8.0 Air Quality

8.1 Introduction

The purpose of this air quality section is to assess the likely impact on air quality from the expanded refinery, taking into account all the relevant factors including:

- Recognised standards aimed at protecting human health;
- Local wind and weather conditions;
- The type of fuel currently burned at the refinery and proposed to be burned at the expanded refinery under normal conditions;
- Abnormal operating conditions such as interruptions to gas due to pipeline maintenance schedules or the possibility of a delay in gas being supplied to Gove;
- The emission of air pollutants from all refinery operations, allowing for the effect of pollution control equipment and tall stacks; and
- The location of residences and other sensitive land uses in the vicinity of the refinery.

The assessment has been undertaken by using mathematical modelling techniques that estimate future air quality using all the above inputs to assess impacts. The modelling was undertaken by consultants Pacific Air & Environment and a copy of their report is given in Appendix B.

Overall, the assessment takes a conservative or safe approach ie. the techniques used tend to over-estimate potential air quality impact rather than running the risk of under-estimating them.

The section concludes that there will be little likelihood of detrimental health or nuisance air quality effects to local communities as a result of the expanded refinery.

8.2 Ambient Air Quality Guidelines

8.2.1 Air NEPM

The National Environment Protection Council (NEPC, 1998) has developed the National Environment Protection Measure (NEPM) for Ambient Air Quality, also known as the Air NEPM. The Air NEPM refers to the so-called criteria or common air contaminants that have for many years been the core set of pollutants for assessing air quality. The Air NEPM comprises a monitoring-based set of goals and is aimed at identifying the safe air quality levels at which human health will be protected for residential communities.

Meeting the NEPM goals is generally a state or territory government responsibility, since the NEPM recognises that there can be many sources (domestic, vehicular, industrial, agricultural, bushfires etc.) contributing to overall air quality. It is the state and territory governments who decide how to achieve the goals. The NEPM also recognises that it can take time to achieve the goals and hence the prescribed levels are written in terms of a 10-year target. It is expected that the state and territory governments will monitor air quality in residential communities and take whatever steps are necessary to achieve the NEPM goals over time.

For Gove, it is recognised that the refinery is the only significant industrial air emission source in the region. Dry season bushfires are a significant non-industrial source of air emissions. It is proposed to assess the air quality impacts of the expanded refinery by comparing projected air quality directly with the NEPM goals.

The NEPM goals are shown in Table 8.2.1

Table 8.2.1
Ambient Air Quality NEPM Goals

Pollutant	Averaging Period	Maximum Concentration (µg/m3)	Maximum Allowable Exceedences
Carbon monoxide (CO)	8 hours	10,000	1 day a year
Nitrogen dioxide (NO_2)	1 hour	226	1 day a year
	1 year	56	none
Sulphur dioxide (SO_2)	1 hour	524	1 day a year
	1 day	210	1 day a year
	1 year	52	none
Lead	1 year	0.5	None
Particles as PM_{10}	1 day	50	5 days a year

Source: NEPC 1998

The NEPM goal for photochemical oxidants is not relevant to Gove as the effects of photochemical oxidants are associated with high motor vehicle usage in large urban centres (Section 8.10).

Particles as PM_{10} are particles with a diameter of less than 10 microns ($10x10^{-6}$ m).

The lead standard was established to set a goal for urban air sheds where lead in petrol was an issue.

8.2.2 NPI/Draft NEPMs

In addition to pollutants considered by the Air NEPM, there has been an increasing focus on other hazardous pollutants. This has lead to the development of the National Pollutant Inventory (NPI) which requires industries to report their emissions of up to 90 substances each year to the Commonwealth Department of Environment and Heritage. The NPI is a reporting requirement which does not set emission or air quality goals.

Recently two new draft NEPM's have been released: one on air toxics covering five compounds; and one on very small particles with a diameter of less than 2.5 microns ($PM_{2.5}$). These drafts are still under consideration by the NEPC following a period of public review and comment.

8.3 Regional Meteorology

8.3.1 Monitoring Stations

Alcan Gove maintains two meteorological stations. One is located inside the plant boundary near the refinery entrance. The other is located at the residue disposal area (RDA). These meteorological stations measure ten-minute averages of the parameters listed in Table 8.3.1.

Table 8.3.1
Meteorological Parameters Collected by Alcan Gove Monitoring Stations

Parameter	Units
Maximum Wind Gust	Kilometres per hour (km/h)
Average Wind Speed	Kilometres per hour (km/h)
Relative Humidity	Percent (%)
Ambient Temp @ 2m	Degrees Celsius (°C)
Temperature @ 10m	Degrees Celsius (°C)
Net Solar Radiation	Watts per meter squared (W/m^2)
Barometric Pressure	Hectapascals (hPa)
WS/WD Sine	No units - sine of (wind speed)/(wind direction)
WS/WD Cosine	No units - cosine of (wind speed)/(wind direction)
Wind Speed E/-W	Kilometres per hour (km/h)
Wind Speed N/-S	Kilometres per hour (km/h)
Wind Direction Vector	degrees
Wind Speed Magnitude	Kilometres per hour (km/h)
Rainfall	Millimetres (mm)
Solar Radiation	Megajoules per meter squared (Mj/m^2)

Data have been collected and archived for several years and were used in the preparation of the meteorological inputs for the dispersion modelling that has been used in this study.

In addition, the Commonwealth Bureau of Meteorology has maintained a weather station at Gove airport since 1944. The observations at this station include synoptic three-hourly surface recordings of horizontal wind speed and direction, dry bulb air temperature, dew point temperature, relative humidity, atmospheric pressure, rainfall, visibility and cloud. Fifty-seven years of data collected at this site were analysed to provide meteorological statistics. These observations provide a long-term database of climatic information that is adequate for planning purposes.

8.3.2 Climatic Conditions

Gove has a tropical monsoon climate with very marked seasonality in rainfall. The wet season lasts from December to April and the dry season from May to October (Table 8.3.2). The five-month wet season accounts for over 90% of annual rainfall in a typical year.

Daily maximum temperatures vary over a small range during the year, averaging 28°C in June and July and rising to an average of 33°C in November in the build-up to the wet season. Average daily minimum temperatures vary from around 19°C in August to about 25°C in December and January.

The surface wind regime of the Gove region is dominated by trade winds from the south-east during the dry season. This flow is often strong and is sometimes influenced by the thermally driven sea and land breezes. During the wet season, surface winds generally reverse direction and blow frequently from the north-west. This reversal of wind combined with rainfall seasonality categorises the climate of the region as monsoonal.

Table 8. 3.2
Long-Term Meteorological Averages for Gove Airport (1944-2001)

Month	Min. Temp (° C)	Max. Temp (° C)	9am Wind Speed (km/h)	3pm Wind Speed (km/h)	Rainfall (mm)
Jan	24.6	32.0	11.0	13.8	278.0
Feb	24.4	31.4	11.7	14.7	281.6
Mar	23.9	31.3	10.7	14.2	239.4
Apr	23.2	30.9	13.2	16.6	166.3
May	22.7	29.9	17.2	19.4	54.8
Jun	21.3	28.3	17.4	19.9	28.6
Jul	20.2	27.7	17.8	20.9	12.4
Aug	19.3	28.6	17.6	20.2	3.3
Sep	19.7	30.2	16.0	18.9	0.0
Oct	21.5	31.6	14.5	17.2	0.6
Nov	23.5	33.1	11.4	15.0	2.5
Dec	24.5	32.8	10.7	14.5	198.3
Annual	22.4	30.7	14.1	17.1	1,353.0

The major features of the wind pattern during the wet season are:

- The predominant wind during the nocturnal hours is from the north-west;
- Winds during the afternoon are predominantly from the north-west to north-east;
- Highest speeds occur with winds from the north-west (monsoon);
- Lowest speeds occur with winds from the east and south-east at night; and
- Calm conditions occur approximately 3% of the time.

The major features of the wind pattern during the dry season are:

- The predominant wind during the nocturnal hours is from the south-east;
- Winds during the afternoon are predominantly from the south-east to north-east (trade winds);
- Highest speeds occur during the day with winds from the south-east;
- Lowest speeds occur with winds from the east and north-east at night; and
- Calm conditions occur 0.2% of the time between May and November 2002.

8.3.3 Mixing Height

Mixing height is defined as the depth of the layer of air beneath an elevated temperature inversion within which pollutants are mixed by turbulence. When the mixing height is low, it can restrict the vertical diffusion of a plume and lead to high ground level concentrations. In coastal regions, the mixing height can vary significantly since water and land surfaces have different thermal and physical properties.

There is no direct measurement of mixing height at Gove. However it has been calculated from other meteorological parameters. It has been determined that 100% of mixing heights equal or exceed 50 m, and no mixing heights were calculated to exceed 2,000 m. Fifty percent of mixing heights (representing mostly night-time conditions) were below 500 m, and more than 10% of mixing heights exceeded 1,500 m. Approximately 30% of calculated mixing heights (representing the majority of day-time conditions) were between 1,000 m and 2,000 m.

Between midnight and 6 am, mixing height is generally lower than 500 m. After sunrise, it increases to between 750m and 2,000 m. Late in the afternoon, mixing height decreases rapidly after the surface heating ceases.

8.3.4 Validation of Meteorological Model

For the purposes of air quality assessment, weather data for 2002 have been used. When using a single year of meteorological data for dispersion modelling, questions arise as to whether the year in question is representative of long-term average meteorological conditions. Selected long-term (57 years) mean parameters for Gove Airport have been compared with the same parameters for January-December 2002. This comparison showed that although conditions in the modelled year (2002) departed from average long-term conditions, the lower wind speeds and slightly higher temperatures are likely to have resulted in less favourable conditions for dispersion of pollutants. Consequently, modelling results presented in this report are likely to be conservative (ie. they over-predict ground level concentrations of emissions).

8.4 Air Quality Monitoring Program

The current ambient air quality monitoring program at Alcan Gove consists of hourly average measurements of sulfur dioxide (SO_2) at the front (southern) fence of the refinery and total suspended dust particles (TSP) at sites within the refinery boundary and at the mine. The air monitoring program has been focussed on these sites because historic concerns relating to air quality have mostly come from the workforce, rather than the nearby residential communities.

In relation to SO_2 emissions, concerns have arisen in the past when infrequent meteorological conditions have caused plumes from the calciners or the power station to come to ground close to the refinery. Under these circumstances, Alcan Gove has responded by temporarily switching to a lower sulfur fuel to reduce the ground level concentrations of SO_2. This usually occurs in the wet season when winds are predominantly from the north-west and are more likely to blow towards nearby communities.

A recent short-term monitoring program at the nearby community of Gunyungara, approximately 3 km to the south-east of the refinery, provided several months of SO_2 data on an hourly basis during the wet season (December 2002-April 2003). The purpose of this program was to gather data to assist in validating the air dispersion model.

Figure 8.4.1 shows the distribution of one-hour ground level concentrations of SO_2 at the monitoring station near the refinery's southern fence for 2001. It shows that the NEPM goal for one-hour SO_2 concentrations (Table 8.2.1) was met 99.4% of the time at the refinery monitoring station.

Figure 8.4.1 also shows that the one-hour ground level concentrations of SO_2 at Gunyangara for December 2002-April 2003 met the NEPM goal for 100% of the time. This was at the time of year (wet season) when the winds were blowing predominantly in the direction of Gunyangara. During the dry season, the predominant wind direction blows refinery emissions away from Gunyangara and SO_2 concentrations there would be much less.

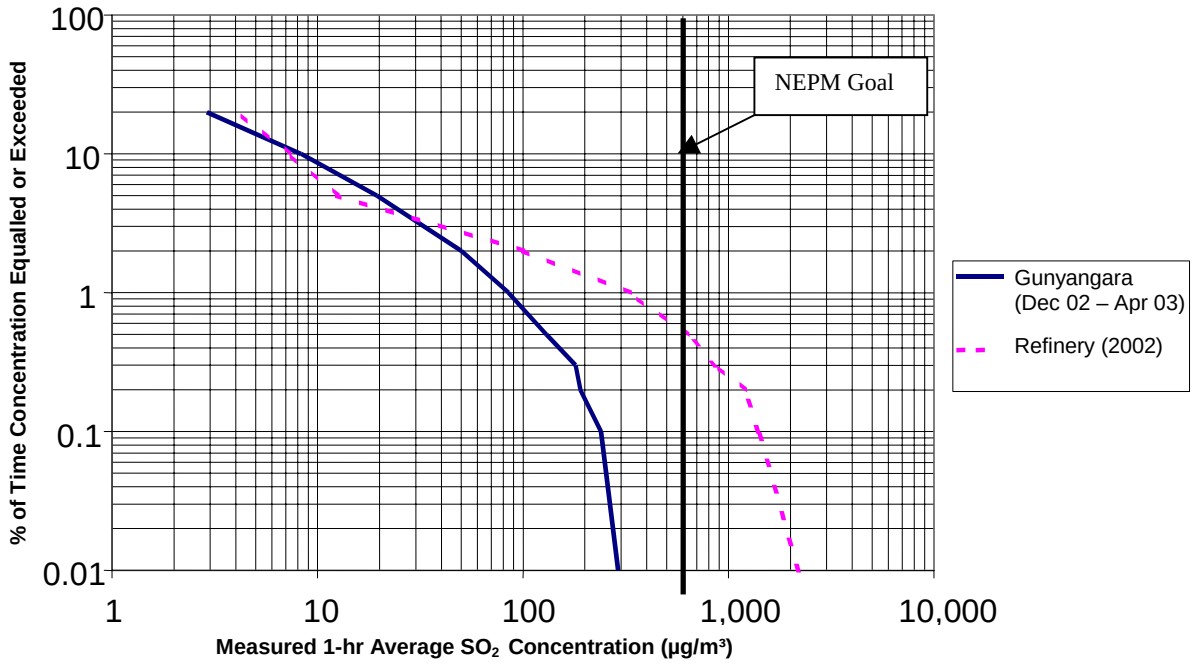


Figure 8.4.1
Existing 1-hour SO_2 concentrations ($\mu g/m^3$)

Similar analysis shows that the NEPM goal for one-day SO_2 concentrations was met at the refinery for 358 days of the year, or approximately 98% of the time, and it was met for 100% of the time at Gunyangara.

The monitoring results demonstrate the important effect of distance from the pollution source to the receptor. The concentrations at Gunyangara are considerably less than at the front fence, even though the wind was blowing in the direction of Gunyangara for much of the sampling period.

8.5 Emissions

8.5.1 Existing Emission Sources

Air emissions from the refinery result from the combustion of fuel, the emission of gases and fine particles (particulates) from production processes, and dust being blown from exposed areas. The point source of emissions included in the modelling are:

- Boilers;
- Calciners;
- Lime kiln;
- Digestion blow-offs;
- Mills vents; and
- Hydrate vacuum exhaust.

The existing refinery burns heavy fuel oil with an average sulfur content of 3.5%. It is burnt in the power station, the calciners, and the lime kiln. Waste oil is also burnt in the lime kiln. The emissions are vented through stacks, which vary in height from 35 m (rotary calciners) to 90 m (steam power station).

Gases and particulates are emitted at the milling and digestion parts of the process. The gases are generated as a result of the digestion of organic material at high temperatures. Particulates are also emitted from the calcining process and the subsequent handling of alumina.

Dust particles are blown from exposed surface areas such as stockpiles and unsealed roads during windy conditions. They are known as fugitive emissions. The shiploader is also currently a source of fugitive dust emissions and this is being addressed via upgrades commencing in 2004. Fugitive dust sources have been included in the modelling.

8.5.2 Emission Sources from the Expanded Refinery

8.5.2.1 General Emissions

As well as the existing sources, new emission sources from the expanded refinery will include:

- One additional boiler;
- An additional digestion area (including high and low temperature components);
- Three new stationary calciners (to replace the existing rotary calciners);
- One additional hydrate vacuum system; and
- One solid-liquid calciner.

The fuel for the expanded refinery will continue to be fuel oil until supply of natural gas is secured. If there are delays in securing the gas supply, the refinery will continue to burn the currently used heavy fuel oil, in conjunction with a strategy of switching to a lower sulfur fuel oil (approx 1.5% sulfur) when winds are blowing towards populated areas.

It is acknowledged that there will be future occasions when gas is not available at the expanded refinery due to maintenance requirements on the gas pipeline. Under these circumstances it is proposed to burn an alternative fuel oil, which will be a higher quality than the fuel oil currently being used. The final specification of the alternative fuel has not yet been set but it is expected to be a light fuel oil with a sulfur content of 1% or less. The current expectation is that this fuel will be needed for approximately eight days per year when gas is not available.

8.5.2.2 Emissions from the Liquor Purification Process

The liquor purification process is a new process for Alcan Gove. As discussed in Section 4.4, the purpose of the liquor purification plant is to remove impurities from the liquor which will help maintain liquor productivity, improve flow capacity from reduced liquor viscosity, minimise the impact of scale, and enable improved recovery of soluble caustic.

In keeping with Alcan's policy on managing change in the workplace in a way that ensures full assessment of likely risks, the solid-liquid calciner used in the liquor purification process has been subject to pilot plant testing at a purpose built facility in Denmark. The test description and results are presented in the report " Emissions Test at Solid Liquid Calcination (SLC) Pilot Plant in Dania, Denmark" - dk Report 19292. The testing was performed over eight days in August 2003 in order to verify the emission levels for a wide range of pollutants.

The liquor purification process involves a number of stages. There is a mixing stage where spent liquor is mixed with the aluminium-rich component(s) followed by a drying stage. After that the dry slurry pellets are calcined, cooled and finally dissolved in refinery liquor. In the pilot plant, these three steps were tested and emissions from each component were measured and analysed.

The means by which emissions from this process are controlled are discussed in Section 4.4.4.

8.5.3 Emission Control

At the existing refinery, the following air emission controls are in place:

- Electrostatic precipitators on calciner stacks;
- Enclosed shiploading conveyors;
- 90 m stacks on the power station, 70 m stack on the stationary calciner, and 35 m stacks on the rotary calciners; and
- Exposed surface areas have been reduced and dust suppression water trucks are in use.

For the expanded refinery, the following air emission controls will apply:

- Conversion to natural gas will reduce combustion emissions of sulfur dioxide and particles dramatically. Alternatively the use of a fuel switching strategy will ensure emissions are lower when winds are blowing towards population centres.
- Fugitive dust to be controlled by:
  - Permanent road and carparks not currently sealed will be sealed
  - Fine water sprays to be used on new stockpiles, reclaimers and stackers when ore is dry
  - Conveyor transfer points to be enclosed and chutes to be designed to minimise dust generation
  - Conveyor loads to be covered where practicable
  - Shiploader to be upgraded
- Installation of 70 m stacks on the new calciners with use of the rotary calciners significantly reduced.
- Installation of particulate control equipment on the new calciners with a design capability of 50 mg/m^3 average performance.
- Installation of particulate controls at the following locations:
  - Lime plant
  - Air slides from new calciners
  - Air lifts to existing alumina silos
- Installation of 90 m stacks and low NO_x burner on new boiler/turbine unit at power station.
- Installation of ceramic filters on the liquor purification process with a design capability of 1 mg/m^3.
- Continued use of dust suppression water trucks.

8.5.4 Emission Rates

Emission rates have been determined for each of the significant emission sources at the existing refinery and from the expanded refinery, including the liquor purification process, based on:

- Direct measurements from the stacks taken in 2000 and 2003 (Environmental Consultancy Services, 2003);
- Calculation formulae accepted under the National Pollutant Inventory guidelines;
- Mass balances based on knowledge of process inputs, fuel quality and operating conditions;
- Direct measurement of pilot plant emissions for the liquor purification process; and
- Formulae published by the USEPA for fugitive dust emissions.

Boiler 6, which is currently under construction, was included in the existing refinery emissions in order to assess the air quality immediately prior to the expanded refinery commencing.

Table 8.5.1, which is based on these estimation techniques, shows a summary comparison of existing emission rates with the expected future emission rates and with the liquor purification emissions for normal operating conditions.

Table 8.5.1
Emissions from Existing Refinery, Expanded Refinery and Liquor Purification (g/s)

	Existing Refinery	Expanded Refinery (burning a combination of 1.5% S and 3.5% S fuel oil due to a gas delay)	Expanded Refinery (gas fired)	Expanded Refinery (burning 1% S fuel oil due to a gas interruption)	Liquor Purification Process
Carbon Monoxide	11.5	5.5	34.7	5.5	0.39
Sulfur Dioxide	943	1008	3.0	376	0.5
Nitrogen Dioxide	62.2	53	69.4	52.7	3.8
Lead	.003	.004	.0003	.004	.0001
Stack PM_{10}*	136	90.4	4.6	66	0.0
Fugitive PM_{10}*	96	89	89	89	NA

* *PM_{10} – small dust particles*

Table 8.5.1 demonstrates that:

- Emission rates will be approximately the same or lower if gas is delayed and a strategy of switching to lower sulfur fuel is adopted when the wind is unfavourable;
- There is a substantial reduction in emission rates for the expanded refinery when gas is the fuel, except for carbon monoxide;
- Emission rates will be reduced compared to current rates when there are short term interruptions to the gas supply due to issues such as pipeline maintenance; and
- Emissions rates from the liquor purification process are small compared to the overall emissions from the expanded refinery.

8.6 Air Dispersion Modelling

8.6.1 Model Descriptions

Air quality models have been used to combine the knowledge of the Gove meteorology as described in Section 8.3 with the refinery emissions in Sections 8.5 to predict the air quality impacts from the expanded refinery.

Three integrated air quality models have been used. The TAPM model is used to simulate on-site meteorological data to predict winds such as sea breezes and terrain induced airflows which are important to local scale air pollution. These data are used as inputs to CALMET, the meteorological pre-processor for the plume dispersion model CALPUFF. CALMET calculates three-dimensional meteorological information based upon a combination of observed and simulated ground level and upper level meteorological data. CALPUFF then calculates the dispersion of plumes within this three-dimensional meteorological field.

8.6.2 Model Validation

Atmospheric dispersion models are mathematical simulations of reality. Consequently, it is necessary to compare these simulations with reality in order to obtain some measure of model performance. Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations. Models are reasonably reliable for estimating the magnitude of highest concentrations occurring sometime, somewhere within an area.

Validation was performed by comparing measured hourly-average SO_2 data from the Gunyangara monitoring station for 16 January 2003 to 26 March 2003, with those predicted by the model.

A concentration frequency distribution plot is shown in Figure 8.6.1. Both modelled and observed concentrations have the highest frequency in the 0–20 μg/m^3 class range (96% for observed and 98% for modelled). In the > 21 μg/m^3 range, observed concentrations occur slightly more frequently than modelled, but the model over-predicts maximum concentrations.

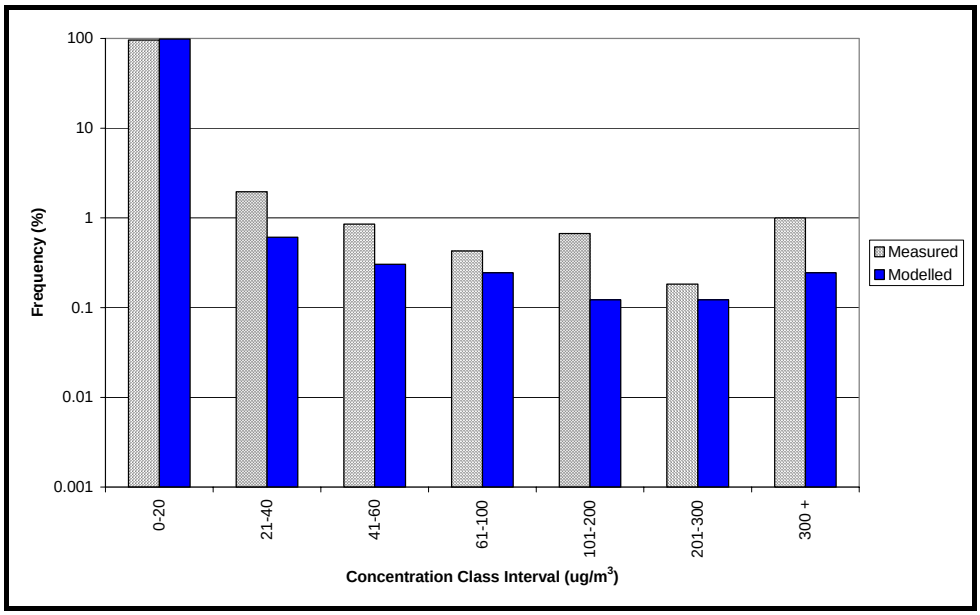


Figure 8.6.1
Comparison between observed and predicted concentrations of SO_2 at Gunyangara

Based on a number of statistical tests, the dispersion model generally predicts within acceptable limits (US-EPA, 2001) for SO_2. The main areas of uncertainty are associated with variations in SO_2 emission rates and details of the often complex meteorological conditions that occur in this coastal area, particularly under sea breeze conditions.

8.7 Results of Air Dispersion Modelling

For the purposes of analysing the results from the air dispersion modelling, six nearby receptors were chosen and the air quality was calculated at these points. The six chosen receptors are:

- Galupa, the nearest residential community (R1);
- The Yacht club, a recreational and accommodation area (R2);
- Gunyangara, a residential community (R3);
- Wallaby Beach, also a residential community (R4);
- Nhulunbuy, the nearest town (R5); and
- Western side of Melville Bay (R6).

As noted in Section 8.4, the air quality monitoring network at Gove is not sufficient to give an overall picture of existing air quality levels at the key community areas. Therefore the existing air quality was assessed by modelling the air emissions from the existing refinery. The future air quality was then predicted by modelling the air emissions from the expanded refinery.

Table 8.7.1 shows the results of the air quality modelling for the following scenarios:

- Existing refinery fired on 3.5% sulfur heavy fuel oil which is currently used.
- Expanded refinery fired on natural gas. This includes the use of 1% S fuel oil for approximately 8 days per year when gas supply could be interrupted. The short-term (1 hr, 8 hrs, 1 day) ground level concentrations given in Table 8.7.1 show the results from using the 1% S fuel oil. The long-term (1 yr) concentrations show the results from using gas.
- Expanded refinery fired on 3.5% sulfur fuel oil and using a fuel switching strategy when winds are blowing towards populated areas. This fuel switching strategy will be facilitated by the use of software that will enable switching to occur in advance when adverse wind conditions are predicted. Table 8.7.1 shows the expected air quality under these conditions, assuming low sulfur fuel oil (1.5% S) is fired during the wet season and the current fuel (3.5% S) is fired during the dry season.

Note that for the gas fired scenario, where the NEPM air quality goal involves comparison with short term one-hour concentrations, the concentrations used are based on the alternative fuel (1% S) being burned during a gas interruption.

Table 8.7.1

Comparison of Predicted Maximum Ground Level Concentrations with NEPM 10 year Air Quality Goals for Existing and Expanded Refinery

	Carbon Monoxide			**Nitrogen Dioxide**						**Sulfur Dioxide**								
NEPM Goal	8 hr av = 10,000µg/m^3, 1 exceedance/ yr allowed			1 hr av = 226 µg/m^3, 1 exceedance/yr allowed 1 yr av = 56 µg/m^3, no exceedances						1 hr av = 524 µg/m^3, 1 exceedance/yr allowed 1 day av = 210 µg/m^3, 1 exceedance/yr allowed 1 yr av = 52 µg/m^3, no exceedances								
Receptor	**Existing Refinery**	**Expanded Refinery Gas Fired**	**Expanded Refinery Oil Fired**	**Existing Refinery**		**Expanded Refinery Gas Fired**		**Expanded Refinery Oil Fired**		**Existing Refinery**			**Expanded Refinery Gas Fired**			**Expanded Refinery Oil Fired**		
				1 Hr	**1 Yr**	**1 Hr**	**1 Yr**	**1 Hr**	**1 Yr**	**1 Hr**	**1 Day**	**1 Yr**	**1 Hr**	**1 Day**	**1 Yr**	**1 Hr**	**1 Day**	**1 Yr**
Galupa	0.002	0.0005	0.0005	17	0.26	7.9	0.20	7.9	0.17	269	80.4	1.84	21.1	4.5	0.44	149	40.8	2.26
Yacht Club	0.001	0.0003	0.0003	15.4	0.09	10.7	0.06	10.7	0.05	121	45.1	0.65	24.3	7.4	0.11	68.7	18.5	0.61
Gunyangara	0 .003	0.0007	0.0007	41.3	0.47	20.9	0.27	20.9	0.16	372	149	4.41	230	37	0.16	350	59.6	2.03
Wallaby Beach	0.0007	0.0002	0.0002	13.2	0.02	6.1	0.02	6.1	0.02	115	26.5	0.16	41.3	7.9	0.03	72.4	18.8	0.25
Nhulunbuy	0.001	0.0002	0.0002	10.9	0.04	5.6	0.04	5.6	0.02	155	40.6	0.54	56.4	15.2	0.0	88.4	23.9	0.31
West Melville Bay	0.003	0.0005	0.0005	40.2	0.23	17.9	0.23	17.9	0.11	**577**	131	3.09	200	26.1	0.04	304	43.8	1.77

Table 8.7.1 Contd.
Comparison of Model results with NEPM 10 year Air Quality Goals for Existing and Expanded Refinery

	Lead			Small Dust Particles (PM_{10})		
NEPM Goal	1 yr av = 0.5 µg/m^3, no exceedances allowed			1 day av = 50 µg/m^3 , 5 exceedances / yr allowed		
Receptor	**Existing Refinery**	**Expanded Refinery Gas Fired**	**Expanded Refinery Oil Fired**	**Existing Refinery**	**Expanded Refinery Gas Fired**	**Expanded Refinery Oil Fired**
Galupa	0.0001	0.00009	0.00009	42.3	45	45
Yacht Club	0.00005	0.00004	0.00005	31.3	32.2	32
Gunyangara	0.00003	0.00001	0.00002	26.3	10.2	10
Wallaby Beach	0.00002	0.00002	0.00002	28.8	26.6	25.9
Nhulunbuy	0.000002	0.0000005	0.000003	4.0	1.6	0.6
West Melville Bay	0.00001	0.000002	0.00001	10.3	3.3	0.7

Table 8.7.1 shows that the NEPM goal is being met by the existing refinery with the exception of the one-hour SO_2 concentrations at West Melville Bay. In this instance, the predicted exceedence is minor (577 µg/m^3 compared to the goal of 524 µg/m^3). With the introduction of the switching strategy or the use of gas in the expanded refinery, the NEPM goal at West Melville Bay will be met.

At all receptors, the NEPM goals are met for the expanded refinery for all fuel scenarios.

8.8 Health Risk Assessment

An assessment of the potential health risk of a wider range of emissions from the expanded refinery on the surrounding population was also undertaken. The health risk assessment was undertaken by specialist consultants Toxikos (2004).

The risk assessment used a screening approach. It assess the risk for a person who is hypothetically subject to the highest exposure that is reasonably expected to occur at the nominated receptor locations (US EPA 1989). It has been performed by comparing predicted air quality with health based air guideline values for the individual emission components. The purpose of a screening risk assessment is to discover any potential problems that are worthy of further investigation. If the assessment discovers no problems then there is high certainty that the actual risk will be acceptable. The risk assessment methodology used was consistent with that recommended by the US EPA (1999a), Vic EPA (2001), and NEPC (1999)[1].

Ground level concentrations of between 60 and 98 different individual emission compounds were modelled for the following scenarios at each of the six nominated receptor locations (Section 8.7):

- Existing refinery;
- Expanded refinery burning gas and including liquor purification;
- Expanded refinery burning gas and excluding liquor purification;

[1] The NEPM methodology is written for contaminated land but contains the essential elements for conducting health risk assessments for airborne chemicals.

- Expanded refinery (including liquor purification) burning 1% sulfur fuel oil on one of the approximately eight days a year that the gas supply may be interrupted; and

- Expanded refinery (including liquor purification) burning 3.5% sulfur fuel oil and using a fuel switching strategy (1.5% sulfur) when winds are blowing in the direction of the surrounding communities.

Liquor purification received close attention because it is a new process for Alcan with the potential to change the mix of atmospheric emissions. As discussed in Section 8.5.2.2, the assessment included pilot plant testing at a purpose-built facility in Denmark. All potentially hazardous emissions from this plant were sampled and analysed. These measured emissions were used in the air dispersion model (Section 8.6) to calculate ground level concentrations to be included in the health risk assessment.

The modelled ground level concentrations were compared with acute and chronic health based guidelines that were sourced from regulatory agencies in Australia and overseas. They were also compared with acceptable irritation thresholds.

For substances that have potential to cause cancer, carcinogenic risk was calculated by multiplying the predicted annual average ground level concentration by the carcinogenic potency of the substance.

Conservatism (ie. safety) was built into the risk assessments in a number of ways, primarily by assuming 'worst case' exposure conditions. For example, when assessing potential acute health impact, the maximum one-hour average ground level concentration was used. This theoretical concentration is achieved for only one hour in the year, while all other concentrations are considerably less. The assumption of "additive risk" (ie. adding the risks from compounds that have different health effects and/or modes of biological action) is a further example of the safe approach taken during the assessment.

The assessment found that at all receptor locations there would be little likelihood of adverse acute or chronic health effects or irritation. Furthermore, the calculated carcinogenic risks were all within or below the acceptable risk band used by regulatory agencies around the world.

8.9 Odour

To quantify the odour levels that provide reasonable protection against community odour annoyance, various regulatory authorities in Australia and elsewhere have developed standards. However, no widely accepted criteria have yet been developed for the assessment of odour impacts. This reflects the difficulties of odour sampling, measurement and modelling, combined with the lack of suitable data on odour levels associated with annoyance and complaints. Assessment criteria have changed substantially over the past decade in response to changes in the understanding of odour nuisance and odour quantification.

Odour emission rates used in dispersion modelling were determined after conducting odour sampling at the Alcan Gove facility in May 2003 by consultants The Odour Unit (2003). These emissions were scaled to account for the higher production rates of an expanded gas fired refinery. Allowance was also made for changes in process such as the change from fuel oil to gas which removes a source of sulfurous odour, and the conversion to high temperature digestion which potentially could result in more odour from that part of the process.

Emission estimation and dispersion modelling (Section 8.6) indicated that there is likely to be a slight increase in ground level odour concentrations at most of the nominated receptor locations from the expanded gas-fired refinery. Table 8.9.1 quantifies the predicted percentage increase in odour concentration at the six receptor locations.

Table 8.9.1
Percentage Increase in Odour Concentration at the Discrete Receptors

	Galupa	Yacht Club	Wallaby Beach	Gunyangara	Nhulunbuy	West Melville Bay
Highest odour concentration	0.1	1.4	0.0	0.1	31.5	20.2
Odour concentration which is the 40th highest	0.1	0.2	4.6	1.5	10.0	14.4
Odour concentration which is the 400th highest	0.3	7.6	-5.2	0.0	0.0	100.0

The above predicted percentage changes in odour concentration are generally small. In some cases (Nhulunbuy and West Melville Bay) where the percentage increase is predicted to be relatively high, the actual odour concentrations are low and are unlikely to be noticed except perhaps in extreme situations. Overall, odour levels will be perceived as similar to the present on the basis of these results. This is because the human response to odour is logarithmic, and the perceived odour strength (known as the odour intensity) does not change at the same rate as the actual odour concentration. This means that a significant change in the odour intensity requires a large change in odour concentration. For most odours, the relationship between odour intensity and concentration suggests that a change of at least 30-50% in concentration is necessary to produce a clearly perceptible change in intensity. The results in Table 8.9.1 indicate that the change in odour exposure is unlikely to be noticeable.

8.10 Ozone

Photochemical smog is produced in the lower atmosphere by reactions between oxides of nitrogen and a group of reactive organic gases in the presence of sunlight. Ozone is a highly oxidising gas formed in urban areas as a product of photochemical smog formation, and is a key indicator of the formation of photochemical oxidants, which can adversely affect human health, as well as other life forms and non-living materials. Ozone is the primary component of photochemical smog.

The following conditions are required for the formation of photochemical smog:

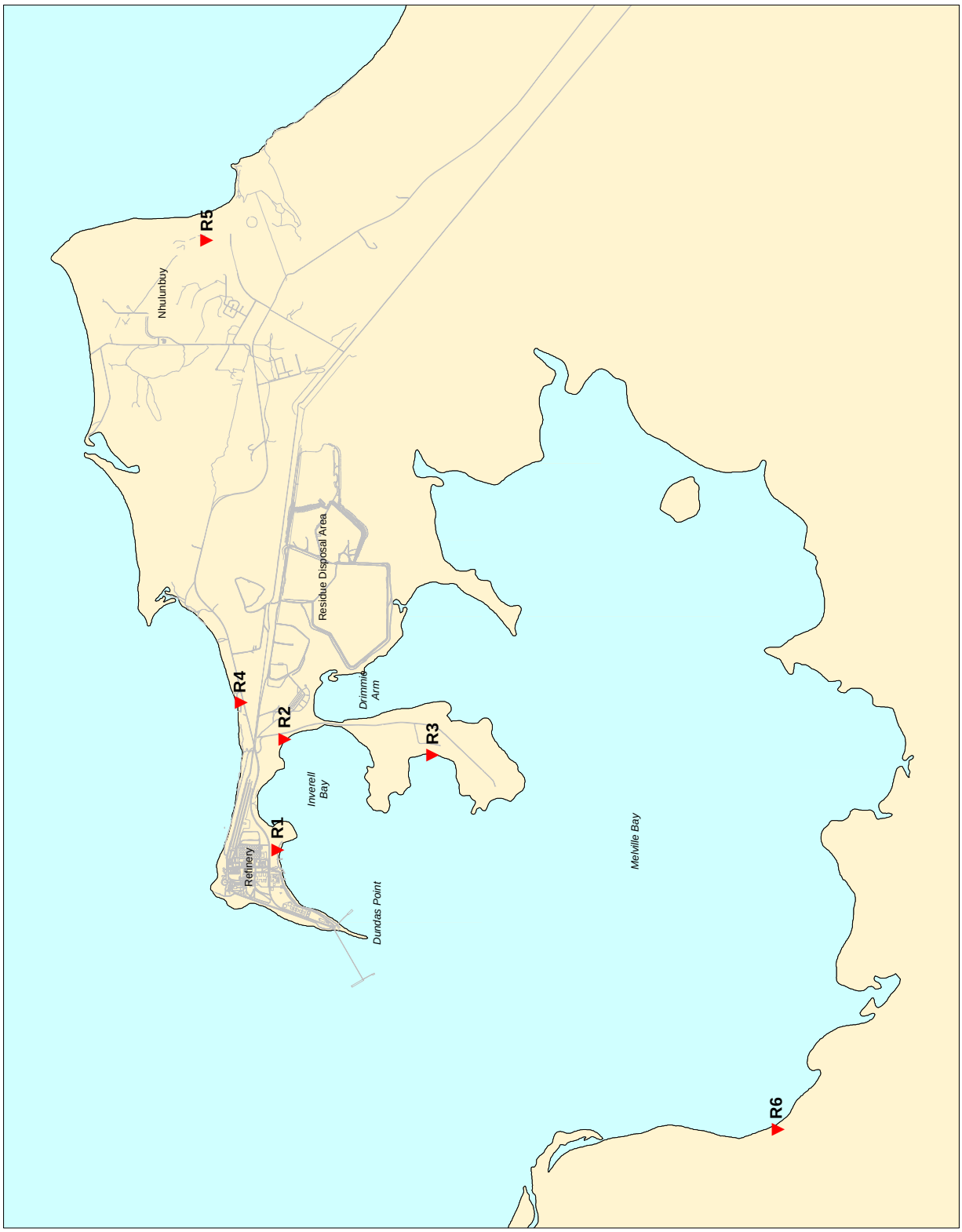
- A large source of volatile organic components (typically a large motor vehicle pool, or a large oil refinery);
- A large source of nitrogen oxides (typically several large power stations, or a large motor vehicle pool);
- Relatively high temperatures;
- Relatively high solar radiation;
- Poor atmospheric mixing.

Photochemical smog and ozone are not an issue for either the existing or expanded refinery for the following reasons:

- Atmospheric mixing at the Gove Peninsula is rapid;
- There is no major source of the required volatile organic carbon species; and
- There are only relatively minor sources of oxides of nitrogen (the steam power station and the calciners).

8.11 Air Quality Management

Strategies for the management and monitoring of air quality effects for both construction and operations are outlined in the strategic management plan given in Section 25.



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ALCAN GOVE REFINERY EXPANSION
ENVIRONMENTAL IMAPCT STUDY

AIR QUALITY
RECEPTOR LOCATIONS

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Figure: **8.7.1**