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Final Report

OREBODY 31 – AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

BHP BILLITON IRON ORE PTY LTD

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EXECUTIVE SUMMARY

PROJECT DESCRIPTION

Orebody 31 (OB31) is located approximately 40 kilometres (km) east of Newman Township in the Pilbara region of Western Australia (Figure 1). OB31 is situated to the east of the existing Orebody 17/18 (OB17/18) Mine within Mineral Lease ML244SA, which is subject to the *Iron Ore (Mount Newman) Agreement Act 1964* (Newman Agreement Act). OB31 has not previously been developed and as such is considered a greenfield development.

The OB17/18 Mine is reaching the end of its economic life, with available ore reserves expected to be depleted by mid 2017. Additional ore sources are required to provide sufficient blend feed in order to maintain the current level of iron ore production from the Eastern Pilbara mines.

The mineralised resource at OB31 has been estimated at approximately 500 million tonnes (Mt). BHP Billiton Iron Ore is currently considering two development options for this resource. The first is a base option of 15 Mtpa as a long-term replacement for OB18 and the second is a growth option of 30 Mtpa.

The objective of the study was to assess the air quality impact from the proposed development options with a specific focus on the 15 Mtpa development scenarios. A greenhouse gas assessment was also carried out, and is contained in Appendix H.

OVERVIEW OF ASSESSMENT

Modelling guidelines issued for Western Australia (DoE, 2006) require air quality impact assessments to account for cumulative impacts (i.e. inclusion of background air quality concentration). Therefore, monitoring data from BHP Billiton Iron Ore background station (BG2) in Newman and modelling of surrounding operations were included in the analysis. Review of meteorological and existing air quality in the region was used and 2010 was identified as a suitably representative modelling year for this study.

Meteorology is one of the critical factors influencing pollutant dispersion (or lack thereof) and various meteorological parameters including temperature, wind, rainfall and humidity were analysed. The Weather Research and Forecasting (WRF) Model, a next-generation mesoscale numerical weather prediction system was used to generate initial meteorology for the study. The WRF generated three dimensional wind fields were input to CALMET for further processing to finer resolution for use in the dispersion modelling. This procedure is hereafter referred to as "WRF-CALMET methodology". The output from the CALMET meteorological model was evaluated and used as input for the CALPUFF dispersion model. The evaluation of WRF-CALMET processed meteorological data against observation data for Newman Airport concluded that the WRF-CALMET surface meteorology was simulated with an acceptable degree of skill.

BHP Billiton Iron Ore empirical equations and NPI emission estimation techniques were used to calculate source specific emissions. The emissions estimation was based on the materials handling for 2022 which according to the projected mining schedule will represent the highest mine production rate and is thereby representative of a worst case emission scenario. Emissions were input into CALPUFF as hourly varying files together with source parameters including initial sigmas, effective height and base elevation.

The CALPUFF model was set to calculate concentrations both on a set grid (gridded receptors) and at specified locations (discrete receptors), specifically the East Pilbara Accommodation Village and other receptors in the Newman area. The model was configured to predict the ground-level concentrations on a rectangular grid. The model domain was defined as 42 km in the north–south direction and 73.5 km in the east-west direction and has its south-west corner at 768, 7396 km (50S UTM).

The model predicted incremental dust concentrations for PM_{10}[a] which were summed with background monitoring data from the Newman station and the impacts from surrounding mining operations (Whaleback, Eastern Ridge and Jimblebar[b])to calculate the cumulative dust impacts.

Dispersion modelling for PM_{10} impacts was undertaken for the following scenarios:

- Scenario 1 – 15 Mtpa, ore hauled via road from OB31 to OB18 and crushed at OB18
- Scenario 2 – 15 Mtpa, ore hauled via road from OB31 to OB18 after being crushed with a new crusher at OB31
- Scenario 3 – 15 Mtpa, ore transported via overland conveyor from OB31 to OB18 and crushed at OB18
- Scenario 4 – 15 Mtpa, ore crushed at OB31 with new crusher and transported via an overland conveyor to OB18.

For each scenario three dust control options were assessed including no controls, standard controls and leading controls (full details are provided in Section 6.3.) All results are presented as standalone and cumulative with existing operations. It should be noted that the standard operating procedure for mines operated by BHP Billiton Iron Ore is with standard controls. No controls have only been modelled to provide a highly unlikely 'worst case' scenario.

KEY FINDINGS OF THE ASSESSMENT – AIR QUALITY

Modelled PM_{10} concentration has been compared to the assessment guidelines selected for this study, based on:

- National Environment Protection Measure standard (NEPM) of 50 µg/m³ for a 24 hour period, with 5 exceedances allowable per year
- Port Hedland Dust Management Taskforce (Taskforce) interim guideline of 70 µg/m³ over a 24 hour period

The cumulative results showed that the assessment guidelines for the nearest receptor, Receptor 9 – the Eastern Pilbara Accommodation Village, were only exceeded for one day for Scenario 2 for the no dust control of operations option (a highly unlikely 'worst case' scenario). All other scenarios demonstrated concentrations below the assessment guidelines at the sensitive receptors identified.

KEY FINDINGS OF THE ASSESSMENT – GREENHOUSE

Greenhouse emissions were estimated for the period 2018 – 2028, for which forecast data were provided by BHP Billiton Iron Ore. For year 2022, when the maximum production rate is expected to be achieved (i.e. 15 Mt of iron ore produced and 25 Mt of waste rock handled), a total of 81,254 tonne CO_2-e will be generated for Scenario 1 and a total of 91,910 tonne CO_2-e will be generated for Scenario 4. This corresponds to a 13% increase in emissions if the iron ore is conveyed and not hauled from OB31 to OB18. However, the cumulative greenhouse emissions for the operation phase of OB31 for the period 2018 – 2028 show that Scenario 4 is expected to emit 9% less greenhouse emissions than Scenario 1.

The average annual and cumulative greenhouse emissions and associated emissions intensity [c] for OB31 were compared to similar projects. Based on this measure, both Scenario 1 and Scenario 4 appear to be comparable to the Simandou and West Pilbara iron ore projects, whereas the Weld Range project appears to be significantly more emissions intensive.

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[a] PM_{10} – particulate matter with an equivalent aerodynamic equal to or less than 10 µm in diameter.

[b] OB18 was included in the modelling of the Existing Operations.

[c] The emission intensity is presented in tonnes CO_2-e per tonne of iron produced for the purpose of this assessment.

The emissions from the OB31 are anticipated to be equivalent to 0.14% (for Scenario 1) and 0.13% (for Scenario 4) of Western Australia's 2011/2012 greenhouse inventory. On a national scale, Scenario 1 will contribute to 0.018% and Scenario 4 will contribute to 0.016% of Australia's 2011/2012 greenhouse inventory. As a result, impacts from OB31 are expected to be minor on a large scale basis.

SUMMARY AND RECOMMENDATIONS

The assessment has been based on the early designs of the mine, and therefore the results and recommendations must be interpreted in the context that design, layout and management strategies will be subject to refinement and change.

The cumulative results as predicted are based on the current level of operations in the area and do not include projected future expansions in nearby mining operations. Compliance was demonstrated for all but one scenario and dust control options (Scenario 2 - no dust control).

Compared to the existing operations the predictions of replacing the operations at OB18 with operations at OB31 showed that for:

- Newman there is little or no additional impact predicted.
- The Eastern Pilbara Accommodation Village (which is the closest receptor), not considering the no dust control option, overall there is a small improvement in the level of PM_{10} dust impacts across the assessed scenarios.

CONTENTS

1 INTRODUCTION 1
1.1 Adjacent Operations 1
1.2 Project Description 1
1.3 Air Quality Assessment Overview 7
1.3.1 Particles 7
1.3.2 Greenhouse Gas 7
1.4 Structure of this Report 7
2 ENVIRONMENTAL ASSESSMENT FRAMEWORK 9
2.1 Assessment Substances (Screening Process) 9
2.1.1 Particulate Matter 9
3 CLIMATE, METEOROLOGY AND AMBIENT AIR QUALITY 11
3.1 Climate of the Pilbara Region 11
3.2 Review of Meteorological Data 12
3.2.1 Wind Speed and Wind Direction 12
3.2.2 Rainfall 13
3.2.3 Temperature 14
3.2.4 Relative Humidity 15
3.3 Review of Ambient Air Quality in Pilbara region 15
3.3.1 Air Quality Monitoring Network 16
3.3.2 Air Quality Monitoring Data 17
4 MODEL SELECTION 19
4.1 Model for OB31 20
4.2 California Puff Model (CALPUFF) 20
5 METEOROLOGICAL MODELLING 21
5.1 WRF Meteorological Model 21
5.2 CALMET Meteorology 23
5.2.1 Surface Air Observations 24
5.2.2 Topography 24
5.2.3 Land Use 25
5.3 WRF-CALMET Meteorology Validation 26
5.3.1 Surface Station 26
5.3.2 Statistical Measures of Model Performance 29
6 EMISSION ESTIMATION 31
6.1 Sources of Emissions - Emissions Inventory 31
6.2 Emission Estimation Process 31
6.3 Assessment Scenarios 34
6.4 Emissions Estimates Summary 35
7 MODEL CONFIGURATION 40
7.1 Other Model Parameters 41
7.1.1 Meteorological Data 41
7.1.2 Grid System 41
7.1.3 Discrete Receptors 41
7.1.4 Emission Rates and Source Parameters 43
7.1.5 Deposition Modelling 43
7.1.6 Model Uncertainty 43
8 MODEL RESULTS 45
8.1 Existing Operations 47
8.2 OB31 Operations Standalone 50
8.2.1 Scenario 1 No Dust Controls 50
8.2.2 Scenario 1 Standard Dust Controls 52

8.2.3 Scenario 1 Leading Dust Controls 54
8.2.4 Scenario 2 No Dust Controls 56
8.2.5 Scenario 2 Standard Dust Controls 58
8.2.6 Scenario 2 Leading Dust Controls 60
8.2.7 Scenario 3 No Dust Controls 62
8.2.8 Scenario 3 Standard Dust Controls 64
8.2.9 Scenario 3 Leading Dust Controls 66
8.2.10 Scenario 4 No Dust Controls 68
8.2.11 Scenario 4 Standard Dust Controls 70
8.2.12 Scenario 4 Leading Dust Controls 72
8.3 OB31 Operations Cumulative with Existing Operations (Excluding OB18) 74
8.3.1 Scenario 1 74
8.3.2 Scenario 2 78
8.3.3 Scenario 3 81
8.3.4 Scenario 4 84
8.4 Summary of Results 87
9 CONCLUSIONS AND RECOMMENDATIONS 90
9.1 Summary Assessment Scenarios 90
9.2 Selection of Representative Model Year 90
9.3 Evaluation of Meteorological Modelling 90
9.4 Assessment Guidelines 90
9.5 Model Results 90
10 REFERENCES 92
APPENDIX A REPRESENTATIVE MODEL YEAR A-1
APPENDIX B METEOROLOGY VALIDATION B-1
APPENDIX C ESTIMATION OF EMISSIONS C-1
APPENDIX D CALPUFF INPUT FILE D-1
APPENDIX E SOURCE PARAMETERS E-1
APPENDIX F STATISTICS OF VARIABLE EMISSIONS F-1
APPENDIX G CUMULATIVE FUTURE OPERATIONS RESULTS CONTOURS G-1
APPENDIX H GREENHOUSE GAS ASSESSMENT H-1

1 INTRODUCTION

Orebody 31 (OB31) is located approximately 40 kilometres (km) east of Newman Township in the Pilbara region of Western Australia (Figure 1). OB31 is situated to the east of the existing Orebody 17/18 (OB17/18) Mine within Mineral Lease ML244SA, which is subject to the *Iron Ore (Mount Newman) Agreement Act 1964* (Newman Agreement Act). OB31 has not previously been developed and as such is considered a greenfield development.

The OB17/18 Mine is reaching the end of its economic life, with available ore reserves expected to be depleted by mid 2017. Additional ore sources are required to provide sufficient blend feed in order to maintain the current level of iron ore production from the Eastern Pilbara mines.

The mineralised resource at OB31 has been estimated at approximately 500 million tonnes (Mt). BHP Billiton Iron Ore is currently considering two development options for this resource. The first is a base option of 15 Mtpa as a long-term replacement for OB18 and the second is a growth option of 30 Mtpa (BHPBIO, 2014).

1.1 Adjacent Operations

BHP Billiton Iron Ore Pty Ltd (BHP Billiton Iron Ore) currently operates a number of iron ore mines and associated rail and port infrastructure within the Pilbara region of Western Australia. Current mining operations in proximity to OB31 include:

- Newman Joint Venture hub, located approximately 2 km west of Newman Township, and consists of Mount Whaleback and Orebodies 29, 30 and 35
- OB17/18 Mine, located approximately 30 km east of Newman Township
- Wheelarra Hill (Jimblebar) Mine, located approximately 40 km east of Newman Township and 5 to 10 km south of OB31
- Orebodies 23, 24 and 25, located approximately 8 km northeast of Newman Township.

The closest operations to OB31 are the OB17/18 Mine and Wheelarra Hill (Jimblebar) Mine, shown in Figure 1.1.

1.2 Project Description

The OB17/18 Mine is reaching the end of its economic life, with available ore reserves expected to be depleted by mid 2017. Additional ore sources are required to provide sufficient blend feed in order to maintain the current level of iron ore production from the Eastern Pilbara mines.

The mineralised resource at OB31 has been estimated at approximately 500 million tonnes (Mt). BHP Billiton Iron Ore is currently considering two development options for this resource. The first is a base option of 15 Mtpa as a long-term replacement for OB18 and the second is a growth option of 30 Mtpa.

Open pits will be developed using conventional drill and blast techniques with ore sent through existing OB18 crusher via heavy vehicle haul road. A possible future plan is also being looked at to have a new primary crusher at OB31 and an overland conveyer for transport of crushed ore to OB18. For the base option (15 Mtpa), ore will be sent through the existing OB18 crusher via heavy vehicle haul road then railed to the Mount Whaleback Mine, where it will be blended with ore produced by the Newman Joint Venture.

Under the growth option (30 Mtpa), 15 Mtpa will be sent via heavy vehicle haul road (in the short term) and via an overland conveyor (in the long term) to ore stockpiles at the OB17/18 mine with the remaining 15 Mtpa sent via conveyor to ore stockpiles at the Wheelarra Hill (Jimblebar) Mine. Ore from both the OB17/18 Mine and Wheelarra Hill (Jimblebar) Mine will be railed to the Mt Whaleback Mine and blended with ore produced by the Newman Joint Venture.

Non-mineralised waste rock will be hauled to new OSAs at OB31 or back to OB17/18 to backfill empty pits.

The OB31 project consists of the following:

- one single open pit, based on initial studies (future update subject to final drilling results)
- three new OSAs, based on initial studies (future update subject to final drilling results)
- a primary crushing facility
- haulage (heavy vehicles (HV)) and light vehicles (LV) access roads linking OB31 to existing OB17/18 Mine infrastructure
- a potential future overland conveyor to existing infrastructure at the OB17/18 Mine
- power, water, fibre optic cable and other associated services which may be required along road and/or conveyor alignments
- topsoil and vegetation stockpiles
- offices, ablutions, LV and HV parking areas, laydown areas, hydrocarbon storage facilities, Ammonium Nitrate storage facilities and magazine areas and other ancillary facilities
- water infrastructure including dewatering/potable/monitoring water bores, diesel generator sets, pipelines, turkeys nests and/or other storage facilities as required.

The extent of the disturbance areas planned for the OB31 project is shown in Figure 1.2 and Figure 1.3. The proximity of the OB31 Project to other nearby projects and receptors (including the Newman Township) are shown in Figure 1.4.

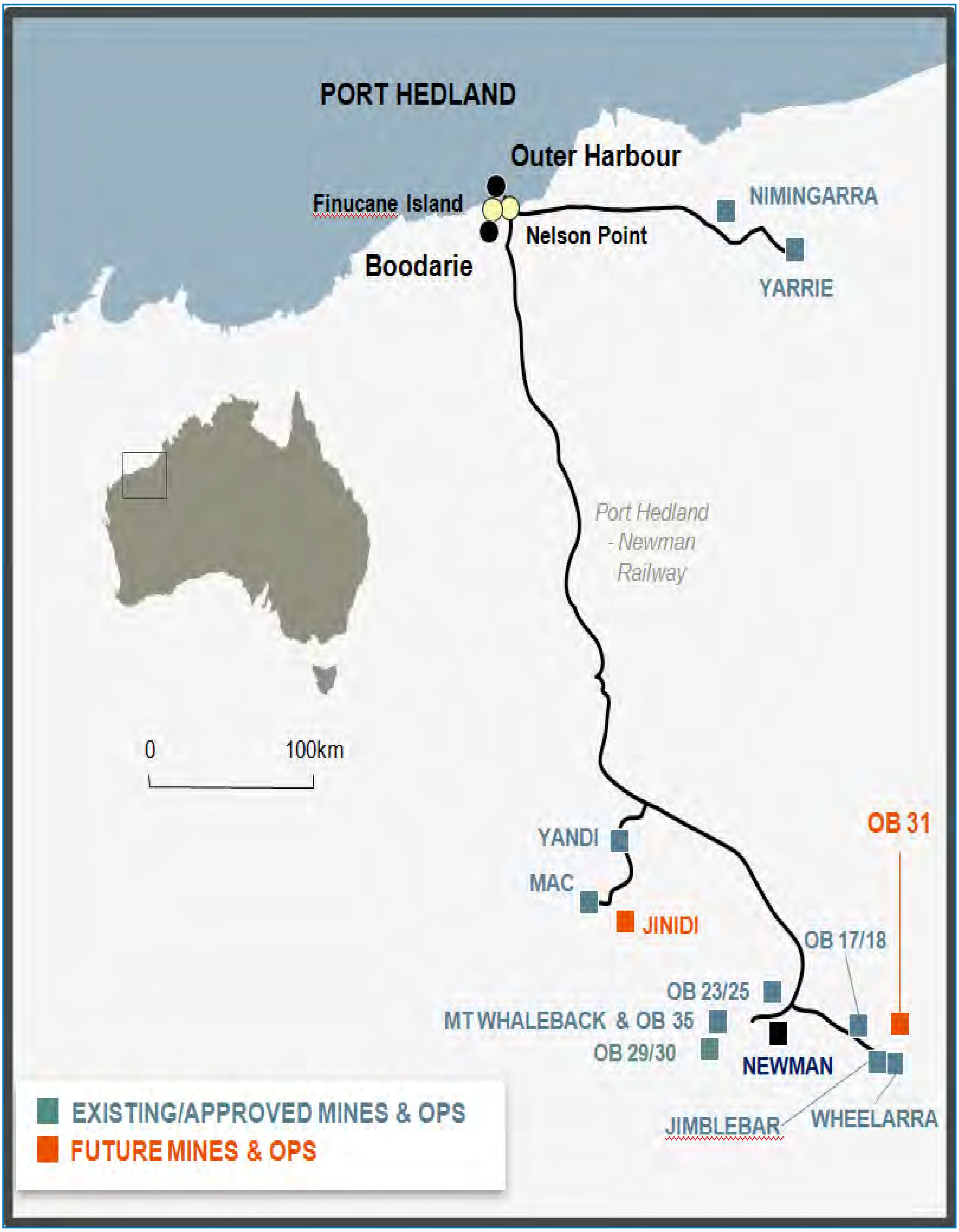

Figure 1.1: Relative location of OB31, regional context (BHPBIO, 2014)

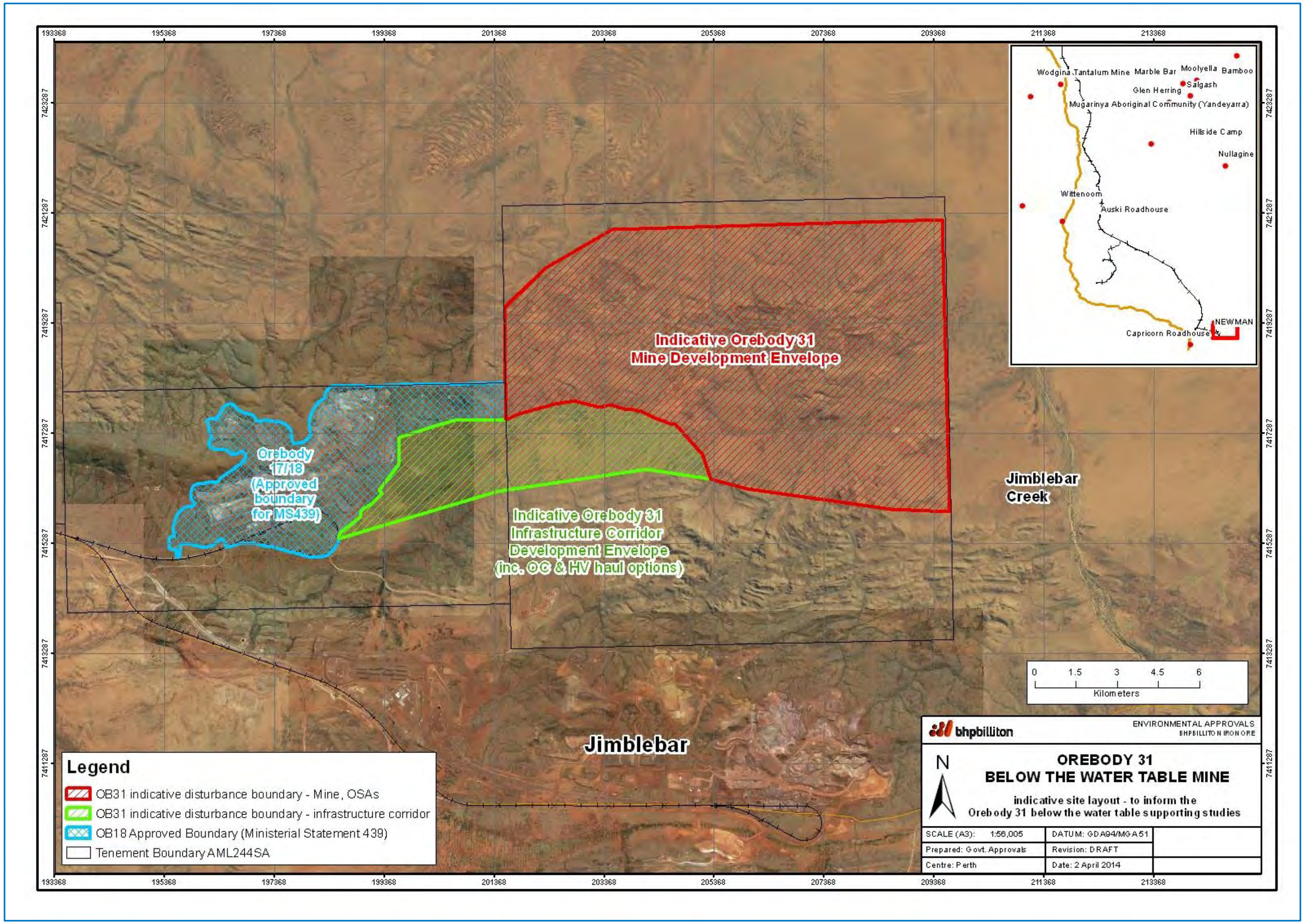

Figure 1.2: Indicative Project Boundary for OB31 (BHPBIO, 2014)

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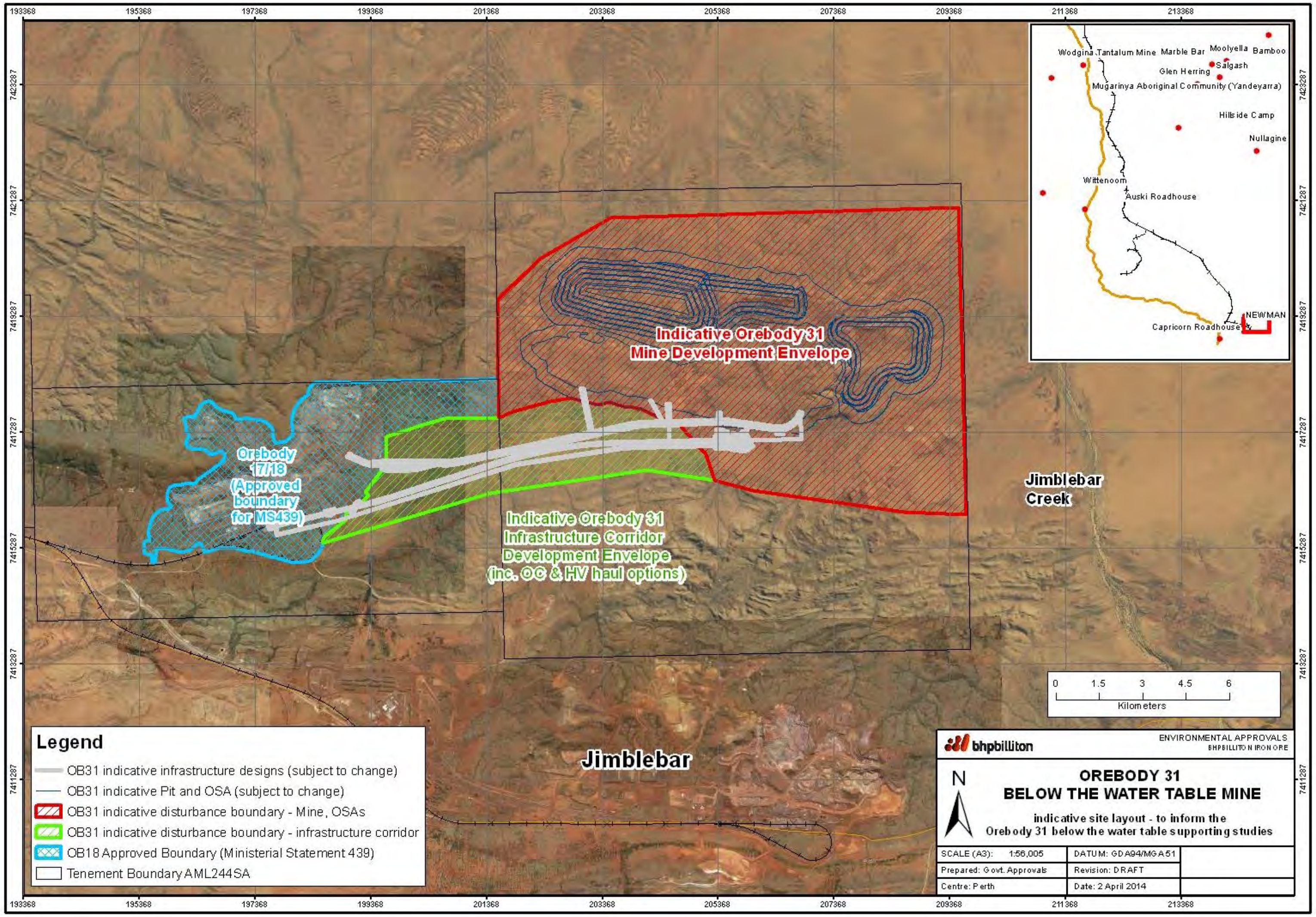

Figure 1.3: Indicative Infrastructure Design for OB31 (BHPBIO, 2014)

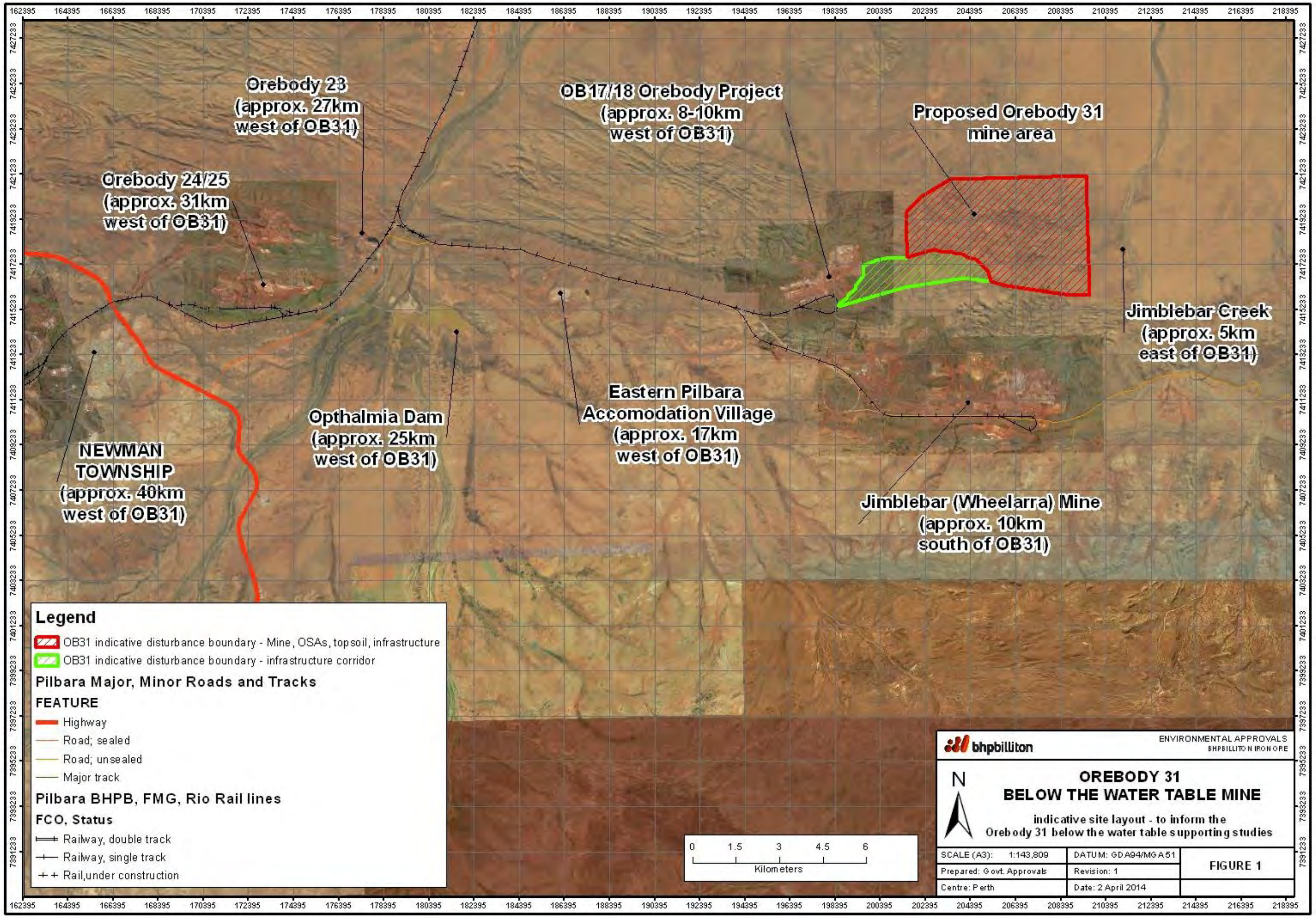

Figure 1.4: OB31 and Nearby Operations and Receptors (BHPBIO, 2014)

1.3 Air Quality Assessment Overview

BHP Billiton Iron Ore commissioned Pacific Environment Limited (PEL) to conduct an air quality assessment of the proposed development of OB31 for the worst case mine plan (year 2022).

1.3.1 Particles

This current air quality assessment has considered the potential release of a number of air quality emissions (particles) associated with the operation of the mine. It evaluates the potential impacts, together with potential mitigation measures, to determine the potential impacts at sensitive receptors, i.e. the Newman Township and other nearby receptors as presented in Figure 1.5.

The key operations and activities included in the assessment of OB31 are:

- open pit mining, of up to 15 Mtpa of ore
- blasting and drilling in open pit areas
- removal of approximately 25 Mtpa of overburden from the open pits and disposal in the out-of-pit overburden storage areas
- stockpiling of ore and waste
- use of haul roads associated with the mine including the infrastructure area, overburden storage areas and pits
- rail load out operations.

The key atmospheric emission of concern during the mine operation phase is particle matter (dust) in the form of PM_{10} (i.e. particles less than 10 microns in aerodynamic diameter). Dust generation will be associated with all operational activities for the mine, including topsoil stripping, blasting, drilling, ore and waste excavation, loading, unloading, crushing and screening, transferring material, reclaiming, wind erosion from open areas and rail load out.

The California Puff Model (CALPUFF) was used for the assessment of air quality impacts (PM_{10}) from the proposed OB31 operations and the regional setting. For the dispersion modelling an annual meteorological dataset was prepared using a combination of the Weather Research and Forecasting Model (WRF) (WRF, 2012) and the CALMET model (Scire, Robe, Fernau, & Yamartino, 2000a). The meteorological data takes into account the range of meteorological conditions that may occur over the year, and includes the worst-case meteorological conditions that are expected to arise at the site.

A detailed emissions inventory has been developed using activity data provided by the client, in conjunction with BHP Billiton Iron Ore empirical equations and emission factors from the Australian National Pollutant Inventory (NPI).

The predicted air quality impacts from the mining operations are presented in the assessment, incorporating potential air quality control methods to maintain air quality impacts to an acceptable level.

1.3.2 Greenhouse Gas

The greenhouse gas assessment is provided in Appendix H. Greenhouse emissions were estimated for each year of the operating phase of the mine development (i.e. 2018 – 2028) for Scenarios 1 and 4 as defined in the air quality dispersion modelling. Scenarios 1 and 2, and Scenarios 3 and 4 are expected to generate a similar amount of greenhouse emissions as emissions are not anticipated to vary whether ore is crushed prior to transport to OB18 or after.

1.4 Structure of this Report

This report outlines the methodology for conducting the air quality impact assessment in Sections 2 to 7. The results are presented in Section 8 and conclusions and recommendations are summarised in Section 9.

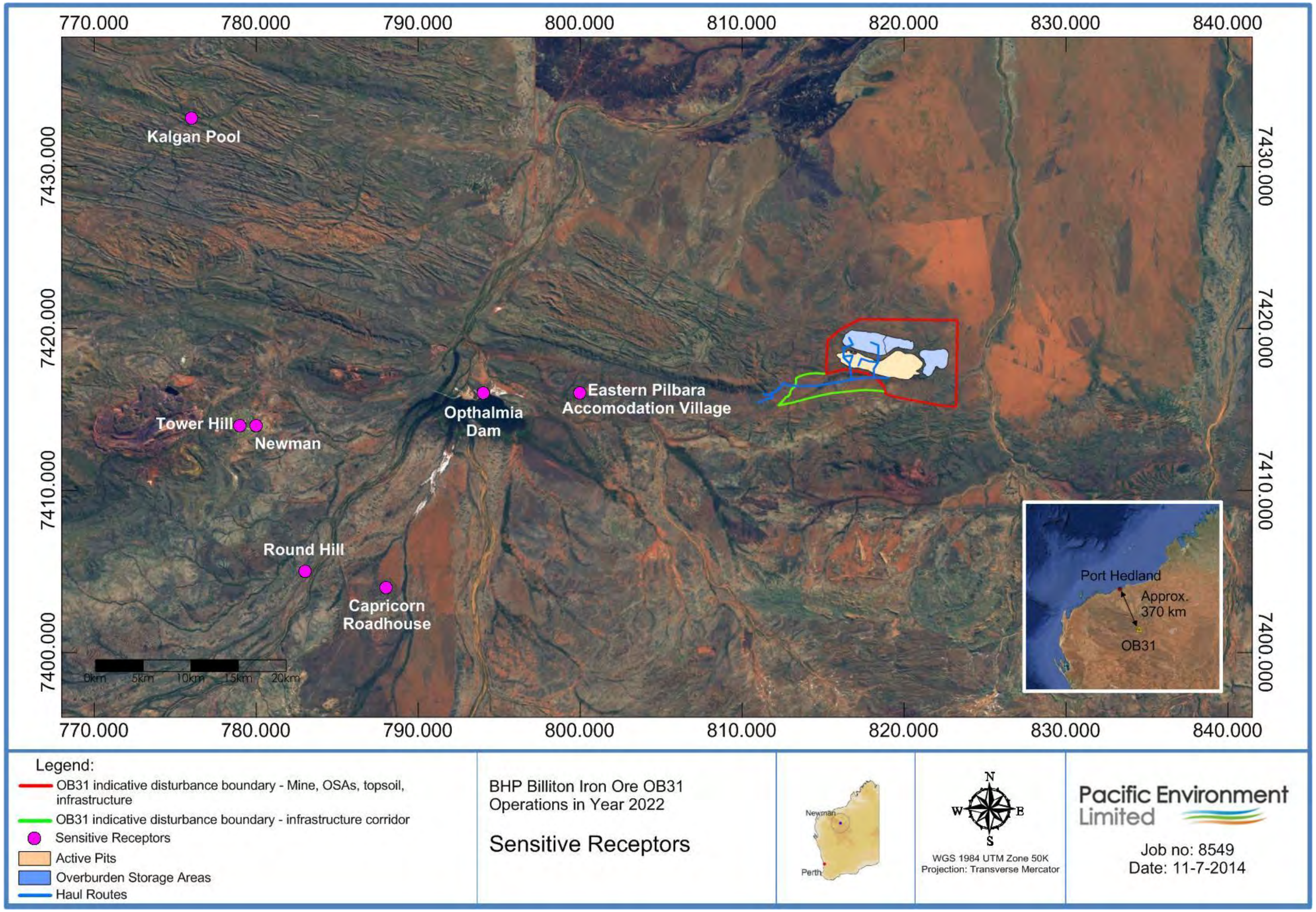

Figure 1.5: OB31 Mine and Sensitive Receptor Locations

2 ENVIRONMENTAL ASSESSMENT FRAMEWORK

This section outlines the ambient air quality parameters and guidelines relevant to this assessment.

2.1 Assessment Substances (Screening Process)

This assessment considers the emissions which are associated with materials handling (including drilling and blasting), unpaved road emissions and mineral processing for mining activities.

Table 2.1 summarises the screening process with a list of the relevant mineral mining activities, the emitted substances from these activities, the substances estimated or quantified as part of the assessment and the substance (PM_{10}) which is assessed in the dispersion modelling.

The screening process defines the scope of the emissions estimation and dispersion modelling for the assessment. Assessment of TSP, $PM_{2.5}$ and combustion emissions (NO_x and SO_2) is not considered necessary in the study context. The air quality impact assessment focuses on assessment of PM_{10} and also includes a greenhouse gas assessment component (see Appendix H).

A description of particulate matter and the selected assessment guidelines are discussed in Section 2.1.1.

Table 2.1: Activities and Emitted Substances Related to Mineral Mining

Mineral Mining Activities	Emitted Substances	Estimated / Quantified	Modelled
Mining Pit Activities: • blasting • drilling • bulldozing	Particulate Matter (TSP, PM_{10} and $PM_{2.5}$) Combustion Emissions (NO_x and SO_2) Greenhouse Gases	Particulate Matter (PM_{10}) Greenhouse Gases	Particulate Matter (PM_{10})
Material Movements: • loading • unloading • bulldozing • conveying	Particulate Matter (TSP, PM_{10} and $PM_{2.5}$) Combustion Emissions (NO_x and SO_2) Greenhouse Gases	Particulate Matter (PM_{10})	Particulate Matter (PM_{10})
Fugitive dust sources: • wind erosion • wheel generated dust from unpaved roads	Particulate Matter (TSP, PM_{10} and $PM_{2.5}$)	Particulate Matter (PM_{10})	Particulate Matter (PM_{10})
Mineral Ore Processing: • crushing • screening • stockpiling	Particulate Matter (TSP, PM_{10} and $PM_{2.5}$)	Particulate Matter (PM_{10})	Particulate Matter (PM_{10})
Fuel Combustion: • mining equipment • light and service vehicles • stationary equipment	Combustion Emissions (NO_x and SO_2) Greenhouse Gases	Greenhouse Gases (reported on separately in Appendix H)	-

2.1.1 Particulate Matter

Suspended solids or liquids in air are referred to as Particulate Matter (PM). Dust is a term often used as substitute for PM, although it is more accurately applied to particles derived from the mechanical breakdown of rock, soil and biota. Concentrations of particles suspended in air can be classified by an aerodynamic diameter, which describes the behaviour of the particle in the air based on its size and shape:

- Total Suspended Particulate (TSP) – refers to the total amount of the PM suspended in air (regardless of size). Particles in air are subject to gravitational settling; particles larger than about 30 µm in aerodynamic diameter are likely to be removed by gravitational settling within a short time of being emitted (i.e. they settle to the ground or other surfaces fairly quickly). These larger particles are primarily associated with amenity or visibility issues, including dust deposition and reduced visibility (Peavy, Tchobanoglous, & Rowe, 1985)
- PM_{10} refers to the total of suspended particulate matter less than 10 µm in aerodynamic diameter. Particles in this size range can enter bronchial and pulmonary regions of the respiratory tract and can impact human health. Particles in this size range can remain suspended for many days in the atmosphere. Coarse, fine and ultra-fine PM fractions shown in Figure 2.1 are included in PM_{10}.
- $PM_{2.5}$ refers to the total of suspended particulate matter less than 2.5 µm in aerodynamic diameter. Epidemiological studies have shown that particles in this size range are associated with greater health impacts on humans than other particle sizes. These particles can remain suspended for months to years.

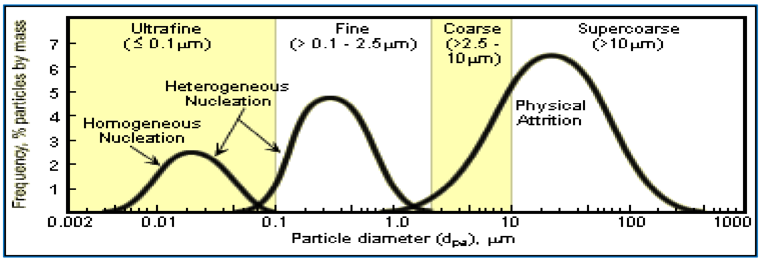

Figure 2.1: PM Size Distribution Categories

Mineral mining activities are known to have significant particulate matter emissions, and ambient particulate matter concentrations. Considering the context of the proposed OB31 operations this study focused on emissions estimation and dispersion modelling of particulate matter as PM_{10}.

This assessment considered the following air quality assessment guidelines as presented in Table 2.2:

- PM_{10} as an indicator of potential impact on human health, referencing the air quality standard criterion specified in the National Environment Protection Measure for Ambient Air Quality (Air NEPM) (NEPC, 1998)
- In Port Hedland, an interim air quality guideline for PM_{10} of 70 µg/m^3 (24 hour average) with 10 exceedances per year has been adopted by the Port Hedland Dust Management Taskforce (Taskforce, 2010) This criterion is based on a health risk management regime appropriate for Port Hedland and replicates operating guidelines set for BHP Billiton Iron Ore by Ministerial Statement 740 (EPA, 2007). This criterion was set taking into account the crustal nature of iron ore dust. (For comparative purposes, the model results are also compared to this criterion).

Table 2.2: PM_{10} Assessment Guidelines

Parameter	Assessment Guidelines	Reference
PM_{10}	50 µg/m^3 24-hour average (allowance for 5 exceedances per year) 70 µg/m^3 24-hour average (allowance for 10 exceedances per year)	(NEPC, 1998) (Taskforce, 2010)

3 CLIMATE, METEOROLOGY AND AMBIENT AIR QUALITY

This section provides a contextual summary of the existing environmental aspects relevant to the air quality assessment. It includes consideration of topography, land use (including sensitive receptors), meteorology, and existing (background) ambient air quality in the study area. To better reflect the actual dust level by an air quality assessment, a representative year is required to be determined. Essential factors to be considered in the selection of a representative year include both meteorology and ambient air quality monitoring data.

The climate and meteorological characteristics of the region control the dispersion, transformation and removal (or deposition) of pollutants from the atmosphere (i.e., ambient air quality). For the purposes of understanding the local climatology, an 11 year data set of meteorological parameters recorded in the region was been reviewed and analysed. The review identified the year 2009 as the most representative of the long term average meteorological conditions, although 2010 is also an acceptable year in terms of meteorological characteristics.

For the purposes of defining ambient air quality characteristic of the region, monitored data from the BHP Billiton Iron Ore monitoring network in Newman was reviewed and analysed. This includes defining background air quality as well as existing air quality. The review identified the year 2010 as the most representative of the average ambient air quality conditions.

Although the meteorological conditions highlight that the most representative year in terms of wind speed, wind direction and rainfall is considered to be 2009, year 2010 is the only practical option for the model year for OB31 based on the analysis of the available monitoring data. More detailed analysis is provided in Appendix A.

Therefore year 2010 has been the year used in the model.

3.1 Climate of the Pilbara Region

The climate in the Pilbara region is arid to tropical characterised by high temperatures, high evaporation rates, occasional intense rainfall and regular cyclonic activity. There are two major seasons: hot summers (October to April) when the majority of rainfall occurs; and mild, relatively dry winters (May to September). The weather is largely controlled by the seasonal oscillation of an anti-cyclonic belt (high-pressure system) in the sub-tropics (Pearce, et al., 2009)

Three specific weather phenomena that are of greatest importance to the Pilbara region are:

- Tropical cyclones frequently accompanied by damaging winds, storm surge and flooding.
- Strong easterly winds in the winter caused by the development and intensification of anti-cyclones over southern Western Australia or South Australia.
- Major cloud bands that develop in winter and extend from the north-west coast, across the continent, bringing rain to the north-west and the interior of the continent.

The study area is approximately 370 km south of Port Hedland (see Figure 1.1). With the assessment area being located in the eastern Pilbara region, it is likely to be affected by dispersion characteristics typical of an inland environment, including:

- unstable (or convective) daytime atmospheric conditions
- stable night and early morning hours atmospheric conditions.

The semi-arid nature of the Pilbara lends itself to being a naturally dusty environment. Wind-blown dust is expected to be a significant contributor to the ambient dust levels in the area.

3.2 Review of Meteorological Data

A comparative study of weather station data in the study area has shown that the Bureau of Meteorology (BoM) Newman Airport monitoring station is representative of prevailing regional conditions. The BoM Newman Airport weather station is located approximately 30 km from the OB31 study area. The data collected from the Newman Airport weather station (BoM, 2013) were used to describe the prevailing meteorological conditions in the study area.

Meteorological data obtained included average hourly wind speed, wind direction and temperature, rainfall and humidity. The analysis of the data included wind roses, diurnal temperature profiles. This data analysis provides a general description and understanding of the local climate and supports the emission estimations and dispersion model set-up and was also used in the analysis to determine the representative year for the dispersion modelling (see Appendix A).

3.2.1 Wind Speed and Wind Direction

The seasonal wind roses for Newman Airport, as recorded at the Bureau of Meteorology location (2001–2012) are presented in Figure 3.1 to Figure 3.4. Collectively these figures show that the dominant annual wind directions are north-westerly during the summer months and south-easterly during the winter months. Spring also shows high north-westerly dominance, driven by land-sea temperature differences in the lead up to the summer months. The distinct seasonal pattern of westerly/north-westerly winds in summer and south-easterly winds in winter is consistent, albeit with some variations from year to year.

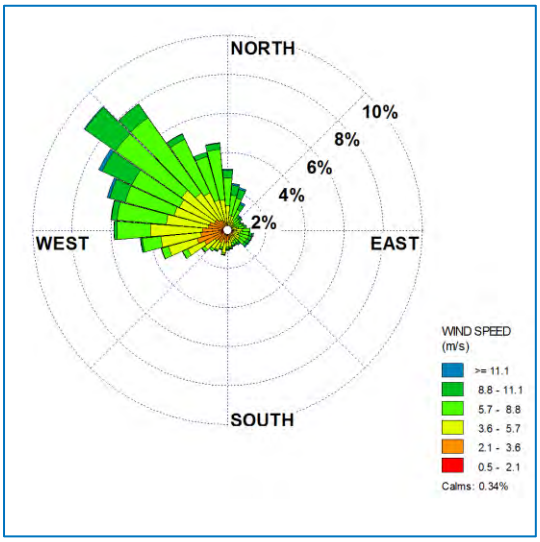

Figure 3.1: Summer wind rose (2001-2012)

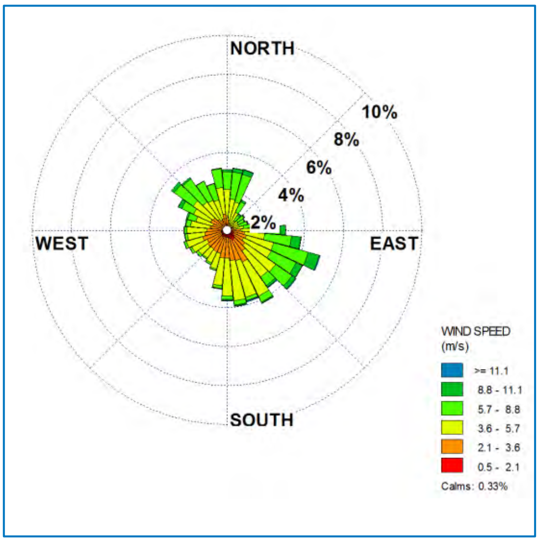

Figure 3.2: Autumn wind rose (2001-2012)

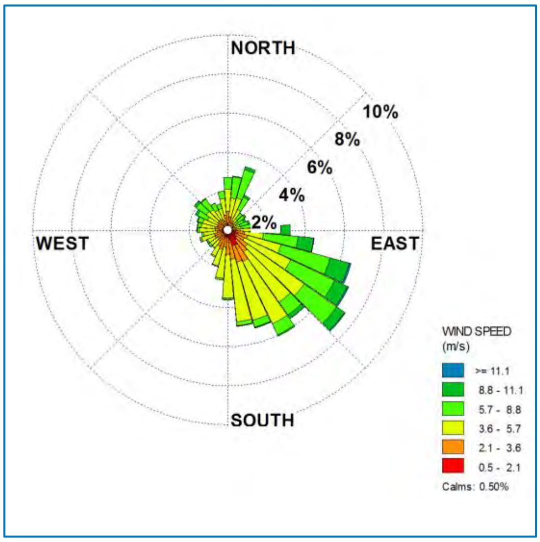

Figure 3.3: Winter wind rose (2001-2012)

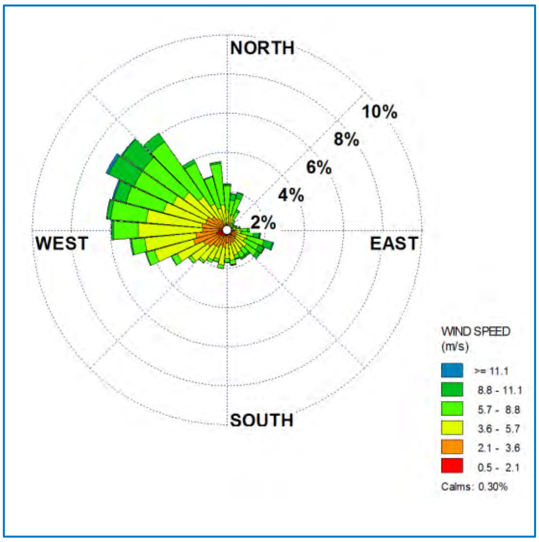

Figure 3.4: Spring wind rose (2001-2012)

Note: Data sourced from Bureau of Meteorology, Newman, (BoM, 2013)

Further analysis of wind speeds was undertaken to identify a year that is representative of the long term (15-year mean) average conditions. This analysis was undertaken using the Mann-Whitney U-test (described in detail in Appendix A). The analysis identified years 1998, 2008, 2009 and 2010 as being representative of the 15-year mean wind conditions.

3.2.2 Rainfall

Rainfall, in the context of dispersion modelling for OB31, is important for understanding the likelihood of natural dust suppression occurring.

Rainfall in the region is highly variable and predominantly limited to the summer and autumn months with very little rainfall occurring between winter and spring. Most rain occurs in the space of a few days (less than 5 days) per month, consistent with the infrequent (but climatically significant) cyclonic and storm events of the region. Rainfall statistics are illustrated in Figure 3.5 (Wittenoom) and Figure 3.6 (Newman). The figure show the mean rainfall and average days of rain per month measured between 1950 and 1971 to 2013, respectively (BoM, 2013). The significant differences between the mean rainfall and the maximum recorded rainfall in each month are due to the impact of tropical depressions in the region.

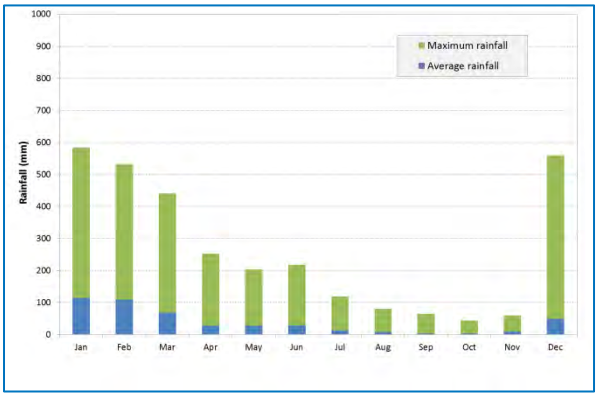

Figure 3.5: Monthly rainfall data for Wittenoom (1950-2013) (BoM, 2013)

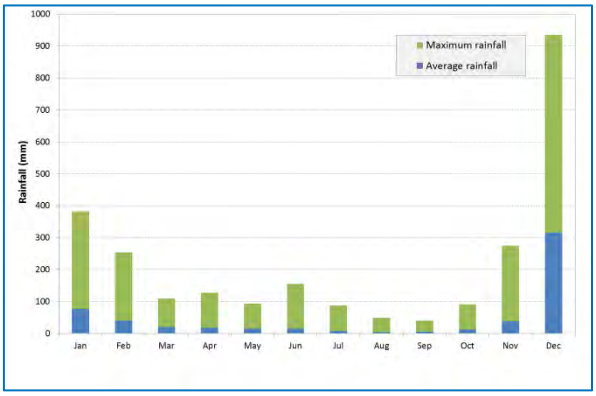

Figure 3.6: Monthly rainfall data for Newman Airport (1971-2013) (BoM, 2013)

Further analysis of the Wittenoom and Newman rainfall statistics were undertaken to identify a year that is representative of the long term (11-year mean) average conditions. This analysis was undertaken comparing total rainfall (described in detail in Appendix A). The analysis identified years 2001 and 2006 as recording rains higher than long term 90th percentile, therefore likely to lead to an underestimate of dust levels; while 2005 and 2007 recording rains in both Wittenoom and Newman are close to the 10th percentile.

The BoM rainfall statistics for Newman over 32 years show only the total rainfall amounts of Year 2002, 2005, 2007, 2008, 2009 and 2010 fall within the 10th and 90th percentile of long term total rainfall amount (BOM, 2013).

3.2.3 Temperature

Air temperature, in the context of dispersion modelling for OB31, is important for understanding the buoyancy of the dust generated on site, and the likelihood of the development of mixing and inversion layers in the model domain.

The long term monthly temperature statistics for Wittenoom and Newman are presented in Figure 3.7 and Figure 3.8 respectively. These figures show the average monthly maxima and minima as well as the highest and lowest temperature recorded during the period 1951 to 2013 (Wittenoom) and 1996 to 2013 (Newman).

Average temperatures in Wittenoom range from 26°C to 39°C during summer, with maximum recorded temperatures of up to 48°C. During winter the temperature typically varies from 11°C to 31°C, with lowest minimum temperatures just above 1°C. Average temperatures in Newman range from 24°C to 39°C during summer, with maximums of up to 47°C. During winter the temperature typically varies from 6°C to 30°C, with lowest minimum temperatures of -2°C. The study area is, therefore, represented by hot summers and cool winters.

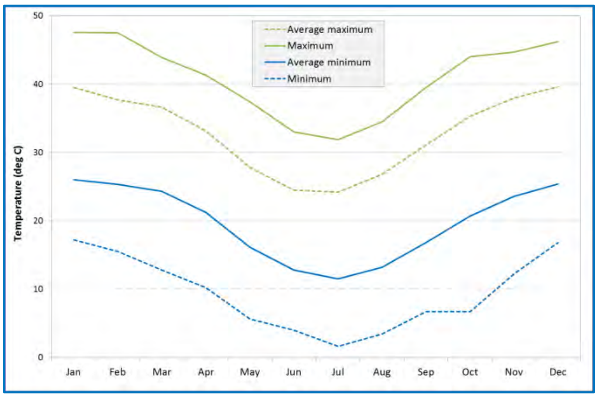

Figure 3.7: Monthly temperature data for Wittenoom (1951-2013) (BoM, 2013)

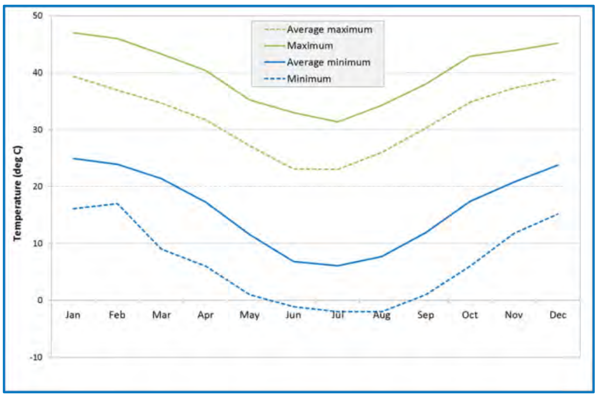

Figure 3.8: Monthly temperature data for Newman Airport (1996-2013) (BoM, 2013)

Further analysis of temperature was also undertaken to identify a year that is representative of the long term (13-year mean) average conditions. This analysis was undertaken using the Mann-Whitney U-test (described in detail in Appendix A). The analysis identified year 2009 being representative of the 15-year mean temperature conditions.

3.2.4 Relative Humidity

Relative humidity, in the context of dispersion modelling for OB31, is important to understand the reduced visibility. High relative humidity can significantly increase the effect of pollution on visibility. Particles would accumulate water and grow to sizes at which they are more efficient at scattering light and reduce visibility.

The long term humidity statistics in Wittenoom and Newman at 9 am and 3 pm are presented in Figure 3.9 and Figure 3.10 respectively. Both figures have similar trends which show the humidity is typically high during the winter period and is generally low during the summer period. This is reflecting the arid nature of the Pilbara region.

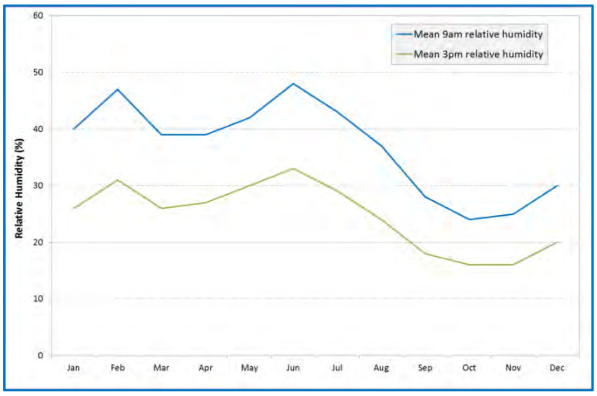

Figure 3.9: Monthly relative humidity data for Wittenoom (1951-2012) (BoM, 2013)

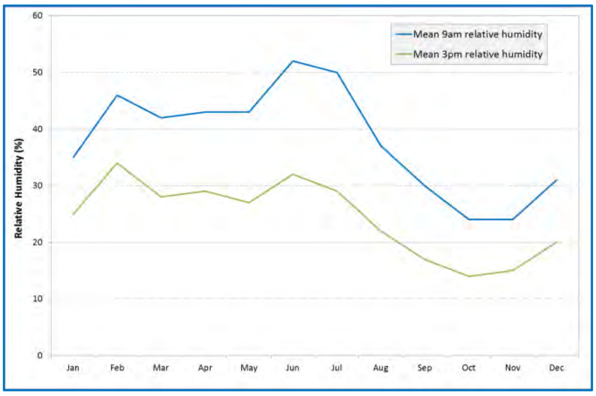

Figure 3.10: Monthly relative humidity data for Newman Airport (1994-2012) (BoM, 2013)

3.3 Review of Ambient Air Quality in Pilbara region

The semi-arid landscape of the Pilbara is a naturally dusty environment with wind-blown dust a significant contributor to ambient dust levels within the region. This was highlighted by the aggregated emission study that was conducted by SKM in 2000 (SKM, 2003). This study found that the Pilbara region emitted around 170,000 tonnes of windblown particulate matter in the 1998/1999 financial year. In order to determine the existing background concentration of PM_{10} to be included in the model, it is necessary to review the ambient air quality data in the region.

3.3.1 Air Quality Monitoring Network

As part of the environmental management regime, BHP Billiton Iron Ore has an ambient air quality monitoring network in place in the vicinity of the inland Pilbara operations. The current network consists of six ambient air monitoring and two meteorological stations in the region, shown in Figure 3.11. Siting of the stations was originally planned or intended to measure background dust concentrations (or regional dust concentrations) and to measure the potential impact of the operations at indicative sensitive receptor locations.

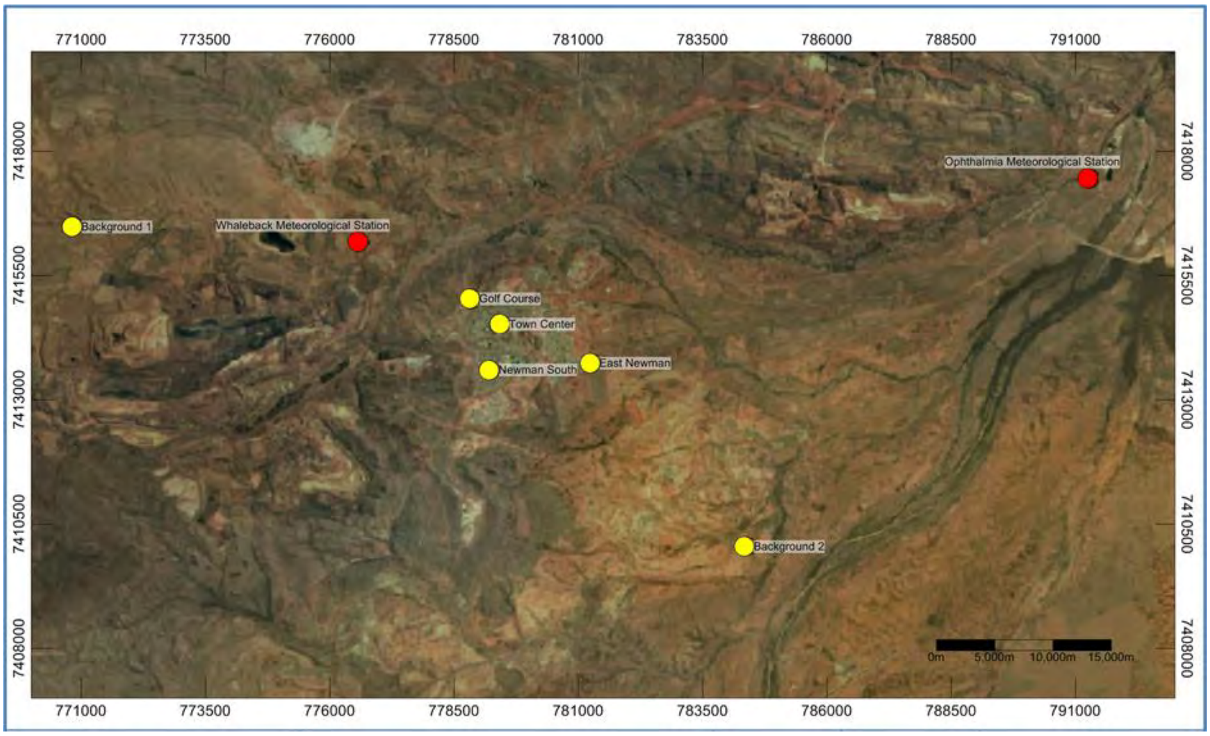

Figure 3.11: BHP Billiton Iron Ore monitoring network at Newman

Previous analysis of data from the BHP Billiton Iron Ore operations has demonstrated the impact of mining operations at each of the ambient monitoring stations, as well as the effect of local topography. BHP Billiton Iron Ore operates two background monitoring stations in the Newman region, identified as Background 1 (BG1) and Background 2 (BG2). BG1 is located less than 1 km to the north west of the Mt Whaleback operation waste dumps (Figure 3.11). The prevailing wind directions in this region are easterly to south easterly and because of this BG1 would be expected to be heavily influenced by emissions from the mining operations at Mt Whaleback. The data from BG1 is therefore not considered to be representative of the regional particulate concentrations.

BG2 is located approximately 5 km south east of the Newman Township (Figure 3.11). The prevailing wind direction in this region is easterly to south easterly. This location is not expected to be impacted significantly in any way by mining activities in the region. Therefore the background concentrations in this assessment have been determined solely from BG2.

3.3.2 Air Quality Monitoring Data

Monitoring data for BG2 was obtained for the period 2009 to 2012. Data obtained included both 10-minute and 24-hour average data for this ambient monitoring station. The analysis of the data included a review of the statistics. The data analysis provides a general description and understanding of the local air quality (based on current emission sources) and supports the emission estimations and dispersion model set-up. Analysis of monitored data is also used in the analysis to identify or determine a representative year for dispersion modelling.

The Total Suspended Particle (TSP) and PM_{10} dust concentrations recorded by BHP Billiton Iron Ore at BG2 from January 2009 through to December 2012 are presented in Figure 3.12 and the concentration statistics are summarised in Table 3.1 (BHP Billiton Iron Ore, 2013).

Particulate concentrations, especially TSP, are extremely high in 2009. Possible contributing reasons to these higher annual concentrations are the contribution by wildfires or over grazing resulting in poor vegetation cover. These factors increased the wind erosion potential in the region. In addition, 2009 and 2012 recorded poor data recovery (ie below 90%). Therefore these two years should be considered less suitable as a representative year for background particulate concentrations.

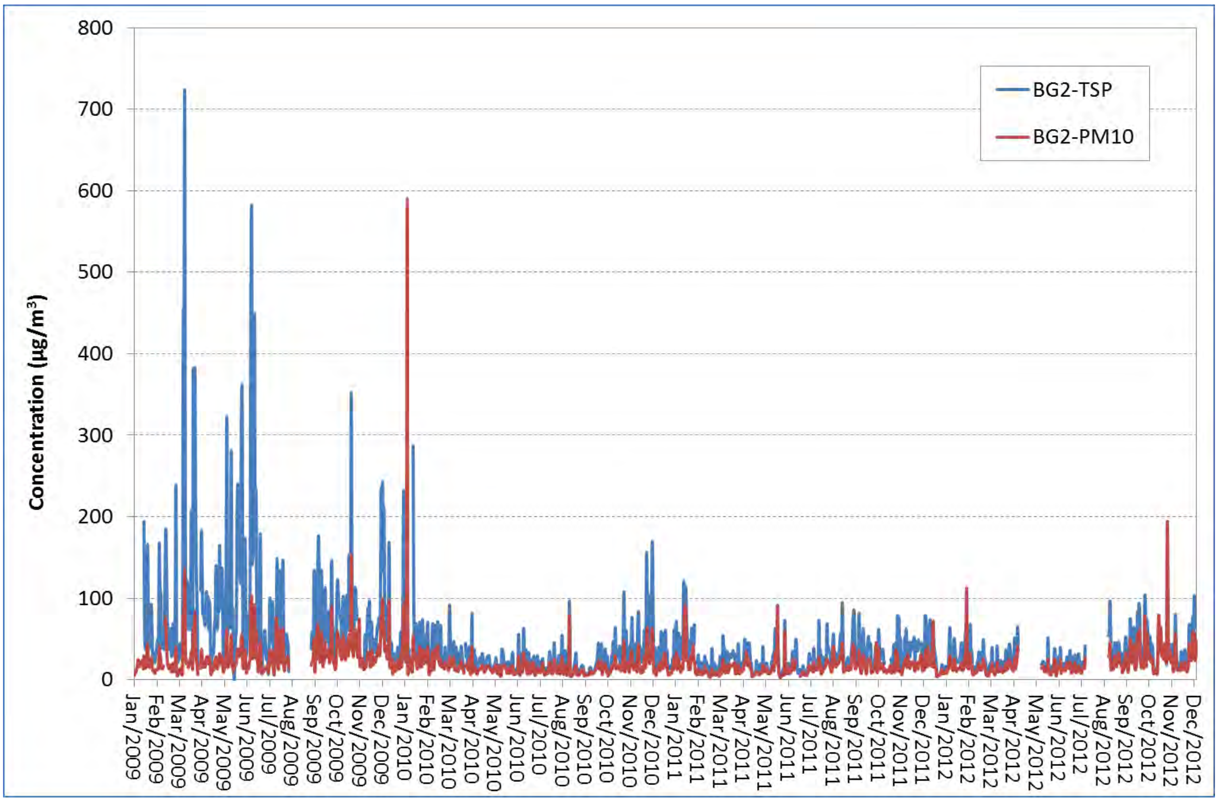

Figure 3.12: Background PM_{10} concentration at Background 2 monitoring station (2010-2013)

The annual average PM_{10} concentrations for BG2 presented in Table 3.1 are slightly higher in 2010 than 2011. Therefore the data from 2010 is recommended as background concentrations for this assessment. For this assessment a background PM_{10} concentration of 18 µg/m^3 was considered to be reflective of the region. This is based on the 70th percentile (which is standard practice in air quality dispersion modelling (Victoria Government Gazette, 2001)) PM_{10} concentration in 2010.

Table 3.1: Statistics for PM_{10} at BG2 monitoring Station

Year	2009	2010	2011	2012
Maximum	153	590	92	194
99th percentile	99	63	70	77
95th percentile	67	37	34	55
90th percentile	54	30	28	35
70th percentile	31	18	19	21
Average	28.5	18.3	16.5	20.4
Standard Deviation	20.1	32.1	11.6	17.4
Data Recovery	85%	99%	95%	83%

4 MODEL SELECTION

Modelling guidelines for Western Australia (DoE, 2006) for assessing air quality impacts through dispersion modelling allow discretion in the choice of model, model set up and emission estimation techniques.

In regulatory applications the prediction of ambient concentrations and deposition using dispersion models influences abatement strategies that may be required (e.g. emission controls). The accuracy of models is therefore important and may affect substantial levels of expenditure on emissions management.

The suite of models that are commonly used in Australia include AUSPLUME, CALPUFF and AERMOD. While AERMOD and AUSPLUME are based on an assumption of steady-state meteorology (generically known as 'plume models'); CALPUFF (California Puff model) is based on non-steady state meteorology ('puff model').

Plume models assume instantaneous, straight-line transport of emissions between source and receptor based on hourly-averaged wind speed and direction data. For that reason they are described as steady-state models: plume calculations for one hour assume a meteorological field that is constant in time and space, and contain no memory of what happened in previous hours. Plumes can appear to travel unrealistic distances in a straight line when winds are light and variable.

Non-steady state models (including puff models) track discrete parcels of emissions as they move with the wind. They calculate variable dispersion depending on position of the puff within the model domain and the corresponding local flow conditions.

An illustration of how the formulation of the two types of models can lead to substantial differences in predicted plume behaviour is presented in Figure 4.1. The non-steady state solution evolves as the wind field changes in both time and space. The figure demonstrates an hourly sequence and shows the differences between steady-state and non-steady-state models in conditions of changing winds and terrain influences. The top sequence was generated by a steady-state model, the lower sequence by a non-steady state model. The same times and emissions source locations have been used. In the lower sequence, arrows indicate surface wind and black lines are terrain contours.

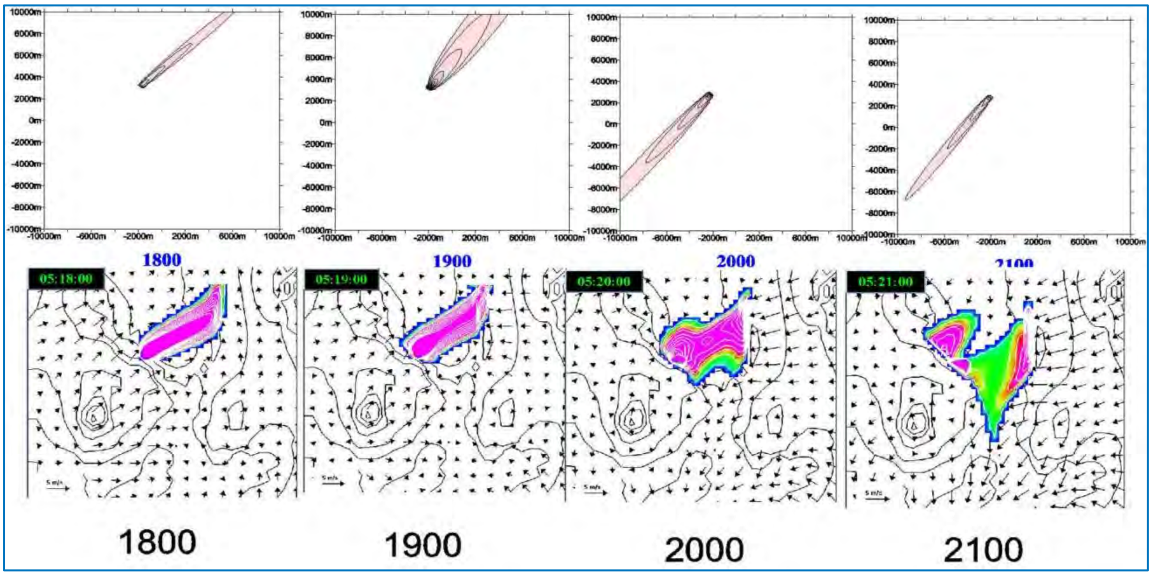

Figure 4.1: Comparison of steady-state and non-steady-state models

Meteorology is a critical component and input to a regional dispersion model. Model configuration and performance needs to be reflective of the actual setting, otherwise the interpretation of results becomes questionable and highly caveated.

4.1 Model for OB31

To best reflect the likely air quality conditions of the OB31 operations and the regional setting, a model has been created, using CALPUFF. CALPUFF can simulate the effects of time- and space- varying meteorological conditions on pollutant transport, transformation and removal (Scire, Strimaitis, & Yamartino, A user's guide for the CALPUFF Dispersion model, January, 2000b). The model employs dispersion equations based on a Gaussian distribution of pollutants across the puff and takes into account the complex arrangement of emissions from point, area, volume and buoyant line sources.

Pacific Environment has coupled the Weather Research Forecast (WRF) model with CALPUFF. This approach is identical to that being applied by Pacific Environment to the Port Hedland Industry Council (PHIC) modelling in Port Hedland, the BHP Billiton Iron Ore Strategic Environmental Assessment in the Pilbara, and for Mining Area C. Further details on the WRF model are provided in Section 5.

4.2 California Puff Model (CALPUFF)

CALPUFF contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as effects such as pollutant removal, chemical transformation, vertical wind shear, a Probability Distribution Function for dispersion in the convective boundary layer and coastal interaction effects (e.g. sea-breeze recirculation and fumigation within the Thermal Internal Boundary Layer).

CALPUFF calculates the pollutant concentration downwind of a source or sources based on the following information:

- pollutant emission rate
- emission source characteristics
- surrounding buildings
- local topography and land-use
- meteorology of the area
- receptor network.

Meteorological data used to drive CALPUFF are processed by the CALMET meteorological pre-processor (Scire, Robe, Fernau, & Yamartino, 2000a) CALMET includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are used in CALPUFF. CALMET uses measured and/or modelled meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region of interest. For this assessment the meteorological data, for input into CALMET, has been derived from the WRF model (Section 5).

CALPUFF is a United States Environment Protection Agency (USEPA) regulatory model for long-range transport and for modelling in regions of complex meteorology (USEPA, 2008). It is widely used in Australia for regulatory purposes. Advanced models like CALPUFF can simulate the effects of terrain effects on pollutant transport and dispersion in a much more realistic way than the Gaussian-plume model, i.e. AUSPLUME and AERMOD, which assumes spatial uniformity in the meteorology.

5 METEOROLOGICAL MODELLING

An overview of the meteorological modelling undertaken using the Weather Research and Forecasting (WRF) Model and CALMET, the CALPUFF meteorological pre-processor is discussed here together with validation of the WRF-CALMET generated meteorology. This WRF-CALMET methodology was adopted to negate some of the disadvantages of using The Air Pollution Model (TAPM) to generate prognostic meteorology appropriate for the project location. The WRF model is required for processing of the broad scale meteorology particularly as there is a lack of observed meteorology in the region, including upper air data. CALMET is required for the fine scale meteorology and for pre-processing the meteorological data to a format readable for CALPUFF (the dispersion model).

5.1 WRF Meteorological Model

WRF is the next-generation mesoscale numerical weather prediction system replacing the MM5 system. The model was primarily designed to serve both operational forecasting and atmospheric research. WRF features multiple dynamical cores, a 3-dimensional variational data assimilation system and a software architecture allowing for computational parallelism.

The model allows for simulations reflecting either real data or idealized configurations and is a computationally efficient operational forecasting tool developed to include recent advances in physics, numerics and data assimilation contributed by the research community. WRF is suitable for scales ranging from metres to thousands of kilometres. Using WRF for processing of meteorological data for dispersion modelling is a recent development and is currently becoming best practice for many applications, especially where there is a paucity of observational data.

WRF was developed (and continues to be developed) in the United States by a collaborative partnership including the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (the National Centers for Environmental Prediction (NCEP), the Forecast Systems Laboratory (FSL), the Air Force Weather Agency (AFWA), the Naval Research Laboratory, the University of Oklahoma, the Federal Aviation Administration (FAA) and others (WRF, 2012). PEL has adopted the WRF-CALMET couped methodology for processing of meteorological data for dispersion modelling with CALPUFF. For this study WRF was run with a three nest structure (40 km, 13.3 km and 4.4 km horizontal grid space resolution) centred on 23.055°S and 119.25°E (Figure 5.1). Vertical resolution consisted of 28 vertical levels.

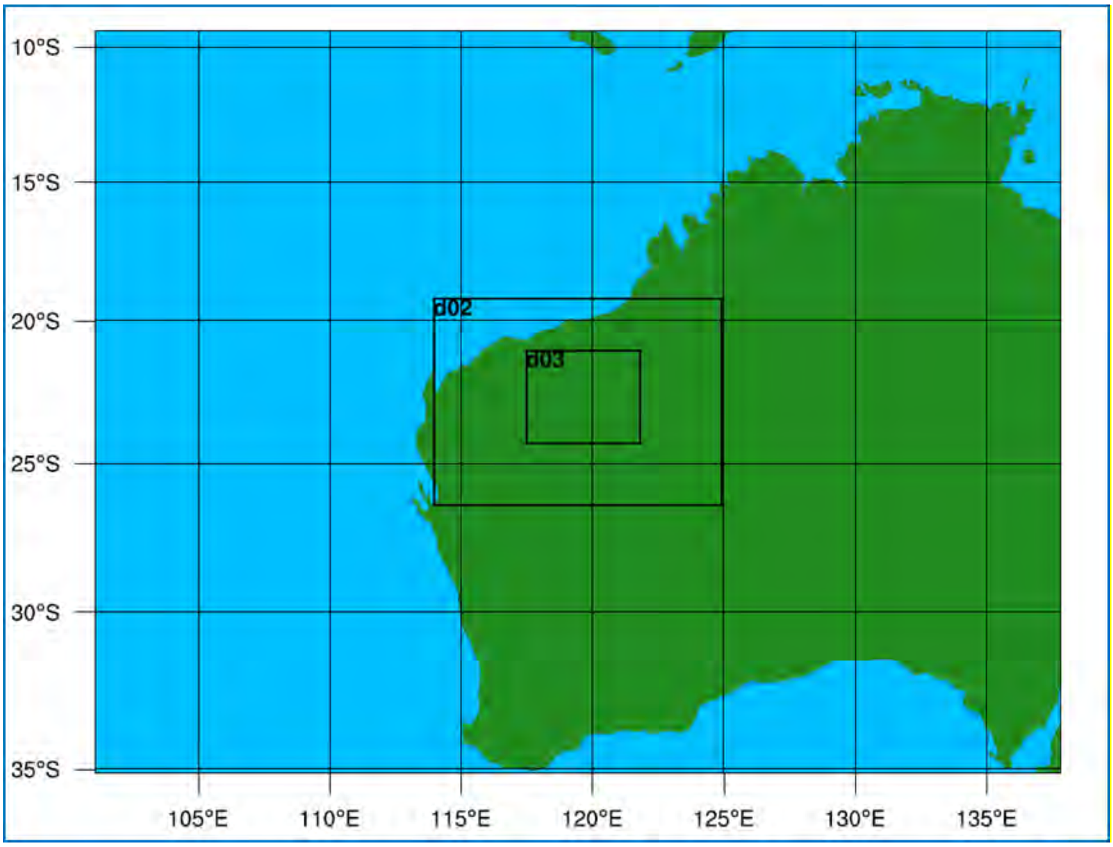

Figure 5.1: WRF Domains

Land-use and terrain data was sourced from the United States Geological Services (USGS) database. Inspection of the land-use indicates an acceptable resolution and category for the area, with shrub land being the dominant vegetation type. A review of the *Landuse.tbl* revealed that they are based on North American parameterisations, with marked seasonal differences to allow for winter snow cover. These are clearly inappropriate for the Pilbara region. A non-seasonally varying roughness length value of 0.4 m was assigned to the shrub land category based on a study by Peel *et al*. (2005) for Spinifex vegetation in the Pilbara. Albedo was also set to 0.2 based on values cited in Peel *et al*. (2005) Other parameters such as Bowen ratio were adjusted to allow for the drier climate of the Pilbara.

Physics options are available in WRF to represent atmospheric radiation, surface and boundary layer as well as cloud and precipitation processes. The physics options selected for the modelling are summarised in Table 5.1.

Table 5.1: Selected WRF Physics Options

	Domain 1*	Domain 2	Domain 3	Explanatory Notes
mp_physics	3	3	3	WRF single moment 3-class scheme
ra_lw_physics	1	1	1	Rapid radiative transfer model scheme
ra_sw_physics	1	1	1	Dudhia scheme for cloud and clear sky absorption and scattering
Radt	30	15	5	Time step for radiation schemes (30 minute)
sf_sfclay_physics	1	1	1	MM5 based on MOST
sf_surface_physics	2	2	2	Noah land surface model with 6 soil layers
bl_pbl_physics	1	1	1	Non-local K-scheme with entrainment layer
bldt	0	0	0	Boundary layer time step (0=every time step)
cu_physics	1	1	0	Kain-Fritch scheme using mass flux approach for domain 1 only.
cudt	5	5	5	Cumulus physics time step (minutes)

Note: Domain 1 (d01) is the full extent of the domain shown in Figure 5.1

Six hourly global 1.0x1.0 degree grid resolution NCEP[d] FNL (Final) Operational Global Analysis data (RDA, 2014) was used to initialise the model and provide boundary conditions. The NCEP data is derived from the Global Data Assimilation System (GDAS), which continuously collects observational data from the Global Telecommunications System (GTS), and other sources. No additional observational data assimilation was undertaken.

5.2 CALMET Meteorology

The three dimensional meteorological data predicted by WRF was input to CALMET for further processing to finer resolution used in the dispersion modelling. This procedure will hereafter be referred as "WRF-CALMET methodology". The output from the CALMET meteorological model is input into the CALPUFF dispersion model.

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

CALMET requires several datasets in order to resolve the surface and upper air meteorology occurring for each hour of the year:

- surface observations
- wind speed
- temperature
- cloud cover amount
- precipitation amount and type
- base cloud height
- upper air observations
- height of observation
- wind speed and direction at each height
- temperature at each height

[d] National Centers for Environmental Prediction

- barometric pressure at each height
- land use data
- topographical data.

The CALMET domain covers a 73.5 km x 42 km area, with the origin (SW corner) at 768.0 km Easting and 7396 km Northing (UTM Zone 50S, km). This consists of 210 x 120 grid points, with a 0.35 km resolution along both the x and y axes. In the vertical, modelling consists of 12 levels extending from the surface to 3,000 m. For the purposes of modelling, a high-resolution terrain dataset was extracted from the 9-second resolution (approximately 250 m) Digital Elevation Model (DEM) from Geoscience Australia.

All surface and upper air meteorological data were generated by WRF.

The methodology used for this project is as follows:

- The 3-dimensional hourly prognostic meteorological data produced by WRF was input to CALMET as an "initial guess field".
- This data was then downscaled to a 350 m resolution to create a gridded 3-D dataset using an objective analysis procedure.
- Terrain effects (i.e. topographic blocking/deflection, acceleration and katabatic flow) were incorporated into the data to create a final hourly, three-dimensional regional meteorological field for the period January to December 2010.

5.2.1 Surface Air Observations

WRF provided a comprehensive data file containing surface and upper air data at every grid point in the model domain. Observation data at Newman (Airport) was used for the meteorological model evaluation. The evaluation is done to ensure that the data is representative of the area and performs as it should. Proper evaluation of the meteorological can only be undertaken at locations where surface observation data is available.

5.2.2 Topography

Topographical data was supplied by The Shuttle Radar Topography Mission (SRTM), which obtained elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of Earth. There are two resolution outputs available, 1 km and 90 m resolutions. The SRTM terrain data with 90 m resolution was used for the terrain file as presented in Figure 5.2.

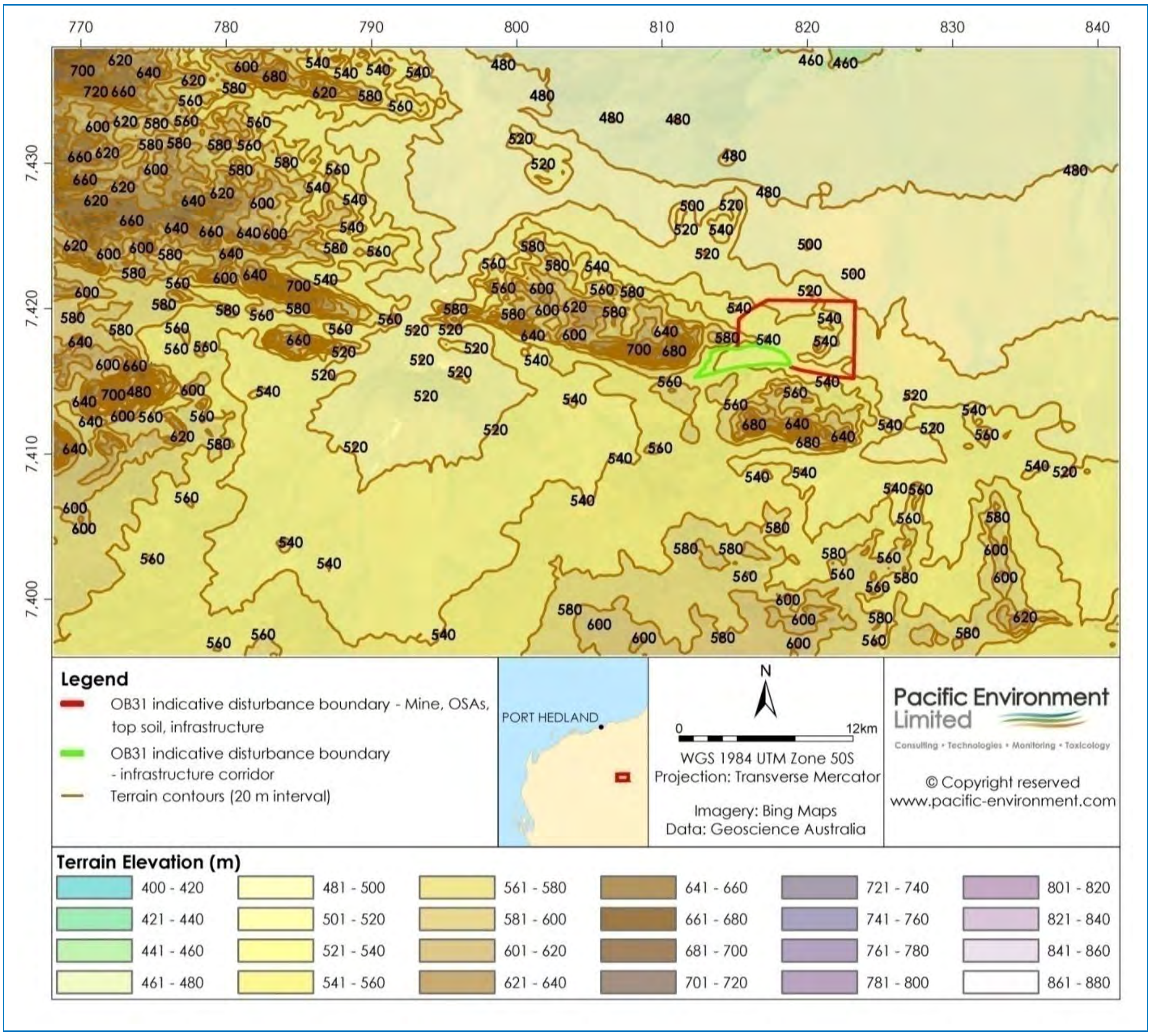

Figure 5.2: CALMET Domain Topography Data

5.2.3 Land Use

CALMET also requires geophysical data including gridded fields of land use categories. Gridded fields of other geophysical parameters may be input into the model if available. The optional inputs include surface roughness length, albedo, Bowen ratio, a soil heat flux parameter, anthropogenic heat flux, and vegetation leaf area index. Default values relating the optional geophysical parameters to land use categories are provided with CALMET.

The default CALMET land use scheme is based on the US Geological Survey (USGS) land use classification system (14 category system). The USGS primary land use categories defined as land use categories within the model domain are listed in Table 5.2 together with the geophysical parameters used. To account for the Australian land use conditions in the Pilbara user defined values were entered for surface roughness and albedo.

Table 5.2: Default CALMET Land Use Categories and Geophysical Parameters

CALMET Land Use Type	CALMET Description	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index
30	Rangeland	0.04 [2]	0.2 [2]	1.0	0.15	0	0.5
70	Barren Land	0.01 [1]	0.25 [1]	1.0	0.15	0	0.05

[1] Source: (WRF, 2012)
[2] Source: (Peel, Pitman, Hughes, Narisma, & Pielke Sr, 2005)

The Rangeland category was used to describe the majority of the landscape, which is defined by spinifex grasses and occasional acacia trees. The deposits with minimal vegetation cover were described by the barren land category.

5.3 WRF-CALMET Meteorology Validation

The CALMET model output was compared against measured temperature, wind speed and direction from the Bureau of Meteorology Newman Airport weather station (inland site) and the outcomes are discussed below.

5.3.1 Surface Station

The hourly measured and corresponding modelled wind speed, wind direction and temperature for the period 1 January 2010 – 31 December 2010 are presented in Figure 5.3 to Figure 5.7.

Figure 5.3 shows a comparison between hourly averages measured and modelled wind speed. Overall, the model predicts wind speed well, notwithstanding a few outlier predictions. The wind speed frequency plot (Figure 5.4) shows a skewed distribution of measured wind speeds, with peak frequencies occurring at 3 m/s. By contrast, modelled wind speeds display a normal distribution with peak frequencies occurring between 4 and 5 m/s. Overall, the measured and modelled wind speed frequencies approximate each other.

The radar plot of measured and modelled wind direction is shown in Figure 5.5. Through visual inspection, it appears that the model forecasts the general pattern of winds (SE-E dominant) satisfactorily. It is important to note that the "spiky" nature of measured wind directions is due to the recorded wind direction intervals occurring in relatively large increments, i.e. 10 degrees.

Time series and frequency plot of measured and corresponding modelled temperature are shown in Figure 5.6 and Figure 5.7 respectively. Although the model slightly over predicts the lower higher temperatures and slightly under predicts the higher temperatures on occasions, it generally performs well for this parameter.

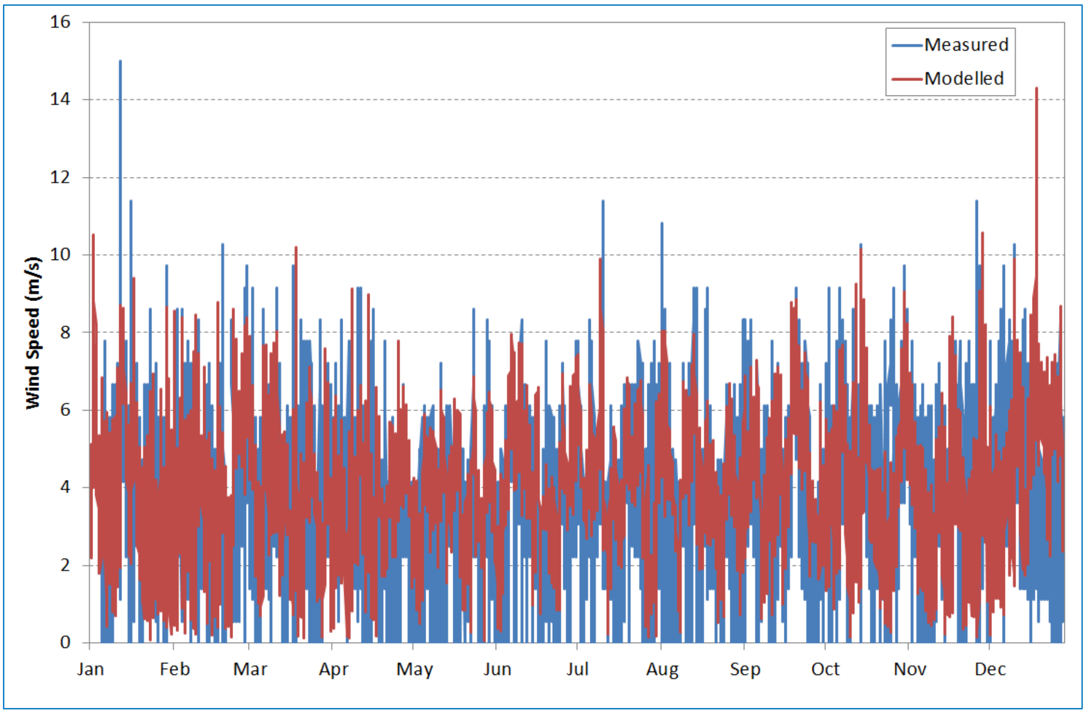

Figure 5.3: CALMET Time series - hourly modelled versus measured wind speed (Newman Airport)

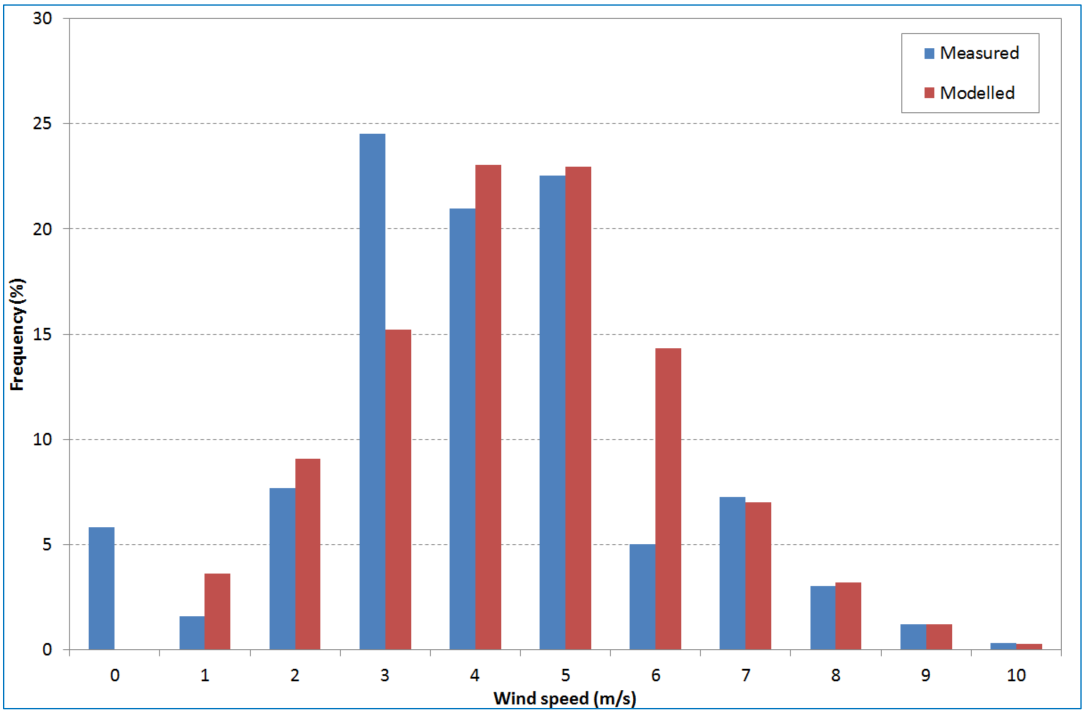

Figure 5.4: Frequency plot - hourly modelled (CALMET) versus measured wind speed (Newman Airport)

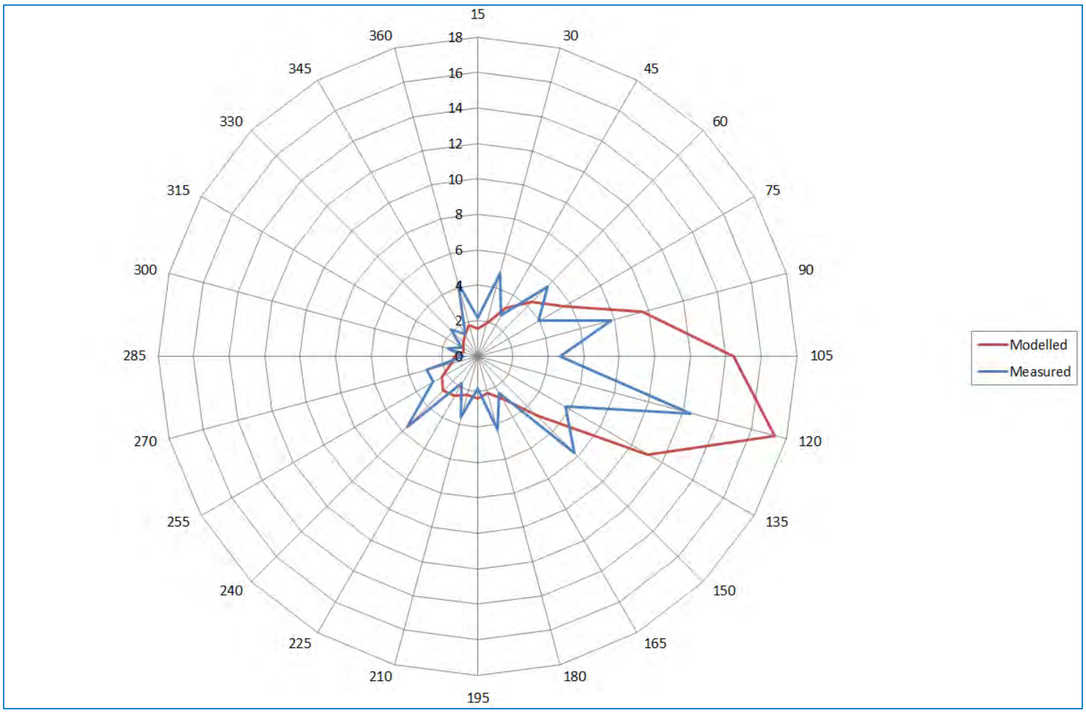

Figure 5.5: Radar plot - modelled in CALMET (red) versus measured (blue) wind direction (Newman Airport)

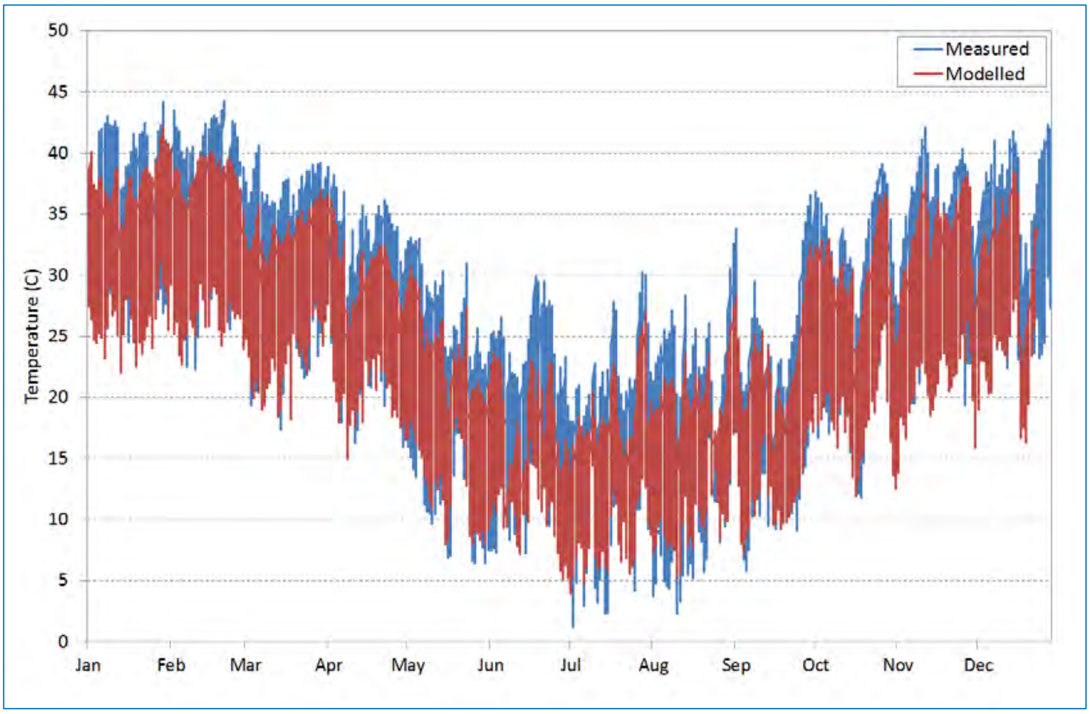

Figure 5.6: Time series - hourly modelled (CALMET) versus measured temperature (Newman Airport)

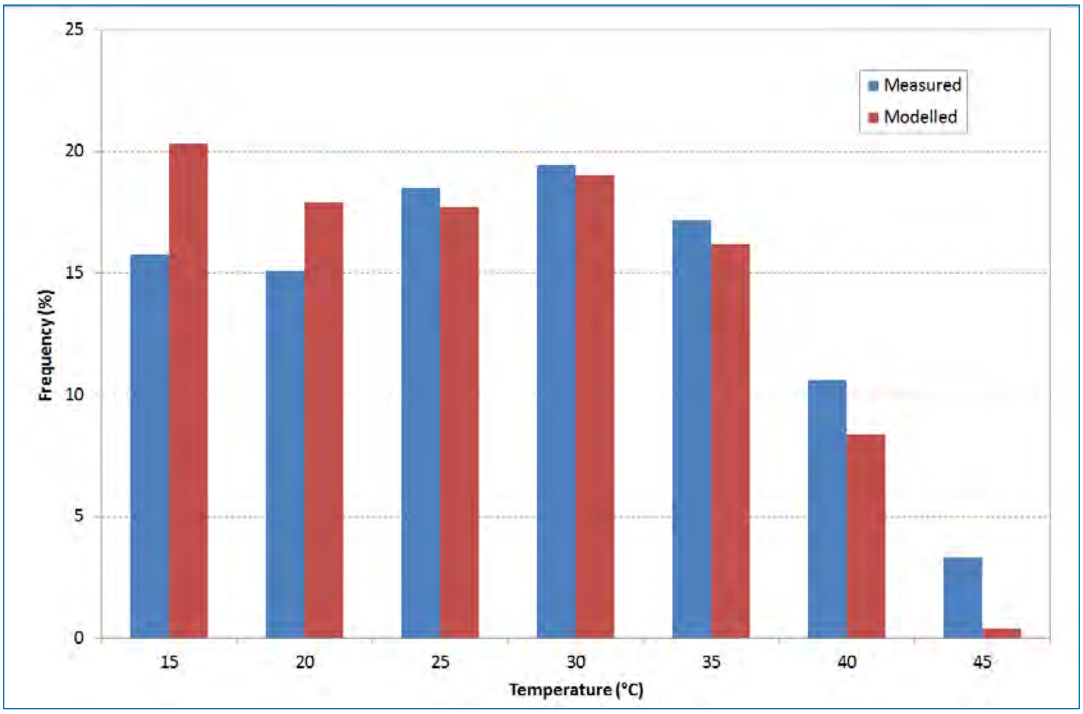

Figure 5.7: Frequency plot - hourly modelled (CALMET) versus measured temperature (Newman Airport)

5.3.2 Statistical Measures of Model Performance

An objective method to evaluate model performance is through the use of statistical tests that have been developed for this purpose. These tests are, *inter alia*, *geometric mean, geometric variance*, *model bias, fraction bias, gross error, root mean square error, Skill_v, Skill_r, index of agreement* and the *coefficient of correlation*. Detailed explanation of these statistical measures is provided in Appendix A.

The results of the statistical model verification are shown in Table 5.3 for Newman Airport.

Temperature, wind speed and wind direction meet most of the validation benchmarks or statistical criteria (Table 5.3). For temperature and wind direction, the gross error values fall just outside the validation benchmark listed in Teschenke *et al*, (2001) However, these values may be impacted by potential wind direction measurement issues (as stated previously).

Overall, it can be statistically concluded that the WRF-CALMET simulates surface meteorology with an acceptable degree of skill at Newman Airport.

Table 5.3: Results of statistical test: Newman Airport*

	MG	GV	MB	FB	Skill_v	Skill_r	GE	r	RMSE	IOA
Ideal Score	0.7-1.3	<1.6	See Table B-1 Mesoscale model benchmarks (after (Emery, Tai, & Yarwood, 2001; Tesche, McNally, Emery, & Tai, 2001);	±0.67	1.0	<1	See Table B-1 Mesoscale model benchmarks (after (Emery, Tai, & Yarwood, 2001; Tesche, McNally, Emery, & Tai, 2001)	1	See Table B-1 Mesoscale model benchmarks (after (Emery, Tai, & Yarwood, 2001; Tesche, McNally, Emery, & Tai, 2001)	1 and see Table B-1 Mesoscale model benchmarks (after (Emery, Tai, & Yarwood, 2001; Tesche, McNally, Emery, & Tai, 2001)
Temp.	1.07	1.00	1.58	0.07	0.94	0.19	2.51	0.95	3.16	0.99
Wind Speed.	0.89	1.01	-0.58	-0.12	0.88	0.34		0.39	1.99	0.90
Wind Dir.	-	-	8.88	-	-	-	40.44	-	-	-

*Note: Shading indicates value within benchmark/criteria

6 EMISSION ESTIMATION

This section outlines the emission estimation process used to develop the emission inventory for the proposed OB31 activities. Emissions are sourced from this inventory for inclusion in the dispersion model.

6.1 Sources of Emissions - Emissions Inventory

The predominant emissions from an iron ore mine and material handling facility, such as the proposed OB31 operations are particulates (as PM_{10}). Emissions from combustion processes, such as the operation of machinery and power generation will also be created, but are considered insignificant in terms of impacts on sensitive receptors when compared to particulate emissions. As such, emissions from combustion processes have not been modelled.

An emissions inventory for the operations was developed for PM_{10}. The emission sources for this assessment are:

- Wheel generated dust from haul roads
- Bulldozing
- Loading
- Unloading
- Wind erosion from stockpiles and open areas
- Blasting
- Drilling
- Crushing
- Conveying.

6.2 Emission Estimation Process

Emissions from all key sources associated with OB31 have been identified and estimated according to accepted estimation methods. These methods have been adopted by previous projects (i.e. Pit 1 East of Mining Area C in the same region (PEL, 2013a).

When determining which emission estimation techniques (EETs) to use for this assessment:

- precedence was given to BHP Billiton Iron Ore site-specific empirical equations. BHP Billiton Iron Ore has undertaken extensive study towards developing site-specific empirical equations. Emission rates were calculated using an empirical equation based on the dustiness index of a given ore type and moisture content (as measure at the time), the specific activity factor, wind speed and throughput.
- In the absence of BHP Billiton Iron Ore site-specific empirical equations, EETs in the relevant National Pollutant Inventory (NPI) EET Manuals were adopted. These methods, although often taken from overseas are subject to a process of regular review regarding their applicability to Australian conditions, and are re-evaluated and updated periodically. Although some EETs from other jurisdictions may be more appropriate in particular instances, it is assumed generally, EETs from the most recent NPI manuals should take precedence unless there is site specific emission factors (direct site evaluations) available.

For activities or substances where Australian NPI data were unavailable, international emission factors were sourced from USEPA AP-42. The specific EETs, emission factors and activity data used for the assessment of the emissions are described in Appendix C.

BHP Billiton Iron Ore provided the activity data for the activities to be conducted as part of the assessment (BHP Billiton Iron Ore, 2014b). Proposed mine plan for OB31, including tonnages, locations of deposits, overburden storage area and haul road distance, provided for this assessment are shown in

Table 6.1, Table 6.2 and Figure 6.1. The location of the mine stages Stage 4 and 5 (S4 and S5) relevant for the assessment year are shown as an insert in Figure 6.1.

Table 6.1: Proposed Movement of OB31 for Year 2022

	Pit Stages (tonnes)		
	Stage 5 (S5)	**Stage 4 (S4)**	**Total**
Ore	7,182,911	7,817,089	15,000,000
Waste	4,177,772	20,822,228	25,000,000
Total	11,360,683	28,639,317	

Table 6.2: Haul Road Distances for OB31 in Year 2022

	Haul distance (km)				
	S5 to OB31 [a]	**S4 to OB31** [a]	**S5 to OB18** [b]	**S4 to OB18** [b]	**OB31 to OB18** [c]
Ore	4	3	8	9	9
Waste	3	3	3	3	-

a. For Scenario 2 to Scenario 4
b. For Scenario 1
c. For Scenario 2

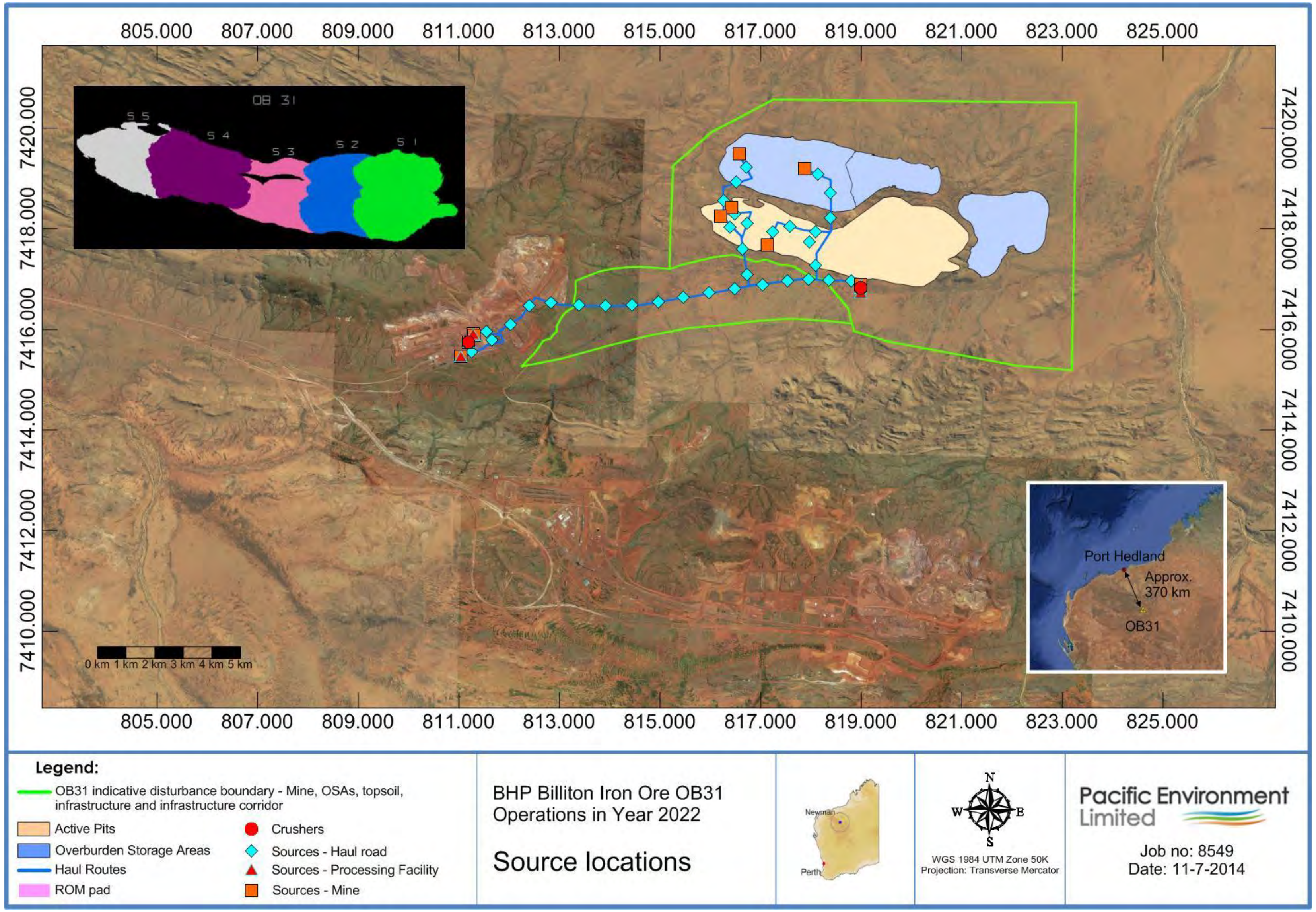

Figure 6.1: Source Locations

6.3 Assessment Scenarios

Four model scenarios for potential OB31 operating options were considered in the air quality assessment:

- Scenario 1 – estimated emissions arising from mining 15 Mtpa with ore hauled via road from OB31 to OB18 and crushed at OB18
- Scenario 2 – estimated emissions arising from mining 15 Mtpa with ore hauled via road from OB31 to OB18 after being crushed with a new crusher at OB31
- Scenario 3 – estimated emissions arising from mining 15 Mtpa with ore transported via overland conveyor from OB31 to OB18 and crushed at OB18
- Scenario 4 – estimated emissions arising from mining 15 Mtpa with ore crushed at OB31 (with a new crusher) and then transported via an overland conveyor to OB18.

There are various ways in which dust emissions from mining operations can be controlled. A summary of dust control methods with standard BHP Billiton Iron Ore operating controls (Standard Controls) and recommended leading dust controls (Leading Controls) are listed in Table 6.3.

All scenarios were assessed with:

- no dust management control
- standard controls
- leading controls.

It should be noted that the standard operating procedure for mines operated by BHP Billiton Iron Ore is with standard controls. No controls have only been modelled to provide a highly unlikely 'worst case' scenario.

All results were presented as standalone and cumulative with existing operations.

Table 6.3: Summary of Control Factors for OB31 Operations

Operation	Control method and emission reduction
Mining	
Bulldozing	No control
Loading ore and waste	Standard: no control Leading: 50% for water sprays
Loading ore from ROM pad to crusher	Standard: 50% for level 1 water sprays Leading: 83% for level 2 water sprays
Unloading waste	No control
Unloading ore at ROM pad	No control
Unloading ore into crusher	Standard: 50% for level 1 water sprays Leading: 83% for level 2 water sprays
Drilling	Standard: 50% for cyclone Leading: 99% for water injection
Blasting	No control
Wind Erosion in OSA and ROM pad	Standard: 50% for water sprays Leading: 90% for chemical surfactant and good housekeeping*
Haul road	
Hauling	Standard: 50% for level 1 watering (2 litres/m^2/h) Leading: 90% for chemical dust suppressant*
Processing facility	
Primary crushing of ore	Standard: 50% for water sprays Leading: 83 % for extraction
Conveyer drop off points	Standard: no control Leading: 50% for water sprays
Loading ore into haul trucks	Standard: 50% for level 1 water sprays Leading: 83% for level 2 water sprays
Unloading ore from haul trucks	Standard: 50% for level 1 water sprays Leading: 83% for level 2 water sprays
Wind erosion in open area	Standard: 50% for water Leading: 90% for chemical surfactant and good housekeeping*
Note: Unless referenced specifically, control efficiencies are based on NPI values. * Based on PEL, 2013b (report prepared for BHP Billiton Iron Ore)	

6.4 Emissions Estimates Summary

The total emissions of PM_{10} associated with the proposed operation scenario 1 to 4 are presented in Table 6.4 to Table 6.7. Detailed emission estimation techniques are presented in Appendix C.

Table 6.4: Emissions of PM_{10} for Scenario 1 by Activity

Scenarios	Activity	PM_{10} Emissions (kg/year)
No Control	Bulldozing	22,764
Standard Controls		22,764
Leading Controls		22,764
No Control	Loading	343,672
Standard Controls		343,672
Leading Controls		171,836
No Control	Unloading	281,601
Standard Controls		249,351
Leading Controls		228,066
No Control	Wheel Generated Dust from Unpaved Roads	4,954,183
Standard Controls		2,477,092
Leading Controls		495,418
No Control	Wind Erosion	16,488
Standard Controls		8,244
Leading Controls		1,649
No Control	Blasting	14,102
Standard Controls		14,102
Leading Controls		14,102
No Control	Drilling	7,718
Standard Controls		3,859
Leading Controls		77
No Control	Crushing	60,060
Standard Controls		30,030
Leading Controls		10,210
No Control	Conveying	4,014
Standard Controls		4,014
Leading Controls		2,007
Total	**No control**	**5,704,602**
Total	**Standard Controls**	**3,153,128**
Total	**Leading Controls**	**946,130**

Table 6.5: Emissions of PM_{10} for Scenario 2 by Activity

Scenarios	Activity	PM_{10} Emissions (kg/year)
No Control	Bulldozing	22,764
Standard Controls		22,764
Leading Controls		22,764
No Control	Loading	343,672
Standard Controls		343,672
Leading Controls		171,836
No Control	Unloading	346,110
Standard Controls		281,605
Leading Controls		239,032
No Control	Wheel Generated Dust from Unpaved Roads	6,400,613
Standard Controls		3,200,306
Leading Controls		640,061
No Control	Wind Erosion	24,908
Standard Controls		12,454
Leading Controls		2,491
No Control	Blasting	14,102
Standard Controls		14,102
Leading Controls		14,102
No Control	Drilling	7,718
Standard Controls		3,859
Leading Controls		77
No Control	Crushing	60,060
Standard Controls		30,030
Leading Controls		10,210
Total	**No control**	**7,219,946**
Total	**Standard Controls**	**3,908,793**
Total	**Leading Controls**	**1,100,574**

Table 6.6: Emissions of PM_{10} for Scenario 3 by Activity

Scenarios	Activity	PM_{10} Emissions (kg/year)
No Control	Bulldozing	22,764
Standard Controls		22,764
Leading Controls		22,764
No Control	Loading	343,672
Standard Controls		343,672
Leading Controls		171,836
No Control	Unloading	281,601
Standard Controls		249,351
Leading Controls		228,066
No Control	Wheel Generated Dust from Unpaved Roads	3,105,606
Standard Controls		1,552,803
Leading Controls		310,561
No Control	Wind Erosion	36,133
Standard Controls		18,067
Leading Controls		3,613
No Control	Blasting	14,102
Standard Controls		14,102
Leading Controls		14,102
No Control	Drilling	7,718
Standard Controls		3,859
Leading Controls		77
No Control	Crushing	60,060
Standard Controls		30,030
Leading Controls		10,210
No Control	Conveying	8,085
Standard Controls		8,085
Leading Controls		4,042
Total	**No control**	**3,879,742**
Total	**Standard Controls**	**2,242,733**
Total	**Leading Controls**	**765,272**

Table 6.7: Emissions of PM_{10} for Scenario 4 by Activity

Scenarios	Activity	PM_{10} Emissions (kg/year)
No Control	Bulldozing	22,764
Standard Controls		22,764
Leading Controls		22,764
No Control	Loading	343,672
Standard Controls		343,672
Leading Controls		171,836
No Control	Unloading	281,601
Standard Controls		249,351
Leading Controls		228,066
No Control	Wheel Generated Dust from Unpaved Roads	3,105,606
Standard Controls		1,552,803
Leading Controls		310,561
No Control	Wind Erosion	24,908
Standard Controls		12,454
Leading Controls		2,491
No Control	Blasting	14,102
Standard Controls		14,102
Leading Controls		14,102
No Control	Drilling	7,718
Standard Controls		3,859
Leading Controls		77
No Control	Crushing	60,060
Standard Controls		30,030
Leading Controls		10,210
No Control	Conveying	4,014
Standard Controls		4,014
Leading Controls		2,007
Total	**No control**	**3,864,445**
Total	**Standard Controls**	**2,233,049**
Total	**Leading Controls**	**762,114**

7 MODEL CONFIGURATION

CALPUFF (Scire, Strimaitis, & Yamartino, A user's guide for the CALPUFF Dispersion model, January, 2000b) is a multi-layer, multi-species non-steady state puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal. The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer-range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across the puff and takes into account the complex arrangement of emissions from point, area, volume, and line sources.

In addition to the three-dimensional meteorological data output from CALMET; CALPUFF requires the following input data:

- source locations
- emission data
- receptor information.

CALPUFF is a USEPA regulatory model for long-range transport or for modelling in regions of complex meteorology. It is the preferred dispersion model for use in coastal and complex terrain situations and is currently the best model to apply for advanced dispersion modelling. Detailed description of CALPUFF is provided in the user manual (TRC, 2011)

The receptor grid for the dispersion modelling was, as for the meteorological modelling, at a grid spacing of 350 m with additional discrete receptors representing the surrounding nearest receptors.

A sample CALPUFF input file typical of those used in this assessment is presented in Appendix D. The main model options and assumptions used are listed below:

- haul roads, stockpiles and open area wind erosion sources were modelled as area sources. It is to be noted that area sources in CALPUFF account for plume meander; remaining sources were modelled as volume sources
- building wake effects were excluded
- surface and upper air data were generated for every grid point in 3 D (Section 5.2)
- terrain information was obtained from Shuttle Radar Topography Mission (SRTM) at 3 arc, 90 m resolution
- pollutant was modelled as a particle accounting for dry depletion. Geometric mean diameter and standard deviation provided in Section 7.1.5.
- wind speed profile set to ISC rural parameters
- dispersion coefficients computed from sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.)
- 12 cell faces heights defined up to 3000 m (0, 20, 40, 60, 80, 100, 150, 200, 250, 500, 1000, 2000, 3000)
- maximum travel distance of a puff (in grid units) during one sampling step set to 2
- maximum number of puffs released from one source during one time step reduced to 60
- maximum number of sampling steps for one puff during one time step reduced to 60
- minimum wind speed (m/s) allowed for non-calm conditions reduced to 0.1 m/s
- default and user defined land use categories with geophysical parameters defined for each grid point as detailed in Section 5.2.3.

The emission source parameters for all modelled sources are presented in Appendix E.

7.1 Other Model Parameters

7.1.1 Meteorological Data

The WRF processed meteorological data was input to CALMET for further processing to finer resolution used in the dispersion modelling. The CALMET output file generated for 2010 contains three-dimensional gridded fields of U, V, W wind components and air temperature, two-dimensional fields of surface friction velocity, mixing height, Monin-Obukhov length, convective velocity scale, and precipitation rate.

A time series air quality meteorological data file, containing hourly values of these parameters at every grid point is input directly into CALPUFF and used to predict pollution dispersion.

7.1.2 Grid System

The CALPUFF model can calculate concentrations both on a set grid (gridded receptors) and at specified locations (discrete receptors). The model was configured to predict the ground-level concentrations on a rectangular grid. The model domain was defined as 42 km in the north–south direction and 73.5 km in the east-west direction and has its south-west corner at 768, 7396 km (50S UTM). This grid approach was chosen to restrict the duration of model runs while using the particle deposition algorithms. Nine discrete receptors were included to give an indication of dust concentrations at specific locations (Section 7.1.3).

7.1.3 Discrete Receptors

PM_{10} concentrations were modelled at seven discrete receptors. The locations (and type descriptions) of these receptors are presented in Table 7.1 and Figure 7.1.

Table 7.1: Sensitive Receptor Locations for Model Interpretation

Receptor ID	Location	Easting (m)	Northing (m)	Type
3	Tower Hill	779,000	7,414,000	Lookout (non residential location)
4	Opthalmia Dam	794,000	7,416,000	Recreation Site (non residential location)
5	Round Hill	783,000	7,405,000	Recreation Site (non residential location)
6	Kalgan Pool	776,000	7,433,000	Recreation Site (non residential location)
7	Capricorn Roadhouse	788,000	7,404,000	Roadhouse (residential location)
8	Newman	780,000	7,414,000	Town Centre (residential location)
9	Eastern Pilbara Accommodation Village	800,000	7,416,000	Accommodation Village (residential location)

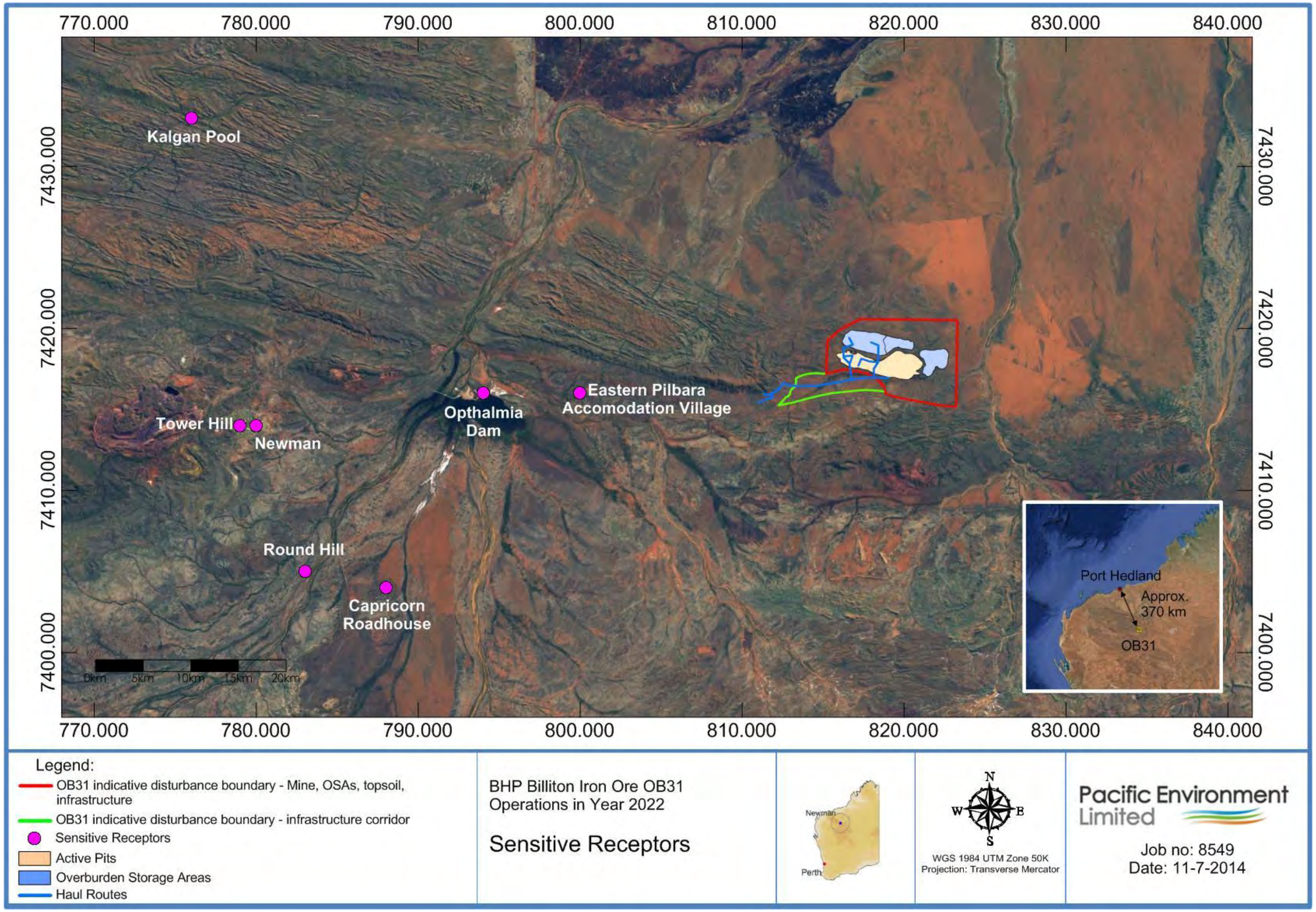

Figure 7.1: Sensitive Receptor Locations

7.1.4 Emission Rates and Source Parameters

Details of the sources including source identification, type, location and characteristics (height, horizontal and vertical spreads) are presented in Appendix E. The source parameters listed in the tables are consistent with those used in the modelling input files and are included in this report for transparency. Statistical summary of hourly varying emission rate for each emission sources are presented in Appendix F.

7.1.5 Deposition Modelling

Dry deposition occurs from gravitational sedimentation, impaction, and diffusion to surfaces. In this assessment, gravitational settling as dry depletion is the only form of dry deposition allowed for. Dust deposition rates were not modelled.

Gravitational deposition of the particles depends on the corresponding settling velocity and airborne concentrations. The settling velocity of a particle depends on the particle size, density and properties of the atmosphere including density and viscosity. In CALPUFF, the particle size distribution for each species is described by the geometric mean diameter and the geometric standard deviation. These are tabulated in Table 7.2.

Table 7.2: Particle Size Distribution input into CALPUFF

Pollutant	Geometric mean diameter (µm)	Geometric standard deviation
PM_{10}	3.25	2.23

7.1.6 Model Uncertainty

Atmospheric dispersion models represent a simplification of the many complex processes involved in determining ground-level concentrations of substances.

Model uncertainty is composed of model chemistry/physics uncertainties, data uncertainties, and stochastic uncertainties. In addition, there is inherent uncertainty in the behaviour of the atmosphere, especially on shorter timescales due to the effects of random turbulence. The main specific sources of uncertainty in dispersion models and their potential effects are summarised in Table 7.3.

If modelling results are to be used for decision-making, it is essential to provide some indication of the model uncertainty. This information about uncertainties associated with modelling results can be as important as the modelling results in some cases.

Table 7.3: Summary of Main Sources of Modelling Uncertainty

Source	Effects
Oversimplification of physics in model code (varies with type of model)	A variety of effects that can lead to both under-prediction and over-prediction. Errors are greater in Gaussian plume models, which do not include the effects of non-steady-state meteorology (i.e., spatially- and temporally-varying meteorology).
Errors in emissions data	Ground-level concentrations are proportional to emission rate. Plume rise is affected by source dimensions, temperature and exit velocity.
Errors in wind data	Wind direction affects direction of plume travel. Wind speed affects plume rise and dilution of plume, resulting in potential errors in distance of plume impact from source, and magnitude of impact.
Errors in stability estimates	Gaussian plume models use estimates of stability class, and 3-D models use explicit vertical profiles of temperature and wind (which are used directly or indirectly to estimate stability class for Gaussian models). In either case, errors in these parameters can cause either under prediction or over prediction of ground-level concentrations.
Errors in temperature	Usually the effects are small, but temperature affects plume buoyancy, with potential errors in distance of plume impact from source, and magnitude of impact.
Inherent uncertainty	Models predict 'ensemble mean' concentrations for any specific set of input data (say on a 1-hour basis), i.e., they predict the mean concentrations that would result from a large set of observations under the specific conditions being modelled. However, for any specific hour with those exact mean hourly conditions, the predicted ground-level concentrations will never exactly match the actual pattern of ground-level concentrations, due to the effects of random turbulent motions and random fluctuations in other factors such as temperature.

The software graphics package ArcGIS has been used in this assessment to present the regional contour plots. This involves the interpolation of results onto the contour grid, and will therefore be associated with some degree of spatial uncertainty. Results are also presented in tabulated form, and are extracted directly from model output, and are a closer representation of the predicted impacts at the designated receptor locations for PM_{10} only.

The tabulated presentation of results is reported to a decimal placing consistent with the selected assessment guidelines. It must be noted that the dispersion model predictions are not verifiable to this level of accuracy.

8 MODEL RESULTS

This section presents the results of the dispersion modelling as presented in Table 8.1.

The modelling results are presented in tabular form and visually in contours of concentration for most scenarios. Full contour plot results are provided in Appendix G. The results are compared to the assessment guidelines and evaluated against the cumulative impacts as predicted.

Table 8.1: Summary of Results Presentation

Report Section	Description
Section 8.1	Existing current operations in the modelling domain.
Section 8.2	OB31 operations as standalone without any surrounding operations or PM_{10} background for all production scenarios (1 to 4) and dust control scenarios (no control, standard control, leading control)
Section 8.2.1	OB31 operations for Scenario 1 – 15 Mtpa ore hauled via road from OB31 to OB18 and crushed at OB18. No dust control.
Section 8.2.2	OB31 operations for Scenario 1 – 15 Mtpa ore hauled via road from OB31 to OB18 and crushed at OB18. Standard dust control.
Section 8.2.3	OB31 operations for Scenario 1 – 15 Mtpa ore hauled via road from OB31 to OB18 and crushed at OB18. Leading dust control.
Section 8.2.4	OB31 operations for Scenario 2 – 15 Mtpa ore hauled via road from OB31 to OB18 after being crushed with a new crusher at OB31. No dust control.
Section 8.2.5	OB31 operations for Scenario 2 – 15 Mtpa ore hauled via road from OB31 to OB18 after being crushed with a new crusher at OB31. Standard dust control.
Section 8.2.6	OB31 operations for Scenario 2 – 15 Mtpa ore hauled via road from OB31 to OB18 after being crushed with a new crusher at OB31. Leading dust control.
Section 8.2.7	OB31 operations for Scenario 3 – 15 Mtpa ore transported via overland conveyor from OB31 to OB18 and crushed at OB18. No dust control.
Section 8.2.8	OB31 operations for Scenario 3 – 15 Mtpa ore transported via overland conveyor from OB31 to OB18 and crushed at OB18. Standard dust control.
Section 8.2.9	OB31 operations for Scenario 3 – 15 Mtpa ore transported via overland conveyor from OB31 to OB18 and crushed at OB18. Leading dust control.
Section 8.2.10	OB31 operations for Scenario 4 – 15 Mtpa ore crushed at OB31 with new crusher and transported via an overland conveyor to OB18. No dust control.
Section 8.2.11	OB31 operations for Scenario 4 – 15 Mtpa ore crushed at OB31 with new crusher and transported via an overland conveyor to OB18. Standard dust control.
Section 8.2.12	OB31 operations for Scenario 4 – 15 Mtpa ore crushed at OB31 with new crusher and transported via an overland conveyor to OB18. Leading dust control.

Report Section	Description
Section 8.3	OB31 Operations as cumulative with existing operations excluding OB18 (as per Section 8.1)
Section 8.3.1	OB31 operations for Scenario 1 – 15 Mtpa ore hauled via road from OB31 to OB18 and crushed at OB18. No dust control, Standard dust control, Leading dust control.
Section 8.3.2	OB31 operations for Scenario 2 – 15 Mtpa ore hauled via road from OB31 to OB18 after being crushed with a new crusher at OB31. No dust control, Standard dust control, Leading dust control.
Section 8.3.3	OB31 operations for Scenario 3 – 15 Mtpa ore transported via overland conveyor from OB31 to OB18 and crushed at OB18. No dust control, Standard dust control, Leading dust control.
Section 8.3.4	OB31 operations for Scenario 4 – 15 Mtpa ore crushed at OB31 with new crusher and transported via an overland conveyor to OB18. No dust control, Standard dust control, Leading dust control.
Section 8.4	Summary of the presented results.

8.1 Existing Operations

The modelled results for the existing operations in Figure 8.1 are presented in Table 8.2 and Figure 8.2. The existing operations include:

- Jimblebar operations
- Eastern Ridge operations
- Whaleback operations
- OB18 operations.

The PM_{10} concentration results for the receptors are compared to the assessment guidelines as outlined in Table 2.2. The results include maximum and various percentiles of predicted 24-hour ground level concentrations.

Key aspects of the results for existing operations, include:

- The assessment guidelines are predicted to not be met at two of the receptor locations.
- Both assessment guidelines are predicted to be met at the Eastern Pilbara Accommodation Village (Receptor 9, i.e. this will be the closest sensitive receptor to the OB31 operations).

Table 8.2: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Existing Operations

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	30	34	**63**	41
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	69%	126%	81%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	49%	90%	58%
99^{th} percentile	**71**	36	30	26	29	**56**	34
95^{th} percentile	**54**	29	27	24	26	46	31
90^{th} percentile	44	26	24	22	23	41	28
70^{th} percentile	30	23	20	20	20	29	24
Average	28	22	20	20	20	26	23
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

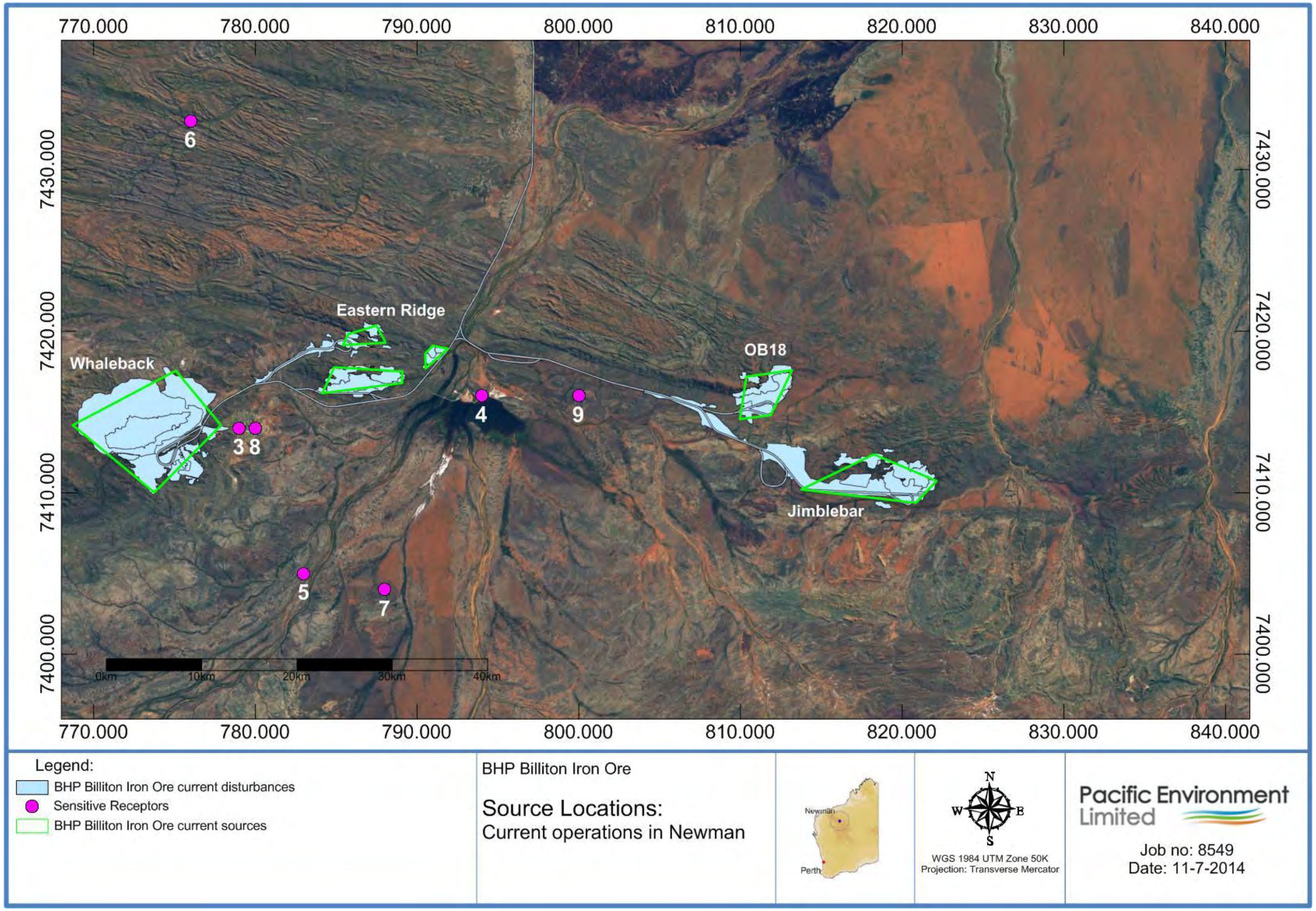

Figure 8.1: Existing Operations Source Locations

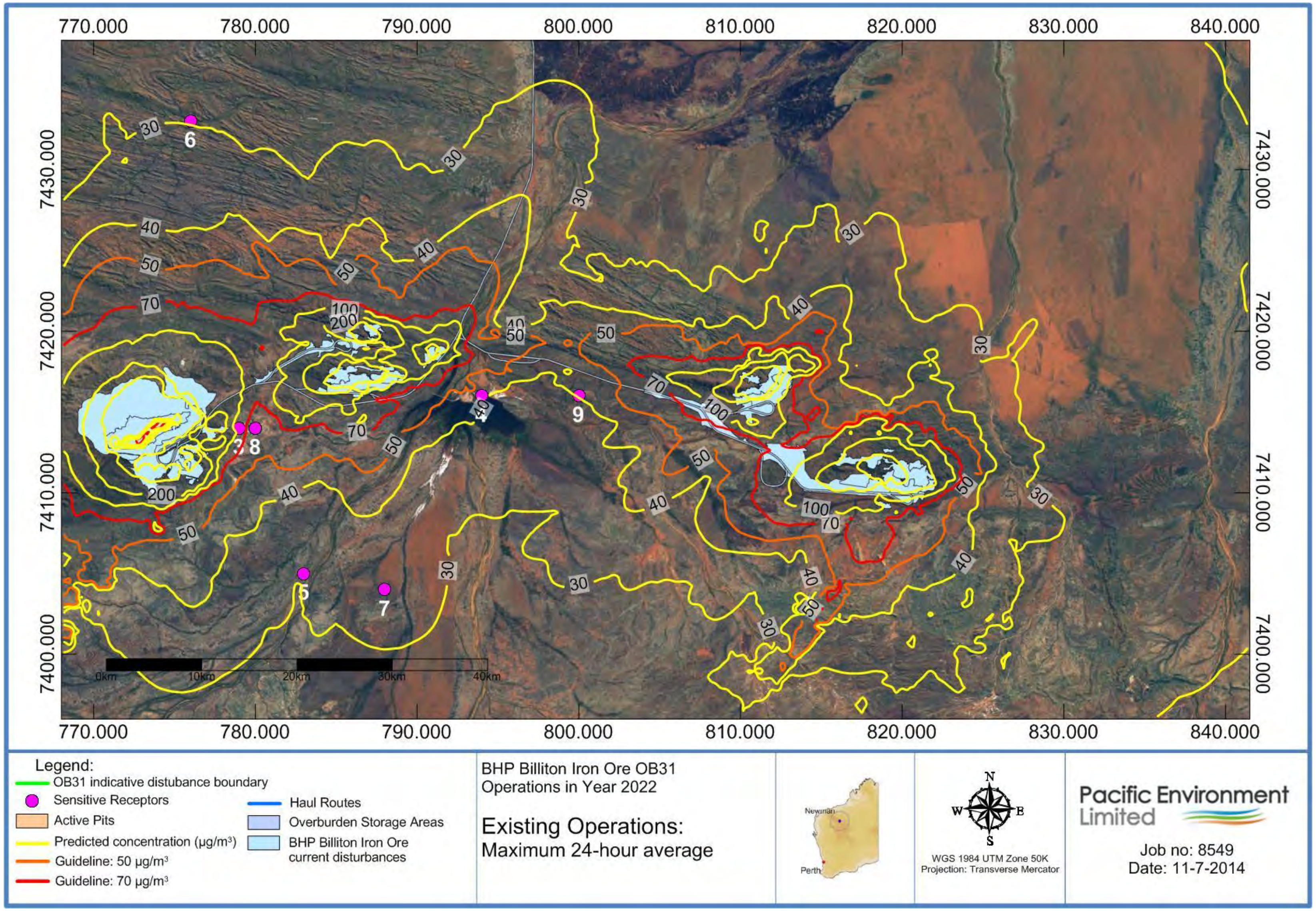

Figure 8.2: Predicted Maximum Daily PM_{10} Concentrations – Existing Operation

8.2 OB31 Operations Standalone

8.2.1 Scenario 1 No Dust Controls

The modelled results for Scenario 1 (15 Mtpa ore hauled via road from OB31 to OB18 and crushed at OB18) as standalone (i.e. no surrounding operations or background) for no dust controls are presented in Table 8.3 and Figure 8.3.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.

Table 8.3: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 1 – OB31 Operations Standalone with No Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	7.5	15.0	10.6	3.5	15.6	7.9	24.2
Maximum (as % of 50 µg/m³)	15%	30%	21%	7%	31%	16%	48%
Maximum (as % of 70 µg/m³)	11%	21%	15%	5%	22%	11%	35%
99th percentile	5.5	13.4	7.7	3.0	7.1	5.9	19.9
95th percentile	2.9	7.1	3.2	2.2	3.7	3.1	11.8
90th percentile	2.1	5.3	2.3	1.9	2.8	2.3	8.8
70th percentile	0.8	2.3	0.5	1.0	0.5	0.9	4.0
Average	0.8	1.9	0.7	0.7	0.8	0.8	3.2

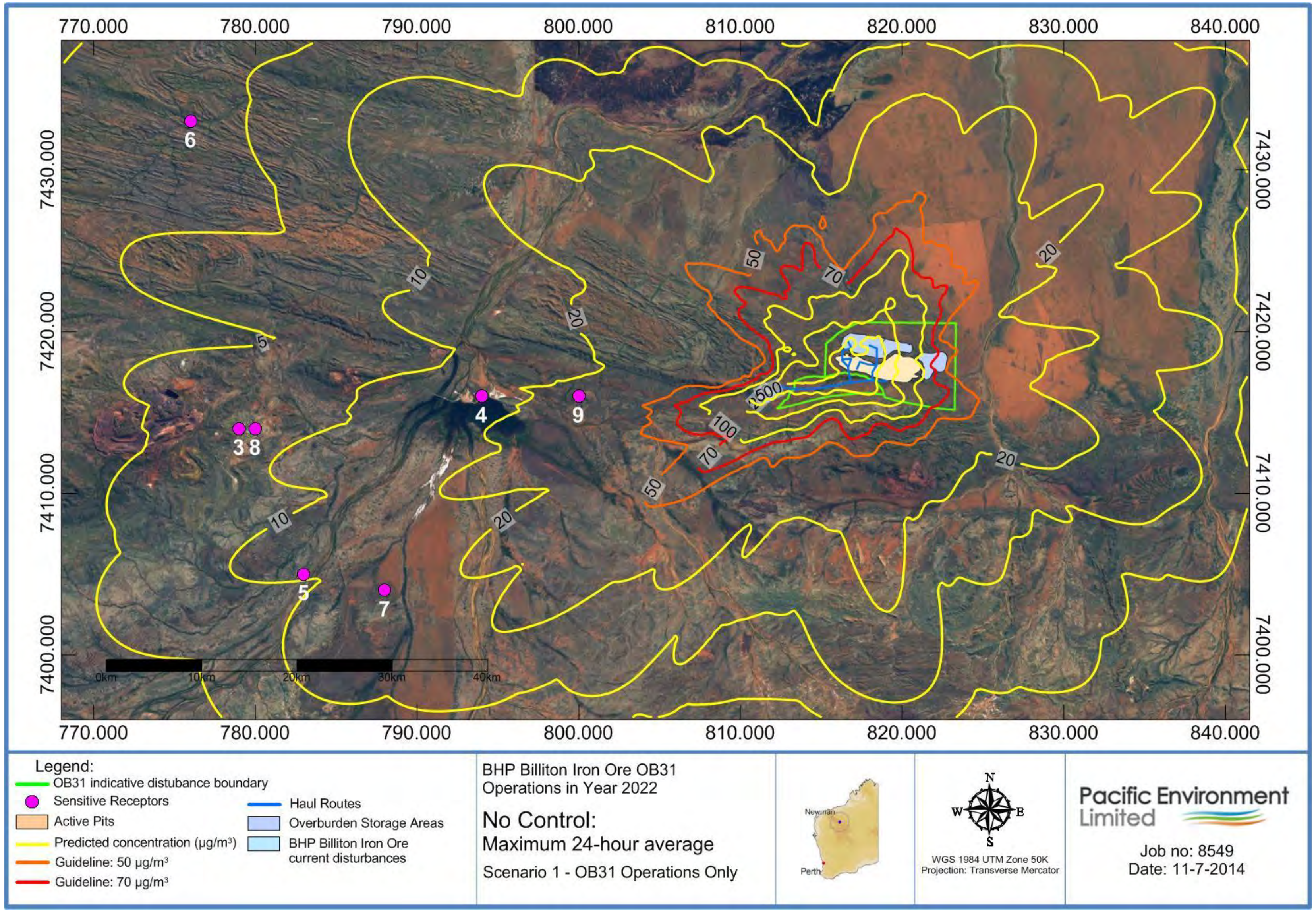

Figure 8.3: Predicted Maximum Daily PM_{10} Concentrations – Scenario 1 – OB31 Operations Standalone, with No Dust Control

8.2.2 Scenario 1 Standard Dust Controls

The modelled results for Scenario 1 (15 Mtpa ore hauled via road from OB31 to OB18 and crushed at OB18) as standalone (no surrounding operations or background) for standard dust controls are presented in Table 8.4 and Figure 8.4.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The level of impact from the OB31 operations at the Eastern Pilbara Accommodation Village (Receptor 9) is approximately halved with standard dust controls applied, compared to the no dust controls option.

Table 8.4: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 1 OB31 Operations Standalone with Standard Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	4.2	8.3	5.9	1.9	8.7	4.4	12.5
Maximum (as % of 50 µg/m³)	8%	17%	12%	4%	17%	9%	25%
Maximum (as % of 70 µg/m³)	6%	12%	8%	3%	12%	6%	18%
99th percentile	3.0	7.4	4.2	1.7	3.9	3.3	10.9
95th percentile	1.6	3.9	1.8	1.2	2.0	1.7	6.6
90th percentile	1.2	2.9	1.3	1.1	1.5	1.2	4.8
70th percentile	0.5	1.3	0.3	0.5	0.3	0.5	2.2
Average	0.4	1.1	0.4	0.4	0.4	0.4	1.8

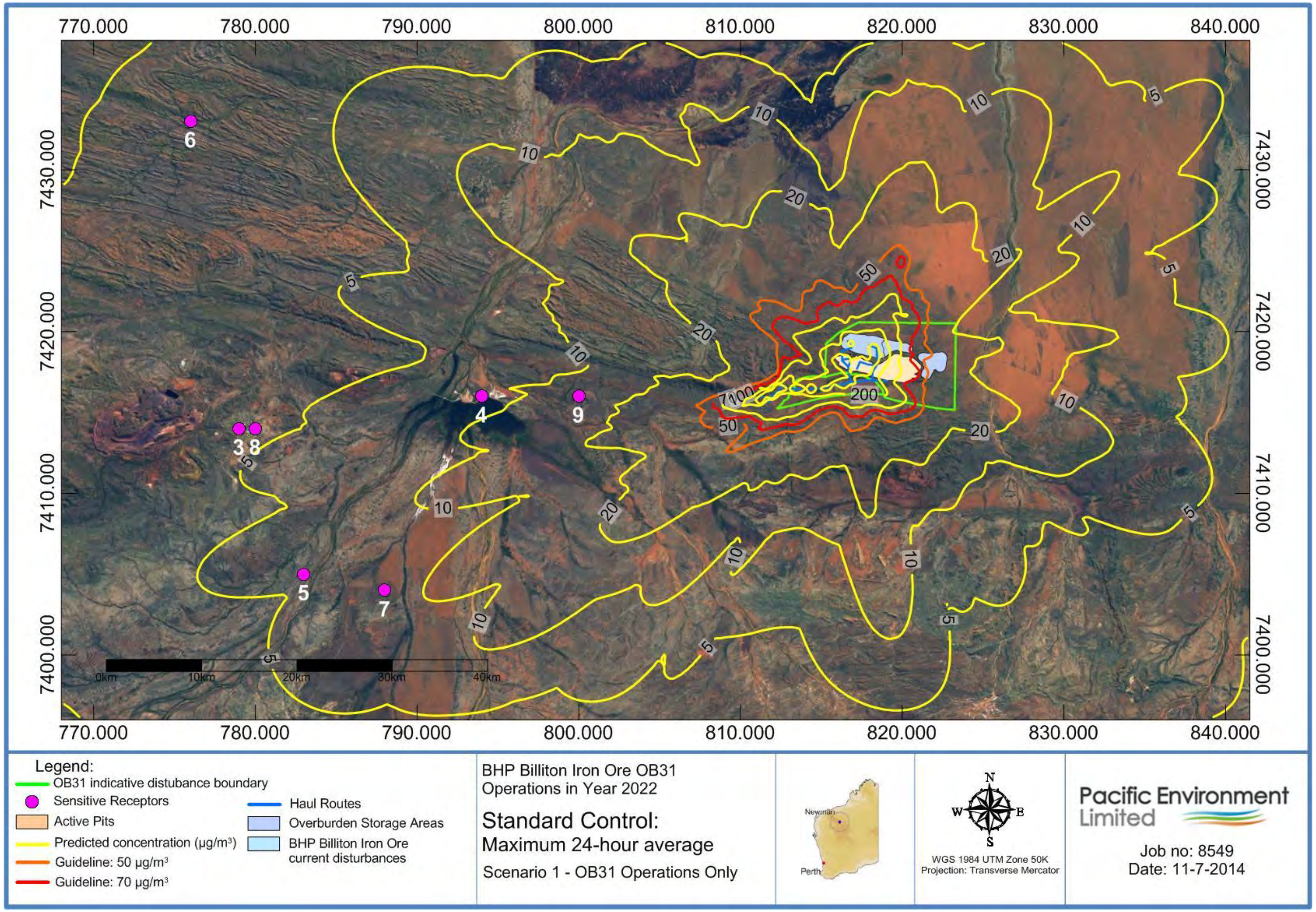

Figure 8.4: Predicted Maximum Daily PM_{10} Concentrations – Scenario 1 – OB31 Operations Standalone, with Standard Dust Control

8.2.3 Scenario 1 Leading Dust Controls

The modelled results for Scenario 1 (15 Mtpa ore hauled via road from OB31 to OB18 and crushed at OB18) as standalone (no surrounding operations or background) for leading dust controls are presented in Table 8.5 and Figure 8.5.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- Compared to the standard dust controls the leading dust controls offer additional reductions in impacts.

Table 8.5: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 1 – OB31 Operations Standalone with Leading Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	1.2	2.5	1.8	0.6	2.7	1.3	3.6
Maximum (as % of 50 µg/m³)	2%	5%	4%	1%	5%	3%	7%
Maximum (as % of 70 µg/m³)	2%	4%	3%	1%	4%	2%	5%
99th percentile	0.9	2.1	1.2	0.5	1.1	0.9	3.2
95th percentile	0.5	1.2	0.6	0.4	0.7	0.5	2.0
90th percentile	0.4	0.9	0.4	0.3	0.5	0.4	1.5
70th percentile	0.2	0.4	0.1	0.2	0.1	0.2	0.7
Average	0.1	0.3	0.1	0.1	0.1	0.1	0.5

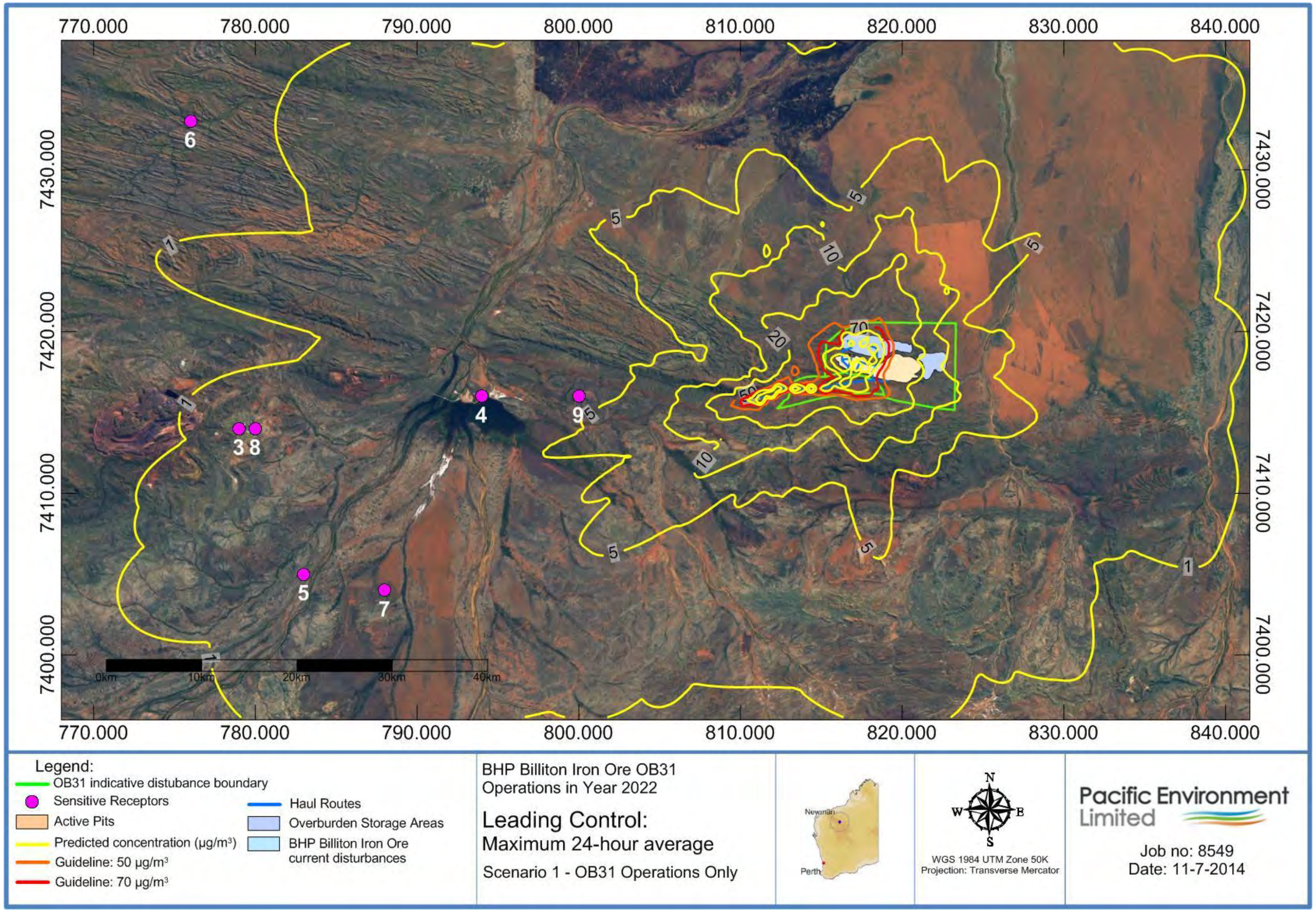

Figure 8.5: Predicted Maximum Daily PM_{10} Concentrations – Scenario 1 - OB31 Operations Standalone, with Leading Dust Control

8.2.4 Scenario 2 No Dust Controls

The modelled results for Scenario 2 (15 Mtpa ore hauled via road from OB31 to OB18, after being crushed with new crusher at OB31) as standalone (no surrounding operations or background) for no dust controls are presented in Table 8.6 and Figure 8.6.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The crushing of ore at OB31 before transport to OB18 for load out, as assessed, involves additional haulage and materials handling which increases the dust emissions and the predicted level of PM_{10} impacts compared to Scenario 1.

Table 8.6: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 2 – OB31 Operations Standalone with No Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	10.0	20.3	14.2	4.8	20.9	10.6	30.2
Maximum (as % of 50 µg/m³)	20%	41%	28%	10%	42%	21%	60%
Maximum (as % of 70 µg/m³)	14%	29%	20%	7%	30%	15%	43%
99th percentile	7.5	16.4	8.3	4.2	9.9	8.0	25.7
95th percentile	3.8	9.4	4.2	3.1	4.8	4.0	15.4
90th percentile	2.7	6.3	2.6	2.6	2.5	2.8	10.4
70th percentile	1.1	2.4	0.6	1.2	0.5	1.1	4.1
Average	0.9	2.3	0.8	0.9	0.9	1.0	3.7

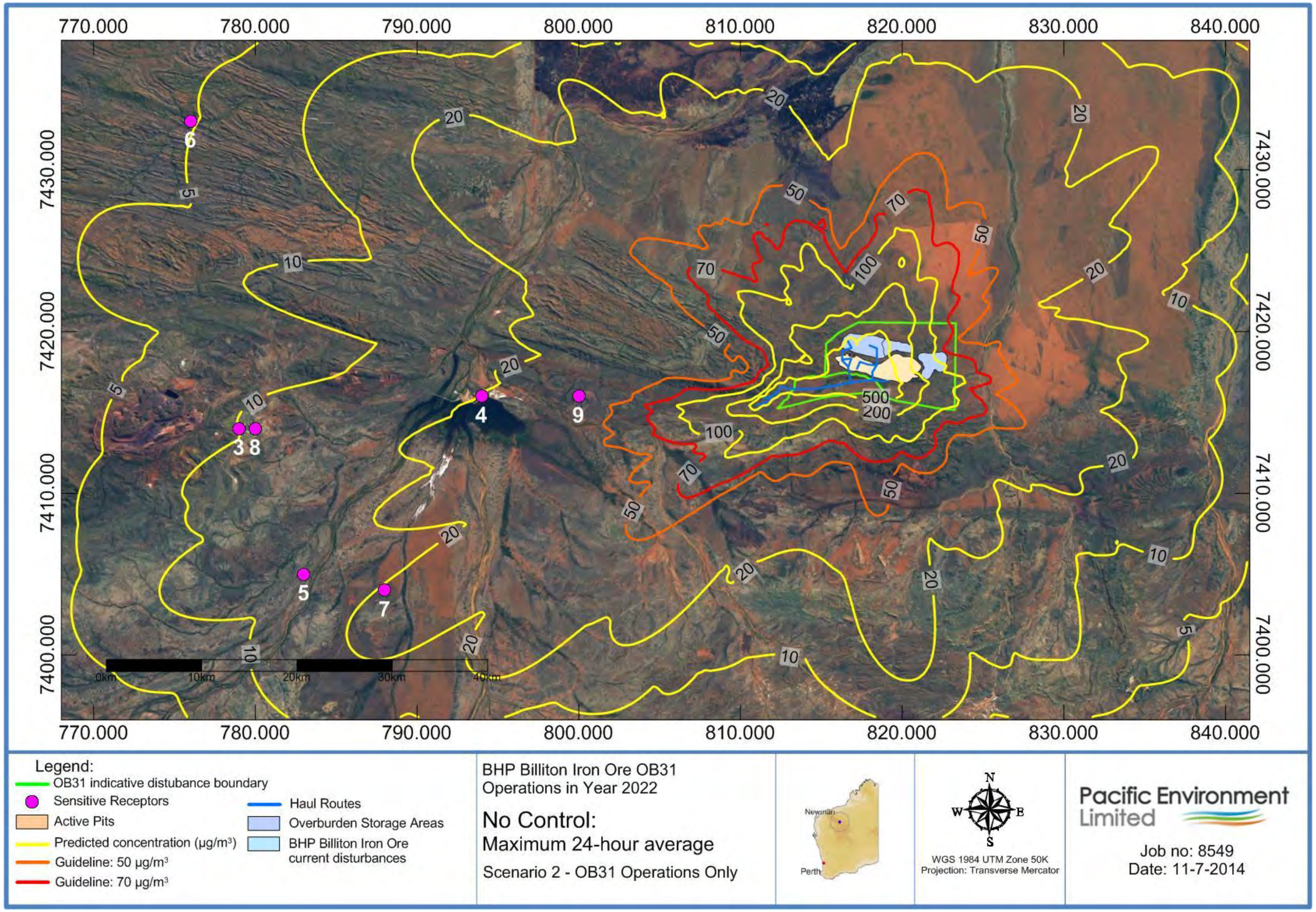

Figure 8.6: Predicted Maximum Daily PM_{10} concentrations – Scenario 2 – OB31 Operations Standalone, with No Dust Control

8.2.5 Scenario 2 Standard Dust Controls

The modelled results for Scenario 2 (15 Mtpa ore hauled via road from OB31 to OB18, after being crushed with new crusher at OB31) as standalone (no surrounding operations or background) for standard dust controls are presented in Table 8.7 and Figure 8.7.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The crushing of ore at OB31 before transport to OB18 for load out, as assessed, involves additional haulage and materials handling which increases the dust emissions and the predicted level of PM_{10} impacts compared to Scenario 1.
- Similar to the outcome for Scenario 1, the level of PM_{10} impacts is approximately halved with standard controls applied and compared to no controls.

Table 8.7: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 2 OB31 Operations Standalone with Standard Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	5.5	11.0	7.7	2.6	11.4	5.8	15.9
Maximum (as % of 50 µg/m³)	11%	22%	15%	5%	23%	12%	32%
Maximum (as % of 70 µg/m³)	8%	16%	11%	4%	16%	8%	23%
99^{th} percentile	4.1	8.8	4.5	2.2	5.4	4.3	13.8
95^{th} percentile	2.1	5.2	2.2	1.7	2.6	2.2	8.1
90^{th} percentile	1.4	3.4	1.4	1.4	1.4	1.5	5.6
70^{th} percentile	0.6	1.3	0.3	0.7	0.3	0.6	2.2
Average	0.5	1.2	0.5	0.5	0.5	0.5	2.0

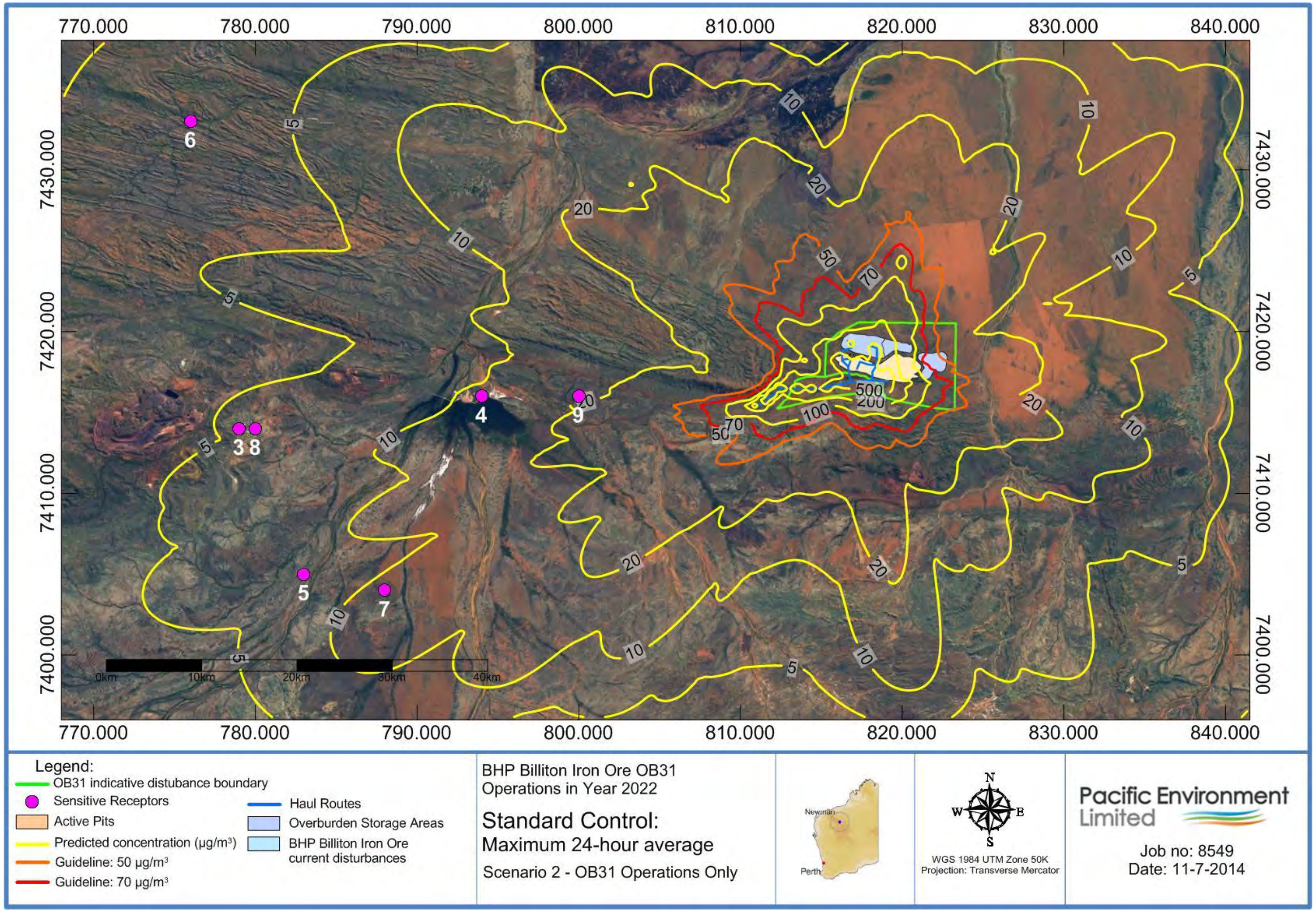

Figure 8.7: Predicted Maximum Daily PM_{10} concentrations – Scenario 2 – OB31 Operations Standalone, with Standard Dust Control

8.2.6 Scenario 2 Leading Dust Controls

The modelled results for Scenario 2 (15 Mtpa ore hauled via road from OB31 to OB18, after being crushed with new crusher at OB31) as standalone (no surrounding operations or background) for leading dust controls are presented in Table 8.8 and Figure 8.8.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The crushing of ore at OB31 before transport to OB18 for load out, as assessed, involves additional haulage and materials handling which increases the dust emissions and the predicted level of PM_{10} impacts compared to Scenario 1.
- Compared to the standard dust controls the leading dust controls offer additional reductions in impacts.

Table 8.8: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 2 – OB31 Operations Standalone with Leading Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	1.5	2.9	2.1	0.7	3.2	1.6	4.0
Maximum (as % of 50 µg/m³)	3%	6%	4%	1%	6%	3%	8%
Maximum (as % of 70 µg/m³)	2%	4%	3%	1%	5%	2%	6%
99^{th} percentile	1.1	2.3	1.2	0.6	1.4	1.1	3.6
95^{th} percentile	0.6	1.4	0.6	0.5	0.7	0.6	2.2
90^{th} percentile	0.4	0.9	0.4	0.4	0.4	0.4	1.4
70^{th} percentile	0.2	0.4	0.1	0.2	0.1	0.2	0.6
Average	0.1	0.3	0.1	0.1	0.1	0.1	0.5

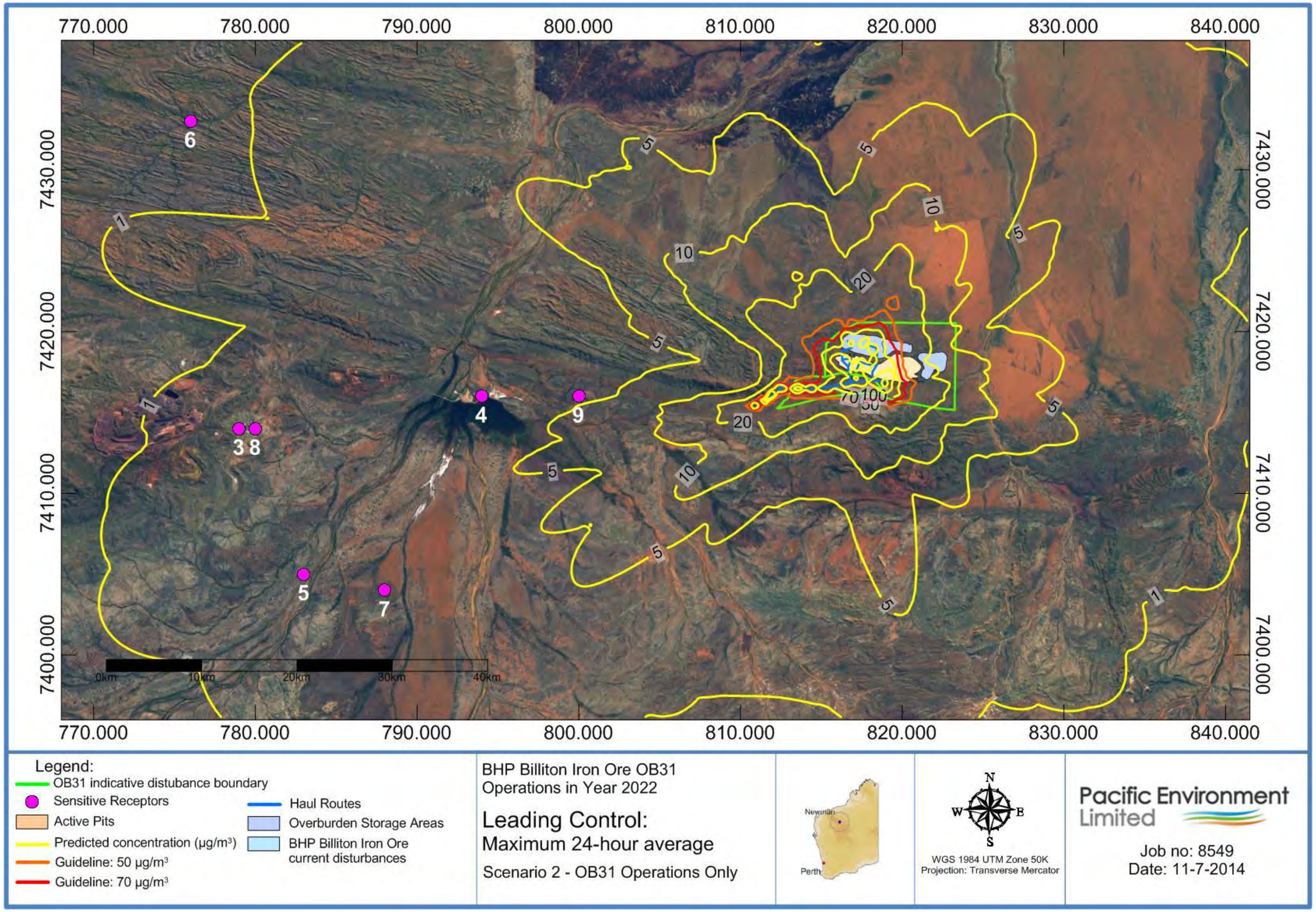

Figure 8.8: Predicted Maximum Daily PM_{10} Concentrations – Scenario 2 - OB31 Operations Standalone, with Leading Dust Control

8.2.7 Scenario 3 No Dust Controls

The modelled results for Scenario 3 (15 Mtpa ore transported via overland conveyor from OB31 to OB18 and crushed at OB18) as standalone (no surrounding operations or background) for no dust controls are presented in Table 8.9 and Figure 8.9.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The reduction in ore haul road transport, compared to Scenario 1 and 2, contributes to a lower level of impact being predicted.

Table 8.9: Predicted 24-hour PM10 Concentrations (µg/m³) at Receptors – Scenario 3 – OB31 Operations Standalone with No Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	4.4	8.0	6.5	2.8	9.3	4.6	13.1
Maximum (as % of 50 µg/m³)	9%	16%	13%	6%	19%	9%	26%
Maximum (as % of 70 µg/m³)	6%	11%	9%	4%	13%	7%	19%
99th percentile	3.3	6.7	4.2	2.3	4.4	3.6	9.5
95th percentile	1.7	4.0	2.1	1.8	2.2	1.8	5.9
90th percentile	1.2	2.7	1.3	1.4	1.5	1.3	4.4
70th percentile	0.5	1.2	0.3	0.7	0.3	0.5	2.0
Average	0.4	1.0	0.4	0.5	0.5	0.5	1.6

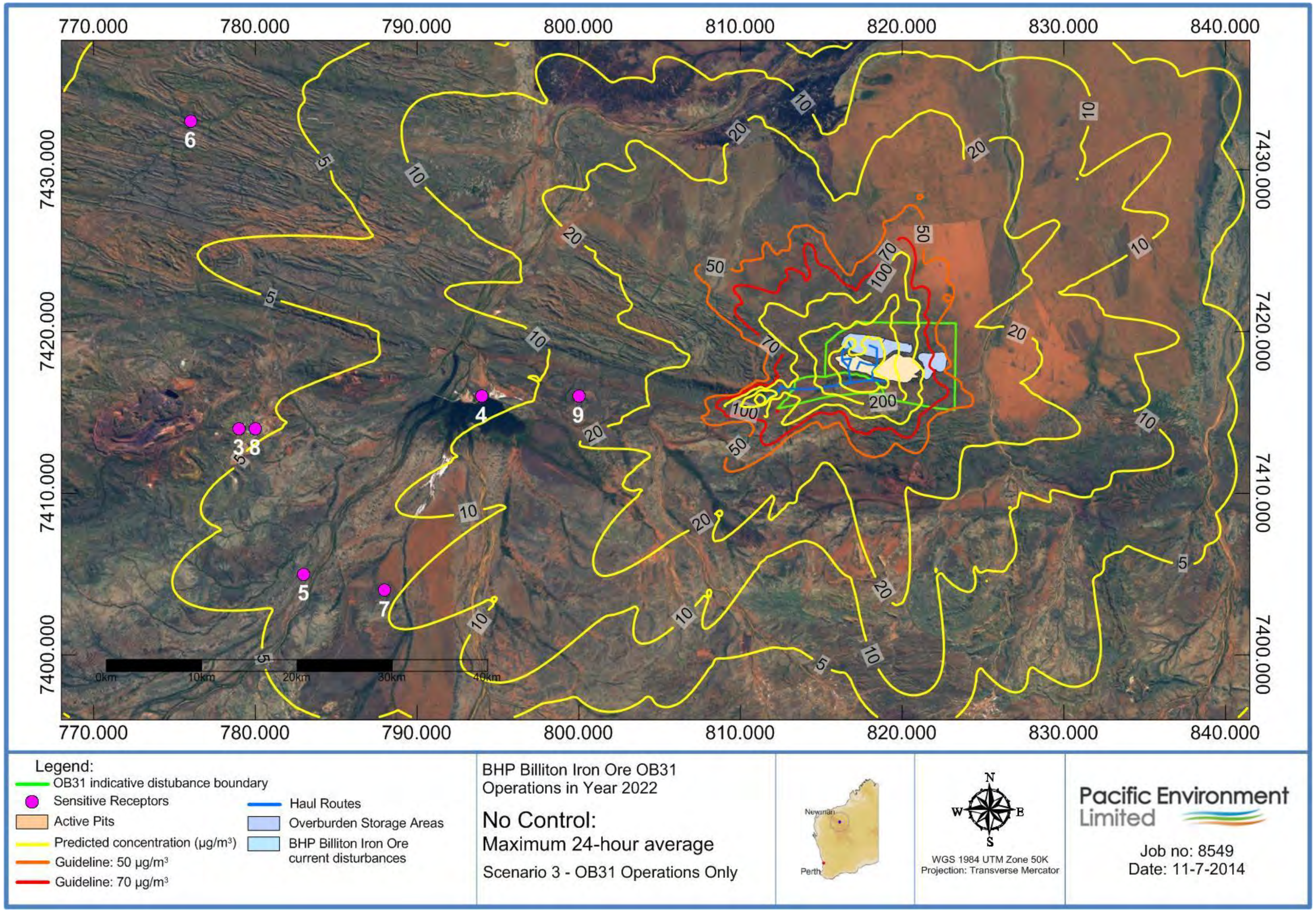

Figure 8.9: Predicted Maximum Daily PM_{10} Concentrations – Scenario 3 – OB31 Operations Standalone, with No Dust Control

8.2.8 Scenario 3 Standard Dust Controls

The modelled results for Scenario 3 (15 Mtpa ore transported via overland conveyor from OB31 to OB18 and crushed at OB18) as standalone (no surrounding operations or background) for standard dust controls are presented in Table 8.10 and Figure 8.10.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The reduction in ore haul road transport, compared to Scenario 1 and 2, contributes to a lower level of impacts.
- The level of PM_{10} impacts is approximately halved for Receptor 9 with standard controls applied and compared to no controls.

Table 8.10: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 3 OB31 Operations Standalone with Standard Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	2.6	4.7	3.9	1.6	5.5	2.7	7.4
Maximum (as % of 50 µg/m³)	5%	9%	8%	3%	11%	5%	15%
Maximum (as % of 70 µg/m³)	4%	7%	6%	2%	8%	4%	11%
99th percentile	1.9	3.8	2.4	1.3	2.5	2.1	5.5
95th percentile	1.0	2.3	1.2	1.1	1.3	1.0	3.4
90th percentile	0.7	1.6	0.8	0.9	0.9	0.7	2.5
70th percentile	0.3	0.7	0.2	0.4	0.2	0.3	1.1
Average	0.3	0.6	0.2	0.3	0.3	0.3	0.9

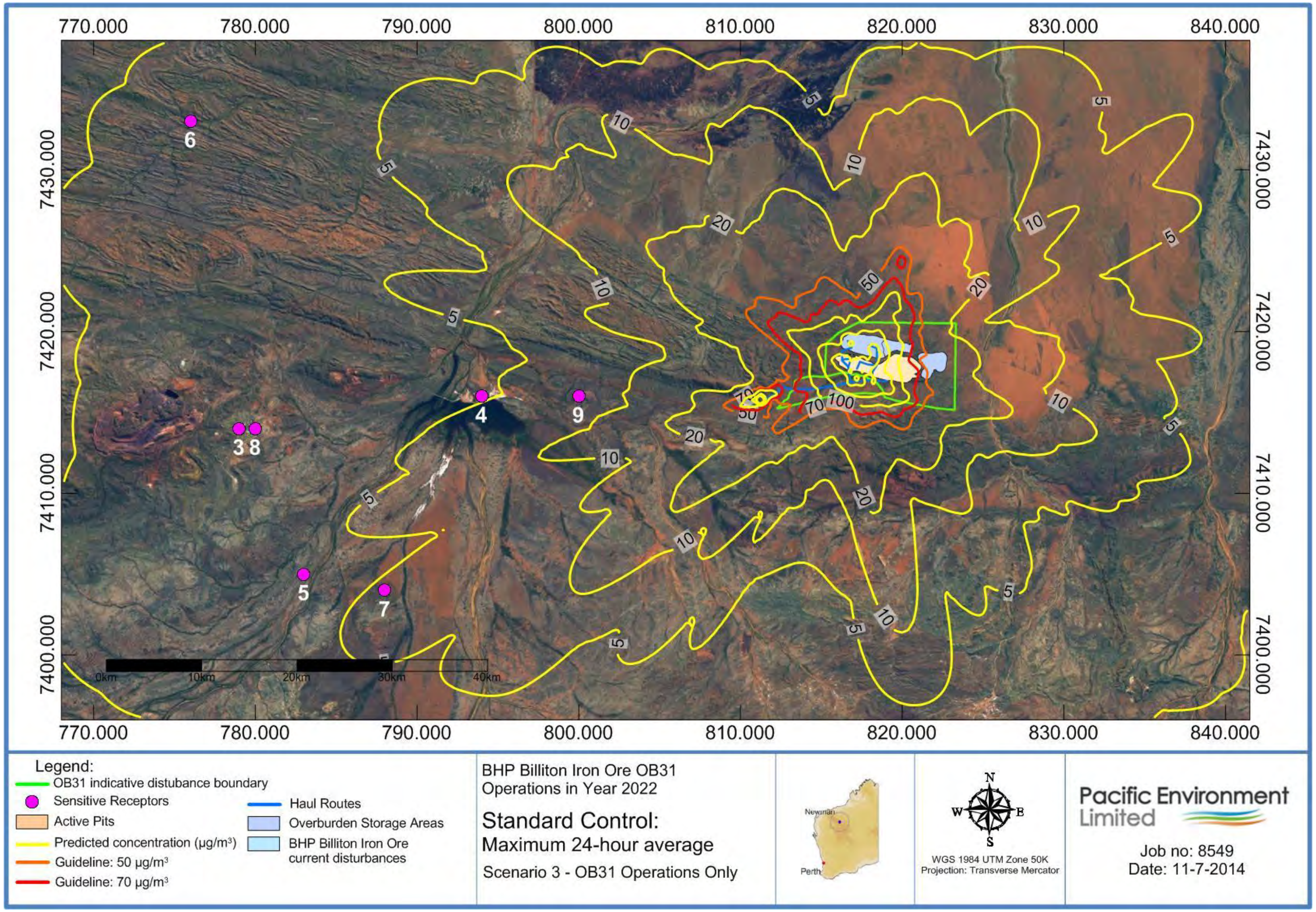

Figure 8.10: Predicted Maximum Daily PM_{10} Concentrations – Scenario 3 – OB31 Operations Standalone, with Standard Dust Control

8.2.9 Scenario 3 Leading Dust Controls

The modelled results for Scenario 3 (15 Mtpa ore transported via overland conveyor from OB31 to OB18 and crushed at OB18) as standalone (no surrounding operations or background) for leading dust controls are presented in Table 8.11 and Figure 8.11.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The reduction in ore haul road transport, compared to Scenario 1 and 2, contributes to a lower level of impacts.
- Compared to the standard dust controls the leading dust controls offer additional reductions in impacts.

Table 8.11: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 3 – OB31 Operations Standalone with Leading Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	0.9	1.7	1.3	0.6	2.0	0.9	2.5
Maximum (as % of 50 µg/m³)	2%	3%	3%	1%	4%	2%	5%
Maximum (as % of 70 µg/m³)	1%	2%	2%	1%	3%	1%	4%
99th percentile	0.6	1.3	0.8	0.5	0.8	0.7	2.0
95th percentile	0.4	0.8	0.4	0.4	0.5	0.4	1.1
90th percentile	0.2	0.5	0.3	0.3	0.3	0.2	0.9
70th percentile	0.1	0.2	0.1	0.1	0.1	0.1	0.4
Average	0.1	0.2	0.1	0.1	0.1	0.1	0.3

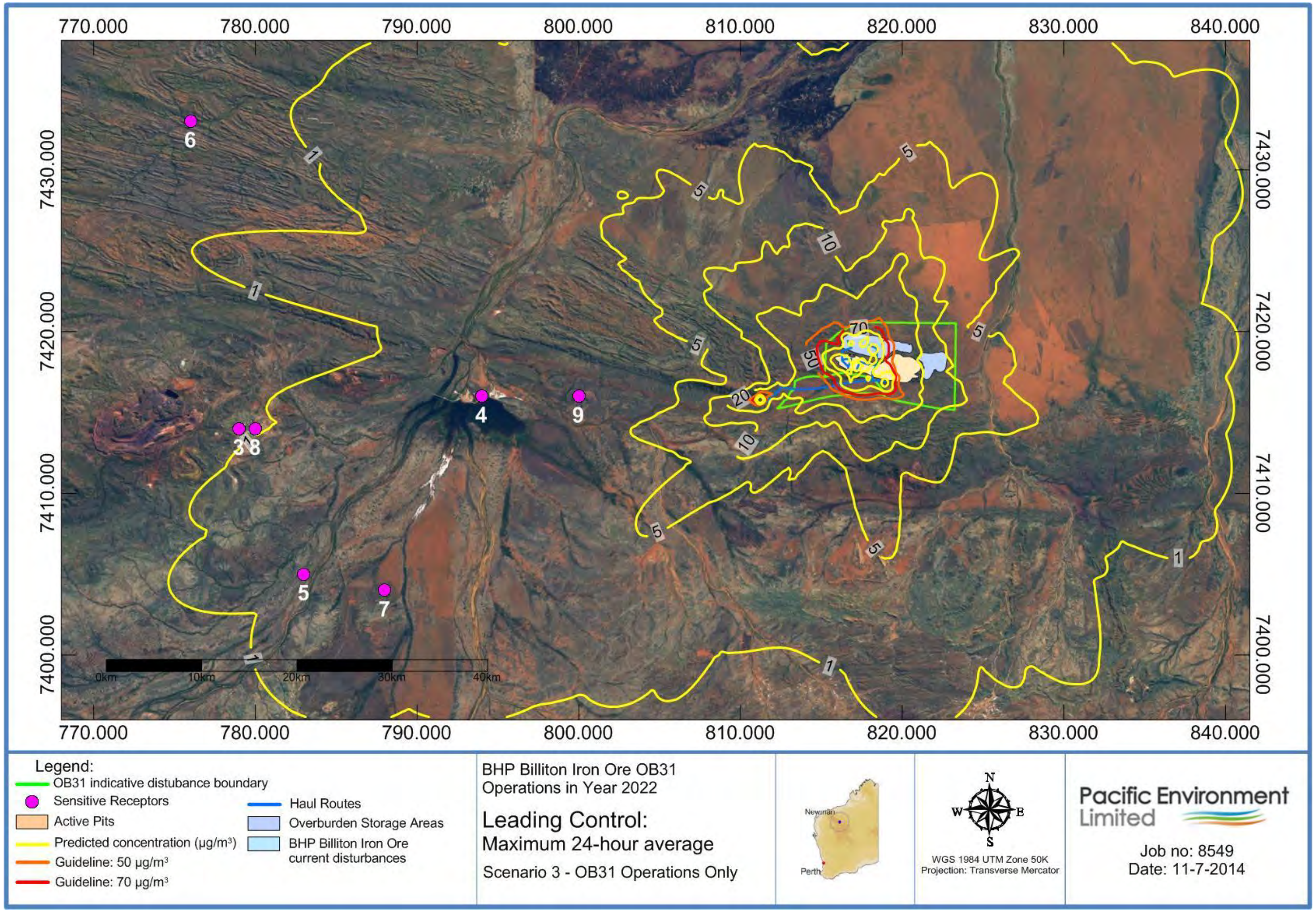

Figure 8.11: Predicted Maximum Daily PM_{10} Concentrations – Scenario 3 - OB31 Operations Standalone, with Leading Dust Control

8.2.10 Scenario 4 No Dust Controls

The modelled results for Scenario 4 (15 Mtpa ore crushed at OB31 with new crusher and transported via an overland conveyor to OB18) as standalone (no surrounding operations or background) for no dust controls are presented in Table 8.12 and Figure 8.12.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The main difference between Scenario 4 and Scenario 3 is the location of ore crushing. The OB31 crusher location is further from the receptors and hence demonstrates a small reduction in impacts compared to Scenario 3, for most receptors.

Table 8.12: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 4 – OB31 Operations Standalone with No Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	4.2	7.5	6.4	2.9	8.8	4.4	11.7
Maximum (as % of 50 µg/m³)	8%	15%	13%	6%	18%	9%	23%
Maximum (as % of 70 µg/m³)	6%	11%	9%	4%	13%	6%	17%
99th percentile	3.3	6.0	4.0	2.4	4.3	3.5	8.6
95th percentile	1.6	3.6	2.0	1.8	2.1	1.7	4.8
90th percentile	1.1	2.4	1.2	1.4	1.4	1.2	3.6
70th percentile	0.5	1.1	0.3	0.6	0.3	0.5	1.7
Average	0.4	0.9	0.4	0.5	0.4	0.4	1.3

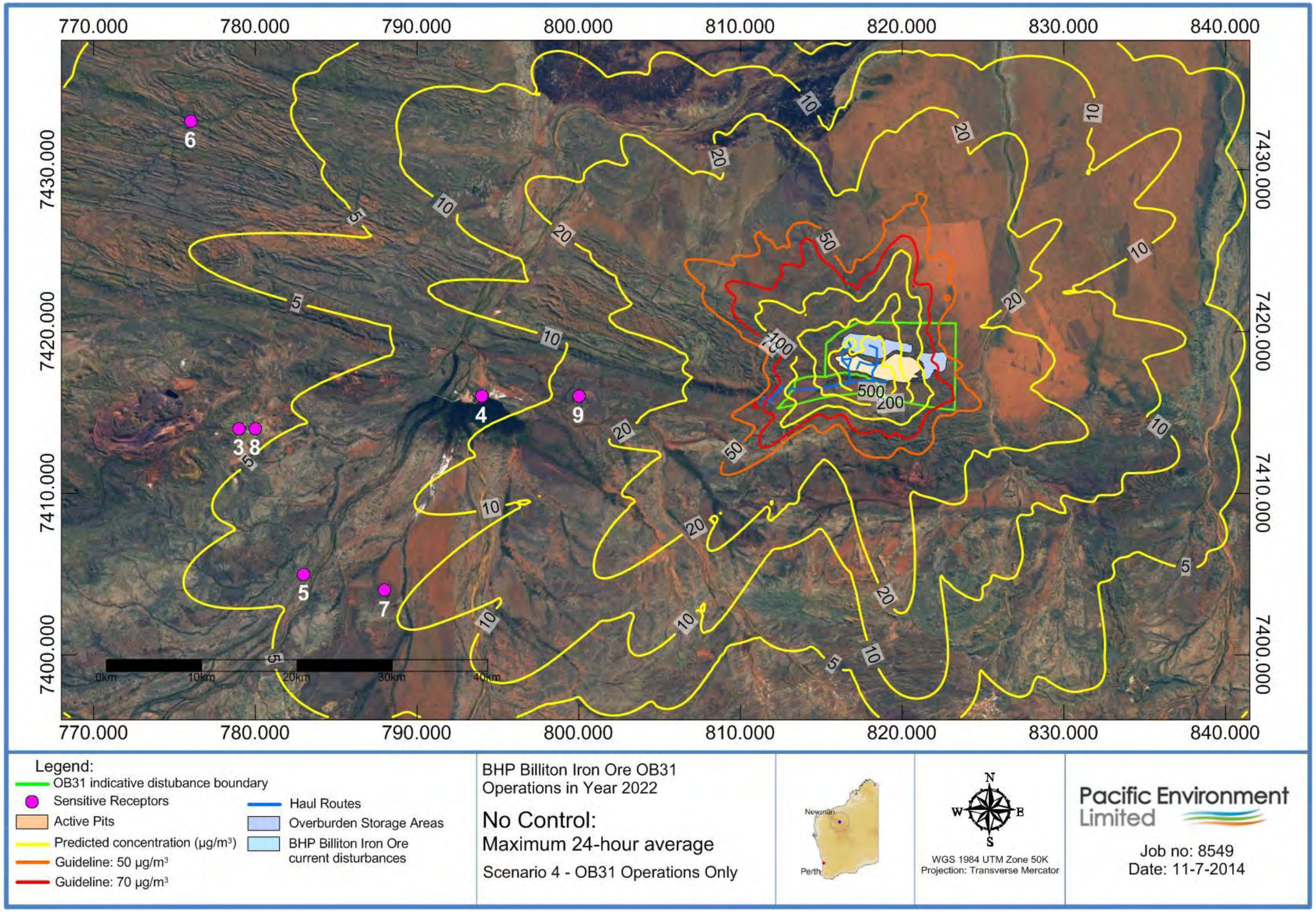

Figure 8.12: Predicted Maximum Daily PM_{10} Concentrations – Scenario 4 – OB31 Operations Standalone, with No Dust Control

8.2.11 Scenario 4 Standard Dust Controls

The modelled results for Scenario 4 (15 Mtpa ore crushed at OB31 with new crusher and transported via an overland conveyor to OB18) as standalone (no surrounding operations or background) for standard dust controls are presented in Table 8.13 and Figure 8.13.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The main difference between Scenario 4 and Scenario 3 is the location of ore crushing. The OB31 crusher location is further from the receptors and hence demonstrates a small reduction in impacts compared to Scenario 3 for most receptors.
- The levels of PM_{10} impact are reduced with standard controls compared to no controls.

Table 8.13: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 4 – OB31 Operations Standalone with Standard Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	2.6	4.7	3.9	1.6	5.5	2.7	7.4
Maximum (as % of 50 µg/m³)	5%	9%	8%	3%	11%	5%	15%
Maximum (as % of 70 µg/m³)	4%	7%	6%	2%	8%	4%	11%
99th percentile	1.9	3.8	2.4	1.3	2.5	2.1	5.5
95th percentile	1.0	2.3	1.2	1.1	1.3	1.0	3.4
90th percentile	0.7	1.6	0.8	0.9	0.9	0.7	2.5
70th percentile	0.3	0.7	0.2	0.4	0.2	0.3	1.1
Average	0.3	0.6	0.2	0.3	0.3	0.3	0.9

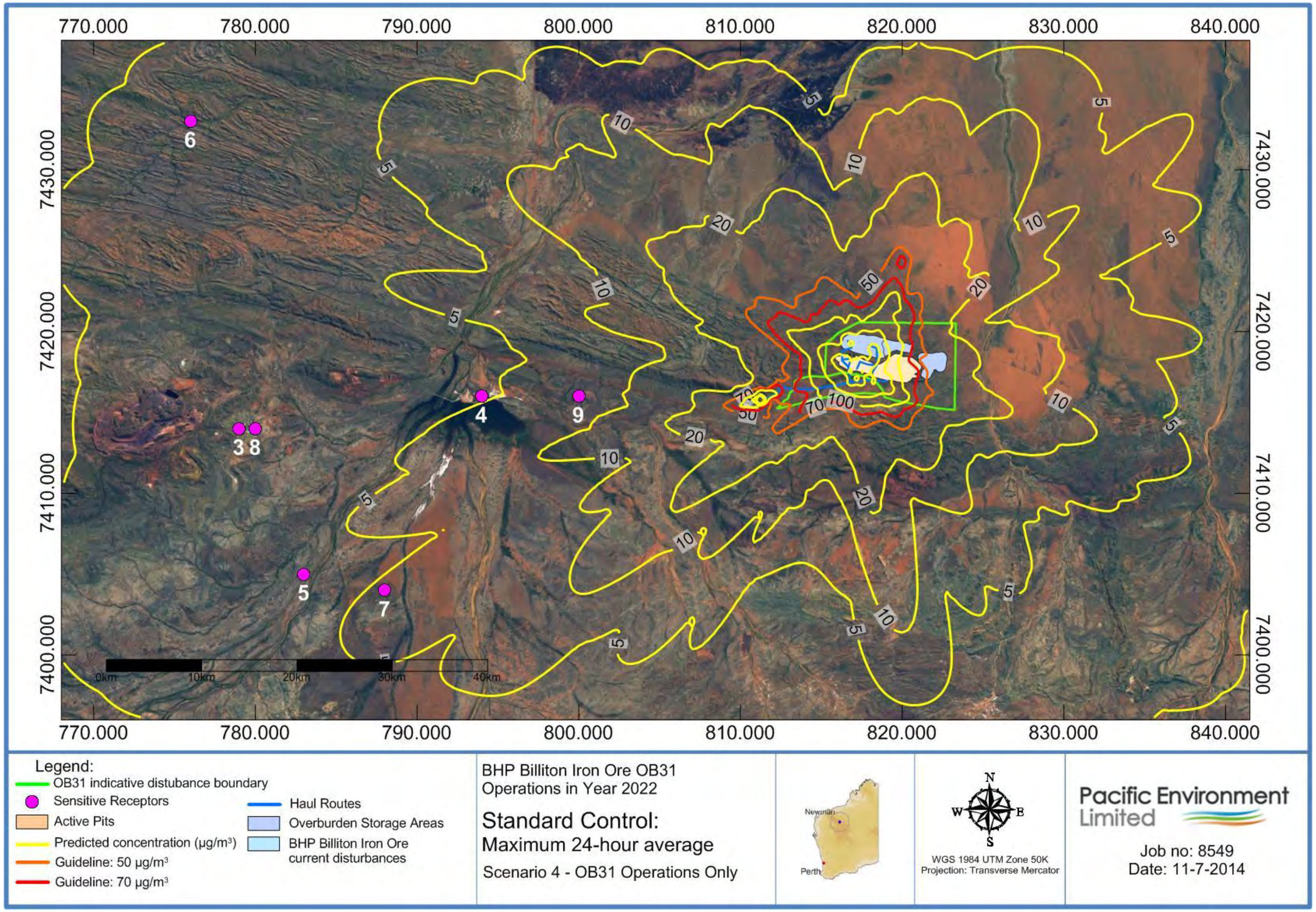

Figure 8.13: Predicted Maximum Daily PM_{10} Concentrations – Scenario 4 – OB31 Operations Standalone, with Standard Dust Control

8.2.12 Scenario 4 Leading Dust Controls

The modelled results for Scenario 4 (15 Mtpa ore crushed at OB31 with new crusher and transported via an overland conveyor to OB18) as standalone (no surrounding operations or background) for leading dust controls are presented in Table 8.14 and Figure 8.14.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment guidelines since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The main difference between Scenario 4 and Scenario 3 is the location of ore crushing. The OB31 crusher location is further from the receptors and hence demonstrates a small reduction in impacts compared to Scenario 3 for most receptors.
- Compared to the standard dust controls the leading dust controls offer additional reductions in impacts.

Table 8.14: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 4 – OB31 Operations Standalone with Leading Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	0.9	1.6	1.3	0.6	1.9	0.9	2.3
Maximum (as % of 50 µg/m³)	2%	3%	3%	1%	4%	2%	5%
Maximum (as % of 70 µg/m³)	1%	2%	2%	1%	3%	1%	3%
99th percentile	0.6	1.2	0.8	0.5	0.8	0.7	1.6
95th percentile	0.3	0.7	0.4	0.4	0.4	0.4	1.0
90th percentile	0.2	0.5	0.2	0.3	0.3	0.2	0.7
70th percentile	0.1	0.2	0.1	0.1	0.1	0.1	0.3
Average	0.1	0.2	0.1	0.1	0.1	0.1	0.3

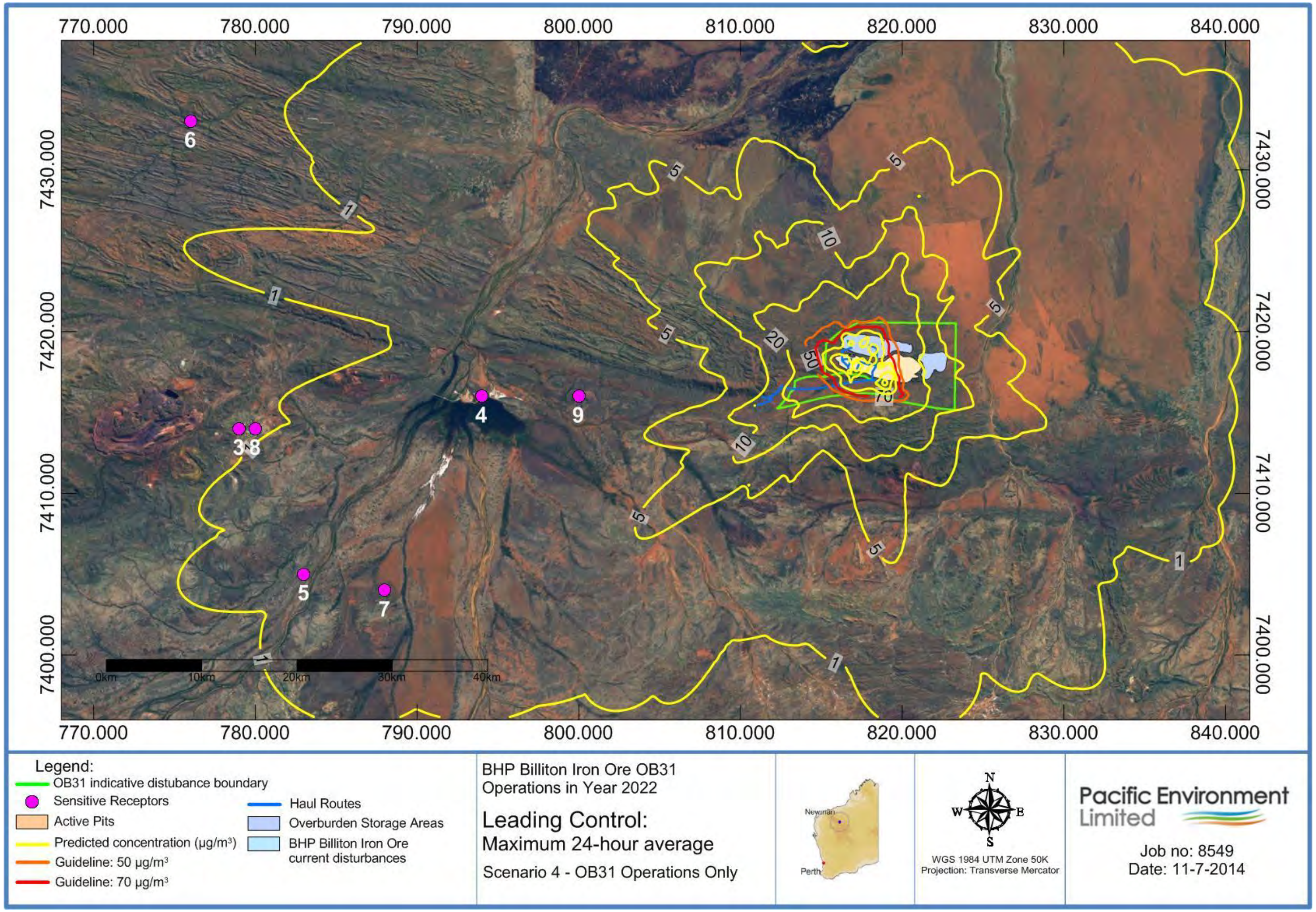

Figure 8.14: Predicted Maximum Daily PM_{10} Concentrations – Scenario 4 - OB31 Operations Standalone, with Leading Dust Control

8.3 OB31 Operations Cumulative with Existing Operations (Excluding OB18)

For the cumulative assessment the existing surrounding mining operations as presented in Section 8.1 were applied. These included the:

- Jimblebar operations
- Eastern Ridge operations
- Whaleback operations.

The OB18 operations were excluded from the existing operations for the cumulative scenario since the OB31 operations will replace the OB18 operations.

8.3.1 Scenario 1

The modelled results for Scenario 1 (15 Mtpa ore hauled via road from OB31 to OB18 and crushed at OB18) as cumulative (including surrounding existing operations as explained above and background) are presented as follows:

- OB31 cumulative results with existing operations excluding OB18 for Scenario 1 with no dust controls for OB31 are presented in Table 8.15 (see Appendix G for contour plot).
- OB31 cumulative results with existing operations excluding OB18 for Scenario 1 with standard dust controls for OB31 are presented in Table 8.16 and Figure 8.15.
- OB31 cumulative results with existing operations excluding OB18 for Scenario 1 with leading dust controls for OB31 are presented in Table 8.17 (see Appendix G for contour plot).

The PM_{10} concentration results for the receptors are compared to the assessment guidelines as presented in Table 2.2. The results include maximum and various percentiles of predicted 24-hour ground level concentrations.

Key aspects of the results include:

- Compared with the existing operations (as presented in Section 8.1) there is an increase in the maximum predicted PM_{10} concentration at Receptor 9 from 41 to 48 $\mu g/m^3$ (for no dust controls).
- Compared with the existing operations there is a decrease in impacts at Receptor 9 for standard and leading dust controls at OB31. The OB31 operations will be located further from Receptor 9 than the OB18 operations (see Section 8.1).
- The assessment guidelines are predicted to be met at Receptor 9.
- Scenario 1 demonstrated the second largest impacts of the assessed scenarios.

Table 8.15: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 1 – Cumulative Existing Operations Excluding OB18, with No Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	33	30	36	**64**	48
Maximum (as % of 50 µg/m³)	160%	87%	65%	60%	72%	128%	97%
Maximum (as % of 70 µg/m³)	115%	62%	47%	43%	52%	91%	69%
99th percentile	**71**	37	30	26	30	**56**	40
95th percentile	**54**	31	28	24	27	46	34
90th percentile	44	28	25	23	24	41	31
70th percentile	31	24	21	21	21	30	25
Average	28	23	20	20	20	27	23
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

Table 8.16: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 1 - Cumulative Existing Operations Excluding OB18, with Standard Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	30	35	**64**	39
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	69%	127%	78%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	49%	91%	56%
99th percentile	**71**	36	30	26	29	**56**	32
95th percentile	**54**	29	27	24	26	46	29
90th percentile	44	26	24	22	23	41	26
70th percentile	30	23	21	20	20	29	23
Average	28	22	20	20	20	26	22
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

Table 8.17: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 1 – Cumulative Existing Operations Excluding OB18 with Leading Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	30	33	**63**	33
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	67%	126%	66%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	48%	90%	47%
99^{th} percentile	**71**	35	30	25	29	**56**	29
95^{th} percentile	**54**	28	26	23	25	45	25
90^{th} percentile	44	24	23	22	22	40	23
70^{th} percentile	29	21	20	20	20	29	21
Average	28	21	20	20	20	26	21
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

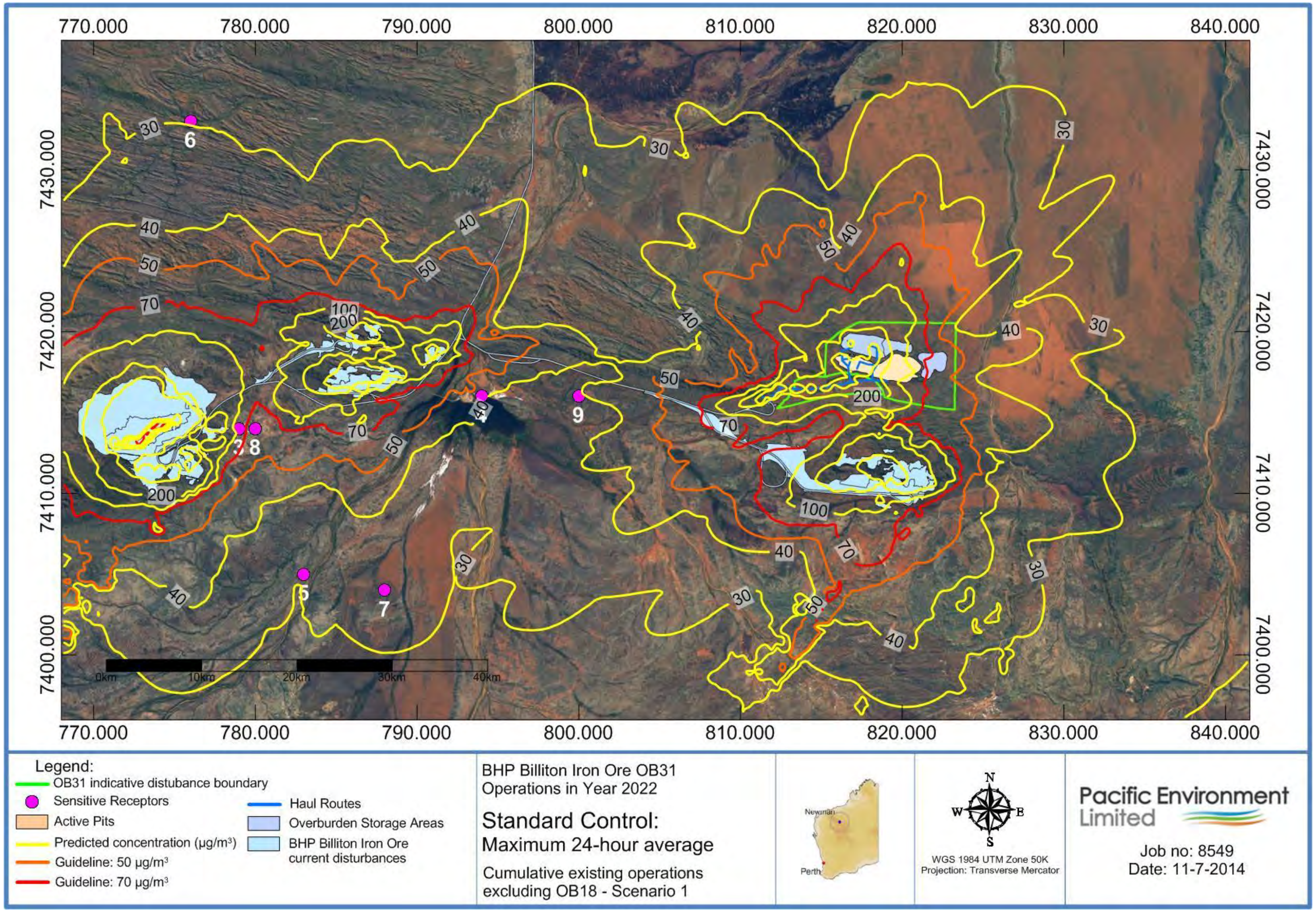

Figure 8.15: Predicted Maximum Daily PM_{10} Concentrations – Scenario 1 – Cumulative Existing Operations Excluding OB18, with Standard Dust Control

8.3.2 Scenario 2

The modelled results for Scenario 2 (15 Mtpa ore hauled via road from OB31 to OB18, after being crushed with new crusher at OB31) as cumulative (including surrounding existing operations as explained above and background) are presented as follows:

- OB31 cumulative results with existing operations excluding OB18 for Scenario 2 with no dust controls for OB31 are presented in Table 8.18 (see Appendix G for contour plot).
- OB31 cumulative results with existing operations excluding OB18 for Scenario 2 with standard dust controls for OB31 are presented in Table 8.19 and Figure 8.16.
- OB31 cumulative results with existing operations excluding OB18 for Scenario 2 with leading dust controls for OB31 are presented in Table 8.20 (see Appendix G for contour plot).

The PM_{10} concentration results for the receptors are compared to the assessment guidelines as presented in Table 2.2. The results include maximum and various percentiles of predicted 24-hour ground level concentrations.

Key aspects of the results include:

- Compared with the existing operations (as presented in Section 8.1) there is an increase to one NEPM exceedance day predicted for Receptor 9 (for no dust controls).
- Compared with the existing operations (as presented in Section 8.1) there is an increase in the maximum predicted PM_{10} concentration at Receptor 9 from 41 to 58 µg/m^3 for no controls and increase from 41 to 44 µg/m^3 for standard dust controls.
- Compared with the existing operations there is a decrease in impacts at Receptor 9 for leading dust controls at OB31.
- The assessment guidelines are predicted to be met at Receptor 9 (for standard and leading dust controls).
- Scenario 2 demonstrated the largest impacts of the assessed scenarios.

Table 8.18: Predicted 24-hour PM_{10} Concentrations (µg/m^3) at Receptors – Scenario 2 – Cumulative Existing Operations Excluding OB18 with No Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	36	30	40	**64**	**58**
Maximum (as % of 50 µg/m³)	160%	87%	73%	59%	79%	129%	116%
Maximum (as % of 70 µg/m³)	115%	62%	52%	42%	57%	92%	83%
99th percentile	**71**	40	31	26	32	**56**	45
95th percentile	**54**	33	28	24	27	46	37
90th percentile	45	30	25	23	25	42	32
70th percentile	31	24	21	21	20	30	25
Average	28	23	21	20	20	27	24
No of Exceedances of 50 µg/m³	26	-	-	-	-	12	1
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

Table 8.19: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 2 – Cumulative Existing Operations Excluding OB18 with Standard Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	30	35	**64**	44
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	71%	127%	87%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	51%	91%	62%
99th percentile	**71**	37	30	26	30	**56**	34
95th percentile	**54**	29	27	24	26	45	31
90th percentile	44	27	24	22	23	41	27
70th percentile	31	23	21	20	20	29	23
Average	28	22	20	20	20	26	22
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

Table 8.20: Predicted 24-hour PM10 Concentrations (µg/m³) at Receptors – Scenario 2 – Cumulative Existing Operations Excluding OB18 with Leading Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	29	33	**63**	33
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	67%	126%	67%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	48%	90%	48%
99th percentile	**71**	36	30	25	29	**56**	29
95th percentile	**54**	28	26	23	25	45	24
90th percentile	44	24	23	22	22	40	23
70th percentile	29	21	20	20	20	29	21
Average	28	21	20	20	20	26	21
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

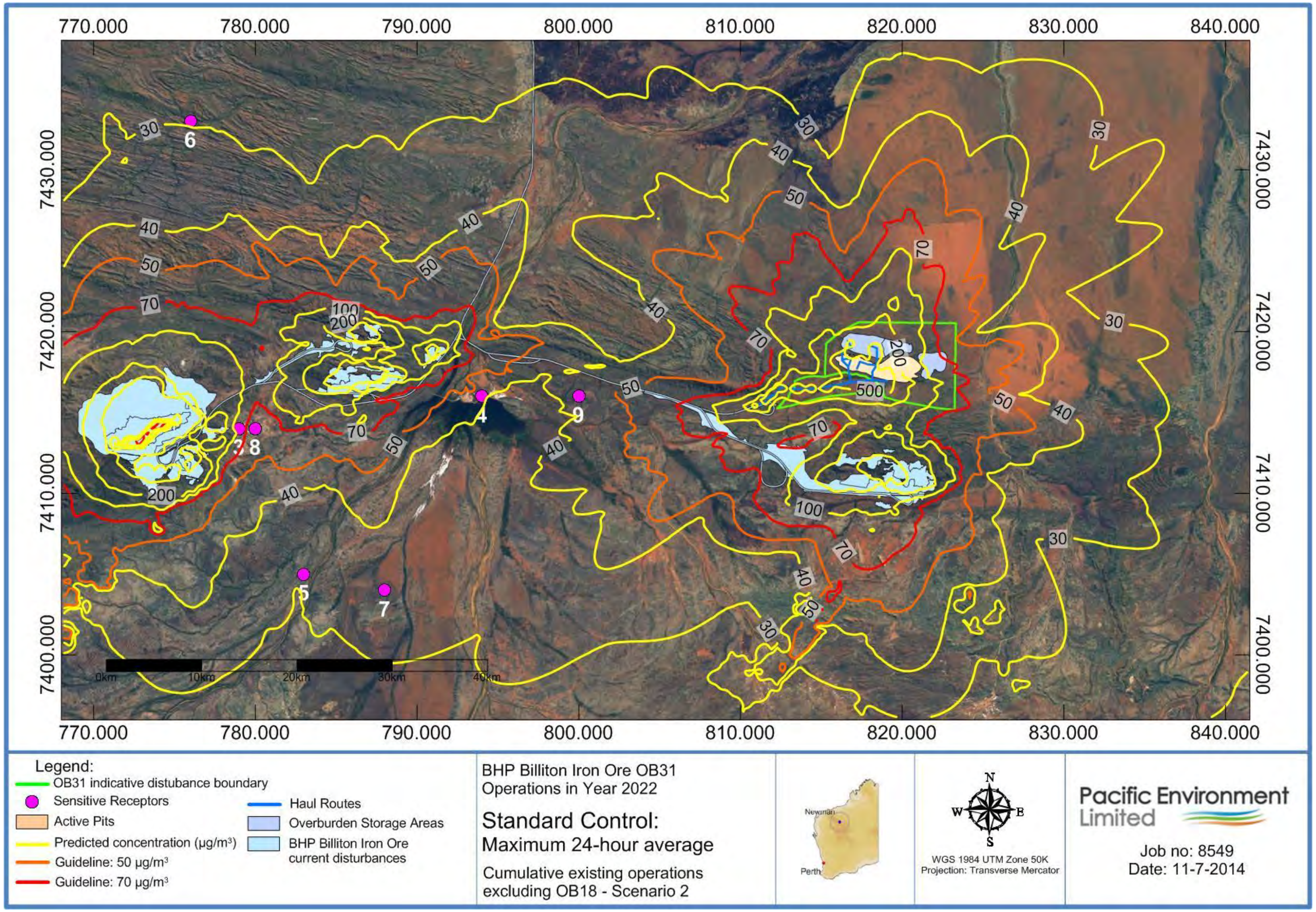

Figure 8.16: Predicted Maximum Daily PM_{10} Concentrations – Scenario 2 – Cumulative Existing Operations Excluding OB18, with Standard Dust Control

8.3.3 Scenario 3

The modelled results for Scenario 3 (15 Mtpa ore transported via overland conveyor from OB31 to OB18 and crushed at OB18) as cumulative (including surrounding existing operations as explained above and background) are presented as follows:

- OB31 cumulative results with existing operations excluding OB18 for Scenario 3 with no dust controls for OB31 are presented in Table 8.21 (see Appendix G for contour plot).
- OB31 cumulative results with existing operations excluding OB18 for Scenario 3 with standard dust controls for OB31 are presented in Table 8.22 and Figure 8.17.
- OB31 cumulative results with existing operations excluding OB18 for Scenario 3 with leading dust controls for OB31 are presented in Table 8.23 (see Appendix G for contour plot).

The PM_{10} concentration results for the receptors are compared to the assessment guidelines as presented in Table 2.2. The results include maximum and various percentiles of predicted 24-hour ground level concentrations.

Key aspects of the results include:

- Compared with the existing operations (as presented in Section 8.1) there is a decrease in maximum predicted PM_{10} concentrations at Receptor 9 for no, standard and leading dust controls.
- The assessment guidelines are predicted to be met at Receptor 9.
- Scenario 3 and 4 demonstrated the smallest impacts of the assessed scenarios and a reduction in impact compared the existing operations based on the conveyer operations replacing haul road traffic.

Table 8.21: Predicted 24-hour PM10 Concentrations (µg/m³) at Receptors – Scenario 3 – Cumulative Existing Operations Excluding OB18 with No Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	30	35	**64**	37
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	70%	128%	74%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	50%	91%	53%
99th percentile	**71**	37	30	26	29	**56**	32
95th percentile	**54**	28	27	24	26	46	28
90th percentile	44	25	24	22	23	41	26
70th percentile	30	23	21	20	20	29	23
Average	28	22	20	20	20	26	22
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

Table 8.22: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 3 – Cumulative Existing Operations Excluding OB18 with Standard Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	30	34	**63**	34
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	68%	127%	67%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	49%	91%	48%
99th percentile	**71**	36	30	25	29	**56**	30
95th percentile	**54**	28	27	23	25	45	25
90th percentile	44	24	23	22	22	41	24
70th percentile	30	22	20	20	20	29	22
Average	28	21	20	20	20	26	21
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

Table 8.23: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 3 – Cumulative Existing Operations Excluding OB18 with Leading Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	29	33	**63**	33
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	66%	126%	66%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	47%	90%	47%
99th percentile	**71**	35	30	25	29	**56**	29
95th percentile	**54**	28	26	23	24	45	24
90th percentile	44	24	23	22	22	40	23
70th percentile	29	21	20	20	20	29	21
Average	28	21	20	20	20	26	20
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

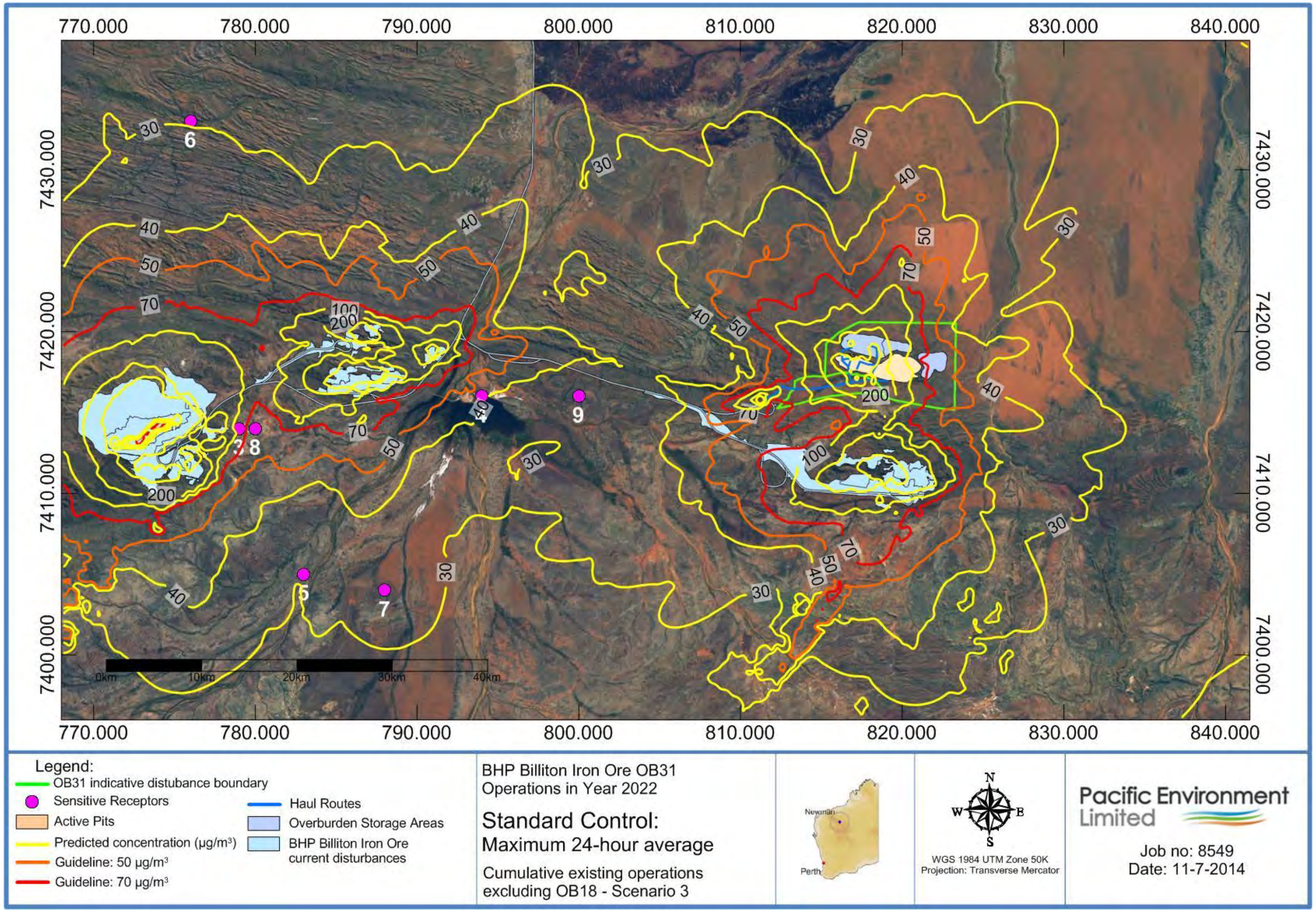

Figure 8.17: Predicted Maximum Daily PM_{10} Concentrations – Scenario 3 – Cumulative Existing Operations Excluding OB18 with Standard Dust Control

8.3.4 Scenario 4

The modelled results for Scenario 4 (15 Mtpa ore crushed at OB31 with new crusher and transported via an overland conveyor to OB18)) as cumulative (including surrounding existing operations as explained above and background) are presented as follows:

- OB31 cumulative results with existing operations excluding OB18 for Scenario 4 with no dust controls for OB31 are presented in Table 8.24 (see Appendix G for contour plot).
- OB31 cumulative results with existing operations excluding OB18 for Scenario 4 with standard dust controls for OB31 are presented in Table 8.25 and Figure 8.18.
- OB31 cumulative results with existing operations excluding OB18 for Scenario 4 with leading dust controls for OB31 are presented in Table 8.26 (see Appendix G for contour plot).

The PM_{10} concentration results for the receptors are compared to the assessment guidelines as presented in Table 2.2. The results include maximum and various percentiles of predicted 24-hour ground level concentrations.

Key aspects of the results include:

- Similarly to Scenario 3 compared with the existing operations (as presented in Section 8.1) there is a decrease in maximum predicted PM_{10} concentrations at Receptor 9 for no, standard and leading dust controls.
- The assessment guidelines are predicted to be met at Receptor 9.
- Scenario 3 and 4 demonstrated the smallest impacts of the assessed scenarios and a reduction in impact compared the existing operations based on the conveyer operations replacing haul road traffic

Table 8.24: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 4 – Cumulative Existing Operations Excluding OB18 with No Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	30	35	**64**	35
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	70%	128%	69%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	50%	91%	50%
99th percentile	**71**	36	30	26	29	**56**	31
95th percentile	**54**	28	27	24	26	46	27
90th percentile	44	25	24	22	23	41	25
70th percentile	30	22	21	20	20	29	22
Average	28	22	20	20	20	26	21
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

Table 8.25: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 4 – Cumulative Existing Operations Excluding OB18 with Standard Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	30	34	**63**	34
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	68%	127%	67%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	49%	91%	48%
99th percentile	**71**	36	30	25	29	**56**	30
95th percentile	**54**	28	27	23	25	45	25
90th percentile	44	24	23	22	22	41	24
70th percentile	30	22	20	20	20	29	22
Average	28	21	20	20	20	26	21
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

Table 8.26: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 4 – Cumulative Existing Operations Excluding OB18 with Leading Dust Control

Receptor	3	4	5	6	7	8	9
Maximum	**80**	43	31	29	33	**63**	33
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	66%	126%	66%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	47%	90%	47%
99th percentile	**71**	35	30	25	29	**56**	29
95th percentile	**54**	28	26	23	24	45	24
90th percentile	44	24	23	22	22	40	23
70th percentile	29	21	20	20	20	29	21
Average	28	21	20	20	20	26	20
No of Exceedances of 50 µg/m³	24	-	-	-	-	12	-
No of exceedances of 70 µg/m³	6	-	-	-	-	-	-
Background concentration included	18	18	18	18	18	18	18

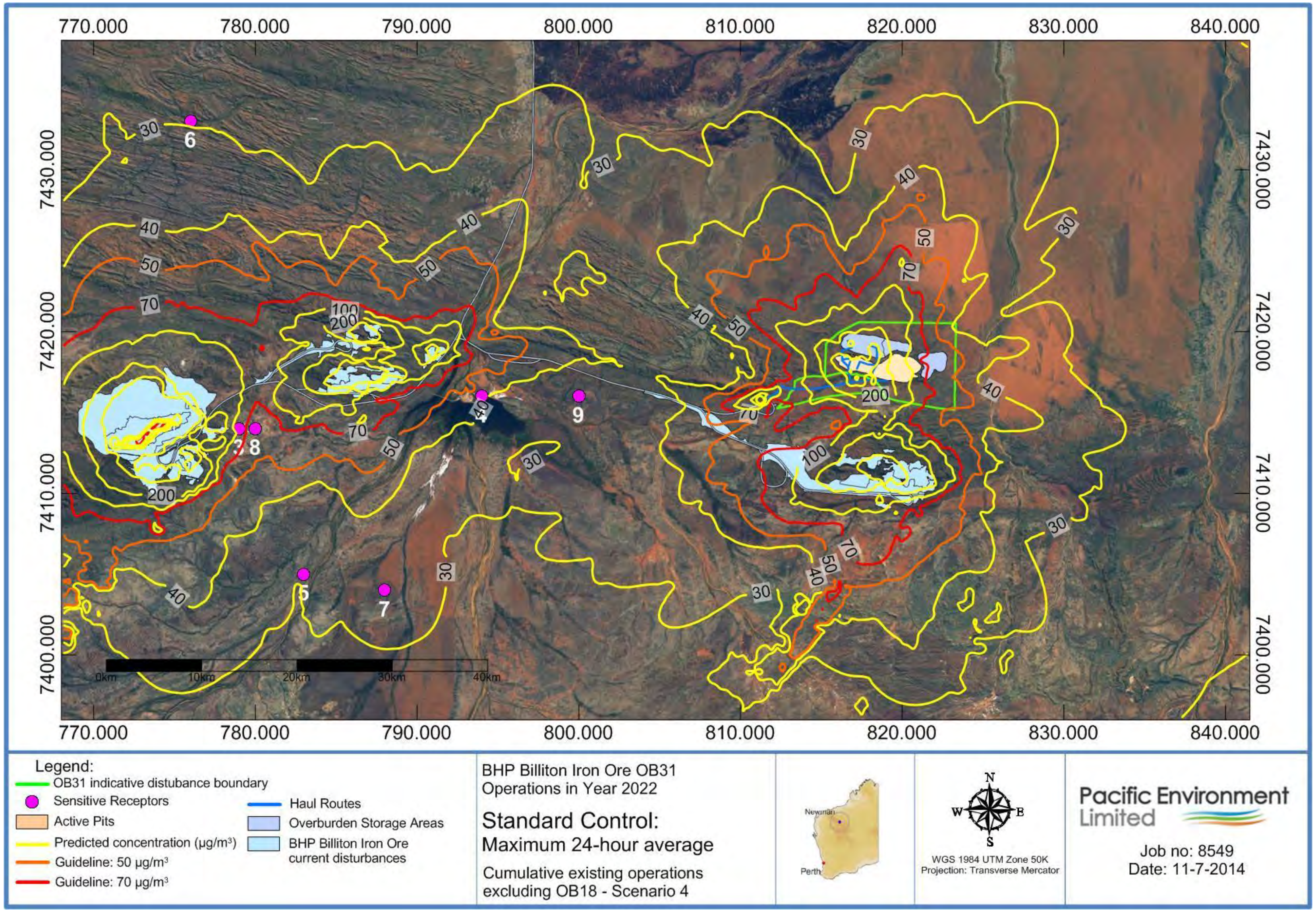

Figure 8.18: Predicted Maximum Daily PM_{10} Concentrations – Scenario 4 – Cumulative Existing Operations Excluding OB18 with Standard Dust Control

8.4 Summary of Results

Consistent with the level of material handling and transport the largest impacts are predicted to occur in the scenarios associated with the haul road transport to OB18. Scenario 2 with crushing at OB31, and additional materials handling compared to Scenario 1, demonstrated the largest impacts followed by Scenario 1.

The outcomes for Scenario 3 and 4 were very similar with the only significant difference in the scenario definition being the location of the ore crushing. In Scenario 4 the crusher location is at OB31 which is further east compared to Scenario 3 with the crusher location at OB18. Of the four scenarios Scenario 4 demonstrated the lowest impacts at the sensitive receptor locations.

The three levels of dust control (no, standard and leading control) demonstrated that while leading dust control achieves minimal additional impact the standard level of dust controls achieves reasonable improvement compared to no dust controls.

The cumulative results based on the modelled impacts from the existing operations excluding the OB18 operations (which OB31 will replace) and the background concentration as established for the Background 2 monitoring location showed that the assessment guidelines for the nearest receptor, Receptor 9 – the Eastern Pilbara Accommodation Village, was only exceeded for 1 day for Scenario 2 for the no dust control of operations option. We note that these results are based on the current level of operations in the area. It should be noted that the standard operating procedure for mines operated by BHP Billiton Iron Ore is with standard controls. No controls have only been modelled to provide a highly unlikely 'worst case' scenario.

The results comparing the existing operations (as presented in Section 8.1, including OB18) to the predicted impacts at the Newman and Eastern Pilbara Accommodation Village receptor locations for the assessment scenarios (as presented in Section 8.3, excluding OB18) are presented in Table 8.27 to Table 8.30.

The results summary shows that for:

- Newman there is little or no additional impact predicted as a result of the OB31 operations replacing the OB18 operations.
- The Eastern Pilbara Accommodation Village, not considering the no dust control option, overall there is a small improvement in the level of PM_{10} dust impacts compared to the existing operations predicted as a result of the OB31 operations replacing the OB18 operations.

Table 8.27: Summary Percentage Change Compared to Existing Operations at Receptors for Scenario 1

Receptor	8 (Newman)			9 (Eastern Pilbara Accommodation Village)		
Dust Control Option	No Control	Standard Control	Leading Control	No Control	Standard Control	Leading Control
Maximum	+2%	+2%	0%	+17%	-5%	-20%
99th percentile	0%	0%	0%	+18%	-6%	-15%
95th percentile	0%	0%	-2%	+10%	-6%	-19%
90th percentile	0%	0%	-2%	+11%	-7%	-18%
70th percentile	+3%	0%	0%	+4%	-4%	-13%
Average	+4%	0%	0%	0%	-4%	-9%

Table 8.28: Summary Percentage Change Compared to Existing Operations at Receptors for Scenario 2

Receptor	8 (Newman)			9 (Eastern Pilbara Accommodation Village)		
Dust Control Option	No Control	Standard Control	Leading Control	No Control	Standard Control	Leading Control
Maximum	+2%	+2%	0%	+41%	+7%	-20%
99th percentile	0%	0%	0%	+32%	0%	-15%
95th percentile	0%	-2%	-2%	+19%	0%	-23%
90th percentile	+2%	0%	-2%	+14%	-4%	-18%
70th percentile	+3%	0%	0%	+4%	-4%	-13%
Average	+4%	0%	0%	+4%	-4%	-9%

Table 8.29: Summary Percentage Change Compared to Existing Operations at Receptors for Scenario 3

Receptor	8 (Newman)			9 (Eastern Pilbara Accommodation Village)		
Dust Control Option	No Control	Standard Control	Leading Control	No Control	Standard Control	Leading Control
Maximum	+2%	0%	0%	-10%	-17%	-20%
99th percentile	0%	0%	0%	-6%	-12%	-15%
95th percentile	0%	-2%	-2%	-10%	-19%	-23%
90th percentile	0%	0%	-2%	-7%	-14%	-18%
70th percentile	0%	0%	0%	-4%	-8%	-13%
Average	0%	0%	0%	-4%	-9%	-13%

Table 8.30: Summary Percentage Change Compared to Existing Operations at Receptors for Scenario 4

Receptor		8 (Newman)			9 (Eastern Pilbara Accommodation Village)	
Dust Control Option	No Control	Standard Control	Leading Control	No Control	Standard Control	Leading Control
Maximum	+2%	0%	0%	-15%	-17%	-20%
99th percentile	0%	0%	0%	-9%	-12%	-15%
95th percentile	0%	-2%	-2%	-13%	-19%	-23%
90th percentile	0%	0%	-2%	-11%	-14%	-18%
70th percentile	0%	0%	0%	-8%	-8%	-13%
Average	0%	0%	0%	-9%	-9%	-13%

9 CONCLUSIONS AND RECOMMENDATIONS

The key findings and recommendations from the assessment are summarised in this section.

9.1 Summary Assessment Scenarios

This assessment evaluated the air quality impacts (as standalone and cumulative) for the proposed OB31 operations in accordance with operation Scenarios 1 to 4:

- Scenario 1 – 15 Mtpa ore hauled via road from OB31 to OB18 and crushed at OB18
- Scenario 2 – 15 Mtpa ore hauled via road from OB31 to OB18 after being crushed with a new crusher at OB31
- Scenario 3 – 15 Mtpa ore transported via overland conveyor from OB31 to OB18 and crushed at OB18
- Scenario 4 – 15 Mtpa ore crushed at OB31 with new crusher and transported via overland conveyor to OB18.

9.2 Selection of Representative Model Year

Two key factors were taken into account to determine the representative model year that can be considered representative of general conditions in the eastern Pilbara region: meteorological conditions, and background air quality.

From the evaluation of available data it was determined that 2010 is, at this point in time, the most representative and suitable model year.

The PM_{10} background concentration applied in the study was 18 µg/m^3.

9.3 Evaluation of Meteorological Modelling

It was concluded (based on statistical assessment) that the WRF-CALMET simulates surface meteorology with an acceptable degree of skill at the Newman Airport location and that the meteorological data for the dispersion modelling can be considered representative of the assessment area.

9.4 Assessment Guidelines

Modelled PM_{10} concentrations for OB31 were assessed against:

- the National Environment Protection Measure standard (NEPM) of 24-hour 50 µg/m^3 with 5 exceedances allowable per year
- the Port Hedland Dust Management Taskforce (Taskforce) guideline of 24-hour 70 µg/m^3 over a 24 hour period (with 10 exceedances allowable per year)
- the predicted levels of PM_{10} for existing regional operations.

We note that while there is a level of uncertainty in the prediction of the absolute concentrations predicted, the relative increases between the different scenarios and the existing operations should be reasonably reliable.

9.5 Model Results

The assessment has been based on the early designs of the mine, and therefore the results and recommendations must be interpreted in the context that design, layout and management strategies will be subject to refinement and change.

The cumulative results based on the modelled impacts from the existing operations excluding the OB18 operations (which OB31 will replace) and the background concentration as established for the Background 2 monitoring location showed that the assessment guidelines for the nearest receptor,

Receptor 9 – the Eastern Pilbara Accommodation Village, was only exceeded for 1 day for Scenario 2 for the no dust control of operations option while compliance was demonstrated for all other scenarios. It is noted that these results are based on the current level of operations in the area. It should be noted that the standard operating procedure for mines operated by BHP Billiton Iron Ore is with standard controls. No controls have only been modelled to provide a highly unlikely 'worst case' scenario.

Compared to the existing operations the predictions of replacing the operations at OB18 with operations at OB31 showed that for:

- Newman there is little or no additional impact predicted.
- The Eastern Pilbara Accommodation Village (which is the closest receptor), not considering the no dust control option, overall there is a small improvement in the level of PM_{10} dust impacts across the assessed scenarios.

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Appendix A REPRESENTATIVE MODEL YEAR

A.1 IDENTIFICATION OF REPRESENTATIVE YEAR

In dispersion modelling, one of the key considerations is the representativeness of the meteorological data used. Once emitted to atmosphere, emissions will:

- rise according to the velocity and temperature at the point of emission
- be advected from the source according to the strength and direction of the wind at the height which the plume has risen in the atmosphere
- be diluted due to mixing with the ambient air, according to the intensity of turbulence, and
- possibly be chemically transformed and/or depleted by deposition processes.

Dispersion is the combined effect of these processes. Dispersion modelling is used as a tool to simulate the air quality effects of specific emission sources, given the meteorology typical for a local area together with the expected emissions. Selection of a year when the meteorological data is atypical means that the resultant predictions may not appropriately represent air quality.

For this assessment, representative meteorological data is not the only factor influencing the appropriateness of a model year. Other factors that must also be considered include:

- monitoring data
- meteorology.

This section sets out the analysis of these key factors to determine the representative year for modelling.

A.1.1 Existing (Background) Air Quality in Pilbara region

Background dust levels for the modelled year are required for input into the model to represent the PM_{10} entering the model domain from background sources. The concentration of PM_{10} recorded by BHP Billiton Iron Ore at the Newman BG2 monitoring station is considered to be representative of the regional air quality.

Background levels of PM_{10} are high in the Pilbara region with the highest concentrations occurring predominately during summer periods. The likely activities contributing to these high background concentrations of PM_{10} include:

- bushfires
- low rainfall periods
- urban and transport related activities.

The statistical summary of PM_{10} concentration at BG2 for the years 2009 to 2011 is presented in Table A.1-1. Year 2009 presents background levels of particulates were elevated, possibly due to some of the contributing factors mentioned above. Year 2009 would represent a conservative model year in terms of background dust levels. In 2011, the annual average concentration of PM_{10} drops below 20 µg/m^3. If the model year was designated as 2011, the contribution of dust from background sources would likely be underestimated. The recorded number of 24 hour average PM_{10} concentrations in 2012 exceeded 50 µg/m^3 a total of 17 times which indicates 2012 is a high background dust level year.

Table A.1-1: Statistical summary for monitoring data in BG2 (µg/m³)

	2009	2010	2011	2012
Max	153.04	590.34	92.43	193.64
99th percentile	98.59	62.82	69.93	76.91
95th percentile	67.49	37.26	34.38	54.93
90th percentile	54.40	29.61	27.62	34.69
70th percentile	31.21	18.16	18.98	21.09
Average	28.49	18.31	16.55	20.37
Recovery	85%	99%	95%	83%
No. of times PM10 > 50 µg/m³	39	9	5	17
No. of times PM10 > 70 µg/m³	16	3	4	6

In summary, dust levels from 2009 and 2012 would provide a conservative approach, 2010 would represent average background dust levels, 2011 would underestimate the contribution of background sources. In terms of background PM_{10} concentration, 2010 is considered representative to the background dust levels. When selecting an appropriate model year the background dust levels must be considered in conjunction with the local meteorology.

A.1.2 Meteorology

In order to determine the year of meteorological data to use for the dispersion modelling, 11-year of historical surface observations from BoM station at Newman and Wittenoom (2001 to 2012 inclusive) were reviewed. Wind speed, ambient temperature and relative humidity were compared to long term averages for the region to determine the most representative year. Data collected from year 2001 to 2012 is summarised in Section A.1.2.1 and A.1.2.2.

A.1.2.1 Wind Speed and Wind Direction (Newman only)

The annual wind roses for the Newman region from 2001 to 2012 are presented Figure A-1. Wind speed and wind direction are not available at Wittenoom monitoring station. This figure shows the dominant wind directions as easterly through to south easterly. However, there is a reasonable proportion of the annual wind from the south westerly direction, but not as predominant as the easterly winds.

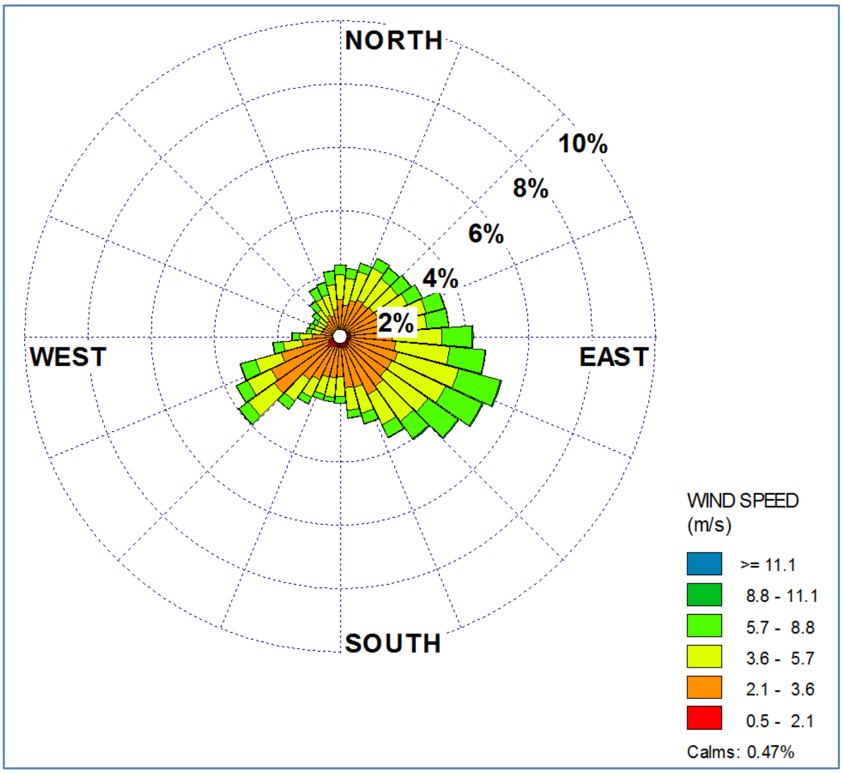

Figure A-1: Annual Wind Rose for Newman (2001 – 2012) (BoM, 2013)

The wind directions for each annual period from 2001 to 2012 at BOM Newman station are presented in Figure A-2. In 2002, there is a reasonable proportion of south westerly winds; and in 2010, there is a reasonable proportion of south-east easterly winds. In general, the wind direction patterns are consistent with the overall pattern of wind directions in the region from 2001 to 2012.

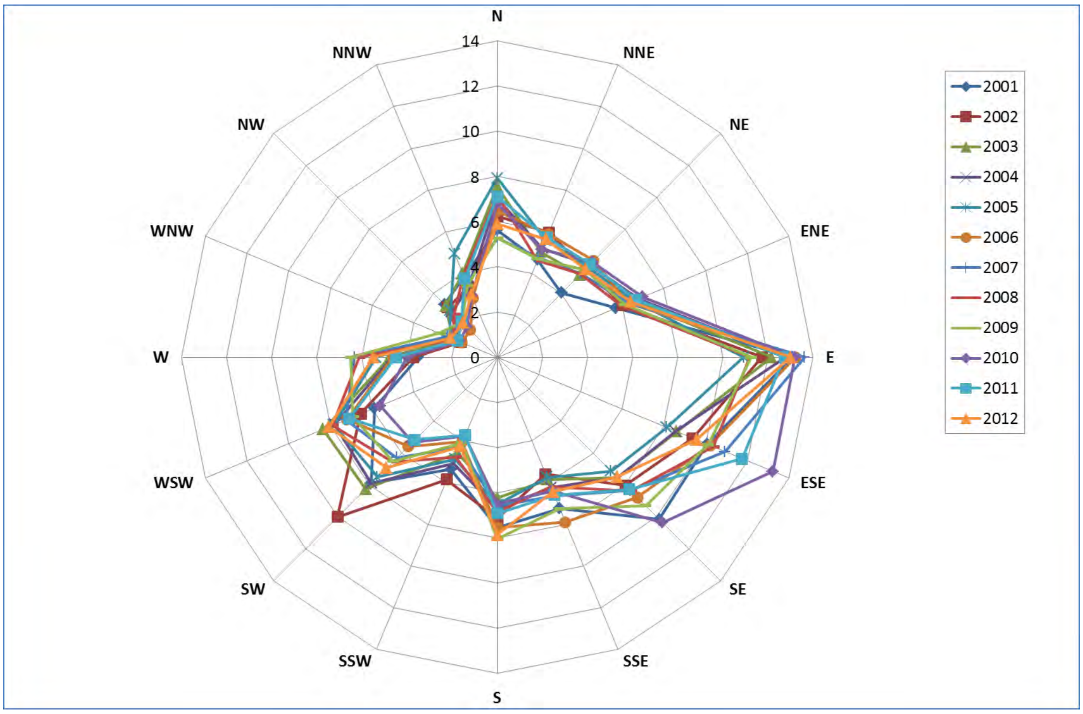

Figure A-2: Annual wind direction (%) for Newman (2001-2012) (BoM, 2013)

The statistics of annual wind speeds recorded at Newman from 2001 to 2012 is shown in Figure A-3. The recorded maximum wind speeds range from 10.8 to 15 metres per second (m/s). The average wind speeds are approximately 3.4 m/s. Year 2001, 2008, 2009, 2010, 2011 and 2012 have relatively high maximum wind speeds, suspected to be influenced by tropical cyclones in the region during those timeframes.

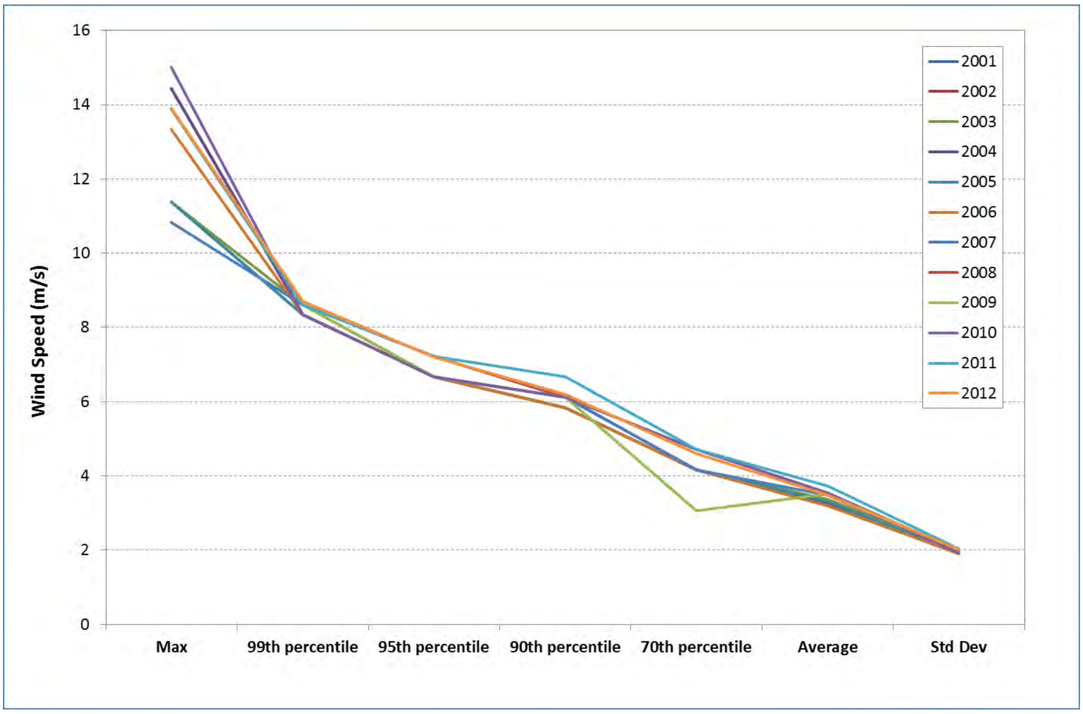

Figure A-3: Annual wind speed for Newman (2001-2012) (BoM, 2013)

A.1.2.2 Rainfall (Newman and Wittenoom)

The long term annual rainfalls in Newman Airport and Wittenoom are displayed in Figure A-4 and Figure A-5 respectively. There is a significant variation of rainfall between each year. High rainfall is likely to supress the generation of dust leading to an under-estimate of the likely emissions of dust in an average year. Conversely, years of low rainfall will cause the model to over-predict the likely emissions of dust.

In Newman, 2006 and 2007 fall outside the range of 10^{th} percentile and 90^{th} percentile (Figure A-4). In Wittenoom, 2006 again fall outside the 90^{th} percentile (Figure A-5). Further analysis was conducted using BoM rainfall statistics in Newman over 32 years. It shows only the total rainfall amounts of Year 2002, 2005, 2007, 2008, 2009 and 2010 fall within the 10^{th} and 90^{th} percentile of long term total rainfall amount. Total rainfalls for Year 2002, 2008 and 2009 are closest to the long term median rainfall total of 322.6 mm (BOM, 2013).

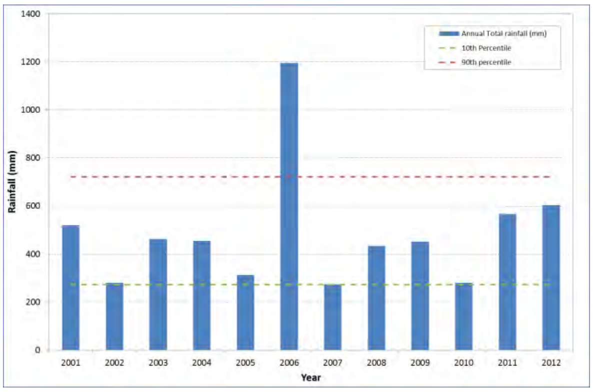

Figure A-4: Total rainfall at Newman Airport (BoM, 2013)

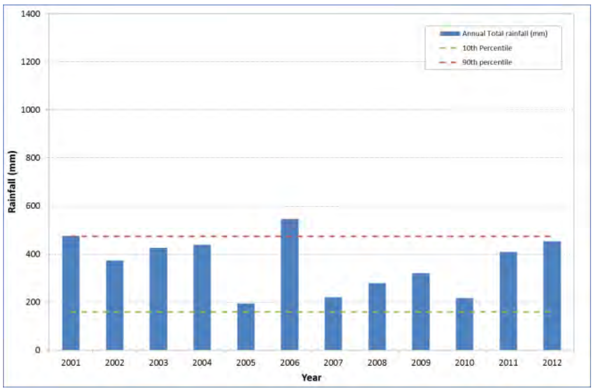

Figure A-5: Total rainfall at Wittenoom (BoM, 2013)

A.1.3 Statistical Analysis

Mann-Whitney U test was used to statistically identify the representative modelling year based on recorded meteorological parameters including wind speed and temperature. This test was used to assess the Newman meteorological data.

The null hypothesis is that there is no significant difference between hourly values in an individual year and the hourly averages for long term average values. If values fall within the vertical lines (at 5% CI, two tailed), then accept the null hypothesis (Figure A-6). It is noted that only scalars were assessed (i.e. temperature and wind speed).

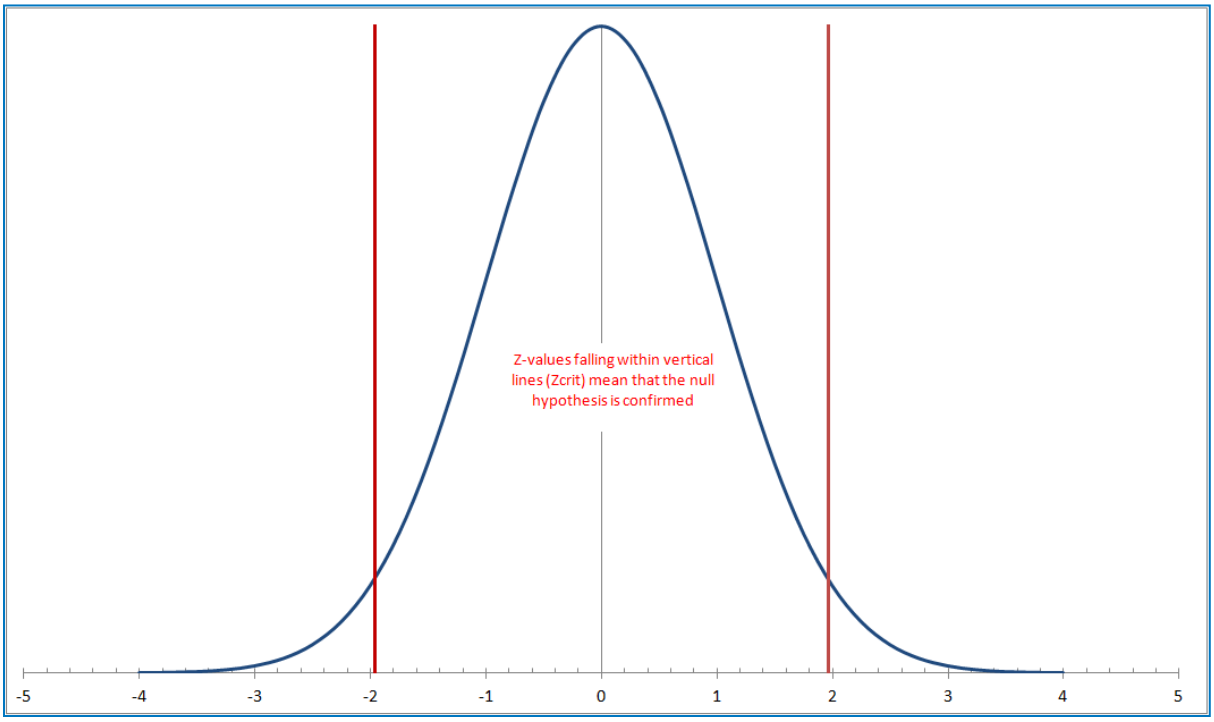

Figure A-6: Null Hypothesis for Mann-Whitney U test

A.1.3.1 Wind Speed (Newman only)

Mann-Whitney U test results for wind speed indicate that 1998, 2008, 2009 and 2010 were representative of 15 year mean conditions (Figure A-7). For meteorological data from 2009 to 2011, Year 2010 provided a better representation followed by 2009 and 2011.

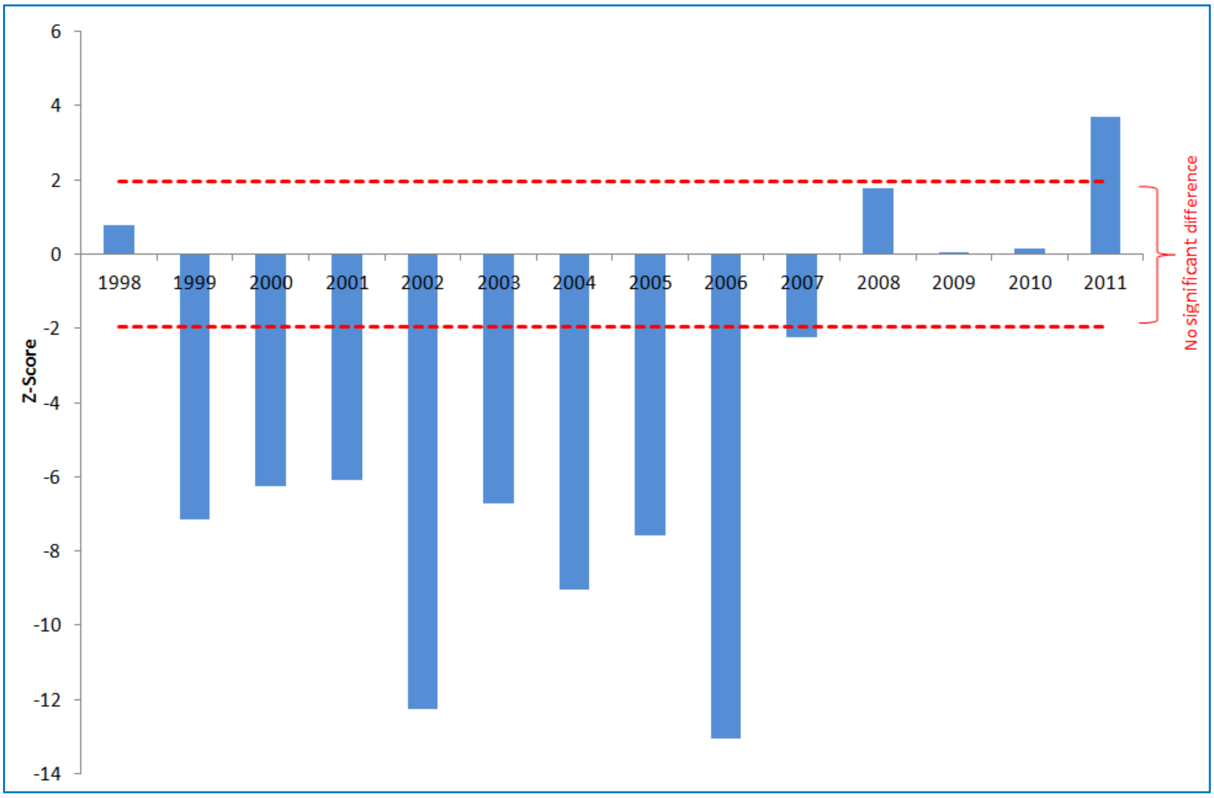

Figure A-7: Mann-Whitney U test result for wind speed

A.1.3.2 Temperature

Mann-Whitney U test results for temperature indicate that only 2009 was representative of 15 year mean conditions (Figure A-8).

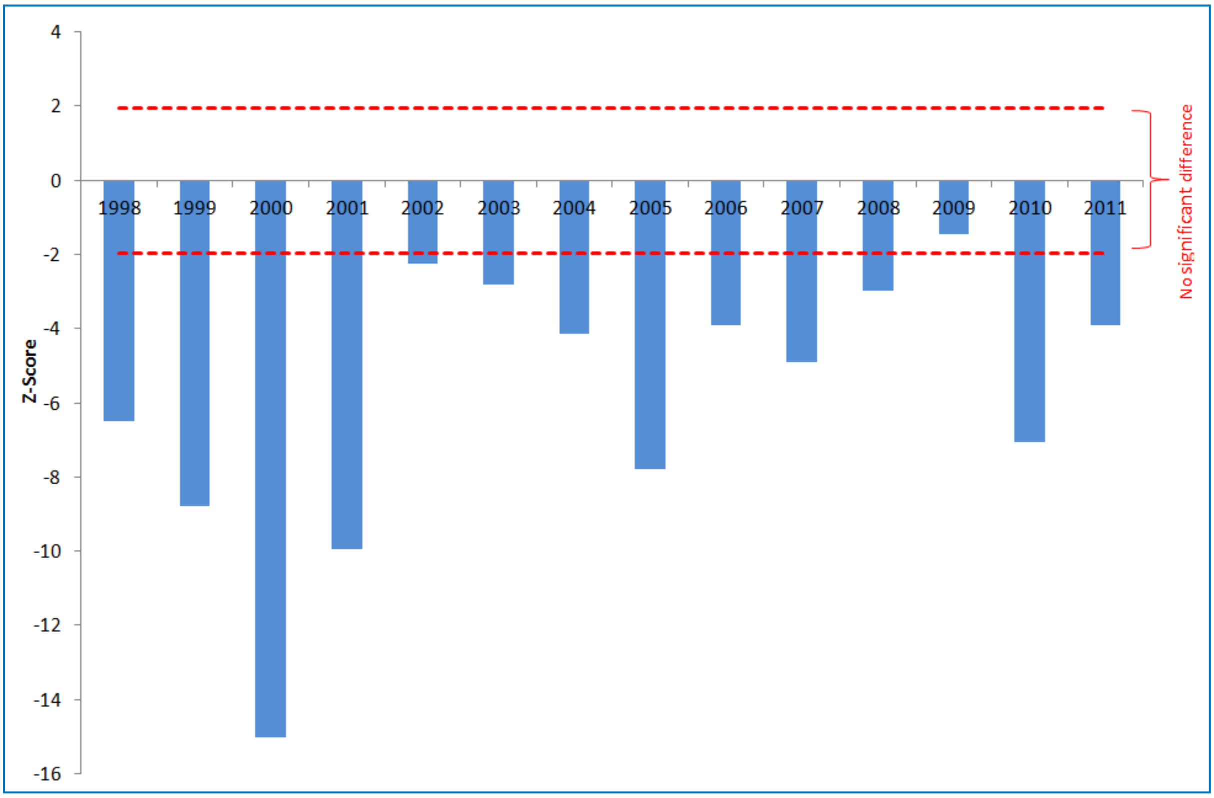

Figure A-8: Mann-Whitney U test result for temperature

A.1.4 Selected Representative Year

The selection of the most representative model year is usually determined by interrogating the meteorological data for the most conservative year, without choosing an outlying year. In this situation, the monitoring data in the study area presents a more compelling reason for the selection of the model year.

Year 2010 is the only full year data set of monitoring available for the area. The monitoring data provides an essential service to the model validation process by providing locations where predictions of ground level concentrations of PM_{10} can be directly compared with sampled concentrations.

The meteorological conditions highlight that the most representative year in terms of wind speed, wind direction and rainfall is considered to be 2009. However, based on the analysis of the available monitoring data, year 2010 is the only practical option for the model year for OB31.

The implications for the meteorology indicate that 2010 has a higher proportion of south east easterly westerly winds, higher maximum wind speeds and relatively low rainfall. The increased precedence of southeast easterly winds in 2010 is likely to influence the locations receiving concentrations of particulate matter. The higher maximum wind speeds may lead to an increase in the dispersion of particulate matter before reaching sensitive receptors however, it may also increase the degree of wind erosion occurring on exposed surfaces and increase the concentration of particulate matter blown down wind. In addition, in terms of wind speed, the Mann Whitney U test has identified year 2010 to be an ideal year followed by 2009 and 2011 in order of preference. Low rainfall is likely to increase the concentration of particulate matter in the air as water droplets (rain) would adsorb onto the surface of the particle and deposit on the ground.

By taking all the factors into account, i.e. background air quality data availability and representative of meteorological parameters recorded, 2010 was identified as the most suitable year for the purpose of this assessment.

Appendix B	METEOROLOGY VALIDATION

B.1 STATISTICAL MEASURE OF MODEL PERFORMANCE

Statistical measure used to evaluate model performances are explained below.

B.1.1 Geometric Mean (MG)

The geometric mean is a type of mean or average, which indicates the central tendency or typical value of a set of numbers. The MG test is given by:

$$MG = exp\left[\overline{ln\left(\frac{O}{P}\right)}\right]$$

Where:

O = the average observed (measured) value

P = the average predicted (modelled) value

A model is considered to be acceptable if the geometric mean is between 0.7 and 1.3 (Chang & Hanna, 2004).

B.1.2 Geometric Variance (GV)

The geometric variance test is given by:

$$GV = exp\left[\overline{ln\left(\frac{O}{P}\right)^2}\right]$$

Where:

O = the average observed (measured) value

P = the average predicted (modelled) value

A model is considered to be acceptable if the geometric variance is less than 1.6 (Chang & Hanna, 2004).

B.1.3 Skill_r

The *Skill_r* test is the ratio of *RMSE* to observed standard deviation:

$$Skill\_r = \frac{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)^2}}{O_{std}}$$

Where:

N = the number of pairs of data

O_i = the observed (measured) value for the i-th hour

P_i = the predicted (modelled) value for the i-th hour

O_{std} = the standard deviation of measured data.

A model is considered to be predicting with skill if the RMSE is less than the standard deviation of the observations (Skill_r <1) (Hurley, 2000; Pielke, 1984).

B.1.4 Skill_v

$$Skill\_v = \frac{P_{std}}{O_{std}}$$

Where:

P_{std} = the standard deviation of predicted data
O_{std} = the standard deviation of observed data.

A model is considered to be predicting with skill if the standard deviations of the predictions and observations are the same (Skill_v = 1) (Hurley, 2000; Pielke, 1984)

B.1.5 Model Bias (MB)

The model bias (MB) is the mean error and is given by:

$$MB = \frac{1}{n}\sum_{i=1}^{n}(O_i - P_i)$$

Where:

n = the number of pairs of observed data
O_i = the observed value for the i-th hour
P_i = the predicted value for the i-th hour

The ideal value for the bias is zero.

B.1.6 Fraction Bias (FB)

The fraction bias (FB) is a normalised index of model performance and is expressed by:

$$FB = 2\frac{\overline{O} - \overline{P}}{\overline{O} + \overline{P}}$$

Where:

$\overline{O}$ = the average observed values
$\overline{P}$ = the average predicted values

The FB varies between +2 and –2 and has an ideal value of zero. FB values of ±0.67 correspond to a prediction within a factor of 2.

B.1.7 Gross Error (GE)

The Gross Error is given by:

$$GE = \frac{1}{N}\sum_{i-1}^{N}|(P_i - O_i)|$$

Where:

N = the number of pairs of data
O_i = the observed (measured) value for the i-th hour
P_i = the predicted (modelled) value for the i-th hour

The bias and gross error for winds are calculated from the predicted-observed residuals in speed and direction (not from vector components u and v). The direction error for a given prediction-observation pairing is limited to range from 0 to ±180° (Emery, et al., 2001).

B.1.8 Root Mean Square Error (RMSE)

The Root mean Square Error is given by:

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

Where:

N = the number of pairs of data
O_i = the observed (measured) value for the i-th hour
P_i = the predicted (modelled) value for the i-th hour

While the ideal RMSE value is 0, large errors in a small section of the data may produce a large RMSE even though errors may be small elsewhere.

B.1.9 Index of Agreement (IOA)

The index of agreement (IOA) is the measure of how well the model estimates departure from the observed mean matches cases by case, the observations departure from the observed mean:

$$IOA = 1 - \left[\frac{N(RMSE)^2}{\sum_{i=1}^{n}\left\{\left|P_i - \bar{O}\right| + \left|O_i - \bar{O}\right|\right\}^2} \right]$$

Where:

n = the number of pairs of observed data
O_i = the observed value for the i-th hour
$\bar{O}_i$ = the mean observed value

The ideal value for IOA is one.

B.1.10 Model Benchmarks

A set of benchmarks were set for mesoscale model evaluation by Emery et. al (2001) and Tesche et. al (2001). These are listed in the table below:

Table B-1: Mesoscale model benchmarks (after (Emery, et al., 2001; Tesche, et al., 2001))

Parameter	Test	Benchmark
Wind Speed	RMSE	≤2 m/s
	BIAS	≤± 0.5 m/s
	IOA	≥0.6
Temp	GE	≤2 K
	BIAS	≤± 0.5 K
	IOA	≥0.8
Wind Direction	GE	≤30 °
	BIAS	≤10 °

B.1.11 Normalised Mean Square Error (NMSE)

The Normalised Mean Square Error is given by:

$$NMSE = \frac{\overline{(O_i - P_i)^2}}{\overline{O_i}\,\overline{P_i}}$$

Where:

O_i	=	the observed (measured) value for the i-th hour
P_i	=	the predicted (modelled) value for the i-th hour
$\bar{O}$	=	average over dataset

B.1.12 Fraction of predictions within a factor of two of observations (FAC2)

The Fraction of data is given by:

$$FAC2 = fraction\ of\ data\ that\ satisfy\ 0.5 \leq \frac{P_i}{O_i} \leq 2.0$$

Where:

O_i	=	the observed (measured) value for the i-th hour
P_i	=	the predicted (modelled) value for the i-th hour

The ideal FAC2 value is 1.

Pacific Environment Limited

Appendix C ESTIMATION OF EMISSIONS

C.1 BHP BILLITON OPERATIONS

C.1.1 Methodology for Estimating Emission Rates

C.1.1.1 Emission Estimation

Numerous studies undertaken at BHP Billiton Iron Ore operations have determined a strong relationship between product type, ore moisture, tonnage of material being handled and wind speed for dust emissions. As a result, two empirical equations have been derived to determine the particulate emissions that could be expected to occur for a given situation (e.g. stacking or reclaiming of various material types during different conditions).

Equation 1 determines the particulate emissions of a specific material handling operation (transferring, stacking, reclaiming or ship loading) for a given ore type and moisture content.

Equation 1

$$\mathrm{PM}_{10_\mathrm{i}} = \frac{0.001 \times (DI + 30)}{F}$$

Where:

$\mathrm{PM}_{10_\mathrm{i}}$	=	Particulate emissions of material handling operation i	(kg/tonne)
DI	=	Dustiness Index determined from the rotating drum tests using the dust testing set up	(-)
F	=	Factor constant	(-)

The value of 30 in Equation 1 was added such that some dust would be generated even at high moistures where the rotating drum tests indicate no dust (SKM, 2002).

The calculated particulate matter value is then converted into an emission rate by incorporating the loading tonnage and the wind speed as presented in Equation 2.

Equation 2

$$\mathrm{EPM}_{10_\mathrm{i}} = \mathrm{PM}_{10_\mathrm{i}} \times \frac{t}{3.6} \times \left(\frac{WS}{2.2}\right)^{1.3}$$

Where:

$\mathrm{EPM}_{10_\mathrm{i}}$	=	Particulate emission rate of material handling operation i	(g/s)
$\mathrm{PM}_{10_\mathrm{i}}$	=	Particulate emissions of material handling operation i	(kg/tonne)
t	=	Loading tonnage	(t/h)
WS	=	Wind speed	(m/s)

C.1.1.2 Rotating Tumble Drum Tests

To determine the dustiness index of the ores processed at Port Hedland a series of rotating tumble drum tests were conducted based on Australian Standard AS4156.6-2000. The tumble drum method was developed to determine the dust/moisture relationship for coals and has been applied to iron ores, bauxite's and other materials. It indicates the likely response of different materials to drying or water addition during mining and handling processes. Ore samples are tumbled for a given duration at carefully controlled moisture contents, and the dust (~150 micron) is collected into a vacuum bag. The resulting dust is weighed and a measure of the dustiness calculated. A graph of the dust/moisture relationship is obtained, and the dust extinction moisture (DEM) is obtained from the graph. Figure C-1 shows the rotating tumble drum tests for a sample of MAC fines analysed during the dust management, measurement, abatement and characterisation study conducted in 2001 (SKM, 2002). A dust index of 10 corresponds to a dust yield of 0.01% at which the dust is effectively suppressed with these results showing that MAC fines have a DEM of approximately 7%.

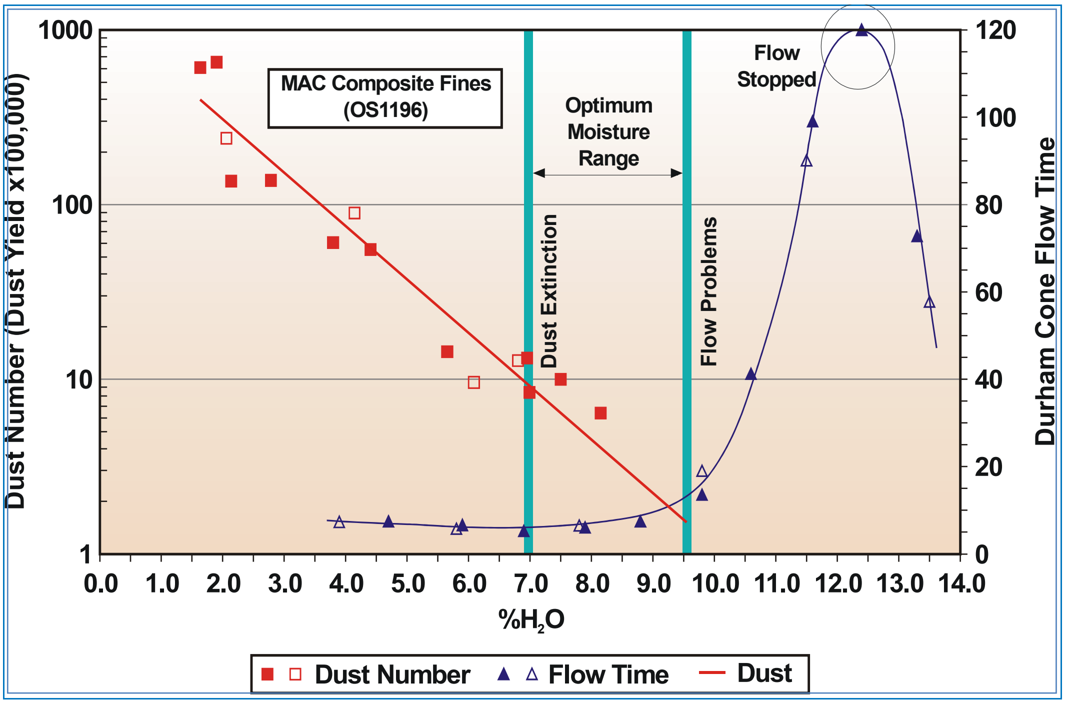

Figure C-1: Results of MAC Fines Rotating Drum and Durham Cone Test

Increasing the moisture of the ore will also have an effect on the ore handling characteristics. As can be observed in Figure C-1, the Durham cone tests on MAC fines (blue line) show that material flow problems are experienced at moisture levels higher than approximately 10%. A target optimum moisture range that suppresses dust and avoids flow problems is indicated when these dust and flow test curves are combined (Figure C-1) and for MAC fines an optimum moisture range of 7.0% to 9.5% was found.

Results from the rotating drum tests conducted on a representative section of material processed at Nelson Point is presented in Figure C-2. This data was used to determine the dustiness index of each ore over a range of ore moistures in Mining Area C. This dustiness index could then be incorporated into Equation 1. The USEPA dustiness equation has been included into this graph to highlight its inability to account for emissions from different ore types. The USEPA equation also relies on the silt loading of a material to determine its potential dustiness.

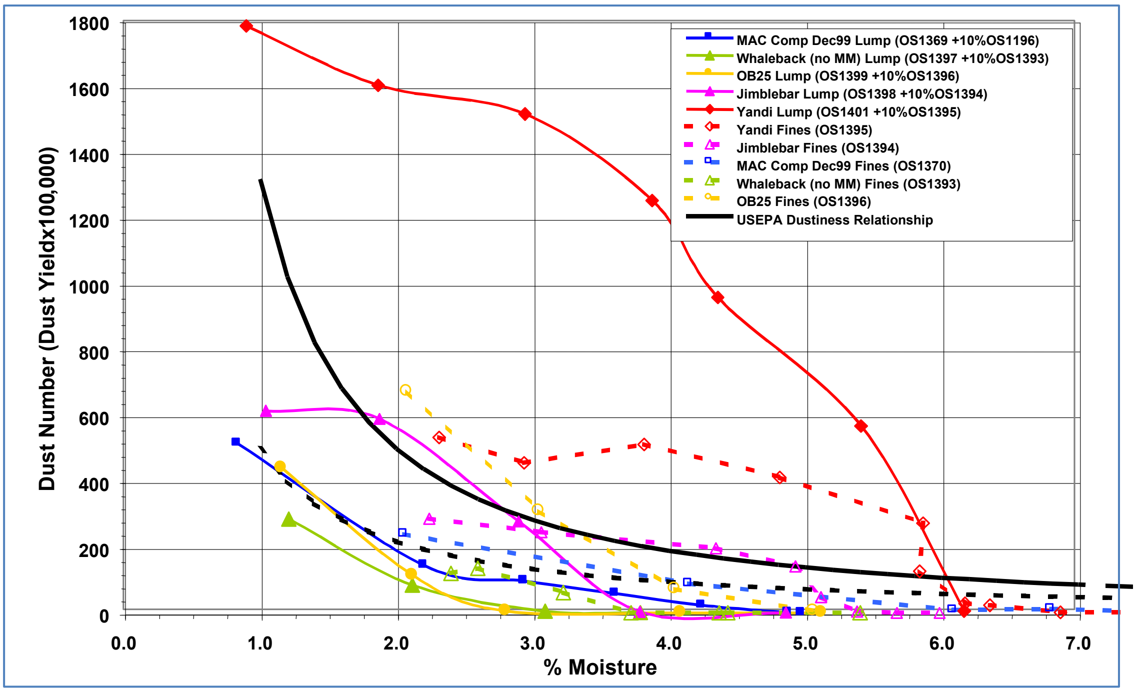

Figure C-2: Rotating Drum Testing for Nelson Point Products

C.1.1.3 Factor Constant

The factor constants used in Equation 1 are presented in Table C-1. These constants were derived by inserting emission measurements taken from various material handling processes at Nelson Point, from a variety of ore types, into Equation 2 and then rearranging to achieve Equation 3.

Equation 3

$$\mathrm{PM}_{10_i} = \mathrm{EPM}_{10_i} \times \frac{3.6}{\left(t \times \left(\frac{WS}{2.2}\right)^{1.3}\right)}$$

Where:

PM_{10_i}	=	Particulate emissions of material handling operation i	(kg/tonne)
EPM_{10_i}	=	Particulate emission rate of material handling operation i	(g/s)
t	=	Loading tonnage	(t/h)
WS	=	Wind speed	(m/s)

Equation 1 was then rearranged to get Equation 4 which is presented below.

Equation 4

$$F = \frac{0.001 \times (DI + 30)}{\mathrm{PM}_{10_i}}$$

Where:

PM_{10i}	=	Particulate emissions of material handling operation i	(kg/tonne)
DI	=	Dustiness Index determined from the rotating drum tests using the dust testing set up	(-)
F	=	Factor constant	(-)

Table C-1: Factor Constants Used for All Model Phases[1]

Material Handling Process	Factor
Transfer Stations and conveying	450

Note: a. Derived from Equation 4

C.1.1.4 Transfer Stations and Conveying

Emissions associated with transfer stations and conveying were estimated using BHP Billiton Iron Ore site specific methodology. The associated data inputs associated in all model phases are provided in Table C-2.

Table C-2: Total Loading Tonnage for Transfer Stations and Conveying

Material	Loading Tonnage	Unit
Ore	15,000,000	tonnes/year

Equation 3 and Equation 4 were used to estimate the PM_{10} rate (g/s) which was the used when setting up an hourly varying CALPUFF emission source file.

C.1.1.5 Potential Sources of Error in Emission Estimation Methodology

While every effort is made to ensure dust sampling and emission calculations are as accurate as possible, there are sources of potential error associated with this methodology. These errors may be associated with either the physical sampling of the dust, or those associated with emission estimation calculations.

Errors associated with physical sampling of dust may include the following:

- The plume sampled may be affected by another dust sources i.e., show an elevated reading dust to another dust source.
- Wind speed is taken as an average value, which may not reflect peaks in dust concentrations associated with wind gusts.
- Calibration of DustTrak to specific ore types.
- Distances of traverse to source were sometimes difficult to measure due to various obstacles between the source and traverse.

Errors may also be associated with source emission calculations. The main error is associated with an "idealised" method of calculating an emission rate where by an empirical equation has been used to provide an hourly average emission rate, however, in reality emissions would vary on a smaller time scale due to wind gusts, ore moisture and ore throughput.

[1] Scenario 1 to 4

C.2 NPI EMISSION ESTIMATION TECHNIQUES

C.2.1 Bulldozing

Bulldozing emission estimation technique was sourced from the *NPI EET Manual for Mining v3.1* (SEWPaC, 2012). The equation used to calculate the emission factor for PM_{10} is given below. The silt and moisture contents used for all phases are provided in Table C-3 and the resulting emission factor is provided in Table C-4.

$$EF_{PM_{10}} = \frac{0.34 \times s^{1.5}}{M^{1.4}}$$

Where:

$EF_{PM_{10}}$	=	Emission factor for PM_{10} due to bulldozer operations	(kg/h)
s	=	Silt content of material bulldozed	(%)
M	=	Moisture content of material bulldozed	(%)

Table C-3: Emission Factor Equation Inputs for Bulldozing for all model phases

Material	Phase	Variable	Value (%)
Ore and Waste	All Phases	Silt Content[a]	10
		Moisture Content[b]	4.75

a. Source: (SEWPaC, 2012), page 55

b. Derived from the target range (3.5%-6%) from ROM Feed (data from BHP Billiton Iron Ore)

Table C-4: Emission Factors for Bulldozing for all model phases

Material	Phase	Emission Factor	Value (kg/h)
Ore and Waste	All Phases	EF_{PM10}	1.21

Source: (SEWPaC, 2012), P15

Total emissions associated with bulldozing for PM_{10} was estimated using the equation below. The data inputs associated with bulldozing for all phases are listed in Table C-5.

$$E_i = OH_{total} \times EF_i \times \left(\frac{100 - CE_i}{100}\right)$$

Where:

E_i	=	Emission rate for pollutant i	(kg/a)
OH_{total}	=	Total operating hours of bulldozers	(hrs/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/h)
CE_i	=	Overall control efficiency for pollutant i	(%)

Table C-5: Activity Data for Bulldozing by Area

Material (Ore and Waste)	Data Input	S5	S4
Ore and Waste in the Pit	Total Operating Hours	4,283	7,106
Waste at the OSA	Total Operating Hours	4,283	7,106

Assumption made by PEL based on information provided by BHP Billiton

C.2.2 Loading

The loading emissions estimation technique was sourced from the *NPI EET Manual for Mining v3.1* (SEWPaC, 2012). The default emission factor was used to estimate PM_{10} emissions from loading for all phases, and is provided in Table C-6.

Table C-6: Emission Factors for Loading for all Model Phases

Material	Emission Factor	Value (kg/t)
Ore and Waste	EF_{PM10}	0.012

Total emissions associated with loading for PM_{10} were estimated using the equation below. The data inputs associated with loading for all phases are listed in Table C-7.

$$E_i = M \times EF_i \times \left(\frac{100 - CE_i}{100}\right)$$

Where:

E_i	=	Emission rate for pollutant i	(kg/a)
M	=	Total amount of material loaded	(tonnes/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/tonne)
CE_i	=	Overall control efficiency for pollutant i	(%)

Table C-7: Activity Data for Loading and Unloading for all Model Phases

Material	Data Input	Value (tonnes)
Ore	Total Ore Loaded	15,000,000
Waste	Total Waste Rock Loaded	25,000,000

C.2.3 Unloading

The unloading emissions estimation technique was sourced from the *NPI EET Manual for Mining v3.1* (SEWPaC, 2012). The default emission factor was used to estimate PM_{10} emissions from unloading for all phases, and is provided in Table C-8.

Table C-8: Emission Factors for Unloading for all Model Phases

Material	Emission Factor	Value (kg/t)
Ore and Waste	EF_{PM10}	0.0043

Total emissions associated with unloading for PM_{10} were estimated using the equation below. The data inputs associated with unloading for all phases are listed Table C-9.

$$E_i = M \times EF_i \times \left(\frac{100 - CE_i}{100}\right)$$

Where:

E_i	=	Emission rate for pollutant i	(kg/a)
M	=	Total amount of material unloaded	(tonnes/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/tonne)
CE_i	=	Overall control efficiency for pollutant i	(%)

Table C-9: Activity Data for Loading and Unloading for all Model Phases

Material	Data Input	Value (tonnes)
Ore	Total Ore Unloaded	15,000,000
Waste	Total Waste Rock Unloaded	25,000,000

C.2.4 Wheel Generated Dust (Unpaved Roads)

Wheel generated dust (unpaved roads) emission estimation techniques were sourced from the *NPI EET Manual for Mining v3.1* (SEWPaC, 2012). The equation used to calculate the emission factor for PM_{10} are given below. Emission factor equation inputs for all phases are provided in Table C-10 and the resulting emission factors are listed in Table C-11.

For heavy vehicle at industrial site:

$$EF_{PM_{10}} = \frac{0.4536}{1.6093} \times 1.5 \times \left(\frac{s_i}{12}\right)^{0.9} \times \left(\frac{W_i \times 1.1023}{3}\right)^{0.45}$$

Where:

$EF_{PM_{10}}$	=	Emissions factor for PM_{10} due to travel on unpaved roads	(kg/km)
s_i	=	Silt content of material i upon which operation is occurring	(%)
W_i	=	Vehicle gross mass operating on material i	(tonnes)
S	=	Mean vehicle speed	(km/h)

Table C-10: Emission Factor Equation Inputs for Wheel Generated Dust (Unpaved Roads) for all Model Phases

Material	Data Input	Value	Units
Ore and Waste	Silt Content[a]	10	%
	Truck Cat 793F Capacity	209	tonnes
	Truck Cat 793F Chasis weight (empty)	122	tonnes
	Truck Cat 793F Loaded weight	331	tonnes

a. Source: (SEWPaC, 2012), page 55

b. Derived from the target range (3.5%-6%) from ROM Feed (data from BHP Billiton Iron Ore)

Table C-11: Emission Factors for Wheel Generated Dust (Unpaved Roads) for All Phases

Vehicle Type	Emission Factor	Value (kg/km)
Truck	EF_{PM10_Loaded}	3.11
	EF_{PM10_Empty}	1.99

Source: (SEWPaC, 2012), page 56

Total emissions of PM_{10} associated with wheel generated dust (unpaved roads) were estimated using the equation below. Equations to calculate the total distance travelled and the number of trips for transferring ore and waste rock on unpaved roads are also listed below.

Emissions have been calculated for unpaved roads for different type of vehicles in all phases. The data inputs associated with vehicles travelling on unpaved roads are presented in Table C.12.

$$E_i = EF_i \times TD \times \left(\frac{100 - CE_i}{100}\right)$$

Where:

E_i	=	Emission rate for pollutant i	(kg/a)
EF_i	=	Uncontrolled emission factor of pollutant i	(kg/km)
TD	=	Total distance travelled on unpaved roads by the vehicle	(km/a)
CE_i	=	Overall control efficiency for pollutant i	(%)

$$TD = L \times N_T$$

Where:

TD	=	Total distance travelled on unpaved roads by the truck	(km/a)
L	=	Haul road length (return trip)	(km)
N_T	=	Number of trips for each truck	(-)

$$N_T = \frac{M}{C_T}$$

Where:

N_T	=	Number of trips	(-)
M	=	Total amount of material loaded onto each truck	(tonnes/a)
C_T	=	Truck capacity	(tonnes)

$$M = \frac{M_T}{P}$$

Where:

M	=	Total amount of material loaded onto each truck	(tonnes/a)
M_T	=	Total amount of material to be moved	(tonnes/a)
P	=	Proportion of material assigned to each truck	(tonnes)

Table C.12: Activity Data for Wheel Generated Dust (Unpaved Roads) by Pit

Material	Haul distance (km)		
	S5	S4	OB31 to OB18
Ore	8	9	9
Waste	3	3	-

C.2.5 Wind Erosion

Site specific wind erosion emission factors were calculated in order to estimate wind erosion emissions. The data inputs associated with wind erosion, i.e. area of stockpiles and active open areas, are provided in Table E-3 and Table E-5 in Appendix E.

The site specific wind erosion emissions factors were calculated using Equation 1. The wind speed threshold (WS_0) and k constant used were 5.23 m/s (SKM, 2005) and $3.75x10^{-07}$ respectively. The constant k and wind speed threshold value is consistent with other dust studies. From Equation 1, the average PM_{10} emission rate was estimated to be 0.40kg/ha/hr, which is greater than the default emission factor of 0.2kg/ha/hr provided in *NPI EET Manual for Mining v3.1* (SEWPaC, 2012) but does represent the greater potential for wind erosion that can occur in the Pilbara.

All stockpiles and active open areas were assumed to be susceptible to wind erosion in this assessment. Equation 2 was used to estimate the PM_{10} rate (g/s) which was used when setting up an hourly varying CALPUFF emission file.

Equation 1

$$EF_{PM10} = k\left[WS^3 \times \left(1 - \frac{{WS_0}^2}{WS^2}\right)\right] \qquad where \;\; WS > WS_0$$

$$EF_{PM10} = 0 \qquad where \;\; WS < WS_0$$

Where:
EF_{PM10} = Emission factor for PM_{10} (g/m²/s)
WS = Wind speed (m/s)
WS_0 = Threshold for dust lift off (m/s)
k = A constant

Equation 2

$$E_{PM10(g/s)} = EF_{PM10} \times A \times \left(\frac{100 - CE_{PM10}}{100}\right)$$

Where:
$E_{PM10(g/s)}$ = Emission rate for PM_{10} (g/s)
EF_{PM10} = Emission factor for PM_{10} (g/s/m²)
A = Total exposed (m²)
CE = Overall control efficiency of PM_{10} (%)

C.2.6 Blasting

The blasting emissions estimation technique was sourced from the *NPI EET Manual for Mining v3.1* (SEWPaC, 2012). The equation used to calculate the emission factors for PM_{10} is given below. Emission factor equation inputs for all phases are provided in Table C-13 and the resulting emission factors are listed in Table C-14.

$$EF_{PM_{10}} = 0.000114 \times A_i^{1.5}$$

Where:

$EF_{PM_{10}}$	=	Emissions factor for PM_{10} due to blasting	(kg/blast)
A_i	=	The area blasted of material i	(m²)

Table C-13: Emission Factor Equation Inputs for Blasting (All Phases)

Material	Data Input		Units
Ore and Waste	Area per blast[a]	11,760	m^2
	Blasting frequency for S5 pit - every[b]	13	day
	Blasting frequency for S4 pit - every[b]	5	
	Number of days per year	365	day
	Width of blasting area[c]	108	m
	Length of blasting area[c]	108	m
	Spacing of blasting area width[a]	7	m
	Spacing of blasting area length[a]	7	m
	Number of holes per blast[d]	272	holes
	Total number of holes	24,819	holes

a. Information provided by BHP Billiton

b. Calculated based on the information moved per pit

c. Calculated from taking square root of blasting area

d. Calculated from: [(Width of blasting area/Spacing of blasting area width) + 1]x[(Length of blasting area/Spacing of blasting area length) + 1]

Table C-14: Emission Factors for Blasting for all Model Phases

Material	Emission Factor	(kg/blast)	(g/s)
Ore and Waste	EF_{PM10}	145.38[a]	40.38[b]

a. Source: (SEWPaC, 2012), p15

b. For an hour every 13 days for S5 pit and an hour every 5 days for S4 pit. Generally mid-days but could be late afternoon on occasions.

Total emissions of PM_{10} associated with blasting were estimated using the equation below. The data inputs associated with blasting operations are listed in Table C-15. It is noted that no control measures were available for blasting.

$$E_i = EF_i \times NB_m \times \left(\frac{100 - CE_i}{100}\right)$$

Where:

E_i	=	Emission rate for pollutant i	(kg/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/blast)
NB_i	=	Number of blasts per year on material i	(blasts/a)
CE_i	=	Overall control efficiency for pollutant i	(%)

Table C-15: Activity Data for Blasting for all Model Phases

Material	Data Input	(blasts)
Ore and Waste	Number of Blasts	97

C.2.7 Drilling

The drilling emissions estimation technique was sourced from the *NPI EET Manual for Mining v3.1* (SEWPaC, 2012). The default emission factor used to estimate emissions from drilling for all phases is provided in Table C-16. Total emissions of PM_{10} associated with drilling were estimated using the equations below. The data inputs associated with drilling for all phases are listed in Table C-17.

Table C-16: Default Emission Factor for Drilling for all Model Phases

Material	Phase	Emission Factor	Value (kg/hole)
Ore and Waste	All Phases	EF_{PM10}	0.31

Source: (SEWPaC, 2012), p15

$$E_i = EF_i \times HD_i \times \left(\frac{100 - CE_i}{100}\right)$$

Where:

E_i	=	Emission rate for pollutant i	(kg/a)
EF_i	=	Uncontrolled emission factor of pollutant i	(kg/hole)
HD_i	=	Holes drilled in material i	(holes/a)
CE_i	=	Overall control efficiency for pollutant i	(%)

$$HD_i = NB_i \times NH_i$$

Where:

HD_i	=	Holes drilled in material i	(holes/a)
NB_i	=	Number of blasts per year on material i	(blasts/a)
NH_i	=	Number of holes for blast i	(holes/blast)

Table C-17: Activity Data for Drilling by Pit

	S5	S4
Number of hole drilled[a]	7,049	17,770

a. Calculated from proportion of total material moved from each pit

C.2.8 Crushing

Emissions associated with crushing were estimated using a technique from the *NPI EET Manual for Mining v3.1* (SEWPaC, 2012). The default emission factor used to estimate emissions of PM_{10} from primary crushing is provided in Table C-18. Total emissions of PM_{10} associated with crushing were estimated using the equation below. The data inputs associated with crushing operations for all phases are listed in Table C-19.

Table C-18: Default Emission Factors for Crushing for all model phases

Material	Description	Emission Factor	Value (kg/tonne)
High Moisture Ore	Primary Crushing	EF_{PM10}	0.004

Source: (SEWPaC, 2012), p20

$$E_i = EF_i \times MC_i \times \left(\frac{100 - CE_i}{100}\right)$$

Where:

E_i	=	Emission rate for pollutant i	(kg/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/tonne)
MC_i	=	The amount of material i crushed	(tonnes/a)
CE_i	=	Overall control efficiency for pollutant i	(%)

Table C-19: Activity Data for all Model Phases

Material	Data Input	Value	(unit)
Ore	Primary crushing	15,000,000	tonnes

Appendix D CALPUFF INPUT FILE

D.1 CALPUFF

```
CALPUFF.INP     2.0             File version record
8549
No Controls
activities at OB31 ROM
---------------- Run title (3 lines) ------------------------------------------

                    CALPUFF MODEL CONTROL FILE
                    --------------------------

-------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names

--------------
Default Name  Type          File Name
------------  ----          ---------
CALMET.DAT    input    ! METDAT =D:\Jobs\8549\CALMET\M01to12.DAT   !
    or
ISCMET.DAT    input    * ISCDAT =              *
    or
PLMMET.DAT    input    * PLMDAT =              *
    or
PROFILE.DAT   input    * PRFDAT =              *
SURFACE.DAT   input    * SFCDAT =              *
RESTARTB.DAT  input    * RSTARTB=              *
--------------------------------------------------------------------------------
CALPUFF.LST   output   ! PUFLST =D:\Jobs\8549\CALPUFF\no control\ob31.LST  !
CONC.DAT      output   ! CONDAT =D:\Jobs\8549\CALPUFF\no control\ob31.CON !
DFLX.DAT      output   * DFDAT  =              *
WFLX.DAT      output   * WFDAT  =              *

VISB.DAT      output   * VISDAT =              *
TK2D.DAT      output   * T2DDAT =              *
RHO2D.DAT     output   * RHODAT =              *
RESTARTE.DAT  output   * RSTARTE=              *
--------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT  =              *
VOLEMARB.DAT  input    ! VOLDAT =D:\Jobs\8549\CALPUFF\no control\ob31.src    !
BAEMARB.DAT   input    * ARDAT  =              *
LNEMARB.DAT   input    * LNDAT  =              *
--------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    * OZDAT  =              *
VD.DAT        input    * VDDAT  =              *
CHEM.DAT      input    * CHEMDAT=              *
AUX           input    ! AUXEXT =AUX     !
(Extension added to METDAT filename(s) for files
 with auxiliary 2D and 3D data)
H2O2.DAT      input    * H2O2DAT=              *
NH3Z.DAT      input    * NH3ZDAT=              *
HILL.DAT      input    * HILDAT=              *
HILLRCT.DAT   input    * RCTDAT=              *
COASTLN.DAT   input    * CSTDAT=              *
```

```
FLUXBDY.DAT   input    * BDYDAT=          *
BCON.DAT      input    * BCNDAT=          *
DEBUG.DAT     output   * DEBUG =          *
MASSFLX.DAT   output   * FLXDAT=          *
MASSBAL.DAT   output   * BALDAT=          *
FOG.DAT       output   * FOGDAT=          *
RISE.DAT      output   * RISDAT=          *
--------------------------------------------------------------------------------
All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = F !
         F = UPPER CASE
NOTE: (1) file/path names can be up to 132 characters in length


Provision for multiple input files
----------------------------------

     Number of Modeling Domains (NMETDOM)
                                     Default: 1       ! NMETDOM =   1   !

     Number of CALMET.DAT files for run (NMETDAT)
                                     Default: 1       ! NMETDAT =   1   !

     Number of PTEMARB.DAT files for run (NPTDAT)
                                     Default: 0       ! NPTDAT =   0   !

     Number of BAEMARB.DAT files for run (NARDAT)
                                     Default: 0       ! NARDAT =   0   !

     Number of VOLEMARB.DAT files for run (NVOLDAT)
                                     Default: 0       ! NVOLDAT =   0   !

!END!

-------------
Subgroup (0a)
-------------

  Provide a name for each CALMET domain if NMETDOM > 1
  Enter NMETDOM lines.
                                    a,b
Default Name             Domain Name
------------             ------------
 none                  * DOMAIN1=     *   *END*
 none                  * DOMAIN2=     *   *END*
 none                  * DOMAIN3=     *   *END*


  The following CALMET.DAT filenames are processed in sequence
  if NMETDAT > 1

  Enter NMETDAT lines, 1 line for each file name.

                                     a,c,d
Default Name  Type          File Name
------------  ----          ---------
 none         input    * METDAT1=     *   *END*
 none         input    * METDAT2=     *   *END*
```

```
 none          input     * METDAT3=     *    *END*

-------------
    a
     The name for each CALMET domain and each CALMET.DAT file is treated
     as a separate input subgroup and therefore must end with an input
     group terminator.
    b
     Use DOMAIN1= to assign the name for the outermost CALMET domain.
     Use DOMAIN2= to assign the name for the next inner CALMET domain.
     Use DOMAIN3= to assign the name for the next inner CALMET domain, etc.
      --------------------------------------------------------------------
      |   When inner domains with equal resolution (grid-cell size)      |
      |   overlap, the data from the FIRST such domain in the list will  |
      |   be used if all other criteria for choosing the controlling     |
      |   grid domain are inconclusive.                                  |
      --------------------------------------------------------------------
    c
     Use METDAT1= to assign the file names for the outermost CALMET domain.
     Use METDAT2= to assign the file names for the next inner CALMET domain.
     Use METDAT3= to assign the file names for the next inner CALMET domain, etc.
    d
     The filenames for each domain must be provided in sequential order

-------------
Subgroup (0b)
-------------

  The following PTEMARB.DAT filenames are processed if NPTDAT>0
  (Each file contains a subset of the sources, for the entire simulation)

Default Name  Type          File Name
------------  ----          ---------
 none         input       * PTDAT=     *    *END*


-------------
Subgroup (0c)
-------------

  The following BAEMARB.DAT filenames are processed if NARDAT>0
  (Each file contains a subset of the sources, for the entire simulation)

Default Name  Type          File Name
------------  ----          ---------
 none         input       * ARDAT=     *    *END*


-------------
Subgroup (0d)
-------------

  The following VOLEMARB.DAT filenames are processed if NVOLDAT>0
  (Each file contains a subset of the sources, for the entire simulation)

Default Name  Type          File Name
------------  ----          ---------
 none         input       * VOLDAT=     *    *END*
```

```
--------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

    Option to run all periods found
    in the met. file     (METRUN)   Default: 0       ! METRUN =   0  !

         METRUN = 0 - Run period explicitly defined below
         METRUN = 1 - Run all periods in met. file

     Starting date:    Year   (IBYR)  --    No default   ! IBYR  =  2010  !
                       Month  (IBMO)  --    No default   ! IBMO  =  1  !
                       Day    (IBDY)  --    No default   ! IBDY  =  1  !
     Starting time:    Hour   (IBHR)  --    No default   ! IBHR  =  0  !
                       Minute (IBMIN) --    No default   ! IBMIN =  0  !
                       Second (IBSEC) --    No default   ! IBSEC =  0  !

     Ending date:      Year   (IEYR)  --    No default   ! IEYR  =  2010  !
                       Month  (IEMO)  --    No default   ! IEMO  =  12  !
                       Day    (IEDY)  --    No default   ! IEDY  =  31  !
     Ending time:      Hour   (IEHR)  --    No default   ! IEHR  =  23  !
                       Minute (IEMIN) --    No default   ! IEMIN =  0  !
                       Second (IESEC) --    No default   ! IESEC =  0  !

     (These are only used if METRUN = 0)

     Base time zone:          (ABTZ)  --    No default   ! ABTZ= UTC+0800 !
      (character*8)
     The modeling domain may span multiple time zones.  ABTZ defines the
     base time zone used for the entire simulation.  This must match the
     base time zone of the meteorological data.
     Examples:
         Los Angeles, USA          = UTC-0800
         New York, USA             = UTC-0500
         Santiago, Chile           = UTC-0400
         Greenwich Mean Time (GMT) = UTC+0000
         Rome, Italy               = UTC+0100
         Cape Town, S.Africa       = UTC+0200
         Sydney, Australia         = UTC+1000

     Length of modeling time-step (seconds)
     Equal to update period in the primary
     meteorological data files, or an
     integer fraction of it (1/2, 1/3 ...)
     Must be no larger than 1 hour
     (NSECDT)                       Default:3600     ! NSECDT =  3600  !
                                    Units: seconds

     Number of chemical species (NSPEC)
                                    Default: 5       ! NSPEC =  1   !

     Number of chemical species
     to be emitted  (NSE)           Default: 3       ! NSE =  0   !

     Flag to stop run after
     SETUP phase (ITEST)            Default: 2       ! ITEST =  2   !
     (Used to allow checking
```

```
of the model inputs, files, etc.)
      ITEST = 1 - STOPS program after SETUP phase
      ITEST = 2 - Continues with execution of program
                  after SETUP

Restart Configuration:

   Control flag (MRESTART)      Default: 0       ! MRESTART =  0   !

      0 = Do not read or write a restart file
      1 = Read a restart file at the beginning of
          the run
      2 = Write a restart file during run
      3 = Read a restart file at beginning of run
          and write a restart file during run

   Number of periods in Restart
   output cycle (NRESPD)        Default: 0       ! NRESPD =  0   !

      0 = File written only at last period
     >0 = File updated every NRESPD periods

Meteorological Data Format (METFM)
                                Default: 1       ! METFM =  1   !

      METFM = 1 - CALMET binary file (CALMET.MET)
      METFM = 2 - ISC ASCII file (ISCMET.MET)
      METFM = 3 - AUSPLUME ASCII file (PLMMET.MET)
      METFM = 4 - CTDM plus tower file (PROFILE.DAT) and
                  surface parameters file (SURFACE.DAT)
      METFM = 5 - AERMET tower file (PROFILE.DAT) and
                  surface parameters file (SURFACE.DAT)

Meteorological Profile Data Format (MPRFFM)
       (used only for METFM = 1, 2, 3)
                                Default: 1       ! MPRFFM =  1   !

      MPRFFM = 1 - CTDM plus tower file (PROFILE.DAT)
      MPRFFM = 2 - AERMET tower file (PROFILE.DAT)

PG sigma-y is adjusted by the factor (AVET/PGTIME)**0.2
Averaging Time (minutes) (AVET)
                                Default: 60.0    ! AVET = 60. !
PG Averaging Time (minutes) (PGTIME)
                                Default: 60.0    ! PGTIME = 60. !


Output units for binary concentration and flux files
written in Dataset v2.2 or later formats
(IOUTU)                         Default: 1       ! IOUTU =  1   !
    1 = mass      -  g/m3 (conc) or g/m2/s (dep)
    2 = odour     -  odour_units (conc)
    3 = radiation -  Bq/m3 (conc) or Bq/m2/s (dep)


Output Dataset format for binary concentration
and flux files (e.g., CONC.DAT)
(IOVERS)                        Default: 2       ! IOVERS =  2   !
    1 = Dataset Version 2.1
```

```
        2 = Dataset Version 2.2


!END!


-------------------------------------------------------------------------------

INPUT GROUP: 2 -- Technical options
--------------


     Vertical distribution used in the
     near field (MGAUSS)                   Default: 1     ! MGAUSS =  1   !
        0 = uniform
        1 = Gaussian

     Terrain adjustment method
     (MCTADJ)                              Default: 3     ! MCTADJ =  3   !
        0 = no adjustment
        1 = ISC-type of terrain adjustment
        2 = simple, CALPUFF-type of terrain
            adjustment
        3 = partial plume path adjustment

     Subgrid-scale complex terrain
     flag (MCTSG)                          Default: 0     ! MCTSG =  0   !
        0 = not modeled
        1 = modeled

     Near-field puffs modeled as
     elongated slugs? (MSLUG)              Default: 0     ! MSLUG =  0   !
        0 = no
        1 = yes (slug model used)

     Transitional plume rise modeled?
     (MTRANS)                              Default: 1     ! MTRANS =  1   !
        0 = no  (i.e., final rise only)
        1 = yes (i.e., transitional rise computed)

     Stack tip downwash? (MTIP)            Default: 1     ! MTIP =  1  !
        0 = no  (i.e., no stack tip downwash)
        1 = yes (i.e., use stack tip downwash)

     Method used to compute plume rise for
     point sources not subject to building
     downwash? (MRISE)                     Default: 1     ! MRISE =  1  !
        1 = Briggs plume rise
        2 = Numerical plume rise

     Method used to simulate building
     downwash? (MBDW)                      Default: 1     ! MBDW =   1  !
        1 = ISC method
        2 = PRIME method

     Vertical wind shear modeled above
     stack top (modified Briggs plume rise)?
     (MSHEAR)                              Default: 0     ! MSHEAR =  0  !
        0 = no  (i.e., vertical wind shear not modeled)
```

```
   1 = yes (i.e., vertical wind shear modeled)

Puff splitting allowed? (MSPLIT)      Default: 0     ! MSPLIT =  0  !
   0 = no (i.e., puffs not split)
   1 = yes (i.e., puffs are split)

Chemical mechanism flag (MCHEM)       Default: 1     ! MCHEM =  0   !
   0 = chemical transformation not
       modeled
   1 = transformation rates computed
       internally (MESOPUFF II scheme)
   2 = user-specified transformation
       rates used
   3 = transformation rates computed
       internally (RIVAD/ARM3 scheme)
   4 = secondary organic aerosol formation
       computed (MESOPUFF II scheme for OH)
   5 = user-specified half-life with or
       without transfer to child species
   6 = transformation rates computed
       internally (Updated RIVAD scheme with
       ISORROPIA equilibrium)
   7 = transformation rates computed
       internally (Updated RIVAD scheme with
       ISORROPIA equilibrium and CalTech SOA)

Aqueous phase transformation flag (MAQCHEM)
(Used only if MCHEM = 6, or 7)        Default: 0     ! MAQCHEM =  0   !
   0 = aqueous phase transformation
       not modeled
   1 = transformation rates and wet
       scavenging coefficients adjusted
       for in-cloud aqueous phase reactions
       (adapted from RADM cloud model
        implementation in CMAQ/SCICHEM)

Liquid Water Content flag (MLWC)
(Used only if MAQCHEM = 1)            Default: 1     ! MLWC =  1   !
   0 = water content estimated from cloud cover
       and presence of precipitation
   1 = gridded cloud water data read from CALMET
       water content output files (filenames are
       the CALMET.DAT names PLUS the extension
       AUXEXT provided in Input Group 0)

Wet removal modeled ? (MWET)          Default: 1     ! MWET =  0   !
   0 = no
   1 = yes

Dry deposition modeled ? (MDRY)       Default: 1     ! MDRY =  1   !
   0 = no
   1 = yes
   (dry deposition method specified
    for each species in Input Group 3)


Gravitational settling (plume tilt)
modeled ? (MTILT)                     Default: 0     ! MTILT =  0   !
   0 = no
```

```
    1 = yes
    (puff center falls at the gravitational
     settling velocity for 1 particle species)

Restrictions:
     - MDRY  = 1
     - NSPEC = 1  (must be particle species as well)
     - sg    = 0  GEOMETRIC STANDARD DEVIATION in Group 8 is
                  set to zero for a single particle diameter

Method used to compute dispersion
coefficients (MDISP)                   Default: 3     ! MDISP =  2   !

    1 = dispersion coefficients computed from measured values
        of turbulence, sigma v, sigma w
    2 = dispersion coefficients from internally calculated
        sigma v, sigma w using micrometeorological variables
        (u*, w*, L, etc.)
    3 = PG dispersion coefficients for RURAL areas (computed using
        the ISCST multi-segment approximation) and MP coefficients in
        urban areas
    4 = same as 3 except PG coefficients computed using
        the MESOPUFF II eqns.
    5 = CTDM sigmas used for stable and neutral conditions.
        For unstable conditions, sigmas are computed as in
        MDISP = 3, described above.  MDISP = 5 assumes that
        measured values are read

Sigma-v/sigma-theta, sigma-w measurements used? (MTURBVW)
(Used only if MDISP = 1 or 5)          Default: 3     ! MTURBVW =  3  !
    1 = use sigma-v or sigma-theta measurements
        from PROFILE.DAT to compute sigma-y
        (valid for METFM = 1, 2, 3, 4, 5)
    2 = use sigma-w measurements
        from PROFILE.DAT to compute sigma-z
        (valid for METFM = 1, 2, 3, 4, 5)
    3 = use both sigma-(v/theta) and sigma-w
        from PROFILE.DAT to compute sigma-y and sigma-z
        (valid for METFM = 1, 2, 3, 4, 5)
    4 = use sigma-theta measurements
        from PLMMET.DAT to compute sigma-y
        (valid only if METFM = 3)

Back-up method used to compute dispersion
when measured turbulence data are
missing (MDISP2)                       Default: 3     ! MDISP2 =  3   !
(used only if MDISP = 1 or 5)
    2 = dispersion coefficients from internally calculated
        sigma v, sigma w using micrometeorological variables
        (u*, w*, L, etc.)
    3 = PG dispersion coefficients for RURAL areas (computed using
        the ISCST multi-segment approximation) and MP coefficients in
        urban areas
    4 = same as 3 except PG coefficients computed using
        the MESOPUFF II eqns.

[DIAGNOSTIC FEATURE]
Method used for Lagrangian timescale for Sigma-y
(used only if MDISP=1,2 or MDISP2=1,2)
```

```
(MTAULY)                              Default: 0     ! MTAULY =  0  !
   0 = Draxler default 617.284 (s)
   1 = Computed as Lag. Length / (.75 q) -- after SCIPUFF
  10 < Direct user input (s)             -- e.g., 306.9


[DIAGNOSTIC FEATURE]
Method used for Advective-Decay timescale for Turbulence
(used only if MDISP=2 or MDISP2=2)
(MTAUADV)                             Default: 0     ! MTAUADV =  0  !
   0 = No turbulence advection
   1 = Computed (OPTION NOT IMPLEMENTED)
  10 < Direct user input (s)   -- e.g., 800


Method used to compute turbulence sigma-v &
sigma-w using micrometeorological variables
(Used only if MDISP = 2 or MDISP2 = 2)
(MCTURB)                              Default: 1     ! MCTURB =  1  !
   1 = Standard CALPUFF subroutines
   2 = AERMOD subroutines

PG sigma-y,z adj. for roughness?      Default: 0     ! MROUGH =  0  !
(MROUGH)
   0 = no
   1 = yes

Partial plume penetration of          Default: 1     ! MPARTL =  1  !
elevated inversion modeled for
point sources?
(MPARTL)
   0 = no
   1 = yes

Partial plume penetration of          Default: 1     ! MPARTLBA =  1  !
elevated inversion modeled for
buoyant area sources?
(MPARTLBA)
   0 = no
   1 = yes

Strength of temperature inversion     Default: 0     ! MTINV =  0  !
provided in PROFILE.DAT extended records?
(MTINV)
   0 = no (computed from measured/default gradients)
   1 = yes

PDF used for dispersion under convective conditions?
                                      Default: 0     ! MPDF =  0  !
(MPDF)
   0 = no
   1 = yes

Sub-Grid TIBL module used for shore line?
                                      Default: 0     ! MSGTIBL = 0  !
(MSGTIBL)
   0 = no
   1 = yes
```

```
Boundary conditions (concentration) modeled?
                                      Default: 0     ! MBCON = 0  !
(MBCON)
   0 = no
   1 = yes, using formatted BCON.DAT file
   2 = yes, using unformatted CONC.DAT file

Note:  MBCON > 0 requires that the last species modeled
       be 'BCON'.  Mass is placed in species BCON when
       generating boundary condition puffs so that clean
       air entering the modeling domain can be simulated
       in the same way as polluted air.  Specify zero
       emission of species BCON for all regular sources.

Individual source contributions saved?
                                      Default: 0     ! MSOURCE = 0  !
(MSOURCE)
   0 = no
   1 = yes


Analyses of fogging and icing impacts due to emissions from
arrays of mechanically-forced cooling towers can be performed
using CALPUFF in conjunction with a cooling tower emissions
processor (CTEMISS) and its associated postprocessors.  Hourly
emissions of water vapor and temperature from each cooling tower
cell are computed for the current cell configuration and ambient
conditions by CTEMISS. CALPUFF models the dispersion of these
emissions and provides cloud information in a specialized format
for further analysis. Output to FOG.DAT is provided in either
'plume mode' or 'receptor mode' format.

Configure for FOG Model output?
                                      Default: 0     ! MFOG =  0   !
(MFOG)
   0 = no
   1 = yes  - report results in PLUME Mode format
   2 = yes  - report results in RECEPTOR Mode format


Test options specified to see if
they conform to regulatory
values? (MREG)                        Default: 1     ! MREG =  0   !

   0 = NO checks are made
   1 = Technical options must conform to USEPA
       Long Range Transport (LRT) guidance
                  METFM    1 or 2
                  AVET     60. (min)
                  PGTIME   60. (min)
                  MGAUSS   1
                  MCTADJ   3
                  MTRANS   1
                  MTIP     1
                  MRISE    1
                  MCHEM    1 or 3 (if modeling SOx, NOx)
                  MWET     1
                  MDRY     1
                  MDISP    2 or 3
```

```
                       MPDF     0 if MDISP=3
                                1 if MDISP=2
                       MROUGH   0
                       MPARTL   1
                       MPARTLBA 0
                       SYTDEP   550. (m)
                       MHFTSZ   0
                       SVMIN    0.5 (m/s)


!END!


-------------------------------------------------------------------------------

INPUT GROUP: 3a, 3b -- Species list
-------------------

------------
Subgroup (3a)
------------

  The following species are modeled:

! CSPEC =         PM10 !         !END!

                                                                   Dry                 OUTPUT
GROUP
    SPECIES          MODELED          EMITTED        DEPOSITED               NUMBER
     NAME          (0=NO, 1=YES)    (0=NO, 1=YES)    (0=NO,                 (0=NONE,
   (Limit: 12                                            1=COMPUTED-GAS         1=1st
CGRUP,
    Characters                                           2=COMPUTED-PARTICLE    2=2nd
CGRUP,
    in length)                                        3=USER-SPECIFIED)      3= etc.)

!         PM10   =         1,              0,           2,                  0    !

!END!

  Note:  The last species in (3a) must be 'BCON' when using the
         boundary condition option (MBCON > 0).  Species BCON should
         typically be modeled as inert (no chem transformation or
         removal).


-------------
Subgroup (3b)
-------------
  The following names are used for Species-Groups in which results
  for certain species are combined (added) prior to output.  The
  CGRUP name will be used as the species name in output files.
  Use this feature to model specific particle-size distributions
  by treating each size-range as a separate species.
  Order must be consistent with 3(a) above.



-------------------------------------------------------------------------------
```

```
INPUT GROUP: 4 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = UTM  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST  = 0.000  !
     (FNORTH)                   Default=0.0     ! FNORTH = 0.000  !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN =  50   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = S  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                    No Default      ! RLAT0 =  0N  !
     (RLON0)                    No Default      ! RLON0 =  0E  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 =  0N  !
     (XLAT2)                    No Default      ! XLAT2 =  0N  !

         LCC :  Projection cone slices through Earth's surface at XLAT1 and XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
```

```
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E


     Datum-region
     ------------

     The Datum-Region for the coordinates is identified by a character
     string.  Many mapping products currently available use the model of the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its output
     consistent with local mapping products.  The list of Datum-Regions with
     official transformation parameters is provided by the National Imagery and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)
     ------------------------------------------------------------------------------
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                    Default: WGS-84    ! DATUM = WGS-84  !


METEOROLOGICAL Grid:

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =  210   !
            No. Y grid cells (NY)      No default     ! NY =  120   !
         No. vertical layers (NZ)      No default     ! NZ =  12   !

           Grid spacing (DGRIDKM)      No default     ! DGRIDKM = .35 !
                                       Units: km

               Cell face heights
                   (ZFACE(nz+1))       No defaults
                                       Units: m
   ! ZFACE = .0, 20.0, 40.0, 60.0, 80.0, 100.0, 150.0, 200.0, 250.0, 500.0,
             1000.0, 2000.0, 3000.0 !

            Reference Coordinates
           of SOUTHWEST corner of
                 grid cell(1, 1):

            X coordinate (XORIGKM)     No default     ! XORIGKM = 768.0 !
            Y coordinate (YORIGKM)     No default     ! YORIGKM = 7396.0 !
                                      Units: km


COMPUTATIONAL Grid:
```

```
     The computational grid is identical to or a subset of the MET. grid.
     The lower left (LL) corner of the computational grid is at grid point
     (IBCOMP, JBCOMP) of the MET. grid.  The upper right (UR) corner of the
     computational grid is at grid point (IECOMP, JECOMP) of the MET. grid.
     The grid spacing of the computational grid is the same as the MET. grid.

        X index of LL corner (IBCOMP)      No default     ! IBCOMP =  1   !
                  (1 <= IBCOMP <= NX)

        Y index of LL corner (JBCOMP)      No default     ! JBCOMP =  1   !
                  (1 <= JBCOMP <= NY)


        X index of UR corner (IECOMP)      No default     ! IECOMP =  210   !
                  (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default     ! JECOMP =  120   !
                  (1 <= JECOMP <= NY)



SAMPLING Grid (GRIDDED RECEPTORS):

     The lower left (LL) corner of the sampling grid is at grid point
     (IBSAMP, JBSAMP) of the MET. grid.  The upper right (UR) corner of the
     sampling grid is at grid point (IESAMP, JESAMP) of the MET. grid.
     The sampling grid must be identical to or a subset of the computational
     grid.  It may be a nested grid inside the computational grid.
     The grid spacing of the sampling grid is DGRIDKM/MESHDN.

        Logical flag indicating if gridded
        receptors are used (LSAMP)         Default: T     ! LSAMP = T !
        (T=yes, F=no)

        X index of LL corner (IBSAMP)      No default     ! IBSAMP =  1   !
         (IBCOMP <= IBSAMP <= IECOMP)

        Y index of LL corner (JBSAMP)      No default     ! JBSAMP =  1   !
         (JBCOMP <= JBSAMP <= JECOMP)


        X index of UR corner (IESAMP)      No default     ! IESAMP =  210   !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default     ! JESAMP =  120   !
         (JBCOMP <= JESAMP <= JECOMP)


       Nesting factor of the sampling
        grid (MESHDN)                      Default: 1     ! MESHDN =  1  !
        (MESHDN is an integer >= 1)

!END!

-------------------------------------------------------------------------------

INPUT GROUP: 5 -- Output Options
```

```
--------------
                                                       *                          *
     FILE                      DEFAULT VALUE             VALUE THIS RUN
     ----                      -------------             --------------

   Concentrations (ICON)              1                  !  ICON =  1   !
   Dry Fluxes (IDRY)                  1                  !  IDRY =  0   !
   Wet Fluxes (IWET)                  1                  !  IWET =  0   !
   2D Temperature (IT2D)              0                  !  IT2D =  0   !
   2D Density (IRHO)                  0                  !  IRHO =  0   !
   Relative Humidity (IVIS)           1                  !  IVIS =  0   !
    (relative humidity file is
     required for visibility
     analysis)
   Use data compression option in output file?
   (LCOMPRS)                           Default: T        ! LCOMPRS = T !

   *
    0 = Do not create file, 1 = create file


    QA PLOT FILE OUTPUT OPTION:

       Create a standard series of output files (e.g.
       locations of sources, receptors, grids ...)
       suitable for plotting?
       (IQAPLOT)                       Default: 1        !  IQAPLOT =  1   !
         0 = no
         1 = yes

    DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:

       Mass flux across specified boundaries
       for selected species reported?
       (IMFLX)                         Default: 0        ! IMFLX =  0  !
         0 = no
         1 = yes (FLUXBDY.DAT and MASSFLX.DAT filenames
                  are specified in Input Group 0)

       Mass balance for each species
       reported?
       (IMBAL)                         Default: 0        ! IMBAL =  0  !
         0 = no
         1 = yes (MASSBAL.DAT filename is
              specified in Input Group 0)


    NUMERICAL RISE OUTPUT OPTION:

       Create a file with plume properties for each rise
       increment, for each model timestep?
       This applies to sources modeled with numerical rise
       and is limited to ONE source in the run.
       (INRISE)                        Default: 0        ! INRISE =  0  !
         0 = no
         1 = yes (RISE.DAT filename is
                  specified in Input Group 0)
```

```
    LINE PRINTER OUTPUT OPTIONS:

       Print concentrations (ICPRT)     Default: 0          ! ICPRT =  0   !
       Print dry fluxes (IDPRT)         Default: 0          ! IDPRT =  0   !
       Print wet fluxes (IWPRT)         Default: 0          ! IWPRT =  0   !
       (0 = Do not print, 1 = Print)

       Concentration print interval
       (ICFRQ) in timesteps             Default: 1          ! ICFRQ =  1   !
       Dry flux print interval
       (IDFRQ) in timesteps             Default: 1          ! IDFRQ =  1   !
       Wet flux print interval
       (IWFRQ) in timesteps             Default: 1          ! IWFRQ =  1   !

       Units for Line Printer Output
       (IPRTU)                          Default: 1          ! IPRTU =  3   !
                       for              for
                  Concentration    Deposition
           1 =        g/m**3         g/m**2/s
           2 =       mg/m**3        mg/m**2/s
           3 =       ug/m**3        ug/m**2/s
           4 =       ng/m**3        ng/m**2/s
           5 =      Odour Units

       Messages tracking progress of run
       written to the screen ?
       (IMESG)                          Default: 2          ! IMESG =  2   !
         0 = no
         1 = yes (advection step, puff ID)
         2 = yes (YYYYJJJHH, # old puffs, # emitted puffs)


     SPECIES (or GROUP for combined species) LIST FOR OUTPUT OPTIONS

                 ---- CONCENTRATIONS ----    ------ DRY FLUXES ------    ------ WET
FLUXES ------   -- MASS FLUX --
   SPECIES
   /GROUP          PRINTED?  SAVED ON DISK?    PRINTED?  SAVED ON DISK?    PRINTED?
SAVED ON DISK?   SAVED ON DISK?
   -------       ------------------------   ------------------------   ------------
------------   ---------------
!          PM10 =      0,             1,             0,             0,             0,
0,            0   !

  Note:  Species BCON (for MBCON > 0) does not need to be saved on disk.


     OPTIONS FOR PRINTING "DEBUG" QUANTITIES (much output)

       Logical for debug output
       (LDEBUG)                                  Default: F     ! LDEBUG = F !

       First puff to track
       (IPFDEB)                                  Default: 1     ! IPFDEB =  1  !

       Number of puffs to track
       (NPFDEB)                                  Default: 1     ! NPFDEB =  1  !

       Met. period to start output
```

```
       (NN1)                                Default: 1      ! NN1 =  1   !

       Met. period to end output
       (NN2)                                Default: 10     ! NN2 =  10  !

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 6a, 6b, & 6c -- Subgrid scale complex terrain inputs
-------------------------

---------------
Subgroup (6a)
---------------
       Number of terrain features (NHILL)       Default: 0      ! NHILL =  0   !

       Number of special complex terrain
       receptors  (NCTREC)                      Default: 0      ! NCTREC =  0   !

       Terrain and CTSG Receptor data for
       CTSG hills input in CTDM format ?
       (MHILL)                                  No Default      ! MHILL =  2   !
       1 = Hill and Receptor data created
           by CTDM processors & read from
           HILL.DAT and HILLRCT.DAT files
       2 = Hill data created by OPTHILL &
           input below in Subgroup (6b);
           Receptor data in Subgroup (6c)

       Factor to convert horizontal dimensions  Default: 1.0    ! XHILL2M = 1.0 !
       to meters (MHILL=1)

       Factor to convert vertical dimensions    Default: 1.0    ! ZHILL2M = 1.0 !
       to meters (MHILL=1)

       X-origin of CTDM system relative to      No Default      ! XCTDMKM = 0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

       Y-origin of CTDM system relative to      No Default      ! YCTDMKM = 0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

! END !

---------------
Subgroup (6b)
---------------

                      1 **
     HILL information


HILL          XC         YC        THETAH  ZGRID  RELIEF    EXPO 1    EXPO 2   SCALE
1    SCALE 2    AMAX1     AMAX2
 NO.         (km)       (km)       (deg.)   (m)     (m)      (m)       (m)       (m)
(m)        (m)        (m)
```

```
----          ----      ----      ------  -----  ------    ------    ------   -----
--    -------    -----     -----

---------------
Subgroup (6c)
---------------

    COMPLEX TERRAIN RECEPTOR INFORMATION

                      XRCT         YRCT        ZRCT          XHH
                      (km)         (km)         (m)
                     ------       -----      ------         ----


-------------------
1
     Description of Complex Terrain Variables:
          XC, YC  = Coordinates of center of hill
          THETAH  = Orientation of major axis of hill (clockwise from
                    North)
          ZGRID   = Height of the  0  of the grid above mean sea
                    level
          RELIEF  = Height of the crest of the hill above the grid elevation
          EXPO 1  = Hill-shape exponent for the major axis
          EXPO 2  = Hill-shape exponent for the major axis
          SCALE 1 = Horizontal length scale along the major axis
          SCALE 2 = Horizontal length scale along the minor axis
          AMAX    = Maximum allowed axis length for the major axis
          BMAX    = Maximum allowed axis length for the major axis

          XRCT, YRCT = Coordinates of the complex terrain receptors
          ZRCT    = Height of the ground (MSL) at the complex terrain
                    Receptor
          XHH     = Hill number associated with each complex terrain receptor
                    (NOTE: MUST BE ENTERED AS A REAL NUMBER)

   **
     NOTE: DATA for each hill and CTSG receptor are treated as a separate
           input subgroup and therefore must end with an input group terminator.

-------------------------------------------------------------------------------


INPUT GROUP: 7 -- Chemical parameters for dry deposition of gases
--------------

      SPECIES        DIFFUSIVITY         ALPHA  STAR        REACTIVITY      MESOPHYLL
RESISTANCE     HENRY'S LAW COEFFICIENT
       NAME          (cm**2/s)                                                    (s/cm)
(dimensionless)
      -------     -----------      ----------      ----------     ------------------
--     -----------------------


!END!


-------------------------------------------------------------------------------
```

```
INPUT GROUP: 8 -- Size parameters for dry deposition of particles
--------------

     For SINGLE SPECIES, the mean and standard deviation are used to
     compute a deposition velocity for NINT (see group 9) size-ranges,
     and these are then averaged to obtain a mean deposition velocity.

     For GROUPED SPECIES, the size distribution should be explicitly
     specified (by the 'species' in the group), and the standard deviation
     for each should be entered as 0.  The model will then use the
     deposition velocity for the stated mean diameter.

      SPECIES      GEOMETRIC MASS MEAN        GEOMETRIC STANDARD
       NAME            DIAMETER                   DEVIATION
                       (microns)                  (microns)
      -------      -------------------        ------------------
!         PM10 =          3.25,                    2.23   !

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 9 -- Miscellaneous dry deposition parameters
--------------

     Reference cuticle resistance (s/cm)
     (RCUTR)                          Default: 30    !  RCUTR = 30.0 !
     Reference ground resistance  (s/cm)
     (RGR)                            Default: 10    !    RGR = 10.0 !
     Reference pollutant reactivity
     (REACTR)                         Default: 8     ! REACTR = 8.0 !

     Number of particle-size intervals used to
     evaluate effective particle deposition velocity
     (NINT)                           Default: 9     !   NINT =  9   !

     Vegetation state in unirrigated areas
     (IVEG)                           Default: 1     !   IVEG =  1    !
        IVEG=1 for active and unstressed vegetation
        IVEG=2 for active and stressed vegetation
        IVEG=3 for inactive vegetation

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 10 -- Wet Deposition Parameters
---------------


                      Scavenging Coefficient -- Units: (sec)**(-1)

       Pollutant      Liquid Precip.       Frozen Precip.
       ---------      --------------       --------------
```

```
!END!


-------------------------------------------------------------------------------


INPUT GROUP: 11a, 11b -- Chemistry Parameters
---------------------

---------------
Subgroup (11a)
---------------

     Several parameters are needed for one or more of the chemical transformation
     mechanisms.  Those used for each mechanism are:
                                          M                 B
                                          A  B  R  R  R     C  B        N
                                    B     V  C  N  N  N  M  K  C  O     D
                                    C  M  G  K  I  I  I  H  H  K  F  V  E
                                 M  K  N  N  N  T  T  T  2  2  P  R  C  C
                                 O  O  H  H  H  E  E  E  O  O  M  A  N  A
     Mechanism (MCHEM)           Z  3  3  3  3  1  2  3  2  2  F  C  X  Y
     --------------------   --------------------------------------------
     0 None                      .  .  .  .  .  .  .  .  .  .  .  .  .  .
     1 MESOPUFF II               X  X  .  .  X  X  X  X  .  .  .  .  .  .
     2 User Rates                .  .  .  .  .  .  .  .  .  .  .  .  .  .
     3 RIVAD                     X  X  .  .  X  .  .  .  .  .  .  .  .  .
     4 SOA                       X  X  .  .  .  .  .  .  .  .  X  X  X  .
     5 Radioactive Decay         .  .  .  .  .  .  .  .  .  .  .  .  .  X
     6 RIVAD/ISORRPIA            X  X  X  X  X  X  .  .  X  X  .  .  .  .
     7 RIVAD/ISORRPIA/SOA        X  X  X  X  X  X  .  .  X  X  X  X  .  .


     Ozone data input option (MOZ)     Default: 1            ! MOZ =  0   !
     (Used only if MCHEM = 1, 3, 4, 6, or 7)
        0 = use a monthly background ozone value
        1 = read hourly ozone concentrations from
            the OZONE.DAT data file

     Monthly ozone concentrations in ppb (BCKO3)
     (Used only if MCHEM = 1,3,4,6, or 7 and either
        MOZ = 0, or
        MOZ = 1 and all hourly O3 data missing)
                                       Default: 12*80.
     !   BCKO3 = 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00,
80.00, 80.00, 80.00 !

     Ammonia data option (MNH3)        Default: 0            ! MNH3 =  0   !
     (Used only if MCHEM = 6 or 7)
        0 = use monthly background ammonia values (BCKNH3) - no vertical variation
        1 = read monthly background ammonia values for each layer from
            the NH3Z.DAT data file

     Ammonia vertical averaging option (MAVGNH3)
     (Used only if MCHEM = 6 or 7, and MNH3 = 1)
        0 = use NH3 at puff center height (no averaging is done)
        1 = average NH3 values over vertical extent of puff
                                       Default: 1            ! MAVGNH3 =  1   !
```

```
     Monthly ammonia concentrations in ppb (BCKNH3)
     (Used only if MCHEM = 1 or 3, or
                if MCHEM = 6 or 7, and MNH3 = 0)
                                  Default: 12*10.
     !  BCKNH3 = 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00,
10.00, 10.00, 10.00 !

     Nighttime SO2 loss rate in %/hour (RNITE1)
     (Used only if MCHEM = 1, 6 or 7)
     This rate is used only at night for MCHEM=1
     and is added to the computed rate both day
     and night for MCHEM=6,7 (heterogeneous reactions)
                                  Default: 0.2          ! RNITE1 = .2 !

     Nighttime NOx loss rate in %/hour (RNITE2)
     (Used only if MCHEM = 1)
                                  Default: 2.0          ! RNITE2 = 2.0 !

     Nighttime HNO3 formation rate in %/hour (RNITE3)
     (Used only if MCHEM = 1)
                                  Default: 2.0          ! RNITE3 = 2.0 !

     H2O2 data input option (MH2O2)    Default: 1       ! MH2O2 =  1   !
     (Used only if MCHEM = 6 or 7, and MAQCHEM = 1)
        0 = use a monthly background H2O2 value
        1 = read hourly H2O2 concentrations from
            the H2O2.DAT data file

     Monthly H2O2 concentrations in ppb (BCKH2O2)
     (Used only if MQACHEM = 1 and either
        MH2O2 = 0 or
        MH2O2 = 1 and all hourly H2O2 data missing)
                                  Default: 12*1.
     !  BCKH2O2 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00,
1.00 !


 --- Data for SECONDARY ORGANIC AEROSOL (SOA) Options
     (used only if MCHEM = 4 or 7)

     The MCHEM = 4 SOA module uses monthly values of:
          Fine particulate concentration in ug/m^3 (BCKPMF)
          Organic fraction of fine particulate     (OFRAC)
          VOC / NOX ratio (after reaction)         (VCNX)

     The MCHEM = 7 SOA module uses monthly values of:
          Fine particulate concentration in ug/m^3 (BCKPMF)
          Organic fraction of fine particulate     (OFRAC)

     These characterize the air mass when computing
     the formation of SOA from VOC emissions.
     Typical values for several distinct air mass types are:

        Month    1    2    3    4    5    6    7    8    9   10   11   12
                Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

     Clean Continental
        BCKPMF   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.
```

```
        OFRAC  .15  .15  .20  .20  .20  .20  .20  .20  .20  .20  .20  .15
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Clean Marine (surface)
        BCKPMF  .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5
        OFRAC  .25  .25  .30  .30  .30  .30  .30  .30  .30  .30  .30  .25
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Urban - low biogenic (controls present)
        BCKPMF  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.
        OFRAC  .20  .20  .25  .25  .25  .25  .25  .25  .20  .20  .20  .20
        VCNX     4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.

     Urban - high biogenic (controls present)
        BCKPMF  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.
        OFRAC  .25  .25  .30  .30  .30  .55  .55  .55  .35  .35  .35  .25
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Regional Plume
        BCKPMF  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.
        OFRAC  .20  .20  .25  .35  .25  .40  .40  .40  .30  .30  .30  .20
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Urban - no controls present
        BCKPMF 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
        OFRAC  .30  .30  .35  .35  .35  .55  .55  .55  .35  .35  .35  .30
        VCNX     2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.

     Default: Clean Continental
     !  BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00,
1.00 !
     !  OFRAC  = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20,
0.15 !
     !  VCNX    = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00,
50.00, 50.00, 50.00 !

 --- End Data for SECONDARY ORGANIC AEROSOL (SOA) Option


     Number of half-life decay specification blocks provided in Subgroup 11b
     (Used only if MCHEM = 5)
     (NDECAY)                            Default: 0      ! NDECAY =  0   !

!END!


--------------
Subgroup (11b)
--------------

     Each species modeled may be assigned a decay half-life (sec), and the
associated
     mass lost may be assigned to one or more other modeled species using a mass
yield
     factor. This information is used only for MCHEM=5.

     Provide NDECAY blocks assigning the half-life for a parent species and mass
yield
     factors for each child species (if any) produced by the decay.
```

```
     Set HALF_LIFE=0.0 for NO decay (infinite half-life).


                             a             b
        SPECIES      Half-Life   Mass Yield
         NAME          (sec)       Factor
        -------      ---------   ----------

     *   SPEC1    =    3600.,        -1.0    *    (Parent)
     *   SPEC2    =     -1.0,         0.0    *    (Child)
   *END*

--------
    a
     Specify a half life that is greater than or equal to zero for 1 parent species
     in each block, and set the yield factor for this species to -1
    b
     Specify a yield factor that is greater than or equal to zero for 1 or more
child
     species in each block, and set the half-life for each of these species to -1

     NOTE: Assignments in each block are treated as a separate input
           subgroup and therefore must end with an input group terminator.
           If NDECAY=0, no assignments and input group terminators should appear.

--------------------------------------------------------------------------------


INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters
---------------

     Horizontal size of puff (m) beyond which
     time-dependent dispersion equations (Heffter)
     are used to determine sigma-y and
     sigma-z (SYTDEP)                           Default: 550.   ! SYTDEP = 5.5E02 !

     Switch for using Heffter equation for sigma z
     as above (0 = Not use Heffter; 1 = use Heffter
     (MHFTSZ)                                   Default: 0      ! MHFTSZ =  0   !

     Stability class used to determine plume
     growth rates for puffs above the boundary
     layer (JSUP)                               Default: 5      ! JSUP =  5   !

     Vertical dispersion constant for stable
     conditions (k1 in Eqn. 2.7-3)  (CONK1)     Default: 0.01   ! CONK1 = .01 !

     Vertical dispersion constant for neutral/
     unstable conditions (k2 in Eqn. 2.7-4)
     (CONK2)                                    Default: 0.1    ! CONK2 = .1 !

     Factor for determining Transition-point from
     Schulman-Scire to Huber-Snyder Building Downwash
     scheme (SS used for Hs < Hb + TBD * HL)
     (TBD)                                      Default: 0.5    ! TBD = .5 !
        TBD < 0   ==> always use Huber-Snyder
        TBD = 1.5 ==> always use Schulman-Scire
        TBD = 0.5 ==> ISC Transition-point
```

```
Range of land use categories for which
urban dispersion is assumed
(IURB1, IURB2)                           Default: 10     ! IURB1 =  10  !
                                                  19     ! IURB2 =  19  !

Site characterization parameters for single-point Met data files ---------
(needed for METFM = 2,3,4,5)

   Land use category for modeling domain
   (ILANDUIN)                            Default: 20     ! ILANDUIN =  20  !

   Roughness length (m) for modeling domain
   (Z0IN)                                Default: 0.25   ! Z0IN = .25 !

   Leaf area index for modeling domain
   (XLAIIN)                              Default: 3.0    ! XLAIIN = 3.0 !

   Elevation above sea level (m)
   (ELEVIN)                              Default: 0.0    ! ELEVIN = .0 !

   Latitude (degrees) for met location
   (XLATIN)                              Default: -999.  ! XLATIN = -999.0 !

   Longitude (degrees) for met location
   (XLONIN)                              Default: -999.  ! XLONIN = -999.0 !

Specialized information for interpreting single-point Met data files -----

   Anemometer height (m) (Used only if METFM = 2,3)
   (ANEMHT)                              Default: 10.    ! ANEMHT = 10.0 !

   Form of lateral turbulance data in PROFILE.DAT file
   (Used only if METFM = 4,5 or MTURBVW = 1 or 3)
   (ISIGMAV)                             Default: 1      ! ISIGMAV =  1  !
       0 = read sigma-theta
       1 = read sigma-v

   Choice of mixing heights (Used only if METFM = 4)
   (IMIXCTDM)                            Default: 0      ! IMIXCTDM =  0  !
       0 = read PREDICTED mixing heights
       1 = read OBSERVED mixing heights

Maximum length of a slug (met. grid units)
(XMXLEN)                                 Default: 1.0    ! XMXLEN = 1.0 !

Maximum travel distance of a puff/slug (in
grid units) during one sampling step
(XSAMLEN)                                Default: 1.0    ! XSAMLEN = 2.0 !

Maximum Number of slugs/puffs release from
one source during one time step
(MXNEW)                                  Default: 99     ! MXNEW =  60   !

Maximum Number of sampling steps for
one puff/slug during one time step
(MXSAM)                                  Default: 99     ! MXSAM =  60   !

Number of iterations used when computing
the transport wind for a sampling step
```

```
      that includes gradual rise (for CALMET
      and PROFILE winds)
      (NCOUNT)                                  Default: 2       ! NCOUNT =  2   !

      Minimum sigma y for a new puff/slug (m)
      (SYMIN)                                   Default: 1.0     ! SYMIN = 1.0  !

      Minimum sigma z for a new puff/slug (m)
      (SZMIN)                                   Default: 1.0     ! SZMIN = 1.0  !

      Maximum sigma z (m) allowed to avoid
      numerical problem in calculating virtual
      time or distance.  Cap should be large
      enough to have no influence on normal events.
      Enter a negative cap to disable.
      (SZCAP_M)                                  Default: 5.0e06 ! SZCAP_M = 5.0E06
!

      Default minimum turbulence velocities sigma-v and sigma-w
      for each stability class over land and over water (m/s)
      (SVMIN(12) and SWMIN(12))

                       ----------  LAND  ----------       ---------  WATER  ---------
-
         Stab Class :  A    B    C    D    E    F         A    B    C    D    E    F
                       ---  ---  ---  ---  ---  ---       ---  ---  ---  ---  ---  --
-
      Default SVMIN : .50, .50, .50, .50, .50, .50,       .37, .37, .37, .37, .37,
.37
      Default SWMIN : .20, .12, .08, .06, .03, .016,      .20, .12, .08, .06, .03,
.016

           ! SVMIN = 0.500, 0.500, 0.500, 0.500, 0.500, 0.500, 0.370, 0.370, 0.370,
0.370, 0.370, 0.370!
           ! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016, 0.200, 0.120, 0.080,
0.060, 0.030, 0.016!

      Divergence criterion for dw/dz across puff
      used to initiate adjustment for horizontal
      convergence (1/s)
      Partial adjustment starts at CDIV(1), and
      full adjustment is reached at CDIV(2)
      (CDIV(2))                                 Default: 0.0,0.0  ! CDIV = .0, .0 !

      Search radius (number of cells) for nearest
      land and water cells used in the subgrid
      TIBL module
      (NLUTIBL)                                 Default: 4       ! NLUTIBL =  4   !

      Minimum wind speed (m/s) allowed for
      non-calm conditions. Also used as minimum
      speed returned when using power-law
      extrapolation toward surface
      (WSCALM)                                  Default: 0.5     ! WSCALM = .1 !

      Maximum mixing height (m)
      (XMAXZI)                                  Default: 3000.   ! XMAXZI = 3000.0 !

      Minimum mixing height (m)
```

```
     (XMINZI)                                   Default: 50.     ! XMINZI = 50.0 !

     Default wind speed classes --
     5 upper bounds (m/s) are entered;
     the 6th class has no upper limit
     (WSCAT(5))                      Default    :
                                     ISC  RURAL  :  1.54,  3.09,  5.14,  8.23,  10.8
(10.8+)

                             Wind Speed Class :  1     2     3     4     5
                                                ---   ---   ---   ---   ---
                                        ! WSCAT = 1.54, 3.09, 5.14, 8.23, 10.80 !

     Default wind speed profile power-law
     exponents for stabilities 1-6
     (PLX0(6))                       Default    : ISC RURAL values
                                     ISC RURAL : .07, .07, .10, .15, .35, .55
                                     ISC URBAN : .15, .15, .20, .25, .30, .30

                              Stability Class :  A     B     C     D     E     F
                                                ---   ---   ---   ---   ---   ---
                                         ! PLX0 = 0.07, 0.07, 0.10, 0.15, 0.35, 0.55
!

     Default potential temperature gradient
     for stable classes E, F (degK/m)
     (PTG0(2))                       Default: 0.020, 0.035
                                        ! PTG0 = 0.020,   0.035 !

     Default plume path coefficients for
     each stability class (used when option
     for partial plume height terrain adjustment
     is selected -- MCTADJ=3)
     (PPC(6))                 Stability Class :  A     B     C     D     E     F
                                 Default  PPC : .50,  .50,  .50,  .50,  .35,  .35
                                                ---   ---   ---   ---   ---   ---
                                         !  PPC = 0.50, 0.50, 0.50, 0.50, 0.35, 0.35
!

     Slug-to-puff transition criterion factor
     equal to sigma-y/length of slug
     (SL2PF)                              Default: 10.       ! SL2PF = 10.0 !

     Puff-splitting control variables ------------------------

       VERTICAL SPLIT
       --------------

       Number of puffs that result every time a puff
       is split - nsplit=2 means that 1 puff splits
       into 2
       (NSPLIT)                           Default:   3       ! NSPLIT =   3  !

       Time(s) of a day when split puffs are eligible to
       be split once again; this is typically set once
       per day, around sunset before nocturnal shear develops.
       24 values: 0 is midnight (00:00) and 23 is 11 PM (23:00)
       0=do not re-split    1=eligible for re-split
       (IRESPLIT(24))                     Default:  Hour 17 = 1
```

```
!  IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !

  Split is allowed only if last hour's mixing
  height (m) exceeds a minimum value
  (ZISPLIT)                           Default: 100.       ! ZISPLIT = 100.0 !

  Split is allowed only if ratio of last hour's
  mixing ht to the maximum mixing ht experienced
  by the puff is less than a maximum value (this
  postpones a split until a nocturnal layer develops)
  (ROLDMAX)                           Default: 0.25       ! ROLDMAX = 0.25 !


  HORIZONTAL SPLIT
  ----------------

  Number of puffs that result every time a puff
  is split - nsplith=5 means that 1 puff splits
  into 5
  (NSPLITH)                           Default:   5        ! NSPLITH =  5  !

  Minimum sigma-y (Grid Cells Units) of puff
  before it may be split
  (SYSPLITH)                          Default:  1.0       ! SYSPLITH = 1.0 !

  Minimum puff elongation rate (SYSPLITH/hr) due to
  wind shear, before it may be split
  (SHSPLITH)                          Default:  2.        ! SHSPLITH = 2.0 !

  Minimum concentration (g/m^3) of each
  species in puff before it may be split
  Enter array of NSPEC values; if a single value is
  entered, it will be used for ALL species
  (CNSPLITH)                          Default:  1.0E-07   ! CNSPLITH = 1.0E-07
!

Integration control variables ------------------------

  Fractional convergence criterion for numerical SLUG
  sampling integration
  (EPSSLUG)                           Default:   1.0e-04  ! EPSSLUG = 1.0E-04
!

  Fractional convergence criterion for numerical AREA
  source integration
  (EPSAREA)                           Default:   1.0e-06  ! EPSAREA = 1.0E-06
!

  Trajectory step-length (m) used for numerical rise
  integration
  (DSRISE)                            Default:   1.0      ! DSRISE = 1.0 !

  Boundary Condition (BC) Puff control variables ------------------------

  Minimum height (m) to which BC puffs are mixed as they are emitted
  (MBCON=2 ONLY).  Actual height is reset to the current mixing height
  at the release point if greater than this minimum.
  (HTMINBC)                           Default:   500.     ! HTMINBC = 500.0 !
```

```
       Search radius (km) about a receptor for sampling nearest BC puff.
       BC puffs are typically emitted with a spacing of one grid cell
       length, so the search radius should be greater than DGRIDKM.
       (RSAMPBC)                           Default:   10.      ! RSAMPBC = 10.0 !

       Near-Surface depletion adjustment to concentration profile used when
       sampling BC puffs?
       (MDEPBC)                            Default:   1        ! MDEPBC =  1  !
          0 = Concentration is NOT adjusted for depletion
          1 = Adjust Concentration for depletion

!END!


--------------------------------------------------------------------------------


INPUT GROUPS: 13a, 13b, 13c, 13d -- Point source parameters
--------------------------------

---------------
Subgroup (13a)
---------------

     Number of point sources with
     parameters provided below      (NPT1)  No default  !  NPT1 =  0  !

     Units used for point source
     emissions below                (IPTU)  Default: 1  !  IPTU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr
           8 =     Bq/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (13d)        (NSPT1) Default: 0  !  NSPT1 =  0  !

     Number of point sources with
     variable emission parameters
     provided in external file      (NPT2)  No default  !  NPT2 =  0  !

     (If NPT2 > 0, these point
     source emissions are read from
     the file: PTEMARB.DAT)

!END!

---------------
Subgroup (13b)
---------------
                                               a
          POINT SOURCE: CONSTANT DATA
```

```
        -----------------------------
                                                                              b
c
  Source        X           Y         Stack     Base      Stack     Exit   Exit     Bldg.
Emission
   No.      Coordinate  Coordinate  Height  Elevation  Diameter   Vel.   Temp.    Dwash
Rates
               (km)       (km)        (m)       (m)        (m)   (m/s)  (deg. K)
  ------    ---------- ---------- ------  ------   -------- ----- -------- ----- ---
-----

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

     SRCNAM  is a 12-character name for a source
             (No default)
     X       is an array holding the source data listed by the column headings
             (No default)
     SIGYZI  is an array holding the initial sigma-y and sigma-z (m)
             (Default: 0.,0.)
     FMFAC   is a vertical momentum flux factor (0. or 1.0) used to represent
             the effect of rain-caps or other physical configurations that
             reduce momentum rise associated with the actual exit velocity.
             (Default: 1.0  -- full momentum used)
     ZPLTFM  is the platform height (m) for sources influenced by an isolated
             structure that has a significant open area between the surface
             and the bulk of the structure, such as an offshore oil platform.
             The Base Elevation is that of the surface (ground or ocean),
             and the Stack Height is the release height above the Base (not
             above the platform).  Building heights entered in Subgroup 13c
             must be those of the buildings on the platform, measured from
             the platform deck.  ZPLTFM is used only with MBDW=1 (ISC
             downwash method) for sources with building downwash.
             (Default: 0.0)

    b
     0. = No building downwash modeled
     1. = Downwash modeled for buildings resting on the surface
     2. = Downwash modeled for buildings raised above the surface (ZPLTFM > 0.)
     NOTE: must be entered as a REAL number (i.e., with decimal point)

    c
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IPTU
     (e.g. 1 for g/s).

---------------
Subgroup (13c)
---------------

           BUILDING DIMENSION DATA FOR SOURCES SUBJECT TO DOWNWASH
           -------------------------------------------------------
Source                                                                   a
 No.       Effective building height, width, length and X/Y offset (in meters)
           every 10 degrees.  LENGTH, XBADJ, and YBADJ are only needed for
```

```
          MBDW=2 (PRIME downwash option)
------     --------------------------------------------------------------------


--------

    a
     Building height, width, length, and X/Y offset from the source are treated
     as a separate input subgroup for each source and therefore must end with
     an input group terminator.  The X/Y offset is the position, relative to the
     stack, of the center of the upwind face of the projected building, with the
     x-axis pointing along the flow direction.

---------------
Subgroup (13d)
---------------
                                              a
          POINT SOURCE: VARIABLE EMISSIONS DATA
          ---------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 13b.  Factors entered multiply the rates in 13b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use PTEMARB.DAT and NPT2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                              Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


--------------------------------------------------------------------------------


INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters
--------------------------------

---------------
Subgroup (14a)
---------------
```

```
     Number of polygon area sources with
     parameters specified below (NAR1)       No default  !  NAR1 =  0   !

     Units used for area source
     emissions below            (IARU)       Default: 1  !  IARU =   1  !
           1 =        g/m**2/s
           2 =       kg/m**2/hr
           3 =       lb/m**2/hr
           4 =     tons/m**2/yr
           5 =     Odour Unit * m/s  (vol. flux/m**2 of odour compound)
           6 =     Odour Unit * m/min
           7 =     metric tons/m**2/yr
           8 =     Bq/m**2/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/m**2/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (14d)        (NSAR1) Default: 0  !  NSAR1 =  0  !

     Number of buoyant polygon area sources
     with variable location and emission
     parameters (NAR2)                      No default  !  NAR2 =  0   !
     (If NAR2 > 0, ALL parameter data for
     these sources are read from the file: BAEMARB.DAT)

!END!

---------------
Subgroup (14b)
---------------
                                           a
          AREA SOURCE: CONSTANT DATA
          ----------------------------
                                                               b
Source           Effect.    Base      Initial    Emission
 No.             Height   Elevation   Sigma z     Rates
                   (m)       (m)        (m)
-------          ------    ------     --------   ---------



--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IARU
     (e.g. 1 for g/m**2/s).

---------------
Subgroup (14c)
---------------

           COORDINATES (km) FOR EACH VERTEX(4) OF EACH POLYGON
           --------------------------------------------------------
Source                                                              a
 No.       Ordered list of X followed by list of Y, grouped by source
```

```
------     ------------------------------------------------------------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------
Subgroup (14d)
---------------
                                               a
          AREA SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 14b.  Factors entered multiply the rates in 14b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use BAEMARB.DAT and NAR2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                         Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------

INPUT GROUPS: 15a, 15b, 15c -- Line source parameters
---------------------------

---------------
Subgroup (15a)
---------------

     Number of buoyant line sources
     with variable location and emission
     parameters (NLN2)                        No default  !  NLN2 =  0   !

     (If NLN2 > 0, ALL parameter data for
```

```
 these sources are read from the file: LNEMARB.DAT)

Number of buoyant line sources (NLINES)        No default   ! NLINES =  0  !

Units used for line source
emissions below                (ILNU)          Default: 1  !  ILNU =   1  !
      1 =         g/s
      2 =        kg/hr
      3 =        lb/hr
      4 =      tons/yr
      5 =      Odour Unit * m**3/s  (vol. flux of odour compound)
      6 =      Odour Unit * m**3/min
      7 =      metric tons/yr
      8 =      Bq/s  (Bq = becquerel = disintegrations/s)
      9 =      GBq/yr

Number of source-species
combinations with variable
emissions scaling factors
provided below in (15c)        (NSLN1) Default: 0  !  NSLN1 =  0  !

Maximum number of segments used to model
each line (MXNSEG)                             Default: 7   ! MXNSEG =  7  !

The following variables are required only if NLINES > 0.  They are
used in the buoyant line source plume rise calculations.

   Number of distances at which                Default: 6   ! NLRISE =  6  !
   transitional rise is computed

   Average building length (XL)                No default   ! XL = .0 !
                                               (in meters)

   Average building height (HBL)               No default   ! HBL = .0 !
                                               (in meters)

   Average building width (WBL)                No default   ! WBL = .0 !
                                               (in meters)

   Average line source width (WML)             No default   ! WML = .0 !
                                               (in meters)

   Average separation between buildings (DXL)  No default   ! DXL = .0 !
                                               (in meters)

   Average buoyancy parameter (FPRIMEL)        No default   ! FPRIMEL = .0 !
                                               (in m**4/s**3)

!END!

---------------
Subgroup (15b)
---------------

          BUOYANT LINE SOURCE: CONSTANT DATA
          ----------------------------------

a
```

```
Source        Beg.  X        Beg.  Y        End.  X      End.  Y       Release      Base
Emission
 No.        Coordinate   Coordinate   Coordinate  Coordinate   Height      Elevation
Rates
             (km)         (km)         (km)         (km)        (m)         (m)
------   ----------  ----------  ---------  ----------  -------   ---------    ----
-----

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by ILNTU
     (e.g. 1 for g/s).

---------------
Subgroup (15c)
---------------
                                                       a
          BUOYANT LINE SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 15b.  Factors entered multiply the rates in 15b.
     Skip sources here that have constant emissions.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------


INPUT GROUPS: 16a, 16b, 16c -- Volume source parameters
```

```
---------------------------

---------------
Subgroup (16a)
---------------

     Number of volume sources with
     parameters provided in 16b,c (NVL1)     No default  !  NVL1 =  0   !

     Units used for volume source
     emissions below in 16b       (IVLU)     Default: 1  !  IVLU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr
           8 =     Bq/s  (Bq = becquerel = disintegrations/s)
           9 =     GBq/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (16c)      (NSVL1)    Default: 0  !  NSVL1 =  0  !

     Number of volume sources with
     variable location and emission
     parameters                   (NVL2)     No default  !  NVL2 =   3   !

     (If NVL2 > 0, ALL parameter data for
      these sources are read from the VOLEMARB.DAT file(s) )

!END!

---------------
Subgroup (16b)
---------------
                                        a
           VOLUME SOURCE: CONSTANT DATA
           ------------------------------
                                                                            b
        X          Y         Effect.    Base     Initial    Initial   Emission
     Coordinate Coordinate   Height   Elevation  Sigma y    Sigma z    Rates
        (km)       (km)       (m)       (m)        (m)       (m)
     ---------- ----------   ------    ------   --------   --------  --------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IVLU
     (e.g. 1 for g/s).
```

```
---------------
Subgroup (16c)
---------------
                                                 a
          VOLUME SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 16b.  Factors entered multiply the rates in 16b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use VOLEMARB.DAT and NVL2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


--------------------------------------------------------------------------------

INPUT GROUPS: 17a & 17b -- Non-gridded (discrete) receptor information
-----------------------

---------------
Subgroup (17a)
---------------

     Number of non-gridded receptors (NREC)  No default  !  NREC =  9   !

!END!

---------------
Subgroup (17b)
---------------
                                               a
           NON-GRIDDED (DISCRETE) RECEPTOR DATA
           ------------------------------------

                       X            Y           Ground         Height    b
Receptor        Coordinate   Coordinate    Elevation     Above Ground
  No.              (km)         (km)          (m)            (m)
```

```
--------        ----------   ----------    ---------   ------------
     1 ! X =        784.0,     7415.0,      526.614,       0.000!   !END!
     2 ! X =        795.0,     7418.0,      515.214,       0.000!   !END!
     3 ! X =        779.0,     7414.0,      551.140,       0.000!   !END!
     4 ! X =        794.0,     7416.0,      514.277,       0.000!   !END!
     5 ! X =        783.0,     7405.0,      529.855,       0.000!   !END!
     6 ! X =        776.0,     7433.0,      584.060,       0.000!   !END!
     7 ! X =        788.0,     7404.0,      528.102,       0.000!   !END!
     8 ! X =        780.0,     7414.0,      543.219,       0.000!   !END!
     9 ! X =        800.0,     7416.0,      523.214,       0.000!   !END!


-------------
    a
     Data for each receptor are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     Receptor height above ground is optional.  If no value is entered,
     the receptor is placed on the ground.
```

Appendix E SOURCE PARAMETERS

E.1 HAUL ROAD

Table E-1: Source Parameters for Haul Roads – Area Sources

Calpuff ID	Easting (m)				Northing (m)				Area (m^2)	Effective Radius (m)	Base Elevation (m)	Effective Height (m)	Sigma Z (m)
HR01	816658.1	816580.3	816629.7	816707.5	7417346.1	7417840.1	7417847.8	7417353.9	25,000	89.2	533.9	1.5	0.75
HR02	816748.5	816662.6	816711.8	816797.7	7416835.3	7417327.9	7417336.4	7416843.9	25,000	89.2	528.2	1.5	0.75
HR03	816237.9	816730.9	816739.3	816246.3	7416799.2	7416882.7	7416833.4	7416749.9	25,000	89.2	529.7	1.5	0.75
HR04	815726.8	816219.8	816228.1	815735.2	7416717.2	7416800.8	7416751.5	7416667.9	25,000	89.2	530.6	1.5	0.75
HR05	815217.9	815710.8	815719.2	815226.2	7416626.6	7416710.2	7416660.9	7416577.3	25,000	89.2	531.8	1.5	0.75
HR06	814713.2	815206.2	815214.5	814721.6	7416536.0	7416619.6	7416570.3	7416486.7	25,000	89.2	532.9	1.5	0.75
HR07	814184.3	814682.7	814686.7	814188.3	7416491.1	7416531.4	7416481.6	7416441.3	25,000	89.2	535.0	1.5	0.75
HR08	813662.2	814162.1	814160.7	813660.9	7416503.1	7416489.3	7416439.3	7416453.1	25,000	89.2	539.5	1.5	0.75
HR09	813144.7	813644.5	813643.1	813143.3	7416520.4	7416506.6	7416456.6	7416470.4	25,000	89.2	544.2	1.5	0.75
HR10	812601.6	813076.1	813060.4	812585.8	7416640.5	7416483.1	7416435.6	7416593.1	25,000	89.2	554.7	1.5	0.75
HR11	812226.4	812528.8	812568.6	812266.2	7416280.8	7416679.0	7416648.7	7416250.5	25,000	89.2	564.9	1.5	0.75
HR12	811809.5	812229.5	812256.6	811836.6	7415985.7	7416256.9	7416214.9	7415943.7	25,000	89.2	563.7	1.5	0.75
HR13	811301.2	811799.1	811794.5	811296.6	7416005.8	7415959.9	7415910.1	7415956.0	25,000	89.2	576.8	1.5	0.75
HR14	818074.1	818071.1	818121.1	818124.1	7417019.4	7417519.4	7417519.7	7417019.7	25,000	89.2	524.5	1.5	0.75
HR15	818104.2	817803.2	817805.6	818106.6	7416966.2	7416980.6	7417030.5	7417016.1	15,063	69.2	524.7	1.5	0.75
HR16	817291.8	817787.1	817794.0	817298.7	7416956.7	7417025.3	7416975.7	7416907.2	25,000	89.2	526.1	1.5	0.75
HR17	816793.5	817288.5	817295.5	816800.6	7416881.3	7416952.0	7416902.5	7416831.8	25,000	89.2	527.9	1.5	0.75
HR18	817357.2	817170.9	817124.5	817310.8	7418154.3	7417690.3	7417709.0	7418172.9	25,000	89.2	542.3	1.5	0.75
HR19	817813.8	817338.6	817354.2	817829.3	7417940.4	7418096.2	7418143.7	7417987.9	25,000	89.2	532.5	1.5	0.75
HR20	818343.1	817844.5	817848.2	818346.9	7417896.1	7417933.2	7417983.0	7417946.0	25,000	89.2	526.4	1.5	0.75
HR21	817870.7	818117.7	818074.2	817827.2	7417966.4	7417531.6	7417506.9	7417941.7	25,000	89.2	527.5	1.5	0.75
HR22	818416.4	818421.9	818371.9	818366.4	7418462.9	7417962.9	7417962.4	7418462.3	25,000	89.2	527.7	1.5	0.75
HR23	818410.0	818415.5	818365.5	818360.0	7418964.5	7418464.6	7418464.0	7418964.0	25,000	89.2	525.9	1.5	0.75
HR24	817923.3	818388.1	818369.7	817904.9	7419204.3	7419020.0	7418973.5	7419157.8	25,000	89.2	519.5	1.5	0.75

Calpuff ID	Easting (m)				Northing (m)				Area (m²)	Effective Radius (m)	Base Elevation (m)	Effective Height (m)	Sigma Z (m)
HR25	816635.9	816788.1	816835.7	816683.5	7417871.7	7418348.0	7418332.7	7417856.5	25,000	89.2	534.2	1.5	0.75
HR26	816740.3	816244.3	816238.0	816734.0	7418295.6	7418232.5	7418282.1	7418345.2	25,000	89.2	534.5	1.5	0.75
HR27	816541.5	816203.5	816240.3	816578.3	7417827.2	7418195.6	7418229.4	7417861.0	25,000	89.2	540.9	1.5	0.75
HR28	816282.8	816288.3	816238.3	816232.8	7418812.1	7418312.2	7418311.6	7418811.6	25,000	89.2	533.0	1.5	0.75
HR29	816759.3	816285.9	816269.8	816743.1	7418980.7	7418819.6	7418867.0	7419028.0	25,000	89.2	528.1	1.5	0.75
HR30	816613.4	816853.3	816809.4	816569.5	7419453.6	7419014.9	7418990.9	7419429.6	25,000	89.2	537.1	1.5	0.75
HR31	818107.3	818607.0	818605.3	818105.6	7417006.7	7416989.8	7416939.8	7416956.7	25,000	89.2	523.1	1.5	0.75
HR32	818606.6	819007.3	819006.0	818606.7	7416991.2	7416991.3	7416942.3	7416941.2	19,784	79.4	522.1	1.5	0.75
HR33	811494.2	811460.0	811824.9	811859.1	7415601.4	7415637.9	7415979.8	7415943.3	25,000	89.2	559.7	1.5	0.75
HR34	811022.9	811006.2	811477.4	811494.1	7415454.4	7415501.5	7415668.8	7415621.7	25,000	89.2	558.3	1.5	0.75

E.2 MINE

Table E-2: Source Parameters for Mining Operations – Volume Source

Calpuff ID	Easting (m)	Northing (m)	Base elevation (m)	Effective height (m)	Sigma Y (m)	Sigma Z (m)
DWOPS4	817646	7417658	532.7	2	225	0.9
DWOPS5	816531	7418127	536.8	2	187	0.9
BIWOPS4	817161	7418268	536.3	20	225	9.3
BIWOPS5	816427	7418416	533.5	20	187	9.3
LOWS4	817137	7417681	540.1	3.5	225	1.6
LOWS5	816210	7418248	536.2	3.5	187	1.6
BuWS4	817877	7419200	518.9	2	324	0.9
BuPS4	817877	7419200	518.9	2	225	0.9
BuWS5	816570	7419481	533.6	2	262	0.9
BuPS5	816570	7419481	533.6	2	187	0.9
UWS4	817877	7419200	518.9	6	324	2.8
UWS5	816570	7419481	533.6	6	262	2.8
UORP18	811293	7415919	577.2	6	61	2.8
LORP18	811296	7415879	577.2	3.5	2	1.6
UOPC18	811190	7415747	565.0	6	2	2.8
UORP31	818996	7416892	521.7	6	72	2.8
LORP31	818996	7416892	521.7	3.5	2	1.6
UOPC31	818994	7416826	521.1	6	2	2.8

Table E-3: Source Parameters for Mining Operations – Area Source

Calpuff ID	Easting (m)				Northing (m)				Area (m²)	Effective Radius (m)	Base Elevation (m)	Effective Height (m)	Sigma Z (m)
WEWS4	817849	817849	817899	817899	7419178	7419228	7419228	7419178	2,500	28.2	518.8	0.5	0.25
WEWS5	816543	816543	816593	816593	7419457	7419507	7419507	7419457	2,500	28.2	533.6	0.5	0.25
WER18	811108	811108	811408	811408	7415848	7415948	7415948	7415848	30,000	97.7	575.9	0.5	0.25
WER31	818845	818845	819145	819145	7416774	7416954	7416954	7416774	54,000	131.1	521.4	0.5	0.25

E.3 PROCESSING FACILITY

Table E-4: Source Parameters for Processing Facility – Volume Source

Calpuff ID	X (m)	Y (m)	Base elevation	Effective Height (m)	Sigma Y (m)	Sigma Z (m)
C18	811190	7415747	565.0	8	4	3.7
TPC18	811039	7415463	557.3	8	4	3.7
C31	818994	7416826	521.1	8	4	3.7
LCO31	818995	7416736	521.3	3.5	2	1.6
UCO31	811039	7415463	557.3	6	2	2.8
TPR18	811293	7415919	577.2	8	4	3.7
TPCJ	813395	7411337	554.4	8	4	3.7
Sc	813456	7412160	556.8	10	20	4.7
TSF	812501	7412686	556.4	8	4	3.7
TSL	812924	7412726	555.8	8	4	3.7
STKF	812501	7412686	556.4	16	100	7.4
STKL	812924	7412726	555.8	16	100	7.4
RECF	812501	7412686	556.4	12	100	5.6
RECL	812924	7412726	555.8	12	100	5.6
OutTS1	811895	7412306	560.6	8	4	3.7
OutTS2	811895	7412306	560.6	8	4	3.7
RLoutF	811895	7412306	560.6	16	50	7.4
RLoutL	811895	7412306	560.6	16	50	7.4

Table E-5: Source Parameters for Processing Facility – Area Source

	Easting (m)				Northing (m)				Area (m^2)	Effective radius (m)	Base elevation (m)	Effective height (m)	Sigma Z (m)
WEC18	811128	811173	811191	811146	7415653	7415742	7415733	7415644	2,000	25.2	563.5	0.5	0.25
WEC31	818809	818909	818910	818810	7416644	7416645	7416625	7416624	2,000	25.2	521.9	0.5	0.25
WECJ	818846	818923	818936	818859	7416515	7416579	7416564	7416500	2,000	25.2	522.1	0.5	0.25
WES	810992	810992	811092	811092	7415412	7415512	7415512	7415412	10,000	56.4	557.2	0.5	0.25

Appendix F STATISTICS OF VARIABLE EMISSIONS

F.1 HAUL ROAD

F.1.1 Scenario 1

Table F-1: Statistical Summary of PM_{10} Emission Rate: Haul Road – Scenario 1 – Area Source (g/m²/s)

Calpuff ID	No Control					Standard Control					Leading Control				
	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
HR01	2.59E-04	2.59E-04	2.59E-04	2.59E-04	1.27E-04	1.30E-04	1.30E-04	1.30E-04	1.30E-04	6.35E-05	2.59E-05	2.59E-05	2.59E-05	2.59E-05	1.27E-05
HR02	2.59E-04	2.59E-04	2.59E-04	2.59E-04	1.27E-04	1.30E-04	1.30E-04	1.30E-04	1.30E-04	6.35E-05	2.59E-05	2.59E-05	2.59E-05	2.59E-05	1.27E-05
HR03	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR04	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR05	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR06	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR07	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR08	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR09	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR10	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR11	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR12	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR13	4.91E-04	4.91E-04	2.59E-04	2.59E-04	2.51E-04	2.46E-04	2.46E-04	1.30E-04	1.30E-04	1.25E-04	4.91E-05	4.91E-05	2.59E-05	2.59E-05	2.51E-05
HR14	2.32E-04	2.32E-04	2.32E-04	2.32E-04	1.24E-04	1.16E-04	1.16E-04	1.16E-04	1.16E-04	6.20E-05	2.32E-05	2.32E-05	2.32E-05	2.32E-05	1.24E-05
HR15	2.32E-04	2.32E-04	2.32E-04	2.32E-04	1.24E-04	1.16E-04	1.16E-04	1.16E-04	1.16E-04	6.20E-05	2.32E-05	2.32E-05	2.32E-05	2.32E-05	1.24E-05
HR16	2.32E-04	2.32E-04	2.32E-04	2.32E-04	1.24E-04	1.16E-04	1.16E-04	1.16E-04	1.16E-04	6.20E-05	2.32E-05	2.32E-05	2.32E-05	2.32E-05	1.24E-05
HR17	2.32E-04	2.32E-04	2.32E-04	2.32E-04	1.24E-04	1.16E-04	1.16E-04	1.16E-04	1.16E-04	6.20E-05	2.32E-05	2.32E-05	2.32E-05	2.32E-05	1.24E-05
HR18	5.72E-04	5.72E-04	5.72E-04	5.72E-04	4.47E-04	2.86E-04	2.86E-04	2.86E-04	2.86E-04	2.23E-04	5.72E-05	5.72E-05	5.72E-05	5.72E-05	4.47E-05
HR19	5.72E-04	5.72E-04	5.72E-04	5.72E-04	4.47E-04	2.86E-04	2.86E-04	2.86E-04	2.86E-04	2.23E-04	5.72E-05	5.72E-05	5.72E-05	5.72E-05	4.47E-05

Calpuff ID	No Control					Standard Control					Leading Control				
	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
HR20	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR21	2.32E-04	2.32E-04	2.32E-04	2.32E-04	1.24E-04	1.16E-04	1.16E-04	1.16E-04	1.16E-04	6.20E-05	2.32E-05	2.32E-05	2.32E-05	2.32E-05	1.24E-05
HR22	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR23	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR24	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR25	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR26	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR27	3.73E-04	3.73E-04	3.73E-04	3.73E-04	1.92E-04	1.86E-04	1.86E-04	1.86E-04	1.86E-04	9.59E-05	3.73E-05	3.73E-05	3.73E-05	3.73E-05	1.92E-05
HR28	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR29	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR30	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06

F.1.1.1 Scenario 2

Table F-2: Statistical Summary of PM_{10} Emission Rate: Haul Road – Scenario 2 – Area Source (g/m²/s)

Calpuff ID	No Control					Standard Control					Leading Control				
	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
HR01	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	1.23E-04	1.23E-04	1.23E-04	1.23E-04	6.00E-05	2.45E-05	2.45E-05	2.45E-05	2.45E-05	1.20E-05
HR02	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	1.23E-04	1.23E-04	1.23E-04	1.23E-04	6.00E-05	2.45E-05	2.45E-05	2.45E-05	2.45E-05	1.20E-05
HR03	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR04	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR05	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR06	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR07	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR08	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR09	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR10	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR11	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR12	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR14	2.35E-04	2.35E-04	2.35E-04	2.35E-04	1.25E-04	1.17E-04	1.17E-04	1.17E-04	1.17E-04	6.27E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	1.25E-05
HR15	5.56E-04	5.56E-04	5.56E-04	5.56E-04	3.75E-04	2.78E-04	2.78E-04	2.78E-04	2.78E-04	1.87E-04	5.56E-05	5.56E-05	5.56E-05	5.56E-05	3.75E-05
HR16	5.56E-04	5.56E-04	5.56E-04	5.56E-04	3.75E-04	2.78E-04	2.78E-04	2.78E-04	2.78E-04	1.87E-04	5.56E-05	5.56E-05	5.56E-05	5.56E-05	3.75E-05
HR17	5.56E-04	5.56E-04	5.56E-04	5.56E-04	3.75E-04	2.78E-04	2.78E-04	2.78E-04	2.78E-04	1.87E-04	5.56E-05	5.56E-05	5.56E-05	5.56E-05	3.75E-05
HR18	5.75E-04	5.75E-04	5.75E-04	5.75E-04	4.48E-04	2.87E-04	2.87E-04	2.87E-04	2.87E-04	2.24E-04	5.75E-05	5.75E-05	5.75E-05	5.75E-05	4.48E-05
HR19	5.75E-04	5.75E-04	5.75E-04	5.75E-04	4.48E-04	2.87E-04	2.87E-04	2.87E-04	2.87E-04	2.24E-04	5.75E-05	5.75E-05	5.75E-05	5.75E-05	4.48E-05
HR20	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR21	2.35E-04	2.35E-04	2.35E-04	2.35E-04	1.25E-04	1.17E-04	1.17E-04	1.17E-04	1.17E-04	6.27E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	1.25E-05
HR22	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05

Calpuff ID	No Control					Standard Control					Leading Control				
	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
HR23	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR24	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR25	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR26	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR27	3.59E-04	3.59E-04	3.59E-04	3.59E-04	1.85E-04	1.79E-04	1.79E-04	1.79E-04	1.79E-04	9.25E-05	3.59E-05	3.59E-05	3.59E-05	3.59E-05	1.85E-05
HR28	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR29	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR30	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR31	7.91E-04	7.91E-04	5.56E-04	5.56E-04	5.00E-04	3.95E-04	3.95E-04	2.78E-04	2.78E-04	2.50E-04	7.91E-05	7.91E-05	5.56E-05	5.56E-05	5.00E-05
HR32	7.91E-04	7.91E-04	5.56E-04	5.56E-04	5.00E-04	3.95E-04	3.95E-04	2.78E-04	2.78E-04	2.50E-04	7.91E-05	7.91E-05	5.56E-05	5.56E-05	5.00E-05
HR33	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05
HR34	3.11E-04	3.11E-04	3.11E-04	3.11E-04	2.55E-04	1.56E-04	1.56E-04	1.56E-04	1.56E-04	1.27E-04	3.11E-05	3.11E-05	3.11E-05	3.11E-05	2.55E-05

F.1.1.2 Scenario 3 and 4

Table F-3: Statistical Summary of PM_{10} Emission Rate: Haul Road – Scenario 3 and 4 – Area Source (g/m²/s)

	No Control					Standard Control					Leading Control				
Calpuff ID	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
HR01	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	1.23E-04	1.23E-04	1.23E-04	1.23E-04	6.00E-05	2.45E-05	2.45E-05	2.45E-05	2.45E-05	1.20E-05
HR02	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	1.23E-04	1.23E-04	1.23E-04	1.23E-04	6.00E-05	2.45E-05	2.45E-05	2.45E-05	2.45E-05	1.20E-05
HR14	2.35E-04	2.35E-04	2.35E-04	2.35E-04	1.25E-04	1.17E-04	1.17E-04	1.17E-04	1.17E-04	6.27E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	1.25E-05
HR15	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	1.23E-04	1.23E-04	1.23E-04	1.23E-04	6.00E-05	2.45E-05	2.45E-05	2.45E-05	2.45E-05	1.20E-05
HR16	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	1.23E-04	1.23E-04	1.23E-04	1.23E-04	6.00E-05	2.45E-05	2.45E-05	2.45E-05	2.45E-05	1.20E-05
HR17	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	1.23E-04	1.23E-04	1.23E-04	1.23E-04	6.00E-05	2.45E-05	2.45E-05	2.45E-05	2.45E-05	1.20E-05
HR18	5.75E-04	5.75E-04	5.75E-04	5.75E-04	4.48E-04	2.87E-04	2.87E-04	2.87E-04	2.87E-04	2.24E-04	5.75E-05	5.75E-05	5.75E-05	5.75E-05	4.48E-05
HR19	5.75E-04	5.75E-04	5.75E-04	5.75E-04	4.48E-04	2.87E-04	2.87E-04	2.87E-04	2.87E-04	2.24E-04	5.75E-05	5.75E-05	5.75E-05	5.75E-05	4.48E-05
HR20	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR21	2.35E-04	2.35E-04	2.35E-04	2.35E-04	1.25E-04	1.17E-04	1.17E-04	1.17E-04	1.17E-04	6.27E-05	2.35E-05	2.35E-05	2.35E-05	2.35E-05	1.25E-05
HR22	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR23	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR24	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	1.70E-04	1.70E-04	1.70E-04	1.70E-04	1.61E-04	3.40E-05	3.40E-05	3.40E-05	3.40E-05	3.23E-05
HR25	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR26	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR27	3.59E-04	3.59E-04	3.59E-04	3.59E-04	1.85E-04	1.79E-04	1.79E-04	1.79E-04	1.79E-04	9.25E-05	3.59E-05	3.59E-05	3.59E-05	3.59E-05	1.85E-05
HR28	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR29	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR30	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	5.67E-05	5.67E-05	5.67E-05	5.67E-05	3.24E-05	1.13E-05	1.13E-05	1.13E-05	1.13E-05	6.48E-06
HR31	4.80E-04	4.80E-04	2.45E-04	2.45E-04	2.45E-04	2.40E-04	2.40E-04	1.23E-04	1.23E-04	1.23E-04	4.80E-05	4.80E-05	2.45E-05	2.45E-05	2.45E-05
HR32	4.80E-04	4.80E-04	2.45E-04	2.45E-04	2.45E-04	2.40E-04	2.40E-04	1.23E-04	1.23E-04	1.23E-04	4.80E-05	4.80E-05	2.45E-05	2.45E-05	2.45E-05

F.1.1.3 Scenario 5

Table F-4: Statistical Summary of PM_{10} Emission Rate: Haul Road – Scenario 5 – Area Source (g/m²/s)

Calpuff ID	No Control					Standard Control					Leading Control				
	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
HR01	4.90E-04	4.90E-04	4.90E-04	4.90E-04	2.40E-04	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	4.90E-05	4.90E-05	4.90E-05	4.90E-05	2.40E-05
HR02	4.90E-04	4.90E-04	4.90E-04	4.90E-04	2.40E-04	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	4.90E-05	4.90E-05	4.90E-05	4.90E-05	2.40E-05
HR14	4.69E-04	4.69E-04	4.69E-04	4.69E-04	2.51E-04	2.35E-04	2.35E-04	2.35E-04	2.35E-04	1.25E-04	4.69E-05	4.69E-05	4.69E-05	4.69E-05	2.51E-05
HR15	4.90E-04	4.90E-04	4.90E-04	4.90E-04	2.40E-04	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	4.90E-05	4.90E-05	4.90E-05	4.90E-05	2.40E-05
HR16	4.90E-04	4.90E-04	4.90E-04	4.90E-04	2.40E-04	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	4.90E-05	4.90E-05	4.90E-05	4.90E-05	2.40E-05
HR17	4.90E-04	4.90E-04	4.90E-04	4.90E-04	2.40E-04	2.45E-04	2.45E-04	2.45E-04	2.45E-04	1.20E-04	4.90E-05	4.90E-05	4.90E-05	4.90E-05	2.40E-05
HR18	1.15E-03	1.15E-03	1.15E-03	1.15E-03	8.96E-04	5.75E-04	5.75E-04	5.75E-04	5.75E-04	4.48E-04	1.15E-04	1.15E-04	1.15E-04	1.15E-04	8.96E-05
HR19	1.15E-03	1.15E-03	1.15E-03	1.15E-03	8.96E-04	5.75E-04	5.75E-04	5.75E-04	5.75E-04	4.48E-04	1.15E-04	1.15E-04	1.15E-04	1.15E-04	8.96E-05
HR20	6.80E-04	6.80E-04	6.80E-04	6.80E-04	6.45E-04	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	6.80E-05	6.80E-05	6.80E-05	6.80E-05	6.45E-05
HR21	4.69E-04	4.69E-04	4.69E-04	4.69E-04	2.51E-04	2.35E-04	2.35E-04	2.35E-04	2.35E-04	1.25E-04	4.69E-05	4.69E-05	4.69E-05	4.69E-05	2.51E-05
HR22	6.80E-04	6.80E-04	6.80E-04	6.80E-04	6.45E-04	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	6.80E-05	6.80E-05	6.80E-05	6.80E-05	6.45E-05
HR23	6.80E-04	6.80E-04	6.80E-04	6.80E-04	6.45E-04	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	6.80E-05	6.80E-05	6.80E-05	6.80E-05	6.45E-05
HR24	6.80E-04	6.80E-04	6.80E-04	6.80E-04	6.45E-04	3.40E-04	3.40E-04	3.40E-04	3.40E-04	3.23E-04	6.80E-05	6.80E-05	6.80E-05	6.80E-05	6.45E-05
HR25	2.27E-04	2.27E-04	2.27E-04	2.27E-04	1.30E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	2.27E-05	2.27E-05	2.27E-05	2.27E-05	1.30E-05
HR26	2.27E-04	2.27E-04	2.27E-04	2.27E-04	1.30E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	2.27E-05	2.27E-05	2.27E-05	2.27E-05	1.30E-05
HR27	7.17E-04	7.17E-04	7.17E-04	7.17E-04	3.70E-04	3.59E-04	3.59E-04	3.59E-04	3.59E-04	1.85E-04	7.17E-05	7.17E-05	7.17E-05	7.17E-05	3.70E-05
HR28	2.27E-04	2.27E-04	2.27E-04	2.27E-04	1.30E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	2.27E-05	2.27E-05	2.27E-05	2.27E-05	1.30E-05
HR29	2.27E-04	2.27E-04	2.27E-04	2.27E-04	1.30E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	2.27E-05	2.27E-05	2.27E-05	2.27E-05	1.30E-05
HR30	2.27E-04	2.27E-04	2.27E-04	2.27E-04	1.30E-04	1.13E-04	1.13E-04	1.13E-04	1.13E-04	6.48E-05	2.27E-05	2.27E-05	2.27E-05	2.27E-05	1.30E-05
HR31	9.60E-04	9.60E-04	4.90E-04	4.90E-04	4.91E-04	4.80E-04	4.80E-04	2.45E-04	2.45E-04	2.45E-04	9.60E-05	9.60E-05	4.90E-05	4.90E-05	4.91E-05
HR32	9.60E-04	9.60E-04	4.90E-04	4.90E-04	4.91E-04	4.80E-04	4.80E-04	2.45E-04	2.45E-04	2.45E-04	9.60E-05	9.60E-05	4.90E-05	4.90E-05	4.91E-05

F.2 MINE AND PROCESSING FACILITY

F.2.1 Scenario 1

Table F-5: Statistical Summary of PM_{10} Emission Rate: Mine and Processing Facility – Scenario 1 – Volume Source (g/s)

Calpuff ID	No Control					Standard Control					Leading Control				
	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
Mine															
DWOPS4	2.43E-01	2.43E-01	2.43E-01	2.43E-01	1.75E-01	1.21E-01	1.21E-01	1.21E-01	1.21E-01	8.76E-02	2.43E-03	2.43E-03	2.43E-03	2.43E-03	1.75E-03
DWOPS5	2.47E-01	2.47E-01	2.47E-01	0.00E+00	6.96E-02	1.24E-01	1.24E-01	1.24E-01	0.00E+00	3.48E-02	2.47E-03	2.47E-03	2.47E-03	0.00E+00	6.96E-04
BIWOPS4	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01
BIWOPS5	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01
LOWS4	1.15E+01	1.15E+01	1.15E+01	1.15E+01	1.09E+01	1.15E+01	1.15E+01	1.15E+01	1.15E+01	1.09E+01	5.74E+00	5.74E+00	5.74E+00	5.74E+00	5.45E+00
LOWS5	7.56E+00	7.56E+00	7.56E+00	7.56E+00	4.32E+00	7.56E+00	7.56E+00	7.56E+00	7.56E+00	4.32E+00	3.78E+00	3.78E+00	3.78E+00	3.78E+00	2.16E+00
BuPS5	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01
BuPS4	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01
BuWS4	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01
BuWS5	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01
UWS4	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00
UWS5	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01
Processing Facility															
UORP18	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00
LORP18	5.72E+00	5.72E+00	5.72E+00	5.72E+00	5.71E+00	2.86E+00	2.86E+00	2.86E+00	2.86E+00	2.85E+00	9.72E-01	9.72E-01	9.72E-01	9.72E-01	9.70E-01
UOPC18	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	1.02E+00	1.02E+00	1.02E+00	1.02E+00	1.02E+00	3.48E-01	3.48E-01	3.48E-01	3.48E-01	3.48E-01
C18	2.78E+00	2.78E+00	2.78E+00	2.78E+00	1.90E+00	1.39E+00	1.39E+00	1.39E+00	1.39E+00	9.52E-01	4.72E-01	4.72E-01	4.72E-01	4.72E-01	3.24E-01
TPC18	1.10E+00	5.46E-01	2.94E-01	1.81E-01	1.27E-01	1.10E+00	5.46E-01	2.94E-01	1.81E-01	1.27E-01	5.48E-01	2.73E-01	1.47E-01	9.03E-02	6.36E-02

Table F-6: Statistical Summary of PM_{10} Emission Rate: Mine and Processing Facility – Scenario 1 – Area Source ($g/m^2/s$)

	No Control					Standard Control					Leading Control				
Calpuff ID	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
Mine															
WEWS4	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEWS5	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
Processing Facility															
WER18	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEC18	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WES	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06

F.2.2 Scenario 2

Table F-7: Statistical Summary of PM_{10} Emission Rate: Mine and Processing Facility – Scenario 2 – Volume Source (g/s)

	No Control					Standard Control					Leading Control				
Calpuff ID	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
Mine															
DWOPS4	2.43E-01	2.43E-01	2.43E-01	2.43E-01	1.75E-01	1.21E-01	1.21E-01	1.21E-01	1.21E-01	8.76E-02	2.43E-03	2.43E-03	2.43E-03	2.43E-03	1.75E-03
DWOPS5	2.47E-01	2.47E-01	2.47E-01	0.00E+00	6.96E-02	1.24E-01	1.24E-01	1.24E-01	0.00E+00	3.48E-02	2.47E-03	2.47E-03	2.47E-03	0.00E+00	6.96E-04
BIWOPS4	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01
BIWOPS5	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01
LOWS4	1.15E+01	1.15E+01	1.15E+01	1.15E+01	1.09E+01	1.15E+01	1.15E+01	1.15E+01	1.15E+01	1.09E+01	5.74E+00	5.74E+00	5.74E+00	5.74E+00	5.45E+00
LOWS5	7.56E+00	7.56E+00	7.56E+00	7.56E+00	4.32E+00	7.56E+00	7.56E+00	7.56E+00	7.56E+00	4.32E+00	3.78E+00	3.78E+00	3.78E+00	3.78E+00	2.16E+00
BuPS5	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01
BuPS4	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01
BuWS4	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01
BuWS5	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01
UWS4	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00
UWS5	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01
Processing Facility															
UORP31	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00
LORP31	5.72E+00	5.72E+00	5.72E+00	5.72E+00	5.71E+00	2.86E+00	2.86E+00	2.86E+00	2.86E+00	2.85E+00	9.72E-01	9.72E-01	9.72E-01	9.72E-01	9.70E-01
UOPC31	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	1.02E+00	1.02E+00	1.02E+00	1.02E+00	1.02E+00	3.48E-01	3.48E-01	3.48E-01	3.48E-01	3.48E-01
C31	2.78E+00	2.78E+00	2.78E+00	2.78E+00	1.90E+00	1.39E+00	1.39E+00	1.39E+00	1.39E+00	9.52E-01	4.72E-01	4.72E-01	4.72E-01	4.72E-01	3.24E-01
LCO31	6.97E+00	6.97E+00	6.97E+00	6.97E+00	5.71E+00	3.48E+00	3.48E+00	3.48E+00	3.48E+00	2.85E+00	1.18E+00	1.18E+00	1.18E+00	1.18E+00	9.70E-01
UCO31	2.50E+00	2.50E+00	2.50E+00	2.50E+00	2.05E+00	1.25E+00	1.25E+00	1.25E+00	1.25E+00	1.02E+00	4.24E-01	4.24E-01	4.24E-01	4.24E-01	3.48E-01

Table F-8: Statistical Summary of PM_{10} Emission Rate: Mine and Processing Facility – Scenario 2 – Area Source (g/m²/s)

	No Control					Standard Control					Leading Control				
Calpuff ID	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
Mine															
WEWS4	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEWS5	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
Processing Facility															
WER31	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEC31	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WES	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06

F.2.3 Scenario 3

Table F-9: Statistical Summary of PM_{10} Emission Rate: Mine and Processing Facility – Scenario 3 – Volume Source (g/s)

	No Control					Standard Control					Leading Control				
Calpuff ID	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
Mine															
DWOPS4	2.43E-01	2.43E-01	2.43E-01	2.43E-01	1.75E-01	1.21E-01	1.21E-01	1.21E-01	1.21E-01	8.76E-02	2.43E-03	2.43E-03	2.43E-03	2.43E-03	1.75E-03
DWOPS5	2.47E-01	2.47E-01	2.47E-01	0.00E+00	6.96E-02	1.24E-01	1.24E-01	1.24E-01	0.00E+00	3.48E-02	2.47E-03	2.47E-03	2.47E-03	0.00E+00	6.96E-04
BIWOPS4	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01
BIWOPS5	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01
LOWS4	1.15E+01	1.15E+01	1.15E+01	1.15E+01	1.09E+01	1.15E+01	1.15E+01	1.15E+01	1.15E+01	1.09E+01	5.74E+00	5.74E+00	5.74E+00	5.74E+00	5.45E+00
LOWS5	7.56E+00	7.56E+00	7.56E+00	7.56E+00	4.32E+00	7.56E+00	7.56E+00	7.56E+00	7.56E+00	4.32E+00	3.78E+00	3.78E+00	3.78E+00	3.78E+00	2.16E+00
BuPS5	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01
BuPS4	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01
BuWS4	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01
BuWS5	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01
UWS4	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00
UWS5	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01
Processing Facility															
UORP31	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00
TPR18	8.22E-01	4.26E-01	2.46E-01	1.63E-01	1.29E-01	8.22E-01	4.26E-01	2.46E-01	1.63E-01	1.29E-01	4.11E-01	2.13E-01	1.23E-01	8.17E-02	6.45E-02
LORP18	5.72E+00	5.72E+00	5.72E+00	5.72E+00	5.71E+00	2.86E+00	2.86E+00	2.86E+00	2.86E+00	2.85E+00	9.72E-01	9.72E-01	9.72E-01	9.72E-01	9.70E-01
UOPC18	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	1.02E+00	1.02E+00	1.02E+00	1.02E+00	1.02E+00	3.48E-01	3.48E-01	3.48E-01	3.48E-01	3.48E-01
C18	2.78E+00	2.78E+00	2.78E+00	2.78E+00	1.90E+00	1.39E+00	1.39E+00	1.39E+00	1.39E+00	9.52E-01	4.72E-01	4.72E-01	4.72E-01	4.72E-01	3.24E-01
TPC18	1.10E+00	5.46E-01	2.94E-01	1.81E-01	1.27E-01	1.10E+00	5.46E-01	2.94E-01	1.81E-01	1.27E-01	5.48E-01	2.73E-01	1.47E-01	9.03E-02	6.36E-02

Table F-10: Statistical Summary of PM_{10} Emission Rate: Mine and Processing Facility – Scenario 3 – Area Source ($g/m^2/s$)

Calpuff ID	No Control					Standard Control					Leading Control				
	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
Mine															
WEWS4	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEWS5	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
Processing Facility															
WER18	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEC18	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WER31	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEC31	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WES	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06

F.2.4 Scenario 4

Table F-11: Statistical Summary of PM_{10} Emission Rate: Mine and Processing Facility – Scenario 4 – Volume Source (g/s)

	No Control					Standard Control					Leading Control				
Calpuff ID	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
Mine															
DWOPS4	2.43E-01	2.43E-01	2.43E-01	2.43E-01	1.75E-01	1.21E-01	1.21E-01	1.21E-01	1.21E-01	8.76E-02	2.43E-03	2.43E-03	2.43E-03	2.43E-03	1.75E-03
DWOPS5	2.47E-01	2.47E-01	2.47E-01	0.00E+00	6.96E-02	1.24E-01	1.24E-01	1.24E-01	0.00E+00	3.48E-02	2.47E-03	2.47E-03	2.47E-03	0.00E+00	6.96E-04
BIWOPS4	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	3.13E-01
BIWOPS5	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	1.34E-01
LOWS4	1.15E+01	1.15E+01	1.15E+01	1.15E+01	1.09E+01	1.15E+01	1.15E+01	1.15E+01	1.15E+01	1.09E+01	5.74E+00	5.74E+00	5.74E+00	5.74E+00	5.45E+00
LOWS5	7.56E+00	7.56E+00	7.56E+00	7.56E+00	4.32E+00	7.56E+00	7.56E+00	7.56E+00	7.56E+00	4.32E+00	3.78E+00	3.78E+00	3.78E+00	3.78E+00	2.16E+00
BuPS5	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01
BuPS4	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01
BuWS4	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.23E-01
BuWS5	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.37E-01
UWS4	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00	4.25E+00	4.25E+00	4.25E+00	4.25E+00	4.03E+00
UWS5	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01	1.41E+00	1.41E+00	1.41E+00	1.41E+00	8.09E-01
Processing Facility															
UORP31	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00
LORP31	5.72E+00	5.72E+00	5.72E+00	5.72E+00	5.71E+00	2.86E+00	2.86E+00	2.86E+00	2.86E+00	2.85E+00	9.72E-01	9.72E-01	9.72E-01	9.72E-01	9.70E-01
UOPC31	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	1.02E+00	1.02E+00	1.02E+00	1.02E+00	1.02E+00	3.48E-01	3.48E-01	3.48E-01	3.48E-01	3.48E-01
C31	2.78E+00	2.78E+00	2.78E+00	2.78E+00	1.90E+00	1.39E+00	1.39E+00	1.39E+00	1.39E+00	9.52E-01	4.72E-01	4.72E-01	4.72E-01	4.72E-01	3.24E-01
TPC18	1.10E+00	5.46E-01	2.94E-01	1.81E-01	1.27E-01	1.10E+00	5.46E-01	2.94E-01	1.81E-01	1.27E-01	5.48E-01	2.73E-01	1.47E-01	9.03E-02	6.36E-02

Table F-12: Statistical Summary of PM_{10} Emission Rate: Mine and Processing Facility – Scenario 4 – Area Source (g/m²/s)

Calpuff ID	No Control					Standard Control					Leading Control				
	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
Mine															
WEWS4	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEWS5	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
Processing Facility															
WER31	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEC31	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WES	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06

F.2.5 Scenario 5

Table F-13: Statistical Summary of PM_{10} Emission Rate: Mine and Processing Facility – Scenario 5 – Volume Source (g/s)

	No Control					Standard Control					Leading Control				
Calpuff ID	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
Mine															
DWOPS4	4.85E-01	4.85E-01	4.85E-01	4.85E-01	3.50E-01	2.43E-01	2.43E-01	2.43E-01	2.43E-01	1.75E-01	4.85E-03	4.85E-03	4.85E-03	4.85E-03	3.50E-03
DWOPS5	4.95E-01	4.95E-01	4.95E-01	0.00E+00	1.39E-01	2.47E-01	2.47E-01	2.47E-01	0.00E+00	6.96E-02	4.95E-03	4.95E-03	4.95E-03	0.00E+00	1.39E-03
BIWOPS4	4.04E+01	4.04E+01	0.00E+00	0.00E+00	6.13E-01	4.04E+01	4.04E+01	0.00E+00	0.00E+00	6.13E-01	4.04E+01	4.04E+01	0.00E+00	0.00E+00	6.13E-01
BIWOPS5	4.04E+01	0.00E+00	0.00E+00	0.00E+00	2.54E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	2.54E-01	4.04E+01	0.00E+00	0.00E+00	0.00E+00	2.54E-01
LOWS4	2.30E+01	2.30E+01	2.30E+01	2.30E+01	2.18E+01	2.30E+01	2.30E+01	2.30E+01	2.30E+01	2.18E+01	1.15E+01	1.15E+01	1.15E+01	1.15E+01	1.09E+01
LOWS5	1.51E+01	1.51E+01	1.51E+01	1.51E+01	8.65E+00	1.51E+01	1.51E+01	1.51E+01	1.51E+01	8.65E+00	7.56E+00	7.56E+00	7.56E+00	7.56E+00	4.32E+00
BuPS5	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	1.36E-01
BuPS4	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01	2.37E-01	2.37E-01	2.37E-01	2.37E-01	2.25E-01
BuWS4	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.70E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.70E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	2.70E-01
BuWS5	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.63E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.63E-01	3.37E-01	3.37E-01	3.37E-01	3.37E-01	1.63E-01
UWS4	5.99E+00	5.99E+00	5.99E+00	5.99E+00	5.68E+00	5.99E+00	5.99E+00	5.99E+00	5.99E+00	5.68E+00	5.99E+00	5.99E+00	5.99E+00	5.99E+00	5.68E+00
UWS5	1.99E+00	1.99E+00	1.99E+00	1.99E+00	1.14E+00	1.99E+00	1.99E+00	1.99E+00	1.99E+00	1.14E+00	1.99E+00	1.99E+00	1.99E+00	1.99E+00	1.14E+00
Processing Facility															
UORP31	4.10E+00	4.10E+00	4.10E+00	4.10E+00	4.09E+00	4.10E+00	4.10E+00	4.10E+00	4.10E+00	4.09E+00	4.10E+00	4.10E+00	4.10E+00	4.10E+00	4.09E+00
LORP31	1.14E+01	1.14E+01	1.14E+01	1.14E+01	1.14E+01	5.72E+00	5.72E+00	5.72E+00	5.72E+00	5.71E+00	1.94E+00	1.94E+00	1.94E+00	1.94E+00	1.94E+00
UOPC31	4.10E+00	4.10E+00	4.10E+00	4.10E+00	4.09E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	2.05E+00	6.97E-01	6.97E-01	6.97E-01	6.97E-01	6.95E-01
C31	5.56E+00	5.56E+00	5.56E+00	5.56E+00	3.81E+00	2.78E+00	2.78E+00	2.78E+00	2.78E+00	1.90E+00	9.44E-01	9.44E-01	9.44E-01	9.44E-01	6.48E-01
TPC18	1.10E+00	5.46E-01	2.94E-01	1.81E-01	1.27E-01	1.10E+00	5.46E-01	2.94E-01	1.81E-01	1.27E-01	5.48E-01	2.73E-01	1.47E-01	9.03E-02	6.36E-02
TPCJ	1.10E+00	5.46E-01	2.94E-01	1.81E-01	1.27E-01	1.10E+00	5.46E-01	2.94E-01	1.81E-01	1.27E-01	5.48E-01	2.73E-01	1.47E-01	9.03E-02	6.36E-02
Sc	7.00E+00	7.00E+00	7.00E+00	7.00E+00	4.98E+00	4.20E+00	4.20E+00	4.20E+00	4.20E+00	2.99E+00	1.19E+00	1.19E+00	1.19E+00	1.19E+00	8.47E-01

Calpuff ID	No Control					Standard Control					Leading Control				
	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
TSF	5.98E-01	2.94E-01	1.54E-01	9.70E-02	6.81E-02	5.98E-01	2.94E-01	1.54E-01	9.70E-02	6.81E-02	2.99E-01	1.47E-01	7.69E-02	4.85E-02	3.41E-02
TSL	3.99E-01	1.96E-01	1.03E-01	6.42E-02	4.50E-02	3.99E-01	1.96E-01	1.03E-01	6.42E-02	4.50E-02	1.99E-01	9.81E-02	5.13E-02	3.21E-02	2.25E-02
STKF	1.35E+00	6.62E-01	3.46E-01	2.18E-01	1.53E-01	9.42E-01	4.64E-01	2.42E-01	1.53E-01	1.07E-01	9.42E-01	4.64E-01	2.42E-01	1.53E-01	1.07E-01
STKL	8.97E-01	4.41E-01	2.31E-01	1.45E-01	1.01E-01	6.28E-01	3.09E-01	1.62E-01	1.01E-01	7.08E-02	6.28E-01	3.09E-01	1.62E-01	1.01E-01	7.08E-02
RECF	2.46E+00	9.68E-01	2.60E-01	0.00E+00	6.54E-02	1.73E+00	6.77E-01	1.82E-01	0.00E+00	4.58E-02	1.73E+00	6.77E-01	1.82E-01	0.00E+00	4.58E-02
RECL	2.77E+00	1.06E+00	0.00E+00	0.00E+00	5.71E-02	1.94E+00	7.44E-01	0.00E+00	0.00E+00	4.00E-02	1.94E+00	7.44E-01	0.00E+00	0.00E+00	4.00E-02
OutTS1	2.46E+00	9.68E-01	2.60E-01	0.00E+00	6.54E-02	2.46E+00	9.68E-01	2.60E-01	0.00E+00	6.54E-02	1.23E+00	4.84E-01	1.30E-01	0.00E+00	3.27E-02
OutTS2	2.77E+00	1.06E+00	0.00E+00	0.00E+00	5.71E-02	2.77E+00	1.06E+00	0.00E+00	0.00E+00	5.71E-02	1.38E+00	5.32E-01	0.00E+00	0.00E+00	2.86E-02
RLoutF	2.46E+00	9.68E-01	2.60E-01	0.00E+00	6.54E-02	1.73E+00	6.77E-01	1.82E-01	0.00E+00	4.58E-02	1.73E+00	6.77E-01	1.82E-01	0.00E+00	4.58E-02
RLoutL	2.77E+00	1.06E+00	0.00E+00	0.00E+00	5.71E-02	1.94E+00	7.44E-01	0.00E+00	0.00E+00	4.00E-02	1.94E+00	7.44E-01	0.00E+00	0.00E+00	4.00E-02

Table F-14: Statistical Summary of PM_{10} Emission Rate: Mine and Processing Facility – Scenario 5 – Area Source ($g/m^2/s$)

	No Control					Standard Control					Leading Control				
Calpuff ID	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average	Maximum	99th Percentile	90th Percentile	70th Percentile	Average
Mine															
WEWS4	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEWS5	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
Processing Facility															
WER31	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WEC31	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WES	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06
WECJ	1.33E-03	1.51E-04	3.48E-05	0.00E+00	1.11E-05	6.63E-04	7.57E-05	1.74E-05	0.00E+00	5.56E-06	1.33E-04	1.51E-05	3.48E-06	0.00E+00	1.11E-06

Appendix G CUMULATIVE FUTURE OPERATIONS RESULTS CONTOURS

G.1 OB31 OPERATIONS CUMULATIVE WITH FUTURE OPERATIONS

The contour plots for the OB31 operations cumulative with background, existing operations excluding OB18 are presented in the following figures.

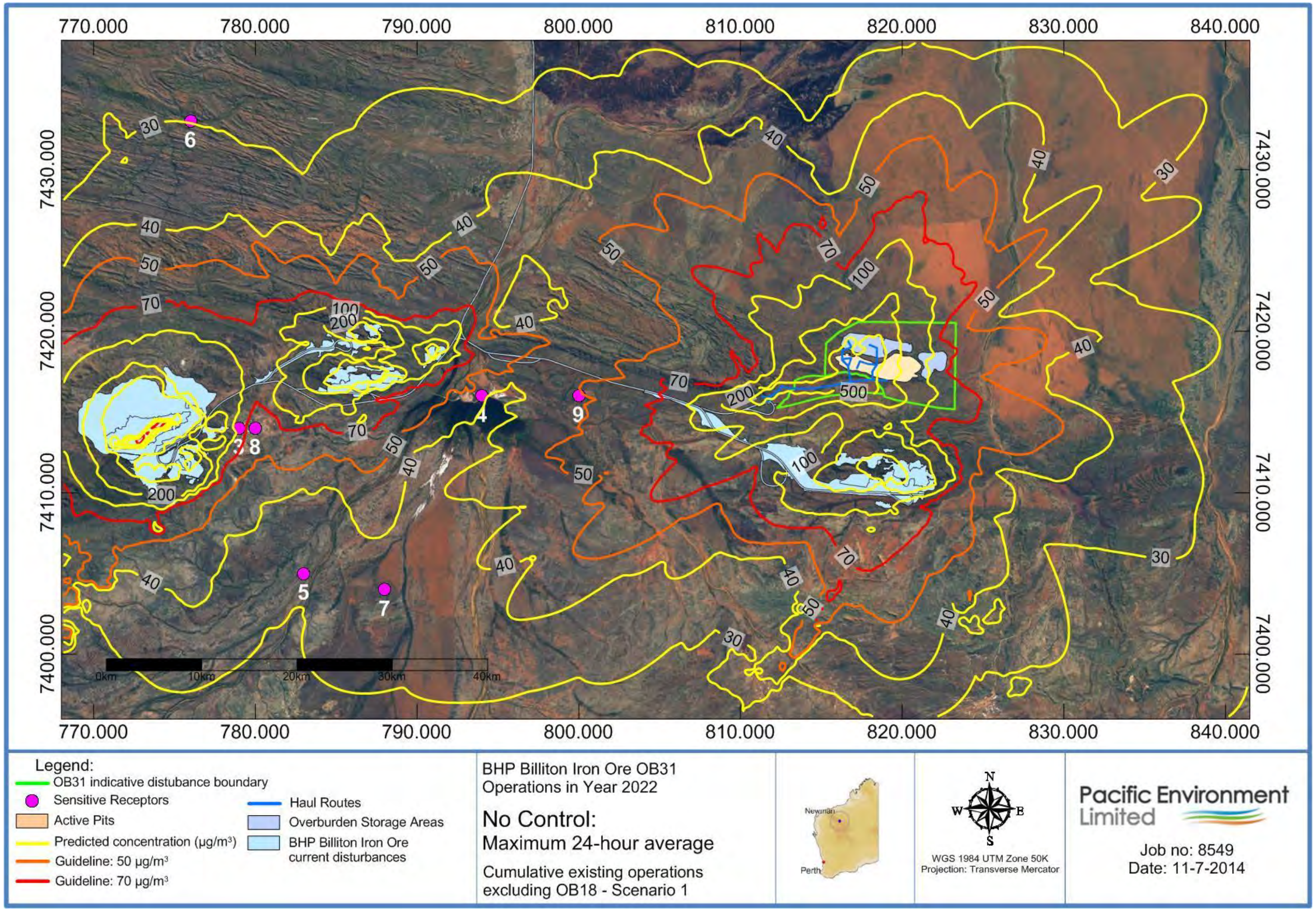

Figure G.1: Predicted Maximum Daily PM_{10} Concentrations – Scenario 1 – Cumulative Existing Operations Excluding OB18 with No Dust Control

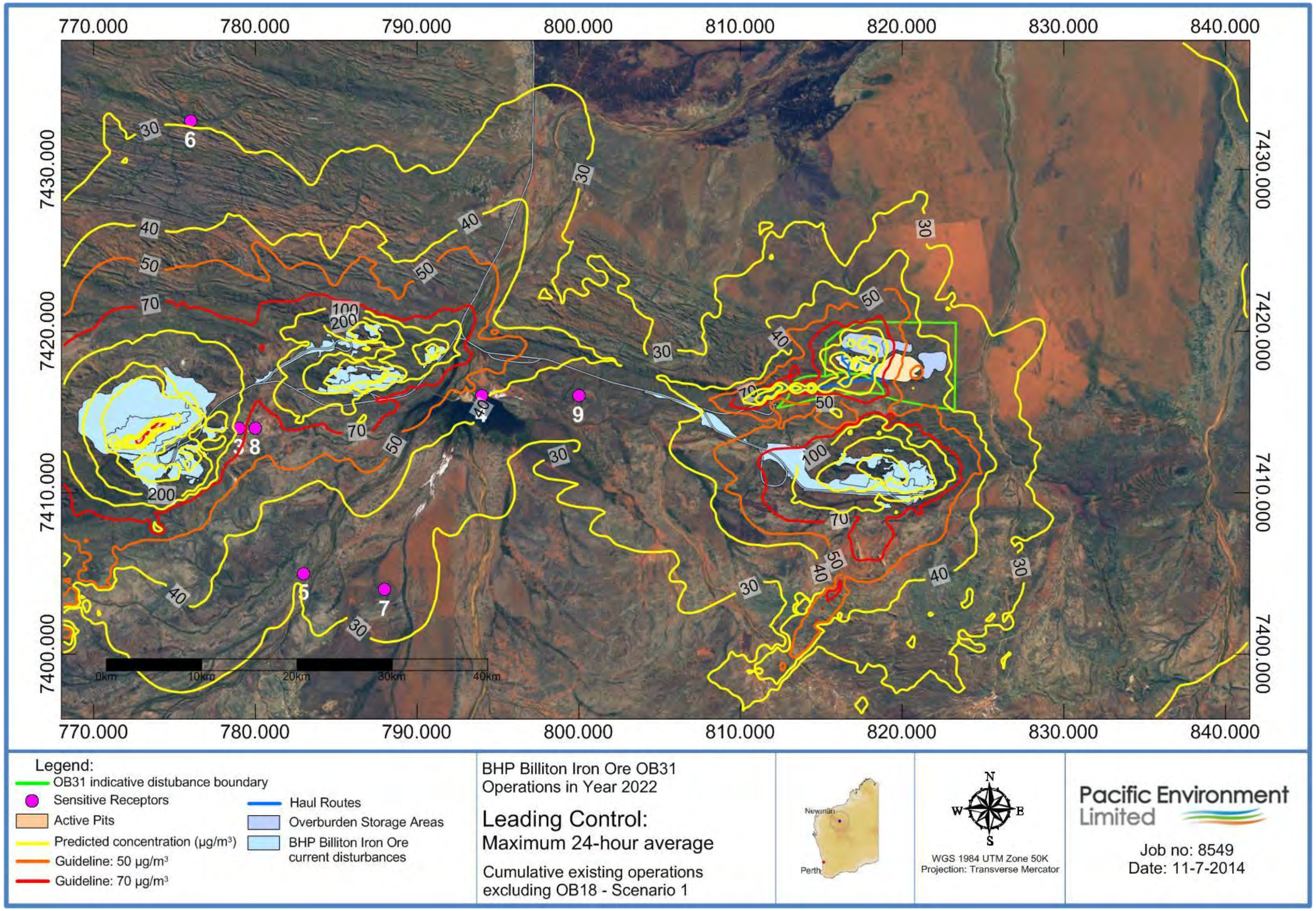

Figure G.2: Predicted Maximum Daily PM_{10} Concentrations – Scenario 1 – Cumulative Existing Operations Excluding OB18 with Leading Dust Control

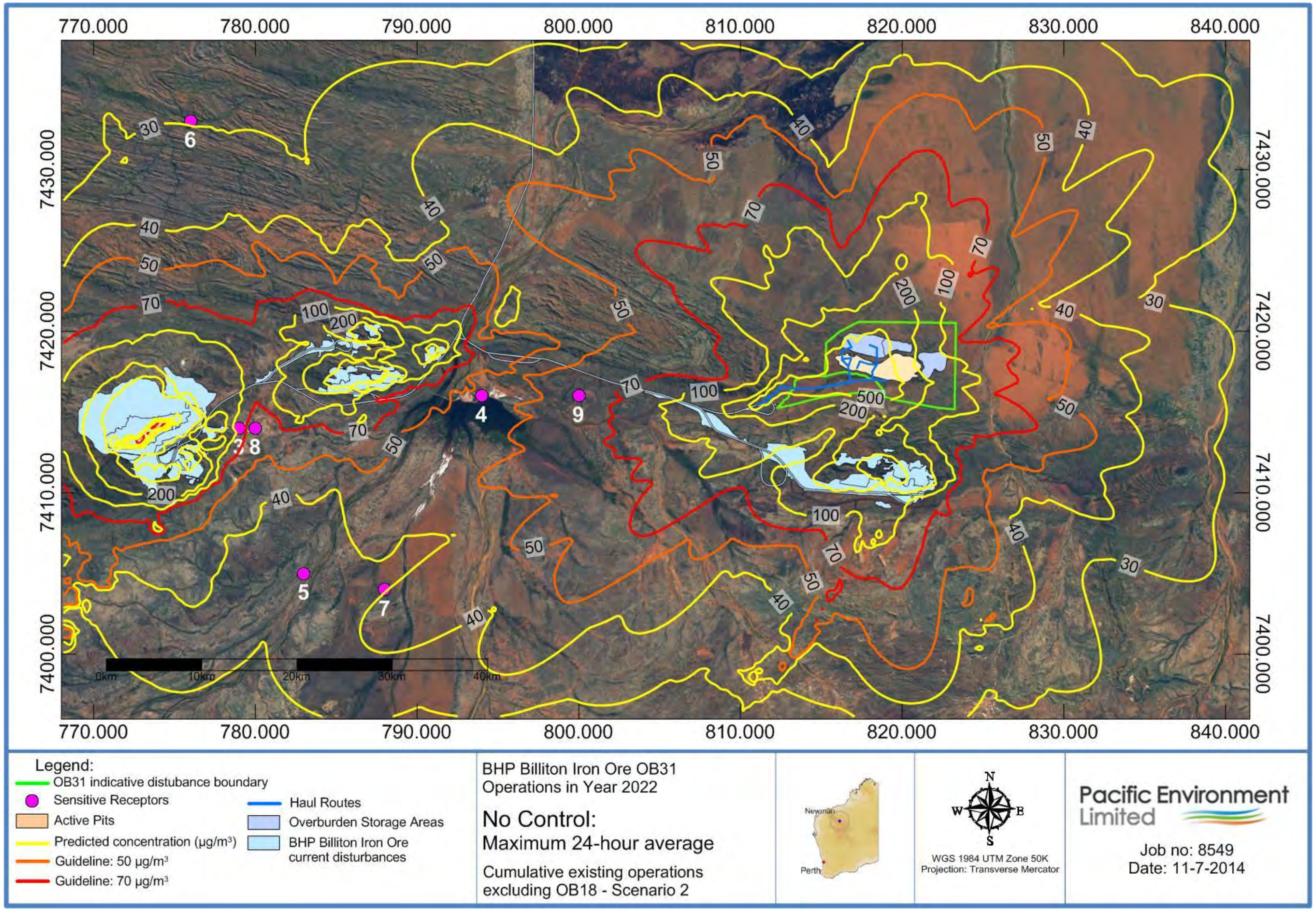

Figure G.3: Predicted Maximum Daily PM_{10} Concentrations – Scenario 2 – Cumulative Existing Operations Excluding OB18 with No Dust Control

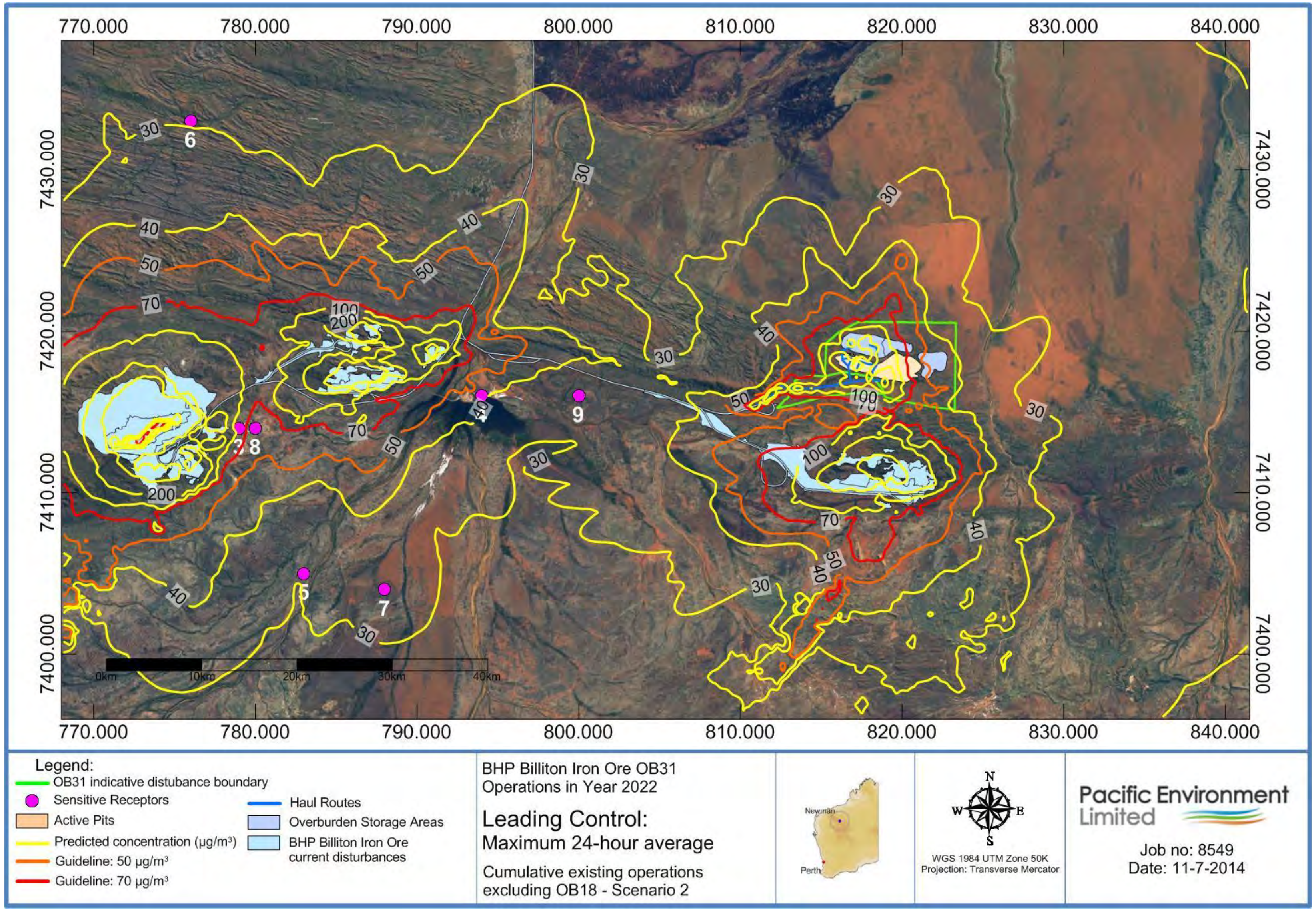

Figure G.4: Predicted Maximum Daily PM_{10} Concentrations – Scenario 2 – Cumulative Existing Operations Excluding OB18 with Leading Dust Control

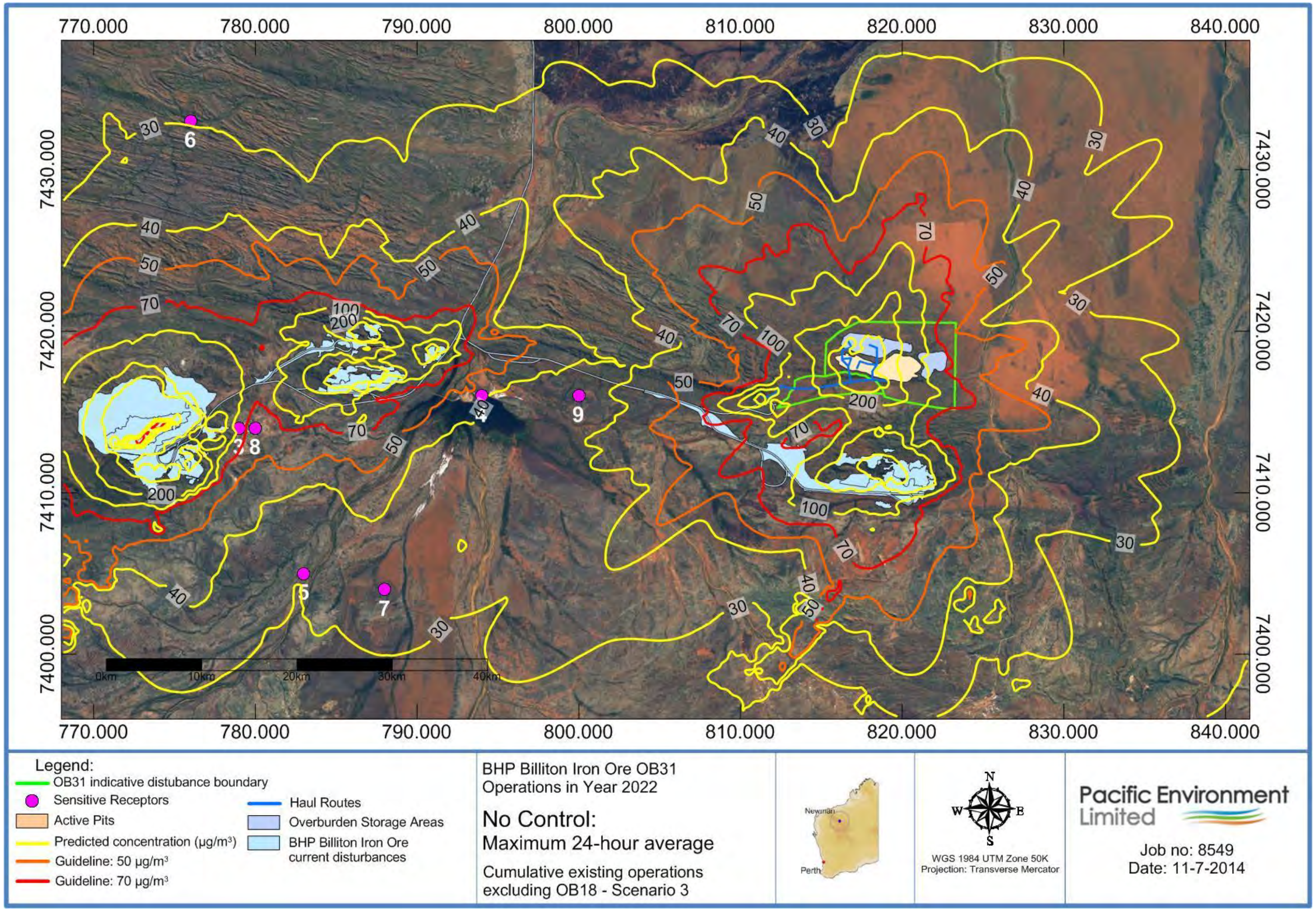

Figure G.5: Predicted Maximum Daily PM_{10} Concentrations – Scenario 3 – Cumulative Existing Operations Excluding OB18 with No Dust Control

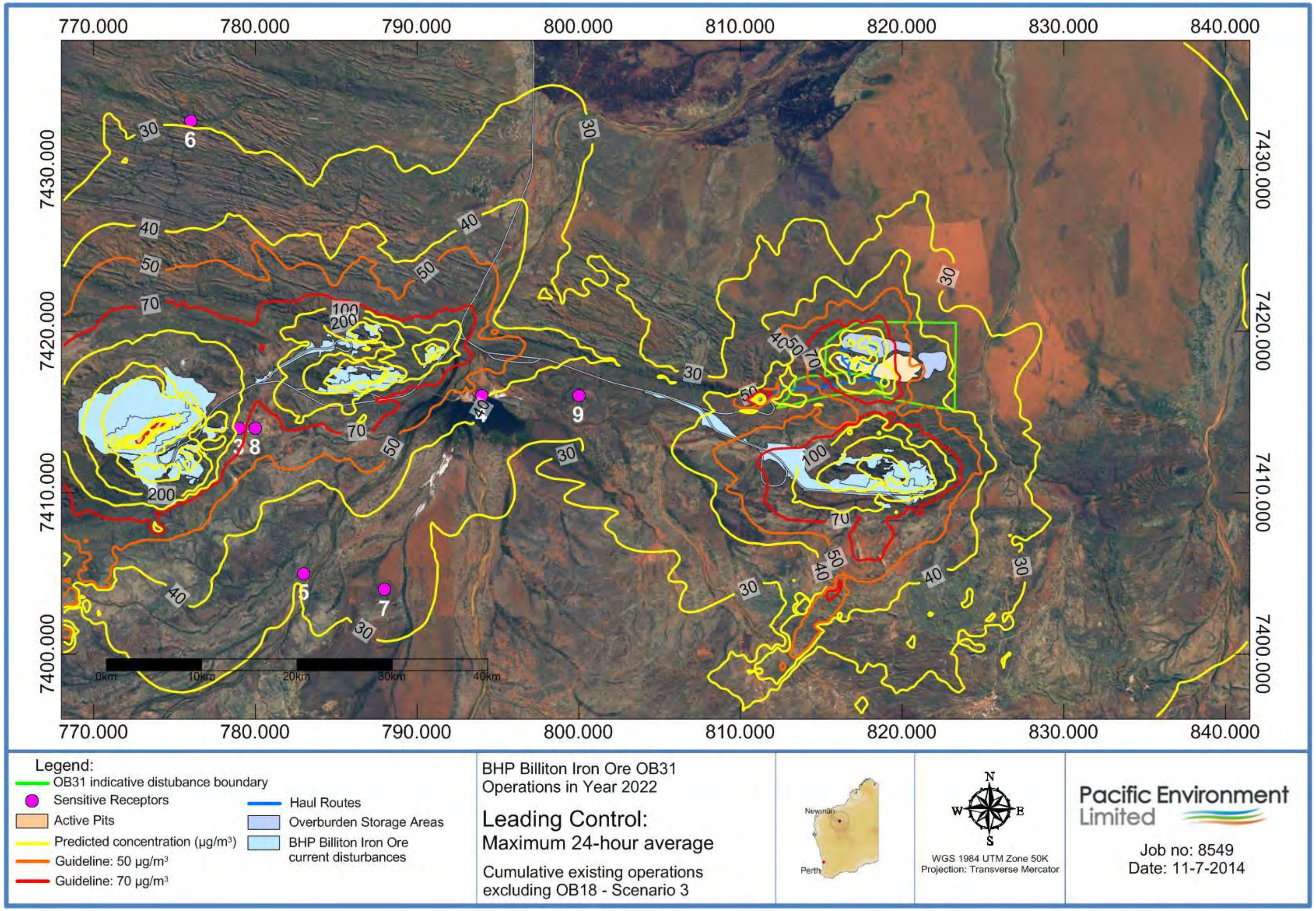

Figure G.6: Predicted Maximum Daily PM_{10} Concentrations – Scenario 3 – Cumulative Existing Operations Excluding OB18 with Leading Dust Control

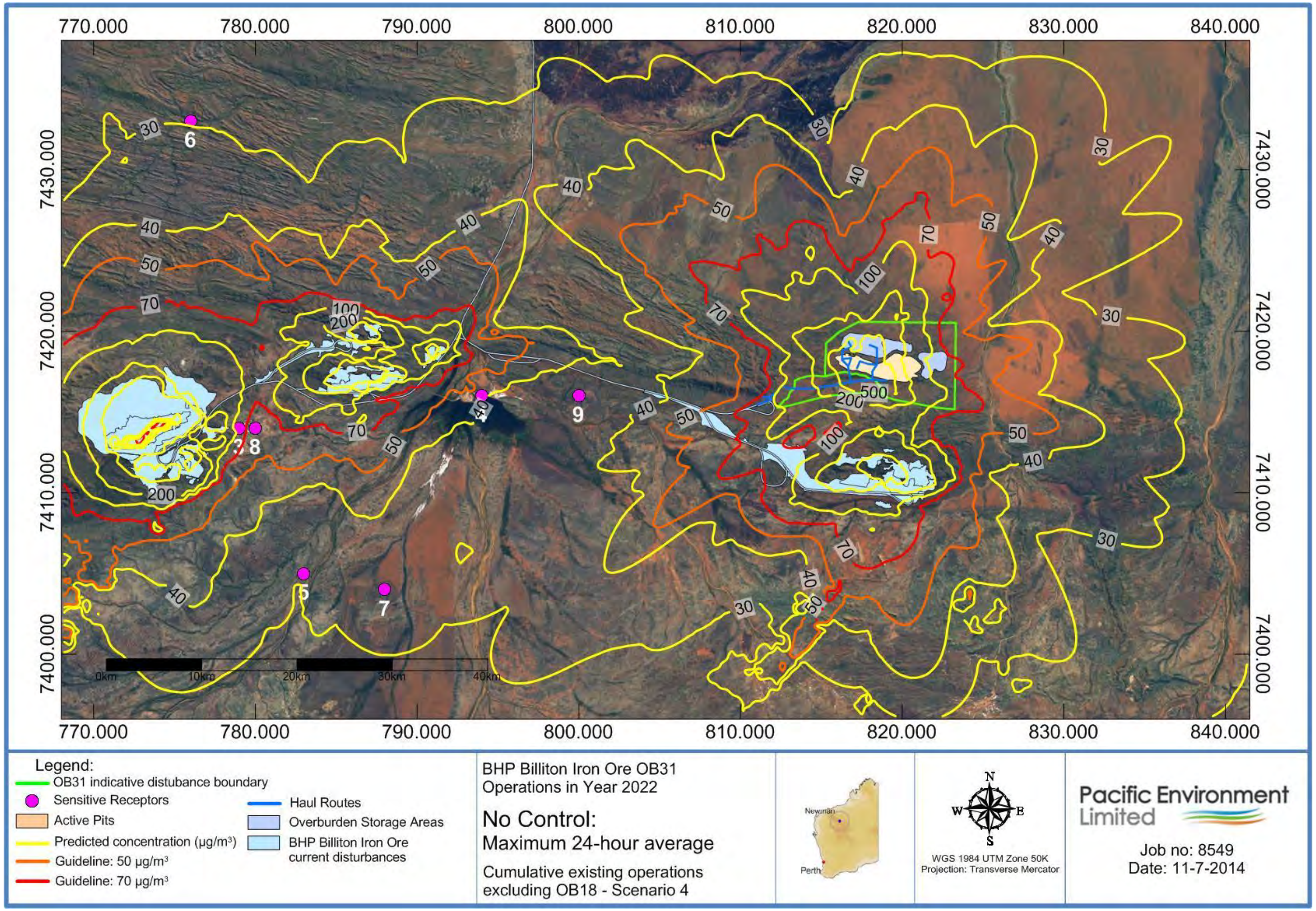

Figure G.7: Predicted Maximum Daily PM_{10} Concentrations – Scenario 4 – Cumulative Existing Operations Excluding OB18 with No Dust Control

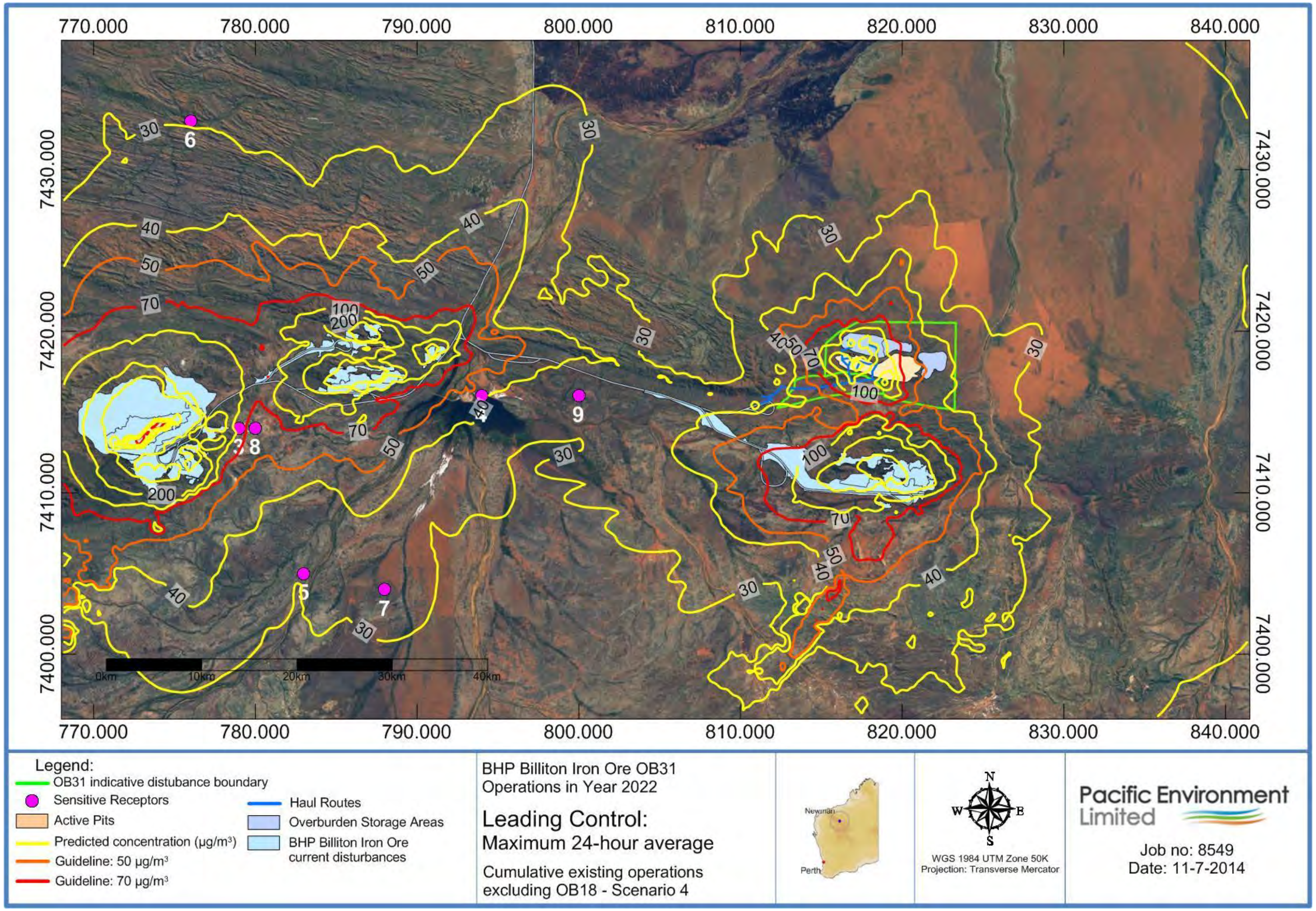

Figure G.8: Predicted Maximum Daily PM_{10} Concentrations – Scenario 4 – Cumulative Existing Operations Excluding OB18 with Leading Dust Control

Appendix H GREENHOUSE GAS ASSESSMENT

H.1 GREENHOUSE GAS ASSESSMENT

A greenhouse gas assessment for OB31 was required to support the environmental impact assessment process. This appendix outlines the assessment requirements, methods and results.

H.1.1 Introduction to Greenhouse Gases

Federal parliament passed the *National Greenhouse and Energy Reporting Act 2007* (the NGER Act) in September 2007. The NGER Act establishes a mandatory obligation on corporations which exceed the defined thresholds to report greenhouse gas emissions, energy consumption, energy production and other related information (CER, 2013a).

The greenhouse gases evaluated in this study are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). As the effects of greenhouse gases are assessed at a global scale, the use of dispersion modelling does not provide useful analysis. Greenhouse gas emissions are considered in terms of total emissions produced and determined using the methodology defined in the National Greenhouse and Energy Reporting System framework requirements. This framework requires the reporting of direct greenhouse emissions (Scope 1) and indirect emissions due to energy used that were produced off-site (Scope 2). Another category of greenhouse gas emissions recognised internationally is other indirect greenhouse gas emissions (Scope 3); however, these emissions were not considered in this assessment as explained further in Section H.1.1.3.

H.1.1.1 Scope 1: Direct Greenhouse Gas Emissions

Direct greenhouse gas emissions occur from sources owned or controlled by the reporting entity. Direct greenhouse gas emissions principally result from the following types of project activities:

- Direct generation of electricity, heat or steam.
- Physical or chemical processing.
- Transportation of materials, products, waste and employees.
- Fugitive emissions.

The Scope 1 emissions identified for the proposed OB31 operations are associated with diesel combustion in mining equipment, stationary engines, haul trucks, light vehicles and service vehicles.

H.1.1.2 Scope 2: Energy Product Use

Scope 2 emissions are from the generation of purchased energy by the entity. Scope 2 emissions physically occur at the facility that generates the electricity, rather than the facility that uses the electricity.

The Scope 2 emissions identified for the proposed OB31 operations are associated with the consumption of electricity generated at the Yarnima Power Station in Newman (previously Alinta). BHP Billiton owns, and operates the combined cycle gas turbine (CCGT) power station. However, emissions from the production of electricity are considered Scope 2 (indirect) emissions with respect to the OB31 mine development because the power station was assessed under a separate environmental impact assessment process. Therefore only the power consumed at OB31 is included in this assessment.

H.1.1.3 Scope 3: Other Indirect Greenhouse Gas Emissions

Scope 3 emissions are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of Scope 3 activities are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

Scope 3 emissions tend to be optional for reporting, particularly when compiling national inventories. If an organisation believes that Scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with Scope 1 and Scope 2 emissions. In addition, reporting Scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult (because reporting is voluntary).As a result, Scope 3 emissions were not estimated for the purpose of this assessment.

H.2 METHODOLOGY

H.2.1 Methodology Documents and Scenarios

Greenhouse gas emissions were estimated based upon the methods outlined in the following documents:

- The National Greenhouse and Energy Reporting (Measurement) Determination 2008 as amended (CER, 2013b).
- The National Greenhouse and Energy Reporting System Measurement Technical Guidelines 2013 (NGER Technical Guidelines) (CER, 2013c).

Greenhouse emissions were estimated for each year of the operating phase of the mine development (i.e. 2018 – 2028) for Scenarios 1 and 4 as defined in the dispersion modelling:

- Scenario 1: 15 Mtpa, ore hauled via road from OB31 to OB18 and crushed at OB18.
- Scenario 4: 15 Mtpa, ore crushed at OB31 with new crusher and transported via an overland conveyor to OB18.

Greenhouse emissions were only estimated for these two scenarios as it is expected that Scenarios 1 and 2, and Scenarios 3 and 4 will generate a similar amount of greenhouse emissions.

H.2.2 Greenhouse Gas Emissions Estimation

The emission sources considered for this assessment are as follows:

- Diesel combustion in mining equipment, haul trucks, stationary engines, light vehicles and service vehicles.
- Electricity consumption for OB31 operations from an off-grid source (i.e. Yarnima Power Station).

H.2.2.1 Scope 1 Emissions from Diesel Combustion

Diesel will be combusted in haul trucks, mining equipment (i.e. bulldozers, excavators, front-end loaders, shovels, graders and drill rigs), stationary engines (e.g. generators), light vehicles and service vehicles.

For Scenario 1, more diesel is expected to be consumed as iron ore will be transported from OB31 to OB18 via haul trucks. For Scenario 4, haul trucks are still anticipated to be used to transport materials such as topsoil and overburden.

Emissions of CO_2, CH_4 and N_2O were estimated using Method 1 (Division 2.4.2, *Method 1- emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum based oils or greases* of the *NGER Technical Guidelines*):

$$E_j = \frac{Q \times EC \times EF_{joxec}}{1000}$$

where:

E_j	=	Estimated emissions of gas type (j) from diesel combustion	(t CO_2-e/yr)
Q	=	Estimated quantity of diesel combusted for the operations of the mine development in the year	(kL/yr)
EC	=	Energy content factor of diesel	(GJ/kL)
EF_{joxec}	=	Emission factor for each gas type (j)	(kg CO_2-e/GJ)

Forecast total annual quantities of diesel combusted for the operations of the mine development were provided by BHP Billiton Iron Ore for the period 2018-2028 and it was assumed that these quantities include fuel consumption in:

- haul trucks
- mining equipment (i.e. bulldozers, excavators, FELs, shovels, graders and drill rigs)
- light vehicles and service vehicles.

Two sources of emission factors are available from the *NGER Technical Guidelines* for estimating greenhouse emissions from the combustion of diesel associated with the operations of the mine development:

- Table 2.4.2A: liquid fuel combustion for stationary energy purposes; i.e. purposes for which fuel is combusted that do not involve transport energy purposes.
- Table 2.4.2B: liquid fuel combustion for transport energy purposes including purposes for which fuel is combusted for any of the following activities:
  - transport by vehicles **registered for road use**
  - rail transport
  - marine navigation
  - air transport.

Haul trucks and mining equipment are not registered for road use and therefore, the emission factors provided in Table 2.4.2A were used to estimate the associated emissions. In addition, the quantity of fuel combusted in light vehicles and service vehicles is anticipated to be insignificant in comparison to the total quantity of fuel combusted for OB31's activities. As a result, the emission factors for **stationary energy purposes** from Table 2.4.2A (refer to Table H.1) were used to estimate all emissions from diesel combustion from the operations of the mine development. Note that the emissions factors provided in Table 2.4.2A and Table 2.4.2B are very similar and that no other emission factors are available for estimating emissions from diesel combustion.

The default energy content factor for diesel was also obtained from Table 2.4.2A of the *Technical Guidelines* and is listed in Table H.1. The activity data provided by BHP Billiton Iron Ore and the estimated annual and cumulative greenhouse emissions are presented in Table H.2.

For Year 2022, when the maximum production rate is expected to be achieved (i.e. 15 million tonnes (Mt)) of iron ore produced and 25 Mt of waste rock handled), Scenario 1 will generate 68,345 tonne CO_2-e and Scenario 4 will generate 69,301 tonne CO_2-e (refer to Table H.2). The difference between the two scenarios is not significant for this particular year; however, the cumulative emissions associated with the entire operating phase of OB31 are expected to be 27% higher for Scenario 1, due to hauling of the iron ore.

Table H.1: Energy Content Factor and Emission Factors Associated with Diesel Combustion

Description	Value	Units
Default energy content factor	38.6	GJ/kL
Scope 1 default CO_2 emission factor	69.2	kg CO_2-e/ GJ
Scope 1 default CH_4 emission factor	0.2	
Scope 1 default N_2O emission factor	0.5	

Reference: Table 2.4.2A, CER (2013c).

Table H.2: Annual Activity Data and Estimated Greenhouse Gas Emissions Associated with Diesel Combustion for Each Scenario

Operational Year	Forecast Quantity of Diesel Combusted (kL/yr) [a]		Scope 1 Emissions (t CO_2-e/annum)	
	Scenario 1	Scenario 4	Scenario 1	Scenario 4
2018	33,631	33,631	90,222	78,590
2019	34,801	34,801	93,360	80,886
2020	25,890	25,890	69,456	61,323
2021	24,159	24,159	64,810	64,443
2022	**25,476**	**25,476**	***68,345***	***69,301***
2023	41,064	41,064	110,163	69,083
2024	40,792	40,792	109,432	68,490
2025	30,840	30,840	82,736	67,627
2026	34,176	34,176	91,683	67,783
2027	31,199	31,199	83,698	62,239
2028	32,769	32,769	87,910	58,722
Cumulative value for 2018 - 2028	**354,798**	**279,005**	**951,817**	**748,486**
Average value for 2018-2028	**32.254**	**25.364**	**86,529**	**68,044**

a Forecast annual quantities of diesel combusted for the operations of the mine development were provided by BHP Billiton Iron Ore for the period 2018-2028. BHP Billiton Iron Ore derived these annual quantities from its mine plan which was current at the time of this study. In future, the mine plan may be subject to change as the OB31 scope is further refined and / or to suit business operational requirements. The worst case year may vary, however, the overall predicted cumulative greenhouse gas emissions are expected to remain similar overall.

H.2.2.2 Scope 2 Emissions from Electricity Consumption

All electricity used for the operations of the mine development will be obtained from the Yarnima Power Station in Newman. BHP Billiton Iron Ore owns and operates the CCGT power station. Forecast annual quantities of electricity used for the operations of the mine development were provided by BHP Billiton Iron Ore and it was assumed that these quantities include the power consumption for the following sources:

- overland conveyor (for Scenario 4 only)
- crusher
- utilities.

For Scenario 4, more electricity is expected to be consumed as iron ore will be transported from OB31 to OB18 via overland conveyors, which are assumed to use electricity.

Scope 2 emissions of CO_2-e associated with purchased electricity were estimated using Method 1 (Division 7.3, *Method 1 – purchase of electricity from other sources* of the *NGER Technical Guidelines*):

$$Y = Q \times \frac{EF_{S2}}{1000}$$

where:

Y	=	Scope 2 greenhouse gas emissions	(t CO_2-e/yr)
Q	=	Quantity of electricity purchased during the year and consumed from the operation of the facility	(kWh/yr)
EF_{S2}	=	Scope 2 emission factor	(kg CO_2-e/kWh)

As the electricity for the operations of OB31 will be obtained from the BHP Billiton Iron Ore's Yarnima Power Station and not the main electricity grid, the default emission factor associated with Western Australia's main electricity grid from Table 7.2 of the *NGER Technical Guidelines* cannot be used. In accordance with Section 7.1 of the *NGER Technical Guidelines*, the Northern Territory (NT) emission factor available from Table 7.2 was used instead, which is presented in Table H.3.

NT electricity generation primarily represents a mix of natural gas and diesel generation which is a reasonable match for the fuel mix used in the generation of off-grid electricity generation.

The forecast activity data provided by BHP Billiton Iron Ore and the estimated annual and cumulative greenhouse emissions are presented in Table H.4.

For year 2022, the greenhouse emissions associated with electricity consumption are expected to be 12,909 tonne CO_2-e for Scenario 1 and 22,609 tonne CO_2-e for Scenario 4 (refer to Table H.4), which corresponds to an increase of 75% in emissions for Scenario 4, due to conveying iron ore. Similarly, the cumulative emissions for Scenario 4 are more significant than those estimated for Scenario 1.

Table H.3: Emission Factor Associated with Electricity Consumption

Description	Value	Units
Scope 2 emission factor for NT	0.69	kg CO_2-e/ kWh

Reference: Table 7.2, CER (2013c).

Table H.4: Annual Activity Data and Estimated Greenhouse Gas Emissions Associated with Electricity Consumption for Each Scenario

Operational Year	Forecast Quantity of Electricity Consumed (kWh/yr)		Scope 2 Emissions (t CO_2-e/annum)	
	Scenario 1	Scenario 4	Scenario 1	Scenario 4
2018	18,834,000	17,790,484	12,995	12,275
2019	18,834,000	31,934,461	12,995	22,035
2020	18,834,000	35,615,323	12,995	24,575
2021	18,834,000	33,299,805	12,995	22,977
2022	***18,708,440***	***32,766,097***	***12,909***	***22,609***
2023	18,708,440	32,766,097	12,909	22,609
2024	18,834,000	35,615,323	12,995	24,575
2025	18,834,000	35,615,323	12,995	24,575
2026	18,834,000	35,615,323	12,995	24,575
2027	18,708,440	35,615,323	12,909	24,575
2028	18,708,440	35,615,323	12,909	24,575
Cumulative emissions for 2018 - 2028	**206,671,760**	**362,248,880**	**142,604**	**249,952**
Average emissions for 2018-2028	**18,788,342**	**32,931,716**	**12,964**	**22,723**

H.2.2.3 Summary of Greenhouse Emissions

Annual and cumulative Scope 1 and Scope 2 emissions associated with the mine development are presented in Table H.5.

For year 2022, when the maximum production rate is expected to be achieved (i.e. 15 Mt of iron ore produced and 25 Mt of waste rock handled), a total of 81,254 tonne CO_2-e will be generated for Scenario 1 and a total of 91,910 tonne CO_2-e will be generated for Scenario 4. This corresponds to a 13% increase in emissions if the iron ore is conveyed from OB31 to OB18.

However, the cumulative greenhouse emissions for the operation phase of OB31 show that Scenario 4 (conveying iron ore) is expected to emit less greenhouse emissions; i.e. Scenario 4 will only generate 91% of the emissions generated for Scenario 1.

Table H.5: Summary of Annual Greenhouse Gas Emissions for Each Scenario

Operational Year	Greenhouse Emissions (t CO_2-e/annum)					
	Scenario 1			Scenario 4		
	Scope 1	Scope 2	Total	Scope 1	Scope 2	Total
2018	90,222	12,995	103,217	78,590	12,275	90,865
2019	93,360	12,995	106,356	80,886	22,035	102,921
2020	69,456	12,995	82,452	61,323	24,575	85,897
2021	64,810	12,995	77,806	64,443	22,977	87,420
2022	***68,345***	***12,909***	***81,254***	***69,301***	***22,609***	***91,910***
2023	110,163	12,909	123,072	69,083	22,609	91,691
2024	109,432	12,995	122,427	68,490	24,575	93,064
2025	82,736	12,995	95,731	67,627	24,575	92,202
2026	91,683	12,995	104,679	67,783	24,575	92,357
2027	83,698	12,909	96,607	62,239	24,575	86,813
2028	87,910	12,909	100,819	58,722	24,575	83,296
Cumulative emissions for 2018 - 2028	**951,817**	**142,604**	**1,094,420**	**748,486**	**249,952**	**998,438**
Average emissions for 2018-2028	**86,529**	**12,964**	**99,493**	**68,044**	**22,723**	**90,767**

H.3 ASSESSMENT OF IMPACTS OF GREENHOUSE EMISSIONS FROM OB31

The average annual and cumulative greenhouse emissions and associated emissions intensity [a] for similar projects are compared in Table H.6. Based on this measure, both Scenario 1 and Scenario 4 appear to be comparable to the Simandou and West Pilbara iron ore projects, whereas the Weld Range project appears to be significantly more emissions intensive.

Table H.7 compares the forecast emissions for OB31 to larger scale emissions. The emissions from the OB31 are anticipated to be equivalent to 0.14% (for Scenario 1) and 0.13% (for Scenario 4) of Western Australia's 2011/2012 greenhouse inventory. On a national scale, Scenario 1 will contribute to 0.018% and Scenario 4 will contribute to 0.016% of Australia's 2011/2012 greenhouse inventory. As a result, impacts from OB31 are expected to be minor on a large scale basis.

Table H.6: Comparison of Forecast Average Emissions and Emissions Intensity with Similar Projects

Project	Description [a]	Average Annual Emissions ($t\ CO_2$-e/yr)	Cumulative Emissions over Project Life ($t\ CO_2$-e)	Forecast Iron Ore Production (Mtpa)	Emissions Intensity [b] ($t\ CO_2$-e/ t iron ore produced)
OB31	**S1 and S2 emissions - Scenario 1**	**99,493**	**1,094,420**	**15**	**0.007**
	S1 and S2 emissions - Scenario 4	**90,767**	**998,438**	**15**	**0.006**
Simandou Mine in Guinea [b]	S1 emissions for full operation (Year 4 to 43)	345,450	13,818,000	2.9	0.005
West Pilbara Iron ore Project Stage 2 [c]	S1 and S2 emissions	70,000	-	15	0.005
Weld Range Iron Ore Project [d]	S1 emissions (Year 1 to 6)	210,823	1,254,753	15	0.014

a S1 : Scope 1 and S2 : Scope 2.
b Rio Tinto (2012).
c API Management (2012)
d Kewan Bond (2008).

Table H.7: Comparison of Forecast Average Emissions from OB31 with Large Scale Emissions

Geographic Coverage	Description	Timescale	Emissions (Mt CO_2-e)
Global [a]	Consumption of fossil fuels	2010	31,387
Australia [b]	All sectors including Land Use, Land Use Change and Forestry (LULUCF) activities	2011-12	554.6
Western Australia [b]	All sectors including Land Use, Land Use Change and Forestry (LULUCF) activities	2011-12	70.5
OB31	**Average S1 and S2 emissions - Scenario 1**	**Estimated annual**	**0.10**
	Average S1 and S2 emissions - Scenario 4	**Estimated annual**	**0.09**

a UNSD (2014).
b Table 3, Department of the Environment (2014).

[a] The emission intensity is presented in tonnes CO_2-e per tonne of iron produced for the purpose of this assessment.

H.4 PROPOSED MITIGATION MEASURES

For both scenarios, diesel consumption is anticipated to be the main source of greenhouse emissions. As a result, it is recommended that fuel efficient equipment and vehicles be purchased for the operations of OB31. The implementation of more fuel efficient technology, optimisation of operations movements and regular maintenance and servicing of machinery and vehicles will assist in reducing greenhouse emissions from fuel combustion.

Electricity will be obtained from a combined cycle gas turbine power station, which has the highest thermal efficiency (i.e. 51.6%) according to best available technology standards (AGO, 2006). However, it is still recommended that electrical equipment (e.g. particularly the crusher) is regularly monitored and maintained to ensure it operates efficiently.

H.5 REFERENCES

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Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

24 July 2014

BHP Billiton
Sonya Brunt
Senior Environmental Approvals Advisor – WA Iron Ore

Email: sonya.brunt@bhpbilliton.com

Dear Sonya

RE: MEMORANDUM – ATMOSPHERIC DISPERSION MODELLING FOR SCENARIO 5 FOR OB31

Please find attached a memorandum regarding the Scenario 5 atmospheric dispersion modelling undertaken for this project. This memorandum is provided in conjunction with the Report to inform of relevant issues and recommendations for your consideration.

This memorandum should be read with knowledge of the modelling procedures (emission estimation and modelling) along with the results contained within the full draft report.

If you require further information or explanation then please let me know.

Yours sincerely

Jon Harper
Manager, WA

1 INTRODUCTION

Orebody 31 (OB31) is located approximately 40 kilometres (km) east of Newman Township in the Pilbara region of Western Australia (Figure 1). OB31 is situated to the east of the existing Orebody 17/18 (OB17/18) Mine within Mineral Lease ML244SA, which is subject to the *Iron Ore (Mount Newman) Agreement Act 1964* (Newman Agreement Act). OB31 has not previously been developed and as such is considered a greenfield development.

The OB17/18 Mine is reaching the end of its economic life, with available ore reserves expected to be depleted by mid 2017. Additional ore sources are required to provide sufficient blend feed in order to maintain the current level of iron ore production from the Eastern Pilbara mines.

The mineralised resource at OB31 has been estimated at approximately 500 million tonnes (Mt). BHP Billiton Iron Ore is currently considering two development options for this resource. The first is a base option of 15 Mtpa as a long-term replacement for OB18 and the second is a growth option of 30 Mtpa.

The objective of the study was to assess the air quality impact from the proposed development options. This memorandum contains details on the growth option for OB31 operations (Scenario 5).

To determine acceptability of the modelled PM_{10} results, the assessment adopted criteria based on:

- National Environment Protection Measure standard (NEPM) of 24-hour 50 µg/m³ (NEPC, 1998)
- Port Hedland Dust Management Taskforce (Taskforce) guideline of 24-hour 70 µg/m³ (Taskforce, 2010)

The selection of these criteria is considered to be a conservative approach, and appropriate given that there may be further revisions to the proposal in the future. Comparison of the modelled results to the assessment criteria is intended to provide an objective evaluation of the potential impact of the operations at the nearest sensitive receptors.

The nearest sensitive receptors included in the modelling is presented Table 1.1 and Figure 1.1.

Table 1.1: Sensitive Receptor Locations for Model Interpretation

Receptor ID	Location	Easting (m)	Northing (m)	Type
3	Tower Hill	779,000	7,414,000	Lookout (non residential location)
4	Opthalmia Dam	794,000	7,416,000	Recreation Site (non residential location)
5	Round Hill	783,000	7,405,000	Recreation Site (non residential location)
6	Kalgan Pool	776,000	7,433,000	Recreation Site (non residential location)
7	Capricorn Roadhouse	788,000	7,404,000	Roadhouse (residential location)
8	Newman	780,000	7,414,000	Town Centre (residential location)
9	Eastern Pilbara Accommodation Village	800,000	7,416,000	Accommodation Village (residential location)

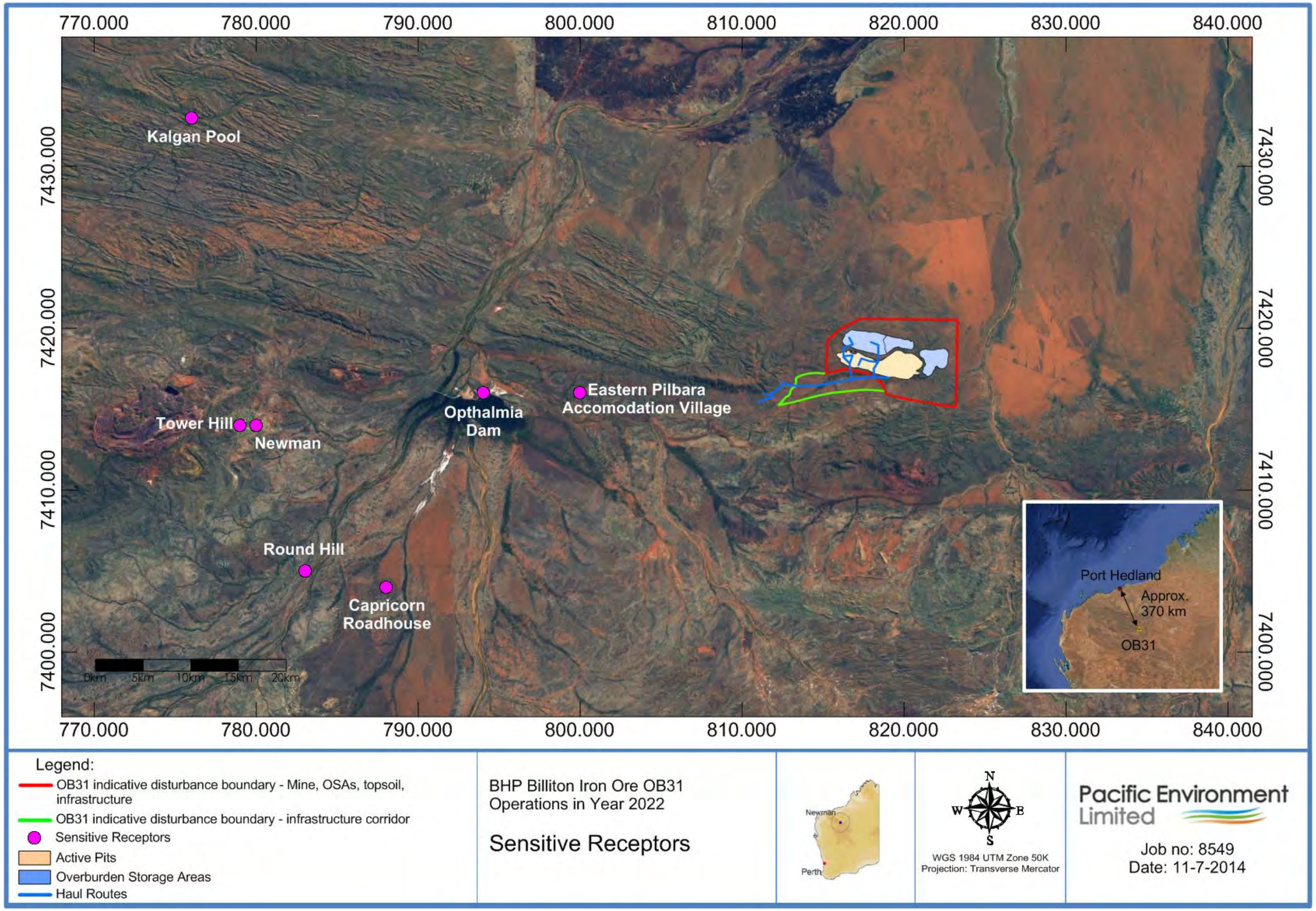

Figure 1.1: Sensitive Receptor Locations

2 EMISSION ESTIMATION AND MODELLING

Dust has the potential to be generated from all operational activities at the mine, including topsoil stripping, blasting, drilling, ore and waste excavation, loading, unloading, stacking, crushing and screening, transferring material, reclaiming, wind erosion (from unpaved haul roads, ore and waste stockpiles and other open areas) and rail load out.

To determine the potential impacts of dust from the operations a number of processes are involved including:

- Emission Estimation: A detailed emissions inventory of the operations for the 2022 year was developed using activity data provided by the client, in conjunction with BHP Billiton Iron Ore on-site specific empirical equation and emission factors from the Australian National Pollutant Inventory emission estimation manual.
- Meteorology: An annual meteorological dataset was compiled using a combination of the Weather Research and Forecasting Model (WRF) and CALMET. The meteorological data takes into account the range of meteorological conditions that may occur over the year, and includes the worst-case meteorological conditions that are expected to arise at the site.
- Modelling: The USEPA regulatory model CALPUFF was used for this assessment. This model is the preferred model for long-range transport or for modelling in regions of complex meteorology and terrain.

Full details of the emission estimation process, meteorological file compilation and the modelling are contained within the air quality assessment main report.

The proposed mine plan for OB31 Scenario 5, including tonnages, locations of deposits, overburden storage area and haul road distance, provided for this assessment are shown in Table 2.1, Table 2.2 and Figure 2.1.

Table 2.1: Proposed Movement of OB31 for Year 2022

	Pit Stages (tonnes)		
	Section 5 (S5)	Section 4 (S4)	Total
Ore	14,365,822	15,634,178	30,000,000
Waste	8,355,544	41,644,456	50,000,000
Total	22,721,366	57,278,634	-

Table 2.2: Haul Road Distances for OB31 in Year 2022

	Haul distance (km)	
	S5 to OB31	S4 to OB31
Ore	4	3
Waste	3	3

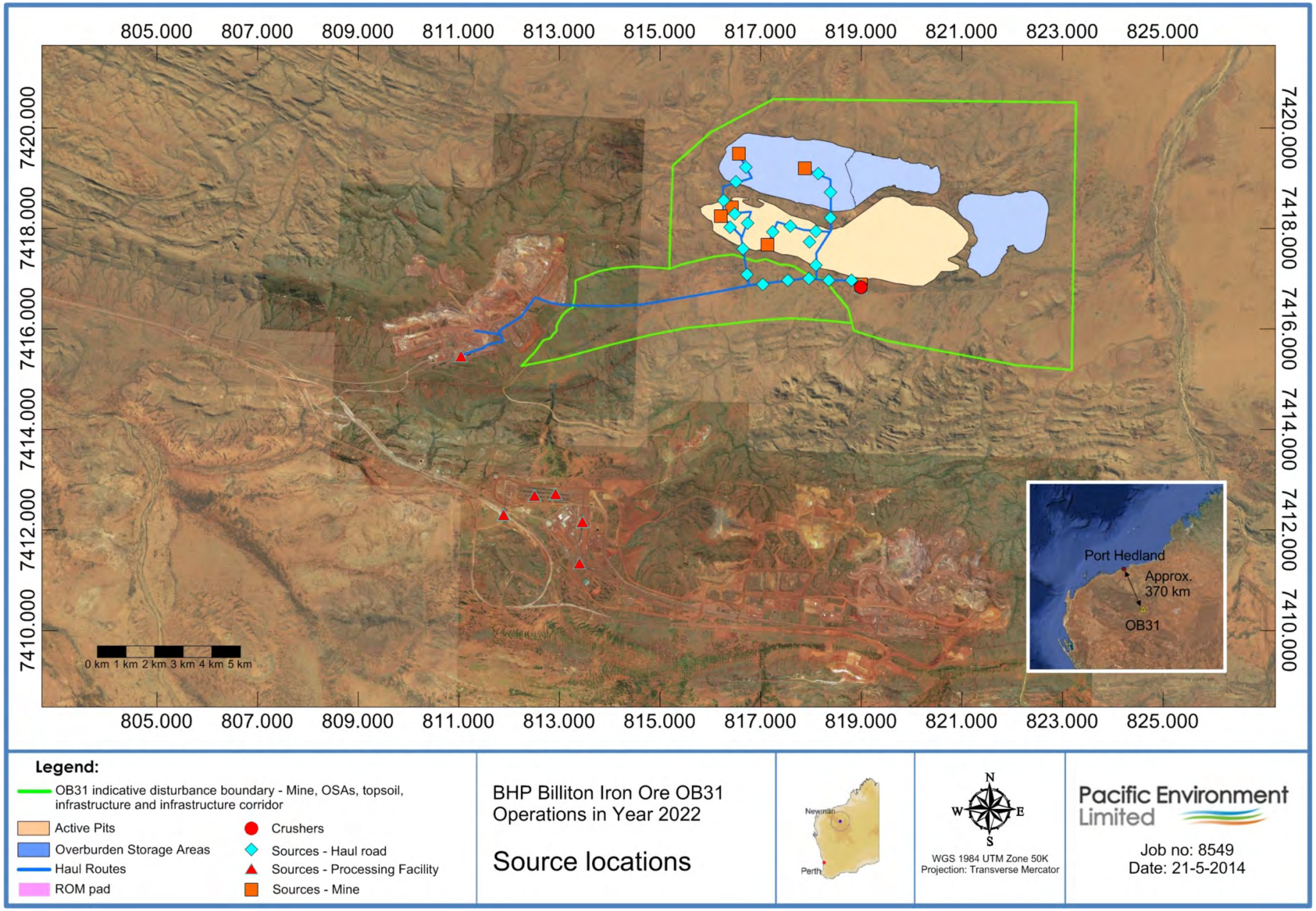

Figure 2.1: Source Locations

The scenario to be modelled is the estimated emissions arising from:

- 15Mtpa – crushed and transported via overland conveyor from OB31 to OB18; and
- 15Mtpa – crushed and transported via overland conveyor from OB31 to Jimblebar.

There are various ways in which dusts emissions from mining operations can be controlled. A summary of dust control methods with standard BHP Billiton Iron Ore operating controls (Standard Controls) and recommended leading dust controls (Leading Controls) are listed in Table 2.3.

This scenario was assessed with:

- no dust management control
- standard controls
- leading controls.

Table 2.3: Summary of control factors for OB31 operations

Operation	Control method and emission reduction
Mining	
Bulldozing	No control
Loading ore and waste	Standard: no control Leading: 50% for water sprays in P 2 and F (West)
Loading ore from ROM pad to crusher	Standard: 50% for level 1 water sprays Leading: 83% for level 2 water sprays
Unloading waste	No control
Unloading ore at ROM pad	No control
Unloading ore into crusher	Standard: 50% for level 1 water sprays Leading: 83% for level 2 water sprays
Drilling	Standard: 50% for cyclone Leading: 99% for water injection
Blasting	No control
Wind Erosion in OSA and ROM pad	Standard: 50% for water sprays Leading: 90% for chemical surfactant and good housekeeping*
Haul road	
Hauling	Standard: 50% for level 1 watering (2 litres/m^2/h) Leading: 90% for chemical dust suppressant*
Processing facility	
Primary crushing of ore	Standard: 50% for water sprays Leading: 83 % for extraction
Conveyer drop off points	Standard: no control Leading: 50% for water sprays
Loading ore into haul trucks	Standard: 50% for level 1 water sprays Leading: 83% for level 2 water sprays
Unloading ore from haul trucks	Standard: 50% for level 1 water sprays Leading: 83% for level 2 water sprays
Screening plant	Standard: 40% for extraction Leading: 83% for extraction with fabric filters
Transfer station	Standard: no control Leading: 50% for water sprays (including BWS)
Stackers	Standard: 30% for boom sprays Leading: 30% for boom sprays
Train load out	Standard: 30% for water sprays Leading: 30% for water sprays
Wind erosion in open area	Standard: 50% for water Leading: 90% for chemical surfactant and good housekeeping*
Note: Unless referenced specifically, control efficiencies are based on NPI values. * Based on PEL, 2013b (report prepared for BHP Billiton Iron Ore)	

2.1 Emissions Estimates Summary

The total emissions of PM_{10} associated with the proposed operation for Scenario 5, is presented in Table 2.4. Detailed emission estimation techniques are presented the within Appendix A.

Table 2.4: Emissions of PM_{10} for Scenario 5 by Activity

Scenarios	Activity	PM_{10} Emissions (kg/year)
No Control	Bulldozing	22,764
Standard Controls		22,764
Leading Controls		22,764
No Control	Loading	687,344
Standard Controls		687,344
Leading Controls		343,672
No Control	Unloading	476,862
Standard Controls		411,204
Leading Controls		368,634
No Control	Wheel Generated Dust from Unpaved Roads	6,211,213
Standard Controls		3,105,606
Leading Controls		621,121
No Control	Wind Erosion	25,609
Standard Controls		12,805
Leading Controls		2,561
No Control	Blasting	27,332
Standard Controls		27,332
Leading Controls		27,332
No Control	Drilling	15,437
Standard Controls		7,718
Leading Controls		154
No Control	Crushing	120,120
Standard Controls		60,060
Leading Controls		20,420
No Control	Screening	157,133
Standard Controls		94,280
Leading Controls		26,713
No Control	Stacking	8,023
Standard Controls		5,616
Leading Controls		5,616
No Control	Reclaiming	3,862
Standard Controls		2,704
Leading Controls		2,704
No Control	Conveying	8,028
Standard Controls		8,028
Leading Controls		4,014
No Control	Transfer Stations	7,428
Standard Controls		7,428
Leading Controls		3,714
Total	**No control**	7,771,154
Total	**Standard Controls**	4,452,887
Total	**Leading Controls**	1,449,418

3 MODELLING RESULTS

This section presents the results of the dispersion modelling for the Scenario 5. The modelling results are presented in tabular form and graphically for most scenarios. The results are compared to the assessment criteria and evaluated against the cumulative impacts as predicted. The results for the existing operations are contained within the main air quality assessment report.

3.1 OB31 Operations Standalone – Model Scenario 5

3.1.1 Scenario 5 No Dust Controls

The modelled results for Scenario 5 (15 Mtpa crushed and transported via overland conveyor from OB31 to OB18 and 15 Mtpa crushed and transported via overland conveyor from OB31 to Jimblebar) as standalone (no surrounding operations or background) for no dust controls are presented in Table 3.1 and Figure 3.1.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment criteria since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.

Table 3.1: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 5 – OB31 Operations Standalone with No Dust Control

Receptor	3	4	6	6	7	8	9
Maximum	8.5	14.9	12.8	5.6	17.6	8.9	23.3
Maximum (as % of 50 µg/m³)	17%	30%	26%	11%	35%	18%	47%
Maximum (as % of 70 µg/m³)	12%	21%	18%	8%	25%	13%	33%
99^{th} percentile	6.4	12.0	8.2	4.7	8.8	6.9	17.4
95^{th} percentile	3.2	7.2	3.9	3.6	4.4	3.4	9.9
90^{th} percentile	2.3	5.1	2.5	2.9	2.9	2.4	7.6
70^{th} percentile	1.0	2.3	0.6	1.3	0.6	1.1	3.6
Average	0.9	1.9	0.8	1.0	0.9	0.9	2.8
No of Exceedances of 50 µg/m³	NA	NA	NA	NA	NA	NA	NA
No of exceedances of 70 µg/m³	NA	NA	NA	NA	NA	NA	NA

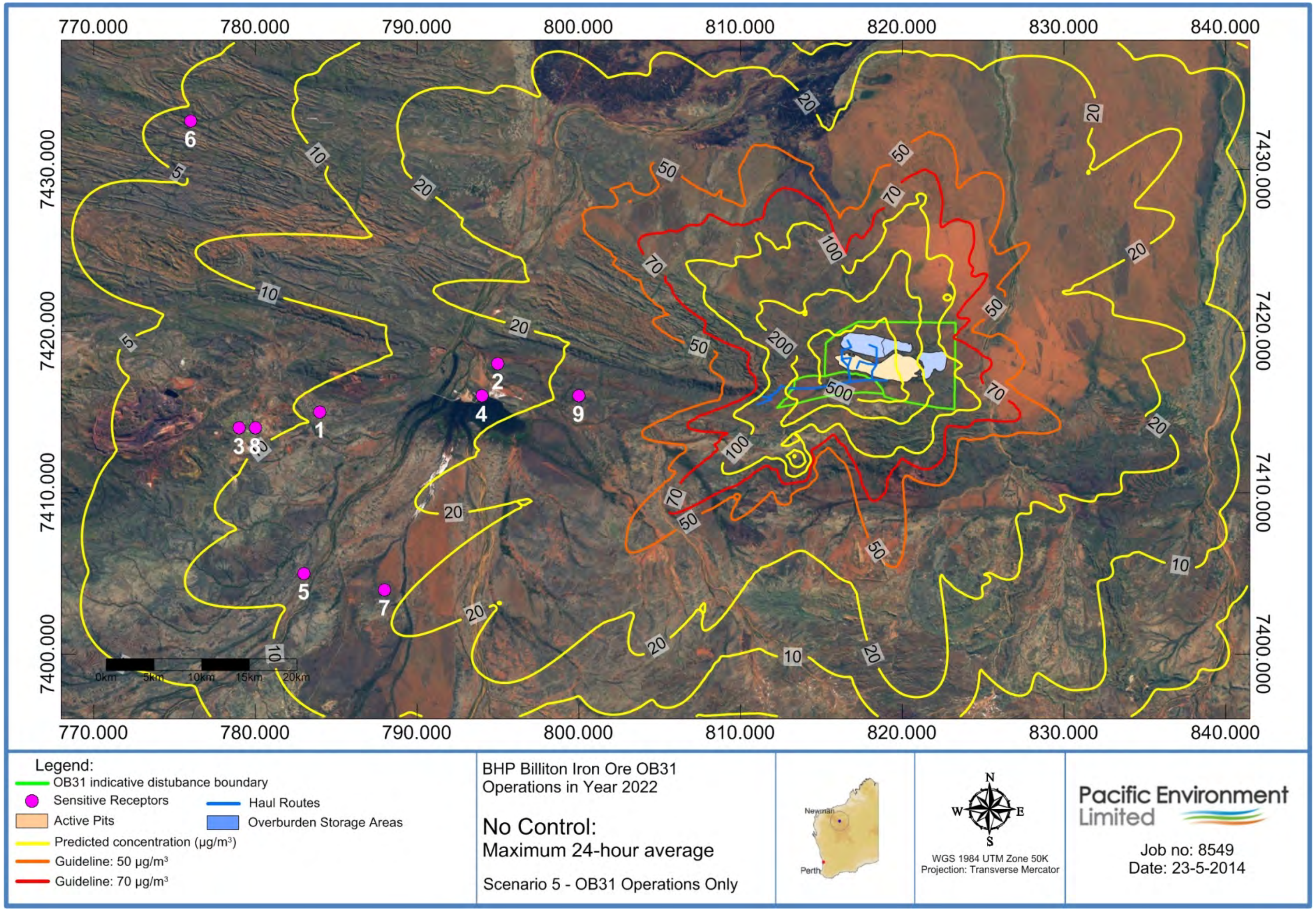

Figure 3.1: Predicted Maximum Daily PM_{10} Concentrations – Scenario 5 – OB31 Operations Standalone with No Dust Control

3.1.2 Scenario 5 Standard Dust Controls

The modelled results for Scenario 5 (15 Mtpa crushed and transported via overland conveyor from OB31 to OB18 and 15 Mtpa crushed and transported via overland conveyor from OB31 to Jimblebar) as standalone (no surrounding operations or background) for standard dust controls are presented in Table 3.2 and Figure 3.2.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment criteria since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- The level of impact from the OB31 operations at the Easter Pilbara Accommodation Village (Receptor 9) is approximately halved with standard dust controls compared to the no dust controls option

Table 3.2: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 5 – OB31 Operations Standalone with Standard Dust Control

Receptor	3	4	6	6	7	8	9
Maximum	5.0	8.9	7.5	3.3	10.4	5.2	13.2
Maximum (as % of 50 µg/m³)	10%	18%	15%	7%	21%	10%	26%
Maximum (as % of 70 µg/m³)	7%	13%	11%	5%	15%	7%	19%
99th percentile	3.7	7.0	4.7	2.7	5.0	4.0	10.1
95th percentile	1.9	4.2	2.3	2.1	2.6	2.0	5.7
90th percentile	1.3	3.0	1.5	1.7	1.7	1.4	4.5
70th percentile	0.6	1.4	0.4	0.7	0.3	0.6	2.1
Average	0.5	1.1	0.5	0.6	0.5	0.5	1.7
No of Exceedances of 50 µg/m³	NA	NA	NA	NA	NA	NA	NA
No of exceedances of 70 µg/m³	NA	NA	NA	NA	NA	NA	NA

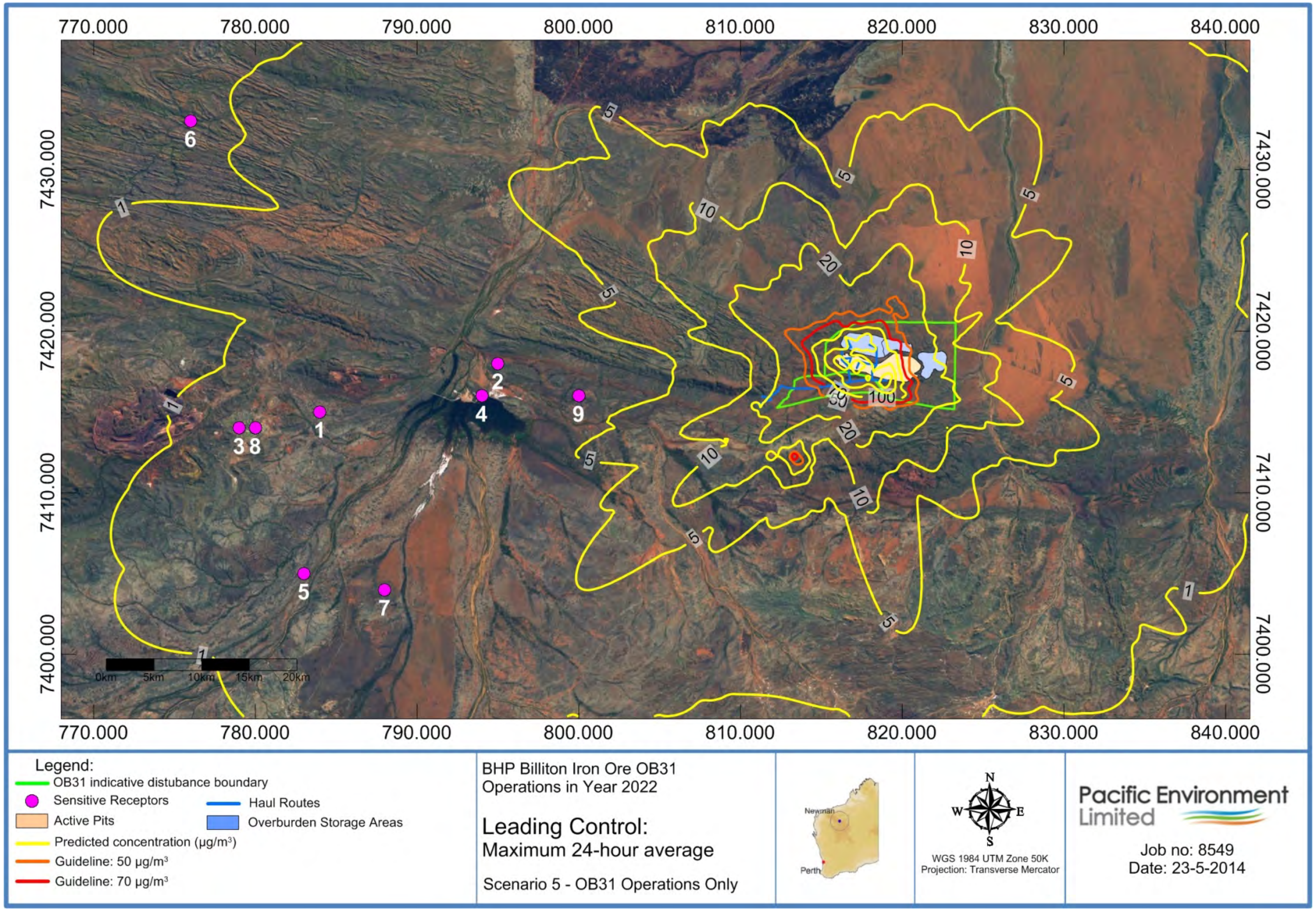

Figure 3.2: Predicted Maximum Daily PM_{10} Concentrations – Scenario 5 – OB31 Operations Standalone with Standard Dust Control

3.1.3 Scenario 5 Leading Dust Controls

The modelled results for Scenario 5 (15 Mtpa crushed and transported via overland conveyor from OB31 to OB18 and 15 Mtpa crushed and transported via overland conveyor from OB31 to Jimblebar) as standalone (no surrounding operations or background) for leading dust controls are presented in Table 3.3 and Figure 3.3.

The PM_{10} concentration results demonstrate the impacts from the OB31 operations alone and are not assessed against the assessment criteria since these results are not cumulative (including background and other sources).

Key aspects of the results include:

- The highest concentration at the receptors is predicted for the Eastern Pilbara Accommodation Village (Receptor 9) which is also closest to the OB31 operations.
- Compared to the standard dust controls the leading dust controls offer additional reductions in impacts.

Table 3.3: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 5 – OB31 Operations Standalone with Leading Dust Control

Receptor	1	2	3	4	6	6	7	8	9
Maximum	1.6	2.2	1.3	2.3	1.9	0.8	2.8	1.3	3.3
Maximum (as % of 50 µg/m³)	3%	4%	3%	5%	4%	2%	6%	3%	7%
Maximum (as % of 70 µg/m³)	2%	3%	2%	3%	3%	1%	4%	2%	5%
99th percentile	1.1	1.8	0.9	1.8	1.2	0.7	1.3	1.0	2.6
95th percentile	0.7	1.1	0.5	1.1	0.6	0.5	0.7	0.6	1.6
90th percentile	0.5	0.8	0.4	0.8	0.4	0.4	0.5	0.4	1.2
70th percentile	0.2	0.4	0.2	0.4	0.1	0.2	0.1	0.2	0.6
Average	0.2	0.3	0.1	0.3	0.1	0.1	0.1	0.1	0.5
No of Exceedances of 50 µg/m³	NA	NA	NA	NA	NA	NA	NA	NA	NA
No of exceedances of 70 µg/m³	NA	NA	NA	NA	NA	NA	NA	NA	NA

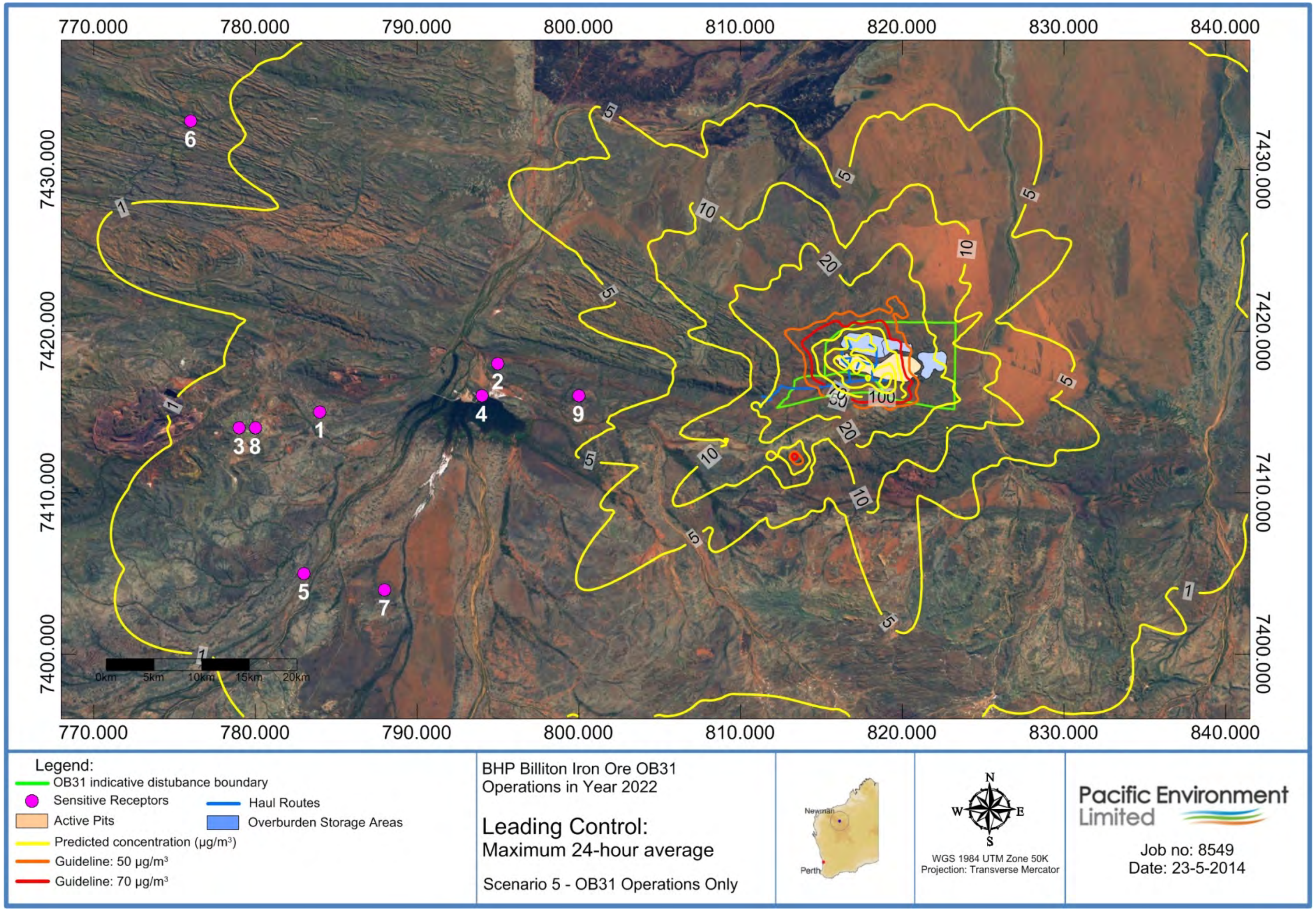

Figure 3.3: Predicted Maximum Daily PM_{10} Concentrations – Scenario 5 – OB31 Operations Standalone with Leading Dust Control

3.2 OB31 Operations Cumulative with Existing Operations (Excluding OB18)

The modelled results for Scenario 5 (15 Mtpa crushed and transported via overland conveyor from OB31 to OB18 and 15 Mtpa crushed and transported via overland conveyor from OB31 to Jimblebar) as cumulative (including background and surrounding existing operations excluding OB18) are presented as follows:

- OB31 cumulative results with existing operations excluding OB18 for Scenario 5 with no dust controls are presented in Table 3.4 and Figure 3.4.
- OB31 cumulative results with existing operations excluding OB18 for Scenario 5 with standard dust controls are presented in Table 3.5 and Figure 3.5.
- OB31 cumulative results with existing operations excluding OB18 for Scenario 5 with leading dust controls are presented in Table 3.6 and Figure 3.6.

The PM_{10} concentration results for the receptors are compared to the assessment criteria (based on NEPM 24 hour 50 µg/m³ and Taskforce 24 hour 70 µg/m³). The results include maximum and various percentiles of predicted 24-hour ground level concentrations.

Key aspects of the results include:

- Compared with the existing operations (as presented in Section 8.1 in the main air quality assessment report there is an increase in the maximum predicted PM_{10} concentration at Receptor 9 from 41 to 44 µg/m³ (for no dust controls).
- Compared with the existing operations there is a decrease in impacts at Receptor 9 for standard and leading dust controls at OB31. The OB31 operations will be located further from Receptor 9 than the OB18 operations.
- The assessment criteria are predicted to be met at Receptor 9.

Table 3.4: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 5 - Cumulative Existing Operations Excluding OB18 with No Dust Control

Receptor	3	4	6	6	7	8	9
Maximum	**80**	43	35	30	37	**65**	44
Maximum (as % of 50 µg/m³)	160%	87%	70%	60%	75%	129%	87%
Maximum (as % of 70 µg/m³)	115%	62%	50%	43%	53%	92%	62%
99th percentile	**71**	37	30	26	31	**56**	38
95th percentile	**54**	30	28	24	27	46	31
90th percentile	44	28	25	23	25	41	29
70th percentile	31	24	21	21	21	30	24
Average	28	23	21	20	20	27	23
No of Exceedances of 50 µg/m³	24	0	0	0	0	12	0
No of exceedances of 70 µg/m³	6	0	0	0	0	0	0
Background concentration included	18	18	18	18	18	18	18

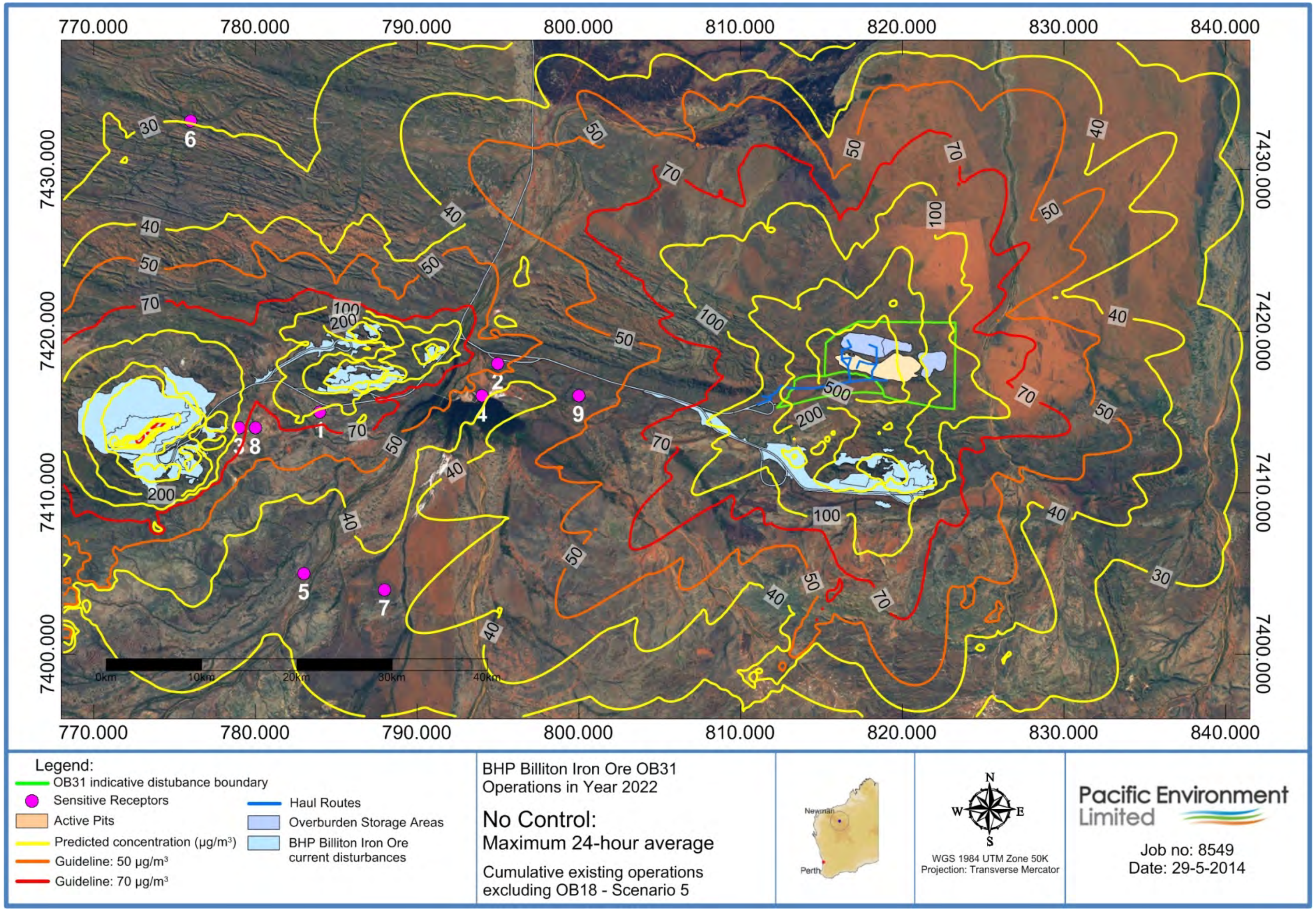

Figure 3.4: Predicted Maximum Daily PM_{10} Concentrations – Scenario 5 – Cumulative Existing Operations Excluding OB18 with No Dust Control

Table 3.5: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 5 - Cumulative Existing Operations Excluding OB18 with Standard Dust Control

Receptor	3	4	6	6	7	8	9
Maximum	**80**	43	31	30	35	**64**	36
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	71%	128%	72%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	51%	91%	51%
99th percentile	**71**	37	30	26	29	**56**	32
95th percentile	**54**	29	27	24	26	46	28
90th percentile	44	26	24	22	24	41	26
70th percentile	31	23	21	21	20	29	23
Average	28	22	20	20	20	26	22
No of Exceedances of 50 µg/m³	24	0	0	0	0	12	0
No of exceedances of 70 µg/m³	6	0	0	0	0	0	0
Background concentration included	18	18	18	18	18	18	18

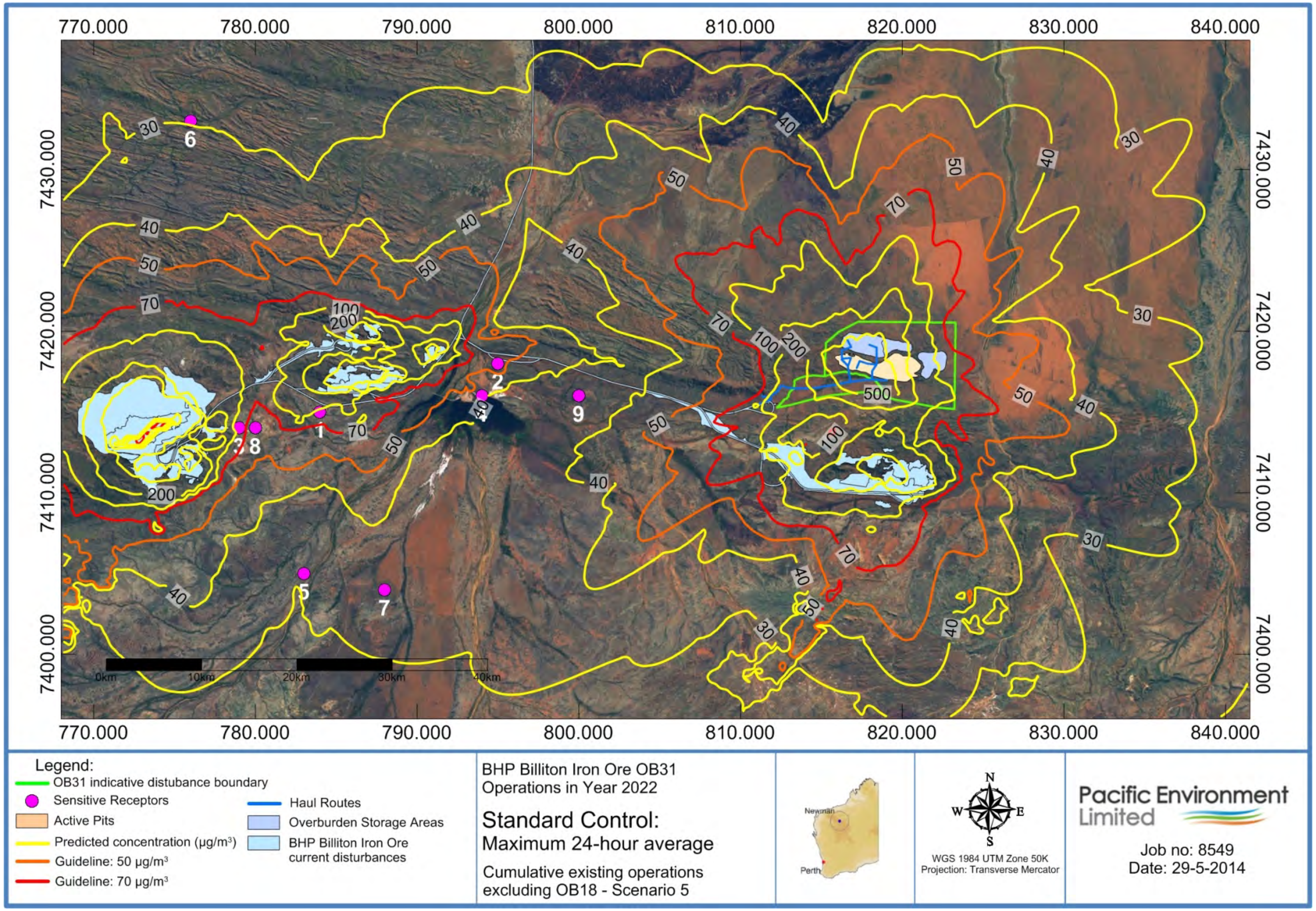

Figure 3.5: Predicted Maximum Daily PM_{10} Concentrations – Scenario 5 – Cumulative Existing Operations Excluding OB18 with Standard Dust Control

Table 3.6: Predicted 24-hour PM_{10} Concentrations (µg/m³) at Receptors – Scenario 5 - Cumulative Existing Operations Excluding OB18 with Leading Dust Control

Receptor	3	4	6	6	7	8	9
Maximum	**80**	43	31	30	33	**63**	33
Maximum (as % of 50 µg/m³)	160%	87%	62%	59%	67%	126%	66%
Maximum (as % of 70 µg/m³)	115%	62%	45%	42%	48%	90%	47%
99th percentile	**71**	35	30	25	29	**56**	29
95th percentile	**54**	28	26	23	25	45	24
90th percentile	44	24	23	22	22	40	23
70th percentile	29	21	20	20	20	29	21
Average	28	21	20	20	20	26	21
No of Exceedances of 50 µg/m³	24	0	0	0	0	12	0
No of exceedances of 70 µg/m³	6	0	0	0	0	0	0
Background concentration included	18	18	18	18	18	18	18

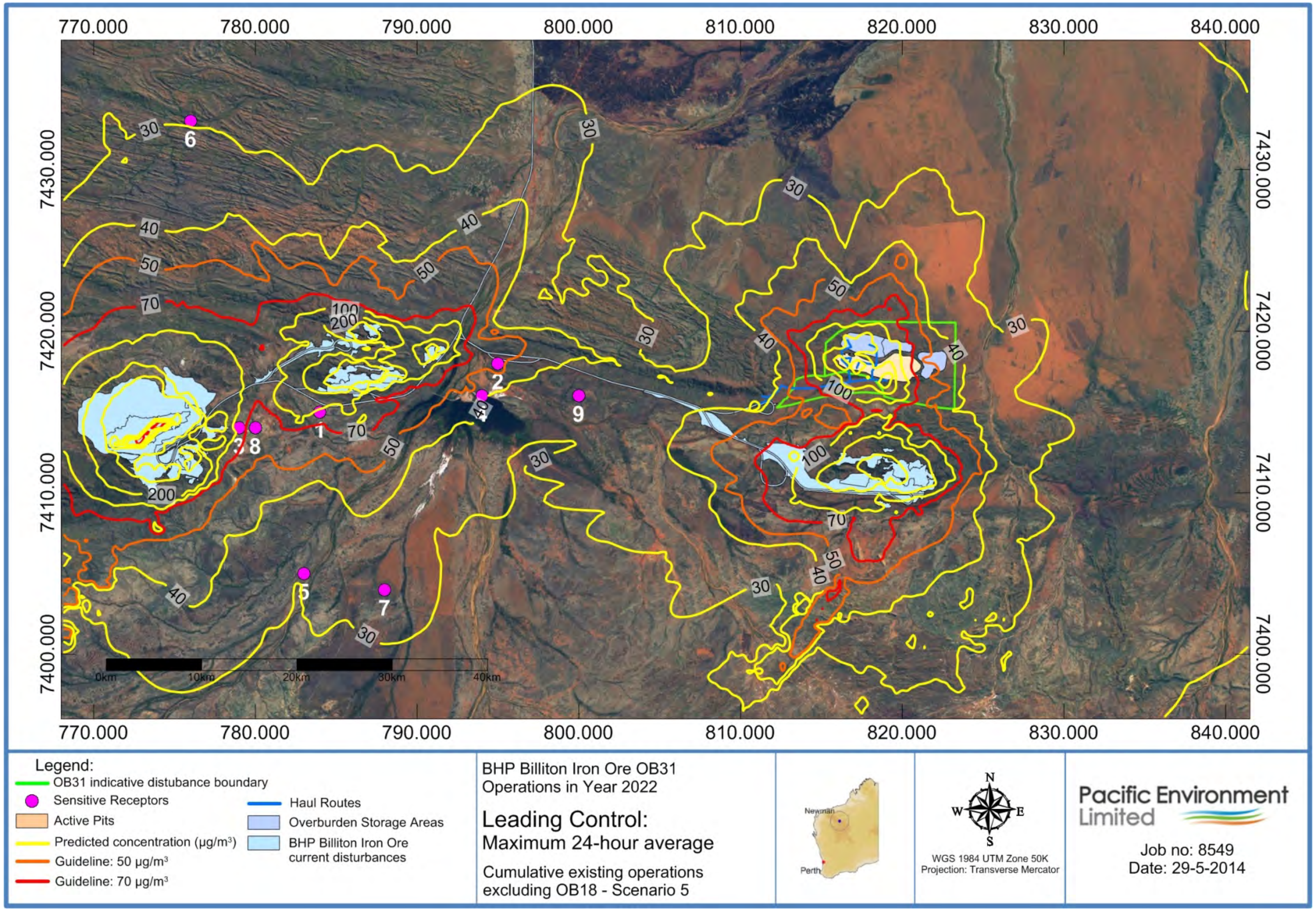

Figure 3.6: Predicted Maximum Daily PM_{10} Concentrations – Scenario 5 – Cumulative Existing Operations Excluding OB18 with Leading Dust Control

4 RESULTS SUMMARY

The assessment has been based on the early designs of the mine, and therefore the results and recommendations must be interpreted in the context that design, layout and management strategies will be subject to refinement and change.

The cumulative results based on the modelled impacts from the existing operations excluding the OB18 operations (which OB31 will replace) and the background concentration as established for the Background 2 monitoring location showed that the assessment criteria for the nearest receptor, Receptor 9 – the Eastern Pilbara Accommodation Village, complies for all dust control levels for Scenario 5. We note that these results are based on the current level of operations in the area.

The results comparing the existing operations (as presented in Section 8.1 in the full draft report) to the predicted impacts at the Newman and Eastern Pilbara Accommodation Village receptor locations for Scenario 5 (as presented in Section 3) are presented in Table 4.1. The results summary shows that for:

- Newman there is little or no additional impact predicted as a result of the OB31 operations replacing the OB18 operations.
- The Eastern Pilbara Accommodation Village, not considering the no dust control option, overall there is a small improvement in the level of PM_{10} dust impacts compared to the existing operations predicted as a result of the OB31 Scenario 5 operations replacing the OB18 operations.

Table 4.1: Summary Percentage Change Compare to Existing Operations at Receptors for Scenario 5

Receptor	8 (Newman)			9 (Eastern Pilbara Accommodation Village)		
Dust Control Option	NC	SC	LC	NC	SC	LC
Maximum	+3%	+2%	0%	+7%	-12%	-20%
99th percentile	0%	0%	0%	+12%	-6%	-15%
95th percentile	0%	0%	-2%	0%	-10%	-23%
90th percentile	0%	0%	-2%	+4%	-7%	-18%
70th percentile	+3%	0%	0%	0%	-4%	-13%
Average	+4%	0%	0%	0%	-4%	-9%