LINDEMAN GREAT BARRIER REEF RESORT PROJECT

ENVIRONMENTAL IMPACT STATEMENT

APPENDIX K - AIR QUALITY

***Addendum:** This EIS was initially prepared assuming that the safe harbour was to be part of the Lindeman Great Barrier Reef Resort Project. With the commencement of the Great Barrier Reef Marine Park Authority's (GBRMPA) Dredging Coral Reef Habitat Policy (2016), further impacts on Great Barrier Reef coral reef habitats from yet more bleaching, and the recent impacts from Tropical Cyclone Debbie, the proponent no longer seeks assessment and approval to construct a safe harbour at Lindeman Island. Instead the proponent seeks assessment and approval for upgrades to the existing jetty and additional moorings in sheltered locations around the island to enable the resort's marine craft to obtain safe shelter under a range of wind and wave conditions. Accordingly, remaining references to, and images of, a safe harbour on various figures and maps in the EIS are no longer current.*

Air Noise Environment
Environmental Monitoring and Assessment

Air Quality Assessment: Lindeman Island Resort - FINAL

White Horse Australia Lindeman Pty Ltd

March 2016

Issued: 23 March 2016

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Where site inspections, testing or fieldwork have taken place, the report is based on the information made available by the client or their nominees during the visit, visual observations and any subsequent discussions with regulatory authorities. It is further assumed that normal activities were being undertaken at the site on the day of the site visit(s).

The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Air Noise Environment Pty Ltd for the purposes of this project is both complete and accurate.

Executive Summary

White Horse Australia Lindeman Pty Ltd commissioned Air Noise Environment to undertaken an air quality assessment for the proposed Lindeman Island resort redevelopment. The proposal includes redeveloping the existing resort at Lindeman Island into a world class integrated tourist resort with a Spa, Tourist Villas and Safe Harbour. The impact assessment is to form a component of the Environmental Impact Statement (EIS) being prepared for the redevelopment.

The key potential air quality impacts associated with the proposed development include particulate emissions during construction, odour emissions from waste storage and sewage treatment, and combustion emissions from diesel power generation. The sensitive receptors considered in the assessment include the residential receptors associated with the proposed resorts, sensitive ecological environments and the marine environment.

Predictions of pollutant concentrations were completed using the computational model CALPUFF for the sources associated with the operation of the redevelopment; whereas, Ausplume was utilised for assessing dust emissions from construction. These predictions were compared to the adopted air quality criteria from the Environmental Protection (Air) Policy 2008 (EPP).

The results of the modelling for the construction phase indicate that the potential for nuisance dust, total suspended particulate, PM_{10} and $PM_{2.5}$ impacts on resort areas are minimal provided that appropriate dust management measures are adopted. Exceedances of the deposited dust nuisance criteria are predicted for the protected vegetation located along the western shoreline and an area extending out 200 m from the shoreline to the south west of the six star resort. Given the conservatism incorporated into the modelling and the lack of evidence of adverse impacts on vegetation and marine park environments at these concentrations, the risk associated with the proposed development is considered to be low.

Similarly air quality impacts associated with the operation of the redevelopment are predicted to be minimal. Predicted ground level concentrations as a result of emissions from power generation, waste storage and sewage treatment activities have been shown to comply with the relevant criteria for all modelled pollutants.

Overall, the results of the air quality impact assessment indicate that the redevelopment of the Lindeman Island resort is unlikely to have a significant impact on the local or regional air quality nor is it expected to adversely impact on any sensitive environment in the area.

Table of Contents

Index of Tables

Index of Figures

1 Introduction

1.1 Lindeman Island Redevelopment

White Horse Australia Lindeman Pty Ltd (WHA) propose to redevelop the existing resort at Lindeman Island into three world class tourist resorts. The proposed design incorporates environmental improvements to protect the values of the Great Barrier Reef World Heritage Area and set new international standards in environmental sustainability and resort design. Key aspects of the proposed development include:

- Beach Resort - redevelopment of the existing resort into a new 5 star Beach Resort with 136 units, conference centre, beach club and a central facilities building with restaurants, bars and lounges;
- Spa Resort - a new 6 star Spa Resort with 59 units, central facilities, entry lounge, spa, sea view restaurant, pool and a signature rock bar providing alfresco dining close to the sea;
- Eco resort - a new 5 star Eco Resort near the existing lake consisting of 41 units, a central facility, boathouse and a restaurant;
- Tourist villa precincts - two precincts accommodating 89 tourist villas are proposed to the north-east and north-west of the existing resort;
- Village - a central village precinct comprising restaurants, bar, night club, conference facility buildings, arrival centre, shops, sport and recreation centre and a staff village;
- Services infrastructure precinct - a new precinct with services including power generation, sewage treatment and water treatment designed to reflect best practice;
- Airstrip - the existing airstrip is proposed to be upgraded to provide for near all-weather status, capable of landing light aircraft and helicopters;
- Golf course – a recreational golf course is proposed;
- Safe Harbour - a new Safe Harbour is proposed to provide reliable access for the transfer of guests via ferries, luxury vessels and private charters offering greater protection from the prevailing wind direction;
- Ecotourism facilities - a National Park and Great Barrier Reef Educational Centre and glamping facilities are being investigated in consultation with the State Government; and
- Environmental enhancements – native vegetation replanting, improvements to stormwater management and a shift towards renewable energy sources are proposed.

Figures 1.1 and 1.2 provide the location of the proposed redevelopment and the proposed layout for the redeveloped resort facilities respectively.

Figure 1.1: Lindeman Island location

Figure 1.2: Proposed development layout

1.2 Scope of Reporting

Air Noise Environment Pty Ltd was commissioned by Cardno Pty Ltd to prepare an air quality impact assessment for the proposed Lindeman Island redevelopment. The impact assessment is to form a component of the Environmental Impact Statement (EIS) being prepared for the redevelopment. This technical report has been prepared in response to the Terms of Reference for the EIS. In accordance with the requirements of an EIS, this report:

- assesses the potential adverse and beneficial environmental impacts of the project and proposes management, monitoring, planning and other measures to minimise any adverse environmental impacts; and
- provides recommendations (where appropriate) for feasible alternative ways to carry out the project.

1.3 This Report

The report is structured in the following manner:

- Section 2 provides a summary of the environmental values to be protected;
- Section 3 provides an overview of the climate of the region;
- Section 4 provides an overview of the development including key features in terms of potential emissions to air;
- Section 5 provides an assessment of potential air quality impacts associated with the project; and
- Section 6 provides the recommendations and conclusions.

A glossary of terms is presented in Appendix A to assist the reader.

2 Protection of Environmental Values

2.1 Environmental Protection Act 1994

The Environmental Protection Act (EP Act) provides the legislative framework by which Queensland's environment is protected while allowing for development that improves the total quality of life, both now and in the future. Specifically, the EP Act seeks to maintain a range of environmental values including:

> '*(a) a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or*
>
> *(b) another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.*'

For the purposes of the environmental impact statement, reference is made to the environmental values provided in the Environmental Protection (Air) Policy 2008 (EPP Air) established under the EP Act.

The following sections provide an overview of the environmental values identified in this policy along with the objectives established achieve their protection.

2.2 Environmental Protection (Air) Policy 2008

The EPP (Air) provides air quality objectives for a range of compounds with the potential to impact on the health and well being and aesthetics of the environment. Specifically, the objectives are intended to enhance or protect the following environmental values:

> '*(a) the qualities of the air environment that are conducive to human health and wellbeing; and*
>
> *(b) the qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property; and*
>
> *(c) the qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems; and*
>
> *(d) the qualities of the air environment that are conducive to protecting agricultural use of the environment.*'

Table 2.1 presents a summary of the air quality objectives applicable to assessment of potential impacts associated with the Lindeman Island redevelopment.

Table 2.1: EPP(Air) Air Quality Goals

Indicator	Environmental value	Air quality objectives µg/m³	Period
Carbon monoxide (CO)	health and wellbeing	11,000	8 hours
Nitrogen dioxide (NO_2)	health and wellbeing	250	1 hour
		62	1 year
	health and biodiversity of ecosystems	33	1 year
$PM_{2.5}$	health and wellbeing	25	24 hours
		8	1 year
PM_{10}	health and wellbeing	0	24 hours
Total suspended particulates (TSP)	health and wellbeing	90	1 year

The construction phase of the redevelopment has a potential to impact on the surrounding sensitive ecological areas (including the Great Barrier Reef Marine Park) through deposition of dust generated by construction activities. It is noted that no specific air quality goals that have been established for dust deposition in Australia and the evidence regarding the impact and mechanisms for impact on marine reef environments remains an area of significant research and debate.

For sensitive flora in the area there is, internationally, a range of research which has considered the potential impacts associated with dust emissions on the productive and economic capacity of various plant species and agricultural uses. Many researchers (Harmens et al. 2005; Naidoo and Chirkoot, 2004; Hirano, Kiyota, and Aiga, 1995; Ricks and Williams, 1974 cited in Grobler and Liebenberg-Enslin (2011:98), McCrea 1986 and Naidoo and Chirkoot (2004)) have reported a range of potential impacts on plants and crops as a result of dust.

Impacts reported typically relate to dust deposition onto the leaves of the plants which in turn has the potential to impact on:

- plant photosynthesis, transpiration and respiration;
- incidence of plant pests and disease;
- reduced light intensity on fruit; and

- flower pollination

Other research into potential impacts of dust loading on plant production has considered situations that would be considered extreme cases by Australian standards. For example, research considering the potential impacts of stone crushing on Shorea robusta and madjuca indica foliage considered impacts on plants at suspended particulate concentrations well in excess of 500 µg/m^3 near to a quarry site and 137 – 183 µg/m^3 at the control (background) site. These concentrations (including the background site) are considered significantly higher than those typically encountered in the Australian environment. Given this, where compliance with Australian air quality objectives is achieved, the impact on vegetation on the island is expected to be negligible.

Given this, the assessment of potential impacts associated with dust deposition of both sensitive human and ecological receptors has adopted the guideline value (see Table 2.2) applied by Department of Environment and Heritage Protection (EHP) in licensing a range of environmentally relevant activities (Department of Environment and Heritage Protection 2014).

Table 2.2: Deposited Dust Nuisance Objective

Indicator	Environmental value	Air quality objectives µg/m^3	Period
Deposited Dust [a)]	Nuisance	120 mg/m^2/day	24 Hours

[a)] Daily nuisance goal typically adopted by the Department of Environment and Heritage Protection

2.3 Odour Impact Assessment from Developments Guideline

To assess the potential for air quality impacts on nearby sensitive receptors, reference has been made to the Odour Impact Assessment from Developments Guidelines (Department of Environment and Heritage Protection 2013). The guideline document specifies the following criteria:

- 0.5 odour units, 1-hour average, 99.5th percentile for tall stacks;
- 2.5 odour units, 1-hour average, 99.5th percentile for ground-level sources and down-washed plumes from short stacks; and

The identified sources of odour emissions at the proposed redevelopment include sewage treatment and refuse storage. Review of the proposed site plans indicate emissions from both of these sources are likely to be emitted at a height of 1.5 m above ground level. As such it is appropriate to adopt the 2.5 odour units (1-hour average, 99.5th percentile) criteria for short stacks for this assessment.

3 Existing Environment

3.1 Climate

Lindeman Island enjoys a tropical climate. The nearest meteorological monitoring station in the area is located on Hamilton Island approximately 15 km to the north of Lindeman Island. Review of long term statistical monitoring data for the Hamilton Island monitoring station indicates maximum daytime temperatures in the region are typically 29-30 degrees during the summer months and 21-25 degrees during the winter months.

A large proportion of rainfall occurs in the months from December through to March with the driest months being August through to October. Figure 3.1 below presents long term temperature and rainfall data for the Hamilton Island monitoring station which is expected to be representative of conditions at the Project Site.

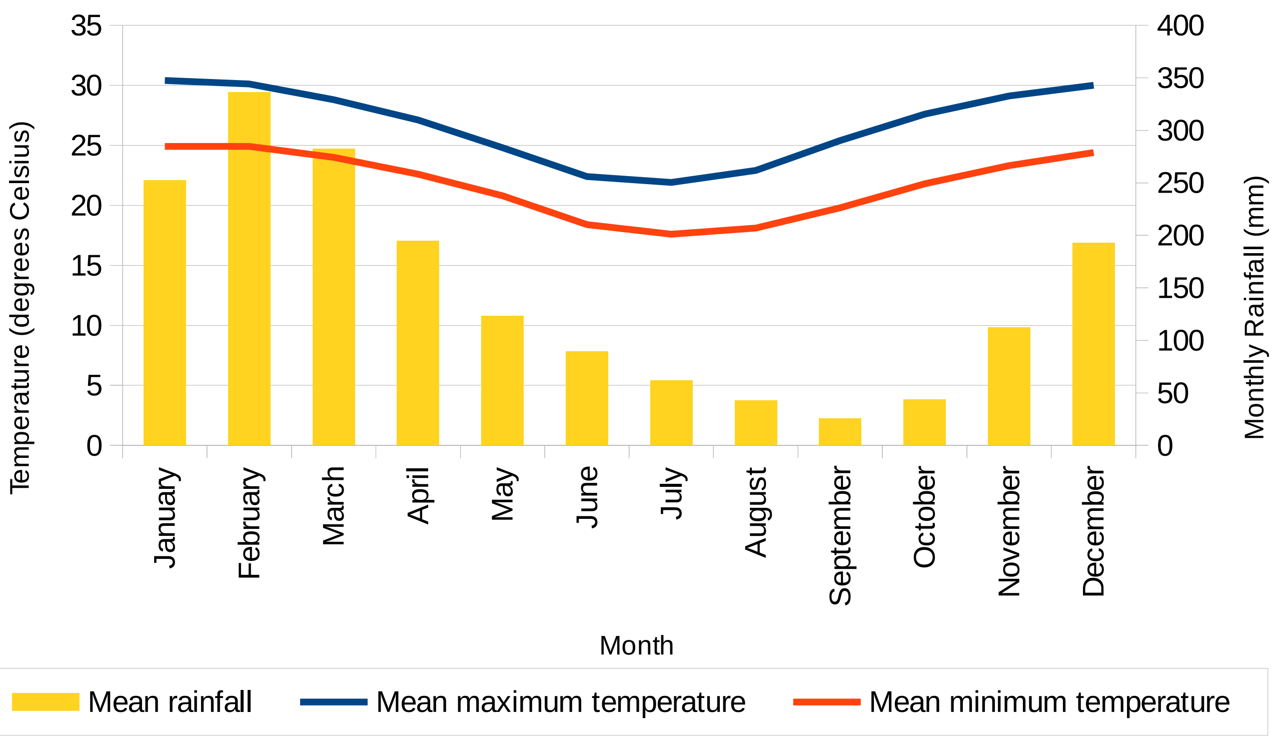
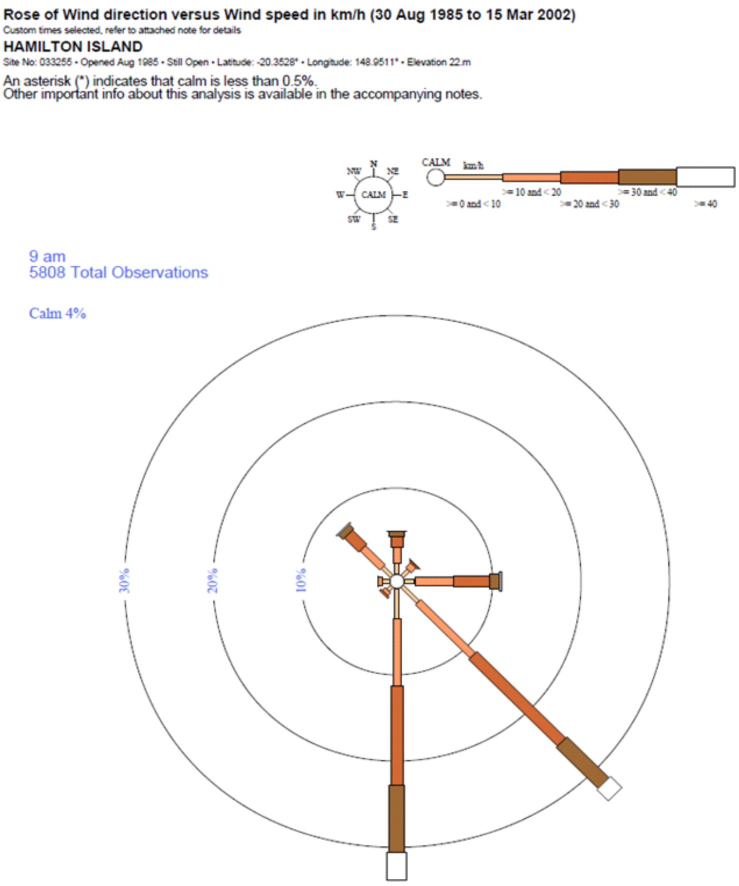
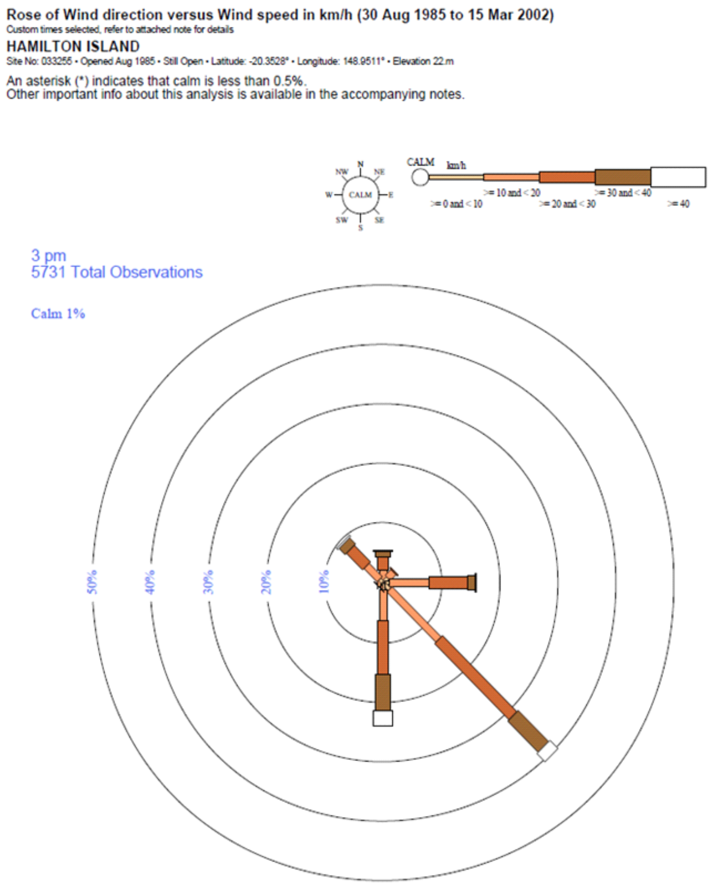


Figure 3.1: Typical rainfall and temperature patterns for Hamilton Island (average over all years from 1985 to 2002)

Lindeman Island is located in the trade wind belt for most of the year resulting in south to south-east winds. During the warmer months afternoon north-east sea breezes are common. Fresh south-easterlies can blow along the coast for lengthy periods during summer and autumn. Figure 3.2 below presents 9 am and 3 pm windroses for the Hamilton Island monitoring station. For all periods the occurrence of calms in the area is low with less than 1 % calms recorded in any season of available monitoring data.





9 am Windrose

3 pm Windrose

Figure 3.2: 9 am and 3 pm windroses for Hamilton Island monitoring station

(Source: Bureau of Meteorology)

3.2 Air Quality

The Lindeman Island airshed is relatively undeveloped with only limited development on the surrounding Whitsunday Islands. The largest nearby development is situated on Hamilton Island located approximately 15 km north of the Project Site.

At a distance of approximately 20 km from the mainland, the existing air quality experienced on the island is expected to be dominated by low levels of particulate matter (including regional dust emissions from the mainland and sea salt). With the exception of the existing generator currently supplying power to the caretakers on the Lindeman Island, there are no significant emission sources on the Island.

For the purposes of the assessment, data from the Queensland Department of Science, Information Technology, Innovation and the Arts (DSITIA) operated Townsville air quality monitoring stations have been utilised in the assessment. Data has been obtained from both the 2014 Queensland Air Monitoring Report (Department of Science, Information Technology, Innovation and the Arts 2015) and monthly air quality bulletins from December 2013 to November 2015 (Queensland. Department of Science et al. 1999).

It should be noted, this is expected to represent a significant over-estimate of actual concentrations experienced on the island given the increased industrial activity typical in Townsville and the increased influence of regional dust loads from mainland Australia when compared with that of Lindeman Island. Table 3.1 presents the estimated baseline particulate concentrations.

Table 3.1: Estimated Baseline Particulate Concentrations

Pollutant	Averaging Period	Ambient Pollutant Concentration $\mu g/m^3$	Monitoring Station
PM_{10}	24 Hour - 75th Percentile	17.4	Townsville (Pimlico)
TSP	Annual Average	29.4	Townsville (Coast Guard)

4 Summary of Potential Impacts

4.1 Overview

The redevelopment of Lindeman Island will include a world class integrated tourist resort with a Spa, Tourist Villas and Safe Harbour. The identified potential air quality impacts include those related to the construction, maintenance and operation of the redevelopment. The following sections outline the activities with potential air quality impacts associated with the redevelopment.

4.2 Resort Operation

4.2.1 Waste Handling Facility

The management of waste at Lindeman Island is expected to incorporate a range of both on-site and off-site treatment and disposal activities. Putrescible waste is proposed to be collected daily from the villas, hotels and other facilities and transferred to a purpose built storage facility located within the services area of the resort. Transfer of the stored waste is expected to occur at least weekly with waste loaded into an enclosed truck and shipped to the mainland for ultimate disposal at a designated landfill.

Potential odour emissions originating from the storage of solid waste has been identified as having a potential to impact on the amenity of the proposed redevelopment.

4.2.2 Sewage Treatment Facility

The proposed redevelopment is expected to necessitate an upgrade to the existing sewage treatment plant (STP). The proposed upgrade of the STP is to incorporate a modular Bioreactor/Membrane Filtration system capable of treating the effluent to Class A or Class A+ quality standard. The primary sources of odour expected as a result of the upgraded STP include the inlet works and sludge press and collection facilities. These have a potential to impact on the amenity of the proposed resort.

4.2.3 Power Generation

Power requirements for the redeveloped resort are expected to be met through on-site generation. The ultimate capacity required, and therefore the option chosen is expected to be impacted by a range of factors including the design of the built form and the opportunities for incorporation of a range of energy minimisation features. It is expected that the development will incorporate a range of state-of-the-art Environmentally Sustainable Design (ESD) features such as:

- Building design to maximise natural flow ventilation and reduce the need for air conditioning;
- Building design to maximise natural light and reduce power requirements;
- Low energy usage appliances installed in all buildings;

- Transportation around the island to be predominantly by foot, bicycle or electric carts;
- Motion sensors to be installed in buildings to reduce energy use wastage;
- State-of-the-art energy metering to monitor and manage energy usage and efficiency.

Through information obtained from the proponent, it is understood the current proposal for power generation will include approximately 35-44% solar PV technology/battery storage with the balance from diesel generation. Initially, it is expected that power generation would be served by diesel generation alone (due to the reduced loads) with increases in loads over time serviced by solar PV technologies. The on-site generation of power using diesel generators provides a potential source of impact on air quality at the resort resulting from emissions of carbon monoxide (CO), nitrogen dioxide (NO_2) and particulates.

4.3 Construction

4.3.1 Methodology and Staging

Given the size and magnitude of the Lindeman Island redevelopment, the required construction work is expected to be undertaken in stages commencing mid 2018 and being completed mid 2021. At this stage it is envisaged that the staging of the development would see all areas with the exception of the Villas constructed concurrently. That is, there is likely to be construction works being undertaken across both five star resorts and the six star resort at the same time. It is noted however that optimisation of these activities is likely to result in different activities being undertaken in different zones of the development.

In addition to the construction crews, it is proposed that the construction operations would include operation of an on-site concrete batching plant (to supply concrete to construction of pre-cast elements and other activities as required) and a hard rock quarry (at the former quarry site) to supply gravel to the construction works and concrete batching plant as required.

Dust emissions from the concrete batching plant, land clearing, demolition and construction have a potential to impact on both the construction camp, the nearby sensitive ecological areas and the marine environment.

Table 4.1 below presents a summary of the expected construction staging along with anticipated sources of emissions to air for each of these stages.

Table 4.1: Summary of Construction Staging

Stage	Items	Anticipated Sources of Emissions
1	Construction camp	Land clearing, demolition.
	Civil Works	Land clearing, demolition.
	Infrastructure	Land clearing.

Stage	Items	Anticipated Sources of Emissions
2	Safe Harbour Retail and Facilities Airport Upgrade Village Sports Centre and Facilities Staff Accommodation Golf Course Five Star Resort	Earth works, demolition. Earth works. Earth works, demolition. Earth works, demolition. Earth works, demolition. Earth works. Earth works, demolition.
3	Eco Resort	Earth works, demolition.
4	Six Star Spa Resort	Earth works, demolition.
5	Villa Construction and glamping facilities	Earth works, demolition.
All Stages	Concrete Batching Plant Quarry operation	Concrete batching plant Excavation, crushing, screening and transportation of hard rock and gravel.

While there are periods of overlap between the various stages of construction, it is proposed that activities will be streamlined such that the structure crew would commence on stage 1. Once nearing completion, the structure crew would commence on stage 2 while the finishes crew worked on stage 1. As such it is expected that emissions associated with bulk earth works, land clearing and demolition would be confined to one stage at a time. The exception to this is the upgrading of the airport and safe harbour which are both expected to utilise work crews separate to the hotel and resort precincts.

5 Assessment of Potential Impacts

5.1 Introduction

Atmospheric dispersion modelling involves the mathematical simulation of the dispersion of air contaminants in the environment. The modelling utilises a range of information to estimate the dispersion of pollutants released from a source including:

- meteorological data including surface and upper air wind, temperature and pressure profiles, as well as humidity, rainfall, cloud cover and ceiling height information;
- emissions parameters including source location and height, source dimensions and physical parameters (e.g. exit velocity and temperature) along with pollutant mass emission rates;
- terrain elevations and land use both at the source and throughout the surrounding region; and
- the location, height and width of any obstructions (such as buildings or other structures) that could significantly impact on the dispersion of the plume.

Dispersion modelling provides a means for both the regulators and the proponents of a project to assess the potential implications of the proposed development on air quality.

The following sections discuss in detail the modelling input parameters, and the basis for their derivation.

5.2 Meteorological Modelling

5.2.1 Overview

The issue of meteorology is of primary importance for completing valid, realistic atmospheric dispersion modelling of emissions. For any predictive modelling assessment, the ability of the meteorological dataset to sufficiently represent the atmospheric conditions is critical in determining the overall modelling accuracy.

CALMET is a meteorological model which includes a diagnostic wind field generator containing objective analysis and parameterised treatments of slope flows, kinematic terrain effects, terrain blocking effects and a divergence minimisation procedure, and micrometeorological model for overland and overwater boundary layers. The terrain handling effects included within the CALMET meteorological processor are able to resolve complex terrain influences on local wind fields including consideration of katabatic (downslope) flows.

Often the use of these advanced predictive modelling techniques is limited by the availability of suitable input data for the model. In particular, a wind field model of the complexity of CALMET requires three-dimensional wind field input data that is not readily available for much of Australia. This is the case for the Lindeman Island redevlopment.

Therefore, the development of a meteorological dataset for the assessment requires the reliance on a prognostic meteorological model. Prognostic models, such as TAPM, permits the development of localised meteorological datasets, based on synoptic weather conditions. The model predicts the regional flows important to dispersion, such as sea breezes and terrain induced flows, against a background of larger-scale meteorology provided by synoptic analyses. It is noted that this approach represents the recommended approach for the modelling of contaminant concentrations using CALMET and CALPUFF (TRC Environmental Corporation 2011).

The following sections provide details of the data sources and methodology utilised for the prediction of a three dimensional meteorological dataset and wind field for the assessment of contaminant dispersion.

5.2.2 TAPM Modelling

Predictions of meteorological parameters for the year 2012 for the region were undertaken using TAPM (Version 4.04). The model was configured with a series of five nested grids chosen to provide an appropriate communication and transfer of information from the broad synoptic to the local scale.

As such, the TAPM predictions of meteorology are likely to be consistent with any larger scale temporal and spatial variations arising from synoptic and other complex events associated with land-sea induced influences, as well as from topographical influences on both a regional and local scale.

For the purposes of the predictions TAPM was run in hydrostatic mode utilising the default deep soil moisture content values. The model was configured to use a domain consisting of 23 × 23 × 23 grid points with nesting spacings of 30 km, 10 km, 3 km, 1 km and 300 m.

Digital Australian terrain height data on a longitude/latitude grid at 9-second grid spacing (approximately 0.3 km) was included in the meteorological modelling. These data are generated and maintained by Geoscience Australia.

Land use data including Australian vegetation and soil type data was sourced from a database provided by CSIRO Wildlife and Ecology. This dataset has a spatial grid spacing of 3-minutes.

No assimilation of observation meteorological data was included in the TAPM predictions. This was done to prevent conflicts that can occur when attempting to 'nudge' prognostic predictions with actual monitoring data.

5.2.3 CALMET Modelling

5.2.3.1 Overview

CALMET predictions for the project area were made, using the three-dimensional prognostic dataset obtained from the TAPM model. CALMET was run in 'no observations' mode with three dimensional prognostic data from the TAPM model output used to provide an initial guess for the CALMET model run. This methodology allows for the spatial variability in the region to be captured. This is of particular importance where sea breeze circulation (with return of plumes of pollutants at higher elevations) is of importance as these features are generally not captured where surface meteorological monitoring data only is used as an input to CALMET.

The following sections provide an overview of the data utilised in the CALMET modelling, along with details of some of the key parameters selected to establish calculation limits within CALMET.

5.2.3.2 Vertical Stations

For the purposes of the modelling, CALMET was initialised with a total of 10 vertical layers with layer boundaries at 0 m, 20 m, 50 m, 80 m, 120 m, 250 m, 500 m, 750 m, 1000 m, 2000 m and 3000 m respectively. The vertical levels used in the modelling were selected to provide the model with the ability to predict the formation of atmospheric conditions near to the ground.

Additional parameterisation allowed for by CALMET includes specification of the minimum and maximum mixing heights. This provides the model with realistic boundaries for calculation of the region of the atmosphere within which contaminants will generally disperse. For the purposes of the project, minimum mixing heights were set to 50 m and maximum mixing heights to 3,000 m.

5.2.3.3 Terrain And Land Use Data

Digital terrain height data used in the CALMET predictive modelling was obtained from 3 second database of terrain data developed by NASA from data collected by the Shuttle Radar Topography Mission (SRTM). The modelling incorporated a 23 km x 23 km grid extending from Hamilton Island in the north to the south-east of Thomas Island in the south.

Figure 5.1 presents the terrain analysis undertaken to determine the value of TERRAD utilised in the dispersion model. As can be seen, the dominant terrain features in the area of interest include Lindeman Island (to a height of approximately 200 m above sea level), Shaw Island (to a height of approximately 260 m above sea level) and Pentacost Island (to a height of approximately 160 m above sea level). Analysis of these terrain features indicates peak to peak distances were in the range of between 4.9 km and 5.3 km. For the purposes of the modelling TERRAD was therefore set to 2 km to allow resolution of the influence of these features.

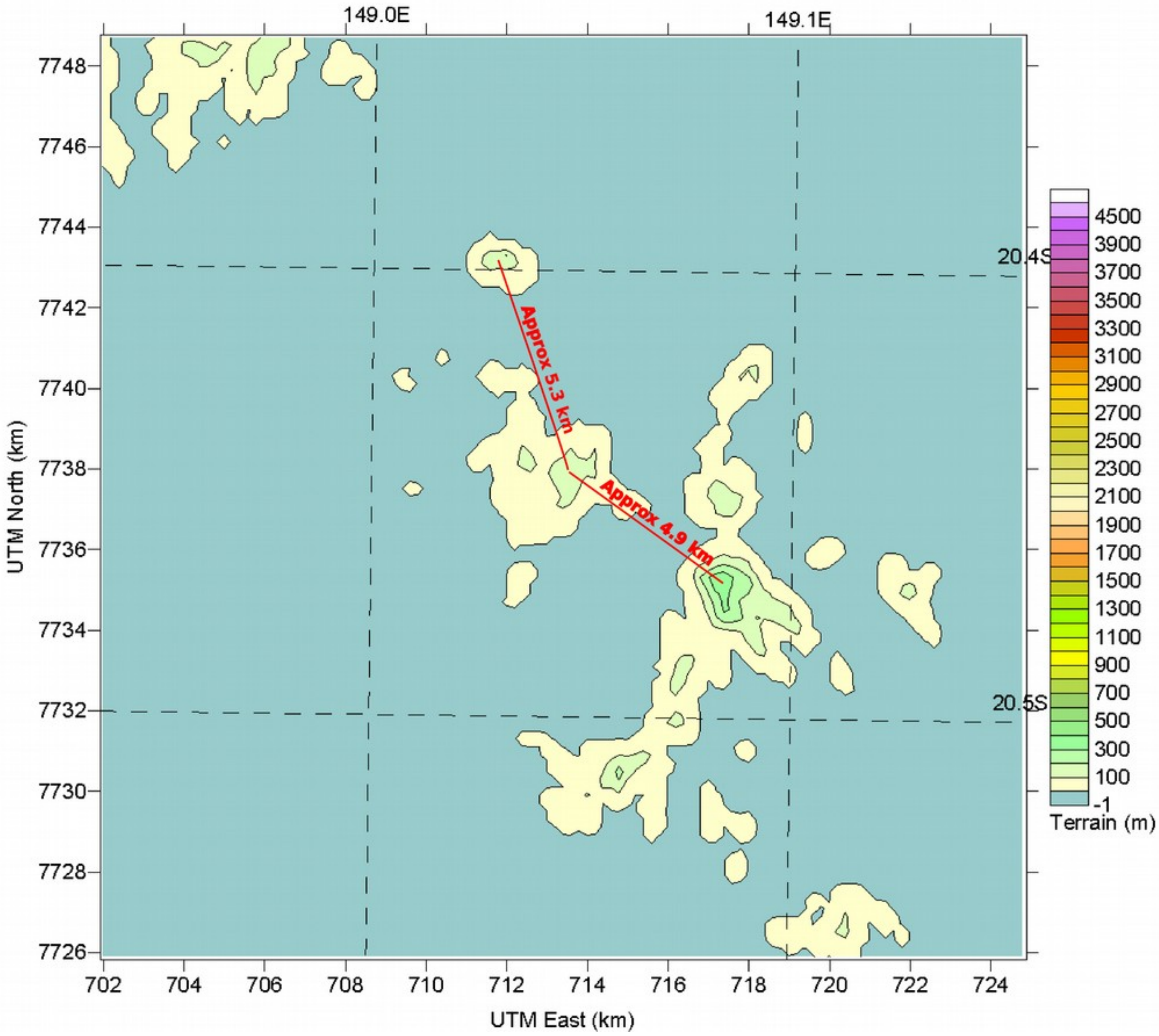


Figure 5.1: Terrain Analysis

Figure 5.2 presents the modelling domain considered for the assessment.

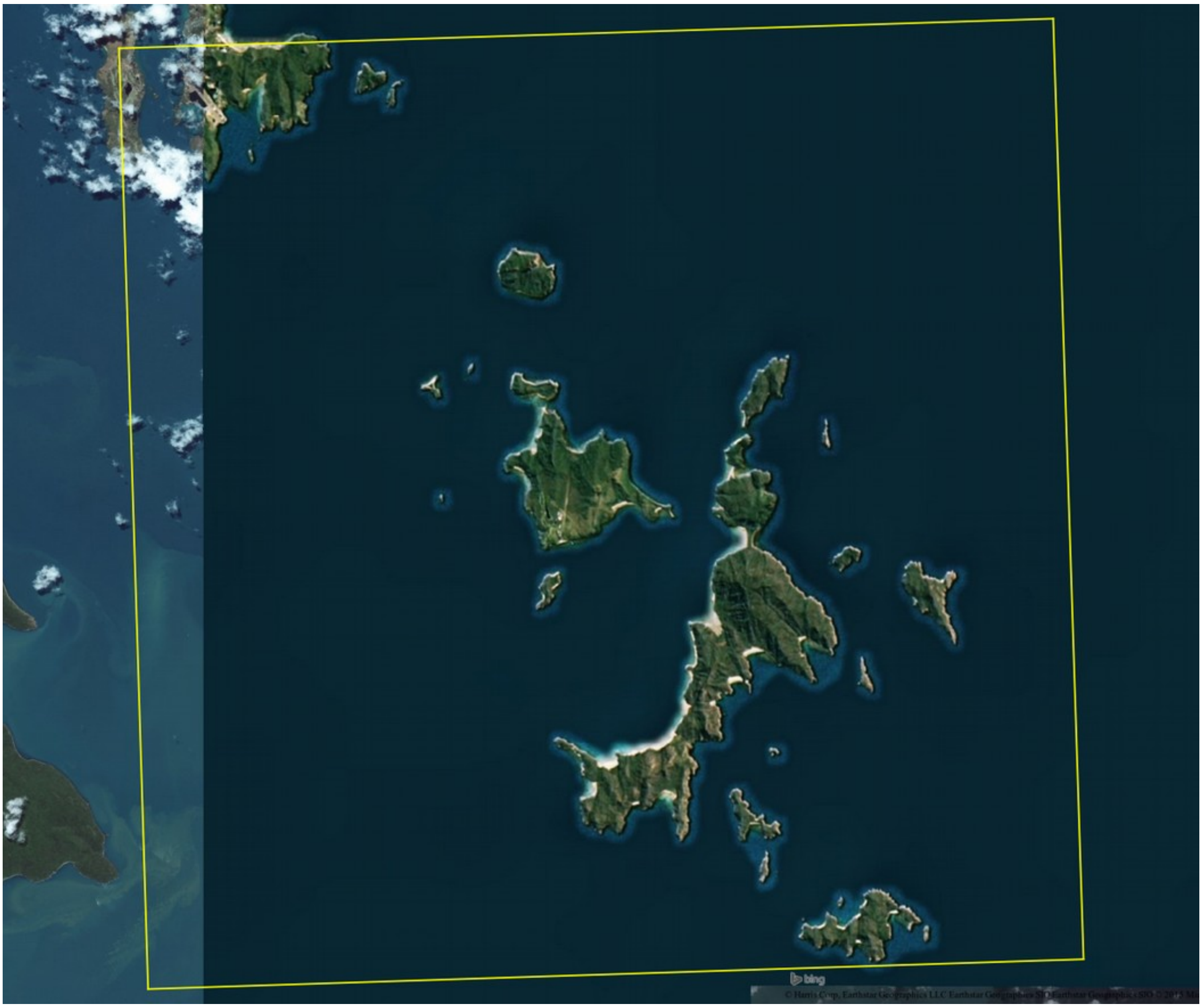


Figure 5.2: CALMET Modelling Domain

5.2.4 Model Validation

Figure 5.3 presents the annual predicted wind rose for Lindeman Island (approximately located at the centre of the airstrip).

Figures 5.4 and 5.5 below present a comparison of 9 am and 3 pm predicted wind roses for the nearby Hamilton Island with historical measured wind roses for the area. Review of the predicted wind rose confirms that the predicted wind fields are consistent with those in the historical observational dataset. It is also noted that for the observed dataset (9 am), wind directions for the Hamilton Island monitoring site have a greater occurrence of winds from southerly sectors when compared with the predicted dataset.

Review of the data indicates that the predicted meteorological dataset is generally representative of conditions expected to be observed over a longer term period in the region.

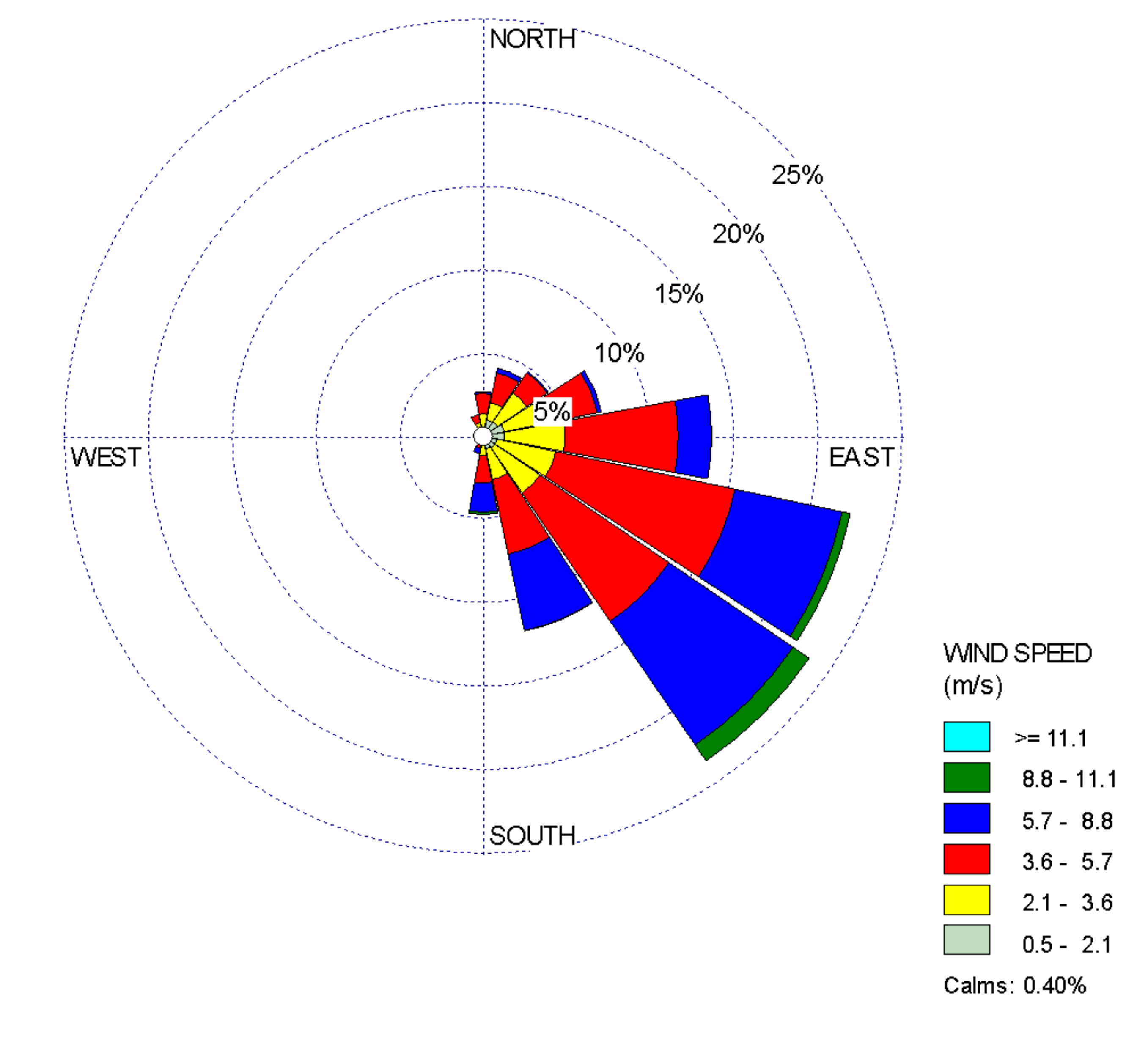
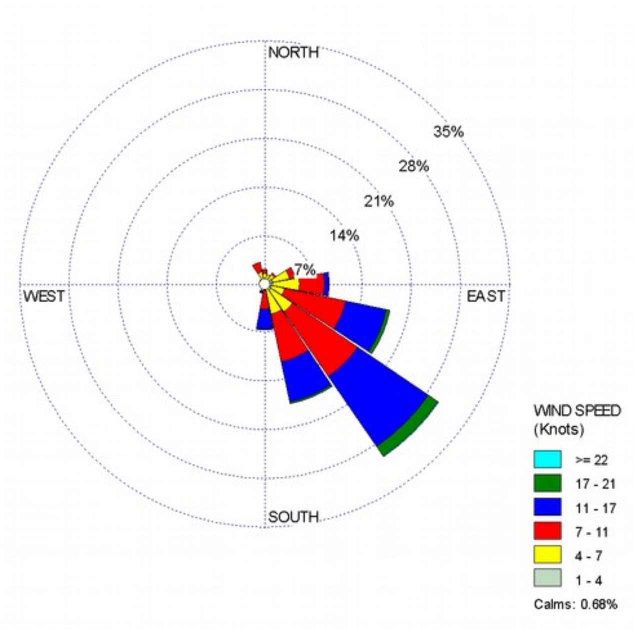


Figure 5.3: Predicted (site) wind fields (12 months of prognostic data)

Predicted 9 am wind rose for Hamilton Island



Historical 9 am wind rose for Hamilton Island

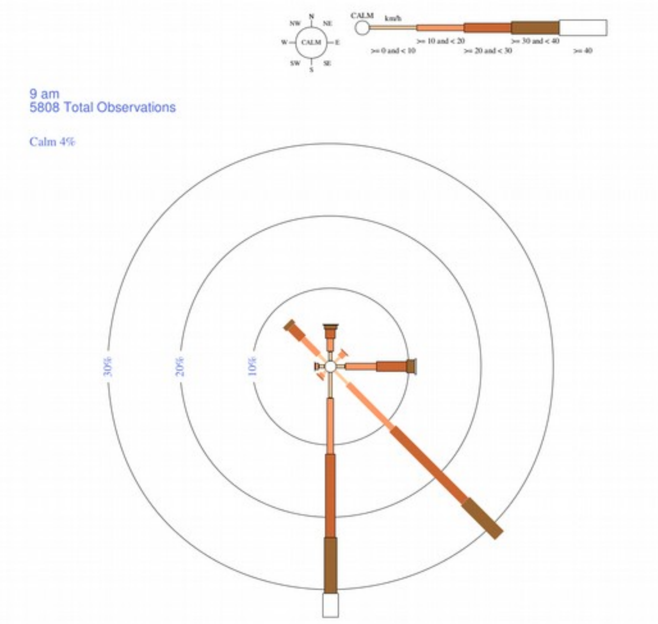
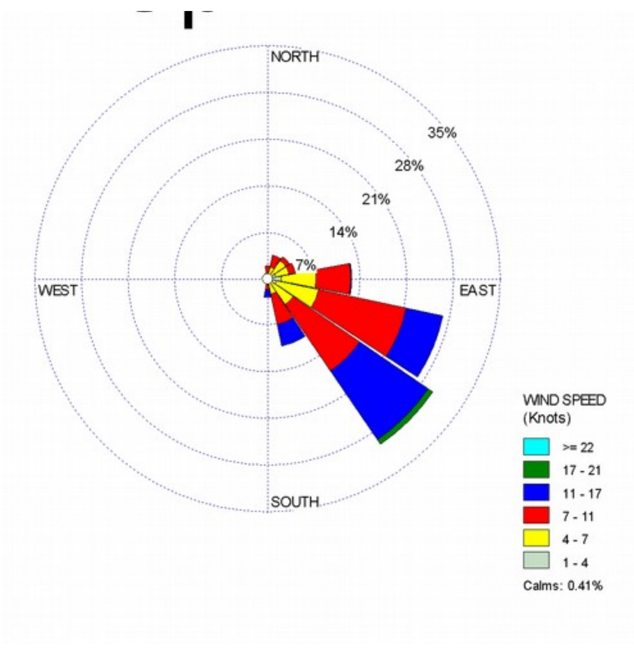


Figure 5.4: Comparison of predicted (Hamilton Island) and measured (Hamilton Island) 9 am wind rose

Predicted 3 pm wind rose for Hamilton Island



Historical 3 pm wind rose for Hamilton Island

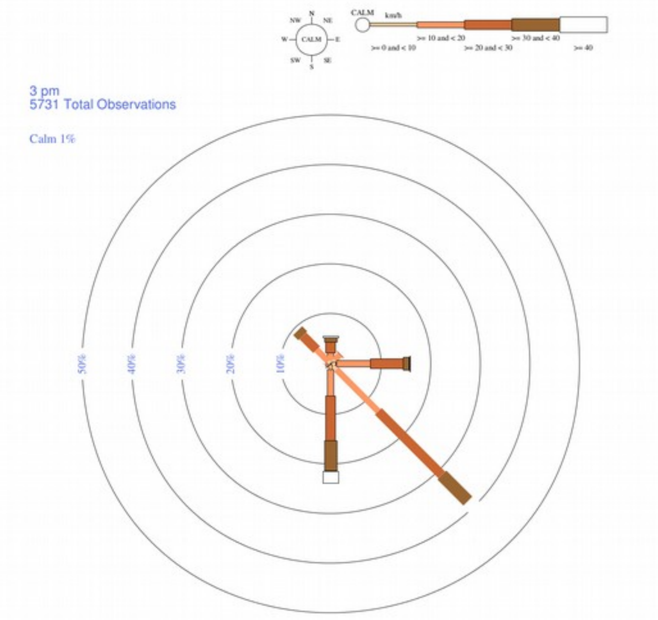


Figure 5.5: Comparison of predicted (Hamilton Island) and measured (Hamilton Island) 3 pm wind rose

5.3 Air Dispersion Modelling

5.3.1 Calpuff

For the purposes of the assessment, the CALPUFF dispersion model has been utilised to assess the potential impacts of emissions from the operation of the facility. CALPUFF is a non-steady state Lagrangian Gaussian puff model able to incorporate effects dispersion effects associated with complex terrain, overwater transport, coastal interaction effects and building downwash.

The CALPUFF modelling system treats emissions as a series of puffs. These puffs are then dispersed throughout the modelling area and allowed to grow and bend with spatial variations in meteorology. In doing so, the model is able to retain a memory of the plume's movement throughout a single hour and from one hour to the next while continuing to better approximate the effects of the complex air flows noted in the project area.

CALPUFF utilises the meteorological processing and prediction model CALMET to provide three dimensional wind field predictions for the area of interest. The final wind field developed by the model (for consideration by CALPUFF) includes an approximation of the effects of local topography, the effects of varying surface temperatures (as is observed in land and sea bodies) and surface roughness (resulting from varied land uses and vegetation cover in an area). The CALPUFF model is able to resolve complex terrain influences on local wind fields including consideration of katabatic flows and terrain blocking along with sea breeze recirculation effects associated with the region.

In particular the model is able to address the following issues considered to be relevant to the assessment:

- incorporation of the three-dimensional wind field data generated by CALMET to allow the consideration of complex terrain effects associated with the elevated terrain features on Lindeman Island and the surrounding islands;
- consider the influence of sea-breezes on dispersion of emissions during both the construction and operational phases of the project; and
- incorporation of building downwash effects associated with building structures via the use of the PRIME building downwash algorithm;

Post processing of modelled emissions is undertaken using the CALPOST package. This allows the rigorous analysis of pollutant predictions generated by the CALPUFF system. In particular CALPOST is able to provide an analysis of predicted pollutant concentrations for a range of averaging periods from 1 hour to 1 year.

The CALPUFF modelling domain incorporated the portion of the domain utilised by CALMET surrounding the site. Gridded receptor positions were included with a scaling factor of 2 providing a gridded receptor point every 50 m both latitudinally and longitudinally.

Predicted contaminant concentrations for each of these receptor grid locations are considered in the air quality assessment.

5.3.2 Ausplume

The Ausplume model (version 6.0) has been used in this assessment to predict dust emissions from the construction phase of the redevelopment. Ausplume is an approved Gaussian plume dispersion model for regulatory assessment in Queensland. The model accounts for meteorological data, building wake effects and terrain effects in the prediction of ground level concentrations of pollutants from stack, area or volume sources. Ausplume assumes steady state meteorology for the field of influence of the source being considered.

Steady state meteorology assumes that for any given time period of model calculation (usually 1 hour), the wind and other meteorological conditions are uniform over the entire area being modelled, and that a plume is assumed to travel instantaneously to the edge of the modelled area in a straight line. A number of additional parameters are considered in the modelling. Each of these parameters is considered in the following sections.

The site specific meteorological predictions generated using TAPM (Version 4.04) was utilised in the model.

5.4 Sensitive Receptors

5.4.1 Overview

The nearest sensitive receptors include residential receptors, ecologically sensitive environments and the marine environment. The following section outlines the receptors considered in the assessment.

5.4.2 Residential Receptors

Given the proposed construction staging, it is considered unlikely that residential uses would commence prior to completion of the majority of construction works. The exception to this is construction of the Villa precinct which is expected to occur over time subject to sales during operation of the balance of the resort. As such, these construction activities are likely to be similar in scale to a residential dwelling construction and therefore are not expected to be significant in terms of their potential for adverse impacts.

Therefore, for the construction phase, the residential receptors considered in the assessment include all staff accommodation areas which are expected to be utilised throughout the construction works.

For the operational phase, sensitive residential receptors considered included all resort areas and worker accommodation zones. Figure 5.6 presents the sensitive residential receptor locations. Predicted concentrations of odour from the STP and solid waste storage as well as combustion emissions from the diesel generator at these locations have been considered in the assessment.

Figure 5.6: Sensitive Residential Receptors

5.4.3 Sensitive Flora

A technical flora report from NRC was prepared for the proposed redevelopment[1]. The report found several areas of significance based on field and desktop studies. NRC's findings regarding conserving significant flora ecosystems for the current lease area is presented in Figure 5.7.

The areas labelled in Figure 5.7 are described as the following:

- Regional Ecosystem 8.3.2 is endangered under the Queensland Vegetation Management Act (VMA) (1999). There is no proposal to clear any of this Woodland under the proposed DBI Master Plan;
- Regional Ecosystem 8.12.13a is a native grassland community occurring in patches primarily on moderate slopes with a southerly aspect. This community has an 'Of Concern' status under the Queensland VMA, but is not a listed community under the EPBC Act. Some of these patches are

1 NRC (August 2015) 'Lindeman Island Resort: Terrestrial Flora and Fauna Technical Report' prepared on behalf of White Horse (Australia).

adjacent to the area proposed to be developed with discrete resort accommodation buildings;

- Regional ecosystem 8.12.11c is has a ‘least concern’ status under the Queensland VMA, but is equivalent to the littoral rainforest and coastal vine thickets of eastern Australia TEC listed under the EPBC Act.

A few ‘of concern’ areas identified as orange in Figure 5.7 are located within and immediately outside the development area.

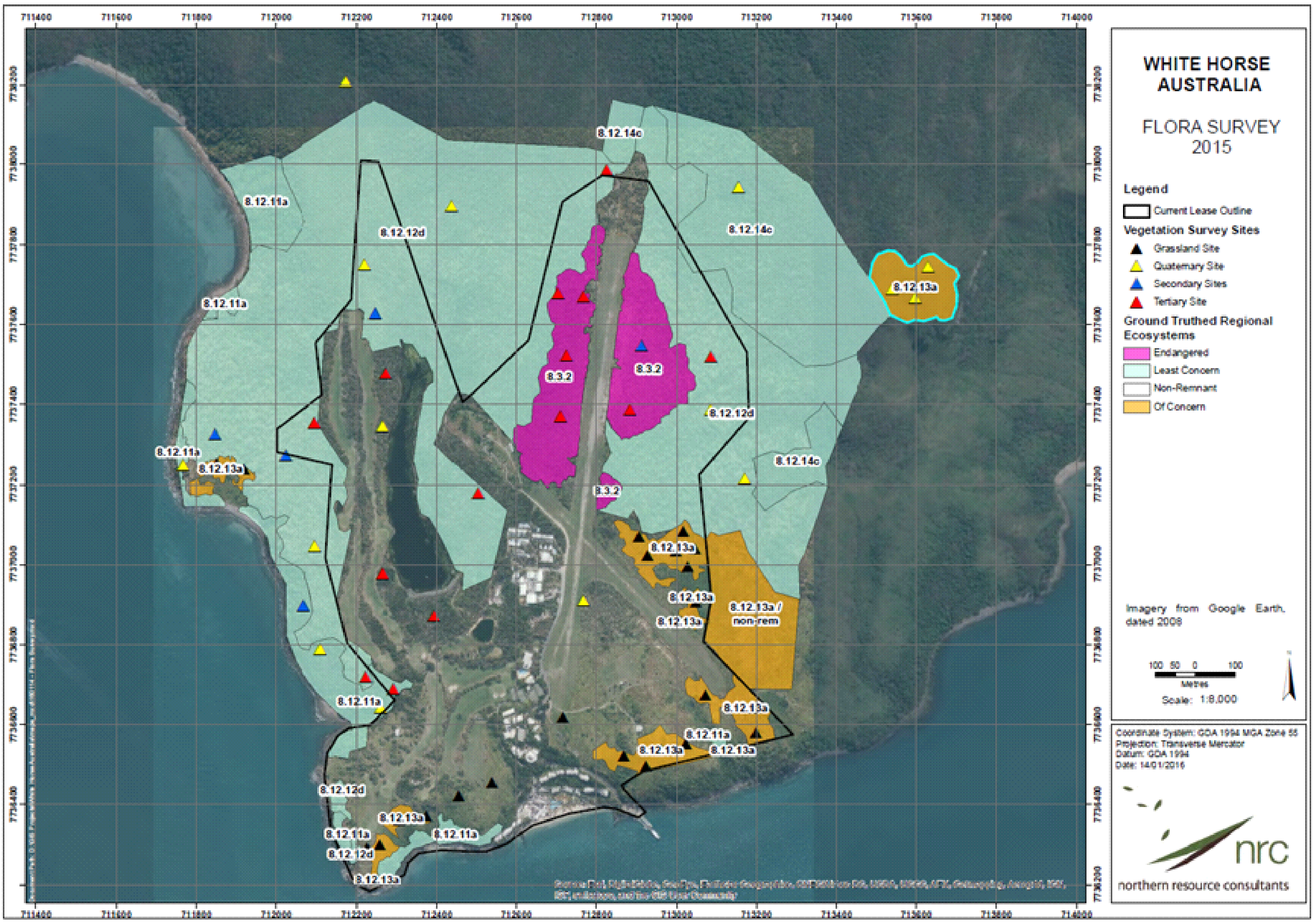


Figure 5.7: Sensitive Ecological Receptors

5.4.4 Marine Environment

Similar to the sensitive ecological receptors, the most significant impacts on the marine environment are expected to occur during the construction phase of the redevelopment. Dust fall emissions on the surrounding marine environment have been considered in the assessment.

5.5 Air Emissions Data

5.5.1 Power Generation

As stated in Section 4.2.3, the current proposal for diesel generation will include a hybrid energy generation system, combining 35-44% solar PV technology/battery storage with the balance from diesel generation. Through information obtained from the proponent, three 880 Kw diesel generators have been considered in the assessment. Technical data has been obtained for likely diesel generators with emissions estimated based on the emission factors provided in the Emissions Estimation Technique Manual for Combustion Engines (National Pollutant Inventory 2008). Tables 5.1 and 5.2 below presents a summary of estimated diesel emissions rates and parameters used in the modelling. Figure 5.8 presents the modelled source locations.

Table 5.1: Emissions Estimates – Power Generation (g/s)

CO	NO_x	$PM_{2.5}$	PM_{10}
0.81	1.45	0.1	0.11

Table 5.2: Diesel Generator Emission Parameters

Parameter	Value
Outlet Vent Diameter (m)	0.3
Efflux Velocity (m/s)	20
Temperature (°C)	500
Outlet Vent Height Above Roof (m)	3 m above roof level

5.5.2 Odour Emissions

Both the storage of refuse and the proposed sewage treatment plant (STP) have been identified as sources of odour with a potential to impact on the amenity of the proposed redevelopment. In order to predict odour emission rates, odour emission factors for both the STP and refuse storage building have been derived based on available scientific literature and studies, and previous odour sampling data obtained by Air Noise Environment. Both the STP and refuse storage have been modelled as volume sources.

Table 5.3 presents the modelled odour emission rates for each odour source. Figure 5.8 presents the modelled source locations.

Table 5.3: Odour Emission Rates

Source	Estimated Odour Concentration (Ou)	Area (m^2)	Estimated Odour Emission Rate (OUV/s)
STP	13.4	45	422.7

Source	Estimated Odour Concentration (Ou)	Area (m^2)	Estimated Odour Emission Rate (OUV/s)
Refuse Storage	9.8	2	275.5

5.5.3 Construction Emissions

5.5.3.1 Overview

For the purpose of assessing construction dust impacts, the modelling has considered emissions associated with construction of the 6 Star Resort as representative of the worst-case potential impacts. This development area is the nearest to 'of concern' and endangered flora species (located directly to north of area) and the Great Barrier Reef Marine Park.

In order to predict emission rates for the air emission sources associated with the construction activities, a review of available published literature relating to the potential air emission sources has been completed. The following documents have been utilised to estimate emissions:

1. AP 42 (5th Edition), Compilation of Air Pollutant Emission Factors, Vol. 1 Stationary Point and Area Sources, Chapter 13.2.2, Unpaved Roads, November 2006.
2. AP 42 (5th Edition), Compilation of Air Pollutant Emission Factors, Vol. 1 Stationary Point and Area Sources, Chapter 13.2.4, Aggregate Handling and Storage Piles, November 2006.
3. National Pollution Inventory, Emission Estimation Technique Manual for Mining, Version 3.1, January 2012.

The following sections present details on the derivation of emission factors and rates used in the modelling.

It should be noted that the derived emission rates assume that all areas of the six star resort subject to construction works would be disturbed at the same time. That is, dust emissions, including wind erosion, land clearing and bulk soil movement sources would occur for all areas of the resort zone concurrently. In reality this is expected to represent a conservative approach with the construction of the zone likely to progress in stages such that smaller areas would be disturbed at any one time.

5.5.3.2 Derivation Of Emission Factors

Table 5.4 presents emission factors derived from the US EPA AP42 and NPI literature.

Table 5.4: Emission Factors

No.	Activity/Source	Units	TSP	PM_{10}	$PM_{2.5}$
F1	Material transfer – excavator to truck	kg/t	0.00869	0.00411	0.00062
F2	Crushing	kg/t	0.20000	0.02000	0.00300

No.	Activity/Source	Units	TSP	PM_{10}	$PM_{2.5}$
F3	Truck Loading	kg/t	0.00869	0.00411	0.00062
F4	Screening	kg/t	0.01250	0.00430	0.00065
F5	Land Clearing/Bulldozing	kg/t	0.00498	0.00373	0.00052
F6	Wind erosion	kg/ha/hr	0.4	0.2	0.1
F7	Haul route – Onsite Haul Truck	g/VKT	6466	1908	191
F8	Haul route – Product Road Truck	g/VKT	4312	1273	127

Emission Factors F1 and F5 have been derived using Equation 1 from the US EPA AP 42 Compilation of Air Pollutant Emission Factors (Chapter 13.2.4, Aggregate handling and storage piles). Equation 1 calculates emissions from material handling as follows:

- Emission Factor (kg/T) = k x 0.0016 x $(U/2.2)^{1.3}$ / $(M/2)^{1.4}$
  - k = 0.74 and 0.35 for particle sizes less than 30 microns and 10 microns
  - U = wind speed (m/s)
  - M = material moisture content (%).

An average wind speed of 4.8 m/s for the surrounding area has been adopted based on annual 3 pm Hamilton Island meteorological station data collected by the Bureau of Meteorology. A moisture content of 3.2% has been adopted obtained from similar studies undertaken by Air Noise Environment.

Emission Factors F2 and F4 are based on crushing and screening data for crushed stone processing as presented in US EPA AP 42 Compilation of Air Pollutant Emission Factors (Chapter 11.19.2, Crushed Stone Processing and Pulverised Mineral Processing, Table 11.19.2-1).

Wind erosion emission factors (F6) have been based on the values presented in Table 1 of the National Pollution Inventory Emission Estimation Technique Manual for Mining and Processing of Non-Metallic Minerals (Version 2.0). This NPI document presents wind erosion emission factors associated with coal mines and are likely to be conservative when applied to the redevelopment.

Finally, Emission Factors F7 and F8 for haul routes have been derived using Equation 1a from the US EPA AP 42 Compilation of Air Pollutant Emission Factors (Chapter 13.2.2, Unpaved Roads). Equation 1a is as follows:

- Emission Factor (g/VKT) = 281.9 x k x $(s/12)^a$ x $(W/3)^b$
  - k = 4.9 and 1.5 for particle sizes less than 30 microns and 10 microns
  - a = 0.7 and 0.9 for particle sizes less than 30 microns and 10 microns

- b = 0.45
- s = silt content (%)
- W = vehicle weight (tons)

A silt content of 10.0 % has been adopted which is considered typical of an unpaved quarry road in Australia. For the purposes of the emissions estimation, haul truck gross vehicle mass has been estimated as 30 tonnes (representative of a truck and dog configuration).

5.5.3.3 Derivation Of Emission Rates

For the dispersion modelling, area sources have been modelled representing the worst-case construction stage as discussed previously. The estimated quantity of materials for each stage has been obtained from the proponent and used in conjunction with emission factors as presented in Table 5.4. in addition to the conservative approach adopted for the emissions estimation, the modelling as also assumed that all sources operate simultaneously 24 hours a day. That is, the modelling assumes that construction is continuous 24 hours per day for the entire year at the worst-case emission level making no allowance for reductions in emissions due to the progress of construction (noting that following completion of bulk earth works emissions would be expected to reduce). This is expected to further increase the significant level of conservatism inherent in the modelling results. Figure 5.8 presents the modelled source locations.

Table 5.5: Modelled Construction Stages

Stage	Quantity of Aggregate (t)	Area (m^2)	TSP ($kg/m^2/hour$)	PM_{10} ($kg/m^2/hour$)	$PM_{2.5}$ ($kg/m^2/hour$)
6 Star Resort	21,343.0	130,610.0	7.20E-05	3.51E-05	1.23E-05

5.5.3.4 Deposited Dust Modelling

The Ausplume model has been utilised to predict deposited dust levels from the construction activities. Particle size distribution data has been interpolated from the derived TSP, PM_{10} and $PM_{2.5}$ emission factors. Table 5.6 presents the adopted particle size distribution data.

Table 5.6: Adopted Particle Size Distribution Data

Particle Size (microns)	Mass Fraction
< 2.5	51 %
< 10	32 %
> 10	17 %

Figure 5.8: Modelled Source Locations

5.6 Modelling Results

5.6.1 Construction Works

Figures 5.9 to 5.12 present the predicted ground level concentrations for deposited dust, TSP, PM_{10} and $PM_{2.5}$ respectively.

The results of the modelling indicate compliance with the 120 mg/m^2/day nuisance criteria at the nearest affected resort receptors, with the exception of a small proportion of the Tourist Villa precinct during construction of the 6 Star Spa Resort area. The results are considered conservative as the modelling assumes worst-case wind directions and the daily dust levels are calculated from a 7-day averaging period (instead of the standard 30 day period). Further, as the Tourist Villa precinct is not expected to be operational prior to completion of the 6 Star Spa Resort, the potential for adverse amenity impacts on these areas is expected to be negligible.

Compliance with the TSP, PM_{10} and $PM_{2.5}$ criteria is also predicted to be achieved for all areas.

Exceedances of the deposited dust nuisance criteria are predicted for the protected vegetation located along the western shoreline and an area extending out 200 m from the shoreline to the south west of the six star resort.

It is noted that the nuisance criteria is based on minimising impacts on human populations. There are currently no guidelines or limits in relation to dust impacts on flora or marine park environments. Of the evidence available in the international literature, impacts on sensitive vegetation would not be expected at the levels predicted to occur as a result of the proposed resort development. Further, given the significant conservatism incorporated into the modelling, the risk associated with the proposed development is considered to be low.

Despite this, it is recommended that best practice dust management measures are adopted during construction of the resort areas on the island including:

- Regular use of water sprays on exposed areas of ground including any internal roadways to ensure soil moisture remains sufficient to suppress visible dust production.
- Minimising dust generating activities such as site clearing, levelling and preparation during dry and windy conditions.
- Limit vehicle speeds on site and/or use of gravel on heavily trafficked haul routes.

Figure 5.9: Predicted Deposited Dust Concentrations – 6 Star Resort Construction Phase	
Scenario: Construction – 6 Star Resort	**Averaging Time:** 24 Hour
Location: Lindeman Island	**Units:** mg/m^2
Pollutant: Deposited Dust	**Criteria:** 120 mg/m^2/day

Figure 5.10: Predicted Ground Level TSP Concentrations (Cumulative) – 6 Star Resort

Scenario: Construction – 6 Star Resort	**Averaging Time:** Annual
Location: Lindeman Island	**Units:** µg/m^3
Pollutant: TSP	**Criteria:** 90 µg/m^3

Figure 5.11: Predicted Ground Level PM_{10} Concentrations (Cumulative) – 6 Star Resort	
Scenario: Construction – 6 Star Resort	**Averaging Time:** 24 Hour
Location: Lindeman Island	**Units:** $\mu g/m^3$
Pollutant: PM_{10}	**Criteria:** 50 $\mu g/m^3$

Figure 5.12: Predicted Ground Level $PM_{2.5}$ Concentrations (Source Only) – 6 Star Resort

Scenario: Construction – 6 Star Resort **Location:** Lindeman Island **Pollutant:** $PM_{2.5}$	**Averaging Time:** 24 Hour **Units:** $\mu g/m^3$ **Criteria:** 25 $\mu g/m^3$

5.6.2 Resort Operation

The results of the dispersion modelling for the operation of the redevelopment are presented in Table 5.7. A 20% conversion factor has been utilised for the conversion of NO_x to NO_2. Figures 5.13 to 5.17 present the predicted ground level contours.

The results of the dispersion modelling indicate the operation of the STP and waste storage area has little potential for impact on the amenity for the surrounding area with results well below the applicable 2.5 odour unit criteria. A maximum predicted concentration of 1.2 odour units is predicted for the staff accommodation followed by concentrations between 0.1 to 0.2 odour units for the remaining resort facilities.

Predicted emissions for power generation are shown to comply with the relevant criteria for all modelled pollutants. The highest concentrations are predicted for the staff accommodation areas followed by the tourist Villas. PM_{10} concentrations are shown to closest to the criteria at 60% (cumulative).

Based on the results of the modelling, the potential for adverse health or amenity impacts as a result of the operation of the resort is expected to be negligible. Despite this, it is recommended that all plant and equipment (including power generation and waste handling equipment) are adequately maintained in accordance with environmental best practice.

Table 5.7: Predicted Ground Level Concentrations at the Residential Receptors (ug/m^3)

Resort Facility	CO 8 Hour	NO_2		PM_{10} 24 Hour (Cumulative)	$PM_{2.5}$ 24 Hour	Odour 1 Hour (99.5th Percentile) (Ou)
		1 Hour	Annual			
Staff Accomodation	44.24	86.40	2.98	30.16	12.47	1.22
Tourist Villas	14.97	49.70	0.12	20.14	2.68	0.06
Beach Resort	7.24	17.92	0.20	18.97	1.53	0.07
6 Star Resort	12.21	28.95	0.49	20.26	2.79	0.23
5 Star Eco Resort	12.26	29.63	1.40	19.78	2.32	0.13
Criteria	***11,000***	***250***	***62*** ***33***	***50***	***25***	***2.5***

Figure 5.13: Predicted Odour Ground Level Odour Concentrations (99.5th Percentile)

Scenario: Operation	**Averaging Time:** 1 Hour
Location: Lindeman Island	**Units:** Ou
Pollutant: $PM_{2.5}$	**Criteria:** 25 µg/m^3

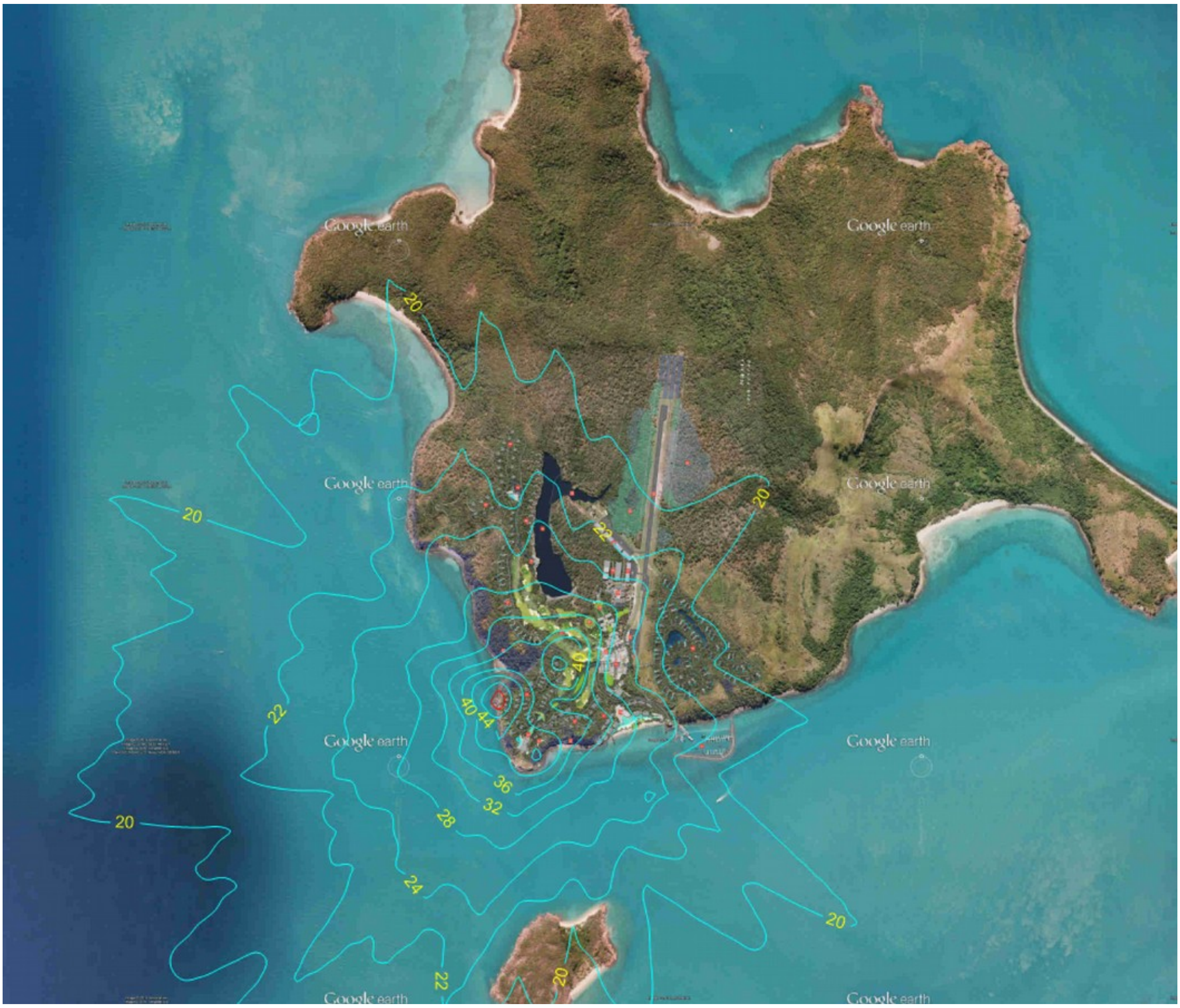


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Figure 5.14: Predicted CO Ground Level Concentrations	
Scenario: Operation – Power Generation **Location:** Lindeman Island **Pollutant:** CO	**Averaging Time:** 8 Hour **Units:** µg/m^3 **Criteria:** 11,000 µg/m^3

Figure 5.15: Predicted NO_2 Ground Level Concentrations	
Scenario: Operation – Power Generation **Location:** Lindeman Island **Pollutant:** NO_2	**Averaging Time:** 1 Hour **Units:** µg/m^3 **Criteria:** 250 µg/m^3

Figure 5.16: Predicted PM_{10} Ground Level Concentrations(Cumulative)	
Scenario: Operation – Power Generation	**Averaging Time:** 24 Hour
Location: Lindeman Island	**Units:** $\mu g/m^3$
Pollutant: PM_{10}	**Criteria:** 50 $\mu g/m^3$

Figure 5.17: Predicted $PM_{2.5}$ Ground Level Concentrations

Scenario: Operation – Power Generation	**Averaging Time:** 24 Hour
Location: Lindeman Island	**Units:** $\mu g/m^3$
Pollutant: $PM_{2.5}$	**Criteria:** 25 $\mu g/m^3$

5.7 Summary of Potential Impacts

Based on the results of the predictive modelling, potential impacts have been summarised using a risk assessment matrix. The risk matrix summarises the extent of impacts based on the probability of an event occurring and the likely consequences. Table 5.8 presents the risk matrix and Table 5.9 presents the outcomes of the assessment.

Table 5.8: Risk Assessment Matrix

Probability	**Consequences**				
	Catastrophic Irreversible Permanent (5)	**Major Long Term (4)**	**Moderate Medium Term (3)**	**Minor Short-Term Manageable (2)**	**Insignificant Manageable (1)**
Almost Certain (5)	(25) Extreme	(20) Extreme	(15) High	(10) Medium	(5) Medium
Likely (4)	(20) Extreme	(16) High	(12) High	(8) Medium	(4) Low
Possible (3)	(15) High	(12) High	(9) Medium	(6) Medium	(3) Low
Unlikely (2)	(10) Medium	(8) Medium	(6) Medium	(4) Low	(2) Low
Rare (1)	(5) Medium	(4) Low	(3) Low	(2) Low	(1) Low

Table 5.9: Risk Assessment

Potential Impact	Significant of Impact (Unmitigated)	Mitigation Measure	Significance of Impact (Mitigated)
Construction			
Dust impacts	Low (4) Unlikely	Dust management measures	Low (2) Insignificant Manageable
Operational			
Nuisance odour from waste storage/treatment	Low (4) Unlikely	Proper maintenance	Low (2) Insignificant Manageable
Diesel generator emissions	Low (4) Unlikely	Proper maintenance	Low (2) Insignificant Manageable

Based on the results of the modelling, the potential for adverse health or amenity impacts as a result of the resorts construction and operation is expected to be negligible. Further, the risk of adverse impacts on the nearby sensitive flora populations and the Great Barrier Marine Park are also expected to be low.

It is noted however that these conclusions (which are based on a conservative assessment of potential impacts) assume a range of best practice environmental controls are incorporated into the developments construction and operation including:

- For the construction phase:
  - Regular use of water sprays on exposed areas of ground including any internal roadways to ensure soil moisture remains sufficient to suppress visible dust production.
  - Minimising dust generating activities such as site clearing, levelling and preparation during dry and windy conditions.
  - Limit vehicle speeds on site and/or use of gravel on heavily trafficked haul routes.
- For the operational phase:
  - maintenance of all plant and equipment (including power generation and waste handling equipment) in accordance with environmental best practice to ensure emissions are minimised as far as practicable.

6 Conclusions

White Horse Australia Lindeman Pty Ltd commissioned Air Noise Environment to undertaken an air quality assessment for the proposed Lindeman Island resort redevelopment. The proposal includes redeveloping the existing resort at Lindeman Island into a world class integrated tourist resort with a Spa, Tourist Villas and Safe Harbour. This air quality impact assessment is to form a component of the Environmental Impact Statement (EIS) being prepared for the redevelopment.

Predictions of pollutant concentrations were completed using the computational model CALPUFF for the activities associated with the operation of the redevelopment and Ausplume for the construction phase. Predictions were compared against the adopted air quality criteria from the EPP Air and other relevant guidelines.

The results of the modelling for the construction phase indicate that the potential for nuisance dust, total suspended particulate, PM_{10} and $PM_{2.5}$ impacts on resort areas are minimal provided that appropriate dust management measures are adopted. Exceedances of the deposited dust nuisance criteria are predicted for the protected vegetation located along the western shoreline and an area extending out 200 m from the shoreline to the south west of the six star resort. Given the conservatism incorporated into the modelling and the lack of evidence of adverse impacts on vegetation and marine park environments at these concentrations, the risk associated with the proposed development is considered to be low. Despite this, it is recommended that best practice dust management measures are adopted during construction of the resort areas on the island including:

- Regular use of water sprays on exposed areas of ground including any internal roadways to ensure soil moisture remains sufficient to suppress visible dust production.
- Minimising dust generating activities such as site clearing, levelling and preparation during dry and windy conditions.
- Limit vehicle speeds on site and/or use of gravel on heavily trafficked haul routes.

Air quality impacts associated with the operation of the redevelopment are predicted to be minimal. Predicted emissions for power generation are shown to comply with the relevant criteria for all modelled pollutants. Furthermore, predictions of odour emissions from waste storage and sewage treatment were shown to have minimal impact on the amenity of the proposed residential receptors. Given this, where all plant and equipment (including power generation and waste handling equipment) is adequately maintained in accordance with environmental best practice to ensure emissions are minimised as far as practicable the potential for adverse air quality impacts is expected to be negligible.

Appendix A - Air Quality Glossary

APPENDIX A: GLOSSARY OF AIR QUALITY TERMINOLOGY	
Conversion of ppm to mg/m^3	Where R is the ideal gas constant; T, the temperature in kelvin (273.16 + T°C); and P, the pressure in mm Hg, the conversion is as follows: $\text{mg m}^{-3} = (P/RT) \times \text{Molecular weight} \times (\text{concentration in ppm})$ $= \frac{P \times \text{Molecular weight} \times (\text{concentration in ppm})}{62.4 \times (273.2 + T°C)}$ For the purposes of the air quality assessment all conversions were made at 25°C.
g/s	Grams per second
mg/m^3	Milligrams (10^{-3}) per cubic metre. Conversions from mg/m^3 to parts per volume concentrations (ie, ppm) are calculated at 25 °C as required by the SEPP(AQM).
µg/m^3	Micrograms (10^{-6}) per cubic metre. Conversions from µg/m^3 to parts per volume concentrations (ie, ppb) are calculated at 25 °C.
ppb	Parts per billion.
ppm	Parts per million.
PM_{10}, $PM_{2.5}$, PM_1	Fine particulate matter with an equivalent aerodynamic diameter of less than 10, 2.5 or 1 micrometres respectively. Fine particulates are predominantly sourced from combustion processes. Vehicle emissions are a key source in urban environments.
50th percentile	The value exceeded for 50 % of the time.
NO_x	Oxides of nitrogen – a suite of gaseous contaminants that are emitted from road vehicles and other sources. Some of the compounds can react in the atmosphere and, in the presence of other contaminants, convert to different compounds (eg, NO to NO_2).
VOC	Volatile Organic Compounds. These compounds can be both toxic and odorous.