

Figure 3-3 Increased northern ventilation facility visual envelope map

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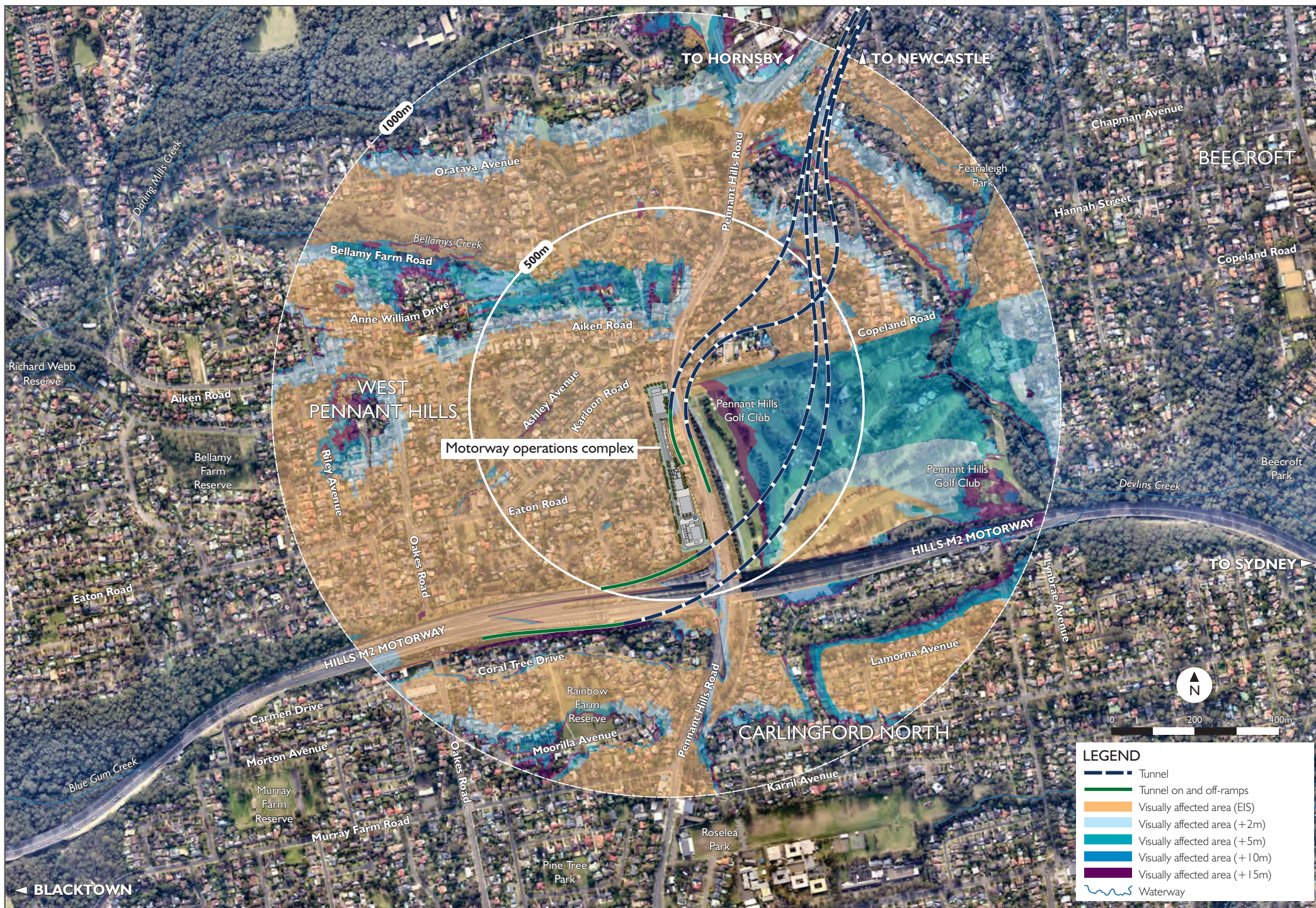


Figure 3-4 Increased southern ventilation outlet visual envelope map

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Engineering considerations

Addition of extra height to the southern and northern ventilation outlets is unlikely to raise significant engineering issues for the height increases considered. Some further design consideration and verification for the ventilation system, particularly in relation to increased pressure drops across the ventilation outlet, may be required. These issues are unlikely to be a significant impediment to any of the height increase scenarios.

Capital and operating costs

Estimated additional capital and operating costs associated with increases in the heights of the southern and northern ventilation outlets are summarised in **Table 3-7**. These costs are incremental additions above the cost of the project as presented in the environmental impact statement, and assume that any change in ventilation outlet height would be applied to both the southern and northern ventilation outlets. If the height of only one ventilation outlet is altered, the costs summarised in **Table 3-7** would be halved.

While there is likely to be a change in operating costs for different ventilation outlet heights (as a result of increased pressure drops across higher ventilation outlets and associated with maintenance of higher outlets), these costs are anticipated to be negligible relative to the operating costs of 15 metre ventilation outlets.

Table 3-7 Estimated increase in capital and operating costs for increased ventilation outlet heights

Relative increase in ventilation outlet height	Increase in project capital cost	Increase in project operating cost
+2 metres	\$0.7 million	Negligible
+5 metres	\$2 million	Negligible
+10 metres	\$5 million	Negligible
+15 metres	\$8 million	Negligible

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3.2.3 Scenario 2 – Relocation of northern and southern ventilation outlets

Potential relocation of the northern and southern ventilation outlets has been considered. For the northern ventilation outlet, relocation to the Asquith Industrial Estate has been considered based on several submissions from the local community raising this as an option. The assessed location of a relocated northern ventilation outlet in the Asquith Industrial Estate is shown in **Figure 3-5**. More detailed micro-siting of the ventilation facility would be required, however, the assessed locations provide representative scenarios involving ventilation outlet locations that are:

- On land zoned for industrial purposes.
- On a site that is not currently developed.
- Broadly equidistant from surrounding residential receivers.

It has been assumed that the tunnel air from the project's main alignment tunnels could be transferred to the relocated northern ventilation outlet for handling and discharge. No changes in the length or configuration of the project's main alignment tunnels have been assumed, to provide a consistent basis for comparison with the project as assessed in the environmental impact statement. The relocated outlet has been assumed to be identical in design, configuration and operation as the northern ventilation outlet described in the environmental impact statement.

For the southern ventilation outlet, relocation to the Pennant Hills Golf Course has been considered based on several submissions from the local community raising this option as preferable to the proposed location of the ventilation outlet. The assessed location of a relocated southern ventilation outlet in the Pennant Hills Golf Course is shown in **Figure 3-6**. The assessment presented in the following sections of this report would apply equally to land adjacent to the golf course, noting for example, the parcel of land next to the south west corner of the golf course which is owned by Roads and Maritime.

The relocated outlet has been positioned in the south west corner of the golf course with the aim of minimising potential disruption to the current configuration and operation of the golf course, and to maintain the ventilation outlet as close to the southbound main alignment tunnel exit portal as possible. The relocated outlet has been assumed to be identical in design, configuration and operation as the southern ventilation outlet described in the environmental impact statement.

Ambient air quality

Table 3-8 and **Table 3-9** summarise the outcomes of air dispersion modelling for the relocated northern ventilation outlet (Asquith Industrial Estate) and the southern ventilation outlet (Pennant Hills Golf Course), respectively. The tables show the maximum annual average predicted around the relocated ventilation outlets, compared with the maximum values for the northern and southern ventilation outlets in the locations identified in the environmental impact statement.

Table 3-8 Effect of relocating the northern ventilation outlet – Asquith Industrial Estate

Parameter	EIS design ¹	Asquith Industrial Estate
PM ₁₀ (annual average) (µg/m ³)	0.057	0.097
Percentage of criterion (30 µg/m ³)	0.19%	0.32%
PM _{2.5} (annual average) (µg/m ³)	0.054	0.092
Percentage of advisory reporting standard (8 µg/m ³)	0.68%	1.15%
NO ₂ (annual average) (µg/m ³)	0.96	1.70
Percentage of criterion (62 µg/m ³)	1.55%	2.74%

¹ This data represent the outcomes of applying the project design in the environmental impact to the screening assessment approach, rather than a reproduction of results from the environmental impact statement.

Table 3-9 Effect of relocating the southern ventilation outlet – Pennant Hills Golf Course

Parameter	EIS design ¹	Pennant Hills Golf Course
PM ₁₀ (annual average) (µg/m ³)	0.046	0.037
Percentage of criterion (30 µg/m ³)	0.15%	0.12%
PM _{2.5} (annual average) (µg/m ³)	0.044	0.035
Percentage of advisory reporting standard (8 µg/m ³)	0.55%	0.44%
NO ₂ (annual average) (µg/m ³)	0.51	0.41
Percentage of criterion (62 µg/m ³)	0.82%	0.66%

¹ This data represent the outcomes of applying the project design in the environmental impact to the screening assessment approach, rather than a reproduction of results from the environmental impact statement.

Table 3-8 shows a predicted increase in maximum annual average concentrations of PM₁₀, PM_{2.5} and NO₂ as a result of relocating the northern ventilation outlet to the Asquith Industrial Area. The contributions of the relocated northern ventilation outlet to surrounding air quality would nonetheless remain within applicable ambient air quality criteria and advisory reporting standards. From an analysis of the air dispersion modelling outcomes, the principal reason for an increase in ground level concentrations is the topography in and around the Asquith Industrial Estate.

The air dispersion modelling also shows that the maximum annual average concentration is expected to occur within the Asquith Industrial Estate. Air quality impacts at surrounding residential receivers are predicted to be equivalent to those presented in the environmental impact statement for receivers around the currently proposed location of the northern ventilation outlet. While relocation of the northern ventilation outlet would increase maximum annual average impacts, these increased impacts would be confined to the industrial estate, with residential receivers experiencing negligible change (either positive or negative) relative to the predicted air quality impacts to residential receivers presented in the environmental impact statement.

Table 3-19 shows an approximate 20 per cent reduction in maximum annual average ground level concentrations around the relocated southern ventilation outlet relative the assessment presented in the environmental impact statement. Notwithstanding a relative decrease in air quality impacts, the predicted ground level concentrations associated with the operation of the southern ventilation outlet in its current proposed location and in its potentially relocated position in the Pennant Hills Golf Course are both very low absolute values (and both well within applicable ambient air quality criteria and advisory reporting standards). As with the potentially relocated northern ventilation outlet, the principal driver for changes in air quality impacts around the potentially relocated southern ventilation outlet is topography. Maximum annual average concentrations around the potentially relocated ventilation outlet remain within residential areas, although the distribution of predicted impacts is shifted in an easterly direction commensurate with the shift in the southern ventilation outlet location.



Figure 3-5 Indicative location of alternative northern ventilation outlet

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Figure 3-6 Indicative location of alternative southern ventilation outlet

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In-tunnel air quality

Changes in the locations of the ventilation outlets would not affect in-tunnel air quality.

Human health risks

A fully quantified human health risk assessment has not been conducted for the relocation of the northern and southern ventilation outlets. However, it has been possible to form the following broad qualitative conclusions about the potential human health implications of relocating the ventilation outlets:

- Peak annual average $PM_{2.5}$ concentrations remain the same for residential receivers around the northern ventilation outlet relocated to the Asquith Industrial Estate, as for residential receivers around the northern ventilation outlet in its currently proposed location. The distribution of $PM_{2.5}$ (annual average) is greater around the relocated northern ventilation outlet than around the outlet at its currently proposed location, however, a significant proportion of the affected area is currently used for industrial land uses or is currently not occupied. On balance, the human health impacts associated with the relocated northern ventilation outlet are expected to be comparable, and potentially marginally lower, than predicted for the current location of the northern ventilation outlet and presented in the environmental impact statement.
- Peak annual average $PM_{2.5}$ concentrations are lower and less widely distributed around the southern ventilation outlet relocated to the Pennant Hills Golf Course, compared with the predicted outcomes for the currently proposed location of the southern ventilation outlet. This reduction in predicted air quality impacts and the reduced area of potentially affected residential receivers (principally within the golf course), means that the relocated southern ventilation outlet in the Pennant Hills Golf Course would have slightly lower human health impacts than presented in the environmental impact statement.

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Other environmental and land use impacts

Relevant environmental and land use impacts (other than air quality and human health risks) for potential increases in ventilation outlet height are presented in **Table 3-10**.

Table 3-10 Assessment of other environmental and land use impacts – relocated northern and southern ventilation outlets

Environmental and land use impacts	Assessment
Visual amenity impacts	<p>Northern ventilation outlet Based on its relocation away from sensitive visual receivers, proximity to an existing industrial facility, adjacent areas of native vegetation and local topography, the location of the northern ventilation outlet in the Asquith Industrial Estate is likely to have reduced visual impacts relative to the assessed outcomes in the environmental impact statement.</p> <p>Southern ventilation outlet Relocating the southern ventilation outlet into the Pennant Hills Golf Course (or immediately adjacent to it) is likely to significantly increase visual impacts because of:</p> <ul style="list-style-type: none"> • The visual (landscape, topographic) prominence of the golf course, particularly the south west corner. • Disaggregation of the currently proposed motorway operations complex which forms a single coherent visual unit. Relocation of the southern ventilation outlet would spread this visual element and introduce a new, isolated structure (the southern ventilation outlet) which is out of context with its immediate surrounds and disassociated from the remainder of the motorway operations complex.
Noise and vibration impacts	<p>Northern ventilation outlet The northern ventilation outlet has been assessed in the environmental impact statement as comfortably complying with applicable operational noise criteria. Compliance is likely to extend even further through relocation of the northern ventilation outlet to the Asquith Industrial Estate, further away from residential receivers.</p> <p>Southern ventilation outlet The southern ventilation outlet (combined with the effects of the southern portals) is currently predicted to be close to, but not exceeding, the applicable operational noise criteria. This includes an operational noise impact of - 40 dB(A) during neutral weather conditions, and 41 dB(A) during adverse weather conditions when measured at the nearest residential receiver (compared with a criterion of 41 dB(A)). The major of this noise impact relates to noise from the southern portals, with a relatively low contribution from the southern ventilation outlet (comparable to operational noise predictions for the northern ventilation outlet). Relocation of the southern ventilation outlet to the Pennant Hills Golf Course, or adjacent to the golf course, would therefore result in some reductions in operational noise, albeit small.</p>

Land acquisition	<p>Northern ventilation outlet Relocation of the northern ventilation outlet would require acquisition of land, which is expected to be slightly greater in area than the currently proposed location of the outlet. This is because the current outlet location relies partly on land within the M1 Pacific Motorway corridor, which is already owned by Roads and Maritime. Depending on the solution used to transfer in-tunnel air to the relocated ventilation outlet, stratum acquisition and potentially surface acquisition, would be required between the main alignment tunnels and the relocated ventilation outlet. Land acquisition requirements would be partially offset by removal of the need to acquire some land at the currently proposed site for the northern ventilation outlet. However, land at the currently proposed location of the northern ventilation outlet would nonetheless still need to be acquired to accommodate facilities such as the fire suppression water tanks.</p> <p>Southern ventilation outlet Part of the Pennant Hills Golf Course would need to be acquired for relocation of the southern ventilation outlet in this area. This would not be offset by a reduction in land acquisition at the currently proposed location for the outlet, noting that the land in that location is currently owned by Roads and Maritime and would continue as the motorway operations complex.</p>
Land use impacts	<p>Northern ventilation outlet The relocated northern ventilation outlet would occupy industrially-zoned land. Subject to appropriate site selection, loss of this industrial land is unlikely to be significant given the context of the broader industrial estate.</p> <p>Southern ventilation outlet Relocation of the southern ventilation outlet is likely to lead to potentially significant disruption of the Pennant Hills Golf Course requiring reconfiguration of facilities/ operations, and disruption during construction.</p>
Construction impacts	<p>Northern ventilation outlet Overall, relocation of the northern ventilation outlet is likely to increase construction impacts relative to the activities assessed in the environmental impact statement. This is because of the significant length of additional ventilation tunnel required to connect the project's main alignment tunnels with the relocation northern ventilation outlet.</p> <p>Southern ventilation outlet Relocation of the southern ventilation outlet is unlikely to reduce construction impacts associated with the southern interchange compound (C5) or construction of the motorway operations complex, given that the ventilation outlet is only one relatively small component of those works. In contrast, relocation of the southern ventilation outlet to the Pennant Hills Golf Course or adjacent to it is likely to spread construction impacts, and introduce new amenity impacts to users of the golf course.</p>

Engineering considerations

Relocation of the northern ventilation outlet to the Asquith Industrial Estate is likely introduce significant additional engineering challenges based on the distance of that site from the main alignment tunnels. This would include additional complexity associated with the construction of a relatively long ventilation connection to the relocated ventilation outlet, and the increased design requirements of the project's ventilation system to manage pressure losses over this distance.

Based on a preliminary review, relocation of the southern ventilation outlet into the Pennant Hills Golf Course has been identified as a potentially feasible option, with expected benefits in terms of air quality impacts. As such, a more detailed engineering assessment of this potential option has been conducted.

Conceptually, relocation of the southern ventilation outlet would potentially involve construction of the ventilation outlet within or around a small section of land owned by Roads and Maritime at the corner of the Pennant Hills Golf Course, adjacent to the Pennant Hills Road/ Hills M2 Motorway. The parcel of land is 297 m² and is located on a steep embankment, between the golf course and the Hills M2 Motorway/ Pennant Hills Road retaining walls.

The main extraction fans and main ventilation building would need to remain in their current proposed location as part of the motorway operations complex. This is because the land available is too small to house, construct or maintain the whole ventilation facility. However, the potential to construct and maintain just an exhaust structure at this location has been considered. This would require a ventilation tunnel to be constructed from the main facility, (under Pennant Hills Road) and then a shaft to be sunk at the relocated ventilation outlet site.

A constructability review of this option has identified four key issues

- Land acquisition requirements for construction.
- Land acquisition for permanent access.
- Anchors to existing retaining walls.

Land acquisition for construction

The site is on a steep embankment and bounded by an arterial road intersection on its frontage and a golf course to its rear. A significant challenge is having room to safely construct the works and the ability to safely access it, both from a temporary and permanent access perspective.

For construction equipment to operate on the site, substantial levelling would be required to create a platform for piling rigs and excavators to operate. A level platform of approximately 15 metres by 20 metres for would be required for this purpose. A platform of this size would require temporary batters to extend beyond the actual lot size into the golf course. This would require additional private land to be acquired from the golf course.

Further land would need to be acquired to enable the remainder of the construction works, notably the shaft sinking operation. The land would need to be large enough to set up and operate concrete pumps and cranes etc.

The site would be required to be serviced by light vehicles, spoil disposal trucks, and general construction delivery trucks for materials such as concrete, reinforcing, formwork and

scaffold. To allow these vehicles to enter and exit the site, access tracks would be required to be constructed. These tracks would have to be suitable for emergency access during construction and would be required to be all weather, (ie road base and seal).

The access tracks would be required to be constructed within the golf course land, due to the steepness of the site and the unsuitable level change from Pennant Hills Road. This would require further private land acquisition and removal of a significant amount of additional trees and vegetation.

It is anticipated that the option of constructing the ventilation facility from Pennant Hills Road would require substantial lane closures. The traffic volumes dictate that daytime closures would not be feasible, as the adjacent intersection would be significantly affected. Adopting road closures only at night or weekends would not provide enough access to practically construct the works within a reasonable timeframe.

Land acquisition for permanent access

In addition to the construction access issues there would need to be a permanent access arrangement for maintenance. Permanent access from Pennant Hills Road would not be feasible due to traffic volumes and topographical issues. A permanent access would likely have to be created through the golf course, similar to that for the construction access.

Anchors to existing retaining walls

It is envisaged the ventilation facility and any related retaining walls would be required to be founded on bored concrete piles. It is anticipated that the ventilation shaft, piled retaining structures and temporary excavations required would interact with the existing anchors retaining the Hills M2 Motorway vertical shotcrete walls. These anchors would require modification to accommodate the interactions, which will be very challenging given the lack of space, traffic and safety implications.

Capital and operating costs

Estimated additional capital and operating costs associated with relocating the southern and northern ventilation outlets are summarised **Table 3-11**. These costs are presented individually for relocation of the southern and northern ventilation outlets. If both ventilation outlets were to be relocated, the costs would be the total of the values presented in **Table 3-11**.

Additional capital and operating costs associated with relocation of the northern ventilation outlet to the Asquith Industrial Estate are largely the result of the significant length of ventilation tunnel that would need to be constructed and operated between the project tunnels and the relocated ventilation outlet.

Some additional capital cost is likely to be incurred with a relocation of the southern ventilation outlet to the Pennant Hills Golf Course, based on the increased engineering complexity at this location. Additional operating costs are likely to be negligible.

Table 3-11 Estimated increase in capital and operating costs for relocation of ventilation outlets

Ventilation outlet relocation	Increase in project capital cost	Increase in project operating cost
Relocation of the northern ventilation outlet to the Asquith Industrial Estate	\$450 million to \$500 million, subject to further design development	\$2 million per annum
Relocation of the southern ventilation outlet to the Pennant Hills Golf Course	\$30 million to \$35 million, subject to further design development	Negligible

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3.2.4 Scenario 3 – Addition of intermediate ventilation outlet(s)

Two variations involving the inclusion of an intermediate ventilation outlet(s) between the currently proposed locations of the northern and southern ventilation outlets:

- A ventilation outlet at around the mid point along the main alignment tunnels. The general location of a potential mid point ventilation outlet is shown in **Figure 3-7**, although more detailed consideration of siting would need to be conducted if this option were to be pursued. The mid point ventilation outlet would be the same design and operated in the same manner as the northern and southern ventilation outlets, and would receive half of the in-tunnel air it would handle from each of the main alignment tunnels. It has been assumed that fresh air would be re-introduced into the main alignment tunnels to balance the volume of in-tunnel air removed from each.
- Conversion of the currently proposed Wilson Road and Trelawney Street emergency smoke extraction facilities to also function as operational ventilation outlets. It has been assumed that both sites would be the same design and operated in the same manner as the northern and southern ventilation outlets. The Wilson Road ventilation outlet would service the southbound main alignment tunnel, while the Trelawney Street ventilation outlet would service the northbound main alignment tunnel.

Ambient air quality

Table 3-12 and **Table 3-13** summarise the outcomes of air dispersion modelling for the provision of an intermediate ventilation outlet(s). For the purpose of comparison with the assessment presented in the environmental impact statement, maximum annual average concentrations of NO₂, PM₁₀ and PM_{2.5} have been identified around each ventilation outlet location (northern ventilation outlet, southern ventilation outlet, mid point ventilation outlet, Wilson Road ventilation outlet and Trelawney Street ventilation outlet). For potential intermediate ventilation outlet locations, these maximum annual average concentrations have been identified from the air dispersion modelling presented in the environmental impact statement, taking into account the effects of the currently proposed ventilation outlets only (ie not taking into account changes in emissions along Pennant Hills Road – reductions as a result of vehicles diverting to Pennant Hills Road into the project tunnels).

Table 3-12 and **Table 3-13** show that:

- With the addition of a mid point ventilation outlet:
 - Air quality impacts around the northern and southern ventilation outlets would reduce by around 20 per cent relative to the levels predicted and assessed in the environmental impact statement.
 - Air quality impact impacts around the mid point ventilation outlet would be around 2.5 times the particulate matter levels predicted and assessed in the environmental impact statement, and around three times the predicted NO₂ levels. Although these relative increases are significant in magnitude, the maximum annual average concentrations predicted around the mid point ventilation outlet are around the same as predicted around the southern ventilation outlet and slightly less than predicted around the northern ventilation outlet.
 - All predicted impacts would remain well within applicable ambient air quality criteria and advisory reporting standards, and in most cases less than one per cent of these criteria and standards. The exception is NO₂ around the northern ventilation outlet, which would remain slightly above one per cent of the applicable criterion.

- With the conversion of the Wilson Road and Trelawney Street sites to ventilation outlets:
 - Air quality impacts around the northern and southern ventilation outlets would reduce by around 50 per cent relative to the levels predicted and assessed in the environmental impact statement.
 - Air quality impacts around the Wilson Road ventilation outlet would be slightly higher (around 10 to 30 per cent higher) than predicted for operation of the project as presented in the environmental impact statement.
 - Air quality impacts around the Trelawney Street ventilation outlet would be significantly higher (around 60 to 120 per cent higher) than predicted for operation of the project as presented in the environmental impact statement. However, in absolute terms, maximum annual average concentrations predicted around the Trelawney Street ventilation outlet would be similar to those predicted around the Wilson Road ventilation outlet.
 - Air quality impacts around all four ventilation outlets are similar in magnitude.

Table 3-12 Effect of installing a mid point ventilation outlet

Parameter	EIS design ¹	With mid point ventilation outlet
Northern ventilation outlet		
PM ₁₀ (annual average) (µg/m ³)	0.057	0.046
Percentage of criterion (30 µg/m ³)	0.19%	0.15%
PM _{2.5} (annual average) (µg/m ³)	0.054	0.044
Percentage of advisory reporting standard (8 µg/m ³)	0.68%	0.55%
NO ₂ (annual average) (µg/m ³)	0.96	0.77
Percentage of criterion (62 µg/m ³)	1.54%	1.23%
Mid point ventilation outlet		
PM ₁₀ (annual average) (µg/m ³)	0.014	0.035
Percentage of criterion (30 µg/m ³)	0.05%	0.12%
PM _{2.5} (annual average) (µg/m ³)	0.013	0.033
Percentage of advisory reporting standard (8 µg/m ³)	0.16%	0.41%
NO ₂ (annual average) (µg/m ³)	0.158	0.483
Percentage of criterion (62 µg/m ³)	0.25%	0.78%
Southern ventilation outlet		
PM ₁₀ (annual average) (µg/m ³)	0.046	0.037
Percentage of criterion (30 µg/m ³)	0.15%	0.12%
PM _{2.5} (annual average) (µg/m ³)	0.044	0.035
Percentage of advisory reporting standard (8 µg/m ³)	0.55%	0.44%
NO ₂ (annual average) (µg/m ³)	0.51	0.41
Percentage of criterion (62 µg/m ³)	0.81%	0.65%

¹ This data represent the outcomes of applying the project design in the environmental impact to the screening assessment approach, rather than a reproduction of results from the environmental impact statement.

Table 3-13 Effect of converting Wilson Road and Trelawney Street into ventilation outlets

Parameter	EIS design ¹	With Wilson Road and Trelawney Street ventilation outlets
Northern ventilation outlet		
PM ₁₀ (annual average) (µg/m ³)	0.057	0.029
Percentage of criterion (30 µg/m ³)	0.19%	0.10%
PM _{2.5} (annual average) (µg/m ³)	0.054	0.028
Percentage of advisory reporting standard (8 µg/m ³)	0.68%	0.35%
NO ₂ (annual average) (µg/m ³)	0.96	0.467
Percentage of criterion (62 µg/m ³)	1.54%	0.75%
Wilson Road ventilation outlet		
PM ₁₀ (annual average) (µg/m ³)	0.025	0.029
Percentage of criterion (30 µg/m ³)	0.08%	0.10%
PM _{2.5} (annual average) (µg/m ³)	0.023	0.028
Percentage of advisory reporting standard (8 µg/m ³)	0.29%	0.35%
NO ₂ (annual average) (µg/m ³)	0.276	0.346
Percentage of criterion (62 µg/m ³)	0.45%	0.56%
Trelawney Street ventilation outlet		
PM ₁₀ (annual average) (µg/m ³)	0.013	0.029
Percentage of criterion (30 µg/m ³)	0.04%	0.10%
PM _{2.5} (annual average) (µg/m ³)	0.013	0.027
Percentage of advisory reporting standard (8 µg/m ³)	0.16%	0.34%
NO ₂ (annual average) (µg/m ³)	0.202	0.325
Percentage of criterion (62 µg/m ³)	0.33%	0.52%
Southern ventilation outlet		
PM ₁₀ (annual average) (µg/m ³)	0.046	0.024
Percentage of criterion (30 µg/m ³)	0.15%	0.08%
PM _{2.5} (annual average) (µg/m ³)	0.044	0.023
Percentage of advisory reporting standard (8 µg/m ³)	0.55%	0.29%
NO ₂ (annual average) (µg/m ³)	0.51	0.373
Percentage of criterion (62 µg/m ³)	0.81%	0.60%

¹ This data represent the outcomes of applying the project design in the environmental impact to the screening assessment approach, rather than a reproduction of results from the environmental impact statement.

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In-tunnel air quality

Table 3-14 summarises the calculated in-tunnel concentrations of NO₂, PM₁₀ and PM_{2.5} under scenarios including installation of additional intermediate ventilation outlets. This data has been developed for direct comparison with Table 7-101 in the environmental impact statement, and is based on the same assumptions and calculation methodology (refer to **Chapter 2** of this report for further discussion of this methodology and interpretation of outputs). The table shows only in-tunnel pollutant concentrations for each main alignment tunnel in the relevant peak hour in 2019 and 2029 (ie a worst-case in-tunnel air quality scenario based on forecast traffic flows).

Table 3-14 shows that:

- With the installation of a mid point ventilation outlet, in-tunnel pollutant concentrations remain the same for the first half of the two main alignment tunnels as presented in the environmental impact statement. At the mid point, in-tunnel concentrations would drop to around half of the predictions made in the environmental impact statement, with removal of half of the in-tunnel air from each main alignment tunnel and replacement with an equivalent volume of ambient air. The in-tunnel pollutant concentration profile for the second half of each main alignment tunnel would then continue consistent with the trend in data presented in the environmental impact statement.
- With the conversion of the Wilson Road and Trelawney Street sites, in-tunnel pollutant concentrations would remain the same for the first two thirds of the two main alignment tunnels as presented in the environmental impact statement. At the two thirds point, in-tunnel concentrations would drop to zero contributions from in-tunnel air (ie in-tunnel air at this location would be entirely drawn from the ambient environment). The in-tunnel pollutant concentration profile for the last one third of each main alignment tunnel would then continue consistent with the trend in data presented in the environmental impact statement.
- Conversion of the Wilson Road and Trelawney Street sites has a greater impact on reducing peak in-tunnel concentrations of pollutants than the addition of a mid point ventilation outlet.

Human health risks

A quantified human health risk assessment has not been conducted for the provision of an intermediate ventilation outlet(s). However, it has been possible to form broad qualitative conclusions about the potential human health implications of an intermediate ventilation outlet(s) assuming that all ventilation outlets operate in a similar manner (consistent with the operation of the ventilation outlets in the environmental impact statement) and assuming a generally consistent composition and distribution of affected populations around each of the ventilation outlet locations.

Potential changes in human health risks relative to those presented in the environmental impact statement are expected to be:

- With the addition of a mid point ventilation outlet:
 - Human health risks for populations around the northern and southern ventilation outlets would be around 20 per cent lower than the risks presented in the environmental impact statement (based on predicted reductions in PM_{2.5} annual average concentrations).
 - Human health risks for the population around the mid point ventilation outlet would be similar to those around the southern ventilation outlet (around 20 cent

lower than the human health risks presented in the environmental impact statement).

- Peak adverse human health risks associated with operation of the project would be slightly reduced when considering the project as a whole. The total population likely to be affected by health risk impacts would however be increased.
- With the conversion of the Wilson Road and Trelawney Street sites to ventilation outlets:
 - Human health risks for populations around the northern and southern ventilation outlets would be around 50 per cent lower than the risks presented in the environmental impact statement (based on predicted reductions in PM_{2.5} annual average concentrations).
 - Human health risks for populations around the Wilson Road and Trelawney Street ventilation outlets would be around 50 per cent lower than the human health risks predicted for the northern and southern ventilation outlets in the environmental impact statement).
 - Peak adverse human health risks associated with operation of the project would be markedly reduced when considering the project as a whole. The total population likely to be affected by health risk impacts would however be increased.

Table 3-14 Calculated in-tunnel air quality with additional ventilation outlets – main alignment tunnels during peak hours

Black – design as presented in the EIS including updates to fuel mix and no change to ratio of NO₂ to NO_x (10%)

Red – design including a mid point ventilation outlet

Blue – design including conversion of Wilson Road and Trelawney Street sites

Pollutant concentrations (mg/m ³) (peak hour)									
Approximate distance along main alignment tunnels									
Pollutant	1 km	2 km	3 km	4 km	5 km	6 km	7 km	8 km	9 km
Southbound main alignment tunnel at 9 am (2019)									
NO ₂ *	0.044	0.111	0.140	0.162	0.186	0.210	0.232	0.282	0.422
	0.044	0.111	0.140	0.162	0.099	0.123	0.145	0.195	0.335
	0.044	0.111	0.140	0.162	0.186	0.210	0.022	0.072	0.212
PM ₁₀	0.040	0.087	0.127	0.164	0.200	0.238	0.275	0.318	0.391
	0.040	0.087	0.127	0.164	0.109	0.147	0.184	0.227	0.300
	0.040	0.087	0.127	0.164	0.200	0.238	0.037	0.080	0.153
PM _{2.5}	0.039	0.085	0.122	0.158	0.195	0.231	0.267	0.308	0.369
	0.039	0.085	0.122	0.158	0.107	0.143	0.179	0.220	0.281
	0.039	0.085	0.122	0.158	0.195	0.231	0.036	0.077	0.138
Southbound main alignment tunnel at 9 am (2029)									
NO ₂ *	0.049	0.124	0.156	0.183	0.209	0.235	0.261	0.317	0.473
	0.049	0.124	0.156	0.183	0.111	0.137	0.163	0.219	0.375
	0.049	0.124	0.156	0.183	0.209	0.235	0.026	0.082	0.238
PM ₁₀	0.051	0.109	0.156	0.203	0.249	0.296	0.343	0.397	0.472
	0.051	0.109	0.156	0.203	0.136	0.183	0.230	0.284	0.359
	0.051	0.109	0.156	0.203	0.249	0.296	0.047	0.101	0.176
PM _{2.5}	0.050	0.102	0.148	0.192	0.236	0.28	0.324	0.375	0.446
	0.050	0.102	0.148	0.192	0.129	0.173	0.217	0.268	0.339
	0.050	0.102	0.148	0.192	0.236	0.28	0.044	0.095	0.166
Northbound main alignment tunnel at 6 pm (2019)									
NO ₂ *	0.005	0.112	0.235	0.358	0.481	0.604	0.719	0.784	0.875
	0.005	0.112	0.235	0.358	0.271	0.394	0.509	0.574	0.665
	0.005	0.112	0.235	0.358	0.481	0.604	0.115	0.180	0.271
PM ₁₀	0.033	0.092	0.156	0.220	0.284	0.347	0.410	0.460	0.515
	0.033	0.092	0.156	0.220	0.158	0.221	0.284	0.334	0.389
	0.033	0.092	0.156	0.220	0.284	0.347	0.063	0.113	0.168

PM _{2.5}	0.031	0.087	0.147	0.207	0.269	0.329	0.387	0.434	0.487
	0.031	0.087	0.147	0.207	0.150	0.210	0.268	0.315	0.368
	0.031	0.087	0.147	0.207	0.269	0.329	0.058	0.105	0.158
Northbound main alignment tunnel at 6 pm (2029)									
NO ₂ *	0.005	0.123	0.258	0.393	0.529	0.664	0.790	0.861	0.963
	0.005	0.123	0.258	0.393	0.299	0.434	0.560	0.631	0.733
	0.005	0.123	0.258	0.393	0.529	0.664	0.126	0.197	0.299
PM ₁₀	0.041	0.111	0.186	0.261	0.337	0.412	0.484	0.543	0.610
	0.041	0.111	0.186	0.261	0.188	0.263	0.335	0.394	0.461
	0.041	0.111	0.186	0.261	0.337	0.412	0.072	0.131	0.198
PM _{2.5}	0.039	0.104	0.176	0.247	0.318	0.389	0.457	0.518	0.576
	0.039	0.104	0.176	0.247	0.177	0.248	0.316	0.377	0.435
	0.039	0.104	0.176	0.247	0.318	0.389	0.068	0.129	0.187

*Note: NO₂ has been assumed to be 10% of total nitrogen oxides, consistent with PIARC (2012)

Other environmental and land use impacts

Relevant environmental and land use impacts (other than air quality and human health risks) for potential increases in ventilation outlet height are presented in **Table 3-15**.

Table 3-15 Assessment of other environmental and land use impacts – provision of intermediate ventilation outlets

Environmental and land use impacts	Assessment
Visual amenity impacts	<p>Mid point ventilation outlet</p> <p>As an exact site for a potential mid point ventilation outlet has not been identified at this time, a visual envelope map has not been produced. However, potential visual impacts on the area surrounding the site are likely to be similar in extent to those considered for the Wilson Road and Trelawney Street ventilation outlets (refer below).</p> <p>With respect to near field visual impacts, the installation of a mid point ventilation outlet is likely to introduce additional impacts over and above those presented in the environmental impact statement. This is due to the location of an additional ventilation outlet in an urban residential context.</p> <p>Wilson Road and Trelawney Street ventilation outlets</p> <p>Figure 3-8 and Figure 3-9 show the visual envelope maps for potential increased heights (addition of ventilation outlets) at the Wilson Road and Trelawney Street sites, respectively.</p> <p>With respect to the Wilson Road ventilation outlet, Figure 3-8 shows a moderate increase in potential visual impacts relative to the visual envelope map provided as Figure 7-53 of the environmental impact statement. It shows that the addition of a 15 metre high ventilation outlet to the five metre Wilson Road facility extends some of the potential near field (less than 500 metre) impacts, with a distinct increase in potentially affected receivers between 500 metres and 1,000 metres to the north east of the site. For consideration in the context of the ventilation outlet height increases discussed under Scenario 1 above, Figure 3-8 also shows the potential extent of visual impacts for a 17 metre, 20 metre, 25 metre and 30 metre ventilation outlet in this location. Key areas of increased impacts at these higher ventilation outlet configurations include areas to the west of the site (500 metres to 1,000 metres) and relatively limited areas to the east (also at 500 metres to 1,000 metres).</p>

	<p>For the Trelawney Street ventilation outlet, Figure 3-9 shows a significant increase in areas potentially visually affected by the Trelawney Street with the addition of a 15 metre ventilation outlet. Compared with Figure 7-56 of the environmental impact statement, the additional of a ventilation outlet extends potential visual impacts over a significant area to the west of the site. Figure 3-9 also shows the potential extent of visual impacts for higher ventilation outlets on the Trelawney Street site. It shows relatively small increases in affected areas over and above the potential impacts of a 15 metre ventilation outlet.</p>
Noise and vibration impacts	<p>Mid point ventilation outlet Based on the operational noise assessment presented in the environmental impact statement for the northern and southern ventilation outlets, it is expected that a ventilation outlet at a mid point location could be designed to achieve acceptable noise outcomes (as derived in accordance with the NSW Industrial Noise Policy (EPA, 2000)). However, further consideration may need to be given to the noise performance of an additional air intake at this location, noting that this has not been previously considered as part of the project (because continuous air intakes are not required with the current project design).</p> <p>Wilson Road and Trelawney Street ventilation outlets Based on the operational noise assessment presented in the environmental impact statement for the northern and southern ventilation outlets, it is expected that ventilation outlets at Wilson Road and Trelawney Street could be designed to achieve acceptable noise outcomes (as derived in accordance with the NSW Industrial Noise Policy (EPA, 2000)). However, further consideration may need to be given to the noise performance of the additional continuous air intakes at these locations, noting that these have not been previously considered as part of the project (because continuous air intakes are not required with the current project design).</p>
Land acquisition	<p>Mid point ventilation outlet Significant additional land acquisition, over and above the requirements of the currently proposed project, are likely to be required for a mid point ventilation outlet. Land acquisition would be required for the ventilation outlet as well as air intake infrastructure, which together is expected to require a larger area than the current northern and southern ventilation outlet footprints.</p> <p>Wilson Road and Trelawney Street ventilation outlets Additional land acquisition may be required at the Wilson Road and Trelawney Street sites to accommodate the inclusion of a ventilation outlet in each of these locations. It has been assumed that infrastructure to allow for air intake at these sites would be similar to the currently proposed emergency smoke extraction facilities on these sites.</p>
Land use impacts	<p>Mid point ventilation outlet Introduction of a mid point ventilation outlet is likely to generate additional land use impacts, noting that most of the land around the mid point of the main alignment tunnels is currently zoned for and developed as urban residential development.</p>

	<p>Wilson Road and Trelawney Street ventilation outlets</p> <p>The potential for additional land use impacts at the Wilson Road and Trelawney Street site beyond those identified and assessed in the environmental impact statement is limited. There may be marginal increases in these impacts if additional land acquisition is required at these locations.</p>
Construction impacts	<p>Mid point ventilation outlet</p> <p>Construction of a mid point ventilation outlet would introduce new construction impacts at a site previously not identified for disturbance in the environmental impact statement. The extent of potential construction impacts would depend on whether this site is also used for tunnel support activities. Notwithstanding, the addition of construction impacts a new site within a residential context is likely to be a significant increase above the impacts already assessed in the environmental impact statement.</p> <p>Wilson Road and Trelawney Street ventilation outlets</p> <p>There is likely to be only a marginal increase in construction impacts at the Wilson Road and Trelawney Street sites if ventilation outlets were to be constructed at these locations. This is based on the two sites already being proposed as major construction sites and tunnelling support sites.</p>

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