Australia Pacific LNG Project
Supplemental information to the EIS
Air Quality and Aviation Safety
LNG Facility

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AUSTRALIA PACIFIC LNG PROJECT SUPPLEMENTAL INFORMATION TO THE EIS AIR QUALITY IMPACT ASSESSMENT LNG FACILITY

Prepared for

WORLEYPARSONS

KE1004937

August 2010

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Document Quality Details

Job Number: KE1004937

Title: AUSTRALIA PACIFIC LNG FACILITY SUPPLEMENTARY AIR QUALITY IMPACT ASSESSMENT

Client: WORLEYPARSONS

Document reference: WorleyParsons_Australia Pacific LNG Plant_ Supplementary.docx

Prepared by: Natalie Shaw and Andrew Vernon

Reviewed by: Christine Killip

Revision	Date	Approved	Signature
Final 1.0	16/08/2010	C. Killip	

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Glossary

Term	Definition
Units of measurement	
µg	microgram
mg	milligram
g	grams
kg	kilograms
t	tonnes
$\mu g/m^3$	micrograms per cubic metre
mg/m^3	milligrams per cubic metre (at stack conditions)
mg/Nm^3	milligrams per normal cubic metre (0^oC, 1 Atm)
ppm	parts per million
tpa	tonnes per annum
Mtpa	million tonnes per annum
µm	microns
mm	millimetre
m	metre
km	kilometre
m^2	square metres
m^3	cubic metres
m/s	metres per second
m^3/s	cubic metres per second
Am^3/s	actual cubic metres per second (at stack conditions)
Nm^3/s	normalised cubic metres per second (0^oC, 1 Atm)
g/s	grams per second
km/h	kilometre per hour
°C	degrees Celsius
J	joule
GJ	gigajoule: $1.0 \times 10^9 J$
GJ/hr	gigajoule per hour
GJ/s	gigajoule per second
Air pollutants and chemical nomenclature	
NO_X	oxides of nitrogen
NO_2	nitrogen dioxide
SO_2	sulphur dioxide
CO	carbon monoxide
THC	total hydrocarbons compounds
PM_{10}	particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than 2.5 microns
ou	odour units

Other abbreviations

APLNG	Australia Pacific LNG
Origin	Origin Energy
CSG	coal seam gas
LNG	liquefied natural gas
DERM	Department of Environment and Resource Management
NPI	National Pollutant Inventory
NEPM	National Environment Protection (Ambient Air Quality) Measure
Air Toxics NEPM	National Environment Protection (Air Toxics) Measure
EPP Air	Environmental Protection (Air) Policy
Approved Methods	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW
VicSEPP	State Environmental Protection Policy of Victoria
TCEQ	Texas Commission on Environmental Quality Effects Screening Levels
Clean Air Regulation	NSW Protection of the Environment Operations (Clean Air) Regulation 2002
ToR	Terms of Reference
EMP	Environmental Management Plan
EIS	Environmental Impact Statement
SAQIA	Supplementary Air Quality Impact Assessment
TAPM	The Air Pollution Model

Executive Summary

Katestone Environmental has been commissioned by Worley Parsons to undertake a Supplementary Air Quality Impact Assessment (SAQIA) as part of the supplementary Environmental Impact Statement (EIS) information for the Australia Pacific LNG Downstream Project. The Australia Pacific LNG Project (the Project) is proposed by Australia Pacific LNG Pty Limited (APLNG) and comprises a coal seam gas (CSG) to liquefied natural gas (LNG) development. Australia Pacific LNG is a joint venture between Origin Energy (Origin) and ConocoPhillips Australia LNG Pty Limited.

The SAQIA considers the more detailed design information that has been developed since the completion of the EIS. The SAQIA seeks to address the key components of the project that have changed as a result of the development of the detailed design. Outside of this, the findings of the air quality study conducted for the EIS, remain valid.

Key changes in the Australia Pacific LNG design of the plant compared to the EIS design are as follows:

- *Revised site layout*
- *Change in source characteristics of gas turbine compressor drivers, power generation turbines and hot oil heaters*
- *Change in emission concentrations of NO_x, CO, SO_2 and $PM_{10}/PM_{2.5}$ for the gas turbine compressor drivers, power generation turbines and hot oil heaters*
- *Addition of the Acid Gas Incinerators*
- *Change in flaring characteristics during upset conditions*

Compared to the total annual emissions reported in the EIS, the total annual emissions from the Australia Pacific LNG facility for the SAQIA have changed as follows for normal operations:

- *Emissions of NO_2, increased by 4%*
- *Emissions of CO, increased by 6%*
- *Emissions of $PM_{10}/PM_{2.5}$, increased by 2%*
- *Emissions of total hydrocarbons, increased by 4%*
- *Emissions of SO_2 are now included.*

Potential emissions of SO_2 were included in this analysis to account for the uncertainty in future coal seam gas quality. The quality of gas drilled to date indicates that there is essentially nil H_2S in the gas feeding the LNG facility. However, as the design life of the LNG plant is at least 20 years, the design includes the H_2S potentially being in the feed gas in the future. Air emissions have been assessed based on the LNG plant design case.

For non-routine operations flaring will occur via 2 x Dry gas flares with a total energy of 64,900 GJ/hour. This results in a 10% decrease in emissions compared with the EIS.

For normal operations the maximum difference between the EIS and the SAQIA for the maximum 1-hour ground-level concentrations of NO_2 due to the project in isolation is 0.9 $\mu g/m^3$ at any sensitive receptor.

A cumulative air quality assessment was undertaken that included all existing industrial sources in Gladstone and proposed future developments (including proposed LNG plants on Curtis Island and at Fishermans Landing) and has shown the following:

- *All air quality objectives are met for normal and non-routine operation of the LNG facility (inclusive of background levels) at sensitive receptors for NO_2, CO, PM_{10}, $PM_{2.5}$, odour, ozone, SO_2 and hydrocarbons.*

For all pollutants the contribution to the regional air quality is dominated by existing sources, which includes industrial, anthropogenic and natural sources.

1. Introduction

Katestone Environmental has been commissioned by Worley Parsons to undertake a Supplementary Air Quality Impact Assessment (SAQIA) as part of the supplementary Environmental Impact Statement (EIS) for the Australia Pacific LNG Downstream Project. The APLNG Project (the Project) is proposed by Australia Pacific LNG Pty Limited (APLNG) and comprises a coal seam gas (CSG) to liquefied natural gas (LNG) development. Australia Pacific LNG is a joint venture between Origin Energy (Origin) and ConocoPhillips Australia LNG Pty Limited.

The proposed Australia Pacific LNG Project comprises the development of a green-field LNG production and export terminal at Curtis Island on the northern shore of Port Curtis, near Gladstone. The Project will facilitate the export of natural gas to international markets from Coal Seam Gas (CSG) extracted from the Australia Pacific LNG gas fields in the Walloons Fairway and Surat and Bowen Basins in central southern Queensland. CSG will be processed in the field to extract moisture and the gas will be pressurised for transmission via a pipeline stretching approximately 450 km to the LNG facility on Curtis Island. The Project is designed to supply up to approximately 18 million tonnes per annum (Mtpa) of LNG product to market through the development of a LNG facility which may comprise four LNG trains each with a production capacity of 4.5 Mtpa.

The SAQIA considers the more detailed design information that has been developed since the completion of the EIS. The SAQIA seeks to address the key components of the project that have changed as a result of the development of the detailed design. Outside of this, the findings of the air quality study conducted for the EIS, remain valid.

Key changes in the Australia Pacific LNG design of the plant compared to the EIS design are as follows:

- Revised site layout
- Change in source characteristics of gas turbine compressor drivers, power generation turbines and hot oil heaters
- Change in emission concentrations of NO_x, CO, SO_2 and PM_{10}/$PM_{2.5}$ for the gas turbine compressor drivers, power generation turbines and hot oil heaters
- Addition of Acid Gas Incinerators
- Change in flaring characteristics during upset conditions

The SAQIA has focused on the primary source of air emissions from the project during normal operations as identified in the EIS:

- Gas turbines used to drive the gas compressors
- Gas turbines used for power generation
- Gas-fired hot oil heaters

The SAQIA also includes four acid gas incinerators (one per train).

The objective of the assessment is to investigate the potential for air emissions from the LNG facility to affect the air quality in the Gladstone region and to present the changes in assessment compared to the EIS. All activities that are likely to emit air pollutants have been considered. The major air pollutant emitted during normal and non-routine operations of the LNG facility is oxides of nitrogen (NO_X), as nitrogen dioxide (NO_2). Minor emissions of carbon monoxide (CO), particulates as PM_{10} and $PM_{2.5}$, sulphur dioxide (SO_2) and hydrocarbons are also emitted from the LNG facility during normal and non-routine operations.

2. Overview of the Assessment Methodology

The air quality impact assessment of the proposed LNG facility has been conducted in accordance with the requirements of the Project's ToR issued by the Coordinator-General. The assessment is based on a dispersion modelling study that incorporates source characteristics and air pollutant emission rates supplied by the client and site-specific meteorology. The air quality impact assessment methodology for the SAQIS is as detailed in Section 2 of the Katestone Environmental's *"Australia Pacific LNG facility, Gladstone, Queensland – Air quality impact assessment"* (2010).

Changes in the methodology are as follows:

- The atmospheric dispersion modelling includes background sources of SO_2 based on GAMSv3 modelling for existing and approved sources.
- An assessment of SO_2 for normal operations, including analysis of cumulative ground-level concentrations (incremental plus background) at sensitive receptor locations with the EPP(Air) quality objectives.

3. Emissions

3.1 Normal Operations

3.1.1 Gas turbine compressor drivers

Source characteristics are presented in Table 1 for normal operating conditions with the gas turbines operating at 100% capacity. There will be a total of 24 LM2500+G4 gas turbines used for the four-train scenario. Sixteen of these gas turbines will be fitted with heat recovery units. This is a worst case scenario as the turbines will not operate at 100% capacity all the time.

Table 1 Source characteristics of the LM2500+G4 gas turbine compressor drivers under normal operating conditions at 100% capacity

Parameter	Units	Without heat recovery	With heat recovery
Number of stacks per turbine unit	--	1	1
Total number of turbine units (4 train case)	--	8	16
Stack base ground elevation (above sea level)	m	7	7
Stack height (above ground level)	m	45	45
Stack diameter	m	3.4	3.18
Exhaust gas temperature	K	790	692
Exhaust gas velocity	m/s	22.86	22.86
Exhaust gas flow rate (actual stack conditions)	m^3/s	207.8	182.03
Normalised exhaust gas flow rate (0^oC, 1 Atm)	Nm^3/s	71.8	71.8

The location of the stacks associated with each of the 24 gas turbine compressor drivers for is presented in Table 2.

Table 2 Locations of the gas turbine compressor driver stacks

	Train 1		Train 2		Train 3		Train 4	
	X	Y	X	Y	X	Y	X	Y
1	315585	7371538	315585	7371733	315585	7371928	315585	7372123
2	315571	7371538	315571	7371733	315571	7371928	315571	7372123
3	315557	7371543	315557	7371738	315557	7371933	315557	7372128
4	315543	7371543	315543	7371738	315543	7371933	315543	7372128
5	315528	7371547	315528	7371742	315528	7371937	315528	7372132
6	315514	7371547	315514	7371742	315514	7371937	315514	7372132
Table note: MGA coordinates referenced to GDA94 (in metres)								

Table 3 presents the concentrations and emission rates for NO_X, CO, $PM_{10}/PM_{2.5}$, SO_2 and total hydrocarbons, while Table 4 presents the likely contribution to total hydrocarbon emissions for all hydrocarbons identified in the US EPA AP-42 emission factors document for Stationary Gas Turbines.

Table 3 Concentration and emission rates of air pollutants from the LM2500+G4 gas turbine compressor drivers under normal operating conditions at 100% capacity

Parameter	Concentration[1] (mg/Nm^3)	Emission rate[2] (g/s)	Total annual emissions[3] (t/yr)
Oxides of nitrogen (as NO_2)	48.19	3.46	2,619
Carbon monoxide	29.39	2.11	1,597
PM_{10} / $PM_{2.5}$	3.34	0.24	182
Total Hydrocarbons[4]	12.67	0.91	690
Sulfur dioxide	1.24	0.09	68

Table note:
[1]Concentration calculated from emission rate data
[2]Information obtained from Australia Pacific LNG
[3] All turbines operating for 8,760 hours per year, 4 trains
[4]Total hydrocarbons presented as methane equivalents

Table 4 Breakdown of emission rates of hydrocarbons from the LM2500+G4 gas turbine compressor drivers

Pollutant	Molecular weight	Emission Factor[1] (lb/MMBtu)	Stack Concentration (mg/Nm^3)	Emission Rate (g/s)
1,3-Butadiene	54.10	4.3E-07	5.0E-04	3.6E-05
Acetaldehyde	44.10	4.0E-05	4.6E-02	3.3E-03
Acrolein	56.06	6.4E-06	7.4E-03	5.3E-04
Benzene	78.10	1.2E-05	1.4E-02	9.9E-04
Ethylbenzene	106.20	3.2E-05	3.7E-02	2.6E-03
Formaldehyde	30.03	7.1E-04	8.2E-01	5.9E-02
Methane	16.00	8.6E-03	9.9E+00	7.1E-01
Naphthalene	128.20	1.3E-06	1.5E-03	1.1E-04
PAH	252.31	2.2E-06	2.5E-03	1.8E-04
Propylene Oxide	58.10	2.9E-05	3.3E-02	2.4E-03
Toluene	92.10	1.3E-04	1.5E-01	1.1E-02
Xylene	106.20	6.4E-05	7.4E-02	5.3E-03

Table note:
[1]Source: US EPA AP-42

3.1.2 Power generation gas turbines

Fourteen operating turbine units have been considered in the air quality assessment; however 13 turbine units are likely to operate at any one time while one unit will be offline. The source characteristics of the Solar Titan 130 gas turbines, used for power generation, are presented in Table 5.

The locations of the stacks associated with each of the gas turbines for power generation for the four-train case are presented in Table 6.

Table 5 Source characteristics of the Solar Titan 130 gas turbines for power generation under normal operating conditions at 100% capacity

Parameter	Units	Value
Number of stacks per turbine unit	--	1
Total number of turbine units (4 train case)[1]	--	14
Stack base ground elevation (above sea level)	m	7
Stack height (above ground level)	m	25
Stack diameter	m	2.41
Exhaust gas temperature	K	792
Exhaust gas velocity	m/s	22.86
Exhaust gas flow rate (actual stack conditions)	m^3/s	104.11
Normalised exhaust gas flow rate (0^oC, 1 Atm)	Nm^3/s	35.89

Table note:
[1] Train 1 has a spare Solar Titan 130 unit that will not operate during normal operations

Table 6 Locations of the power generation gas turbine emission stacks

	Train 1		Train 2		Train 3		Train 4	
	X	Y	X	Y	X	Y	X	Y
1	315833	7371498	315833	7371433	315833	7371700	315833	7371739
2	315833	7371485	315833	7371420	315833	7371713	315833	7371752
3	315833	7371472	315833	7371407	315833	7371726		
4	315833	7371459	315833	7371394				
5	315833	7371446						

Table note:
MGA coordinates referenced to GDA94 (in metres)

Table 7 presents the concentrations and emission rates of NO_X, CO, $PM_{10}/PM_{2.5}$, SO_2 and total hydrocarbons, while Table 8 presents the likely contribution to total hydrocarbon emissions for all hydrocarbons identified in the US EPA AP-42 emission factors.

Table 7 Concentration and emission rates of air pollutants from the Solar Titan 130 gas turbines for power generation under normal operating conditions at 100% capacity

Parameter	Concentration[1] (mg/Nm^3)	Emission rate[2] (g/s)	Total annual emissions[3] (t/yr)
Oxides of nitrogen (as NO_2)	45.42	1.63	720
Carbon monoxide	56.0	2.01	887
PM_{10} / $PM_{2.5}$	2.51	0.09	40
Total Hydrocarbons[4]	15.88	0.57	252
Sulfur dioxide	1.85	0.07	29

Table note:
[1]Concentration calculated from emission rate data
[2]Information obtained from Australia Pacific LNG
[3] Assumed capacity for all turbines operating for 8,760 hours per year
[4]Total hydrocarbons presented as methane equivalents.

Table 8 Breakdown of emission rates of hydrocarbons from the LM2500+G4 gas turbines for power generation

Pollutant	Molecular weight	Emission Factor (lb/MMBtu)	Stack Concentration (mg/Nm^3)	Emission Rate (g/s)
1,3-Butadiene	54.10	4.3E-07	6.2E-04	2.2E-05
Acetaldehyde	44.10	4.0E-05	5.8E-02	2.1E-03
Acrolein	56.06	6.4E-06	9.2E-03	3.3E-04
Benzene	78.10	1.2E-05	1.7E-02	6.2E-04
Ethylbenzene	106.20	3.2E-05	4.6E-02	1.7E-03
Formaldehyde	30.03	7.1E-04	1.0E+00	3.7E-02
Methane	16.00	8.6E-03	1.2E+01	4.5E-01
Naphthalene	128.20	1.3E-06	1.9E-03	6.7E-05
PAH	252.31	2.2E-06	3.2E-03	1.1E-04
Propylene Oxide	58.10	2.9E-05	4.2E-02	1.5E-03
Toluene	92.10	1.3E-04	1.9E-01	6.7E-03
Xylene	106.20	6.4E-05	9.2E-02	3.3E-03
Table note: [1]Source: US EPA AP-42				

3.1.3 Hot oil heaters

The Hot Oil Heaters will be used during start-up conditions, with the waste heat recovery system to provide pre-heating for various LNG production processes during normal operations. The Hot Oil Heaters will then be used during normal operation, at a 40% load, to trim the heating requirements of the facility and assist the waste heat recovery system. The heaters have been included in the air quality assessment for continual use during normal operating conditions at an assumed 100% load; this therefore constitutes a worst case scenario.

The heaters are gas-fired and heat a closed loop hot fluid system. Consequently, four Hot Oil Heaters for the four LNG train scenario have been used in this assessment.

The source characteristics of the Hot Oil Heaters are presented in Table 9.

Table 9 Source characteristics of the Hot Oil Heaters under normal operating conditions at 100% capacity

Parameter	Units	Value
Number of stacks per unit	--	1
Total number of units (4 train case)	--	4
Stack base ground level (above sea level)	m	7
Stack height (above ground level)	m	37
Stack diameter	m	0.75
Exhaust gas temperature	K	477
Exhaust gas velocity	m/s	13.5
Exhaust gas flow rate (actual stack conditions)	m^3/s	5.93
Normalised exhaust gas flow rate (0^oC, 1 Atm)	Nm^3/s	3.39

The location of the stacks associated with each of the four Hot Oil Heaters for the four-train case is presented in Table 10.

Table 10 Locations of the Regeneration Oil Heater emission stacks

Train 1		Train 2		Train 3		Train 4	
X	Y	X	Y	X	Y	X	Y
315728	7371537	315728	7371732	315728	7371927	315728	7372122

Table note:
MGA coordinates referenced to GDA94 (in metres)

Table 11 presents the concentrations and emission rates for NO_X, CO, $PM_{10}/PM_{2.5}$, SO_2 total hydrocarbons, while Table 12 presents the likely contribution to total hydrocarbon emissions for all hydrocarbons identified in the US EPA AP-42 emission factors document for gas-fired boilers (assumed similar to the Hot Oil Heaters). It should be noted that such factors used here are for generic hot oil heaters using a generic natural gas but CSG is a very lean gas and so is extremely unlikely to result in any such products at the quoted emission rates/stack concentrations and so the following should be considered extremely conservative, but included here for assessment purposes.

Table 11 Concentration and emission rates of air pollutants from the Hot Oil Heaters under normal operating conditions at 100% capacity

Parameter	Concentration[1] (mg/Nm^3)	Emission rate[2] (g/s)	Total annual emissions[3] (t/yr)
Oxides of nitrogen (as NO_2)	138.64	0.47	59
Carbon monoxide	115.04	0.39	49
PM_{10} / $PM_{2.5}$	11.80	0.04	5
Total Hydrocarbons[4]	2.9	0.01	1
Sulfur dioxide	1.15	0.004	0.5

Table note:
[1]Concentration calculated from emission rate data
[2]Information obtained from Australia Pacific LNG
[3] Assumed capacity for all heaters operating for 8,760 hours per year, which is conservative

Table 12 Breakdown of emission rates of hydrocarbons from the Hot Oil Heaters

Pollutant	Molecular weight	Emission Factor (lb/MMBtu)	Stack Concentration (mg/Nm^3)	Emission Rate (g/s)
2-Methylnaphthalene	142.19	2.4E-05	6.4E-06	2.2E-08
3-Methylchloranthrene	268.35	1.8E-06	4.8E-07	1.6E-09
7,12-Dimethylbenz(a) anthracene	256.34	1.6E-05	4.3E-06	1.5E-08
Acenaphthene	154.20	1.8E-06	4.8E-07	1.6E-09
Acenaphthylene	152.18	1.8E-06	4.8E-07	1.6E-09
Anthracene	178.23	2.4E-06	6.4E-07	2.2E-09
Benz(a)anthracene	228.28	1.8E-06	4.8E-07	1.6E-09
Benzene	78.10	2.1E-03	5.6E-04	1.9E-06
Benzo(a)pyrene	252.31	1.2E-06	3.2E-07	1.1E-09
Benzo(b)fluoranthene	252.32	1.8E-06	4.8E-07	1.6E-09
Benzo(g,h,i)perylene	276.32	1.2E-06	3.2E-07	1.1E-09
Benzo(k)fluoranthene	252.30	1.8E-06	4.8E-07	1.6E-09
Butane	58.12	2.1E+00	5.6E-01	1.9E-03
Chrysene	228.00	1.8E-06	4.8E-07	1.6E-09
Dibenzo(a,h)anthracene	278.33	1.2E-06	3.2E-07	1.1E-09
Dichlorobenzene	147.01	1.2E-03	3.2E-04	1.1E-06
Ethane	30.07	3.1E+00	8.3E-01	2.8E-03
Fluoranthene	202.26	3.0E-06	8.0E-07	2.7E-09
Fluorene	166.22	2.8E-06	7.5E-07	2.5E-09
Formaldehyde	30.03	7.5E-02	2.0E-02	6.8E-05
Hexane	86.18	1.8E+00	4.8E-01	1.6E-03
Indeno(1,2,3-cd) pyrene	276.32	1.8E-06	4.8E-07	1.6E-09
Methane	16.00	2.3E+00	6.2E-01	2.1E-03
Naphthalene	128.17	6.1E-04	1.6E-04	5.5E-07
Pentane	72.15	2.6E+00	7.0E-01	2.4E-03
Phenanathrene	178.23	1.7E-05	4.6E-06	1.5E-08
Propane	44.10	1.6E+00	4.3E-01	1.5E-03
Pyrene	202.25	5.0E-06	1.3E-06	4.5E-09
Toluene	92.10	3.4E-03	9.1E-04	3.1E-06

Table note:
[1]Source: US EPA AP-42

3.1.4 Acid Gas Incinerators

The source characteristics of the acid gas incinerators are presented in Table 13.

Table 13 Source characteristics of the AG Incinerators under normal operating conditions at 100% capacity

Parameter	Units	Value
Number of stacks per unit	--	1
Total number of units (4 train case)	--	4
Stack base ground level (above sea level)	m	7
Stack height (above ground level)	m	23
Stack diameter	m	0.98
Exhaust gas temperature	K	631
Exhaust gas velocity	m/s	30
Exhaust gas flow rate (actual stack conditions)	m^3/s	22.6
Normalised exhaust gas flow rate (0^oC, 1 Atm)	Nm^3/s	9.8

The location of the stacks associated with each of the four acid gas incinerators for the four-train case is presented in Table 14.

Table 14 Locations of the AG incinerator emission stacks

Train 1		Train 2		Train 3		Train 4	
X	Y	X	Y	X	Y	X	Y
315759	7371549	315759	7371744	315759	7371939	315759	7372134
Table note: MGA coordinates referenced to GDA94 (in metres)							

Table 15 presents the concentrations and emission rates of NO_X, CO, and SO_2. Emissions of $PM_{10}/PM_{2.5}$ and total hydrocarbons are expected to be negligible.

Table 15 Concentration and emission rates of air pollutants from the acid gas incinerator under normal operating conditions at 100% capacity

Parameter	Concentration[1] (mg/Nm^3)	Emission rate[2] (g/s)	Total annual emissions[3] (t/yr)
Oxides of nitrogen (as NO_2)	26.71	0.26	33
Carbon monoxide	22.66	0.22	28
Sulfur dioxide	527.08	5.16	651

Table note:
[1]Concentration calculated from emission rate data
[2]Information obtained from Australia Pacific LNG
[3] Assumed capacity for all incinerators operating for 8,760 hours per year. Total includes additional flash gas plus supplemental fuel gas firing.

3.1.5 Summary of total annual emissions

A summary of the possible total annual emissions from the Australia Pacific LNG facility operating normally is presented in Table 16. The summary includes all units operating at 100% load for 8760 hours per year, which is very conservative. Emissions from the Flares or shipping have not been included as they do not operate continuously and therefore will not contribute significantly to the total annual emissions from the facility.

Compared to the total annual emissions reported in the EIS, the total annual emissions from the Australia Pacific LNG facility for the SAQIA have changed as follows for normal operations:

- Emissions of NO_x, increased by 4%
- Emissions of CO, increased by 6%
- Emissions of $PM_{10}/PM_{2.5}$, increased by 2%
- Emissions of total hydrocarbons, increased by 4%
- Emissions of SO_2 are now included

Table 16 Summary of total annual emissions from the Australia Pacific LNG facility (normal operations) in tonnes per year

Source	Number of units operating	Emission Rate (t/yr)				
		NO_X	CO	PM_{10}/ $PM_{2.5}$	THC[1]	SO_2
Gas turbine compressor drivers	24	2,619	1,597	182	690	67
Power generation turbines	14	720	887	40	252	29
Hot Oil Heaters	4	59	49	5	1	0
Acid gas incinerators	4	33	28	0	0	651
Total Annual Plant Emissions [2]	--	3431	2562	226	942	748

Table note:
[1] Total hydrocarbons (THC) presented as methane equivalents.
[2] Normal operation does not include emissions from the Flares or shipping

3.2 Non-routine Operations

The principle function of the process system flares is to dispose of excess gases safely by controlled combustion in the event of an upset or plant maintenance. Gas flaring will be staged, and it is expected that a process blowdown will occur for a duration of approximately fifteen minutes to half normal pressure, with the flow rate and energy release diminishing with time.

In the EIS, the worst case conditions during non-routine operations were assumed to be the simultaneous flaring of a wet and dry gas ground flares (emergency upset scenario). The Australia Pacific LNG plant design indicates that a two dry gas ground flare (one at 52% capacity and the second at 48% capacity) is more likely to be a worst case scenario during an upset.

The source characteristics and assumptions applied to the modelling of the two Dry Gas Ground Flare System during an upset and blowdown are presented in Table 17.

Table 17 Energy release and plume buoyancy characteristics of the 2 x Dry Gas Ground Flare system

Parameter	Units	Dry gas flare		Dry gas flares combined
		52 %	48%	
Peak Energy out[1]	MMBTU/hr	31,987	29,526	61,513
Peak Energy out[2]	GJ/hr	33,748	31,152	64,900
Peak Energy out[2] (per 15 minute blow down)	GJ/15 min	8,437	7,788	16,225
Peak Energy out[2] (per 15 minute blow down)	GJ/s	9.37	8.65	18.03
Temperature[1]	^oC	1000	1000	1000
Area of ground flare[1]	m^2	3,254	3,254	6,507
Effective radius[2]	m	32.18	32.18	45.41
Effective rise velocity[2,3]	m/s	10.6	9.79	10.19

Table note:
[1] Information provided by Australia Pacific LNG
[2] Calculated by Katestone Environmental
[3] Parameter calculated for CALPUFF dispersion model inputs

Only limited information is available for flare emissions and consequently emission factors have been employed based on US EPA AP-42 documents (Chapter 13.5, Industrial Flares) in conjunction with information supplied by Australia Pacific LNG. The emission factors for industrial flares and the emission rates used in the assessment for each of the pollutants are presented in Table 18. The USEPA AP-42 emission factors for industrial flares also consider particulate emissions for a range of flare types. Australia Pacific LNG propose to use smokeless flares with a negligible particulate emission.

Table 18 Emission factors and emission rates for the 2 x Dry Gas Ground Flare system during upset conditions

Parameter	Units	NO_x	CO	THC
Emission factor	g/GJ	29.3[1]	159.1[1]	60.2[1]
2 x Dry gas flare emission rate	g/s	132[2]	717[2]	257[2]

Table note:
[1] From AP-42 Emission Factors
[2] Calculated from data supplied by Australia Pacific LNG as an hourly average assuming duration of flaring event is 15 minutes

Compared to the emissions reported in the EIS, the emissions from the Australia Pacific LNG flare during upset conditions for the SAQIA have changed as follows:

- Emissions of NO_2, decreased by 10%
- Emissions of CO, decreased by 10%
- Emissions of total hydrocarbons, decreased by 4%

As the emissions have decreased no further assessment of the air quality impacts associated with flaring events have been considered. The results presented in the EIS represent a worst case impact.

4. Air Quality Criteria

Table 19 presents a summary of the relevant ambient air quality goals for criteria pollutants adopted for this assessment.

Table 19 Relevant ambient air quality objectives for criteria air pollutants (EPP Air 2008)

Indicator	Environmental value	Averaging period	Air quality objective[1] (µg/m³)	Number of days of exceedance allowed per year
Nitrogen dioxide	Health and wellbeing	1-hour	250	1
		1-year	62	N/A
	Health and biodiversity of ecosystems	1-year	33	N/A
Sulphur dioxide	Health and wellbeing	1-hour	570	1
		24-hours	230	1
		1-year	57	N/A
	Protecting agriculture	1-year	32	N/A
	Health and biodiversity of ecosystems	1-year	22	N/A
Carbon monoxide	Health and wellbeing	8-hour	11,000	1
Particles as PM_{10}	Health and wellbeing	24-hour	50	5
Particles as $PM_{2.5}$	Health and wellbeing	24-hour	25	N/A
		1-year	8	N/A
Ozone	Health and wellbeing	1-hour	210	1
		4-hour	160	1

Table note:
[1] Air quality objective at $0^{o}C$
N/A: Not applicable

In addition to the air pollutants detailed above, the combustion of coal seam gas in the gas turbines, gas-fired heaters and flares is also likely to produce small quantities of hydrocarbons. Where an air quality objective for a particular pollutant is not published in the EPP Air, an appropriate objective from another jurisdiction has been adopted. These include:

- NSW Department of Environment and Climate Change (NSW DECC) *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2005)*
- EPA Victoria (Vic SEPP) *State Environment Protection Policy (Air Quality Management)*
- World Health Organisation (WHO) Guidelines for Air Quality (Chapter 3) 2000a
- National Exposure Standards for Atmospheric Contaminants in the Occupational Environment (NOHSC:1003(1995))
- Texas Commission on Environmental Quality (TCEQ) Effects Screening Levels 2008

5. Atmospheric Dispersion Modelling Methodology

Details of the atmospheric dispersion modelling methodology (including model configuration, development of site meteorology and analysis of site meteorology and cumulative impact methodology) used in the SAQIA are provided in Section 7 of Katestone Environmental's *"Australia Pacific LNG facility, Gladstone, Queensland – Air quality impact assessment"* (2010).

In summary:

- TAPM(v3.0.7)/Calmet (v6.3) models were used for meteorological modelling
- Calpuff (v6.113) model was used for plume dispersion modelling
- For the assessment of impacts to air quality associated with NO_X emissions, a two-level approach was adopted to predict the cumulative effect of emissions from the LNG facility and existing, approved and other potential industrial developments (four LNG plants) in the Gladstone region. This assessment utilised the Gladstone Airshed Modelling System Version 3 (GAMSv3)
- Background concentrations of CO and PM_{10} were based on DERM monitoring data in the region.
- The prediction of ground-level concentrations of NO_2 has been conducted by modelling the total emission rate in grams per second for NO_X from each source, with the results scaled by an empirical nitric oxide/nitrogen dioxide conversion ratio. For this assessment a conservative ratio of 30% conversion of the NO_X to NO_2 has been applied.

For this SAQIA an assessment of SO_2 for normal operations, including analysis of cumulative ground-level concentrations (incremental plus background) at sensitive receptor locations with the EPP(Air) quality objectives has been conducted. The atmospheric dispersion modelling includes background sources of SO_2 based on GAMSv3 modelling for existing and approved sources in the Gladstone region.

6. Air Quality Impact Assessment Scenarios

The Australia Pacific LNG plant design has been assessed with plant operating at 100% load, 365 days per year.

For normal operations the Australia Pacific LNG plant design comprises the following air emission sources:

- 4 LNG trains (worst case scenario)
  - 6 gas compressor units per LNG train (4 units per train to have waste heat recovery (WHR))
  - 1 hot oil heater per LNG train
  - 1 incinerator per LNG train
- 14 power generation turbines

For NO_2 contour plots have been presented for the plant in isolation for 1- hour and annual averages. Contours are also presented with the inclusion of GAMSv3 background and with GAMSv3 plus other LNG facilities proposed in the region. These results are also presented in tabular form at the sensitive receptors.

The assessment of sulphur dioxide has been done for the plant in isolation for 1- hour, 24-hour and annual averages and with the inclusion of GAMSv3 background. Results have been tabulated to present the predicted concentrations at sensitive receptors.

7. Results of Air Quality Impact Assessment

This section presents the results of the air quality impact assessment for NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO, ozone, odour and all identified hydrocarbons for the normal operating conditions.

7.1 Nitrogen Dioxide

The assessment of the maximum 1-hour average ground-level concentrations of NO_2 has been made for the 99.9th percentile value.

Table 20 compares the predicted maximum 1-hour and annual average ground-level concentrations for the Australia Pacific LNG plant design with the EIS results. Ground-level concentrations presented are for the facility in isolation.

The results show that the change in the maximum 1-hour ground-level concentrations of NO_2 due to the Australia Pacific LNG plant design is an increase of 0.9 $\mu g/m^3$, at sensitive receptor 1 and a decrease of 0.9 $\mu g/m^3$ at sensitive receptor 6.

Table 20 Comparison of predicted ground-level concentrations of NO_2 due to the facility in isolation for the Australia Pacific LNG plant design (SAQIA) with the EIS

Location	1-hour average ($\mu g/m^3$)			Annual average ($\mu g/m^3$)		
	EIS	SAQIA	Diff	EIS	SAQIA	Diff
R1	6.9	7.8	0.9	0.16	0.17	0.01
R2	6.0	5.7	-0.3	0.09	0.09	0
R3	4.8	5.4	0.6	0.07	0.07	0
R4	5.0	5.0	0.0	0.06	0.06	0
R5	6.9	6.9	0.0	0.07	0.07	0
R6	6.9	6.0	-0.9	0.06	0.07	0.01
R7	7.6	7.8	0.3	0.07	0.07	0
R8	3.3	3.5	0.1	0.04	0.04	0
R9	3.0	2.9	-0.1	0.03	0.03	0
R10	4.7	4.9	0.3	0.05	0.05	0
R11	4.8	4.9	0.1	0.05	0.05	0
R12	3.7	4.1	0.4	0.02	0.03	0
R13	3.5	3.8	0.4	0.02	0.02	0
R14	2.8	2.9	0.1	0.02	0.02	0
R15	2.8	2.9	0.2	0.02	0.02	0
R16	2.6	2.6	-0.1	0.02	0.02	0
R17	2.8	3.0	0.1	0.01	0.01	0
R18	2.7	2.7	0.1	0.01	0.01	0
R19	2.3	2.4	0.1	0.01	0.01	0
R20	9.9	10.3	0.4	0.11	0.11	0
R21	12.2	11.4	-0.7	0.11	0.11	0
Air quality objective	250		-	62[1] /33[2]		-

Table 21 presents the predicted maximum 1-hour and annual average ground-level concentrations at sensitive receptors in isolation, including existing and approved industries (GAMSv3), and the other proposed LNG facilities in the Gladstone region. The table indicates that the predicted maximum concentrations of NO_2 are low and well below the air quality objectives. The concentrations within the region are dominated by existing sources with only a minor contribution due to the addition of the Australia Pacific LNG facility (no change within significant figures presented in the table).

Table 21 Predicted maximum 1-hour and annual average ground-level concentrations of nitrogen dioxide for the LNG facility in isolation, existing and approved industries (GAMSv3), and LNG facility with existing and approved industries (GAMSv3) and other proposed LNG plants (in µg/m³)

Location	Australia Pacific LNG facility in isolation		Australia Pacific LNG facility with existing and approved industries (GAMSv3)		Australia Pacific LNG facility with existing and approved industries (GAMSv3) and proposed LNG plants	
	1-hour average	Annual average	1-hour average	Annual average	1-hour average	Annual average
R1	7.8	0.17	41	1.8	41	2.2
R2	5.7	0.09	42	2.5	42	2.7
R3	5.4	0.07	42	3.0	42	3.2
R4	5.0	0.06	50	3.0	50	3.3
R5	6.9	0.07	58	3.8	58	4.1
R6	6.0	0.07	75	5.1	75	5.3
R7	7.8	0.07	69	4.0	69	4.3
R8	3.5	0.04	73	5.0	73	5.1
R9	2.9	0.03	50	2.1	51	2.1
R10	4.9	0.05	40	0.9	40	1.1
R11	4.9	0.05	45	0.9	45	0.9
R12	4.1	0.03	29	0.5	30	0.5
R13	3.8	0.02	30	0.5	30	0.6
R14	2.9	0.02	23	0.4	23	0.5
R15	2.9	0.02	16	0.5	17	0.5
R16	2.6	0.02	25	0.4	27	0.4
R17	3.0	0.01	19	0.3	21	0.4
R18	2.7	0.01	19	0.3	20	0.4
R19	2.4	0.01	18	0.3	21	0.3
R20	10.3	0.11	50	1.1	55	1.4
R21	11.4	0.11	43	1.0	48	1.5
Air quality objective	250	62[1] /33[2]	250	62[1] /33[2]	250	62[1] /33[2]

Table notes:
[1] Objective for health and wellbeing
[2] Objective for health and biodiversity of ecosystems

Figure 2 and Figure 5 present the predicted maximum 1-hour and annual average ground-level concentrations of NO_2, respectively, for the LNG facility during normal operations operating in isolation.

Figure 3 and Figure 6 present the predicted maximum 1-hour and annual average ground-level concentrations of NO_2, respectively, for the LNG facility during normal operations operating including existing and approved industries (GAMSv3).

Figure 4 and Figure 7 present the predicted maximum 1-hour and annual average ground-level concentrations of NO_2, respectively, for the LNG facility during normal operations and including existing and approved industries (GAMSv3) and the other proposed LNG facilities in the Gladstone region.

The plots show that the maximum short-term concentrations due to the plant are predicted to occur on site and on elevated terrain to the north and at Mount Larcom. The highest annual average concentrations are predicted to occur to the northwest of the site due to the dominance of winds from the southeast.

7.2 Sulfur dioxide

The assessment of the maximum 1-hour average ground-level concentrations of SO_2 has been made for the 99.9th percentile value.

Table 22 presents the predicted maximum 1-hour, 24-hour and annual average ground-level concentrations at sensitive receptors in isolation and including existing and approved industries (GAMSv3).

The table indicates that the predicted maximum short term and long term concentrations of SO_2 are low and well below the air quality objectives.

Table 22 Predicted maximum 1-hour, 24-hour and annual average ground-level concentrations of sulfur dioxide for the LNG facility in isolation and LNG facility with existing and approved industries (GAMSv3) (in µg/m³)

Location	Australia Pacific LNG facility in isolation			Australia Pacific LNG facility with existing and approved industries (GAMSv3)		
	1-hour average	24-hour average	Annual average	1-hour average	24-hour average	Annual average
R1	37	9	0.5	218	56	9
R2	26	6	0.2	178	61	13
R3	29	6	0.2	183	75	14
R4	30	5	0.2	208	54	12
R5	24	6	0.2	197	63	14
R6	38	11	0.2	270	113	18
R7	19	4	0.1	209	55	13
R8	18	4	0.1	228	150	20
R9	19	3	0.1	132	40	5
R10	24	4	0.2	109	21	3
R11	25	4	0.1	117	35	3
R12	13	3	0.1	74	20	2
R13	12	2	0.1	84	25	2
R14	9	1	0.0	71	20	2
R15	10	2	0.1	63	20	2
R16	11	3	0.04	75	21	1
R17	4	1	0.02	58	14	1
R18	4	1	0.02	58	14	1
R19	4	1	0.02	59	15	1
R20	36	8	0.3	137	40	4
R21	70	21	0.7	127	41	4
Air quality objective	570	230	57	570	230	57

Table notes:
[1] Objective for health and wellbeing
[2] Objective for health and biodiversity of ecosystems

Figure 8 to Figure 10 present the predicted maximum 1-hour, 24-hour and annual average ground level concentrations of sulfur dioxide for the LNG facility in isolation. Figure 11 to Figure 13 present the predicted maximum 1-hour, 24-hour and annual average ground level concentrations of sulfur dioxide for the LNG facility and with existing and approved industries (GAMSv3).

7.3 Other pollutants

The total annual emissions of NO_2, CO, PM_{10} and $PM_{2.5}$ and total hydrocarbons has increased less than 5% from the EIS to the SAQIA. The predicted ground-level concentrations of NO_2 presented in Section 7.1 illustrated that the changes in the design of the facility results in minimal change in ground-level concentrations. As NO_2 is the most critical pollutant from the facility, it can be inferred that there will be minimal change in the predicted ground-level concentrations of CO, PM_{10}/$PM_{2.5}$ and total hydrocarbons as presented in the EIS and the conclusions remain the same:

- All air quality objectives are met for normal operation of the LNG facility (inclusive of background levels) at sensitive receptors for CO, PM_{10}, $PM_{2.5}$, odour, ozone and hydrocarbons.

8. Conclusions

A SAQIA has been conducted for the proposed LNG facility to be constructed and operated on the western shore of Curtis Island in Port Curtis near Gladstone, Queensland. The SAQIA considers the more detailed design information that has been developed since the completion of the EIS.

Key changes in the Australia Pacific LNG design of the plant compared to the EIS design are as follows:

- Revised site layout
- Change in source characteristics of gas turbine compressor drivers, power generation turbines and hot oil heaters
- Change in emission concentrations of NO_x, CO, SO_2 and PM_{10}/$PM_{2.5}$ for the gas turbine compressor drivers, power generation turbines and hot oil heaters
- Addition of the Acid Gas Incinerators
- Change in flaring characteristics during upset conditions

Compared to the total annual emissions reported in the EIS, the total annual emissions from the Australia Pacific LNG facility for the SAQIA have changed as follows for normal operations:

- Emissions of NO_2, increased by 4%
- Emissions of CO, increased by 6%
- Emissions of PM_{10}/$PM_{2.5}$, increased by 2%
- Emissions of total hydrocarbons, increased by 4%
- Emissions of SO_2 are now included

For non-routine operations flaring will occur via 2 x Dry gas flares with a total energy of 64,900 GJ/hour. This results in a 10% decrease in emissions compared with the EIS.

For normal operations the maximum difference between the EIS and the SAQIA for the maximum 1-hour ground-level concentrations of NO_2 due to the project in isolation is 0.9 $\mu g/m^3$ at any sensitive receptor.

A cumulative air quality assessment was undertaken that included all existing industrial sources in Gladstone and proposed future developments (including proposed LNG plants on Curtis Island and at Fishermans Landing) and has shown the following:

- All air quality objectives are met for normal and non-routine operation of the LNG facility (inclusive of background levels) at sensitive receptors for NO_2, CO, PM_{10}, $PM_{2.5}$, odour, ozone, SO_2 and hydrocarbons.

For all pollutants the contribution to the regional air quality is dominated by existing sources, which includes industrial, anthropogenic and natural sources.

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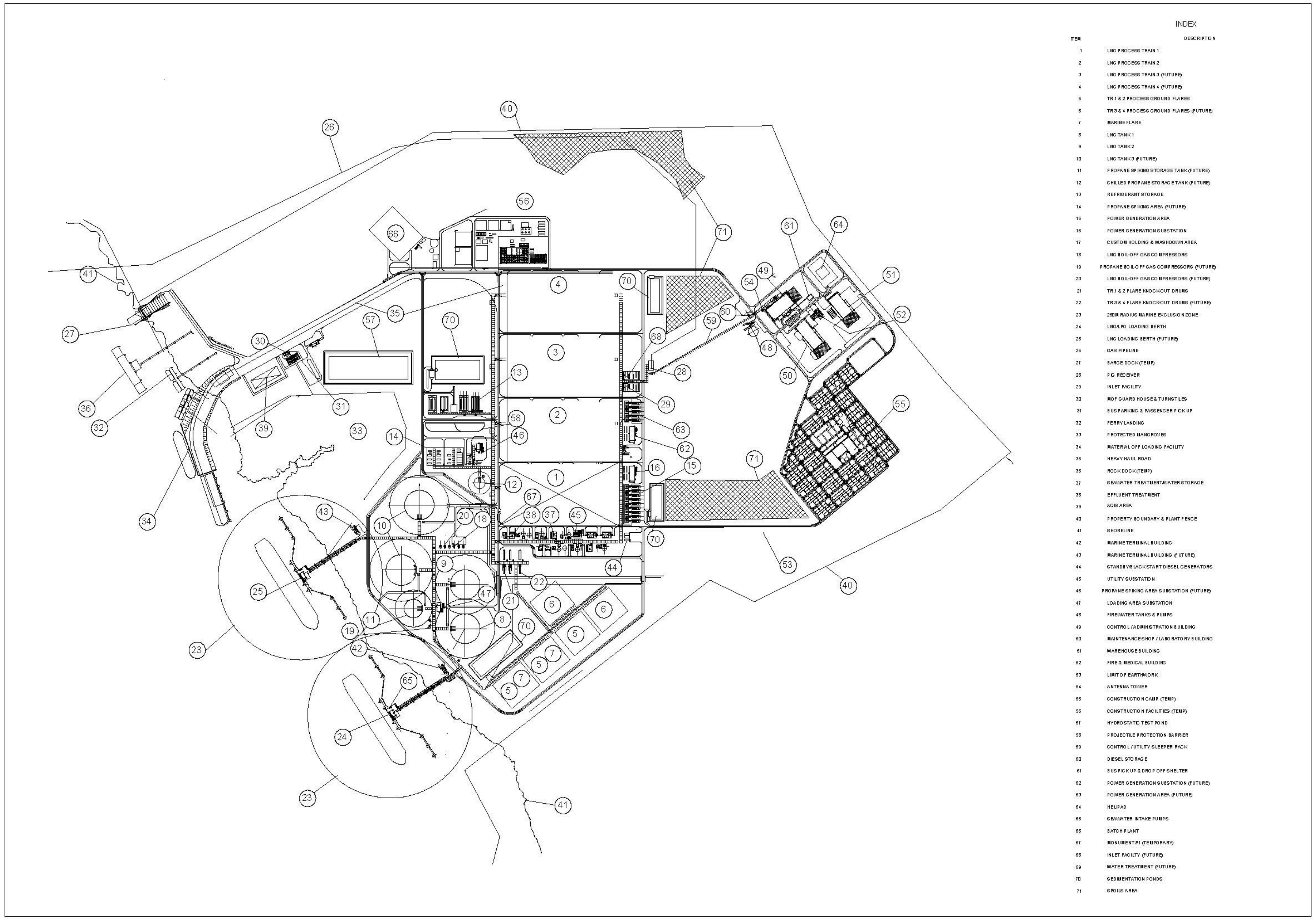

Figure 1 The layout of the proposed Australia Pacific LNG Project on Curtis Island

Location: Curtis Island, Gladstone region, QLD	**Type:** Australia Pacific LNG Project plan	**Provided by:** Australia Pacific LNG

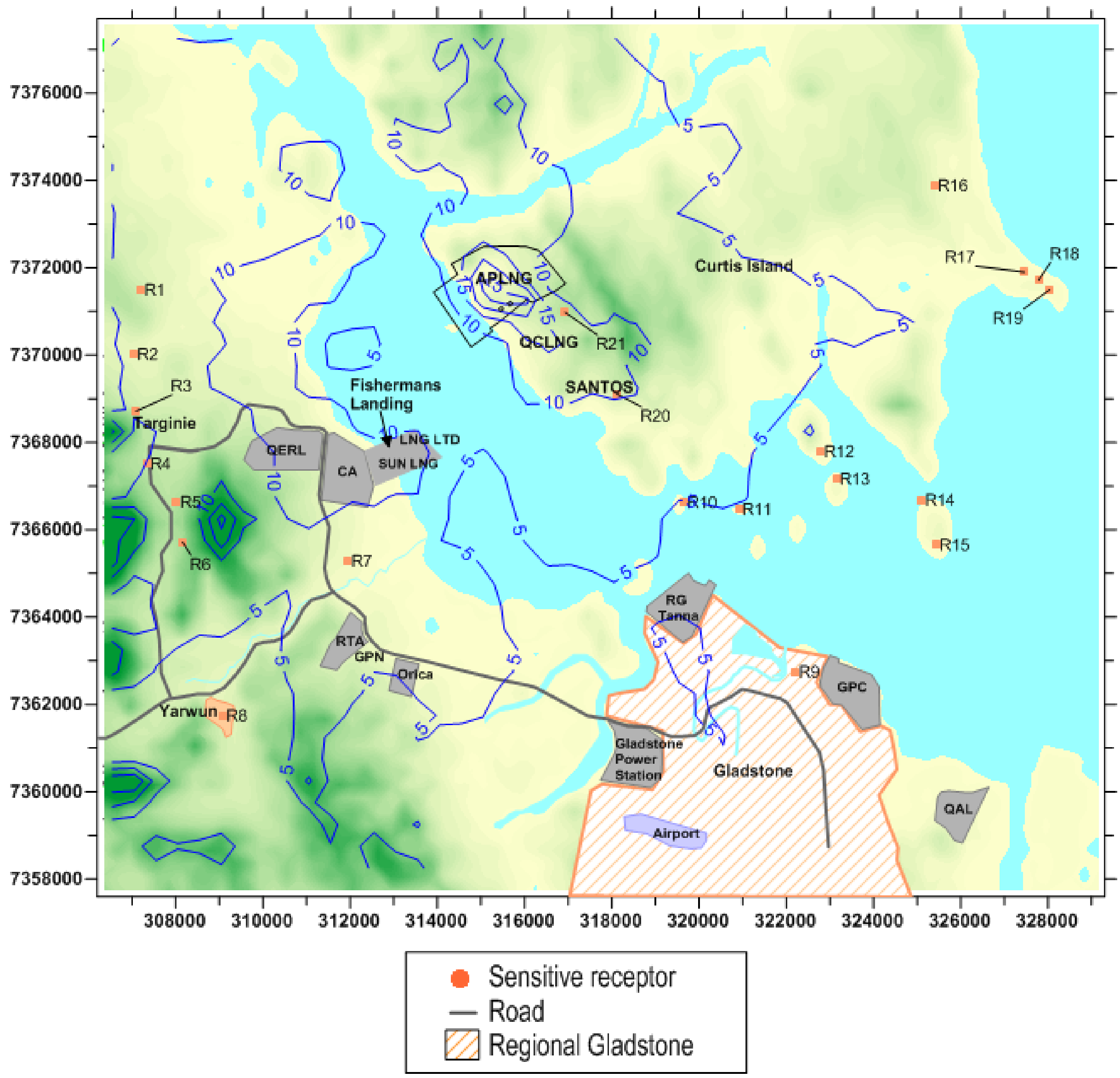

Figure 2 **Predicted maximum 1-hour average ground-level concentrations of nitrogen dioxide for the LNG facility during normal operations, in isolation**

Location: Australia Pacific LNG project area, Gladstone	**Averaging period:** 1-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: NO_2 maximum (99.9th percentile) 1-hour average contour plot	**Air quality objective:** Health and wellbeing: 250 µg/m³	**Prepared by:** N. Shaw	**Date:** July 2010

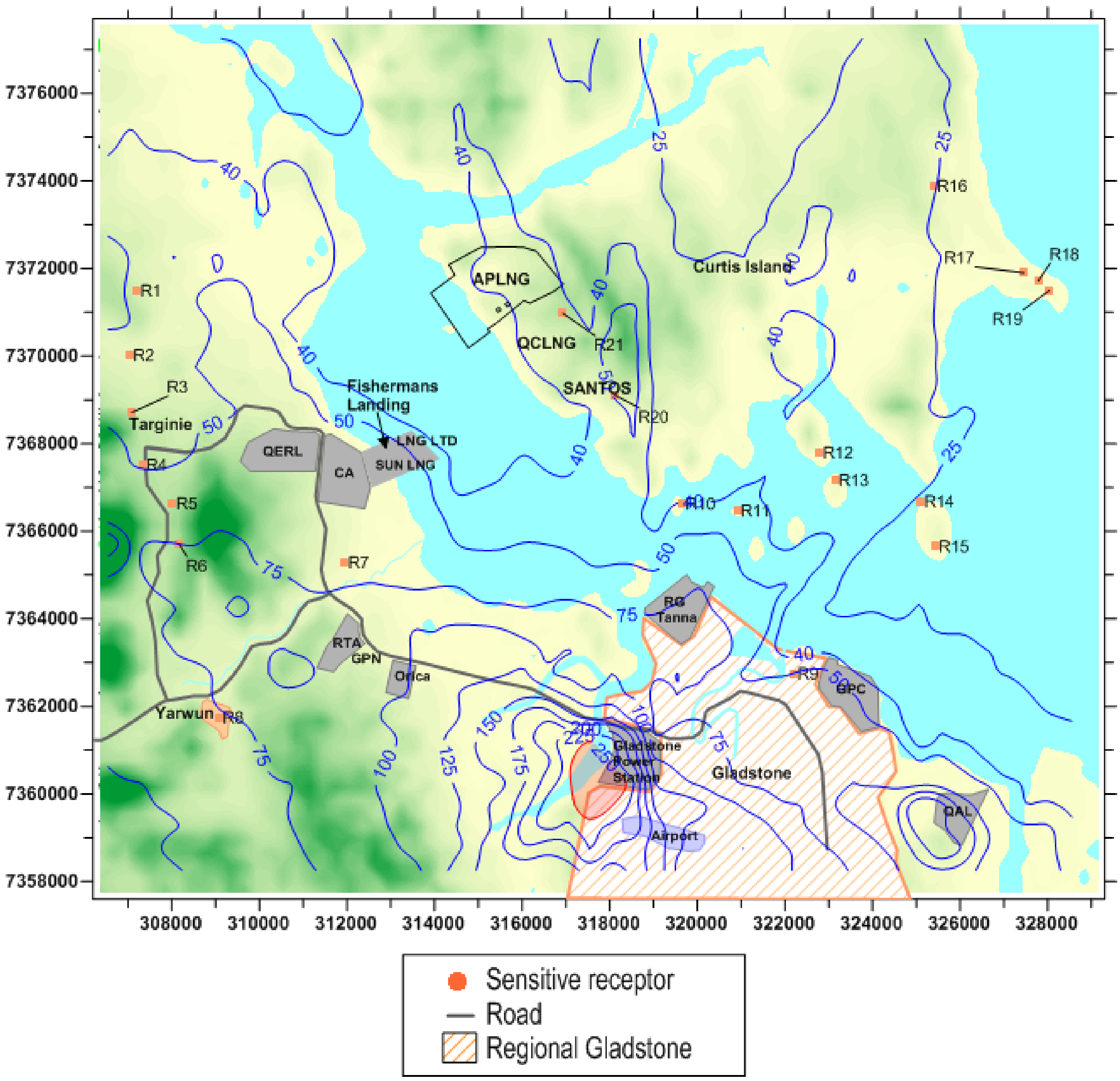

Figure 3	**Predicted maximum 1-hour average ground-level concentrations of nitrogen dioxide for the LNG facility during normal operations, with GAMSv3 background**		
Location: Australia Pacific LNG project area, Gladstone	**Averaging period:** 1-hour	**Data source:** CALPUFF and GAMSv3	**Units:** µg/m³
Type: NO_2 maximum (99.9th percentile) 1-hour average contour plot	**Air quality objective:** Health and wellbeing: 250 µg/m³	**Prepared by:** N. Shaw	**Date:** July 2010

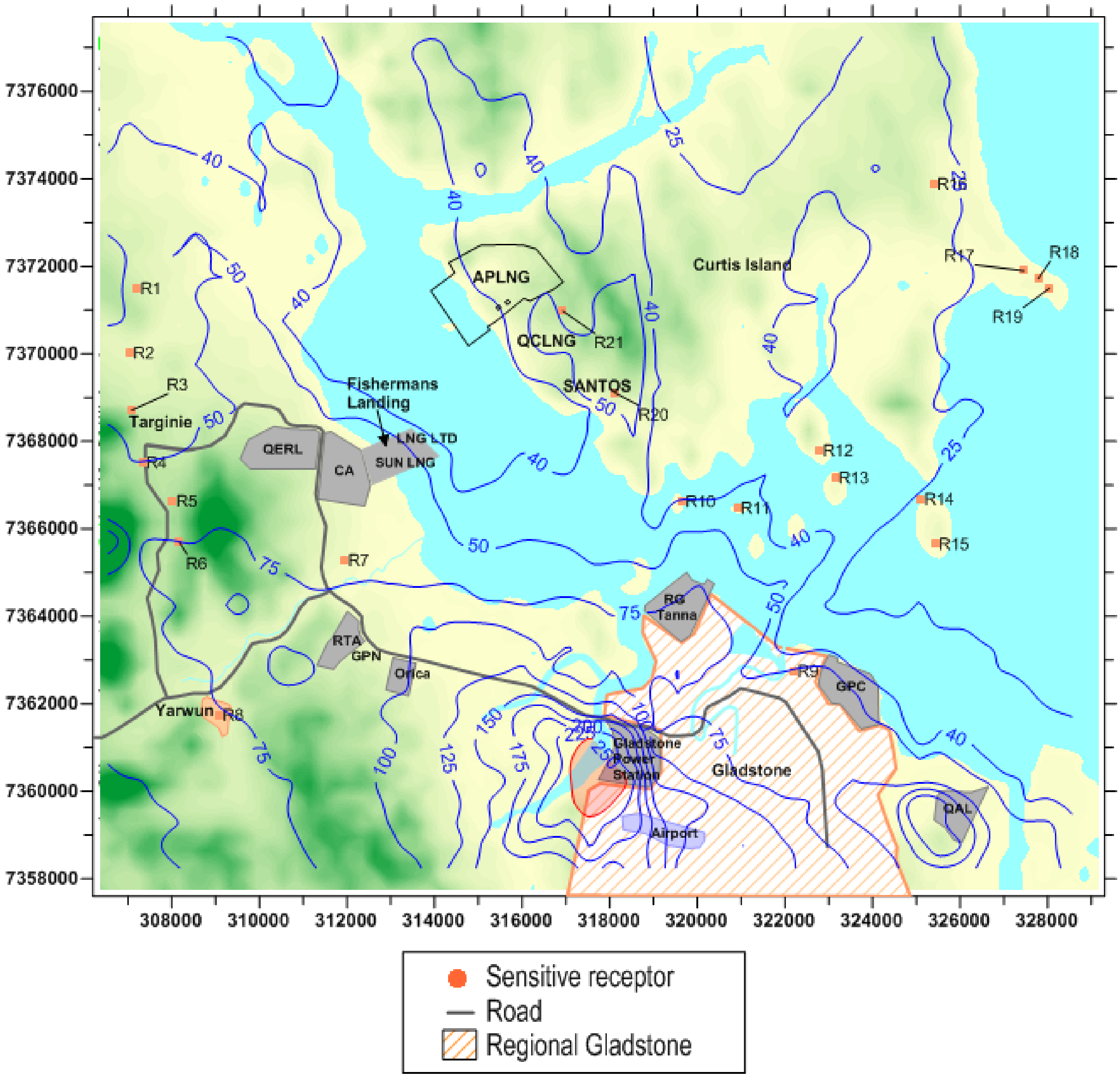

Figure 4 **Predicted maximum 1-hour average ground-level concentrations of nitrogen dioxide for the LNG facility during normal operations, with GAMSv3 background plus all other LNG plants**

Location: Australia Pacific LNG project area, Gladstone	**Averaging period:** 1-hour	**Data source:** CALPUFF and GAMSv3	**Units:** µg/m³
Type: NO_2 maximum (99.9th percentile) 1-hour average contour plot	**Air quality objectives:** Health and wellbeing: 250 µg/m³	**Prepared by:** N. Shaw	**Date:** July 2010

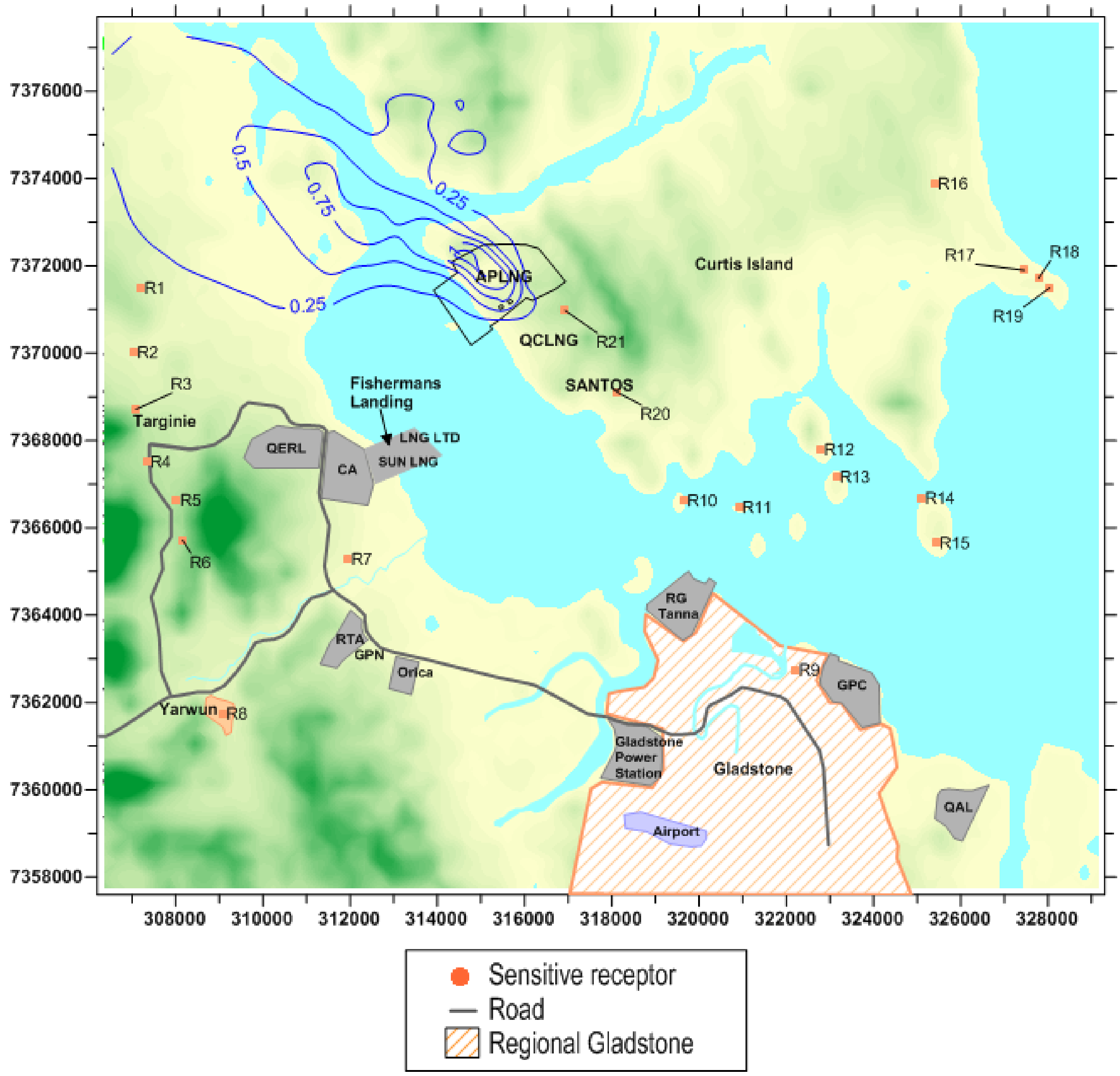

Figure 5 Predicted annual average ground-level concentrations of nitrogen dioxide for the LNG facility during normal operations, in isolation

Location: Australia Pacific LNG project area, Gladstone	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³ and metres
Type: NO_2 annual average contour plot	**Air quality objectives:** Health and wellbeing: 62 µg/m³ Health and Biodiversity of ecosystems: 33 µg/m³	**Prepared by:** N. Shaw	**Date:** July 2010

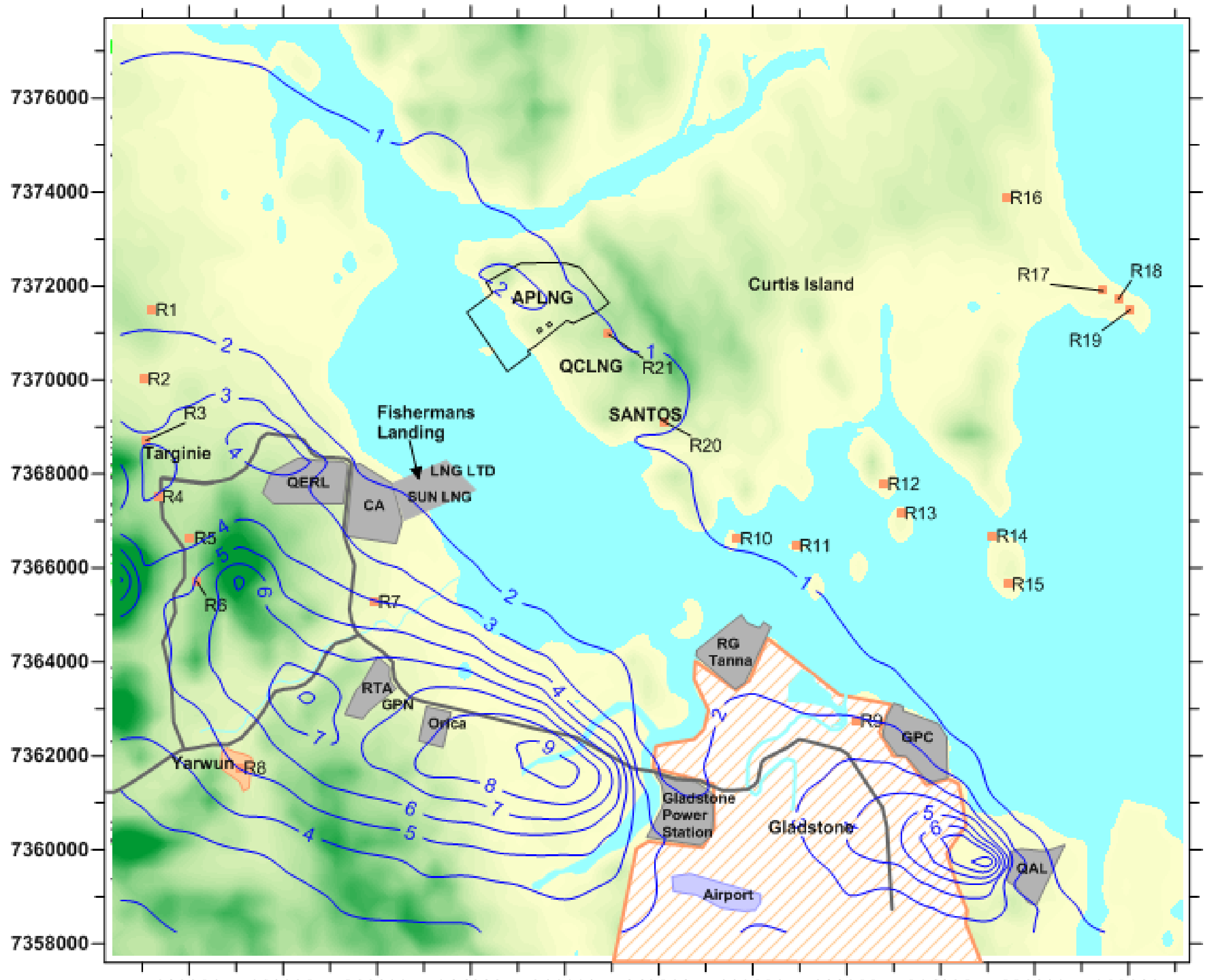

Figure 6 **Predicted annual average ground-level concentrations of nitrogen dioxide for the LNG facility during normal operations, with GAMSv3 background**

Location: Australia Pacific LNG project area, Gladstone	**Averaging period:** Annual	**Data source:** CALPUFF and GAMSv3	**Units:** µg/m³
Type: NO_2 annual average contour plot	**Air quality objectives:** Health and wellbeing: 62 µg/m³ Health and Biodiversity of ecosystems: 33 µg/m³	**Prepared by:** N. Shaw	**Date:** July 2010

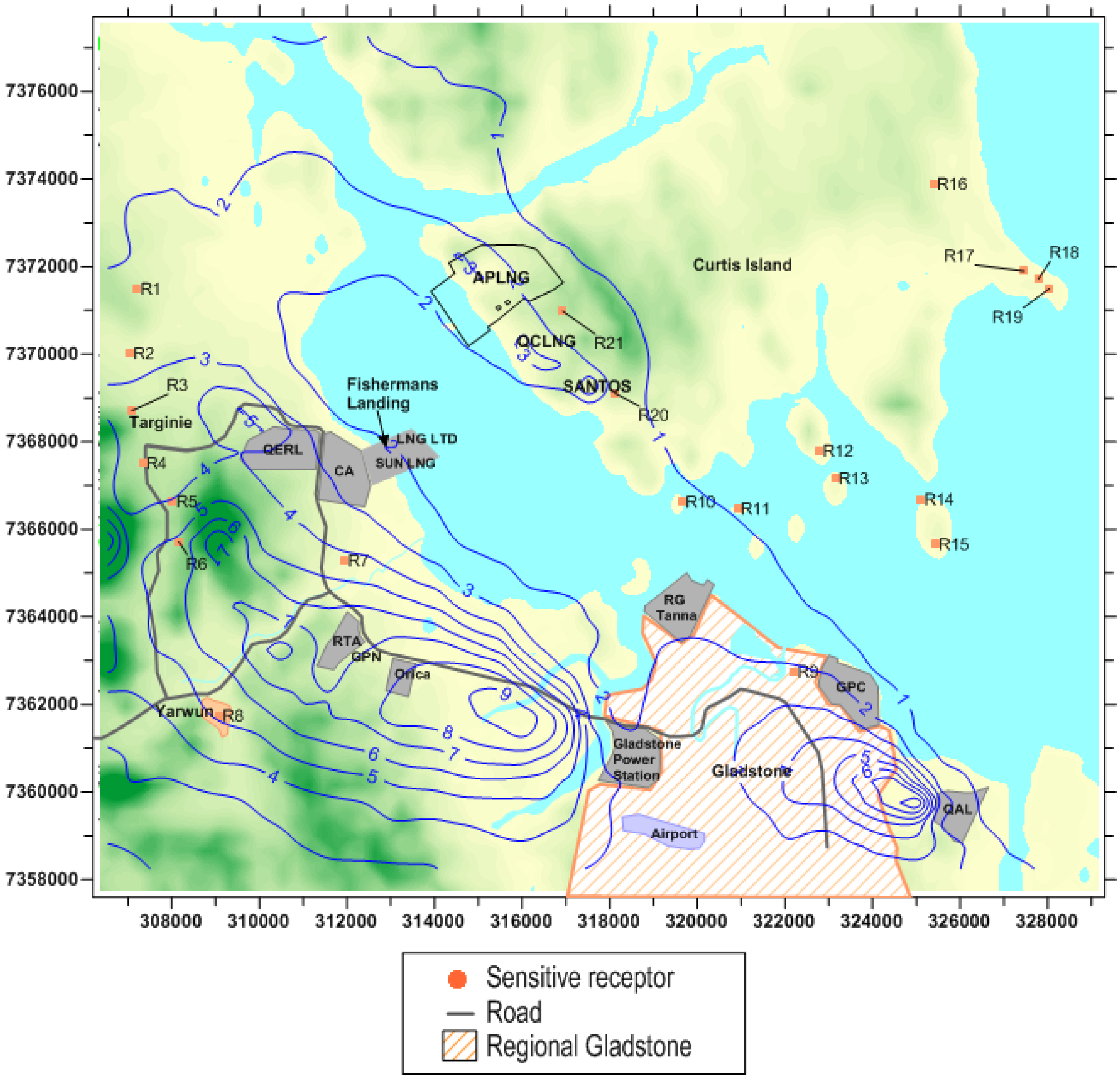

Figure 7	**Predicted annual average ground-level concentrations of nitrogen dioxide for the LNG facility during normal operations, with GAMSv3 background plus all other LNG plants**

Location:	**Averaging period:**	**Data source:**	**Units:**
Australia Pacific LNG project area, Gladstone	Annual	CALPUFF and GAMSv3	µg/m³
Type:	**Air quality objectives:**	**Prepared by:**	**Date:**
NO_2 annual average contour plot	Health and wellbeing: 62 µg/m³ Health and Biodiversity of ecosystems: 33 µg/m³	N. Shaw	July 2010

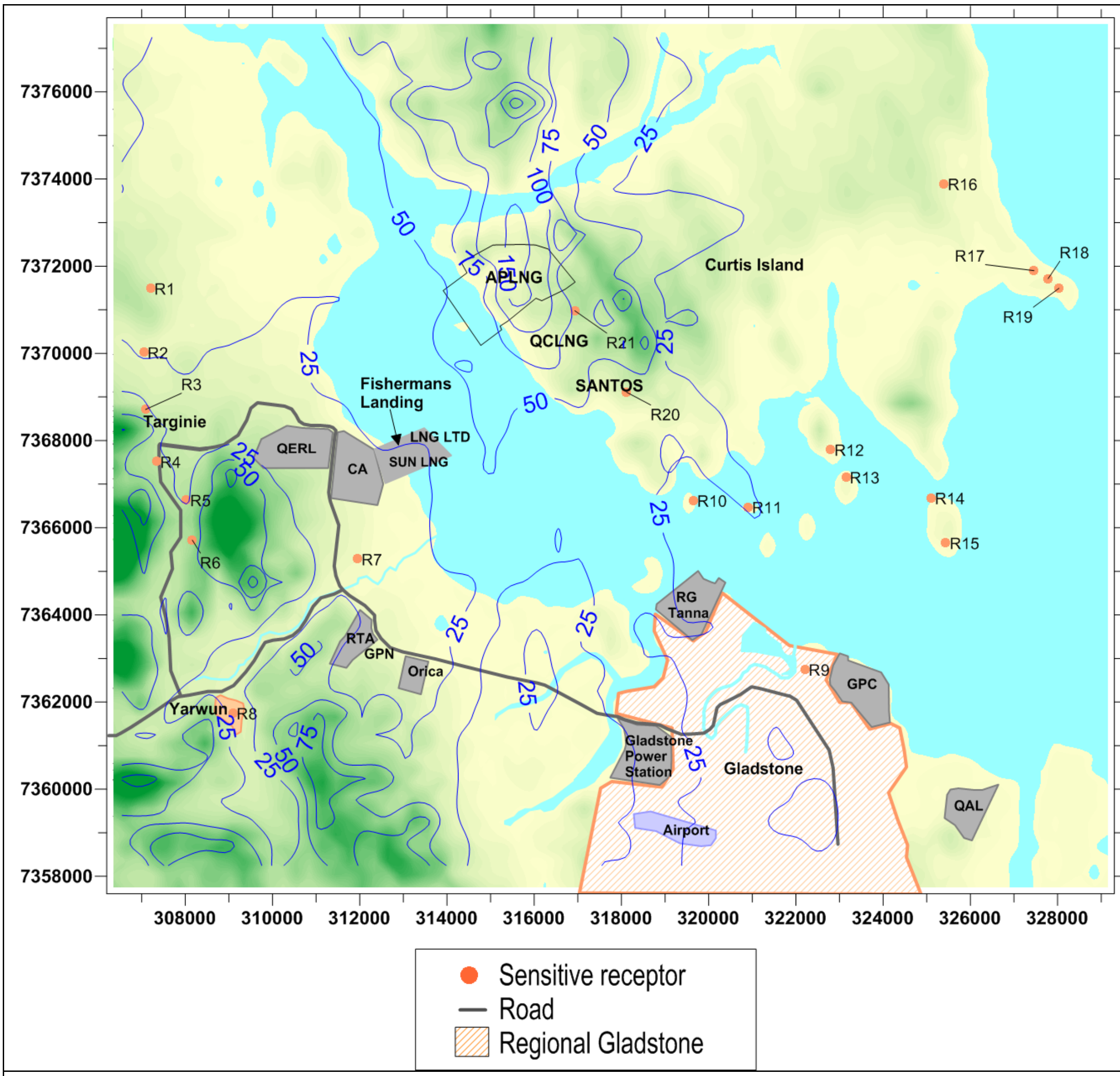

Figure 8 Predicted maximum 1-hour average ground-level concentrations of sulfur dioxide for the LNG facility during normal operations, in isolation

Location: Gladstone, Qld	**Averaging period:** 1-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: Maximum (99.9th percentile) 1-hour average contour plot	**Objective:** 570 µg/m³ (EPP(Air))	**Prepared by:** A. Vernon	**Date:** July 2010

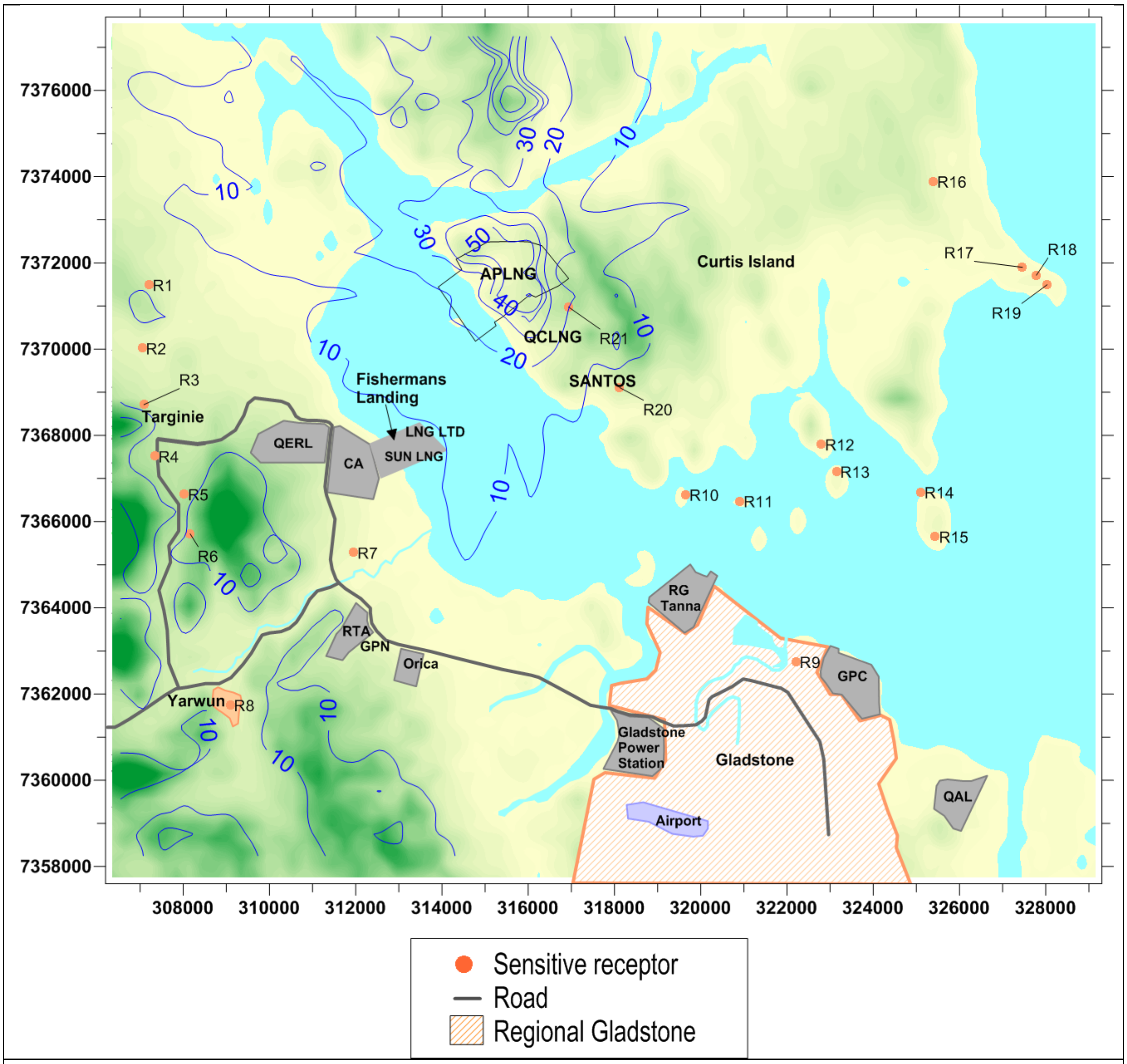

Figure 9 **Predicted maximum 24-hour average ground-level concentrations of sulfur dioxide for the LNG facility during normal operations, in isolation**

Location: Gladstone, Qld	**Averaging period:** 24-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: Maximum 24-hour average contour plot	**Objective:** 230 µg/m³ (EPP(Air))	**Prepared by:** A. Vernon	**Date:** July 2010

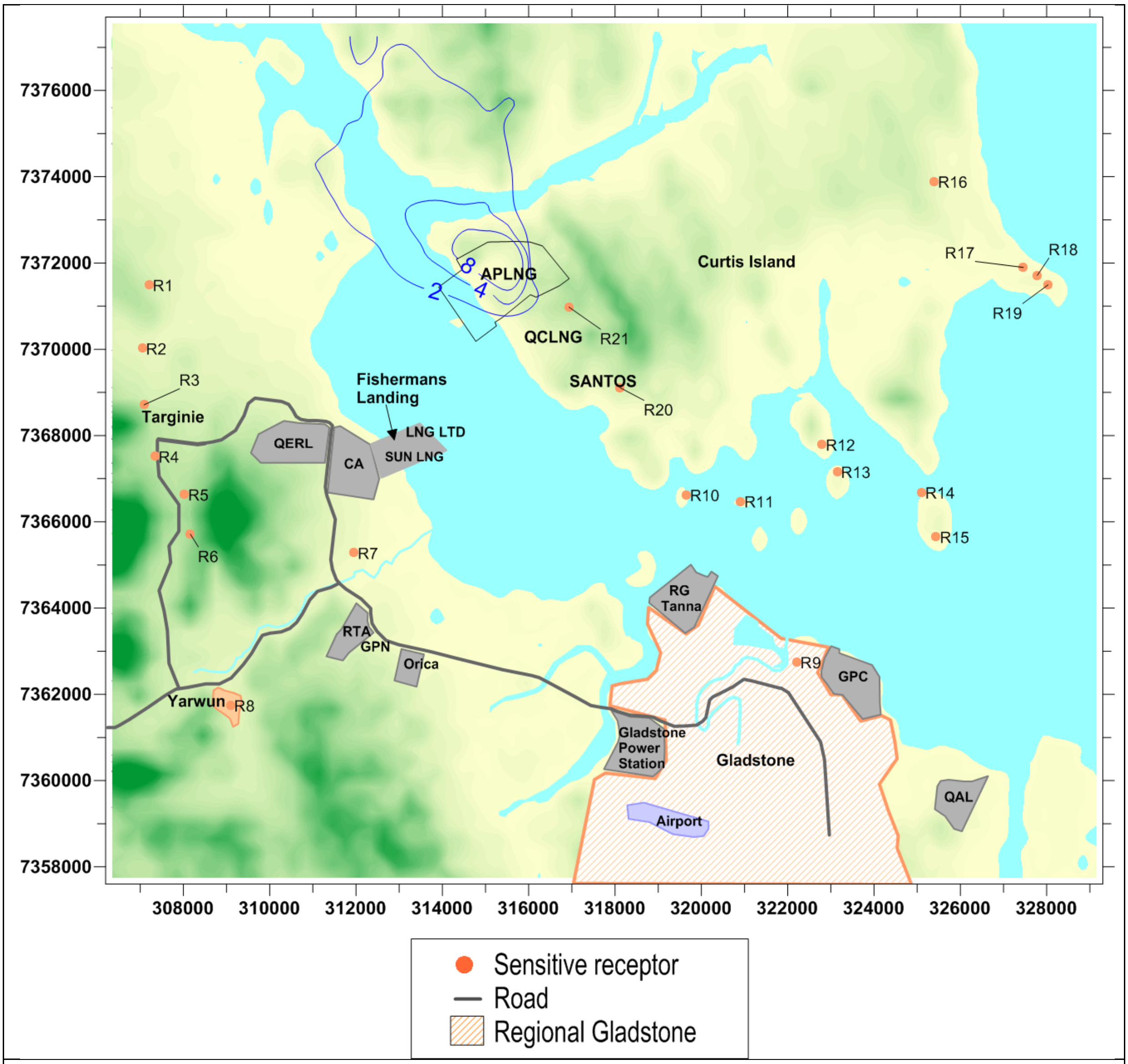

Figure 10 Predicted annual average ground-level concentrations of sulfur dioxide for the LNG facility during normal operations, in isolation

Location: Gladstone, Qld	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Annual average contour plot	**Objective:** 57 µg/m³ (EPP(Air))	**Prepared by:** A. Vernon	**Date:** July 2010

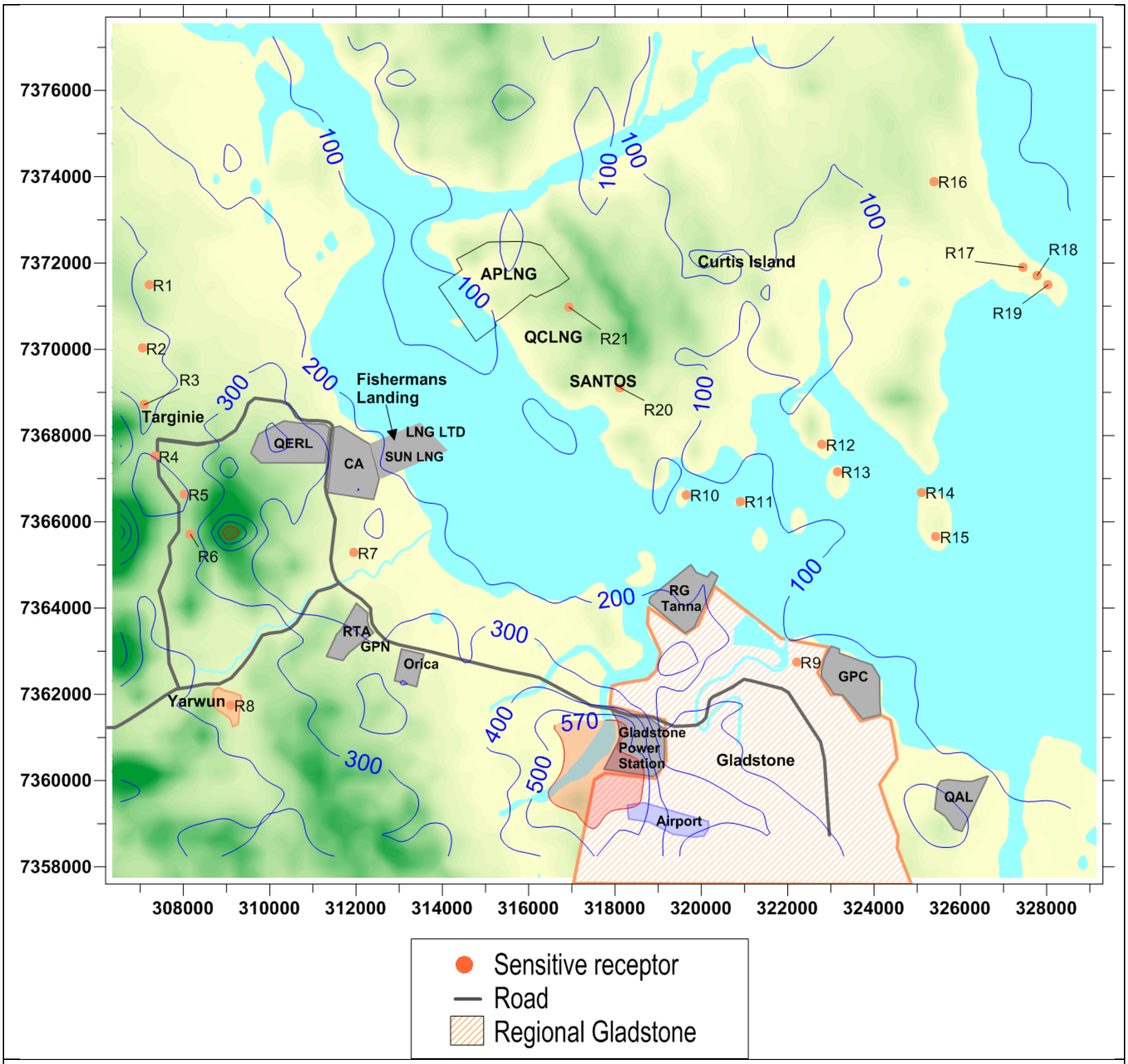

Figure 11	**Predicted maximum 1-hour average ground-level concentrations of sulfur dioxide for the LNG facility during normal operations, with GAMSv3 background**

Location:	**Averaging period:**	**Data source:**	**Units:**
Gladstone, Qld	1-hour	CALPUFF	µg/m³
Type: Maximum (99.9th percentile) 1-hour average contour plot	**Objective:** 570 µg/m³ (EPP(Air)) (red contour)	**Prepared by:** A. Vernon	**Date:** July 2010

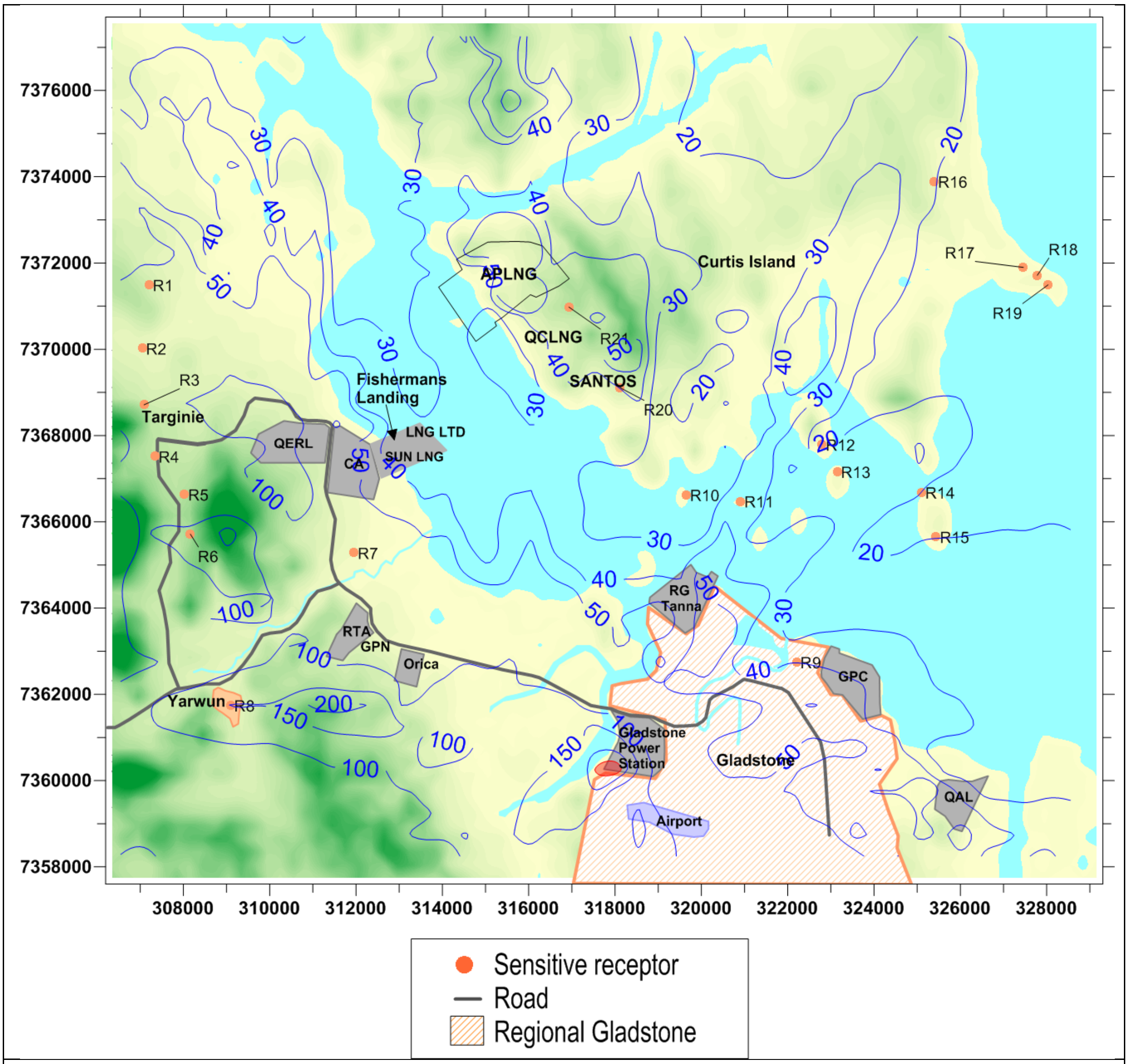

Figure 12 Predicted maximum 24-hour average ground-level concentrations of sulfur dioxide for the LNG facility during normal operations, with GAMSv3 background

Location: Gladstone, Qld	**Averaging period:** 24-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: Maximum 24-hour average contour plot	**Objective:** 230 µg/m³ (EPP(Air)) (red contour)	**Prepared by:** A. Vernon	**Date:** July 2010

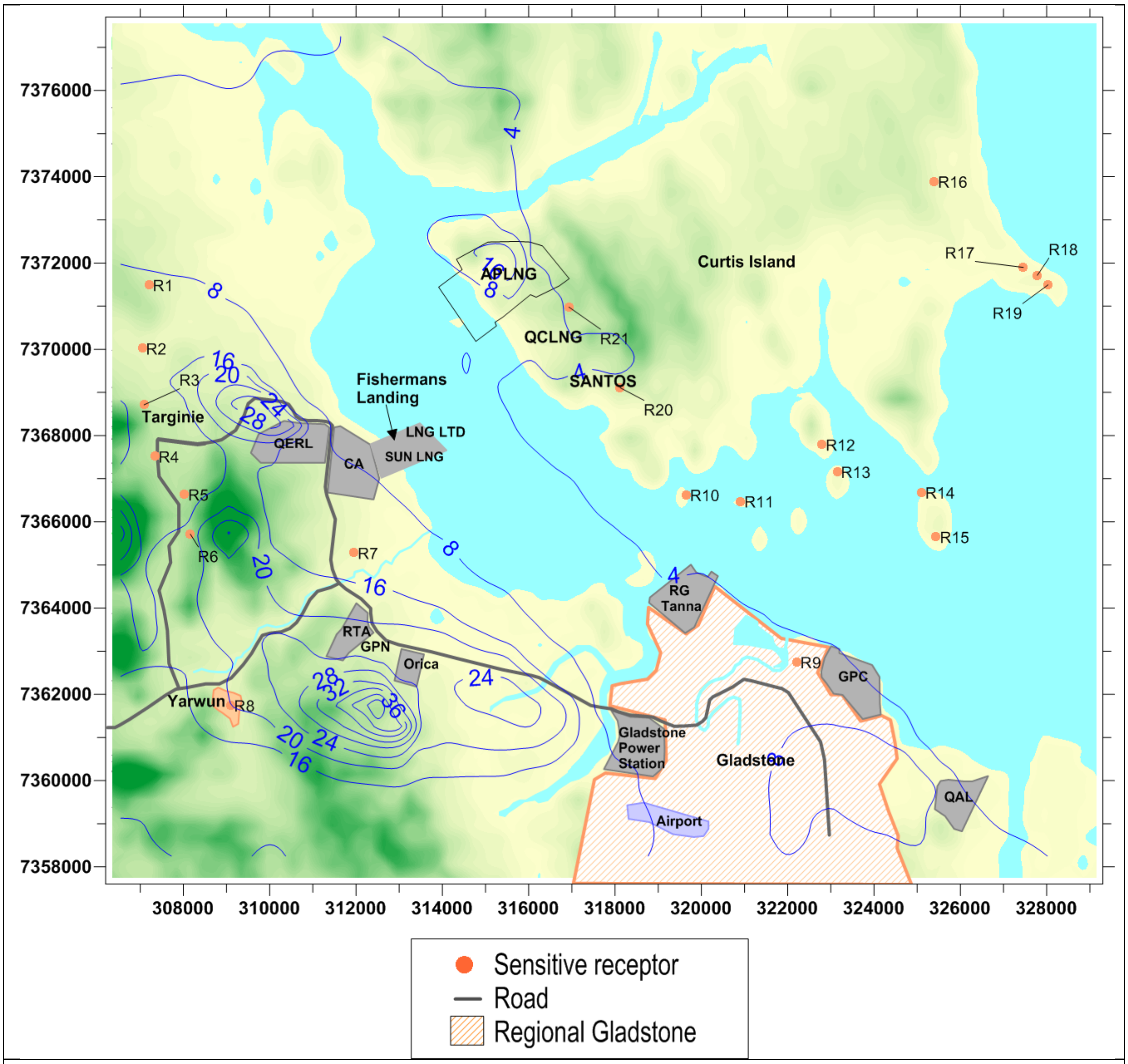

Figure 13 Predicted annual average ground-level concentrations of sulfur dioxide for the LNG facility during normal operations, with GAMSv3 background

Location: Gladstone, Qld	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Annual average contour plot	**Objective:** 57 µg/m³ (EPP(Air))	**Prepared by:** A. Vernon	**Date:** July 2010