June 2014

ADDENDUM TO AIRSHED MODELLING REPORT

Meteorological Data Sets for the Hawke's Bay Region - AERMET

Prepared for

Hawke's Bay Regional Council

June 2014

Submitted to:
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New Zealand

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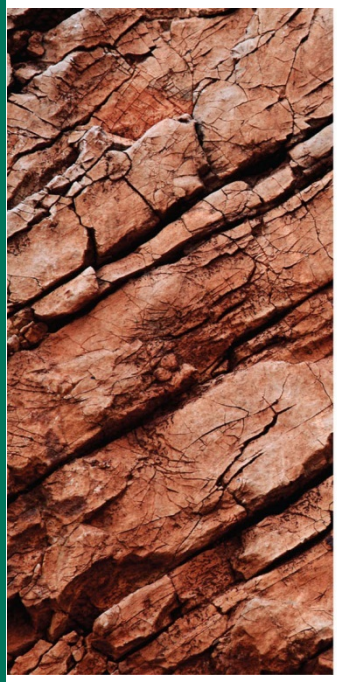

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REPORT

Golder Associates

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1.0 INTRODUCTION

The report, *Airshed Modelling of Exposure to Particulates in the Hawke's Bay Region – Urban Airshed Model and Meteorological Data Sets*, was submitted to the Hawke's Bay Regional Council (HBRC) by Golder Associates (NZ) Limited in July 2012 (Golder 2012). As part of that project, CALMET and AUSPLUME meteorological data sets were developed for use by air quality consultants as a basis for air dispersion modelling components of industrial assessments. The reader is referred to Appendix D of Golder (2012) for a full description of the CALMET and AUSPLUME data sets themselves, and is strongly advised to read this report in conjunction with Appendix D of that report.

This report is provided subject to the report limitations in Appendix A.

The CALMET data sets covered the industrial areas of Napier (Onekawa), Hastings, Awatoto, Whirinaki and Wairoa, and were prepared for use with the CALPUFF dispersion model (see Scire et al. 1999 and TRC 2011). Meteorological files were extracted from CALMET at one location in each area and re-formatted for use with AUSPLUME (see EPA 2000). Modelled years were 2006 and 2010, selected in consultation with HBRC.

The dispersion model AERMOD (Cimorelli et al. 2004) has been a regulatory model in the United States (US) since 2005. It is not widely used in New Zealand, but it is anticipated that it will become more common. AERMOD has been adopted as a regulatory model by Environment Protection Authority Victoria (EPAVic) for air assessments carried out from 2014 onwards, in place of AUSPLUME. Recognizing the potential shift from AUSPLUME to AERMOD in New Zealand, HBRC has contracted Golder to provide AERMOD-ready meteorological files, for the same locations and years as the AUSPLUME files. The meteorological files were produced using AERMOD's pre-processor, AERMET, for the locations shown in Figure 1. Details of the site locations are given in Table 1. The AERMET meteorological files are based on the original CALMET outputs produced in 2012, and have been developed using methods consistent with the AUSPLUME data sets. Therefore the surface wind and temperature should have the same values in the AERMET and AUSPLUME data sets as extracted from CALMET. Other parameters such as mixing height may differ, as the models each derive them differently.

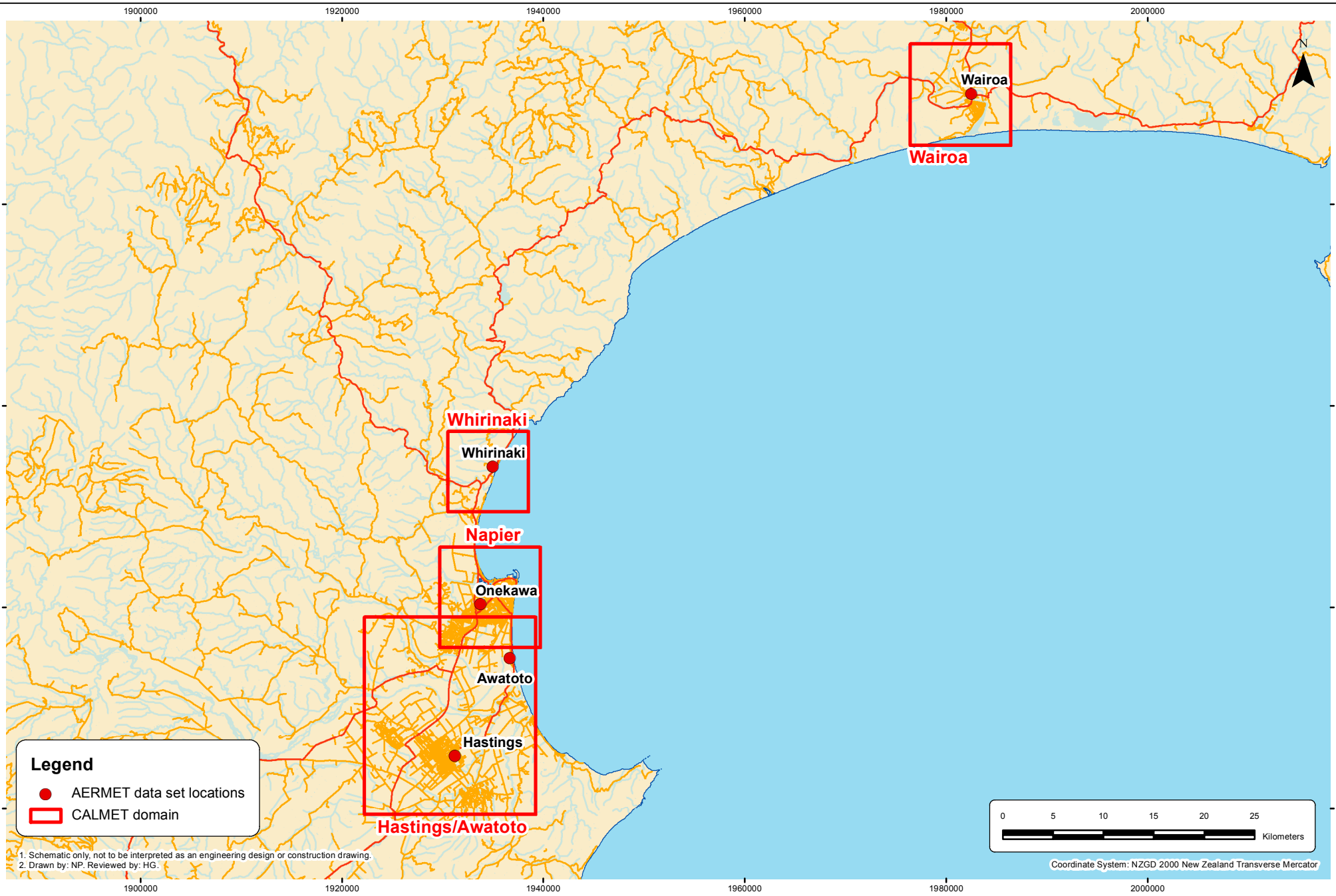
Table 1: Locations of meteorological data sets for AERMOD.

Filename[&]	Location	X (m, NZTM)[%]	Y (m, NZTM)
OnekawaNN.ABC	Industrial zone in Onekawa West CAU.	1933695	5620252
HastingsNN.ABC	St John's College monitoring site (Mayfair CAU).	1931162	5605203
AwatotoNN.ABC	Representative location in the Awatoto CAU.	1936625	5614923
WhirinakiNN.ABC	Representative location in the Whirinaki industrial area (Eskdale CAU).	1934933	5633946
WairoaNN.ABC	Industrial zone to the north of the residential area.	1982450	5670950

[&]NN refers to the year, 06 or 10; file suffix ABC refers to AERMET .sfc and .pfl files.

[%]Coordinates are New Zealand Transverse Mercator (NZTM).

This report describes the development of the AERMOD-ready meteorological files. Section 2.0 outlines the methods used to create the meteorological files. Section 3.0 provides guidance on relevant settings for AERMOD. Section 4.0 contains some concluding remarks. Section 5.0 introduces the report limitations statement. Section 6.0 contains a list of references. Appendix A contains Golder's full report limitations statement. Wind roses for the data sets are shown in Appendix B.



1. Schematic only, not to be interpreted as an engineering design or construction drawing.
2. Drawn by: NP. Reviewed by: HG.

Golder Associates

TITLE CALMET DOMAINS AND AERMET DATA SET LOCATIONS IN THE HAWKE'S BAY REGION

JUNE 2014

PROJECT 1478704164

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2.0 METHODS

2.1 Approach to the AERMOD Meteorological File Production

AERMOD's meteorological inputs consist of an hourly time series of parameters from a single location, representative of the area to be modelled using AERMOD. The time series includes observable parameters such as surface wind, temperature, pressure, humidity, rainfall, and derived boundary layer parameters such as heat fluxes and mixing heights. These are contained in a 'surface' file and a 'profile' file, which are generated by the pre-processor AERMET. The meteorological files provided by this project have therefore been created using AERMET.

AERMET was designed to be run based on observations from weather stations, and requires the following inputs:

- Hourly surface observations.
- Twice-daily upper-air soundings.
- Terrain and land-use parameters.

The CALMET data sets mentioned above were based on hourly three-dimensional outputs from the meteorological component of The Air Pollution Model (TAPM, see Hurley, Physick & Luhar 2005), in combination with surface-based observations from weather stations run by HBRC, MetService and NIWA. The hourly surface information required by AERMET was extracted from CALMET outputs, and AERMET files at the locations of the weather stations contain the observed wind, temperature and other parameters where available. Cloud cover information is not output by CALMET, but was calculated from TAPM's relative humidity and input to CALMET. The same cloud information was also used in AERMET.

The upper-air information for AERMET was extracted from TAPM as an hourly, vertical profile at each site location. The information was extracted from TAPM, rather than CALMET, as some upper-air parameters required by AERMET are not contained in CALMET's outputs. Note that AERMET only incorporates twice-daily soundings, so that most of the hourly profiles from TAPM were ignored by AERMET.

In summary, the meteorological inputs to AERMET were largely based on model outputs, rather than observations. However, if the model locations coincide with weather station sites whose data were used by CALMET, then the data from those sites are passed through CALMET and output by AERMET.

The following sections provide more details on the use of meteorological information in AERMET, and on other aspects of its configuration.

2.2 AERMET Configuration

2.2.1 Surface-based meteorological information

For each site and year, an hourly time series of meteorological parameters was extracted from the CALMET outputs at the lowest model level (10 m above ground). The parameters comprised wind speed, wind direction, temperature, relative humidity, pressure and precipitation amount[1]. These were merged with the cloud cover information used by CALMET, and input to AERMET as "on-site" data.

Light-wind conditions must be treated carefully. If the wind speed input to AERMOD is too low, there is a risk of unrealistically high concentrations. A threshold wind speed may be specified in AERMET, below which data are treated as calm. In this work, a threshold wind speed of 0.5 m/s has been chosen.

[1] Precipitation information allows the assessment of wet deposition in AERMOD. Precipitation data were available representative of all sites except Wairoa.

2.2.2 Upper-air profiles

Hourly profiles at the site locations were extracted from TAPM and converted into the Forecast Systems Laboratory (FSL) format for input to AERMET. The profiles contain height, pressure, dry bulb temperature, dew-point temperature, wind speed and wind direction. The upper-air profiles are used to provide an estimate of mixing height.

AERMET expects twice-daily upper-air soundings, which are taken routinely around the world at 0000 UTC and 1200 UTC (midday and midnight in New Zealand). To initialize the growth of the daytime boundary layer, the model uses the nearest available sounding before sunrise. In New Zealand this would be the sounding taken at midnight. However, as a modelled sounding is available for every hour, the option is taken in AERMET to use the modelled sounding closest to sunrise[2]. As mentioned above, AERMET does not use all 24 soundings.

2.2.3 Land-use sectors

AERMET requires site surface parameters, namely, surface roughness length, midday Albedo and Bowen ratio. These parameters depend on land use type, and if there are a number of land use types in the vicinity of the meteorological site, the parameters are averaged. This is done automatically by AERSURFACE, which uses high resolution land use data from the US. AERMET also allows the parameters to vary with direction from the meteorological site, allowing sectors of differing land use. The surface-layer and boundary-layer characteristics calculated by AERMET can therefore depend on wind direction, and this follows through to the plume dispersion characteristics modelled by AERMOD. The surface characteristics are also allowed to vary by season or by month.

For the Hawke's Bay region, Golder has examined the land-use classes used in CALMET within 1 km of the meteorological site location and averaging their parameter values. The parameter values used are taken from the AERSURFACE manual (USEPA 2013), averaged over all seasons. In built-up areas, suburban parameter values were used, rather than urban. Inland locations (Onekawa, Hastings and Wairoa) were given a single set of parameter values, whereas as coastal locations (Awatoto and Whirinaki) were each divided into two sectors – land and sea – with a set of surface parameters for each. The parameters used by AERMET for each data set location are summarized in Table 2.

Table 2: AERMET data set surface characteristics.

Location	Elevation[$]	Sectors[%]	Description[&]	Albedo	Bowen ratio	Roughness length
Awatoto	1 m	1: 165°–355°	Agricultural	0.18	0.98	0.24 m
		2: 355°–165°	Water	0.1	0.1	0.001 m
Hastings	9 m	All directions	Suburban	0.18	0.93	0.41 m
Onekawa	1 m	All directions	Suburban	0.18	0.98	0.42 m
Wairoa	7 m	All directions	Suburban	0.17	0.84	0.32 m
Whirinaki	9 m	1: 25°–200°	Water	0.1	0.1	0.001 m
		2: 200°–25°	Agricultural	0.18	0.68	0.19 m

[%]The direction ranges are defined with 0° northward, 90° eastward, 180° southward and 270° westward. For example, a range from 0° to 90° is in the direction of the northeast quadrant.

[$]The elevation is that used by CALMET at the site.

[&]The description indicates the majority of the land use around each site.

[2] To do this in AERMET, include the method "UASELECT SUNRISE" in the METPREP pathway.

2.2.4 Other AERMET configuration parameters

This section outlines further aspects of the AERMET configuration, with the options and parameter values used shown in Table 3. They are shown here for completeness, and do not have to be implemented by the user. Parameters related to meteorology that are required by the user in the configuration of AERMOD are described in Section 3.0,

Table 3: AERMET options and parameter values.

Description	Option or value(s)	Notes
Dates	1 Jan 2006 00:00 to 1 Jan 2007 00:00; 1 Jan 2010 00:00 to 1 Jan 2011 00:00 (NZST)	Two years have been modelled.
Time step	Hourly	
Anemometer height	10 m	Wind data are extracted from CALMET; this is the mid-level of CALMET's surface layer.
Critical wind speed	0.5 m/s	A few hours per year output by CALMET are therefore treated as calm by AERMET. The percentage of calms is shown on the wind rose for each site, in Appendix A.
Randomization of wind direction	Off	This is used when wind direction data are only available to the nearest ten degrees.
Interpolation of temperature data	On	By default, AERMET interpolates missing temperatures between hours. This will not happen here, as a full time series of temperatures has been extracted from CALMET.
Interpolation of cloud cover values	On	By default, AERMET interpolates missing cloud cover values between hours. This will not happen here, as a full time series of cloud cover is used.
Upper-air profile option	Use a sunrise profile	The upper-air profile nearest to the sunrise hour is used to initialize the day-time mixing height development.

2.2.5 AERMET runs and AERMOD testing

The meteorological data sets were produced using AERMET and tested using AERMOD, version 14134. The version number denotes the release year and Julian day, with 14134 being 14 May 2014. AERMET was run to produce ten pairs of files – surface and upper air files for two years at the five locations shown in Figure 1. All reports and messages output by AERMET were examined to ensure no errors occurred, and the wind roses for each site and year checked to ensure they matched the wind speeds and directions produced by CALMET. For reference, the CALMET wind roses have been taken from Golder (2012) and shown in Appendix B of this report. Testing was done in AERMOD with idealized sources to ensure that the AERMET meteorological files are compatible with the dispersion model.

3.0 AERMOD CONFIGURATION

In this project, AERMET runs and AERMOD tests were carried out within the AERMODView package (version 8.5.1), developed by Lakes Environmental Software[3]. These create the standard input files required by the models. The following describes the meteorology-related options which should be selected within AERMODView, and also the pathways, keywords and options that should be used if the run is created manually. It is assumed that the reader has experience with AERMOD in general and is familiar with the format of its input files and the meaning of the options described here.

In AERMODView:

1) Under Meteorology Pathway, Met Input Data, browse folders for the AERMET output surface and profile files (file suffices .sfc and .pfl) and select these.

2) Under Meteorology Pathway, Data Period, select “No” for “Read Entire Met Data File”. Then tick “Specify Data Period to Process”, with Start Date January 1, Hour 1, and End Date December 31, Hour 24. The year is either 2006 or 2010.

Manual set-up of AERMOD runs:

The AERMOD input file contains the pathway details as a text file. The following options are required in the Meteorology Pathway:

1) The keywords SURFFILE and PROFFILE point to the AERMET output surface and profile data.

2) The keyword STARTEND specifies the start and end hours of the run (1 January, hour 1, to 31 December, hour 24).

3) Site information is found in the AERMET output files, and entered as options for the keywords SURFDATA, UAIRDATA, SITEDATA and PROFBASE.

For example, an AERMOD run using the Onekawa 2006 meteorological data set would contain the following input information (assuming the AERMET files are in the AERMOD working directory).

```
ME STARTING
  SURFFILE .\onekawa06.sfc
  PROFFILE .\onekawa06.pfl
  SURFDATA 0 2006
  UAIRDATA 42032 2006
  SITEDATA 2001 2006
  PROFBASE 1.0 METERS
  STARTEND 2006 1 1 1 2006 12 31 24
ME FINISHED
```

[3] See http://www.weblakes.com/products/aermod/ (accessed 28 May 2014).

4.0 CONCLUSION

This report describes the creation of meteorological data sets for use in air dispersion modelling assessments with AERMOD at locations in the Hawke's Bay region. These data sets are based on CALMET modelling carried out for HBRC as part of project on airshed modelling of exposure to airborne particulates in the region (Golder 2012), and are therefore expected to be consistent with previous meteorological data sets produced for the region. This report should be read in conjunction with the Golder (2012) report, particularly Appendix D, which details the creation of the CALMET data sets. Note that the guidance given in Section 4.0 of Appendix D on the choice between the Gaussian-plume model AUSPLUME and the puff model CALPUFF also applies to the Gaussian-plume model AERMOD.

5.0 LIMITATIONS

Your attention is drawn to the document, "Report Limitations", in Appendix A. The statements presented in that appendix are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks to which this report relates which are associated with this project. The document is not intended to exclude or otherwise limit the obligations necessarily imposed by law on Golder Associates (NZ) Limited, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

6.0 REFERENCES

Cimorelli A, Perry S, Venkatram A, Weil J, Paine R, Wilson R, Lee RF, Peters W, Brode R & Paumier J 2004. AERMOD: description of model formulation. EPA-454/R-03-004, September 2004. p. 91.

EPA 2000. AUSPLUME Gaussian Plume Dispersion Model - Technical User Manual. Prepared by the Centre for Air Quality Studies, EPA, Victoria, Australia, November 2000. p. 107.

Golder 2012. Airshed Modelling of Exposure to Particulates in the Hawke's Bay Region. Report prepared by Golder Associates (NZ) Limited for the Hawke's Bay Regional Council, June 2012.

Hurley P, Physick W & Luhar A 2005. TAPM - A practical approach to prognostic meteorological and air pollution modelling. Environmental Modelling & Software. 20737–752.

Scire J, Robe F, Fernau M & Yamartino R 1999. A User's Guide for the CALMET Meteorological Model (Version 5.0). Earth Tech, Concord, Massachusetts.

TRC 2011. CALPUFF Modeling System - Version 6 User Instructions. Report prepared by Atmospheric Studies Group, TRC Companies, Inc., April 2011. p. 873.

USEPA 2013. AERSURFACE User's Guide. Report EPA-454/B-08-001. January 2008, revised January 2013. p. 34.

APPENDIX A

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APPENDIX B

Wind Roses for the Meteorological Data Sets

This Appendix contains wind roses from the CALMET modelling in Golder (2012), Appendix D. Wind roses from AERMET are the same as these.

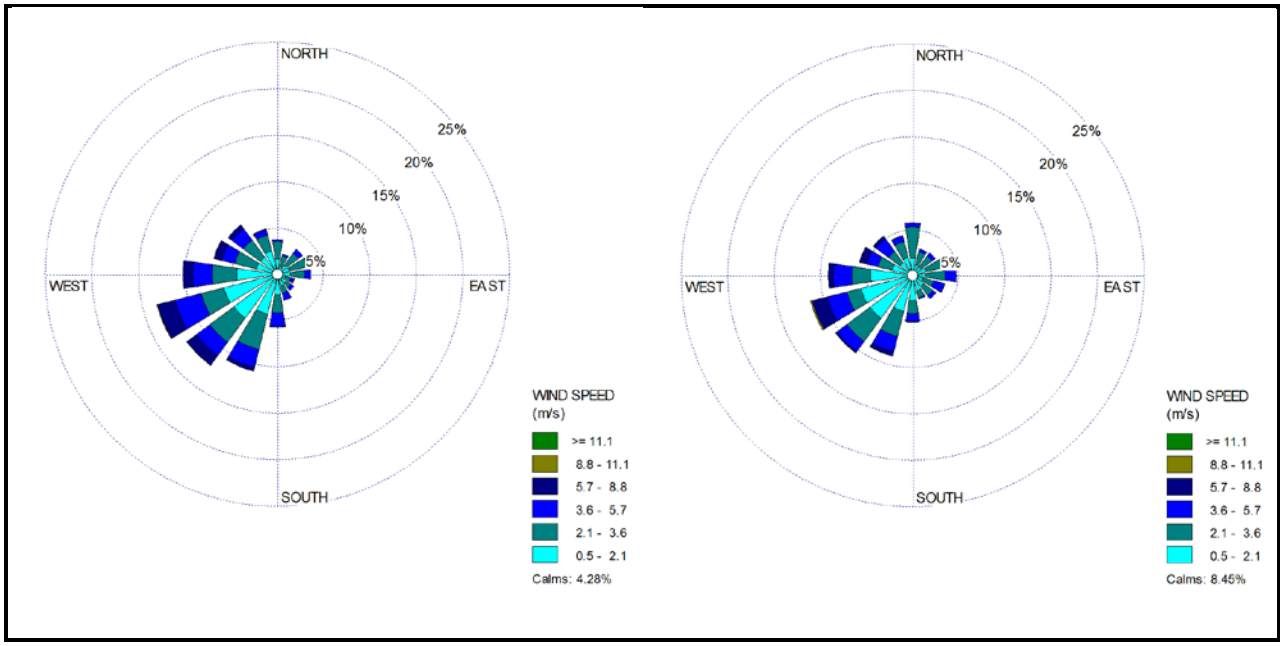

Figure 1: Wind roses for Onekawa, years 2006 (left) and 2010 (right).

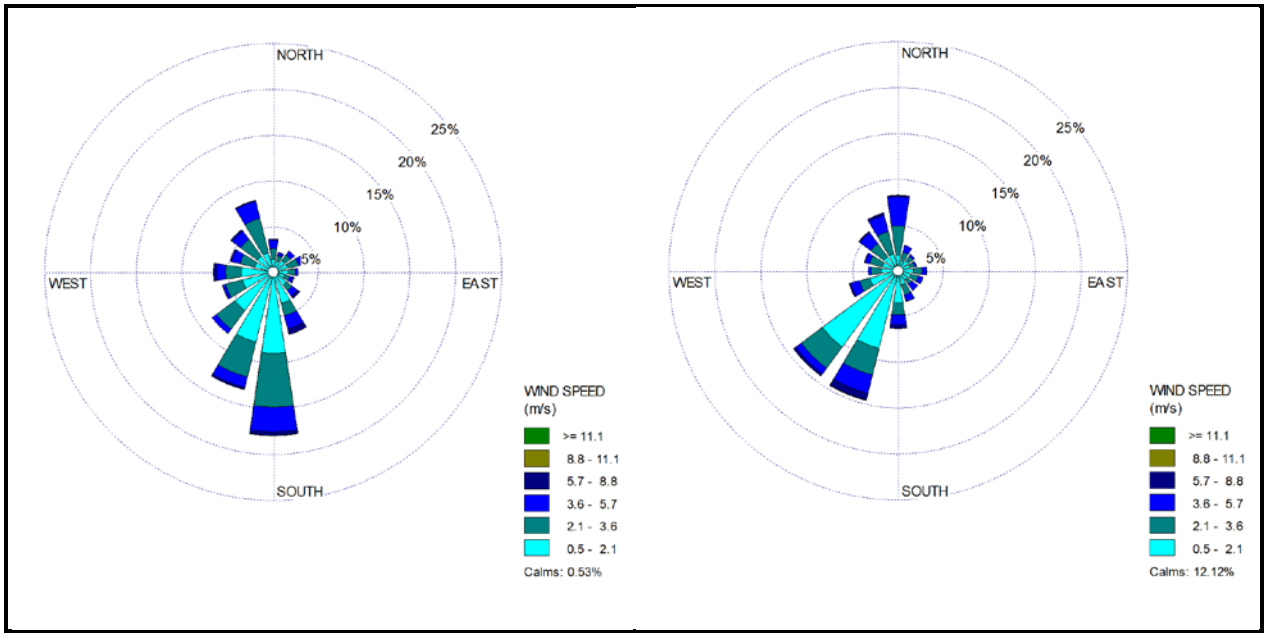

Figure 2: Wind roses for St John's College, Hastings, years 2006 (left) and 2010 (right).

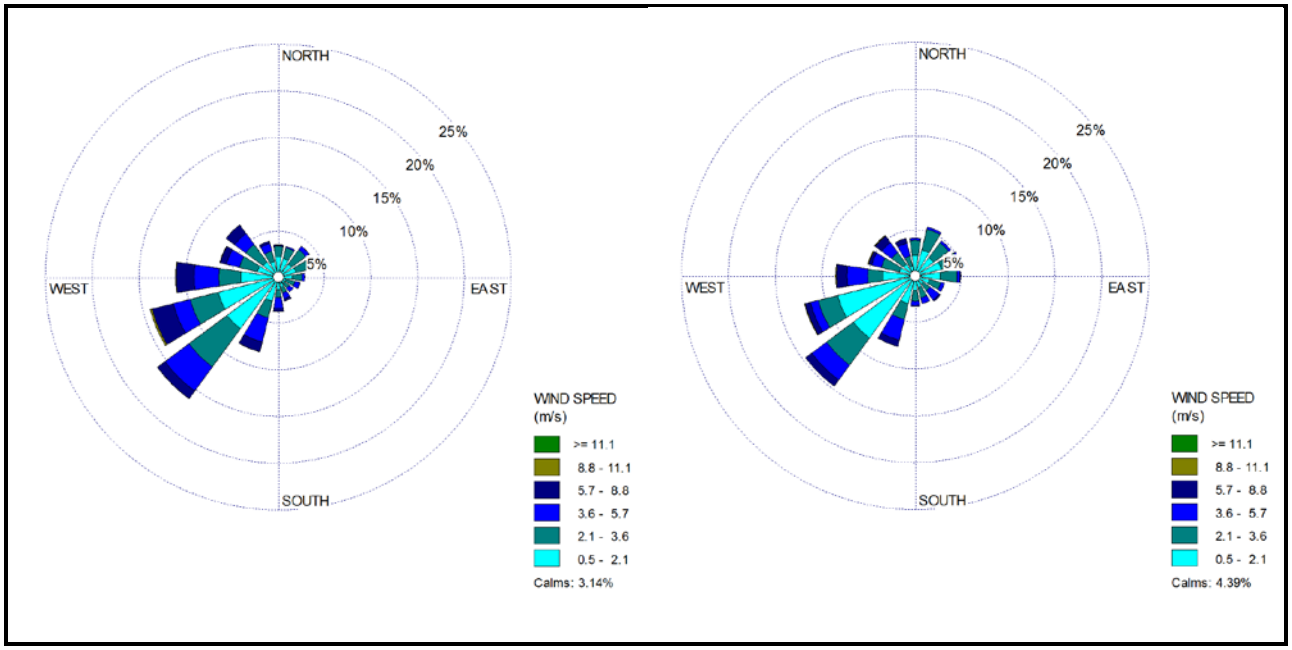

Figure 3: Wind roses for Awatoto, years 2006 (left) and 2010 (right).

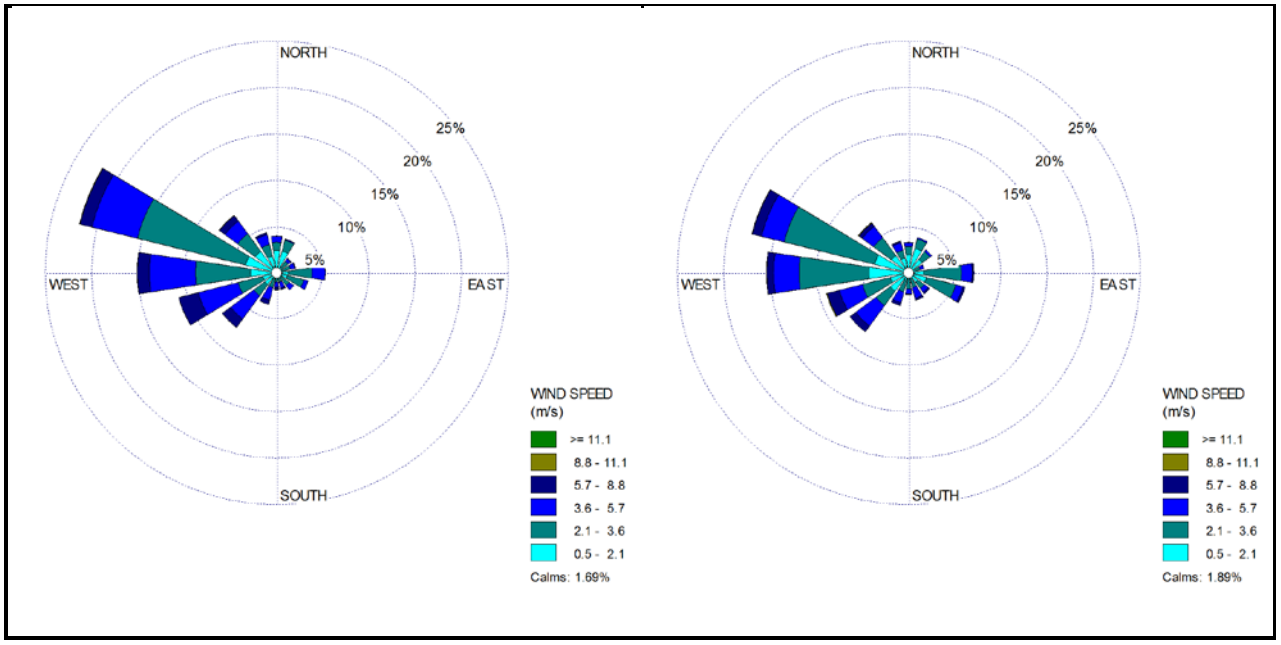

Figure 4: Wind roses for Whirinaki, years 2006 (left) and 2010 (right).

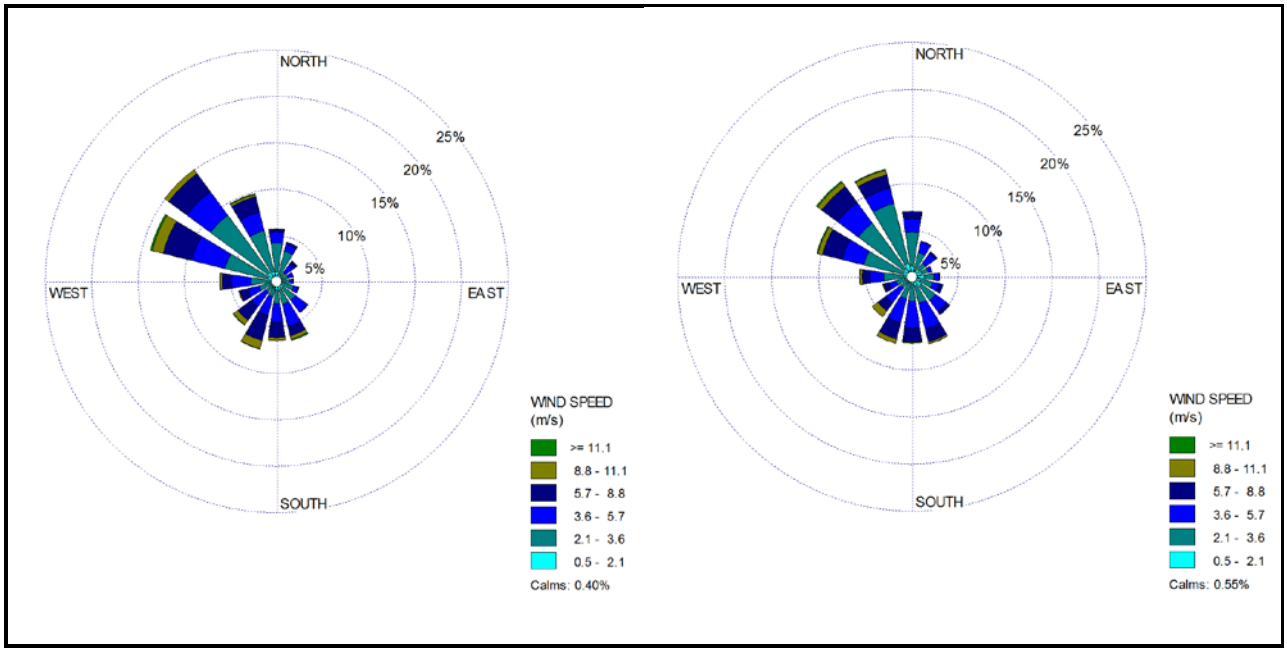

Figure 5: Wind roses for Wairoa, years 2006 (left) and 2010 (right).

Reference

Golder 2012. Airshed Modelling of Exposure to Particulates in the Hawke's Bay Region. Report prepared by Golder Associates (NZ) Limited for the Hawke's Bay Regional Council, June 2012.

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