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REPORT

WERRIS CREEK PRP – IDENTIFICATION OF ADVERSE WEATHER CONDITIONS FOR OVERBURDEN HANDLING

Whitehaven Coal Limited

Job No: **7487C**

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1 INTRODUCTION

Whitehaven Coal Limited (WCL) holds Environmental Protection Licence (EPL) 12290 for the Werris Creek Coal Mine (Werris Creek). Condition U2 (*Particulate Matter Control Best Practice Implementation - Disturbing and Handling Overburden under Adverse Weather Conditions)* requires Werris Creek to alter or cease the use of equipment on overburden and the loading and dumping of overburden during adverse weather conditions. The licence must:

- Undertake daily visual dust level assessments, continuously record real-time PM_{10} levels and continuously measure and record real-time meteorological conditions, and
- Record changes to mining activities due to adverse weather conditions.

The purpose of this report is to define "adverse conditions" that may result in unacceptable dust levels beyond the site boundary. Trigger levels will be identified for these adverse conditions to inform a Trigger Action Response Plan (TARP) for overburden handling activities in critical locations.

1.1 Scope of Work

The following methodology is used to identify adverse conditions:

- Identify critical locations where overburden (OB) handling may result in elevated dust concentrations at or beyond the site boundary.
- Represent each location using two sources to simulate dozer and loading/unloading operations simultaneously occurring in one location. A TSP emission rate of 1,000,000 kg/y has been assumed, with loading and dumping emissions varying with wind speed according to the US EPA AP-42 emissions factor.
- Use a screening level atmospheric dispersion model to predict dust plume behaviour under various meteorological conditions (using site representative data).
- At boundary locations where the highest impacts are predicted, analyse the meteorological conditions that correspond to the highest 1-hour dust concentrations.
- Based on these "adverse" meteorological conditions, determine appropriate trigger values to inform a TARP.

2 METHODOLOGY

2.1 Critical locations

The active OB dump area currently in operation at Werris Creek is located towards the southern end of the site.

A number of selected locations where OB activities occur are shown in **Figure 1** and were determined in consultation with Werris Creek. Dust sources are released from the OB dump at the location shown and the resultant dust concentration predictions are made at each of the numbered boundary locations shown.

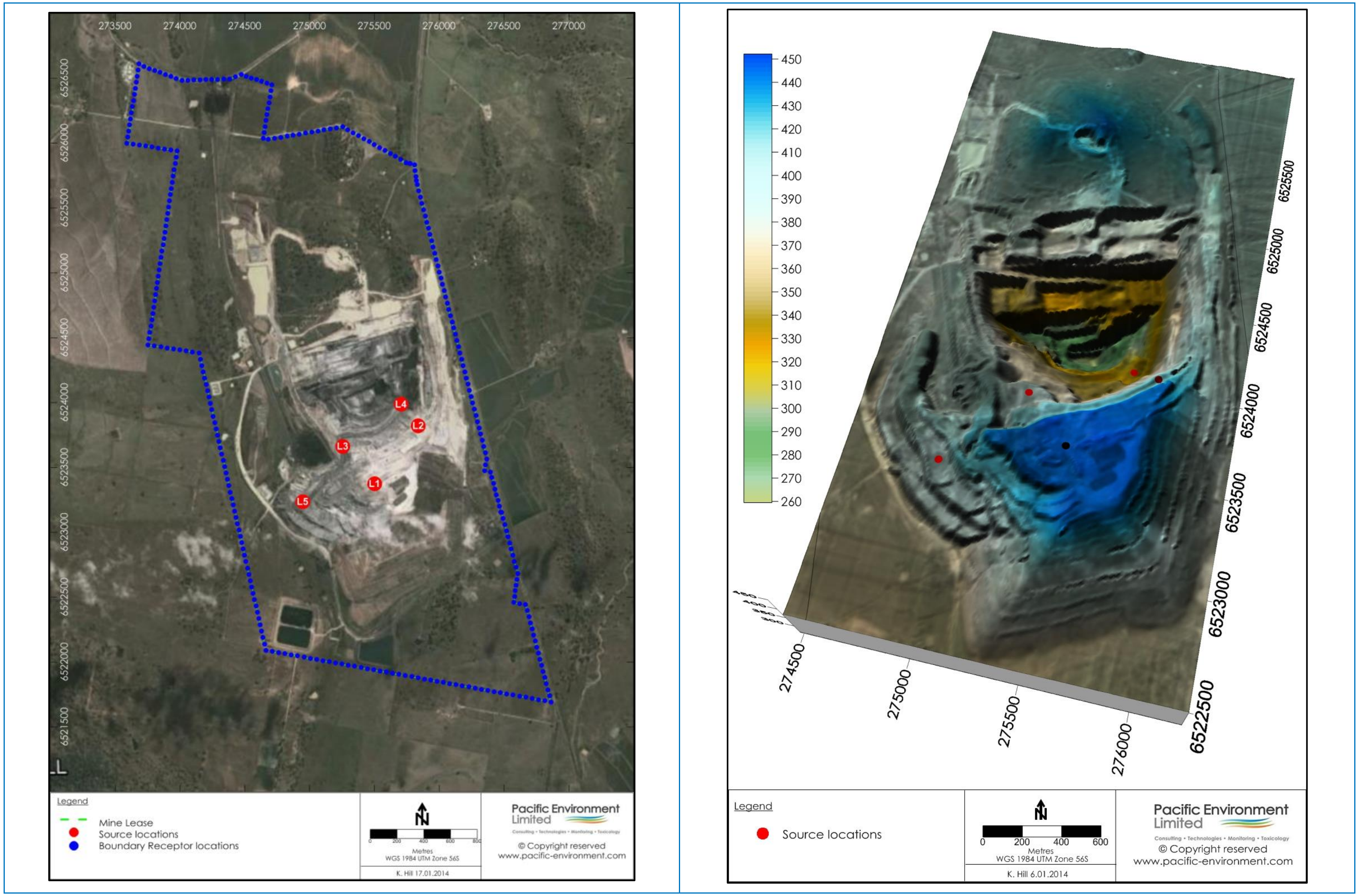

Figure 1: Overburden Activity Source Locations

2.2 Model Inputs

Overburden handling activities are assumed to include loading / unloading of OB, dozers operating on OB and wind erosion from the disturbed surfaces. Each activity is assumed to operate simultaneously and an emission rate for total suspended particulate (TSP) is assumed to be 1,000,000 kg/y from each source.

Adjustments are made to hourly emissions as follows:

- **Loading/dumping OB**. Emissions are assumed to be dependent on wind speed to account for wind dependency in the overburden handling emission factor equation and hourly emissions are adjusted for wind speed as follows (**US EPA, 1987**):

$$Emission_{adjusted} = Emission_{unadjusted} \times \left({Hourly\ Wind\ Speed}/{2.2}\right)^{1.3}$$

- **Dozers**. Emissions are independent of wind speed, as per the dozer emission factor equation.

By varying emissions in this way, "adverse conditions" will not only be influenced by the meteorological conditions under which dust disperses but also include those conditions under which higher emissions are generated at source (i.e. high wind speeds).

A meteorological modelling file was compiled using measured data from the Werris Creek meteorological station, from July 2011 to June 2012. The source and receptors heights took mine terrain into account. The scenarios modelled are as summarised in **Table 1**.

Table 1: Modelling Scenarios

Scenario ID	Terrain Height (m)	Distance from boundary (m)	Comments for selection
L1	445	850	Highest location on emplacement area
L2	423	450	Closest location on level to the eastern boundary
L3	394	920	Closest location on level to the eastern boundary
L4	321	540	Lowest level of emplacement areas
L5	403	520	Close to the western boundary

3 ANALYSIS OF MODELLING RESULTS

The location of the 10 highest TSP boundary predictions for each OB activity location was, as expected, at locations closest to the active OB area. The ten boundary receptors for each OB location (shown in **Figure 2**) were selected for analysis of the meteorological conditions under which these high concentrations occur.

An hourly time series of predicted TSP concentrations at each of these top ten receptors was extracted for each scenario. The time series data were then normalised to enable the different scenarios to be directly compared with each other. The aim of normalising the predicted TSP concentrations across the scenarios was to enable identification of the scenarios (or locations) where the highest concentrations occur. In other words, the focus is on relative concentrations rather than actual concentrations.

Normalisation takes a large number of data sets that are on different scales and consolidates them to a single common scale. In this case, the activities were modelled with the same emissions and therefore the predicted levels at the receptors are not a reflection of actual levels which will be experienced, but rather how the results relate to one another. The concentrations determined from dispersion modelling have been normalised to the maximum predicted TSP concentrations for the parameter investigated (i.e. wind speed or wind direction). This enables all the data from the different scenarios to be compared on a scale of 0 to 1, across all scenarios. The plots therefore represent normalised levels not actual TSP concentrations.

It is important to note that the data were analysed separately based on wind speed and wind direction and therefore the graphs shown for wind speed and wind direction do not relate to each other.

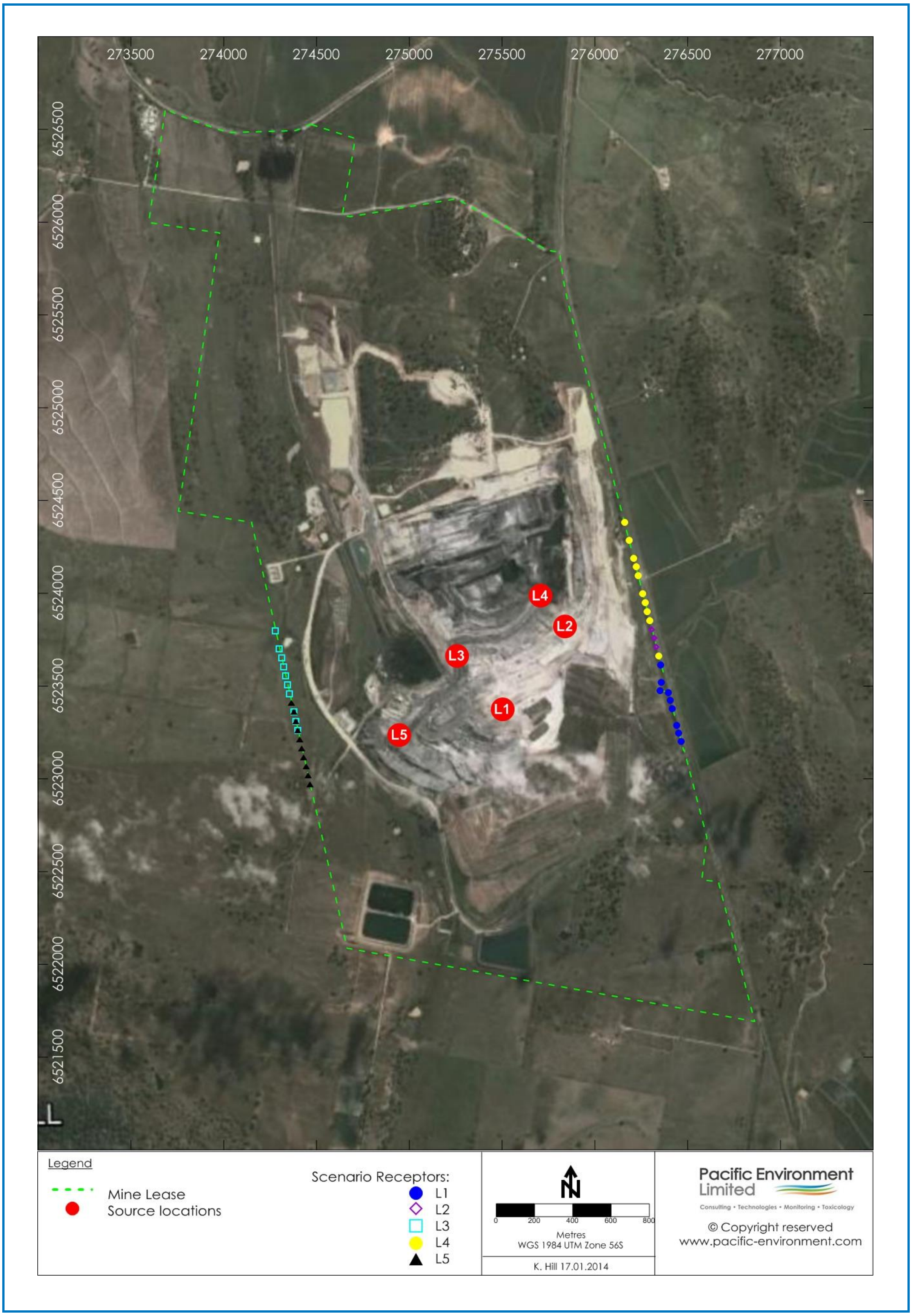

Figure 2: Location of highest boundary predictions for each OB activity location

3.1 Wind speed analysis

The normalised 1-hour TSP concentrations for each hour of the year were averaged into a corresponding wind speed bin (at 0.1 m/s increments) and the results are presented in **Figure 3**, for sources located on the eastern side of the dump – scenarios L1, L2 and L4. **Figure 4** shows the results for the sources located on the western side of the dump – scenarios L3 and L5. Each line shows the hourly prediction (averaged by wind speed) for each of the 10 highest boundary receptors for each scenario, as identified in **Figure 2**. The time series data were then normalised to enable the different scenarios to be directly compared with each other. The aim of normalising the predicted TSP concentrations across the scenarios was to enable identification of the scenarios (or locations) where the highest impacts occur relative to each other.

The analysis shows that the predicted TSP concentrations are relatively unchanged up to wind speeds of approximately 7 – 7.5 m/s. At wind speeds greater than 9 m/s there is a clear increase in predicted TSP concentrations, peaking at approximately 12 m/s.

It is noted that there are some elevated levels experienced at lower wind speeds, around 2 m/s, which are particularly noticeable for location L5, closest to the western boundary. These higher concentrations generally occur at night when the atmosphere is stable and winds are lighter. At these times, it is not the emissions that are the issue, but rather dispersion conditions for those particles already airborne. In other words, emissions are lower for wind speed dependant sources, but dispersion conditions are less favourable. These conditions are therefore not as relevant for management issues and determining trigger levels.

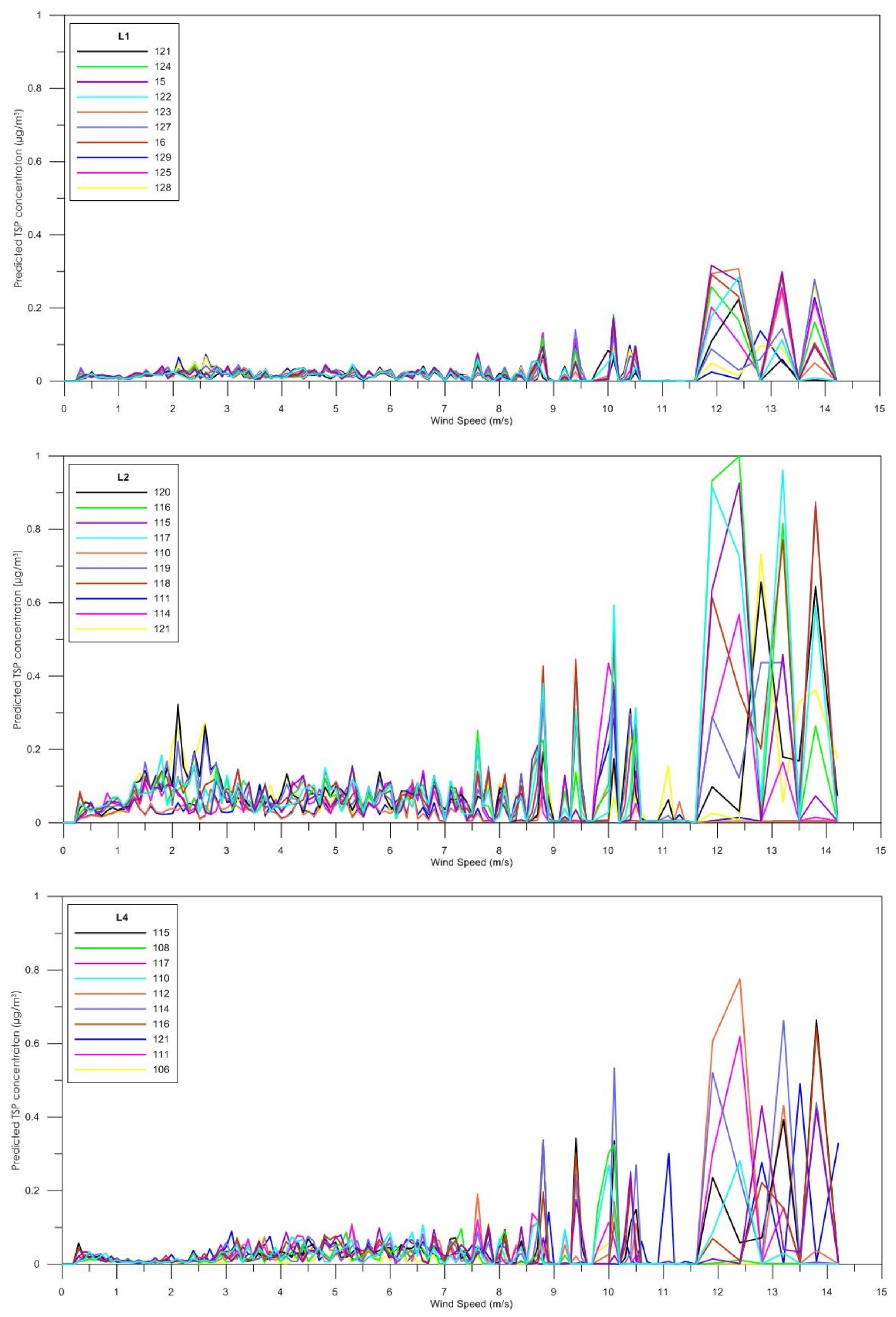

Figure 3: Normalised TSP concentrations by wind speed on eastern side (L1, L2 and L4)

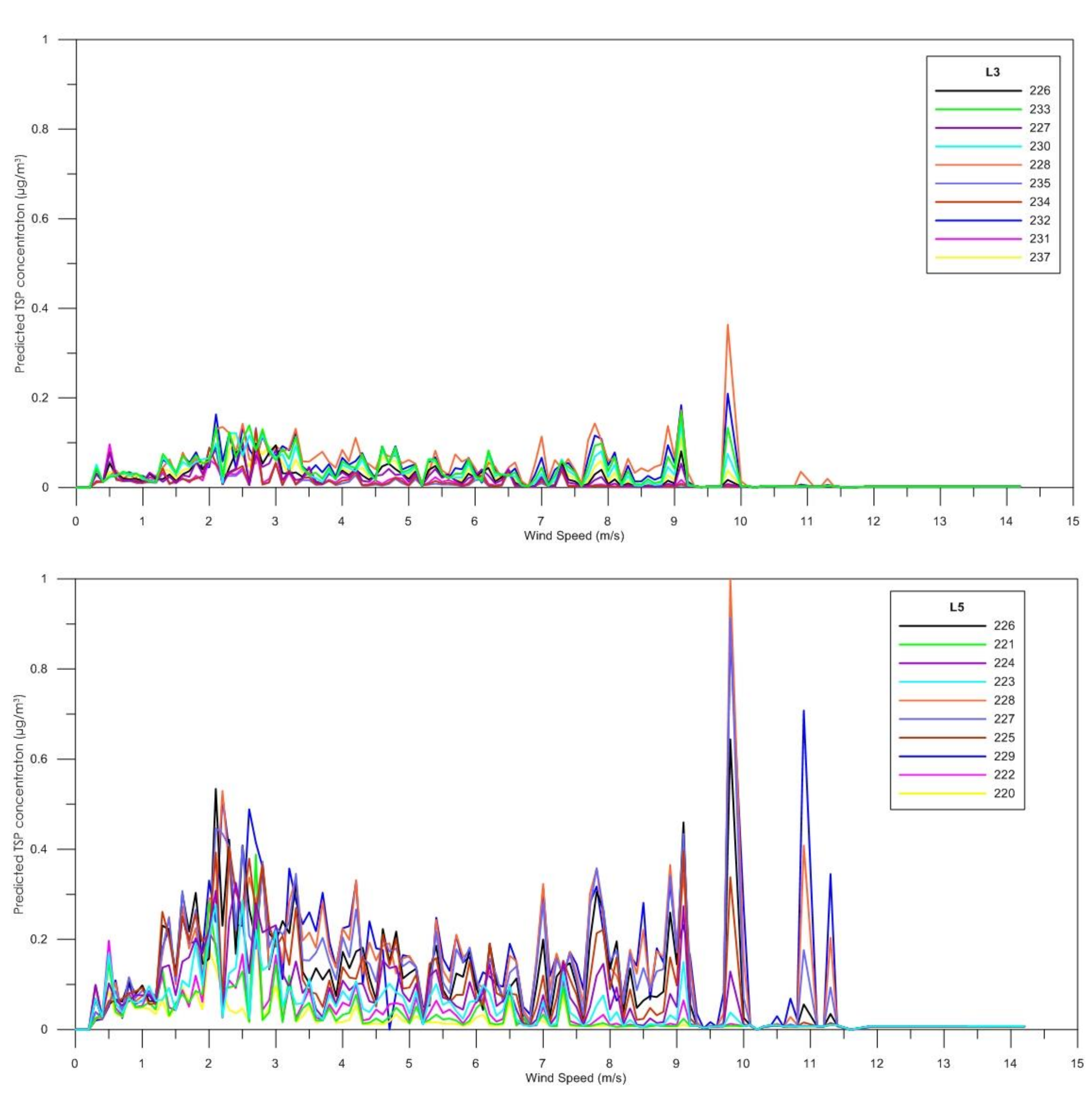

Figure 4: Normalised TSP concentrations by wind speed on western side (L3 and L5)

3.2 Time of day analysis

An analysis of the 1-hour TSP concentrations by hour of the day is presented in **Figure 5**. This analysis has been carried out for L2 and L5, the highest predicted levels for the eastern and western sides of the dump areas, respectively. A clear pattern is evident with higher concentrations at the boundaries during night-time conditions.

Hour of the day can be used as a surrogate for atmospheric stability, an indicator of turbulence or dispersive capacity. A descriptor of turbulence, known as Monin-Obukhov length (L), can be interpolated from the modelling files and used to describe whether conditions are unstable (enhanced dust dispersion) or stable (dust dispersion is suppressed). The inverse of Monin-Obukhov length (1/L) is plotted below the time of day analysis, showing highest concentration during stable conditions (when Monin-Obukhov length is positive).

What is evident from the time of day analysis is that the normalised TSP concentrations are significantly lower (< 0.5 as shown in **Figure 5**) relative to those presented for the wind speed analysis (up to 1, as shown in **Figure 3** and **Figure 4**). This means that although boundary concentrations increase during stable atmospheric conditions, they would not necessarily be considered "adverse" based on the relatively low normalised dust concentration.

It should be noted when making these comparisons that these TSP concentrations are not actual values but rather those which have been normalised so as to be compared to each other (see discussion regarding normalisation in **Section 3**).

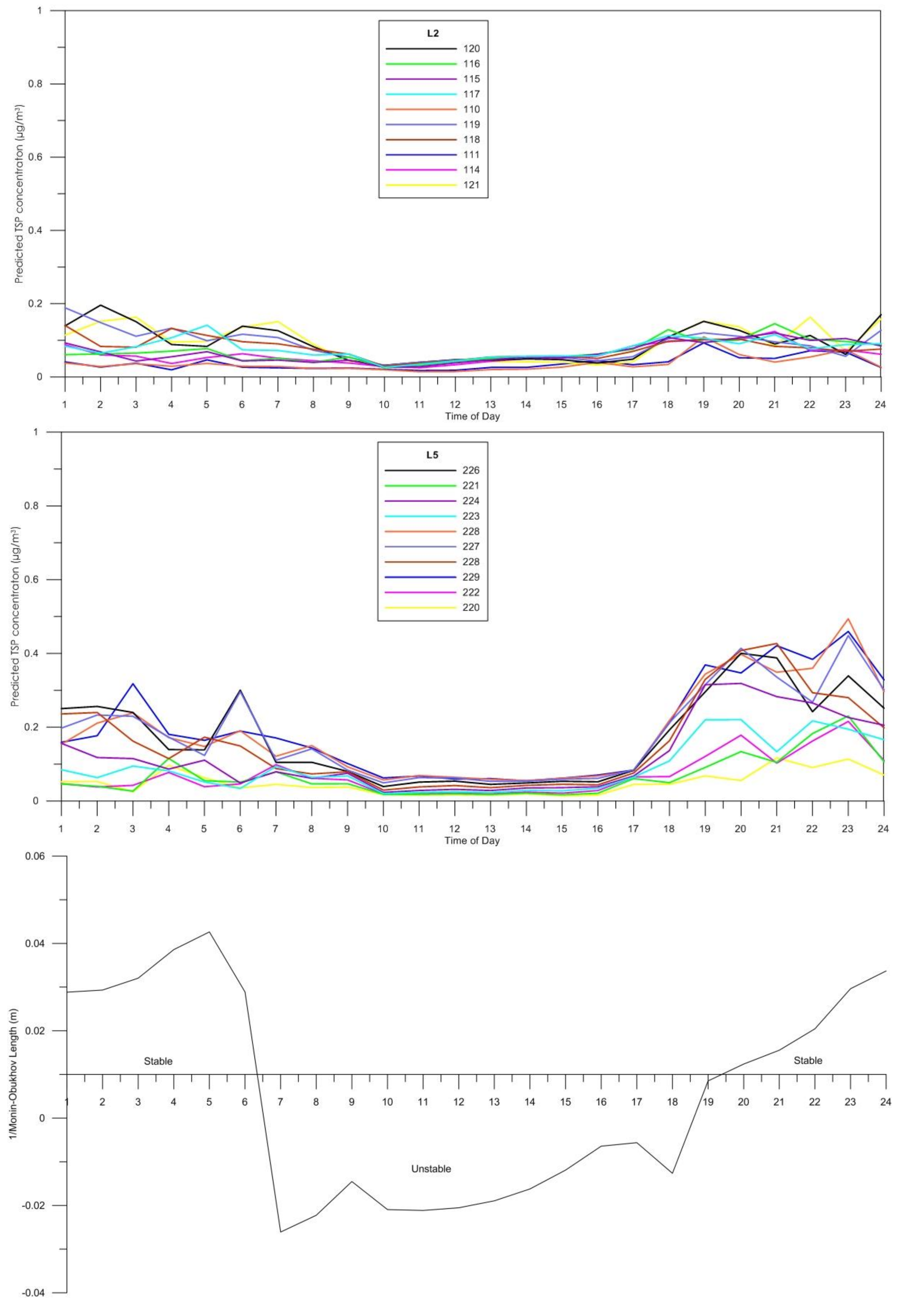

Figure 5: Normalised TSP concentrations and Monin-Obukhov length by hour of the day (L2 and L5)

3.3 Wind direction analysis

Normalised TSP concentrations for scenarios L1, L2 and L4 are plotted against wind direction for the same top 10 boundary receptors discussed previously (**Figure 6**). The pollution rose shows the wind directions under which highest TSP concentrations at the boundary locations occur, which as expected are when winds blow from the west. The highest levels are predicted for scenario L4 with winds from the western quadrant, because the source is the closest to the boundary.

Results for sources located on the western side of the dump (L3 and L5) are shown in **Figure 7** and show the highest levels are predicted on the western boundary when winds are from the eastern quadrant. This is not unexpected given the close proximity of the dump area to that western boundary.

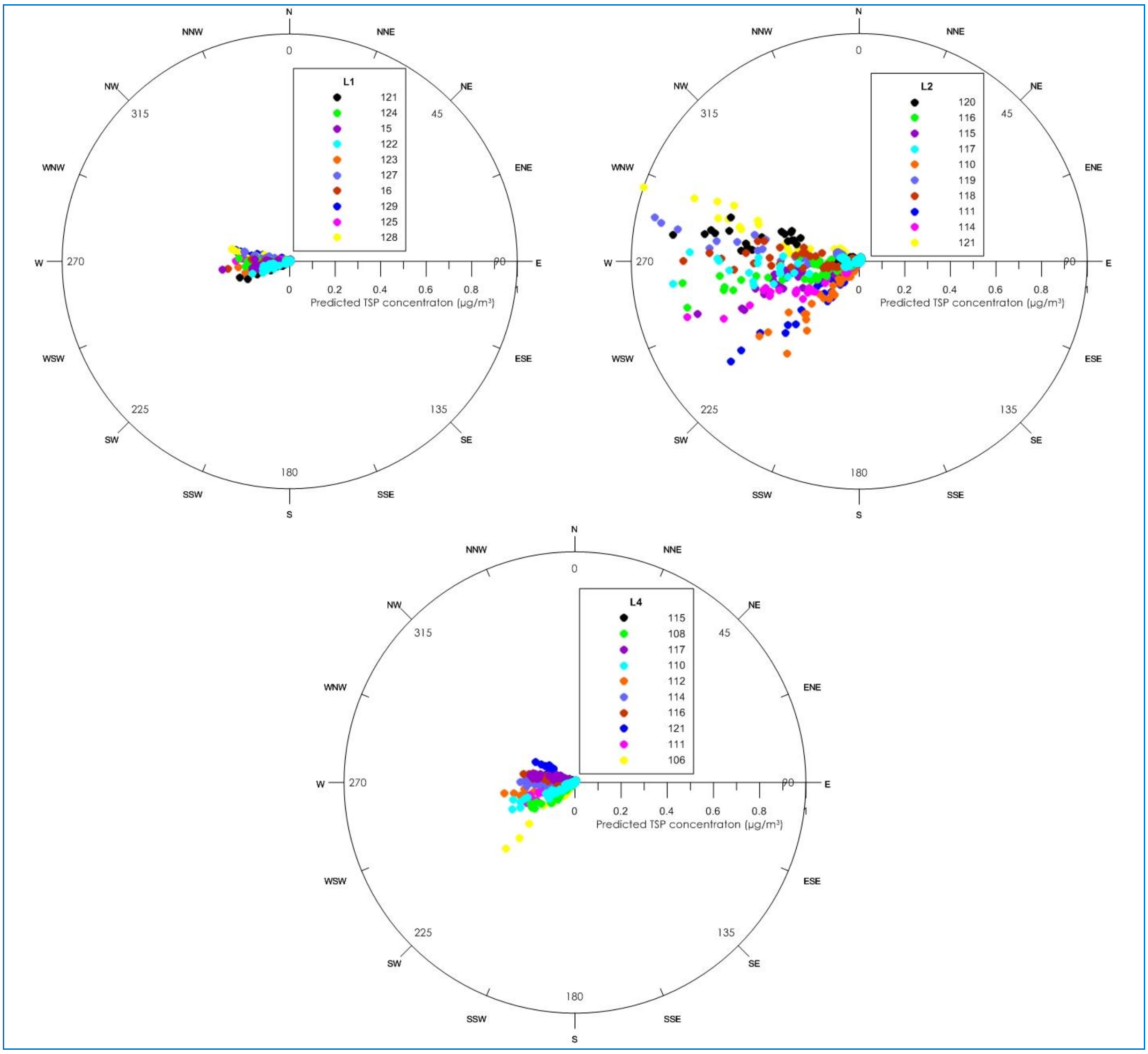

Figure 6: Normalised TSP concentrations with wind direction (L1, L2 and L4)

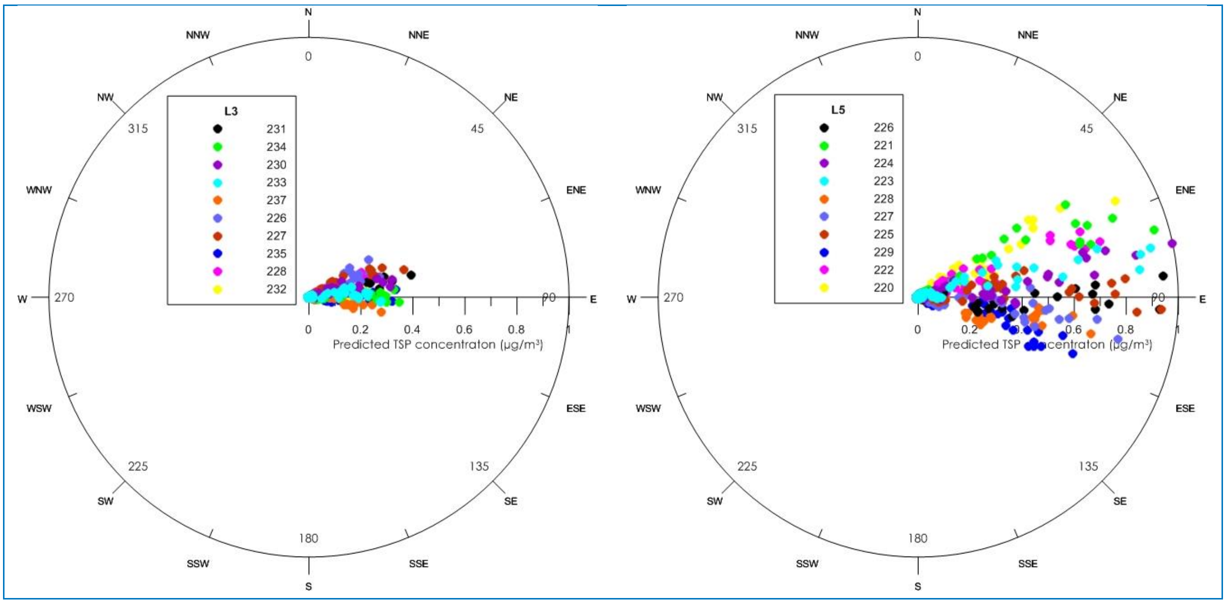

Figure 7: Normalised TSP concentrations with wind direction (L3 and L5)

4 DEVELOPMENT OF TRIGGER LEVELS

Based on the analysis presented above, adverse conditions for unacceptable dust levels beyond the site boundary are identified as wind speeds greater than 7 m/s. This is the case for both the sides of the OB dump area.

The pollution roses for the overburden area (refer to **Figure 6** and **Figure 7**) identify the wind directions where highest levels may occur are from the western quadrant (approximately 225° to 292.5°) for sources in the east (L1, L2 and L5) and the eastern quadrant (approximately 45° to 112.5°) for sources in the west (L3 and L5).

The following trigger levels are therefore broadly defined for the Werris Creek TARP:

- Investigation Level – wind speed ≥ 7 m/s
- Action Level – wind speed ≥ 9 m/s

Given the orientation of the site and the relevant dumping locations, it is practical to further refine the trigger levels depending on which OB area is operational. That is, depending on the wind speed and direction, it may be appropriate to operate in some areas, but not others. **Table 2** presents a breakdown of potential actions at individual locations for the above trigger levels.

The term 'Check for visible dust', as noted in the table, indicates that staff should carry out a visual inspection of the active overburden dump areas and determine whether or not dust is excessive at the source and being transported towards the boundary. If so, then the source should be mitigated immediately and activity ceased. The table indicates that this level of investigation should suffice for all wind directions where wind speeds are between 7 m/s and 9 m/s and above 9 m/s for winds from the northern and southern quadrants. At the In Pit dumps, this should also be sufficient for all wind speeds and all wind directions. There will however be times under these conditions where wind speeds are sufficiently high to warrant cessation of all activity once the visual inspection has been carried out.

For the Out of Pit dumps where they are close to the boundary (L2 and L5) and elevated (L1), the action required for the 9 m/s trigger level will be to stop, as shown in **Table 2**.

Table 2: Action levels at each location

<table>
<tr><th rowspan="2">Dump locations (Scenario ID)</th><th>≥ 7 and < 9 m/s</th><th colspan="4">Wind speeds greater than 9 m/s from each quadrant</th></tr>
<tr><th>All wind directions</th><th>Eastern quadrant (45° - 135°)</th><th>Western quadrant (225° - 315°)</th><th>Northern quadrant (315° - 45°)</th><th>Southern quadrant (135° - 225°)</th></tr>
<tr><td>Top Centre (L1)</td><td rowspan="3">Check for visible dust</td><td>Stop</td><td>Stop</td><td>Stop</td><td>Stop</td></tr>
<tr><td>Out of Pit East (L2)</td><td>Check for visible dust</td><td>Stop</td><td>Stop</td><td>Stop</td></tr>
<tr><td>Out of Pit West (L5)</td><td>Stop</td><td>Check for visible dust</td><td>Stop</td><td>Stop</td></tr>
<tr><td>In Pit West (L3)</td><td rowspan="2" colspan="5">Check for visible dust</td></tr>
<tr><td>In Pit East (L4)</td></tr>
</table>

4.1 Analysis of the frequency of "adverse conditions"

The percentage occurrence of adverse conditions at Werris Creek can be inferred from the information presented in **Table 3**, based on a review of all available meteorological data from 2009 to May 2012. The frequency distribution of wind speeds are presented in **Figure 8** showing how often the wind speed triggers may be reached. The wind roses show the occurrence of wind speeds for different directions (**Figure 9**). These plots and the data presented in **Table 3** show that while the higher wind speeds are relatively infrequent, they are from the southeastern quadrant for approximately half the time. In other words, when the wind speed is such to activate a trigger the wind will often be from the southeastern quadrant.

From the data presented in **Table 3** it can be seen that winds above 7 m/s (in any direction) occur approximately 5% of the time and for less than 1% of the time above 9 m/s. During this 1% of the time, activity may still be able to occur at the In Pit dumps, depending whether or not dust is visible.

Table 3: Frequency distribution of wind speeds and direction

Wind Direction		Wind Speed (m/s)		
		≤ 7	> 7 and ≤ 9	> 9
>=0 – 22.5	N	5.4%	0.1%	0.0%
>22.5 – 45	NNE	3.1%	0.1%	0.0%
>45 – 67.5	NE	2.7%	0.1%	0.0%
>67.5 – 90	ENE	3.2%	0.1%	0.0%
>90 – 112.5	E	5.1%	0.3%	0.1%
>112.5 – 135	ESE	8.5%	0.6%	0.1%
>135 – 157.5	SE	11.0%	0.6%	0.1%
>157.5 – 180	SSE	9.5%	0.4%	0.1%
>180 – 202.5	S	6.4%	0.2%	0.0%
>202.5 – 225	SSW	4.0%	0.1%	0.0%
>225 – 247.5	SW	3.7%	0.1%	0.0%
>247.5 – 270	WSW	4.6%	0.2%	0.1%
>270 – 292.5	W	6.6%	0.3%	0.1%
>292.5 – 315	WNW	8.4%	0.3%	0.1%
>315 – 337.5	NW	7.9%	0.1%	0.1%
>337.5 – 360	NNW	5.1%	0.1%	0.0%
Total	**All directions**	**95.2%**	**3.9%**	**0.9%**

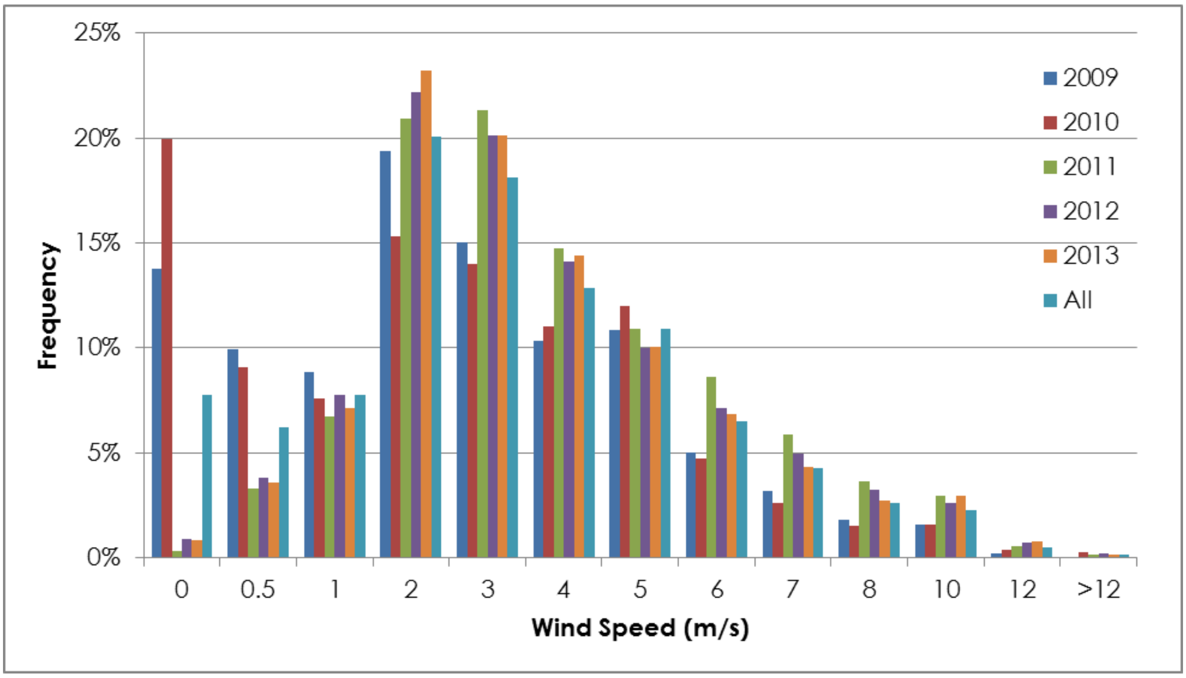

Figure 8: Frequency of wind speeds and Werris Creek

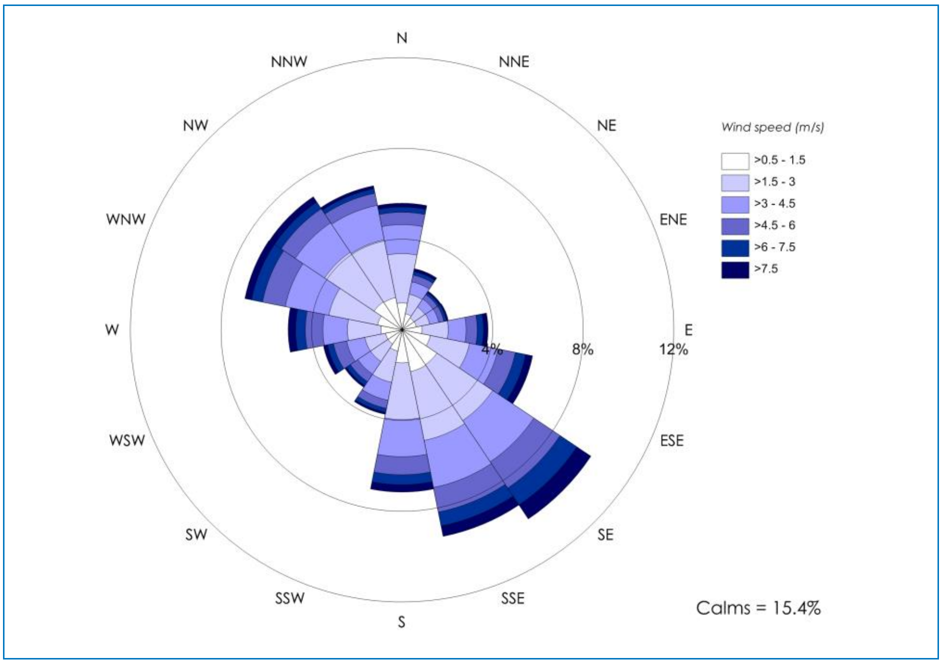

Figure 9: Windrose for all data from 2009 to 2013 at Werris Creek

5 REFERENCES

US EPA (1985). Compilation of Air Pollutant Emission Factors, AP-42, Fourth Edition United States Environmental Protection Agency, Office of Air and Radiation Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.