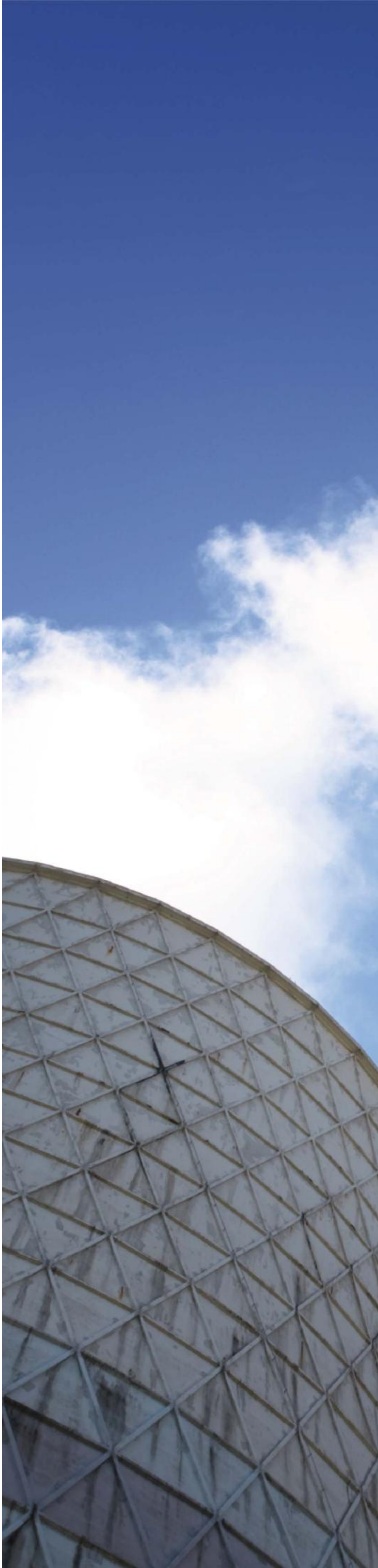
Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology



REPORT

SURAT GAS PROJECT – SUPPLEMENTARY AIR QUALITY ASSESSMENT

Coffey Environments

Job No: **3568D**

7 June 2013

PROJECT TITLE:	Surat Gas Project – Supplementary Air Quality Assessment
JOB NUMBER:	3568D
PREPARED FOR:	Coffey Environments
APPROVED FOR RELEASE BY:	Chaim Kolominskas
DISCLAIMER & COPYRIGHT:	This report is subject to the copyright statement located at www.pacific-environment.com © Pacific Environment Operations Pty Ltd ABN 86 127 101 642

DOCUMENT CONTROL			
VERSION	**DATE**	**PREPARED BY**	**REVIEWED BY**
01	29.04.2013	Mitch Kelly and Li Fitzmaurice	Robin Ormerod
02	07.05.2013	Mitch Kelly	Robin Ormerod
03	22.05.2013	Mitch Kelly	Robin Ormerod
Final	07.06.2013	Mitch Kelly	Chaim Kolominskas

Pacific Environment Operations Pty ABN 86 127 101 642

BRISBANE
Level 1, 59 Melbourne Street, South Brisbane Qld 4101
PO Box 3306, South Brisbane Qld 4101
Ph: +61 7 3004 6400
Fax: +61 7 3844 5858

Unit 1, 22 Varley Street
Yeerongpilly, Qld 4105
Ph: +61 7 3004 6460

ADELAIDE
35 Edward Street, Norwood SA 5067
PO Box 3187, Norwood SA 5067
Ph: +61 8 8332 0960
Fax: +61 7 3844 5858

SYDNEY
Suite 1, Level 1, 146 Arthur Street
North Sydney, NSW 2060
Ph: +61 2 9870 0900
Fax: +61 2 9870 0999

MELBOURNE
Suite 62, 63 Turner Street, Port Melbourne Vic 3207
PO Box 23293, Docklands Vic 8012
Ph: +61 3 9681 8551
Fax: +61 3 9646 3408

PERTH
Level 1, Suite 3
34 Queen Street, Perth WA 6000
Ph: +61 8 9481 4961
Fax: +61 7 3844 5858

DISCLAIMER

Pacific Environment acts in all professional matters as a faithful advisor to the Client and exercises all reasonable skill and care in the provision of its professional services.

Reports are commissioned by and prepared for the exclusive use of the Client. They are subject to and issued in accordance with the agreement between the Client and Pacific Environment. Pacific Environment is not responsible for any liability and accepts no responsibility whatsoever arising from the misapplication or misinterpretation by third parties of the contents of its reports.

Except where expressly stated, Pacific Environment does not attempt to verify the accuracy, validity or comprehensiveness of any information supplied to Pacific Environment for its reports.

Reports cannot be copied or reproduced in whole or part for any purpose without the prior written agreement of Pacific Environment.

Where site inspections, testing or fieldwork have taken place, the report is based on the information made available by the client or their nominees during the visit, visual observations and any subsequent discussions with regulatory authorities. The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Pacific Environment is both complete and accurate. It is further assumed that normal activities were being undertaken at the site on the day of the site visit(s), unless explicitly stated otherwise.

CONTENTS

FIGURES

TABLES

1 INTRODUCTION

Arrow Energy Pty Ltd (Arrow) proposes to expand its coal seam gas operations in the Surat Basin through the Surat Gas Project.

An air quality assessment (PAEHolmes, 2011) was submitted for inclusion in the Environmental Impact Statement (EIS) for the project. Following submission of the EIS, further developments regarding design of the Surat Gas Project occurred, leading to a number of design changes for the project.

Arrow is required to prepare a supplementary report to the EIS (SREIS) to:

- present information on any material changes to the project description
- address issues identified in the EIS as requiring further consideration and/or information
- respond to comments raised in submissions on the EIS.

1.1 Objectives

This supplementary air quality assessment for the Surat Gas Project identifies and assesses subsequent changes to the EIS air quality assessment (PAEHolmes, 2011) that result from the proposed project design changes.

2 PROJECT DESCRIPTION

All of the project description changes relevant to the Surat Gas Project air quality assessment will be addressed in this SREIS assessment.

2.1 SREIS Project Description

Since preparation of the Surat Gas Project EIS, further knowledge of the gas reserves has been gained resulting in refinement of the field development plan and basis for design of coal seam gas infrastructure. The updates which are applicable to the air quality assessment include:

- A reduction in the size of the project development area including the number of wells and facilities.
- An increase in the capacity of production facilities and changes in associated equipment.
- A revised power supply option for facilities and wells, with short-term power generation to be used only in the initial phase of operation until a grid connection is made.
- An update of the well type described within the EIS to include the addition of multi-well pads.
- A revised flaring scenario.

Details of these refinements to the project description are provided below.

Due to the relinquishment of parcels of land within Arrow's exploration tenements, there has been a reduction in the overall size of the project development area from 8,600 km^2 to 6,100 km^2. Advancement in the field development planning since the preparation of the EIS has seen the project development area being separated into eleven drainage areas. It is currently expected that eight of these drainage areas will be initially developed for the Surat Gas Project with each drainage basin incorporating wells with connections to a water gathering network, a gas gathering network and a central gas processing facility (CGPF). The anticipated commissioning of production wells and facilities has been revised in line with the approach to the initial development of eight drainage areas.

Arrow has identified the properties on which four of the eight CGPFs will be located, two of which will have water treatment facilities located adjacent to them (reduced from six water treatment facilities assessed in the EIS). In the EIS, this arrangement was referred to as an integrated processing facility. This term will no longer be used and the facilities will be referred to by their function i.e., CGPF and water treatment facility. The exact locations of infrastructure within the properties have not been determined with the final siting of infrastructure to be determined through a constraints analysis.

With the smaller project development area, there has been a reduction in the number of production wells anticipated to be drilled, reducing from 7,500 to approximately 6,500 wells. For the SREIS, there will be both multi-well pads and single wells arrangements. Multi-well pads will comprise up to 12 wellheads with the most common configuration being nine wellheads, spaced approximately 8 m apart.

The EIS assessed the potential impacts associated with power being supplied through self-generation at the site of the facilities and wells, with the alternate consideration being the supply of power from the Queensland electricity grid.

Refinements to Arrow's basis for design include consideration for their power supply, with the alternate option of grid power now being favoured. Self-generated power may, however, still be necessary until connection to a third party's infrastructure can be made. It is not expected that the short-term power generation would be required for a period longer than two years. The power requirements for self-generated power at a multi-well pad of up to 12 wells and at a CGPF (with a capacity greater than that assessed in the EIS), has been included in this assessment.

Wells will be either supplied with power from the nearest CGPF or in a few exceptional circumstances may have short-term power generation from a gas engine. A multi-well pad has a power requirement of 720 kW, which for the short-term self-generated power supply option has been assessed through consideration of a 749 kW engine.

Development of the basis for design currently proposes that each facility will comprise between one to and three compressor trains. Each train will have the capacity to process 75 TJ/d (i.e., terajoules per day) of gas. The CGPFs will typically compress 75 to 225 TJ/d of gas (in contrast to between 30 and 150 TJ/d of gas presented in the EIS). A sparing capacity of one additional train may be adopted at each facility (or 75 TJ/d).

The short-term self-generated power supply option for a CGPF allows for up to 50 MW of power to be supplied, which has been assessed by considering configurations of two typical power generation equipment. As detailed design has not yet commenced and the procurement strategy has not been developed, the specific engine or turbine type is not known. A review of available plant has found that there are small and medium capacity engine and turbine units available that would meet the power requirements e.g., 1.1 MW high-speed reciprocating gas engines and 5.7 MW gas turbines. For this reason, configurations of 47 engines with 1.1 MW capacity and 10 gas turbines with 5.7 MW capacity were considered in the supplementary air quality assessment to capture the range of possible scenarios that may result.

Ramp-up flaring is expected to result from commissioning of only eight CGPFs. Planned and unplanned maintenance flaring at CGPFs includes partial and full shutdowns which have changed due to the increased capacity of a CGPF and larger train sizes. Pilot flaring of the CGPF will no longer occur as nitrogen will be used for purging. No gas will be flared at a field compression facility.

2.2 Project Description Changes Relevant to Regional Air Quality

This section discusses changes to the project description that have a significant impact on the regional air quality assessment.

The following changes to the project description have been made for wells and multi-well pads:

- The number of wellheads has reduced from 7,500 wells in the EIS to 6,500 wells for the SREIS.
- Queensland electricity grid power will be supplied to the CGPF, where it will then be distributed to water treatment facilities, wells and water transfer stations. Short-term power generation using gas engines or turbines will be retained as a power supply option when grid power is not available.
- The number of CGPFs has reduced from twelve to eight. Two of these CGPFs will have co-located water treatment facilities.
- The SREIS worst-case year for traffic estimates a total of 37,837,798 km travelled, which is an increase of 30% from the EIS.

2.3 Project Description Changes Relevant to Local Air Quality

This section discusses changes to the project description that have a significant impact on the local air quality assessment.

2.3.1 Central Gas Processing Facilities and Water Treatment Facilities

The following changes to the project description have been made for CGPF and water treatment facilities:

- The maximum compression facility capacity has increased from 150 TJ/d to 225 TJ/d with an additional train (75 TJ/d) if required. The "N+1" sparing capacity is based on three operating trains at any one time (i.e., N) and one spare train (i.e., +1). Electric-driven 4-stage centrifugal compressors are now proposed.
- CGPFs will now have a 50 MW temporary power requirement, which includes the power supplied to water treatment facilities. In the EIS, CGPFs had a power requirement of 48 MW, and 56 MW for a CGPF with water treatment facility.

- Following grid power connection, electricity will power CGPFs. Water treatment facilities will be powered via the nearest CGPF.
- A typical gas engine, with a capacity of 1.1 MW, and a typical gas turbine, with a capacity of 5.7 MW, are being considered to supply the short-term self-generated power supply option, updated to allow for a 50 MW power requirement of the CGPF. A 3 MW gas engine was assessed in the EIS for permanent local power generation.
- The layout of CGPFs has been updated (Appendix A).
- Unplanned and planned maintenance flaring has been updated as follows:
    - One occurrence per year at a rate of 225 TJ/d for 12 hours.
    - One occurrence per year at a rate of 225 TJ/d for 24 hours.
    - Four occurrences per year at a rate of 75 TJ/d for 32 hours.
    - Six occurrences per year at a rate of 25 TJ/d for 48 hours.
- There will no longer be pilot flaring at CGPFs.
- There will no longer be flaring at field compression facilities.

2.3.2 Multi-well Pads

The following changes to the project description have been made for multi-well pads:

- Production wells will now be arranged in multi-well pads in some instances. Multi-well pad arrangements will comprise up to 12 wellheads with the most common configuration being nine wellheads.
- These multi-well pads share common surface infrastructure, including the power supply which necessitates a larger gas engine. The supplementary assessment considers a 749 kW gas engine to be representative of the self-generated power requirements for a multi-well pad with up to 12 wellheads.
- Following grid power connection, electricity will power wells and multi-well pads from the relevant CGPFs.

3 LEGISLATIVE CONTEXT

As discussed in the EIS, air discharges in Queensland are currently regulated through the:

- Queensland Environmental Protection Act 1994 (Qld EP Act 1994)
- Environmental Protection (Air) Policy 2008 (EPP (Air)).

The framework for air quality regulation is administered by the Department of Environment and Heritage Protection (EHP), formerly the Department of Environment and Resource Management (DERM). For more information on the legislation and how it relates to the Surat Gas Project, refer to the air quality assessment completed for the EIS.

There have been no changes to the air quality guidelines used for the EIS assessment (see EIS Appendix C, Section 4.3 for details on the air quality criteria implemented).

3.1 Environmental Protection (Air) Policy 2008

The EPP (Air) was reprinted in November 2012 to incorporate amendments; however, there have been no changes to the EPP (Air) air quality guidelines.

3.2 Greentape Reduction Act

The Environment Protection (Greentape Reduction) and Other Legislation Amendment Act 2012 (Greentape Reduction Act) was passed on 31 July 2012 and commenced on 31 March 2013. The Greentape Reduction Act amends both the Qld EP Act 1994 and the EPP (Air).

The Greentape Reduction Act includes a reform of the licensing framework under the Qld EP Act 1994, with changes to the approval process and activities covered (environmentally relevant activities (ERAs), or environmental authorities).

Accordingly, the Greentape Reduction Act will affect how Arrow applies for licences to operate the facilities constructed for the Surat Gas Project, but should not affect the methodology or guideline values used in the current EIS assessment process.

4 STUDY APPROACH AND METHODOLOGY

4.1 Surat Gas Project Air Quality Assessment

The following assessments make up the EIS air quality assessment as per the Surat Gas Project EIS Appendix C:

- Emissions from single wells were estimated in Section 6.3.5 of the EIS assessment, with local impacts assessed in Section 7.2.
- Emissions from CGPF power generation were estimated in Section 6.3.4 of the EIS assessment, with local impacts assessed in Section 7.2.
- Emissions from ramp-up flaring and planned and unplanned maintenance flaring were estimated in Section 6.3.1 and 6.3.2 of the EIS assessment, respectively. The local impacts of flaring were assessed in Section 7.2.
- Emissions from fugitive leaks were estimated in Section 6.3.3 of the EIS assessment, with local impacts assessed in Section 7.2.
- The regional assessment was presented in Section 7.1 of the EIS assessment.

The following reassessments were required due to the refinements made to the project description:

- Regional assessment – a qualitative assessment was conducted, with comparison made to the EIS assessment.
- Localised assessment of a CGPF – Ausplume modelling was conducted to compare EIS and SREIS power generation emissions. A qualitative assessment was conducted with comparison to the EIS assessment for flaring emissions.
- Localised assessment of a multi-well pad – dispersion modelling was conducted to determine the impact of the multi-well pads.

Please note the 99.99th percentile 1-hour concentration was used in the supplementary air quality impact assessment. This percentile is in practice the second highest model prediction within a year, and it was used to ensure that the modelling results are not heavily influenced by the maximum values that could be outliers. This methodology is widely used and recommended in many jurisdictions around the world, including Queensland.

4.2 Regional Assessment

To evaluate the project's regional impacts on air quality, the EIS considered two scenarios for the photochemically reactive compounds nitrogen dioxide (NO_2) and ozone (O_3) as follows:

- Scenario 1 was for a representative operational year (2020)
- Scenario 2 considered all facilities and wells in operation.

For the EIS, the background air quality of the Surat Gas Project region was modelled using TAPM-CTM and data obtained from monitoring stations, where available (see EIS Appendix C, Section 5.2 and Section 5.3 for more information on the modelling parameters). The model also included natural sources (such as vegetation) and a comprehensive list of 96 existing and approved future sources.

The EIS dispersion modelling of the worst-case regional scenarios predicted no exceedances of the EPP (Air) guidelines within the study area.

The SREIS qualitative assessment involved comparing the revised numbers of CGPFs and wellheads to the worst-case numbers of these sources in EIS Scenario 2 (regional impacts assessed in EIS Appendix C, Section 7.1), as these sources were the largest contributors to regional impacts. The impact of the revised traffic data was compared to the largest regional contributors.

The air quality impact of supplying grid electricity to CGPFs and wellheads was also considered.

As discussed in the EIS, only non-methane volatile organic compounds (VOC) and oxides of nitrogen (NO_x) emissions are considered in the TAPM-CTM modelling completed for the regional assessment, as these substances contribute to the generation of NO_2 and O_3.

4.3 Local Assessment

4.3.1 Modelling Approach

For the EIS, the dispersion of emissions for the local assessments was modelled with Ausplume, the 'default' air quality regulatory model in Queensland. The same general methodology has been employed to assess the local impacts of emissions for the SREIS. As outlined in the EIS assessment, site-specific Ausplume meteorological files extracted from the TAPM prognostic meteorological model were used in the local dispersion modelling. Refer to EIS Appendix C, Section 4.4 for more information on the modelling methodology.

In the EIS assessment, NO_x ground level concentrations were predicted at model receptors set out at different distances from the emission sources. The EIS assessment used meteorological data for three locations in the Surat Basin, representing the northern, central and southern parts of the basin. The results from the site with the highest predicted ground level concentrations were then applied to the whole region to assess the potential local impacts and separation distance requirements. For this SREIS evaluation, the same general approach was employed but only the dataset producing the highest predicted ground level concentrations, the northern site dataset, was used.

As there is an air quality guideline for NO_2 and not NO_x or nitric oxide (NO), the predicted ground level concentrations of NO_2 are of most relevance. To conservatively estimate downwind NO_2 concentrations, an ambient NO_x: NO_2 ratio of 0.3 was used as per the EIS. A conservative ambient air quality background concentration of 23.2 µg/m³ for NO_2 was adopted as per the EIS. For more information on how the background concentration and NO_x:NO_2 ratio were determined, please review EIS Appendix C, Section 4.4.3.3.

4.3.2 Central Gas Processing Facility

To evaluate the local impacts of power generation and flaring at CGPFs (including those with water treatment facilities), the EIS modelled the emissions from a 3 MW engine, and several flaring rates with results as follows:

- The modelling of the 16 engines, each with a capacity of 3 MW, indicated a maximum 175 m separation distance between a CGPF (48 MW) and sensitive receptors, to meet the EPP (Air) guideline concentration of NO_x.
- The flaring assessment indicated that no exceedances of the guidelines would occur, for any pollutant. Consistent with the assessment of power generation impacts, NO_x was determined to be the pollutant of most interest. For the maximum flare rate assessed, the NO_x concentrations were well below the guideline value.

While all pollutants of concern were assessed (NO_x, VOC, carbon monoxide [CO], sulfur dioxide [SO_2] and particulate matter with an aerodynamic diameter less than 10 µm [PM_{10}]), only NO_x had sufficient emission rates to lead to ground level concentrations similar in magnitude to the guidelines.

To determine the revised impact of a CGPF, the supplementary air quality impact assessment involved:

- Modelling the emissions from CGPF short-term power equipment for the SREIS and EIS using Ausplume to determine a revised separation distance and reviewing engine and turbine emission data.
- Comparison of the flare rates of the EIS to those proposed for the SREIS and interpolation and extrapolation of NO_2 concentrations.

The impact of supplying grid electricity to CGPFs was also considered.

4.3.3 Multi-well Pads

The EIS assessed the emissions from a 60 kW engine for a single well. The multi-well pad requires a larger engine to power 12 wells and therefore a 749 kW engine was assessed for the SREIS. The Ausplume methodology described above has been employed to assess the larger multi-well pad engine. The localised NO_X impacts from the multi-well pads have been modelled to determine whether a separation distance is required due to NO_2 concentrations.

Emission rates for NO_x, CO and VOC are based on manufacturer's data. The emission rate for PM_{10} was calculated using the emission factor provided for four-stroke engines in US EPA AP 42 Section 3.2 'Natural Gas-fired Reciprocating Engines'. Note that the emission factors for the EIS were sourced for four-stroke rich-burn engines, which produce more particulate matter per amount of fuel combusted.

The localised impacts of CO, VOC and PM_{10} emissions were assessed using the results of the NO_x modelling and the emission factors for each substance.

The impact of supplying grid electricity to multi-well pads, when available, was also considered.

5 ASSESSMENT OF IMPACTS

5.1 Regional Assessment

The regional air quality assessment is concerned with the cumulative effect of atmospheric photochemistry on the fate of NO_x plumes emitted from the Project. Emissions of NO_x interact with reactive VOCs, ozone and sunlight in reactions that have complex effects on the ground level concentrations of NO_2, O_3 and other constituents of photochemical smog.

In the EIS, the wells, followed by CGPFs, were the most significant emission sources in relation to regional impacts. With the proposed changes, the overall air emissions from the project will be reduced compared to EIS Scenario 2 due to a reduction in the number of wells (from 7,500 to 6,500) and CGPFs (from 12 to eight).

Grid power will be used to power both wells and CGPFs when available. No project-related emissions are associated with the use of electricity from outside sources. Therefore the air quality impacts associated with the short-term power generation equipment will cease once grid connections are established, with only flaring, transport and fugitive emissions continuing to be released from the project operations. Those sources were shown to be relatively minor sources of air emissions in the EIS.

With such a large decrease in potential emissions compared to the scenario evaluated for the EIS, a quantitative assessment was not completed given that Scenario 2, as presented in the EIS, already represents worst-case.

As described in the EIS, the VOC and NO_x emissions from the project will lead to an increase in the concentrations of the photochemical compounds NO_2 and O_3 compared to their existing (background) levels in the project development area. From the above analyses, it is clear that the increase in concentrations of photochemical compounds (compared to existing levels) predicted in the SREIS will be much smaller than the increase predicted in EIS Appendix C, Section 7.1.

The regional modelling completed for the EIS indicates that while NO_2 and O_3 concentrations were projected to increase slightly compared with background concentrations, the EPP (Air) objectives would not be exceeded. For the SREIS, the revised emissions from the Project are significantly lower than the EIS assessment and therefore it can be predicted with higher confidence that the EPP (Air) objectives will not be breached as a result of project emissions.

In the EIS, the constant emission rate of NO_x due to transport for the worst-case year (with respect to distance travelled) of the project was calculated to be 4.9 g/s. For the SREIS, the number of kilometres travelled has increased by 30% in the worst-case year and the emission rate over the entire project area has increased to 6.35 g/s. However, the emission rate at any point or on any road would be significantly less than 6.35 g/s, and would be spread across a large area. The impact of these diffuse emissions would be less than for a single stationary source. In comparison, the NO_x emission rate for one CGPF in the EIS was 24 g/s.

As indicated in the EIS, no regional impacts of PM_{10}, SO_2, CO, odour, or dust deposition were assessed. It was determined that these pollutants were not released from the project in large enough quantities to trigger the need for an assessment at a regional level.

5.2 Localised Impacts

5.2.1 Central Gas Processing Facility Assessment and Water Treatment Facilities

The localised air quality impacts associated with central gas processing facilities have been assessed in terms of emissions from short-term power generation equipment, flaring, and connection to grid electricity.

5.2.1.1 Short-Term Power Generation Equipment

Table 1 lists two typical configurations for power generation at CGPFs. Note that the total power requirement for a CGPF with N+1 sparing capacity to process 225 TJ/d gas (and if required support a water treatment facility) is 50 MW.

Table 1: Typical Gas Engine and Turbine for Short-Term CGPF Power Supply

CGPF Short-Term Power	Technology	Power required	Rating	No of Units
Configuration 1	Reciprocating Gas Engine	50 MW	1,160 kW	47
Configuration 2	Open Cycle Gas Turbine	50 MW	5,700 kW	10

The stack parameters for the power generation configurations considered for CGPFs are shown in Table 2, which compares them with the values used in the EIS. Most data in this table for the SREIS typical equipment were provided by the manufacturers of the equipment.

Table 2: CGPF Power Generation Equipment Stack Parameters

Scenario	Height of Release (m)	Stack Diameter (m) [a]	Exit Velocity (m/s) [a]	Exhaust Volume Flow Rate (m^3/s) [a]	Exit Temperature (°C)
SREIS Configuration 1 (47 x 1.1MW gas engines)	5.21	0.3	55	3.88	469
SREIS Configuration 2 (10 x 5.7 MW gas turbines)	7.3	1.06	49	43.1	514
EIS Configuration (16 x 3 MW gas engines)	7.0	0.635	28.4	9.0	385

a Data presented are for each unit at the CGPF.

Emission rates from the two SREIS configurations are provided in Table 3, which also shows how they compare to those used in the EIS assessment. The rates shown are for 100% load.

Table 3: Typical Power Generation Emission Estimates per CGPF

Source	Pollutant	Emission Rate (g/s) [a]	Source	Emission Factor (kg/Sm^3) [b]
SREIS Configuration 1 (47 x 1.1MW gas engines)	CO	31	Equipment Manufacturer	
	NO_x	22	Equipment Manufacturer	
	VOC	7.0	AP-42 (US EPA, 2000)	2.13 x10^{-3} (0.118 lb/MMBtu)
	PM_{10}	0.005	AP-42 (US EPA, 2000)	1.39 x10^{-6}(7.71 x10^{-5}lb/MMBtu) [c]
SREIS Configuration 2 (10 x 5.7 MW gas turbines)	CO	9.3	Equipment Manufacturer	
	NO_x	11.6	Equipment Manufacturer	
	VOC	2.7	Equipment Manufacturer	
	PM_{10}	0.15	AP-42 (US EPA, 2000b)	3.43 x10^{-5} (1.90 x10^{-3} lb/MMBtu)
EIS Configuration (16 x 3 MW gas engines)	CO	48	Arrow	
	NO_x	24	Arrow	
	VOC	7.2	Arrow	
	PM_{10}	0.56	AP-42 (US EPA, 2000)	1.59x10^{-4} (9.5x10^{-3} lb/MMBtu)[d]

a Emission rates presented are for the total emissions due to engines or turbines from each CGPF.
b Sm^3 is defined as m^3 at standard conditions; 15°C, 101.325 kPa.
c 4-stroke lean-burn engines or turbines.
d 4-stroke rich-burn engines.

The net emissions for both CGPF equipment configurations in the SREIS are lower than those in the EIS, for all four assessed pollutants: NO_x, CO, PM_{10} and VOC.

The proposed SREIS configurations 1 and 2 for power generation equipment have higher exit temperatures (469°C and 514°C) than the value of 385°C for the 3 MW engine assessed in the EIS. They also have higher exit velocities (55 m/s and 49 m/s) than the 28.4 m/s for the 3 MW engine. However, the smaller exhaust flow rate for Configuration 1 will counteract the other changes to result in lower plume buoyancy per engine than assumed in the EIS. This has a tendency to increase ground level concentrations but is offset by the wider spatial distribution of the engines, which produces a more diffuse plume.

In order to determine how the different power generation configurations would affect local air quality, modelling with Ausplume was conducted for NO_x using emission rates (Table 3) and stack characteristics (Table 2) for the revised scenarios.

This analysis yields results for the 99.99th percentile 1-hour average NO_2 concentration as shown in Figure 1. As for the EIS, the ambient NO_2:NO_x ratio is assumed to be 0.3, but for the relatively short distances downwind shown here the actual ratio is likely to be much closer to the source ratio of 0.1. This would result in lower downwind concentrations than shown. Figure 1 shows the highest 1-hour ground level concentration as 140 µg/m^3 for SREIS Configuration 1, and 45 µg/m^3 for SREIS Configuration 2. Both SREIS configurations produce significantly lower concentrations than shown for the EIS configuration.

From the above analyses, it is therefore expected that both SREIS configurations would comply with the EPP (Air) 1-hour NO_2 objective of 250 µg/m^3 at all downwind distances. Depending on the other emission sources from a CGPF and final equipment choice, it is considered that there may be no need for an air quality separation distance for a CGPF, although this does not account for potential noise effects.

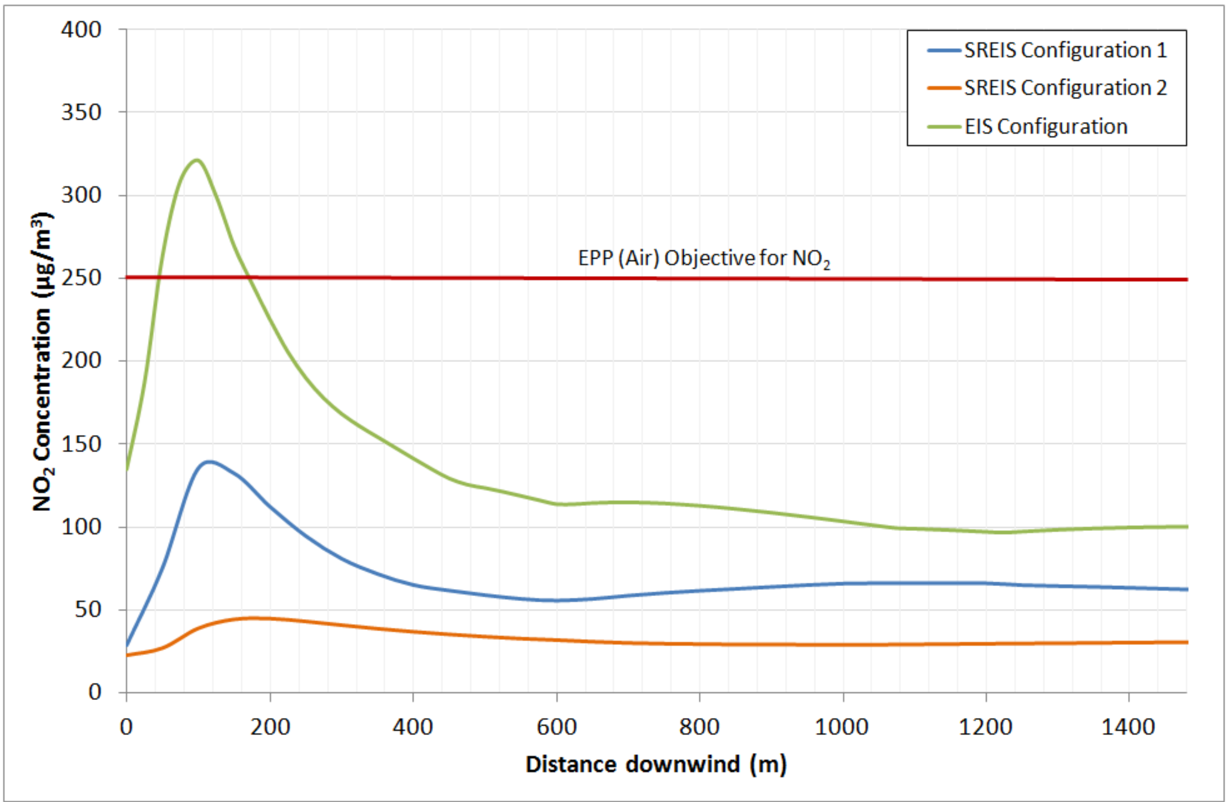


Figure 1: Predicted 99.99th percentile 1-hr NO2 ground level concentrations as a function of distance downwind from EIS and SREIS CGPF short-term power generation equipment

5.2.1.2 Planned and Unplanned Maintenance Flaring

The comparison of planned and unplanned maintenance flaring scenarios for the SREIS and EIS are presented in Table 4.

Table 4: Planned and Unplanned Maintenance Flaring Scenarios for the EIS and SREIS

Assessment	Duration (hours)	Occurrences	Flare Rate (TJ/d)	Scenario	Overall Flare Rate (TJ/year)
SREIS	12	1 per year	225	All trains shutdown	112.5
	24	1 per year	225	All trains shutdown	225
	48	4 per year	75	One train shutdown	400
	32	6 per year	25	Part train shutdown	300
EIS	24	1 per year	150	All trains shutdown	150
	8	2 per month	30	One train shutdown	240
	8	4 per month	10	Part train shutdown	160

As shown in Table 4, the maximum flaring rate for planned and unplanned maintenance flaring for the SREIS (225 TJ/d) is larger than what was assessed in the EIS (150 TJ/d). It should be noted that for short-term air quality impacts associated with flaring, the flare rate per hour, and therefore emission rate per hour, is more important than duration. This is because in modelling of flaring impacts, the model evaluates flaring at the rate specified over an entire year at the nominated flare rate. The worst case dispersion conditions are therefore incorporated into the model results by using a full year of meteorological data.

While flaring gas will release a number of pollutants, the impact assessment completed for the EIS explains that the emissions of NO_2 have the highest probability of leading to exceedances of the guidelines. The potential impacts of VOC, PM_{10}, SO_2, CO, odour, or dust deposition are very minor in comparison, with predicted values less than 1% of their respective guidelines.

The results of the localised impact assessment for flaring in the EIS are presented in Table 5.

Table 5: 99.99th Percentile Predicted Flaring NO_2 Concentrations for the EIS Flaring Scenario

Flare Rate (TJ/d)	Predicted NO_2 Concentration (µg/m³)
10	0.7
30	1.0
150	3.5

In the EIS, several flare rates were modelled, ranging from 10 TJ/d to 150 TJ/d. The results of interpolation of the EIS concentrations for the SREIS flare rates of 25 TJ/d and 75 TJ/d, and extrapolation for the maximum SREIS flare rate of 225 TJ/d, are presented in Table 6.

Table 6: 99.99th Percentile Predicted Flaring NO_2 Concentrations for the SREIS Flaring Scenario

Flare Rate (TJ/d)	Predicted NO_2 Concentration (µg/m³)
25	0.96
75	1.98
225	5.03

Table 6 shows a maximum predicted ground-level NO_2 concentration of approximately 5 µg/m³ for the 225 TJ/d SREIS flaring scenario. While the predicted impacts associated with planned and unplanned maintenance flaring have increased for the SREIS compared to the EIS, this concentration is still well below the guideline concentration of 250 µg/m³.

5.2.1.3 Connection to Grid Electricity

As noted in the regional assessment in Section 5.1, once the CGPFs are supplied with electricity from the grid, air quality impacts associated with power generation will cease.

Connecting the CGPFs to grid electricity will not affect the potential emissions from flaring.

5.2.1.4 Summary of Central Gas Processing Facility Localised Impact Assessment

The assessment of impacts from both power generation and flaring at CGPFs indicates that the assessment completed for the EIS represents worst case. However, it is considered that there may be no need for an air quality separation distance for a CGPF due to the significant reduction in emissions from the short-term power generation equipment assessed for the SREIS.

Once local power generation at CGPFs is replaced by electricity, the local air quality impacts from the power generation equipment will cease.

5.2.2 Multi-Well Pads

The SREIS has introduced the concept of locating up to 12 wellheads at a central surface location i.e., a multi-well pad. A multi-well pad has a power requirement of 720 kW and for assessment purposes is powered by a 749 kW gas engine, which is significantly more than the 60 kW engine for a single wellhead.

The stack parameters of the multi-well pad engines are shown in Table 7, with a comparison to the EIS values for a single wellhead.

Table 7: Multi-well Pad and Single Well Gas Engine Stack Parameters

Source	Height of Release (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exhaust Volume Flow Rate (m^3/s)	Exit Temperature (°C)
SREIS for a multi-well pad	10	0.3	37.8	2.67	446
EIS for a single wellhead	2.5	0.08	29.1	0.146	649

Estimated emission rates from a multi-well pad are presented in Table 8, with a comparison to the EIS assessment of a single wellhead. These rates are for 100% engine load.

Table 8: Multi-well Pad and Single Well Gas Engine Emission Estimates

Assessment	Pollutant	Emission Rate (g/s)	Source	Emission Factor (kg/Sm^3)
SREIS for a multi-well pad	CO	0.57	Equipment Manufacturer	
	NO_x	0.56	Equipment Manufacturer	
	VOC	0.083	Equipment Manufacturer	
	PM_{10}	0.000072	AP-42	1.39 x10^{-6} kg/Sm^3 (7.71 x10^{-5} lb/MMBtu) [a]
EIS for a single wellhead	CO	0.3354	AP-42	6.23x10^{-2} kg/Sm^3 [b]
	NO_x	0.2047	AP-42	3.80x10^{-2} kg/Sm^3 [b]
	VOC	0.0090	AP-42	1.68x10^{-3} kg/Sm^3 [b]
	PM_{10}	0.0009	AP-42	1.59x10^{-4} kg/Sm^3 [b]

a 4-stroke lean-burn engines.
b 4-stroke rich-burn engines.

The estimated CO and NO_x emission rates for a multi-well pad are slightly higher than those modelled in the EIS for a single wellhead. The PM_{10} emission rate for a multi-well pad is lower than that used in the EIS due to the use of lean-burn technology.

VOC is a group of pollutants important in the formation of photochemical pollution. The VOC emission rate for a multi-well pad is higher than for a single well in the EIS. However, when divided by the number of wellheads in a multi-well pad (12), the emission rate per well is slightly lower than in the EIS. Hence, the use of multi-well pads is very unlikely to lead to higher levels of photochemical pollutants than predicted in the EIS.

The localised impacts of CO, SO_2, VOC and PM_{10} emissions were assessed in relation to the predicted NO_2 concentrations, and in all cases the predicted concentrations were less than 1% of the respective guidelines.

Table 9 presents the second highest predicted 1-hour NO_2 concentrations at different distances from the multi-well pad engine. Multi-well pad engines are predicted to require no separation distance, since the predicted 99.99th percentile 1-hour concentrations of NO_2 are far below the guideline concentration.

Table 9: Predicted 99.99th percentile 1-hour NO_2 Concentration with Distance from a Multi-well Pad

Scenario	Distance (m)	Predicted Concentration (μg/m³) [a]	EPP (Air) Guideline (μg/m³)
Multi-well pad	0	23.2	**250**
	25	25.8	
	50	29.0	
	75	28.5	
	100	27.8	

a The predicted concentration includes assumed background existing concentration of 23.2 μg/m³.

As discussed in Section 5.1 and 5.2.1, the air quality impacts associated with local power generation at multi-well pads will cease once the CGPF is connected to the grid and power distribution infrastructure to the multi-well pads is installed.

6 BENCHMARKING

This section provides a comparison of emission rates with best practice national and international source emission standards. Please note the typical power generation equipment included in the SREIS are configurations for assessment purposes only, and are not finalised project equipment.

In the absence of specific Queensland emission source guidelines, the emission characteristics of power generation sources were compared to Group 6 emission standards in NSW's Protection of the Environment Operations (POEO) (Clean Air) Regulation 2010.

It should be noted that the NSW POEO Group 6 standards (post 1/09/2005 facility) were used for comparison purposes only. In the case of exceeding the POEO standards, dispersion modelling of the impacts once power generation equipment and sites have been selected will determine whether the impacts are acceptable. The POEO criteria were specifically designed to address long-standing photochemical smog issues in the greater Sydney region, where the NEPM ozone goal has been exceeded every year since 1995 and a 25% reduction in NO_x emissions is considered to be necessary (NSW Office of Environment & Heritage, 2011). Assessment based on dispersion modelling is used in the NSW regulatory framework, and routinely in Queensland, to establish whether licence conditions need to be more or less stringent in specific cases. The POEO guideline value NO_x concentration and reference conditions for Group 6 are presented in Table 10.

Table 10: POEO Guideline NO_x Concentration and Reference Conditions for Group 6

Air Impurity	Activity or Plant	POEO Standard Concentration (mg/m^3)	Reference Conditions
Nitrogen dioxide (NO_2) or Nitric oxide (NO) or both, as NO_2 equivalent	Stationary reciprocating internal combustion engines	450	Dry, 273 K (0°C), 101.3 kPa, 3% O_2
	Any turbine operating on gas, being a turbine used in connection with an electricity generating system with a capacity of less than 10 MW	70	Dry, 273 K (0°C), 101.3 kPa, 15% O_2

The power generation engine and turbine considered in the SREIS have also been benchmarked against the Standards of Performance for Stationary Compression Ignition and Spark Ignition Internal Combustion Engines (US EPA, 2011), as done in the EIS. The comparison of power generation emissions from the multi-well pad and CGPF to the US EPA and POEO standards is presented in Table 11.

Table 11: Comparison of Typical Power Generation Equipment to Relevant NOx Emission Standards

Engine	POEO Standard NO_x Concentration (mg/m^3)	SREIS NO_x Concentration (mg/m^3)	US EPA Guideline/Standard NO_x Emission Rate (g/kW-hr)	SREIS NO_x Emission Rate per Engine (g/kW-hr)
749 kW Multi-well pad engine	**450**	549	**2.68**	2.68
1.1 MW CGPF gas engine		551		1.42
5.7 MW CGPF gas turbine	**70**	70		0.71

As shown in Table 11, the two power generation configurations considered for the SREIS do not exceed the US EPA guideline for emissions of NO_x from stationary gas engines or turbines. However, the multi-well pad and 1.1 MW CGPF engines exceed the POEO standard.

It should be noted that the US EPA standards depend on the size of the equipment and are more realistic. The POEO standards are meant to indicate best available industrial technology for installation in regions with problematic photochemical smog.

7 CONCLUSIONS

Refinements to the project description for the proposed Surat Gas Project that may affect the air quality assessment prepared for the EIS have been identified and evaluated.

The key substances of concern are NO_X released during combustion processes which may take the form of NO_2. NO_x participates in photochemistry and significant background emission sources exist within the study area.

7.1 Regional Impacts

For the EIS, the Surat Gas Project's cumulative impacts on the regional air quality were evaluated by modelling. The Project was shown to generally increase the concentrations of the photochemical compounds NO_2 and O_3.

Overall, while ground level concentrations were predicted to increase, the regional modelling suggested that emissions from the project would not cause the EPP (Air) objectives to be exceeded. Although the kilometres travelled by project related vehicles have increased, this source is spread over a large area and is 26% of the emissions from one CGPF. For the SREIS with the decreased number of wells and CGPFs, coupled with the use of grid electricity instead of self-generation when available, the project's emissions will be significantly decreased. The regional assessment conducted for the EIS therefore still represents worst case emissions and impacts.

7.2 Local Impacts

Two typical power generation configurations for CGPFs were assessed in the SREIS. It was determined through modelling, that the impacts of the two SREIS power generation configurations would be less than the impacts of the CGPF engine configuration considered in the EIS and below the objectives at all downwind distances. As such, the separation distance of 175 m for a CGPF determined in the EIS is not necessary to ensure compliance with ambient air quality guidelines at sensitive sites for the assessed SREIS equipment; however, this will depend on final equipment choices.

Planned and unplanned maintenance flaring scenarios in the SREIS have increased in magnitude compared to those considered in the EIS. The increase in air quality impacts is relatively minor (from 3.5 $\mu g/m^3$ to 5.03 $\mu g/m^3$), and flaring sources are still very small compared to impacts from power generation. It was found that the ground level concentrations associated with flaring would still be well below the guideline values.

Dispersion modelling of wellhead gas engine emissions was completed for single wellheads in the EIS and for multi-well pads in the SREIS. The results suggest that wellhead engines will not contribute to significant levels of NO_x in the immediate vicinity of the wells and thus no constraint on well placement is required, based on estimated emissions of this pollutant.

VOCs are not emitted from the project in significant quantities, and therefore buffer distances around facilities are not required with respect to VOC regulatory guidelines. As there are no significant impacts from SO_2, CO, PM_{10}, odour or dust deposition, no further constraints on the project are required.

It should be noted that the separation distance determined in the EIS was based on a generic assessment which simulated worst-case topographical conditions, as opposed to site-specific terrain and terrain-induced meteorology. It is understood that once the facility locations are known and equipment options are finalised, a dispersion assessment which considers localised terrain will be conducted to refine the predicted impacts.

8 REFERENCES

NSW (2010) *Protection of the Environment Operations (Clean Air) Regulation 2010*, OEH, NSW.

OEH (2011) *Interim OEH Nitrogen Oxide Policy for Cogeneration in Sydney and the Illawarra*, Office of Environment & Heritage, 2011, accessed via: http://www.environment.nsw.gov.au/resources/air/20110442CogenNOx.pdf

PAEHolmes (2011) *Surat Gas Project Impact Assessment Report – Air Quality*, PAEHolmes Brisbane, 16 September 2011.

US EPA (2000) *Natural Gas-fired Reciprocating Engines*, AP42, Fifth Edition, Volume 1, Chapter 3.2, August 2000, Environmental Protection Agency

US EPA (2000b) *Stationary Gas Turbines*, AP42, Fifth Edition, Volume 1, Chapter 3.1, April 2000, Environmental Protection Agency

US EPA (2011) *Standards of Performance for Stationary Compression Ignition and Spark Ignition Internal Combustion Engines*; Final Rule, Environmental Protection Agency.

Appendix A EXAMPLE CGPF LAYOUT

A.1 SREIS CENTRAL GAS PROCESSING FACILITY LAYOUT