9. AIR QUALITY

This section provides a description of the air quality environmental values within the project development area and an assessment of the potential for these values to be affected by direct and indirect impacts associated with the all phases of the project. For the detailed findings of the project's air quality impacts refer to Appendix C, Air Quality Impact Assessment. Environmental protection objectives have been developed and the mitigation and management measures to achieve these objectives identified. The residual impact assessment assumes that the proposed mitigation and management measures have been applied.

9.1 Legislative Context and Standards

The following legislation, policy and guidelines are relevant to identifying values, and mitigating and managing impacts on air quality during construction, operation and decommissioning of the project.

Environmental Protection Act 1994 **(Qld).** The objective of the Environmental Protection Act (EP Act) is to protect Queensland's environment by promoting ecologically sustainable development. The Environmental Protection Regulation 2008 provides a mechanism to enforce the EP Act and allows for an assessment of the risk that an environmentally relevant activity poses to environmentally sensitive areas.

Environmental Protection Policy (Air) 2008 (Qld). This policy sits under the *Environmental Protection Act 1994* and aims to protect and enhance environmental values relating to Queensland's air environment. The Environmental Protection Policy (Air) (EPP (Air)) provides air quality objectives for the protection and enhancement of the environmental values.

National Environment Protection Measures (Ambient Air Quality) 2003 and National Environment Protection Measures (Air Toxics) 2004. These environment protection measures produced by the National Environmental Protection Council provide ambient air quality objectives for Australia that are consistent with the objectives set out in the EPP (Air). The Department of Environment and Resource Management (DERM) uses the relevant objectives to set licence conditions relating to ambient air quality.

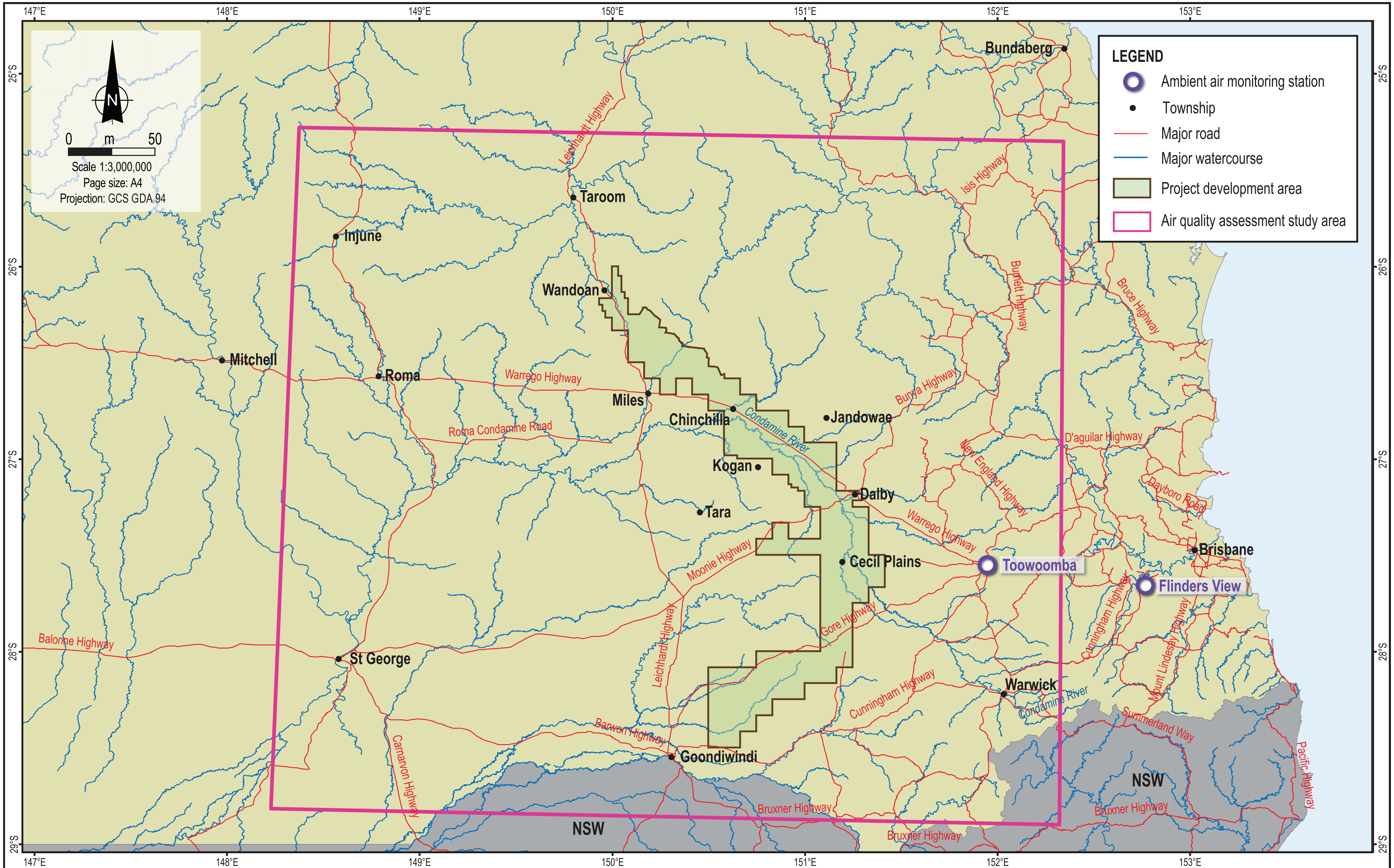
National Environment Protection (National Pollutant Inventory) Measure 1998. The National Environment Protection (National Pollutant Inventory) Measure requires facilities to report their use and emissions of a prescribed list of substances.

Odour Impact Assessment from Developments (QEPA, 2004). This guideline sets out various approaches to assess potential odour impacts from new or expanding developments.

Unratified DERM Guidelines. Unratified guidelines have also been taken into consideration including DERM's dust deposition guideline of 120 mg/m^2/day.

9.2 Assessment Methods

The air quality assessment involved evaluation of baseline air quality and assessment of potential impacts to the air quality from project activities. The assessment study area included the project development area as well as the wider region likely to be affected by emissions from the project development area (Figure 9.1). The study area allowed for the modelling of large-scale meteorological events that may have a regional impact.



Source:
Place names, roads and watercourses from GEODATA250k.
Project development area from Arrow Energy.
Air quality assessment study area from PAE Holmes.
Ambient air monitoring stations from DERM (indicative locations only).

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Air quality assessment study area

Figure No: 9.1

9.2.1 Baseline Study Method

Air quality data from DERM ambient air monitoring stations, located in Toowoomba and Flinders View approximately 45 km and 135 km east of the project development area respectively, was used to establish the ambient air quality of the existing environment. Data was obtained for relevant parameters including sulfur dioxide (SO_2), carbon monoxide (CO) and particulate matter (PM).

The Chemical Transport Model (CTM), which is a photochemical dispersion model, was used to determine existing and predicted concentrations of ground-level nitrogen dioxide (NO_2) and ozone (O_3). NO_2 and O_3 concentrations in the atmosphere are dependent on meteorological conditions as well as types and concentrations of emissions. Meteorological data for the CTM was generated using The Air Pollution Model (TAPM). Generated data included wind, temperature, humidity, cloud, rain, snow, turbulence, eddy and radiative flux factors. A total of 96 existing and approved future major emissions sources contributing to key air pollutants within the study area, were included in the modelling.

9.2.2 Impact Study Method

A regional and local assessment of air quality impacts from the project was conducted.

Regional impacts were assessed using the same photochemical model that was used for the evaluation of baseline air quality.

Localised ambient air quality impacts (close to emission sources) were assessed using AUSPLUME, a plume dispersion model. This model simulated atmospheric conditions and behaviour of a plume based on mathematical calculations and predicted ground-level air concentrations. Meteorological data generated by TAPM was used as input into AUSPLUME and was selected to illustrate worst-case scenario meteorological conditions with regard to dispersion of air pollution. Meteorological data was selected for three meteorological regions (northern, central and southern) within the project development area.

The assessment of NO_2 utilised an empirical NO_x/NO_2 relationship to simulate NO_x (nitric oxide and NO_2) chemistry for typical combustion sources. For modelling purposes, all NO_x emissions are assumed to be 5% NO_2 and 95% NO (nitric oxide). These fractions are typical of combustion. Further technical details on modelling method and assumptions are provided in Appendix C, Air Quality Impact Assessment.

Emission sources used in the regional and local models included point sources from wellheads and production facilities including flares. The following stack parameters were used in air quality emission calculations:

- Flare stacks: 9.1-m height of release, 0.56-m stack diameter and exit temperature of 753 K.
- Production facility gas engine stacks: 7.0-m height of release, 0.64-m stack diameter, exit velocity of 28.4 m/s, gas volume flow rate of 0.207 Nm^3/s, exhaust volume flow rate of 9.0 m^3/s and exit temperature of 658 K.
- Wellhead gas engine stacks: 2.5-m height of release, 0.08-m stack diameter, exit velocity of 29 m/s, gas volume flow rate of 0.005 Nm^3/s, exhaust volume flow rate of 0.2 m^3/s and exit temperature of 922 K.

Emission concentrations are provided at standard temperature and pressure. The oxygen content of flue gases is not a determining parameter in the modelling development. However, it is expected that piston-driven engines will have 3 to 5% oxygen content, and that gas turbine systems will have 15% oxygen content.

The specific locations of project facilities are yet to be determined and regional modelling appropriate for this level of uncertainty has been carried out using conceptual locations of wellheads and production facilities (see Figure 5.11).

9.3 Existing Environment and Environmental Values

This section provides a description of the existing air quality and includes a summary of climate and meteorology, land use and existing concentrations of key pollutants.

9.3.1 Climate and Meteorology

The study area has a climate typical of subtropical regions and is summarised as follows:

- Mean monthly minimum temperatures range from 3.6˚C in winter (June to August) to 21˚C in summer (December to February).
- Mean monthly maximum temperatures range from 17°C in winter to 35°C in summer.
- Rainfall displays a consistent pattern across the study area and ranges from an average of 20 to 40 mm in winter to 70 to 100 mm summer.
- Evaporation rates are up to approximately five times higher in summer months than in winter months.
- Wind patterns differ across the northern, central and southern parts of the project development area. The central area around Dalby has winds characterised by easterly/westerly flow in the afternoons. The northern and southern areas show a more even spread of wind direction. There is a high frequency of calm (less than 0.5 m/s) and very light winds across all three regions. Calm winds form 19% and 18% of morning winds (at 9:00 am) and 9% and 13% of afternoon winds (at 3:00 pm) at Dalby and Goondiwindi, respectively. Miles has a lower frequency of calm winds at 3% in the morning and 2% in the afternoon, and there is a higher frequency of light wind speeds, close to 10% for most wind directions in the afternoon.
- Temperature inversions are expected to occur relatively frequently over the northern portion of the study area. Temperature inversions involve a layer of air in the atmosphere in which the temperature cools or warms at a much lower rate with height in comparison to other parts of the atmosphere. During night time the ground is cooled by radiating heat into space and air in contact with the ground becomes cooler than the air above it. This climatic condition is prevalent when skies are clear and winds light and it suppresses convective mixing resulting in atmospherically stable meteorological conditions in the lower air layers.
- Around 20 thunderstorm days per year occur within the study area, often involving strong winds, heavy rainfall and flooding.

9.3.2 Land Use

The existing land use within the study area consists primarily of bushland and agricultural land along with industry that includes coal-fired power stations, coal mines and industrial manufacturing. Rural road networks connect a number of sparsely located small regional towns.

9.3.3 Relevant Pollutants

The key pollutants identified under applicable legislation that are relevant to the project are described in Table 9.1.

Table 9.1 Key air pollutants relevant to the Surat Gas Project

Pollutant	Description/Potential Impact
Carbon monoxide (CO)	Produced from incomplete combustion of carbon-based materials and potentially harmful to human health when inhaled.
Oxides of nitrogen (NO_x)	Oxides of nitrogen include nitric oxide (NO) and nitrogen dioxide (NO_2). The ratios of these pollutants post-release are determined by photochemical activity in the atmosphere, and pollutants can be converted to a more toxic form, e.g., conversion of NO to NO_2 in the presence of oxygen. NO_2 is the primary pollutant of concern associated with the combustion of gas. Biogenic sources of NO_2 are from soil, vegetation and bushfire emissions. Net releases of NO_2 into the air can contribute to acid rain, eutrophication (increased nutrient load) of watercourses and formation of photochemical smog. Eutrophication, in particular, is likely to be a potential issue in the project development area due to excess nutrients from agricultural runoff and sewage discharge potentially resulting in inputs of phosphorus and nitrogen to watercourses.
Photochemical smog (O_3)	O_3 is the primary pollutant of concern within photochemical smog and is commonly used as a key indicator of smog. Volatile organic compounds (discussed below) can contribute to reactions that form O_3 by reacting with nitric oxide and NO_2 in the presence of sunlight. O_3 is a strong oxidiser and is active in converting nitric oxide to the more hazardous NO_2. Significant exposure to O_3 can cause damage to living cells.
Particulate matter	Particulate matter refers to suspended solids or liquids in air. Particulate matter is emitted via mechanical processes such as wind erosion and vehicle disturbance of dust or chemical processes such as incomplete combustion or formed as a secondary product of photochemical smog reactions. Particulate matter is classified by size. Particulate matter less than10 µm (PM_{10}) and particulate matter less than 2.5 µm ($PM_{2.5}$) can remain suspended in the air for many days and are generally associated with greater health impacts than larger particle sizes. These small-sized particles can enter the respiratory tract and impact human health. Deposited particulate matter (dust) can also impact amenity through accumulation on surfaces such as laundry and cars.
Sulfur dioxide (SO_2)	SO_2 is formed when substances containing sulfur are burnt. Inhalation of high concentrations of SO_2 can lead to respiratory and other illnesses, and SO_2 is a major precursor to acid rain. The combustion of diesel and the operation of large coal-fired power stations within the study area will produce emissions of SO_2.
Volatile organic compounds (VOC)	VOCs include a number of organic compounds emitted from natural and anthropogenic processes, some of which are toxic. VOCs can contribute to photochemical smog when combined with NO_x in the presence of sunlight. Coal seam gas contains negligible VOCs.
Odour	Odour can lead to annoyance and some potential health effects. Hydrogen sulfide is a key source of odour; however, no significant impacts are expected from the project as hydrogen sulfide is present only in trace quantities in the gas stream. Flaring and unplanned releases are expected to be infrequent and it is not anticipated that odour will cause nuisance. Odour has not been considered further in the assessment of air quality.
Carbon dioxide (CO_2)	CO_2 is created through natural biological processes and also as a by-product of combustion. CO_2 is a greenhouse gas and potential impacts of this gas are covered in Chapter 10, Greenhouse Gas Emissions.

9.3.4 Existing Air Quality

Table 9.2 provides the existing maximum ground level concentrations of pollutants modelled within the study area. Health-based EPP (Air) objectives are provided for reference.

Table 9.2 Existing maximum ground level concentrations of key pollutants

Pollutant	EPP (Air) Objective ($\mu g/m^3$)[a]	Averaging Period	Existing Concentration ($\mu g/m^3$)
Nitrogen dioxide (NO_2)	250[b]	1 hr	22[c]
	62	Annual	2.2
Ground level ozone (O_3)	210[b]	1 hr	136[c]
	160[b]	4 hr	123[c]
Sulfur dioxide (SO_2)	570	1 hr	40.0[d]
	230	24 hr	5.7[d]
	57	Annual	2.9[d]
Carbon monoxide (CO)	11,000	8 hr	750.1[d]
Particulate matter (PM_{10})	50	24 hr	25.7 [d]
Particulate matter ($PM_{2.5}$)	25	24 hr	6.8[d]
	8	Annual	3.6[d]

[a] Health-based objectives at standard temperature and pressure (0˚C, 1 atm).
[b] Allowed one-day exceedence per annum.
[c] Second highest day per annum.
[d] Average of DERM monitoring station results for Toowoomba with the exception of SO_2, which is taken from Flinders. View (DERM, 2007, DERM, 2008, DERM, 2009a, DERM, 2010b). The ninetieth percentile of the data was taken for subannual averaging periods.

Table 9.2 indicates that existing ground level concentrations of all key pollutants within the study area would be below EPP (Air) objectives.

9.3.5 Environmental Values

In accordance with the EPP (Air), the environmental values in and around the project development area include:

- The qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems.
- The qualities of the air environment that are conducive to human health and wellbeing.
- The qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property.
- The qualities of the air environment that are conducive to protecting agricultural use of the environment.

Regulatory air quality parameters, objectives and environmental values relevant to the project are displayed in Table 9.3.

Table 9.3 Relevant air quality objectives

<table>
<tr><th colspan="2">Substance</th><th>Objective (µg/m³)</th><th>Environmental Value[a]</th><th>Time Period</th><th>Regulatory Agency</th><th>Allowable Exceedence (days per annum)[c]</th></tr>
<tr><td colspan="2">Carbon monoxide (CO)</td><td>11,000</td><td>Health</td><td>8 hr</td><td>EPP (Air)/NEPM</td><td>1</td></tr>
<tr><td colspan="2" rowspan="2">Nitrogen dioxide (NO_2)</td><td>250</td><td>Health</td><td>1 hr</td><td>EPP (Air)/NEPM</td><td>1</td></tr>
<tr><td>62</td><td>Health</td><td>Annual</td><td>EPP (Air)/NEPM</td><td>n/a</td></tr>
<tr><td colspan="2" rowspan="2">Ozone (O_3)</td><td>210</td><td>Health</td><td>1 hr</td><td>EPP (Air)</td><td>1</td></tr>
<tr><td>160</td><td>Health</td><td>4 hr</td><td>EPP (Air)</td><td>1</td></tr>
<tr><td colspan="2">Total suspended particulate</td><td>90</td><td>Health</td><td>Annual</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td colspan="2">Particulate matter <10 µm (PM_{10})</td><td>50</td><td>Health</td><td>24 hr</td><td>EPP (Air)/NEPM</td><td>5</td></tr>
<tr><td colspan="2" rowspan="2">Particulate matter <2.5 µm ($PM_{2.5}$)</td><td>25</td><td>Health</td><td>24 hr</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td>8</td><td>Health</td><td>Annual</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td colspan="2" rowspan="5">Sulfur dioxide (SO_2)</td><td>570</td><td>Health</td><td>1 hr</td><td>EPP (Air)/NEPM</td><td>1</td></tr>
<tr><td>230</td><td>Health</td><td>24 hr</td><td>EPP (Air)/NEPM</td><td>1</td></tr>
<tr><td>57</td><td>Health</td><td>Annual</td><td>EPP (Air)/NEPM</td><td>n/a</td></tr>
<tr><td>33</td><td>Agriculture</td><td>Annual</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td>22</td><td>Ecosystems</td><td>Annual</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td colspan="2">VOC</td><td>-</td><td>-</td><td>-</td><td>-</td><td>n/a</td></tr>
<tr><td colspan="2">1,2-dichloroethane</td><td>750</td><td>Health</td><td>24 hr</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td colspan="2">1,3-Butadiene</td><td>2.4</td><td>Health</td><td>Annual</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td colspan="2">Benzene</td><td>10</td><td>Health</td><td>Annual</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td colspan="2">Benzo(a)pyrene</td><td>0.0003</td><td>Health</td><td>Annual</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td colspan="2" rowspan="3">Toluene</td><td>4100</td><td>Health</td><td>24 hr</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td>410</td><td>Health</td><td>Annual</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td>1100</td><td>Nuisance</td><td>30 mins</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td colspan="2" rowspan="2">Xylene</td><td>1200</td><td>Health</td><td>24 hr</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td>950</td><td>Health</td><td>Annual</td><td>EPP (Air)</td><td>n/a</td></tr>
<tr><td colspan="2">Dust deposition</td><td>120 ($mg/m^2/d$)</td><td>Nuisance</td><td>Monthly</td><td>Informal criterion</td><td>n/a</td></tr>
<tr><td rowspan="2">Odour</td><td>Tall stacks</td><td>0.5 (OU)</td><td>Nuisance</td><td>1 hr</td><td>Qld guideline</td><td>44</td></tr>
<tr><td>Ground level/short stacks[b]</td><td>2.5 (OU)</td><td>Nuisance</td><td>1 hr</td><td>Qld guideline</td><td>44</td></tr>
</table>

[a] Health; protection of health and wellbeing, agriculture; protection of agriculture, ecosystems; health and biodiversity of ecosystems (for forests and natural vegetation), nuisance; prevention of nuisance.

[b] Ground-level sources and down-washed plumes from short stacks.

[c] Where the regulatory framework is silent on the number of days per annum where exceedence is permitted, n/a is used to represent ‘not applicable’.

9.4 Issues and Potential Impacts

Air quality issues associated with the project relate to the generation of emissions during each phase of the project. The key project-related emission sources include power generation and flaring of gas. The increase in air pollutant concentrations from project activities is the key potential impact on the environmental values.

9.4.1 Emission Sources

Air quality can potentially be impacted during construction and operations through to eventual decommissioning. Table 9.4 shows emission sources associated with each phase of the project.

Table 9.4 Emission sources associated with each phase of the project

Project Activity/ Emission Source	Phase	Source Characteristics	Type	Emissions
Production well installation	Construction	Once-off at each well location	Fugitive or point	Combustion emissions associated with drilling equipment and fugitive dust associated with vehicle and material movement.
		Stationary sources	Point	Combustion emissions. Ramp-up flaring prior to facility commission. Flaring would occur at the nearest facility.
Gas and water gathering line installation	Construction	Once-off associated with construction	Fugitive	Combustion emissions associated with construction equipment and fugitive dust associated with vehicle and material movement.
Production facility installation (and construction camps)	Construction	Once-off associated with construction	Fugitive	Combustion emissions associated with construction equipment and fugitive dust associated with construction.
Medium- and high-pressure gas pipeline installation	Construction	Once-off associated with construction	Fugitive	Combustion emissions associated with construction equipment and fugitive dust associated with vehicle and material movement.
Production well operation (wellhead engines): gas combustion and fugitive emissions	Operations	Continuous stationary sources	Point	Combustion emissions and unburnt gas (e.g., from valves, periodic emissions from well workovers).
Processing facility operation: pilot flaring and upset conditions flaring	Operations	Continuous stationary sources	Point	Combustion emissions.
Production facility operation: fugitive emissions	Operations	Continuous stationary sources	Fugitive	Unburnt gas (e.g., from valves, flanges, compressors and pumps).
Production facility operation: tri-ethylene glycol reboiler	Operations	Continuous stationary sources	Point	Combustion emissions and unburnt gas.
Production facility operation (power generation): gas combustion	Operations	Continuous stationary sources	Point	Combustion emissions.

Table 9.4 Emission sources associated with each phase of the project (cont'd)

Project Activity/ Emission Source	Phase	Source Characteristics	Type	Emissions
Transport	Operations	Intermittent mobile sources	Fugitive	Combustion emissions and fugitive dust.
Production well, gathering line and pipeline decommissioning	Decommissioning	Once-off	Fugitive	Combustion emissions and unburnt gas, fugitive dust emissions associated with vehicle or material movement.
Production facility decommissioning	Decommissioning	Once-off	Fugitive	Combustion emissions and unburnt gas, fugitive dust emissions associated with vehicle or material movement.

The majority of emission sources associated with construction are transient and limited in duration, with the exception of ramp-up flaring prior to production facility commissioning. Operational emissions are ongoing sources, which have the greatest potential to cause impacts.

9.4.2 Regional Impacts to Ambient Air Quality

Two emission scenarios were considered in the regional impact assessment:

- Scenario 1 included emissions from all 18 production facilities operating at once across the entire project development area. This scenario provides a theoretical worst-case scenario as it does not take the staging of development into consideration.
- Scenario 2 included emissions generated in the year of maximum expected operations (2020), at which stage nine production facilities were likely to be operating across the project development area.

Both these scenarios assumed the number of wellhead engines operational as those in the year 2020 (a total of 2,307). Estimations were based on the assumption that facilities were operating at peak power capacity.

The main substances of concern regionally are NO_2 and O_3, commonly used as indicators of photochemical smog. Other key air pollutants (see Section 9.3.4, Existing Air Quality) are currently below relevant guidelines in the study area and project activities are not expected to generate emissions that are significant on a regional scale. Key pollutants other than NO_2 and O_3 are discussed further under modelling of localised impacts.

The main emission sources likely to affect smog production in the study area are anthropogenic (e.g., from human impact such as oil and gas extraction, coal mining, electricity generation, agricultural activities, petrol stations) and biogenic (produced by living organisms or biological processes). Oxides of nitrogen are released during combustion processes, and background emission sources exist within the study area.

Emissions from motor vehicles and domestic activities were not considered in the assessment due to the lack of publicly available information and likely insignificant contribution to regional air quality.

Maximum predicted concentrations of NO_2 and O_3 for each emission scenario are shown in Table 9.5, along with existing air quality concentrations and health-based EPP (Air) objectives.

Table 9.5 NO_2 and O_3 maximum concentrations and health-based objectives

	EPP (Air) (µg/m³)	Averaging Time	Existing Value (µg/m³)	Scenario 1 - All Facilities (µg/m³)	Scenario 2 - Year 2020 (µg/m³)
NO_2	250[a]	1 hr	22[b]	85[b]	86[b]
	62	Annual	2.2	9	9
O_3	210[a]	1 hr	136[b]	160[b]	160[b]
	160[a]	4 hr	123[b]	154[b]	154[b]

[a] Value considers one-day exceedence allowable per annum as per EPP (Air).
[b] Second highest day modelled value.

Modelling of Scenario 1 and Scenario 2 demonstrates that, while there is variation in ground-level NO_2 and O_3 concentrations within the study area, there is effectively no difference in the overall maximum experienced within the study area. This indicates that the separation distance between conceptual locations of production facilities ensures that the dispersion of plumes does not result in a cumulative air quality impact. Activities undertaken as part of the project are not predicted to cause exceedences of the ground-level EPP (Air) objectives for NO_2 and O_3 in the region.

Scenario 1 contour plots are shown in Figures 9.2 to 9.5. Annual contour plots take into consideration a one-day exceedence allowable per annum under EPP (Air) guidelines, and one-hour and four-hour averaged plots display the second highest-day modelled value.

9.4.3 Localised Impacts to Ambient Air Quality

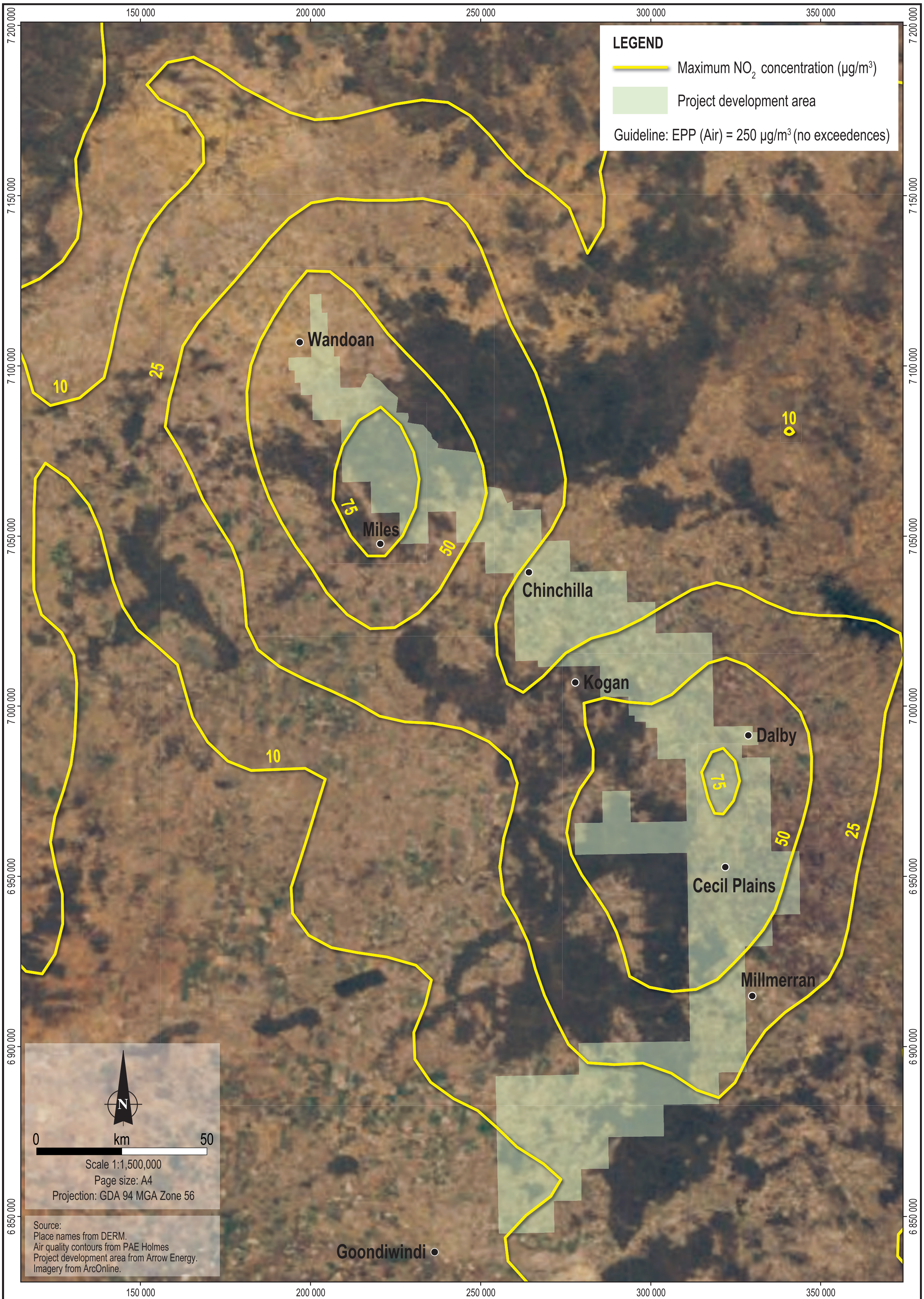
Localised emissions of NO_2, VOC and particulate matter were modelled assuming typical maximum emission rates and continuous power generation or flaring as a worst-case scenario.

Emissions of SO_2 and CO were excluded from modelling for the following reasons:

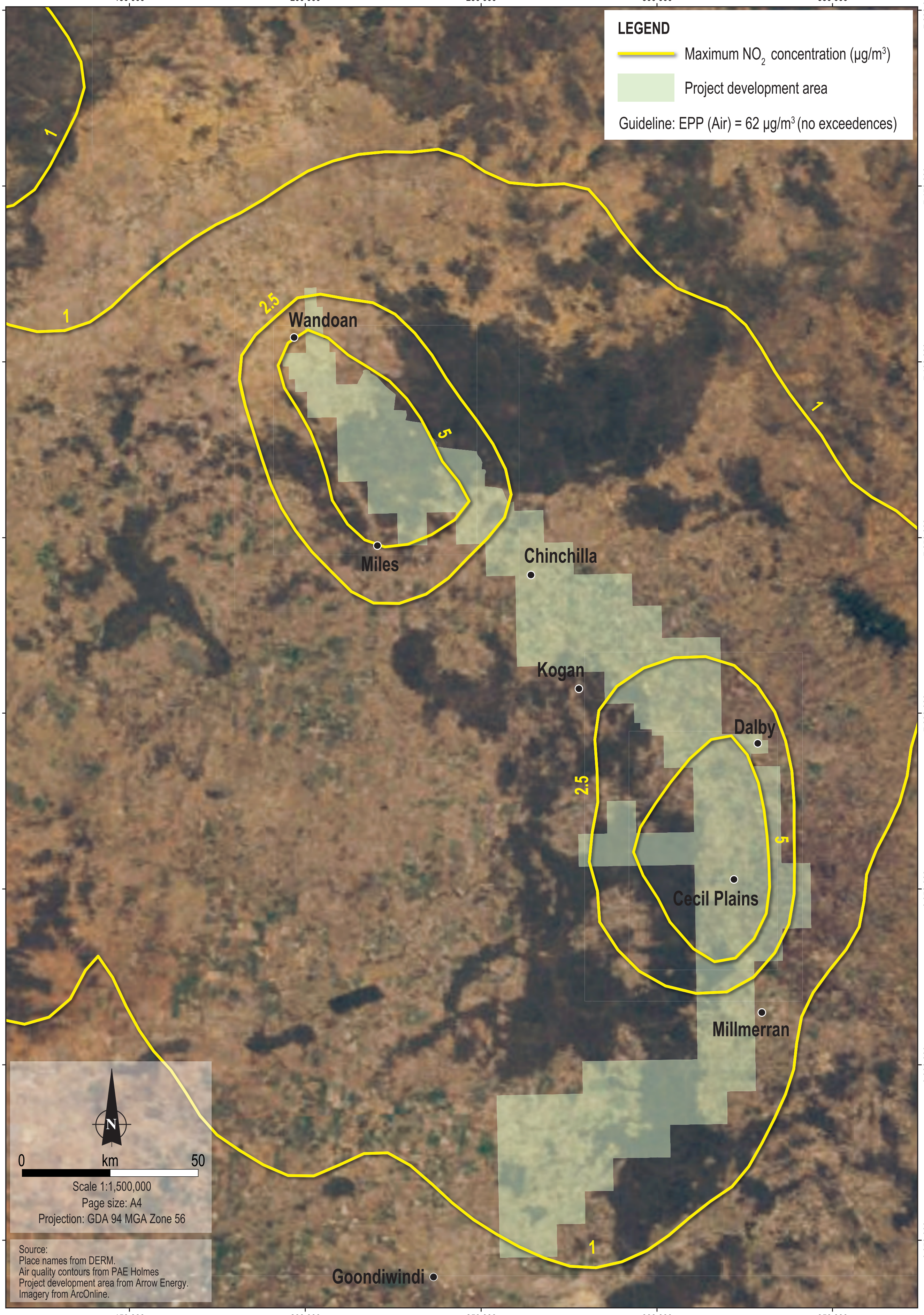
- Coal seam gas contains only trace quantities of sulfur. There are no significant SO_2 emissions associated with proposed project activities and no existing issues with baseline SO_2 concentrations.
- Typically, CO concentrations that are harmful to human health are associated with large volumes of motor-vehicle activity and the project is not expected to cause a significant CO impact.

Modelling of VOC and particulate matter indicated that there were no significant impacts associated with these air pollutants and no concentrations in excess of the EPP (Air) objectives.

Predicted NO_2 ground level concentrations from production facilities and wellhead power generation emissions are shown in Figures 9.6 to 9.9. Values are inclusive of background concentrations and are second highest values, in line with the commonly used New South Wales Level 2 assessment method (DECCW, 2005) and US Environmental Protection Agency short-term steady-state plume assessment (USEPA, 2005). The EPP (Air) objective is displayed on each graph.



coffey environments	Date: 22.11.2011 MXD: 7040AC_04_GIS121_v1_3 File Name: 7040_04_F09.02_GIS_HB	Arrow Energy Surat Gas Project	arrow energy go further	Scenario 1: maximum NO_2 (1 hr averaged) concentrations	Figure No: 9.2



Source:
Place names from DERM.
Air quality contours from PAE Holmes
Project development area from Arrow Energy.
Imagery from ArcOnline.

coffey environments	Date: 10.11.2011 MXD: 7040AC_04_GIS122_v1_3 File Name: 7040_04_F09.03_GIS_HB	Arrow Energy Surat Gas Project	arrow energy go further	Scenario 1: annual average NO_2 concentrations

Figure No: 9.3

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Scenario 1: maximum O_3 (1 hr averaged) concentrations

Figure No: 9.4

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Date: 22.11.2011
MXD: 7040AC_04_GIS124_v1_3
File Name: 7040_04_F09.05_GIS_HB

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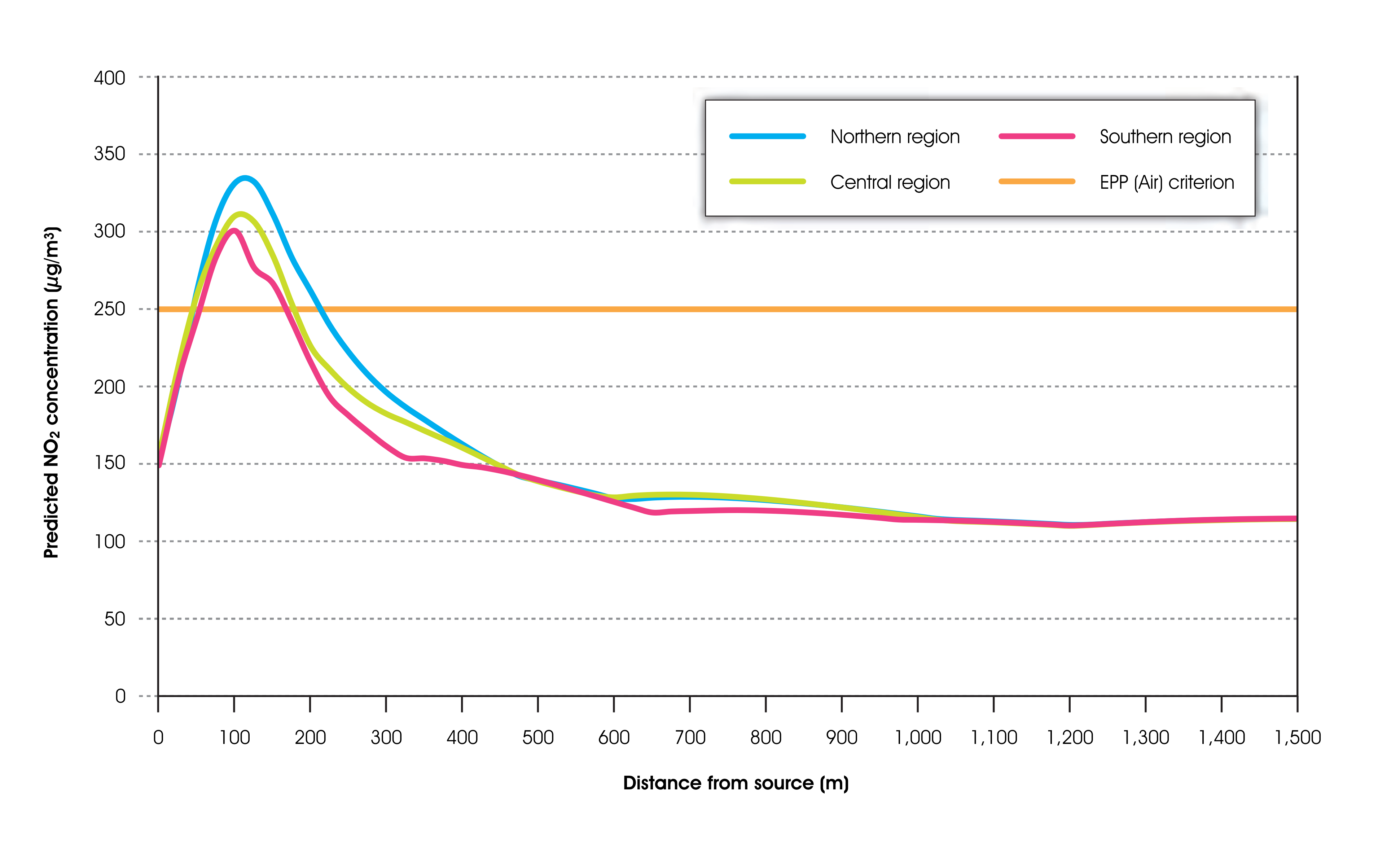
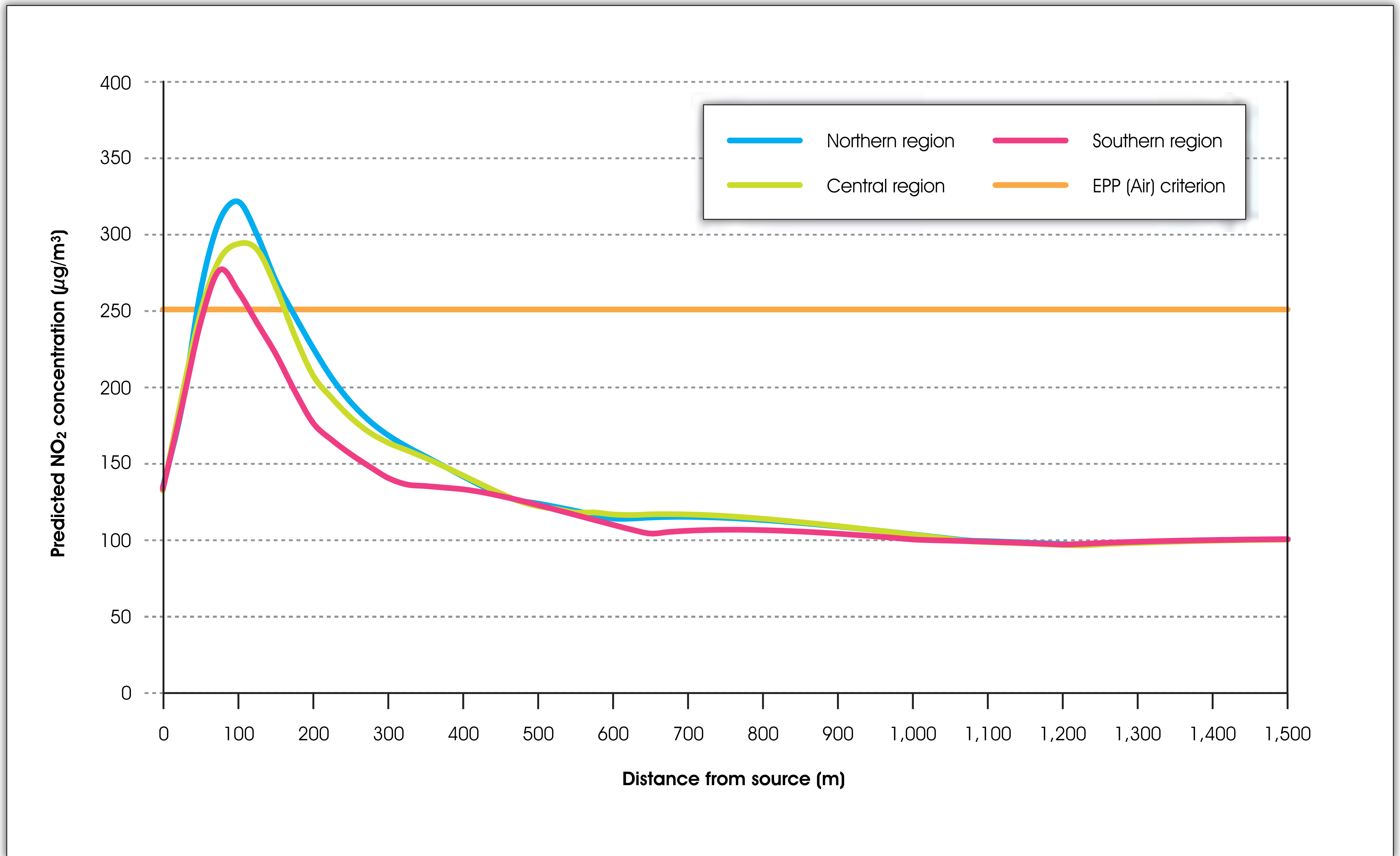
Scenario 1: maximum O_3 (4 hr averaged) concentrations

Figure No: 9.5



Source: Data from pae holmes	coffey environments	Job No: 7040	Arrow Energy	arrow energy go further	Maximum NO_2 concentrations at distance from an integrated processing facility
		File Name: 7040_04_F09.06_GL	Surat Gas Project		Figure No: 9.6



Source: Data from pae holmes

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Job No: 7040

File Name: 7040_04_F09.07_GL

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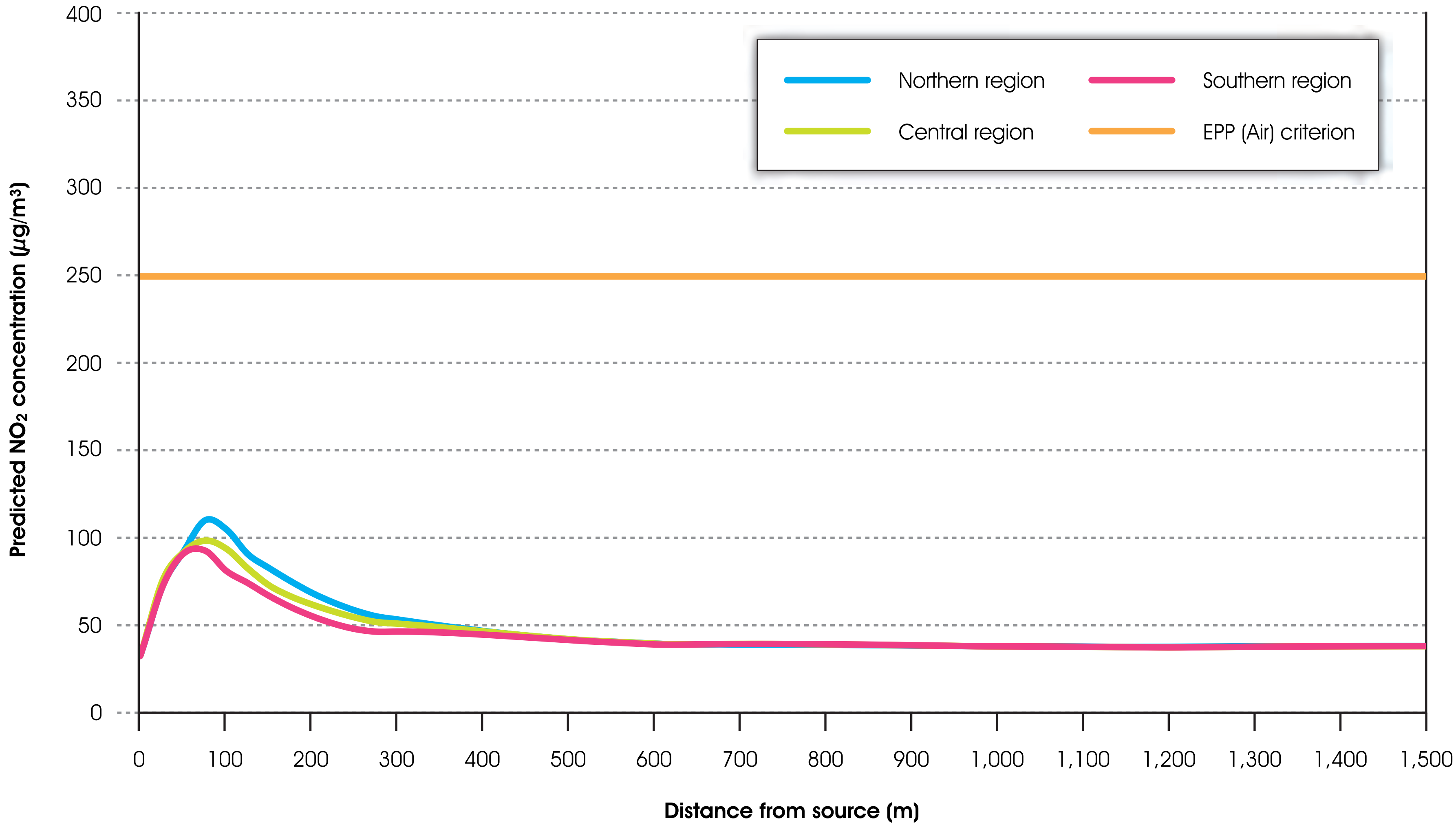
Maximum NO_2 concentrations at distance from a central gas processing facility

Figure No: 9.7

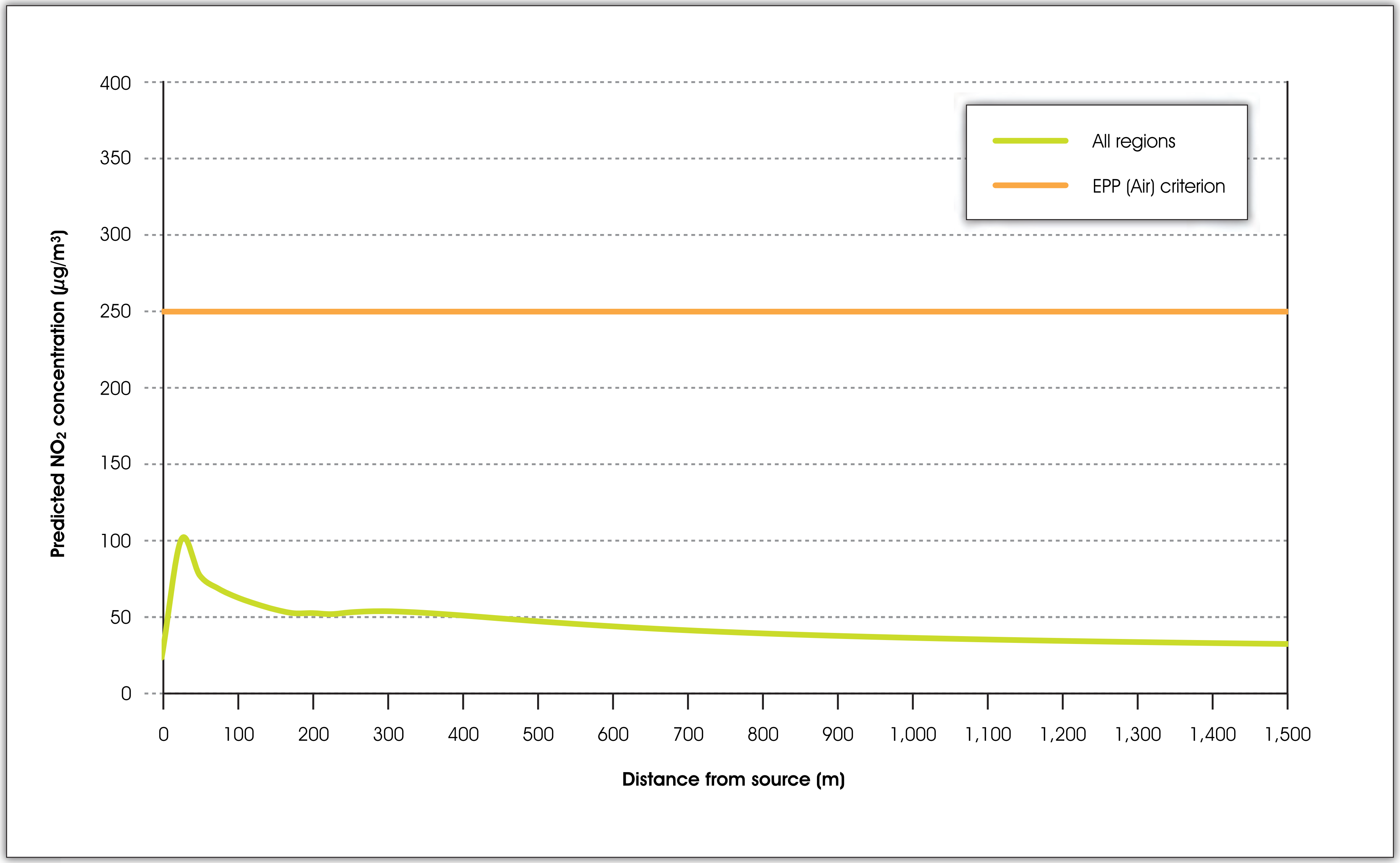


Source: Data from pae holmes

coffey environments

Job No: 7040	Arrow Energy	Maximum NO_2 concentrations at distance from a field compression facility	Figure No: 9.8
File Name: 7040_04_F09.08_GL	Surat Gas Project		

arrow energy go further



Source: Data from pae holmes	coffey environments	Job No: 7040 File Name: 7040_04_F09.09_GL	Arrow Energy Surat Gas Project	arrow energy go further	Maximum NO_2 concentrations at distance from a wellhead	Figure No: 9.9

The assessment of localised impacts to ambient air quality (as shown in Figures 9.6 to 9.9) indicates that:

- Maximum predicted one-hour NO_2 concentrations close to field compression facilities and wellhead generators are below the EPP (Air) objective.
- With appropriate separation distances between sensitive receptors and integrated processing and central gas processing facilities, maximum predicted one-hour NO_2 concentrations are below the EPP (Air) objective.

The separation distance required for integrated processing facilities is greater than that required for central gas processing facilities, due to additional power generation associated with water treatment at integrated processing facilities.

Modelling predicted that the maximum NO_2 concentrations associated with flaring would be well below the EPP (Air) objective of 250 μg/m^3.

9.4.4 Emission Rates

In the absence of Queensland guidelines for emission sources, the emission characteristics of power generation sources in the project were compared to the New South Wales Protection of the Environment Operations (Clean Air) Regulation 2002 and its amendment. These guidelines are adopted in New South Wales for the purpose of reducing pollution in constrained airsheds.

Table 9.6 presents the clean air regulation's standards of concentration for activities relevant to the project (represented under 'Group 6' of the regulation).

Table 9.6 Standards of concentration relevant to the Surat Gas Project

Pollutant	Activity or Plant	Standard of Concentration
Solid particles (total)	Any activity or plant	50 mg/m^3
NO_2 or NO or both, as NO_2 equivalent	Stationary reciprocating internal combustion engines	450 mg/m^3
Sulfuric acid mist or sulfur trioxide (SO_3) or both, as SO_3 equivalent	Any activity or plant	100 mg/m^3
Hydrogen sulfide	Any activity or plant	5 mg/m^3
Fluorine and any compound containing fluorine, as total fluoride equivalent	Any activity or plant, other than the manufacture of aluminium from alumina	100 mg/m^3
Chlorine	Any activity or plant	200 mg/m^3
Hydrogen chloride	Any activity or plant	100 mg/m^3
Antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, selenium, tin, vanadium (in aggregate)	Any activity or plant	1 mg/m^3
Cadmium or mercury (individually)	Any activity or plant	0.2 mg/m^3
Volatile organic compounds, as n-propane	Any stationary reciprocating internal combustion engine using a liquid fuel	VOCs: 1,140 mg/m^3 or CO: 5,880 mg/m^3
	Any other activity or plant involving combustion	VOCs: 40 mg/m^3 or CO: 125 mg/m^3
Smoke	An activity or plant involving combustion	Ringelmann 1 or 20% opacity

The emission rate of NO_x played a large role in modelling of regional and localised impacts, and therefore benchmarking of emission rates against relevant guidelines was carried out. The most directly relevant guidelines available for emission rates of NO_x are the performance standards for stationary spark ignition engines (USEPA, 2011), presented in Table 9.7. Concentrations of NO_x are calculated based on flue gases having an oxygen content of 15%.

Table 9.7 NO_x emission rates and guidelines for stationary natural gas engines

Engine Type and Fuel	Maximum Engine Power	Emission Rate (g/HP-hr)	Emission Rate (g/kW-hr)	NO_x (ppmvd)	NO_x (mg/m³)
Non-emergency spark ignition natural gas	100≤HP<500 and HP≥500	2.0	2.68	160	305

HP = horsepower; ppmvd = parts per million (volumetric dry); g/kW = grams per kilowatt.

A comparison of the power generation and wellhead engines to the relevant standards and guidelines, following conversion of emission characteristics to the same units as the emission rate guidelines, is shown in Table 9.8.

Table 9.8 Comparison of power generation and wellhead engines to relevant standards

Engine	Guideline/Standard		Predicted Rate/Concentration	
	Emission Rate (g/kW-hr)	Concentration of NO_x (mg/m³)	Emission Rate (g/kW-hr)	Concentration of NO_x (mg/m³)
Facility gas engines	2.68	450	1.8	167
Wellhead gas engines	2.68	450	16.4	1,402

The production facility power generation emission characteristics do not exceed the relevant standards. However, the concentration of NO_x for wellhead engine emissions exceeds the Protection of the Environment Operations (Clean Air) Regulation standard and the USEPA guideline.

Although exceedences are indicated, the Surat Basin is not representative of a constrained airshed. Therefore, natural airshed processes are likely to disperse NO_x emissions from wellheads in a similar manner to NO_x emissions from production facilities (see Section 9.4.3, Modelling of Localised Impacts), minimising potential impacts.

9.5 Environmental Protection Objectives

The environmental protection objectives for air quality are to:

- Avoid, minimise and manage project-related contribution of air pollutants to the existing air quality environment.
- Avoid exceedences of relevant air quality guidelines near sensitive receptors to ensure that the existing air quality environment continues to maintain aesthetics and human and environmental health.

9.6 Avoidance, Mitigation and Management Measures

Avoidance, mitigation and management measures have been proposed to achieve the identified environmental protection objectives. The primary means by which avoidance is achieved is through design and site selection. Arrow's environmental framework focuses on early identification of sensitive locations that should be avoided by project activities, as described within Chapter 8, Environmental Framework.

Specific mitigation measures to minimise air quality impacts associated with the Surat Gas Project will require Arrow to:

- Design facilities to meet relevant EPP (Air) objectives at sensitive receptors. [C003]
- Consult with potentially affected landowners prior to undertaking activities. [C014]
- Conduct site-specific air quality modelling once site locations are known to ensure project-related air emissions meet EPP (Air) objectives at the nearest sensitive receptor. [C001]
- Select equipment with consideration for low emissions to air (NO_x, SO_x), high energy efficiency and fuel efficiency. [C002]
- Ensure all engines, machinery equipment and pollution control mechanisms are operated and maintained in accordance with manufacturer's recommendations. [C011]
- Minimise the disturbance footprint and vegetation clearing. [C020]
- Clear areas progressively and implement rehabilitation as soon as practicable following construction and decommissioning activities. [C015]
- Implement dust suppression measures for roads and construction sites to ensure that dust does not cause a nuisance. [C012]
- Cover dust-generating materials prior to transportation. [C013]
- Manage odours so that they do not cause a nuisance or harm to sensitive receptors. [C017]
- Prevent venting and flaring of gas as far as practicable and where safe to do so. [C016]

Additional mitigation measures relating to dust suppression are provided in Chapter 12, Geology, Landform and Soils, and Chapter 19, Roads and Transport.

9.7 Residual Impacts

The avoidance, mitigation and management measures outlined above will avoid or reduce the severity of the magnitude of potential impacts on air quality environmental values.

Management of localised impacts should consider appropriate separation distances to ensure that air quality objectives are not exceeded in proximity to sensitive receptors.

9.8 Inspection and Monitoring

Monitoring and inspection of mitigation and management measures will be implemented to ensure that the calculated ground-level concentrations of relevant pollutants do not exceed EPP (Air) objectives throughout the lifetime of the project. [C511]

Inspection will be undertaken regularly to ensure mitigation measures are performing as predicted and to intervene as early as practicable for any mitigation measures that require management.