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Nyrstar Port Pirie Smelter Transformation Proposal
Public Environmental Report

Appendices

LIST OF APPENDICES

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Appendix A:
Acoustic impact assessment

Nyrstar

Port Pirie Smelter Upgrade

Acoustic Assessment

R001

Issue | 25 July 2013

Job number 230587-00

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APPENDIX A

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1 Executive Summary

Measured noise levels from the Port Pirie smelter meet the existing noise limits; however unusual site activities such as equipment maintenance or mobile plant use near boundaries may cause noise limits to be exceeded at times. There is no significant vibration from the smelter outside its boundary.

The predicted noise level for the Transformation meets the noise limits.

The change in operational noise level due to the Transformation is predicted to be in the order of 1 dB and is considered to be unnoticeable at sensitive receivers with respect to the existing noise level. In some cases it is predicted that noise will decrease due to the new configuration and location of noise sources on the upgraded site.

The character of the noise is not predicted to change or contain any noticeable tones, impulse, modulation or low frequency content.

New and upgraded plant items are not expected to introduce any further or increased vibration sources into the smelter and therefore vibration levels for the Transformation are expected to remain below the vibration limits.

On this basis, no specific noise or vibration mitigation recommendations are proposed for the Transformation following construction.

Construction noise may potentially impact on the acoustic amenity of sensitive receivers at times; therefore practicable measures to reduce this impact must be taken. The recommended measures include:

- community contact and communication
- activity scheduling and planning
- considering plant noise emissions and mitigating where practical.

The predicted vibration levels for construction are not considered to be perceptible to humans at receiver locations.

2 Introduction

Nyrstar's lead smelter is located at Port Pirie, approximately 230 km north of Adelaide, South Australia. Noise sensitive receivers are located to the West and South of the smelter, with the nearest noise sensitive receiver approximately 450 m from significant noise sources associated with the smelter.

The smelter has operated continuously since 1889, with periods of shutdown for equipment maintenance and replacement.

A major upgrade of the smelter is proposed which includes replacement of existing plant items and introduction of new plant items. The Port Pirie Smelter Transformation (Transformation) includes the following changes:

- decommissioning of the existing sinter plant
- new oxygen enclosed bath smelting furnace
- new sulphuric acid plant
- new electricity cogeneration plant.

Operational and construction noise and vibration must be controlled to meet noise limits provided in the South Australia Environmental Protection (Noise) Policy 2007[1].

To meet these requirements, noise from new or upgraded plant items associated with the Transformation must be assessed with respect to noise limits.

Nyrstar engaged Arup to undertake an assessment of noise and vibration emissions from the Transformation. This assessment includes:

- noise and vibration criteria
- noise and vibration measurement of existing sources
- noise and vibration prediction
- operational and construction noise and vibration assessment.

In principle mitigation or noise level recommendations are provided where required.

This assessment takes into account the most recent available information and all relevant assumptions are provided. The assumptions provided in this assessment must be considered as part of the detailed design, and further noise assessment or measurement may be required to confirm compliance.

Acoustic terminology is presented in Appendix A.

[1] South Australia Government, *Environmental Protection (Noise) Policy*, 2007 (Version 31.3.2008)

3 Site Description

3.1 Locality

Port Pirie is a town located approximately 230 km north of Adelaide, South Australia. The smelter is located within an Industrial Zone (*Pasminco Metals Policy Area 15*[2]) on Ellen Street, north of the Town Centre.

The Industrial Zone (*Policy Area 15*) is bordered by a Residential Zone to the south west and a Public Purposes Zone, Commercial Zone and Industrial Zone to the south. The Regional Centre Zone, which includes residential receivers, is located approximately 150 m from the Industrial Zone (*Policy Area 15*) boundary to the south, beyond the interfacing Commercial and Public Purposes Zones. The nearest residential receiver is approximately 450 m from significant noise sources associated with the smelter.

The Rural Coastal Zone interfaces with the Industrial Zone (*Policy Area 15*) to the west and north as well as to the east over the Port Pirie River. However, it does not include any noise sensitive receivers and therefore has not been considered further in this noise assessment.

The Industrial Zone (*Policy Area 15*) accommodates major special industry and associated minor industry and includes an objective to maintain a *substantial visual and acoustic buffer between any development in this zone and the adjacent zones*.

The location of the Port Pirie smelter with respect to surrounding areas is provided in Figure 1 below, with Council zones relevant to this assessment marked.

[2] Department of Planning, Transport and Infrastructure, *Port Pirie (RC) Development Plan*, Consolidated 10 January 2013.

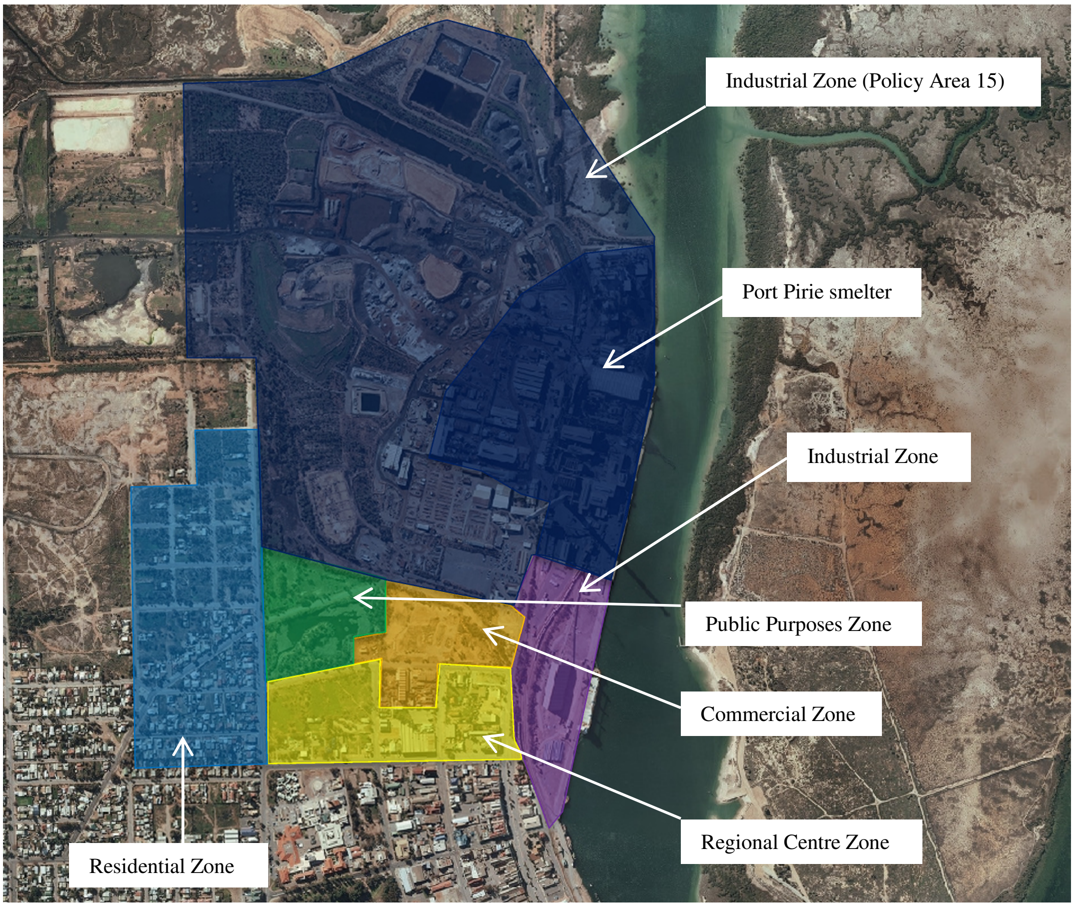

Figure 1: Location of Port Pirie smelter and surrounding Development Plan zones.

3.1.1 Existing Smelter

The smelter includes areas of processing plant, storage (e.g. stockpiling or warehousing) and offices. Noise generating plant items are generally located to the east of the Industrial Zone (*Policy Area 15*) and adjacent to the Port Pirie River.

Deliveries of feed materials come to the smelter by ship or rail. The railway enters the site from the south east corner of the smelter and is received at a nearby tippler. Deliveries coming from the ship are directly unloaded to storage sheds located north east of the smelter.

Some mobile plant items operate within the smelter. Mobile plant that is considered to have a significant noise impact includes front end loaders, forklifts and some heavy transport vehicles, mainly associated with furnaces and the refinery. These vehicles include reversing alarms.

A general layout of the smelter relevant to this acoustic assessment, including plant infrastructure considered to emit significant noise, is provided in Figure 2 below.

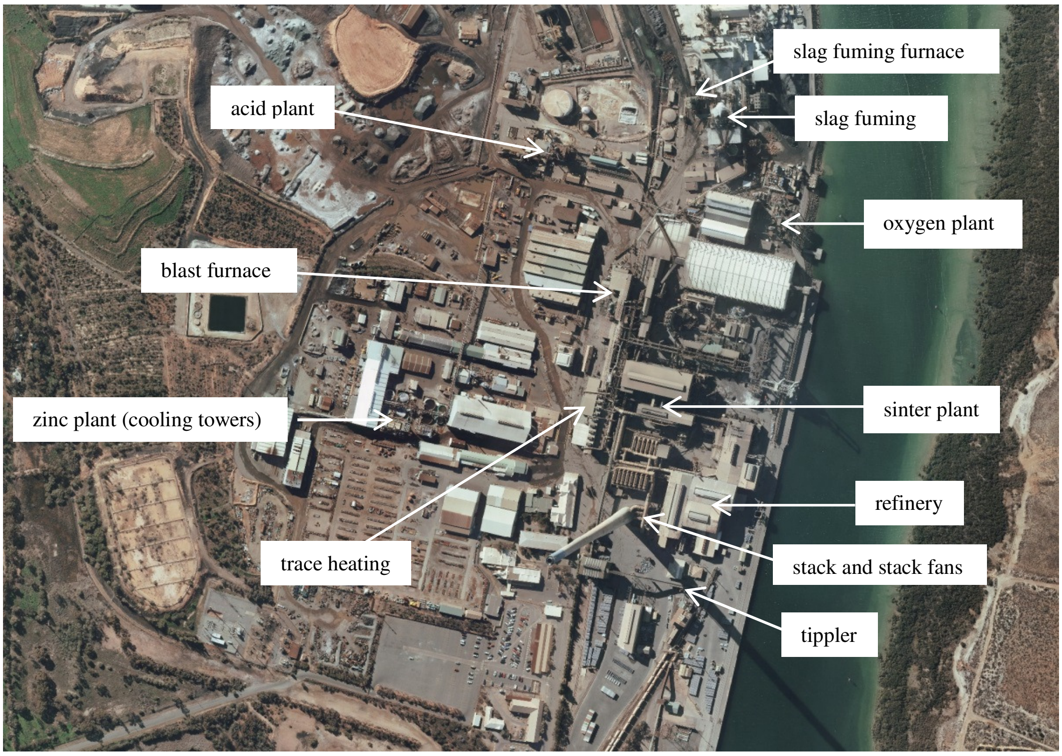

Figure 2: Port Pirie smelter showing noise emitting plant infrastructure.

3.1.2 Proposed Smelter Upgrade

The Transformation will allow for advanced poly-metallic processing and recovery. Broadly, this upgrade includes the following significant changes:

- decommissioning of the existing sinter plant
- new oxygen enclosed bath smelting furnace
- new sulphuric acid plant
- new electricity cogeneration plant.

Three brands of EBS furnaces are being considered. They differ mainly in the application of fuel (top or bottom lancing). On this basis, the noise levels are not considered to vary significantly between the technologies and a noise level for a bath smelting furnace has been determined and used in this assessment.

The Transformation may be rolled out in stages; however this assessment assumes final operation at full capacity. Options are also being considered that either retain the existing blast furnace or replace this furnace with an enclosed bath smelting furnace. For this assessment, it has been assumed that the blast furnace is retained to take a conservative approach for noise assessment (i.e. the blast furnace is considered louder than a new bath smelting furnace).

For the purpose of noise assessment, the following changes are considered:

- decommissioning of the existing sinter plant
- decommissioning of the existing acid plant
- new oxygen enclosed bath smelting furnace
- new waste heat boiler

- new cooling tower
- new cogeneration power plant
- new/increased capacity oxygen production plant
- new fuel coal preparation and conveying plant (includes fans and mill)
- new sulphuric acid plant
- upgrade to the existing reduction furnace

In addition to the above plant changes, buildings that are expected to be demolished as part of the Transformation have been considered as part of the assessment.

It should be noted that the Transformation includes a general increase in site hygiene, including the addition of hoods, chutes and ducts to existing conveyor and transfer points as well as hygiene capture directed to the existing brick flue, bag house and tall stack system. While this is expected to decrease the noise level of existing plant items, it has not been explicitly allowed for in this noise assessment, further allowing for a conservative approach to noise assessment.

3.1.3 Smelter Operations

Generally, the smelter operates continuously and therefore the worst case assessment undertaken in this report is for the night-time period.

In some cases, plant operations may shut down due to maintenance requirements and some smaller items of plant such as steam outlets, valves, pumps or motors may only operate periodically.

For this assessment, it is considered that all significant plant items are operating simultaneously and continuously, including equipment associated with raw material delivery and mobile plant items.

As some plant items operate periodically, it is expected that the worst case assessment undertaken in this report would rarely occur and that on this basis, the assessment is considered to be conservative.

4 Noise and Vibration Limits

The Port Pirie Smelter Transformation Public Environment Report Guidelines[3] (PER Guidelines) make reference to the South Australian Environmental Protection Act[4] and specifically require noise and vibration assessment with respect to the South Australian Environment Protection (Noise) Policy[1] **Error! Bookmark not defined.** (The EPP).

Operational and construction noise will be assessed against the EPP.

Vibration is not addressed in the EPP and legislation does not exist in Australia or been identified in the PER Guidelines, therefore guidance will be taken from Australian Standards as detailed below.

4.1 Operational Noise

Operational noise limits have been determined in accordance with EPP and in consultation with the Environment Protection Authority (EPA).

The defined land use category determines an 'indicative noise level' under clause 5 of the EPP. The land use and zoning that are used to determine the 'indicative noise level' is provided in Table 1 below.

Council Zone	**Promoted Land Use**	**EPP Land Use Category**
Residential	Residential	Residential
Regional Centre	Commercial	Commercial
Rural Coastal*	Farming, (Excluding Residential)	Rural Industry
Public Purposes**	Commercial	Commercial
Commercial, Policy Area 13	Commercial	Commercial
Industrial Zone, Policy Area 23***	Industry (Specifically Port Related)	Industrial
Industrial Zone, Policy Area 15	Major mineral processing industry	Special Industry

*No buildings exist in this zone

**Although zoned for public purposes, this land is fenced off from public access

***No sensitive receivers exist in this zone

Table 1: Applied EPP land use categories.

A zone that is greater than 100 m exists between the Industrial Zone (*Policy Area* 15) and the Regional Centre Zone to the south of the smelter and therefore the EPP clause 5 (subclause 6) is taken into account.

A summary of the 'indicative noise levels' as defined in the EPP and applicable to the smelter is provided in Table 2 below.

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[3] Development Assessment Commission South Australia, *Guidelines for the Preperation of a Public Environmental Report for the Port Pirie Smelter Transformation Proposal (Mid North)*, 10 May 2013.

[4] South Australia Government, *Environment Protection Act*, 1993

Receiver Location	Indicative Noise Level	
	Daytime (0700 to 2200)	Night-time (2200 to 0700)
Residential (West)	61	53
Regional Centre (South)	62	55
Rural Coastal	64	55
Public Purposes (South)	66	58
Commercial (South)	66	58
Industrial (South)	68	58

Table 2: EPP 'Indicative Noise Level'.

For existing plant at the smelter, the noise limit is equal to the indicative noise level. The noise limits for existing plant at the smelter are provided in Table 3 below.

Receiver Location	Noise Limit, $dBL_{Aeq,\ 15\ minute}$	
	Daytime (0700 to 2200)	Night-time (2200 to 0700)
Residential (West)	61	53
Regional Centre (South)	62	55
Rural Coastal	64	55
Public Purposes (South)	66	58
Commercial (South)	66	58
Industrial (South)	68	58

Table 3: Noise limits for existing plant items.

For new or upgraded plant items associated with the Transformation, the EPA has confirmed that Part 5, clause 20 of the EPP for 'new developments' is applicable. The following changes to noise limits apply under clause 20:

- The noise limit is the 'indicative noise level' less 5 dB(A); and
- Residential receivers are considered to be in a 'quiet locality' and noise limits are based on World Health Organization limits instead of the 'indicative noise level'.

For new or upgraded plant items associated with the Transformation, the noise limits are provided in Table 4 below.

Receiver Location	Noise Limit, dBL_{Aeq}	
	Daytime (0700 to 2200)	Night-time (2200 to 0700)
Residential (West)	52	45 (60 dBL_{Amax})
Regional Centre (South)	57	50
Rural Coastal	59	50
Public Purposes (South)	61	53
Commercial (South)	61	53
Industrial (South)	63	53

Table 4: Noise limits for new or upgraded plant items associated with the Transformation.

As the operation of the smelter is not expected to change between daytime or night-time periods, a worst case assessment has been undertaken assuming all plant operating for comparison with the relevant **night-time** noise limit.

Clauses 13 and 14 of the EPP are adjustments that allow for noise character (e.g. tonal, impulsive) and have been considered as part of the noise assessment in Section 6 of this report.

Noise from the smelter is compared against the noise limits provided in Table 3 to provide an understanding of the existing noise environment. However, assessment for the purposes of the Transformation is for new and upgraded equipment only and shall be with respect to the noise limits provided in Table 4.

4.2 Construction Noise

Construction noise requirements have been determined in accordance with the EPP Part 6.

Construction noise is considered to have an adverse impact on amenity at noise sensitive receivers when:

- the continuous noise source level exceeds **45 dB(A)** or the ambient continuous noise level (whichever is higher), or
- the maximum noise level exceeds **60dB(A)** or the ambient maximum noise level that is reached consistently (whichever is higher)

Noise that is considered to have an adverse impact on amenity should:

- not occur on a Sunday or public holiday
- not occur during between the hours of **1900 to 0700**.

An exception may be made if it can be shown that construction must be undertaken to:

- avoid unreasonable interruption of vehicle or pedestrian traffic movement, or
- if other grounds exist that the administering agency determines to be sufficient.

Where construction noise is considered to have an adverse impact on amenity, all reasonable and practicable measures must be taken to minimise construction noise and its impact.

4.3 Vibration

Operational and construction vibration limits have been determined using Australian Standards. AS2670.2[5] provides guidance to vibration limits for human exposure.

Maximum vibration levels to maintain human comfort in residences and offices is provided in Table 5 below. These limits make reference to the curves provided in Figure 3 for the frequency spectrum between 1 to 100 Hz.

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[5] Australian Standard, *2670.2-1991 Part 2: Continuous and shock induced vibration in buildings (1 to 80Hz)*, 1990

AS2670.2 Receiver	Application	Limit
Residences (night)	Residential	0.2mm/s (Curve 1.4)
Residences (day)	Residential	0.3mm/s (Curve 2)
Offices and Retail	Commercial	0.6mm/s (Curve 6)

Table 5: Vibration limits.

It is noted in Section 4.1 of AS2670.2 that construction (or excavation) may present a temporary disturbance where vibration levels magnitudes above those provided in Table 5 may be tolerated with warning signals, announcements and public relations used to mitigate the impact. Therefore the vibration limits provided in Table 5 will be used as construction vibration *targets*, and any exceedance will be investigated using mitigation techniques identified in Section 4.1 of SA2670.2.

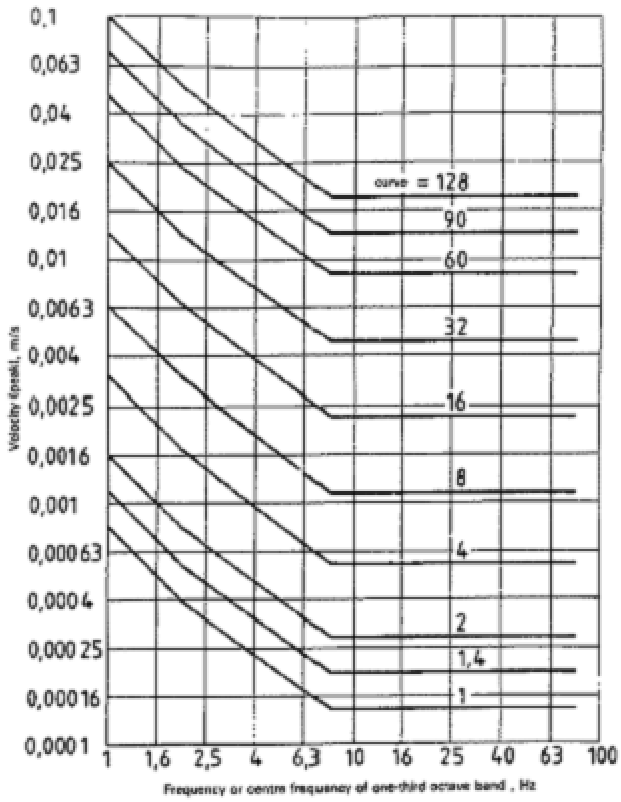


Figure 3: Vibration Limit Curves, AS2670.2.

5 Existing Noise and Vibration Environment

Noise and vibration measurements were undertaken at the smelter and surrounding environment between 15 and 22 May 2013. The measurements undertaken at surrounding noise sensitive receivers and localities, in accordance with the EPP, were to determine the existing noise levels at and in the vicinity of the smelter.

Attended noise measurements of the smelter were undertaken with any extraneous noise excluded from the measurement.

Unattended noise monitoring was used to compliment the attended noise measurement and validate these measurements over a longer period, however they include local noise events such as vehicle pass-by on the local roads.

Source noise level measurements were also undertaken at each significant noise source. More detail is provided in Section 6.

Measurement locations are provided in Figure 4below. Description of each location is provided in the Sections below.

Figure 4: Measurement locations

5.1 Attended Noise Measurement

Attended noise measurement was undertaken during the night-time period between 15 and 16 May 2013 in accordance with the EPP. The night-time period is expected to be representative of all other periods as the smelter operates continuously.

Measurement was undertaken at sensitive receiver locations that were most exposed to noise from the smelter and provide a good understanding of the noise environment surrounding the smelter.

For the purposed of describing the existing noise environment, a summary of the average measured night-time smelter noise level is provided in **Error! Reference source not found.** below. Full details of each measurement are provided in Appendix B.

Location	Measured Noise Level, dBL_{Aeq}	Comments
A1. Crn Duffy Ln and the Tce	43	General plant noise and some distant alarm and banging noise audible. Slag fuming steam noise can be identified.
A2. Crn Frederick St and the Tce	46	General plant noise and some distant alarm noise audible.
A3. Crn George St and the Tce	47	General plant noise and some distant alarm and banging noise audible.
A4. George St West	48	General plant noise and some distant alarm and banging noise audible.
A5. George St East	47	General plant noise and some distant alarm and banging noise audible.
A6. Ellen St	47*	General plant noise and some distant alarm and banging noise audible at times where traffic is low. Smelter is inaudible at times of high traffic (ie shift change).

Table 6: Attended measured noise level at sensitive receivers.

*Value has been determined as the average between the L_{eq} at 2200 hours and L_{90} at 0530 hours as a high level of road traffic at 0530 hours (likely shift change) affected the L_{eq} noise measurement at this time.

It has been noted that during the attended measurements, distant alarm and banging noise was audible. Banging and alarms are considered to be impulsive and tonal at the source, however this noise was only just audible above the general plant noise at the measurement locations. Therefore characteristic penalties have not been applied to these measurement locations.

5.2 Unattended Noise Monitoring

Unattended noise monitoring was undertaken between 15 and 22 May 2013 in accordance with the EPP.

In the absence of an operator to exclude extraneous noise and due to the constant nature of the smelter noise emission, the L_{90} and L_{min} parameters are considered to provide an environmental noise description that is most relevant to the operation of the smelter.

The arithmetic average of the 15 minute noise levels for the daytime and night-time period are provided in Table 6 below. Full details and graphs are provided in Appendix B.

Location	Average L_{A90} Noise Level, (dB)		Average L_{Amin} Noise Level, (dB)
	Day	Night	
M1. west	42	43	41
M2. south	43	44	42

Table 6: Average L_{90} and L_{min} noise monitoring levels.

5.3 Attended Vibration Measurement

An attended vibration measurement was undertaken at 5.00 pm on 15 May 2013 at the smelter boundary, adjacent to the nearest vibration sensitive receiver located on the Terrace, near the corner of Duffy Lane (location V1 in Figure 4).

The measured vibration levels were significantly below the vibration limits proposed in Section 4.3. The measured vibration levels are considered to be representative of typical ambient vibration levels.

No vibration was perceptible to the acoustic consultant undertaking the measurement.

5.4 Existing Noise and Vibration Summary

Subjectively, the noise from the existing smelter is audible at accessible boundary locations and at adjacent noise sensitive receivers.

The average measured noise levels from the existing smelter, with any extraneous noise sources that are not associated with the smelter excluded, are provided in Table 7 below for comparison with the most relevant night-time noise limit at each location.

Location	Measured Noise Level, dBL_{Aeq}	Night-time Noise Limit, dBL_{Aeq}	Excess over Noise Limit, dB(A)
A1. Crn Duffy Ln and the Tce	43	53	0
A2. Crn Frederick St and the Tce	46	53	0
A3. Crn George St and the Tce	47	53	0
A4. George St West	48	55	0
A5. George St East	47	55	0
A6. Ellen St	47	55	0

Table 7: Existing noise level assessment.

The average measured noise levels from the smelter meet the noise limits at all sensitive receiver locations. These measurements are considered to be a typical representation of noise from the smelter under full operation.

Noise monitoring results generally support the attended noise measurements. Based on site observations, it is likely that the peaks in monitored noise level are due to local noise sources such as traffic associated with shift changes or wildlife (e.g. frogs, insects). Troughs in the monitored noise level may be due to plant item shutdown and maintenance.

It was noted during site attendance that some unusual site activities may occur that cause changes to the smelter noise level such as noisy equipment maintenance (banging) or mobile plant near boundary locations (reversing alarms). It is possible that these types of activity could cause the noise limit to be temporarily exceeded, and may have been measured as part of the unattended noise monitoring.

Changes in weather conditions with respect to conditions during measurement may also affect noise levels.

There is no significant vibration from the smelter outside its boundaries.

6 Upgraded Operational Noise Impact

6.1 Prediction Methodology

Noise levels have been predicted at noise sensitive receivers due to existing and upgraded plant operating at the smelter.

SoundPLAN version 7.1 environmental noise prediction software has been used to implement the CONCAWE[6] calculation methodology for environmental noise propagation. This methodology considers noise attenuation by mechanism of geometrical spreading, atmospheric absorption, ground effects, meteorological conditions and barriers.

As the CONCAWE methodology is only validated for distances greater than 100 m, SoundPLAN calculates the values for distances between 0 and 100 m with linear interpolation. The use of CONCAWE methodology has been found to be conservative with respect to other calculation methodologies at these distances and also allows consideration of wind effects.

6.2 Acoustic Model and Modelling Assumptions

The acoustic model for the Transformation has been constructed using the detailed information presented in Appendix C and the assumptions below. This information includes:

- topography
- building structures
- noise sources
- receivers
- meteorological conditions
- ground absorption.

The octave band sound power levels for existing plant used in the acoustic model have been calculated from measurements using standard acoustic calculations. Details of these measurements and the calculated sound power levels are provided in Appendix C.

The octave band sound power levels for new or upgraded plant used in the acoustic model have been based on previous measurements, manufacturer's data, or assumptions based on equipment specification and discussion with manufacturers. Details of these measurements and the calculated sound power levels are provided in Appendix C.

The following assumptions have been made when calculating noise levels using the acoustic model:

- a facade correction has not been included in the prediction to reflect measurement location identified in clause 13(a)(i) of the EPP

[6] CONCAWE, *the Propagation of Noise from Petroleum and Petrochemical Complexes to Neighbouring Communities*, C.J Manning 1981.

- a worst case meteorological condition has been considered as CONCAWE metrological Category 6 in accordance with the EPP Guideline discussion of clause 20(2) of the EPP
- receivers are located at 1.5 m above ground level
- buildings outside the smelter are assumed to be a height of 4.5 m (buildings associated with the Transformation are as provided by the design team or measured on site)
- ground cover has been considered to be soft for vegetated areas and hard in all other locations in accordance with CONCAWE.

6.3 Acoustic Model Validation

The acoustic model has been used to predict noise levels of the smelter at locations where a noise measurement has also been undertaken and are provided in Table 8 below for comparison. Neutral meteorological conditions were used for these predictions to represent the conditions during the measurement period. Results have been rounded to the nearest whole number.

Location	**Measurement Type**	**Predicted Noise Level, dB(A)**	**Measured Noise Level, dB(A)**	**Difference, dB**
1. Crn Duffy Ln and the Tce	Attended	45	43	2
2. Crn Frederick St and the Tce	Attended	48	47	1
3. Crn George St and the Tce	Attended	47	46	1
4. George St West	Attended	49	48	1
5. George St East	Attended	49	47	2
6. Ellen St	Attended	48	47	1
Logger Terrace (north)	Unattended	46	40-51	In range
Logger Terrace (south)	Unattended	49	47-51	In range

Table 8: Predicted noise levels compared with measured noise levels.

There is good correlation between the predicted noise levels and measured noise levels and therefore no specific calibration factors have been used for this acoustic model. The predicted noise levels are conservative at all measurement locations.

The most significant noise sources contributing to the overall noise level at western receivers are the slag fuming ventilation, sinter plant and zinc plant cooling towers.

The most significant noise sources contributing to the overall noise level at southern receivers are the sinter plant, zinc plant cooling towers and the tippler.

Predicted noise contours for the acoustic model validation (i.e. the pre-transformation smelter under neutral weather conditions), are provided in Appendix D.

6.4 Predicted Noise Levels

The following scenarios have been assessed under adverse conditions that are equivalent to CONCAWE meteorological condition 6[7]:

- Transformation with only new or upgraded plant operating, including any significant mobile plant, alarms and site traffic that is associated with the transformation.
- Transformation with all plant operating, including all mobile plant, alarms, site traffic and deliveries.

The predicted noise levels for the most exposed receivers in each Council zone for the Transformation with only new or upgraded plant operating are provided in Table 9 below. Where no noise sensitive building exists, the most exposed receiver is considered to be at the boundary of the Council zone.

Council Zone	Predicted Noise Level, dBL_{Aeq}	Night-time Noise Limit, dBL_{Aeq}	Excess over Noise Limit, dB(A)
Residential (West)	45	45	0
Regional Centre (South)	44	50	0
Rural Coastal	47	50	0
Public Purposes (South)	47	53	0
Commercial (South)	46	53	0

Table 9: Predicted transformation noise levels for upgraded plant only.

The **60 dBL_{Amax}** criterion is also predicted to be met on the basis that the acoustic model considers all significant noise sources operating at maximum capacity and including any alarms or operational events, therefore providing prediction of the maximum (continuous) noise level.

The predicted noise levels for the most exposed receivers in each Council zone for Transformation with all plant operating (including mobile plant traffic and associated sirens or alarms) are provided in Table 10 below. Where no noise sensitive building exists, the most exposed receiver is considered to be at the boundary of the Council zone.

Council Zone	Predicted Noise Level, dBL_{Aeq}	Night-time Noise Limit, dBL_{Aeq}	Excess over Noise Limit, dB(A)
Residential (West)	53	53	0
Regional Centre (South)	55	55	0
Rural Coastal	54	55	0
Public Purposes (South)	56	58	0
Commercial (South)	56	58	0

Table 10: Predicted transformation noise levels for all plant.

[7] Pasquil Stability Category D and 3 m/s wind worst case direction (from source to receiver).

Predicted noise contours for the scenarios considered in this section are provided in Appendix D.

6.4.1 Predicted Noise Character

Spectral data has been used for each noise source considered and the predicted spectrum and level has been assessed for characteristics at receiver locations.

A typical noise spectrum for receiver locations is provided in Table 11 below as an example of the noise character.

	Sound Pressure Level Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Typical noise spectrum at adjacent receivers	53	60	59	55	52	46	42	33	15

Table 11: Typical Noise Spectrum

1/3 octave band predictions have not been undertaken, however no reversals in the declining noise level with respect to increasing frequency are expected and therefore it is not expected that any 1/3 octave frequency band will exceed each adjacent frequency band by 5dB or more. On this basis, no tonal characteristics are predicted. The tonal noise associated with reversing or equipment alarms is predicted to be masked by the noise of plant.

Although there is low frequency noise content in the predicted noise, it is not considered to be dominate or provide a fundamental component. The dB(C) level of the typical spectrum provided in Table 11 is 63 dB, which is below the recommendation in the policy guidelines for an objective test to determine low frequency content. No noise sources are expected to create significant noise below 63Hz.

Changes in noise level are expected due to the powering up or down of major plant items, however this not considered to be consistent change and would be for long periods of time. On this basis, the Smelter noise is not considered to be modulating.

Due to the nature of major industrial sites, some occasional activities at the Smelter may create impact noise. These impact noise events are not considered to be a consistent part of the Smelter noise and on this basis, the Smelter noise is not considered to have the impact noise characteristic.

Due to the consistent audibility of the Smelter at a level close to the noise limits, characteristics such as modulation from operation of a forklift, tonality of a reversing alarm, and operational impact noise is predicted to be masked with the continuous overall operational noise from the Smelter.

No characteristic is considered dominate or provide a fundamental component to the predicted noise level and therefore Clause 14(3) of the EPP has not been applied to the predicted noise level.

6.5 Upgraded Operational Noise Impact Summary

An acoustic model of the smelter was created and validated against noise measurements.

The acoustic model was updated to assess the following scenarios:

- Transformation with only new or upgraded plant operating, including any significant mobile plant, alarms and site traffic that is associated with the transformation.
- Transformation with all plant operating, including all mobile plant, alarms, site traffic and deliveries.

These scenarios were assessed against separate EPP noise limits.

It is predicted that noise from the Transformation will meet the EPP noise limits during the night-time period for both scenarios described above. As the smelter operates continuously, it is also predicted that the daytime noise limit will be met.

The acoustic model has considered all significant noise sources operating at their maximum capacity, including any alarms or operational events (such as tippler operation). The noise level is expected to be continuous and additionally is expected to reflect the maximum noise level from the Smelter. On this basis, the 60 dBL_{Amax} criterion is also predicted to be met.

When adverse weather conditions are excluded, the change in noise level due to the Transformation is predicted to be in the order of 1 dB and unnoticeable at sensitive receivers. In some cases there is a noise decrease due to the new configuration and location of noise sources from the Transformation.

On this basis, no specific mitigation requirements are recommended. This assumes that the assumptions identified in this assessment are considered as part of the Transformation design.

7 Upgraded Operational Vibration Impact

The measured vibration levels of the smelter were significantly below the proposed vibration limits and are considered to be representative of typical ambient vibration levels.

New and upgraded plant items are not expected to introduce any further or increased vibration sources into the smelter.

Therefore, vibration levels are considered to remain below the vibration limits set out in Section 4.3of this report and are not expected to be perceptible at any receiver locations.

8 Construction Noise and Vibration Impact

Noise from construction activities including clearing, demolition and construction are predicted to be above 45 dB at the nearest noise sensitive receiver at times. Therefore construction noise may have an adverse impact on amenity at noise sensitive receivers.

All reasonable and practicable measures will be taken to minimise construction noise impact including, but not limited to:

- Where an adverse impact is predicted, the construction will not occur on a Sunday or other public holiday and not occur on any other day except between 7am and 7pm.
- Scheduling construction activities such that Environment Protection (Noise) Policy noise emissions will be met during early morning, evening, weekends and public holidays
- liaison with potentially affected residents where noisier works such as pile driving and vibratory rollers will be used
- recording and responding to any noise complaints
- scheduling noisier works such as pile driving and compacting to avoid very early or evening time periods
- construction planning to locate site buildings, access roads and plant such that minimum disturbance occurs to the community
- maintaining all equipment to manufacturer’s specifications
- enclosing noisy equipment where possible in accordance with standard industry practice
- fitting and maintaining appropriate mufflers on earth-moving and other equipment on site
- turning off plant when not in use.

The predicted vibration levels for construction are not considered perceptible at receiver locations on the following basis:

- blasting is not being considered as part of the construction
- piling occurs at a minimum of 400 m from the nearest sensitive receiver

No measures are required to address construction vibration.

9 Report Summary

Subjectively, the noise from the smelter is audible at accessible boundary locations surrounding the smelter and at adjacent noise sensitive receivers.

The average measured noise level from the existing smelter met existing noise limits. These measurements are considered to be a typical representation of noise from the smelter under full operation. Unusual site activities such as equipment maintenance or mobile plant use near boundaries may cause noise levels to be exceeded.

There is no significant vibration from the existing smelter outside its boundary.

To meet noise and vibration requirements, noise from new or upgraded plant associated with the Transformation must be assessed in accordance with the Environment Protection (Noise) Policy (EPP).

Construction noise must also be assessed with respect to the EPP.

Australian Standards have been used for guidance to determine vibration limits.

It is predicted that noise from new or upgraded plant associated with the Transformation will meet the EPP noise limits.

Noise from the Transformation with all plant operating was also predicted and assessed to provide an understanding of the expected noise environment.

It is predicted that noise from the Transformation with all plant operating will meet the EPP noise limits.

The change in noise level due to the Transformation operation is predicted to be in the order of 1 dB and considered unnoticeable at sensitive receivers with respect to the existing noise level. In some cases there is a noise decrease due to the new configuration and location of noise sources after the Transformation.

New and upgraded plant items are not expected to introduce any further or increased vibration sources into the smelter and therefore vibration levels are expected to remain below vibration limits.

On this basis, no specific noise or vibration mitigation requirements are proposed for the Transformation.

Construction noise may potentially impact on the acoustic amenity of sensitive receivers at times, therefore practicable measures to reduce this impact must be taken. The recommended measures include:

- community contact and consideration
- activity scheduling and planning
- considering the noise emission of plant, and addressing with typical measures (section 8) where practical.

The predicted vibration levels for construction are not considered to be perceptible at receiver locations.

Appendix A

Acoustic Terminology

A1 Acoustic Terminology

Ambient Noise Level

The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a city building is being investigated, the ambient noise level is the noise level from all other sources without the fan running. This would include sources such as traffic, birds, people talking and other nearby fans on other buildings.

Background Noise Level

The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects.

Decibel

The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore a logarithmic scale, the decibel (dB) scale, is used to describe sound levels.

An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.

dB(A)

dB(A) denotes a single-number sound pressure level that includes a frequency weighting (“A-weighting”) to reflect the subjective loudness of the sound level.

The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).

Some typical dB(A) levels are shown below.

Noise Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m

Noise Level dB(A)	Example
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

L_1

The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dB(A) or higher for 1% of the 15 minute measurement period.

L_{10}

The L_{10} statistical level is often used as the "average maximum" level of a sound level that varies with time.

Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dB(A) or higher for 10% of the 18 hour measurement period.

L_{90}

The L_{90} statistical level is often used as the "average minimum" or "background" level of a sound level that varies with time.

Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dB(A) or higher for 90% of the 15 minute measurement period.

L_{eq}

The 'equivalent continuous sound level', L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.

L_{eq} is often used as the "average" level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dB(A) weighting is applied, the level is denoted dB $L_{Aeq.}$ Often the measurement duration is quoted, thus $L_{Aeq,15\ min}$ represents the dB(A) weighted energy-average level of a 15 minute measurement.

L_{max}

The Lmax statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time.

Mathematically, Lmax is the highest value recorded during the measurement period. As an example, 94 dB LAmax is a highest value of 94 dB(A) during the measurement period.

Since Lmax is often caused by an instantaneous event, Lmax levels often vary significantly between measurements.

Frequency

Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as "pitch". Sounds towards the lower end of the human hearing frequency range are perceived as "bass" or "low-pitched" and sounds with a higher frequency are perceived as "treble" or "high pitched".

Sound Exposure Level (SEL)

The Sound Exposure Level or Single Event Noise Exposure Level, denoted SEL or L_{AE}, is a measure of the total amount of acoustic energy contained in an acoustic event. The SEL is the constant sound pressure level that would produce in a period of one second the same amount of acoustic energy contained in the acoustic event. SEL is commonly used to quantify the total acoustic energy contained in transient events such as a vehicle pass-by.

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Sound Reduction Index (R)

The sound reduction index (or transmission loss) of a building element is a measure of the loss of sound through the material, i.e. its sound attenuation properties. It is a property of the component, unlike the sound level difference, which is affected by the common area between the rooms and the acoustics of the receiving room. R is the ratio (expressed in decibels) of the sound energy transmitted through the building element to the sound energy incident on the building element for a particular frequency.

The weighted sound reduction index, R_w, is a single figure description of sound reduction index across a wider frequency range and is defined in BS EN ISO 717-1: 1997. R_w values are calculated from measurements in an acoustic laboratory. Sound insulation ratings derived from site measurements (which are invariably lower than the laboratory figures) are referred to as apparent sound reduction index (R'_w) ratings.

Structureborne Noise

The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, i.e. expansion joints and floating floors.

Vibration

Waves in a solid material are called “vibration”, as opposed to similar waves in air, which are called “sound” or “noise”. If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage.

A vibrating structure (eg a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space.

Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s^2) or else using a decibel scale.

Appendix B

Measurement Details

B1 Noise Measurement Details

B1.1 Approach

Measurements were undertaken in accordance with the EPP.

Equipment used for measurement is provided in Table 12 below.

Description	Type	Manufacturer	Serial
Sound Level Meter	2270	Brüel & Kjær	2754328
Handheld Calibrator	2270	Brüel & Kjær	179060
Noise Logger	NGARA	ARL	8780D1
Noise Logger	NGARA	RTA	RTA04

Table 12: Measurement equipment

All equipment holds current calibration certification and was checked onsite before and after each series of measurements.

B1.1.1 Attended Noise Measurement

Attended noise measurement was undertaken during the night-time period between 15 and 16 May 2013. Two sets of measurements were undertaken, first between 2200 and 2300 and second between 0500 and 0700 hours.

The night-time period is expected to be representative of all other times as the smelter operates continuously and the night-time period is considered to have less extraneous noise sources that may affect measurement.

Measurements were undertaken at outside locations with the microphone located at 1.5 m above ground level, 3.5 m away from any reflective vertical surface and pointed toward the smelter. The manufacturer windshield was used for all measurements.

Measurement locations are provided in Section 5, Figure 4.

Attended measurement duration was for a minimum of 5 minutes at each location. This duration is considered to be representative of the continuous noise from the smelter. All extraneous noise that was not from the smelter was excluded from the measurements. Fast time weighting was used for all measurements.

B1.1.2 Unattended Noise Monitoring

Unattended noise monitoring was undertaken between 15 and 22 May 2013. The EPP attended measurement procedures have been applied to the unattended noise monitoring where possible.

The EPP attended measurement procedures have been applied to the unattended noise monitoring where possible.

Noise monitors were located at outside locations with the microphone located at 1.5 m above ground level, 3.5 m away from any reflective vertical surface. The manufacturer windshield was used for all measurements.

Measurement locations are provided in Section 5, Figure 4.

The noise monitors were set up to record 15 minute intervals in line with the EPP source noise measurement requirements.

The unattended noise monitoring was undertaken for the following reasons:

- to understand the existing noise environment
- To verify the acoustic model outputs

Unattended noise measurements are not considered to represent smelter noise levels at all times due to the presence of extraneous noise sources.

B1.2 Meteorological Conditions

Meteorological conditions during attended noise measurements were generally calm with some gusts of wind. Attended measurements are not considered to be affected by weather conditions.

Meteorological conditions during unattended noise monitoring were generally fine with no extended periods of rain or wind that would be expected to significantly impact on measurements.

B2 Attended Noise Measurement Results

Attended noise measurements undertaken between 2200 and 2300 on 15 May 2013 are provided are Table 13 below.

Location	Measured Noise Level, (dB)				Comments
	L_{eq}	L_{max}	L_{10}	L_{90}	
1. Corner Duffy Lane and the Terrace	44	47	44	42	Nyrstar slag fuming and mobile plant audible. Distant traffic audible, local traffic has been excluded from measurement.
2. Corner Frederick Street and the Terrance	50	52	51	49	Nyrstar smelter general plant noise, mobile plant operation and some distant alarm. Distant traffic audible, local traffic has been excluded from measurement.
3. Corner George Street and the Terrace	49	51	50	48	Nyrstar smelter general plant noise and some distant alarm and knocking audible. Distant traffic audible, local traffic has been excluded from measurement.
4. George Street West	49	55	50	47	Nyrstar smelter general plant noise and some distant alarm and knocking audible. Insects audible.
5. George Street East	52	56	52	50	Nyrstar smelter general plant noise and some distant alarm and

					knocking audible. Insects audible.
6. Ellen Street	49	53	50	47	Nyrstar smelter general plant noise and some distant alarm audible. Some cars audible to the south and insect noise audible.

Table 13: Measured noise levels 2200 to 2300, 15 May 2013

Attended noise measurements undertaken between 0500 and 0700 on 16 May 2013 are provided in Table 14 below.

Location	Measured Noise Level, (dB)				Comments
	L_{eq}	L_{max}	L_{10}	L_{90}	
1. Corner Duffy Lane and the Terrace	41	48	43	38	Nyrstar slag fuming and mobile plant audible. Distant traffic audible, local traffic has been excluded from measurement.
2. Corner Frederick Street and the Terrance	42	49	45	38	Nyrstar smelter general plant noise, mobile plant operation and some distant alarm. Distant traffic audible, local traffic has been excluded from measurement. Plant is subjectively quieter than previous measurement.
3. Corner George Street and the Terrace	45	57	46	39	Nyrstar smelter general plant noise and some distant alarm and knocking audible. Distant traffic audible, local traffic has been excluded from measurement.
4. George Street West	47	52	48	45	Nyrstar smelter general plant noise and some distant alarm and knocking audible. Some distant traffic and dogs barking audible.
5. George Street East	41	48	42	38	Nyrstar smelter general plant noise and some distant alarm and knocking audible. Some distant traffic audible.
6. Ellen Street	62	72	68	45	Traffic to smelter is main noise source, likely shift change. Traffic cannot be practically excluded. Smelter audible at times where traffic noise is low.

Table 14: Measured noise levels 0500 to 0700, 15 May 2013

B3 Unattended Noise Monitoring Results

Unattended noise monitoring results undertaken between 15 and 22 May 2013 at the western boundary (location M1 in Section 5, Figure 4) are provided in Figure 5 to Figure 7 below.

Unattended noise monitoring results undertaken between 15 and 22 May 2013 at the southern boundary (location M2 in Section 5, Figure 4) are provided in Figure 8to Figure 10 below.

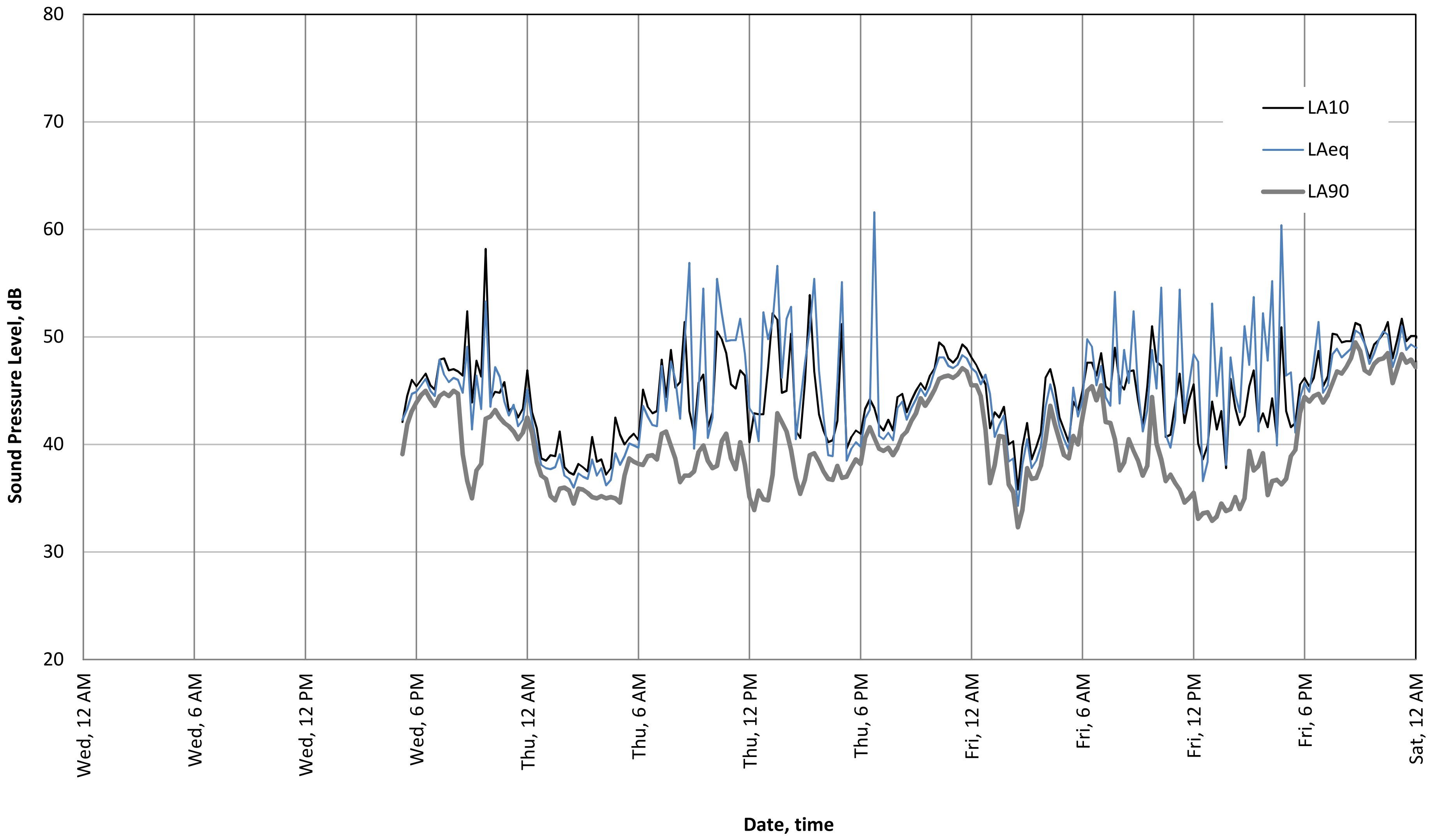


Figure 5: Noise monitoring, Wednesday 15 to Friday 17 May 2013, Location M1 at the western boundary.

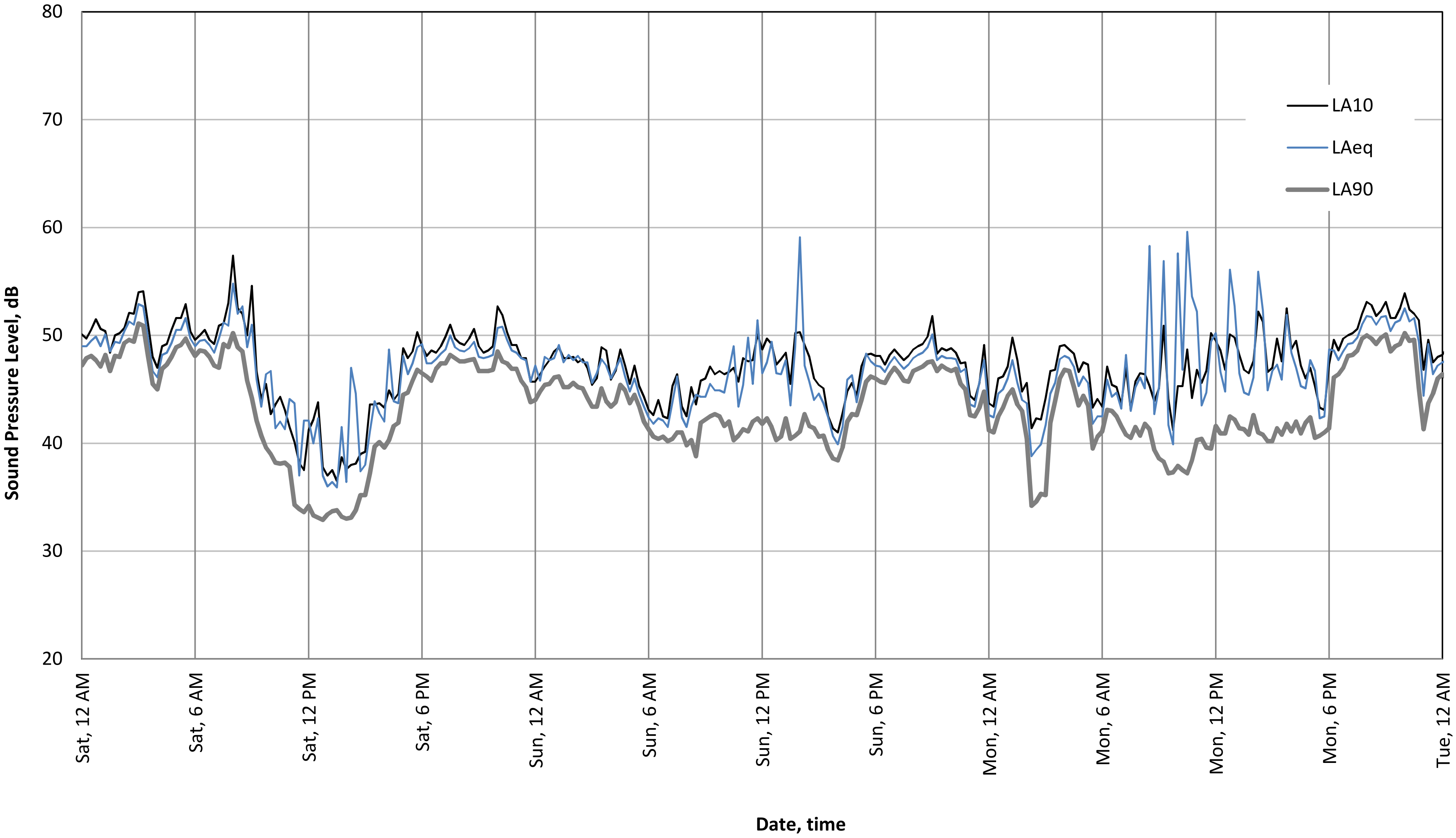


Figure 6: Noise monitoring, Saturday 16 to Tuesday 21 May 2013, Location M1 at the western boundary.

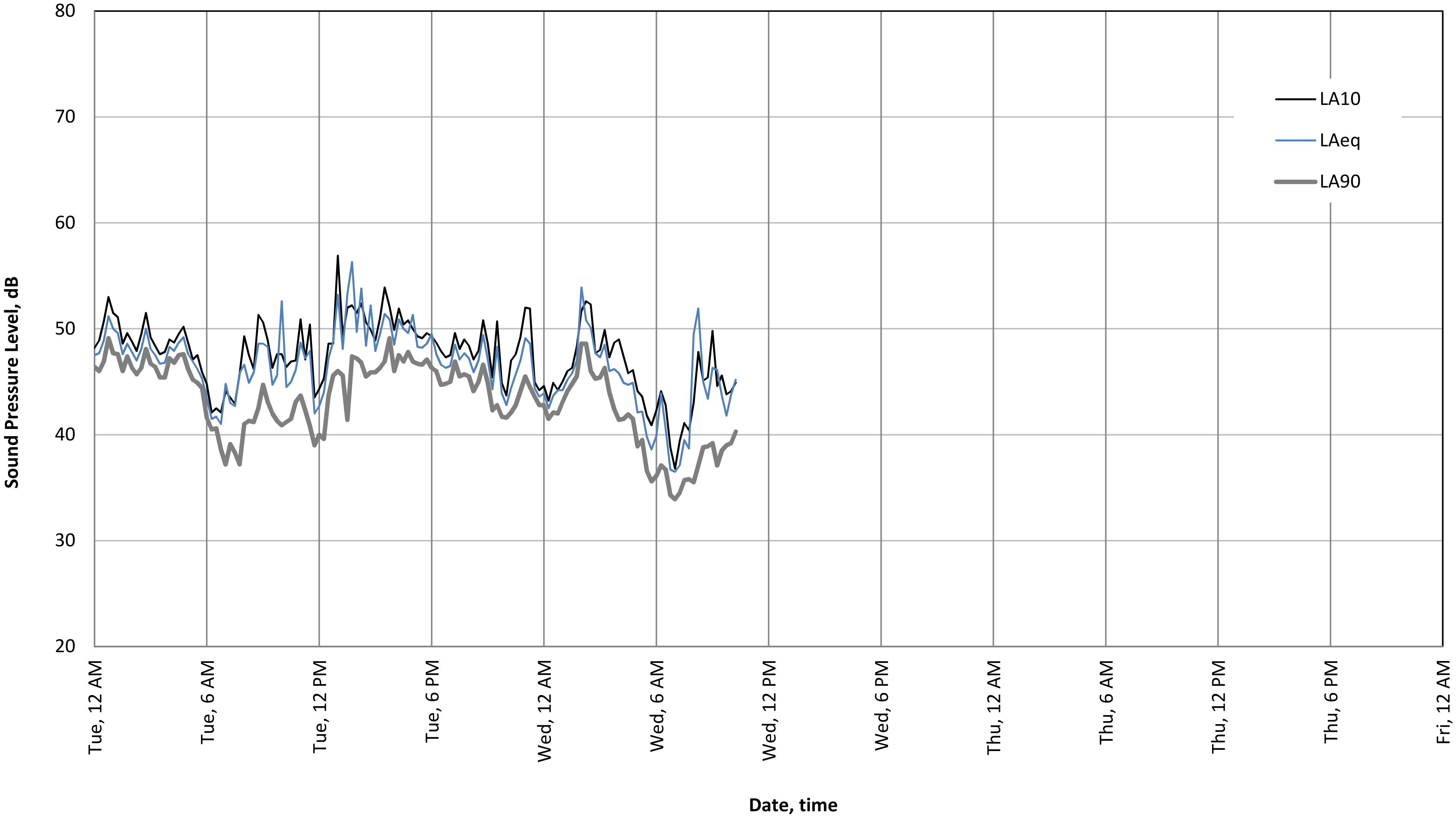


Figure 7: Noise monitoring, Tuesday 21 to Friday 24 May 2013, Location M1 at the western boundary.

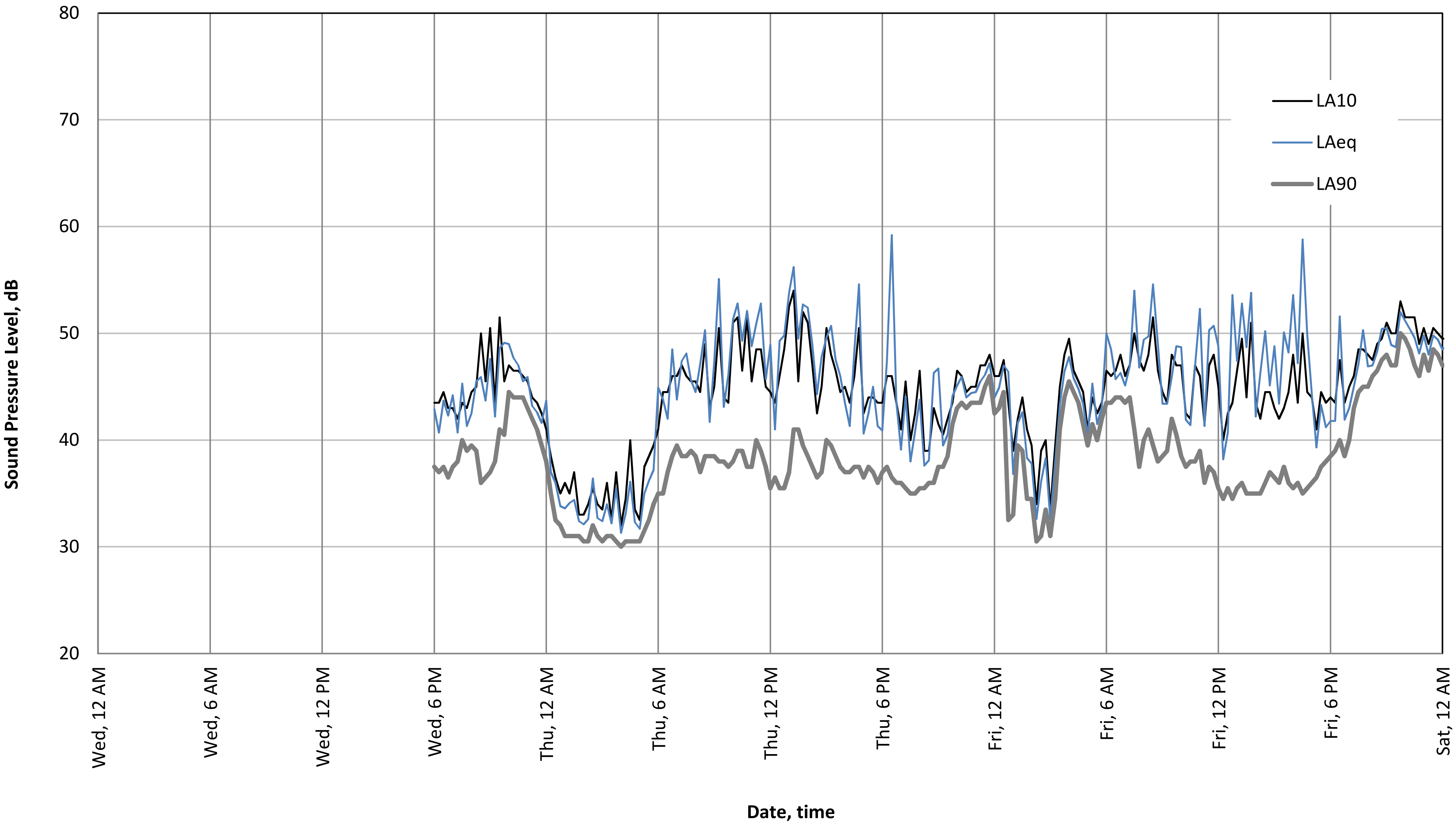


Figure 8: Noise monitoring, Wednesday 15 to Friday 17 May 2013, Location M2 at the southern boundary.

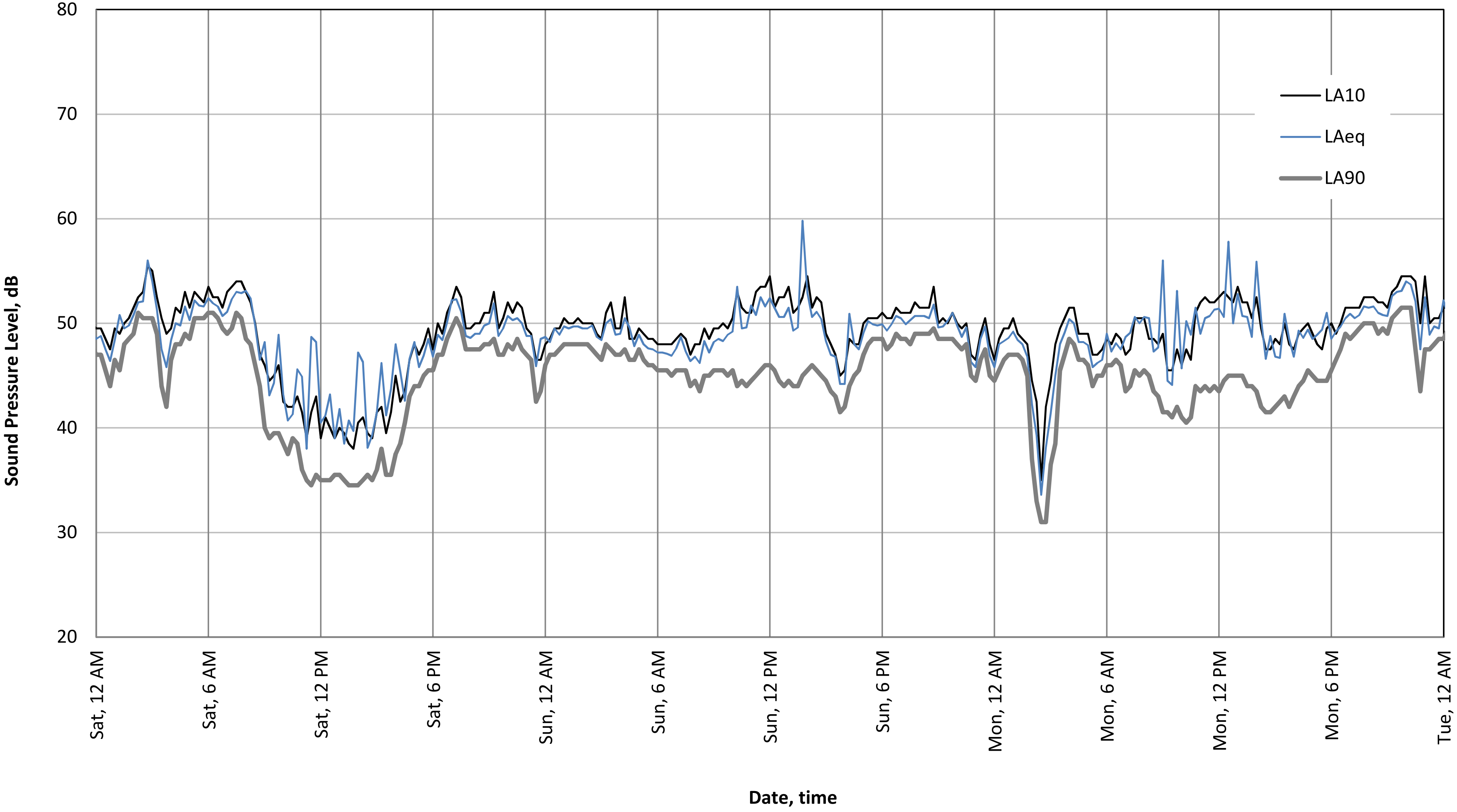


Figure 9: Noise monitoring, Saturday 16 to Tuesday 21 May 2013, Location M2 at the southern boundary.

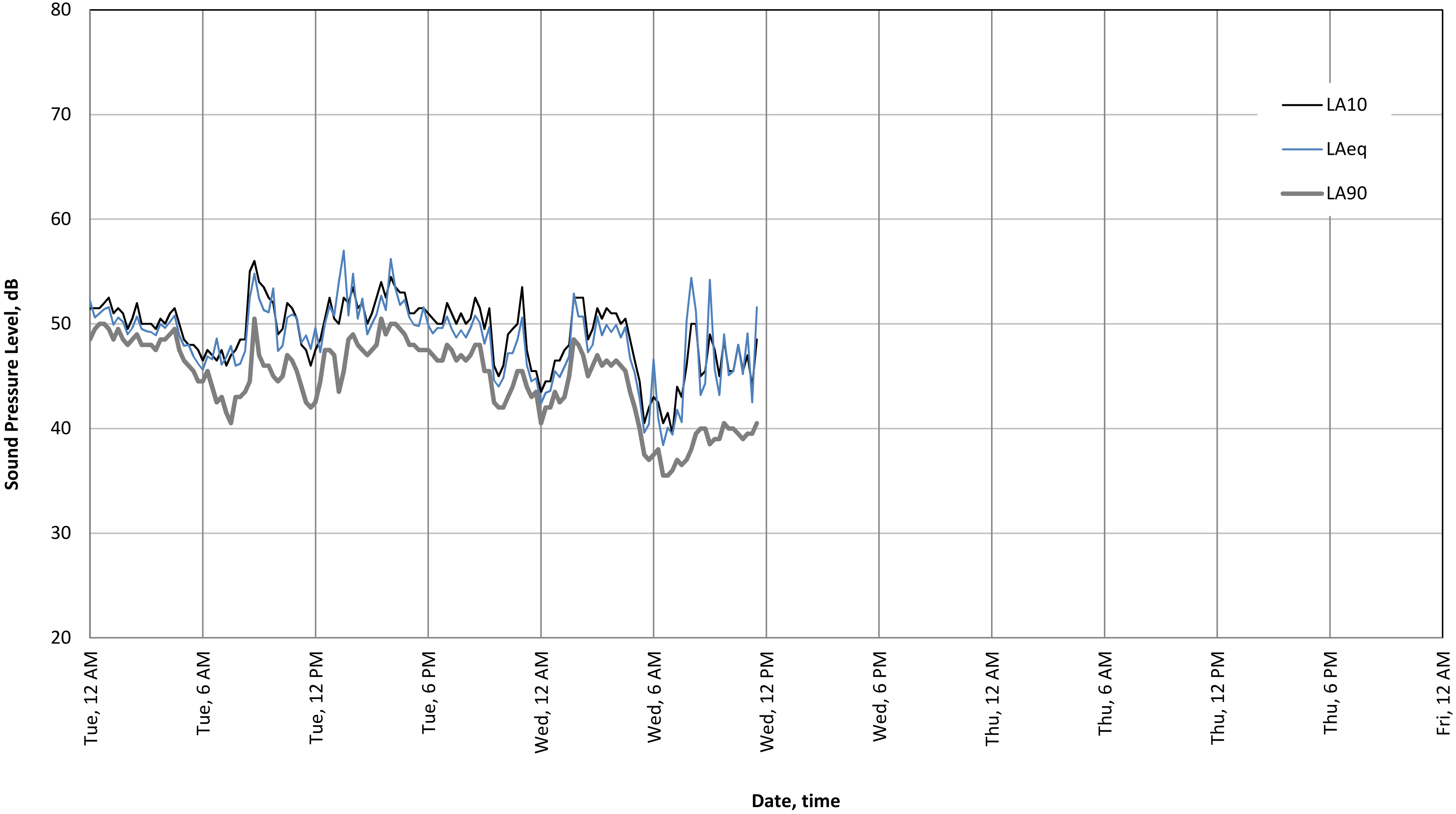


Figure 10: Noise monitoring, Tuesday 21 to Friday 24 May 2013, Location M2 at the southern boundary.

Appendix C

Acoustic Model Details

C1 Acoustic Model Approach

An acoustic model has been created based on electronic survey data provided from both DEWNR and the design team, aerial photography, site photography and site visits.

Noise source data for the existing plant in the acoustic model has been measured on site during full operation and sound power levels have been calculated using standard acoustic calculation methods.

Noise source data for new plant items in the proposed upgrade has been determined based on design team input, measurement of similar plant items and manufacturer information where possible.

For plant that will be located in an enclosure, Arup has calculated the reverberant noise level due to locating the specified plant items in the enclosure, and then calculating the expected sound power level breakout through specified constructions. The calculated sound power level is then used in the acoustic model as an area source to represent an enclosure wall.

The calculated sound power levels specified constructions and assumed transmission loss data are provided in the sections below.

C2 Data Input

Data used to create the acoustic model is detailed in the table below.

Name	Date	Description
Site plan.pdf	15 May 213	Smelter site plan, including plant identification.
30016_overall240703.dwg	31 May 2013	2D CAD site smelter point elevations marked at some locations.
PP 01 to 20 .ecw	3 June 2013	Aerial photography of Port Pirie
SpotHeights_50K.shp	4 June 2013	5m interval spot height elevation data.
00829-0000-CI-DAL, DST and DGA PDF series.	13 June 2013	Transformation smelter layout and process plant.
WP Prefeasibility Study Report	14 June 2013	Transformation smelter equipment description
00829-0000-GE-DSK PDF series.	20 June 2013	Transformation smelter 3d images.

Table 15: Acoustic model input data

C3 Sound Power Data

Source noise measurements of all significant noise emitting equipment have been undertaken at smelter, including details of the location and nature of item measured. The octave band sound power levels of all significant noise emitting plant at the smelter have been calculated from measurements using standard acoustic calculations.

The A-weighted calculated sound power levels used in this assessment are provided in the sections below.

C3.1 Existing Plant

Sounds power noise levels for existing plant is based on measurement with the exception of mobile plant items that are based on manufacturer's data or previous noise measurements of equivalent plant.

C3.1.1 Refinery

The eastern façade is open at the ground floor and is considered to be a significant sound source that is a combination of all refinery plant operating inside enclosure. Other facades are not considered to be significant sources with respect to the smelter noise environment and have not been included in the acoustic model as a sound source.

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Refinery eastern ground floor façade (/m2)	96	100	101	97	92	90	88	82	71

C3.1.2 Stack

The most significant noise source associated with the stack is the fans located at the base. Top of stack noise could not be measured directly; however noise mitigation due to stack length and air filtration is expected to reduce noise levels to a level that does not provide significant contribution.

Directivity has been applied to the fans to reflect a 5dB loss from inlet to the side of casing.

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Stack fans	103	103	103	102	99	98	96	92	88

C3.1.3 Tippler

Measurement undertaken during tippler operation.

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Tippler and tippler fan	110	114	107	109	106	105	102	98	91
Bag house fan	108	110	112	113	103	100	95	97	93

C3.1.4 Blast Furnace

The western façade of the structure housing the blast furnace is open at the ground floor and is considered to be a significant sound source that is due to the blast furnace operation. Other facades are not considered to be significant sources with respect to the smelter noise environment and have not been included in the acoustic model as a sound source.

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Blast furnace western facade	106	119	116	108	102	98	95	91	84

C3.1.5 Zinc Plant

The most significant noise source associated with the Zinc plant is a pair of large elevated cooling fans. Two fans are in operation.

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Zinc plant fans	112	111	115	113	111	104	99	94	90

C3.1.6 Slag Fuming

The slag fuming furnace has two significant noise sources; the furnace and surrounding structure and an elevated steam vent/outlet. Both sources were measured and the influence of one on the other was taken into account when calculating the sound power level.

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Slag fuming furnace area (/m2)	102	100	99	96	92	94	96	96	93
Steam outlet/vent	120	103	102	97	110	109	111	116	113

C3.1.7 Acid Plant

Noise from the acid plant is generally associated with ground level plant.

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Acid plant (/m2)	94	99	95	88	88	88	87	87	79

C3.1.8 Oxygen Plant

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Oxygen plant	107	98	99	98	95	100	100	102	101
Compressor	97	95	97	94	94	92	89	86	83

C3.1.9 Sinter Plant

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Sinter Plant North	108	113	110	112	105	100	98	94	97
Sinter Plant South	113	115	114	0	106	103	110	94	89

C3.1.10 Mobile Plant

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Front end loader	108	99	113	111	102	101	100	93	99
Electric Forklift (including alarm)	84	87	85	83	80	78	76	73	72
29t Dump Truck Loading	104	110	99	103	98	98	99	92	88

C3.2 Upgraded Plant

C3.2.1 Enclosed Bath Smelting Furnace

No manufacturer or previous measurement data is available for similar bath smelting operations. Smelter plant is typically custom designed for each installation.

It is expected that noise from a new bath smelter furnace will be quieter than noise from the existing blast furnace due to the following:

- A lance (either top or bottom) injects heat into the bath as opposed to blasting the heat from outside the molten material.
- There is no associated air heating plant, as the fuel is directly injected into the bath.

- A lance (either top or bottom) injects heat deep into the bath as opposed to blasting the heat from outside the molten material.
- New plant is typically more efficient which often leads to less noise sources (ie gas leakages, mechanical movement, thermal noise)
- A bath has higher thermal stability

As no data is available to support the above considerations, noise levels for the new bath smelter have been assumed to be the same as the measured blast furnace. This is considered to be a conservative approach.

A manufacturer of the proposed bath smelter has confirmed that major noise sources would be considered to be flow noise associated with pipes and any turbulence of the bath. Off gas and other pressure outlets are not considered to be major noise sources for this furnace, as they are all directed towards other plant items for further processing. These ancillary plant items such as waste heat boiler, cogeneration and acid plant have been considered individually in this assessment.

Noise levels for the mill, waste heat boiler and cooling tower have been based on previous measurements of equivalent plant items.

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	dB(A)	63	125	250	500	1k	2k	4k	8k
Furnace	106	115	115	109	104	96	92	89	84
Mill	115	115	117	118	113	109	104	100	96
Waste Heat Boiler	90	95	91	90	86	84	81	80	79
Cooling	97	105	101	97	93	92	89	85	82

The smelter is to be located inside a large enclosure approximately 70m x 30m x 25m. A grinding mill will also be located inside the enclosure and a waste heat boiler and cooling tower will be located outside the enclosure

The enclosure is proposed to be constructed from typical metal cladding. The following construction and transmission loss has been assumed.

	Transmission Loss, dB Octave Band Centre Frequency, Hz							
Description	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Standard 0.6mm Steel Cladding	10	11	27	41	44	48	54	50
Assumed Field Performance	**5**	**6**	**22**	**36**	**39**	**43**	**49**	**45**

Based on the grinding mill and furnace operating inside a 0.6mm steel enclosure, the following sound power level has been determined for the external facades of the enclosure.

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	dB(A)	63	125	250	500	1k	2k	4k	8k
Furnace Enclosure (/m2)	106	115	115	109	104	96	92	89	84

C3.2.2 Cogeneration Plant

The noise level for cogeneration plant is based on Solar Turbine manufacturer data for plant of a similar capacity (the Centaur 50) as published in the 'Noise Prediction Guidelines for Industrial Gas Turbines'. This unit is enclosed in a manufacturer provided enclosure and operating at full capacity.

	Sound Power Level, dB re 1 pW Octave Band Centre Frequency, Hz								
Description	dB(A)	63	125	250	500	1k	2k	4k	8k
Turbine Enclosure (/m2)	104	111	106	107	102	96	92	91	83

Inlet and outlets are not considered to be significant noise sources for this plant as the super-heated steam is circulated in a closed loop. (The smelter exhaust is through the stack, after passing through cleaners and acid recovery).

C3.2.3 Oxygen Plant

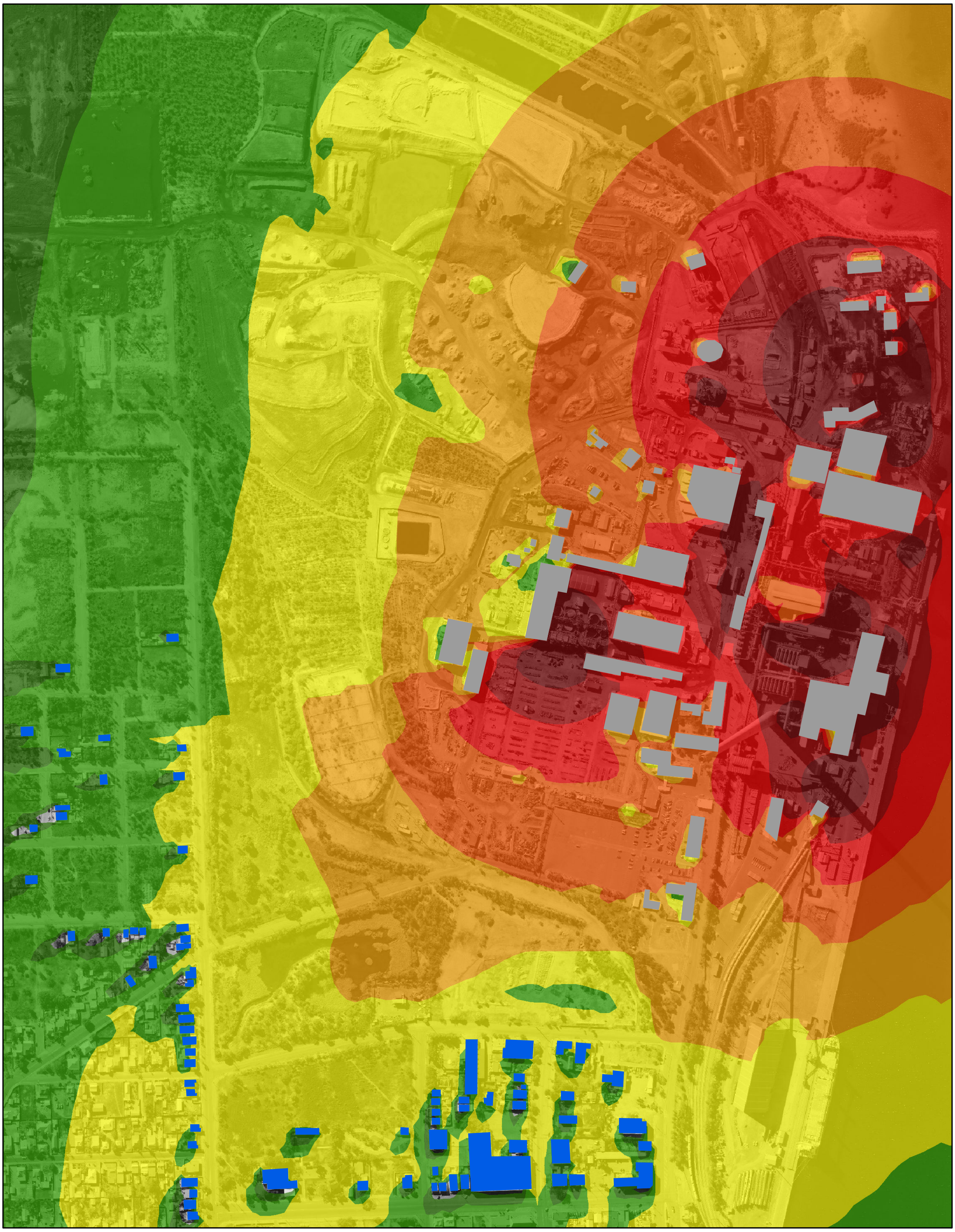
The new oxygen plant has been modelled based on measurements of the existing oxygen plant. This approach is considered to be conservative as new plant is typically more efficient which often leads to less noise sources (ie leakages, mechanical movement, thermal noise)

C3.2.4 Acid Plant

The new acid plant has been modelled based on measurements of the existing acid plant applied over a larger area on a per meter basis. This approach is considered to be conservative as new plant is typically more efficient which often leads to less noise sources (ie leakages, mechanical movement, thermal noise)

Appendix D

Predicted Noise Contours



ARUP

0 50 100 N
Metres

Legend

Building

Smelter structure

Noise Level, dBL_{Aeq}

35 - 39
40 - 44
45 - 49
50 - 54
55 - 59
60 - 64
65 - 69
≥ 70

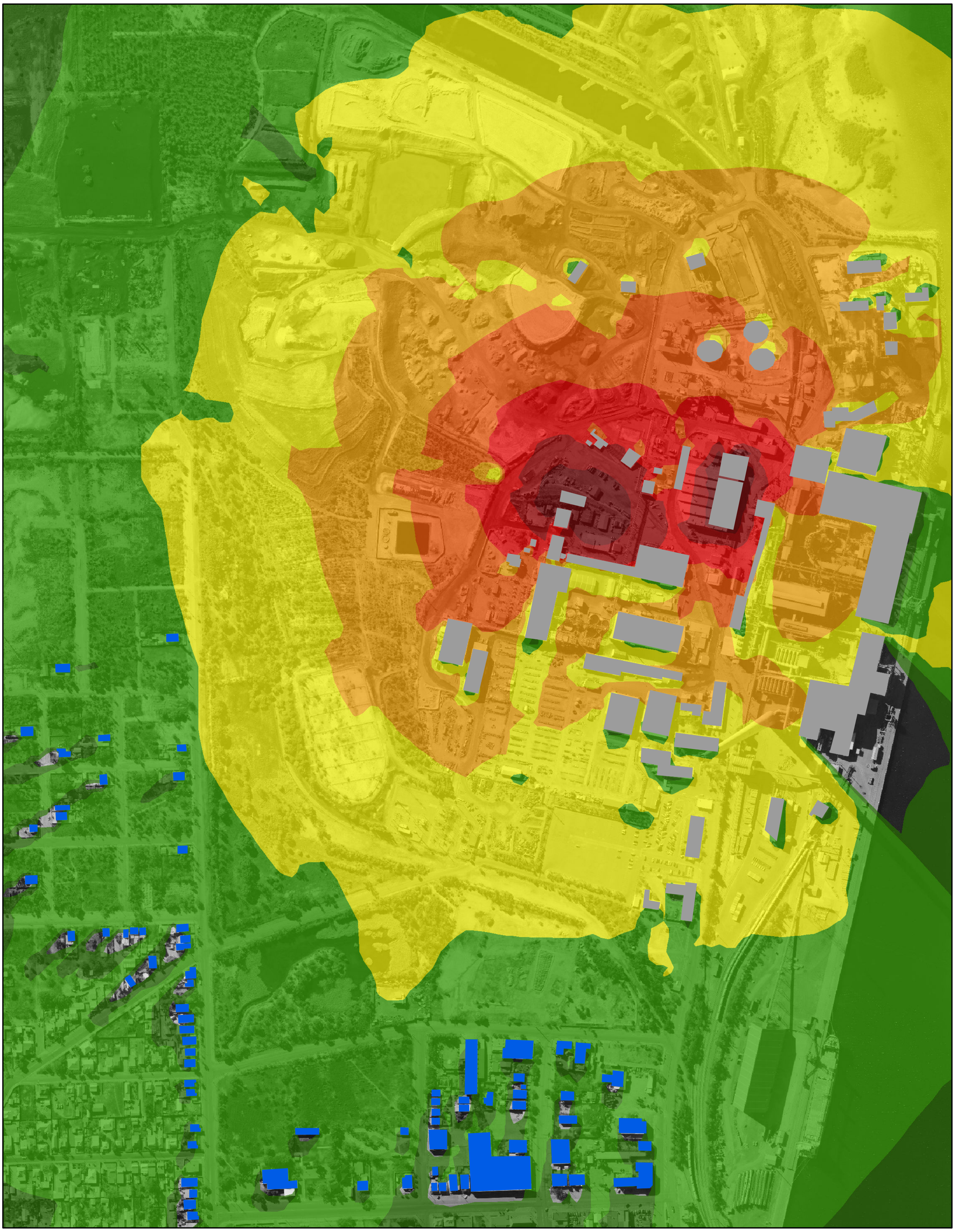
Title **Pre-transformation with neutral weather (validation)**

Project Port Pirie Smelter Upgrade

Dwg No. MAP-001_RevB

Job No. 230587-01

Date 27/06/2013



ARUP

0 50 100
Metres
N

Legend

- Building
- Smelter structure

Noise Level, dBL_{Aeq}

35 - 39	55 - 59
40 - 44	60 - 64
45 - 49	65 - 69
50 - 54	≥ 70

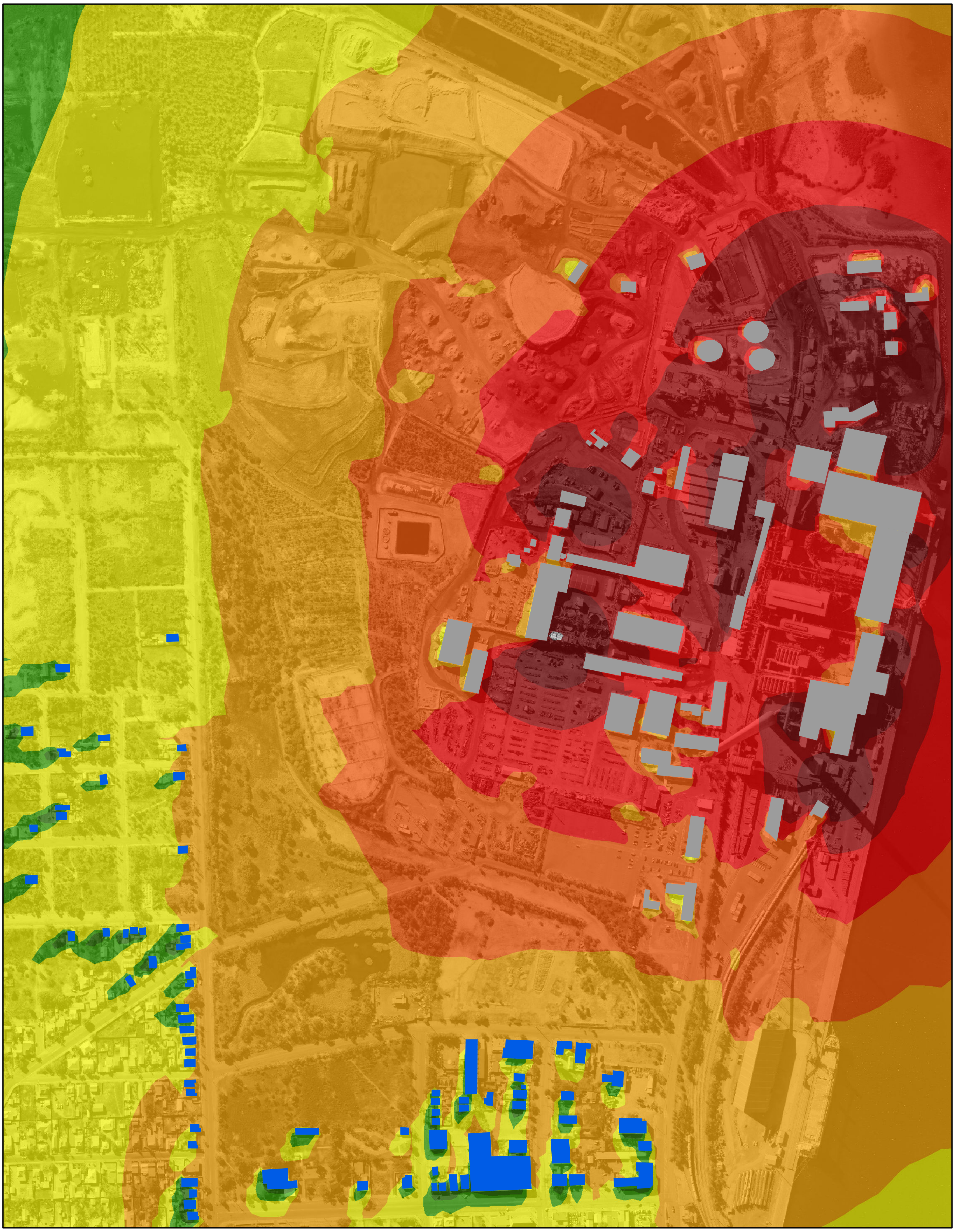
Title **Transformation with adverse weather (new plant only)**

Project Port Pirie Smelter Upgrade

Dwg No. MAP-001_RevB

Job No. 230587-01

Date 27/06/2013



ARUP

Legend

- Building
- Smelter structure

Noise Level, dBL_{Aeq}

35 - 39	55 - 59
40 - 44	60 - 64
45 - 49	65 - 69
50 - 54	≥ 70

0 50 100 Metres N

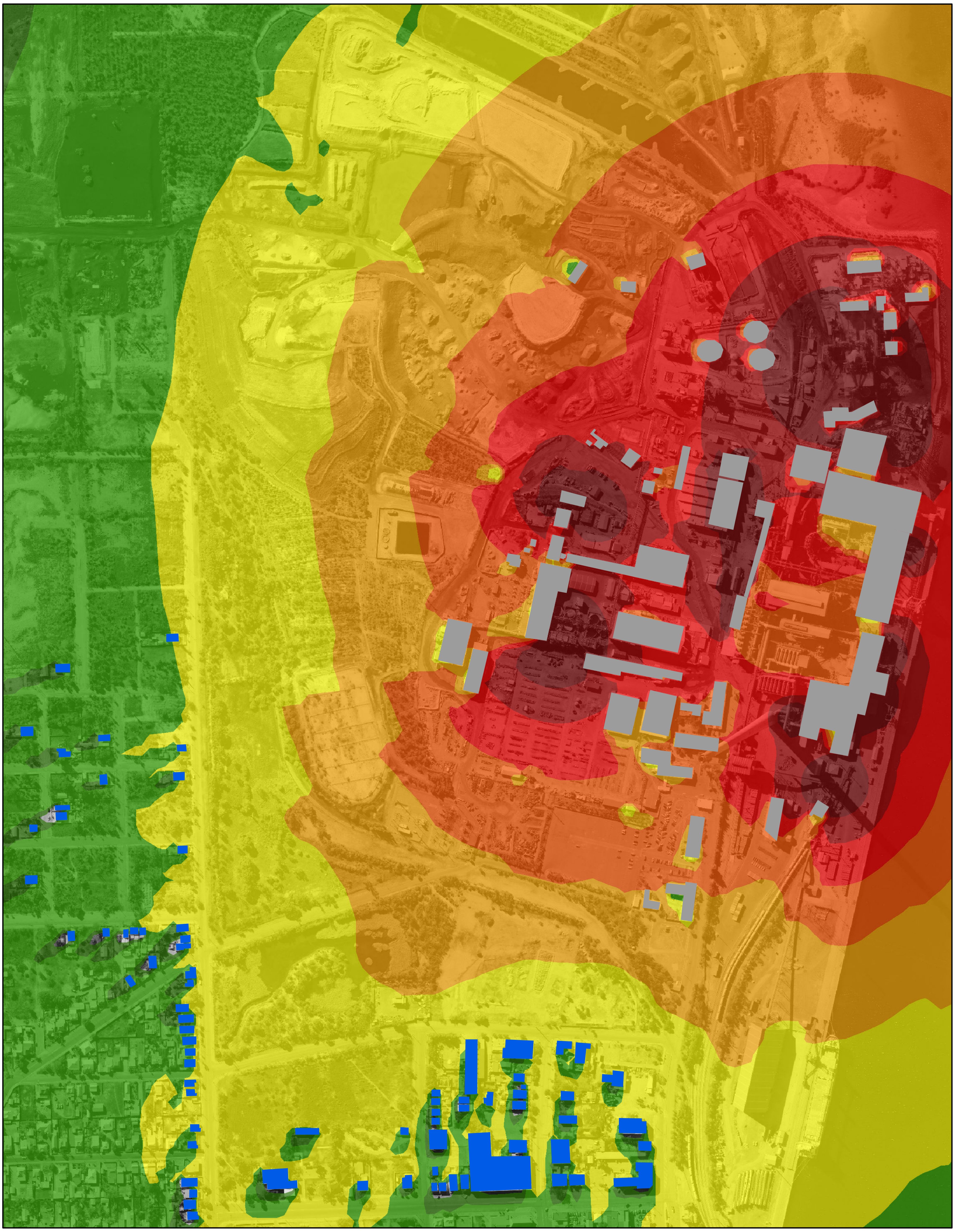
Title **Transformation with adverse weather (all plant operating)**

Project Port Pirie Smelter Upgrade

Dwg No. MAP-001_RevB

Job No. 230587-01

Date 27/06/2013



ARUP

0 50 100 N

Metres

Legend

Legend	
Building	
Smelter structure	

Noise Level, dBL$_{Aeq}$

35 - 39	55 - 59
40 - 44	60 - 64
45 - 49	65 - 69
50 - 54	≥ 70

Title **Transformation with neutral weather (all plant operating)**

Project Port Pirie Smelter Upgrade

Dwg No. MAP-001_RevB

Job No. 230587-01

Date 27/06/2013

nyrstar
Resources for a changing world

Appendix B:

Air lead impact assessment

Port Pirie Smelter Transformation

Air Lead
Impact Assessment

Prepared for

Nyrstar

Prepared by

Air Assessments

July 2013

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Client: Nyrstar

Version	Prepared	Date	Reviewed	Date
Draft	David Pitt EnvAll	29th June 2013	Owen Pitts	1st July 2013
Draft	David Pitt EnvAll	1st July 2013	Mark Hibberd - CSIRO	1st July 2013
Final – v3	David Pitt EnvAll	2nd July 2013	Mark Hibberd - CSIRO	3rd July 2013
Final – v4	David Pitt EnvAll	29th July 2013	Owen Pitts	29th July 2013

Table of Contents

APPENDIX B

List of Tables

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1 Introduction

Nyrstar are proposing a significant upgrade and redevelopment of the Port Pirie Smelter, referred to as the Transformation. This development comprises an upgrade and redevelopment of the existing sintering plant, blast furnace, acid making operations and associated infrastructure and equipment. This upgrade should significantly reduce emissions of atmospheric pollutants into the air and therefore result in a significant decrease in pollutant concentrations in Port Pirie. Nyrstar have requested Air Assessment to provide a proposal to undertake the air quality assessment for inclusion in the Public Environmental Review (PER). This report describes the modelling of air lead (Pb) emissions.

2 Summary of Outcomes from Previous Studies

2.1 SKM (1999) Fugitive Particulate Emission Study

SKM undertook an investigation of fugitive emissions to air of lead, zinc, cadmium and arsenic with an emphasis on quantifying emissions from the blast furnace (BF), sinter plant (SP), slag fumer (SF) and kiln dust recovery (KDR) area (SKM 1999).

The methodology entailed using a portable dust monitor to measure downwind concentrations from the key sources, then using a dispersion model and the prevailing meteorology to "back-calculate" the emission rate required to give the downwind measurements. A High Volume Air Sampler (HVAS) was used to determine the elemental composition, particle size distribution and calibration of the portable dust sampler for each source.

The study estimated the major sources of Pb were from blast furnace blows (37 tpa), slag fumer (24 tpa) and sinter plant area (21 tpa) with a total annual Pb emissions of 88 tpa. The report did not provide estimates for all sources (such as from the pit area, though measuring one wind erosion event) and as such was not a complete inventory. Using the Gaussian plume model ISC3 and the above emissions good agreement was found with the annual average monitoring data in Port Pirie.

The report was noted as a preliminary investigation, with further work to refine estimates, and concluded that "the good agreement indicates that the derived emission rates are of the right order, though the analysis undertaken to date can not verify whether the relative contributions from the different sources are correct (SKM, 1999, p37).

2.2 Source characterisations by SA Health

A large number of studies have been undertaken to characterise physically and chemically the lead dust in Port Pirie and the smelter such as to be able to determine the sources of air lead. These studies include:

- Ohmsen (2002) used optical and chemical measurements of the indoor air samples and samples at source at the smelter and a source apportionment model to determine the major sources. The indoor air deposition samples were collected in the front room on $1m^2$ stainless steel plates with the window left 30cm open to allow air exchange and penetration of airborne material. Therefore it is noted that they are not ambient air concentrations and the relationship between ambient air concentrations may be complicated.

  The study found that the "Pb concentrates and the Slag Fumer were identified as the major sources of Pb in the indoor samples, accounting for 23-71% and 6-42% respectively. Blast furnace fume accounted for <2% to the total indoor samples, but accounted for ~4-20% of the total Pb". (Ohmsen 2002, page 6);
- Maynar et al (2005) reporting on the state of knowledge to then with respect to indoor air lead levels stated "By 2003, joint understanding of smelter emission sources had improved substantially to the point that the slag fumer, roasting kilns and sinter plants were identified as

the 3 most important of 5 major source areas in terms of their contribution to bioaccessible indoor household contamination" (Maynar et al 2005, page 33); and

- Ohmsen (2006a) used indoor air free fall (deposition) measurements collected in a front room with an open window and source apportionment model to determine smelter sources. The data analysed collected from 1999 to 2005 showed that at Solomontown Pb concentrates (PbS) was the "major source of Pb, 29-58% (ave. 45%), sinter plant, 11-23% (ave. 19%), blast furnace (4-12%, ave. 6%), Zn concentrates (3-14%, ave. 6%) and raw ZnO fume (1-9%, ave. 5%). Roast ZnO fume (0.3-5%, ave. 2%) and paragoethite (1-4%, ave. 2%) contributed lesser amounts of Pb." Similar results were found for the Pirie West site with Pb concentrates being the major source, followed by the sinter plant. (Ohmsen 2006a, p 38).

  By using the Pb bioaccessibility of these source materials (determined from an acid digest at pH of 2, the percent contribution of smelter sources to bioaccessible Pb was estimated. This showed that "sinter plant dusts to be the main source of bioaccessible Pb, contributing 20-50% (ave. 37%). Raw ZnO fume was also responsible for an appreciable fraction of bioaccessible Pb, contributing 5-33% (ave. 20%). Pb concentrates contributed 6-22% (ave. 14%) with blast furnace fume (6-22%, ave. 12%), paragoethite (7-16%, ave. 9%) and roast ZnO fume (1-12%, ave 6%)." (Ohmsen 2006a, p 38).

It is noted that these studies do not, for indoor air at least, find that the same indicative order as determined by SKM (1999) with the blast furnace as less important. The Ohmsen 2006 study finding that Pb concentrates (source samples were obtained from the concentrate storage bins (CSB) and co-treatment shed) was the major source. Presumably this source was the handling after the storage shed (as this is considered well controlled), to the feed end of the sinter machine and the dust deposited in these areas that could be picked up by the wind. Therefore the sinter plant area is indicated as the largest source as well as being a large source of Pb concentrate, it also is the major source of sinter material, though SKM (1999) argued the blast furnace emissions were not just fume but in cases entrained sinter from the top of the blast furnace.

These studies and the others such as SKM (1999) are, of course, "snapshots" at the time, from 1999 to 2006 with there being substantial work since 2001 (particularly after 2005) to improve the various sources such as:

- Improvement in the primary ducting of the blast furnace in 2001/2003;
- Enclosure of the blast furnace - Began in July 2006 and was completed in August 2007;
- Slag Fumer projects;
  - Improve gas draughting systems;
  - Removal of any sources of instability that can give rise to emissions;
  - Brick flue water sprays;
  - Coal injection system replacement, completed in September 2007; and
  - Charge port venting, May 2008.
- Sinter plant ignition and fume extraction – March 2009; and
- Revegetation around the plant, wind breaks, increased road cleaning etc.

As such the relative contribution of each of the sources to off-site Pb levels have likely changed over time. It is noted that there has been insufficient work to date to resolve the differences between the modelling studies deriving emissions and the optical/chemical characterisation source apportionment methods.

2.3 Pacific Air and Environment

PAE Holmes (2012) undertook a study to develop more accurate estimations of fugitive emissions to air of lead, zinc, arsenic and cadmium. This involved updating the emission estimates methods used by Nyrstar, incorporating additional sources and revising were necessary. Then models were used to predict the resultant ground level concentrations and deposition rates, with the emission rates then modified based on analysis of the concentration data to better match the emission rates.

PAE Holmes used the dispersion model CALPUFF (Californian Puff model) and meteorology derived from a combination of surface wind measurements and the output from mesoscale modelling.

Using the derived emission rates, the modelling system over-predicted the annual average air lead concentrations at the various monitoring sites, more so in the western sites, with better agreement for the eastern sites. PAE Holmes then adjusted the overall emissions by correction factors of 0.64 and 0.40 for the two years, 2010 and 2011 respectively, to best match the measurements. This adjustment of the emissions is therefore an approximate first pass correction and did not take into account which sources may be over predicting (it presumes all sources are) and did not identify the reasons for the better predictions at the eastern monitors, and the greater over-prediction at the western monitors. This could either be due to the Port Pirie winds not being adequately resolved or to overestimating the sources which have more of an impact at the western sites.

2.4 CSIRO

CSIRO undertook an analysis of the meteorological and air lead data from the Nyrstar and EPA ambient monitoring network in Port Pire (Hibberd 2012). The main findings relevant to this modelling study were:

- Some problems were identified in the anemometers alignments – it is understood that the meteorological data as supplied (1/11/2007 to 31/12/2012) for our study was corrected for this; and
- From a back-trajectory analysis of ambient measurements at the Dental Clinic and Boat Ramp monitoring sites, the region of the smelter identified as most likely to contain the sources responsible for the majority of high air lead days was identified as the vicinity of the blast furnace and the sinter plant.

3 Review of Ambient Monitoring Data

3.1 Analysis of Meteorological Data as Supplied

For the modelled period 2010 and 2011, there were three sites with wind data available - the Dental Clinic, Boat Ramp and Oliver Street (EPA site). Of these, analysis of the data for the period indicated the following issues:

- The Boat Ramp data until October 2011 often recorded winds through north as from other directions, due to scalar averaging of the wind directions. As such, this direction data could not be corrected and was discounted from the modelling study;
- The Dental Clinic wind direction shows an apparent orientation along a NNW to SSE axis (more than that observed at the other sites), which may be influenced by the building immediately to the SW of this site; and
- The Oliver Street site is considered to be affected by the presence of trees to the east and north-east in particular which may cause the wind speeds in these directions to be under-reported.

In order to construct the best data set, two wind sites were used. The Oliver Street wind data and the Boat Ramp wind data, but with the wind directions specified as from the Oliver street site. It is acknowledged this is not optimum and introduces some uncertainty into the air lead analyses by wind direction in this report.

It is noted that for periods after October 2011, the Boat Ramp should provide good quality data.

3.2 Ambient Pb Data

Ambient Pb concentrations are measured at a number of ambient monitoring sites around Port Pirie.

Measurements from the sites shown in **Table 3-1** and **Figure 3-1** were used in this study. **Table 3-1** shows generally that measured concentrations tend to decrease with increasing distance from the smelter, as would be expected.

Table 3-1 Ambient Pb Monitoring Data

Sites	Easting UTM 53S[(a)] (km)	Northing UTM 53S[(a)] (km)	Distance from Tall Stack (m)	Substances (averaging time)	Average Pb Conc. 2010 ($\mu g/m^3$)	Average Pb Conc. 2011 ($\mu g/m^3$)	Average Pb Conc. 2010-11 ($\mu g/m^3$)
York Road	779.206	6325.088	1848	Pb (24-hr)	0.23	0.15	0.19
Senate Sports Park	779.332	6324.194	2229	Pb (24-hr)	0.24	0.18	0.21
Frank Green Park	779.491	6322.966	3175	Pb (24-hr)	0.17	0.13	0.15
Terrace	780.146	6326.291	835	Pb (24-hr)	1.07	0.92	1.00
Dental Clinic	780.687	6325.642	246	Pb (24-hr), PM_{10} (1-hr)	3.49	3.16	3.33
Ellen Street	780.682	6325.420	451	Pb (24-hr)	2.35	2.09	2.22
Pirie West Primary School	780.096	6324.539	1508	Pb (24-hr)	0.40	0.37	0.39
Baseball Club	780.631	6323.668	2169	Pb (24-hr)	0.20	0.21	0.21
Boat Ramp	781.437	6324.499	1538	Pb (24-hr)	0.52	0.67	0.60
Solomontown	781.657	6323.660	2319	Pb (24-hr)	0.37	0.42	0.40
St. Marks College	780.396	6321.976	3888	Pb (24-hr)	0.11	0.11	0.11
Oliver Street	781.546	6323.031	2869	Pb (24-hr)	0.26	0.28	0.27

[(a)] Note: Coordinates used in the report are based on UTM zone 53S. The Port Pirie township lies across the border of UTM 53S and UTM 54S hence either coordinate system could be used for geo-referencing. UTM 53S coordinates were also used in the PAE Holmes (2012) study.

Figure 3-1 Location of ambient Pb monitoring sites

The highest Pb concentrations are measured at the Dental Clinic site.

The Dental Clinic site has good exposure to air emissions from the smelter (see **Figure 3-2**) in that it can discriminate between the various source areas (e.g. process area and pit area) and possibly some individual sources depending on the availability of representative wind data.

PM_{10} is also measured with data available for 1-minte averages and above. For this study, the 1-hourly data is the shortest period that is used in the analysis. These Pb and PM_{10} data were considered to be the most useful for developing a data set of ambient measurements for modelling validation.

Figure 3-2 Location map of major Sources and the Dental Clinic and Boat Ramp monitor

Note: Source abbreviations described in **Table 4-3**.

3.3 Estimating 1-hour average Air Lead Concentrations

For this purpose, an estimate of pseudo 1-hourly Pb concentrations was derived by assuming the variation in Pb was in direct proportion to the variation in TEOM PM_{10} over each 24 hour period sampled for Pb. Therefore, the 1-hour PM_{10} concentrations were multiplied by the ratio of the 24-hour Pb/PM_{10} concentration for that day.

A reasonable assumption for estimating the contribution of a substance from various sources to an ambient measurement is that concentrations are associated with the wind direction from the source to the monitor. The relationship between concentrations, wind directions and therefore likely upwind contributing sources can be illustrated using polar plots.

Polar plots showing average PM_{10} and Pb concentrations are shown in **Figure 3-3**. The wind direction data has been derived from measurements at Oliver Street as discussed in **Section 3.1.** Therefore its representivity for winds between the smelter and Dental Clinic site has some uncertainties.

While polar plots of average Pb concentrations with wind direction show which wind directions are associated with the highest Pb levels, the average Pb concentration (and for example, total deposition) over a year also depends on the frequency that winds blow from each direction. This issue is discussed further in **Section 4.7.11**.

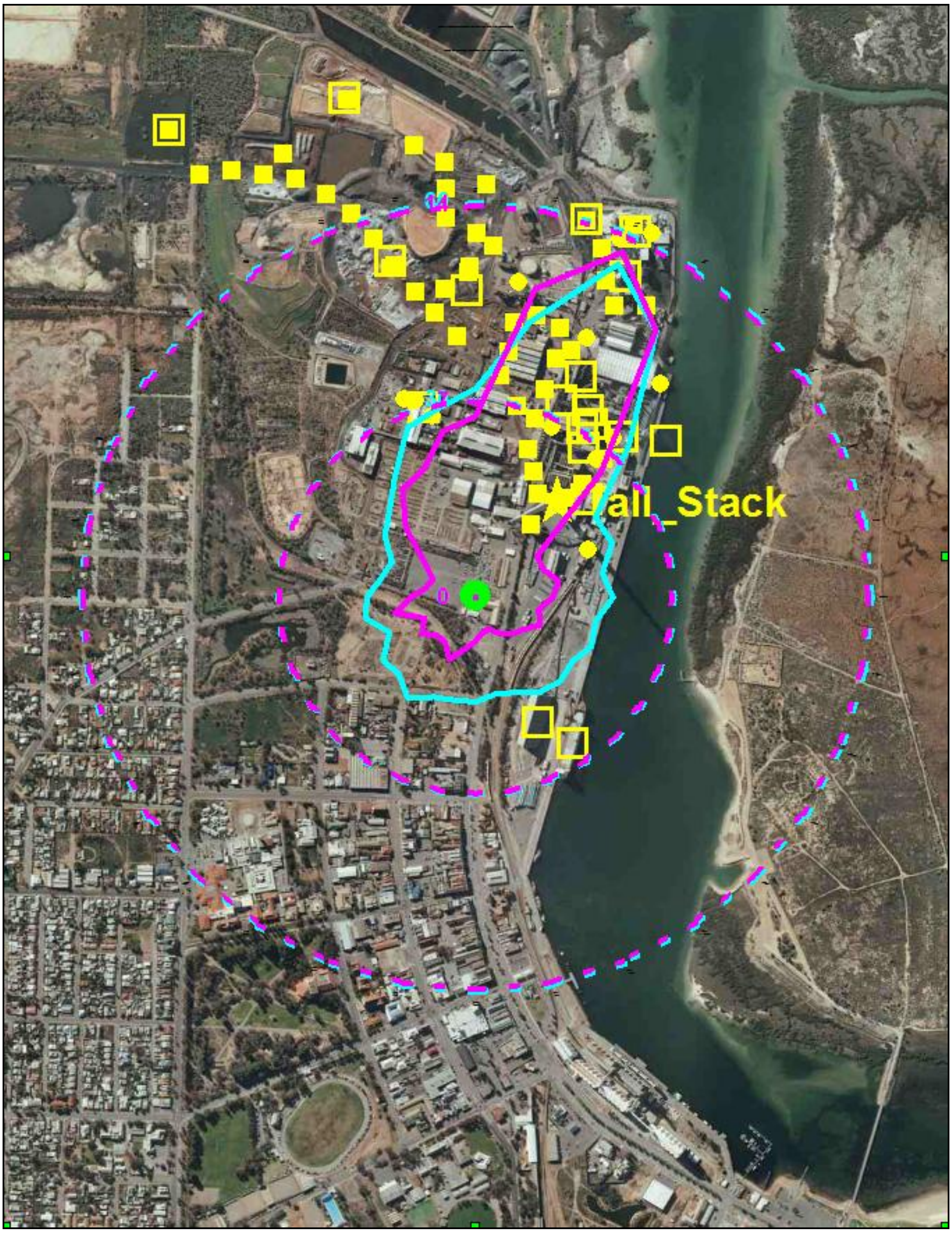

Figure 3-3 Polar plots of average PM_{10} (blue) and Pb (pink) concentrations at the Dental Clinic 2010-11 (green circle). Note: open squares are "volume" sources, closed squares are "area" sources and dots are "point" sources of Pb as used in the modelling.

Figure 3-3 show that the process area to the NNE to NE of the monitor is indicated as the origin of the highest proportion of lead-containing particles in PM_{10}. Conversely the areas to the south of the monitor are the origin of the lowest proportion of lead-containing particles. Given that this is reflected in the relativities of the extents of the PM_{10} and Pb contours, it is considered that derivation of pseudo 1-hour Pb by the normalisation of the 1-hourly PM_{10} concentrations to the 24-hour Pb concentrations provides a useful measure to identify Pb sources for the purpose of model validation. For simplicity, these are referred to hereafter in this report as "observations" though strictly speaking, they are "estimates".

3.4 Analysis of 1-hour average Pb Observations

The estimated 1-hourly Pb concentrations at Dental Clinic 2010-11 versus time of day is shown in **Figure 3-4**.

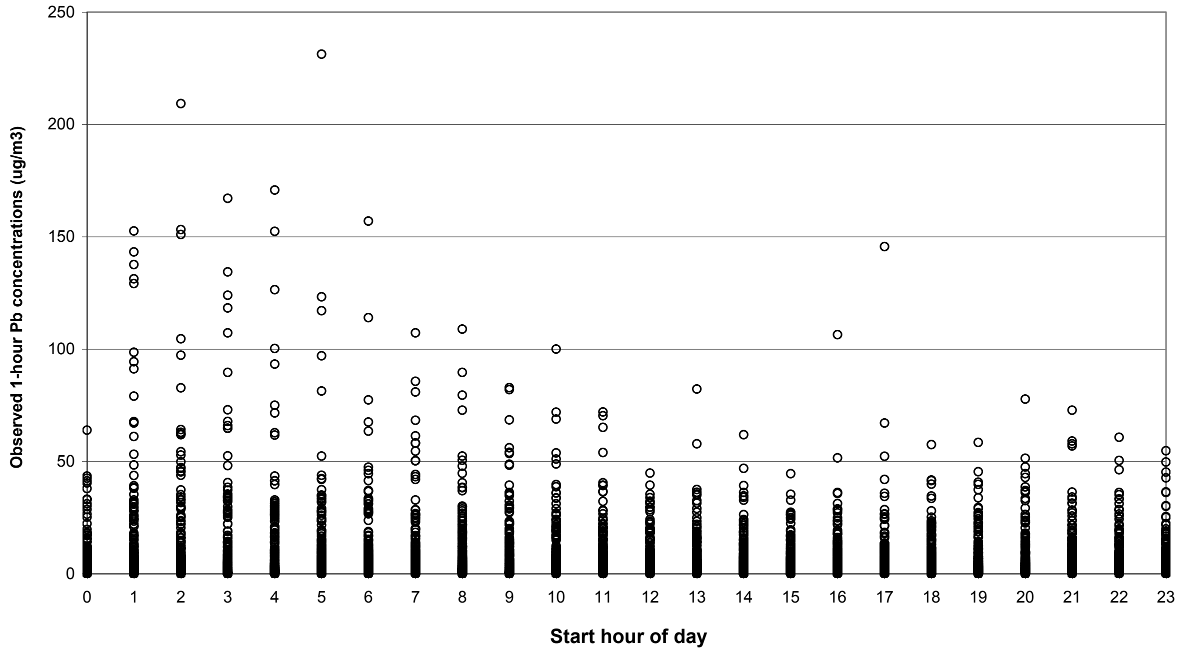

Figure 3-4 Observed 1-hour Pb concentrations at Dental Clinic 2010-11 versus time of day

The highest concentrations tend to occur between around midnight to 0700 hours. The estimated 1-hourly Pb concentrations at Dental Clinic 2010-11 versus wind speed is shown in **Figure 3-5**.

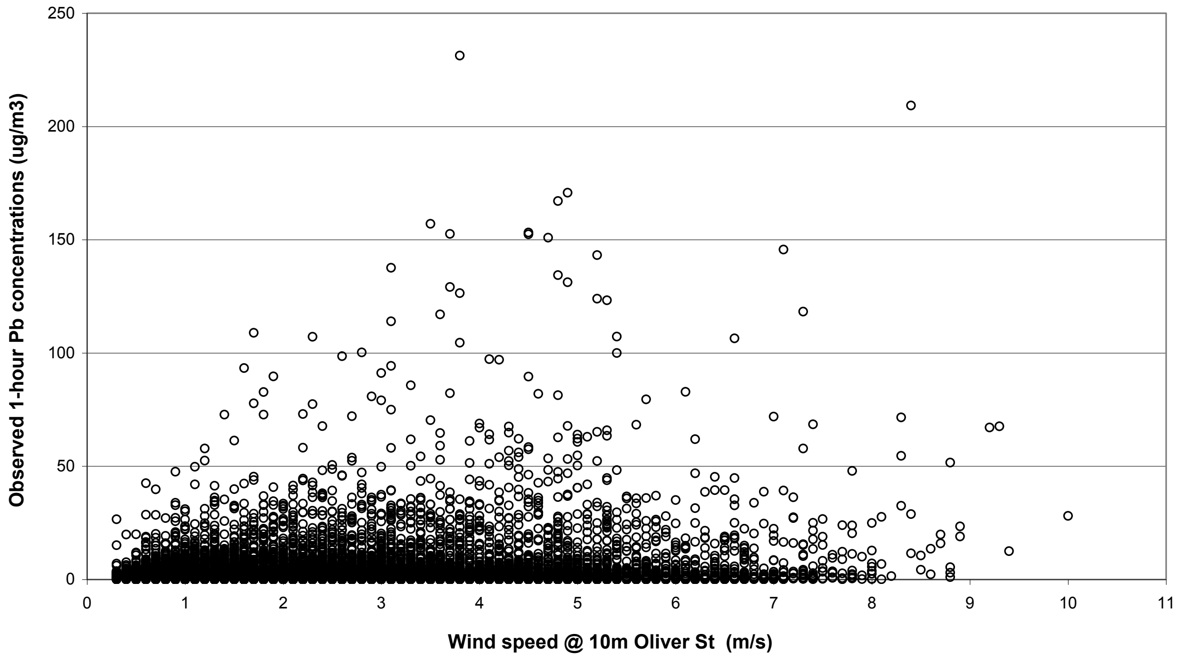

Figure 3-5 Observed 1-hour Pb at Dental Clinic 2010-11 versus wind speed

This shows the highest concentrations are measured during moderate to relatively high wind speeds. This is particularly noteworthy because plume dispersion is proportional to wind speed, therefore for relatively high downwind concentrations to be associated with wind speed implies:

- The emission rate has increased at a greater rate than the wind speed increase; and/or
- A buoyant plume is being brought to ground due to increasing wind speed.

Of these two implications, it is considered unlikely that the decrease in plume rise with increasing wind speed from the buoyant sources (Blast Furnace, Slag Fumer and Sinter Plant building emissions) can account for all the highest concentrations at moderate wind speeds, hence it is considered there is a significant wind speed dependency in the key dust emissions sources. This would be expected for sources where dust is generated in a process or material handling where there is less-than-full enclosure and from dust generated by wind erosion.

Additionally, a significant proportion of dust from materials handling operations, during light winds, settles nearby, to be re-emitted when wind speeds increase. It is considered all of the above mechanisms may occur to some degree from most of the fugitive process sources at Nyrstar. For example at the sinter plant area (Ohmsen, 2006b, page 18), notes: “the widespread occurrence of fine lead-bearing material on horizontal surfaces and open structure of the sinter building all make this plant susceptible to increased fugitive emissions from re-entrainment under elevated (>5-6m/s) wind conditions.”

4 Modelling Current Emissions

4.1 Introduction and Model Choice

The CALPUFF model (Version 6) has been used for the prediction of Pb levels from the Nyrstar operation. This model has been adopted by the U.S. Environmental Protection Agency (USEPA) in its "Guideline of Air Quality Models" (US EPA 2005) as the preferred model for assessing long range transport of pollutants and their impacts on Federal Class I areas and on a case-by-case basis for certain near-field applications involving complex meteorological conditions.

More specifically to this study, the Guideline provides for the use of CALPUFF on a case-by-case basis for air quality estimates involving complex meteorological flow conditions, where steady-state straight-line transport assumptions are inappropriate.

Downwind concentrations from the low level emissions sources will be sensitive to dispersion under low wind speed, stable conditions which are best handled by puff models. Also, the requirement to handle dispersion over various surface characteristics – land and water implies the use of a three dimensional model. For example the dispersion to the Boat Ramp is primarily over water, whilst to the Port Pirie West Primary School is over a suburban area.

The CALPUFF modelling system consists of three main components; CALMET - a diagnostic 3-dimensional meteorological model, CALPUFF - an air quality dispersion model, and CALPOST - a post-processing package.

4.2 Model Set-Up

Model set ups and parameters used were:

- The CALMET(V6.333)/CALPUFF (V6.42) modelling system was used;
- The source configurations and emissions were as supplied by PAE Holmes (2012)[1] except where changed as described later in this document;
- Unless described otherwise, the sigma y and sigma z values for volume sources nominated by PAE Holmes (2012) were retained;
- Dry deposition of particles;
- Building wake effects on buoyant point source emissions;
- Domain Grid 25 x 28 x 200m cells; and
- Assumption of flat terrain.

Due to time constraints, the modelling was restricted to air ead (Pb) as the metal of most concern.

---

[1] We are grateful for the assistance provided by PAE Holmes in the form of modelling configuration files and spreadsheets showing emissions calculations. It would not have been possible to undertake this work in the time available without the substantial work undertaken beforehand by PAE Holmes, much of which was utilised for this study.

4.3 Geophysical Data

The land use data was based on data used by PAE Holmes (2012), modified as follows:

The geophysical file showed a land use category of 10 for both the Nyrstar site as well as the Port Pirie residential area. CALMET would have assigned a default roughness length of 1.0 metre for these areas which is reasonable for the Nyrstar processing area but too high for the residential area, which is typically assigned a roughness length of 0.4 metres. This was modified accordingly. An illustration of the land use parameters is shown in **Figure 4-1**. The representivity of the land use data could be improved with more time, however any inaccuracies in the grid cell assignments are considered unlikely to significantly affect modelling predictions.

The other geophysical parameters associated with the land use categories are shown in **Table 4-1**. Again, with more time, a more detailed review could improve the accuracy of some grid cell assignments. The roughness lengths assigned to the Nyrstar pit areas is probably slightly high, but this would have a minimal effect on modelling predictions over the bulk of the Port Pirie township.

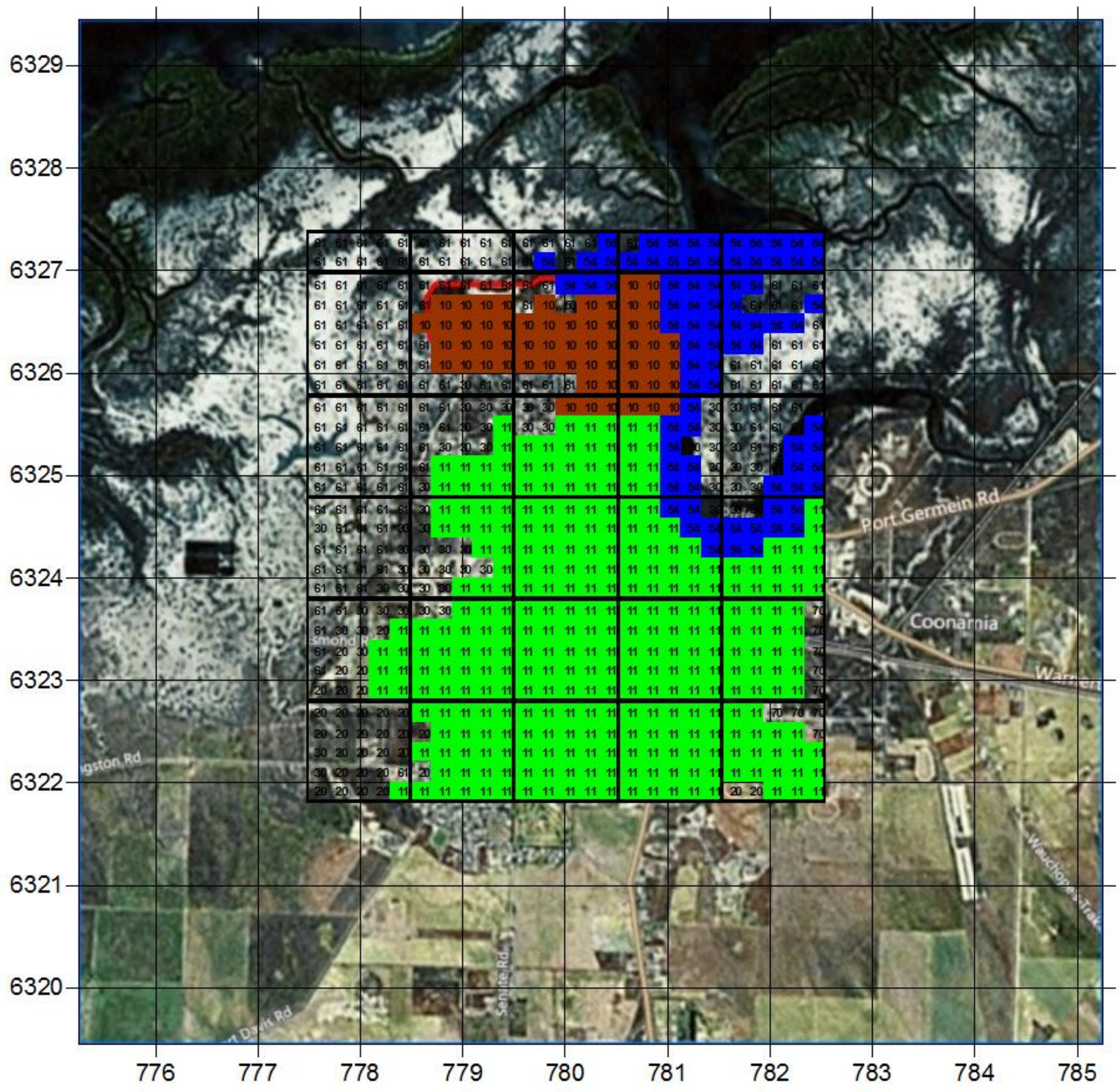

Figure 4-1 Illustration of land use categories set up for CALMET. Note: Green shows residential areas; Brown shows Nyrstar site; blue shows water.

Table 4-1 Geophysical Parameters Associated with the Land Use Categories

Specific Land Use Category	Land Type Description	Transformed Land Use Category for Default Parameters	Roughness Length (m)	Bowen Ratio	Leaf Area Ratio
11	Suburban	10	0.4	1.5	0.2
13	Industrial	10	1	1.5	0.2
20	Agricultural land Unirrigated	20	0.25	3	2
30	Rangeland (Undisturbed land)	30	0.25	3	0.5
50	Bays and Estuaries	54	0.001	0	0
54	Bays and Estuaries	54	0.001	0	0
55	Large Water Body (Ocean)	55	0.001	0	0
61	Wetland	60	0.2	0.5	2
70	Barren	70	0.05	4	0.05

4.4 Meteorological Data

The modelling period was 1/1/2010 to 31/12/2011 to make best use of the ambient Pb monitoring data available for model verification.

The meteorological data sets developed for the AERMOD model based on wind direction measurements at Oliver Street, and wind speed measurements at Oliver Street and the Boat Ramp, were used as surface observational data for CALMET. Three pseudo-sites were located on the inlet approximately 2 kms, 4 km and 6 km north of the Boat Ramp. These were used to bias the surface windfield developed by CALMET along, and east of, the inlet, by the Boat Ramp wind speed measurements, which are considered to be more representative of over-water wind speeds.

An upper air profile for the Nyrstar location was generated using TAPM with default assumptions apart from soil moistures set to 0.1 kg/kg and with minor adjustments to soil categories.

Hourly cloud data was obtained from the hourly automatic weather station observations from the Bureau of Meteorology weather station at Whyalla 43 km to the west, as this was closest site with these observations. Note rainfall was not used with no wet deposition of particulate included.

The wind rose for the data period is shown in **Figure 4-2**.

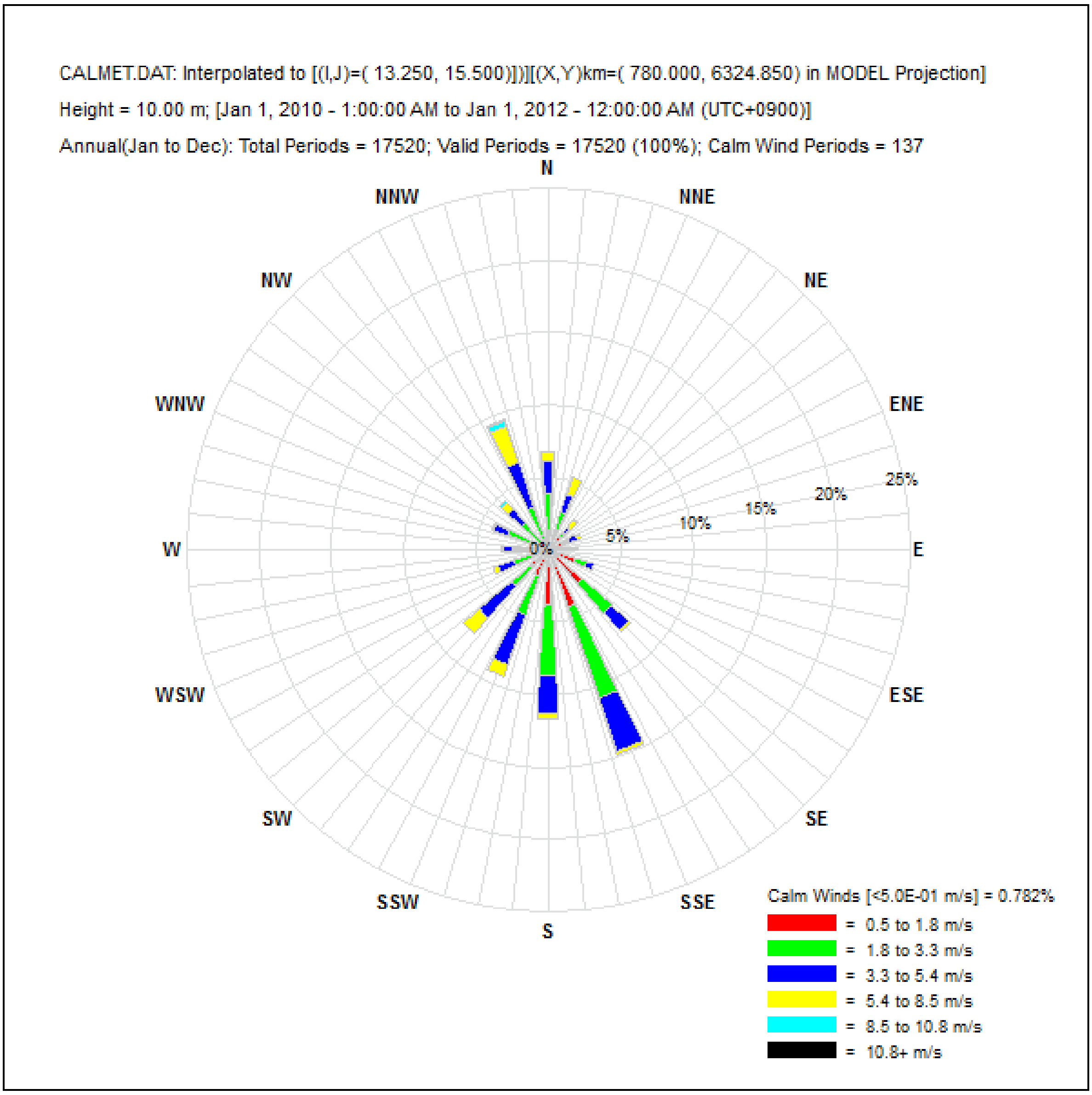

Figure 4-2 Wind rose for Nyrstar site for 2010-11

The stability distribution from CALMET for the Nyrstar site is shown in **Table 4-2**. Due to the reasonably low wind speeds at night-time, there is a relatively high occurrence of extremely stable (F class) conditions which is associated with poor dispersion from low level, non-buoyant emissions.

Table 4-2 PG Stability Distribution with Wind Direction at Nyrstar site from CALMET 2010-11 (values as percentages)

PGT class	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Totals
1	0.04	0.03	0.00	0.01	0.01	0.04	0.02	0.06	0.07	0.12	0.18	0.11	0.23	0.27	0.15	0.08	1.4
2	0.74	0.61	0.26	0.27	0.26	0.46	0.89	1.16	1.06	0.92	1.47	0.96	0.84	1.30	1.20	1.46	13.9
3	1.34	0.85	0.38	0.27	0.25	0.48	1.39	1.91	1.48	1.78	2.07	0.58	0.49	0.74	1.15	2.33	17.5
4	1.39	1.51	0.73	0.38	0.12	0.17	0.53	1.34	1.76	2.92	2.50	1.00	0.55	0.70	1.10	3.73	20.4
5	1.03	0.68	0.34	0.39	0.17	0.16	0.64	2.27	1.26	0.91	0.30	0.38	0.33	0.35	0.26	0.82	10.3
6	2.31	1.71	1.11	1.11	1.28	2.03	4.21	8.33	6.08	2.69	1.32	0.95	0.86	0.79	0.63	1.13	36.5
Totals	6.83	5.39	2.83	2.41	2.09	3.34	7.69	15.06	11.72	9.34	7.83	3.97	3.30	4.16	4.48	9.55	100%

4.5 Background Concentrations

In modelling, background concentrations and the contribution from other nearby sources are required to estimate a cumulative or total impact. For Pb modelling there are no other sources known in the region, with background levels determined to be low at 0.005µg/m^3 (see PAE Holmes, 2012, page 29). This is only around at most several percent of the existing annual average concentrations of 0.11 to 3.33 µg/m^3 (see **Table 3-1**) and has been omitted in the assessment given the level of other uncertainties.

4.6 Generic Modifications to PAE Treatment of Sources

For reference to descriptions in subsequent section, the PAE Holmes (2012) sources of Pb emissions used in the study are summarised in **Table 4-3**.

"Volume" sources are those where initial emissions are considered to be spread in the vertical and horizontal, such as buildings and stationary materials handling equipment. "Point" sources are stacks. "Area" sources are those where initial emissions are considered to be spread in two horizontal directions, such as roads.

A number of minor process sources emit more or less continuously due to the underlying continuous nature of the facility's operation and were modelled with a continuous, constant emission rate.

The emissions from many of the larger emitting sources however, vary according to process variations of the operation and/or prevailing wind conditions. The PAE Holmes (2012) emissions inventory was derived using process data over 2011-12, where it was reasonably available. No changes were made to the operational basis of the hourly-varying emissions data for this study.

The PAE annual inventories were also two hours short of the full year. The missing hours were filled with zero emissions for this modelling, which may cause slight differences in calculated annual averages.

Table 4-3 Modelled Emissions Sources of Pb

Constant Volume Sources		**Time Varying Area Sources**	
ID	Description	ID	Description
REF	Lead Refinery	u1-19	Unpaved roads
LC	Lead Casting	p1-21	Paved roads (for various usages)
ZC	Zinc Casting	PIT	PIT/Crusher area
EAF	Electric Arc Furnace (EAF) Dust	PGP	Uncovered PGP Stockpile
SR	Sinter Returns, Sludge & Residue Mixes handling	SRS	Sinter Returns, Sludge & Residue Mixes Stockpiles
BSE	Black Sand export	BSS	Black Sand Stockpile
BS	Black Sand	KDRW	KDR wind blown dust
PGP	PGP – TRUCK	PIT2	pit 2
PTP	Perylia Concentrate TP1,2,3	PIT3	pit 3
PSHIP	Perylia Ship Concentrate TP4	BSE	Black Sand Stockpile to export
Constant Point Sources		**Time Varying Volume Sources**	
ID	Description	ID	Description
S1	Tippler Baghouse Stack (incl Perilya Concentrates)	SHIP	Ship Unloading
S2	Co-Treatment Shed Baghouse Stack – East	SM	Sinter Machine
S3	Co-Treatment Shed Baghouse Stack – West	BF	Blast Furnace
S4	Sinter Plant #6 Scrubber Stack	SF	Slag Fumer
S5	Sinter Plant Combined Stack	KDR	KDR System
S7	Blast Furnace Enclosure Baghouse Stack	DL	D&L building
S10	Tall Stack	PP	Proportioning Plant (Mixing Plant)
S12	Acid Plant Stack	BBDP	Battery Bay & Duck Pond
S15	Slag Fuming Main Baghouse Stack	SB	Sinter Bins
S18	Kilns Dust Recovery Stack #2 (Scrubbers #2 and #3)	EN	Eagles Nest
S21	Zinc Ajax Furnace Baghouse Stack	TDO	Telpher Drop Off
S22	Zinc Dust Baghouse Stack		
S23	Zinc Dross Treatment Baghouse Stack		

4.6.1 Specification of particle sizes

Particles emitted into the air tend to undergo gravitational settling at rates according to the size, mass and other aerodynamic properties.

For the incorporation of particle settling in the modelling, the lead-containing particles were modelled:

- For sources other than below, in three size categories as shown in **Table 4-4**; and
- For the Blast Furnace, Sinter Machine, Slag Fumer and KDR emissions, in six size categories as shown in **Table 4-5** as per the SKM (1999) study.

APPENDIX B

Table 4-4 Size Parameters for Dry Deposition of Particles for Sources other than Indicated in Table 4-5

Description	Nominal Classification	Mean Diameter (µm)
Particulates with an aerodynamic diameter of less than or equal to 2.5 µm	$PM_{2.5}$	0.5
Particulates with an aerodynamic diameter of less than or equal to 10 µm and greater than 2.5 µm	$PM_{2.5}$-PM_{10}	7
Particulates with an aerodynamic diameter greater than 10 µm (up to approximately 30 µm)	PM_{10}-PM_{30}	22

Table 4-5 Size Parameters for Dry Deposition of Particles from Blast Furnace, Sinter Machine, Slag Fumer and KDR Emissions

Nominal Classification	Mean Diameter (µm)
$PM_{0.5}$	0.5
PM_{2}	2
PM_{7}	7
PM_{12}	12
PM_{22}	22
PM_{40}	40

It is considered that using more bins to define the range of particle sizes across all sources may improve modelling predictions.

4.6.2 Paved area sources

The PAE Holmes (2012) emissions inventory calculated specific Pb emissions rates for each of the segments used to define paved surfaces. These showed little variation and hence for simplicity, each of these was modelled using the average emission rate for all the paved surfaces.

4.7 Treatment of Emissions from Key Sources

4.7.1 Emission review methodology

4.7.1.1 Operational factors

The first step in reviewing the Pb emissions developed in the PAE Holmes (2012) inventory was to make changes where – and only where, there appeared to be a strong operational basis for doing so. One example discussed subsequently is that the emissions rate for visible plumes determined in the SKM (1999) study on the basis of a rising plume should, for consistency, be modelled assuming some degree of plume rise. Another change was the inclusion of water control in a materials handling operation which had not been taken into account. In the end however, there were only a few changes to the emissions made on this basis, in part because a more exhaustive review was limited by the time available.

4.7.1.2 Short term peak concentrations

In theory, it may be possible to correlate observations of visible releases from various areas of the smelter with measured 1-hourly Pb concentrations[2] at the Dental Clinic and effectively use a dispersion modelling "back-calculation" to estimate an emissions rate. Given more time, this may be a useful task. Issues that would need to be taken into account include:

- Better resolving the emissions rates of sources during high short term dust impacts may have little bearing on predicted annual average concentrations if such events only occur infrequently for relatively short time periods anyway;
- This procedure requires accurate wind direction data representative of the trajectory between the source and the monitor. The meteorological data set developed for this work was for dispersion modelling across the Port Pirie township and during this work, the quality of the wind measurements at the Dental Clinic site was considered unsuitable. More time is required to identify periods of adequate quality wind data at the Dental Clinic to investigate source emission back-calculations. An unimpeded 30 m tower in the vicinity of the smelter would provide a source of high quality wind data; and
- The process sources considered most likely to be the main contributors to short-term high Pb concentrations – Blast Furnace and Sinter Building, lie on a fairly similar bearing to the Dental Clinic. On one hand, the 1-hourly Blast Furnace emissions were estimated by PAE as up to three times higher than the highest emissions from any other source. On this basis, it could be assumed that the Blast Furnace causes the highest modelled 1-hour Pb concentrations at the Dental Clinic. On the other hand, a brief review of the major visible release incident reports tends to suggest the Sinter operation as the cause of most of these. (An issue not previously recognised is sinter plant start-ups). Given that a key benefit of the Transformation is cessation of the sintering operation, increasing the sinter plant Pb emissions could be viewed as exaggerating the benefits of the proposal noting that the sintering process emissions were already the highest in the inventory (notwithstanding the first point above).

4.7.1.3 Modelling calibration

Given the basis of most of the emissions estimates – some source back-calculations by SKM in 1999 and generally otherwise very empirical emission factors used by PAE Holmes (2012), it is considered that there is a reasonable uncertainty regarding the emissions estimates from each of the various sources. Nevertheless, with one exception as described in **Section 4.7.11**, we have limited making changes to overall emissions from various sources merely for the sake of improving modelling predictions. Instead, more realistic emission and dispersion mechanisms were identified without making substantial changes to the overall average emissions from any source which might bias the assessment of the Transformation. While most of these changes appeared to improve modelling predictions, even those that did not were still made on the basis that ultimately, accurate modelling predictions depend on the most realistic assumptions.

[2] In hindsight, it would have been useful to do the source identification analysis to the short term 1-hour events using the TEOM PM_{10} data directly, as it is a more precise indicator of a general, visible dust event than the pseudo 1-hourly Pb concentrations.

4.7.2 Preliminary review of significant emissions sources

A preliminary review of the emission inventory showed that over 2010-11 (**Table 4-6**), the top three sources of Pb in PAE Holmes (2012) were estimated to contribute approximately 77% of the total Pb emissions. These were:

- Sinter Process Sources 38%
- Blast Furnace Process Sources 19%
- Slag Fuming Process Sources 17%

These were all modelled by PAE (2012) as fugitive sources with near ground level release heights hence for this configuration, their contribution to average off-site Pb concentrations should be approximately proportional to their emission rates.

Table 4-6 Summary of PAE Holmes (2012) 2010-2011 Pb Emissions Inventory

ID	**Source**	**Pb Emission 2010-11 (kg/year)**	**Percentage of Total (%)**
SHIP	Ship Unloading	2,052	3
PP	Proportioning Plant (Mixing Plant)	1,637	2
Blast Furnace sources			
BF	Blast Furnace	12,032	
TDO	Telpher Drop Off	1,622	
Sub-Total Blast Furnace Process sources		13,654	19
Sinter Process Sources			
SM	Sinter Machine	6,438	
SB	Sinter Bins	2,895	
BBDP	Battery Bay & Duck Pond	224	
EN	Eagles Nest	13,357	
DL	D&L building	5,044	
Sub-Total Sinter Process Sources		27,959	39
OPAVS	All Other Process Area Volume Sources	1,561	2
APAPS	All Process Area Point Sources	3,588	5
Slag Fuming Process Sources			
SF	Slag Fumer	9,147	
KDR	KDR System	3,014	
Sub-Total Slag Fuming Process Sources		12,161	17
p1-21	Paved Roads	1,553	2
Pit Sources			
OPAS	Other Pit Area Sources	1,430	
u1-19	Unpaved Roads	2,186	
SRS	Sinter Returns, Sludge & Residue Mixes Stockpiles	4,013	
Sub-Total Pit Area Sources		7,630	11
TOTAL		**71,794 (2)**	**100**
TOTAL (Adjusted for Predicting Concentrations) (1)		**38,800**	

Notes:

1) The original estimated emissions of PAE were subsequently corrected downwards to provide a best fit against the ambient observations

2) Emissions in this and other tables may be presented with more significant figures that appropriate give the basis of estimates. This is simply done to assist referencing to spreadsheet calculations.

4.7.3 Sinter Plant, Blast Furnace and Slag Fumer operational emissions versus visible plumes

PAE determined variable fugitive process emissions for the Sinter Plant, Blast Furnace and Slag Fumer calculated from a log of visible plumes, recorded by Nyrstar. In the emissions log, the length of time for each visible plume was provided. This allowed variable emissions to be estimated allowing for plant upsets and visible plume emissions. For the visible plume emissions the emission rate from the SKM Fugitive Particulate Emission Study (1999) was assumed for the length of the emission.

When visible plume events overlapped within the hour, the emission rates were added together. If visible plume events were recorded for longer than one hour, the emission rate was set for the length of the emission rounded up to the nearest whole hour[3].

The PAE emissions calculations were based on "visible" plumes emissions rates excluding the contribution from materials handling associated with that process, referred to in this report as "fugitive"[4] emissions. It is considered however, that the short term visible emission events occur independently on the ongoing fugitive emissions from materials handling and therefore should be assumed to continue to occur during the visible plume events.

This change was applied to the sinter machine (SM), blast furnace (BF) and slag fumer (SF) sources. Since the visible emissions occurred quite infrequently, the effect of this change was only a minor increase in average emission rates for each of the sources.

In September 2011 Nyrstar introduced a rating system to the log of visible plume observations with a severity rating of 1, 2 or 3 in addition to previously logged release duration. Visible plume observations now used by Nyrstar refer to the dustier operations with a severity rating introduced in September 2011 and were therefore not available for the entire 2010-11 modelling period.

4.7.4 Adjustment of emissions for wind speed dependency

From sensitivity testing of the modelling, it was found that adding a wind speed dependence to the emissions for all sources produced a significant improvement to the agreement between predicted and observed concentrations. The generic form for the wind speed dependence used was the US EPA batch drop equation (U/2.2)^1.3.

This is, however, based on wind speed dependence in the open air and it is difficult to justify this for all the Nyrstar sources.

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[3] Where emissions overlapped an hour, the emission was actually allocated to the start hour. For example, the Blast Furnace visible emission observed for 19/2/2010 23:51 lasting 44 minutes was allocated to the 2300 to 0000 hours hour whereas most of the emissions and most of the PM10 concentration measured at the Dental Clinic was within the 20/2/2010 0000 to 0100 hours hour. It would have been better to apportion emissions by time within each hour.

[4] Note PAE tend to refer to the "visible" plumes as "fugitive" emissions as distinguished from "materials handing" emissions, however the latter are also fugitive emissions.

An adjustment of (max(1,WS)/2.6)^1.2 was applied to the fugitive emissions from the Sinter Machine (i.e. non-visible releases only), D&L Building, Sinter Bins, Proportioning Plant, Battery Bay & Duck Pond, Eagles Nest and Telpher Drop Off sources. The basis of this was:

- 2.6 m/s was the average wind speed for Port Pirie derived from the Oliver Street data. Using 2.6 m/s in the denominator normalises the emissions such that for wind speeds higher than 2.6 m/s the emissions are greater than on average, whilst below 2.6 m/s the emissions are lower than average; and
- The downward adjustment to estimated emissions was limited by the 1 m/s minimum as emissions arising from materials handling would not become zero on the basis of a zero wind speed.
- The 1.2 exponent made the adjustment less severe than the US EPA exponent of 1.3.

The overall effect was to increase total emissions from each of these sources by 4% which is considered only a minor change.

The outcome of this in relation to predicted concentrations with wind speed is shown in **Figure 4-3** and predicted concentrations with time of day, which is often related to wind speed, shown in **Figure 4-4**. Whilst the correspondence is not unreasonable, the highest predicted concentrations are slightly skewed towards low wind speeds at night-time compared to the observations.

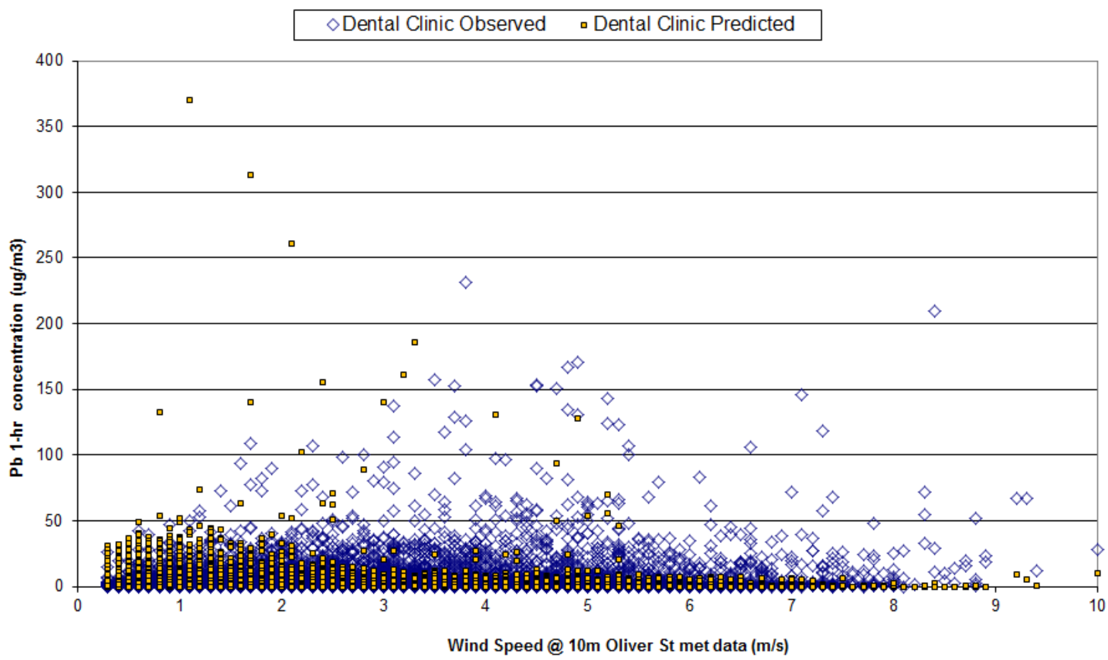

Figure 4-3 Predicted and observed 1-hour average Pb concentrations by wind speed at Dental Clinic 2010-11

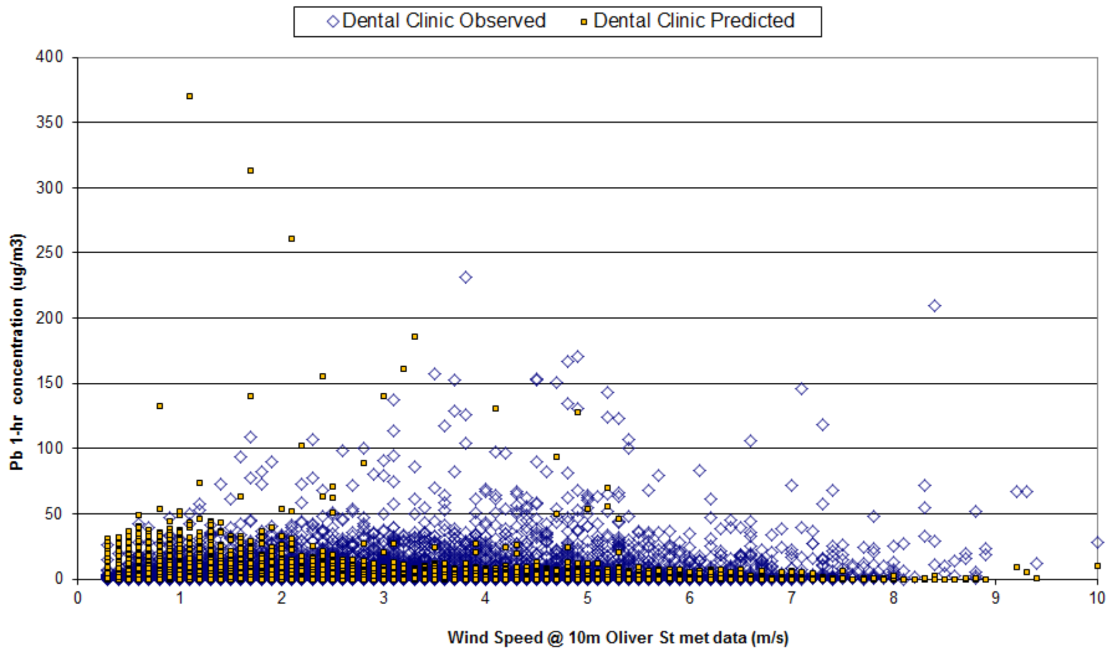

Figure 4-4 Predicted and observed 1-hour average Pb concentrations by hour of day at Dental Clinic 2010-11

4.7.5 Eagles Nest and Telpher Sources

The Telpher operation is the overhead system that picks up material from the sinter plant areas using a skip which is filled with material from a loading hopper (referred to as the Eagles Nest) and drops the material into the hopper at the top of the Blast Furnace.

The Telpher materials handling emissions were derived by PAE Holmes (2012) using NPI emissions factors and operating periods for the following transfer points and loading/unloading:

- Battery Bay and Duck Pond pick up and drop off by front end loader (2 emissions sources) (BBDP);
- Conveyer from Sinter Bins to Eagles nest (SB);
- Charging from Eagles nest into Telpher grabs (2 emissions sources- transfer point at Eagles Nest and transfer from Eagles Nest to Telpher Grabs) (EN); and
- Discharge (“drop off”) of Telpher grabs into Blast Furnace (TDO).

The emissions were based on the daily materials handling rate (tph) provided by Nyrstar - assumed constant for that 24 hour period and multiplied by a default emission factor for a dry ore of 0.03 kg/tonne (i.e. 0.03 kg tonne of TSP for every tonne of ore moved). The hourly emissions data showed that there is little real variation in the estimated emissions while operating – presumably because the operating rates don’t vary much.

The TSP emission rates are shown in **Table 4-7**.

Table 4-7 Estimated TSP Emission Rates from "Telpher" System

ID	Source	TSP (g/s)
BBDP	Battery Bay and Duck Pond pick up by FE loader Make up sinter fed to hopper by FE loader drop off to sinter bin	0.018 0.003
SB	Sinter Bins to eagles nest (Conveyer from sinter to eagles nest)	0.215
EN	Drop into Eagles Nest	0.501
EN	Eagles Nest into telpher grabs (load in)	0.501
TDO	Telpher Drop Off to Blast Furnace	0.122

It was advised by Nyrstar that the material from the Sinter Plant discharged to the conveyor feeding the Eagles Nest has water applied to cool the material and prevent it from burning holes in the conveyor belt. Therefore the material is highly wetted (see Error! Reference source not found.). This is inconsistent with the dry material assumed in PAE Holmes (2102) inventory and as a result, the "Telpher" system being the largest single Pb emissions source in the emissions inventory. Additionally, the sinter comprises large fused lumps of material between gravel sized and baseball size with very few fines attached and as such bears little resemblance to typical ore that the NPI factor is based on.

Given that the sinter material is deluged with water to the level of cooling the material, an argument could be made for negligible dust emissions from the Sinter Bins (SB), Eagle Nest (EN)and Telpher Drop Off (TDO). Nevertheless, the emissions were reduced by 75% on the basis that the material returned to the Sinter Bin from Pit storage (CV61 is reversible) may be dry and hence dustier. On balance, it is considered that these emissions may still be over-estimated.

4.7.6 Blast Furnace

4.7.6.1 Source configuration

The PAE Holmes (2012) report states that Blast Furnace visible emissions occurred for 1.8% of the time (2011) for all blows. The TSP emission rate for the visible plume of 30 g/s is very high. The author of the SKM (1999) report has advised that this would represent a level 3 severity blow.

Preliminary modelling using the PAE Holmes (2012) configuration in the time varying file as a volume source with zero sigma y and z (combined with possibly overestimates of northerly winds with very low wind speeds from the Dental Clinic meteorological data in the PAE modelling files), produced extremely high, unrealistic 1-hour Pb predictions at the Dental Clinic.

An important characteristic of the Blast Furnace visible plume emissions from observations is some degree of plume rise as was incorporated in the SKM (1999) modelling based on qualitative assessments of the plume heights from blows.

SKM (1999) used a 10 m diameter point source with temperature of 50°C and velocity of 2 m/s to provide a best fit to their observations for the large blows. This was for the plume rise associated with large blows observed in 1999. The smaller blows that generally occur now will have less plume rise – as well as a lower emission rate.

Therefore for this study, the source was configured as a wake affected point source with the same temperature and exit velocity parameters as SKM (1999) except that the "stack diameter" was reduced to 5 m, which reduced the effective area and hence plume buoyancy to 25% of that determined by SKM (1999)[5].

4.7.6.2 Visible plumes versus ongoing emissions

The emissions from the visible and operational Blast Furnace emissions were treated as independent emissions as described previously in **Section 4.7.1.2.**

4.7.6.3 Emissions from visible plumes

It was initially assumed that the Blast Furnace would cause the highest predicted 1-hour concentrations. Notwithstanding the comments in **Section 4.7.1.2**:

- As an example of a high predicted concentration, the third highest predicted 1-hour Pb concentration over 2010-11 of 261 µg/m^3 over 19/2/2010 2300 hours to 20/2/2010 0000 hours coincided with a Blast Furnace visible observation for 19/2/2010 23:51 lasting 44 minutes (note there was a synchronisation issue in the PAE emission file discussed in **Section 4.7.3**); and
- The largest observed 1-hour Pb concentration in the 2010-11 data set reviewed (231 µg/m^3 for 0400 to 0500 hours) coincided with visible plume reports for the Blast Furnace on 14/3/2010 at 0141 hours (11 minutes), 0601 hours (5 minutes) and 0811 hours (25 minutes) and Sinter Plant 0255 hours (29 minutes), with the Blast Furnace appearing to cause most of the impact.

A time series plot of the predicted and observed 1-hour Pb concentrations at the Dental Clinic shown in **Figure 4-5** indicates reasonable correspondence in time with a number of the predicted and observed high events.

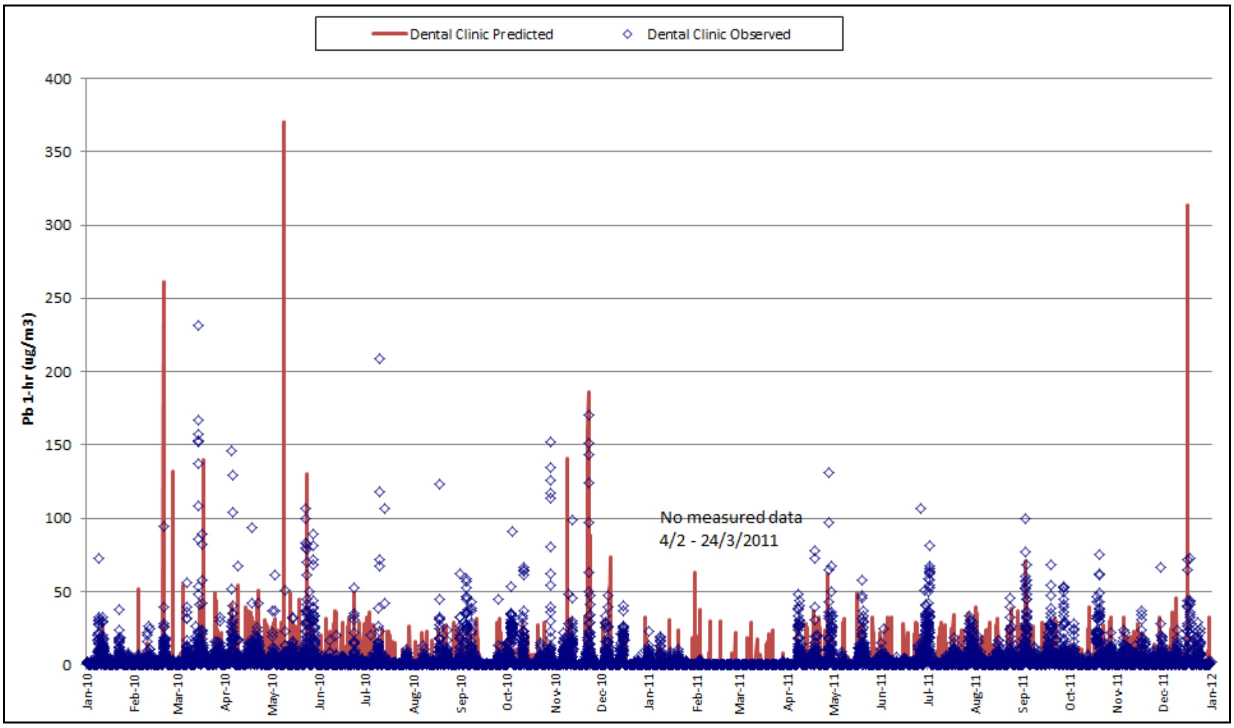

Figure 4-5 Time series of predicted and observed 1-hour average Pb concentrations at the Dental Clinic 2010-11

[5] It would be preferable to treat the visible emissions using a variable plume rise with a 3 severity equating to the SKM (1999) parameters, and decreasing the velocity to match 1 and 2 severities as 1/5 and 1/3 of the large blows. However, this is not easy to implement using CALPUFF given the time constraints for this work.

A Quantile:Quantile comparison of predicted versus observed 1-hour Pb concentrations with the Blast Furnace and all other emission sources is shown in **Figure 4-6**. While the top six concentrations are over-predicted, the predicted concentrations are mostly still lower than observed[6].

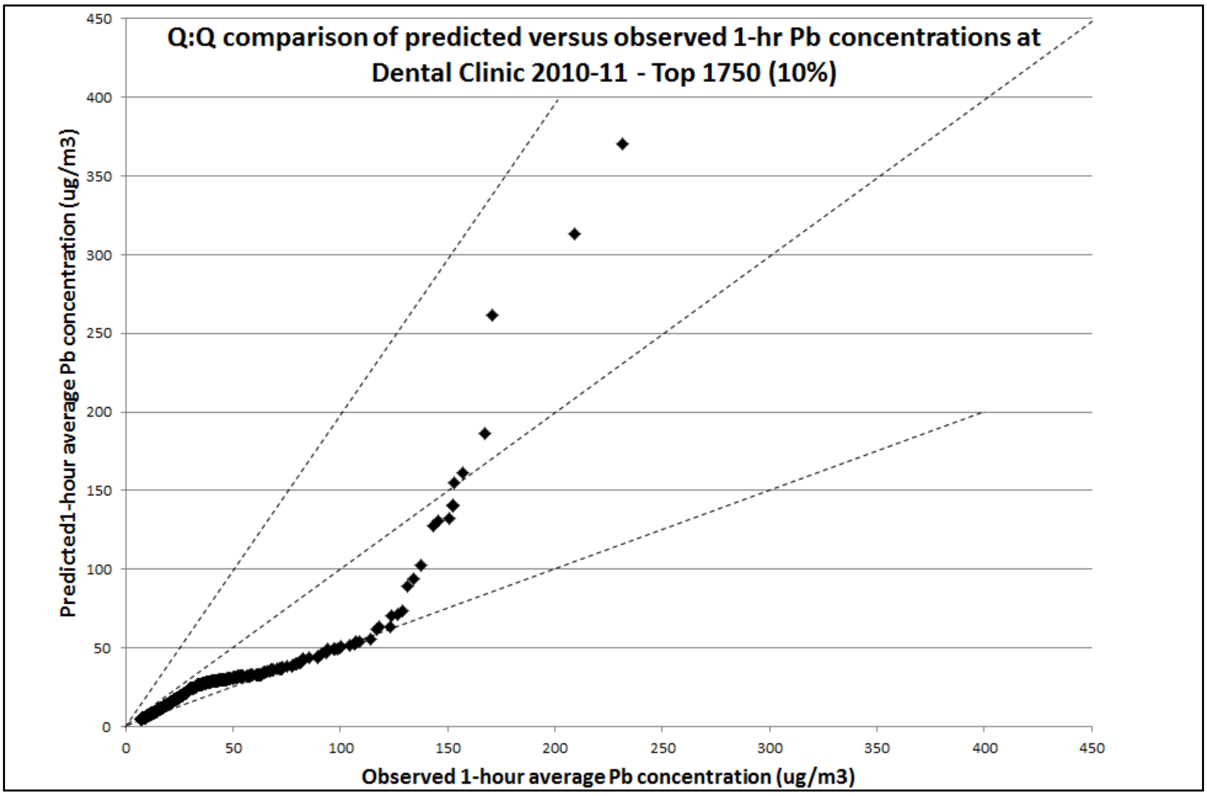

Figure 4-6 Q:Q (top 10% of predicted 1-hour average Pb versus observed at Dental Clinic 2010-11

Note: The plot includes all changes to emissions discussed in this Section and hence is a final predicted versus observed data comparison.

Apart from the top six events being over-predicted **Figure 4-6** indicates that the model is under-predicting by a factor of two the many 1-hour observations in the 50 to 150 $\mu g/m^3$ range. This may possibly be due to greater average emission from the blast furnace, but is more likely the other sources in that direction, such as the Sinter Plant especially at start-up, and even the slag fumer and KDR operations as they are all in the approximate same direction from the Dental Clinic monitor.

As a note, the US EPA provide an emission factor of 0.034 kg Pb/tonnes of bullion from a blast furnace and assuming 245,000 t/year of Pb produced by Nyrstar gives a Pb emission rate of 0.264 g/s, therefore the estimated emission rate of 0.45 to 0.46 g/s is higher.

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[6] Owen Pitts (pers. comm.. 23 June 2013), who was the author of SKM (1999), considers that based on the data in that report (see Appendix), it would be reasonable to equate a severity 3 visible plume to 50 g/s, a severity 2 to 20 g/s and a severity 1 to 8 g/s. (See the small blow listed as 5.41 g/s the medium to large 5 minute blow listed as 24.5 g/s with the maximum blow listed as about 86 g/s but only for a short period - probably more like 50 g/s over 10 to 20 minutes). These would have required the recalculation of the hourly emissions also taking into account the logged durations of each visible plume, which could be a refinement in any subsequent review of the modelling, although it could only be implemented for the period after September 2011 when the severity ratings were introduced.

4.7.7 Sinter Machine

As described in **Section 4.7.3**, the emissions from the Sinter Machine can be considered as two components:

- Visible plumes; and
- Emissions from materials handling operations when the Sinter Machine is running.

The PAE inventory used a TSP emissions rate of 1.9 g/s as the basis of emissions during visible plumes and configured the Sinter machine emissions as a volume source (i.e. no plume rise) as in SKM (1999).

The author of the SKM (1999) report considered that:

- The TSP emission rate of 1.9 g/s derived for the Sinter Plant would correspond to a severity rating of approximately 1 as it was the average emission of when there was just a slight visible plume (often in 1999 measurements it was just a haze from the building);
- This emission in SKM (1999) was considered to occur whenever the sinter plant was operational (88% of the time) and therefore it was a typical average operational emission;
- Since the SKM study, a fume captured and treatment system for the Sinter Machine feed end has been installed that should improve capture; and
- As well as the sinter plant, the 1999 estimate included the adjacent materials handling (e.g. Eagles Nest) and the D & L building and is better termed a sinter plant area emission.

The PAE Holmes (2012) inventory included separate estimates for emissions from the Sinter Bins, Eagles Nest and D&L Building hence the appropriate basis upon which to estimate emissions from the Sinter Machine is not clear.

4.7.7.1 Visible component

For modelling, the visible component of the emissions were:

- Considered to have low buoyancy and hence was reconfigured as a point source with Temp = 50°C, Vel = 2 m/s, D = 5 m which gives a plume rise of approximately 30m at a wind speed of 2 m/s[7]; and
- Adjusted for severity as below.

The severity ratings for September 2011 to December 2011 were correlated against emission duration (see **Table 4-8** and **Figure 4-7**). Assuming that severity was based on plume extent rather than duration, it appears that larger plumes are also longer lasting.

Table 4-8 Sinter Machine Emission Severities Versus Duration

Severity	Count (no. of events 7/9/2011-31/12/2011)	Avg Length of emission (seconds)	% of time of emission
1	35	387	0.14
2	43	1672	0.72
3	37	3384	1.26

[7] This buoyancy was considered to occur for the category 3 severity emissions, but as a first approximation was applied to all visible sinter plume emission severities.

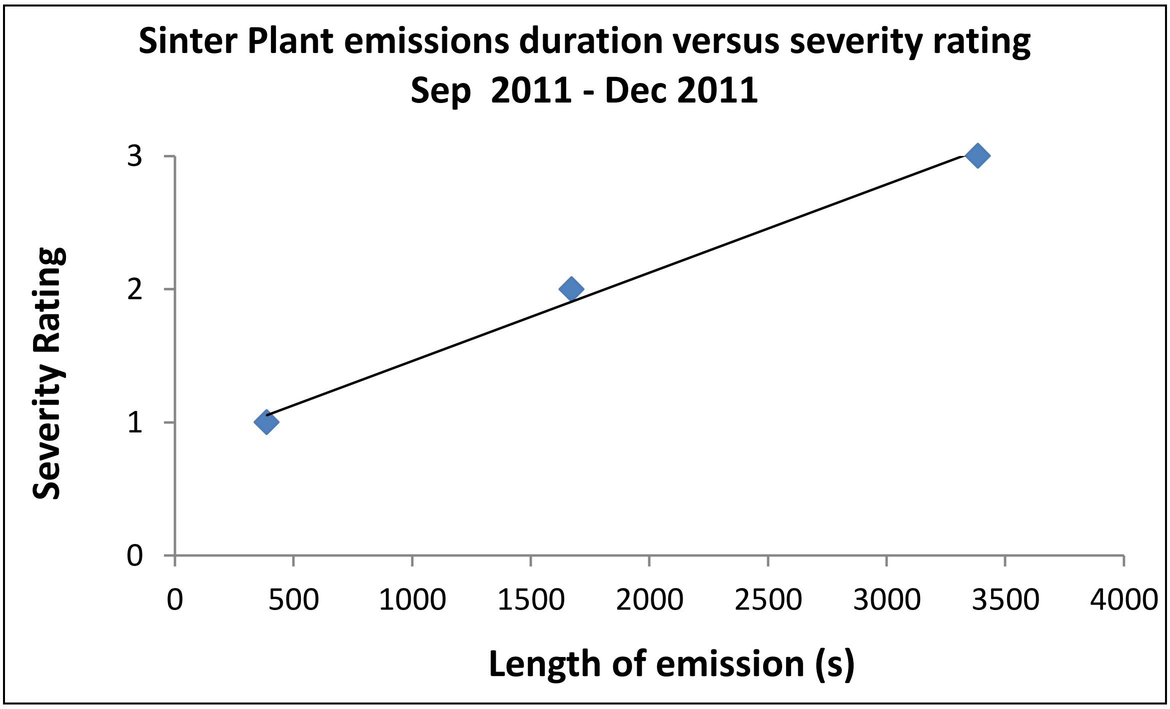

Figure 4-7 Sinter plant emission severities versus duration

In order to take this effect into account, the visible emissions for the Sinter Machine were adjusted by MAX (MIN(Emission duration(s)/1065,5),1), where 1065 is the estimated duration for a 1.5 severity event. The increase was limited to a maximum of 5 times the base emission.

The effect of this change was to increase average Pb emissions rate for the visible plumes from 0.0345 g/s to 0.0378 g/s – a 10% increase, but that the maximum hourly Pb emission rate increases to 5.74 g/s. It is considered that that this maximum emission rate would still understate the very visible plumes sometimes observed for the Sinter Plant in site videos.

4.7.7.2 Operational component of emissions

The operation component of the emissions was retained as a volume source using the PAE Holmes (2012) intended sigma y and z.

The operational and transfer points emissions were adjusted for wind speed as described in **Section 4.7.4** above to incorporate the effect of increasing wind speed in reducing fume capture efficiency. The resulting Pb average emission rate is 0.195 g/s.

4.7.7.3 Comparison against literature estimates

It was noted that the US EPA (US EPA, 1995)[8] have the following Pb emission factors for Sinter emissions:

- Sinter Machine (weak gas) of 0.009 kg Pb/tonne sinter produced; and

[8] US EPA AP-42 12.6 Primary Lead Smelting. Sinter machine emissions controlled at test facility by ESP and scrubbers.

- fugitive emissions of 0.016 kg Pb/tonne sinter produced.

Assuming Nyrstar Sinter production of 482,046 tonnes/year[9], these give the following emissions:

- Sinter machine (weak gas) emissions of 0.138 g/s;
- Fugitive emissions of is 0.245 g/s; and
- Total Pb emissions of 0.382 g/s.

The resulting total Sinter Machine Pb emission of 0.233 g/s from the revisions described above, is lower than this, indicating that emissions may still be underestimated. However, this may be compensated by the inclusion of other sinter production related sources such as the D&L Building, Battery Bay and Duck Pond, Sinter Bins and Eagle Nest emissions (discussed in **Section 4.7.5**), which gives a total "sinter plant area" emission of up to 0.540 g/s. The US EPA estimate of 0.382 g/s lies within this range of 0.233 g/s to 0.5401 g/s and therefore not knowing the basis of the US EPA estimate and how it corresponds to the machine here, the sinter plant area average emission estimate seems reasonable.

4.7.8 Mixing Plant and D & L Building

Emissions from the Mixing Plant and D & L Building were estimated by PAE Holmes (2012) using NPI emission factors. Operational data was based on the average materials handled and assumed to be constant for all hours of operation. It was assumed that the hours of operation would be the same as the sinter plant operational hours (91% of the time).

There was no change made to these emissions except for wind speed dependence as described in **Section 4.7.4** above. It was noted that the mixing plant was reasonably dusty with top floor reasonably exposed and such if anything could be a larger source than estimated here.

4.7.9 Slag Fumer

In the PAE Holmes (2012) report, visible plume emissions from the Slag Fumer occurred 11.7% of the time. The visible emissions were split into four categories based on the emissions log provided by Nyrstar:

- Charge Port Venting – TSP emission rate of 12.5 g/s during visible emission;
- Tapping – TSP emission rate of 7.7 g/s during visible emission;
- Main Baghouse – TSP emission rate of 0.8 g/s during visible emission; and
- Coal Mill – TSP emission rate of 0.8 g/s during visible emission.

For this study, the Slag Fumer was modelled as per SKM (1999) to produce a buoyant plume rise using an assumed diameter of 10m, an exit temperature of 50°C and velocity of 2 m/s to match the observed plume rise from the charging events. Given that the Slag Fumer has improved fume capture with an improved hood arrangement in the mid 2000s, the plume rise was reduced by an approximate factor of two ("stack" diameter decreased to 7.1m). This is to account for the lower amount of hot air and fume

[9] See EE-Volume_Sources_2010a.xlxs tab Transfer Points

Sinter Make for year (tonnes)	Sinter Reversed for year (tonnes)	Ratio Sinter Reversed to Sinter Made
482,047	132,290	0.2744

released than observed in 1999. This of course should imply that the fume should be reduced as well. In effect, the use of the above emissions estimate assumed no improvements in the Slag Fumer since the SKM (1999) study.

4.7.10 Adjustment of area sources for traffic time of day

All area source emissions (eg wheel generated dust, pit area materials handling) were weighted 0.2:0.8 for night:day emissions based on assumed reduced traffic use at night. The overall annual average emissions of each source were not changed.

4.7.11 Other Sources to the North to North West of the Dental Clinic site

After implementing the changes as described above, while the modelling predictions versus observations was generally good, it was considered that the modelling was failing to adequately identify the source contributions observed at the Dental Clinic from the north west.

In **Figure 4-8**, while the average concentrations from this sector are much lower than from the process area to the north-east (**Figure 4-8**, left), the very much larger frequency of winds from this sector mean that even relatively smaller ongoing emissions can have a large effect on the annual average concentration at the Dental Clinic site. This is shown in **Figure 4-8**, right) which shows the annual contribution to Pb levels at the Dental Clinic and is derived by the average concentration when the wind is from that direction multiplied by the frequency that the wind is from that direction.

It is noted that the "observed" hourly Pb data also includes contributions from directions not downwind of the smelter (from the SW to SE) which are not considered in the predictions based directly on emissions from the smelter. These could be due to the process of estimating the "observed" hourly air lead values. For example if a day with high air lead concentrations happens to have a few southerly hours of wind and associated PM_{10}, it will assign some of the Pb to this direction.

Therefore, while it was considered that Pb concentrations indicated from the north-west of the Dental Clinic could be measurement "noise", the relative increase in the contour to the north-west in **Figure 3-3** for Pb versus PM_{10} however, indicates that there is a sizeable Nyrstar source emission component with elevated Pb concentrations to the north-west. This is also seen in Figures 5, 6 and 10, 11 of Hibberd (2012) based on analysis of days with 24-hour Pb levels greater than 10 $\mu g/m^3$.

It is considered that higher Pb emissions than in the PAE Holmes (2012) inventory could occur on the basis of:

- The PAE Holmes (2012) emission estimates for pit areas are quite uncertain. The loading and unloading emission factors used by PAE were based on coal emission factors. Use of factors for metallurgical mines would give higher emissions;
- The control factors applied for wind breaks and water sprays are considered to be overstated. Wind breaks and water sprays were assumed for all wind erosion in the pit and loading and unloading operations. It is considered that wind breaks will have little effect in the area as they are small;
- Wheel generated dust estimates appear to have neglected the non product moving operations that are sometimes very dusty (site videos) as well as light vehicles, other trucks, water carts,

street sweeper etc. Also, a control factor of 75% for level 2 (> 2 litres/m2/hour) watering was incorporated;

- The unpaved roads estimates assume a vehicle speed reduction factor which is applied to the NPI factor. Though a reduction will occur applying the basis to applying it to the NPI factor has not been demonstrated;
- It was advised during an on-site visit that there is substantial spillage on many of the paved roads, hence dust emissions estimates from these may be under-estimated;
- The inventory does not include screening in the pit, which is noted in the site incident reports as sometimes a dusty operation; and
- It was advised during an on-site visit there are other known dusty roads in vicinity of the pits not used directly for the transport of materials to and from the pits and in our judgement may not have been included in the wheel dust emissions component of the inventory.

Ideally, the emissions inventory requires a more complete revising of dust generation from the pits areas. For the purpose of this assessment the emissions from the pit area and nearby have not been changed and it is considered that the emissions from this area are understated.

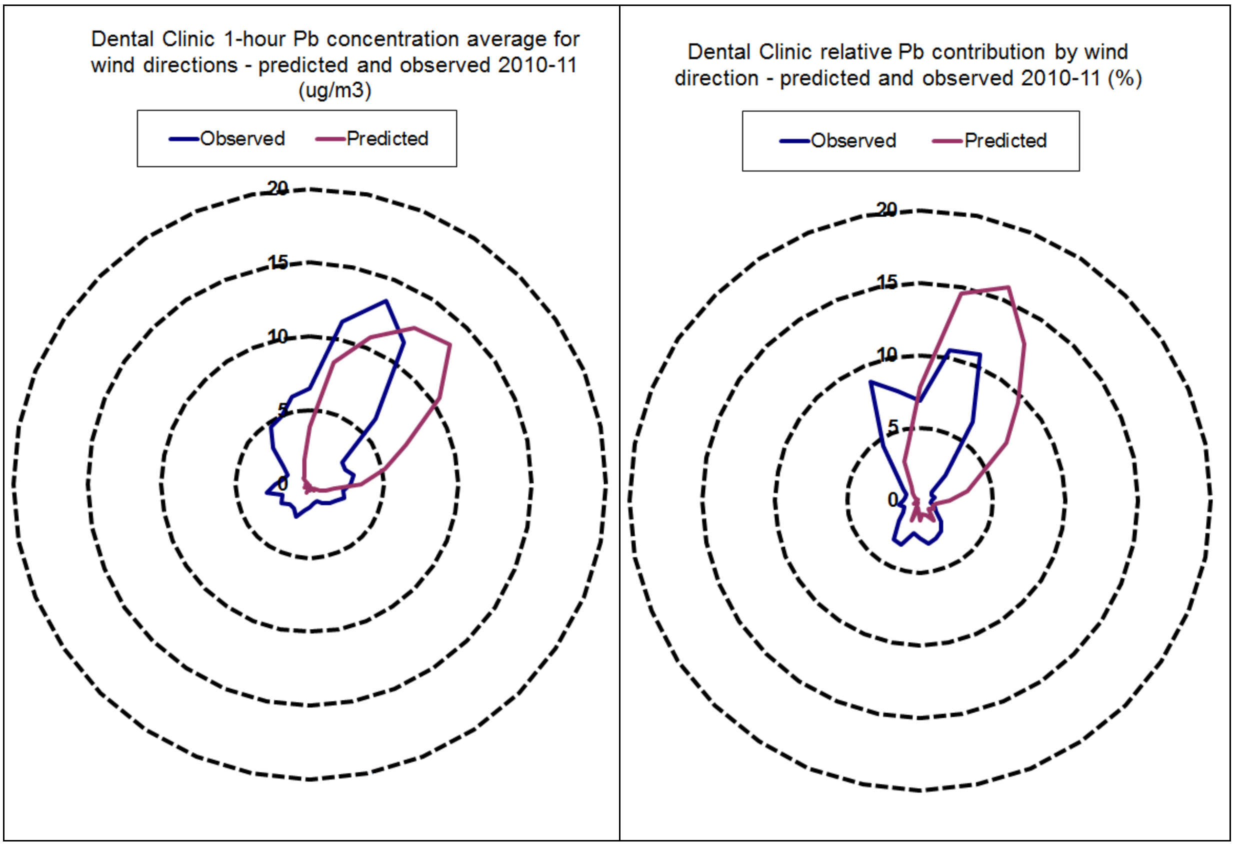

Figure 4-8 Pb pollution roses for 2010-2011 at the Dental Clinic monitor showing (left) average concentrations as a function of wind direction and (right) percentage contribution

4.7.12 Summary of changes to emissions

The changed emissions from the PAE Holmes (2012) original emission inventory for modelling in this report are shown in **Table 4-9** with the distribution of emissions from all sources is shown in **Figure**

4-9. Note, as described in PAE then revised these emissions estimates downwards by reducing all emissions by a constant factor to provide a better fit to the observed annual average Pb concentrations.

Table 4-9 Summary of Changes to Estimated Pb Emissions

ID	Source	PAE Holmes (2012) Original Pb Inventory [1]			Revised Pb for this Study		
		Average (g/s)	Total (kg/year)	% of Total	Average (g/s)	Total kg/year)	% of Total
SHIP	Ship Unloading	0.065	2,052	3	0.065	2,051	3
PP	Proportioning Plant (Mixing Plant)	0.052	1,637	2	0.054	1,701	3
Blast Furnace Sources							
BF	Blast Furnace	0.382	12,032	17	0.460	14,518	23
TDO	Telpher Drop Off	0.051	1,622	2	0.013	421	1
Sub-Total Blast Furnace sources		0.433	13,654	19	0.474	14,938	24
Sinter Process Sources							
SM	Sinter Machine	0.204	6,438	9	0.233	7,341	12
SB	Sinter Bins	0.092	2,895	4	0.024	751	1
BBDP	Battery Bay & Duck Pond	0.007	224	0	0.007	236	0
EN	Eagles Nest	0.424	13,357	19	0.110	3,464	5
DL	D&L building	0.160	5,044	7	0.166	5,240	8
Sub-Total Sinter Process Sources		0.887	27,959	39	0.540	17,033	27
OPAVS	All Other Process Area Volume Sources	0.049	1,561	2	0.050	1,561	2
APAPS	All Process Area Point Sources	0.114	3,588	5	0.114	3,588	6
Slag Fuming Process Sources							
SF	Slag Fumer	0.290	9,147	13	0.290	9,145	14
KDR	KDR System	0.096	3,014	4	0.095	3,013	5
Sub-Total Slag Fuming Process Sources		0.386	12,161	17	0.386	12,158	20
p1-21	Paved Roads	0.049	1,553	2	0.049	1,553	2
Pit Sources							
OPAS	Other Pit Area Sources	0.045	1,430	2	0.045	1,430	2
u1-19	Unpaved Roads	0.069	2,186	3	0.069	2,186	3
SRS	Sinter Returns, Sludge & Residue Mixes Stockpiles	0.127	4,013	6	0.127	4,013	6
Sub-Total Pit Area Sources		0.242	7,630	11	0.242	7,630	12
TOTAL		**2.28**	**71,794**	**100.0**	**1.973**	**62,213**	**100**

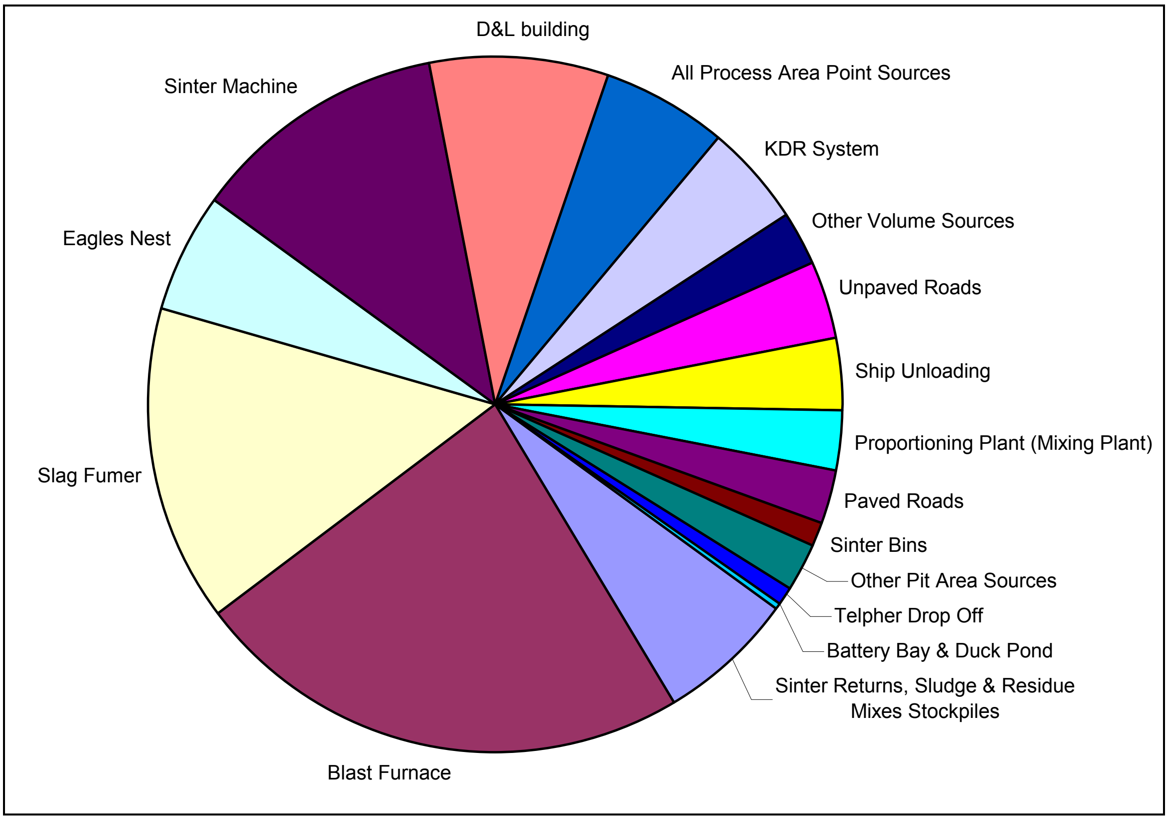

Figure 4-9 Sources relative contribution to Pb emissions 2010-11

4.8 Comparison to Other Emission Estimates and Emission Uncertainty

A summary of the annual Pb emission estimates from this study and the Nyrstar NPI estimates and PAE Holmes (2012) estimates are presented in **Table 4-10**.

Table 4-10 Summary of Estimated Annual Pb Emissions (tpa)

Period	Nyrstar NPI	PAE Original Estimates	PAE Revised Estimates (1)	This Study
2010	41.6	73.5	31.5	-
2011	44.6	69.9	46.0	-
2010-2011	43.1	71.8	38.8	62.2

Note: 1) The PAE estimated emissions were subsequently revised downwards such that the modelled data better fitted the observed ambient concentrations in Port Pirie. This required multiplying the original 2010 emissions by 0.40 and the original 2011 emissions by 0.64 to provide a best fit with the observed data.

Table 4-10 indicates that the:

- Emissions estimated for this report are higher than the final PAE emission estimates and the Nyrstar NPI estimates, but lower than the original derived PAE estimates;
- Compared to the original PAE estimates the emission estimates are lower due primarily to the reduction in sinter handling emissions (i.e. Telpher operations); and

- The original PAE estimates were higher than Nyrstar as PAE included a number of sources not included in the Nyrstar estimates, including some materials handling operations including sinter handling (Telpher operations), material loading and unloading at the pit etc. It is considered that the PAE estimates were generally reasonable for these additional sources (apart from the sinter handling operations, though probably low for the pit area) and that the Nyrstar emissions should be higher. It is considered that the PAE model adjusted emission estimates are too low and were due primarily due to issues with their model set ups and the wind data used as detailed in **Section 4.7**. This resulted in the model over-predicting the concentrations and therefore finding that a reduction in the emissions was necessary. It is noted that the wind data used for the two years had different issues and as such would result in two very different correction factors as is observed.

Therefore in conclusion it is considered that the emission estimates here are more reasonable, though there is still a reasonable degree of uncertainty in the overall emissions, and particularly the contribution from individual emission source.

As a last note, the original SKM (1999) emissions were verified using the model ISC3. It is subsequently known that ISC3 did not apply a time average correction to estimate the 1-hour average lateral dispersion and as such tended to over-predict concentrations and provide conservative concentration predictions. This was seen as desirable by the US EPA at the time. Therefore if a model such a CALPUFF was used in the 1999 assessment, the predicted concentrations would most likely be lower, therefore indicating that there were still unresolved sources or that some of the resolved source emissions, such as from the sinter plant should be higher. In other words the 1999 Pb emission estimates of 88 tpa would be on the low side, with emissions probably greater than 100 tpa.

4.9 Model Correspondence and Discussion

The summary of predicted versus observed average Pb concentrations at monitoring sites is shown in **Table 4-11**. These show that:

- The average predicted concentrations are all within the factor of two normally considered a benchmark of acceptable modelling predictive accuracy;
- The median predicted versus observed concentration ratio across all sites for 2010-11 is 0.98; and
- The modelling also predicted higher concentrations relative to observations for 2010 compared to 2011. The reasons for this are not known.

Quantile:Quantile plots of ranked 24-hour average Pb concentrations are shown in **Figure 4-10** and **Figure 4-11**. The correspondence for most sites is within a factor of two except for the Dental Clinic and Solomontown sites.

Table 4-11 Summary of Predicted Versus Observed Annual Pb Concentrations at the Monitoring Sites

	2010			2011			2010-11		
Site	Obs (µg/m^3)	Pred (µg/m^3)	Pred/ Obs	Obs (µg/m^3)	Pred (µg/m^3)	Pred/ Obs	Obs (µg/m^3)	Pred (µg/m^3)	Pred/ Obs
York Road	0.23	0.33	1.5	0.15	0.18	1.2	0.19	0.26	1.4
Senate Sports Park	0.24	0.28	1.2	0.18	0.15	0.8	0.21	0.21	1.0
Frank Green Park	0.17	0.19	1.1	0.13	0.11	0.9	0.15	0.15	1.0
Terrace	1.07	1.37	1.3	0.92	1.07	1.2	1.00	1.22	1.2
Dental Clinic	3.49	1.96	0.6	3.16	1.61	0.5	3.33	1.78	0.5
Ellen Street	2.35	1.35	0.6	2.09	1.09	0.5	2.22	1.22	0.6
Port Pirie PS	0.40	0.46	1.1	0.37	0.29	0.8	0.39	0.38	1.0
Baseball Club	0.20	0.31	1.6	0.21	0.25	1.2	0.21	0.28	1.4
Boat Ramp	0.52	0.39	0.7	0.67	0.35	0.5	0.60	0.37	0.6
Solomontown	0.37	0.22	0.6	0.42	0.19	0.5	0.40	0.21	0.5
St Marks College	0.11	0.12	1.1	0.11	0.10	0.9	0.11	0.11	1.0
Oliver Street	0.26	0.19	0.7	0.28	0.16	0.6	0.27	0.18	0.6
Median (all)	**0.32**	**0.32**	**1.13**	**0.33**	**0.22**	**0.81**	**0.33**	**0.27**	**0.98**
Average (all)	**0.78**	**0.60**	**1.00**	**0.72**	**0.46**	**0.80**	**0.75**	**0.53**	**0.91**
Excluding the three close north sites: The Terrace, Ellen Street and Dental Clinic									
Median	0.24	0.28	1.14	0.21	0.18	0.83	0.21	0.21	0.99
Average	0.28	0.28	1.07	0.28	0.20	0.82	0.28	0.24	0.95

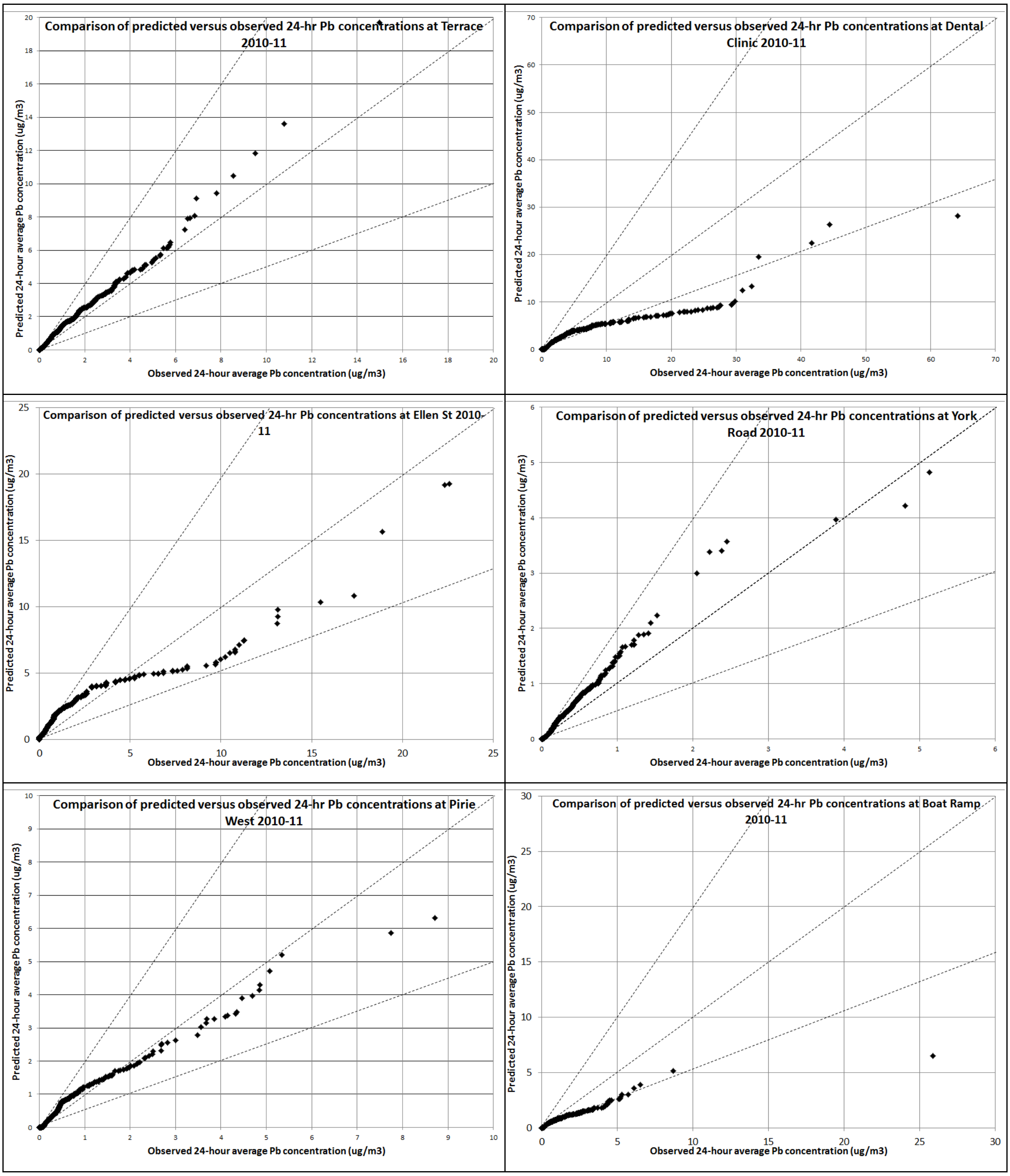

Figure 4-10 Q:Q plots of predicted versus observed 24-hour average Pb concentrations at Terrace, Dental Clinic, Ellen Street, York Rd, Pirie West and Boat Ramp monitoring sites 2010-11

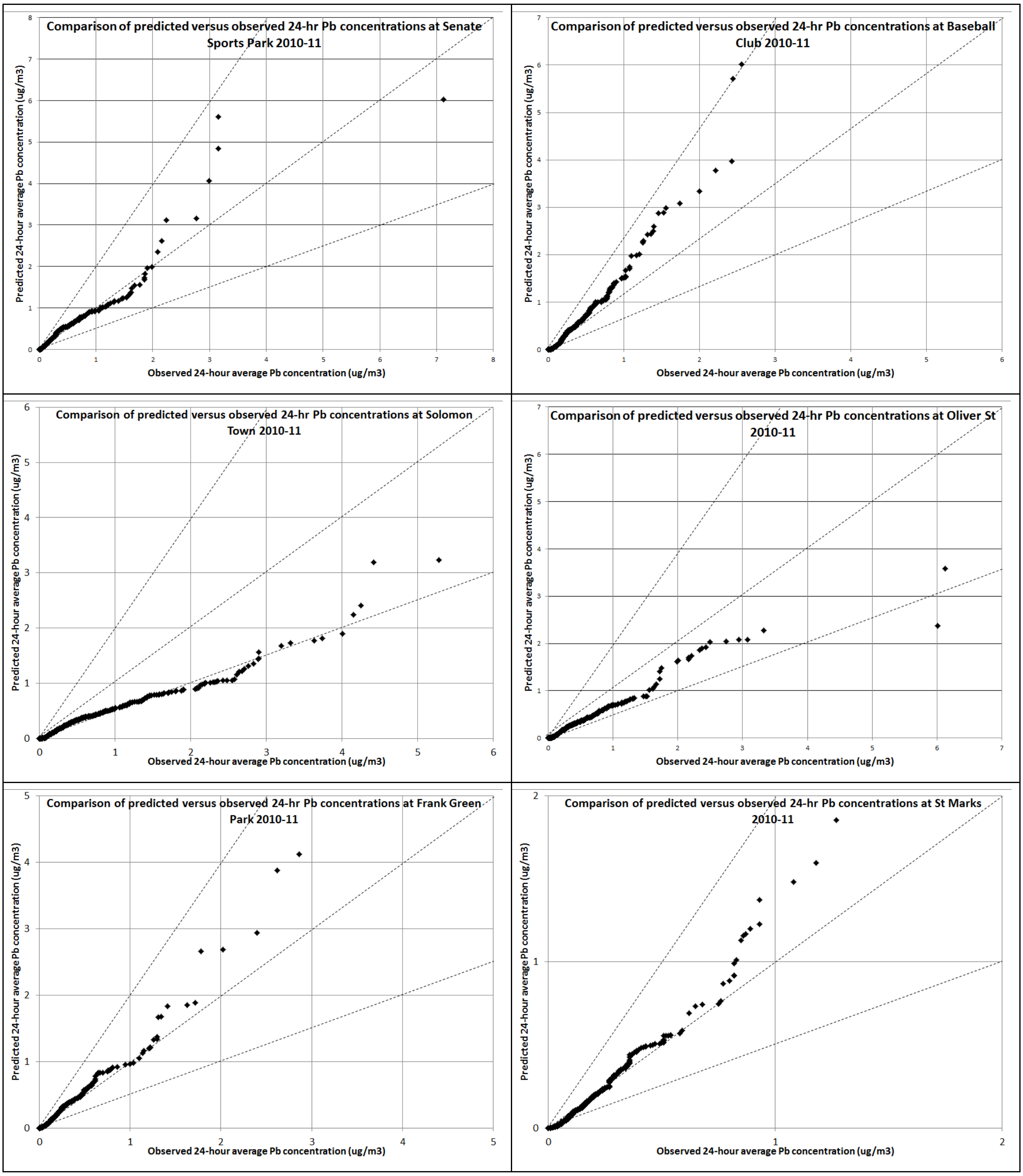

Figure 4-11 Q:Q plots of predicted versus observed 24-hour average Pb concentrations at Senate Sports Park, Baseball Club, Solomon Town, Oliver Street, Frank Green Park and St Marks monitoring sites 2010-11

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4.9.1 The Terrace

The worst over-prediction is at the Terrace. Even noting the wind directions frequencies, it is unclear why the observed concentrations are so much lower than at Dental Clinic and Ellen Street which are a similar distance to the main sources. Possible explanations are that firstly, the sources that have the major impact at this site are probably different from those that influence most of Port Pirie and secondly, the location of the monitor is to the east of a large embankment which may be affecting the wind flow, especially during near calm, stable conditions.

4.9.2 Spatial relativities

The modelling is under-predicting Pb at the nearer monitors to the south at Dental Clinic and Ellen Street but over predicting at the more distance sources to the south. This could be because roughness length through the township is under-estimated. In this case, the PAE value of 1.0 m would have delivered a better modelling result, and also improved the relativity of the predictions between the Boat Ramp and Port Pirie PS monitoring sites to better match observed levels. As noted before, a roughness length of 1.0 m is considered too high for Port Pirie and therefore some other mechanism may account for this. It is also possible the Pb deposition through the township is being under-estimated, possibly due to a greater proportion of particulate being larger than assumed (i.e. more PM30), or physical chemistry associated with Pb fume being quickly agglomerated with larger particles in the air.

4.9.3 Plume rise of process area sources

It is considered that a key issue for accurate predictions of downwind concentrations from the process building emissions during low wind speeds at night-time with a stable atmosphere would be better treatment of emission buoyancy. These situations are important because dispersion models will predict the highest concentrations from low level sources during these conditions, and are arguably prone to over-predict. Therefore, the plume rise, even if limited to a few tens of metres, becomes a key driver of the predicted concentrations. While the modelling incorporated this for the process areas which would more obviously have some heat associated with the emissions i.e. Blast Furnace, Sinter Machine and Slag Fumer, it is considered that an improved understanding of plume rise from these sources as well as considering whether emissions from the Proportioning Plant, D&L Building are likely to achieve some buoyancy related plume rise during stable conditions, would be a useful improvement to the modelling. Some models allow the incorporation of local night-time anthropogenic heat flux into the wind field determinations which might be the appropriate mechanism to incorporate plume rise from sources attributable to heat fluxes arising from nearby hot processes.

4.9.4 Diurnal variation of area source emissions

A useful improvement to the diurnal distribution of emissions from vehicles and materials handling to the pit area would be use the specific times of truck movements, if known.

4.9.5 Contours

Contours of predicted annual average Pb concentrations predicted from the modelling are shown in **Figure 4-12**.

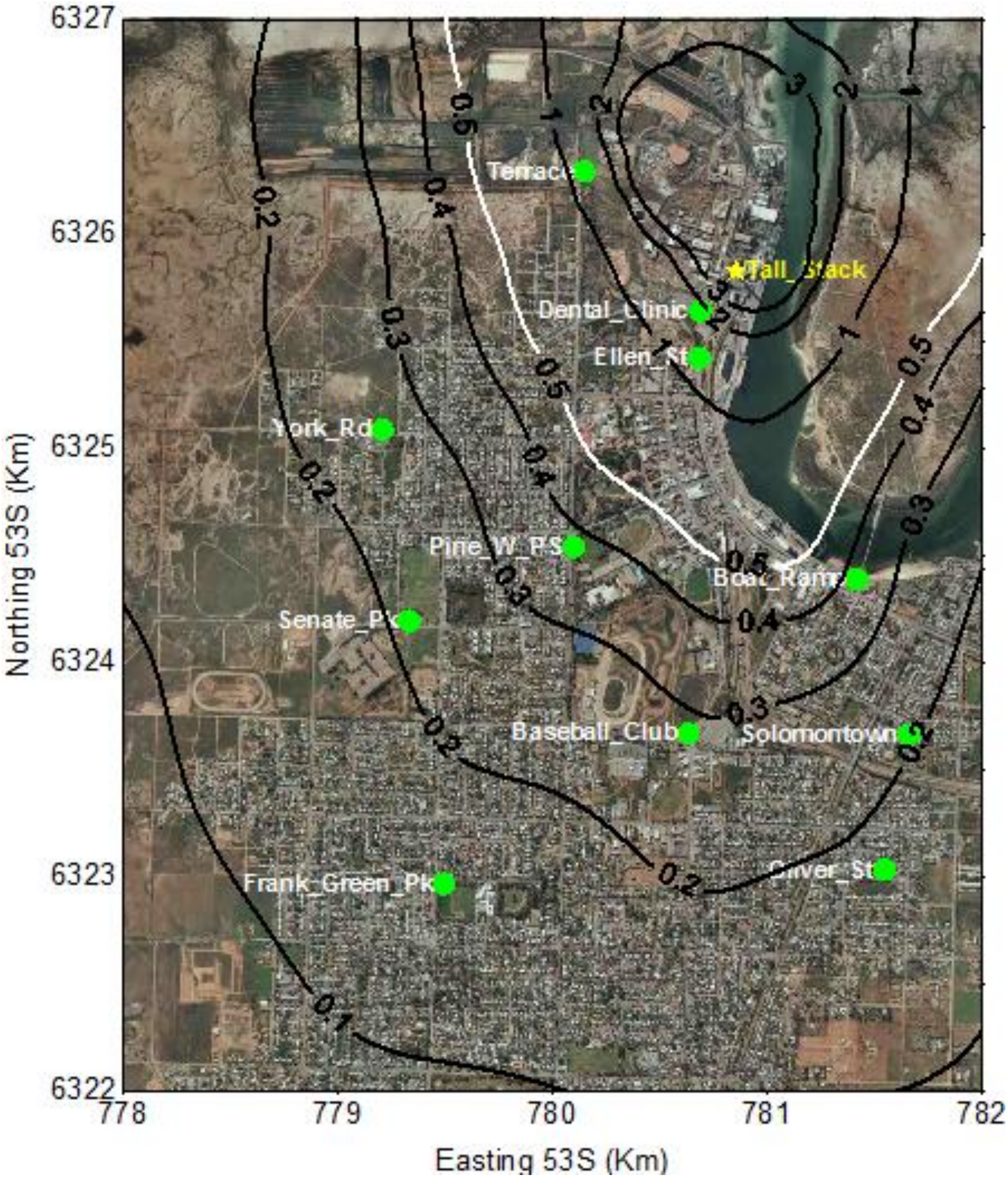

Figure 4-12 Predicted average (2010-11) Pb concentrations from current emissions. White contour is 0.5 µg/m^3 for reference to the NEPM Standard.

Figure 4-12 and **Table 4-11** indicate that the model is tending to over-predict for the western monitors and under-predicting for the eastern monitors. The relative predicted concentrations east-to-west across the town will be very sensitive to the representivity of the wind data used for modelling across the model domain. The wind data used may not have been optimal due to issues with some of the available data.

5 Modelling Emissions for the Transformation

5.1 Changes to Pb Emissions

Given the fugitive and site specific nature of the Pb emissions from the smelter, the only practicable option for estimating emissions for the changes arising from the Transformation was to base them on existing source emissions.

The exact nature of the Transformation is not defined in detail as it is at the pre-feasibility study stage. As such, in the estimated changes reasonably conservative assumptions (i.e. understate improvements) in the estimation of future emissions, consistent with the practice of erring towards conservatism where there is uncertainty were made.

5.1.1 Proportioning Plant

The Pre-feasibility Study has allowed for:

- Point source draughting whereby at certain discharge points within the mixing plant there will be individual drafting units with dust extraction and return back onto the belts or bins;
- Dedicated draughting with extraction at points for areas where a FEL is delivering to a grizzly and then feed system conveyor's transfer points;
- The side and end walls and roof will be made good to ensure improved enclosure; and
- A centralised vacuum system for spill cleanup within the plant.

It has been assumed that these improvements will reduce fugitive emissions in this area by 50%.

5.1.2 Blast Furnaces

5.1.2.1 Existing Blast Furnace

As described in **Section 4.7.6,** there are three components of the Blast Furnace emissions:

- Periodic visible emissions caused by process instability;
- Normal operating component fume not captured by hood and discharged as a fugitive emissions from the building; and
- Normal operating component fume captured by hood and treated by baghouse.

The Transformation includes:

- Improvements to the operating stability therefore reducing the frequency of the short term high emission rate visible emissions; and
- Improved fume capture for treatment by the baghouse – the effectiveness of which from our understanding, will mostly be achieved by a re-design of the materials feed system which allows a more effective enclosure from the drop point to the blast furnace entry.

It was assumed that:

- The improvements to the operating stability would reduce the magnitude of the periodic visible emissions by 50%; and
- Improved fume capture would reduce the visible emissions and operational emissions by 50%.

- The NPI workbook for mining (NPI 2012) indicates a control factor of 83% for emissions from hooding with fabric filters. A more conservative (i.e. lower) control factor of 50% has been assumed here on the possibility that a retrofitted improvement to the existing Blast Furnace may be less effective than a new purpose-built furnace system with fume control.

Therefore, the visible component of the Blast Furnace emissions would be reduced by 75% and the normal operating emissions reduced by 50%.

Also, the fugitive emissions from the Telpher Drop off source will be eliminated since this will be completely replaced.

5.1.2.2 Enclosed Bath Smelting Furnace

The Transformation includes an enclosed bath smelting (EBS) furnace to replace the sinter plant. It is fitted with fully enclosed materials handling systems and fume extraction.

The EBS fume will be directed through a Waste heat Boiler, Electrostatic Precipitator (ESP), Acid Gas Cleaning system before discharge into the air via the Acid Plant stack.

For this source, it was assumed that:

- Periodic visible emissions caused by process instability would be 50% less than from the existing Blast Furnace due, similarly, to improved process control;
- The fume capture system would be 83% effective based in NPI workbook for mining (NPI 2012) – for hooding with fabric filters; and
- The captured fume would be treated similarly as for the existing Blast Furnace Baghouse, which achieves a very low (basically negligible) emission of 0.000001 g/s of Pb (based on median of stack testing results giving an emission concentration of 1 mg/m^3).

The EBS fugitive emissions were modelled at the same location and using the same configuration assumptions as the existing Blast Furnace as a simplifying assumption in the absence of a final design. This will almost certainly be conservative as the EBS will be spatially separated.

5.1.2.3 Summary of blast furnaces emissions assumptions

The above reasoning is summarised in **Table 5-1.**

Table 5-1 Estimation of Pb Emissions for Transformation Furnaces

Equipment	Item	Visible component of emissions	Ongoing fugitive component of emissions	Treated component of emissions[(a)]	Total
Existing Blast Furnace	Pb emission (g/s)	0.367	0.093	0.000001	0.460
	Reduction in emission	50 % for improved control 50% for improved capture	50% for improved capture	0%	
	Estimated Pb emission (g/s)	0.0918	0.0465	0.000001	0.138
Encapsulated Bath Smelting (EBS) unit – replaces sinter process	Reduction in Blast Furnace emission	50 % for better control than existing BF 83% for capture (NPI, Mining 2012)	83% for improved capture	0%	
	Pb emission (g/s)	0.0312	0.0158	0.000001	0.047
	Reports to / Discharge source	EBS source (modelled at same location as existing Blast Furnace for conservatism)	EBS source (modelled at same location as existing Blast Furnace for conservatism)	Acid Plant stack (S12)	

Note: (a) From Blast Furnace Baghouse Stack - considered negligible.

5.1.3 Sintering sources

The elimination of sintering means that emission from the D&L Building, Sinter Machine, Battery Bay & Duck Pond sources will no longer exists. For the same reason as above, the emissions from handling sinter to and from the pits will no longer exist.

The Telpher blast furnace charging system will be replaced by an enclosed conveyor, therefore the Eagles Nest source will no longer exist.

5.1.4 Wheel generated dust from unpaved and paved roads

The elimination of the requirement to transport sintering materials to and from the pit areas should substantially reduce dust and Pb emissions from roads. Nyrstar consider the reduction from existing levels should be in the order of 80%.

5.1.5 Minor sources

The elimination of emissions from the Sinter Plant #6 Scrubber Stack and Sinter Plant Combined Stack has not been incorporated into the modelling as these are negligible contributors.

5.1.6 Summary of Transformation emissions

The change in the average Pb emission for each and the relative contribution from each source is shown in **Table 5-2**.

Table 5-2 Changes in Source Pb Emissions for the Transformation

ID	Source	Current Pb Emissions as Modelled		Transformation		
		(kg/year)	% of Total	Emission Change as % of Existing	(kg/year)	% of Total
SHIP	Ship Unloading	2,051	3	100	2,051	7
PP	Proportioning Plant (Mixing Plant)	1,701	3	50	850	3
Blast Furnace Sources						
BF	Blast Furnace	14,518	23	30	4,363	15
TDO	Telpher Drop Off	421	1	0	0	0
Sub-Total Blast Furnace sources		***14,938***	***24***		***4,363***	***15***
Sinter Process Sources						
SM	Sinter Machine	7,341	12	0	0	0
SB	Sinter Bins	751	1	0	0	0
BBDP	Battery Bay & Duck Pond	236	0	0	0	0
EN	Eagles Nest	3,464	6	0	0	0
DL	D&L building	5,240	8	0	0	0
NOF	EBS Furnace	0	0		1,483	5
Sub-Total Sinter Process Sources		***17,033***	***27***		***1,483***	***5***
OPAVS	All Other Process Area Volume Sources	1,561	3	100	1,561	5
APAPS	All Process Area Point Sources	3,588	6	100	3,588	12
Slag Fuming Process Sources						
SF	Slag Fumer	9,145	15	100	9,145	31
KDR	KDR System	3,013	5	100	3,013	10
Sub-Total Slag Fuming Process Sources		***12,158***	***20***		***12,158***	***42***
p1-21	Paved Roads	1,553	2	20	311	1
Pit Sources						
OPAS	Other Pit Area Sources	1,430	2	100	1,430	5
u1-19	Unpaved Roads	2,186	4	20	437	2
SRS	Sinter Returns, Sludge & Residue Mixes Stockpiles	4,013	6	20	803	3
Sub-Total Pit Area Sources		***7,630***	***12***		***2,670***	***9***
TOTAL		**62,213**	**100**		**29,036**	**100**

5.2 Predicted Pb Concentrations from the Transformation

A summary of predicted ambient average Pb concentrations and reductions from modelling current emissions at the monitoring sites is shown in **Table 5-3**. These have been presented as based on the model only (**Table 5-3,** column 3) and using the model predicted changes in concentrations to multiply by the current concentrations to determine the future levels. Of the two, it is considered the use of the observed concentrations multiplied by the modelled relative changes provides the best estimate, since

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the modelling validation showed that the predicted concentrations for current emissions do not perfectly match the observations at each site.

Table 5-3 Summary of Predicted Pb Concentrations (2010-11) at Monitoring Sites from the Transformation

Site	Predicted Existing (as per Table 4-11) (µg/m³)	Predicted for Transformation (µg/m³)	Predicted Change as % of Existing (%)	Predicted using Observed Concentrations and Percent Change from Transformation (µg/m³) (1)
York Road	0.26	0.13	52	0.10
Senate Sports Park	0.21	0.11	53	0.11
Frank Green Park	0.15	0.08	53	0.08
Terrace	1.22	0.48	39	0.39
Dental Clinic	1.78	0.88	49	1.64
Ellen Street	1.22	0.59	48	1.08
Port Pirie PS	0.38	0.19	51	0.20
Baseball Club	0.28	0.14	51	0.10
Boat Ramp	0.37	0.17	47	0.28
Solomontown	0.21	0.10	47	0.19
St Marks College	0.11	0.06	52	0.06
Oliver Street	0.18	0.09	49	0.13
Median	0.27	0.14	50	0.16
Average	0.53	0.25	49	0.36

Note: (1) Considered the best future estimate

Contours of the predicted change in annual average Pb concentrations from the Transformation as a percentage of current predicted concentrations is shown in **Figure 5-1**.

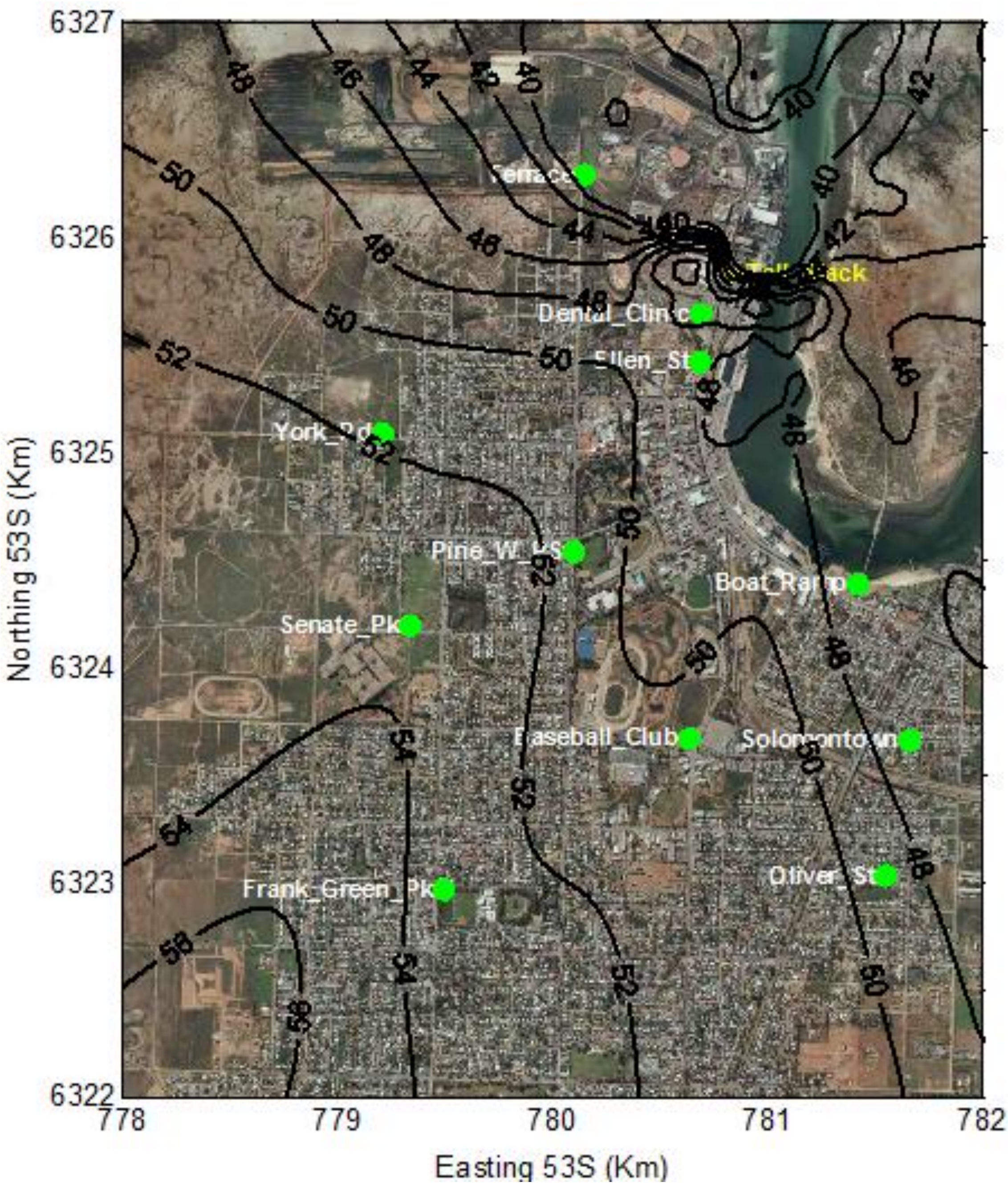

Figure 5-1 Predicted change in annual average Pb concentrations from the Transformation as a percentage of current annual concentrations

The average Pb concentrations are predicted to reduce to approximately 48 to 56% of current levels as a result of the Transformation with the benefit being slightly larger on the east side of the township and closer in to the smelter. On average this is 50% of the current levels. Overall the change in predicted concentrations is slightly less than the change in future emissions which is estimated at 47% of the existing emissions, reflecting the impacts that dispersion processes have.

Contours of the predicted average Pb concentrations following the Transformation are shown in **Figure 5-2**.

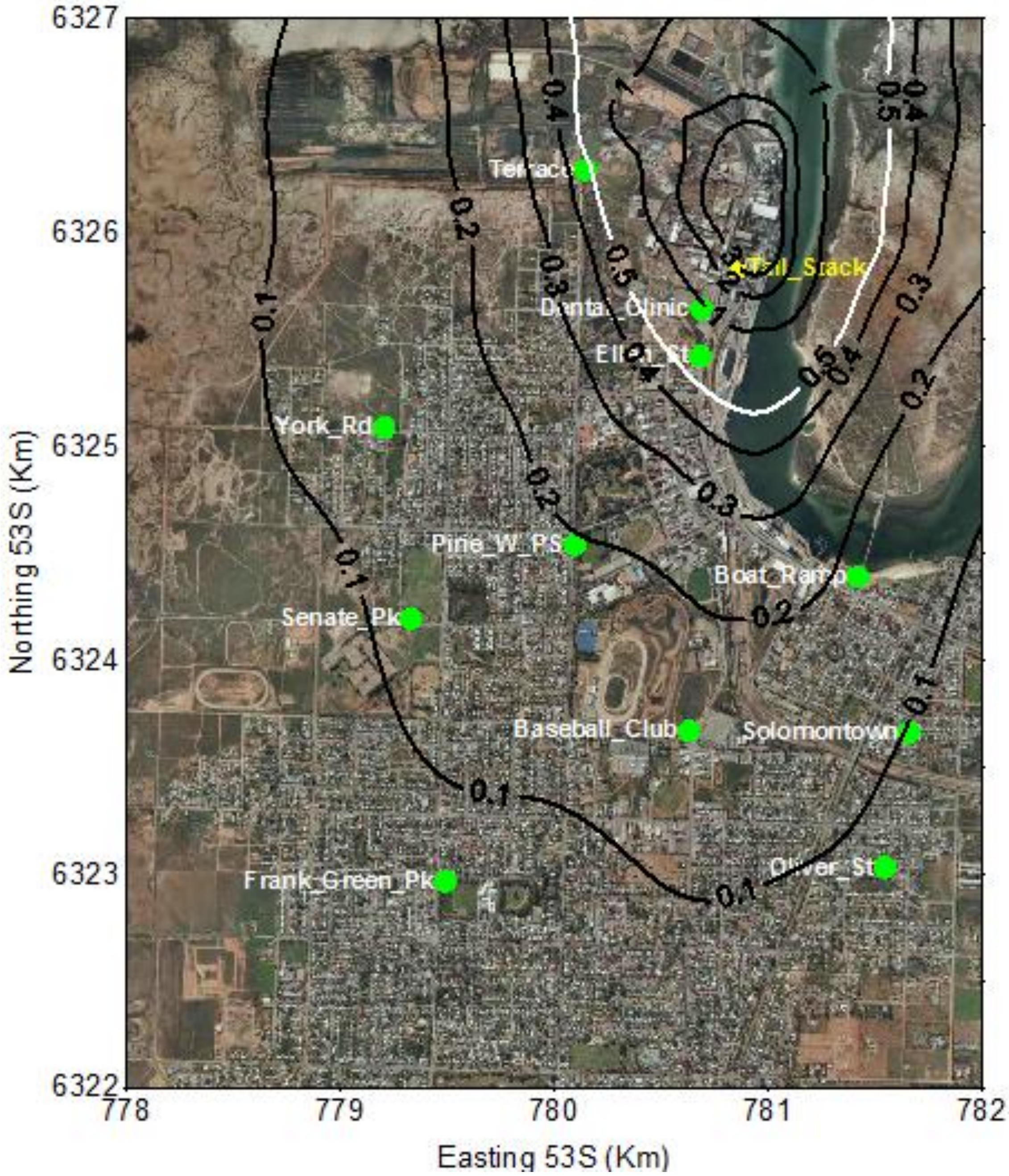

Figure 5-2 Predicted average Pb concentrations following Transformation. White contour is 0.5 μg/m^3 for reference to the NEPM Standard.

6 Conclusions

Nyrstar are proposing a significant upgrade and redevelopment of the Port Pirie Smelter, referred to as the Transformation. This development comprises an upgrade and redevelopment of the existing sintering plant, blast furnace, acid making operations and associated infrastructure and equipment.

As a component of seeking environmental approvals for the development, Nyrstar have been requested assess the impact on ambient air lead levels.

The methodology followed was to review and make use of a previously compiled emissions inventory (PAE Holmes, 2012), to model the dispersion of air lead and compare the predicted levels against ambient monitoring data.

By comparing the model predictions against the ambient measurements and dispersion parameters such as wind speed and time of day, inferences can be made regarding the characteristics of the emissions, and the modelling refined to give more accurate predictions.

Modelling was conducted using the models CALMET/CALPUFF to model the period from January 2010 to December 2011 (2 years) which was the period used for compiling the emissions inventory.

The sources of air lead emissions from the smelter vary widely in their characteristics, however in relation to the most important/largest sources, the emissions characteristics considered important to take into account in modelling include:

- Wind speed dependence of "fugitive" emission sources, which includes dust lift-off from open areas and dust emissions from process areas where materials handling is not fully enclosed and the re-suspension of dust in these areas; and
- Plume rise during light wind, stable conditions from sources associated with hot emissions.

As a consequence of the analysis, the original PAE Holmes (2012) inventory with annual air lead emission from the smelter of 72 tpa was reduced to 62 tpa, though with wind speed and plume rise dependency added to many of the sources. It was found that the bulk correction factors needed by PAE Holmes (2012) to reduce the emissions to 39 tpa were not necessary, as they did not take into account the aspects above. Additionally, it is also considered there were issues in their model setups and wind data used.

The comparison of the modelling predictions against measured air lead levels across 12 monitoring sites showed:

- The predicted concentrations were within a factor of two for all sites;
- The predicted concentrations tended to be higher than the measured concentrations on the western side of Port Pirie (i.e. south-west of the smelter) and lower than the measured concentrations on the eastern side of Port Pirie (i.e. south-east of the smelter); and
- The median predicted:measured concentration ratio across all sites was 0.98 and 0.99 excluding the sites closest to the smelter considered less representative of community exposures.

While the modelling predictions are considered acceptably accurate for the purpose and context of this report, there remain uncertainties regarding the emissions from individual sources. It is considered that the contribution to ambient concentrations from emissions from some areas of the process may be over-stated, whilst emissions from the sinter plant and from the pit and adjacent areas may be under-stated.

The main features of the Transformation with respect to air lead emissions are:

- The Sinter producing operation will be replaced with a new enclosed bath smelting furnace with modern emissions capture and treatment; and
- The existing blast furnace will be enclosed with upgraded emissions capture and treatment.

A preliminary estimate of the change in emissions is a reduction to approximately 47% of the current emissions.

The modelling of this reduction indicates a corresponding reduction in the average ambient Pb concentrations to approximately 48 to 56% of current levels, with the benefit being slightly larger on the east side of the township and closer to the smelter.

The modelling is indicative and preliminary only, utilising indicative (but conservative) emissions estimates for changes.

With the incorporation of the final design of the blast furnace configurations, it is expected that modelling will produce lower predicted concentrations on the basis of spatial separation of the furnaces and emissions control specifications more superior to the estimates used.

If required, further work to improve the predictions could be conducted by:

- Improving the air lead emissions estimates for the pit and surrounding area, as it is considered that they are under-predicted as a result of missing sources in the emission inventory (e.g. screening) and that many of the current emission estimates are considered on the low side, due to overstating the effectiveness of dust controls and uncertainties in the (uncontrolled) emission factors used. Further work on analysing the Dental Clinic air lead (and wind) data and more data on the operations, such as screening would assist in this;
- There are some sources in KDR area not included, such as using the FEL to load the hopper, and movement and opening of bulka bags;
- The Blast Furnace emission rate should be determined as a function of the visible plume severity index. Currently these are all assigned the emission rate determined in SKM (1999), which is considered applies to category 3 blows only;
- More precise analysis of visible emission records from the process area by correlations with wind speed, ambient temperature, emission severity and for north-west to north-east winds, ambient PM_{10} monitoring data, to provide better formations of emission rates, especially from the sinter plant area, which are considered may be understated (see **Figure 4-6**); and
- Improving the wind data used in the modelling and the inclusion of rain and wet deposition processes.

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8 Glossary

Term	Definition
%	percent
$\mu g/m^3$	micrograms per cubic metre
µm	micro metre
<	less than
>	greater than
^0C	degrees Celsius
AERMOD	US EPA short range dispersion model
BoM	Bureau of Meteorology
CALMET	Californian Puff Model meteorological pre-processor
CALPUFF	Californian Puff Model
CSIRO	Commonwealth Scientific Industrial Research Organisation
e.g.	for example
EBS	Enclosed Bath Smelting
EPA	Environmental Protection Agency (or Authority)
g/s	grams per second
HVAS	High Volume Air Sampler
i.e.	that is
km	kilometre
KDR	Kiln Dust Recovery
m	metre
M	million
m/s	metres per second
m^2	square metres
m^3	cubic metres
m^3/s	cubic metres per second
mg	milligram
Mt	million tonnes
Mtpa	million tonnes per annum
NEPM	National Environmental Protection Measure
No.	Number
NPI	National Pollution Inventory
PM	Particulate matter (fine dust)
$PM_{2.5}$ and PM_{10}	Particulate matter less than 2.5 or 10 microns, respectively
TAPM	The Air Pollution Model
tpa	tonnes per annum
tph	tonnes per hour

Resources for a changing world

Appendix C:
Sulphur dioxide impact assessment

Port Pirie Smelter Transformation

Sulphur Dioxide
Impact Assessment

Prepared for

Nyrstar

Prepared by

Air Assessments

July 2013

APPENDIX C

Disclaimer and Limitation

Client: Nyrstar

Version	Prepared	Date	Reviewed	Date
Draft	Owen Pitts	29th June 2013	David Pitt - EnvAll	29th June 2013
Draft	Owen Pitts	29th June 2013	Mark Hibberd – CSIRO	1st July 2013
Final – v3	Owen Pitts	3rd July 2013	Mark Hibberd – CSIRO	3rd July 2013
Final – v4	Owen Pitts	29th July 2013		29th July 2013

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1 Introduction

Nyrstar are proposing a significant upgrade and redevelopment of the Port Pirie Smelter. This development (the Transformation) comprises an upgrade and redevelopment of the existing sintering plant, blast furnace, acid making operations and associated infrastructure and equipment. This upgrade should significantly reduce emissions of atmospheric pollutants into the air and therefore result in a significant decrease in pollutant concentrations in Port Pirie. Nyrstar have requested Air Assessment to undertake the air quality assessment for inclusion in the Public Environmental Review (PER). This report presents the assessment of the likely sulphur dioxide (SO_2) concentrations.

2 Previous Dispersion Modelling Studies

2.1 CSIRO – Hibberd *et al* (1996)

CSIRO (Hibberd *et al*, 2006) conducted a comprehensive assessment of the sources and impacts of SO_2 emitters at Port Pirie in 1996. Meteorological data were collected from four towers, radiosondes, and a research aircraft. A scanning LIDAR measured the location and dispersion of the plumes released from the smelter stacks, which were made visible by flyash injection. This was supported by time-lapse videos and still camera photographs. An SO_2 analyser mounted in a vehicle was used to obtain traverses of ground level concentrations to complement the fixed SO_2 monitoring sites in Port Pirie.

The report's findings relevant to this study include:

- Tall stack emissions were the primary source of high SO_2 levels in town;
- Highest concentrations occurred during highly convective conditions – hot sunny days, light winds with a northerly component and inversion heights above 400 m;
- The impact of the emissions from the shorter stacks (acid plant, slag fumer baghouse, kiln dust recovery (KDR) stacks) is significant and on occasions approached the then current licence limits; and
- To meet a 200 ppb (1-hour average) guideline, the tall stack emissions of SO_2 would need to be reduced by at least 80%. To meet lower levels, consideration would also need to be given to the impact of the emissions from the shorter stacks—acid plant stack, slag fumer baghouse stack, and KDR stacks.

2.2 CSIRO – Hibberd (2000)

In 2000, CSIRO undertook a model validation study for Pasminco to determine the capabilities of CSIRO's advanced air pollution model, TAPM (The Air Pollution Model), for modelling plume dispersion from the Port Pirie smelter. This study used an early version of TAPM (version 1.3) and relatively small model grids (due to less computing power being readily available) with 20 by 20 grid points on four nested grids of 10, 3 and 1 km grid and a pollution grid of 27 by 27 points at 500 m resolution. The modelling used 30 vertical levels, which is higher than typically used at the time. The results were:

- Generally good agreement with wind observations although the night time S-SE winds were not predicted well. At the two SO_2 monitoring sites Golden North and John Pirie Secondary School (JPSS), the model over-predicted the number of exceedances of a 1-hour 250 ppb level, though good agreement was found at JPSS if the emissions were reduced by 10% (which was considered to be within the uncertainty of the measurements);
- Highest concentrations were predicted in the Golden North area indicating that this monitoring station is well sited to detect the maximum number of exceedances of the 250 ppb hourly-average level in the Port Pirie urban area; and
- The study did note some limitations in the evaluation due to limitations in the accuracy of both the emissions (considered over-estimated) and the monitoring data.

2.3 GHD (2009)

In 2009, GHD conducted a modelling assessment using TAPM (version3) to model ground-level SO_2 concentrations for the financial year 2005/2006, with the data validated against the four SO_2 monitoring stations at the time (Golden North, JPSS, Oliver Street and Frank Green Park). Overall the model predicted the surface wind patterns, including the lack of easterly winds. The model findings were:

- Highest concentrations occurred within 2 km of the main stack;
- The model tended to over-predict the maximum and the 9th highest concentrations;
- The model over-predicted by between 50% at Oliver Street and up to a factor of two at JPSS and Golden North;
- Evaluating the relative contribution of the tall and the short stacks, GHD found that :
    - The tall stack emissions are the main contributing source for most of the urban area; and
    - Urban areas within 1 km of the tall stack have a higher percentage contribution from the lower stacks located further north.; and
- The monitoring locations especially the Golden North site were located in the area of maximum impacts and therefore were well sited to provide data on the highest impacts in residential areas.

3 Impact Assessment Criteria

3.1 Ambient Air Quality Criteria

Ambient SO_2 criteria adopted from this assessment are the National Environmental Protection Measure (NEPM) for SO_2 and the SA EPA design ground level concentrations (DGLC) for SO_2.

The NEPM SO_2 standards are listed in **Table 3-1**.

Table 3-1 National Environmental Protection Measure - Air Quality Standards and Goals

Pollutant	Averaging Period	Maximum Concentration (ppm)	Goal
Sulphur Dioxide	1-hour	0.20	1 day a year
	1-day	0.08	1 day a year
	1-year	0.02	None

The SO_2 standards are given for three averaging periods, hourly, daily and yearly, with the hourly and daily standards having a goal of no more than 1 day in which exceedances occur per year.

The SA EPA also have a 1-hour modelling DGLC for SO_2 of 0.17 ppm, which must not be exceeded at all locations. Design ground-level concentrations are to "provide advice and criteria for proponents of new developments that may emit pollutants to the atmosphere. The information is also relevant to established facilities seeking to determine the ground level impact caused by their emissions" (SA EPA, 2006).

4 Smelter Plant Emissions

4.1 Existing Smelter

Major sources of SO_2 from the smelter are the tall stack, the slag fumer baghouse stack, the KDR stacks and the acid plant stack. This section details the derivation of the emission data for these sources used in the modelling assessment.

4.1.1 Stack Test Results

Emissions from the smelter were obtained from a number of sources dependent on the size and variability of the emissions. Emissions from the smaller stacks and less variable sources, the acid plant and KDR were derived from the periodic stack testing undertaken on site from 1999 through to 2010. The stack test results from the slag fumer, KDR #2 and acid plant stack are presented in **Table 4-1** along with the derived data for the main tall stack.

Table 4-1 Emission Parameters for the Smelter Major SO_2 Sources

Parameters	Units	Tall Stack	Slag Fumer Baghouse Stack	KDR2 Stack	Acid Plant Stack
Easting	(Zone 54, GDA 94) (m)	221,324	221,419	221,480	221,231
Northing	(Zone 54, GDA 94) (m)	6,325,890	6,326,430	6,326,435	6,326,331
Stack Height	(m)	205	44.2	36.5	50
Stack Tip Diameter	(m)	5.0	1.85	0.9	1.0
Exit Temperature					
10^{th} Percentile	(deg C)	97	104	57	58
Median	(deg C)	93	161	64	61
90^{th} Percentile	(deg C)	90	169	70	66
Exit Velocity					
10^{th} Percentile	(m/s)	15.2	26	8.0	18.4
Median	(m/s)	16.7	32	9.6	20.0
90^{th} Percentile	(m/s)	18.1	36	17.2	21.2
SO_2 Emissions					
10^{th} Percentile	(g/s)	1374	2	16	20
Median	(g/s)	1970	56	27	28
90^{th} Percentile	(g/s)	2215	177	54	47
Maximum		3315	307	109	57
Source of temperature, velocity and emission rate data		Continuous monitor and stack tests (1)	Stack tests from 1999 to 2010		
Number of Tests Used (2)		74, 13	74, 12	82, 15	80, 33

Notes:

1) Tall stack flow parameters calculated from the combination of the main baghouse and refinery baghouse stack flows (see **Section 4.1.3**).
2) The first number is the number of tests available for velocity and temperature statistics, whilst the second is the number of SO_2 tests.

Other stacks such as sinter #6 stack emit minor amounts of SO_2, generally < 0.6 g/s, and have not been included in the modelling.

The other significant source of SO_2 is the KDR #3 stack which is used infrequently (<5% of the time) and generally not when #2 KDR stack is operational (Robert Hoskings, pers. comm.., 5 June 2013) and has been omitted in the modelling. The omission of KDR #3 stack and use of medians for the KDR #2 and the acid plant stacks for this modelling assessment is intended to provide a realistic assessment of the current and future levels. It is noted that higher emissions can occur from these sources, but to incorporate them, more detail on the hourly variability is needed to be able to model them with hourly variable emissions. Alternatives such as modelling maximum measured emissions from each stack continuously (or even a lower statistic such as the 70^{th} percentile emission rate), would give a very unrealistic assessment of the current situation. That the medians are appropriate is also demonstrated by the good agreement of predicted concentrations with the monitored data (see **Section 6**).

Table 4-1 indicates that the tall stack emits at least ten times as much SO_2 as the next largest source, the slag fumer baghouse stack. The data also indicates that each stack has a reasonable degree of variability, especially the slag fumer stack.

4.1.2 Slag Fumer Baghouse Emissions

In 1996, CSIRO as part of their intensive study of the smelter's SO_2 impact, installed a portable stack monitor for 28 days on the slag fumer baghouse stack. As the slag fumer is a batch process with cycles of charging, the fuming cycle and then tapping, the emissions are very variable. Additionally with two slag fumers operating, the emissions have added variability. The results of the 1996 testing are reproduced in **Figure 4-1** and **Figure 4-2**.

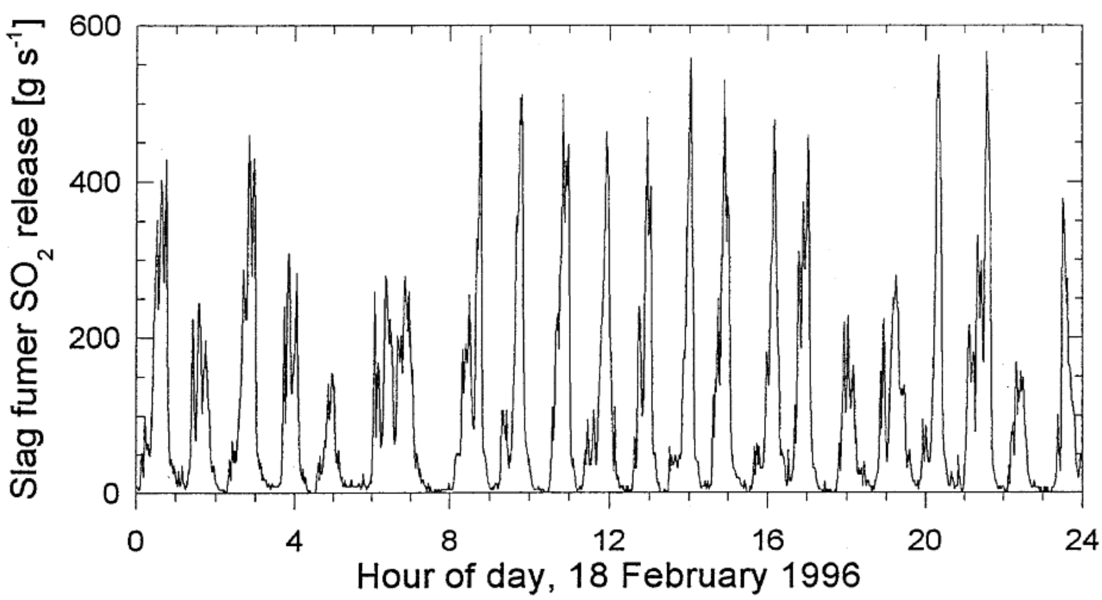

Figure 4-1 Typical pattern of SO_2 release from the Slag Fumer baghouse stack (1-minute readings from a portable stack monitor) on 18 February 1996 from Hibberd *et al* (1996)

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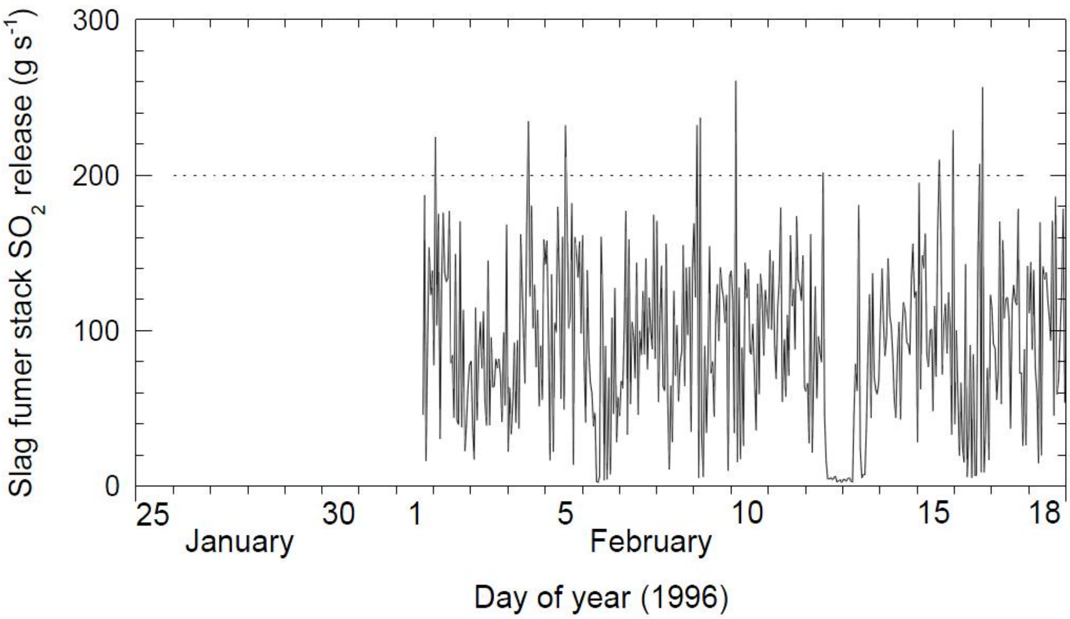

Figure 4-2 Hourly average SO_2 emission rate from the Slag Fumer baghouse stack during the 1996 field study. The dashed line is the conservative emission rate used in the 2000 modelling from Hibberd (2000)

Figure 4-1 and **Figure 4-2** show highly variable emissions with a:

- Peak 1-minute average emission rate of up to 600g/s;
- Peak 15-minute average emission rate of up to 350 g/s;
- Peak 1-hourly average emission rate of up to 260 g/s; and
- Average emission rate of 92 g/s.

With the significant variability in slag fumer emissions, the emissions were modelled as a variable emission source generated randomly to reproduce the emission distribution as monitored in 1996. The source was modelled with emissions in five discrete ranges with emission parameters listed in **Table 4-2** along with the frequency of occurrence. The exit temperature and exit velocity for each category were determined from fitting best fit lines to the 1999 to 2010 stack test data. These show that with increasing SO_2 emissions there is a corresponding increases in the temperature and exit velocity.

Table 4-2 Emission Parameters for the Slag Fumer Baghouse Stack

Range (g/s)	Modelled Value (g/s)	Frequency of Occurrence (%)	Exit Temperature (deg C)	Exit Velocity (m/s)
0 to 50	25	24	133	29.4
50 to 100	75	32	142	30.7
100 to 150	125	30	150	32.1
150 to 200	175	11	160	33.4
200 to 265	225	3	169	34.8

4.1.3 Tall Stack Emissions

The tall stack emissions are the largest source of SO_2 from the smelter with primary source of SO_2 from the sinter plant and to a lesser degree from the blast furnace and minor emissions from the refinery process. These emissions vary depending on whether the sources are on or offline and also with the acid plant status, as when the acid plant is offline, all emissions from the sinter plant are directed to the tall stack.

The tall stack emissions are not directly routine measured, but rather the two main sources to it, the 5 m flue from the main baghouse (that serves the sinter pant and blast furnace primary extraction) and the 3-m flue from the refinery baghouse. These two flues are sampled routinely by stack sampling, with the emissions from the 5-m flue also measured using a continuous monitor to measure SO_2, air volume and temperature.

As there is reasonable variation in this source, hourly emission estimates were estimated by using the:

- Hourly emission parameters from the 5 m flue continuous monitoring; and
- A constant emission from the 3 m flue emissions derived from the stack testing results. With the low frequency of testing of this flue (as there are low emissions), variable parameters could not be estimated and therefore the median of the data from 2001 to 2012 was used. This resulted in a median flow rate of 66.7 Nm^3/s at a temperature of 97 degrees C[1] with median SO_2 emissions of 4 g/s.

The total tall stack emissions were then determined on an hourly basis with the statistics for 2005/2006 presented in **Table 4-1**.

The use of median flow rate from the 3 m flue will lead to some uncertainty in the tall stack flow rate for any hour as there is ± 30% variability (from the 10^{th} to 90^{th} percentile flows) in the refinery flue flows, with the refinery flow being 30% of the 5 m flue flow.

Further SO_2 emission rates statistics for 2005/2006 from the tall stack are also presented in **Table 4-3**.

Table 4-3 SO_2 Emission Rates for the Smelter Tall Stack

Statistic	2005/2006 (g/s)	Post-Transformation (g/s)	Ratio Post-Transformation to Present
Maximum	3315	613	0.18
99^{th} Percentile	2521	446	0.18
98^{th} Percentile	2407	386	0.16
90^{th} Percentile	2215	226	0.10
70^{th} Percentile	2070	209	0.10
Median	1970	199	0.10
Average	1836	202	0.11
25^{th} Percentile	1797	183	0.10
Minimum	0	0	NA

[1] Note in the 2009 modelling a lower flow rate of 56 Nm^3/s at 92 deg C was used (GHD, 2009, page 6)

4.2 Post-Transformation Emissions

For the Smelter Transformation, the important changes with respect to the SO_2 emissions is the installation of a new acid plant with greater capacity to take all the SO_2 off gases from the enclosed bath smelter (the replacement of the sinter plant). Therefore there is estimated to be a reduction of about 90% in the SO_2 emissions to the tall stack. Though the new acid plant will be treating a larger amount of SO_2 there will only be a slight increase in emissions from the larger acid plant because of improved technology, including a double contact process.

The tall stack emission estimates for this study have been derived using the 2005/2006 hourly emissions from the main stack modified as follows:

- Acid plant operating. When the acid plant is operating, the emissions from the EBS (sinter plant) are directed to the acid plant. The tall stack SO_2 emissions will decrease by 90% or to a minimum of 150 g/s which is the typical emission when the sinter plant is not operating, due to emissions from the blast furnace and refinery;
- Acid plant trip. In the event of an acid plant emergency bypass, the EBS furnace off-gas from the exit of the electrostatic precipitators is diverted to the existing hygiene system connected to the tall stack. If this occurs, emergency sprays incorporated in the duct will activate to maintain temperature control to the existing baghouse system. The EBS furnace will not continue to be on feed during these periods. In such a trip, the EBS unit will be shut down unless the acid plant can be brought on-line quickly (within 15-minutes). Therefore the new EBS plant will only continue to emit significant off-gas for about 15 minutes after the acid plant has gone off-line. In the case of an acid plant trip, the gas in the flue connecting the EBS plant to the acid plant will be vented via the acid plant stack.

  For this modelling assessment, to account for this possible 15-minute of venting to the main stack, the emissions to the tall stack have been estimated as the maximum of 1/4 of the existing (2005/2006) tall stack emission for that hour or 150 g/s (the non sinter plant emissions) for the hour with an acid plant trip; and
- EBS plant down. In this case, the emissions have been assumed the same as at present, with these emissions being those from the blast furnace etc. These emissions are typically around 150 g/s.

Note that when the acid plant trips, the short duration of higher emissions from the acid plant stack that results from venting the remaining SO_2 in the flue from the ESP to the acid plant has not been modelled. Additionally higher SO_2 and SO_3 emissions that occur from the acid plant stack during acid plant start up, especially a cold start up have not been addressed in this assessment.

The resultant emissions and the ratio of existing to post-transformation tall stack emissions are presented in **Table 4-3**. This shows on average the emissions decrease to 10% of the current emissions, though the maximum emissions reduce somewhat less to 18% of current maximum emissions.

Exit velocity and temperatures for the tall stack post-transformation were estimated based on the current SO_2 emission versus temperature and velocity relationships derived from the 2005/2006 data. These show a slight decrease with lower SO_2 emissions of:

$$\text{Temp } (^{o}K) = 0.009 \times SO_2 \text{ (g/s)} + 347$$

Vel (m/s) = 0.0011 x SO_2 (g/s) + 14.5

As such, the post-transformation exit temperature and velocity are slightly lower than the present conditions for the tall stack at 349 ^{o}K and 14.7 m/s.

For the acid plant, emissions per tonne of SO_2 treated will be lower with a modern double pass system used. Therefore SO_2 emissions from the larger acid plant under routine operations are expected to be, at most, only slightly higher than existing emissions. The emission parameters used for the new acid plant stack are listed in Table **4-4**.

Table 4-4 Emission Parameters for the New Acid Plant Stack

Parameters	Units	Acid Plant Stack
Easting	(m) (Zone 54, GDA 94)	221,260
Northing	(m) (Zone 54, GDA 94)	6,326,250
Stack Height	(m)	60
Stack Tip Diameter	(m)	1.42
Exit Temperature	(deg C)	61
Exit Velocity	(m/s)	20
Median SO_2 Emissions	(g/s)	42

Note: The 60 m stack is an indicative stack height. This is to be finalised once the plant layouts are finalised, such that effects of nearby building structures are minimised (see **Section 5.2**)

5 Modelling

5.1 Model Selection

For modelling emissions of SO_2 from the smelter, based on the work by Hibberd *et al* (1996), Hibberd (2000) and GHD (2009), the following processes are considered important for the tall stack:

- Convective dispersion;
- Influence of the Thermal Internal Boundary Layer (TIBL) for air flow from over-water to overland; and
- Wind shear in the vertical.

For the shorter stacks, dispersion under night time conditions is considered more important as moderate winds have sufficient turbulence to mix plumes from short stacks to ground. As indicated in other studies, the tall stack emissions should remain elevated at night and not be mixed to ground until some tens of kilometres downwind.

To model the above processes, two models were considered, TAPM as used in the previous assessments and AERMOD, the USEPA regulatory model. Both models were initially trialled but TAPM was found to provide more realistic results[2]. Based on this and the fact that TAPM can model all the above processes realistically, it has been used in this assessment.

5.2 Model Set Up

For modelling, the latest version of TAPM (version 4.05) was used with the following set-up:

- Four nested meteorological grids with resolutions 15 km, 6 km, 2.5 km and 1 km with 39 by 33 grid points in the east/west and north/south direction. This domain was selected to include the adjacent part of the Flinders ranges in the inner domain because this is found to be a significant influence in developing the NNW to SSE wind patterns (see later);
- All grids centred at 33^{o} 10.5' Latitude South and 138^{o} 0.5' Longitude East, or 221,035 m Easting and 6,325,325 m Northing (Zone 54, GDA 94);
- Model was run in two monthly blocks with two spin up days;
- No wind data assimilation;
- Land use modified for the town to a category 11 (shrubland tall sparse) such that an effective roughness length of 0.45 m is created. The default category of "urban" had a roughness of 1.3 m that was considered too high. This default category reflects a denser urban area with higher buildings and is not representative of Port Pirie's lower density suburban area;
- Some modification of the coastline to better reflect the location of the land/sea interface;
- Deep soil moistures that varied from 0.12 in summer to 0.15 in winter;
- Pollution grid with 250 m resolution over 23 by 27 grid points;
- Default sea temperatures;

[2] This was based on some preliminary testing as there was insufficient time for a more complete evaluation of the two models.

- Default turbulence, land use and rainfall schemes; and
- No buildings. Building effects for the existing stacks, except possibly for the small KDR stacks are not considered an issue. Note in modelling the new acid plant emissions, one of the options is for the EBS to have a 70 m main building, which is only about 80 m from the acid plant stack of height 60 m. This building will likely affect the acid plant plume dispersion and may itself be impacted by the plume from the acid plant if constructed as is. Therefore in the modelling, the 60 m stack is noted as an indicative stack height, which has been modelled without including building wake effects, with the exact stack height to be finalised once the plant layout is finalised.

5.3 Modelled Period

Modelling was conducted for the 12 month period from 1 July 2005 to 30 June 2006. This period was selected as it had the best ambient monitoring site data to undertake model validation (4 monitors compared to two for most other years and had also been used for model validation exercise by GHD (2009). Nyrstar advise that throughput has not changed significantly since 2005/2006 (Andrew Gilbert, pers. comm., 10 June 2013). The monitoring data shows some variation from year to year (as expected with variation in meteorology), though with a slight increase in the number of exceedances in last three years (see **Figure 5-1**).

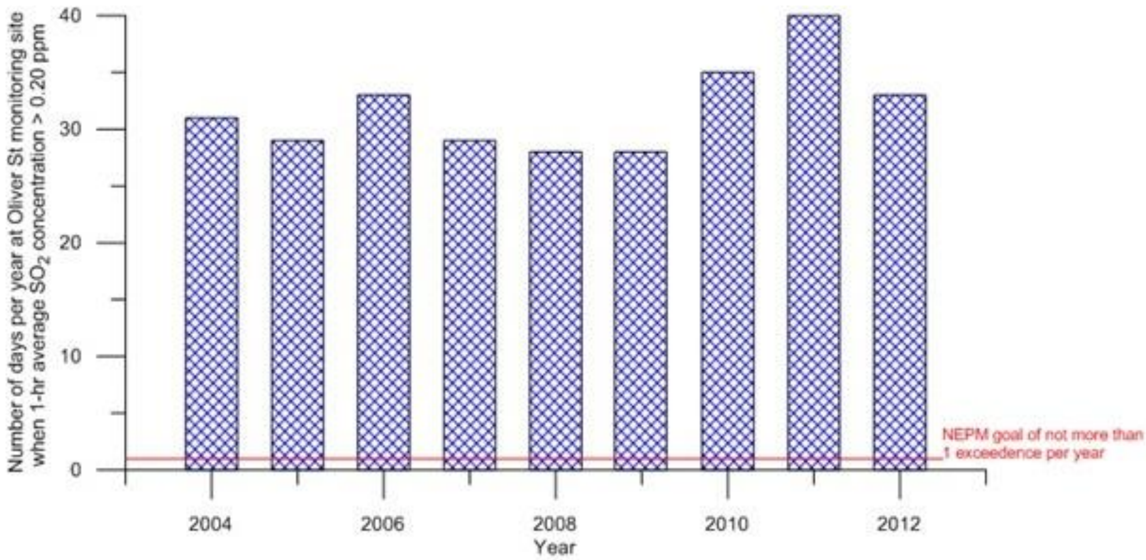

Figure 5-1 Number of days per year at Oliver Street monitoring site when the 1-hour average SO_2 concentration exceeds 0.20 ppm

The number of exceedances is very sensitive to changes in concentrations around the exceedance threshold (see **Section 6.3)**: small changes in predicted concentrations can have a big impact on the number of exceedances. Therefore, the slight increase in **Figure 5-1** probably reflects even smaller increases in SO_2 concentrations. Though a small increase in SO_2 emissions may have occurred, for the purpose of this modelling it is not considered necessary to reproduce the last year's impacts exactly, but instead to provide a basis for model validation such that the model can be used with some confidence for future predictions.

APPENDIX C

6 Model Validation

6.1 Introduction

TAPM has been validated extensively throughout Australia for predicting both meteorology and pollutants (see Hurley *et al*, 2009). In terms of meteorology it has been found to provide generally good agreement, though it has a tendency to under-predict the strong winds, and has a simplistic treatment of clouds and rain processes. In terms of the accuracy of the predictions it can be dependent on the se- up options, such as the choice of domain sizes, grid resolution and land uses etc.

Good quality data is needed to undertake a model validation. For meteorology in the Port Pirie region there are currently only 3 sites in the town itself where winds at 10 m above ground are measured (these are commonly referred to as surface winds). Of these, two, the Boat Ramp site and to a lesser degree the Dental Clinic site, have changes in land use close by, or obstructions – the effects of which a model such as TAPM will not be able to reproduce. For the Boat Ramp, winds from the north will reflect over-water winds, whilst from the south they will reflect winds from over a suburban area, but TAPM winds at one grid point can only reflect one land use. The winds at Oliver Street are considered the best for evaluation as they represent a more uniform land use, though there is some influence due to trees within 30 m to the east to NE, which may decrease the wind speeds from these directions. Therefore the wind data will provide some ability to compare the model, but ideally winds closer to plume height are needed and over a larger scale. With regards to pollutants, for the period 2005/2006, four SO_2 monitoring sites were available which provides a more comprehensive data set than recent years to evaluate the model.

In this study a comprehensive evaluation will not be undertaken against the meteorology, with only a comparison of the surface winds at the Oliver Street site, with the focus on correctly reproducing the pattern of the winds from the north, being presented. A fuller evaluation will be undertaken of the pollutant predictions as a more comprehensive data base exists.

6.2 Predicted Winds

The observed and predicted wind roses for July 2005 to June 2005 are presented in **Figure 6-1** and **Figure 6-2**.

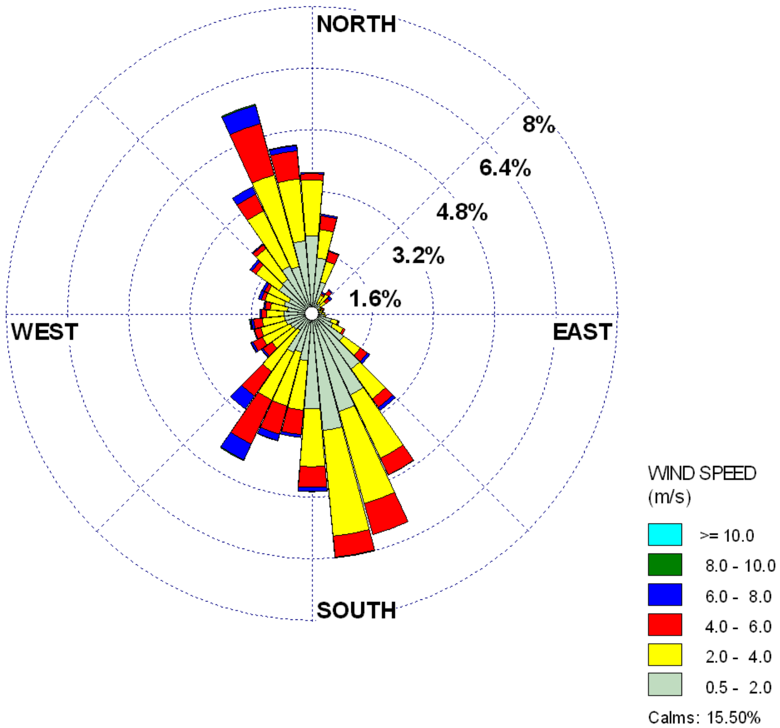

Figure 6-1 Observed wind rose for 1 July 2005 to 30 June 2006 at Oliver Street

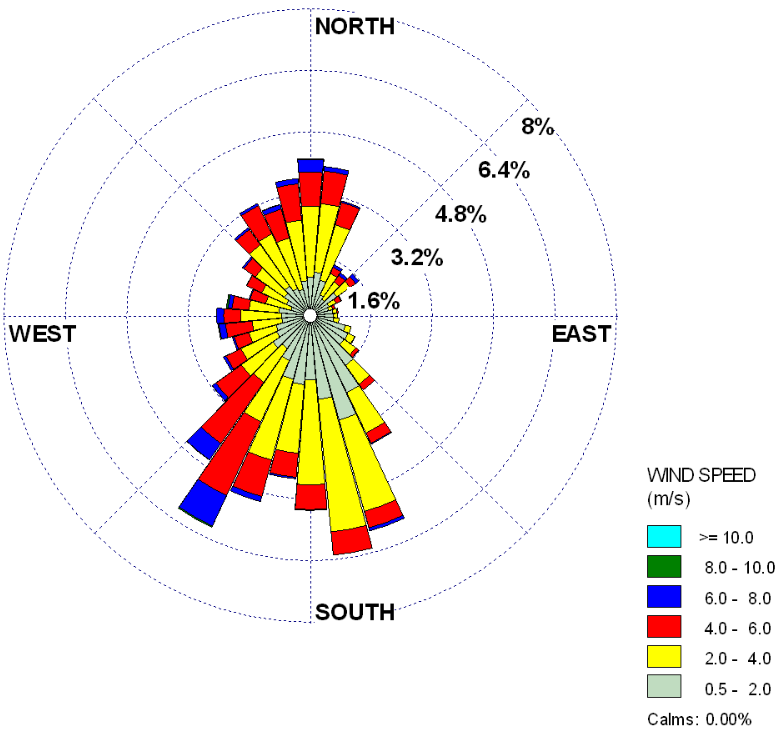

Figure 6-2 TAPM predicted wind rose for 1 July 2005 to 30 June 2006 at Oliver Street

Figure 6-1 and **Figure 6-2** show that TAPM (as set up here), reproduces the SW and SSE winds, but has a tendency to predict the NNW winds as more northerly than observed. This feature is somewhat dependent on the domain size and the land use specifications. This could perhaps be improved, but was accepted for this assessment due to time constraints. TAPM correctly predicts the very low frequency of easterly winds at Port Pirie which is considered to be due to the presence of the nearby Flinders Ranges. Winds tend to be aligned along the Flinders Ranges in a SSE to NNW direction.

Therefore, based on the predicted winds, it would be expected that TAPM would predict slightly higher concentrations to the south of the smelter than in the observations.

6.3 Predicted Concentrations

TAPM was used to predict SO_2 concentrations for the period 1 July 2005 to 30 June 2006 using the model set-up described in **Section 5** and the best estimate of the emission parameters in **Section 4**. Any model validation is dependent on the quality of the emissions data and that there is some uncertainty for example in the tall stack flows and particularly in the smaller stack emissions with the use of median stack test values.

A summary of the observed and predicted concentrations at the four sites is presented in **Table 6-1** and **Table 6-2** with plots of the predicted concentrations over Port Pirie presented in **Figure 6-3** to **Figure 6-10**. Note in the contour plots only the tall stack and slag fumer stack are shown to enable the figures to be legibile. The KDR stack is just to the NE of the slag fumer stack, with the acid plant stack approximately midway between the tall stack and slag fumer stack.

Table 6-1 Summary Statistics of Observed and Predicted SO_2 Concentrations (ppb) for 2005/2006

Statistic	Golden North		John Pirie SS		Frank Green Pk		Oliver Street	
	Obs.	TAPM [1]	Obs.	TAPM	Obs.	TAPM	Obs.	TAPM
Maximum 1-hour	639	459	543	450	489	453	513	490
RHC [2] 1-hour	522	438	501	367	404	373	422	424
99.9^{th} Percentile 1-hour	398	354	348	298	225	268	362	341
99.5^{th} Percentile 1-hour	238	277	202	202	108	147	219	241
99^{th} Percentile 1-hour	169	225	120	156	75	111	165	189
95^{th} Percentile 1-hour	37	71	24	76	8	28	49	52
90^{th} Percentile 1-hour	21	18	9	29	1	3	17	12
Maximum 24-hour	117	65	35	72	104	81	66	86
Average	10	11	8	10	3	5	8	8
# exceedances of a 1-hour 170 pbb level [3]	88	156	54	68	18	36	82	112
# exceedances of a 1-hour 200 pbb level [3]	62	125	46	45	16	24	58	75
# of days with an exceedance of a 1-hour 200 ppb level (NEPM standard)	35	56	29	28	12	16	37	36

Notes:

1) Model predictions converted to ppb using a conversion of 1 ppb = 2.616 $\mu g/m^3$ which is valid at 25°C and one atmosphere which is typical modelled temperature.
2) RHC is the robust highest concentration, evaluated here based on the top 11 events (see Hurley *et al*, 2008).
3) The observations have been normalised to a full year to account that for missing monitoring data.

Table 6-2 Ratio of Predicted to Observed SO_2 Concentrations (ppb) for 2005/2006

Statistic	Golden North	John Pirie SS	Frank Green Pk	Oliver Street	Average of four sites
Maximum 1-hour	0.72	0.83	0.93	0.96	0.86
RHC (2) 1-hour	0.84	0.73	0.92	1.00	0.87
99.9th Percentile 1-hour	0.89	0.86	1.19	0.94	0.97
99.5th Percentile 1-hour	1.16	1.00	1.36	1.10	1.15
99th Percentile 1-hour	1.33	1.31	1.48	1.15	1.32
95th Percentile 1-hour	1.95	3.17	3.36	1.05	2.38
90th Percentile 1-hour	0.88	3.08	2.51	0.72	1.80
Maximum 24-hour	0.88	1.24	1.89	1.19	1.30
Average	1.08	1.27	1.80	0.99	1.28
# exceedances of a 1-hour 170 pbb level (3)	1.77	1.26	2.00	1.37	1.60
# exceedances of a 1-hour 200 pbb level (3)	2.02	0.97	1.52	1.30	1.45
# of days with an exceedance of a 1-hour 200 ppb level (NEPM standard)	1.60	0.97	1.33	0.97	1.22

Notes:

1) Model predictions converted to ppb using a conversion of 1 ppb = 2.616 µg/m^3 which is valid at 25°C and one atmosphere which is typical modelled temperature.
2) RHC is the robust highest concentration, evaluated here based on the top 11 events (see Hurley *et al*, 2008).
3) The observations have been normalised to a full year to account that for missing monitoring data.

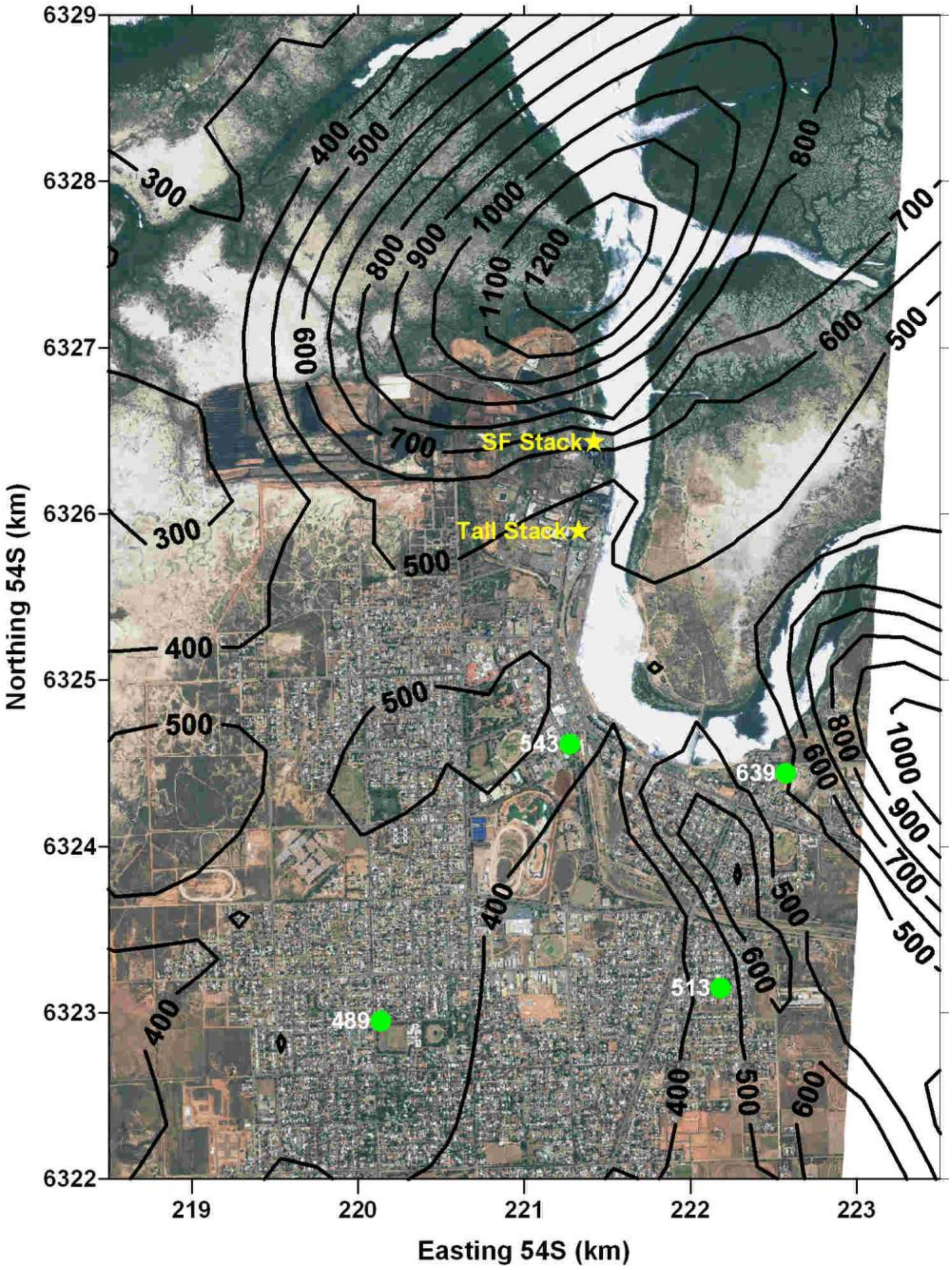

Figure 6-3 Predicted maximum 1-hour SO_2 concentrations (ppb) for 2005/2006 along with the observed data at the four monitoring sites

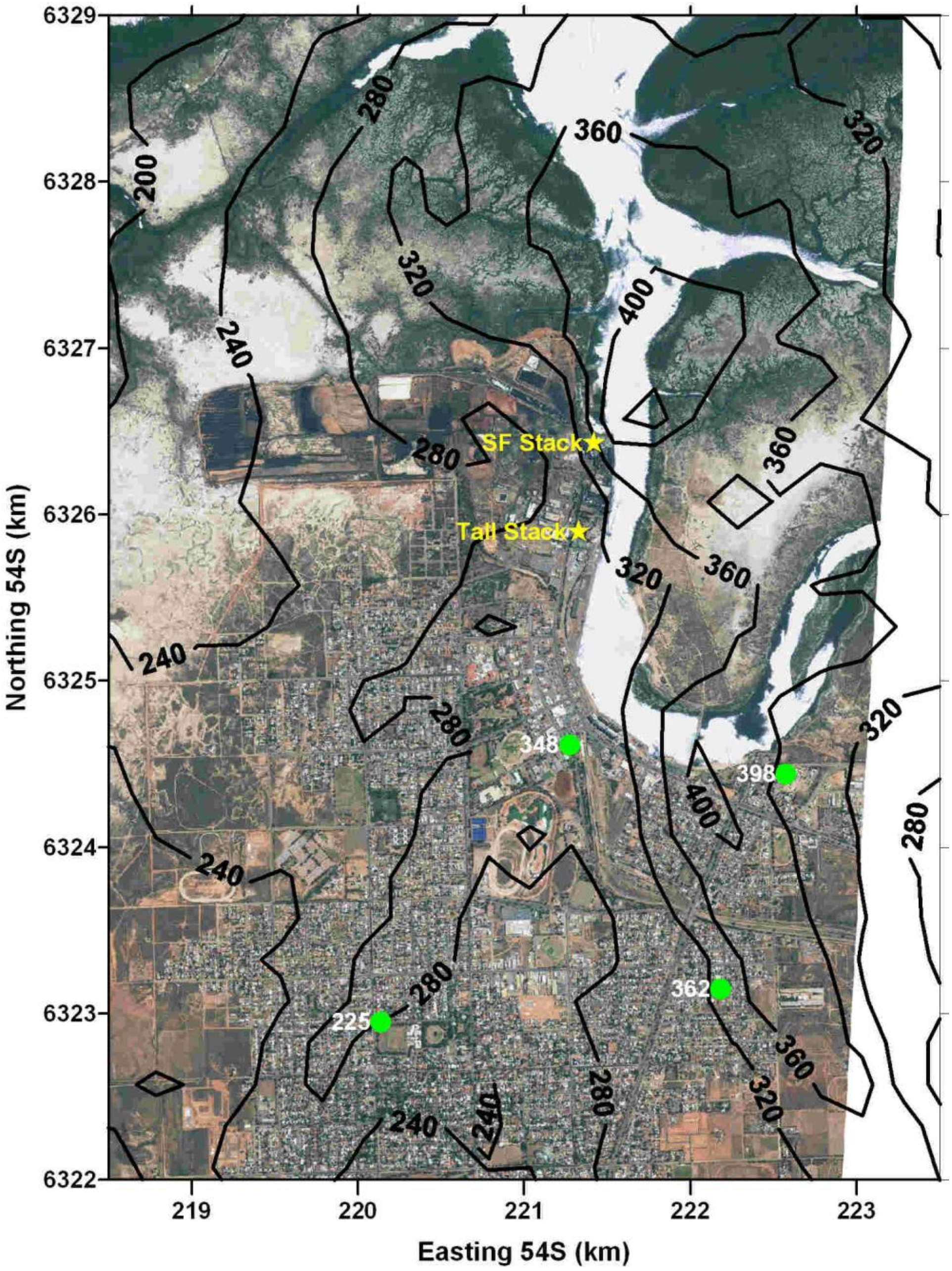

Figure 6-4 Predicted 99.9th 1-hour SO_2 concentrations (ppb) for 2005/2006 along with the observed data at the four monitoring sites

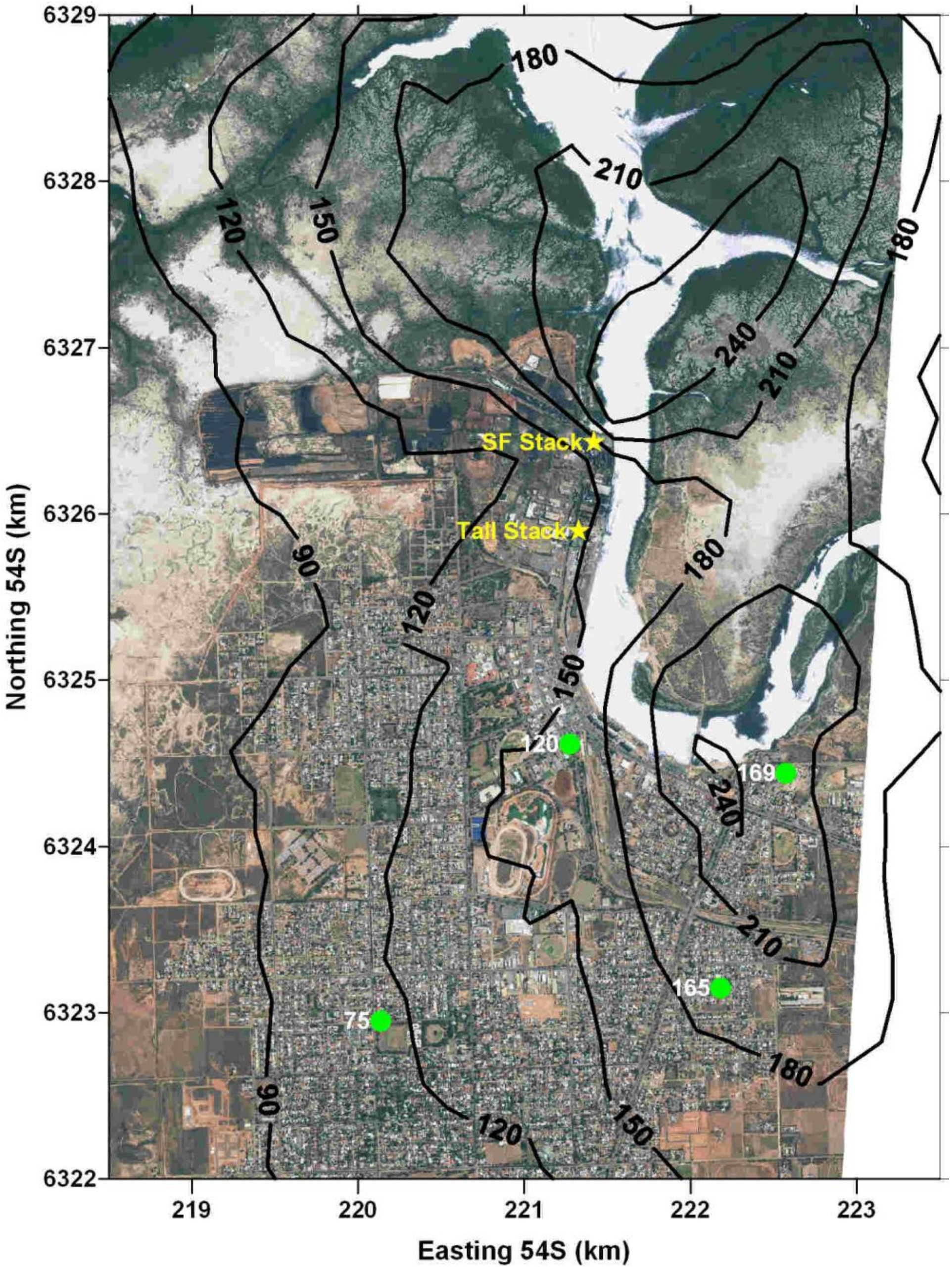

Figure 6-5 Predicted 99th 1-hour SO_2 concentrations (ppb) for 2005/2006 along with the observed data at the four monitoring sites

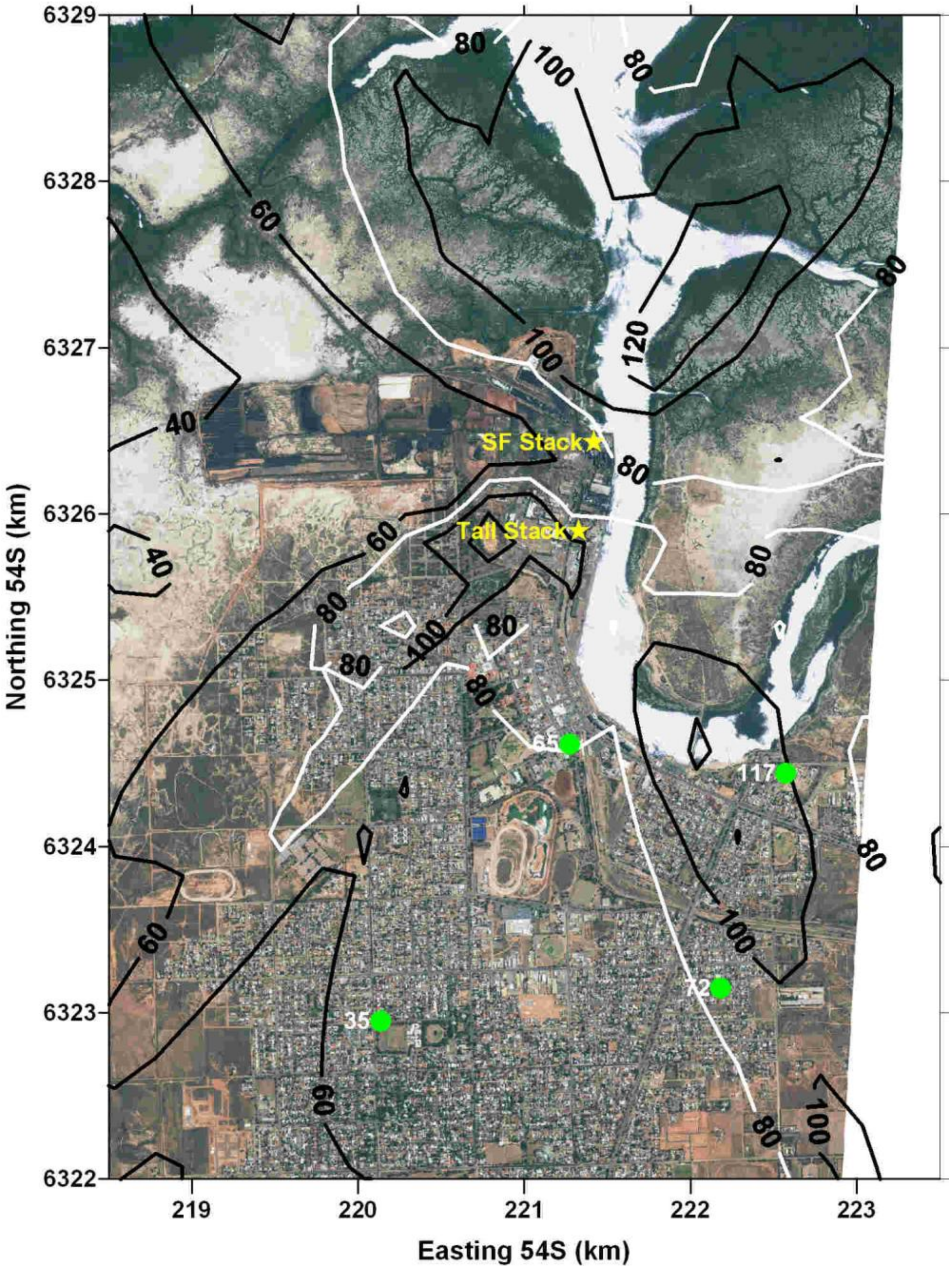

Figure 6-6 Maximum 24-hour SO_2 concentrations (ppb) for 2005/2006 along with the observed data at the four monitoring sites. White line is 80 ppb contour for reference to the NEPM standard

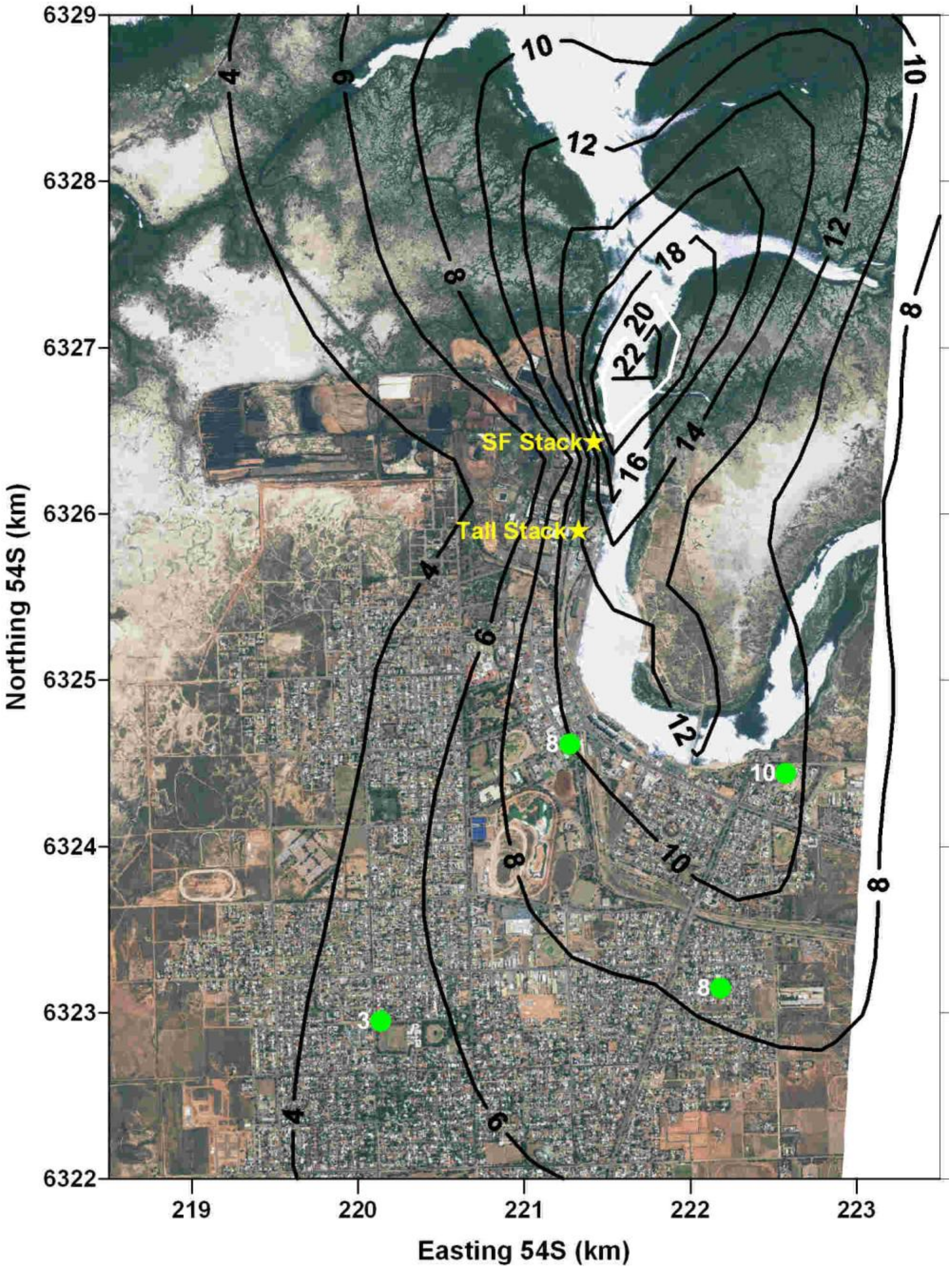

Figure 6-7 Predicted annual average SO_2 concentrations (ppb) for 2005/2006 along with the observed data at the four monitoring sites. White line is 20 ppb contour for reference to the NEPM standard

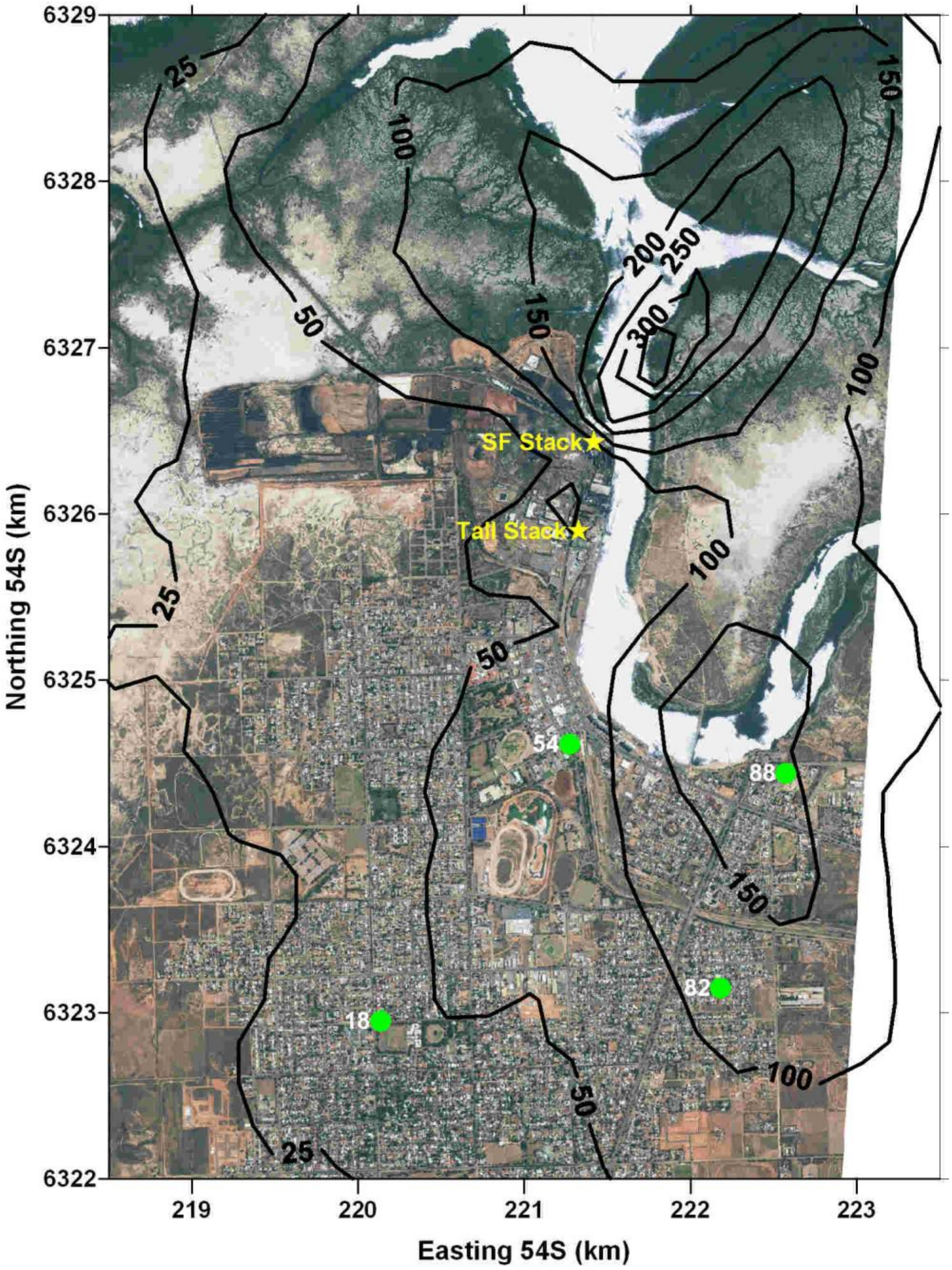

Figure 6-8 Predicted number of exceedances of a 1-hour SO_2 level of 170 ppb for 2005/2006 along with the observed data at the four monitoring sites

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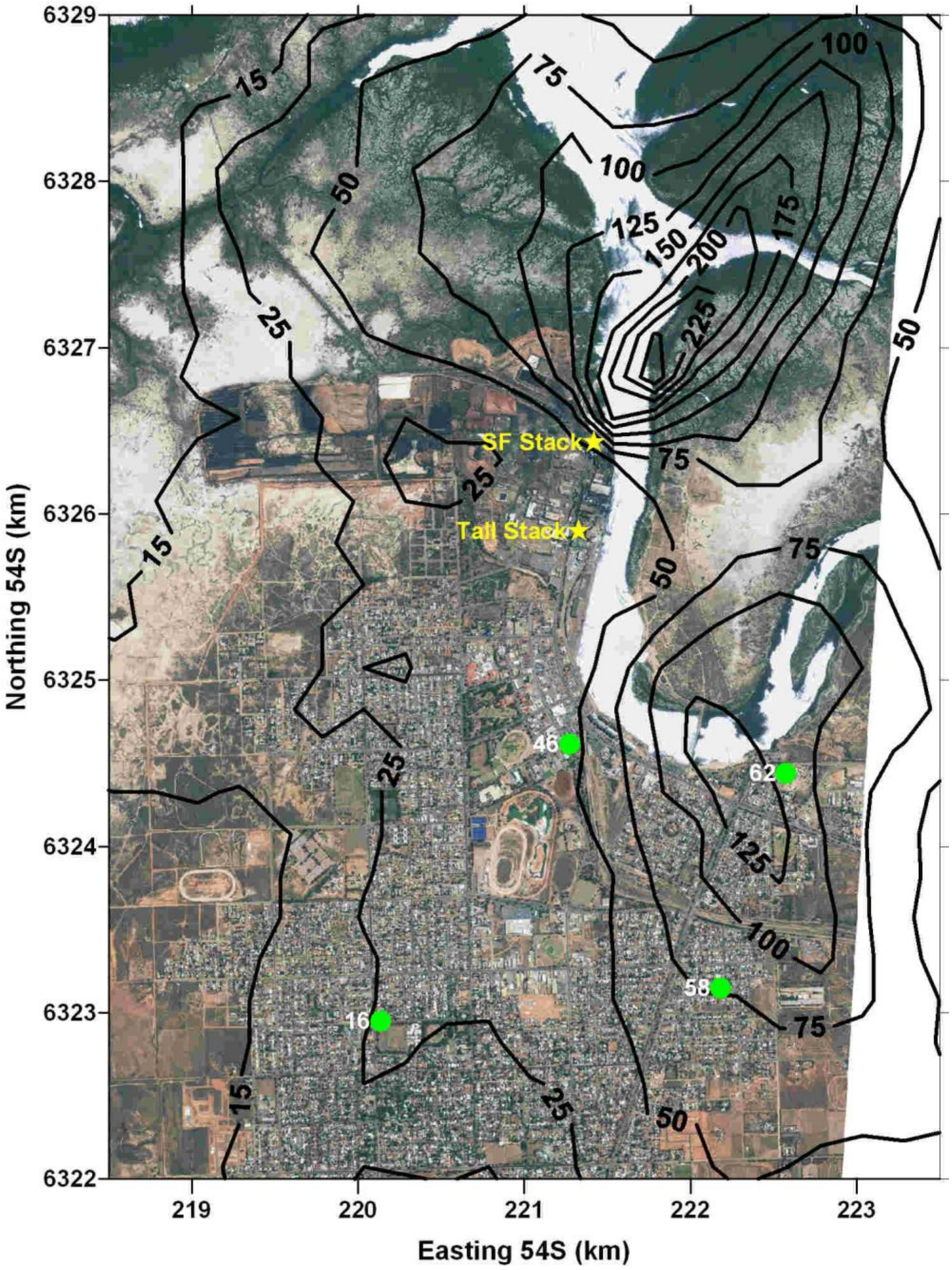

Figure 6-9 Predicted number of exceedances of a 1-hour SO_2 level of 200 ppb for 2005/2006 along with the observed data at the four monitoring sites.

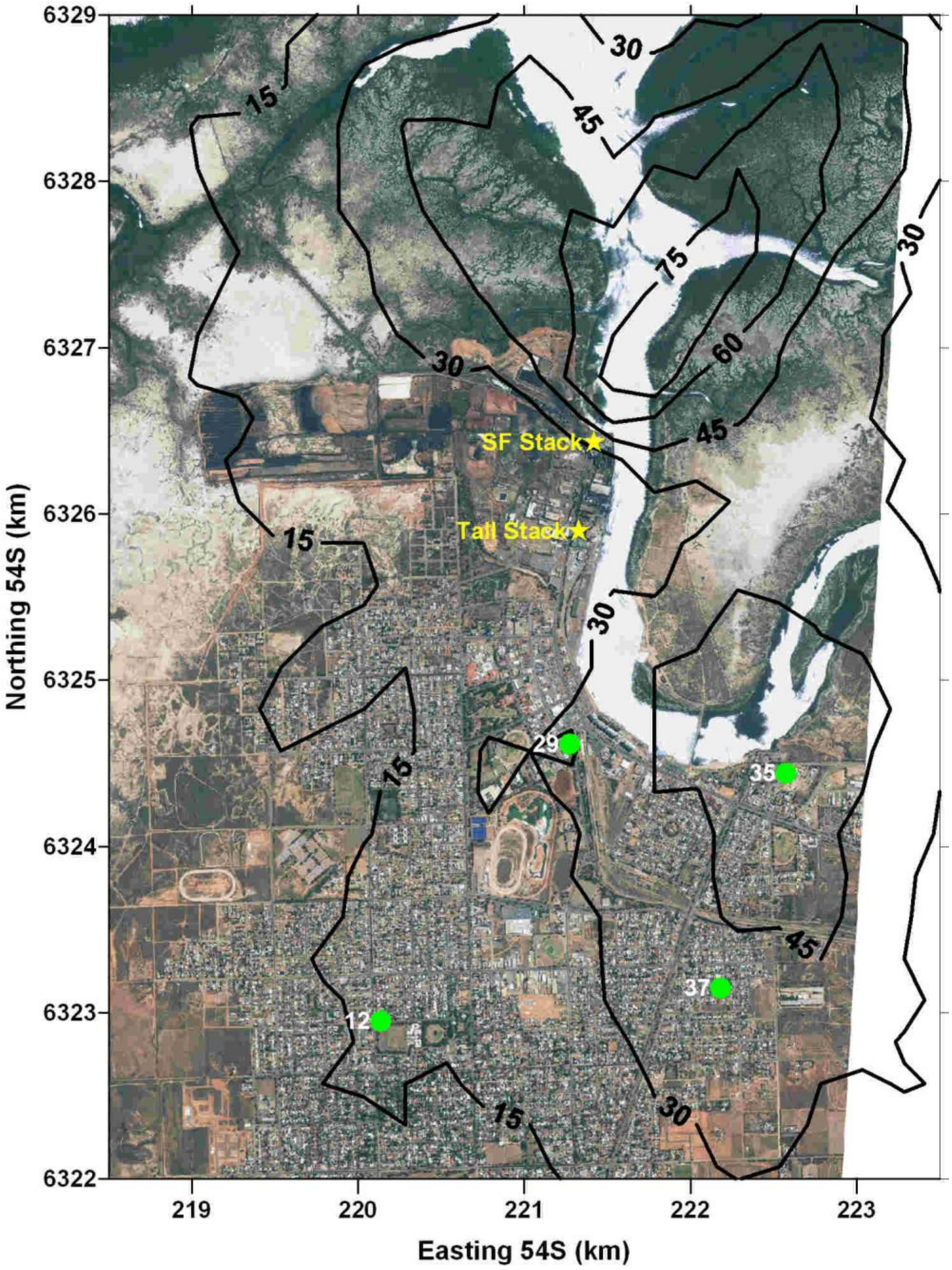

Figure 6-10 Predicted number of days with an exceedances of a 1-hour SO_2 level of 200 ppb for 2005/2006 along with the observed data at the four monitoring sites. NEPM standard allows no more than one day of exceedances

Table 6-1 and **Table 6-2** and **Figure 6-3** to **Figure 6-10** indicate the following:

- The model tends to under-predict the maximum 1-hour concentrations, but over-predicts the lower percentile concentrations such as the 1-hour 90th and 95th percentile concentrations;
- The maximum 1-hour concentration is not a robust statistic (as seen by the maximum predicted concentrations being isolated "plume hits", in a few cases just missing the monitors, see **Figure 6-3**). The predicted robust highest concentration (RHC) shows a better comparison to the observations, which confirms this; and
- The model does however provide good predictions of the 99.9th to 99th percentiles and the number of days with an exceedance of 1-hour 200 ppb level, which is the NEPM standard.

6.4 Predicted Concentrations by Time of Day

To further verify the ability of the model to predict SO_2 concentrations under the correct meteorological conditions, observed and predicted concentrations at the four monitors by time of day are presented in **Figure 6-11** to **Figure 6-14**.

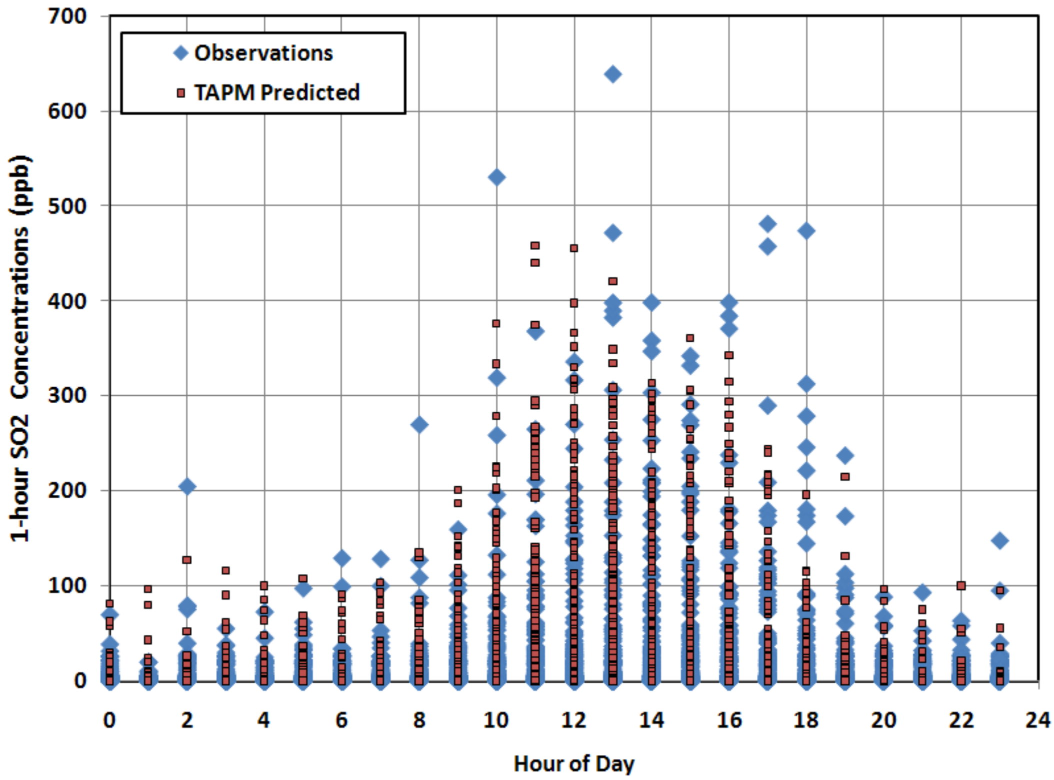

Figure 6-11 Observed and predicted 1-hour SO_2 concentrations (ppb) by hour of day at the Golden North monitor for 2005/2006

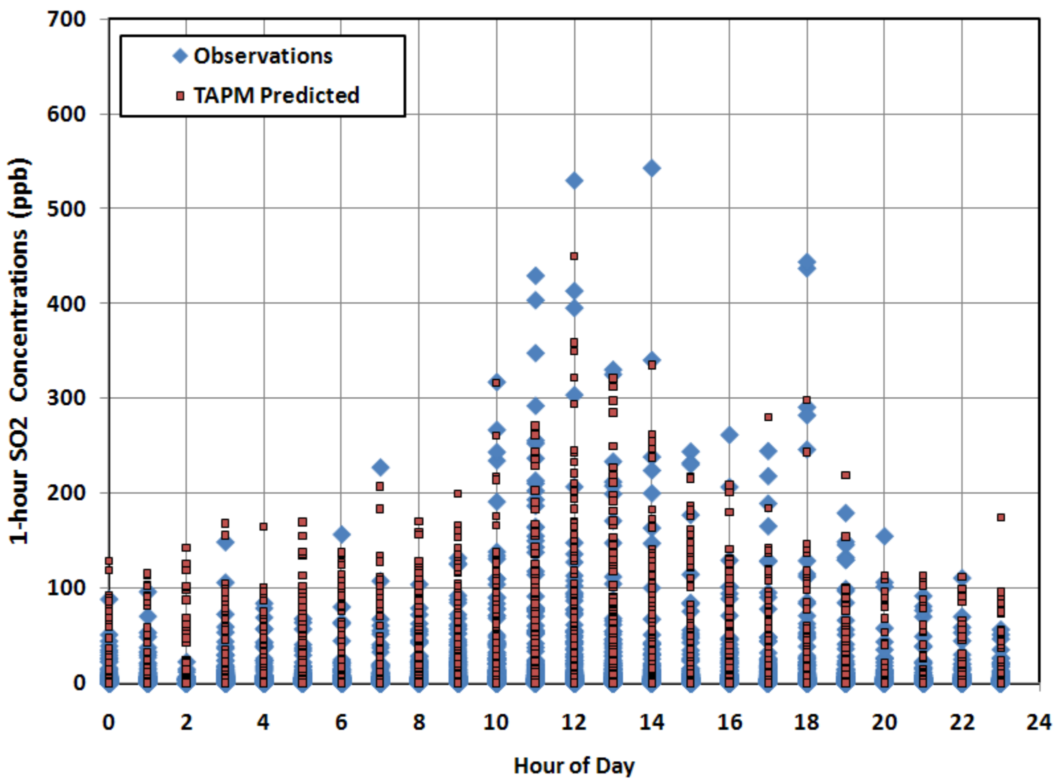

Figure 6-12 Observed and predicted 1-hour SO_2 concentrations (ppb) by hour of day at the John Pirie Secondary School monitor for 2005/2006

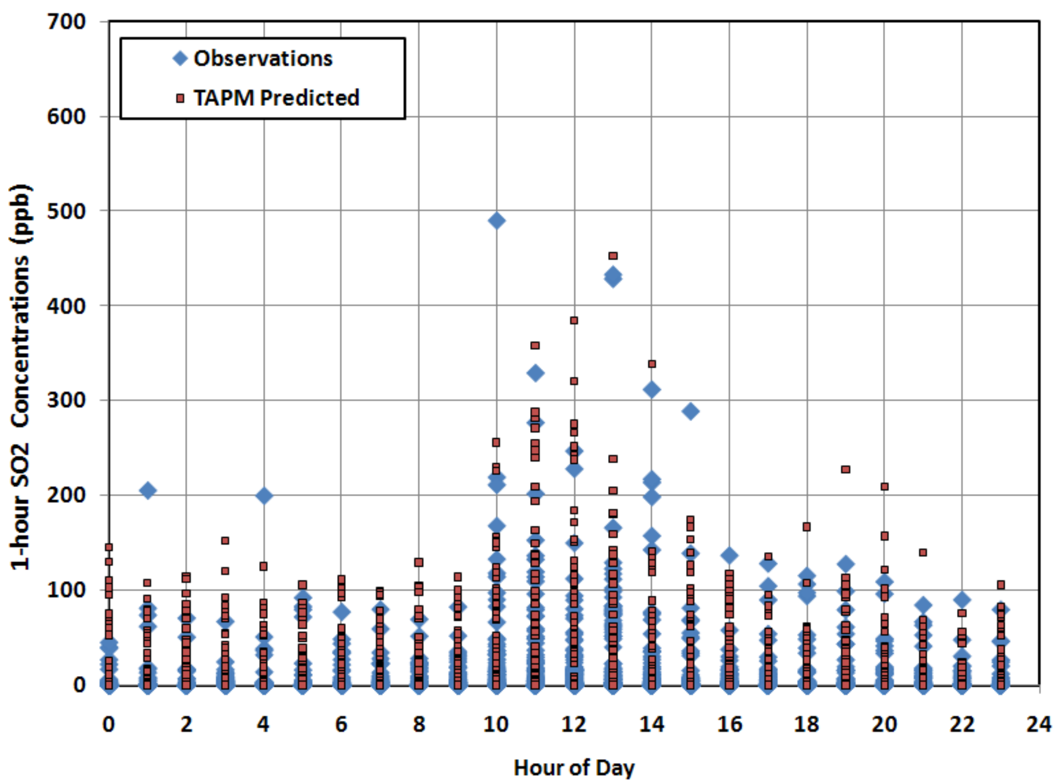

Figure 6-13 Observed and predicted 1-hour SO_2 concentrations (ppb) by hour of day at the Frank Green Park monitor for 2005/2006

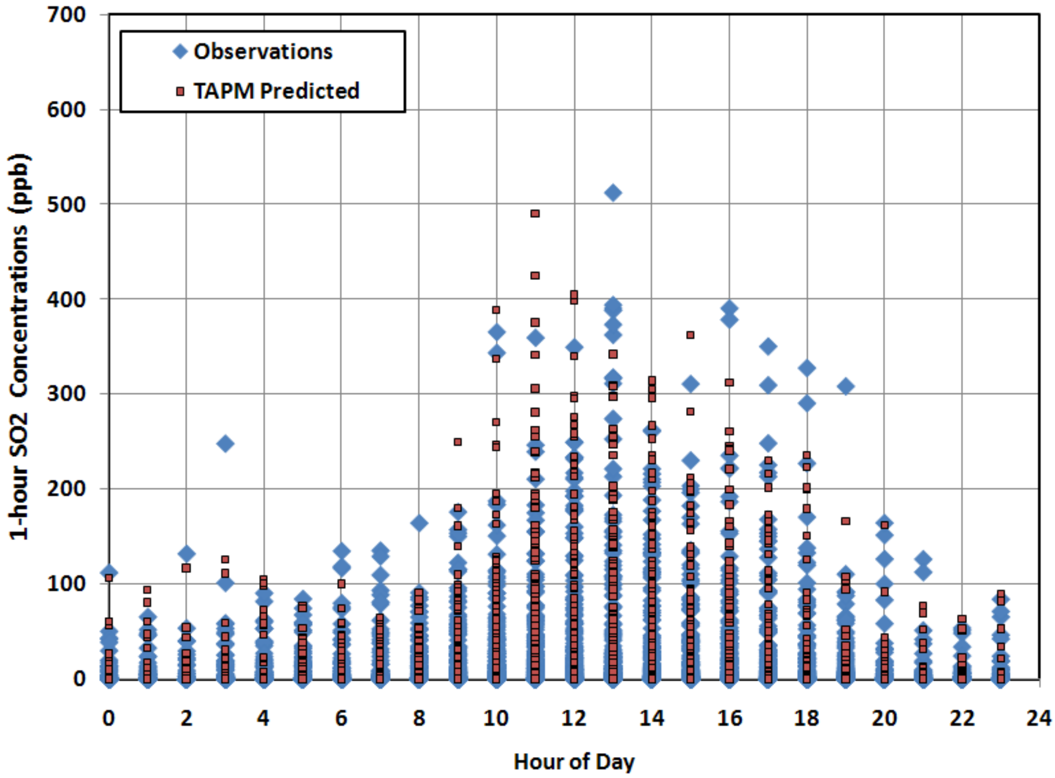

Figure 6-14 Observed and predicted 1-hour SO_2 concentrations (ppb) by hour of day at the Oliver Street monitor for 2005/2006

Figure 6-11 to **Figure 6-14** indicate good agreement with the maximum concentrations predicted at all sites during the daytime between 1000 and 1800 hours (hour ending). This indicates the importance of convective dispersion with the greatest contribution from the tall stack emissions. Lower night time concentrations are predicted due to the emissions from the short stacks, with the emissions from the tall stack predicted to make little contribution at night.

7 Predicted Levels with the Smelter Transformation

7.1 Predicted Annual Statistics

Predicted SO_2 concentrations of SO_2 from the Smelter Transformation are summarised in **Table 7-1** with contour plots presented in **Figure 7-1** to **Figure 7-6**.

Table 7-1 Summary Statistics of Predicted SO_2 Concentrations (ppb) Before and After the Smelter Transformation

Statistic	Ellen Street	Pirie West PS	Frank Green Pk	JP SS	Oliver Street	Golden North	York Rd	Average
Present								
Maximum 1-hour	480	505	453	450	490	459	415	-
99.9^{th} Percentile 1-hour	290	283	268	298	341	354	273	-
Maximum 24-hour	91	75	66	81	86	104	78	-
Average	9.8	6.6	5.1	9.9	8.5	10.5	3.3	-
# exceedances of a 1-hour 170 pbb level (3)	52	59	36	58	112	156	32	-
# exceedances of a 1-hour 200 pbb level (3)	34	40	24	45	75	125	24	-
# of days with an exceedance of a 1-hour 200 ppb level (NEPM standard)	21	25	16	24	36	56	16	-
Post-Transformation								
Maximum 1- hour	264	243	170	228	182	245	194	-
99.9^{th} Percentile 1-hour	187	158	120	173	125	142	138	-
Maximum 24-hour	91	70	47	81	35	37	69	-
Average	7.2	4.0	2.8	6.5	3.4	4.3	1.6	-
# exceedances of a 1-hour 170 pbb level (3)	18	5	1	9	1	3	2	-
# exceedances of a 1-hour 200 pbb level (3)	5	1	0	4	0	1	0	-
# of days with an exceedance of a 1-hour 200 ppb level (NEPM standard)	4	1	0	2	0	1	0	-
Post-Transformation as a Percentage of Current Values								
Maximum 1- hour	0.55	0.48	0.38	0.51	0.37	0.53	0.47	**0.47**
99.9^{th} Percentile 1-hour	0.64	0.56	0.45	0.58	0.37	0.40	0.51	**0.50**
Maximum 24-hour	1.00	0.93	0.71	1.00	0.41	0.36	0.88	**0.76**
Average	0.73	0.61	0.55	0.66	0.40	0.41	0.48	**0.55**
# exceedances of a 1-hour 170 pbb level (3)	0.35	0.08	0.03	0.16	0.01	0.02	0.06	**0.10**
# exceedances of a 1-hour 200 pbb level (3)	0.15	0.03	0.00	0.09	0.00	0.01	0.00	**0.04**
# of days with a 1-hour exceedance of a 1-hour 200 ppb level (NEPM standard)	0.19	0.04	0.00	0.08	0.00	0.02	0.00	**0.05**

Note: Model predictions converted to ppb using a conversion of 1 ppb = 2.616 $\mu g/m^3$ which is valid at 25°C and one atmosphere which is typical temperature

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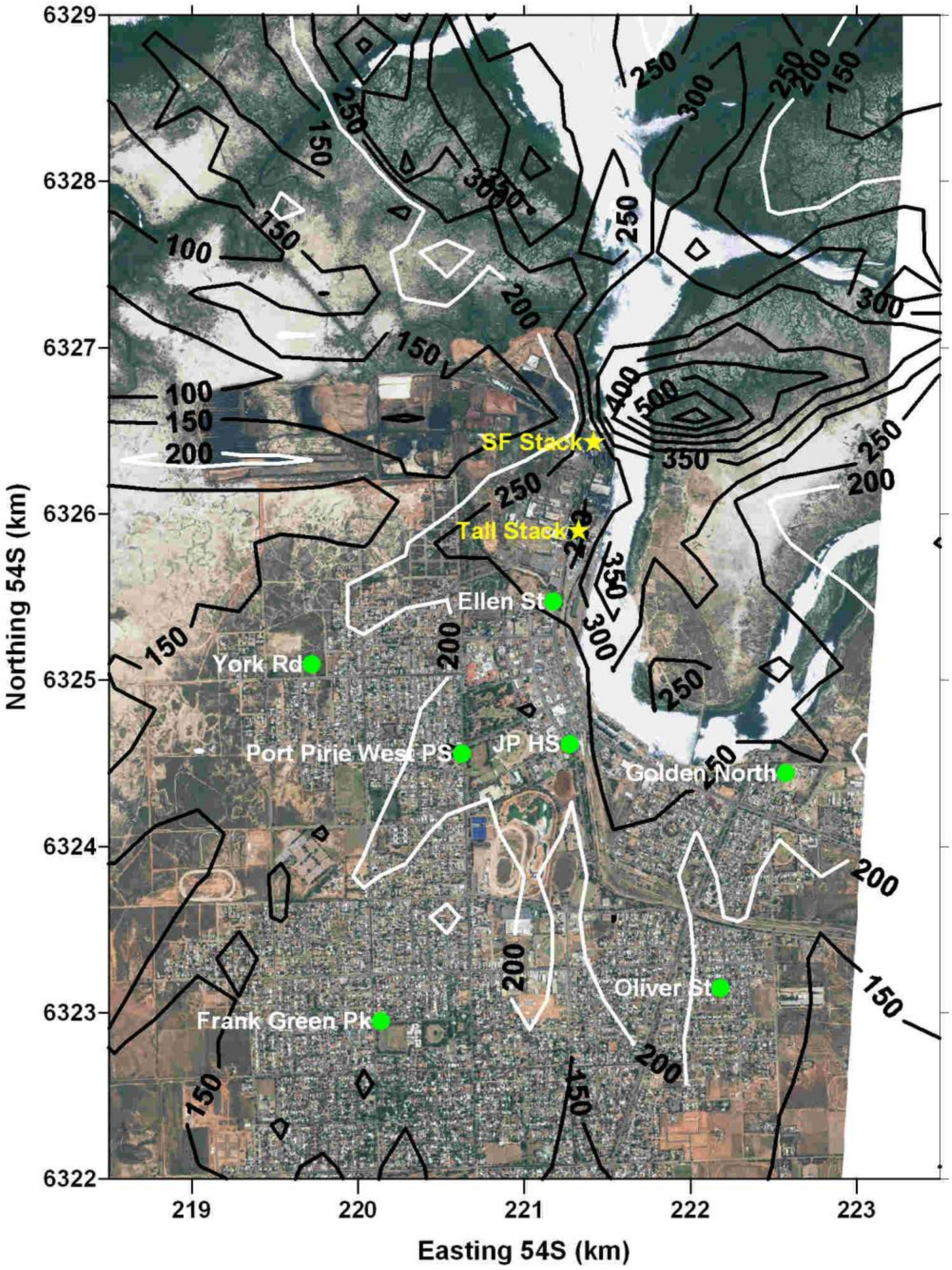

Figure 7-1 Predicted maximum 1-hour SO_2 concentrations (ppb) with the Transformation. White line is 200 ppb contour for reference to the NEPM standard that allows no more than one day of exceedances

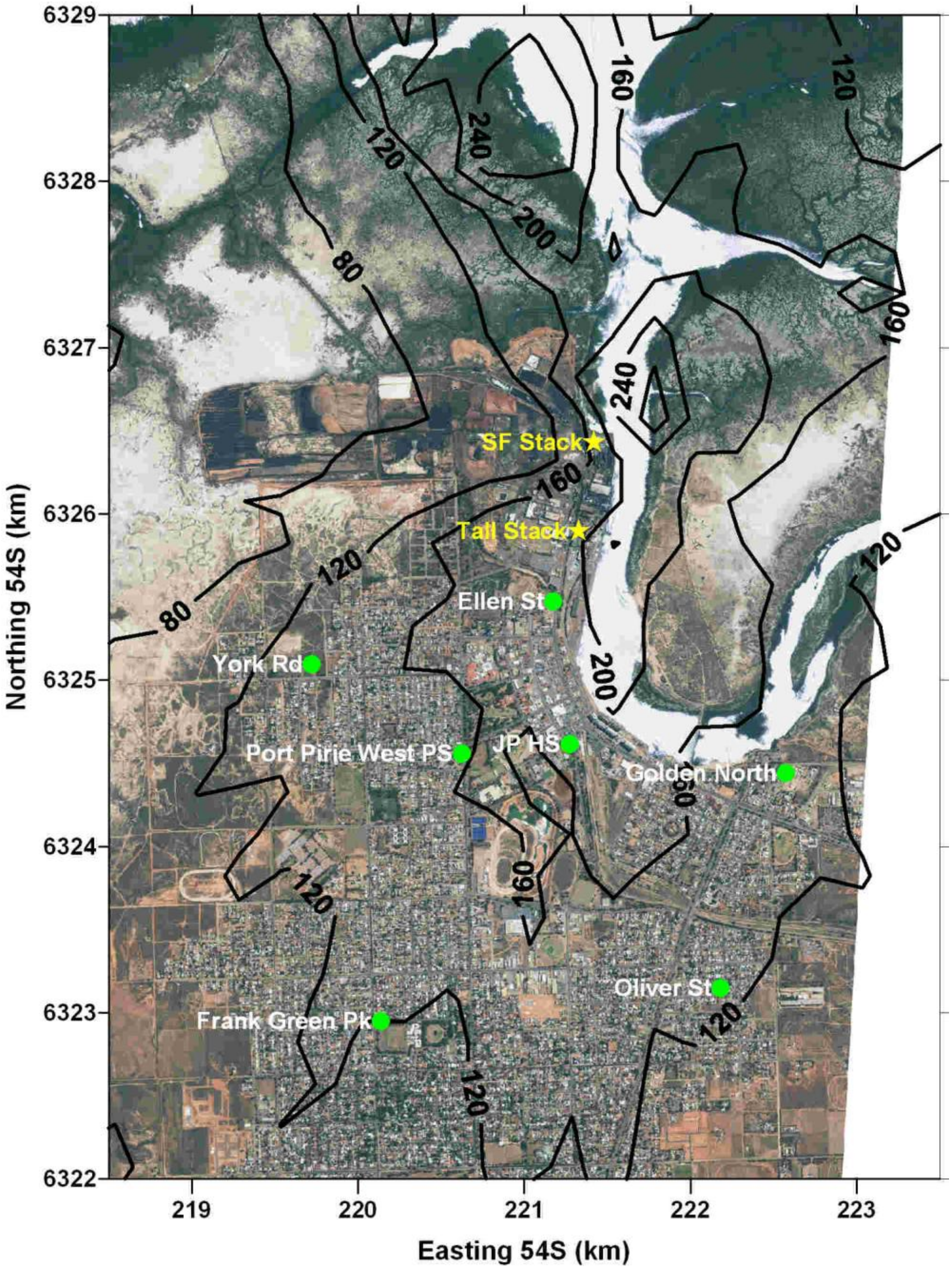

Figure 7-2 Predicted 99.9th 1-hour SO_2 concentrations (ppb) with the Transformation

APPENDIX C

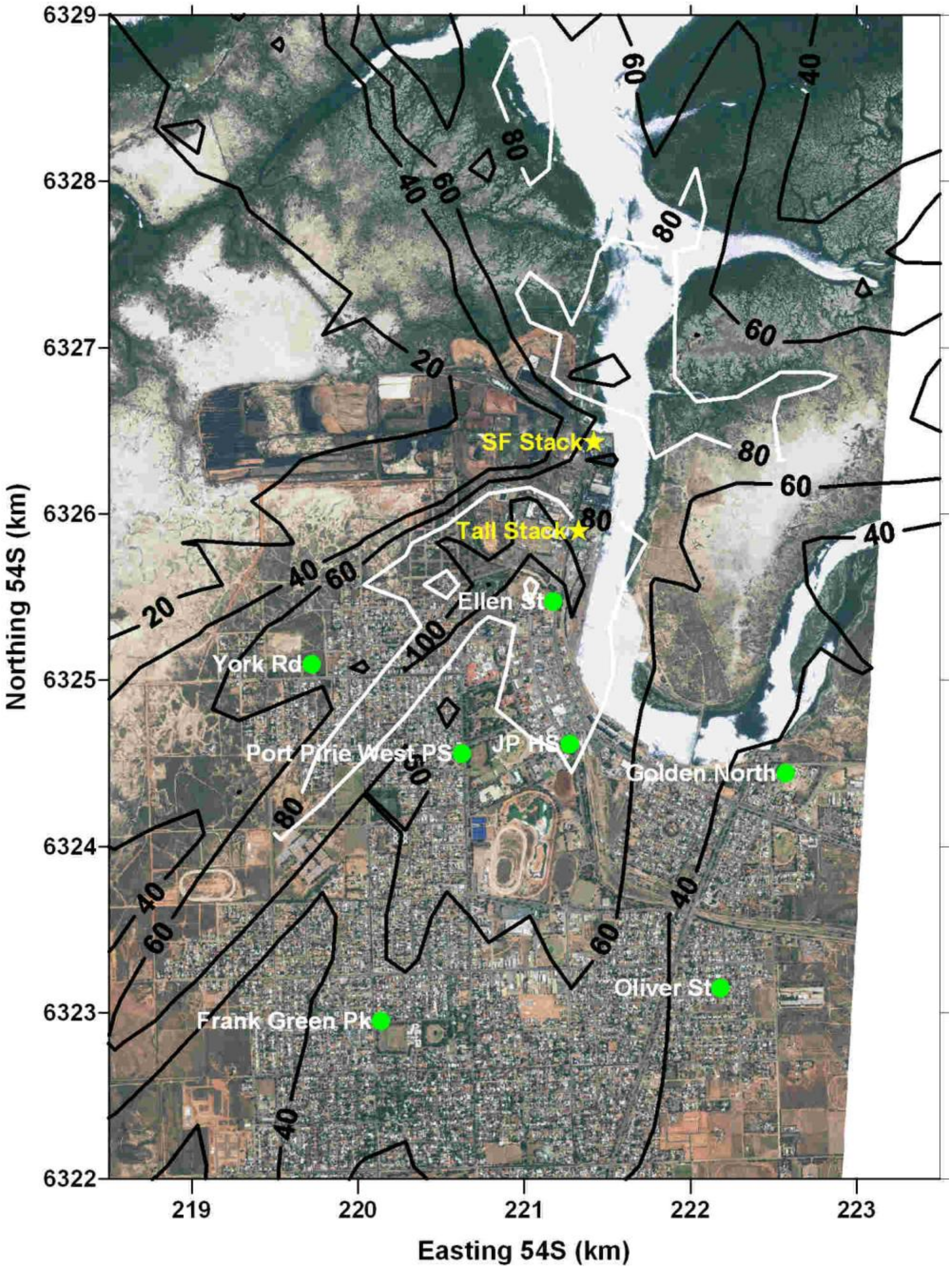

Figure 7-3 Predicted maximum 24-hour SO_2 concentrations (ppb) with the Transformation. White line is 80 ppb contour for reference to the NEPM standard

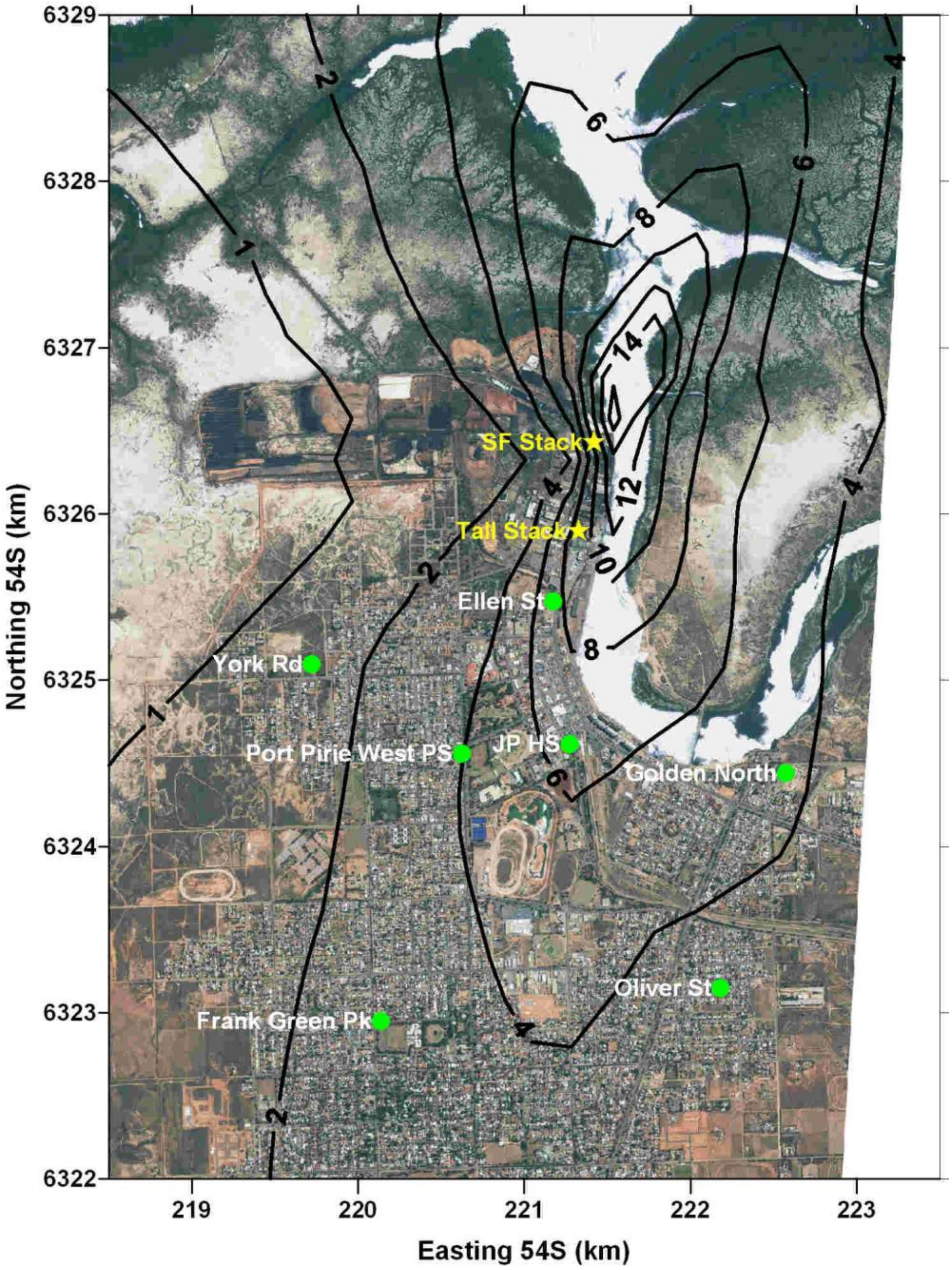

Figure 7-4 Predicted annual average SO_2 concentrations (ppb) with the Transformation. The NEPM standard is 20 ppb

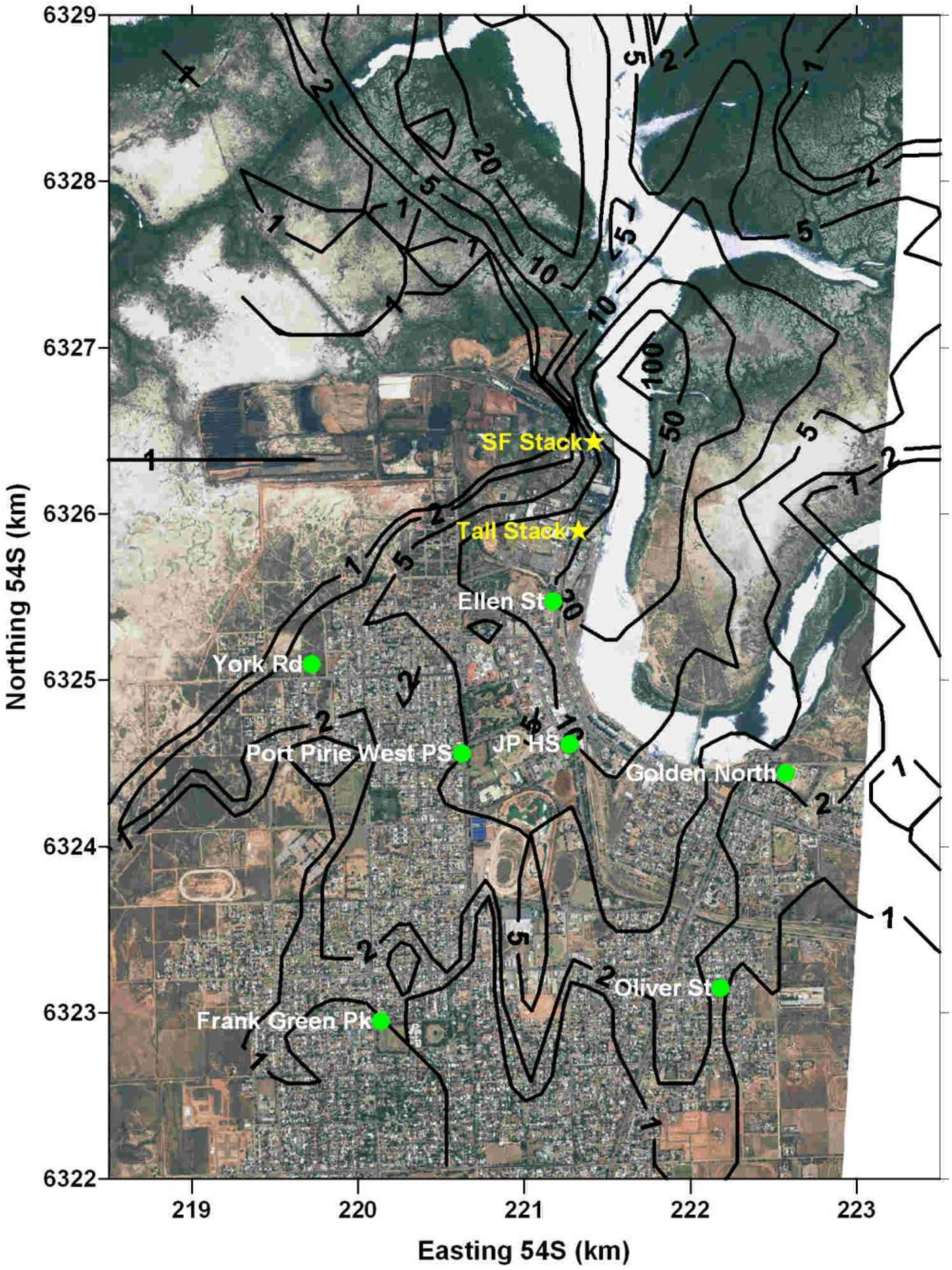

Figure 7-5 Predicted number of exceedances of a 1-hour SO_2 level of 170 ppb with the Transformation

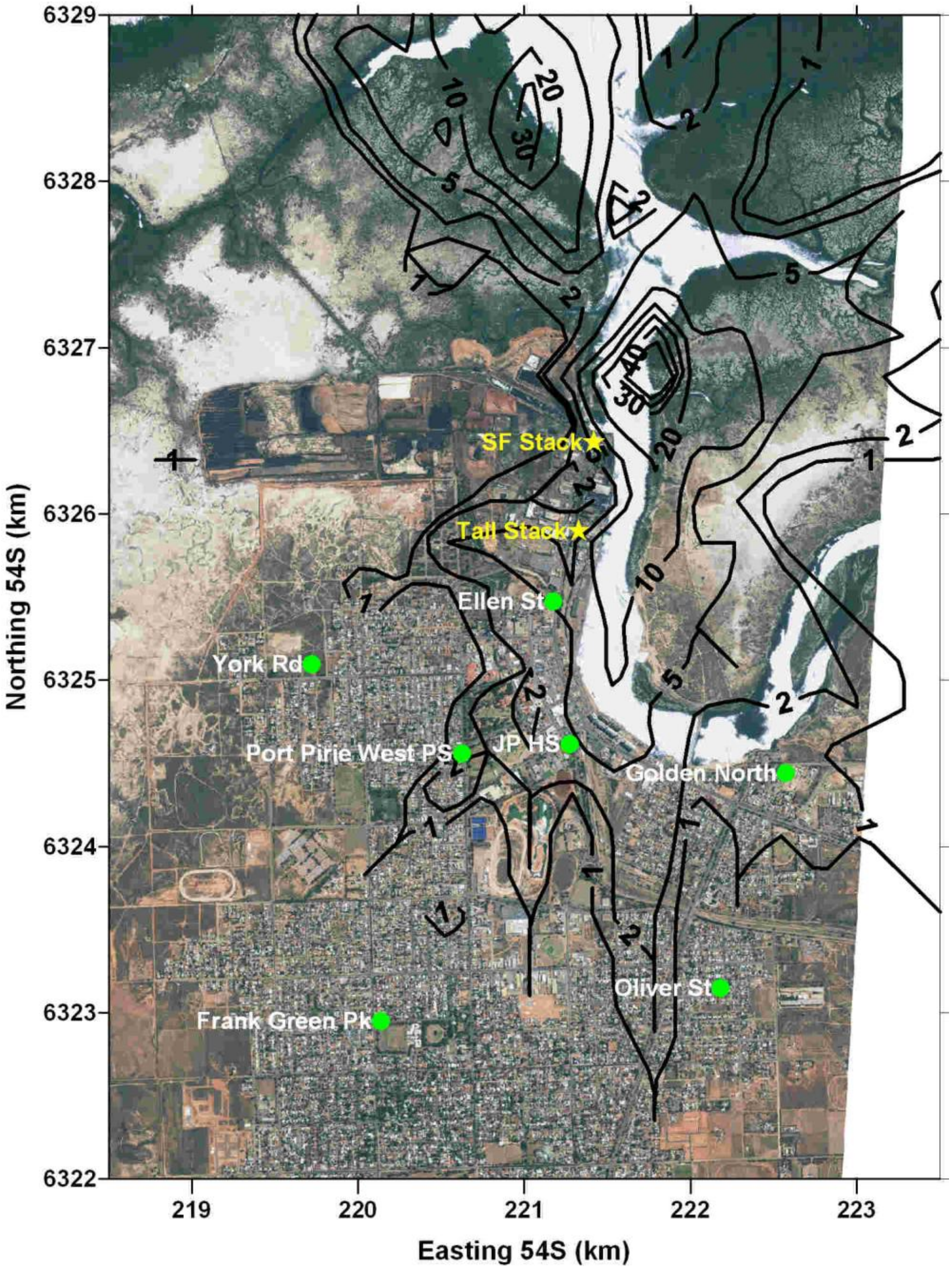

Figure 7-6 Predicted number of exceedances of a 1-hour SO_2 level of 200 ppb with the Transformation

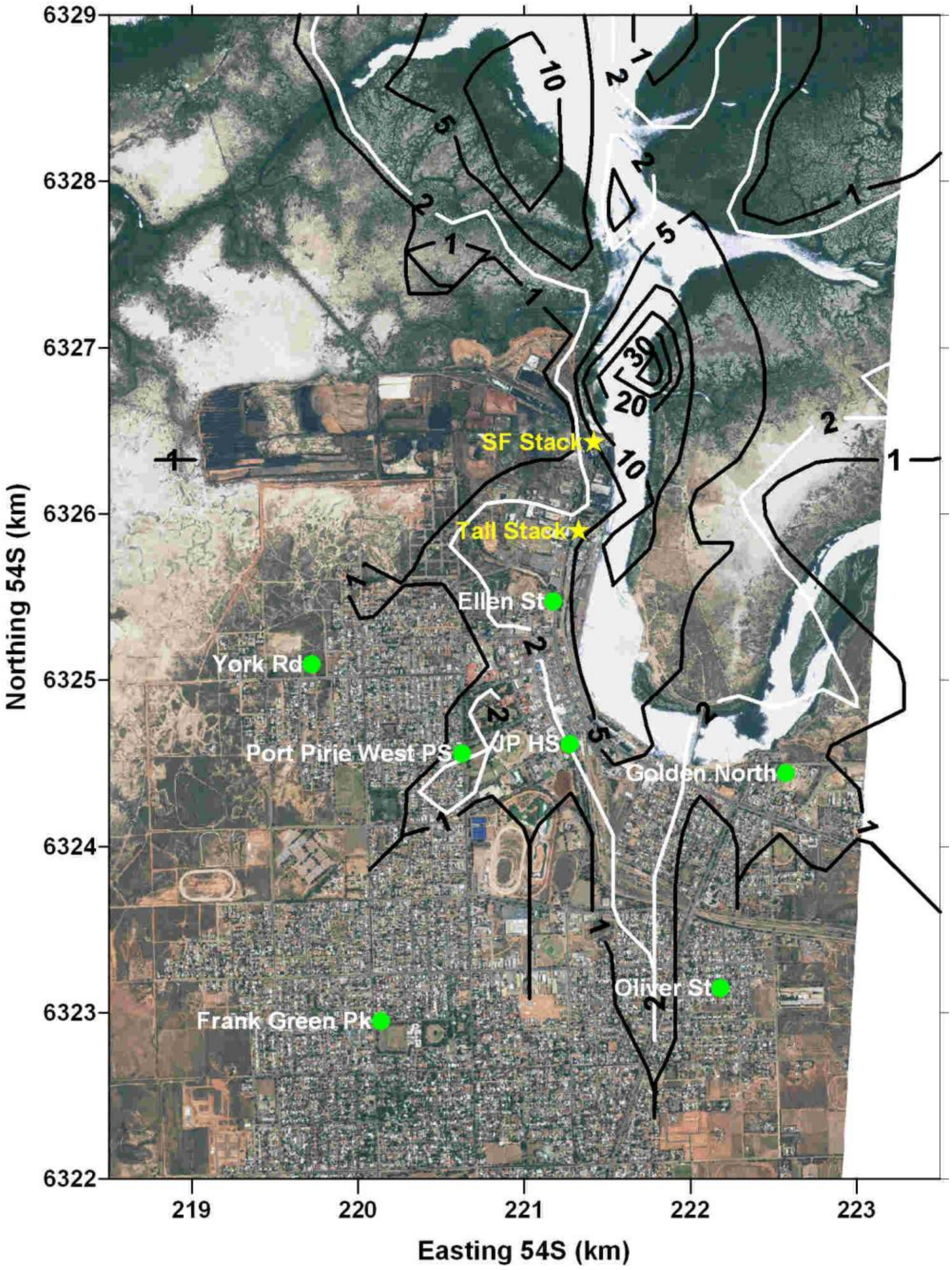

Figure 7-7 Predicted number of days with an exceedances of a 1-hour SO_2 level of 200 ppb with the Transformation. White line for reference to the NEPM standard that allows no more than one day of exceedances

Table 7-1 and **Figure 7-1** to **Figure 7-6** indicate that:

- The concentrations are predicted to generally decrease to 50% of current values, i.e. by a factor of 2, except the maximum 24-hour concentrations that are predicted to decrease on average to 76% of the current levels;
- Greater reduction in concentrations occur at the more distant sites (Frank Green Park and Oliver Street) with the 1-hour statistics generally decreasing to less than 40% of the current levels. At the monitors closer to the smelter, the concentrations decrease less to between 48 to 64% of the current levels (Ellen Street, Pirie West PS and John Pirie Secondary School). The reason for this change in spatial distribution is that the monitors closer to the smelter are predicted to have

a greater contribution from the shorter stacks, from which the emissions do not change appreciably; and

- The area over which the NEPM standard for 1-hour SO_2 is exceeded is greatly contracted post-Transformation, but there is still an area closer in to the smelter and along the river in which occasional exceedances are predicted. With these exceedances it is stressed that these are indicative only as they are primarily determined by the low level sources for which the emissions are approximate and for which it is considered that TAPM tends to over-predict ground-level concentrations.

7.2 Predicted Contribution from the Different Sources

To determine the contribution from the various stacks, the predicted 99.9th 1-hour concentrations from each stack in isolation are presented in **Table 7-2**. The 99.9th percentile is a more stable statistic to determine the peak concentration impacts of the source, unlike the maximum which can be variable.

Table 7-2 1-hour 99.9th Concentrations of SO_2 (ppb) from the Various Sources After Transformation

Statistic	Ellen Street	Pirie West PS	Frank Green Pk	JP SS	Oliver Street	Golden North	York Rd
All Sources	187	158	120	173	125	142	138
Tall Stack	38	39	33	39	44	46	32
Slag Fumer	101	79	65	96	73	95	64
KDR #2	120	119	75	125	71	71	90
New Acid Plant	63	38	34	52	35	40	31

Notes:

1) Model predictions converted to ppb using a conversion of 1 ppb = 2.616 µg/m^3 which is valid at 25°C and one atmosphere which is typical temperature.
2) The concentrations form the four stacks will not sum to the overall concentrations as the peaks may occur under different conditions.

Table 7-2 indicates that the tall stack and the new acid plant stack will be the smaller of the four contributors to SO_2 levels in Port Pirie, with the KDR #2 stack the and slag fumer stacks the contributors to the highest 1-hour SO_2 levels.

APPENDIX C

8 Conclusions

This report presents an assessment of the predicted SO_2 concentrations and the predicted change in levels with the Port Pirie Transformation. Modelling was conducted using the model TAPM (version 4.05) to model the meteorology for July 2005 to June 2006. This 12 month period was selected as it contained the most comprehensive monitoring data with data available from four SO_2 monitoring stations to enable model validation.

Results from the model validation showed generally good agreement, especially for 1-hour 99.9th to 99th percentiles and the number of days with 1-hour exceedances of 200 ppb (the NEPM standard), though under-predicting slightly, the maximum 1–hour concentrations and over-predicting the 90th to 95th 1-hour percentile concentrations. The model correctly predicted the distribution by time of the events, with the maximum concentrations occurring during the daytime due to the tall stack emissions. Lower concentrations are predicted at night, primarily due to the smaller stacks at the north of the smelter.

With the Transformation replacing the sinter plant with the new enclosed bath smelting furnace and the new larger capacity acid plant, emissions from the tall stack are predicted to decrease to approximately 10% of current levels. However, peak hourly emissions will decrease less, to approximately 20% of current levels. Using indicative emissions for the Transformation and TAPM it is predicted that:

- Maximum 1-hour concentrations will decrease to around 50% of the present levels. Locations towards the south of Port Pirie will have a greater reduction with levels decreasing to below 40% of the current levels. Areas close to the smelter (Ellen Street monitor, Pirie West PS and John Pirie SS) will decrease to between 48 to 64% of present levels;
- The reduction closer to the smelter is not as great as the reduction in the tall stack emissions because the smaller stack sources are then predicted to become the dominant sources, with the highest concentrations occurring during the night time; and
- The predicted number of exceedances of the NEPM standard will decrease significantly with the majority of Port Pirie predicted to be compliant. The model predicts that only an area nearer to the river, but extending possibly as far south to Oliver Street, will be in exceedance due primarily to the shorter stacks sources.

The modelling is indicative and preliminary only, utilising indicative (but conservative) emissions for the tall stack and indicative emission from the new acid plant. To improve future predictions, refinement in the emissions of the shorter stacks and further validation for the shorter stacks impacts is needed as they are predicted to be the major source with the Transformation. It is considered that the impacts from these are likely to be overstated in the modelling outcomes.

Model outcomes for the new acid plant will need to be reviewed once the EBS building and plant layout is finalised to ensure that an adequate acid stack height is selected to minimise building affects on plume dispersion. Additionally, consideration of the impacts from the acid plant during bypass events and acid plant start up should be investigated.

9 References

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10 **Glossary**

Term	***Definition***
%	percent
<	less than
>	greater than
^{0}C	degrees Celsius
e.g.	for example
g/s	grams per second
i.e.	that is
km	kilometre
m	metre
m/s	metres per second
Nm^3	Normal cubic metres (at 0 deg C and 1 atmosphere)
µg/m^3	micrograms per cubic metre
µm	micro metre
AERMOD	United States EPA regulatory dispersion model
CSIRO	Commonwealth Scientific Industrial Research Organisation
JPSS	John Pirie Secondary School
KDR	Kiln Dust Recovery
NEPM	National Environmental Protection Measure
NPI	National Pollution Inventory
ppb	Parts per billion
ppm	Parts per million by volume
RHC	Robust Highest Concentration
SO_2	Sulphur dioxide
TAPM	The Air Pollution Model
TIBL	Thermal Internal Boundary Layer

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Appendix D:
Land use assessment

Port Pirie Regional Council Development Plan: Appropriate Land Use

1.1 The existing and proposed land use

An important part of the assessment of a proposed development is the consideration of the appropriateness of the land use.

The Transformation includes the upgrade and redevelopment of the current sintering, blast furnace and acid making operations and associated infrastructure and equipment, as well as the decommissioning and/or demolition of current infrastructure.

Schedule 1 of the *Development Regulations 2008* defines special industry as follows.

> ***special industry*** *means an industry where the processes carried on, the methods of manufacture adopted or the particular materials or goods used, produced or stored, are likely—*
>
> *(a) to cause or create dust, fumes, vapours, smells or gases; or*
>
> *(b) to discharge foul liquid or blood or other substance or impurities liable to become foul, and thereby—*
>
> *(c) to endanger, injure or detrimentally affect the life, health or property of any person (other than any person employed or engaged in the industry); or*
>
> *(d) to produce conditions which are, or may become, offensive or repugnant to the occupiers or users of land in the locality of or within the vicinity of the locality of the land on which (whether wholly or partly) the industry is conducted;*

Therefore, the existing and proposed development may be reasonably defined as a form of "special industry".

1.2 The Port Pirie Development Plan Provisions

The Port Pirie (Regional Council) Development Plan is one of the key planning documents against which the proposed smelter upgrade is assessed, and is particularly relevant to the issue of land use.

The subject land is located within Policy Area 15:Pasminco Metals Policy Area of the Industry Zone in the Port Pirie (Regional Council) Development Plan (Consolidated 10 January 2013).

The following Objective and Principles of Development Control in the Industry Zone guide land use on the site of the proposed development.

> ***Objective 1:*** *A zone primarily accommodating <u>industrial, storage and warehouse development</u> to satisfy the requirements of the region. (underlining added)*
>
> ***Principles of Development Control***

1 *Development undertaken in the Industry Zone should be primarily light and general industries, warehousing and storage. (underlining added)*

4 *Retail and office development should be of a minor nature and should only occur to support the primary use of the zone. (underlining added)*

In summary, the land use focus in the Industry Zone is on industrial development, together with secondary land uses in the form of storage and warehouse development, as well as shops and offices only where they support (and do not limit) the primary land use.

The following Objective and Principle of Development Control in Policy Area 15 also guide land use on the site of the proposed development.

Objective 1: *A policy area accommodating major special industrial, commercial and storage activities and associated minor industrial activities and the handling of goods by transport by sea, road or rail. (my underlining added)*

Principle of Development Control

1 *Development undertaken in the Pasminco Metals Policy Area should be primarily major special industry, commercial and storage activities and associated minor industrial industries. (my underlining added)*

The primary land use in this Policy Area is major special industry (note: the definition of "special industry" in Schedule 1 of the Development Regulations 2008 is quoted earlier in this section of the report). Secondary land uses include commercial, storage and associated minor industrial activities.

"Commercial" development referred to in Objective 1 and Principle of Development Control 1 of this Policy Area is an undefined land use. "Commercial" is often a term used broadly in Development Policy to provide a degree of flexibility in relation to a range of non-residential land use activities that might be reasonably anticipated in varied circumstances (e.g. commercial development in a Residential Zone may include a convenience shop, commercial development in an Industry Zone may include stores, warehouses etc). It is clear that, in this particular circumstance, it does not encompass consulting rooms, hotels, offices on their own allotment and unrelated to industrial or port related development, or shops greater than $450m^2$ in area, given that these land uses are listed as non-complying in the Industry Zone.

The only land uses other than special industry, stores and warehouses expressly anticipated in the Industry Zone and Policy Area 15 are light industry and general industry, as well as retail (shops, bulky goods outlets or retail showrooms) and offices that support the primary uses of the Zone (e.g. industry).

The use of the term "commercial" within Policy Area 15 should not be interpreted as seeking/ permitting land uses that limit the development of the primary land use – major special industry.

More simply stated, not only is the proposed smelter (otherwise referred to as "special industry") a land use that is already operating on the site, it is also a land use that is clearly anticipated in Policy Area 15: Pasminco Metals Policy Area of the Industry Zone in the Port Pirie (Regional Council) Development Plan (Consolidated 10 January 2013) that cover the site.