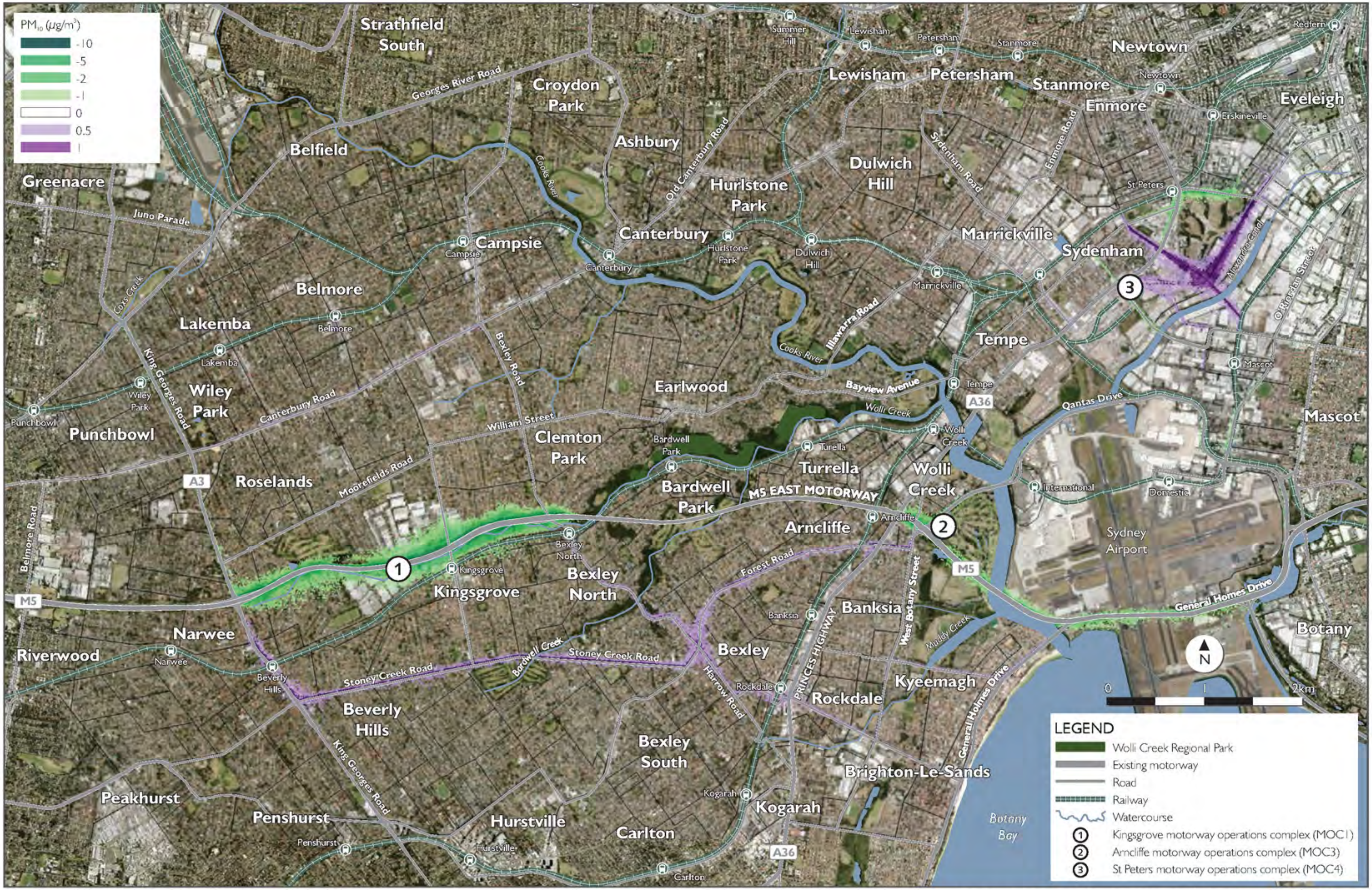

Figure 10-41 Contour plot showing change in annual mean PM_{10} with the project (2021-DS)

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Contour plots for ventilation outlets only

The annual mean PM_{10} concentrations near the New M5 Kingsgrove, Arncliffe and St Peters interchange ventilation outlets only in 2021 are shown in **Figure 10-42**, **Figure 10-43** and **Figure 10-44**.

Contribution of project ventilation outlets to annual mean PM_{10} across the grid is given in **Table 10-28**. The maximum value of 0.3 µg/m^3 (St Peters interchange, 2031 'do something (cumulative)') is two orders of magnitude lower than the criterion for annual mean PM_{10} of 30 µg/m^3.

Table 10-28 Contribution of project ventilation outlets to annual mean PM_{10} concentration in 2 km x 2 km grid around outlet

Ventilation outlet	Outlet contribution to annual mean PM_{10} (µg/m^3)		
	2021-DS	2031-DS	2031-DSC
Kingsgrove	0.02 – 0.05	0.02 – 0.06	0.03 – 0.09
Arncliffe	0.02 – 0.04	0.02 – 0.04	0.05 – 0.10
St Peters Interchange	0.02 – 0.09	0.01 – 0.09	0.05 – 0.30

For each ventilation outlet, the range of annual mean PM_{10} concentrations for each ventilation outlet PM_{10} (maximum 24-hour mean)

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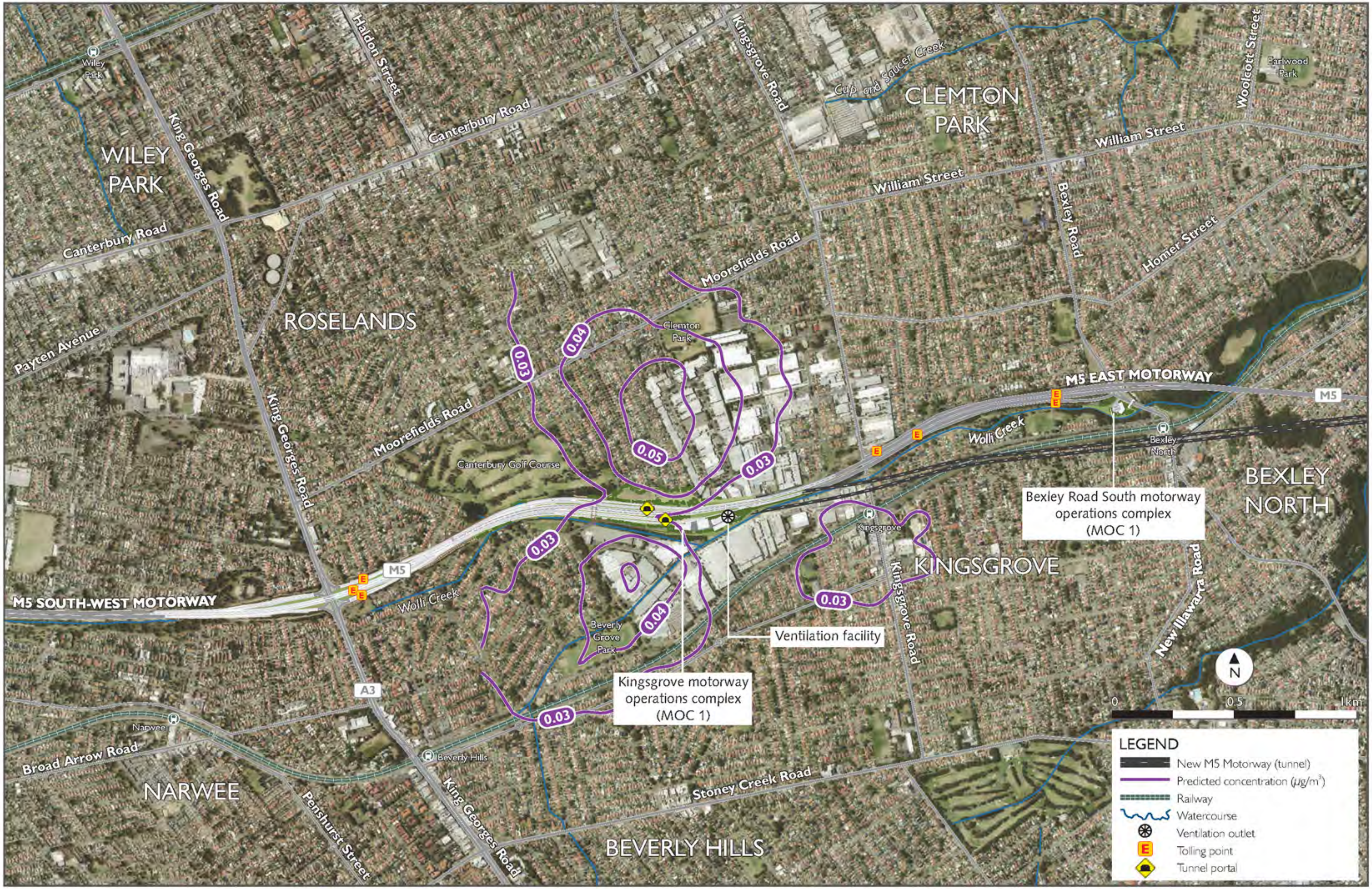

Figure 10-42 Contour plot showing annual mean PM_{10} for ventilation outlets only (Kingsgrove outlet, 2021-DS)

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Figure 10-43 Contour plot showing annual mean PM_{10} for ventilation outlets only (Arncliffe outlet 2021-DS)

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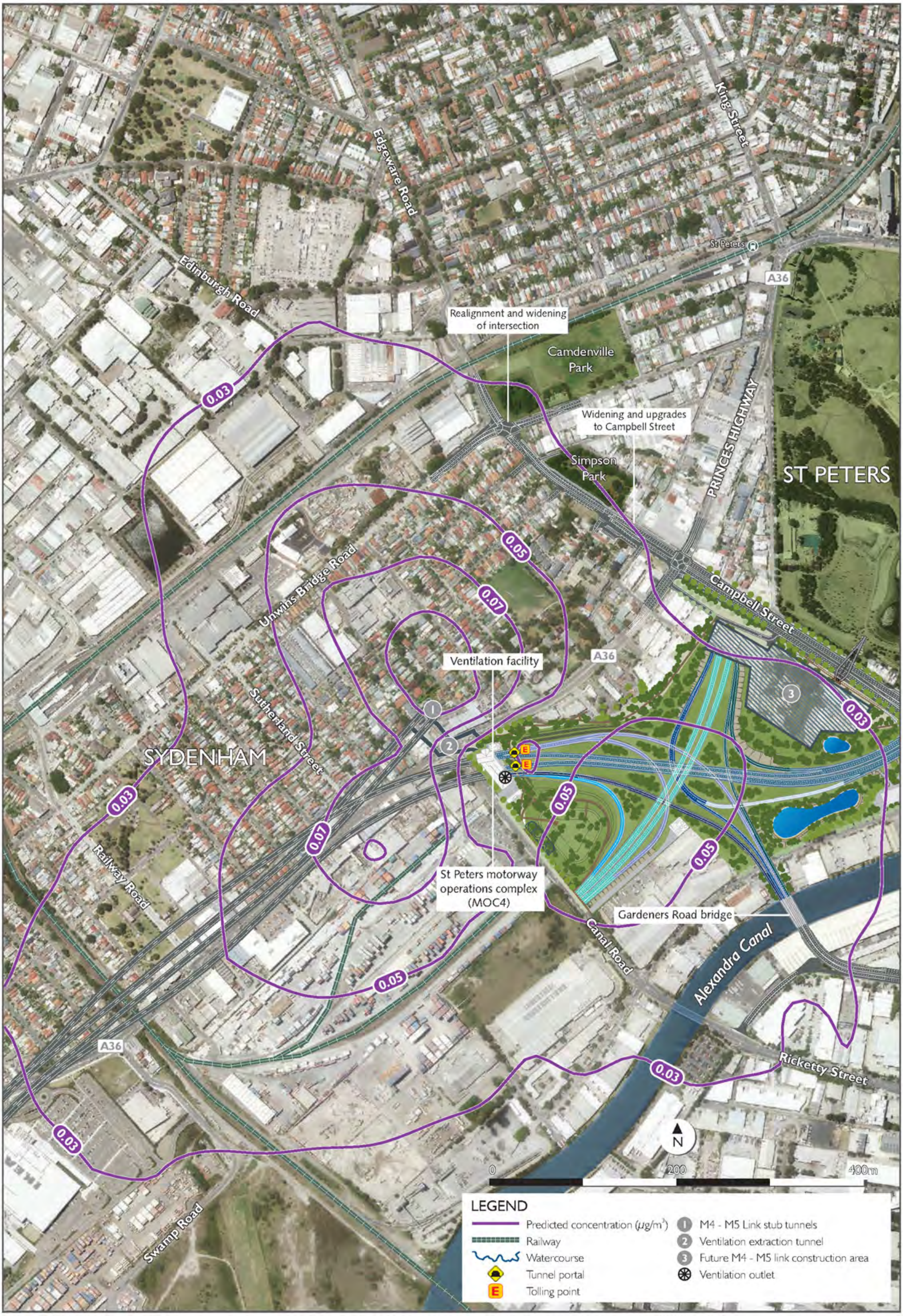

Figure 10-44 Contour plot showing annual mean PM_{10} for ventilation outlets only (SPI outlet, 2021-DS)

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Results for community receivers

The maximum 24-hour mean PM_{10} concentrations at the 35 community receivers in the 'do something' scenario in 2021 and 2031 are shown in **Figure 10-45**. At all receiver locations the maximum PM_{10} concentration was below the NSW impact assessment criterion of 50 µg/m^3, which is also the most stringent standard internationally. At all but one of the receivers, the maximum total 24-hour PM_{10} concentration occurred on one day of the year (10 February), and coincided with the highest 24-hour PM_{10} background concentration in the synthetic PM_{10} profile (44.5 µg/m^3). This provided support for the use of a maximum or high percentile value as the background for the RWR receivers across the New M5 GRAL domain.

The surface road contribution to the maximum 24-hour PM_{10} concentration at each receiver was small (generally less than 2 µg/m^3), as shown in **Figure 10-46**. The tunnel ventilation outlet contributions to 24-hour PM_{10} at community receivers were negligible (mostly less than 0.1 µg/m^3).

Figure 10-47 shows the changes in concentration in the 'do something' scenarios relative to the 'do minimum' scenarios for the community receivers. The changes were generally small (<1 µg/m^3).

Results for residential, workplace and recreational (RWR) receivers

The ranked maximum 24-hour mean PM_{10} concentrations at the RWR receivers in the 2021 'do something' scenario are shown in **Figure 10-48**. The results for the RWR receivers were highly dependent on assumption for the background air quality. The concentration at the majority of receivers was below the NSW impact assessment criterion of 50 µg/m^3. The proportion of receivers with a concentration above the criterion decreased slightly as a result of the project, from 2.6 per cent in the 2021 'do minimum' scenario to 2.1 per cent in the 2021 'do something' scenario. The contributions of surface roads and ventilation outlets were not significant. The maximum contribution of tunnel ventilation outlets at any receiver was 0.5 µg/m^3 in 2021 and 1.8 µg/m^3 in 2031.

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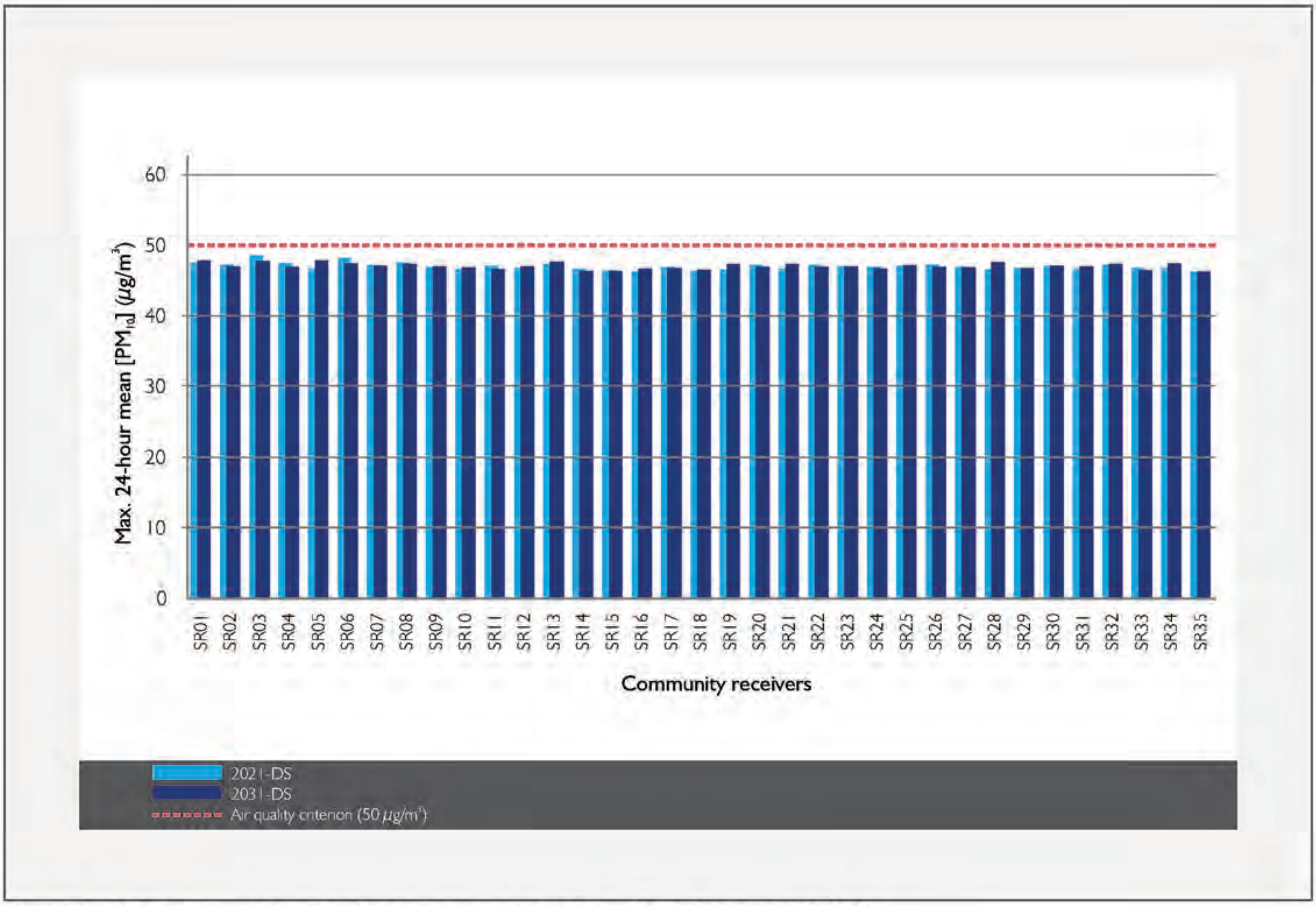

Figure 10-45 Maximum 24-hour PM_{10} at community receivers (2021-DS and 2031-DS)

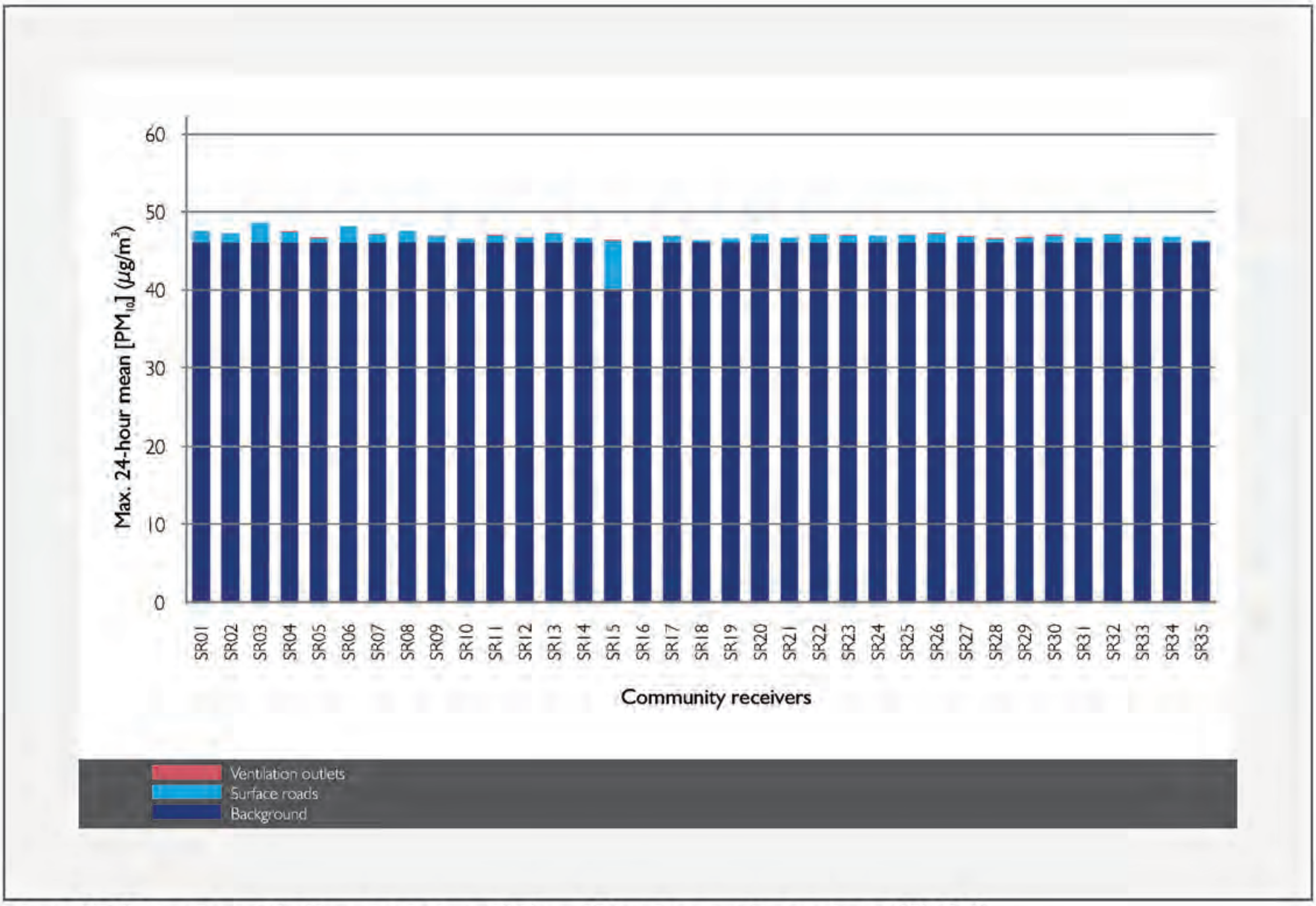

Figure 10-46 Source contributions to maximum 24-hour PM_{10} at community receivers (2021-DS)

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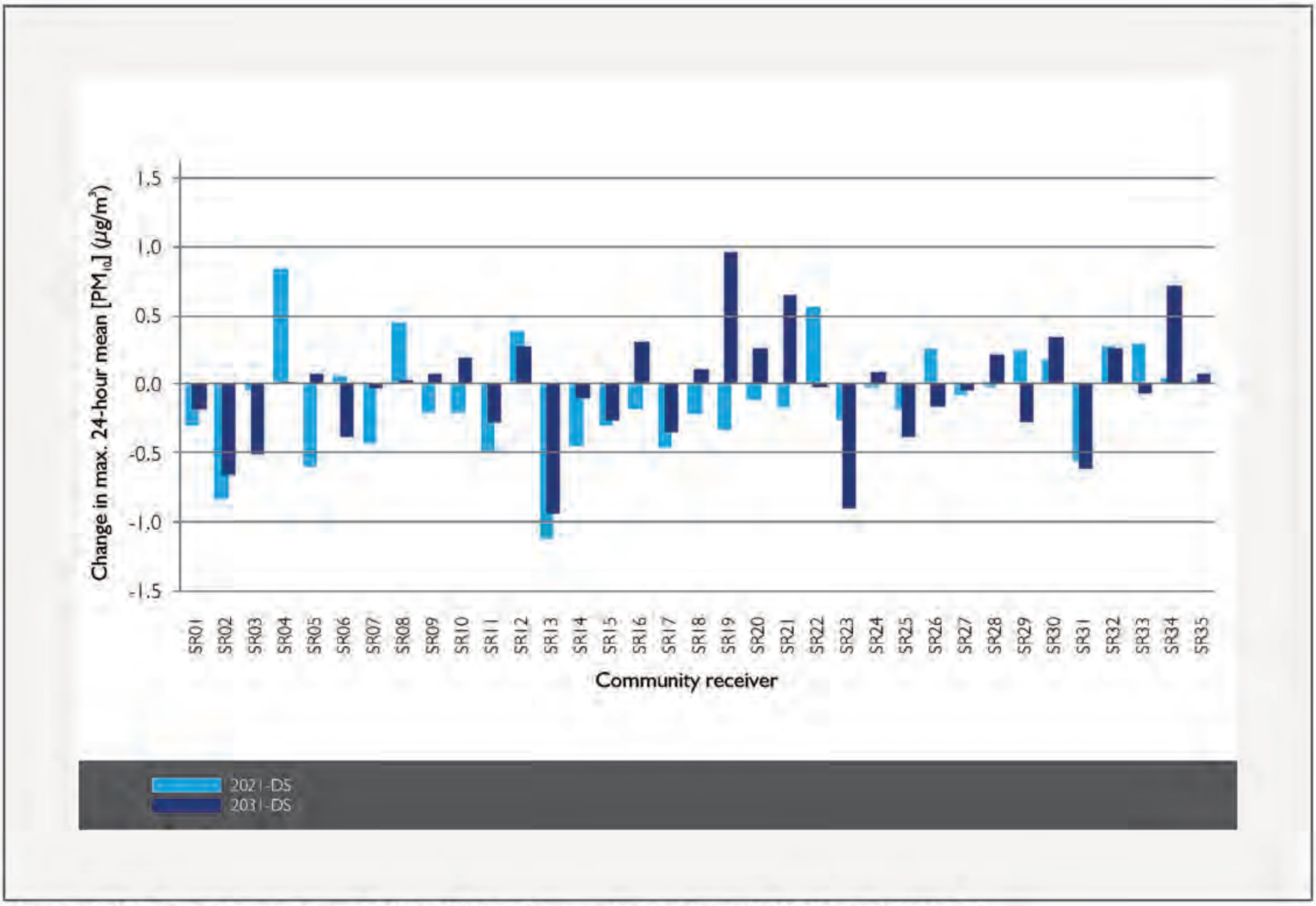

Figure 10-47 Change in maximum 24-hour PM_{10} at community receivers (2021-DS and 2031-DS)

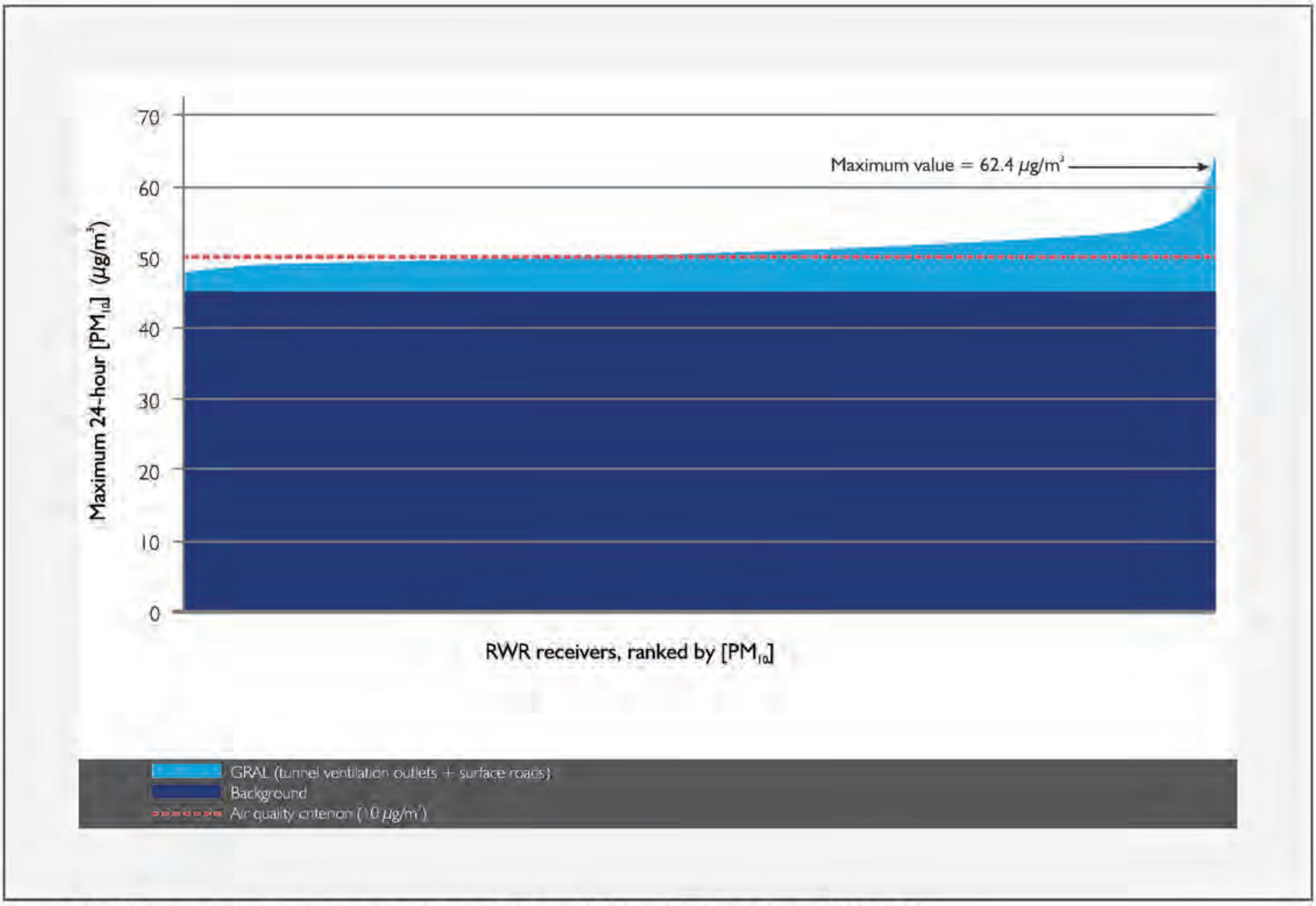

Figure 10-48 Source contributions to maximum 24-hour PM_{10} at RWR receivers (2021-DS)

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Figure 10-49 shows the changes in the maximum 24-hour mean PM10 concentration with the project in 2021, ranked by change in concentration. There was an increase in maximum 24-hour mean PM10 concentration at 54 per cent of the receivers. The largest predicted increase in concentration at any receiver as a result of the project in 2021 was 6.8 µg/m3 and the largest predicted decrease was 18.3 µg/m3. At 2.4 percent of receivers, there was an increase in maximum 24-hour PM10 concentration greater than 2 µg/m3.

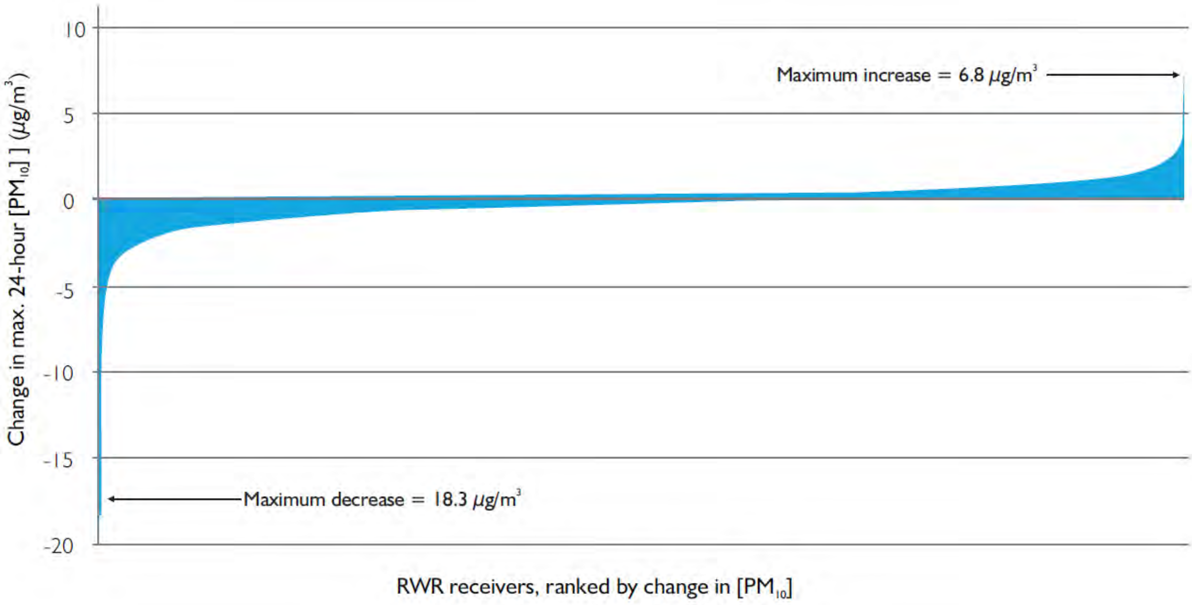

Figure 10-49 Changes in maximum 24-hour PM_{10} at RWR receivers (2021-DS)

Contour plots

The contour plots for maximum 24-hour average PM10 in 2021 under the 'do minimum' and 'do something' scenarios are shown in **Figure 10-50** and **Figure 10-51**. The change in maximum 24-hour average PM10 in 2021 with the project is shown in **Figure 10-52**.

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Figure 10-50 Contour plot showing maximum 24-hour average PM_{10} without the project (2021-DM)

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Figure 10-51 Contour plot showing maximum 24-hour average PM_{10} with the project (2021-DS)

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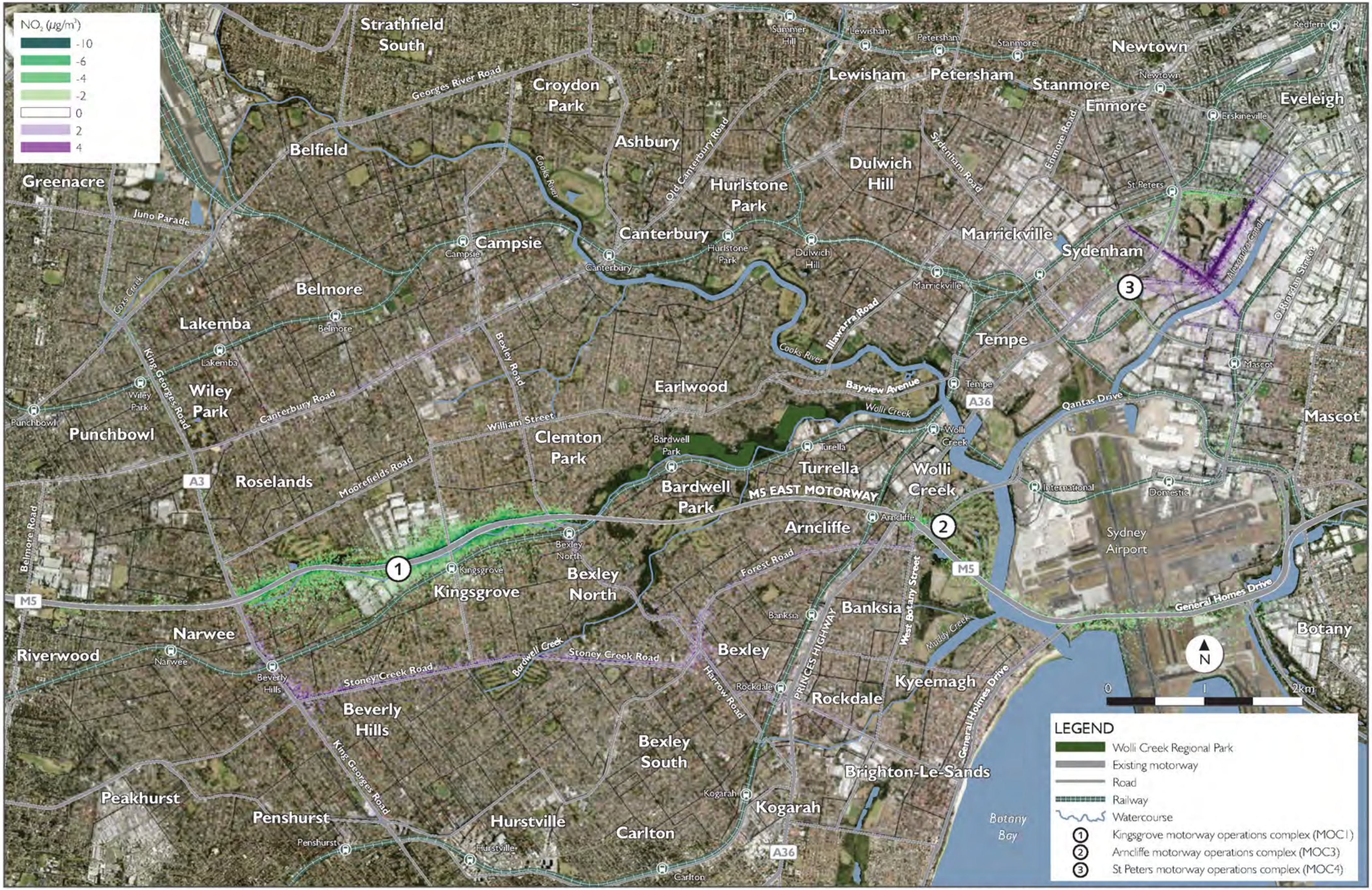

Figure 10-52 Contour plot showing change in maximum 24-hour PM$_{10}$ with the project (2021-DS)

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Contour plots for ventilation outlets only

The contour plots for annual mean PM_{10} concentrations near the New M5 ventilation outlets at Kingsgrove, Arncliffe and St Peters interchange only are shown in **Figure 10-53**, **Figure 10-54** and **Figure 10-55** respectively.

For each ventilation outlet, the range of maximum 24-hour PM_{10} concentrations across the grid is provided in **Table 10-29**. The maximum value of 1.5 µg/m^3 (St Peters interchange, 2031 'do something (cumulative)') is much lower than the 50 µg/m^{3}criterion for 24-hour PM_{10}.

Table 10-29 Contribution of project ventilation outlets to maximum 24-hour PM_{10} concentration

Ventilation outlet	Outlet contribution to max. 24-hour PM_{10} (µg/m^3)		
	2021-DS	2031-DS	2031-DSC
Kingsgrove	0.10 – 0.30	0.10 – 0.30	0.10 – 0.40
Arncliffe	0.06 – 0.16	0.06 – 0.17	0.20 – 0.40
St Peters interchange	0.10 – 0.40	0.10 – 0.45	0.30 – 1.50

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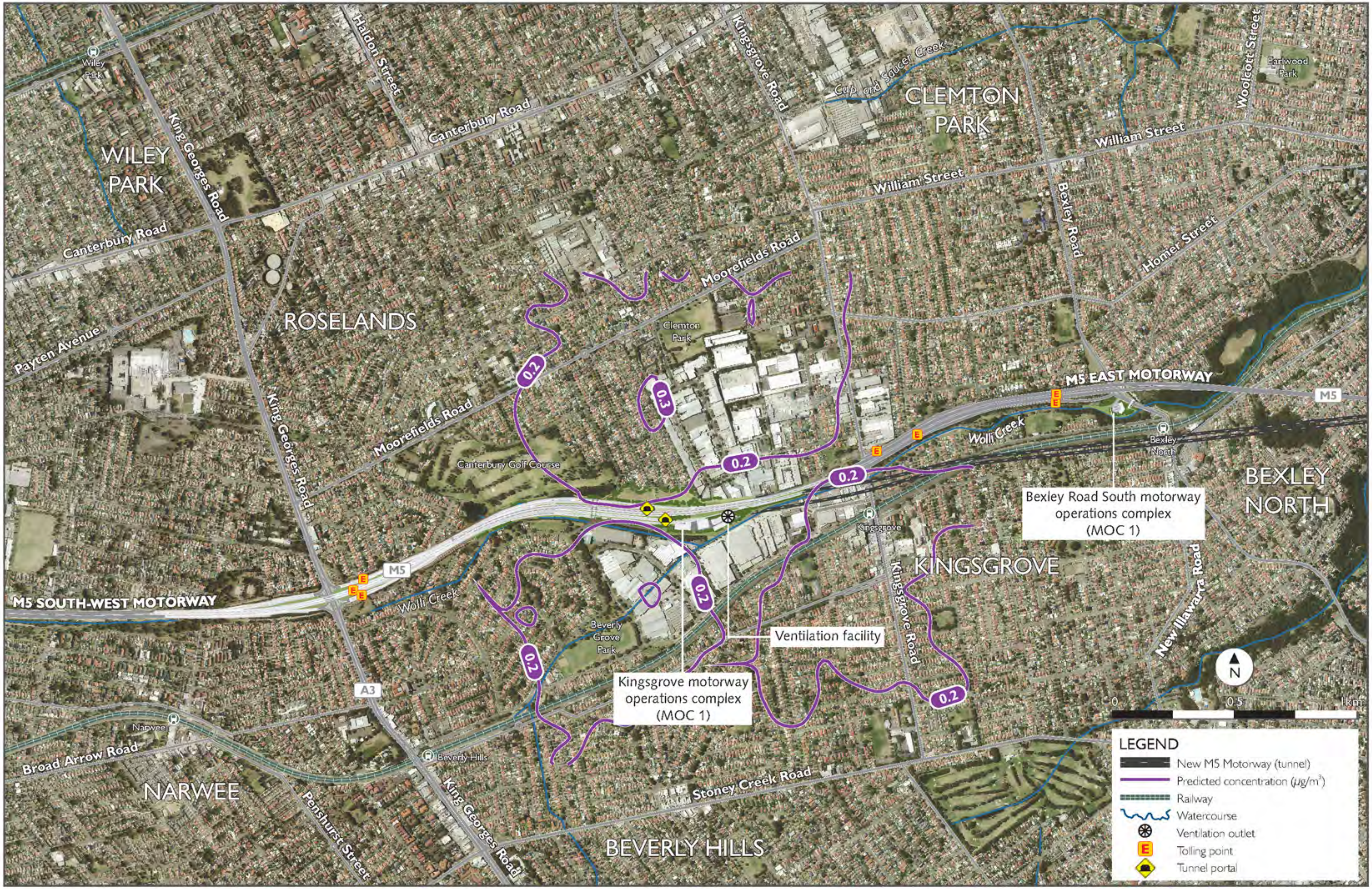

Figure 10-53 Contour plot showing maximum 24-hour PM_{10} for ventilation outlets only (Kingsgrove outlet, 2021-DS)

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Figure 10-54 Contour plot showing annual maximum 24-hour PM_{10} for ventilation outlets only (Arncliffe outlet 2021-DS)

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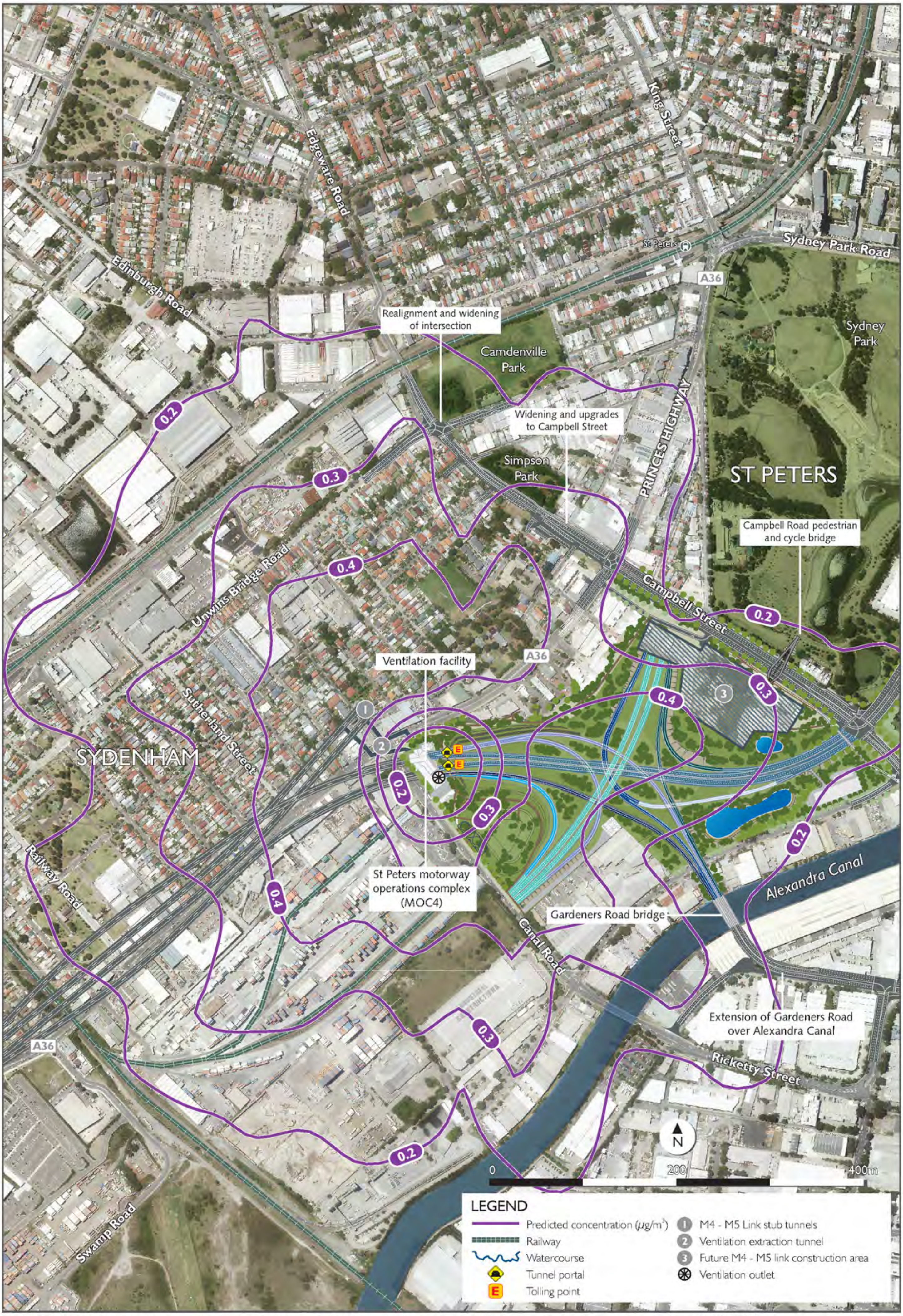

Figure 10-55 Contour plot showing maximum 24-hour PM_{10} for ventilation outlets only (SPI outlet, 2021-DS)

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10.8.6 $PM_{2.5}$ (annual mean)

Results for community receivers

The annual mean PM2.5 concentrations at the 35 community receivers in the 2021 and 2031 'do something' scenarios are presented in **Figure 10-56**. The results are based on an assumed background concentration of 8 µg/m3 (the AAQ NEPM advisory reporting standard) and therefore shows exceedances at all receivers. There would also be exceedances of the proposed NSW target of 7 µg/m3.

Figure 10-57 shows that the modelled annual mean of $PM_{2.5}$ concentrations were dominated by the background contribution in 2021. The surface road contribution was between 0.6 µg/m^3 and 2.1 µg/m^3. The largest contribution from tunnel ventilation outlets was 0.06 µg/m^3.

Figure 10-58 shows the changes in PM2.5 concentration in the 'do something' scenarios relative to the 'do minimum' scenarios for the community receivers in 2021 and 2031. The changes in concentration with the project were generally less than ±0.2 µg/m3. At receiver SR06 (Regina Coeli Catholic Primary School) an increase in concentration of around 0.5 µg/m3 was predicted in 2021, but the increase in 2031 was much smaller. An increase of just below 0.4 µg/m3 was predicted in 2031 for receiver SR04 (Beverly Hills Girls High School). These increases represented less than 6% of the air quality criterion for annual mean PM2.5.

Results for residential, workplace and recreational (RWR) receivers

The ranked annual mean PM2.5 concentrations at the 46,219 RWR receivers in the 2021 'do something' scenario are shown in

Figure 10-59, including the contributions of surface roads and ventilation outlets. As the background concentration was taken to be the same as the NSW criterion of 8 µg/m3, the concentration at all receivers was above this value. The highest concentration at any receiver in this scenario was 12.7 µg/m3. However, as with the other pollutants and metrics, the highest values were only predicted for a small proportion of receivers. In 2021, the surface road contribution was between 0.4 µg/m3 and 4.7 µg/m3. The largest contribution from tunnel ventilation outlets in both 2021 and 2031 was 0.08 µg/m3.

The change in the annual mean PM2.5 concentration at the RWR receivers in the 2021-do something scenario are ranked in **Figure 10-60**. The pattern here was similar to that for annual mean PM10.

There was an increase in concentration at 63 per cent of the receivers. The largest predicted increase in concentration at any receiver as a result of the project in 2021 was 1.2 µg/m3, and the largest predicted decrease was 3.5 µg/m3. Only 0.04 per cent of receivers would experience an increase greater than 0.5 µg/m3.

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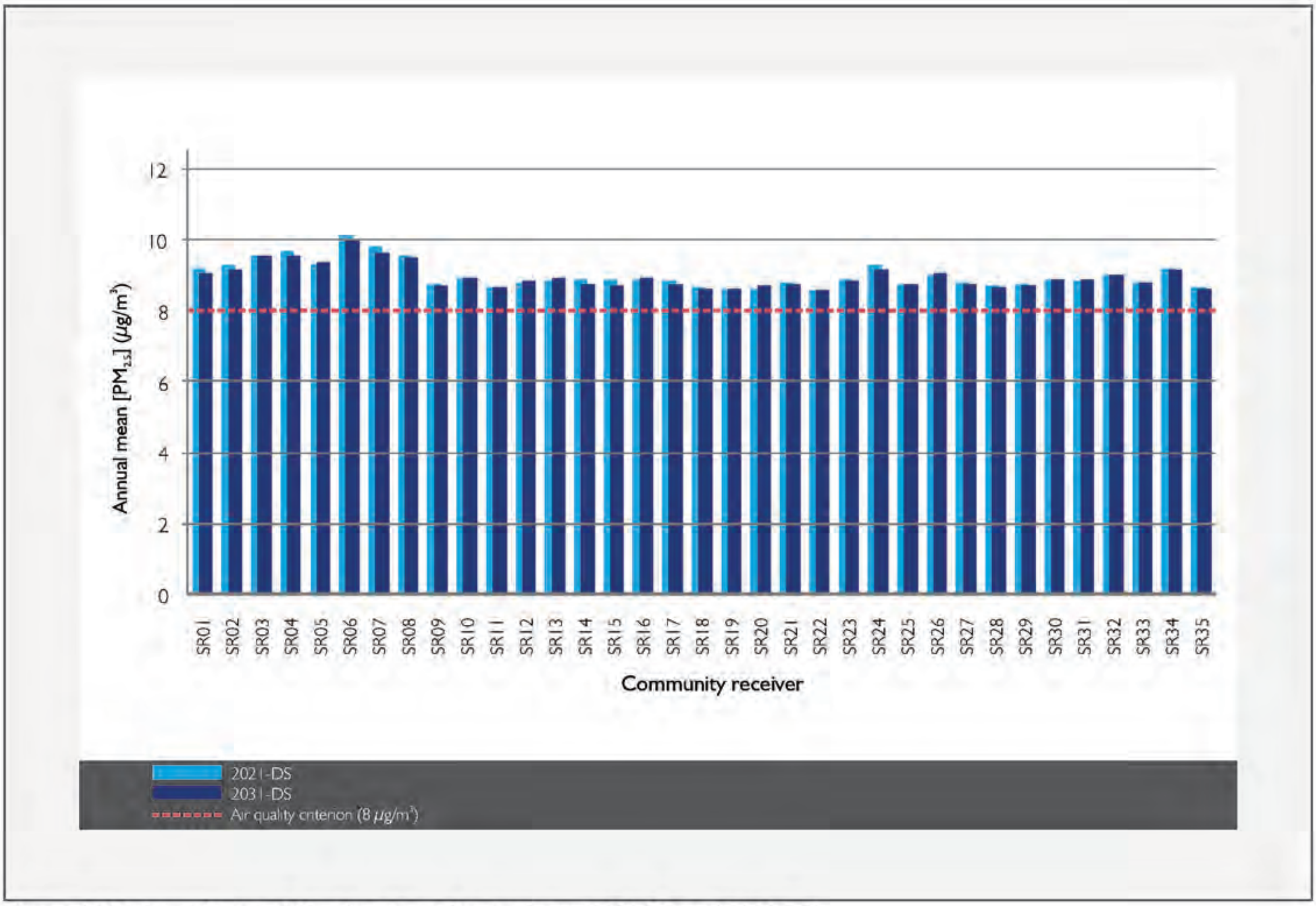

Figure 10-56 Annual mean $PM_{2.5}$ at community receivers (2021-DS and 2031-DS)

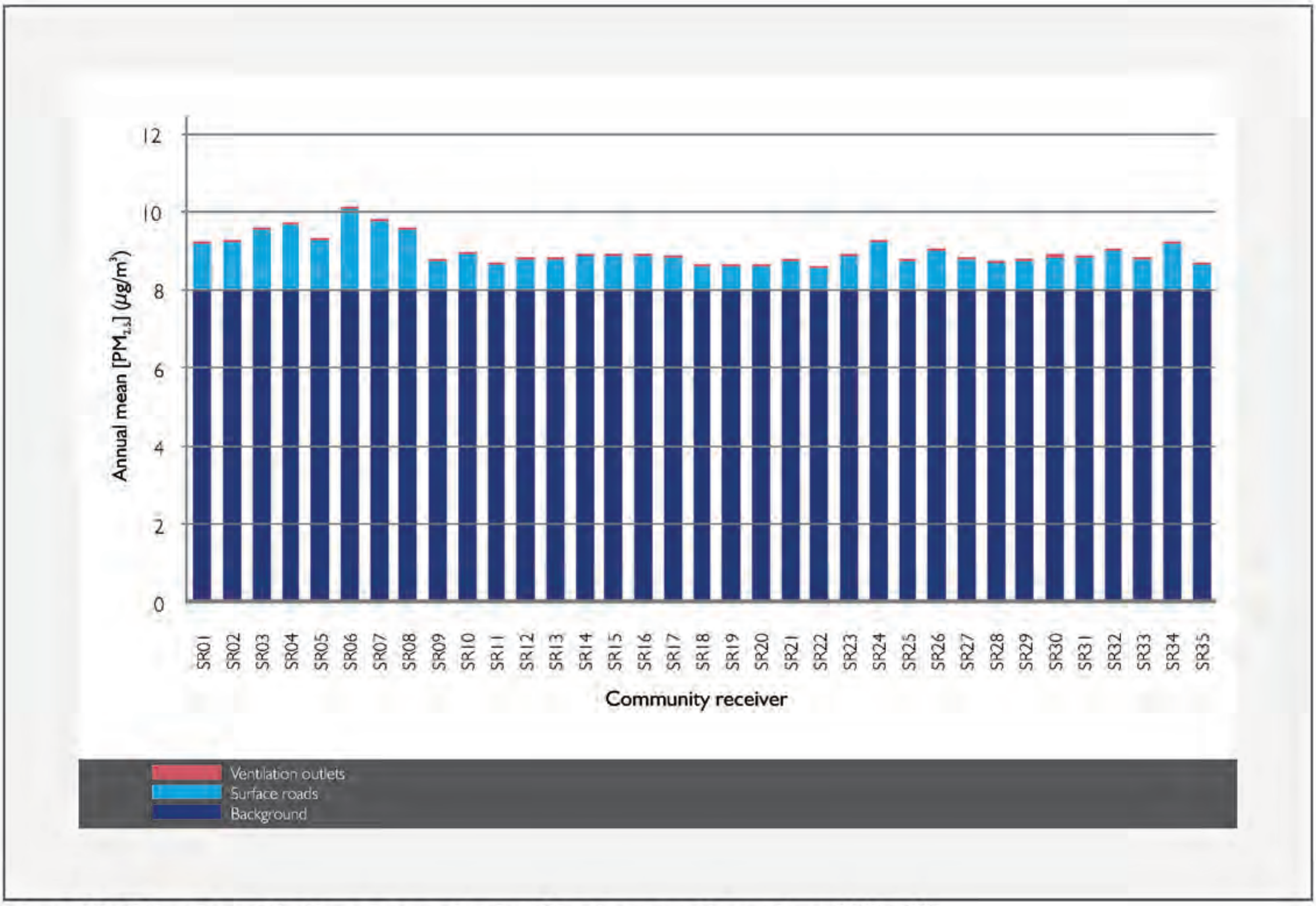

Figure 10-57 Source contributions to annual mean $PM_{2.5}$ at community receivers (2021-DS)

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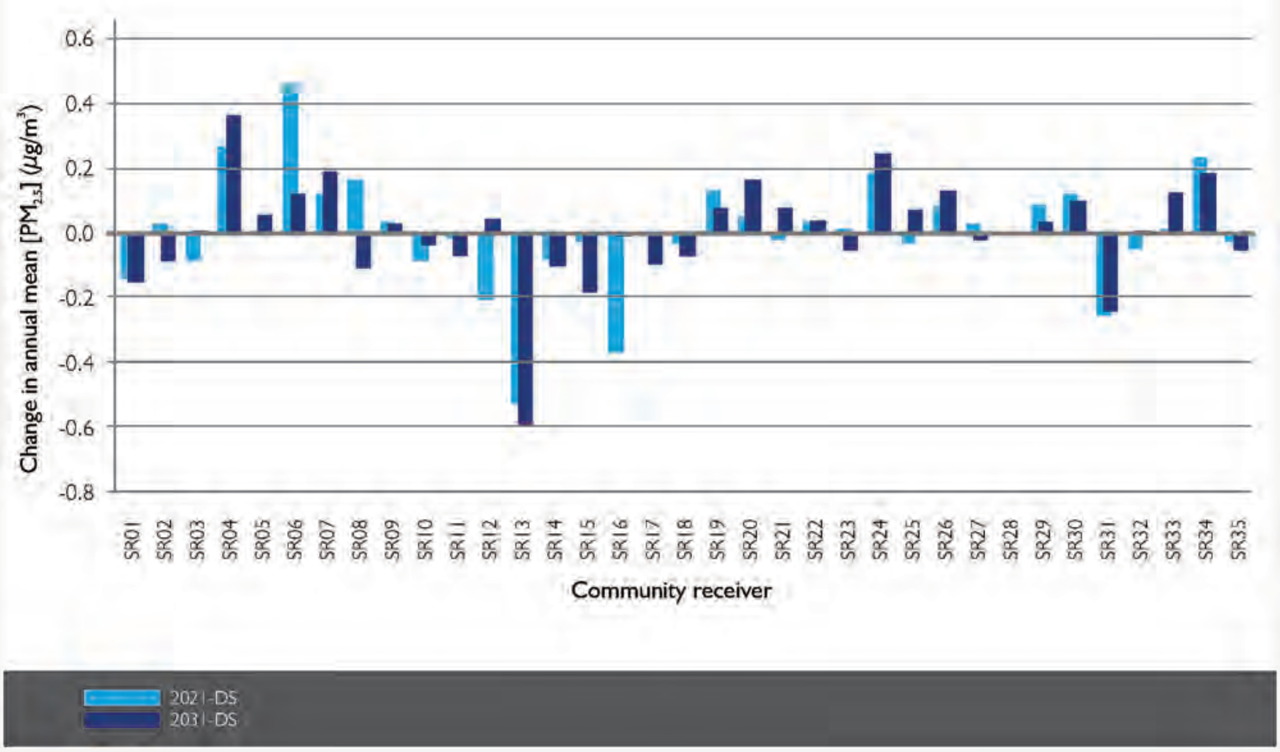

Figure 10-58 Change in annual mean $PM_{2.5}$ at community receivers (2021-DS and 2031-DS)

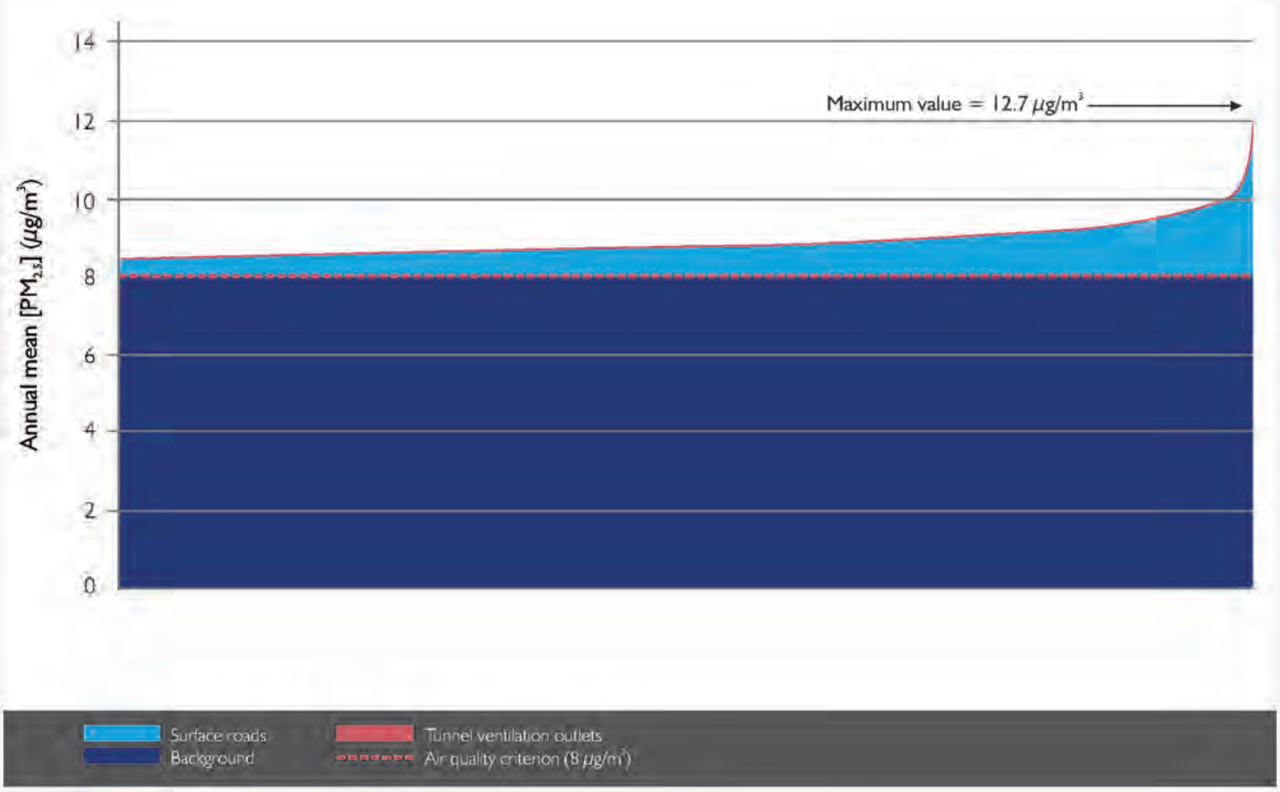

Figure 10-59 Source contributions to annual mean $PM_{2.5}$ at RWR receivers (2021-DS)

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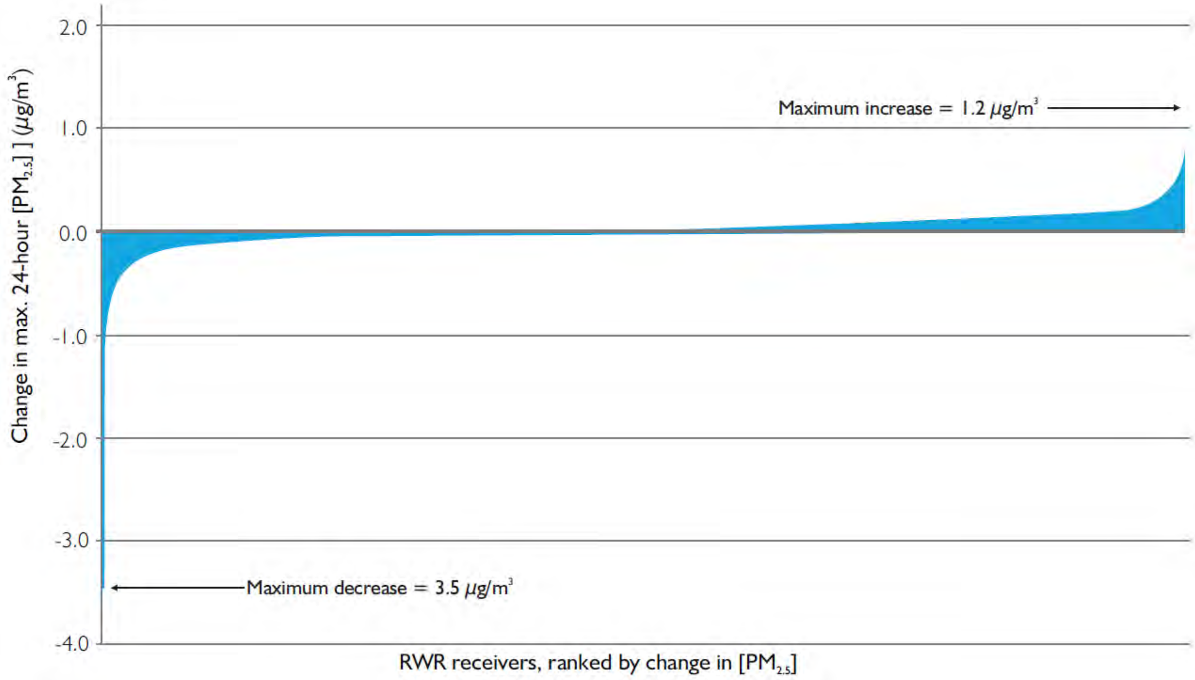

Figure 10-60 Changes in annual mean $PM_{2.5}$ at RWR receivers (2021-DS)

Contour plots – all sources

The contour plots for absolute annual mean $PM_{2.5}$ in 2021 under the 'do minimum' and 'do something' scenarios are presented in **Figure 10-61** and **Figure 10-62** respectively. The contour plot for the change in concentration with the project in 2021 is shown in **Figure 10-63**.

Contour plots for ventilation outlets only

The contour plots for annual mean $PM_{2.5}$ concentrations for the New M5 ventilation outlets only at Kingsgrove, Arncliffe and St Peters are shown in **Figure 10-64**, **Figure 10-65** and **Figure 10-66** respectively.

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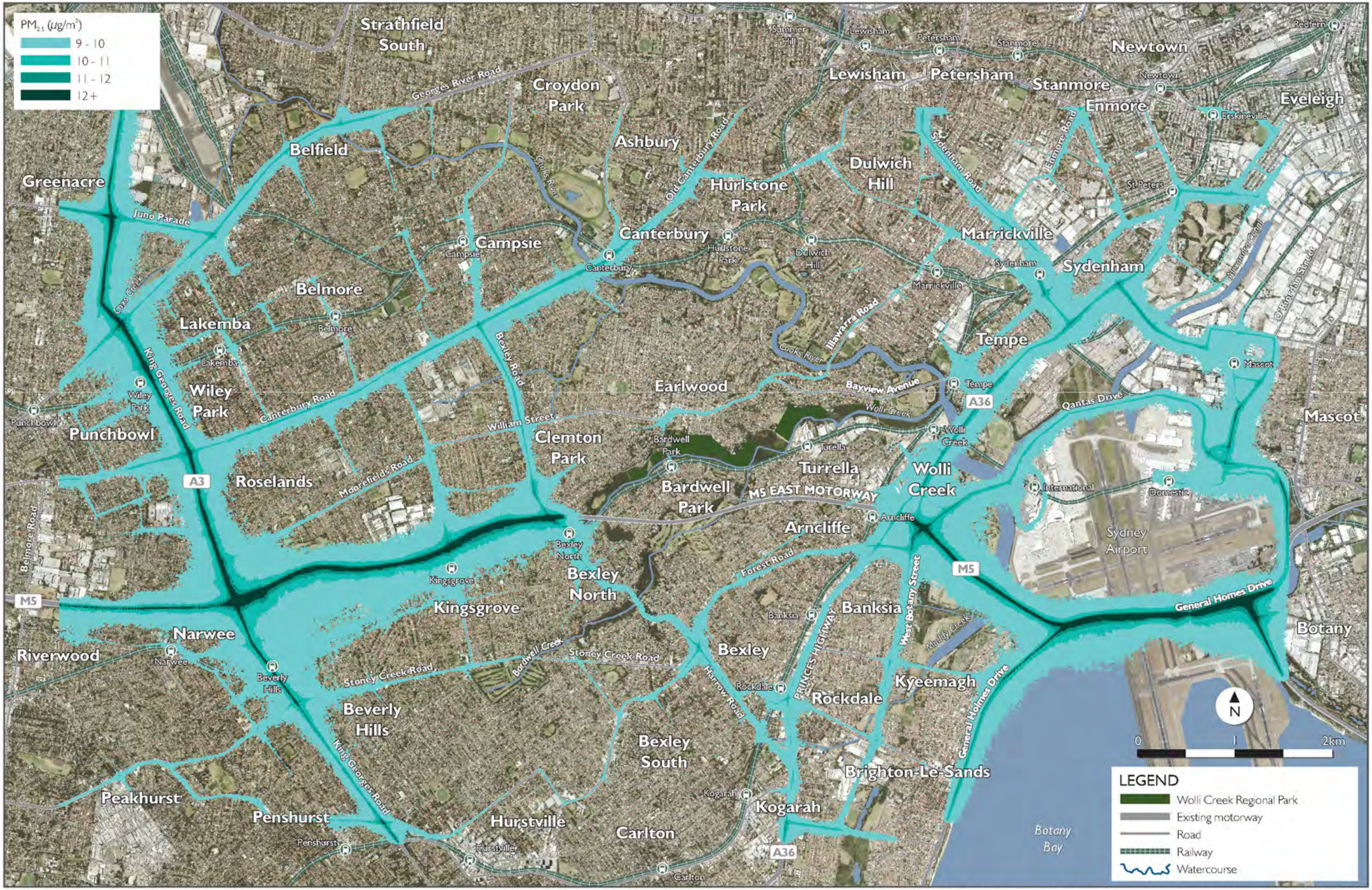

Figure 10-61 Contour plot showing annual mean $PM_{2.5}$ without the project (2021-DM)

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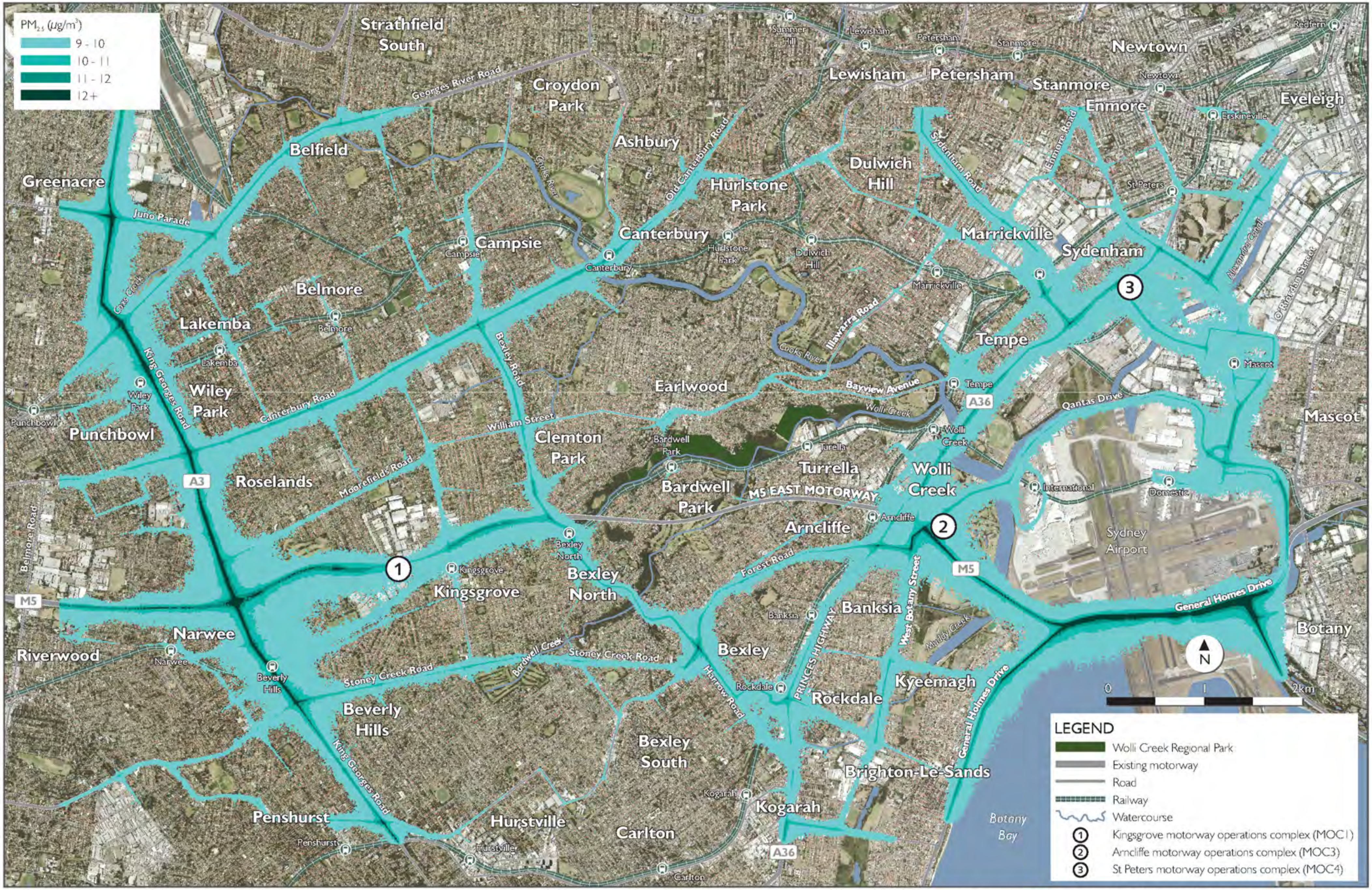

Figure 10-62 Contour plot showing annual mean $PM_{2.5}$ with the project (2021-DM)

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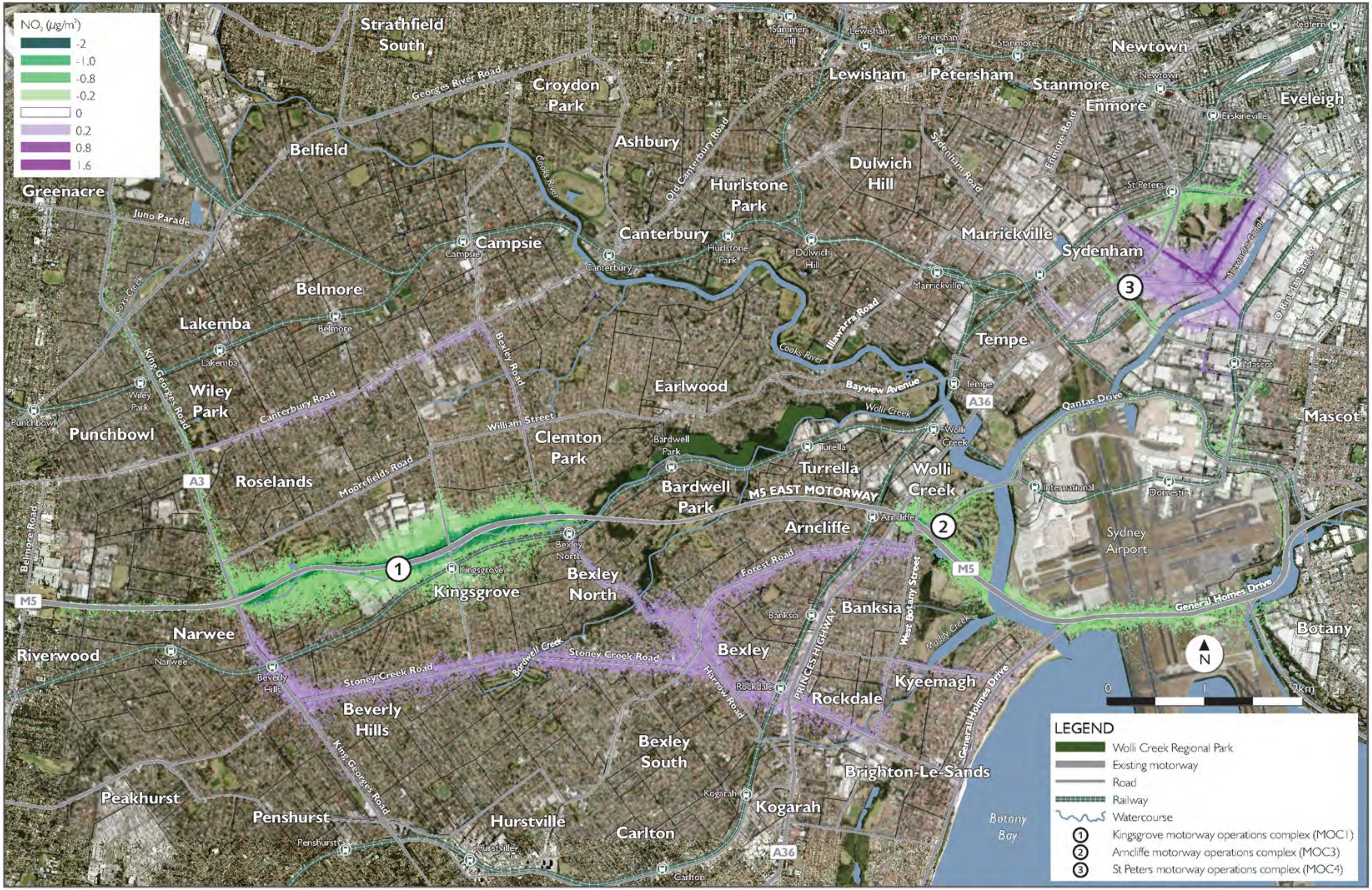

Figure 10-63 Contour plot showing change in annual mean $PM_{2.5}$ with the project (2021-DS)

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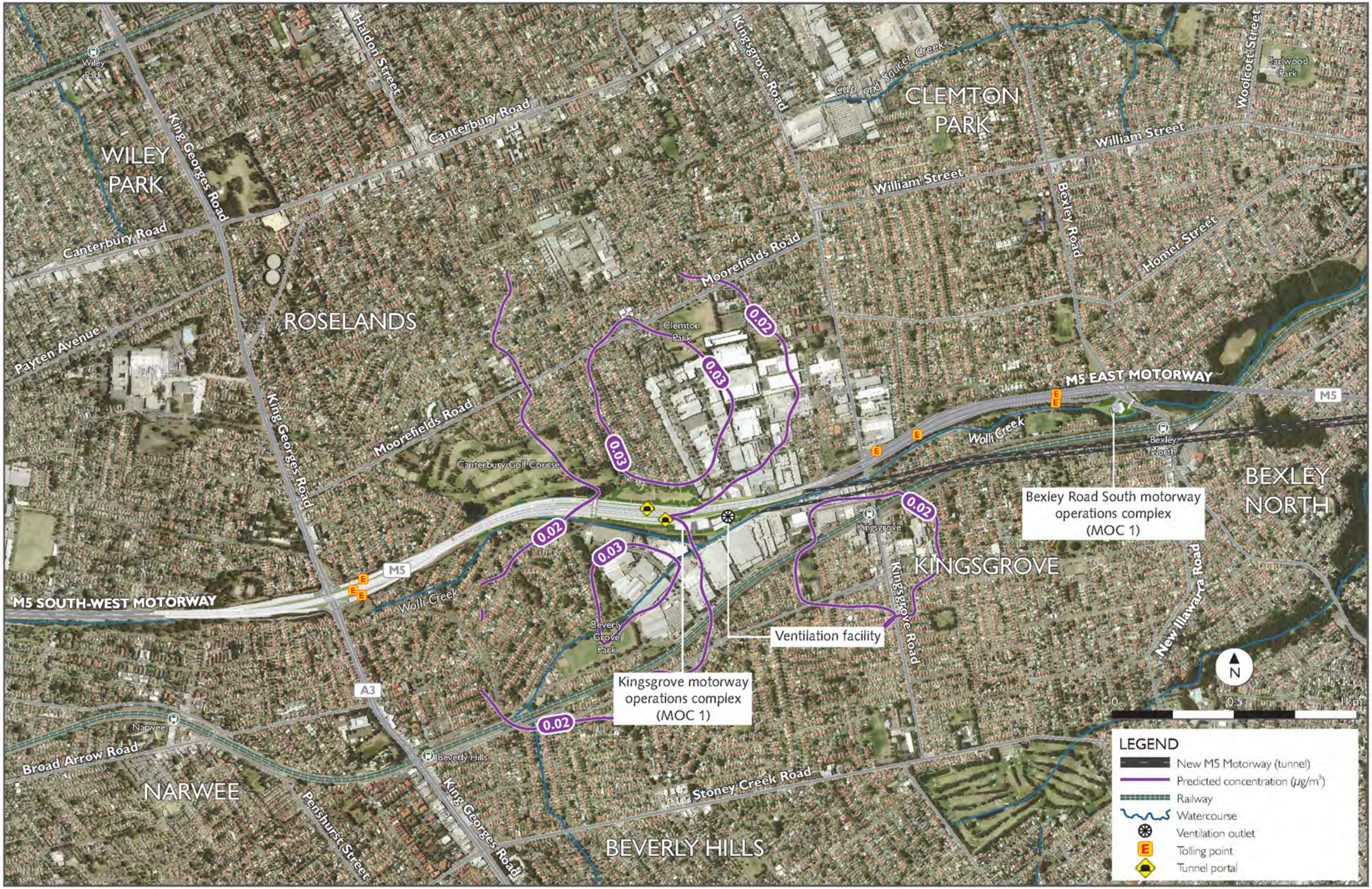

Figure 10-64 Contour plot showing annual mean $PM_{2.5}$ for ventilation outlets only (Kingsgrove outlet, 2021-DS)

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Figure 10-65 Contour plot showing annual mean $PM_{2.5}$ for ventilation outlets only (Arncliffe outlet 2021-DS)

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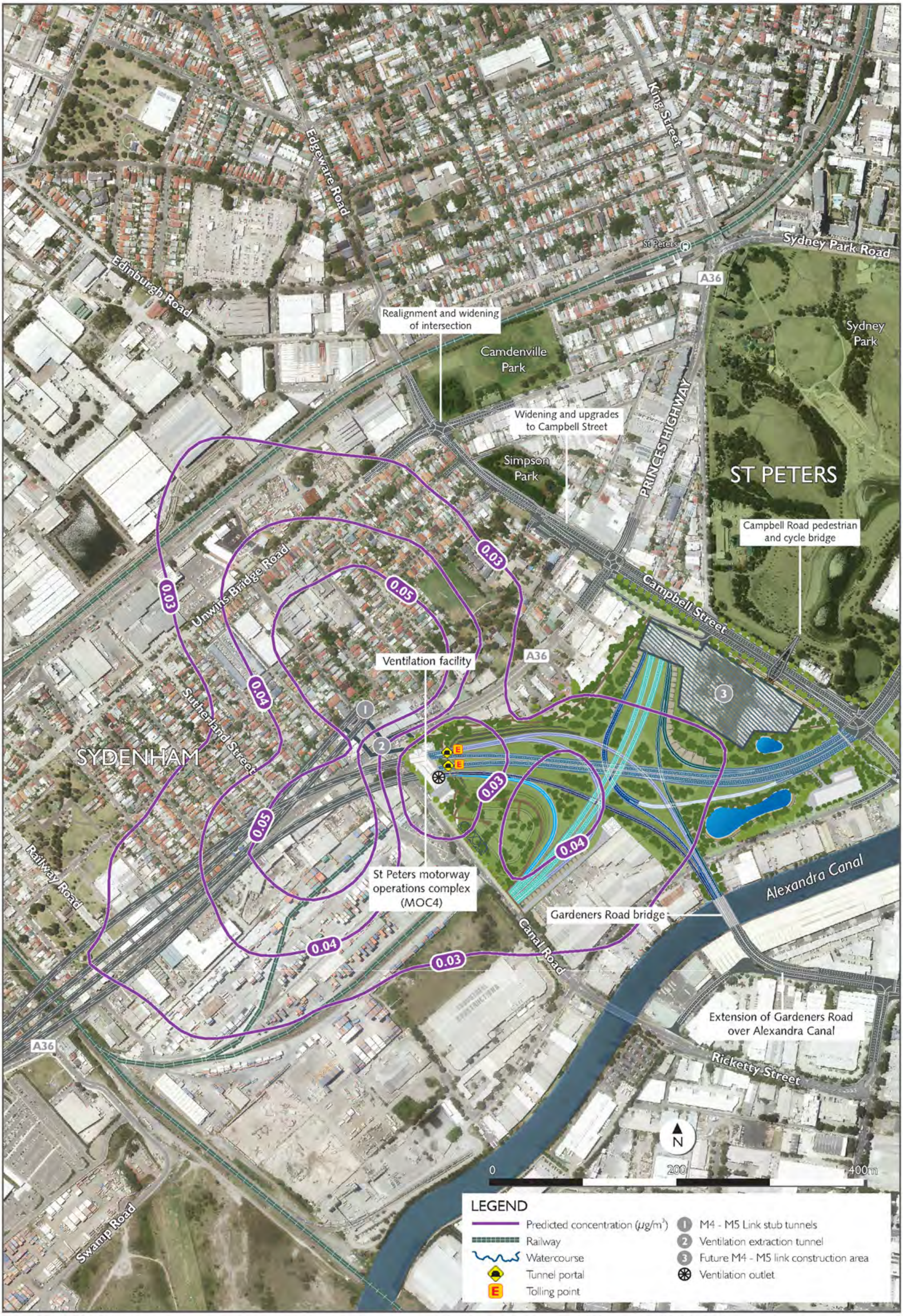

Figure 10-66 Contour plot showing annual mean $PM_{2.5}$ for ventilation outlets only (SPI outlet, 2021-DS)

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For each ventilation outlet, the range of annual mean $PM_{2.5}$ concentrations across the grid is provided in **Table 10-30**. The maximum value of 0.2 µg/m^3 (St Peters interchange, 2031-DSC) is much lower than the criterion for annual mean $PM_{2.5}$ of 8 µg/m^3

Table 10-30 Contribution of project ventilation outlets to annual mean $PM_{2.5}$ concentration

Ventilation outlet	Outlet contribution to annual mean $PM_{2.5}$ (µg/m^3)		
	2021-DS	2031-DS	2031-DSC
Kingsgrove	0.01 – 0.04	0.01 – 0.04	0.02 – 0.05
Arncliffe	0.01 – 0.03	0.01 – 0.03	0.04 – 0.07
SPI	0.01 – 0.06	0.01 – 0.06	0.05 – 0.20

10.8.7 Air toxics

Four air toxics – benzene, PAH (as benzo(a)pyrene), formaldehyde and 1,3-butadiene – were considered in the assessment. These compounds were taken to be representative of the much wider range of air toxics associated with motor vehicles and have commonly been assessed for road projects.

The changes in the maximum one-hour benzene concentration at the community receivers in the 2021 and 2031 'do something' scenarios were compared against the NSW impact assessment criterion from the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005b), taking into account emissions from both surface roads and tunnel ventilation outlets. **Figure 10-67** shows that where there was an increase in the concentration in the maximum 1-hour benzene concentration, it still remained significantly below the assessment criterion of 29 mg/m^3.

The changes in the maximum one-hour benzo(a)pyrene, formaldehyde and 1,3-butadiene concentration in the 2021 and 2031 'do something' scenarios are presented in **Figure 10-68**, **Figure** 10-69, and **Figure 10-70** respectively. For each compound, where there was an increase in the concentration this was well below the NSW impact assessment criterion. The largest increases for the community receivers were also representative of the largest increases for the RWR receivers.

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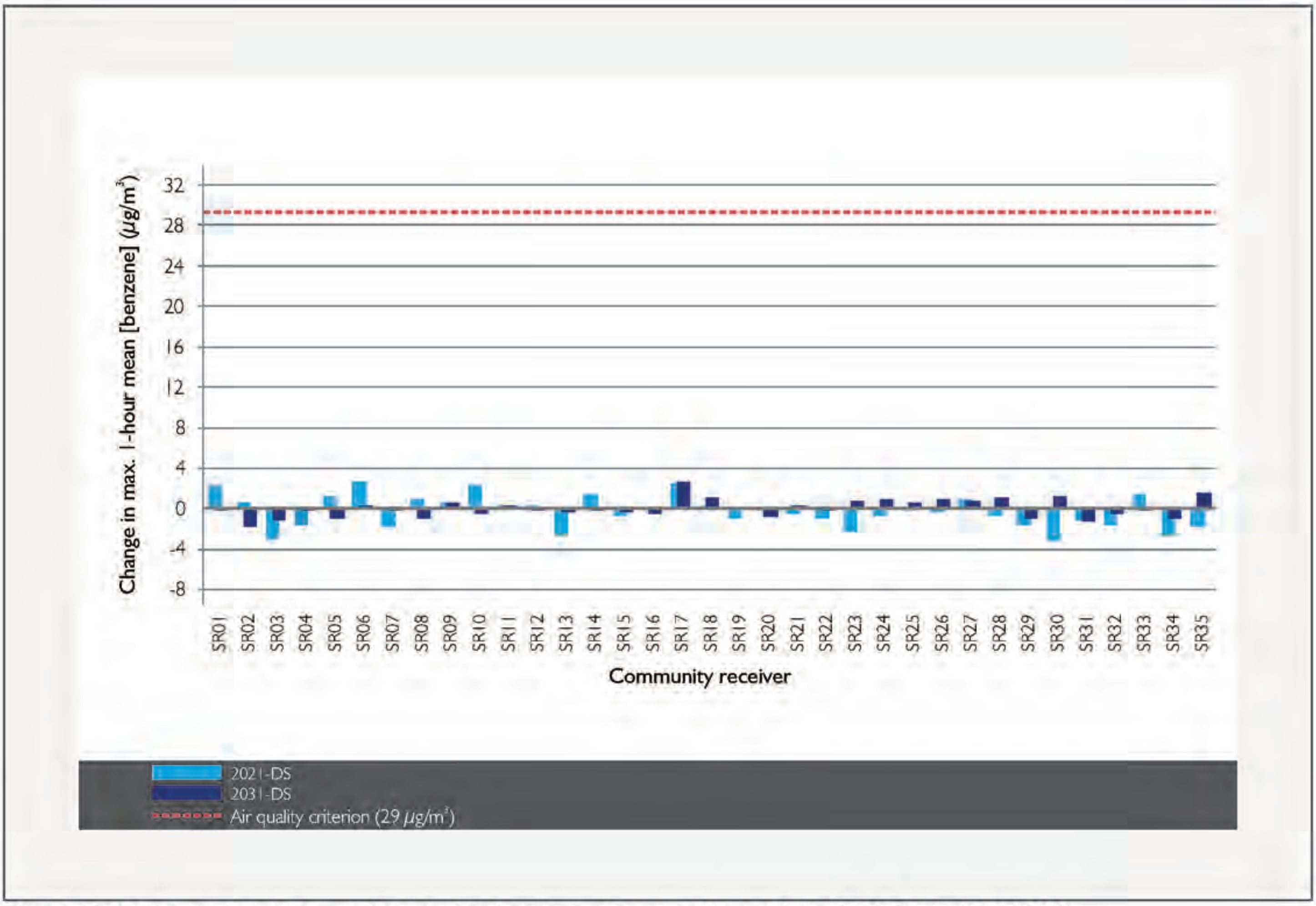

Figure 10-67 Change in maximum 1-hour mean benzene at community receiver (2021-DS and 2031-DS)

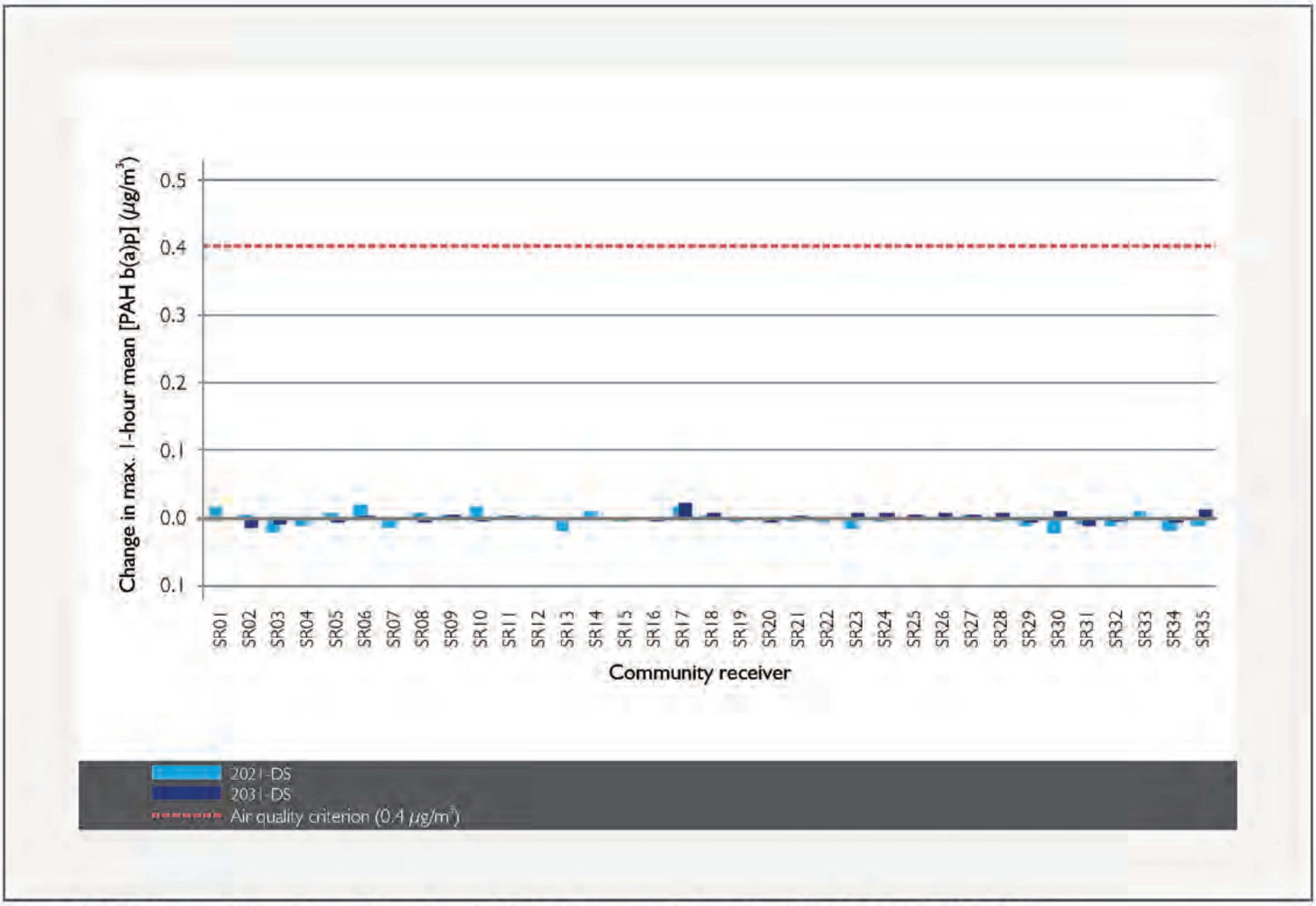

Figure 10-68 Change in maximum 1-hour mean b(a)p at community receiver (2021-DS and 2031-DS)

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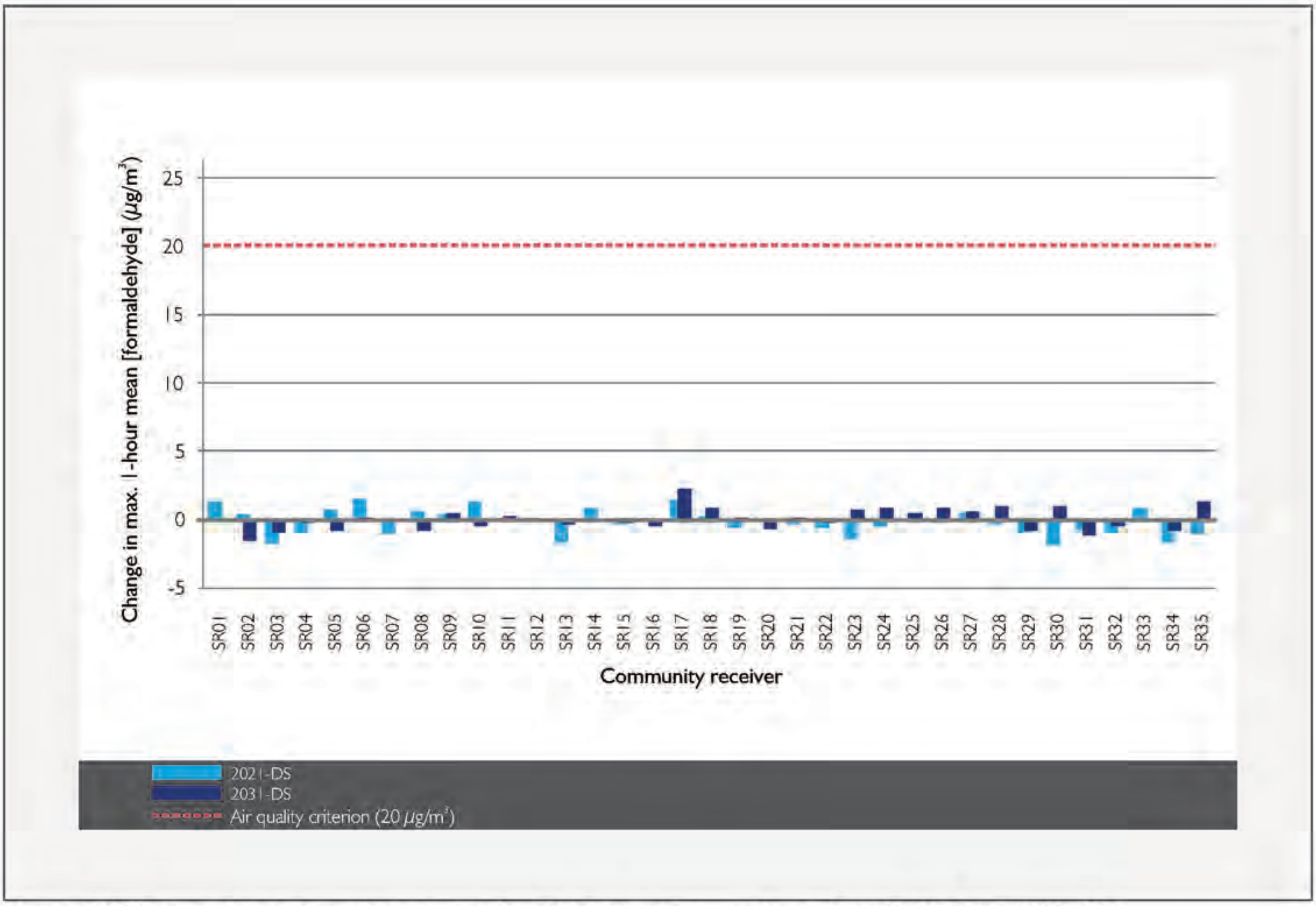

Figure 10-69 Change in maximum 1-hour mean formaldehyde at community receiver (2021-DS and 2031-DS)

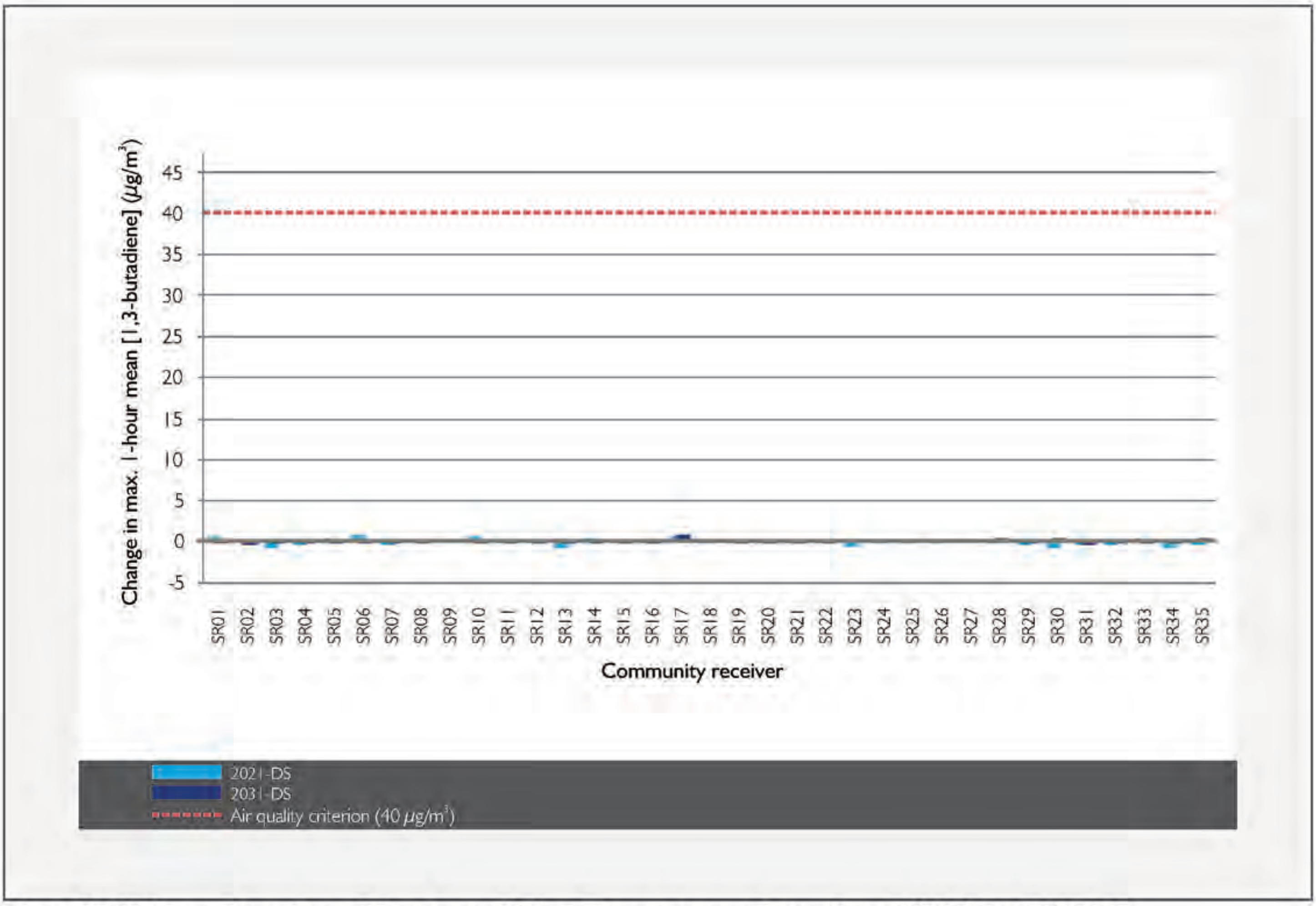

Figure 10-70 Change in maximum 1-hour mean 1,3-butadiene at community receivers (2021-DS and 2031-DS)

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10.8.8 Odour

Odours associated with motor vehicle emissions tend to be very localised and short-lived. The project is not expected to result in any significant, predictable or detectable changes in odour. For each of the RWR receivers, the change in the maximum one hour THC concentration in the 2021 and 2031 ‘do something’ scenarios was calculated. The largest change in the maximum 1-hour THC concentration across all receivers was then determined and converted to an equivalent change for three of the odorous pollutants identified in the Approved Methods (toluene, xlyenes and acetaldehyde). These pollutants were taken to be representative of other odorous pollutants from motor vehicles.

The changes in the levels of toluene, xlyenes and acetaldehyde as a result of the project, and the corresponding odour assessment criteria from the Approved Methods, are provided in **Table 10-31**. The change in the maximum 1-hour concentration of toluene, xlyenes and acetaldehyde was an order of magnitude below the corresponding odour assessment criterion in the Approved Methods.

Table 10-31 Comparison of changes in odorous pollutant concentrations with criteria in Approved Methods (RWR receivers)

Scenario	Largest increase in maximum 1-hour THC concentration relative to ‘do minimum’ scenario (μg/m^3)	Largest increase in maximum 1-hour concentration for specific compounds		
		Toluene (μg/m^3)	Xylenes (μg/m^3)	Acetaldehyde (μg/m^3)
2021-DS	243.7	19.8	16.3	3.1
2031-DS	170.8	13.9	11.5	2.6
2031-DSC	111.8	9.1	7.5	1.7
Odour criterion (μg/m^3)		360	190	42

10.9 Assessment of cumulative impacts

This assessment considers the potential cumulative impacts of the project and the future M4-M5 Link.

By 2031, the New M5 is predicted to accommodate a two-way average weekday traffic volume of about 34,500 vehicles per day with the project and about 81,500 vehicles per day with the full WestConnex program of works. The complete WestConnex program of works would result in about a 134 percent increase in two-way average weekday traffic volumes using the future M4-M5 Link and the future Southern extension. If the full WestConnex program of works is completed, the two-way daily volume on Stoney Creek Road is forecast to reduce and two-way daily traffic on the Princes Highway, north of the M5 East Motorway interchange, is forecast to decrease from 79,000 vehicles per day without the project to about 25,000 vehicles per day. This 69 per cent decrease is a substantial reduction along this congested section of the strategic road network.

10.9.1 In-tunnel air quality

The peak in-tunnel concentrations for the expected traffic cumulative scenario (2031 ‘do something (cumulative)’) were assessed in Appendix L of the Technical working paper: Air quality in **Appendix H**. The results showed that the peak concentrations for all traffic scenarios, including worst-case conditions, were well within the concentrations associated with the regulatory worst case.

10.9.2 Ambient air quality

Results for expected traffic scenarios

The results for the expected traffic scenarios and all pollutants under the 2031 ‘do something’ cumulative scenario are presented in Appendix K of the Technical working paper: Air quality in **Appendix H**. In the majority of cases the results for the community receivers in the 2031 ‘do something cumulative’ scenario were very similar to those in the 2031 ‘do something’ scenario.

The ambient air quality results for the 2031 ‘do something cumulative’ scenario at the RWR receivers were broadly similar to those for the 2031 ‘do something’ scenario. However, there are predicted to be some increases in concentration for a very small number of receivers. These are illustrated in **Figure** 10-71 to **Figure 10-79**.

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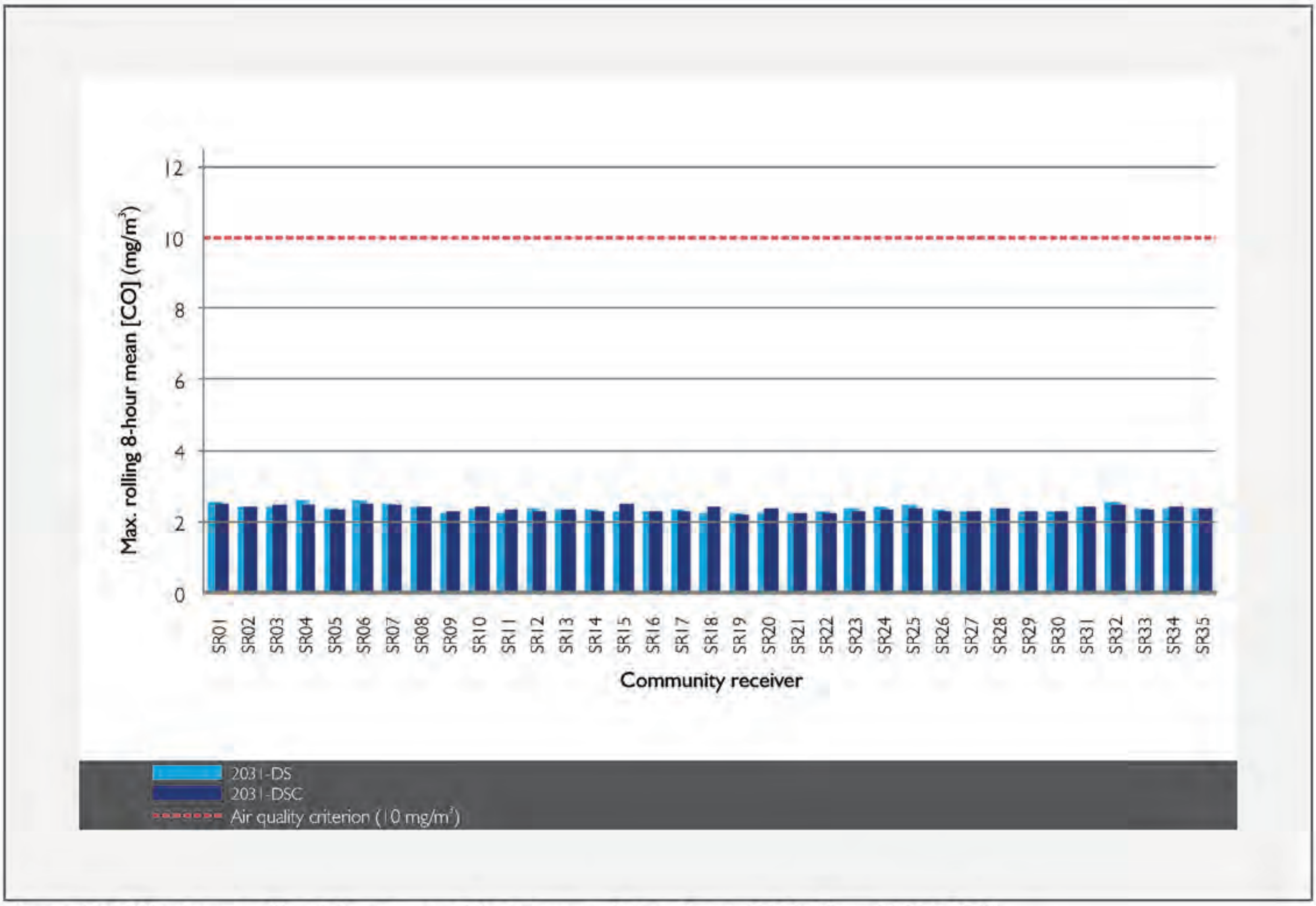

Figure 10-71 Maximum rolling 8-hour mean CO at community receivers (2031-DS and 2031-DSC)

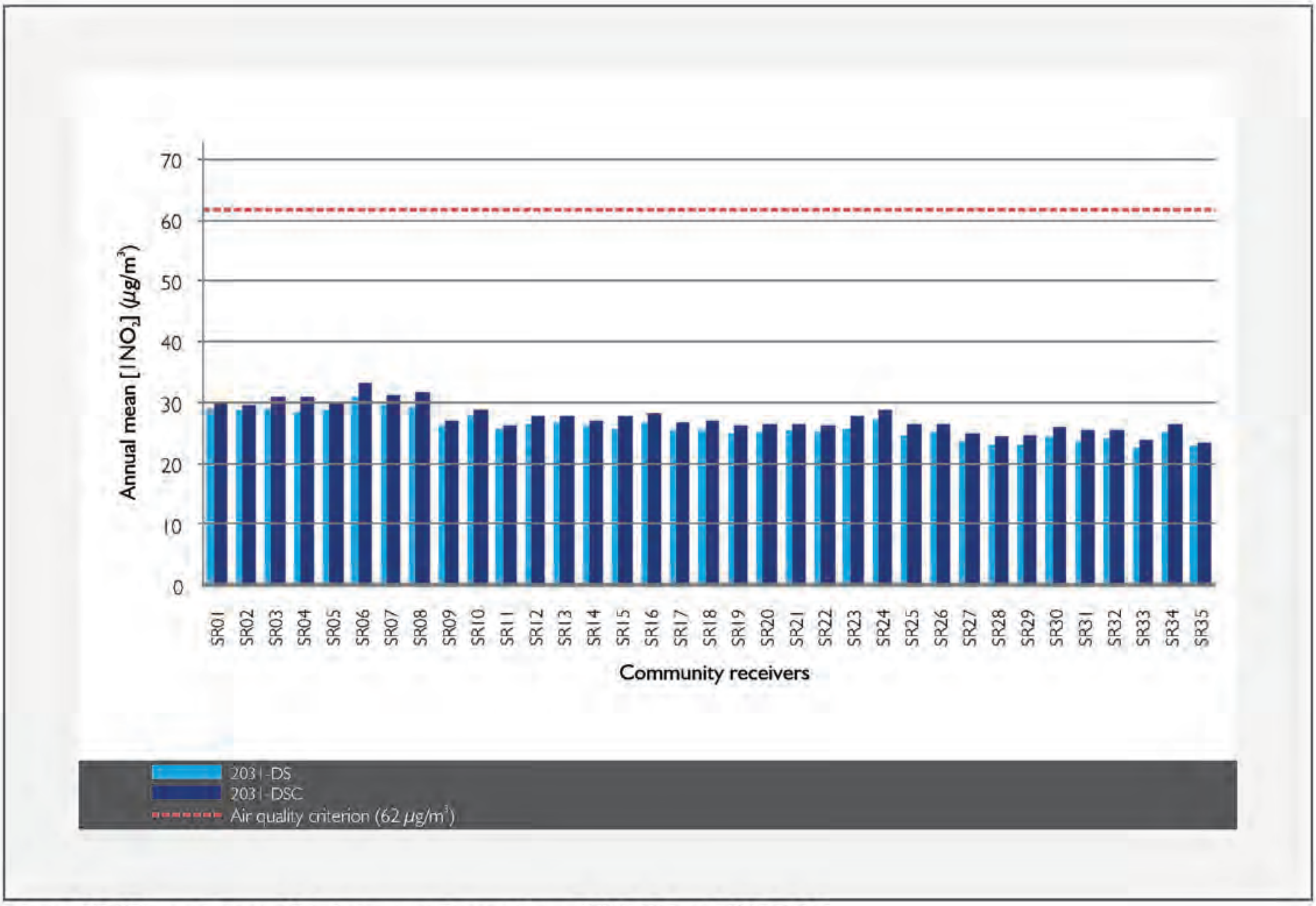

Figure 10-72 Annual mean NO_2 at community receivers (2031-DS and 2031-DSC)

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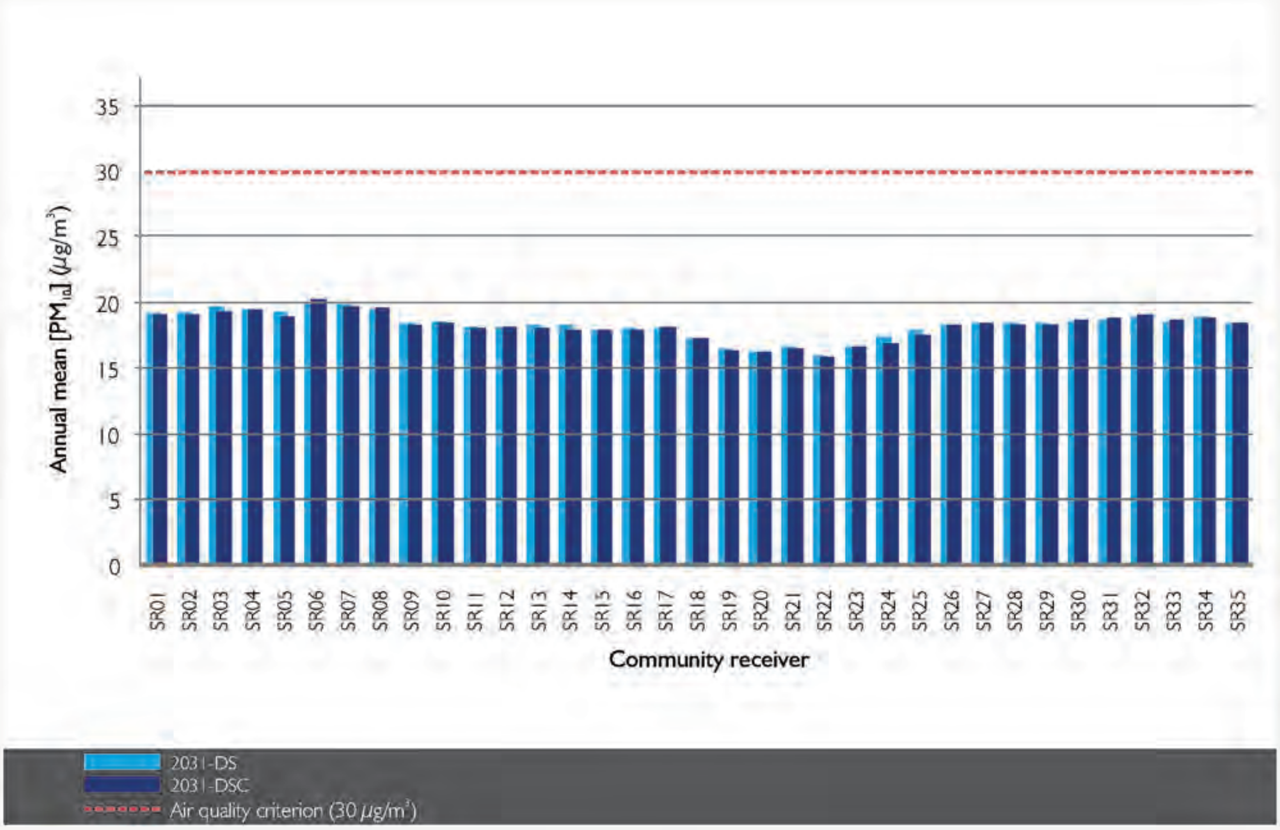

Figure 10-73 Annual mean PM_{10} at community receivers (2031-DS and 2031-DSC)

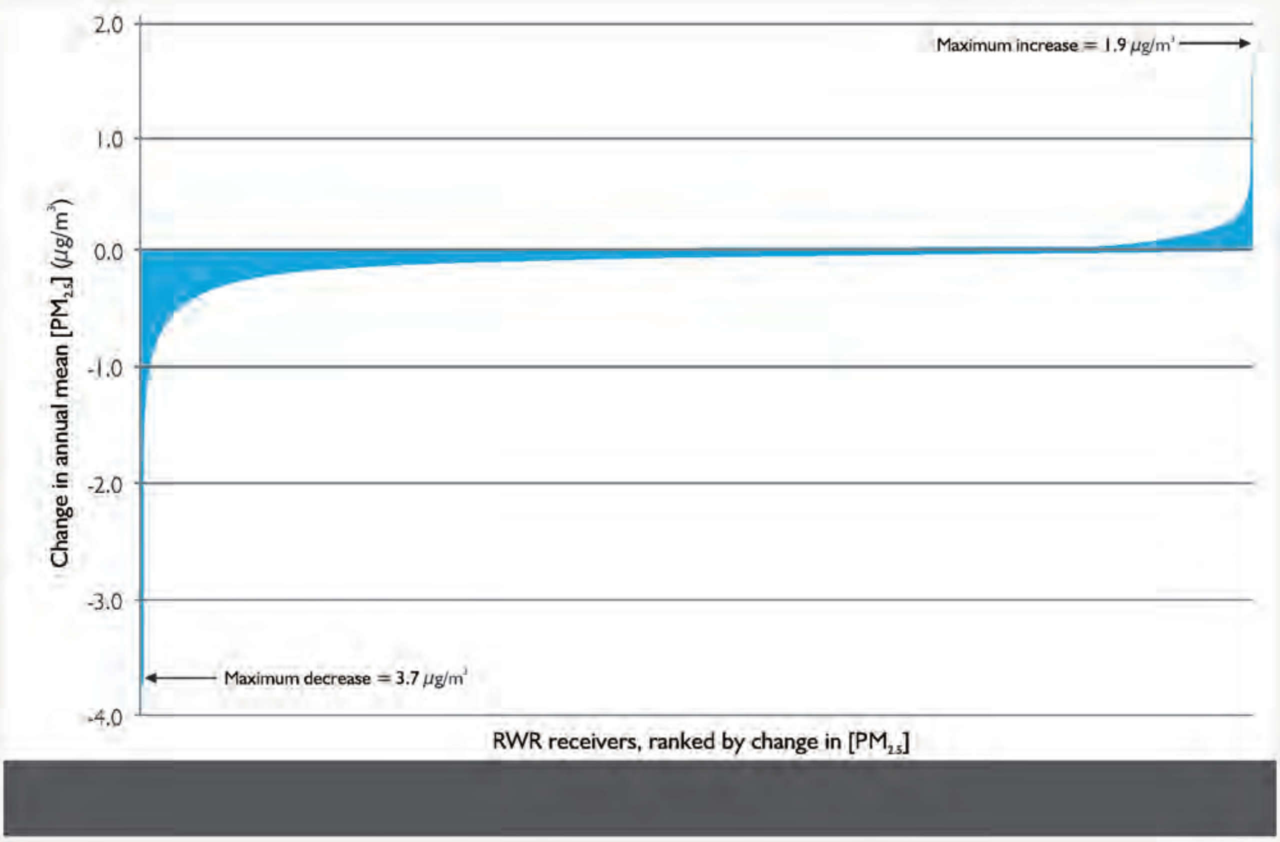

Figure 10-74 Changes in annual mean $PM_{2.5}$ at RWR receivers (2031-DSC)

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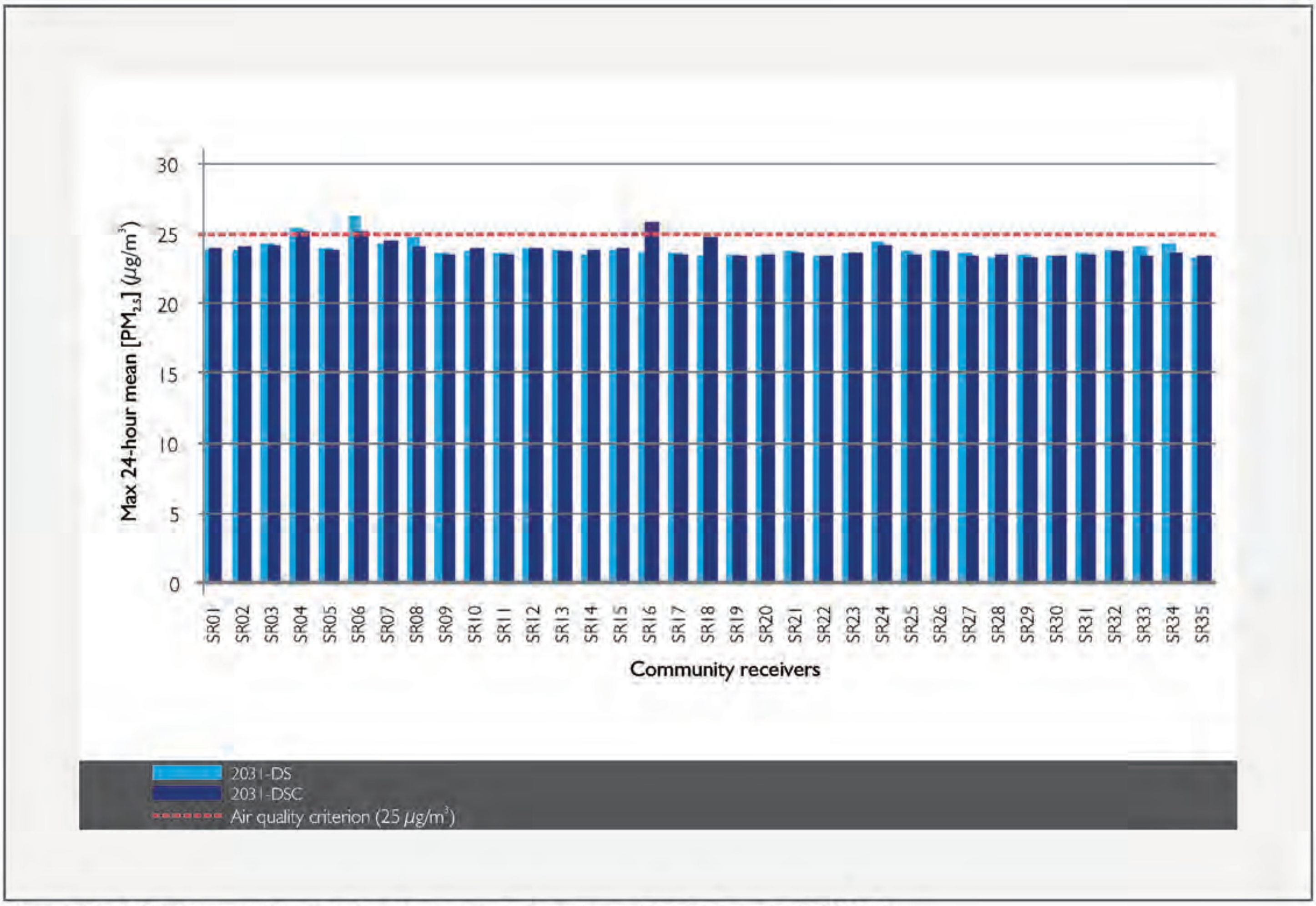

Figure 10-75 Maximum 24-hour $PM_{2.5}$ at community receivers (2031-DS and 2031-DSC)

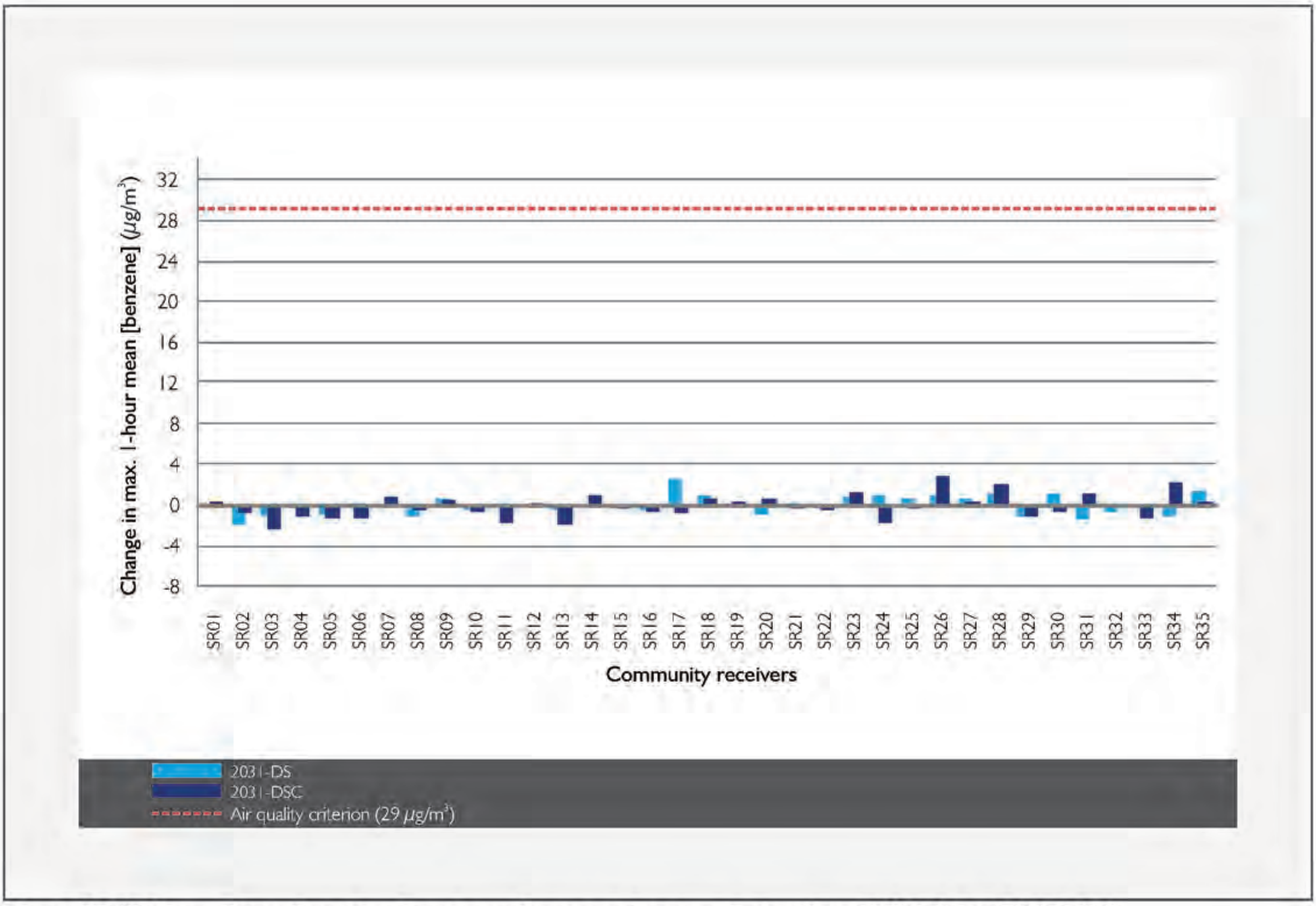

Figure 10-76 Change in maximum one hour mean benzene at community receivers (2031-DS and 2031-DSC)

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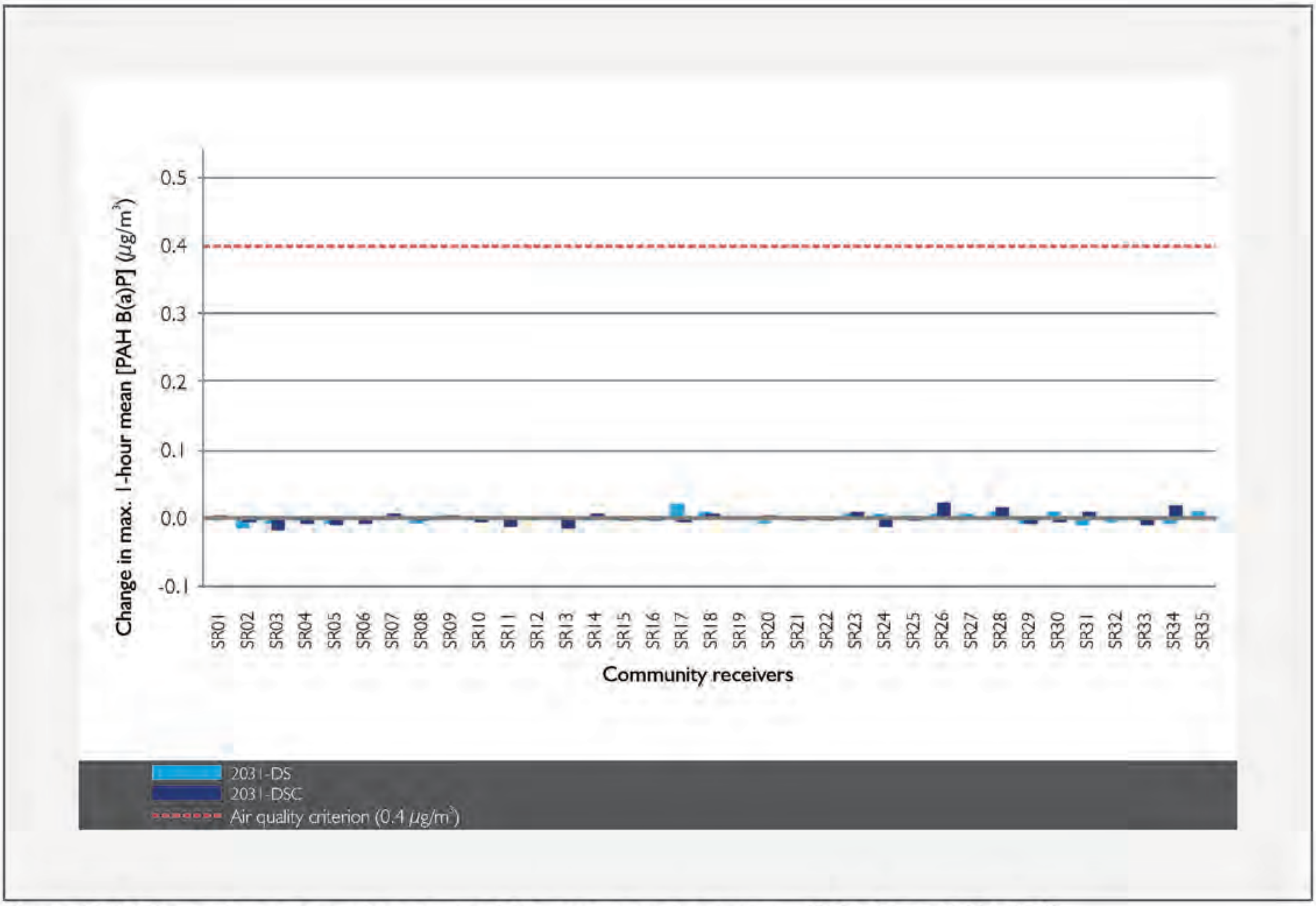

Figure 10-77 Change in maximum 1-hour mean b(a)p at community receivers (2031-DS and 2031-DSC)

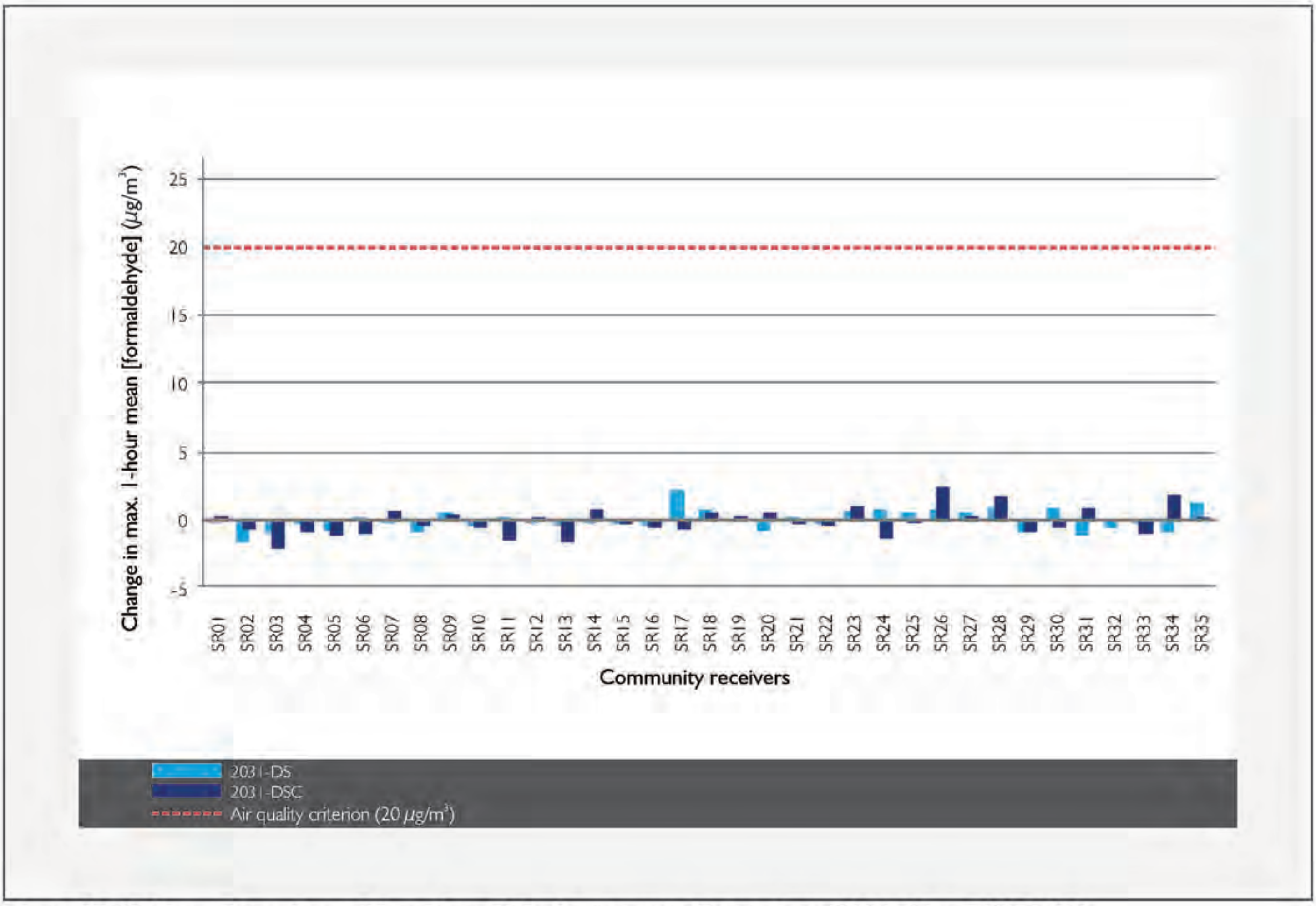

Figure 10-78 Change in maximum 1-hour formaldehyde at community receivers (2031-DS and 2031-DSC)

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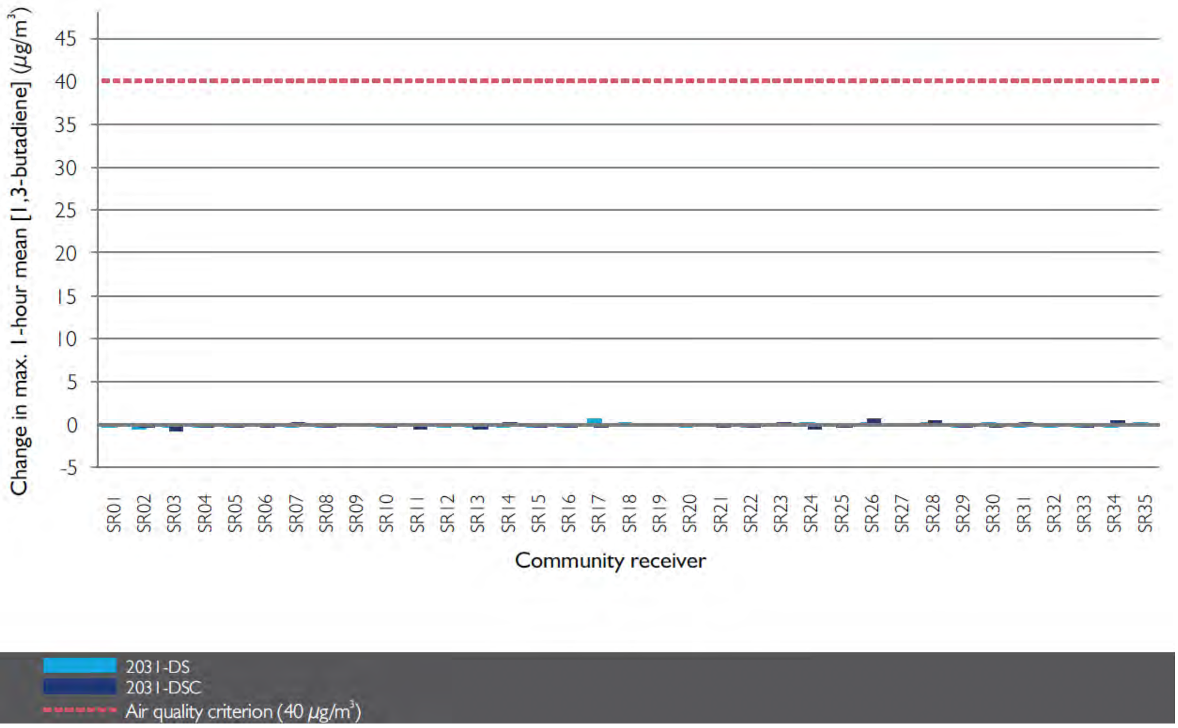

Figure 10-79 Change in max. one-hour 1,3-butadiene at community receivers (2031-DS and 2031-DSC)

10.10 Environmental management measures

10.10.1 Construction impacts

Environmental management measures to be applied during construction of the project are provided in **Table 10-32**. Most of the measures are routinely employed as 'good practice' on construction sites.

A Construction Air Quality Management Plan would be produced to cover all construction stages of the project. This plan would contain details of the site-specific mitigation measures to be applied. Additional guidance on the control of dust at construction ancillary facilities in NSW is provided as part of the NSW EPA Local Government Air Quality Toolkit.

Table 10-32 Environmental management measures – air quality

Impact	No.	Environmental management measure	Responsibility	Timing
Construction				
General	AQ1	Develop and implement a Construction Air Quality Management Plan in consultation with the NSW EPA. Any measures that are required will differ depending on the activities occurring, and so will need to be tailored for each individual site.	Construction contractor	Pre-construction
	AQ2	Carry out regular site inspections to monitor compliance with the Construction Air Quality Management Plan, record inspection results.	Construction contractor	Construction
	AQ3	Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.	Construction contractor	Pre-construction

Impact	No.	Environmental management measure	Responsibility	Timing
	AQ4	Display the name and contact details of person(s) accountable for air quality and dust issues at the boundaries of each construction area. This may be the environment manager/engineer or the site manager. Display the head or regional office contact information.	Construction contractor	Construction
Dust management	AQ5	Plan site layout so that machinery and dust causing activities are located away from receivers, as far as is possible.	Construction contractor	Construction
	AQ6	Erect solid screens or barriers around dusty activities or the site boundary.	Construction contractor	Construction
	AQ7	Ensure, where reasonable and feasible, that appropriate control methods are implemented to minimise dust emissions from the project site.	Construction contractor	Construction
	AQ8	Remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site, cover as soon as practicable.	Construction contractor	Construction
	AQ910	Impose and signpost a maximum-speed-limit of 20 km/h on surfaced and unsurfaced haul roads and in work areas.	Construction contractor	Construction
	AQ11	Where practicable, only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, (e.g. suitable local exhaust ventilation systems).	Construction contractor	Construction
	AQ12	Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.	Construction contractor	Construction
	AQ13	Where possible, use enclosed chutes and conveyors and covered skips.	Construction contractor	Construction
	AQ14	Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.	Construction contractor	Construction
	AQ15	Ensure equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using appropriate cleaning methods.	Construction contractor	Construction
	AQ16	Avoid scabbling (roughening of concrete surfaces) if possible.	Construction contractor	Construction

Impact	No.	Environmental management measure	Responsibility	Timing
Stockpile management	AQ17	Stockpiles would be located outside overland flowpaths, and where left exposed and undisturbed for longer than 28 days, would be finished and contoured to minimise loss of material in flood or rainfall events. Materials which require stockpiling for longer than 28 days would be stabilised by compaction, covering with anchored fabrics, or seeded with sterile grass where appropriate.	Construction contractor	Construction
	AQ18	Where a stockpile, eg sand or fine aggregate, has the potential to generate dust, control measures would be implemented. These would include wetting the stockpile, covering the stockpile or contouring the stockpile.	Construction contractor	Construction
	AQ19	Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery.	Construction contractor	Construction
	AQ20	For smaller supplies of fine powder materials ensure bags are sealed after use and stored appropriately to prevent dust.	Construction contractor	Construction
Tracking of material on roads	AQ21	Use water-assisted dust sweeper(s) on the access and local roads, to remove, as necessary, any material tracked out of the site.	Construction contractor	Construction
	AQ22	Avoid dry sweeping of large areas.	Construction contractor	Construction
	AQ23	Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	Construction contractor	Construction
	AQ24	Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.	Construction contractor	Construction
	AQ25	Record all inspections of haul routes and any subsequent action in a site log book.	Construction contractor	Construction
	AQ26	Where reasonable and feasible, haul roads will be maintained with water carts and graders, and the condition of the roads will be monitored.	Construction contractor	Construction
	AQ27	Implement site exit controls (e.g. wheel washing system and rumble grids) to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable.	Construction contractor	Construction
	AQ28	Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits.	Construction contractor	Construction

Impact	No.	Environmental management measure	Responsibility	Timing
	AQ29	Access gates to be located at least 10 metres from receivers where possible.	Construction contractor	Construction
Emissions management	AQ30	Ensure all construction vehicles comply with their relevant emission standards.	Construction contractor	Construction
	AQ31	Ensure that, where practicable, engine idling is minimised when stationary.	Construction contractor	Construction
	AQ32	Avoid the use of diesel or petrol powered generators and use mains electricity or battery powered equipment where practicable.	Construction contractor	Construction
	AQ33	Promote and encourage sustainable travel (public transport, cycling, walking, and car-sharing).	Construction contractor	Construction
	AQ34	No bonfires and burning of waste materials.	Construction contractor	Construction
Demolition	AQ35	Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust).	Construction contractor	Construction
	AQ36	Ensure effective water suppression is used during demolition operations. Hand held sprays are more effective than hoses attached to equipment as the water can be directed to where it is needed. In addition high volume water suppression systems, manually controlled, can produce fine water droplets that effectively bring the dust particles to the ground and may be more useful for covering larger areas.	Construction contractor	Construction
	AQ37	Minimise explosive blasting where possible during demolition, using appropriate manual or mechanical alternatives.	Construction contractor	Construction
	AQ38	Bag and remove any biological debris or other hazardous materials such as asbestos, damp down such material before demolition.	Construction contractor	Construction
Earthworks	AQ39	Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable.	Construction contractor	Construction
	AQ40	Use hessian, mulches or tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.	Construction contractor	Construction
	AQ41	Where possible, only remove any cover for exposed areas in small areas during work and not all at once.	Construction contractor	Construction

Impact	No.	Environmental management measure	Responsibility	Timing
Cumulative impacts	AQ42	Regular communication with other high risk construction ancillary facilities within 500 metres of the site boundary, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised. It is important to understand the interactions of the off-site transport/deliveries which might be using the same strategic road network routes.	Construction contractor	Construction
	AQ43	Undertake regular on-site and off-site inspection, where receivers are nearby, to monitor dust, record inspection results.	Construction contractor	Construction
Complaints management	AQ44	Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.	Construction contractor	Construction
	AQ45	Make complaints available to the Secretary upon request.	Construction contractor	Construction
	AQ46	Record any exceptional incidents that cause dust and/or air emissions, either on- or offsite, and the action taken to resolve the situation in the log book.	Construction contractor	Construction

10.10.2 Operational impacts

The SEARs for the project require details of, and justification for, the air quality management measures that were considered for the project. This section reviews the environmental management measures that are available for improving tunnel-related air quality, and then describes their potential application in the context of the project. The measures are categorised as follows:

- Tunnel design
- Ventilation design and control
- Air treatment systems
- Emission controls and other measures
- Monitoring.

Tunnel design

It is important that the tunnel infrastructure is designed in such a way that the generation of pollutant emissions by traffic using the tunnel is minimised. The main considerations include avoiding large gradients and congested traffic conditions, including the management of traffic on the roads leading in and out of the tunnel. In addition, the risk of incidents leading to congestion would be addressed, including accidents involving oversized vehicles.

Ventilation design and control

There are several reasons why a tunnel needs to be ventilated. The main reasons are:

- Control of the internal environment - it must be safe and comfortable to drive through the tunnel. Vehicle emissions must be sufficiently diluted so as not to be hazardous during normal operation, or when traffic is moving slowly

- Protection of the external environment - it is unacceptable for polluted air from tunnel portals or ventilation outlets to present a health or nuisance hazard to the community. Ventilation, and the dispersion of pollutants, is overwhelmingly the most effective and accepted method for minimising the impacts of tunnels on ambient air quality. Collecting emissions and venting them via ventilation outlets is a very efficient way of dispersing pollutants. Studies show that the process of removing surface traffic from heavily trafficked roads and dispersion of emissions from an elevated location results in substantially lower concentrations at sensitive receivers (PIARC, 2008)
- Ventilation outlets need to be designed and sited accordingly. Discharge velocities from outlets must be assessed to ensure dispersion of pollutants is achieved
- Emergency situations. When a fire occurs in a tunnel it is a requirement to be able to control the heat and other combustion products in the tunnel, to permit safe evacuation of occupants, and to provide the emergency services with a safe access route to deal with the fire and to rescue anyone trapped or injured.

A two-fold approach to ventilation design is generally adopted:

- The amount of fresh air required to dilute pollutants to acceptable levels is calculated based on the likely emissions from vehicles in the tunnel, and the ventilation system is designed accordingly. The choice and design of a suitable ventilation system depends on:
  - Tunnel length and geometry
  - Traffic flow and composition
  - Fresh air requirement under normal and specific traffic conditions
  - Admissible air pollution levels around tunnel portals
  - Fire safety considerations.
- Sensors are installed in the tunnel to initiate the operation of the ventilation system in order to maintain the level of pollutants below limit values, or to force the closure of the tunnel should certain limit values be exceeded.

Short tunnels can be adequately and safely ventilated by the piston effect. The external wind may also generate a flow of air within a tunnel due to the static air pressure difference between the portals.

There are three basic concepts for mechanical tunnel ventilation and these are described and illustrated in **Chapter 4** (Project development and alternatives)

- Longitudinal ventilation, whereby air is introduced to, or removed from, the tunnel at a limited number of points
- Transverse ventilation, whereby air may be introduced into a tunnel at regular points along its length, and extracted at corresponding points along its length
- Semi-transverse ventilation. Semi-transverse ventilation involves a combination of longitudinal and transverse ventilation. For example, fresh air can be delivered uniformly (and transversely) over the length of the tunnel, and exhaust air is removed longitudinally through the tunnel portals.

Jet fans may also be mounted within the tunnel space, usually at fixed intervals along the tunnel and near to the tunnel ceiling. Ventilation control is achieved by adjusting the number of fans in operation at any one time, with each unit being operated at full power or not running. A further refinement is available in installations where fan speed is controllable. The required level of ventilation at any particular time tends is determined in response to NO_x, CO and visibility levels.

The predicted criteria in-tunnel pollutant levels for this tunnel support the use of a longitudinal ventilation system for the project as the air quality criteria can be achieved under all traffic conditions within the tunnel.

Emergency procedures

Except for short sections at exit portals, prior to an incident the air would be flowing strongly with the traffic. At the onset of a fire, any exit portal flow against traffic would be reversed, with the flow direction maintained for the majority of the tunnel. Exit portal inflows can be reversed quickly by turning off the ventilation station fans which extract the tunnel air prior to the portal.

Jet fans maintain an air flow in the traffic direction in order to prevent people held behind the fire from being affected by smoke. Sufficient jet fans would be provided to control backlayering of the smoke at the fire-site.

Under normal operation, traffic control measures would be applied to ensure that the traffic speed in the tunnel does not drop below 20 km/h for any significant period. This would ensure that, if a vehicle ignites, the smoke movement does not overtake downstream traffic.

Depending on the fire location, the smoke may be discharged through the normal ventilation outlet, using the ventilation station fans. The alternative is to drive the smoke out the exit portal. The non-incident tube will be closed to traffic and the airflow in that tube will be reversed using jet fans. This is to ensure that smoke issuing from a portal is not drawn into the adjacent portal of the non-incident tube. The jet fans would also be used to maintain the non-incident tube at a higher pressure than the incident tube, to prevent smoke flow through cross passages

Air treatment systems

There are several air treatment options for mitigating the effects of tunnel operation on both in-tunnel and ambient air quality. Where in-tunnel treatment technologies have been applied to road tunnels, these technologies have focused on the management and treatment of particulate matter. The most common of these is the electrostatic precipitator (ESP), often used for improving visibility in long tunnels. Other techniques include filtering, denitrification and biofiltration, agglomeration and scrubbing.

In Australia, the issue of air treatment frequently arises during the development of new tunnel projects. All tunnel projects rely instead on the primary approach of dilution of air pollution in the tunnel and effective dispersion though elevated outlets through ventilation systems (Cente d'Etudes des Tunnels (CETU), 2010 and Roads and Maritime Services, 2014a). Further details of air treatment systems and their use internationally are presented in the Technical working paper: Air quality in **Appendix H**.

The air quality assessment demonstrates that ventilation outlets are effective at maintaining local air quality. Provision of a tunnel filtration system does not represent a feasible and reasonable mitigation measure and is therefore not being proposed.

Mitigation of potential impacts by design

Tunnel design

The project design would reduce pollutant emissions and concentrations within the tunnel by including:

- Minimal gradients. The main alignment tunnels would have a maximum gradient of four per cent. By comparison, the M5 East tunnel has a grade of up to eight per cent on the western exit, which causes trucks to slow down and increase emissions
- Large main line tunnel cross-sectional area (90 square metres). The tunnel will have a large cross-sectional area to reduce the pollutant concentration for a given emission into the tunnel volume, and to permit greater volumetric air throughput
- Increased height. The height of the New M5 tunnel (5.3 metres) would be significantly greater than that of the M5 East tunnel (4.6 metres). This would reduce the risk of incidents involving high vehicles blocking the tunnel and leading to disruption of traffic.

Ventilation design and control

The project ventilation system has been designed so that it would achieve some of the most stringent standards in the world for in-tunnel air quality and would be effective at maintaining local air quality. The design of the ventilation system would provide zero portal emissions.

The ventilation system would be automatically controlled using real-time traffic data covering both traffic mix and speed, and feedback from air quality sensors in the tunnel, to ensure in-tunnel conditions are managed effectively in accordance with the agreed criteria. Furthermore, specific ventilation modes would be developed to manage breakdown, congested and emergency situations.

Air treatment

The effectiveness of the treatment of tunnel emissions has been evaluated as part of the environmental assessment phase of a number of existing Sydney road tunnels, including the M5 East, Cross City Tunnel and Lane Cove Tunnel. It has also been subject of numerous NSW Legislative Council (Upper House) inquiries and independent scientific reviews including by the CSIRO. In general these evaluations have indicated that it is more cost-effective to reduce pollutants at the source, using improved fuel standards and engine technology, which will result in greater benefits to air quality, both in-tunnel and in the ambient air, at the local and regional scales (WDA, 2013).

Incorporating filtration to the ventilation outlets would have negligible benefit and require a significant increase in the size of the tunnel facilities to accommodate the equipment. It would result in increased project size, community footprint, and capital cost. The energy usage would be substantial and does not represent a sustainable approach. Further, the air leaving the outlet is not highly concentrated with pollutants (as demonstrated by the air quality assessment) since it must be of a quality to be acceptable for tunnel users. Any predicted impact on local air quality is very small even without a filtration system.

In summary, the provision of a tunnel filtration system does not represent a feasible and reasonable mitigation measure and is not being proposed.

Emission controls

Smoky vehicle cameras would be installed to automatically detect vehicles with excessive exhaust smoke, with penalties applying to offenders. A similar initiative is in place for the M5 East tunnel and has resulted in a reduction of smoky vehicles using the tunnel.

Monitoring

The assessment has demonstrated that even at the regulatory worst case, any changes in ambient air quality due to emissions from the ventilation outlets would be small and unlikely to result in adverse impacts on local air quality. Nevertheless, ambient air quality monitoring would be conducted to validate the EIS predictions.