Advice Note

Date: Thursday, 14 April 2022

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To:	Ethos Urban	From:	Northstar Air Quality

Name:	**Kings Park Expansion – Air Quality**
Reference:	**22.1097.FM2V1**
Status:	**Final**

Please find overleaf the supporting information to the Ethos Urban consolidated responses to NSW EPA comments (ref: DOC21/1142757-14) regarding the Kings Park Expansion – Air Quality assessment report (Northstar Air Quality, ref: 20.1074.FR4V1, dated: 17 December 2021).

If you have any queries, please let me know.

For and on behalf of

Northstar Air Quality Pty Ltd

Gary Graham

Director

Reviewed by: Martin Doyle

1. EMISSION ESTIMATION (INCLUDING ADDITIONAL CONTROLS)

The emissions inventory remains unchanged from that presented in the AQIA document (Northstar, Dec 2021), with the exception of adopting additional particulate matter emission factors commensurate with the identified additional controls derived from the Best Management Practice Dust Control assessment as documented in Section 7.3.2 and Appendix E of 20.1074.FR4V1, being:

- **RH1**: sweeping of on-site sealed road haulage routes;
- **C1**: enclosure of transfer points on the conveyors;
- **HT1**: water sprays on handling and transfer points;
- **HT2**: minimisation of material drop point heights on handling and transfer points.

The revised emissions inventory adopting these controls is presented in the following tables.

All other factors and assumptions remain unchanged from the previous emissions inventory.

1.1. Controls (Existing and Additional)

1.1.1. Controls (Existing)

The previous AQIA (Northstar, Dec 2021), Section 5.2 and Appendix C presents a comprehensive summary of the emission estimation process adopted within that assessment report. On page 67-68 and on page 118 of that report, the controls assumed and the corresponding control factors applied are documented.

The control factor (CF) assumed for material handling points MH1-MH14, truck dumping points TRKD01 and TRK02 and transfer points TP 01-08 have been assumed to be controlled by 70 % through enclosure. Conveyor points CV1-CV33 are considered to be controlled by water sprays (50 %) and by enclosure (70 %) (50 % & 70% = 85 %).

An emission reduction of 30 % has been applied for the watering of paved roads as per (USEPA, 2011) which indicates that an hourly water flushing at a rate of 0.48 gal·yd^{-2} (equivalent to 2.2 L·m^{-2}·hr^{-1}) could result in emissions reductions of between 30 % and 70 %. For the purposes of this assessment, the lower (conservative) reduction factor of 30 % has been adopted.

1.1.2. Controls (Additional)

The following additional controls were identified through the Best Management Practice (BMP) Dust Control assessment, which is presented in Section 7.3.2 of (Northstar, Dec 2021):

- **RH1**: sweeping of on-site sealed road haulage routes
- **C1**: enclosure of transfer points on the conveyors[(a)]
- **HT1**: water sprays on handling and transfer points
- **HT2**: minimisation of material drop point heights on handling and transfer points[(b)]

Note (a) It is noted that Sell & Parker will need to maintain some form of access for inspection cameras and ongoing fire and operational maintenance.
(b) It is noted that Sell & Parker will minimise drop heights, whilst remaining consistent with safety requirements.

These additional controls have been judiciously applied to the relevant emission sources. RH1 has been applied to road vehicle sources (see Section 1.3.3, Table 7 and Table 8), and identified controls C1, HT1 and HT2 have been applied to the relevant volume sources which are presented in Section 1.3.1, Table 3 and Table 4.

As stated in 20.1074.FR4V1, the following control efficiencies have been assumed:

- **RH1**: 50 % control efficiency on on-site road vehicle emissions by road sweeping
- **C1**: 70 % control efficiency on conveyor transfer points by enclosure
- **HT1**: 50 % control efficiency on conveyor transfer points by water sprays
- **HT2**: 30 % control efficiency on material drop point heights by managing drop heights. This factor has been only applied to engineered drop points, as applying drop point height control from vehicles may not be realistically achievable, given they may be performed by third-party operators and may be hard to implement holistically. That is not to say such controls are not achievable, but to provide a robust assessment those controls have not been applied in this assessment.

1.2. Point Source Emission Estimates

Presented in Table 1 are the estimated emission rates associated with point sources at the site.

Table 1 Emission estimates – point source emissions

Source	Units	Oxycutter[1]	Hammermill[2]
Emission source	value	C1	WSS01
Easting	m	306 613	306 567
Northing	m	6 263 608	6 263 613
Elevation	m	44.73	44.21
Start time	hh:mm	09:00	06:00
End time	hh:mm	15:00	21:00
Stack height	m AGL	1	16.7
Diameter at point of discharge	m ID	0.05	0.440
Emission temperature	°C	31	39
Emission velocity (discharge)	$m \cdot s^{-1}$	14.0	50.0
Gas flow	$Nm^3 \cdot s^{-1}$	0.1	6.6
ER (odour)	$OU \cdot m^3 \cdot s^{-1}$	2.50E+02	1.216E+04
ER (TSP)	$g \cdot s^{-1}$	2.17E-02	7.50E-02
ER (PM_{10})	$g \cdot s^{-1}$	-	5.33E-02
ER ($PM_{2.5}$)	$g \cdot s^{-1}$	-	3.33E-02
ER (NO_X)	$g \cdot s^{-1}$	5.50E-02	3.33E-02
ER (Ag)	$g \cdot s^{-1}$	1.500E-07	-
ER (Al)	$g \cdot s^{-1}$	2.833E-05	-
ER (As)	$g \cdot s^{-1}$	3.333E-06	1.667E-05
ER (Ba)	$g \cdot s^{-1}$	5.000E-05	-
ER (Be)	$g \cdot s^{-1}$	1.333E-07	6.667E-06
ER (Ca)	$g \cdot s^{-1}$	5.000E-05	-
ER (Cd)	$g \cdot s^{-1}$	1.167E-07	5.000E-06
ER (Co)	$g \cdot s^{-1}$	3.333E-07	6.667E-06
ER (CO II)	$g \cdot s^{-1}$	6.333E-06	-
ER (Cr)	$g \cdot s^{-1}$	1.267E-06	1.833E-05
ER (CrVI)	$g \cdot s^{-1}$	-	3.333E-05
ER (Cu)	$g \cdot s^{-1}$	5.167E-06	2.000E-05
ER (Fe)	$g \cdot s^{-1}$	5.500E-03	2.333E-04
ER (FE II,III)	$g \cdot s^{-1}$	2.333E-02	-
ER (Hg)	$g \cdot s^{-1}$	8.333E-08	2.167E-05
ER (K)	$g \cdot s^{-1}$	3.333E-05	-
ER (Li)	$g \cdot s^{-1}$	1.500E-07	-
ER (Mg)	$g \cdot s^{-1}$	3.333E-05	-
ER (Mg IV)	$g \cdot s^{-1}$	1.467E-04	-
ER (Mn)	$g \cdot s^{-1}$	9.167E-05	2.000E-05
ER (Mo)	$g \cdot s^{-1}$	8.333E-07	-

Source	Units	Oxycutter(1)	Hammermill(2)
ER (Na)	$g \cdot s^{-1}$	3.333E-05	-
ER (Ni)	$g \cdot s^{-1}$	1.567E-06	1.667E-05
ER (P)	$g \cdot s^{-1}$	1.517E-05	-
ER (Pb)	$g \cdot s^{-1}$	3.333E-06	2.000E-05
ER (Sb)	$g \cdot s^{-1}$	1.167E-06	5.000E-05
ER (Se)	$g \cdot s^{-1}$	1.167E-06	5.000E-05
ER (Sn)	$g \cdot s^{-1}$	5.333E-07	1.667E-05
ER (Ti)	$g \cdot s^{-1}$	-	1.267E-05
ER (Th)	$g \cdot s^{-1}$	5.000E-07	-
ER (V)	$g \cdot s^{-1}$	-	3.333E-05
ER (W)	$g \cdot s^{-1}$	-	1.167E-05
ER (Zn)	$g \cdot s^{-1}$	1.833E-04	1.500E-03

Note: (1) Source data derived from Ektimo Emission Test Report (Ektimo, Sep 2019) as appended to (ERM, Sep 2019). The tests were performed in duplicate, and the maximum value has been used to quantify the emission rates. See **Appendix F of 20.1074.FR4V1** (Northstar, Dec 2021)

(2) Source data derived from Ektimo Emission Test Reports (Ektimo, May 2017), (Ektimo, Sep 2018), (Ektimo, Oct 2019), (Ektimo, Sep 2020). The maximum measured emission rate from all test reports has been adopted in this supplementary AQIA. Emission conditions, including flow rates, temperatures etc., were derived from (Ektimo, Sep 2020). See **Appendix F of 20.1074.FR4V1** (Northstar, Dec 2021) for the complete monitoring reports.

To provide additional clarification on the adoption of the maximum measured emission rates for the Hammermill, a summary of those emission rates derived from the NATA accredited emissions monitoring reports is presented in Table 2, as reproduced from the AQIA (Northstar, Dec 2021).

The highlighted yellow cells represent the adopted data points, noting that these data represent the maximum values for each parameter.

Table 2 Hammermill – measured emission rates

Parameter	Units	18-Jun-14	26-May-17	27-Sep-18	11-Oct-19	4-Sep-20	26-May-21	Adopted	% $PM_{2.5}$
		N92746	R003396	R006468-1	R008184	R009653	R010794		
Flow	$Nm^3 \cdot s^{-1}$, STP		8.0	6.1	6.2	6.7	6.6		
Flow	$m^3 \cdot s^{-1}$ actual		9.2	7	7.1	7.6	7.6		
Temperature	°C		28	31	36	27	39	39	
Measured velocity	$m \cdot s^{-1}$		25	25	26	27	27		
Diameter at sampling plane	m ID		0.680	0.595	0.595	0.595	0.595		
Diameter at discharge	m ID			0.440	0.440	0.440	0.440		
Velocity at sampling plane	$m \cdot s^{-1}$		25	25	26	27	27		
Velocity at discharge	$m \cdot s^{-1}$			46	47	50	50	50	
ER (TSP)	$g \cdot s^{-1}$		7.500E-02	4.167E-02	2.333E-02	1.667E-02	4.833E-02	7.500E-02	
ER (PM_{10})	$g \cdot s^{-1}$		5.333E-02					5.333E-02	
ER ($PM_{2.5}$)	$g \cdot s^{-1}$		3.333E-02					3.333E-02	
ER (NO_X)	$g \cdot s^{-1}$		3.333E-02	1.667E-02				3.333E-02	
ER (H_2S)	$g \cdot s^{-1}$		5.000E-05	5.000E-05				5.000E-05	
ER (HF)	$g \cdot s^{-1}$			8.333E-05				8.333E-05	
ER (HCl)	$g \cdot s^{-1}$			8.333E-05				8.333E-05	
ER (Cl_2)	$g \cdot s^{-1}$			8.333E-05				8.333E-05	
ER (odour)	$OU \cdot m^3 \cdot s^{-1}$	1.216E+04						1.216E+04	
ER (As)	$g \cdot s^{-1}$		1.167E-05	8.333E-06	1.667E-05	1.667E-05	1.667E-05	1.667E-05	0.050%
ER (Be)	$g \cdot s^{-1}$		6.667E-06			5.000E-06	6.667E-06	6.667E-06	0.020%
ER (Cd)	$g \cdot s^{-1}$		3.333E-06	2.833E-06	5.000E-06	5.000E-06	5.000E-06	5.000E-06	0.015%
ER (Co)	$g \cdot s^{-1}$		3.333E-06	3.333E-06	6.667E-06	6.667E-06	6.667E-06	6.667E-06	0.020%

Parameter	Units	18-Jun-14	26-May-17	27-Sep-18	11-Oct-19	4-Sep-20	26-May-21	Adopted	% $PM_{2.5}$
		N92746	R003396	R006468-1	R008184	R009653	R010794		
ER (Cr)	$g \cdot s^{-1}$		4.833E-06	4.167E-06	8.333E-06	1.833E-05	1.300E-05	1.833E-05	0.055%
ER (Cr_{VI})	$g \cdot s^{-1}$		3.333E-05					3.333E-05	0.100%
ER (Cu)	$g \cdot s^{-1}$		2.000E-05					2.000E-05	0.060%
ER (Fe)	$g \cdot s^{-1}$		2.333E-04					2.333E-04	0.700%
ER (Hg)	$g \cdot s^{-1}$		5.500E-06	2.167E-05		6.667E-06	1.667E-05	2.167E-05	0.065%
ER (Mn)	$g \cdot s^{-1}$		8.333E-06	1.000E-05	1.667E-05	2.000E-05	4.167E-05	4.167E-05	0.125%
ER (Ni)	$g \cdot s^{-1}$		6.667E-06	5.000E-06	1.667E-05	1.167E-05	3.333E-05	3.333E-05	0.100%
ER (Pb)	$g \cdot s^{-1}$		8.667E-06	1.083E-05	2.000E-05	2.000E-05	4.667E-05	4.667E-05	0.140%
ER (Sb)	$g \cdot s^{-1}$		3.333E-05	1.667E-05	5.000E-05	5.000E-05	1.333E-04	1.333E-04	0.400%
ER (Se)	$g \cdot s^{-1}$		3.333E-05	1.667E-05	5.000E-05	5.000E-05		5.000E-05	0.150%
ER (Sn)	$g \cdot s^{-1}$		1.167E-05	8.333E-06	1.667E-05	1.667E-05	1.667E-05	1.667E-05	0.050%
ER (Ti)	$g \cdot s^{-1}$		1.267E-05					1.267E-05	0.038%
ER (V)	$g \cdot s^{-1}$		6.667E-06	5.000E-06	1.333E-05	3.333E-05	1.333E-05	3.333E-05	0.100%
ER (W)	$g \cdot s^{-1}$		1.167E-05					1.167E-05	0.035%

1.3. Volume Source Emission Estimates

1.3.1. Material Handling

Emissions for material handling (MH*n*), transfer points (TP*n*) and conveyors (CV*n*) have been estimated using the US EPA batch drop equations. The assumed variables used have been highlighted for clarity.

Sources have been modelled as wind speed dependent volume sources during hours of operation.

The activity rates relevant to each material handling are presented in Table 3 and the corresponding emission estimates are presented in Table 4.

$$ER = EF \times A \times (1 - CF) \times \frac{1000}{3600}$$

$$EF = k \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

where:

ER	=	emission rate ($g \cdot s^{-1}$)
EF	=	emission factor ($kg \cdot t^{-1}$)
A	=	throughput ($t \cdot hr^{-1}$)
CF	=	control factor
k	=	particle size multiplier
		(TSP: 0.74; PM_{10}: 0.35; $PM_{2.5}$: 0.053)
U	=	hourly wind speed ($m \cdot s^{-1}$) (ave 2.48 $m \cdot s^{-1}$)
M	=	moisture content (assumed 2 %)

As discussed in Section 1.1.2, additional controls identified through the BMP assessment have been adopted in this revised assessment. Where these controls have been applied in Table 4 they have been highlighted for clarity. Controls previous applied through the AQIA (Northstar, Dec 2021) are denoted as 'CF'.

1.3.2. Wind Erosion Sources

Emissions for wind erosion sources (i.e. material stockpiles) (WE*n*) have been modelled as wind speed varying volume sources using the NPI Wind Erosion equation. The activity rates relevant to each wind erosion source are presented in Table 5 and the corresponding emission estimates are presented in Table 6.

$$ER_{TSP,hr} = WF_{hr} \times ER_{TSP}$$

$$ER_{PM10,hr} = WF_{hr} \times ER_{PM10}$$

$$ER_{PM2.5,hr} = WF_{hr} \times ER_{PM2.5}$$

$$WF_{hr} = \begin{cases} 0 & U \leq 3.1 \\ \dfrac{(U^* - U_t^*)^3}{\sum_{hr=1}^{8760} (U^*{}_{hr} - U_t^*)^3} & U > 3.1 \end{cases}$$

where:

ER	=	emission rate (g·s^{-1})
WF	=	hourly weighting factor
U	=	hourly wind speed (m·s^{-1}) (ave 2.48 m·s^{-1})
U^*	=	threshold friction velocity (assumed 0.11U)
U^*_t	=	threshold friction vel. (m·s^{-1}) for 3.1 m·s^{-1}

1.3.3. Paved Roads at Industrial Sites

Wheel generated dust emissions have been modelled for all site vehicles using the US EPA equation. The activity rates relevant to each road source are presented in Table 7 and the corresponding emission estimates are presented in Table 8.

$$E = k(sL)^{0.91} \times (W)^{1.02}$$

where:

E = particulate emission factor

k = particle size multiplier

sL = road silt loading (9.7 g·m^{-2})

W = average weight (15 t) of the vehicles

As discussed in Section 1.1.2, additional controls identified through the BMP assessment have been adopted in this revised assessment. Where these controls have been applied in Table 8 they have been highlighted for clarity. Controls previous applied through the AQIA (Northstar, Dec 2021) are denoted as 'CF'.

Table 3 Emission estimate – volume source emissions – peak activity rates

Source	Co-ordinates		Description	Source Type	Emission	Time		Source Group	Peak Activity Rates		
	mE	mS				Start	Stop		$t \cdot day^{-1}$	$hr \cdot day^{-1}$	$t \cdot hr^{-1}$
MH01	306607	6263635	Non-ferrous metal transferred to the non-ferrous processing building	volume	Constant	6am	9pm	TRANS	150	15	10.0
MH02	306519	6263572	Transfer of raw material directly to the inspected stockpile of scrap metal (bypass pre-shredder)	volume	Constant	6am	9pm	TRANS	1500	15	100.0
MH03	306503	6263664	Transfer of raw material directly to the inspected stockpile of scrap metal (bypass pre-shredder)	volume	Constant	6am	9pm	TRANS	1500	15	100.0
MH04	306509	6263576	Transfer of raw material from stockpile to pre-shredder	volume	Constant	6am	9pm	TRANS	600	15	40.0
MH05	306522	6263569	Transfer of raw material from stockpile to pre-shredder	volume	Constant	6am	9pm	TRANS	600	15	40.0
MH06	306523	6263581	Transfer of pre-shredder output to a truck to inspected stockpile of scrap metal close to the conveyor into the hammer mill	volume	Constant	6am	9pm	TRANS	600	15	40.0
MH07	306503	6263664	Transfer of pre-shredder output to a truck to inspected stockpile of ap metal close to the conveyor into the hammer mill	volume	Constant	6am	9pm	TRANS	600	15	40.0
MH08	306503	6263664	Transfer of the inspected stockpile of scrap metal close to the conveyor onto the hammer mill conveyor	volume	Constant	6am	9pm	TRANS	2100	15	140.0
MH09	306483	6263652	Transfer of the inspected stockpile of scrap metal close to the conveyor onto the hammer mill conveyor	volume	Constant	6am	9pm	TRANS	2100	15	140.0
MH10	306503	6263664	Ferrous metals are collected from the stockpile by FEL and loaded into trucks	volume	Constant	6am	9pm	TRANS	1050	15	70.0
MH11	306533	6263680	Ferrous metals are collected from the stockpile by FEL and loaded into trucks	volume	Constant	6am	9pm	TRANS	1050	15	70.0

Source	Co-ordinates		Description	Source Type	Emission	Time		Source Group	Peak Activity Rates		
	mE	mS				Start	Stop		$t \cdot day^{-1}$	$hr \cdot day^{-1}$	$t \cdot hr^{-1}$
MH12	306633	6263573	Heavy ferrous pick up	volume	Constant	6am	9pm	TRANS	384	15	25.6
MH13	306561	6263643	Non ferrous material collected and loaded into trucks	volume	Constant	6am	9pm	TRANS	150	15	10.0
MH14	306603	6263616	Heavy ferrous drop point	volume	Constant	6am	9pm	TRANS	384	15	25.6
TP01	306525	6263577	Pre-shredder drop point	volume	Constant	6am	9pm	TRANS	600	15	40.0
TP02	306517	6263691	The cleaned fragmented material (on a conveyor C1) passes under a drum magnet, where ferrous metals are dropped onto the picking conveyor (C2)	volume	Constant	6am	9pm	CONV	1610	15	107.3
TP03	306529	6263701	Ferrous metals transferred from C2, where operators remove remaining non-ferrous materials to C3	volume	Constant	6am	9pm	CONV	1610	15	107.3
TP04	306541	6263711	Ferrous metals are conveyed to the product stockpile	volume	Constant	6am	9pm	CONV	1550	15	103.4
TP05	306512	6263687	Non-ferrous materials drop beneath the drum magnet to a conveyor (C4) that runs perpendicular to the ferrous product	volume	Constant	6am	9pm	CONV	79	15	5.2
TP06	306494	6263732	Transfer point at conveyor bend 1	volume	Constant	6am	9pm	CONV	471	15	31.4
TP07	306563	6263721	Transfer point at conveyor bend 2	volume	Constant	6am	9pm	CONV	471	15	31.4
TP08	306551	6263643	Transfer point at conveyor bend 3	volume	Constant	6am	9pm	CONV	471	15	31.4
CV01	306484	6263660	Material from the stockpiles is conveyed into the hammer mill	volume	Constant	6am	9pm	CONV	1800	15	120.0
CV02	306486	6263672	Material from the stockpiles is conveyed into the hammer mill	volume	Constant	6am	9pm	CONV	1800	15	120.0
CV03	306489	6263687	Material from the stockpiles is conveyed into the hammer mill	volume	Constant	6am	9pm	CONV	1800	15	120.0

Source	Co-ordinates		Description	Source Type	Emission	Time		Source Group	Peak Activity Rates		
	mE	mS				Start	Stop		$t \cdot day^{-1}$	$hr \cdot day^{-1}$	$t \cdot hr^{-1}$
CV04	306489	6263694	Material from the hammer mill is carried upward by an incline conveyor and dropped into a chute	volume	Constant	6am	9pm	CONV	1800	15	120.0
CV05	306513	6263691	The cleaned fragmented material from the cascade chute passes under the drum magnet and ferrous metals are removed	volume	Constant	6am	9pm	CONV	1354	15	90.3
CV06	306520	6263693	Operators remove remaining non ferrous materials	volume	Constant	6am	9pm	TRANS	1354	15	90.3
CV07	306527	6263699	Operators remove remaining non ferrous materials	volume	Constant	6am	9pm	TRANS	1354	15	90.3
CV08	306534	6263704	Ferrous materials are taken and dropped onto a conveyor, which are conveyed to the product stockpile	volume	Constant	6am	9pm	CONV	1354	15	90.3
CV09	306538	6263708	Ferrous materials are taken and dropped onto a conveyor, which are conveyed to the product stockpile	volume	Constant	6am	9pm	CONV	1354	15	90.3
CV10	306514	6263695	Non-ferrous materials are dropped onto a conveyor, which transports material to the conveyor before the non-ferrous processing building	volume	Constant	6am	9pm	CONV	69	15	4.6
CV11	306515	6263702	Non-ferrous materials are dropped onto a conveyor, which transports material to the conveyor before the non-ferrous processing building	volume	Constant	6am	9pm	CONV	69	15	4.6
CV12	306516	6263711	Conveys non-ferrous material into the non-ferrous recovery plant (3/3)	volume	Constant	6am	9pm	CONV	69	15	4.6
CV13	306491	6263710	Floc product is transferred onto conveyor	volume	Constant	6am	9pm	CONV	377	15	25.1
CV14	306492	6263718	Floc product is transferred onto conveyor	volume	Constant	6am	9pm	CONV	377	15	25.1
CV15	306493	6263727	Floc product is transferred onto conveyor	volume	Constant	6am	9pm	CONV	377	15	25.1

Source	Co-ordinates		Description	Source Type	Emission	Time		Source Group	Peak Activity Rates		
	mE	mS				Start	Stop		$t \cdot day^{-1}$	$hr \cdot day^{-1}$	$t \cdot hr^{-1}$
CV16	306503	6263732	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV17	306512	6263731	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV18	306522	6263729	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV19	306533	6263727	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV20	306542	6263726	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV21	306551	6263725	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV22	306558	6263724	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV23	306558	6263713	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV24	306556	6263703	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV25	306555	6263693	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV26	306553	6263683	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4

Source	Co-ordinates		Description	Source Type	Emission	Time		Source Group	Peak Activity Rates		
	mE	mS				Start	Stop		$t \cdot day^{-1}$	$hr \cdot day^{-1}$	$t \cdot hr^{-1}$
CV27	306552	6263674	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV28	306551	6263663	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV29	306550	6263653	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV30	306551	6263643	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV31	306557	6263635	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV32	306562	6263625	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
CV33	306567	6263617	Conveyor transports floc product to the post shredder processing building	volume	Constant	6am	9pm	CONV	411	15	27.4
TRKD01	306502	6263580	Truck dumping at raw material delivery	volume	Constant	6am	9pm	TRANS	2634	15	175.6
TRKD02	306503	6263664	Truck carries pre-shredder output to the inspected stockpile of scrap metal close to the conveyor into the hammer mill	volume	Constant	6am	9pm	TRANS	600	15	40

Note: source group please refer to Appendix E of 20.1074.FR4V1 (Northstar, Dec 2021)

Table 4 Emission estimate – volume source emissions – peak emission rates

Source ID	Emission Factor (AP42 batch drop)			Emission Rate (Uncontrolled) (ERu)			Control Factors				Emission Rate (Controlled) (ERc)		
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	Existing	Additional			TSP	PM_{10}	$PM_{2.5}$
	$kg \cdot t^{-1}$	$kg \cdot t^{-1}$	$kg \cdot t^{-1}$	$g \cdot s^{-1}$	$g \cdot s^{-1}$	$g \cdot s^{-1}$	CF %	C1 %	HT1 %	HT2 %	$g \cdot s^{-1}$	$g \cdot s^{-1}$	$g \cdot s^{-1}$
MH01	0.0014	0.0007	0.0001	3.843E-03	1.818E-03	2.753E-04	70	0	0	0	1.153E-03	5.453E-04	8.258E-05
MH02	0.0014	0.0007	0.0001	3.843E-02	1.818E-02	2.753E-03	70	0	0	30	8.071E-03	3.817E-03	5.780E-04
MH03	0.0014	0.0007	0.0001	3.843E-02	1.818E-02	2.753E-03	70	0	0	30	8.071E-03	3.817E-03	5.780E-04
MH04	0.0014	0.0007	0.0001	1.537E-02	7.271E-03	1.101E-03	70	0	0	30	3.228E-03	1.527E-03	2.312E-04
MH05	0.0014	0.0007	0.0001	1.537E-02	7.271E-03	1.101E-03	70	0	0	30	3.228E-03	1.527E-03	2.312E-04
MH06	0.0014	0.0007	0.0001	1.537E-02	7.271E-03	1.101E-03	70	0	0	30	3.228E-03	1.527E-03	2.312E-04
MH07	0.0014	0.0007	0.0001	1.537E-02	7.271E-03	1.101E-03	70	0	0	30	3.228E-03	1.527E-03	2.312E-04
MH08	0.0014	0.0007	0.0001	5.380E-02	2.545E-02	3.854E-03	70	0	0	30	1.130E-02	5.344E-03	8.092E-04
MH09	0.0014	0.0007	0.0001	5.380E-02	2.545E-02	3.854E-03	70	0	0	30	1.130E-02	5.344E-03	8.092E-04
MH10	0.0014	0.0007	0.0001	2.690E-02	1.272E-02	1.927E-03	70	0	0	0	8.071E-03	3.817E-03	5.780E-04
MH11	0.0014	0.0007	0.0001	2.690E-02	1.272E-02	1.927E-03	70	0	0	0	8.071E-03	3.817E-03	5.780E-04
MH12	0.0014	0.0007	0.0001	9.838E-03	4.653E-03	7.046E-04	70	0	0	0	2.952E-03	1.396E-03	2.114E-04
MH13	0.0014	0.0007	0.0001	3.843E-03	1.818E-03	2.753E-04	70	0	0	0	1.153E-03	5.453E-04	8.258E-05
MH14	0.0014	0.0007	0.0001	9.838E-03	4.653E-03	7.046E-04	70	0	0	0	2.952E-03	1.396E-03	2.114E-04
TP01	0.0014	0.0007	0.0001	1.537E-02	7.271E-03	1.101E-03	0	70	50	0	2.306E-03	1.091E-03	1.652E-04
TP02	0.0014	0.0007	0.0001	4.125E-02	1.951E-02	2.954E-03	0	70	50	30	4.331E-03	2.049E-03	3.102E-04
TP03	0.0014	0.0007	0.0001	4.125E-02	1.951E-02	2.954E-03	0	70	50	30	4.331E-03	2.049E-03	3.102E-04
TP04	0.0014	0.0007	0.0001	3.972E-02	1.879E-02	2.845E-03	0	70	50	30	4.171E-03	1.973E-03	2.987E-04
TP05	0.0014	0.0007	0.0001	2.011E-03	9.513E-04	1.441E-04	0	70	50	30	2.112E-04	9.989E-05	1.513E-05
TP06	0.0014	0.0007	0.0001	1.207E-02	5.708E-03	8.643E-04	0	70	50	30	1.267E-03	5.993E-04	9.076E-05

Source ID	Emission Factor (AP42 batch drop)			Emission Rate (Uncontrolled) (ERu)			Control Factors				Emission Rate (Controlled) (ERc)		
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	Existing	Additional			TSP	PM_{10}	$PM_{2.5}$
	$kg \cdot t^{-1}$	$kg \cdot t^{-1}$	$kg \cdot t^{-1}$	$g \cdot s^{-1}$	$g \cdot s^{-1}$	$g \cdot s^{-1}$	CF %	C1 %	HT1 %	HT2 %	$g \cdot s^{-1}$	$g \cdot s^{-1}$	$g \cdot s^{-1}$
TP07	0.0014	0.0007	0.0001	1.207E-02	5.708E-03	8.643E-04	0	70	50	30	1.267E-03	5.993E-04	9.076E-05
TP08	0.0014	0.0007	0.0001	1.207E-02	5.708E-03	8.643E-04	0	70	50	30	1.267E-03	5.993E-04	9.076E-05
CV01	0.0014	0.0007	0.0001	1.153E-02	5.453E-03	8.258E-04	85	0	0	0	1.729E-03	8.180E-04	1.239E-04
CV02	0.0014	0.0007	0.0001	1.153E-02	5.453E-03	8.258E-04	85	0	0	0	1.729E-03	8.180E-04	1.239E-04
CV03	0.0014	0.0007	0.0001	1.153E-02	5.453E-03	8.258E-04	85	0	0	0	1.729E-03	8.180E-04	1.239E-04
CV04	0.0014	0.0007	0.0001	1.153E-02	5.453E-03	8.258E-04	85	0	0	0	1.729E-03	8.180E-04	1.239E-04
CV05	0.0014	0.0007	0.0001	6.940E-03	3.282E-03	4.970E-04	85	0	0	0	1.041E-03	4.923E-04	7.455E-05
CV06	0.0014	0.0007	0.0001	6.940E-03	3.282E-03	4.970E-04	85	0	0	0	1.041E-03	4.923E-04	7.455E-05
CV07	0.0014	0.0007	0.0001	6.940E-03	3.282E-03	4.970E-04	85	0	0	0	1.041E-03	4.923E-04	7.455E-05
CV08	0.0014	0.0007	0.0001	6.940E-03	3.282E-03	4.970E-04	85	0	0	0	1.041E-03	4.923E-04	7.455E-05
CV09	0.0014	0.0007	0.0001	6.940E-03	3.282E-03	4.970E-04	85	0	0	0	1.041E-03	4.923E-04	7.455E-05
CV10	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV11	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV12	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV13	0.0014	0.0007	0.0001	3.221E-03	1.523E-03	2.307E-04	85	0	0	0	4.831E-04	2.285E-04	3.460E-05
CV14	0.0014	0.0007	0.0001	3.221E-03	1.523E-03	2.307E-04	85	0	0	0	4.831E-04	2.285E-04	3.460E-05
CV15	0.0014	0.0007	0.0001	3.221E-03	1.523E-03	2.307E-04	85	0	0	0	4.831E-04	2.285E-04	3.460E-05
CV16	0.0014	0.0007	0.0001	1.054E-02	4.986E-03	7.550E-04	85	0	0	0	1.581E-03	7.479E-04	1.132E-04
CV17	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV18	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV19	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06

Source ID	Emission Factor (AP42 batch drop)			Emission Rate (Uncontrolled) (ERu)			Control Factors				Emission Rate (Controlled) (ERc)		
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	Existing	Additional			TSP	PM_{10}	$PM_{2.5}$
	$kg \cdot t^{-1}$	$kg \cdot t^{-1}$	$kg \cdot t^{-1}$	$g \cdot s^{-1}$	$g \cdot s^{-1}$	$g \cdot s^{-1}$	CF %	C1 %	HT1 %	HT2 %	$g \cdot s^{-1}$	$g \cdot s^{-1}$	$g \cdot s^{-1}$
CV20	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV21	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV22	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV23	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV24	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV25	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV26	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV27	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV28	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV29	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV30	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV31	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV32	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
CV33	0.0014	0.0007	0.0001	5.856E-04	2.770E-04	4.194E-05	85	0	0	0	8.784E-05	4.155E-05	6.291E-06
TRKD01	0.0014	0.0007	0.0001	6.749E-02	3.192E-02	4.833E-03	70	0	0	0	2.025E-02	9.576E-03	1.450E-03
TRKD02	0.0014	0.0007	0.0001	1.537E-02	7.271E-03	1.101E-03	70	0	0	0	4.612E-03	2.181E-03	3.303E-04

Table 5 Emission estimate – open area wind erosion sources – peak activity rates

Source ID	Co-ordinates		Description	Emissions	Time		Source Group	Peak Activity Rates	
	mE	mS			Start	Stop		Area	hr·day^{-1}
WE01	306,494	6,263,578	Scrap stockpile	Hourly varying	12am	12am	WE	653 sqm	24
WE02	306,507	6,263,543	Scrap stockpile	Hourly varying	12am	12am	WE	428 sqm	24
WE03	306,631	6,263,571	Post pre-shredder stockpile 1- at pre-shredder	Hourly varying	12am	12am	WE	2100 sqm	24
WE04	306,503	6,263,664	Post pre-shredder stockpile 2- at hammer mill	Hourly varying	12am	12am	WE	2562 sqm	24
WE05	306,542	6,263,709	Ferrous product stockpile.	Hourly varying	12am	12am	WE	303 sqm	24
WE06	306,544	6,263,695	Ferrous product stockpile.	Hourly varying	12am	12am	WE	303 sqm	24

Table 6 Emission estimate – open area wind erosion sources – peak emission rates

The variables used in these estimations are presented in **Appendix C** of 20.1074.FR4V1

Source ID		Emission Factor kg·ha^{-1}·yr^{-1}			Emission Rate kg·yr^{-1}		
		TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
WE01	NPI Mining	925.8	462.9	370.3	60.5	30.2	24.2
WE02	NPI Mining	925.8	462.9	370.3	39.6	19.8	15.8
WE03	NPI Mining	925.8	462.9	370.3	194.4	97.2	77.8
WE04	NPI Mining	925.8	462.9	370.3	237.2	118.6	94.9
WE05	NPI Mining	925.8	462.9	370.3	28.1	14.0	11.2
WE06	NPI Mining	925.8	462.9	370.3	28.1	14.0	11.2
				Total	588	294	235

Table 7 Emission estimate – wheel generated dust – peak activity rates

Source	Gate in	Destination	Gate out	Dist. (m)	Veh·day^{-1}	VKT·day^{-1}	W (ave t)	sL	Sources
ROAD 1	Western	Shred/Floc	Eastern	457	92	42.044	15	9.7	16
ROAD 2	Central	Non Ferrous	Eastern	336	103	34.608	15	9.7	16
ROAD 3	Western	Pre Shred	Eastern	604	24	14.496	15	9.7	16
ROAD 4	Western	Shear & Oxy	Eastern	564	23	12.972	15	9.7	16

Table 8 Emission estimate – wheel generated dust – peak emission rates

Source	EF (kg·VKT^{-1})			ERu (kg·day^{-1})			CF		ERc (kg·day^{-1})		
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	CF %	CF % (HR1)	TSP	PM_{10}	$PM_{2.5}$
ROAD 1	0.4044	0.0776	0.0188	17.001	3.263	0.790	30	50	5.950	1.142	0.276
ROAD 2	0.4044	0.0776	0.0188	13.994	2.686	0.650	30	50	4.898	0.940	0.227
ROAD 3	0.4044	0.0776	0.0188	5.862	1.125	0.272	30	50	2.052	0.394	0.095
ROAD 4	0.4044	0.0776	0.0188	5.245	1.007	0.244	30	50	1.836	0.352	0.085

The variables used in these estimations are presented in **Appendix C** of 20.1074.FR4V1.

1.4. Data Cross Check

The only emission rates affected by the additional BMP assessment controls relate to the following emission sources:

- Material handling and conveyors (as illustrated in Table 4); and
- Road traffic (as illustrated in Table 8).

All other emissions remain as previously reported (Northstar, Dec 2021) and as re-presented above for clarity.

In regard to material handling and conveyors, these have been judiciously applied to various sources (i.e. not universally), as described in Section 1.1.2, and as can be seen by the highlighted cells in Table 4.

The aggregated sum of uncontrolled and controlled emissions for TSP, PM_{10} and $PM_{2.5}$ from the sources subjected to the additional BMP controls presented in this report and the AQIA (Northstar, Dec 2021) is summarised in Table 9 below.

Table 9 Comparison of aggregated emissions subject to additional BMP controls

Source	Report	Emission controls	TSP $kg{\cdot}yr^{-1}$	PM_{10} $kg{\cdot}yr^{-1}$	$PM_{2.5}$ $kg{\cdot}yr^{-1}$
Material handling and conveyors	AQIA (20.1074.FR4V1)	uncontrolled	1.377E+04	6.512E+03	9.861E+02
		controlled by 'CF'	6.223E+03	2.943E+03	4.457E+02
	This report (22.1097.DM2V1)	uncontrolled	1.377E+04	6.512E+03	9.861E+02
		controlled by 'CF', and additional C1, HT1, HT2	2.699E+03	1.276E+03	1.933E+02
Road	AQIA (20.1074.FR4V1)	uncontrolled	1.317E+04	2.528E+03	6.117E+02
		controlled by 'CF'	9.221E+03	2.299E+03	5.980E+02
	This report (22.1097.DM2V1)	uncontrolled	1.317E+04	2.528E+03	6.117E+02
		controlled by 'CF' and additional RH1	4.610E+03	8.849E+02	2.141E+02

2. DISPERSION MODELLING

The methodology adopted in this revised modelling is consistent with that previously performed (Northstar, Dec 2021), except for:

- Additional emission controls have been adopted, commensurate with those identified in the BMP assessment (see Section 1);
- The CALMET meteorological modelling has been additionally extracted at Prospect AWS as an additional validation point; and
- The predicted concentrations of particulates have been assessed at all receptor locations.

2.1. Meteorology

The CALMET modelling has been extracted at the BoM Prospect AWS and subjected to further validation testing. That validation is presented in Appendix A (AQS, Mar 2022) at the following locations:

- Prospect AWS; and
- Horsley Park AWS.

The model validation has been performed at those two locations, and performs within acceptable bounds applicable for a modelling assessment in NSW.

2.2. Receptors

As requested by EPA, the predicted particulate concentrations and deposition rates have been presented at all off-site receptor locations.

Note: It is maintained that the selection of receptor locations needs to account for the likely exposure period at those locations, and the respective averaging period of air pollutants is a key factor in that determination. The application of a predicted 24-hour concentration at a location where 24-hour exposure would be highly atypical (i.e. working for 24-hours) is not considered to apply reasonable scientific principles to the assessment. More reasonably, a 24-hour time weighted average (TWA) may be applied such that it weights a 24-hour exposure by work and non-work hours[1].

For clarity, the predicted impacts of PM (TSP, PM_{10} and $PM_{2.5}$, and as dust deposition) have been presented at all receptor locations for all averaging periods as requested by NSW EPA, although the results should be viewed as highly conservative for the reasons expressed in the AQIA and as above.

[1] https://www.safeworkaustralia.gov.au/system/files/documents/1705/guidance-interpretation-workplace-exposure-standards-airborne-contaminants-v2.pdf

Conversely, it is agreed that short-term criteria (e.g. 1-hour averages) would apply at workplaces (i.e. R10-R19) as equally as residential for the reasons expressed in the December 2021 report, which is consistent with the rationale outlined above.

Table 10 presents a summary of the receptor locations used in this assessment.

Table 10 Receptor locations used in the study

Rec	Address	Land use	Location (UTM)		Northstar	ERM	TAS
			mE	mS	2020	2015	2019
R1	1 Anthony Street, Blacktown	Residential	306 993	6 263 656	✓	✓	✓
R2	2 Redwood Street, Blacktown	Residential	306 975	6 263 528	✓	✓	✓
R3	191-209 Sunnyholt, Road Blacktown	Nature Reserve	306 963	6 263 414	✓	✓	✓
R4	5 Chedley Place, Marayong	Residential	305 627	6 263 452	✓	✓	✓
R5	12 Railway Road, Marayong	Residential	305 527	6 263 624	✓	✓	
R6	28 Railway Road, Marayong	Residential	305 475	6 263 762	✓	✓	✓
R7	12 Cobham Street, Kings Park	Residential	305 584	6 264 114	✓	✓	✓
R8	65 Faulkland Crescent, Kings Park	Residential	306 081	6 264 458	✓	✓	✓
R9	32 Elsom Street, Kings Langley	Residential	307 080	6 264 227	✓	✓	
R10	62 Tattersall Road Kings Park	Industrial	306 442	6 263 762	✓	✓	
R11	50 Tattersall Road Kings Park	Industrial	306 531	6 263 749	✓	✓	
R12	38 Tattersall Road Kings Park	Industrial	306 602	6 263 739	✓	✓	
R13	32 Tattersall Road Kings Park	Industrial	306 653	6 263 748	✓	✓	
R14	21 Tattersall Road Kings Park	Industrial	306 728	6 263 659	✓	✓	
R15	21 Tattersall Road Kings Park	Industrial	306 723	6 263 581	✓	✓	
R16	34 Forge Street Blacktown	Industrial	306 489	6 263 446	✓	✓	
R17	24 Forge Street Blacktown	Industrial	306 406	6 263 371	✓	✓	
R18	48 Bessemer Street Blacktown	Industrial	306 325	6 263 369	✓	✓	
R19	57 Tattersall Road Kings Park	Industrial	306 423	6 263 682	✓	✓	
R20	56 Isaac Smith Parade, Kings Langley	Nature Reserve	307 599	6 264 228	✓		
R21	87 Turner Street, Blacktown	School	307 887	6 263 160	✓		
R22	2 Stephen Street, Blacktown	Residential	306 919	6 263 049	✓		✓
R23	24 Bedford Road, Blacktown	Nature Reserve	307 124	6 262 564	✓		
R24	19 Fifth Avenue ,Blacktown	School	306 559	6 262 232	✓		
R25	1 Bowmans Road, Kings Park	Commercial	305 557	6 263 991	✓		
R26	30 Ironwood Crescent, Blacktown	Residential	305 892	6 262 648	✓		
R27	Noel Street, Marayong	Nature Reserve	305 458	6 262 957	✓		
R28	90 Sunnyholt Road Blacktown	School	306 709	6 262 724	✓		✓
R29	305 Vardys Road Blacktown	Residential	307 037	6 263 846	✓		✓
R30	29 Camorta Close Kings Park	Residential	306 386	6 264 424	✓		✓

Rec	Address	Land use	Location (UTM)		Northstar 2020	ERM 2015	TAS 2019
			mE	mS			
R31	7 Camorta Close Kings Park	Residential	306 723	6 264 372	✓		✓
R32	49 Cobham Street Kings Park	Residential	305 695	6 264 456	✓		✓
R33	5 Springfield Avenue Blacktown	Residential	305 974	6 262 378	✓		✓
R34	S&P AQMS "Out station"	On-site	306 589	6 263 715	✓		
R35	S&P AQMS "In station"	On-site	306 434	6 263 491	✓		

.

The receptors adopted in this assessment are consistent with the AQIA and are presented in Figure 1 and Figure 2.

Figure 1 Sensitive receptors surrounding the Proposal site (all receptors)

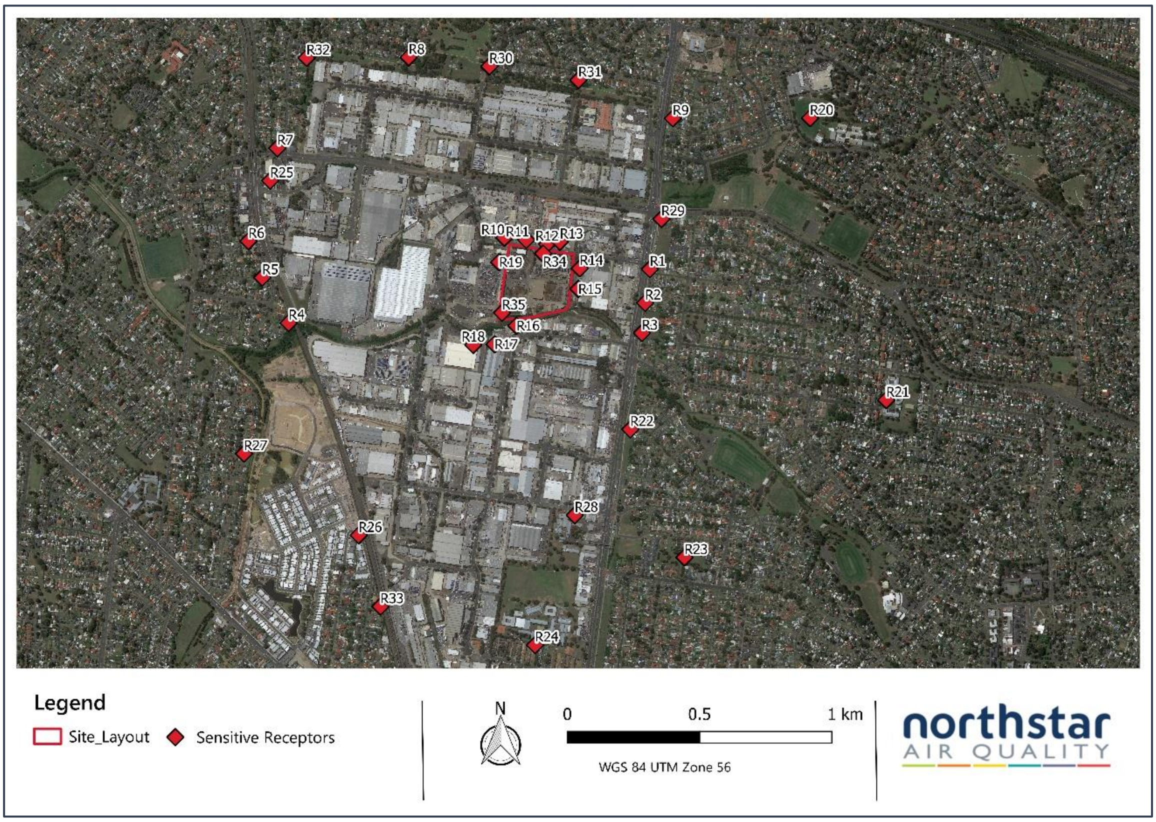


Figure 2 Sensitive receptors surrounding the Proposal site (close receptors)

3. RESULTS

This section presents the results of the dispersion modelling assessment and uses the following terminology:

- Incremental impact – relates to the concentrations predicted as a result of the construction and operation of the Proposal in isolation.
- Cumulative impact – relates to the incremental concentrations predicted as a result of the construction and operation of the Proposal PLUS the background air quality concentrations discussed in Section 4.4 of 20.1074.FR4V1.

The results are presented in this manner to allow examination of the likely impact of the Proposal in isolation and the contribution to air quality impacts in a broader sense.

Note: Due to the inclusion of the additional controls identified through the BMP assessment (Northstar, Dec 2021), the predicted results are significantly lower than those presented in the AQIA report.

In the presentation of results (Table 11 to Table 20) the shaded cells represent the following:

Model prediction	Pollutant concentration / deposition rate less than the relevant criterion	Pollutant concentration / deposition rate equal to, or greater than the relevant criterion

3.1. Annual Average TSP, PM_{10} and $PM_{2.5}$

The predicted results at all receptor locations are presented in Table 11 below.

Table 11 Predicted annual average TSP, PM_{10} and $PM_{2.5}$ concentrations

Receptor	Annual Average Concentration (µg·m⁻³)								
	TSP			PM_{10}			$PM_{2.5}$		
	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact
R1	0.6	44.8	45.4	0.2	21.8	22.0	<0.1	8.4	<8.5
R2	0.6	44.8	45.4	0.2	21.8	22.0	<0.1	8.4	<8.5
R3	0.5	44.8	45.3	0.2	21.8	22.0	<0.1	8.4	<8.5
R4	0.3	44.8	45.1	0.1	21.8	21.9	<0.1	8.4	<8.5
R5	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R6	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R7	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R8	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5

Receptor	Annual Average Concentration (µg·m^{-3})								
	TSP			PM_{10}			$PM_{2.5}$		
	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact	Incremental Impact	Background	Cumulative Impact
R9	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R10	5.5	44.8	50.3	2.1	21.8	23.9	0.4	8.4	8.8
R11	10.1	44.8	54.9	4.1	21.8	25.9	0.7	8.4	9.1
R12	5.8	44.8	50.6	2.1	21.8	23.9	0.4	8.4	8.8
R13	3.7	44.8	48.5	1.2	21.8	23.0	0.3	8.4	8.7
R14	2.9	44.8	47.7	0.9	21.8	22.7	0.2	8.4	8.6
R15	2.8	44.8	47.6	0.8	21.8	22.6	0.2	8.4	8.6
R16	3.9	44.8	48.7	1.3	21.8	23.1	0.3	8.4	8.7
R17	1.9	44.8	46.7	0.7	21.8	22.5	0.2	8.4	8.6
R18	1.5	44.8	46.3	0.5	21.8	22.3	0.1	8.4	8.5
R19	8.0	44.8	52.8	2.9	21.8	24.7	0.6	8.4	9.0
R20	0.1	44.8	44.9	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R21	<0.1	44.8	<44.9	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R22	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R23	<0.1	44.8	<44.9	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R24	0.1	44.8	44.9	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R25	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R26	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R27	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R28	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R29	0.5	44.8	45.3	0.2	21.8	22.0	<0.1	8.4	<8.5
R30	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R31	0.2	44.8	45.0	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R32	0.1	44.8	44.9	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R33	0.1	44.8	44.9	<0.1	21.8	<21.9	<0.1	8.4	<8.5
R34	8.0	44.8	52.8	2.9	21.8	24.7	0.6	8.4	9.0
R35	5.2	44.8	50.0	1.7	21.8	23.5	0.4	8.4	8.8
Criterion	-	**90**		-	**25**			**8**	

There is a predicted exceedance of the cumulative annual average PM_{10} criterion at R11. The management of this air quality risk is discussed in Section 4.2. The assessment of annual average $PM_{2.5}$ shows an already exceeding background.

3.2. Annual Dust Deposition Rates

The predicted results at all receptor locations are presented in Table 12 below. It is noted that there are no predicted exceedances of the dust deposition criteria.

Table 12 Predicted annual dust deposition rates

Receptor	Annual Average Dust Deposition ($g \cdot m^{-2} \cdot month^{-1}$)		
	Incremental Impact	Background	Cumulative Impact
R1	<0.1	2.0	<2.1
R2	<0.1	2.0	<2.1
R3	<0.1	2.0	<2.1
R4	<0.1	2.0	<2.1
R5	<0.1	2.0	<2.1
R6	<0.1	2.0	<2.1
R7	<0.1	2.0	<2.1
R8	<0.1	2.0	<2.1
R9	<0.1	2.0	<2.1
R10	0.7	2.0	2.7
R11	1.5	2.0	3.5
R12	0.9	2.0	2.9
R13	0.5	2.0	2.5
R14	0.4	2.0	2.4
R15	0.4	2.0	2.4
R16	0.5	2.0	2.5
R17	0.2	2.0	2.2
R18	0.2	2.0	2.2
R19	1.0	2.0	3.0
R20	<0.1	2.0	<2.1
R21	<0.1	2.0	<2.1
R22	<0.1	2.0	<2.1
R23	<0.1	2.0	<2.1
R24	<0.1	2.0	<2.1
R25	<0.1	2.0	<2.1
R26	<0.1	2.0	<2.1
R27	<0.1	2.0	<2.1
R28	<0.1	2.0	<2.1
R29	<0.1	2.0	<2.1
R30	<0.1	2.0	<2.1
R31	<0.1	2.0	<2.1

Receptor	Annual Average Dust Deposition ($g \cdot m^{-2} \cdot month^{-1}$)		
	Incremental Impact	Background	Cumulative Impact
R32	<0.1	2.0	<2.1
R33	<0.1	2.0	<2.1
R34	1.4	2.0	3.4
R35	0.7	2.0	2.7
Criterion	**<0.1**	**-**	**4**

3.3. Incremental 24-hour Average PM_{10} and $PM_{2.5}$

The predicted results at all receptor locations are presented below in Table 13. The maximum incremental PM_{10} and $PM_{2.5}$ predictions are predicted at R11.

Table 13 Predicted maximum incremental 24-hour PM_{10} and $PM_{2.5}$ concentrations

Receptor	Maximum 24-hour average concentration ($\mu g \cdot m^{-3}$)	
	PM_{10}	$PM_{2.5}$
R1	2.4	0.5
R2	3.3	0.7
R3	2.4	0.5
R4	1.1	0.2
R5	1.0	0.2
R6	1.0	0.2
R7	1.0	0.2
R8	1.0	0.2
R9	1.0	0.2
R10	11.6	2.2
R11	**19.7**	**3.3**
R12	13.0	2.2
R13	7.6	1.5
R14	5.7	1.3
R15	8.2	1.8
R16	9.0	1.8
R17	3.8	0.8
R18	3.8	0.9
R19	12.0	2.3
R20	0.8	0.2
R21	0.6	0.2
R22	1.9	0.4
R23	1.1	0.2

Receptor	Maximum 24-hour average concentration (µg·m^{-3})	
	PM_{10}	$PM_{2.5}$
R24	1.0	0.2
R25	0.9	0.2
R26	0.9	0.2
R27	1.1	0.3
R28	1.1	0.2
R29	2.3	0.5
R30	1.4	0.3
R31	1.2	0.3
R32	0.7	0.2
R33	0.6	0.2
R34	16.3	2.7
R35	7.7	1.7

The predicted incremental 24-hour PM_{10} and $PM_{2.5}$ concentrations are illustrated in Figure 3 and Figure 4 respectively.

Figure 3 Predicted 24-hour average PM_{10} concentrations

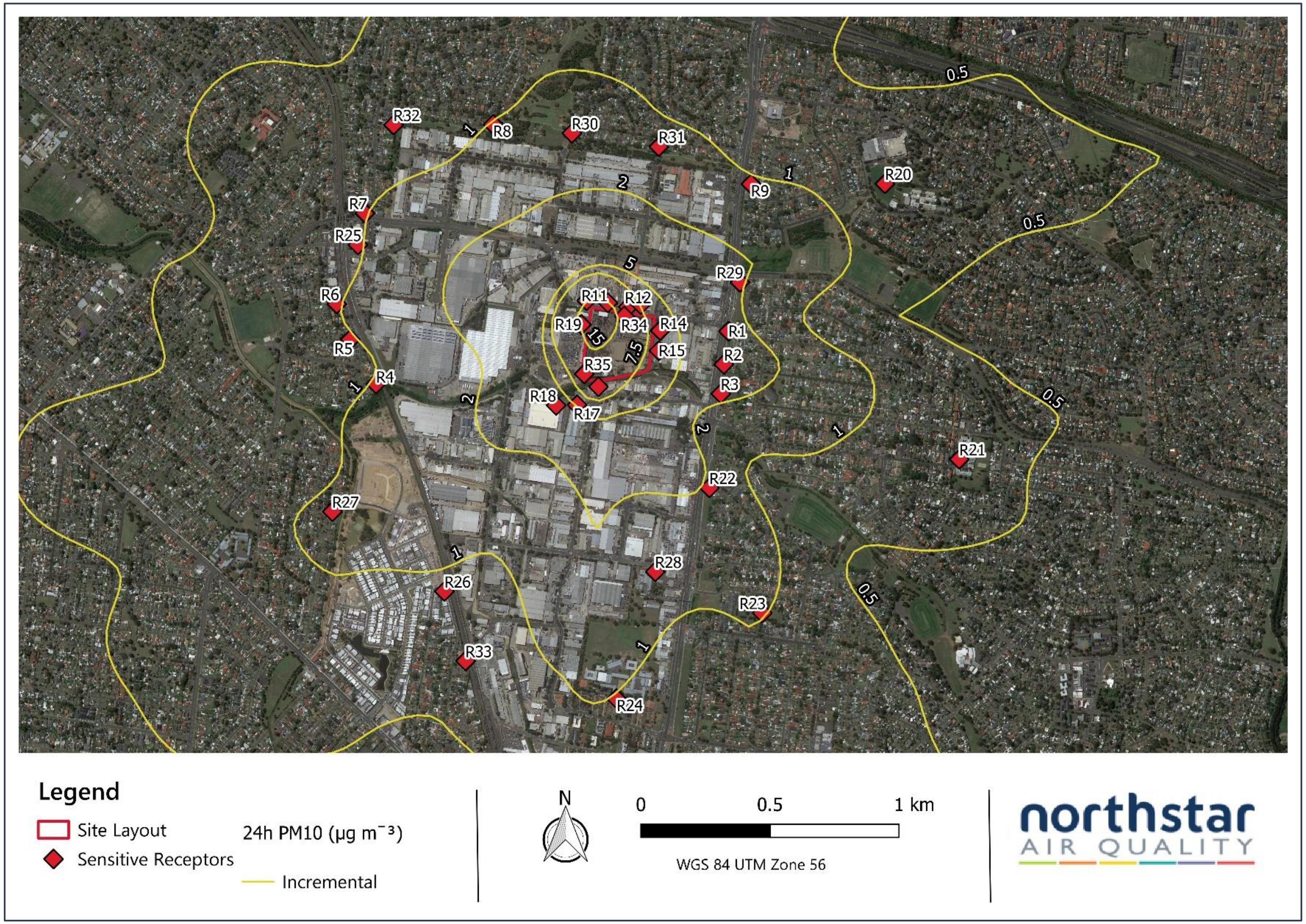
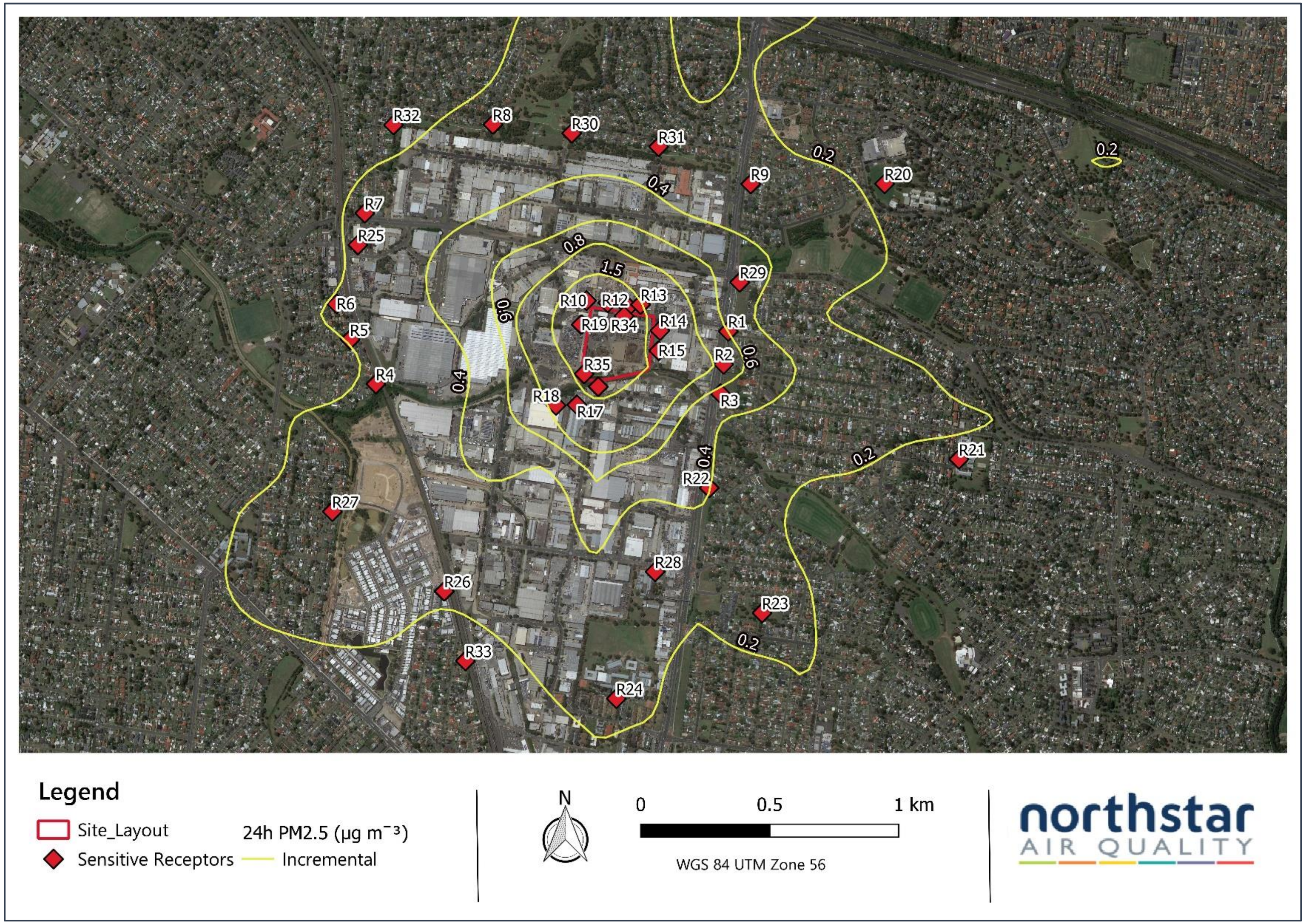


Figure 4 Predicted 24-hour average $PM_{2.5}$ concentrations



3.4. Cumulative 24-hour Average PM_{10} and $PM_{2.5}$ Concentrations

The predicted top-10 cumulative PM_{10} and $PM_{2.5}$ concentrations are presented in the following tables:

- Table 14 Predicted top-10 cumulative PM_{10} concentrations (receptors R1 to R18)
- Table 15 Predicted top-10 cumulative PM_{10} concentrations (receptors R19 to R35)
- Table 16 Predicted Top-10 cumulative $PM_{2.5}$ concentrations (Receptors R1 to R18)
- Table 17 Predicted Top-10 cumulative $PM_{2.5}$ concentrations (Receptors R19 to R35)

Table 14 Predicted top-10 cumulative PM_{10} concentrations (receptors R1 to R18)

Rank	Predicted Top-10 Cumulative PM_{10} Concentrations ($\mu g \cdot m^{-3}$) (Receptors R1 to R18)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	113.83	114.11	114.01	113.30	113.30	113.30	113.30	113.30	113.30	113.30	113.56	114.85	114.18	115.62	116.81	113.33	113.30	113.30
2	70.21	70.22	70.22	70.63	70.69	70.58	70.35	70.22	70.33	71.85	74.59	71.99	71.25	70.62	70.41	70.98	70.62	70.56
3	65.81	65.81	65.81	65.93	65.83	65.82	65.81	65.80	65.80	65.82	65.82	65.82	65.81	65.82	67.28	70.10	69.13	68.93
4	62.57	63.61	63.81	62.16	61.90	61.90	61.90	61.90	61.93	62.17	62.91	63.77	62.92	64.93	65.88	67.71	62.54	62.36
5	61.61	61.61	61.61	61.90	61.90	61.76	61.64	61.62	61.64	61.90	62.72	62.41	62.16	61.89	61.73	62.86	62.26	61.90
6	58.71	58.74	58.80	58.70	58.70	58.70	58.70	58.70	58.70	58.70	59.71	58.71	58.71	58.79	59.16	62.64	61.94	60.11
7	55.85	56.10	56.22	55.70	55.70	55.70	55.70	55.70	55.70	55.70	58.70	55.94	55.83	56.78	58.02	59.62	55.94	55.73
8	54.40	54.40	54.43	54.40	54.40	54.40	54.40	54.40	54.40	54.40	55.72	54.40	54.40	54.49	54.67	56.91	55.84	54.64
9	48.46	48.54	48.51	47.90	47.90	47.90	47.90	47.90	47.97	51.19	54.40	48.16	48.21	48.98	49.65	52.06	48.91	48.17
10	47.80	47.82	47.90	47.80	47.80	47.80	47.80	47.80	47.80	47.93	48.01	48.07	47.80	48.05	48.50	49.34	47.91	47.81

Table 14 shows additional exceedances of the cumulative 24-hour PM_{10} criterion at R10, R11 and R16. Section 3.5 assesses these additional exceedances at those receptors, and Section 4 discusses how the Trigger Action Response Plan (TARP) will be implemented through the Air Quality Management Plan (AQMP) (Ethos Urban, Apr 2022) to manage that risk.

Table 15 Predicted top-10 cumulative PM_{10} concentrations (receptors R19 to R35)

Rank	Predicted Top-10 Cumulative PM_{10} Concentrations ($\mu g \cdot m^{-3}$) (Receptors R19 to R35)																
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	113.30	113.30	113.42	113.37	113.31	113.30	113.30	113.30	113.30	113.30	113.38	113.30	113.30	113.30	113.30	121.13	113.30
2	75.10	70.21	70.20	70.22	70.21	70.21	70.42	70.23	70.24	70.22	70.23	70.24	70.44	70.25	70.22	72.02	73.09
3	67.92	65.80	65.80	65.83	65.81	65.88	65.81	66.48	66.48	65.90	65.80	65.80	65.80	65.80	66.25	67.33	71.56
4	66.08	61.93	62.42	62.66	62.28	61.92	61.90	61.90	61.90	62.14	62.07	61.90	61.90	61.90	61.90	65.82	64.62
5	61.91	61.61	61.60	61.61	61.61	61.61	61.67	61.67	61.83	61.61	61.63	61.63	61.65	61.62	61.64	62.48	64.06
6	58.92	58.70	58.70	59.00	58.91	59.70	58.70	58.97	58.71	59.79	58.70	58.70	58.70	58.70	59.18	58.89	62.06
7	55.71	55.70	55.76	55.95	55.85	55.76	55.70	55.70	55.70	55.97	55.71	55.70	55.70	55.70	55.70	58.71	57.15
8	54.46	54.40	54.40	54.57	54.49	54.87	54.40	54.41	54.40	54.74	54.40	54.40	54.40	54.40	54.50	54.44	56.05
9	47.99	47.96	48.02	48.33	48.13	48.11	47.90	47.92	47.90	48.45	48.16	47.91	47.92	47.90	47.94	50.09	49.87
10	47.80	47.80	47.80	48.32	48.10	47.84	47.80	47.80	47.80	48.05	47.80	47.80	47.80	47.80	47.80	49.66	48.12

Table 15 shows additional exceedances of the cumulative 24-hour PM_{10} criterion at R34. R34 is an on-site location of the Sell & Parker 'out station' air quality monitoring station, and consequently no additional analysis has been performed on that receptor location.

Table 16 Predicted Top-10 cumulative $PM_{2.5}$ concentrations (Receptors R1 to R18)

Rank	Predicted Top-10 Cumulative $PM_{2.5}$ Concentrations ($\mu g \cdot m^{-3}$) (Receptors R1 to R18)																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	47.50	47.51	47.52	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.50	47.52	47.61	49.30	48.28	47.78
2	42.50	42.50	42.50	42.53	42.51	42.50	42.50	42.50	42.50	42.51	42.50	42.50	42.50	42.50	42.52	43.55	43.30	43.22
3	27.21	27.21	27.19	27.15	27.11	27.10	27.10	27.10	27.12	27.18	27.26	27.34	27.33	27.43	27.44	27.87	27.51	27.45
4	27.00	27.00	27.00	27.06	27.01	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.04	27.08	27.54	27.35	27.38
5	23.27	23.31	23.31	23.10	23.10	23.10	23.10	23.10	23.10	23.11	23.13	23.16	23.17	23.52	23.86	24.02	23.31	23.16
6	21.78	21.76	21.75	21.71	21.70	21.70	21.70	21.70	21.71	21.74	21.76	21.80	21.79	21.87	21.90	22.78	22.40	22.21
7	20.63	20.62	20.61	20.76	20.69	20.65	20.62	20.62	20.65	21.31	21.40	21.07	20.98	20.78	20.69	20.72	20.67	20.73
8	19.97	19.98	19.98	19.92	19.98	20.03	20.03	19.91	19.92	20.81	20.56	21.01	20.69	20.71	20.54	20.14	20.03	19.98
9	19.89	19.85	19.78	19.50	19.50	19.50	19.50	19.51	19.73	19.68	20.44	20.26	20.14	20.05	20.08	19.80	19.62	19.56
10	18.65	18.64	18.62	18.42	18.41	18.41	18.41	18.42	18.50	18.60	18.70	18.78	18.78	18.87	18.96	19.73	19.24	18.98

Table 16 shows no additional exceedances of the cumulative 24-hour $PM_{2.5}$ criterion at any receptor locations.

Table 17 Predicted Top-10 cumulative $PM_{2.5}$ concentrations (Receptors R19 to R35)

Rank	Predicted Top-10 Cumulative $PM_{2.5}$ Concentrations ($\mu g \cdot m^{-3}$) (Receptors R19 to R35)																
	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	47.55	47.50	47.50	47.57	47.55	47.73	47.50	47.55	47.50	47.75	47.50	47.50	47.50	47.50	47.60	47.50	48.64
2	42.89	42.50	42.50	42.51	42.50	42.52	42.50	42.66	42.66	42.53	42.50	42.50	42.50	42.50	42.61	42.51	44.06
3	27.66	27.13	27.11	27.13	27.11	27.10	27.10	27.12	27.24	27.11	27.19	27.10	27.11	27.10	27.11	27.37	28.19
4	27.49	27.00	27.00	27.02	27.01	27.05	27.00	27.06	27.16	27.06	27.00	27.00	27.00	27.00	27.05	27.01	27.88
5	23.13	23.10	23.14	23.36	23.27	23.18	23.10	23.11	23.10	23.33	23.15	23.10	23.10	23.10	23.11	23.39	23.48
6	21.99	21.72	21.71	21.78	21.75	21.75	21.70	21.84	21.73	21.79	21.77	21.70	21.70	21.70	21.79	21.81	22.86
7	21.90	20.61	20.60	20.60	20.60	20.60	20.63	20.61	20.70	20.60	20.64	20.62	20.67	20.62	20.60	21.18	20.98
8	21.56	19.91	19.92	19.94	19.91	19.91	20.07	19.91	19.90	19.93	19.95	19.91	19.92	19.93	19.90	21.07	20.15
9	19.68	19.63	19.55	19.61	19.55	19.54	19.50	19.51	19.50	19.56	19.89	19.52	19.57	19.50	19.52	20.28	19.79
10	18.85	18.46	18.44	18.56	18.47	18.48	18.41	18.53	18.43	18.53	18.58	18.44	18.46	18.41	18.52	18.79	19.71

Table 17 shows no additional exceedances of the cumulative 24-hour $PM_{2.5}$ criterion at any receptor locations.

3.5. Cumulative 24-hour Average PM_{10} Predictions at Receptor Locations

With reference to Table 14 and Table 15, additional predicted days of exceedance of the 24-hour PM_{10} criterion are shown at Receptors R10, R11, R16 and R34. R34 is the location of the on-site AQMS (S&P 'Out Station') (see Figure 9 in (Northstar, Dec 2021)) and has not been assessed further. There are no additional exceedances of the corresponding 24-hour $PM_{2.5}$ criterion, and therefore this section addresses PM_{10} only.

3.5.1. Receptor R11

With reference to Table 13, the maximum incremental PM_{10} and $PM_{2.5}$ impacts are predicted at R11. As per the requirements of the Approved Methods, a detailed evaluation of the top-10 impacts at that receptor have been performed.

Table 18 Predicted top-10 incremental and cumulative PM_{10} impacts at R11

Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$)			Date	24-hour average PM_{10} concentration ($\mu g \cdot m^{-3}$)		
	Incremental Impact	Background	Cumulative Impact		Incremental Impact	Background	Cumulative Impact
22/11/2018	0.3	113.3	113.6	20/06/2018	19.7	20.0	39.7
19/03/2018	4.4	70.2	74.6	14/05/2018	18.2	16.9	35.1
28/05/2018	<0.1	65.8	<65.9	28/04/2018	18.2	11.9	30.1
15/02/2018	1.3	61.6	62.9	29/04/2018	18.0	9.7	27.7
18/07/2018	0.8	61.9	62.7	22/12/2018	17.9	10.2	28.1
20/03/2018	14.5	45.2	59.7	8/09/2018	17.7	17.4	35.1
29/05/2018	<0.1	58.7	<58.8	14/01/2018	17.7	11.0	28.7
21/11/2018	<0.1	55.7	<55.8	10/06/2018	17.7	9.9	27.6
19/07/2018	<0.1	54.4	<54.5	4/06/2018	17.7	12.1	29.8
18/03/2018	0.1	47.9	48.0	26/02/2018	17.5	11.8	29.3
These data represent the highest Cumulative Impact 24-hour PM_{10} predictions outlined in red as a result of the operation of the project.				These data represent the highest Incremental Impact 24-hour PM_{10} predictions outlined in blue as a result of the operation of the project.			

The results presented above in Table 18 indicates that there is one additional exceedance of the 24-hour PM_{10} criterion predicted at R11, on 20/03/2018. How this risk is to be managed is discussed in Section 4.2.

3.5.2. Receptor R10

The data presented in Table 14 indicates an additional exceedance at R10. A detailed evaluation of the top-10 impacts at that receptor have been performed and is summarised in Table 19.

Table 19 Predicted top-10 incremental and cumulative PM_{10} impacts at R10

Date	24-hour average PM_{10} concentration ($\mu g{\cdot}m^{-3}$)			Date	24-hour average PM_{10} concentration ($\mu g{\cdot}m^{-3}$)		
	Incremental Impact	Background	Cumulative Impact		Incremental Impact	Background	Cumulative Impact
22/11/2018	<0.1	113.3	<113.4	2/07/2018	11.6	13.9	25.5
19/03/2018	1.7	70.2	71.9	21/04/2018	9.6	27.1	36.7
28/05/2018	<0.1	65.8	<65.9	3/09/2018	9.6	12.6	22.2
15/02/2018	0.6	61.6	62.2	24/09/2018	9.5	13.9	23.4
18/07/2018	<0.1	61.9	<62	11/10/2018	9.4	11.6	21.0
29/05/2018	<0.1	58.7	<58.8	6/03/2018	9.3	15.4	24.7
21/11/2018	<0.1	55.7	<55.8	21/03/2018	9.3	13.9	23.2
19/07/2018	<0.1	54.4	<54.5	22/03/2018	9.2	15.2	24.4
20/03/2018	6.0	45.2	51.2	7/03/2018	9.2	14.7	23.9
18/03/2018	<0.1	47.9	<48	20/02/2018	9.1	14.6	23.7
These data represent the highest Cumulative Impact 24-hour PM_{10} predictions outlined in red as a result of the operation of the project.				These data represent the highest Incremental Impact 24-hour PM_{10} predictions outlined in blue as a result of the operation of the project.			

The results presented above in Table 19 indicate that there is one additional exceedance of the 24-hour PM_{10} criterion predicted at R10, predicted on 20/03/2018 (the same day as at R11 discussed above at Section 3.5.1). How this risk is to be managed is discussed in Section 4.2.

3.5.3. Receptor R16

The data presented in Table 14 indicates an additional exceedance at R16. A detailed evaluation of the top-10 impacts at that receptor have been performed and is summarised in Table 20.

Table 20 Predicted top-10 incremental and cumulative PM_{10} impacts at R16

Date	24-hour average PM_{10} concentration (µg·m^{-3})			Date	24-hour average PM_{10} concentration (µg·m^{-3})		
	Incremental Impact	Background	Cumulative Impact		Incremental Impact	Background	Cumulative Impact
22/11/2018	<0.1	113.3	<113.4	29/05/2018	9.0	58.7	67.7
19/03/2018	0.8	70.2	71.0	12/06/2018	6.5	20.8	27.3
28/05/2018	4.3	65.8	70.1	4/07/2018	6.2	17.9	24.1
29/05/2018	9.0	58.7	67.7	8/06/2018	6.1	18.5	24.6
18/07/2018	1.0	61.9	62.9	7/05/2018	5.8	21.0	26.8
15/02/2018	1.0	61.6	62.6	5/07/2018	5.5	10.9	16.4
19/07/2018	5.2	54.4	59.6	26/08/2018	5.2	19.2	24.4
21/11/2018	1.2	55.7	56.9	19/07/2018	5.2	54.4	59.6
18/03/2018	4.2	47.9	52.1	23/07/2018	5.1	21.5	26.6
14/04/2018	1.5	47.8	49.3	5/08/2018	5.1	24.1	29.2
These data represent the highest Cumulative Impact 24-hour PM_{10} predictions outlined in red as a result of the operation of the project.				These data represent the highest Incremental Impact 24-hour PM_{10} predictions outlined in blue as a result of the operation of the project.			

The results presented above in Table 20 indicate that there is one additional exceedance of the 24-hour PM_{10} criterion predicted at R16, predicted on 18/03/2018. How this risk is to be managed is discussed in Section 4.2.

4. DISCUSSION

The modelling presented within this advice note adopts the additional control measures identified through the BMP assessment, as requested by NSW EPA. The updated emission estimation adopting those controls is presented in Section 1.1.2.

4.1. Predicted Impacts

Note: Due to the inclusion of the additional controls identified through the BMP assessment (Northstar, Dec 2021), the predicted results are significantly lower than those presented in the AQIA report.

The assessment predicts a potential exceedance of the cumulative annual average PM_{10} criterion at Receptor R11, and single additional exceedances of the 24-hour PM_{10} criterion at receptors R10, R11 and R16.

For clarity, R10 and R11 are industrial receptors located on Tattersall Road to the north of the site, and R16 is an industrial receptor located on Forge Street to the south of the site (see Figure 2).

The assessment predicts the maximum incremental 24-hour PM_{10} and $PM_{2.5}$ impacts at R11, which is an industrial receptor located on Tattersall Road.

4.2. Management of Air Quality Risks through the TARP

The limitations of assessing 24-hour PM_{10} at industrial receptors are briefly discussed at Section 2.2, but to manage off-site control of particulates, the conditions that would potentially result in off-site impacts will be managed through the Trigger Action Response Plan (TARP), implemented through the Air Quality Management Plan (AQMP) (Ethos Urban, Apr 2022).

The trigger to initiate the TARP is the PM_{10} measurement data at the two Sell & Parker AQMS, and therefore the effective implementation of the TARP would manage that risk through the definition of the limiting PM_{10} concentration. With specific regard to the predicted exceedances at R10 and R11 to the north of the site, the TARP would utilise rolling 24-hour average PM_{10} measurement data obtained from the Sell & Parker 'Out Station' AQMS, and correspondingly utilise the Sell & Parker 'In Station' data for R16 to the south of the site.

In response to the EPA comment at 2(d), the effectiveness of control through the TARP would be that required to achieve the 50 $\mu g \cdot m^{-3}$ on days of non-exceeding backgrounds, and manage incremental contributions on days of exceeding backgrounds, such as regional events (such as bushfires and dust storms).

It is impractical to set a trigger on the annual average PM_{10} criterion as that would not provide a reasonable metric to initiate pro-active and reactive dust control measures through the TARP, however it is considered that controls targeting compliance of the 24-hour criterion and impact minimisation would provide a longer-term beneficial air quality outcome of managing long-term PM_{10} risks as a consequence.

5. REFERENCES

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APPENDIX A

D19A-14: Technical Support – Dispersion Modelling Study – Kings Park, NSW

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27 March 2022

Gary Graham
Director | Air Quality Scientist
Northstar Air Quality

By email: gary.graham@northstarairquality.com

D19A-14: Technical Support – Dispersion Modelling Study – King's Park, NSW

Dear Gary

Air Quality Support (AQS) was commissioned by Northstar Air Quality to provide technical support in dispersion modelling of the proposed upgrade operations of the Sell and Parker Metal Recycling facility in King's Park, NSW.

The assessment is based on a dispersion modelling study that incorporates site-specific meteorological data, geographic features, and source characteristics in order to predict ground-level concentrations of pollutants at specific receptors and the surrounding environment.

Key components of the dispersion modelling study include:

- Site-specific three-dimensional dataset used in the study was generated using the TAPM and CALMET meteorological models.
- The period of modelling was conducted for January to December 2018.
- Characterisation of sources, including locations, parameters, and emissions rates were based on the proposed operations. Hours of operations for the sources are as follows:
    - 21 Hours: 06:00 am to 09:00 pm - Materials handling, conveyors, transfer points, and trucks dumping modelled as windspeed dependent volume sources.
    - 21 Hours: 06:00 am to 09:00 pm - Hammermill wet scrubber stack modelled with constant emission rates.
    - 6 hours: 09:00 am to 03:00 pm - C1 Oxy cutter operations modelled with constant emission rates.
    - 24 hours: windspeed dependent emissions due to wind erosion.
- The study considered potential impacts to 35 sensitive receptors and the surrounding environment.
- The study considered potential impacts due to the proposed operations in isolation, and with the inclusion of background concentrations of pollutants.

This memorandum summarises the information received and used for the dispersion modelling study. This memo accompanies the CALPOST output files (grid files and time series data, available for at https://we.tl/t-aW6UropSjk. The files will be available for download for four weeks. Please let us know if you require an extension.

If you have any questions or comments, please feel free to contact the undersigned.

Kind regards,

Ella Castillo

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M: +61 424 707794

1 Meteorological modelling

1.1 TAPM

Key features of the TAPM model configuration:

- TAPM version 4.0.5 was used
- Grid points nx * ny * nz = 35 * 35 *25
- 4 nests with grid resolutions of 30km, 10km, 3km, and 1km
- Grid centred at LAT: -33° 45' 0", LONG: 150° 54' 30" / (306258 mE, 6263597 mN)
- 4 spin-up days and meteorology output after 2 days.
- TAPM default database used for all geographic data
- Modelled 1 January to 31 December 2018
- No assimilation

1.2 CALMET modelling

Key features of the CALMET configuration:

- CALMET version 6.5.0
- Model configuration based on CALMET/CALPUFF model guidance document
- NOOBS mode
- 120 * 120 grids
- 12 vertical levels
- Landuse based on European Space Agency GlobCover Portal
- Elevation based on 90-m SRTM dataset

2 Validation of TAPM model

To assess model performance, observations at the Horsley Park Eq Centre AWS and the air quality monitoring station at Prospect were compared with predictions by the TAPM model. This was conducted for meteorological parameters that are important to dispersion, such as wind speed, and U and V components of wind (to account for wind direction).

The data validation process took into account statistical measures as described in the meteorological monitoring guidance for regulatory modelling applications (USEPA, 2000). Model predictions were validated using the following statistical measures:

- Root Mean Square Error (RMSE)
- Systematic Root Mean Square Error ($RMSE_S$)
- Unsystematic Root Mean Square Error ($RMSE_U$)
- Mean Error (ME)
- Mean Absolute Error (MAE)
- Index of Agreement (IOA)
- Skill E
- Skill V
- Skill R

In addition to these measures, basic statistics such as the minimum, mean, maximum, and standard deviation were also derived and compared.

It should be noted that there are no defined standards for numerical weather model performance. Statistical scores simply provide a means to quantify the magnitude of the difference between predictions and observations. These provide a useful guide to performance benchmarks of what should be expected from a model. These values are guidelines and not absolute determinants of pass or fail.

2.1 Statistics

2.1.1 Root mean square error (RMSE)

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)^2}$$

Where:

N = number of observed and predicted hours in analysis (i.e. one year)

P = hourly prediction

O = hourly observation

The RSME can be described as the standard deviation of the difference for hourly predicted and observed pairings at a specific point. The RMSE is a quadratic scoring rule, which measures the average magnitude of the error. The difference between predicted and corresponding observed values are each squared and then averaged over the sample. Finally, the square root of the average is taken. Since the errors are squared before they are averaged, the RMSE gives a relatively high weight to large errors. This means the RMSE is most useful when large errors are particularly undesirable. Overall, the RSME is a good overall measure of model performance, but since large errors are weighted heavily (due to squaring), its value can be distorted. RMSE is equal to the unit of the values being analysed i.e., an RMSE of 1.2 for wind speed = 1.2 m/s.

2.1.2 Systematic root mean square error (RMSEs)

$$RMSE_S = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\bar{P} - O_i)^2}$$

Where:

N = number of observed and predicted hours in analysis (i.e. one year)

$\bar{P}$ = mean of predictions

O = hourly observation

The RMSEs is calculated as the square root of the mean square difference of hourly predictions from the regression formula and observation pairings, at a specific point. The regressed predictions are taken from the least squares formula. The RMSEs estimates the model's linear (or systematic) error. The systematic error is a measure of the bias in the model due to user input or model deficiency, i.e., data input errors, assimilation variables, and choice of model options. The RMSEs is a metric for the model's accuracy.

2.1.3 Unsystematic root mean square error (RMSEu)

$$RMSE_U = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\bar{P} - P_i)^2}$$

Where:

N = number of observed and predicted hours in analysis (i.e. one year)

$\bar{P}$ = mean of predictions

P = hourly prediction

The RMSEu is calculated as the square root of the mean square difference of hourly predictions from the regression formula and model prediction value pairings, at a specific point. The RMSEu is a measure of how much of the difference between predictions and observations result from random processes or influences outside the legitimate range of the model. This error may require model refinement, such as new algorithms or higher resolution grids, or that the phenomena being simulated cannot be fully resolved by the model. The RMSEu is a metric for the model's precision.

Ultimately, for good model performance, the RMSE should be a low value, with most of the variation explained in the observations. Here, the systematic error RMSEs should approach zero and the unsystematic error, RMSEu, should approach the RMSE since:

$$RMSE^2 = {RMSE_S}^2 + {RMSE_U}^2$$

2.1.4 Mean error and mean absolute error

The Mean Error (ME) is simply the average of the hourly modelled values minus the hourly observed values. It contains both systematic and unsystematic errors and is heavily influence by high and low errors.

The Mean Absolute Error (MAE) measures the average magnitude of the errors in a set of predictions, without considering their direction. It measures accuracy for continuous variables. Expressed in words, the MAE is the average of the absolute values of the differences between predictions and the corresponding observation. The MAE is a linear score, which means that all the individual differences are weighted equally in the average. The MAE and the RMSE can be used together to diagnose the variation in the errors in a set of predictions. The RMSE will always be larger or equal to the MAE; the greater difference between them, the greater the variance in the individual errors in the sample. If the RMSE = MAE, then all the errors are of the same magnitude. Both the MAE and RMSE can range from 0 to ∞. They are negatively-oriented scores, i.e., lower values are better.

2.1.5 Index of agreement

The Index of Agreement (IOA) is defined as:

$$IOA = 1 - \frac{\sum_{i=1}^{N}(P_i - O_i)^2}{\sum_{i=1}^{N}(|P_i - O_{mean}| + |O_i - O_{mean}|)^2}$$

The IOA is calculated using a method described in Willmott (1982). The IOA can take a value between 0 and 1, with 1 indicating perfect agreement. The IOA is the ratio of the total RMSE to the sum of two differences, i.e., the difference between each prediction and the observed mean, and the difference between each observation and observed mean. From another perspective, the IOA is a measure of the match between the departure of each prediction from the observed mean and the departure of each observation from the observed mean. A value of 0.5 is considered acceptable and >0.6 is considered good performance for time and space predictions.

Where:

N = number of observations

P_i = hourly model predictions

O_i = hourly observations

O_{mean} = observation mean

2.1.6 Skill measures

Skill measure statistics are given in terms of a score, rather than in absolute terms. A model's skill can be measured by the difference in the standard deviation of the modelled and observed values (Chang and Hanna, 2004).

The Skill_E (s_e) is indicative of how much of the standard deviation in the observations is predicted to be due to random/natural processes (unsystematic) in the atmospheric boundary layer. i.e., turbulence/chaos. For good model performance, the value for Skill_E should be less than one, i.e.:

SKILL_E = (RMSE_U/ STDEV OBS) < 1 shows skill

Skill_V (s_v) is ratio of the standard deviation of the model predictions to the standard deviation of the observations. For good model performance, the value for Skill_V should be close to one, i.e.:

SKILL_V = (STDEV_MOD/ STDEV _OBS) close to 1 shows skill

SKILL_R (s_r) takes into account systematic and unsystematic errors in relation to the observed standard deviation. For good model performance, the value for Skill_E should be less than one, i.e.:

SKILL_R = (RMSE/ STDEV _OBS) < 1 shows skill

2.2 Model Performance Evaluation

2.2.1 Horsley Park Equestrian Centre AWS

Table 2-1 Statistics for meteorological observations and TAPM model predictions

Parameter	Units	Source	Average	Standard deviation	Minimum	Maximum
Wind speed	m/s	Obs	2.2	1.7	0.0	9.7
		TAPM	2.9	1.6	0.5	12.3
U component	m/s	Obs	0.0	2.1	-7.0	9.0
		TAPM	0.3	2.4	-5.8	12.3
V component	m/s	Obs	0.4	1.9	-6.9	7.6
		TAPM	0.3	2.2	-6.3	9.0
Temperature	°C	Obs	17.6	6.4	-1.3	44.1
		TAPM	17.1	5.6	4.4	40.4

Table 2-2 Correlation statistics for TAPM meteorological model performance

Statistic	Ideal score	Wind speed	U component	V component	Temperature
Root Mean Square Error	0	1.6	1.6	1.6	2.4
Systematic RMSE	0	1.8	2.1	1.9	6.4
Unsystematic RMSE	0	1.6	2.4	2.2	5.6
Mean Error	0	0.6	0.3	-0.1	-0.5
Mean Absolute Error	0	1.2	1.2	1.2	1.9
Index of Agreement	1	0.8	0.9	0.8	1.0
$Skill_e$	< 1	1.0	1.2	1.2	0.9
$Skill_v$	1	1.0	1.2	1.2	0.9
$Skill_r$	< 1	0.9	0.8	0.9	0.4

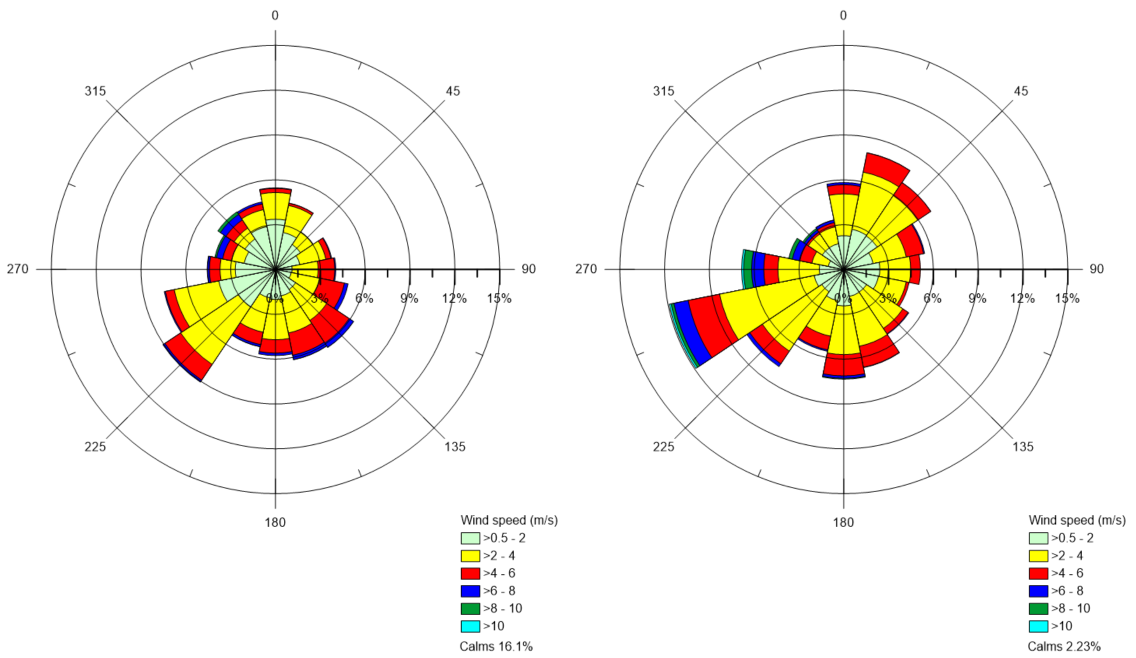

Figure 2-1 Distribution of observed (left) and modelled (right) winds

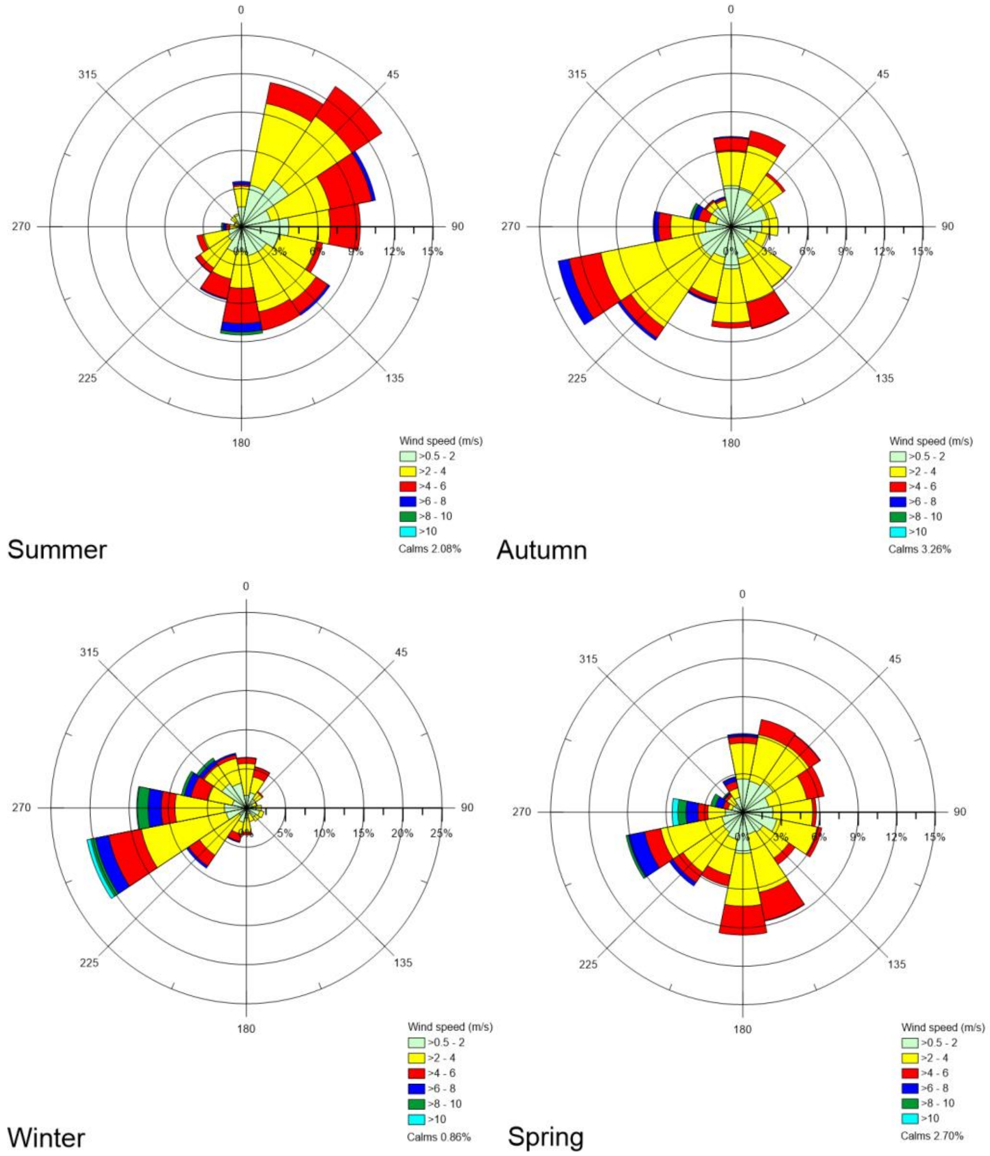

Figure 2-2 Seasonal distribution of modelled winds

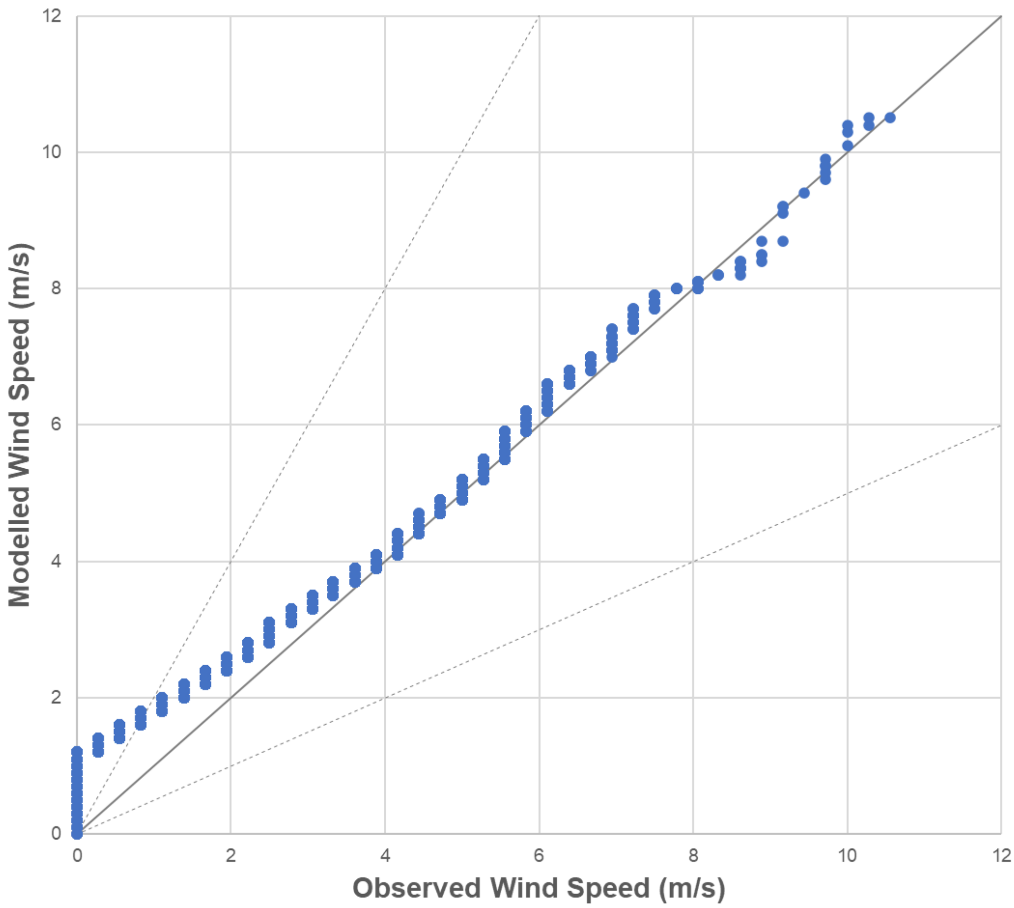

Figure 2-3 Quantile-quantile (QQ) plot

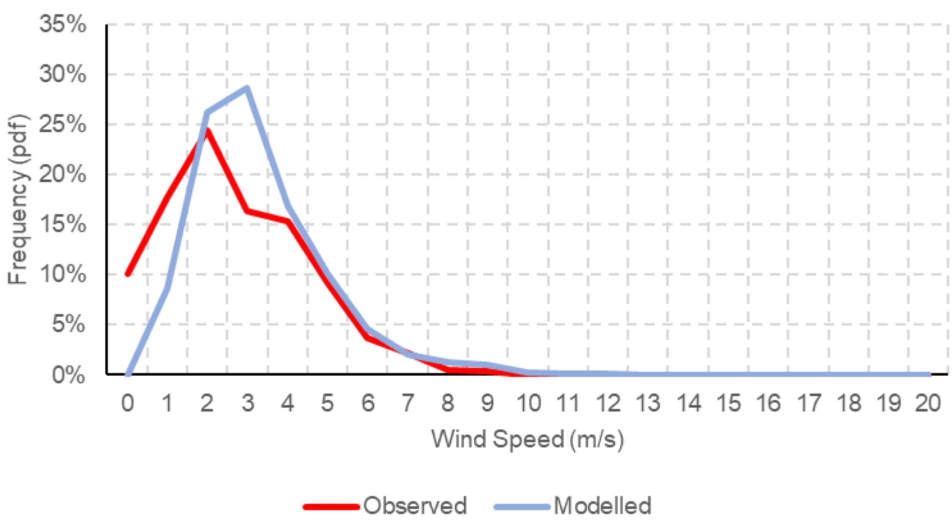

Figure 2-4 Distribution of wind speeds

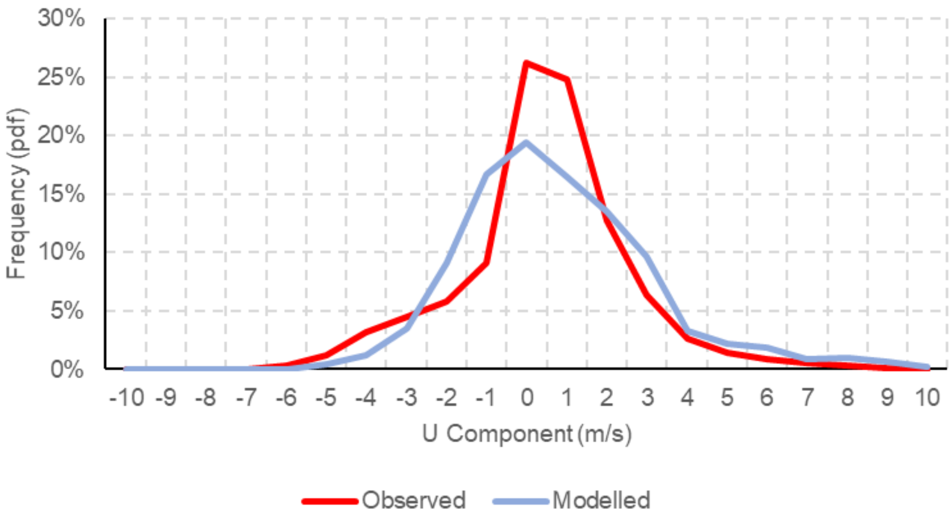

Figure 2-5 Distribution of U-component of wind

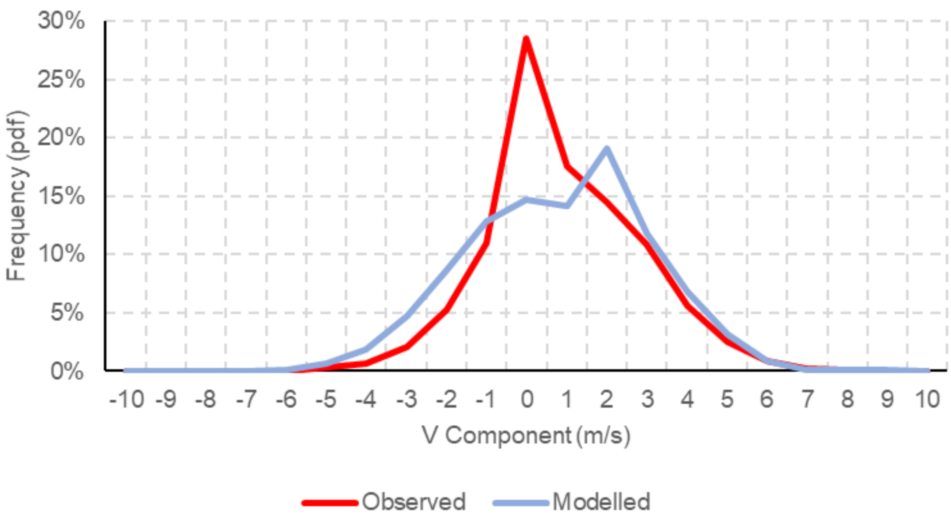

Figure 2-6 Distribution of V-component of wind

2.2.2 Prospect air quality monitoring station

Table 2-3 Statistics for meteorological observations and TAPM model predictions

Parameter	Units	Source	Average	Standard deviation	Minimum	Maximum
Wind speed	m/s	Obs	1.9	1.4	0.0	9.5
		TAPM	2.0	1.0	0.0	7.5
U component	m/s	Obs	0.1	1.6	-5.1	9.3
		TAPM	0.2	1.6	-3.7	7.4
V component	m/s	Obs	0.1	1.7	-7.9	5.7
		TAPM	0.0	1.6	-4.4	5.2
Temperature	°C	Obs	18.2	6.3	0.5	43.6
		TAPM	17.8	5.6	5.3	41.0

Table 2-4 Correlation statistics for TAPM meteorological model performance

Statistic	Ideal score	Wind speed	U component	V component	Temperature
Root Mean Square Error	0	1.0	1.1	1.2	2.1
Systematic RMSE	0	1.4	1.6	1.7	6.3
Unsystematic RMSE	0	1.0	1.6	1.6	5.6
Mean Error	0	0.1	0.0	-0.1	-0.4
Mean Absolute Error	0	0.8	0.8	0.9	1.7
Index of Agreement	1	0.8	0.9	0.9	1.0
$Skill_e$	< 1	0.8	1.0	0.9	0.9
$Skill_v$	1	0.8	1.0	0.9	0.9
$Skill_r$	< 1	0.7	0.7	0.7	0.3

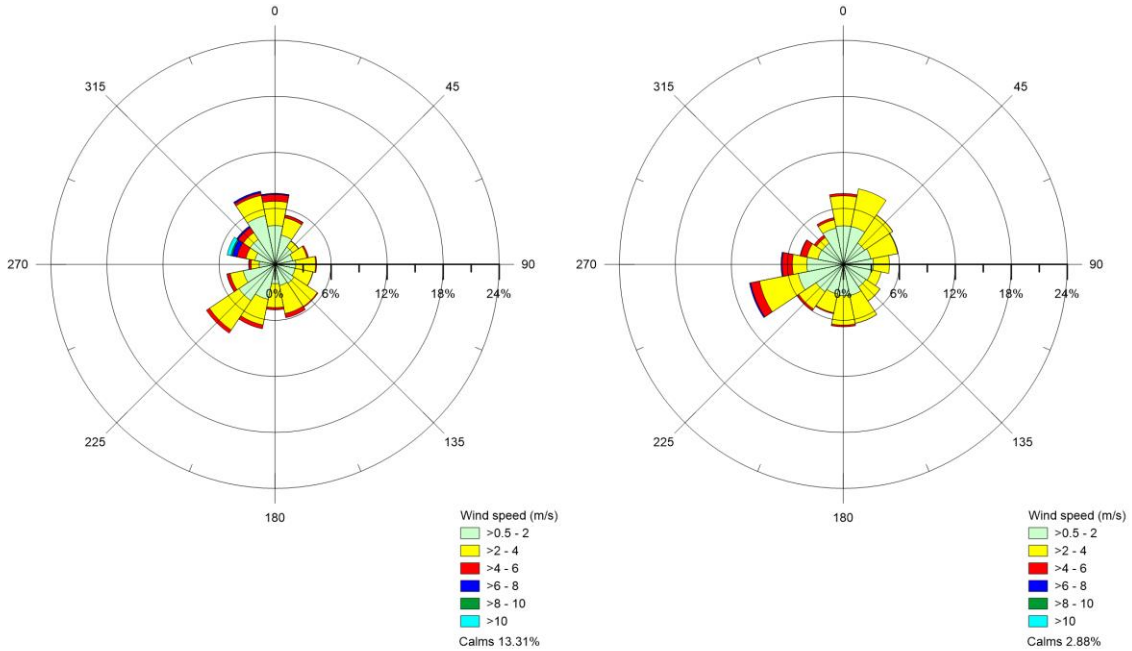

Figure 2-7 Distribution of ocreabserved (left) and modelled (right) winds

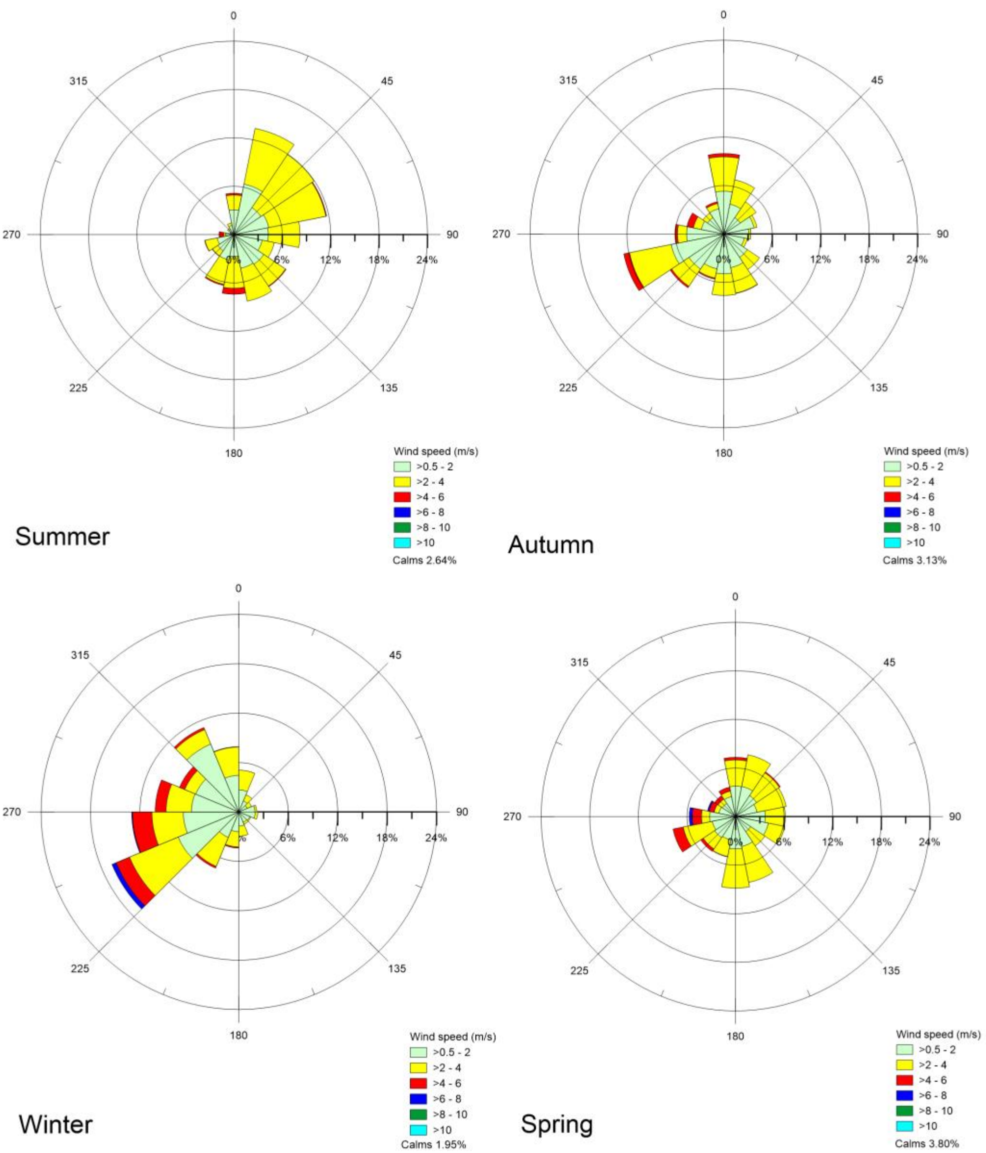

Figure 2-8 Seasonal distribution of modelled winds

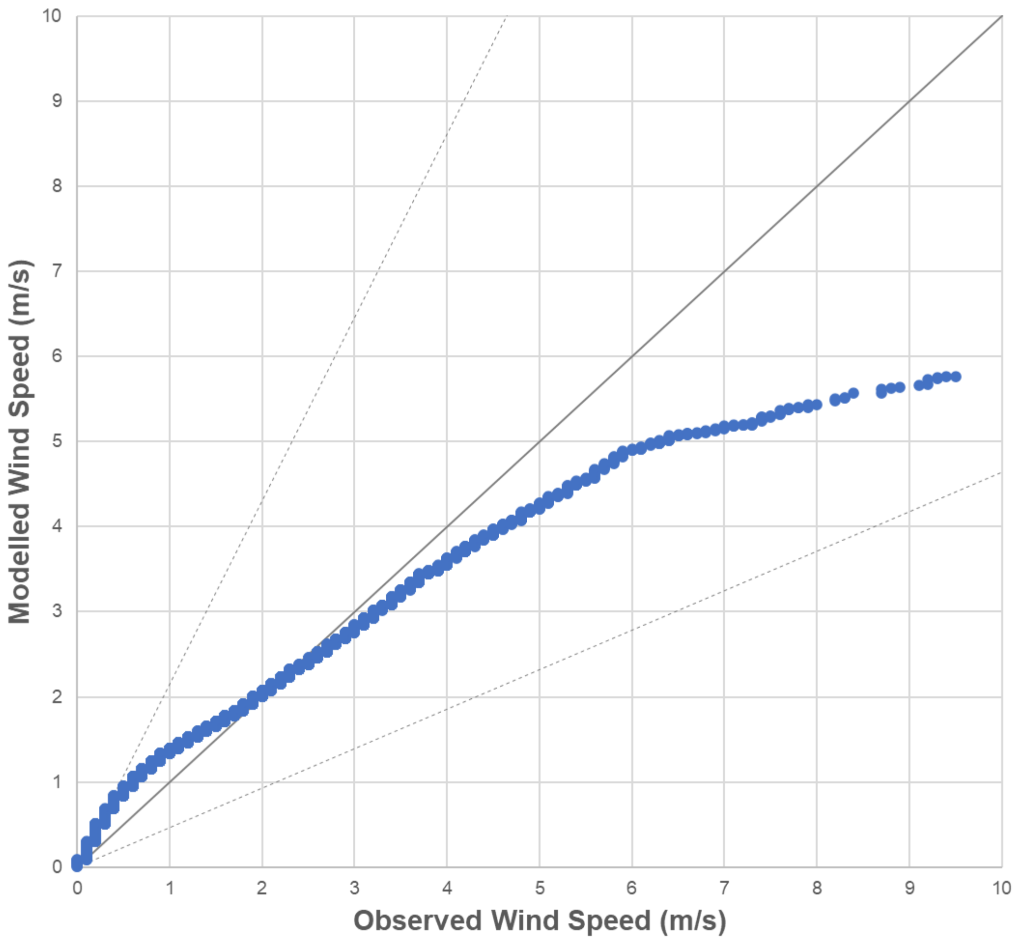

Figure 2-9 Quantile-quantile (QQ) plot of Horsley Park Eq Centre AWS

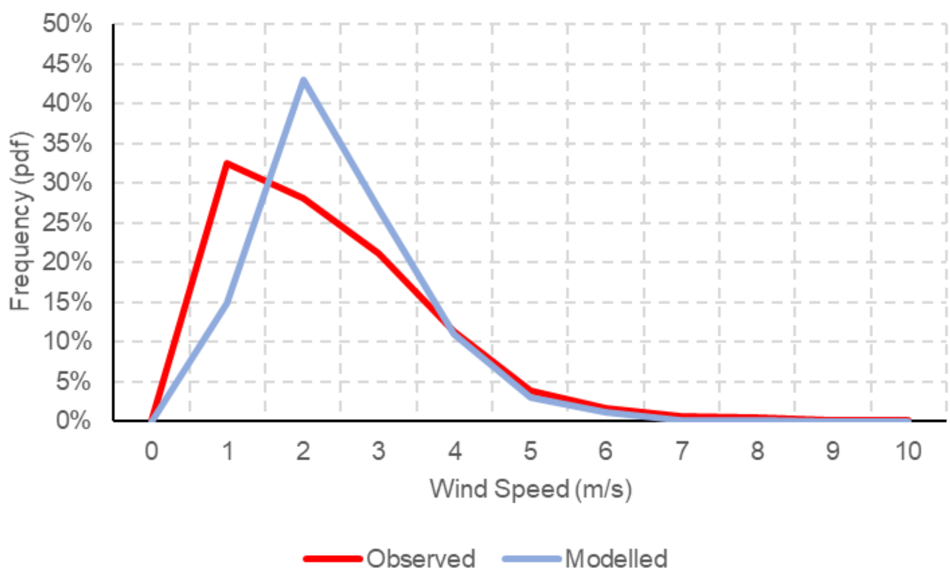

Figure 2-10 Distribution of wind speeds

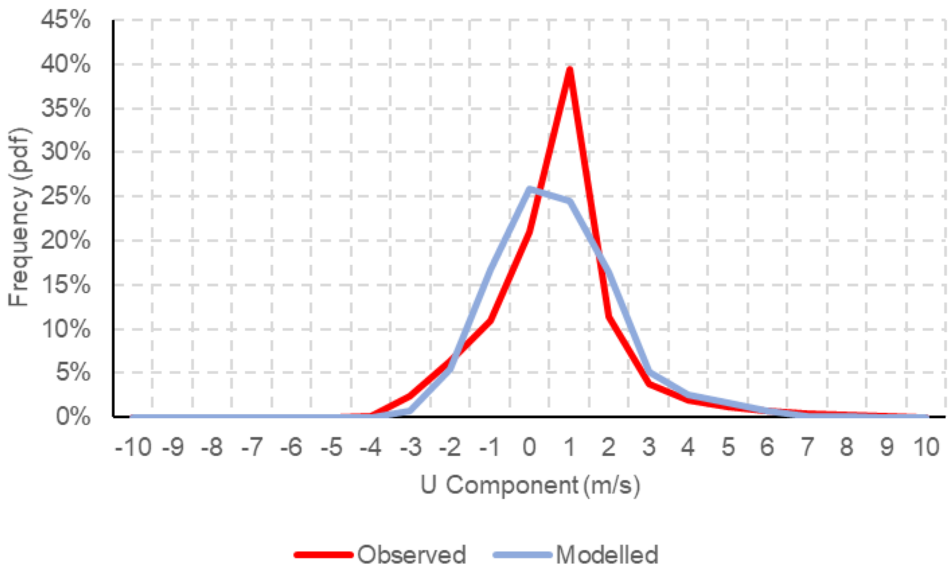

Figure 2-11 Distribution of U-component of wind

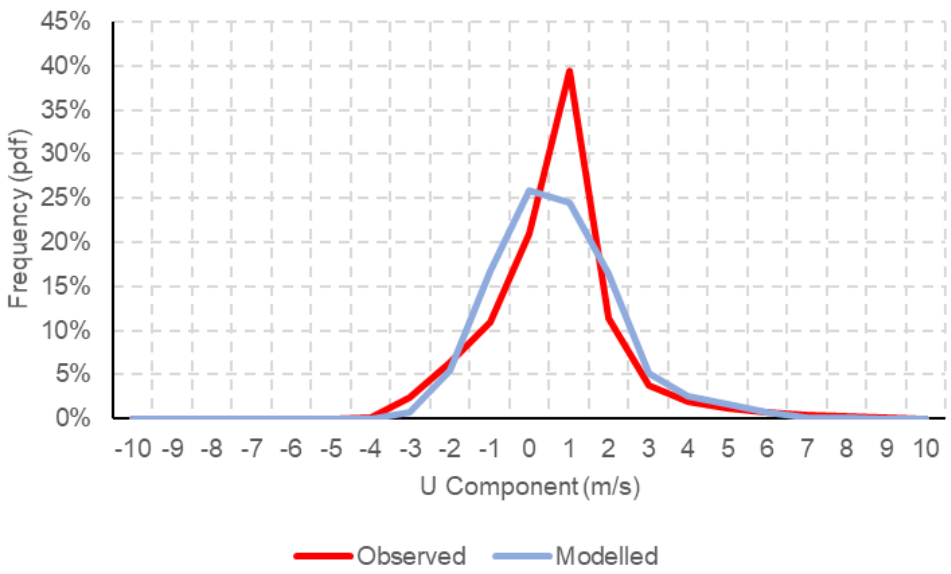

Figure 2-12 Distribution of V-component of wind

3 Dispersion modelling

3.1 CALPUFF modelling

CALPUFF (version 7.2.1) was configured based on information provided:

- Model configuration based on CALMET/CALPUFF model guidance document
- Computational domain equivalent to CALMET domain
- Sampling grid equivalent to computation domain
- Sources details for 3 POINTS and 60 VOLUME sources detailed in Section 1.
- Most sources modelled during operating hours only, except for wind erosion sources.
- 18 sensitive receptors (Table 3-3)
- Source and receptor elevations extracted from CALMET terrain information (using grid residuals)
- Air pollutants listed in Section 3.2.
- Dust modelled as particles with size distributions to account for deposition. Grouped into TSP, PM_{10}, and $PM_{2.5}$ for processing concentrations.
    - Size A (> 10 µm, average mean diameter: 20 µm) = [TSP] – [PM_{10}]
    - Size B (2.5 – 10 µm, average mean diameter: 7.5 µm) = [PM_{10}] – [$PM_{2.5}$]
    - Size C (<2.5 µm, average mean diameter: 2.5 µm) = [$PM_{2.5}$]

3.2 Air pollutants

The dispersion modelling study was conducted to assess potential impacts due to the proposed upgrade of the operations at the facility.

Table 3-2 lists the pollutants expected to be emitted from the activities at the facility.

Table 3-1 Air pollutants and sources

Source	Pollutants
Material handlings Transfer of materials Conveyors Trucks dumping materials Wind erosion from stockpiles Wheel-generated dust from paved roads	fugitive dust (TSP, PM_{10}, $PM_{2.5}$)
Oxy cutter	odour particulate matter from combustion (TSP) Ag, Al, As, Ba, Be, Ca, Cd, Co, Co II, Cr, Cu, Fe, Fe II,III, Hg, K, Li, Mg, Mg IV, Mn, Mo, Na, Ni, NO_X, P, Pb, Sb, Se, Sn, Th, TSP, Zn
Hammermill west scrubber stack	odour particulate matter from combustion (TSP, PM_{10}, $PM_{2.5}$) As, Be, Cd, Cl2, Co, Cr, CrVI, Cu, Fe, H2S, HCl, HF, Hg, Mn, Ni, NOX, OU.m3/s, Pb, PM10, PM2.5, Sb, Se, Sn, Ti, TSP, V, W, Zn

3.3 Cumulative assessment

Table 3-2 Background concentrations to be used in the cumulative assessment

Pollutant	Averaging Period	Concentration	Notes
TSP	annual	45.01	estimated on a TSP:PM_{10} ratio of 2.0551 : 1
PM_{10}	24-hour	daily varying	The 24-hour maximum for PM_{10} in 2018 was 113.3 µg·m-3 (exceeding the criterion)
	annual	21.9	
$PM_{2.5}$	24-hour	daily varying	The 24-hour maximum for $PM_{2.5}$ in 2015 was 47.5 µg·m-3 (exceeding the criterion)
	annual	8.5	
Dust deposition	annual	2 g/m²/month	difference in NSW DPIE maximum allowable and incremental impact criterion
NO_2	1-hour	224.7	hourly max 1-hr average in 2018
	annual	39.8	annual average in 2018

3.4 Sensitive Receptors

Table 3-3 Receptor Locations (WGS-84 UTM Zone 56S)

Receptor Id	Easting m	Northing m	Elevation (m)
R1	306993	6263656	49.81
R2	306975	6263528	48.97
R3	306963	6263414	49.5
R4	305627	6263452	38.57
R5	305527	6263624	38.31
R6	305475	6263762	38.52
R7	305584	6264114	43.00
R8	306081	6264458	60.10
R9	307080	6264227	58.55
R10	306442	6263762	43.24
R11	306531	6263749	43.57
R12	306602	6263739	44.13
R13	306653	6263748	44.91
R14	306728	6263659	45.41
R15	306723	6263581	45.93
R16	306489	6263446	45.11
R17	306406	6263371	44.52
R18	306325	6263369	43.27
R19	306423	6263682	42.38
R20	307599	6264228	56.57
R21	307887	6263160	67.61
R22	306919	6263049	53.84
R23	307124	6262564	64.93
R24	306559	6262232	55.86
R25	305557	6263991	42.33
R26	305892	6262648	43.24
R27	305458	6262957	42.51
R28	306709	6262724	51.64
R29	307037	6263846	50.45
R30	306386	6264424	59.99
R31	306723	6264372	57.35
R32	305695	6264456	50.68
R33	305974	6262378	46.82
R34	306589	6263715	43.48
R35	306434	6263491	43.92

3.5 Emissions Sources

Table 3-4 Source parameters and dust emission rates for point sources

Parameter	Units	Source 1	Source 2
Src Id	-	C1Oxy	WSS01
Description	-	oxycutter metal cutting at scrap area	hammermill wet scrubber stack
Easting	m	306613	306567
Northing	m	6263608	6263613
Elev	m	44.73	44.21
Operation hours	#	6	15
Start time	hh:mm	09:00	06:00
End time (exc)	hh:mm	15:00	21:00
Stack height	m	1.0	16.7
Stack Diameter	m	0.05	0.595
Exit velocity	m/s	14.00	49.98
Stack temperature	° C K	31 304.15	27 300.15
TSP emission rate	g/s	2.17E-02	7.50E-02
PM_{10} emission rate	g/s	-	5.33E-02
$PM_{2.5}$ emission rate	g/s	-	3.33E-02

Table 3-5 Emission rates (g/s) for point sources

Pollutant	C1Oxy	WSS01
Odour (OU m³/s)	250	12,160
Ag	1.50E-07	-
Al	2.83E-05	-
As	3.33E-06	1.67E-05
Ba	5.00E-05	-
Be	1.33E-07	6.67E-06
Ca	5.00E-05	-
Cd	1.17E-07	5.00E-06
Cl_2	-	8.33E-05
Co	3.33E-07	6.67E-06
Co II	6.33E-06	-
Cr	1.27E-06	1.83E-05
Cr VI	-	3.33E-05
Cu	5.17E-06	2.00E-05
Fe	5.50E-03	2.33E-04
Fe II,III	2.33E-02	-
H_2S	-	5.00E-05
HCl	-	8.33E-05
HF	-	8.33E-05
Hg	8.33E-08	2.17E-05
K	3.33E-05	-
Li	1.50E-07	-
Mg	3.33E-05	-
Mg IV	1.47E-04	-
Mn	9.17E-05	4.17E-05
Mo	8.33E-07	-
Na	3.33E-05	-
Ni	1.57E-06	3.33E-05
NO_X	5.50E-04	3.33E-02
P	1.52E-05	-
Pb	3.33E-06	4.67E-05
Sb	1.17E-06	1.33E-04
Se	1.17E-06	5.00E-05
Sn	5.33E-07	1.67E-05
Th	5.00E-07	-
Ti	-	1.27E-05
V	-	3.33E-05
W	-	1.17E-05
Zn	1.83E-04	1.50E-03

Table 3-6 Volume sources – modelled as windspeed dependent volume sources during hours of operation (21 Hours: 06:00 am to 09:00 pm)

Id	Easting (m)	Northing (m)	Elev (m)	Rel Ht (m)	σ_y (m)	σ_z (m)	Initial Control (%)	Enclosure (%)	Spray (%)	Drop Ht (%)	Total Reduction (%)	Throughput (tpd)	Throughput (tph)
MH01	306607	6263635	44.42	4.00	1.02	0.37	70%	-	-	-	70%	150	10.0
MH02	306519	6263572	44.13	3.50	1.02	2.16	70%	-	-	30%	79%	1,500	100.0
MH03	306503	6263664	43.03	4.00	1.02	0.37	70%	-	-	30%	79%	1,500	100.0
MH04	306509	6263576	43.99	3.50	1.02	2.16	70%	-	-	30%	79%	600	40.0
MH05	306522	6263569	44.19	4.00	1.02	0.37	70%	-	-	30%	79%	600	40.0
MH06	306523	6263581	44.08	2.00	1.02	2.16	70%	-	-	30%	79%	600	40.0
MH07	306503	6263664	43.03	4.00	1.02	0.37	70%	-	-	30%	79%	600	40.0
MH08	306503	6263664	43.03	2.00	1.02	2.16	70%	-	-	30%	79%	2,100	140.0
MH09	306483	6263652	42.94	2.00	1.02	0.37	70%	-	-	30%	79%	2,100	140.0
MH10	306542	6263691	43.19	3.50	0.84	2.21	70%	-	-	-	70%	1,050	70.0
MH11	306533	6263680	43.20	4.00	0.84	0.37	70%	-	-	-	70%	1,050	70.0
MH12	306633	6263573	45.24	3.50	0.84	2.21	70%	-	-	-	70%	384	25.6
MH13	306561	6263643	43.86	4.00	0.84	0.37	70%	-	-	-	70%	150	10.0
MH14	306603	6263616	44.55	4.00	0.84	0.37	70%	-	-	-	70%	384	25.6
TP01	306525	6263577	44.14	7.00	0.47	0.23	0%	70%	50%	-	85%	600	40.0
TP02	306517	6263691	42.9	1.00	0.47	0.09	0%	70%	50%	30%	89.5%	1,610	107.3
TP03	306529	6263701	42.94	1.00	0.47	0.09	0%	70%	50%	30%	89.5%	1,610	107.3
TP04	306541	6263711	42.98	7.00	0.47	0.23	0%	70%	50%	30%	89.5%	1,550	103.4
TP05	306512	6263687	42.88	1.00	0.47	0.09	0%	70%	50%	30%	89.5%	79	5.2
TP06	306494	6263732	42.74	3.00	0.70	0.09	0%	70%	50%	30%	89.5%	471	31.4
TP07	306563	6263721	43.27	3.00	0.70	0.09	0%	70%	50%	30%	89.5%	471	31.4
TP08	306551	6263643	43.75	3.00	0.70	0.09	0%	70%	50%	30%	89.5%	471	31.4
CV01	306484	6263660	42.87	2	1.4	0.47	85%	-	-	-	85%	1800	120.0
CV02	306486	6263672	42.76	2	1.4	0.47	85%	-	-	-	85%	1800	120.0
CV03	306489	6263687	42.64	2	1.4	0.47	85%	-	-	-	85%	1800	120.0
CV04	306489	6263694	42.57	3.5	0.47	0.81	85%	-	-	-	85%	1800	120.0
CV05	306513	6263691	42.86	1	0.47	0.23	85%	-	-	-	85%	1354	90.3
CV06	306520	6263693	42.92	1	0.47	0.23	85%	-	-	-	85%	1354	90.3
CV07	306527	6263699	42.94	1	0.47	0.23	85%	-	-	-	85%	1354	90.3
CV08	306534	6263704	42.97	3.5	0.47	0.81	85%	-	-	-	85%	1354	90.3
CV09	306538	6263708	42.97	3.5	0.47	0.81	85%	-	-	-	85%	1354	90.3
CV10	306514	6263695	42.83	1	0.47	0.23	85%	-	-	-	85%	69	4.6
CV11	306515	6263702	42.77	1	0.47	0.23	85%	-	-	-	85%	69	4.6
CV12	306516	6263711	42.69	1	0.47	0.23	85%	-	-	-	85%	69	4.6
CV13	306491	6263710	42.42	3	0.7	0.7	85%	-	-	-	85%	377	25.1
CV14	306492	6263718	42.38	3	0.7	0.7	85%	-	-	-	85%	377	25.1
CV15	306493	6263727	42.61	3	0.7	0.7	85%	-	-	-	85%	377	25.1
CV16	306503	6263732	42.84	3	0.7	0.7	85%	-	-	-	85%	411	27.4

Id	Easting (m)	Northing (m)	Elev (m)	Rel Ht (m)	σ_y (m)	σ_z (m)	Initial Control (%)	Enclosure (%)	Spray (%)	Drop Ht (%)	Total Reduction (%)	Throughput (tpd)	Throughput (tph)
CV17	306512	6263731	42.92	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV18	306522	6263729	42.98	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV19	306533	6263727	43.06	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV20	306542	6263726	43.14	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV21	306551	6263725	43.22	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV22	306558	6263724	43.27	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV23	306558	6263713	43.15	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV24	306556	6263703	43.22	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV25	306555	6263693	43.31	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV26	306553	6263683	43.39	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV27	306552	6263674	43.46	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV28	306551	6263663	43.56	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV29	306550	6263653	43.65	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV30	306551	6263643	43.75	3	0.7	0.7	85%	-	-	-	85%	411	27.4
CV31	306557	6263635	43.90	5	0.7	1.16	85%	-	-	-	85%	411	27.4
CV32	306562	6263625	44.04	5	0.7	1.16	85%	-	-	-	85%	411	27.4
CV33	306567	6263617	44.17	5	0.7	1.16	85%	-	-	-	85%	411	27.4
TRKD01	306502	6263580	43.88	4.0	1.0	1.0	70%	-	-	-	70%	2,634	175.6
TRKD02	306503	6263664	43.03	4.0	1.0	1.0	70%	-	-	-	70%	600	40

Table note: [a] Hourly varying emission rates calculated using Equation A.

Table 3-7 Wind erosion (24 hours) – modelled as hourly varying volume source

Id	Easting (m)	Northing (m)	Elev (m)	Rel Ht (m)	σ_y (m)	σ_z (m)	Control (%)	TSP (g/s) [a]	PM_{10} (g/s) [a]	$PM_{2.5}$ (g/s) [a]
WE01	306494	6263578	43.83	4.0	2.33	3.26	0%	1.92E-03	9.59E-04	7.67E-04
WE02	306507	6263543	44.32	4.0	2.33	3.26	0%	1.26E-03	6.28E-04	5.03E-04
WE03	306631	6263571	45.25	4.0	1.16	3.26	0%	6.16E-03	3.08E-03	2.47E-03
WE04	306503	6263664	43.03	4.0	2.33	3.26	0%	7.52E-03	3.76E-03	3.01E-03
WE05	306542	6263709	43.01	4.0	2.33	3.26	0%	8.90E-04	4.45E-04	3.56E-04
WE06	306544	6263695	43.17	4.0	2.33	3.26	0%	8.90E-04	4.45E-04	3.56E-04

Table note: [a] Hourly varying emission rates calculated using Equation B.

Table 3-8 Wheel-generated dust (paved roads) – modelled with constant emission rates during hours of operation (21 Hours: 06:00 am to 09:00 pm)

Id	Easting (m)	Northing (m)	Elev (m)	Rel Ht (m)	σ_y (m) [a]	σ_z (m) [b]	Initial Control (%)	Additional control (%)	Total reduction (%)	TSP (g/s) [c]	PM_{10} (g/s) [d]	$PM_{2.5}$ (g/s) [e]
Rd01	306464	6263726	42.42	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd02	306453	6263650	42.78	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd03	306457	6263600	43.26	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd04	306494	6263612	43.47	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd05	306499	6263532	44.35	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd06	306538	6263569	44.34	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd07	306589	6263616	44.40	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd08	306566	6263533	44.96	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd09	306670	6263569	45.64	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd10	306567	6263717	43.22	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd11	306686	6263700	44.70	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd12	306557	6263653	43.72	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd13	306681	6263617	45.34	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd14	306640	6263614	44.95	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd15	306637	6263528	45.67	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04
Rd16	306456	6263548	43.72	10	3.72	4.65	30%	50%	65%	1.71E-02	3.27E-03	7.92E-04

Table note:

[a] Estimated based on an assumed road width of 8 m. SigmaY = [Road length] / 2.15 – based on standard modelling assumptions (AERMOD modelling guidance for volume sources)

[b] SigmaZ = [Effective height] / 2.15 – based on standard modelling assumptions (AERMOD modelling guidance for volume sources)

[c] Total TSP emissions from unpaved roads = 1.96 kg/hr = 0.55 g/s. Distributed evenly between 16 sources.

[d] Total PM_{10} emissions from unpaved roads = 0.38 kg/hr = 0.10 g/s. Distributed evenly between 16 sources.

[e] Total $PM_{2.5}$ emissions from unpaved roads = 0.09 kg/hr = 0.03 g/s. Distributed evenly between 16 sources.

Equation A:

$$ER = EF * A * (1 - CF) * 1000/3600$$

$$EF = k * 0.0016 * \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{2}{2}\right)^{1.4}}$$

ER	emission rate (g/s)
EF	emission factor (kg/t)
A	throughput (t/h)
CF	control factor (%)
k	particle size multiplier (dimensionless): TSP: 0.74; PM_{10}: 0.35; $PM_{2.5}$: 0.053
U	hourly wind speed (m/s)
M	material moisture content (%) – assumed 2% based on information provided

Equation B:

$$WeightFactor_{hr} = \begin{cases} 0 & U \leq 3.1 \\ \frac{(U^*{}_{hr} - U^*{}_t)^3}{\sum_{hr=1}^{8760}(U^*{}_{hr} - U^*{}_t)^3} & U > 3.1 \end{cases}$$

$$ER_{TSP,hr} = WeightFactor_{hr} * ER_{TSP}$$

$$ER_{PM10,hr} = WeightFactor_{hr} * ER_{PM10}$$

$$ER_{PM2.5,hr} = WeightFactor_{hr} * ER_{PM2.5}$$

$WeightFactor_{hr}$	hourly weighting factor
U^*	wind speed (m/s)
U^*	friction velocity (m/s) – assumed to be 0.11 * U
$U^*{}_t$	threshold friction velocity (m/s) for 3.1 m/s
$ER_{TSP,hr}$	hourly emission rate – TSP (g/s)
$ER_{PM10,hr}$	hourly emission rate – PM_{10} (g/s)
$ER_{PM2.5,hr}$	hourly emission rate – $PM_{2.5}$ (g/s)
ER_{TSP}	annual average emission rate – TSP (g/s)
ER_{PM10}	annual average emission rate – PM_{10} (g/s)
$ER_{PM2.5}$	annual average emission rate – $PM_{2.5}$ (g/s)