affected (i.e. highly annoyed people)
20-25 (23)	17
25-30 (28)	26
30-35 (33)	37
Above 35	49

D3.2.4.2
Sleep disturbance assessment method

Miedema and Vos (2007) analysed 24 field studies from different countries about peoples' responses to aircraft sleep disturbance. They developed scales, per decibel band, describing the percentage of people 'sleep-disturbed' and 'highly sleep-disturbed'.

Several effects categorised under sleep disturbance are risk factors for health problems. They include changes in motility, duration of sleep stages, difficulty getting to sleep, reduced sleeping time, and use of sleep-inducing drugs (WHO, 2009; Civil Aviation Authority, 2014).

Miedema and Vos (2004) also used nine aircraft noise studies to develop an exposure-effect model for self-reported chronic sleep disturbance at night. Their work allows the percentage of the population who are sleep-disturbed and highly sleep-disturbed to be calculated from the LA_{eq} night decibel measure (the average sound-pressure level over night-time). Compared to the European WHO (2018) Environmental noise guidelines, the values used in this chapter are the most conservative.

Sleep disturbance was assessed in this HIA using the period 11pm to 6am (consistent with the National Airports Safeguarding Framework). Table D3.2 sets out the noise exposure levels and consequent percentages of those expected to be 'sleep-disturbed' or 'highly sleep-disturbed'.

D3.2.4.3
Noise-induced awakenings assessment method

Night-time noise-induced awakenings can be approximated from the frequency of overflights where maximum noise levels exceed 60 decibels.

Chapter C4: Aircraft Noise and Vibration states the number of events exceeding 60 decibels (A-weighted) (dB(A)) external to a building. This would typically result in a maximum noise level of 50 dB(A) inside a building with its windows open to a normal extent. At 50 (A) LA_{max} or an equivalent noise level in an alternate metric, approximately three per cent of aircraft noise events were found to cause awakenings in field trials (Bullen et al, 1997). The N60 contours calculated for the night-time period reasonably describe the number of events that may, in some circumstances, cause awakenings. They have therefore been adopted for assessment of night-time noise from aircraft.

The same is true for daytime noise-induced awakenings for institutions where people may be sleeping (such as day-care centres, hospitals, aged residential-care facilities) and shift workers.

D3.2.4.4
Myocardial infarction assessment method

Myocardial infarction is commonly known as a heart attack. There is evidence linking myocardial infarction to transport noise (road, rail, aircraft). A substantial review of aircraft noise and health effects (Civil Aviation Authority, 2013) summarised cardiovascular effects as:

> *'In terms of cardiovascular impact there are mixed conclusions from the various reviews and papers on the evidence for effects. Some reviewers consider that there is sufficient evidence, others that the evidence does not convincingly demonstrate an association. Based on existing evidence, it is possible that exposure to aircraft noise may be a risk factor for cardiovascular disease and all would agree that further research is needed to examine the impact of noise on cardiovascular health. For myocardial infarction, the WHO Environmental Burden of Disease report suggests that night-time effects may be of the same magnitude as day-time effects and therefore proposes an odds ratio of 1.1 for 60-65 decibels (A-weighted) Lnight and an odds ratio of 1.2 for 65-70 decibels (A-weighted) L_{night}.'*

The 'odds ratios' – a description of the level of association between an exposure and an outcome – referred to have been used in calculating potential myocardial infarction effects. UK Civil Aviation Authority (2016) research describes the association with aircraft noise and cardiovascular disease measures as continuing to evolve.

Table D3.2
Sleep disturbance at various noise exposure levels

$L_{Aeq\ night}$ (decibels)	Percentage of sleep disturbed people	Percentage of highly sleep disturbed people
45-49	8.9	5.1
50-54	12.2	7.4
55-59	16.4	10.4
60-64	21.3	14.1
65-70	27.0	18.6
70+	33.4	23.8

There is emerging evidence to suggest that cardiovascular effects (i.e. myocardial infarction and hypertension) are more strongly linked to night-time noise exposure than daytime or total (24-hour) noise exposure. For example, WHO (2018) describes the quality of evidence associating ischaemic heart disease and L_{den} (a 24-hour noise metric) as very low quality. enHealth (2018) describes the quality score of the evidence base for hypertension and noise as 'low', with most studies focused on road traffic noise rather than aircraft noise.

The same is true regarding the quality of the evidence base for stroke, rated as 'very low'.

Finally, for cardiovascular outcomes enHealth (2018) says 'the magnitude of the reported effects across studies is small'.' Taking all this into account, the focus of this chapter is on potential myocardial infarction arising from night-time noise, in line with other Australian airport HIAs and those around the world.

D3.2.4.5
Communication interference assessment method

A maximum external overflight level of 70dB(A) has been adopted for this assessment for the following reasons:

- An internal noise level of 60 dB(A) is the sound-pressure level of a noise event likely to interfere with conversation or listening to the radio or television
- The Commonwealth's then Department of Transport and Regional Services (2000) described how a single external noise event would be attenuated by approximately 10 dB(A) by the walls of a house with its windows open.

Chapter C4: Aircraft Noise and Vibration describes how the N70 contours change throughout the year due to variations in day-to-day, week-to-week airport operations. For this quantitative assessment, annual N70 contours have been used.

The number of institutions (such as day care, primary and secondary schools, hospitals, aged residential-care facilities and community centres, and libraries) exposed to individual instances of noise interference with speech and communication each day is reported in this chapter.

The modelling shows the number of times a day that an institution has an overflight exceeding 70 dB(A) (represented by the N70 contour). For schools, the modelling is for 9am to 3pm, matching their time of operation. The detailed data underpinning this assessment can be found in Chapter D4: Social Impact.

Table D3.3 shows how frequently an N70 category event will occur.

D3.2.4.6
Reading comprehension in children: assessment method

Research applicable to this assessment includes the Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health (RANCH) study (Stansfeld et al., 2005). It studied 2,844 children from 89 schools in three countries, around London Heathrow, Madrid Barajas and Amsterdam Schiphol airports. The children were aged between eight years 10 months and 10 years 10 months.

This was a well-designed cross-sectional study that measured noise exposure (analysis via LA_{eq} 16-hour outdoor, dB(A)) and considered several cognitive and health outcomes. Major 'confounding factors' such as age were controlled in the analysis.

Table D3.3
Median frequency of overflights: 9am to 3pm and 6am to 7pm

N70 category overflights 9am to 3pm (median)	Minutes in the period 9am to 3pm	Median frequency of overflights
5-9 (7)	360	One per 51 minutes
10-19 (14.5)		One per 25 minutes
20-49 (34.5)		One per 10 minutes
50-99 (74.5)		One per 5 minutes
100-199 (149.5)		One per 2 minutes
200-499 (349.5)		One per 1 minute
N70 category overflights 6am to 7pm (median)	**Minutes in the period 6am to 7pm**	**Median frequency of overflights**
5-9 (7)	780	One per 111 minutes
10-19 (14.5)		One per 54 minutes
20-49 (34.5)		One per 23 minutes
50-99 (74.5)		One per 10 minutes
100-199 (149.5)		One per 5 minutes
200-499 (349.5)		One per 2 minutes

The study showed a linear exposure-effect association between aircraft noise and impairment of reading comprehension between 37 decibels and 67 decibels. In other words, as noise exposure increased from low to high levels, reading comprehension decreased. However, the magnitude is described as 'small' by the study authors, with a 20-decibel change being equivalent to one-fifth of a standard deviation of the mean reading comprehension score.

Two more studies have shown that the effects of aircraft noise on children's learning ceased once noise levels were reduced, i.e. that the effect is reversible.

For this assessment, the LA_{eq} 9am to 3pm outdoor decibels data were modelled (2046 Build versus No Build) and plotted against the locations of primary schools in the study area.

The change in LA_{eq} 9am to 3pm for each school exposed to greater than 37 decibels(A) in the 2046 Build scenario was contrasted against the relevant reading comprehension delay. 37 dB(A) was chosen as the lower cut-off because the RANCH study showed no effect on reading comprehension from aircraft noise below this level, and noise less than 37 dB(A) would be negligible within urban and suburban environments. While the effect is robust, quantitative findings for individual schools are overly precise and so a qualitative description of the findings is presented in **Section D3.6.2.6**.

A small number of schools in the study area were both primary and secondary schools (i.e. P-12) but despite having secondary pupils they were also included in the analysis - special development schools were also included.

D3.2.5
Employment assessment method

Several airport HIAs – e.g. Stansted G1, Belfast City, Birmingham, London City –qualitatively assessed the health effects of income and employment effects (RPS, 2015) and one quantitatively (Environmental Resources Management, 2008). No previous Australian airport HIA has considered the health effects of employment (Mott MacDonald, 2014; Sunshine Coast Council, 2014), instead focusing on only physical environment effects.

For this chapter, data to inform the qualitative and quantitative assessment of employment on health have been sourced from **Chapter D2: Economic Impact Assement**. Jobs Victoria data was used for the qualitative assessment of employment on health. The data was analysed to identify both qualitative and quantitative health effects from employment, describe barriers to employment and recommend mitigations where required.

D3.2.5.1
Qualitative employment assessment method

The potential health effects of employment have typically been assessed qualitatively in previous HIAs. That is, estimating whether the effect is likely positive or negative and while not measuring the size of effect, other airport HIAs do make comment on the likelihood of the effect occurring (Arup and Partners Ltd, 2012; RPS, 2015). This is a practical approach for dealing with certain employment impacts that cannot easily be quantified.

D3.2.5.2
Quantitative employment assessment method

A large-scale meta-analysis considered data from 20 million people from 42 previous studies in 15 countries including Australia and New Zealand (Roelfs et al., 2011). This study concluded that the mean hazard ratio for mortality and unemployment (adjusted for age and other covariates) is 1.63. That is, people who are unemployed have a mortality rate 63 per cent higher than people who are employed. This is a large effect that further demonstrates the critical nature of the social determinants of health, and is the mortality hazard ratio used in this chapter.

Consequently, it is possible to estimate mortality effects for indirect new employment opportunities arising from the 2046 Build scenario.

The other piece of data needed for a quantitative employment assessment is the base case mortality rate (per 100,000 persons) for those aged 18 to 64 years. The M3R calculation is made by multiplying the base-case mortality rate by the unemployed mortality hazard ratio, multiplied by the number of job opportunities created. The difference is the mortality avoided.

The number of jobs created by M3R is sourced from **Chapter D2: Economic Impact Asement**. The number of jobs created is different from the other jobs statistics in that it is more a 'flow' than a 'stock' measure. This means that unless the airport made an explicit commitment to employing unemployed people, the direct impact would likely be zero. Instead, the raw number of jobs created by M3R will, all else being equal, lead to an increase in the overall level of employment across the economy. This in turn will filter down to an approximate level of employment opportunities for the unemployed. That is, as the newly created M3R jobs are filled, the person taking that job creates an opportunity for a new employee at their former job – and so on, until it provides an opportunity for a person not employed (i.e. a person entering or re-entering the workforce).

The benefit relating to unemployment is therefore an indirect employment benefit.

Finally, the role of Jobs Victoria is explicitly focused on this aspect of gaining employment for unemployed people (i.e. for roles made vacant by people moving into the new M3R operation roles). As M3R construction jobs are temporary (i.e. only available over a fixed time frame) and require specialist skills (e.g. construction skills) and are more likely to support existing jobs rather than create new ones, the indirect employment benefit across the economy is less assured. Therefore, construction jobs are not included in the quantitative analysis of health effects that considers long-term health outcomes (however they are discussed further in the qualitative analysis).

D3.2.6
Consideration of ways to avoid and mitigate, or enhance, the health impacts of M3R

The opportunities for avoidance, mitigation or enhancement measures have been considered throughout this HIA, beginning with a preliminary assessment undertaken at the same time as the scoping exercise. This allows any measures to be incorporated into the design from the outset and throughout.

D3.3
STATUTORY REQUIREMENTS

D3.3.1
Statutory framework for this health assessment

The statutory framework for this assessment is provided in **Chapter A8: Assessment and Approvals Process**. For context, the *Airports Act 1996* (Cth) (Airports Act), the National Airports Safeguarding Framework (NASF) and the Melbourne Airport Master Plan are included in the statutory framework relevant to this HIA.

The statutory framework relevant to air quality assessment with respect to health is described in **Section D3.3.3**.

This chapter's sections on health (**Section D3.3.2**), noise (**Section D3.3.4**) and employment (**Section D3.3.5**) have no directly relevant legislation, nor are there particular measures that must be completed in a health assessment. Instead, the relevant regulatory context supporting the statutory framework for health, noise and employment is presented.

D3.3.2
Regulatory context: health

The *Public Health and Wellbeing Act 2008* (Vic) (PHWB Act) is a major legislative driver in improving the health and wellbeing of Victorians.

It recognises that the Victorian Government has a significant role in promoting and protecting the public health and wellbeing of people living in Victoria. The Act requires that a Victorian Government public health and wellbeing plan be prepared every four years. It establishes six principles to guide public health efforts in Victoria:

1. Evidence-based decision-making: The best available, relevant and reliable evidence should be used to inform decisions regarding use of resources and selection of interventions that promote and protect public health and wellbeing
2. Precautionary principle: Where a health risk poses a serious threat, lack of full scientific certainty should not be used as a reason to postpone measures to prevent or control the health risk
3. Primacy of prevention: The prevention of disease, illness, injury, disability and premature death is preferable to remedial measures
4. Accountability: Decisions relating to the PHWB Act should be made in transparent, systematic and appropriate ways that include promoting a good understanding of public health issues to Victorians and providing the opportunity to participate in policy and program development
5. Proportionality: Decisions made and actions taken relating to the PHWB Act should be proportionate to the identified health risk sought to be prevented, minimised or controlled
6. Collaboration: Public health and wellbeing in Victoria, and at the national and international levels, can be enhanced through collaboration between all levels of government and industry, business, communities and individuals.

There are also several guidelines and plans that are not statutory but which inform the scope of work of this HIA because they help to determine best practice. They include:

- Health Impact Assessment Guidelines (enHealth, 2001): Provide guidance on how to produce a HIA, including the necessary steps, in Australia
- Environmental Health Risk Assessment Guidelines (enHealth, 2012): Provide guidance on how to undertake a health-risk assessment, particularly assumptions underpinning quantitative assessment of human health effects
- Victorian Public Health and Wellbeing Plan 2015-2019 (Department of Health and Human Services, 2015) and the 2019-2023 Plan (Department of Health and Human Services, 2019): Set out the priorities for action in Victoria to improve health and wellbeing including healthy eating, tobacco, alcohol, mental health, violence and injury, and reproductive health. Mental health is indirectly related to M3R via the pathway of noise exposure.

Legislation that imposes controls to prevent or minimise air, water, soil and noise pollution plays an important role in protecting human health and ecosystems. It includes the *Environment Protection Act 1970* (Vic) and consequent SEPPs.

The standards and guidelines relevant to air quality and noise are presented briefly below but discussed in greater detail in the relevant chapters (**Chapter B10: Air Quality** and **Chapter C4: Aircraft Noise and Vibration**) and apply to land outside Melbourne Airport's boundary.

D3.3.3
Regulatory context: air quality

Commonwealth and state legislative requirements underpin **Chapter B10: Air Quality**. However, state legislation does not apply at Melbourne Airport because it is on Commonwealth land. Nevertheless, consideration has been given to the requirements of state legislation where relevant and to be thorough.

At the Commonwealth level, the National Environment Protection Council (NEPC) has set out National Environment Protection Measures.

The NEPM Ambient Air Quality (AAQ) (NEPC, 1998) is used in Australian jurisdictions to monitor and assess ambient air quality. In 1998, standards for ambient air quality were set for six primary air pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulphur dioxide (SO_2), lead and particulate matter.

NEPC (2016) strengthened the air quality reporting standards for particulate matter PM_{10} and amended the previous 'advisory reporting standard' for $PM_{2.5}$ to a 'performance standard' (i.e. requiring the same level of reporting compliance as other pollutants). The revision also includes new objectives for $PM_{2.5}$ by 2026. New standards for the NEPC were proposed for sulphur dioxide, nitrogen dioxide and ozone in an Impact Statement by the NEPC in May 2019.

The NEPC (2003) and NEPC (2016) air-quality monitoring standards are set out in **Table D3.4**.

The NEPM (Air Toxics) 2011 (NEPC, 2011) was established to facilitate a consistent approach to the monitoring and reporting of five key hydrocarbons that impact on human health; benzene, toluene, formaldehyde, xylenes and polycyclic aromatic hydrocarbons (PAHs). The NEPC (2011) monitoring investigation levels for the primary hydrocarbons are also described in **Table D3.4**.

State legislative requirements are set by the SEPP (AAQ) (Victorian Government, 1999) and the SEPP Air Quality Management (AQM) (Victorian Government, 2001).

These adopted the original (1998) objectives and goals of NEPC (2003). The Victorian Government (2016) adopted the changes set out in the amended NEPC (2016), in relation to the new standards for PM_{10} and $PM_{2.5}$. The Victorian Government (1999) air quality monitoring standards and Victorian Government (2016) variations relevant to this assessment are set out in **Table D3.4** alongside the corresponding NEPM standards.

To determine whether M3R meets the SEPP (AQM) legislation requiring air quality impact assessments to be cumulative, the predicted air quality impacts for a given facility are added to the existing background air pollutant (or 'indicator') levels (see **Chapter B10: Air Quality** for further information).

For burden-of-disease calculations, the air quality measures calculated the difference between the Build and No Build scenarios (considering background air quality for each scenario).

D3.3.4
Regulatory context: noise

There are no quantitative criteria legislated for the evaluation of aircraft noise in Australia. The assessment of noise has therefore followed recent best practice as described in **Chapter C3: Aircraft Noise Modelling Methodology**.

The *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) is the Commonwealth Government's central piece of environmental legislation. The EPBC Act also addresses actions that have a significant environmental impact on Commonwealth land or that are carried out by a Commonwealth agency – including a change of airspace (and thus aircraft noise).

Table D3.4
NEPM standard and SEPP (AQM) criteria relevant to M3R

Pollutant	Averaging period	Assessment criteria	Reference
PM_{10}	24-hour average	50 µg/m³	NEPM (NEPC, 2016)
	Annual average	20 µg/m³	NEPM (NEPC, 2016)
$PM_{2.5}$	24-hour average	25 µg/m³	NEPM (NEPC, 2016)
	24-hour average	20 µg/m³	NEPM (NEPC, 2016) goals for 2026
	Annual average	8.0 µg/m³	NEPM (NEPC, 2016)
Sulphur Dioxide	1-hour average	200 ppb (523µg/m³)	Victorian Government (1999)
Carbon monoxide	1-hour average	29 mg/m³	Victorian Government (1999)
Nitrogen Dioxide	1-hour average	120 ppb (226 µg/m³)	Victorian Government (1999)
Formaldehyde	Three-minute average	40µg/m³	Victorian Government (2001)
Benzene	Three-minute average	53 µg/m³	Victorian Government (2001)

The Airports Act requires that each airport lessee company, such as Australia Pacific Airports Melbourne (APAM), develop a Master Plan. This is an important document for managing environmental matters – including noise.

The airport Master Plan is required to include measures relevant to noise. They include an endorsed ANEF, flight paths, and plans for managing aircraft noise intrusion in areas forecast to be subject to exposure above the significant ANEF levels. Similarly, an MDP must also include plans for managing aircraft noise intrusion above the significant ANEF levels (under the Airports Act, 'significant ANEF levels means a noise above 30 ANEF levels').

D3.3.5
Regulatory context: employment

Although there are several regulations concerning employment in Victoria, none are directly relevant to the potential health effects explored in this chapter.

Table D3.5
Severity criteria

Impact categories	Description
Major	• The impact is considered critical to the decision-making process, including very large changes in manifest health conditions such as hospitalisations, cancer or mortality • Impacts tend to be permanent or irreversible or otherwise long-term and can occur over large-scale areas affecting very large populations • People can no longer safely live/work/learn/recreate within an area because of impacts associated with operation of the airport
High	• The impact is considered likely to be important to decision-making, including large changes in manifest health conditions such as hospitalisations, cancer or mortality • Impacts tend to be permanent or irreversible or otherwise long to medium-term • Impacts can occur over large or medium-scale areas affecting large populations • Many dwellings are located within ANEF/C contours of 30 or greater (significant noise level as per the Airports Act) • Public buildings are located within ANEF/C contours of 30 or greater (significant noise level as per the Airports Act) • People can continue to live/work/learn/ recreate within an area but many people are severely impacted by the operation of the airport.
Moderate	• The effects of the impact are relevant to decision-making including the development of environmental mitigation measures • Impacts can range from long-term to short-term in duration • Impacts can occur over medium-scale areas or otherwise represents a significant impact at the local scale affecting specific subpopulations • People continue to live/work/learn/recreate within the area but some are severely or moderately affected by impacts, e.g. highly annoyed, highly sleep-disturbed, communication interference or reading comprehension.
Minor	• Impacts are recognisable/detectable but acceptable • These impacts may be raised as local issues but are unlikely to be of importance in the decision making process. Nevertheless, they are relevant in the consideration of standard mitigation measures • People can continue to live/work/learn/recreate within the area but with measurable yet small effects.
Negligible	• Minimal change to the existing situation. For example, impacts which are beneath levels of detection or impacts that are inconsequential given existing context.
Beneficial	• Effects of the impact are beneficial to health.

D3.4
DESCRIPTION OF SIGNIFICANCE CRITERIA

The severity criteria appropriate to this health impact assessment are described in **Table D3.5**.

Development of these criteria has been related to similar criteria described in **Chapter D4: Social Impact**. It has also incorporated the relevant aspects of the whole-of-environment assessment requirement as defined in *Significant Impact Guidelines 1.2 – Actions on, or impacting upon, Commonwealth land and Actions by Commonwealth Agencies* (Significant impact guidelines 1.2) (DSEWPaC, 2013).

D3.5 EXISTING CONDITIONS: COMMUNITY PROFILE AND HEALTH BASELINE

D3.5.1 Geographic setting

The setting for the health assessment is Melbourne Airport, which is approximately 22 kilometres north-west of the Melbourne Central Business District (CBD). There are urban areas to the east and south of Melbourne Airport made up of industrial and residential developments. **Figure D3.1** shows Melbourne Airport and the health study area as discussed in **Section D3.2.2**.

D3.5.2 Demographic profile of the study areas

Full details on the demographic profile of the study areas, their deprivation data (Index of Relative Socio-Economic Advantage and Disadvantage, IRSAD) and the geographic areas that could be affected more than others (for example by noise contours) are described in **Chapter D4: Social Impact**.

Chapter D4: Social Impact describes how areas around the airport have different IRSAD scores, some relatively high (indicating socio-economic advantage, such as those towards the CBD) and some relatively low (indicating socio-economic disadvantage such as those to the east and south-west. A variety of socio-economically advantaged and disadvantaged areas are found around the airport.

While it could be inferred that the health status of socio-economically disadvantaged populations may be worse than the more socio-economically advantaged suburbs, health data does not exist at the ABS's statistical area 1 level which would allow statistical significance to be determined. The most disadvantaged suburbs (with the lowest IRSAD scores) are not those areas directly bordering the airport.

Therefore, for the health indicators section of the health profile, the reliance on LGA data in **Section D3.5.3** is maintained.

D3.5.3 Existing profile of the study areas

D3.5.3.1 Overall health status of the community

The Victorian Population Health Survey (Department of Health, 2019) shows that for the six LGAs in the community baseline assessment, 84 per cent of the 648 indicators (544 indicators) are the same as the Victorian averages, five per cent (32 indicators) better and nine per cent (60 indicators) worse.

Given that Australia and Victoria have some of the world's best health statistics, this shows that the communities which would experience any potential effects of M3R are in good health overall.

The 60 indicators below the Victorian averages are presented in **Table D3.6**. Forty-six of them (77 per cent) reflect lifestyle-related issues and consequent chronic diseases such as obesity.

Table D3.6
Health indicators in LGAs which are below the Victorian averages

Health indicator grouping	Health indicators in LGAs which are below the Victorian averages (# of indicators per category)					
	Hume	Moreland	Moonee Valley	Brimbank	Melton	Maribyrnong
Fruit and vegetable intake Physical activity Smoking Alcohol	Fruit and vegetable intake (11) Physical activity (2) Smoking (1)	Alcohol (2)	Physical activity (1) Alcohol (1)	Vegetable intake (3) Physical activity (3) Smoking (1)	Fruit and vegetable intake (5) Smoking (1) Alcohol (1)	0
Chronic diseases and obesity	Heart disease (1) Obesity (2) Daily consumption of sugar sweetened beverages (1)	Type 1 diabetes (1)	0	Stroke (1) Weekly consumption of takeaway meals or snacks (1)	Obesity (3) Daily consumption of sugar sweetened beverages (1) Weekly consumption of takeaway meals or snacks (1)	Weekly consumption of takeaway meals or snacks (1) Access health check for blood lipid or blood glucose (1)
Mental health and wellbeing	Mental health (2) Self-reported health status (1)Life satisfaction (2) Life worthwhile (1)	0	0	Self-reported health status (2)	0	Mental health (2)
Dental health	0	0	0	Self-reported dental health status (2) Self-reported gum disease (1)	Avoided visiting a dental professional due to cost (1)	0

D3.5.3.2 Local services and facilities

Situated within the boundary of Melbourne Airport are the terminal buildings and associated food, retail, airport office facilities and the Melbourne Airport Business Park. Beyond Melbourne Airport, many facilities and amenities are available to the local communities within study area one. These include:

- Education facilities
- Community services
- Places of worship
- Hospital and health services
- Aged residential-care facilities.

These services are assessed for potential effects from airspace noise within this chapter.

D3.5.3.3 Background incidence of mortality and hospitalisations for relevant conditions

Specific data was requested from the Australian Institute of Health and Welfare regarding mortality data, and from the Victorian Agency for Health Information regarding hospitalisation data. Baseline mortality rates and baseline hospitalisation rates are calculated from the provided data and for transparency are presented in each assessment calculation (see **Section D3.6**).

D3.5.4 Existing conditions: air quality

Two air quality monitoring programs operate at the airport. They cover the two broad categories of air pollutants:

- Criteria pollutants (NO_2, SO_2, O_3, CO, PM_{10} and $PM_{2.5}$)
- Air toxics - including benzene, toluene, xylene, formaldehyde and PAHs.

The existing conditions were summarised during the baseline assessment as:

- CO concentrations are low, with no exceedances of the NEPM standard
- NO_2 concentrations are low, with no exceedances of the NEPM standard
- SO_2 concentrations are very low, with no exceedances of the NEPM standard
- PM_{10} exceedances (more than 50 micrograms per cubic metre) occurred but were related to Melbourne-wide issues due to bushfire smoke. Otherwise, 24-hour average values varied, but are typically within a range of eight to 35 micrograms per cubic metre
- $PM_{2.5}$ exceedances (more than 25 micrograms per cubic metre) also occurred but again were related to Melbourne-wide issues due to bushfire smoke. Otherwise, 24-hour average values varied, but are typically within a range of five to 18 micrograms per cubic metre
- Benzene concentrations are low, with all analytical results below the laboratory limits of detection, with no exceedances of the NEPM standard
- Formaldehyde concentrations are low, with results typically around 10 micrograms per cubic metre, with no exceedances of the NEPM standard.

Further details are described in **Chapter B10: Air Quality**.

D3.5.5 Existing conditions: aircraft noise

Melbourne Airport operates curfew-free, 24-hours per day, seven days a week. Existing aircraft noise is detailed in **Chapter C4: Aircraft Noise and Vibration**, showing that aircraft operations occur over almost all of the study area. These overflights differ in operation type, altitude, noise level and frequency. Although almost all of the Greater Melbourne Basin is overflown at some stage, most flights are reasonably concentrated along specific arrival and departure paths.

The day and evening N70 contours extend north, south, east and west of the existing runways.

The prevalence of arrivals onto the north-south runway (particularly from the north to runway 16) is evident in the contours. To the north, the N70=5 contour extends approximately 15 kilometres from the runway – corresponding to arrivals approaching the runway with a steady, shallow glide slope (relative to most departure climb rates).

In the east-west direction, the bias toward runway 27 (i.e. departures to the west and arrivals from the east) is evident. The N70=5 contour extends approximately 15 kilometres from runway 27, with N70 contours as high as 100 extending 11 kilometres to the west. Although the N70=5 extends similarly to the east its contours are narrower, consistent with arrival operations. It is noteworthy that the N70=100 contour does not extend particularly far east of the airport, indicating fewer 70 dB(A) events to the east compared to other directions.

The night-time N-above contours generally extend along the extended runway centre lines in each direction. The most significant noise emissions are north and south of the airport, with reduced emissions levels to the east and west.

Further details are described in **Chapter C4: Aircraft Noise and Vibration**.

D3.5.6 Existing conditions: employment

Melbourne's current population is nearly five million, representing 20 per cent of Australia's total population and about the same proportion of Australian jobs. The Melbourne Airport local region contains approximately nine per cent of state-wide employment. Two of the industries in the Melbourne Airport local area (transport and construction) have twice the percentage of jobs that would be expected if the area correlated with the Victoria average.

D3.6 ASSESSMENT OF POTENTIAL IMPACTS

This section describes the findings of the assessment of M3R's potential health effects for air quality, noise and employment.

This assessment determines the effect of the 2046 M3R Build versus the 2046 No Build scenario. As can be seen from projected annual aircraft movements, the largest difference is in the 2046 scenario (see Figure D3.2) which therefore gives the greatest insight into potential effects on health.

D3.6.1 Air quality

This section assesses the potential health effects of air quality modelled to occur during M3R operation. Current and potential future airport operations were included in air quality models within Chapter B10: Air Quality – including particulate and gaseous emissions (e.g., PM_{10}, $PM_{2.5}$, oxides of nitrogen and hydrocarbons) from jet aircraft engine exhausts, road vehicles on the airport and surrounding roadways, airport ground support equipment during operations and aircraft auxiliary power units.

As described in Section D3.3, the statutory framework requires assessment against certain air quality standards. The health assessment has considered several additional air quality measures to further explore and communicate health outcomes.

Health impacts from exposure to poor air quality include hospitalisations and mortality. This study aimed to identify whether exposure for local communities was significant regarding health outcomes.

D3.6.1.1 PM_{10} assessment of M3R operation: 2046 Build v No Build

The following individual assessments of PM_{10} exposure were done:

- Comparison of PM_{10} concentrations against NEPM (AQM) standards for both annual average exposure and 24-hour average exposure for the 2046 Build versus No Build scenarios
- Calculation of potential mortality effects from PM_{10} exposure for both annual average exposure and 24-hour average exposure for the 2046 Build versus No Build scenarios
- Calculation of potential hospitalisation effects for 24-hour average of the 2046 Build versus No Build scenarios.

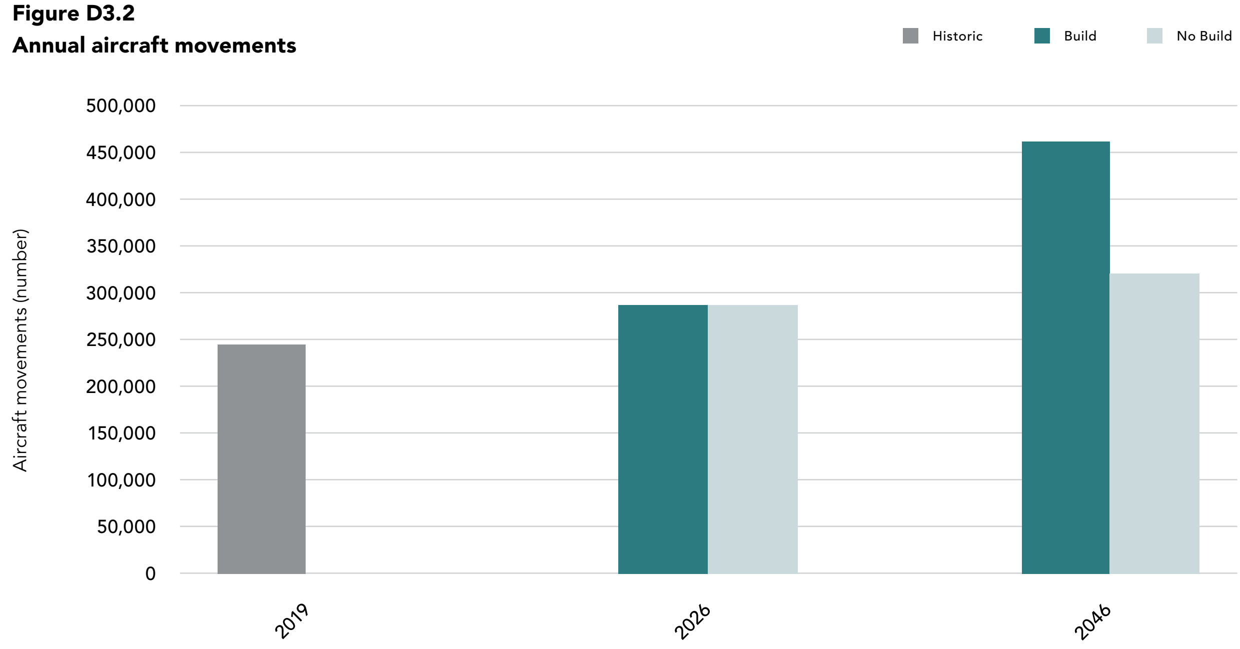
The following paragraphs summarise the outcomes of each of the PM_{10} assessments. For full air quality data sets refer to Chapter B10: Air Quality.

Comparison against the NEPM (AQM) for PM_{10}

The total annual average PM_{10} concentrations are forecast to be below the SEPP (AQM) – equivalent to the NEPM (AQM) – standard of 20 micrograms per cubic metre at all modelled receptors in the 2046 Build and No Build scenarios.

All modelled receptors are in the range of 18.9 to 19.0 micrograms per cubic metre, where the health risks are considered acceptable. For reference, of the highest value of 19.0 micrograms per cubic metre PM_{10},18.9 micrograms per cubic metre PM_{10} is from ambient background concentration and 0.1 microgram per cubic metre PM_{10} is from the 2046 Build scenario.

Figure D3.2
Annual aircraft movements



Source: M3R and MP Forecasts v1

The 24-hour average PM_{10} concentrations are forecast to be below the NEPM standard of 50 micrograms per cubic metre at all modelled receptors in 2046 Build and No Build scenarios. All modelled receptors are in the range of 45.6 to 46.2 micrograms per cubic metre, where the health risks are considered acceptable. For reference, of the highest value of 46.2 micrograms per cubic metre PM_{10}, 45.6 micrograms per cubic metre PM_{10} is from ambient background concentration and 0.6 microgram per cubic metre PM_{10} from the 2046 Build scenario.

Calculation of potential mortality effects for PM_{10}, annual average

While PM_{10} annual average concentrations are lower than the NEPM standard, it is best practice to calculate if there are any residual effects from long-term (i.e. annual) exposure. For all suburbs, the severity of the potential health effect is negligible (Table D3.7).

Calculation of potential mortality effects for PM_{10} 24-hour average

While PM_{10} 24-hour average concentrations are lower than the NEPM standard, it is best practice to calculate if there are any residual effects from short-term (i.e. daily) exposure. For all age groups calculated, for all suburbs, the severity of the potential health effect is negligible (see Table D3.8).

Calculation of potential hospitalisation effects for PM_{10} 24-hour average

Daily PM_{10} has the potential to affect daily hospitalisation rates - six individual hospital admissions were assessed across different age ranges in the life course (using the CRF methodology described in Section D3.2.3). Across the six hospital admissions, across all suburbs and age ranges, the severity of the potential health effect is negligible.

Table D3.7
Annual all-cause mortality from PM_{10} annual average exposure

Suburb (SA2)	Population, all ages	Maximum change in annual PM_{10} exposure (µg/m³)	Relative risk increase per µg/m³	Baseline rate: all-cause mortality, all ages	Absolute mortality brought forward per annum per suburb	Change in life expectancy across population
Greenvale Bulla	14,245	0.01	0.0039	523/100,000	0.003	1 to 3 sec
Gladstone Park Westmeadows	17,815	0	0.0039	523/100,000	0	0
Tullamarine	6,763	0	0.0039	523/100,000	0	0
Keilor	8,673	0.02	0.0039	534/100,000	0.004	2 to 6 sec
Taylors Lakes	18,574	0	0.0039	534/100,000	0	0

Table D3.8
Annual cardiovascular mortality, all ages combined, from PM_{10} 24-hour average exposure

Suburb (SA2)	Population, all ages	Maximum change in annual PM_{10} exposure (µg/m³)	Relative risk increase per µg/m³	Baseline rate: all-cause mortality, all ages	Absolute mortality brought forward per annum per suburb	Change in life expectancy across population
Greenvale Bulla	14,245	0.05	0.0024	148/100,000	0.0025	1 to 3 sec
Gladstone Park Westmeadows	17,815	0	0.0024	148/100,000	0	0
Tullamarine	6,763	0	0.0024	148/100,000	0	0
Keilor	8,673	0.12	0.0024	146/100,000	0.0036	2 to 6 sec
Taylors Lakes	18,574	0.08	0.0024	146/100,000	0.0052	1 to 4 sec

D3.6.1.2 $PM_{2.5}$ assessment of M3R operation: 2046 Build v No Build

The following individual assessments of $PM_{2.5}$ exposure were done:

- Comparison of $PM_{2.5}$ concentrations against NEPM (AQM) standards for both annual average exposure and 24-hour average exposure for 2046 Build versus No Build scenarios
- Calculation of potential mortality effects from $PM_{2.5}$ exposure for both annual average exposure and 24-hour average exposure for the 2046 Build versus No Build scenarios
- Calculation of potential hospitalisation effects for 24-hour average of the 2046 Build versus No Build scenarios.

The following paragraphs summarise the outcomes of each $PM_{2.5}$ assessment. For full air quality data sets refer to Chapter B10: Air Quality.

Comparison against the NEPM (AQM) standard and 2026 goals for $PM_{2.5}$

The total annual average $PM_{2.5}$ concentrations are forecast to be above the SEPP (AQM) standard (equivalent to NEPM standard) of 8.0 micrograms per cubic metre for all receptors in 2046 Build and No Build scenarios.

All receptors are in the range of 9.40 to 9.44 micrograms per cubic metre. The background/ambient annual average $PM_{2.5}$ is 9.43 micrograms per cubic metre contributing 99.9 per cent of the $PM_{2.5}$ concentration in air, meaning the 2046 Build versus No Build contributes just 0.01 p of the $PM_{2.5}$ concentration in air.

In contrast, the average $PM_{2.5}$ 24-hour concentrations are forecast to be below the NEPM standard of 25 micrograms per cubic metre at all modelled receptors in 2046 Build and No Build scenarios. All modelled receptors are in the range of 9.54 to 10.22 micrograms per cubic metre.

Regarding the 2026 goals, the average $PM_{2.5}$ 24-hour maximum concentrations are forecast to be below the NEPM 2026 goals of 20 micrograms per cubic metre at all modelled receptors in 2046 Build and No Build scenarios. As above, all modelled receptors are in the range of 9.54 to 10.22 micrograms per cubic metre.

Calculation of potential mortality effects for $PM_{2.5}$, annual average

Given receptors are above the NEPM standard for $PM_{2.5}$ annual average (of 8.0 micrograms per cubic metre) it is important to calculate if there might be any health effects from long-term (i.e. annual) exposure. For all suburbs, the severity of the potential health effect is categorised as negligible (see Table D3.9).

The potential effect on mortality due to $PM_{2.5}$ exposure (annual mean) is also calculated for:

- Cardiopulmonary disease mortality, aged 30+ years
- Ischaemic heart disease mortality, aged 30+ years
- Lung cancer mortality, aged 30+ years.

For all calculations above (all suburbs) the severity of potential health effect is negligible.

Calculation of potential mortality effects for total 24-hour average $PM_{2.5}$

Although average $PM_{2.5}$ 24-hour maximum concentrations are lower than the NEPM standard and 2026 goals (NEPC, 2016) it is best practice to calculate if there are any residual effects (per annum) from short-term (i.e. daily) exposure. For all age groups calculated and for all suburbs, the health significance is categorised as negligible (see Table D3.10). Calculations are also undertaken for cardiovascular mortality and the severity of the potential health effect is categorised as negligible.

Calculation of potential hospitalisation effects for 24-hour average $PM_{2.5}$

Daily $PM_{2.5}$ has the potential to affect daily hospitalisation rates and so 14 different hospital admissions are assessed across different age ranges spanning the full life course (using the CRF methodology described in Section D3.2.3). Across the 14 hospital admissions calculated, across all suburbs and age ranges, the severity of the potential health effect is negligible.

D3.6.1.3 Nitrogen dioxide (NO_2) assessment: 2046 Build v No Build

The following individual assessments of NO_2 exposure were done:

- Comparison of NO_2 concentrations against SEPP (AQM) standards for one-hour average exposure of 2046 Build versus No Build scenarios
- Calculation of potential mortality effects from NO_2 exposure for both annual average exposure and 24-hour average exposure for the 2046 Build versus No Build scenarios
- Calculation of potential hospitalisation effects for 24-hour average for the 2046 Build versus No Build scenarios.

The following paragraphs summarise the outcomes of each of the NO_2 assessments. For full air quality data sets refer to Chapter B10: Air Quality.

Table D3.9
Annual all-cause mortality from $PM_{2.5}$ annual average exposure

Suburb (SA2)	Population, ages 30+ years	Maximum change in annual $PM_{2.5}$ exposure (µg/m³)	Relative risk increase per µg/m³	Baseline rate: all-cause mortality, all ages	Absolute mortality brought forward p/a per suburb	Change in life expectancy across population
Greenvale Bulla (AQ ref Bulla)	7,756	0.01	0.006	481/100,000	0.022	2 to 4 seconds
Gladstone Park Westmeadows (AQ ref Threadneedle St)	11,236	0.00	0.006	481/100,000	0.00	0 seconds
Tullamarine (AQ ref Janus St)	4,341	0.00	0.006	481/100,000	0.00	0 seconds
Keilor (AQ ref Arundel Rd)	5,775	0.01	0.006	485/100,000	0.016	1 to 4 seconds
Taylors Lakes (AQ ref Keilor Village)	11,178	0	0.006	485/100,000	0	0

Table D3.10
Annual mortality from $PM_{2.5}$ 24-hour average exposure

Suburb (SA2)	Population, all ages	Maximum change in annual $PM_{2.5}$ exposure (µg/m³)	Relative risk increase per µg/m³	Baseline rate: all-cause mortality, all ages	Absolute mortality brought forward per annum per suburb	Change in life expectancy across population
Greenvale Bulla (AQ ref Bulla)	14,245	0.06	0.0024	493/100,000	0.010	4 to 11 seconds
Gladstone Park Westmeadows (AQ ref Threadneedle St)	17,815	0.00	0.0024	493/100,000	0.00	0.00
Tullamarine (AQ ref Janus St)	6,763	0.00	0.0024	493/100,000	0.00	0.00
Keilor (AQ ref Arundel Rd)	8,673	0.12	0.0024	497/100,000	0.012	7 to 22 seconds
Taylors Lakes (AQ ref Keilor Village)	18,574	0.08	0.0024	497/100,000	0.018	5 to 15 seconds

<u>Comparison against the SEPP (AQM) for NO_2</u>

The one-hour average NO_2 concentrations are forecast to be below the SEPP (AQM) standard of 190 micrograms per cubic metre at all modelled receptors in 2046 Build and No Build scenarios. All modelled residential receptors for the 2046 Build are in the range of 67.9 to 114.3 micrograms per cubic metre, where the health risks are considered acceptable.

<u>Calculation of potential mortality effects for annual average NO_2</u>

Although the 99th percentile hourly average NO_2 concentrations are lower than the SEPP (AQM) standard it is best practice to calculate whether there are any residual effects from long-term (i.e. annual) NO_2. For all suburbs, the health significance is categorised as Negligible (**Table D3.11**).

Potential annual mortality due to annual NO_2 exposure for people aged 30+ years is also calculated for annual cardiovascular mortality and annual respiratory mortality. This shows that between 87 and 90 per cent of all-cause mortality is due to cardiovascular mortality, while respiratory mortality contributed seven to eight per cent of all-cause mortality.

<u>Calculation of potential mortality effects for 24-hour average NO_2</u>

While the 99th percentile hourly average NO_2 concentrations are lower than the SEPP (AQM) standard, it is best practice to calculate if there are any residual effects from short-term (i.e. daily) exposure. For all suburbs, the health significance is minor. The highest value is for Keilor, where the health significance is minor: a less than 106-minute reduction in life expectancy shared between the entire population of 8,673 people (see **Table D3.12**)

The potential mortality due to daily NO_2 exposure for people of all ages is also calculated for cardiovascular disease mortality and respiratory disease mortality, showing that approximately 25 per cent of all-cause mortality is due to each of cardiovascular disease mortality and respiratory disease mortality.

<u>Calculation of potential hospitalisation effects for 24-hour NO_2</u>

Daily NO_2 has the potential to affect daily hospitalisation rates and so seven different hospital admissions were assessed across different age ranges spanning the life course (using the CRF methodology described in **Section D3.2.3**). Across the seven hospital admissions calculated, across all suburbs and age ranges, the severity of the potential health effect is negligible.

D3.6.1.4
CO assessment of M3R operation: 2046 Build v No Build

The one-hour average CO concentration is forecast to be below the SEPP (AQM) standard (Victorian Government, 1999) (29 micrograms per cubic metre) at all modelled receptors in all scenarios. All modelled receptors are less than 1.2 milligrams per cubic metre (full data is available in **Chapter B10: Air Quality**). The SEPP (AQM) is set at a level where the health risks are considered acceptable.

D3.6.1.5
SO_2 assessment of M3R operation: 2046 Build v No Build

The one-hour average SO_2 concentrations are forecast to be below the SEPP (AQM) standard (Victorian Government, 1999) (523 micrograms per cubic metre) at all modelled receptors in all scenarios. That is, all modelled receptors are less than 53 micrograms per cubic metre (full data is available **Chapter B10: Air Quality**). The SEPP (AQM) is set at a level where the health risks are considered acceptable.

D3.6.1.6
Air toxics (formaldehyde and benzene) assessment of M3R operation: 2046 Build v No Build

<u>Formaldehyde comparison against SEPP (AQM) standard</u>

The three-minute average formaldehyde concentrations are forecast to be below the SEPP (AQM) standard (Victorian Government, 2001) (40 micrograms per cubic metre) at all sensitive receptors in the 2046 Build scenario.

The highest modelled residential receptor in the 2046 Build scenario is 22.0 micrograms per cubic metre, 55 per cent of the standard (full data is available in **Chapter B10: Air Quality**). Despite not exceeding the standard, it is still considered important to carry out additional calculations of any potential health risk.

<u>Formaldehyde comparison against Air Quality Assessment Criteria</u>

The annual average formaldehyde concentrations are forecast to be below the draft Air Quality Assessment Criteria (Environment Protection Authority Victoria, 2021) of 9.8 micrograms per cubic metre at all modelled residential receptors, in all scenarios.

The highest modelled residential receptor in the 2046 Build scenario is 0.107 micrograms per cubic metre, 1.1 per cent of the standard. Despite not exceeding the assessment criteria, it is still considered important to carry out additional calculations of any potential health risk.

<u>Formaldehyde lifetime cancer risk</u>

When comparing the 2046 Build scenario with the No Build scenario, the differences for modelled residential receptors are in the range of 0.002 to 0.034 micrograms per cubic metre for annual average formaldehyde. Taking the highest value (0.034), multiplied by the unit risk factor for formaldehyde, the maximum predicted increase in lifetime risk of cancer is 2.0×10^{-7} (0.0000002). The severity of the potential health effect is therefore concluded to be negligible.

Table D3.11
Annual all-cause mortality from NO_2 annual average exposure

Suburb (SA2)	Population, 30+ years	Maximum change in annual $PM_{2.5}$ exposure (µg/m³)	Relative risk increase per µg/m³	Baseline rate: all-cause mortality, all ages	Absolute mortality brought forward per annum per suburb	Change in life expectancy across population
Greenvale Bulla (AQ ref Bulla)	7,756	0.2	0.004	511/100,000	0.03	0 to 1 min
Gladstone Park Westmeadows (AQ ref Threadneedle St)	11,236	0.5	0.004	511/100,000	0.11	1 to 3 min
Tullamarine (AQ ref Janus St)	4,341	0.3	0.004	511/100,000	0.03	1 to 2 min
Keilor (AQ ref Arundel Rd)	5,775	0.7	0.004	522/100,000	0.08	1 to 4 min
Taylors Lakes (AQ ref Keilor Village)	11,178	0.1	0.004	522/100,000	0.02	11 to 32 sec

Table D3.12
Annual all-cause mortality from NO_2 24-hour average exposure

Suburb (SA2)	Population, all ages	Maximum change in annual $PM_{2.5}$ exposure (µg/m³)	Relative risk increase per µg/m³	Baseline rate: all-cause mortality, all ages	Absolute mortality brought forward per annum per suburb	Change in life expectancy across population (minutes)
Greenvale Bulla (AQ ref Bulla)	14,245	14.92	0.0019	523/100,000	2.11	13 to 38
Gladstone Park Westmeadows (AQ ref Threadneedle St)	17,815	32.34	0.0019	523/100,000	5.73	28 to 83
Tullamarine (AQ ref Janus St)	6,763	22.98	0.0019	523/100,000	1.54	20 to 59
Keilor (AQ ref Arundel Rd)	8,673	40.34	0.0019	534/100,000	3.55	35 to 106
Taylors Lakes (AQ ref Keilor Village)	18,574	10.37	0.0019	534/100,000	1.95	9 to 27

Benzene comparison against SEPP (AQM) standard

The three-minute average benzene concentrations are forecast to be below the SEPP (AQM) (Victorian Government, 2001) standard of 53 micrograms per cubic metre at all modelled residential receptors in all scenarios. The highest modelled residential receptor in the 2046 Build scenario is 2.7 micrograms per cubic metre, five per cent of the standard (full data is available in **Chapter B10: Air Quality**). Despite not exceeding the standard, it is still considered important to carry out additional calculations of any potential health risk.

Benzene comparison against Air Quality Assessment Criteria

The annual average benzene concentrations are forecast to be below the draft Air Quality Assessment Criteria (Environment Protection Authority Victoria, 2021) of 9.6 micrograms per cubic metre at all modelled residential receptors, in all scenarios. The highest modelled residential receptor in the 2046 Build scenario is 0.014 micrograms per cubic metre, 0.1 per cent of the standard. Despite not exceeding the assessment criteria, it is still considered important to carry out additional calculations of any potential health risk.

Benzene lifetime cancer risk

When comparing the 2046 Build scenario with the No Build scenario, the differences for modelled residential receptors are in the range of 0.000 to 0.004 micrograms per cubic metre for annual average benzene. Taking the highest value (0.004), multiplied by the unit risk factor for benzene, the maximum predicted increase in lifetime risk of cancer is $1.2x10^{-7}$ (0.00000012). The severity of the potential health effect is therefore concluded to be negligible.

D3.6.2 Noise

This section assesses the potential health effects of altered noise due to M3R's operation in the 2046 Build versus No Build scenario. Although there are no quantitative criteria legislated for the evaluation of aircraft noise in Australia, the legislative framework for M3R MDP is described in **Chapter A8: Assessment and Approvals Process**.

Melbourne Airport is regulated under the Commonwealth Airports Act. In the case of environmental protection, the *Airports (Environment Protection) Regulations 1997* (Cth) (AEP Regulations) are also relevant and applicable. In addition, noise assessment for this project has been modelled on the recent assessment of similar projects (that is, having regard to other recent Australian projects for similar airfield infrastructure assessments). This collective approach is further described in **Chapter C3: Aircraft Noise Modelling Methodology**.

As described in **Section D3.3.4**, no specific noise legislation exists against which M3R could be assessed. Instead, frameworks and guidelines are available. Therefore, the health assessment complements the noise assessment by considering the magnitude and distribution of noise exposure upon communities.

The focus of this report is on non-auditory health effects that may be associated with exposure to aircraft noise. The pathways and strength of the evidence base differ for various noise health effects - the health and wellbeing effects studied in this report are those included in authoritative evidence bases and previous airport HIAs (from around the world and in Australia). They include:

- Annoyance
- Sleep disturbance
- Noise-induced awakenings
- Cardiovascular effects (i.e. myocardial infarction)
- Reading comprehension in children
- Interference with speech and communication.

D3.6.2.1 Annoyance assessment: 2046 Build v No Build

The potential effects of annoyance from noise were calculated by comparing the 2046 Build composite versus No Build scenario (**Table D3.13**).

The modelled ANEC contours show that an estimated 1,900 additional people are projected to be 'highly annoyed' by aircraft noise in the 2046 Build versus No Build scenario.

Figures showing the geographic areas and dwelling counts under each ANEC contour are presented in **Chapter C4: Aircraft Noise and Vibration**. It is important to note that most of the annoyance effect is seen in the lower ANEC contours (20-25 and 25-30). There are no regulations to restrict flights within these ranges. Due to the number of people affected, the severity of the potential health effect is categorised as moderate. Appropriate mitigation is discussed in **Section D3.7**.

D3.6.2.2 Sleep disturbance assessment: 2046 Build v No Build

The potential effects on sleep disturbance from noise have been calculated by comparing the 2046 Build scenarios against the No Build scenario for 'highly sleep-disturbed' people. At night, the two potential operating strategies are predicted to produce distinctly different outcomes. Analysis of the two options is therefore presented separately.

The analysis shows the difference between options 1 and 2 in terms of the share of sleep disturbance predicted when compared to the No Build scenario. The potential number of people 'highly sleep-disturbed' for options 1 and 2 are projected to be approximately 141 and 797.

Due to the number of people affected, the severity of the potential health effect is categorised as moderate.

Table D3.13
Estimated number of 'highly annoyed' people, 2046 Build versus No Build

ANEC Contour	Corresponding percentage of highly annoyed	Number of dwellings		Number of people highly annoyed		
		Build Composite	No Build	Build Composite	No Build	Difference
20-25	17	4,477	1,418	2,055	651	1,404
25-30	26	708	30	497	21	476
30-35	37	27	8	27	8	19
35 and above	49	1	0	1	0	1
Total						**1,900**

Note: Assumes 2.7 people per dwelling

Table D3.14
Estimated number of 'highly sleep-disturbed' people: 2046 Build Option 1 versus No Build

$L_{Aeq\ night\ 11pm\ to\ 6am}$ (decibels)	Percentage of highly sleep disturbed people	Difference of number of dwellings in noise contour	Difference of number of people in noise contour	Number of highly sleep-disturbed people
45-49	5.1	-1,236	-3,337	-170
50-54	7.4	756	2,041	151
55-59	10.4	568	1,534	159
60-64	14.1	1	3	0
65-69	18.6	0	0	0
70+	23.8	0	0	0
Total	–	**89**	**240**	**141**

Table D3.15
Estimated number of 'highly sleep-disturbed' people: 2046 Build Option 2 versus No Build

$L_{Aeq\ night\ 11pm\ to\ 6am}$ (decibels)	Percentage of highly sleep disturbed people	Difference of number of dwellings in noise contour	Difference of number of people in noise contour	Number of highly sleep-disturbed people
45-49	5.1	3,746	10,114	516
50-54	7.4	1,321	3,567	264
55-59	10.4	44	119	12
60-64	14.1	12	32	5
65-69	18.6	0	0	0
70+	23.8	0	0	0
Total	–	**5,123**	**13,832**	**797**

D3.6.2.3 Potential for noise induced awakenings: 2046 Build v No Build

Noise-induced awakenings can be assessed from the frequency of overflights at night when maximum noise levels exceed a given threshold. That threshold is typically N60 i.e. the number of overflights exceeding 60 dB(A). This noise level equates to about 50 dB(A) inside a house with its windows open. And at this level, in field trials approximately three per cent of aircraft overflights have been found to cause awakenings.

N60 data is presented in contours, with each contour showing the number of houses that would experience a particular number of night overflights. Some households are projected to experience more N60 overflights in the 2046 No Build scenario compared with Build between the times of 11pm and 6am, and some are projected to experience fewer N60 overflights. The N60 contours are:

- Houses experiencing five to 19 overflights: It is projected that approximately 34,000 fewer dwellings (than compared to No Build scenario) are predicted to be impacted by five to 19 N60 overflights with Option 1. Approximately 17,793 fewer dwellings would be so impacted with Option 2 which involves more equitable distribution of operations and noise
- Houses experiencing 20 to 49 overflights: Both options are predicted to see an increase in the number of dwellings impacted by more than 20 N60 overflights, 9,658 additional dwellings are within the 20-49 contour for N60 overflights in Option 1, and 3,971 additional dwellings in Option 2
- Houses experiencing 50 to 99 overflights: Approximately nine to19 additional dwellings are predicted to be in the N60 50-99 contour with either option.

Overall numbers

There is a substantial overall reduction in households – of between 13,813 and 24,330 fewer dwellings overall by 2046 – projected to be within the five-or-greater contours for N60 overflights between 11pm to 6am compared to the No Build scenario.

It is likely that the small proportion of people who are sensitive to night noise-induced awakenings would take action (such as closing a window) to mitigate sleep disruption. In these circumstances, the assumed 10 dB reduction through a building's walls (which results in N60 externally to describe the number of 50 dB(A) events internally) would be further reduced.

D3.6.2.4 Myocardial infarction assessment: 2046 Build v No Build

Cardiovascular disease includes ischaemic heart disease, hypertension (high blood pressure) and strokes. Ischaemic heart diseases include angina (the chest pain or discomfort when an area of heart muscle does not get enough oxygen-rich blood) and myocardial infarction (commonly known as a heart attack) (WHO, 2011).

The potential effects on myocardial infarction from noise, comparing the 2046 Build versus No Build scenarios, have been calculated (Table D3.16) for an age-standardised rate of 421 hospital admissions per 100,000 population (NHF, 2015).

The effect on myocardial infarction from night-time noise when comparing the 2046 Build versus No Build scenario is 0.0013 events for Option 1 (equating to one new case of myocardial infarction every 769 years) and 0.012 events for Option 2 (equating to once new case every 83 years) across the entire population. The severity of the potential health effect is therefore concluded to be negligible.

Table D3.16
Number of potential myocardial infarction hospital admissions from night-time aircraft noise 2046 Build v No Build

	Noise band L_{night} dB(A)	Households exposed		Increase in Odds Ratio	Potential cases		Difference Number of potential myocardial infarction hospital admissions – night-time aircraft noise
		No Build	Option 1 Build*		at 421 per 100,000	at 463 or 505 per 100,000	
Option 1	60-64	8	9 (+1)	0.1	0.0126	0.0139	0.0013
	65+	0	0 (0)	0.2	0	0	0
	Total	**8**	**9 (+1)**	-	-	-	**0.0013**
Option 2	60-64	8	20 (+12)	0.1	0.131	0.143	0.012
	65+	0	0	0.2	0	0	0
	Total	**8**	**20 (+12)**	-	-	-	**0.012**

(difference from No Build)

D3.6.2.5 Communication interference effects from noise assessment: 2046 Build v No Build

enHealth (2004) concluded that 'speech cannot be used to communicate effectively when background sound drowns out the voice'. To avoid communication interference, Standards Australia (2015) recommends L_{max} indoors of 60 dB(A) in Australian dwellings (Australian Standard AS2021- 2015).

This assessment calculated potential effects on the following institutions:

- Schools
- Early childcare/kindergartens
- Hospitals, hospice and respite care facilities
- Aged-care facilities
- Libraries
- Maternal and child health centres.

Chapter D4: Social Impact sets out the details for how each of these institutions is potentially affected by the three different operating models: mixed mode, Option 1, Option 2. For some institutions, the assessment shows no change as they remain in the same N70 contour for the Build versus No Build scenario. However, others are projected to be:

- In a lower N70 category of overflights in the 2046 Build operating models (i.e. moving to a category with fewer overflights – some even move to zero)
- In a higher N70 category of overflights in the 2046 Build operating models (i.e. moving to a category with a higher number of overflights)
- Newly receiving N70 overflights in the 2046 Build operating models
- No longer receiving N70 overflights in the 2046 Build operating models.

Table D3.17 summarises the number of facilities located within the N70 regions for overflight for the 2046 Build versus No Build scenarios, for the time day and evening periods. The frequency of these events is reflected based upon the methodology described in**Section D3.2.4.5**

Table D3.17
Rates of overflight for community facilities 2046 No Build vs Build options

N70 Contour (6am to 11pm)	2046 No Build						2046 Build																	
							Mixed mode						Option 1						Option 2					
Facility Type	5-9	10-19	20-49	50-100	100-199	200+	5-9	10-19	20-49	50-100	100-199	200+	5-9	10-19	20-49	50-100	100-199	200+	5-9	10-19	20-49	50-100	100-199	200+
Schools (9am-3pm)	2	2	1	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
College (9am-3pm)	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0
Education Facility (9am-3pm)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Places of worship	2	1	0	0	3	0	5	2	0	2	2	2	5	2	0	2	0	4	5	1	2	1	2	2
Retirement village	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Library	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2
Hospital, Hospice, Respite Care	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1
Maternal and Child Health Centres	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Correctional facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Community centre / neighbourhood house	0	1	0	0	0	0	6	4	2	0	0	2	6	5	1	0	0	2	6	4	3	0	0	2
Senior Citizens centres	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Childcare and kindergarten	4	1	6	2	3	0	16	6	4	2	2	2	17	1	4	3	1	2	13	8	4	2	2	2
Aged care	2	1	2	1	0	0	4	0	3	1	2	0	3	0	3	2	1	0	2	2	3	1	2	0
Subtotals	11	6	12	3	9	0	32	12	12	6	6	9	32	8	11	8	2	11	27	15	15	5	6	9
Totals	**41**						**77**						**72**						**77**					
Frequency of overflight	51 minutes	25 minutes	10 minutes	5 minutes	< 5 minutes		51 minutes	25 minutes	10 minutes	5 minutes	< 5 minutes		51 minutes	25 minutes	10 minutes	5 minutes	5 minutes		51 minutes	25 minutes	10 minutes	5 minutes	5 minutes	

Communication interference in schools assessment

Table D3.17 demonstrates the predicted noise impact and frequency for N70 overflights for schools for the 2046 Build versus No Build for the time period from 9am to 3pm.

Given enHealth Council (2004), Standards Australia (2015) and Department of Transport and Regional Services (2000) all recommend the same L_{max} indoors of 60 dB(A), the severity of the potential health effect is moderate. Mitigation is discussed in Section D3.7 and Chapter D4: Social Impact.

Communication interference in childcare and kindergartens assessment

Table D3.17 demonstrates the predicted noise impact and frequency for N70 overflights for childcare and kindergarten facilities for the 2046 Build versus No Build for the time period from 9am to 7pm.

Given enHealth Council (2004), Standards Australia (2015) and Department of Transport and Regional Services (2000) all recommend the same L_{max} indoors of 60 dB(A), the significance of the health effect is moderate. Mitigation is discussed in Section D3.7 and Chapter D4: Social Impact Section D4.7.3.

Communication interference in hospitals, hospice and respite care assessment

Table D3.17 demonstrates the predicted noise impact and frequency for N70 overflights for hospital, hospice and respite care facilities for the 2046 Build versus No Build for the time period from 6am to 11pm.

There is one facility located in the N70 contour in all 2046 Build scenarios.

The significance of the health effect is negligible.

Communication interference in aged care facilities assessment

Table D3.17 demonstrates the predicted noise impact and frequency for N70 overflights for aged care facilities for the 2046 Build versus No Build for the time period from 6am to 11pm.

Given enHealth Council (2004), Standards Australia (2015) and Department of Transport and Regional Services (2000) all recommend the same L_{max} indoors of 60 dB(A), the severity of the potential health effect is moderate. Mitigation is discussed in Section D3.7 and Chapter D4: Social Impact Section D4.7.3.

Communication interference in libraries assessment

Table D3.17 demonstrates the predicted noise impact and frequency for N70 overflights for libraries for the 2046 Build versus No Build for the time period from 6am to 11pm.

Given enHealth Council (2004), Standards Australia (2015) and Department of Transport and Regional Services (2000) all recommend the same L_{max} indoors of 60 dB(A), the severity of the potential health effect is moderate. Mitigation is discussed in Section D3.7 and Chapter D4: Social Impact Section D4.7.3.

Communication interference in maternal and child health centres assessment

Table D3.17 demonstrates the predicted noise impact and frequency for N70 overflights for maternal and child health centres for the 2046 Build versus No Build for the time period from 6am to 11pm.

Given enHealth Council (2004), Standards Australia (2015) and Department of Transport and Regional Services (2000) all recommend the same L_{max} indoors of 60 dB(A), the severity of the potential health effect is minor.

D3.6.2.6 Reading comprehension in children assessment: 2046 Build v No Build

Some studies on the effect of aircraft and road traffic noise show a 'linear exposure-effect association' between aircraft noise and the impairment of reading comprehension. That is, as noise exposure increases (across a range from low levels to high levels) reading comprehension may decrease.

In the RANCH study, the effect size of a one-fifth standard deviation of reading comprehension occurred with a 20dB(A) change in noise. Although this effect size is described as 'small' by the original study authors (Stansfeld et al., 2005) it has been included in this HIA.

The study done for M3R assessed primary, primary-secondary (P-12) and special development schools (greater than 37 dB(A) in the 2046 No build scenario) for any dB(A) increase in noise (LAeq 9am to 3pm).

The increase in aircraft noise between the 2046 Build and No Build scenarios shows no schools with a greater than 20dB(A) increase in noise LAeq. Therefore the severity of the potential health effect is concluded to be negligible.

D3.6.2.7 Migraine assessment

Participants at the Melbourne Airport Community Aviation Consultation Group raised the importance of migraines as part of the health assessment. It was therefore included in the study. As shown in Table D3.18, migraines may be triggered by over 30 factors and stimuli (NHS, 2016).

Identification of trigger factors and/or precipitants is often recommended as a basic strategy in preventing and treating migraine and tension-type headache. Trigger factors increase the probability of headache in the short term. Potential trigger factors have been examined most frequently in migraine and less often in tension-type headache. Data from prospective and controlled studies has shown that virtually all aspects of life have been suspected of triggering migraine or tension-type headache although scientific evidence for many of these triggers is poor (Wober and Wober-Bingol, 2010).

For individuals who are concerned about how existing aircraft noise and the M3R Build scenario might affect migraines, stress and anxiety may also be potential triggers. Unfortunately, it is extremely difficult to identify the underlying cause of migraines for any given individual, and no definitive association can be drawn between M3R and migraines.

Similar conclusions are also drawn in the WHO (2009) Night Noise Guidelines: as above, the WHO could not exclude an effect of noise in causing some acute psychological symptoms. This lack of empirical evidence linking aircraft noise and migraines precludes its inclusion in authoritative assessments (enHealth, 2004; WHO, 2012; European Environment Agency, 2010; Civil Aviation Authority, 2014; WHO, 2018).

Major project consultations, such as this MDP, in and of themselves could result in varying degrees of stress and anxiety in affected populations that could, if unaddressed, lead to manifest health disorders. As stated earlier, it is extremely difficult to identify the underlying cause of migraines for an individual person and therefore no association is drawn between the MDP process and migraines. Community involvement in the planning process, and provision of factual and robust information tailored to local community requirements to understand how and where community health is assessed and addressed, is one way to mitigate any potential stress and anxiety.

D3.6.3 Employment

Social and economic factors are the most significant determinants of health and wellbeing. They contribute to up to half of the typical health-status measures. In contrast, the contributions of the physical environment such as air quality and noise exposure are far less significant. These contribute approximately 10 per cent to health status – five times less than the contribution to health status from social and economic factors (Canadian Institute for Advanced Research, 2002). Of social and economic factors, employment and income are the two most dominant.

D3.6.3.1 Employment: qualitative assessment of health effects

The Melbourne Airport Master Plan (2018 current and 2022 proposed) discusses employment. It cites Melbourne Airport as a major employer in its own right, as the centrepiece of a major employment cluster, and as an enabler of wider employment for the state (e.g. tourism, freight). Likely substantial growth in jobs is highlighted and tourism spend is also a major contributor.

The employment and income effects of the Build scenario will be both direct and indirect, occur during construction and operation, and have implications at the local, state and national levels.

How employment affects community health

The social effects of having a job are experienced at three levels: by an individual, their family and communities. Having a job is critical to an individual's health and wellbeing, to others in the household, and to sustaining a vibrant community in which the household is situated (Ministry for Primary Industries, 2014).

The World Bank Development Report (2013) surmises:

> *'Jobs are transformational. They are more than just the earnings and benefits they provide. They are also the output they generate and part of who we are and how we interact with others in society. Jobs boost living standards, raise productivity and foster social cohesion.'*

Good jobs are those that improve the wellbeing of the individual who holds the job (without harming others). The best jobs for society are those that not only serve the individual person but which also produce positive

Table D3.18
The triggers of migraine

Emotional triggers	Physical triggers	Dietary triggers	Environmental triggers	Medication
Stress, anxiety, tension, shock, depression, excitement.	Tiredness, poor quality sleep, shift work, poor posture, neck or shoulder tension, jet lag, low blood sugar, strenuous exercise (if unaccustomed).	Missed, delayed or irregular meals, dehydration, alcohol, the food additive tyramine, caffeine products, specific foods (e.g. chocolate, citrus, cheese).	Bright lights, flickering screens such as a television or computer screen, smoking (or smoky rooms), loud noises, changes in climate (such as changes in humidity or very cold temperatures), strong smells, a stuffy atmosphere.	Some types of sleeping tablets, the combined contraceptive pill, Hormone Replacement Therapy (HRT).

spill-over benefits to the community (World Bank, 2013).

Individual physical and mental health benefits from employment

There is consistent and high-quality evidence that being out of work (i.e. unemployed) is bad for the physical and mental health of people of all ages. The opposite is also evident – a job is good for physical and mental health (Royal Australasian College of Physicians, 2011; Waddell and Burton, 2006).

When people move off social welfare and into a job, their physical and mental health improves. It is concluded by evidence-based documents (Royal Australasian College of Physicians, 2011; Royal College of Psychiatrists, 2014; Waddell and Burton, 2006) that 'These findings are not just associations. For people, being in-work causes, contributes to or accentuates…' outcomes such as (Winkelmann et al., 1998):

- Lower death rates (i.e. the number of deaths in a population over a specific time period calculated for all-causes of death or specific diseases/events) particularly from cardiovascular disease and suicide
- Better physical health – particularly lower rates of cardiovascular disease, lung cancer and respiratory infections
- Better mental health, psychological wellbeing and self-esteem
- Lower rates of long-standing illness
- Lower rates of poor general health
- Lower rates of somatic complaints (mental disorder where symptoms suggest physical illness or injury but no medical cause can be found)
- Lower rates of disability
- Lower GP consultation rates, use of medication, and admissions to hospital
- Higher self-respect.

In contrast to the positive effects of employment, Aylward (2010) did a comprehensive review of studies that showed long-term unemployment led to a:

- Health risk similar to smoking 10 packets of cigarettes per day
- 40-fold increase in risk of suicide for young men out of work for longer than six months compared to those in work
- Six-fold increase in risk of suicide for all population groups out of work longer than six months compared to those in work
- For young people in particular, unemployment causes or accentuates depression, anxiety and/or low self-esteem.

These in turn affect physical health outcomes for many young people. These include heavy tobacco, alcohol and drug use, as well as higher death rates from suicide and accidents (Royal Australasian College of Physicians, 2011).

Although there has been considerable debate about the causality of unemployment in mortality outcomes, recent work supports causality (Clemens et al., 2014; Meneton et al., 2015; Roelfs et al., 2011).

Importantly for this assessment, the adjusted effects from Roelfs et al. (2011) showed no significant changes in the association over the past four decades. The authors suggest the association is stable enough for use in future-focused assessments (such as HIA). The authors also said that policy differences between countries did not statistically alter the association (Roelfs et al., 2011), meaning the findings may be applied across countries.

Family health benefits from employment

The influence of having at least one person in the household with a job extends to a family's children. The impact on them from a parent in a job paying a living wage is (Royal Australasian College of Physicians, 2011):

- A lower likelihood of chronic illnesses and psychosomatic symptoms, and higher wellbeing
- Less likely to be unemployed as adults, either intermittently or over their entire life
- Psychological distress is less likely when their parents face reduced economic pressure. This in turn lessens the likelihood of withdrawal, anxiety and depression in the children, and reduces the likelihood of aggressive, delinquent behaviour and substance abuse.

A substantial position statement from the US also reports similar impacts on families and children from one or more parents having a job (American Psychological Association, 2014) including:

- Higher individual and family wellbeing
- Less punitive and arbitrary punishment of children
- Lower rates of distress and depressive symptoms in children, which leads to reduced risk of academic problems, substance abuse and risk of suicide.

The World Bank Development Report (2013) also concludes a lack of employment could lower the self-esteem and undermine the social status of other family members.

Community health benefits from employment

The health benefits for local communities from employment have not previously been studied for airport developments.

Only a small number of cohort studies have tackled the links between employment and community health effects. There are therefore insufficient relative risks or odds ratios from which to develop quantitative estimates.

The cohort studies considering the social gradient of health (whereby people less advantaged in terms of socioeconomic position have worse health and shorter lives than those more advantaged) substantially overlap with employment and mortality studies. This means further calculation here may substantially double-count the effect. Therefore, this health assessment adopts a similar qualitative approach (Arup and Partners Ltd, 2012) and considers if the employment effect is likely positive or negative, while making comment on the likelihood of the effect occurring. This is a practical approach for dealing with impacts that cannot easily be quantified.

The qualitative health effects likely from creation of 37,000 jobs in 2046 (comparing the Build versus No Build) include improvements in:

- Social contact and cohesion
- Sense of identity and contribution to society
- Placement on the social gradient of health and consequent improvement in physical and mental health.

Main job types created by M3R construction

During the construction process an additional 10,700 direct and indirect construction jobs are expected to be created, and are considered in the qualitative assessment.

These will be concentrated in the construction industry with associated benefits – largely in the construction industry – but with flow-on effects in wholesale trade, retail and manufacturing.

Many of the new jobs added in retail, manufacturing and wholesale are likely to be more diffused around Melbourne. Of the 10,700 direct and indirect construction jobs, 500+ direct construction jobs a year are expected to be created in the Melbourne Airport local area.

Main job types created by M3R operation

For Build versus No Build, the additional direct and indirect employment created in 2046 is ~37,000 jobs. When construction is complete and the airport is operational, approximately 500 additional jobs per year are expected to be created as a result of M3R. This will increase over time, to more than 2,000 jobs per year.

Historically, at least two-thirds of employees in direct airport jobs are drawn from the six LGAs closest to Melbourne Airport. Of these, Melbourne Airport provides direct employment for one in six in the City of Hume's workforce, and approximately one in 20 across the six LGAs in total. It is expected that the workforce required to support the additional direct jobs generated by M3R will continue to be sourced from these surrounding communities in coming decades.

The indirect jobs generated are expected to predominantly be in accommodation services, 'other construction', business services, wholesale trade and retail. These are more likely to be diffused throughout Victoria. Although some new retail and accommodation jobs will be located at the airport due to increased flights, boosts to the tourism industry attributable to M3R will result in more jobs in tourist areas around Melbourne and Victoria.

In terms of employment more generally, it is important to note that the infrastructure expansion provided at Melbourne Airport (in the Build scenario) will improve Victoria's infrastructure system. Together with the proposed Melbourne Metro, there will be a cumulative enhancement of the state's ability to connect to the global economy. This will help improve the long-term productivity outcomes for all employees and businesses.

Skill base, barriers and employment-support programs

To be able to take advantage of the jobs created by M3R, the workforce in the Melbourne region needs a skill set matching the job types created. Based on information from Jobs Victoria, there is expected to be a match as there are large existing retail, wholesale trade and construction sectors in the Melbourne region.

At the Commonwealth Government level, Jobactive would work closely with major subcontractors to place unemployed workers. Jobactive connects job seekers with employers and is delivered by a network of Jobactive providers in over 1,700 locations across Australia.

Employers can use a local Jobactive provider for tailored recruitment services, at no cost to their business. Jobactive providers can work closely with employers to understand their recruitment needs, and for job seekers, a Jobactive provider can help them get and keep a job. Jobactive providers have the flexibility to tailor their services to a job seeker's assessed needs. According to Jobs Victoria, most major subcontractors would already have a strategic relationship with Jobactive.

Jobs Victoria Employment Network is a Victorian Government agency to help disadvantaged Victorian jobseekers gain employment. Its services are delivered by specialist employment experts who work closely with employers to identify job opportunities and prepare job seekers for those roles.

The network engages with employers to identify job opportunities and assist industries to meet their workforce needs. The network also offers flexible services to disadvantaged jobseekers and is responsive to local and regional needs. It provides services that address gaps in, and complement, existing services including Commonwealth services. According to Jobs Victoria, most major subcontractors would already have a strategic relationship with Jobs Victoria Employment Network.

D3.6.3.2
Indirect employment: quantitative assessment of health effects Build v No Build

A quantitative assessment of deaths avoided can be calculated from the numbers of unemployed provided with jobs and the mortality hazard ratio for being unemployed.

The calculation provides a best-case scenario (based on the methodology described in **Section D3.2.5.2**). A similar calculation has been done only twice before for an airport HIA. These were for two airports in the UK: Stansted Airport's second runway (Environmental Resources Management, 2008) and Manston Airport (RiverOak Strategic Partners, 2018). Several caveats exist around the data:

- Estimates hold only if, as these new jobs are filled, the person taking that job creates an opportunity for a new employee at their old job and so on – until it provides an opportunity for a person not employed (i.e. a person entering or re-entering the workforce who is previously unemployed). This is a valid assumption for measurement of flow-on effects such as jobs created
- The hazard ratio is derived from adjusted data from multiple jurisdictions (including Australia)
- The hazard ratio is based on the negative health effects of unemployment rather than the positive effects of employment, and so may overestimate the effect
- Different types of employment are associated with different sets of health gains.

The assessment of mortality avoided for the 2046 Build versus No Build is presented in **Table D3.19**.

Thirty-eight indirect deaths are projected to be avoided due to employment (2046 Build versus No Build).

Table D3.19
Mortality avoided, indirect employment (regional employment)

Change in number of jobs created (in 2046 Build vs No Build)	Unemployed mean adjusted mortality hazard ratio	Premature mortality rate (per 10,000) for Greater Melbourne	Difference in indirect deaths
37,000	1.63 (difference of 0.63) (Roelfs et al, 2011)	161	-38

D3.7 MITIGATION AND ENHANCEMENT OF POTENTIAL HEALTH EFFECTS

Melbourne Airport recognises that it has to balance its role as a primary aviation gateway for passengers and freight in Victoria with the needs of the local communities. Melbourne Airport therefore continues to implement the long-term planning decisions made regarding its Tullamarine site and the safeguarding policies of successive governments.

This assessment of M3R's health impacts has been described in terms of the severity of each type of impact. Regarding the assessment framework described in **Section D3.4**, when combined with the likelihood of the impact, medium risk ratings are assessed for communication interference, annoyance and sleep disturbance. APAM will continue to work proactively with governments, airlines, Airservices Australia, industry partners and local communities to manage and mitigate these impacts.

Chapter C4: Aircraft Noise and Vibration describes the noise mitigation and operational management measures that have flowed through into the data assessed in this chapter.

As part of developing the detailed airspace design (following this MDP), APAM will continue to work with stakeholders to develop a noise-monitoring and management plan based on the International Civil Aviation Organisation's Balanced Approach to managing aircraft noise.

This Balanced Approach includes principles such as reducing the noise at source (e.g. quieter aircraft engines), enhancing land use planning controls to prevent inappropriate development in noise-sensitive areas and operational procedures that can be designed to reduce noise impacts for local communities.

Mitigation measures to reduce NO_2 and PM are included in **Chapter B10: Air Quality** and, when implemented, will further reduce the PM and NO_2 emissions generated. It is also worth noting that, for the 2046 Build scenario assessment, the modelling assumed no future reductions in aircraft emissions technology. However, on the basis that emissions reduction has occurred over the past several decades – and is expected to continue into the future – the results of this chapter are likely to overestimate the actual level of risk. Therefore, no further mitigation or monitoring is recommended for these emission types.

Regarding enhancement of employment, Jobs Victoria places vulnerable people into roles and does not require any direct assistance from Melbourne Airport for this. Keeping Jobs Victoria up to date with M3R progress would assist their internal planning. No mitigation or monitoring is therefore recommended.

The ongoing Master Plan process will continue to develop and evolve monitoring and management strategies to ensure that health commitments are appropriately delivered.

D3.8 CONCLUSION

This chapter provides the assessment of the health effects caused by aircraft noise and emissions resulting from the M3R project.

The noise health assessment is based on data from chapters **C4: Aircraft Noise and Vibration** and **D4: Social Impact**; the air quality health assessment is based on data from **Chapter B10: Air Quality**; and the employment impact assessment based on data from **Chapter D2: Economic Impact Assement**. Data from **Chapter D4: Social Impact** is used to underpin the understanding of local communities impacted by the project.

The chapter assessment summary is presented in **Table D3.20**. Overall, when comparing the 2046 Build versus No Build scenarios, across air quality, noise and employment, the findings/assessments are:

- Adverse risk of impact from daytime aircraft noise is projected to occur for communication interference in community buildings and annoyance of people. The likelihood of these effects occurring is likely
- Arising from night night-time aircraft noise, a potential moderate effect on sleep disturbance is projected to occur. The likelihood of this effect is likely.
- For air quality, the risks of impact for PM_{10}, $PM_{2.5}$, NO_2, benzene and formaldehyde are negligible. CO and SO_2 concentration is forecast to be below the SEPP (AQM) at all modelled receptors in all scenarios, and therefore acceptable
- Beneficial impacts due to employment are projected in terms of avoided mortality - and on community, family and individual health
- M3R provides alternative modes of parallel runway operation that give significant opportunities for night-time noise abatement to minimise impacts of noise and disturbance – and to provide relief – for areas of the Greater Melbourne urban district
- It is not only extremely difficult to identify the underlying cause of migraines for the individual but also for this M3R health assessment. Therefore, no association between the 2046 Build and migraines can be made.

Overall, from a health outcome perspective, the beneficial health outcomes that affect mortality outweigh the less-serious negative health outcomes of sleep disturbance, annoyance and communication interference. However, it is important not to disregard the impact of these less-serious noise effects on those affected.

Table D3.20
Impact assessment summary

Environment aspect & baseline condition	Assessment of original impact: Original Impact	Mitigation inherent in design/practice	Significance: Duration	Severity	Likelihood	Impact	Mitigation and/or management measures	Assessment of residual impact: Residual Impact	Significance: Duration	Severity	Likelihood	Impact
Operation												
Air quality – PM2.5 in dust PM2.5 exceeded the NEPM standard during baseline monitoring but were related to Melbourne-wide issues due to bushfire smoke	Negative effect, mortality and hospitalisation	See **Chapter B10: Air Quality**	Permanent	Negligible	Rare	Negligible	See **Chapter B10: Air Quality**					
Air quality – PM10 As per PM2.5 above	Mortality and hospitalisation	See **Chapter B10: Air Quality**	Permanent	Negligible	Rare	Negligible	See **Chapter B10: Air Quality**					
Air quality – NO2 Low. with no exceedances	Mortality and hospitalisation		Permanent	Minor	Rare	Negligible						
Air quality – CO Very low, no exceedances	Exceedance of standard to protect health		Permanent	Negligible	Rare	Negligible						
Air quality – SO2 Very low, no exceedances	Exceedance of standard to protect health		Permanent	Negligible	Rare	Negligible						
Air quality – benzene and formaldehyde Low, no exceedances	Lifetime risk of cancer		Permanent	Negligible	Unlikely	Negligible						
Employment Substantial existing employment in related job types	Individual, family and community health benefits	See **Chapter D2: Economic Impact Assement**	Permanent	Beneficial	Almost certain	Beneficial	N/A					
	Indirect effect on deaths avoided		Permanent	Beneficial	Likely	Beneficial						

Environment aspect & baseline condition (cont.)	Assessment of original impact (cont.)						Mitigation and/or management measures (cont.)	Assessment of residual impact (cont.)				
	Original Impact	Mitigation inherent in design/practice	Duration	Significance: Severity	Significance: Likelihood	Significance: Impact		Residual Impact	Duration	Significance: Severity	Significance: Likelihood	Significance: Impact
Operation												
Noise – day and night N70 (over a 24-hour period) extends north, south, east and west of the existing runways. N-above extends along the runway centrelines in each direction	Communication interference at community institutions	See **Chapter C4: Airspace Noise and Vibration**	Permanent	Moderate	Likely	Medium	As part of the work to develop the detailed airspace design (post-MDP), APAM will continue to work proactively with stakeholders to develop a noise monitoring and management plan based on the International Civil Aviation Organisation (ICAO) 'Balanced Approach' to managing aircraft noise. There are several operating modes available for consideration that reduce the number of dwellings exposed to night noise (e.g. segregated modes Option 1 and 2). These options shall be included in community engagement initiatives. Melbourne Airport will encourage Airservices Australia to manage operations to extend the use of the noise abatement preferred modes procedures in the evening and early mornings as long as possible whilst operating conditions allow (based on safety, operational, efficiency and weather considerations).		Permanent	Moderate	Likely	Medium
	Reading comprehension in primary school children		Permanent	Negligible	Unlikely	Negligible			Permanent	Negligible	Unlikely	Negligible
	High annoyance of people		Permanent	Moderate	Likely	Medium			Permanent	Moderate	Likely	Medium
	Noise induced awakenings		Permanent	Minor	Possible	Low			Permanent	Minor	Possible	Low
	Highly sleep disturbed people		Permanent	Moderate	Likely	Medium			Permanent	Moderate	Likely	Medium
	Myocardial infarction		Permanent	Negligible	Rare	Negligible			Permanent	Negligible	Rare	Negligible

REFERENCES

American Psychological Association (APA) 2014, Psychological effects of unemployment and under employment, Washington.

Arup and Partners Ltd 2012, London Luton Airport health impact assessment, Ove Arup and Partners Ltd, accessed 2017, http://www.apho.org.uk/resource/item.aspx?RID=134376

Australia Pacific Airports (Melbourne) Pty. Ltd. (APAM) 2018, Melbourne Airport Master Plan 2018 Preliminary Draft, accessed August 2018, https://www.melbourneairport.com.au/ Corporate/Planning-projects/Master-plan

Aylward, M. 2010, Realising the health benefits of work, Australasian Faculty of Occupational and Environmental Medicine, accessed 2017, https://sia.org.au/downloads/ News-Updates/Realising_the_health_benefits_of_work_AFOEM_Draft.pdf

Brisbane Airport Corporation Pty Ltd. (BAC) 2007, New Parallel Runway Draft EIS/MDP. Supplementary Report. Volume D. Airspace Health Impact Assessment, Brisbane.

R. Bullen, A. Hede and T. Willams. "Sleep disturbance due to environmental noise: a proposed assessment index." Acoustics Australia 24 (1996): 91-96.; Federal Interagency Committee on Aviation Noise (FICAN), "Effects of Aviation Noise on Awakenings from Sleep", June 1997)

Canadian Institute for Advanced Research 2002, Estimated impact of determinants of health status of the population, Canada.

Civil Aviation Authority 2013, ERCD Report 1208, Aircraft noise, sleep disturbance and health effects: a review, Environmental Research.

Civil Aviation Authority 2014, Aircraft noise, sleep disturbance and health effects, Environmental Research, accessed 2017 http://publicapps.caa.co.uk/docs/33/CAP%20 1164_Aircraft%20noise_and_health.pdf

Civil Aviation Authority 2016, Aircraft noise and health effects: Recent findings, CAP 1278, accessed 2017, https://publicapps.caa.co.uk/docs/33/CAP%201278%20MAR16.pdf

Civil Aviation Authority 2016, CAP 725 CAA Guidance On The Application Of The Airspace Change Process, accessed 2017 https://publicapps.caa.co.uk/docs/33/CAP%20725%20update%20March%202016%20amend.pdf

Clemens, T., Popham, F. and Boyle, P. 2014, What is the effect of unemployment on all-cause mortality? A cohort study using propensity score matching, European Journal of Public Health, vol. 25, no. 1, pp. 115-121.

Department of Health 2014, Victorian Population Health Survey 2017, Victorian Govt. Pub. Services, https://www2.health.vic.gov.au/public-health/population-health-systems/health-status-of-victorians/survey-data-and-reports/victorian-population-health-survey/victorian-population-health-survey-2017.

Department of Health and Human Services 2015, Victorian Public Health and Wellbeing Plan 2015-2019, Victorian Govt. Pub. Services, accessed 2017, https://www2.health.vic.gov.au/ about/health-strategies/public-health-wellbeing-plan

Department of Health and Human Services 2019, Victorian Public Health and Wellbeing Plan 2019-2023, Victorian Government.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2013, Significant Impact Guidelines 1.2 – Actions on, or impacting upon, Commonwealth land and Actions by Commonwealth Agencies.

Department of Transport and Regional Services 2000, Discussion Paper, Expanding Ways to Describe and Assess Aircraft Noise, Australian Govt. Pub. Services, accessed 2017, https://infrastructure.gov.au/aviation/environmental/transparent_noise/expanding/pdf/sepb_discussion_paper.pdf

enHealth 2001, Health impact assessment guidelines, Canberra, Australian Govt. Pub. Services.

enHealth 2004, The health effects of environmental noise – other than hearing loss, enHealth Council', accessed 2017, http://waubrafoundation.org.au/wp-content/ uploads/2013/03/EnHealth-Environmental-Noise-in-Australia-2004.pdf

enHealth 2012, Environmental health risk assessment: Guidelines for assessing human health risks from environmental hazards, enHealth Council, accessed 2017, http://www.eh.org.au/documents/item/916

enHealth 2018, The health effects of environmental noise, Canberra, Department of Health.

Environment Protection Authority Victoria 2021, Guideline for assessing and minimising air pollution in Victoria, Victoria State Government.

Environment Protection and Heritage Council (EPHC) 2005, Expansion of the multi-city mortality and morbidity study, Final Report, Volume 3, Tabulated results, Environment Protection and Heritage Council, accessed 2017, http://www.nepc.gov.au/system/files/resources/220add0d-0265-9004-1d22-0c312998402c/files/aq-multi-city-mm-vol3- data-sept-final-201009.pdf

Environmental Resources Management 2008, The Stansted Generation 2 Project: A health impact assessment, United Kingdom, BAA Ltd.

European Environment Agency 2010, Good practice guide on noise exposure and potential health effects, European Environment Agency, accessed 2017, https://www.eea.europa.eu/publications/good-practice- guide-on-noise

Hygge, S., Evans, G., and Bullinger, M. 2002, A prospective study of some effects of aircraft noise on cognitive performance in school children, Psychological Science, vol. 13, no. 5, pp. 1-6.

Jalaludin, B., and Cowie, C. 2012, Health Risk Assessment– Preliminary Work to Identify Concentration-Response Functions for Selected Ambient Air Pollutants, Victorian Govt. Pub. Services, accessed 2017, http://www.nepc.gov.au/ system/files/pages/18ae5913-2e17-4746-a5d6-ffa972cf4fdb/ files/health-report.pdf

KR/AF and Arup 2013, London Luton Health Impact Assessment, London.

Meneton, P., Kesse-Guyot, E., Mejean, C., Fezeu, L., Galan, P., Hercberg, S., and Ménard, J. 2015, Unemployment is associated with high cardiovascular event rate and increased all-cause mortality in middle aged socially privileged individuals, Int Arch Occup Environ Health, vol. 88, pp. 707-716.

Miedema, H., and Vos, H. 2007, Associations between self- reported sleep disturbance and environmental noise based on reanalyses of pooled data from 24 studies, Behavioural sleep medicine, vol. 5, pp. 5-20.

Miedema, H., and Vos, H. 2004, Self-reported sleep disturbance caused by aircraft noise, Institute for Traffic and Transport, Logistics and Spatial Development, accessed 2017, https://circabc.europa.eu/webdav/CircaBC/env/noisedir/Library/Public/health_effects_noise/Aircraft%20noise%20and%20sleep%20TNO%202004.pdf

Ministry for Primary Industries 2014, The social value of a job, New Zealand Government, accessed 2017, https://www.mpi.govt.nz/document-vault/5266

Mott MacDonald 2014, Expansion of Hong Kong International Airport into a three-runway system, Environmental Impact Assessment Report, Chapter 17 Health impact, EPD Hong Kong, accessed 2017, http://www.epd.gov.hk/eia/register/report/eiareport/eia_2232014/html/ES_Rev%20C.pdf

National Environment Protection Council 1998, National Environment Protection (Ambient Air Quality) Measure, National Environment Protection Council Service Corporation, https://www.comlaw.gov.au/Details/C2004H03935

National Environment Protection Council 2003, Impact statement for the National Environment Protection (air toxics) Measure, National Environment Protection Council Service Corporation, Adelaide.

National Environment Protection Council 2011, National Environment Protection (Air Toxics) Measure, Australian Govt. Pub. Services, accessed 2017, https://www.legislation.gov.au/ Details/F2011C00855

National Environment Protection Council 2016, National Environment Protection (Ambient Air Quality) Measure, Australian Govt. Pub. Services, accessed 2017, https://www.legislation.gov.au/Details/F2016C00215

National Environment Protection Council 2019, Draft Variation to the National Environment Protection (Ambient Air Quality) Measure for sulfur dioxide, nitrogen dioxide and ozone. Canberra: Commonwealth of Australia.

National Health Service (NHS) 2016, Causes of Migraine, accessed 2017 https://www.nhs.uk/conditions/migraine/ causes/

Office of Environmental Health Hazard Assessment 2017, Cancer Potency Information: Formaldehyde and Benzene, California Office of Environmental Health, http://oehha.ca.gov/ chemicals/formaldehyde; and http://oehha.ca.gov/ chemicals/benzene.

Pacific Environment Ltd 2015, Appendix G Community health report, Western Sydney Airport EIS, Pacific Environment Ltd, accessed 2017, http://westernsydneyairport. gov.au/resources/eis/files/WSA-EIS-Volume-4-Appendix-G- Community-health.pdf

Perth Airport Corporation 2017, New Runway Project, Preliminary Draft Major Development Plan, Volume C: Airspace Management Plan, Chapter 24: Health.

RiverOak Strategic Partners 2018, 5.2-2 Environmental Statement Volume 2:Main Text – Chapters 11– 16, RiverOak Strategic Partners, accessed 2020, https://infrastructure.planninginspectorate.gov.uk/projects/south-east/manston-airport/?ipcsection=overview

Roelfs, D., Shor, E., Davidson, K., and Schwartz, J.E. 2011, Losing life and livelihood: A systematic review and meta- analysis of unemployment and all-cause mortality, Social Science and Medicine, vol. 72, pp. 840-854.

Royal Australasian College of Physicians 2011, Australian and New Zealand Consensus Statement of the health benefits of work, Position Statement: Realising the health benefits of work, Wellington.

Royal College of Psychiatrists 2014, Is work good for your mental health?', accessed 2017, http://www.rcpsych.ac.uk/usefulresources/workandmentalhealth/worker/isworkgoodforyou.aspx

RPS 2013, London City Airport: City Airport Development Programme, Health and Equalities Impact Assessment, RPS Group, Brighton.

RPS 2015, City Airport Development Programme, Updated health impact assessment, accessed 2017, https://www.londoncityairport.com/content/cadp/CADP%201%20Submitted%20Material/CADP%20Updated%20Reports/CADP%20HIA%20(Final).pdf

Sharp, B., Connor, T., McLaughlin, D., Clark, C., Stansfeld, S.A., and Hervey, J. 2014, Assessing aircraft noise conditions affecting student learning, Airport Cooperative Research Program, accessed 2017, https://www.scribd.com/document/301662729/Assessing-Aircraft-Noise-Conditions-Affecting-Student-Learning

Standards Australia 2015, Acoustics – Aircraft noise intrusion – Building siting and construction, accessed 2017, https://www.planning.vic.gov.au/__data/assets/pdf_ file/0014/10508/2021-2015.pdf

Stansfeld, S., Berglund, B., Clark, C., et al. 2005, Aircraft and road traffic noise and children's cognition and health: A cross national study, The Lancet, vol. 365, pp. 1942-1949, 2005.

Sunshine Coast Council 2014, Sunshine Coast Airport Expansion Project Environmental Impact Statement, Queensland Govt. Pub. Services, accessed 2017, http://statedevelopment.qld.gov.au/assessments-and-approvals/sca-expansion-project-eis-documents.html

The Committee on the Medical Effects of Air Pollutants (COMEAP) 2009, Long-Term Exposure to Air Pollution: Effect on Mortality, accessed 2017, https://www.gov.uk/government/publications/comeap-long-term-exposure-to- air-pollution-effect-on-mortality

The Committee on the Medical Effects of Air Pollutants (COMEAP) 2011, Review of the UK air quality index. A report by the Committee on the Medical Effects of Air Pollutants, accessed 2017, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/304633/COMEAP_ review_of_the_uk_air_quality_index.pdf

The Committee on the Medical Effects of Air Pollutants (COMEAP) 2015, Interim statement on quantifying the association of long-term average concentrations of nitrogen dioxide and mortality, accessed 2017, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/485373/COMEAP_NO2_Mortality_Interim_Statement.pdf

Thurston, G.D., Burnett, R.T., Turner, M.C., Shi, Y., Krewski, D., Lall, R., Ito, K., Jerrett, M., Gapstur, S.M., Diver, W.R., and Pope, C.A. III. 2016, Ischemic Heart Disease Mortality and Long-Term Exposure to Source-Related Components of U.S. Fine Particle Air Pollution, Environmental Health Perspectives, vol. 124, pp. 6.

Victorian Government 1999, State Environment Protection Policy (Ambient Air Quality) No. S 19, Victoria Government Gazette, accessed 2017, http://www.gazette.vic.gov.au/gazette/Gazettes1999/GG1999S019.pdf

Victorian Government. (2001). State Environment Protection Policy (Air Quality Management). No. S240, Victoria Government Gazette, accessed 2017.

Victorian Government 2016, 2016 – Variation to the State Environment Protection Policy (Ambient Air Quality): G 30, Victoria Government Gazette, accessed 2016, http://www.epa. vic.gov.au/about-us/legislation/~/media/Files/about_us/Legislation/Air/GG2016G030-AAQ-SEPP-particles-variation.pdf

Waddell, G., and Burton, K. 2006, Is work good for your health and well-being? The Stationery Office, London.

Winkelmann, L., and Winkelmann, R. 1998, Why are the unemployed so unhappy? Evidence from panel data, Economica, vol. 65, pp. 1-15.

Wober, C., and Wober-Bingol, C. 2010, Triggers of migraine and tension-type headache, Handbook of Clinical Neurology, vol. 97, pp. 161-72.

World Bank 2013, Development Report: Jobs, accessed 2017, http://siteresources.worldbank.org/EXTNWDR2013/Resources/8258024-1320950747192/8260293-1322665883147/WDR_2013_Report.pdf

World Health Organization (WHO) 2005, Air Quality Guidelines, Global Update, WHO, Copenhagen.

World Health Organization (WHO) 2009, Night noise guidelines for Europe, accessed 2017, http://www.euro.who. int/__data/assets/pdf_file/0017/43316/E92845.pdf

World Health Organization (WHO) 2011, Burden of disease from environmental noise, World Health Organization Regional Office for Europe and JRC European Commission, http://www.euro.who.int/__data/assets/pdf_ file/0008/136466/e94888.pdf.

World Health Organization (WHO) 2012, Burden of disease from environmental noise, Geneva.

World Health Organization (WHO) 2018, Environmental noise guidelines for the European region, accessed 27 November 2018, http://www.euro.who.int/en/health-topics/ environment-and-health/noise/environmental-noise-guidelines-for-the-european-region