Additions to Awaba Waste Management Facility

Environmental Assessment - VOLUME 4 (Appendices L to O)

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29 August 2012

Prepared for Lake Macquarie City Council
138 Main Road Speers Point NSW 2284

Additions to Awaba Waste Management Facility

Appendix L

Air Quality and Odour Report

Lake Macquarie City Council

pae holmes

REPORT

AIR QUALITY AND ODOUR ASSESSMENT – AWABA LANDFILL EXTENSION

Cardno Pty Ltd

Job No: 5505

28 March 2012

A PEL Company

PROJECT TITLE:	**AIR QUALITY AND ODOUR ASSESSMENT – AWABA LANDFILL EXTENSION**
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ES1 EXECUTIVE SUMMARY

Overview

Lake Macquarie City Council is proposing an expansion of the Awaba landfill site through the excavation of two new landfill cells. An air quality assessment has been completed to address the NSW Department of Planning and Infrastructure (DPI) Director-General's Requirements for assessment.

Existing Environment

The Awaba Landfill is located approximately 1.5 km south of the township of Awaba in undulating topography and surrounded by native bushland.

Prevailing winds have been described based on data collected at the Bureau of Meteorology (BoM) Cooranbong weather station, located 10 km southwest of Awaba. These data were also used as input into a dispersion modelling system using the models TAPM and CALMET/CALPUFF. From this, a 1-year representative meteorological dataset was compiled and used to describe the prevailing dispersion meteorology.

Emissions and Modelling Approach

A quantitative assessment of the potential odour impacts from the landfill has been assessed based on two scenarios to account for variation in the locations of odour emitting sources and worst case potential odour impacts over the course of the landfill life. An existing operations scenario was also completed. Odour emissions have been characterised based on measurements taken from a similar facility. An onsite renewable energy facility consists of a 1 MW power generation unit and a backup flare for excess landfill gas destruction. Air quality impacts from this facility have been assessed based on emissions for a worst case scenario, derived based on monthly landfill gas reports. Dust emissions generated during construction and landfilling operations have also been addressed quantitatively.

Results & Assessment

The results of the odour modelling predictions for the two future scenarios indicate that the predicted odour concentrations at any residential receptor are significantly less than 2 OU and below 1 OU (the odour threshold or theoretical odour level at which no impact is experienced) within 500 m of the site.

Modelling of emissions from the operation of the flare and power generation facility indicates that the air quality goals would not be comprised, even when background concentrations are considered.

Predicted dust levels during construction and operation are predicted to be low and should be largely controllable through good site environmental practice and commonly applied dust management measures. Prior to construction, an Environmental Management Plan will be developed which will include air quality and dust management / mitigation procedures.

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1 INTRODUCTION

Lake Macquarie City Council (LMCC) operates the Awaba landfill at Wilton Road, Awaba, licensed by the NSW Environmental Protection Agency[a] to accept Class 1 waste. The lifespan of the Awaba facility is extremely limited, with only 4-6 years capacity remaining at current filling rates and projected population increases. LMCC are proposing an expansion of the landfill site through the excavation of two new landfill cells.

The expansion of the Awaba Landfill requires approval under Section 75F of the Environmental Planning & Assessment Act 1979 (EP&A Act) and in accordance with State Environmental Planning Policy (Major Developments) 2005.

Cardno Pty Ltd are managing the preparation of the Environmental Assessment (EA) to support the application and PAEHolmes have been engaged to prepare an Air Quality Impact Assessment (AQIA) to form part of the EA.

1.1 Objectives of the Study

The primary objective of the study is to assess the potential air quality / odour impacts from the expansion by addressing the NSW Department of Planning and Infrastructure (DPI) Director-General's Requirements for assessment (DGRs), outlined as follows:

- *a quantitative assessment of the potential air quality and odour impacts of the project, including cumulative impacts;* and
- *a demonstration that the proposal is able to comply with the Protection of the Environment Operations (POEO) Action 1997 and the POEO (Clean Air) Regulation 2002*.

The air quality / odour assessment is carried out in accordance with the NSW Office of Environment and Heritage (OEH) "Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales" (**NSW DEC, 2005**).

[a] The NSW EPA exists as a legal entity operated within the Office of Environment and Heritage (OEH) which came into existence in April 2011. OEH was previously part of the Department of Environment, Climate Change and Water (DECCW). The DECCW was also recently known as the Department of Environment and Climate Change (DECC), and prior to that the Department of Environment and Conservation (DEC). The terms NSW EPA, OEH, DECCW, DECC and DEC are interchangeable in this report.

2 PROJECT DESCRIPTION AND LOCAL SETTING

The Awaba Landfill expansion would extend the lifespan of the landfill out to 20 years and is proposed to occur in two areas, Area A to the northeast of the current landfilled area and Area B to the northwest. The addition of these new landfill cells will also allow for an increased depth of waste to be deposited in the existing landfill area. The existing landfill (cells C1-C4) and future landfilling areas (A and B) are shown in **Figure 2.1**.

The proposed modifications include:

- removal of native vegetation;
- excavation for two additional landfill cells;
- construction of leachate, stormwater, gas, and groundwater infrastructure;
- construction of waste transfer station;
- construction of service roads and a green waste processing area;
- provision for new on-site staff amenities;
- site rehabilitation;
- retention of existing landfill operations approved under DA/82/1994;
- relocation of weighbridge; and,
- construction of a wheel wash unit.

It is proposed that Area A will be initially excavated and Cell A1 filled to the final levels and then capped with a final capping. The area that can be capped will be less than the total area of the cell due to the batters of the waste where the cell adjoins Cells A2 and B1. The filling of Area A would then continue with the subsequent development of Cells A2 and A3 continuing from the north and moving south.

Area B would be developed and filled in a similar manner to Area A, commencing at the northern end (Cell B1) and developing cells moving south. The active cell would be capped with a final capping at the completion of each stage.

Area C is to be built over the previously landfilled areas. Like the other areas, Area C will be developed commencing at the northern end (Cell C1) and progressively move south, down the natural slope of the site.

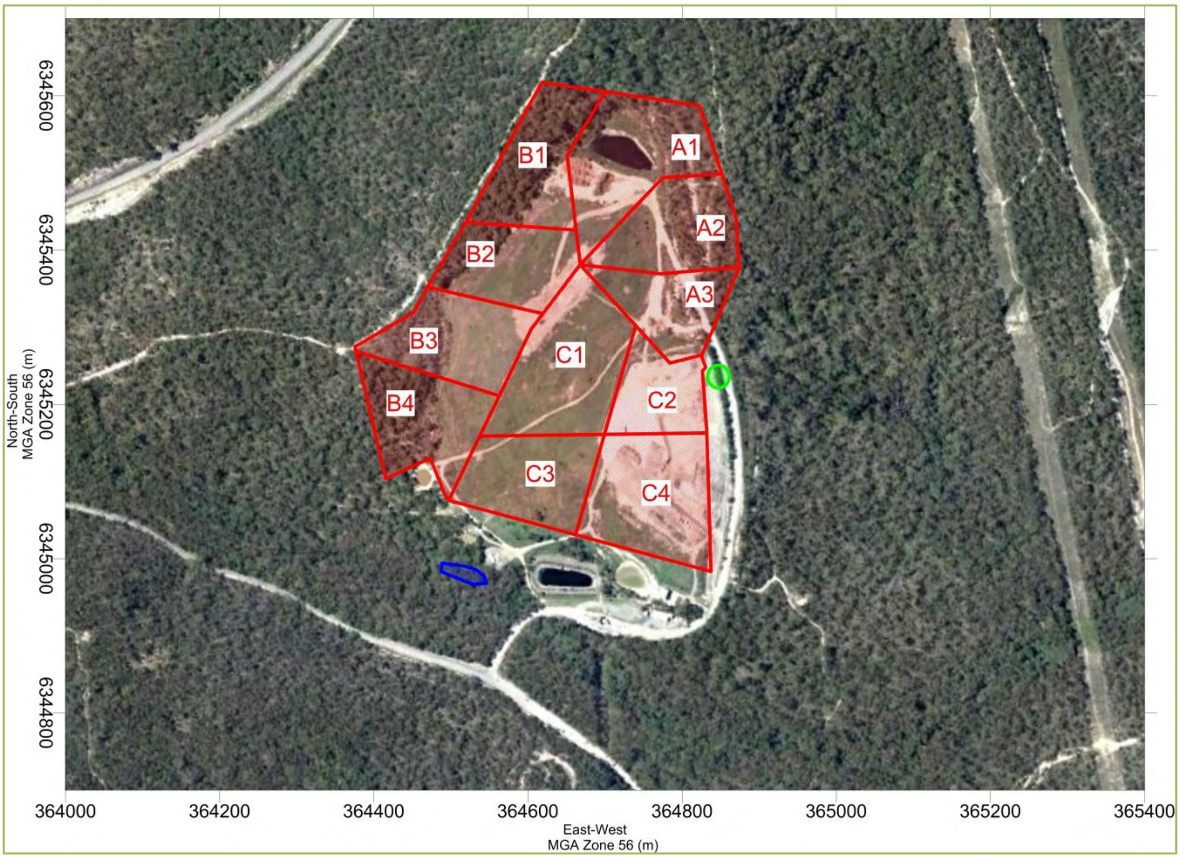


Figure 2.1: Overview of Awaba Landfill Modification

2.1 Local Setting

The Awaba Landfill is located on Wilton Road, Awaba, approximately 1.5 km south of the township of Awaba and appropriately 4 km inland from the suburbs of Lake Macquarie. For the purposes of assessing impacts from the site, receptor locations are selected and presented in **Table 2.1**. The site is located in undulating topography and surrounded by native bushland (refer **Figure 2.2** and **Figure 2.3**).

Table 2.1: Receptor Locations

Receptor ID	MGA56 Easting (m)	MGA56 Northing (m)	Elevation (m)
1	363719	6346138	23.33
2	363705	6346051	24.68
3	363556	6346138	24.23
4	363770	6346478	53.22
5	364161	6346537	37.66
6	364203	6346566	38.59
7	364305	6346654	32.37
8	364389	6346737	30.17
9	364449	6346798	28.45
10	364560	6346891	22.76
11	366263	6346732	34.78
12	366312	6346774	35.18
13	366376	6346784	34.59
14	366421	6346797	34.65
15	366275	6346422	34.42
16	366339	6346405	32.47
17	366381	6346405	31.32
18	366456	6346399	34.36
19	366546	6346422	31.17
20	366588	6346349	40.68
21	366776	6346270	36.58
22	366701	6346291	39.6
23	366903	6346255	41.25
24	366975	6346268	38.25
25	366875	6345564	42.92
26	366659	6345057	27.34
27	367154	6345260	16.19
28	367637	6345727	56.28
29	367962	6345617	59.45
30	367972	6345545	60.0
31	368000	6345306	49.38
32	366057	6344730	27.19
33	365820	6344515	21.82
34	366293	6344321	22.17
35	365844	6344175	12.92
36	365240	6344038	27.93
37	363245	6346289	43.88

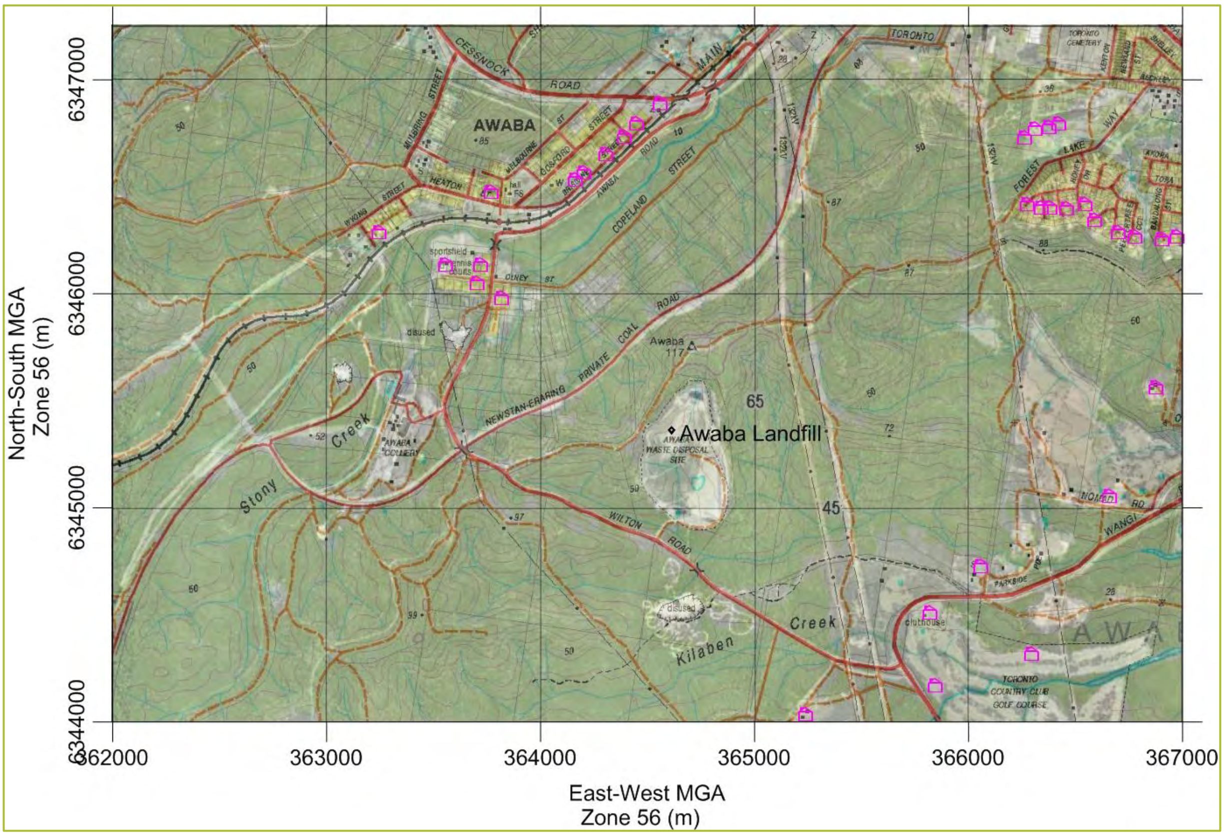


Figure 2.2: Local Setting and receptor locations

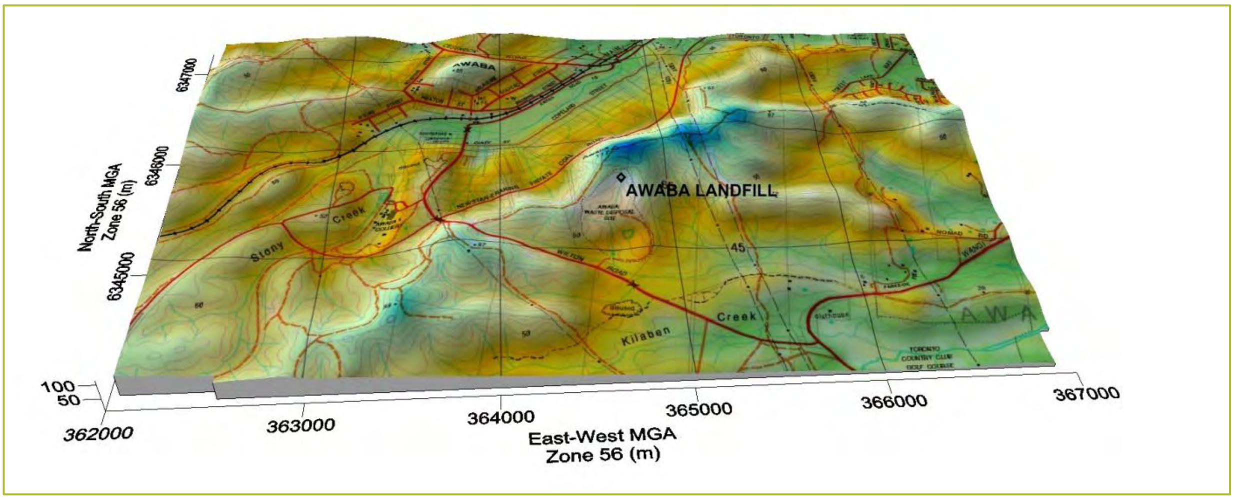


Figure 2.3: 3-Dimensional Representation of Local Topography

3 AIR QUALITY CRITERIA

During operation of the landfill odour emissions can be expected from the active tipping face, leachate storage ponds, gas collection infrastructure and intermediate cover areas.

Trucks travelling along unsealed sections of the site and heavy plant at the active face will results in emissions of dust and particulate matter (PM). During construction and excavation of the cells, fugitive dust emissions can also be expected.

Combustion emissions, including oxides of nitrogen (NO_x), carbon monoxide (CO) and volatile organic compounds (VOCs) from power generation and flaring will also occur onsite. Emissions of CO, NO_x, and sulphur dioxide (SO_2) will occur from diesel-powered construction equipment; however these are typically too small and too widely dispersed to give rise to significant off-site concentrations.

3.1 Odour

The OEH has developed odour goals and the way in which they should be applied with dispersion models to assess the likelihood of nuisance impact arising from the emission of odour. There are two factors that need to be considered:

1. what "level of exposure" to odour is considered acceptable to meet current community standards in NSW and

2. how can dispersion models be used to determine if a source of odour meets the goals which are based on this acceptable level of exposure

The term "level of exposure" has been used to reflect the fact that odour impacts are determined by several factors the most important of which are:

- the Frequency of the exposure
- the Intensity of the odour
- the Duration of the odour episodes and
- the Offensiveness of the odour (the so-called FIDO factor)

Whether or not an individual considers an odour to be a nuisance will depend on the FIDO factors outlined above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any individual to an odour is still unpredictable. Odour goals need to take account of these factors.

The OEH Approved Methods include ground-level concentration (glc) criterion for complex mixtures of odorous air pollutants. They have been refined by the OEH to take account of population density in the area. **Table 3.1** lists the odour glc criterion to be exceeded not more than 1% of the time, for different population densities.

Table 3.1: Impact Assessment Criteria for the Assessment of Odorous air pollutants

Population of affected community	Impact Assessment Criteria for Complex Mixtures of Odorous Air Pollutants (OU, nose-response-time average, 99th percentile)
≤ ~2	7
~10	6
~30	5
~125	4
~500	3
Urban (2000) and/or schools and hospitals	2

The difference between odour goals is based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area.

Although the Awaba Landfill facility is located in a sparsely populated rural area, the most stringent impact assessment criterion of 2 OU is adopted for this assessment.

3.1.1 Peak-to-mean ratios

It is a common practice to use dispersion models to determine compliance with odour goals. This introduces a complication because typically dispersion models predict concentrations over an averaging period of 1-hour or greater. The human nose, however, responds to odours over periods of the order of a second or so. To determine more rigorously the ratio between the one-second peak concentrations and three-minute and longer period average concentrations (referred to as the peak-to-mean ratio) that might be predicted by a Gaussian dispersion model, the OEH commissioned a study by **Katestone (1995, 1998)**. This study recommended peak-to-mean ratios for a range of circumstances, dependent on atmospheric stability and the distance from the source. The OEH Approved Methods take account of this peaking factor and the goals shown in **Table 3.1** are based on nose-response time.

3.2 Particulate Matter

Construction of the cells will generate particulate matter (PM) from activities including vegetation stripping, topsoil removal, excavation of material, hauling and emplacement of material by trucks and wind erosion from exposed surfaces. Suspended PM can be defined by its size, chemical composition and source. Particle size is an important factor influencing its dispersion and transport in the atmosphere and its potential effects on human health. Typically, the size of suspended particles ranges from approximately 0.005 to 100 micrometers (μm) and is often described by the aerodynamic diameter of the particle.

The particulate size ranges are commonly described as:

- TSP – total suspended particulate matter refers to all suspended particles in the air In practice, the upper size range is typically 30 μm – 50 μm;
- PM_{10} –refers to all particles with equivalent aerodynamic diameters of less than 10μm, that is, all particles that behave aerodynamically in the same way as spherical particles with a unit density.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5 μm diameter (a subset of PM_{10}). Often referred to as the fine particles;

- PM2.5-10 – defined as the difference between PM_{10} and $PM_{2.5}$ mass concentrations. Often referred to as coarse particles;

Both natural and anthropogenic processes contribute to the atmospheric load of PM. Coarse particles (PM2.5-10) are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal[b] materials from roads, farming, mining, dust storms, and so forth. Coarse particles also include sea salts, pollen, mould, spores, and other plant parts.

Fine particles or $PM_{2.5}$ are derived primarily from combustion processes, such as vehicle emissions, wood burning, coal burning for power generation, and natural processes, such as bush fires. Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosol from volatile organic compound emissions.

Dust generated during construction of the cells is likely to be composed of predominantly coarse particulate matter (and larger). The Approved Methods specifies air quality assessment criteria relevant for assessing impacts from PM (**DEC, 2005**). The air quality goals relate to the total dust burden in the air and not just the dust from the Project. In other words, consideration of background dust levels needs to be made when using these goals to assess potential impacts. **Table 3.2** summarises the air quality goals for concentrations of particulate matter that are relevant to this study.

Table 3.2: OEH air quality standards/goals for particulate matter concentrations

Pollutant	Averaging period	Standard / Goal	Agency
Total suspended particulate matter (TSP)	Annual mean	90 $\mu g/m^3$	National Health and Medical Research Council (NHMRC)
Particulate matter with an equivalent aerodynamic diameter less than 10 µm (PM_{10})	24-hour maximum	50 $\mu g/m^3$	OEH impact assessment criteria; NEPM reporting goal, allows five exceedances per year for bushfires and dust storms;[1]
	Annual mean	30 $\mu g/m^3$	OEH impact assessment criteria;

Notes: $\mu g/m^3$ – micrograms per cubic metre, µm – micrometre;

In addition to health impacts, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, including vegetation. Larger particles do not tend to remain suspended in the atmosphere for long periods of time and will fallout relatively close to source. Dust fallout can soil materials and generally degrade aesthetic elements of the environment and are assessed for nuisance or amenity impacts. **Table 3.3** shows the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust fallout levels are set to protect against nuisance impacts (**DEC, 2005**).

Table 3.3: OEH criteria for dust (insoluble solids) fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

Notes: g/m^2/month – grams per square metre per month.

[b] Crustal dust refers to dust generated from materials derived from the earth's crust.

3.3 Oxides of Nitrogen

The key pollutant released from power generation and flaring of excess landfill gas will be oxides of nitrogen (NO_x). NO_x is comprised of nitric oxide (NO) and nitrogen dioxide (NO_2), however NO is not considered harmful to human health and generally not considered an air pollutant at the concentrations that are typically found in ambient environments. Effects of NO_2 include respiratory infections, asthma and chronic lung disease. The NSW OEH prescribes ambient impact assessment criteria for NO_2, as outlined in **Table 3.4**.

Table 3.4: Ambient Air Quality Goals for NO_2 and CO

Pollutant	Averaging Period	Goal
Nitrogen Dioxide	1-Hour	0.12 ppm
	Annual	0.03 ppm

4 EXISTING ENVIRONMENT

4.1 Climate data

Climatic data collected over a 147 year period is available from the Bureau of Meteorology monitoring station located at Newcastle Nobbys Signal Station Automatic Weather Station (AWS, 061055). This provides information on the long-term average values of climatic elements such as temperature, humidity, rainfall, the number of raindays per year etc.

Table 4.1 presents temperature, humidity and rainfall data collected at Newcastle Nobbys Signal Station for 147 years between 1864 and 2011. The annual average maximum and minimum temperatures experienced at Newcastle Nobbys Signal Station are 21.8°C and 14.2°C respectively. On average January is the hottest month with an average maximum temperature of 25.6.7°C. July is the coldest month, with average minimum temperature of 8.4°C.

The annual average humidity reading collected at 9am at Newcastle Nobbys Signal Station is 75 percent, and at 3pm the annual average is 66 percent. The month with the highest humidity on average is June with a 9am average of 80 percent, and the lowest is August with a 3pm average of 56 percent.

Rainfall data collected at Newcastle Nobbys Signal Station shows that March is the wettest month, with an average rainfall of 119.7 mm. The average annual rainfall is 1134.3 mm with an average of 99 rain days.

Table 4.1: Climate Statistics for Newcastle Nobbys Signal Station AWS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
9 am Mean Dry-bulb and Wet-bulb Temperatures (ºC) and Relative Humidity (%)													
Dry-bulb	21.9	21.9	20.9	18.1	14.6	12.1	10.9	12.2	15.1	17.9	19.5	21.1	17.2
Humidity	77	80	79	78	79	79	77	72	69	68	72	74	75
3 pm Mean Dry-bulb and Wet-bulb Temperatures (ºC) and Relative Humidity (%)													
Dry-bulb	23.3	23.5	22.9	21.3	18.8	16.5	15.9	16.9	18.5	19.8	21	22.4	20.1
Humidity	72	74	72	66	64	63	59	56	59	64	68	71	66
Daily Maximum Temperature (ºC)													
Mean	25.6	25.4	24.7	22.8	20	17.5	16.7	18	20.2	22.1	23.5	24.9	21.8
Daily Minimum Temperature (ºC)													
Mean	19.2	19.3	18.3	15.3	12	9.7	8.4	9.2	11.4	14	16.1	18	14.2
Rainfall (mm)													
Mean	88.3	107	120	116	118	117	94.4	74.1	72.7	73.3	70.3	81.1	1134.3
Rain days (Number)													
Mean	11.1	11.2	12.4	12.3	12.7	12.2	11.1	10.4	10.1	11	10.7	10.6	135.8

Station number 061055; Commenced: 1862; Last record: 2011; Latitude (deg S): -32.920; Longitude (deg E): 151.80 (Bureau of Meteorology)

4.2 Prevailing Winds

Annual and seasonal wind roses prepared from data collected at the Cooranbong BoM weather station, located 10 km southwest of Awaba, for the period January 2009 to December 2009 are presented in **Figure 4.1**.

On an annual basis, the most common winds are from the east as well as from the north and south. The winds, to a much lesser extent are recorded from all other directions of the compass. During all seasons except winter the predominant winds are easterly which are northerly. During summer the next most common wind direction is southerly, while in spring it is northerly and southerly. During winters the winds appear to mainly come from the north-western quadrant. The percentage of calm winds (those with wind speeds less than 0.5 m/s) for the year at Cooranbong is 6.0%. The average annual wind speed is 2.8 m/s.

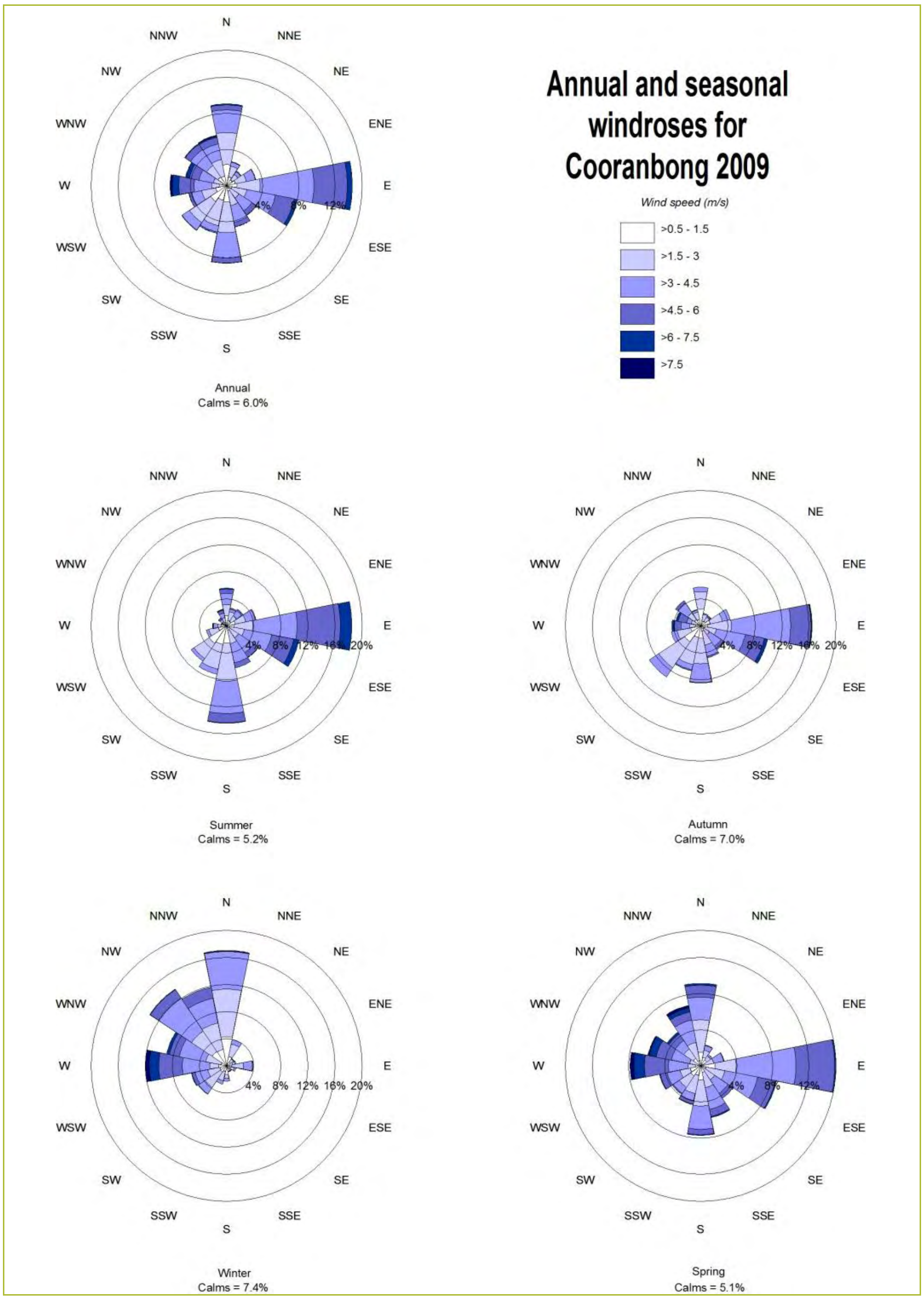


Figure 4.1: Annual and Seasonal Windroses for 2009 at Cooranbong

4.3 Existing Air Quality

Air quality standards and goals are used to assess the total pollutant level in the environment, including the contribution from specific projects and existing sources. To fully assess impacts against all the relevant air quality standards and goals it is necessary to have information on the background concentrations to which the project is likely to contribute.

Eraring Power Station, located approximately 5 km southwest of the Awaba Landfill, operates two ambient air quality monitoring stations. These stations are located at the Dora Creek Bowling Club and the Marks Point Primary School and historical 1-hour and annual NO_2 concentrations are available for both stations between 2000 and 2005 (**Table 4.2**).

Both annual average and 1-hour average NO_2 concentrations recorded between 2000 and 2005 are below the impact assessment criteria of at both sites.

Table 4.2: Marks Point and Dora Creek ambient monitoring data

Pollutant (µg/m^3)	Monitoring Year						Impact Assessment Criteria (µg/m^3)
	2000	2001	2002	2003	2004	2005	
Marks Point Ambient Monitoring Data							
NO_2 (max 1-hour average)	98.0	112.5	90.2	136.2	90.2	88.4	246
NO_2 (annual average)	16.9	18.3	13.6	18.3	13.4	12.6	62
Dora Creek Ambient Monitoring Data							
NO_2 (max 1-hour average)	66.6	75.3	62.0	141.0	95.9	105.3	246
NO_2 (annual average)	12.6	12.3	3.3	10.4	16.9	12.8	62

The NSW EPA operates a number of monitoring stations in NSW, including a monitoring site at Wallsend, approximately 17 km north of Awaba. A summary of the monitoring data for PM_{10} and NO_2 for 2011 at the Wallsend monitoring site is shown in **Table 4.3** and is used in consideration of cumulative impacts (refer **Section 7.3.1**).

Table 4.3: Wallsend Monitoring Data

Pollutant	Averaging Period	Value (µg/m^3)	Impact Assessment Criteria (µg/m^3)
PM_{10}	Annual Average	14.2	30
	Max 24-Hour Average	38.9	50
NO_2	Annual Average	32.8	62
	Max 1-Hour Average	75.9	246

4.4 Odour

It is not always practical to assess the cumulative odour impact of all odour sources that may impact on discrete receptors, although in a rural area such as Awaba, the number and type of odour sources may be more easily identified. However it is common in odour assessment to assess the incremental increase in odour from a proposed development against the assessment criteria, particularly where no other sources of similar odour character are present.

5 APPROACH TO ASSESSMENT

5.1 Modelling Overview

The air dispersion modelling conducted for this assessment is based on an advanced modelling system using the models TAPM and CALMET/CALPUFF. The modelling system works as follows:

- TAPM is a prognostic meteorological model that generates gridded three-dimensional meteorological data for each hour of the model run period.
- CALMET, the meteorological pre-processor for the dispersion model CALPUFF, calculates fine resolution three-dimensional meteorological data based upon observed ground and upper level meteorological data, as well as observed or modelled upper air data generated for example by TAPM.
- CALPUFF then calculates the dispersion of plumes within this three-dimensional meteorological field.

Output from TAPM, plus regional observational weather station data was entered into CALMET, a meteorological pre-processor endorsed by the US EPA and recommended by the NSW OEH for use in non-steady state conditions. From this, a 1-year representative meteorological dataset suitable for use in the 3-dimensional plume dispersion model, CALPUFF, was compiled. Details on the model configuration and data inputs are provided in the following sections.

5.1.1 TAPM

The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. Detailed description of the TAPM model and its performance is provided elsewhere. The Technical Paper by **Hurley (2008)** describes technical details of the model equations, parameterisations, and numerical methods. A summary of some verification studies using TAPM is also given in **Hurley *et al*. (2008)**.

TAPM utilises fundamental fluid dynamics and scalar transport equations to predict meteorology and (optionally) pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

For the Project Assessment, TAPM was set up with 3 domains, composed of 25 grids along both the X and the Y axes, centred on -33.025 ° Latitude and 151.55 ° Longitude. Each nested domain had a grid resolution of 30 km, 10 km and 3 km respectively.

Default TAPM terrain values are based on a global 30-second resolution (approximately 1 km) dataset provided by the US Geological Survey, Earth Resources Observation Systems (EROS). Default land use and soils data sets for TAPM were used.

TAPM was used to generate gridded prognostic data (3D.dat) for the CALMET modelling domain.

5.1.2 CALMET

The choice of the CALMET/CALPUFF modelling system for this study is based on the fact that simple Gaussian dispersion models such as AUSPLUME assume that the meteorological conditions are uniform spatially over the entire modelling domain for any given hour. While this may be valid for some applications, in complex flow situations, such as areas with complex terrain, the meteorological conditions may be more accurately simulated using a wind field model such as CALMET.

CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are utilised in the CALPUFF dispersion model.

CALMET was run with a single domain covering a 30 km x 20 km area, with the origin (SW corner) at 370 km Easting and 6345 km Northing (UTM Zone 56S). This consisted of 150 x 100 grid points, with a 0.2 km resolution along both the X and Y axes. Land use for the domain was determined by aerial photography. Terrain for this area was derived from 90 m DEM data sourced from NASA.

The files generated by TAPM were used as input to CALMET to create a coarse resolution three-dimensional meteorological field for the region. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to generate a fine resolution three-dimensional wind field the region.

Table 5.1 summarises the inputs used for both the TAPM and CALMET models.

Table 5.1: Meteorological Parameters used for TAPM and CALMET

TAPM (v 4.0.4)	
Number of grids (spacing)	30 km, 10 km, 3 km
Number of grid points	25 x 25 x 25
Year of analysis	January 2009 – December 2009
Centre of analysis	Awaba Landfill (33.025^{0}S, 151.55^0 E)
CALMET (v. 6.327)	
Meteorological grid domain	30 km x 20 km
Meteorological grid resolution	0.2 km
Upper air	Data extracted from TAPM – 3D.dat

5.2 Modelling Scenarios

5.2.1 Odour

Two future operational scenarios are modelled to account for variations in the location of odour emitting sources as landfilling progresses over the course of the landfill life. The highest odour emissions from landfills occur from the active tipping face and the scenarios chosen represent snapshots of the landfill life where the active tipping face is located closest to residents to the northwest and southeast respectively.

Scenario 1 represents worst case impacts when active landfill is occurring towards the north of the site and closest to the town of Awaba. In Scenario 1, Area A is nearly completed, with cells A1 and A2 filled and capped and Cell A3 active. An active tipping face is assigned in the southeast corner with the remaining area of A3 having an intermediate cover. Cells C1-C4 are capped (from current landfill activities), while cells B1-B4 are not yet filled.

Scenario 2 represents a worst case scenario where the landfill is approaching end of life and odour emissions across a maximum footprint are expected. This is also reflected in the higher total odour emission rates (OERs) presented in **Table 5.3**. Scenario 2 represents the end of the life of the landfill with all cells filled and capped except C4. C4 has the active tipping face in the southeast corner, while the remaining area has intermediate cover.

The Awaba landfill has recently received odour complaints, predominantly from local community members in the Awaba township. An existing operations scenario was therefore modelled to assess the potential extent of odour impact from existing operations. The existing scenario includes an area of intermediate cover across the landfill site, an active tipping face based on existing operations, daily cover area and three leachate ponds to the north and south of the site. A visual presentation of the odour modelling scenarios is shown in **Figure 5.1**, **Figure 5.2** and **Figure 5.3**.

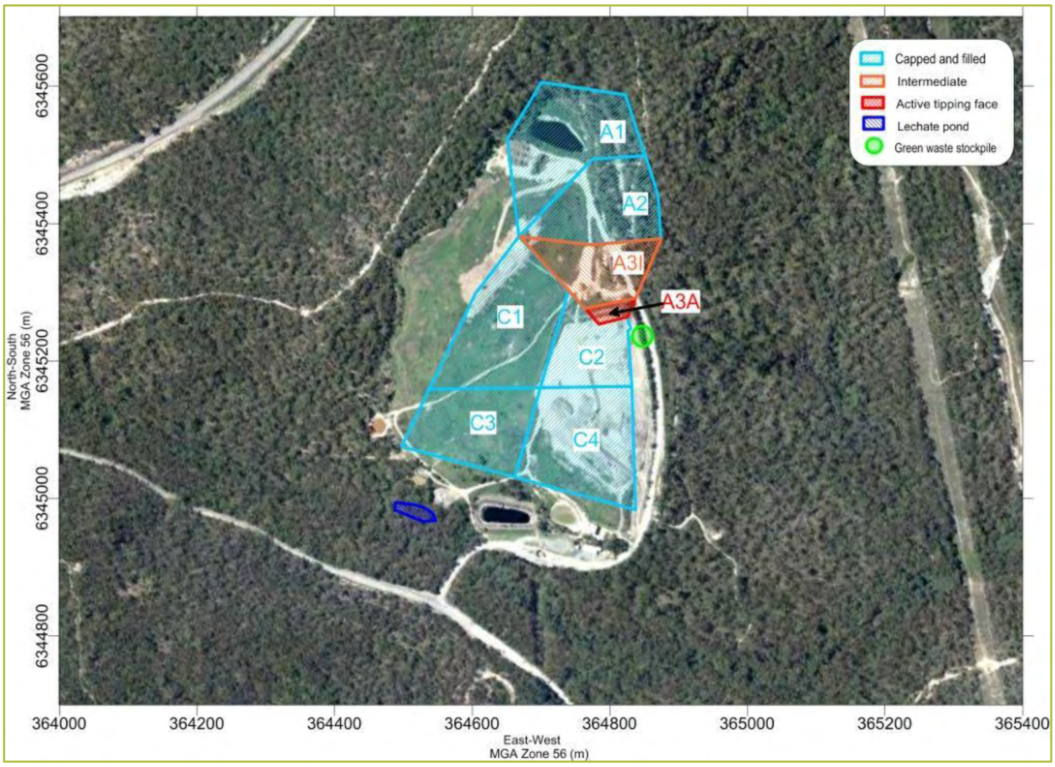


Figure 5.1: Future Operations – Scenario 1

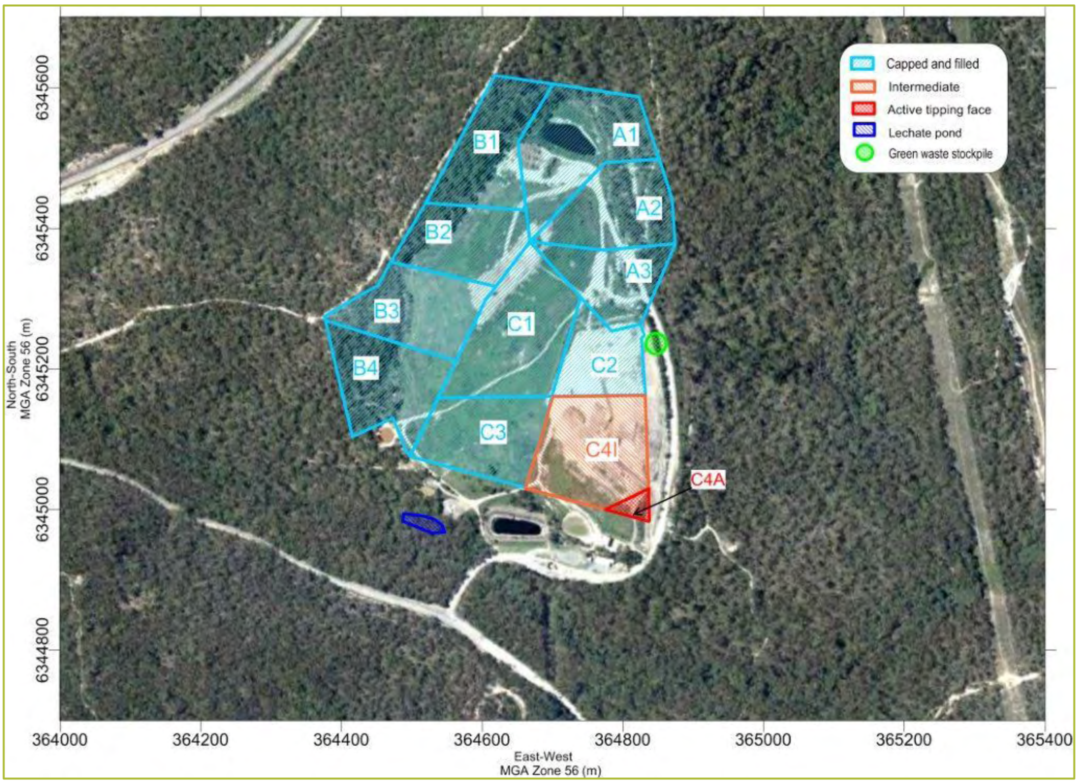


Figure 5.2: Future Operations – Scenario 2

Figure 5.3: Existing Operations – Scenario 3

5.2.2 Dust and Particulate Matter

A scenario was modelled to represent the construction of the landfill cells and the ongoing operation of landfilling within previously constructed cells. Excavation in cell A2 was chosen as representative of worst case construction based on the volume of material estimated for removal. The following activities have been represented for this scenario.

- Construction Activity: excavation in cell A2, loading material to trucks, hauling to a stockpile area in cell A1 and unloading from trucks;
- Landfill Operations: Trucks delivery waste to site travelling on unsealed roads to landfill cell A1. Cover material loading to trucks, hauling to cell A1 and unloading. Dozers spreading daily cover for cell A1.

Water spraying has been assumed as a control, applied to haul roads and active exposed areas during construction and operation. A visual presentation of this modelling scenarios is shown in **Figure 5.4**. Dust source locations are represented by the numbered dots, and represent all activities described above.

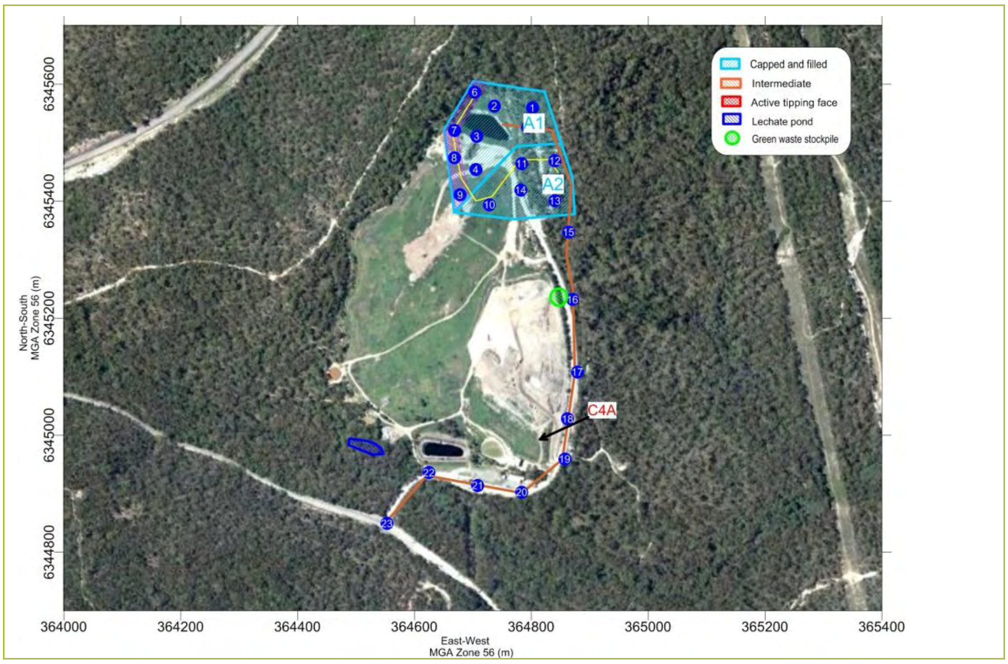


Figure 5.4: Construction and operational dust modelling scenario

5.3 Emission Estimation

5.3.1 Odour

In the absence of any on-site odour measurement data, odour measurement data from odour sampling at Eastern Creek Landfill in NSW has been used in this assessment (**PAEHolmes, 2010**). Odour measurements were taken from an active tipping face, daily cover, intermediate and filled/capped areas at the Eastern Creek landfill on the 28 July 2009. Up to three sets of odour measurements were taken at random locations along each area. **Table 5.2** summarises the specific odour emission rate (SOER) measurements taken.

Table 5.2: Summary of odour measurements from active tipping face, Eastern Creek Landfill.

ID	Active tipping face (SOER - ou.m^3/m^2/s)	Daily cover (SOER - ou.m^3/m^2/s)	Filled and capped area (SOER - ou.m^3/m^2/s)	Intermediate area (SOER - ou.m^3/m^2/s)
1	1.91	1.59	0.04	0.04
2	0.361	2.16	0.03	
3	3.65	1.48	0.06	
4			0.03	
5			0.05	
6			0.02	

For the purpose of the modelling in this report the average emission rates were used to estimate the odour emission for previously placed waste (capped and intermediate cover). For the active tipping face, the sample results show a ten-fold variation in the odour emission rate with an average odour emission rate of 1.97 ou.m^3/m^2/s. As a conservative approach the maximum odour emission rate of 3.65 ou.m^3/m^2/s has been applied for this assessment. Estimated emissions for each scenario are presented in **Table 5.3**.

Table 5.3: Estimated emission rates for each scenario

Location / Source	Cells	SOER (ou.m³/m²/s)	Assumed Area (m²)	Total OER (ou.m³/s)
Leachate Pond	N/A	0.15	2,000	300
Green Waste	N/A	0.03	3,500	105
Existing Scenario				
Filled and capped Area	N/A	0.04	2,082	83
Active tip face	N/A	3.65	3,758	13,717
Intermediate cover	N/A	0.04	134,226	5,369
Daily cover	N/A	1.74	7,775	13,529
Scenario 1				
Filled and capped Area	C1-C4 and A1,A2	0.04	122,841	4,914
Active tip face	A3	3.65	1,490	5,437
Intermediate cover	A3	0.04	12,448	498
Scenario 2				
Filled and capped Area	A1-A3, B1-B4, C1-C3	0.04	184,644	7,386
Active tip face	C4	3.65	1,466	5,349
Intermediate cover	C4	0.04	22,717	909

5.3.2 Renewable Energy Facility

A renewable energy facility is operated on the site by LMS Generation Pty Ltd (LMS). The facility consists of a 1 MW power generation unit and a backup flare for excess landfill gas destruction.

Estimated emissions for a worst case scenario were derived based on monthly gas landfill gas reports prepared by LMS. The worst case scenario assumes flaring and power generation occur at the same time and the gas consumption for both the power generation and flare are taken from December 2010, when both were operational. The assumed release parameters and emissions rates are presented in **Table 5.4**.

Table 5.4: Estimated emission for the Landfill gas flaring and power generation

	Flare Stack	Gas Power generation
Location (E, N MGA)	364552, 6345020	364558, 6345020
Height (m)	8	4
Diameter (m)	4	0.25
Temperature (k)	1273	846
Exit Velocity (m/s)	20	3.4
Pollutant Emission Rates (g/s)		
NO_x	0.040	2.716

5.3.3 Dust Emissions

Dust emissions arising from the construction activities have been estimated based on the material removal schedule for each cell and intensity of dust generating activities. The operations which apply for this case have been combined with emission factors developed, both locally (**SPCC 1983**) and by the **US EPA (1985 and updates)**, to estimate the amount of dust produced by each activity.

Estimates of emissions for each source were developed on an hourly time step taking into account the activities that would take place at that location. Thus, for each source, for each hour, an emission rate was determined which depended upon the level of activity and the wind speed.

The most significant dust generating activities have been identified and the dust emission estimates for the modelling scenario are presented in **Table 5.5**. The operations were represented by a series of volume sources located according to the location of activities for the modelled scenario (see **Figure 5.4**).

Table 5.5: Estimated dust emission during construction and landfilling operations

ACTIVITY	TSP emissions (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	Units	Variable 5	Units	Variable 6	Units	source type
A2 - Ex/FEL loading	36	86,233	t/y	0.00042	kg/t	0.94	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %									2
Hauling A2 -> A1	5,172	86,233	t/y	0.0450	kg/t	136	t/load	181.2	Vehicle gross mass (t)	0.7607	km/return trip	8.0417	kg/VKT	10	% silt content	75	% control	1
Emplacing at stockpile @ A1	36	86,233	t/y	0.00042	kg/t	0.94	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %									2
Waste hauling	55,979	418,547	t/y	0.53498	kg/t	10	t/load	15.0	Vehicle gross mass (t)	2.0416	km/return trip	2.620455	kg/VKT	10	% silt content	75	% control	1
Loading cover to trucks	36	86,233	t/y	0.00042	kg/t	0.94	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %									2
Emplacing cover @ A1	36	86,233	t/y	0.00042	kg/t	0.94	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %									2
Dozers spreading daily cover @ A1	19,846	2,920	h/y	6.79666	kg/h	4	moisture content in %	10	silt content in %									1
WIND EROSION																		
WE - Stockpiles	858	0.49	ha	0.4	kg/ha/h	8760	h/y	50	% control									3
WE - Exposed area	7,261	4	ha	0.4	kg/ha/h	8760	h/y	50	% control									3

6 DISPERSION METEOROLOGY

6.1 Prevailing Winds

A summary of the annual wind behaviour predicted from CALMET is presented in **Figure 6.1** On an annual basis, winds are experienced from all directions. There is a distinct seasonal pattern with summer winds from the northeast through southeast, shifting to dominant west-northwest winds during winter. Spring and autumn winds shown similar patterns to annual.

The CALMET generated windroses for the site differ somewhat from those measured the Cooranbong BoM weather station (located 10 km southwest of Awaba) however the shift in seasonal patterns are well reflected across the two datasets. It is expected that winds for the Awaba site would be strongly influenced by the local topography and landuse and difference in the two datasets is not unexpected.

Further analysis of the CALMET generated meteorology is presented in **Figure 6.2**. This analysis suggests the model is performing well. As expected diurnal variations are noted in temperature and wind speed, with maximums occurring during the afternoon. Also evident in the wind direction versus time of day plot is the diurnal variations between offshore breezes at night, switching to a seabreezes during the afternoons, which is expected given the proximinty to the coast and Lake Macquarie.

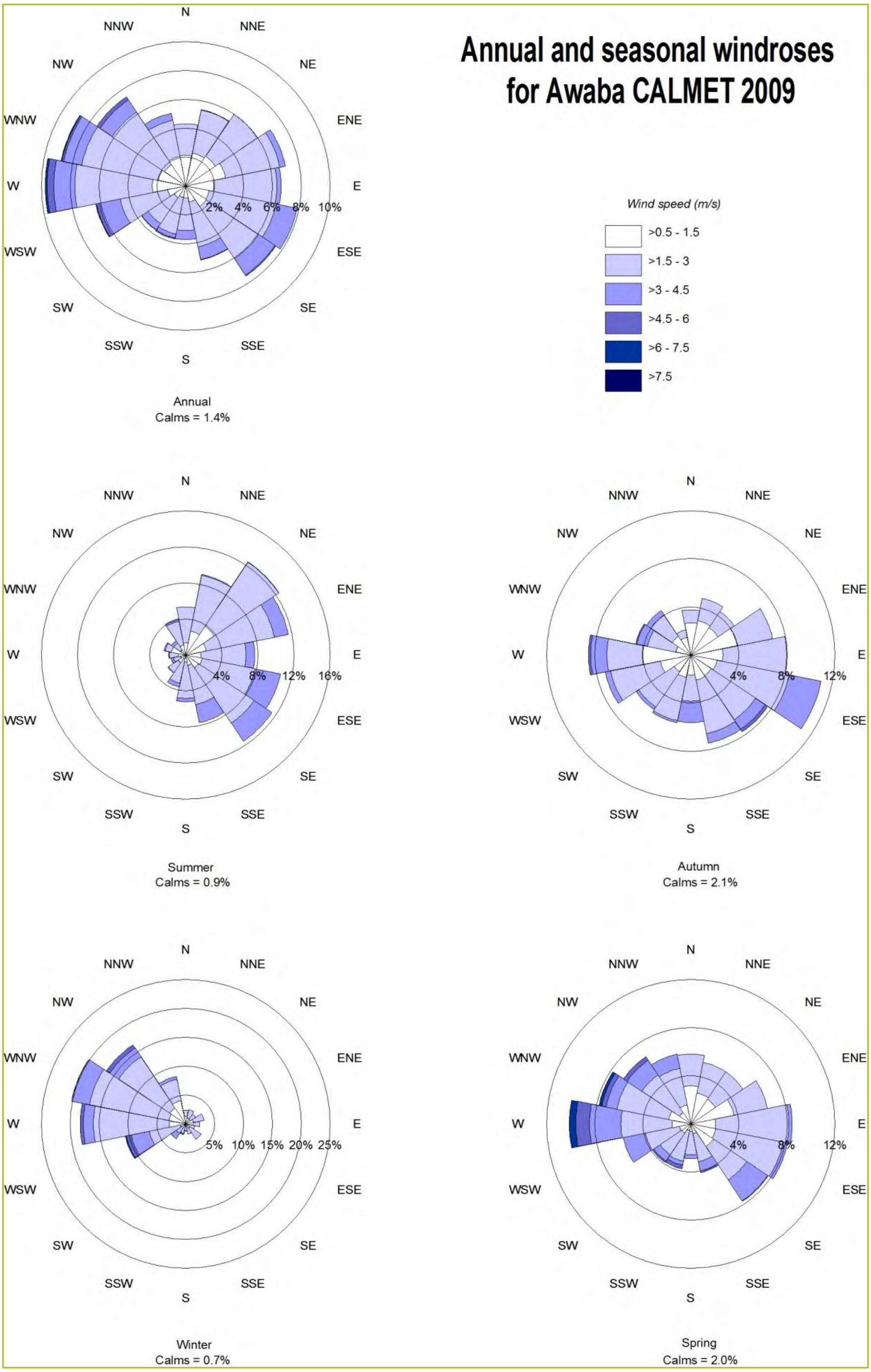


Figure 6.1: CALMET Annual and Seasonal Windroses

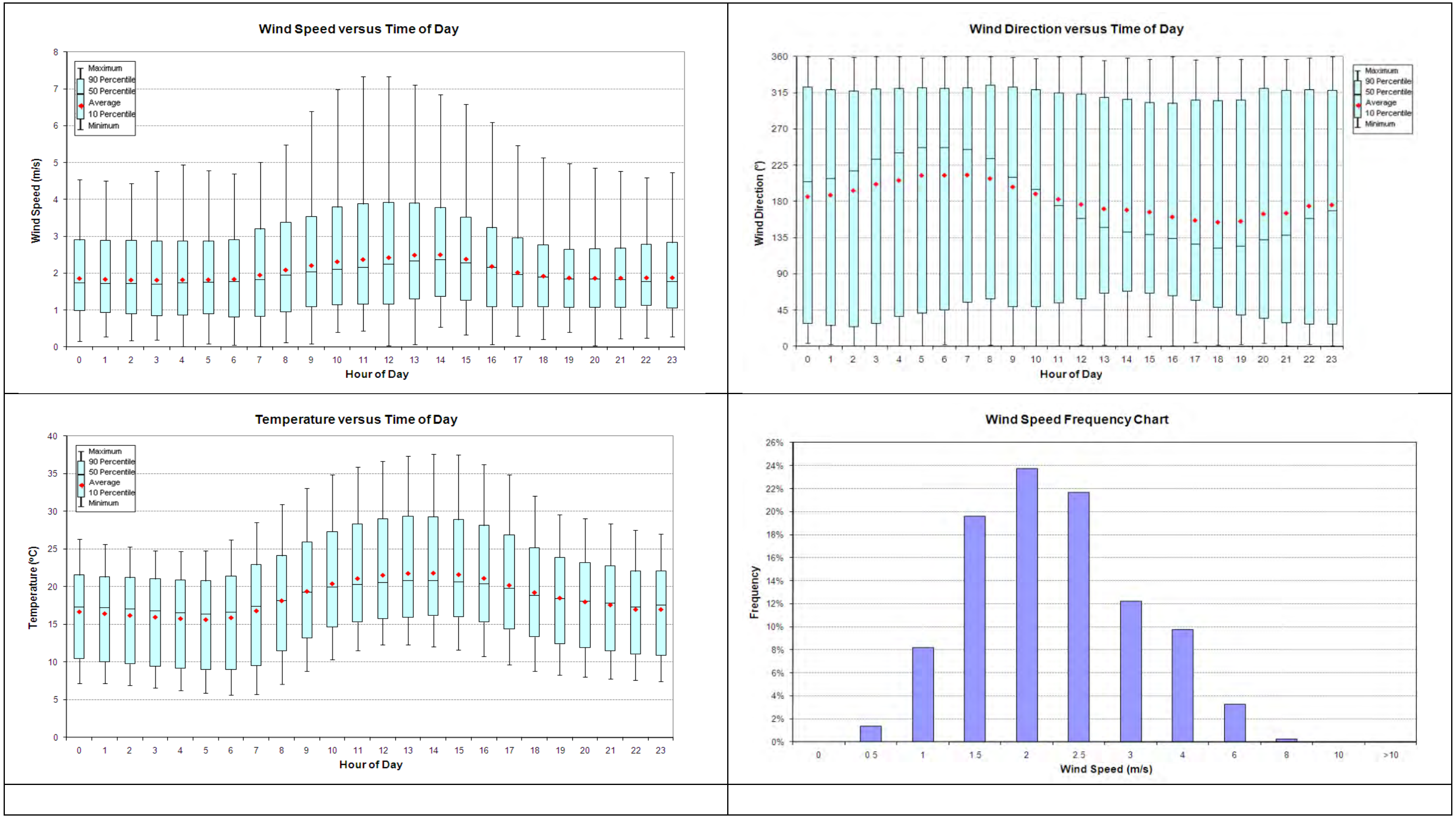


Figure 6.2: Analysis of CALMET Meteorology

6.2 Stability Class and Mixing Heights

The term atmospheric stability refers to the dispersive capacity of the atmosphere. The most well-known stability classification is the Pasquill-Gifford scheme, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind.

Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small. As a general rule, unstable (or convective) conditions dominate during the daytime and stable flows are dominant at night. This diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds.

The frequency distribution of estimated stability classes in the CALMET file is presented in **Figure 6.3**: . Overall the stability class F occurs for the greatest proportion of time within the surrounding area. It is noted that a turbulence based scheme within CALPUFF was used in the modelling and the Pasquill-Gifford stability class frequency is shown for information only.

The use of turbulence based dispersion coefficients is recommended (**TRC, 2010**) for the same reasons that the US EPA has replaced PG-based dispersion with a turbulence-based approach in their regulatory model (AERMOD) and is in accordance with best science practice and model evaluation studies.

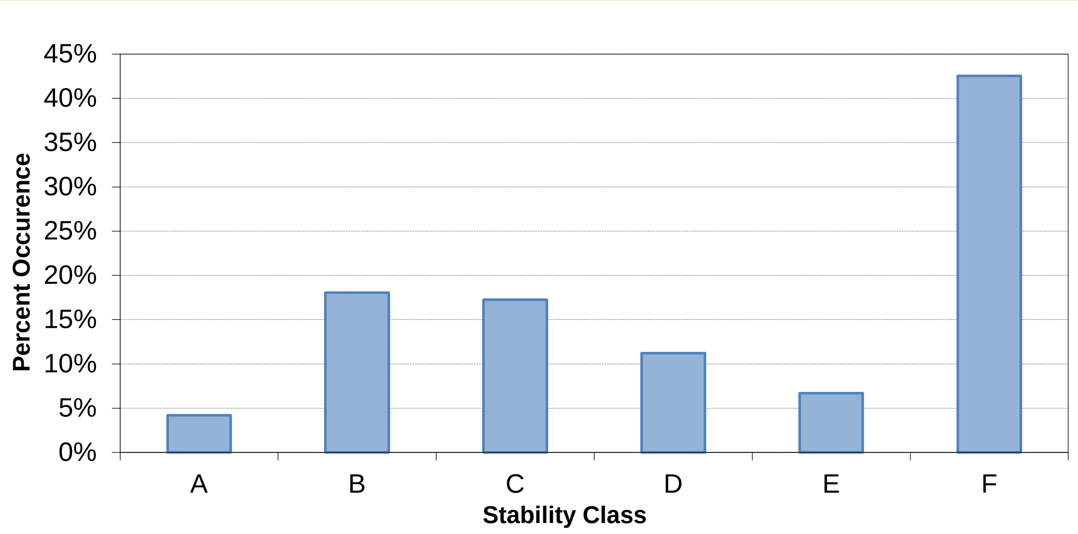


Figure 6.3: Stability class distribution

The term mixing height refers to the height of the turbulent layer of air near the earth's surface into which ground-level emissions will be rapidly mixed. A plume emitted above the mixed-layer will remain isolated from the ground until such time as the mixed-layer reaches the height of the plume. The height of the mixed-layer is controlled mainly by convection (resulting from solar heating of the ground) and by mechanically generated turbulence as the wind blows over the rough ground.

Mixing heights show diurnal variation and can change rapidly after sunrise with the onset of vertical convective mixing. The CALMET derived mixing heights are shown in **Figure 6.4** which shows the minimum, maximum, mean and upper and lower quartile mixing depths. Maximum heights are reached in mid to late afternoon.

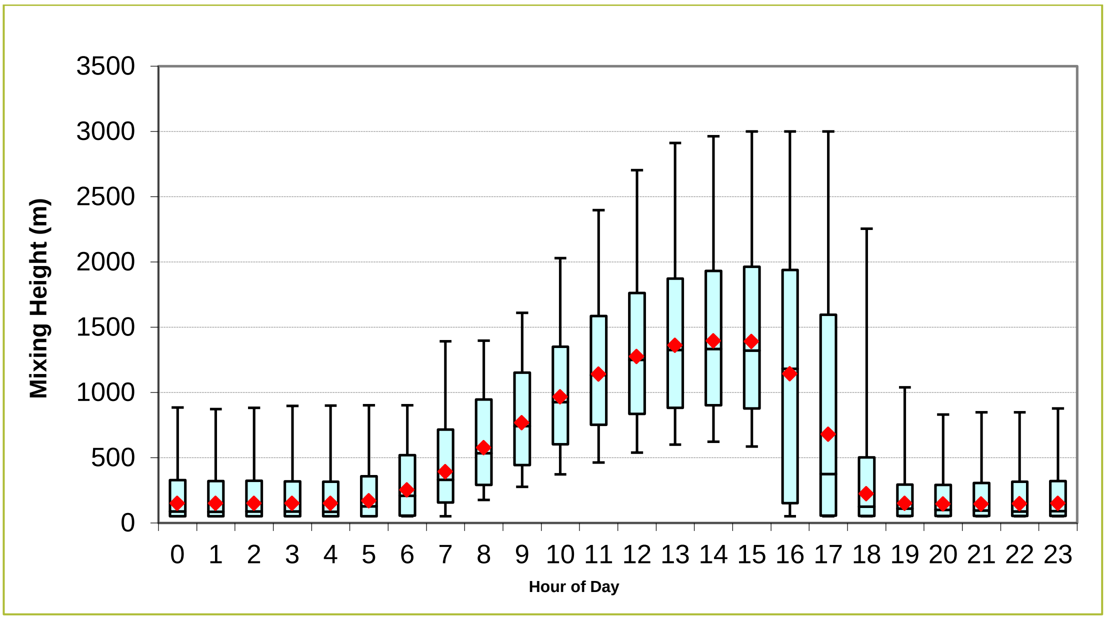


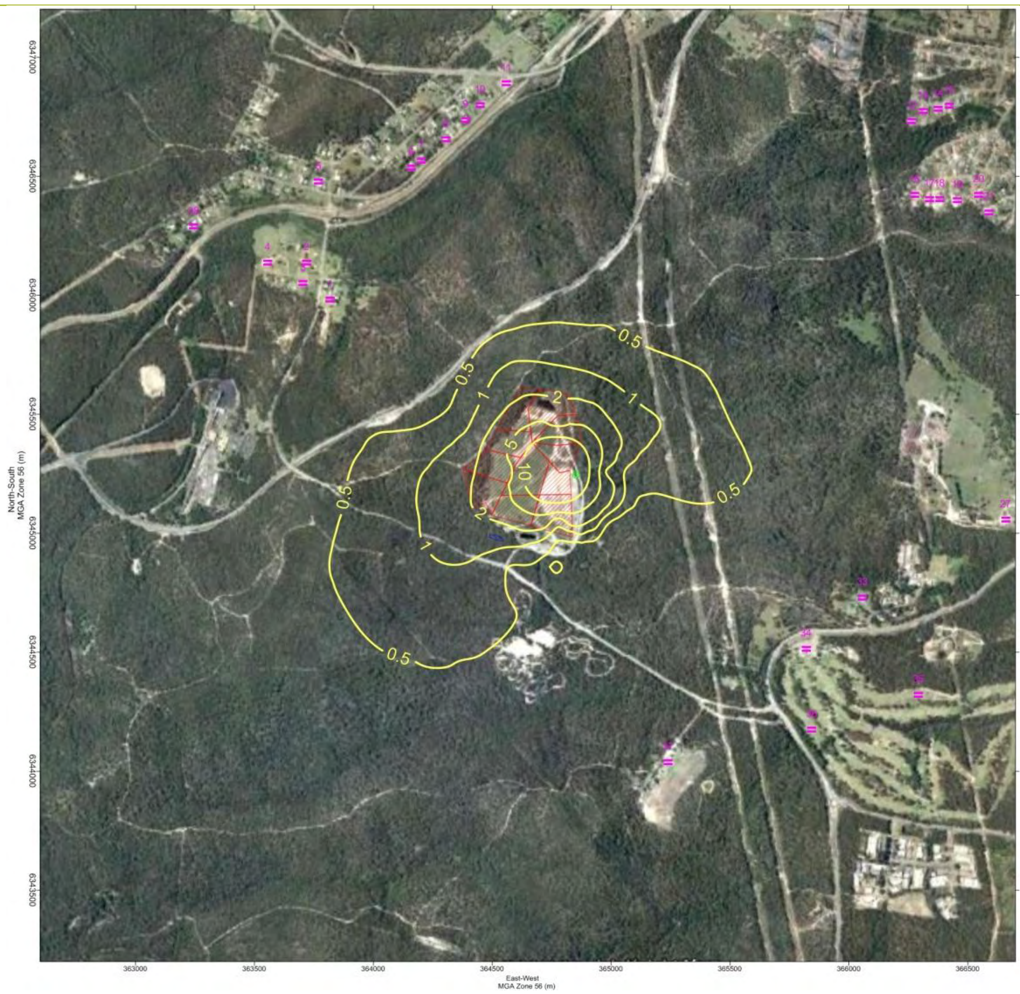
Figure 6.4: Mixing Height

7 MODELLING RESULTS

7.1 Predicted Ground Level Concentrations of Odour

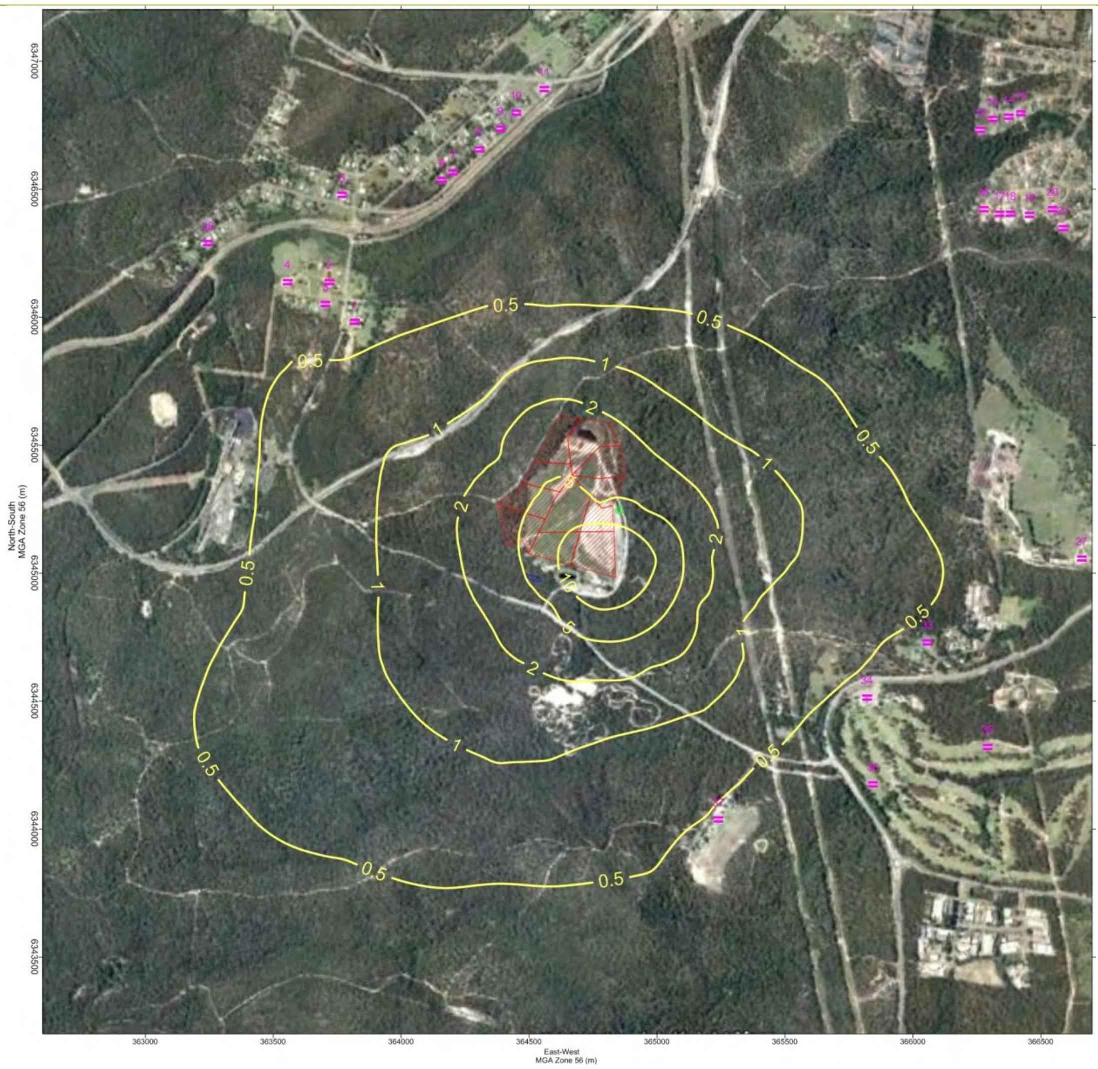
The results of the odour modelling predictions for the two future scenarios are presented in **Figure 7.1** and **Figure 7.2**. The contours show the predicted ground level concentration (glc) of odour at 0.25 OU, 0.5 OU, 1 OU, 2 OU, 5 OU and 10 OU at the 99th percentile level and expressed as a nose response average (1-second) value. The peak to-mean ratio applied are 2.3 for neutral conditions (stability class A-D) and 1.9 for stable conditions (stability class E-F).

The glc contour plots are indicative of the concentrations that could potentially be exceeded for 1% of the time, under the conditions modelled. The results indicate that the predicted glc odour at any residential receptor are significantly less than 2 OU and below 1 OU (the odour threshold or theoretical odour level at which no impact is experienced) within 500m of the site.



Species: Odour	**Location:** Awaba Landfill	**Scenario:** Scenario 1	**Percentile:** 99th	**Averaging Time:** Nose response
Model Used: CALPUFF v6.267	**Units:** OU	**Guideline:** OEH = 2 OU (shown in red)	**Met Data:** 2009 CALMET-Generated	**Plot:** K. Hill

Figure 7.1: 99 percentile predicted odour levels for Scenario 1

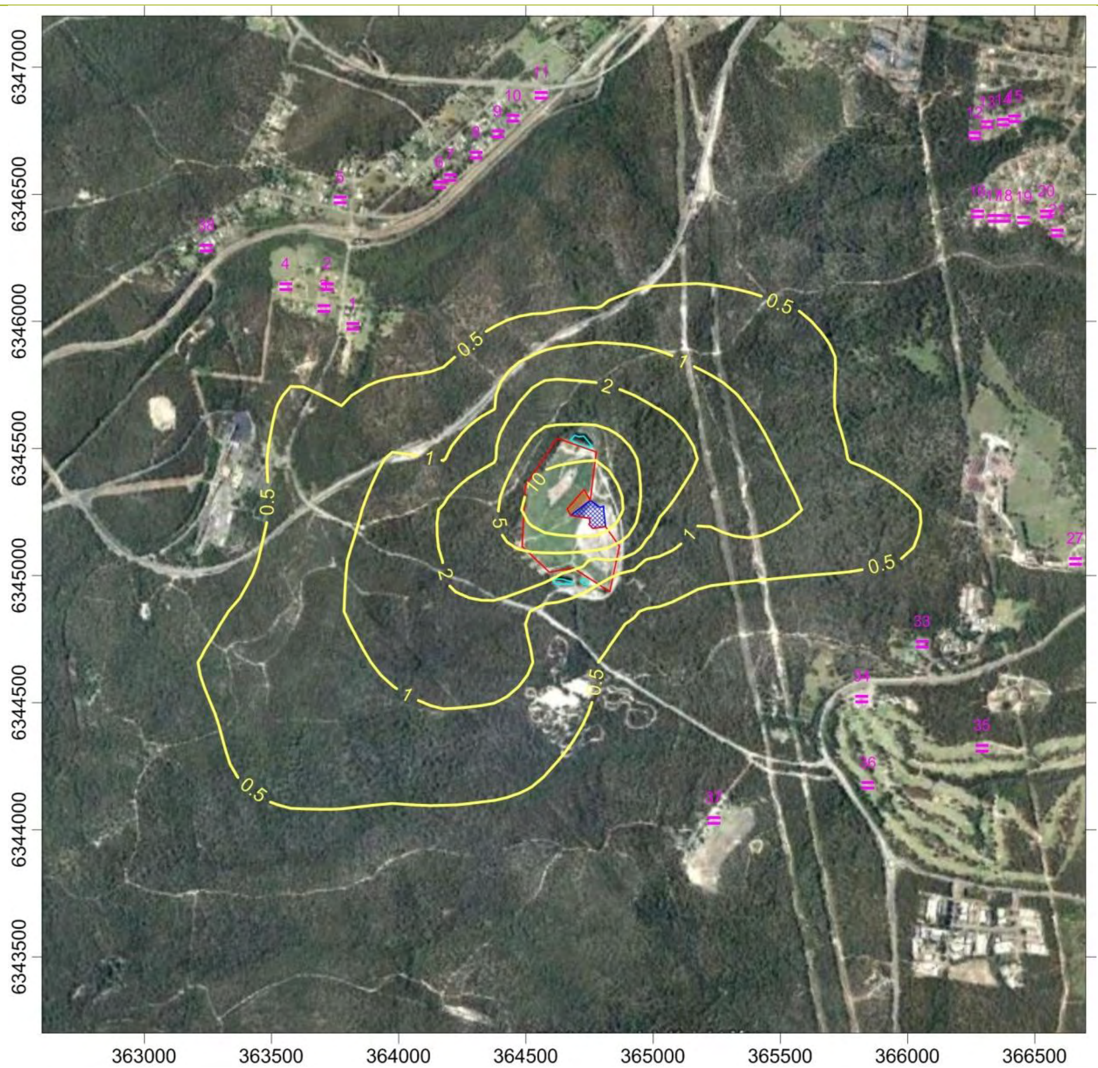


Species:	Location:	Scenario:	Percentile:	Averaging Time:
Odour	Awaba Landfill	Scenario 2	99th	Nose response
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.267	OU	OEH = 2 OU (shown in red)	2009 CALMET-Generated	K. Hill

Figure 7.2: 99 percentile predicted odour for Scenario 2

The results of the odour modelling predictions for the existing operations of the landfill are presented in **Figure 7.3**. Although recent odour complaints have been received, the modelling predictions indicate that beyond 500 m, odour should not be detected and beyond 250 m the impact assessment criterion is not exceeded.

It is noted, however, that the glc contour plots present the 99th percentile model prediction and are indicative of the concentrations that could potentially be exceeded for 1% of the time, under the conditions modelled.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
Odour	Awaba Landfill	Existing Scenario	99th	Nose response
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.267	OU	OEH = 2 OU (shown in red)	2009 CALMET-Generated	K. Hill

Figure 7.3: 99 percentile predicted odour levels for existing operations

Table 7.1 presents the predicted 99th percentile glc odour at each receptor location.

Table 7.1: Predicted GLC odour (99th percentile, nose response average)

ID	MGA56 Easting (m)	MG56 Northing (m)	Existing Scenario Odour concentration (OU)	Scenario 1 Odour concentration (OU)	Scenario 2 Odour concentration (OU)
1	363719	6346138	0.2	0.1	0.3
2	363705	6346051	0.3	0.1	0.4
3	363556	6346138	0.2	0.1	0.3
4	363770	6346478	0.3	0.2	0.3
5	364161	6346537	0.3	0.1	0.3
6	364203	6346566	0.3	0.1	0.3
7	364305	6346654	0.2	0.1	0.2
8	364389	6346737	0.2	0.1	0.2
9	364449	6346798	0.2	0.1	0.2
10	364560	6346891	0.1	0.1	0.2
11	366263	6346732	0.1	0.1	0.1
12	366312	6346774	0.1	0.1	0.1
13	366376	6346784	0.1	0.1	0.1
14	366421	6346797	0.1	0.1	0.1
15	366275	6346422	0.1	0.1	0.2
16	366339	6346405	0.1	0.1	0.2
17	366381	6346405	0.1	0.1	0.2
18	366456	6346399	0.1	0.1	0.2
19	366546	6346422	0.1	0.1	0.1
20	366588	6346349	0.1	0.1	0.2
21	366776	6346270	0.1	0.1	0.2
22	366701	6346291	0.1	0.1	0.2
23	366903	6346255	0.1	0.1	0.2
24	366975	6346268	0.1	0.1	0.1
25	366875	6345564	0.2	0.1	0.2
26	366659	6345057	0.2	0.1	0.3
27	367154	6345260	0.1	0.1	0.1
28	367637	6345727	0.1	0.1	0.1
29	367962	6345617	0.1	0.1	0.1
30	367972	6345545	0.1	0.1	0.1
31	368000	6345306	0.1	0.1	0.1
32	366057	6344730	0.2	0.1	0.5
33	365820	6344515	0.2	0.1	0.4
34	366293	6344321	0.1	0.1	0.3
35	365844	6344175	0.1	0.1	0.3
36	365240	6344038	0.3	0.1	0.5
37	363245	6346289	0.2	0.1	0.3

7.2 Predicted Ground Level Concentrations from Landfill Gas Flaring and Power Generation

Modelling of emissions from the operation of the flares and power generation facility was conducted based on the emission rates provided in **Table 5.4**. Emissions of NO_x will consist of both nitric oxide (NO) and nitrogen dioxide (NO_2). NO_2 is the regulated oxide of nitrogen and is assessed for compliance in this report. Estimates of NO_2 concentrations are commonly derived from NO_x predictions and the approach adopted for this assessment is outlined below.

Nitrogen oxides (NO_x) are produced in most combustion processes and are formed during the oxidation of nitrogen in the fuel and nitrogen in the air. Generally during high-temperature processes a number of nitrogen oxides are formed including nitric oxide (NO) and nitrogen dioxide (NO_2). Generally at the point of emission NO will comprise the greatest proportion of emission and typically constitute 95% by volume of the NO_x and NO_2 will comprise 5%.

Ultimately, however all nitric oxides emitted into the atmosphere are oxidised to NO_2 and to other higher oxides of nitrogen. The rate at which this oxidisation takes place depends on prevailing atmospheric conditions including temperature, humidity and the presence of other substances in the atmosphere such as ozone. It can vary from a few minutes to many hours. The rate of conversion is quite important because from the point of emission to the point of maximum ground-level concentration there will be an interval of time during which some oxidation will take place. Generally, for plumes impacting close to the source (as is the case here) the time interval for oxidation is not sufficient to have converted a large proportion of the plume to the more harmful NO_2.

A conservative assumption for the assessment in this study is that the ratio of NO_2 to NO_x is 20% by the time that the plume has reached the point where the maximum ground-level concentrations are predicted. For example, based on the average wind speed for the hour of maximum glc, it is estimated that it would have taken the plume less than 1 minute to reach this point and significant oxidation would not therefore have occurred.

It is noted that at residence locations over 1 km away, the plume would take longer to travel this distance (i.e. 23 minutes for the worst case prediction). However, at this point the predicted dispersion is sufficient to have diluted the plume to the point where the glc is very low and it is not important how much oxidation has taken place.

Predicted 1-hour NO_2 concentrations for the flaring and power generation for the proposed extension of operations are presented in **Figure 7.4**.

Species:	Location:	Scenario:	Percentile:	Averaging Time:
NO_2	Awaba Landfill	Worst case	Maximum	1-hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.267	µg/m^3	246 µg/m^3	2009 CALMET-Generated	K. Hill

Figure 7.4: Predicted 1-Hr NO_2 concentrations for operation of Renewable Energy Facility

Table 7.2 presents the predicted 1-hour and annual average NO_2 concentrations at each receptor location. The maximum predicted 1-hour NO_2 concentration at a residence is 12.5 µg/m^3 which is well below the assessment criteria of 246 µg/m^3. All annual average predictions are less than 1 µg/m^3. As discussed previously it has been assumed that 20% of the NO_x is NO_2 by the time that the plume has reached the point where the maximum 1-hour ground-level concentrations are predicted.

Table 7.2: Predicted 1-hour NO_2 at the closest residences

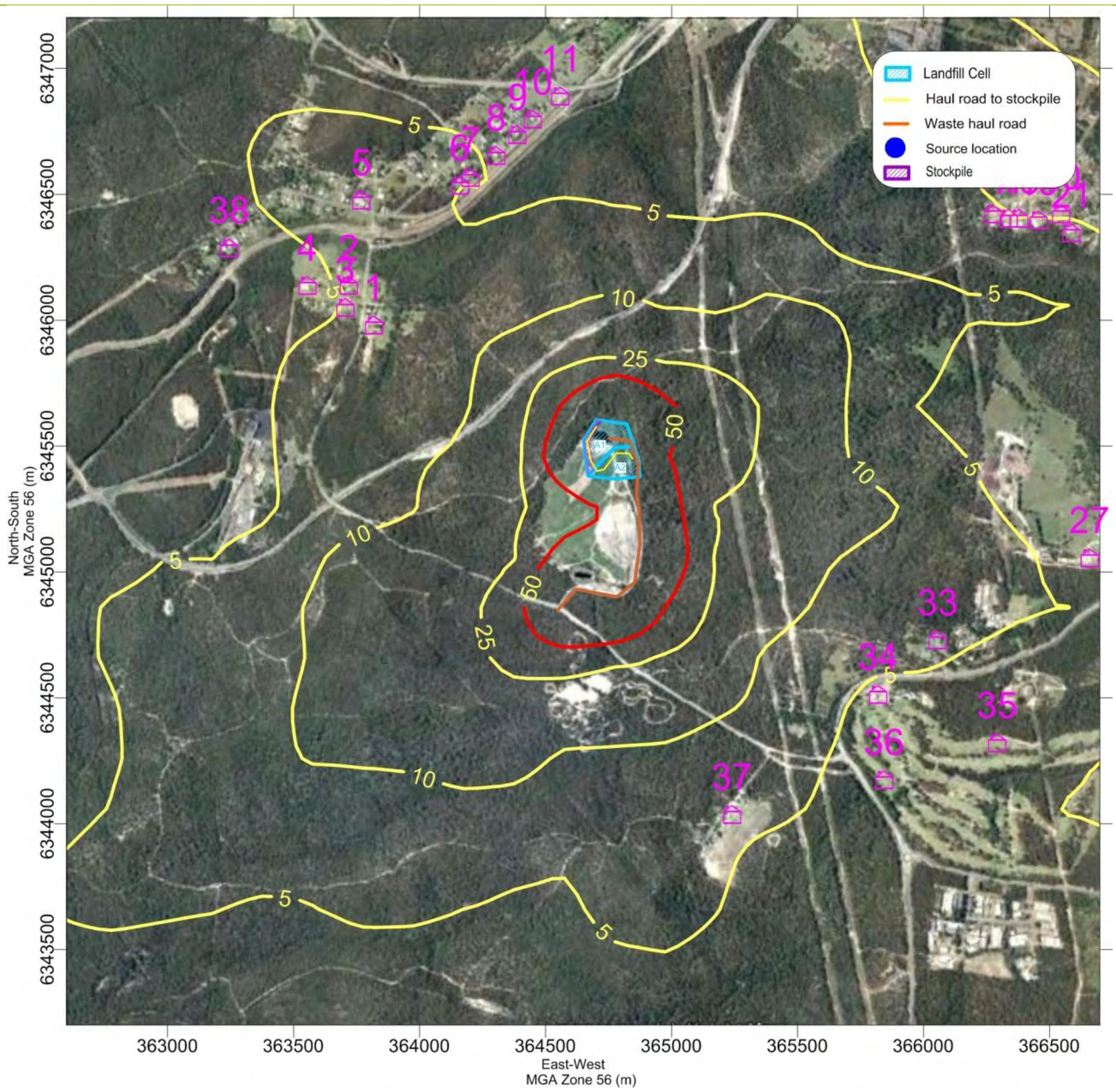
ID	Easting (m)	Northing (m)	1-hour NO_2 concentration (µg/m^3)	Annual NO_2 concentration (µg/m^3)
1	363719	6346138	9.8	0.16
2	363705	6346051	10.5	0.17
3	363556	6346138	9.0	0.16
4	363770	6346478	15.0	0.19
5	364161	6346537	11.9	0.12
6	364203	6346566	11.6	0.11
7	364305	6346654	8.7	0.09
8	364389	6346737	7.1	0.08
9	364449	6346798	6.9	0.07
10	364560	6346891	5.7	0.06
11	366263	6346732	5.6	0.06
12	366312	6346774	5.5	0.06
13	366376	6346784	5.2	0.05
14	366421	6346797	5.1	0.05
15	366275	6346422	6.2	0.07
16	366339	6346405	5.7	0.07
17	366381	6346405	5.3	0.07
18	366456	6346399	5.5	0.07
19	366546	6346422	4.5	0.07
20	366588	6346349	6.9	0.09
21	366776	6346270	5.8	0.08
22	366701	6346291	6.7	0.09
23	366903	6346255	6.5	0.09
24	366975	6346268	5.8	0.08
25	366875	6345564	8.9	0.16
26	366659	6345057	7.1	0.18
27	367154	6345260	4.6	0.11
28	367637	6345727	10.3	0.13
29	367962	6345617	9.0	0.12
30	367972	6345545	8.7	0.13
31	368000	6345306	7.1	0.12
32	366057	6344730	12.5	0.30
33	365820	6344515	9.2	0.29
34	366293	6344321	7.4	0.20
35	365844	6344175	6.6	0.20
36	365240	6344038	12.3	0.26
37	363245	6346289	10.1	0.18

7.2.1 Cumulative Impacts

Historical NO_2 monitoring data from Marks Point and Dora Creek monitoring stations (see **Section 4.3**) shows a range of 1-hour concentrations between 62 µg/m^3 and 141 µg/m^3 across all years. More recent data recorded at Wallsend shows a maximum 1-hour concentration of 76 µg/m^3. Adding a maximum background of 141 µg/m^3 to the predicted maximum 1-hour concentration of 12.5 µg/m^3 gives a concentration of 153.5 µg/m^3 which is below the criteria of 246 µg/m3. Similarly, the addition of annual average NO_2 concentrations of less than 1 µg/m^3 would not result in cumulative annual average impacts.

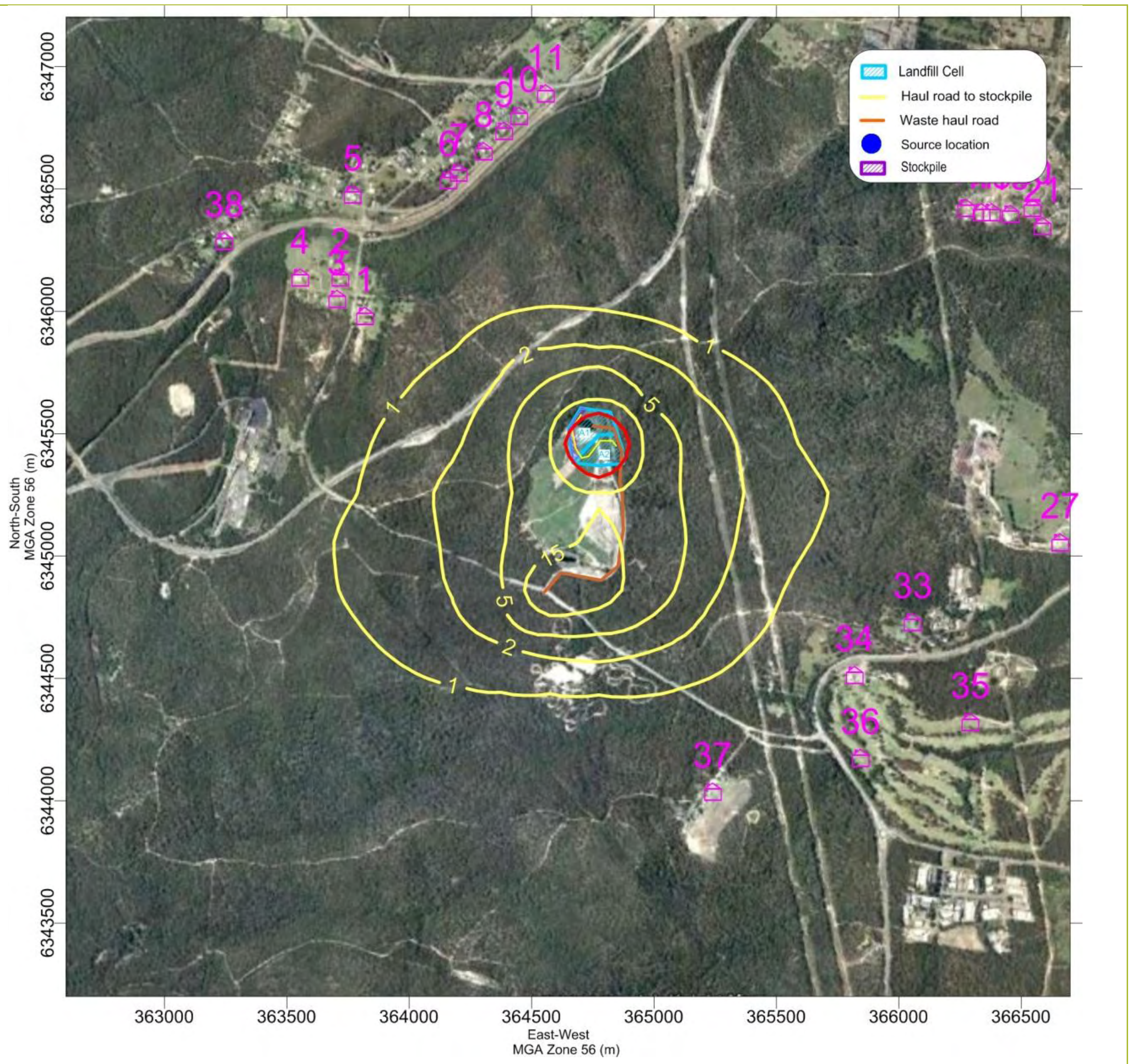
7.3 Predicted Ground Level Concentrations of Dust

The results of the dust modelling predictions for the construction and operational scenario are presented in **Figure 7.5, Figure 7.6** and **Figure 7.7**. The OEH criterion for each dust pollutant is shown with the red line.



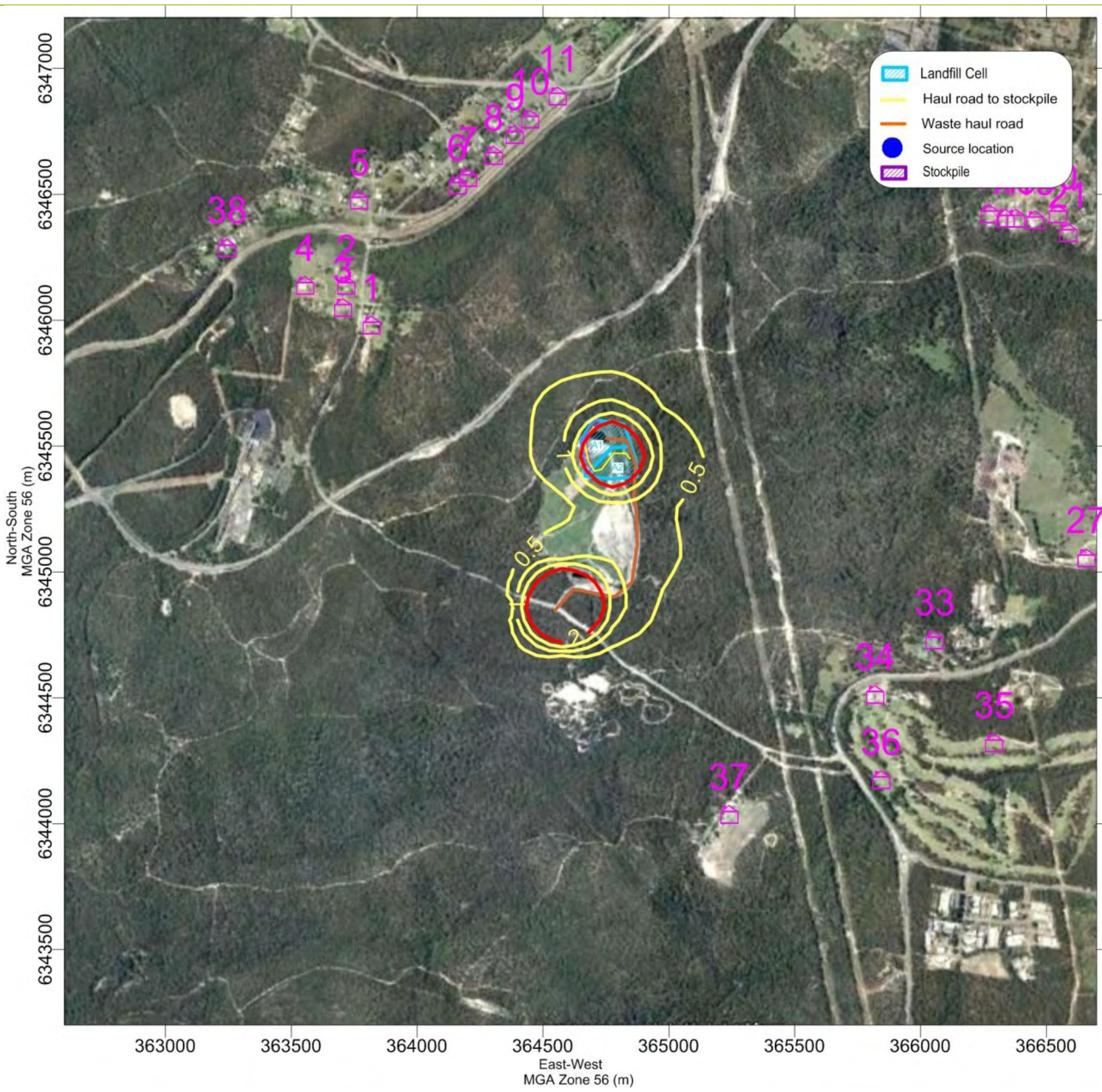
Species: PM$_{10}$	**Location:** Awaba Landfill	**Scenario:** Construction/Operation	**Percentile:** Maximum	**Averaging Time:** 24-hour
Model Used: CALPUFF v6.267	**Units:** µg/m^3	**Guideline:** OEH = 50 µg/m^3 (shown in red)	**Met Data:** 2009 CALMET-Generated	**Plot:** K. Hill

Figure 7.5: Predicted 24-Hr PM$_{10}$ concentrations for construction and operation



Species: PM10	Location: Awaba Landfill	Scenario: Construction/Operation	Percentile:	Averaging Time: Annual
Model Used: CALPUFF v6.267	**Units:** µg/m³	**Guideline:** OEH = 30 µg/m³ (shown in red)	**Met Data:** 2009 CALMET-Generated	**Plot:** K. Hill

Figure 7.6: Predicted annual PM_{10} concentrations for construction and operation



Species: Dust Deposition	**Location:** Awaba Landfill	**Scenario:** Construction/Operation	**Percentile:**	**Averaging Time:** Annual
Model Used: CALPUFF v6.267	**Units:** g/m^2/month	**Guideline:** OEH = 2 g/m^2/month (shown in red)	**Met Data:** 2009 CALMET-Generated	**Plot:** K. Hill

Figure 7.7: Predicted annual dust deposition concentrations for operation

Table 7.3 presents the predicted 24-hour and annual average PM_{10} and annual dust deposition concentrations at each receptor location. The maximum predicted 24-hour PM_{10} concentration at a residence is 7.1 µg/m^3 which is well below the assessment criteria of 50 µg/m^3. All annual average predictions are well below 1 µg/m^3. Dust deposition levels are predicted to be minor beyond 50 m to 100 m of the site.

Table 7.3: Predicted dust at the closest residences

Construction Scenario			PM_{10}		Dust deposition
ID	MGA56 Easting (m)	MG56 Northing (m)	24 hour (µg/m3)	Annual (µg/m^3)	g/m^2/month
1	363719	6346138	5	0.4	0.05
2	363705	6346051	5	0.4	0.05
3	363556	6346138	4	0.4	0.04
4	363770	6346478	7	0.4	0.04
5	364161	6346537	5	0.4	0.04
6	364203	6346566	5	0.4	0.04
7	364305	6346654	5	0.3	0.03
8	364389	6346737	4	0.3	0.03
9	364449	6346798	4	0.2	0.03
10	364560	6346891	3	0.2	0.02
11	366263	6346732	2	0.1	0.01
12	366312	6346774	2	0.1	0.01
13	366376	6346784	2	0.1	0.01
14	366421	6346797	2	0.1	0.01
15	366275	6346422	2	0.1	0.02
16	366339	6346405	2	0.1	0.02
17	366381	6346405	2	0.1	0.02
18	366456	6346399	2	0.1	0.02
19	366546	6346422	2	0.1	0.02
20	366588	6346349	2	0.1	0.02
21	366776	6346270	2	0.1	0.02
22	366701	6346291	2	0.1	0.02
23	366903	6346255	2	0.1	0.02
24	366975	6346268	2	0.1	0.02
25	366875	6345564	3	0.2	0.02
26	366659	6345057	4	0.3	0.03
27	367154	6345260	2	0.2	0.02
28	367637	6345727	2	0.1	0.02
29	367962	6345617	2	0.1	0.01
30	367972	6345545	2	0.1	0.01
31	368000	6345306	2	0.1	0.02
32	366057	6344730	6	0.4	0.06
33	365820	6344515	4	0.5	0.06
34	366293	6344321	3	0.3	0.03
35	365844	6344175	4	0.3	0.04
36	365240	6344038	6	0.4	0.04
37	363245	6346289	4	0.3	0.03

7.3.1 Cumulative Impacts

Recent PM_{10} monitoring data recorded at Wallsend shows a maximum 24-hour concentration of 38.9 µg/m^3. The highly conservative approach of adding a maximum background to the maximum predicted 24-hour concentration gives a cumulative concentration of 46 µg/m^3 which is below the criteria of 50 µg/m3. The addition of annual average concentrations of less than 1 µg/m^3 would not result in cumulative annual average impacts.

8 DUST IMPACTS – CONSTRUCTION/OPERATIONAL PHASES

As presented in **Section 7.3**, the potential for adverse dust impacts during construction and operation of the site is expected to be minimal given separation distances to private residences of 1.5 km and the additional screening influence of local topography and vegetation.

During operation of the site, dust emissions can be expected from trucks travelling on unsealed section of the site delivering waste, unloading waste, plant and equipment involved in capping and filling and wind erosion from exposed ground. Dust impacts from current landfilling operations are controlled using a water truck and a fixed cannon spray irrigation system, part of the onsite leachate recycling. The spray system helps to dampen areas of the site subject to dust.

During construction there will be significantly more earthmoving activity and truck movements and the following activities are identified as a potential source of dust generation:

- Vegetation clearing for new landfill areas;
- Excavation of new landfill cells and stockpiling of excavated material;
- Haulage of excavated material and movement of heavy plant and machinery within the site;
- Graders / scrapers working road construction and upgrades; and
- Wind erosion from exposed ground.

Construction impacts are typically controllable through good site environmental practice and commonly applied dust management measures. Prior to construction, an Environmental Management Plan will be developed which will include air quality and dust management / mitigation procedures and will:

- outline procedures for controlling / managing dust;
- define roles, responsibilities and reporting requirements;
- outline the dust control inspection regime; and
- outline potential contingency measures for dust control where standard measures are deemed ineffective.

The following dust mitigation measures should be considered as part of construction phase environmental management plan.

8.1 Haulage and Heavy Plant and Equipment

Vehicles travelling over paved or unpaved surfaces tend to produce wheel generated dust, while the loads carried by trucks can result in fugitive dust emissions from wind erosion or spillages. Dirt track-out can also be a problem on paved surfaces surrounding the work areas.

- All vehicles on site should be confined to a designated route with a speed limit enforced;
- Number of trips and trip distances should be controlled and reduced where possible;
- Delivery and removal of materials should be planned and coordinated to avoid unnecessary trips;
- Dirt that has been tracked onto sealed roads should be cleaned as soon as practicable;
- Spoil trucks should be covered when the load is dry and tailgates should be effectively sealed prior to leaving the site;

- When conditions are excessively dusty and windy a water truck (for water spraying of travel routes) should be used;
- Use of a water cart to dampen surfaces prior to grading / scraping.

8.2 Clearing / Excavation

Emissions from vegetation clearance, topsoil stripping and excavation can be significant, particularly during dry and windy conditions. Emissions can be effectively controlled by increasing the moisture content of the soil / surface. This could be achieved using a mobile water cart and the canon spray system.

Other controls that will be considered are:

- Modify working practices by limiting excavation during periods of high winds; and
- Limiting the clearing of vegetation and topsoil to the designated footprint required for construction.

8.3 Wind Erosion

Wind erosion from exposed ground should be limited by avoiding unnecessary vegetation clearing. Wind erosion from temporary stockpiles can be limited by minimising the number of stockpiles on site and minimising the number of work faces on stockpiles. As material is removed or added to stockpiles, the area should be compacted to promote particle cohesion.

9 CONCLUSIONS

Dispersion modelling predictions of the proposed Awaba Landfill expansion indicates that local air quality will not be compromised. The predicted odour glcs are below the most stringent air quality goals at all residential areas.

Based on a worst case assessment of the onsite power generation plant, air pollutant levels due to the gas turbines and excess flaring of landfill gas are predicted to be well below relevant goals.

Predicted dust levels during construction and operation are expected to be low and should be largely controllable through good site environmental practice and commonly applied dust management measures.

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Additions to Awaba Waste Management Facility

Appendix M

AWMF Aboriginal Heritage Report

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Aboriginal Cultural Heritage Impact Assessment
Proposed Expansion Awaba Waste Treatment Facility
Awaba, NSW

Report to
Cardno
on behalf of
Lake Macquarie City Council

December 2011

Lake Macquarie City Council Local Government Area

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	Insite Heritage	A Besant E Wyatt
Our Reference	AwabaWTF_ACHIA_FINALdraft	
Date	7th December 2011	
Authors	A Besant Director E Wyatt Archaeologist	
Document Status	**FINAL**	

NB Sections of this report, specifically Figure 4, Figure 5, Section3.3 and Appendix D, contains culturally sensitive material relating to the location of recorded Aboriginal archaeological sites. This information is included in this report to satisfy the Director General of the Department of Planning and Infrastructure requirements for assessment. This information should not be released into the public domain. This information must be removed from this report prior to it being placed on public display.

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Executive Summary

Insite Heritage Pty Ltd were commissioned by Cardno on behalf of the Lake Macquarie City Council to assist in preparing an Aboriginal Cultural Heritage Impact Assessment for the proposed expansion of the Awaba Waste Treatment Facility, Wilton Road, Awaba. The project is being assessed under Part 3A by the Department of Planning and Infrastructure.

Aboriginal community consultation for the project was conducted in accordance with the Director General's of the Department of Planning and Infrastructure requirements for the project, as per the 2005 consultation guidelines maintained by the Office of Environment & Heritage, formerly the Department of Environment Climate Change & Water. Four Aboriginal parties registered their interest in the project; Awabakal Descendants Traditional Owners Aboriginal Corporation, Awabakal Traditional Owners Aboriginal Corporation, Cacatua Culture Consultants and Awabakal Local Aboriginal Land Council on behalf of Koompahtoo Local Aboriginal Land Council.

A search of the Aboriginal Heritage Information Management System (AHIMS) database maintained by the Office of Environment and Heritage was conducted in order to ascertain if any previously recorded archaeological sites occur within the project area which may be impacted by the proposed development. No previously recorded archaeological sites occur within the study area. The National Native Title Tribunal also conducted a search for the project area. No Native Title Registrations or Claims were present over the study area.

The preliminary investigations involved a foot survey conducted over the study area and subsurface testing in the area of the proposed leachate basins as these are located within 200m of a proposed watercourse. Survey visibility was hindered by thick vegetation / ground cover in some parts of the study area. Other areas were notably disturbed by existing track ways / road ways, rubbish dumping and surface disturbances. The survey identified three possible culturally modified trees located within the project area (AWTF_ST1, AWTF_ST2, AWTF_ST3). The preliminary subsurface testing excavated a total 1.75m². One artefact, a silcrete broken flake was recovered from the least disturbed probe, Test Probe 7, in the area of highest landscape sensitivity close to the creek line within the proposed southern most leachate basin. The details of all four identified sites will be lodged on the Aboriginal Heritage Information Management System maintained by the Office of Environment and Heritage.

AWTF_ST1 lies to the north of one of the proposed sediment ponds. Impacts on the tree should therefore be able to be avoided. AWTF_ST2 is located within the proposed expansion of the waste treatment facility and will therefore be impacted by the proposed development. AWTF_ST3, is located on the very north west boundary of the proposal, on the edge of an existing access track. Impacts on the AWTF_ST3 should therefore be avoidable.

The proposed southern most leachate basin will also impact on the identified area of archaeological sensitivity on the northern side of the creek line associated with Test Probe 7.

The following management recommendations are made in consultation with the registered Aboriginal parties for the project, please also refer to Appendix A for their complete reports and Section 5.0.

It is recommended that the identified possible culturally modified trees should remain in-situ. However, as AWTF_ST2 is dead it may be possible to relocate the tree into the conservation area adjacent to Wilton Road if project approval is granted, and if impacts are unavoidable.

As AWTF_ST1 is located outside of the proposed boundary of the leachate basins, it should therefore not be impacted by the proposed development. To avoid unintentional impacts during construction it is recommended that a 5m perimeter / buffer zone be placed around the tree, surrounded by barrier tape or appropriate bunting/fencing. As AWTF_ST3 is located on the on the edge of the existing track / roadway that runs along the ridge line, it should not be impacted by the proposal. As with AWTF_ST1, a perimeter/buffer zone around the tree should be established to avoid unintentional impacts during construction. If impacts are unavoidable, then management of the affected trees should be discussed with the Aboriginal Stakeholders.

The preliminary testing narrowed down the area of archaeological sensitivity to a level bench area on the north side of the creek within the southernmost proposed leachate basin around Test Probe 7. Should the project receive approval it is recommended that additional excavation works be undertaken in this area prior to impact. This will initially comprise of $1m^2$ probes spaced evenly over the area of impact along the creek line. These probes may be expanded if artefact densities warrant further investigation / salvage.

Following completion of the archaeological subsurface excavation works in this area, it is recommended that a monitoring and collection programme is undertaken by the registered Aboriginal stakeholders during all proposed subsurface excavations works for the project within the margins of the creek/watercourse. This would involve a process in which the proponent engages the Aboriginal Stakeholders to monitor all sections of surface disturbance works to allow for collection of any artefacts that may be disturbed in this area.

Artefacts collected during this observation and collection process along with any artefacts excavated from the subsurface excavations should then be relocated and reburied on site by the Aboriginal Stakeholders at a location that will not be subject to any impacts. This will ensure that any recovered artefacts will remain 'in country'. The artefacts and the location of their reburial would then be recorded and their details added to the Aboriginal Heritage Information Management System maintained by the Office of Environment and Heritage.

It is recommended that a Cultural Heritage Management Plan (CHMP) in consultation with the registered Aboriginal stakeholders be prepared for the project, if approval is granted prior to any works commencing. The CHMP will outline the proposed additional excavation works in the area of impact within the southernmost leachate basin including methodologies for monitoring of surface disturbance works in this area and protocols for collection and reburial of artefacts by the registered Aboriginal stakeholders. The CHMP will also outline protocols for ongoing management of cultural heritage values including suggestions for the relocation of AWTF_ST2 and its ongoing conservation and management.

It is also recommended that should the project receive approval Cultural Heritage Awareness Training be implemented either through an oral and/or PowerPoint presentation for all contractors involved in the project.

The registered Aboriginal stakeholders for the project have also requested that the proponent take all necessary steps to locate, protect and preserve Awabakal Cultural Heritage.

1.0 *Introduction*

1.1 Location & Objectives

Insite Heritage Pty Ltd were commissioned by Cardno on behalf of the Lake Macquarie City Council to assist in preparing an Aboriginal Cultural Heritage Impact Assessment as per the Director General of the Department of Planning and Infrastructure requirements for the proposed expansion of the Awaba Waste Treatment Facility, Wilton Road, Awaba. The project is being assessed under Part 3A by the Department of Planning and Infrastructure.

The project is located at Lot 372 DP723259, 367 Wilton Road Awaba and lies within the boundaries of Lake Macquarie City Council's Local Government Area (refer to Figure 1 for location map).

1.2 Investigators & Contributors

The investigation was conducted by the following personnel

Ms Kerrie Brauer - Awabakal Traditional Owners Aboriginal Corporation (ATOAC)
Ms Jodie Wilson - ATOAC
Mr Shane Frost - Awabakal Descendants Traditional Owners Aboriginal Corporation (ADTOAC) whom also supplied a copy of the draft AHMS (2009) report
Mr Ray Smith - Awabakal Local Aboriginal Land Council (ALALC) on behalf of Koompahtoo Local Aboriginal Land Council (KLALC)
Mr Allen Smith - ALALC on behalf of KLALC
Ms D Sampson - Cacatua Culture Consultants
Liz Wyatt - Archaeologist Insite Heritage Pty Ltd

Mr Chris Holloway and Ms Jenny Smithson of Cardno provided information regarding the proposed development, project details and plans. Acknowledgment also goes to Mr Steve Merritt, Manager Awaba Waste Treatment Facility.

1.3 Aboriginal Community Consultation

As per the Director General of the NSW Department of Planning and Infrastructure requirements, the assessment was conducted as per the Office of Environment and Heritage *Guidelines for Community Consultation* (2005).

The registered Aboriginal parties for the project are;
Awabakal Local Aboriginal Land Council on behalf of Koompahtoo LALC
Awabakal Descendants Traditional Owners Aboriginal Corporation
Awabakal Traditional Owners Aboriginal Corporation
Cacatua Culture Consultants

Please refer to Appendix A for the Cultural Heritage Assessments undertaken by the registered Aboriginal parties for the project. A summary of the consultation process undertaken for the project is provided in Appendix B

A search of the National Native Title Register was also conducted for the Lake Macquarie Local Government Area. This was undertaken in order to identify if there are any Native Title Registrations, Claims or Unregistered Claimant Applications within the project area who will need to be consulted. The search did not identify any Native Title Registrations, Claims or Unregistered Claimant Applications within the project area. An Indigenous Land Use Agreement was identified in relation to the mining lease associated with Powercoal Pty Ltd, this encompasses the project area but is associated with the mining activities of Powercoal Pty Ltd and is not relevant to the project (refer to Appendix C).

1.4 Relevant Legislation

This project has been accepted by the NSW Department of Planning and Infrastructure as a Part 3A application. Whilst Part 3A does not require approvals from the Office Environment and Heritage, the report aims to address the intent of the NP&W Act 1974, which protects Aboriginal cultural heritage objects and places.

The National Parks & Wildlife Act 1974 (NPW Act) As Amended

The NPW Act provides statutory protection for all material evidence of Aboriginal occupation of NSW. The objects of the act, as outlined in Section 2A include;

(*b) the conservation of objects, places or features (including biological diversity) of cultural value within the landscape, including, but not limited to:*
(i) places, objects and features of significance to Aboriginal people

An Aboriginal object means any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises New South Wales, being habitation before or concurrent with (or both) the occupation of that area by persons of non-Aboriginal extraction, and includes Aboriginal remains.

It is an offence to harm an Aboriginal object or declared Aboriginal place without first obtaining an Aboriginal Heritage Impact Permit from the Director General of the Office of Environment and Heritage.

1.5 Proposed Development

The proposed development involves the upgrading and expansion of the existing Awaba Waste Treatment Facility and will involve the following works:

- Excavation of 184,000m^3 soil to create two new landfill cells;
- Stockpiling of excavated soil;
- Removal of native vegetation;
- An increase in maximum height for the entire landform on-site;
- Surface, groundwater and leachate management systems;
- Landfill gas monitoring and capture;
- Green waste processing; and

- Associated infrastructure; this will primarily include the construction of a new reuse centre, wheel wash facility, weighbridge and transfer station. The transfer station will provide an area where waste is transferred from domestic/commercial vehicles to the transfer station. The waste is then transported to the tip face by Council vehicles on site. This will allow for more efficient waste management and reduces the number of vehicles at the active tipping face.

The proposed expansion works cover an area of approximately 10ha around the perimeter of the existing Waste Treatment Facility. A preliminary concept plan of the proposed development is outlined in Figure 2 and a more detailed plan of the associated infrastructure is shown in Figure 3 below.

Figure 1 Location of Proposed Development

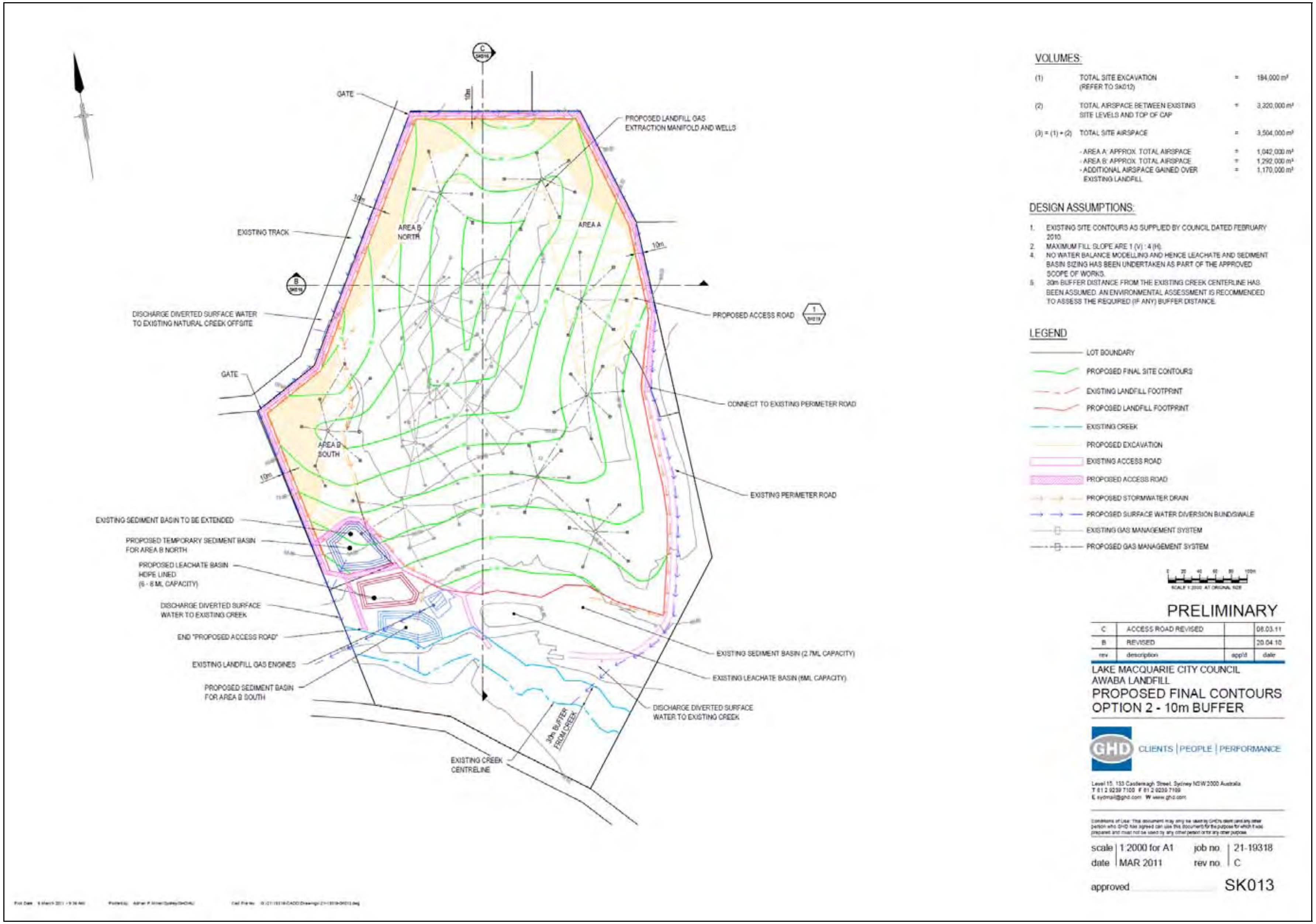

Figure 2 Preliminary Concept Plan.

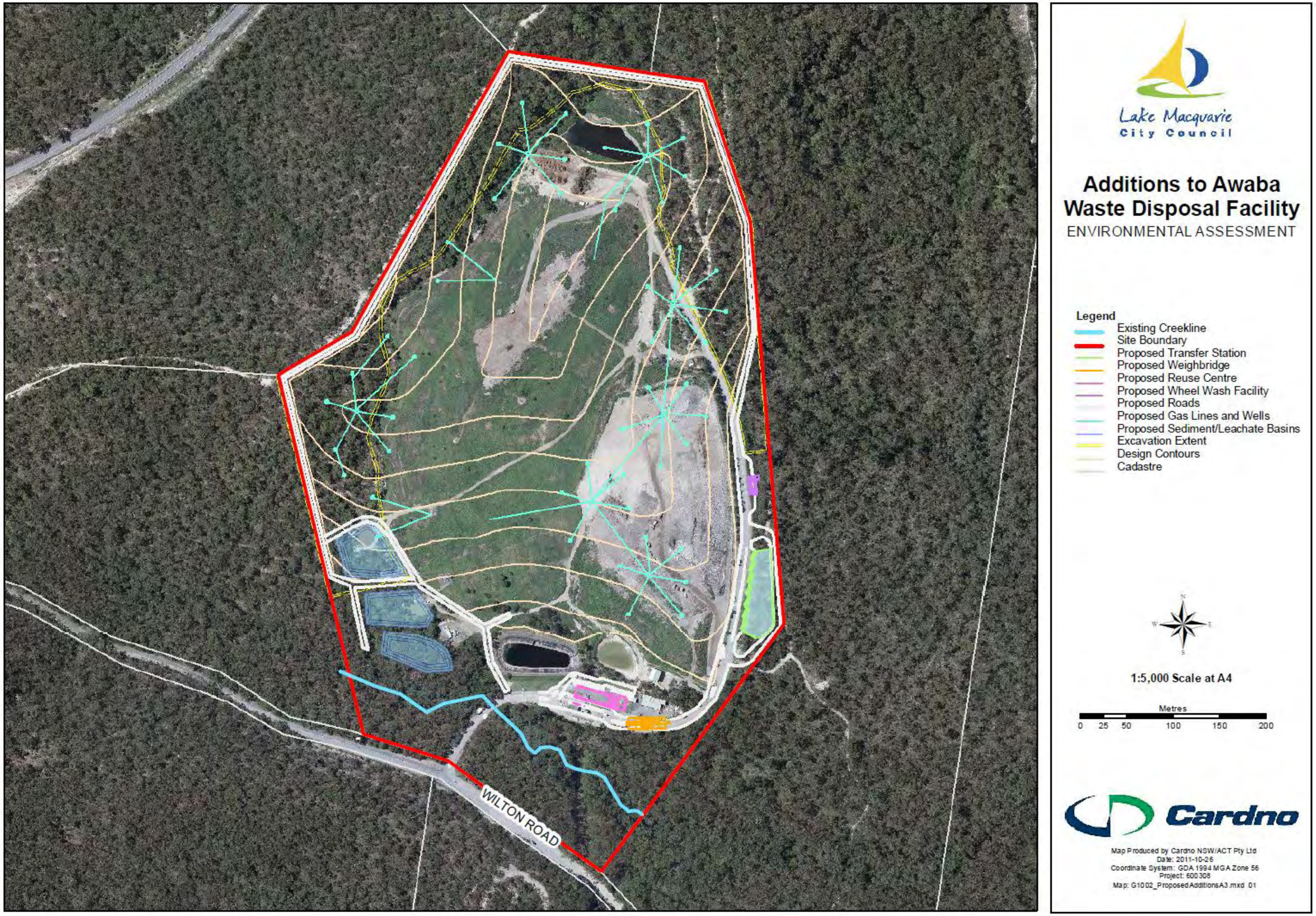

Figure 3 Detail of proposed infrastructure

2.0 Aboriginal Archaeological Context

2.1 Regional Archaeological Context

The antiquity of occupation of Australia by Aboriginal peoples has been a contentious issue frequently debated within the field of archaeology. The majority of evidence dates to the Holocene (the last 10,000 years) although it is generally accepted that Aboriginal occupation could date to 60,000 or more years ago.

In NSW a number of archaeological sites have been dated back to the Pleistocene. To the north west of the project area Koettig (1986) recorded a date of 20,200 BP from a hearth at Glennies Creek, north of Singleton. An Aboriginal site on the Liverpool Plains has been dated to at least 19,000 BP (Gorecki *et al,* 1984) and one of the world's oldest ritual cremation sites dated to 26,000 years ago is located at Lake Mungo in western NSW (Mulvaney et al 1999). Navin & Officer (2005) citing Haglund (1985) notes that Aboriginal occupation of the Darling Basin has been dated to 40,000 years ago.

During the Pleistocene sea levels were significantly lower than present day with the coast line kilometers off shore to its present position, some evidence of occupation during this period is likely to be below sea level. Relic sand dunes from the Pleistocene were the source of dates of Aboriginal occupation to 17,000 years B.P, about 60 km, north of the project area at Moffats Swamp (Baker 1994). At Swansea on Lake Macquarie, midden material was dated to 7,850 and although this date has been disputed (Dallas et al.1993). At Newcastle, to the north east of the project area, radio carbon dating of material recovered from an archaeological excavation of a large complex campsite located within a buried sand body have yielded dates between 6716 and 6502 years B.P (AHMS 2011).

Sites dating back to the Holocene (the last 10,000 years) are far more common in the open site context and sites within the project area are likely to date from this period. Within this period the morphology of the stone artefacts has been used to give a general estimate of the antiquity of the manufacturing technique. Earlier reduction techniques have been known as the 'core and scraper tradition' that focused on the initial reduction of cores to produce large flake blanks for use as tools (Koettig 1990). The replacement of this technological approach with the manufacture of microliths (small artefacts) that were then hafted to produce a composite tool occurred about 5,000 years ago. Reasons for change in technological characteristics have been proposed by Hiscock (1994) who suggested that increased mobility may have become necessary during the Holocene, as people occupied areas of unfamiliar environmental resources, or as climatic fluctuations rendered the environment less predictable. The extension of stone resources to include small pebbles and small outcrops would have increased the amount of time between visits to the stone sources previously used (Besant et al 2009). The presence of microliths at a site can therefore provide an indicative date of occupation.

2.2 Local Ethnographic Context

The project area is a part of the country of the Awabakal whose territory extended from the southern reaches of Lake Macquarie to the Sugarloaf ranges in the west and the Hunter River in the north.

An insight into the society and culture of the Awabakal in the early 1800s is provided by the works of L.E Threlkeld. L. E. Threlkeld was a missionary who established a Mission initially on the eastern side of Lake Macquarie near Belmont and subsequently relocated to the western side of Lake Macquarie in 1824. Threlkeld maintained records of the Awabakal in this area, documenting 'observations' which serve as one of the few records of Aboriginal culture from this period. The documentation of Awabakal language, clan territories, kinship and mythology, by Threlkeld, has produced some of the best ethno-history from the early 19th Century (Gunson 1974, Mulvaney 1992).

Food sources referred to by Threlkeld include; *cobra* a 'maggot' found inside grass tree stumps, described to Threlkeld as *"all the same as oyster to you, and just as nice!"* (Gunson 1974:55). The fern root was roasted and ground to make bread. Marsupials, particularly large kangaroo were favoured as were the plentiful wild ducks, geese, swans and pigeons. Large craw-fish (lobster) were collected with some difficulty at times, when *"choosing a calm day at sea, in one of their frail canoes … dive along side of the rock, and pull the fish out of the holes in the rock …..sometimes a shark would make its appearance, when the utmost agility would be required to escape the monster, who would, as readily seize the legs of the biped and devour him as …. [a] cretaceous one."* Threlkeld describes a shark attack on the lake; a canoe upset and sunk, was attacked by a shark taking the woman and then pursuing the man to the shore, and lacerating his legs (Gunson 1974:56).

Threlkeld recorded some of the material culture of the Awabakal. In spite of the frequency with which stone artefacts can be located in the Lake Macquarie area, there are surprisingly few references to stone implements use within Threkeld's records. Threlkeld noted that hunting and fishing spears were tipped with hard wood that was hardened by heat treatment. These tips are unlikely to be preserved in open archaeological deposits.

The information recorded by Threlkeld shows the adaptation of tradition methods to new materials, for example the replacement of stone barbs on war spears with barbs of glass.

"The battle -spear ......[has] pieces of sharp quartz stuck along the hard wood joint on one side so as to resemble the teeth of a saw. The march of intellect directed the blacks, latterly, to use fragments of broken glass-bottles instead of quartz, thus inflicting fearfully lacerated wounds with the deadly weapon" (Threlkeld in Turner & Blyton 1995:67). These modified fragments of glass may survive in the open site context due to their durability.

Threlkeld also noted that his Aboriginal adviser M'Gill whose traditional name was Biraban (Awabakal for sea eagle), may have been *"a knight of the ancient order of the holy Eagle-stones"*. Threlkeld noted that high places were held as sacred, and on elevated ranges there were circular structures of stone, *"5 or 6 feet diameter, and* *two or three feet high, evidently built......"* (Turner & Blyton 1995:66). Tradition held that the structures were built by the Eagle-Hawks, *"a bird of mysterious omen, and much reverence.."* Miles in (Turner & Blyton 1995:78).

2.3 Local Indigenous Archaeological Context

The following section provides a summary of previous archaeological studies undertaken in proximity to the project area, the results of which provide an indication into the site types which may be located within the project area.

Koettig in 1980 surveyed the Eraring to Kemps Creek Transmission Line. While conducting the survey an isolated artefact was located south west of Mount Nellinda. A second artefact was found 1km northeast of Dora Creek.

Mary Dallas in 1990 surveyed approximately 116 ha between Wangi Wangi and Myuna Bay. During the survey an open midden was identified within the foreshore reserve. In 1991, Dallas and Navin also surveyed approximately 112 ha between Dora Creek and Myuna Bay. No Indigenous sites were located.

Dallas in 1992, undertook a survey at Wangi Peninsula. Six shell middens were identified during this survey. In 1992 Dallas and Navin also surveyed Fishing Point Peninsula. During this survey two Indigenous shell middens were found. Dallas, Navin and McConchie conducted a survey of Morisset Peninsula in 1993 during which twelve Aboriginal shell middens were found.

In 1993, Nelson and Ruig surveyed the site of the Henry Kendall Retirement Village at Bonnells Bay. During the survey an isolated artefact and an Aboriginal shell midden (on the foreshore of the lake) were identified. Later in 1998 Mills surveyed the Dynamic Lifter Plant site on Wyee Road, Morisset. No sites were located during the survey, however, an area of potential archaeological deposit was identified on Wyee Creek.

Bonhomme Craib & Associates undertook a study of Central Coast shell middens in the 1990's for the National Parks and Wildlife Service of New South Wales in order to "…*better identify the archaeological record in this area, assess its significance, identify potential impacts to the remaining middens and establish appropriate management strategies for these resources*" (Bonhome et al 1993). The results of the study would seem to indicate that Aboriginal people used the coast for long periods of the year with very little movement away from the main camps. Indigenous sites would have consisted of the following types: a main camp, smaller field camps, locations were food was gathered, areas where ceremonies were held and places where tools are stored. An analysis of the evidence gathered suggests that most of the middens on the lakes and bays of the Central Coast area were probably locations where shellfish was gathered, prepared and eaten as there is little evidence to suggest that other activities were taking place. The report does however state that some of these midden sites (especially those located on headlands next to open beaches) may have in fact been main camps as these sites are larger than lake and bay sites and they contain a lot of shell. In addition they have stone tools and fireplaces.

Envirosciences in 1995 investigated the midden site Coal Point 1 with auger sampling to determine the extent of the midden deposit. The midden was found not to be as extensive as previously thought when recorded by Dallas in 1995, with its boundaries defined the midden was avoided by the development.

In 1996, Navin Officer carried out test excavations at 'The Hole 1' Mannering Bay, Lake Macquarie to the south of the study area. An Indigenous site had been previously recorded adjacent to a ventilation or flushing channel on land Pacific Power leased at Mannering Bay on the south western shore of Lake Macquarie. The investigations conducted by Navin Officer Archaeological Resource Management established that the maximum dimensions of the site were 180m by 100m. The site yielded a hundred and thirty-seven artefacts. Ninety-five of the artefacts occurred on the surface and an additional forty-two were found in eight test pits. Shell material observed on the site was identified as having a natural or recent human origin.

In 2004 Besant surveyed the site a flood evacuation road on the south side of Dora Creek adjacent to the western side of the railway easement. During the survey no indigenous cultural material was found and no areas of potential archaeological deposit were identified.

No. 55 Alton Road, Cooranbong was surveyed by Besant in 2004. No archaeological material was found during this survey and no areas of potential archaeological deposit were identified.

Besant (2004) survey of Lot 9 DP 244002 and Lot 358 DP 755242 Morisset Park Road, Morisset Park found no Aboriginal sites were located in the course of this survey although an area of potential archaeological deposit was noted. Subsequent test probes of the PAD failed to find any artefactual material.

HLA Envirosciences (2007) surveyed a water pipeline route from Fennell Bay to Toronto to the north of the study area. Three locations were identified as sensitive, two areas of archaeological potential and one area of midden.

AHMS (2009) conducted subsurface testing at AHIMS Site 45-7-0261 located approximately 1km south east of the project area. The site was the location of a proposed EnergyAustralia substation and associated infrastructure which would impact on the identified PAD area. The PAD area was located on a terrace of Stockyard Creek in the vicinity of Wangi Wangi and Wilton Roads, Rathmines. Radiocarbon dating of a burnt wood fragment recovered from the subsurface testing provides a tentative date of 433 ± 55 C^{14} year B.P for the archaeological assemblage. A total of 16 $1m^2$ test probes were excavated over a low slope / benched terrace on the northern side of Stockyard Creek covering an area of 80 x 30m The excavation uncovered 41 stone artefacts predominantly of coarse to medium grained silcrete with minor tuff and FGS of which 9 complete artefacts were noted. The assemblage was also considered to be highly disturbed as artefacts occurred throughout the soil profile.

Insite Heritage Pty Ltd have undertaken staged salvage excavations under S90 permits for the Trinity Point Housing development (2006 – 2010), located about 20 kilometers south of the study area, at Morisset Park, Lake Macquarie. To date the excavations have salvaged subsurface sites including open camp sites, with peak artefact densities of 15.3 per m², including a large knapping floor. During the 2010 excavations a large subsurface midden site overlying an in situ stone hearth was uncovered (Besant et al in prep 2011).

AHMS Pty Ltd (2011) undertook subsurface archaeological investigations of a buried sand body adjacent to Hunter Street at the former Palais Hotel site in Newcastle located approximately 35km north east of the study area. A total of 48m² of open area excavations were undertaken with excavations depths of 1-2m below ground level. The excavation recovered 5,534 Aboriginal objects representing three occupation periods dating from 6,716-6,502 years BP. The site is of very high cultural and scientific significance.

2.4 AHIMS Search

A search of the Aboriginal Heritage Information Management System (AHIMS) database maintained by the Office of Environment & Heritage (OEH), formerly the Department of Environment Climate Change & Water, was conducted in order to ascertain if any previously recorded archaeological sites occur within the project area which may be impacted by the proposed development. The results of the AHIMS search will also aid in compiling the predictive model of archaeological potential for the project area.

A search of the database was conducted for Lot 372 DP723259 with a 50m buffer and for a 5km area around the proposed development (Easting 362000 – 357000, Northing 6343000 – 6348000). No previously recorded sites occur within the project area, however six previously recorded archaeological sites were located within the broader 5km search (please refer to Appendix D for AHIMS search results). Table 1 below outlines the site types identified by the search, and their locations are shown in Figure 3 below.

Four of the identified sites are located approximately 1km from the project area boundary, they comprise of a set of grinding grooves located on a drainage line to the east of the project area, a shelter with deposit and axe grinding grooves to the north of the study area at Awaba, and an open campsite / artefact scatter to the north west of the project area, south west of Awaba township. An area of PAD (Potential Archaeological Deposit) was identified at AHIMS Site 45-7-0261 adjacent to Stockyard Creek approximately 1km south east of the project area.

Table 1 Site types identified by AHIMS search

Site Type	Count
Artefact Scatter / Open Camp Site	2
PAD*	1
Artefact, Grinding Groove, Shelter with Deposit	1
Grinding Groove	1
Grinding Groove with Waterhole	1
Total	**6**

* Potential Archaeological Deposit

2.5 Landscape Context

A review of the landscape context for the project area is provided below in order to place the project area in its environmental context and assist in developing the predictive model of archaeological potential for the project area.

Murphy & Tille (1993) places the project area within the Awaba Soil Landscape. The Awaba Soil Landscape classified as an erosional landscape located within the rolling low hills with broad crests and short side slopes of the Awaba Hills. Local relief ranges from 20-80m with slope gradients of 20-60%.

Dominant soil types comprise of shallow Lithosols on steep slopes, shallow to moderately deep Soloths and Yellow Podzolic Soils on gentler slopes with Soloths in drainage lines (Murphy & Tille 1993). The underlying geology comprises of coarse grained sediments of the Narrabeen Greep – Munmorah Conglomerate Formation and Newcastle Coal Measures (Murphy 1993:46).

Vegetation with this soil landscape is described as regenerating tall open forest. Dominant woodland tree species include brown stringybark (*Eucalyptus capitellata),* scribbly gum (*E. haemastoma)*, grey gum *(E. punctata)*, smooth barked apple (*Angophora costata*) and black shea-oak (*Allocasuarina littoralis*) with spotted gum (*E. maculata*) on heavier clay soils. Within sheltered drainage lines red blood wood (*E. gummifera*) and brown stringy bark (*E. capitellata*) also occur (Murphy 1993:46).

The southern portion of the project area is bisected by an unnamed tributary which flows eastwards into the western shore of Lake Macquarie at Rathmines approximately 3km to the east. Kilaben Creek is located approximately 700m south of the project area.

2.6 Predictive Model of Archaeological Potential

Based on previous studies and landform context, the predictive model of archaeological potential outlines the main site types to be expected within the project area.

Previous archaeological investigations have shown that archaeological sites are more prevalent in areas in close proximity to water sources with the number and density of archaeological sites increasing with the permanence of the water resource. Areas surrounding creek confluences have also been shown to be of importance in the region and potentially contain larger and more complex archaeological sites. River terraces have also been noted to have been favoured areas for Aboriginal encampments. The preference for occupation close to water resources may also lead to the re-deposition of artefacts in alluvial sediments and the exposure of subsurface archaeological material as a result of geomorphological processes. Whilst these areas can be favoured for larger camp sites, smaller artefact scatters may occur in all landscapes, resulting from movement between areas and the procuring of resources.

Ridgelines and rock overhangs have also high potential to contain shelter sites with deposits. These sites may also contain art, rock engravings and axe grinding grooves where suitable rock types and aspects occur. Shelter sites also have the potential to contain stratified deposits. Grinding grooves may also occur in creek lines where suitable rock outcrops (predominantly sedimentary) occur. As the project area falls adjacent to a creek line and ridge line shelter sites and grinding grooves may occur if suitable outcrops are present.

Areas of PAD (Potential Archaeological Deposit) may occur either in shelter sites or in areas in close proximity to water resources which have a suitable soil profile. There is also the potential for modified trees to occur in areas that have not been previously cleared.

Artefact scatters and isolated finds are likely to be located in eroded exposures in suitable landscape contexts and are the site type most likely to be located within the study area if suitable areas of exposure occur.

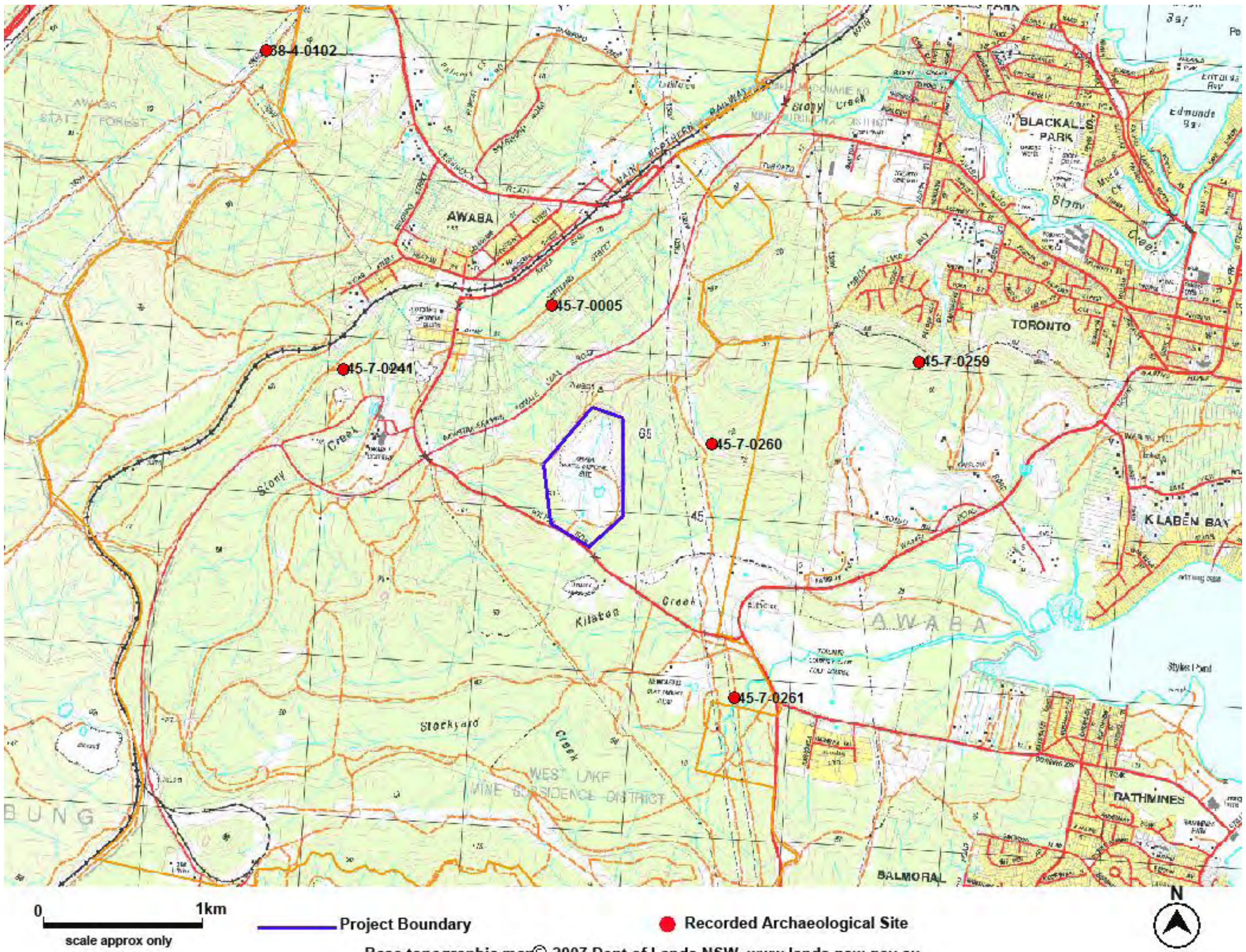

Figure 4 Location of Previously Recorded Archaeological Sites in Proximity to the Project Area