Australia Pacific LNG Project

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Attachment 47: Marsh Plume Rise - Gas Fields

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Process & Exhaust Gas Plume Rise Assessment

Australia Pacific LNG Pty Limited

MARSH

MARSH MERCER KROLL
GUY CARPENTER OLIVER WYMAN

Project:	AP LNG Project
Prepared by:	Tom Croese, Principal Justin Rees, Consultant
Q/A Review:	Paul Shardlow, Senior Consultant Tom Croese, Principal
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1. Executive Summary

Australia Pacific LNG Pty Limited is currently compiling an Environmental Impact Statement for a proposed coal seam gas collection and gathering network in south west Queensland. This project includes the construction and operation of various gas collection infrastructures and gas processing facilities. It is proposed that one of the gas processing facilities could be situated near the town of Miles. The aim of this report is to study the plume rise effect from this gas processing facility. This gas processing facility site covers a surface area of approximately 266,000m^2 and has anticipated centre point coordinates of 26°48' south, 150°12' east. The gas processing facility is expected to consist of a number of essential process units including compressors, power generation units, cooling fans, reboilers, and an emergency gas flaring system.

For this particular gas processing facility, the process units have the potential to produce plumes that could cause interference for nearby aviation operations at the Miles Aeroplane Landing Area. This interference may arise if the proposed gas processing facilities' emission plumes exceed a velocity of 4.3 m/s (CASA, 2004) in the direction of the aviation operations as determined by the Civil Aviation Safety Authority (CASA). The Civil Aviation Safety Authority requires the proponent of the facility with an exhaust plume which has a vertical velocity greater than 4.3 m/s at a height of 110 m or higher to assess the potential hazard to aviation operations. In this context, plume velocity is the criteria for emission plumes when assessing their potential to create an obstacle, as velocity is a function of buoyancy which is dependent on plume and ambient temperature. Hence low velocity plumes will exist at lower temperatures and are the result of plume dissipation and heat transfer to the surroundings.

Miles Aeroplane Landing Area is located 2.2 km south west of the gas processing facilities and supports the Royal Flying Doctor Service and private operations such as the Western Downs Flying School. The Civil Aviation Safety Authority set out prescribed guidelines for determining the limit of an Obstacle Free Area (OFA) to ensure safe aviation operations (CAA, 1992). In addition to this obstacle free area, the Civil Aviation Safety Authority prescribes an unofficial Obstacle Limitation Surface (OLS) with a height of 110 m at all sites regardless of the proximity to an aeroplane landing area, or aerodrome (CASA, 2004). Any obstacles, including plumes as described above, over this height must undertake a hazard and risk analysis. The obstacle free area determined for Miles Airport extends to a distance approximately 1350 m west of the proposed gas processing facilities. See Figure 2.1 & 5.2

To determine the extent of the expected emission plumes, and the probability and consequences of these obstacles, emissions have been tracked using The Air Pollution Model (TAPM), a predictive metrological modelling program developed by the CSIRO (CSIRO, 2008). The input data required for The Air Pollution Model has been combined for two individual plume events, plumes created during normal operations and plumes created during flaring events. Using data collated from the two scenarios, the resulting plumes have been modelled and the results summarized, based on meteorological data over a one year period.

The data in Figure 5.3 and 5.5 allow a good estimation of the likelihood of a plume, when considered a buoyant obstacle, to breach a prescribed height. Based on the Civil Aviation Advisory Publication No. 92-1(1) (CASA 1992) it would be unlikely for any plume to breach the prescribed Obstacle Free Area as the proposed gas processing facility is located outside the boundary of the Obstacle Free Area. The prescribed Obstacle Free Area does not extend further than 905m north east of the Miles Airport Runway while the gas processing facility site is located 2.25km away at the closest boundary. The greatest distance travelled by any plume was approximately 40m during flaring operations, which places the plume within the gas processing facility land area and at least 1.35km from the Obstacle Free Area and 1km from the expected flight path.

Both the flaring operations and normal operations exceed the limitation height of 110m approximately 0.18% and 1.7% of hours in the investigated year. In order to evaluate the risk to aviation operations however, the frequency of exposure also takes into account the probability that an aircraft would be in the vicinity of the Aeroplane Landing Area at the same time as an exhaust plume hazard.

The probability of an aircraft being in the vicinity of the Aeroplane Landing Area is based on local knowledge provided by the Facilities Project Officer at Miles Airport and can be assumed to occur 0.6 % of the time. This gives a combined probability of a plume existing in the vicinity of an aircraft to be 0.0011 % for flaring events and 0.0102 % for normal operations. This data would suggest that on average a plume is likely to be in the vicinity of an aircraft 0.013 % of the time. Due to The Air Pollution Model modelling every hour of the year, this becomes 1.14 hours every year. However this does not give the probability of an aircraft/plume incident which requires a pilot to travel 1km off course and then lose control of the plane resulting in an accident. This information can be assessed however by the Civil Aviation Safety Authority which will determine the threat to aircraft safety.

With respect to the proximity of the plume and the aircraft, the location of the plume is still 2.25km from the runway, 1.35km from the obstacle free area and 1km from the flight path of an Aircraft. Therefore, the probability of an aircraft actually interacting with a potentially hazardous plume is a fraction of the estimated 0.013% probability, which only places a plume and aircraft concurrently in the vicinity of the airport. The probability of an interaction resulting in an aircraft incident is also even less likely; however there is insufficient flight data for this airspace to quantify this further.

According to the Civil Aviation Safety Authority Advisory Circular AC 139.05(0) (June 2004) CASA must be notified if the universal obstacle limitation surface of 110m is at risk of being breached by an exhaust gas plume. CASA may then request information regarding the breach of height and may also need to assess the height of the stacks as they may be classified as a “tall structure”. CASA will then determine the effect on aircraft safety and determine whether or not the exhaust plume should be classified as a hazardous object under CASR Part 139.

In the event that the Miles airport experiences increased occupancy, the probability and consequences of aviation operations flying in or near the gas processing facility land area will have to be reassessed based on the runway classification and the increase in operations. However, the facilities project officer at Miles Airport noted that there is no planned development for the airport. In the event of future developments, it would be required to reassess the plumes and tall objects resulting from the Gas Processing Facility when assessing the plume effects on aircraft safety.

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2. Introduction

2.1 Overview

Australia Pacific LNG Pty Limited (Australia Pacific LNG) are currently compiling an Environmental Impact Statement for a proposed coal seam gas collection, gathering network and processing facilities in south west Queensland. The coal seam gas production process is designed to collect gas from existing coal seams in the region and will comprise of numerous gas extraction wells, gas gathering networks, main line vents, regional gas processing facilities, water treatment facilities, and transmission pipeline.

The transmission pipeline will deliver the coal seam gas to coastal facilities at Gladstone for further processing to produce liquefied natural gas.

It is proposed that one of the gas processing facilities with a capacity of 150 TJ/day could be situated near Miles, a small country town in the heart of the Western Downs region of Southern Queensland. The town is serviced by a non-commercial air field which supports the Royal Flying Doctors Service and other private aircraft operations including the Western Downs Flying School. This report details an assessment Australia Pacific LNG has undertaken to identify and evaluate potential risks to aviation safety associated with the proposed gas processing facility.

The gas processing facility covers an area of approximately 1000 m X 500 m and has centre point coordinates of 26°48’ south, 150°12’ east. The facility is expected to contain a number of essential process units including compressors, power generation units, cooling fans, reboilers, and an emergency gas flaring system.

These units are expected to produce exhaust and thermal emissions (with the majority of the emissions being thermal that is hot air) during normal operations. Periods of process interruptions, primarily due to scheduled maintenance requirements, can involve exhaust gas release. It has been estimated that this is unlikely to occur more than a total of 3.25 days every year on average.

2.2 Scope

The Risk Consulting practice of Marsh Pty Ltd (Marsh) has been engaged to complete this exhaust plume risk assessment for Australia Pacific LNG’s proposed gas processing facility located within the vicinity of the Miles Aeroplane Landing Area.

Specifically, this assessment is to determine if exhaust plumes might represent a hazard to aircraft operations in accordance with the Australian Civil Aviation Safety Authority's (CASA) Advisory Circular (CASA, 2004), Guidelines for Conducting Plume Rise Assessments (AC 139-05(0)). Furthermore, those plumes which are shown to represent a potential hazard will be analysed to determine the frequency and severity of the hazard, in order that it may be assessed by the Civil Aviation Safety Authority for aircraft safety.

2.3 Assumptions and Limitations

To effectively develop a plume rise model that represents the behaviour of the plumes produced at the proposed Gas Processing Facility the following assumptions have been made:

- The only plumes produced at or around the 150 TJ/day facilities are the direct result of the facility and there are no other contributing plumes from third party's that may affect the buoyancy of these plumes.
- The plumes developed occur under weather conditions with standard synoptic data and do not consider plume effects during catastrophic weather events.
- The synoptic data of 2008 is considered standard normal conditions and accurately represents predicted future weather conditions.
- The Miles Aeroplane Landing Area operates as per standard aeroplane landing areas.
- Aircraft land and take off from both ends of the airport depending on the direction and strength of prevailing winds. (Wayne Osbourne, Miles Facilities Project Officer, December 2009)
- In the scenario specified "Flaring Event" it has been assumed that the flares are both running at maximum capacity in order to encompass the worst case scenario flaring event.
- The Royal Flying Doctor operates out of Miles Airport once every week whilst the Western Downs Flying School operates once every quarter.
- Taking off and Landing has been assumed to give a total time of one hour of possible aircraft/plume interaction in an average week.

2.4 Definition of Terms

Table 2.1 Definition of Terms

The Air Pollution Model (TAPM)	A combined predictive meteorological modelling program developed by the CSIRO to model exhaust gas plumes velocity, location and concentration.
Aeroplane Landing Areas (ALA)	An area in private ownership and not used for scheduled public aircraft flights, which is set apart for the taking off and landing of light aircraft, but does not include a helipad.

The Air Pollution Model (TAPM)	A combined predictive meteorological modelling program developed by the CSIRO to model exhaust gas plumes velocity, location and concentration.
Civil Aviation Safety Authority (CASA)	The Civil Aviation Safety Authority (CASA) was established on 6 July 1995 as an independent statutory authority. Under section 8 of the, *Civil Aviation Act 1988,* CASA is a body corporate separate from the Commonwealth. CASA's primary function is to conduct the safety regulation of civil air operations in Australia and the operation of Australian aircraft overseas.
Obstacle Limitation Surfaces (OLS)	The Obstacle Limitation Surfaces are a series of surfaces that define the limits to which objects may project into the airspace.
Emission Plumes	A vertically or longitudinally moving, rising, or expanding fluid body resulting from a stack, flue, chimney or fan.
Gas Processing Facility (GPF)	Operations involving the compression, refining, treating or cleaning of gas.
Obstacle Free Area (OFA)	Refers to an area where there should not be wires or any other form of obstacles above the approach and take off runway strips, fly over areas or water channels.

2.5 Aviation Safety Requirements

The Civil Aviation Safety Authority Advisory Circular (CASA 2004) states that, among other sources, exhaust plumes may include instantaneous releases from pressurised gas systems, as well as continuous release sources. Potential aviation hazards are those which result in a plume rise velocity of greater than 4.3m/s at the Obstacle Limitation Surface of an aerodrome or at heights greater than 110 metres, regardless of the proximity to an aerodrome.

The proponent of a facility which creates such a hazard is required to submit to the Civil Aviation Safety Authority:

- Electronic data file of plume assessment simulation models;
- Summary of findings suitable for an aeronautical assessment;
- Probability distribution of the height and lateral limit of the plume vertical velocity exceeding 4.3m/s, and
- Probability of activation and duration of each plume event.

The Department of Transport and Regional Services (DOTARS) can prohibit the construction of any facility producing an exhaust plume with an average vertical velocity greater than 4.3m/s at the lower limit of the prescribed airspace. In this circumstance, the Civil Aviation Safety Authority also requires the proponent of the facility to assess the potential hazards to aircraft operations.

2.6 Objectives

The main objectives of this plume risk assessment report, in line with the proposed scope, are to:

- Determine any sources of gas plumes created by the proposed gas processing facility in the vicinity of the Miles aeroplane landing area;

- Assess the size and frequency of the expected plumes created;
- Calculate the velocity and extent of expected plumes;
- Identify potential gas plumes with velocities greater than or equal to 4.3m/s; and
- Assess the likelihood of these types of emissions affecting nearby aircraft operations.

2.7 Miles Airport

Miles Airport is located approximately 2.2km south west of the proposed gas processing facility as seen in Figure 2.1. The aerodrome is currently primarily used by the Flying Doctor and private aviation operations. A designated flight circuit surrounding the aerodrome is also used for training and landing approaches a few times every year.

Due to the size and infrequent use of the runway, an Obstacle Limitation Surface has not been established for the Miles Aeroplane Landing Area and it is not known if the site has been inspected by Civil Aviation Safety Authority.

Based on the current Obstacle Limitation Surface, as prescribed by the Civil Aviation Safety Authority under CAAP 92-1: Guidelines for Aeroplane Landing Areas (CAA 1992), the Obstacle Free Area for the Miles Aeroplane Landing Area is illustrated in Figure 2.4 and Figure 2.5. Figure 2.4 indicates a transitional slope and distance required for a standard Obstacle Free Area whilst Figure 2.5 provides the runway start and end, slope and distance prescribed for an Obstacle Free Area during night operations. These dimensions were chosen to cover the most extensive Obstacle Free Area in order to take into account the worst case scenario.

In accordance with the Civil Aviation Safety Authority guidelines when applying the Obstacle Free Areas to the location of the gas processing facility, a distance of 1350m still remains between the furthest limit of the Obstacle Free Area and the closest point of the gas processing facility. In addition, obstacles that reach a height of 110m above ground level must be assessed for the potential hazard to aircraft operations, regardless of the proximity to the aerodrome.

Figure 2.1: Miles Aeroplane Landing Area (A) and the Proposed Gas Processing Facility (Yellow)

The wind directions experienced at Miles are also presented below as Wind Roses. These figures display the dominant wind direction and speed as yearly averages.

Figure 2.2: 3pm Average Wind Direction and Speed at Miles (Australian Bureau of Meteorology, 2009)

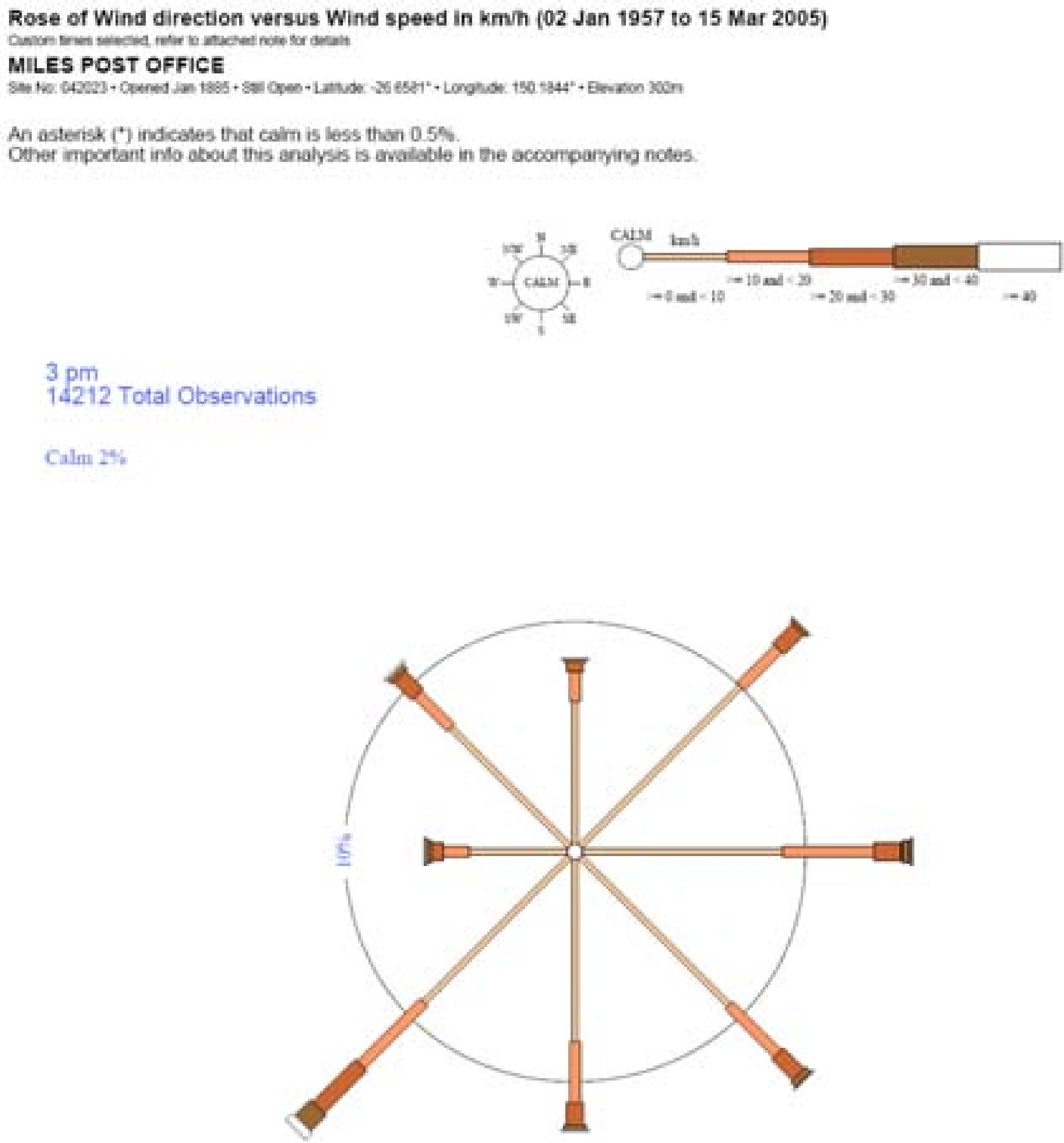


Figure 2.3: 9am Average Wind Direction and Speed at Miles (Australian Bureau of Meteorology, 2009)

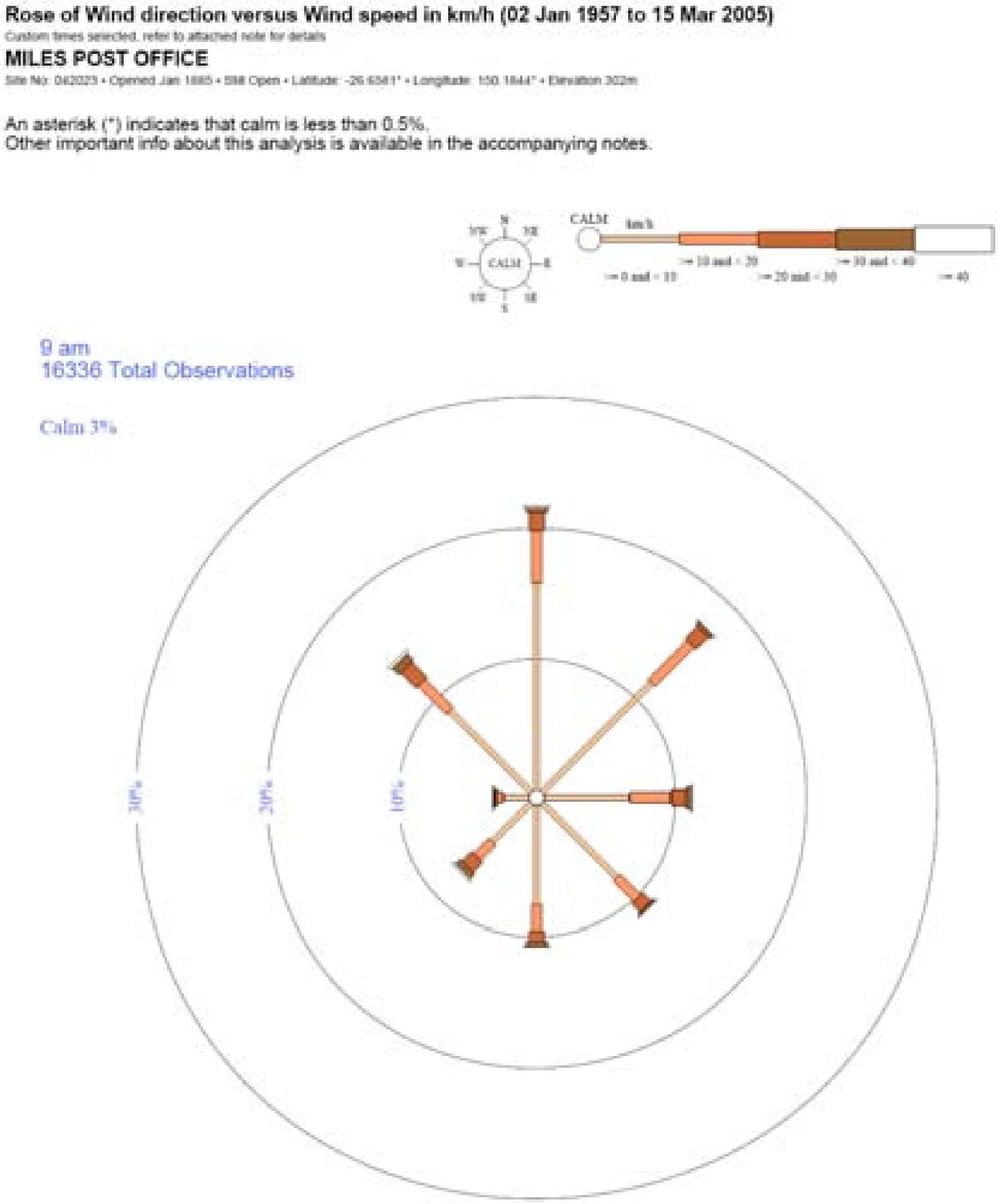


Figure 2.4 Guidelines for Aeroplane Landing Areas (CAA 1992)

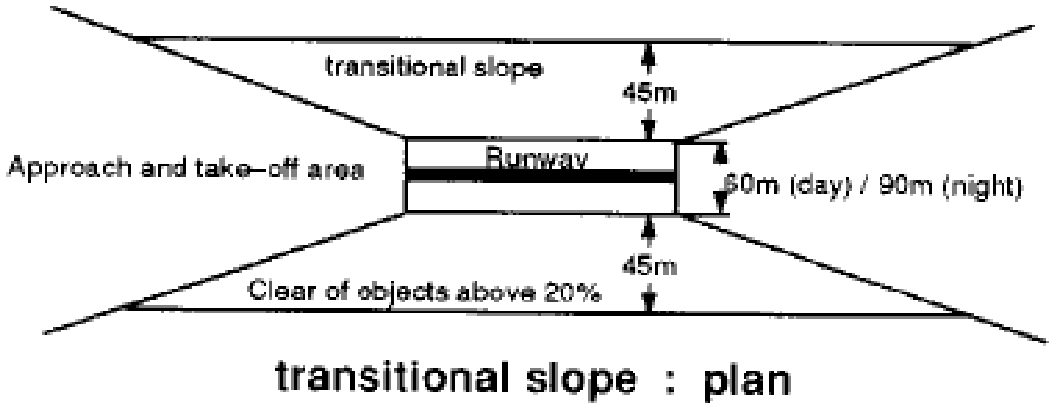
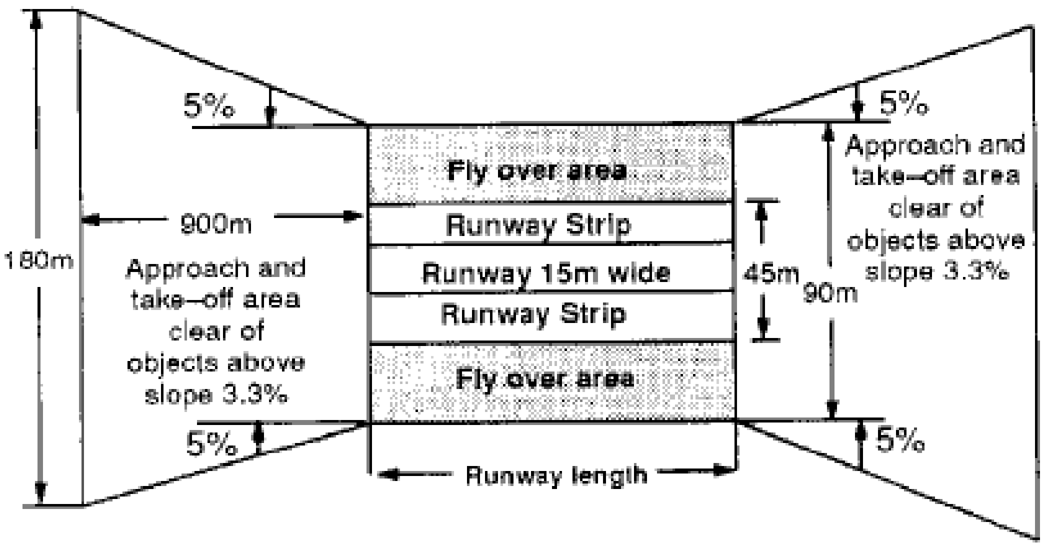


Figure 2.5 Dimensions for Night Operations (CAA1992)



2.8 Proposed Operations

The process units associated with the proposed gas processing facility have been described briefly in the introduction. To determine their contribution to the exhaust plumes created on site, the units have been assessed independently. Two different scenarios have been observed that allow for exhaust plume release, namely *normal operations*, and *flaring events*.

Normal operations include the standard day to day operations that would be expected to take place during the gas processing facilities normal running periods. This specifically involves exhaust gas generated from the following sources:

- gas dehydration boilers;
- gas compressors; driven by gas engines;

- power generators; driven by gas engines;
- cooling fan operations, and
- combustion of pilot and purge gas in the flare.

Flaring events are categorised as excess ‘gas flaring’ as a result of start-up / shutdown, unit maintenance, commissioning and process disturbances attributed to changes in upstream or downstream operations.

On average, it has been assumed that the whole gas processing facility could shutdown for two days every year, or 0.5% of the total running time for maintenance works. It is also assumed that there is six plant shutdowns per year lasting five days from a total of 24 proposed plants and therefore the possible shut down schedule gives a total of (6 x 5/24) + 2 = 3.25 days of shutdowns per plant every year during the life of the project.

Both scenarios have the potential to create plumes varying in size and speed, and similarly have different probabilities of occurring.

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3. Methods

This section describes the methods that have been used to determine the major sources of exhaust gas, the size and extent of the plumes and the locations which may be considered an obstacle to existing aviation operations. It makes recommendations on identifying the plumes that could be considered major contributors during normal and flaring event operations. The tools used for this analysis are introduced and the required inputs and set-up procedures are illustrated. Potential impacts as a result of plume exhaust within and nearby to the Miles Airport Aeroplane Landing Area are also evaluated.

3.1 Exhaust Plume Identification

Exhaust plumes are created from the emission of process gas at different speeds, pressures, temperatures or compositions to that of the surrounding atmosphere. This includes, but is not limited to any substance that has different properties to that of the immediate atmosphere that allow it to behave differently when released into its surroundings. Examples of such plumes include hot air, high velocity gases, exotic gases and combustion products.

To evaluate the point source emissions produced at the proposed Australia Pacific LNG gas processing facility, the sources of exhaust gas and process gas were identified. These sources were identified on the basis of flow rate, temperature and the number of units operating at any one time. The more significant sources (higher flow rates and temperatures) were identified through this process and the less significant sources are assumed to be negligible. Significant contributors include:

- gas engine exhaust streams from stacks,
- flares, and
- industrial fans associated with gas compressor coolers.

Negligible point sources would include:

- fugitive emissions from process valves,
- emissions from flanges,
- emissions from waste material,
- emissions from small vehicles and;

- emissions from small combustion engines.

Exhaust plumes interact with the surrounding environment through the difference in properties of plumes and the ambient surroundings. Generally, plumes with high temperatures and velocity will travel the furthest. This is especially the case where ambient conditions are cool and still. Low wind speeds prevent the dispersion of plumes and cool temperatures allow for increased rising velocities due to differences between plume densities and the density of the ambient atmosphere. If the wind speeds are high the plumes are likely to be dispersed quickly and are unlikely to experience any high speed vertical velocities.

3.2 TAPM Plume Rise Modelling

The Air Pollution Model is a predictive meteorological modelling program developed by the CSIRO (CSIRO 2008). The Air Pollution Model provides estimates of plume dispersion, plume rise and dispersion/displacement. This is used to develop a three dimensional grid type simulation model designed for estimating the extent of plume events.

Section 2.9: Proposed Operations, outlines the difference between normal and flaring operations. For the purpose of achieving accurate plume modelling data it is important to distinguish the point sources and plume sizes expected during different scenarios before collating the Air Pollution Model input data.

The Air Pollution Model tracks the location of plumes with respect to the point source based on one plume release every hour. The plume is tracked for the first five minutes of every hour at which time the plume is considered dispersed due to losses in temperature, velocity, buoyancy and structure (the basis is velocity which is proportional to temperature). Data can be extracted to determine the time and location at which the plume would decrease below the critical velocity as defined by the user.

In this study the critical velocity was set to 4.3m/s by editing one of the Air Pollution Model run files. The data extracted provides the maximum three dimensional distances the plume will travel whilst still being considered an obstacle as defined by the Civil Aviation Safety Authority guidelines. This can then provide the user with the probability of plume emissions entering flight space as an obstacle to aviation operations.

3.2.1 Flaring Events

Flaring is conducted as a means of converting flammable coal seam gas into the environmentally preferable and non-combustible products of combustion. In the event that production from the gas processing facility is interrupted, flaring of coal seam gas is undertaken for safety reasons. Flaring events are generally infrequent and short lived. Flaring events can also be part of planned operations such as shut downs in accordance with maintenance schedules, although there remains a potential for unplanned process interruptions to result in the necessity to flare gas.

In order to encompass the worst possible interruption and essentially the most extensive and comprehensive plume event, it was assumed that both flares would be running at maximum capacity in such circumstances. This assumption was used to base The Air Pollution Model input data for flaring scenarios.

3.2.2 Normal Operations

During normal operations it is expected that all gas processing facilities will be operating. This assumption allowed for the compilation of relevant data and the assessment of plume contribution based on the expected buoyancy flux resulting from each emission source. For the purpose of this assessment, emission sources were grouped based on the emission source type, including the grouping of replica compression and power generation units. This assumption is considered reliable as replica type emission sources have replicated operating parameters. They are also located close together and therefore the plumes may be conservatively considered to merge at or near the general source.

3.2.3 The Air Pollution Model (TAPM) Configuration

The Air Pollution Model was configured to accommodate the distance between the point source and the Miles Airport aviation operations. Unless otherwise specified, the default settings were applied to the model as recommended by CSIRO personnel. For the purpose of this study one year of hourly meteorological data was considered, represented by the entire year of 2008. Specific settings applied for both interrupted and uninterrupted operations included:

- Grid Centre Coordinates - 26°48’ Latitude 150°12’ Longitude
- Meteorological grid containing four nests of 25 x 25 grid points at 30km, 10km, 3km and 0.9km spacing with 25 vertical grid levels from 10 to 8000m
- Terrain at nine arc-second (approximately 270m) resolution from the Geoscience Australia terrain database. Land characterisation data at approximately 1km resolution, sourced from the US Geological Survey, Earth Resources Observation System (EROS) Data Centre Distributed Active Archive Centre (EDC DAAC). Sea surface temperature data at 100km grid intervals from the US National Centre for Atmospheric Research (NCAR)
- Six hourly synoptic scale meteorology data from the Bureau of Metrology on a 75 to 100km grid. This data is derived from the Bureau of Metrology Limited Area Prediction System (LAPS) output, and
- Eulerian dispersion was used on the outer nests, whilst Lagrangian dispersion was used on the innermost nest.

3.3 Plume Rise Impacts

The output data collected from The Air Pollution Model allows the assessment of potential plume effects at different heights and distances from the point of emission release to be undertaken. This data can be used to determine the height and distance plumes are likely to travel with a vertical velocity of 4.3m/s or greater. At this critical velocity plumes are considered an obstacle by the *Civil Aviation Act* and are likely to impose undesirable impacts to nearby aircraft and other aviation operations. With the use of this data potential impacts can be predicted. Similarly measures can be considered and implemented when required to reduce the potential consequence and likelihood of plume rise impacts.

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4. Analysis

To undertake an assessment of expected plume characteristics, source information was determined based on the design capacity of individual units contributing to emissions. Standard design specifications were chosen as the most likely process parameters for the normal operation of the gas processing facility.

4.1 Flaring Events

Normal operations can be interrupted due to scheduled maintenance, commissioning, unplanned incidents or supply chain disturbances. In such circumstances, one or more units may not be running at full capacity, which can result in overpressures and other process complications. In order to ensure the safety of both employees and assets, gas flaring becomes a necessary operation. When assessing the plumes created during flaring, a worst case scenario has been assumed whereby both flares at the facility will be running at maximum capacity.

The flares have been modelled as a single exhaust source with a combined radius, mass flow rate, temperature and velocity. However, flares behave differently to normal exhaust stacks when running at full capacity. This is due to the generation of heat and combustion products within the flare's flame and the associated lift and expansion impacts.

The approach taken to modelling the flare source is to convert the flare into an equivalent exhaust stack using a method which was originally adapted for Atmospheric Dispersion Modelling (AERMOD). Essentially this requires calculation of an effective stack height, based on the heat release characteristics of the flare, as well as calculation of an effective stack diameter. The latter is achieved by equating the buoyancy flux of the flare to an exhaust stack buoyancy flux equation and solving for the effective stack diameter.

The required input parameters and the new output parameters have been presented in Table 4.1 below.

Table 4.1 Modified Flare Point Sources

Modified Flare	
Design Parameters	
Individual Flare Diameter (m)	0.71
Individual Flare SA (m^2)	0.40
Actual Flare Height (m)	40
Combined Theoretical Parameters	
Combined Flare SA (m)	0.79
Combined Flare Theoretical Diameter (m)	1.00
Modified Flare Input Parameters	
Combined Flare Theoretical Diameter (m)	1
Stack Temperature (C)	1,000
Volumetric Flowrate (ACFM)	110,012
Actual Stack Height (m)	40
Modified Flare Output Parameters	
Combined Effective Height (m)	60.4
Combined Effective Diameter (m)	3.6

Once this data has been summarised it can be combined with the standard flare process parameters that are not affected by the flame dimensions such as exhaust flow and temperature. The worst case scenario for combined flaring makes the assumption that the remaining units would not contribute to the plume created by this flare system. This can be justified by:

- comparing the buoyancy flux of the flares at maximum capacity to the remaining units in normal operation;
- assuming that the remaining units will not be running at design capacity during a worst case flare event and;
- observing that the flares are approximately 50m higher than the remaining units and are unlikely to affect or be affected by the other emission sources.

The final flare parameters required for The Air Pollution Model have been summarised in Table 4.3. The composition of the gas flared is described in Table 4.2

Table 4.2 Flared Gas Compositions and Flow

CSG Components	Mol%
Carbon Dioxide (CO_2)	0.56
Nitrogen (N_2)	2.08
Methane (CH_4)	97.30
Water (H_2O)	0
Ethane (C_2H_6)	0.06
Flowrate kg/hr	120,000

Table 4.3 Effective Flare Process Parameters

Emission Source	Units	Elevation (m)	Diameter (m)	Temperature (C)	Velocity (m/s)	Mass Flowrate (g/s)
Flare (Interrupted Event)	1	60.4	3.59	1,000	65.6	305,556

4.2 Emissions during Normal Operations

During normal operations a number of process units are expected to produce significant quantities of exhaust gas at higher temperatures and velocities than ambient air. In total there are potentially 67 point sources including the flares. The emission sources are expected to be quite clustered and all occur within 200 m of each other. Due to the close proximity of the emission sources, the exhaust gas has been conservatively combined into a single plume for assessment purposes.

When determining the specific parameters for the single plume, the initial Buoyancy Flux (Fo), Momentum Flux (Mo) and Volume Flux (Go) need to be collated. The flux equations can then be solved to produce the merged Temperature, Velocity and Diameter of the expected combined plume. Further, for assessment purposes the average elevation for the merged emission source was assumed to be 9 m, which is the efflux height of the expected tallest units contributing to plumes during normal operation.

Table 4.4 Point Sources during Normal Operations

Emission Source	No. of Stacks	Elevation (m)	Diameter (m)	Temperature (C)	Velocity (m/s)	Fo (m^4/s^3)	Mo (m^4/s^2)	Go (m/s^3)
Screw Compressors Exhaust	13	9	0.36	537	49.2	128.2	374.3	7.6
Reciprocating Compressors Exhaust	14	9	0.46	469	45.66	195.74	612.14	13.4
Screw Compressor Fans	13	6	2.97	73	2.2	84.4	115.9	53.5

Emission Source	No. of Stacks	Elevation (m)	Diameter (m)	Temperature (C)	Velocity (m/s)	Fo (m^4/s^3)	Mo (m^4/s^2)	Go (m/s^3)
Reciprocating Compressor Fans	21	6	2.97	73	9.4	594.8	3559.8	376.8
Power Generation Unit	2	4.5	0.36	477	54.91	21	77.6	1.4
Dehydration Reboiler	2	7	0.20	500	4.38	0.53	0.15	0.034
Flare (Pilot, Non - Event)	2	40	0.71	1000	0.17	0.33	0.002	0.01
Merged Plume Source								
Normal Operations	**67**	**9**	**14.6**	**93.8**	**10.46**	**1025**	**4740**	**453**

In order to gauge the contribution of each source to the total buoyancy of the merged plume, emissions were compared using their individual Buoyancy Flux (Fo). In Table 4.5 the total contribution from flaring during normal operations is expected to be less than 0.05%. This has led to the exclusion of the flares when considering the overall emission plume.

Table 4.5 Normal Operations Buoyancy Contribution

Emission Source	Fo (Buoyancy Flux m^4/s^3)	Percentage Contribution
Screw Compressors Exhaust	128.23	12.51%
Reciprocating Compressors Exhaust	195.74	19.10%
Screw Compressors Fans	84.43	8.24%
Reciprocating Compressors Fans	594.80	58.04%
Power Generation Unit	21.01	2.05%
Dehydration Reboiler	0.53	0.05%
Flares (Non-Event)	0.33	0.03%
Total	1025	100%

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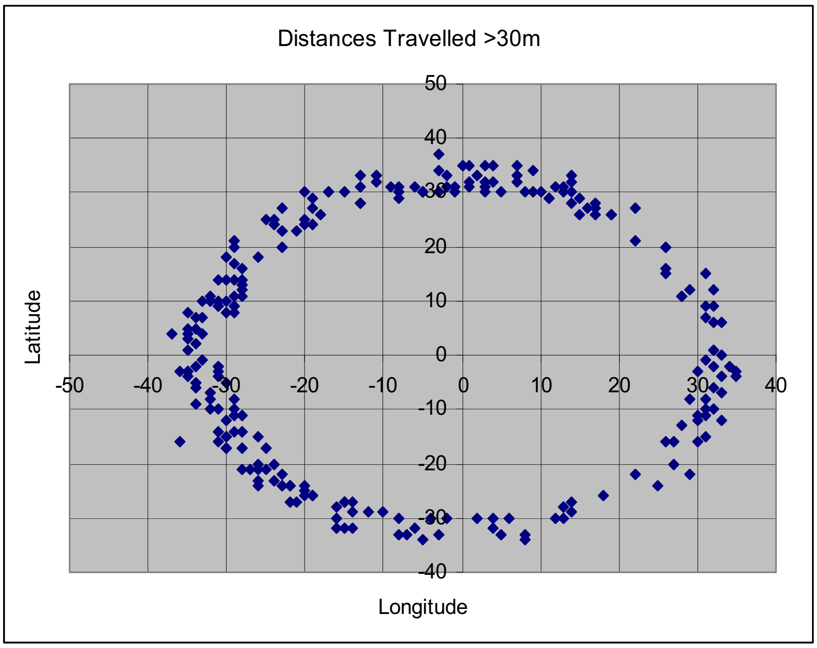
5. Results

5.1 Flaring Event

5.1.1 Maximum Extent of the Plume

The data considered is based on a continuous flaring event over the entire year of 2008. All plumes released travelling at speeds greater than the critical velocity of 4.3m/s have been filtered based on the maximum distance travelled in all directions. When considering the synoptic conditions for the given year, the plume has been observed to never leave the latitudinal or longitudinal location of the gas processing facility. The graph below represents distances travelled greater than 30 m at the critical velocity. The reference point is the point of emission source.

Figure 5.1 Distances Travelled >30 m at Critical Velocity



As indicated in Figure 5.1:

- the greatest horizontal distance travelled by any plume with a velocity greater than 4.3 m/s is 39.4 m west north west
- the greatest horizontal distance travelled by a plume reaching critical velocity in any cardinal direction is 37 m north, 37 m west, 35 m east and 34 m south, and
- the greatest height travelled by a plume at the specified critical velocity is 804 m above the ground and 744 m above the stack height. This plume was located at a land distance of 19.1 m north east from the point source.

Figure 5.2 3D Representation of the Gas Processing Facility Emission Plumes (Graphis 2007)

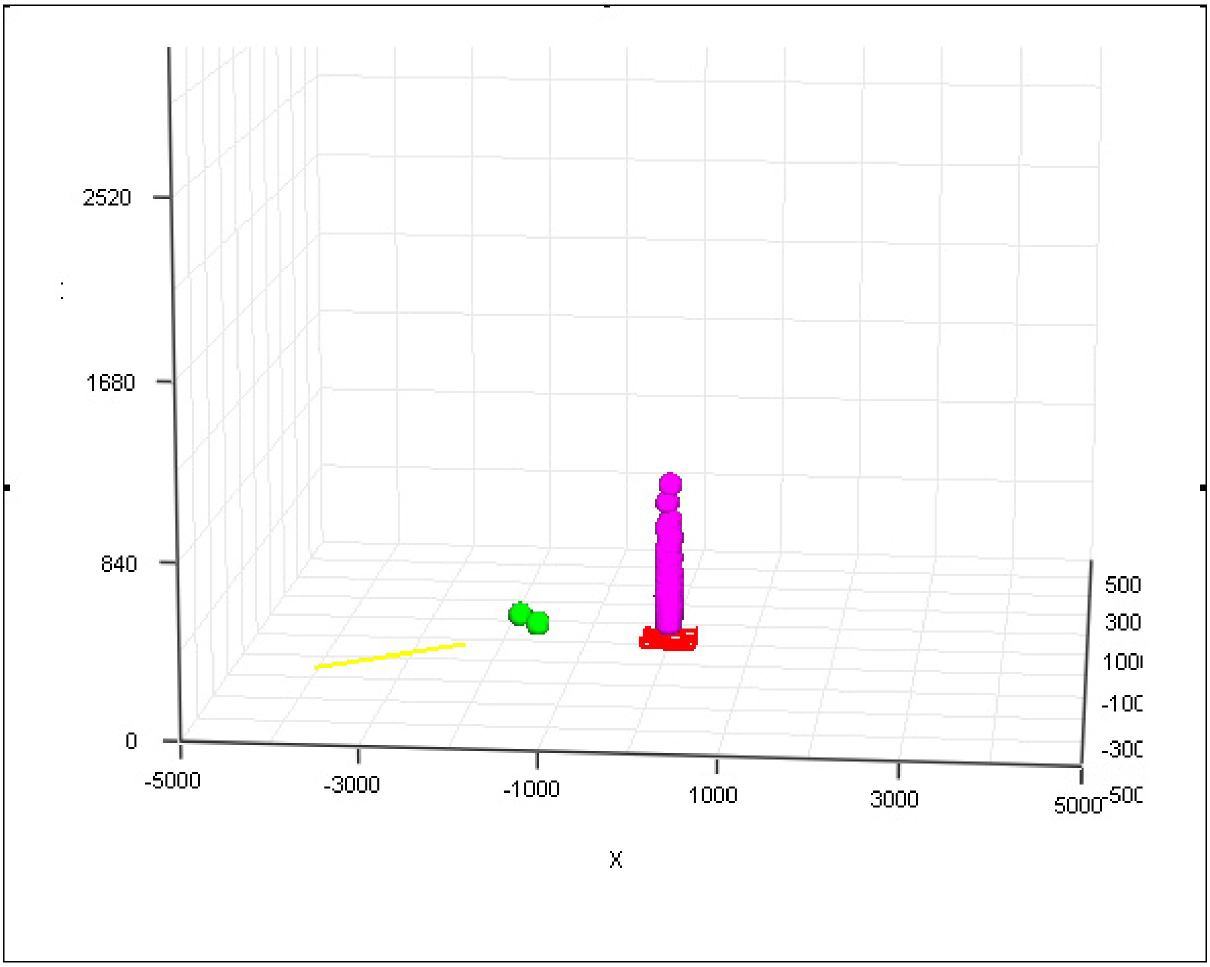


Figure 5.2 displays the location of the:

- 150 TJ/day Gas Processing Facility (Red),
- Miles Airport Runway (Yellow),
- Extent of the Obstacle Free Area (Green) and;
- The critical velocity gas plumes that reach heights greater than 110 m from flaring and normal operations (Purple).

This figure highlights the significance of the plumes greater than 110 m and displays the possible interactions aircraft may have with these plumes during weekly flight take off and landing. It can be seen that the limits of the obstacle free area are beyond the range of the critical velocity plumes, this area extends from the green points parallel to the ground creating a square. However the two green points are the extent of the area closest to the nearest plume.

5.1.2 Minimum Extent of the Plume

Based on the synoptic data for 2008, constant emissions from the combined flare source with a critical velocity of 4.3m/s show that:

- the minimum land distance travelled by the plumes is 5 m due west
- the minimum land distance travelled by a plume in any cardinal direction is zero, and
- the minimum height travelled is 79 m above ground level and approximately 19 m above the stack height. This height was usually reached at a land distance of about 10 m from the point source.

5.1.3 Average Extent of the Plume

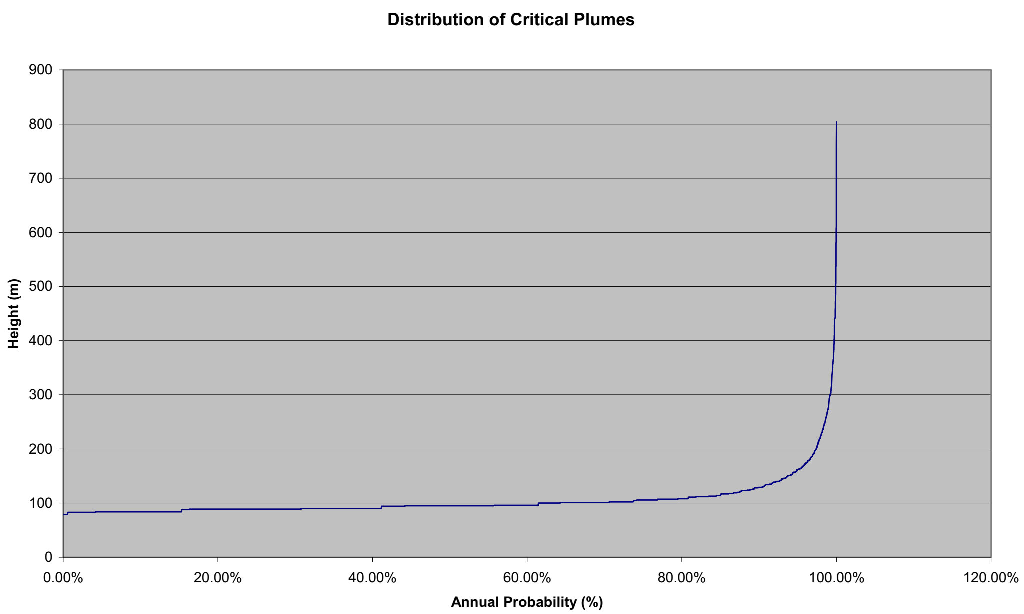
Based on the synoptic data for 2008, constant emissions from the combined flare source with a critical velocity of 4.3m/s show that:

- the average land distance travelled by the plume is 19 m, and
- the average height travelled is 105 m above ground level and approximately 45 m above the stack height.

5.1.4 Plume Height Cumulative Distribution

Figure 5.3 displays the probability of a plume with critical velocity >4.3 m/s reaching a given height. It can be seen that approximately 80% of the year exhaust plumes will not reach a height greater than 110 m. Similarly 97% of the year plumes will reach no higher than 200 m.

Figure 5.3 Cumulative Distributions of Critical Plume Heights



5.1.5 Flaring Event Frequency

The flare system is generally operated during plant disruptions and scheduled plant maintenance periods. The emission plumes that have been modelled during interrupted operations are infrequent events. The flares assessed may be operational for a total period of 3.25 days per year on average as demonstrated in section 2.9: Proposed Operations. Due to this, the probability of an exhaust plume created from the flaring system reaching the heights described in section 5.1 can be reduced by a factor of 0.009. This would give a probability of any plume reaching a height of 110 m (CASA, 2004) on average to be 0.2x0.009 = 0.18% of a year.

From the assessment of flight operations conducted at the Miles airport, it can be conservatively assumed that aircraft will be landing and taking of for approximately 1 hour every week (i.e., in the vicinity of the airport). This assumption is based on the flying doctor landing once every week and the Western Downs Flying School landing approximately 4 times every year. This gives a probability of aircraft operations being in the vicinity of the airport 0.6% of the year. Combining this with the probability of a flaring event exceeding the obstacle limitation surface gives on average 0.0011% chance of a plume existing while an aircraft is taking off or landing.

5.1.6 Discussion

The data in Figure 5.3 allows a good estimation of the likelihood of a plume, when considered a buoyant obstacle, to breach a prescribed height. Based on the Civil Aviation Advisory Publication No. 92-1(1) (CASA 1992) it would be unlikely for any plume to breach the prescribed Obstacle Free Area as the proposed gas processing facility is located outside the boundary of the Obstacle Free Area. The prescribed Obstacle Free Area does not extend further than 905 m north east of the Miles Airport Runway while the gas processing facility site is located 2.25 km away at the closest boundary. The greatest distance travelled by any plume was approximately 40 m which places the plume within the gas processing facility land area and at least 1.35 km from the Obstacle Free Area.

The frequency data above provides the likelihood of a plume reaching the Obstacle Limitation Surface prescribed height at a time in which an aircraft may be in the vicinity, however, an aircraft in the vicinity does not necessarily mean that aircraft/plume interaction can be attributed to this likelihood. The probability of a plane deviating from the normal take off and landing path also needs to be considered as the gas processing facility is 2.25 km from the site and 1 km from the predicted flight path. Furthermore, the probability that an aircraft/plume interaction actually causes an aircraft incident should also be taken into account. There is insufficient data available to quantify this accurately; however it would be reasonable to conclude that the probability is a small fraction of the 0.0011% potential interaction frequency.

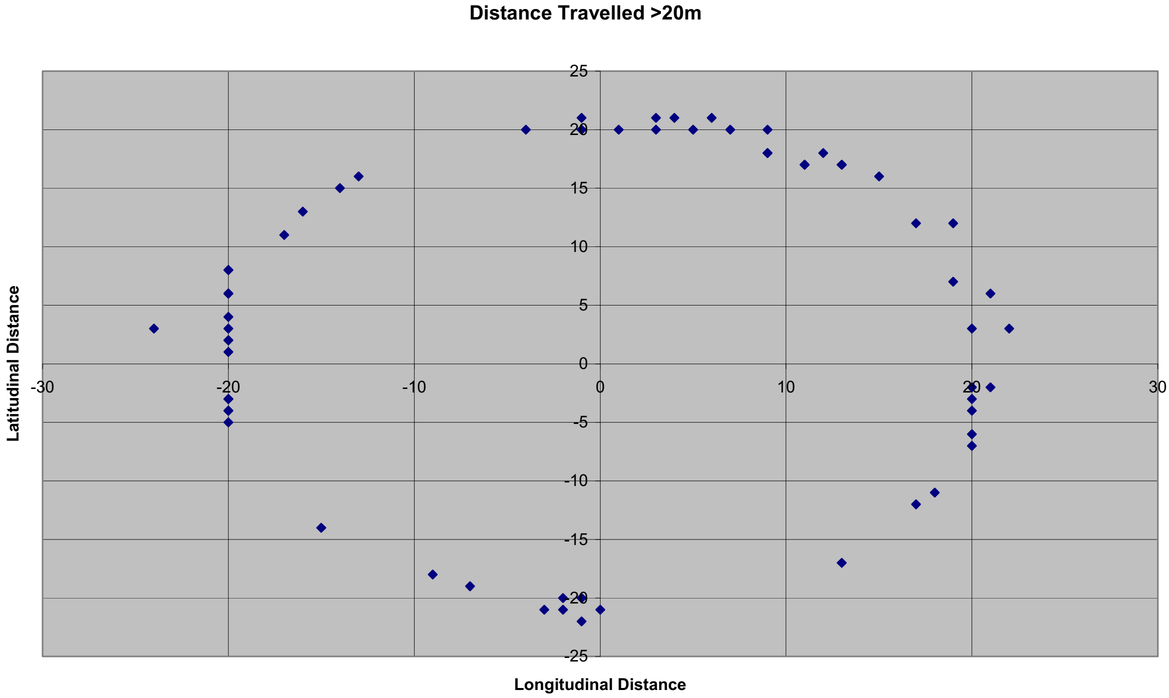
In the event that the Miles Airport experiences increased occupancy the probability and consequences of aviation operations flying in or near the gas processing facility land area will need to be reassessed.

5.2 Normal Operations

5.2.1 Maximum Extent of the Plume

The data considered is based on continuous operations over the entire year of 2008. All plumes released travelling at speeds greater than 4.3 m/s have been filtered based on the maximum distance travelled in all directions. When considering synoptic conditions for the given year, the plume never leaves the latitudinal or longitudinal location of the gas processing facility. The graph below represents distances travelled greater than 20 m at the critical velocity. The reference point represents the point of emission source.

Figure 5.4 Distances Travelled >20 m at Critical Velocity



As indicated by Figure 5.4:

- the greatest horizontal distance travelled by any plume in this period with a velocity greater than 4.3 m/s is 24.2 m West-North West
- the greatest horizontal distance travelled by a plume reaching critical velocity in any cardinal direction is 21 m north, 24 m west, 22 m east and 22 m south, and
- the greatest height travelled by a plume at the specified critical velocity is 348 m above the ground and 339 m above the greatest stack height, this plume was located 11 m north north - east of the emission source.

5.2.2 Minimum Extent of the Plume

Based on the synoptic data for 2008, constant emissions from the combined source and a critical velocity of 4.3 m/s:

- the minimum land distance travelled by the plume is 2.2 m, this is due to conditions that provide low ambient temperatures and light winds that the plume travels straight up and reaches the critical velocity before travelling a significant distance.
- the minimum height travelled is 18 m above ground level and approximately 9 m above the stack height. This height was usually reached at a land distance of about 12 m from the point source.

5.2.3 Average Extent of the Plume

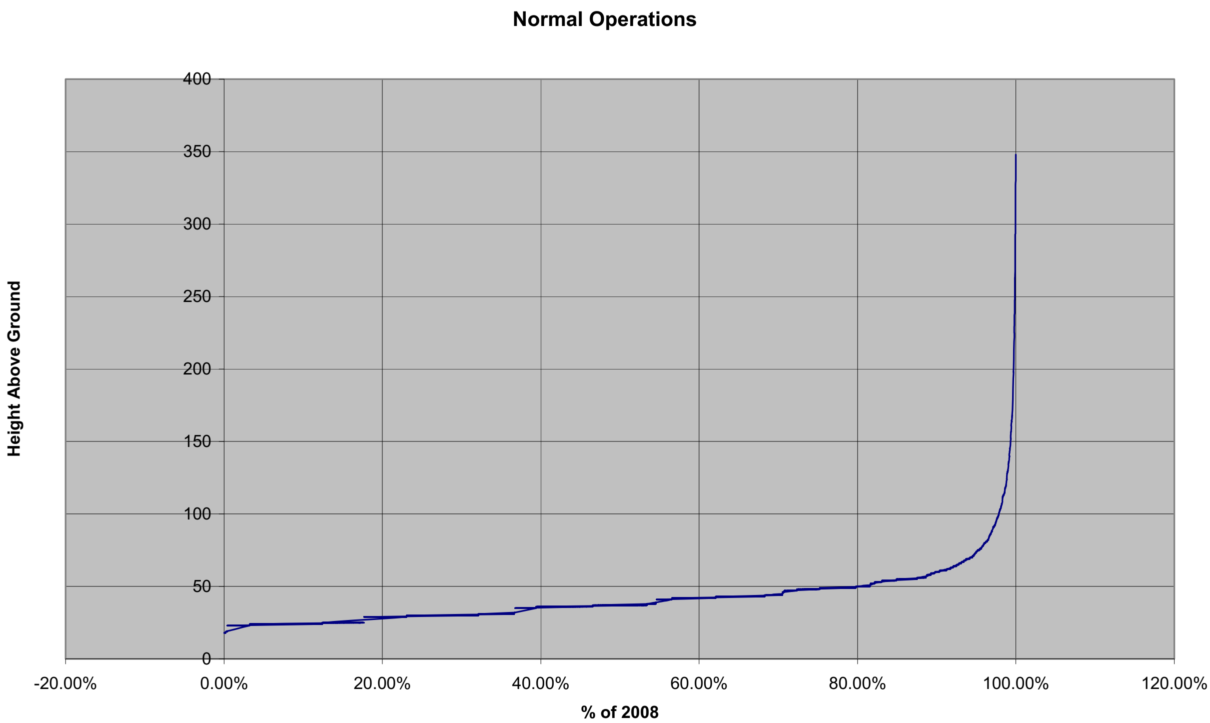
Based on the synoptic data for 2008, constant emissions from the combined source and a critical velocity of 4.3 m/s:

- the average land distance travelled by the plume is 15.36 m, and
- the average height travelled is 42.1 m above ground level and approximately 33.1 m above the stack height.

5.2.4 Plume Height Cumulative Distribution

Figure 5.6 displays the probability of a plume with critical velocity >4.3 m/s reaching a given height. It can be seen that approximately 98.3% of the year exhaust plumes will not reach a height greater than 110 m (the suggested obstacle limitation surface prescribed by the Civil Aviation Safety Authority) (CASA 2004).

Figure 5.5 Cumulative Distributions of Critical Plume Heights



5.2.5 Discussion

A review of the data presented in the previous headings suggests that the plumes created from normal operations will not affect the Miles Airport Obstacle Free Area. However 1.7% of the time in the investigated year, the universal limitation area for all elevated obstacles (110 m) is exceeded by the emission plumes (CASA, 2004). The maximum height achieved during this period was 348 m above the ground and occurred about 12 m (land distance) from the point source and therefore will not impose on the flight path of aircraft landing at the Miles Airport. Similarly the maximum distance travelled from the source was only 24 m which places the furthest plume still well within the boundary of the facility.

Statistically the plume will reach the obstacle limitation surface 1.7% of the year and is likely be in the vicinity (within 1 km) of aviation operations 1 hour every week or 1/(24*7)= 0.6% of the year. This gives an average likelihood of a plume reaching the prescribed obstacle limitation surface to be 0.0102% of the year. However, as described in the discussion for the flaring event this is only the probability of an aircraft operating in the vicinity of Miles Airport whilst a plume is breaching the OLS and can not be attributed to the probability of a plume/aircraft interaction, much less one which results in an aircraft incident. Such an occurrence is less likely and would require a flight path deviation of at least 1 km from the predicted flight path. The flight path of an aircraft is the expected path of an aircraft travelling in the same cardinal direction of the airport runway during either landing or take off.

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6. Conclusions

The operations to be conducted at the proposed gas processing facility 2.25 km North East of Miles Aircraft Landing Area have been assessed for possible risks imposed on nearby aviation operations. The operations of the gas processing facility have been carefully divided into two possible scenarios, namely a flaring event and normal operations. Using data collated from the two scenarios the resulting plumes have been summarized.

Table 6.1 Summarized Plume Data

	Flaring Event	Normal Operations
Maximum Height Travelled	804m	348m
Maximum Distance Travelled	39m	24m
Probability of Exceeding 110m during an event.	20%	1.7%
Probability of Event Occurring	0.9%	100%
Probability of Exceeding 110m at any given time.	0.18%	1.7%
Probability of an Aircraft in the Vicinity (approx 1km away)	0.6%	0.6%
Probability of possible aviation interaction (see note).	0.0011%	0.0102%
Site Centre Distance from the Obstacle Free Area	1662.8m	
Most Westerly Plume Distance	34m	24m
Plume Distance from the Obstacle Free Area	1629m	1639m

Note: The probability of possible aviation interaction represents the chance that an aircraft might be operating in the vicinity (~1km) of the airport whilst a plume exceeds the 110 m threshold. In order for an accident to occur, the aircraft would need to deviate significantly form the expected flight path and be dangerously impacted by the plume. Hence the individual risk is a fraction of this number.

During both normal operations and flaring events, high speed plumes (>4.3 m/s) remain more than 1600 m lateral distance from the Obstacle Free Area determined by the Civil Aviation Safety Authority.

Both the flaring operations and normal operations exceed the limitation height of 110 m approximately 0.18% and 1.7% of the hours in the investigated year. In order to evaluate the risk to aviation operations however, the frequency of exposure also takes into account the probability that an aircraft would be in the vicinity of the Aeroplane Landing Area at the same time as an exhaust plume hazard.

The probability of an aircraft being in the vicinity of the Aeroplane Landing Area is based on local knowledge provided by the Facilities Project Officer at Miles Airport and can be assumed to occur 0.6% of the time. This gives a combined probability of a plume existing in the vicinity of an aircraft to be 0.0011% for flaring events and 0.0102% for normal operations. This data would suggest that on average a plume is likely to be in the vicinity of an aircraft 0.013% of the time. The Air Pollution Model provides data for every hour of the year and this probability becomes 1.14 hours every year. However this does not give the probability of an aircraft/plume incident which requires a pilot to travel 1km off course and then lose control of the plane resulting in an accident.

With respect to the proximity of the plume and the aircraft, the location of the plume is still 2.25 km from the runway, 1.35 km from the obstacle free area and 1 km from the flight path of an Aircraft. Therefore, the probability of an aircraft actually interacting with a potentially hazardous plume is a fraction of the estimated 0.013% probability. Furthermore, the probability of an interaction resulting in an aircraft incident is also even less likely; however there is insufficient flight data for this airspace to quantify this further. This information can be assessed however by the Civil Aviation Safety Authority which will determine the threat to aircraft safety.

In the event that the Miles airport experiences increased occupancy or significantly different usage patterns (egg, regular circuit training), the probability and consequences of aviation operations flying in or near the gas processing facility land area will need to be reassessed based on the runway classification and the increase in operations. However, the Facilities Project Officer at Miles Airport noted that there is no planned development for the airport.

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7. References

Civil Aviation Authority (CAA); July1992, *Guidelines for Aeroplane Landing Areas, Version 92-1(1),* Accessed 1st December 2009.

CSIRO Marine and Atmospheric Research; October 2008, *CSIRO TAPM V4 Part 1: Technical Description*, Accessed 1st December 2009

CSIRO Marine and Atmospheric Research, October 2008, *TAPM, Version 4.0*, Accessed 29th November 2008

Civil Aviation Safety Authority (CASA); June 2004, *Guidelines for Conducting Plume Rise Assessments*, Accessed 1st December 2009.

Civil Aviation Authority (CAA); November 2008; *Standards for Aircraft Landing Areas*, Chapter 8, Accessed 28th November 2009.

Graphis ; 2007, Graphis 2D and 3D graphing software, www.kylebank.com , accessed December 2009

Miles Airport Wind Roses from Australian Bureau of Meteorology, www.bom.gov.au, accessed October 2009

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8. Appendices

A. The Air Pollution Model Input Data
B. Raw Data

Appendix A

The Air Pollution Model (TAPM) Input Data

The table over is a summary of the input data used in The Air Pollution Model.

Default Settings - Stack 1 & 2			
Buoy. Enhancement	1		Default
Fraction FPM/APM	0.5		Default
Fraction NO/Nox	1		Default
Use EGM + LPM (Eulerian grid + Lagrangian near-source)			Default
Emissions are Constant in Time			Default
Combined Stack Conditions			
Exit Temperature	1273	k	Default stack temperature supplied from flare excel file
Exit Velocity	65.60355399	m/s	Refer to "Input Data" worksheet
Exhaust Emission Rate	305556	g/s	Basis of 1100 tph combustion products
Source Radius	1.793748	m	Effective stack diameter of 5.86ft determined by flare excel file
Source Height	60.38	m	Effective stack height of 282.4ft determined by flare excel file
Source X value	3027.5	m	Gas Processing Facility Near Mile Aerodome RJ 27/10/09
Source Y value	1028	m	Gas Processing Facility Near Mile Aerodome RJ 27/10/09
Total Flare Gas Flowrate kg/h	120000	kg/h	
Methane m3/kg @ 40 dc	1.5576	m3/kg	
Gas flowrate m3/min	3115.26	m3/min	
Gas flowrate m3/s	51.92	m3/s	
ft3/m3	35.31		
Gas flowrate ft3/min	110012.4611	ft3/min	
Gas flowrate per flare	55006.23053	ft3/min	
Stack Diameter (Velocity Ref)	0.71		
Gas Velocity m/s	65.60	m/s	
Stack Height m	40	m	
Stack Height ft	131.2335958	ft	
Flares Combining Before Getting Effective H & D			
Individual Flare Diameter	0.71	m	
Individual Flare SA	0.3957185	m2	
Combined Flare SA	0.791437	m2	
Combined Flare Theoretical Diamter (m)	1.004091629	m	
Combined Flare Theoretical Diamter (ft)	3.294263876	ft	
Actual Flare Height	40	m	
Combined Effective Height	60.38	m	
Combined Effective Diameter	3.59	m	
Other Pollution Information			
Output 3-d concentration files			
Output final plume rise heights			
Surface Info. Settings			
clat	_-26deg-48min	(S 26.80871 E 150.16583)	http://mapper.acme.com/
clong	_150deg_12min	(S 26.80871 E 150.16583)	http://mapper.acme.com/

Appendix B

Raw Data A and B

The table over is a summary of the raw data used in the Air Pollution Model.

Emission Source	Stack Exit Temperature (C)	Elevation (m)	Number of Exhaust Stacks	Flowrate per stack (m3/s)	Total Flowrate (m3/s)	Stack Diameter (m)	Up Exit Velocity (m/s)	Stack Exit Temperature K	Rp Stack Radius
Screw Compressors Exhaust	537	9	13	5	65	0.36	49.1	810.0	0.18
Reciprocating Compressors Exhaust	469	9	14	7	105	0.457	45.7	742.0	0.23
Screw Compressors Fans	73	6	13	15	195	2.97	2.2	346.0	1.49
Reciprocating Compressors Fans	73	6	21	65	1374	2.97	9.4	346.0	1.49
Power Generation Unit	477	4.5	2	6	11	0.36	54.9	750.0	0.18
Dehydration Reboiler	500	7	2	0.14	0.275	0.20	4.4	773.0	0.10
Flare (Pilot, Non - Event)	1000	40	2	0.07	0.137	0.71	0.2	1273.0	0.36
Flare (Interrupted Operations)	1000	60.38	2	25.96	52	3.6	2.6	1273.0	1.80
Total			42	86	1750	-	-	-	-

Emission Source	Fo (Buoyancy Flux m4/s3)	Percentage Contribution	% Contribution (Flare Excluded)	Stack Height Averaged
Screw Compressors Exhaust	128.23	12.51%	12.51%	1.126
Reciprocating Compressors Exhaust	195.74	19.10%	19.10%	1.719
Screw Compressors	84.43	8.24%	8.24%	0.494
Reciprocating Compressors	594.80	58.04%	58.04%	3.483
Power Generation Unit	21.01	2.05%	2.05%	0.092
Dehydration Reboiler	0.53	0.05%	0.05%	0.004
Flares (Non-Event)	0.33	0.03%	0.03%	-
Total	1025	100%	-	-
Total (Flare Excluded)	1024.74	100.00%	100.00%	6.918

MARSH

MARSH MERCER KROLL
GUY CARPENTER OLIVER WYMAN

Marsh Pty Ltd
ABN 86 004 651 512
Riverside Centre
123 Eagle Street
BRISBANE QLD 4000
GPO Box 2743
BRISBANE QLD 4001
61 7 3115 4555