Technical Appendix B1

Air Quality Assessment

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The Gorgon Gas Development

AIR QUALITY ASSESSMENT

TECHNICAL APPENDIX B1

Prepared for

Chevron Texaco Australia Pty Ltd

The Gorgon Gas Development

AIR QUALITY ASSESSMENT

Prepared for

Chevron Texaco Australia Pty Ltd

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1 Executive Summary

The Gorgon Venture proposes to develop the Gorgon gas fields. The Gorgon gas development proposal includes establishing a gas processing facility within a limited area of Barrow Island. Currently, two LNG trains are proposed, each with a production capacity of 5 Mtpa.

Atmospheric emissions from the LNG plant will vary depending on the operating and tanker loading conditions. These include normal plant operations, ship loading and non-routine operations such as plant start up, plant shutdown and emergency venting of the CO_2 gas stream.

Two different atmospheric dispersion models were used to assess the impacts. DISPMOD modelled near-field dispersion of combustion products, while TAPM was used to evaluate regional impacts in the form of photochemical smog and the local deposition of combustion products.

Results indicate that the proposed facility will increase NO_2 concentrations but these will remain well below the relevant NEPM standard of 120ppb across the island. From a regional perspective, although current industrial emissions on the Burrup Peninsula may give rise to relatively hight peak concentrations on rare occasions, the proposed LNG facility makes negligible impact on these peaks.

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2 Introduction

The proposed gas processing plant will be located at Town Point on the central-east coast of Barrow Island. The development of the gas processing facility would occur in different phases based on market demand. This has been assumed to be achieved via the construction of one LNG train with a nominal capacity of five million tonnes per annum and a second similar capacity train as soon as there is sufficient market demand (anticipated to be within a few years of the first train).

During operation of the LNG plant, atmospheric emissions of greenhouse gases and other combustion products will occur. Ozone depleting substances may also be released. These air emissions have potential global, regional and local impacts. For example global effects are caused by the accumulation of greenhouse gases and the depletion of ozone in the stratosphere. Regional impacts are those encountered from several kilometres to several hundred kilometres of the source. Potential regional impacts could be related to gases such as volatile organic compounds (VOCs) and NO_x that react at ground level or sea level to form ozone. Ground-level ozone does not replace the ozone depleted in the stratosphere, but remains in the stratosphere where it can contribute to health problems. Local effects are related to health effects, e.g. due to an increase in exposure within the LNG plant.

The Gorgon Venture is proposing to employ the latest production technology, resulting in reduced emissions over similar LNG facilities currently operating in Australia. Use of the latest technology has eliminated all emission sources except combustion of clean-burning natural gas. The principal emission from the plant will be NO_x. Consequently, an assessment of the likely impact on downwind nitrogen dioxide concentrations and potential photochemical smog has been conducted.

This report presents an estimate of the emissions from the LNG plant based on preliminary design information, and an assessment of the impact using atmospheric dispersion modelling. All combustion sources are assumed to have stack heights and emission velocities sufficient to prevent building wake effects. This requirement will be included in all relevant design specifications.

The report is divided into three sections as follows:

- Section 3 describes the likely emissions from the facility;
- Section 4 presents the relevant air quality criteria;
- Section 5 presents the atmospheric dispersion modelling results.

As requested by the Department of Environment, the modelling study predicts concentrations from existing sources in the area and the contribution from the proposal. Regional impacts are also addressed. Non-routine operating conditions are also considered, including start-ups, emergency flaring and venting due to failure of CO_2 re-injection system.

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3 Emissions to Atmosphere

A full description of the gas processing facility is provided in the EIS/ERMP. Only a summary is presented in this document.

The gas processing facility would separate gas and condensate (light oil) received from the Gorgon gas fields. After separation from the gas, the condensate will be stabilised prior to shipping to market. The gas component of the stream will then be treated to remove carbon dioxide (CO_2), hydrogen sulphide (H_2S), trace amounts of mercury (Hg) and water vapour. At this point the gas can be either liquefied for export as LNG, compressed and exported as domestic gas or utilised as feed gas other gas processing facilities.

Atmospheric emissions from the LNG plant will vary depending on the operating and tanker loading conditions. These include normal plant operations, ship loading and non-routine operations such as plant start up, plant shutdown and emergency venting of the CO_2 gas stream. It is expected however that normal conditions will predominate for the great majority of the time and will occur in excess of 92% of the time. For 30% of this time, plant operations will be accompanied by the loading of product onto LNG tankers. It is anticipated that the level of production may be reduced for 4 to 5 days per year, with another 22 days where the plant is shutdown for maintenance. Emergency operations may occur for up to 10 times per year. A shutdown will result in less than 1 hour of peak flaring, while start-up will be of approximately 6 hours duration.

3.1 Emissions from Normal Operation of LNG Plant

Combustion Products

The principal emissions from the LNG process arise from combustion of natural gas. The most significant products of gas combustion include: carbon dioxide (CO_2), oxides of nitrogen (NO_x) and carbon monoxide (CO) and unburnt hydrocarbons (VOCs). There may also be traces of particulate and sulphur dioxide (SO_2) but such emissions are generally considered negligible due to the firing of very low sulphur content natural gas in a controlled environment. NO_x will be the predominant pollutant.

Combustion sources from the 10 Mtpa LNG plant include:

- Power generation: 3 x Frame 9 gas turbines with dry low NO_x burners.
- Gas compressors: 4 x Frame 7 gas turbines with dry low NO_x burners powering direct drives with heat recovery steam generator to produce steam for steam drives.
- Package boilers: 2 x boilers raising the equivalent of 150 MW of steam.

Emissions of nitrogen dioxides would be minimised by the use of low-NO_x burners in all gas turbines. Emissions of sulphur oxides are expected to be low, as 75% of fuel gas would be sourced from treated "end-flash" gas that has negligible sulphur content. Initial sulphur levels in the raw feed gas would also be very low. Any hydrogen sulphide in the raw feed gas would be removed along with CO_2 in the "acid gas" removal process and re-injected into saline reservoirs 2000 m below Barrow Island. There would be no continuous hydrocarbon vents or emissions.

Table 3-1 lists the emissions produced from combustion during normal operation of the 10 mtpa LNG plant. The model input files presented in Appendix A give details of chimney heights and exhaust conditions.

Table 3-1 Combustion Emissions during Normal Operations

Source	Emissions			
	NO_X		Particulate	
	(kg/hr)	(tpa)	(kg/hr)	(tpa)
Frame 9 gas turbines	190	1700	12	105
Frame 7 gas turbines	240	2100	10	80
Boilers	70	630	7	56
Total	**500**	**4430**	**29**	**241**

Non-combustion Products

Major sources of potential fugitive emissions include volatilisation from storage and loading of products, compressor seals and component leaks (e.g., valves, flanges and pumps). The use of latest engineering practices has significantly reduced the level of fugitive emissions from gas plants. Historically, compressor seals have been a significant source of fugitive emissions from gas processing facilities. The proposed Gorgon gas development would utilise dry compressor seals that virtually eliminate fugitive emissions from this source. Vapour recovery on storage and loading facilities would be utilised where practicable. Selection of equipment would include consideration of the potential for fugitive emissions.

Typically almost all of the emissions from an LNG plant occur from the CO_2 removal process. The Gorgon Joint Venture has implemented several strategies to virtually eliminate BTEX emissions from the gas development. Gorgon has approached this issue in three ways:

- Re-injection of CO_2 and associated traces of BTEX and H_2S
- Use of a MDEA solvent to minimise the removal of BTEX from the gas stream
- Hydrocarbons from the CO_2 waste stream are recovered and sent back into the process or used as fuel gas.

Under normal operations there will be no emissions due to the CO_2 removal process. The only other potential source of BTEX from the facility is from the regeneration of MEG and TEG. In both these cases a similar regeneration process is used with the BTEX rich flash gases being recovered back to the process.

The proposal will include two 135 000 m^3 LNG storage tanks. The tanks will include both a double containment system and a vapour recovery system. Any LNG boil off gas will be captured and returned to the LNG plant as fuel gas for the turbines.

There will also be two 35 000 m^3 condensate storage tanks, which will have internal floating roofs to minimise fugitive emissions.

There will a vapour recovery system installed for the loading of LNG tankers. As with the storage tanks, any LNG boil off gas will be captured and returned to the LNG plant as fuel gas for the turbines. It is proposed to load condensate through the existing WA Oil tanker loading facility. This facility does not have a vapour recovery system, so there will be minor emissions of VOCs.

3.2 Emissions from Non-Routine Operation of LNG Plant

To minimise the risk to personnel and the plant in the event of process upsets, flaring will be used as a safety measure to release gases from high pressure vessels rather than venting. Gas processing facility flare systems collect and dispose of hydrocarbons released during start-up, shutdown, upset and emergency conditions. Where practicable and without compromising the safety of the plant and personnel, all significant continuous flaring or venting sources will be eliminated.

Emissions from flaring will occur due to emergencies, process upsets, plant start-up and plant shutdown. The design will incorporate a high efficiency flare to minimise the portion of unburnt hydrocarbon to as low as reasonably practicable. The height of the flare will depend on the final facility layout and flare structure location, but is expected to be approximately 120 m.

It is expected that the LNG plant will be shut down for sufficient time to require a cold start on up to ten occasions per year. Each start up will be of approximately 6 hours duration, during which time scrub overheads, which represent 30% of the normal flow rate of a single train, will be directed to the dry gas flare. Maximum emissions from the flare include up to 420 kg/hr of particulate matter and 25 kg/hr of oxides of nitrogen. Peak emissions are unlikely to remain at the full maximum for the full duration of the start-up process.

During a cold start power will be supplied by a 5 MW diesel generator, which could discharge approximately 75 kg/hr of oxides of nitrogen. The only appreciable emissions of SO_2 will occur from operation of the diesel generator where a maximum emission of 3.6 kg/hr may occur.

Shutdowns of the LNG plant could take several forms. They could be required for a planned maintenance program, in which case there will be the opportunity to minimise emissions. Alternatively, there could be an emergency shutdown of both trains, requiring release of the total plant inventory of LNG, feed gas etc. In either case, gases will be released via both wet and dry flares. It is anticipated that such emergency situations will occur less than ten times per year and be of less than one hour peak flaring. The total design capacity of the two flares is 4200 t/hr and this will represent a worst case event. Maximum emissions from the two flares include up to 2500 kg/hr of particulate matter and 160 kg/hr of oxides of nitrogen.

It is proposed to re-inject reservoir carbon dioxide into saline reservoirs beneath Barrow Island. Emergencies may occur, for example failure of the CO_2 compressor unit, whereby the re-injection system is not available. In this event, it will be necessary to vent CO_2 from both trains to the atmosphere. As H_2S is also present in the feed gas, it will be released with the CO_2. It is estimated that approximately 100 kg/hr of uncombusted H_2S will be vented with the CO_2. The LNG plant will continue to operate normally whilst venting of the CO_2 and H_2S occurs. Therefore, the emissions of these two gases will be the same as for that described for "normal operations".

Table 3-2 gives a summary of emissions resulting from non-routine operation of the LNG plant.

Table 3-2 Emissions from Non-routine Operation of LNG Plant.

Operating Scenario	Emissions			
	NO_x (kg/hr)	H_2S (kg/hr)	SO_2 (kg/hr)	Particulate (kg/hr)
Shutdown Emissions are for worst case, emergency shut down of both trains	160	0	0	2 500
Start-Up For both trains	378	0	3.6	440
Failure of CO_2 Re-Injection System	500	100	< 1	29

3.3 Existing Emission Sources

Local Emissions

Current atmospheric emissions on Barrow Island are associated with existing oil field operations and include emissions from diesel and gas engines, the local power station, ground based flare and crude oil storage and transport.

The Central Power Station which consists of 2 x 2.5 MW gas turbines fuelled by low pressure gas supply, is currently the main source of power generation for Barrow Island. Products of combustion are the most significant emissions from the turbines, with oxides of nitrogen being the predominant pollutant.

A summary of current atmospheric emissions is presented in Table 3-3.

Table 3-3 Current Annual Atmospheric Emissions from Barrow Island (from Barrow Island Annual Environmental Report, 2003).

Source Description	SO_x (tonne)	NO_x (tonne)	VOC (tonne)	CO (tonne)
Diesel Engines	3	-	-	-
Barrow Island Power Station	-	927	23	736
Barrow Island Well field Operations	-	638	19	582
Crude oil transport and storage	-	-	33	-
Flare	26	31	246	169
Flashing	-	-	18	-
Venting	-	-	502	-
Fugitive Emissions	-	-	544	-
Total	**29**	**1 596**	**1 385**	**1 487**

Regional Emissions

At the time of writing, the existing industrial activities that emit significant quantities of related contaminants to the proposed LNG plant include:

- The Woodside onshore gas treatment facility on the Burrup Peninsula including the domestic gas plant, LNG and LPG facilities;
- Hamersley Iron's power station at Parker Point near Dampier.

Woodside is also currently constructing Train 4 for their existing facility.

Table 3-4 lists emissions from these sources and compares them with the proposed LNG plant under normal operations.

Table 3-4 Regional Industry Emissions as modelled.

Source	Emissions (kg/hr)	
	NO_x as NO_2	VOC
Dampier Power Station	76	0
Woodside Facilities (with Trains 4 and 5)	911	4 752

As part of the assessment of regional photochemical reactions, it is necessary to also account for both biogenic and area source emissions from the general area. A recent study of the Pilbara region undertaken by CSIRO Atmospheric Research and the

Department of Environmental Protection (CSIRO, DEP 2001) has evaluated these emissions with respect to determining appropriate dispersion models for the region. The relevant data input files for TAPM used were provided by the CSIRO.

4 Air Quality Criteria

Within Western Australia, the Environmental Protection Authority (EPA) assesses any new project in terms of emissions at stack and the resultant ambient ground level concentrations.

4.1 Emission Standards and Limits

For emissions from industrial sources, the EPA requires that "all reasonable and practicable means should be used to prevent and minimise the discharge of waste" (EPA, 1999a). For new assessments the EPA requires an assessment of the best available technologies for minimising the discharge of waste for the processes and justification for the adopted technology.

The EPA has developed a guidance statement for oxides of nitrogen emissions from gas turbines, with limits for emissions following the AEC/NHMRC National Guidelines (EPA, 2000). These limits are 0.07 g/m^3 (STP, dry and 15% O_2) for gaseous fuels" and 0.15 g/m^3 for "other fuels". The Guidance Statement goes on to say that modern natural gas-fired systems, employing NO_x control technology can be expected to achieve lower emissions than 0.07 g/m^3.

4.2 Ambient Air Quality Standards

For ambient ground level concentrations, the EPA does not have state-wide standards. For these, the EPA requires that pollutants meet the National Environmental Protection Measure (NEPM) standards (NEPC, 1998) as listed below in Table 4-1. These specify a maximum concentration and the goal that is to be achieved within 10 years.

Table 4-1 Relevant Environmental Protection Measures – Standards and Goals.

Pollutant	Averaging Period	Maximum Concentration	Goals within 10 years Maximum allowable exceedences
Nitrogen Dioxide	1 hour 1 year	0.12 ppm (246 μm/m^3) 0.03 ppm (62 μm/m^3)	1 day per year
Photochemical oxidants (as ozone)	1 hour 4 hours	0.10 ppm (214 μm/m^3) 0.08 ppm (171 μm/m^3)	1 day per year 1 day per year
Sulphur dioxide	1 hour 1 day 1 year	0.20 ppm 0.08 ppm 0.02 ppm	1 day per year 1 day per year none
Particles as PM10	1 day	50 μg/m^3	5 days a year

These NEPM standards and goals have not been implemented in legislation throughout the state as yet, the DoE intend to implement them through the development of a state-wide Environmental Protection Policy (EPA, 1999b). Throughout Western Australia, these standards apply outside industrial areas and residence free buffer areas around industrial estates" (EPA, 1999b, pp3).

For other pollutants, the DoE tends to reference the lowest standards that are in use throughout Australia. For this plant, the only other pollutant of concern is hydrogen sulphide. For this project the Victorian State Environmental Protection Policy (Victorian Government Gazette, 2001) design ground level concentration of 470 $\mu g/m^3$ (0.32 ppm) for a 3-minute average has been adopted. This concentration corresponds to the toxicity level, it is likely that odour from the gas will be detected at a much lower concentration.

These standards apply outside industrial areas and residence-free buffer areas around industrial estates. With no formally defined industrial buffer zone applied to Barrow Island, we have elected to apply the NEPM at the nearest permanent residence, namely the current ChevronTexaco accommodation facility.

5 Atmospheric Dispersion Modelling

5.1 Important Dispersion Processes

For pollutants released in near coastal environments the following four dispersion processes are considered important:

- Dispersion under convective conditions when the buoyant plumes can be mixed to ground level within a short distance of the stacks;
- The influence of the sea breeze with the creation of the Thermal Internal Boundary layer (TIBL) where onshore winds can lead to complex vertical dispersion. For onshore flows during the day time, the relatively cooler, stable onshore air will be warmed by the heated land surface. As such, a region of unstable convective turbulence (the TIBL) will grow with distance downwind. For tall stacks sited at the coast or very buoyant plumes, the plumes will rise above the TIBL and initially be relatively concentrated, not having had an opportunity to disperse. Further inland when the TIBL has grown to the height of these plumes, the plumes will then undergo rapid vertical mixing resulting in relatively high ground level concentrations. Alternatively plumes from short stacks and/or low buoyancy plumes will remain trapped beneath the TIBL resulting in higher ground level concentrations than would otherwise occur;
- The influence of the buildings and structures around facilities that may lead to increased dispersion and reduced plume rise from the stacks; and
- The presence of terrain features like hills and ridges in the surrounding area can impact on dispersion and be subject to elevated concentrations.

To assess all four processes, two models CALPUFF and TAPM are available. CALPUFF (Californian Puff model) performs well under convective conditions, allows for puffs to drift in light winds or to be recirculated and can cover both local and regional scales. However, CALPUFF has not been used in this study due to the long run times and the complexities involved in establishing a suitable meteorological file. TAPM is a 3-dimensional prognostic model that predicts both meteorology and dispersion of air pollutants including the chemical transformations involved in the production of ozone (EPA, 2004). TAPM is limited by the resolution of the grid and it is recommended that alternative models be used to predict near source ground level concentrations. TAPM has been used in this assessment to model:

- Regional impacts (ozone);
- Determine dry deposition rates; and
- Determine if building wakes will increase dispersion and reduce plume rise from the stacks.

To predict local air quality impacts from existing and future industries in this study, DISPMOD, the Western Australian Department of Environmental Protection (WA DEP) dispersion model was used. DISPMOD was specifically developed to model dispersion in coastal regions and under convective conditions.

5.2 DISPMOD

DISPMOD is primarily suitable for near field predictions, particularly for non-reactive gases and is the recommended model for predictions within 2 to 3 km of a source. In general, it appears that this model is likely to over-predict concentrations but it has limitations in areas where fumigation of recirculated emissions are involved, or where area sources contribute to background emissions. DISPMOD was used for this project to predict concentrations of NO_x, SO_2, H_2S and particulates for the proposed plant over a 5.5 by 8.5-km receptor grid.

The model used the following parameters:

- Dispersion in the layer above the TIBL governed by plume self generated turbulence;
- Account for wind shear in the new PDF model;
- Numerical model to predict TIBL heights;
- Convective plume trapping cases to be modelled using the PDF approach; and
- Coastal file developed from the 1:100,000 Barrow Island topographical map.

TAPM ver2.5 (The Air Pollution Model) was used to obtain both the hourly surface meteorological file and the upper air potential temperature lapse rate file required by DISPMOD. TAPM is a prognostic three-dimensional model designed by CSIRO that can used to predict meteorological and air pollution parameters on an hourly basis (Physick *et al* 2001). The meteorological parameters predicted by the model have been compared to actual readings recorded during the Kwinana Coastal Fumigation study (Hurley *et al* 2000) and the Pilbara air quality study (Physick *et al* 2001). It was found that the model predicts near-surface parameters very well while the upper parameters were also well predicted. An observed file containing hourly wind speed and direction for the year 2003 from the Bureau of Meteorology station at the Barrow Island airstrip was used to 'force' the model.

The model was setup with the following parameters:

- Grid centre at 21°47'S and 115°27.5'E (339700E 7699950N);
- 30 km, 10 km, 3 km and 1 km grids nested at 21 x 21 x 20; and
- Elevation changed to agree with the 1:100,000 Barrow Island topographical map.

Maximum nitrogen dioxide concentrations were estimated from the DISPMOD simulations by assuming the following relationship for all parts of the grid:

$$NO_2 = 0.3NO_x + 14.39 \qquad \text{for } NO_x \geq 20\ .56\ \mu g/m^3$$

$$NO_2 = NO_x \qquad \text{for } NO_x < 20.56\ \mu g/m^3$$

This is based on monitoring data from Dampier, which shows the ratio of NO_2 to NOx to generally remain well below 0.3.

DISPMOD was used to model both normal and non-routine operations.

Appendix A gives examples of DISPMOD input files. All combustion sources are assumed to have stack heights and emission velocities sufficient to prevent building wake effects.

5.3 TAPM

Atmospheric Deposition on the Surrounding Environment

The deposition of atmospheric pollutants can occur through two mechanisms, these being wet and dry deposition. Wet deposition describes the deposition of acidic pollutants through rainfall, and is commonly referred at as "acid rain". Dry deposition refers to the fall-out of gases and particulates on the ground surface without any interaction with water. Dry deposition tends to occur close to the source of pollution, depending upon prevailing weather conditions, and dominates in dry climates (EPA, 2001). Dry deposition is expected to be the dominant mechanism on Barrow Island by which atmospheric pollutants are deposited on terrestrial and aquatic environments.

It is important to note that there are large uncertainties with the predicted deposition values predicted by TAPM. This uncertainty is present in all models that predict deposition due to the large uncertainty in the water, soil and vegetation surface resistances used. Extensive programs using both measurements and model calibration are necessary to reduce this uncertainty, and this will only reduce the uncertainty in that particular study area (Hurley et al, 2003). The deposition values presented in this report can only be considered 'indicative' of what may occur until measurements can be conducted to validate the model.

Regional Impacts

The impact of the operation of the LNG plant on regional air quality was investigated using TAPM to model photochemistry. The model was run using both existing sources and existing plus future on both Barrow Island and the Burrup Peninsula.

For this purpose, the model simulation was set up with the following parameters:

- Grid centre at 21°47'S and 115°27.5'E (339700E 7699950N);
- 30 km and 10 km grids nested at 31 x 31 x 20; and
- Biogenic and gridded inventory files obtained from the CSIRO (Hurley et al, 2003 and SKM 2003).

The existing sources on the Burrup Peninsula consisted of the Woodside Onshore Treatment plant and the Hamersley Iron power station adjacent to Dampier. The stack parameters and emission values were obtained from Hurley et al (2003). The stack parameters for the existing sources on Barrow Island were not available, therefore the stack parameters were taken as identical to a similar plant at the Woodside plant. NO_x and VOC emissions were obtained from the Barrow Island Annual Environmental Report 2003 (ChevronTexaco Australia Pty Ltd, 2003).

The stack and emission parameters for the future sources on the Burrup were also obtained from Hurley et al (2003) with the exception that Methanex, Dampier Nitrogen and GTL were not included as these projects are unlikely to proceed. The future sources on Barrow Island are identical to that used in the DISPMOD modelling for normal operations with the inclusion of a Rsmog emission rate of 0.4 g/s. Using a Rsmog of this rate is considered an over-estimate as the process is using the latest production technology that should reduce fugitive emissions of volatile organic compounds.

The stack and emission parameters are presented in Appendix A.

The same NO_x emissions data was used as for the DISPMOD normal operations run with a NO/NO_x ratio of 0.9 for all sources.

Part of a sample list file for TAPM is presented in Appendix A.

5.4 Modelling Results

Local Ground Level Concentration

Normal Operations

Figures 5-1 and 5-2 present the local distribution of the maximum NO_2 concentrations (ppm) for normal operations predicted using DISPMOD. The maximum 1-hour NO_2 concentration predicted over the entire grid is 0.06 ppm, compared to the NEPM value of 0.12 ppm. Similarly, the predicted maximum annual concentration of NO_2 is 0.003 ppm, which is approximately 10 times less than the NEPM value of 0.03 ppm. Maximum annual averages occur to the north east of the proposed LNG plant, reflecting the dominant south westerly winds.

Figure 5-3 presents the maximum predicted 24-hour PM10 concentrations ($\mu g/m^3$) for normal operations. The maximum predicted value of 3 $\mu g/m^3$ is approximately 6% of the corresponding NEPM value of 50 $\mu g/m^3$.

A summary of the maximum concentrations of the various pollutants for routine operations is presented in Table 5-1.

Non-Routine Operations

As described in Section 3-2, under non-routine operations, emissions from the flare and diesel generator will be much greater than under normal operations and potentially may lead to higher ground level concentrations. Dispersion modelling was conducted to predict the maximum concentrations of the various emissions resulting from the three non-routine operating scenarios; shutdown, start-up and failure of the CO_2 re-injection system. The modelling considered worst case emissions whereby both trains were considered to in operating in the non-routine mode.

Maximum predicted 1-hour concentrations of NO_2 resulting from a cold start of both trains of the LNG plant are presented in Figure 5-4. Maximum concentrations are predicted to be well below the corresponding NEPM standards. The only other emissions released during a cold start are small quantities of SO_2 (less than 5 g/s) and particulate matter. As expected the dispersion modelling predicted that the ground level concentrations of both emissions are well below the NEPM standards.

The only emissions due to an emergency flaring during shutdown are oxides of nitrogen and particulate matter. Maximum 1-hour concentrations of NO_2 resulting from an emergency shutdown of the LNG plant are presented in Figure 5-5. The maximum value of 0.049 μg/m^3 is less than 50% of the relevant NEPM standard. The predicted maximum 1-hour concentration of particulate during an emergency shutdown assuming that the flaring occurred at the worst case meteorological conditions is 4561 μg/m^3. This equates to a 24-hour average of approximately 200 μg/m^3. The maximum concentration occurs within the boundary of the plant. The peak concentrations decrease rapidly with distance from the plant, such that at the current ChevronTexaco accommodation camp the maximum 24-hour particulate concentration is estimated to be 30 μg/m^3, which is below the NEPM standard of 50 μg/m^3.

Maximum predicted 1-hour concentrations of NO_2 occurring during a failure of CO_2 re-injection system are the same as those presented in Figure 5-1. . The maximum 3-minute concentrations of H_2S generated by flaring due to failure of CO_2 re-injection system are presented in Figure 5-6. The maximum value of 113 μg/m^3 is less than a quarter of the Victorian EPA design ground level concentration of 470 μg/m^3.

A summary of the maximum concentrations of the various pollutants for non-routine operations is presented in Table 5.1.

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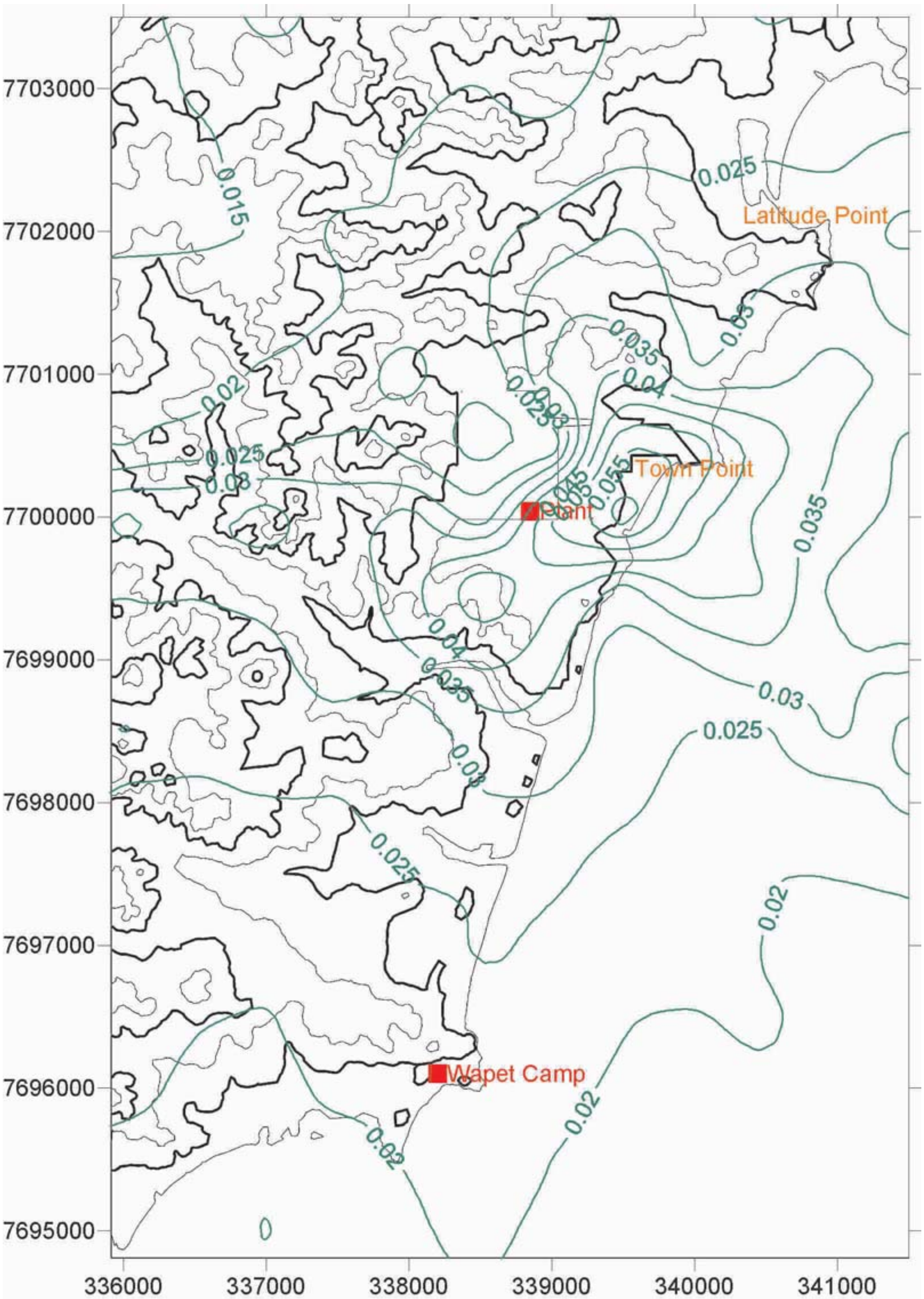

Figure 5-1 Maximum predicted 1-hour NO_2 concentrations (ppm) for proposed LNG plant under normal operation

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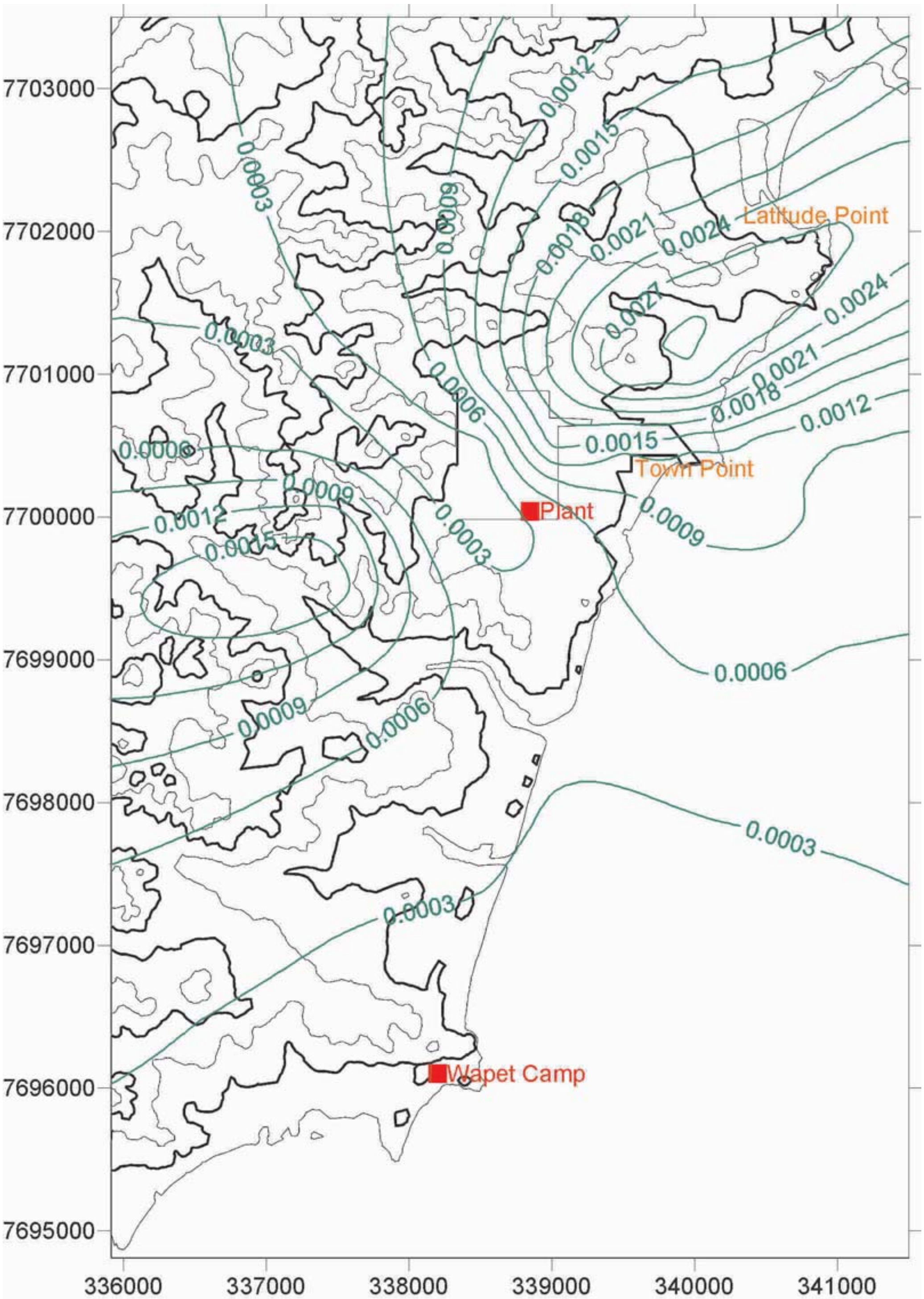

Figure 5-2 Maximum predicted annual NO_2 concentrations (ppm) for proposed LNG plant under normal operation

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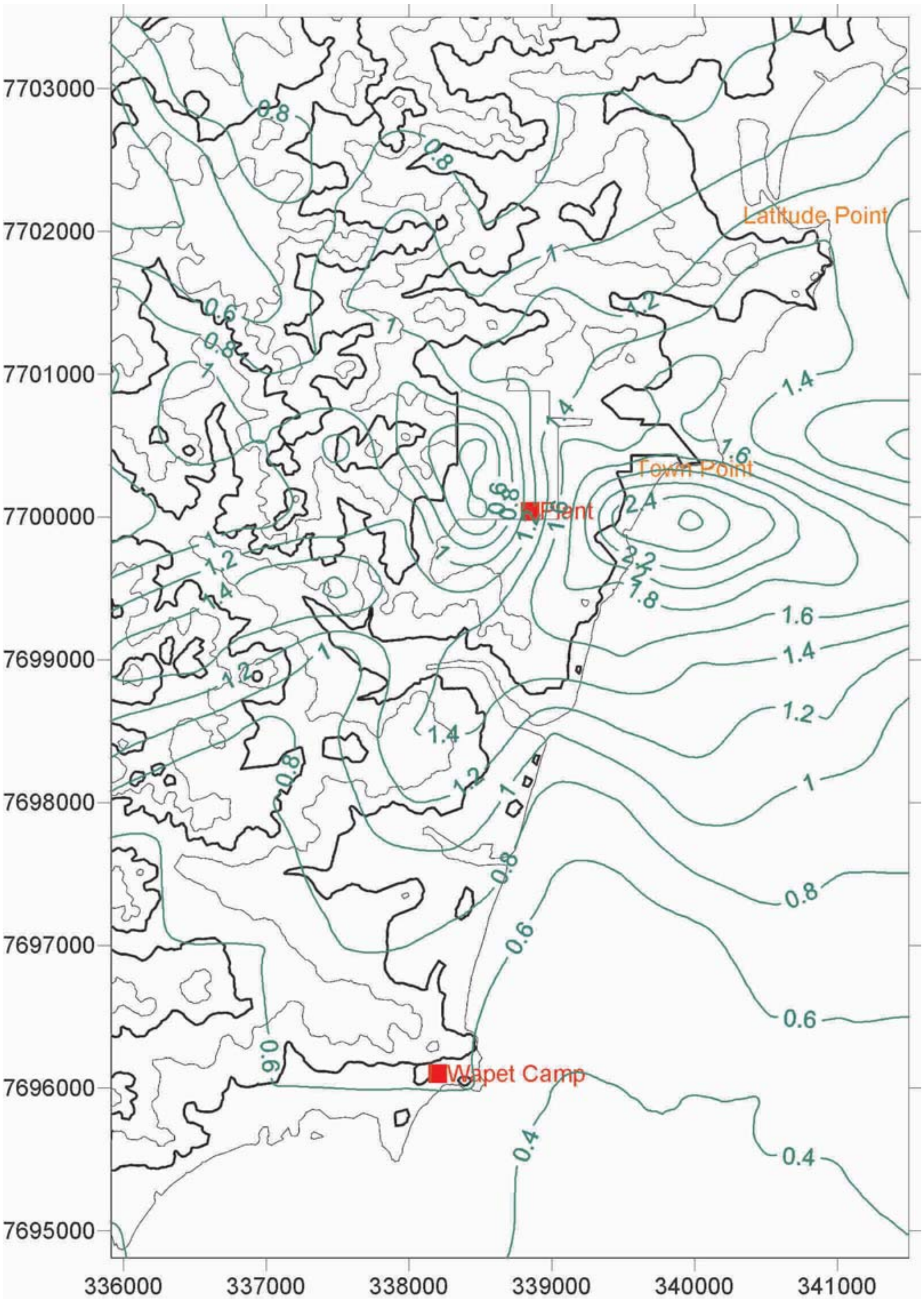

Figure 5-3 Maximum predicted 24-hour PM10 concentrations (μg/m^3) for proposed LNG plant under normal operation

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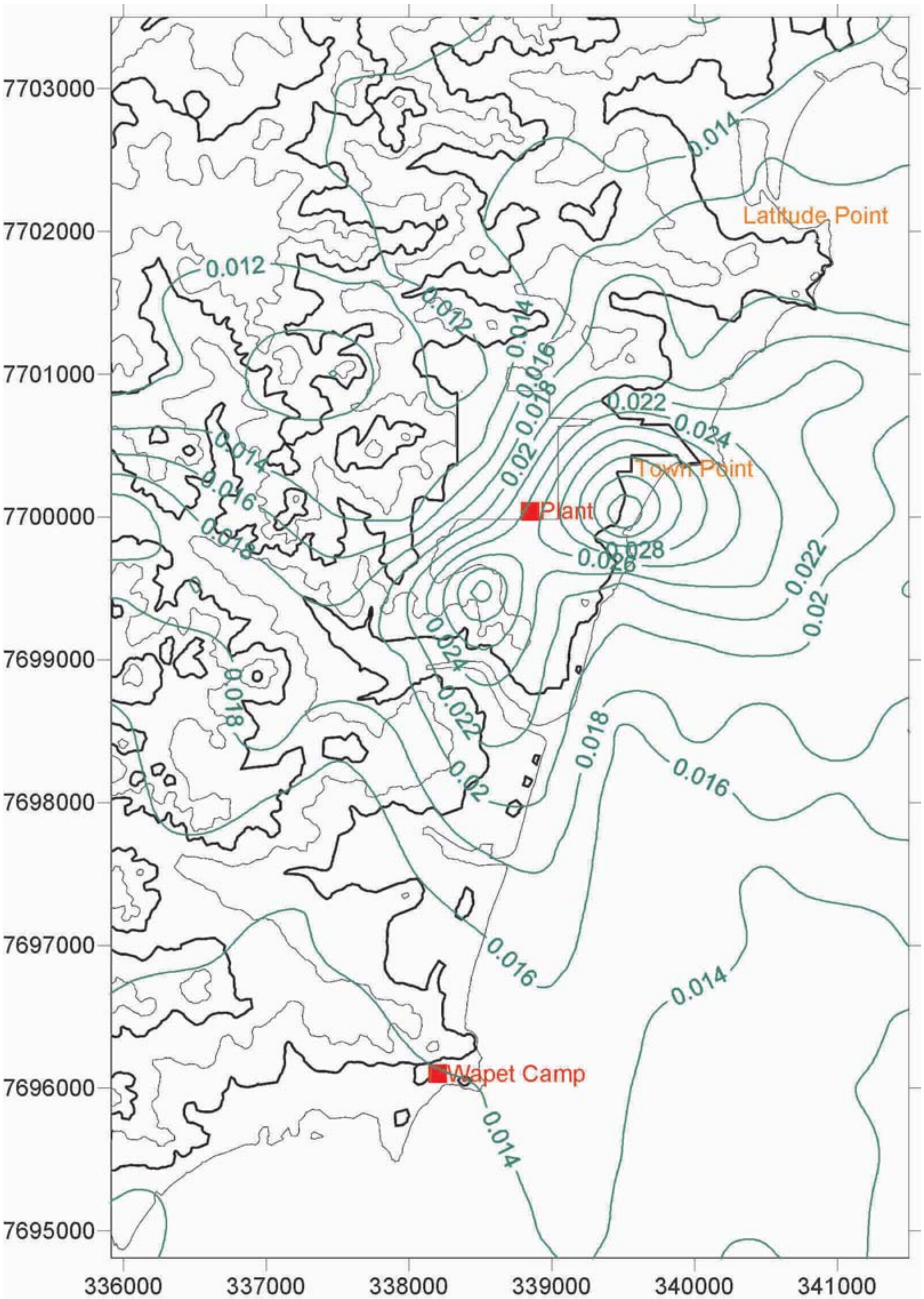

Figure 5-4 Maximum predicted 1-hour NO_2 concentrations (ppm) for proposed LNG plant under a cold start-up

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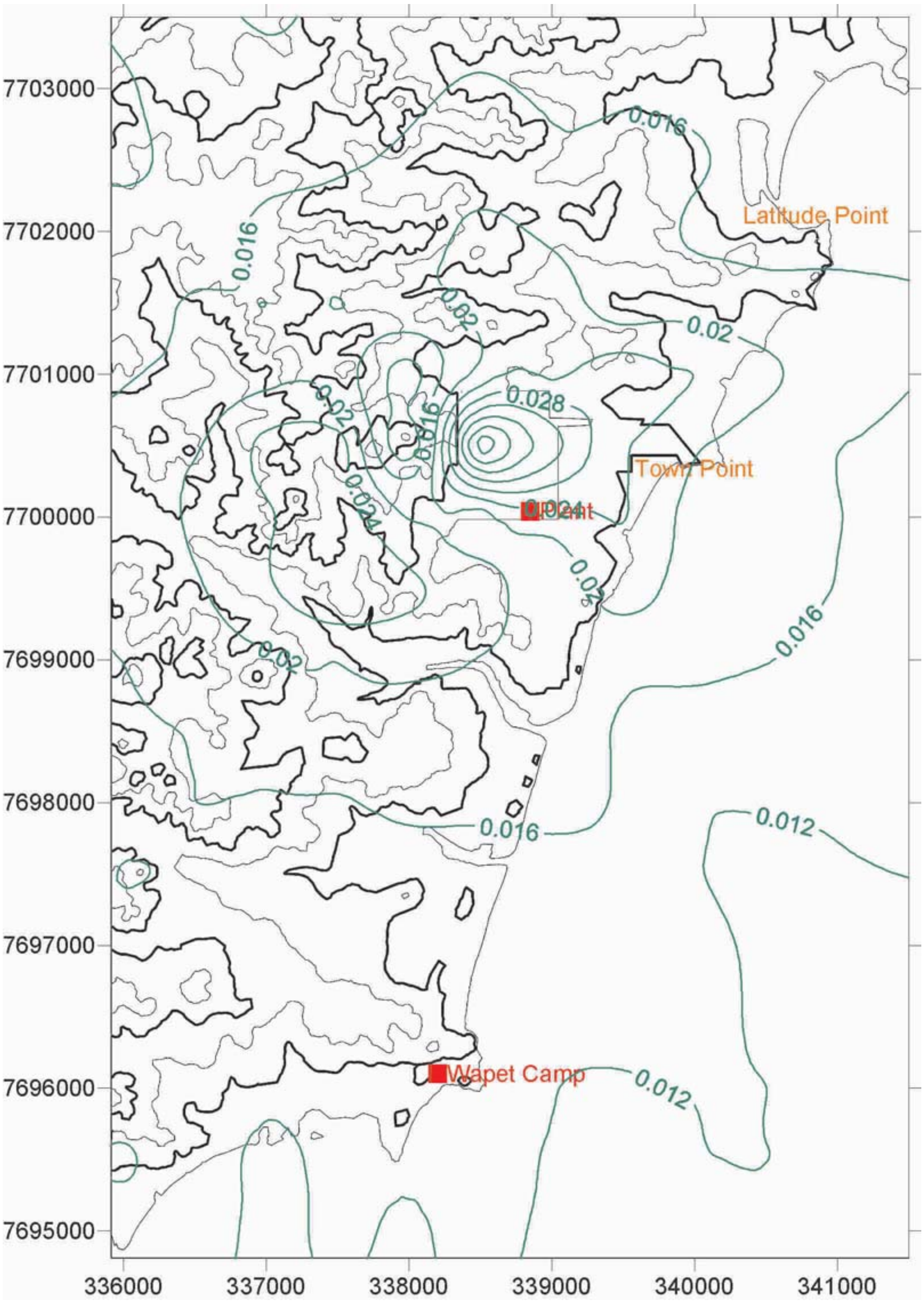

Figure 5-5 Maximum predicted 1-hour NO_2 concentrations (ppm) for proposed LNG plant resulting from an emergency shut-down

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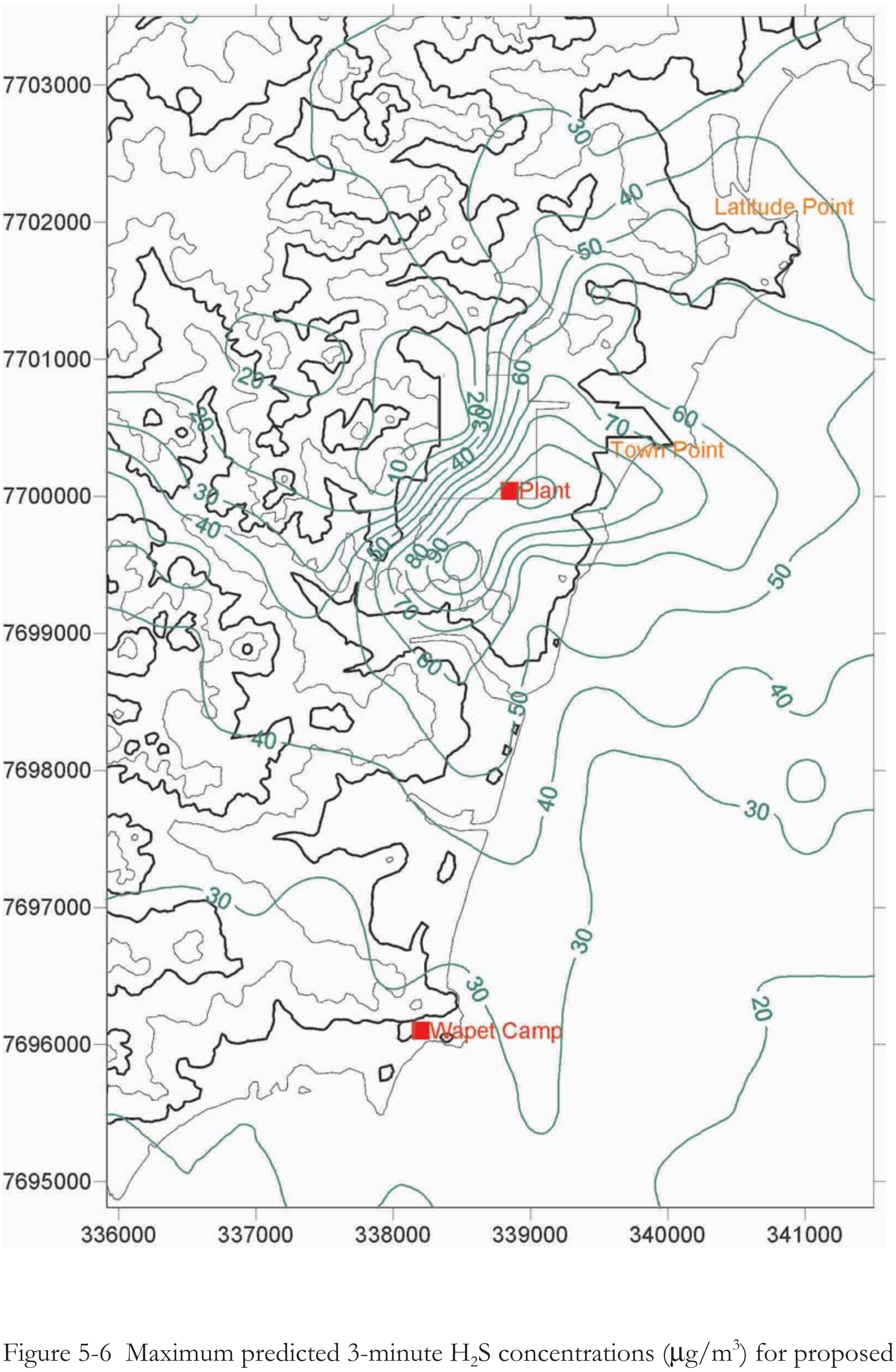

Figure 5-6 Maximum predicted 3-minute H_2S concentrations ($\mu g/m^3$) for proposed LNG plant generated by flaring due to failure of CO_2 re-injection system

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Table 5-1 Maximum ambient concentrations with low NO_x Burners for various Operating Scenarios.

Operating Scenario	**NO_x**		**NO_2**		**PM_{10}**	**H_2S**		**SO_2**	
	1-hour (ppm)	Annual (ppm)	1-hour (ppm)	Annual (ppm)	24-hour ($\mu g/m^3$)	3 minute ($\mu g/m^3$)	1-hour ($\mu g/m^3$)	1-hour (ppm)	24-hour (ppm)
Normal Operations	0.287	0.003	0.063	0.003	3	N/A	N/A	N/A	N/A
Start Up	0.150	N/A	0.037	N/A	54	N/A	N/A	0.001	N/A
Shutdown	0.212	N/A	0.049	N/A	330	N/A	N/A	N/A	N/A
Failure of CO_2 Re-injection system	0.293	N/A	0.064	N/A	3	113	62	N/A	N/A

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A summary of the maximum concentrations of the various pollutants for non-routine operations is presented in Table 5-1.

5.5 TAPM

Local Deposition Rates

The total dry deposition to the ground (vegetation, soil/rock and any water bodies) of NO_2 from TAPM are presented in Figure 5-7. The highest NO_2 deposition rates occur over water. This is considered to be primarily due to the deposition to vegetation being dependent on daylight and the photosynthesis process and that TAPM uses a moderately high solubility factor for NO_2; the maximum deposition rates are around 180 000 $\mu g/m^3$ (1.8 kg/ha/year).

Comparison to the WHO (2000) critical load for N deposition of 15-20 kg/ha/year for dry heathland, indicates that the deposition over land of between 0.2 to 1.8 $kgNO_2$/ha/year (0.06 to 0.55kgN/ha/year) is relatively insignificant (0.4-3.6% of the criteria).

Regional Impacts

Photochemical smog forms when pollutants such as nitrogen oxides and reactive organic compounds react together under the influence of sunlight and high temperature. The principal component of smog is ozone and consequently it is used to define smog levels. Ozone near the ground (as distinct from the "ozone layer" that occurs tens of kilometres up in the atmosphere) occurs typically in the range of 15 to 35 ppb and at such concentrations is a colourless gas. Ozone is a strong oxidant which reduces pulmonary function and can damage vegetation and susceptible materials at higher levels.

Figure 5-8 presents the peak TAPM predictions for existing sources. The 1-hour maximum concentrations of ozone are slightly higher than those predicted by the CSIRO in their Burrup modelling (0.087 ppm to 0.081 ppm). This is thought to be mainly due to the inclusion of emissions from Barrow Island. These emissions were based solely on information supplied by (WA Oil) and consisted only of total annual emissions of VOC and NO_x.

The maximum 1-hour concentrations of ozone (ppm) predicted for future operations are presented in Figure 5-9. The modelling considered emissions from the current WA Oil operations on Barrow Island, regional emissions (e.g. industrial plants currently in operation or under construction on the Burrup Peninsula) and the proposed Gorgon LNG plant.

With the inclusion of emissions from the proposed LNG facility, the maximum 1-hour ozone concentration (anywhere on the grid) increased slightly from 0.087 ppm to 0.092 ppm. There is little change over the existing scenario, apart from an increase in maximum ozone concentration to the south west of Barrow Island. The concentrations predicted for the Burrup Peninsula and Dampier/Karratha region exhibit very little, if any, change.

The maximum peak 1-hour ozone concentrations on the grid are predicted to be below the NEPM standard of 0.10 ppm. Thus, while the current and proposed emissions on the Burrup Peninsula may give rise to relatively high peak concentrations on rare occasions, the proposed LNG facility makes little impact on these peaks.

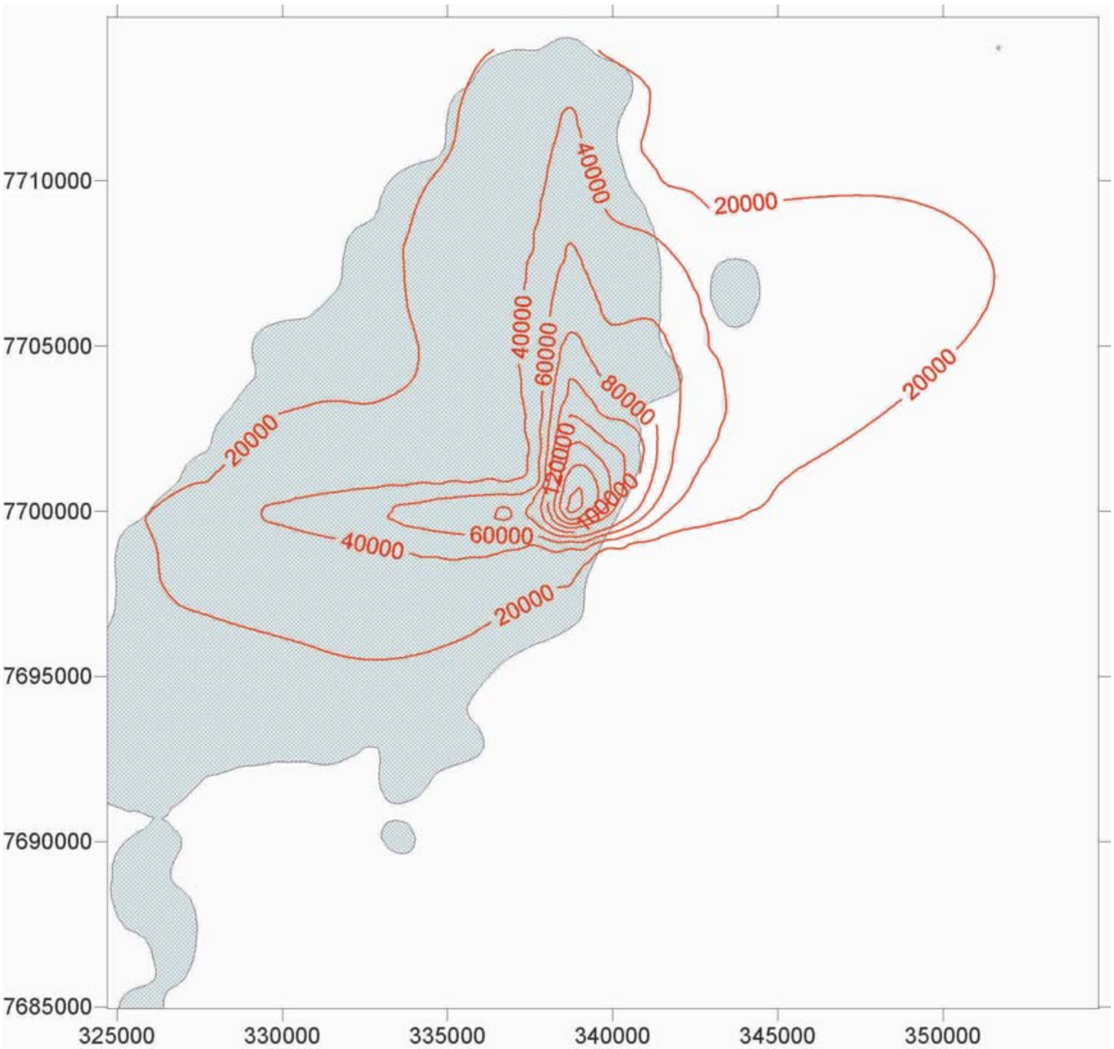

Figure 5-7 Annual dry NO_x deposition ($\mu g/m^2/yr$) for proposed LNG plant

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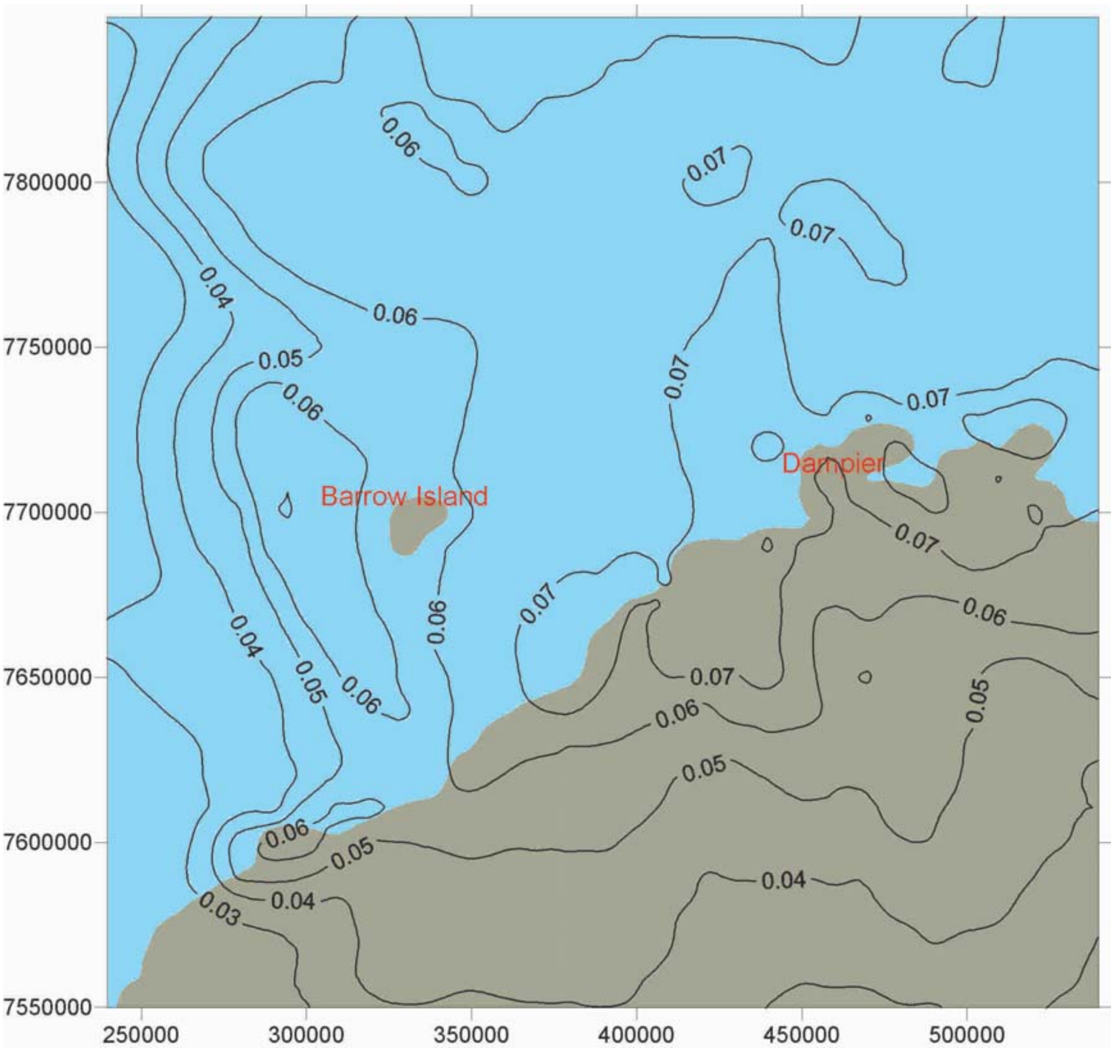

Figure 5-8 Maximum 1-hour ozone predictions using TAPM for existing emissions

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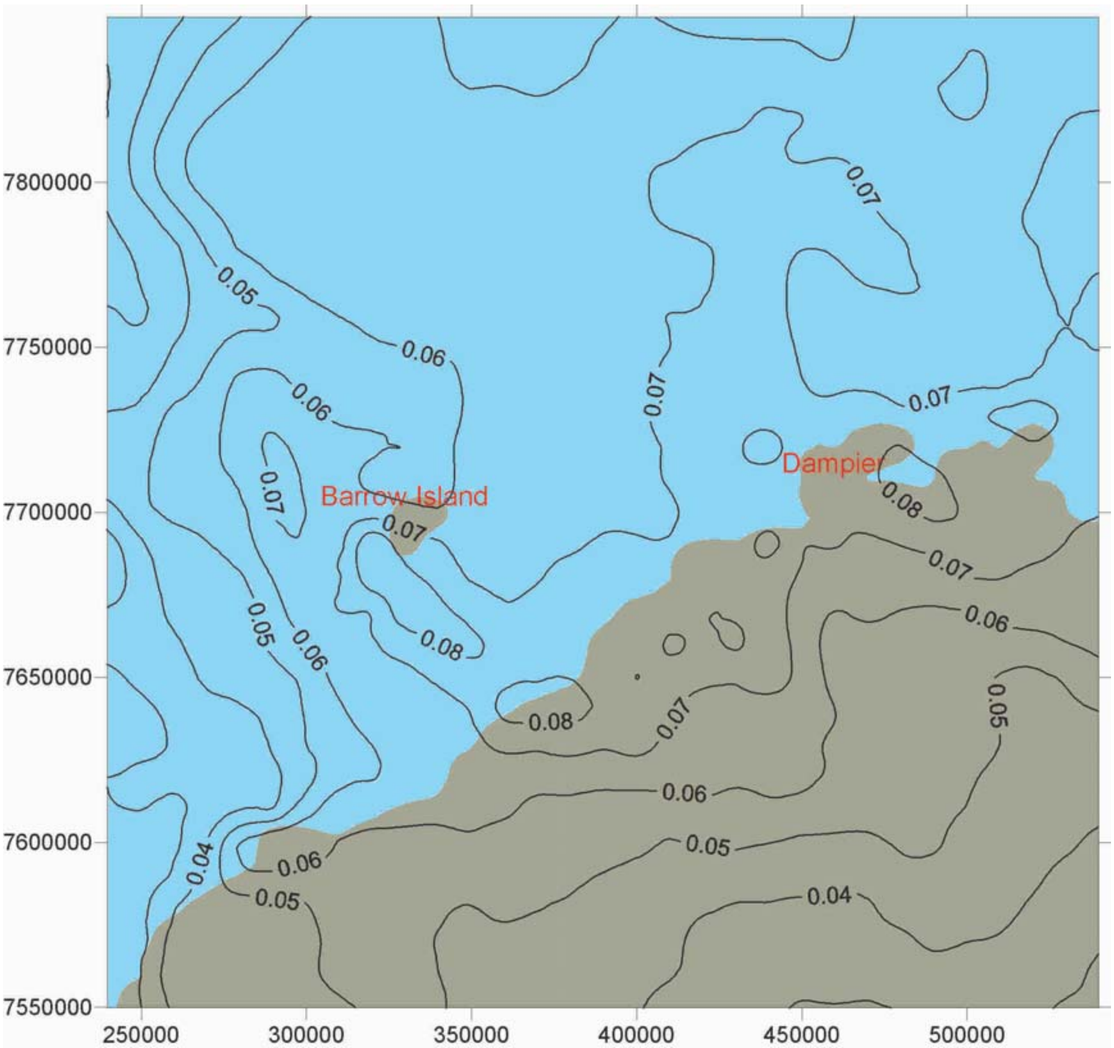

Figure 5-9 Maximum 1-hour ozone predictions using TAPM for existing and proposed LNG emissions

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6 References

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Appendix A Model Input Files

Existing Sources

Source	Location		Height	Radius	EF	Velocity	Temperature	PM10	NOx	SO2	Rsmog
	(Easting)	(Northing)	(m)	(m)		(m/s)	(K)	(g/s)	(g/s)	(g/s)	(g/s)
Woodside											
GT4001	476910	7722765	40	1.98	2.7	20.2	777	0	13.5	0.2	0
GT4002	476910	7722800	40	1.98	2.7	20.2	777	0	13.46	0.24	0
GT4003	476910	7722810	40	1.98	2.7	20.2	777	0	13.46	0.24	0
GT4004	476910	7722845	40	1.98	2.7	20.2	777	0	13.46	0.24	0
GT4005	476910	7722855	40	1.98	2.7	20.2	777	0	13.46	0.24	0
GT4006	476910	7722890	40	1.98	2.7	20.2	777	0	13.46	0.24	0
1KT1410	476540	7722965	40	1.94	2.1	23.9	790	0	15.8	0.3	0
1KT1420	476590	7722965	40	1.94	2.1	23.9	790	0	15.6	0.27	0
1KT1430	476610	7722965	40	1.87	2.1	25.8	790	0	15.3	0.27	0
1KT1440	476660	7722965	40	1.87	2.1	26.3	806	0	15.5	0.27	0.4
1KT1450	476510	7722960	40	1.36	2.1	21.2	784	0	9.4	0.1	0
2KT1410	476540	7722845	40	1.94	2.1	23.9	790	0	15.8	0.3	0
2KT1420	476590	7722845	40	1.94	2.1	23.9	790	0	15.6	0.27	0
2KT1430	476610	7722845	40	1.87	2.1	25.8	790	0	15.3	0.27	0
2KT1440	476660	7722845	40	1.87	2.1	26.3	806	0	15.5	0.27	0.4
2KT1450	476510	7722840	40	1.36	2.1	21.2	784	0	9.4	0.1	0
3KT1410	476540	7722610	40	1.94	2.1	23.9	790	0	15.8	0.3	0
3KT1420	476590	7722610	40	1.94	2.1	23.9	790	0	15.6	0.27	0
3KT1430	476610	7722610	40	1.87	2.1	25.8	790	0	15.3	0.27	0
3KT1440	476660	7722610	40	1.87	2.1	26.3	806	0	15.5	0.27	0.4
3KT1450	476510	7722605	40	1.36	2.1	21.2	784	0	9.4	0.1	0
1F2001	477152	7722915	33	0.73	1.7	6	700	0	0.3	0	0
2F2001	477152	7722905	33	0.73	1.7	6	700	0	0.3	0.01	0
3F2001	477152	7722895	33	0.73	1.7	6	700	0	0.3	0.01	0
4F2001	476968	7722880	33	0.73	1.7	6	700	0	0.3	0.01	0
5F2001	476968	7722870	33	0.73	1.7	6	700	0	0.3	0.01	0
1KT2420	477035	7722698	24	1	2.5	40.7	816	0	9.4	0.1	0
1KT2430	477050	7722698	24	1.45	2.5	30.6	620	0	20.3	0.2	0
2KT2420	477065	7722698	24	1	2.5	40.7	816	0	9.4	0.1	0
2KT2430	477080	7722698	24	1.45	2.5	30.6	620	0	20.3	0.2	0
SealOil	476500	7722500	20	1	1	0	400	0	0	0	0.1
Hamersley											
HAM_stack1	471500	7717000	60	1.3	1	7	393	0	5.7	1	0
HAM_stack2	471500	7717000	60	1.3	1	7	393	0	5.7	1	0
Barrow Island											
BI_GT1	332000	7697000	30	1.98	2.7	20.2	777	0	25.3	0.3	0
BI_GT2	332000	7697045	30	1.98	2.7	20.2	777	0	25.3	0.3	0
BI_OilSeal	331900	7697150	20	1	1	0	400	0	0	0	0.1
BI_Vent	332200	7697200	20	0.73	1.7	6	700	0	0	0	0.1

Future Sources

Source	Location		Height	Radius	EF	Velocity	Temperature	PM10	NOx	SO2	Rsmog
	(Easting)	(Northing)	(m)	(m)		(m/s)	(K)	(g/s)	(g/s)	(g/s)	(g/s)
Woodside											
GT4001	476910	7722765	40	1.98	2.7	20.2	777	0	13.5	0.2	0
GT4002	476910	7722800	40	1.98	2.7	20.2	777	0	13.46	0.24	0
GT4003	476910	7722810	40	1.98	2.7	20.2	777	0	13.46	0.24	0
GT4004	476910	7722845	40	1.98	2.7	20.2	777	0	13.46	0.24	0
GT4005	476910	7722855	40	1.98	2.7	20.2	777	0	13.46	0.24	0
GT4006	476910	7722890	40	1.98	2.7	20.2	777	0	13.46	0.24	0
1KT1410	476540	7722965	40	1.94	2.1	23.9	790	0	15.8	0.3	0
1KT1420	476590	7722965	40	1.94	2.1	23.9	790	0	15.6	0.27	0
1KT1430	476610	7722965	40	1.87	2.1	25.8	790	0	15.3	0.27	0
1KT1440	476660	7722965	40	1.87	2.1	26.3	806	0	15.5	0.27	0.4
1KT1450	476510	7722960	40	1.36	2.1	21.2	784	0	9.4	0.1	0
2KT1410	476540	7722845	40	1.94	2.1	23.9	790	0	15.8	0.3	0
2KT1420	476590	7722845	40	1.94	2.1	23.9	790	0	15.6	0.27	0
2KT1430	476610	7722845	40	1.87	2.1	25.8	790	0	15.3	0.27	0
2KT1440	476660	7722845	40	1.87	2.1	26.3	806	0	15.5	0.27	0.4
2KT1450	476510	7722840	40	1.36	2.1	21.2	784	0	9.4	0.1	0
3KT1410	476540	7722610	40	1.94	2.1	23.9	790	0	15.8	0.3	0
3KT1420	476590	7722610	40	1.94	2.1	23.9	790	0	15.6	0.27	0
3KT1430	476610	7722610	40	1.87	2.1	25.8	790	0	15.3	0.27	0
3KT1440	476660	7722610	40	1.87	2.1	26.3	806	0	15.5	0.3	0.4
3KT1450	476510	7722605	40	1.36	2.1	21.2	784	0	9.4	0.1	0
1F2001	477152	7722915	33	0.73	1.7	6	700	0	0.3	0	0
2F2001	477152	7722905	33	0.73	1.7	6	700	0	0.3	0.01	0
3F2001	477152	7722895	33	0.73	1.7	6	700	0	0.3	0.01	0
4F2001	476968	7722880	33	0.73	1.7	6	700	0	0.3	0.01	0
5F2001	476968	7722870	33	0.73	1.7	6	700	0	0.3	0	0
1KT2420	477035	7722698	24	1	2.5	40.7	816	0	9.4	0.1	0
1KT2430	477050	7722698	24	1.45	2.5	30.6	620	0	20.3	0.2	0
2KT2420	477065	7722698	24	1	2.5	40.7	816	0	9.4	0.1	0
2KT2430	477080	7722698	24	1.45	2.5	30.6	620	0	20.3	0.2	0
SealOil	476500	7722500	20	1	1	0	400	0	0	0	0.1
4KT1430a	476664	7722465	40	1.45	2	28.2	490	0	5	0.3	0
4KT1430b	476664	7722461	40	1.45	2	28.2	490	0	5	0.3	0
4KT1410	476650	7722461	40	3.05	1	23.4	814	0	10.6	0.6	0
1F1251	476933	7722944	40	1.46	1.8	21.3	1373	0	0.8	2.8	0
GT4007	476972	7722702	40	1.65	1.7	23	694	0	3.3	0.2	0
GT4008	476972	7722668	40	1.65	1.7	23	694	0	3.3	0.2	0
GT4009	476972	7722626	40	1.65	1.7	23	694	0	3.3	0.2	0
GT4010	476972	7722592	40	1.65	1.7	23	694	0	3.3	0.2	0
5KT1430a	476664	7722335	40	1.45	2	28.2	490	0	5	0.3	0
5KT1430b	476664	7722331	40	1.45	2	28.2	490	0	5	0.3	0
5KT1410	476560	7722331	40	3.05	1	23.4	814	0	10.6	0.6	0
2F1251	476953	7722944	40	1.46	1.8	21.3	1373	0	0.8	2.8	0
Hamersley											
HAM_stack1	471500	7717000	60	1.3	1	7	393	0	5.7	1	0
HAM_stack2	471500	7717000	60	1.3	1	7	393	0	5.7	1	0
Barrow Island											
BI_GT1	332000	7697000	30	1.98	2.7	20.2	777	0	25.3	0.3	0.01
BI_GT2	332000	7697045	30	1.98	2.7	20.2	777	0	25.3	0.3	0
BI_OilSeal	331900	7697150	20	1	1	0	400	0	0	0	0.1
BI_Vent	332200	7697200	20	0.73	1.7	6	700	0	0	0	0.1
Burrup Fertiliser											
BF1	476915	7718833	36	1.78	1	12.7	413	0.3	15.4	0	0
BF2	477060	7718820	15	0.85	1	5	450	0	1.3	0	0
Gorgon											
G_GTG1	338372	7700255	40	2.25	1	34.5	692	1.1	17.9	0	0
G_GTG2	338418	7700255	40	2.25	1	34.5	692	1.1	17.9	0	0
G_GTG3	338464	7700255	40	2.25	1	34.5	692	1.1	17.9	0	0
G_1-1541_MJ	338850	7700040	40	2.25	1	14.9	423	0.6	16.7	0	0
G_1-1544_MJ	338850	7700040	40	2.25	1	14.9	423	0.6	16.7	0	0.4
G_2-1541_MJ	338850	7700040	40	2.25	1	14.9	423	0.6	16.7	0	0
G_2-1544_MJ	338850	7700040	40	2.25	1	14.9	423	0.6	16.7	0	0
G_4212-MCA	338485	7700135	40	1.1	1	20	448	0.9	10	0	0
G_4212-MCB	338485	7700135	40	1.1	1	20	448	0.9	10	0	0

DISPMOD Files

Input File

```
barrow.ctl
lm_nox.out
y              ! Use self generated turbulence
y              ! use pdf
y              ! Account for wind shear
n              ! Is yearly shear data available?
y              ! use numerical TIBL
50             ! Distance to extend TIBL
y              ! use coast amg coords for TIBL calcs
barrow.coa
y              ! Model convective plume trapping using PDF?
n              ! Account for wind shear in the model within TIBL
n              ! use stability classes
n              ! centreline concentrations
5              ! option for onshore lapse rate , 6 = Pilbara
n              ! apply standard seasonal variation
n              ! use measured sigma theta
n              ! mixing into TIBLS sharper than sgphi
y              ! use greater of direction varaince to calculated variance
n              ! log of events exceeding a certain value
n              ! Ausplume plume penetration
n              ! write all timestep conc to a disk file
chev2003.wml
chev2003.stb
lm_nox.emi
windveer.dat
```

Control File

```
Gorgon_Barrow Island
 332000. 7694000.  500. 20 20 0.2833 -20.6 220.7   90.0  3.0  .083  .047  0.25
 01012003 31122003 0000 2400  6  6 77  1.9  2.3
14 0.00 0350. 0500. 0700. 1000. 0   5000.
 1  1  1  1  1  1  1  1  1  1  1  1  1  1
 1  2  3  4  5  6  7  8  9 10 11 12 13 14
  0       ! NUMBER OF STACKS THAT ARE NOT BEING USED
4101_MJA      40.0  5.50 338372 7700255 1.00  0. 500
4101_MJB      40.0  5.50 338418 7700255 1.00  0. 500
4101_MJC      40.0  5.50 338464 7700255 1.00  0. 500
1-1541_MJ     40.0  5.50 338850 7700040 1.00  0. 500
1-1544_MJ     40.0  5.50 338785 7700040 1.00  0. 500
1-1541_MJ     40.0  5.50 338850 7700205 1.00  0. 500
1-1544_MJ     40.0  5.50 338785 7700205 1.00  0. 500
4108_MJA      40.0  0.79 338500 7700226 1.00  0. 500
4108_MJB      40.0  0.79 338500 7700238 1.00  0. 500
Pack_Boil1    40.0  2.22 338485 7700135 1.00  0. 500
Pack_Boil2    40.0  2.22 338485 7700145 1.00  0. 500
WetGasFlare  150.0  1.27 338104 7700505 1.00  0. 500
```

```
DryGasFlare   150.0 1.27 338104 7700505 1.00  0. 500
BOGasFlare     40.0 1.27 339165 7700170 1.00  0. 500

1
340000. 7692000.      ! Airport

HM_NOx.dis

TITLE
(A)
XREF,YREF,GINT,NUMX,NUMY,DTSL,ALAT,CSTDIR,ZLSB,SGTHSB,SGPHSB,TIBPEN
(2F9.1,F6.1,2I3,F7.4,3F6.1,3F6.0)
IDS,IMS,IYS,IDF,IMF,IYF,IT1,IT2,IAV,IDATAV,IY1,CSIGON,CSIGOF
(2(1X,3I2),2I5,3I3,2F5.1)
**** NOTE - IAV    = MODEL TIME STEP IN MULTIPLES OF 10 MINUTES (EG. 3 = 30 MIN
                TIMESTEP.
        - IDATAV = INPUT MET DATA AVERAGING TIME IN MULTIPLES OF 10 MINUTES
                (EG. 3 = 30 MIN INPUT DATA)
**** NOTE - IAV CANNOT BE LESS THAN IDATAV AND IDATAV MUST BE GREATER THAN 0
NUMSCE,QMIN,ALEV1,ALEV2,ALEV3,ALEV4,I
(I3,F5.1,4F6.0,I2)
**** NOTE - POLPOT MODE IS NOW FOR MULTIPLE SOURCES WITH FIXED EMISSIONS.
READ IN THE NUMBER OF STACKS PER SOURCE GROUP
KSCE(I),I=1,NUMSCE
(22I3)
READ IN THE STACK NUMBERS IN THE ORDER OF USE (.IE SOURCE GROUPING)
(ISTNUM(I),I=1,ISTTOT
READ IN THE NUMBER OF STACKS NOT TO BE USED
NSNTUS
READ IN STACK INFORMATION DATA
C STKHGT - HEIGHT OF STACK
C STKDIA - DIAMETER OF STACK
C STKX   - LATITUDE OF STACK AMG COORDS
C STKY   - LONGITUDE OF STACK AMG COORDS
C TEMSL  - SLOPE OF THE TEMPERATURE LOSS EQUATION FOR STACK
C TEMIN  - INTERCEPT OF THE TEMPERATURE LOSS EQUATION FOR STACK
C TEMSL AND TEMIN ARE USED TO AMKE ALLOWANCE FOR THE TEMPERATURE LOSS OF
C        FLUE GASES IN THE STACK WHEN GAS TEMPERATURES ARE MEASURED AT
C        THE BASE OF THE STACK
C DCOAST - ARRAY DISTANCE (METRES) FROM THE COAST OF EACH SOURCE GROUP
C Q      - SOURCE STRENGTH (KG/S)
C STKVOL - SOURCE VOLUME (M**3/S) AT STACK TEMP (IE. GAS FLOW RATE)
C STKRHO - EMISSION DENSITY (KG/M**3) AT STACK TEMP
C IBUILD - BUILDING EFFECTS FOR THIS SOURCE (1=YES, 0=NO)
C HBSTK  - HEIGHT OF BUILDING
C WBSTK  - WIDTH OF BUILDING
STKHGT(K),STKDIA(K),STKX(K),STKY(K),DCOAST(K),Q(K),STKVOL(K),STKRHO(K),
IBUILD(K),HBSTK(K),WBSTK(K)
(14X,F5.1,F5.2,F7.0,F8.0,F5.2,F4.0,F6.0,3F8.0,I2,2F4.0)
*** NOTE- WITH BUILDING EFFECTS IT IS ASSUMED THAT THE LAST SOURCE IN THE
        SOURCE GROUP HAS THE BUILDING DIMENSIONS. THIS LAST SOURCE ALSO
        CONTAINS THE LOGICAL (IBUILD) WHICH DETERMINE WHETHER BUILDING
        EFFECTS ARE TO BE USED.
```

Emissions File

Gorgon_Barrow Island

Name	Q	V	Rho	Nd	Nh	Int
4101_MJA	.0179	832.0	0.503			0
4101_MJB	.0179	832.0	0.503			0
4101_MJC	.0179	832.0	0.503			0
1-1541_MJ	.0167	353.2	0.835			0
1-1544_MJ	.0167	353.2	0.835			0
1-1541_MJ	.0167	353.2	0.835			0
1-1544_MJ	.0167	353.2	0.835			0
4108_MJA	.0000	000.0	0.000			0
4108_MJB	.0000	000.0	0.000			0
Pack_Boil1	.0100	77.5	0.789			0
Pack_Boil2	.0100	77.5	0.789			0
WetGasFlare	.0000	20.0	0.278			0
DryGasFlare	.0000	20.0	0.278			0
BOGasFlare	.0000	20.0	0.278			0

TAPM List File

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|----------------------------------------|
| THE AIR POLLUTION MODEL (TAPM V2.5).   |
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RUN INFORMATION:
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NUMBER OF GRIDS=  2
GRID CENTRE (longitude,latitude)=( 115.458298 , -20.7833309 )
GRID CENTRE (cx,cy)=( 339700 , 7699950 ) (m)
GRID DIMENSIONS (nx,ny,nz)=( 31 , 31 , 20 )
NUMBER OF VERTICAL LEVELS OUTPUT = 17
DATES (START,END)=( 20030101 , 20030331 )
DATE FROM WHICH OUTPUT BEGINS = 20030104
LOCAL HOUR IS GMT+ 7.69999981
SYNOPTIC WIND SPEED MAXIMUM = 30 (m/s)
SYNOPTIC PRESSURE-GRADIENT SCALING FACTOR = 1.00000000
SYNOPTIC PRESSURE-GRADIENT FILTERING FACTOR = 1.00000000
VARY SYNOPTIC WITH 3-D SPACE AND TIME
INCLUDE VEGETATION
EXCLUDE NON-HYDROSTATIC EFFECTS
EXCLUDE RAIN AND SNOW
INCLUDE PROGNOSTIC EDDY DISSIPATION RATE EQUATION
POLLUTION : CHEMISTRY (APM,NOX,NO2,O3)
EXCLUDE POLLUTANT CROSS-CORRELATION EQUATION
EXCLUDE POLLUTANT VARIANCE EQUATION
POLLUTANT GRID DIMENSIONS (nxf,nyf)=( 29 , 29 )
BACKGROUND APM    = 0.00000000E+00 (ug/m3)
BACKGROUND NOX&NO2= 0.00000000E+00 (ppb)
BACKGROUND O3     = 20.0000000 (ppb)
BACKGROUND Rsmog  = 0.500000000 (ppb)
pH of liquid water= 4.50000000

---------------------------------
START GRID 1 D:\TAPM_run\Chevron\Regional\Chev300
GRID SPACING (delx,dely)=( 30000 , 30000 ) (m)
POLLUTANT GRID SPACING (delxf,delyf)=( 30000 , 30000 ) (m)
NO MET. DATA ASSIMILATION FILE AVAILABLE
NO BUILDING FILE AVAILABLE
NUMBER OF pse SOURCES= 37
NO lse EMISSION FILE AVAILABLE
NO ase EMISSION FILE AVAILABLE
USING gse EMISSIONS AND MIXING THEM OVER FIRST 1 LEVEL(S)
USING bse EMISSIONS AND MIXING THEM OVER FIRST 1 LEVEL(S)
NO whe EMISSION FILE AVAILABLE
NO vpx EMISSION FILE AVAILABLE
NO vdx EMISSION FILE AVAILABLE
NO vlx EMISSION FILE AVAILABLE
NO vpv EMISSION FILE AVAILABLE
```

INITIALISE
LARGE TIMESTEP = 300.000000
METEOROLOGICAL ADVECTION TIMESTEP = 300.000000 (s)
Deep Soil Moisture Content (kg/kg)= 0.150000006
Deep Soil & Sea Temperatures (K) = 299.799988 299.799988
POLLUTION ADVECTION TIMESTEP = 300.000000 (s)
pse KEY :
is = Source Number
ls = Source Switch (-1=Off,0=EGM,1=EGM+LPM)
xs,ys = Source Position (m)
hs = Source Height (m)
rs = Source Radius (m)
es = Buoyancy Enhancement Factor
fs_no = Fraction of NOX Emitted as NO
fs_fpm= Fraction of APM Emitted as FPM
INIT_pse

is,	ls,	xs,	ys,	hs,	rs,	es,	fs_no,	fs_fpm
1,	0,	476910.,	7722765.,	40.00,	1.98,	2.70,	0.90,	0.50,
2,	0,	476910.,	7722800.,	40.00,	1.98,	2.70,	0.90,	0.50,
3,	0,	476910.,	7722810.,	40.00,	1.98,	2.70,	0.90,	0.50,
4,	0,	476910.,	7722845.,	40.00,	1.98,	2.70,	0.90,	0.50,
5,	0,	476910.,	7722855.,	40.00,	1.98,	2.70,	0.90,	0.50,
6,	0,	476910.,	7722890.,	40.00,	1.98,	2.70,	0.90,	0.50,
7,	0,	476540.,	7722965.,	40.00,	1.94,	2.10,	0.90,	0.50,
8,	0,	476590.,	7722965.,	40.00,	1.94,	2.10,	0.90,	0.50,
9,	0,	476610.,	7722965.,	40.00,	1.87,	2.10,	0.90,	0.50,
10,	0,	476660.,	7722965.,	40.00,	1.87,	2.10,	0.90,	0.50,
11,	0,	476510.,	7722960.,	40.00,	1.36,	2.10,	0.90,	0.50,
12,	0,	476540.,	7722845.,	40.00,	1.94,	2.10,	0.90,	0.50,
13,	0,	476590.,	7722845.,	40.00,	1.94,	2.10,	0.90,	0.50,
14,	0,	476610.,	7722845.,	40.00,	1.87,	2.10,	0.90,	0.50,
15,	0,	476660.,	7722845.,	40.00,	1.87,	2.10,	0.90,	0.50,
16,	0,	476510.,	7722840.,	40.00,	1.36,	2.10,	0.90,	0.50,
17,	0,	476540.,	7722610.,	40.00,	1.94,	2.10,	0.90,	0.50,
18,	0,	476590.,	7722610.,	40.00,	1.94,	2.10,	0.90,	0.50,
19,	0,	476610.,	7722610.,	40.00,	1.87,	2.10,	0.90,	0.50,
20,	0,	476660.,	7722610.,	40.00,	1.87,	2.10,	0.90,	0.50,
21,	0,	476510.,	7722605.,	40.00,	1.36,	2.10,	0.90,	0.50,
22,	0,	477152.,	7722915.,	33.00,	0.73,	1.70,	0.90,	0.50,
23,	0,	477152.,	7722905.,	33.00,	0.73,	1.70,	0.90,	0.50,
24,	0,	477152.,	7722895.,	33.00,	0.73,	1.70,	0.90,	0.50,
25,	0,	476968.,	7722880.,	33.00,	0.73,	1.70,	0.90,	0.50,
26,	0,	476968.,	7722870.,	33.00,	0.73,	1.70,	0.90,	0.50,
27,	0,	477035.,	7722698.,	24.00,	1.00,	2.50,	0.90,	0.50,
28,	0,	477050.,	7722698.,	24.00,	1.45,	2.50,	0.90,	0.50,
29,	0,	477065.,	7722698.,	24.00,	1.00,	2.50,	0.90,	0.50,
30,	0,	477080.,	7722698.,	24.00,	1.45,	2.50,	0.90,	0.50,
31,	0,	476500.,	7722500.,	20.00,	1.00,	1.00,	0.90,	0.50,
32,	0,	471500.,	7717000.,	60.00,	1.30,	1.00,	0.90,	0.50,
33,	0,	471500.,	7717000.,	60.00,	1.30,	1.00,	0.90,	0.50,
34,	0,	332000.,	7697000.,	30.00,	1.98,	2.70,	0.90,	0.50,
35,	0,	332000.,	7697045.,	30.00,	1.98,	2.70,	0.90,	0.50,
36,	0,	331900.,	7697150.,	20.00,	1.00,	1.00,	0.90,	0.50,
37,	0,	332200.,	7697200.,	20.00,	0.73,	1.70,	0.90,	0.50,

LAGRANGIAN (LPM) MODE IS OFF FOR THIS GRID
IN_pse
IN_gse
IN_bse
DATE=20030101,HOUR= 1.000
IN_pse
REWIND_pse
IN_gse
IN_bse
REWIND_bse
IN_bse
IN_SYNOPTIC
Deep Soil Moisture Content (kg/kg)= 0.150000006
Deep Soil & Sea Temperatures (K) = 299.799988 299.799988