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Volume 4

Environmental Impact Statement

Submissions and Preferred Infrastructure Report
Chapters 9 - 12 and Appendices

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Roads and Maritime Services

NorthConnex

Submissions and preferred infrastructure report

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Appendix B Wind roses

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9 Preferred Infrastructure Report

9.1 Overview

During and subsequent to the exhibition of the environmental impact statement, five changes have been made to the project described in the environmental impact statement. These changes are a result of ongoing design development, refinement of construction methods or in response to concerns raised in public submissions and other community and stakeholder engagement mechanisms. These five changes are:

- Increase in the height of the northern and southern ventilation outlets by five metres based on the outcome of further consideration of alternative ventilation design configurations documented in **Section 3.2** of this report.
- Increase in bus movements per hour from the Pioneer Avenue compound (C8), to maximise use of this facility and to minimise potential construction employee traffic and parking impacts on the road network surrounding the other construction compounds.
- Amended construction haulage routes for the southern interchange compound (C5), the Trelawney Street compound (C7) and the northern interchange compound (C9) to reduce impacts on local residential roads.
- Inclusion of additional uses at the Junction Road compound (C11), to allow for construction materials laydown and improve construction phase management.
- Additional property acquisition at the Wilson Road compound (C6) to provide safe access arrangements.

Bracketed references to construction compounds are consistent with those used throughout the environmental impact statement.

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9.2 Increased height of the ventilation outlets (plus five metres)

9.2.1 Description of changes

Based on further analysis of ventilation system design options and alternatives presented in **Section 3.2** of this report, an increase in the height of the northern and southern ventilation outlets by five metres has been identified as a feasible and reasonable measure to optimise the ventilation systems and further reduce the ambient air quality impacts and associated human health risks as a result of operation of the project.

As such, the project is proposed to be amended to increase the ventilation outlet heights by five metres.

9.2.2 Environmental overview of changes

The increase in ventilation outlet height from that presented in the environmental impact statement has been reviewed to identify relevant potential environmental impacts for further, more detailed assessment. This review has concluded that an increase in the height of the ventilation outlets would result in changes to:

- Ambient air quality. Further assessment of ambient air quality impacts has therefore been conducted, and is included in **Section 9.2.3**.
- Human health impacts. Further assessment of human health impacts has therefore been conducted, and is included in **Section 9.2.4**.
- Operational visual impacts. Further assessment of operational visual impacts has therefore been conducted, and is included in **Section 9.2.5**.

The change in ventilation outlet height would not affect other environmental and land use impacts. In particular, the noise and vibration performance of the ventilation outlets is not anticipated to change as a result of the increase in ventilation outlet height.

9.2.3 Ambient air quality

The increased height of the ventilation outlets would alter the potential ambient air quality impacts of the project. As part of the revised air quality impact assessment, changes have been made to the assessment methodology to address relevant issues raised in submissions, including those from the Environment Protection Authority, NSW Health and various members of the community. Key changes have included:

- Increased resolution in the receiver grid applied around each ventilation outlet (ie reduced receiver grid spacing).
- Application of higher resolution topographic data.
- Revision of future projections of vehicle fleet fuel mix, to reflect an increased use of diesel fuel in the future).
- Amendment to the ozone limiting method equation to take into account a NO_2:NO_x ratio of 16 per cent, as recommended by the Environment Protection Authority.

A summary of how these changes have been made to the air quality impact assessment is provided in **Table 9-1**. Full details of the methodology, assumptions and inputs that have been applied to this air quality impact assessment are provided in **Chapter 2** of this report.

Table 9-1 Changes to dispersion model inputs

Issue raised with the EIS assessment	Change made to the assessment approach
Receiver grid spacing of 150 metres may be too coarse.	The receiver grid has been recalculated for the following refined 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.
The 90 metre SRTM topographic data used to determine the receiver grid elevations may be too coarse or may not reflect local conditions.	The topographic 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.
Vehicle fleet composition data was based on 2013 Australia Bureau of Statistics data. This may potentially underestimate the future percentage of diesel vehicles as sales trends show an increase in diesel passenger vehicles.	2008 and 2013 Australian Bureau of Statistics data have been used to extrapolate predicted fleet compositions for 2019 and 2029. The data have then been used when calculating vehicle emissions to inform the project's emissions inventory. The emission rates in the air quality dispersion model have been adjusted accordingly.
Ozone limiting method (OLM) equation does not reflect the ratio of NO_2:NO_x identified from the NSW vehicle fleet by the Environment Protection Authority.	The ozone limiting method calculation has been amended to reflect a NO_2:NO_x of 16 per cent, as detailed in the response to the submission made by the Environment Protection Authority (refer to **Section 7.1.1.3** of this report).

Table 9-2 summarises the outcomes of the revised air quality dispersion modelling, under forecast traffic volumes in 2019 and 2029, and for 'design analysis A' (the worst case traffic scenario). Modelling outputs are presented as project contributions (without the addition of background pollutant concentrations), for direct comparison with modelling outcomes for the original ventilation outlet heights (as presented in the environmental impact statement).

Table 9-3 presents the outcomes of the air quality modelling included in the environmental impact statement and compares them with the outcomes of the revised air quality dispersion modelling. As expected with an increase in ventilation outlet height, most ground level concentrations of emissions would decrease by a significant percentage (up to 60 per cent reduction in some cases), although it is recognised that the concentrations were originally very low and remain very low. However, counterintuitively, some peak ground level concentrations of emissions are predicted to increase, despite the increase in ventilation outlet heights. This would only occur for one hour in three years and is still within the applicable impact assessment criteria.

Further analysis has identified the cause of this increase in some peak ground level concentrations as the same rare meteorological conditions that produced the infrequent elevated NO_2 concentrations presented in the environmental impact statement. This issue has been discussed in response to the submission received from the Environment Protection Authority (refer to **Section 7.1.1.3** of this report) and is analysed in more detail below.

Table 9-2 Revised predicted air quality outcomes for project operation in 2019, 2029 and design analysis A (increased ventilation outlet height)

Pollutant	Averaging period	Value	Predicted maximum project contributions (μg/m³): With project – forecast traffic in 2019: Northern ventilation outlet	With project – forecast traffic in 2019: Southern ventilation outlet	With project – forecast traffic in 2029: Northern ventilation outlet	With project – forecast traffic in 2029: Southern ventilation outlet	Design analysis A: Northern ventilation outlet	Design analysis A: Southern ventilation outlet	Impact assessment criteria/ standards (μg/m³)
PM_{10}	24 hour maximum	Peak project contribution	1.0	0.6	1.3	1.2	1.8	1.9	50
		% of criterion	2.0%	1.3%	2.6%	2.4%	3.6%	3.9%	-
	Annual average	Peak project contribution	0.05	0.05	0.08	0.06	0.12	0.11	30
		% of criterion	0.2%	0.2%	0.3%	0.2%	0.4%	0.4%	-
$PM_{2.5}$	24 hour maximum	Peak project contribution	1.0	0.6	1.2	1.1	1.7	1.8	25
		% of reporting standard	2.5%	4.8%	4.5%	6.8%	7.3%	2.5%	-
	Annual average	Peak project contribution	0.05	0.04	0.08	0.05	0.11	0.11	8
		% of reporting standard	0.6%	0.5%	1.0%	0.7%	1.4%	1.3%	-
NO_2	1 hour maximum	Peak project contribution	54.3	69.0	58.3	76.0	70.4	91.8	246
		% of criterion	22.1%	28.0%	23.7%	30.9%	28.6%	37.3%	-
	Annual average	Peak project contribution	0.6	0.8	0.8	1.3	1.3	1.8	62
		% of criterion	1.0%	1.3%	1.3%	2.0%	2.1%	2.9%	-
CO	1 hour maximum	Peak project contribution	181.8	48.4	217.5	57.9	172.0	114.5	100,000
		% of criterion	0.18%	0.05%	0.22%	0.06%	0.17%	0.11%	-

Pollutant	Averaging period	Value	Predicted maximum project contributions (µg/m³)						Impact assessment criteria/ standards (µg/m³)
			With project – forecast traffic in 2019		With project – forecast traffic in 2029		Design analysis A		
			Northern ventilation outlet	Southern ventilation outlet	Northern ventilation outlet	Southern ventilation outlet	Northern ventilation outlet	Southern ventilation outlet	
	8 hour maximum	Peak project contribution	36.0	17.2	45.5	31.5	59.0	51.5	30,000
		% of criterion	0.12%	0.06%	0.15%	0.10%	0.20%	0.17%	-
Total VOC	1 hour 99.9th percentile	Peak project contribution	2.6	1.7	3.5	2.3	5.4	4.2	29*
		% of criterion	9.1%	5.8%	12.2%	8.0%	18.5%	14.6%	-
PAHs	1 hour 99.9th percentile	Peak project contribution	0.0005	0.0003	0.0006	0.0004	0.0011	0.0008	0.4**
		% of criterion	0.12%	0.08%	0.15%	0.10%	0.27%	0.21%	-
* as benzo(a)pyrene		** as benzene							

Table 9-3 Comparison of revised air quality modelling results against EIS modelling results

Pollutant	Averaging period	Design	Predicted maximum project contributions (μg/m³)						Impact assessment criteria (μg/m³)
			With project – forecast traffic in 2019		With project – forecast traffic in 2029		Design analysis A		
			Northern ventilation outlet	Southern ventilation outlet	Northern ventilation outlet	Southern ventilation outlet	Northern ventilation outlet	Southern ventilation outlet	
PM_{10}	24 hour maximum	+5 metre ventilation outlet	1.02*	0.65	1.28	1.18	1.80	1.93	50
		EIS predictions	0.95	1.39	1.37	2.14	2.23	3.13	
		% change	**7%***	**-53%**	**-7%**	**-45%**	**-19%**	**-38%**	
	Annual average	+5 metre ventilation outlet	0.05	0.05	0.08	0.06	0.12	0.11	30
		EIS predictions	0.09	0.11	0.11	0.13	0.17	0.26	
		% change	**-41%**	**-60%**	**-25%**	**-58%**	**-32%**	**-57%**	
$PM_{2.5}$	24 hour maximum	+5 metre ventilation outlet	0.96*	0.62	1.20	1.13	1.70	1.82	25
		EIS predictions	0.90	1.34	1.30	2.01	2.11	2.97	
		% change	**7%***	**-54%**	**-7%**	**-44%**	**-19%**	**-39%**	
	Annual average	+5 metre ventilation outlet	0.05	0.04	0.08	0.05	0.11	0.11	8
		EIS predictions	0.08	0.11	0.10	0.13	0.16	0.25	
		% change	**-41%**	**-60%**	**-25%**	**-59%**	**-31%**	**-57%**	
NO_2	1 hour maximum	+5 metre ventilation outlet	54.3	69.0**	58.3	76.0**	70.4	91.8	246
		EIS predictions	68.9	61.8	74.6	65.0	114.8	98.2	
		% change	**-21%**	**12%****	**-22%**	**17%****	**-39%**	**-7%**	

Pollutant	Averaging period	Design	Predicted maximum project contributions (μg/m³): With project – forecast traffic in 2019: Northern ventilation outlet	With project – forecast traffic in 2019: Southern ventilation outlet	With project – forecast traffic in 2029: Northern ventilation outlet	With project – forecast traffic in 2029: Southern ventilation outlet	Design analysis A: Northern ventilation outlet	Design analysis A: Southern ventilation outlet	Impact assessment criteria (μg/m³)
	Annual average	+5 metre ventilation outlet	0.6	0.8	0.8	1.3	1.3	1.8	62
		EIS predictions	1.4	1.2	1.7	1.4	2.5	2.4	
		% change	**-55%**	**-31%**	**-53%**	**-10%**	**-47%**	**-24%**	
CO	1 hour maximum	+5 metre ventilation outlet	181.8**	48.4	217.5**	57.9	172.0	114.5	100,000
		EIS predictions	86.6	70.1	107.4	90.3	179.3	166.7	
		% change	**110%****	**-31%**	**103%****	**-36%**	**-4%**	**-31%**	
	8 hour maximum	+5 metre ventilation outlet	36.0**	17.2	45.5	31.5	59.0	51.5	30,000
		EIS predictions	32.4	33.1	54.2	57.9	80.3	81.7	
		% change	**11%****	**-48%**	**-16%**	**-46%**	**-27%**	**-37%**	
Total VOC	1 hour 99.9th percentile	+5 metre ventilation outlet	2.63	1.67	3.53	2.33	5.35	4.24	29***
		EIS predictions	4.07	3.72	5.38	5.36	7.40	8.96	
		% change	**-35%**	**-55%**	**-35%**	**-56%**	**-28%**	**-53%**	
PAHs	1 hour 99.9th percentile	+5 metre ventilation outlet	0.0005	0.0003	0.0006	0.0004	0.0011	0.0008	0.4****
		EIS predictions	0.0007	0.0007	0.0009	0.0009	0.0015	0.0018	
		% change	**-34%**	**-54%**	**-31%**	**-56%**	**-28%**	**-53%**	

* Occurs 1 day in three years ** Occurs 1 hour in three years *** as benzo(a)pyrene **** as benzene

When compared to the concentrations presented in the environmental impact statement, the increase in ventilation outlet heights by five metres generally results in a decrease in ground level concentrations. For the forecast traffic volumes, these decreases are:

- Annual average PM_{10} and $PM_{2.5}$ concentrations, up to 60 per cent at the southern ventilation outlet and up to 41 per cent at the northern ventilation outlet.
- Annual average nitrogen dioxide concentrations, up to 31 per cent at the southern ventilation outlet and up to 55 per cent at the northern ventilation outlet.
- Eight hour maximum carbon monoxide concentrations, up to 48 per cent at the southern ventilation outlet and up to 16 per cent at the northern ventilation outlet.
- Total volatile organic compounds, up to 56 per cent at the southern ventilation outlet and up to 35 per cent at the northern ventilation outlet.
- Polycyclic aromatic hydrocarbons, up to 56 per cent at the southern ventilation outlet and up to 34 per cent at the northern ventilation outlet.

There is, however, an increase in some pollutants for some averaging periods. As identified above some changes have been made to the dispersion modelling inputs and, therefore, the revised concentrations are not directly comparable with those presented in the environmental impact statement. These changes to the dispersion modelling input may explain some of these increases in pollutants. The meteorological conditions during these modelling outcomes have also been investigated. The period of this increase is limited to one day over three years (in the case of particulate matter) or one hour over three years (in the case of nitrogen dioxide and carbon monoxide).

A detailed analysis of the rare and infrequent meteorological conditions that cause predicted peak concentrations of some pollutants to increase is provided in **Section 2.15.2** of this report. This analysis demonstrates that these predicted peak pollutant concentrations are rare and not typical of normal conditions experienced during operation of the project.

Rare peak concentrations have been identified as being caused by predicted strong winds. As wind speed increases with height above the ground, the wind speeds occurring at the top of the increased ventilation outlets are higher than experienced at the top of the ventilation outlets as presented in the environmental impact statement.

When the ambient winds are higher than the exit velocity of the plume, such as occurs during the predicted peak concentrations, outlet tip downwash is more likely to occur (where the plume is quickly brought down towards ground level before any substantial dispersion can occur). Such conditions occur rarely (refer to **Section 2.15.2**), and while the ambient wind speeds calculated by the meteorological model are likely to be overestimates of actual conditions, it is possible for these conditions to occur. As such, the meteorological conditions and the associated pollutant predictions are considered to be valid, but conservative.

This issue can be further contextualised by considering the relative contributions of the project to ambient pollutant concentrations, as distinct from the contributions made by background air quality. A review of the pollutants which show increased concentrations is provided below (NO_2, CO and particulate matter (PM_{10} and $PM_{2.5}$).

Nitrogen dioxide

Figure 9-1 shows the frequency distribution for predicted nitrogen dioxide (one hour average) contributions at the most affected receiver location. The figure shows predictions for ventilation heights as presented in the environmental impact statement and with an increase in ventilation outlet height by five metres. Data are presented for 2019, being the year in which modelling outcomes have been identified as increasing above the predictions presented in the environmental impact statement.

Data presented in **Figure 9-1** are also provided numerically in **Table 9-4**.

Figure 9-1 and **Table 9-4** show:

- The maximum project contribution of nitrogen dioxide (one hour average) at the most affected location in 2019 (69 µg/m^3) for the increased ventilation height configuration would be an unusual and infrequent event. Nitrogen dioxide concentrations of this level are only expected to occur for one hour in three years (around 0.004 per cent of the time).
- The peak value is nearly twice the second highest concentration, confirming the anomalous nature of the peak value.
- For all but four hours in the three year period assessed, the project contributions are expected to be less than 30 µg/m^3 (12 per cent of the applicable criterion).
- Over a three year period, the contribution from the project is expected to represent less than four per cent of the applicable ambient air quality criterion for NO_2 (one hour average) (20 µg/m^3) for 98 per cent of the time.
- The predicted concentrations for the increased ventilation outlet height configuration are clearly lower than the environmental impact statement predictions for the vast majority of the hours ranked between the third highest and 500th highest predicted concentrations. Beyond this, predicted concentrations for all scenarios (original ventilation outlet height and increased ventilation height are all very low (less than 10 µg/m^3)
- Overall, with the exception of the singular peak concentration (one hour in three years), the project contribution of nitrogen dioxide to the airshed would be minor and less than that predicted in the environmental impact statement.

Table 9-4 Frequency of NO_2 (one hour average) project contributions at the most affected location (2019 forecast traffic, increased ventilation outlet height)

Project contribution (NO_2, one hour) (µg/m^3)	Number of hours in three years	Percentage of hours in three years	Percentage of ambient air quality criterion
Maximum – 68.96 µg/m^3	1	0.004%	28%
35 µg/m^3 to 68.96 µg/m^3	2	0.008%	14% to 28%
30 µg/m^3 to 35 µg/m^3	1	0.004%	12% to 14%
20 µg/m3 to 30 µg/m^3	95	0.36%	8% to 12%
10 µg/m^3 to 20 µg/m^3	439	1.67%	4% to 8%
Total	**538**	**2.0%**	**> 4%**

Carbon monoxide

Figure 9-2 shows the frequency distribution for predicted carbon monoxide (one hour average) contributions at the most affected receiver location. The figure shows predictions for ventilation heights as presented in the environmental impact statement and with an increase in ventilation outlet height by five metres. Data are presented for 2019, being the year in which modelling outcomes have been identified as increasing above the predictions presented in the environmental impact statement.

Data presented in **Figure 9-2** are also provided numerically in **Table 9-5**. The figure and the table show:

- The maximum project contribution of carbon monoxide (one hour average) at the most affected location in 2019 (181.8 µg/m^3) for the increased ventilation outlet height configuration would be an unusual and infrequent event. This peak concentration is predicted to occur for only one hour in three years (around 0.004 per cent of the time).
- The peak value is more than twice the second highest predicted concentration, confirming the anomalous nature of the peak value.
- Project contributions of less than 1 µg/m^3 (ie less than 0.003 per cent of the applicable criterion) are predicted to occur more than 99 per cent of the time.
- The predictions for the increased ventilation outlet height configuration are clearly lower than the environmental impact statement predictions for the hours ranked between the fifth and 400th highest prediction concentration.
- Overall, the predicted project contribution of carbon monoxide to the airshed is considered would be minor and less than that predicted in the environmental impact statement.

Table 9-5 Frequency of CO (one hour average) project contributions at the most affected location (2019 forecast traffic, increased ventilation outlet height)

Project contribution (CO, one hour) (µg/m^3)	Number of hours in three years	Percentage of hours in three years	Percentage of ambient air quality criterion
Maximum – 181.8 µg/m^3	1	0.004%	0.6%
100 µg/m^3 to 181.8 µg/m^3	0	0%	0.3% to 0.6%
30 µg/m^3 to 100 µg/m^3	2	0.008%	0.1% to 0.3%
5 µg/m^3 to 30 µg/m^3	13	0.05%	0.02% to 0.1%
1 µg/m^3 to 5 µg/m^3	185	0.7%	0.003% to 0.02%
Total	**201**	**0.8%**	**> 0.003%**

Particulate matter

Analysis of particulate matter has focused on $PM_{2.5}$, given its significance in terms of human health risks. The outcomes would be very similar for PM_{10}, noting the similarity in mass emissions of PM_{10} and $PM_{2.5}$ from the project's ventilation outlets.

Figure 9-3 shows the frequency distribution for predicted $PM_{2.5}$ (24 hour average) contributions at the most affected receiver location. The figure shows predictions for ventilation heights as presented in the environmental impact statement and with an increase in ventilation outlet height by five metres. Data are presented for 2019, being the year in which modelling outcomes have been identified as increasing above the predictions presented in the environmental impact statement.

Data presented in **Figure 9-3** are also provided numerically in **Table 9-6**. The figure and the table show:

- The maximum project contribution of $PM_{2.5}$ (24 hour average) at the most affected location in 2019 (0.96 µg/m^3) would be an unusual and infrequent event. This peak concentration is predicted to occur for only one day in three years (around 0.09 per cent of the time).
- The peak value is more than twice the second highest concentration, confirming the anomalous nature of the peak concentration.
- The project contributions of $PM_{2.5}$ (24 hour) are expected to be less than 0.05 µg/m^3 (0.002 per cent of the advisory reporting standard) for more than 99 per cent of the time.
- The predicted project contributions for the increased ventilation outlet height configuration are clearly lower than the environmental impact statement predictions for the days ranked between third and 200th highest predicted concentrations.
- The project contribution of $PM_{2.5}$ would be minor and less than that predicted in the environmental impact statement.

Table 9-6 Frequency of $PM_{2.5}$ (24 hour average) project contributions at the most affected location (2019 forecast traffic, increased ventilation outlet height)

Project contribution (PM_{10}, 24 hour) (µg/m^3)	Number of days in three years	Percentage of days in three years	Percentage of reporting standard
Maximum – 0.96 µg/m^3	1	0.09%	2%
0.4 µg/m^3 to 0.96 µg/m^3	0	0%	1% to 2%
0.1 µg/m^3 to 0.4 µg/m^3	2	0.18%	0.% to 1%
0.05 µg/m^3 to 0.1 µg/m^3	2	0%	0.02% to 0.2%
0.01 µg/m^3 to 0.05 µg/m^3	144	13%	0.002% to 0.02%
Total	**149**	**14%**	**> 0.002%**

Conclusion

The outcome of this investigation into the peak concentrations is supported by the modelling predictions for total volatile organic compounds and polycyclic aromatic hydrocarbons, which are reported as 99.9th percentile concentrations (which exclude the peaks). The increased ventilation outlet height configuration results for these pollutants are between 28 per cent and 55 per cent lower than the environmental impact statement predictions. Furthermore, the predicted annual average concentrations for the increased ventilation outlet height configuration, which represent longer term trends, are all much lower than presented in the environmental impact statement.

Based on the analysis presented in **Section 2.15.2** of this report, the meteorological conditions that cause predicted peak ground level concentrations are rare events that would not be characteristic of typical conditions during operation of the project.

The analysis presented in **Section 2.15.2** has identified a number of factors affecting predicted short term average concentrations of emissions around the northern and southern ventilation outlets. These include rare and infrequent meteorological conditions leading to outlet tip downwash, and conditions associated with onshore-offshore winds.

Based on the results provided, the increase in ventilation outlet heights results in an overall decrease in concentrations with the exception of a very small number of hours that are characterised by outlet tip downwash conditions. These downwash conditions are not common and can be considered a rare event and not likely to result in regular ongoing elevated pollutant concentrations. The analysis presented above also demonstrates that although onshore-offshore wind switch occur regularly, the frequency of these conditions leading to an elevated ground level concentration is very low (so as to be an extreme outlier in the data set).

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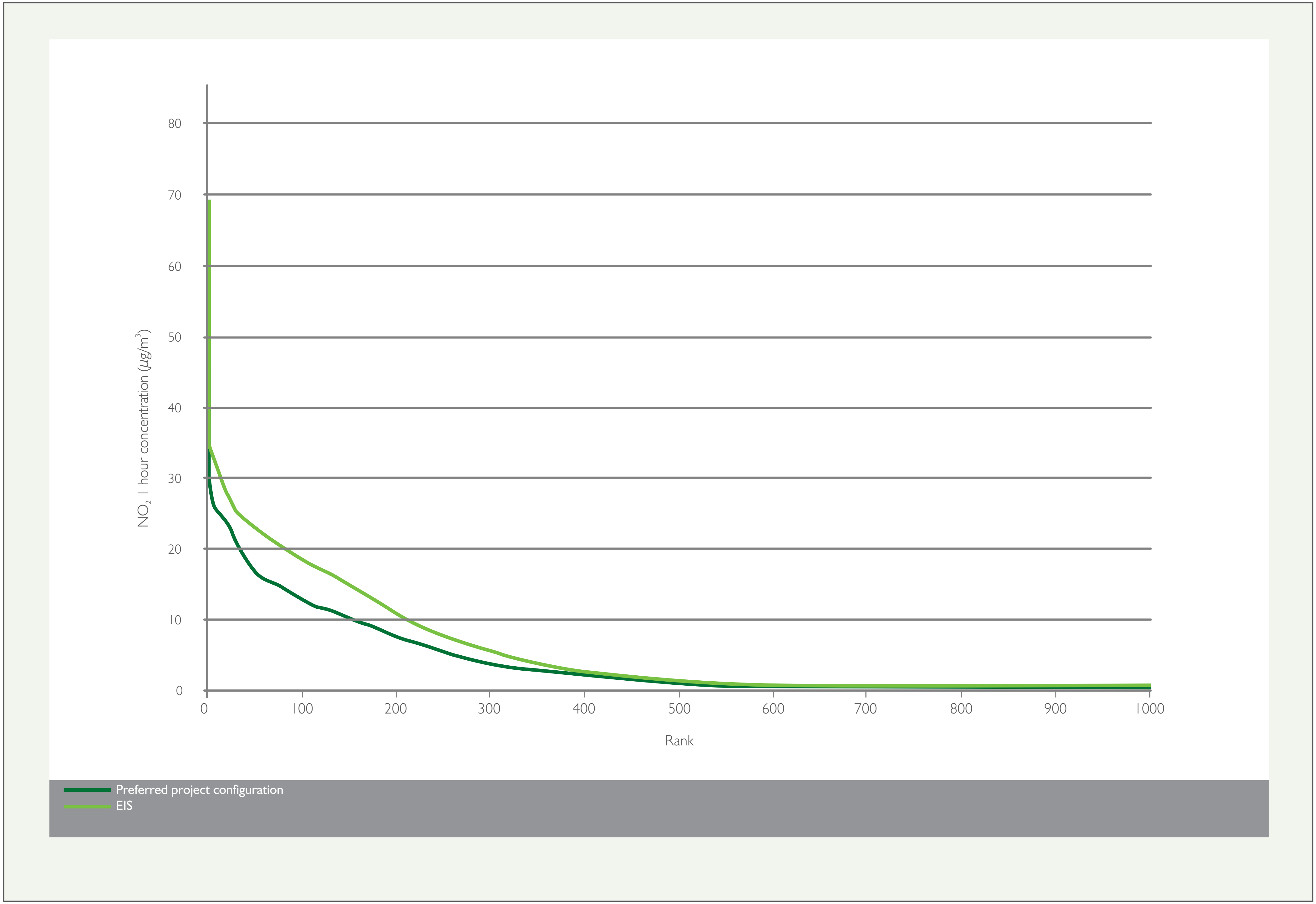

Figure 9-1 Comparison of ranked values – preferred project and EIS configurations – with project, expected traffic flows 2019 (scenario 2a) – NO_2 1 hour average

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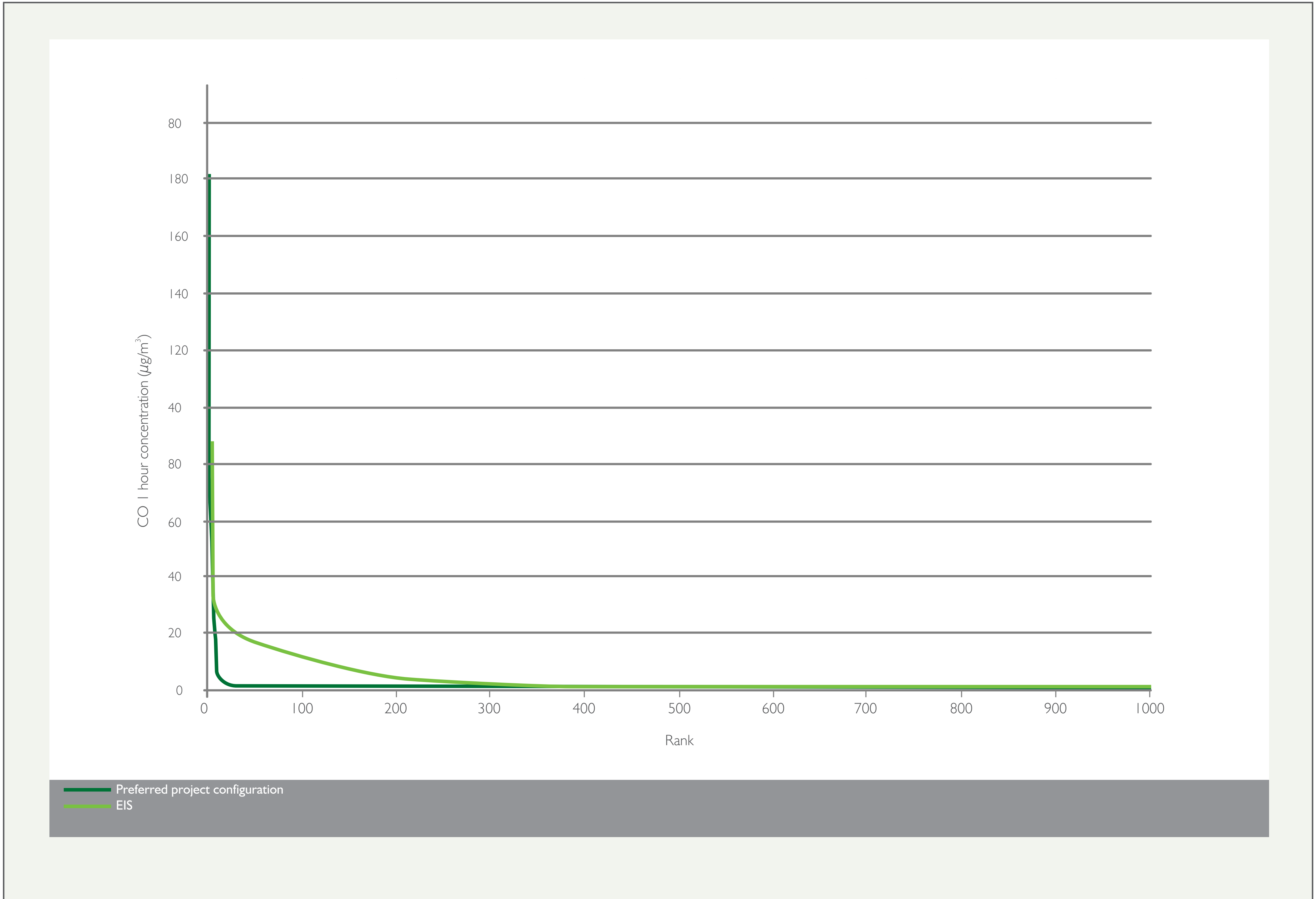

Figure 9-2 Comparison of ranked values – preferred project and EIS configurations – with project, expected traffic flows 2019 (scenario 2a) – CO 1 hour average

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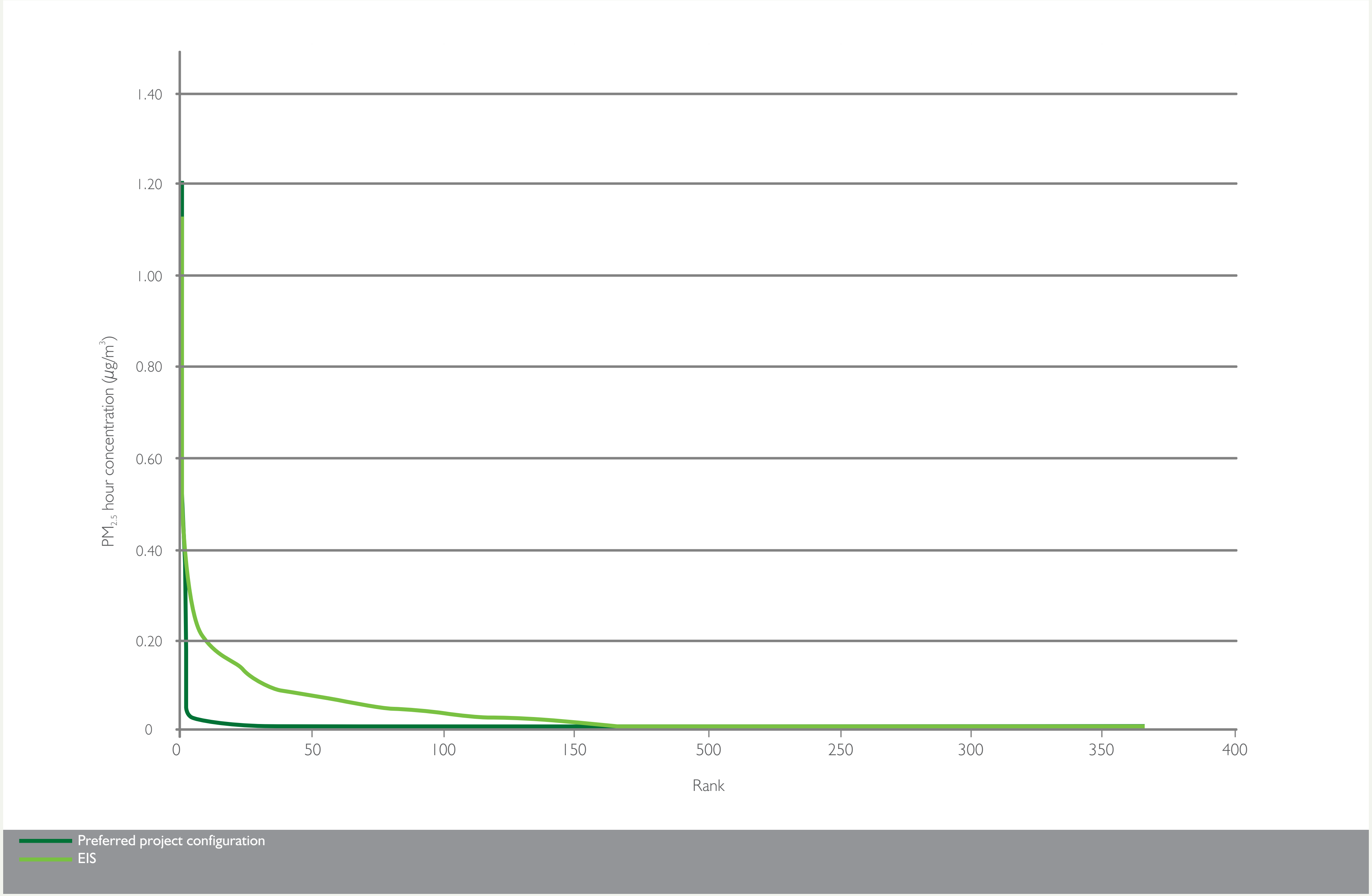

Figure 9-3 Comparison of ranked values – preferred project and EIS configurations – with project, expected traffic flows 2019 (scenario 2a) – $PM_{2.5}$ 24 hour average

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9.2.4 Human health

As shown above, the relevant concentration levels for oxides of nitrogen, carbon monoxide, volatile organic compounds and polycyclic aromatic hydrocarbons all decrease as a result of the increased ventilation outlet height and, as such, all remain below the level at which adverse health outcomes are expected to occur. Consistent with the approach for the environmental impact statement, these pollutants have not been carried forward for more detailed assessment. As the human health risk assessment is concerned with long term (or chronic) exposures to pollutants, the short term (or acute) increases in pollutants over those presented in the environmental impact statement would not result in increased health risks and have, therefore, not been considered further.

Human health risks associated with emissions from the project's ventilation outlets are principally a function of chronic (longer term) exposure to $PM_{2.5}$. Changes in human health risks as a consequence of increasing the height of the ventilation outlets would therefore be similar to the predicted reductions in annual average $PM_{2.5}$ concentrations.

Table 9-7 summarises estimated increases in incidence of primary health indicators as a result of increasing the ventilation outlet height by five metres and includes a comparison with the same data presented in the environmental impact statement for 15 metre ventilation outlets. Similar changes in health outcomes would be expected for the other health indicators examined as part of the environmental impact statement (secondary health indicators, exposure to diesel particulate matter and asthma).

The results show a decrease in annual incidence for all primary health indicators by between 25 per cent and 50 per cent when compared to the health indicators presented in the environmental impact statement. These health effects are very low and significantly less than the normal variability in cases per year in the population.

Table 9-7 Estimated increases in incidence of primary health effects (per year) – increased ventilation outlet heights

Primary health indicator	Baseline incidence per year (per 100,000)	Normal incidence variability (cases per year)	Increased incidence (cases per year) - EIS		Increased incidence (cases per year) – increased ventilation outlet height	
			2019	2029	2019	2029
Northern ventilation outlet						
Mortality from all causes (≥ 30 years of age)	1,087	1	0.03	0.04	0.02	0.03
Rate of hospitalisation with cardiovascular disease (≥ 65 years of age)	23,352	40	0.02	0.03	0.01	0.02
Rate of hospitalisation with respiratory disease (≥ 65 years of age)	8,807	17	0.005	0.005	0.003	0.004
Southern ventilation outlet						
Mortality from all causes (≥ 30 years of age)	1,087	1	0.03	0.03	0.01	0.01
Rate of hospitalisation with cardiovascular disease (≥ 65 years of age)	23,352	40	0.02	0.02	0.01	0.01
Rate of hospitalisation with respiratory disease (≥ 65 years of age)	8,807	17	0.004	0.004	0.002	0.002

9.2.5 Operational visual impacts

The increased height of the ventilation outlets would alter the extent of visual impacts associated with these facilities. The urban design and landscaping treatments of these facilities are not proposed to be altered, although it is noted that this would be subject to the future development of the Urban Design and Landscape Plan for the project. As identified in Appendix D of the environmental impact statement, this plan would be developed in consultation with the local community and the relevant local council(s).

A revised assessment of the potential visual impacts from the two ventilation outlets is provided below.

Northern ventilation facility

Figure 9-4 illustrates the theoretical visibility (the visual envelope) of the northern ventilation facility from the surrounding area. This figure shows the visibility based on the ventilation outlet height within the environmental impact statement, and the increased visibility based on an increased height of five metres. This shows the increased height results in a marked increase in the visibility of the ventilation outlet as the new outlet height would be visible above screening features such as vegetation and existing noise walls.

This increased visibility, however, is of a discrete raised element of the facility and, for the majority of receivers, would be viewed as a relatively small component within the broader landscape.

Revised artist's impressions of the facility from surrounding residential areas and from the M1 Pacific Motorway are provided in **Figure 9-5** to **Figure 9-7**. Revised visual impact ratings are presented in **Table 9-8**.

As the increased ventilation outlet height only affects a discrete component of the facility, it would not result in a significant change in the visual impacts for the most affected receivers. The overall visual impact rating would be consistent with that described in the environmental impact statement.

Southern ventilation facility

Figure 9-8 illustrates the theoretical visibility of the southern ventilation facility from the surrounding area. This figure shows the visibility based on the ventilation outlet height within the environmental impact statement, and the increased visibility based on an increased height of five metres. This shows the increased height results in a slight increase in the visibility of the operational infrastructure.

This increased visibility is of a discrete raised element of the broader motorway operations complex and, for the majority of receivers, would be viewed as a small component within the broader landscape.

Revised artist's impressions of the facility from surrounding residential areas and from Pennant Hills Road are provided in **Figure 9-9** to **Figure 9-11**. Revised visual impact ratings are presented in **Table 9-8**.

As the increased height only affects a discrete component of the larger motorway operations complex, it would not result in a significant change in the visual impacts for the most affected receivers. The overall visual impact rating would be consistent with that described in the environmental impact statement.

Table 9-8 Operational visual impact assessment – increased ventilation outlet height

Receiver number	Receiver	EIS			+5 metres		
		Sensitivity of receivers	Magnitude of change	Overall rating	Sensitivity of receivers	Magnitude of change	Overall rating
Northern ventilation facility							
1	Residential – Woonona Avenue and Bareena Avenue	High to moderate	High to moderate	High to moderate	High to moderate	High to moderate	High to moderate
2	Motorists – M1 Pacific Motorway	Moderate to low	Moderate to low	Moderate to low	Moderate to low	Moderate to low	Moderate to low
Southern ventilation facility/ motorway operations complex							
1	Residential – Gum Grove Place	High to moderate	High to moderate	High to moderate	High to moderate	High to moderate	High to moderate
2	Residential – Karloon Road/ Eaton Road intersection	High	High	High	High	High	High
3	Residential – Coral Tree Drive	Moderate	High to moderate	High to moderate	Moderate	High to moderate	High to moderate
4	Motorists – Pennant Hills Road/ Hills M2 Motorway interchange	Low	Low	Low	Low	Low	Low
5	Motorists – Copeland Road/ Pennant Hills Road intersection	Low	Low	Low	Low	Low	Low

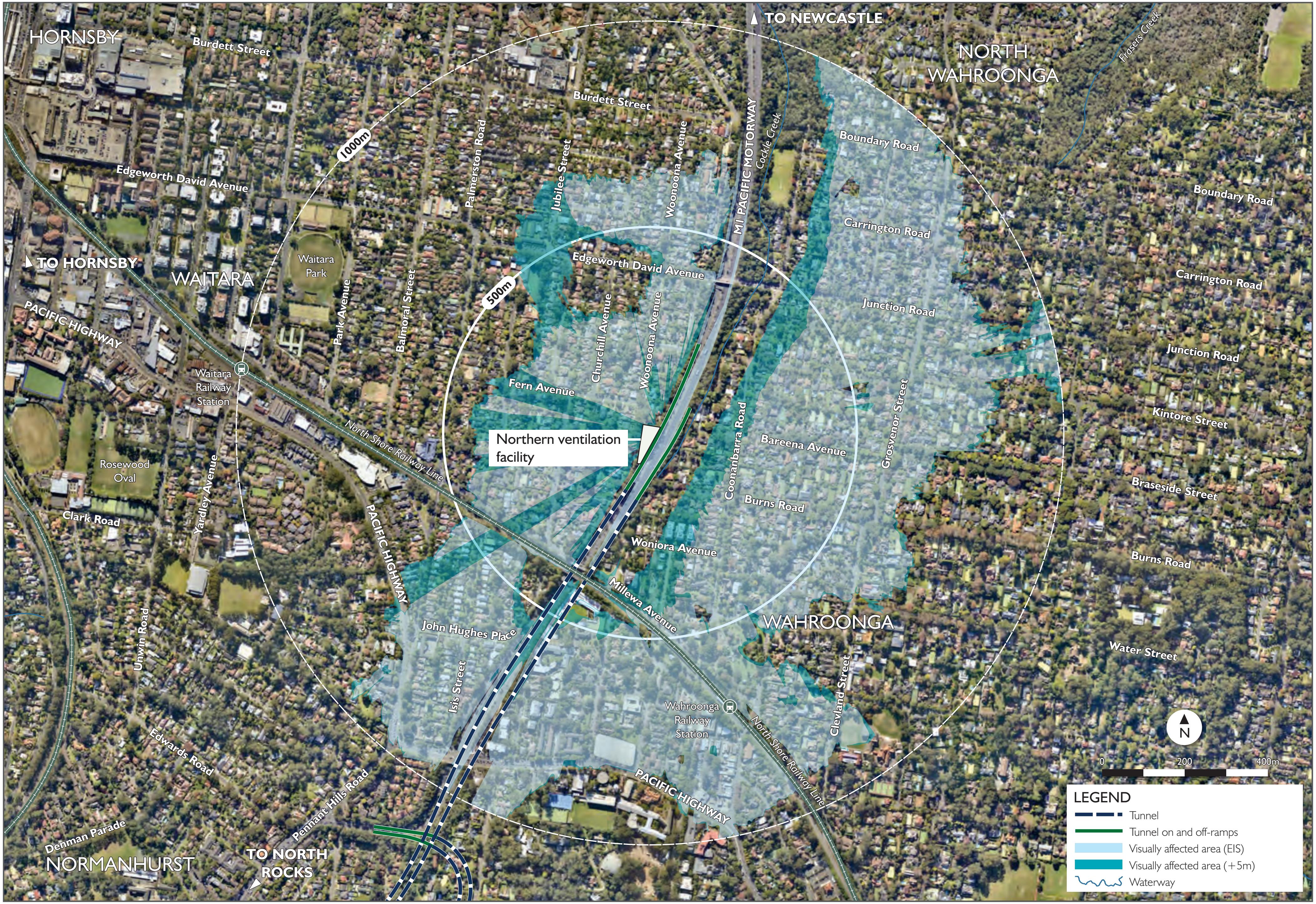

Figure 9-4 Northern ventilation facility visual envelope map

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