2.11.2 Approach to particulate matter concentrations ($PM_{2.5}$)

$PM_{2.5}$ concentrations are not monitored at the Lindfield or Prospect monitoring stations. In order to estimate ambient $PM_{2.5}$ concentrations, the ratios of PM_{10} to $PM_{2.5}$ measured at other monitoring stations within the Sydney basin were calculated. Monitoring data from Liverpool, Chullora, Earlwood and Richmond recorded between 2009 and 2011 were used. The PM_{10} to $PM_{2.5}$ ratios were calculated for each of the monitoring stations for each hour of the day. These ratios were then averaged across the monitoring stations for each hour of the day, and the maximum of the hourly averages was adopted as the conversion ratio for the air quality impact assessment presented in the environmental impact statement, which was 0.35. This ratio was applied to the combined PM_{10} monitoring data from Lindfield/Prospect to estimate hourly $PM_{2.5}$ concentrations.

This assumption has been revisited since publication of the environmental impact statement to test whether it is reasonable. A sensitivity analysis has been conducted, which considers whether a higher ratio (0.50 $PM_{2.5}$ to PM_{10}) would significantly alter the outcomes of the air quality impact assessment (in terms of the acceptability or otherwise of predicted ground level concentrations of $PM_{2.5}$)

Five receiver locations with predicted elevated $PM_{2.5}$ concentrations (as identified from the modelling and assessment presented in the environmental impact statement) have been selected for analysis. All of these receiver locations had background pollutant contributions based on ambient (OEH) monitoring data (rather than from outputs from the CAL3QHCR model for roadside receiver locations). The background (ambient) concentration of $PM_{2.5}$ at each of these receiver locations was amended to reflect $PM_{2.5}$ as 50 per cent of PM_{10} and compared with the approach taken in the environmental impact statement (ie $PM_{2.5}$ as 35 per cent of PM_{10}).

The results of this comparison are presented in **Table 2-53**. The results are based on the forecast traffic volume scenario in 2019.

The results of the analysis of the five receiver locations with elevated $PM_{2.5}$ concentrations shows that while the cumulative concentrations increase for $PM_{2.5}$, no additional exceedances of the advisory reporting standard (that is, exceedances in addition to those present in the background) are expected when the data are considered contemporaneously. The increased $PM_{2.5}$ background concentrations are due to the higher $PM_{2.5}$ ratio which, when applied to the ambient monitoring data from Prospect/ Lindfield, result in five additional exceedances in 2009. As the exceedances are related to the background concentrations and not project contributions, however, these additional exceedances are not an issue of concern for compliance for the project.

Table 2-53 Comparison of cumulative $PM_{2.5}$ concentrations (35% and 50% $PM_{2.5}$)

Pollutant	Background Calculation Method	Statistic	Receiver location				
			1	2	3	4	5
$PM_{2.5}$ (24 hour)	35% $PM_{2.5}$ to PM_{10} ratio	Maximum ($\mu g/m^3$)	77.6	77.6	77.6	77.6	77.6
		Average	7.5	7.5	7.5	7.5	7.5
		Number of exceedances of advisory reporting standard	4	4	4	4	4
	50% $PM_{2.5}$ to PM_{10} ratio	Maximum value	110.8	110.8	110.8	110.8	110.8
		Average value	10.6	10.6	10.6	10.6	10.6
		Number of exceedances of advisory reporting standard	9	9	9	9	9

2.11.3 Representativeness of background air quality data

To demonstrate the representativeness of the Lindfield/ Prospect monitoring for conditions along the project corridor, data from those monitoring stations has been compared with data collected the project ambient monitoring stations (Rainbow Park Reserve, James Park and Headen Park). The analysis has compared data between January 2014 and August 2014 contemporaneously (data collected at the same time at each monitoring station has been compared).

The monitoring data from the project monitoring stations at Brickpit Park and Observatory Park is affected by surface road emissions (due to the proximity of Pennant Hills Road) and has been used separately to validate surface road dispersion modelling (refer to **Section 2.13.3**).

Figure 2-13 and **Figure 2-14** show this comparison for NO_2 (one hour average) and PM_{10} (24 hour average).

The data shown from the monitoring stations at Prospect and Lindfield represent the maximum concentrations recorded at either Prospect or Lindfield for each monitoring period. This approach has been taken to be consistent with the methodology applied to the air quality impact assessment for the project.

For one hour average NO_2, the project monitoring data and the maximum Prospect/ Lindfield data (refer to **Figure 2-13**) follow the same general trends. The Prospect/ Lindfield monitoring data follows the most similar in trend to the Rainbow Park data, while the Headen Park data are typically much lower than the data recorded at the other monitoring stations. Overall, the maximum Prospect/ Lindfield data are considered to be representative of NO_2 levels in the project area, and slightly higher than data collected from monitoring stations along the project corridor in most cases.

For 24 hour average PM_{10}, the data from the three project monitoring stations typically follow the same trends (refer **Figure 2-14**). The project monitoring data shows a high degree of agreement with the maximum Prospect/ Lindfield data, with the maximum Prospect/ Lindfield data generally being higher than the project monitoring data. The peak value of the Prospect/ Lindfield data is higher than the project monitoring data. As such, the data indicate that the Prospect/ Lindfield maximum data represent a conservative estimate of ambient PM_{10} levels in the project area.

As the Prospect/ Lindfield data are currently similar to the project monitoring data, and there are no known reasons to assume that significant differences might have occurred between the project area and the Prospect/ Lindfield monitoring locations in the recent past (since 2009), the use of the maximum Prospect/ Lindfield data for ambient pollutant concentrations in the dispersion modelling undertaken for the environmental impact statement and in this report, measured between 2009 and 2011, is considered to be appropriate.

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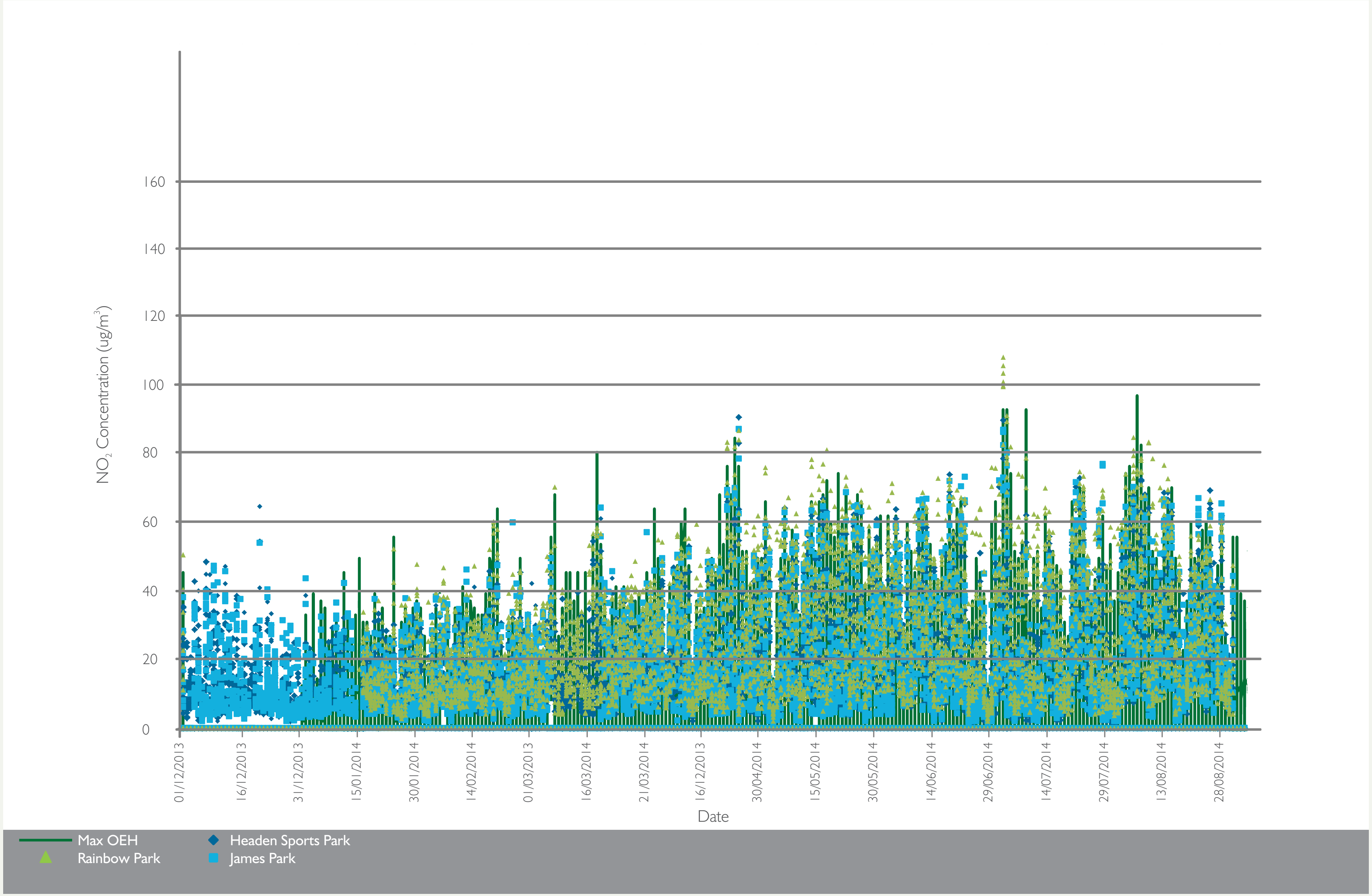

Figure 2-13 24 hour NO_2 concentrations (ug/m3) - January to August 2014

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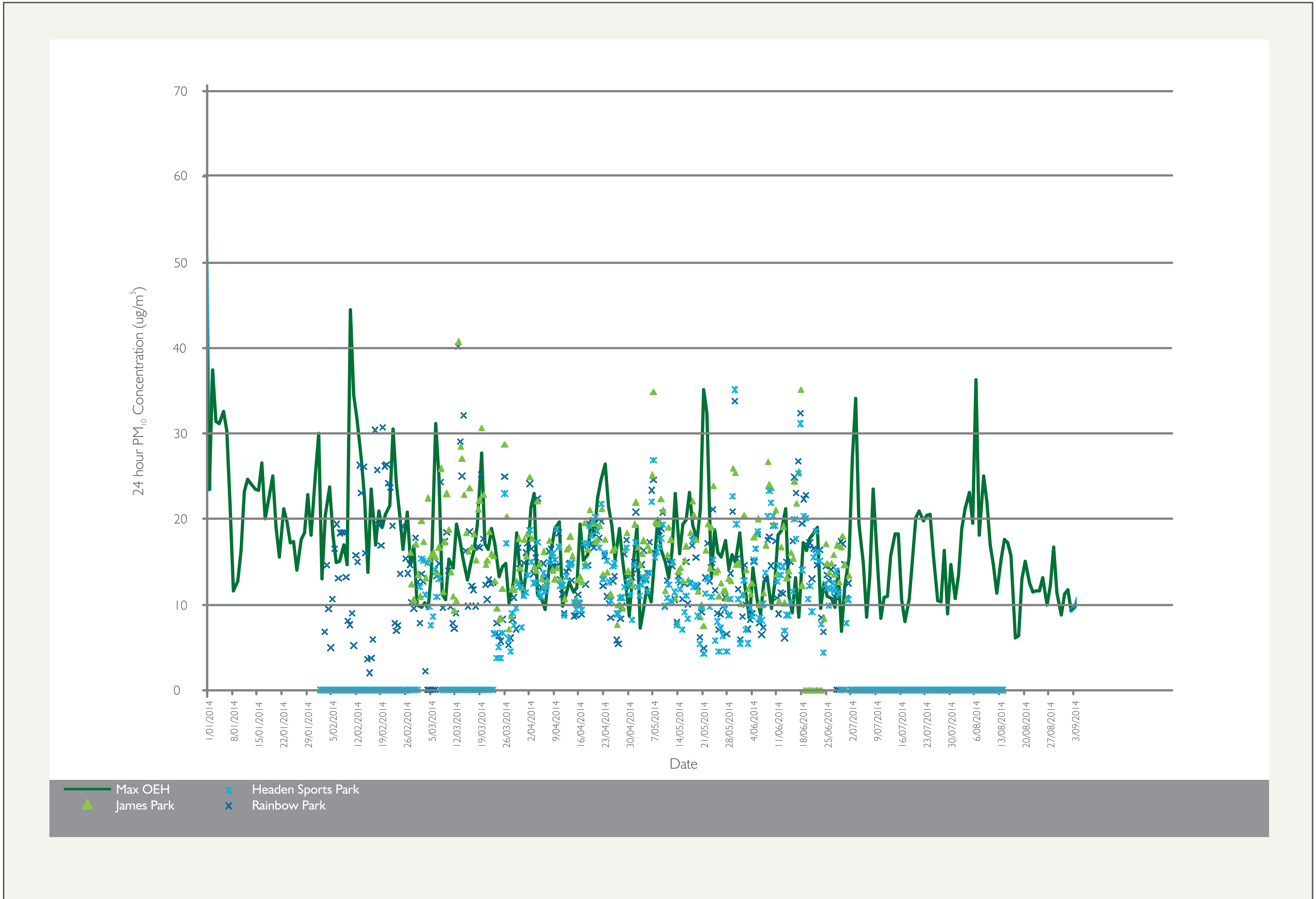

Figure 2-14 24 hour PM_{10} concentrations (ug/m3) - January to August 2014

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2.12 Local and regional terrain

This section provides information and discussion in relation to:

- Local and regional terrain data used in the air quality impact assessment.
- A sensitivity analysis to test the terrain data that has been used.

2.12.1 Terrain data used in the air quality impact assessment

The air quality impact assessment for the project (as presented in the environmental impact statement) has relied on topographic data from the Shuttle Radar Topography Mission (SRTM), which utilised a modified radar system on board the Space Shuttle Endeavour to gather topographic data across almost all of the Earth. The SRTM was an international project directed by the United States National Geospatial-Intelligence Agency (NGA) and the National Aeronautics and Space Administration (NASA).

The SRTM topographic data has been used in the air quality impact assessment in two key areas:

- In the meteorological modelling using the CALMET model (refer to **Section 2.10**).
- In the air dispersion modelling using the CALPUFF model (refer to **Section 2.13**).

SRTM topographic data has been used for the air quality impact assessment presented in the environmental impact statement at a resolution of approximately 90 metres.

The CALMET meteorological model has been with a model grid resolution of 250 metres. The terrain height in the CALMET meteorological model has been determined based on an interpolated average of all the terrain heights that fall within the corresponding SRTM topographic data cells. That is, within each 250 metre by 250 metre CALMET model grid cell, there are at least four 90 metre by 90 metre SRTM topographic data cells which have been used to determine terrain height.

In the case of the CALPUFF air dispersion model, a finer resolution modelling grid has been used with defined receiver locations. The terrain elevations for each receiver location, and for the northern and southern ventilation outlet emission sources, have been separately interpolated from the 90 metre resolution SRTM topographic data in the same manner as for the CALMET model terrain data. If a receiver location fell between two horizontally displaced 90 metre terrain height locations, the CALPUFF model could either interpolate between the two heights or take the peak between the two. In the case of the air dispersion modelling carried out for the project, the more conservative approach of taking the peak terrain value for these receivers have been applied. This approach will tend to overestimate the height of the receiver relative to the ventilation outlet height, leading to a more conservative (overestimate) of ground level concentrations of emissions.

The approach taken to terrain assumptions and the use of topographic data in the air quality impact assessment for the project is consistent with Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia (OEH, 2011). This guideline states that '*the SRTM data is recommended* *for all applications conducted in NSW, Australia*', and makes specific reference to the use of 90 metre SRTM data.

2.12.2 Sensitivity analysis of terrain data

Some of the submissions received in response to the exhibition of the environmental impact statement for the project have questioned the accuracy and reliability of SRTM topographic data.

All empirical data sets have an associated degree of uncertainty or error, typically as a result of the accuracy of the data gathering equipment and/ or the measurement methodology. The accuracy of SRTM topographic data has been assessed in An Assessment of the SRTM Topographic Products (Rodríguez et at, undated). The Rodríguez et al report compares topographic elevations from the SRTM with data gathered at 'ground control points' (GCPs) via a global positioning system (GPS) across a series of transects on each continent. Ground control points were generally accurate to around 0.5 metres.

With respect to SRTM data for Australia, the Rodríguez et al report identified that:

- The SRTM data has a mean error of 1.8 metres, with a standard deviation of 3.5 metres. The 90% absolute error in the data set for all of Australia was identified as 6.0 metres (refer to Table 2.1 in the Rodríguez et al report).
- The SRTM data was slightly more likely to overestimate topographic height than to underestimate it (refer to Figure 2.1 of the Rodríguez et al report).

These findings support the conclusion that the SRTM data is accurate with relatively low error magnitudes on average. Where errors do occur, they are more likely to overestimate the height of topography which, in the case of air quality dispersion modelling such as presented in the NorthConnex project, poses a greater risk of assessing elevated and more highly impacted receivers, rather than the converse. That is, there is a risk that SRTM data has overestimated the height of receiver locations around the ventilation outlets, which would have led to an overestimation of potential impacts at those locations.

To test the sensitivity of terrain data and assumptions in the air quality impact assessment, a screening level air dispersion model and assessment has been conducted for the northern ventilation outlet (as an example, with comparable results anticipated for the southern ventilation outlet). This screening level assessment considered:

- Terrain inputs based on SRTM topographic data, consistent with the approach taken in the environmental impact statement.
- Terrain inputs based on LiDAR topographic data measured along the project corridor.

LiDAR topographic data with resolution of one metre (and accuracy of ±150 millimetres) was collected along the project corridor in August 2013. The data was collected for the purpose of informing the engineering design of the project, and provides an accurate, high resolution and recent topographic data set. The LiDAR data was only collected along the project corridor, and was therefore not sufficient for use across the broader modelling domain considered as part of the air quality impact assessment. It is, however, useful in testing the sensitivity of the air dispersion modelling of the project to topographic data and assumptions around the project's ventilation outlets.

A discrete receiver grid has been established using the one metre resolution LiDAR topographic data with a grid spacing of 150 metres, to match the grid spacing applied to the air quality assessment for the project. All other modelling inputs and assumptions, including source parameters (ventilation outlet height, emissions inventory, flow rates etc) and meteorology (one year of data) have not been altered from the inputs presented in the environmental impact statement.
Table 2-54 presents the outcomes of the screening level assessment based on terrain inputs based on SRTM 90 metre resolution topographic data and the LiDAR one metre resolution topographic data. The table presents ground level concentrations at the most affected receiver location based on forecast traffic data in 2019.

Table 2-54 shows that using the higher resolution LiDAR data produces lower predicted air quality impacts for all modelled pollutants. By corollary, this indicates that the air dispersion modelling presented in the environmental impact statement and employing SRTM 90 metre resolution data (as interpolated using the approach summarised above) is likely to have conservatively overestimated potential air quality impacts. Based on the screening level assessment using LiDAR data, the predicted air quality impacts (and associated human health risks) presented in the environmental impact statement may be overstated by around 10 to 20 per cent.

Table 2-54 Comparison of data sets

Pollutant (averaging period)	EIS design (90 metre SRTM)	LiDAR data (one metre)	Percentage change relative to EIS design
NO_x (one hour average)	119.0 µg/m^3	109.9 µg/m^3	-7.6%
NO_x (annual average)	1.29 µg/m^3	1.09 µg/m^3	-15.5%
PM_{10} (24 hour average)	0.94 µg/m^3	0.84 µg/m^3	-10.6%
PM_{10} (annual average)	0.08 µg/m^3	0.06 µg/m^3	-25.0%
$PM_{2.5}$ (24 hour average)	0.88 µg/m^3	0.79 µg/m^3	-10.2%
$PM_{2.5}$ (annual average)	0.07 µg/m^3	0.06 µg/m^3	-14.3%

As part of the further air quality impact assessment conducted for the submissions and preferred infrastructure report (to assess an increase in height of the northern and southern ventilation outlets by five metres), the assumptions and inputs relating to terrain have been reviewed.

The assumptions and inputs relating to terrain have been reviewed in light of submissions that suggested the 90 metre SRTM topographic data used to determine the receiver grid elevations may be too coarse or may not reflect local conditions. In response, the terrain data have been re-extracted using five metre resolution Land and Property Information (LPI) data. The elevations of the discrete receivers and the ventilation outlet locations have been identified using this revised data.

Section 2.15 of this report details the outcomes of the further air quality modelling taking into account this updated assumption/ input data.

2.13 Dispersion modelling

This section provides information and explanatory discussion relevant to the air dispersion modelling for the project, including:

- The receiver grid considered in the air quality impact assessment.
- Set up of the CALPUFF model for dispersion modelling from the ventilation outlets.
- Set up of the CAL3QHCR model for dispersion modelling from surface roads.

2.13.1 Receiver location grids

The CALMET meteorological modelling conducted in the air quality impact assessment employed a 60 kilometre by 62.5 kilometre modelling domain, with 250 metre resolution.

The CALPUFF air dispersion modelling conducted in the air quality impact assessment employed a 17 kilometre by 10 kilometre modelling domain. A 250 metre grid spacing was used to match the CALPUFF model with the CALMET model. Within that 250 metre grid spacing, finer modelling grids were applied for the purpose of modelling ground level concentrations of air emissions for relevant receivers.

Relevant receivers for the purpose of the air dispersion modelling, which were indicative locations rather than specific individual premises, were determined through the use of variable grid sizes depending on distance from a project ventilation outlet or a major road (Pennant Hills Road, the Hills M2 Motorway or the M1 Pacific Motorway).

As indicated in Section 4.2.6 of the environmental impact statement, a high density receiver grid of 150 metre spacing was applied to a five kilometre by five kilometre area around each of the project ventilation outlets. Outside this area (more than 2.5 kilometres from each ventilation outlet) a receiver grid with 300 metre spacing was applied.

For receivers along major road corridors, receiver locations were spaced at 10 metres, 35 metres, 105 metres, 160 metres and 225 metres from the road centreline.

In total, 6,919 receiver locations were considered in the air quality impact assessment. Figure 8 in the Technical Working Paper: Air Quality shows the receiver locations considered in the assessment.

The resolution of the receiver grids applied as part of the air quality impact was developed having regard to the guidance document Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, Australia (OEH, 2011). One of the authors of that document, who is an internationally-recognised meteorological and air dispersion modelling specialist, peer reviewed and endorsed the CALMET and CALPUFF parameters used in the air quality assessment for the project. This included the receiver grid resolution.

As noted in Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, Australia (OEH, 2011), the best receiver grid spacing for each modelling project is dependent on the size of the modelling domain and the complexity of the terrain within the domain. The guidance document states that typical CALMET applications should include between 100 and 300 grid cells in both the x and y directions (OEH, 2011, page 18). Furthermore, it states that near-field applications may require modelling grid spacings of about 250 metres, while grid spacings of 150 metres may be required to resolve dominant terrain features (OEH, 2011, page 18).

Modelling domains and receiver grid resolutions for the air quality impact assessment have been developed consistent with the direction provided in the abovementioned guidance document. The CALMET meteorological modelling domain had 240 by 250 cells with a 250 metre spacing, while the CALPUFF air dispersion modelling domain had a grid spacing of 150 metres around the ventilation outlets to accommodate near-field effects. The terrain around the ventilation outlets is undulating, but was not considered to be complex with dominant terrain features. Based on advice provided in the guidance document (OEH, 2011), the project location and the project scale, the meteorological and air dispersion modelling grids were considered appropriate.

In addition the base receiver grids applied to the air quality impact assessment, a further 60 receiver locations were included in the air quality modelling. These receiver locations were health sensitive sites, including schools, hospitals, aged care and nursery care centres. Air quality modelling outcomes for these 60 locations were used to inform specific health risk assessments for those locations as part of the broader human health risk assessment presented in Section 7.4 and Appendix H of the environmental impact statement.

Although a 150 metre grid spacing around the project ventilation outlets is considered to be appropriate, a further screening level analysis has been conducted to demonstrate the potential effect of a reduced grid spacing. The screening level assessment has been based on:

- A 150 metre and a 25 metre receiver grid around the northern ventilation outlet.
- Forecast traffic flows in 2019.
- One year of meteorological data.
- Annual and 24 hour average $PM_{2.5}$ concentrations.

Table 2-55 summarises the outcomes of the screening level assessment. It presents the maximum value modelled in the domain around the northern ventilation outlet, as well as the average value across the modelling domain. The table shows that:

- On average across the modelling domain around the northern ventilation outlet, a 25 metre grid spacing produces a slightly higher 24 hour average and annual average value $PM_{2.5}$ concentration. However, the increase in the average value across the modelling domain is less than 0.5% of the advisory reporting standard in both cases.
- The peak 24 hour average and annual average $PM_{2.5}$ concentrations are both higher with a 150 metre grid spacing than with the application of a 25 metre spacing. In the case of the 24 hour average, the relative difference is two percent of the advisory reporting standard. The difference in the annual average is less, at only 0.13%.

This demonstrates that the difference in the modelling domain grid spacing has a negligible impact on predicted ground level concentrations, on average. However, the use of a 150 metre grid spacing in the air quality impact assessment for the project is likely to have led to an overestimation of impacts at the most affected receiver location. This overestimation is negligible in the case of the annual average $PM_{2.5}$ concentration, but up to two percent of the advisory reporting standard for the 24 hour average. This supports the conclusion that a 150 metre grid spacing is appropriate, and may in fact be conservative for shorter duration averaging periods.

Table 2-55 Comparison of 150 metre and 25 metre receiver grid spacings

Pollutant	Statistic	Ground level concentrations and percentage of advisory standard				Relative change (% of standard)
		150 metre grid	% of standard	25 metre grid	% of standard	
$PM_{2.5}$ (24 hour average)	Average across domain	0.21 µg/m^3	0.84%	0.33 µg/m^3	1.32%	+0.48%
	Peak value	1.21 µg/m^3	4.84%	0.71 µg/m^3	2.84%	-2.0%
$PM_{2.5}$ (annual average)	Average across domain	0.014 µg/m^3	0.18%	0.026 µg/m^3	0.33%	+0.15%
	Peak value	0.075 µg/m^3	0.94%	0.065 µg/m^3	0.81%	-0.13%

Notwithstanding the analysis above, the receiver grid has been revised and an updated grid spacing has been applied to the air quality impact assessment of the five metre increase in height at the northern and southern ventilation outlets. The receiver grid has been recalculated for the following spacings:

- 25 metre spacing for an area of 500 metres by 500 metres centred on each ventilation outlet.
- 50 metre spacing for an area of 1,000 metres by 1,000 metres centred on each ventilation outlet.
- 100 metre spacing for an area of 4,000 metres by 4,000 metres centred on each ventilation outlet.

2.13.2 Ventilation outlet modelling (CALPUFF)

This section provides information and discussion of:

- How the CALPUFF model has been set up and used to model dispersion from the project's ventilation outlets.
- Validation studies of the CALPUFF model.

Set up of the CALPUFF model

This section summarises the parameters applied to the CALPUFF model.

CALPUFF model parameters

CALPUFF model parameters, as applied to the air quality impact assessment presented in the environmental impact statement and as used for the assessments in this report are provided in **Table 2-56**.

Table 2-56 CALPUFF model input parameters

Parameter	Input
Modelling domain	Modelling domain of around 15 kilometres by 10 kilometres. MGA SW Coordinates (km): 315.300 E, 6260.500 S MGA NE Coordinates (km): 330.600 E, 6270.701 S
Modelling grid resolution	250 metre grid resolution as per the CALMET meteorological model.
Number of receivers	All grid resolutions provided above were modelled as discrete receiver locations (i.e. no gridded receivers) to account for varying grid resolution over the modelling domain. A total of 6,919 discrete receiver locations resulted from the modelling grids, including 3,332 receivers along the project corridor.
Dispersion algorithm	Turbulence-based coefficients
Hours modelled	26,280 hours (1,095 days) (8,760 hours per year)
Meteorological modelling period	1 January 2009 – 31 December 2011

Building wake effects

Potential building wake effects have been taken into account in the CALPUFF modelling. Assumptions and parameters adopted in this regard include:

- Northern ventilation outlet parameters (refer to **Table 2-57**).
- Southern ventilation outlet parameters (refer to **Table 2-58**).
- Parameters for other structures around the ventilation outlets (refer to **Table 2-59**).

Building wakes have been calculated using the PRIME algorithm.

Table 2-57 Northern ventilation outlet parameters

Parameter	Value	Reference	Comments and assumptions
Outlet location	325,359 m E, 6,268,211 m S (MGA 56)	F3M2-5000-DR-UD-547	Estimated from plan.
Outlet height	15 metres	F3M2-5000-DR-UD-550	Outlet 15 metres above adjacent land taken from plan.
Outlet diameter	Hourly variable	F3M2-440-DR-US-0106	Based on maximum outlet opening area of 46 m^2.
Outlet temperature	Hourly variable	CALMET.DAT files	Hourly temperature data assumed to be equal to ambient temperature with a correction. Temperature data were extracted from CALMET outputs at 325,060 metres East, 6,267,858 metres South (MGA 56). Ventilation outlet temperature differentials were added to outlet parameters to better replicate the expected hotter air leaving the ventilation outlets than the ambient air conditions.
Outlet velocity	Hourly variable	Not applicable	Hourly velocity was calculated based on the hourly volumetric flow rates corrected for the expected ventilation outlet temperatures.
Building wakes	Variable	F3M2-5000-DR-UD-547 F3M2-5000-DR-UD-550 F3M2-5000-DR-UD-555 F3M2-5000-DR-UD-556	Building dimensions from the sub-station, northern ventilation station (VS07) and deluge tanks were estimated from plans and input into the BPIP to estimate building wake effects on the northern outlet

Table 2-58 Southern ventilation outlet parameters

Parameter	Value	Reference	Comments and assumptions
Outlet location	319,233 m E, 6,262,984 m S (MGA 56)	F3M2-5000-DR-UD-0516	Estimated from plan.
Outlet height	15 metres	F3M2-5000-DR-SK-UD-0525	Outlet 15 metres above adjacent land taken from plan
Outlet diameter	Hourly variable	F3M2-440-DR-US-0100.	Based on outlet opening area of 46 m^2.
Outlet temperature	Hourly variable	CALMET.DAT Files	Hourly temperature data assumed to be equal to ambient temperature with a correction. Temperature data were extracted from CALMET output at 319.244 metres East, 6,262,993 metres South (MGA 56). Ventilation outlet temperature differentials were added to outlet parameters to better replicate the expected hotter air leaving the

Parameter	Value	Reference	Comments and assumptions
			ventilation outlets than the ambient air conditions.
Outlet velocity	Hourly variable	Not applicable	Hourly velocities were calculated based on the hourly volumetric flow rates.
Building wakes	Variable	F3M2-5000-DR-UD-0516 F3M2-5000-DR-SK-UD-0510 F3M2-5000-DR-SK-UD-0508 F3M2-5000-DR-UD-DU-0513 F3M2-5000-DR-SK-UD-0525	Building dimensions from the southern ventilation station (VS01), water tank, covered service yard, workshop and Motorway Control Centre (MCC) were estimated from plans and input into the BPIP to estimate building wake effects on the southern outlet. Building parameters used to calculate building wakes are presented in the following table.

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Table 2-59 Building parameters used to calculated building wakes

Description	Tier	Tier height (metres)	Diameter (metres)	Coordinates (MGA 56)							
				X1	Y1	X2	Y2	X3	Y3	X4	Y4
Deluge Tank 1	1	6.0	12	325,339	6,268,237						
Deluge Tank 2	1	6.0	12	325,356	6,268,235						
Northern ventilation facility	1	7.0		325,352	6,268,217	325,369	6,268,208	325,345	6,268,163	325,328	6,268,172
	2	15.0		325,355	6,268,215	325,353	6,268,210	325,362	6,268,206	325,364	6,268,211
North substation	1	4.5		325,328	6,268,168	325,311	6,268,135	325,318	6,268,131	325,336	6,268,164
Southern ventilation facility	1	6.0		319,206	6,263,028	319,196	6,263,026	319,198	6,263,016	319,208	6,263,018
	2	6.0		319,201	6,263,016	319,205	6,262,992	319,213	6,262,994	319,208	6,263,018
	3	6.0		319,213	6,262,994	319,202	6,262,992	319,205	6,262,981	319,215	6,262,983
	4	13.2		319,244	6,263,041	319,205	6,263,034	319,216	6,262,978	319,255	6,262,985
	5	18.0		319,227	6,262,985	319,238	6,262,988	319,240	6,262,981	319,228	6,262,979
	6	20.4		319,232	6,262,980	319,232	6,262,979	319,239	6,262,981	319,239	6,262,981
Covered service yard	1	8.7		319,192	6,263,095	319,200	6,263,055	319,225	6,263,060	319,217	6,263,100
Workshop	1	8.4		319,183	6,263,187	319,172	6,263,185	319,185	6,263,115	319,196	6,263,117
	2	8.4		319,205	6,263,118	319,194	6,263,175	319,185	6,263,174	319,196	6,263,117
Motorway control centre	1	11.5		319,127	6,263,370	319,139	6,263,306	319,169	6,263,312	319,156	6,263,376
Water tank	1	7.6	9	319,230	6,263,045	319,230	6,263,045	319,230	6,263,045	319,230	6,263,045

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Validation studies of the CALPUFF model

Dispersion modelling from the project ventilation outlets utilised the CALPUFF suite of models which have been approved for use in NSW by the Environment Protection Authority and internationally by bodies such as the United States Environmental Protection Agency. The CALPUFF model is an advanced Gaussian modelling system for the simulation of atmospheric dispersion. It was first developed in the late 1980s and issued for use in 1990. Since that time, it has continued to be refined and updated, and continues to be an internationally-recognised air dispersion model.

The United States Environmental Protection Agency has designated CALPUFF as a 'Guideline Model' which means that it has undergone an extensive, multi-year (15 years) model assessment and evaluation process, including:

- Evaluation of the model performance relative to real-life observations.
- Requirements for model documentation, access and computer codes.
- An open, public review process involving public hearings.
- Formal peer review by committees created by the United States Environmental Protection Agency, professional organisations such as the United States Air and Waste Management Association (A&WMA), and private sector industry groups such as the American Petroleum Institute (API), the United States Utility Air Regulatory Group (UARG) and the United States Electric Power Research Institute (EPRI).

The CALPUFF model has been accepted for use in several international jurisdictions, including Australia, Canada, Chile, Iceland, Italy, New Zealand, Saudi Arabia and the United States of America (among others).

The CALPUFF model has been evaluated against most well-known classic data sets, including in relation to long-range transport, short to intermediate-range transport and offshore/ coastal data sets. Some key evaluation and verification studies based on monitored, real-life data include:

- The Lovett Power Station Study (New York) which compared modelled and monitored concentrations of sulfur dioxide from the power station ventilation outlet for the CALPUFF, CTDMPLUS and RTDM models. The study demonstrated that the CALPUFF model most accurately reflected actual monitoring data, and in most cases over-estimated ambient concentrations.
- The European Tracer Experiment (ETEX), which evaluated the performance of five models based on experimental release and monitoring of a perfluoromethylcyclohexane (PMCH) tracer. Of the five models that were evaluated, the combination of the CALPUFF model with MM5 meteorological data (as was used to model and assess the NorthConnex project) was identified at most accurately reflecting behaviour of the PMCH tracer in the atmosphere.
- The Kincaid Data Set, which compared modelled and monitored concentrations of a sulfur hexafluoride (SF6) tracer using the CALPUFF and the AERMOD models. The study demonstrated that the CALPUFF model most accurately reflected monitored tracer concentrations in the atmosphere, and in most cases over-estimated the actual ambient concentrations (within 10 kilometres of the source).

On the basis of extensive evaluation studies and adoption of the model by several international jurisdictions, including within New South Wales, the CALPUFF model and modelling approach taken for the NorthConnex project are considered to be robust and appropriate.

2.13.3 Surface road modelling (CAL3QHCR)

This section provides information and discussion of:

- How the CAL3QHCR model has been set up and used to model dispersion from surface roads.
- Validation of the CAL3QHCR model outputs.

Set up of the CAL3QHCR model

The assessment of surface road air quality contributions has been conducted using the CALROADs modelling suite incorporating the CAL3QHCR model. A series of 'roadway links' or lengths of road have been assessed (refer to **Section 2.7.2**), each of which assumed that a certain number of vehicles were travelling along the roadway emitting pollution according to the vehicle fleet mix and traffic forecasts. The resultant pollutant concentrations have been predicted at receiver locations positioned perpendicular to the roadway links at distances up to 200 metres from the road centreline.

As part of the development of the overall modelling environment for the project, there was a need to define the background pollutant concentrations along the roadway at each of the receiver locations. The methodology adopted for the environmental impact statement assumed that the concentration at each receiver location was the maximum of the existing ambient pollution levels (as defined by the monitoring data from the Prospect and Lindfield monitoring stations) or modelled pollution levels from the CAL3QHCR model. The rationale for this methodology was that receiver locations close to surface roads would experience air quality dominated by surface road contributions (ie predicted with the CAL3QHCR) and receiver locations further away would experience air quality similar to ambient conditions, without the influence of surface roads.

The adopted methodology resulted in a spatially consistent background monitoring pattern with little to no spatial variation in pollution concentrations as the pollution moved away from the road. It is acknowledged that, in practice, the pollution would be expected to decrease rapidly in the area immediately adjacent to the surface road, and then decrease more slowly away from the surface road edge.

Validation of the CAL3QHCR model

Since publication of the environmental impact statement, the CAL3QHCR modelling has been reviewed to determine the extent to which it accurately reflects surface road air quality impacts, particular at very close distances. To clearly characterise the potential air quality conditions close to the edge of the road (within 30 metres of the road centreline) an analysis of the project monitoring data from Brickpit Park and Observatory has been conducted. Both of these monitoring stations have been established for the project, in proximity to Pennant Hills Road, to assess air quality conditions in areas influenced by emissions from Pennant Hills Road.

Monitoring data from Brickpit Park and Observatory Park have been compared with modelling results from CAL3QHCR at those locations. Monitoring data have been compared with outputs from the CAL3QHCR under forecast traffic volumes in 2019 (without the project). As discussed in the Technical Working Paper: Traffic and Transport, Pennant Hills Road is currently heavily congested and operating at or above its design capacity in many areas. As a consequence, there has been no appreciable growth in traffic volumes along Pennant Hills Road in recent years and this trend is anticipated to continue in the future without implementation of the project. Because traffic growth is being constrained by having largely reached its maximum capacity, it is considered reasonable to compared CAL3QHCR model outputs in 2019 with monitoring data from 2014.

Figure 2-15 and **Figure 2-16** compare CAL3QHCR model outputs and monitoring data for NO_2 (one hour) at Brickpit Park and Observatory Park, respectively. A similar analysis has been conducted for $PM_{2.5}$ (24 hour), and is shown in **Figure 2-17** and **Figure 2-18** for Brickpit Park and Observatory Park, respectively

Figure 2-17 and **Figure 2-18** show that the concentrations of $PM_{2.5}$ predicted by the CAL3QHCR model at the Brickpit Park and Observatory Park monitoring station locations are lower than monitored $PM_{2.5}$ concentrations. Particulate matter emissions in the area around Pennant Hills Road would not be expected to be solely due to vehicle traffic along Pennant Hills Road, but road emissions would be expected to represent a substantial proportion of the measured particulate matter concentrations. The predicted $PM_{2.5}$ concentrations at Brickpit Park from the CAL3QHCR model are, on average, 53 per cent below the monitored values, while the Observatory Park model outputs are on average 29 per cent of the monitored concentrations.

Figure 2-15 and **Figure 2-16** show that CAL3QHCR NO_2 model outputs are lower than monitoring data, but more closely reflect monitoring data than in the case of $PM_{2.5}$.

These comparisons results demonstrate that the surface road modelling predictions do not account for 100 per cent of the background pollutant concentrations measured at the Brickpit Park and Observatory Park monitoring stations.

To determine whether the CAL3QHCR model accurately predicts pollutant concentrations close to surface roads, monitoring data from roadside monitoring stations (Brickpit Park and Observatory Park) have been compared with ambient monitoring data (from the project monitoring station at Headen Sports Park). The objective of this analysis was to provide an indication of the relative contribution of the surface roads to monitored pollutant concentrations – that is, the difference between Headen Sports Park (away from major surface roads) and Brickpit Park and Observatory Park (close to Pennant Hills Road). The difference between monitored concentrations of pollutants at these locations has been used to provide an indication of the level of monitored pollutants that may be contributed by Pennant Hills Road.

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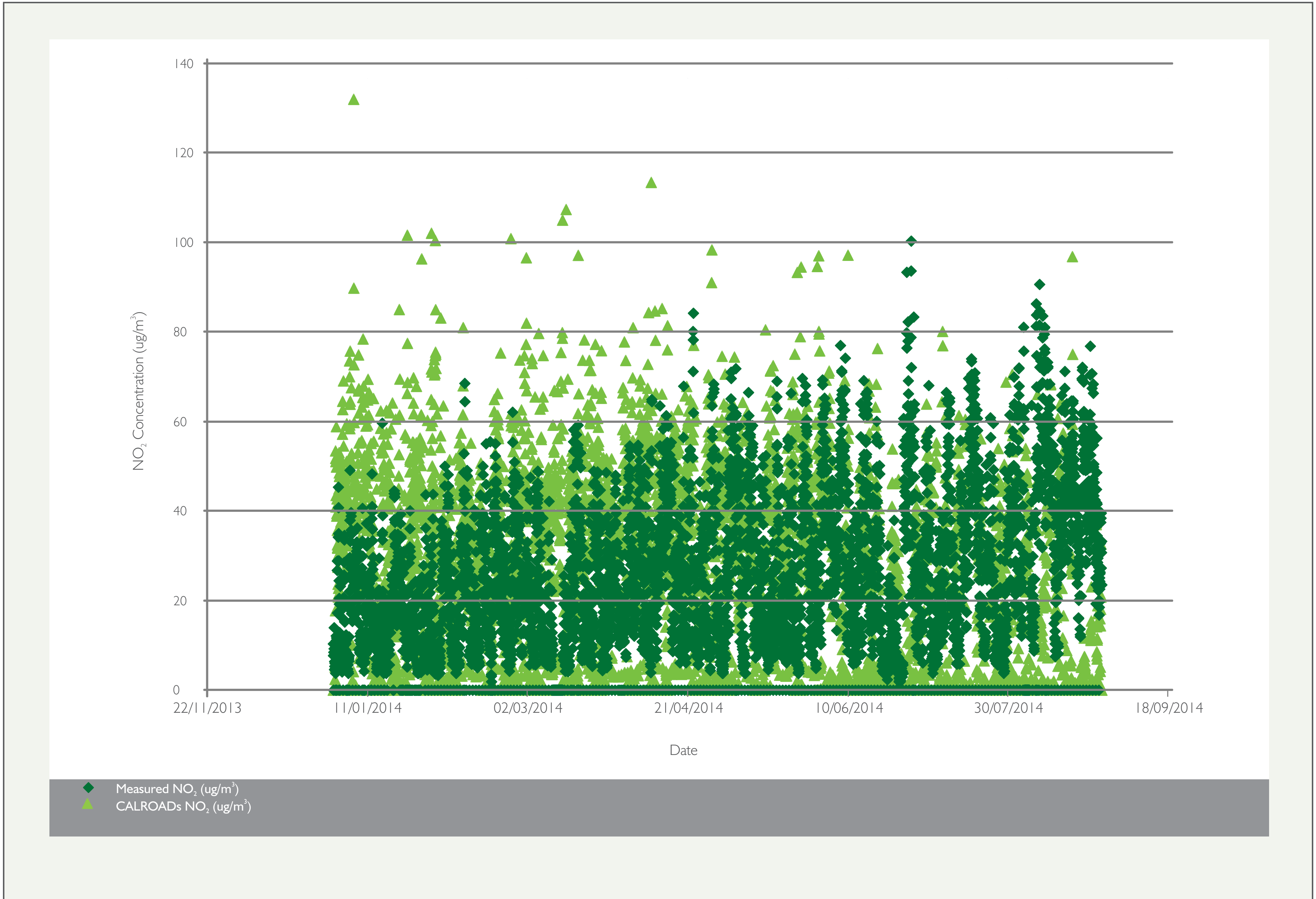

Figure 2-15 CAL3QHCR validation - Brickpit Park NO_2 (1 hour)

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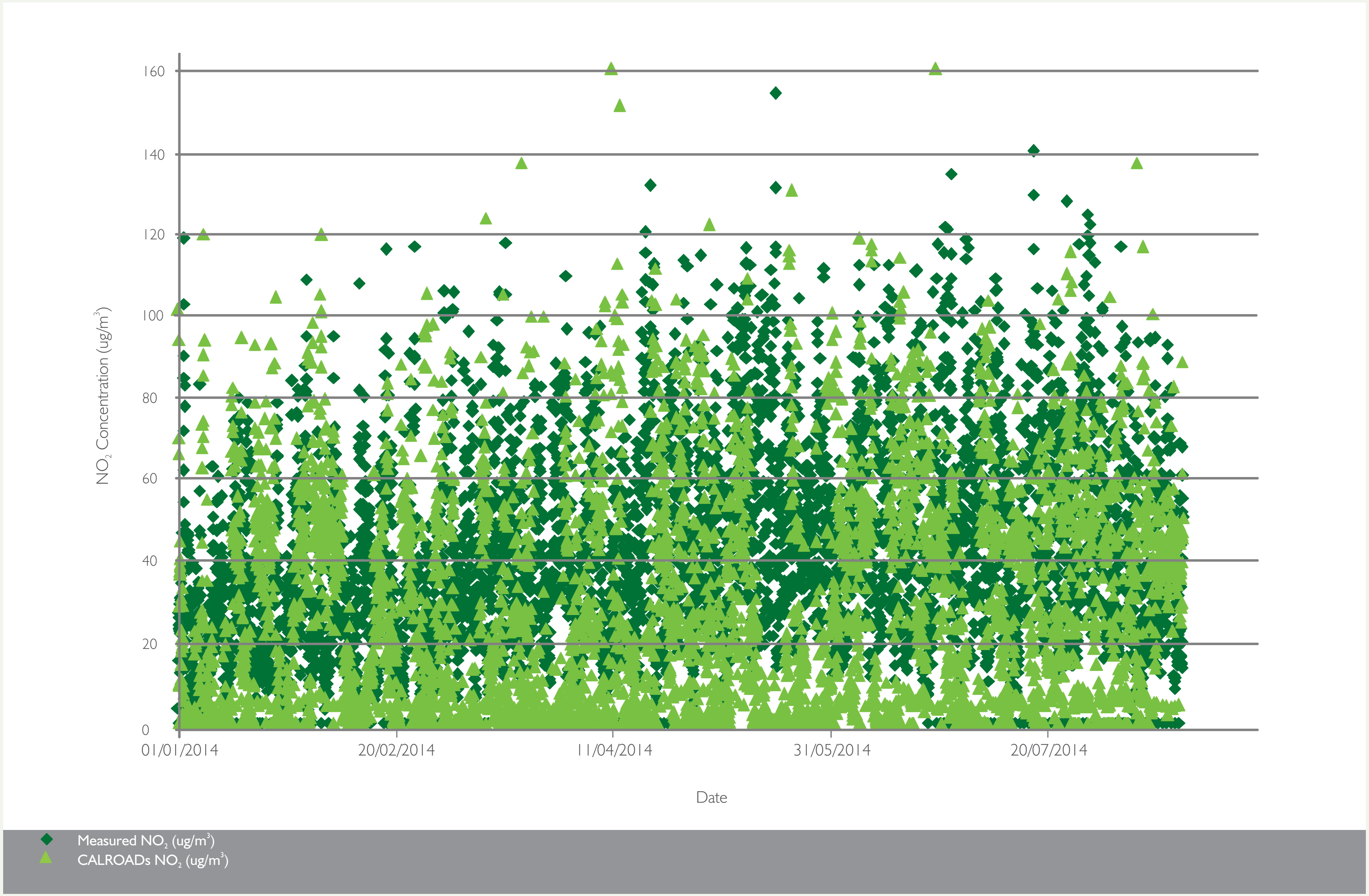

Figure 2-16 CAL3QHCR validation - Observatory Park NO_2 (1 hour)

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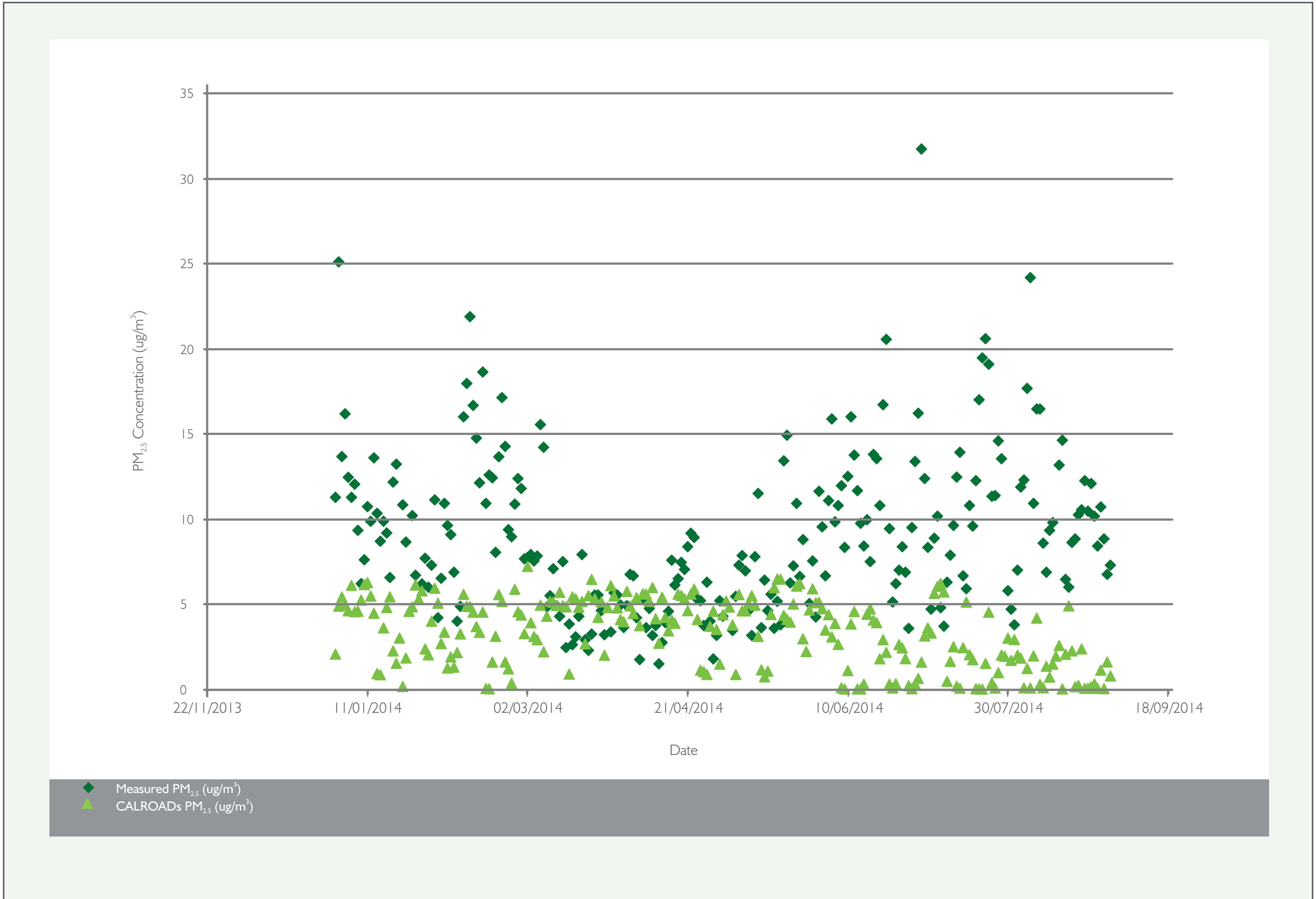

Figure 2-17 CAL3QHCR validation - Brickpit Park $PM_{2.5}$ (24 hour)

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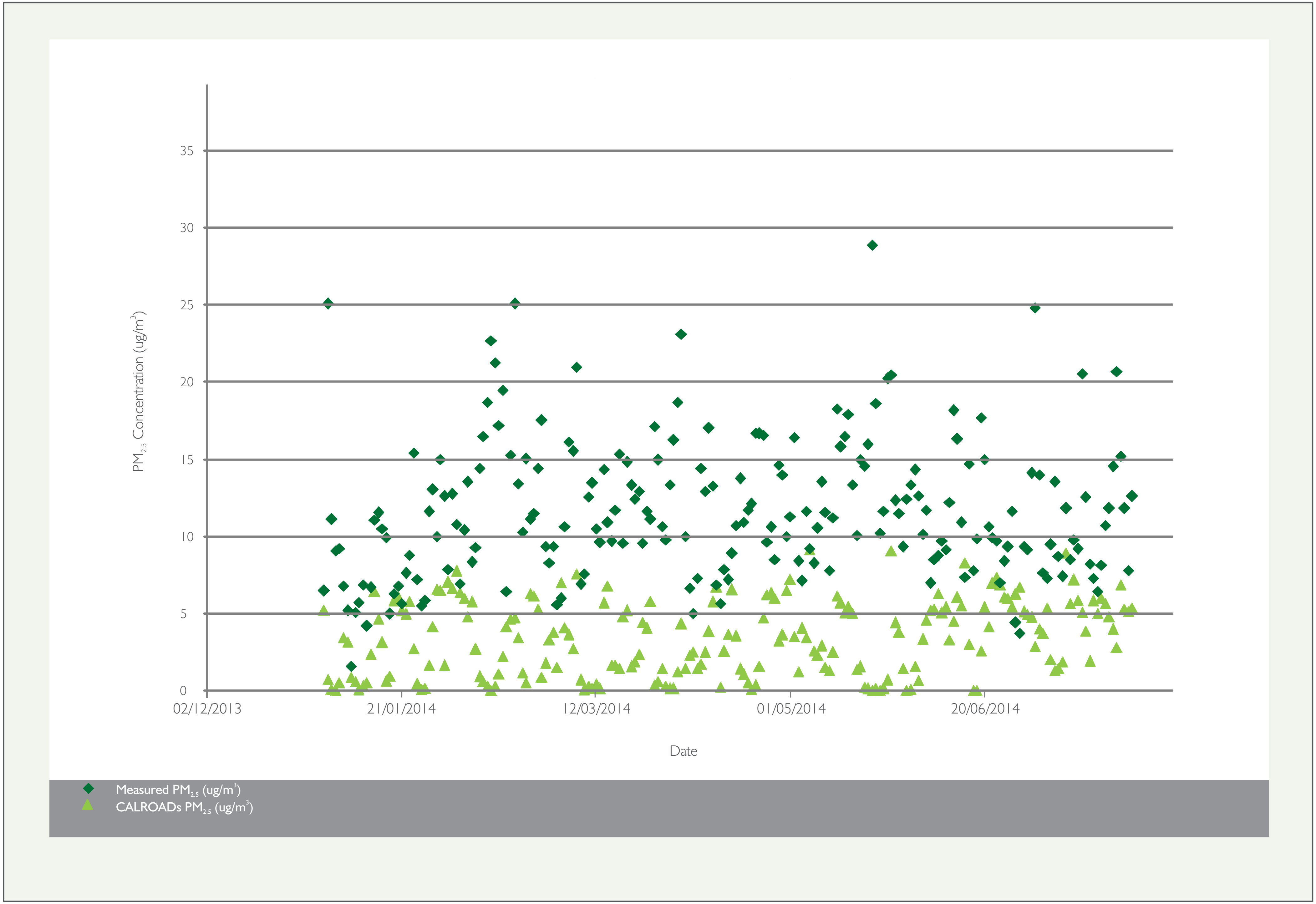

Figure 2-18 CAL3QHCR validation - Observatory Park $PM_{2.5}$ (24 hour)

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This analysis considers three different values:

- **Modelled road contribution** – being the CAL3QHCR model output at the relevant location (Brickpit Park or Observatory Park).
- **Monitored roadside background** – being the monitored pollutant concentration at the relevant roadside monitoring location (Brickpit Park or Observatory Park).
- **Monitored ambient background** – being the monitored pollutant concentration at the Headen Sports Park monitoring station.

Because CAL3QHCR modelling relates to 2019 and monitoring data is available for 2014, a contemporaneous evaluation of values is not possible. As such, average values for each data set have been analysed and compared. Comparison of average values is intended to provide a high level analysis only, and provides an indication of relative differences rather than a definitive, absolute measure of the difference between the data sets.

Contributions from Pennant Hills Road have been estimated by subtracting Headen Sports Park average values from average values at Observatory Park (refer to **Table 2-60**) and Brickpit Park (refer to **Table 2-61**).

Table 2-60 Estimated surface road contribution (Observatory Park)

Pollutant	Monitored roadside background (Observatory Park) (μg/m^3)	Monitored ambient background (Headen Sports Park) (μg/m^3)	Estimated road contribution (μg/m^3)
Average PM_{10} (24 hour)	19.9	14.5	5.4
Average $PM_{2.5}$ (24 hour)	11.7	10.4	1.3
Average NO_2 (one hour)	43.1	17.9	25.2

Table 2-61 Estimated surface road contribution (Brickpit Park)

Pollutant	Monitored roadside background (Brickpit Park) (μg/m^3)	Monitored ambient background (Headen Sports Park) (μg/m^3)	Estimated road contribution (μg/m^3)
Average PM_{10} (24 hour)	17.9	14.5	3.4
Average $PM_{2.5}$ (24 hour)	9.0	10.4	-1.4
Average NO_2 (one hour)	24.8	17.9	6.9

Table 2-60 and **Table 2-61** show a marked difference between the estimated road contributions at Observatory Park and at Brickpit Park (with the latter showing lower estimated values). The potential reasons for this difference have been considered through visual analysis of the locations of the Observatory and Brickpit Park monitoring sites.

Both monitoring stations are located close to the road edge, with the Observatory Park monitoring station sited marginally closer to the road edge than at Brickpit Park. A solid retaining wall (around one metre in height) is located between the Brickpit Park monitoring station and Pennant Hills Road. This solid barrier may be affecting the flow of air between Pennant Hills Road and the Brickpit Park monitoring station, and may be leading to the formation of down-wind wakes (ie away from the road). These effects and presence of the retaining wall may be resulting in lower concentrations of pollutants being recorded at the Brickpit Park monitoring station (compared to what may be recorded in the absence of the effects of the retaining wall).

In comparison, visual analysis of the Observatory Park monitoring station site shows no similar structures or factors that may affected concentrations of monitored pollutants.

On this basis, monitoring data from Observatory Park has been used as the basis for further analysis, noting that it is more likely to represent a higher quality monitoring data set.

The estimated road contribution using data from the Observatory Park monitoring station (refer to **Table 2-60**) can be compared to the monitoring results from the CAL3QHCR model at this location. This comparison is presented in **Table 2-62** below. The table shows that there is good agreement between CAL3QHCR model predictions and estimated road contributions for NO_2. Model predictions are slightly higher than monitored data (estimated road contribution) for $PM_{2.5}$ and slightly lower in the case of PM_{10}.

Table 2-62 Comparison of CAL3QHCR model predictions and estimated road contributions at Observatory Park

Pollutant	CAL3QHCR model predictions at Observatory Park (μg/m^3)	Estimated road contribution (μg/m^3) at Observatory Park
Average PM_{10} (24 hour)	3.6	5.4
Average $PM_{2.5}$ (24 hour)	3.4	1.3
Average NO_2 (one hour)	25.5	25.2

The outcome of this analysis is that the contributions of surface road pollution to background air quality for receivers close to surface roads (within about 30 metres) may not have been fully reflected in the cumulative concentrations calculated and presented in the environmental impact statement.

To test the effect of additional surface road pollution contributions for receivers close to surface roads, cumulative concentrations of pollutants have been compared for:

- The EIS scenario – as presented in the environmental impact statement, which assumed background air quality was the higher of CAL3QHCR model outputs or ambient monitoring data from Prospect/ Lindfield monitoring stations.
- The higher roadside scenario – which has added a further increment to background air quality data to account for higher pollutant concentrations near roads. The applied increments are:
  - PM_{10} – 5.4 µg/m^3 (24 hour).
  - $PM_{2.5}$ – 1.3 µg/m^3 (24 hour).
  - NO_2 – 25.2 µg/m^3 (one hour)

These two scenarios have been considered for the five receiver locations predicted to experience the highest project contribution (ie highest contribution from operation of the project's ventilation outlets). The five receivers have been identified from the 2019 forecast traffic scenario using the 2009 meteorological data set.

It is relevant to note that for the five identified receiver locations for this analysis, all five had background contributions equal to ambient monitoring data from the Prospect/ Lindfield monitoring stations (rather that CAL3QHCR model outputs) for the air quality impact assessment presented in the environmental impact statement. Al five receivers are close to surface roads around the northern ventilation outlet.

Comparison of cumulative concentration (project contribution plus background contribution) results for the two background calculation methods – the EIS method and the higher roadside method – is provided in **Table 2-63**. The table shows the effect of increasing background pollutant concentrations to take into account elevated surface road contributions for receiver locations close to roads (within about 30 metres) (the higher roadside method). The background concentration at each receiver location has been calculated contemporaneously.

Table 2-63 shows that neither the EIS method nor the higher roadside method lead to an exceedance of the applicable NO_2 criterion (246 µg/m^3) at any of the assessed receiver locations.

In the case of PM_{10} and $PM_{2.5}$ exceedances of the applicable ambient air quality criterion/ advisory reporting standard are predicted for both the EIS method and the higher roadside method. Importantly, the higher roadside method leads to no additional exceedances of the criterion/ standard for $PM_{2.5}$ and four additional exceedances for PM_{10}.

This analysis shows that applying the higher roadside method does not alter the outcomes of the air quality impact assessment (in terms of cumulative concentration compliance with applicable air quality criteria), although adopting this approach for roadside receivers would increase the magnitude of predicted cumulative concentrations. It is important to recognise that this is a high level analysis and only applicable to receiver locations close to roads (within around 30 metres). It should not be applied further across the modelling domain for receiver locations away from the influence of surface roads.

Table 2-63 Cumulative air quality concentrations at roadside receivers

Pollutant	Background contribution calculation method	Statistic	Receiver location (ranked, 1 = highest, 5 = 5th highest project contribution)				
			1	2	3	4	5
NO_2 (one hour)	EIS method	Maximum value	133.7	133.4	131.9	130.5	128.3
		Average value	23.2	23.1	22.7	22.7	23.2
	Higher background method	Maximum value	158.9	158.6	157.1	155.7	153.5
		Average value	48.4	48.3	47.9	47.9	48.4
PM_{10} (24 hour)	EIS method	Maximum value	221.6	221.6	221.6	221.6	221.6
		Average value	21.3	21.2	21.2	21.2	21.3
		Number of exceedances of criterion	9	9	9	9	9
	Higher background method	Maximum value	227.1	227.0	227.0	227.0	227.0
		Average value	26.7	26.6	26.6	26.6	26.7
		Number of exceedances of criterion	13	13	13	13	13
$PM_{2.5}$ (24 hour)	EIS method	Maximum value	77.59	77.57	77.57	77.56	77.56
		Average value	8.5	7.9	8.6	8.2	7.5
		Number of exceedances of advisory standard	4	4	4	4	4
	Higher background method	Maximum value	78. 9	78.9	78.9	78.9	78.9
		Average value	9.8	9.2	9.9	9.5	8.8
		Number of exceedances of advisory standard	4	4	4	4	4

2.14 Post-processing of model outputs

The section provides information and explanatory discussion in relation to:

- Calculation of cumulative impacts and consideration of background air quality (refer to **Section 2.14.1**).
- Atmospheric conversion of oxides of nitrogen to nitrogen dioxide (refer to **Section 2.14.2**).

2.14.1 Cumulative impacts – consideration of background air quality

This section includes information and explanatory discussion relating to:

- The methodology used to consider the project, background and cumulative air quality contributions in the air quality impact assessment conducted for the project and presented in the environmental impact statement.
- A sensitivity analysis comparing the methodology adopted for the project (as presented in the environmental impact statement) with an alternative methodology, developed through different definitions and allocations of project, background and cumulative air quality contributions.

Approach taken for the project

The primary focus of the air quality impact assessments conducted for the project has been understanding the implications of the project's ventilation outlets for local air quality during operation.

As discussed in **Section 2.7.1** of this report, the project will also contribute to changes in traffic on surface roads which may also contribute to changes in air quality. These changes may result through a combination of direct changes to surface infrastructure (such as the Hills M2 Motorway integration works, the M1 Pacific Motorway tie-in works and the minor upgrade works at Pearces Corner) and as an indirect consequence of redistribution of surface traffic. Where direct changes to surface infrastructure are not proposed, changes in traffic volumes as a consequence of the project remain within the design capacity of the affected roads and generally represent a maintenance or improvement in current performance of those roads.

For the purpose of the air quality impact assessments conducted for the project, the following characterisation of changes in air quality have been applied:

- 'Project contributions' have been taken to be those changes in air quality directly attributable to the operation of the project's ventilation outlets.
- 'Background contributions' have been taken to be all other air quality contributions, including pollutant levels in ambient air in the region and contributions from surface roads (which includes both increases and decreases in road contributions as an indirect consequence of operation of the project). The approach to determining 'background contributions' for the purpose of the air quality impact assessments is detailed further below.
- 'Cumulative concentrations' have been taken to be the sum of the project contribution (from the ventilation outlets) and the background contribution (from

surface road modelling or ambient monitoring data) for a particular receiver location.

The air quality impact assessments for the project have taken the background contribution for a particular receiver as being the higher of either:

- The ambient concentration of a particular pollutant established through monitoring data collected by the Office of Environment and Heritage (refer to **Section 2.8** of this report); or
- The modelled pollutant concentration for a receiver location obtained from modelling air quality along major roads in the area using the CAL3QHCR model (refer to **Section 2.13.3** of this report).

The intention of this approach is to recognise that receiver locations along major roads are likely to experience air quality that is significantly affected by contributions from vehicles travelling along that road.

The project corridor is in an area that is not a major hub of industry or manufacturing facilities, and a review of the National Pollutant Inventory (NPI) indicates that there are very few sites within or around the project corridor that are required to report their emissions (i.e. major pollutant emitters). In contrast, receiver locations away from the influence of major roads are likely to experience similar air quality, consistent with the suburban nature of developments around the project corridor. **Section 2.11** of this report provides further discussion of the ambient air quality.

An alternative approach and sensitivity analysis

It is acknowledged that alternative approaches to the definition of 'project contributions' and 'background contributions' and the calculation of 'cumulative concentrations' could have been adopted for the project.

Different jurisdictions within Australian and internationally adopt different approaches to this issue.

An alternative approach involves the addition of three components to calculate a cumulative concentration by considering the sum of:

- Contributions from the project's ventilation outlets.
- Contributions from surface roads (which may be positive or negative, depending on the influence of the project on surface traffic distribution).
- Contributions from ambient air quality, such as is monitoring at ambient air quality monitoring stations.

A comparison of this three component alternative approach, compared to the two component approach used in the assessment of the project (as presented in the environmental impact statement), has been conducted to review the sensitivity of the assessment results to the selected methodology adopted.

Figure 2-19 shows the difference in approach between the methodology applied to the project (the project methodology) and this alternative approach (the alternative methodology). **Table 2-61** also summarises the components that are included in each aspect of the cumulative concentration calculation for the two assessment approaches.

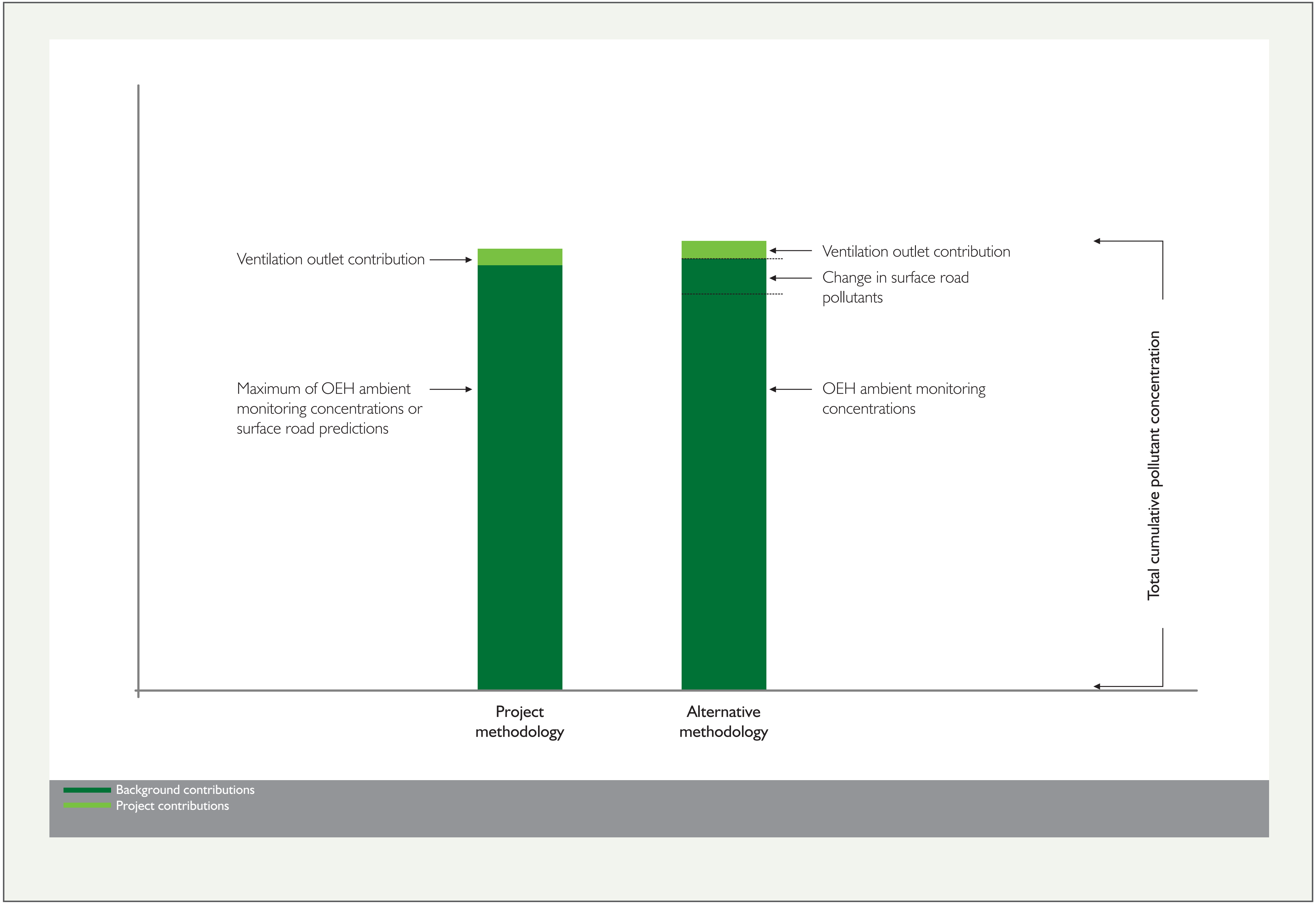

Figure 2-19 Comparison of project methodology and alternative methodology

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Table 2-64 Comparison of project contribution and cumulative concentration calculation methods

Component	Ventilation outlet contribution	Modelled surface road contribution			Ambient air quality monitoring data
		Without project (2019/ 2029)	With project (2019/ 2029)	Difference between 'with project' and 'without project' (2019/ 2029)	
Project methodology					
Project contribution	✓				
Background contribution			✓	← maximum of →	✓
Cumulative concentration	✓		✓	← →	✓
Alternative methodology					
Project contribution	✓			✓	
Background contribution					✓
Cumulative concentration	✓			✓	✓

The project methodology and the alternative methodology differ in two key respects:

- Assignment of surface traffic contributions. In the case of the project methodology, contributions from surface roads are allocated to background air quality rather than to project contributions. The alternative methodology assigns changes in surface road contributions (between the 'with project' and without project' scenarios) as a component of the project contribution (these surface road contributions may be positive or negative, depending on how the project affects surface traffic volumes).
- Both methodologies attempt to avoid 'double counting' surface road contributions to background air quality (which may result, for example, from adding monitored ambient air quality and contributions from surface roads). The project methodology endeavours to avoid this by taking the maximum value of either the monitored ambient air quality or the modelled surface road contributions. The alternative methodology takes a difference approach, and adds the change in surface road contributions (rather than the total surface road contributions from either the 'with project' or 'without project' scenarios) to the monitored ambient air quality.

The implications of the project methodology and the alternative methodology for the outcomes of the air quality impact assessments for the project have been tested by applying both approaches to three transects across the project corridor. A summary of the transects is provided in **Table 2-65**. The transects have been considered under forecast traffic volumes in 2019, with a summary of relevant traffic data at each transect provided in **Table 2-66**.

Table 2-65 Summary of assessed transects

Transect	Location	Forecast traffic
Northern	This transect is located across the M1 Pacific Motorway, north of the northern ventilation outlet and the northern portals (refer to **Figure 2-20**). It is positioned in a location that would be influenced by traffic entering and exiting the northern portals, and within the area affected by the northern ventilation outlet.	Total traffic volumes at this location are forecast to be **higher** with the project than without it. Heavy vehicle volumes at this location are forecast to be **higher** with the project than without it (refer to **Table 2-66**).
Central	This transect is located across Pennant Hills Road, south of Brickpit Park (around the mid point of the project) (refer to **Figure 2-21**). It is positioned in a location that is beyond the influence of the southern and northern ventilation outlets.	Total traffic volumes at this location are forecast to be **lower** with the project than without it. Heavy vehicle volumes at this location are forecast to be **lower** with the project than without it (refer to **Table 2-66**).
Southern	This transect is located across the Hills M2 Motorway, to the west of the southern interchange (refer to **Figure 2-22**). It is positioned in a location that would reflect traffic volumes on the motorway, including traffic entering and exiting the southern portals. The transect has been positioned to the west of the southern interchange to avoid the complexity of traffic movements through the interchange. The transect lies in an area beyond the immediate effects of the southern ventilation outlet.	Total traffic volumes at this location are forecast to be **higher** with the project than without it. Heavy vehicle volumes at this location are forecast to be **lower** with the project than without it (refer to **Table 2-66**). Importantly, heavy vehicles in this location are forecast to be lower in 2019 only, with an increase forecast in 2029. If the 2029 were to be considered, the result would be comparable to the northern transect, at which both total vehicles and heavy vehicles are forecast to increase.

The distinction made in the table above in relation to total traffic volumes and heavy vehicle volumes is important because heavy vehicles have a greater contribution to emissions than passenger vehicles. Where total vehicle numbers are forecast to increase, the total change in surface road emissions may not necessarily also increase if the forecast decreases in heavy vehicle numbers are sufficient to offset the increase in emissions from passenger vehicles. The effect of heavy vehicle volume changes (whether an increase or a decrease) will be more pronounced where the change in total traffic volumes are relatively small (ie where there is little change in passenger vehicle volumes between 'without project' and 'with project' scenarios, the effect of changes in heavy vehicle volumes will be more obvious).

Taking into account traffic forecasts, as summarised in **Table 2-66**, the forecast changes in traffic volumes could be expected to result in:

- At the northern transect – an increase in surface road emissions from the 'without project' to the 'with project' scenarios because total traffic volumes and heavy vehicle volume are both forecast to increase.
- At the central transect – a decrease in surface road emissions from the 'without project' to the 'with project' scenario, because total traffic volumes and heavy vehicle volume are both forecast to decrease.
- At the southern transect – either a decrease or an increase in surface road emissions from the 'without project' to the 'with project' scenario. Whether surface road emissions will decrease or increase will depend on the relative change in total vehicle numbers and heavy vehicle numbers (ie which change has a greater influence on total surface road emissions).

Along each transect, receiver locations have been identified to give a sense of air quality impacts in areas that are likely to be dominated by adjacent surface roads, and receiver locations further away (ie those areas more likely to be characterised by ambient air quality conditions away from the influence of surface roads). The locations of the three transects and the assessed receiver locations are shown in **Figure 2-20** (northern transect), **Figure 2-21** (central transect) and **Figure 2-22** (southern transect).

Each of the receiver locations has been assessed for PM_{10} and NO_2 as project contributions, background contributions and cumulative concentrations using the project methodology and the alternative methodology. The assessment has been based on:

- Forecast traffic volumes in 2019 (Scenario 2a).
- One year of meteorological data (the 2009 meteorological year).

The results of this analysis are presented in the following sections.

Note that the discussion above and the following analysis is a simplification of a complex model that has a number of factors influencing results (such as traffic volumes, traffic mix, meteorology and topography). An important area of potential 'interference' for the transects that have been assessed is the possibility of changes within nearby road links. These changes may alter the modelled outcomes at each transect depending on wind conditions (ie transfer of additional pollutant loads from a nearby road link to the transect being assessed). This potential for interference thas been addressed through the location of the transects away from any potential interference where practicable. This was practicable for the central transect and the southern transect, but not the northern transect which has a high potential to be influenced by nearby road links.

Table 2-66 Forecast traffic by transect

	Total vehicles (AADT)	Heavy vehicles (%)	Heavy vehicles (number)	Light vehicles (%)	Light vehicles (number)	NO_X emissions (g/vehicle kilometre)	PM_{10} emissions (g/vehicle kilometre)
Northern transect							
Without project	92,541	13.3	12,339	86.7	80,203	0.56	0.34
With project	103,161	12.1	12,458	87.9	90,703	0.60	0.37
Central transect							
Without project	66,864	15.2	10,164	84.8	56,699	0.66	0.45
With project	53,681	6.6	3,528	93.4	50,153	0.39	0.22
Southern transect							
Without project	101,756	14.0	14,278	86.0	87,478	0.80	0.09
With project	103,166	13.0	13,419	87.0	89,747	0.75	0.09