# 12 *AIR QUALITY*

This chapter provides a response to specific submissions received relating to air quality for the Queensland Curtis LNG (QCLNG) Project's LNG Facility as described in the draft environmental impact statement (EIS), and addresses implications for the air quality impact assessment provided in the draft EIS of changes in the Project description.

## 12.1 *RESPONSE TO SUBMISSIONS ON DRAFT EIS*

Submissions relating to LNG Component air quality (and in particular draft EIS *Volume 5, Chapter 12: Air Quality*, and *Appendix 5.13 - LNG Facility - Air Quality Impact Assessment*) as described and assessed in the draft EIS are summarised in *Table 5.12.1* below. These were principally requests for further detail on the modelling methodology and the inputs to the modelling. Also included in *Table 5.12.1* are submissions and responses relating to the Assessment of Vertical Plumes for Aviation Safety, which was included in *Volume 5, Chapter 12* of the draft EIS.

### *Table 5.12.1 Response to Submissions on Draft EIS*

| Issue Raised | QCLNG Response | Relevant Submission(s) |
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| The air pollutants concentration levels of gas turbines and oil heaters are given in *Tables 6, 10, 17,* and *21* of *Appendix 5.13 – LNG Facility – Air Quality Impact Assessment*. The oxygen reference levels of these pollutants are not provided in the EIS. This information is necessary to compare the emissions against the best practice standards (e.g. NSW POEP Regulations 2005 in terms of mg/Nm3 (dry) at 3 per cent $O_2$).<br><br>It is recommended that the oxygen reference levels of air pollutants released from gas turbines and oil heaters as given in *Tables 6, 10, 17,* and *21* be specified. | The QCLNG Project design emission limits for air pollutants that are relevant to gas-turbines and gas-fired oil heaters are specified in *Table 5.12.2*. Relevant oxygen correction factors and other information are also contained in *Table 5.12.2*. Note that the oxygen reference levels provided in *Table 5.12.2* for oil heaters are the NSW Regulation limits and oxygen correction basis. Like the IFC Guidelines for gas turbines, the NSW Regulation includes an emission limit value and a basis that includes the correction to 3 per cent $O_2$. | 32 |
| Total hydrocarbons emissions (as methane equivalent) are provided in *Tables 6, 10, 17,* and *21* of *Appendix 5.13 – LNG Facility – Air Quality Impact Assessment*. The information on total VOCs expressed as total carbon, n-hexane or n-propane equivalent is not provided in the EIS. This information is necessary to compare the emissions against the best practice standards and will be specified in the licence conditions.<br><br>The total volatile organic compound (VOC) emissions from sources such as gas turbines and oil heaters should be specified and expressed them in terms of total carbon, n-hexane or n-propane equivalent. | As noted in *Appendix 5.13* of the draft EIS, hydrocarbon emissions associated with the gas turbines, regeneration gas heater, hot oil heaters and flares were derived from United States Environmental Protection Authority (USEPA) AP-42 data, referenced to determine the potential composition of hydrocarbon emissions associated with each emission source. This was due to the fact that chemical speciation of exhaust emissions from the gas turbines, gas-fired heaters and process flares has not been conducted for specific hydrocarbon composition.<br><br>Further as noted in *Appendix 5.13* of the draft EIS, the AP-42 emission factors have been determined for gas-fired combustion sources using natural gas fuel in the US, and therefore have a different fuel composition to the CSG fuel being used for the QCLNG Project. The composition of the natural gas fuel combusted in AP-42 emission tests will likely be a composition of methane, ethane, propane and butane, with trace amounts of sulfur, inerts (typically $N_2$, $CO_2$ and helium) and other hydrocarbons. Consequently, the composition of hydrocarbons in the gas turbine and gas-fired boiler (heaters) exhaust may differ from that outlined in the AP-42 documents due to the combustion of CSG, which is primarily $CH_4$ in its composition.<br><br>In addition, the AP-42 emissions factors (Stationary Gas Turbines, Chapter 3.1) have been determined by measurement of a range of gas turbine models and are provided for "uncontrolled" gas turbine units, while the LM2500+G4 DLE units being used for the QCLNG Project are lean pre-mix staged combustion turbines, also referred to as Dry Low $NO_X$ combustion. Additionally, the power ranges and inlet air temperature and conditions for the data provided in the AP-42 documents is different to the operating conditions for the QCLNG Project. This will have a significant influence on the performance of the turbines and the subsequent composition of the exhaust gases. Consequently, the emission rates for hydrocarbons do not represent the precise emission rates for hydrocarbons associated with the gas turbines at QCLNG. The emission rates calculated for the air | 32 |

| Issue Raised | QCLNG Response | Relevant Submission(s) |
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| | quality impact assessment are, at best, an approximation of the potential for hydrocarbon composition of the gas turbine exhaust gas based of a generic mix of gas turbine units with uncontrolled exhausts.<br><br>It should be noted that provision of information on total VOCs as total carbon, n-hexane or n-propane equivalent was not a requirement of the Terms of Reference for the Project. Notwithstanding, see response to this issue above (including reference to *Table 5.12.2* below). | |
| It is stated in *Appendix 5.13 – LNG Facility – Air Quality Impact Assessment*, *Section 3.2.3,* that the emissions from the acid gas ($CO_2$) removal unit will be vented directly to atmosphere, and comprises primarily $CO_2$ and small quantities of $CH_4$. The methane emissions are provided *Table 14* and in terms of both concentration and mass seem to be very high compared to any other sources at the site.<br><br>The concentration and mass emission rates of methane from the acid gas ($CO_2$) removal unit should be checked, and description provided of how this emission rate was estimated. | Mass emission rates of methane from the acid gas removal unit as provided in *Table 14* of *Appendix 5.13* are based on the LNG Facility design rates and reflect the anticipated feed gas supply rate. While the emission rate may seem relatively high compared to other site sources, it should be considered in the light of the total gas flow rate. Methane emission concentration was calculated on the basis of the design emission rate.<br><br>The apparently high methane emission rate from this source is due in part to the limited number of other methane sources on the site, although the emission rate from the nitrogen vent (32.76 g/s – refer *Table 25* of *Appendix 5.13*) will be higher than from $CO_2$ vent. Total hydrocarbons expressed as methane equivalents are also described for regeneration oil heaters, hot oil heaters, and flares, but the concentrations anticipated from these sources are negligible in comparison to the emission rates from the $CO_2$ and nitrogen vents.<br><br>It should be noted that methane emissions from sources on site other than the acid gas removal unit and nitrogen vent will result primarily from incomplete combustion, and combustion efficiency under normal operations will be high. For the acid gas removal unit, the methane emissions are a function of the efficiency of stripping $CO_2$ from the methane product. The vented $CO_2$ rates are based on the maximum design feed gas concentration of 1mol per cent. It is expected that the LNG feed gas will initially contain on 0.25 mol per cent. Thus the methane discharge rates will be only a quarter of those shown in Table 25 of *Appendix 5.13* of the draft EIS.<br><br>Overall the vented methane from the acid gas removal unit represents approximately 0.002 per cent of the feed gas rate. Alternative methods of disposal by incineration will require a greater flow of methane fuel, than is currently being vented at the acid gas removal unit. Thus the current arrangement represents the lowest practicable emission rate. | 32 |

| Issue Raised | QCLNG Response | Relevant Submission(s) |
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| It is stated in *Appendix 5.13, Section 3.2.5* of the EIS that three hot oil heaters will be provided per train, with one unit per train being kept in reserve in the event of the failure of either of the other two units. Consequently, only six hot oil heaters were modelled.<br><br>The EIS should clarify whether the proponent is seeking the licence for nine units of hot oil heaters as the release points, with the understanding that only six units will be used at a time and the remaining three units are the standby units only. | For three LNG trains there are eight heaters provided, with six hot oil heaters on line during normal operation, all using waste heat recovery on each of the methane refrigeration compressor turbines. The two additional fired heaters, common to Trains 1, 2 & 3, will be used at any one time during each LNG train start-up (assuming that one LNG train is being started up at any one point in time) when waste heat recovery is not available.<br><br>Notwithstanding the above proposed usage of the hot oil heaters, it should be noted that relative to the entire Project, the hot oil heaters produce very small amounts of oxides of nitrogen, carbon monoxide and VOCs. For example, if all nine hot oil heaters were operating on fuel gas at the same time, total non-flaring emissions of oxides of nitrogen, carbon monoxide and VOCs would increase by less than 3 per cent, 4 per cent and 0.2 per cent, respectively. Given the overall findings of the air quality assessment that *All air quality objectives are met for normal operation of the QCLNG Plant (inclusive of background levels) at sensitive receptors for NO2, CO, PM10, odour, ozone and hydrocarbons*, such minor increases in emissions and, hence, ground-level concentrations of air pollutants would not change the outcome of the assessment.<br><br>It should be noted that the configuration of hot oil heaters and waste heat recovery continues to be optimised through detailed design, with potential for variation in the number of heaters from what was described in the draft EIS. However, the assumed emission rates associated with the hot oil heater should reflect the emission rates provided in the draft EIS. | 32 |
| Oxides of nitrogen and sulfur dioxide emissions from the LNG carrier and tug boat are given in *Appendix 5.13, Section 3.3.3, Non-normal operations*. These emissions rates (in terms of concentration and mass) are very high compared to any other sources at the site.<br><br>The concentration and mass emission rates of oxides of nitrogen and sulfur dioxide from the LNG carrier and the tug boat should be checked, and description provided as to how the emission rates were estimated. | Emission data for LNG carriers is from the engine manufacturer's data. For tugs, the data is based on Savannah, GA's 90 ton bollard pull engine manufacturer's data. They are based on a 3 hour inward transit, 1 hour berthing, 16 hour cargo loading, 6 hour idle period, and 3 hour outward transit for each vessel port call. It is assumed the vessels will burn heavy fuel oil and gas while manoeuvring, but heavy fuel oil only during cargo loading, which is anticipated to represent a conservative (worst-case scenario).<br><br>It should further be noted that LNG carriers and tugs burning heavy fuel oil represent the major anticipated sources of $SO_2$ emissions for LNG Facility operations, with negligible other sources given that sulfur compounds have not been identified in the LNG Facility feed gas (CSG). | 32 |

| Issue Raised | QCLNG Response | Relevant Submission(s) |
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| The CALPUFF dispersion model's pre-processor program CALMET needs the cloud cover data as input to this model. *Appendix 5.13, Section 6.1.2, CALMET Meteorological Simulations*, states that the cloud cover data was estimated from the TAPM's (The Air Pollution Model) generated relative humidity. However, this data is not available from the prognostic meteorological model TAPM.<br><br>The EIS should clarify how the cloud cover data was estimated and re-run the model if necessary using an appropriate source of cloud cover data. | The coupled TAPM and CALMET modelling system calculates cloud cover from the three-dimensional information generated by the TAPM prognostic meteorological model. This approach is an appropriate basis to represent cloud cover and, hence, revision of the modelling is unnecessary.<br><br>The coupled TAPM and CALMET modelling approach that has been adopted in the GAMS modelling system and in the QCLNG Project Air Quality Assessment is a robust approach that has been accepted by the Department of Environment and Resources Management (DERM) for many projects in Queensland and in particular, in the Gladstone airshed. The approach that has been taken is an effective way of characterising cloud cover within the meteorological modelling system. While cloud cover information is recorded by the Bureau of Meteorology, it is unsuitable for assimilation into the TAPM and CALMET modelling system because its spatial coverage is inadequate and the observations are not of sufficient temporal resolution.<br><br>CALMET is an advanced non-steady-state diagnostic three-dimensional meteorological model with micro-meteorological modules for overwater and overland boundary layers. The model is the meteorological pre-processor for the CALPUFF dispersion model.<br><br>CALMET v6.3 was used to simulate meteorological conditions around Curtis Island. The modelling domain was set up to be nested within the 1 km TAPM domain. CALMET treats the TAPM prognostic model output as the initial guess field for the diagnostic model wind fields. CALMET then adjusts the initial guess field for the kinematic effects of terrain, slope flows, blocking effects and three-dimensional divergence minimisation. The coupled approach unites the mesoscale prognostic capabilities of TAPM with the refined terrain and land use capabilities of CALMET.<br><br>The use of the three-dimensional wind field provides a complete set of meteorological variables for every grid point and vertical level for each hour of the simulation period. This is a significant improvement in modelling approach to the method of data assimilation from discrete surface stations. No data assimilation was used in CALMET as no local data was available for the Curtis Island site. Regionally representative sites were, however, assimilated into TAPM.<br><br>The model was set up with 12 vertical levels with heights at 20 m, 60 m, 100 m, 180 m, 260 m, 360 m, 460 m, 600 m, 800 m, 1600 m, 2600 m and 4600 m at each grid point. The terrain and land use were further refined from those used in the TAPM model to account for the increased resolution. The terrain was generated from the Geosciences Australia nine-second arc DEM dataset at a resolution of 300 m. All default options and factors were selected except where noted below.<br><br>The TAPM model provides predictions of the meteorological variables in three dimensions that are used to calculate cloud cover by the CALMET model. These variables include temperature, relative humidity and vapour mixing ratio. | 32 |

| Issue Raised | QCLNG Response | Relevant Submission(s) |
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| The ambient air ozone concentration (as an indicator of photochemical smog) value is estimated from the peak contribution of QCLNG projected levels of $NO_2$ at a sensitive receptor as 24.4μg/$m^3$ (*Appendix 5.13, Section 7.1.5*). It is not clear from EIS how the ozone concentration value of 22.9μg/$m^3$ is estimated from the above $NO_2$ value.<br><br>A description should be provided as to how the incremental ozone concentration of 22.9μg/$m^3$ was estimated. | Photochemical smog is not directly released from the QCLNG Facility as a primary pollutant, but rather is generated through photochemical oxidation of $NO_2$ and nitrates in the atmosphere over time. The exhaust from the QCLNG fuel burning sources contains approximately 90-95 per cent of oxides of nitrogen as NO. Once this NO has been transformed into $NO_2$ and nitrates, ozone may be produced via a multi-stage process. The rate at which photochemical smog is generated is a function of:<br>• the in-plume concentration of oxides of nitrogen<br>• the concentration and reactivity of volatile organic compounds in the ambient air<br>• the rate of plume dispersion<br>• the prevailing atmospheric conditions, including temperature and solar radiation fluxes.<br><br>Within Queensland, there are relatively few studies of ozone generation within industrial plumes. Monitoring networks around Tarong, Callide and Gladstone power stations have tended to focus on those areas within 10-15 km of the main sources, areas that are unlikely to experience extra ozone generation. There have not been any readily identifiable episodes of ozone generation during those times when the industrial plumes have been present at the monitoring locations.<br><br>The first investigation of the chemical transformations in industrial plumes was undertaken in 1986 around Gladstone Power Station, a major emitter of nitrogen oxides (over 2000 g/s at full load, or more than 100 times the emission rate for the proposed QCLNG Project). An aerial survey measured $NO_X$ and ozone concentrations at distances out to 200 km for a set of late winter conditions. These studies have been very useful to determine the relatively slow rate of transformation of emitted nitric oxide into $NO_2$. However, there were no events when an ozone generation stage was encountered.<br><br>Due to the proportionally low emissions for $NO_X$ from the QCLNG Facility in comparison to the background emissions from the power station and other industrial sources in Gladstone, photochemical modelling has not been conducted for this assessment. In order to assess the potential of the QCLNG Project to cause air quality impacts in relation to ozone, an extremely conservative method has been applied. The assessment has assumed that 30 per cent of the available $NO_X$ is converted to $NO_2$ by the time the plume reaches the ground. The amount of ozone generated by the conversion of $NO_X$ to $NO_2$ has been assumed to be equivalent on a stoichiometric basis. That is, one mole of NO converted to $NO_2$ produces one mole of ozone.<br><br>The maximum ground-level concentration on the domain due to the QCLNG Project in isolation was predicted to be 24.4 μg/$m^3$. This equates to 0.53 μmoles/$m^3$ of $NO_2$ and is therefore assumed to produce 0.53 μmoles/$m^3$ of ozone. This is equivalent to an increase of 25.5 μg/$m^3$ of ozone at the | 32 |

| Issue Raised | QCLNG Response | Relevant Submission(s) |
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| | location of the maximum ground-level concentration of $NO_2$. The maximum concentration of ozone recorded at the Targinie monitoring station is 109.8 µg/m³. The addition of the maximum measured and predicted concentrations of ozone produces a maximum ozone concentration of 135.3 µg/m³, which is 64 per cent of the ambient air quality objective of 210 µg/m³ for a one-hour average. Therefore, the contribution of the proposed QCLNG Project to regional photochemical activity is at worst, minor and unlikely to be of any cause for concern or require further assessment.<br><br>Note that the EIS contained a minor error in calculation that has been rectified in the information presented above. | |
| *Volume 5, Chapter 12* of the draft EIS states that the "US DERM's AP-42" database is used in the selection of emission factors. It should be corrected to "US EPA AP-42". | This is a typographical error. The correct reference is US EPA AP-42. | 32 |
| The EIS does not identify other proposed LNG plants on Curtis Island as the nearest sensitive receptor and states that there is a large distance to the nearest noise sensitive receptors. Assuming that other proposed LNG developments proceed, this assertion is not correct as proposed LNG plants are adjacent to the QCLNG site and will be regarded as sensitive receptors.<br><br>Further information should be provided on the potential impact of noise and air emissions from the proposed operations on sensitive receptors associated with the LNG Plant and other LNG plants on Curtis Island and how these impacts will be mitigated. | This response deals with the air emissions aspect only. A response addressing noise emissions is provided in *Volume 5, Chapter 13* of this supplementary EIS.<br><br>Modelling undertaken for the air quality assessment for the draft EIS (refer *Volume 5 Chapter 12*, and *Appendix 5.13* of the draft EIS) indicates that ground-level concentrations of air pollutants at the construction camp of the neighbouring Gladstone LNG (GLNG) facility to the immediate south of the QCLNG site would be below applicable air quality objectives, with a summary as follows:<br><br>• The maximum one-hour average ground-level concentration of nitrogen dioxide under relevant QCLNG modelling scenarios predicted at the GLNG facility is between 40 µg/m³ and 60 µg/m³ with the inclusion of background. The higher bound of this range is 24 per cent of the air quality objective.<br><br>• The annual average ground-level concentrations of nitrogen dioxide under relevant QCLNG modelling scenarios predicted at the GLNG facility are less than 2 µg/m³ with the inclusion of background. This is 3 per cent of the air quality objective.<br><br>• The maximum eight-hour average ground-level concentration of carbon monoxide under relevant QCLNG modelling scenarios predicted at the GLNG facility is less than 477.4 µg/m³ with the inclusion of background. This is less than 4.3 per cent of the air quality objective.<br><br>• The maximum one-hour average ground-level concentration of sulfur dioxide under relevant QCLNG modelling scenarios predicted at the GLNG facility is less than 250 µg/m³ with the inclusion of background. This is less than 44 per cent of the air quality objective.<br><br>• The maximum 24-hour average ground-level concentration of sulfur dioxide under relevant QCLNG modelling scenarios predicted at the GLNG facility is less than 40 µg/m³ with the inclusion of background. This is less than 17 per cent of the air quality objective. | 32 |

| Issue Raised | QCLNG Response | Relevant Submission(s) |
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| | • The annual average ground-level concentrations of sulfur dioxide under relevant QCLNG modelling scenarios predicted at the GNG facility are less than 5 µg/m³ with the inclusion of background. This is 9 per cent of the air quality objective.<br>• The maximum 24-hour average ground-level concentration of PM10 due to all relevant QCLNG modelling scenarios predicted at the GLNG facility is less than 30 µg/m³ with the inclusion of background of 29 µg/m³. This is less than 60 per cent of the air quality objective. The QCLNG Project contributes 2 per cent to this.<br>• The maximum ground-level concentration of speciated hydrocarbons under relevant QCLNG modelling scenarios predicted at the Santos LNG facility is less than the air quality objectives. The most important hydrocarbon was found to be formaldehyde. At the GLNG facility, formaldehyde is predicted to be less than 59 per cent of the air quality objective. | |
| Assessment of Vertical Plumes for Aviation Safety<br>A submission was received noting that the Assessment of Vertical Plumes for Aviation Safety (*Volume 5, Chapter 5, Section 12.9* of the draft EIS) was undertaken against the Pans-Ops Surface for Gladstone Airport (approximately 300-350 m above the LNG Facility site), but that the assessment did not consider:<br>• the Obstacle Limitation Surface for Gladstone Airport at 164.5 m above the LNG Facility site<br>• the Obstacle Limitation Surface for the planned runway on Kangaroo Island.<br>The submission further noted that plume impacts may present airspace restrictions at Gladstone Airport, and that other proposed LNG projects in the Gladstone region may further constrain Gladstone Airport operations. A holistic view of potential aviation risks associated with LNG projects in Gladstone was requested from "*The LNG Industry and/or the state Government*". The submission also requested QGC to commit to consultation with the Gladstone Airport owner in conjunction with the Civil Aviation Safety Authority (CASA) to achieve the best overall outcome, and develop, as far as practicable, management strategies based upon the minimisation of airspace impacts through project design rather than simply through placing impacts on aircraft operations. | *Appendix 5.13: Air Quality Impact Assessment of the QCLNG Project, Gladstone, Queensland* of the draft EIS does note that CASA requirements state that the limiting value for assessment of impact of plumes on aviation safety is 4.3 m/s at the Obstacle Limitation Surface, PANS-OPS or at 110 m above ground level anywhere else. While the OLS and 110 m criteria for Gladstone airport were not specifically addressed in the EIS, it was considered that the impacts described at the higher limiting value (the PANS-OPS surface) must result in corresponding or higher impacts at the OLS and 110 m levels. Given that the assessment indicated the need for management and mitigation of this issue at the PANS-OPS surface, this also implies that management and mitigation at the lower limits is also required. QCLNG has advised Air Services Australia and CASA of the results of the Assessment of Vertical Plumes for Aviation Safety, and continues to work with these regulators to consider appropriate management and mitigation measures to be taken with consideration for all appropriate CASA limitation requirements (PANS-OPS, OLS and 110 m above ground).<br>Potential impacts on the OLS, PANS-OPS or other limiting factors for a runway on Kangaroo Island have not been assessed as this runway is not shown in the existing planning scheme currently applicable to Kangaroo Island (Restricted Development Precinct of the Gladstone State Development Area).<br>With regard to a "holistic view of the potential aviation risks" associated with potentially several LNG facilities on Curtis Island or elsewhere in the Gladstone Region, and development of management strategies, QGC will continue to work with Air Services Australia, CASA, and other appropriate stakeholders, including the operator of Gladstone airport, with regard impacts from the QCLNG Project. Where appropriate, QGC will work with regulators to develop management and mitigation measures that may be required if additional LNG Facilities are operational. | 29 |

### *Table 5.12.2 QCLNG Project Estimated Emission Limits*

| Air pollutant | Applicability | Concentration limit | Basis |
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| Oxides of nitrogen | Gas turbines | 25 ppm | Dry gas, 15% O2 |
| | Oil heaters | 170 ppm | Dry gas, 3% O2 |
| Carbon monoxide[1] | Gas turbines | 125 mg/Nm³ | Dry gas, 273K, 101.3 kPa,15% O2 |
| | Oil heaters | 125 mg/Nm³ | Dry gas, 273K, 101.3 kPa, 3% O2 |
| VOCs as n-propane equivalent[1] | Gas turbines | 40 mg/Nm³ | Dry gas, 273K, 101.3 kPa,15% O2 |
| | Oil heaters | 40 mg/Nm³ | Dry gas, 273K, 101.3 kPa, 3% O2 |

1 The Clean Air Regulation applies the limit on carbon monoxide or the limit on VOCs

## *12.2 AMENDMENTS TO BASELINE AND UPDATE OF IMPACTS*

The description of the air quality baseline and assessment of impacts for the LNG Facility as described in *Volume 5, Chapter 12* and *Appendix 5.13* of the draft EIS remains valid. Changes to Facility layout as described in *Volume 2, Chapter 9* of this sEIS are not anticipated to result in any significant change in the air quality or aviation safety impacts as described in the draft EIS.