Australian Government

Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Western Sydney International (Nancy-Bird Walton) Airport – Airspace and flight path design

Draft Environmental Impact Statement

Technical paper 2: Air quality

September 2023

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Terms and abbreviations

Term/abbreviation	Definition
µg	Mass in micrograms
µg/m³	Micrograms per cubic metre
Airshed	The volume of atmosphere over the area of interest
AEDT	Aviation Environmental Design Tool (US FAA)
Anthropogenic	Human sourced
ATC	Air traffic control
ATM	Air traffic movement
AWS	Automatic weather station
Background levels	Existing concentration of pollutants in the ambient air
BOM	Bureau of Meteorology
CALPUFF	A multi-layer, multi-species, non-steady state Gaussian puff dispersion model that is able to simulate the effects of time- and space-varying meteorological conditions on pollutant transport
CO	Carbon monoxide
CMAQ	Community Multiscale Air Quality Model
Cth	Commonwealth
Diffuse source	Activities that are generally dominated by fugitive area or volume-source emissions, which can be relatively difficult to control directly, for example emissions from traffic or domestic activities)
Dispersion modelling	Modelling by computer to mathematically simulate the effect on plume dispersion under varying atmospheric conditions; used to calculate spatial and temporal fields of concentrations and particle deposition due to emissions from various source types
DPE	Department of Planning and Environment
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPA	Environment Protection Authority (EPA – New South Wales)
EPBC Act	Environment Protection and Biodiversity Conservation (1999 – Cth)
FAA	Federal Aviation Administration (US)
Ft	Feet
GHG	Greenhouse gases
GMR	(Sydney) Greater Metropolitan Region
HAP	Hazardous air pollutant

Term/abbreviation	Definition
ICAO	International Civil Aviation Organization
Incremental impact	The impact due to an emission source (or group of sources) in isolation, i.e., without including background levels
Km/h	Kilometres per hour
KSA	Kingsford Smith Airport (Sydney)
LTO (cycle)	Landing take-off (phases of flight up to 3,000 feet)
m	metre
m^3	Volume in cubic metres
Mg/m^3	Milligrams per cubic metre
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen, including NO (Nitrogen Oxide) and NO_2
NOS	National Operating Standard (Airservices)
NSW	New South Wales
O_3	Ozone
O-D	Origin and destination (flight route)
PAAM	Plan for Aviation Airspace Management (the Action)
PM_{10}	Particulate matter less than 10 µm in aerodynamic equivalent diameter
$PM_{2.5}$	Particulate matter less than 2.5 µm in aerodynamic equivalent diameter
POEO Act	Protection of the Environment and Operations Act (1997 – NSW)
ppm	Parts per million
ppb	Parts per billion
RAAF	Royal Australian Air Force
RRO	Reciprocal runway operations
Sensitive receptor	A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area
SIA	Social Impact Analysis
SID	Standard instrument departure
SO_2	Sulfur dioxide
SO_3	Sulfur trioxide
STAR	Standard arrival route

Term/abbreviation	Definition
THC	Total hydrocarbons
US	United States
VOC	Volatile organic compounds
WRF	Weather Research and Forecasting
WSA	Western Sydney Airport Company Limited
WSI	Western Sydney International (Nancy-Bird Walton) Airport

Executive summary

Introduction

This technical paper investigates the potential air quality effects that may arise from the Western Sydney International (Nancy-Bird Walton) Airport (WSI) airspace and flight path design (the project). The assessment considers air quality effects at a local level near the airport, and at a regional level due to the aircraft movements.

It is important to note that the airfield, terminal, surface transport and landside infrastructure of WSI is not altered by the project and is not the subject of this EIS. This assessment is about the effects on air quality arising due to the revised design of flight paths, airspace changes, air traffic control procedures for the single runway operation of WSI which define the project. This will be a single runway for use by civil commercial passenger and freight aircraft. The airspace and flight path design considers the safety of air navigation, efficiency, capacity to meet projected demand and minimising adverse effects on the environment from WSI aircraft operations.

The local and regional air quality assessments prepared as part of the WSI Environmental Impact Statement (EIS) 2016 quantified the potential impacts associated with the single runway operation and included all land-based sources as well as all aircraft emissions. The aircraft emissions were based on the anticipated air traffic movement schedules, expected aircraft fleet and air emission estimate data available at the time of the assessment. The proposed airspace and flight path design developed as part of this project is based on a more contemporary aircraft fleet and associated air emissions.

This technical paper quantifies the existing environmental conditions and the potential effect of the project on the environment, including cumulative effects within the local and a regional assessment. The local assessment is focused on direct emissions near to the source, whereas the regional assessment also considers secondary pollutants, such as ozone (O_3), which may form in the atmosphere sometime after the emission of any precursor pollutants such as oxides of nitrogen (NO_X) and Volatile Organic Compounds (VOC).

The assessment for the EIS addresses the obligations under sections 28 and 160 of the Commonwealth (Cth) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Commonwealth agencies are required by the EPBC Act to assess the potential environmental significance of the proposed airspace arrangements and flight paths in the PAAM. This includes taking all reasonable and practicable steps to meet the requirements of prescribed in Airservices internal Environmental Management of Changes to Aircraft Operations standard (AA-NOS-ENV2.100 Version 18: Effective 1 July 2022).

This assessment also considers recognised Australian air quality impact assessment criteria, guidelines and recommended practices. The current, more stringent air quality impact assessment criteria for several pollutants of relevance to this assessment, including nitrogen dioxide (NO_2) and ozone (O_3) have been adopted for use in this study.

Existing environment

The prevailing wind flows in the area surrounding the WSI are influenced by the topography of the Sydney Basin region and include significant periods of stable night time temperature inversions in Western Sydney. The ambient air quality levels that are monitored at various locations surrounding the WSI indicate that air quality in the area is generally good and pollutant concentrations in the ambient air are typically below the relevant New South Wales (NSW) Environment Protection Authority (EPA) goals except for annual average particulate matter (PM) less than 2.5 micrometres in diameter ($PM_{2.5}$) levels and O_3. Historically, adverse air quality conditions arise from time to time due to extraordinary events such as dust storms and bushfires and periods of summer time elevated ozone.

Assessment methodology

The emissions from aircraft were derived using the United States (US) Federal Aviation Administration (FAA) Aviation Environmental Design Tool (AEDT). AEDT calculates both air and noise emissions from individual types of aircraft in the fleet per specific flight configurations and engine trust settings. Whilst lower emissions from future more modern aircraft are likely to arise in the future scenarios, the assessment conservatively assumes that future air emissions will remain per the current emission rates for aircraft. The flight paths have been optimised to minimise community noise, and the optimisation changes are reflected in the air emissions; for example where lower thrust settings are used to minimise noise, this reduces air emissions commensurately per the AEDT calculation methodology.

Air dispersion modelling for the local assessment is conducted with the CALPUFF modelling suite which is utilised in conjunction with the AEDT estimated emission rates for the air pollutants generated by the aircraft along the flight paths. The regional assessment uses the same AEDT emissions in the Community Multiscale Air Quality Model (CMAQ) model and covers the area of the greater Sydney Basin. The regional assessment uses complete NO_X and O_3 chemistry calculations over a large area, whereas the local assessment uses a simplified chemical conversion per the US EPA Ozone Limiting Method (OLM).

Main findings

The local air quality assessment indicates the predicted levels would be below criteria for all the assessed air pollutants except for $PM_{2.5}$ and NO_2 during 2055 at several receptors located to the immediate northwest of the runway. However, the elevated $PM_{2.5}$ levels arise due to existing elevated background levels, and the effect of the project would be intangible and insignificant. Whilst the project would contribute significantly to 1-hour average NO_2 levels at the nearest receptors to the northwest of the runway, the predicted levels of NO_2 are slightly above the more stringent, recently updated EPA criteria for only several hours out of 8,760 hours in the year that were assessed. (Notably, the predicted levels would meet the NO_2 criterion that was superseded whilst the study was being completed). The elevated NO_2 levels only occur at a few locations immediately near to the project. This area has been zoned to restrict further residential intensification, which facilitates the mitigation of potential future impact. When considering this and that the predicted results are likely to be conservative (overestimating of impacts) and as it is likely there will be improvements in fuel efficiency (for aircraft and motor vehicles) and decreases in aircraft emissions in the future, it is reasonable to conclude that no significant impacts would arise. The WSI would however incorporate mitigation measures within its control to monitor and minimise the generation of NO_X emissions wherever possible.

The regional assessment shows a similar small scale of NO_2 impacts to the local assessment, with predicted levels above the new more stringent EPA criteria in close vicinity to the airport in 2055. The regional ozone results indicate that in the locations with the maximum ozone concentrations, the project makes no significant difference to the impact that would arise in any case without the project. The results also show that the maximum changes in ozone (i.e. in locations away from where the maximum total ozone levels occur at the time) are up to 0.8, 0.6 and 0.6 pphm for 1-hour, 4-hour and 8-hour ozone respectively in 2055, however these maximum changes only occur where ozone concentrations are below criteria. On this basis the results show that the project does not generate any unacceptable level of impact.

The project’s impact on the concentrations of all other assessed pollutants would be negligible and unlikely to be discernible or measurable within the existing background concentrations.

Mitigation

In general aircraft air emissions can be reduced in one of 4 ways:

- renew fleets with cleaner, more fuel-efficient next-generation aircraft (i.e., Airbus A32N and Boeing B73M)
- retrofit aircraft for improved efficiency
- optimise airspace structures, flight routes and air traffic management services to reduce fuel consumption
- substitute fuel with less carbon intensive alternatives (e.g., SAF – bio or power to liquid feedstocks).

Changes to operating procedures and flight paths could significantly impact fuel consumption and the emissions of CO_2e from aircraft engine use. For instance, engine power (thrust) during take-off directly affects aircraft performance and cannot be directed towards achieving environmental outcomes without considering possible safety consequences. The selection of the take-off engine power (thrust) setting for an individual flight involves careful consideration of aircraft performance, engine life and maintenance requirements, aircraft status (inoperative components/systems), terrain, weather and runway conditions.

The measures to help reduce emissions from aircraft operations generally involve procedures and techniques to optimise the vertical profiles of aircraft climbing or descending to an airport engine power (thrust) settings and the configuration of flight paths relative to terrain and receptor communities. The measures tend to result in lower air emissions from the aircraft. The measures are described in the corresponding noise assessment (Technical paper 1 (Aircraft noise) (Technical paper 1)). The aerospace industry is continually developing technology to advance aerodynamic and engine propulsion systems to improve fuel efficiency and lower emissions. As these technologies mature and are commercialised at scale air emissions are expected to reduce in future due to the uptake of next generation aircraft in the fleet and retirement of older operating aircraft. To minimise the effects of WSI's flight operations on the surrounding air quality environment and at residential receptor locations, all reasonable and practicable mitigation measures would be utilised, as outlined in the Western Sydney Airport EIS – Local Air Quality and Greenhouse Gas Assessment (PEL, 2016). The measures include monitoring to quantify and verify actual pollutant concentrations near the WSI.

Conclusion

Overall, it can be concluded that the predicted impacts for NO_2 are small, infrequent and highly localised, $PM_{2.5}$ impacts arise due to elevated background pollutant levels, and that the results show no discernible changes in the maximum ozone impacts with or without the project. The impacts presented in this assessment are overestimated as there has been no accounting for the likely reduction in emissions from aircraft, motor vehicles and other such emission sources in future. With potential future reductions it is reasonably likely that no actual impacts would arise. Thus, the impacts are considered acceptable per the Minister's Guidelines EPBC 2022/9143.

Chapter 1 Introduction

This chapter provides an overview of the proposed airspace and flight path design for the Western Sydney International (Nancy-Bird Walton) Airport (WSI). This includes the background to WSI and its accompanying airspace and flight path design (the project) which impacts on the existing Sydney Basin airspace. It describes the key features and objectives of the project and identifies the purpose and structure of this this technical paper.

1.1 Western Sydney International (Nancy-Bird Walton) Airport

1.1.1 Background

In 2016, the then Australian Minister for Urban Infrastructure approved development for a new airport for Western Sydney, now known as the Western Sydney International (Nancy-Bird Walton) Airport (WSI), under the *Airports Act 1996* (Commonwealth). The site of the new airport (the Airport Site) covers approximately 1,780 hectares (ha) at Badgerys Creek, as shown in Figure 1.1. The Airport Site is located within the Liverpool local government area (LGA).

Following the finalisation of the *Western Sydney Airport – Environmental Impact Statement* (2016 EIS), the Western Sydney Airport – Airport Plan (Airport Plan) was approved in December 2016. The Airport Plan authorised the construction and operation of the Stage 1 Development. It also set the requirements for the further development and assessment of the preliminary airspace design for WSI. The Australian Government has committed to developing and delivering WSI by the end of 2026.

The 2016 approval provided for the on-ground development of Stage 1 Development of WSI (a single runway and terminal facility capable of initially handling up to 10 million passengers per year) utilising indicative ‘proof of concept’ flight paths. These flight paths, presented in the 2016 EIS demonstrated that WSI could operate safely and efficiently in the Sydney Basin. WSI will be a 24-hour international airport and will:

- cater for ongoing growth in demand for air travel, particularly in the rapidly expanding Western Sydney region, as well as providing additional aviation capacity in the Sydney region more broadly
- provide a more accessible and convenient international and domestic airport facility for the large and growing population of Western Sydney
- provide long term economic and employment opportunities in the surrounding area
- accelerate the development of critical infrastructure and urban development.

The Australian Government has committed to developing and delivering WSI by the end of 2026.

The design and assessment process for the next phase of the airspace design (referred to as the preliminary airspace design) was set by Condition 16 of the Airport Plan. This included the future airspace design principles and the establishment of an Expert Steering Group. Key to these design principles was the need to minimise the impact on the community and other airspace users while maximising safety, efficiency and capacity of WSI and the Sydney Basin airspace. The airspace design must also meet the requirements of Airservices Australia and civil aviation safety regulatory standards.

Led by the Australian Government Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA), the Expert Steering Group has developed the preliminary flight paths and airspace arrangements for WSI (the project). The preliminary airspace design is the subject of the Draft EIS and this assessment on the impacts to human health.

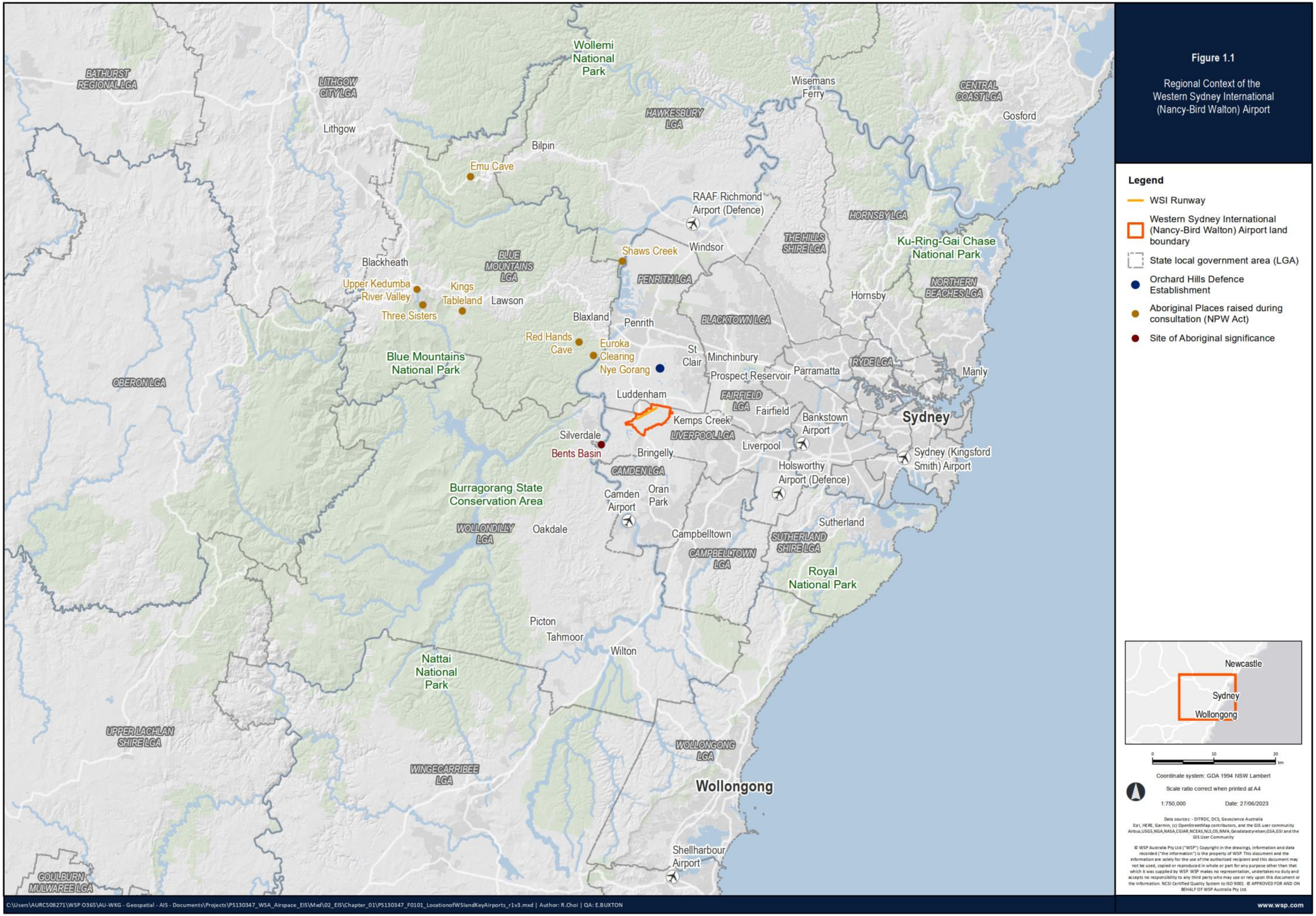

Figure 1.1 Regional Context of the Western Sydney International (Nancy-Bird Walton) Airport

1.1.2 The Airport

1.1.2.1 Stage 1 Development

The Stage 1 Development of WSI has been approved and is limited to single runway operations. It will handle up to 10 million annual passengers and around 81,000 air traffic movements per year by 2033 including freight operations (a movement being a single aircraft arrival or departure). Single runway operations are expected to reach capacity at around 37 million annual passengers and around 226,000 air traffic movements per year in 2055.

The approval provides for the construction of the aerodrome (including the single runway), terminal and landside layout and facilities, and ground infrastructure such as the instrument landing systems and high intensity approach lighting arrays. Construction of the Stage 1 Development commenced in 2018. Figure 1.2 shows location of the single runway within the Airport Site.

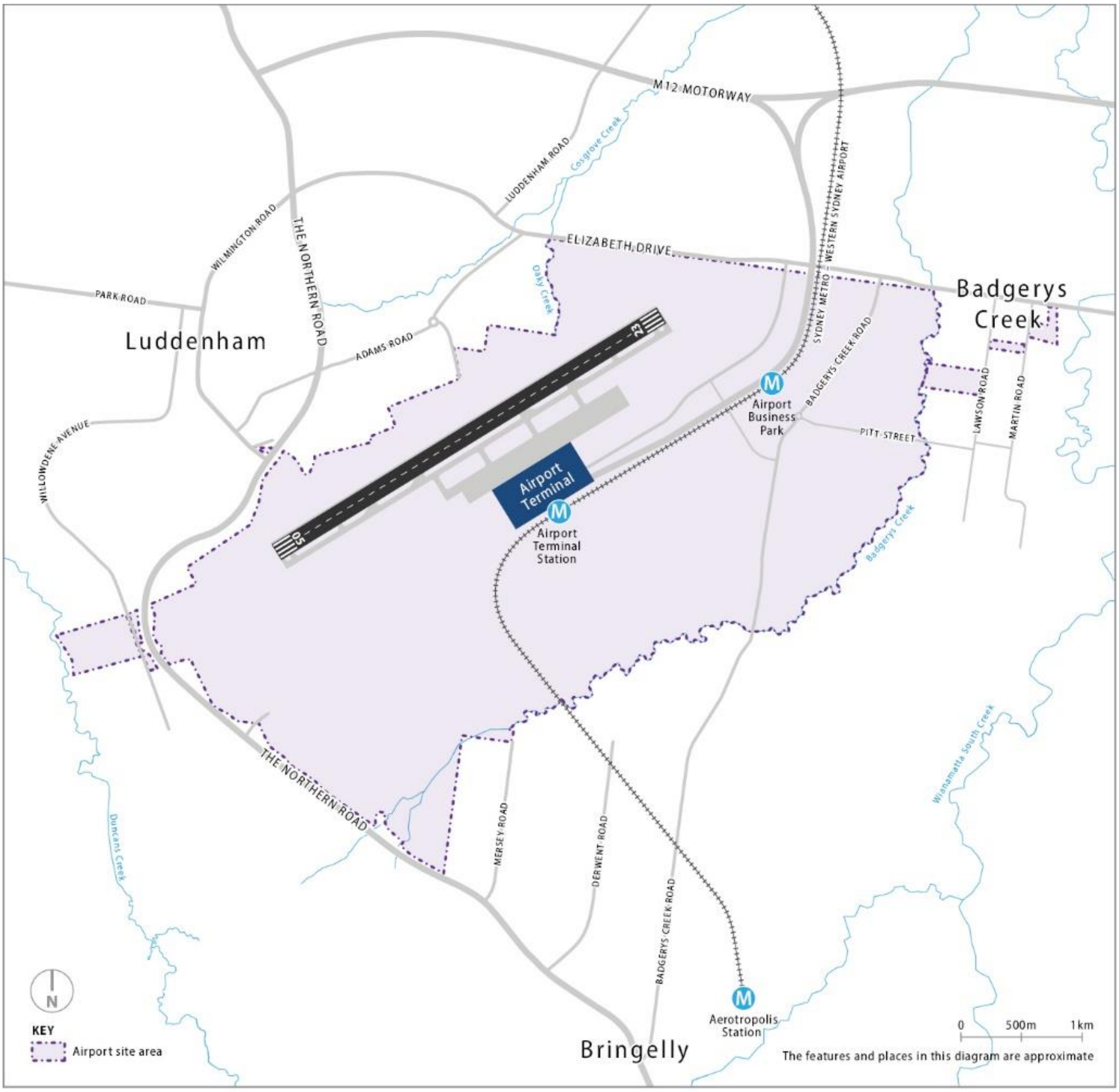

Figure 1.2 Western Sydney International Stage 1 Development

1.1.3 The 2016 EIS

An EIS for the WSI was finalised and approved by the then Minister for Environment and Energy in September 2016 and included a local and regional air quality assessment.

The *Western Sydney Airport EIS – Local Air Quality and Greenhouse Gas Assessment* (PEL, 2016) quantified the potential local air quality impacts due to the operation of Stage 1 airport development and long-term airport development. The Stage 1 Development considered a single runway with associated landside and airside facilities. The long-term development included parallel runways and additional facilities to cater for the additional passenger movements.

Air emissions associated with the operation of the airport were estimated using the United States (US) Federal Aviation Administration (FAA) Emissions and Dispersion Modelling System (EDMS) (Version 5.1.4, June 2013). Aircraft movements were identified to be largest source of PM_{10}, $PM_{2.5}$, NO_X and SO_2 followed by the operation of the auxiliary power units and ground support equipment. The biggest contributor of VOC emissions was determined to be from aircraft and fuel storage tanks. The air dispersion model applied to assess potential impacts was AERMOD with a study area defined as within a 5 kilometre radius of the airport site.

The local assessment states that for the Stage 1 operations no predicted exceedances of the applicable air quality criteria at the residential receptors were found, and that the highest predicted off-site concentrations were found to generally occur to the north and northeast of the airport site and were associated with the location of the runway and the prevalence of south-westerly winds in the modelling. The long-term operational impacts were only evaluated for key air quality metrics, i.e., NO_2, PM_{10} and $PM_{2.5}$. The results indicated some exceedances of the predicted 1-hour average NO_2 concentrations at 6 residential receptors, intermittently over the modelling period. Two off-site receptors were also predicted to experience an annual average $PM_{2.5}$ level above the relevant criterion.

The *Western Sydney Airport EIS Regional Air Quality Assessment* (Ramboll, 2016) considered the formation of secondary pollutants (i.e., ozone) due to emissions of precursor gases associated with the operation of the airport. Ozone impacts were evaluated using the Comprehensive Air quality Model with extension (CAMx). The modelling domain covered the wider Sydney Basin with air emissions from the airport estimated using EMDS.

In the regional assessment component, the modelling results were compared against the air quality objectives for maximum 1-hour and 4-hour ozone concentrations. For the Stage 1 Development (2030 Airport Case) the peak predicted 1-hour and 4-hour ozone concentrations were relatively unchanged compared to the base case, and the predicted ozone concentrations associated with the airport occurred to the south and southwest.

For the long-term development (2063 Airport Case) the maximum predicted 1-hour ozone concentrations remain unchanged, however the maximum 4-hour ozone concentrations increased on some days. The highest change in 1-hour and 4-hour results are above the level set out in the NSW tiered procedure for ozone assessment.

1.1.3.1 Key differences

Since the preparation of the 2016 EIS there have been updates to the applied emission estimation techniques and the air quality standards and criteria. The flight paths are also now able to be precisely modelled, and the assessment can use more contemporary meteorological and background air quality data. These contemporary differences make a direct comparison with the previous assessment difficult.

The emission estimation techniques in this assessment include an updated, contemporary emission database of aircraft and new fleet associated with the project. The relevant air quality criteria have also become more stringent for some key air pollutants such as NO_2 and O_3. Further details regarding these key differences are covered as relevant in the various sections of this report.

It is relevant to note that this project is about optimisation of the flight paths, and no changes arise with the operational ground level activities. Accordingly, a significantly more detailed evaluation of the flight paths is provided in this assessment, and there is no effect on any construction activities or operational ground level activities arising from this project. Cumulative impacts are considered, thus the predicted impacts due to operational ground level activities are included in this study as taken directly from the 2016 assessment.

1.2 The project

The project consists of the development and implementation of proposed flight paths and a new controlled airspace volume for single runway operations at WSI. The project also includes the associated air traffic control and noise abatement procedures for eventual use by civil, commercial passenger and freight aircraft. The airspace and flight paths would be managed by the Air Navigation Services Provider (ANSP), Airservices Australia.

The project involves flight paths for all-weather operations on Runway 05 and Runway 23 during the day (5:30 am to 11 pm) and night (11 pm to 5:30 am), as well as head-to-head Reciprocal Runway Operations (RRO) during night-time periods (when meteorological conditions and low flight demand permit) to minimise the number of residences subjected to potential noise disturbance.

The flight paths differ during the day and night. Flight paths at night differ to take advantage of the additional airspace capacity offered when the curfew for Sydney (Kingsford Smith) Airport is in force. The proposed flight paths are depicted in Figure 1.3 to Figure 1.7.

The project does not include any physical infrastructure or construction work.

1.2.1 Objectives of the project

The overall objectives for WSI are to:

- improve access to aviation services for Western Sydney
- resolve the long-term aviation capacity constraints in the Sydney Basin
- maximise the economic benefit for Australia by maximising the value of the Airport as a national asset
- optimise the benefit of WSI for employment and investment in Western Sydney
- deliver sound financial, environmental and social outcomes for the Australian community.

The project will assist in achieving these overall objectives as it would enable single runway operations to commence at WSI through the introduction of new flight paths and a new controlled airspace volume.

The Western Sydney Airport Plan sets out 12 airspace design principles that the design process is required to follow. The principles were informed by and reflect community and industry feedback on the 2016 EIS. The principles seek to maximise safety, efficiency and capacity, while minimising impacts on the community and the environment. For further information on the airspace design principles refer to Chapter 6 (Project development and alternatives) in the Draft EIS.

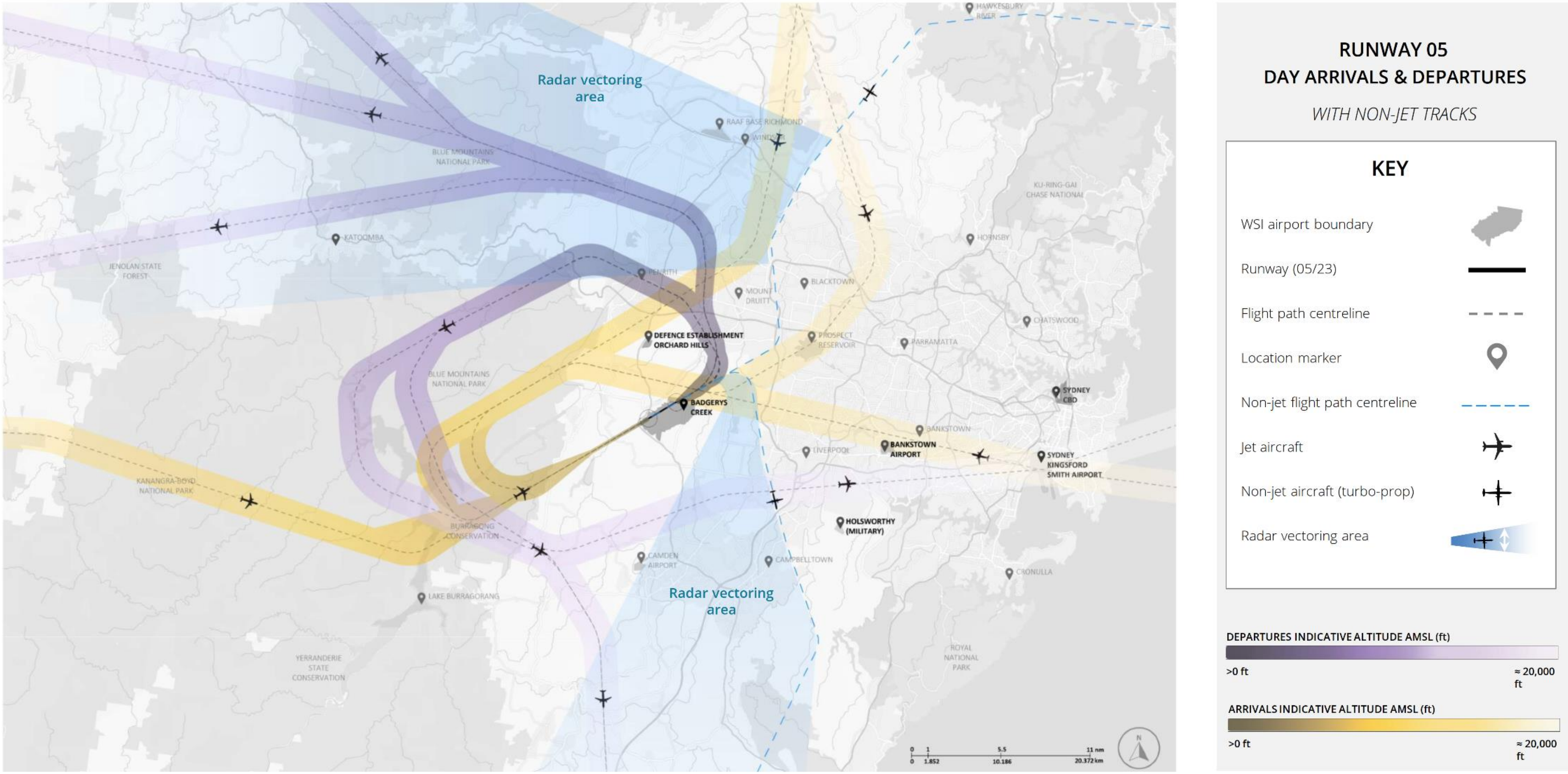

Figure 1.3 Proposed flight paths for Runway 05 (day)

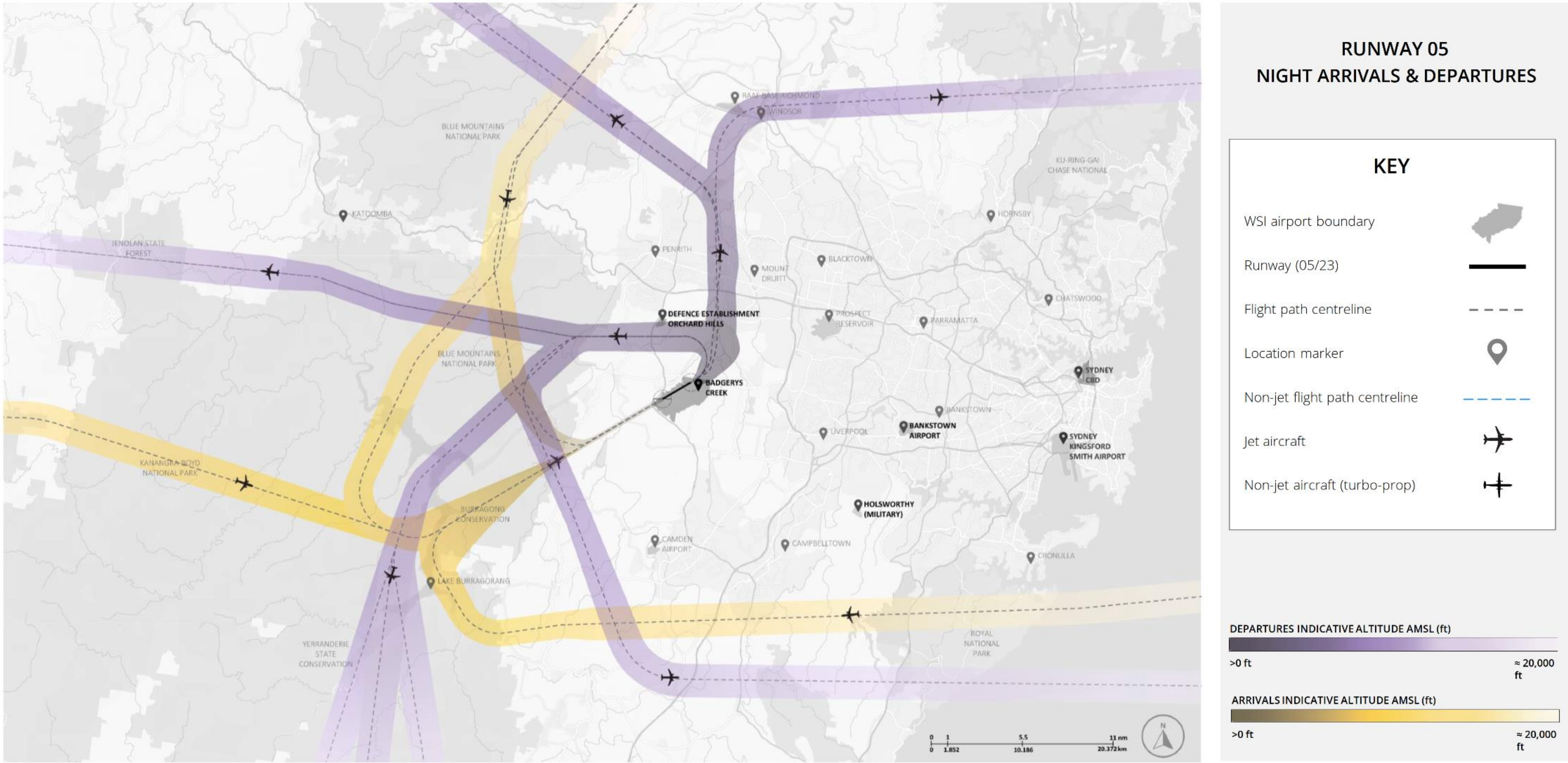

Figure 1.4 Proposed flight paths for Runway 05 (night)

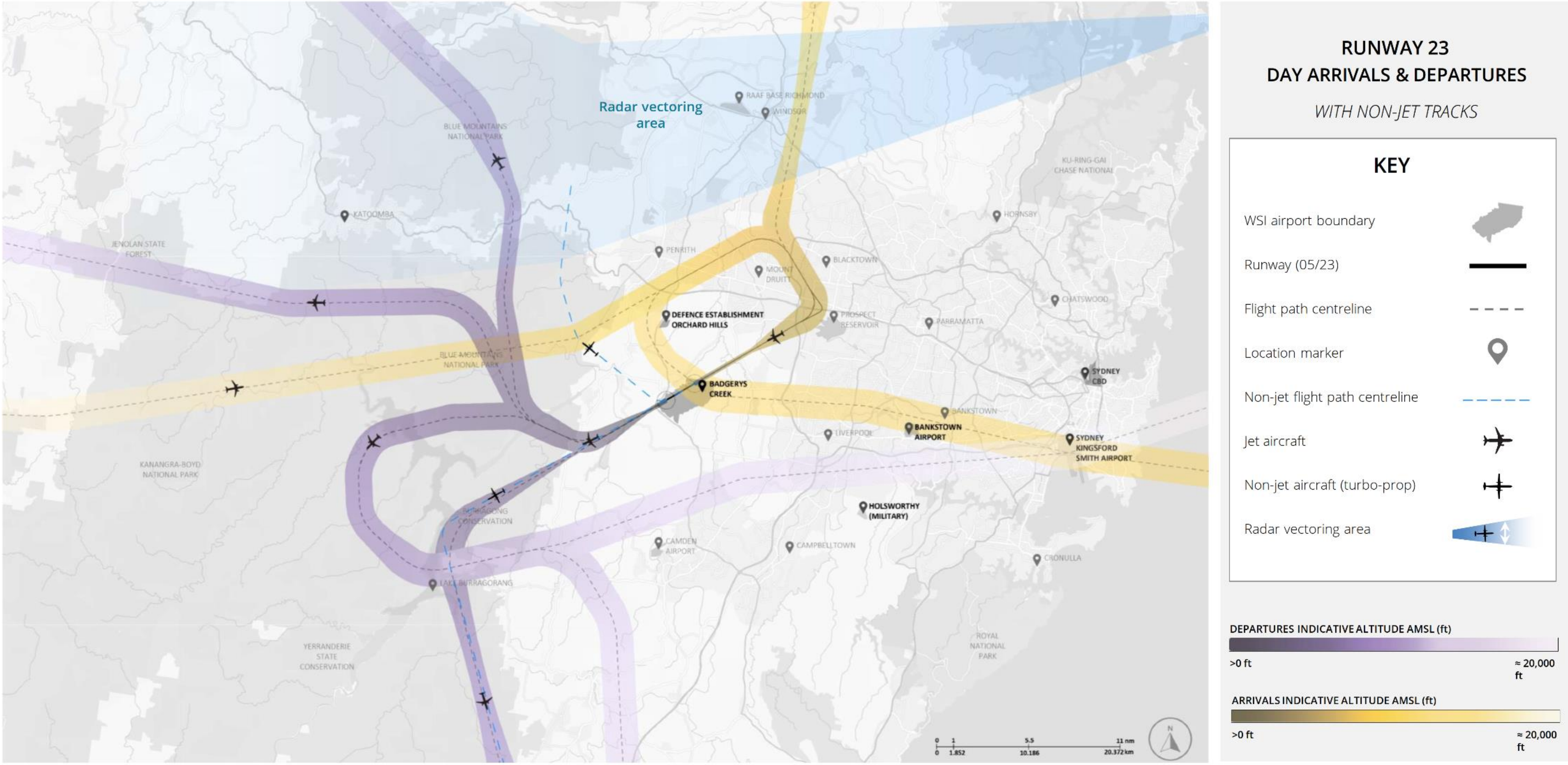

Figure 1.5 Proposed flight paths for Runway 23 (day)

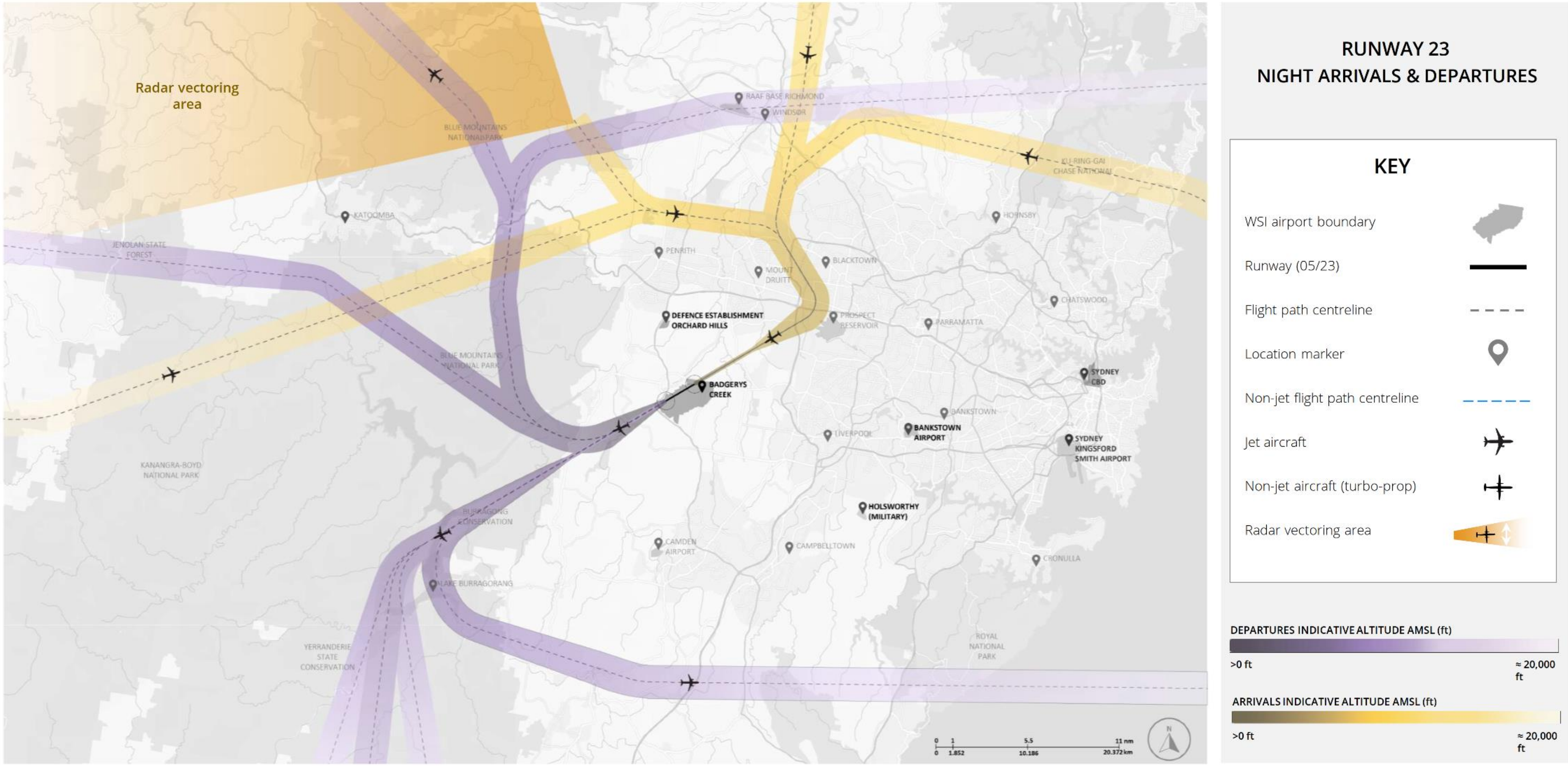

Figure 1.6 Proposed flight paths for Runway 23 (night)

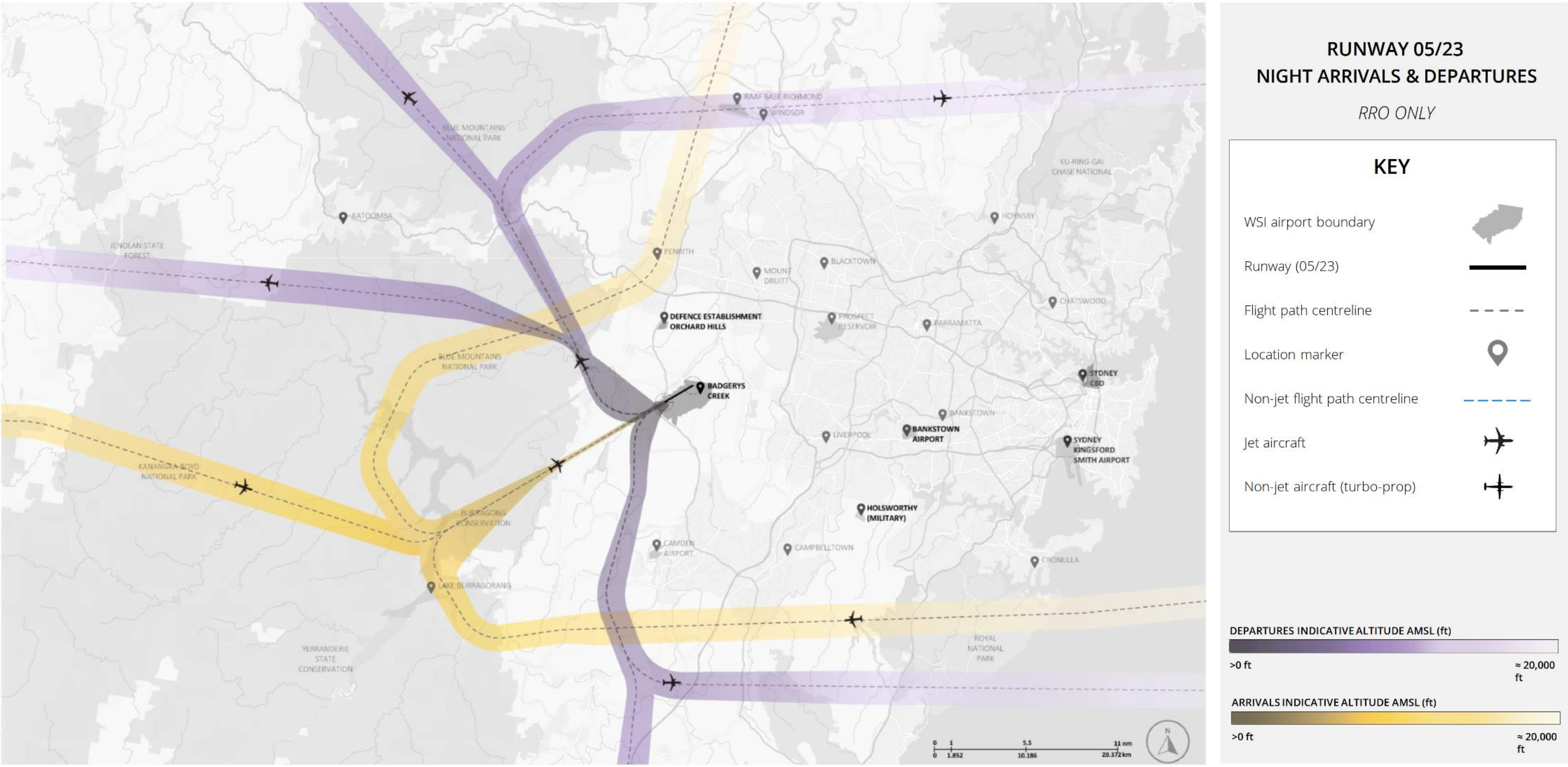

Figure 1.7 Proposed flight paths for Runway 05/23 (night)

1.3 Purpose of this technical paper

This report provides a technical assessment of the potential air quality impacts associated with the WSI's airspace and flight path design (the project) at a local and regional scale. The assessment it describes follows the current New South Wales (NSW) Environment Protection Authority (EPA) guidelines for assessing potential air quality impacts at ground level receptors. The report also addresses matters set out in the Minister's Guidelines (refer to EPBC 2022/9143) and the Airservices National Operating Standard (AA-NOS-ENV2.100).

The report quantifies the existing environmental conditions and the potential effect of the project on the environment, including cumulative effects. The results are compared with the applicable national air quality standards and state impact assessment criteria as a means of assessing acceptable impacts or compliance. It is noteworthy that for some air pollutants, the standard or criteria may already be exceeded in the existing environment, and this does not indicate that the project would have an unacceptable effect.

The report sets out the approach employed to undertake a local and regional assessment and presents the findings of the detailed modelling and analysis conducted for both assessments. The local assessment is focussed on direct emissions near WSI, whereas the regional assessment covers a much larger area and also considers secondary pollutants, such as ozone (O_3), which may form in the atmosphere sometime after the emission of any precursor pollutants such as Nitrogen Oxides (NO_X) and Volatile Organic Compounds (VOC).

1.3.1 Assessment requirements

The project was referred to the Minister for the Environment and Water in 2021 (EPBC 2022/9143) in accordance with Section 161 of the EPBC Act and Condition 16 of the Airport Plan. In response, the delegate for the Minister for the Environment and Water determined that an EIS would be required and issued the EIS Guidelines on 26 April 2022.

All requirements that need to be addressed regarding air quality are set out in Table 1.1, including where they are addressed in this report.

Table 1.1 Summary of Minister's EIS Requirements (EPBC 2022/9143)

EIS Guidelines reference	Information required	Location in this report
6.0 – Description of the environment	The EIS must include a description of the environment, land uses and character of the proposal site and the surrounding areas that may be affected by the action.	Chapter 4 outlines the existing environment including air quality.
7.1 – Describe and assess relevant Impacts	The EIS must include a description of all the relevant impacts of the action (including direct, indirect, facilitated and cumulative), including the magnitude, duration and frequency of the impacts.	This study considers the impact of the action on local and regional air quality.

EIS Guidelines reference	Information required	Location in this report
7.5.1 – Air Pollution	• analyse and describe the contribution and impacts of the proposed action on air quality at the relevant local, regional and national[1] scales • having regard to relevant weather characteristics including winds, fogs and temperature inversions and any topographic features which may affect the dispersion of air pollutants • reference must be made to levels of oxides of nitrogen, hydrocarbons, reactive organic compounds, sulphur dioxide, carbon monoxide, odours, air toxics and ultrafine particles • include specific reference to impacts on rainwater tanks and drinking water catchment areas from dispersion of air pollutants. Estimate greenhouse gas emissions and include a discussion on design and procedural measures to reduce such emissions. Provide context and comparisons to other sources at local, regional and national levels as appropriate.	• Chapter 6, Appendix C and Appendix D show the results. • Section 3.1.1 and Appendix A describe weather and topography. • Chapter 6, Appendix C and Appendix D show the results including, odours, air toxics and ultrafine particles. • Section 3.2.2 considers impacts on rainwater tanks and drinking water catchments. A separate assessment of GHG emissions is provided in Technical paper 3 (Greenhouse gas emissions) (Technical paper 3).
7.5.2 – Air pollution	Detail emergency fuel dumping procedures, including designated locations for such contingencies, effects of weather conditions on fuel dumping locations, notification to emergency services of fuel dumping occurring, and effects of fuel dumping.	Section 3.2.1. A separate assessment is provided in Technical paper 4 (Hazard and risk).
8.0 – Proposed safeguards and mitigation measures	The EIS must provide information on proposed safeguards and mitigation measures to deal with the relevant impacts of the action.	Chapter 8 considers proposed mitigation measures and safeguards.
–	Airservices Australia Environmental Management of Changes to Aircraft Operations AA-NOS-ENV2.100 version 18 effective 1 July 2022: Appendix A Environmental Screening Criteria, and Appendix B, Part 2. Fuel Burn and Emissions Assessment.	The NOS requires an assessment of air quality, which this study provides.

[1] It is noted that the Minister's guidelines seek an impact assessment at a national scale. Whilst this is relevant for any greenhouse gas assessment, the Project would not tangibly contribute to national air quality impacts beyond the local and regional effects presented in this report. A separate GHG assessment is provided in Technical paper 3.

1.4 Study area

1.4.1 Local study area

The WSI is located approximately 15 kilometres south-southeast of Penrith and approximately 20 kilometres east of Liverpool. The existing land use surrounding WSI consists of a mixture of low density residential and rural properties.

Figure 1.8 presents a 3-dimensional visualisation of the terrain features surrounding WSI. Please note that the regional assessment study area is significantly larger and is described in other sections, for example refer to Appendix B or Figure 5.9.

The topography of WSI and immediate surroundings is gently undulating with decreasing elevation to the east and southeast towards Thompsons Creek. Outside of WSI there are elevated ridges to the southwest and northwest. To the east of the site the terrain remains relatively flatter with some slight undulations. The Blue Mountains are to the west with the terrain becoming elevated and complex to the west of the north flowing riverine channel.

The terrain features of the surrounding area influence the local wind distribution patterns and flows which are important for the dispersion and propagation of air emissions.

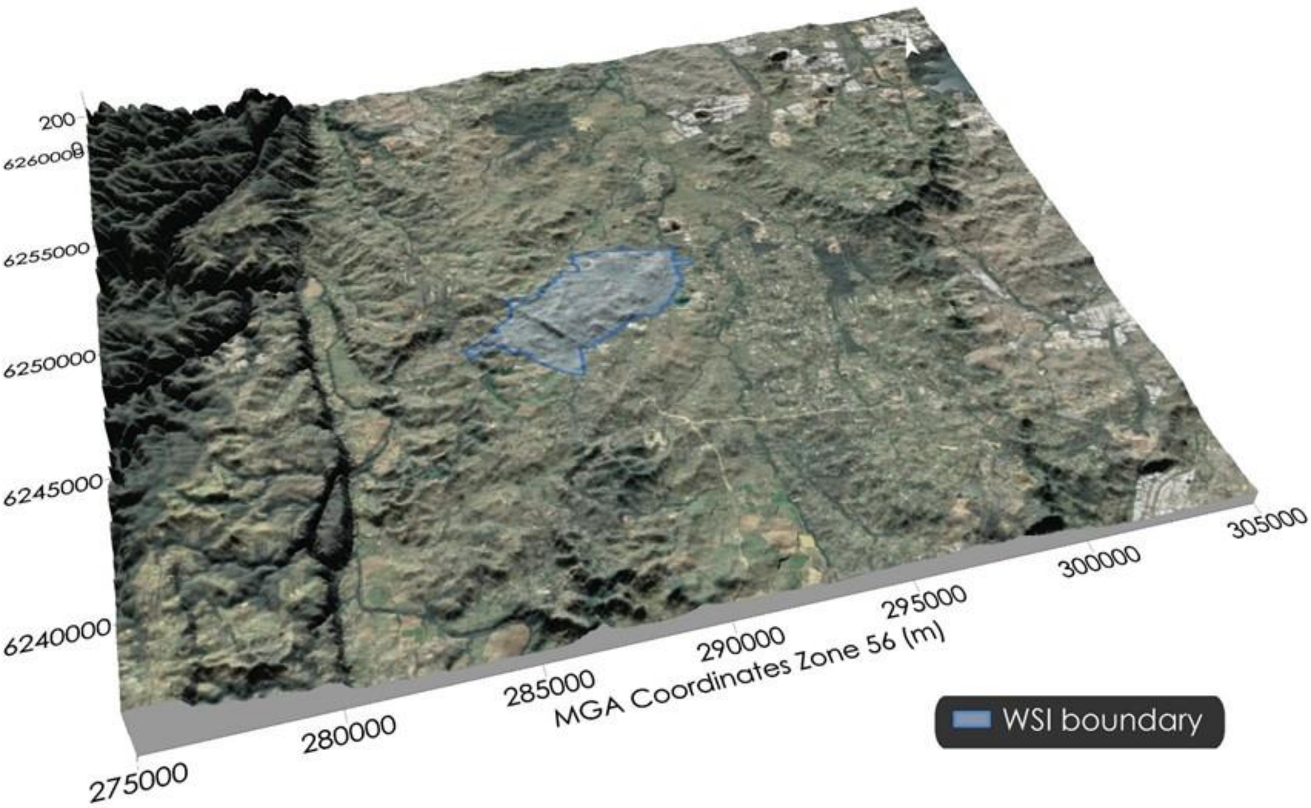

Figure 1.8 Representative visualisation of the local topography

Chapter 2 Legislation and strategic context

This chapter provides an overview of the broader air quality policies, legislation and strategies relevant to the project and considered in this technical paper.

The assessment for the EIS should also meet the applicable obligations under sections 28 and 160 of the Commonwealth (Cth) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Commonwealth agencies are required by the EPBC Act to assess the potential environmental significance of the proposed airspace arrangements and flight paths in the Plan for Aviation Airspace Management (PAAM). This includes taking all reasonable and practicable steps to meet the requirements of Airservices' prescribed in its internal Environmental Management of Changes to Aircraft Operations standard (AA-NOS-ENV2.100 Version 18: Effective 1 July 2022), which requires that an assessment of air quality is made. This study responds to that requirement.

The assessment for the EIS also considers recognised international and Australian national standards and recommended practices.

2.1 Commonwealth legislation and guidelines

2.1.1 Environment Protection and Biodiversity Conservation Act

The development of a greenfield airport at Badgerys Creek was the subject of an earlier EIS that was finalised and approved in September 2016 by the then Minister for the Environment and Energy under the EPBC Act.

As the action is referred under section 161 of the EPBC Act, the PAAM is subject to environmental assessment. It represents a clean-sheet-of-paper design from what was exhibited in 2015-2016 in the draft EIS for the Stage 1 Development of WSI, while following the principles and conditions set out in the Airport Plan.

The significance of any potential environmental effects of the project will be assessed in the EIS under the EPBC Act.

2.1.2 Airports (Environmental Protection) Regulation 1997

The *Airports (Environmental Protection) Regulation 1997* provides the regulatory framework for air pollution generated at an airport site from stationary sources and would exclude aircraft movements. As such this is only presented for background context and is not directly applicable to this project. The Regulation applies less stringent ambient air quality objectives at the airport (relative to the criteria adopted in this study to assess impacts outside the airport), as would be appropriate and expected at an airport.

Schedule 1 of the *Airports (Environmental Protection) Regulation 1997* includes accepted limits of contamination by specific sources and also ambient air quality objectives. The ambient air quality objectives apply at an airport and are not a key focus of this study, which considers the potential effects on the surrounding environment from aircraft movements.

The ambient air quality objectives in the Regulation are outlined in Table 2.1.

Table 2.1 Ambient air quality objectives for airport

Pollutant	Averaging period	Ambient objective (maximum averaged concentration)	
Lead (Pb)	3 months		1.5 ppm
Photochemical oxidants (ozone – O_3)	1 hour	210 µg/m³	0.1 ppm
	4 hours	170 µg/m³	0.08 ppm
Sulphur dioxide (SO_2)	10 minutes	700 µg/m³	0.25 ppm
	1 hour	570 µg/m³	0.2 ppm
	1 year	60 µg/m³	0.02 ppm
Total suspended particulates (TSP)	1 year	90 µg/m³	
Nitrogen dioxide (NO_2)	1 hour	320 µg/m³	0.16 ppm
Sulphates (SO_4)	1 year	15 µg/m³	
Carbon monoxide (CO)	8 hours	10 mg/m³	9 ppm

2.1.3 Air Navigation (Aircraft Engine Emissions) Regulation 1995

The *Air Navigation (Aircraft Engine Emissions) Regulation 1995* was created under the *Air Navigation Act 1920* and provides the regulatory framework for air pollution generated by aircraft.

Part 2 Regulation 4 of the *Air Navigation (Aircraft Engine Emissions) Regulation 1995* outlines the requirements necessary for aircraft to fly, which is determined through existing international certifications (i.e. Annex 16 – Environmental Protection, Chicago Convention). The regulations apply to any Australian domestic or international aircraft movements unless otherwise outlined in Part 2 Regulation 6.

These requirements are achieved by aircraft permitted to use Australian airspace and are reflected in the contemporary emissions database applied in this study.

2.1.4 Air Services Act 1995

The *Air Services Act 1995* established Airservices Australia and details the organisation's functions and powers relating to aircraft operations and Australia's airspace.

Section 9 of the *Air Services Act 1995* outlines Airservices Australia's obligations in exercising its powers, which must be in accordance with Australia's commitment to the Chicago Convention and any other international agreement. Specifically, Section 9 (2), expresses that the environment must be protected (where practicable);

a. *the effects of the operation and use of aircraft; and*

b. *the effects associated with the operation and use of aircraft.*

The *Air Services Act 1995* provides Australian aviation standards to ensure safety, consistency and efficiency of air navigation across Australia and internationally.

This assessment has been prepared to allow compliance with these environmental obligations to be demonstrated.

2.1.5 National Environment Protection (Ambient Air Quality Measure)

The *National Environment Protection Council (NEPC) Act 1994* and subsequent amendments define the National Environment Protection Measures (NEPMs) as instruments for setting environmental objectives in Australia.

The Ambient Air Quality NEPM specifies national ambient air quality standards for air pollutants and is similar to the NSW EPA air quality impact assessment criteria only in regard to the numerical value for many pollutants, but not in regard to how the standard applies (i.e. the NEPM standards do not apply to the assessment of impact from a project).

It is important to note that NEPM air quality standards are not designed to be applied to specific projects. The NEPM standards apply to the average exposure to air pollutants of the general population, in each state. The NEPM requires that the states report to the Commonwealth on the trends in air quality by way of reference to the standards. The NEPM allows communities to understand their local air quality and assists by providing data that can be used in the air quality policy development process.

The air quality standards for pollutants are outlined in Table 2.2.

The Ambient Air Quality NEPM also includes standards appliable from 2025 onwards for SO_2 of 0.075 ppm and also 2025 goals for $PM_{2.5}$ of 20 µg/m³ for a one day averaging period and 7 µg/m³ for one year averaging period.

Table 2.2 Ambient air quality NEPM standards for pollutants

Pollutant	Averaging period	Maximum concentration standard
CO	8 hours	9.0 ppm (11,250 µg/m³)
NO_2	1 hour	0.08 ppm (164 µg/m³)
	1 year	0.015 ppm (31 µg/m³)
O_3	8 hours	0.065 ppm (139 µg/m³)
SO_2	1 hour	0.10 ppm (286 µg/m³) (goal of 0.075 ppm from 2025)
	1 day	0.02 ppm (57 µg/m³)
PM_{10}	1 day	50 µg/m³
	1 year	25 µg/m³
$PM_{2.5}$	1 day	25 µg/m³ (goal of 20 µg/m³ from 2025)
	1 year	8 µg/m³ (goal of 7 µg/m³ from 2025)

Source: Australian Government (2021)

It important to note that the NEPM standards are not criteria that are applicable to this project.

2.1.6 National Environment Protection (Air Toxics) Measure

The Air Toxics NEPM specifies investigation levels for ambient air toxics concentrations. Like the Ambient Air Quality NEPM, the Air Toxics NEPM aims to facilitate the development of standards that will allow for the equivalent protection of human health and well-being.

The investigation levels for air toxics are outlined in Table 2.3.

Table 2.3 Air Toxics NEPM investigation levels

Pollutant	Averaging period	Investigation level
Benzene	1 year	0.003 ppm
Benzo[a]pyrene	1 year	0.3 ng/m³
Formaldehyde	1 day	0.04 ppm
Toluene	1 day	1 ppm
	1 year	0.1 ppm
Xylene	1 day	0.25 ppm
	1 year	0.2 ppm

Source: Australian Government (2021)

2.1.7 Minister's guidelines

The Australian Environment Minister issued guidelines for the content of a draft EIS for the WSI airspace and flight path design, (refer to Minister's Guidelines EPBC 2022/9143). The aspects that directly relate to air quality are copied below:

7.5 Air Pollution

Information required	
7.5.1	*Analyse and describe the contribution and impacts of the proposed action on air quality at the relevant local, regional and national scales, having regard to relevant weather characteristics including winds, fogs and temperature inversions and any topographic features which may affect the dispersion of air pollutants.* *Reference must be made to levels of oxides of nitrogen, hydrocarbons, reactive organic compounds, sulphur dioxide, carbon monoxide, odours, air toxics and ultrafine particles.* *Include specific reference to impacts on rainwater tanks and drinking water catchment areas from dispersion of air pollutants.* *Estimate greenhouse gas emissions and include a discussion on design and procedural measures to reduce such emissions. Provide context and comparisons to other sources at local, regional and national levels as appropriate.*
7.5.2	*Detail emergency fuel dumping procedures, including designated locations for such contingencies, effects of weather conditions on fuel dumping locations, notification to emergency services of fuel dumping occurring, and effects of fuel dumping.*

This assessment has been prepared to address these requirements (note however that the fuel dumping requirements are is addressed in detail in a separate assessment (insert link here>.

2.1.8 Environmental Management of Changes to Aircraft Operations Standard (NOS)

The purpose of the NOS Standard is to prescribe the requirements for environmental impact assessment (EIA), social impact analysis (SIA) and community engagement that must be met, prior to implementing changes to aircraft operations.

Because the proposed change introduces an entirely new flight path or area exposed to aircraft noise, per Stage C, Table 1 of Appendix A, the NOS requires an EIA and notification to community engagement.

The NOS states that "*…criteria have been developed by Airservices to provide a quantitative mechanism for determining proposed changes to aircraft operations with the potential to result in 'significant impact' to the environment (as defined under the EPBC Act). All proposed changes that meet the criteria shall be avoided wherever practicable through flight path redesign. Where it is not reasonably practicable for a change to be redesigned to avoid the potential environmental impact (for example, due to a clear safety imperative) Airservices shall seek advice from the Commonwealth Environment Minister prior to implementing the change (in accordance with sections 28 and 160 of the EPBC Act).*

Where the criterion is not met for a given change, Airservices may still decide to seek advice from the Commonwealth Environment Minister for potential significant impact (for example, if social impact analysis indicates a heightened risk of community or socio-political sensitivities to a change)."

Section 2 of Appendix B of the NOS provides criteria to determine whether to seek advice under the EPBC Act regarding potentially significant environmental impacts associated with increases in aircraft fuel burn and emissions, because of proposed changes to air traffic management practices. It also provides steps in applying fuel burn and emissions criteria: if specific criteria are met, advice must be sought from the Australian Environment Minister regarding the potential for the change to cause 'significant impact'.

This study considers the potential for air emissions (including NO_X, SO_X and PM) from aircraft fuel burn. In a separate technical paper, an assessment has been undertaken of aircraft fuel burn and associated greenhouse gas (GHG) emissions (CO_2 and CO_2e) from main engine use in phases of flight within a landing take-off (LTO) cycle up to 10,000 feet, along with full flight emissions across the route network to be served by WSI. The specific criteria from the NOS in this regard are copied directly below, including the footnotes:

2. Fuel Burn and Emissions Assessment

Table 4 provides criteria to determine whether to seek advice under the EPBC Act regarding potentially significant environmental impacts associated with increases in aircraft fuel burn and emissions, as a result of proposed changes to our air traffic management practices.

Table 4: Fuel burn and emissions criteria for seeking advice under the EPBC Act

Assessment element	***Criteria***
1. Airport and flight characteristics	
Airport size and category	*A large airport that has both a staffed Air Traffic Control tower and runways equal to or wider than Category 4C*[2]
Airport movements	*≥ 100 Regular Public Transport (RPT*[3]*) movements per day* *≥ 200 movements per day at a training airport*

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2 *Runway Code number 4 with Code letter of C, D, E or F. Table 6.2-1 minimum runway width. CASA Manual of Standards Part 139—Aerodromes. https://www.legislation.gov.au/Details/F2012C00095*

3 *Civil Aviation Safety Regulations 1998 (CASR). Part 121 - Commercial air transport operations (aeroplanes). "Fitted with more than 9 passenger seats in its approved configuration." https://www.casa.gov.au/standard-page/casr-part-121*https://www.casa.gov.au/standard-page/casr-part-121-commercial-air-transport-operations-aeroplanes*commercial-air-transport-operations-aeroplanes*

Assessment element	***Criteria***
Change in distance flown	*≥ 20% increase in flight path (within a 20NM radius from the Aerodrome Reference Point or ARP)* [4]
2. Fuel burn and emissions characteristics	
*Increase in fuel burn, CO_2 and other CO_2e emissions below 10,000 ft (compared to the existing situation)**	*≥ 20%*
*Increase in fuel burn, NOx, SOx and Particulate Matter (PM) below 3,000 ft (compared to the existing situation)**	*≥ 20%*

** Using AEDT modelling*

Steps in applying fuel burn and emissions criteria:

Step A	Determine the airport and flight characteristics and compare with associated criteria in Table 4. [If all ‘(1) Airport and flight characteristics’ criteria have been met, then proceed to steps B and C to assess ‘(2) Fuel burn and emissions characteristics’. If these criteria are not ALL met, then no further fuel burn or emissions analysis is required (proceed to Biodiversity assessment)]
Step B	*Using AEDT modelling, calculate any increase in fuel burn, CO_2 and other CO_2-e emissions below 10,000 ft altitude. Compare with Table 4 criteria.*
Step C	*Using AEDT modelling, calculate any increase in NOx, SOx and particulate matter (PM) emissions below 3,000 ft altitude. Compare with Table 4 criteria.*
► *Outcome:*	
	If the criteria in Steps B or C are met, then advice must be sought from the Commonwealth Environment Minister regarding the potential for the change to cause ‘significant impact’.
	If criteria are not triggered for steps B or C, then no further fuel burn and emissions analysis is required (proceed to Biodiversity assessment).

The NOS seeks that flightpath changes be designed to avoid environmental (and social) impacts to the greatest extent practicable, whilst prioritising operational safety.

Where an environmental impact assessment (EIA) is prepared, the NOS states that the purpose of the EIA is to appropriately identify and assess potential environmental impacts, provide information on potential impacts to support the social impact assessment process and community engagement, and to ensure that flight path designs are informed by environmental considerations and minimise the effect of aircraft operations on the environment (including communities) to the greatest extent practicable. (Section 6.2.1 of the NOS).

In summary, and air quality impact assessment is likely to be required (i.e., this study) and per Step C, the United States Federal Aviation Administration’s (US FAA) Aviation Environmental Design Tool (AEDT) software may be used to calculate the NO_X, SO_X and PM emissions from fuel burn below 3,000 ft (914 m) and compare it with the criteria in Table 4 (of the NOS), as set out above.

4 *The change in distance flown should consider all changes being undertaken by the proposal (so, if multiple procedures, 20% of all distances, but if a single procedure, 20% of that procedure).*

2.2 NSW legislation and guidelines

2.2.1 Protection of the Environment Operations Act 1997

The Action considers the requirements of the NSW *Protection of the Environment Operations Act, 1997* (POEO Act) and the relevant Regulations made under the Act (i.e., the NSW *Protection of the Environment Operations (Clean Air) Regulation, 2021*) as may be applicable.

The NSW legislative requirements are not specific to Commonwealth airport activities or aircraft operations, but the general provisions in this legislation are relevant for consideration, (and are like the NOS requirements for flight path designs to avoid potential environmental impacts). These aspects include appropriately managing and mitigating potential emissions to reduce overall environmental harm or impact in the environment due to operations from the project.

A core aspect of the project is to minimise the impact of the aircraft flight activities upon the community. Whilst the key potential environmental impact being managed via the flight path design is noise impact, it is noted that air quality impacts from aircraft operations are inherently minimised by minimising noise impacts and also due to direct commercial cost pressures. This occurs because the emissions from aircraft arise from the combustion of fuel, which is expensive and carries a commercial imperative to be minimised. An example is that aircraft generally take-off using derated or flexible engine thrust (reduced power) to save on fuel (and this in turn minimises atmospheric emissions) as well as the wear and tear of the engine parts and materials.

Whilst there are many physical activities that can be controlled to minimise air emissions, it is important to note that this assessment is about aircraft flight path design changes, and does not alter the approved ground level activities, which remain unchanged.

2.2.2 NSW Environment Protection Authority impact assessment criteria

Air quality criteria are benchmarks set to protect the general health and amenity of the community in relation to air quality. The sections below identify the potential air emissions generated by the Action and the NSW EPA air quality criteria, noting that these criteria do not formally apply to Commonwealth activities.

2.2.2.1 Air pollutants

The NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2022) includes criteria for a range of pollutants that may be emitted from a development or facility.

The key air emissions generated by airport operations include particulate matter/dust, CO, SO_2, NO_x and air toxics such as Volatile Organic Compounds (VOC).

Secondary air pollutants, namely O_3 is not directly emitted and may indirectly form in the atmosphere due to emissions of NOx and VOC. Ozone is a regional issue and is considered in detail in the regional assessment.

Table 2.4 summarises the air quality goals that are current at the time of the modelling for this assessment as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2022).

Table 2.4 NSW EPA air quality impact assessment criteria

Pollutant	Averaging period	Percentile	Criterion	Criterion	Location
Total suspended particulates (TSP)	Annual	100	90 µg/m^3	–	Receptor
Particulate matter ≤10 µm (PM_{10})	Annual	100	25 µg/m^3	–	Receptor
	24-hours	100	50 µg/m^3	–	Receptor
$PM_{2.5}$	Annual	100	8 µg/m^3	–	Receptor
	24-hours	100	25 µg/m^3	–	Receptor
Deposited dust	Annual	100	2 g/m^2/month [a]	–	Receptor
	Annual	100	4 g/m^2/month [b]	–	Receptor
CO	15 minutes	100	100 mg/m^3	87 ppm	Receptor
	1 hour	100	30 mg/m^3	25 ppm	Receptor
	8 hours	100	10 mg/m^3	9 ppm	Receptor
SO_2	1 hour	100	[c] 286 µg/m^3	[a] 0.1 ppm	Receptor
	1 hour	100	[d] 215 µg/m^3	[b] 0.075 ppm	Receptor
	24-hours	100	57 µg/m^3	0.02 ppm 2 pphm	Receptor
NO_2	1 hour	100	164 µg/m^3	0.08 ppm 8 pphm	Receptor
	Annual	100	31 µg/m^3	0.015 ppm 1.5 pphm	Receptor
O_3	8 hours	100	139 µg/m^3	0.065 ppm 6.5 pphm	Receptor
Benzene	1 hour	99.9	0.029 mg/m^3	0.009 ppm	Boundary
Benzo[a]pyrene	1 hour	99.9	0.0004 mg/m^3	–	Boundary
Formaldehyde	1 hour	99.9	0.02 mg/m^3	0.018 ppm	Boundary

Notes: µm = micrometre, g/m^2/month = grams per square metre per month, µg/m^3 = micrograms per cubic metre, mg/m^3 = milligrams per cubic metre, ppm = parts per million, pphm = parts per hundred million.

[a] maximum increase in deposited dust level

[b] maximum total deposited dust level

[c] this impact assessment criterion applies to assessments prepared before 1 January 2025

[d] this impact assessment criterion applied to assessment prepared after 1 January 2025.

2.2.2.2 Odour

In NSW, odour in a regulatory context needs to be considered in 2 similar, but different ways depending on the situation.

NSW legislation (POEO Act*)* prohibits emissions that cause offensive odour to occur at any off-site receptor. Offensive odour is evaluated in the field by authorised officers, who are obliged to consider the odour in the context of its receiving environment, frequency, duration, character and so on and to determine whether the odour would interfere with the comfort and repose of the normal person unreasonably. In this context, the concept of offensive odour is applied to operational facilities and relates to actual emissions in the air.

However, in the approval and planning process for proposed new operations or modifications to existing projects, no actual odour exists, and it is necessary to consider hypothetical odour. In this context, odour concentrations are used and are defined in odour units. The number of odour units represents the number of times that the odour would need to be diluted to reach a level that is just detectable to the human nose. Thus, by definition, odour less than one odour unit (OU), would not be detectable to most people.

The range of a person’s ability to detect odour varies greatly in the population, as does their sensitivity to the type of odour. The wide-ranging response in how any particular odour is perceived by any individual poses specific challenges in the assessment of odour impacts and the application of specific air quality goals related to odour. The NSW Odour Policy (NSW DEC, 2006) sets out a framework specifically to deal with such issues.

It needs to be noted that the term odour refers to complex mixtures of odours, and not “pure” odour arising from a single chemical. Odour from a single, known chemical rarely occurs in the ambient environment (but when it does, it is best to consider that specific chemical in terms of its concentration in the air). In most situations odour will be comprised of a cocktail of many substances which is referred to as a complex mixture of odour, or more simply odour.

For activities with potential to release significant odour it may be necessary to predict the likely odour impact that may arise. This is done by using air dispersion modelling which can calculate the level of dilution of odours emitted from the source at the point to where odour reaches surrounding receptors. This approach allows the air dispersion model to produce results in terms of OUs.

The NSW criteria for acceptable levels of odour range from 2 to 7 OU, with the more stringent 2 OU criteria applicable to densely populated urban areas and the 7 OU criteria applicable to sparsely populated rural areas, as outlined below.

2.2.2.3 Complex mixtures of odorous air pollutants

Table 2.5 presents the assessment criteria as outlined in the NSW EPA document Approved Methods for the Modelling *and Assessment of Air Pollutants in NSW* (NSW EPA, 2022). This criterion has been refined to consider population densities of specific areas and is based on a 99th percentile of dispersion model predictions calculated as 1-second averages (nose-response time).

Table 2.5 Impact assessment criteria for complex mixtures of odorous air pollutants (nose-response-time average, 99th percentile)

Population of affected community	Impact assessment criteria for complex mixtures of odorous air pollutants (OU)
Urban (≥~2000) and/or schools and hospitals	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
Single rural residence (≤~2)	7.0

Source: NSW EPA, 2022

The NSW odour goals are based on the risk of odour impact within the general population of a given area. In sparsely populated areas the criteria assume there is a lower risk that some individuals within the community would find the odour unacceptable, hence higher criteria apply.

Whilst the odour criteria are shown here for context, the potentially odorous emissions from an airport relate to specific substances in the fuel, and the potential for odorous impact is assessed for each substance per its impact assessment criteria, as set out in the next section.

2.2.2.4 Individual odorous air pollutants

The NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2022) includes criteria for individual odorous air pollutants that may be emitted from a development or facility. The criteria are based on the threshold of odour annoyance, which is a concentration that is lower than the concentration of that substance which may relate to any health impact.

The individual odorous air pollutants generated by airport operations principally include toluene and xylene. Table 2.6 summarises the air quality goals that are current at the time of the modelling for this assessment as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2022).

Table 2.6 NSW EPA air quality impact assessment criteria for individual odorous air pollutants

Pollutant	Averaging period	Percentile	Criterion	Criterion	Location
Toluene	1 hour	99.9	0.36 mg/m³	0.09 ppm	Receptor
Xylene	1 hour	99.9	0.19 mg/m³	0.19 ppm	Receptor

Chapter 3 Methodology

This chapter provides an overview of the methodology for the air quality assessment, including the approach to assessment, dependencies with other studies and any limitations and assumptions.

3.1 Impact assessment approach

Separate technical air modelling methods are needed to complete the local and regional air quality impact assessments.

The local air quality impact assessment focuses on the potential for air quality impacts to arise in the immediate vicinity of the WSI and assess a range of potential air pollutants that are directly emitted into the air.

The regional air quality impact assessment focuses on the potential for air pollutants to affect the regional air quality environment in the Sydney Basin, and specifically considers the potential formation of secondary pollutants, namely ground level O_3. The regional assessment is thus focussed on any additional formation of ozone that may arise from the direct emissions of the precursor pollutants, NO_X and VOC[5].

3.1.1 Local air quality methodology

The local air assessment utilises well established, commonly used modelling methods to calculate the dispersal of air pollutants with distance away from the source. The modelling methods follow the NSW EPA guidelines set out in *Approved Methods for the Modelling and Assessment of Air Pollutants in New* South Wales (NSW EPA, 2022), and the NSW EPA document *Generic Guidance and Optimum Model Setting for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'* (TRC Environmental Corporation, 2011).

The CALPUFF modelling system is used in this study to assess local air quality effects. The model uses aircraft emissions data from AEDT which is applied by others on this project to develop the noise and air emissions profiles of the proposed aircraft operations. CALPUFF is an approved regulatory model by the US EPA and the NSW EPA. CALPUFF is suitable for use for the local assessment and is capable of accurately considering the dispersion of emissions during calm and temperature inversion conditions which may arise in the area. It is noted that the AEDT model which develops air and noise emissions for aircraft contains the AERMOD air dispersion model within it. However, the current version of AEDT does not contain the current preferred AERMOD defaults/model version. In any case AERMOD is inherently not ideally suited for accurately modelling calm wind conditions, which are significant in Western Sydney, hence these are 2 key factors for the selection of the CALPUFF model in this case.

At the time of the air dispersion modelling for this report the NSW EPA updated the Approved Methods, and adopted the recently updated NEPM air quality standards as impact assessment criteria in the now current version of the Approved Methods. This report presents an assessment of local are quality per the currently appliable EPA criteria. These include more stringent criteria for NO_2 and O_3.

Modelling inputs include:

- air emissions – emissions for the aircraft are sourced from AEDT, Version 3e, which have been provided by Airbiz. Emissions from ground-based project activities are sourced from the previous 2016 EIS, noting that no changes to ground level operations are proposed (PEL, 2016)
- background air quality data are applied for assessing cumulative impacts with existing sources of local air pollution. The DPIE data at Bringelly are closest and have been used as far as possible

[5] The reactive organic compounds (ROC) subset of the VOC are primarily involved in the chemical reaction forming ozone.

- weather conditions – weather conditions for each hour of a representative year have been developed by TAS using the available local weather monitoring data and other inputs. The CSIRO TAPM model, along with site observations from the surrounding DPE and BOM weather stations has been used to prepare a site-specific weather file. The meteorological modelling also relies on terrain and land use inputs, as set out below:
  - terrain – terrain data for the Sydney Basin at 30 metre resolution has been used to characterise the topography that may affect surface air currents, but also larger geographical features such as the Great Dividing Range/ Blue Mountains, and the coastline that affect meteorological air dispersion conditions throughout the study area. These data used as inputs in the development meteorological model to ensure the effects of the terrain on induced flows, such as katabatic drainage flows under inversions conditions, and calm potentially foggy conditions are adequately characterised, along with any effects on the wind fields
  - land use data – the type of land use also affects air dispersion conditions, for example the man-made concrete and bitumen surfaces may cause a heating effect whereas natural vegetation may cause a cooling effect, and this heat difference can affect air dispersion patterns. Land use is another input to the meteorological model.

Various other technical model settings are detailed in Appendix A.

3.1.2 Regional air quality methodology

The regional air quality assessment is focused on the effects of the project on ground level air quality within the modelling domain, spanning over the Sydney Basin air shed. The regional model is thus focused on atmospheric chemistry as it affects ozone at ground level.

As noted, the current impact assessment criteria for ozone is based on an 8-hour average which was adopted by the NSW EPA in late 2022 and is based on the NEPM reporting standard that came into force in May 2021. The previous ozone criteria was based on a 1 hour and 4-hour average criteria. The current 8-hour averaging period criteria is more stringent than the previous. All 3 averaging periods are considered in this study.

The modelling follows the current NSW EPA guidelines, specifically the *Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources*, (NSW EPA, 2011), it is noted that this guideline is not strictly applicable to the project as it applies to stationary sources, however it is the only generally suitable ozone guideline available that is specifically designed for use in NSW. The procedure indicates that the emissions from the proposal are significant enough to warrant a Level 2 assessment of ozone.

Regional ozone modelling systems have a meteorological modelling component and also an air dispersion and atmospheric chemistry modelling component. The performance of regional ozone modelling systems that are suitable for application in the Sydney airshed were recently evaluated by a group of leading researchers in the field. The evaluation was done in 2 parts, the first part examined the performance of the meteorological component (Monk et al., 2019), and the second part considered the performance of the whole modelling system, i.e. the overall results from the meteorological and air dispersion/chemistry components in combination (Guerette et al., 2020) The research involved various Australian Universities, EPA's, planning and environment departments and the CSIRO, and led to improvements in how the various models can be parameterised/implemented in the Sydney region to improve their performance.

The Weather Research and Forecasting (WRF) meteorological model and the Community Multiscale Air Quality Modelling System (CMAQ) model were available for use in this study are one of the 7 modelling systems evaluated. The evaluation found that the WRF/CMAQ system performed well and was suitable for reliably modelling of potential ozone impacts. Refer to Appendix B.

The WRF/CMAQ model was selected for use in this study as it was found by leading researchers to perform reliably well in the Sydney airshed, and also because it was available for use in the period for December 2021 to January 2022 with the same parametrisation (settings) as those implemented in the evaluation study (Guerette et al., 2020).

It is relevant to note that the previous assessment by Ramboll did not identify any significant ozone impacts in the community at ground level, however at that time the (now current) NEPM 8-hour ozone standard did not exist. (More ozone impacts arise due to nothing other than the more stringent 8-hour value, and this does not mean there has been any significant change in the impacts relative to previous assessments.)

Unlike the local air quality assessment, only selected periods of high ozone impact potential are analysed. This is in accordance with the EPA guidelines and is necessary because the model is complex and requires a high level of human and computing effort and time to run, making it impractical to consider every hour of the year. The periods of high ozone impact potential arise in the warmer seasons, when the conditions are most conducive to the chemical reactions in the atmosphere that form ozone. The requirement is that several days should be selected for assessment, as a minimum at least 3 to enable comparison of source impacts across multiple high ozone days.

The NSW EPA air emissions Inventory (NSW EPA, 2019) was used to characterise existing sources of air emissions in the Sydney Greater Metropolitan Region (GMR), including Biogenic emissions (from plants).

The model was run without including the potential new emissions from the WSI and compared with the measured data as part of the due diligence or verification of model performance (Appendix D).

Similar to the local assessment, the AEDT Version 3e was run by others to develop an air emissions file. The emissions taken from AEDT are key inputs to the regional model and represent the emissions from all aircraft movements at WSI per the project.

The verified regional model was then re-run with the WSI emissions included, and the results compared with the base case to determine the effects on air quality that may arise due to the project. Further details of the methodology are provided in Appendix B and the results are set out in Appendix D.

As a guide, incremental contributions (from only the project in isolation) of one per cent and 6 per cent of the O_3 criterion value are considered not to be significant (Environ, 2011). The analysis mainly considers the ratio of the model's future predicted impacts to current (baseline) predictions at monitors, as the model is reliable in a relative sense and less reliable in an absolute sense.

Notably the current 8-hour ozone standard excludes extraordinary events such as bushfires. Whilst such events are noted and reported, they do not count as conditions leading to an exceedance. Thus, potential impacts are to be assessed by determining the highest number of ozone exceedance days not significantly impacted by bushfires events.

Technical aspects of the modelling are detailed in Appendix B, key points include:

- the model uses a grid resolution of one kilometre by one kilometre, noting that flying aircraft take only seconds to pass through each grid cell
- emissions from the project were modelled as elevated point sources, with heights determined based on distance travelled along flight paths
- all points source emissions from commercial and industrial sources, and all area source emissions from on-road mobile sources, and all area source emission and fugitive emissions from biogenic (with exclusions), commercial, domestic, industrial and off-road mobile sources in the NSW GMR inventory are used as specified by the NSW EPA, and
- the ozone impacts of the new source have been determined from the difference between the 2 model runs (with and without the project).

Various other technical model settings are detailed in Appendix B.

3.2 Dependencies and interactions with other technical papers

The key project air emissions from aircraft have been provided by Airbiz using the AEDT model. Todoroski Air Sciences used these emissions as the basis for developing modelling emissions input files for the air dispersion models used in this study. The AEDT model provides both noise and air emission outputs. The anticipated noise and air emissions have thus been calculated based on the same assumptions, ensuring consistency between these 2 technical disciplines.

The assessment of GHG emissions is not presented in this technical paper but is also based on the same emissions assumptions derived from the AEDT model. The GHG assessment has been conducted by Airbiz, please refer to Technical paper 3.

The outputs of the Air Quality Assessment are one of the inputs into the Human Health Risk Assessment by EnRisks, which can be found at Technical paper 12 (Human health) (Technical paper 12). The health risk assessment includes consideration of material deposition on surfaces, including drinking water catchments and rainwater tanks.

3.2.1 Fuel dumping

Fuel dumping is undertaken in accordance with appropriate procedures (specifically, the Manual of Air Traffic Services (MATS) Section 4.2.11 – Fuel Dumping) and does not result in impacts at ground level. Fuel jettisoned at a sufficient altitude will volatise as it falls and is completely dispersed as vapour before any liquid reaches ground level to avoid any ground contamination.

3.2.2 Effects on rainwater tanks and drinking water catchments

The potential deposition of air pollutants associated with the project on local rainwater tanks and the drinking water catchment has been considered in the local air quality assessment. The model has been run with deposition enabled, which allows the amount of contributed air pollutants to these receiver types to be determined. Conservative calculations (that overestimate any potential impacts) have been applied to determine the amount of potentially deposited pollutants.

The impact of the contribution due to the project is presented in the Human Health Risk Assessment by EnRisks (Technical paper 12). This air quality study provides the calculated values of any deposited air pollutants into rainwater tanks and water catchments, and the health risk assessment uses these values to determine whether these pollutants may cause any adverse effect.

3.3 Limitations and assumptions

Key limitations arise for the future scenarios, including the following areas of uncertainty or conservatism:

- The AEDT model only utilises verified emissions performance for existing aircraft. However, it is likely that more efficient and less polluting aircraft will be developed and become operational in the future scenarios. Thus, the model may overestimate likely emissions from aircraft in the future scenarios.
- The NSW EPA GMR inventory projections do not stretch out to 2055, and there is a relatively high degree of uncertainty about traffic and other anthropogenic air emissions at that time (including other aircraft emissions from Sydney (Kingsford Smith) Airport). For example, it may be reasonable to assume a larger proportion of electric vehicles in the NSW fleet in 2055, and this would reduce baseline NO_2 levels in the Sydney airshed (noting that vehicle emissions are the dominant contributor to the measured levels). However, it is challenging to define a specific proportion of the fleet that may be electrified so far into the future. Therefore, relatively conservative, (overestimating of emissions) assumptions are applied.
- Present trends indicate the climate is warming and increasing global temperatures. Even the best-case estimates project tangible temperature increases. Higher temperatures may increase reactions that form O_3 in the future, provided there is sufficient NO_X present to sustain the reactions (which may not be the case due to de-carbonisation of energy and transport that will likely limit future fuel combustion). Hence an increase in reactivity may be tempered by any decreasing NO_X concentrations in the Sydney air shed. Figure 3.1 and Figure 3.2 present the daily maximum 1-hour average O_3 and NO_2 concentrations, respectively, for the Sydney Basin.

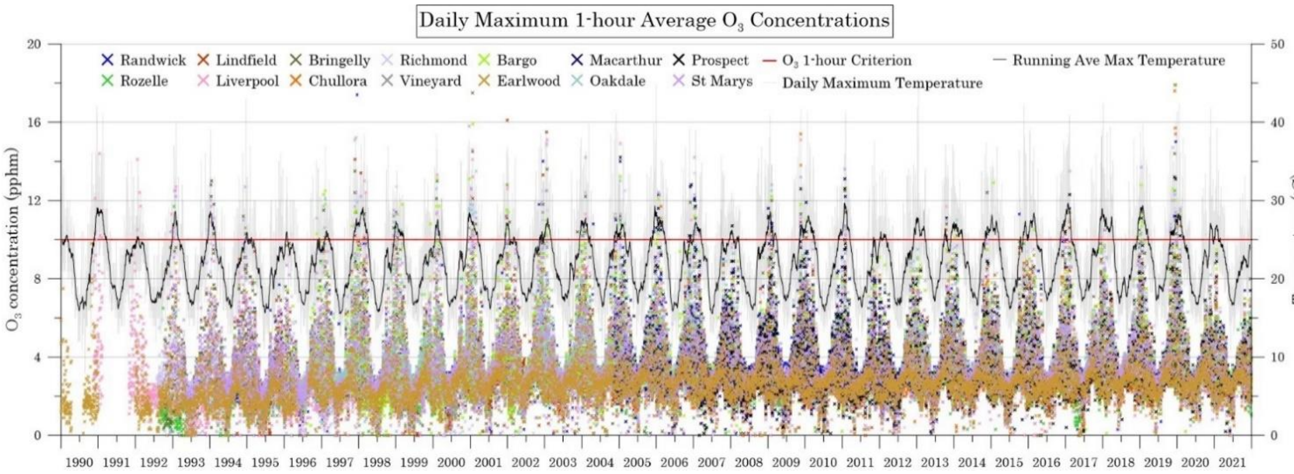


Figure 3.1 Daily maximum 1-hour average O_3 concentrations for Sydney Basin

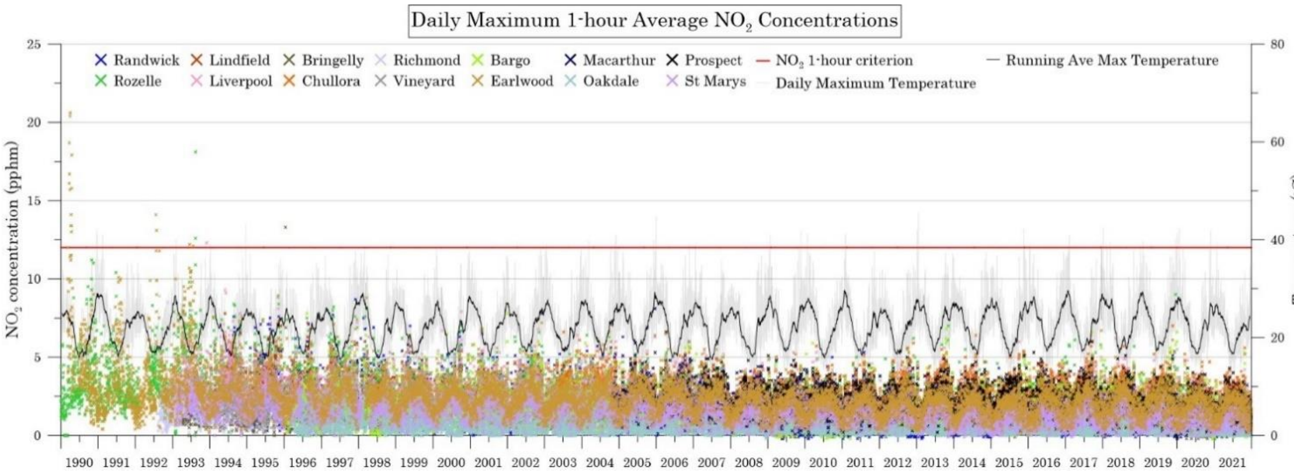


Figure 3.2 Daily maximum 1-hour average NO_2 concentrations for Sydney Basin

- As a guide, we note that in 2008 the CSIRO provided ozone impact projections for 2020–30 and 2040–50 (Cope M. et al., 2008). These projections indicate more widespread but not more frequent ozone impacts and align very well with the actual measured levels in 2021. Whilst it appears likely that the projections of more widespread, but not greatly more frequent ozone exceedances may arise in future, this cannot be known with a high degree of certainty at this time.

3.4 Modelling process overview

The Figure 3.3 provides a depiction of the process and data flow for the local and regional modelling. The AEDT aircraft emissions are a common data input to the local and regional assessments. The various data inputs are shaded blue, data processors are green, models used are orange and results processing are shown in purple.

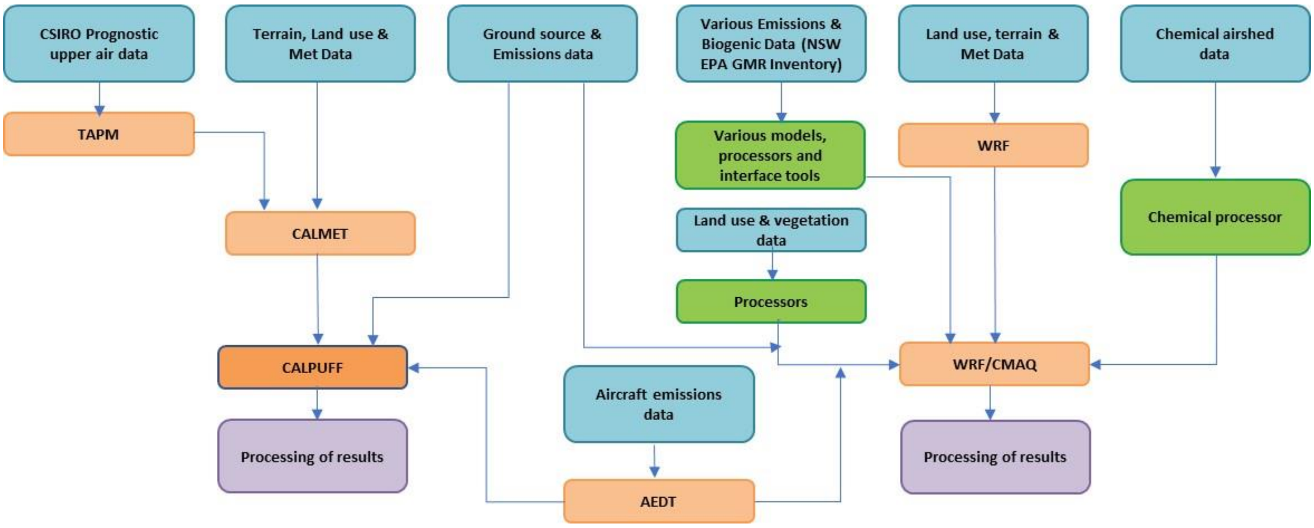


Figure 3.3 Modelling process (local assessment left side, regional assessment right side)

Chapter 4 Existing conditions

This chapter describes the existing conditions and features of the study area to provide a baseline against which the project's impacts can be assessed. This includes information on background air pollutant concentrations in the surrounding environment.

4.1 Sensitive receptors

Figure 4.1 presents the location of the project and key residential and community receptors considered in this assessment. According to the Australian Bureau of Statistics 2021 census, there are more than 5.2 million of residents in the Greater Sydney area (refer to: www.abs.gov.au/census/find-census-data/quickstats/2021/1GSYD), and only a selection of suitably representative receptors can be assessed in this technical paper (refer to Figure 4.1). Receptors that represent the key potentially affected community and residential locations are summarised in Table 4.1, and it is important to note that less impacts are likely in other locations. The sensitive receptors are identical to the locations assessed in the 2016 EIS.

Table 4.1 identifies the approximate address of each of the key residential receptors.

Table 4.1 Details of key assessed sensitive receptors

Receptor ID	Address	Type	Receptor ID	Address	Type
R1	Bringelly	Residential	R75	Trinity Catholic Primary School	Community
R2	Luddenham	Residential	R76	Bringelly Public School	Community
R3	Greendale, Greendale Road	Residential	R78	Mulgoa Public School	Community
R4	Kemps Creek	Residential	R79	Rossmore Public School	Community
R6	Mulgoa	Residential	R80	Wallacia Public School	Community
R7	Wallacia	Residential	R82	Bellfield College – Junior campus	Community
R8	Twin Creeks, Corner Twin Creek Drive and Humewood Place	Residential	R84	Bringelly Park	Community
R14	Lawson Road, Badgerys Creek	Residential	R85	Bents Basin State Conservation reserve and Gulguer Nature reserve	Community
R15	Mersey Road, Greendale	Residential	R86	Blaxland Crossing Reserve	Community
R17	Luddenham road	Residential	R87	Bill Anderson Reserve	Community
R18	Corner Adams and Elizabeth Drive	Residential	R88	Kemps Creek Nature Reserve	Community
R19	Corner Adams and Anton Road	Residential	R91	Western Sydney Parklands	Community
R21	Corner Willowdene Avenue and Victor Park Lane	Residential	R93	Rossmore Grange	Community
R22	Rossmore, Victor Avenue	Residential	R94	Freeburn Park	Community

Receptor ID	Address	Type	Receptor ID	Address	Type
R23	Wallacia, Greendale Road	Residential	R95	Overett Reserve	Community
R24	Badgerys Creek 1 NE	On-site	R97	Mulgoa Park	Community
R25	Badgerys Creek 2 SW	On-site	R98	Wallacia Bowling and Recreation Club	Community
R27	Greendale, Dwyer Road	Residential	R99	Hubertus Country Club	Community
R30	Rossmore residential	Residential	R100	Sugarloaf Cobbitty Equestrian Club	Community
R31	Mt Vernon residential	Residential	R102	Panthers Wallacia	Community
R34	Emmaus residential aged care	Community	R103	Twin Creeks golf and country club	Community
R35	Mamre after school and vacation care	Community	R104	Sydney international shooting centre	Community
R36	Head start after school care	Community	R108	Luddenham showground	Community
R37	Schoolies at Mulgoa	Community	R109	Kemps Creek sporting and bowling club	Community
R38	Do-re-mi day care centre	Community	R110	St James Luddenham	Community
R39	Little Amigos Austral early learning centre	Community	R111	Lin Yang temple	Community
R40	Little Smarties childcare centre	Community	R112	Vat Ketanak Khmer Kampuchea Krom	Community
R41	The Grove Academy	Community	R114	Anglican Church Sydney Diocese	Community
R42	Horsely Kids	Community	R115	Anglican Parish of Mulgoa	Community
R44	Bringelly childcare centre	Community	R117	Bringelly Vineyard Church	Community
R46	Clementson Drive early educational centre	Community	R118	Free Church of Tonga	Community
R48	Kids Korner West Hoxton early learning centre	Community	R120	Our Lady Queen of Peace	Community
R49	Luddenham childcare centre	Community	R122	St Anthony	Community
R52	The Frogs Lodge	Community	R123	St Marys Church	Community
R53	Rossmore Community Preschool	Community	R124	Wallacia Christian Church	Community
R54	Mulgoa Preschool	Community	R126	St Francis Xavier Church	Community
R55	Jillys educational childcare centre	Community	R127	Luddenham Uniting Church	Community
R57	Wallacia progress hall	Community	R130	Hopewood health retreat	Community
R59	Bringelly community centre	Community	R131	Science of the soul study centre	Community
R63	Luddenham progress hall	Community	R132	Bringelly shops	Community

Receptor ID	Address	Type	Receptor ID	Address	Type
R64	Mulgoa Hall	Community	R134	Kemps Creek shops	Community
R65	Emmaus Catholic College	Community	R135	Luddenham shops	Community
R66	University of Sydney Farms	Community	R136	Mulgoa shops	Community
R68	Christadelphian Heritage College Sydney	Community	R137	Rossmore shops	Community
R69	Mamre Anglican School	Community	R138	Wallacia shops	Community
R72	Irfan College	Community	R140	Holy Family Catholic primary and Church	Community
R73	Luddenham Public School	Community	R141	Edmund Rice retreat and conference centre	Community
R74	Kemps Creek Public School	Community			

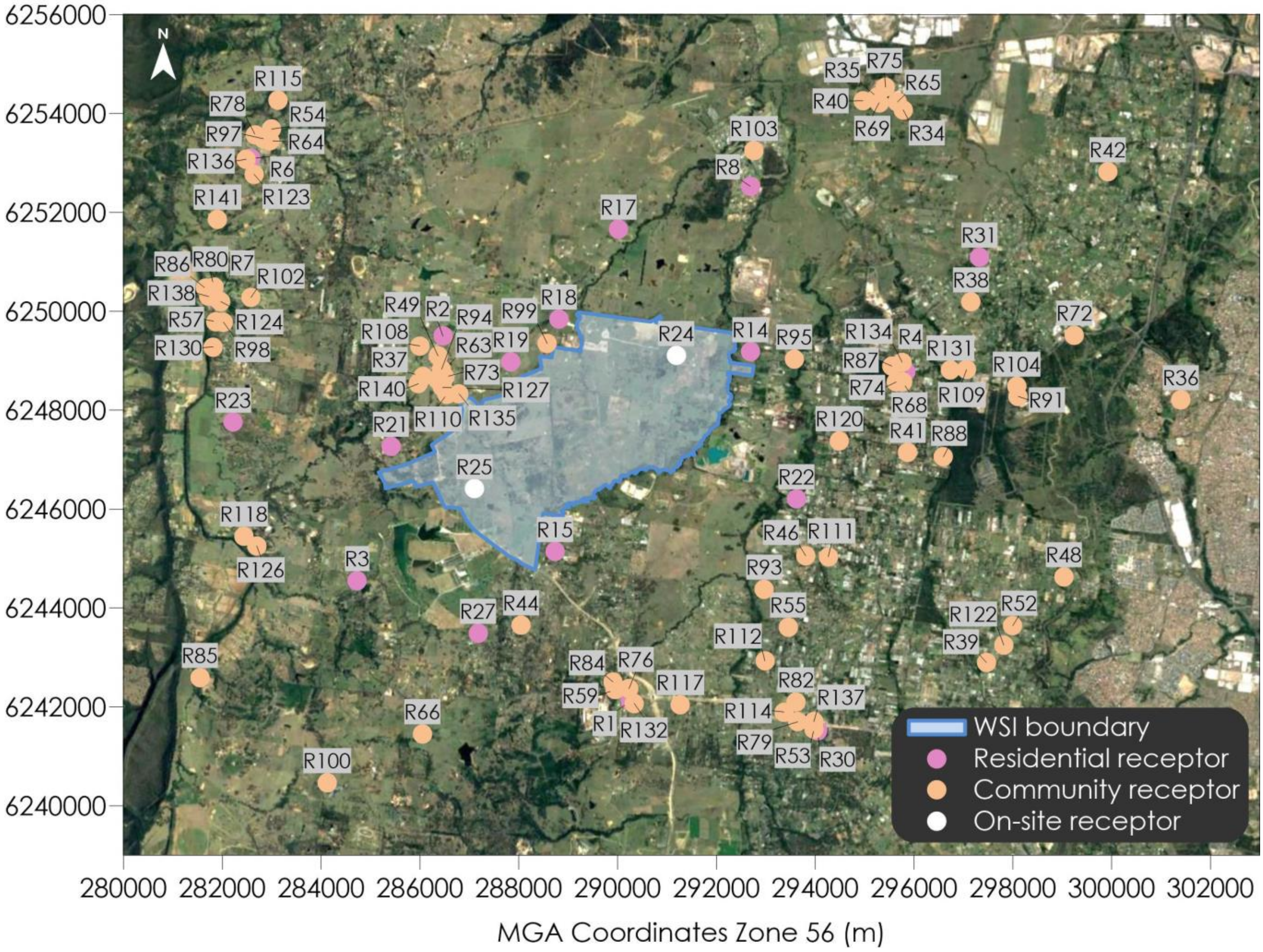


Figure 4.1 **Location of sensitive receptors assessed**

4.2 Climatic conditions

Long term climatic data collected at the Bureau of Meteorology (BOM) weather station at Badgerys Creek Automatic Weather Station (AWS) (Station Number 067108) were analysed to characterise the local climate in the proximity of the project.

Table 4.2 presents a summary of the data collected from the Badgerys Creek AWS over an approximate 14 to 27-year period for the various meteorological parameters. These data assist in characterising the local climatic conditions based on the long-term meteorological parameters.

The data indicate that January is the hottest month with a mean maximum temperature of 30.2°C and July is the coldest month with a mean minimum temperature of 4.1°C.

Rainfall is higher during the first half of the year, with an annual average rainfall of 675.0 millimetres over 69.2 days. The data show March is the wettest month with an average rainfall of 112.4 millimetres over 8.3 days and July is the driest month with an average rainfall of 24.5 millimetres over 3.8 days.

Relative humidity levels exhibit variability over the day and seasonal fluctuations. Mean 9 am relative humidity levels range from 62 per cent in October to 84 per cent in June. Mean 3 pm relative humidity levels vary from 44 per cent in August and September to 56 per cent in June.

Wind speeds during the warmer months have a greater spread between the 9 am and 3 pm conditions compared to the colder months. The mean 9 am wind speeds range from 8.4 kilometres per hour in March to 11.8 kilometres per hour in October. The mean 3 pm wind speeds vary from 13.7 kilometres per hour in June to 19.9 kilometres per hour in October.

Table 4.2 Monthly climate statistics summary – Badgerys Creek AWS

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temp. (°C)	30.2	28.7	26.7	24.1	20.7	17.8	17.5	19.2	22.6	24.9	26.5	28.6	24.0
Mean min. temp. (°C)	17.3	17.1	15.4	11.5	7.7	5.6	4.1	4.7	7.7	10.6	13.6	15.5	10.9
Rainfall													
Rainfall (mm)	78.3	111.6	112.4	47.9	38.5	58.6	24.5	36.7	34.2	54.0	69.9	56.5	675.0
No. of rain days (≥1 mm)	7.1	7.7	8.3	5.7	3.9	5.7	3.8	3.3	4.7	5.8	6.8	6.4	69.2
9 am conditions													
Mean temp. (°C)	21.8	21.2	19.0	17.3	13.7	10.5	9.8	11.7	15.5	18.1	19.1	20.9	16.6
Mean R.H. (%)	73	80	83	76	80	84	81	72	66	62	69	69	75
Mean W.S. (km/h)	9.4	8.7	8.4	9.8	9.6	9.1	9.6	10.6	11.7	11.8	11.0	9.8	10.0

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
3 pm conditions													
Mean temp. (°C)	28.1	26.9	25.3	22.4	19.4	16.7	16.1	17.9	21.0	22.8	24.3	26.5	22.3
Mean R.H. (%)	49	55	55	52	53	56	50	44	44	45	50	48	50
Mean W.S. (km/h)	17.9	15.9	14.5	14.4	13.9	13.7	15.4	17.8	19.2	19.9	18.9	18.5	16.7

Notes: R.H. = relative humidity, W.S. = wind speed

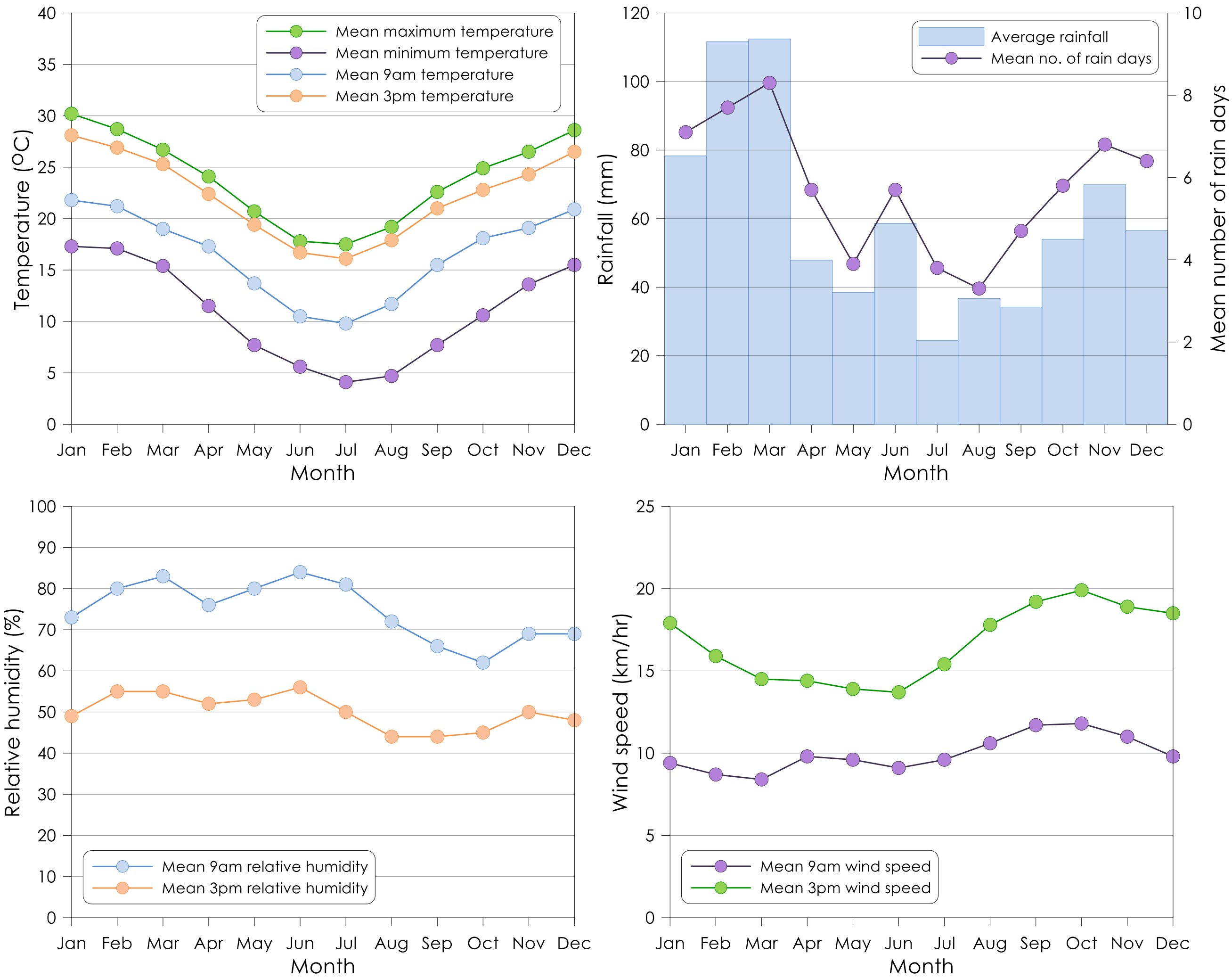


Figure 4.2 Monthly climate statistics summary – Badgerys Creek AWS

4.3 Meteorological conditions

Period and seasonal windroses for the Badgerys Creek AWS for the period from 2014 to 2021 are presented in Figure 4.3.

For the period reviewed, winds are varied and predominantly occur from the south-west and the west south-west. In summer, winds predominantly occur from the east. The autumn distribution is like the annual distribution with varied winds predominantly from the south-west and the west south-west. In winter winds typically occur from the south-west and the west south-west. In spring, the winds from the south-west are most dominant and varied winds from other directions.

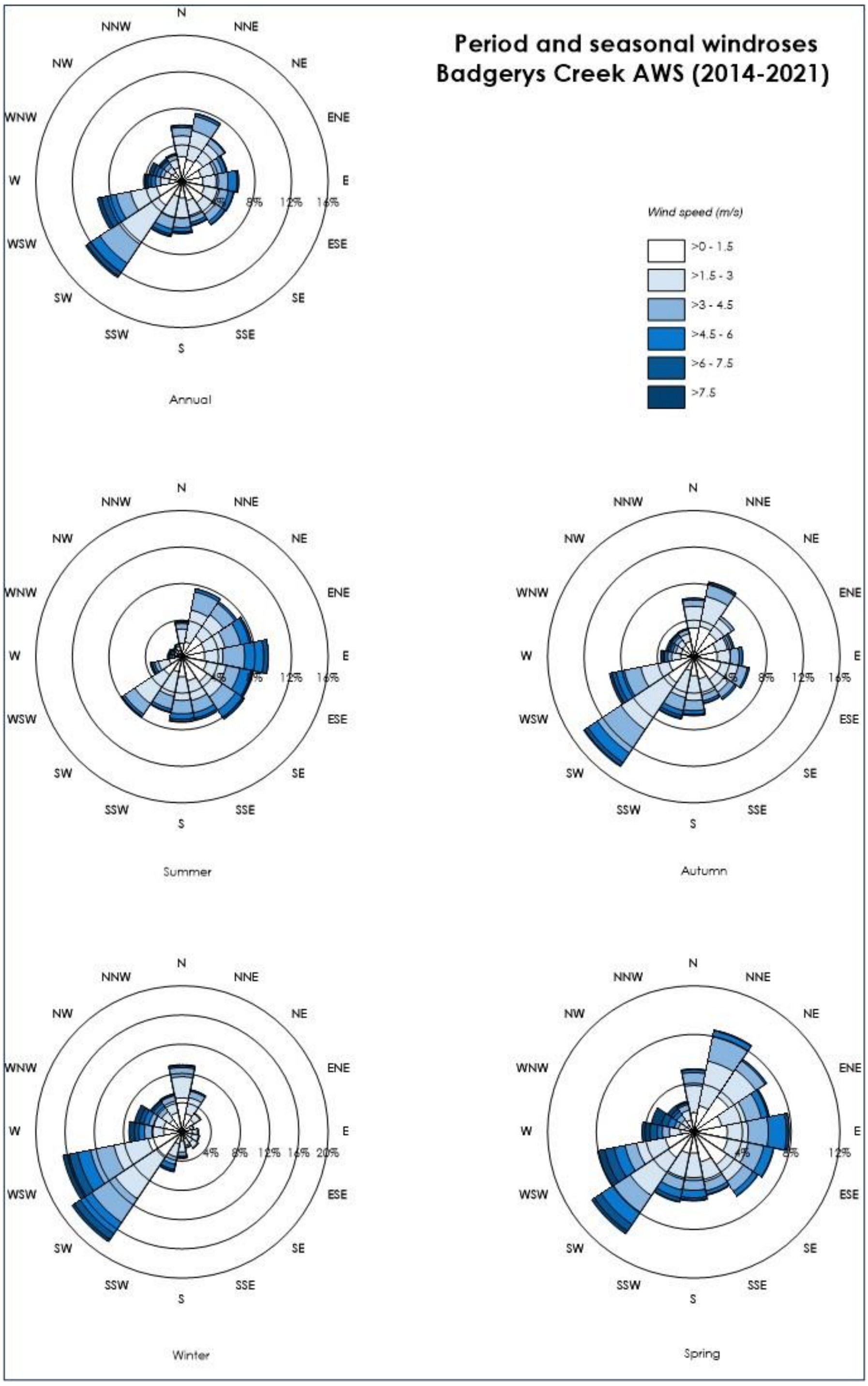


Figure 4.3 Period and seasonal windroses for Badgerys Creek AWS (2014–2021)

4.4 Ambient air quality

The main sources of air pollutants in the wider area surrounding WSI include industrial and commercial operations and local anthropogenic activities such as wood heaters and motor vehicle exhaust.

This section reviews the available ambient air quality monitoring data sourced from the nearest air quality monitors operated by the NSW Department of Planning and Environment (DPE) at Bringelly, St Marys and Camden.

Figure 4.4 shows the approximate location of each of the monitoring stations with reference to the project.

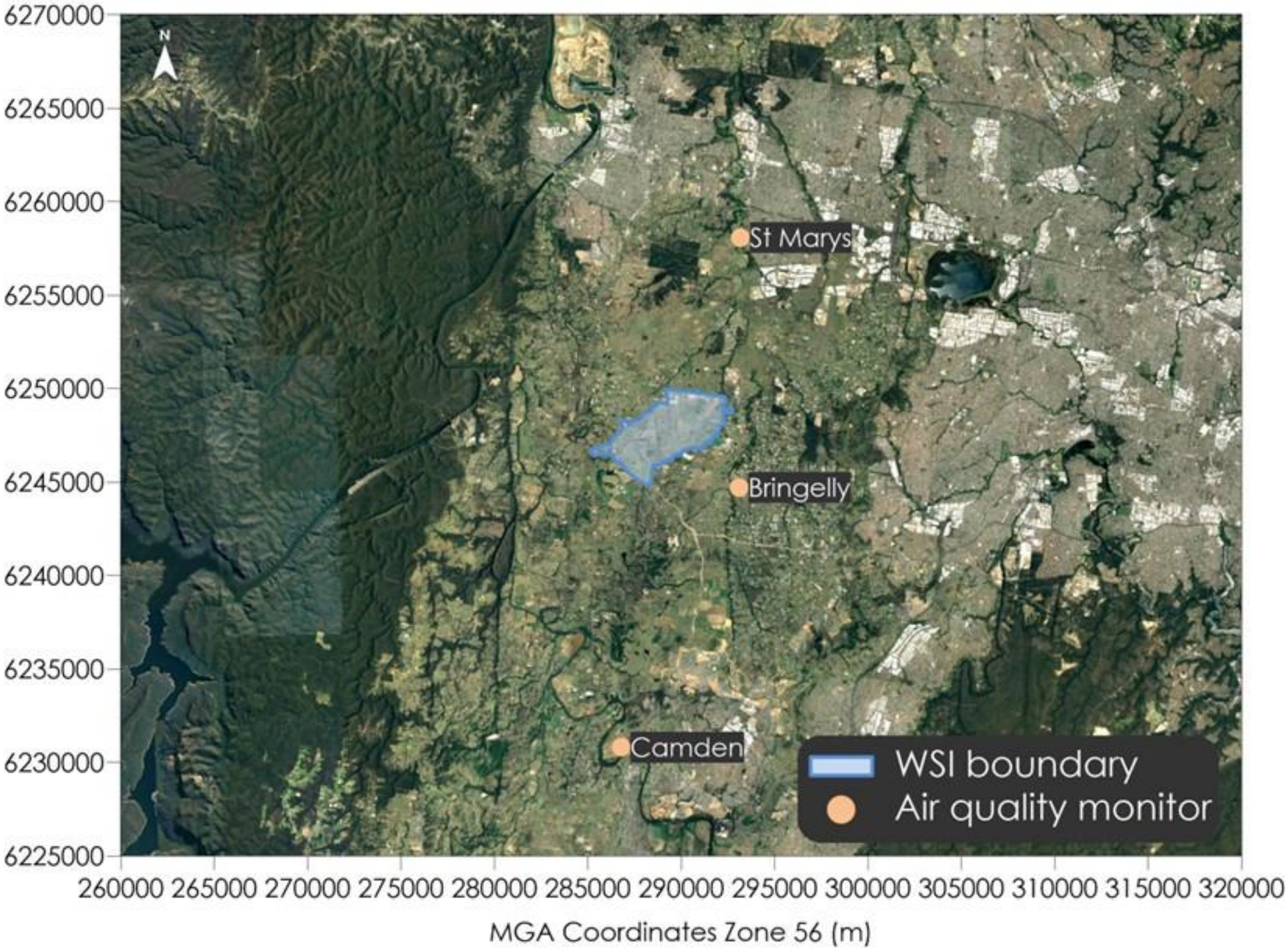


Figure 4.4 Air quality monitoring locations

4.4.1 PM_{10} monitoring

A summary of the available annual average PM_{10} monitoring data from the NSW DPE monitoring stations is presented in Table 4.3.

A review of Table 4.3 indicates that the annual average PM_{10} concentrations for all monitoring stations reviewed were below the relevant NSW EPA criterion of 25 µg/m³.

Table 4.3 Summary of annual average PM_{10} levels from NSW DPE monitoring (µg/m³)

Year	Bringelly	St Marys	Camden	Criterion
2014	16.6	16.7	15.6	25
2015	15.8	15.0	13.8	25
2016	16.9	16.1	14.4	25
2017	19.8	16.2	14.7	25
2018	21.2	19.4	17.5	25
2019	23.6	24.7	22.5	25
2020	18.3	18.9	16.6	25
2021	15.3	16.2	13.0	25

Recorded 24-hour average PM_{10} concentrations are presented in Figure 4.5.

An examination of the elevated PM_{10} levels indicates that they typically correspond with regional dust events and bushfires which affect a wide area, this is particularly evident in 2019/2020 because of the NSW bushfires in November to January. At other times, potential dust sources such as local sources, industrial activity and other such dust sources may have contributed to brief periods of elevated PM_{10} levels.

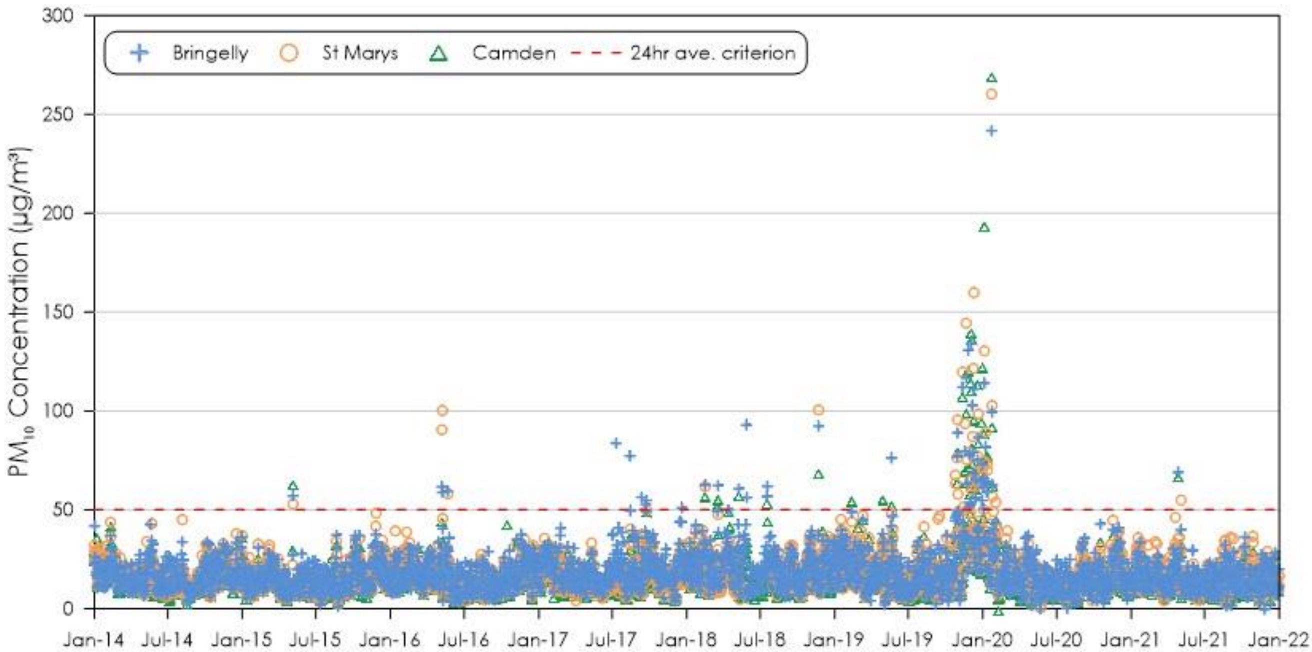


Figure 4.5 24-hour average PM_{10} concentrations

4.4.2 $PM_{2.5}$ monitoring

A summary of the available annual average $PM_{2.5}$ monitoring data from the NSW DPE monitoring stations is presented in Table 4.3.

A review of Table 4.3 indicates that the annual average $PM_{2.5}$ concentrations for all monitoring stations reviewed were below the relevant NSW EPA criterion of 8 µg/m³ except for all monitors in 2019 and the Bringelly monitor in 2020. The likely cause of the elevated annual levels at the monitors are attributed to bushfire events, wood smoke from domestic wood heaters and automobile exhaust.

Table 4.4 Summary of annual average $PM_{2.5}$ levels from NSW DPE monitoring (µg/m³)

Year	Bringelly	St Marys	Camden	Criterion
2014			6.3	8
2015			6.2	8
2016		7.9	6.4	8
2017	7.5	7.0	6.7	8
2018	8.0	7.8	7.2	8
2019	11.3	9.8	11.8	8
2020	8.5	7.6	7.7	8
2021	7.2	5.8	6.1	8

Recorded 24-hour average $PM_{2.5}$ concentrations are presented in Figure 4.6.

It can be seen from Figure 4.6 that 24-hour average $PM_{2.5}$ concentrations are below the impact assessment criteria most of the time, but do exceed the criteria at times, and may significantly exceed the criteria during extraordinary events such as bushfires. As described for PM_{10}, 24-hour average levels above the criteria are generally associated with dust storms, bushfires, and potentially hazard reduction burns. The prolonged very high $PM_{2.5}$ levels seen in late 2019 and early 2020 are a result of smoke impacts from the widespread NSW bushfires.

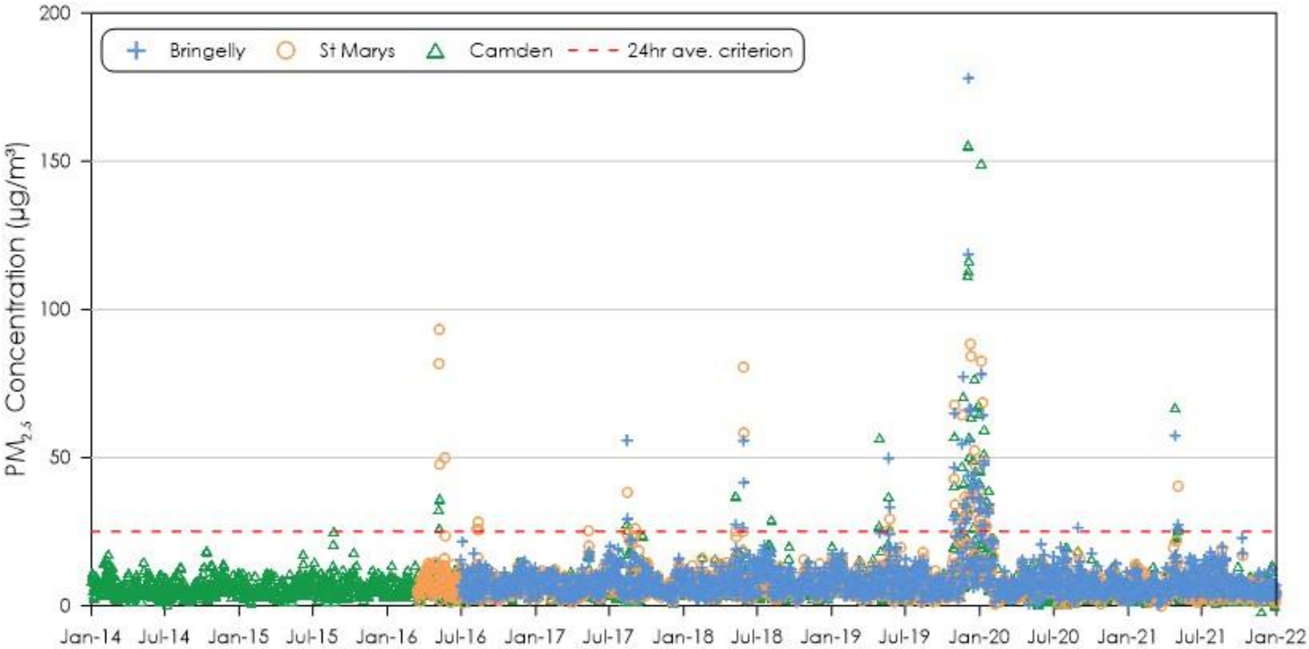


Figure 4.6 24-hour average $PM_{2.5}$ concentrations

4.4.3 NO_2 monitoring

A summary of the available annual average NO_2 monitoring data from the NSW DPE monitoring stations is presented in Table 4.5.

A review of Table 4.5 indicates that the annual average NO_2 concentrations for all monitoring stations reviewed were below the relevant NSW EPA criterion of 62 µg/m³.

Table 4.5 Summary of annual average NO_2 levels from NSW DPE monitoring (µg/m³)

Year	Bringelly	St Marys	Camden	Criterion
2014	9.8	10.4	9.9	62
2015	9.2	10.4	9.1	62
2016	10.4	10.6	9.6	62
2017	10.9	11.4	10.0	62
2018	12.1	12.4	11.3	62
2019	12.0	11.1	11.2	62
2020	9.7	10.1	9.1	62
2021	9.1	9.6	8.2	62

Recorded daily maximum 1-hour average NO_2 concentrations are presented in Figure 4.7.

It can be seen from Figure 4.7 the NO_2 concentrations are generally higher in cooler months when temperatures are low and there is less sunlight, making it more difficult for NO_2 to react in the atmosphere and convert to ozone. Notably this trend is the reverse of that for ozone. The levels are well below the criteria.

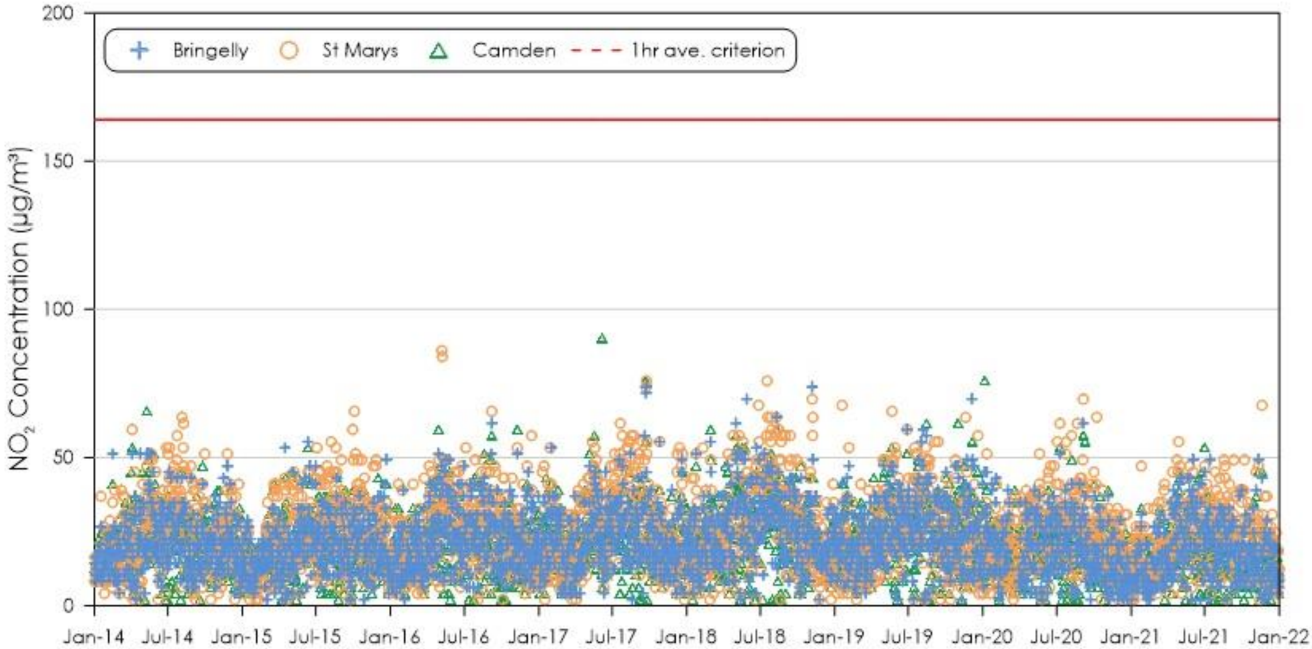


Figure 4.7 Daily maximum 1-hour average NO_2 concentrations

4.4.4 SO_2 monitoring

A summary of the available SO_2 data from the NSW DPE monitoring stations is presented in Table 4.6. Only the Bringelly monitor records SO_2.

A review of Table 4.6 indicates that the annual average SO_2 concentrations for the Bringelly monitoring station was below the NSW EPA criterion of 60 µg/m³.

Table 4.6 Summary of annual average SO_2 levels from NSW DPE monitoring (µg/m³)

Year	Bringelly	Criterion
2014	3.9	60
2015	3.8	60
2016	3.8	60
2017	3.8	60
2018	4.0	60
2019	4.3	60
2020	3.3	60
2021	3.3	60

Recorded daily maximum 1-hour average SO_2 concentrations are presented in Figure 4.8.

It can be seen from Figure 4.8 that SO_2 concentrations are low and there is no apparent seasonal trend. The levels are well below the applicable criteria.

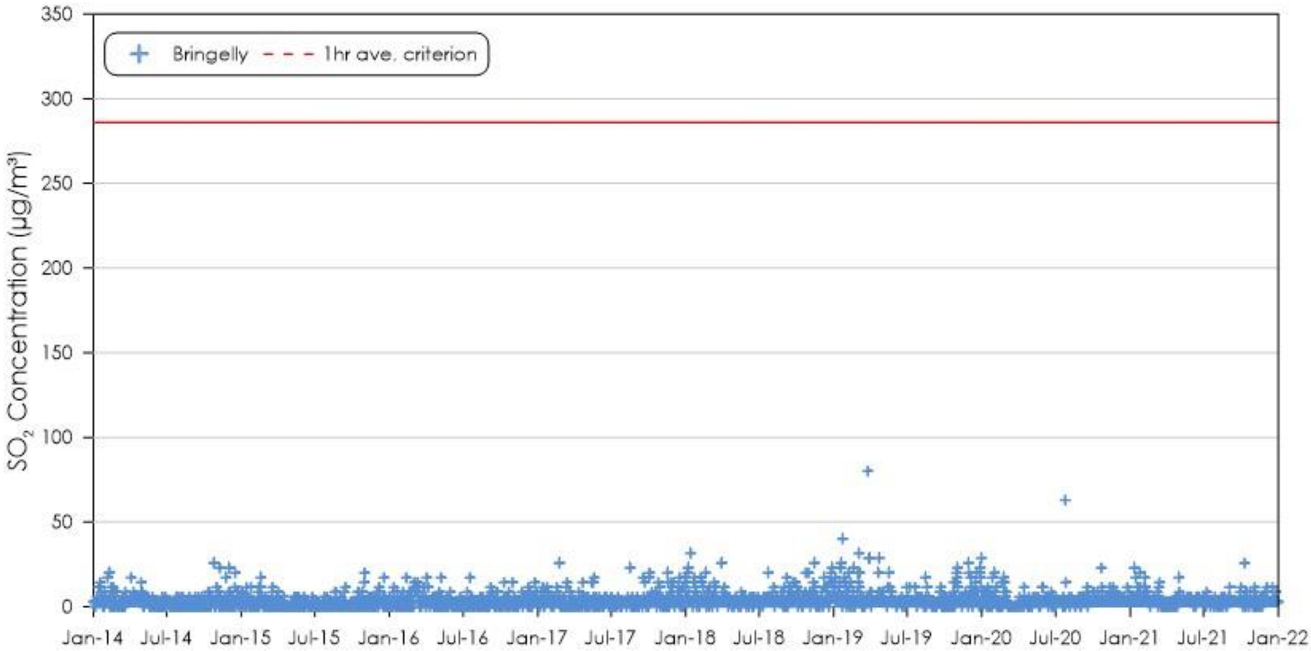


Figure 4.8 Daily maximum 1-hour average SO_2 concentrations

4.4.5 CO monitoring

A summary of the available maximum 1-hour average CO data from the NSW DPE monitoring stations is presented in Table 4.7. Only the Camden monitor records CO.

Table 4.7 indicates that the maximum 1-hour average CO concentrations for all monitors during the review period are well below the NSW EPA criterion.

Table 4.7 Summary of annual average CO levels from NSW DPE monitoring (µg/m³)

Year	Camden	Criterion
2014	187.7	30,000
2015	182.4	30,000
2016	174.5	30,000
2017	174.3	30,000
2018	192.4	30,000
2019	242.7	30,000
2020	221.3	30,000
2021	181.8	30,000

Recorded daily maximum 1-hour average CO concentrations are presented in Figure 4.9.

Figure 4.9 shows the CO data are low, with some elevated levels corresponding with major bushfire events. The levels are well below the applicable criteria.

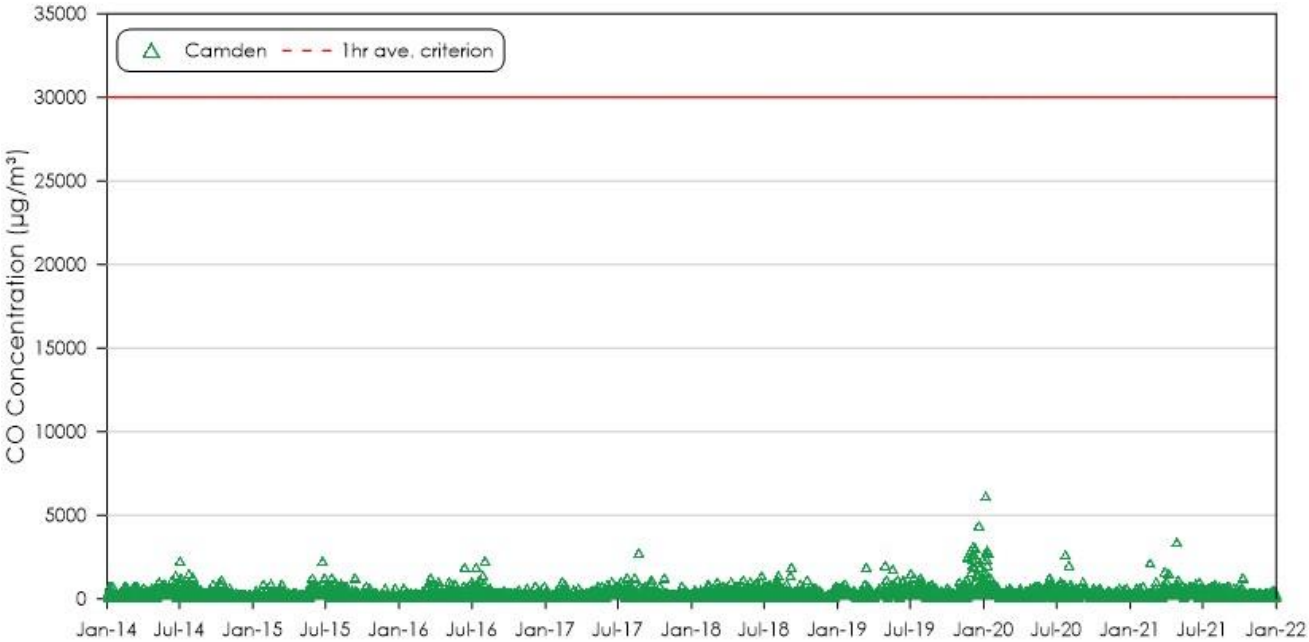


Figure 4.9 Daily maximum 1-hour average CO concentrations

4.4.6 O_3 monitoring

Recorded daily maximum 1-hour and 4-hour average O_3 concentrations are presented in Figure 4.10 to Figure 4.11. The ozone levels regularly exceed the EPA impact assessment criteria in the summertime. Some of these elevated levels are associated with the effects of bushfires, but exceedances of the criteria also arise at other times due to anthropogenic (man-made) emissions. Notably the trend in ozone is the reverse of that for NO_2.

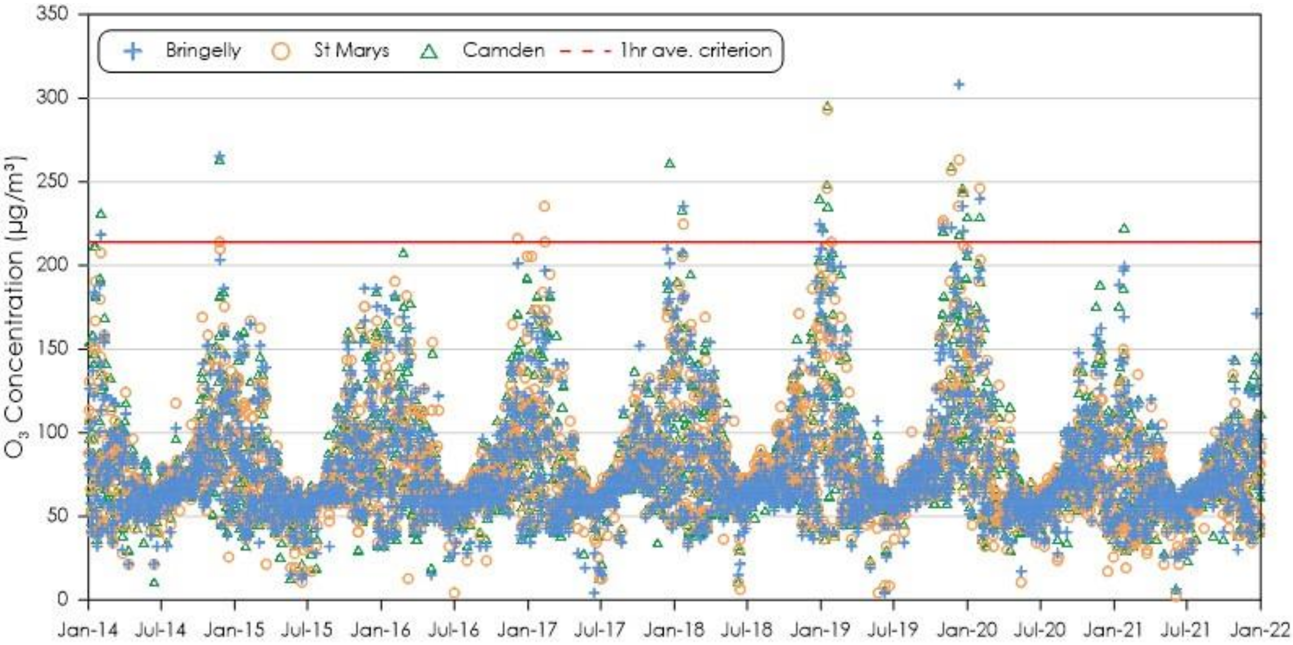


Figure 4.10 Daily maximum 1-hour average O_3 concentrations

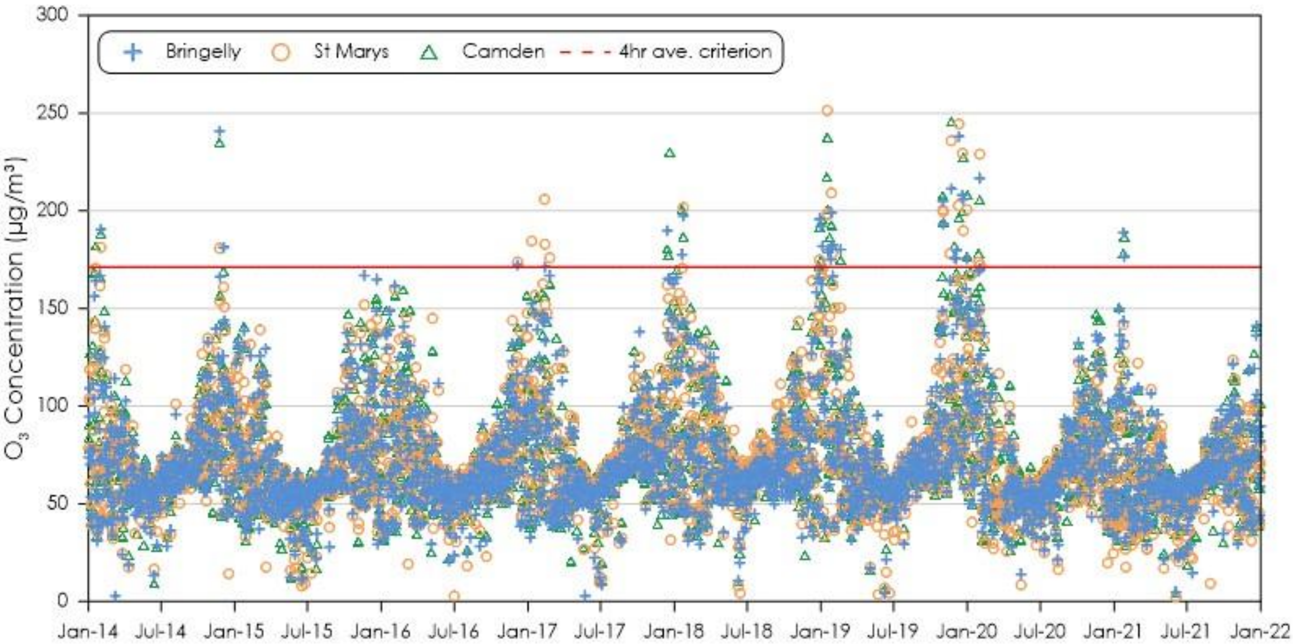


Figure 4.11 Daily maximum 4-hour average O_3 concentrations

A summary of ozone exceedances for 2021 is set out in the NSW DPE 2021 Annual Air Quality Statement (Statement) is presented in Figure 4.12. The extract from the Statement set out in Figure 4.12 provides a useful comparison between the rescinded 1-hour and 4-hour NEPM standards and the current NEPM 8-hour standard. It can be seen from the above graphs and the Statement that exceedances of the 8-hour ozone criteria are more frequent and more widespread, confirming that the new NEPM standard is more stringent.

Effect of new standards

The new NEPM standards came into force part-way through the year during 2021. For the NSW annual air quality statement 2021, it has been assumed that the new and more stringent standards would apply for the whole year. But for the purpose of assessing the impacts of the changes, the relevant elevated pollutant levels for 2021 are compared against both new and old standards below.

Ozone | Nitrogen dioxide | Sulfur dioxide

There were 5 days in 2021 with ozone levels recorded over the new 8-hour ozone standard at one or more stations in New South Wales. There would have been only one exceedance day when compared to the older 1-hour standard and three exceedance days when compared to the older 4-hour standard. The extent of the exceedances would also have generally been lesser with the older standards, in that fewer stations would have been impacted.

Number of stations which recorded ozone levels over the old and new NEPM standards by calendar day during 2021

	Number of monitors exceeding standard			
	Old NEPM		New NEPM	
Date	1-hour average	4-hour average	8-hour average	Exceptional event?*
23/01/2021	0	3	4	No
24/01/2021	0	0	6	No
25/01/2021	1	5	8	No
09/10/2021	0	0	1	Yes
21/12/2021	0	2	2	No
Total days above standard	**1**	**3**	**5**	

Note: *The exceptional events rule only applies to the new NEPM ozone standard, which is applied to the 8-hour average. An exceedance day determined to be impacted by bushfires or planned burns is deemed exceptional.

Figure 4.12 Extract from DPE NSW Annual Air Quality Statement (2021) regarding new ozone standards

4.4.7 Background air quality levels

Background air quality levels from the nearby DPE monitoring stations were used to represent the background levels surrounding WSI in the local air quality assessment. For the regional air quality modelling the background sources of pollution and the chemical transformation of pollutants is incorporated into the model.

Table 4.8 presents a summary of the applied background levels.

Table 4.8 Summary of background air quality levels

Pollutant	Averaging period	Background level	Source
$PM_{2.5}$	24-hours	21 µg/m³	Maximum value below the criterion of 25 µg/m³ recorded at the Bringelly monitor for 2020, excluding exceptional event days (NSW DPIE, 2021)
	Annual	7.6 µg/m³	Average level recorded at Bringelly monitor for 2017, 2018 and 2021. These years are not affected by significant bushfire events
PM_{10}	24-hours	43.5 µg/m³	Maximum value below the criterion of 50 µg/m³ recorded at the Bringelly monitor for 2020, excluding exceptional event days (NSW DPIE, 2021)
	Annual	18.8 µg/m³	Annual average Bringelly monitor for 2020
NO_2	1-hour	OLM*	NO_2 and O_3 data from Bringelly monitor for 2020 applied
	Annual	OLM*	NO_2 and O_3 data from Bringelly monitor for 2020 applied
SO_2	1-hour	80 µg/m³	Maximum value recorded at the Bringelly monitor for 2020
	24-hours	10.3 µg/m³	Maximum value recorded at the Bringelly monitor for 2020
CO	1-hour	6,125 µg/m³	Maximum value recorded at the Camden monitor for 2020

*The Ozone Limiting Method (OLM) assumes that all the available ozone in the atmosphere will react with NO in the plume until either all the O_3 or all the NO is used up. This approach assumes that the atmospheric reaction is instant. In reality, the reaction takes place over a number of hours. (NSW Environment Protection Authority, 2016). Hourly background concentrations for NO_2 using OLM are added contemporaneously to the project's calculated NO_2 increment (i.e. the predicted project increments for each hour of the year are combined with background NO_2 levels for the corresponding hour).

Chapter 5 Aircraft emissions

The different aircraft expected to be in operation at the WSI will generate varying emissions depending on the aircraft manufacturer, the size of the aircraft and the number of available engines, destination to be served, payload and weight, individual pilot techniques and meteorological conditions at the time of flight.

Aircraft emissions arise from the operation of the aircraft main engines and the rate of emissions are governed by the thrust settings during the different modes of flight in the LTO cycle between the runway and up to 3,000 feet (914 metres) above. These modes include:

- taxi/idle mode – the taxiing and idling operations of arriving and departing aircraft on the ground
- take-off mode – the period between commencement of acceleration on the runway and the aircraft reaching a height of 656 feet (200 metres)
- climb-out mode – period between 656 feet (200 metres) and 3,000 ft (914 metres) above ground level, and
- approach mode – period between 3,000 feet (914 metres) to ground level for arrivals.

The time and location in which the aircraft emissions are released will vary depending on the flight schedule and the allocation of aircraft to a flight path, in line with the runway mode of operation in use at that time.

These factors are analysed in detail to determine the air emissions associated with the aircraft at the project, and to allocate them correctly in space and time in the airspace being modelled in the local and regional air assessments.

It is likely that with improvements in fuel and aircraft technology that actual emissions from aircraft will decrease over time, however the exact extent of any improvement or when it may occur in practice cannot be known with a high degree of certainty. Thus, the most current verified information is used, as sourced from the International Civil Aviation Organization (ICAO) to represent emissions in all stages.

5.1 Flight schedule

The approved single runway operation of WSI comprises a single 3,700 metre long and 45 metre wide runway oriented on an approximate northeast (Runway 05) and southwest axis (Runway 23).

A representative average weekly demand schedule for both the northern summer and northern winter was provided by WSI and analysed to identify the relevant scenario for detailed assessment. Demand schedules for 2 different reference years were assessed including: 2033 (early years of operation) and 2055 (as the single runway approaches capacity). They represent different stages of WSI's single runway operations over time.

Analysis of these 2 reference years were most suitable for the air assessment as they represent the period most closely aligning with existing most quantifiable air quality conditions and baseline conditions (i.e., 2033) and the period with maximum numbers of air traffic movements projected to occur as single runway operations approach capacity (i.e., 2055).

For each reference year, the set of runway modes of operation (RMO) scenarios, including the 'selection rules' that define the conditions under which each mode would be selected by air traffic control were applied. The mode selection rules consider the meteorological conditions, hourly flight arrivals and departures, and the 'priority' assigned to each RMO – mostly reflecting a judgement on preference in relation to aircraft noise management and mitigation. The weekly schedules were annualised and combined with historic meteorological data, to determine the pattern of RMO scenario. Aircraft operating in a mode were assigned to flight paths based on the runway in use (i.e., 05, 23 or reciprocal runway operations (RRO) during night operations only), the type of aircraft, and the location of the airport of origin or its destination (O-D). Rather than solely assess average utilisation, this assessment has also considered demand, meteorological and seasonality variations across the year, as well as the potential for periods of respite. Table 5.1 presents a summary of the RMO scenarios considered.

Table 5.1 Summary of RMO scenarios

Scenario	RMO selection criteria	Day-time RMO priority (5:30 – 23:00)	Night-time RMO priority (23:00 – 5:30)
S1 (No preference)	No Priority	No Priority	No Priority
S2	No Priority with RRO	No Priority	1. RRO 2. No Priority
S3 (Prefer Runway 05)	Prioritise 05 with RRO	Runway 05 Preferred	1. RRO 2. No Priority
S4 (Prefer Runway 23)	Prioritise 23 with RRO	Runway 23 Preferred	1. RRO 2. No Priority
S5	Prioritise 05 with RRO Limited Peak-Time Change	Runway 05 Preferred	1. RRO 2. No Priority
S6	Prioritise 23 with RRO Limited Peak-Time Change	Runway 23 Preferred	1. RRO 2. No Priority
S7	Prioritise 23 with a period of no priority during the day with RRO	Non-Peak Runway 23 Preferred Peak No Priority	1. RRO 2. No Priority

The scenario representing a relatively even modal split between Runway 05 and Runway 23 is the No preference scenario. Aircraft emissions from flight path use in this scenario were considered in 2033. This scenario has been chosen for detailed assessment as it is commensurate with the previous 2016 EIS and is used to assess relative differences arising from the application of current aircraft fleet emissions to essentially the same 50/50 runway split scenario of the 2016 EIS. The airspace design has evolved since 2016. While track deviation compared to the previous design could significantly change aircraft noise exposure away from the airport, the air quality assessment focuses on ground level impacts near the airport, where flight track deviations are insignificant in the near ground aircraft movements that are the focus of this assessment.

The Prefer Runway 05 and Prefer Runway 23 scenarios were also chosen for detailed assessment as they prioritise the operation of Runway 05 and Runway 23 respectively. This means most aircraft arrive from southwest and depart to the northeast or arrive from the northeast and depart to the southwest. Aircraft emissions from flight path use under these scenarios were considered in 2033 and in 2055 in the air assessment. These scenarios result in the greatest aircraft movement intensities in the parts of the airshed (i.e., the volume of atmosphere above the area of interest) most susceptible to air quality impacts (noting that air quality varies spatially across the airshed according to the time of day, meteorological conditions, seasonal and other factors).

Table 5.2 presents a summary of the air traffic movements for the 2033 and 2055 reference years. These are shown as daily movements across a representative average week and then annualised.

Table 5.2 Air traffic movements

Weekday	2033			2055		
	All	Arrival	Departures	All	Arrival	Departures
Monday	238	122	116	644	325	319
Tuesday	226	113	113	621	310	311
Wednesday	232	116	116	629	315	314
Thursday	232	116	116	633	316	317
Friday	240	120	120	638	318	320
Saturday	200	97	103	602	300	302
Sunday	188	94	94	593	296	297
Total Weekly	1,556	778	778	4,360	2,180	2,180
Annual	81,134	40,567	40,567	227,343	113,671	113,671
Reference year target	81,000			266,000		

The hourly and daily air traffic movements for a week in summer and winter for both the 2033 and 2055 reference years is presented in Figure 5.1. The flight numbers are affected by changes in the seasonal demand between the northern and southern hemispheres (i.e., northern summer and northern winter), as relevant for an international airport. The numbers increase for 2055.

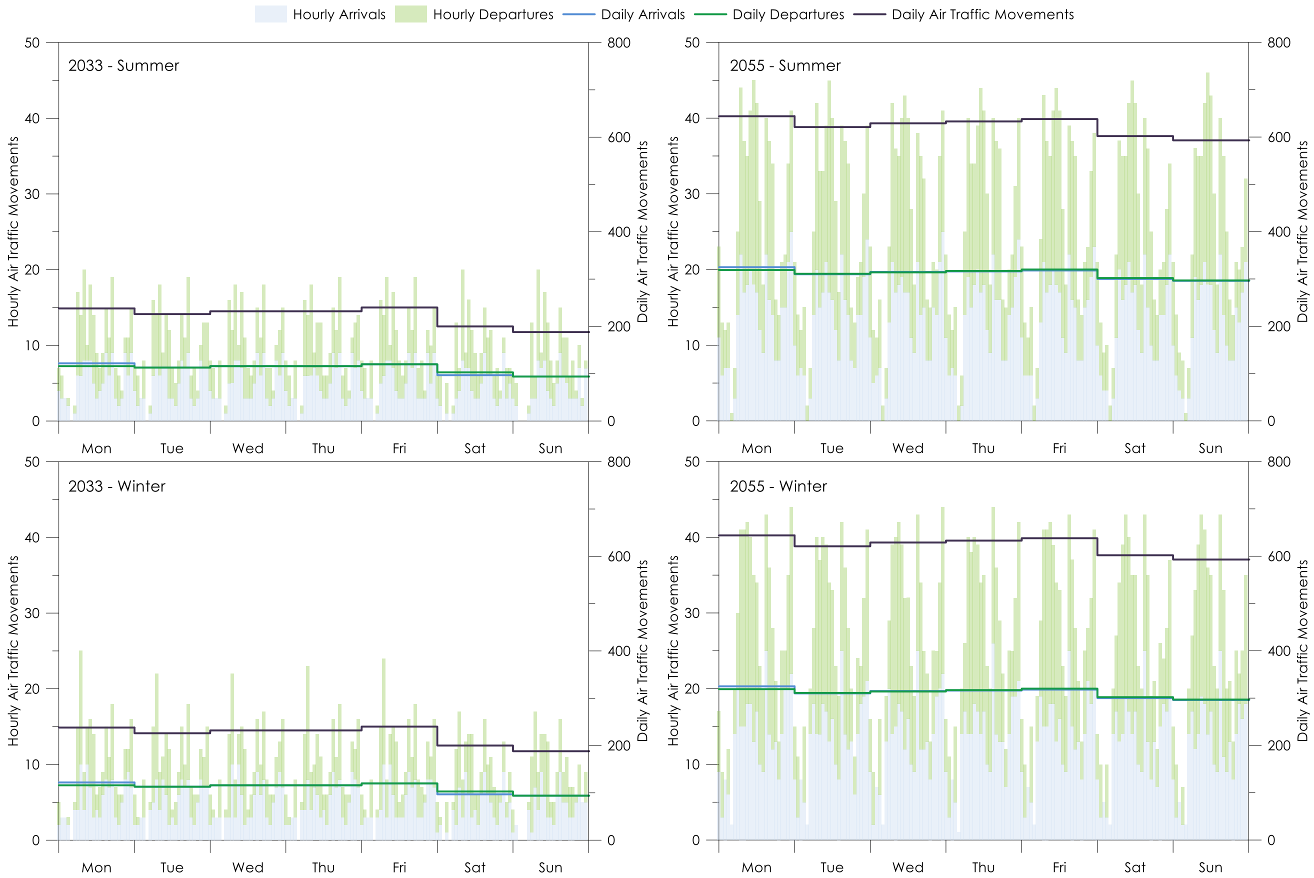


Figure 5.1 Hourly air traffic movements

Weather data during the 2020 period were analysed to allocate runways to the demand schedule in the different operating scenarios of No preference and Prefer Runway 23. Figure 5.2 presents the percentage of daily air traffic movements for each runway (05/23) in both scenarios over an annual period.

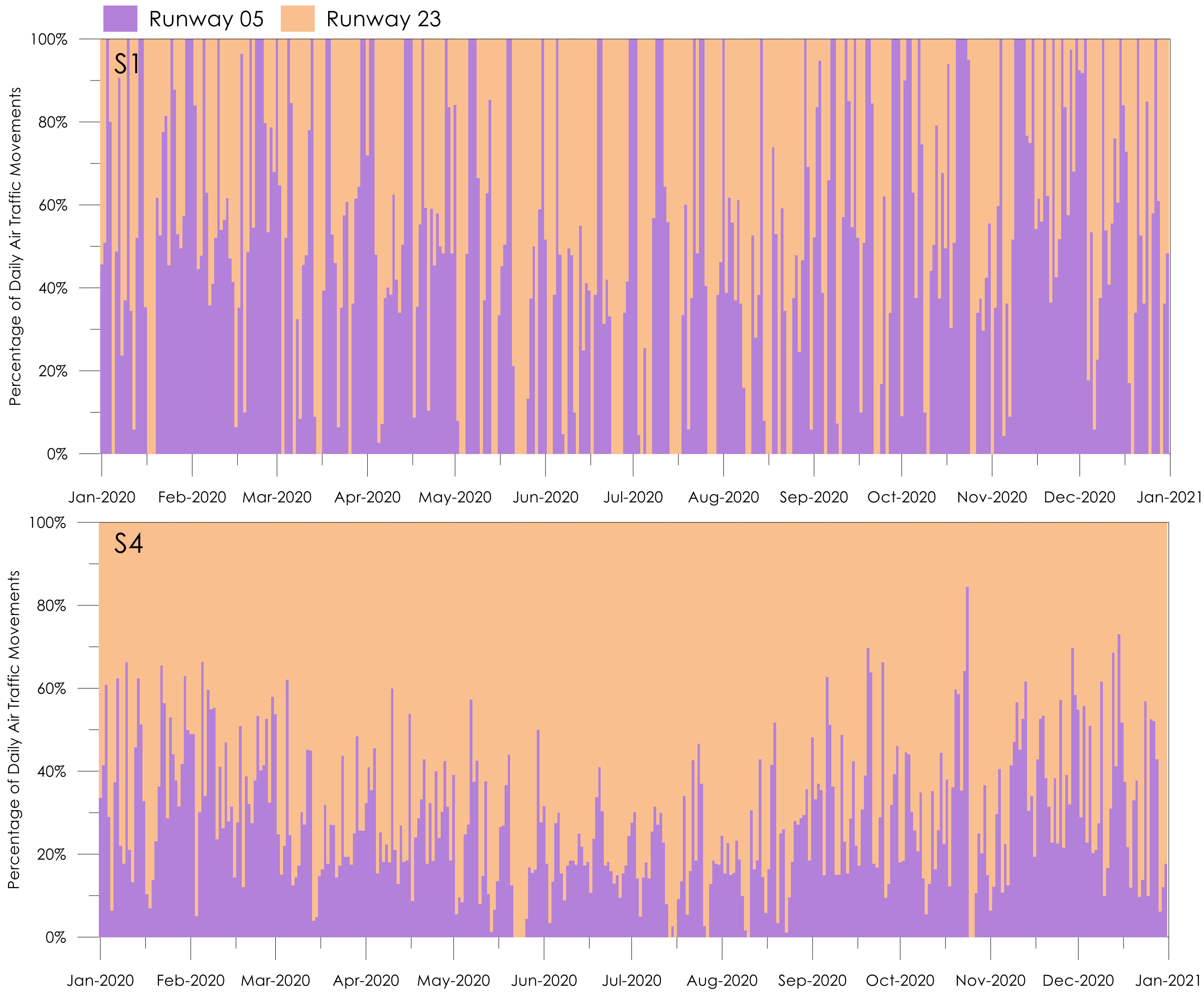


Figure 5.2 Percentage of daily air traffic movements for No Preference (top) and Prefer Runway 23 (bottom) according to runway

5.2 Flight paths

To safely separate aircraft movements, aircraft will arrive at and depart from WSI according to a set of operating rules (i.e., compliance with separation minima) and flight path procedures. These procedures are known as Standard Instrument Departures (SIDs) and Standard Instrument Arrivals (STARs).

SIDs and STARs have predetermined lateral and vertical navigation requirements which pilots must adhere to when flying in and out of an airport. All departure aircraft from WSI will fly a SID with an initial track extending in the direction of the take-off runway, either Runway 05 or Runway 23.

There are many factors which influence the operation of aircraft once in-flight, including wind speed and direction relative to the aircraft's flight path, the weight and performance characteristics of the aircraft and tolerances of navigational equipment. Aircraft do not fly in the same way as a train running on a linear railway track. This means that there will be some variation as to where different aircraft will be on the SID flight path because all aircraft perform slightly differently or may be affected by weather conditions, which can cause drift to the left or right or to vary positioning when flying between waypoints. The variation of aircraft around a nominated flight path is referred to as dispersion (not to be confused with air pollutant dispersion as relevant to air quality).

SID flight paths commence as an extension of the runway centreline. Generally, and due to the factors outlined above, the path will progressively widen to notionally 2 kilometres either side of the nominal centreline of the SID flight path; beyond 30 nautical miles or 55 kilometres from the airport the aircraft join the enroute flight network. This broad band is known as the 'flight path corridor' and caters for aircraft dispersion away from the nominal centreline. All departure aircraft must follow a SID flight path unless instructed to do otherwise by air traffic control. The day-to-day direction of air traffic, including the choice of a SID flight path, is primarily determined by the aircraft's departure point and its destination. ATC will vary this flight path for reasons of safety or traffic sequencing when required.

Figure 5.3 presents a typical vertical profile of a flight path considered for the assessment.

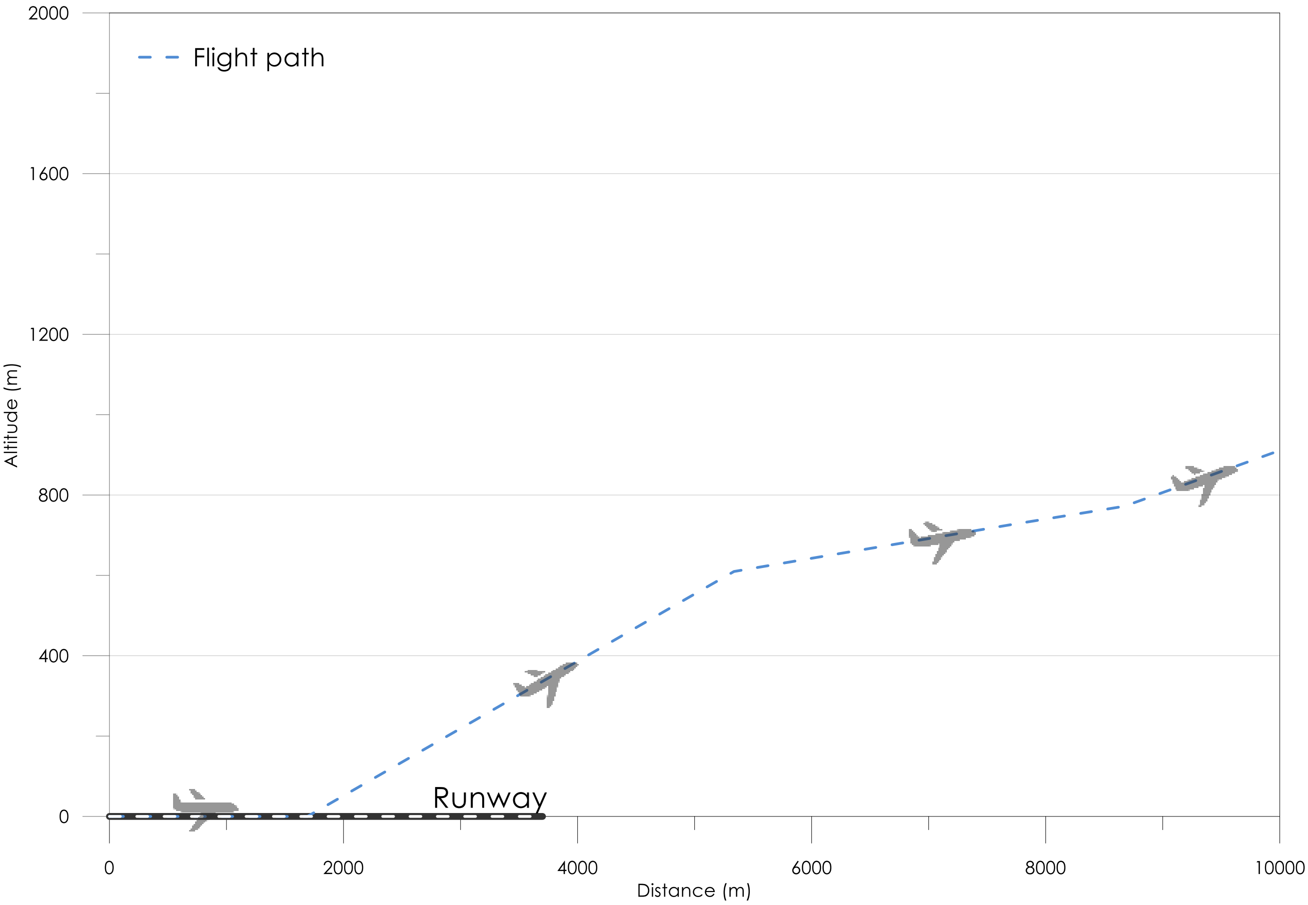


Figure 5.3 Typical vertical profile of a departing flight path considered for the assessment

Figure 5.4 presents a visualisation of the nominal centrelines of the arriving and departing flight paths for Runway 05 and Runway 23 over the Sydney Basin. The less opaque colours represent areas in which there are fewer flight tracks.

The demand schedule information in Section 5.1 were analysed to allocate flight paths to each flight in the schedule (i.e., for each aircraft). This included consideration of the operating scenario, allocated runway, time of day, wind conditions and direction of travel of the aircraft (which was based on the O-D of the flight).

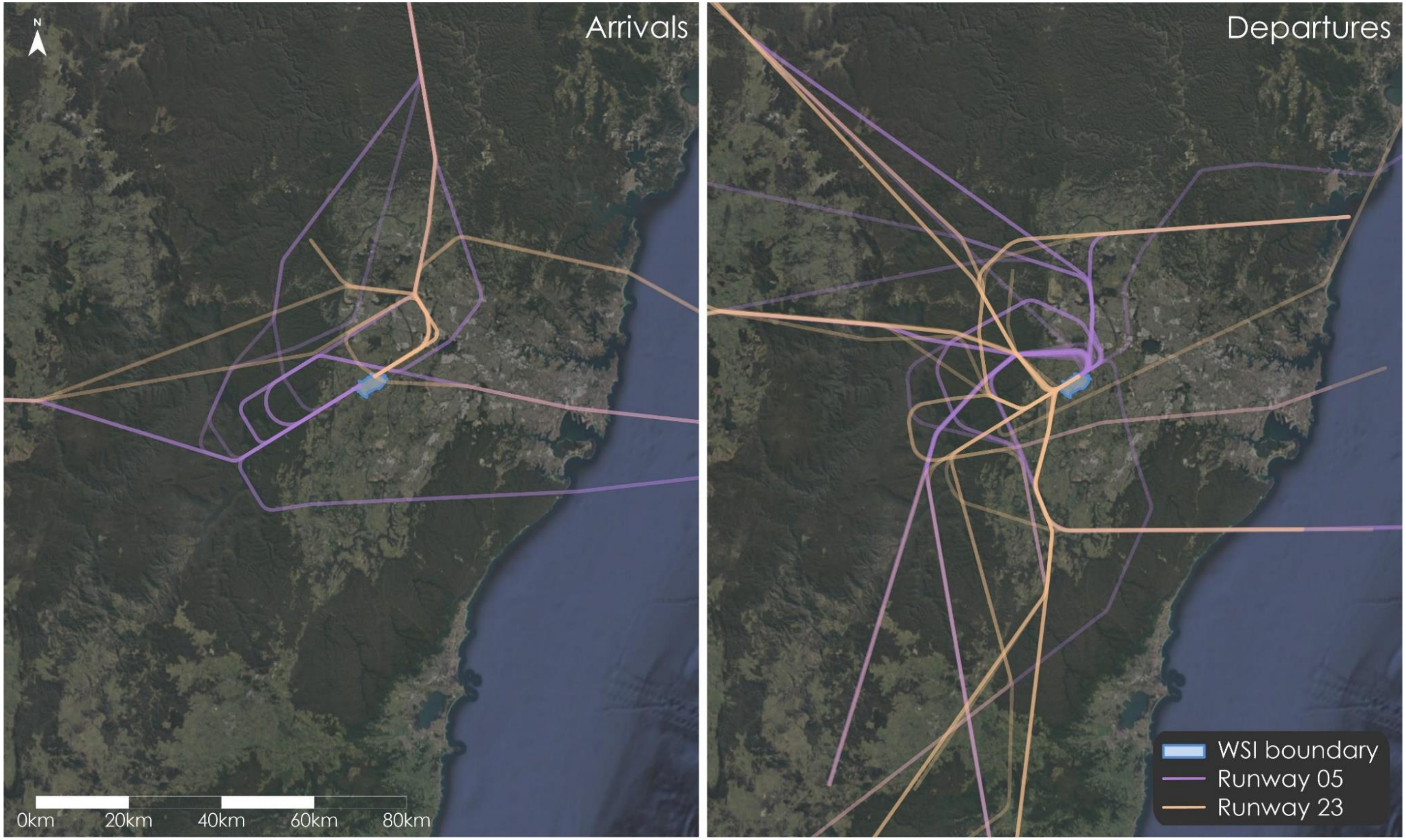


Figure 5.4 Visualisation of flight paths over the Sydney Basin

5.3 Estimated air emissions

Aircraft emissions were estimated using the US FAA's AEDT software, the Aviation Environmental Design Tool (AEDT) and were provided by Airbiz. AEDT is a software system that models aircraft performance in space and time to estimate fuel consumption, emissions, noise, and air quality effects. It updates the superseded EDMS software. The aircraft emissions that arise below 1,000 ft were used in the local assessment as these have the potential to affect local air quality at ground level near the airport. Above this height, aircraft begin to exit the local modelling domain and impacts on ground level air quality would be negligible in comparison to those emissions from sources at or near ground level (i.e. taxi, take-off and landing). Aircraft emissions for all heights along the available flight paths were used in the regional assessment. The regional assessment also included all other anthropogenic and biogenic emissions.

AEDT provides air emissions for aircraft for different modes of operation for the following substances:

- carbon monoxide (CO)
- total hydrocarbons (THC)
- non-methane hydrocarbons (NMHC)
- volatile organic compounds (VOC)
- total organic gases (TOG)
- oxides of nitrogen (NOx)
- sulfur oxides (SOx)
- particulate matter (PM)
- carbon dioxide (CO_2)
- water (H_2O), and
- speciated organic gases (SOG), including hazardous air pollutants (HAPs).

Typically, for local and regional air quality, one of the most critical aircraft emission pollutants is oxides of nitrogen (NOx) due to the transformation into nitrogen dioxide (NO_2) and ozone (O_3), and $PM_{2.5}$.

A representative sample of the most common aircraft in the fleet expected at WSI were selected to represent emissions from the airport. These included the following aircraft: Airbus A320, A320 new engine option (neo) (A32N), A321, A330-300, A330-800neo, A350-900 and the Boeing B737-800, B747-800 Freighter (F), B777-300 extended range (ER), B787-900, B737-MAX8 (B7M8) and the Bombardier Dash 8 (DH-4).

Emission profiles from AEDT were output for each aircraft during different modes of flight. The AEDT flight phases can be summarised into different categories, including:

- taxi out
- climb ground
- climb below 1,000 ft above field elevation (AFE)
- climb below mixing height
- climb below 10,000 ft AFE
- above 10,000 ft AFE
- descend below 10,000 ft AFE
- descend below mixing height
- descend below 1,000 ft AFE
- descend ground, and
- taxi ground.

An example of the NO_X and emissions for the departure and arrival of the representative aircraft are presented in Figure 5.5 and Figure 5.6 respectively. An example of the $PM_{2.5}$ and emissions for the departure and arrival of the representative aircraft are presented in Figure 5.7 and Figure 5.8 respectively. The figures show a large variation in emissions between types of aircraft and between arrivals and departures.

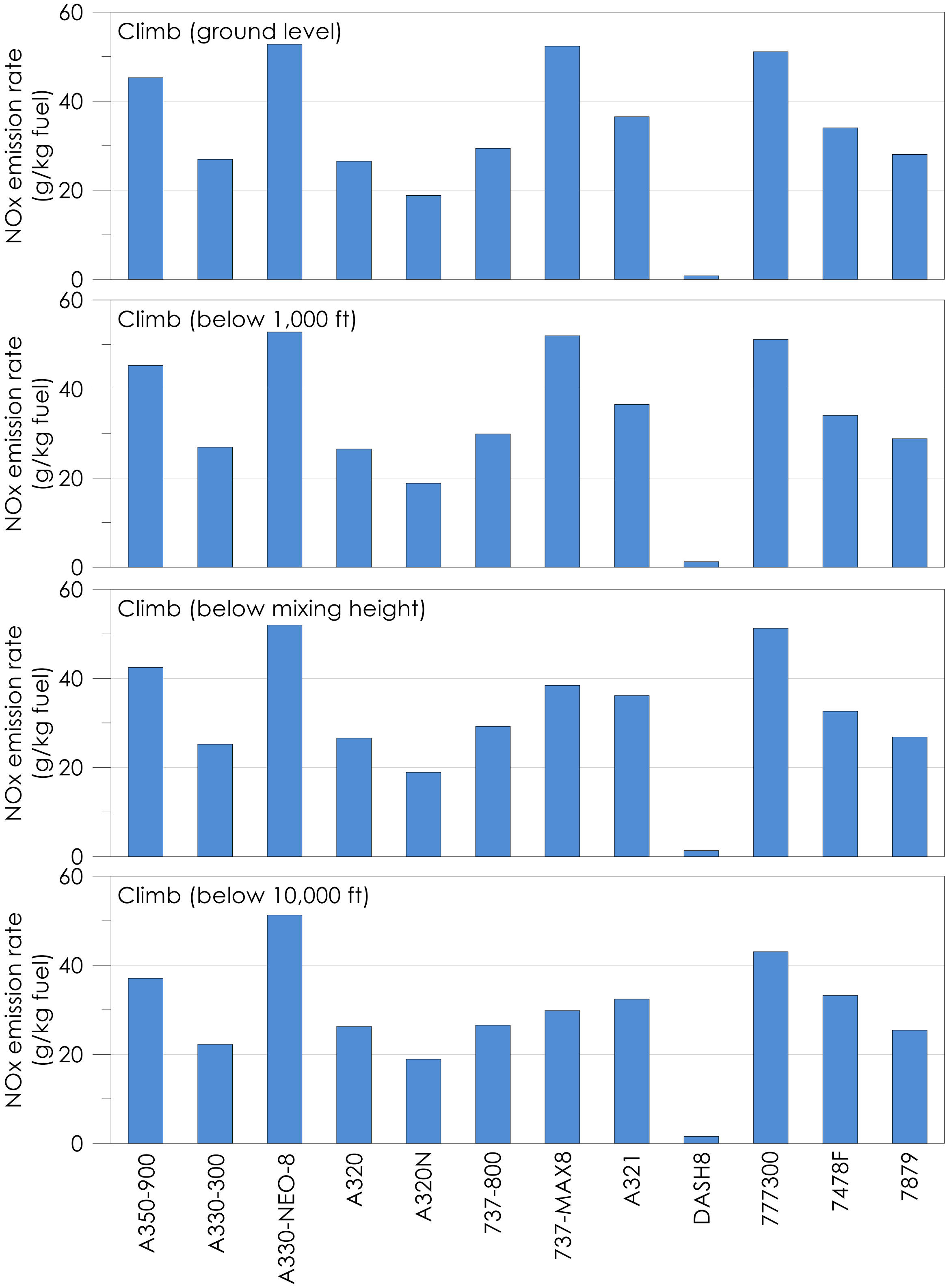


Figure 5.5 Estimated NOx emissions rate for aircraft during departure

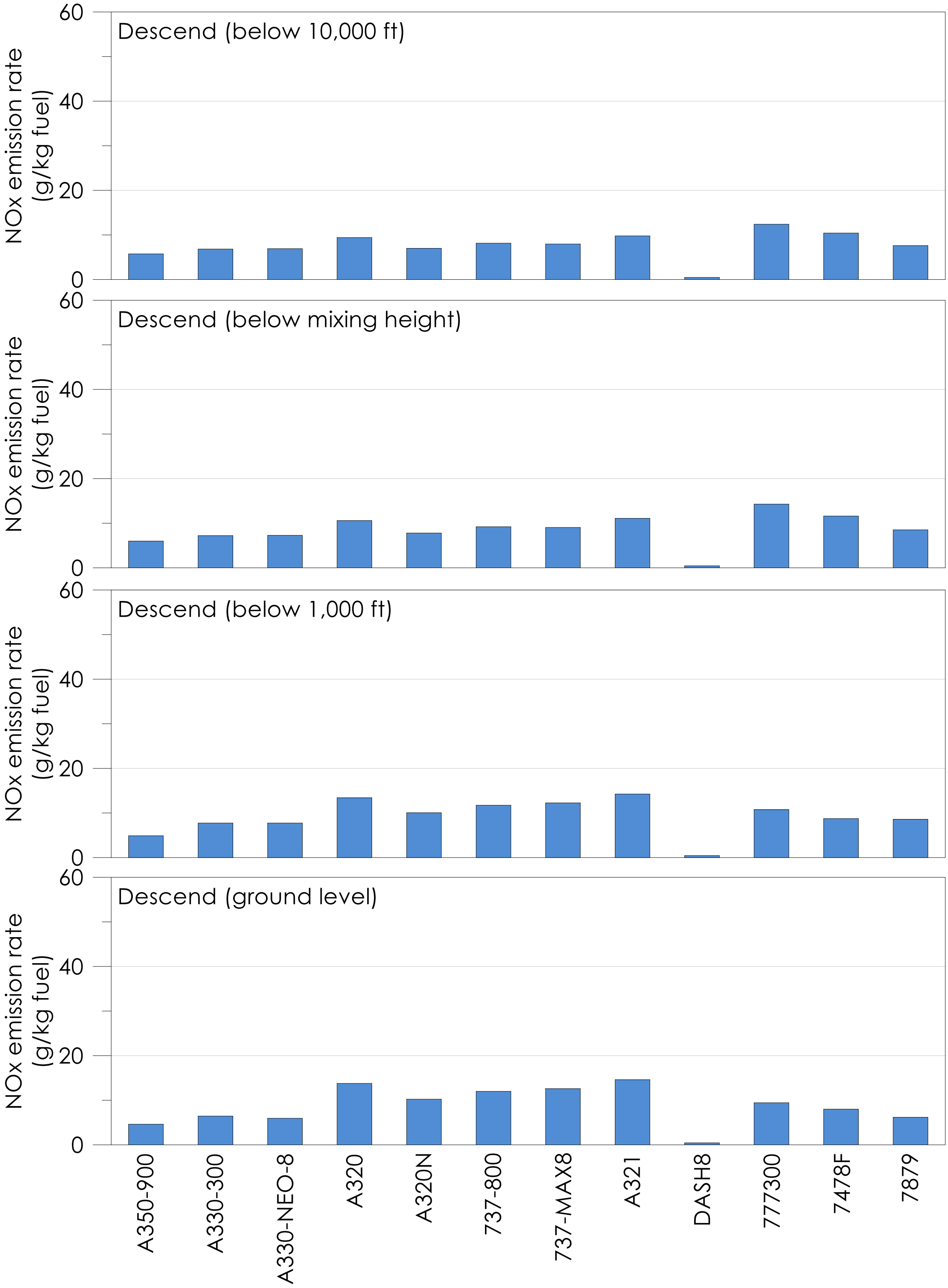


Figure 5.6 **Estimated NOx emissions rate for aircraft during arrival**

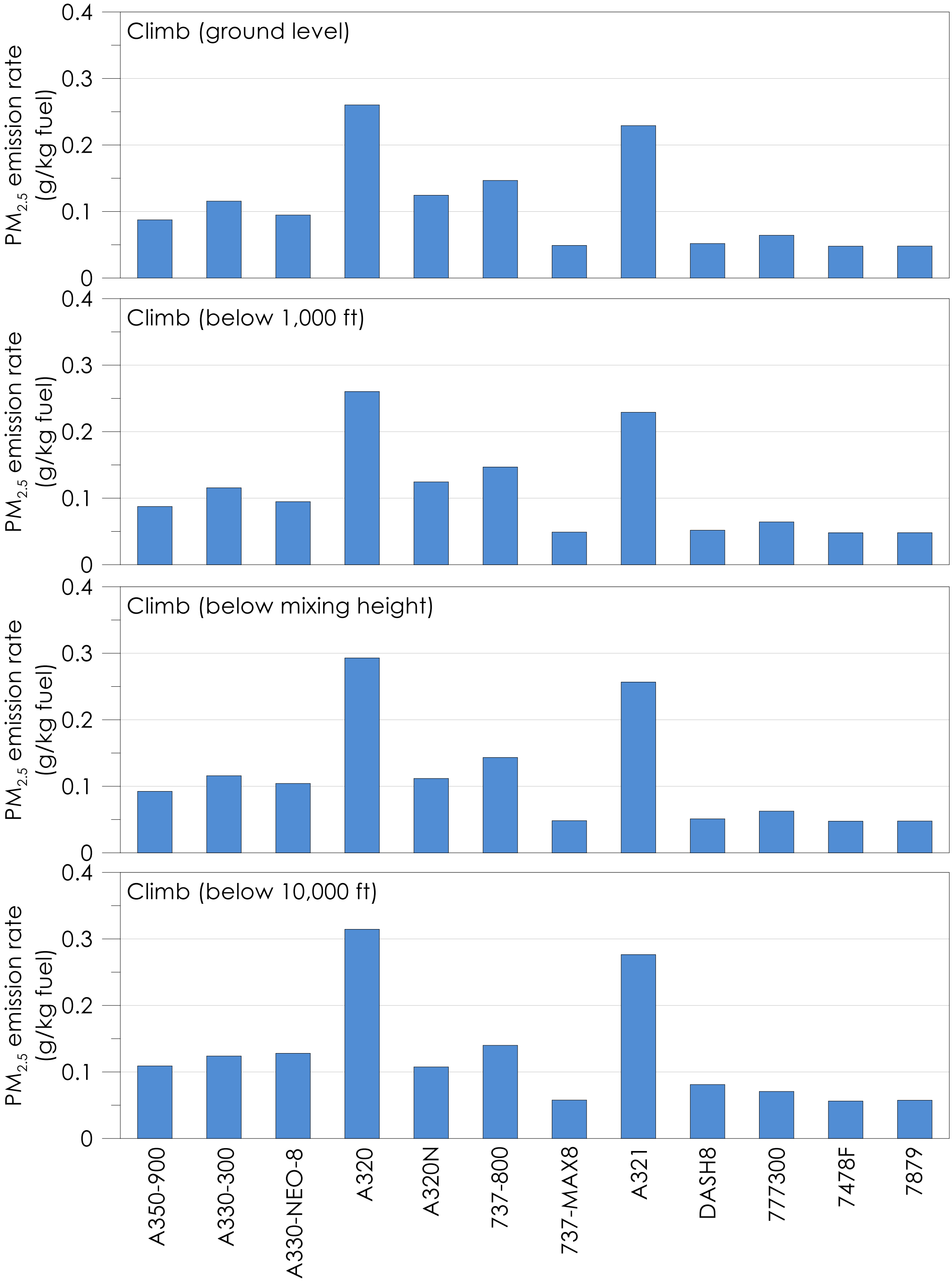


Figure 5.7 Estimated $PM_{2.5}$ emissions rate for aircraft during departure

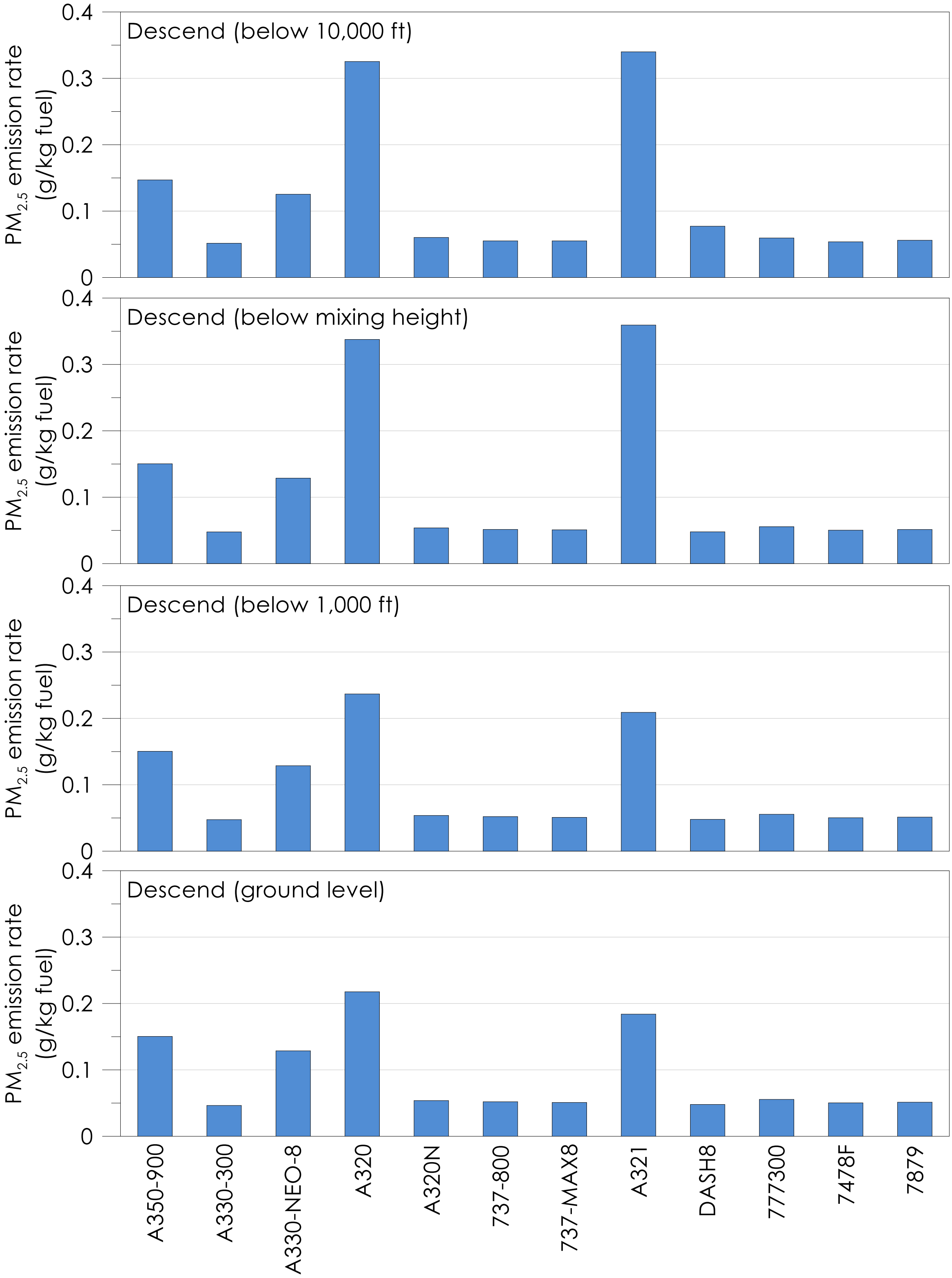


Figure 5.8 **Estimated $PM_{2.5}$ emissions rate for aircraft during arrival**

Aircraft emissions for the different phases of flight were allocated to sources which were representative of segments of the vertical profiles and flight paths shown in Figure 5.3 and Figure 5.4. Emissions from each flight were distributed amongst the representative sources of the appropriate flight paths, which considered the flight schedule (including type of aircraft), the operating scenario, allocated runway, time of day, wind conditions and direction of travel of the aircraft (which was based on the flight's O-D route).

Aircraft taxi emissions were calculated using the standard ICAO taxi out and taxi in times of 19 and 7 minutes respectively, using the ICAO taxi emission factors for the aircraft in the schedule. These taxi times are likely to be conservative and overestimate taxi emissions given the traffic levels projected in 2033.

Emissions were then summed up for each source (a location along a flight path) and hour of the year to generate an hourly emissions profile along each flight path for the purpose of air dispersion modelling.

Figure 5.9 to Figure 5.13 present the flight paths and distances travelled by the aircraft in the different scenarios, as well as the local air quality modelling domain and the larger regional modelling domain. The figures present the total cumulative distance travelled all aircrafts in each scenario at every location (on a regular 1 kilometre x 1 kilometre grid) within the modelling domains. They provide a visual representation of the total distribution of flights over the modelling domains in an annual period and highlight the differences between the modelling scenarios (No preference, Prefer Runway 05 and Prefer Runway 23) and future schedules (2033 and 2055). The regional domain covers the maximum available extent which incorporates the most current NSW EPA modelled anthropogenic and biogenic emissions.

The emissions which were input into the local and regional air dispersion models include the same level of detail shown in these figures Figure 5.9 to Figure 5.13**,** but for every hour in the modelling period, and the kilometres are multiplied by the pollutant emission rates for each type of aircraft (including differing emissions along the different stages of flight), refer to Figure 5.5 and Figure 5.6.

The total estimated annual aircraft emissions for the local air quality assessment are summarised in Table 5.3 and include taxi, arriving and departing aircraft emissions within the modelling domain, for approximately up to a height of 3,000 ft. Aircraft emissions estimates for 2055 are larger than 2033 as would be expected considering the increase in aircraft movements.

Table 5.3 Estimated aircraft emissions (total tonnes/year)

Pollutant	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
CO	177.5	177.5	177.5	593.0	593.0
VOC	25.0	25.0	25.0	67.9	67.9
NO_X	518.8	518.8	518.8	1928.0	1927.9
SO_X	30.5	30.5	30.5	102.1	102.1
$PM_{2.5}$	3.7	3.7	3.7	9.7	9.7
PM_{10}	3.7	3.7	3.7	9.7	9.7

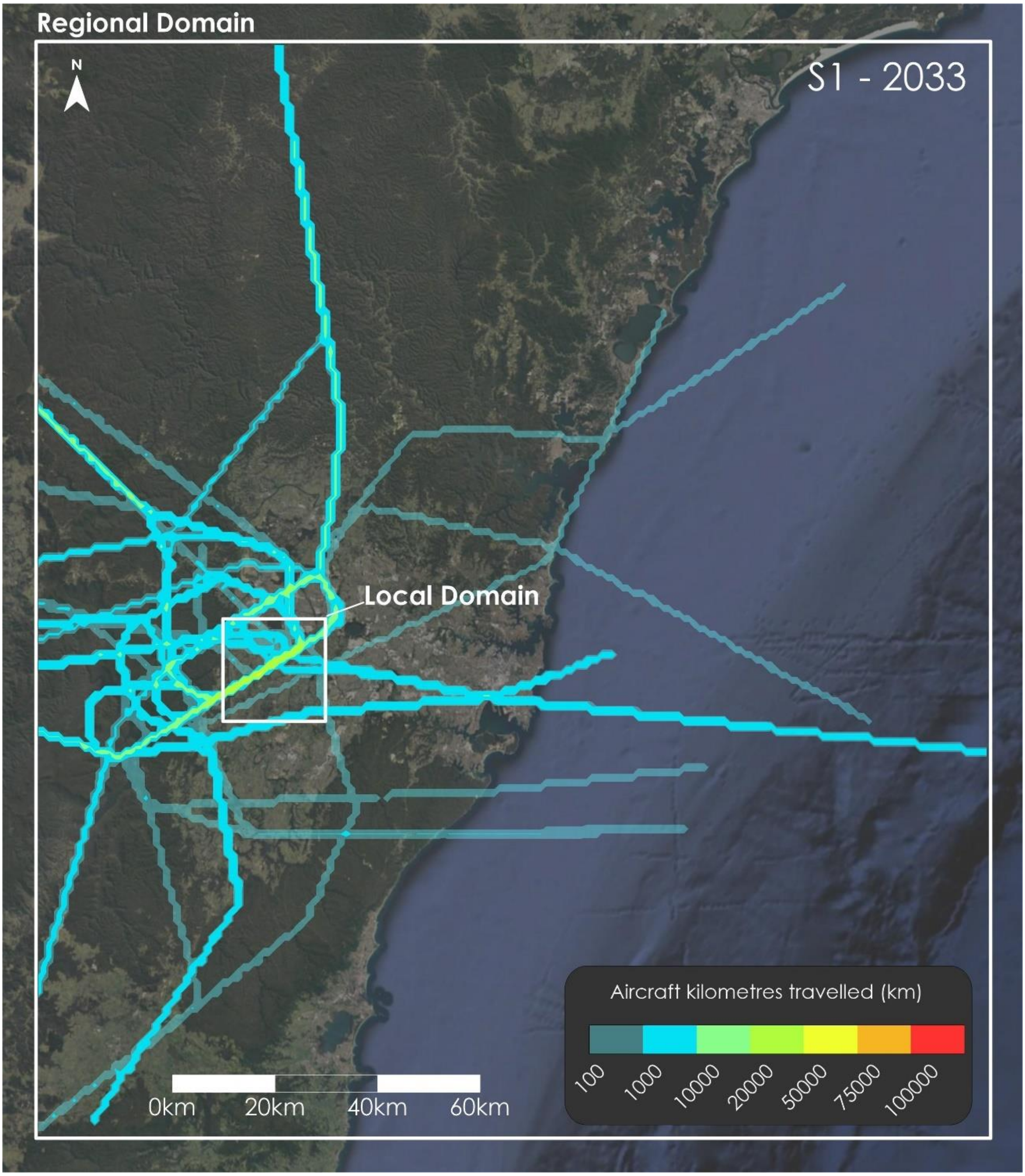


Figure 5.9 Flight paths and kilometres travelled for No preference in 2033

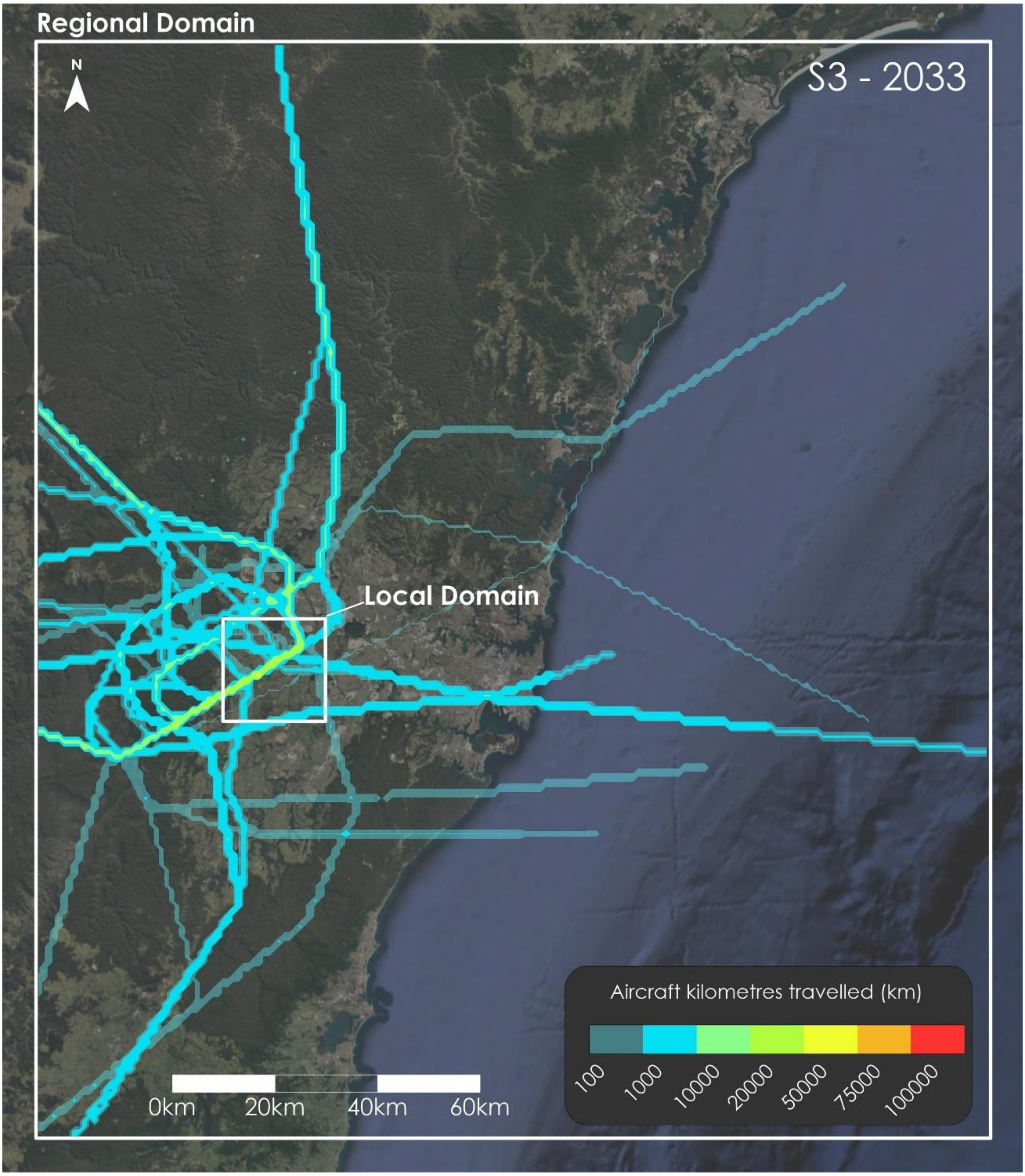


Figure 5.10 Flight paths and kilometres travelled for Prefer Runway 05 in 2033

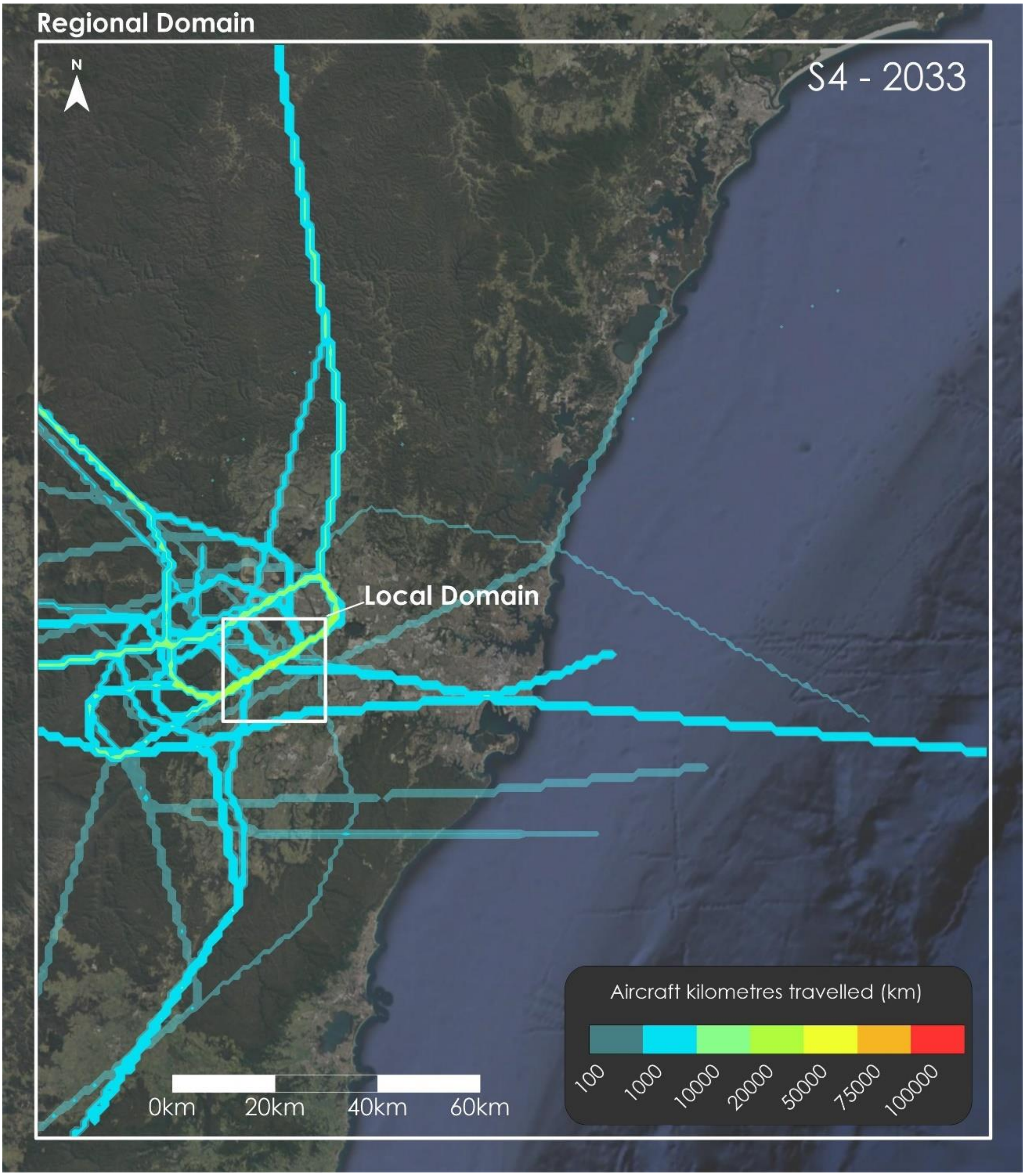


Figure 5.11 Flight paths and kilometres travelled for Prefer Runway 23 in 2033

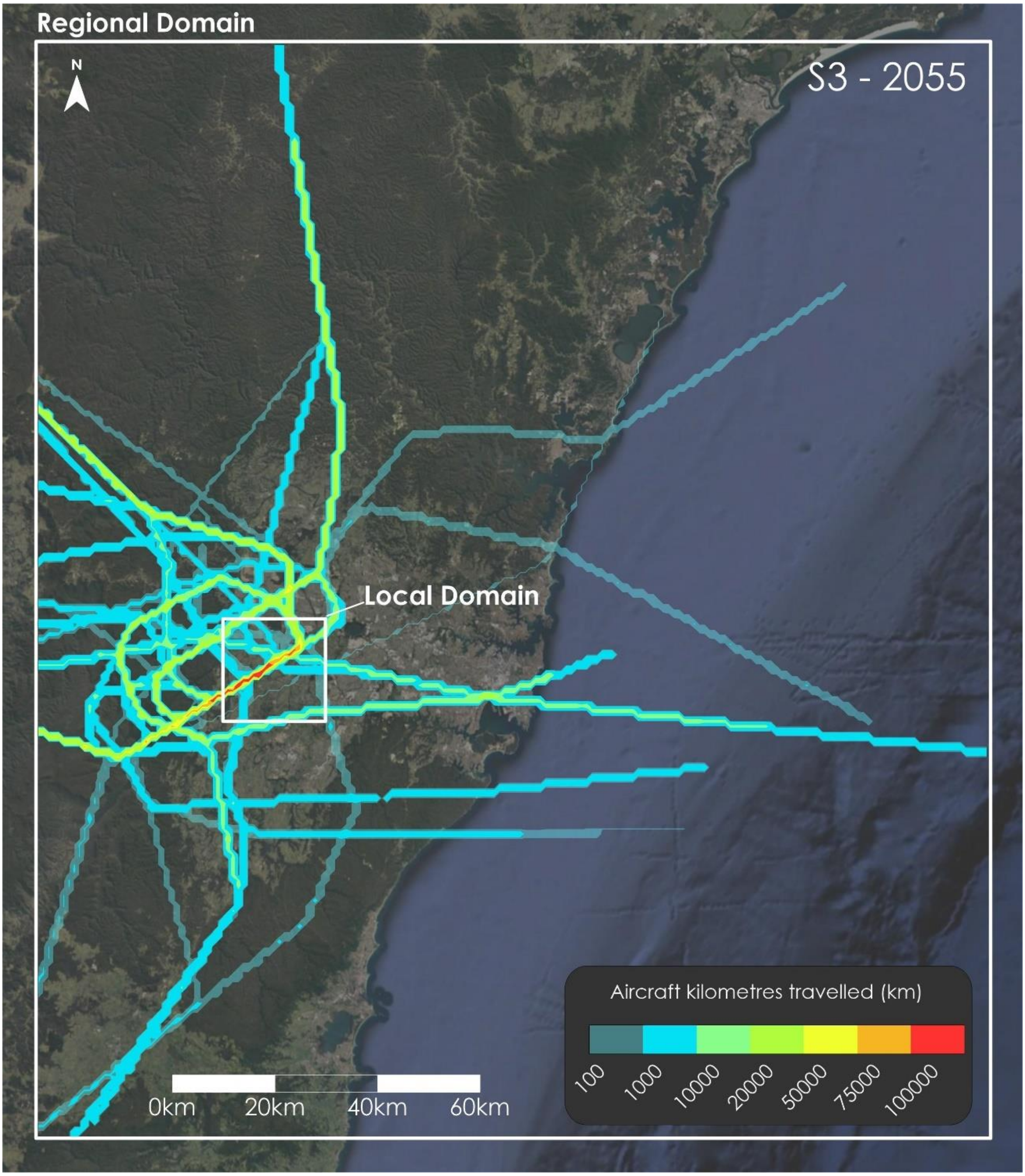


Figure 5.12 Flight paths and kilometres travelled for Prefer Runway 05 in 2055

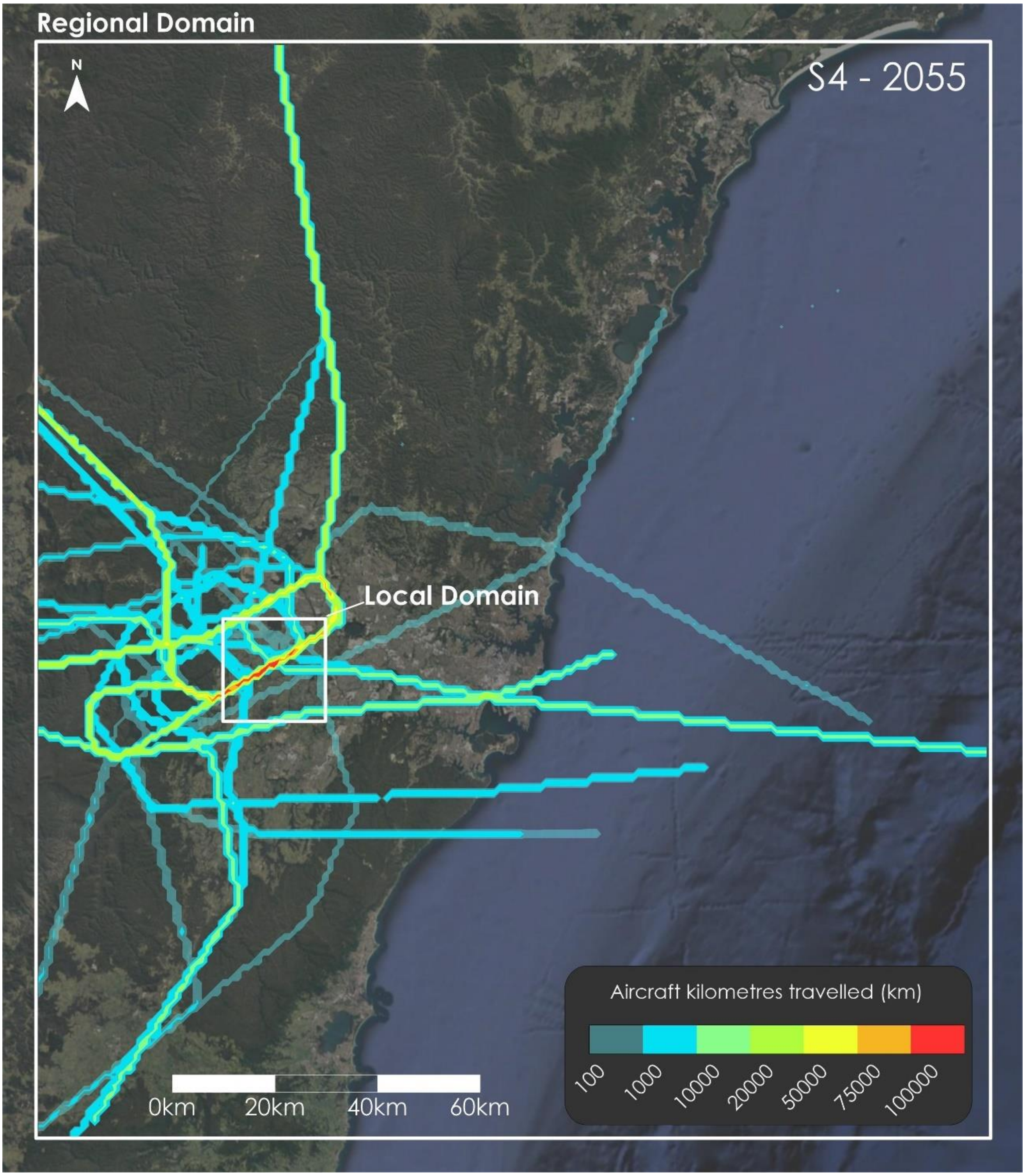


Figure 5.13 Flight paths and kilometres travelled for Prefer Runway 23 in 2055

Chapter 6 Impact assessment

6.1 Local air quality

The dispersion modelling predictions for each assessed scenario in the local air quality assessment are summarised in this section. The results presented include those for the project in isolation (incremental impact) and the project with other approved sources i.e., ground-based operations, and background levels (cumulative impact). Only a summary of the results is presented in this section. Detailed modelling predictions at each assessed receptor location and associated isopleth diagrams of the dispersion modelling results are presented in Appendix C.

No exceedances were identified for 2033, and only minor exceedances were found for 2055.

The results indicate the project would not result in any tangible or significant impact above criteria, noting that the criteria are more stringent than those applied in the 2016 EIS. Further details of the results and a discussion of the significance of the potential impacts is set out in Chapter 7.

6.1.1 Summary of modelling results for 2033

The results indicate compliance with all criteria for 2033, noting the existing background levels of annual average $PM_{2.5}$ are already close to the criteria value.

Complete results are set out in Appendix C.

6.1.1.1 Particulate matter concentrations

The predicted incremental particulate matter concentrations for the project are summarised in Table 6.1 for the residential receptor locations. The results indicate the project would only make a small air quality contribution at these receptor locations with the maximum predicted 24-hour average level of 0.61 µg/m³ and a maximum annual average level of 0.13 µg/m³ for the scenarios assessed. These are low values, which are well below any typical year to year variability in the ambient data. Note that 100 per cent of the PM_{10} is assumed to be in the $PM_{2.5}$ size fraction, hence the PM_{10} and $PM_{2.5}$ incremental values are the same.

Table 6.1 Summary of incremental particulate matter concentrations for 2033 (µg/m³)

Receptor ID	24-hour average			Annual average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
R1	0.05	0.05	0.05	0.00	0.00	0.01
R2	0.28	0.32	0.27	0.05	0.05	0.04
R3	0.17	0.14	0.11	0.01	0.01	0.01
R4	0.03	0.04	0.04	0.00	0.00	0.00
R6	0.05	0.04	0.03	0.00	0.00	0.00
R7	0.04	0.03	0.03	0.00	0.00	0.00
R8	0.07	0.06	0.07	0.01	0.01	0.01
R14	0.11	0.10	0.13	0.01	0.01	0.01
R15	0.24	0.22	0.22	0.02	0.02	0.02

Receptor ID	24-hour average			Annual average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
R17	0.14	0.11	0.14	0.02	0.02	0.02
R18	0.36	0.24	0.38	0.05	0.06	0.09
R19	0.40	0.52	0.61	0.09	0.11	0.13
R21	0.45	0.43	0.20	0.06	0.05	0.03
R22	0.06	0.06	0.06	0.00	0.00	0.00
R23	0.04	0.04	0.03	0.01	0.01	0.00
R27	0.23	0.19	0.10	0.02	0.01	0.01
R30	0.02	0.02	0.02	0.00	0.00	0.00
R31	0.03	0.03	0.03	0.00	0.00	0.00
Max value	0.45	0.52	0.61	0.09	0.11	0.13

The contribution associated with the ground-based operations at WSI was included in the assessment using the emissions estimated from the modelling predictions presented in the 2016 EIS (PEL, 2016), given that the ground-based sources are not proposed to change. The emission estimates for Stage 1 in the 2016 EIS are used to determine the potential contribution of ground-based operations compared to the total emission modelled for the WSI. The contribution is then added to the predictions at the sensitive receptor locations, assuming a direct correlation to the total emissions. The estimated contribution along with the background levels described in Section 4.4.7 are applied to determine the total cumulative level.

Table 6.2 presents a summary of the predicted cumulative $PM_{2.5}$ concentrations for 2033 at the most impacted residential receptor location. The results indicate the predicted cumulative 24-hour average and annual average levels are below all relevant criteria.

Table 6.2 Summary of cumulative $PM_{2.5}$ concentrations for 2033 (µg/m³)

	24-hour average			Annual average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
Max value at residential receptors	0.45	0.52	0.61	0.09	0.11	0.13
Estimated contribution at equivalent residential receptor location due to ground-based operations from 2016 EIS	0.44	1.06	1.06	0.11	0.11	0.11
Background level	21	21	21	7.6	7.6	7.6
Cumulative level	21.9	22.6	22.7	7.8	7.8	7.8
Criterion	25	25	25	8	8	8

Table 6.3 presents a summary of the predicted cumulative PM_{10} concentrations for 2033. The results indicate the predicted cumulative 24-hour average and annual average levels are below all relevant criteria.

Table 6.3 Summary of cumulative PM_{10} concentrations for 2033 (µg/m³)

	24-hour average			Annual average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
Max value at residential receptors	0.45	0.52	0.61	0.09	0.11	0.13
Estimated contribution at equivalent residential receptor location due to ground-based operations from the 2016 EIS	0.51	1.13	1.13	0.11	0.11	0.11
Background level	43.5	43.5	43.5	18.8	18.8	18.8
Cumulative level	44.5	45.2	45.2	19.0	19.0	19.0
Criterion	50	50	50	25	25	25

6.1.1.2 NO_2 concentrations

The predicted NO_2 concentrations for the project are summarised in Table 6.4 for the residential receptor locations. The modelling predictions include consideration of background levels using the OLM method.

Table 6.4 Summary of NO_2 concentrations for 2033 (µg/m³)

Receptor ID	1-hour average			Annual average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
R1	61.6	61.6	61.6	6.8	6.8	6.8
R2	97.4	97.4	78.4	9.3	9.7	9.2
R3	66.1	68.3	66.1	7.6	7.5	7.3
R4	61.5	61.5	61.5	6.6	6.6	6.7
R6	61.6	61.6	61.6	6.8	6.8	6.8
R7	61.8	61.8	61.7	6.9	6.9	6.8
R8	61.8	61.8	61.6	7.3	7.3	7.4
R14	64.0	61.6	64.0	7.1	7.1	7.2
R15	73.5	73.5	86.6	7.6	7.7	7.8
R17	91.9	93.1	93.1	8.0	8.0	8.3
R18	113.8	112.1	112.9	10.3	10.5	12.8
R19	99.4	96.2	112.3	10.9	12.1	12.5

Receptor ID	1-hour average			Annual average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
R21	84.1	84.0	68.0	9.6	9.2	8.3
R22	61.6	61.6	61.5	6.7	6.7	6.8
R23	62.3	62.3	62.2	7.1	7.0	6.9
R27	84.9	84.9	73.2	7.6	7.5	7.4
R30	61.6	61.6	61.5	6.5	6.5	6.6
R31	61.5	61.5	61.5	6.6	6.6	6.6
Max	113.8	112.1	112.9	10.9	12.1	12.8

Table 6.5 presents a summary of the predicted cumulative NO_2 concentrations for 2033. Note that background data are included contemporaneously for each hour of the year using the OLM method (refer to Table 4.8). The results indicate predicted cumulative 1-hour average and annual average levels are below the relevant criterion in 2033.

Table 6.5 Summary of cumulative NO_2 concentrations for 2033 (µg/m³)

	24-hour average			Annual average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
Max value at residential receptors	113.8	112.1	112.9	10.9	12.1	12.8
Estimated contribution at equivalent residential receptor location due to ground-based operations from the 2016 EIS	8.2	8.2	8.2	1.5	1.5	1.5
Cumulative level	121.9	120.3	121.0	12.3	13.5	14.3
Criterion	164.0	164.0	164.0	31.0	31.0	31.0

6.1.1.3 SO_2 concentrations

The predicted SO_2 concentrations for the project are summarised in Table 6.6 for the residential receptor locations.

Table 6.6 Summary of SO_2 concentrations for 2033 (µg/m³)

Receptor ID	1-hour average			24-hour average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
R1	3.8	3.9	3.9	0.5	0.5	0.6
R2	24.1	22.4	19.8	3.0	3.1	2.9
R3	10.7	5.4	5.4	1.9	1.5	1.2
R4	3.3	3.8	3.7	0.4	0.5	0.5
R6	2.6	1.9	2.3	0.5	0.4	0.4
R7	2.4	2.2	2.2	0.4	0.3	0.3
R8	5.1	5.2	5.2	0.8	0.8	0.8
R14	10.5	10.6	10.6	1.2	1.2	1.5
R15	16.5	15.1	14.3	2.5	2.3	2.3
R17	14.8	15.1	15.1	1.4	1.3	1.5
R18	21.9	26.9	29.3	3.4	2.9	3.8
R19	41.4	33.5	43.4	5.2	5.5	6.0
R21	32.5	23.7	13.3	4.7	4.4	2.3
R22	5.5	5.7	5.6	0.7	0.7	0.7
R23	2.9	2.6	2.2	0.4	0.4	0.3
R27	9.8	7.9	7.0	2.4	1.9	1.2
R30	1.5	1.4	1.4	0.2	0.2	0.3
R31	2.8	2.9	2.9	0.3	0.3	0.3
Max	41.4	33.5	43.4	5.2	5.5	6.0

Table 6.7 presents a summary of the predicted cumulative SO_2 concentrations for 2033. The results indicate predicted cumulative 1-hour average and 24-hour average levels are below the relevant criterion in 2033.

Table 6.7 Summary of cumulative SO_2 concentrations for 2033 (µg/m³)

	24-hour average			Annual average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
Max value at residential receptors	41.4	33.5	43.4	5.2	5.5	6.0
Estimated contribution at equivalent residential receptor location due to ground-based operations from the 2016 EIS	5.8	5.8	5.8	0.4	0.4	0.4
Background	80.0	80.0	80.0	10.3	10.3	10.3
Cumulative level	127.2	119.4	129.2	15.9	16.1	16.7
Criterion	286.0	286.0	286.0	57.0	57.0	57.0

6.1.1.4 CO concentrations

The predicted CO concentrations for the project are summarised in Table 6.8 for selected sensitive receptor locations.

Table 6.8 Summary of CO concentrations for 2033 (µg/m³)

Receptor ID	15-minute average			1-hour average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
R1	38.8	42.2	42.3	29.4	32.0	32.0
R2	296.1	271.0	296.6	224.4	205.4	224.8
R3	116.8	62.3	60.7	88.5	47.2	46.0
R4	38.1	47.3	47.1	28.9	35.9	35.7
R6	27.6	24.6	26.7	20.9	18.7	20.2
R7	25.3	23.5	24.1	19.1	17.8	18.2
R8	58.6	65.2	65.0	44.4	49.4	49.2
R14	137.4	118.5	137.3	104.1	89.8	104.1
R15	188.0	187.8	173.4	142.5	142.3	131.4
R17	176.8	159.6	176.9	134.0	121.0	134.1
R18	236.4	269.3	282.8	179.1	204.1	214.4
R19	512.7	512.7	539.3	388.6	388.6	408.7
R21	323.4	255.8	187.4	245.1	193.8	142.0

Receptor ID	15-minute average			1-hour average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
R22	59.1	64.8	64.8	44.8	49.1	49.1
R23	31.0	26.8	24.7	23.5	20.3	18.7
R27	364.2	201.8	364.1	276.0	153.0	276.0
R30	18.3	16.6	16.7	13.9	12.6	12.6
R31	31.1	32.7	32.5	23.6	24.8	24.6
Max	512.7	512.7	539.3	388.6	388.6	408.7

Table 6.9 presents a summary of the predicted cumulative CO concentrations for 2033. The results indicate predicted cumulative 15-minute average and 1-hour average levels are below the relevant criterion in 2033.

Table 6.9 Summary of cumulative CO concentrations for 2033 (µg/m³)

	15-minute average			1-hour average		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
Max value at residential receptors	512.7	512.7	539.3	388.6	388.6	408.7
Estimated contribution at equivalent residential receptor location due to ground-based operations from the 2016 EIS	839.5	839.5	839.5	620.5	620.5	620.5
Background	–	–	–	6,125	6,125	6,125
Cumulative level	1,352	1,352	1,379	7,134	7,134	7,154
Criterion	100,000	100,000	100,000	30,000	30,000	30,000

6.1.1.5 VOC and odour concentrations

The predicted VOC concentrations for the project are summarised in Table 6.10 and Table 6.11 for the residential receptor locations. The results indicate predicted 1-hour average levels are below the relevant criterion in 2033. The odorous air pollutants are below the relevant criterion which indicates the odour would not be detectable.

Table 6.10 Summary of benzene and formaldehyde concentrations for 2033 (µg/m³)

Receptor ID	99.9th percentile 1-hour average -Benzene			99.9th percentile 1-hour average -Formaldehyde		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
R1	0.0	0.1	0.1	0.4	0.4	0.4
R2	0.4	0.4	0.3	2.9	2.9	2.5
R3	0.1	0.1	0.1	1.0	0.8	0.7
R4	0.0	0.0	0.0	0.3	0.3	0.4
R6	0.0	0.0	0.0	0.3	0.3	0.3
R7	0.0	0.0	0.0	0.3	0.3	0.3
R8	0.1	0.1	0.1	0.7	0.6	0.7
R14	0.1	0.1	0.2	1.2	1.0	1.4
R15	0.3	0.3	0.2	2.1	2.1	1.7
R17	0.1	0.1	0.2	1.1	1.2	1.2
R18	0.3	0.4	0.4	2.7	3.2	3.4
R19	0.7	0.7	0.8	5.6	5.6	5.9
R21	0.5	0.4	0.3	3.8	3.2	2.2
R22	0.1	0.1	0.1	0.4	0.5	0.6
R23	0.0	0.0	0.0	0.3	0.3	0.3
R27	0.1	0.1	0.1	1.1	1.0	0.7
R30	0.0	0.0	0.0	0.2	0.2	0.2
R31	0.0	0.0	0.0	0.2	0.3	0.3
Max value	0.7	0.7	0.8	5.6	5.6	5.9
Criterion	29	29	29	20	20	20

Table 6.11 Summary of toluene and xylene concentrations for 2033 ($\mu g/m^3$)

Receptor ID	99.9th percentile 1-hour average – Toluene			99.9th percentile 1-hour average – Xylene		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
R1	0.0	0.0	0.0	0.0	0.0	0.0
R2	0.1	0.1	0.1	0.1	0.1	0.1
R3	0.0	0.0	0.0	0.0	0.0	0.0
R4	0.0	0.0	0.0	0.0	0.0	0.0
R6	0.0	0.0	0.0	0.0	0.0	0.0
R7	0.0	0.0	0.0	0.0	0.0	0.0
R8	0.0	0.0	0.0	0.0	0.0	0.0
R14	0.0	0.0	0.0	0.0	0.0	0.0
R15	0.1	0.1	0.1	0.1	0.1	0.1
R17	0.0	0.0	0.0	0.0	0.0	0.0
R18	0.1	0.1	0.1	0.1	0.1	0.1
R19	0.2	0.2	0.2	0.2	0.2	0.2
R21	0.1	0.1	0.1	0.1	0.1	0.1
R22	0.0	0.0	0.0	0.0	0.0	0.0
R23	0.0	0.0	0.0	0.0	0.0	0.0
R27	0.0	0.0	0.0	0.0	0.0	0.0
R30	0.0	0.0	0.0	0.0	0.0	0.0
R31	0.0	0.0	0.0	0.0	0.0	0.0
Max value	0.2	0.2	0.2	0.2	0.2	0.2
Criterion	360	360	360	190	190	190

6.1.2 Summary of modelling results for 2055

The cumulative impact assessment for 2055 is limited to the maximum impacting scenarios Prefer Runway 05 and Prefer Runway 23, for $PM_{2.5}$, PM_{10} and NO_2, as only such results are available for ground levels sources from the 2016 EIS. Complete results are set out in Appendix C.

The results indicate compliance with all criteria except for NO_2 and $PM_{2.5}$. Some small and infrequent exceedances of the 1-hr NO_2 criteria are predicted at a few receptors adjacent to the project. The assessment however uses conservative assumptions, and actual NO_2 impacts are unlikely. For $PM_{2.5}$, the exceedance arises due to elevated background levels, and there is no tangible impact due to the project. A detailed discussion of the impacts is provided in Chapter 7.

6.1.2.1 Particulate matter concentrations

The predicted incremental particulate matter concentrations for the project are summarised in Table 6.12 for the residential receptor locations. Note that 100 per cent of the PM_{10} is assumed to be in the $PM_{2.5}$ size fraction, hence the PM_{10} and $PM_{2.5}$ incremental values are the same.

Table 6.12 Summary of incremental particulate matter concentrations for 2055 (µg/m³)

Receptor ID	24-hour average		Annual average	
	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
R1	0.13	0.13	0.01	0.01
R2	0.77	0.65	0.13	0.11
R3	0.35	0.28	0.03	0.03
R4	0.11	0.12	0.01	0.01
R6	0.10	0.09	0.01	0.01
R7	0.07	0.08	0.01	0.01
R8	0.17	0.19	0.02	0.02
R14	0.27	0.31	0.02	0.02
R15	0.51	0.53	0.05	0.05
R17	0.27	0.33	0.04	0.05
R18	0.66	0.88	0.16	0.24
R19	1.28	1.42	0.29	0.32
R21	0.94	0.47	0.11	0.07
R22	0.15	0.15	0.01	0.01
R23	0.09	0.07	0.02	0.01
R27	0.44	0.26	0.04	0.03
R30	0.05	0.06	0.01	0.01
R31	0.07	0.07	0.01	0.01
Max value	1.28	1.42	0.29	0.32

Table 6.13 presents a summary of the predicted cumulative $PM_{2.5}$ concentrations for 2055 at the most impacted receptor location (R19 near to the northern boundary of the airport). The results indicate the predicted cumulative annual average levels are above the relevant criteria. This arises primarily as the assumed future background levels are set at the current background levels, which are already near to the criteria. The maximum annual average contribution of 0.32 µg/m^3 represents the effect of all flight activity associated with the project.

The results indicate the effect of the project on annual average $PM_{2.5}$ is very small and would not result in any tangible effect on air quality.

Table 6.13 Summary of cumulative $PM_{2.5}$ concentrations for 2055 ($\mu g/m^3$)

	24-hour average		Annual average	
	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
Max value at residential receptors	1.28	1.42	0.29	0.32
Estimated contribution at equivalent residential receptor location due to ground-based operations from the 2016 EIS	2.22	2.22	0.33	0.33
Background level	21	21	7.6	7.6
Cumulative level	24.5	24.6	**8.2**	**8.3**
Criterion	25	25	8	8

Table 6.14 presents a summary of the predicted cumulative PM_{10} concentrations for 2055. The results indicate the predicted cumulative 24-hour average and annual average levels are below all relevant criteria.

Table 6.14 Summary cumulative PM_{10} concentrations for 2055 ($\mu g/m^3$)

	24-hour average		Annual average	
	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
Max value at residential receptors	1.28	1.42	0.29	0.32
Estimated contribution at equivalent residential receptor location due to ground-based operations from the 2016 EIS	4.18	4.18	0.63	0.63
Background level	43.5	43.5	18.8	18.8
Cumulative level	49.0	49.1	19.7	19.8
Criterion	50	50	25	25

6.1.2.2 NO_2 concentrations

The predicted NO_2 concentrations for the project are summarised in Table 6.15 for the residential receptor locations.

The predicted 1-hour average levels are found to above the relevant criterion of 164 µg/m³ at some receptor locations near the northern boundary and northwest of the WSI. The significance of impacts is considered in Section 6.1.2.3.

Table 6.15 Summary of NO_2 concentrations for 2055 (µg/m³)

Receptor ID	1-hour average		Annual average	
	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
R1	62.1	63.7	7.6	7.7
R2	134.3	116.0	13.8	12.8
R3	104.4	90.4	9.1	8.7
R4	61.6	61.6	7.2	7.3
R6	69.6	68.4	7.8	7.7
R7	67.3	63.2	7.9	7.7
R8	70.3	70.3	9.0	9.2
R14	73.7	73.8	8.3	8.6
R15	84.5	92.1	9.8	10.0
R17	126.5	126.5	10.6	11.3
R18	151.3	162.4	16.4	21.0
R19	**185.3**	**238.1**	19.8	20.5
R21	130.5	110.0	12.8	10.9
R22	62.2	61.8	7.5	7.6
R23	66.2	65.4	8.2	7.9
R27	88.6	86.9	9.4	9.2
R30	61.9	61.6	7.0	7.0
R31	61.5	61.5	7.1	7.1
Max value	**185.3**	**238.1**	19.8	21.0

Table 6.16 presents a summary of the predicted cumulative NO_2 concentrations for 2055 at the maximum impacted receptor location. The results indicate predicted cumulative 1-hour average levels are above the relevant criterion and the annual average levels are below the relevant criterion.

Table 6.16 Summary of cumulative NO_2 concentrations for 2055 (µg/m³)

	24-hour average		Annual average	
	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
Max value at residential receptors	185.3	238.1	19.8	21.0
Estimated contribution at equivalent residential receptor location due to ground-based operations from the 2016 EIS	16.1	16.1	3.6	2.9
Cumulative level	**201.5**	**254.2**	23.4	23.9
Criterion	164.0	164.0	31.0	31.0

6.1.2.3 Discussion of predicted NO_2 impacts

The elevated NO_2 levels are predicted to occur in the 2055 year as the single runway approaches capacity for both the Prefer Runway 05 and Prefer Runway 23 scenarios.

A key contributor to the elevated NO_2 levels is the higher NO_X emissions associated with the aircraft operating at WSI during 2055 (refer to Table 5.3 for comparison).

It is crucial however to understand that the contribution due to aircraft operations is only somewhat changed by the changes in the flight paths (this project). The actual change due to the project is only a component of the contribution of the aircraft operations.

It is also important to note that in the local assessment the predicted levels of NO_2 are likely to be conservative (overestimating of impacts) due to 3 key factors:

- the local modelling uses the highly conservative OLM approach for chemical transformations to predict the NO_2 levels
- the modelling assumes the worst case scenario for every hour of the year (and in reality this may not be occurring in the predicted hour of maximum impact), and
- the modelling does not account for any improvement in emissions due to better fuel or engine emission control in the future.

The combination of these factors, means these predicted impacts are unlikely to actually occur.

The predicted impacts are also relatively minor, they occur for only a few hours out of the 8,760 hour modelled, and only at a few locations very near to the WSI. Details in this regard are set out in the figures below for the 2 most impacted locations R19 and R135. The small dark section above the red dotted criteria line indicates the level and frequency of impact relative to the rest of the predicted grey shaded concentrations that are less than criteria.

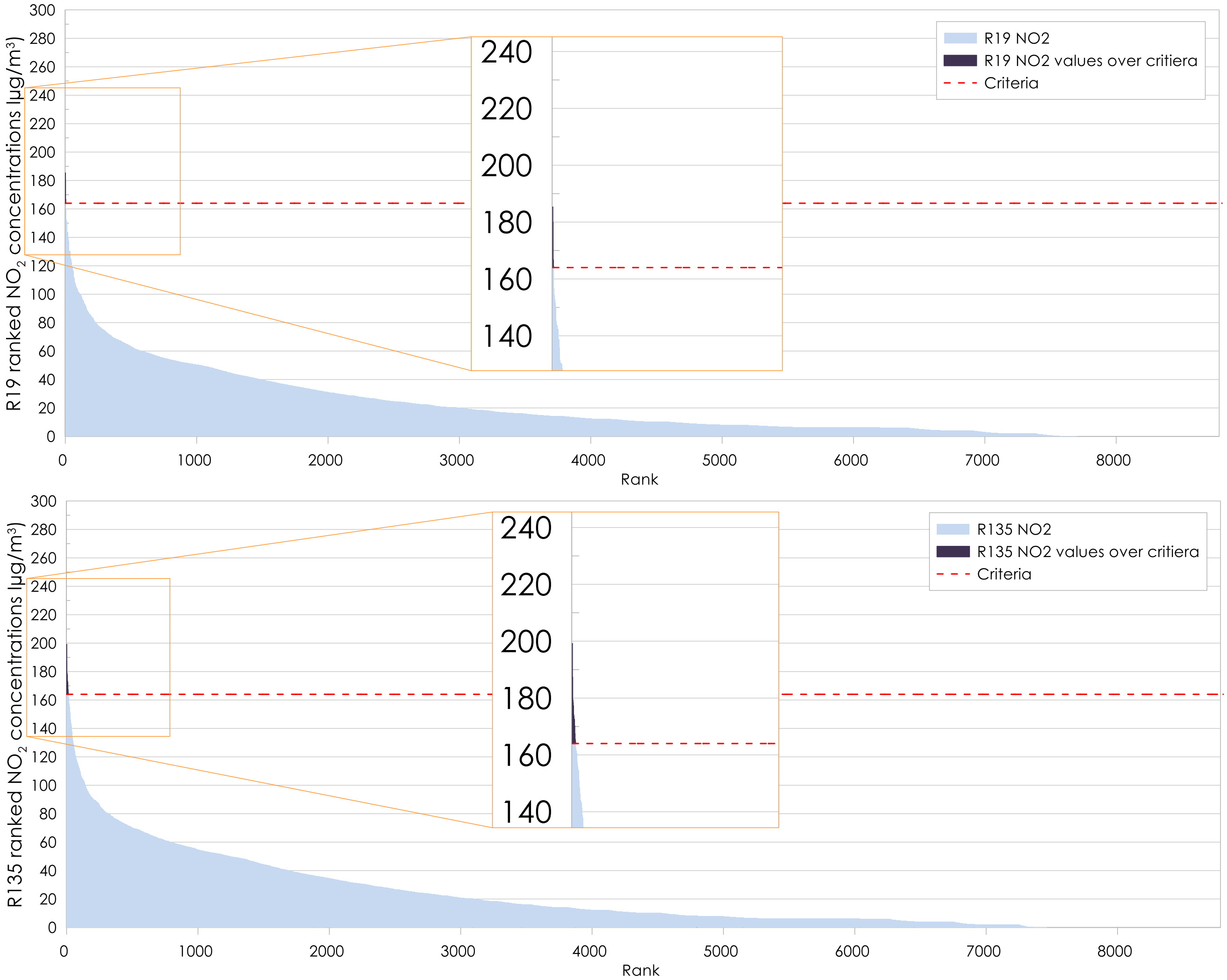


Figure 6.1 Ranked OLM predicted 1-hour average NO_2 concentrations (µg/m³) for all hours, 2055 – Prefer Runway 05

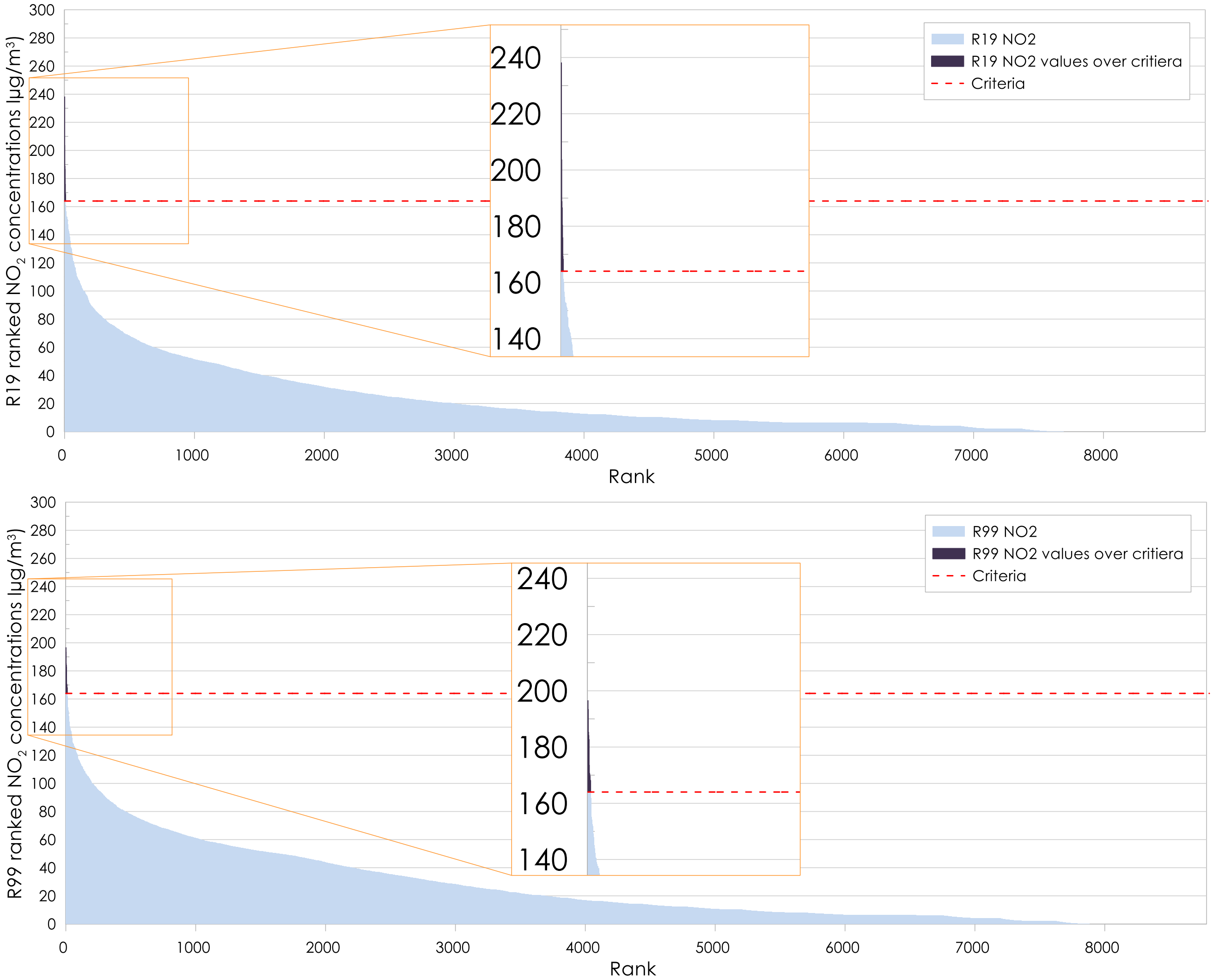


Figure 6.2 Ranked OLM predicted 1-hour average NO_2 concentrations (µg/m³) for all hours, 2055 – Prefer Runway 23

Irrespective of the actual likelihood of no tangible impact arising, the WSI would nevertheless incorporate mitigation measures that are within its control, such as selecting electric or low NO_X emission ground vehicles and conducting maintenance per manufacturer's specifications to minimise the generation of NO_X emissions wherever possible (refer to Chapter 8).

Isopleth diagrams of the modelling predictions showing the spatial location of the predicted maximum 1-hour average NO_2 concentrations for the Prefer Runway 05 and Prefer Runway 23 scenarios in 2055 is presented in Figure 6.3 and Figure 6.4. The modelling predictions indicate the elevated levels occur to the northwest of the site aligning with the length of the runway.

In this regard it is relevant to also note that the area surrounding the airport has been rezoned by the State Government per the planning initiatives for the Western Sydney Aerotropolis. Specifically the area of interest to the northwest of the site is now zoned to restrict intensification residential development, which facilitates the mitigation of potential future impacts. Figure 6.5 presents the current land use and structure plan for the Western Sydney Aerotropolis.

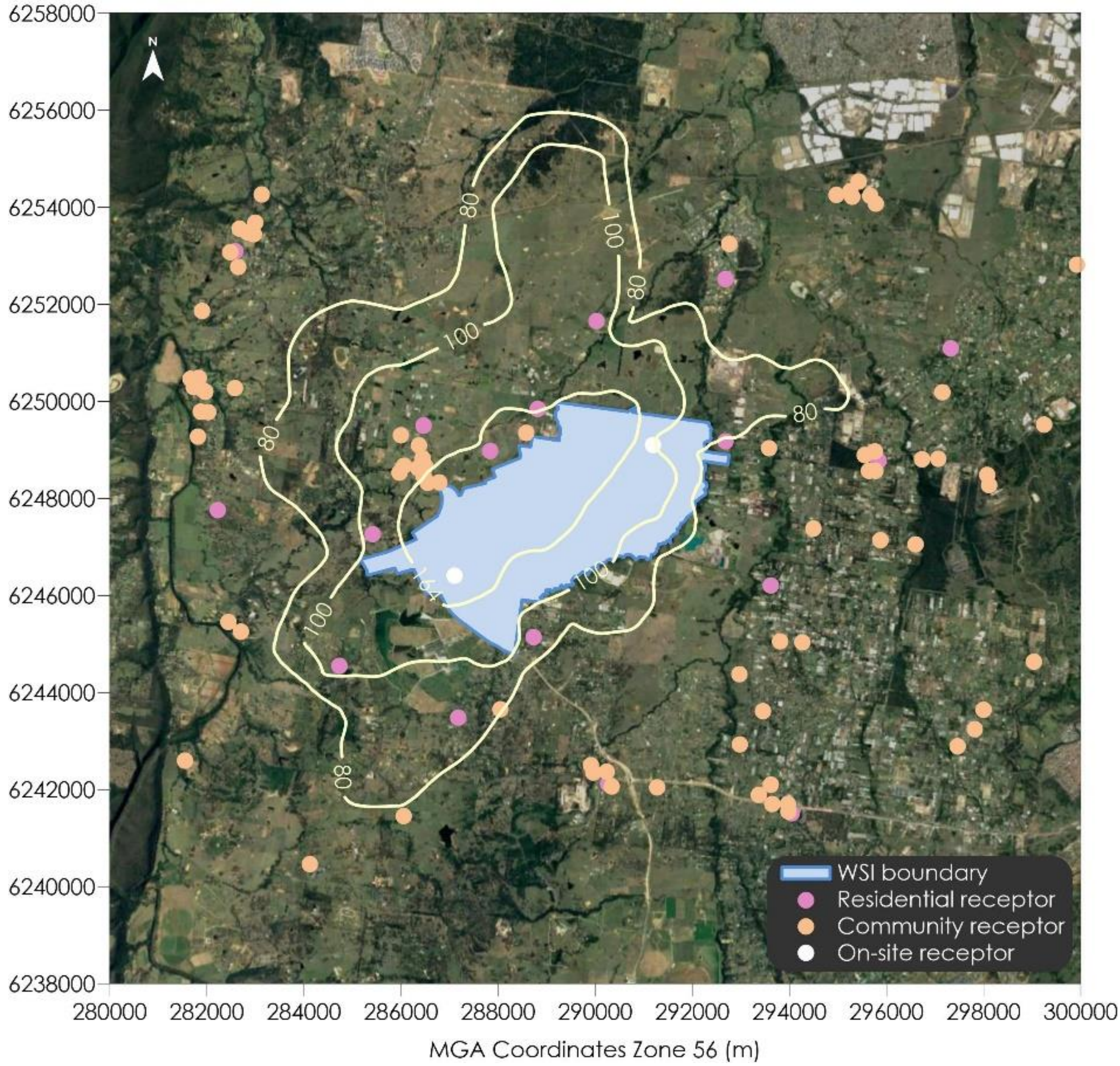


Figure 6.3 Predicted maximum 1-hour average NO_2 concentrations (µg/m³) for 2055 – Prefer Runway 05

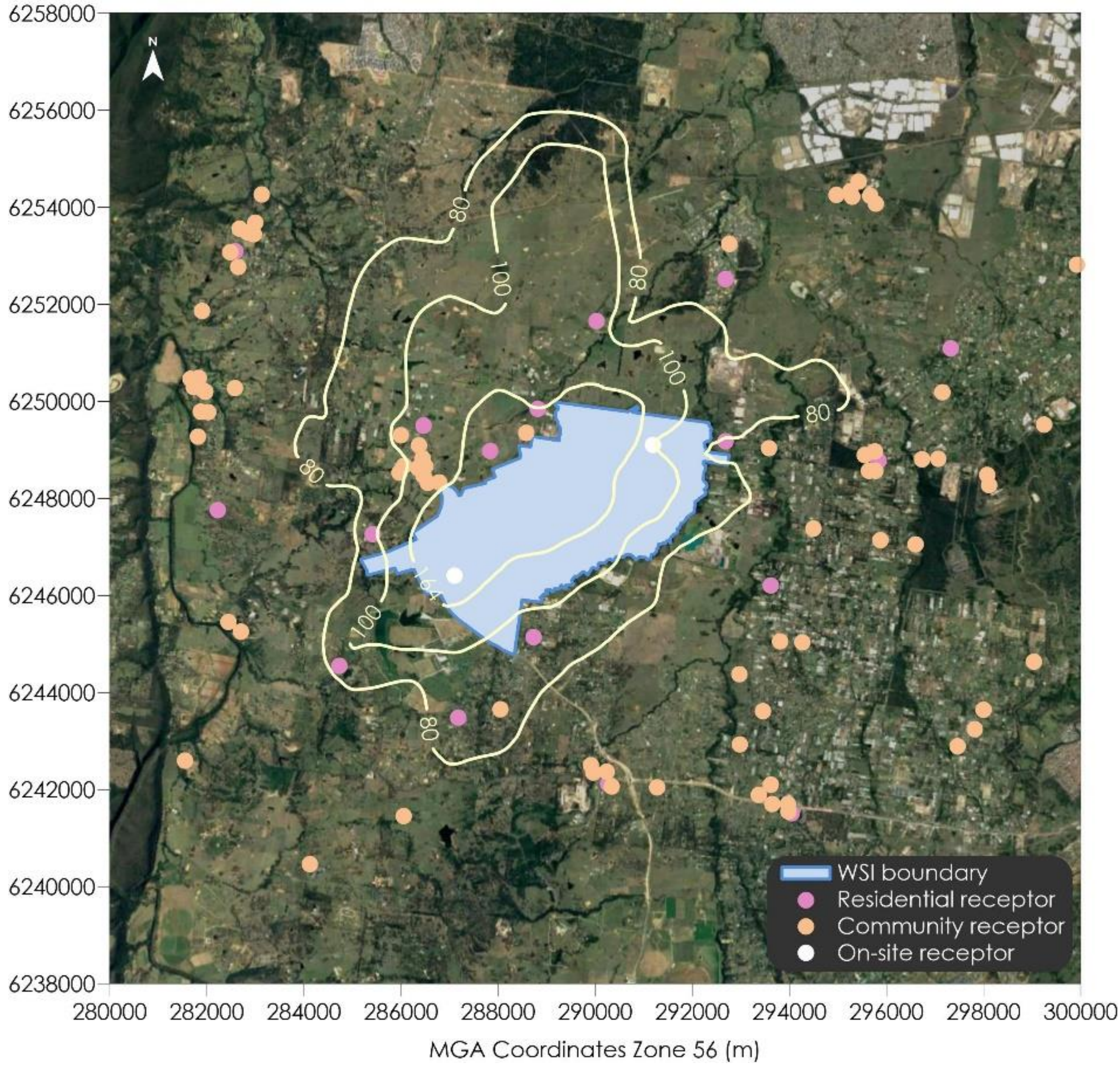
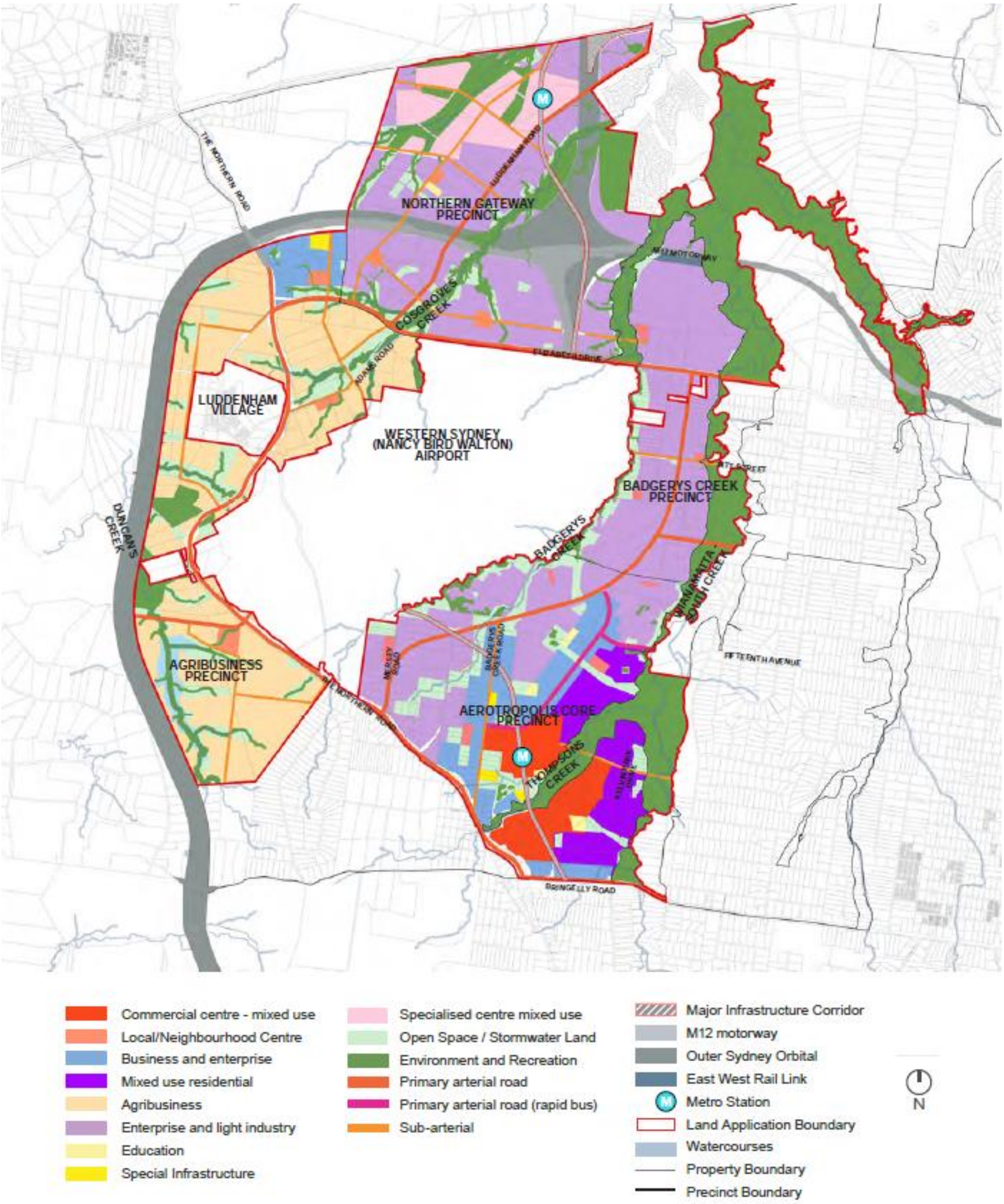


Figure 6.4 Predicted maximum 1-hour average NO_2 concentrations (µg/m³) for 2055 – Prefer Runway 23



Source: NSW DPE (2022)

Figure 6.5 Aerotropolis land use and structure plan

6.1.2.4 SO_2 concentrations

The predicted SO_2 concentrations for the project are summarised in Table 6.17 for the residential receptor locations. The results are well below the applicable criteria.

Table 6.17 Summary of SO_2 concentrations for 2055 (µg/m³)

Receptor ID	1-hour average		24-hour average	
	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
R1	9.6	9.7	1.7	1.7
R2	50.7	59.0	9.3	8.6
R3	20.2	15.3	4.4	3.6
R4	10.7	10.5	1.5	1.6
R6	5.8	6.6	1.3	1.1
R7	6.2	6.5	1.0	1.0
R8	14.9	14.9	2.3	2.6
R14	27.1	27.5	3.8	4.2
R15	39.9	40.0	6.6	6.9
R17	39.9	39.9	4.0	4.4
R18	78.5	77.9	9.2	11.5
R19	101.3	116.0	15.9	18.0
R21	58.5	34.0	11.4	6.2
R22	15.7	15.4	2.1	2.1
R23	6.4	6.2	1.1	0.9
R27	22.2	20.8	5.3	3.5
R30	4.2	4.2	0.7	0.8
R31	7.8	7.6	0.9	1.0
Max value	101.3	116.0	15.9	18.0
Criterion	285	285	57	57

The SO_2 results are well below the applicable criteria.

6.1.2.5 CO concentrations

The predicted CO concentrations for the project are summarised in Table 6.18 for the residential receptor locations. The results are well below the applicable criteria.

Table 6.18 Summary of CO concentrations for 2055 (µg/m³)

Receptor ID	15-minute average		1-hour average	
	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
R1	112.9	113.6	85.6	86.1
R2	693.8	693.9	525.8	525.8
R3	234.7	191.5	177.9	145.2
R4	139.0	137.2	105.3	104.0
R6	75.5	80.5	57.2	61.0
R7	71.7	73.2	54.4	55.5
R8	188.6	186.1	143.0	141.0
R14	327.0	329.5	247.8	249.7
R15	491.8	492.4	372.7	373.2
R17	447.2	446.8	338.9	338.6
R18	877.2	873.7	664.8	662.1
R19	1342.9	1359.9	1017.7	1030.6
R21	652.9	516.1	494.8	391.1
R22	187.3	185.4	141.9	140.5
R23	73.6	75.8	55.8	57.5
R27	265.4	244.1	201.1	185.0
R30	51.8	51.6	39.3	39.1
R31	93.3	91.9	70.7	69.7
Max value	1342.9	1359.9	1017.7	1030.6
Criterion	100,000	100,000	30,000	30,000

The CO results are well below the applicable criteria.

6.1.2.6 VOC and odour concentrations

The predicted VOC concentrations for the project are summarised in Table 6.19 and Table 6.20 for the residential receptor locations. The results are well below the applicable criteria. The odorous air pollutants are below the relevant criterion which indicates the odour would not be detectable.

Table 6.19 Summary of benzene and formaldehyde concentrations for 2055 (µg/m³)

Receptor ID	99.9th percentile 1-hour average -Benzene		99.9th percentile 1-hour average -Formaldehyde	
	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
R1	0.1	0.1	1.1	1.0
R2	0.8	0.8	6.6	6.2
R3	0.3	0.2	2.0	1.9
R4	0.1	0.1	0.9	0.9
R6	0.1	0.1	0.7	0.7
R7	0.1	0.1	0.6	0.7
R8	0.2	0.2	1.6	1.7
R14	0.3	0.3	2.5	2.6
R15	0.5	0.5	3.9	4.0
R17	0.4	0.4	3.0	3.2
R18	1.0	1.0	7.7	8.2
R19	1.8	1.8	14.3	14.3
R21	0.8	0.6	6.5	4.9
R22	0.2	0.2	1.3	1.5
R23	0.1	0.1	0.8	0.7
R27	0.3	0.2	2.2	1.9
R30	0.1	0.1	0.5	0.5
R31	0.1	0.1	0.6	0.6
Max value	1.8	1.8	14.3	14.3
Criterion	29	29	20	20

Table 6.20 Summary of toluene and xylene concentrations for 2055 (µg/m³)

Receptor ID	99.9th percentile 1-hour average -Toluene		99.9th percentile 1-hour average -Xylene	
	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
R1	0.0	0.0	0.0	0.0
R2	0.2	0.2	0.2	0.2
R3	0.1	0.1	0.1	0.1
R4	0.0	0.0	0.0	0.0
R6	0.0	0.0	0.0	0.0
R7	0.0	0.0	0.0	0.0
R8	0.1	0.1	0.1	0.1
R14	0.1	0.1	0.1	0.1
R15	0.1	0.1	0.1	0.1
R17	0.1	0.1	0.1	0.1
R18	0.3	0.3	0.2	0.3
R19	0.5	0.5	0.4	0.4
R21	0.2	0.2	0.2	0.2
R22	0.0	0.1	0.0	0.0
R23	0.0	0.0	0.0	0.0
R27	0.1	0.1	0.1	0.1
R30	0.0	0.0	0.0	0.0
R31	0.0	0.0	0.0	0.0
Max value	0.5	0.5	0.4	0.4
Criterion	360	360	190	190

6.1.3 Assessment of deposited matter

The predicted incremental deposited particulate matter concentrations for the project in the Prefer Runway 05 and Prefer Runway 23 scenarios during 2055 are presented as isopleths in Figure 6.6 and Figure 6.7, respectively.

The levels due to the project are shown to range from 0.0001 to 0.00001 g/m²/month and are simply too low to be measurable or detectable. The effects of the project further away, for example at Prospect reservoir would be even lower, and insignificant. Note that the appliable criteria for deposited dust is 2 to 4 g/m²/month.

Based on the total estimated particulate matter emissions during 2055 (refer to Table 5.3) we can estimate a potential dilution ratio for the deposition and apply this for the other pollutants. We note that the other modelled pollutants are gaseous, and no tangible deposition of the gasses on any surfaces is likely, hence this represents a very large overestimate of potential surface deposition of the other pollutants.

Applying this dilution ratio a likely maximum rate of deposition for CO is 0.006 g/m²/month, for NO_X is 0.02 g/m²/month and for SO_X is 0.001 g/m²/month. These are very small and insignificant quantities, despite the very large overestimation.

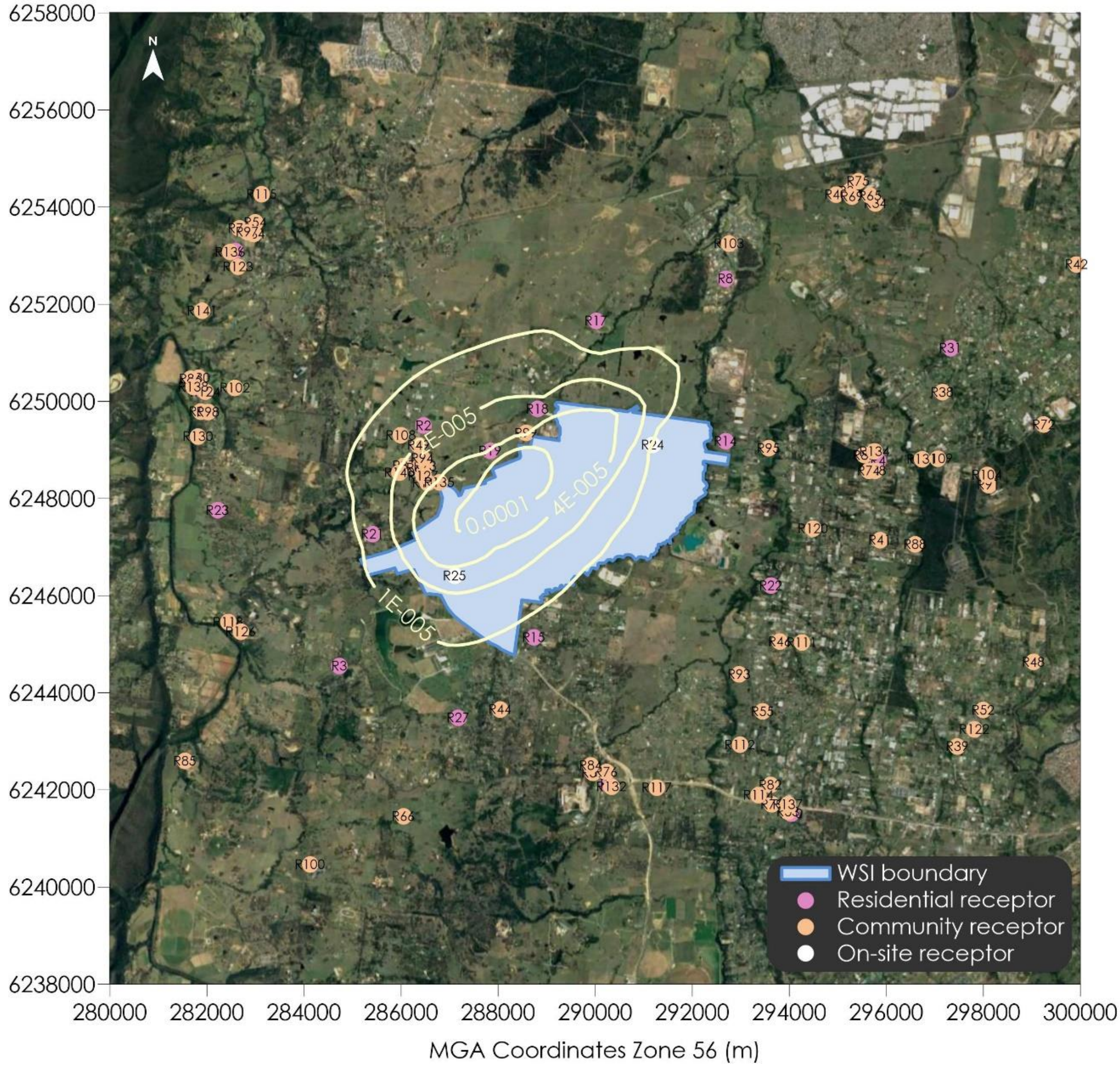


Figure 6.6 Predicted incremental annual average deposited particulate matter concentrations from the project (g/m²/month) for 2055 – Prefer Runway 05

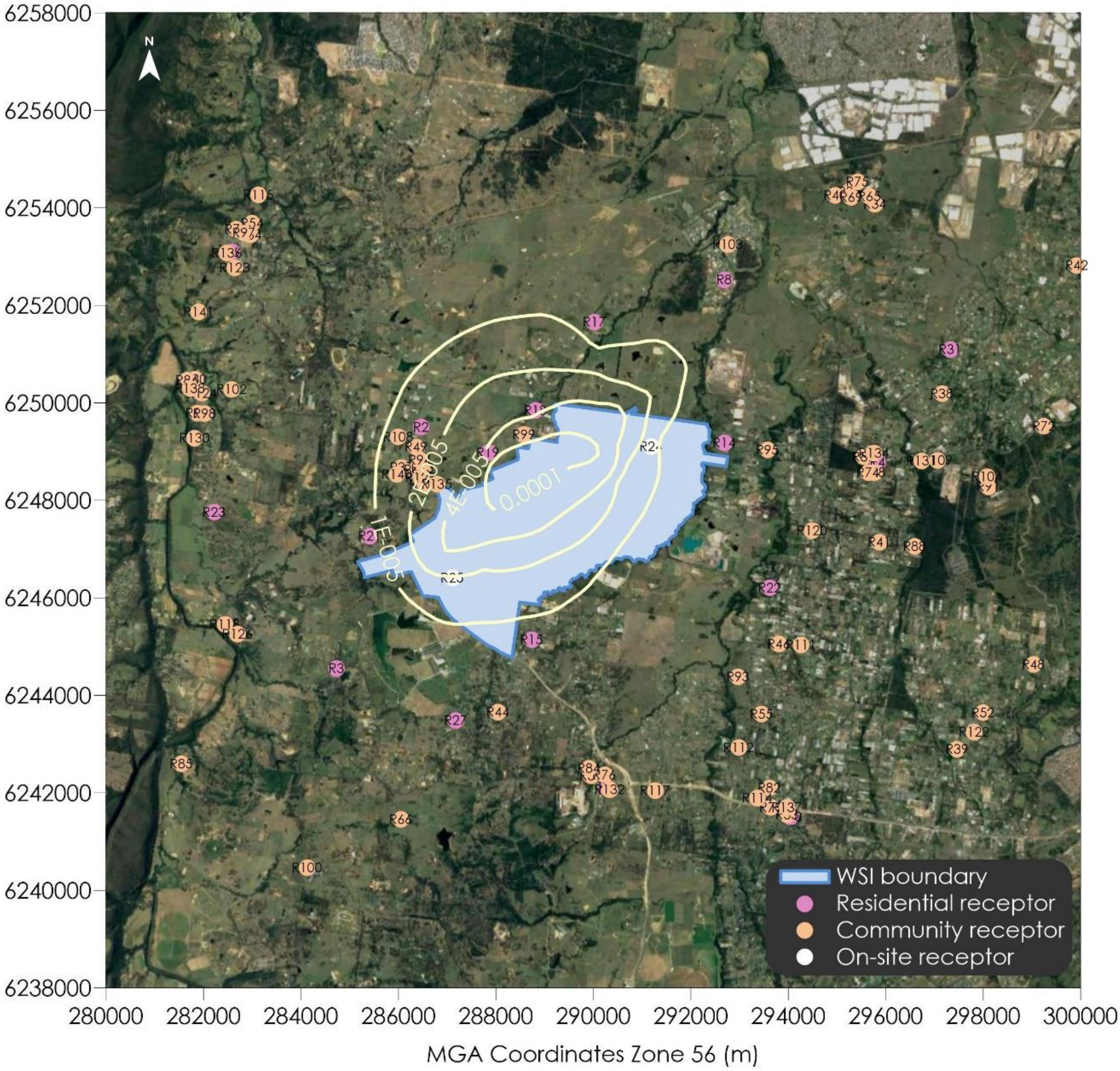


Figure 6.7 **Predicted incremental annual average deposited particulate matter concentrations from the project (g/m²/month) for 2055 – Prefer Runway 23**

6.2 Regional air quality

The results of the regional air quality assessment are presented in this section. The regional model focusses on a large area and includes detailed chemical transformation calculations to estimate the concentrations of substances that form in the air after the pollutants are released, for example, the concentration of NO_2 and ozone that form in the atmosphere after precursor substances are released.

All of the known sources of air emissions within the greater Sydney area are included in the model, along with emissions that occur outside of the area but may blow in, for example natural biogenic emissions, such as volatile organic compounds from vegetation. (Notably, the Blue Mountains are named after the blue haze that can sometimes been seen there, which is mainly comprised of such biogenic substances.) The regional model covers all hours of a week with high ozone pollution days.

It is noted that the regional model should not be used to determine impacts at receptors close into the airport as the resolution of the model is too coarse for detailed examination of near field impacts. Receptor locations close to the airport are assessed in detail the local assessment in Section 6.1.

Regional results for the modelled scenarios which include emissions from the project (2033 – No preference, 2033 – Prefer Runway 05 and 2055 – Prefer Runway 05) are compared the baseline/basecase model in order to determine the impact of the project in relation to the existing background concentrations from other sources. Regional results for gases (including ozone, NO_2, SO_2, and CO) are output in ppm or pphm, and hence are reported against the criteria in these units rather than $\mu g/m^3$.

6.2.1 Baseline air quality results

To assess the performance of the regional model, existing emissions from all pollution sources across the GMR were modelled (i.e. without the project) and compared with DPE monitoring data for the same period and location.

It is technically challenging to develop a model that can provide an accurate result at a specific place at a specific time. General model performance is evaluated according to statistical indicators, (for example whether the scale and frequency of model results are comparable to the actual ranges of data over a year). However, the regional model needs to perform many complex chemical calculations which rely on good spatial and temporal performance for accuracy. The model performance in this case therefore needs be evaluated in in terms of how well it predicts air pollutant levels at specific locations at specific times.

The results from the baseline scenario were used to evaluate the model's ability to predict current, and by inference the future air quality impacts due to the project. The baseline scenario does not include emissions from the project, and the purpose is to confirm the model is reliable at predicting known values at the DPE ambient air quality monitoring locations. Where the model can conduct the complex chemical calculations and produce reliable results at the DPE monitoring sites, it is inferred that it will also provide reliable results once the source under investigation (the project) is included.

Data for all existing emission sources in the GMR was obtained from the NSW EPA Air Emissions Inventory. This included all point and area source emissions from all commercial, industrial, domestic, biogenic, and on-road and off-road sources across NSW. The GMR emission inventory data are used as anthropogenic emissions input along with the global emission database EDGAR for emissions outside the GMR, the biogenic emissions are based on the MEGAN biogenic model, the marine aerosol (sea salt) and soil dust emissions as provided in the CMAQ model.

A comparison of the O_3 and NO_2 concentrations between the baseline scenario and DPE monitoring data are shown in Figure 6.8 and Figure 6.9. The baseline O_3 and NO_2 model results show excellent alignment with the monitoring data, and reliably follow the diurnal trends.

The results indicate the model is performing well and that it is reliable and accurate.

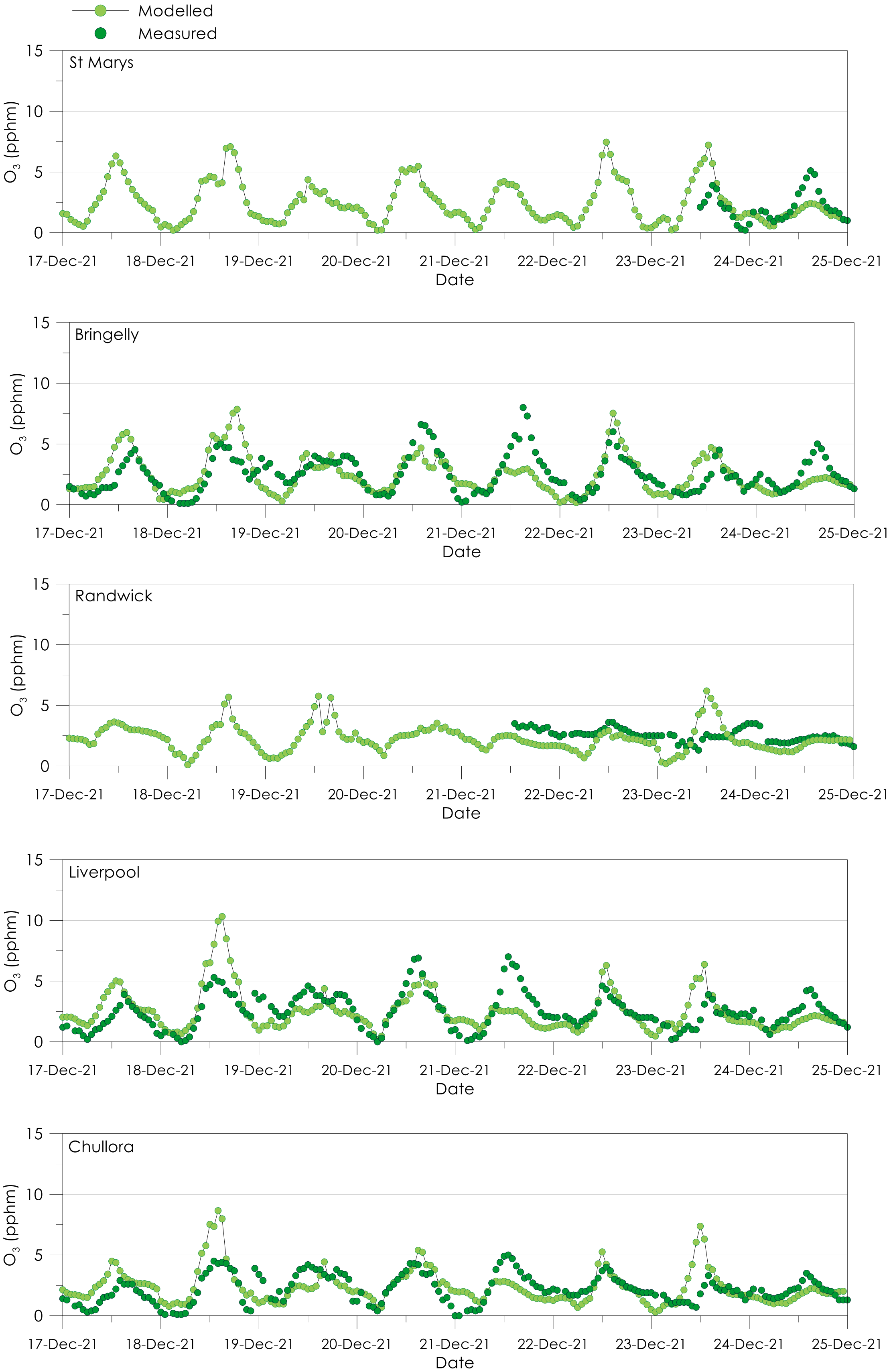


Figure 6.8 Hourly average baseline O_3 results compared with monitoring data

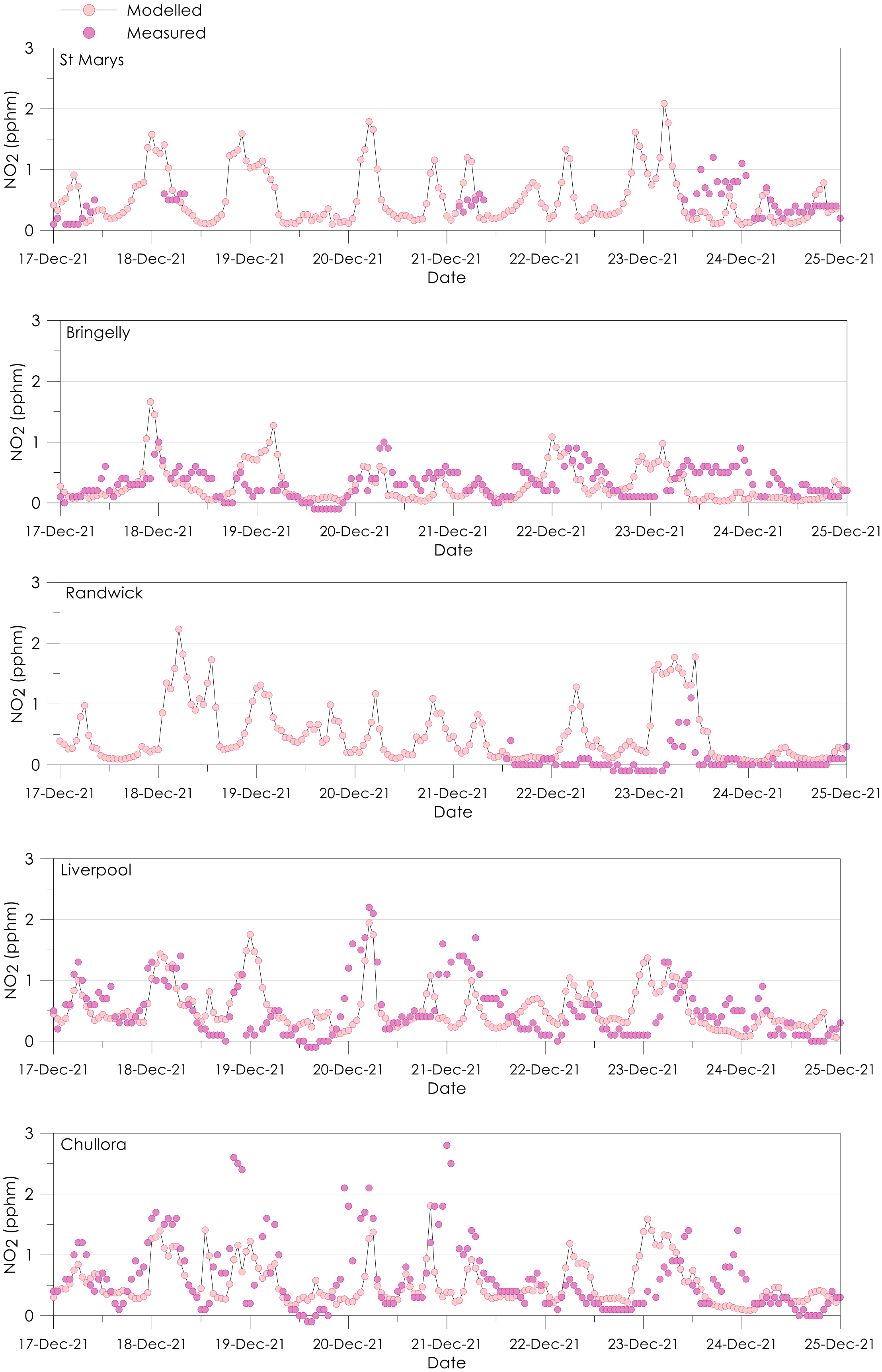


Figure 6.9 Hourly average baseline NO_2 results compared with monitoring data

6.2.2 Summary of modelling results for 2033

6.2.2.1 Ozone concentrations

This section presents the daily maximum ozone concentrations and change in ozone concentrations due to the project for the modelled high ozone period. It is noted that ozone is assessed based on the total maximum concentration and the change in ozone level due to the project that is predicted to arise over a period with high ambient ozone concentrations. This approach allows the complex calculations to be made in a reasonable time frame and recognises it is likely there may already be existing ozone levels above the criteria.

Table 6.21 and Table 6.22 present summaries of the daily maximum ozone concentrations with and without the project, and the change in concentrations due to the project at the time and location of the maximum, for 2033 – No preference and 2033 – Prefer Runway 05 respectively.

The full results including contour plots of the concentrations and changes in ozone are presented for 2033 – No preference and 2033 – Prefer Runway 05 in Appendix D2 and D3 respectively.

The results indicate that in the locations with the maximum ozone concentrations, the project makes no significant difference to the impact that would arise in any case without the project. For example, the change is generally nil, but up to 0.1 pphm for 4 hr and 8 hr average ozone levels, and 0.0 pphm where ozone levels already exceed the criteria of 6.5 pphm (as shown in bold font in the tables).

The results also show that the maximum changes in ozone (i.e. in locations away from where the maximum total ozone levels occur at the time) are up to 0.4, 0.2 and 0.2 pphm for 1-hour, 4-hour and 8-hour ozone respectively in the No preference scenario, however these maximum changes only occur where ozone concentrations are below criteria, as can be seen in the figures and tables in Appendix D. For example, the most significant increase in 8-hour average ozone is 0.2 pphm and occurs on 23/12/2021 (Figure D.28) in area with a total cumulative level 4.7 pphm which is below the NEPM criteria of 6.5 pphm.

On this basis the results show that the project does not generate any unacceptable level of impact.

Table 6.21 Daily maximum ozone concentrations – 2033 – No preference

Date	2033 No preference maximum 1-hour average (pphm)			2033 No preference maximum 4-hour average (pphm)			2033 No preference maximum 8-hour average (pphm)		
	Bg.	Cumul.	Change*	Bg.	Cumul.	Change*	Bg.	Cumul.	Change*
17/12/2021	7.8	7.8	0.0	6.4	6.5	0.1	5.4	5.5	0.1
18/12/2021	12.2	12.2	0.0	10.9	10.9	0.0	**8.4**	**8.4**	**0.0**
19/12/2021	10.1	10.1	0.0	8.8	8.8	0.0	**7.1**	**7.1**	**0.0**
20/12/2021	7.6	7.6	0.0	7.4	7.4	0.0	6.4	6.4	0.0
21/12/2021	6.4	6.4	0.0	7.0	7.0	0.0	**6.8**	**6.8**	**0.0**
22/12/2021	9.2	9.2	0.0	7.5	7.5	0.0	6.1	6.1	0.0
23/12/2021	9.3	9.3	0.0	8.3	8.3	0.0	**7.6**	**7.6**	**0.0**
24/12/2021	4.0	4.0	0.0	3.6	3.6	0.0	4.6	4.6	0.0

Bg. – domain maximum background concentration without the project (basecase)

Cumul. – domain maximum concentration with the project

Change – change in concentration with the project

* Maximum change in any part of domain is 0.4, 0.2 and 0.2 pphm (1 hr, 4 hr and 8 hr respectively), but occurs where total levels are below criteria.

Table 6.22 Daily maximum ozone concentrations – 2033 – Prefer Runway 05

Date	2033 Prefer Runway 05 maximum 1-hour average (pphm)			2033 Prefer Runway 05 maximum 4-hour average (pphm)			2033 Prefer Runway 05 maximum 8-hour average (pphm)		
	Bg.	Cumul.	Change	Bg.	Cumul.	Change	Bg.	Cumul.	Change
17/12/2021	7.8	7.8	0.0	6.4	6.5	0.1	5.4	5.5	0.1
18/12/2021	12.2	12.2	0.0	10.9	10.9	0.0	**8.4**	**8.4**	**0.0**
19/12/2021	10.1	10.1	0.0	8.8	8.8	0.0	**7.1**	**7.1**	**0.0**
20/12/2021	7.6	7.6	0.0	7.4	7.4	0.0	6.4	6.4	0.0
21/12/2021	6.4	6.4	0.0	7.0	7.0	0.0	**6.8**	**6.8**	**0.0**
22/12/2021	9.2	9.2	0.0	7.5	7.5	0.0	6.1	6.1	0.0
23/12/2021	9.3	9.3	0.0	8.3	8.3	0.0	**7.6**	**7.6**	**0.0**
24/12/2021	4.0	4.0	0.0	3.6	3.6	0.0	4.6	4.6	0.0

Bg. – domain maximum background concentration without the project (basecase)

Cumul. – domain maximum concentration with the project

Change – change in concentration with the project

* Maximum change in any part of domain is 0.3, 0.2 and 0.2 pphm (1 hr, 4 hr and 8 hr respectively), but occurs where total levels are below criteria.

Further details on the change in ozone concentrations are provided in Figure 6.10 which shows an hourly timeseries of ozone and NO_2 concentrations from the baseline scenario and 2033 – Prefer Runway 05. The timeseries results have been extracted from a location in the most impacted area by airport emissions on the northern project boundary. The results show that ozone concentrations in the Prefer Runway 05 scenario are typically equal to the baseline scenario in day-time periods and lower than the baseline at night. The times at which ozone concentrations reduce from the baseline scenario correspond with an increase NO_2 concentrations.

Ozone is produced in a photochemical reaction primarily between NOx and VOCs in the presence of sunlight (Duc, et al., 2018). The complex trends in ozone formation and destruction for a given location can be more simply described by classifying the existing conditions into one of 2 NOx categories; NOx limited and NOx rich/ saturated regimes. Concentrations of ozone in NOx limited regimes show a trend of increasing ozone with increasing NOx concentrations. Ozone formation is restricted with additional NOx in NOx rich regimes due to a lack of VOCs and/or light, and instead can exhibit trends of increasing ozone with increasing VOC concentrations. In NOx rich regimes, increasing NOx generally does not cause an increase and can even cause a decrease in ozone due to the formation of NO_2 from the reaction of ozone and NO.

The data in Figure 6.10 indicate that emissions from the project during the modelling period generally cause a net reduction in ozone concentrations in certain conditions near to the airport, likely due to an already NOx rich atmosphere.

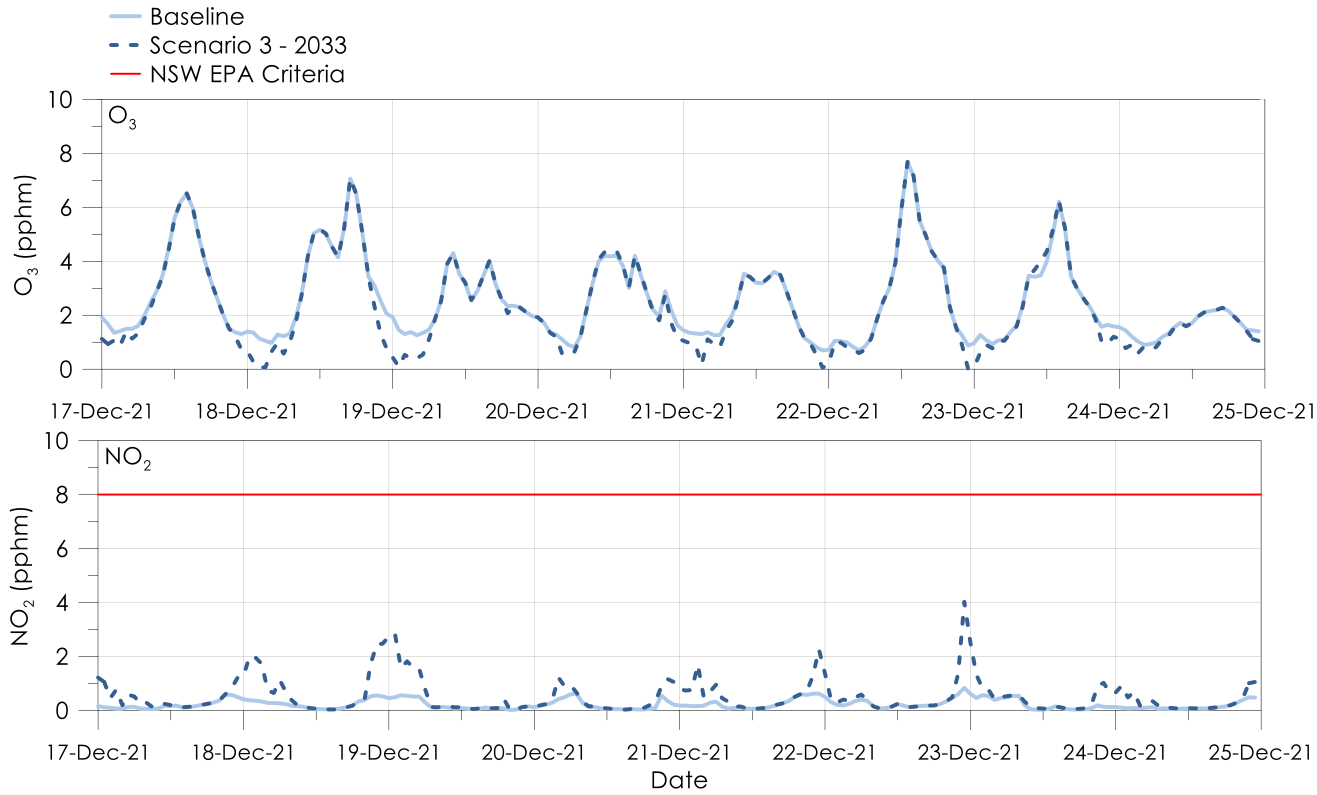


Figure 6.10 Predicted 1-hour average O_3 and NO_2 concentrations (µg/m³) for 2033 – baseline compared with Prefer Runway 05 for generally most impacted location

6.2.2.2 NO_2 concentrations

Figure 6.11 presents the maximum 1-hour average NO_2 concentrations for 2033 – No preference and 2033 – Prefer Runway 05, compared to the baseline scenario.

The figures show emissions originating from the project result in an increase in NO_2 concentrations in the vicinity of the airport. Impacts from the No preference and Prefer Runway 05 scenarios are very similar and indicate that the difference in flight plans in these scenarios does not have any significant effect on the ground level concentrations. The results indicate the only significant difference in ground level NO_2 concentrations between the scenarios is due to situational differences in the choice of runway for departures (either Runway 05 or 23) in combination with the prevailing winds at that time (true for both local and regional assessments). The choice of runway will thus concentrate emissions on one end of the runway or the other, and in certain prevailing wind conditions this can lead to slightly higher concentrations of pollutants in one area compared to another scenario. This effect would be evident for all pollutants however is highly localised and does not have any significant bearing on the regional air quality.

Any discernible increases in NO_2 are generally limited to a radius of approximately 5–6 kilometres of the airport. This suggests that the impact of the project's emissions on ground level concentrations is primarily attributable to aircraft near or at ground level, primarily during take-off and landing.

The results show that the emissions released higher than a few hundred metres above ground level do not appear to have any significant influence on ground level concentrations.

6.2.2.3 Other pollutant concentrations

Maximum pollutant contours for NO_2, SO_2, CO, $PM_{2.5}$ and PM_{10} for all scenarios compared with the baseline are presented in Appendix D5. The results in the appendix show that for all other pollutants except NO_2, the impact of emissions from the project on the existing pollutant concentrations would be negligible and would be unlikely to be discernible above background concentrations.

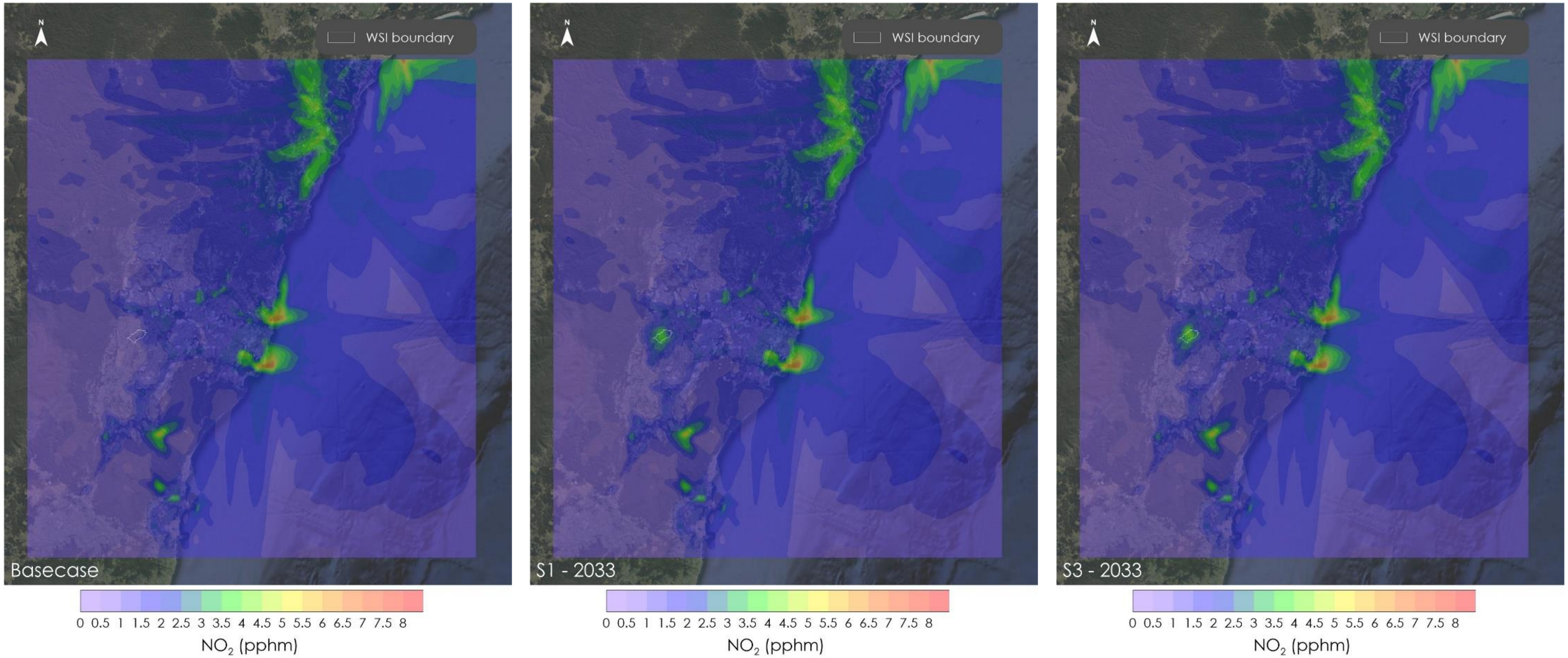


Figure 6.11 Maximum predicted 1-hour NO_2 concentrations for basecase, 2033 – No preference and 2033 – Prefer Runway 05

6.2.3 Summary of modelling results for 2055

6.2.3.1 Ozone concentrations

This section presents the daily maximum ozone concentrations and change in ozone concentrations due to the project for the modelled high ozone period. It is noted that ozone is assessed based on the total maximum concentration and the change in ozone level due to the project that is predicted to arise over a period with high ambient ozone concentrations. This approach allows the complex calculations to be made in a reasonable time frame and recognises it is likely there may already be existing ozone levels above the criteria.

Table 6.23 presents a summary of the daily maximum ozone concentrations with and without the project, and the change in concentrations due to the project at the time and location of the maximum for 2055 – Prefer Runway 05. The data indicates that the Prefer Runway 05 scenario would result in the greatest impacts, hence the assessment is limited to this scenario.

The full results including contour plots of the concentrations and changes in ozone are presented for 2055 – Prefer Runway 05 in Appendix D4.

The results indicate that in the locations with the maximum ozone concentrations, the project makes no significant difference to the impact that would arise in any case without the project. For example, the change is generally nil, but up to 0.2 pphm for 4 hr and 8 hr average ozone levels and up to 0.1 pphm where ozone levels already exceed the criteria (shown in bold font in Table 6.23).

The results also show that the maximum changes in ozone (i.e. in locations away from where the maximum total ozone levels occur at the time) are up to 0.8, 0.6 and 0.6 pphm for 1-hour, 4-hour and 8-hour ozone respectively, however these maximum changes only occur where ozone concentrations are below criteria, as can be seen in the figures and tables in Appendix D. For example the most significant increase in 8-hour average ozone occurs on 23/12/2021 (Figure D.76) in an area when the total cumulative level is 5.0 pphm, which is below the NEPM criteria of 6.5 pphm.

On this basis the project does not generate any unacceptable level of impact.

Table 6.23 Daily maximum ozone concentrations – 2055 – Prefer Runway 05

Date	2055 Prefer Runway 05 maximum 1-hour average (pphm)			2055 Prefer Runway 05 maximum 4-hour average (pphm)			2055 Prefer Runway 05 maximum 8-hour average (pphm)		
	Bg.	Cumul.	Change*	Bg.	Cumul.	Change*	Bg.	Cumul.	Change*
17/12/2021	7.8	7.8	0.0	6.4	6.6	0.2	5.4	5.6	0.2
18/12/2021	12.2	12.2	0.0	10.9	10.9	0.0	**8.3**	**8.4**	**0.1**
19/12/2021	10.1	10.1	0.0	8.8	8.8	0.0	**7.1**	**7.1**	**0.0**
20/12/2021	7.6	7.6	0.0	7.4	7.4	0.0	6.4	6.4	0.0
21/12/2021	6.4	6.4	0.0	7.0	7.0	0.0	**6.8**	**6.8**	**0.0**
22/12/2021	9.2	9.2	0.0	7.5	7.5	0.0	6.1	6.2	0.1
23/12/2021	9.3	9.4	0.0	8.3	8.4	0.0	**7.6**	**7.6**	**0.0**
24/12/2021	4.0	4.0	0.0	3.6	3.6	0.0	4.6	4.6	0.0

Bg. – domain maximum background concentration without the project (basecase)

Cumul. – domain maximum concentration with the project

Change – change in concentration with the project

* Maximum change in any part of domain is 0.8, 0.6 and 0.6 pphm (1 hr, 4 hr and 8 hr respectively), but occurs where total levels are below criteria.

Figure 6.12 shows an hourly timeseries of ozone and NO_2 concentrations from the baseline scenario and 2055 – Prefer Runway 05. The timeseries results have been extracted from a location in the most impacted area by airport emissions on the northern project boundary.

Similar to the 2033 results, the figure shows that ozone concentrations in the Prefer Runway 05 scenario are typically equal to the baseline scenario in day-time periods and lower than the baseline at night. The times at which ozone concentrations reduce from the baseline scenario correspond with an increase NO_2 concentrations.

The data from the 2055 scenario show a similar signature to the 2033 results with an existing NOx rich atmosphere near the airport which would limit ozone formation, indicating that higher NOx near the project would not be likely to increase the ozone concentrations during high ozone events (typically on sunny summer days).

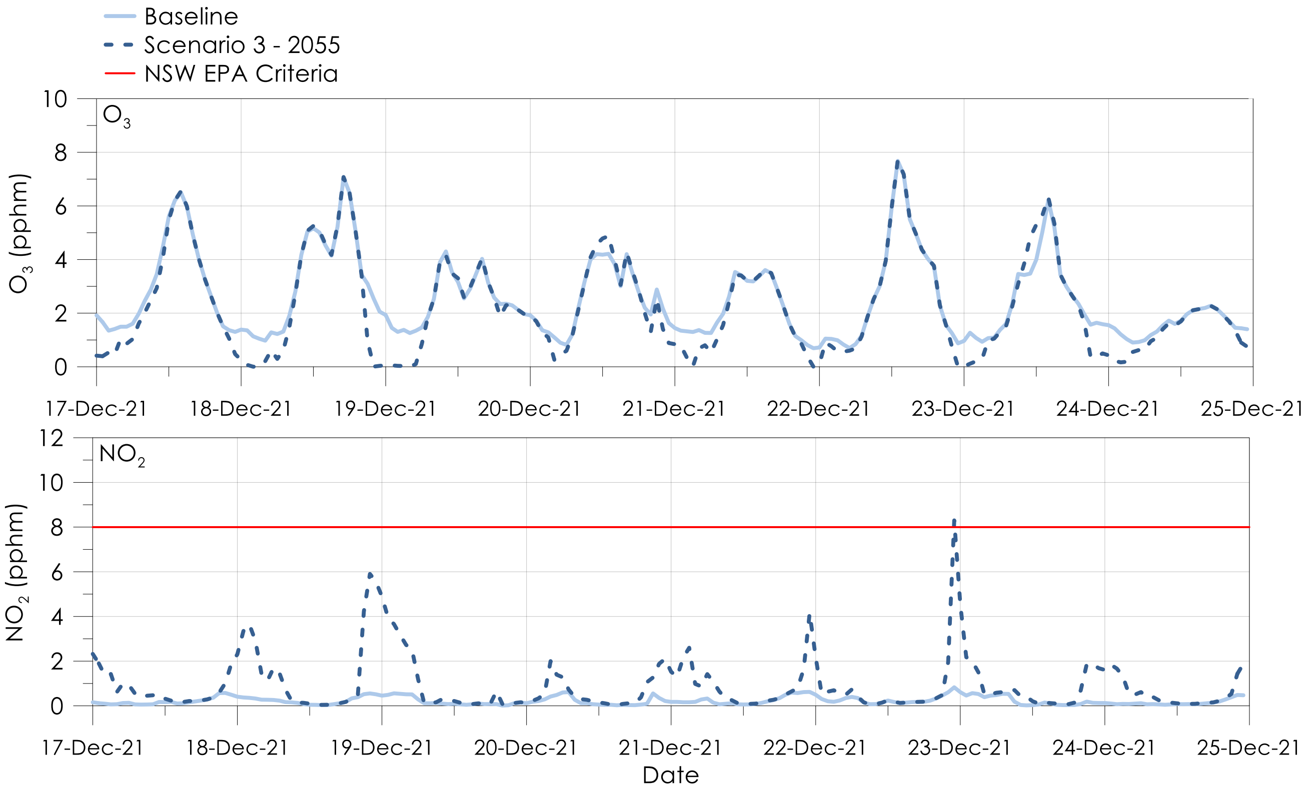


Figure 6.12 Predicted 1-hour average O_3 and NO_2 concentrations for 2055 – baseline compared with Prefer Runway 05 for generally most impacted location

6.2.3.2 NO_2 concentrations

Figure 6.12 presents the maximum 1-hour average NO_2 concentrations for 2055 – Prefer Runway 05, compared to the baseline scenario.

The results show emissions originating from the project result in an increase in NO_2 concentrations in the vicinity of the airport. The figure indicates that NO_2 concentrations are predicted to be above the criterion of 8 pphm (164 µg/m^3) adjacent to the runway, just outside the northwestern section of the project boundary. This aligns well with the local air quality modelling results in Section 6.1 which show a similar scale of impact for NO_2, noting that there will be some differences due the different meteorology and spatial resolution of the models.

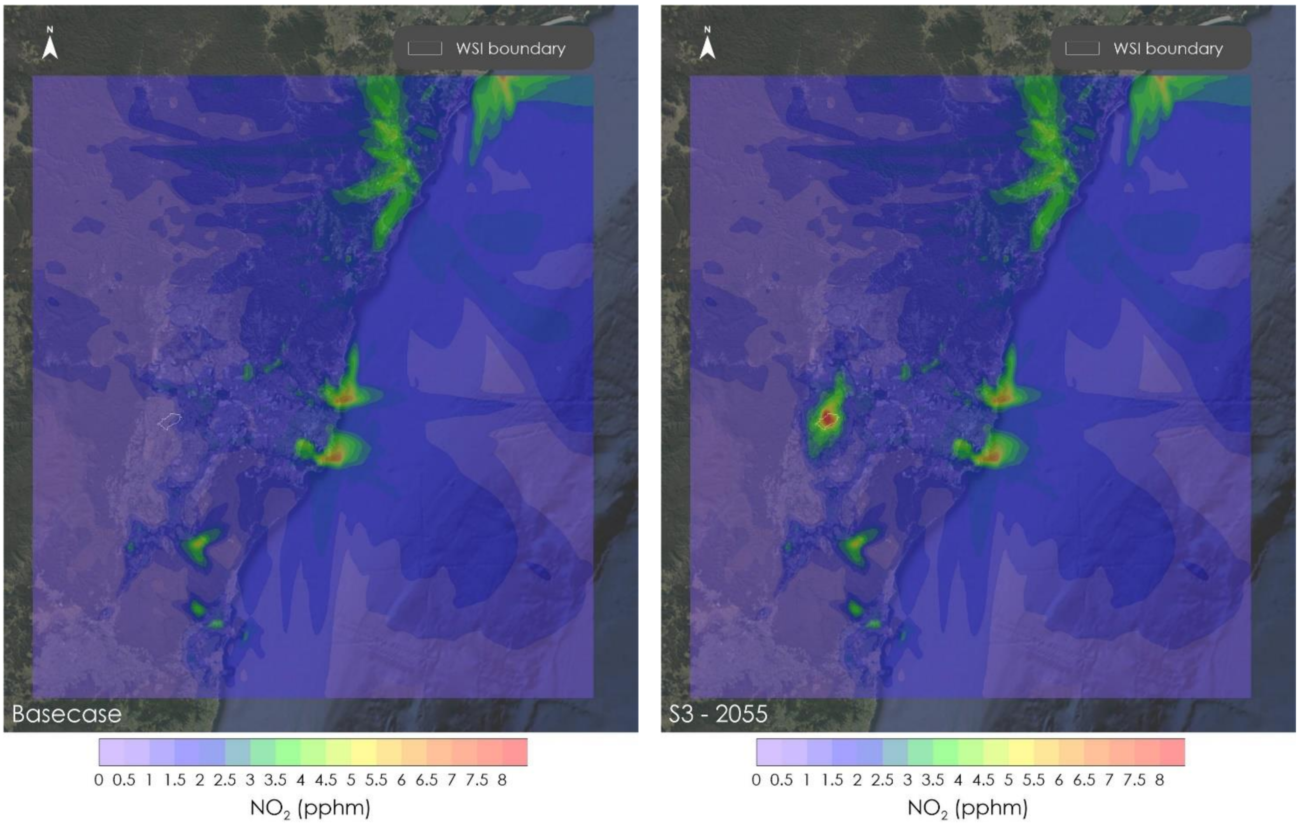


Figure 6.13 Maximum predicted 1-hour NO_2 concentrations for basecase and 2055 – Prefer Runway 05

6.2.3.3 Other pollutant concentrations

Maximum pollutant contours for NO_2, SO_2, CO, $PM_{2.5}$ and PM_{10} for all scenarios compared with the baseline are presented in Appendix D5. The results in the appendix show that for all other pollutants except for NO_2, the impact of emissions from the project on the existing pollutant concentrations would be negligible and would be unlikely to be discernible above background concentrations.

Chapter 7 Facilitated impacts

Facilitated impacts refers to the impact involved with all other things associated with the development of the project (i.e., the construction and operation of the ground level activities at the WSI, roads associated with the WSI etc). The potential facilitated impacts associated with the development of Stage 1 of WSI have been considered in the 2016 EIS. For example, the local air quality assessment (PEL, 2016) included air dispersion modelling of traffic along the surrounding roadways. The surrounding roadways were identified as a significant contributor of air emissions compared to the airport and the main contributor to the predicted levels at receptors located near existing or proposed roadways.

This study has conducted a detailed assessment of the potential air quality impact of the project, which relates to flight paths. The project flight paths do not lead to any significant changes in other activities (i.e. projected traffic, ground activities etc, remain unchanged). No construction activities are associated with the project either. Changes to the flight paths at other airports are facilitated by the project, however in terms of air quality, the changes are generally small and occur at altitudes where the modelling results indicate there is no significant effect of the aircraft emissions upon ground level concentrations in any case. Thus, the project does not facilitate changes in other things that may lead to any discernible changes in air quality impacts.

Facilitated impacts associated with noise from the project are covered in Technical paper 13 (Facilitated changes).

Chapter 8 Management and mitigation measures

8.1 Description

The project considers changes to the flight paths, and the emissions for any changes due to the project inherently occur from aircraft. Emissions from aircraft movements are predominantly due to the engine emissions, which are required to meet Australian (and international) performance specifications.

In general aircraft air emissions can be reduced in one of 4 ways:

- renew fleets with cleaner, more fuel-efficient next-generation aircraft (i.e., Airbus A32N and Boeing B73M)
- retrofit aircraft for improved efficiency
- optimise airspace structures, flight routes and air traffic management services to reduce fuel consumption
- substitute fuel with less carbon intensive alternatives (e.g., SAF – bio or power to liquid feedstocks).

Changes to operating procedures and flight paths could significantly impact fuel consumption and the emissions of CO_2e from aircraft engine use. For instance, engine power (thrust) during take-off directly affects aircraft performance and cannot be directed towards achieving environmental outcomes without considering possible safety consequences. The selection of the take-off engine power (thrust) setting for an individual flight involves careful consideration of aircraft performance, engine life and maintenance requirements, aircraft status (inoperative components/systems), terrain, weather and runway conditions.

The measures to help reduce emissions from aircraft operations generally involve procedures and techniques to optimise the vertical profiles of aircraft climbing or descending to an airport engine power (thrust) settings and the configuration of flight paths relative to terrain and receptor communities. The measures tend to result in lower air emissions from the aircraft. The measures are described in the corresponding noise assessment (Technical paper 1).

The aerospace industry is continually developing technology to advance aerodynamic and engine propulsion systems to improve fuel efficiency and lower emissions. As these technologies mature and are commercialised at scale air emissions are expected to reduce in future due to the uptake of next generation aircraft in the fleet and retirement of older operating aircraft.

To minimise the effects of WSI's flight operations on the surrounding air quality environment and at residential receptor locations, all reasonable and practicable mitigation measures would be utilised, as outlined in the Western Sydney Airport EIS – Local Air Quality and Greenhouse Gas Assessment (PEL, 2016).

The WSI has control over ground level activities, which are not the subject of this project. To ensure these activities have a minimal effect on the surrounding environment and at residential receptor locations, all reasonable and practicable mitigation measures would be utilised, as outlined in the *Western Sydney Airport EIS – Local Air Quality and Greenhouse Gas Assessment* (PEL, 2016). Each measure would be assessed on a case-by-case basis to ensure it is viable.

The measures include to monitoring to quantify and verify actual operational performance, as set out below.

It is relevant to note the study identifies the potential for annual average $PM_{2.5}$ and 1-hour average NO_2 impacts to arise in 2055. It is relevant to note that the analysis of the annual average $PM_{2.5}$ impacts indicates the predicted exceedance occurs largely due to the elevated background level and there is no tangible impact due to the project. We note the modelling includes conservative assumptions which may overstate the actual predicted impacts. These include:

- assuming all the modelling particulate matter is comprised of $PM_{2.5}$
- the emissions estimates are based on current fleet mix and does not factor in any improvement to engine efficiency or control that may arise in the future (i.e. in 2055 for the assessed scenario), and
- the applied background level is based on the meteorological year (i.e. 2020) and does not factor in future changes which would improve to background levels overtime.

The 1-hour average NO_2 impacts small and infrequent and are predicted at a few receptors adjacent to the project. As noted, the predicted levels of NO_2 are likely to be conservative (overestimating of impacts) due to 3 key factors:

- the local modelling uses the conservative OLM approach for chemical transformations to predict the NO_2 levels
- the modelling assumes the worst case scenario for every hour of the year (and in reality this may not be occurring in the predicted hour of maximum impact), and
- the modelling does not account for any improvement in emissions due to better fuel or engine emission control in the future.

8.2 Ambient air quality monitoring

Other management measures could include the installation of an air quality monitoring network to monitor ambient air quality in the vicinity of the airport. An ambient air quality monitoring station would quantify the existing levels and monitor trends in pollutant concentrations over time and identify any exceedances or improvements achieved through implementation of mitigation measures.

However, as this assessment did not identify any significant change in the approved ground level impacts per the 2016 EIS, no specific air quality monitoring for aircraft emissions is required.

Chapter 9 Conclusion

The study has provided a detailed assessment of the project, which relates to flight paths, and does not affect ground level activities, including construction.

The analysis identified that the project would meet all air quality criteria, except for 1-hour average NO_2 and annual $PM_{2.5}$ at some very near receptors to the runway in the future 2055 case. The assessment identified that no increases in ozone impacts would arise, and that decreases were likely. The effect of all other pollutants was found to be insignificant.

The assessment also outlines that conservative (overestimating) assumptions were made because it cannot at present be precisely quantified to what degree and when future improvements in aircraft emissions would occur, for example from improved fuels and technology. As some improvements would arise, it is important to note that the currently predicted impacts in 2055 may not occur in reality. Air quality monitoring however would be carried out to test what the actual pollutant levels near the airport are.

The local air quality assessment indicates the predicted levels would be below criteria for all the assessed air pollutants except for $PM_{2.5}$ and NO_2 during 2055 at several receptors located to the immediate northwest of the runway. However, the elevated $PM_{2.5}$ levels arise due to existing elevated background levels, and the effect of the project would be intangible and insignificant. Whilst the project would contribute significantly to 1-hour average NO_2 levels at the nearest receptors to the northwest of the runway, the predicted levels of NO_2 are slightly above the more stringent, recently updated EPA criteria for only several hours out of 8,760 hours in the year that were assessed. (Notably, the predicted levels would meet the NO_2 criterion that was superseded whilst the study was being completed). The elevated NO_2 levels only occur at a few locations immediately near to the project. This area has been zoned to restrict further residential intensification, which facilitates the mitigation of potential future impact. When considering this and that the predicted results are likely to be conservative (overestimating of impacts) and as it is likely there will be improvements in fuel efficiency (for aircraft and motor vehicles) and decreases in aircraft emissions in the future, it is reasonable to conclude that no significant impacts would arise. The WSI would however incorporate mitigation measures within its control to monitor and minimise the generation of NO_X emissions wherever possible.

The regional assessment shows a similar small scale of NO_2 impacts to the local assessment, with predicted levels above the new more stringent EPA criteria in close vicinity to the airport in 2055. The regional ozone results indicate that in the locations with the maximum ozone concentrations, the project makes no significant difference to the impact that would arise in any case without the project. The results also show that the maximum changes in ozone (i.e. in locations away from where the maximum total ozone levels occur at the time) are up to 0.8, 0.6 and 0.6 pphm for 1-hour, 4-hour and 8-hour ozone respectively in 2055, however these maximum changes only occur where ozone concentrations are below criteria. On this basis the results show that the project does not generate any unacceptable level of impact.

The project's impact on the concentrations of all other assessed pollutants would be negligible and unlikely to be discernible or measurable within the existing background concentrations.

Overall, it can be concluded that the predicted impacts for NO_2 are small, infrequent and highly localised, $PM_{2.5}$ impacts arise due to elevated background pollutant levels, and that the results show no discernible changes in the maximum ozone impacts with or without the project. The impacts presented in this assessment are overestimated as there has been no accounting for the likely reduction in emissions from aircraft, motor vehicles and other such emission sources in future. With potential future reductions it is reasonably likely that no actual impacts would arise. Thus, the impacts are considered acceptable per the Minister's Guidelines EPBC 2022/9143.

To ensure the WSI activities have a minimal effect on the surrounding environment and at residential receptor locations, all reasonable and practicable mitigation measures would be utilised, as outlined in the Western Sydney Airport EIS – Local Air Quality and Greenhouse Gas Assessment (PEL, 2016). The measures include to monitoring to quantify and verify actual pollutant concentrations near the WSI.

As this assessment did not identify any significant change in the approved ground level impacts per the 2016 EIS, no specific air quality monitoring for aircraft emissions is required.

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Appendix A

Local air quality – CALPUFF model

A1 CALPUFF model description

The CALPUFF is an advanced air dispersion model which can deal with the effects of complex local terrain on the dispersion meteorology over the modelling domain in a 3-dimensional, hourly varying time step. The CALPUFF Modelling System includes 3 main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard, routinely available meteorological and geophysical datasets.

CALPUFF is an approved air dispersion model by the NSW EPA and described in the Approved Methods. The model was setup in general accord with the methods provided in the NSW EPA document *Generic Guidance and Optimum Model Setting for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'* (TRC Environmental Corporation, 2011).

A1.1 CALPUFF model settings

CALPUFF modelling is based on the key pollutants derived from the emissions estimates. Emissions from each activity were represented by a series of volume sources.

The effect of precipitation rate (rainfall) in removing particulates from the atmosphere has not been considered in this assessment.

A summary of the key CALPUFF model setting is outlined in Table A.1.

Table A.1 Model settings - CALPUFF

Option	Parameter	Value
Vertical distribution used in the near field	MGAUSS	1
Terrain adjustment method	MCTADJ	3
Sub grid-scale complex terrain	MCTSG	0
Near-field puffs modelled as slugs	MSLUG	0
Transitional plume rise	MTRANS	1
Stack tip downwash	MTIP	1
Method to compute plume rise for point sources not subject to downwash	MRISE	1
Method to simulate building downwash	MBDW	2
Vertical wind shear modelled above stack top	MSHEAR	0
Puff Splitting allowed	MSPLIT	0
Chemical transformation	MCHEM	1
Aqueous phase chemistry	MACHEM	0
Wet removal modelled	MWET	0
Dry deposition modelled	MDRY	0
Gravitational settling (plume tilt)	MTILT	0
Dispersion coefficients	MDISP	2
σv / $\sigma\theta$ and σw measurements from PROFILE.DAT to compute σy and σz	MTURBVW	3

Option	Parameter	Value
Backup method used to compute dispersion when measured turbulence data are missing	MDISP2	3
Method used for Lagrangian time scale for σy	MTAULY	0
Method used to compute turbulence σv and σw profiles	MCTURB	1
PG σy, σz adjusted for roughness	MROUGH	0
Partial plume penetration into elevated inversions	MPARTL	1

A1.1.1 Meteorological data

The meteorological data from the BoM weather station at Badgerys Creek AWS was used in the AERMET model.

The selection of the meteorological year for modelling considered various aspects including:

- the representativeness of meteorological data against available long-term dataset
- the representativeness of meteorological data against the latest 8 years, and
- the rainfall conditions during the last 8 years.

Figure A.1 presents a summary of the monthly meteorological parameters for the Badgerys Creek AWS. For temperature the seasonal trend is clearly seen with temperatures increasing during summer and decreasing during winter. Wind speed, relatively humidity and rainfall do not appear to have any clear trend.

A statistical analysis of 5 contiguous years of meteorological data from the Badgerys Creek AWS is presented in Table A.2. The standard deviation of the 5 years was analysed against the long-term measured wind speed, temperature and relative humidity spanning a 14 to 15-year period recorded at the station.

The analysis indicates that 2018 is closest to the long-term average for wind speed followed closely by 2019. 2021 is the closest to the long-term average for temperature followed by 2020 and 2014. For relative humidity, 2020 is the closest and shows greater variation between the selected years.

This analysis suggests 2020 could be considered as the most representative of the long-term measured wind speed, temperature and relative humidity. Further analysis of 2020 against the other years was performed to determine its suitability.

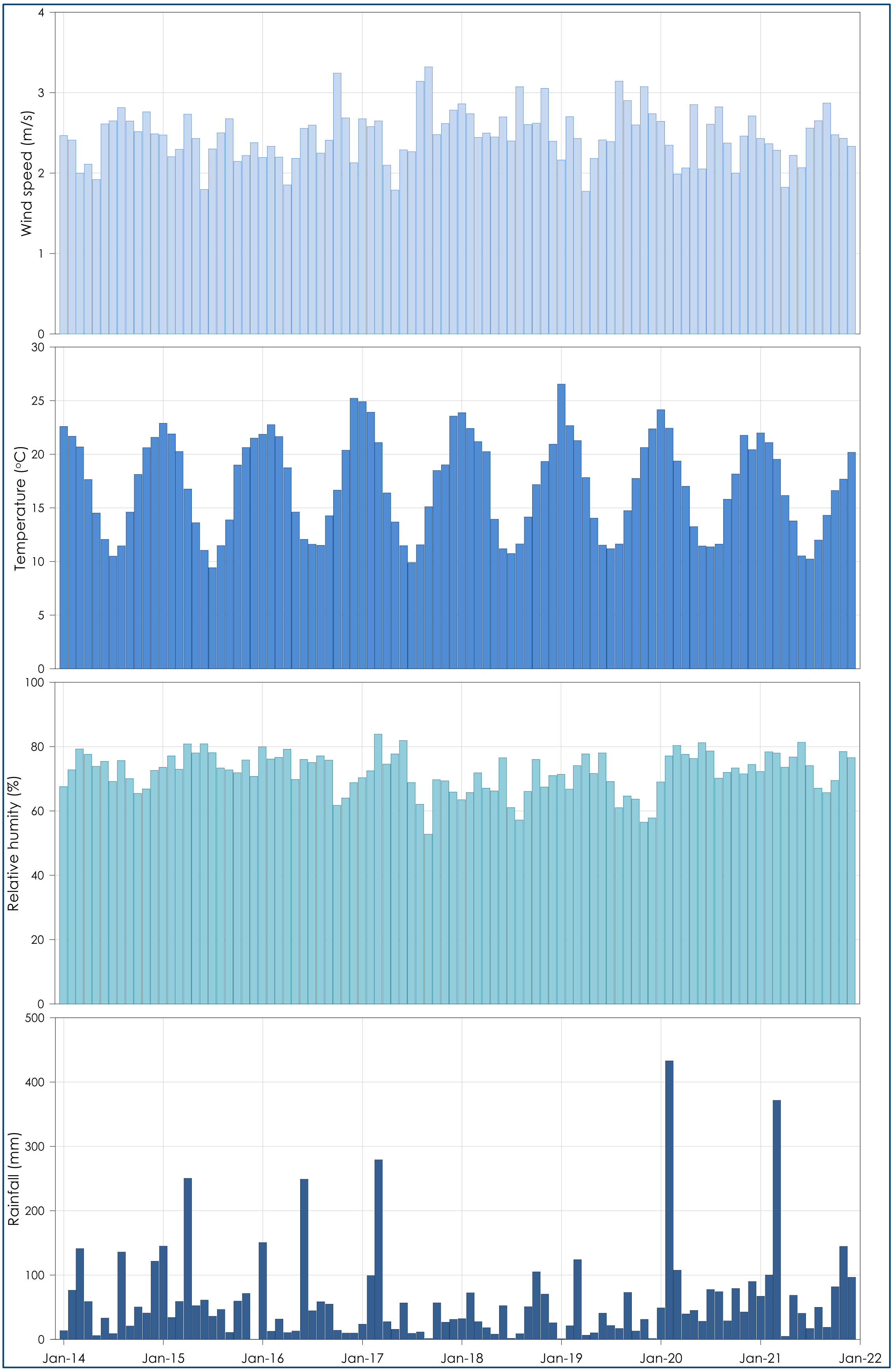


Figure A.1 Monthly meteorological parameters for Badgerys Creek AWS

Table A.2 Statistical analysis results of standard deviation from long-term meteorological data at Badgerys Creek AWS

Year	Wind speed	Temperature	Relative humidity
2014	0.5	0.7	3.5
2015	0.7	0.9	3.6
2016	0.6	1.2	4.4
2017	0.4	1.1	4.3
2018	0.3	1.0	6.2
2019	0.4	1.2	5.2
2020	0.5	0.7	2.8
2021	0.6	0.6	2.9

A frequency distribution of the meteorological parameters is shown in Figure A.2.

The graphs indicate that the 2020 year trends very close to the mean value for each of the meteorological parameters assessed. Overall, this analysis indicates that 2020 is generally representative of the long-term average and does not indicate any significant variation of the last 8 years of data.

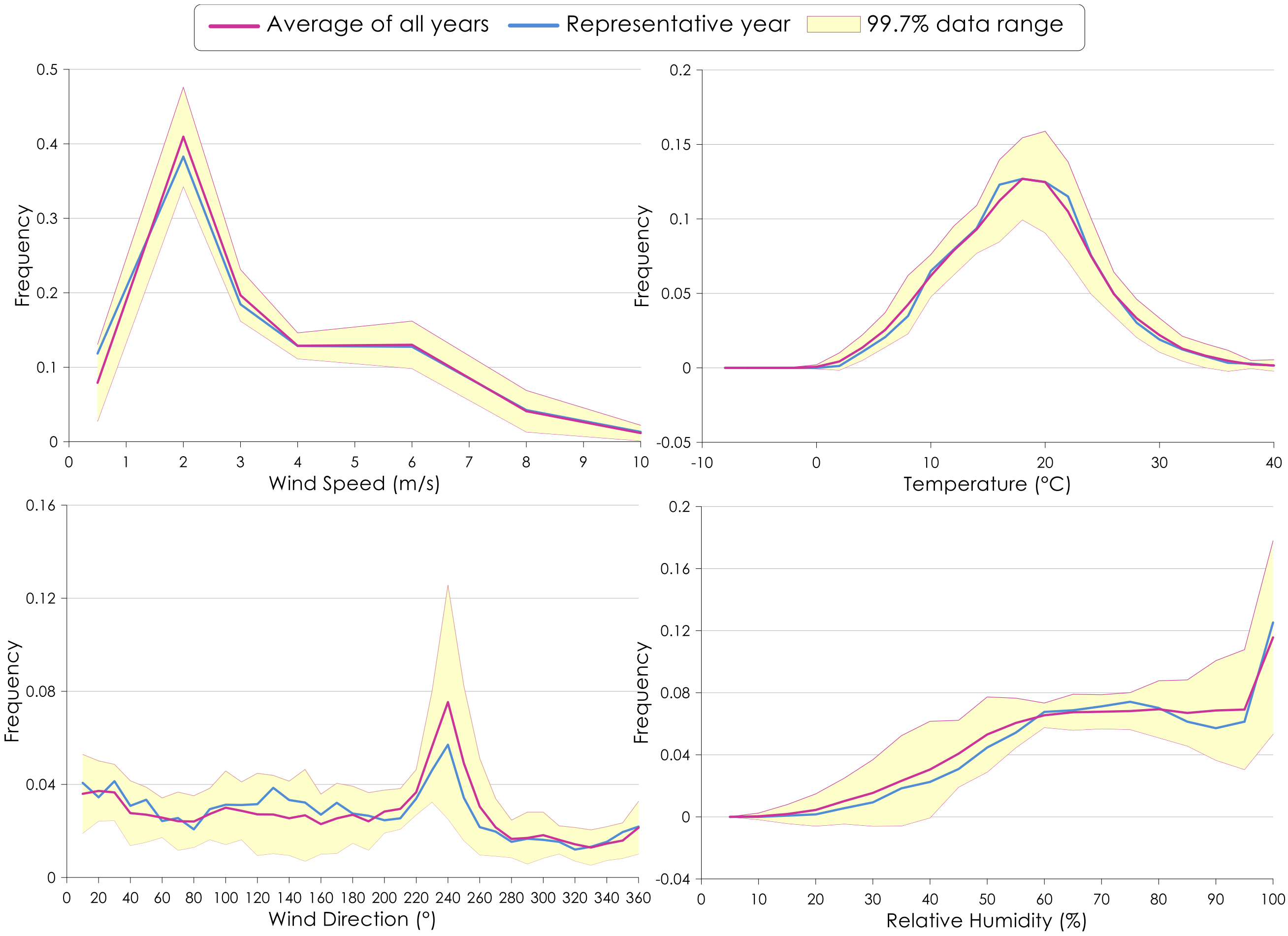


Figure A.2 Frequency distribution of meteorological parameters (2014–2021)

Annual rainfall over the last eight-year period at the Badgerys Creek AWS with the long-term average is shown in Figure A.3.

Annual rainfall during 2016 to 2019 was below the long-term average of 675 millimetres with the 2014, 2015, 2020 and 2021 above the long-term average.

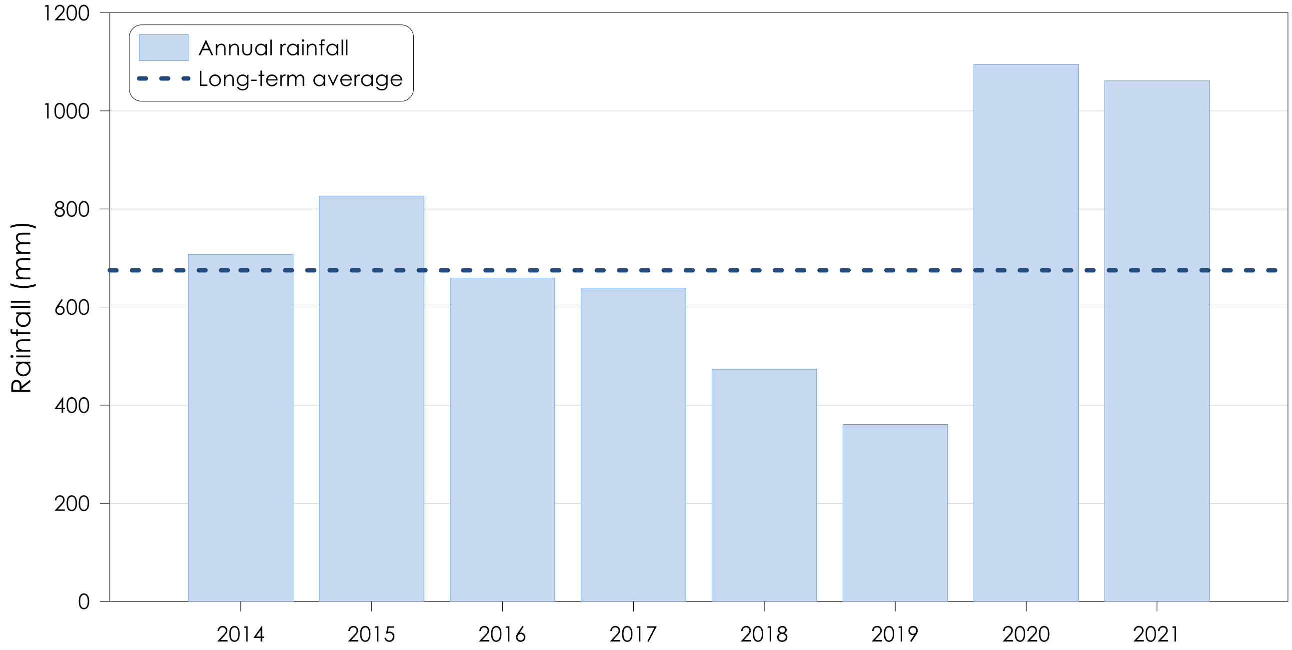


Figure A.3 Annual rainfall

A1.1.2 TAPM settings

The Air Pollution Model (TAPM) is a prognostic air model used to simulate a 3-dimensional upper air data for CALMET input.

The meteorological component of TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical coordinate for 3-dimensional simulations. The model predicts the flows important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analysis.

The TAPM model settings are outlined in Table A.3.

Table A.3 Model settings - TAPM

Parameter	Value
Grid centre coordinates	33° 53′ E
	150° 43′ S
Number of grid points	nx = 30
	nx = 30
Outer grid spacing	dx1 = 30000 m
	dy1 = 30000 m
Number of grid domains	4
Number of vertical grid levels	nz = 35

A1.1.3 Modelling domain

The dispersion modelling domain is centred over the project site and run with a domain size of 20 kilometre by 20 kilometre and a grid spacing of 200 m.

A1.1.4 Terrain

Local terrain was sourced from the 30 metre DEM NASA Shuttle Radar Topography Mission (SRTM) for use in the model. Figure A.4 presents a visualisation of terrain used in CALMET.

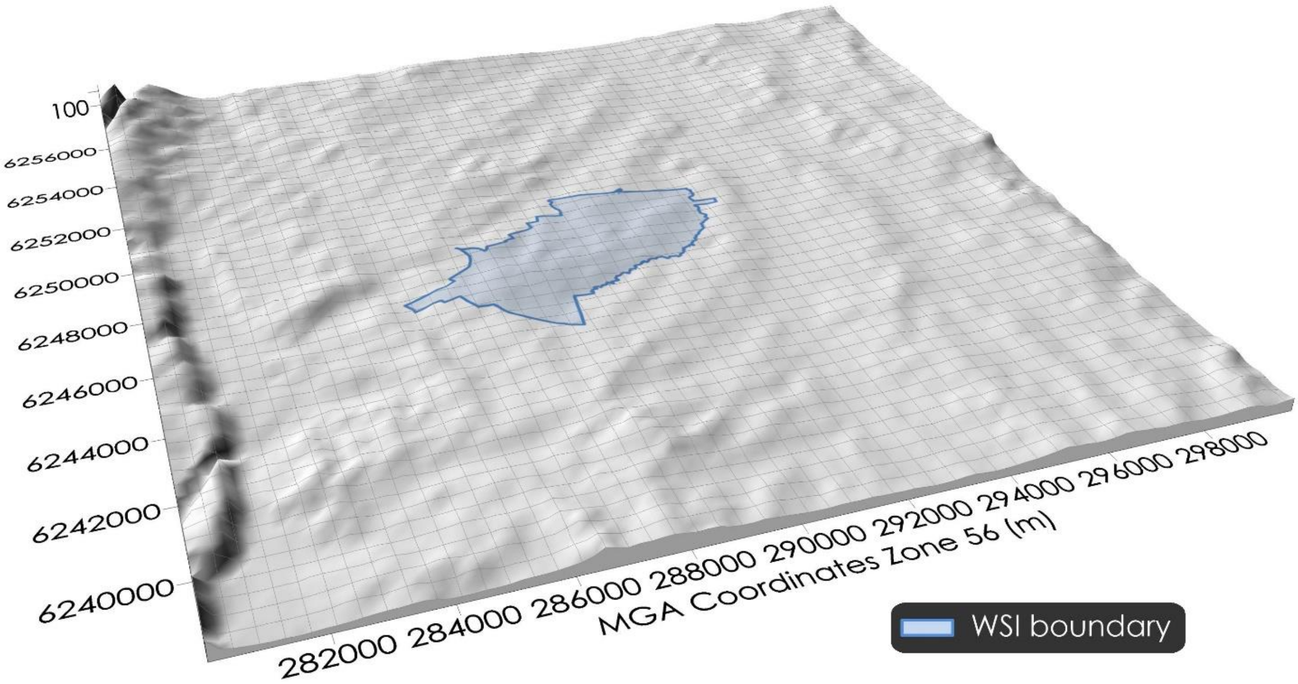


Figure A.4 Visualisation of terrain used in CALMET

A1.1.5 Land use

Land use for the model domain was characterised based on recent satellite imagery. The designated areas are shown in Figure A.5.

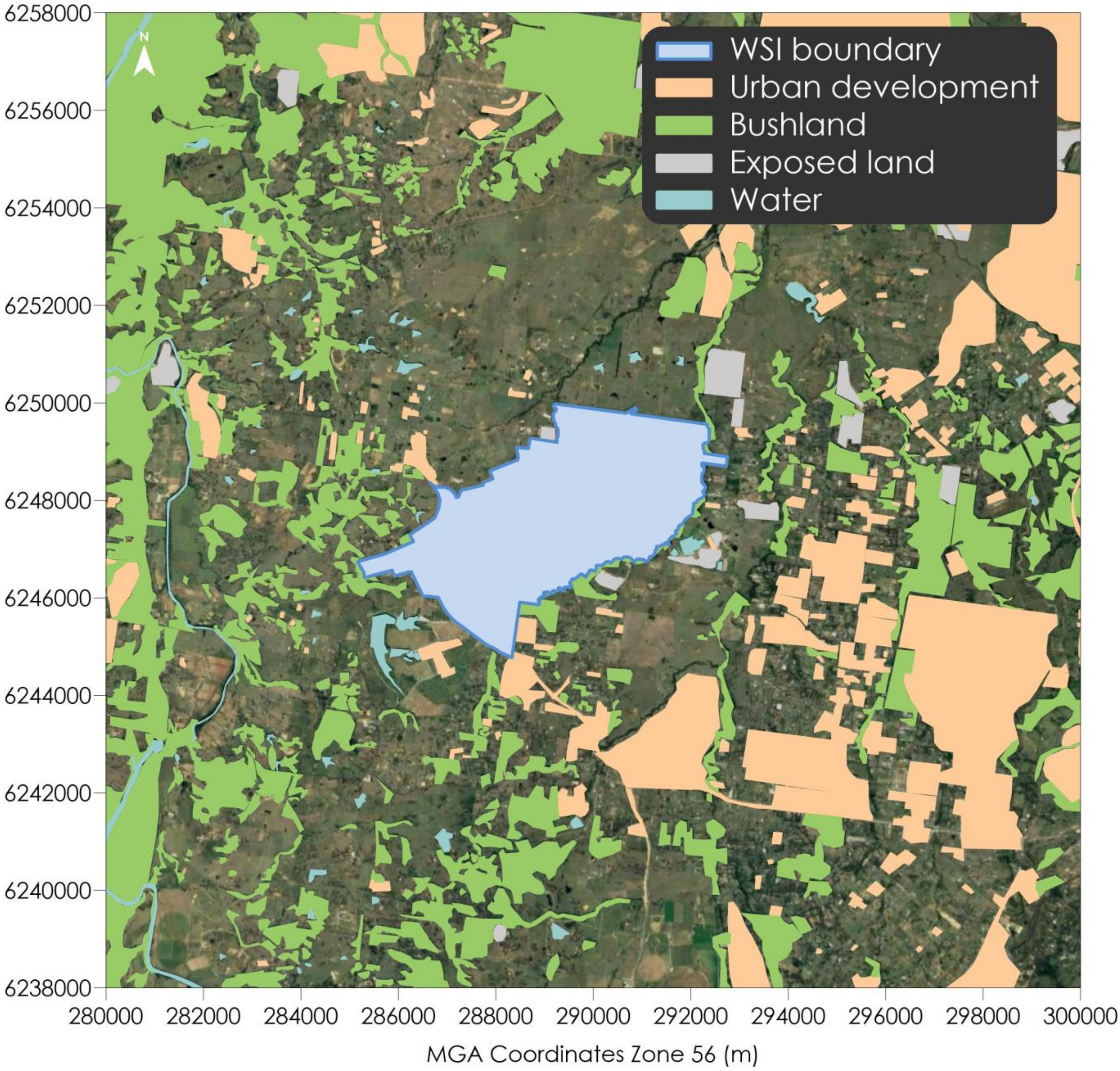


Figure A.5 Visualisation of land use characterised for CALMET

A1.1.6 Surface observations

Meteorological data from 4 surrounding BOM weather stations for the 2020 calendar period were included in the CALMET simulation. Table A.4 outlines the parameters used from each station.

Table A.4 Surface observation stations

Weather stations	Parameters
Badgerys Creek AWS (Station No. 067108)	Wind speed, wind direction, temperature, relative humidity and station level pressure
Camden Airport AWS (Station No. 068192)	Wind speed, wind direction, cloud height, cloud amount temperature, relative humidity and station level pressure
Penrith Lakes AWS (Station No. 067113)	Wind speed, wind direction, temperature and relative humidity
Bankstown Airport AWS (Station No. 066137)	Wind speed, wind direction, cloud height, cloud amount temperature, relative humidity and station level pressure

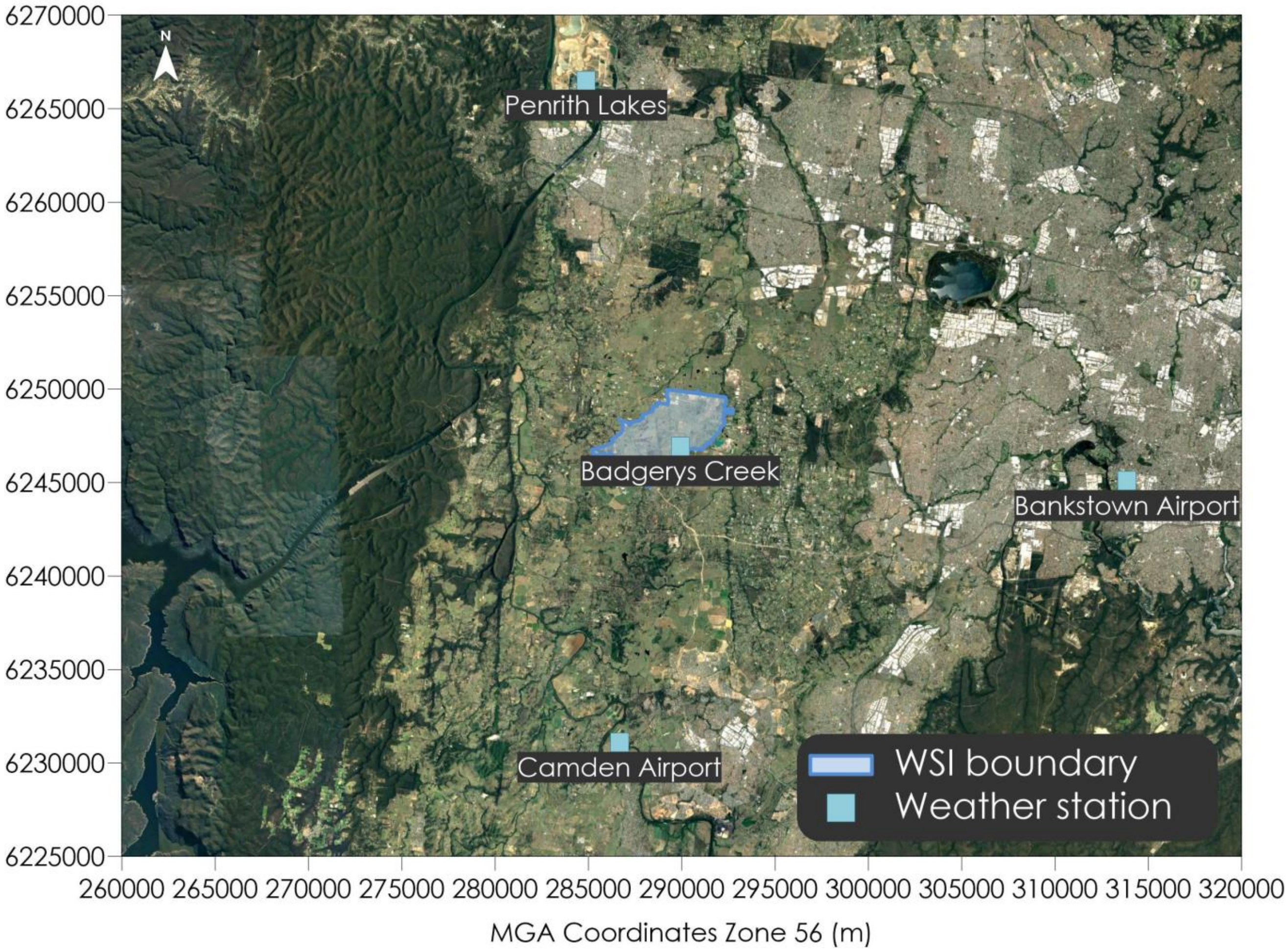


Figure A.6 Location of weather stations surrounding WSI

A1.1.7 CALMET settings

The 7 critical parameters used in the CALMET modelling are presented in Table A.5.

Table A.5 Model settings - CALMET

Parameter	Value
TERRAD	10
IEXTRP	-4
BIAS (NZ)	-1, -0.5, -0.25, 0, 0, 0 ,0 ,0
R1 and R2	10, 10
RMAX1 and RMAX2	15, 15

A1.1.8 Meteorological modelling evaluation

The settings in the CALMET modelling are evaluated using visual analysis of the output wind fields and through a statistical evaluation of the modelled output results.

Figure A.7 presents an example visualisation of the wind field generated by CALMET for just one hour of the 8,760-hour modelling period. The wind fields are seen to follow the terrain well and indicate the simulation produces realistic fine scale flow fields (such as terrain forced flows) in surrounding areas. Many other periods over the year modelled were examined and in each the wind field was found to behave as would be expected in the given terrain under the seasonally varying conditions.

CALMET generated meteorological data were extracted at a location within the CALMET domain and are graphically represented in Figure A.8 and Figure A.9.

Figure A.8 presents annual and seasonal windroses extracted at a location within the CALMET domain. Overall, the windroses generated in the CALMET modelling reflect the expected wind distribution patterns of the area as expected based on the available measured data and the expected effects due to the action of the prevailing winds upon the terrain. This is evident as the windroses based on the CALMET data also compare well with the windroses generated with the measured data.

Figure A.9 includes graphs of the temperature, wind speed, mixing height and stability classification over the modelling period and shows sensible trends considered to be representative of the area.

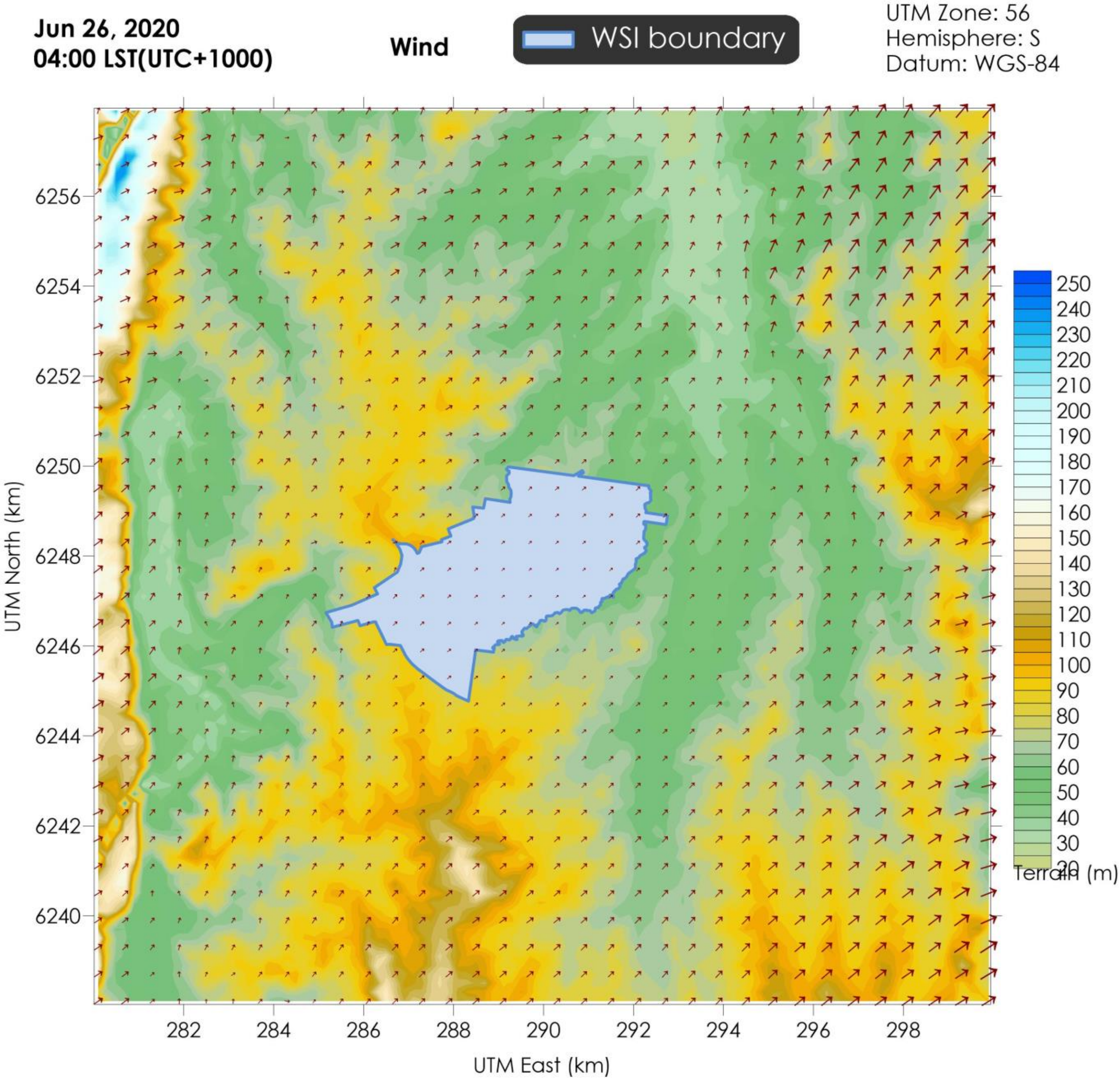


Figure A.7 Example of the wind field for one of the 8,760 hours of the year that are modelled

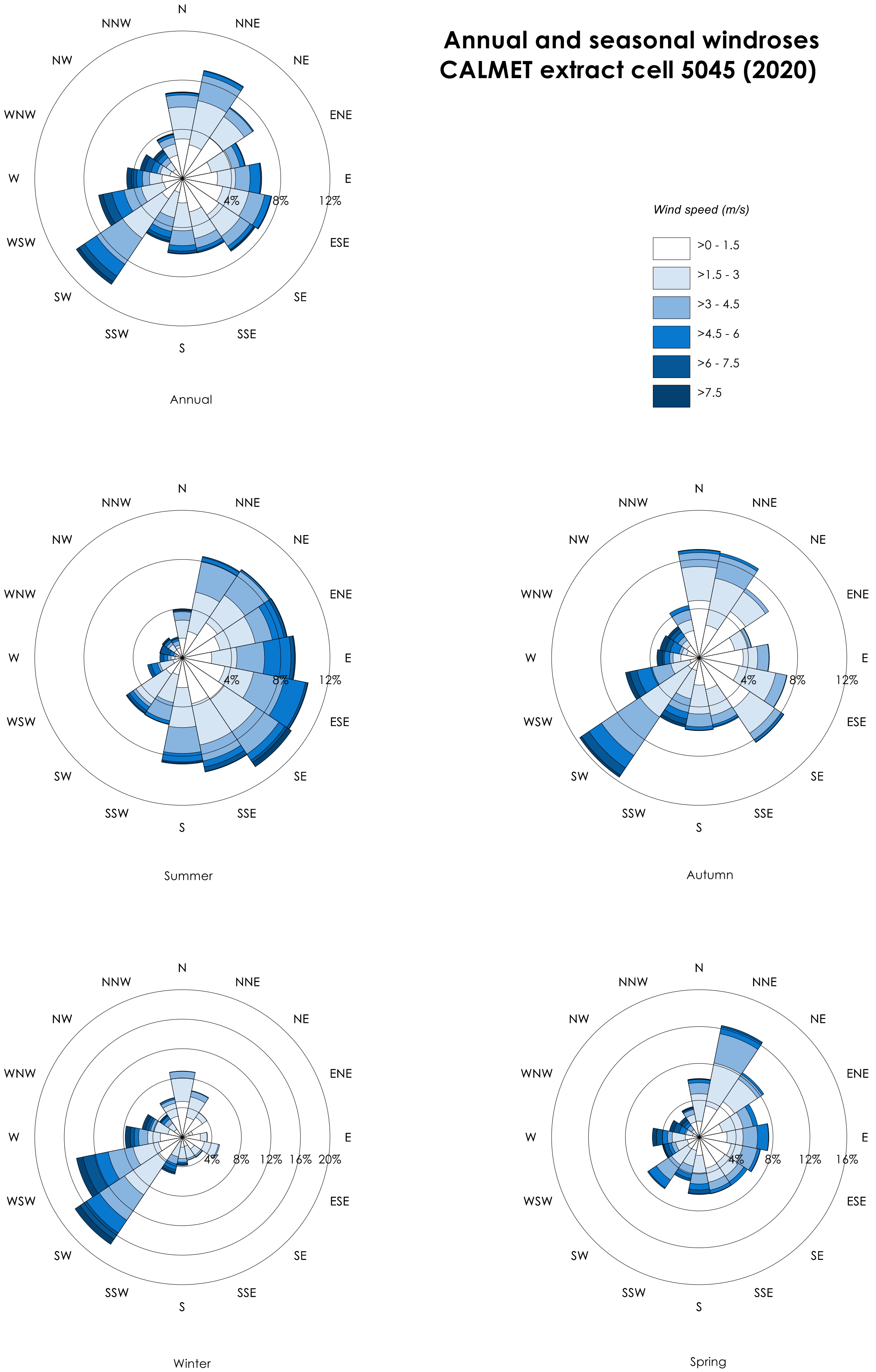


Figure A.8 Windroses from CALMET extract cell 5045 (2020)

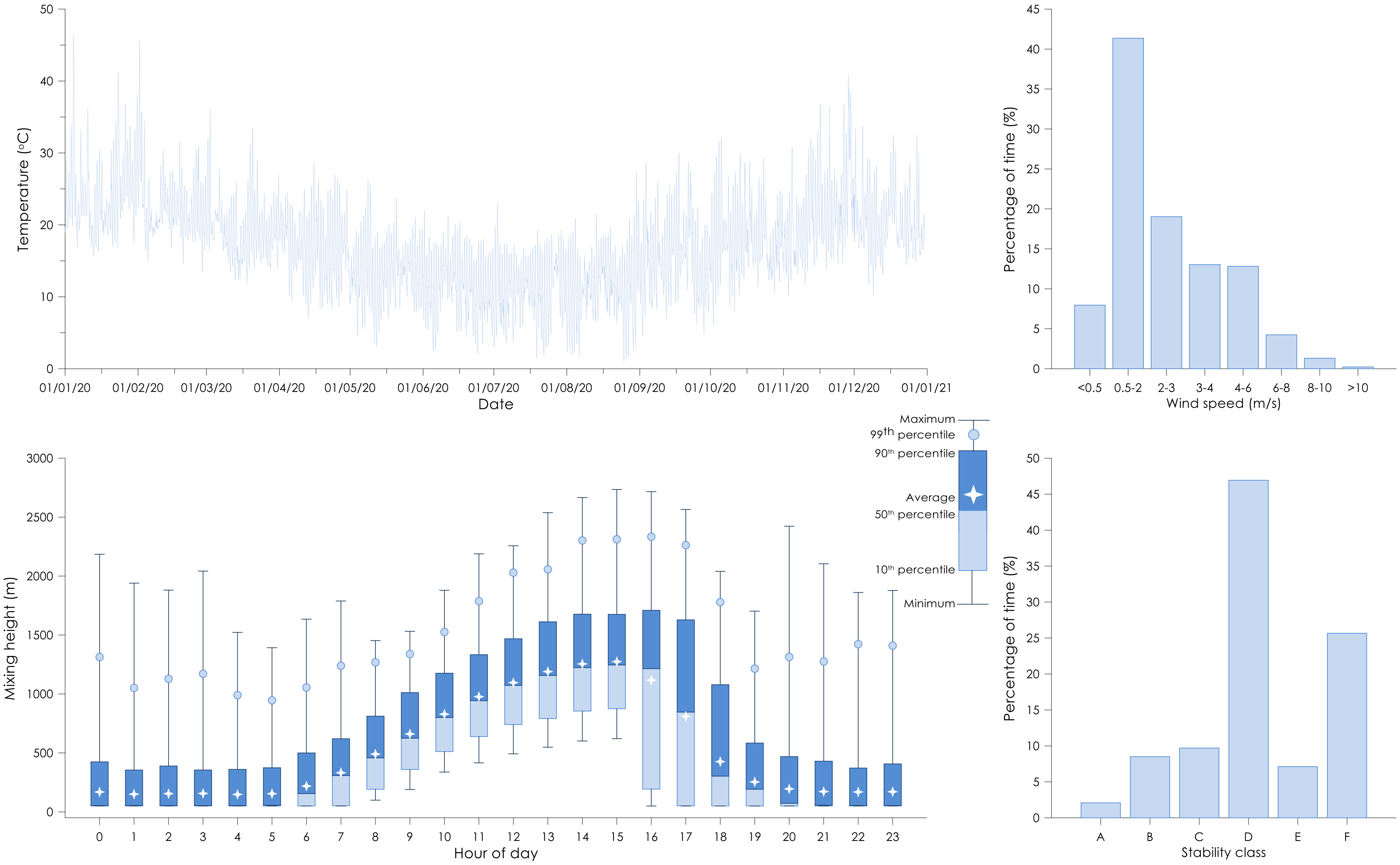


Figure A.9 Meteorological analysis of CALMET extract cell 5045 (2020)

To further evaluate the meteorological model performance a statistical evaluation was performed for weather station locations, at which the actual measured data was not used as an input assimilated into the model. These sites are the BOM Badgerys Creek AWS and the Bringelly DPE weather station.

Figure A.10 presents the location of both weather stations relative to the WSI.

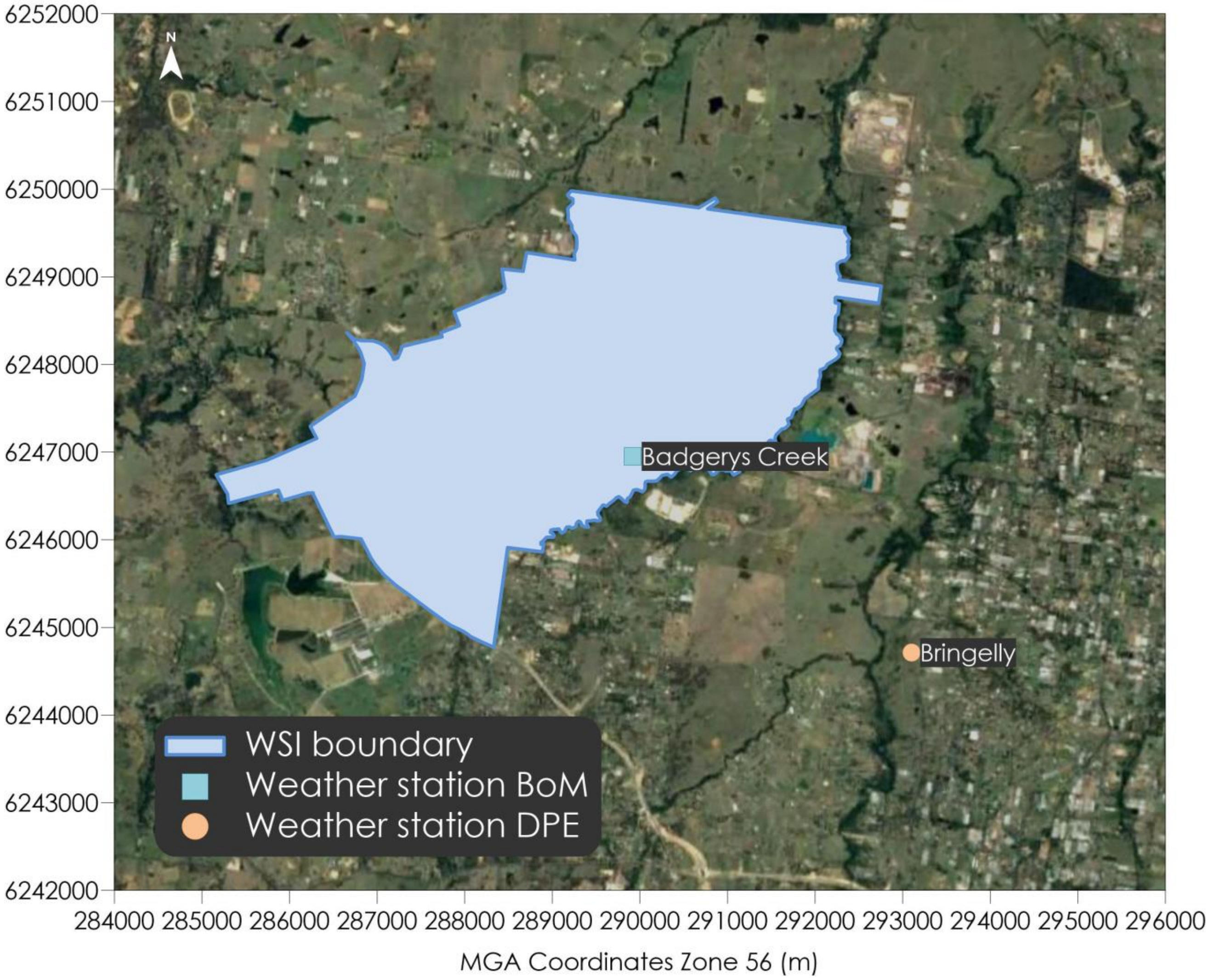


Figure A.10 Location of weather stations for the evaluation

CALMET generated meteorological data is extracted at the location of the weather stations within the modelling domain and compared with the actual measurement data for the same period.

A comparison of the wind speed, wind direction and temperature data for Bringelly is presented in Figure A.11 to Figure A.13. Based on the figures the wind speeds observed at the Bringelly monitor appear lower in general relative to the model predictions. It is normal for metrological models to somewhat overestimate wind speeds. The wind direction and temperature display much closer agreement between the observed and model predictions.

Figure A.14 presents a regression plot of the wind speed and temperature for Bringelly. The elevated wind speeds in the model prediction are evident in the plot.

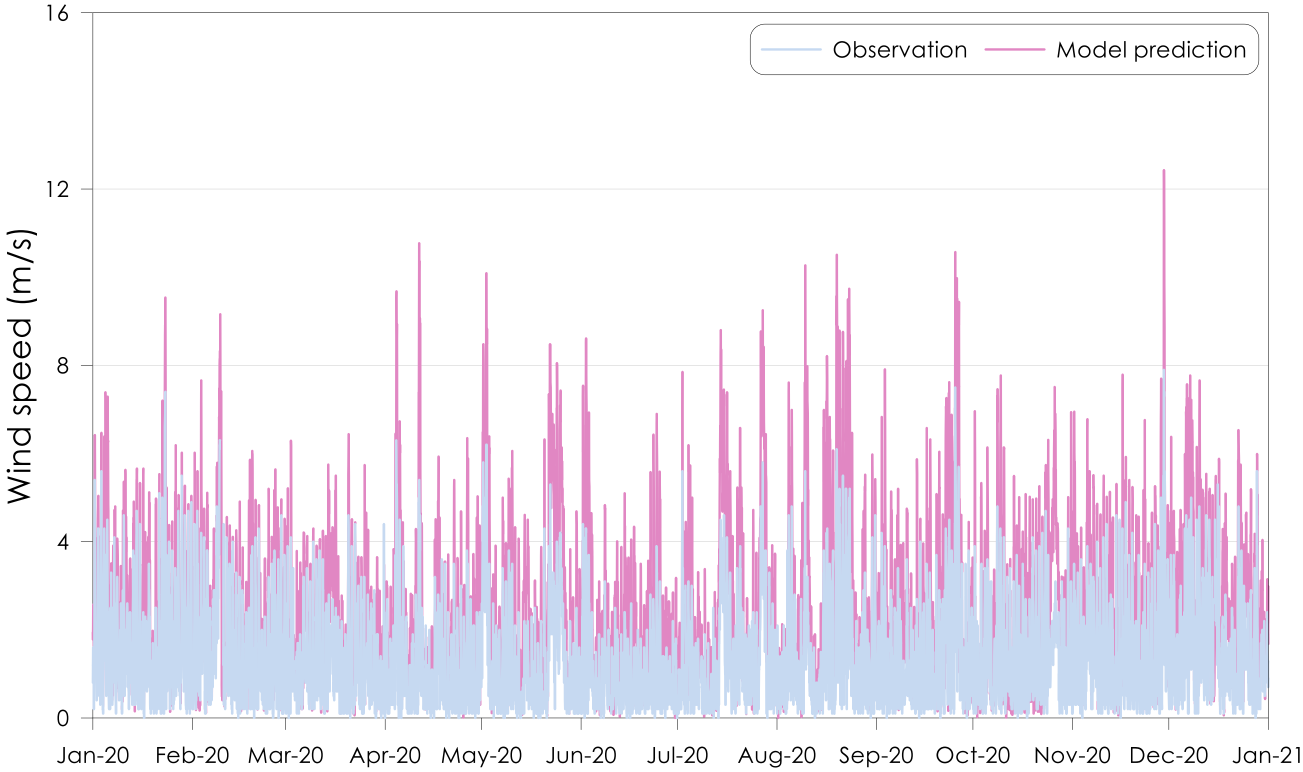


Figure A.11 Comparison of modelled and observed wind speed data for Bringelly

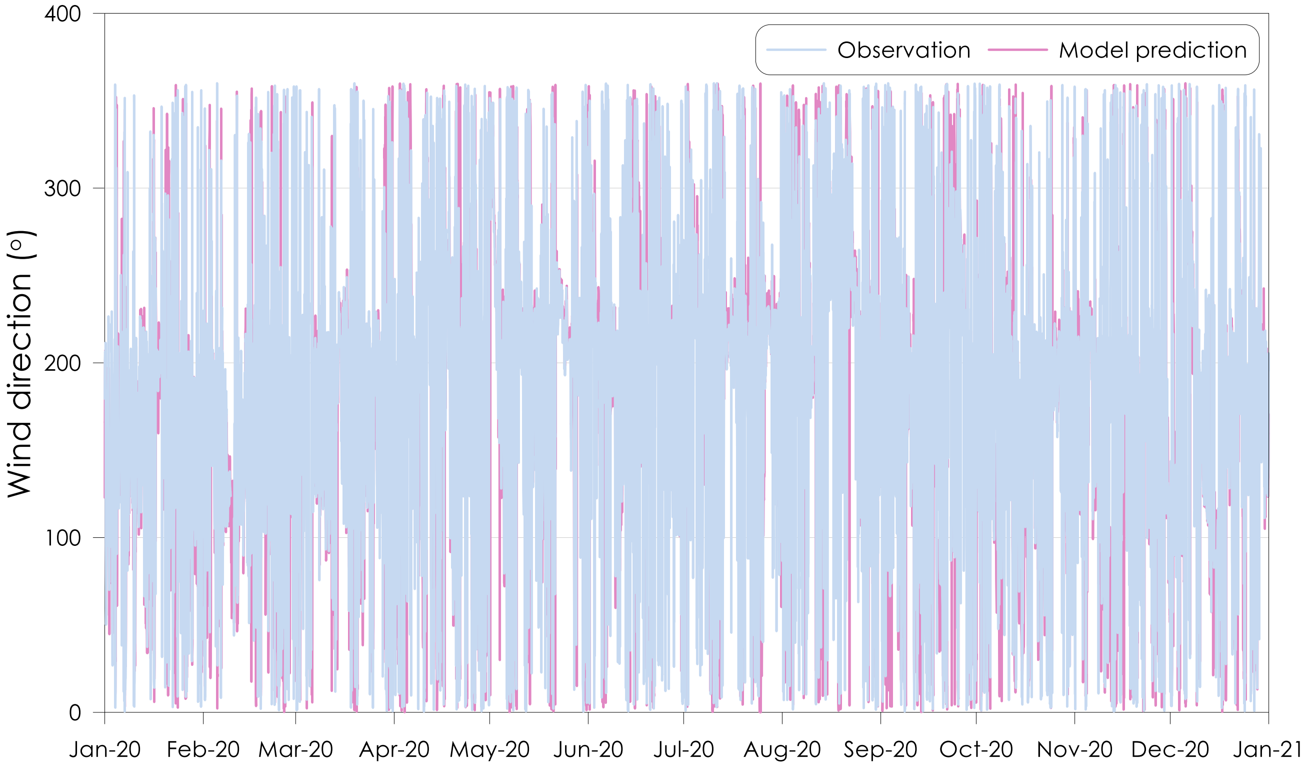


Figure A.12 Comparison of modelled and observed wind direction data for Bringelly

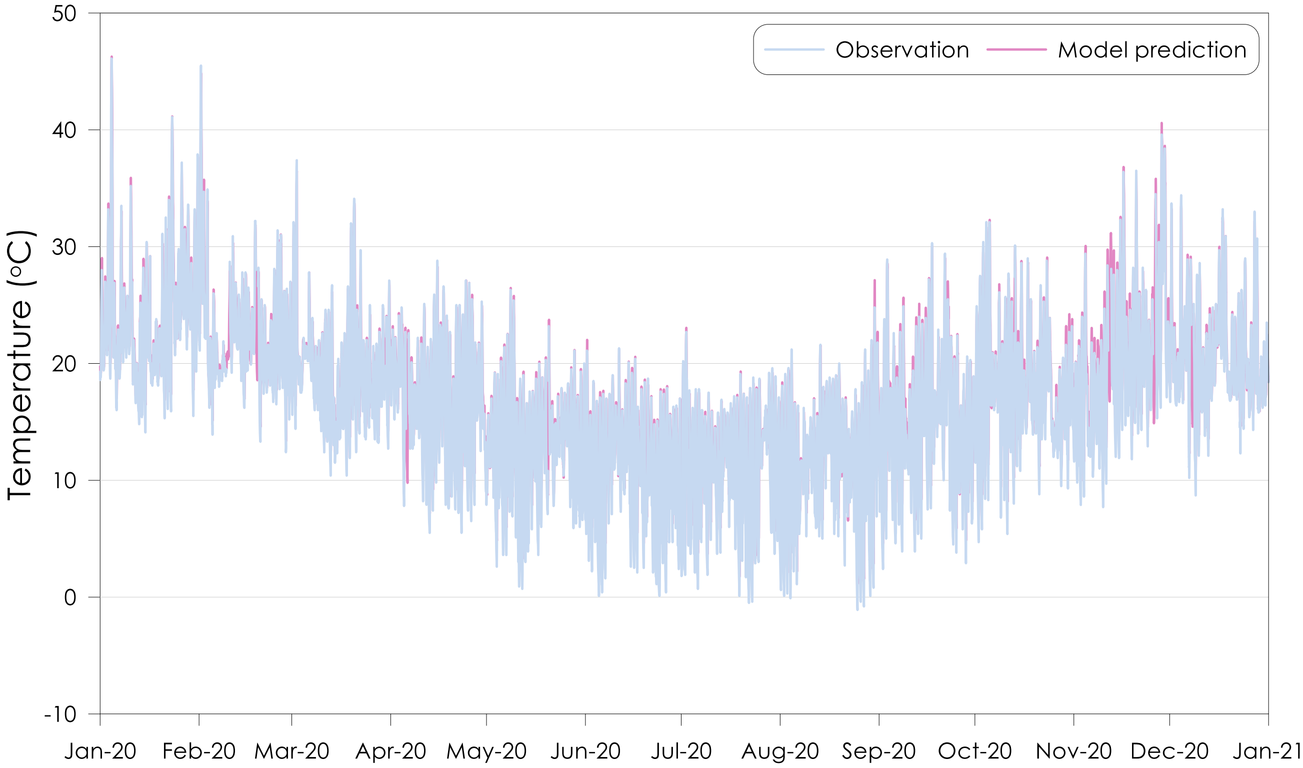


Figure A.13 Comparison of modelled and observed temperature data for Bringelly

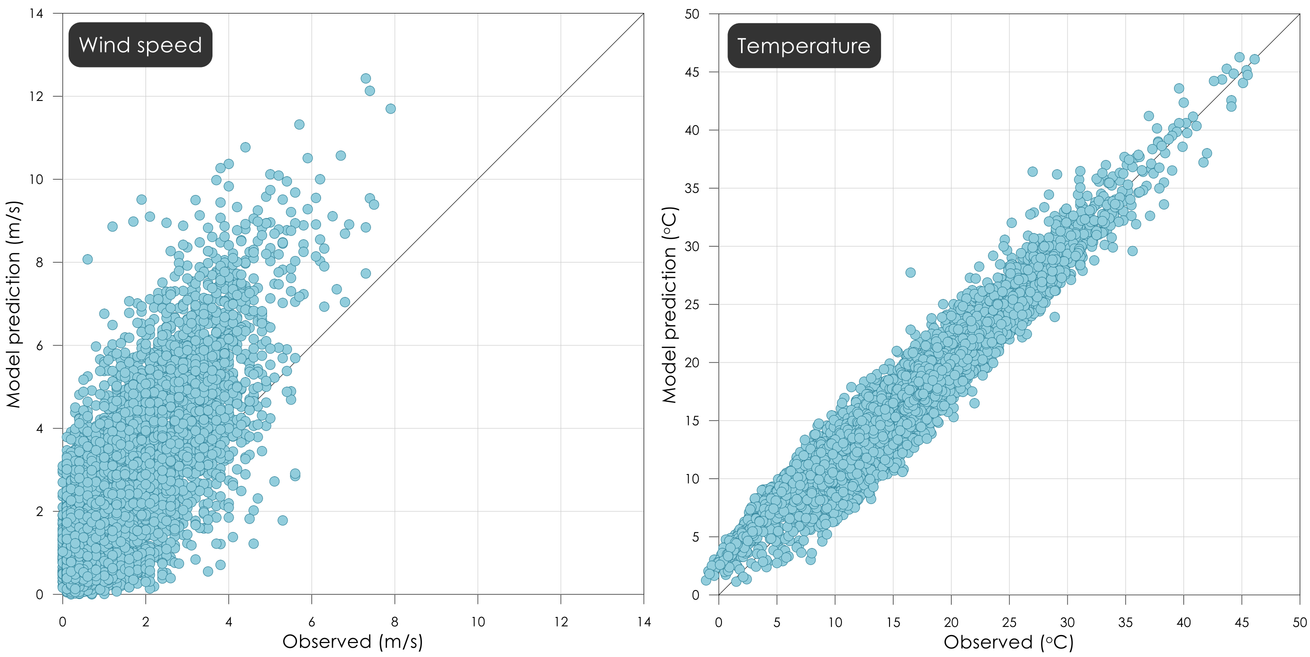


Figure A.14 Regression plot for wind speed (left) and temperature (right) for Bringelly

The statistical measures and performance benchmarks used for evaluation of the modelling simulation of the meteorological parameters are adopted from Emery et al (2001). These include the root-mean-square error (RMSE), bias error, Index of Agreement (IOA) and gross error.

The associated benchmarks for each of the meteorological parameters are outlined in Table A.6.

Table A.6 Adopted benchmarks to evaluate meteorological performance

Parameter	Statistical test	Benchmark
Wind speed	RMSE	≤ 2 m/s
	Bias	≤ ± 0.5 m/s
	IOA	≥ 0.6
Wind direction	Gross Error	≤ 30 deg
	Bias	≤ ± 10 deg
Temperature	Gross Error	≤ 2 K
	Bias	≤ ± 0.5 K
	IOA	≥ 0.8

Source: Emery et al, (2001)

A summary of the statistical evaluation of the sites are presented in Table A.7. The evaluation indicates the Badgerys Creek results are well within the benchmarks as expected considering the weather data was included in the simulation. For the Bringelly results at least one of the statistical tests for each parameter fall outside the benchmarks. This can suggest that model performance is reasonable.

Table A.7 Statistical evaluation of model performance

Parameter	Statistical test	Badgerys Creek	Bringelly	Benchmark
Wind speed	RMSE	0.3	1.6	≤ 2 m/s
	Bias	0.1	1.1	≤ ± 0.5 m/s
	IOA	0.98	0.32	≥ 0.6
Wind direction	Gross Error	3.3	51.4	≤ 30 deg
	Bias	2.7	0.8	≤ ± 10 deg
Temperature	Gross Error	0.3	1.7	≤ 2 K
	Bias	0.2	1.0	≤ ± 0.5 K
	IOA	0.99	0.91	≥ 0.8

Given the overestimation in wind speeds, a detailed physical review of the siting the Bringelly weather station was conducted and found the site is non-compliant with the relevant siting standards for weather stations in the Australian Standards (AS 2923-1987 or AS/NZS 3580.14-2014) due to tall trees located within approximately 20 metres of the station and other tree lines located to the south and west approximately 50 metres away. Figure A.15 presents a photograph of the Bringelly weather station showing the problematic trees. These trees would obstruct the wind flows near this weather station and the monitoring data would not be representative of the wider area. Whilst this may explain some of the overestimation of wind speeds, it is important to note that this effect is a recognised inherent aspect of meteorological modelling.

Figure A.15 Photo of Bringelly weather station facing southwest

Appendix B

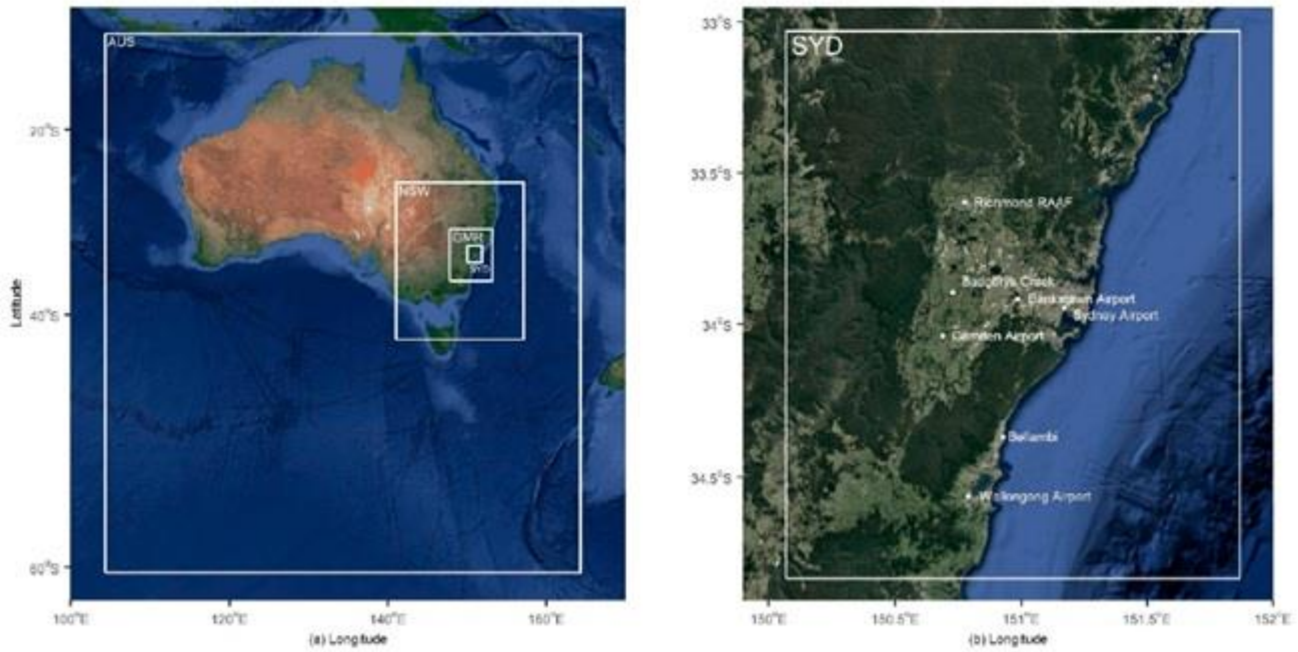
Regional air quality – WRF/CMAQ model

B1 Model selection

The recent two-part study titled Evaluation of Regional Air Quality Models Over Sydney and Australia (Monk et al, 2019 & Guerette et al., 2020) was reviewed to determine the most suitable model for the purpose of a regional assessment in the Sydney Basin. The first part of the study focused on the meteorological component and the second part of the study looked at different chemical transport models.

The study set out to perform an intercomparison of air quality models across the Sydney area evaluate current modelling abilities, spot any issues, and offer the essential regional model validation. To evaluate the meteorological component of these air quality modelling systems, 7 different simulations based on varying configurations of inputs, integrations and physical parameterizations of 2 meteorological models (the Weather Research and Forecasting (WRF) and Conformal Cubic Atmospheric Model (CCAM)) were examined.

The modelling was conducted for 4 common domains covering the area of interest as identified in Figure B.1.



Source: Monk et al. 2019

Figure B.1 Modelling domain configuration

The common configuration of the 7 different simulations tested are shown in Figure B.2. The WRF model was used to drive one configuration of Community Multiscale Air Quality Model (CMAQ) and 4 configurations of WRF-Chem. CCAM was used to drive 2 variations of the Chemical Transport Model (CTM), as set out in Figure B.2 (Monk et al, 2019).

Model Identifier	Parameter	W-UM1	W-UM2	W-A11	O-CTM	C-CTM	W-NC1	W-NC2
	Research Group	Univ. Melbourne	Univ. Melbourne	ANSTO	NSW OEH	CSIRO	NCSU	NCSU
Model specifications	Met. model	WRF	WRF	WRF	CCAM	CCAM	WRF	WRF
	Chem. model	CMAQ	WRF-Chem	WRF-Chem with simplified Radon only	CSIRO-CTM	CSIRO-CTM	WRF-Chem	WRF-Chem-ROMS
	Met model version	3.6.1	3.7.1	3.7.1	r-4271:4285M	r-2796	3.7.1	3.7.1
Domain	Nx	80, 73, 97, 103	80, 73, 97, 103	80, 73, 97, 103	75, 60, 60, 60	88,88,88,88	79, 72, 96, 102	79, 72, 96, 102
	Ny	70, 91, 97, 103	70, 91, 97, 103	70, 91, 97, 103	65, 60, 60, 60	88,88,88,88	69, 90, 96, 102	69, 90, 96, 102
	Vertical layers	33	33	50	35	35	32	32
	Thickness of first layer (m)	33.5	56	19	20	20	35	35
Initial & Boundary conditions	Met input/BCs	ERA Interim	ERA Interim	ERA Interim	ERA Interim	ERA Interim	NCEP/FNL	NCEP/FNL
	Topography/Land use	Geoscience Australia DEM for inner domain, USGS elsewhere	Geoscience Australia DEM for inner domain. USGS elsewhere.	Geoscience Australia DEM for inner domain, USGS elsewhere. MODIS land use	MODIS	MODIS	USGS	USGS
	SST	High-res SST analysis (RTG_SST)	High-res SST analysis (RTG_SST)	High-res SST analysis (RTG_SST)	SST from ERA Interim	SSTs from ERA Interim	High-res SST analysis (RTG_SST)	Simulated by ROMS
	Integration	24-h simulations, each with 12-h spin-up	Continuous with 2-d spin up	Continuous with 10-d spin up	Continuous with 1 mth spin up.	Continuous with 1 mth spin up.	Continuous with 8-d spin up	Continuous with 8-d spin up
	Data assimilation	Grid-nudging outer domain above the PBL	Grid-nudging outer domain above the PBL	Spectral nudging in domain 1 above the PBL (scale-selective relaxation to analysis)	Scale-selective filter to nudge towards the ERA-Interim data	Scale-selective filter to nudge towards the ERA-Interim data	Gridded analysis nudging above the PBL	Gridded analysis nudging above the PBL

Model Identifier	Parameter	W-UM1	W-UM2	W-A11	O-CTM	C-CTM	W-NC1	W-NC2
	Research Group	Univ. Melbourne	Univ. Melbourne	ANSTO	NSW OEH	CSIRO	NCSU	NCSU
Parameterisations	Microphysics	Morrison	Lin	WSM6	Prognostic condensate scheme	Prognostic condensate scheme	Morrison	Morrison
	LW radiation	RRTMG	RRTMG	RRTMG	GFDL	GFDL	RRTMG	RRTMG
	SW radiation	RRTMG	GSFC	RRTMG	GFDL	GFDL	RRTMG	RRTMG
	Land surface	NOAH	NOAH	NOAH	Kowalczyk scheme	Kowalczyk scheme	NOAH	NOAH
	PBL	MYJ	YSU	MYJ	Local Richardson number and non-local stability	Local Richardson number and non-local stability	YSU	YSU
	UCM	3-category UCM	NOAH UCM	Single layer UCM	Town Energy budget approach	Town Energy budget approach	Single layer UCM	Single layer UCM
	Convection	G3 (domains 1-3, off for domain 4)	G3	G3	Mass-flux closure	Mass-flux closure	MSKF	MSKF
	Aerosol feedbacks	No	No	No	Prognostic aerosols with direct and indirect effects	Prognostic aerosols with direct and indirect effects	Yes	Yes
	Cloud feedbacks	No	No	No	Yes	Yes	Yes	Yes

ANSTO: Australian Nuclear Science and Technology Organisation WRF: Weather Research and Forecasting NSW OEH: New South Wales Office of Environment and Heritage CSIRO: Commonwealth Scientific and Industrial Research Organisation NCSU: North Carolina State University CCAM: Conformal Cubic Atmospheric Model BCs: Boundary Conditions ERA: European Centre for Medium Range Forecasting (ECMWF) Re-Analysis NCEP/FNL: National Centre for Environmental Prediction Final Analysis DEM: Digital Elevation Model USGS: United States Geological Survey MODIS: Moderate Resolution Imaging Spectroradiometer SST: Sea Surface Temperature PBL: Planetary Boundary Layer WSM6: WRF Single-Moment 6-class Scheme RRTMG: Rapid Radiative Transfer Model for GCMs GFDL: Geophysical Fluid Dynamics Scheme GSFC: Goddard Space Flight Centre Scheme MYJ: Mellor-Yamada-Janjic Scheme YSU: Yonsei University Scheme UCM: Urban Canopy Model G3: Grell 3D ensemble Scheme MSKF: Multi-Scale Kain-Fritsch Scheme.

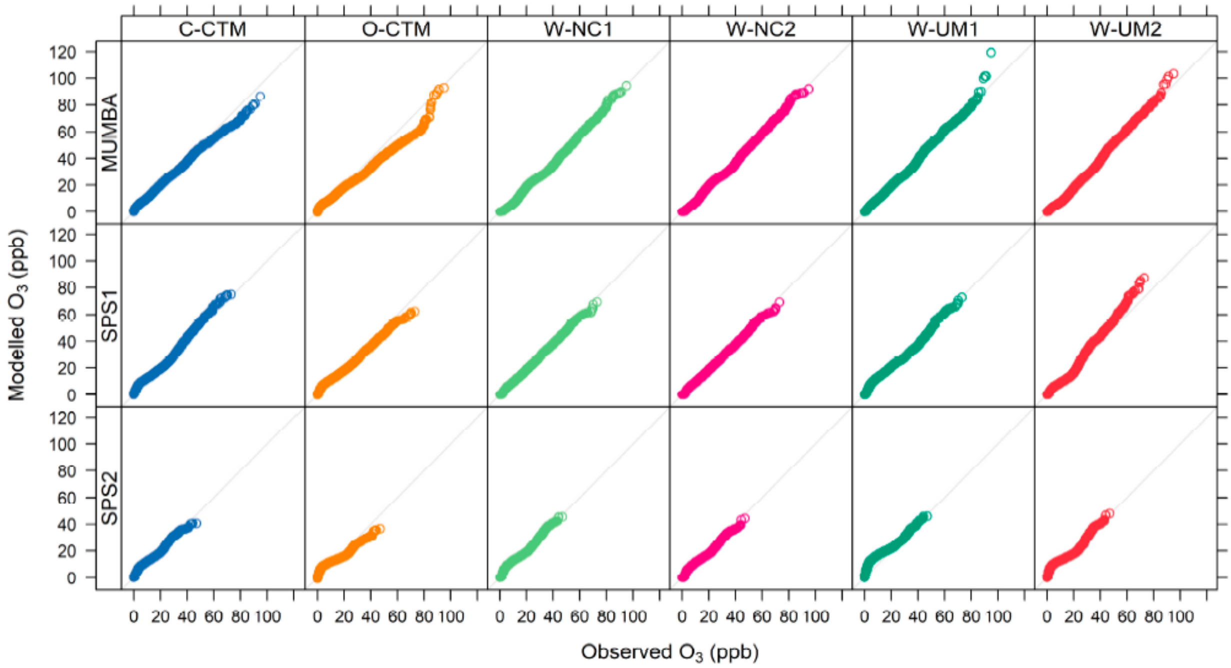
Source: Monk et al (2019)

Figure B.2 Overview of configuration of the meteorological models

The models were evaluated using a statistical analysis of observed data collected at 7 BOM stations in the Sydney and Wollongong area for 3 periods coinciding with intensive air quality monitoring campaigns. These include the 2 Sydney Particle Study (SPS) measurements campaigns and the Measurement of Urban, Marine and Biogenic Air (MUMBA).

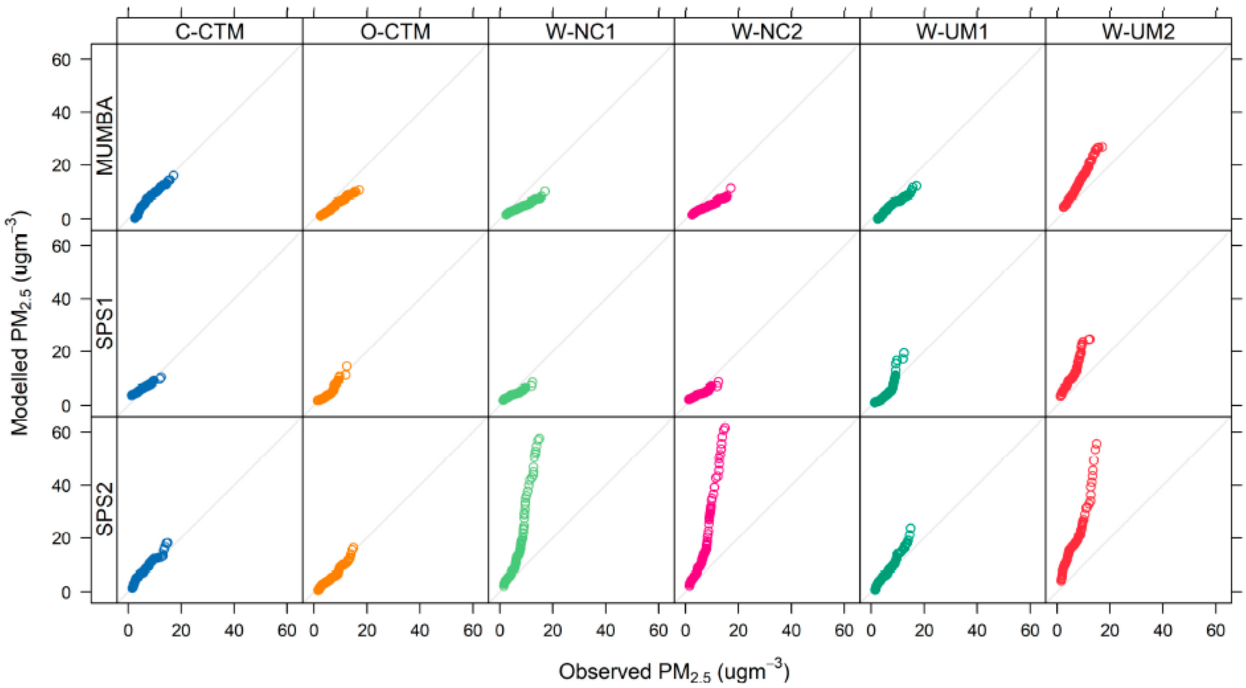
Overall, the study found that the model simulation performance meets the benchmarks of key atmospheric variables for input into air quality models Monk et al (2019).

The second part of the study compared 6 chemical transport models to replicate short-term hourly to 24-hourly concentrations of O_3 and $PM_{2.5}$. The model performance was evaluated by comparison to air quality measurements made at 16 locations for O_3 and 5 locations for $PM_{2.5}$. A comparison of the O_3 predictions and observations are shown in Figure B.3 and indicates relatively accurate predictions. A comparison of the $PM_{2.5}$ predictions and observations are shown in Figure B.4 and indicate variability.



Source: Guerette et al., 2020

Figure B.3 Comparison of modelled and observed O_3 distributions



Source: Guerette et al., 2020

Figure B.4 Comparison of modelled and observed $PM_{2.5}$ distributions

The evaluation found that the WRF/CMAQ system performed well and was suitable for reliably modelling of potential ozone impacts. The WRF/CMAQ model was selected for use in this study as it was found to perform reliably well in the Sydney airshed, and also because it was available for use in the period for December 2021 to January 2022 with the same parametrisation (settings) as those implemented in the evaluation study.

B1.1 WRF/WRF/CMAQ model description

The WRF model is a mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications. WRF can produce simulations based on actual atmospheric conditions (i.e., from observations and analyses) or idealised conditions.

The development of WRF was a collaborative partnership of the National Centre for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (represented by the National Centres for Environmental Prediction (NCEP) and the Earth System research laboratory), the US Air Force, the Naval Research laboratory, the University of Oklahoma, and the Federal Aviation Administration (FAA).

The US EPA website for the Community Multiscale Air Quality Model (CMAQ) describes it as a numerical air quality model that relies on scientific first principles to predict the concentration of airborne gases and particles, and the deposition of these pollutants back to Earth's surface. Because it includes information about the emissions and properties of compounds and classes of compounds, CMAQ can also inform users about the chemical composition of a mixture of pollutants.

CMAQ is capable of simulating air quality over many geographical scales. CMAQ is able to simulate the changes of pollutant concentrations in the atmosphere using a set of mathematical equations characterising the chemical and physical process in the atmosphere. The US EPA website states that the purpose of CMAQ is to provide fast, technically sound estimates of ozone, particulates, toxics, and acid deposition. CMAQ is designed to meet the needs of the scientific community and concerned community leaders by combining current knowledge in atmospheric science and air quality modelling, multi-processor computing techniques, and an open-source framework into a single modelling system.

The CMAQ modelling is applied with consideration of the guidance for the NSW EPA Level 2 Refined Assessment Procedure presented in the *Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources* (Environ, 2011).

B1.1.1 Model settings

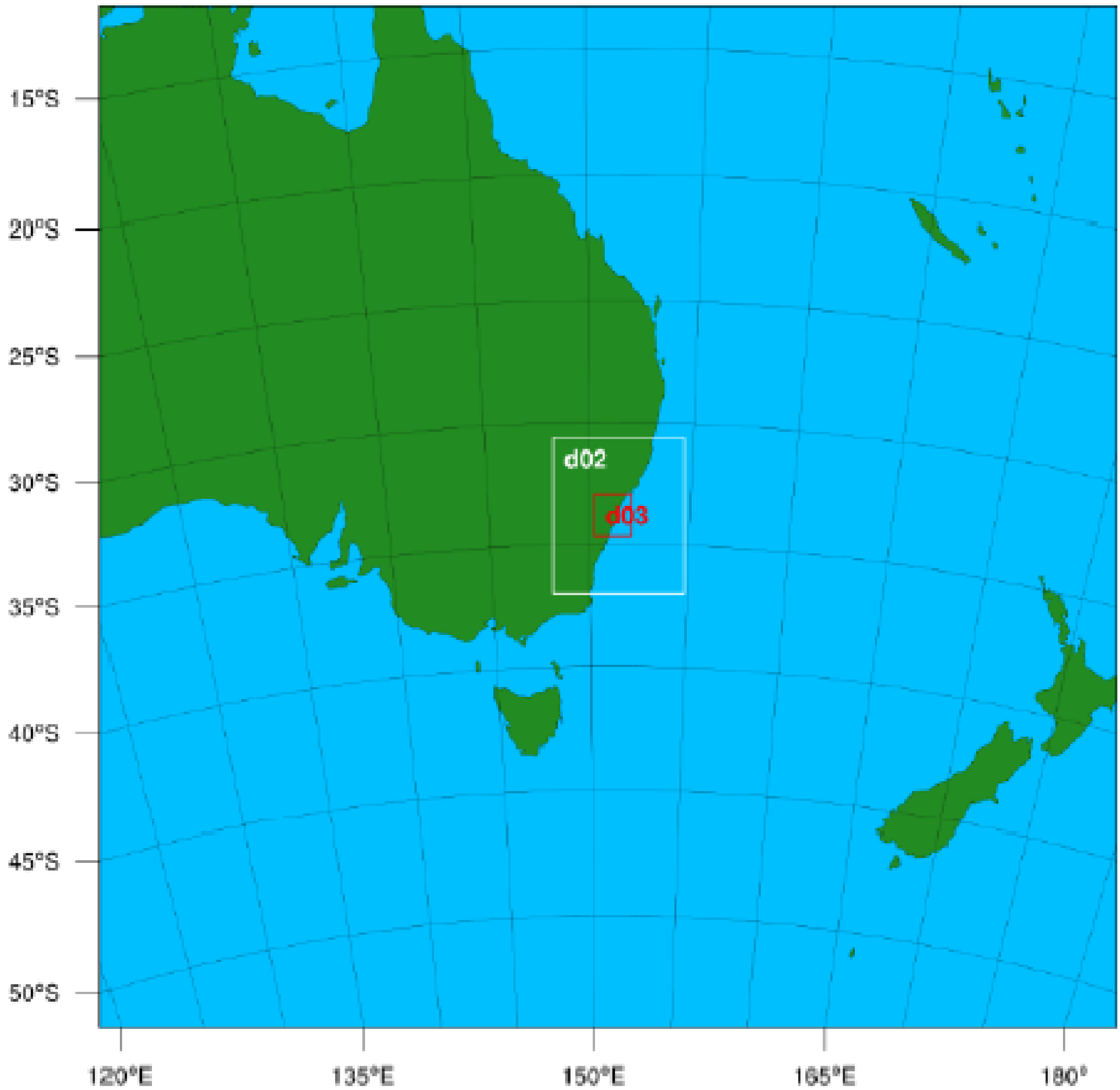
The WRF Model simulation is run for 3-nested domains with the outer domain covering much of Eastern Australia, the inner domain covering most of NSW and the innermost domain covering the Greater Metropolitan Region (GMR) of Sydney.

The WRF model grid spacings is presented in Table B.1. Figure B.5 presents a visualisation of the WRF domain configuration.

The initial and boundary conditions for meteorology applied to the WRF model is from NCEP Final Reanalysis data.

Table B.1 WRF grid spacing

Domain	Name	Resolution
1	Outer domain – Eastern Australia	12 x 12 kilometre
2	Inner domain – NSW	4 x 4 kilometre
3	Innermost domain – GMR	1 x 1 kilometre

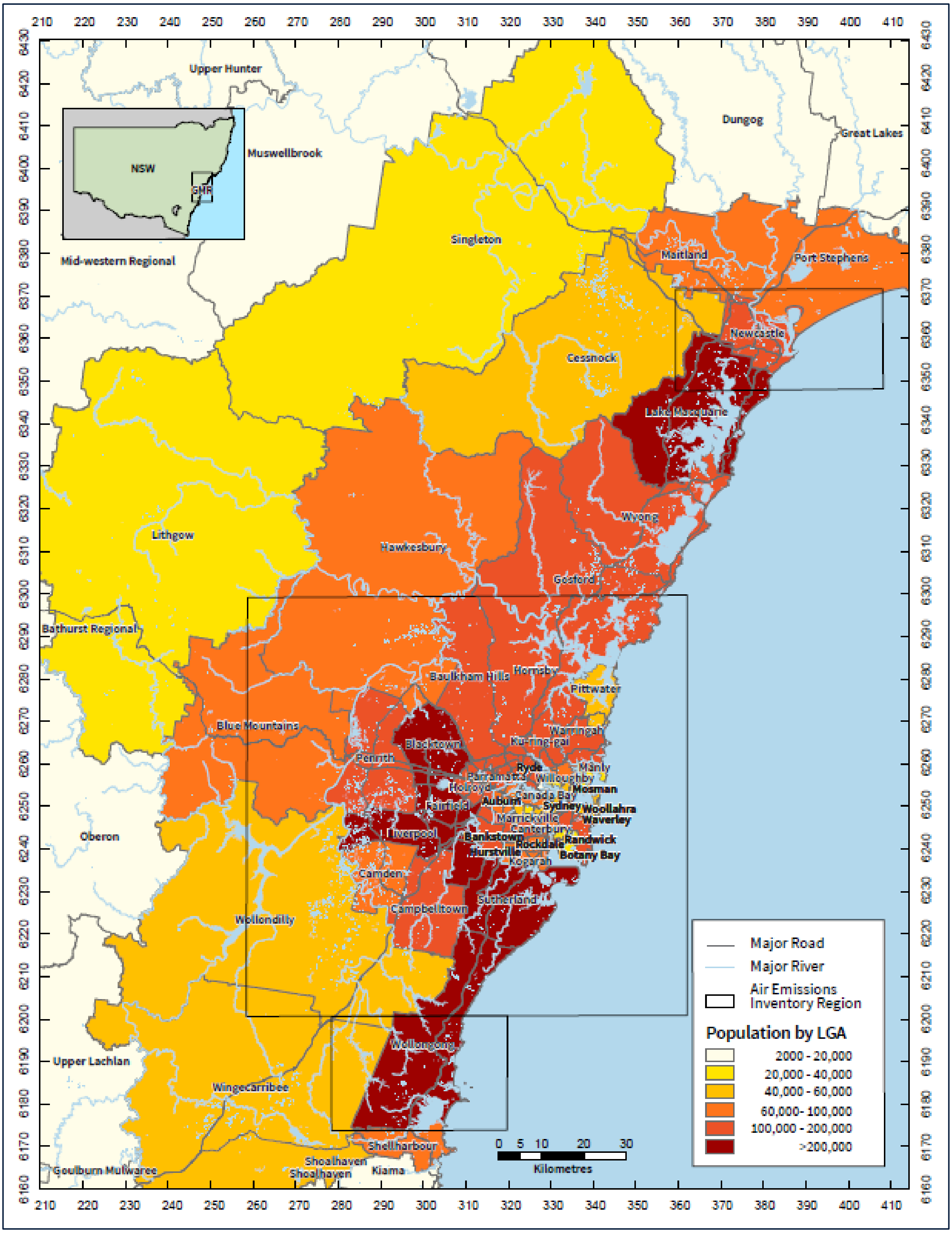


Source: Duc, et al. (2021)

Figure B.5 WRF domain configuration

The geographical extent of the innermost modelling domain for the regional air quality model is defined by the NSW EPA Air Emission Inventory GMR. Figure B.6 presents the extent of the GMR.

The modelling domain is assigned a grid resolution one kilometre by one kilometre.



Source: NSW EPA (2019)

Figure B.6 Definition of GMR and the Sydney, Newcastle and Wollongong regions

B1.1.2 Selection of modelling period

As per the Level 2 Refined Assessment Procedure, the ozone impacts of the new source are determined from the difference between 2 model runs (with and without the project). Several days are selected for assessment, as a minimum at least 3 to enable comparison of source impacts across multiple high ozone days. Model performance evaluation is made using normalised mean bias and normalised mean error for spatially and temporally paired ozone.

To select the period of modelling a review of the most relevant days in the most recent summer period was conducted.

Figure B.7 presents the measured ozone levels for Sydney during the 2021/2022 summer period.

Figure B.8 presents the measured NOX levels and temperature for Sydney during the 2021/2022 summer period.

Figure B.9 presents the measured rainfall, PM_{10} and $PM_{2.5}$ levels for Sydney during the 2021/2022 summer period.

The review identified that the peak temperature period from 17 to 23 December 2021 would be most suitable for a detailed analysis. This period coincides with a day exceeding the criteria and several days near to the criteria, and which need to be tested to determine whether the project may lead to any further exceedance periods. The period also includes dry and wet conditions, a wide temperature variation including some of the highest temperatures, high NO_2 levels and otherwise generally representative more elevated PM_{10} and $PM_{2.5}$ levels, making it the most suitable for a detailed regional analysis.

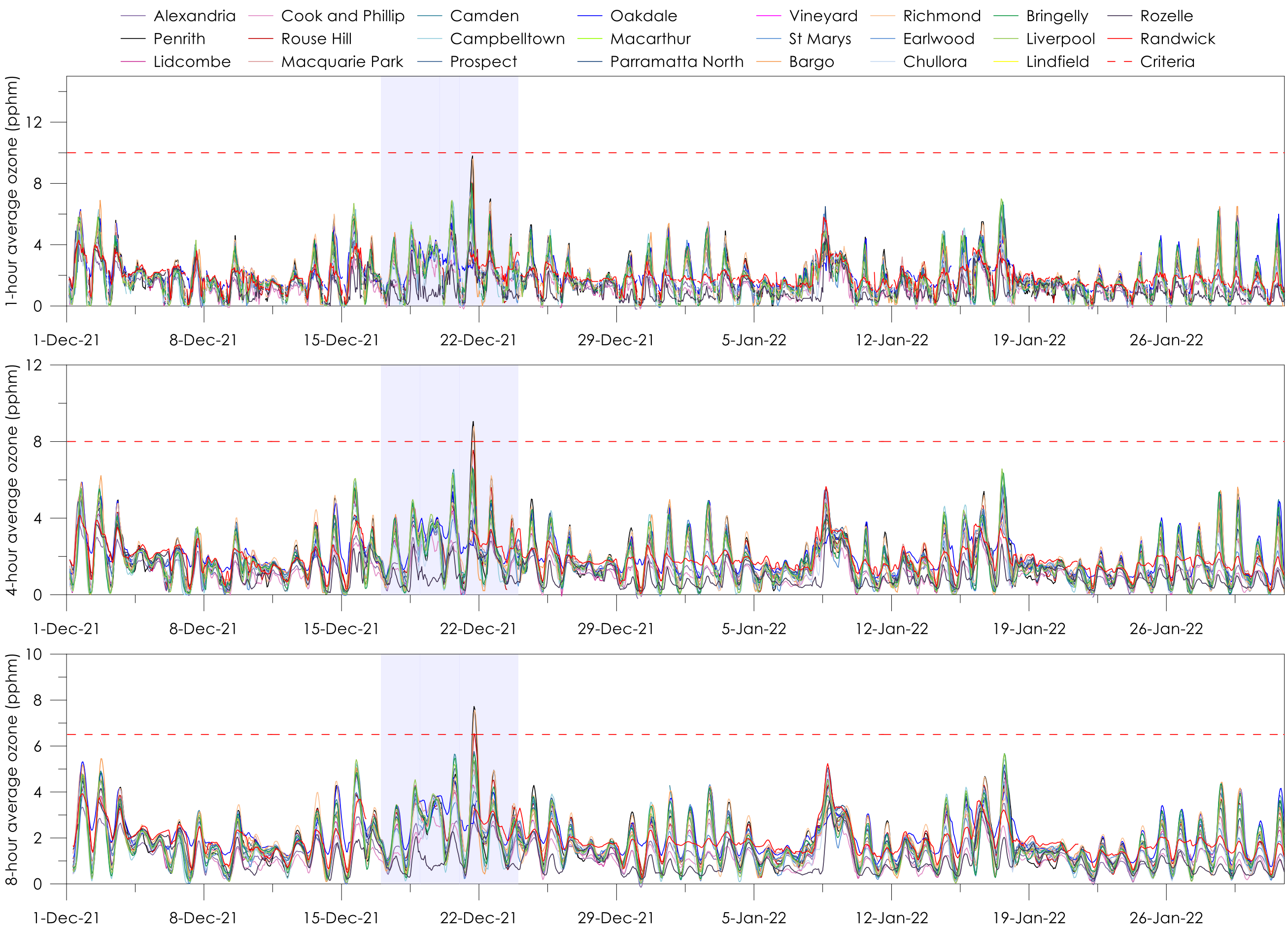


Figure B.7 Measured ozone levels during the 2021/2022 summer period

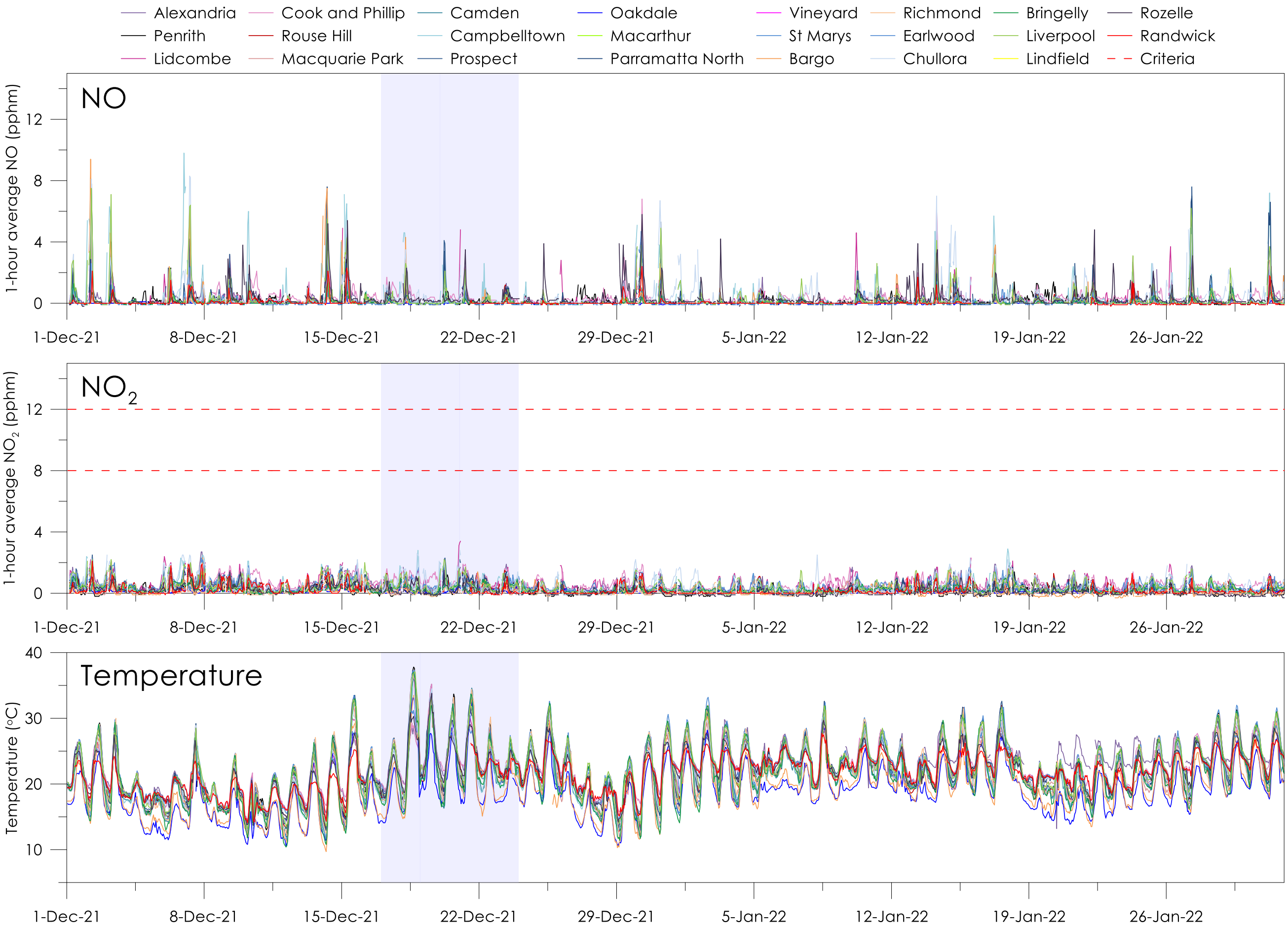


Figure B.8 Measured NOx levels and temperature during the 2021/2022 summer period

Figure B.9 Measured rainfall, PM_{10} and $PM_{2.5}$ levels during the 2021/2022 summer period

B1.1.3 Emission data

Baseline emissions data obtained from the NSW EPA Air Emissions Inventory for the GMR and included anthropogenic and biogenic emissions. The NSW EPA Air Emissions inventory included all points source emissions from commercial and industrial sources, all area source emissions from on-road mobile sources, all area source emission and fugitive emissions from biogenic, commercial, domestic, industrial and off-road mobile sources.

The GMR emission inventory data are used as anthropogenic emissions input along with the global emission database EDGAR for emissions outside the GMR, the biogenic emission based on the MEGAN biogenic model, the marine aerosol (sea salt) and soil dust emissions as provided with CMAQ model.

The emission associated with the project are also incorporated as elevated point sources and the methodology for the emission estimation is outlined in Chapter 5.

Appendix C

Local air quality – results

C1 Local air quality results

This section presents the predicted impacts on air quality which may arise from air emissions generated by the project in isolation (the incremental impact) and a brief analysis of the results.

C1.1 Particulate matter concentrations

Isopleths showing the spatial distribution of predicted incremental impacts due to the project for maximum 24-hour average and annual average particulate matter concentrations (as $PM_{2.5}$) are presented in Figure C.1 to Figure C.10 for the various scenarios assessed.

Table C.1 presents the predicted particulate dispersion modelling results at each of the assessed sensitive receptor locations. The results show minimal incremental effects would arise at the receiver locations due to the project.

Table C.1 Dispersion modelling results for particulate matter

Receptor ID	Maximum 24-hour average					Annual average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 - No preference	2033 - Prefer Runway 05	2033 - Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R1	0.05	0.05	0.05	0.13	0.13	0.00	0.00	0.01	0.01	0.01
R2	0.28	0.32	0.27	0.77	0.65	0.05	0.05	0.04	0.13	0.11
R3	0.17	0.14	0.11	0.35	0.28	0.01	0.01	0.01	0.03	0.03
R4	0.03	0.04	0.04	0.11	0.12	0.00	0.00	0.00	0.01	0.01
R6	0.05	0.04	0.03	0.10	0.09	0.00	0.00	0.00	0.01	0.01
R7	0.04	0.03	0.03	0.07	0.08	0.00	0.00	0.00	0.01	0.01
R8	0.07	0.06	0.07	0.17	0.19	0.01	0.01	0.01	0.02	0.02
R14	0.11	0.10	0.13	0.27	0.31	0.01	0.01	0.01	0.02	0.02
R15	0.24	0.22	0.22	0.51	0.53	0.02	0.02	0.02	0.05	0.05
R17	0.14	0.11	0.14	0.27	0.33	0.02	0.02	0.02	0.04	0.05
R18	0.36	0.24	0.38	0.66	0.88	0.05	0.06	0.09	0.16	0.24
R19	0.40	0.52	0.61	1.28	1.42	0.09	0.11	0.13	0.29	0.32
R21	0.45	0.43	0.20	0.94	0.47	0.06	0.05	0.03	0.11	0.07
R22	0.06	0.06	0.06	0.15	0.15	0.00	0.00	0.00	0.01	0.01
R23	0.04	0.04	0.03	0.09	0.07	0.01	0.01	0.00	0.02	0.01
R24	0.28	0.25	0.36	0.64	0.83	0.02	0.02	0.03	0.05	0.07
R25	0.88	0.76	0.64	1.64	1.53	0.09	0.08	0.05	0.20	0.13
R27	0.23	0.19	0.10	0.44	0.26	0.02	0.01	0.01	0.04	0.03
R30	0.02	0.02	0.02	0.05	0.06	0.00	0.00	0.00	0.01	0.01

Receptor ID	Maximum 24-hour average					Annual average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 - No preference	2033 - Prefer Runway 05	2033 - Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R31	0.03	0.03	0.03	0.07	0.07	0.00	0.00	0.00	0.01	0.01
R34	0.04	0.04	0.04	0.10	0.10	0.00	0.00	0.00	0.01	0.01
R35	0.04	0.04	0.04	0.10	0.11	0.00	0.00	0.00	0.01	0.01
R37	0.39	0.33	0.21	0.78	0.50	0.06	0.06	0.03	0.15	0.09
R38	0.02	0.03	0.03	0.07	0.07	0.00	0.00	0.00	0.01	0.01
R39	0.02	0.02	0.02	0.04	0.04	0.00	0.00	0.00	0.00	0.00
R40	0.05	0.04	0.05	0.10	0.11	0.00	0.00	0.00	0.01	0.01
R41	0.04	0.04	0.04	0.10	0.10	0.00	0.00	0.00	0.01	0.01
R44	0.19	0.19	0.13	0.43	0.32	0.01	0.01	0.01	0.03	0.03
R46	0.04	0.04	0.04	0.10	0.11	0.00	0.00	0.00	0.01	0.01
R48	0.01	0.01	0.01	0.03	0.03	0.00	0.00	0.00	0.00	0.00
R49	0.35	0.36	0.30	0.86	0.70	0.06	0.06	0.04	0.15	0.11
R52	0.01	0.01	0.01	0.04	0.04	0.00	0.00	0.00	0.00	0.00
R53	0.02	0.02	0.02	0.06	0.07	0.00	0.00	0.00	0.01	0.01
R54	0.04	0.04	0.04	0.10	0.09	0.00	0.00	0.00	0.01	0.01
R55	0.03	0.04	0.04	0.10	0.12	0.00	0.00	0.00	0.01	0.01
R57	0.04	0.03	0.03	0.08	0.08	0.01	0.00	0.00	0.01	0.01
R59	0.06	0.06	0.06	0.15	0.15	0.01	0.01	0.01	0.01	0.02
R63	0.44	0.40	0.24	0.97	0.57	0.08	0.07	0.04	0.18	0.11
R64	0.05	0.04	0.04	0.10	0.09	0.00	0.00	0.00	0.01	0.01
R65	0.04	0.04	0.04	0.10	0.10	0.00	0.00	0.00	0.01	0.01
R66	0.09	0.08	0.05	0.19	0.13	0.01	0.01	0.01	0.02	0.02
R68	0.03	0.04	0.05	0.11	0.12	0.00	0.00	0.00	0.01	0.01
R69	0.05	0.04	0.05	0.10	0.11	0.00	0.00	0.00	0.01	0.01
R72	0.01	0.01	0.01	0.04	0.04	0.00	0.00	0.00	0.00	0.00
R73	0.48	0.43	0.26	1.04	0.62	0.08	0.08	0.05	0.20	0.13
R74	0.04	0.04	0.05	0.12	0.13	0.00	0.00	0.00	0.01	0.01
R75	0.04	0.04	0.04	0.09	0.10	0.00	0.00	0.00	0.01	0.01

Receptor ID	Maximum 24-hour average					Annual average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 - No preference	2033 - Prefer Runway 05	2033 - Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R76	0.05	0.05	0.06	0.14	0.14	0.00	0.01	0.01	0.01	0.01
R78	0.04	0.04	0.03	0.10	0.09	0.00	0.00	0.00	0.01	0.01
R79	0.02	0.02	0.03	0.06	0.07	0.00	0.00	0.00	0.01	0.01
R80	0.04	0.03	0.03	0.07	0.07	0.00	0.00	0.00	0.01	0.01
R82	0.02	0.03	0.03	0.07	0.08	0.00	0.00	0.00	0.01	0.01
R84	0.06	0.06	0.07	0.15	0.16	0.01	0.01	0.01	0.02	0.02
R85	0.04	0.04	0.03	0.09	0.08	0.00	0.00	0.00	0.01	0.01
R86	0.03	0.03	0.02	0.07	0.07	0.00	0.00	0.00	0.01	0.01
R87	0.04	0.05	0.05	0.12	0.13	0.00	0.00	0.00	0.01	0.01
R88	0.03	0.03	0.03	0.07	0.07	0.00	0.00	0.00	0.01	0.01
R91	0.02	0.02	0.02	0.04	0.05	0.00	0.00	0.00	0.00	0.00
R93	0.03	0.04	0.05	0.11	0.13	0.00	0.00	0.00	0.01	0.01
R94	0.42	0.40	0.28	0.96	0.67	0.07	0.07	0.04	0.17	0.12
R95	0.05	0.05	0.06	0.14	0.16	0.00	0.00	0.01	0.01	0.01
R97	0.05	0.04	0.04	0.10	0.09	0.00	0.00	0.00	0.01	0.01
R98	0.04	0.03	0.03	0.08	0.08	0.01	0.01	0.00	0.01	0.01
R99	0.48	0.33	0.57	0.88	1.26	0.07	0.09	0.15	0.25	0.37
R100	0.05	0.04	0.04	0.11	0.10	0.00	0.00	0.00	0.01	0.01
R102	0.05	0.04	0.03	0.09	0.09	0.01	0.01	0.01	0.02	0.01
R103	0.05	0.05	0.05	0.12	0.13	0.01	0.01	0.01	0.02	0.02
R104	0.02	0.02	0.02	0.05	0.05	0.00	0.00	0.00	0.00	0.00
R108	0.28	0.29	0.25	0.68	0.60	0.04	0.04	0.03	0.11	0.08
R109	0.02	0.02	0.03	0.07	0.07	0.00	0.00	0.00	0.01	0.01
R110	0.60	0.51	0.33	1.21	0.73	0.12	0.10	0.05	0.26	0.14
R111	0.04	0.04	0.04	0.10	0.11	0.00	0.00	0.00	0.01	0.01
R112	0.03	0.04	0.04	0.09	0.11	0.00	0.00	0.00	0.01	0.01
R114	0.02	0.03	0.03	0.07	0.08	0.00	0.00	0.00	0.01	0.01
R115	0.04	0.04	0.04	0.09	0.09	0.00	0.00	0.00	0.01	0.01

Receptor ID	Maximum 24-hour average					Annual average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 - No preference	2033 - Prefer Runway 05	2033 - Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R117	0.04	0.04	0.04	0.10	0.11	0.00	0.00	0.00	0.01	0.01
R118	0.06	0.05	0.04	0.12	0.10	0.01	0.01	0.01	0.02	0.01
R120	0.05	0.05	0.05	0.13	0.13	0.00	0.00	0.00	0.01	0.01
R122	0.02	0.01	0.02	0.04	0.04	0.00	0.00	0.00	0.00	0.00
R123	0.05	0.04	0.04	0.11	0.09	0.00	0.00	0.00	0.01	0.01
R124	0.04	0.03	0.03	0.08	0.08	0.00	0.00	0.00	0.01	0.01
R126	0.06	0.05	0.04	0.13	0.11	0.01	0.01	0.01	0.02	0.01
R127	0.52	0.45	0.29	1.09	0.65	0.10	0.09	0.05	0.22	0.13
R130	0.04	0.03	0.03	0.08	0.07	0.01	0.00	0.00	0.01	0.01
R131	0.02	0.03	0.03	0.07	0.08	0.00	0.00	0.00	0.01	0.01
R132	0.05	0.05	0.05	0.13	0.13	0.00	0.00	0.01	0.01	0.01
R134	0.03	0.04	0.05	0.11	0.12	0.00	0.00	0.00	0.01	0.01
R135	0.70	0.58	0.39	1.36	0.87	0.14	0.13	0.06	0.31	0.16
R136	0.05	0.04	0.03	0.10	0.08	0.00	0.00	0.00	0.01	0.01
R137	0.02	0.02	0.03	0.06	0.07	0.00	0.00	0.00	0.01	0.01
R138	0.04	0.03	0.03	0.07	0.07	0.00	0.00	0.00	0.01	0.01
R140	0.41	0.33	0.19	0.78	0.45	0.07	0.06	0.03	0.15	0.09
R141	0.04	0.04	0.03	0.09	0.06	0.00	0.00	0.00	0.01	0.01

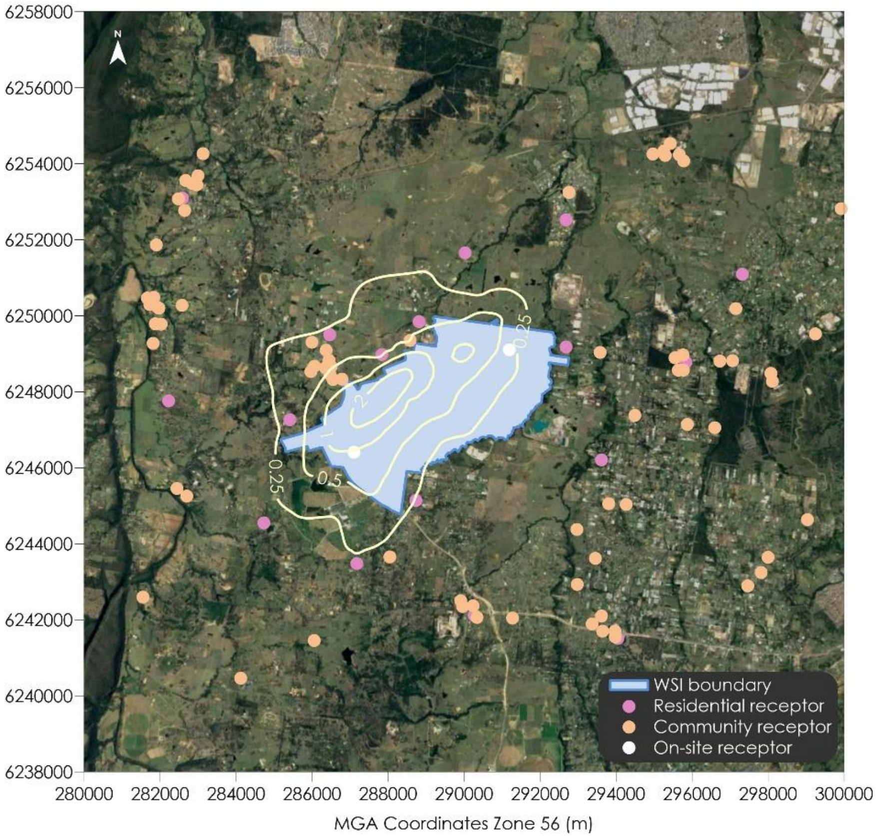


Figure C.1 Predicted incremental maximum 24-hour average $PM_{2.5}$ concentrations (µg/m³) for 2033 - No preference

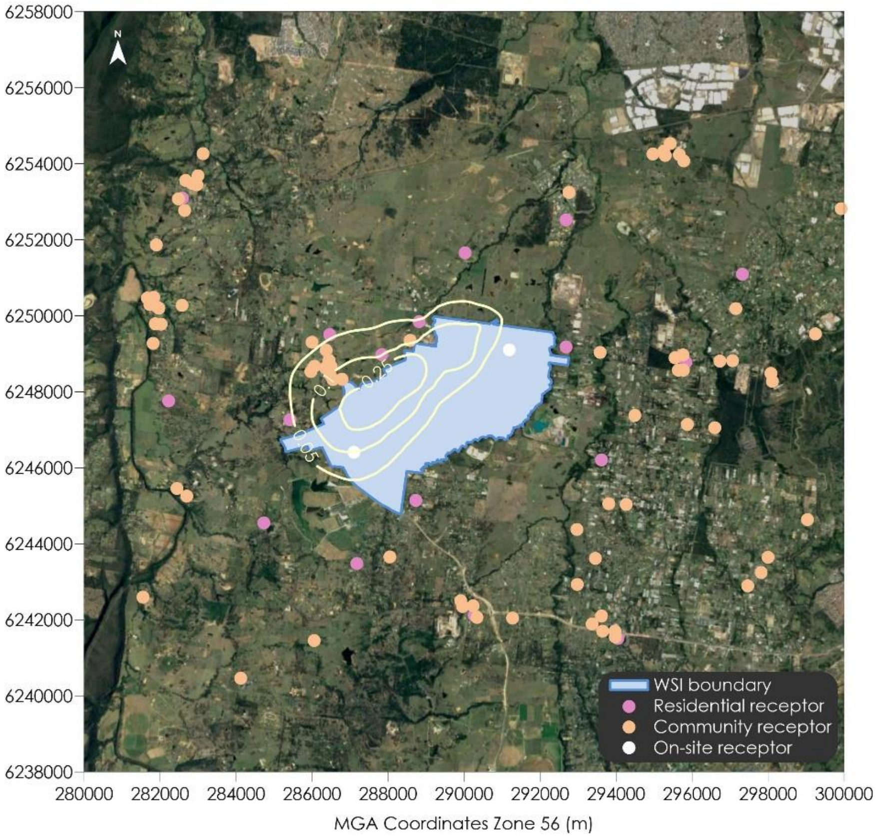


Figure C.2 Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³) for 2033 – No preference

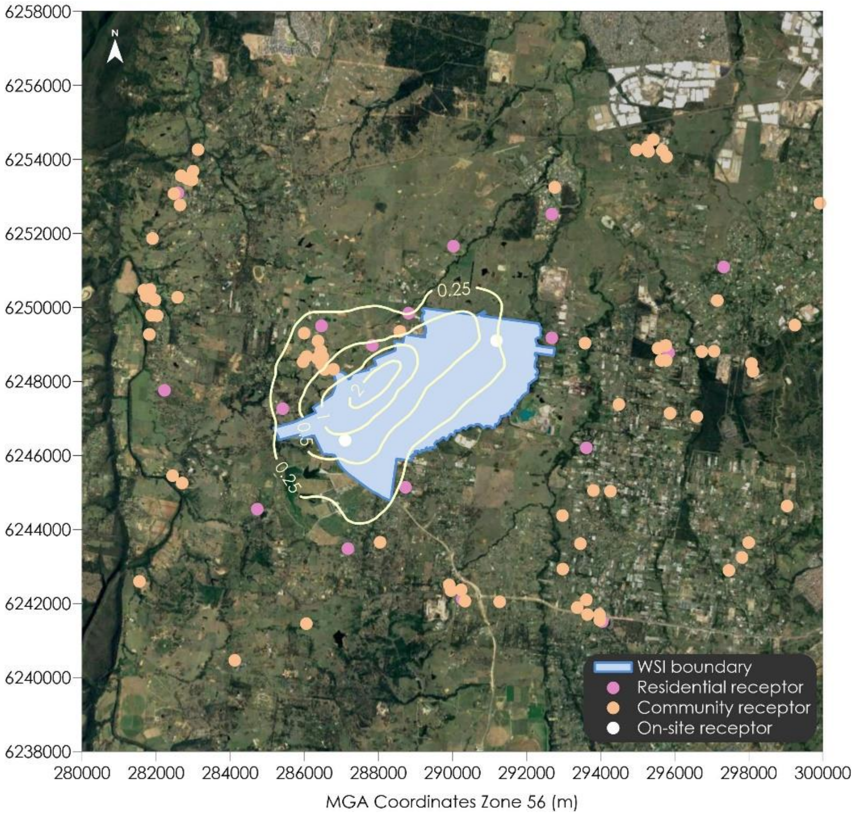


Figure C.3 Predicted incremental maximum 24-hour average $PM_{2.5}$ concentrations (µg/m³) for 2033 – Prefer Runway 05

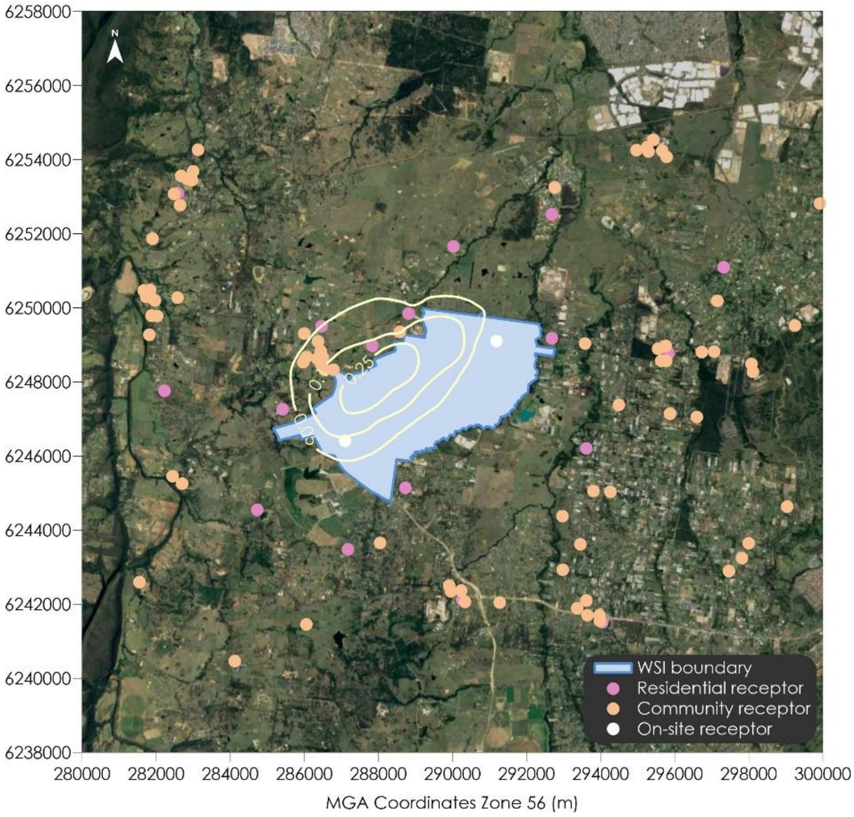


Figure C.4 Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³) for 2033 – Prefer Runway 05

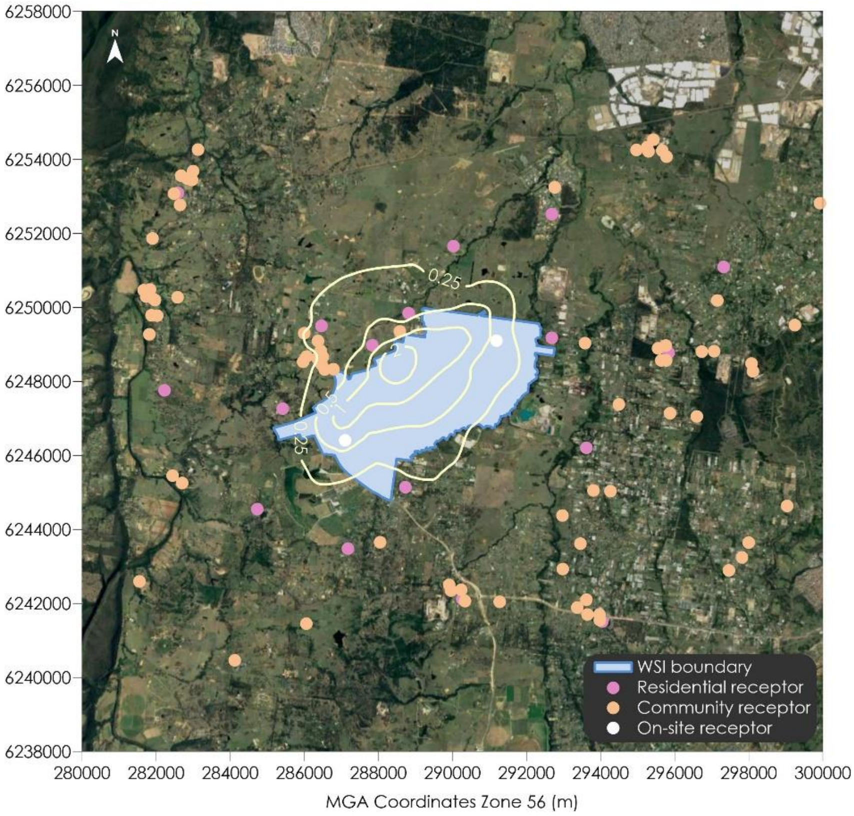


Figure C.5 Predicted incremental maximum 24-hour average $PM_{2.5}$ concentrations (µg/m³) for 2033 – Prefer Runway 23

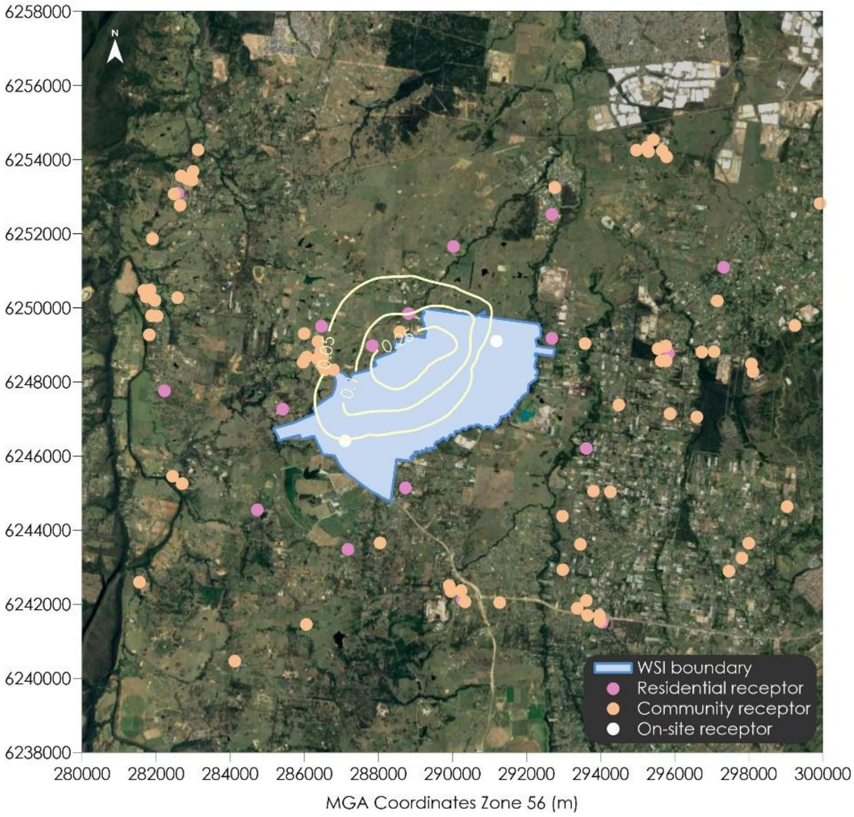


Figure C.6 Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³) for 2033 – Prefer Runway 23

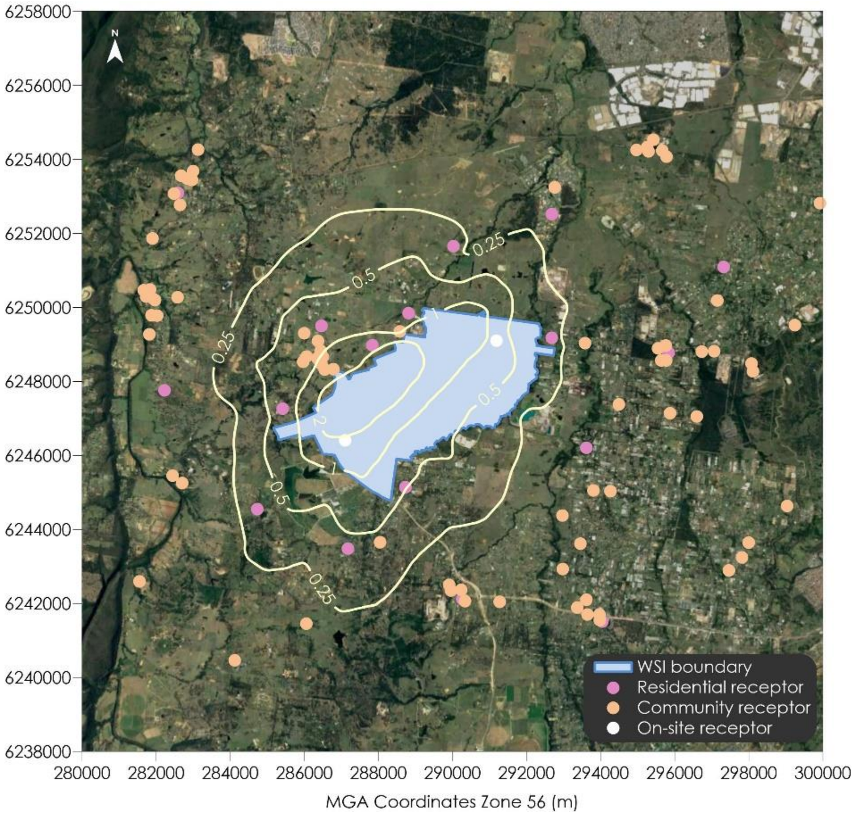


Figure C.7 Predicted incremental maximum 24-hour average $PM_{2.5}$ concentrations (µg/m³) for 2055 – Prefer Runway 05

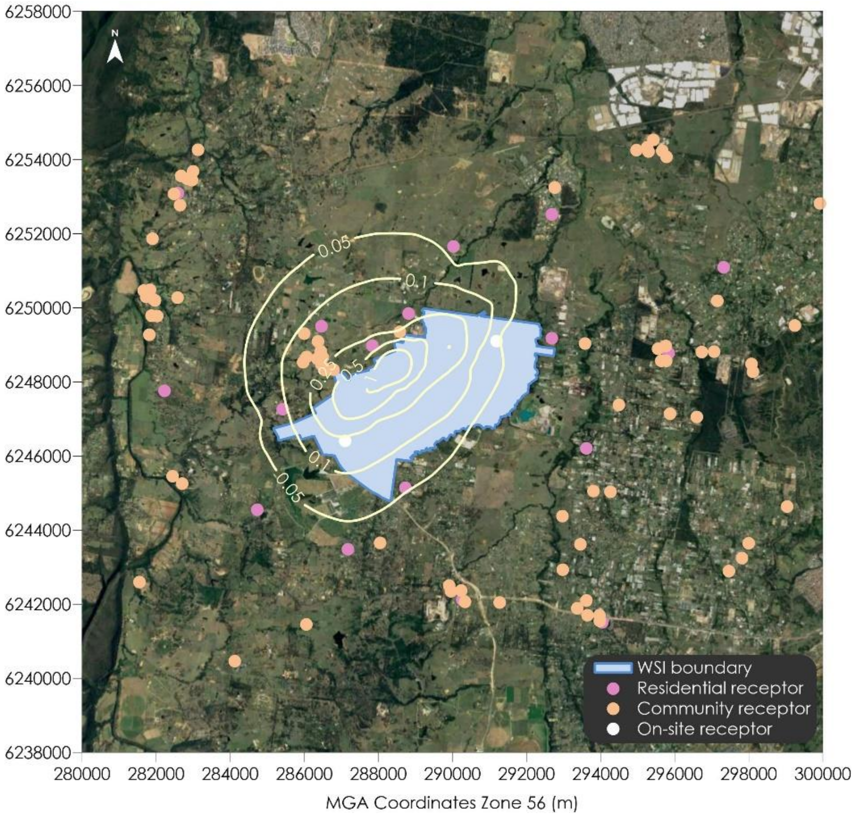


Figure C.8 Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³) for 2055 – Prefer Runway 05

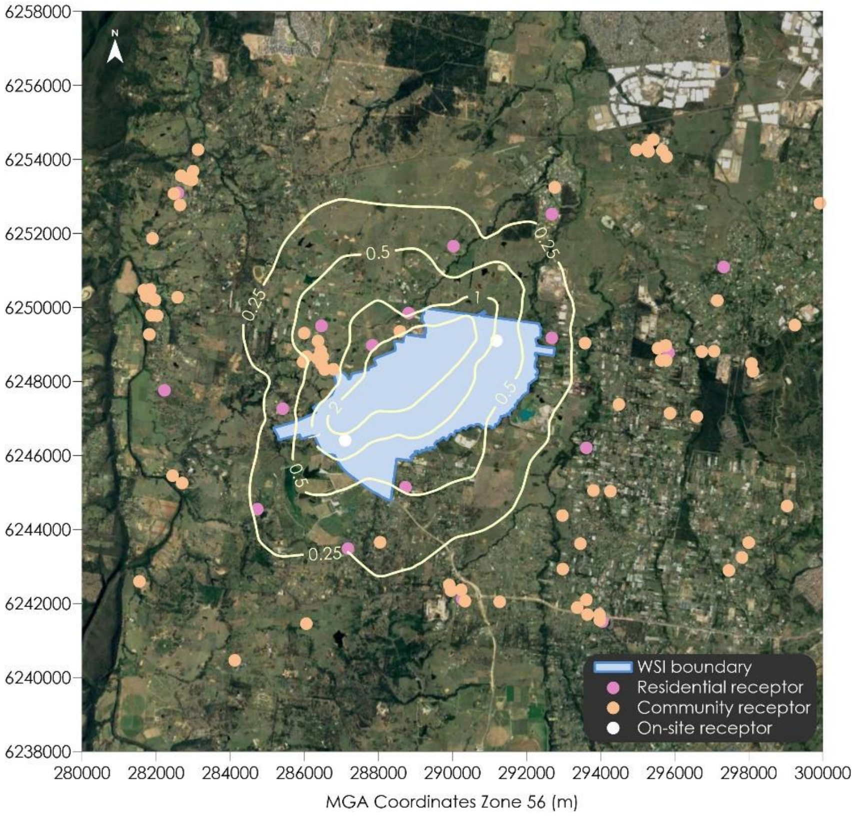


Figure C.9 Predicted incremental maximum 24-hour average $PM_{2.5}$ concentrations (µg/m³) for 2055 – Prefer Runway 23

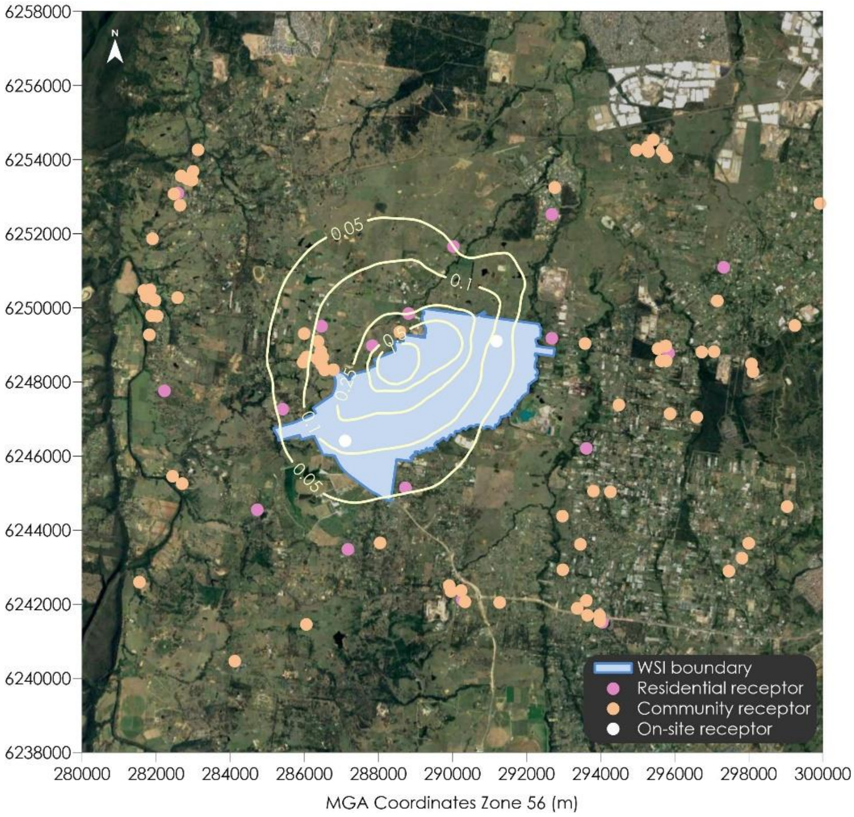


Figure C.10 Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³) for 2055 – Prefer Runway 23

C1.2 NO_2 concentrations

Isopleths showing the spatial distribution of predicted impacts due to the project for maximum 1-hour average and annual average NO_2 concentrations are presented in Figure C.11 to Figure C.20 for the various scenarios assessed.

Table C.2 presents the predicted NO_2 dispersion modelling results at each of the assessed sensitive receptor locations. The results show generally minimal effects would arise at the receptor locations due to the project.

There are 5 receptors predicted to experience maximum 1-hour average levels above the NSW EPA impact assessment criterion of 164 µg/m³ in 2055.

Table C.2 Dispersion modelling results for NO_2

Receptor ID	Maximum 1-hour average					Annual average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R1	61.6	61.6	61.6	62.1	63.7	6.8	6.8	6.8	7.6	7.7
R2	97.4	97.4	78.4	134.3	116.0	9.3	9.7	9.2	13.8	12.8
R3	66.1	68.3	66.1	104.4	90.4	7.6	7.5	7.3	9.1	8.7
R4	61.5	61.5	61.5	61.6	61.6	6.6	6.6	6.7	7.2	7.3
R6	61.6	61.6	61.6	69.6	68.4	6.8	6.8	6.8	7.8	7.7
R7	61.8	61.8	61.7	67.3	63.2	6.9	6.9	6.8	7.9	7.7
R8	61.8	61.8	61.6	70.3	70.3	7.3	7.3	7.4	9.0	9.2
R14	64.0	61.6	64.0	73.7	73.8	7.1	7.1	7.2	8.3	8.6
R15	73.5	73.5	86.6	84.5	92.1	7.6	7.7	7.8	9.8	10.0
R17	91.9	93.1	93.1	126.5	126.5	8.0	8.0	8.3	10.6	11.3
R18	113.8	112.1	112.9	151.3	162.4	10.3	10.5	12.8	16.4	21.0
R19	99.4	96.2	112.3	185.3	238.1	10.9	12.1	12.5	19.8	20.5
R21	84.1	84.0	68.0	130.5	110.0	9.6	9.2	8.3	12.8	10.9
R22	61.6	61.6	61.5	62.2	61.8	6.7	6.7	6.8	7.5	7.6
R23	62.3	62.3	62.2	66.2	65.4	7.1	7.0	6.9	8.2	7.9
R24	69.1	65.8	69.1	97.3	97.3	7.8	7.7	8.1	10.1	10.9
R25	120.8	120.8	95.9	257.6	257.6	10.8	10.5	9.3	16.8	14.1
R27	84.9	84.9	73.2	88.6	86.9	7.6	7.5	7.4	9.4	9.2
R30	61.6	61.6	61.5	61.9	61.6	6.5	6.5	6.6	7.0	7.0
R31	61.5	61.5	61.5	61.5	61.5	6.6	6.6	6.6	7.1	7.1
R34	61.5	61.5	61.5	61.5	61.5	6.8	6.7	6.8	7.6	7.6
R35	61.5	61.5	61.5	67.5	67.5	6.8	6.8	6.8	7.7	7.8

Receptor ID	Maximum 1-hour average					Annual average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R37	99.0	99.0	68.2	138.7	95.4	10.0	10.1	8.8	14.6	11.9
R38	61.5	61.5	61.5	61.5	64.4	6.6	6.6	6.6	7.0	7.1
R39	61.5	61.5	61.5	61.7	61.5	6.5	6.5	6.5	6.8	6.8
R40	61.5	61.5	61.5	68.2	68.2	6.8	6.8	6.9	7.8	7.9
R41	61.5	61.5	61.5	61.7	61.6	6.6	6.6	6.6	7.2	7.2
R44	75.1	75.1	74.7	80.5	87.0	7.4	7.4	7.4	9.1	9.0
R46	61.6	61.6	61.5	62.0	61.7	6.7	6.7	6.7	7.4	7.4
R48	61.5	61.5	61.5	61.6	61.5	6.4	6.4	6.4	6.7	6.7
R49	100.5	100.5	76.6	140.4	115.3	9.8	10.1	9.2	14.6	12.7
R52	61.5	61.5	61.5	61.7	61.5	6.4	6.5	6.5	6.7	6.8
R53	61.6	61.6	61.5	61.9	61.6	6.5	6.5	6.6	7.0	7.0
R54	61.5	61.5	61.6	69.1	68.8	6.8	6.8	6.8	7.7	7.7
R55	61.6	61.6	61.6	62.0	61.7	6.6	6.7	6.7	7.3	7.4
R57	61.8	61.8	61.8	63.8	63.4	7.0	6.9	6.8	8.0	7.7
R59	61.6	61.6	61.6	62.2	63.4	6.8	6.8	6.9	7.8	7.8
R63	102.9	102.9	71.0	148.2	108.9	10.6	10.7	9.1	16.1	12.7
R64	61.5	61.5	61.6	69.6	68.9	6.8	6.8	6.8	7.8	7.7
R65	61.5	61.5	61.5	65.9	65.9	6.8	6.7	6.8	7.6	7.6
R66	61.7	61.7	61.7	76.6	64.3	7.0	7.0	6.9	8.2	8.0
R68	61.5	61.5	61.5	61.7	61.6	6.6	6.6	6.7	7.2	7.3
R69	61.5	61.5	61.5	67.2	67.2	6.8	6.8	6.8	7.7	7.8
R72	61.5	61.5	61.5	61.5	61.5	6.5	6.5	6.5	6.8	6.8
R73	104.1	104.1	73.1	151.4	115.9	10.7	11.0	9.4	16.8	13.2
R74	61.5	61.5	61.5	61.7	61.6	6.6	6.7	6.7	7.3	7.3
R75	61.5	61.5	61.5	67.3	67.3	6.8	6.7	6.8	7.6	7.7
R76	61.6	61.6	61.6	62.1	64.8	6.8	6.8	6.9	7.7	7.8
R78	61.5	61.5	61.6	69.0	68.4	6.8	6.8	6.8	7.7	7.6
R79	61.6	61.6	61.5	61.9	61.7	6.5	6.6	6.6	7.1	7.1
R80	61.7	61.7	61.7	66.6	63.0	6.9	6.9	6.8	7.9	7.6

Receptor ID	Maximum 1-hour average					Annual average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R82	61.6	61.6	61.5	61.9	61.7	6.6	6.6	6.6	7.1	7.1
R84	61.6	61.6	61.6	62.2	63.4	6.8	6.9	6.9	7.8	7.9
R85	61.7	61.7	61.9	63.6	63.0	6.7	6.7	6.7	7.4	7.3
R86	61.7	61.7	61.7	62.9	63.1	6.9	6.8	6.8	7.8	7.6
R87	61.5	61.5	61.5	62.1	61.6	6.7	6.7	6.7	7.3	7.4
R88	61.5	61.5	61.5	61.7	61.6	6.5	6.5	6.6	7.0	7.0
R91	61.5	61.5	61.5	61.5	61.5	6.5	6.5	6.5	6.9	6.9
R93	61.6	61.6	61.6	62.1	61.7	6.7	6.7	6.7	7.4	7.5
R94	102.5	102.5	76.4	144.5	107.4	10.3	10.6	9.2	15.8	12.9
R95	61.6	61.6	61.5	67.4	67.4	6.8	6.8	6.9	7.7	7.9
R97	61.5	61.5	61.6	69.4	68.8	6.8	6.8	6.8	7.8	7.7
R98	61.9	61.9	61.8	63.5	63.7	7.0	6.9	6.8	8.0	7.8
R99	110.4	116.6	116.6	193.1	196.5	11.1	11.7	14.7	19.3	25.4
R100	61.7	61.7	61.7	62.5	62.5	6.8	6.8	6.7	7.6	7.5
R102	62.0	62.0	61.8	69.4	67.7	7.1	7.0	6.9	8.2	8.0
R103	61.6	61.6	61.5	63.3	63.3	7.1	7.1	7.1	8.6	8.7
R104	61.5	61.5	61.5	61.5	61.5	6.5	6.5	6.5	6.9	6.9
R108	96.6	96.6	73.2	128.7	107.2	9.2	9.4	8.7	13.1	11.7
R109	61.5	61.5	61.5	61.6	61.5	6.5	6.5	6.6	7.0	7.0
R110	112.6	109.4	71.3	179.2	121.5	11.8	12.0	9.5	19.0	13.6
R111	61.6	61.6	61.5	61.9	61.6	6.6	6.7	6.7	7.3	7.4
R112	61.6	61.6	61.6	62.0	61.7	6.6	6.6	6.7	7.2	7.3
R114	61.6	61.6	61.5	62.0	61.7	6.6	6.6	6.6	7.1	7.1
R115	61.5	61.5	61.5	68.1	68.3	6.7	6.7	6.8	7.6	7.6
R117	61.6	61.6	61.6	62.1	61.8	6.7	6.7	6.7	7.4	7.5
R118	62.5	62.5	62.5	69.7	65.5	7.1	7.0	6.9	8.1	7.9
R120	61.6	61.6	61.5	62.0	78.8	6.7	6.7	6.7	7.4	7.5
R122	61.5	61.5	61.5	61.7	61.5	6.4	6.5	6.5	6.8	6.8
R123	62.3	62.3	61.6	70.4	68.7	6.9	6.9	6.9	7.9	7.8

Receptor ID	Maximum 1-hour average					Annual average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R124	61.8	61.8	61.8	66.6	63.2	6.9	6.9	6.8	7.9	7.7
R126	62.8	62.8	62.6	70.9	65.7	7.1	7.0	6.9	8.2	7.9
R127	107.1	106.0	71.8	160.8	117.1	11.2	11.4	9.3	17.5	13.2
R130	61.9	61.9	61.9	65.6	63.6	6.9	6.9	6.8	7.9	7.7
R131	61.5	61.5	61.5	61.6	61.5	6.6	6.6	6.6	7.0	7.1
R132	61.6	61.6	61.6	62.1	63.1	6.8	6.8	6.8	7.6	7.7
R134	61.5	61.5	61.5	61.8	61.6	6.6	6.6	6.7	7.2	7.3
R135	116.6	112.1	75.7	199.2	135.6	12.5	13.0	9.9	21.1	14.7
R136	61.6	61.6	61.6	69.5	68.3	6.8	6.8	6.8	7.8	7.7
R137	61.6	61.6	61.5	61.9	61.6	6.5	6.5	6.6	7.0	7.1
R138	61.7	61.7	61.7	64.1	63.2	6.9	6.9	6.8	7.8	7.6
R140	97.5	97.5	66.2	134.2	95.1	10.1	10.1	8.7	14.6	11.8
R141	61.6	61.6	61.6	68.9	62.3	6.8	6.8	6.8	7.8	7.6

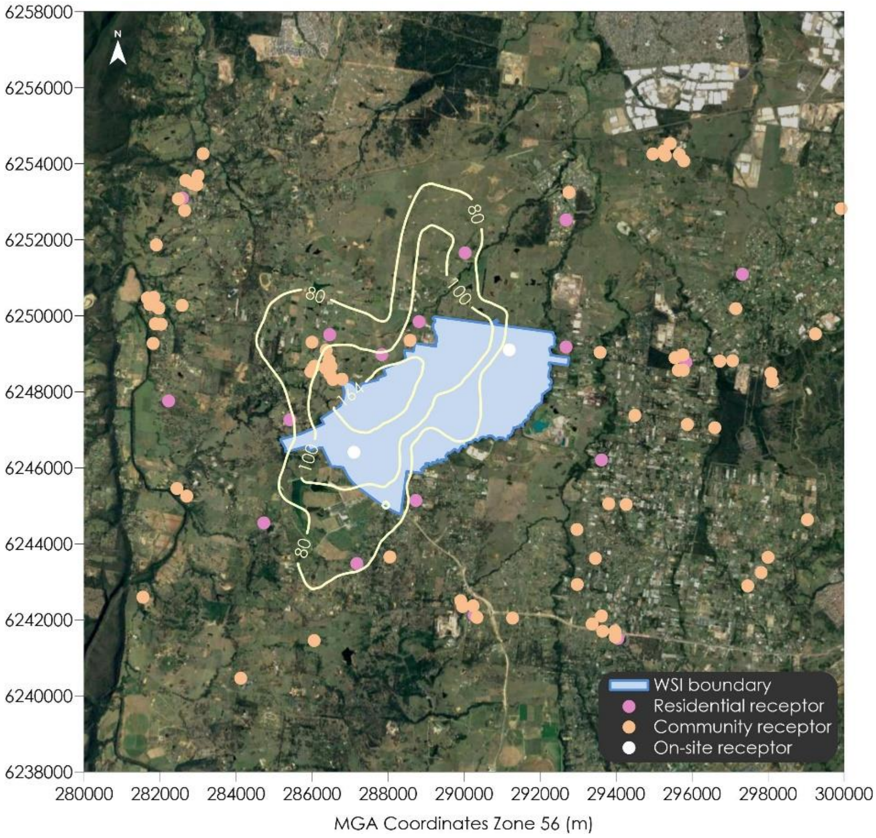


Figure C.11 Predicted maximum 1-hour average NO_2 concentrations (µg/m³) for 2033 – No preference

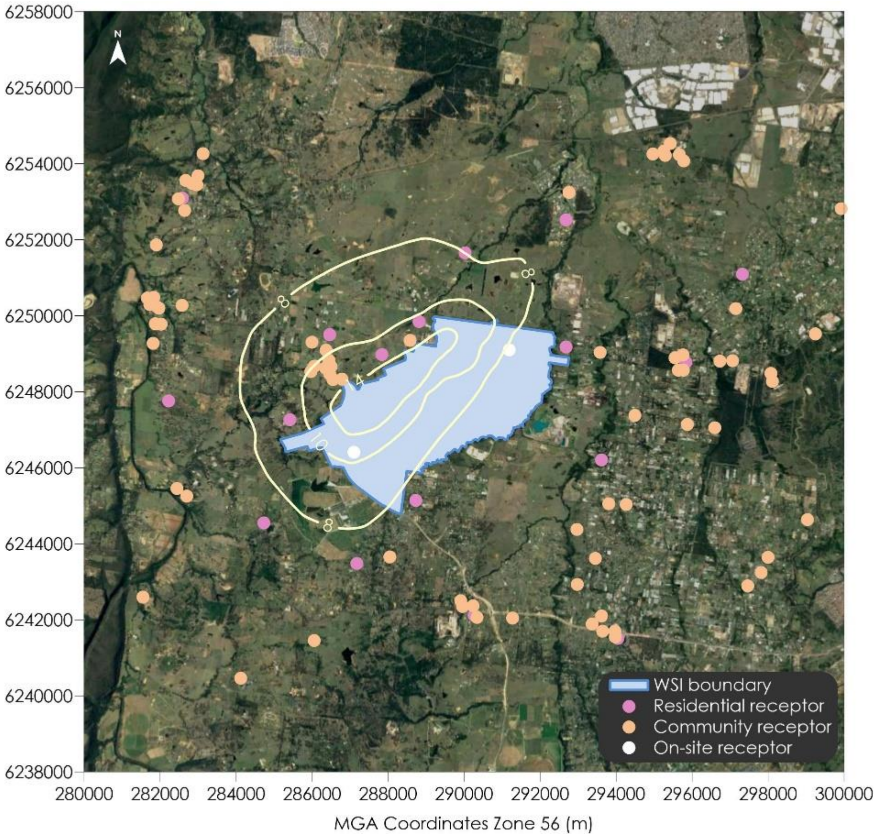


Figure C.12 Predicted annual average NO_2 concentrations (µg/m³) for 2033 – No preference

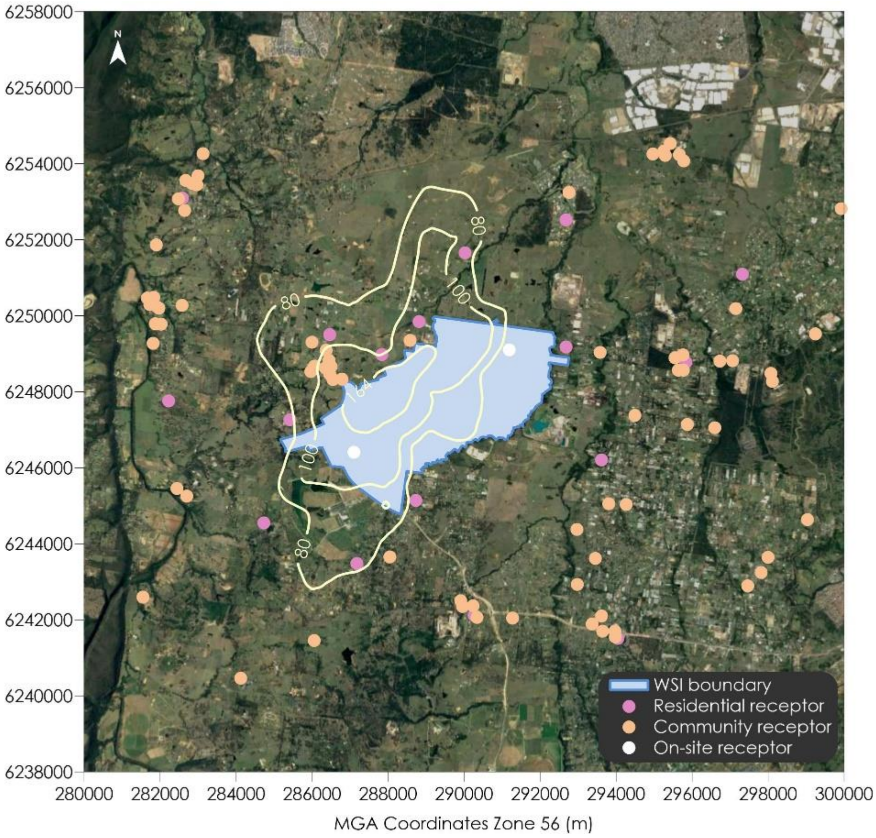


Figure C.13 Predicted maximum 1-hour average NO_2 concentrations (µg/m³) for 2033 – Prefer Runway 05

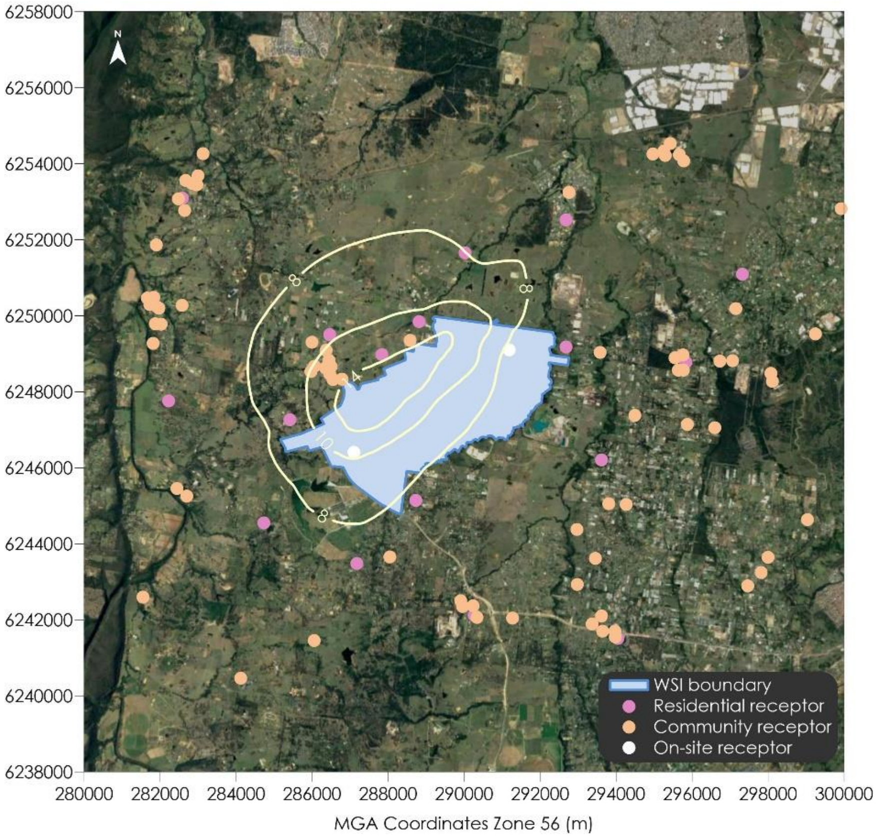


Figure C.14 Predicted annual average NO_2 concentrations (µg/m³) for 2033 – Prefer Runway 05

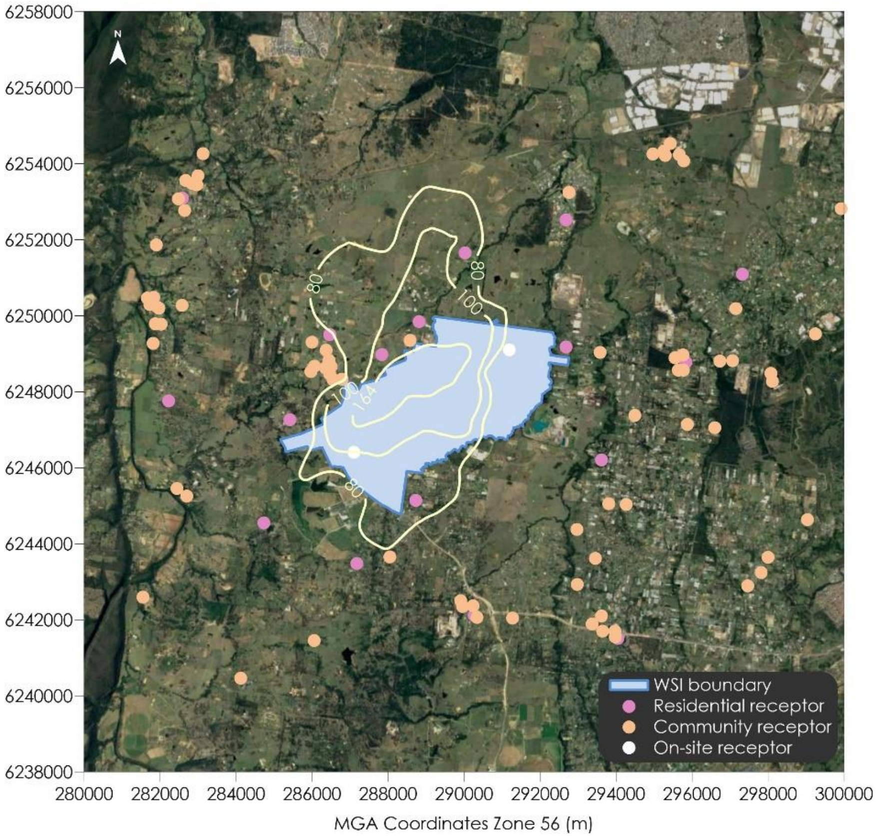


Figure C.15 Predicted maximum 1-hour average NO_2 concentrations (µg/m³) for 2033 – Prefer Runway 23

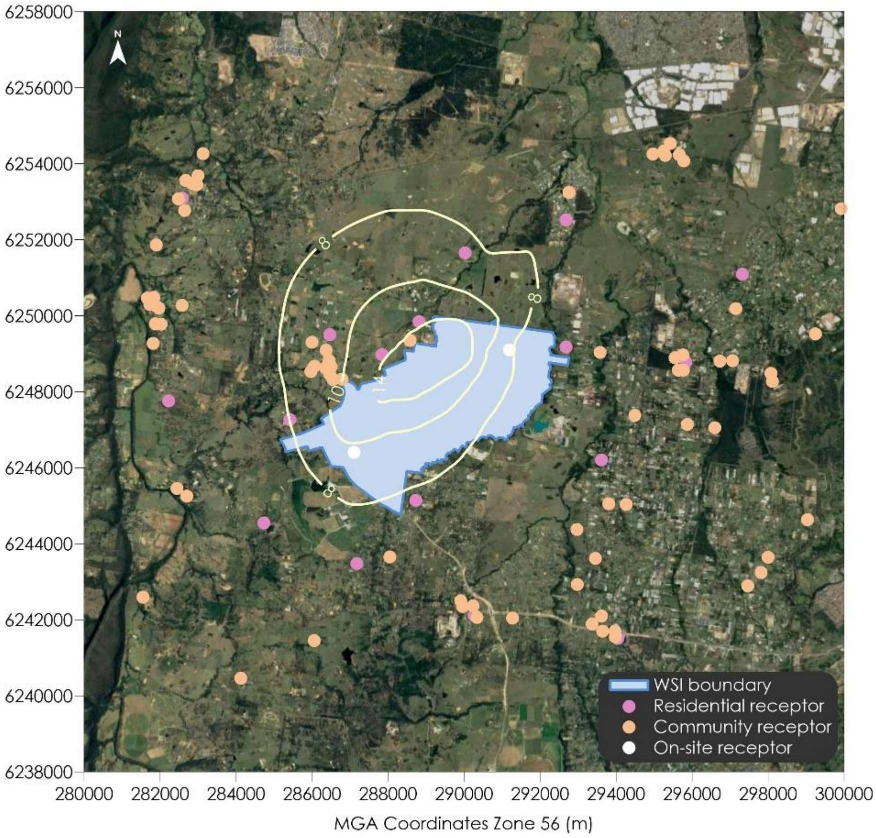


Figure C.16 Predicted annual average NO_2 concentrations (µg/m³) for 2033 – Prefer Runway 23

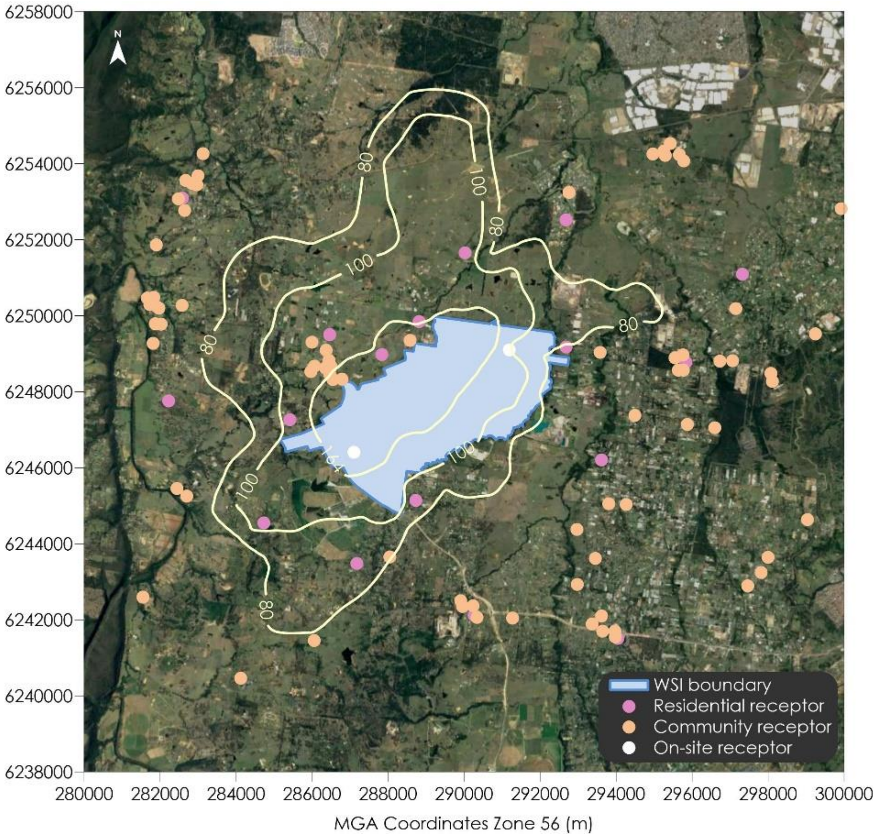


Figure C.17 Predicted maximum 1-hour average NO_2 concentrations (µg/m³) for 2055 – Prefer Runway 05

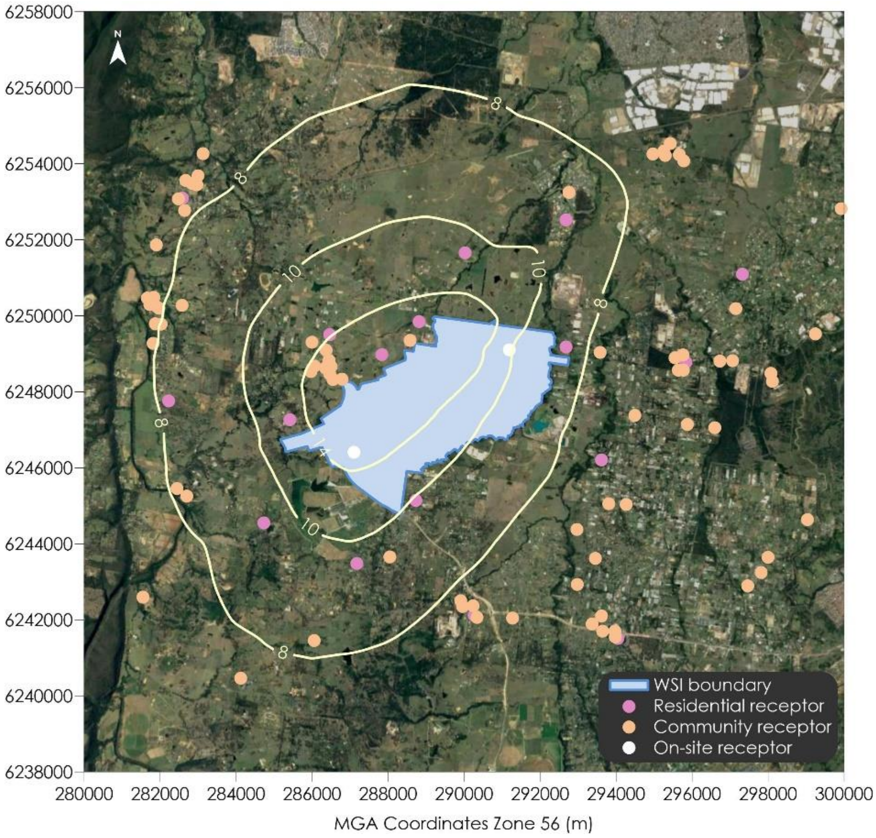


Figure C.18 Predicted annual average NO_2 concentrations (µg/m³) for 2055 – Prefer Runway 05

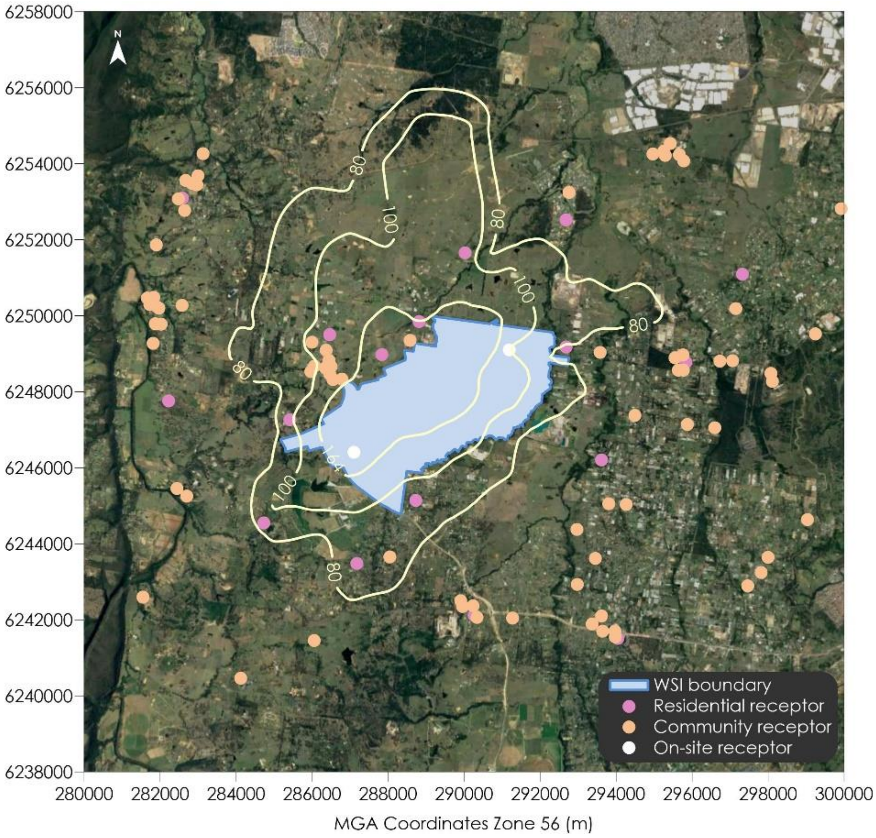


Figure C.19 Predicted maximum 1-hour average NO_2 concentrations (µg/m³) for 2055 – Prefer Runway 23

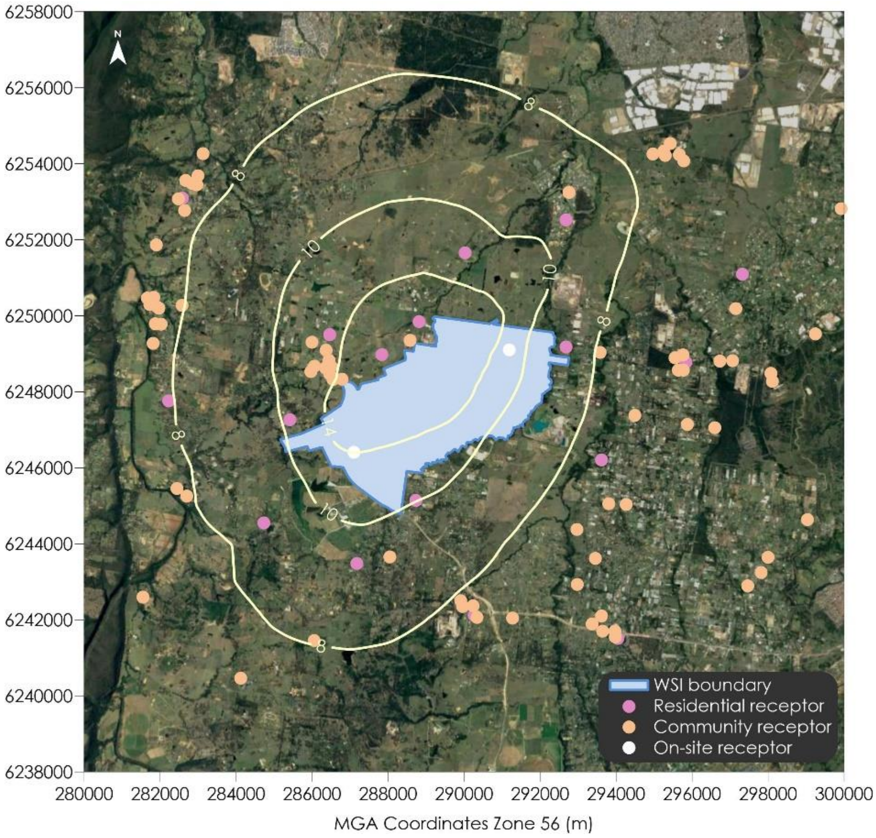


Figure C.20 Predicted annual average NO_2 concentrations (µg/m³) for 2055 – Prefer Runway 23

C1.3 SO_2 concentrations

Isopleths showing the spatial distribution of predicted incremental impacts due to the project for maximum 1-hour average and 24-hour average SO_2 concentrations are presented in Figure C.21 to Figure C.30 for the various scenarios assessed.

Table C.3 presents the predicted incremental SO_2 dispersion modelling results at each of the assessed sensitive receptor locations. The results show generally minimal effects would arise at the receptor locations due to the project.

Table C.3 Dispersion modelling results for SO_2

Receptor ID	Maximum 1-hour average					Maximum 24-hour average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R1	3.79	3.91	3.92	9.56	9.67	0.54	0.55	0.55	1.68	1.72
R2	24.08	22.44	19.77	50.73	59.04	3.01	3.06	2.94	9.31	8.59
R3	10.72	5.44	5.43	20.24	15.29	1.87	1.54	1.23	4.42	3.60
R4	3.32	3.75	3.68	10.74	10.51	0.37	0.48	0.51	1.53	1.59
R6	2.56	1.92	2.28	5.79	6.60	0.49	0.44	0.39	1.28	1.11
R7	2.42	2.16	2.19	6.25	6.54	0.45	0.31	0.29	1.00	1.03
R8	5.13	5.23	5.18	14.91	14.91	0.79	0.78	0.80	2.32	2.61
R14	10.47	10.56	10.56	27.15	27.47	1.16	1.20	1.48	3.79	4.25
R15	16.50	15.13	14.33	39.93	39.95	2.47	2.34	2.33	6.64	6.86
R17	14.78	15.15	15.15	39.91	39.89	1.43	1.25	1.46	3.97	4.43
R18	21.89	26.94	29.30	78.49	77.93	3.42	2.85	3.84	9.23	11.50
R19	41.39	33.52	43.38	101.25	116.04	5.19	5.45	6.00	15.89	18.03
R21	32.53	23.66	13.29	58.51	34.03	4.71	4.43	2.27	11.42	6.15
R22	5.47	5.66	5.62	15.66	15.40	0.65	0.67	0.71	2.05	2.13
R23	2.94	2.63	2.17	6.36	6.21	0.39	0.39	0.31	1.09	0.92
R24	29.33	17.44	29.33	47.19	53.82	3.00	2.93	3.90	9.12	11.04
R25	50.90	46.89	46.89	146.61	146.61	9.18	7.70	6.68	20.41	19.55
R27	9.80	7.87	7.01	22.23	20.78	2.41	1.90	1.15	5.27	3.47
R30	1.53	1.35	1.36	4.22	4.19	0.24	0.24	0.26	0.73	0.83
R31	2.83	2.92	2.86	7.81	7.60	0.28	0.28	0.30	0.94	0.97
R34	2.93	2.99	3.00	8.44	8.62	0.48	0.44	0.48	1.33	1.39
R35	3.02	3.07	3.07	8.67	8.79	0.49	0.45	0.49	1.37	1.42
R37	28.39	29.93	19.05	54.11	49.08	3.82	3.15	2.30	9.24	6.52

Receptor ID	Maximum 1-hour average					Maximum 24-hour average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R38	2.86	2.96	2.89	7.91	7.67	0.29	0.30	0.31	0.95	0.98
R39	1.10	1.20	1.19	3.38	3.33	0.18	0.18	0.18	0.51	0.53
R40	3.14	3.20	3.19	9.02	9.09	0.51	0.47	0.51	1.41	1.54
R41	3.79	3.90	3.91	10.57	10.59	0.46	0.47	0.47	1.33	1.34
R44	10.15	7.62	6.32	19.52	18.46	2.01	1.93	1.43	5.38	4.27
R46	3.14	3.89	3.89	10.69	11.42	0.45	0.44	0.48	1.38	1.45
R48	0.78	0.86	0.88	2.53	2.74	0.14	0.15	0.15	0.43	0.44
R49	27.11	26.18	19.67	54.56	52.24	3.56	3.36	2.85	9.58	8.11
R52	1.13	1.14	1.14	3.20	3.27	0.16	0.17	0.17	0.51	0.51
R53	1.55	1.39	1.36	4.27	4.24	0.24	0.25	0.27	0.75	0.85
R54	2.42	1.95	2.12	6.34	6.38	0.49	0.45	0.40	1.28	1.21
R55	2.80	3.11	3.13	9.24	9.24	0.39	0.43	0.49	1.31	1.50
R57	2.74	2.40	2.24	7.15	6.41	0.44	0.31	0.29	1.03	1.03
R59	4.09	4.28	4.29	10.46	10.80	0.62	0.63	0.65	1.92	1.96
R63	32.77	32.12	19.94	61.48	54.41	4.22	3.72	2.50	10.67	7.18
R64	2.61	2.02	2.29	6.37	6.65	0.50	0.46	0.41	1.32	1.22
R65	2.95	3.00	3.01	8.47	8.65	0.48	0.45	0.49	1.34	1.40
R66	5.17	3.10	3.18	8.85	9.27	1.00	0.81	0.58	2.28	1.68
R68	3.43	3.78	3.70	10.81	10.56	0.38	0.49	0.53	1.57	1.62
R69	3.17	3.23	3.23	9.09	9.22	0.51	0.47	0.51	1.43	1.48
R72	1.63	1.71	1.64	4.82	4.61	0.16	0.16	0.16	0.48	0.50
R73	34.01	33.79	20.62	65.16	58.74	4.37	3.93	2.76	11.28	7.87
R74	3.70	4.05	3.97	11.56	11.28	0.40	0.52	0.56	1.66	1.72
R75	2.71	2.76	2.76	7.80	7.93	0.44	0.41	0.45	1.25	1.30
R76	3.96	4.10	4.11	9.97	10.56	0.57	0.58	0.61	1.80	1.87
R78	2.42	1.87	2.14	5.78	6.18	0.47	0.43	0.39	1.23	1.11
R79	1.63	1.62	1.57	4.44	4.31	0.26	0.28	0.30	0.84	0.95
R80	2.31	1.99	1.97	6.52	6.85	0.42	0.29	0.28	0.94	0.98
R82	1.76	1.70	1.66	5.21	5.19	0.27	0.31	0.34	0.93	1.06

Receptor ID	Maximum 1-hour average					Maximum 24-hour average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R84	4.15	4.38	4.39	10.74	11.25	0.64	0.65	0.70	2.00	2.07
R85	2.54	1.57	1.63	4.57	4.81	0.45	0.40	0.36	1.18	1.06
R86	2.07	1.93	1.84	6.10	6.44	0.39	0.28	0.26	0.90	0.93
R87	3.94	4.29	4.22	12.23	11.96	0.41	0.54	0.57	1.71	1.77
R88	2.59	2.67	2.67	7.35	7.38	0.33	0.34	0.34	0.95	0.96
R91	1.76	1.81	1.79	4.99	4.71	0.20	0.19	0.20	0.63	0.63
R93	3.70	3.23	4.05	10.10	10.10	0.40	0.49	0.57	1.50	1.73
R94	31.52	30.07	20.70	57.72	55.68	4.02	3.70	2.90	10.57	8.25
R95	6.38	6.67	6.67	17.78	17.77	0.61	0.59	0.67	2.02	2.25
R97	2.56	1.97	2.25	6.12	6.53	0.49	0.45	0.40	1.29	1.18
R98	2.86	2.47	2.35	7.41	6.73	0.44	0.32	0.30	1.07	1.07
R99	31.57	38.01	41.66	95.39	98.11	4.70	3.66	5.23	11.80	15.30
R100	2.59	2.33	2.33	6.64	6.64	0.48	0.46	0.44	1.46	1.37
R102	3.26	2.33	2.70	7.64	7.90	0.56	0.38	0.35	1.21	1.23
R103	3.77	3.95	3.87	11.14	10.75	0.59	0.58	0.60	1.69	1.81
R104	1.81	1.90	1.82	5.35	5.06	0.20	0.20	0.20	0.64	0.65
R108	20.69	22.16	17.98	47.03	47.30	2.93	2.79	2.39	8.40	6.85
R109	2.21	2.29	2.21	6.25	5.98	0.25	0.29	0.30	0.93	0.96
R110	42.04	41.53	22.35	80.57	60.39	5.32	4.70	3.36	13.24	9.36
R111	2.88	3.81	3.81	10.68	11.67	0.47	0.46	0.50	1.44	1.51
R112	2.33	2.33	2.43	6.37	6.38	0.35	0.41	0.45	1.23	1.39
R114	1.73	1.84	1.79	4.88	4.73	0.28	0.31	0.34	0.95	1.06
R115	2.01	1.80	1.84	5.88	5.99	0.45	0.41	0.39	1.17	1.16
R117	2.79	2.87	2.77	7.58	7.25	0.42	0.41	0.44	1.30	1.38
R118	3.13	2.51	2.53	6.55	6.53	0.61	0.51	0.46	1.46	1.33
R120	5.35	5.51	5.51	14.54	14.53	0.58	0.61	0.60	1.72	1.76
R122	1.13	1.16	1.16	3.26	3.25	0.16	0.17	0.17	0.51	0.51
R123	2.80	2.11	2.48	6.38	7.21	0.52	0.47	0.40	1.35	1.14
R124	2.41	2.19	2.24	6.23	6.49	0.44	0.31	0.30	1.02	1.05

Receptor ID	Maximum 1-hour average					Maximum 24-hour average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R126	3.45	2.81	2.48	7.60	6.98	0.67	0.56	0.49	1.59	1.42
R127	37.00	36.90	20.53	72.11	59.80	4.76	4.13	2.88	11.93	8.48
R130	2.84	2.51	1.94	7.11	4.99	0.39	0.29	0.27	1.01	0.97
R131	2.18	2.28	2.25	6.59	6.52	0.27	0.31	0.32	0.99	1.02
R132	3.72	3.82	3.83	9.32	9.40	0.52	0.53	0.54	1.63	1.67
R134	3.46	3.89	3.82	11.12	10.88	0.38	0.49	0.52	1.56	1.62
R135	47.04	46.95	25.75	89.20	72.82	6.19	5.08	4.00	14.22	11.04
R136	2.52	1.89	2.25	5.69	6.51	0.48	0.44	0.38	1.26	1.09
R137	1.59	1.44	1.40	4.62	4.60	0.25	0.26	0.28	0.78	0.89
R138	2.19	2.06	2.00	5.98	6.28	0.41	0.29	0.28	0.94	0.97
R140	29.50	30.65	17.92	55.24	47.74	4.00	3.18	1.99	9.26	5.90
R141	2.37	2.17	1.89	5.67	6.16	0.43	0.38	0.29	1.10	0.84

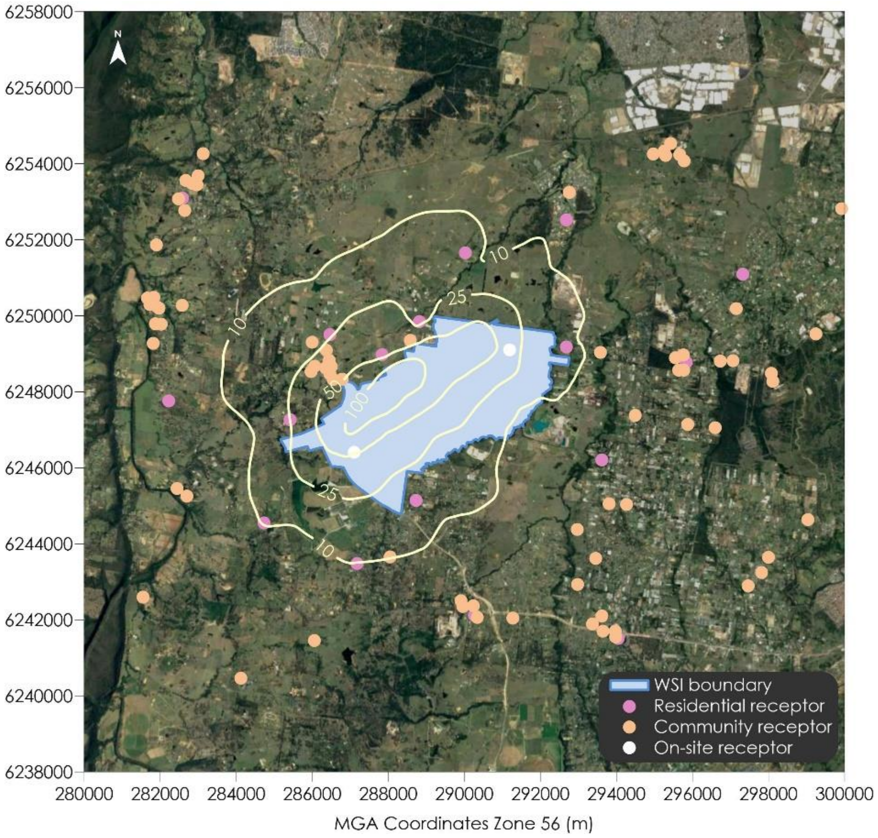


Figure C.21 Predicted incremental maximum 1-hour average SO_2 concentrations (µg/m³) for 2033 – No preference

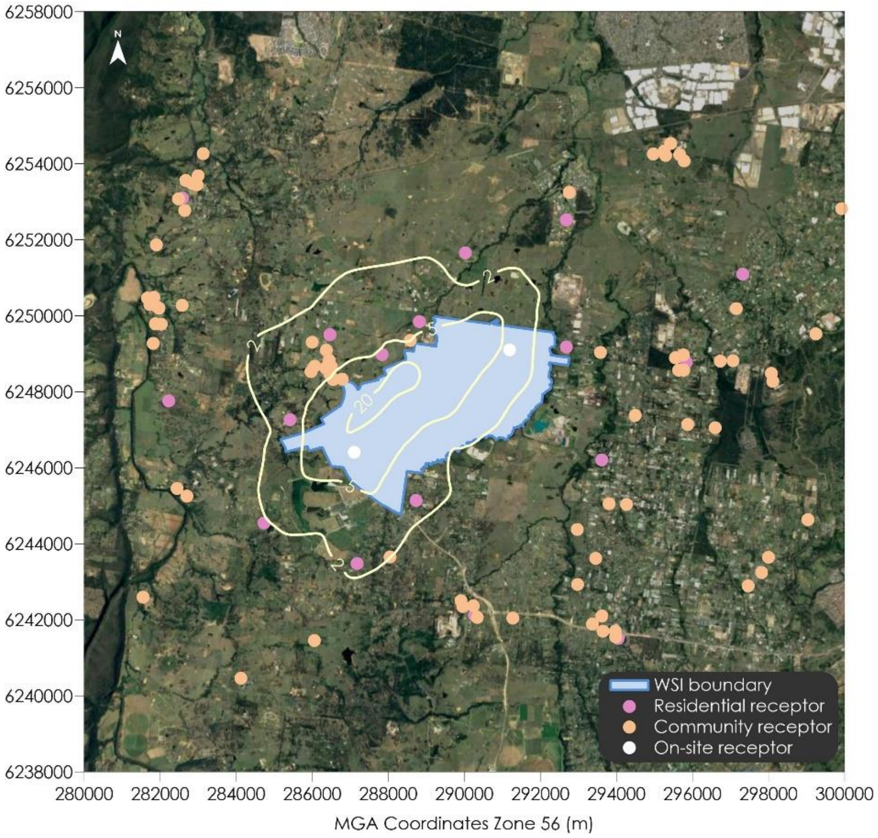


Figure C.22 Predicted incremental maximum 24-hour average SO_2 concentrations (µg/m³) for 2033 – No preference

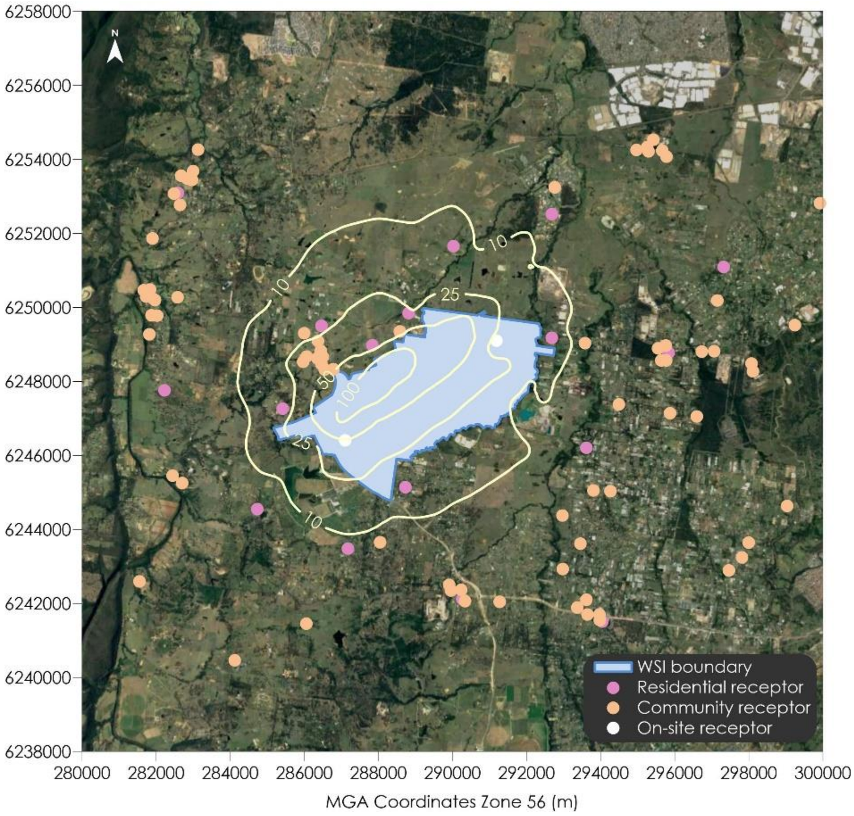


Figure C.23 Predicted incremental maximum 1-hour average SO_2 concentrations (µg/m³) for 2033 – Prefer Runway 05

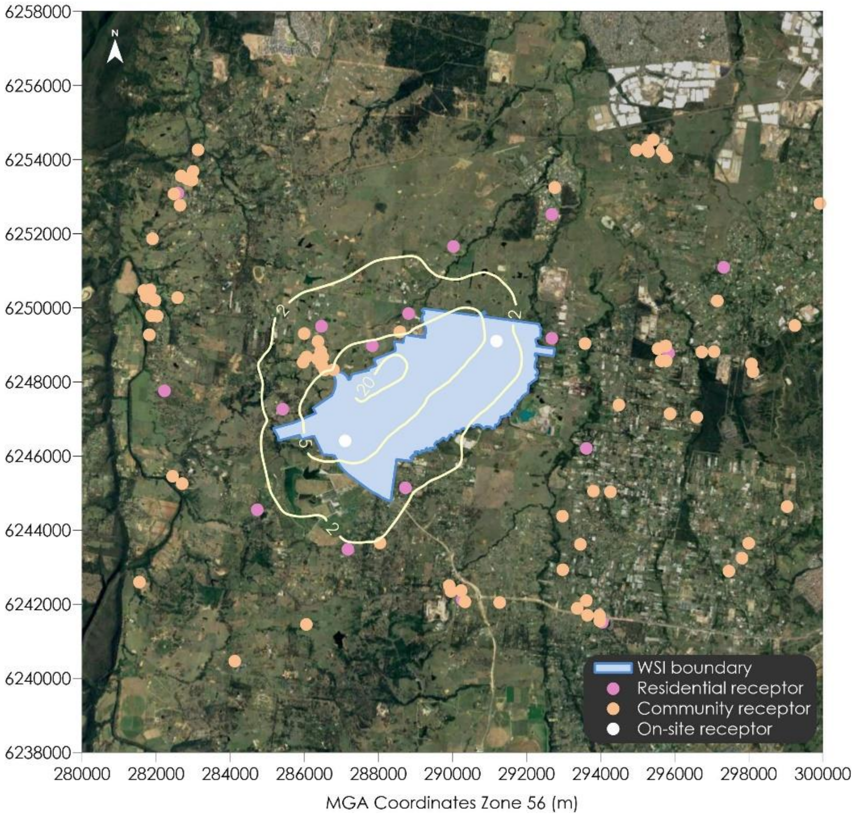


Figure C.24 Predicted incremental maximum 24-hour average SO_2 concentrations (µg/m³) for 2033 – Prefer Runway 05

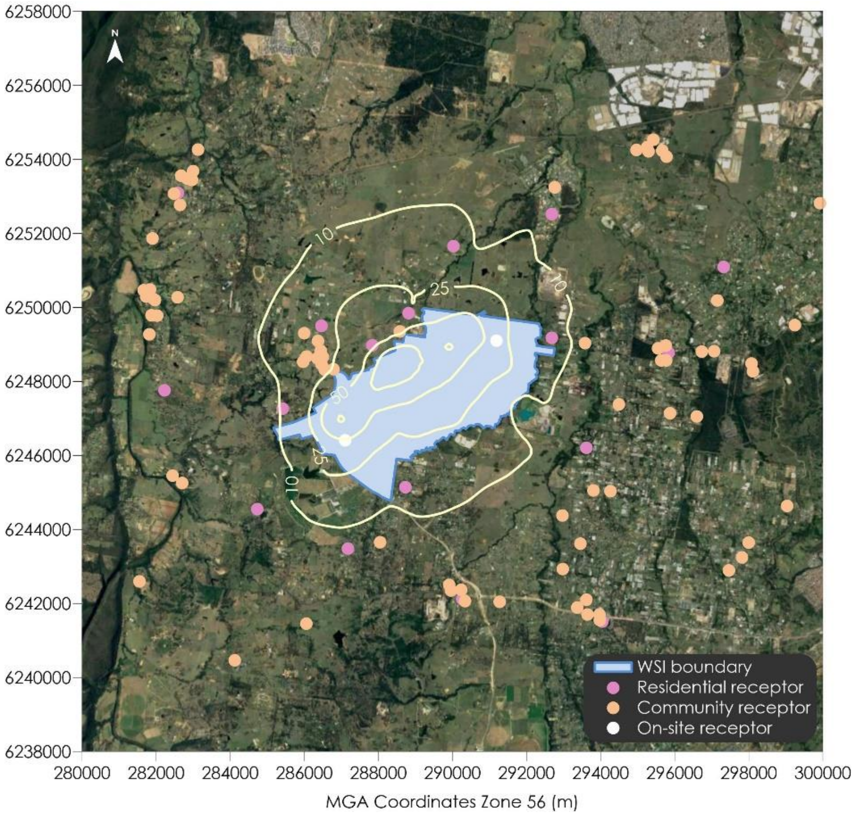


Figure C.25 Predicted incremental maximum 1-hour average SO_2 concentrations (µg/m³) for 2033 – Prefer Runway 23

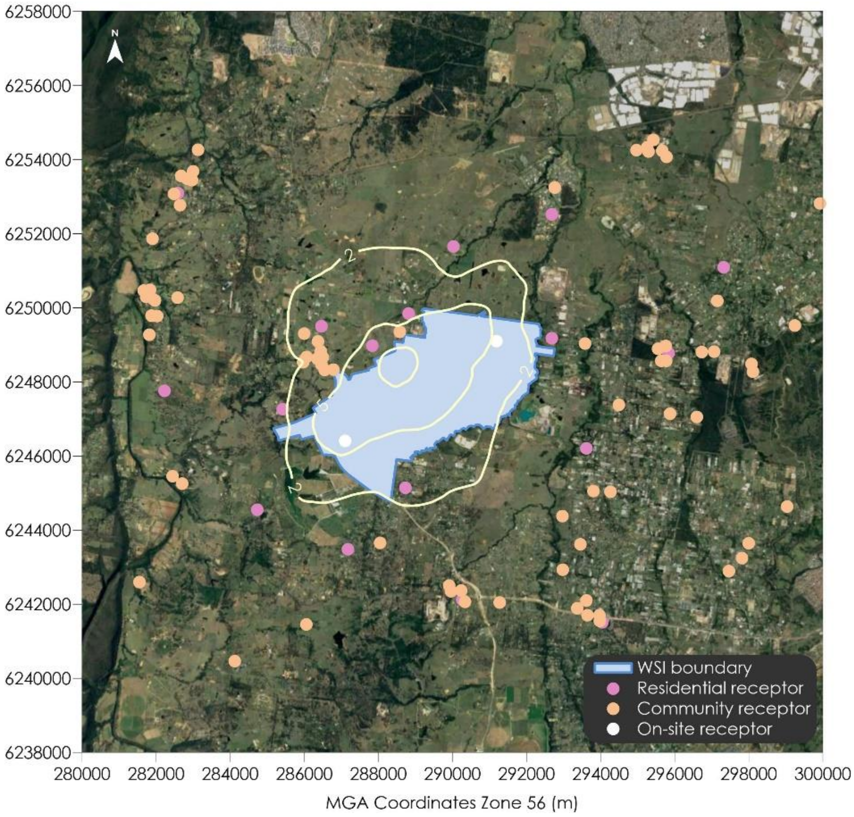


Figure C.26 Predicted incremental maximum 24-hour average SO_2 concentrations (µg/m³) for 2033 – Prefer Runway 23

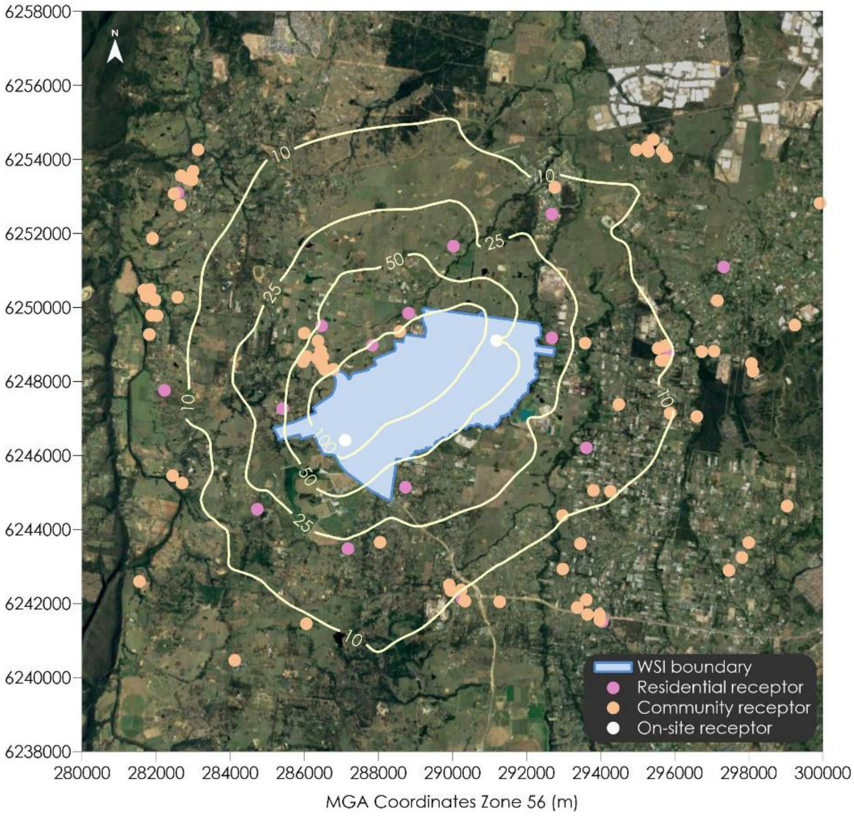


Figure C.27 Predicted incremental maximum 1-hour average SO_2 concentrations (µg/m³) for 2055 – Prefer Runway 05

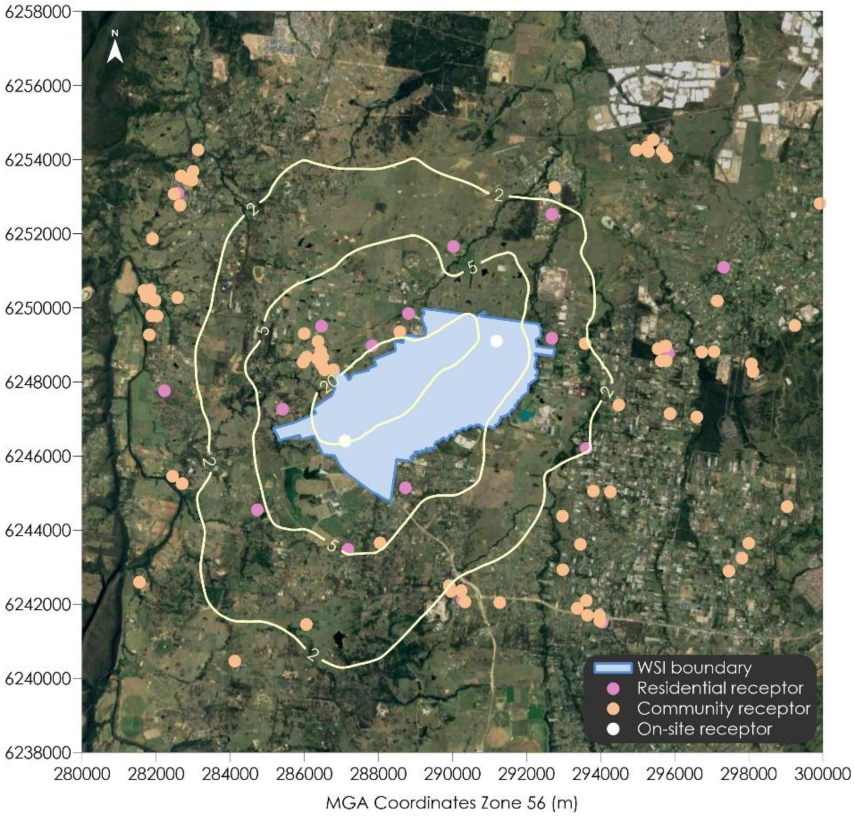


Figure C.28 Predicted incremental maximum 24-hour average SO_2 concentrations (µg/m³) for 2055 – Prefer Runway 05

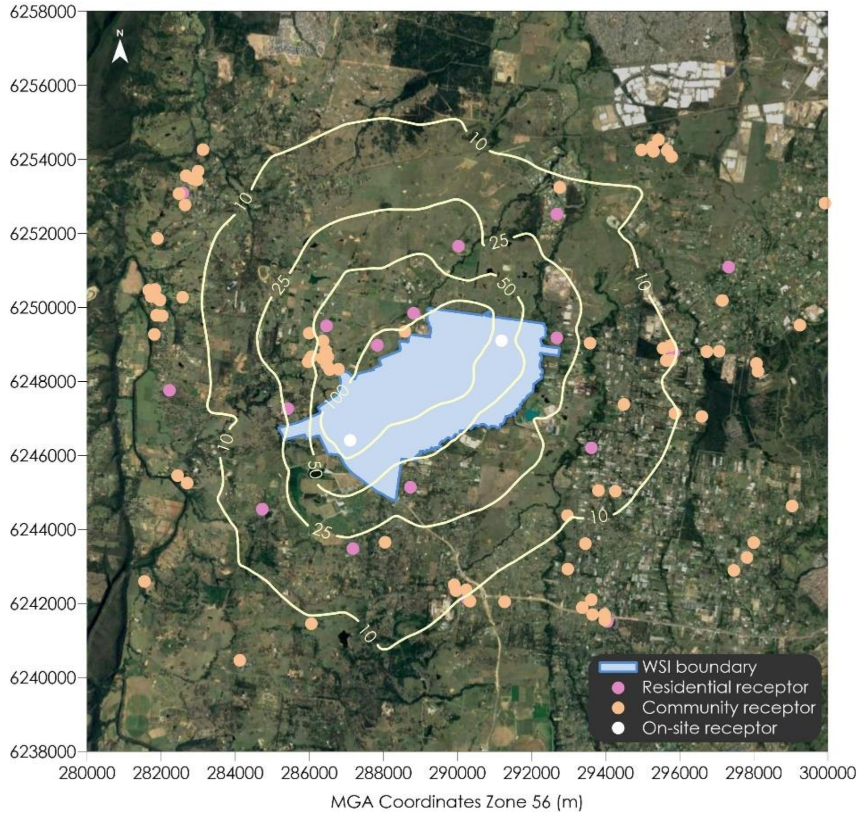


Figure C.29 Predicted incremental maximum 1-hour average SO_2 concentrations (µg/m³) for 2055 – Prefer Runway 23

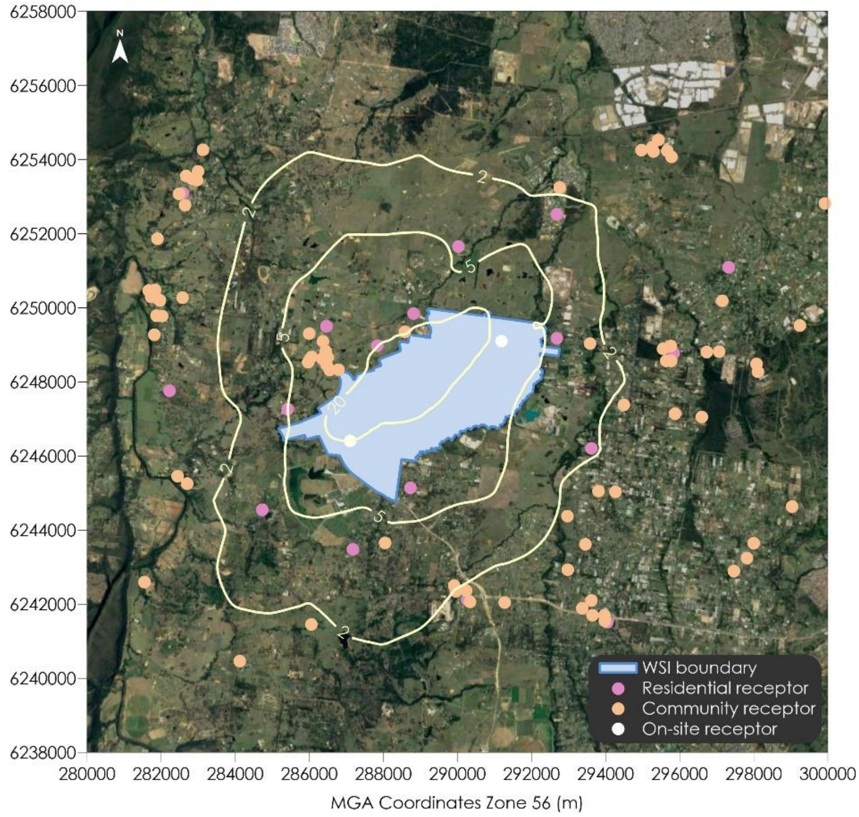


Figure C.30 Predicted incremental maximum 24-hour average SO_2 concentrations (µg/m³) for 2055 – Prefer Runway 23

C1.4 CO concentrations

Isopleths showing the spatial distribution of predicted incremental impacts due to the project for maximum 15-minute, 1-hour average and 8-hour average CO concentrations are presented in Figure C.31 to Figure C.45 for the various scenarios assessed.

Table C.4 presents the predicted incremental CO dispersion modelling results at each of the assessed sensitive receptor locations. The results show generally minimal effects would arise at the receptor locations due to the project.

Table C.4 Dispersion modelling results for CO

Receptor ID	Maximum 15-minute average					Maximum 1-hour average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R1	39	42	42	113	114	29	32	32	86	86
R2	296	271	297	694	694	224	205	225	526	526
R3	117	62	61	235	192	89	47	46	178	145
R4	38	47	47	139	137	29	36	36	105	104
R6	28	25	27	75	81	21	19	20	57	61
R7	25	24	24	72	73	19	18	18	54	55
R8	59	65	65	189	186	44	49	49	143	141
R14	137	119	137	327	329	104	90	104	248	250
R15	188	188	173	492	492	142	142	131	373	373
R17	177	160	177	447	447	134	121	134	339	339
R18	236	269	283	877	874	179	204	214	665	662
R19	513	513	539	1343	1360	389	389	409	1018	1031
R21	323	256	187	653	516	245	194	142	495	391
R22	59	65	65	187	185	45	49	49	142	141
R23	31	27	25	74	76	23	20	19	56	57
R24	364	202	364	603	684	276	153	276	457	518
R25	483	483	473	1504	1504	366	366	358	1140	1140
R27	101	94	81	265	244	76	72	61	201	185
R30	18	17	17	52	52	14	13	13	39	39
R31	31	33	32	93	92	24	25	25	71	70
R34	36	36	36	106	107	27	28	27	80	81
R35	34	37	36	107	107	26	28	28	81	81
R37	258	313	205	556	575	195	238	156	422	436

Receptor ID	Maximum 15-minute average					Maximum 1-hour average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R38	32	34	33	96	94	24	25	25	73	71
R39	12	14	14	42	42	9	11	11	32	32
R40	36	37	37	110	110	27	28	28	83	83
R41	39	43	43	122	126	29	32	32	93	95
R44	108	93	80	240	228	82	71	61	182	173
R46	36	45	46	139	144	27	34	35	106	109
R48	9	11	11	33	34	7	8	8	25	26
R49	232	306	231	647	694	176	232	175	491	526
R52	12	14	13	40	41	9	10	10	30	31
R53	19	17	17	53	52	14	13	13	40	39
R54	26	23	25	73	75	20	17	19	55	57
R55	34	36	42	106	106	26	27	32	80	80
R57	28	27	26	79	78	21	20	20	60	59
R59	43	46	46	124	125	32	35	35	94	95
R63	314	337	221	641	650	238	256	168	486	492
R64	28	25	27	76	81	21	19	20	57	61
R65	35	36	36	106	107	27	28	27	80	81
R66	51	35	35	102	103	38	26	26	77	78
R68	40	48	48	142	140	30	37	36	107	106
R69	36	38	38	112	113	28	29	29	85	86
R72	19	20	20	59	57	14	15	15	45	43
R73	333	351	234	698	704	252	266	177	529	534
R74	43	52	51	151	149	32	39	39	114	113
R75	31	33	33	96	97	23	25	25	73	73
R76	41	45	45	119	122	31	34	34	90	92
R78	26	23	25	70	75	20	17	19	53	57
R79	20	20	19	55	54	15	15	14	42	41
R80	23	21	21	75	77	18	16	16	57	59
R82	22	22	23	61	61	17	17	17	47	46

Receptor ID	Maximum 15-minute average					Maximum 1-hour average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R84	45	48	48	130	133	34	36	36	99	101
R85	29	20	19	56	56	22	15	15	42	42
R86	21	20	20	69	72	16	15	15	53	55
R87	45	53	53	156	154	34	40	40	118	116
R88	27	30	30	86	86	21	23	23	65	65
R91	20	21	20	61	59	15	16	15	46	45
R93	44	37	54	117	117	34	28	41	89	89
R94	293	331	224	671	677	222	251	170	508	513
R95	69	78	78	217	217	53	59	59	165	165
R97	28	24	26	74	79	21	18	20	56	60
R98	29	28	28	82	82	22	21	21	62	62
R99	386	386	424	1092	1110	292	292	321	827	841
R100	27	30	30	88	88	21	23	23	66	66
R102	32	28	29	92	94	24	21	22	70	71
R103	42	45	45	134	131	32	34	34	101	99
R104	22	22	22	65	63	16	17	17	50	48
R108	204	257	189	540	582	154	195	143	409	441
R109	26	27	27	79	79	19	20	20	60	60
R110	402	401	262	810	812	304	304	199	614	615
R111	35	45	47	140	147	27	34	35	106	112
R112	32	32	34	81	81	24	24	26	62	62
R114	23	23	21	60	60	17	17	16	46	45
R115	22	21	21	67	68	17	16	16	51	52
R117	30	31	31	88	87	23	24	24	67	66
R118	34	34	34	78	85	26	26	26	59	65
R120	55	61	61	178	179	42	46	46	135	136
R122	12	14	14	40	40	9	10	10	31	31
R123	30	27	29	83	88	23	20	22	63	67
R124	25	24	25	73	75	19	18	19	55	57

Receptor ID	Maximum 15-minute average					Maximum 1-hour average				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R126	37	34	32	86	82	28	26	24	65	62
R127	362	361	242	725	755	275	274	184	550	572
R130	31	31	23	77	66	24	24	17	58	50
R131	25	29	29	87	86	19	22	22	66	65
R132	38	41	41	110	111	29	31	31	83	84
R134	39	48	48	142	140	30	37	36	107	106
R135	437	436	297	945	920	331	330	225	717	697
R136	27	24	26	74	79	21	18	20	56	60
R137	19	18	18	55	53	14	14	14	42	40
R138	23	22	22	68	70	17	16	17	51	53
R140	266	318	206	559	561	201	241	156	423	425
R141	24	22	22	65	68	18	17	17	49	52

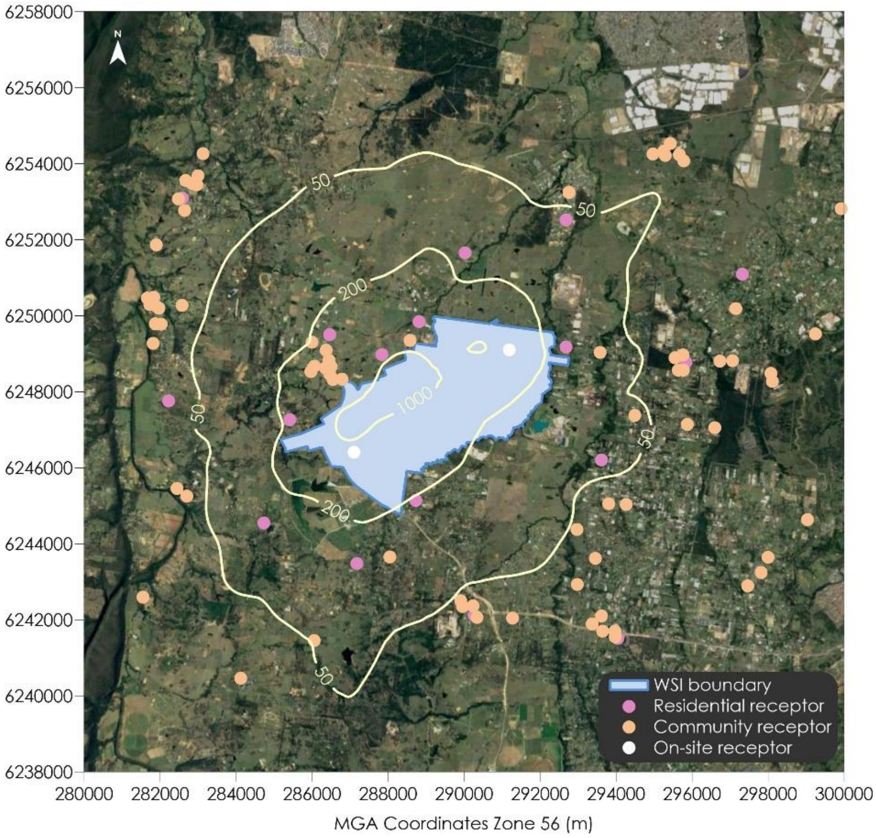


Figure C.31 Predicted incremental maximum 15-minute average CO concentrations (µg/m³) for 2033 – No preference

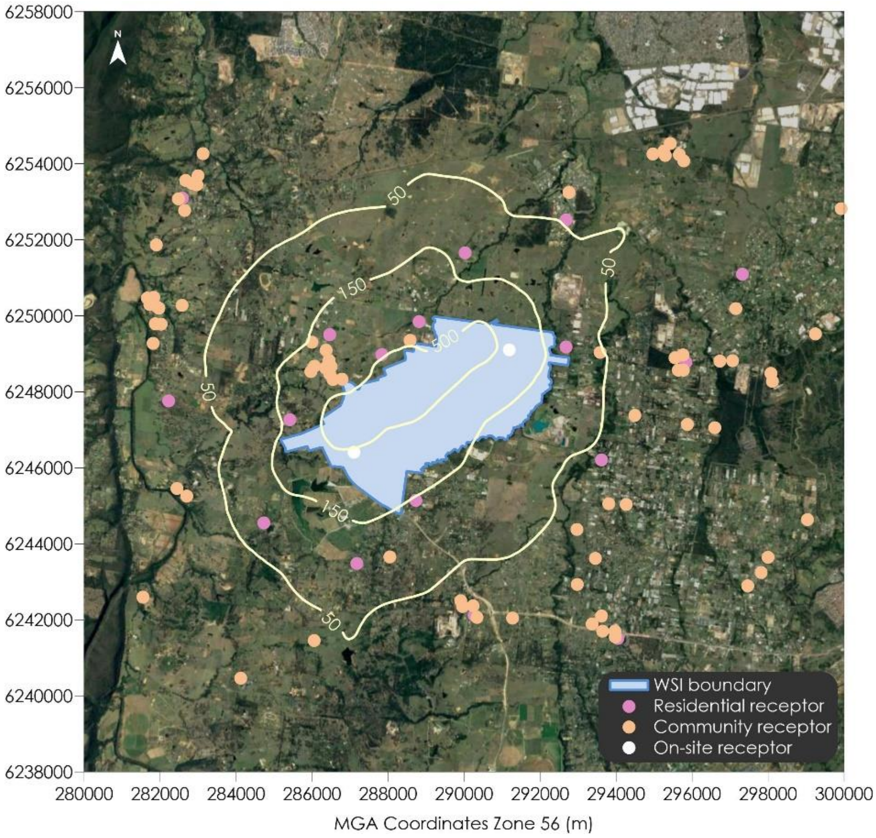


Figure C.32 Predicted incremental maximum 1-hour average CO concentrations (µg/m³) for 2033 – No preference

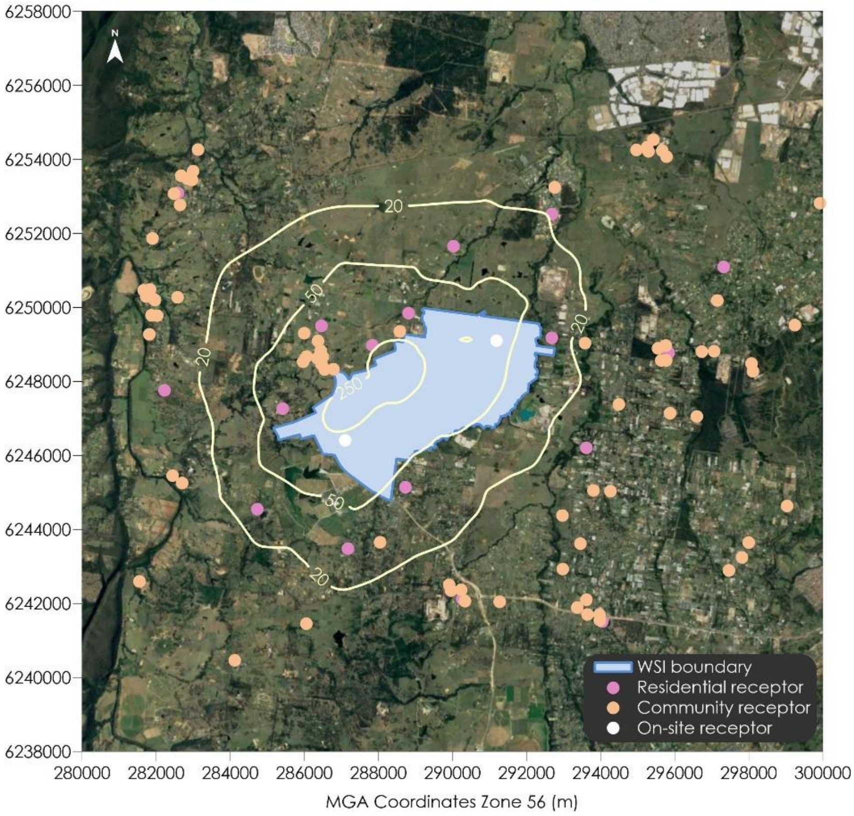


Figure C.33 Predicted incremental maximum 8-hour average CO concentrations (µg/m³) for 2033 – No preference

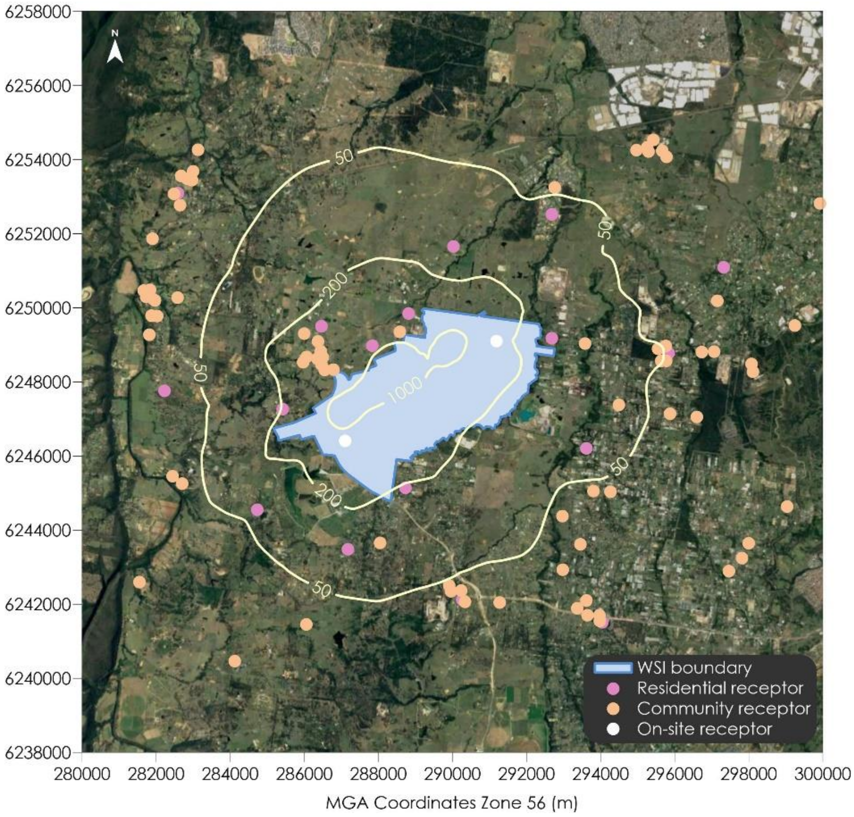


Figure C.34 Predicted incremental maximum 15-minute average CO concentrations (µg/m³) for 2033 – Prefer Runway 05

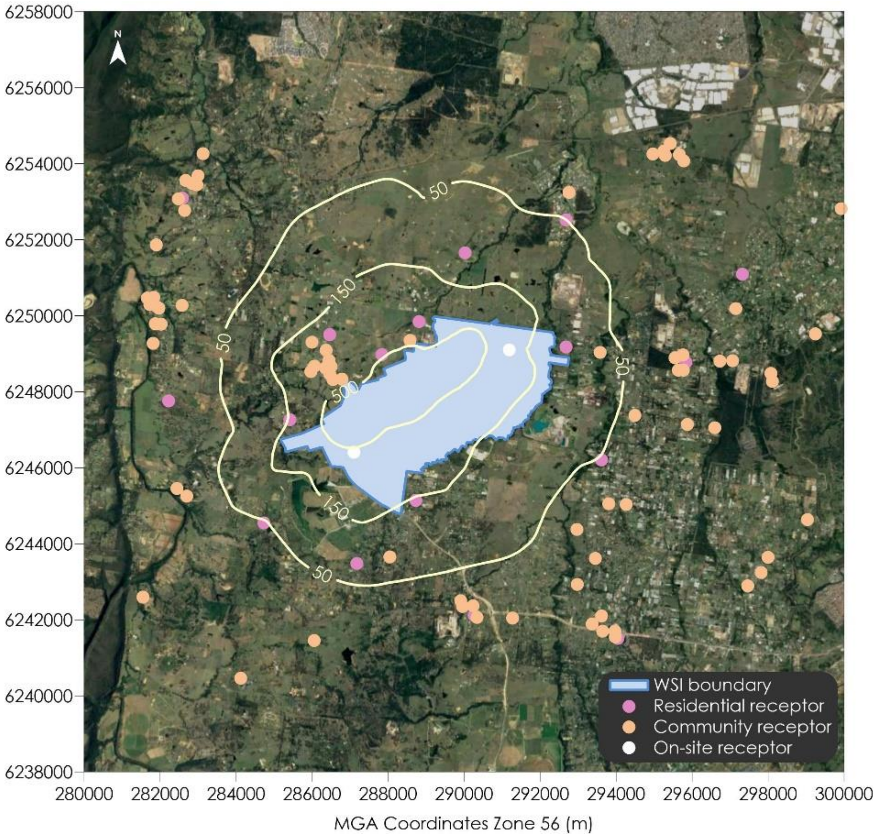


Figure C.35 Predicted incremental maximum 1-hour average CO concentrations (µg/m³) for 2033 – Prefer Runway 05

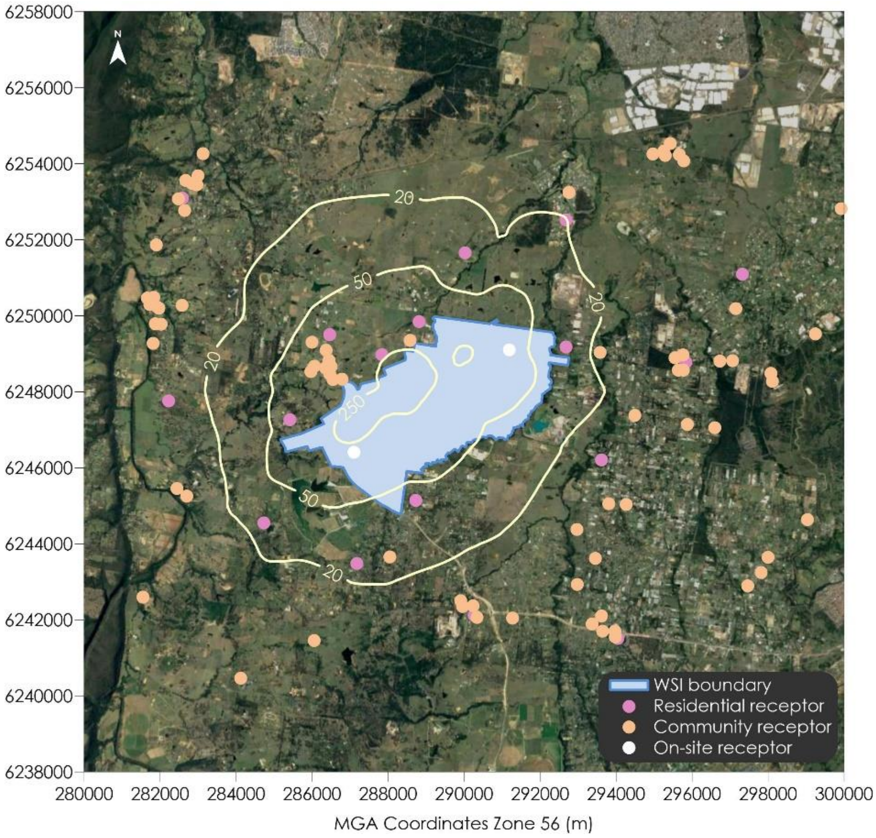


Figure C.36 Predicted incremental maximum 8-hour average CO concentrations (µg/m³) for 2033 – Prefer Runway 05

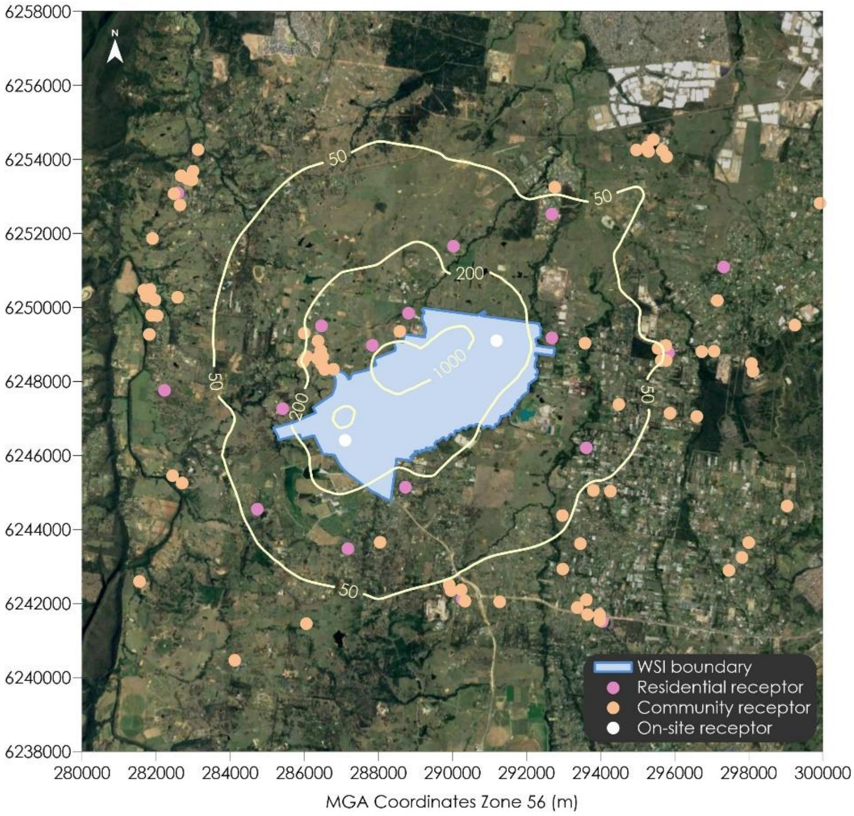


Figure C.37 Predicted incremental maximum 15-minute average CO concentrations (µg/m³) for 2033 – Prefer Runway 23

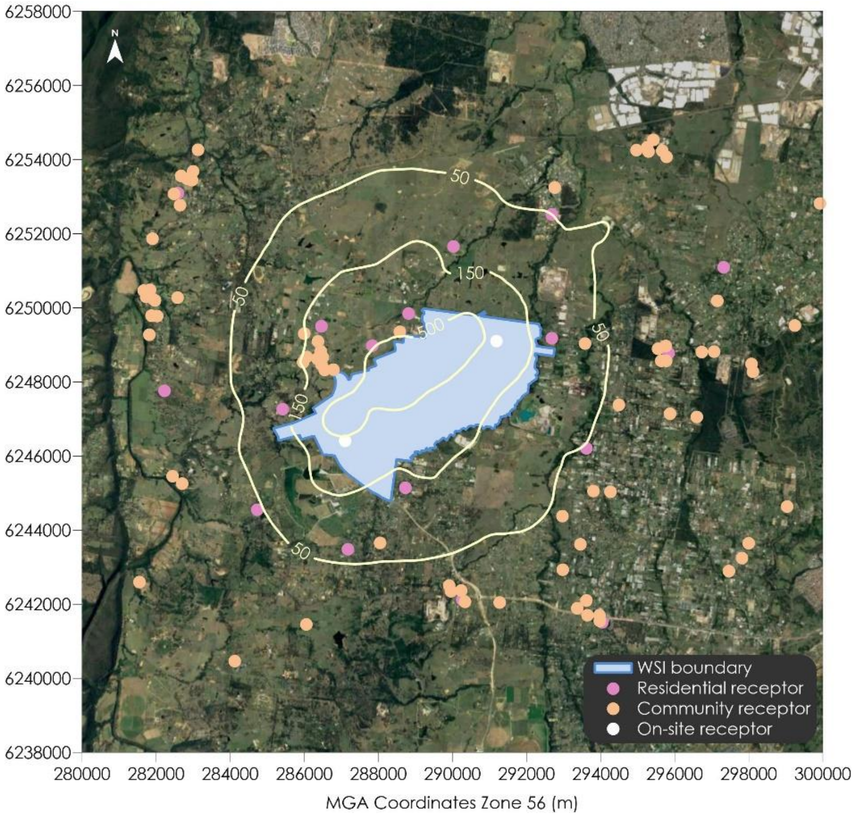


Figure C.38 Predicted incremental maximum 1-hour average CO concentrations (µg/m³) for 2033 – Prefer Runway 23

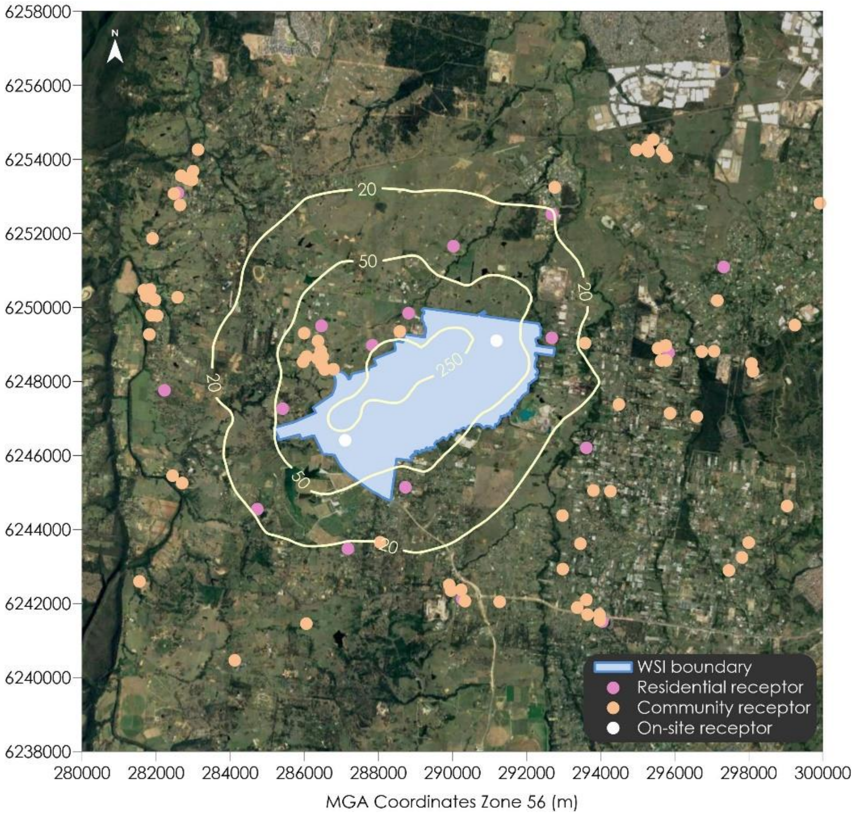


Figure C.39 Predicted incremental maximum 8-hour average CO concentrations (µg/m³) for 2033 – Prefer Runway 23

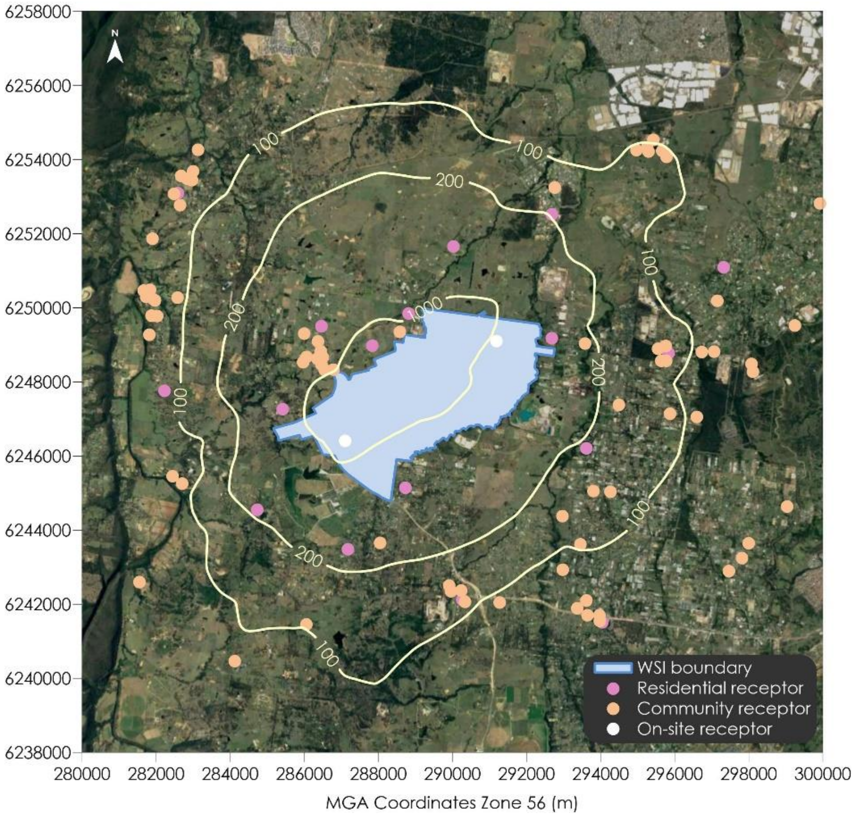


Figure C.40 Predicted incremental maximum 15-minute average CO concentrations (µg/m³) for 2055 – Prefer Runway 05

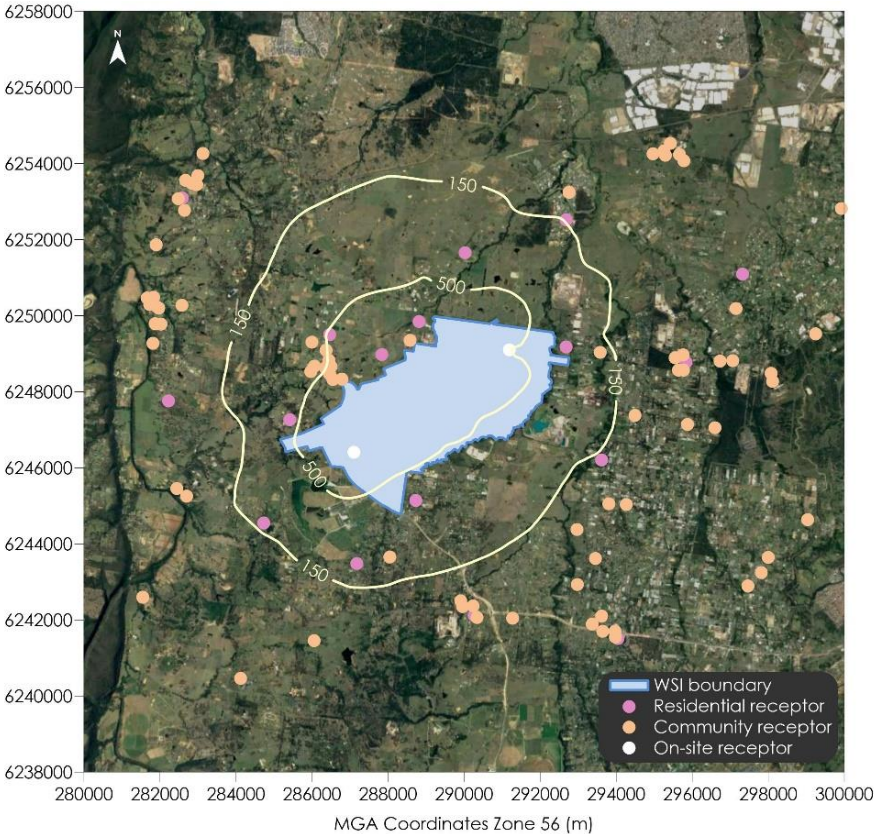


Figure C.41 Predicted incremental maximum 1-hour average CO concentrations (µg/m³) for 2055 – Prefer Runway 05

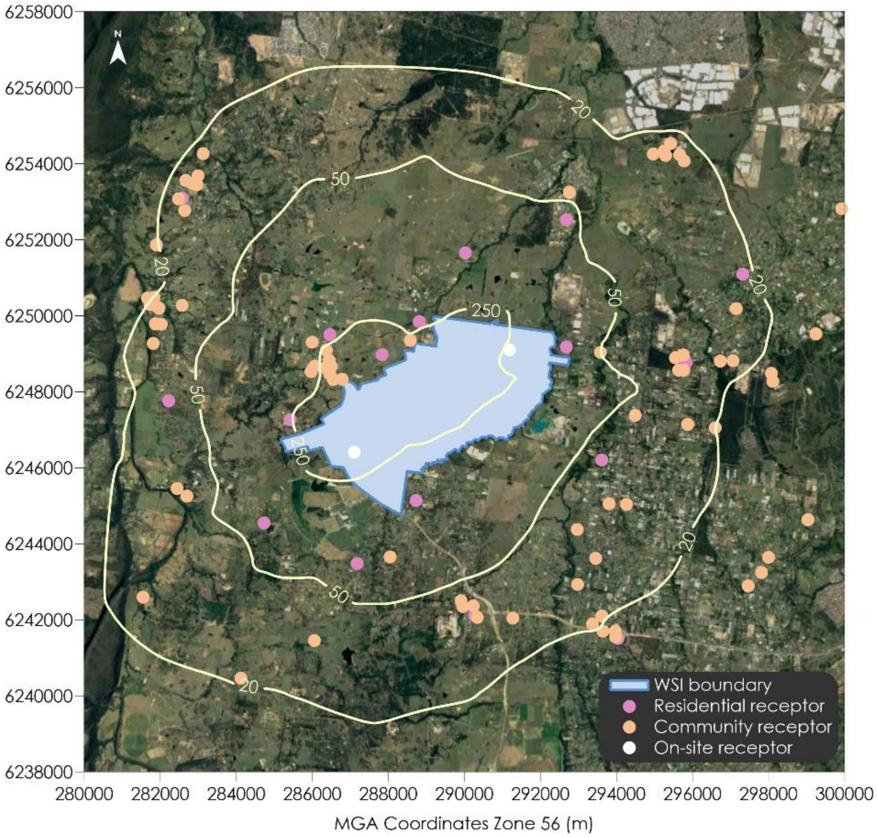


Figure C.42 Predicted incremental maximum 8-hour average CO concentrations (µg/m³) for 2055 – Prefer Runway 05

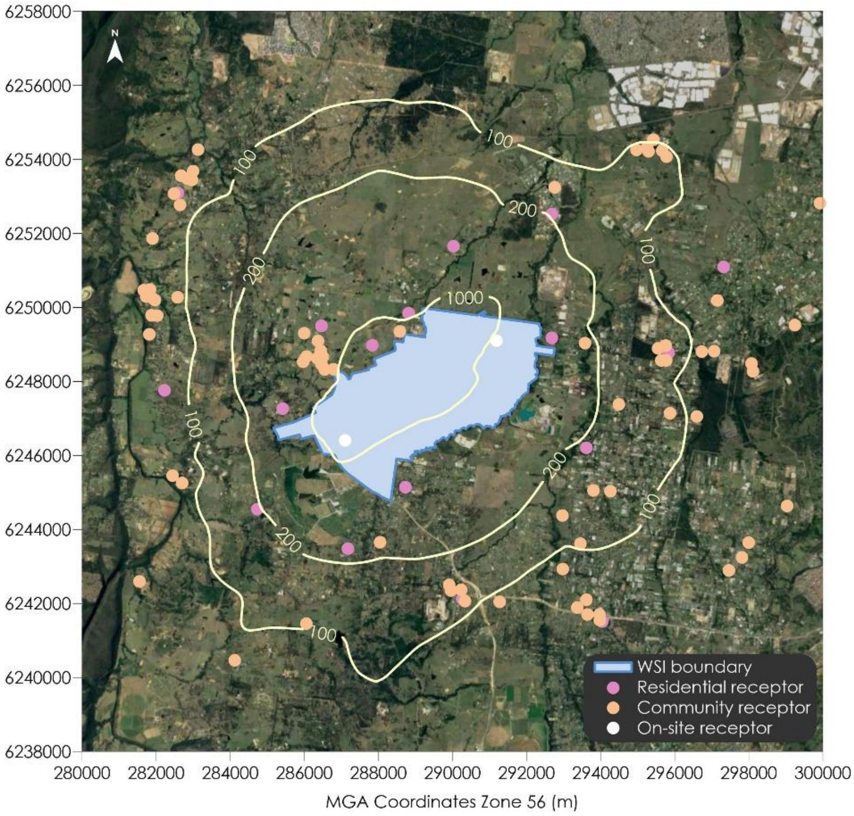


Figure C.43 Predicted incremental maximum 15-minute average CO concentrations (µg/m³) for 2055 – Prefer Runway 23

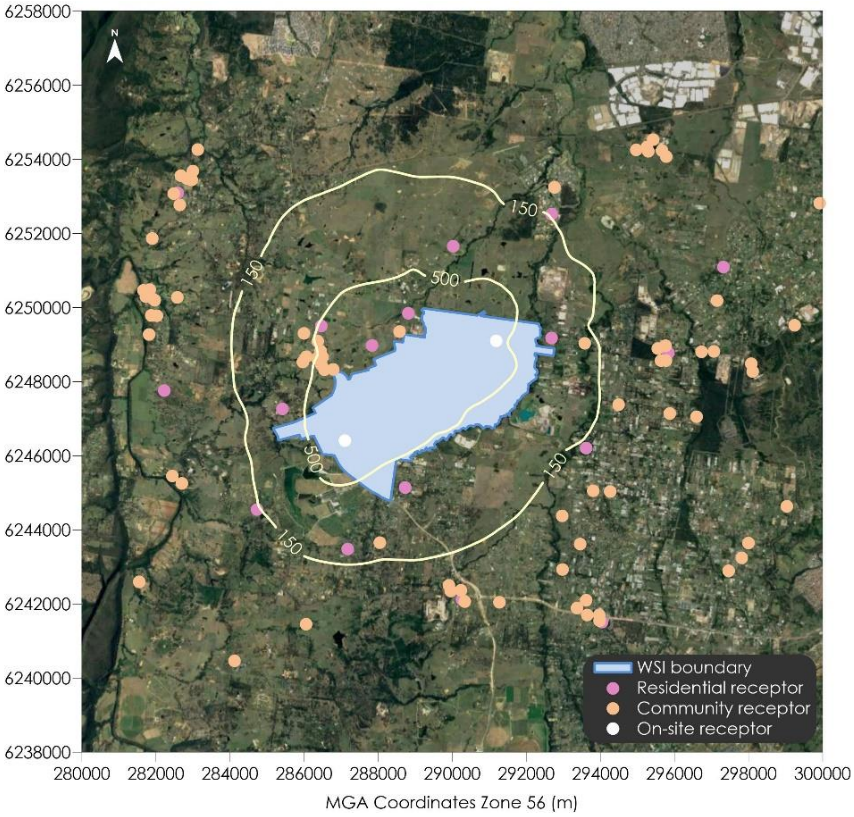


Figure C.44 Predicted incremental maximum 1-hour average CO concentrations (µg/m³) for 2055 – Prefer Runway 23

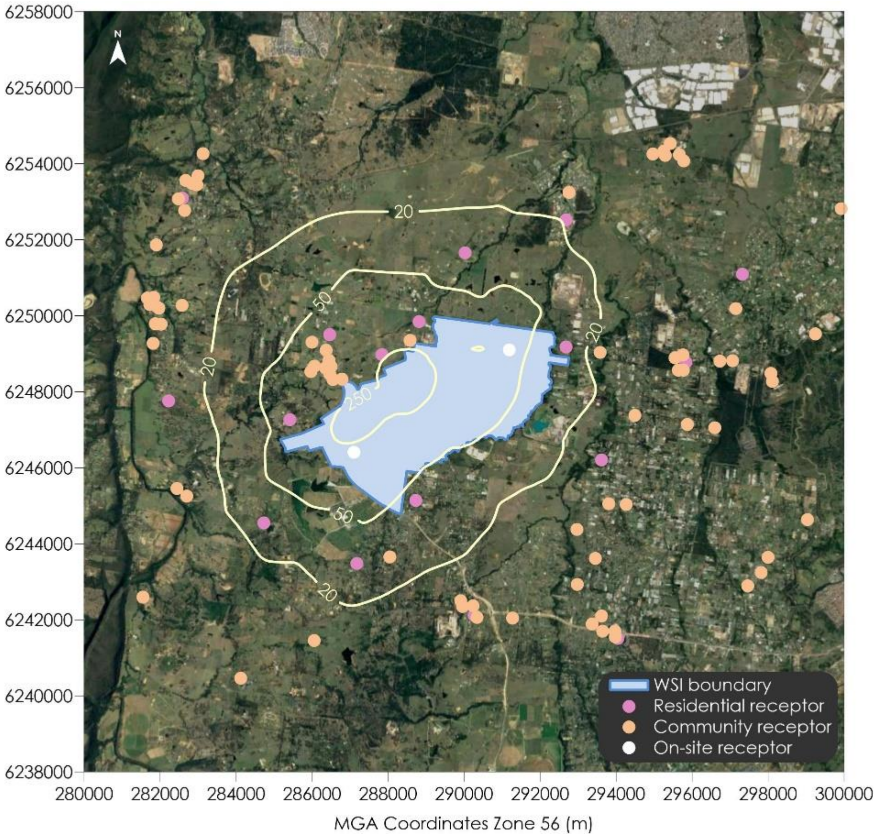


Figure C.45 Predicted incremental maximum 8-hour average CO concentrations (µg/m³) for 2055 – Prefer Runway 23

C1.5 VOC concentrations

Isopleths showing the spatial distribution of predicted incremental impacts due to the project for 99.9th percentile 1-hour average benzene, formaldehyde, toluene and xylene concentrations are presented in Figure C.46 to Figure C.65 for the various scenarios assessed.

Table C.5 and Table C.6 presents the predicted incremental benzene, formaldehyde, toluene and xylene dispersion modelling results at each of the assessed sensitive receptor locations. The results show generally minimal effects would arise at the receptor locations due to the project.

Table C.5 Dispersion modelling results for benzene and formaldehyde

Receptor ID	99.9th percentile 1-hour average – Benzene					99.9th percentile 1-hour average – Formaldehyde				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R1	0.05	0.05	0.05	0.13	0.13	0.38	0.41	0.41	1.06	1.02
R2	0.36	0.36	0.31	0.84	0.79	2.86	2.85	2.47	6.60	6.24
R3	0.12	0.10	0.09	0.26	0.25	0.97	0.79	0.74	2.04	1.94
R4	0.04	0.04	0.05	0.11	0.11	0.34	0.34	0.37	0.87	0.86
R6	0.04	0.03	0.03	0.09	0.09	0.29	0.27	0.26	0.70	0.68
R7	0.04	0.04	0.03	0.08	0.08	0.31	0.28	0.27	0.65	0.66
R8	0.09	0.08	0.09	0.21	0.22	0.70	0.64	0.74	1.65	1.73
R14	0.15	0.12	0.17	0.31	0.33	1.17	0.97	1.37	2.48	2.64
R15	0.27	0.27	0.21	0.50	0.51	2.14	2.13	1.69	3.94	3.99
R17	0.13	0.15	0.15	0.38	0.41	1.06	1.18	1.20	2.99	3.21
R18	0.34	0.40	0.44	0.97	1.03	2.72	3.16	3.45	7.66	8.16
R19	0.71	0.71	0.75	1.82	1.81	5.62	5.63	5.93	14.34	14.31
R21	0.48	0.40	0.27	0.82	0.63	3.79	3.15	2.15	6.51	4.95
R22	0.06	0.07	0.07	0.17	0.18	0.45	0.52	0.58	1.35	1.46
R23	0.04	0.04	0.04	0.10	0.09	0.35	0.32	0.30	0.76	0.71
R24	0.40	0.31	0.42	0.76	0.83	3.16	2.45	3.33	5.99	6.53
R25	0.85	0.84	0.48	1.57	1.22	6.71	6.60	3.80	12.42	9.62
R27	0.15	0.13	0.09	0.28	0.24	1.15	0.99	0.74	2.18	1.89
R30	0.02	0.03	0.03	0.06	0.06	0.19	0.20	0.20	0.49	0.50
R31	0.03	0.03	0.03	0.08	0.08	0.25	0.26	0.26	0.64	0.63
R34	0.04	0.04	0.04	0.09	0.10	0.34	0.32	0.34	0.71	0.77
R35	0.04	0.04	0.04	0.09	0.10	0.35	0.35	0.35	0.71	0.76
R37	0.39	0.33	0.29	0.79	0.75	3.09	2.63	2.29	6.23	5.95

Receptor ID	99.9th percentile 1-hour average – Benzene					99.9th percentile 1-hour average – Formaldehyde				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R38	0.03	0.03	0.03	0.08	0.08	0.23	0.26	0.26	0.65	0.65
R39	0.02	0.02	0.02	0.05	0.05	0.14	0.15	0.15	0.37	0.38
R40	0.05	0.05	0.05	0.09	0.10	0.37	0.38	0.38	0.74	0.80
R41	0.04	0.04	0.04	0.11	0.11	0.32	0.34	0.33	0.88	0.90
R44	0.15	0.12	0.11	0.27	0.26	1.19	0.98	0.84	2.17	2.09
R46	0.05	0.06	0.06	0.15	0.15	0.42	0.44	0.47	1.15	1.17
R48	0.01	0.01	0.01	0.04	0.04	0.11	0.11	0.11	0.28	0.28
R49	0.39	0.37	0.33	0.86	0.81	3.08	2.91	2.60	6.82	6.42
R52	0.02	0.02	0.02	0.05	0.05	0.14	0.15	0.15	0.37	0.38
R53	0.02	0.03	0.03	0.06	0.06	0.19	0.20	0.21	0.50	0.51
R54	0.04	0.04	0.03	0.09	0.09	0.28	0.28	0.27	0.72	0.73
R55	0.05	0.05	0.05	0.12	0.13	0.37	0.36	0.36	0.98	1.03
R57	0.04	0.04	0.03	0.09	0.08	0.33	0.30	0.28	0.71	0.66
R59	0.06	0.06	0.06	0.15	0.15	0.43	0.46	0.48	1.19	1.16
R63	0.44	0.38	0.35	0.90	0.87	3.50	3.04	2.74	7.11	6.85
R64	0.04	0.04	0.04	0.09	0.09	0.30	0.28	0.28	0.75	0.73
R65	0.04	0.04	0.04	0.09	0.09	0.34	0.32	0.34	0.69	0.73
R66	0.06	0.05	0.05	0.13	0.12	0.46	0.40	0.37	1.05	0.97
R68	0.05	0.05	0.05	0.12	0.12	0.36	0.37	0.39	0.91	0.91
R69	0.05	0.05	0.05	0.10	0.10	0.37	0.36	0.37	0.76	0.77
R72	0.02	0.02	0.02	0.05	0.05	0.13	0.13	0.14	0.36	0.38
R73	0.45	0.42	0.36	0.93	0.92	3.59	3.29	2.88	7.32	7.23
R74	0.05	0.05	0.05	0.12	0.12	0.38	0.39	0.42	0.97	0.97
R75	0.04	0.04	0.04	0.08	0.09	0.32	0.33	0.33	0.67	0.73
R76	0.05	0.06	0.06	0.14	0.14	0.41	0.46	0.45	1.11	1.09
R78	0.04	0.03	0.03	0.09	0.09	0.29	0.26	0.26	0.71	0.69
R79	0.03	0.03	0.03	0.07	0.07	0.21	0.23	0.23	0.56	0.59
R80	0.03	0.03	0.03	0.08	0.08	0.28	0.26	0.26	0.64	0.63
R82	0.03	0.03	0.03	0.08	0.08	0.22	0.25	0.26	0.62	0.64

Receptor ID	99.9th percentile 1-hour average – Benzene					99.9th percentile 1-hour average – Formaldehyde				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R84	0.06	0.06	0.06	0.16	0.15	0.47	0.49	0.51	1.27	1.22
R85	0.03	0.02	0.02	0.06	0.06	0.21	0.19	0.18	0.49	0.47
R86	0.03	0.03	0.03	0.08	0.08	0.27	0.25	0.25	0.60	0.61
R87	0.05	0.05	0.05	0.12	0.12	0.39	0.42	0.42	0.95	0.94
R88	0.03	0.03	0.03	0.08	0.08	0.21	0.25	0.25	0.63	0.65
R91	0.02	0.02	0.03	0.06	0.06	0.19	0.19	0.21	0.48	0.47
R93	0.05	0.05	0.06	0.15	0.15	0.39	0.42	0.44	1.18	1.22
R94	0.42	0.38	0.35	0.89	0.89	3.33	3.03	2.78	7.07	7.03
R95	0.07	0.06	0.07	0.15	0.16	0.57	0.48	0.57	1.20	1.23
R97	0.04	0.03	0.03	0.09	0.09	0.30	0.27	0.27	0.74	0.73
R98	0.04	0.04	0.04	0.09	0.09	0.33	0.30	0.29	0.71	0.68
R99	0.50	0.52	0.60	1.27	1.40	3.93	4.15	4.71	10.01	11.10
R100	0.03	0.03	0.03	0.08	0.08	0.27	0.26	0.24	0.63	0.62
R102	0.05	0.04	0.04	0.10	0.10	0.38	0.34	0.33	0.79	0.78
R103	0.06	0.06	0.06	0.14	0.14	0.45	0.46	0.48	1.10	1.09
R104	0.02	0.02	0.03	0.06	0.06	0.18	0.19	0.21	0.48	0.49
R108	0.32	0.29	0.27	0.73	0.68	2.53	2.33	2.14	5.76	5.35
R109	0.03	0.03	0.03	0.08	0.08	0.23	0.25	0.25	0.64	0.64
R110	0.54	0.54	0.37	1.09	0.94	4.24	4.23	2.89	8.62	7.39
R111	0.05	0.05	0.06	0.16	0.16	0.42	0.43	0.45	1.27	1.25
R112	0.04	0.04	0.04	0.10	0.10	0.31	0.32	0.32	0.81	0.81
R114	0.03	0.03	0.03	0.08	0.08	0.24	0.25	0.25	0.62	0.63
R115	0.03	0.03	0.03	0.08	0.08	0.25	0.24	0.24	0.66	0.67
R117	0.04	0.05	0.05	0.11	0.11	0.32	0.36	0.36	0.88	0.90
R118	0.04	0.04	0.04	0.11	0.10	0.35	0.33	0.31	0.85	0.80
R120	0.06	0.06	0.07	0.15	0.15	0.46	0.49	0.53	1.18	1.20
R122	0.02	0.02	0.02	0.05	0.05	0.13	0.14	0.14	0.36	0.36
R123	0.04	0.04	0.04	0.10	0.09	0.32	0.29	0.29	0.76	0.72
R124	0.04	0.04	0.03	0.08	0.08	0.31	0.29	0.27	0.65	0.67

Receptor ID	99.9th percentile 1-hour average – Benzene					99.9th percentile 1-hour average – Formaldehyde				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R126	0.05	0.04	0.04	0.11	0.10	0.39	0.35	0.32	0.89	0.76
R127	0.48	0.46	0.37	1.00	0.94	3.81	3.65	2.96	7.93	7.45
R130	0.04	0.04	0.03	0.08	0.08	0.31	0.28	0.26	0.66	0.61
R131	0.03	0.03	0.03	0.08	0.08	0.24	0.25	0.25	0.63	0.63
R132	0.05	0.05	0.05	0.13	0.12	0.36	0.41	0.41	1.06	0.98
R134	0.04	0.05	0.05	0.11	0.11	0.35	0.37	0.38	0.90	0.89
R135	0.59	0.59	0.42	1.17	1.10	4.66	4.65	3.28	9.22	8.67
R136	0.04	0.03	0.03	0.09	0.08	0.29	0.27	0.26	0.69	0.66
R137	0.02	0.03	0.03	0.07	0.07	0.20	0.21	0.22	0.53	0.55
R138	0.04	0.03	0.03	0.08	0.08	0.28	0.26	0.26	0.64	0.63
R140	0.39	0.35	0.30	0.77	0.69	3.09	2.76	2.34	6.05	5.48
R141	0.03	0.03	0.03	0.08	0.07	0.27	0.23	0.22	0.62	0.57

Table C.6 Dispersion modelling results for toluene and xylene

Receptor ID	99.9th percentile 1-hour average – Toluene					99.9th percentile 1-hour average – Xylene				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R1	0.01	0.01	0.01	0.04	0.04	0.01	0.01	0.01	0.03	0.03
R2	0.10	0.10	0.09	0.23	0.22	0.09	0.09	0.08	0.21	0.19
R3	0.03	0.03	0.03	0.07	0.07	0.03	0.02	0.02	0.06	0.06
R4	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.03
R6	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R7	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R8	0.02	0.02	0.03	0.06	0.06	0.02	0.02	0.02	0.05	0.05
R14	0.04	0.03	0.05	0.09	0.09	0.04	0.03	0.04	0.08	0.08
R15	0.07	0.07	0.06	0.14	0.14	0.07	0.07	0.05	0.12	0.12
R17	0.04	0.04	0.04	0.10	0.11	0.03	0.04	0.04	0.09	0.10
R18	0.09	0.11	0.12	0.27	0.28	0.08	0.10	0.11	0.24	0.25
R19	0.19	0.20	0.21	0.50	0.50	0.17	0.18	0.18	0.45	0.45

Receptor ID	99.9th percentile 1-hour average – Toluene					99.9th percentile 1-hour average – Xylene				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R21	0.13	0.11	0.07	0.23	0.17	0.12	0.10	0.07	0.20	0.15
R22	0.02	0.02	0.02	0.05	0.05	0.01	0.02	0.02	0.04	0.05
R23	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.01	0.02	0.02
R24	0.11	0.08	0.12	0.21	0.23	0.10	0.08	0.10	0.19	0.20
R25	0.23	0.23	0.13	0.43	0.33	0.21	0.21	0.12	0.39	0.30
R27	0.04	0.03	0.03	0.08	0.07	0.04	0.03	0.02	0.07	0.06
R30	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R31	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R34	0.01	0.01	0.01	0.02	0.03	0.01	0.01	0.01	0.02	0.02
R35	0.01	0.01	0.01	0.02	0.03	0.01	0.01	0.01	0.02	0.02
R37	0.11	0.09	0.08	0.22	0.21	0.10	0.08	0.07	0.19	0.19
R38	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R39	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01
R40	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.02	0.02
R41	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.03
R44	0.04	0.03	0.03	0.08	0.07	0.04	0.03	0.03	0.07	0.07
R46	0.01	0.02	0.02	0.04	0.04	0.01	0.01	0.01	0.04	0.04
R48	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01
R49	0.11	0.10	0.09	0.24	0.22	0.10	0.09	0.08	0.21	0.20
R52	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01
R53	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R54	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.02	0.02
R55	0.01	0.01	0.01	0.03	0.04	0.01	0.01	0.01	0.03	0.03
R57	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R59	0.02	0.02	0.02	0.04	0.04	0.01	0.01	0.01	0.04	0.04
R63	0.12	0.11	0.09	0.25	0.24	0.11	0.09	0.09	0.22	0.21
R64	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.02	0.02
R65	0.01	0.01	0.01	0.02	0.03	0.01	0.01	0.01	0.02	0.02
R66	0.02	0.01	0.01	0.04	0.03	0.01	0.01	0.01	0.03	0.03

Receptor ID	99.9th percentile 1-hour average – Toluene					99.9th percentile 1-hour average – Xylene				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R68	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.03
R69	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.02	0.02
R72	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01
R73	0.12	0.11	0.10	0.25	0.25	0.11	0.10	0.09	0.23	0.23
R74	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.03
R75	0.01	0.01	0.01	0.02	0.03	0.01	0.01	0.01	0.02	0.02
R76	0.01	0.02	0.02	0.04	0.04	0.01	0.01	0.01	0.03	0.03
R78	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R79	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R80	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R82	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R84	0.02	0.02	0.02	0.04	0.04	0.01	0.02	0.02	0.04	0.04
R85	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.01
R86	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R87	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.03
R88	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R91	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.01
R93	0.01	0.01	0.02	0.04	0.04	0.01	0.01	0.01	0.04	0.04
R94	0.12	0.11	0.10	0.24	0.24	0.10	0.09	0.09	0.22	0.22
R95	0.02	0.02	0.02	0.04	0.04	0.02	0.02	0.02	0.04	0.04
R97	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.02	0.02
R98	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R99	0.14	0.14	0.16	0.35	0.38	0.12	0.13	0.15	0.31	0.35
R100	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R102	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.02	0.02
R103	0.02	0.02	0.02	0.04	0.04	0.01	0.01	0.01	0.03	0.03
R104	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R108	0.09	0.08	0.07	0.20	0.19	0.08	0.07	0.07	0.18	0.17
R109	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02

Receptor ID	99.9th percentile 1-hour average – Toluene					99.9th percentile 1-hour average – Xylene				
	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23	2033 – No preference	2033 – Prefer Runway 05	2033 – Prefer Runway 23	2055 – Prefer Runway 05	2055 – Prefer Runway 23
R110	0.15	0.15	0.10	0.30	0.26	0.13	0.13	0.09	0.27	0.23
R111	0.01	0.01	0.02	0.04	0.04	0.01	0.01	0.01	0.04	0.04
R112	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.03
R114	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R115	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R117	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.03
R118	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.02
R120	0.02	0.02	0.02	0.04	0.04	0.01	0.02	0.02	0.04	0.04
R122	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01
R123	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.02	0.02
R124	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R126	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.02
R127	0.13	0.13	0.10	0.27	0.26	0.12	0.11	0.09	0.25	0.23
R130	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R131	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R132	0.01	0.01	0.01	0.04	0.03	0.01	0.01	0.01	0.03	0.03
R134	0.01	0.01	0.01	0.03	0.03	0.01	0.01	0.01	0.03	0.03
R135	0.16	0.16	0.11	0.32	0.30	0.15	0.14	0.10	0.29	0.27
R136	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R137	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R138	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
R140	0.11	0.10	0.08	0.21	0.19	0.10	0.09	0.07	0.19	0.17
R141	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02

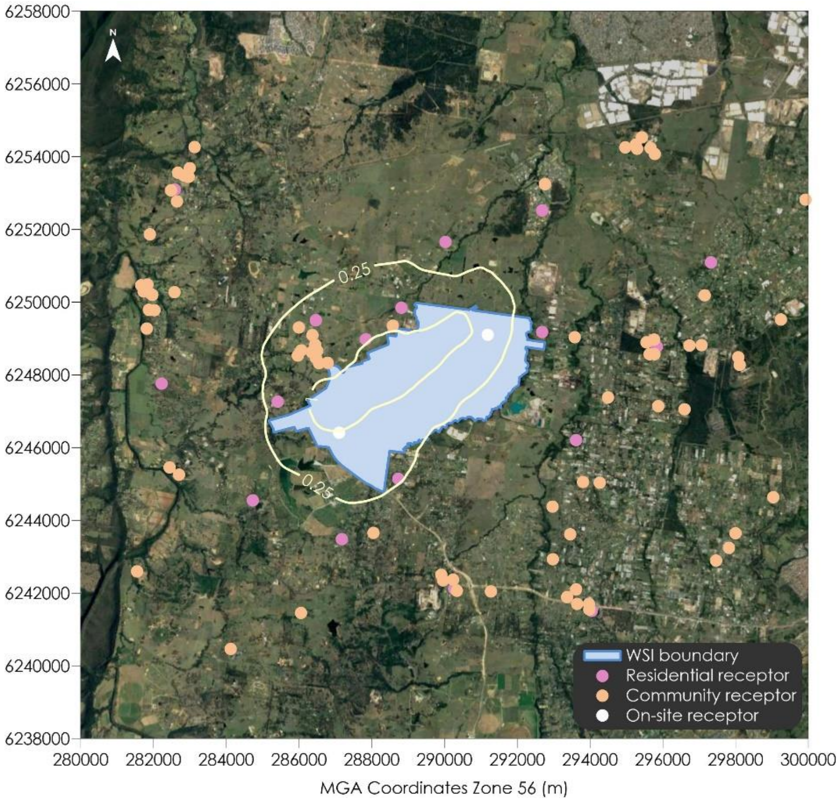


Figure C.46 Predicted incremental 99.9th percentile 1-hour average benzene concentrations (µg/m³) for 2033 – No preference

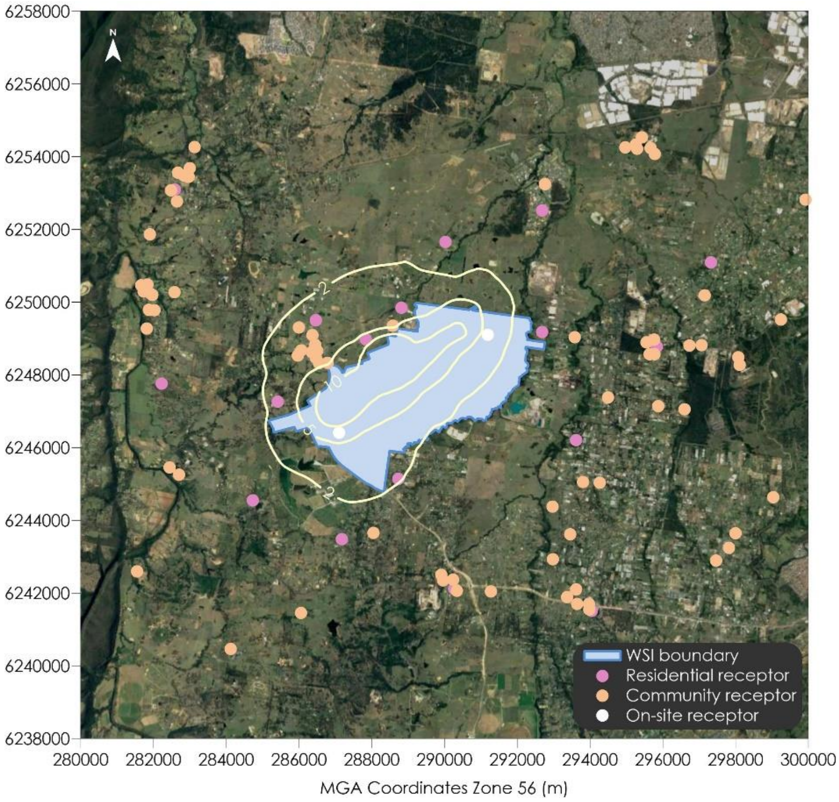


Figure C.47 Predicted incremental 99.9th percentile 1-hour average formaldehyde concentrations (µg/m³) for 2033 – No preference

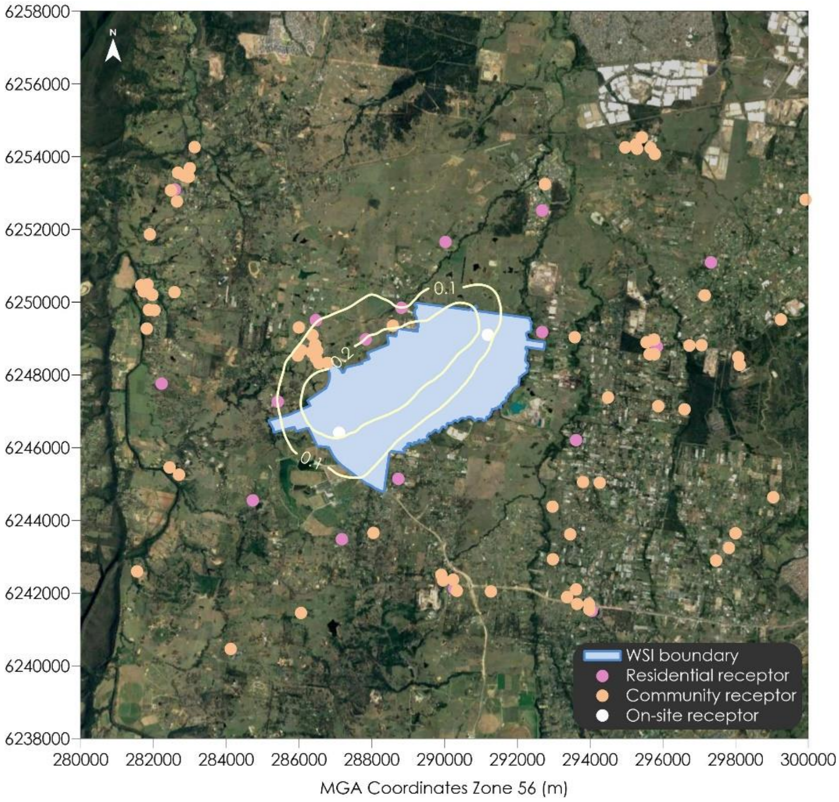


Figure C.48 Predicted incremental 99.9th percentile 1-hour average toluene concentrations (µg/m³) for 2033 – No preference

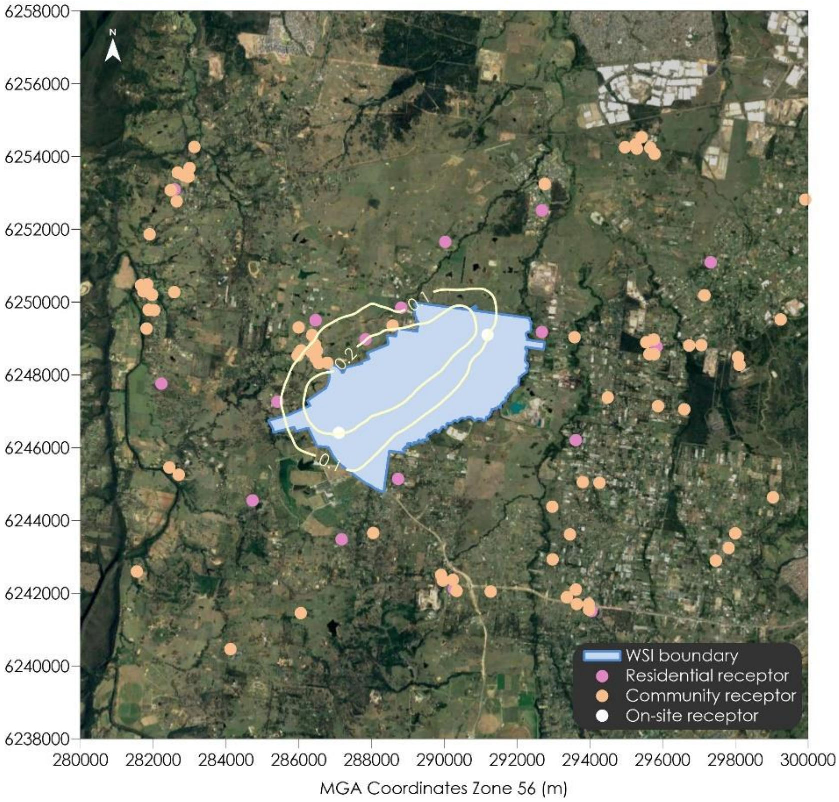


Figure C.49 Predicted incremental 99.9th percentile 1-hour average xylene concentrations (µg/m³) for 2033 – No preference

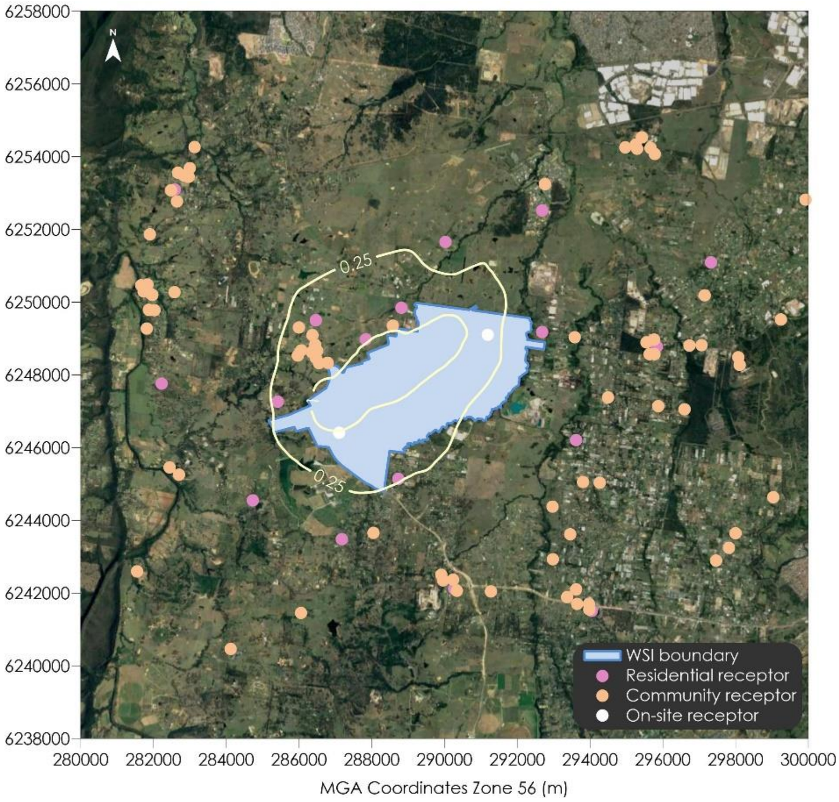


Figure C.50 Predicted incremental 99.9th percentile 1-hour average benzene concentrations (µg/m³) for 2033 – Prefer Runway 05

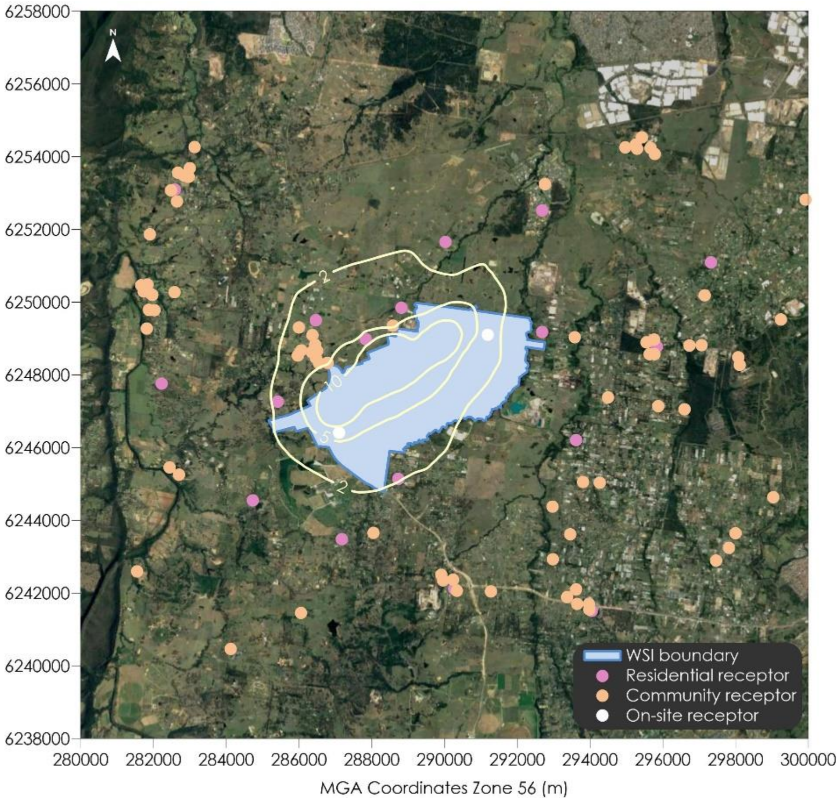


Figure C.51 Predicted incremental 99.9th percentile 1-hour average formaldehyde concentrations (µg/m³) for 2033 – Prefer Runway 05

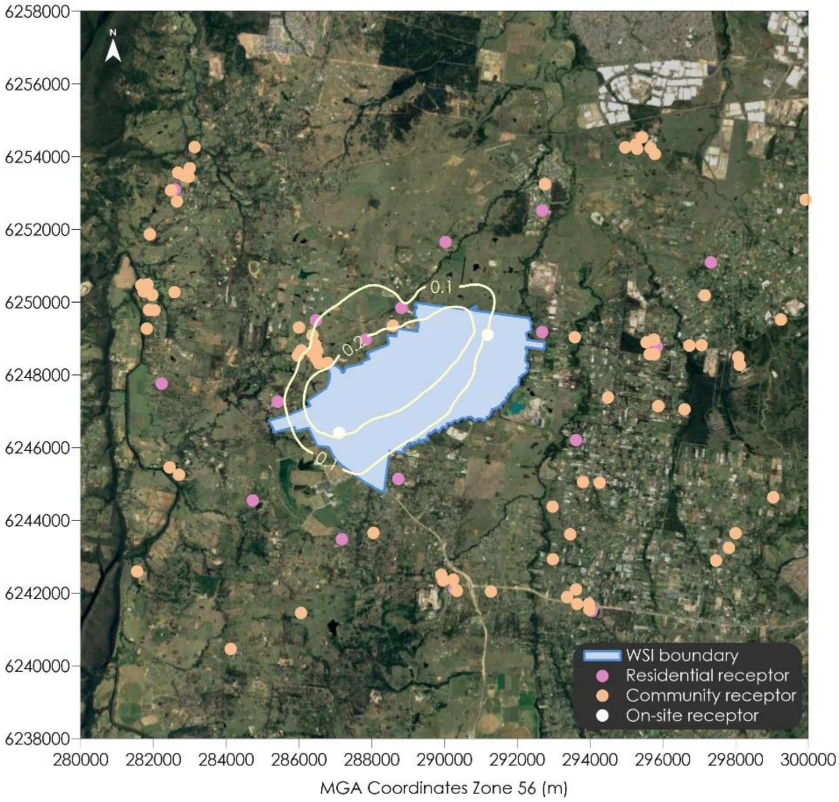


Figure C.52 Predicted incremental 99.9th percentile 1-hour average toluene concentrations (µg/m³) for 2033 – Prefer Runway 05

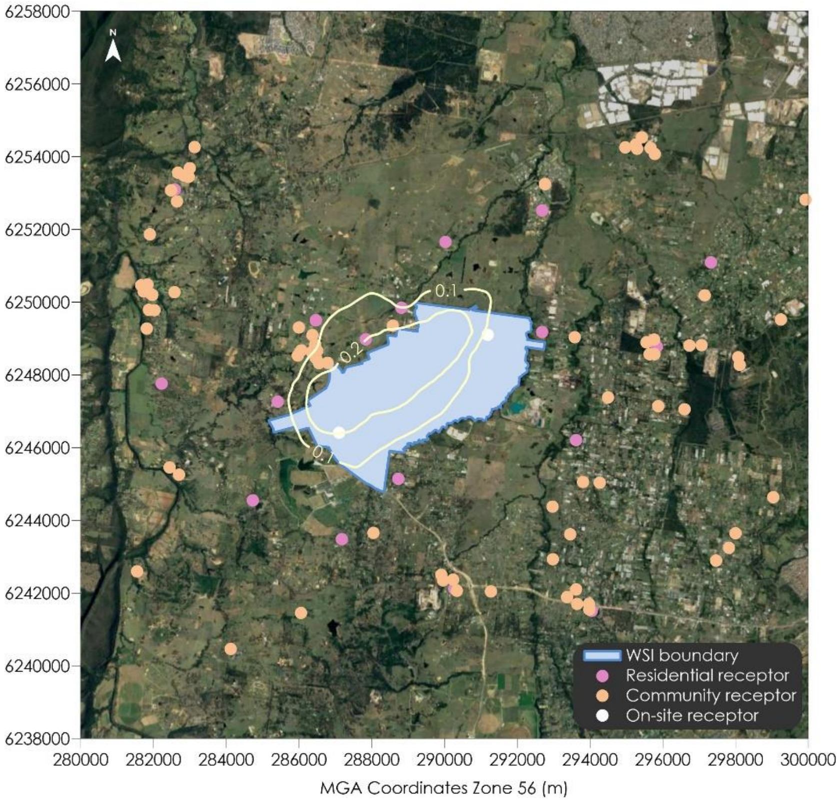


Figure C.53 Predicted incremental 99.9th percentile 1-hour average xylene concentrations (µg/m³) for 2033 – Prefer Runway 05

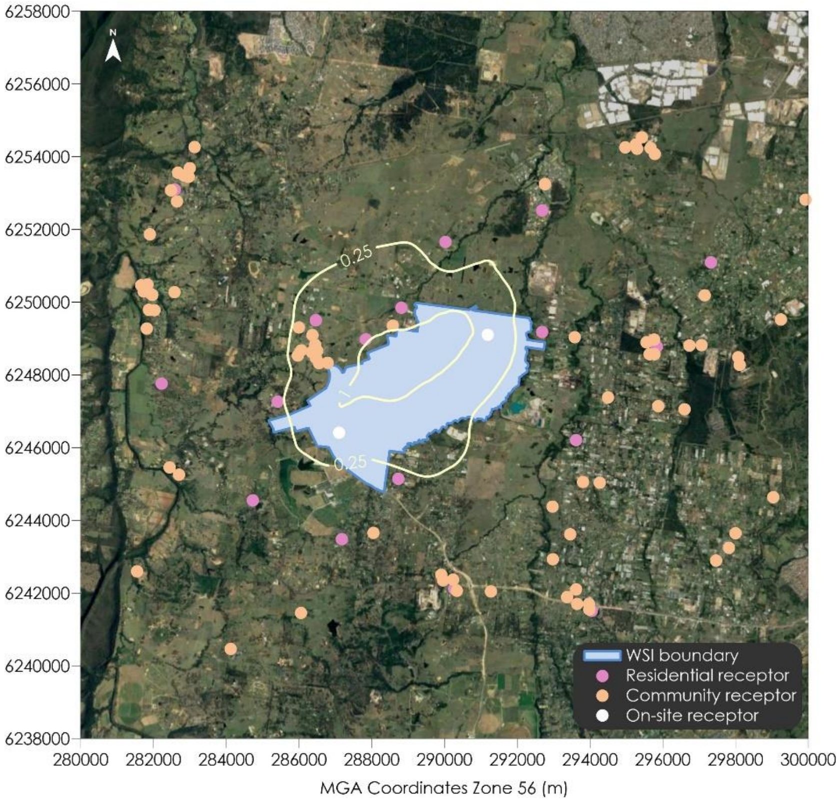


Figure C.54 Predicted incremental 99.9th percentile 1-hour average benzene concentrations (µg/m³) for 2033 – Prefer Runway 23

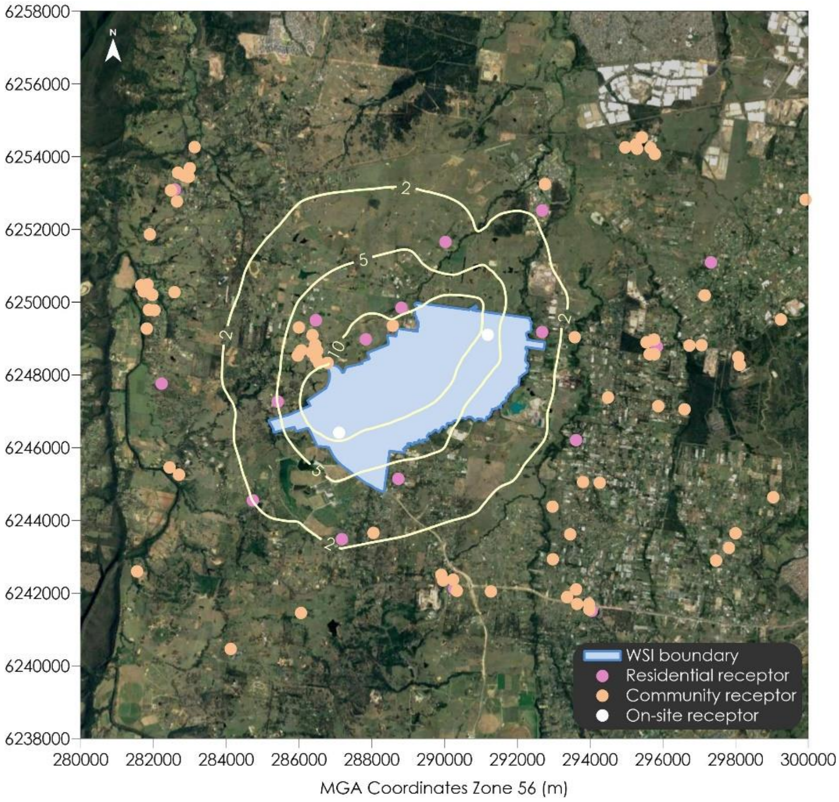


Figure C.55 Predicted incremental 99.9th percentile 1-hour average formaldehyde concentrations (µg/m³) for 2033 – Prefer Runway 23

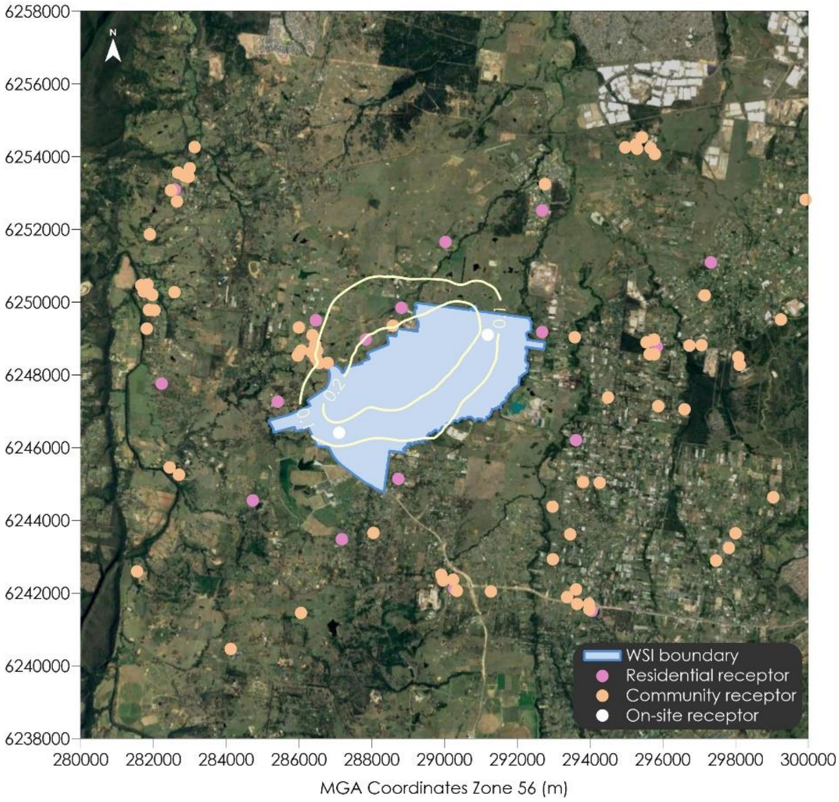


Figure C.56 Predicted incremental 99.9th percentile 1-hour average toluene concentrations (µg/m³) for 2033 – Prefer Runway 23

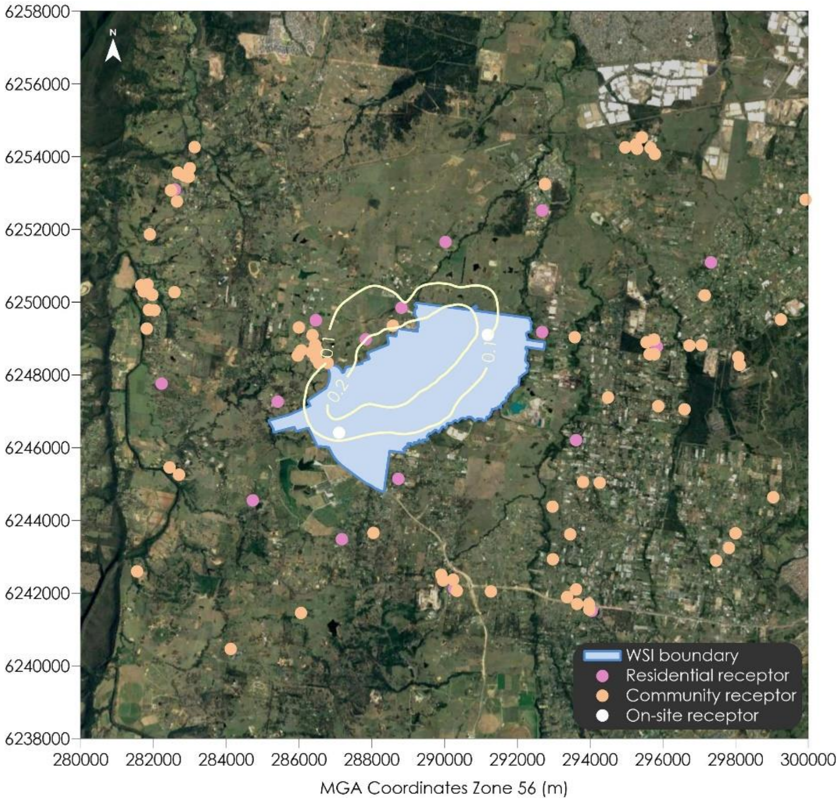


Figure C.57 Predicted incremental 99.9th percentile 1-hour average xylene concentrations (µg/m³) for 2033 – Prefer Runway 23

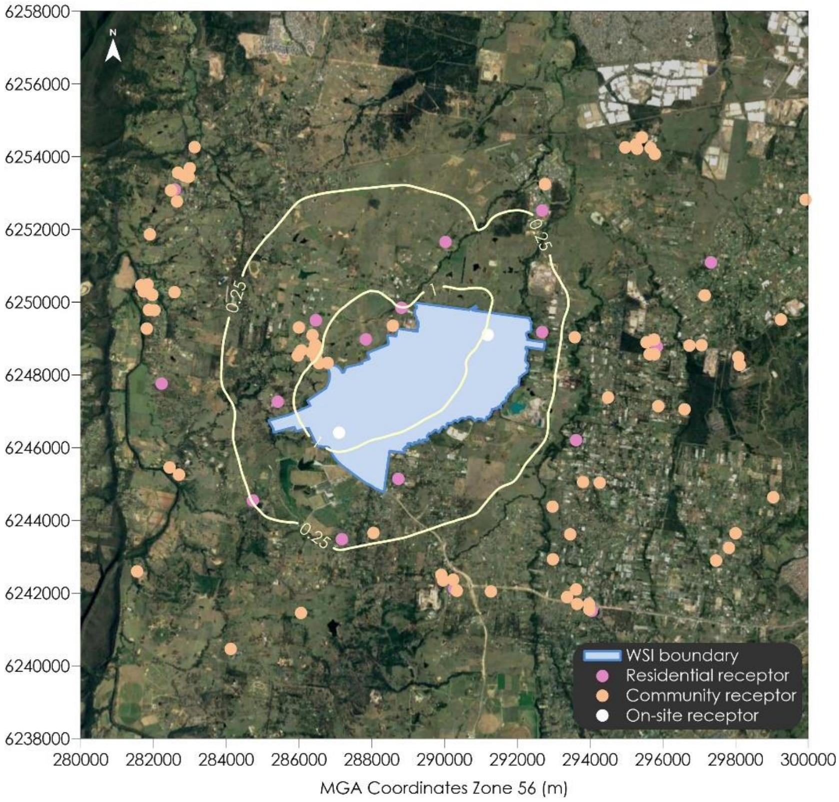


Figure C.58 Predicted incremental 99.9th percentile 1-hour average benzene concentrations (µg/m³) for 2055 – Prefer Runway 05

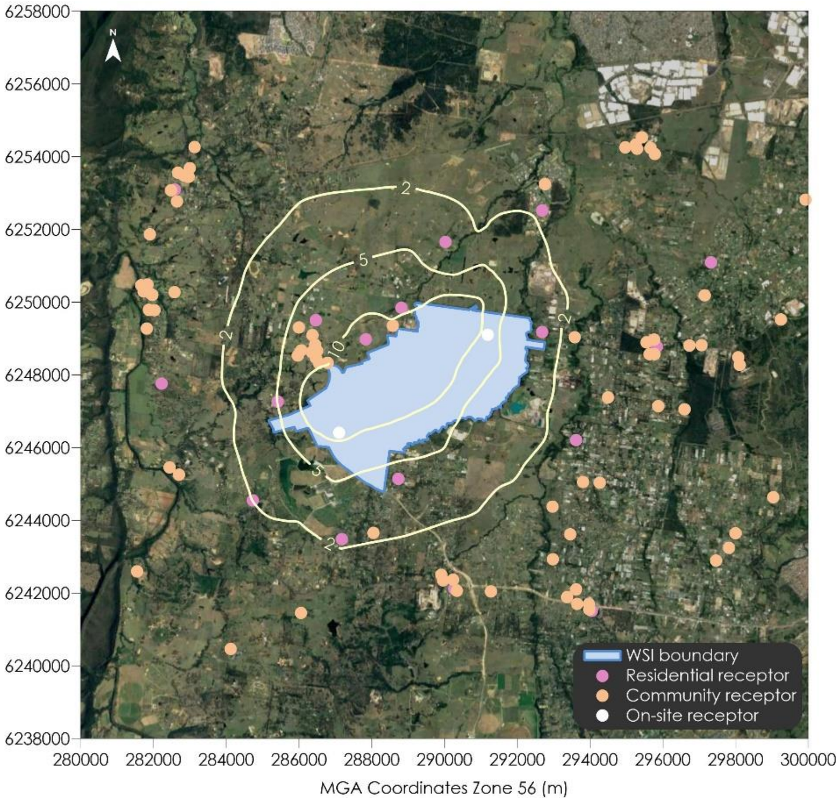


Figure C.59 Predicted incremental 99.9th percentile 1-hour average formaldehyde concentrations (µg/m³) for 2055 – Prefer Runway 05

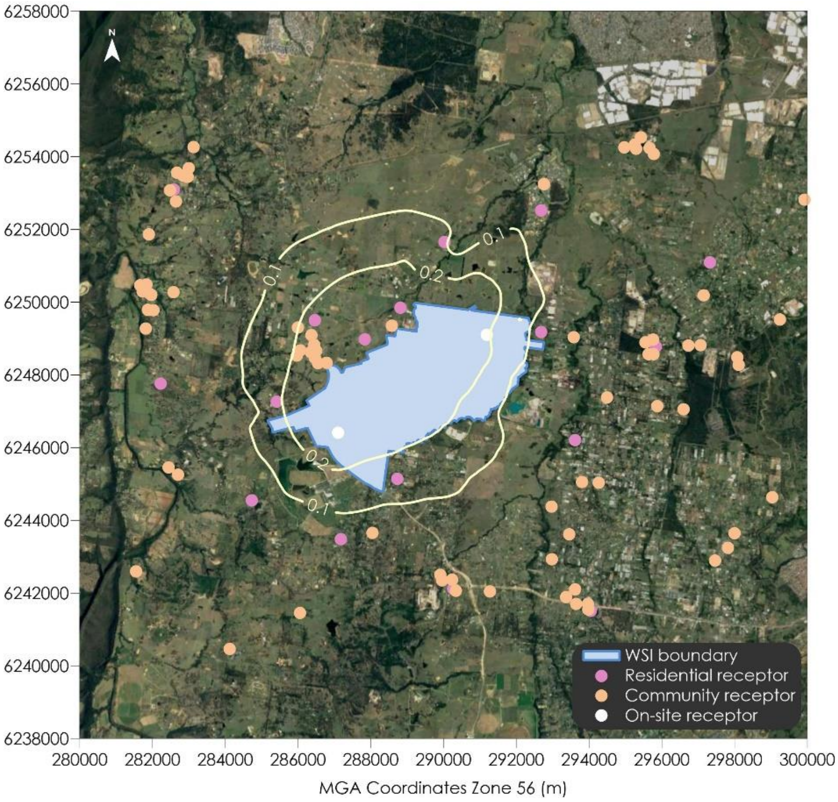


Figure C.60 Predicted incremental 99.9th percentile 1-hour average toluene concentrations (µg/m³) for 2055 – Prefer Runway 05

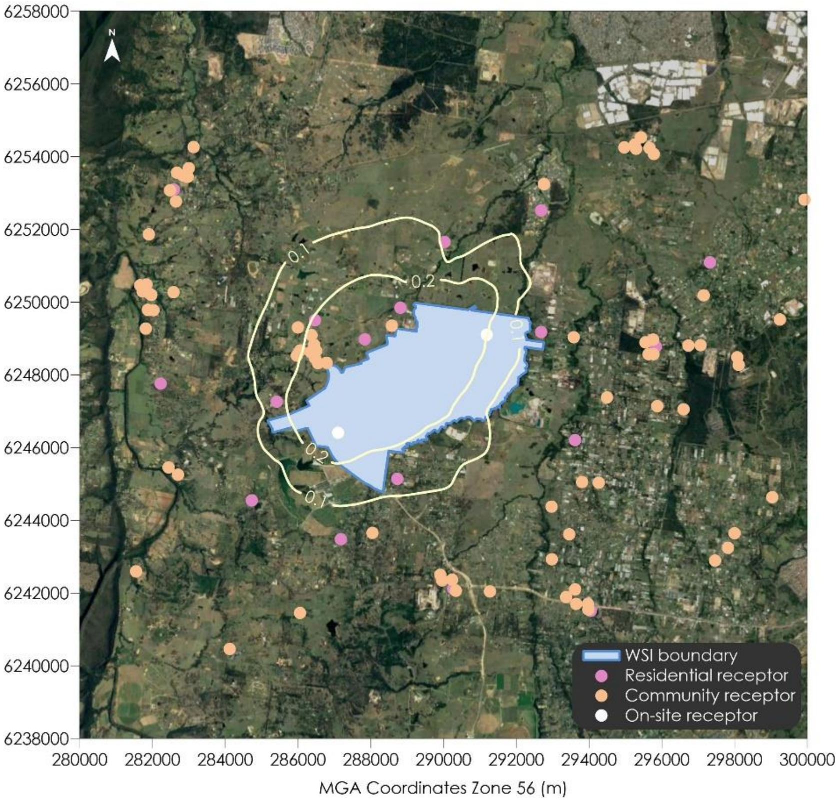


Figure C.61 Predicted incremental 99.9th percentile 1-hour average xylene concentrations (µg/m³) for 2055 – Prefer Runway 05

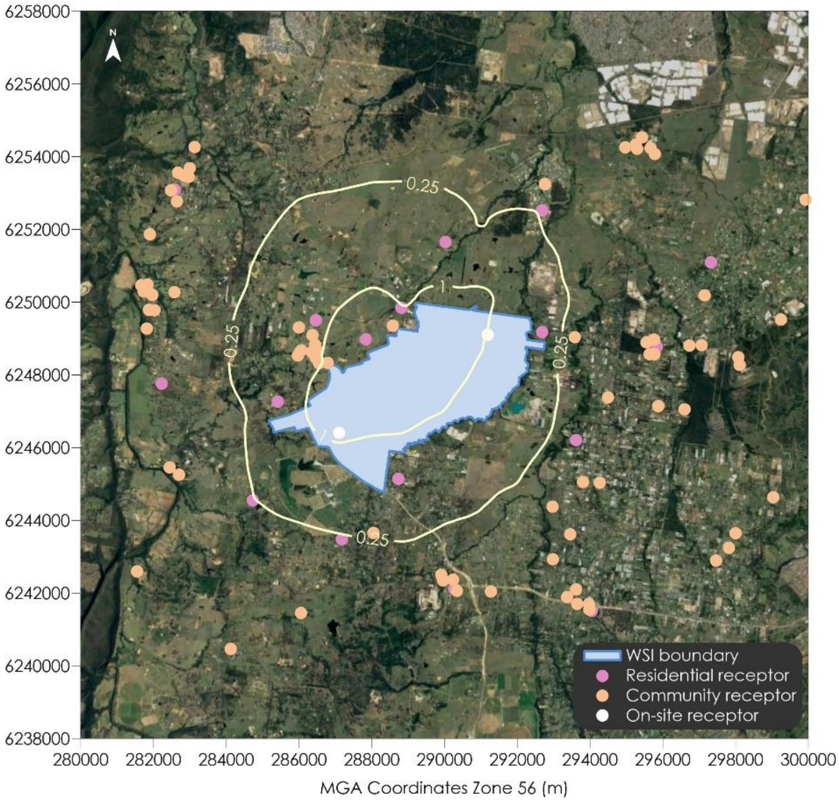


Figure C.62 Predicted incremental 99.9th percentile 1-hour average benzene concentrations (µg/m³) for 2055 – Prefer Runway 23

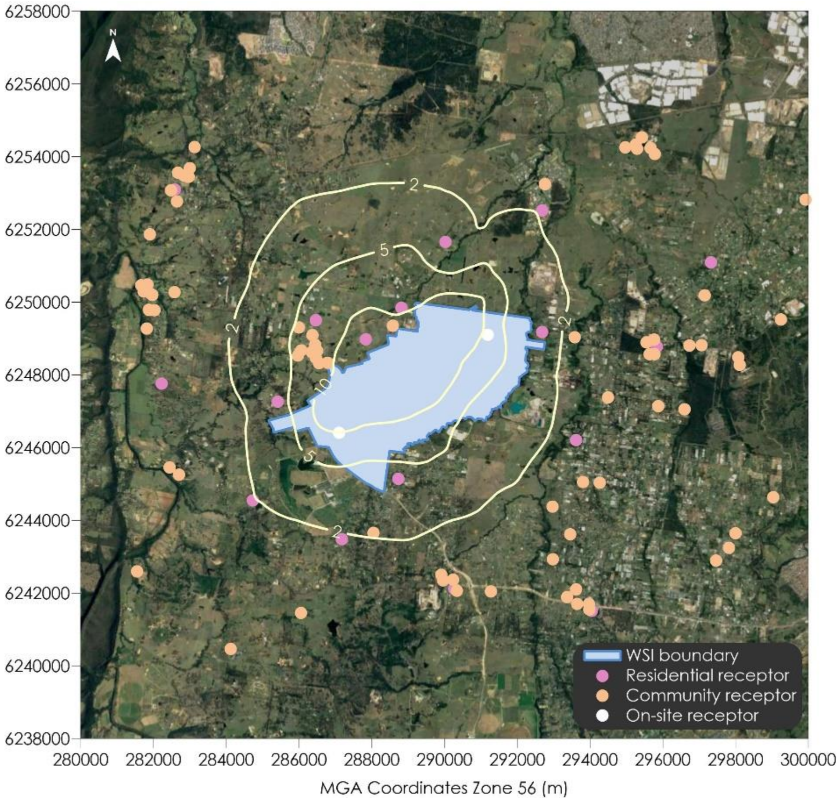


Figure C.63 Predicted incremental 99.9th percentile 1-hour average formaldehyde concentrations (µg/m³) for 2055 – Prefer Runway 23

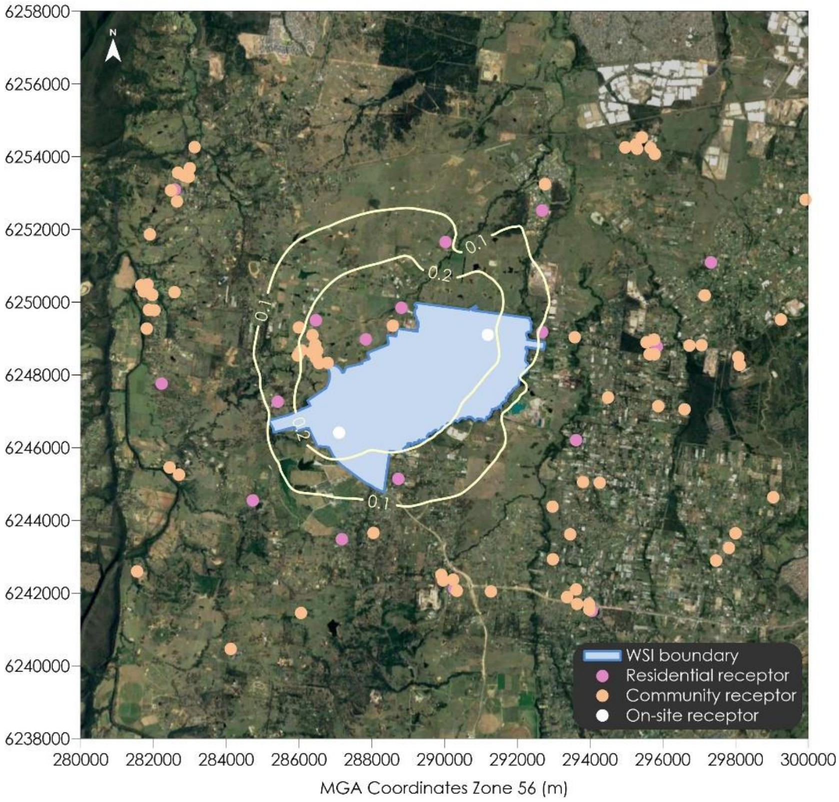


Figure C.64 Predicted incremental 99.9th percentile 1-hour average toluene concentrations (µg/m³) for 2055 – Prefer Runway 23

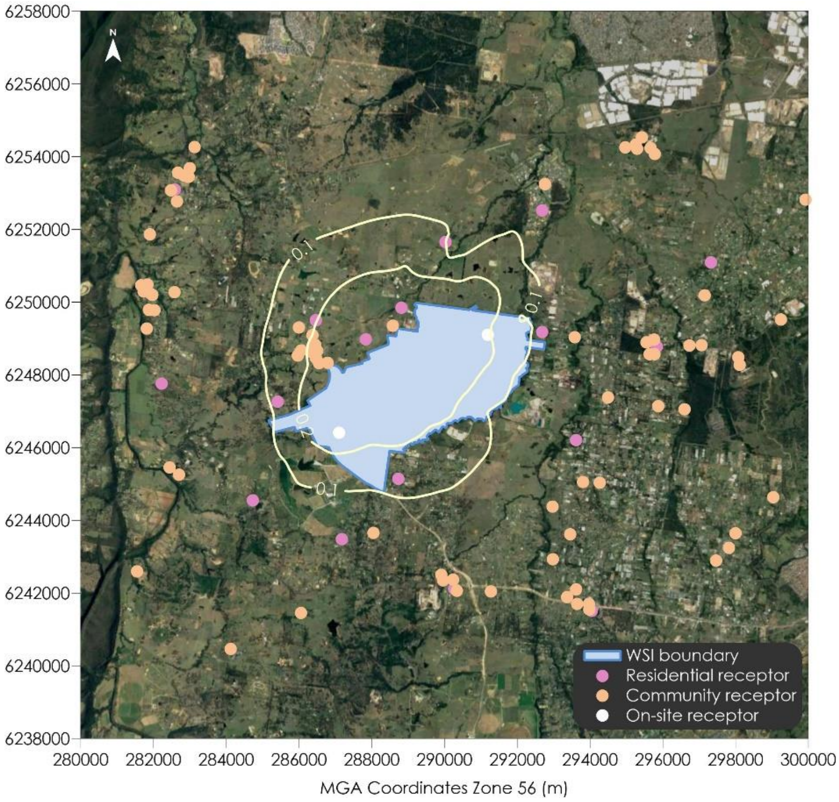


Figure C.65 Predicted incremental 99.9th percentile 1-hour average xylene concentrations (µg/m³) for 2055 – Prefer Runway 23

Appendix D

Regional air quality – results

D1 Regional air quality results

D1.1 Baseline air quality results

To assess the validity and performance of the regional model, existing emissions from all pollution sources across the GMR were modelled (i.e. without the project) and compared with DPE monitoring data for the same period and location.

It is technically challenging to develop a model that can provide an accurate result at a specific place at a specific time. General model performance is evaluated according to statistical indicators, (for example whether the scale and frequency of model results are comparable to the actual ranges of data over a year). However, the regional model needs to perform complex chemical calculations which rely on good spatial and temporal performance for accuracy. The model performance in this case must therefore be evaluated in in terms of how well it predicts air pollutant levels at specific locations at specific times.

The results from the baseline scenario were used to evaluate the model's ability to predict current, and by inference the future air quality impacts due to the project. The baseline model results do not include emissions from the project, and their purpose it to confirm the model is reliable at predicting known values at various locations. Where the model can conduct the complex chemical calculations and produce reliable results at the DPE monitoring sites, it is inferred that it will also provide reliable results once the source (the project) is included.

As previously mentioned, data for all existing emission sources in the GMR was obtained from the NSW EPA Air Emissions Inventory. This included all point and area source emissions from all commercial, industrial, domestic, biogenic, and on-road and off-road sources across NSW. The GMR emission inventory data are used as anthropogenic emissions input along with the global emission database EDGAR for emissions outside the GMR, the biogenic emissions are based on the MEGAN biogenic model, the marine aerosol (sea salt) and soil dust emissions as provided in the CMAQ model.

A comparison of the O_3 and NO_2 concentrations between the baseline scenario and DPE monitoring data are shown in Figure D.1 and Figure D.2. The baseline O_3 and NO_2 model results show excellent alignment with the monitoring data, and reliably follow the diurnal trends. The Ozone results at Bringelly, the nearest DPE station to the project are especially good, the NO_2 results at Chullora are less good, but this is expected because the monitoring site is in an industrial area with many nearby confounding sources such as emissions from mobile heavy machinery and trucks that operate variously each hour. This large erratic local variability in the NO_2 emissions cannot be accounted for in that level of detail (i.e. each truck each hour) in a model of this scale, and some scatter is to be expected. The key trends however are well represented.

The results indicate the model is performing very well and that it is reliable and accurate.

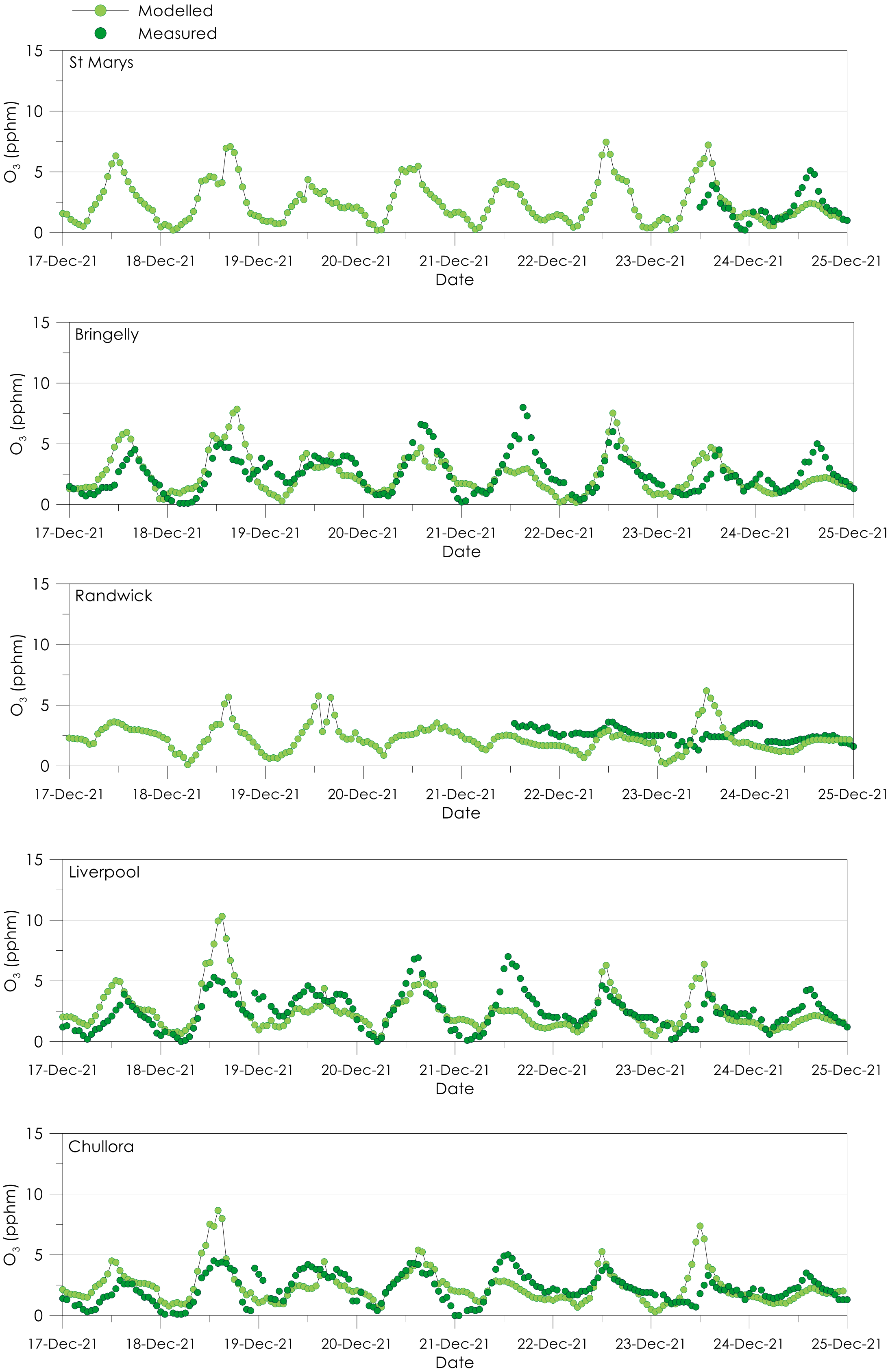


Figure D.1 Hourly average baseline O_3 results compared with monitoring data

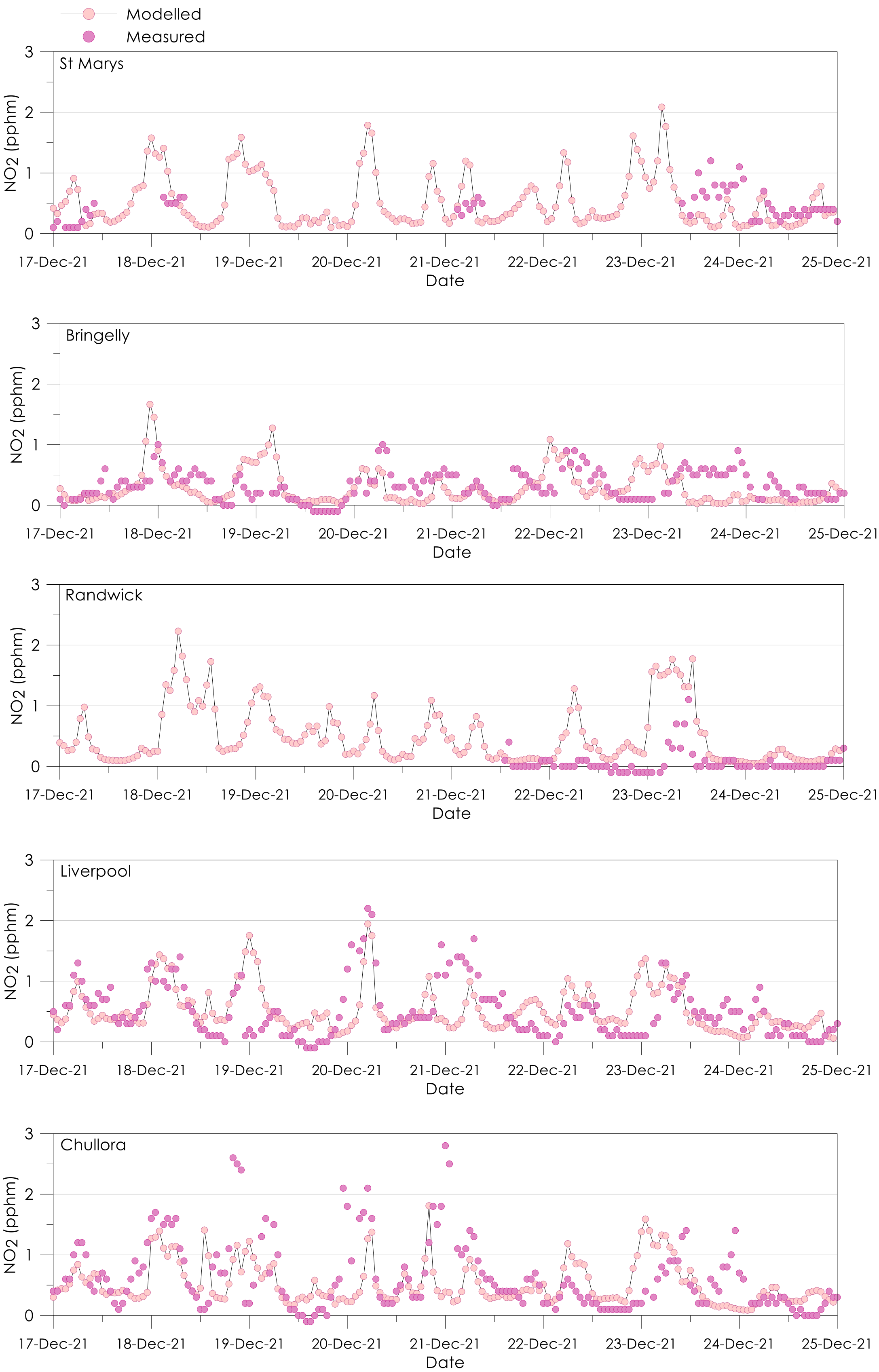


Figure D.2 Hourly average baseline NO_2 results compared with monitoring data

Maximum pollutant contours for ozone, NO_2, SO_2, CO, $PM_{2.5}$ and PM_{10} for all scenarios compared with the baseline are presented in the Figure D.3 to Figure D.82. These figures show reduced maximum ozone concentrations over densely populated areas, but increased maximum ozone concentrations over forested land and sparsely populated areas.

The results show that Increases in levels of NO_2 are largely limited to the immediate vicinity of the project, $PM_{2.5}$ and that the impact of all other emissions from the project on the existing pollutant concentrations would be negligible and unlikely to be discernible above background concentrations.

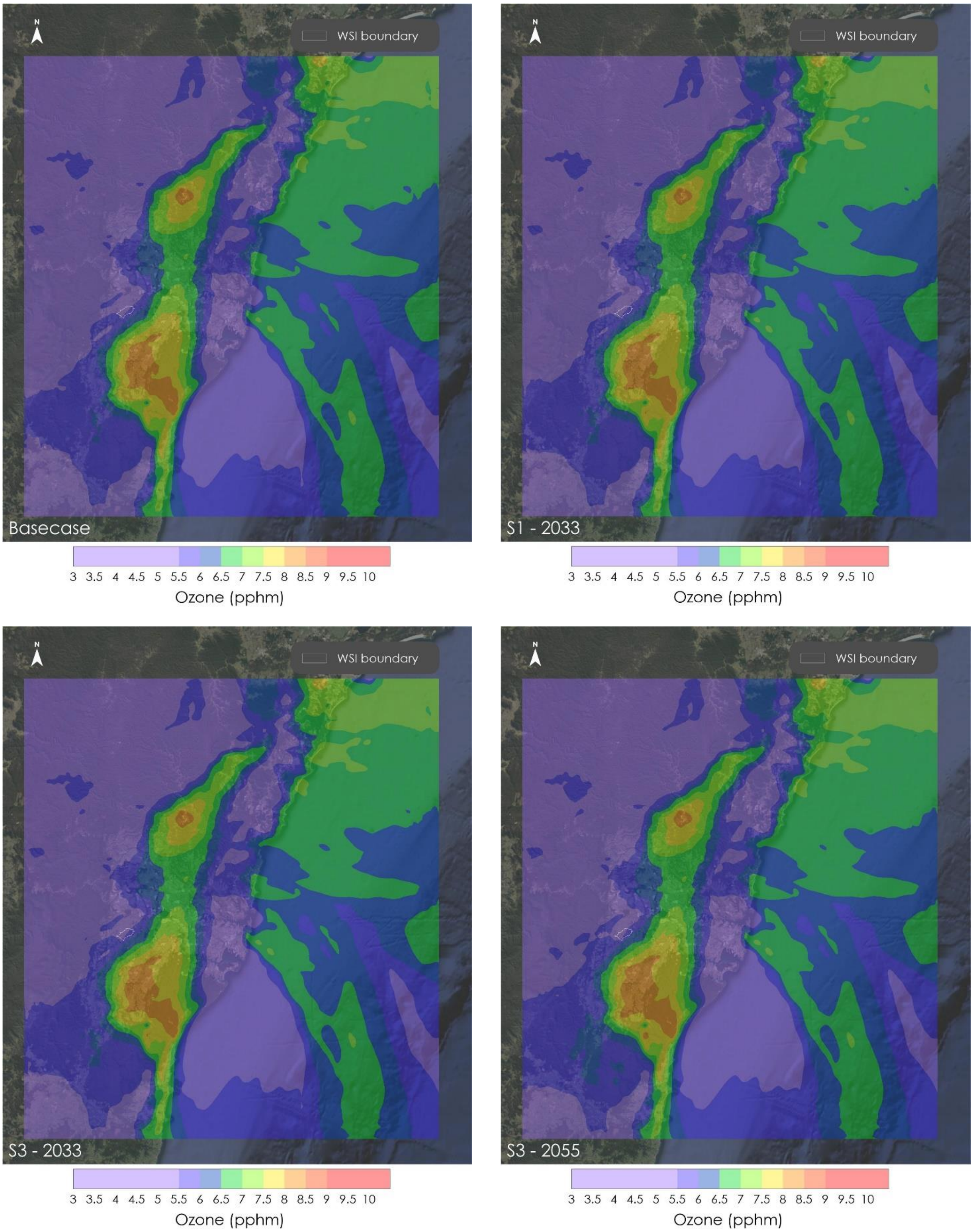


Figure D.3 Maximum predicted rolling 8-hour average ozone concentrations for basecase, 2033 - No preference, 2033 – Prefer Runway 05 and 2055 – Prefer Runway 05

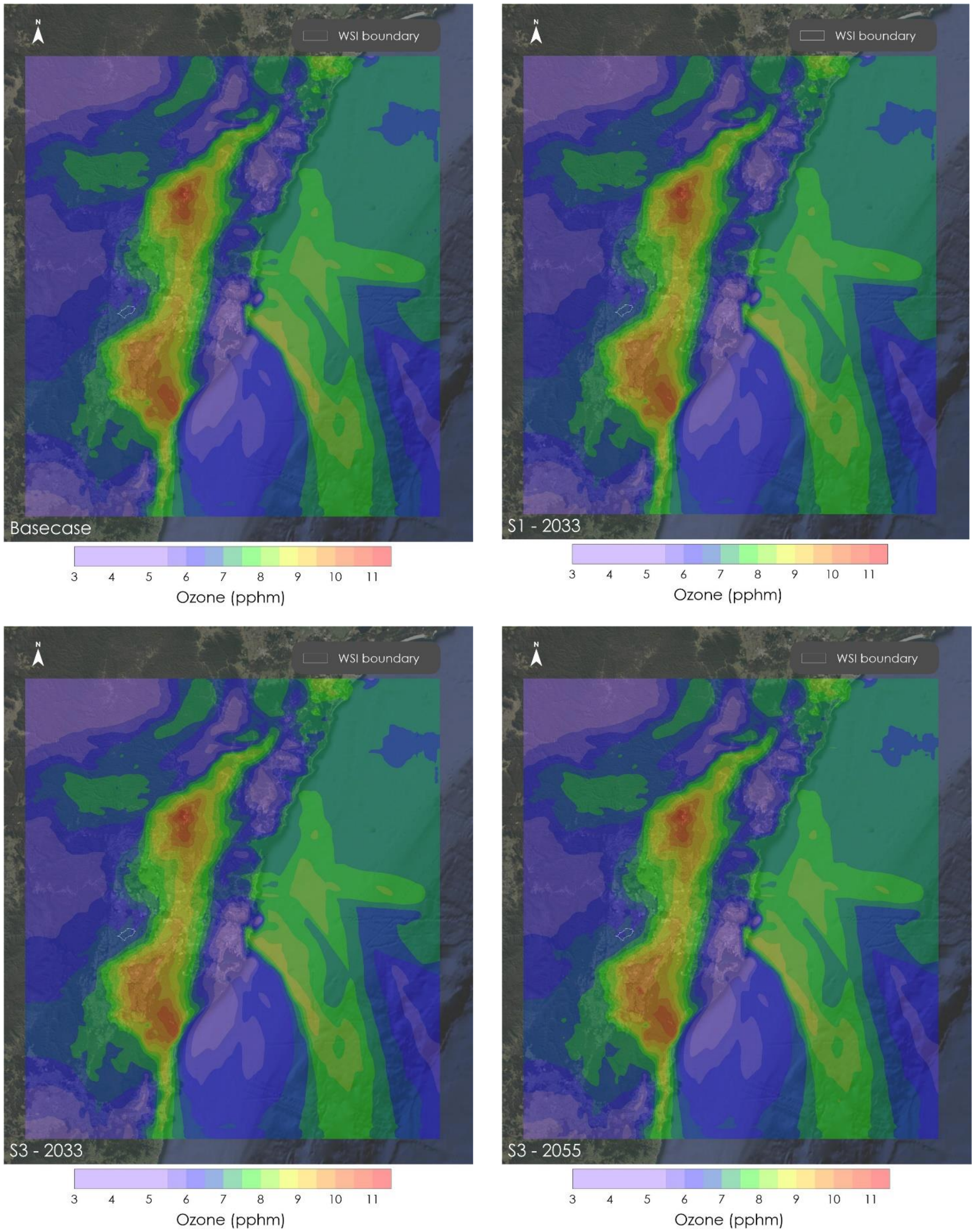


Figure D.4 Maximum predicted rolling 4-hour average ozone concentrations for basecase, 2033 - No preference, 2033 – Prefer Runway 05 and 2055 – Prefer Runway 05

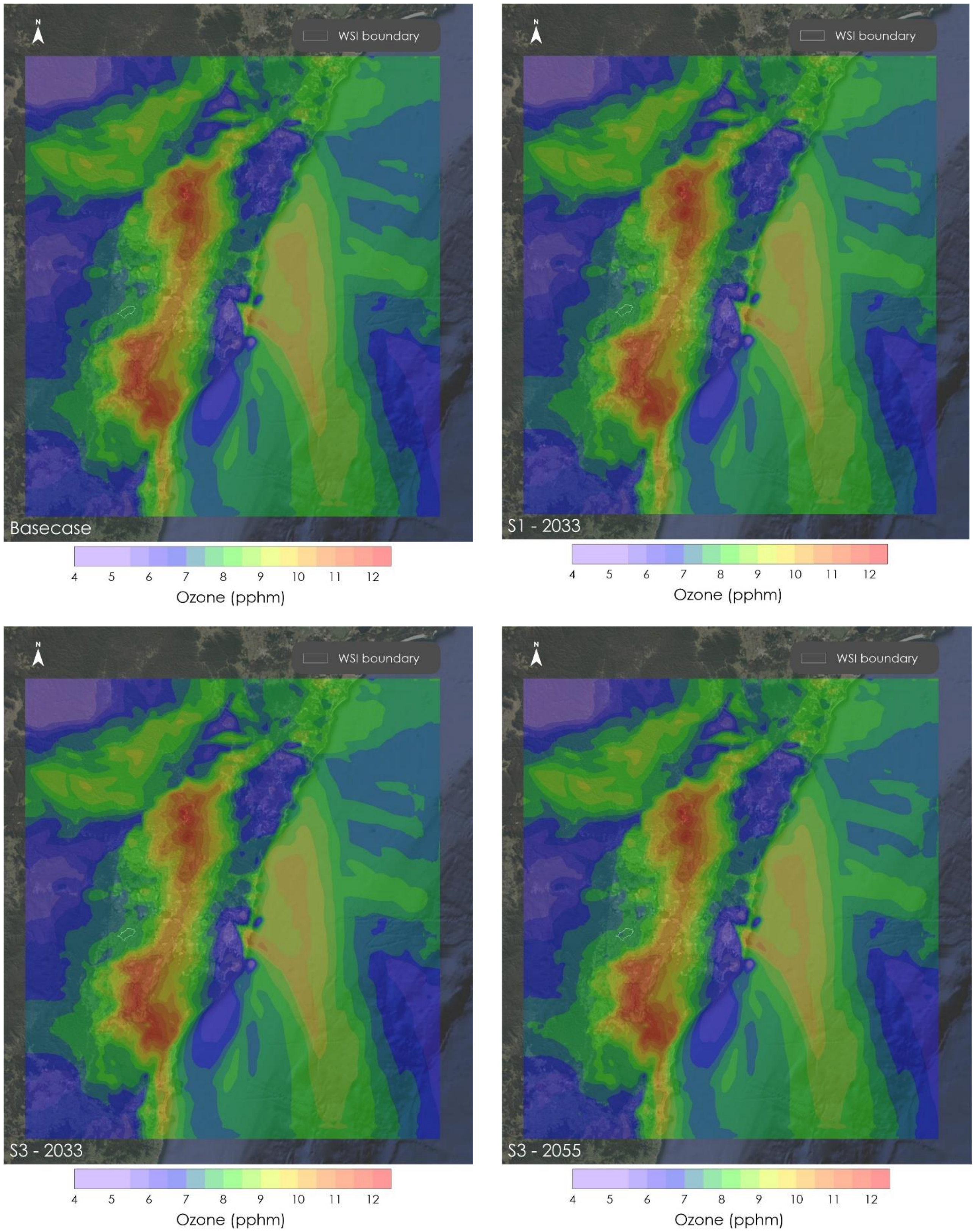


Figure D.5 Maximum predicted 1-hour average ozone concentrations for basecase, 2033 - No preference, 2033 – Prefer Runway 05 and 2055 – Prefer Runway 05

D2 Daily ozone change 2033 – No preference

Table D.1 Daily maximum ozone concentrations – 2033 - No preference

Date	2033 No preference maximum 1-hour average (pphm)			2033 No preference maximum 4-hour average (pphm)			2033 No preference maximum 8-hour average (pphm)		
	Background	Cumulative	Change	Background	Cumulative	Change	Background	Cumulative	Change
Change in maximum ozone concentration									
17/12/2021	7.8	7.8	0.0	6.4	6.5	0.0	5.4	5.5	0.1
18/12/2021	12.2	12.2	0.0	10.9	10.9	0.0	8.4	8.4	0.0
19/12/2021	10.1	10.1	0.0	8.8	8.8	0.0	7.1	7.1	0.0
20/12/2021	7.6	7.6	0.0	7.4	7.4	0.0	6.4	6.4	0.0
21/12/2021	6.4	6.4	0.0	7.0	7.0	0.0	6.8	6.8	0.0
22/12/2021	9.2	9.2	0.0	7.5	7.5	0.0	6.1	6.1	0.0
23/12/2021	9.3	9.3	0.0	8.3	8.3	0.0	7.6	7.6	0.0
24/12/2021	4.0	4.0	0.0	3.6	3.6	0.0	4.6	4.6	0.0
Concentration of maximum change in ozone									
17/12/2021	6.6	6.7	0.1	6.2	6.3	0.1	5.1	5.2	0.1
18/12/2021	5.0	5.0	0.0	5.8	5.8	0.0	5.7	5.8	0.1
19/12/2021	4.2	4.4	0.1	3.6	3.7	0.1	4.0	4.1	0.0
20/12/2021	3.6	4.0	0.4	3.5	3.7	0.2	3.2	3.4	0.1
21/12/2021	3.8	3.9	0.1	4.0	4.1	0.1	3.7	3.8	0.1
22/12/2021	7.0	7.1	0.1	6.3	6.4	0.1	5.6	5.6	0.1
23/12/2021	6.7	6.8	0.1	4.7	4.9	0.1	4.5	4.6	0.2
24/12/2021	2.3	2.4	0.0	2.3	2.3	0.0	2.5	2.5	0.0

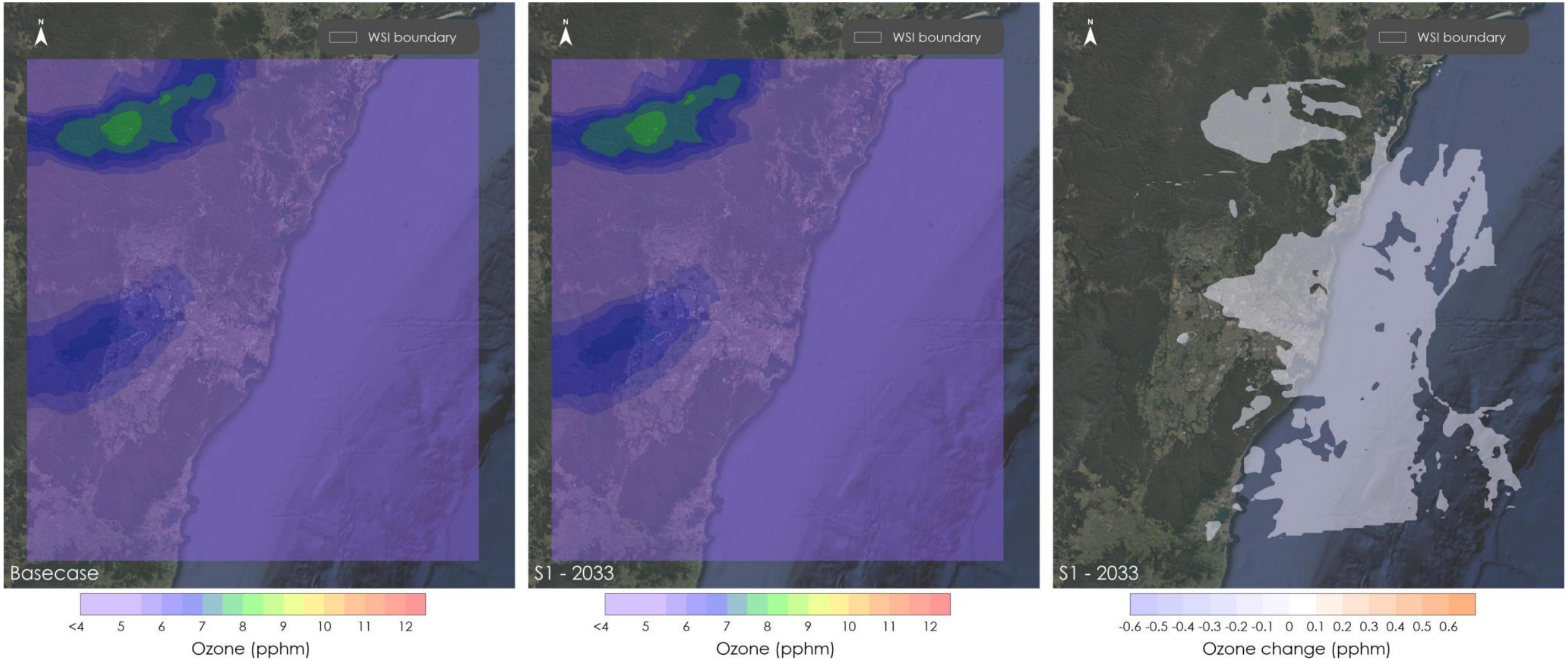


Figure D.6 Daily maximum 1-hour average ozone concentrations 2033 - No preference 17/12/2021

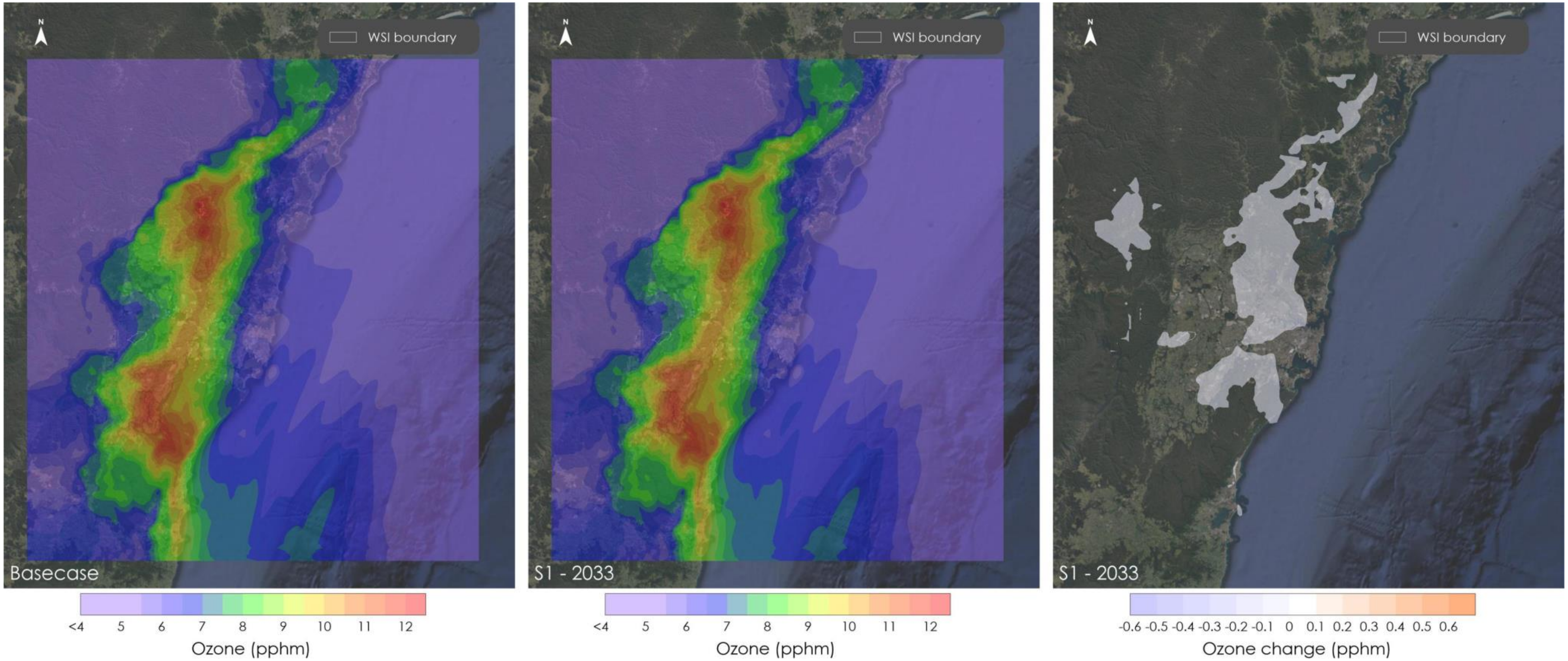


Figure D.7 Daily maximum 1-hour average ozone concentrations 2033 - No preference 18/12/2021

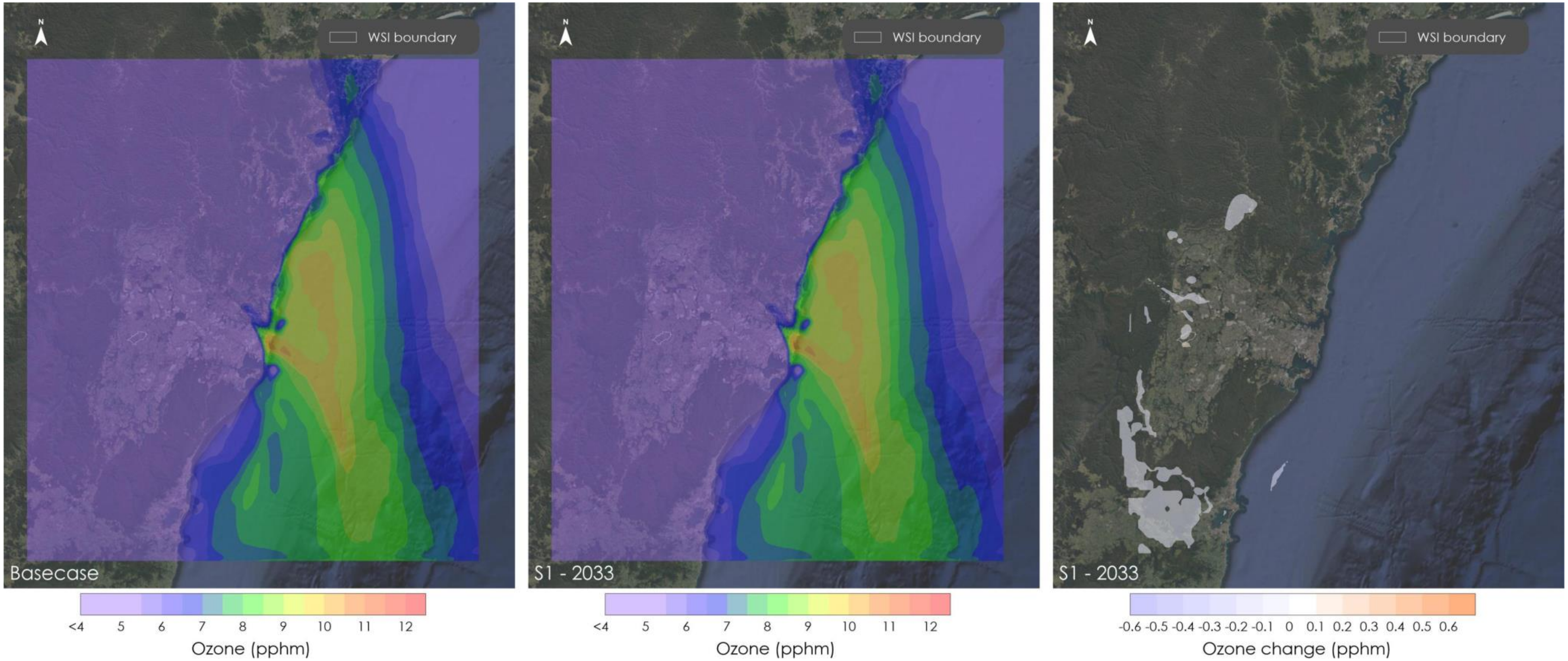


Figure D.8 Daily maximum 1-hour average ozone concentrations 2033 - No preference 19/12/2021

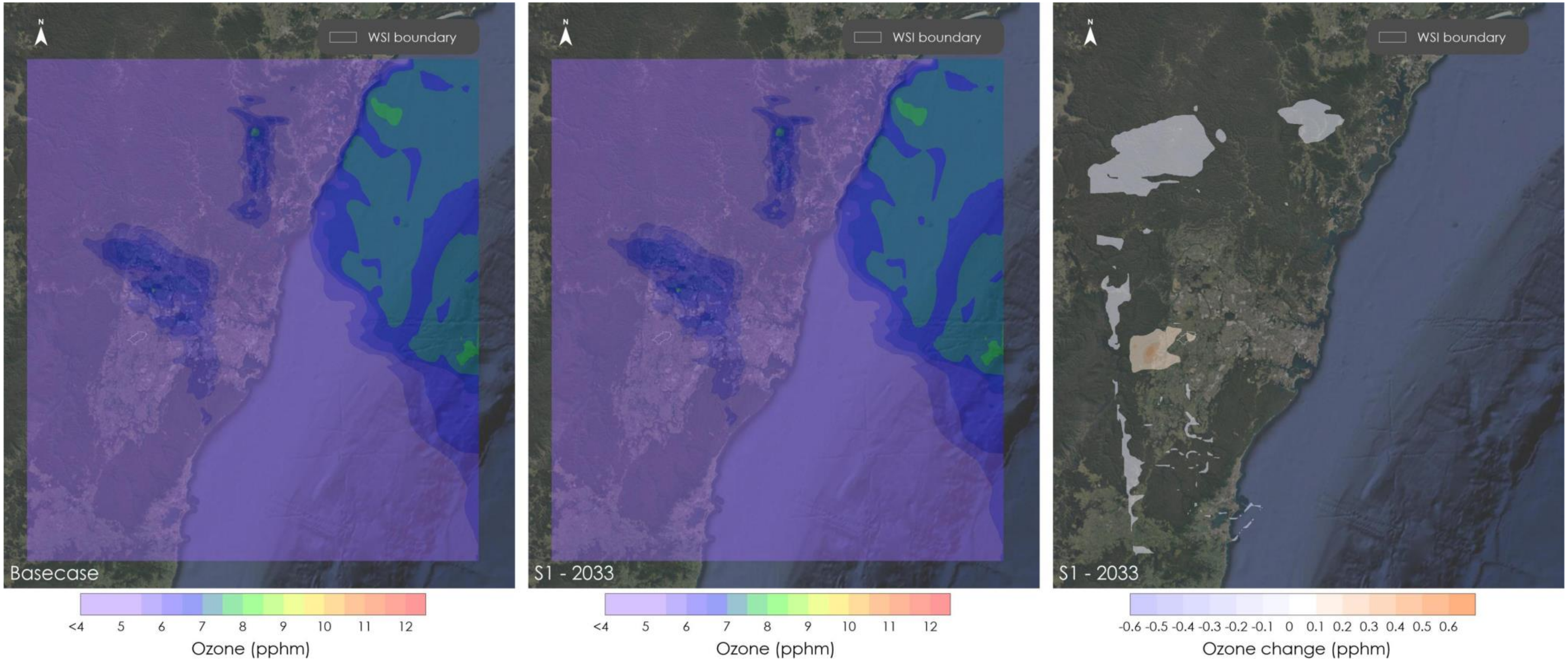


Figure D.9 Daily maximum 1-hour average ozone concentrations 2033 - No preference 20/12/2021

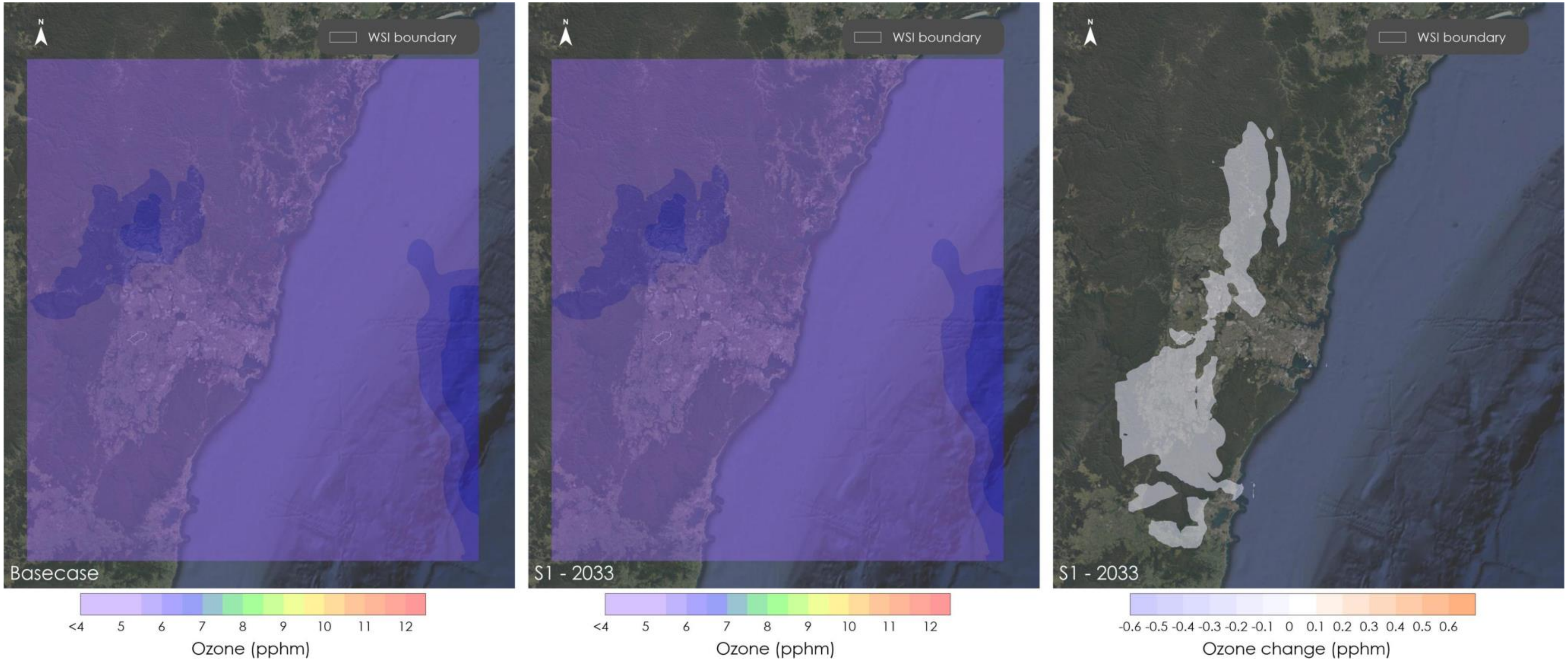


Figure D.10 Daily maximum 1-hour average ozone concentrations 2033 - No preference 21/12/2021

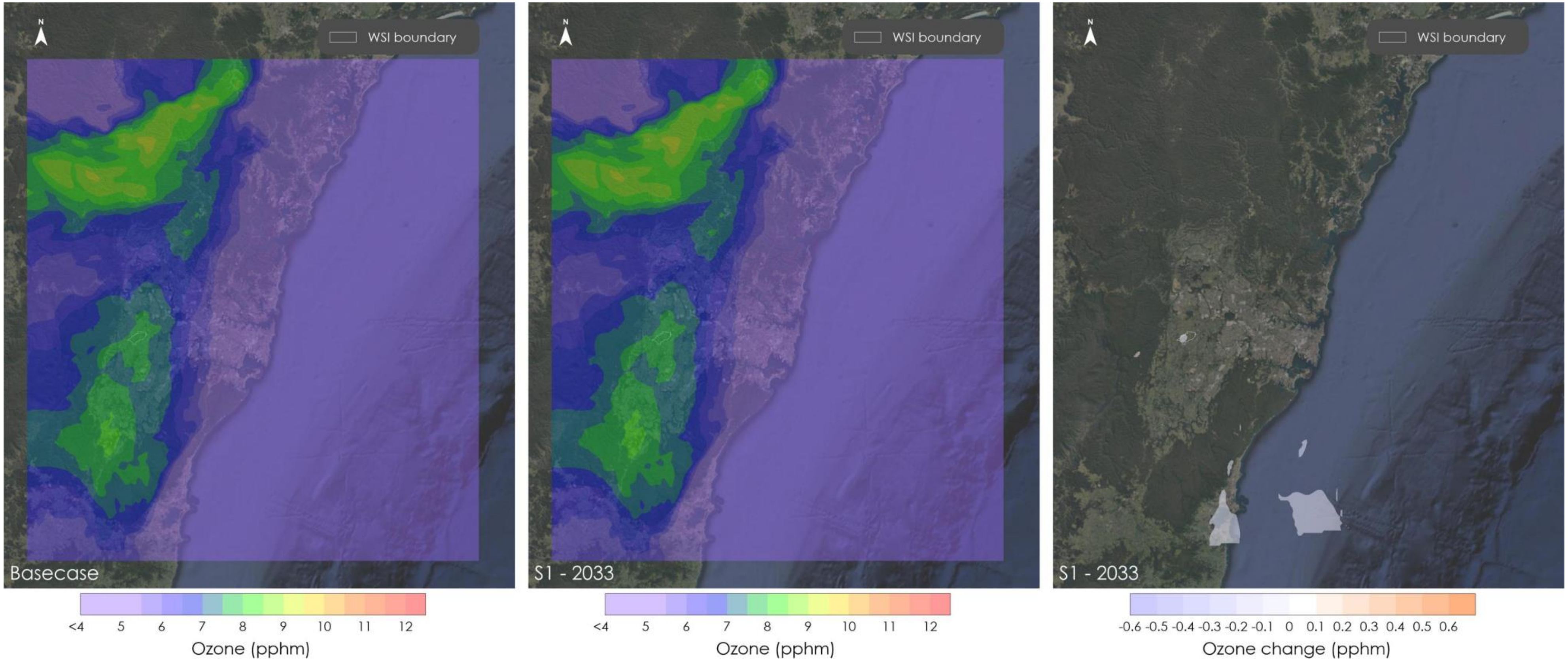


Figure D.11 Daily maximum 1-hour average ozone concentrations 2033 - No preference 22/12/2021

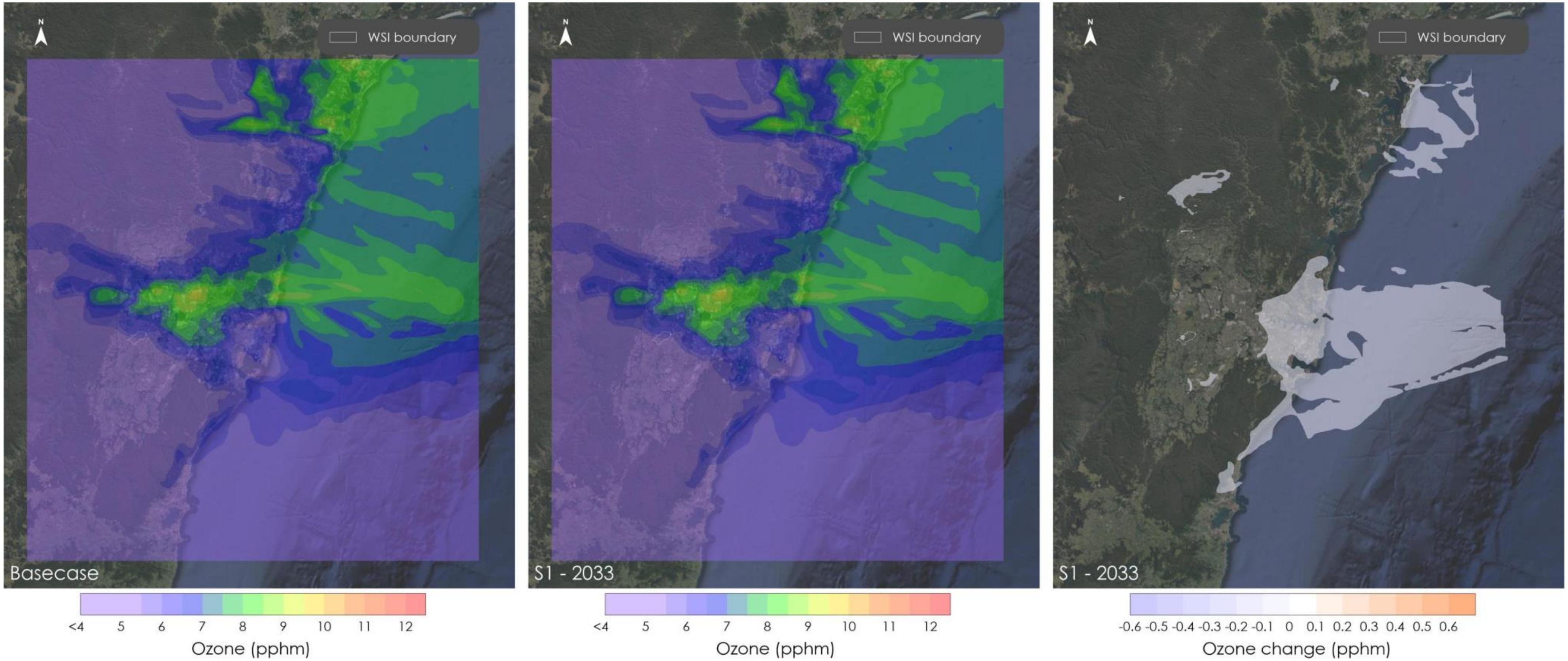


Figure D.12 Daily maximum 1-hour average ozone concentrations 2033 - No preference 23/12/2021

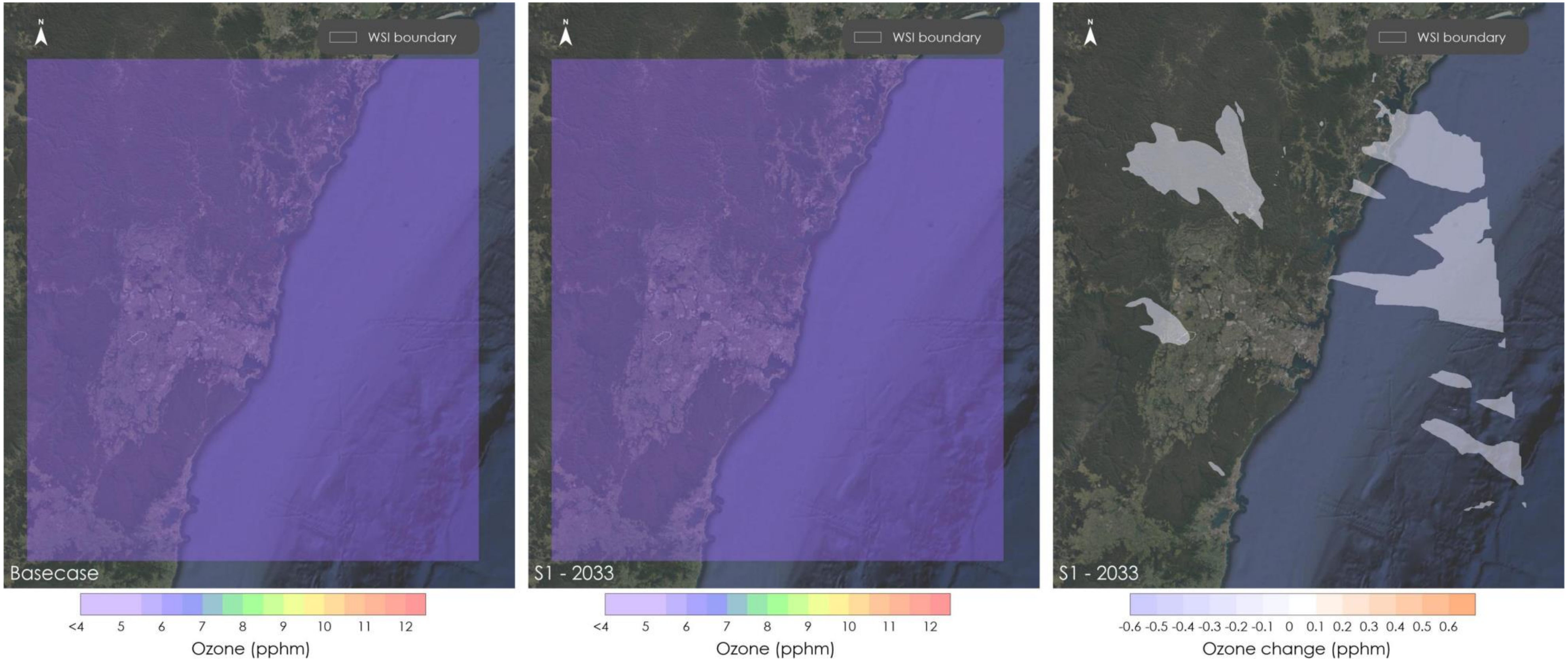


Figure D.13 Daily maximum 1-hour average ozone concentrations 2033 - No preference 24/12/2021

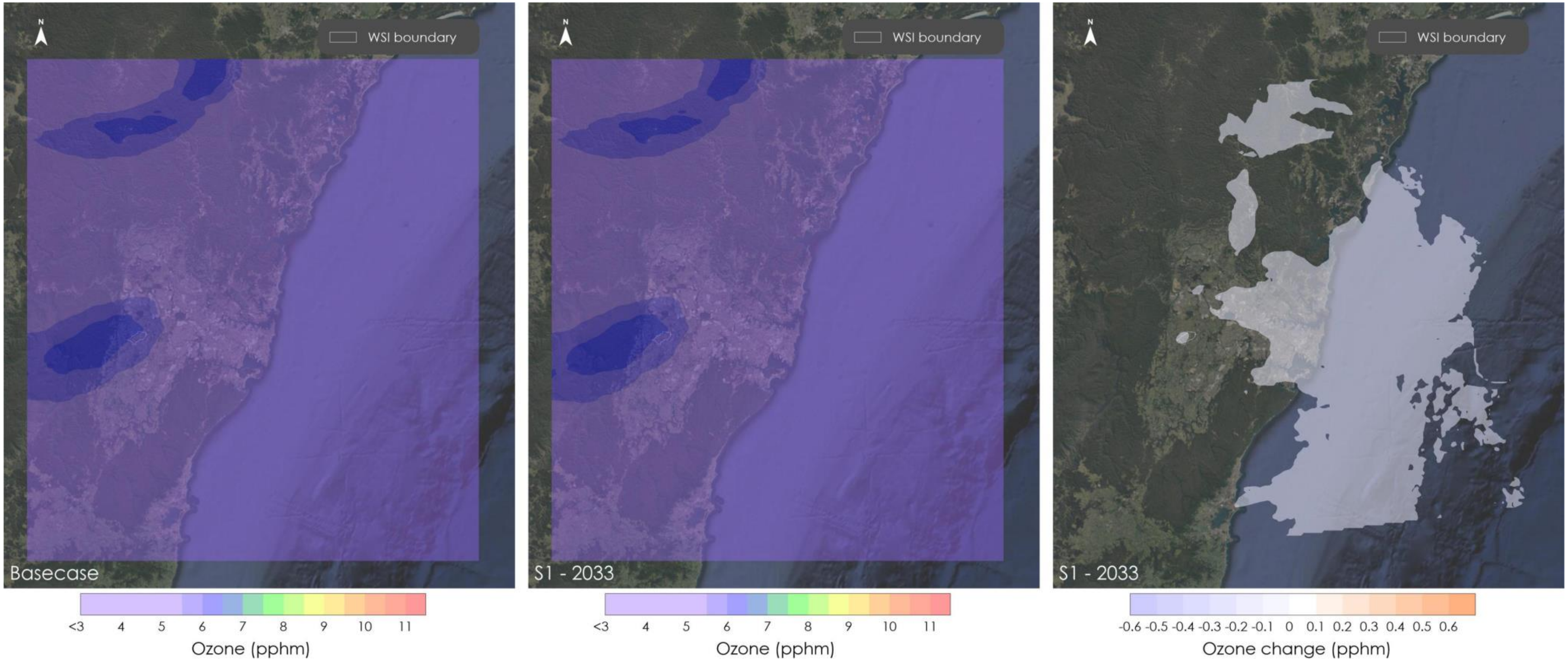


Figure D.14 Daily maximum 4-hour average ozone concentrations 2033 - No preference 17/12/2021

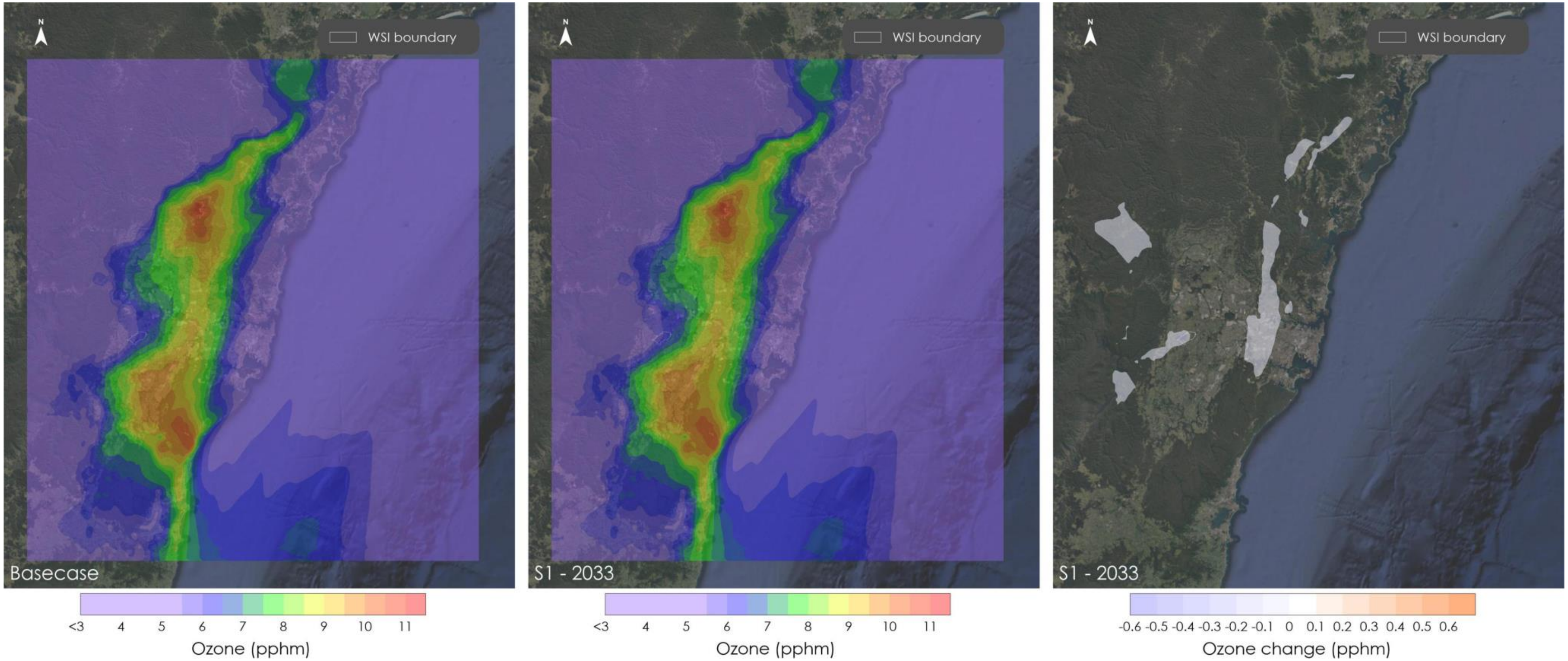


Figure D.15 Daily maximum 4-hour average ozone concentrations 2033 - No preference 18/12/2021

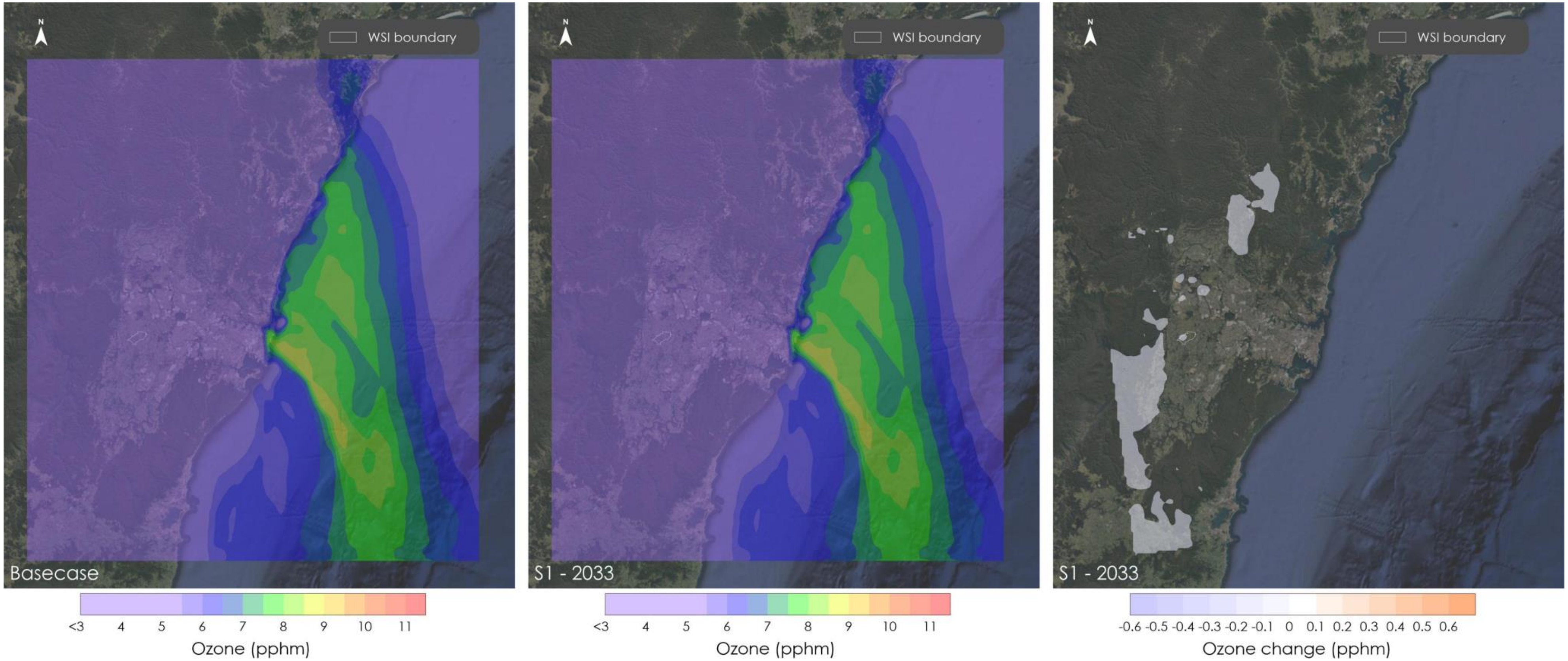


Figure D.16 Daily maximum 4-hour average ozone concentrations 2033 - No preference 19/12/2021

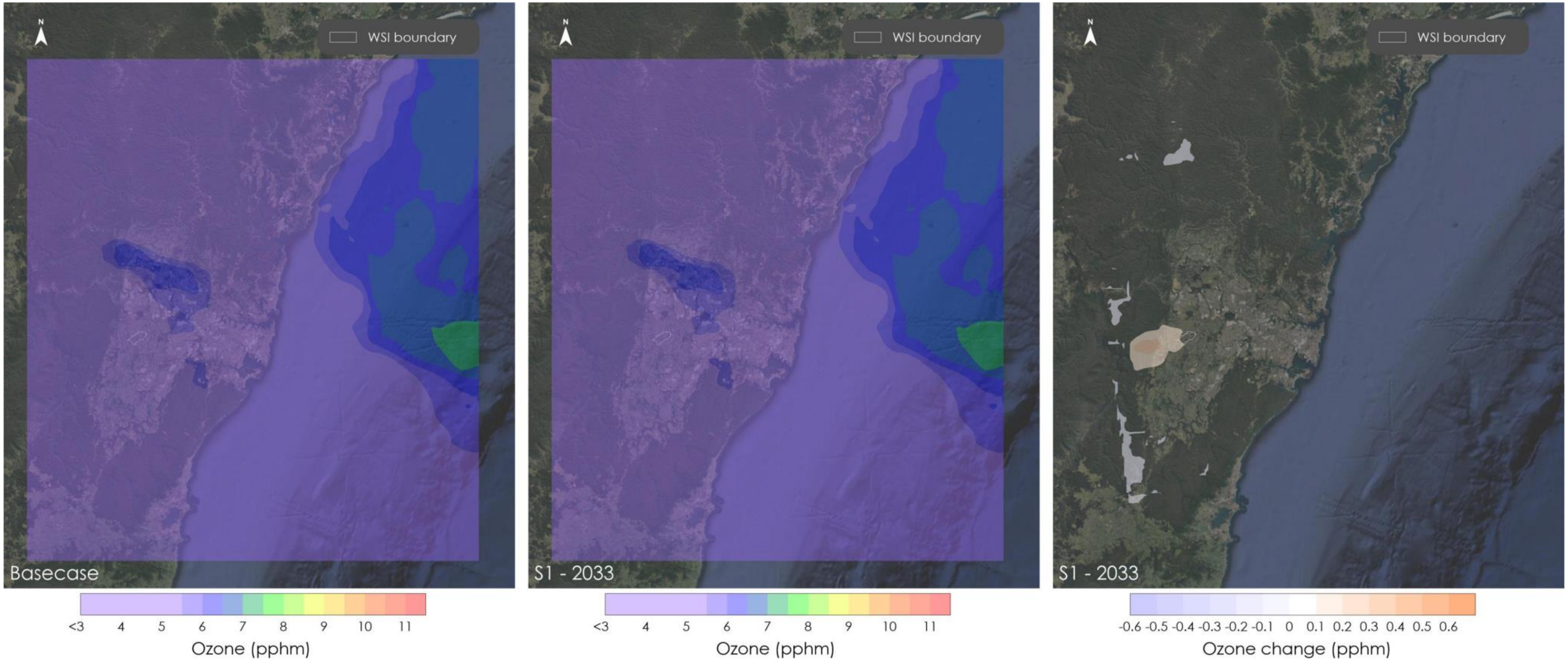


Figure D.17 Daily maximum 4-hour average ozone concentrations 2033 - No preference 20/12/2021

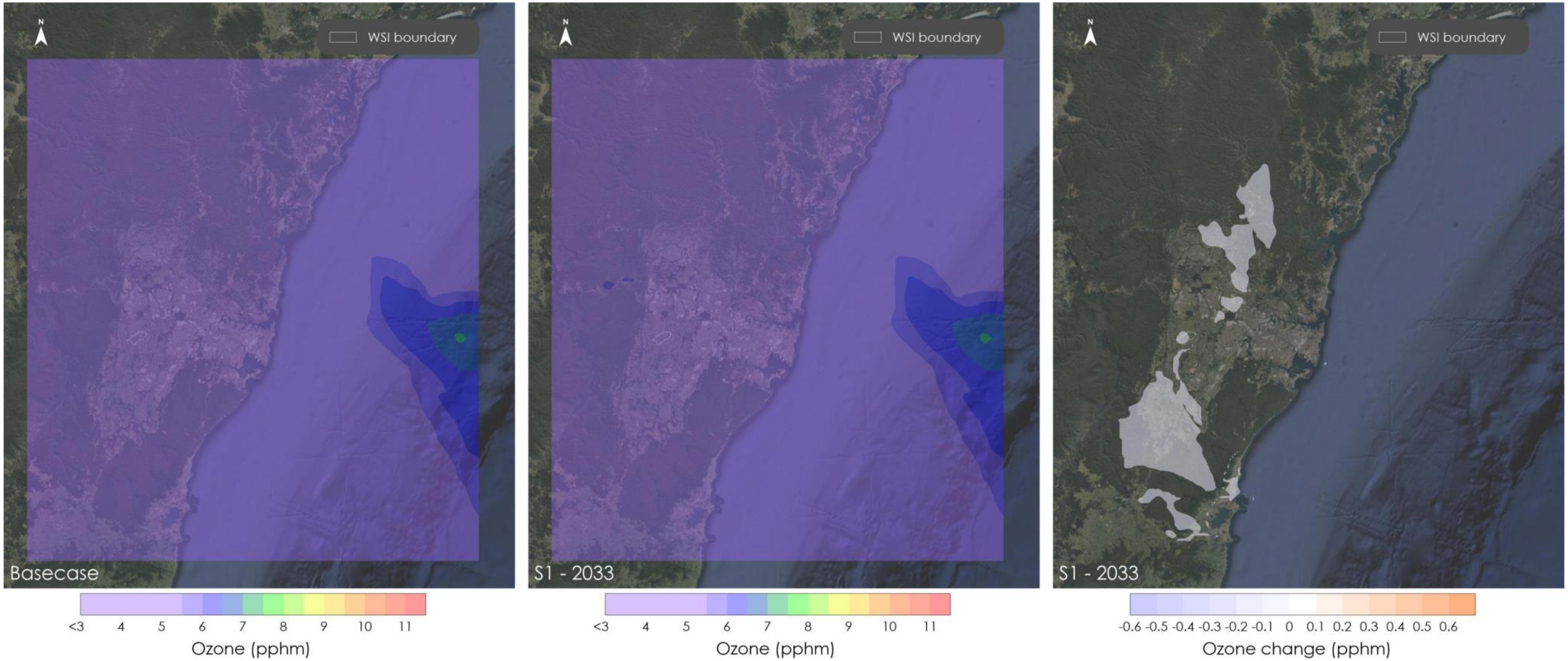


Figure D.18 Daily maximum 4-hour average ozone concentrations 2033 - No preference 21/12/2021

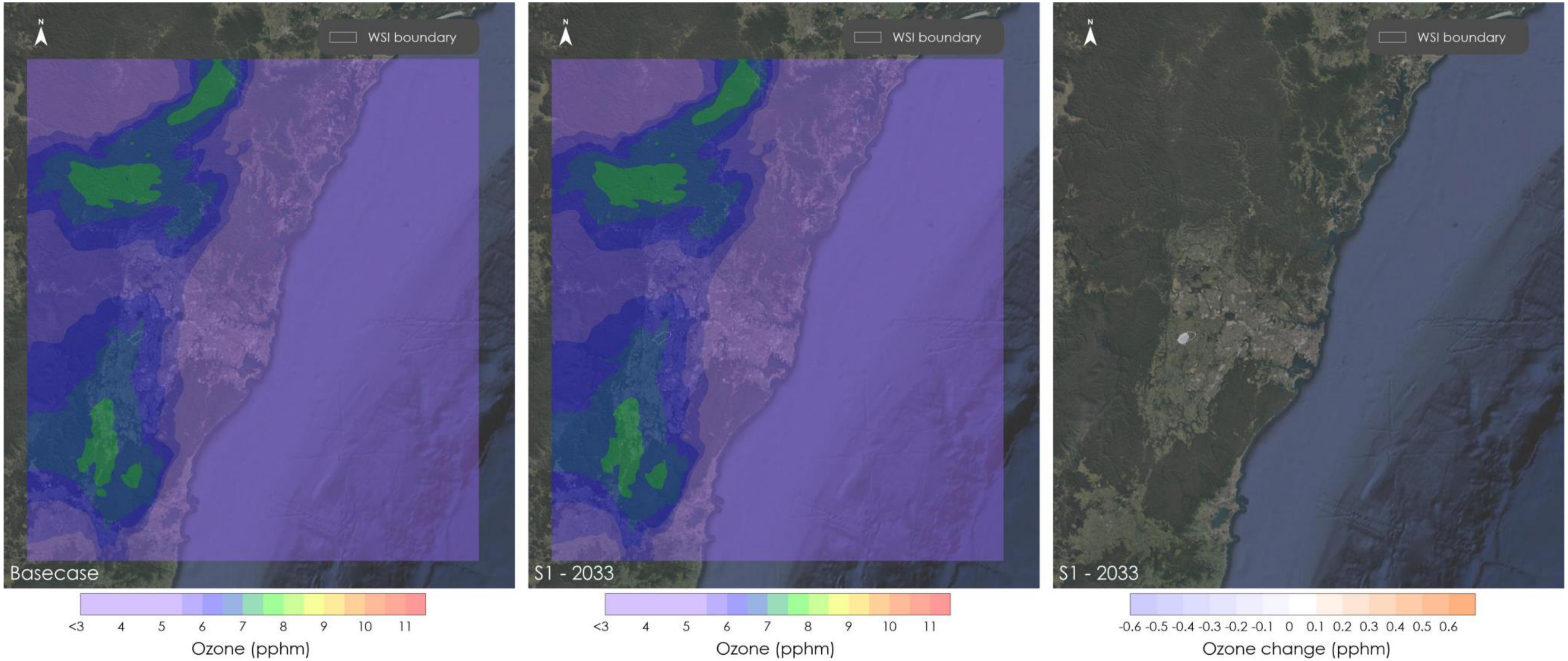


Figure D.19 Daily maximum 4-hour average ozone concentrations 2033 - No preference 22/12/2021

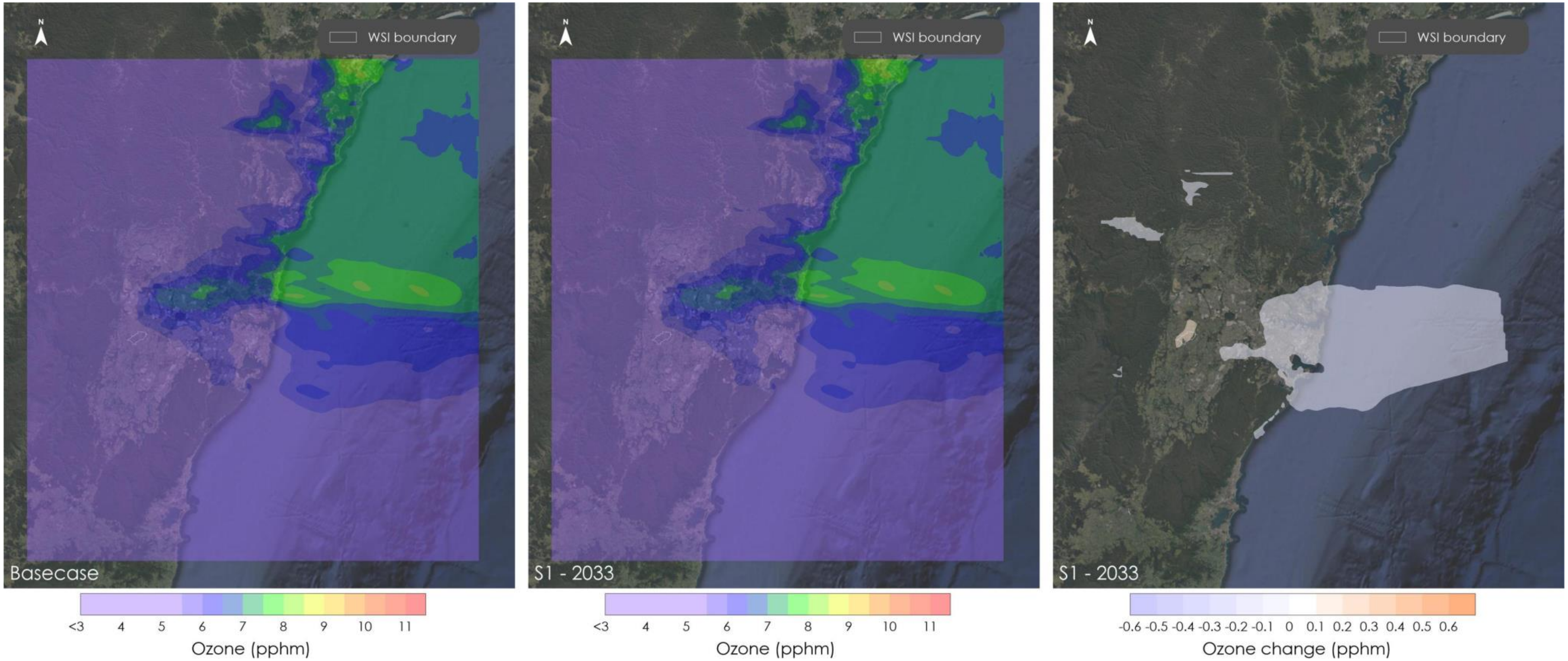


Figure D.20 Daily maximum 4-hour average ozone concentrations 2033 - No preference 23/12/2021

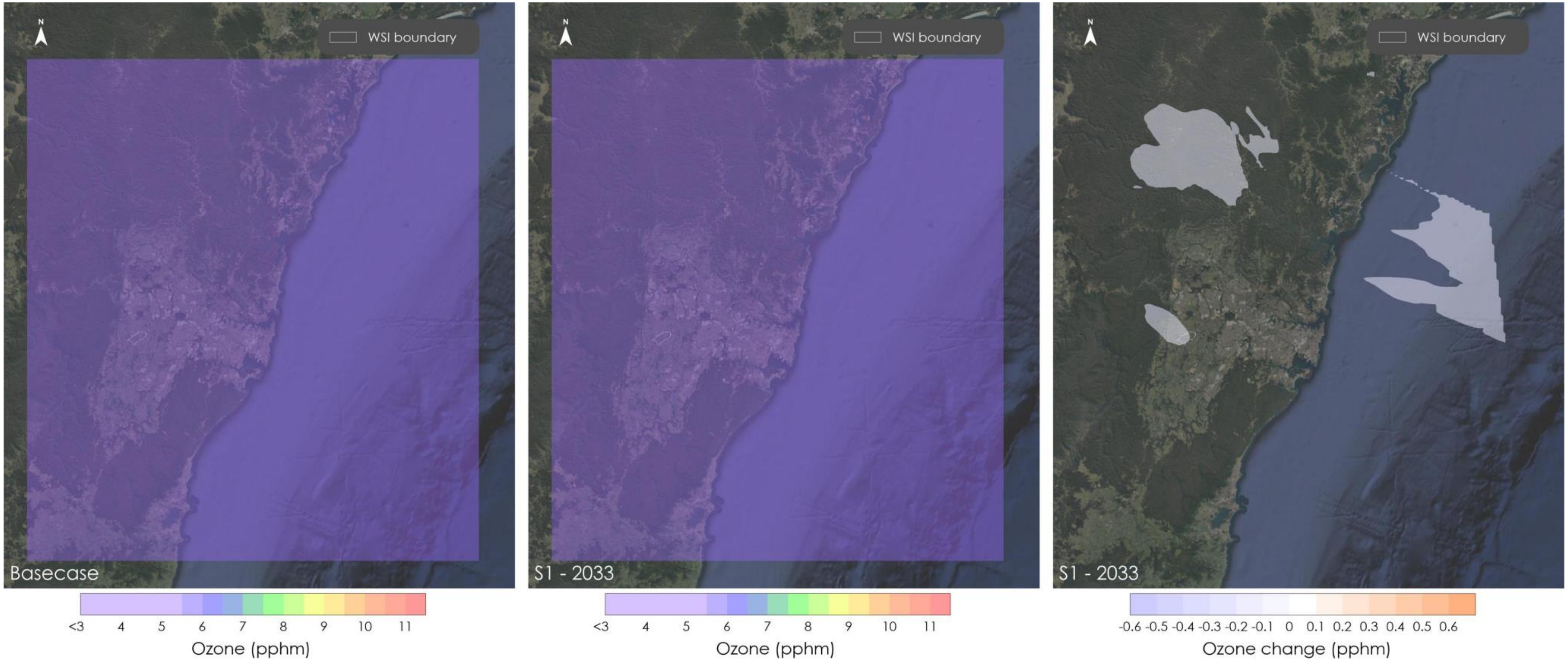


Figure D.21 Daily maximum 4-hour average ozone concentrations 2033 - No preference 24/12/2021

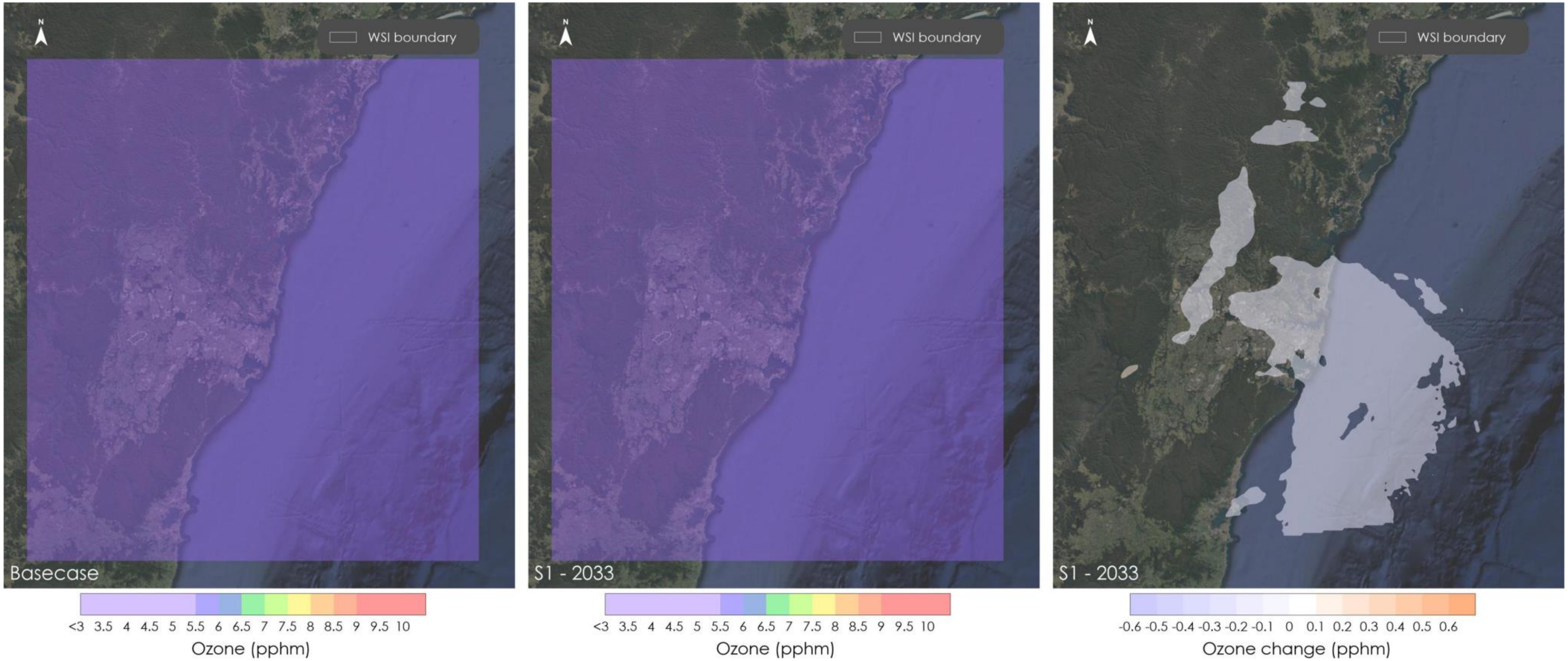


Figure D.22 Daily maximum 8-hour average ozone concentrations 2033 - No preference 17/12/2021

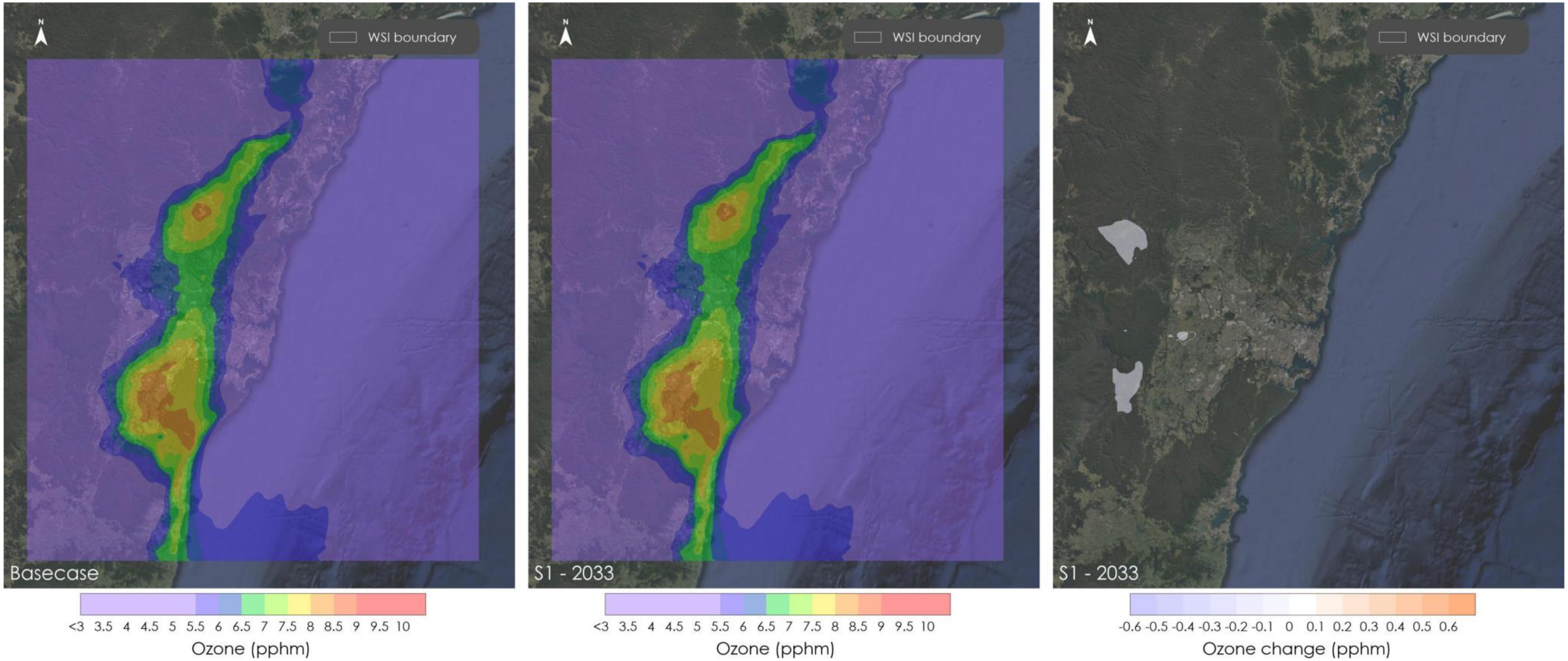


Figure D.23 Daily maximum 8-hour average ozone concentrations 2033 - No preference 18/12/2021

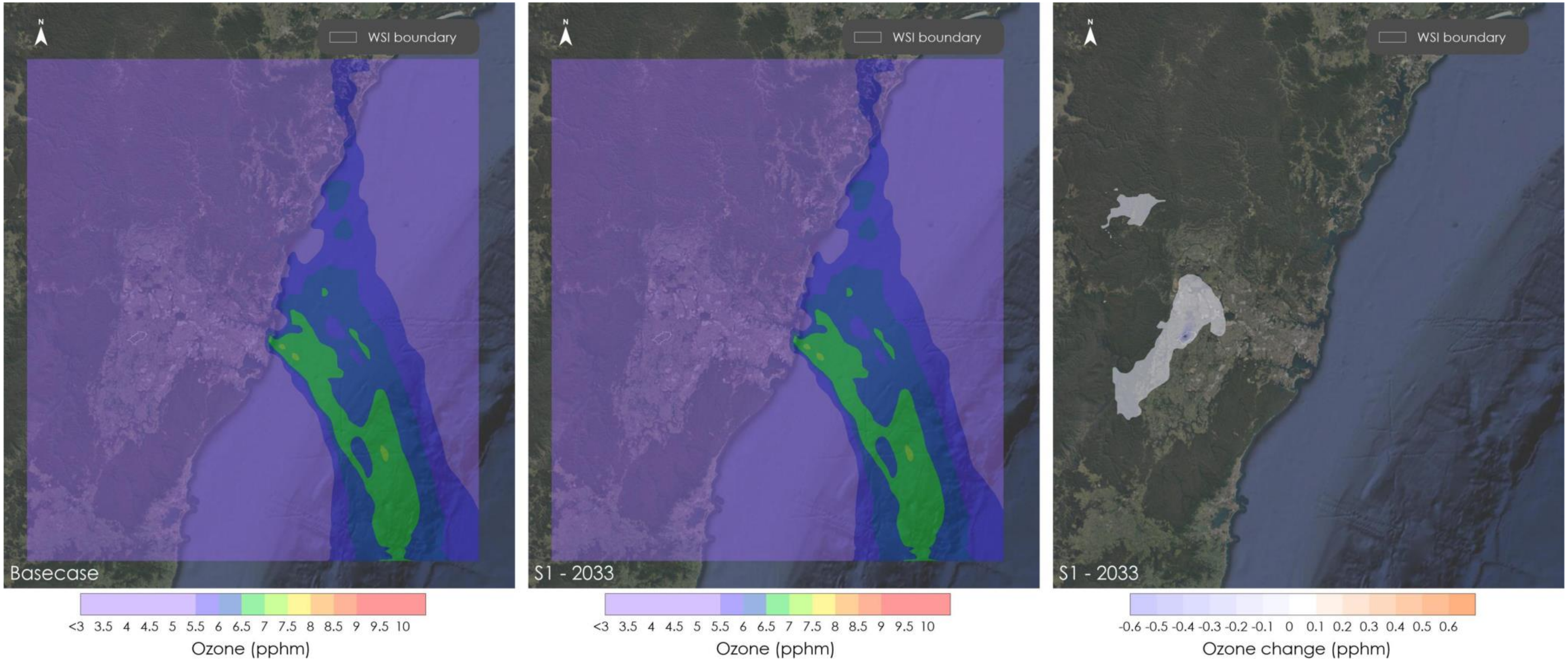


Figure D.24 Daily maximum 8-hour average ozone concentrations 2033 - No preference 19/12/2021

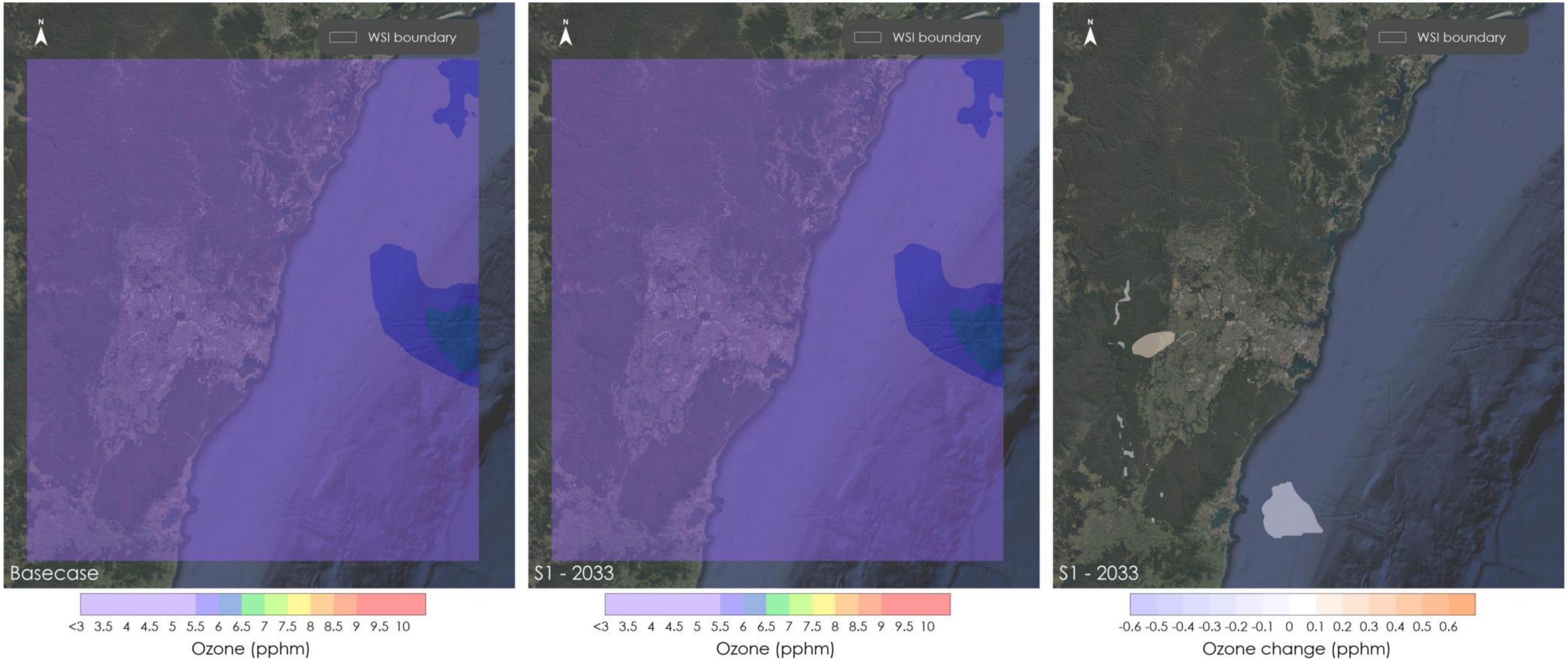


Figure D.25 Daily maximum 8-hour average ozone concentrations 2033 - No preference 20/12/2021

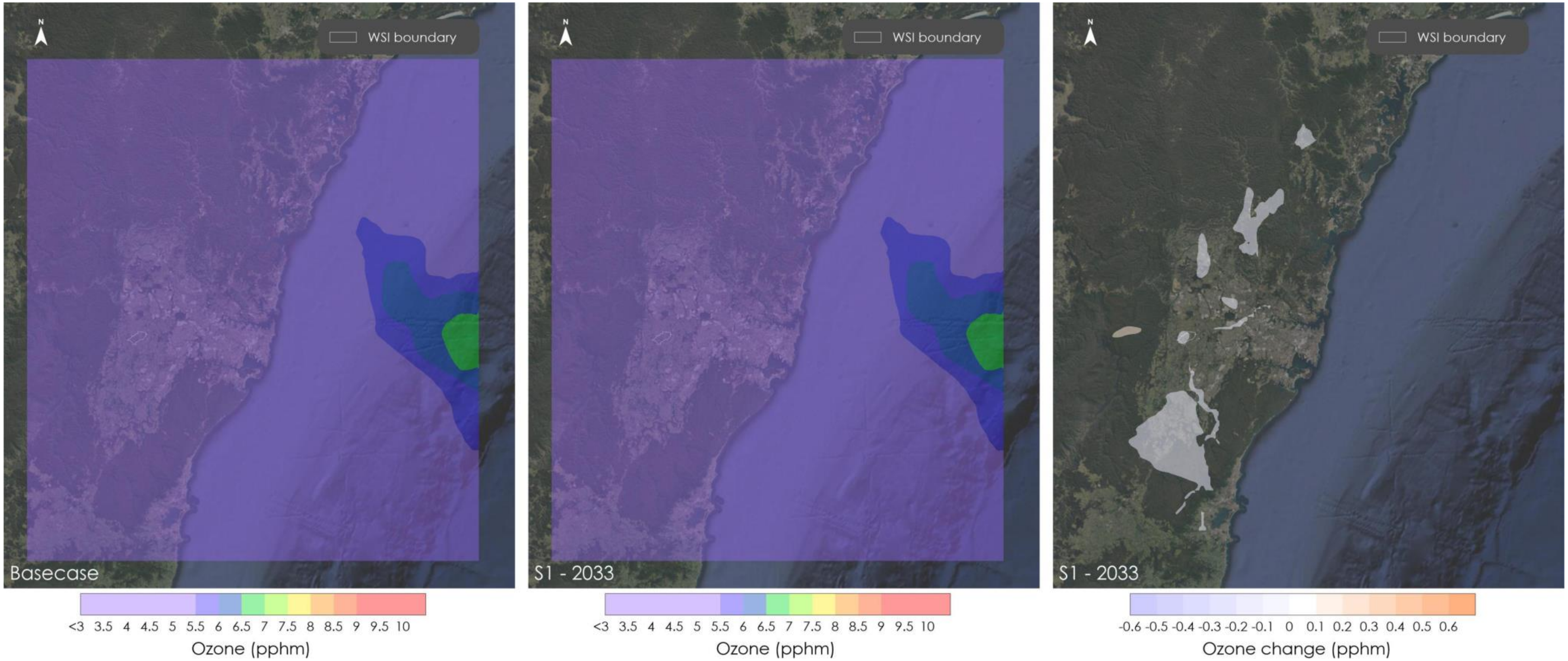


Figure D.26 Daily maximum 8-hour average ozone concentrations 2033 - No preference 21/12/2021

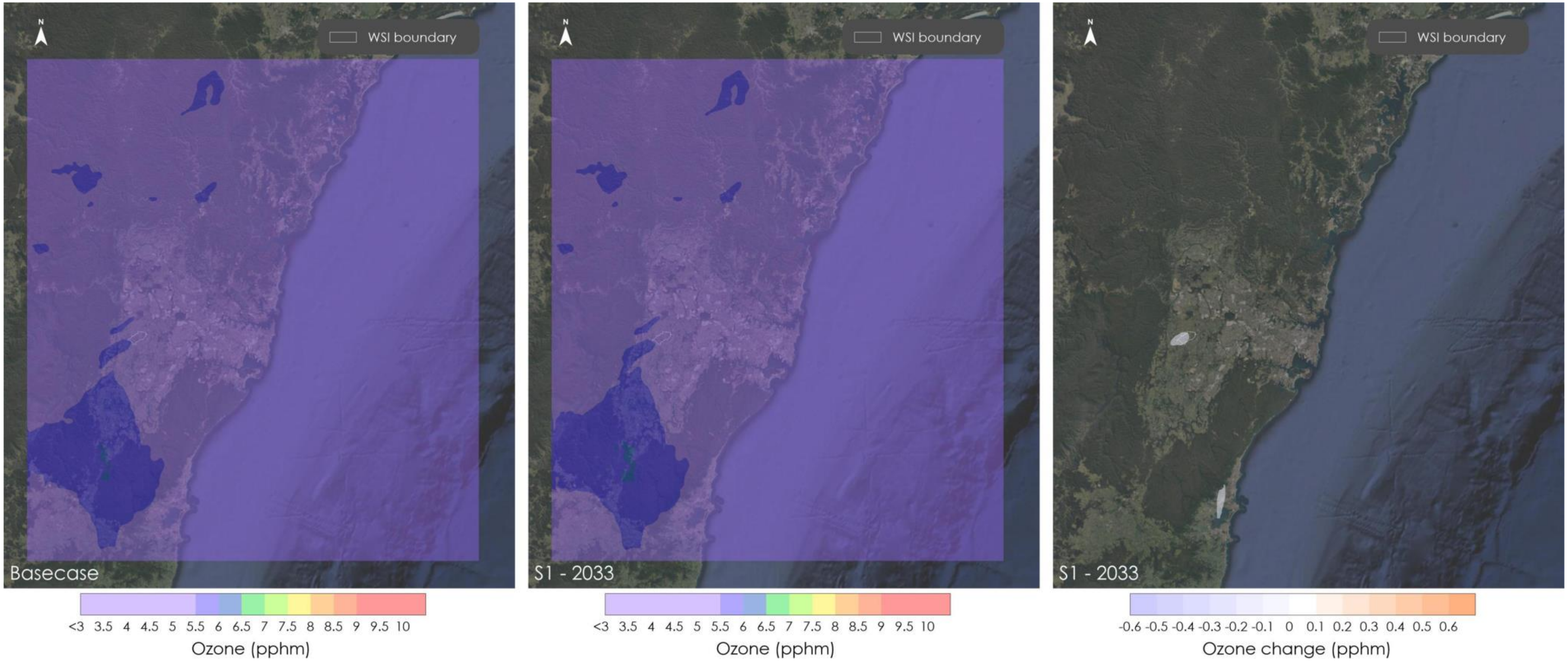


Figure D.27 Daily maximum 8-hour average ozone concentrations 2033 - No preference 22/12/2021

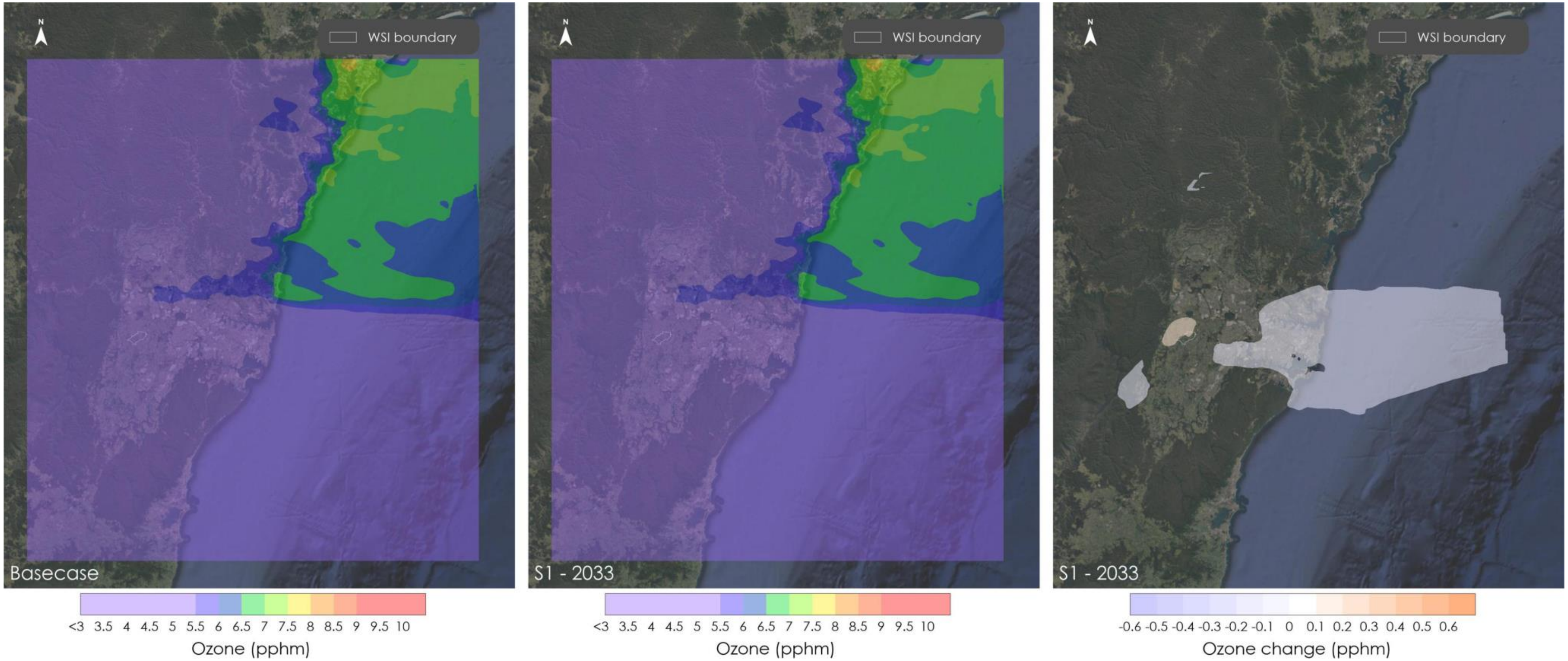


Figure D.28 Daily maximum 8-hour average ozone concentrations 2033 - No preference 23/12/2021

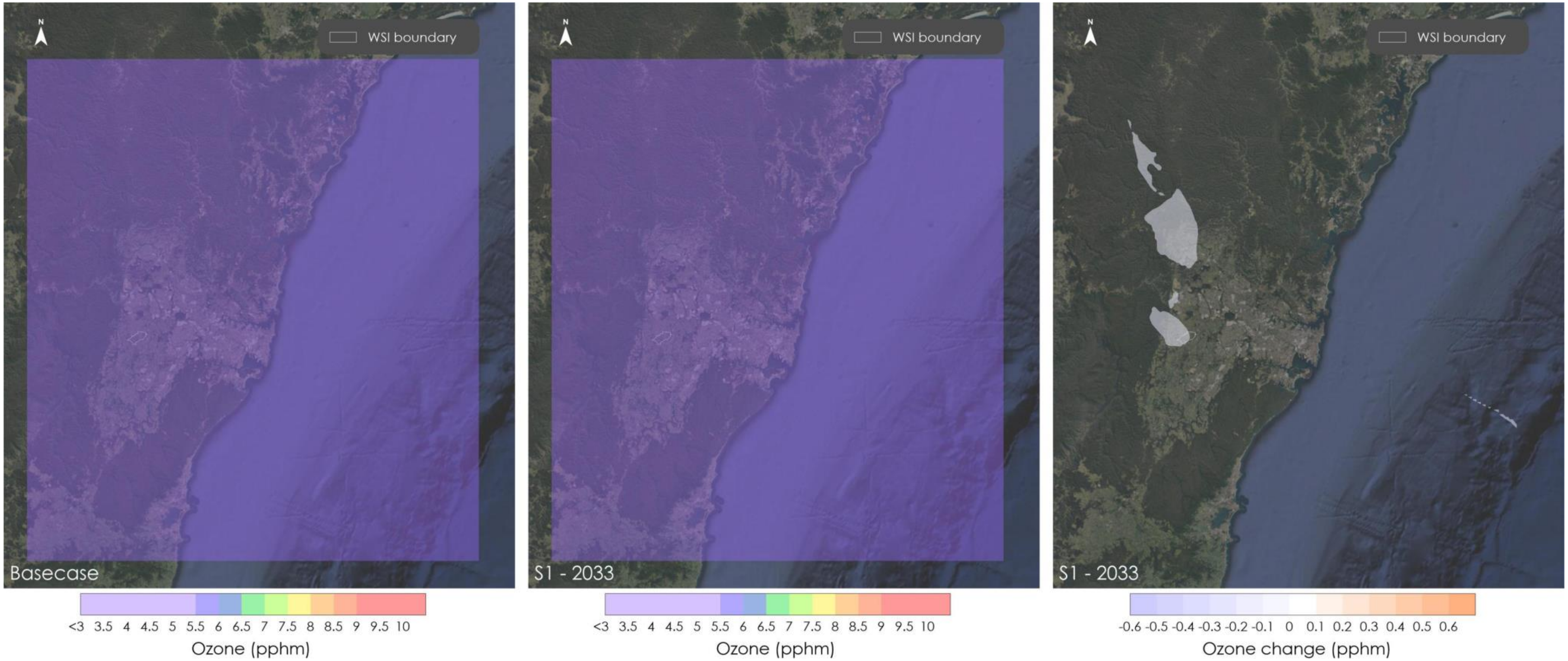


Figure D.29 Daily maximum 8-hour average ozone concentrations 2033 - No preference 24/12/2021

D3 Daily ozone change 2033 – Prefer Runway 05

Table D.2 Daily maximum ozone concentrations – 2033 - Prefer Runway 05

Date	2033 Prefer Runway 05 maximum 1-hour average (pphm)			2033 Prefer Runway 05 maximum 4-hour average (pphm)			2033 Prefer Runway 05 maximum 8-hour average (pphm)		
	Background	Cumulative	Change	Background	Cumulative	Change	Background	Cumulative	Change
Change in maximum ozone concentration									
17/12/2021	7.8	7.8	0.0	6.4	6.5	0.1	5.4	5.5	0.1
18/12/2021	12.2	12.2	0.0	10.9	10.9	0.0	8.4	8.4	0.0
19/12/2021	10.1	10.1	0.0	8.8	8.8	0.0	7.1	7.1	0.0
20/12/2021	7.6	7.6	0.0	7.4	7.4	0.0	6.4	6.4	0.0
21/12/2021	6.4	6.4	0.0	7.0	7.0	0.0	6.8	6.8	0.0
22/12/2021	9.2	9.2	0.0	7.5	7.5	0.0	6.1	6.1	0.0
23/12/2021	9.3	9.3	0.0	8.3	8.3	0.0	7.6	7.6	0.0
24/12/2021	4.0	4.0	0.0	3.6	3.6	0.0	4.6	4.6	0.0
Concentration of maximum change in ozone									
17/12/2021	6.6	6.7	0.1	6.2	6.3	0.1	5.1	5.2	0.1
18/12/2021	5.0	5.0	0.0	5.8	5.8	0.0	5.7	5.8	0.1
19/12/2021	4.2	4.4	0.1	3.6	3.7	0.1	4.0	4.1	0.0
20/12/2021	4.1	4.4	0.3	4.0	4.2	0.2	3.6	3.8	0.1
21/12/2021	4.2	4.3	0.1	4.0	4.1	0.1	3.7	3.8	0.1
22/12/2021	7.0	7.1	0.1	6.3	6.4	0.1	5.6	5.6	0.1
23/12/2021	6.7	6.8	0.1	5.5	5.7	0.2	4.5	4.7	0.2
24/12/2021	2.3	2.4	0.0	2.3	2.3	0.0	2.5	2.6	0.1

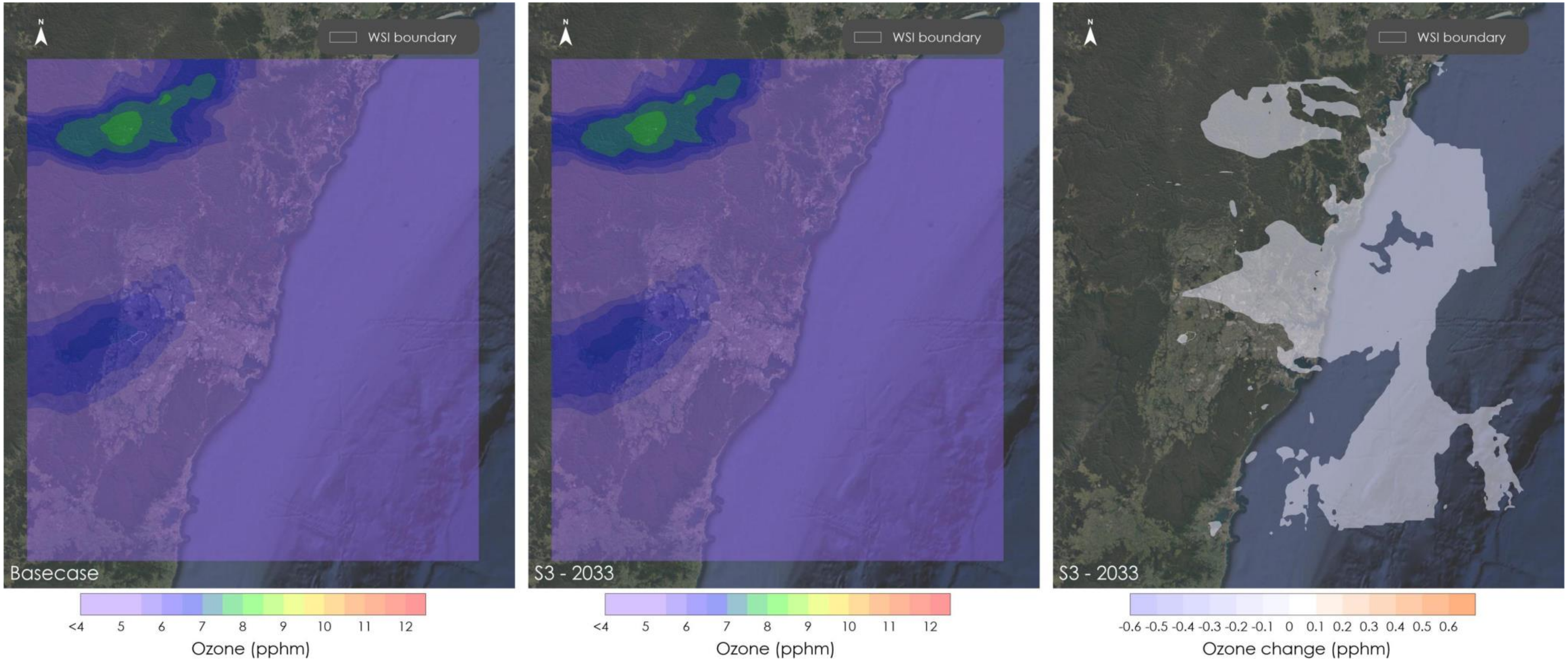


Figure D.30 Daily maximum 1-hour average ozone concentrations 2033 Prefer Runway 05 17/12/2021

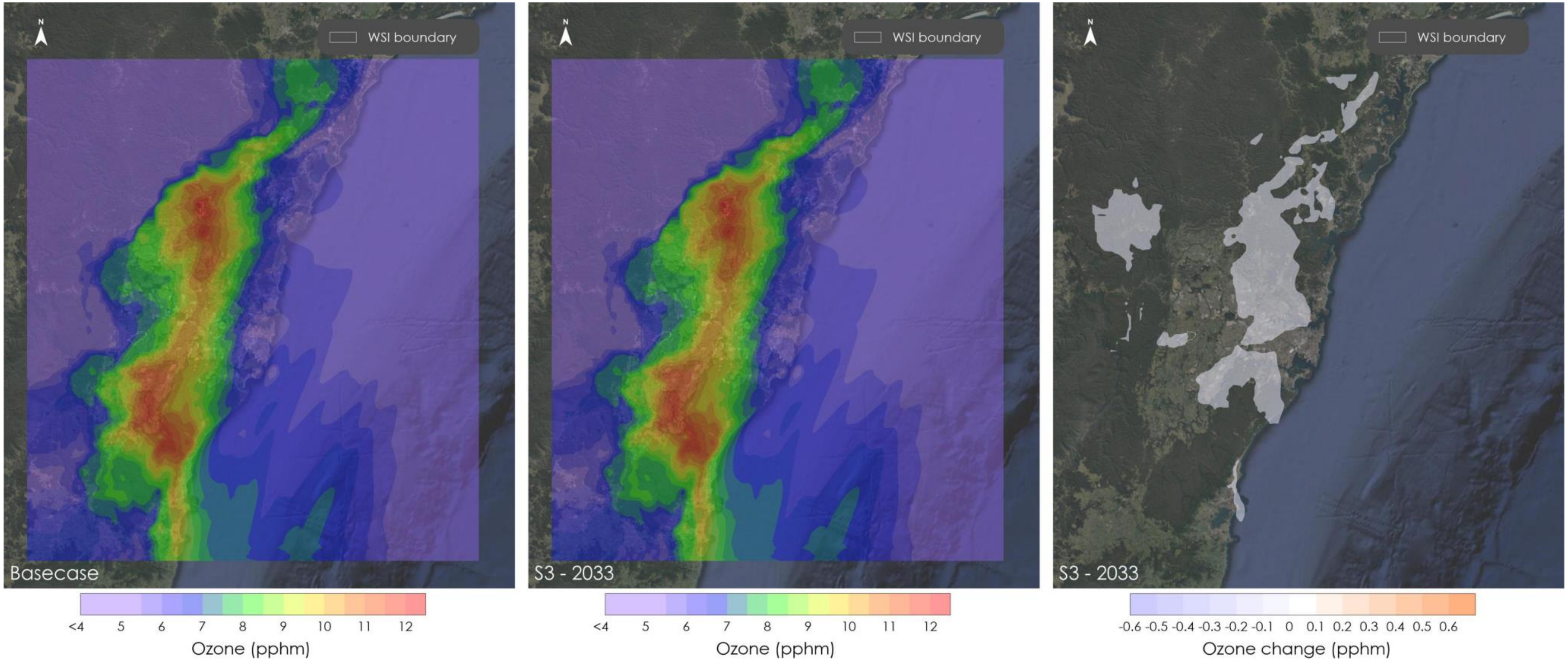


Figure D.31 Daily maximum 1-hour average ozone concentrations 2033 Prefer Runway 05 18/12/2021

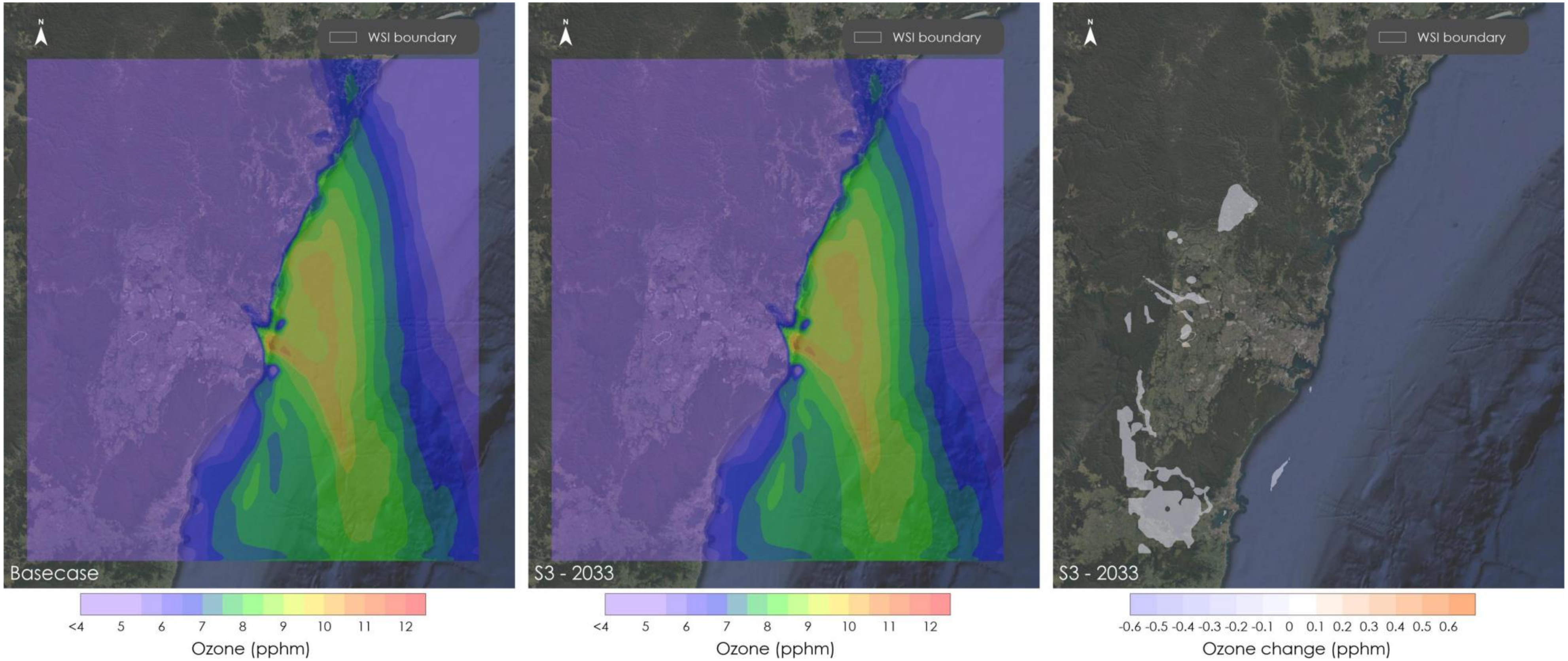


Figure D.32 Daily maximum 1-hour average ozone concentrations 2033 Prefer Runway 05 19/12/2021

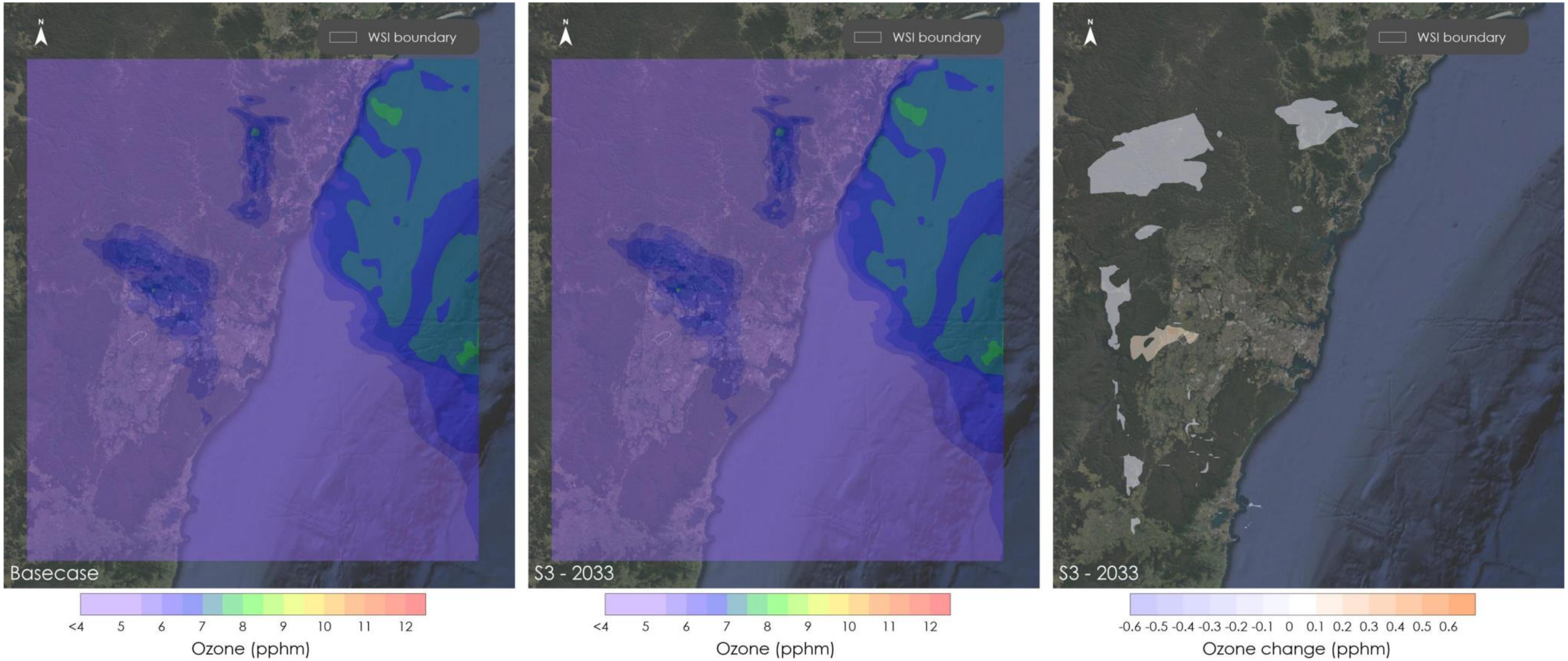


Figure D.33 Daily maximum 1-hour average ozone concentrations 2033 Prefer Runway 05 20/12/2021

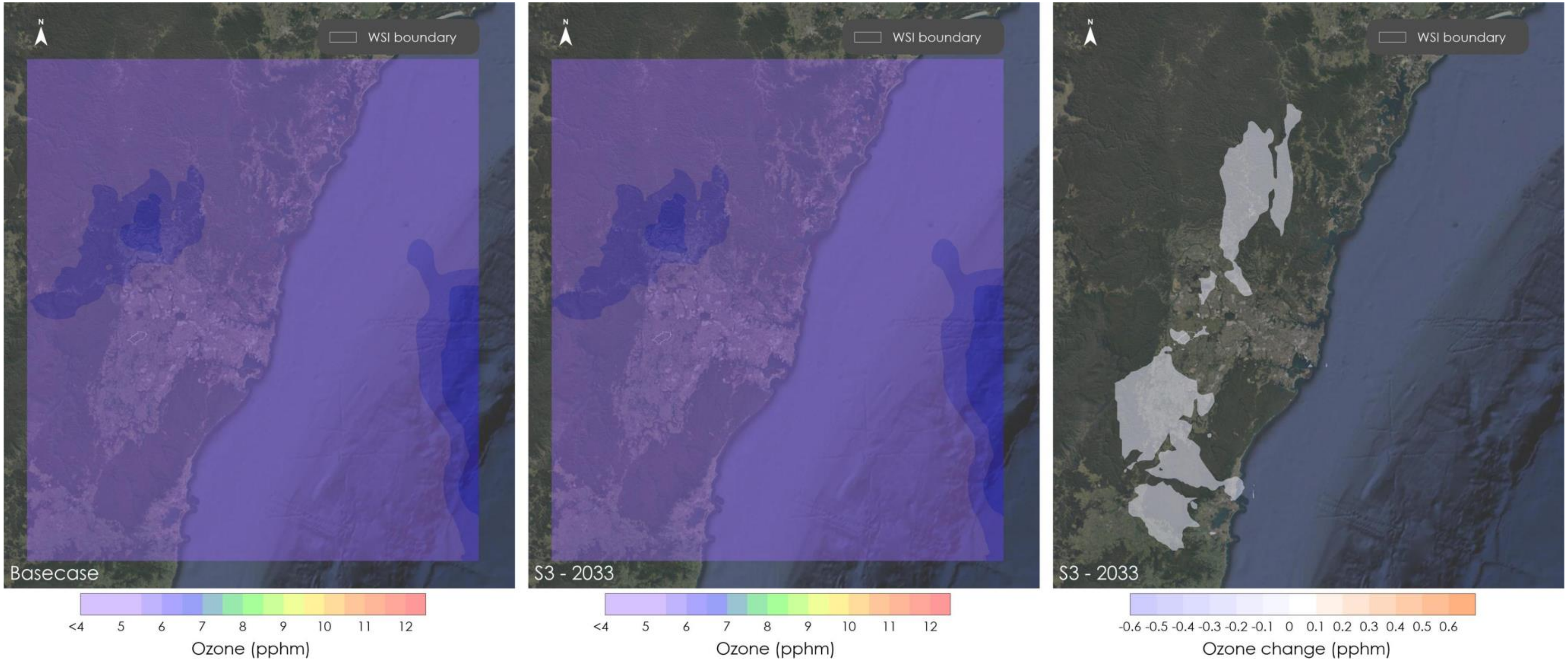


Figure D.34 Daily maximum 1-hour average ozone concentrations 2033 Prefer Runway 05 21/12/2021

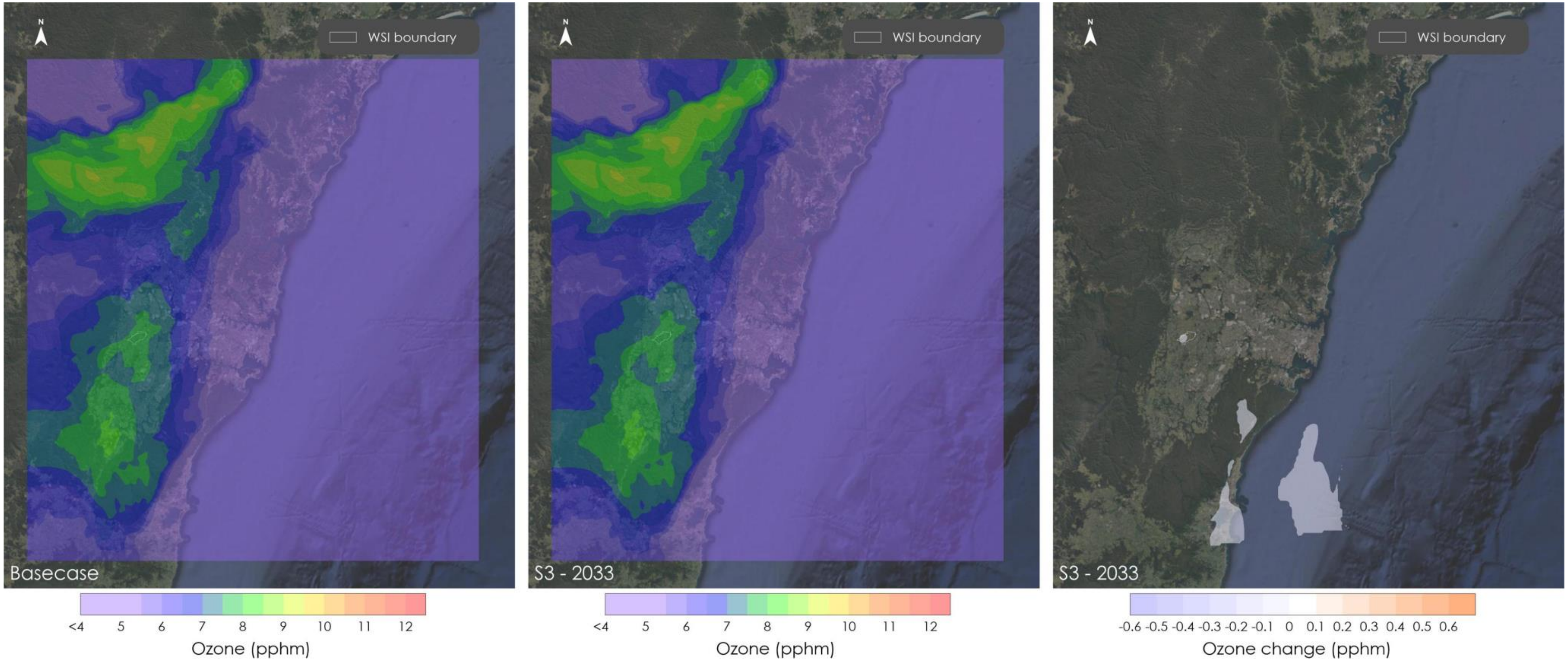


Figure D.35 Daily maximum 1-hour average ozone concentrations 2033 Prefer Runway 05 22/12/2021

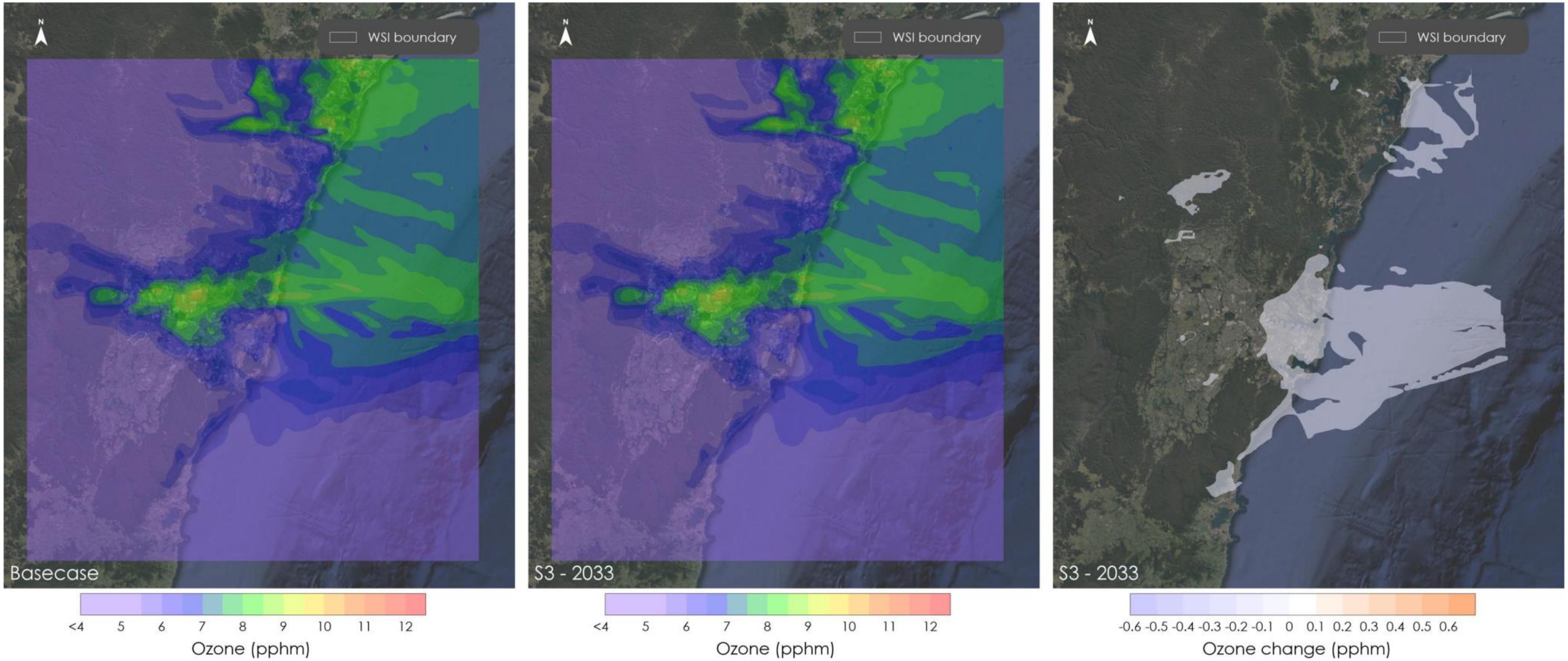


Figure D.36 Daily maximum 1-hour average ozone concentrations 2033 Prefer Runway 05 23/12/2021

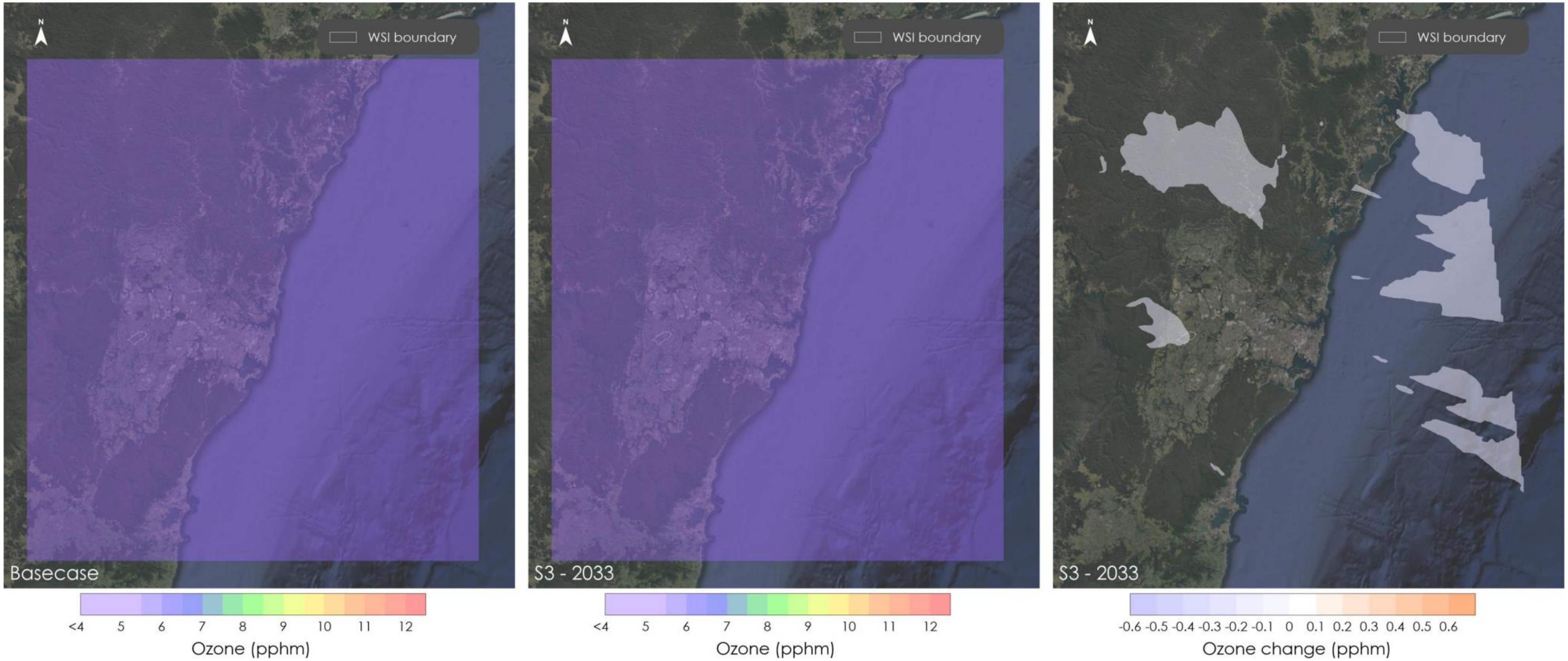


Figure D.37 Daily maximum 1-hour average ozone concentrations 2033 Prefer Runway 05 24/12/2021

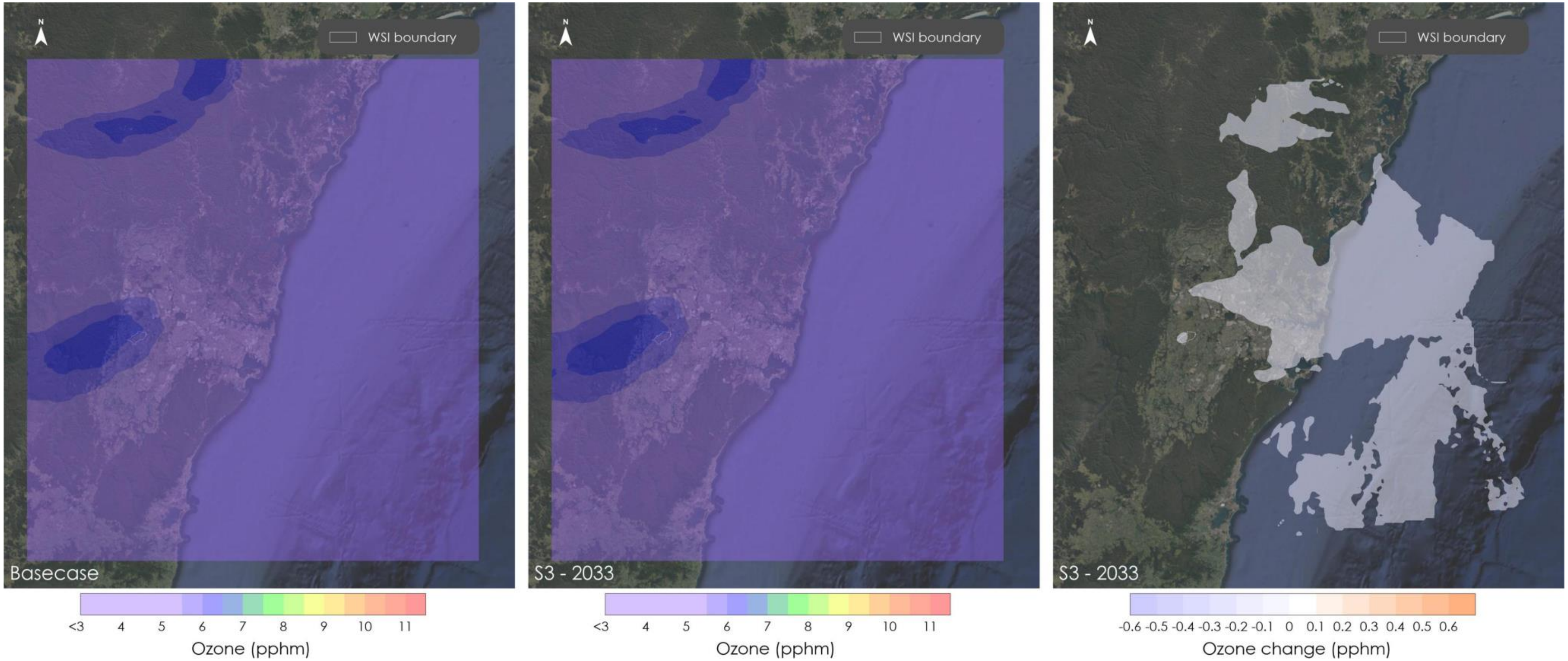


Figure D.38 Daily maximum 4-hour average ozone concentrations 2033 Prefer Runway 05 17/12/2021

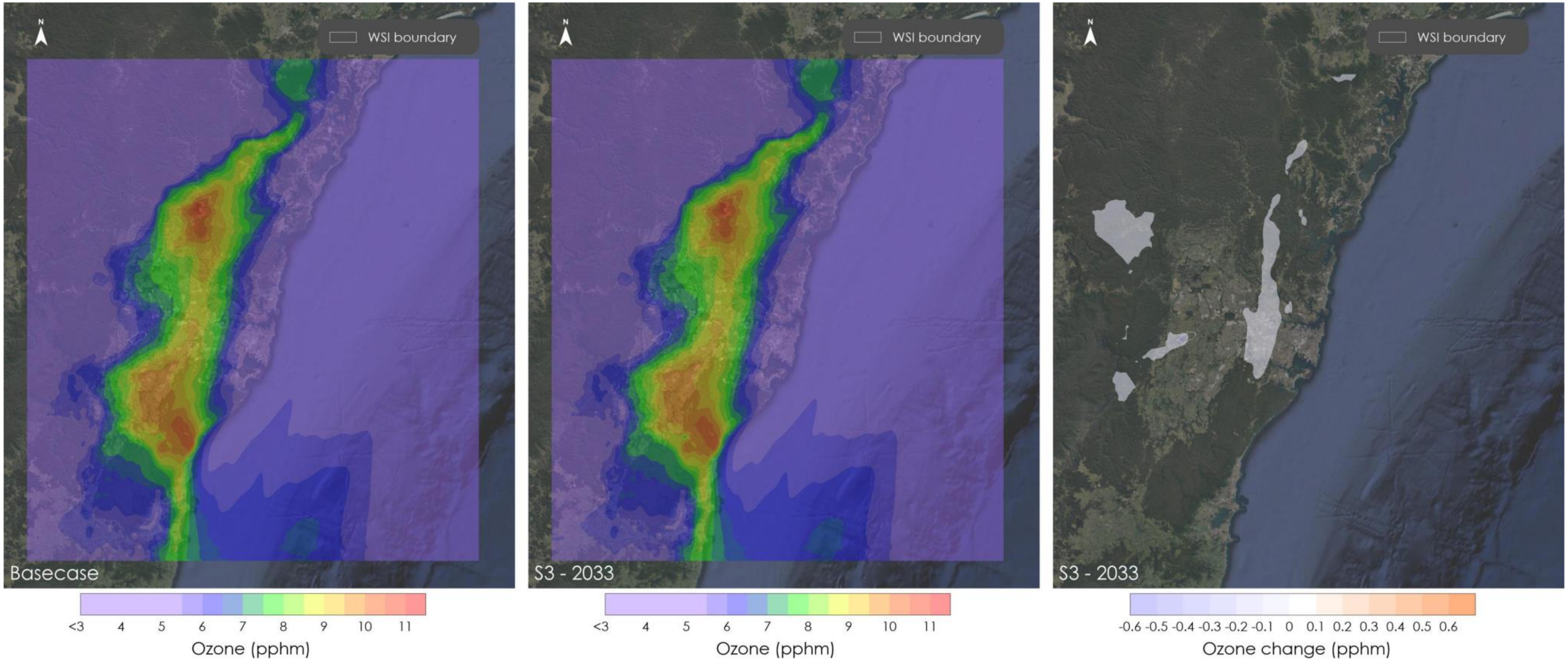


Figure D.39 Daily maximum 4-hour average ozone concentrations 2033 Prefer Runway 05 18/12/2021

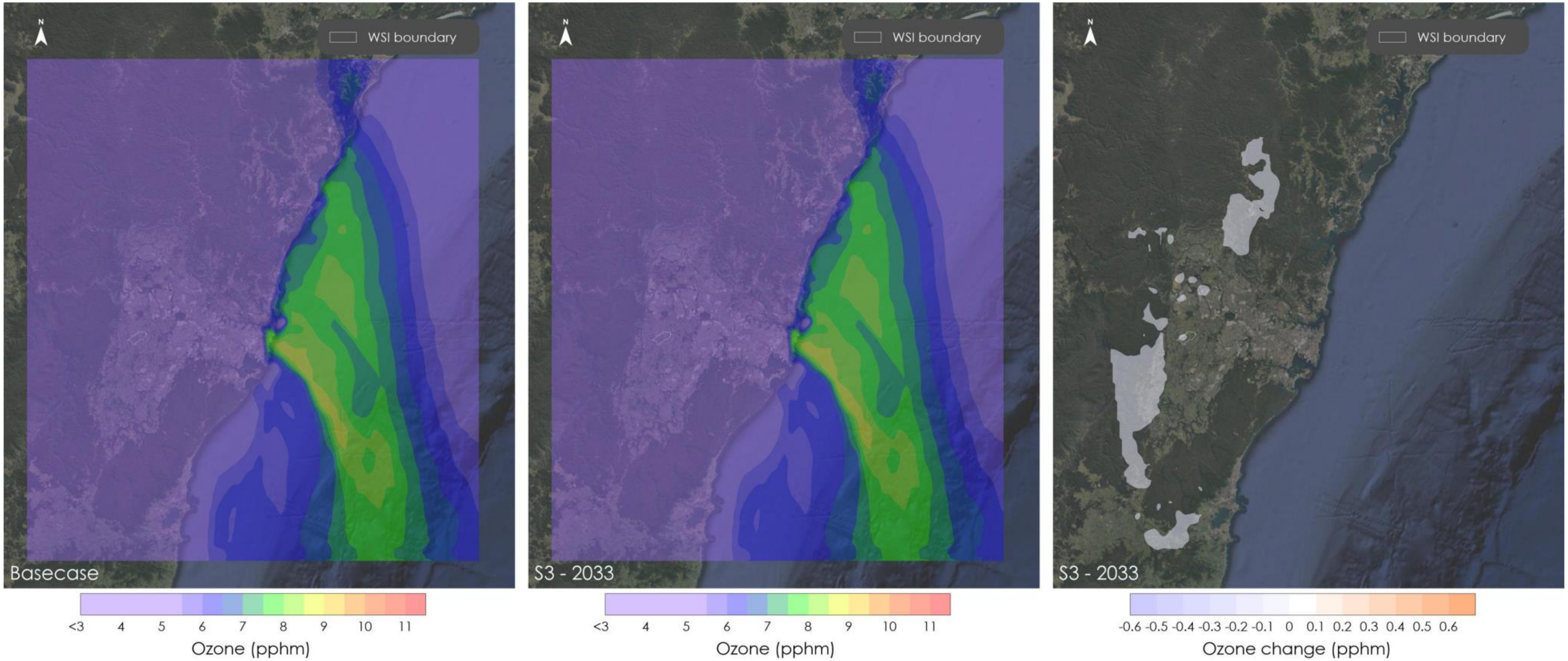


Figure D.40 Daily maximum 4-hour average ozone concentrations 2033 Prefer Runway 05 19/12/2021

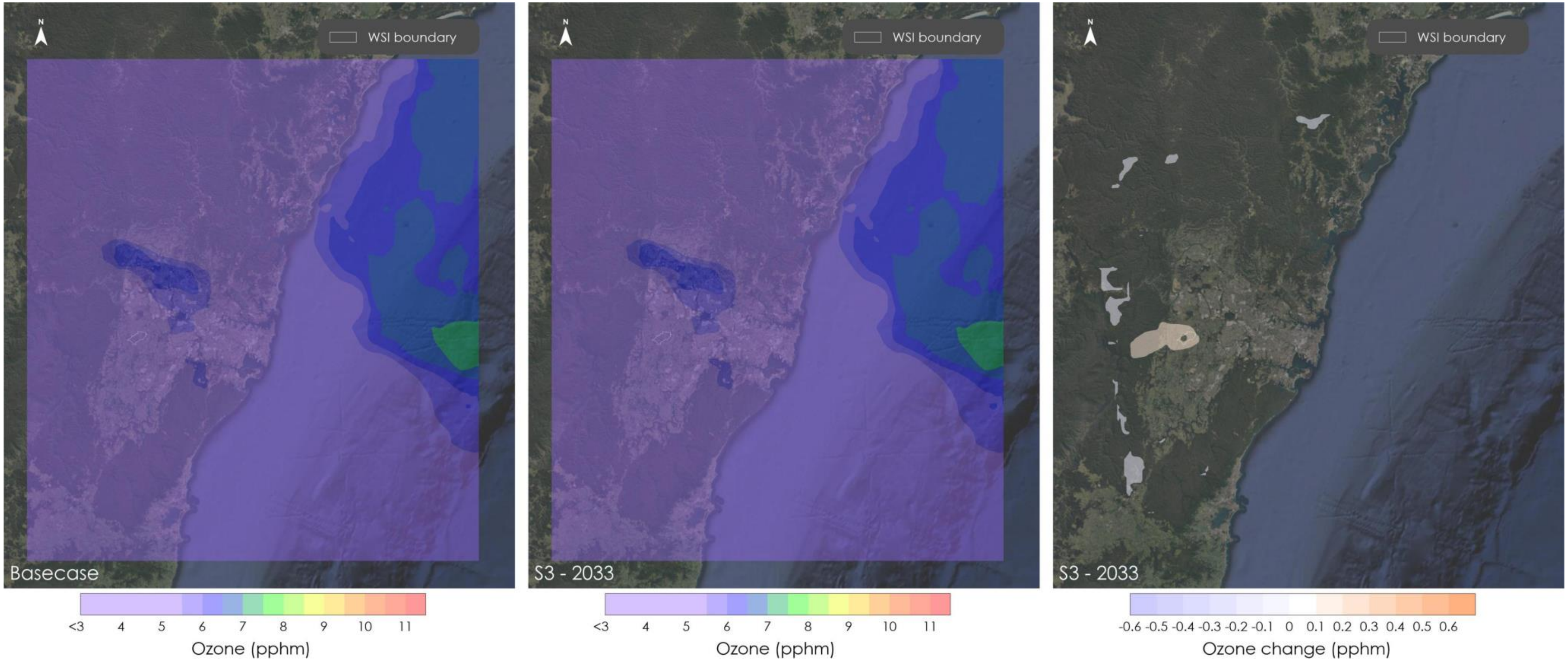


Figure D.41 Daily maximum 4-hour average ozone concentrations 2033 Prefer Runway 05 20/12/2021

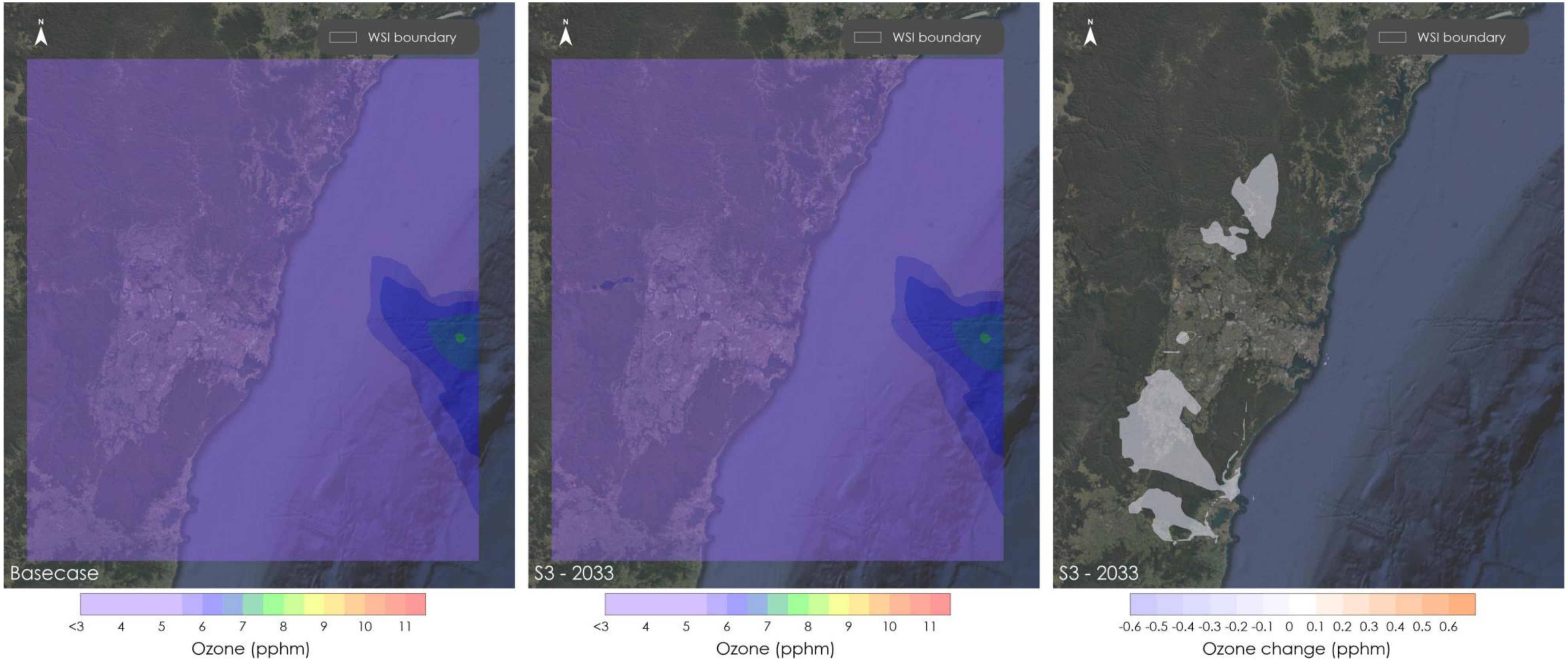


Figure D.42 Daily maximum 4-hour average ozone concentrations 2033 Prefer Runway 05 21/12/2021

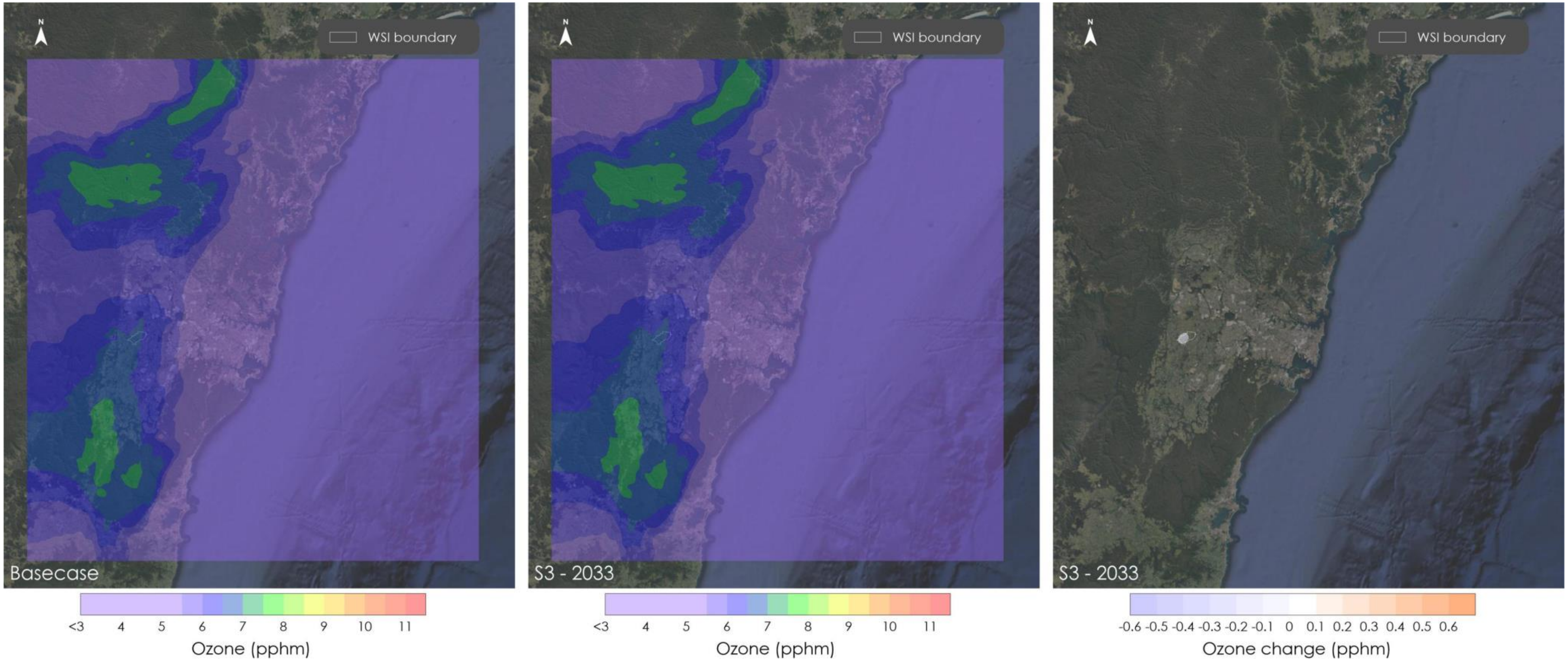


Figure D.43 Daily maximum 4-hour average ozone concentrations 2033 Prefer Runway 05 22/12/2021

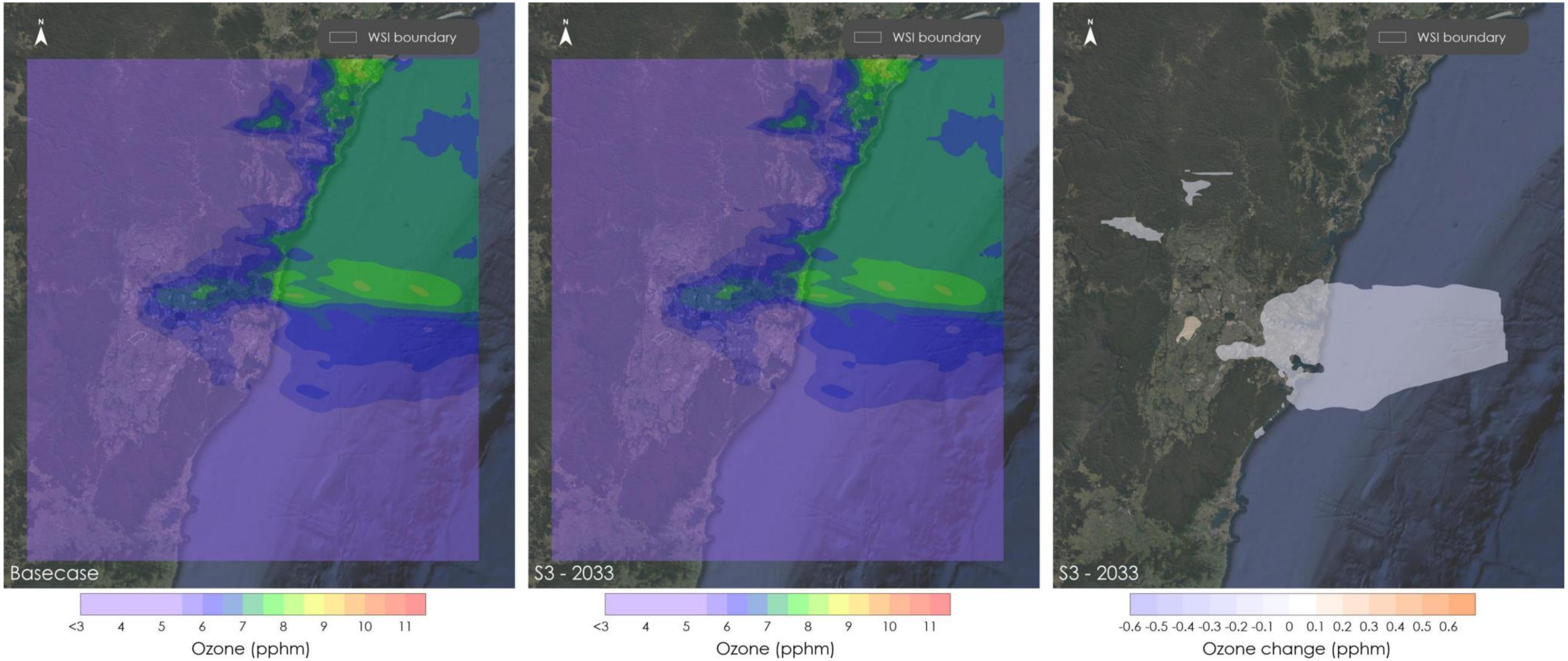


Figure D.44 Daily maximum 4-hour average ozone concentrations 2033 Prefer Runway 05 23/12/2021

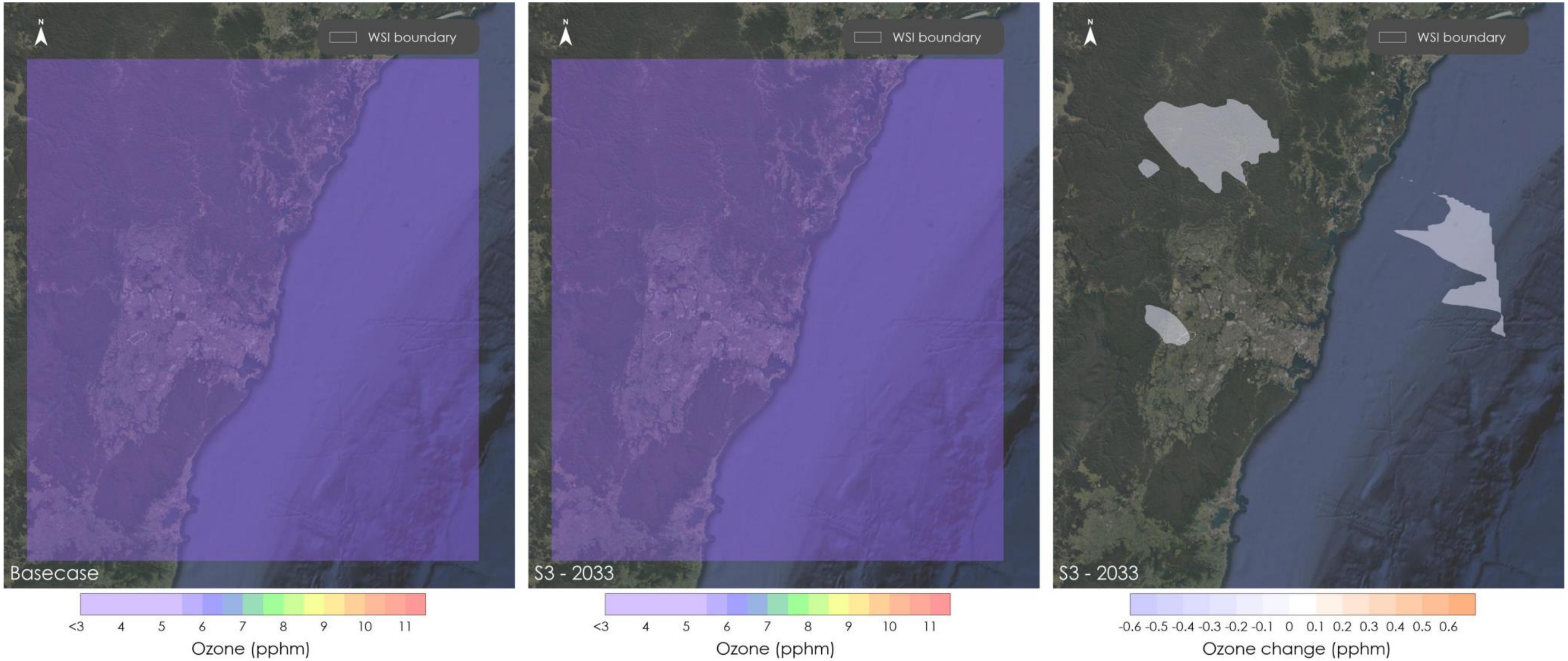


Figure D.45 Daily maximum 4-hour average ozone concentrations 2033 Prefer Runway 05 24/12/2021

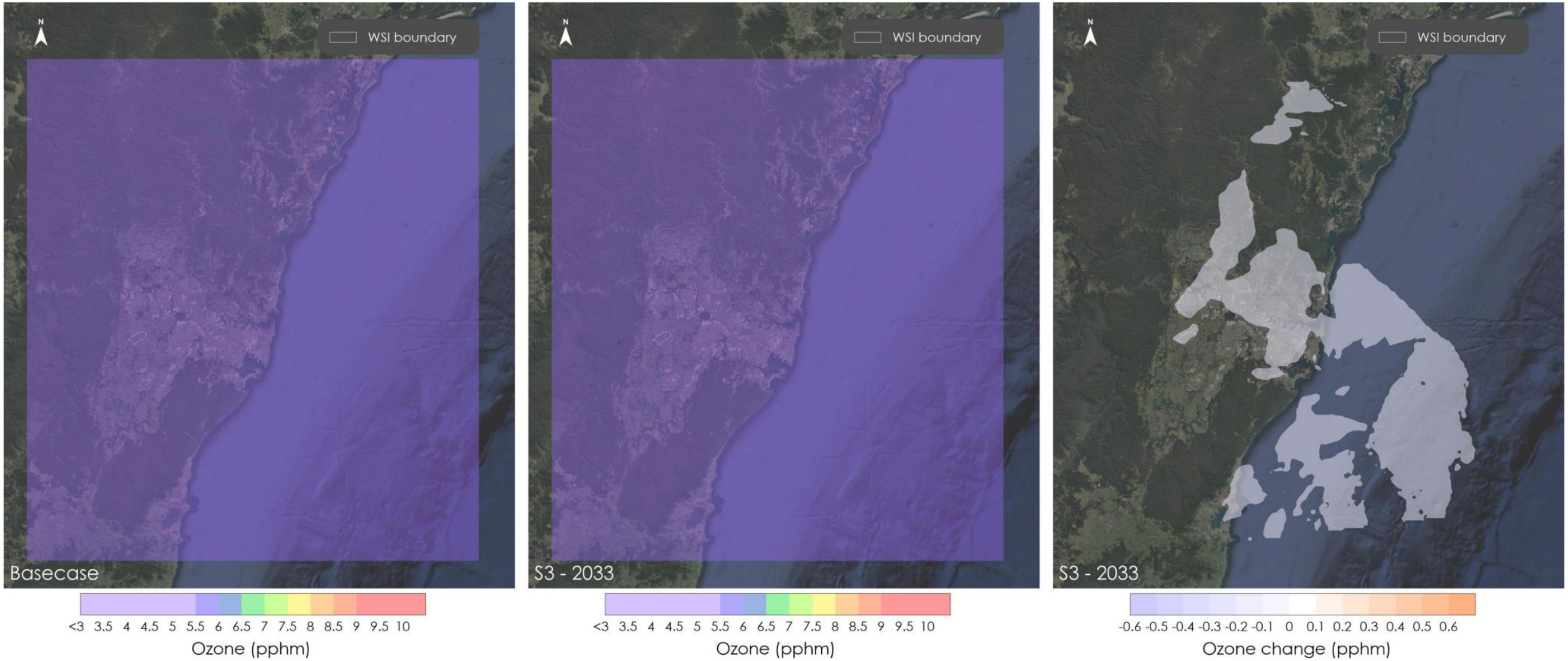


Figure D.46 Daily maximum 8-hour average ozone concentrations 2033 Prefer Runway 05 17/12/2021

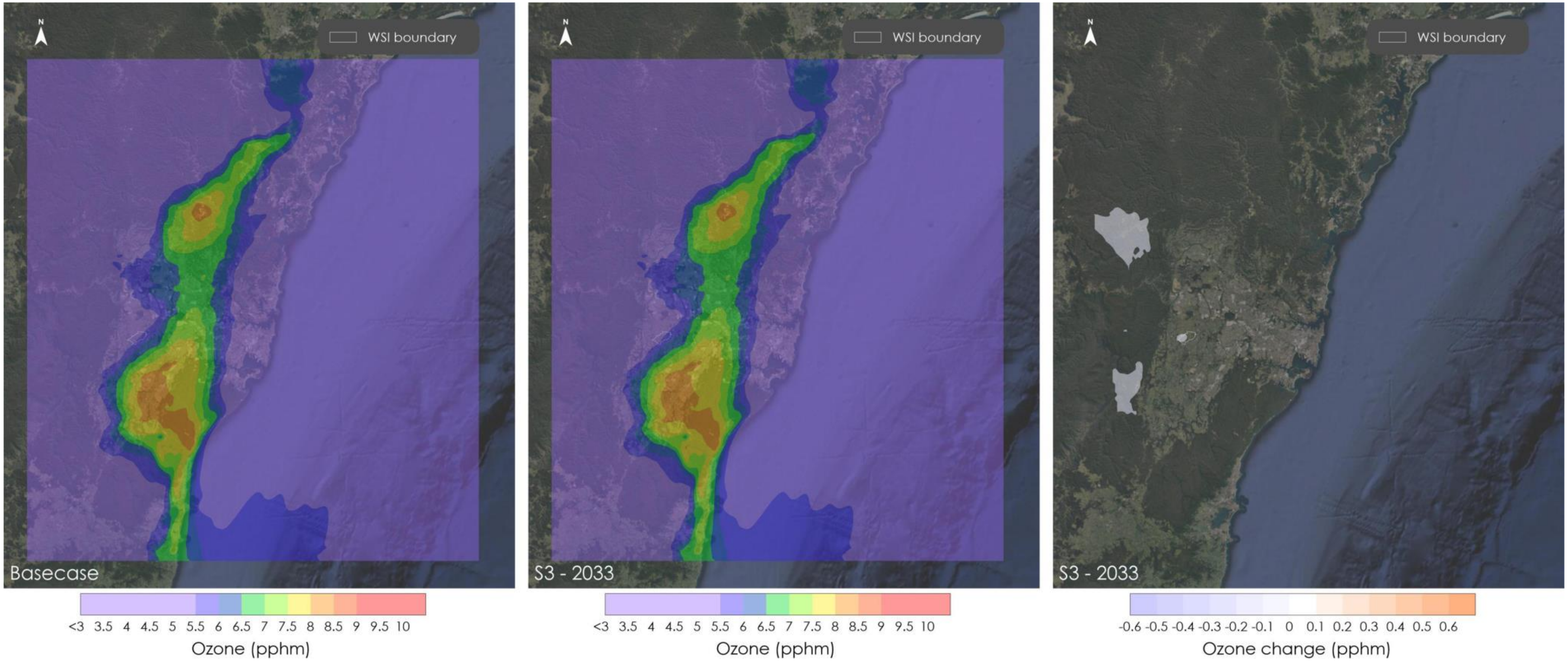


Figure D.47 Daily maximum 8-hour average ozone concentrations 2033 Prefer Runway 05 18/12/2021

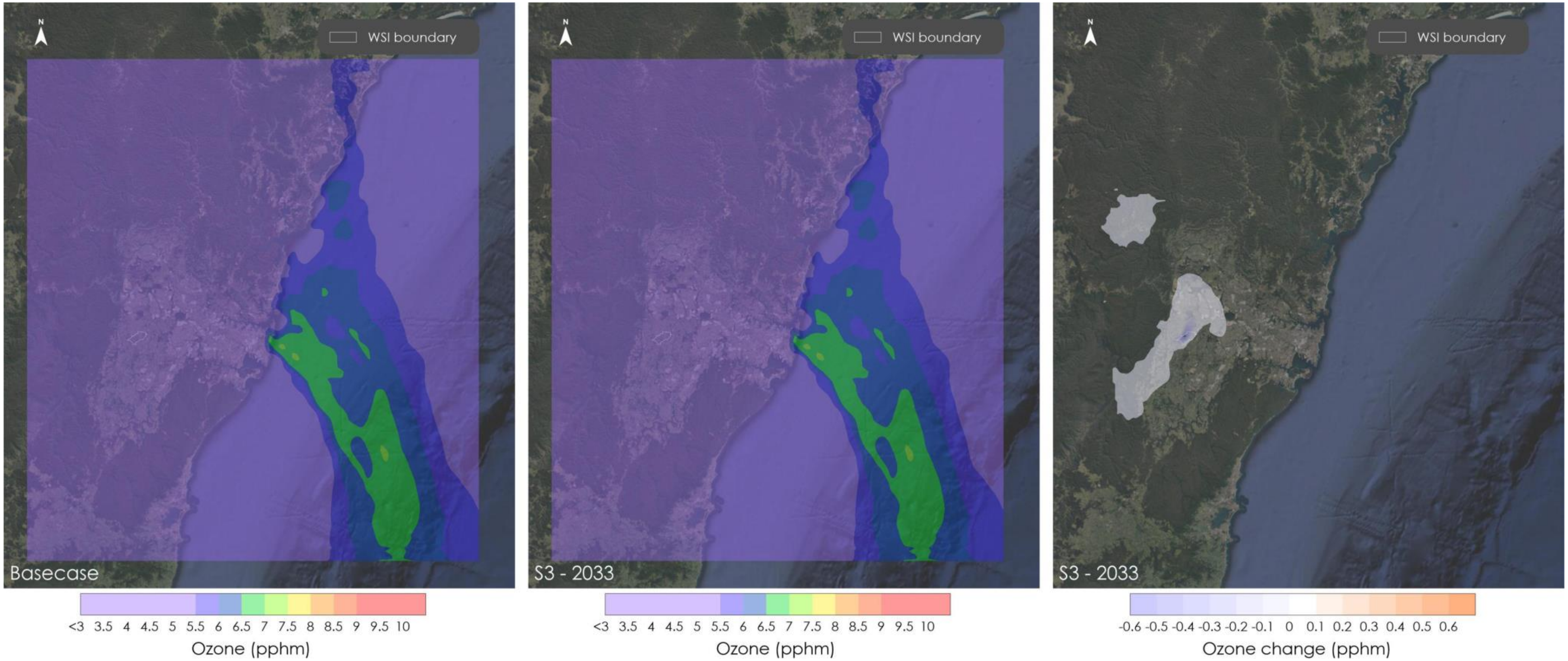


Figure D.48 Daily maximum 8-hour average ozone concentrations 2033 Prefer Runway 05 19/12/2021

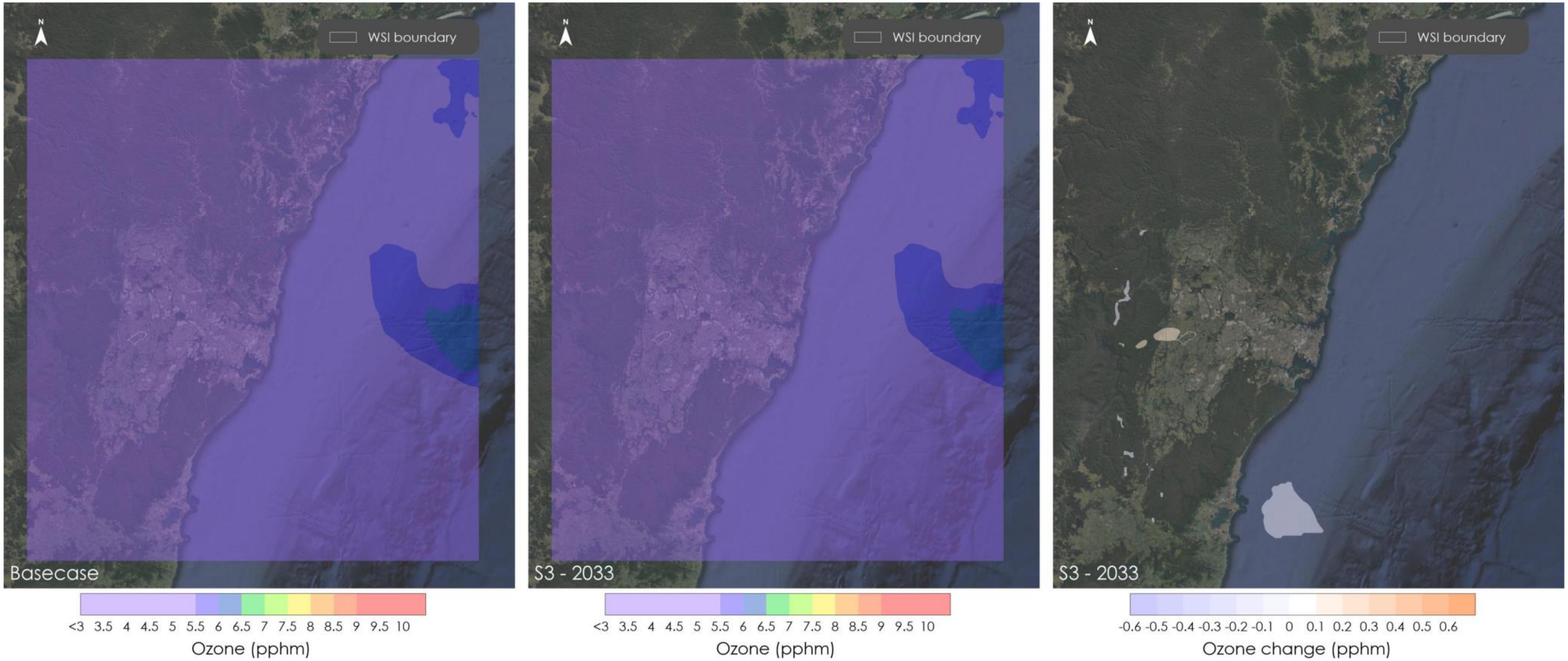


Figure D.49 Daily maximum 8-hour average ozone concentrations 2033 Prefer Runway 05 20/12/2021

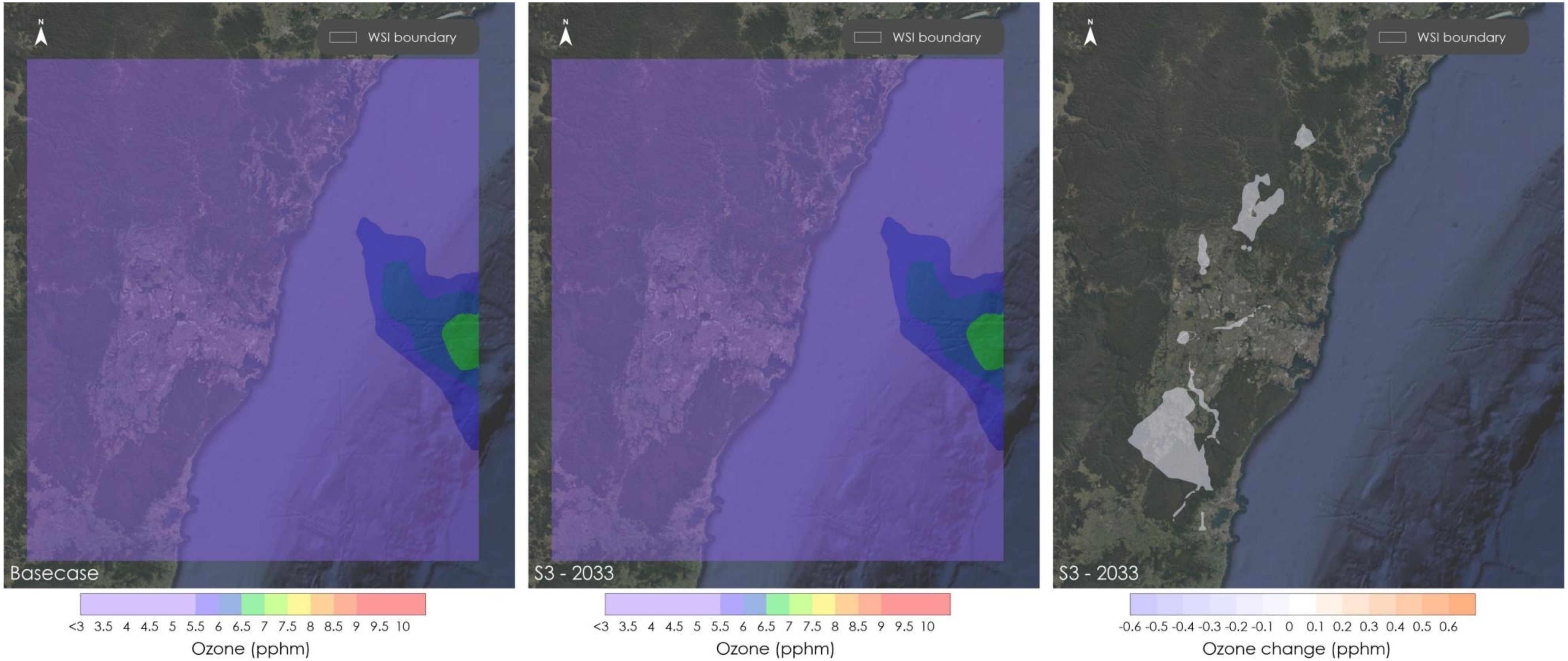


Figure D.50 Daily maximum 8-hour average ozone concentrations 2033 Prefer Runway 05 21/12/2021

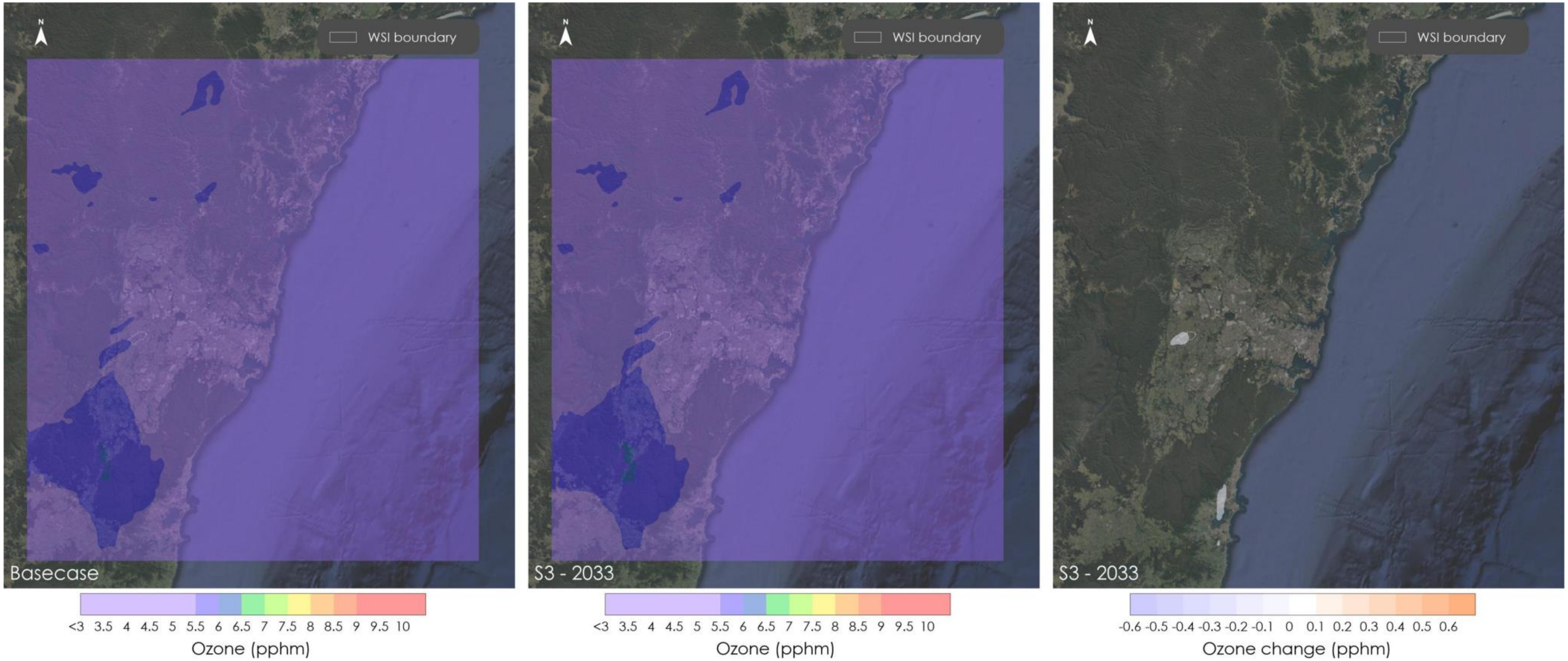


Figure D.51 Daily maximum 8-hour average ozone concentrations 2033 Prefer Runway 05 22/12/2021

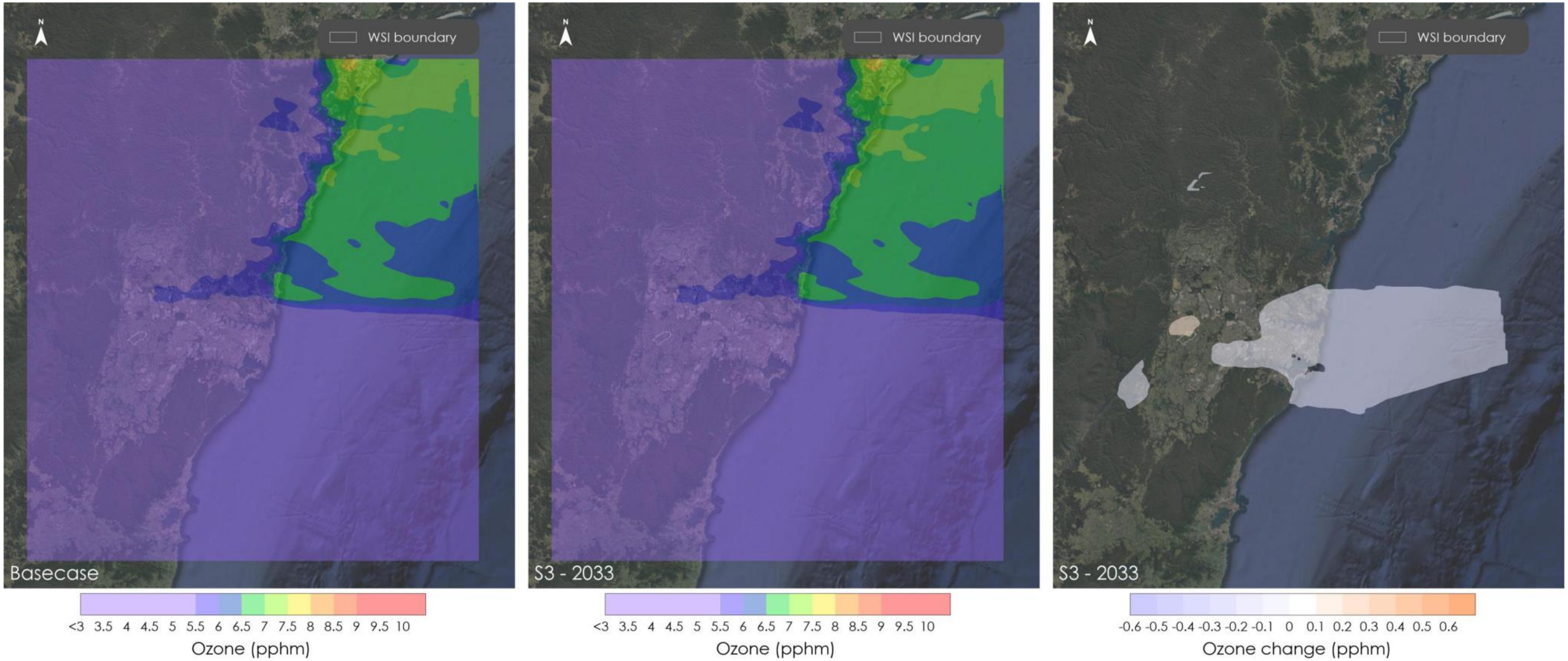


Figure D.52 Daily maximum 8-hour average ozone concentrations 2033 Prefer Runway 05 23/12/2021

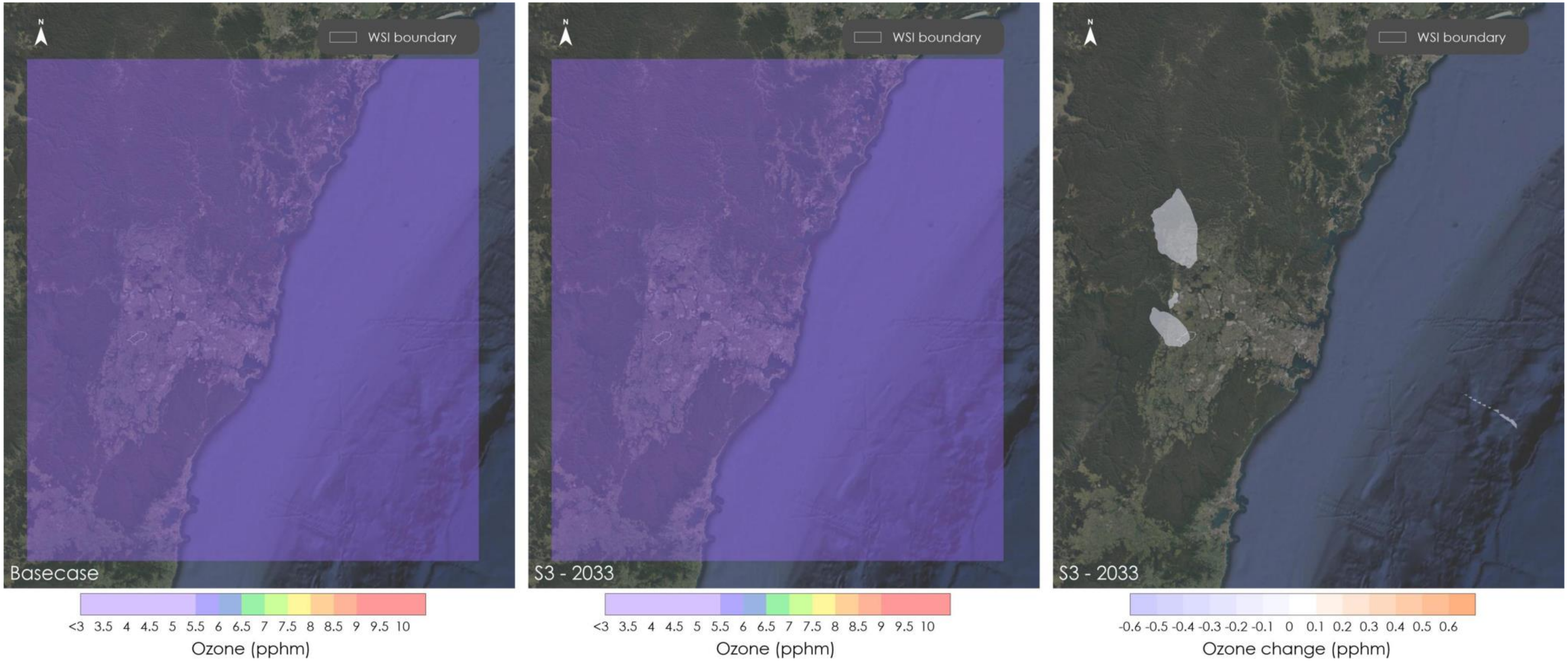


Figure D.53 Daily maximum 8-hour average ozone concentrations 2033 Prefer Runway 05 24/12/2021

D4 Daily ozone change 2055 Prefer Runway 05

Table D.3 Daily maximum ozone concentrations – 2055 Prefer Runway 05

Date	2055 Prefer Runway 05 maximum 1-hour average (pphm)			2055 Prefer Runway 05 maximum 4-hour average (pphm)			2055 Prefer Runway 05 maximum 8-hour average (pphm)		
	Background	Cumulative	Change	Background	Cumulative	Change	Background	Cumulative	Change
Change in maximum ozone concentration									
17/12/2021	7.8	7.8	0.0	6.4	6.6	0.2	5.4	5.6	0.2
18/12/2021	12.2	12.2	0.0	10.9	10.9	0.0	8.3	8.4	0.1
19/12/2021	10.1	10.1	0.0	8.8	8.8	0.0	7.1	7.1	0.0
20/12/2021	7.6	7.6	0.0	7.4	7.4	0.0	6.4	6.4	0.0
21/12/2021	6.4	6.4	0.0	7.0	7.0	0.0	6.8	6.8	0.0
22/12/2021	9.2	9.2	0.0	7.5	7.5	0.0	6.1	6.2	0.1
23/12/2021	9.3	9.4	0.0	8.3	8.4	0.0	7.6	7.6	0.0
24/12/2021	4.0	4.0	0.0	3.6	3.6	0.0	4.6	4.6	0.0
Concentration of maximum change in ozone									
17/12/2021	6.6	6.8	0.2	6.3	6.5	0.2	5.0	5.3	0.3
18/12/2021	5.0	5.1	0.1	8.7	8.8	0.1	6.2	6.4	0.3
19/12/2021	4.2	4.6	0.4	3.6	3.8	0.3	3.5	3.6	0.1
20/12/2021	4.1	4.9	0.8	3.5	4.1	0.6	3.5	3.9	0.4
21/12/2021	4.2	4.5	0.3	4.1	4.4	0.3	3.7	4.1	0.4
22/12/2021	7.6	7.9	0.3	6.3	6.6	0.3	5.6	5.8	0.2
23/12/2021	6.5	7.0	0.5	5.5	6.1	0.6	4.5	5.0	0.6
24/12/2021	2.5	2.6	0.1	2.6	2.7	0.1	2.5	2.7	0.2

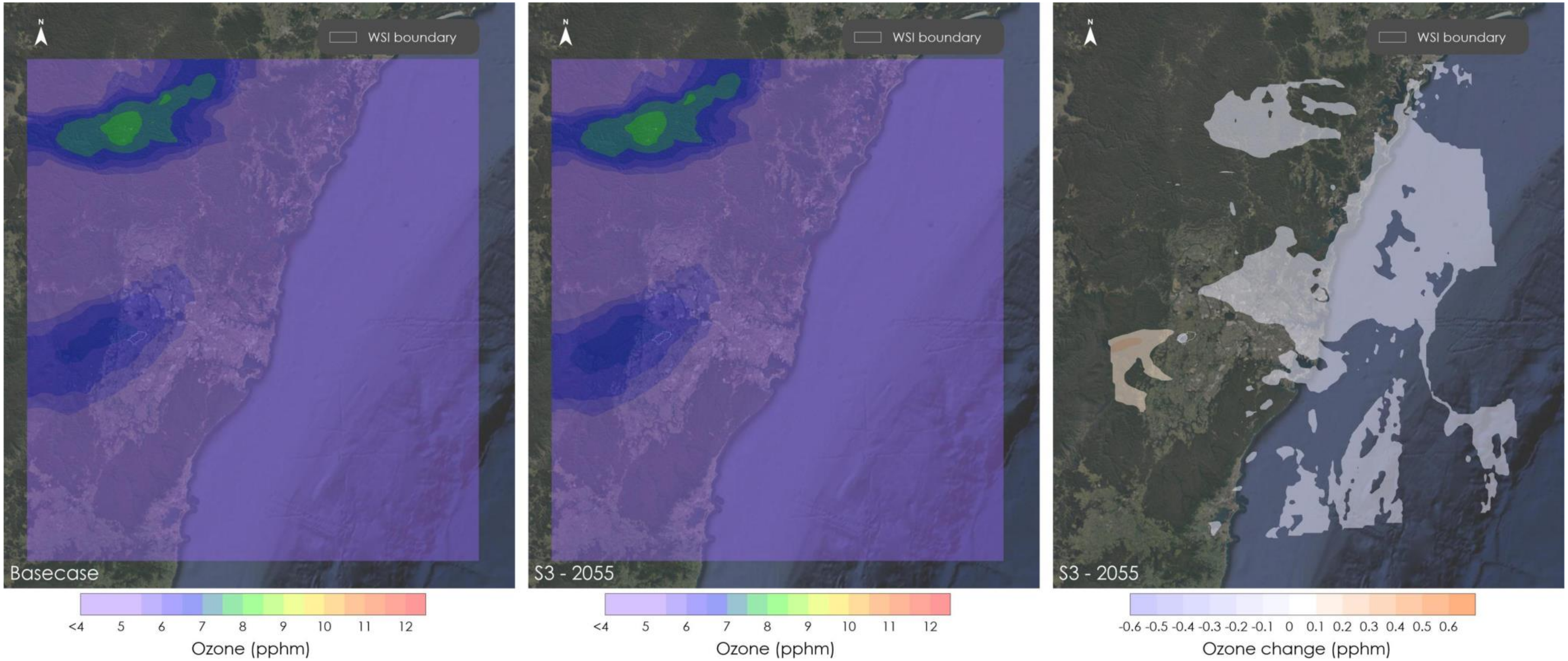


Figure D.54 Daily maximum 1-hour average ozone concentrations 2055 Prefer Runway 05 17/12/2021

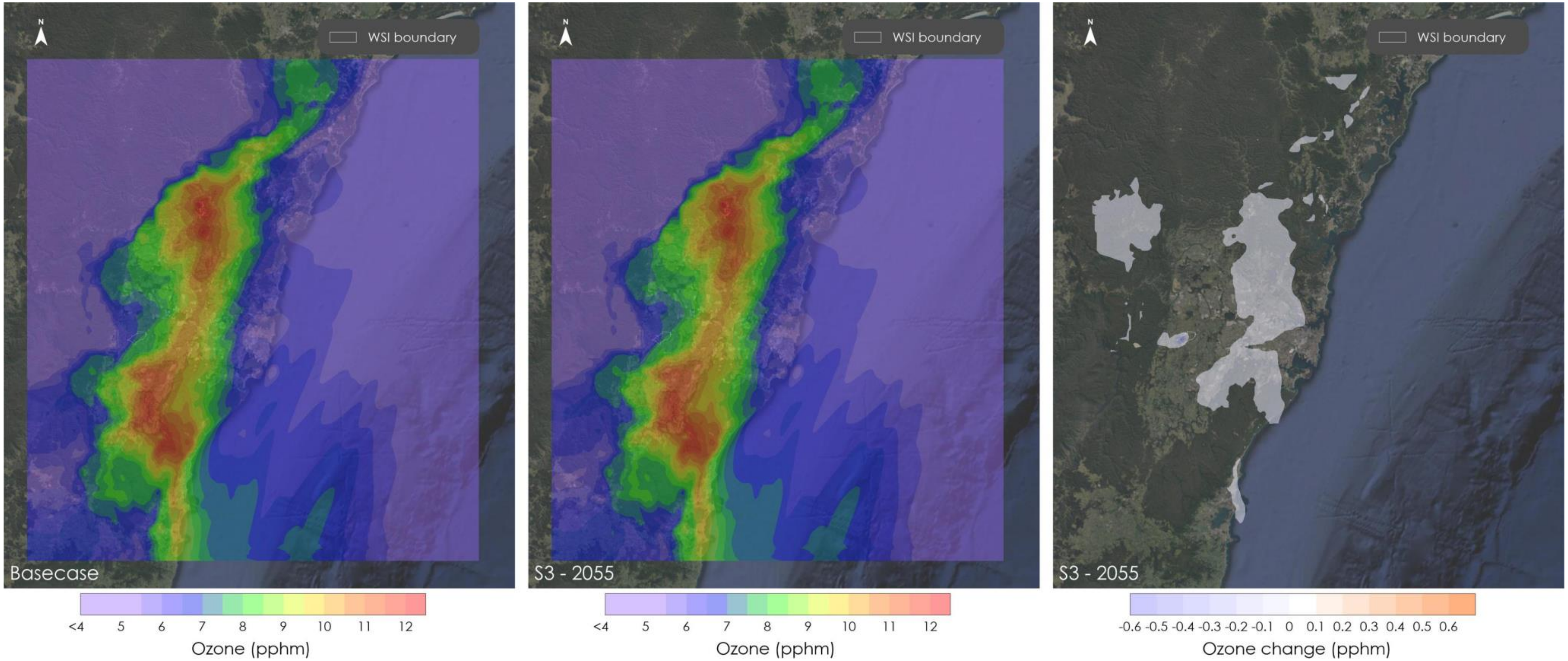


Figure D.55 Daily maximum 1-hour average ozone concentrations 2055 Prefer Runway 05 18/12/2021

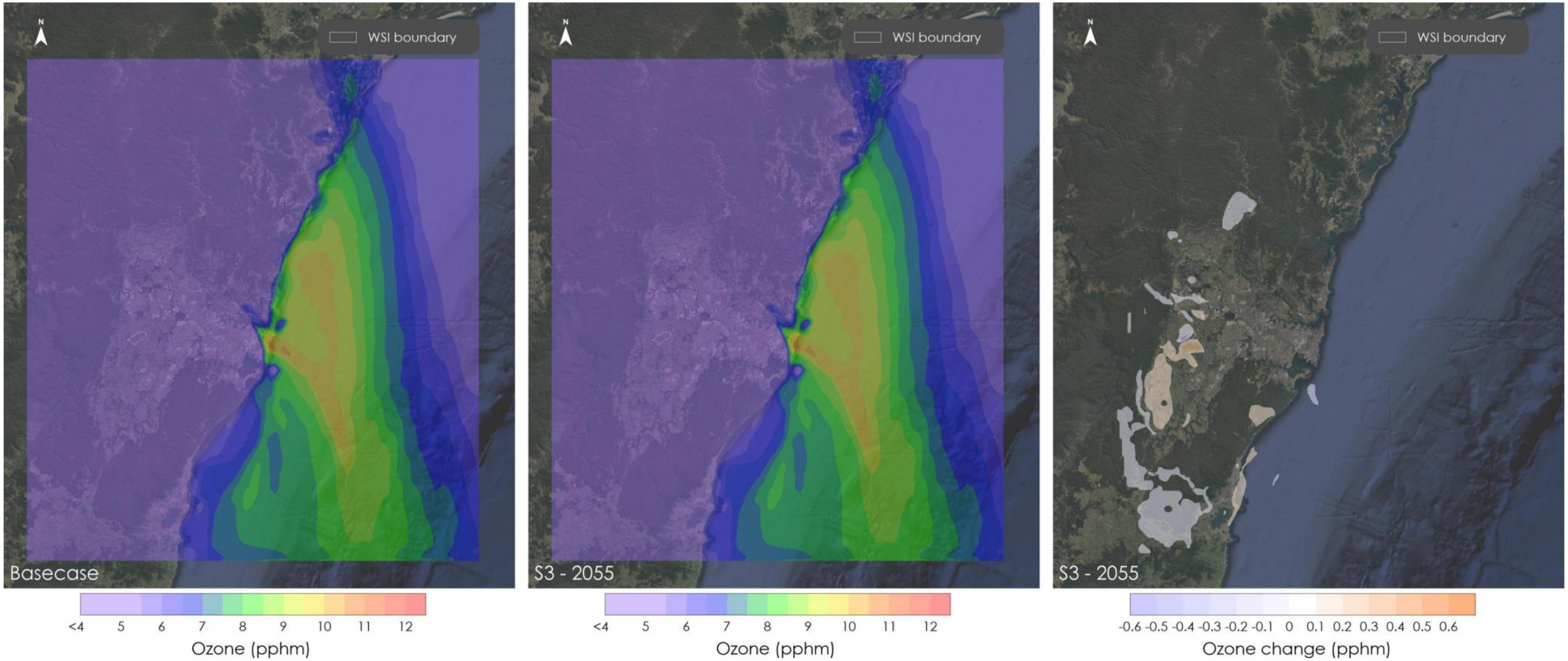


Figure D.56 Daily maximum 1-hour average ozone concentrations 2055 Prefer Runway 05 19/12/2021

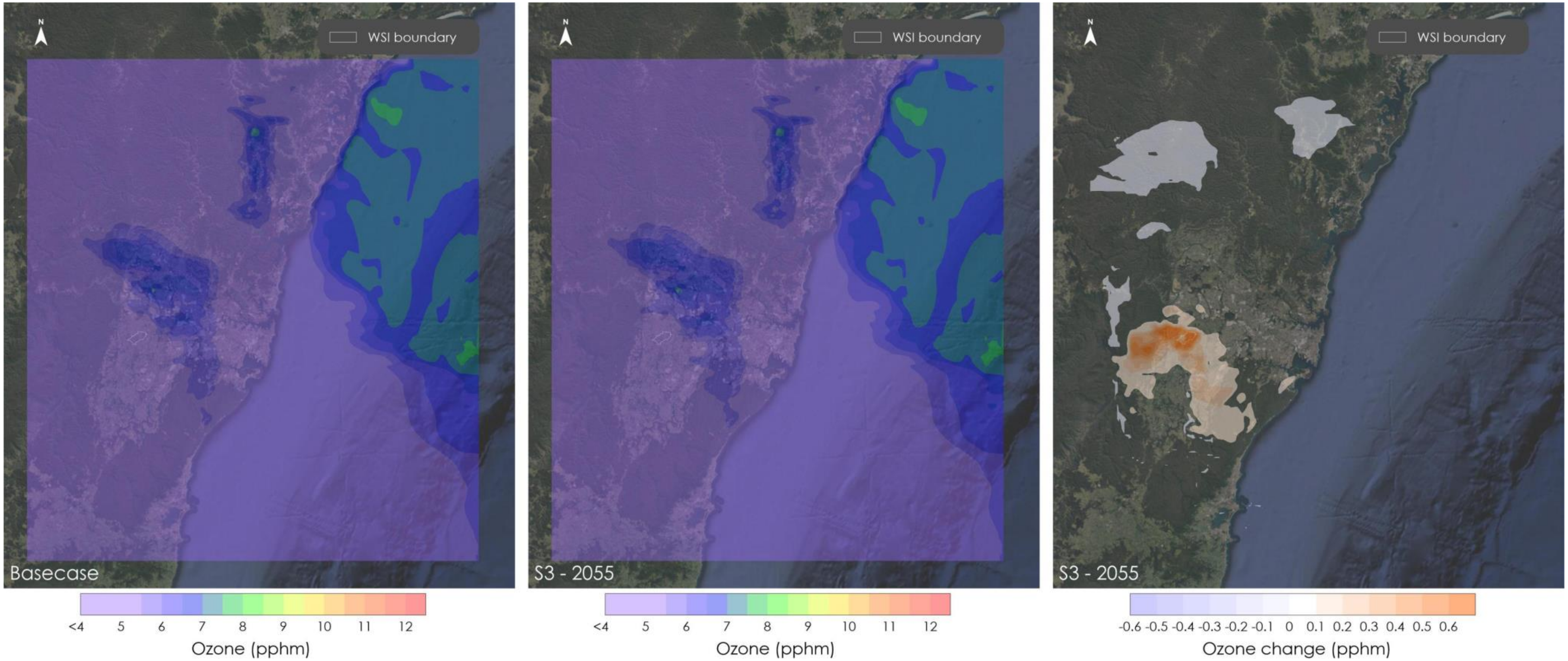


Figure D.57 Daily maximum 1-hour average ozone concentrations 2055 Prefer Runway 05 20/12/2021

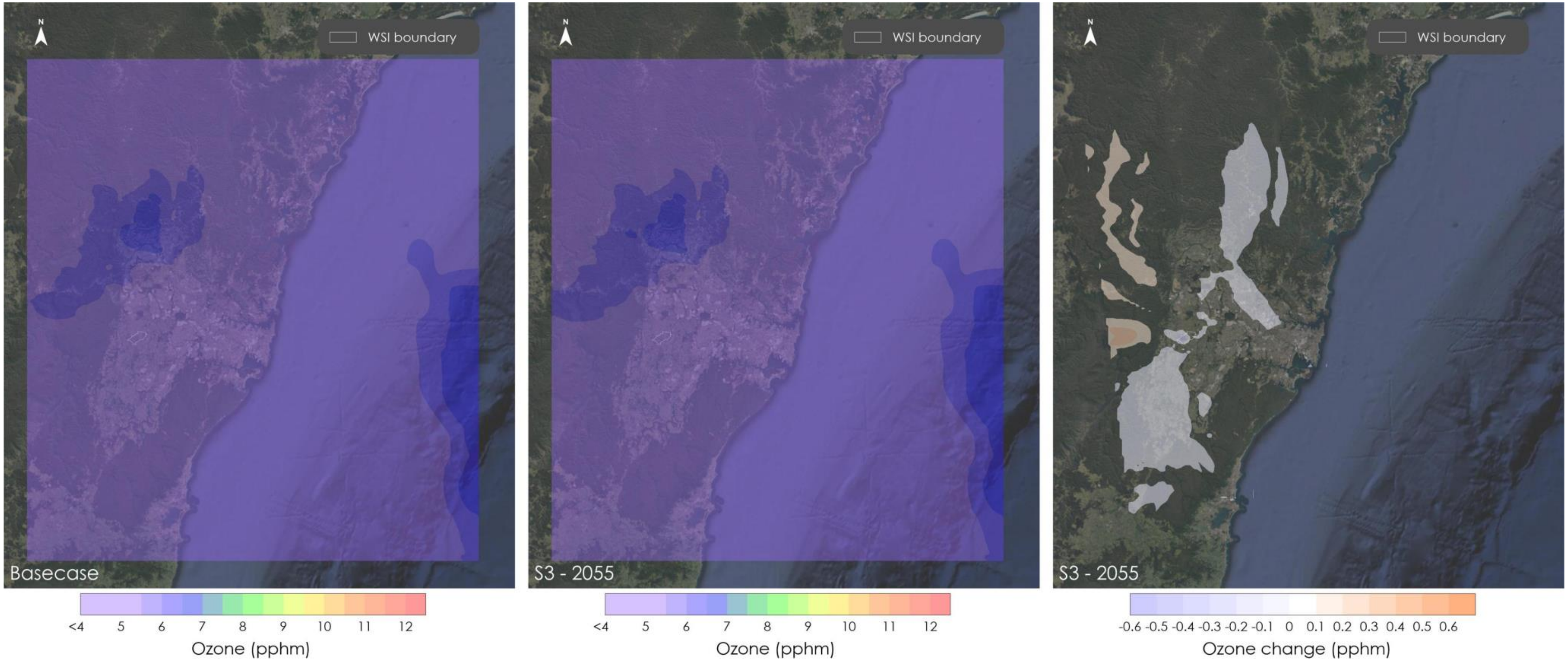


Figure D.58 Daily maximum 1-hour average ozone concentrations 2055 Prefer Runway 05 21/12/2021

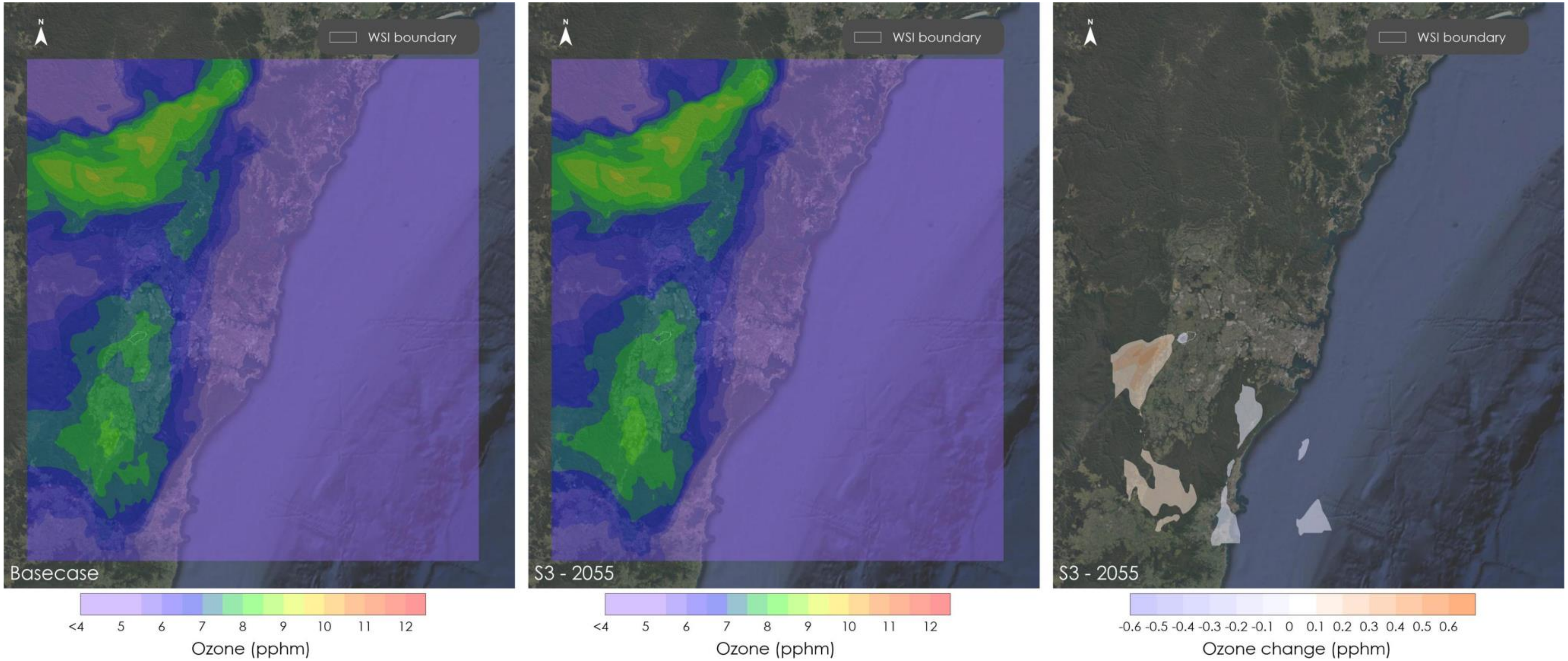


Figure D.59 Daily maximum 1-hour average ozone concentrations 2055 Prefer Runway 05 22/12/2021

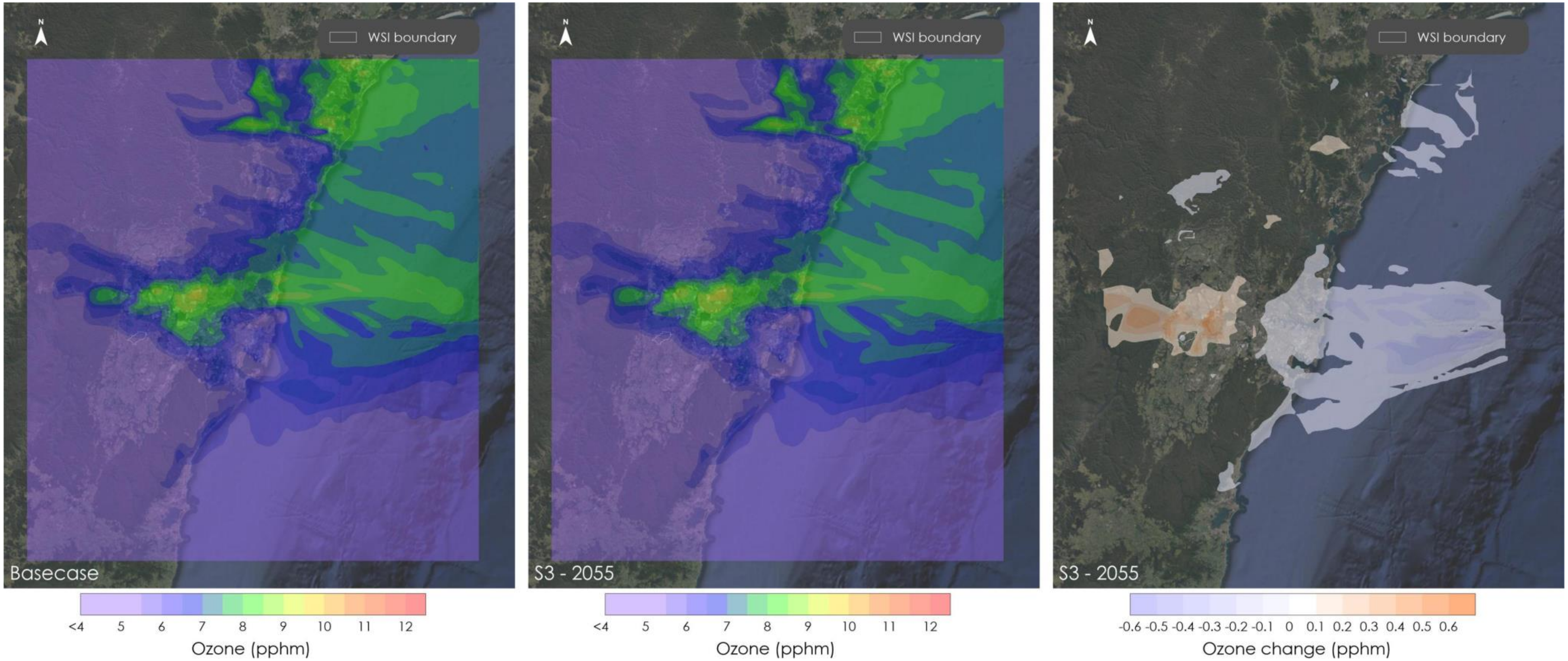


Figure D.60 Daily maximum 1-hour average ozone concentrations 2055 Prefer Runway 05 23/12/2021

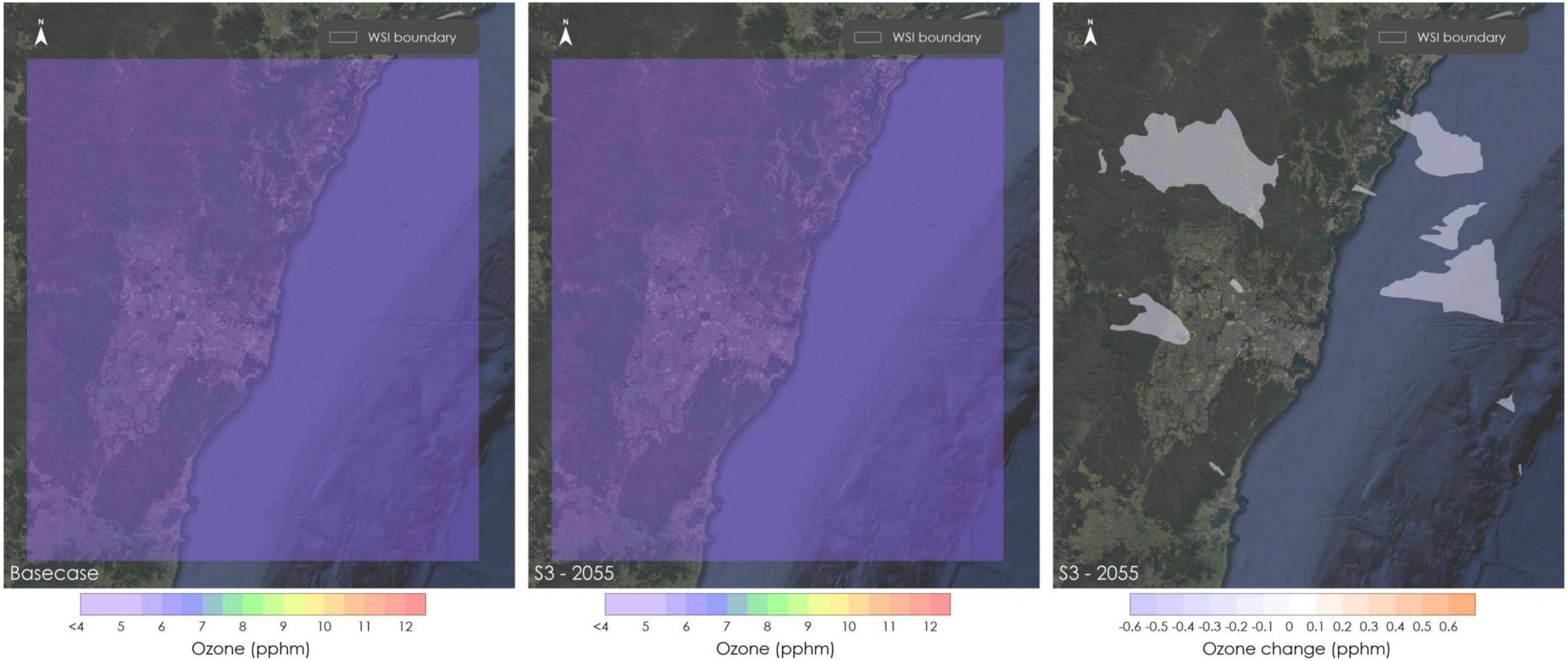


Figure D.61 Daily maximum 1-hour average ozone concentrations 2055 Prefer Runway 05 24/12/2021

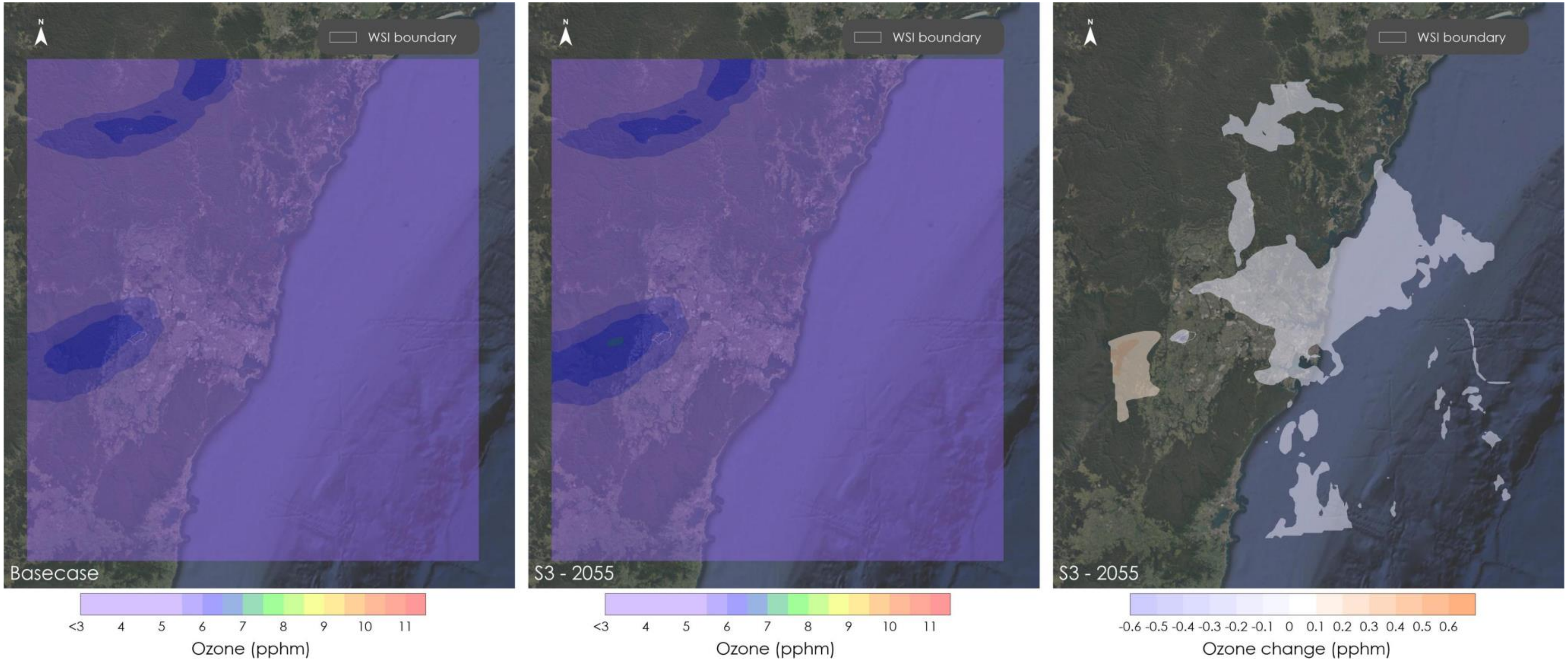


Figure D.62 Daily maximum 4-hour average ozone concentrations 2055 Prefer Runway 05 17/12/2021

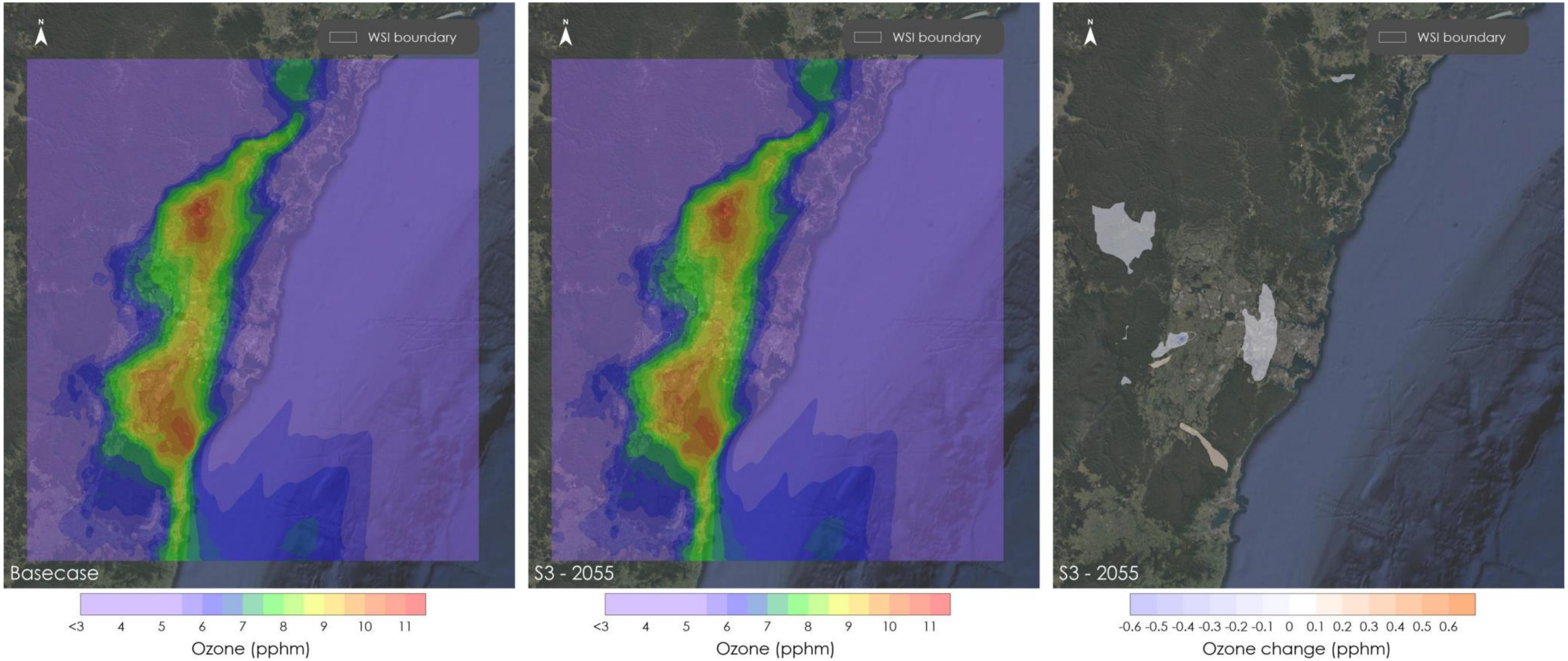


Figure D.63 Daily maximum 4-hour average ozone concentrations 2055 Prefer Runway 05 18/12/2021

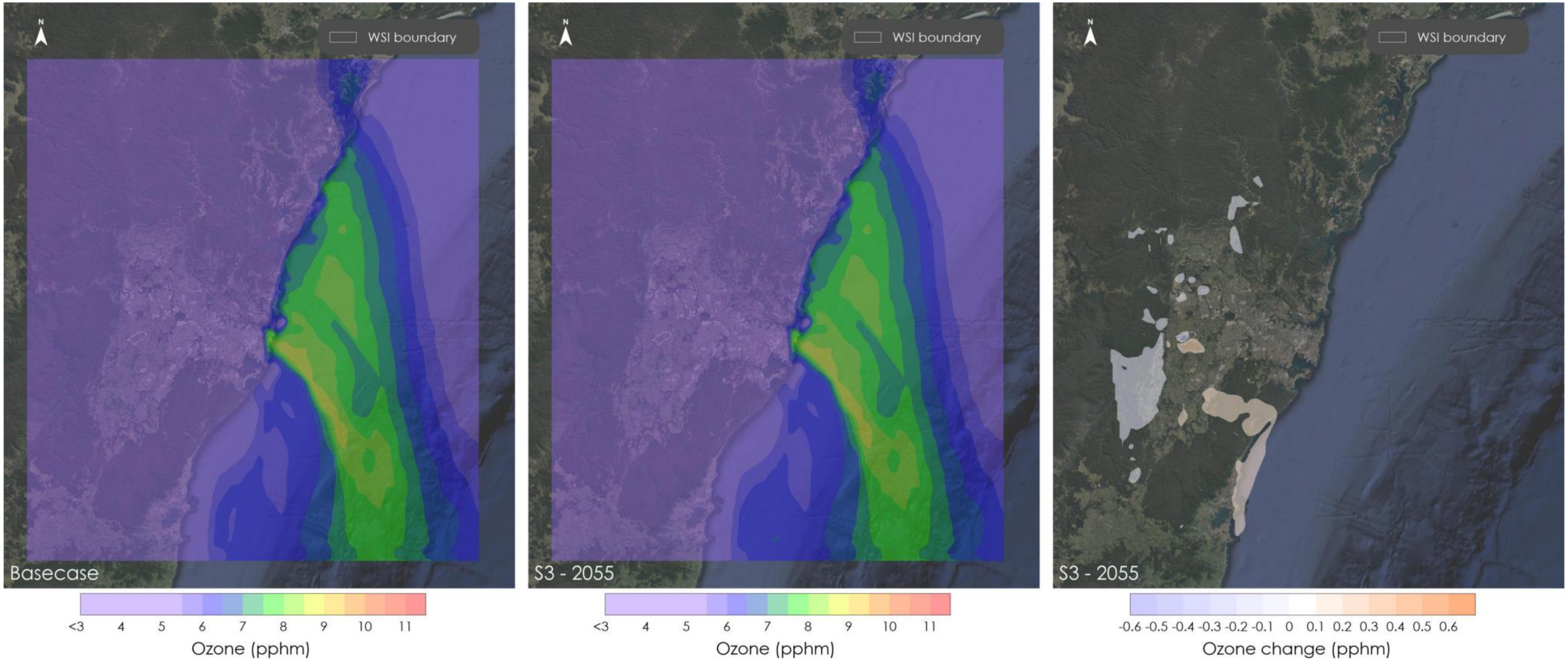


Figure D.64 Daily maximum 4-hour average ozone concentrations 2055 Prefer Runway 05 19/12/2021

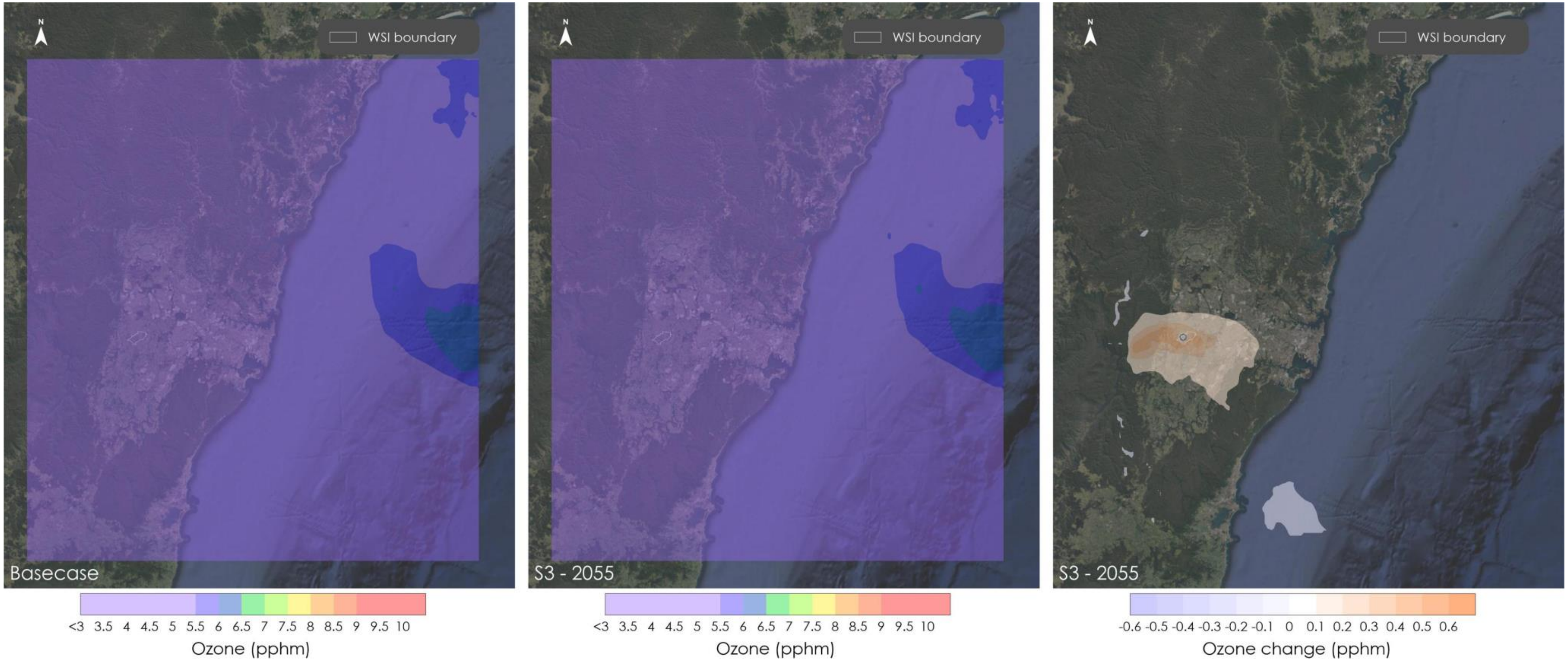


Figure D.65 Daily maximum 4-hour average ozone concentrations 2055 Prefer Runway 05 20/12/2021

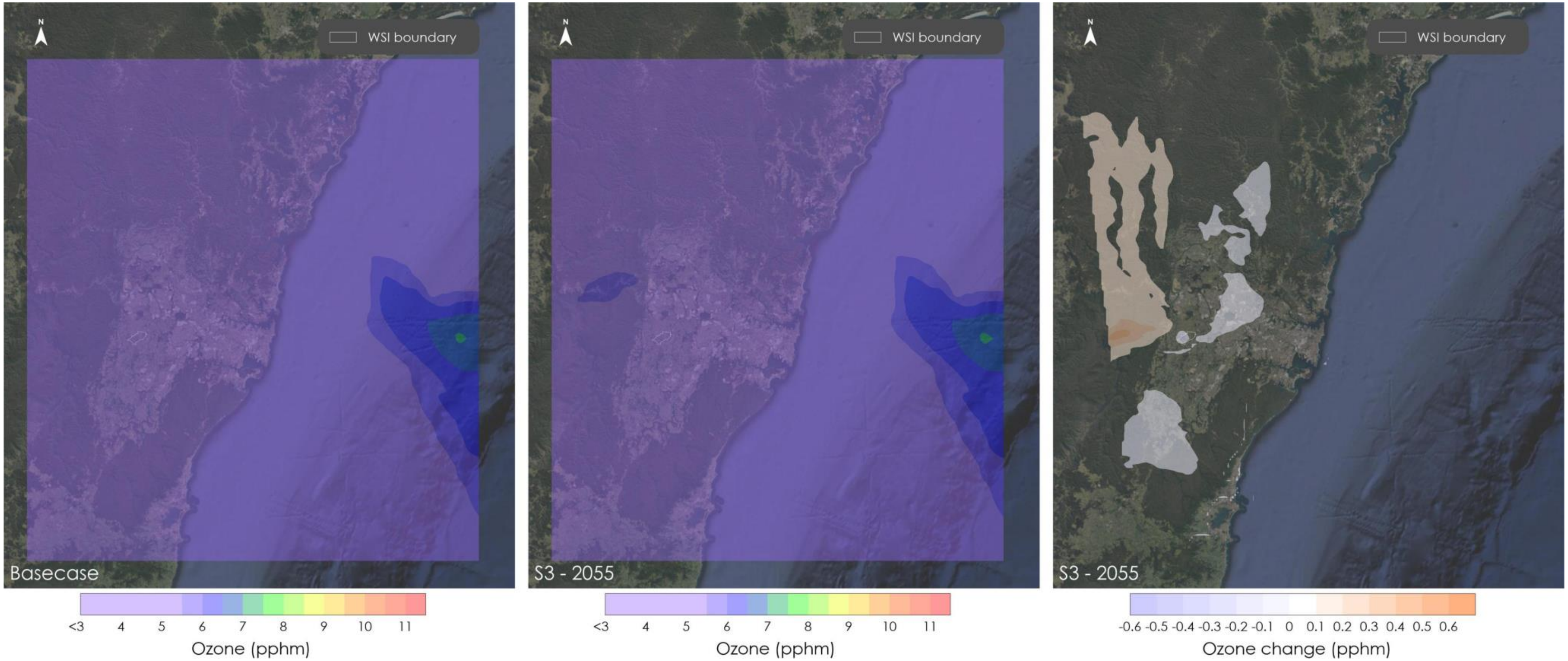


Figure D.66 Daily maximum 4-hour average ozone concentrations 2055 Prefer Runway 05 21/12/2021

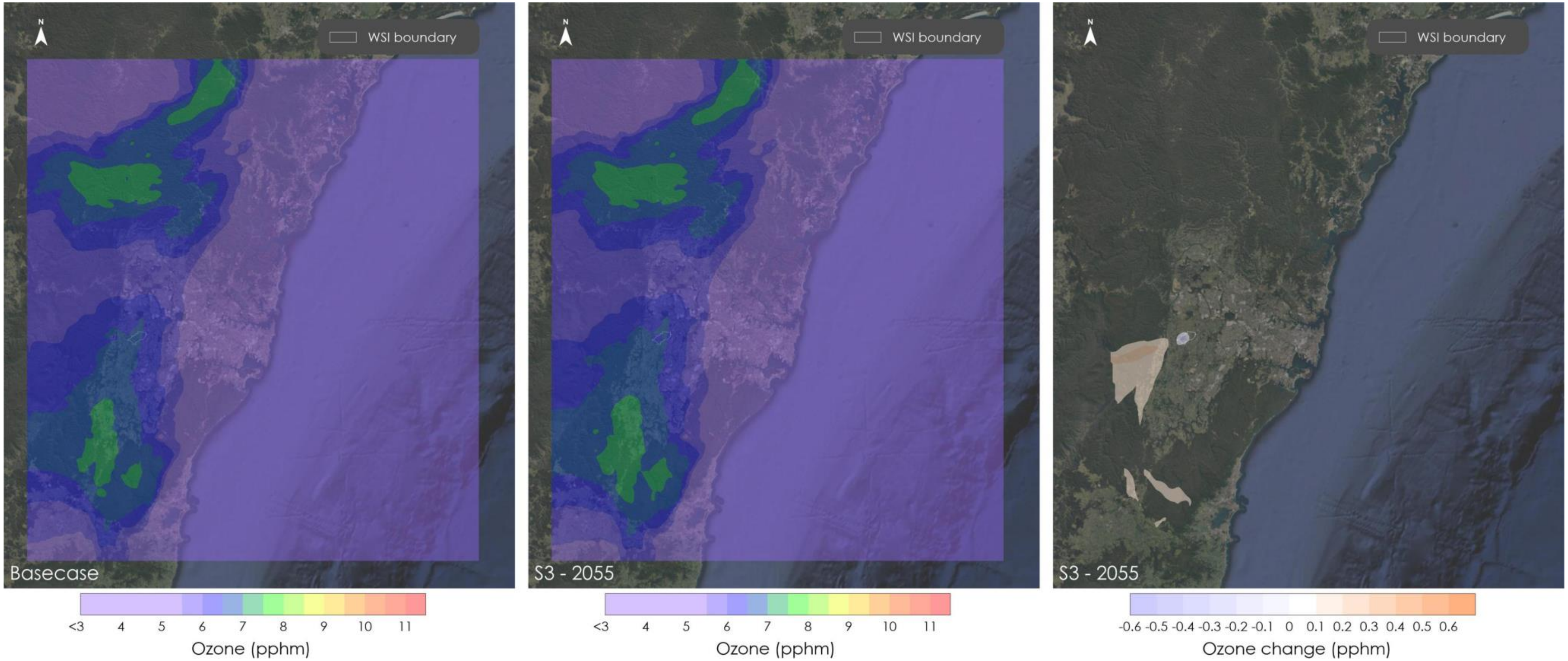


Figure D.67 Daily maximum 4-hour average ozone concentrations 2055 Prefer Runway 05 22/12/2021

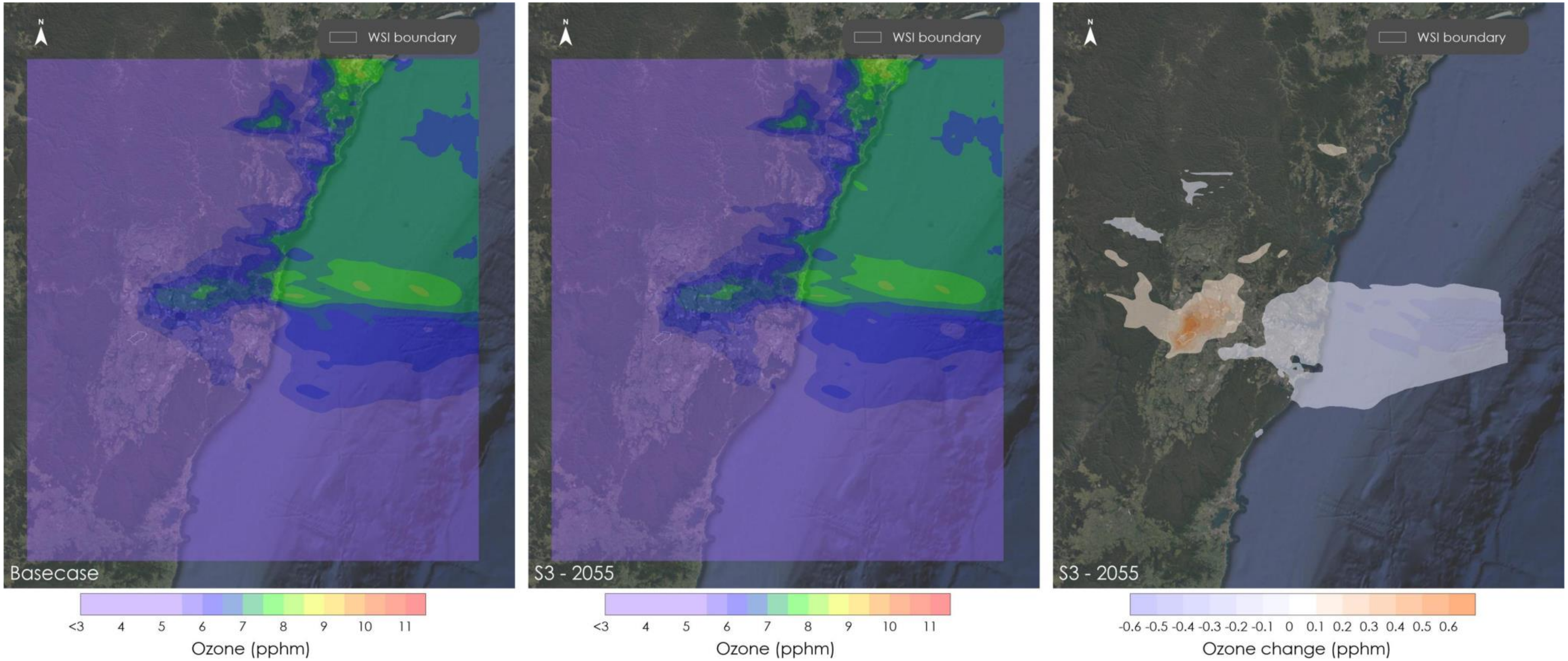


Figure D.68 Daily maximum 4-hour average ozone concentrations 2055 Prefer Runway 05 23/12/2021

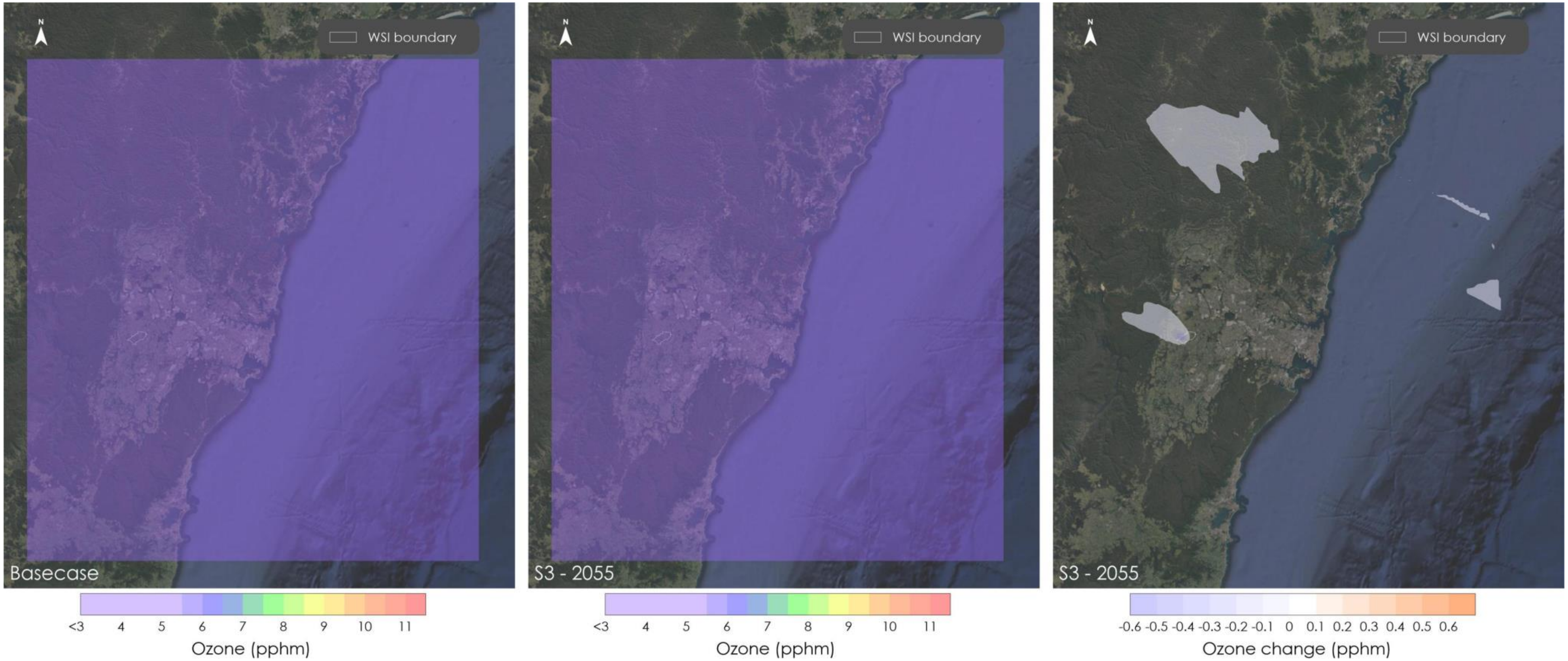


Figure D.69 Daily maximum 4-hour average ozone concentrations 2055 Prefer Runway 05 24/12/2021

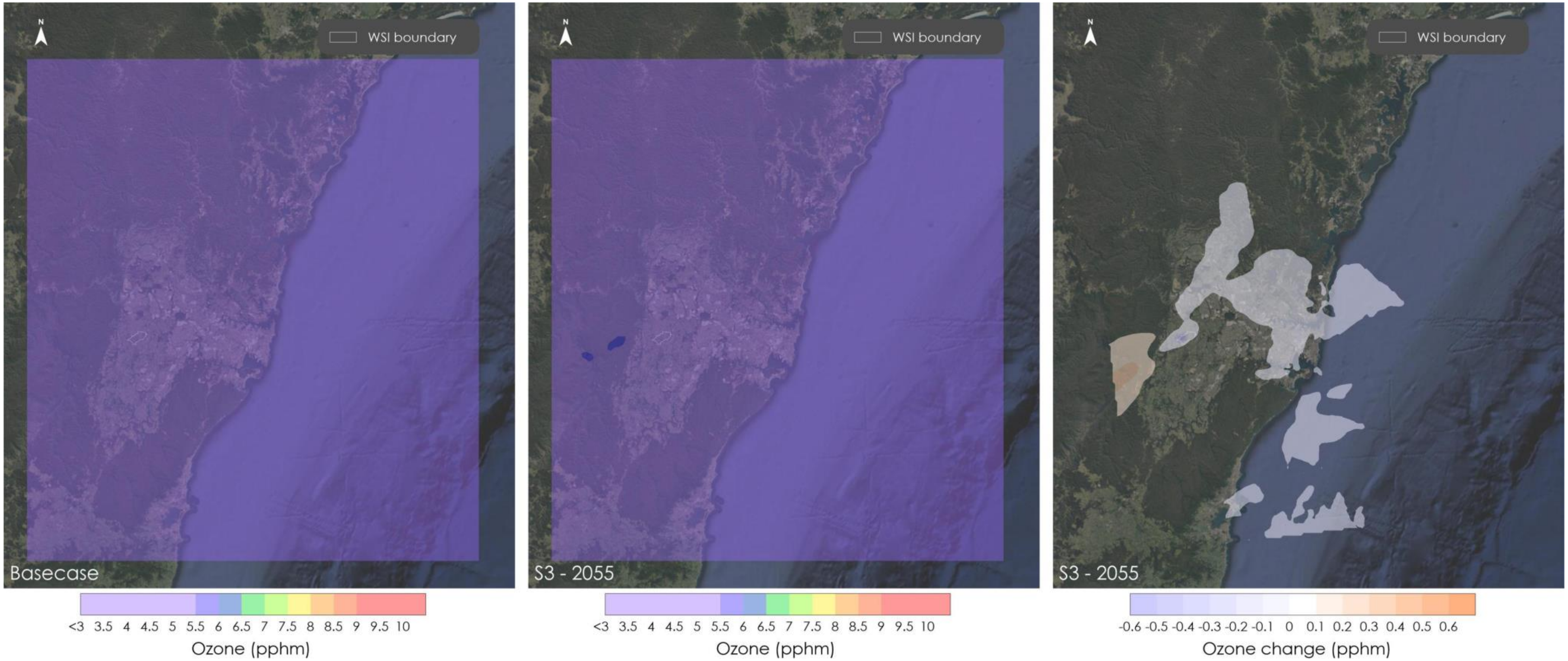


Figure D.70 Daily maximum 8-hour average ozone concentrations 2055 Prefer Runway 05 17/12/2021

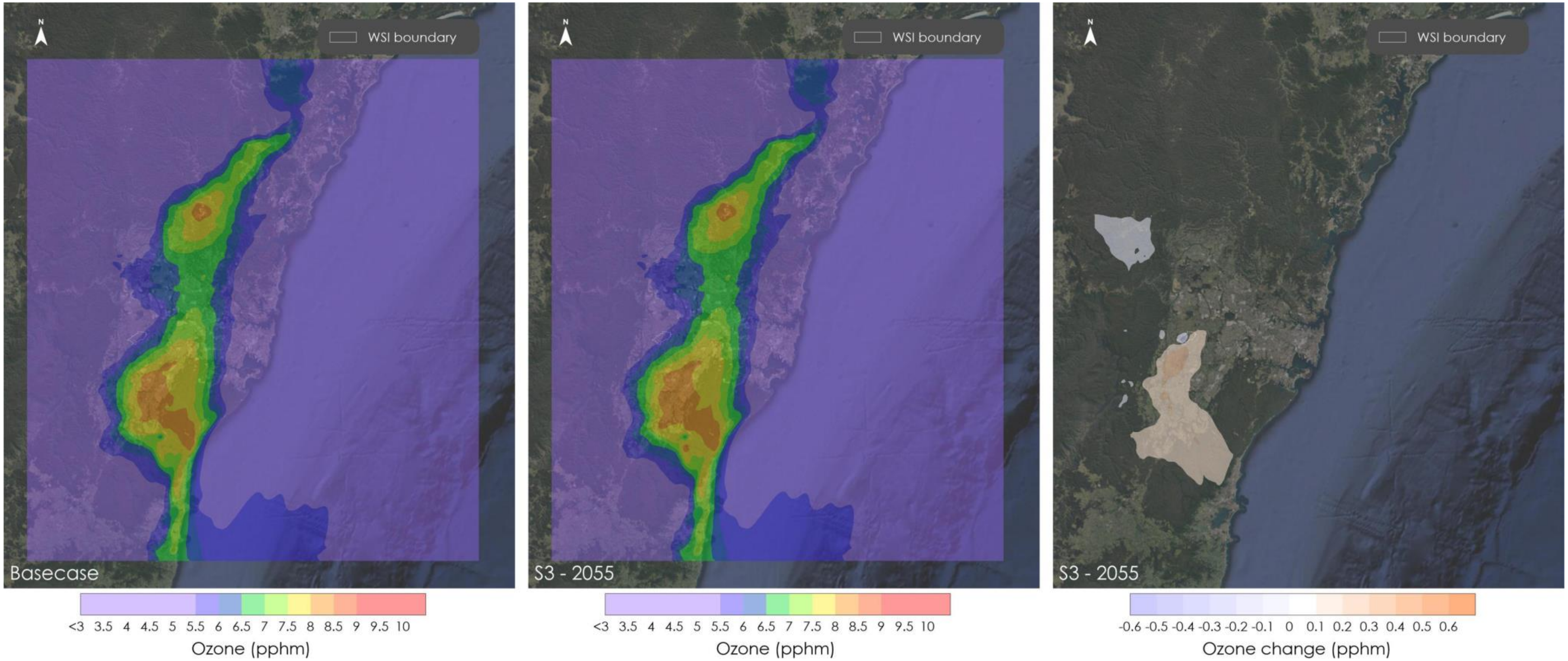


Figure D.71 Daily maximum 8-hour average ozone concentrations 2055 Prefer Runway 05 18/12/2021

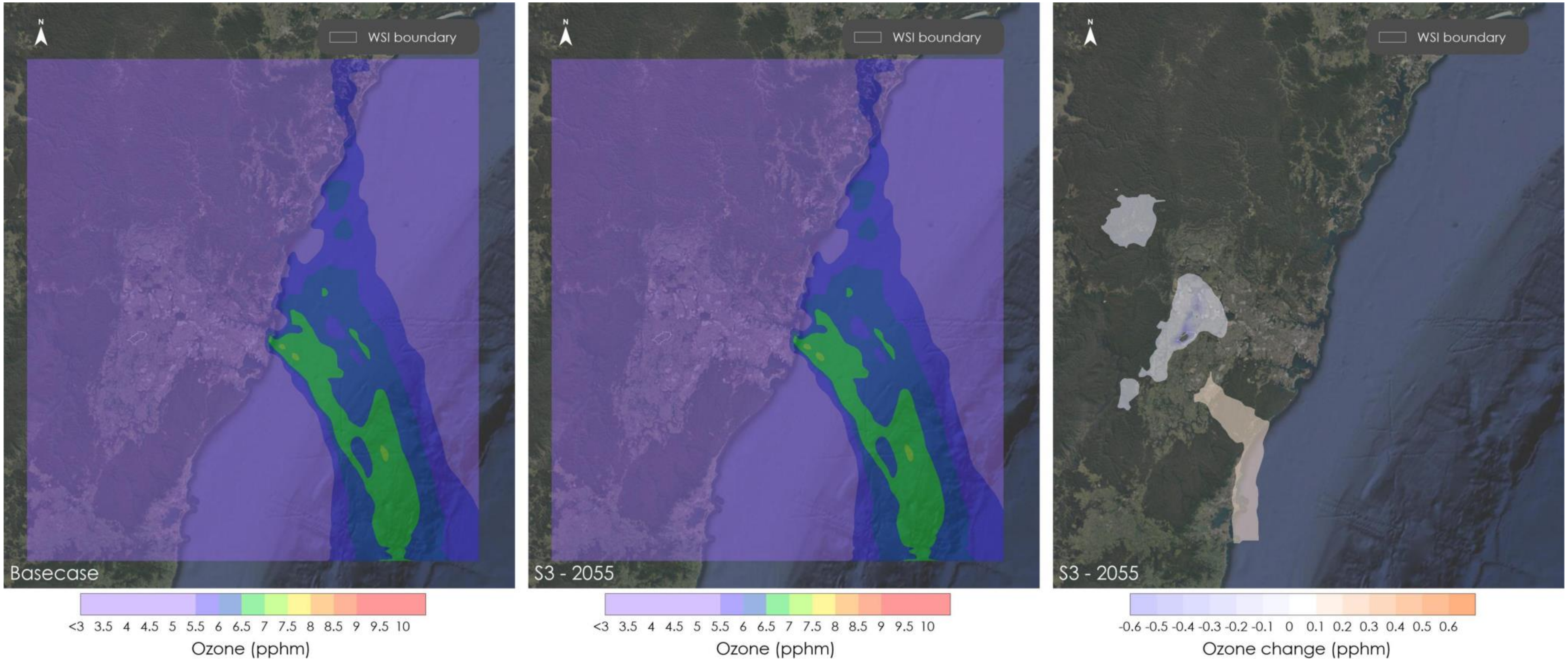


Figure D.72 Daily maximum 8-hour average ozone concentrations 2055 Prefer Runway 05 19/12/2021

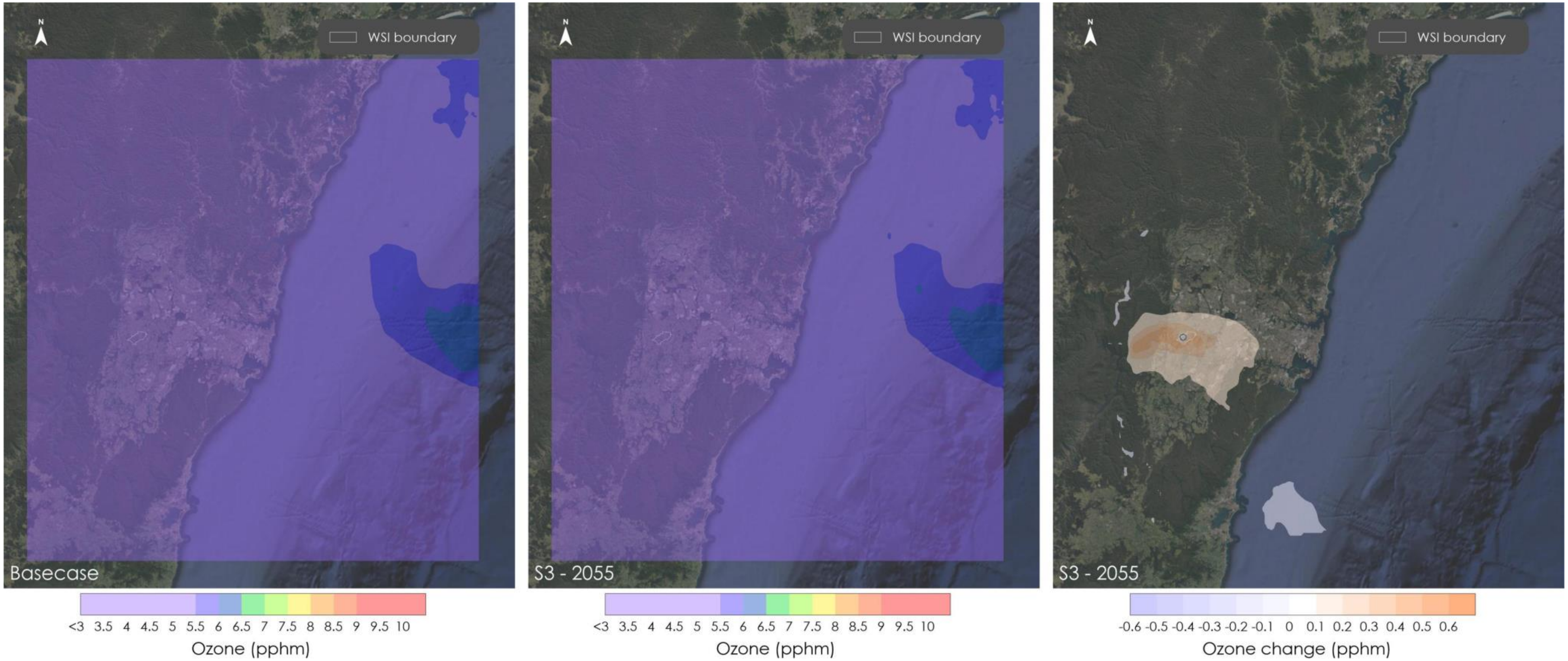


Figure D.73 Daily maximum 8-hour average ozone concentrations 2055 Prefer Runway 05 20/12/2021

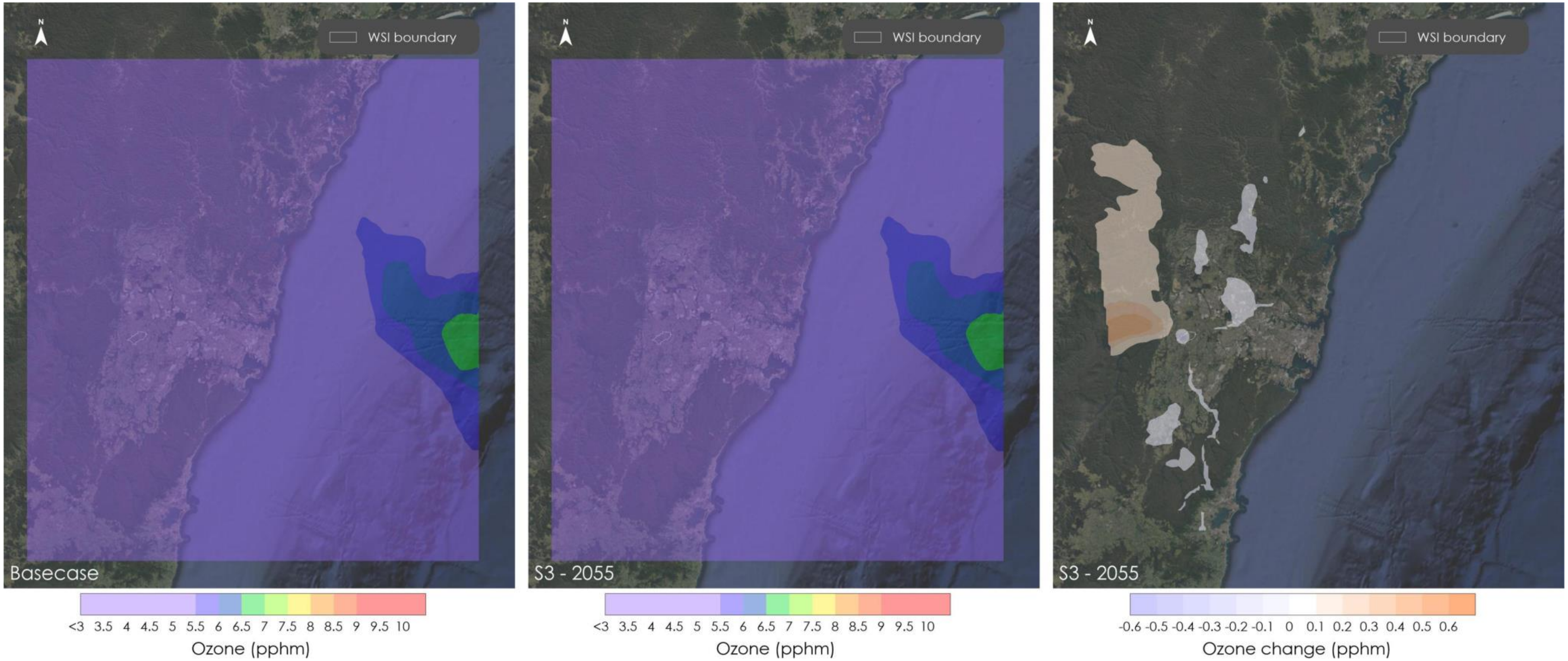


Figure D.74 Daily maximum 8-hour average ozone concentrations 2055 Prefer Runway 05 21/12/2021

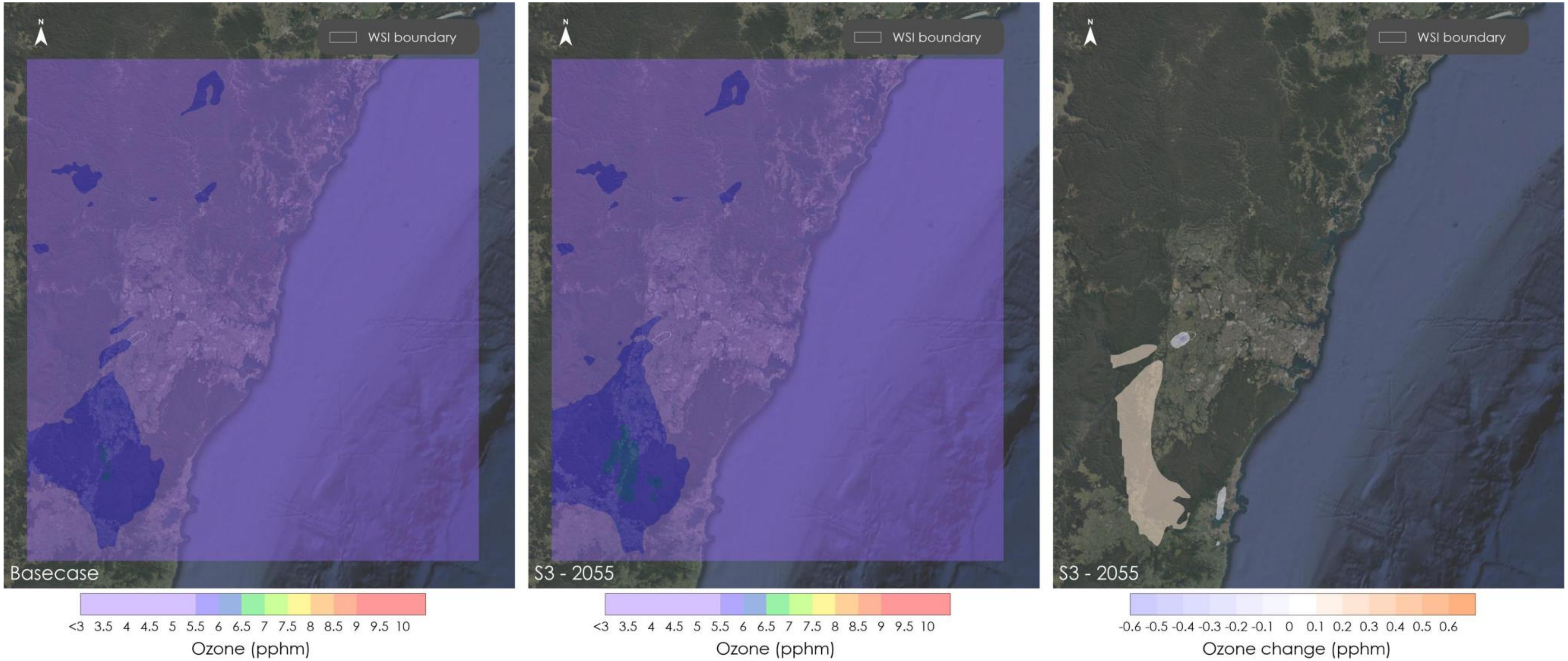


Figure D.75 Daily maximum 8-hour average ozone concentrations 2055 Prefer Runway 05 22/12/2021

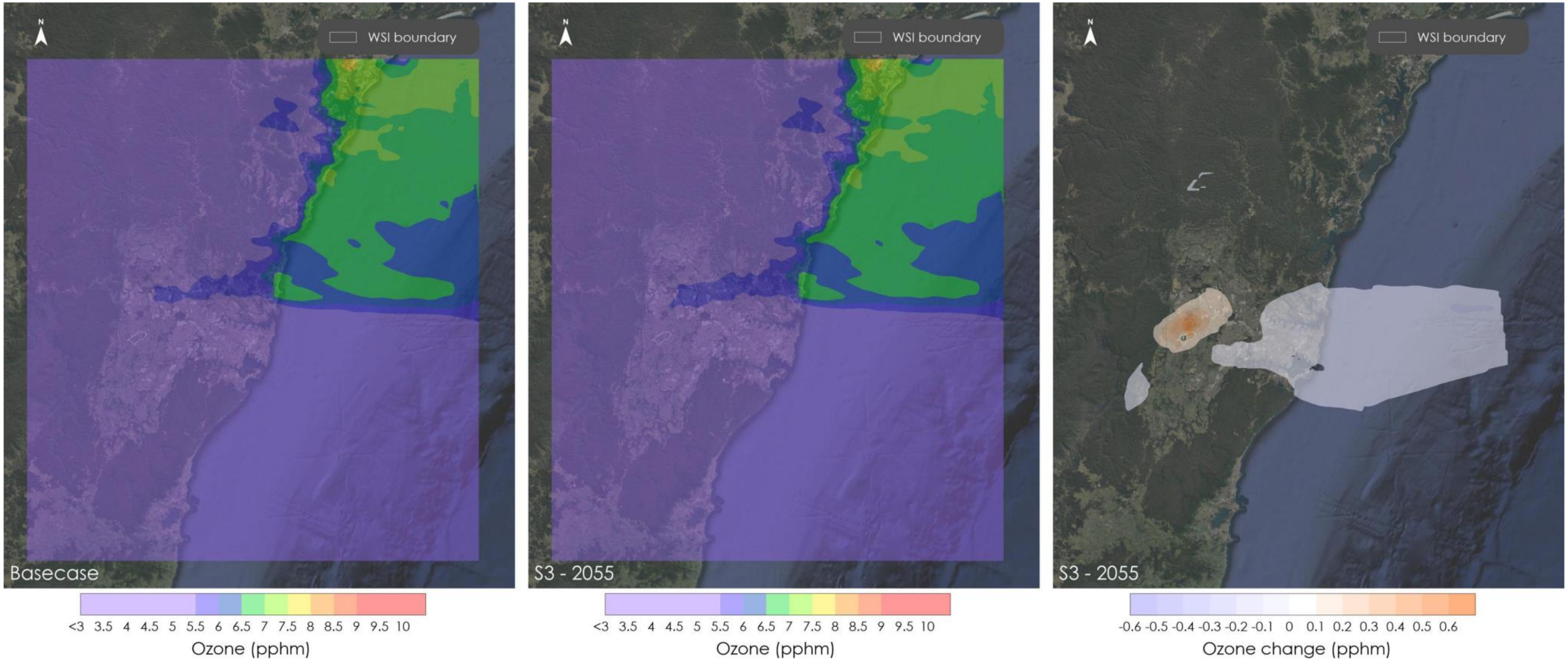


Figure D.76 Daily maximum 8-hour average ozone concentrations 2055 Prefer Runway 05 23/12/2021

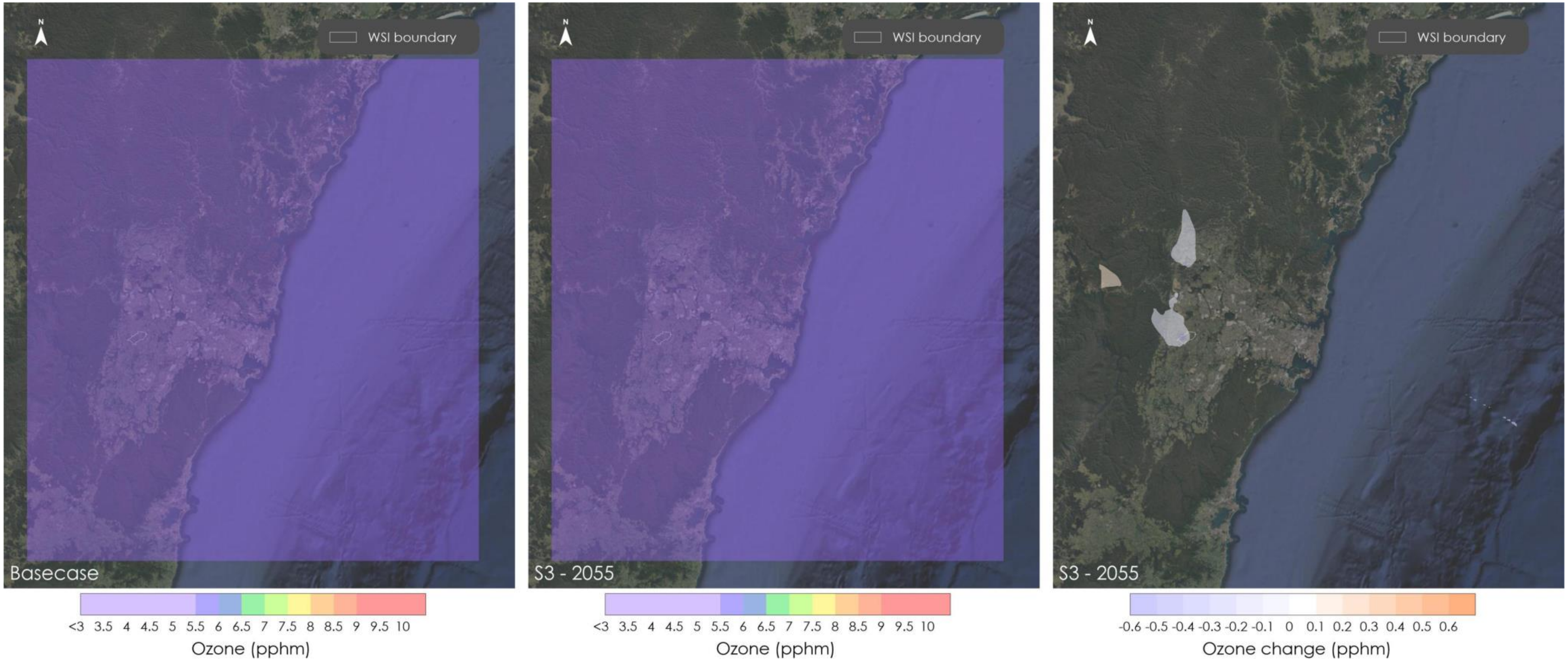


Figure D.77 Daily maximum 8-hour average ozone concentrations 2055 Prefer Runway 05 24/12/2021

D5 Other pollutants

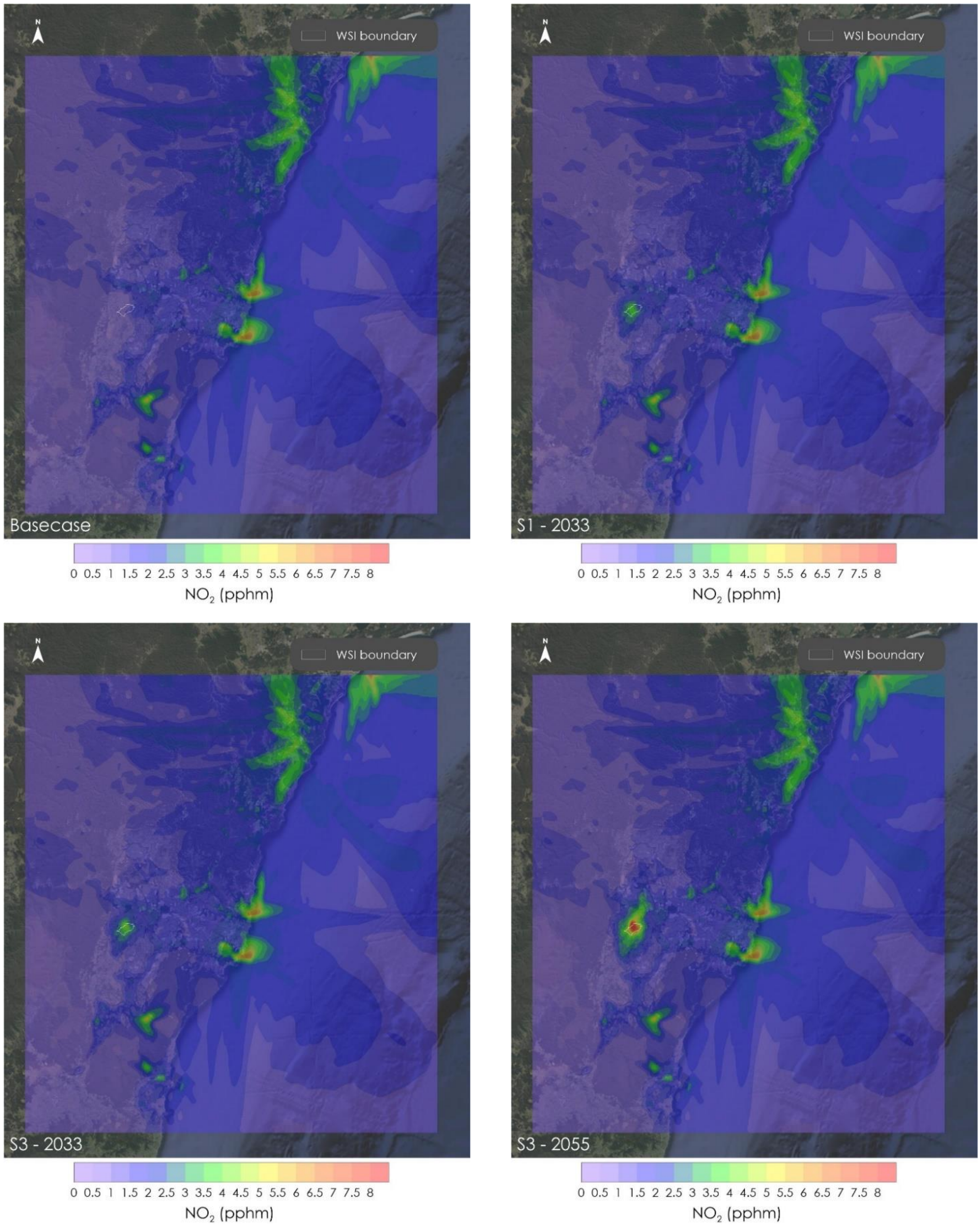


Figure D.78 Maximum predicted 1-hour average NO_2 concentrations for basecase, 2033 - No preference, 2033 – Prefer Runway 05 and 2055 – Prefer Runway 05

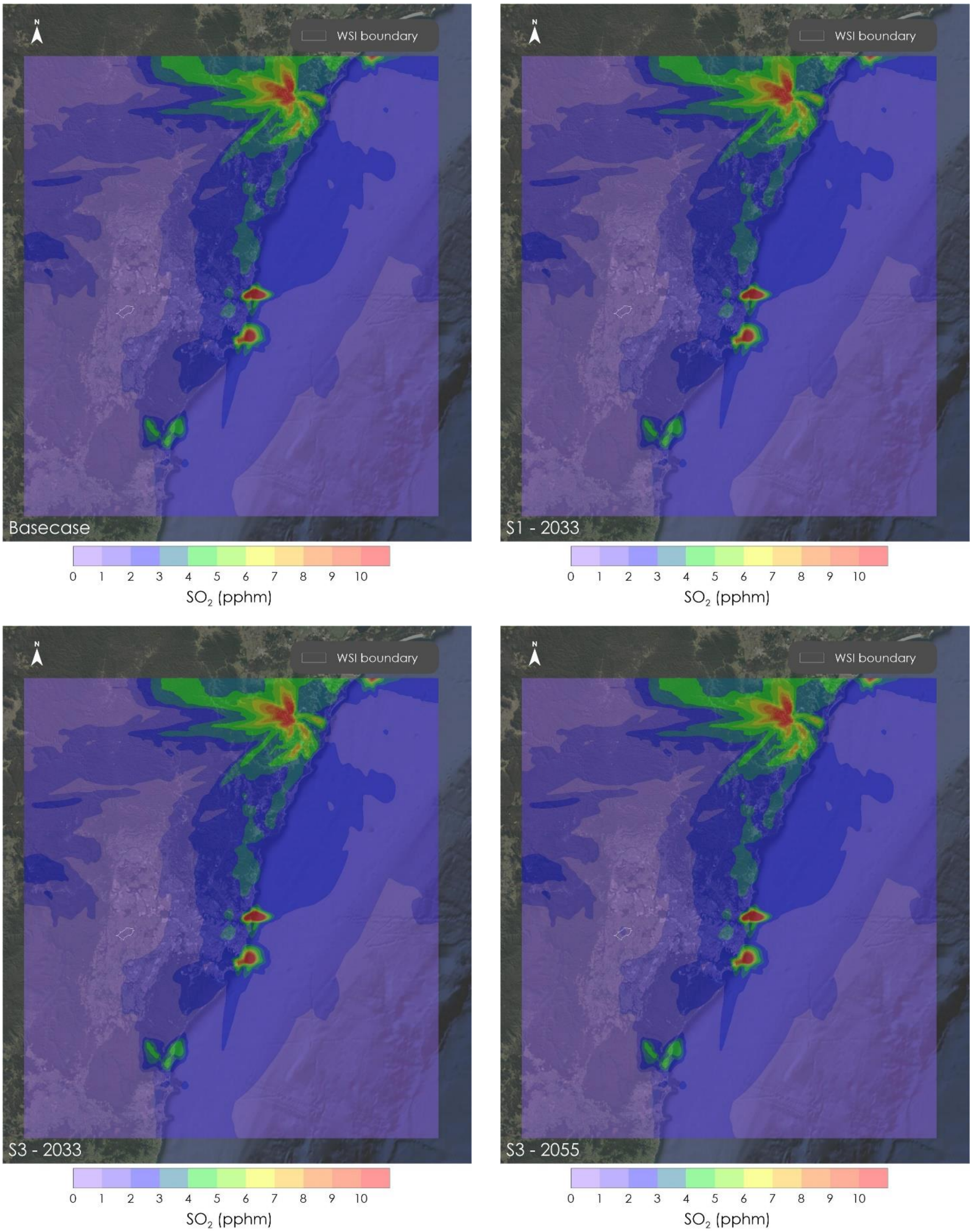


Figure D.79 Maximum predicted 1-hour average SO_2 concentrations for basecase, 2033 - No preference, 2033 – Prefer Runway 05 and 2055 – Prefer Runway 05

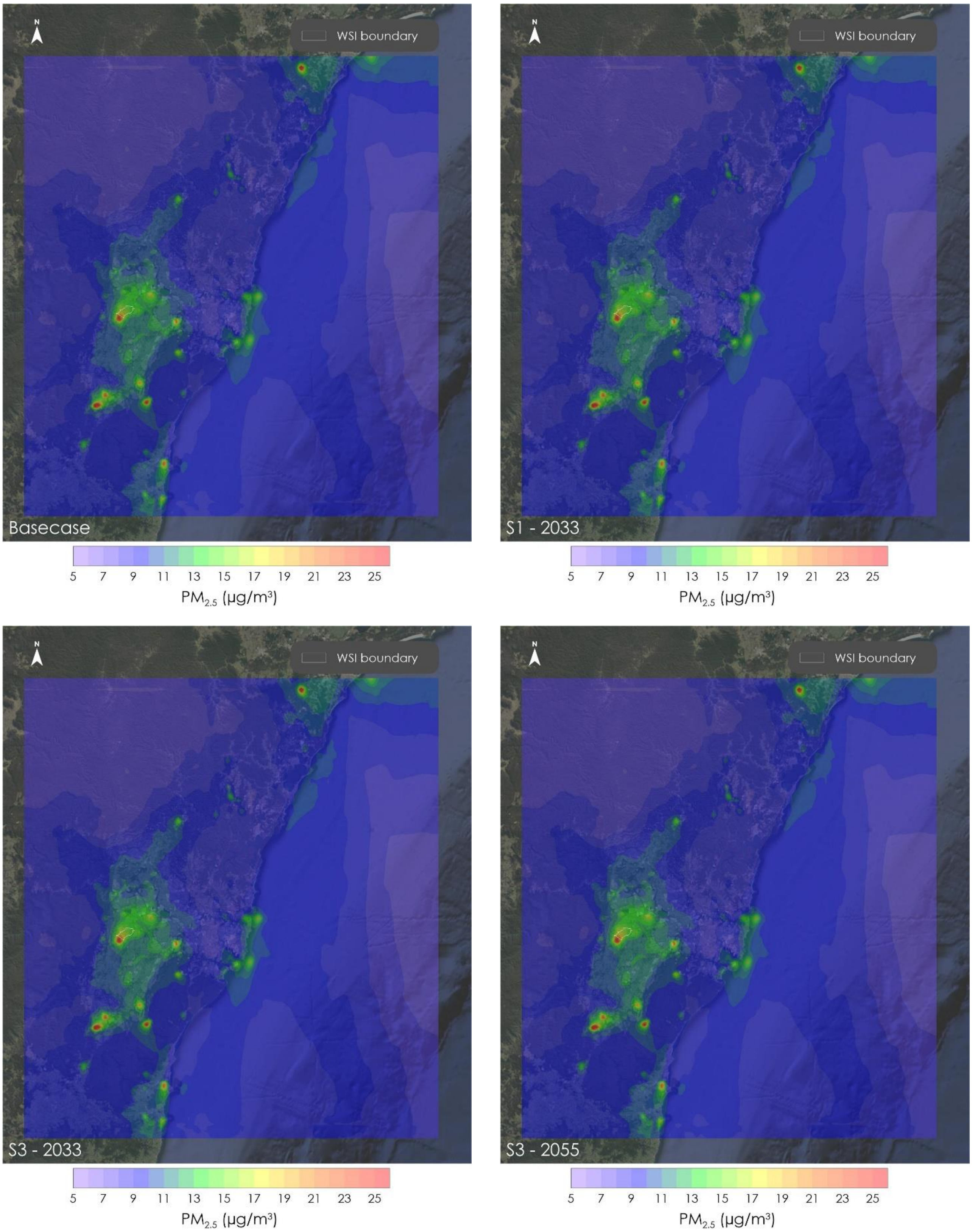


Figure D.80 Maximum predicted 24-hour average $PM_{2.5}$ concentrations for basecase, 2033 - No preference, 2033 – Prefer Runway 05 and 2055 – Prefer Runway 05

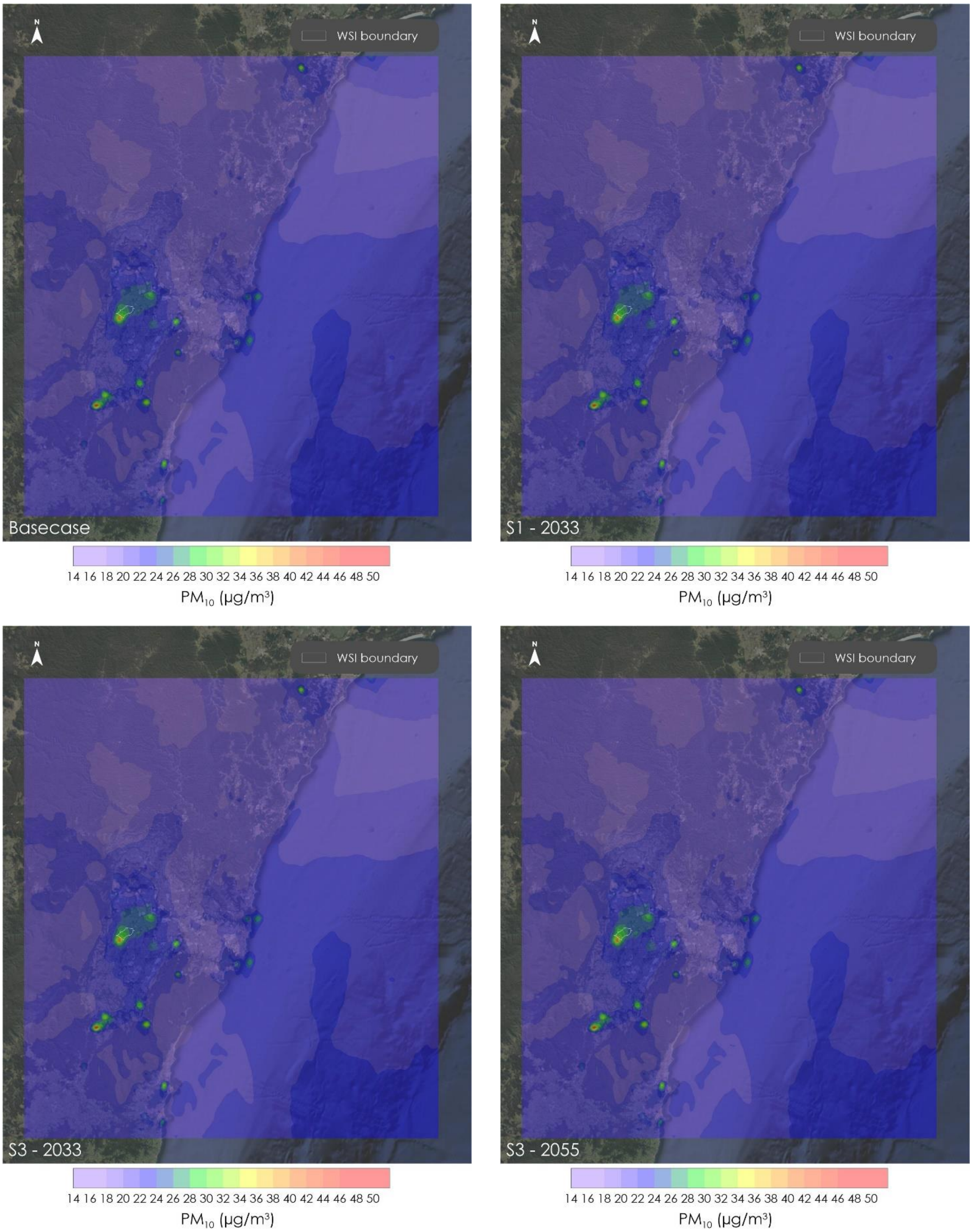


Figure D.81 Maximum predicted 24-hour average PM_{10} concentrations for basecase, 2033 - No preference, 2033 – Prefer Runway 05 and 2055 – Prefer Runway 05

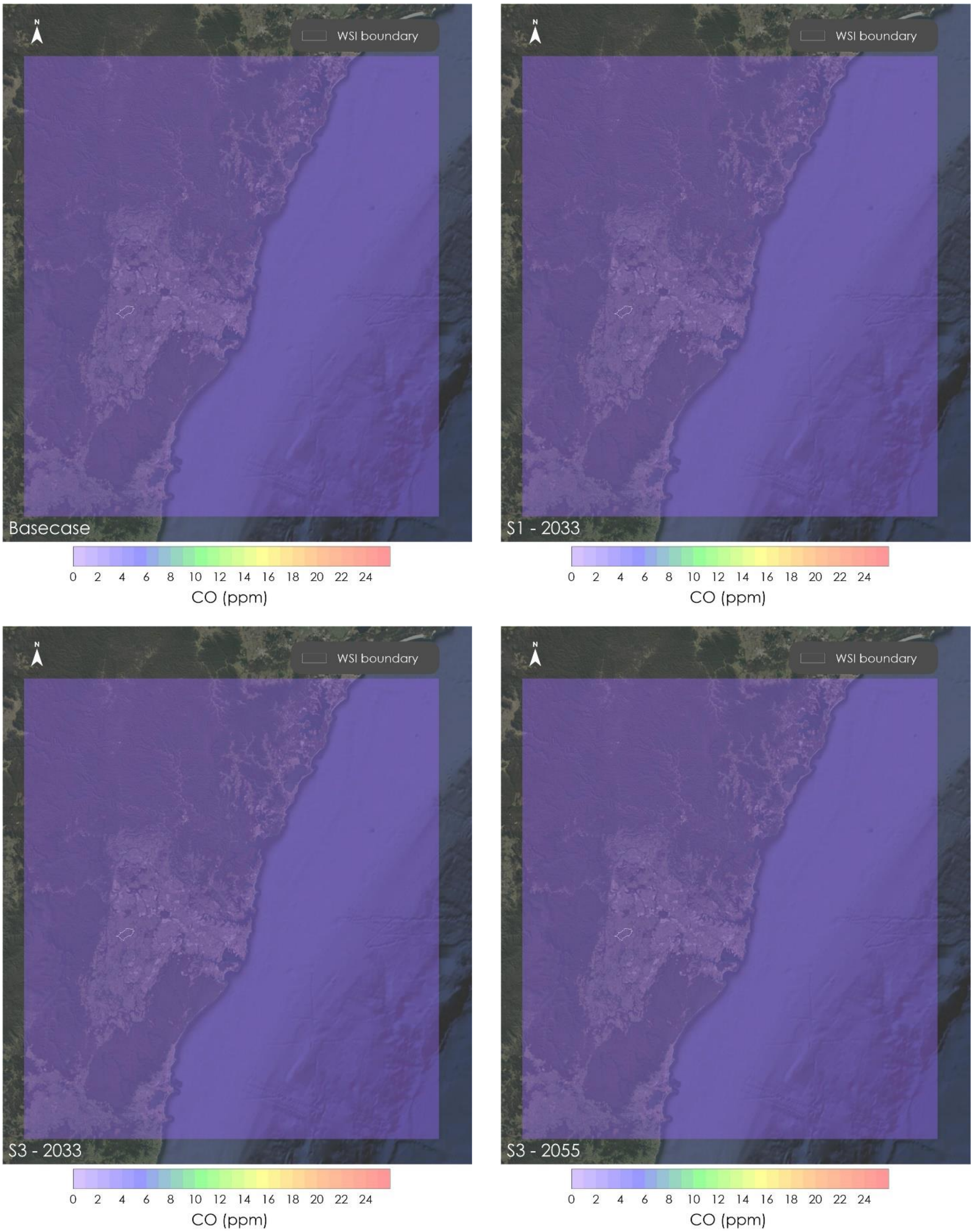


Figure D.82 Maximum predicted 1-hour average CO concentrations for basecase, 2033 - No preference, 2033 – Prefer Runway 05 and 2055 – Prefer Runway 05

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