Riverview Projects (ACT) Pty Limited
18-Jun-2014

West Belconnen Strategic Environmental Assessment

Air Quality Review

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Client: Riverview Projects (ACT) Pty Limited

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Executive Summary

West Belconnen is a major area of future development for Canberra over the next 30 to 40 years. The proposed development involves the creation of new residential suburbs and their associated community and commercial facilities, accommodating around 11,500 dwellings and 30,000 people when fully developed. The purpose of this Air Quality Review (AQR) was to assess the potential effects on air quality in the local area that might result from the development and particularly the impact on the use of domestic wood burners on air quality.

This AQR reviewed the climate and geographic setting of the development area and identified existing air quality issues in the Australian Capital Territory (ACT) region that might affect the West Belconnen development and potential changes to air quality that the development may cause. Additionally, mitigation measures were recommended to minimise any potential adverse effects.

The development area consists of relatively flat lands for the majority of the site with only moderate slopes on the western and southern borders. A drainage line running on the western border of the site has the potential to carry katabatic winds (drainage flows) from the development down to other areas of Canberra. The development area and, more specifically, the southern regions of the ACT are likely to experience significant temperature inversions during cold, clear nights; the potential for pollution entrapment at ground level increases under such conditions. The presence of pollution emissions during these times, specifically wood heater emissions during winter, might exacerbate the potential health impacts on those residents in the development and surrounding areas.

Existing air quality in the ACT is considered to be excellent, with the exception of particulate matter and possibly ozone. The proposed development will affect air quality in the local area by introducing additional pollution sources above those already present. The primary potential pollution sources likely to affect air quality in the development area are bushfires (including back-burning/hazard reduction activities), wood heaters and vehicles.

Following the release of the 2011 ACT Air Quality Report that identified breaches of the particulate reporting standard, the Minister for Environment and Sustainable Development announced the prohibition of wood heaters in the majority of the neighbouring Molonglo Development. Similar considerations were suggested in a review of air quality issues in the Molonglo Valley prepared by AECOM (2011). A review of current literature regarding wood heater use was undertaken and identified and discussed several updated sources of knowledge and options for the control and mitigation of wood smoke emissions pertinent to the development.

The issue of wood heater emissions control and regulation is an ongoing area of research, with several outstanding research projects / legislative reviews still to be delivered. Given the progressive nature of wood smoke and particulate research, and the pending delivery of several significant projects, strong consideration should be given to implementing a strict level of wood heater efficiency or even prohibiting wood heaters in the development area until such time as an industry / government approach has been reached.

The mitigation measures provided below have been selected from cited literature sources and represent the more stringent level of efficiency and emissions referenced (specifically ACT Parliamentary Counsel 2012) and should be considered for the West Belconnen development together with continued government campaigns and regulation:

- Wood heater overall efficiency standard of not less than 65%;
- Wood heater emissions standard not greater than 1 g/kg;
- Education on the use of wood heaters;
- Controls on installation and 2nd-hand heaters;
- Encouragement for the use of pellet heaters over standard wood heaters;
- Continuation of the ACT Government education and information programs such as the ‘Don’t Burn Tonight’ campaign; and
- Continual review of relevant legislation, industry standards and guidelines and documents prepared such as the impending delivery of the National Plan for Clean Air and COAGs response to the Regulation Impact Statement.

The AQR recommends that the ACT government should re-assess its initial decision to discontinue ambient monitoring in the north of the ACT. Anecdotal evidence suggests that this is in the process of occurring, with money set aside in the budget for the station. Monitoring information can provide the necessary recommendations to residents as required by the *Don't Burn Tonight* and other campaigns. Such an action will enable pollutant concentrations in the area to be monitored, and will further increase the available knowledge of the Canberra airshed.

Considering the development is still at an early design phase, and with the progressive delivery of key research projects and legislative reviews, consideration should be given to re-evaluating the findings of this report when more information is available at a later stage of design development.

1.0 Introduction

The Australian Capital Territory (ACT) Government has identified the West Belconnen development as a major area of future development for Canberra over the next 30 to 40 years, supporting approximately 11,500 dwellings and 30,000 people when fully developed. The proposed development is to be staged over a number of years, resulting in the creation of new residential suburbs, and will include community and commercial facilities such as schools, shops, parks, green spaces and playgrounds in the West Belconnen area.

The ACT Government intends to implement best practice urban design, including the highest standards in energy efficiency, water conservation, solar access and ecological sustainability, to minimise the effects of the development on the natural environment.

Riverview Projects (ACT) Pty Ltd (Riverview) commissioned AECOM to review the potential air quality impacts associated with the proposed development of the West Belconnen development area. The key objectives of the Air Quality Review (AQR) were to:

- Understand the climate of the West Belconnen development area;
- Identify the current air quality risks for the West Belconnen development;
- Identify impacts that development within the West Belconnen area may have on the local air quality; and
- Recommend potential mitigation measures.

1.1 Scope of Work

The scope of work for the AQR was as follows:

- Identification of the climate/geographic setting of the West Belconnen development by reviewing available existing meteorological and topographical data representative of the study area;
- Identification of the current air quality issues for the West Belconnen development by reviewing available existing air quality data representative of the study area;
- Identification of the effects that development within the West Belconnen development may have on the air quality of the area; and
- Recommendation of potential mitigation measures during the operational phases of the development.

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2.0 Background

2.1 Project Background

In 2004, the ACT Government released The Canberra Plan (CMD, 2004) to guide Canberra's future growth and development. The Canberra Plan has three main components: The Canberra Spatial Plan, the Canberra Social Plan and the Canberra Economic White Paper. The aim of the strategic direction outlined in the Spatial Plan is to manage the change necessary to achieve sustainable urban growth that balances social, economic and environmental outcomes and fulfils the aspirations of the community.

The West Belconnen development plan commenced under ACT Legislation in December 2008. This plan enabled urban development in parts of the West Belconnen development through the introduction of urban zones and a structure plan. It responds to the strategic direction provided by The Canberra Spatial Plan, which identified the West Belconnen development as Canberra's next major urban area.

2.2 Location and Regional Context

The proposed development is in an area covering around 1,600 hectares adjacent to the existing ACT suburbs of Holt and Macgregor and approximately 13 km northwest of the Canberra central business district as shown in **Figure 1** . The two main connections from the existing suburbs are from Parkwood Road and Drake Brockman Drive. The site is surrounded by undulating land particularly on the western edge of the development. The Murrumbidgee River runs from the south to the north through the valley on the west of the proposed development and the Ginninderra Creek runs on the east of the proposed site. The land has historically been used for rural purposes, and much of the area has been cleared. There is also an existing recycling facility which is located in the centre of the proposed development.

2.3 Site Description

The key site features are summarised in the following sections.

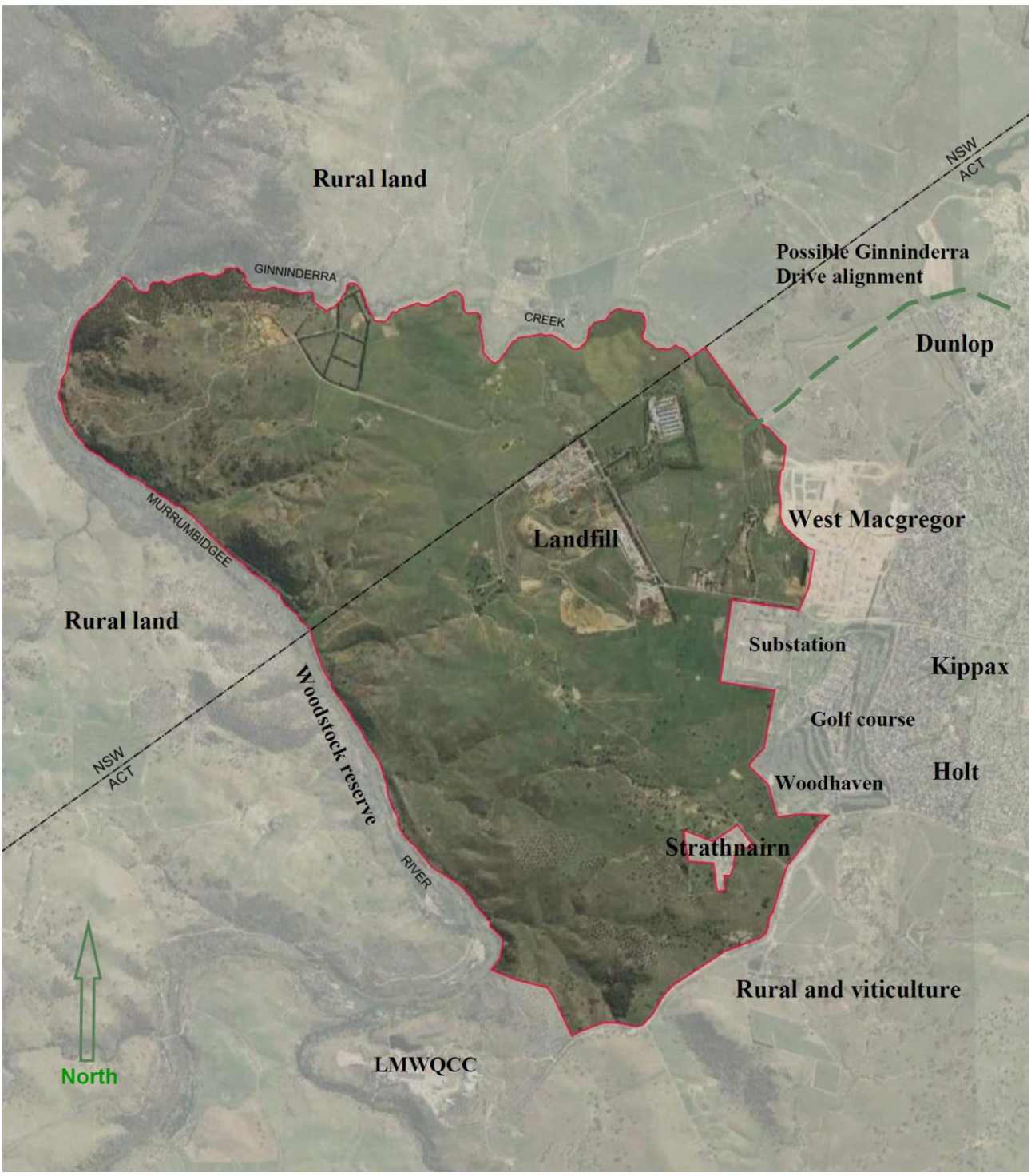

Figure 1 West Belconnen Site Location

2.3.1 Topography

The area of the valley consists of flat land interspersed with moderate slopes, the steepest of which are located in the Murrumbidgee river gorge on the western border of the development. A gully line on the border south of the development site also exists. Elevations within the proposed development area range up to 560 metres above sea level.

Figure 2 is a Google Earth image (accessed April 2014) of the proposed development site showing the topography of the land. The image shows the depression to the west of the site while the remained of the land is relatively flat with some undulation. The development site is delimited by the Murrumbidgee river gorge on the western side and a gully on the south border.

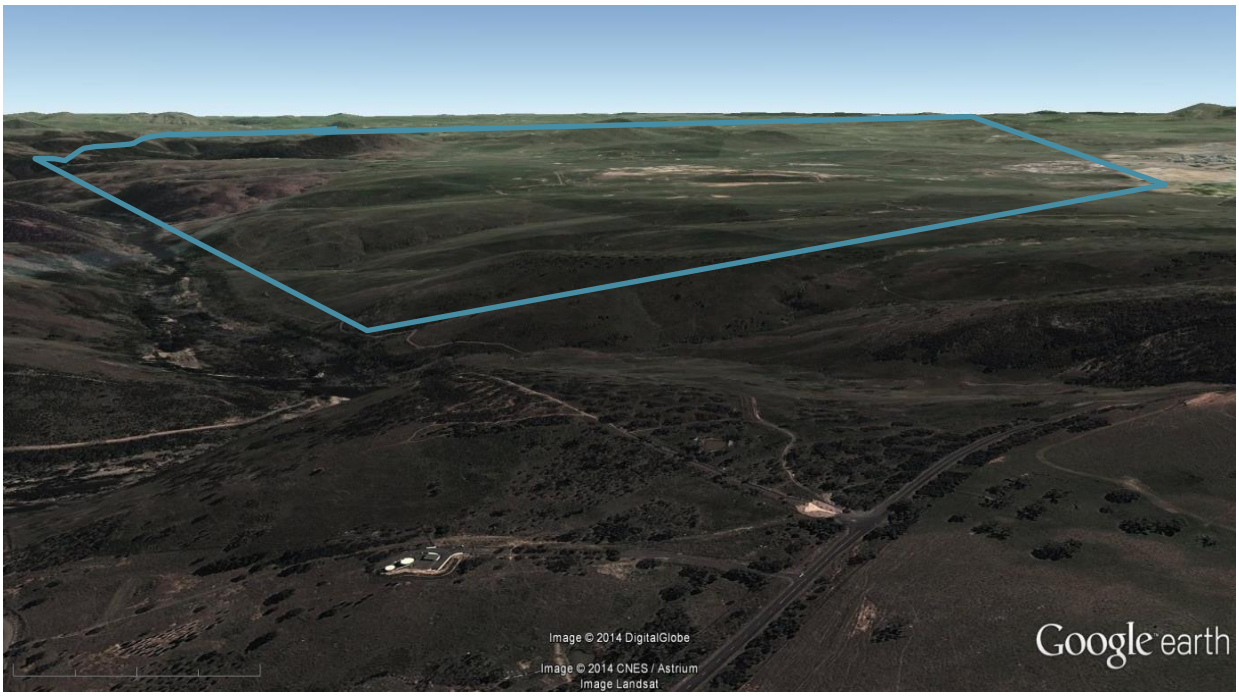

Figure 2 Google Earth's image of the proposed development site

Figure 3 shows two wire frames of the general topography, the first overlaid on an aerial image and the second showing the terrains with a colour scale for the elevations in meters. The terrain data was sourced from the Shuttle Radar Topography Mission (SRTM) ~90m global data base. Again, the figure shows the valley to the western side of the development area as the main topographical feature, while the development area is relatively flat with some minor undulations. The bottom of the valley is approximately 420m, compared to the general elevation of the development site of around 550m, resulting in a valley depth of around 130m.

As further discussed in **Section 4.2.1**, the gorge presents the potential for ground-level pollution relating to cold air drainage flow during temperature inversions to flow down the valley and into the central and southern regions of the ACT. This is specifically relevant to the use of wood heaters during still winter nights.

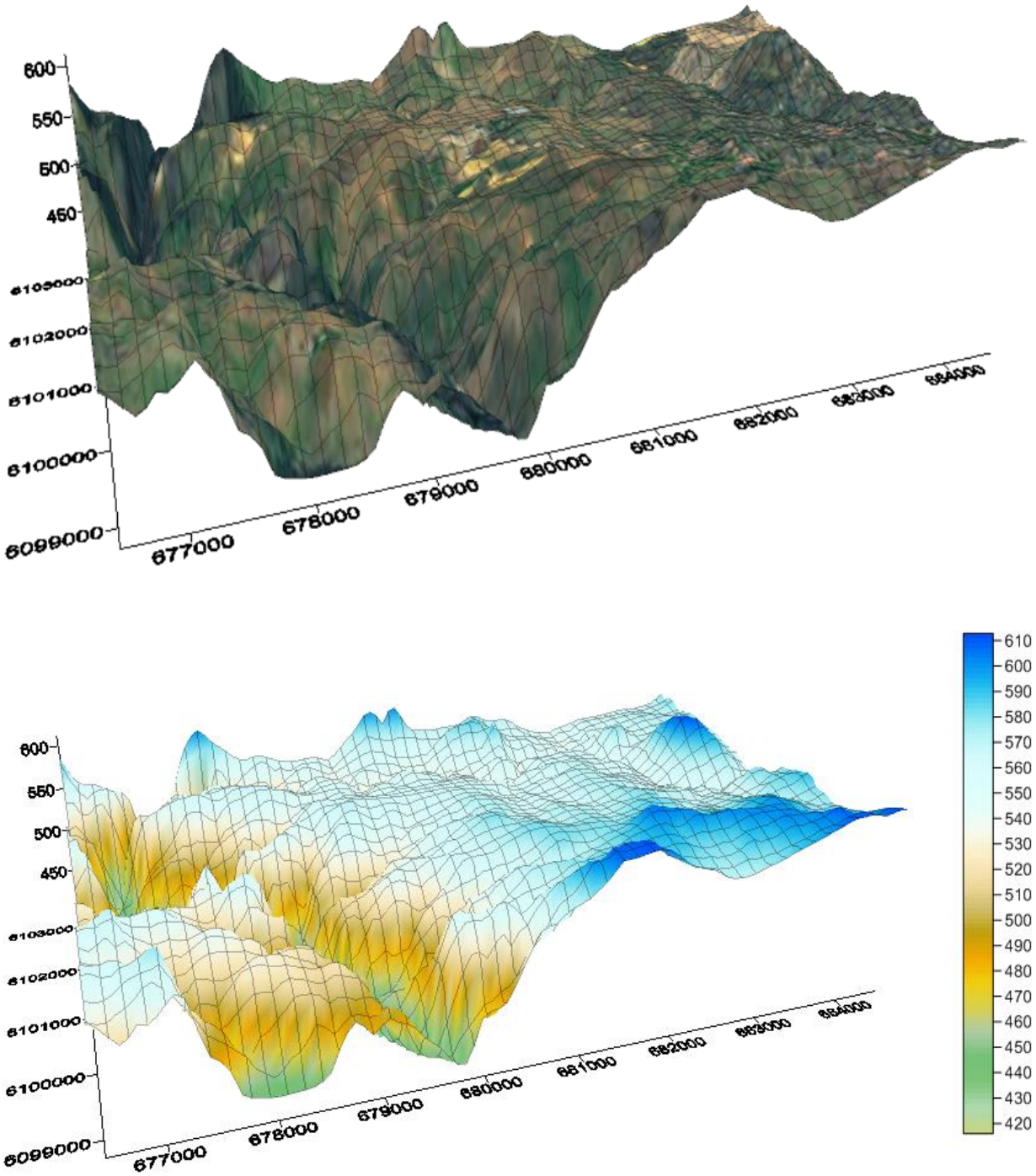

Figure 3 Wire Frame of Site Topography

2.3.2 Vegetation

As mentioned above, the site has been extensively cleared, largely as a consequence of existing farming activities and the existing recycling facility centre. Existing vegetation primarily consists of pasture land, with some pine plantations in the western areas. Lowland woodlands and grasslands are also present.

2.3.3 Bushfire Risk

Bushfires are a known hazard in the ACT due to the dry summers and flammable vegetation. Severe, damaging fires occur on a regular basis, generally every 6 – 27 years. The most serious fires occurred in 2003, and affected the Molonglo and Mount Stromlo areas, just south of the proposed development.

The risk of bushfires occurring is most prominent when strong winds from central Australia are directed towards Canberra. The most dangerous wind direction for Canberra and its surrounding regions (north-west) is also a common wind direction for the area (ACTPLA, 2007).

2.4 Project Staging

The Master Planning is still at an early phase in a draft form and the development stages have not been finalised yet. It is expected, however, that land within the proposed development will be released in a staged manner. A preliminary timing of development is provided in **Figure 4**. Key site uses provided in **Figure 5** below have been extracted from the draft Master Planning available at the time of writing from *http://talkwestbelconnen.com.au/planning/evolving-draft-master-plan/*.

Figure 4 Preliminary Staging Plan

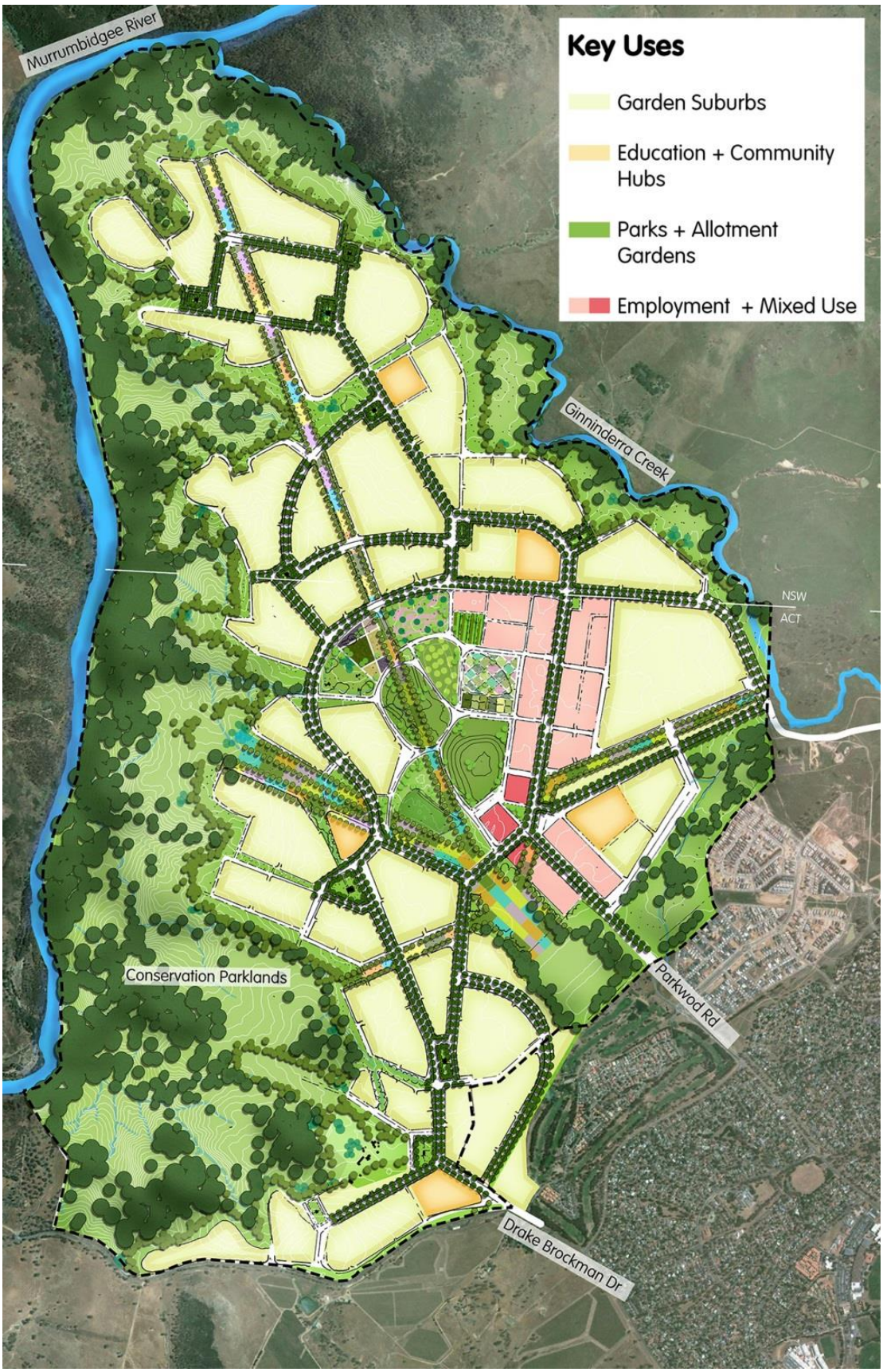

Figure 5 Draft Master Planning

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3.0 Legislation

3.1 National Environment Protection Measures

National Environment Protection Measures (NEPMs) are broad framework-setting statutory instruments that outline agreed national objectives for protecting or managing particular aspects of the environment. Air quality in the ACT is governed by the National Environment Protection (Ambient Air Quality) Measure (the Air Quality NEPM) as amended (2003). This NEPM provides guidance relating to air in the external environment, which does not include air inside buildings or structures.

The Air Quality NEPM outlines monitoring, assessment and reporting procedures for the following criteria pollutants:

- Carbon monoxide;
- Nitrogen dioxide;
- Sulfur dioxide;
- Particles as PM_{10} (particles with diameters less than or equal to 10 μm);
- Particles as $PM_{2.5}$ (particles with diameters less than or equal to 2.5 μm);
- Photochemical oxidants (as ozone); and
- Lead.

The Air Quality NEPM standards apply to air quality experienced by the general population within a region, and not to air quality in areas within the region affected by localised air emissions, such as heavily trafficked streets. The goal of the Air Quality NEPM was to achieve the standards with the allowable exceedences, as assessed in accordance with the associated monitoring protocol, by 2008. The standards were set at a level intended to adequately protect human health and well-being. The ambient air quality standards defined in the Air NEPM are listed in **Table 1**.

Table 1 Air NEPM Air Quality Standards

Pollutant	Air NEPM Standards	Averaging Period
Carbon monoxide	9.0 ppm	8 hour*
Nitrogen dioxide	0.12 ppm 0.03 ppm	1 hour* Annual
Sulfur dioxide	0.20 ppm 0.08 ppm 0.02 ppm	1 hour* 24 hour* Annual
PM_{10}	50 μg/m^3	24 hour**
$PM_{2.5}$	25 μg /m^3 8 μg /m^3	24 hour (advisory only) Annual (advisory only)
Photochemical oxidants (as ozone)	0.10 ppm 0.08 ppm	1 hour* 4 hour*
Lead	0.50 μg /m^3	Annual

ppm: parts per million
μg / m^3: micrograms per cubic metre
* Not to be exceeded more than one day per year
** Not to be exceeded more than five days per year

In addition to the Air Quality NEPM, the National Environment Protection (Air Toxics) Measure (Air Toxics NEPM) provides a framework for monitoring, assessing and reporting on ambient levels of air toxics. The purpose of this NEPM is to collect information to facilitate the development of standards for ambient air toxics.

The Air Toxics NEPM includes monitoring investigation levels for use in assessing the significance of monitored levels of air toxics with respect to human health. The monitoring investigation levels are levels of air pollution below which lifetime exposure, or exposure for a given averaging time, does not constitute a significant health risk. If these limits are exceeded in the short term, it does not mean that adverse health effects automatically occur; rather some form of further investigation by the relevant jurisdiction of the cause of the exceedence is required. The relevant monitoring investigation levels defined in the Air Toxics NEPM are listed in **Table 2**.

Table 2 Air Toxics NEPM Air Quality Monitoring Investigation levels

Pollutant	Air Toxics NEPM Monitoring Investigation Level	Averaging Period
Benzene	0.003 ppm	Annual
Formaldehyde	0.04 ppm	24 hours
Benzo(a)pyrene as a marker for polycyclic aromatic hydrocarbons (PAHs)	0.3 ng/m^3	Annual
Toluene	1 ppm 0.1 ppm	24 hour Annual
Xylenes (as a total of ortho, meta and para isomers)	0.25 ppm 0.2 ppm	24 hour Annual
ppm: parts per million ng/m^3: nanograms per cubic metre		

3.2 Air Environment Protection Policy

The Air Environment Protection Policy 1999 (AEPP) was prepared by the Environment Management Authority to manage air emissions in the ACT such that the air quality standards in the Territory at least meet the NEPM standards. The AEPP provides guidance to assist people to meet their environmental obligations, but is not legally binding, and does not apply to motor vehicles operating on public streets, trains, or aircraft.

The major sources of air emissions in the ACT are transportation and fires from non-industrial activities. The AEPP recommends different strategies to control emissions for different types of activities, including:

- Restricting the purposes for which the activity may be undertaken;
- Requiring the activity to be undertaken in a particular way; and
- Requiring emissions from the activity to meet specified standards.

3.2.1 Transportation Activities

Emissions from motor vehicles are the major source of air pollution in the ACT. Urban planning, vehicle design and emission controls, and fuel composition are the primary means of mitigating the environmental impacts of their emissions.

Emissions from motor vehicles being driven on public streets are subject to the *Motor Traffic Act 1936* except when taking part in reliability trials or speed tests for which a permit under the Motor Traffic Act has been issued. Vehicles covered by the Motor Traffic Act are subject to random in-service testing. Where the Motor Traffic Act does not apply, emissions from the vehicle are subject to the Environment Protection Act. Under these circumstances, the vehicle must comply with the emission requirements of the Motor Traffic Act and the general environmental duty.

Part IV of Schedule 2 of the Act includes provisions that regulate the composition and sale of petrol.

3.2.2 Domestic, Social, Rural and Open Space Management Activities

The main air pollutants produced by these activities are smoke and fumes from fires, spray and fumes from the use of chemicals, and dust. Of these, fires are the main source of air emissions.

Outdoor fires are controlled both in the types of material that can be burned, when the fires may be lit, and in the allowable emissions, which are dependent on the purpose for which the fire was lit. Indoor fires are also restricted in the types of materials that can be burned and the way in which the fires are managed. Synthetic substances, painted or chemically treated woods, chemicals, unseasoned wood and wastes are not allowed to be burned, except in incinerators that hold an environmental authorisation to do so.

Under Regulation 14, a person must take "*such steps as are practicable and reasonable to prevent or minimise the environmental harm caused, or likely to be caused, by the emission of pollutants into the air from the fire*." These steps include managing the fire such that excessive smoke is not produced.

3.3 The Territory Plan

The Territory Plan guides the planning and development of the ACT. It is used to: manage development, particularly how land is used and what can be built; to assess development applications; and to guide the development of new estate areas (future urban land) and manage public land.

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4.0 Climatic Conditions

The term climate refers to long-term average weather patterns that are experienced in an area. While substantial variation in weather conditions can occur between years, the climate of an area remains relatively stable, with changes occurring on a gradual basis. Weather parameters commonly used to define climate include temperature, rainfall, wind speed and humidity. The following sections provide a summary of both the long-term trends for the regional area as well as the microclimate specific to the development area.

4.1 Long-term Climate Averages

The Bureau of Meteorology (BoM) records long-term meteorological data at a number of automatic weather stations across the country. The BoM station closest to the West Belconnen development is located at the Canberra Airport (latitude 35.30°S, longitude 149.2°E, height 577 m), approximately 16 km east of the West Belconnen development. This monitoring station is located on flat land between Canberra city and the Fairbairn Pine Plantation. The airport site is comparatively flatter than the West Belconnen development, which, as described in **Section 2.3.1**, has undulating hills and valleys. As such, differences in wind patterns between the two sites would be expected. As hills and valleys create wind turbulence, drainage flows/katabatic winds not likely to be experienced on a flat plain, the wind conditions at Canberra Airport are not considered likely to represent equivalent conditions at the development site. Other climate parameters are, however, considered to be generally indicative of conditions at the site, such as temperature and relative humidity.

Data recorded at Canberra Airport between 1939 and 2010 are summarised in **Table 3**. It should be noted that the recent weather conditions experienced in the area do not greatly affect the current climate averages (which are based on over 70 years of average weather data).

Table 3 BoM Climate Averages - Canberra Airport (1939 – 2010)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Average temperature (° C)													
Maximum	28	27	25	20	16	12	11	13	16	19	23	26	19.7
Minimum	13	13	11	6.7	3.2	1	-0.1	1	3.3	6.1	8.8	11	6.5
Rainfall													
Average rainfall (mm)	59	56	51	46	44	40	41	46	52	62	64	54	616.4
Decile 5 (median) rainfall (mm)	49	55	32	30	38	31	36	46	52	55	60	44	616.6
Mean number of days of rain ≥ 1 mm	5.6	5.1	4.8	4.8	5.1	5.7	5.8	7	7	7.8	7.5	5.9	72.1
Average 9 am conditions													
Temperature (°C)	19	18	16	12	8	5	3.9	5.9	9.6	13	16	18	12.1
Relative humidity (%)	63	68	71	75	82	85	85	78	71	65	63	60	72
Wind speed (km/h)	7.5	6.4	6.1	6.5	6.9	7.8	8.5	9.9	10	11	9.8	9.1	8.3
Average 3 pm conditions													
Temperature (°C)	27	26	23	19	15	11	11	12	15	18	21	25	18.5
Relative humidity (%)	37	40	42	46	54	60	58	52	49	47	41	37	47
Wind speed (km/h)	17	15	15	14	14	15	17	20	21	21	20	19	17.3
red = highest value blue = lowest value													

Climate data from these BoM stations are summarised in the following sections.

4.1.1 Wind Conditions

Wind roses are used to show the frequency of occurrence of winds by direction and strength. Each wind rose arm represents a wind blowing from the direction it is projected i.e. arm pointing up represents northerly winds. The length of the bar represents the frequency of occurrence of winds from that direction, and wind speed categories are defined by different colours.

The Canberra Airport long-term wind roses for 9 am and 3 pm data are provided in **Figure 6**. The data was measured from March 1939 to September 2010 and represents the closest long-term monitoring station to the development.

The areas wind patterns are generally dominated by winds from the northwest in both the morning and afternoon, with calm winds more prevalent in the morning with 42% calms compared to 9% in the afternoon. **Table 3** shows that the 9am average wind speed is 8.3 km/h (2.3 m/s) compared to the higher 3pm average of 17.3 km/h (4.8 m/s). These data support the high calm conditions in the morning. The table also shows that higher winds are expected in the spring time with the lowest winds in the autumn time. The wind pattern suggests that dispersion would generally be at its worst during the early hours of autumn and best in the later hours of spring.

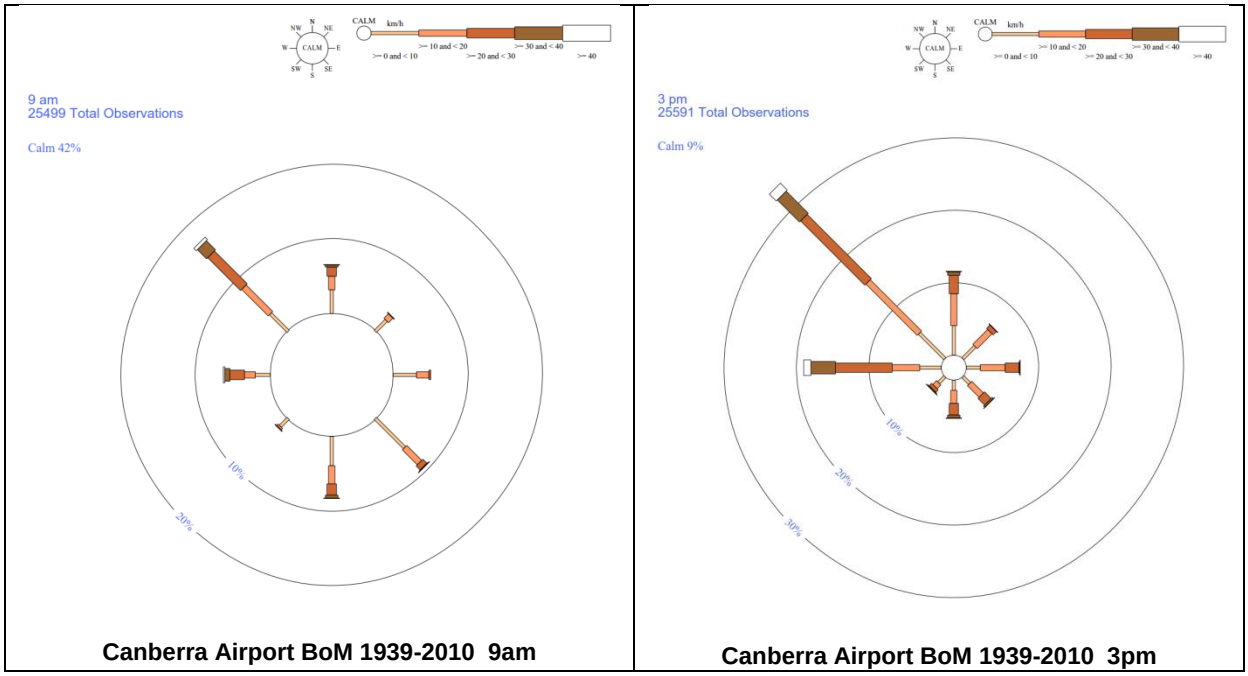

Figure 6 Canberra Airport Long-term Wind Roses

4.1.2 Temperature

The BoM reported that the average maximum temperature at Canberra Airport during 2013 was 21.7 °C, 2.0 °C above the historical average. This is the second-warmest year on record for Canberra, following 21.8 °C in 2006. Every month during 2013 recorded above-average daytime temperatures. January, July and September all broke their long-term monthly records, and winter was the equal-warmest on record.

The particularly warm temperatures during the cool season were reflected in a lack of cold days for the year: only four days dropped to 10 °C or lower (long-term average was 19 days), the fewest on record for Canberra. Temperatures reached at least 30 °C on 47 days (long-term average was 32 days), including the second-hottest day on record for Canberra with 42.0 °C on 18 January.

The average minimum temperature at Canberra Airport during 2013 was 6.2 °C, 0.3 °C below the historical average. There were 52 nights below 0 °C during the year, slightly below the historical average of 60 days, but only two nights dropped below -5 °C (average 7 nights). Night-time temperatures were well below average during both autumn and spring, but above average during winter. October and November were both more than 2 °C below normal, with several severe frosts causing widespread agricultural damage during October.

The very warm daytime temperatures but the only slightly cool nights meant the mean temperature for Canberra Airport was 14.0 °C, 0.9 °C above the historical average.

4.1.3 Rainfall

The highest rainfall occurs in spring with an average rainfall of 64mm in November, while the lowest rainfall occurs during winter with 40mm and 41mm in June and July respectively. The greatest rain frequency was found in spring and the lowest rain frequency in autumn.

4.1.4 Relative Humidity

Relative humidity is a measure of how much moisture is in the air, and varies throughout the day. The highest relative humidities occur in winter while the lowest are in summer. Humidity levels at 9 am are higher than at 3 pm.

4.2 Project Area Microclimate

The term microclimate refers to a local atmospheric zone where the weather conditions may differ from that of the surrounding regional area. The term is typically applied to a relatively small area, within a few metres of the Earth's surface.

Microclimates are affected by a number of factors including: latitude; soil type; the presence of (or proximity to) water bodies such as oceans, lakes and rivers; the slope or aspect of the area; vegetation coverage; and land use aspects, such as the presence of buildings and asphalt. Without detailed, site-specific data available, the microclimate of the West Belconnen development area is difficult to determine. As such, only general comments regarding the current microclimate and the potential changes resulting from the proposed development are discussed below.

4.2.1 Meteorology

As no meteorological monitoring is undertaken in the West Belconnen development or adjacent areas, actual meteorological conditions in the valley are not known. The CSIRO has, however, developed a computer model (The Air Pollution model, or TAPM) that can be used to predict meteorological conditions in any area of Australia based on its extensive databases containing synoptic weather data, topography, and land use information (among other factors). TAPM predicts three-dimensional meteorology, including terrain-induced circulations. TAPM is a PC-based interface that is connected to databases of terrain, vegetation and soil type, leaf area index, sea-surface temperature, and synoptic-scale meteorological analyses for various regions around the world. TAPM is commonly used for environmental impact assessments where on-site meteorological stations are not present, such as this development, and its use is prescribed in the NSW EPA *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC 2005).

TAPM was run for the 2012 calendar year to estimate meteorological conditions at the site (the most recent calendar year available at the start of the report preparation). The resultant microclimate data are summarised in the following sections.

4.2.1.1 Wind Conditions

Wind roses from the 2012 TAPM development area data are presented for the seasonal averages in **Figure 7** and for the 9am, 3pm and annual averages in **Figure 8**.

The vector average winds in the development area blow from the north-eastern quadrant with higher winds present from the south-eastern quadrant, although there is substantial seasonal variation according to time of day. Light winds tend to blow from the northeast in the morning, while stronger winds blow from the northwest in the afternoon. Seasonally there is some apparent variation in wind direction, with winds generally blowing from the northeast quadrant for all months, with summer, autumn and spring showing stronger winds from the southeast while winter shows stronger winds from the northwest. Winter and spring tend to have a wider pattern of data compared to other months.

The frequency distribution of the predicted winds is presented in **Figure 9**. The average wind speed for the area is 3.6 m/s. Approximately half the wind speeds are between 4 – 6 m/s. The highest calm wind (<0.5 m/s) percentage is predicted for autumn with 1.5%, however it must be noted that TAPM tends to under predict the frequency of calm conditions. This is evident by the long-term data showing a high calm percentage compared to the lower TAPM calm percentages.

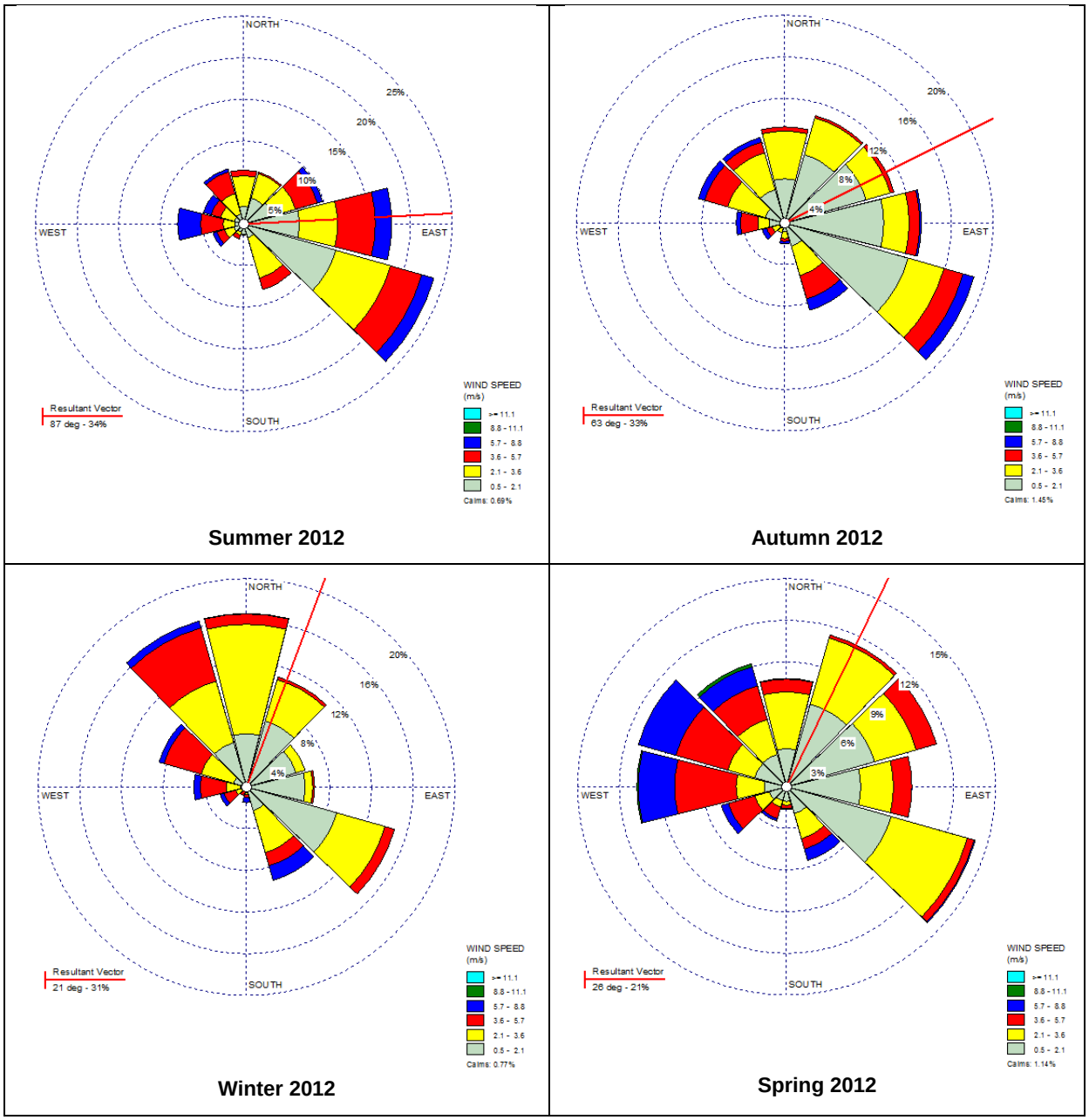

Figure 7 Seasonal Microclimate Wind Roses for the West Belconnen Project Area

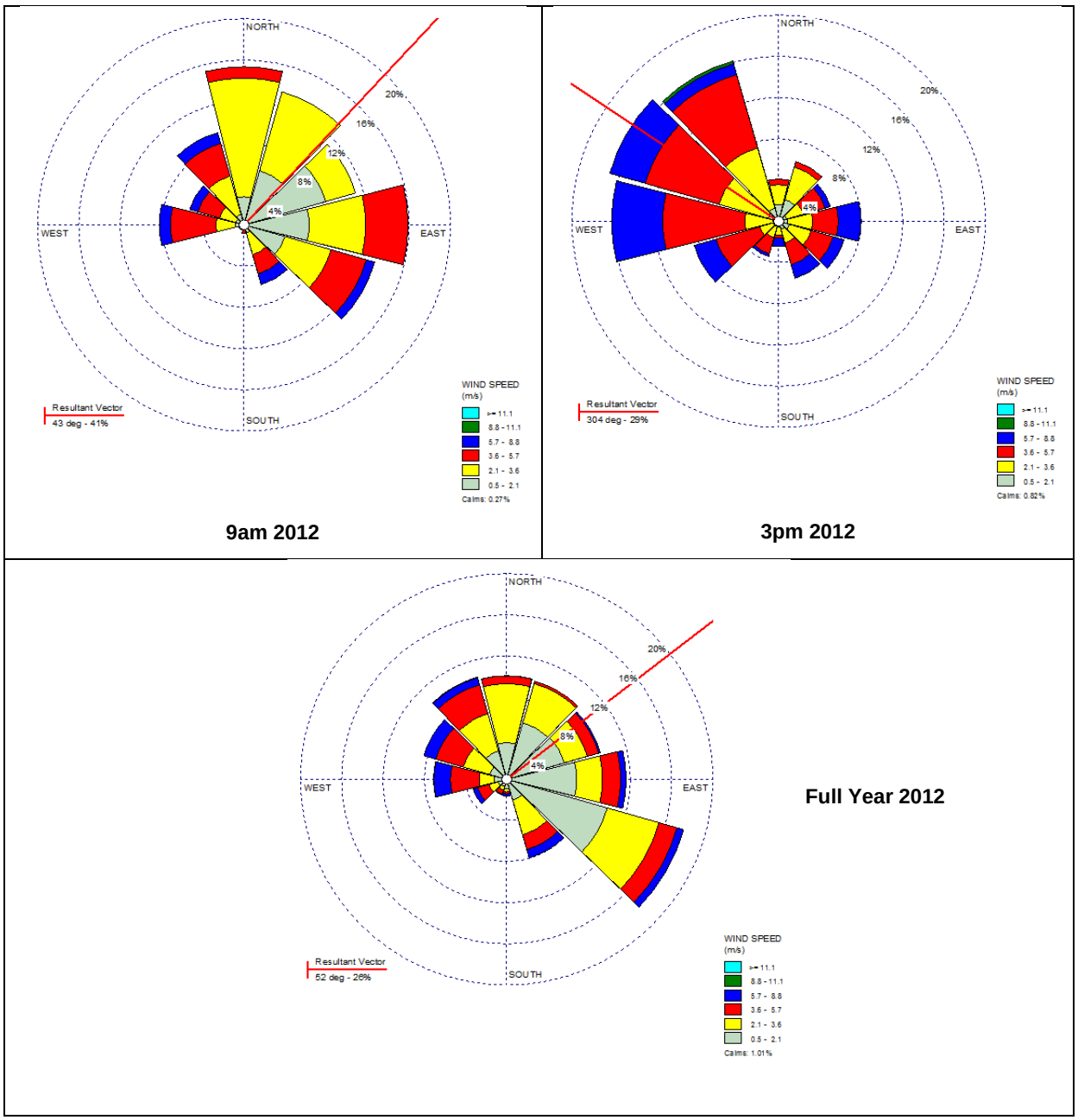

Figure 8 Diurnal and Annual Microclimate Wind Roses for the West Belconnen Project Area

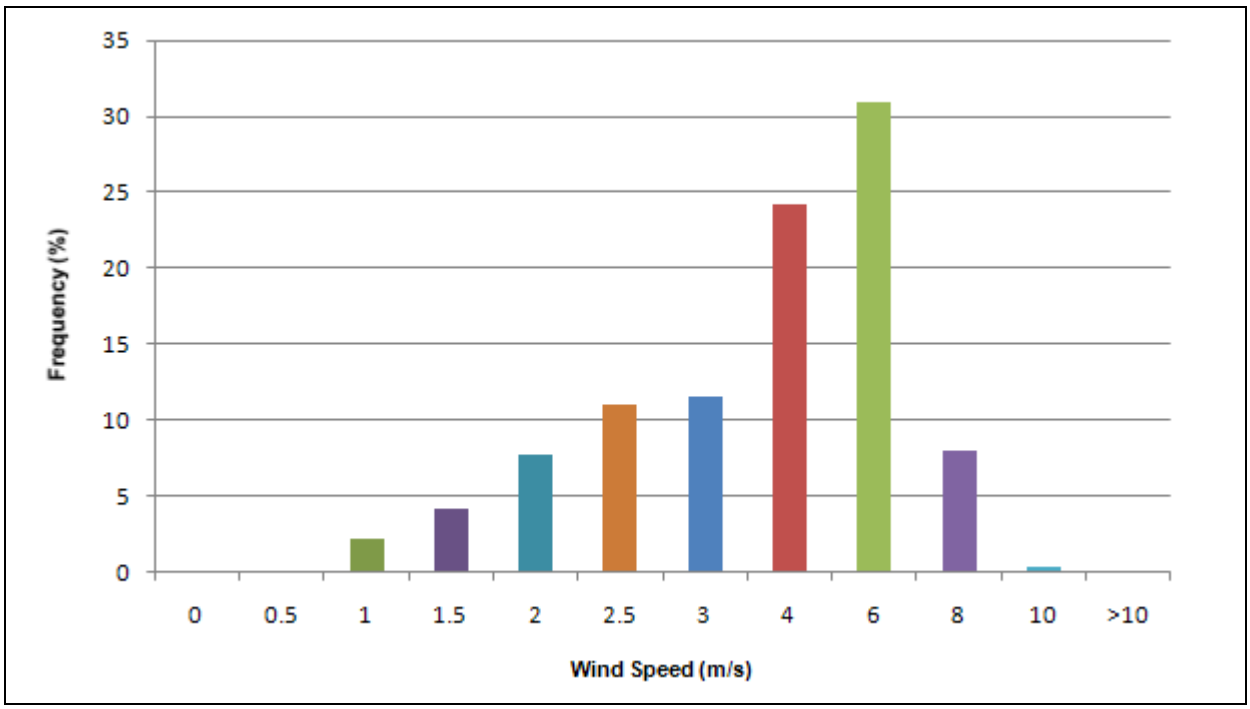

Figure 9 Frequency Distribution of Wind Speed

4.2.1.2 Stability Class

An important aspect of pollutant dispersion is the atmospheric turbulence level in the region of the pollution plume (near the ground in this case). Turbulence acts to increase the cross-sectional area of the plume due to random motions, thus diluting or diffusing a plume. Atmospheric stability categories are used in conjunction with other meteorological data to describe atmospheric conditions and thus dispersion.

The most well-known stability classification is the Pasquill-Gifford scheme, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions, plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade through moderately unstable (B), slightly unstable (C), neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

As a general rule, unstable (or convective) conditions dominate during the daytime and stable flows are dominant at night. This diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds.

The frequency distribution of estimated stability classes in the 2012 TAPM data for the project area is provided in **Figure 10.** The data show a higher trend towards neutral and stable wind classes. The breakdown of classes was 13% for A and B (unstable), 47% for C and D (neutral) and 40% for E and F (stable) class, which is consistent with the pattern expected for an inland location in a valley setting. Together, the high likelihood of stable and neutral classes indicates a high likelihood for pollution released within the area to have limited dispersion.

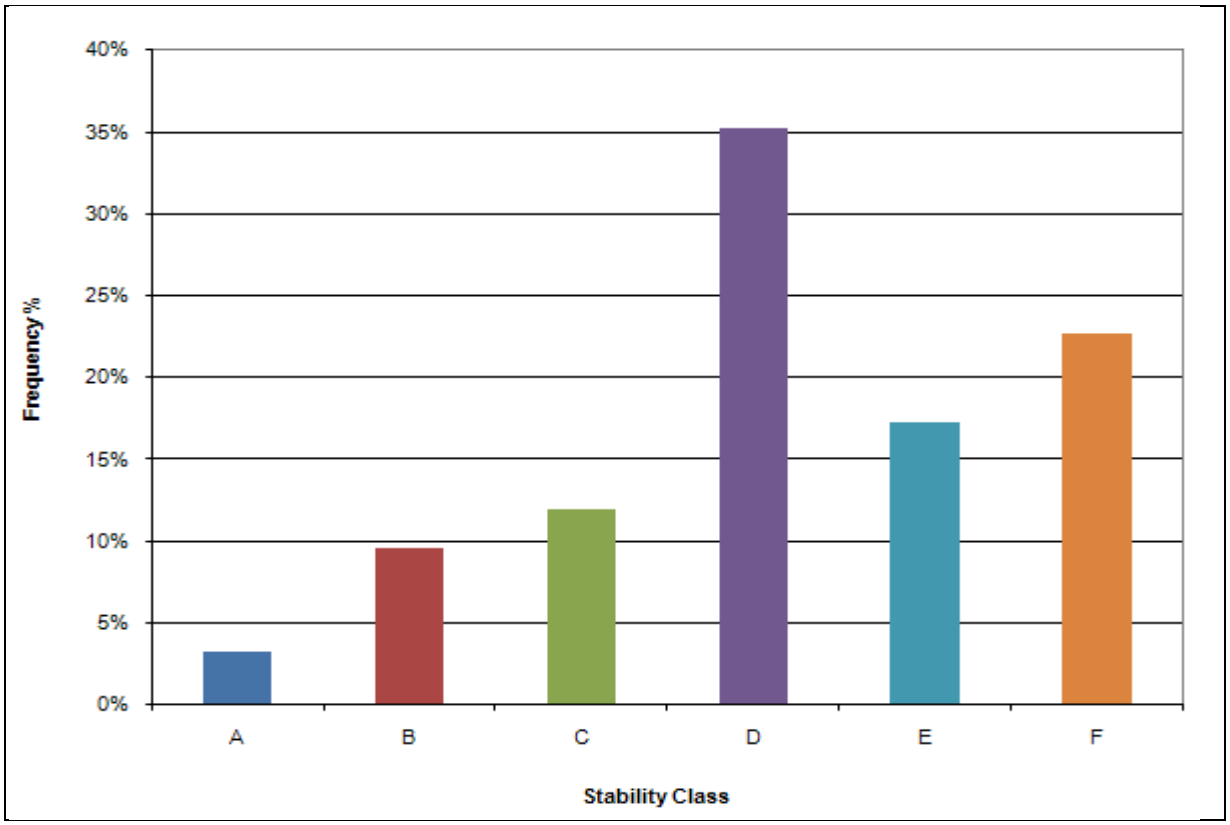

Figure 10 Frequency Distribution of Stability Class

4.2.1.3 Mixing Height

Mixing height is the depth of the atmospheric surface layer beneath an elevated temperature inversion and is an important parameter within air pollution meteorology. The mixing height defines the height above the earth's surface where the mixing of air occurs. Vertical diffusion or mixing of a plume is generally considered to be limited by the mixing height, as the air above this layer tends to be stable, with restricted vertical motions. High mixing heights are therefore associated with the greatest pollutant dispersion. Low mixing heights mean there is less air for pollutants to be dispersed within, leading to greater pollutant concentrations at ground level.

The predicted mixing heights for 2012 for the project area are provided in **Figure 11,** and are likely to be representative of the surrounding area as mixing height is a phenomenon that would affect the local airshed as a whole. Diurnal variation is seen in mixing heights, with the maximum heights seen in the early afternoon and minimum mixing heights occurring during the early morning. As with most developed valleys in ACT, average mixing heights in the West Belconnen development are relatively low, with an average maximum of around 1,000 m and an average minimum of around 250 m, although the predicted maximum was around 3,500m. Again, this may lead to higher pollutant concentrations at ground level if pollutants are present in the airshed and specifically if pollution sources are active at night-time. This is particularly relevant to sources such as residential wood heaters and constant industrial emissions.

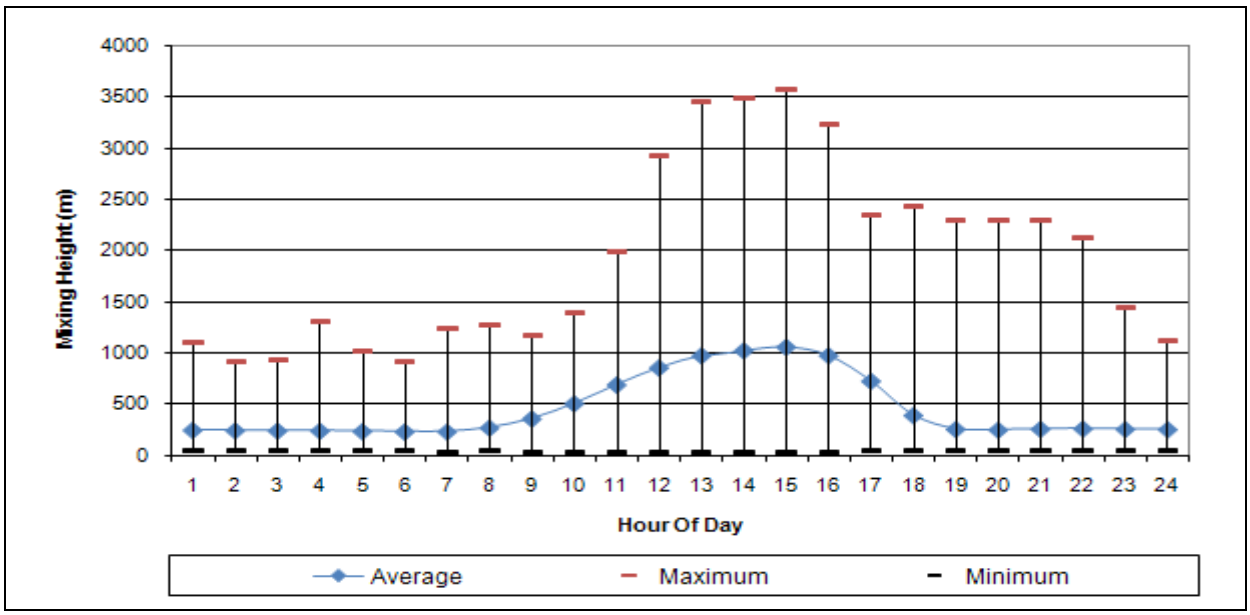

Figure 11 Hourly Mixing Height

4.2.1.4 Temperature

Under normal atmospheric conditions, air temperature decreases with increasing height. Under temperature inversions, this pattern is reversed such that the ground is rapidly cooled, making the air close to the ground cooler than the air above it. Cold air is denser than warm air, so the cold air tends to flow down hill (known as cold air drainage or katabatic winds), and pools in frost hollows (low topographic areas). Pollution within the cold air drainage flow can become trapped and accumulate below the inversion layer, resulting in high pollutant concentrations.

As temperature inversions commonly occur during winter, on still nights, air quality issues are exacerbated at these times, as these are the conditions during which domestic heating is likely to be employed. Particulates emitted from wood heaters are a major concern. As the meteorological conditions cannot be controlled, management of air quality associated with these conditions must be addressed through control of night-time pollutant emissions should temperature inversions be likely.

As previously discussed, the gorge to the west of the development area presents the potential for ground-level pollution relating to cold air drainage flow during temperature inversions to flow down the valley and into the central and southern regions of the ACT. This issue is likely heightened by the north-easterly vector wind direction trend shown in the winter wind rose in **Figure 7** and the annual wind rose in **Figure 8** that would push the air from the development towards the western gorge and further down into the ACT. This is specifically relevant to the use of wood heaters during still winter nights. The long-term regional data also shows a high level of calm wind conditions associated with cold air drainage.

Figure 12 presents the predicted average hourly temperatures for 2012. The graph shows the expected diurnal variation in temperature, where the highest temperatures are found during the afternoon, and the lowest temperatures occur in the early morning.

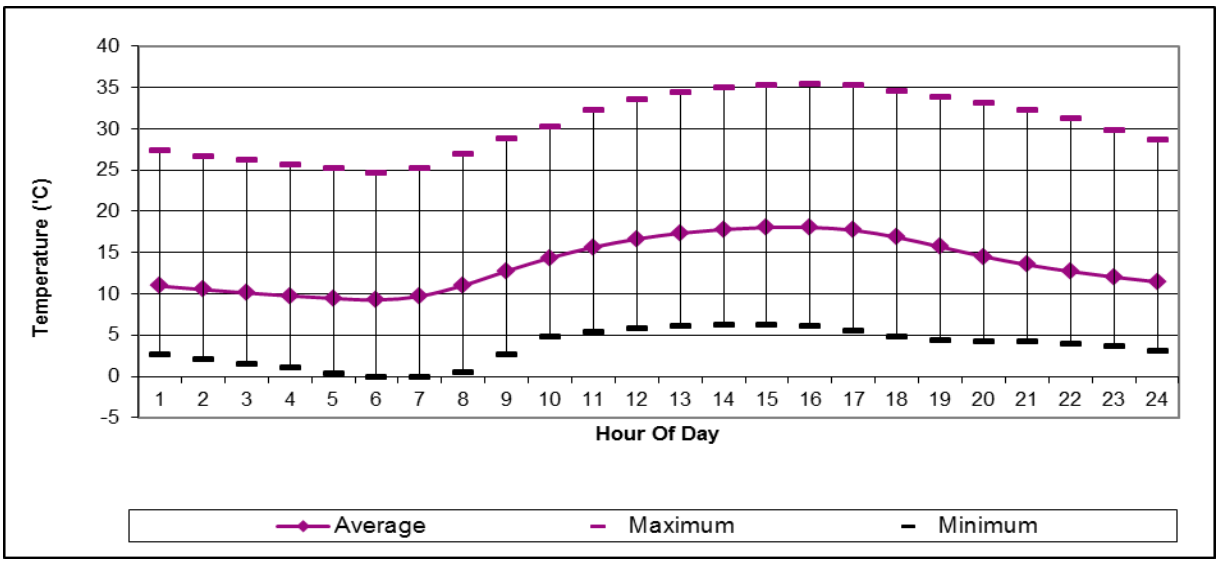

Figure 12 Diurnal Temperature Spread

4.2.2 Vegetation

Vegetation absorbs both light and heat. The proposed development site has been extensively cleared, with much of the area now consisting of grassland and remnant trees. The proposed development would involve further clearing to remove much of the current vegetation in many areas, and replacing it with buildings and asphalt roads, which radiate heat back into the air. As such, the temperature close to the ground in the area is likely to increase as a result of the proposed development. Adverse temperature increases can potentially be mitigated through the extensive installation of solar collection devices, which would absorb sunlight and generate useful electricity. Maximising green space in the development plan can also help mitigate any potential impacts. The current draft Master Plan includes for such green spaces in the form of parks, ponds and wetlands which should be retained to mitigate some of this ground floor temperature's increase.

4.2.3 Solar Access

The north-facing slopes within the area are exposed to more direct sunlight than the south-facing slopes and, as such, are warmer for longer. The degree to which this occurs depends on the exact orientation of the slopes.

4.3 Climate Change

The average global temperature has increased by 0.6° C over the past century. In Australia, an increase of around 0.7° C has been documented, and further increases of between 1 - 6 ° C are predicted to occur by 2070. Rainfall events are expected to decrease in frequency but become more intense, resulting in greater flooding (ACTPLA, 2007).

Climate change is likely to affect the ACT, including the West Belconnen development, in a number of ways. Temperatures in the area are expected to increase over the coming decades, resulting in a greater number of hot days and fewer cold nights (ACT Government, 2007). This may result in additional energy requirements during the warmer months to power air conditioning, but may also result in lower demand for heating during winter. The higher temperatures may also result in decreased water availability due to increased evaporation, particularly as the total annual rainfall is not expected to dramatically change. Conversely, however, evaporation may decrease as a result of global dimming, which refers to a reduction of solar energy reaching the surface due to higher pollution levels in the atmosphere reflecting the energy back into space (ACTPLA, 2007).

A change in the distribution of rain events is, however, anticipated – summer and autumn are predicted to become wetter, while winter and spring are expected to become drier. More intense storm events are also expected to occur, and droughts are predicted to become both more severe and more frequent, particularly in winter and spring (ACT Government, 2007).

Average wind speeds are predicted to increase in summer months in the ACT (ACT Government, 2007). The risk of fires is also predicted to increase, with the number of days classified as having very high or extreme fire danger potentially increasing by 13 – 26 % (ACT Government, 2007).

At this stage it is still very difficult to predict the impact that climate change may have on the development. As climate change is an issue that affects large scale areas, such as whole states or countries, climate change legislation is generally driven by federal government approaches and, as such, no specific issues or measures have been discussed in this report.

5.0 Existing Air Quality

Air quality in the ACT is considered to be excellent, particularly in relation to other Australian capital cities, mainly because the area has no heavy industry (ACT Government 2013). The primary sources of air pollution in the ACT are motor vehicles, wood smoke, and bushfires/dust storms. Other sources as gained from a review of the 2011/2012 National Pollutant Inventory (NPI) database for the regional area include landfills, agriculture, asphalt plants, quarries, hospitals, aviation, sewerage treatment plants and pipelines, and power stations. The full list of the NPI data sorted by facility and by substance is provided in **Appendix A**.

Temperature inversions during winter are often associated with excessive particulate levels in some areas, particularly developed valley areas. High particulate levels also occur in summer due to bushfires.

5.1 Air Quality Monitoring

ACT Health operates an ambient air quality network on behalf of the ACT Government, consisting of two monitoring stations. One station is located at Monash, approximately 200 m west of Cockcroft Avenue in the district sporting fields. The other station is located at Civic, near Allara Street, and is the closest station to West Belconnen development as shown in **Figure 13**. It should be noted, however, that there is a substantial ridgeline between West Belconnen development and both of the monitoring stations (**Section 2.3.1**). As such, the meteorology within the West Belconnen development may be different to that recorded at those monitoring stations.

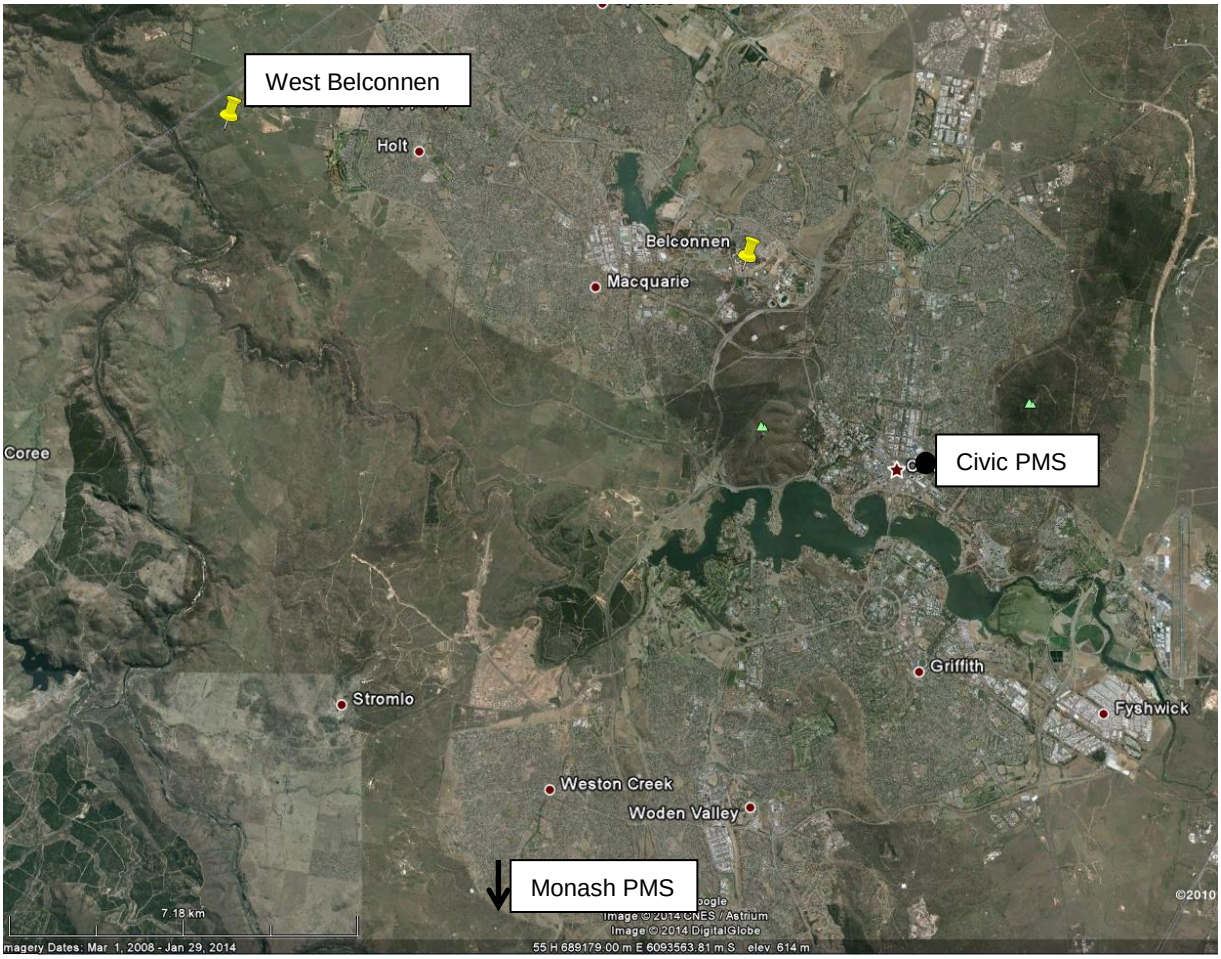

Figure 13 **Performance Monitoring Station Locations, Google copyright**

Continuous monitoring of carbon monoxide, nitrogen dioxide, and ozone is undertaken at both monitoring stations. Particulate matter (PM_{10} and $PM_{2.5}$) is only monitored at Monash. The stations ceased monitoring of lead in 2002, while sulphur dioxide has never been monitored due to the lack of heavy industry (EPA, 2012).

The Environment Protection Authority (EPA) recently published a report on air quality in the ACT (EPA, 2013). Overall air quality in the area is considered to be excellent, particularly in comparison to other capital cities, with all pollutant concentrations below NEPM standards. The only exception is elevated particulate concentrations, which are a recognised issue during with winter months, and are likely to be "attributed to domestic wood heater emissions in winter" (EPA, 2013). Other identified sources include hazard reduction burns and dust storms.

The following sections summarise the data presented in the 2012 ACT Air Quality Report (EPA 2013). It should be noted that while the existing data are generally indicative of pollutant levels in the proposed development area, the proposed development is located in an area that is quite different topographically to that of the existing monitoring stations, and that is currently undeveloped.

This section provides a summary of the data only, with more detailed discussion of pollutant sources provided in **Section 6.0** and mitigation measures provided in **Section 7.0**.

5.2 Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless gas produced by the incomplete combustion of fuels containing carbon (e.g. oil, gas, coal and wood). Carbon monoxide is absorbed through the lungs of humans, where it reacts to reduce the blood's oxygen-carrying capacity. In urban areas, motor vehicles account for up to 90 % of all CO emissions.

Historically, no exceedences of the 8-hour NEPM standard for carbon monoxide have occurred since 1999. Maximum concentrations at Monash have steadily declined since 2000, with the maximum concentration measured in 2012 of 1.8 ppm representing around half the maximum concentration of 3.7 ppm recorded in 2003 and 2006 (the maximum concentrations recorded since 2003). A rapid decline in carbon monoxide concentrations is also apparent from the monitoring data from Civic. The highest 8-hour maximum concentration of 4.6 ppm since 2003 occurred in 2004; in contrast, the maximum 8-hour concentration in 2012 was 1.8 ppm, which represents less than half of the highest recorded concentration.

Because of both an improvement in vehicle emissions and a decline in wood heater numbers, levels are trending down. The highest recorded value in the ACT during 2012 was 1.8ppm at both stations. This is only 20% of the standard.

Wood heating is considered to be the main source of carbon monoxide emissions (ACT Government, 2008), and explains the seasonal concentration pattern, with peak concentrations occurring in winter (highest measurement for 2012 was in June). Should wood burning heaters be permitted in the proposed development, local carbon monoxide concentrations would be expected to increase. Carbon monoxide levels in Canberra are not currently a cause for concern, however, and the Canberra airshed has the capacity to accommodate a substantial increase in carbon monoxide levels without exceeding the NEPM standard. Although wood heaters are not a direct concern for carbon monoxide due to the relatively low levels measured, they may be a concern for other pollutants as detailed in the following sections.

5.3 Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a brownish gas with a pungent odour. It exists in the atmosphere in equilibrium with nitric oxide. The mixture of these two gases is commonly referred to as nitrogen oxides (NO_x). Nitrogen oxides are a product of combustion processes. In urban areas, motor vehicles and industrial combustion processes are the major sources of ambient nitrogen oxides. Nitrogen dioxide can cause damage to the human respiratory tract, increasing a person's susceptibility to respiratory infections and asthma. Sensitive populations, such as the elderly, children, and people with existing health conditions are most susceptible to the adverse effects of nitrogen dioxide exposure. Nitrogen dioxide can also cause damage to plants, especially in the present of other pollutants such as ozone and sulphur dioxide. Nitrogen oxides are also primary ingredients in the reactions that lead to photochemical smog formation.

The data trend at both Monash and Civic between 2003 and 2012 indicates nitrogen dioxide levels have been essentially stable during the monitoring period, with maximum hourly concentrations varying between 0.033 – 0.103 ppm at Monash and 0.039 – 0.087 ppm at Civic. The NEPM standard is 0.12 ppm.

In 2012, recorded levels of nitrogen dioxide were well below the NEPM standards for hourly and annual concentrations and have remained stable over the last decade. The highest recorded 1 hour value during 2012 was 0.044ppm at Civic, which is only 37% of the standard. The highest recorded annual average in 2012 was 0.008ppm at Civic. This is only 27% of the annual standard 0.03ppm.

An increase in motor vehicles during the construction and operational phases of the development would contribute to increased levels of nitrogen dioxide or nitrogen oxides. The available air quality data, however, suggest that there is substantial room within the airshed to accommodate an increase in nitrogen dioxide concentrations.

5.4 Ozone

Photochemical oxidants (often referred to as photochemical smog) are a complex mixture of chemicals produced in the atmosphere by the action of sunlight. The principal component of photochemical oxidants is ozone. Ozone measurements are commonly used as a surrogate for photochemical oxidants. Ozone is a colourless, highly reactive gas with a distinctive sharp odour. At ground level, elevated concentrations of ozone can cause respiratory problems and cardiovascular disease in humans, and can affect the healthy normal population as well as sensitive sub-populations. It can worsen bronchitis, emphysema, and asthma. Ozone can also affect the growth of vegetation and damage materials and ecosystems.

At ground level, ozone is created by a chemical reaction between nitrogen oxides and volatile organic compounds (VOCs) in the presence of sunlight. As such, nitrogen oxides and volatile organic compounds are referred to as ozone precursors. Motor vehicle exhaust, industrial emissions, gasoline vapours, chemical solvents as well as natural sources (such as bushfires) emit ozone precursors. The highest concentrations of ozone normally occur on summer afternoons, downwind of major sources of ozone precursors. Elevated concentrations are most likely to occur on warm sunny days in areas where the surrounding topography prevents the precursors from dispersing.

Ozone levels have been relatively stable between 2003 and 2012 at Monash, with maximum 1-hour concentrations typically between 0.05 – 0.10 ppm. An exceedence occurred in 2003, where the maximum 1-hour concentration was recorded at 0.102 ppm, slightly exceeding the guideline value of 0.1 ppm. At Civic, exceedences occurred on 4 days during the past 10 years – three in 2006 (with a maximum concentration of 0.252 ppm, which is more than double the NEPM standard), and one in 2007 (0.112 ppm). Concentrations of ozone at Civic are generally higher than those recorded at Monash. The average hourly maximum concentration at Civic between 2003 and 2012 was 0.087 ppm, which is close to the standard level, compared to 0.067 ppm at Monash.

In 2012, Ozone levels were below the AAQ NEPM standard. The highest recorded 1-hour value in the ACT during 2012 was 0.055ppm at Monash, which is 55% of the standard. The highest recorded 4-hour value in the ACT during 2012 was 0.052ppm at Monash. This is 65% of the standard.

Ozone concentrations were elevated from August to April at both monitoring locations, with peak concentrations occurring in summer. An increase in motor vehicle use during the construction and operational phases of the development could increase the potential for ozone formation. Unlike carbon monoxide and nitrogen dioxide, there is less capacity in the Canberra airshed to accommodate increased ozone concentrations.

5.5 Particulate Matter (PM_{10} and $PM_{2.5}$)

Particulate matter is the term for solid or liquid particles found in the air. Some particles are large or dark enough to be seen as soot or smoke, but fine particulate matter is tiny and is generally not visible to the naked eye. Particulate matter is produced by the mechanical breakup of larger solid particles. The larger or coarse fraction can include dust from roads, agricultural processes, uncovered soil or mining operations, as well as non-combustible materials released when burning fossil fuels. Pollen grains, mould spores, and plant and insect parts can also contribute to the coarse fraction. Evaporation of sea spray can produce large particles near coasts. The smaller or fine particulates are largely formed by the oxidation of primary gases.

Particulate matter can be emitted from natural sources (bushfires, dust storms, pollens and sea spray) or as a result of human activities such as combustion activities (motor vehicle emissions, power generation and incineration), excavation works, bulk material handling, crushing operations, unpaved roads and, of particular importance to this project, wood heaters.

Airborne particles are commonly differentiated according to size based on their equivalent aerodynamic diameter. Particles with a diameter of less than or equal to 50 micrometres (μm) are collectively referred to as total suspended particulates (TSP). TSP primarily cause aesthetic impacts associated with coarse particles settling on surfaces, which also causes soiling and discolouration. These large particles, however, can cause some irritation of mucosal membranes and can increase health risks from ingestion if contaminated. Particles with diameters less than or equal to 10 μm (known as PM_{10} or fine particles) tend to remain suspended in the air for longer periods than larger particles, and can penetrate into human lungs. Epidemiological studies show a correlation between exposure to particles and adverse health effects. No safe threshold for particle exposure has been established.

Deposited dust refers to the larger fractions that fall from the air and deposit on exposed surfaces. While deposited dust generally has an aerodynamic diameter of greater than about 20 μm, there is no sharp size cut off between these particles and the smaller particles that remain suspended in the air for long periods. Larger dust particles are generally responsible for nuisance (amenity) effects, including vegetation damage and surface soiling. Depending on its physical or chemical characteristics, dust may also cause surface deterioration of materials due to its abrasive or corrosive properties. If the dust composition is dangerous, the dust is considered a hazardous air pollutant (and may contain toxic material).

Exceedences of the 24-hour PM_{10} standard commonly occur at both Monash and Civic. At Monash, exceedences were recorded in 7 of the reported 10 years of monitoring (47 exceedences in total). The highest historical concentrations occurred in 2003, which was the year Canberra experienced severe bush fires. The 95th percentile data, which demonstrate trends excluding extreme events, show a gradual decline between 2003 and 2012 (with the exception of 2009 when severe dust storms were experienced across the ACT and NSW).

In 2012, measured PM_{10} levels were below the AAQ NEPM standard. The highest PM_{10} level recorded during 2012 was 49.5μg/m3 at Civic on 7 January 2012. This is close to but still below the AAQ NEPM standard.

Fewer PM_{10} exceedences were recorded at Civic, occurring in 4 of the reported 10 years, but with a lower frequency (5 in total) and scale than those at Monash. No clear trend in pollutant concentrations is evident from inspection of the data recorded between 2003 and 2012.

$PM_{2.5}$ is only monitored at Monash. Exceedences of the 24 hour NEPM standard were recorded every year between 2004 and 2012, with 74 exceedences occurring over the nine year period. The average maximum concentration of 38.7 $\mu g/m^3$ exceeds the NEPM standard of 25 $\mu g/m^3$.

In 2012, the 24-hour advisory reporting standard for $PM_{2.5}$ was exceeded three times at Monash with a maximum of 29.2 ug/m^3 (criteria of 25 ug/m^3). The exceedences happened during late May to early July 2012 and are likely to be attributed to particle emissions from wood heaters during winter.

The World Health Organisation (WHO) air quality guidelines and risk assessment (WHO 2006) summarise that all the population is affected by particulate matter, but susceptibility to the pollution may vary with health or age. It states that "*the risk for various outcomes has been shown to increase with exposure and there is little evidence to suggest a threshold below which no adverse health effects would be anticipated*" and that evidence shows adverse effects for both short-term and long-term exposures. It provides that adverse effects from low concentrations are not greatly above the background concentration, which for particles smaller than 2.5 □m has been estimated to be 3–5 □g/m^3 in both the United States and western Europe.

Particulate matter is evidently an existing issue for the Canberra region, with concentrations in the southern areas appearing to be greater than those in the north. Exceedences occur during both the winter and summer seasons, likely to result from wood fire smoke and bushfires. Current sources of dust in the West Belconnen development are primarily particulates from neighbouring areas and bushfires. Local particulate levels are likely to increase as a result of the development. Activities expected to generate dust include land-clearing activities, vehicle traffic (during both construction and settlement), and, if permitted, the use of wood-burning stoves and heaters during the winter months.

6.0 Pollutant Sources

Due to the lack of major industry in the region, motor vehicles, domestic wood heaters, hazard reduction burns and dust storms are the likely primary sources of pollution in the ACT, with the ACT Government acknowledging that "*woodsmoke from domestic wood heaters is the largest source of air pollution in Canberra*" (2013). Ambient pollutant levels, therefore, are likely to increase to some degree as a result of the proposed development due to increased vehicle traffic and other domestic sources and, more specifically, through potential wood heater use.

As existing levels of nitrogen dioxide and carbon monoxide are well below the NEPM standards, increases in levels of these pollutants are not expected to negatively affect air quality to a large degree. Of particular concern, however, is the potential increase in particulate matter, which is already present in concentrations above national goals. Wood heater particulate emissions have been identified as a particular issue of concern for the ACT.

6.1 Motor Vehicle Emissions

Data from the NPI indicate that motor vehicles are the largest source of pollution in the ACT, accounting for approximately one quarter of all air emissions in the territory. Motor vehicles emit a range of pollutants including carbon monoxide, nitrogen oxides, particulates, sulphur, and hydrocarbons. The greater concentration of motor vehicles in the city centre compared to Monash is associated with the greater ozone concentrations found at the city monitoring station.

The pollution generated by motor vehicles results from both the amount of fuel burned; fuel type and composition; and the emission control standards of the engines.

6.2 Wood Smoke

Wood smoke pollution can harm the health of both the wood heater users and others in the community. Health effects depend on exposure levels and the age and health status of exposed people; people particularly susceptible to adverse effects include infants and very young children, the elderly, and people with existing cardiac, respiratory or vascular problems. Potential adverse health effects include asthma, chronic lung disease, heart problems and premature births and deaths, primarily as a result of the particulate matter. In addition to the particulates released, wood heaters can release excessive levels of carbon monoxide and polycyclic aromatic compounds, which can be carcinogenic.

Residential wood smoke is a common cause of air pollution problems in cooler areas, particularly those associated with residential developments in valley areas such as Tuggeranong (Bridgman, 2009). The ACT Government acknowledge that "*woodsmoke from domestic wood heaters is the largest source of air pollution in Canberra*" (2013), with a layer of wood smoke over the city a common occurrence, particularly in the Tuggeranong Valley. Under temperature inversion conditions, the wood smoke hangs in the air close to ground level rather than dispersing, leading to elevated particulate concentrations that have the potential to result in adverse health effects (refer to **Section 5.5**).

The ACT Government has implemented a range of programs to address wood smoke, including a don't burn tonight campaign and a wood heater replacement program (refer to **Section 7.2**). The programs have shown to be effective in reducing woodsmoke with particle levels continuing to trend down (ACT Government 2013). Of note is the 2012 ACT ambient air monitoring program that reported that there were no exceedences of the PM_{10} standard in 2012 because of wood heater emissions, although monitoring clearly shows that particle levels increase during the winter months (ACT Government 2013). The monitoring locations were in central and southern Canberra, with particulate levels likely to be lower in the development area than that measured.

The topography and meteorological conditions, particularly valley drainage flows, expected in the West Belconnen development suggest that wood smoke could be a significant issue for the proposed development should wood heaters be installed. As the West Belconnen development is likely to receive drainage flows from other areas of Canberra and NSW, the use of wood heaters in other areas may also potentially contribute to elevated pollutant concentrations within the proposed development area under inversion conditions. The valley drainage flows from the project area to other areas of Canberra is also an important consideration for the particulate levels in the greater region.

6.3 Greenhouse Gas Emissions

Increased population typically leads to increased greenhouse emissions through the increased use of fuel associated with transport and household appliances. Building design, siting and material use can significantly affect the greenhouse gas emissions associated with structures by affecting the amount of cooling and heating required to maintain comfortable temperatures within the buildings. Retention/replanting of vegetation in urban areas can help to offset the emissions associated with development.

7.0 Mitigation Measures

7.1 Motor Vehicles

Emissions from motor vehicles are affected by fuel use and content; engine efficiency and emission controls; transport mode; and trip distance.

The content of automotive fuels (petrol, diesel, biodiesel and auto gas) in Australia is governed by the Fuel Quality Standards Act 2000. Sulphur is the main pollutant of concern in fuel. The latest content reductions were made in 2009 and 2008, where the allowable sulphur contents were reduced to 10 ppm and 50 ppm in automotive diesel and petrol respectively. Reducing the sulphur content within fuel also reduces particulate emissions and enables treatment devices for exhaust gases to be installed.

Vehicle exhaust emissions of carbon monoxide, hydrocarbons and oxides of nitrogen are regulated by national legislation in the form of Australian Design Rules (ADRs), which have successively required more stringent emission controls for new vehicles. The latest ADR for light vehicles was introduced in 2010 (ADR 79/02; Euro 4), while the latest ADR for heavy vehicles was introduced in 2011 (ADR 80/03; Euro 5). The average age of private motor vehicles in the ACT is about 10 years, and most would have been built to comply with the 1986 legislation; much of it would now comply with the 1997 ADR and more recent ones (ACT Government, 2008).

The increased use of public transport is believed to greatly reduce overall transport emissions. The proposed development addresses this aspect by providing multi-modal transport options for residents, and encouraging the use of walking and bicycle use through the provision of walkways and bicycle paths that link the residential and community facilities. The proximity of the proposed development site to the main employment and entertainment centres of the ACT (particularly Civic, Woden, Belconnen and Weston Creek) means that the residents of the proposed development will have shorter trip distances than if the development was located elsewhere. Additionally, the proposed development includes a focus on public transport and fuel-free transport modes, by locating services and facilities within walking/cycling distance.

It should be noted, however, that recent evidence suggests that the differences between public transport and private vehicle emissions is not as large as commonly thought, and that improvements in the use of hybrid cars and uptake of new technologies will reduce the existing differences even further (Wendell Cox Consultancy, 2007). Furthermore, there is also evidence that greenhouse gas emissions are lower in areas where there are more cars when data are assessed according to consumption at the household level within a statistical area, which is quite contrary to popular belief that greater car numbers result in greater greenhouse gas emissions (Wendell Cox Consultancy, 2007). As such, it appears that the relationships between motor vehicle use and greenhouse gas emissions are more complex than originally thought. This should be taken into account with any assessment of greenhouse gas emissions.

7.2 Wood Smoke

7.2.1 Existing ACT Programs on Wood Heaters

The ACT Government has undertaken a number of actions to address the problem of wood smoke, including:

- Implementation of a Wood Heater Replacement Program in 2004 that offers financial incentives of up to $800 to encourage people to replace existing wood heaters with new natural gas heaters to improve air quality;
- Provision of education and assistance programs to help homeowners to use their wood heaters most efficiently;
- Running an annual campaign (Don’t Burn Tonight) since 2001. This community education program involves alerts being broadcast by local media on cold still nights, when dispersion conditions are poor, that encourage residents to use alternative heating methods;
- Regulating the sale and supply of firewood in the ACT, which requires an environmental authorisation issued by the Environment Protection Authority, with conditions of authorisation including requiring only seasoned timber to be supplied to minimise smoke emissions; and
- Residents also have a responsibility to minimise air pollution in the ACT under the Environment Protection Act 1997, with penalties applicable for breaches.

7.2.2 COAG National Plan for Clean Air

In 2011 the Council of Australian Governments (COAG) identified air quality as a *Priority Issue of National Significance* and agreed that the COAG Standing Council on Environment and Water would develop a National Plan for Clean Air to improve air quality, and community health and well-being. A primary goal of the National Plan is to identify a consistent approach to managing wood heater emissions. The National Plan for Clean Air will bring together a strategy for responding to the review of the National Environment Protection (Ambient Air Quality) Measure, including the revision of air quality standards and development of an exposure reduction framework, and a robust framework for identifying cost effective actions and implementation arrangements to reduce air pollution. It will be delivered to COAG by the end of 2014. Further details of the plan can be found at www.scew.gov.au/strategic-priorities/national-plan-for-clean-air.html

When released The National Plan should be reviewed and its information and outcomes considered during any future development planning.

7.2.3 National Environment Protection Council Service Corporation - Regulation Impact Statement

The National Environment Protection Council Service Council (NEPCSC) engaged BDA Group, in collaboration with Environment Link, to prepare a consultation Regulation Impact Statement (the Statement) that assesses options to reduce emissions from wood heaters in Australia. The Statement was published in April 2013 and reviewed the characteristics of the wood heating industry including wood heater usage and technologies, a summary of the health problems with wood smoke, provided a rationale for government intervention and a benefit-cost analysis of policy options. A primary purpose of the Statement is to gain feedback on the data, information and options within the document and the potential impact of the options presented.

The following is a brief summary of the Statement as it relates to the development with selected text extracted for reporting consistency. It is strongly recommended that any planning decisions relating to the use of wood heaters in the West Belconnen area take into consideration the data presented in the Statement and the conclusions reached, noting these conclusions are of a regulatory nature and not all are appropriate to planning decisions required for the current development.

The Statement identified that there is a large range of potential policy measures that could be implemented to reduce emissions from wood heaters. The potential measures fall into three major categories:

- wood heater design or performance standards;
- measures to promote compliance of retail models against these standards; and
- measures influencing the in-service operational performance of wood heaters.

These measures could be delivered through a range of policy 'vehicles'. The policy delivery approaches examined were a voluntary national program, a collaborative approach or a national regulatory approach. A full list of the policy actions and policy delivery vehicles, as provided in the Statement, is provided in **Appendix B**.

Under the business-as-usual or 'base case' scenario, particulate emissions from wood heaters in Australia are expected to fall by around 5000 tonnes (or 12%) over the next twenty years, as old heaters are progressively replaced with new, lower particulate emitting heaters. The reduction in annual particulate emissions from wood heaters under the policy options examined, over and above the business-as-usual reductions, range from 3% (for Option 1; national audits and education targeted at critical airsheds) to 18% (for Option 9; emissions labelling, efficiency standard of 60% and 1.5 g/kg, national audits and independent testing, education, controls on modification and installation, controls on 2nd-hand heaters and wood heater replacement incentives).

The Statement concludes that the net benefits are greatest for the options involving national regulation and including a broad range of measures covering standards, compliance and in-service emissions (Options 7, 8 and 9). The statement authors conclude that option 7 is estimated to provide the highest net benefits. Option 7 involves the following policy actions:

- Emissions labelling (compliance plate);
- Efficiency standard of 60% and emissions standard of 3 g/kg;
- National audits and independent testing;
- Education;
- Common definition of excessive smoke;
- Controls on modification and installation;
- Controls on 2nd-hand heaters; and
- Wood heater replacement incentives.

7.2.4 Tuggeranong Valley Preliminary Assessment

The paper entitled "*Preliminary Assessment of Wintertime Air Quality in the Tuggeranong Valley, ACT*" (2009) prepared by Howard Bridgman (Conjoint Associate Professor, School of Environmental and Life Sciences University of Newcastle, and Fellow, Clean Air Society of Australia and New Zealand) provides the following recommendations on the use of domestic wood fire in the Tuggeranong Valley. The recommendations are relevant to areas where particulate matter is considered a potential issue, which may include the West Belconnen development although to a lesser degree then the Tuggeranong Valley.

- Recommendation 1: The data sets created by the current ACT government monitoring instruments need more attention. A revisit of the methods used to handle the measurement instruments and the monitoring data, with the objective to improve data availability and data quality, especially for the GRIMM and LoVol data sets, would be of considerable benefit. Major differences between the HiVol, TEOM and GRIMM winter measurements should be resolved. Good comparisons between measurements from different instruments will provide considerable flexibility and backup possibilities over time.
- Recommendation 2: Evaluating the relationship between PM_{10} and meteorology for winter months where hourly PM_{10} is available. If the relationship remains strong, ACT Government can use these data to issue daily forecast alerts to the public associated with Don't Light Tonight and similar management campaigns.
- Recommendation 3: Efforts to reduce the use of solid fuel burners in the Tuggeranong Valley in winter have been successful and should continue. Natural gas can create a similar social cozy winter night environment, and is a much cleaner fuel. Wood pellets, substituted for wood logs, burn more efficiently and create minimal smoke emissions.
- Recommendation 4: The NSW EPA AQI calculation for PM_{10} and $PM_{2.5}$ should be adopted for Canberra, and daily information issued based on measurement locations that meet NEPM standards. Forecasts of expected poorer AQI can be included with BOM forecasts of low wind speeds, low temperatures, and high humidity, especially in winter, and especially for the Tuggeranong Valley.
- Recommendation 5: Upgrading the Health Protection Service website to include details about where, what, how and over what period of time air quality monitoring has been and is occurring, would be of benefit to the community.
- Recommendation 6: Providing air quality measurements from all stations on-line, in real-time mode, along with AQI information, and if possible, weather measurements, would provide current information useful for the community.
- Recommendation 7: Consideration be given to measuring particulate chemistry at the Monash site for a period of at least one winter to determine the composition of the PM. Comparison measurements for one other season would be useful.

In summary, the recommendations that may be relevant to the West Belconnen development are that the ACT government should consider gaining a better understanding on the monitoring methods and collected data, specifically the relationship between meteorology and $PM_{10,}$ the collected data should be made more accessible to the public through on-line reporting and the possibility of employing an AQI similar to that employed by the NSW EPA.

The above recommendations from Mr Bridgman highlight the potential need for a local ambient monitoring station in proximity to the West Belconnen and other high residential development areas, as discussed in **Section 7.2.5**.

7.2.5 Ambient Air Monitoring Review

The previous air quality monitoring station at Belconnen was discontinued in June 1996. A recommendation was made in the 1997 State of the Environment Report to maintain monitoring at Belconnen, but at the time the ACT Government considered that resources required for an additional station at Belconnen would exceed the benefits obtained from the data which could be collected. The Government considered that the number and location of existing monitoring stations is adequate to meet the NEPM requirements. Since this time the ACT government has allocated money in budgets for an ambient monitoring station in Belconnen, although to the authors' knowledge the station has yet to be commissioned.

The decision not to continue the monitoring of air pollution, specifically particulate matter, in the northern ACT region should be re-assessed given the ongoing particulate exceedences and the increase of residential and commercial development in the area, such as the West Belconnen and Molonglo Valley developments. The collected data would increase the available information on the ACT airshed in general, as well as identifying any issues specific to the West Belconnen development that cannot be identified using the existing monitoring station data. If installed the station should be sited in accordance with relevant Australian Standards (e.g. AS/NZS 3580.1.1:2007 and AS 2923 – 1987).

7.2.6 Wood Heater Technology Standards

The Australian/New Zealand Standard *4013:1999 Domestic solid fuel burning appliances – Method for determination of flue gas emission* specifies that combustion heaters without catalytic combustors must have a particulate emissions factor not greater than 4.0g/kg. There is currently no efficiency criterion, but there is a requirement that the efficiency result be reported (along with other information) on a label permanently attached to the appliance.

In April 2012, the Australian Home Heating Association (AHHA) submitted an application to Standards Australia to update the standards applicable to emission and efficiency requirements for all new wood heaters offered for sale in Australia. The AHHA proposal specifically sought a revision of the emissions and efficiency criteria respectively to 2.5 grams of particulate matter (PM_{10}) emitted per kilogram of fuel burnt (2.5g/kg) and a new efficiency standard of 55 %.

In 2012 the ACT Parliamentary Counsel released the *Exposure Draft Legislation: Environment and Construction Occupations Legislation (Wood Heaters) Amendment Bill 2012* which recommended a minimum 65% efficiency and 1g/kg emissions standard that would reduce particulate emissions per kg of wood burned from the average new wood heater by approximately 34%, as summarised as follows;

- The 65% efficiency standard would reduce total wood use over 15 years by about 10%;
- A combined 1g/kg emissions standard and 65% efficiency standard could reduce particulate matter pollution over 15 years by up to 65%.

A list of certified wood heaters is available from the Australian Home Heating Association Inc (AHHA) - http://www.homeheat.com.au/certified.php. There are currently a large number of products that meet the stricter criteria or 1g/kg and minimum 65% efficiency as recommended by the ACT Parliamentary Counsel.

A new alternative technology is pellet heaters (Australian Government, 2005). They use compressed sawdust pellets, which is the waste product of sawmilling processes, using a hopper to feed pellets into the firebox without the need for human intervention. Pellet heaters have very low emissions and are almost smokeless.

7.2.7 Australian Government Wood Heater Fuel Recommendations

The Australian Government *Woodheaters and Woodsmoke; Air Quality Fact Sheet* (2005) (http://www.environment.gov.au/resource/woodheaters-and-woodsmoke) provides the following recommendations on the fuel of wood heater in order to minimise smoke and maximise efficiency.

- burn only dry, seasoned, untreated wood;
- use smaller logs instead of only one large log;
- do not pack the fire box too full as this will starve the fire of oxygen and cause it to smoulder;
- keep the fire burning brightly for the first 20 minutes after lighting and reloading – the faster you can get the fire going the les smoke there will be; and
- always have a visible flame if you plan to keep the fire going overnight.

The fact sheet also discusses the virtues of the pellet heaters previously discussed.

7.3 Greenhouse Gas Emissions

In addition to the measures to be employed to reduce transport emissions, the plan for the West Belconnen development involves a number of energy efficiency initiatives (including appropriate siting and orientation of properties to maximise solar access; mandatory energy efficiency ratings; education and training for residents regarding appliance purchasing and sustainable living; and, potentially, use of renewable energy sources) that will reduce residential electricity consumption. Improving the thermal efficiency of households would also reduce the need for heating. As such, the potential increases in greenhouse gas emissions are reduced.

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8.0 Conclusion

Existing air quality in the ACT is considered to be excellent, with the exception of particulate matter and possibly ozone. The proposed development will affect air quality in the local area by introducing additional pollution sources above those already present. The primary potential pollution sources likely to affect air quality in the development area are bushfires (including back-burning/hazard reduction activities), wood heaters and vehicles.

A review of the meteorology and topography of the development area suggests that temperature inversions that occur on cold, stable, clear nights may occur in the development area and that there is the potential for katabatic/ valley drainage of night-time pollution to and from the development to occur. The presence of pollution emissions during these times, specifically wood heater emissions during winter, therefore might exacerbate the potential health impacts on those residents in the development and surrounding areas.

Existing legislative measures are considered suitable for minimising the adverse effects of vehicle emissions in the area. As bushfires are a significant source of particulate emissions during summer months, appropriate measures should be taken to minimise bushfire risk around the development area, particularly as the incidence of bushfires is expected to increase over the coming years due to climate change.

Following the release of the 2011 ACT Air Quality Report that identified breaches of the particulate reporting standard, the Minister for Environment and Sustainable Development announced the prohibition of wood heaters in the majority of the neighbouring Molonglo Development. Similar considerations were suggested in a review of air quality issues in the Molonglo Valley prepared by AECOM (2011). A review of current literature regarding wood heater use was undertaken and identified and discussed several updated sources of knowledge and options for the control and mitigation of wood smoke emissions pertinent to the development.

The issue of wood heater emissions control and regulation is an ongoing area of research, with several outstanding research projects / legislative reviews still to be delivered. Given the progressive nature of wood smoke and particulate research, and the pending delivery of several significant projects, strong consideration should be given to implementing a strict level of wood heater efficiency or even prohibiting wood heaters in the development area until such time as an industry / government approach has been reached.

The mitigation measures provided below have been selected from cited literature sources and represent the more stringent level of efficiency and emissions referenced (specifically ACT Parliamentary Counsel 2012). The more stringent standards have been selected so that should regulation be passed that is less stringent (e.g. 2.5 g/kg emissions) any purchased heaters would comply with the regulation; whereas the selection of less stringent standards may lead to purchased heaters not complying with future stricter regulations (such as that proposed by the ACT Parliamentary Counsel 2012). The following selected mitigation measures should be considered for the West Belconnen development together with continued government campaigns and regulation:

- Wood heater overall efficiency standard of not less than 65%;
- Wood heater emissions standard not greater than 1 g/kg;
- Education on the use of wood heaters;
- Controls on installation and 2nd-hand heaters;
- Encouragement for the use of pellet heaters over standard wood heaters;
- Continuation of the ACT Government education and information programs such as the ‘Don’t Burn Tonight’ campaign; and
- Continual review of relevant legislation, industry standards and guidelines and documents prepared such as the impending delivery of the National Plan for Clean Air and COAGs response to the Regulation Impact Statement.

The AQR recommends that the ACT government should re-assess its initial decision to discontinue ambient monitoring in the north of the ACT. Anecdotal evidence suggests that this is in the process of occurring, with money set aside in the budget for the station. Monitoring information can provide the necessary recommendations to residents as required by the *Don’t Burn Tonight* and other campaigns. Such an action will enable pollutant concentrations in the area to be monitored, and will further increase the available knowledge of the Canberra airshed.

Considering the development is still at an early design phase, and with the progressive delivery of key research projects and legislative reviews, consideration should be given to re-evaluating the findings of this report when more information is available at a later stage of design development.

9.0 References

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Appendix A

NPI Data for Reporting Year 2011/2012

Appendix A NPI Data for Reporting Year 2011/2012

Pollutant Emissions for Each Facility Listed in the National Pollution Inventory for the Regional Area 2011/2012 data

Facility Name	Substance	Air (kg)
LOWER MOLONGLO WATER QUALITY CONTROL [Holt-ACT]	Total Nitrogen	
	Fluoride compounds	71
	Chlorine & compounds	
	Mercury & compounds	7
	Cadmium & compounds	2
AUSTRALIAN NATIONAL UNIVERSITY [Acton-ACT]	Cadmium & compounds	0
	Lead & compounds	0
	Mercury & compounds	0
	Sulfur dioxide	104
	Arsenic & compounds	0
BORAL ASPHALT -MUGGA [Symonston-ACT]	Polycyclic aromatic hydrocarbons (B[a]Peq)	6
	Sulfur dioxide	1,197
	Carbon monoxide	4,618
	Total Volatile Organic Compounds	1,386
	Oxides of Nitrogen	1,845
Boral Mugga Lane Quarry [Symonston-ACT]	Sulfur dioxide	398
	Carbon monoxide	5,157
	Total Volatile Organic Compounds	956
	Polycyclic aromatic hydrocarbons (B[a]Peq)	0
	Oxides of Nitrogen	8,412
Caltex Aviation Canberra [Majura-ACT]	Ethylbenzene	3
	Benzene	22
	Total Volatile Organic Compounds	1,100
	Xylenes (individual or mixed isomers)	9
	Toluene (methylbenzene)	30
FYSHWICK DEPOT [Fyshwick-ACT]	Ethylbenzene	4
	Cyclohexane	14
	Total Volatile Organic Compounds	3,860
	Benzene	19
	n-Hexane	46
CALVARY HEALTH CARE ACT LIMITED [Bruce-ACT]	Cadmium & compounds	0
	Lead & compounds	0
	Mercury & compounds	0

Facility Name	Substance	Air (kg)
	Sulfur dioxide	16
	Arsenic & compounds	0
BLACK MOUNTAIN [Acton-ACT]	Cadmium & compounds	0
	Lead & compounds	0
	Mercury & compounds	0
	Sulfur dioxide	21
	Arsenic & compounds	0
Australian Defence Force Academy [Campbell-ACT]	Sulfur dioxide	26
	Carbon monoxide	1,957
	Total Volatile Organic Compounds	128
	Polycyclic aromatic hydrocarbons (B[a]Peq)	0
	Oxides of Nitrogen	2,323
HMAS Harman [Harman-ACT]	Total Volatile Organic Compounds	23
Royal Military College Duntroon [Duntroon-ACT]	Sulfur dioxide	12
	Carbon monoxide	878
	Total Volatile Organic Compounds	57
	Polycyclic aromatic hydrocarbons (B[a]Peq)	0
	Oxides of Nitrogen	1,042
Russell Offices [Canberra-ACT]	Sulfur dioxide	25
	Carbon monoxide	1,908
	Total Volatile Organic Compounds	125
	Polycyclic aromatic hydrocarbons (B[a]Peq)	0
	Oxides of Nitrogen	2,265
PARLIAMENT HOUSE [Canberra Parliament House-ACT]	Cadmium & compounds	0
	Lead & compounds	0
	Mercury & compounds	0
	Sulfur dioxide	27
	Arsenic & compounds	0
Mobil Depot Fyshwick [Fyshwick-ACT]	Lead & compounds	0
	Ethylbenzene	5
	Total Volatile Organic Compounds	6,035
	Cyclohexane	22
	Benzene	28
Hume Asphalt Plant [Hume-ACT]	Polycyclic aromatic hydrocarbons (B[a]Peq)	7
	Mercury & compounds	0
	Sulfur dioxide	290
	Carbon monoxide	19,805

Facility Name	Substance	Air (kg)
	Chromium (III) compounds	2
Mugga Lane LFG Power Station [Symonston-ACT]	Carbon monoxide	450,000
	Total Volatile Organic Compounds	10,900
	Mercury & compounds	0
	Oxides of Nitrogen	208,000
	Sulfur dioxide	1,340
West Belconnen LFG Power Station [Macgregor-ACT]	Carbon monoxide	116,000
	Mercury & compounds	0
	Sulfur dioxide	346
	Total Volatile Organic Compounds	2,800
	Oxides of Nitrogen	53,500
Spotless Linen Services [Fyshwick-ACT]	Sulfur dioxide	17
	Carbon monoxide	1,319
	Total Volatile Organic Compounds	87
	Polycyclic aromatic hydrocarbons (B[a]Peq)	0
	Oxides of Nitrogen	1,568
THE CANBERRA HOSPITAL [Canberra-ACT]	Cadmium & compounds	0
	Lead & compounds	0
	Mercury & compounds	0
	Sulfur dioxide	53
	Arsenic & compounds	0
Canberra Bakery [Fyshwick-ACT]	Total Volatile Organic Compounds	9,164
	Sulfur dioxide	10
	Carbon monoxide	836
	Ethanol	9,084
	Polycyclic aromatic hydrocarbons (B[a]Peq)	0
RailCorp Canberra Refuelling Facility [Kingston-ACT]	Total Volatile Organic Compounds	11
MUGGA LANE LANDFILL [Canberra-ACT]	Cadmium & compounds	0
	Lead & compounds	0
	Mercury & compounds	0
	Ethylbenzene	10
	Sulfur dioxide	91
CAPITAL LINEN SERVICE [Canberra-ACT]	Cadmium & compounds	0
	Lead & compounds	0
	Mercury & compounds	0
	Sulfur dioxide	23
	Arsenic & compounds	0

Facility Name	Substance	Air (kg)
UNIVERSITY OF CANBERRA [Canberra University Lpo-ACT]	Cadmium & compounds	0
	Lead & compounds	0
	Mercury & compounds	0
	Sulfur dioxide	18
	Arsenic & compounds	0
Kleenheat Gas - Canberra [Mitchell-ACT]	Total Volatile Organic Compounds	42

Pollutant Emissions for Each Substance and Source Type Listed in the National Pollution Inventory for the Regional Area 2011/2012 data

Substance	Source	Air (kg)
Acetaldehyde	Total	211,610
	Solid fuel burning (domestic) [*]	154,348
	Barbeques [*]	35,033
	Motor Vehicles [*]	21,091
	Cigarettes [*]	1,138
	Central Government Administration [751]	0
Acetone	Total	182,123
	Solid fuel burning (domestic) [*]	114,281
	Architectural Surface Coatings [*]	28,231
	Barbeques [*]	25,909
	Motor Vehicles [*]	13,085
	Cigarettes [*]	609
Acetonitrile	Total	1
	Waste Treatment, Disposal and Remediation Services [292]	1
Acrylic acid	Total	0
	Domestic/Commercial solvents/ aerosols [*]	0
Acrylonitrile (2-propenenitrile)	Total	55
	Cigarettes [*]	48
	Waste Treatment, Disposal and Remediation Services [292]	7
Ammonia (total)	Total	17
	Water Supply, Sewerage and Drainage Services [281]	17
	Waste Treatment, Disposal and Remediation Services [292]	
Antimony & compounds	Total	27
	Burning(fuel red., regen., agric.)/ Wildfires [*]	20
	Solid fuel burning (domestic) [*]	4
	Liquid fuel burning (domestic) [*]	2
	Barbeques [*]	0
	Fuel Combustion - sub reporting threshold facilities [*]	0
Arsenic & compounds	Total	5
	Solid fuel burning (domestic) [*]	3
	Water Supply, Sewerage and Drainage Services [281]	1
	Liquid fuel burning (domestic) [*]	1
	Barbeques [*]	0
	Gaseous fuel burning (domestic) [*]	0
Benzene	Total	464,808

Substance	Source	Air (kg)
	Motor Vehicles [*]	399,372
	Solid fuel burning (domestic) [*]	43,857
	Lawn Mowing [*]	13,012
	Service stations [*]	7,846
	Architectural Surface Coatings [*]	472
Biphenyl (1,1-biphenyl)	Total	15
	Cutback Bitumen [*]	15
1,3-Butadiene (vinyl ethylene)	Total	43,897
	Motor Vehicles [*]	37,236
	Solid fuel burning (domestic) [*]	3,280
	Lawn Mowing [*]	1,653
	Barbeques [*]	1,422
	Burning(fuel red., regen., agric.)/ Wildfires [*]	191
Cadmium & compounds	Total	37
	Motor Vehicles [*]	27
	Burning(fuel red., regen., agric.)/ Wildfires [*]	3
	Water Supply, Sewerage and Drainage Services [281]	2
	Gaseous fuel burning (domestic) [*]	2
	Solid fuel burning (domestic) [*]	1
Carbon monoxide	Total	35,900,000
	Motor Vehicles [*]	26,800,000
	Solid fuel burning (domestic) [*]	6,116,965
	Lawn Mowing [*]	806,546
	Electricity Generation [261]	566,000
	Barbeques [*]	508,265
Chloroethane (ethyl chloride)	Total	5
	Waste Treatment, Disposal and Remediation Services [292]	5
Chloroform (trichloromethane)	Total	140
	Domestic/Commercial solvents/ aerosols [*]	140
	Water Supply, Sewerage and Drainage Services [281]	
	Waste Treatment, Disposal and Remediation Services [292]	0
Chromium (III) compounds	Total	636
	Motor Vehicles [*]	632
	Water Supply, Sewerage and Drainage Services [281]	2
	Petroleum and Coal Product Manufacturing [170]	2
	Liquid fuel burning (domestic) [*]	0
	Tertiary Education [810]	0

Substance	Source	Air (kg)
Chromium (VI) compounds	Total	17
	Solid fuel burning (domestic) [*]	4
	Lawn Mowing [*]	3
	Motor Vehicles [*]	3
	Gaseous fuel burning (domestic) [*]	2
	Burning(fuel red., regen., agric.)/ Wildfires [*]	1
Cobalt & compounds	Total	13
	Motor Vehicles [*]	5
	Lawn Mowing [*]	3
	Liquid fuel burning (domestic) [*]	2
	Barbeques [*]	1
	Solid fuel burning (domestic) [*]	1
Copper & compounds	Total	35
	Water Supply, Sewerage and Drainage Services [281]	10
	Motor Vehicles [*]	18
	Lawn Mowing [*]	3
	Gaseous fuel burning (domestic) [*]	1
	Burning(fuel red., regen., agric.)/ Wildfires [*]	1
Cumene (1-methylethylbenzene)	Total	3,528
	Cutback Bitumen [*]	3,518
	Mineral, Metal and Chemical Wholesaling [332]	9
	Waste Treatment, Disposal and Remediation Services [292]	1
	Traffic (Road Line) Marking [*]	0
Cyclohexane	Total	192,436
	Architectural Surface Coatings [*]	182,620
	Motor Vehicles [*]	6,500
	Service stations [*]	2,615
	Lawn Mowing [*]	396
	Gaseous fuel burning (domestic) [*]	163
Di-(2-Ethylhexyl) phthalate (DEHP)	Total	0
	Solid fuel burning (domestic) [*]	0
	Barbeques [*]	0
1,2-Dichloroethane	Total	1
	Domestic/Commercial solvents/ aerosols [*]	1
	Waste Treatment, Disposal and Remediation Services [292]	0
Dichloromethane	Total	13,823
	Architectural Surface Coatings [*]	8,662

Substance	Source	Air (kg)
	Domestic/Commercial solvents/ aerosols [*]	5,151
	Waste Treatment, Disposal and Remediation Services [292]	10
	Water Supply, Sewerage and Drainage Services [281]	
	Solid fuel burning (domestic) [*]	0
Ethanol	Total	30,225
	Bakeries [*]	15,838
	Bakery Product Manufacturing [117]	9,084
	Architectural Surface Coatings [*]	5,293
	Mineral, Metal and Chemical Wholesaling [332]	9
	Waste Treatment, Disposal and Remediation Services [292]	0
2-Ethoxyethanol acetate	Total	11,469
	Architectural Surface Coatings [*]	11,469
Ethyl acetate	Total	29
	Bakeries [*]	25
	Waste Treatment, Disposal and Remediation Services [292]	3
Ethylbenzene	Total	69,987
	Motor Vehicles [*]	65,525
	Lawn Mowing [*]	3,030
	Service stations [*]	872
	Domestic/Commercial solvents/ aerosols [*]	294
	Cutback Bitumen [*]	241
Ethylene glycol (1,2-ethanediol)	Total	19,034
	Domestic/Commercial solvents/ aerosols [*]	12,927
	Architectural Surface Coatings [*]	6,081
	Traffic (Road Line) Marking [*]	27
Ethylene oxide	Total	2,139
	Domestic/Commercial solvents/ aerosols [*]	2,139
Fluoride compounds	Total	130
	Water Supply, Sewerage and Drainage Services [281]	71
	Solid fuel burning (domestic) [*]	23
	Liquid fuel burning (domestic) [*]	15
	Construction Material Mining [091]	8
	Petroleum and Coal Product Manufacturing [170]	5
Formaldehyde (methyl aldehyde)	Total	268,363
	Solid fuel burning (domestic) [*]	166,279
	Motor Vehicles [*]	61,171
	Barbeques [*]	37,725

Substance	Source	Air (kg)
	Lawn Mowing [*]	2,334
	Waste Treatment, Disposal and Remediation Services [292]	254
n-Hexane	Total	289,957
	Architectural Surface Coatings [*]	182,620
	Motor Vehicles [*]	73,107
	Service stations [*]	16,564
	Domestic/Commercial solvents/ aerosols [*]	12,216
	Gaseous fuel burning (domestic) [*]	2,706
Hydrochloric acid	Total	149
	Liquid fuel burning (domestic) [*]	136
	Water Supply, Sewerage and Drainage Services [281]	12
	Barbeques [*]	0
	Domestic/Commercial solvents/ aerosols [*]	0
	Waste Treatment, Disposal and Remediation Services [292]	0
Hydrogen sulfide	Total	33
	Waste Treatment, Disposal and Remediation Services [292]	21
	Water Supply, Sewerage and Drainage Services [281]	11
	Natural/Town Gas Leakage [*]	1
Lead & compounds	Total	13,210
	Motor Vehicles [*]	13,130
	Water Supply, Sewerage and Drainage Services [281]	32
	Lawn Mowing [*]	31
	Solid fuel burning (domestic) [*]	12
	Burning(fuel red., regen., agric.)/ Wildfires [*]	2
Magnesium oxide fume	Total	42
	Water Supply, Sewerage and Drainage Services [281]	42
	Barbeques [*]	0
Manganese & compounds	Total	52
	Water Supply, Sewerage and Drainage Services [281]	
	Petroleum and Coal Product Manufacturing [170]	15
	Motor Vehicles [*]	14
	Solid fuel burning (domestic) [*]	9
	Burning(fuel red., regen., agric.)/ Wildfires [*]	5
Mercury & compounds	Total	9
	Water Supply, Sewerage and Drainage Services [281]	7
	Burning(fuel red., regen., agric.)/ Wildfires [*]	1
	Gaseous fuel burning (domestic) [*]	0

Substance	Source	Air (kg)
	Fuel Combustion - sub reporting threshold facilities [*]	0
	Electricity Generation [261]	0
	Total	134,130
	Domestic/Commercial solvents/ aerosols [*]	99,723
Methanol	Architectural Surface Coatings [*]	34,407
	Total	62,292
	Architectural Surface Coatings [*]	49,404
	Domestic/Commercial solvents/ aerosols [*]	7,151
	Solid fuel burning (domestic) [*]	5,173
	Traffic (Road Line) Marking [*]	328
Methyl ethyl ketone	Cigarettes [*]	116
	Total	6,390
	Architectural Surface Coatings [*]	5,293
	Domestic/Commercial solvents/ aerosols [*]	1,073
	Motor Vehicle Refinishing [*]	19
	Waste Treatment, Disposal and Remediation Services [292]	4
Methyl isobutyl ketone	Traffic (Road Line) Marking [*]	0
	Total	11
Methyl methacrylate	Traffic (Road Line) Marking [*]	11
	Total	58
	Water Supply, Sewerage and Drainage Services [281]	5
	Liquid fuel burning (domestic) [*]	32
	Fuel Combustion - sub reporting threshold facilities [*]	6
	Motor Vehicles [*]	5
Nickel & compounds	Lawn Mowing [*]	3
	Total	8,235,087
	Motor Vehicles [*]	7,287,412
	Electricity Generation [261]	261,500
	Gaseous fuel burning (domestic) [*]	140,921
	Aeroplanes [*]	117,140
Oxides of Nitrogen	Fuel Combustion - sub reporting threshold facilities [*]	91,648
	Total	913,426
	Solid fuel burning (domestic) [*]	637,856
	Motor Vehicles [*]	90,220
	Barbeques [*]	68,579
	Burning(fuel red., regen., agric.)/ Wildfires [*]	43,481
Particulate Matter 10.0 um	Construction Material Mining [091]	19,133

Substance	Source	Air (kg)
Particulate Matter 2.5 um	Total	6,209
	Construction Material Mining [091]	2,104
	Waste Treatment, Disposal and Remediation Services [292]	1,072
	Tertiary Education [810]	991
	Water Supply, Sewerage and Drainage Services [281]	622
	Hospitals [840]	461
Phenol	Total	170
	Cigarettes [*]	170
Polycyclic aromatic hydrocarbons (B[a]Peq)	Total	24,289
	Solid fuel burning (domestic) [*]	16,072
	Motor Vehicles [*]	7,234
	Lawn Mowing [*]	685
	Cutback Bitumen [*]	278
	Petroleum and Coal Product Manufacturing [170]	13
Selenium & compounds	Total	2
	Water Supply, Sewerage and Drainage Services [281]	
	Solid fuel burning (domestic) [*]	1
	Barbeques [*]	0
	Liquid fuel burning (domestic) [*]	0
	Burning(fuel red., regen., agric.)/ Wildfires [*]	0
Styrene (ethenylbenzene)	Total	9,848
	Motor Vehicles [*]	7,203
	Solid fuel burning (domestic) [*]	1,594
	Barbeques [*]	691
	Lawn Mowing [*]	233
	Traffic (Road Line) Marking [*]	65
Sulfur dioxide	Total	347,937
	Liquid fuel burning (domestic) [*]	185,195
	Motor Vehicles [*]	102,023
	Fuel Combustion - sub reporting threshold facilities [*]	21,336
	Solid fuel burning (domestic) [*]	12,942
	Aeroplanes [*]	11,919
Tetrachloroethylene	Total	17,629
	Dry Cleaning [*]	13,614
	Domestic/Commercial solvents/ aerosols [*]	4,009
	Waste Treatment, Disposal and Remediation Services [292]	6
	Solid fuel burning (domestic) [*]	0

Substance	Source	Air (kg)
	Barbeques [*]	0
Toluene (methylbenzene)	Total	706,245
	Motor Vehicles [*]	530,396
	Domestic/Commercial solvents/ aerosols [*]	60,665
	Architectural Surface Coatings [*]	45,876
	Solid fuel burning (domestic) [*]	26,893
	Lawn Mowing [*]	21,892
Total Volatile Organic Compounds	Total	12,800,000
	Motor Vehicles [*]	5,903,579
	Solid fuel burning (domestic) [*]	2,008,589
	Domestic/Commercial solvents/ aerosols [*]	1,607,821
	Architectural Surface Coatings [*]	1,161,329
	Service stations [*]	869,470
Trichloroethylene	Total	2,411
	Solvent Use - Sub-threshold facilities [*]	2,340
	Domestic/Commercial solvents/ aerosols [*]	69
	Waste Treatment, Disposal and Remediation Services [292]	2
Vinyl Chloride Monomer	Total	2
	Waste Treatment, Disposal and Remediation Services [292]	2
Xylenes (individual or mixed isomers)	Total	523,281
	Motor Vehicles [*]	434,181
	Domestic/Commercial solvents/ aerosols [*]	28,802
	Architectural Surface Coatings [*]	22,938
	Lawn Mowing [*]	16,067
	Solid fuel burning (domestic) [*]	11,332
Zinc and compounds	Total	900
	Solid fuel burning (domestic) [*]	483
	Motor Vehicles [*]	262
	Water Supply, Sewerage and Drainage Services [281]	
	Barbeques [*]	55
	Gaseous fuel burning (domestic) [*]	44

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Appendix B

NEPCSC Regulation Impact Statement – Policy Actions and Policy Delivery Vehicles

Appendix B NEPCSC Regulation Impact Statement – Policy Actions and Policy Delivery Vehicles

Extracted from National Environment Protection Council Service Corporation (2013) *Consultation regulation impact statement for reducing emissions from wood heaters*, prepared by BDA Group.

Option	Type of approach	Policy vehicle/s	Policy actions		
			Standards	Compliance	In-service
1	**Voluntary**	National program		National audits	Education (targeted at critical airsheds)
2	"			as above	Education Wood heater replacement incentives
3	**Collaborative**	Enhanced jurisdictional regulatory arrangements calling up Australian Standards, with complementary Commonwealth programs	Emissions labelling (compliance plate)	Nationally coordinated funding for state-based standard audit and enforcement	Education
4	"		Emissions labelling (compliance plate) National star rating labelling scheme	as above	as above
5	"		Emissions labelling (compliance plate) National star rating labelling scheme Efficiency standard (60%)	as above	as above
6	**National regulatory approach**	Sub-options: A. NEPM B. Commonwealth legislation C. Mirror legislation	Emissions labelling (compliance plate) Efficiency standard (60%) Emission standard (3 g/kg)	Independent testing and national certification National audits	Education
7	"		as above	as above	Education Common definition of excessive smoke Controls on modification and installation Controls on 2nd-hand heaters Wood heater replacement incentives

Option	Type of approach	Policy vehicle/s	Policy actions		
			Standards	Compliance	In-service
8	"		Emissions labelling (compliance plate) Efficiency standard (65%) Emission standard (3 g/kg)	as above	as above
9	"		Emissions labelling (compliance plate) Efficiency standard (60%) Emission standard (1.5 g/kg)	as above	as above