Gemini Project: Air Quality and Greenhouse Gas Assessment

Prepared for:

Magnetic South Pty Ltd

October 2019

Final

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Document Control

Deliverable #:	D16063-3
Title:	Gemini Project: Air Quality and Greenhouse Gas Assessment
Version:	1.0 (Final)
Client:	Magnetic South Pty Ltd
Document reference:	D16063-3_AQ_Gemini_V1.0.docx
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Approved by:	NJShaw Natalie Shaw 02/10/2019

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Contents

Tables

Figures

Contour Plates

Glossary

Term	Definition
%	percentage
µg/m^3	micrograms per cubic metre
m^3	cubic metre
g/s	gram per second
ha	hectare
kg/year	Kilogram per year
km	kilometre
km/h	kilometre per hour
L/m^2/hour	litres per metre square per hour
m	metre
m/s	metre per second
µm	micrometre (micron)
mg/m^2/day	milligram per square metre per day
Mtpa	million tonnes per annum
t	tonne (metric)
tCO_2-e	tonnes of carbon dioxide equivalents
VKT	vehicle kilometre travelled
Nomenclature	**Definition**
PM_{10}	particulate matter with an equivalent aerodynamic diameter of 10 µm or less
$PM_{2.5}$	particulate matter with an equivalent aerodynamic diameter of 2.5 µm or less
TSP	total suspended particles
Abbreviations	**Definition**
Air EPP	*Environmental Protection (Air) Policy 2019*
CHPP	Coal Handling and Processing Plant
DES	Department of Environment and Science
E	East
EA	Environmental Authority
EF	Emission Factor
EHP	Department of Environment and Heritage Protection
EP Act	*Environmental Protection Act 1994*
GHG	Greenhouse Gas
MIA	Mine Infrastructure Area
ML	Mining Lease
MLA	Mining Lease Application
N	North
NGER Act	*National Greenhouse and Energy Reporting Act 2007*
NPI	National Pollutant Inventory
OB	Overburden
Project	Gemini Project
ROM	Run of Mine
SE	Southeast
SSE	South-southeast
SSW	South-southwest
TLO	Train loadout facility
US EPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

Katestone Environmental Pty Ltd (Katestone) was commissioned by Magnetic South Pty Ltd on behalf of Magnetic South Pty Ltd to conduct an air quality and greenhouse gas assessment of the proposed Gemini Project (the Project).

The Project involves the development of an open cut coal mine located approximately 3 km west of the township of Dingo and 35 kilometres east of Blackwater in Central Queensland.

This air quality assessment has investigated the potential for the Project to affect air quality in the region. Three operational scenarios have been considered that represent the worst-case potential for dust emissions over the life of the Project, given the proposed mining schedule and proximity of sensitive receptors. The assessment has used site-specific meteorological data and industry standard dispersion modelling techniques to predict ground-level concentrations of particulate matter (TSP, PM_{10} and $PM_{2.5}$) and dust deposition rates due to the Project.

The air quality assessment has considered the potential impacts of the Project in isolation and with the inclusion of representative background levels of dust. Predicted ground-level concentrations of dust have been presented across a 20 x 20 kilometre domain and at identified sensitive receptors. Predictions have been compared with the relevant air quality objectives and guidelines.

The findings of the cumulative impact assessment are as follows:

- Predicted annual average concentrations of TSP ***comply*** with the relevant air quality objective at all sensitive receptors using standard mitigation measures
- Predicted maximum 24-hour and annual average concentrations of PM_{10} ***comply*** with the relevant air quality objective at all sensitive receptors using standard mitigation measures and additional mitigation when necessary
- Predicted 24-hour and annual average concentrations of $PM_{2.5}$ ***comply*** with the relevant air quality objectives at all sensitive receptors using standard mitigation measures
- Predicted monthly dust deposition rates ***comply*** with the relevant air quality guideline at all sensitive receptors using standard mitigation measures.

The greenhouse gas assessment of the Project found the following:

- Maximum annual greenhouse gas emissions associated with Scope 1 and 2 from the Project are estimated to be 205 kt CO2-e (Year 16)
- Greenhouse gas emissions from the Project are predominantly due to diesel use (67.9%), electricity generation (indirect emissions) (10.4%) and fugitive methane releases (20.4%)
- Compared to national and state greenhouse gas inventory levels, the maximum annual GHG emissions from the Project would account for approximately 0.04% and 0.13%, respectively.

It is recommended that Magnetic South manages potential particulate matter impacts of the Project at sensitive receptors by:

- Developing and implementing an ambient air quality monitoring program
- Developing and implementing an Air Quality Management Plan
- As appropriate, consult with surrounding landholders in relation to appropriate mitigation measures or property purchases.

It is also recommended the Magnetic South monitor, manage and assess Project related greenhouse gas emissions.

1. INTRODUCTION

Magnetic South Pty Ltd (Magnetic South) is the project proponent and the applicant for the Mining Lease (ML) and Environmental Authority (EA) to develop the Gemini Project, a greenfield open cut mine to produce Pulverised Coal Injection (PCI) coal and Coking Coal products for export for steel production. The Project term is anticipated to be 25 years from grant of the ML with this term including initial construction, mine operation and rehabilitation activities.

Katestone Environmental Pty Ltd (Katestone) was commissioned by Magnetic South to conduct the air quality and greenhouse assessments for the Project.

The scope of works for the air quality and greenhouse assessment includes:

Air quality

- A description of the Project with a focus on elements pertaining to impacts to air quality
- A description of regulatory requirements relevant to the Project, including air quality objectives and indicators in the *Environmental Protection (Air) Policy 2019*
- A description of the environmental values in and surrounding the Project areas including sensitive receptors, site topography and built environment, background levels of air pollutants, and an assessment of meteorology
- A description of onsite sources of air pollutants and production of an air pollutant emission inventory for three worst-case scenarios of the mine
- A dispersion modelling assessment to predict ground-level concentrations of air pollutants associated with each scenario for the mine
- Analysis of incremental and cumulative concentrations of air pollutants associated with the mine against the relevant air quality criteria and objectives for dust deposition and suspended particulates
- A discussion of proposed management and mitigation measures for minimising air quality impacts.

Greenhouse gas

- Determine obligations under the Commonwealth *National Greenhouse and Energy Reporting Act 2007* (NGER Act)
- Provide an inventory of projected annual emissions of greenhouse gases (GHG) in terms of tonnes of carbon dioxide equivalents (tCO_2-e)
- Assess the potential impacts of the Project on the state and national greenhouse gas inventories and propose greenhouse gas abatement measures.

This report presents the findings of an air quality and greenhouse gas impact assessment conducted for the Project.

2. PROJECT DESCRIPTION

The Gemini Project is located in the Queensland Central Highlands, approximately 3 kilometres west of the township of Dingo and 15 kilometres east of the town of Bluff (refer Figure 1).

The main activities associated with the Project include:

- Exploration activities continuing in order to support mine planning
- Development of a Mine Infrastructure Area (MIA) including mine offices, bathhouse, crib rooms, warehouse/stores, workshop, fuel storage, refuelling facilities, wash bay, laydown area, sewage, effluent and liquid waste storage, and heli-pad
- Construction and operation of a Coal Handling Preparation Plant (CHPP) and coal handling facilities adjacent to the MIA (including Run-of-Mine (ROM) coal and product stockpiles, and rejects bin/overflow [coarse and fine rejects])
- Construction and operation of a surface conveyor from the product stockpiles to a Train Load Out (TLO) facility and rail loop connecting to the Blackwater-Gladstone Branch Rail to transport product coal to coal terminals at Gladstone for export
- Construction of access roads from the Capricorn Highway to the MIA, and from the accommodation facility to the TLO facility
- Installation of a raw water supply pipeline to connect to the Blackwater Pipeline network
- Construction of a 66 kV transmission line and switching/substation to connect to the existing regional network
- Other associated minor infrastructure, plant, equipment and activities
- Development of mine areas (open cut pits) and out-of-pit waste rock emplacements
- Drilling and blasting of competent waste material
- Mine operations using conventional surface mining equipment (excavators, front end loaders, rear dump trucks, dozers)
- Mining up to 1.9 Mtpa ROM Coal – average 1.8 Mtpa for a construction/production period of approximately 20 years
- Progressive placement of waste rock in:
  - Emplacements, adjacent to and near the open cut voids
  - Mine voids, behind the advancing open cut mining operations
- Progressive rehabilitation of waste rock emplacement areas and mined voids
- Progressive establishment of soil stockpiles, laydown area and borrow pits (for road base and civil works). Material will be sourced from local quarries where required
- Disposal of CHPP rejects (coarse and fine rejects) in out of pit spoil dumps, and in-pit behind the mining void
- Progressive development of internal roads and haul roads including a causeway over Charlevue Creek to enable coal haulage and pit access
- Development of water storage dams and sediment dams, and the installation of pumps, pipelines, and other water management equipment and structures including temporary levees, diversions and drains.

The proposed mine layout is shown in Figure 2.

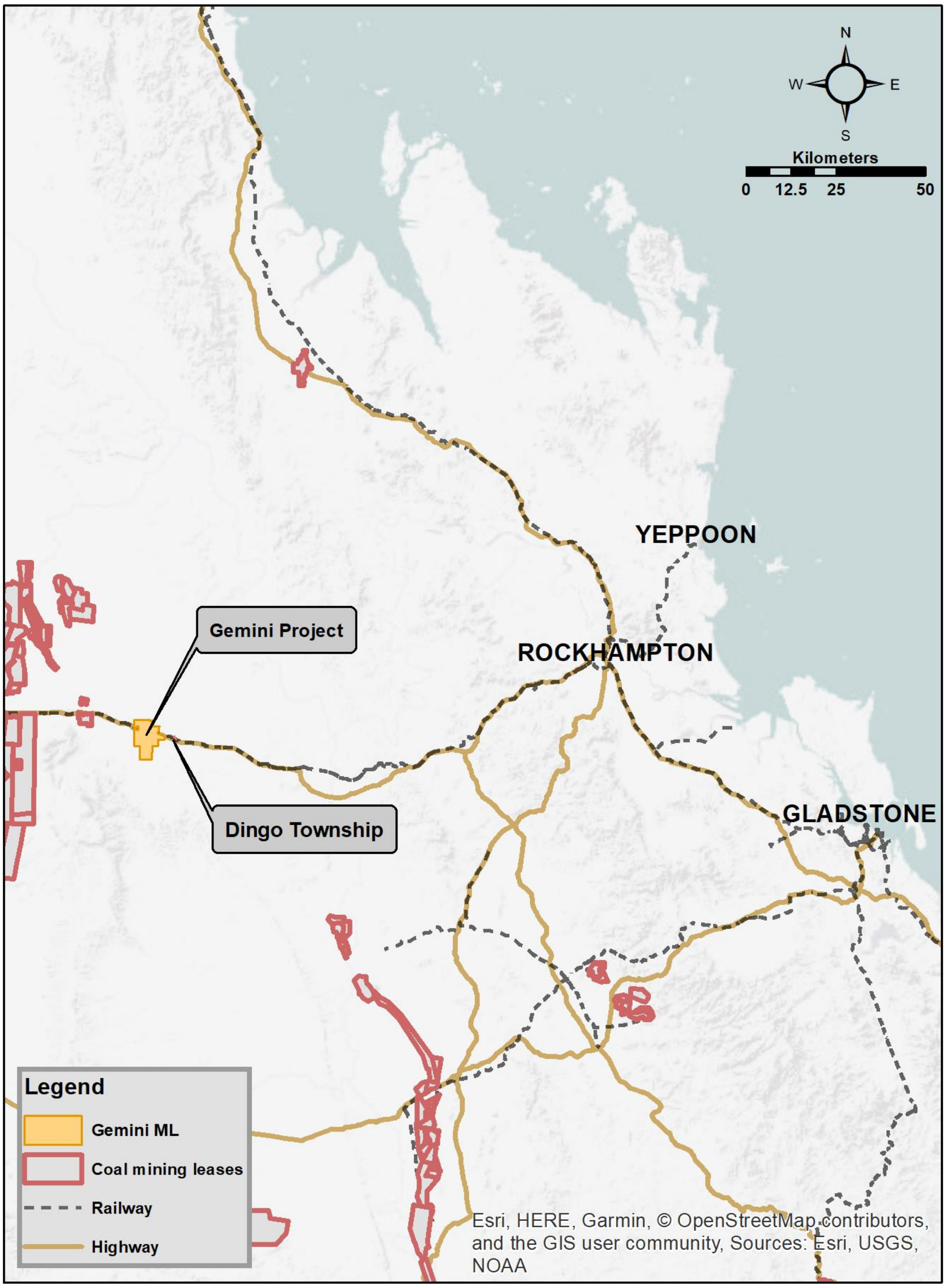

Figure 1 Project Location

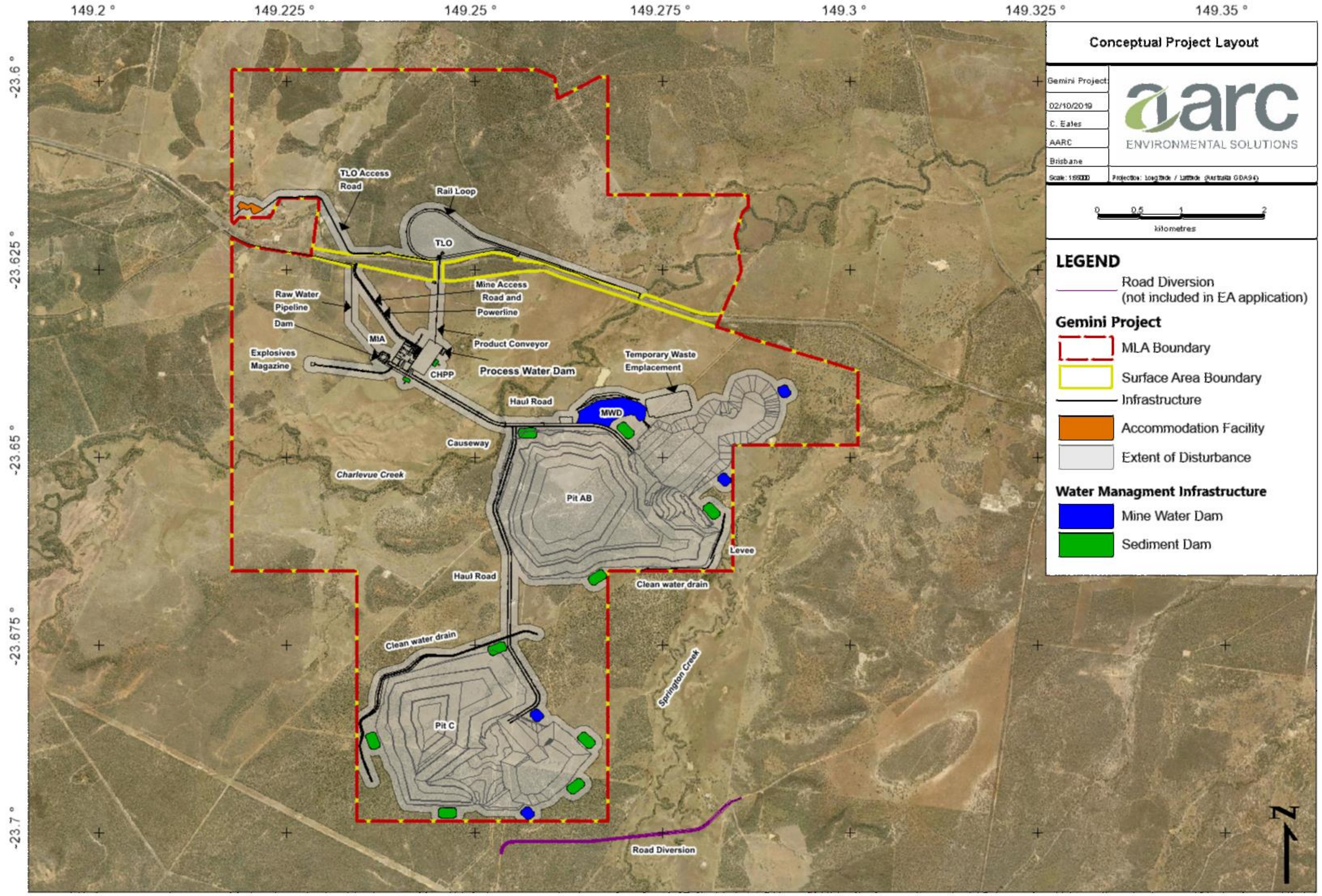

Figure 2 Proposed Project Layout

3. AIR QUALITY ASSESSMENT

3.1 Regulatory framework for air quality in Queensland

The *Environmental Protection Act 1994* (EP Act) provides for the management of the air environment in Queensland. The EP Act gives the Department of Environment and Science (DES) the power to create Environmental Protection Policies that identify, and aim to protect, environmental values of the atmosphere that are conducive to the health and well-being of humans and biological integrity. *The Environmental Protection (Air) Policy* (Air EPP) was made under the EP Act and gazetted in 1997; the Air EPP was revised and reissued in 2019.

The objective of the Air EPP is:

> *...to identify the environmental values of the air environment to be enhanced or protected and to achieve the objective of the Environmental Protection Act 1994, i.e. ecologically sustainable development.*

The environmental values to be enhanced or protected under the Air EPP are the qualities of the environment that are conducive to:

- protecting health and biodiversity of ecosystems
- human health and wellbeing
- protecting the aesthetics of the environment, including the appearance of building structures and other property
- protecting agricultural use of the environment.

The administering authority must consider the requirements of the Air EPP when it decides an application for an environmental authority, amendment of a licence or approval of a draft environmental management plan. Schedule 1 of the Air EPP specifies air quality indicators and objectives for approximately 93 contaminants that may be present in the air environment.

The Air EPP air quality objectives relevant to the key air pollutants that may be generated from the Project are presented in Table 1.

Also relevant is the DES's *Application requirements for activities with impacts to air*, which outlines the information to be provided to DES as part of the application process for environmentally relevant activities and how the information is used. This outlines how the proposed activity will be assessed by comparison with the requirements stipulated in the EP Act.

In particular, this requires an application to include, if applicable:

- Description of the site and surrounding areas, including topography, prevailing winds and ambient air quality (Section 3.3 and Appendix A1)
- Identification of any nearby sensitive places must be identified and assessed appropriately (Section 3.3.2)
- Identification and evaluation of possible impacts on air quality (Section 3.5)
- Proposed management (Section 3.4).

This air quality assessment has been conducted in accordance with the application requirements.

Table 1 Relevant ambient air quality objectives (Air EPP)

Pollutant	Environmental Value	Averaging Period	Air Quality Objective	Number exceedances allowed per year
TSP	Health and wellbeing	1 year	90 µg/m³	None
PM_{10} [a]		24 hours	50 µg/m³	None
		1 year	25 µg/m³	None
$PM_{2.5}$ [b]		24 hours	25 µg/m³	None
		1 year	8 µg/m³	None
Dust deposition [c,d]	Amenity	1 month	120 mg/m²/day	None

Table note:

[a] PM_{10} are particles that have aerodynamic diameters that are less than 10 µm.

[b] $PM_{2.5}$ are particles that have aerodynamic diameters that are less than 2.5 µm.

[c] Applies to total insoluble solids.

[d] Value provided for dust deposition is a DES recommended design objective rather than Air EPP objective.

3.2 Methodology

The following sections describe the modelling methodology that was adopted for the air quality assessment. The methodology uses standard industry dispersion models suitable for use in Australia and regulatory approved assessment techniques to predict ground-level concentrations of air pollutants in the areas surrounding the Project.

3.2.1 Surrounding environment

The location of the Project and surrounding environment has been described in terms of land use, terrain features and sensitive receptor locations. Details are provided in Section 3.3.

3.2.2 Site-specific meteorology

Site-specific meteorological data was generated by coupling the prognostic model TAPM (version 4.0.5) (The Air Pollution Model) with the diagnostic meteorological model CALMET (version 6.5.0). The coupled TAPM/CALMET modelling system was developed to enable high resolution modelling capabilities for regulatory and environmental assessments. The modelling system incorporates synoptic, mesoscale and local atmospheric conditions, detailed topographic and land use categorisation schemes to simulate synoptic and regional scale meteorology for input into pollutant dispersion models such as CALPUFF.

The assessment was conducted using the most recent versions of TAPM and CALMET available at the time of undertaking the study.

Technical details of the TAPM and CALMET model configurations are provided in Appendix A.

3.2.3 Assessment scenarios

Based on a review of the proposed mining schedule, annual production schedule and the relative location of the closest sensitive receptors, Year 2, Year 8, and Year 15 of the Project were identified as being likely to generate the worst-case potential for dust impacts over the life of the Project.

3.2.4 Dust emission rates

To assess potential air quality impacts due to the Project, potential dust emissions from individual mining activities for the modelling scenario were accounted for and have been explicitly modelled. Specific activity information used to calculate dust emission rates associated with individual mining activities were provided or confirmed by Magnetic South.

Dust emission rates were estimated using the base equation:

$$ER = A \times EF \times (1 - CF)$$

where:

ER	emission rate
A	activity / operations data
EF	emission factor
CF	reduction in emissions due to the implementation of control measures.

Emissions of TSP, PM_{10} and $PM_{2.5}$ from mining activities were estimated using recognised and accepted methods of dust emissions estimation. These include approximation of emission rates from NPI emissions estimation technique handbooks and the United States Environmental Protection Agency (US EPA) AP42 emission handbooks (US EPA, 1998; US EPA, 2006; NPI, 2012).

The emissions estimation techniques applied in this assessment are based on standard methods that are applied throughout Australia and in the United States. These methods are consistent with those adopted for other air quality assessments conducted for other coal mines in Australia. The size distribution of dust particles was derived from the emission rates estimated for TSP, PM_{10}, and $PM_{2.5}$.

A dust emission inventory for years 2, 8, and 15 is detailed in Section 3.4. The activity data that were used to estimate dust emissions are detailed in Appendix B.

3.2.5 Dispersion modelling

Source characteristics and dust emission rates for each scenario were incorporated into a dispersion modelling study conducted using a standard and regulated model developed by Earth Tech, Inc., namely, the CALPUFF dispersion model (version 7.2.1).

CALPUFF is an advanced non-steady-state air quality modelling system. The meteorological data generated by TAPM/CALMET was used as input for CALPUFF in order to include all weather conditions likely to be experienced in the region during a typical year. This system has been used to predict ground-level particulate concentrations and dust deposition rates at nearby sensitive receptor locations and across a cartesian grid representing the Project region.

Dust emissions have been modelled over a 365-day year, assuming 24-hour mine operation with the exception of haulage of ROM that will occur for 15 hours per day and blasting that will only occur during daylight hours.

Technical details of the CALPUFF model configuration are provided in Appendix A.

3.2.6 Limitations of dispersion modelling

This study relies on the accuracy of a number of datasets including, but not limited to:

- Meteorological information
- Calculation of emission rates from mining activities.

It is important to note that numerical models are based on an approximation of governing equations that represent complex natural processes. These will inherently be associated with some degree of uncertainty. The more complex the physical model, the greater the number of physical processes that must be included. Where uncertainty exists in characterising important properties of the environment or activities associated with the Project, this study has erred on the side of caution and selected conservative inputs.

3.2.7 Cumulative impacts

In order to assess the potential impacts of the Project upon the surrounding environment, representative ambient levels of particulate matter and dust deposition have been added to dispersion modelling predictions for the Project. These levels are derived in Section 3.3.3.

3.2.8 Presentation of results

Modelling results for particulate matter are presented as ground-level concentrations or dust deposition rates at sensitive receptors as well as contours across the modelling domain and are presented in Section 3.5.

3.3 Existing environment

3.3.1 Local terrain and land-use

Figure 3 illustrates the area considered in the air quality impact assessment of the Project. The study area covers approximately 400 km^2 and extends beyond the borders of the proposed Mining Lease Application (MLA) in order to assess the potential impact of the Project on the air quality of the wider community and, in particular, the sensitive receptors in the region as shown in Figure 4 and Table 2.

The terrain and land-use in the surrounding area is primarily flat open and agricultural bush and shrubland. Other features include Taunton National Park to the north of the proposed MLA, established as conservation land for the endangered Bridled Nailtail Wallaby, and Blackdown Tablelands National Park approximately 9 km south-west of the Project ML boundary.

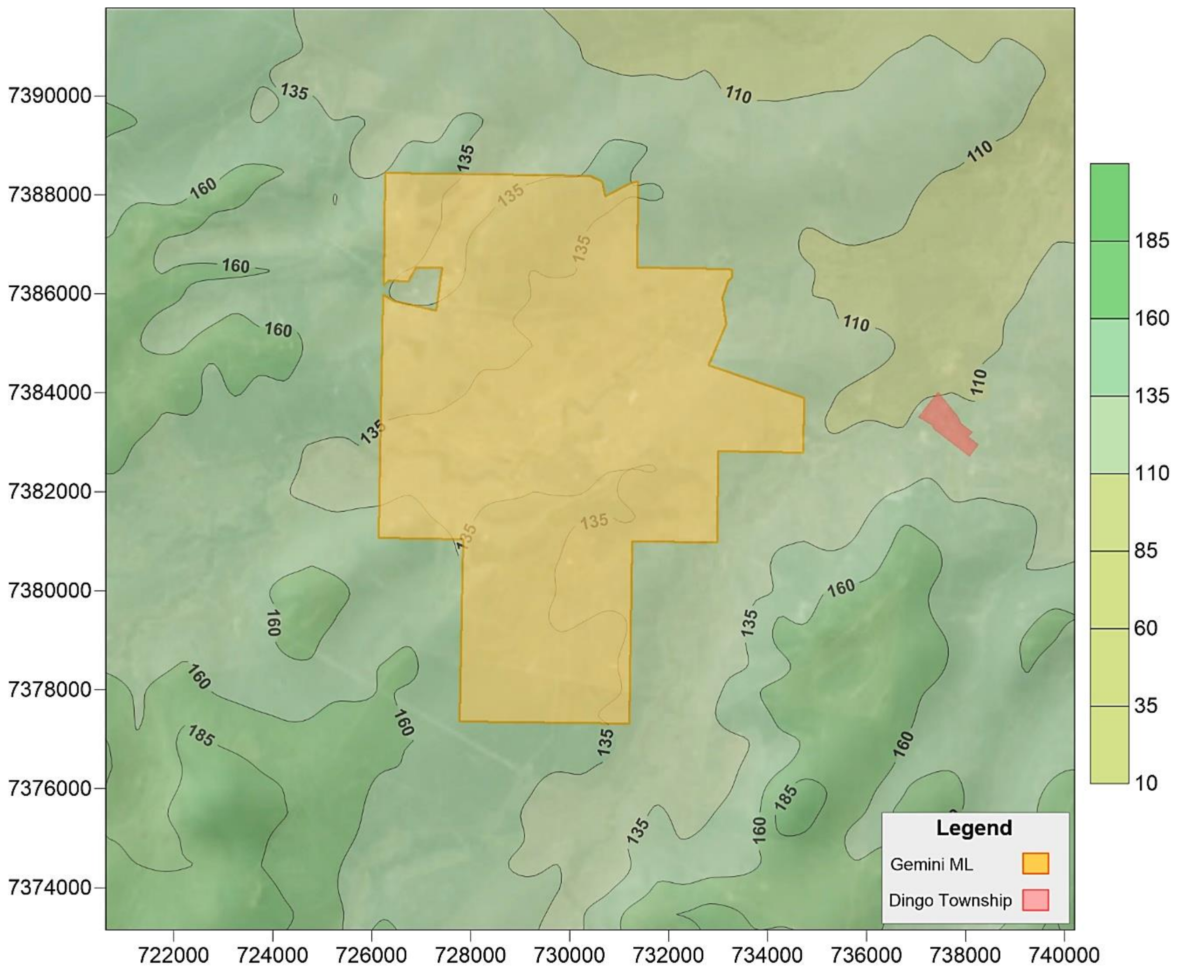

Figure 3 **Study area terrain (contours in metres above sea-level)**

3.3.2 Sensitive receptors

Sensitive receptors considered in the assessment are presented in Table 2 and Figure 4, encompassing residences, businesses, and recreational areas.

Table 2 Sensitive receptors surrounding the Project

Receptor ID	Receptor type	Property name	Easting (m)	Northing (m)	Location relative to ML boundary
SR01	Residential	Unknown	721380	7386940	4.8 km W
SR03	Residential	Unknown	737915	7382328	3.2 km E
SR05	Residential	Charlevue	721937	7382077	4.2 km W
SR07	Residential, facilities (sports oval, tennis court, school) & businesses (Post Office, hotel, shops, sawmills, etc.)	Dingo Township	737777 (town centre)	7383220 (town centre)	2.3 km E (from point closest to the Project)
SR08	Residential	Dunkerinn	722022	7384327	4.2 km W
SR09	Residential	Ellesmere	731988	7385624	Within ML
SR10	Residential	Fairview Park	736181	7382995	1.4 km E
SR13	Residential	Fairview Park	737113	7382802	2.3 km E
SR14	Residential	Glenwood	728569	7374873	2.5 km S
SR15	Residential	Gum Flat	729144	7388750	0.3 km N
SR16	Residential	Lanlea	735273	7388705	3 km NE
SR17	Residential	Myimbarr	722415	7384928	3.9 km W
SR18	Residential	Namoi Hills	729626	7384531	Within ML
SR19	Residential	Namoi Hills	732684	7377515	1.5 km SE
SR20	Residential	Namoi Hills	732671	7377581	1.5 km SE
SR21	Residential	Namoi Hills	732614	7377700	1.4 km SE
SR22	Residential and Accommodation Facility	Redrock Park	726358	7386469	Within ML
SR23	Residential	Rubina	734446	7383534	Within ML
SR24	Residential	Shark Park/Springton Villa	735824	7384500	1.2 km NE
SR26	Residential	The Lazy H and Hopevale	739747	7382306	5 km E
SR27	Residential	The Lazy H and Hopevale	739278	7383145	4.5 km E
SR28	Residential	The Lazy H and Hopevale	739157	7383337	4.4 km E
SR30	Residential	The Lazy H and Hopevale	739319	7383894	4.6 km E
SR31	Residential	Unknown	725109	7385743	1.1 km NW
SR32	Residential	Unknown	725075	7386813	1.2 km NW

At the time of report preparation, Magnetic South is the landowner of Lot 2, HT138, on which sensitive receivers SR19, SR20 and SR21 are located. Discussions between Magnetic South and landowners of properties located within the ML are ongoing.

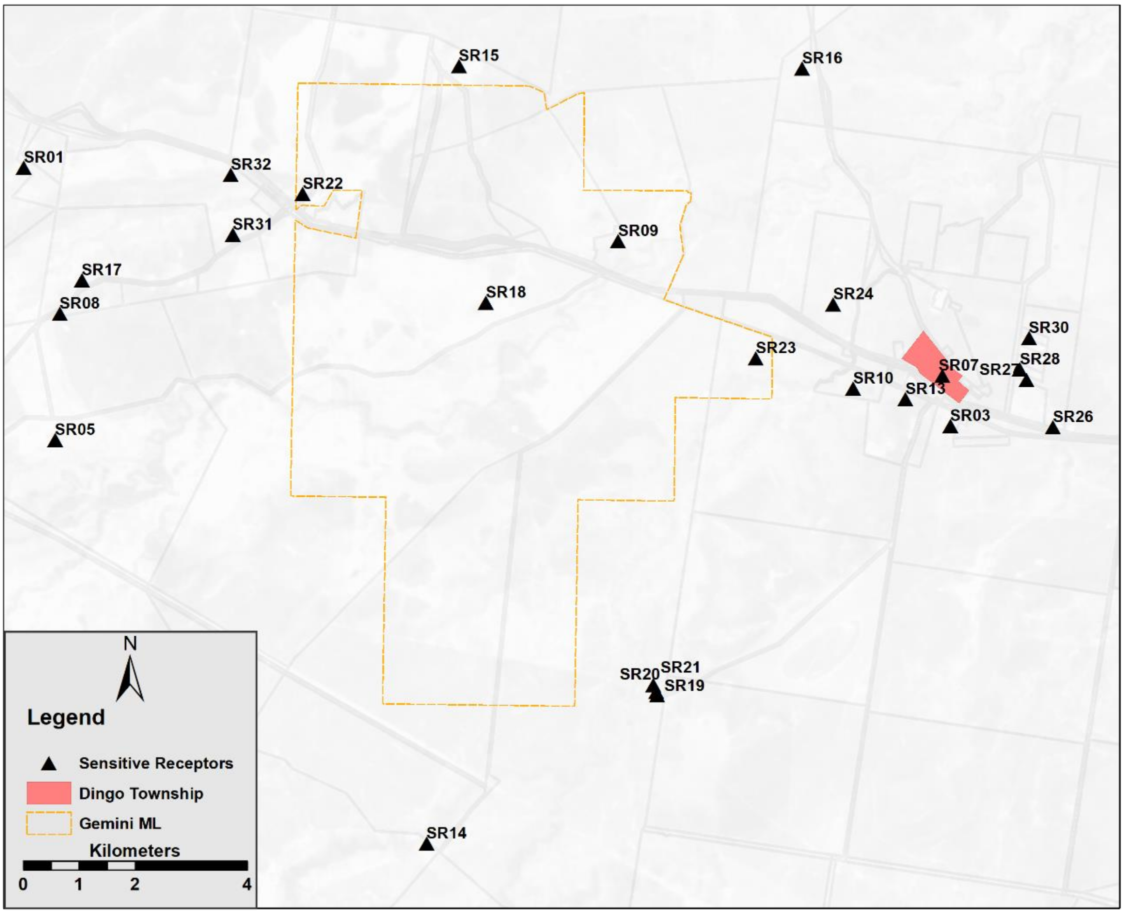

Figure 4 Location of sensitive receptors

3.3.3 Existing air quality

3.3.3.1 Existing sources of emissions

Ambient dust levels across the area will be influenced by natural sources of dust such as wind erosion and fires, as well as dust emissions from existing anthropogenic sources in the area, possibly including local agriculture or horticulture, and existing mines.

The National Pollution Inventory (NPI) is a public database of annual emissions of 93 substances reported by industries across Australia. Within the study domain (approximately 20 km radius) there are no facilities currently reporting to the NPI program. The closest facility currently reporting to the NPI program is more than 40 km away from the Project and is unlikely to contribute existing levels of dust within the study domain. NPI reporting facilities within a 50 km radius of the Project are listed in Table 3, presenting reported emissions of PM_{10} and $PM_{2.5}$ for the 2017 - 2018 reporting period. As indicated, the coal mines are sufficiently far from the Project site to have a minimal impact on the local dust levels near the Project area.

Table 3 **2017 - 2018 Annual NPI dust emissions existing coal mines surrounding the Project**

Facility	Approximate Distance from Project boundary(km)	Dust emissions (kg/year)	
		PM_{10}	$PM_{2.5}$
Blackwater Mine	40 km west	14,000,000	84,000
Jellinbah Mine	35 km north-west	10,000,000	150,000
Curragh Mine	35 km north-west	10,000,000	150,000
Tolmie Creek Quarry	40 km west	25,000	620
Yancoal - Yarrabee	35 km north-west	4,000,000	130,000

3.3.3.2 Existing ambient air quality

3.3.3.2.1 PM_{10} and $PM_{2.5}$

The nearest available monitoring site for PM_{10} and $PM_{2.5}$ is located at Blackwater Township, approximately 35 km west of the Project site. Operated by DES, monitoring commenced in April 2019. The nearest alternative monitoring station for particulates is 200 km north-west of the Project at Moranbah. Therefore, the Blackwater monitoring site is likely more representative of ambient particulate levels local to the Project. Nevertheless, background particulate values based on the Blackwater monitoring site are likely to be representative of the region and reflect the existing mines in the Blackwater region (included in Table 3).

Timeseries of the measured 24-hour average concentrations of PM_{10} and $PM_{2.5}$ are provided in Figure 5 and Figure 6. PM_{10} concentrations at Blackwater exceeded the Air EPP 24-hour PM_{10} objective of 50 µg/m³ on 3 June 2019. DES's Air Quality Bulletin Central Queensland June 2019 (DES, 2019) attributed this to strong southwesterly winds carrying dust from a possible combination of surrounding dry surfaces, ground works, or mining activities.

For the purposes of the cumulative impact assessment, the ambient background concentrations of PM_{10} and $PM_{2.5}$ were taken as the 70th percentile 24-hour average from the Blackwater monitoring site. Use of the 70th percentile value is based on the methodology published by EPA Victoria (EPA Victoria, 2007) and is accepted in Queensland.

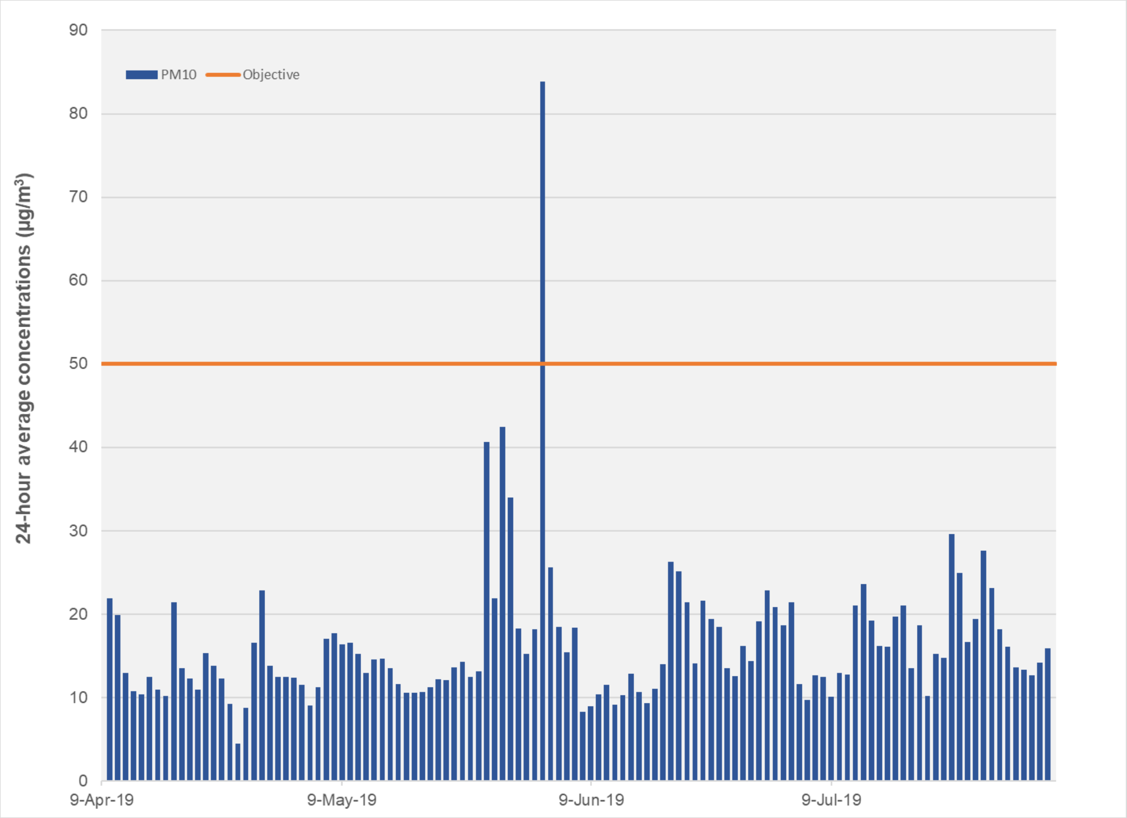

Figure 5 Timeseries of 24-hour average PM_{10} for Blackwater

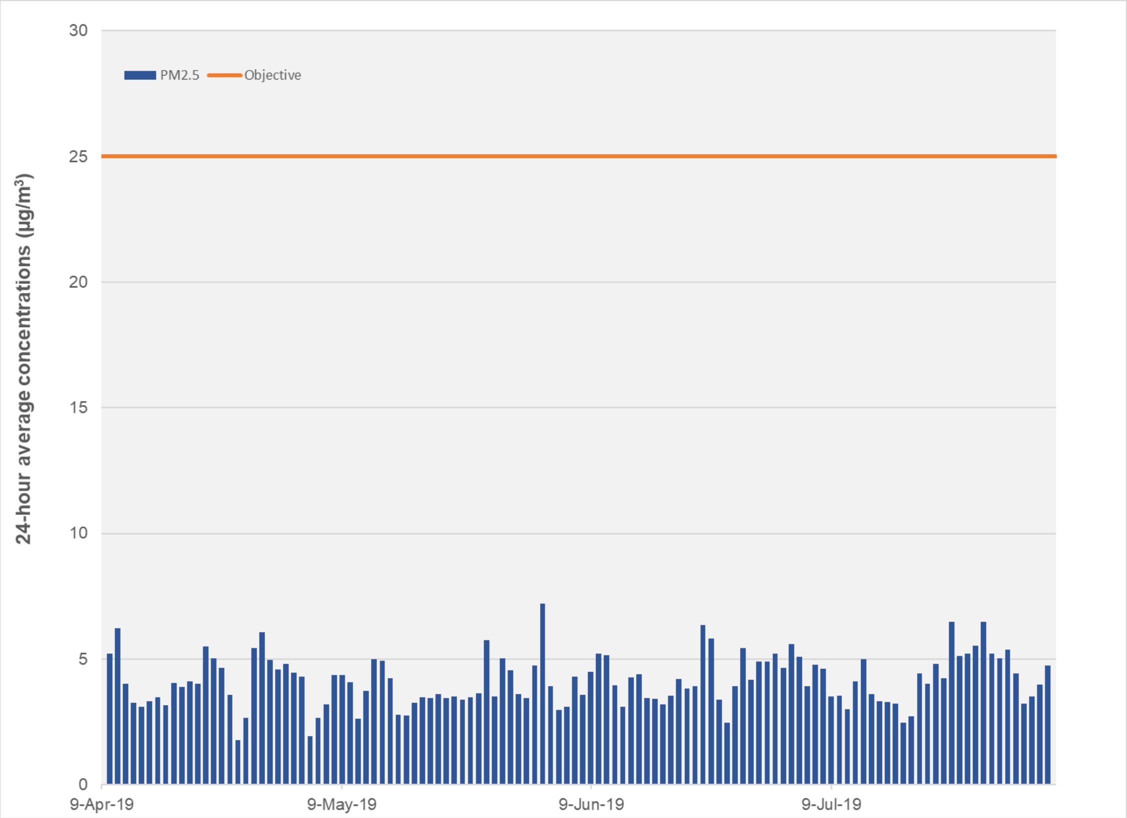

Figure 6 Timeseries of 24-hour average $PM_{2.5}$ for Blackwater

3.3.3.2.2 TSP and dust deposition

DES does not conduct monitoring for TSP and dust deposition at its Blackwater site and publicly available data for the region is limited. Therefore, background levels of TSP have been derived from the measured PM_{10} data at Blackwater. Dust deposition rates have been based on typical dust deposition rates for rural areas.

3.3.3.2.3 Summary of background levels

Representative background levels of TSP, PM_{10}, $PM_{2.5}$ and dust deposition for the region, as derived in the preceding sections, are summarised in Table 4. These values have been used to assess potential cumulative impacts of the Project in the context of the existing environment.

Table 4 Ambient background concentrations used to assess cumulative impacts

Pollutant	Averaging Period	Concentration	Source
TSP	Annual	32.8 µg/m³	Calculated from the average PM_{10} data measured at Blackwater using PM_{10}/TSP ratio of 0.5
PM_{10}	24-hour	18.2 µg/m³	70th percentile of monitoring data at Blackwater
	Annual	16.4 µg/m³	Average of monitoring data at Blackwater
$PM_{2.5}$	24-hour	4.7 µg/m³	70th percentile of monitoring data at Blackwater
	Annual	4.2 µg/m³	Average of monitoring data at Blackwater
Dust deposition	Monthly	30 mg/m²/day	Typical value

3.4 Emissions to the atmosphere

Dust emissions will be generated over the life of the Project as a result of material extraction, handling, haulage and wind erosion of exposed mine areas. Emissions of oxides of nitrogen, sulfur dioxide and carbon monoxide would also occur due to blasting activities and vehicle movements (combustion of fuels) on site. However, these emissions are transient (contained within the haul road corridor and open-cut pits) and low in magnitude, Their impact outside of the Project site likely to be negligible. For these reasons, dust (and associated particulate matter) is the critical air pollutant for this assessment.

Odour is unlikely to be emitted from typical mining activities. Spontaneous combustion is a potential source of odour from mining activities but the potential for this is low and, therefore, odour has not been assessed further in this assessment.

The following sections provide an inventory of dust emissions for the assessment scenarios and a description of dust mitigation measures proposed by Magnetic South.

3.4.1 Overview

Key dust-generating activities associated with the Project include:

- Drilling and blasting
- Material extraction and handling (overburden and ROM coal)
- Bulldozer activity
- Material haulage (overburden and ROM coal)
- Road grading
- Wind erosion of exposed mine areas.

3.4.2 Standard mitigation measures

Dust mitigation and operational controls have been included in the Project design to minimise dust emissions from mining activities, including application of water to haul roads. Standard efficiency factors for these control measures are presented in Table 5.

Table 5 Standard dust control measures and relative reduction in emissions

Activity	Control measure	Reduction
ROM coal haulage	Watering	85%
Overburden haulage	Watering	85%
Drilling	Drill dust suppression sprays	70%
ROM unloading at CHPP	Water sprays	70%
Crushing	Enclosure	70%
Product stockpile	Wet from CHPP	50%
Train loading	Telescopic chute with water spray	85%
Conveyor	Enclosure	70%
Conveyor	Uncovered	0%

3.4.3 Additional mitigation measures

For the Project, there will be ongoing implementation of the standard dust control measures. Application of additional mitigation measures will occur under adverse meteorological conditions that are conducive to dust impacts, when necessary. Additional mitigation measures may include but are not limited to the modification of activity rate or ceasing of certain operations. Specific measures are detailed in section 3.5.

3.4.4 Emissions inventory

A breakdown of the total dust emission rates estimated for years 2, 8, and 15 of the Project is presented in Table 6. The corresponding emission areas are illustrated schematically in Figure 7, Figure 8, and Figure 9. Emissions have been estimated as described in Section 3.2.4 and are presented inclusive of standard mitigation control factors described in Table 5.

Table 6 Emissions inventory for year 2, year 8 and year 15

Activity	Year 2 (kg/year)			Year 8 (kg/year)			Year 15 (kg/year)		
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Active Pit									
Drilling	2,936	1,543	88	2,240	1,177	67	2,055	1,080	62
Blasting	46,090	23,883	1,383	35,211	18,246	1,056	32,263	16,718	968
Bulldozer assist after blasting - coal	79,839	27,072	1,756	63,871	21,657	1,405	159,678	54,144	3,513
Bulldozer assist after blasting - OB	24,267	4,607	2,548	24,267	4,607	2,548	24,267	4,607	2,548
Excavator - ROM removal	146	69	10	193	91	14	184	87	13
Excavator overburden removal	9,281	4,390	665	10,625	5,025	761	10,187	4,818	730
Truck loading /dumping overburden	9,281	4,390	665	10,625	5,025	761	10,187	4,818	730
Bulldozer on overburden spoil	16,178	3,071	1,699	16,178	3,071	1,699	16,178	3,071	1,699
Bulldozer on rehabilitation	24,267	4,607	2,548	24,267	4,607	2,548	8,089	1,536	849
CHPP/TLO									
Processing activities (crushing/screening)	31,050	11,207	2,578	32,731	11,814	2,718	31,211	11,265	2,592
Truck dumping ROM	55	26	4	58	27	4	55	26	4
Load to CHPP	91	43	7	96	46	7	92	43	7
Dozer reclaim from product stockpile to conveyor	205	97	15	205	97	15	210	99	15
Transfer from conveyor to surge bin	45	21	3	45	21	3	45	21	3
Train loading from surge bin	68	32	5	68	32	5	68	32	5
Truck loading reject coal	41	19	3	51	24	4	38	18	3
Conveying	234	110	17	234	110	17	234	110	17
HAULS									
ROM haulage	231,494	65,986	6,599	304,744	86,866	8,687	365,959	104,315	10,432
Overburden haulage	1,310,944	373,679	37,368	1,186,931	338,330	33,833	1,627,043	463,782	46,378
Rejects haulage	105,330	47,954	27,366	128,159	36,531	3,653	191,356	54,545	5,455
GRADING - ROM hauls	87,410	16,772	2,710	128,565	24,669	3,986	124,168	23,825	3,849
GRADING - other hauls	74,722	41,173	6,652	33,567	6,441	1,041	37,964	7,285	1,177

Activity	Year 2 (kg/year)			Year 8 (kg/year)			Year 15 (kg/year)		
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
WIND EROSION									
Exposed mine area	53,908	26,954	4,043	62,677	31,339	4,701	46,560	23,280	3,492
Coal stockpiles	150,331	75,166	11,275	150,331	75,166	11,275	150,331	75,166	11,275
Active rehabilitation areas	89,353	44,677	6,702	91,910	45,955	6,893	75,365	37,682	5,652
Rehabilitated areas	NA	NA	NA	81,779	40,889	6,133	222,157	111,079	16,662
Overburden dump areas	164,270	82,135	12,320	90,871	45,436	6,815	163,211	81,605	12,241
Total	**2,511,837**	**859,684**	**129,027**	**2,480,498**	**807,299**	**100,648**	**3,299,153**	**1,085,058**	**130,368**

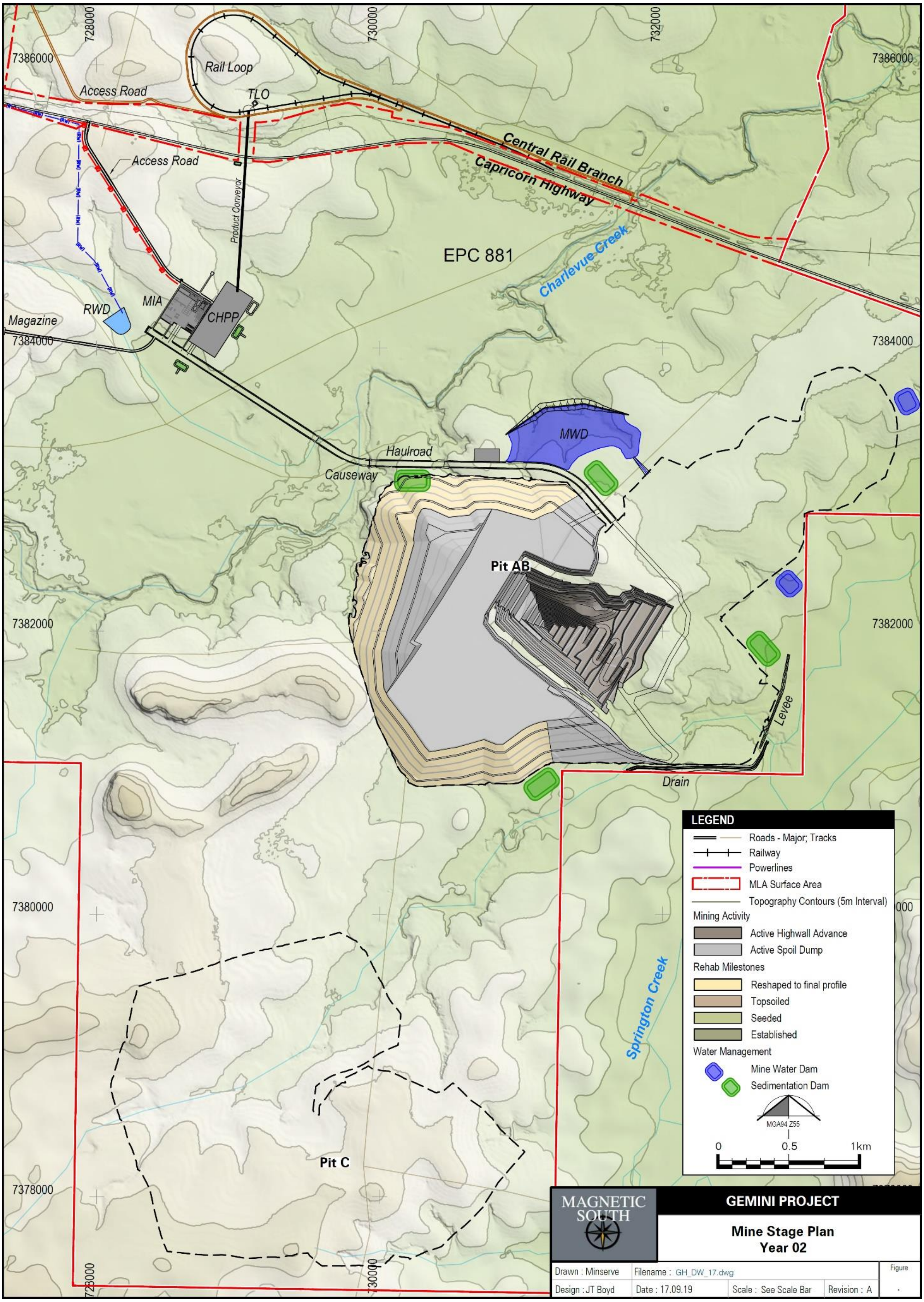

Figure 7 **Year 2 - Dust emission source areas**

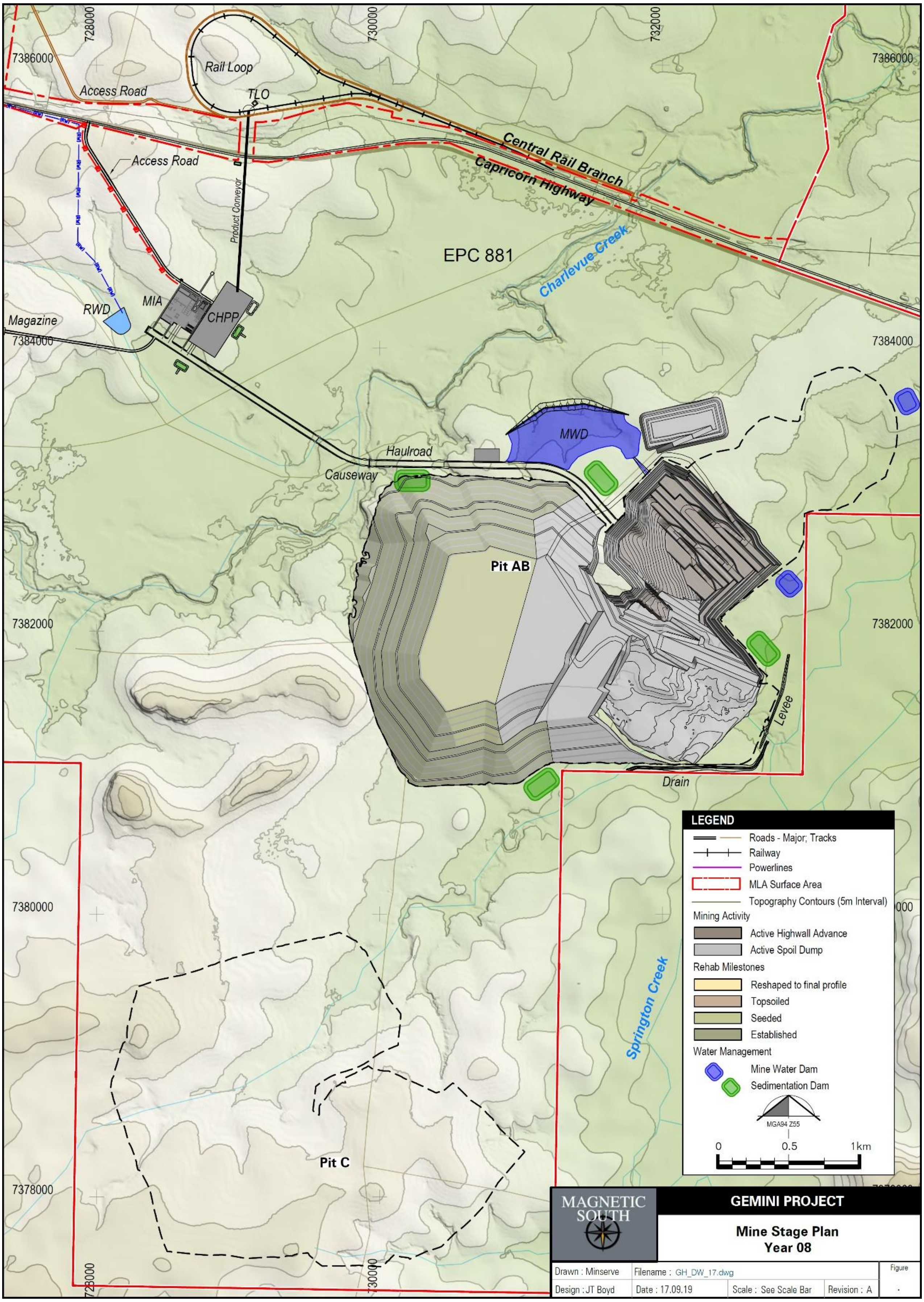

Figure 8 **Year 8 - Dust emission source areas**

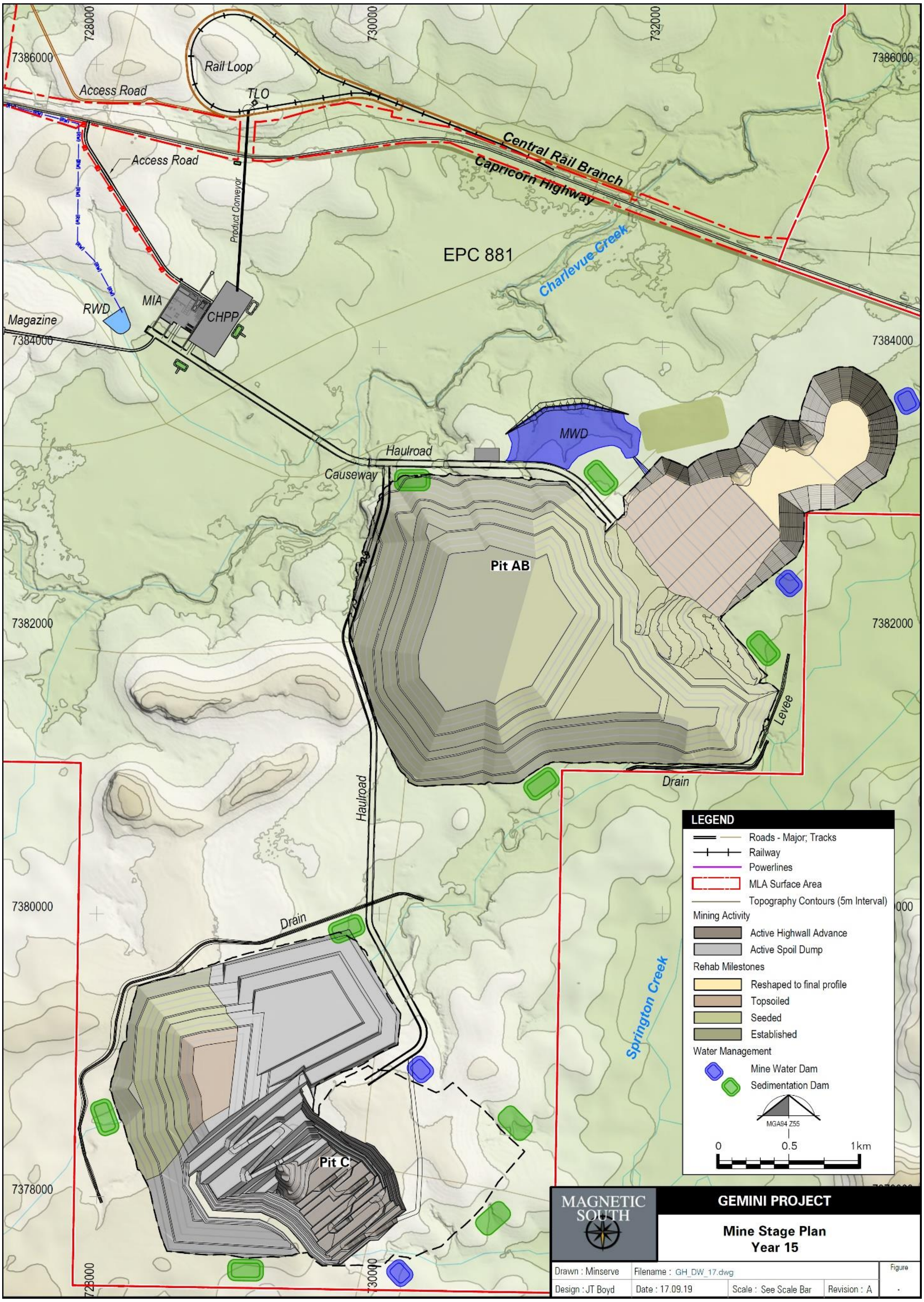

Figure 9 Year 15 - Dust emission source areas

3.5 Air quality impact assessment

This section presents the results of the dispersion modelling assessment of the Project. As outlined in Section 3.2.6, this study has erred on the side of caution and selected conservative inputs and, therefore, the predicted concentrations of dust are conservative overestimates. Results have been presented for mining years 2, 8, and 15 as ground-level concentrations or deposition rates at the sensitive receptors as well as contours across the modelling domain. These results are subject to the standard mitigation measures outlined in Section 3.4.2.

Background dust levels have been added to the incremental model predictions in order to estimate the potential cumulative impacts of the Project with existing sources of dust in the region. Results have been assessed by comparing the cumulative concentrations and dust deposition rates with the air quality objectives described in Section 3.1.

When interpreting the results, it is important to note that the predictions are not contemporaneous. The values presented are the maximum concentration predicted independently at each sensitive receptor or grid point for the entire modelling period and thus constitute a worst-case or near worst-case result. These values do not necessarily occur at the same time or under the same meteorological conditions.

3.5.1 Year 2

Table 7 presents the predicted ground-level concentrations of TSP, PM_{10} and $PM_{2.5}$ as well as dust deposition rates at the sensitive receptors due to the Project in year 2 in isolation and with a background. The corresponding contours for each cumulative scenario are presented in Plate 1 to Plate 6.

The results show that using standard mitigation measures:

- Predicted annual average concentrations of TSP ***comply*** with the relevant air quality objective at all sensitive receptors (Plate 1)
- Predicted 24-hour average concentrations of PM_{10} ***comply*** with the relevant air quality objective at most sensitive receptors with the exception of SR03, SR07 (Dingo Township), SR09, SR13, SR18, SR19, SR20, SR21, SR22, SR23 and SR32 (Plate 2)
- Predicted annual average concentrations of PM_{10} ***comply*** with the relevant air quality objective at all sensitive receptors with the exception of SR18 (within Project ML) (Plate 3)
- Predicted 24-hour and annual average concentrations of $PM_{2.5}$ ***comply*** with the relevant air quality objectives at all sensitive receptors (Plate 4 and Plate 5)
- Predicted monthly dust deposition rates ***comply*** with the relevant air quality guideline at all sensitive receptors using standard mitigation measures (Plate 6).

Table 8 presents the number of days per year when 24-hour average concentrations of PM_{10} are predicted to exceed the Air EPP objective due to the Project operating with standard mitigation. With the exception of SR09 and SR18, predicted 24-hour average concentrations of PM_{10} are only expected to exceed at most one to three days per year.

Using standard and, when necessary, additional mitigation measures predicted 24-hour average and annual average concentrations of PM_{10} ***comply*** with the relevant air quality objective at all sensitive receptors. (Plate 7 and Plate 8). Additional mitigation measures include restricting overburden and ROM haul to between 7am and 6pm on days when 24-hour averaged maximum PM_{10} is predicted to exceed 50 µg/m^3.

Figure 10 and Figure 11 illustrate a timeseries of predicted 24-hour average PM_{10} concentrations at SR09 and SR18 when standard and additional mitigation is applied when necessary. Compliance at SR18 and SR09 would result in compliance at all other sensitive receptors.

Table 7 **Predicted ground-level concentrations of TSP, PM_{10}, $PM_{2.5}$ and dust deposition rates at sensitive receptors during year 2 using standard mitigation measures**

Label	PM_{10} (µg/m³)				$PM_{2.5}$ (µg/m³)				TSP (µg/m³)		Dust deposition rate (mg/m²/day)	
	Maximum 24-hour		Annual		Maximum 24-hour		Annual		Annual		Maximum monthly	
	Project	With bkgd	Project	With bkgd	Project	With bkgd	Project	With bkgd	Project	With bkgd	Project	With bkgd
SR01	12.1	30.3	1.0	17.4	3.4	8.1	0.2	4.4	1.2	34.0	3.0	33.0
SR03	32.6	50.8	0.9	17.3	5.1	9.8	0.1	4.3	1.0	33.8	3.5	33.5
SR05	7.6	25.8	1.0	17.4	2.0	6.7	0.2	4.4	1.3	34.1	2.1	32.1
SR07	51.0	69.2	0.7	17.1	4.8	9.5	0.1	4.3	0.8	33.6	3.3	33.3
SR08	14.1	32.3	1.2	17.6	3.8	8.5	0.3	4.5	1.4	34.2	3.1	33.1
SR09	61.4	79.6	6.9	23.3	7.9	12.6	1.0	5.2	9.7	42.5	17.7	47.7
SR10	25.8	44.0	0.9	17.3	3.9	8.6	0.1	4.3	1.2	34.0	4.3	34.3
SR13	40.8	59.0	0.9	17.3	5.8	10.5	0.1	4.3	1.2	34.0	4.7	34.7
SR14	15.0	33.2	0.7	17.1	3.4	8.1	0.1	4.3	0.9	33.7	2.7	32.7
SR15	23.4	41.6	4.6	21.0	4.2	8.9	0.8	5.0	5.3	38.1	11.5	41.5
SR16	24.8	43.0	1.1	17.5	4.7	9.4	0.2	4.4	1.2	34.0	1.1	31.1
SR17	15.9	34.1	1.4	17.8	4.3	9.0	0.3	4.5	1.6	34.4	3.9	33.9
SR18	70.2	88.4	17.4	33.8	12.4	17.1	2.6	6.8	28.6	61.4	50.9	80.9
SR19	39.4	57.6	2.4	18.8	6.8	11.5	0.4	4.6	3.0	35.8	5.8	35.8
SR20	40.0	58.2	2.4	18.8	6.9	11.6	0.4	4.6	3.1	35.9	6.1	36.1
SR21	40.6	58.8	2.5	18.9	6.7	11.4	0.4	4.6	3.3	36.1	6.5	36.5
SR22	32.2	50.4	3.9	20.3	5.5	10.2	0.8	5.0	4.6	37.4	5.8	35.8
SR23	42.8	61.0	1.8	18.2	7.3	12.0	0.3	4.5	2.5	35.3	6.0	36.0
SR24	26.5	44.7	0.9	17.3	4.0	8.7	0.1	4.3	1.1	33.9	2.3	32.3
SR26	23.0	41.2	0.5	16.9	4.0	8.7	0.1	4.3	0.5	33.3	1.7	31.7
SR27	30.6	48.8	0.5	16.9	4.7	9.4	0.1	4.3	0.6	33.4	2.3	32.3
SR28	29.7	47.9	0.5	16.9	4.7	9.4	0.1	4.3	0.6	33.4	2.2	32.2
SR30	16.4	34.6	0.4	16.8	2.6	7.3	0.1	4.3	0.5	33.3	1.5	31.5
SR31	29.5	47.7	3.1	19.5	6.7	11.4	0.6	4.8	3.5	36.3	5.9	35.9
SR32	38.8	57.0	2.8	19.2	7.4	12.1	0.6	4.8	3.3	36.1	4.4	34.4
Objective	**-**	**50**	**-**	**25**	**-**	**25**	**-**	**8**	**-**	**90**	**-**	**120**

Table 8 Number of days per year predicted to exceed in year 2

ID		Number of days above 50 µg/m³
SR03	Residential	1
SR07	Dingo Township	1
SR09	Residential (within ML)	14
SR13	Residential	1
SR18	Residential (within ML)	54
SR19	Residential	2
SR20	Residential	2
SR21	Residential	2
SR22	Residential and Accommodation Facility (within ML)	1
SR23	Residential (within ML)	3
SR32	Residential	1

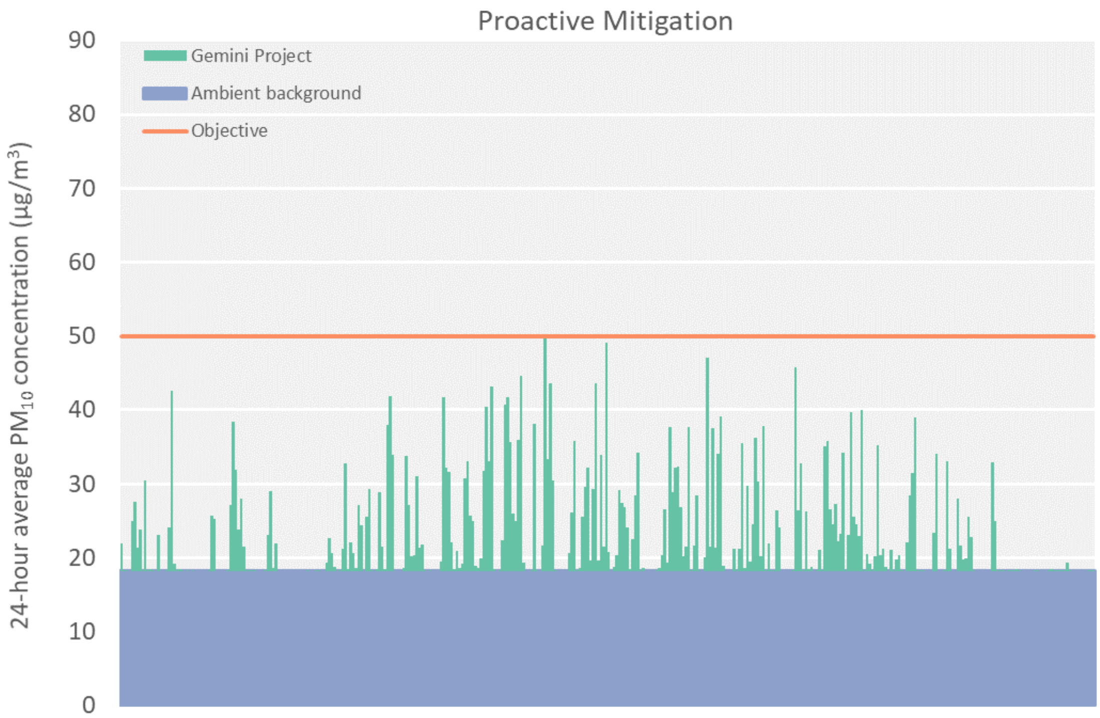

Figure 10 Year 2 – Timeseries of 24-hour average PM_{10} at SR09 including additional mitigation (when required)

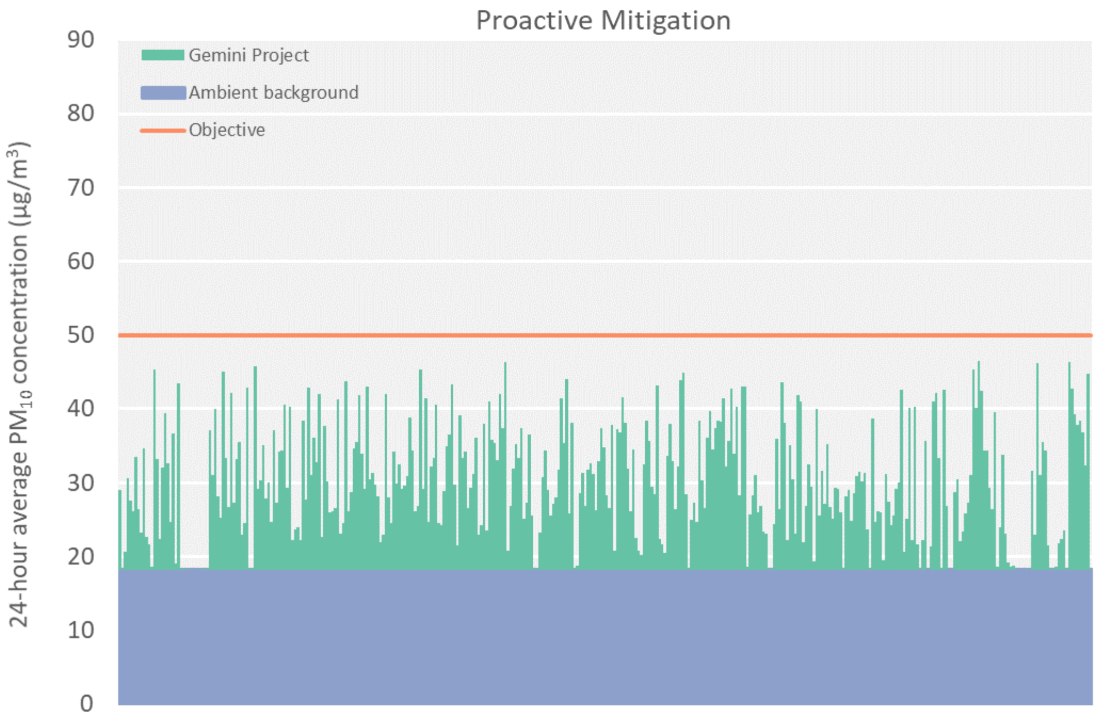

Figure 11 **Year 2 - Timeseries of 24-hour average PM_{10} at SR18 including additional mitigation (when required)**

3.5.2 Year 8

Table 9 presents the predicted ground-level concentrations of TSP, PM_{10} and $PM_{2.5}$ as well as dust deposition rates at the sensitive receptors due to the Project in year 8 in isolation and with a background.

The corresponding contours for each cumulative scenario are presented in Plate 9 to Plate 14.

The results show that using standard mitigation measures:

- Predicted annual average concentrations of TSP ***comply*** with the relevant air quality objective at all sensitive receptors (Plate 9)
- Predicted 24-hour average concentrations of PM_{10} ***exceed*** the relevant air quality objective at 16 sensitive receptors; SR03, SR07, SR09, SR10, SR13, SR18, SR19, SR20, SR21, SR22, SR23, SR26, SR27, SR28, SR31 and SR32 (Plate 10)
- Predicted annual average concentrations of PM_{10} ***comply*** with the relevant air quality objective at all sensitive receptors with the exception of SR09 and SR18 (within Project ML) (Plate 11)
- Predicted 24-hour and annual average concentrations of $PM_{2.5}$ ***comply*** with the relevant air quality objectives at all sensitive receptors (Plate 12 and Plate 13)
- Predicted monthly dust deposition rates ***comply*** with the relevant air quality guideline at all sensitive receptors using standard mitigation measures (Plate 14).

Table 10 presents the number of days per year when 24-hour average concentrations of PM_{10} are predicted to exceed the Air EPP objective due to the Project operating with standard mitigation. With the exception of SR09, SR18 and SR23, predicted 24-hour average concentrations of PM_{10} are only expected to exceed at most one to three days per year.

Using standard and, when necessary, additional mitigation measures predicted 24-hour average and annual average concentrations of PM_{10} ***comply*** with the relevant air quality objective at all sensitive receptors. (Plate 15 and Plate 16). Additional mitigation measures may include restricting overburden and ROM haul to between 7am and 6pm on days when 24-hour averaged maximum PM_{10} is predicted to exceed 50 µg/m^3.

Figure 12 and Figure 13 illustrate a timeseries of predicted 24-hour average PM_{10} concentrations at SR09 and SR18 when standard and when necessary additional mitigation is applied. Compliance at SR18 and SR09 would result in compliance at all other sensitive receptors.

Table 9 Predicted ground-level concentrations of TSP, PM_{10}, $PM_{2.5}$ and dust deposition rates at sensitive receptors during year 8 using standard mitigation measures

Label	PM_{10} (µg/m³)				$PM_{2.5}$ (µg/m³)				TSP (µg/m³)		Dust deposition rate (mg/m²/day)	
	Maximum 24-hour		Annual		Maximum 24-hour		Annual		Annual		Maximum monthly	
	Project	With bkgd	Project	With bkgd	Project	With bkgd	Project	With bkgd	Project	With bkgd	Project	With bkgd
SR01	9.1	27.3	0.8	17.2	2.8	7.5	0.2	4.4	0.9	33.7	2.2	32.2
SR03	72.4	90.6	1.1	17.5	11.6	16.3	0.2	4.4	1.2	34.0	3.2	33.2
SR05	7.1	25.3	0.9	17.3	1.9	6.6	0.2	4.4	1.0	33.8	1.4	31.4
SR07	37.6	55.8	0.9	17.3	6.2	10.9	0.1	4.3	1.0	33.8	2.9	32.9
SR08	10.7	28.9	1.0	17.4	3.2	7.9	0.2	4.4	1.1	33.9	1.9	31.9
SR09	100.4	118.6	12.8	29.2	14.1	18.8	1.9	6.1	15.5	48.3	23.0	53.0
SR10	40.4	58.6	1.1	17.5	5.7	10.4	0.2	4.4	1.4	34.2	3.9	33.9
SR13	52.8	71.0	1.3	17.7	7.7	12.4	0.2	4.4	1.5	34.3	4.6	34.6
SR14	12.6	30.8	0.6	17.0	2.7	7.4	0.1	4.3	0.7	33.5	1.5	31.5
SR15	20.7	38.9	3.6	20.0	4.1	8.8	0.7	4.9	3.8	36.6	5.1	35.1
SR16	29.9	48.1	1.3	17.7	5.6	10.3	0.3	4.5	1.4	34.2	1.2	31.2
SR17	11.4	29.6	1.2	17.6	3.5	8.2	0.3	4.5	1.3	34.1	2.6	32.6
SR18	69.8	88.0	12.6	29.0	10.2	14.9	2.0	6.2	19.3	52.1	35.6	65.6
SR19	41.8	60.0	2.0	18.4	6.3	11.0	0.3	4.5	2.3	35.1	2.9	32.9
SR20	43.8	62.0	2.1	18.5	6.5	11.2	0.4	4.6	2.3	35.1	3.1	33.1
SR21	48.8	67.0	2.2	18.6	7.2	11.9	0.4	4.6	2.5	35.3	3.3	33.3
SR22	44.6	62.8	3.2	19.6	8.6	13.3	0.7	4.9	3.7	36.5	4.4	34.4
SR23	56.7	74.9	2.4	18.8	9.6	14.3	0.4	4.6	3.1	35.9	6.1	36.1
SR24	31.4	49.6	1.0	17.4	4.6	9.3	0.2	4.4	1.2	34.0	2.1	32.1
SR26	50.0	68.2	0.6	17.0	8.8	13.5	0.1	4.3	0.7	33.5	1.7	31.7
SR27	34.6	52.8	0.6	17.0	5.0	9.7	0.1	4.3	0.7	33.5	1.8	31.8
SR28	35.1	53.3	0.6	17.0	5.6	10.3	0.1	4.3	0.7	33.5	1.8	31.8
SR30	23.8	42.0	0.4	16.8	3.9	8.6	0.1	4.3	0.5	33.3	1.2	31.2
SR31	33.2	51.4	2.5	18.9	8.2	12.9	0.6	4.8	2.8	35.6	4.4	34.4
SR32	37.4	55.6	2.3	18.7	7.8	12.5	0.5	4.7	2.6	35.4	3.2	33.2
Objective	**-**	**50**	**-**	**25**	**-**	**25**	**-**	**8**	**-**	**90**	**-**	**120**

Table 10 Number of days per year predicted to exceed in year 8

ID		Number of days above 50 µg/m³
SR03	Residential	3
SR07	Residential, facilities (sports oval, tennis court, school) & businesses (Post Office, hotel, shops, sawmills, etc.)	3
SR09	Residential (within ML)	59
SR10	Residential	2
SR13	Residential	2
SR18	Residential (within ML)	24
SR19	Residential	1
SR20	Residential	1
SR21	Residential	1
SR22	Residential and Accommodation Facility (within ML)	2
SR23	Residential (within ML)	9
SR26	Residential	1
SR27	Residential	1
SR28	Residential	2
SR31	Residential	1
SR32	Residential	1

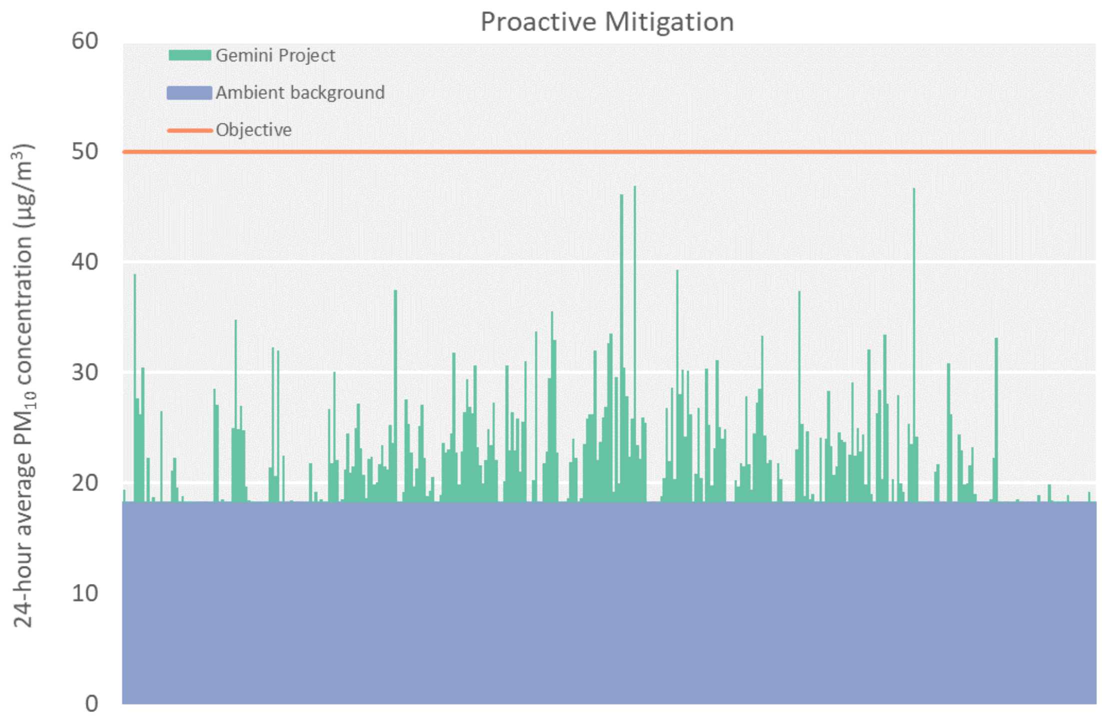

Figure 12 Year8 – Timeseries of 24-hour average PM_{10} at SR09 including additional mitigation (when required)

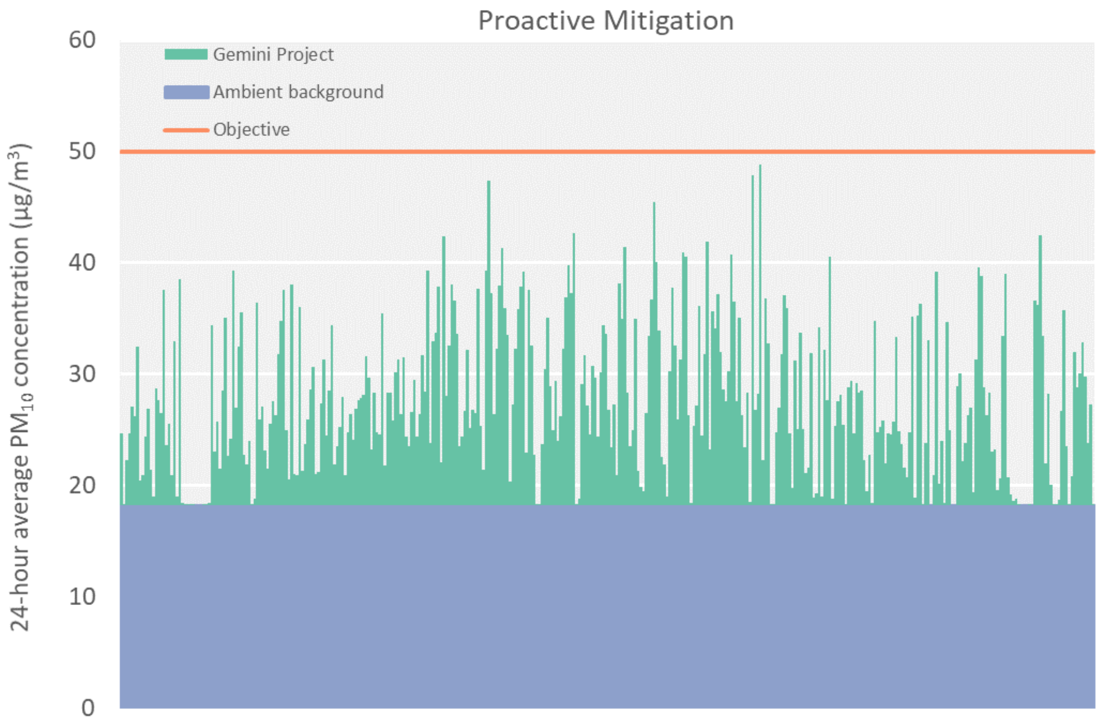

Figure 13 **Year 8 – Timeseries of 24-hour average PM_{10} at SR18 including additional mitigation (when required)**

3.5.3 Year 15

Table 11 presents the predicted ground-level concentrations of TSP, PM_{10} and $PM_{2.5}$ as well as dust deposition rates at the sensitive receptors due to the Project in year 15 in isolation and with a background.

The corresponding contours for each cumulative scenario are presented in Plate 17 to Plate 22.

The results show that using standard mitigation measures:

- Predicted annual average concentrations of TSP ***comply*** with the relevant air quality objective at all sensitive receptors (Plate 17)
- Predicted 24-hour average concentrations of PM_{10} ***exceed*** the relevant air quality objective at 8 sensitive receptors; SR14, SR18, SR19, SR20, SR21, SR22, SR31 and SR32 (Plate 18)
- Predicted annual average concentrations of PM_{10} ***comply*** with the relevant air quality objective at all sensitive receptors with the exception of SR22 (Plate 19)
- Predicted 24-hour and annual average concentrations of $PM_{2.5}$ ***comply*** with the relevant air quality objectives at all sensitive receptors (Plate 20 and Plate 21)
- Predicted monthly dust deposition rates ***comply*** with the relevant air quality guideline at all sensitive receptors using standard mitigation measures (Plate 22).

Table 12 presents the number of days per year when 24-hour average concentrations of PM_{10} are predicted to exceed the Air EPP objective due to the Project operating with standard mitigation. The greatest number of exceedances are expected for SR18 and SR22.

Using standard and, when necessary, additional mitigation measures predicted 24-hour average and annual average concentrations of PM_{10} ***comply*** with the relevant air quality objective at all sensitive receptors. (Plate 23 and Plate 24). Additional mitigation measures may include restricting overburden and ROM haul to between 7am and 6pm on days when 24-hour averaged maximum PM_{10} is predicted to exceed 50 µg/m^3.

Figure 14 and Figure 15 illustrate a timeseries of predicted 24-hour average PM_{10} concentrations at SR18 and SR22 when standard and when necessary additional mitigation is applied. Compliance at SR18 and SR22 would result in compliance at all other sensitive receptors.

Table 11 Predicted ground-level concentrations of TSP, PM_{10}, $PM_{2.5}$ and dust deposition rates at sensitive receptors during year 15 using standard mitigation measures

Label	PM_{10} (µg/m³)				$PM_{2.5}$ (µg/m³)				TSP (µg/m³)		Dust deposition rate (mg/m²/day)	
	Maximum 24-hour		Annual		Maximum 24-hour		Annual		Annual		Maximum monthly	
	Project	With bkgd	Project	With bkgd	Project	With bkgd	Project	With bkgd	Project	With bkgd	Project	With bkgd
SR01	10.8	29.0	1.5	17.9	2.8	7.5	0.3	4.5	1.7	34.5	2.9	32.9
SR03	5.8	24.0	0.2	16.6	1.0	5.7	0.0	4.2	0.3	33.1	0.8	30.8
SR05	9.3	27.5	1.3	17.7	1.9	6.6	0.3	4.5	1.6	34.4	3.9	33.9
SR07	7.7	25.9	0.3	16.7	1.2	5.9	0.1	4.3	0.3	33.1	0.7	30.7
SR08	16.0	34.2	1.8	18.2	4.4	9.1	0.4	4.6	2.1	34.9	4.2	34.2
SR09	25.7	43.9	1.6	18.0	4.4	9.1	0.3	4.5	1.9	34.7	1.9	31.9
SR10	9.0	27.2	0.4	16.8	1.7	6.4	0.1	4.3	0.5	33.3	1.0	31.0
SR13	9.2	27.4	0.3	16.7	1.4	6.1	0.1	4.3	0.4	33.2	0.8	30.8
SR14	53.7	71.9	3.0	19.4	9.0	13.7	0.5	4.7	3.8	36.6	11.9	41.9
SR15	21.5	39.7	1.3	17.7	3.7	8.4	0.2	4.4	1.4	34.2	1.9	31.9
SR16	19.8	38.0	0.5	16.9	3.9	8.6	0.1	4.3	0.5	33.3	0.5	30.5
SR17	26.7	44.9	2.2	18.6	4.7	9.4	0.5	4.7	2.5	35.3	4.4	34.4
SR18	63.8	82.0	7.6	24.0	9.9	14.6	1.2	5.4	11.8	44.6	26.9	56.9
SR19	55.0	73.2	2.2	18.6	7.8	12.5	0.3	4.5	2.9	35.7	8.2	38.2
SR20	52.2	70.4	2.2	18.6	7.4	12.1	0.3	4.5	2.9	35.7	8.3	38.3
SR21	46.6	64.8	2.2	18.6	6.6	11.3	0.3	4.5	2.8	35.6	8.5	38.5
SR22	53.5	71.7	11.1	27.5	10.0	14.7	1.9	6.1	12.5	45.3	12.5	42.5
SR23	22.5	40.7	0.7	17.1	3.7	8.4	0.1	4.3	0.8	33.6	1.7	31.7
SR24	12.3	30.5	0.4	16.8	1.9	6.6	0.1	4.3	0.5	33.3	0.9	30.9
SR26	5.2	23.4	0.2	16.6	0.9	5.6	0.0	4.2	0.2	33.0	0.7	30.7
SR27	5.1	23.3	0.2	16.6	0.8	5.5	0.0	4.2	0.2	33.0	0.6	30.6
SR28	5.2	23.4	0.2	16.6	0.8	5.5	0.0	4.2	0.2	33.0	0.6	30.6
SR30	5.7	23.9	0.2	16.6	0.9	5.6	0.0	4.2	0.2	33.0	0.5	30.5
SR31	46.2	64.4	7.6	24.0	8.1	12.8	1.4	5.6	8.5	41.3	8.0	38.0
SR32	49.6	67.8	8.4	24.8	8.5	13.2	1.5	5.7	9.3	42.1	7.0	37.0
Objective	**-**	**50**	**-**	**25**	**-**	**25**	**-**	**8**	**-**	**90**	**-**	**120**

Table 12 Number of days per year predicted to exceed in year 15

ID		Number of days above 50 µg/m³
SR14	Residential	6
SR18	Residential (within ML)	22
SR19	Residential	9
SR20	Residential	9
SR21	Residential	8
SR22	Residential and Accommodation Facility (within ML)	29
SR31	Residential	5
SR32	Residential	9

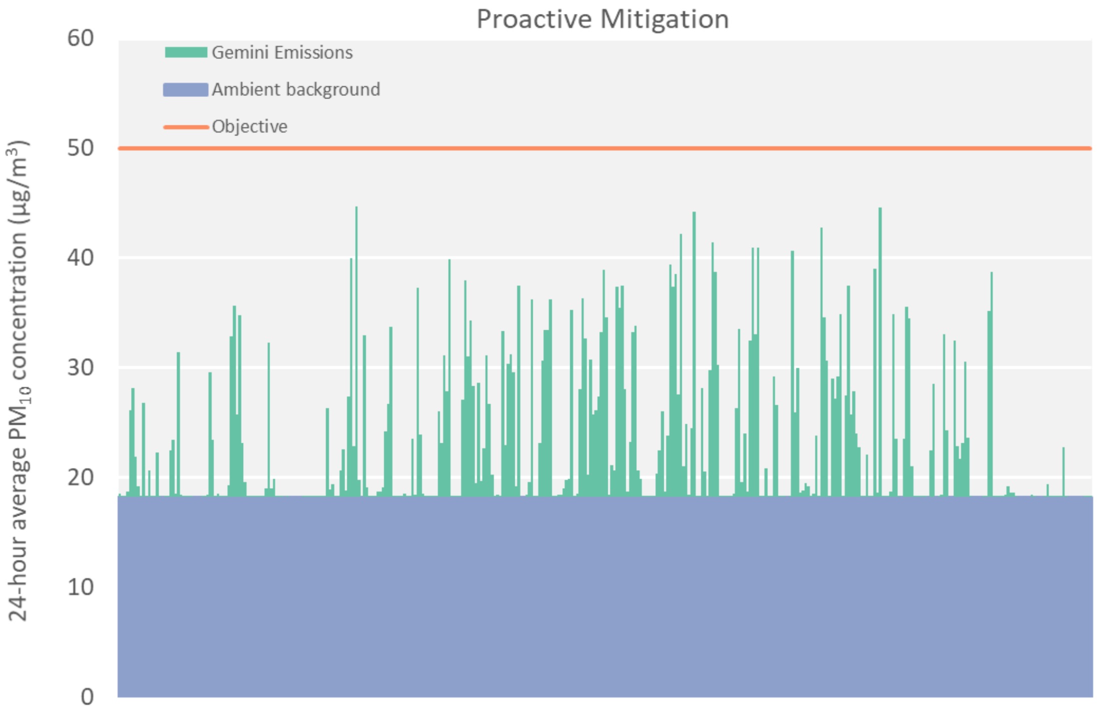

Figure 14 Year 15 - Timeseries of 24-hour average PM_{10} at SR18 including additional mitigation (when required)

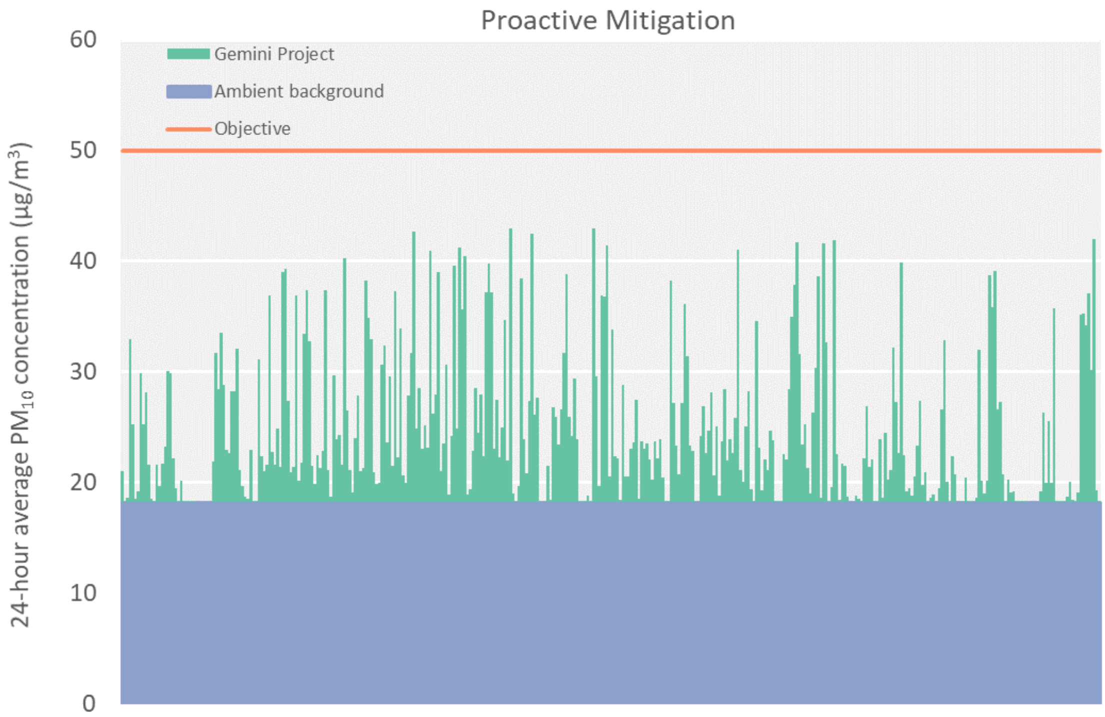

Figure 15 **Year 15 – Timeseries of 24-hour average PM_{10} at SR22 including additional mitigation (when required)**

3.6 Mitigation

Dust management and mitigation measures will be implemented for the Project. It is recommended that Magnetic South implement the following measures:

1. Develop and implement an ambient air quality monitoring program at sites representative of surrounding sensitive receptors
2. Develop an Air Quality Management Plan (AQMP) and include a range of available measures to be implemented as necessary to ensure compliance with approval conditions. Measures that would be considered for inclusion in the AQMP include:
    - Use of real-time measurement of dust levels and meteorological conditions
    - Nomination of triggers (e.g. based on complaints and/or real-time dust and meteorological measurement) and a range of additional measures which will be implemented, as necessary, for example:
        - applying additional at-source and/or at-receptor dust controls
        - increasing the intensity of dust controls
        - modifying certain operations
    - Procedures to investigate, if monitoring indicates unexpected exceedances of air quality objectives.
3. Enter into discussions and, as appropriate, commercial arrangements with surrounding landholders which could include:
        - measures (e.g. purchase or relocation) which result in homesteads no longer being considered a sensitive receptor
        - installation of receptor-side mitigation (e.g. air conditioners / purifiers in affected residences).

4. GREENHOUSE GAS ASSESSMENT

4.1 Background

The term greenhouse gases (GHG) comes from the 'greenhouse effect', which refers to the natural process that warms the Earth's surface. GHG in the atmosphere absorb the solar radiation released by the Earth's surface and then radiate some heat back towards the ground, increasing the surface temperature. Human activity, especially burning fossil fuels and deforestation, is increasing the concentration of GHG in the atmosphere and hence increasing the absorption of outgoing heat energy. Even a small increase in long-term average surface temperatures has numerous direct and indirect consequences for climate.

Australia is a signatory to United Nations Framework Convention on Climate Change (UNFCCC), the associated Kyoto Protocol signalling its commitment to reducing GHG emissions at a national level. Under the Paris Agreement, the most recent progression of the UNFCCC, Australia has set an ambitious target to reduce emissions by 26-28 per cent below 2005 levels by 2030, building on the 2020 target of reducing emissions by five per cent below 2000 levels.

The main GHG associated with the Project is carbon dioxide (CO_2), with smaller contributions from methane (CH_4) and nitrous oxide (N_2O). These gases vary in effect and longevity in the atmosphere, however a system named Global Warming Potential (GWP) allows them to be described in terms of CO_2 (the most prevalent greenhouse gas) called carbon dioxide equivalents (CO_2-e). A unit of one tonne of CO_2-e is the basic unit used in carbon accounting. In simple terms the greenhouse gas emissions associated with the Project can be expressed as the sum of the emission rate of each greenhouse gas multiplied by its associated GWP (denoted in squares). For example:

tonnes **CO_2-e** = tonnes **CO_2** x $\boxed{1}$ + tonnes **CH_4** x $\boxed{25}$ + tonnes **N_2O** x $\boxed{310}$

While few, if any, individual Projects would make a noticeable change to the Earth's climate, the summation of human activities increasing the concentrations of GHG in the upper atmosphere does. Climate change is an environmental concern at a global level. Governments and the global scientific community have established conventions for accounting for GHG emissions to enable the transparent and verifiable assessment of GHG emissions among all global jurisdictions. This assessment employs these established conventions so that the relative impact of the Project can be assessed and understood.

4.2 Regulatory Framework for Greenhouse Gas Emissions

4.2.1 National policy

Australia will meet its targets through the Government's Direct Action Plan. The Emissions Reduction Fund (ERF) is a central component of the Direct Action policies that is made up of an element to credit emissions reductions, a fund to purchase emissions reductions, and a Safeguard Mechanism.

The Safeguard Mechanism has been put in place to ensure that emissions reductions purchased by the Government through the ERF are not offset by significant increases in emissions by large emitters elsewhere in the economy. The Safeguard Mechanism commenced on 1 July 2016 and requires Australia's largest emitters to keep emissions within baseline levels. It applies to around 140 large businesses that have facilities with direct emissions (Scope 1 Emissions) of more than 100,000 tonnes of carbon dioxide equivalent (t CO_2-e) a year and is expected to cover approximately half of Australia's emissions.

Direct emissions associated with the Project are anticipated to exceed 100,000 t CO_2-e for all years with the exception of the first year of operation (2020). As a result, the Project will be subject to the requirements of the Safeguard Mechanism.

4.2.2 National Greenhouse and Energy Reporting (NGER)

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) established a national framework for corporations to report GHG emissions and energy consumption.

The NGER Regulation recognises Scope 1 and Scope 2 emissions as follows:

- Scope 1 emissions – in relation to a facility, means the release of GHG into the atmosphere as a direct result of an activity or series of activities (including ancillary activities) that constitute the facility.
- Scope 2 emissions – in relation to a facility, means the release of GHG into the atmosphere as a direct result of one or more activities that generate electricity, heating, cooling or steam that is consumed by the facility but that do not form part of the facility.

Registration and reporting is mandatory for corporations that have energy production, energy use or GHG emissions that exceed specified thresholds. GHG emission thresholds include Scope 1 and Scope 2 emissions. NGER reporting thresholds are summarised in Table 13.

Table 13 NGER annual reporting thresholds – greenhouse gas emissions and energy use

Threshold level	Threshold type	
	GHG (kt CO_2-e)	Energy consumption (TJ)
Facility	25	100
Corporate	50	200
Note: kt CO_2-e = kilotonnes of carbon dioxide equivalent. TJ = terajoules.		

With annual emissions (Scope 1 + Scope 2) ranging from 18 kt CO_2-e to 211kt CO_2-e, Magnetic South will have reporting obligations associated with the Project under the NGER Scheme, including estimating and reporting their GHG emissions on an annual basis.

4.3 Methodology

Pollutants of importance to climate change, associated with the Project, are carbon dioxide, methane and nitrous oxide. This study will assess the emissions of greenhouse gases from the Project during construction and operation based on activity data representative of the proposed activities and the methods described in the following resources:

- The National Greenhouse Accounts, July 2017 (Commonwealth Department of the Environment and Energy, 2017)
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008*
- The Greenhouse Gas Protocol
- FullCAM – Full Carbon Accounting Model (used to account for GHG emissions from land clearing).

4.3.1 Emissions

Scope 1 and 2 greenhouse gas emissions will be estimated on an annual basis for the Project. This will include emissions from:

Scope 1 GHG emissions

- Diesel combustion
  - Heavy machinery and equipment
  - Haulage vehicles
- Fugitive emissions of methane from mining of coal deposits – also referred to as waste mine gas
- Explosives use

Scope 2 GHG Emissions

- Electricity usage
  - Conveyors
  - Coal processing plant
  - Amenities.

A summary of emission sources associated with the both the construction phase and mining production is provided in Table 14. Emissions sources would reduce during the post production/rehabilitation phase of the mine.

Table 14 Summary of GHG emission sources by year of mining operations

Year	ROM Coal (t)	Product Coal (t)	Diesel (kL)	Electricity (MWh)	Explosives (t/yr)
Year 1	-	-	6,200,000	2,000,000	-
Year 2	900,000	868,000	56,911,490	22,527,890	19,867
Year 3	1,900,000	1,831,000	37,531,815	22,527,890	11,234
Year 4	1,900,000	1,831,000	40,987,689	22,527,890	12,409
Year 5	1,900,000	1,831,000	45,413,261	22,527,890	14,139
Year 6	1,900,000	1,831,000	38,148,132	22,527,890	11,431
Year 7	1,900,000	1,831,000	48,778,289	22,527,890	13,622
Year 8	1,900,000	1,831,000	51,109,310	22,527,890	15,185
Year 9	1,900,000	1,831,000	38,913,541	22,527,890	11,004
Year 10	1,900,000	1,831,000	38,107,769	22,527,890	11,100
Year 11	1,900,000	1,831,000	37,030,381	22,527,890	10,689
Year 12	1,900,000	1,831,000	40,218,955	22,527,890	12,094
Year 13	1,800,000	1,735,465	43,619,124	22,527,890	13,982
Year 14	1,800,000	1,756,341	46,218,509	22,527,890	14,316
Year 15	1,800,000	1,744,742	45,322,232	22,527,890	13,913
Year 16	1,800,000	1,742,282	54,648,151	22,527,890	16,330
Year 17	1,800,000	1,732,307	44,877,181	22,527,890	11,846
Year 18	1,800,000	1,737,463	54,606,897	22,527,890	16,239
Year 19	1,593,048	1,536,368	26,028,185	22,527,890	5,744

4.3.2 Emissions estimation

GHG emissions associated with the Project have been considered on an annual basis for the life of the Project. A summary of estimated emissions associated with mining operations, expressed as tonnes per annum expressed in terms of CO_2-e is presented. Reporting obligations based on a conservative estimate of annual GHG emissions are summarised, along with measures to mitigate GHG emissions through avoidance and minimisation.

The methodologies used to estimate the GHG emissions resulting from the Project are consistent with:

1. *National Greenhouse and Energy Reporting (Measurement) Determination 2008*
2. The National Greenhouse Accounts, July 2017 (Commonwealth Department of the Environment and Energy, 2017)
3. The Greenhouse Gas Protocol.

In particular, the methodology is consistent with a Method 1 approach as detailed in the *National Greenhouse and Energy Reporting (Measurement) Determination*.

The emission factors and energy content for each of the emissions sources that have been used in the assessment are summarised in Table 15.

Table 15 Emission factors and energy content for GHG emission sources

Emission source	Scope	Energy content	Units	Emission factor	Units
Diesel	1	38.6	GJ/kL	70.2	kg CO_2-e/GJ
Fugitive methane (Qld – open cut)	1	-	-	0.02	t CO_2-e/t ROM
Explosives (Ammonium Nitrate Fuel Oil [ANFO])	1	2.4	GJ/t	0.17	t CO_2-e/t ANFO
Electricity (Queensland)	2	3.6	MJ/kWh	0.81	kg CO_2-e/kWh
Coking coal	3	30	GJ/t	92	kg CO_2-e/GJ

Sources: *National Greenhouse and Energy Reporting (Measurement) Determination*, National Greenhouse Accounts Factors (July 2019), NGA Workbook (January 2008).

Note:
GJ/kL = gigajoules per kilolitres. GJ/t = gigajoules per tonne. MJ/kWh = megajoules per kilowatt hour. Kg CO_2-e/GJ = kilograms of carbon dioxide equivalent per gigajoule. T CO_2-e/t ROM = tonnes of carbon dioxide equivalent per tonne of ROM coal. T CO_2-e/t ANFO = tonnes of carbon dioxide equivalent per tonne of ANFO. Kg CO_2-e/kWh = kilograms of carbon dioxide equivalent per kilowatt hour.

4.4 Results

4.4.1 Scope 1 and 2 GHG emissions and energy use summary

A summary of anticipated annual GHG emissions, by scope, along with estimated energy consumption corresponding with the mining years are summarised in Table 16 and Table 17.

Table 16 Summary of GHG emissions by year of mining operations

Year	GHG Emissions (t CO_2-e/yr)				
	Scope 1			Scope 2	TOTAL (Scope 1 & 2)
	Fugitive methane	Diesel usage	Explosives	Electricity usage	
Year 1	-	16,800	-	1,620	18,420
Year 2	18,000	154,214	3,377	18,248	193,839
Year 3	38,000	101,701	1,910	18,248	159,858
Year 4	38,000	111,065	2,110	18,248	169,422
Year 5	38,000	123,057	2,404	18,248	181,708
Year 6	38,000	103,371	1,943	18,248	161,562
Year 7	38,000	132,176	2,316	18,248	190,739
Year 8	38,000	138,492	2,581	18,248	197,321
Year 9	38,000	105,445	1,871	18,248	163,563
Year 10	38,000	103,261	1,887	18,248	161,396
Year 11	38,000	100,342	1,817	18,248	158,407
Year 12	38,000	108,982	2,056	18,248	167,286
Year 13	36,000	118,196	2,377	18,248	174,820
Year 14	36,000	125,239	2,434	18,248	181,920
Year 15	36,000	122,811	2,365	18,248	179,423
Year 16	36,000	148,081	2,776	18,248	205,105
Year 17	36,000	121,605	2,014	18,248	177,866
Year 18	36,000	147,969	2,761	18,248	204,978
Year 19	31,861	70,529	977	18,248	121,614
Total	**645,861**	**2,153,336**	**39,975**	**330,077**	**3,169,248**

Table 17 Summary of energy use (GJ/y) by year of mining operations

Year	Energy use (GJ/y)			
	Diesel usage	Explosives	Electricity usage	TOTAL
Year 1	239,320	-	7,200	246,520
Year 2	2,196,784	48,112	81,100	2,325,996
Year 3	1,448,728	27,205	81,100	1,557,033
Year 4	1,582,125	30,050	81,100	1,693,276
Year 5	1,752,952	34,239	81,100	1,868,291
Year 6	1,472,518	27,682	81,100	1,581,301
Year 7	1,882,842	32,987	81,100	1,996,930
Year 8	1,972,819	36,772	81,100	2,090,691
Year 9	1,502,063	26,649	81,100	1,609,812
Year 10	1,470,960	26,879	81,100	1,578,940
Year 11	1,429,373	25,886	81,100	1,536,359
Year 12	1,552,452	29,288	81,100	1,662,840
Year 13	1,683,698	33,858	81,100	1,798,657
Year 14	1,784,034	34,667	81,100	1,899,802
Year 15	1,749,438	33,693	81,100	1,864,232
Year 16	2,109,419	39,546	81,100	2,230,065
Year 17	1,732,259	28,688	81,100	1,842,047
Year 18	2,107,826	39,325	81,100	2,228,252
Year 19	1,004,688	13,910	81,100	1,099,699

The relative influence of the emissions sources on GHG emissions over the Project life is summarised in Figure 16. A similar breakdown of GHG by emissions scopes and emission sources is observed for individual years of operations. Over half of the GHG emissions associated with the Project are associated with diesel combustion for heavy machinery, mining equipment, haulage and other onsite vehicles as well as supplementary electricity generation. Fugitive methane and electricity have also been identified as significant sources of GHG emissions.

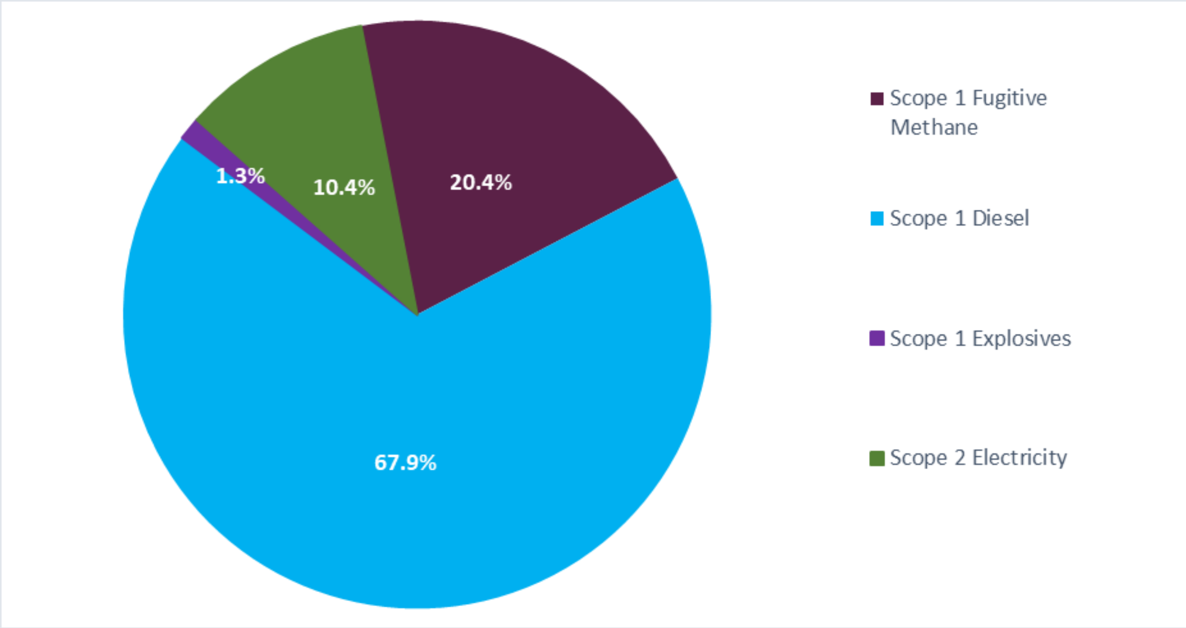

Figure 16 Summary of GHG emissions by scope

For comparative purposes the latest GHG inventory estimates for Australia and Queensland (excluding emissions from Land Use, Land Use Change and Forestry [LULUCF]) are 538 Mt CO_2-e and 162 Mt CO_2-e, respectively (Commonwealth of Australia, 2019a and Commonwealth of Australia, 2019b). With maximum annual GHG emissions of 205 kt CO2-e in Year 16, the Project could contribute up to 0.04% of national emissions and 0.13% of state emissions.

4.4.2 Regulatory obligations – NGER and the safeguard mechanism

As detailed in Table 16, the annual GHG emissions of the Project range from:

- Scope 1: 17 – 187 kt CO_2-e/y
- Scope 2: 2 – 18 kt CO_2-e/y
- Total: 18 – 205 kt CO_2-e/y

Based on the NGER Reporting thresholds detailed in Table 13, Magnetic South Pty Ltd will have ongoing reporting obligations associated with the Project including annual assessment of GHG emissions as set out by the *NGER Act* and the *National Greenhouse and Energy Reporting (Measurement) Determination*.

In all years apart from Year 1 Scope 1 emissions exceed 100 kt CO_2-e/y. Under the current Safeguard Mechanism facilities with Scope 1 emissions of more than 100 kt CO2-e/y are required to keep their emissions within baseline levels. This Safeguard Mechanism would apply to the Project, however the exact implications of this would need to be reviewed on an annual basis in communication with the regulator.

4.4.3 GHG mitigation and management

A range of options for Magnetic South Pty Ltd to manage Project related GHG emissions include:

General

- Continuous improvement approach through ongoing monitoring and reporting GHG emissions and identifying opportunities to reduce GHG emissions

Diesel

- Reduce mine equipment diesel consumption through equipment selection, load optimisation, route optimisation and production scheduling as well as reduced idle time
- Maintain equipment based on manufacturer/supplier guidelines and recommendations

Electricity

- On site power factor correction optimised to minimise the usage of grid electricity
- Use of solar-powered lighting to reduce electricity demand
- Adjust peak demand through production scheduling to allow for optimal and well utilised diesel power generation capacity.

5. CONCLUSIONS

Katestone Environmental Pty Ltd (Katestone) was commissioned by Magnetic South Pty Ltd on behalf of Magnetic South Pty Ltd to conduct an air quality and greenhouse gas assessment of the proposed Gemini Project (the Project).

The Project involves the development of an open cut coal mine located approximately 3 km west of the township of Dingo and 35 kilometres east of Blackwater in Central Queensland.

This air quality assessment has investigated the potential for the Project to affect air quality in the region. Three operational scenarios have been considered that represent the worst-case potential for dust emissions over the life of the Project, given the proposed mining schedule and proximity of sensitive receptors. The assessment has used site-specific meteorological data and industry standard dispersion modelling techniques to predict ground-level concentrations of particulate matter (TSP, PM_{10} and $PM_{2.5}$) and dust deposition rates due to the Project.

The air quality assessment has considered the potential impacts of the Project in isolation and with the inclusion of representative background levels of dust. Predicted ground-level concentrations of dust have been presented across a 20 x 20 kilometre domain and at identified sensitive receptors. Predictions have been compared with the relevant air quality objectives and guidelines.

The findings of the cumulative impact assessment are as follows:

- Predicted annual average concentrations of TSP ***comply*** with the relevant air quality objective at all sensitive receptors using standard mitigation measures.
- Predicted maximum 24-hour and annual average concentrations of PM_{10} ***comply*** with the relevant air quality objective at all sensitive receptors using standard mitigation measures and additional mitigation when necessary.
- Predicted 24-hour and annual average concentrations of $PM_{2.5}$ ***comply*** with the relevant air quality objectives at all sensitive receptors using standard mitigation measures.
- Predicted monthly dust deposition rates ***comply*** with the relevant air quality guideline at all sensitive receptors using standard mitigation measures.

The greenhouse gas assessment of the Project found the following:

- Maximum annual greenhouse gas emissions associated with Scope 1 and 2 from the Project are estimated to be 205 kt CO2-e (Year 16)
- Greenhouse gas emissions from the Project are predominantly due to diesel use (67.9%), electricity generation (indirect emissions) (10.4%) and fugitive methane releases (20.4%)
- Compared to national and state greenhouse gas inventory levels, the maximum annual GHG emissions from the Project would account for approximately 0.04% and 0.13%, respectively

It is recommended that Magnetic South manages potential particulate matter impacts of the Project at sensitive receptors by:

- Developing and implementing an ambient air quality monitoring program
- Developing and implementing an Air Quality Management Plan
- As appropriate, consult with surrounding landholders in relation to appropriate mitigation measures or property purchases.

It is also recommended the Magnetic South monitor, manage and assess Project related greenhouse gas emissions.

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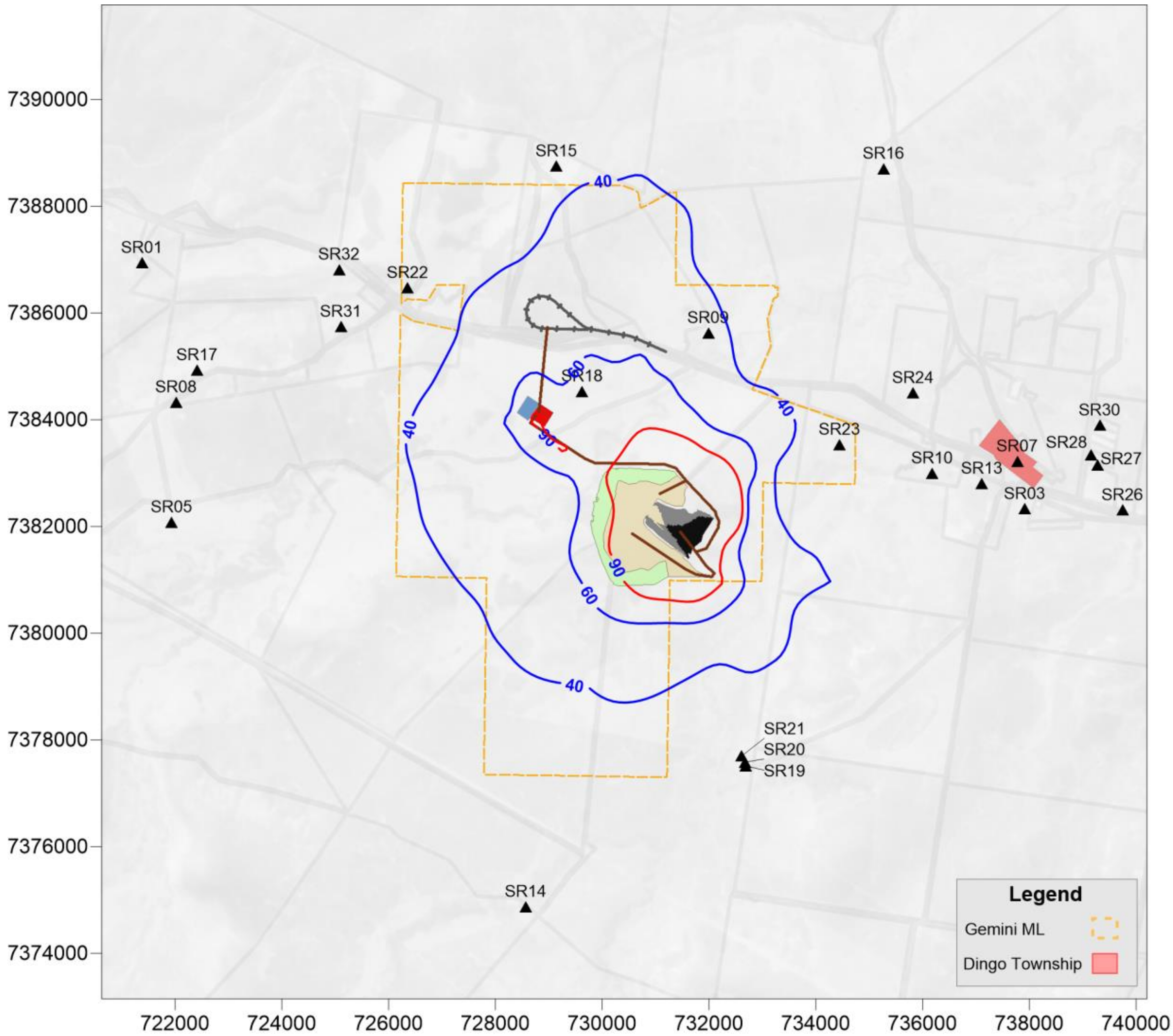

Plate 1	**Year 2 - Predicted annual average cumulative ground-level concentration of TSP using standard mitigation measures**		
Location: Gemini Project	**Averaging period:** 1 year	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 90 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

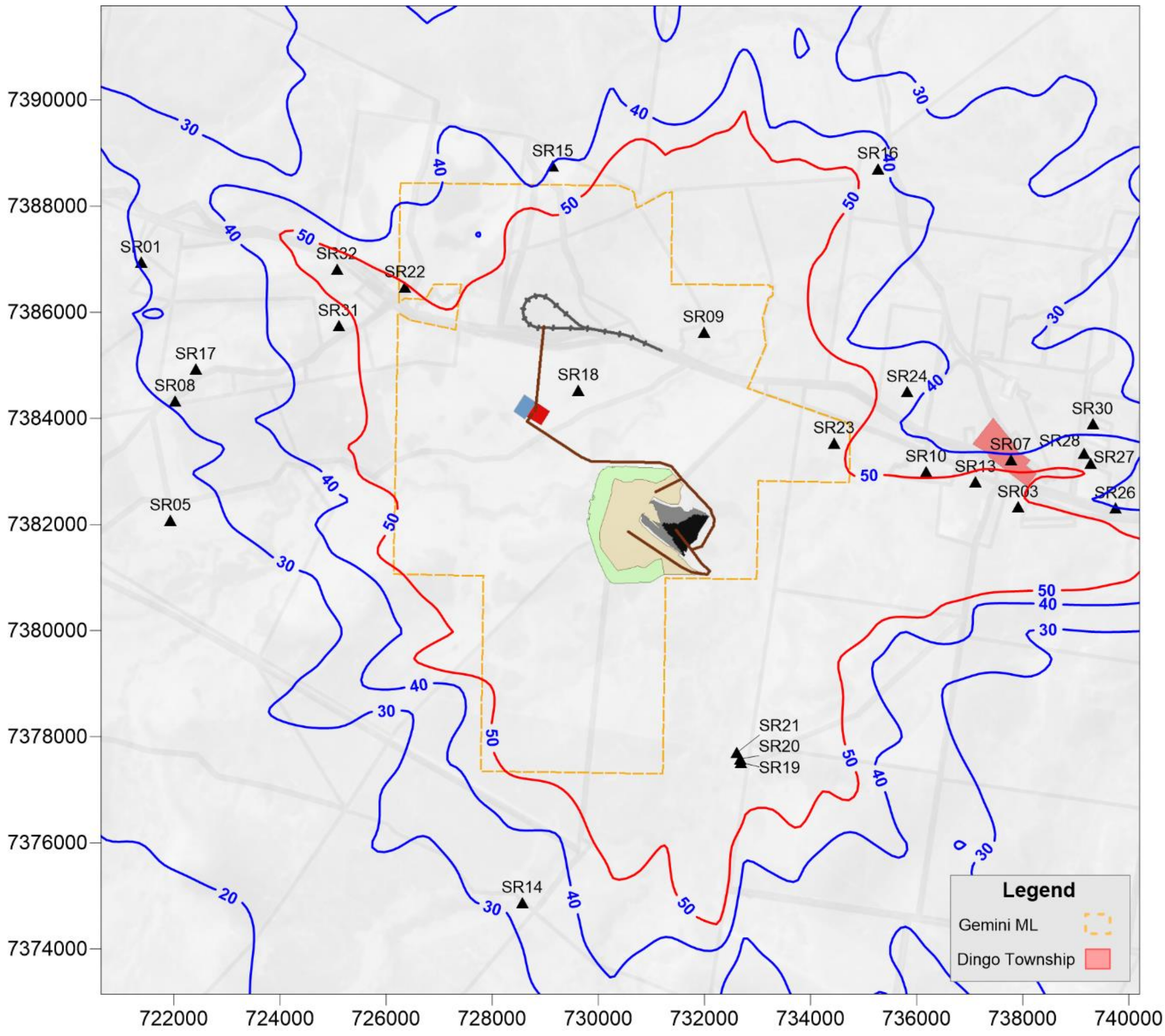

Plate 2	**Year 2 - Predicted maximum 24-hour average cumulative ground-level concentration of PM_{10} using standard mitigation measures**		
Location: Gemini Project	**Averaging period:** 24 hours	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 50 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

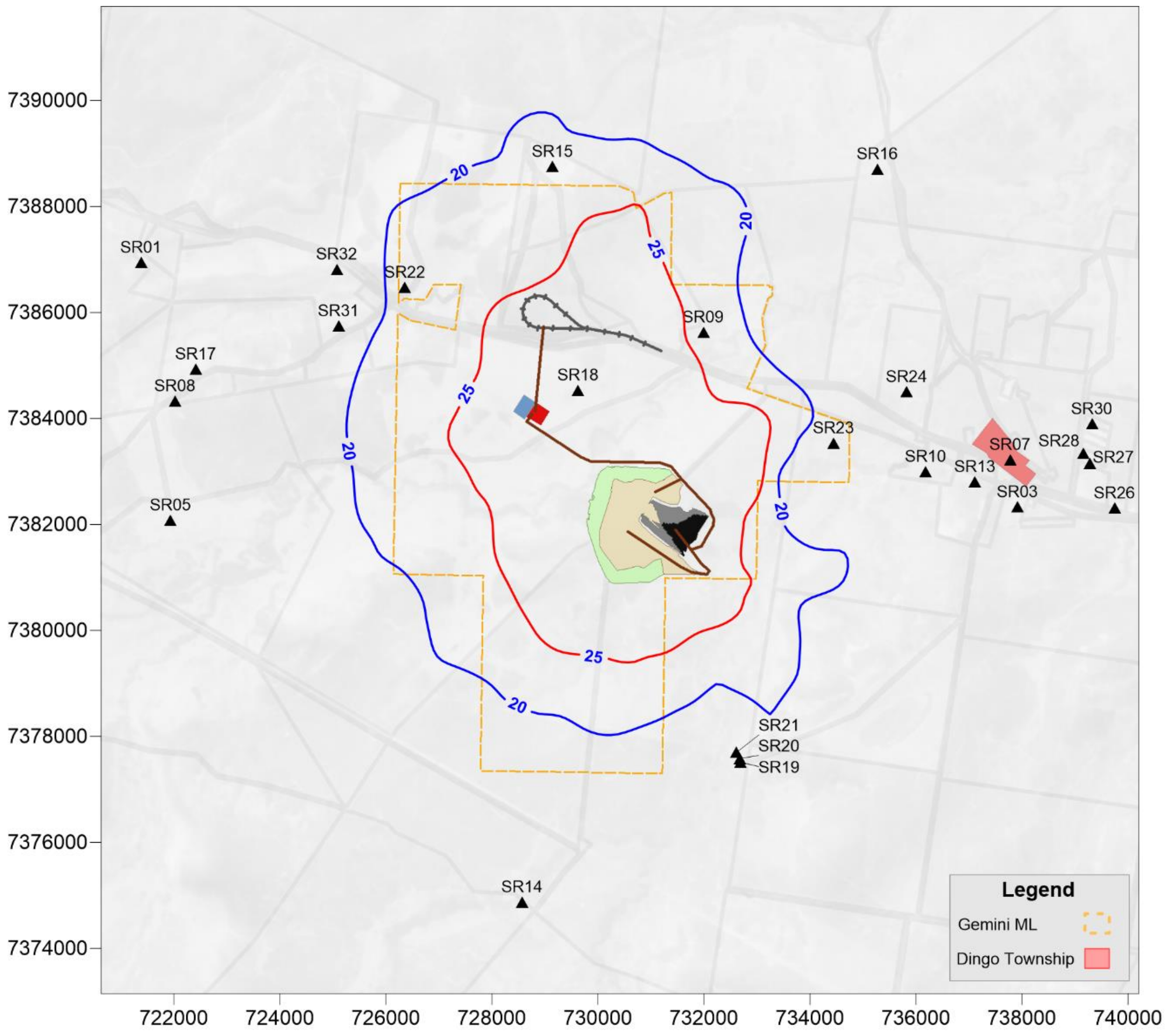

Plate 3	**Year 2 - Predicted annual average cumulative ground-level concentration of PM_{10} using standard mitigation measures**

Location: Gemini Project	**Averaging period:** 24 hours	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 25 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

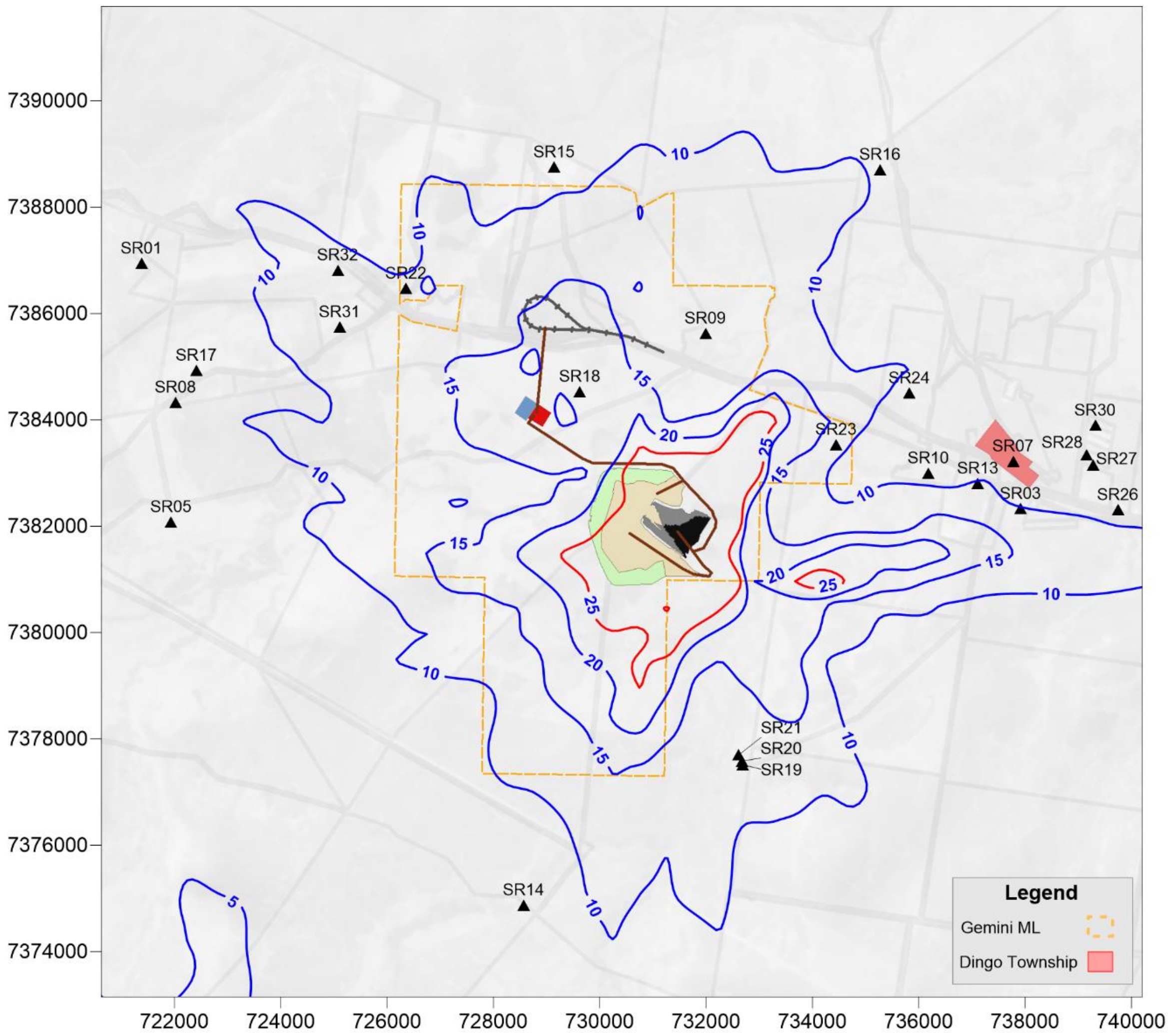

Plate 4	**Year 2 - Predicted maximum 24-hour average cumulative ground-level concentration of $PM_{2.5}$ using standard mitigation measures**		
Location: Gemini Project	**Averaging period:** 24 hours	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 25 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

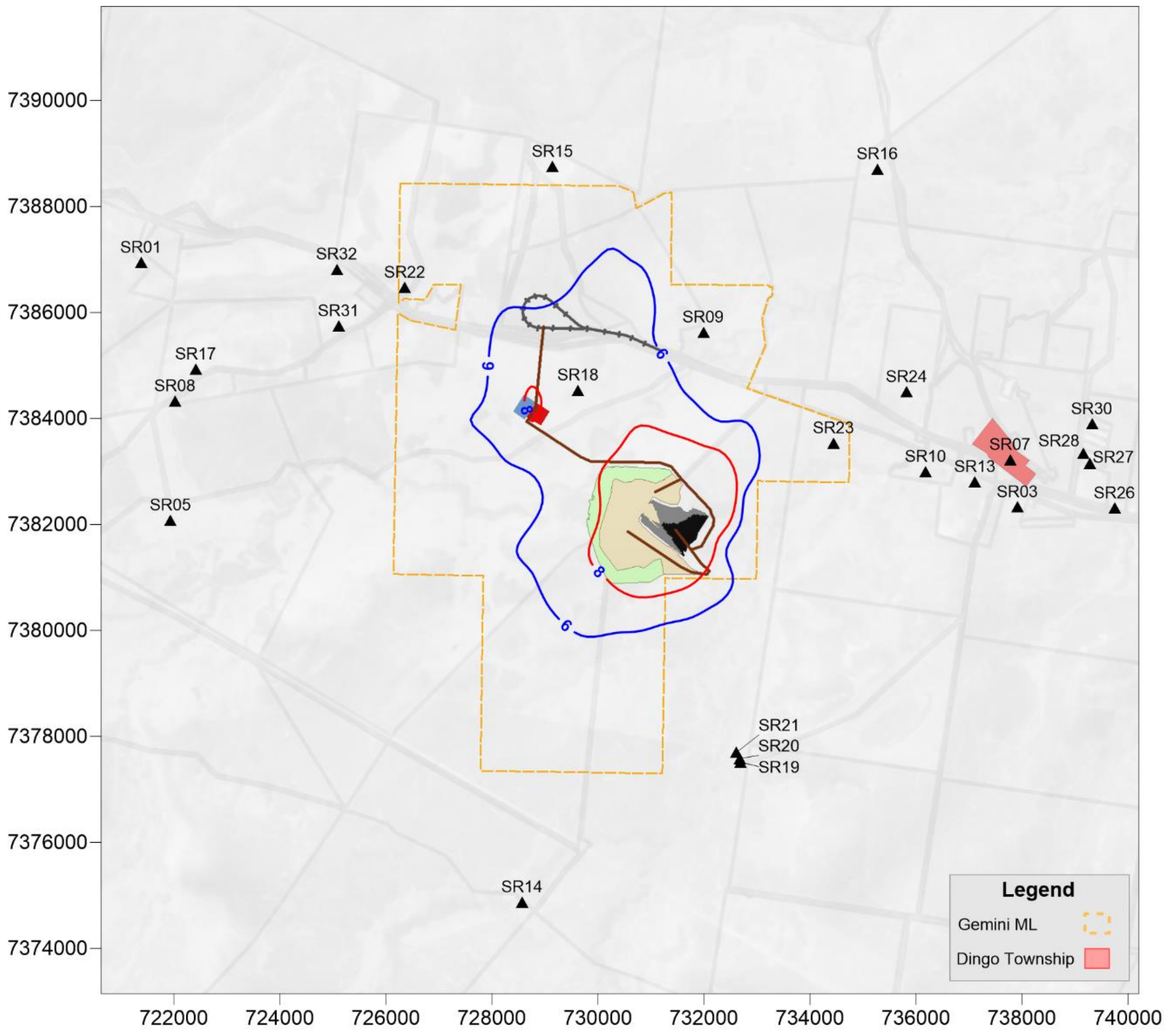

Plate 5	**Year 2 - Predicted annual average cumulative ground-level concentration of $PM_{2.5}$ using standard mitigation measures**		
Location: Gemini Project	**Averaging period:** 1 year	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 8 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

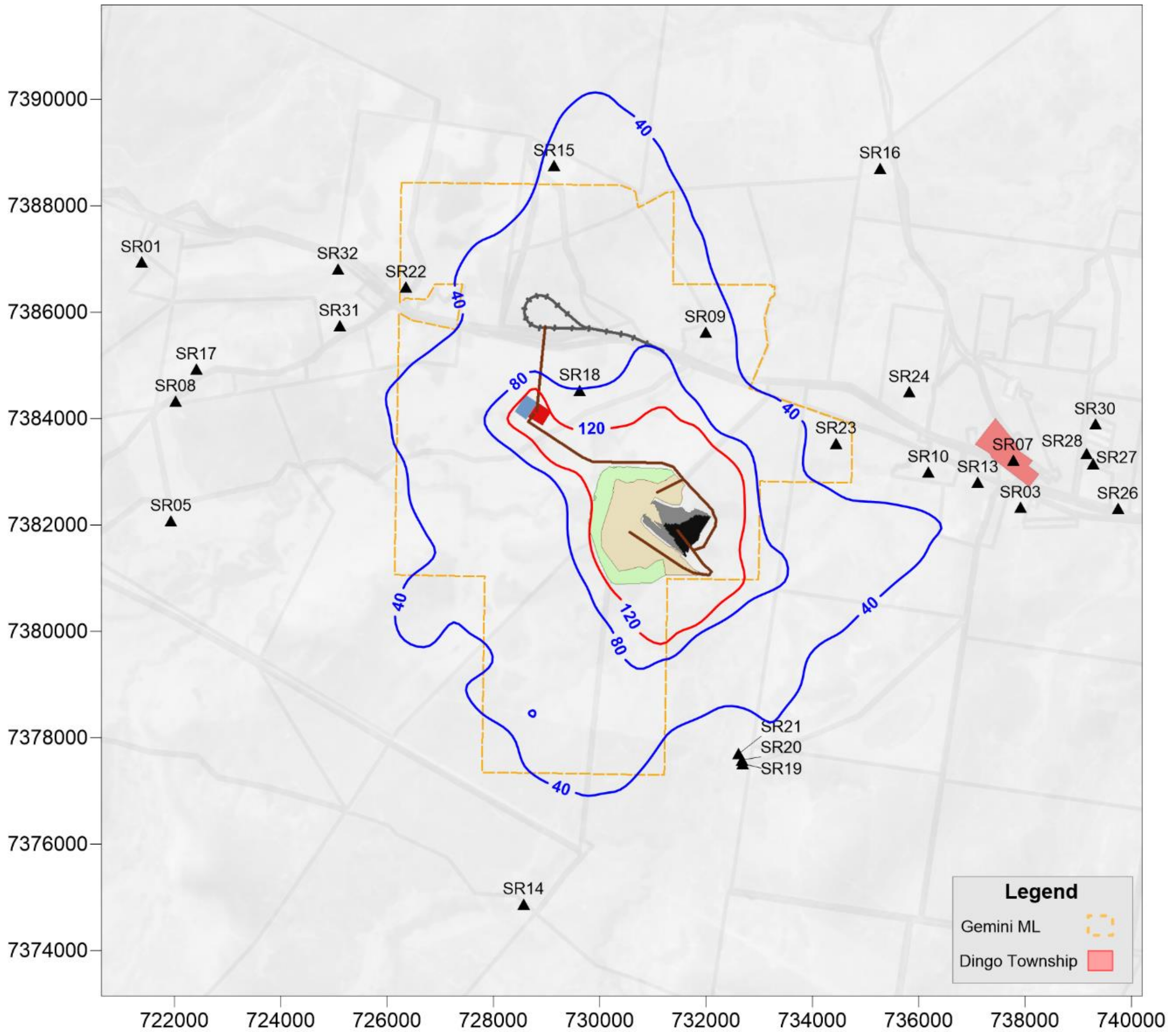

Plate 6	**Year 2 - Predicted maximum monthly cumulative dust deposition rate using standard mitigation measures**

Location:	**Averaging period:**	**Data source:**	**Units:**
Gemini Project	1 month	CALPUFF	µg/m³
Type:	**Guideline:**	**Prepared by:**	**Date:**
Contour plot	120 mg/m²/day (red)	Daniel Gallagher	September 2019

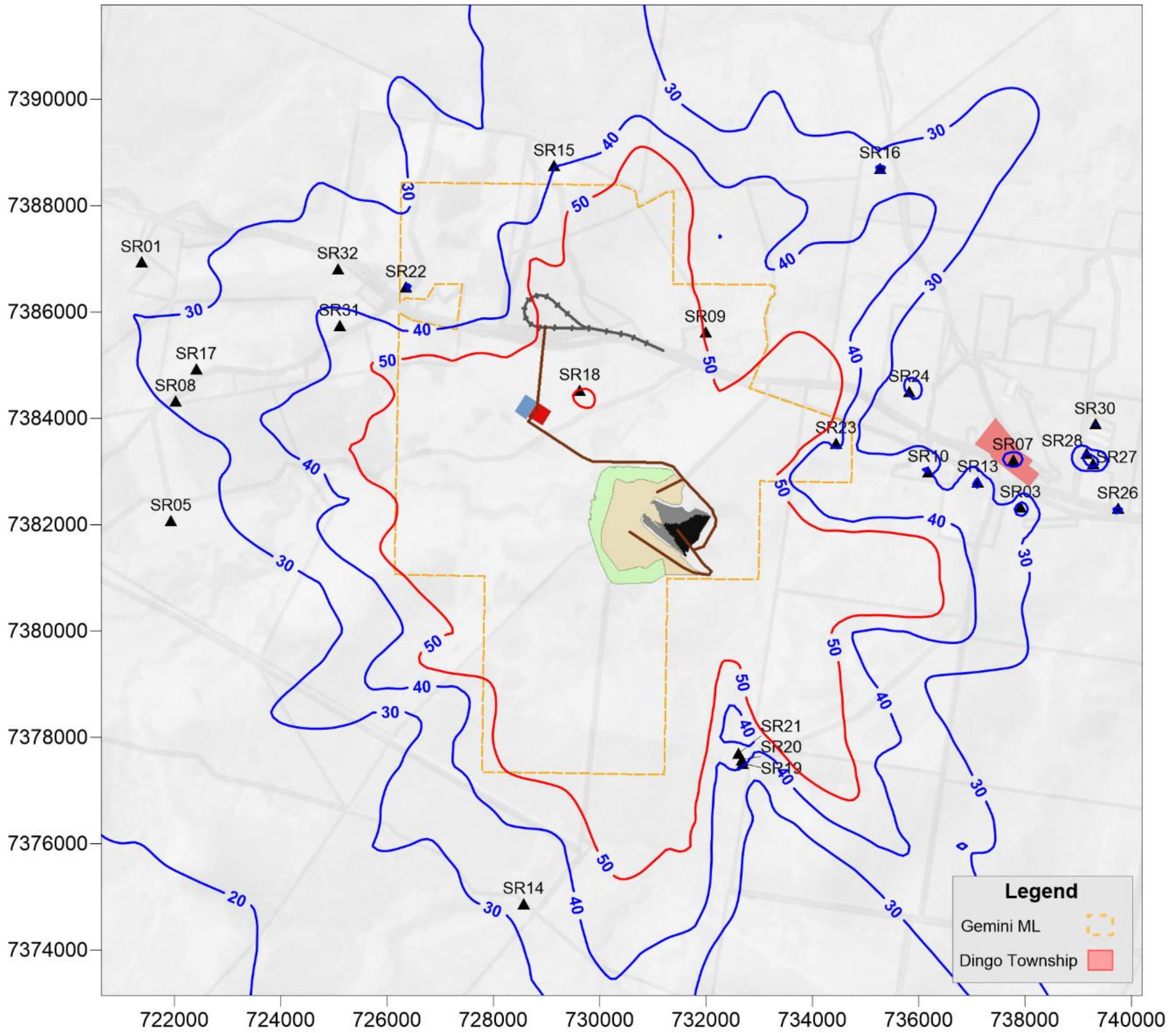

Plate 7	**Year 2 - Predicted maximum 24-hour average cumulative ground-level concentration of PM_{10} using standard mitigation measures and additional mitigation when necessary**

Location: Gemini Project	**Averaging period:** 24 hours	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 50 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

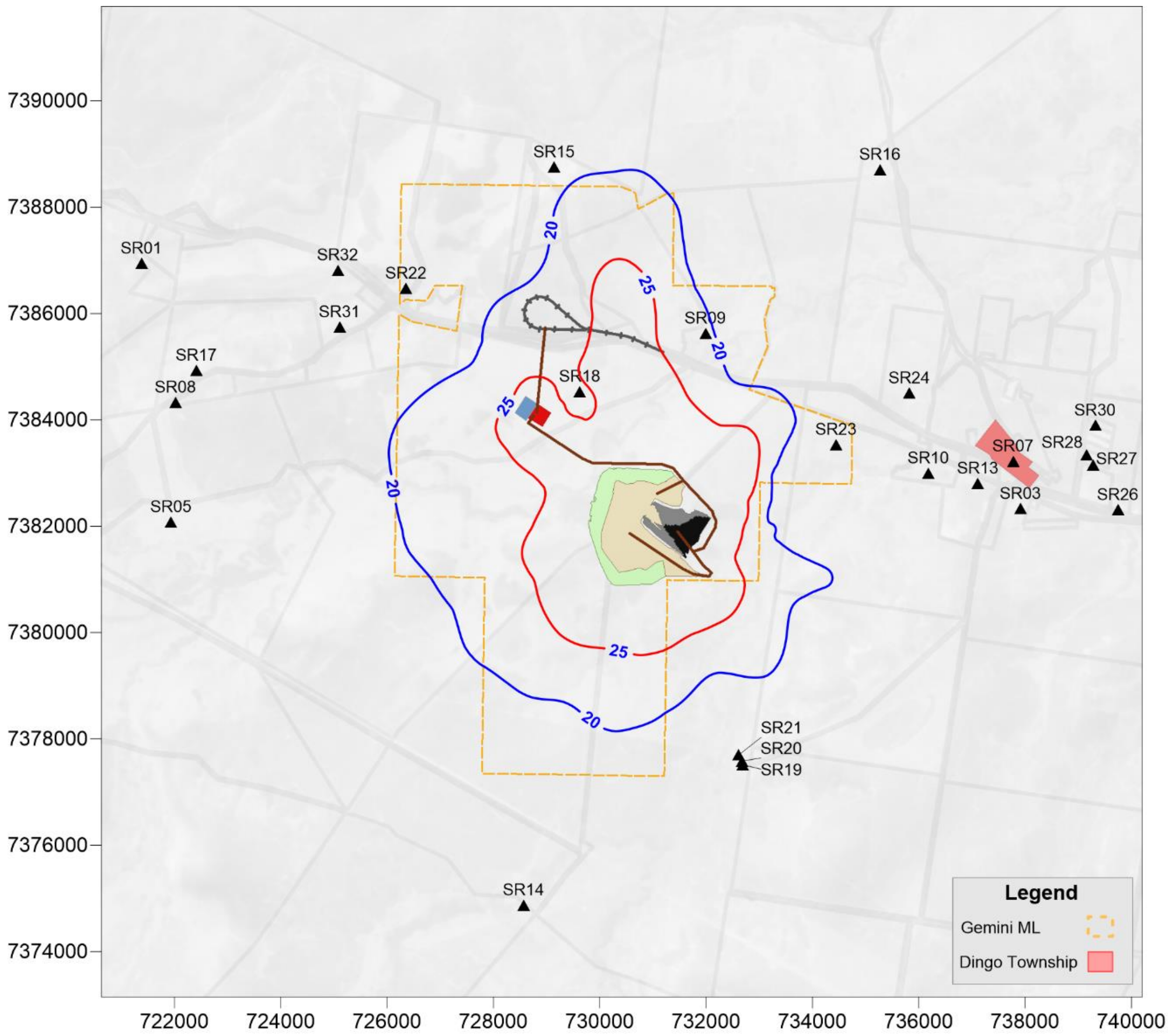

Plate 8	**Year 2 - Predicted annual average cumulative ground-level concentration of PM_{10} using standard mitigation measures and additional mitigation when necessary**		
Location: Gemini Project	**Averaging period:** 1 year	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 25 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

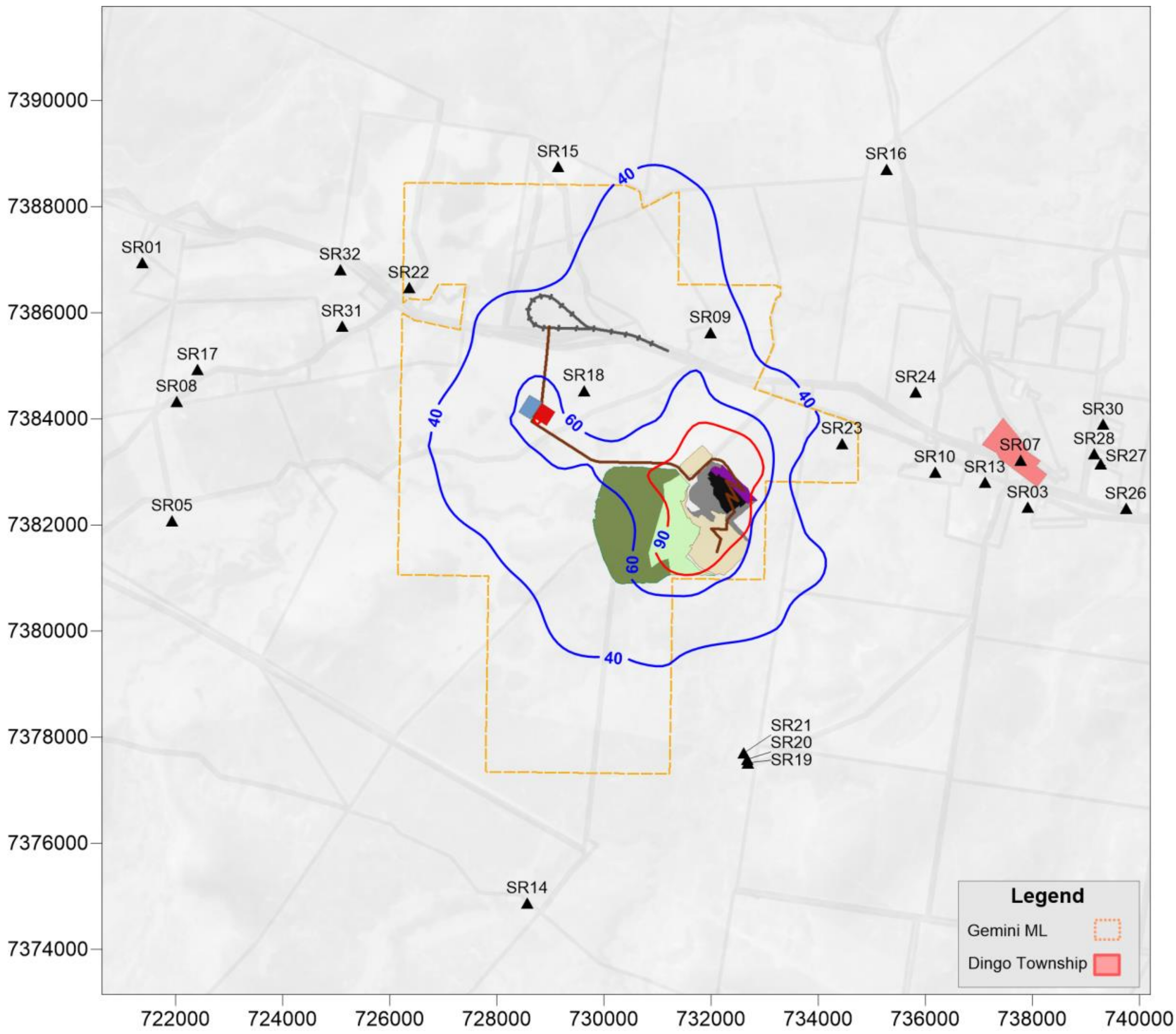

Plate 9	**Year 8 - Predicted annual average cumulative ground-level concentration of TSP using standard mitigation measures**		
Location: Gemini Project	**Averaging period:** 1 year	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 90 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

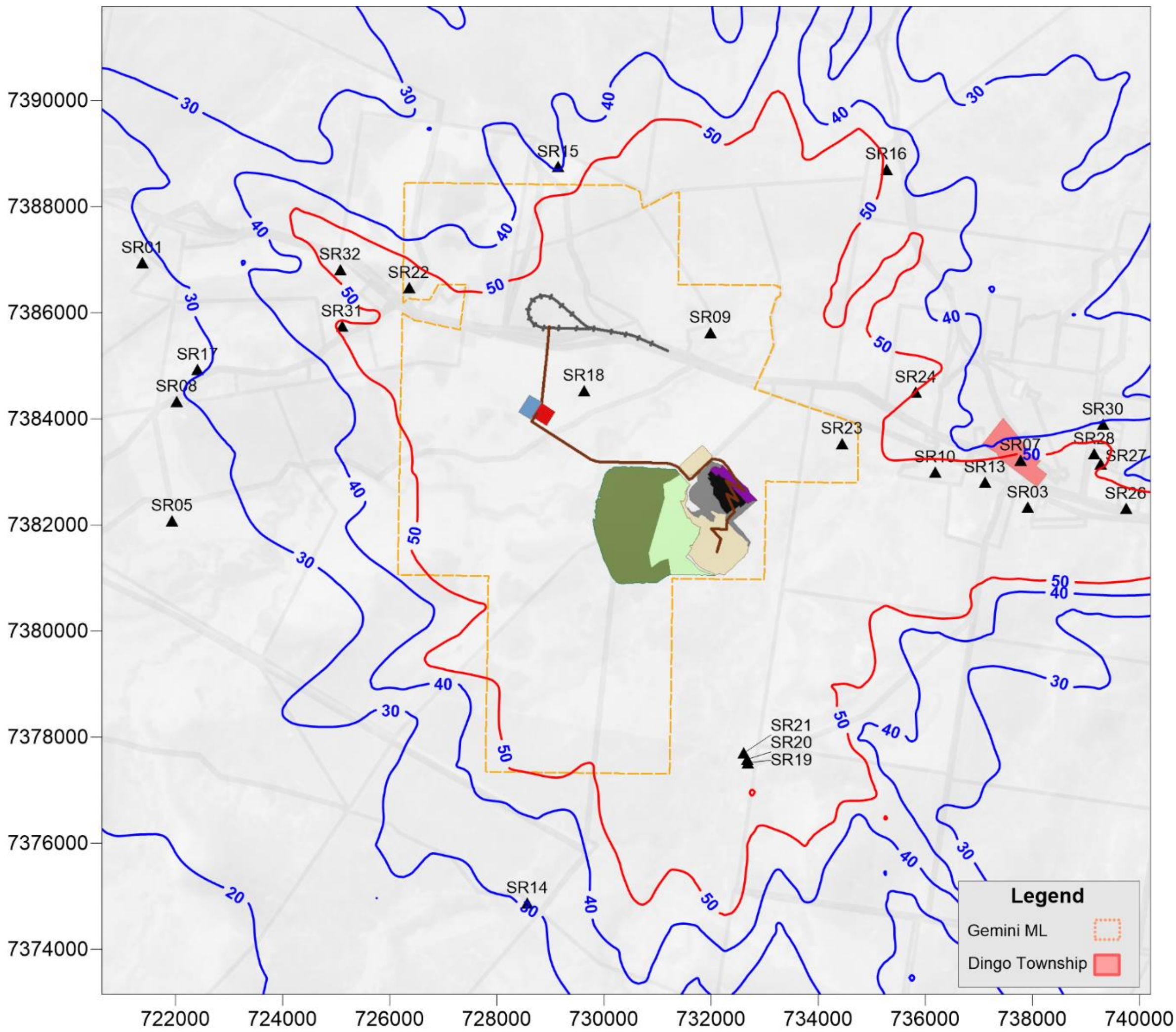

Plate 10	Year 8 - Predicted maximum 24-hour average cumulative ground-level concentration of PM_{10} using standard mitigation measures

Location: Gemini Project	**Averaging period:** 24 hours	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 50 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

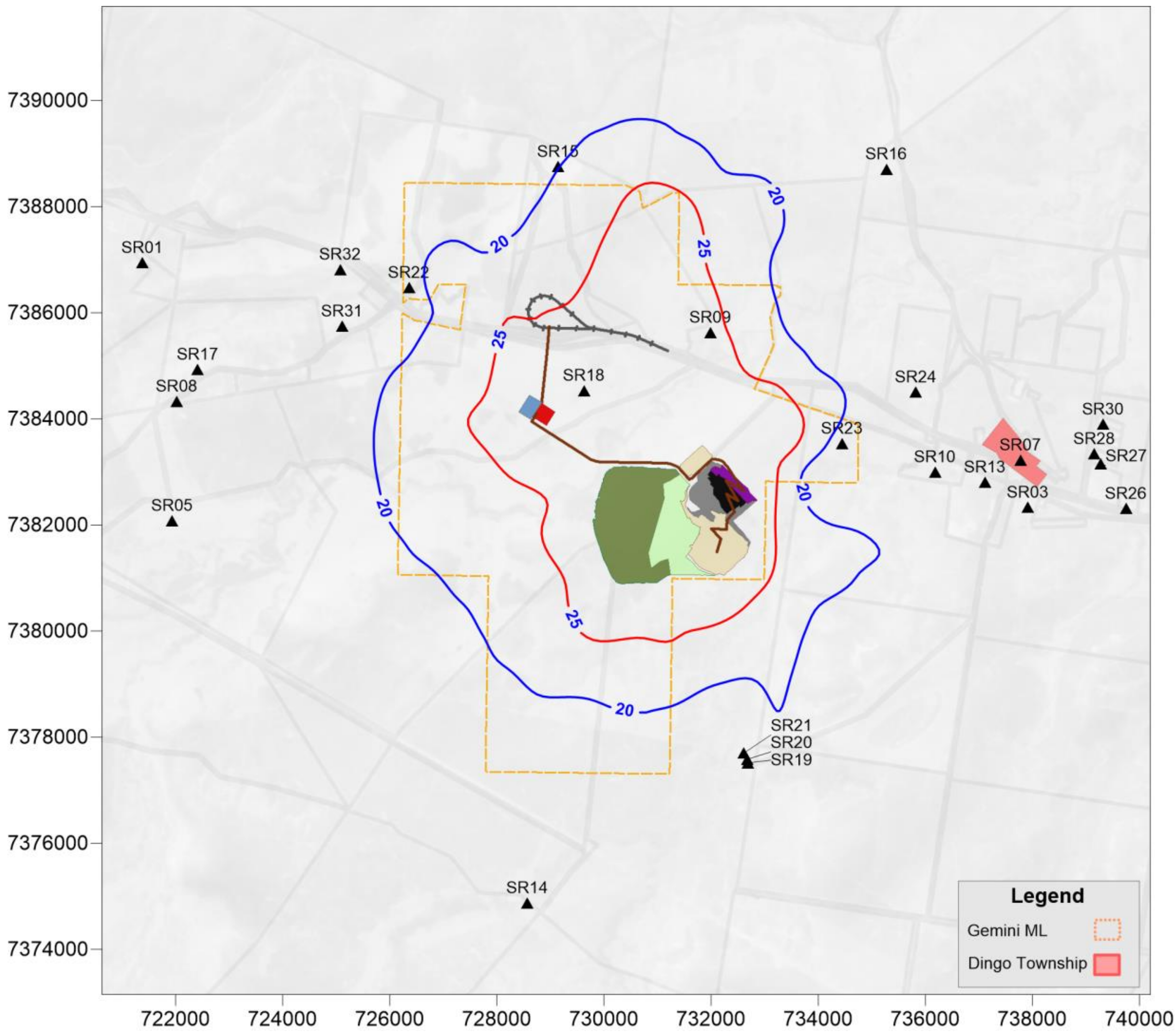

Plate 11 **Year 8 - Predicted annual average cumulative ground-level concentration of PM_{10} using standard mitigation measures**

Location:	Averaging period:	Data source:	Units:
Gemini Project	1 year	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Contour plot	25 µg/m³ (red)	Daniel Gallagher	September 2019

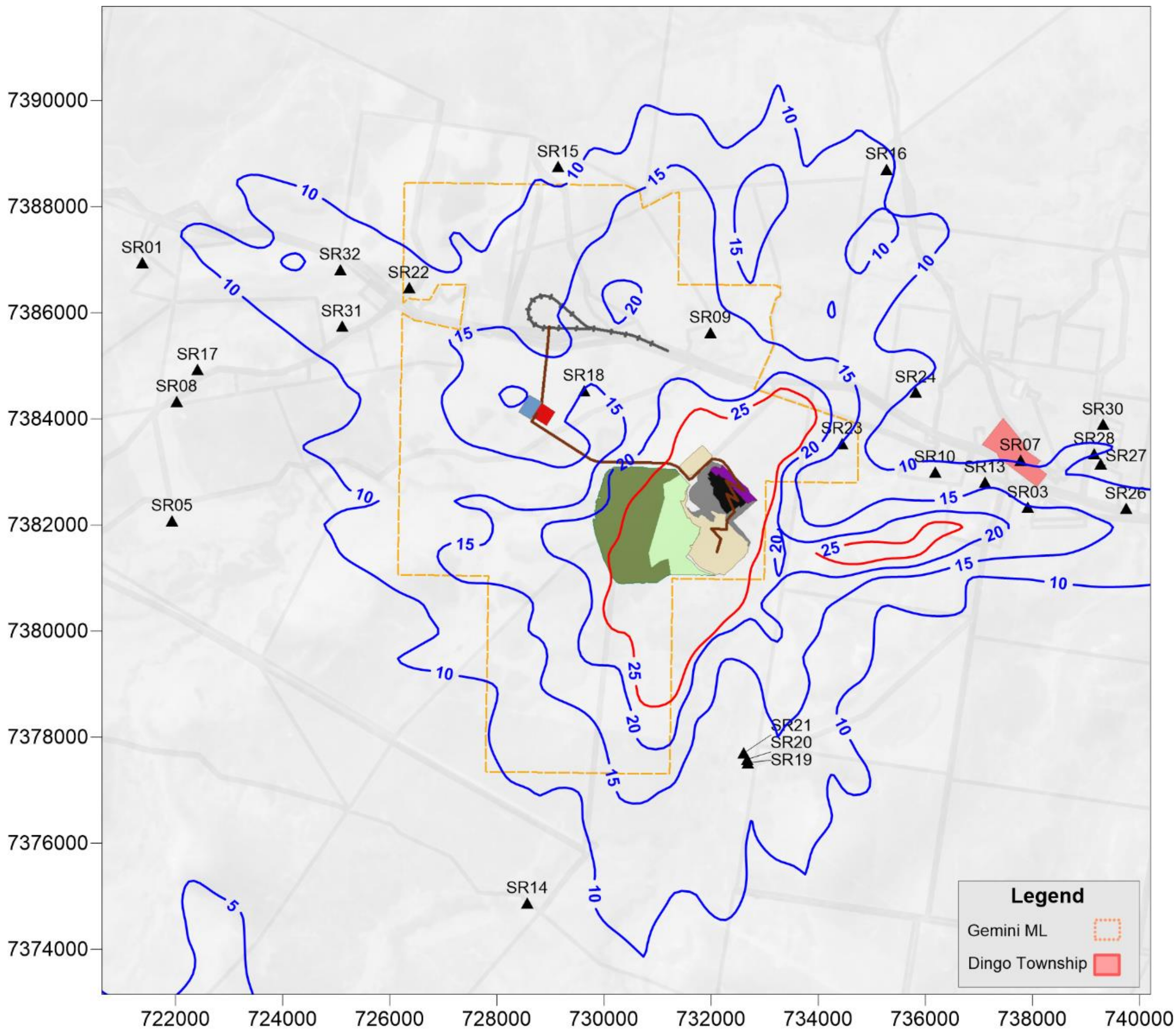

Plate 12	**Year 8 - Predicted maximum 24-hour average cumulative ground-level concentration of $PM_{2.5}$ using standard mitigation measures**

Location:	**Averaging period:**	**Data source:**	**Units:**
Gemini Project	24 hours	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Contour plot	25 µg/m³ (red)	Daniel Gallagher	September 2019

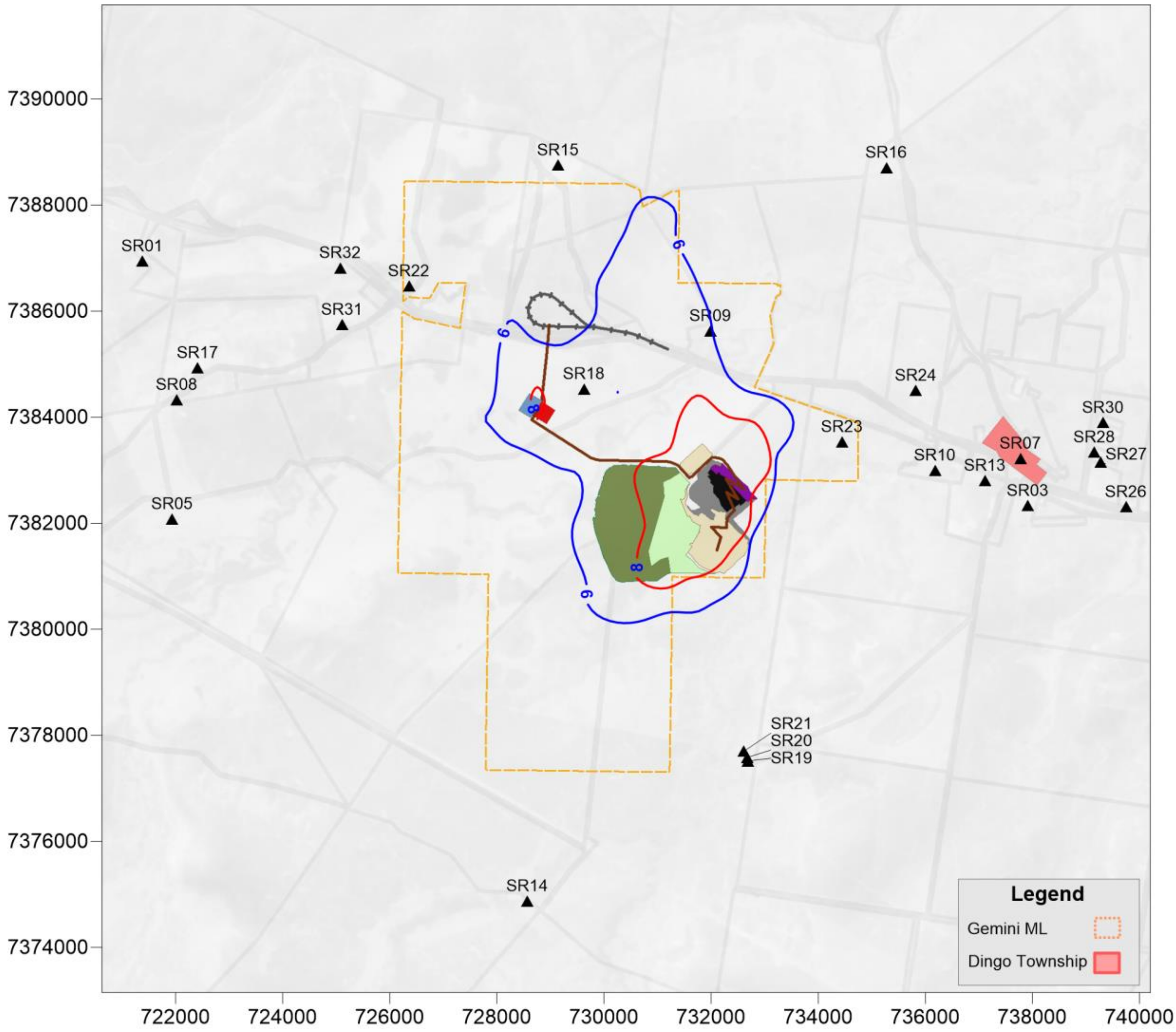

Plate 13	**Year 8 - Predicted annual average cumulative ground-level concentration of $PM_{2.5}$ using standard mitigation measures**

Location:	**Averaging period:**	**Data source:**	**Units:**
Gemini Project	1 year	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Contour plot	8 µg/m³ (red)	Daniel Gallagher	September 2019

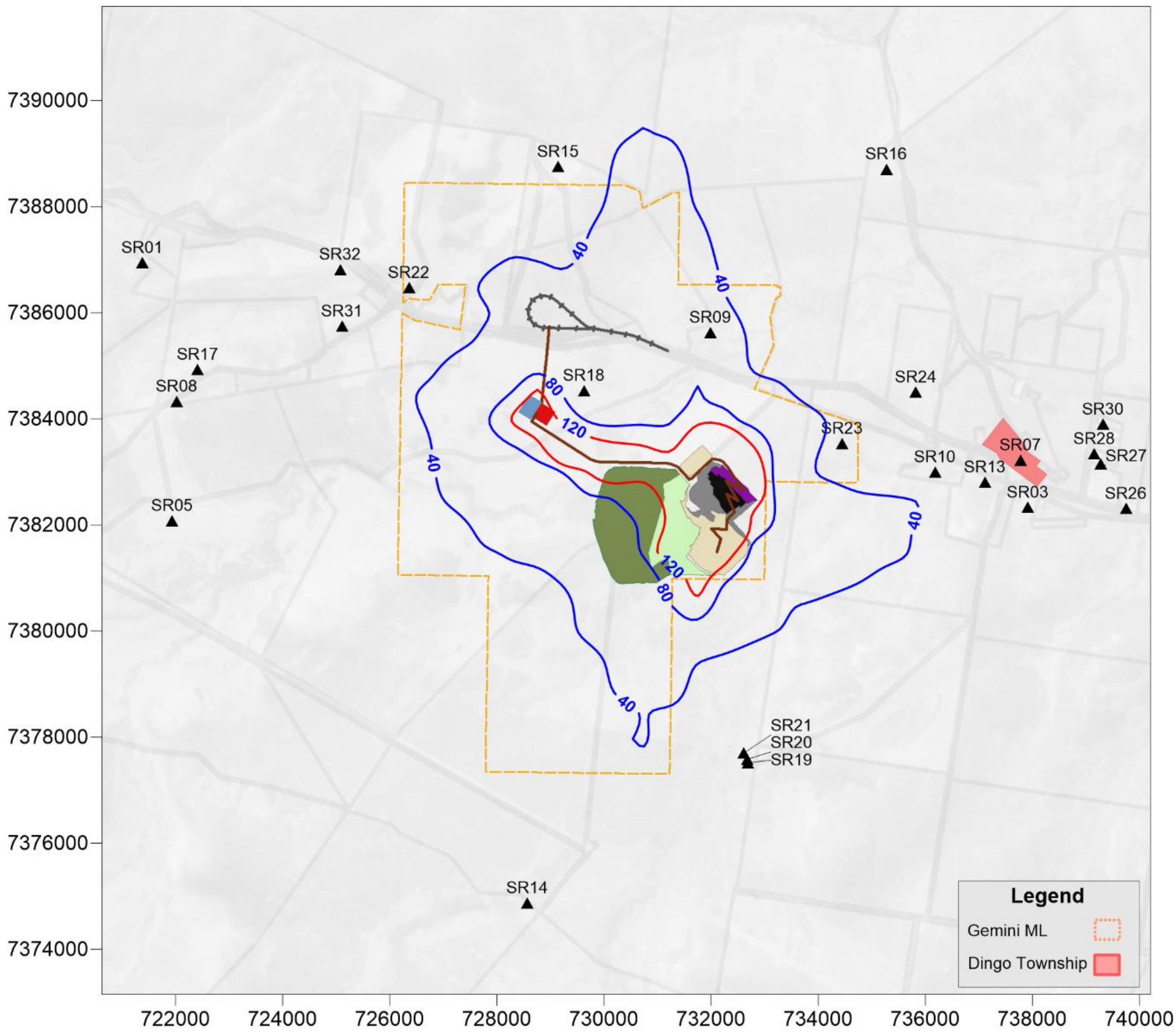

Plate 14	**Year 8 - Predicted maximum monthly cumulative dust deposition rate using standard mitigation measures**

Location:	**Averaging period:**	**Data source:**	**Units:**
Gemini Project	1 month	CALPUFF	µg/m³
Type:	**Guideline:**	**Prepared by:**	**Date:**
Contour plot	120 mg/m²/day (red)	Daniel Gallagher	September 2019

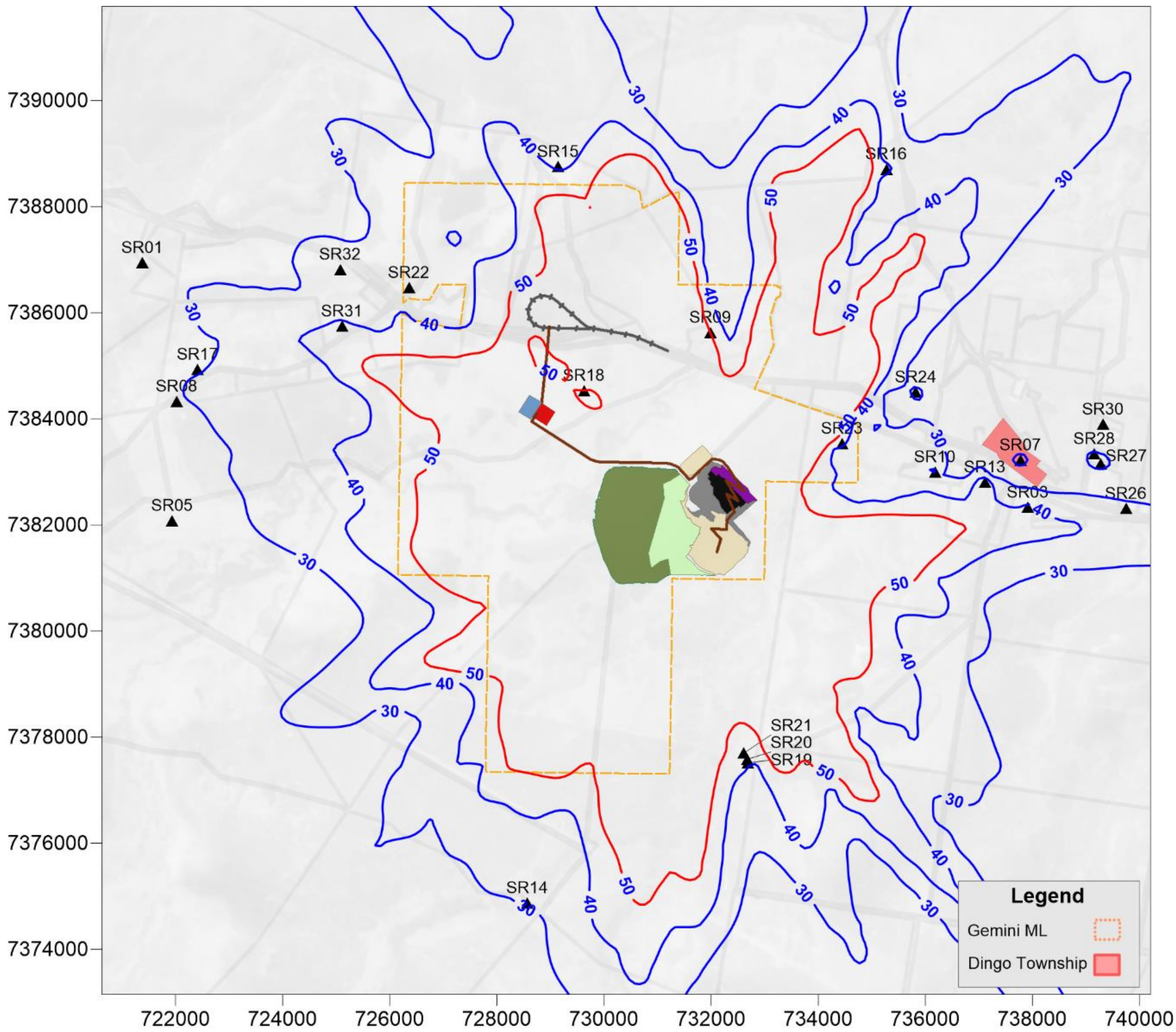

Plate 15	Year 8 - Predicted maximum 24-hour average cumulative ground-level concentration of PM_{10} using standard mitigation measures and additional mitigation when necessary

Location: Gemini Project	**Averaging period:** 24 hours	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 50 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

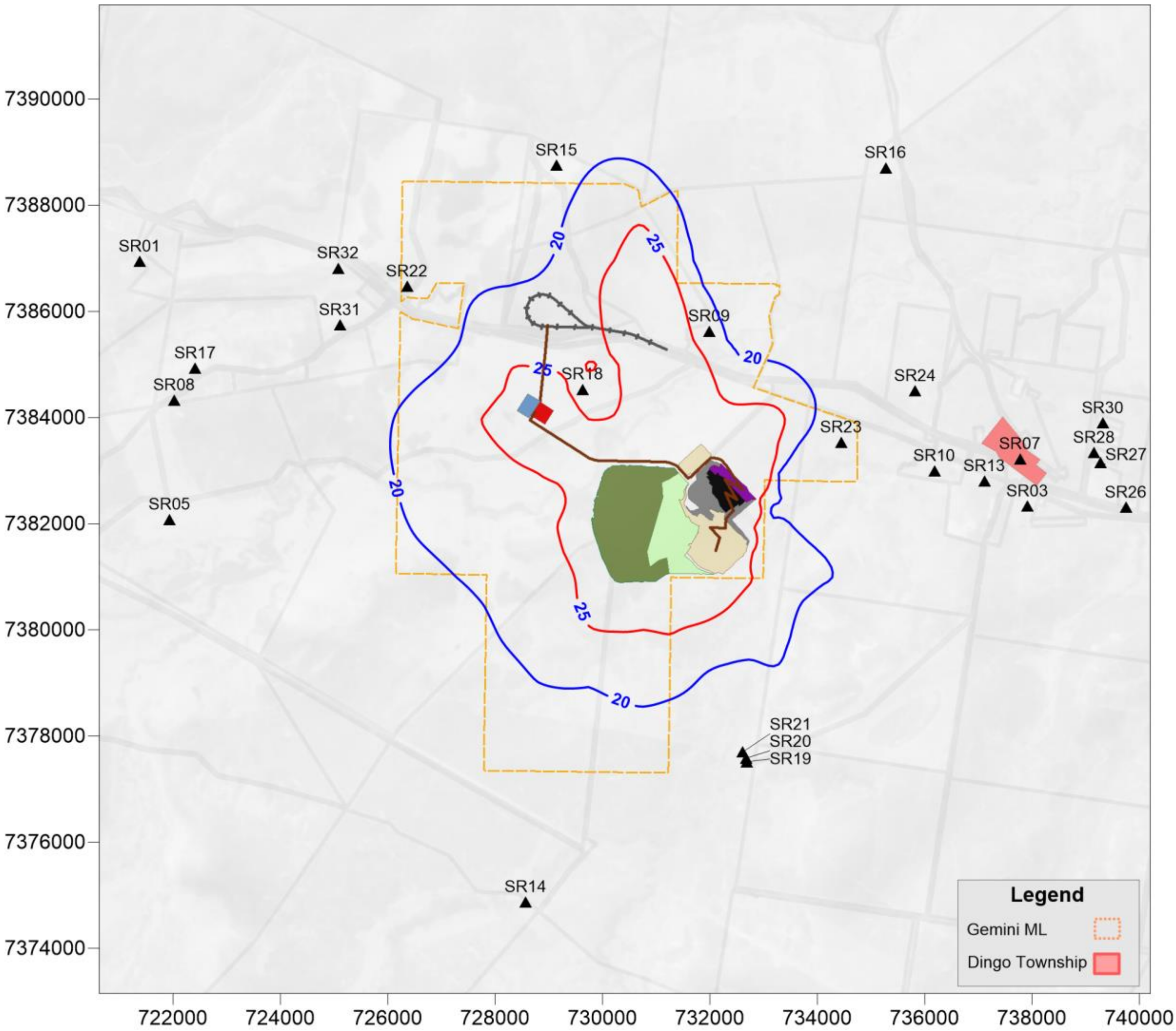

Plate 16	**Year 8 - Predicted annual average cumulative ground-level concentration of PM_{10} using standard mitigation measures and additional mitigation when necessary**

Location:	**Averaging period:**	**Data source:**	**Units:**
Gemini Project	1 year	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Contour plot	25 µg/m³ (red)	Daniel Gallagher	September 2019

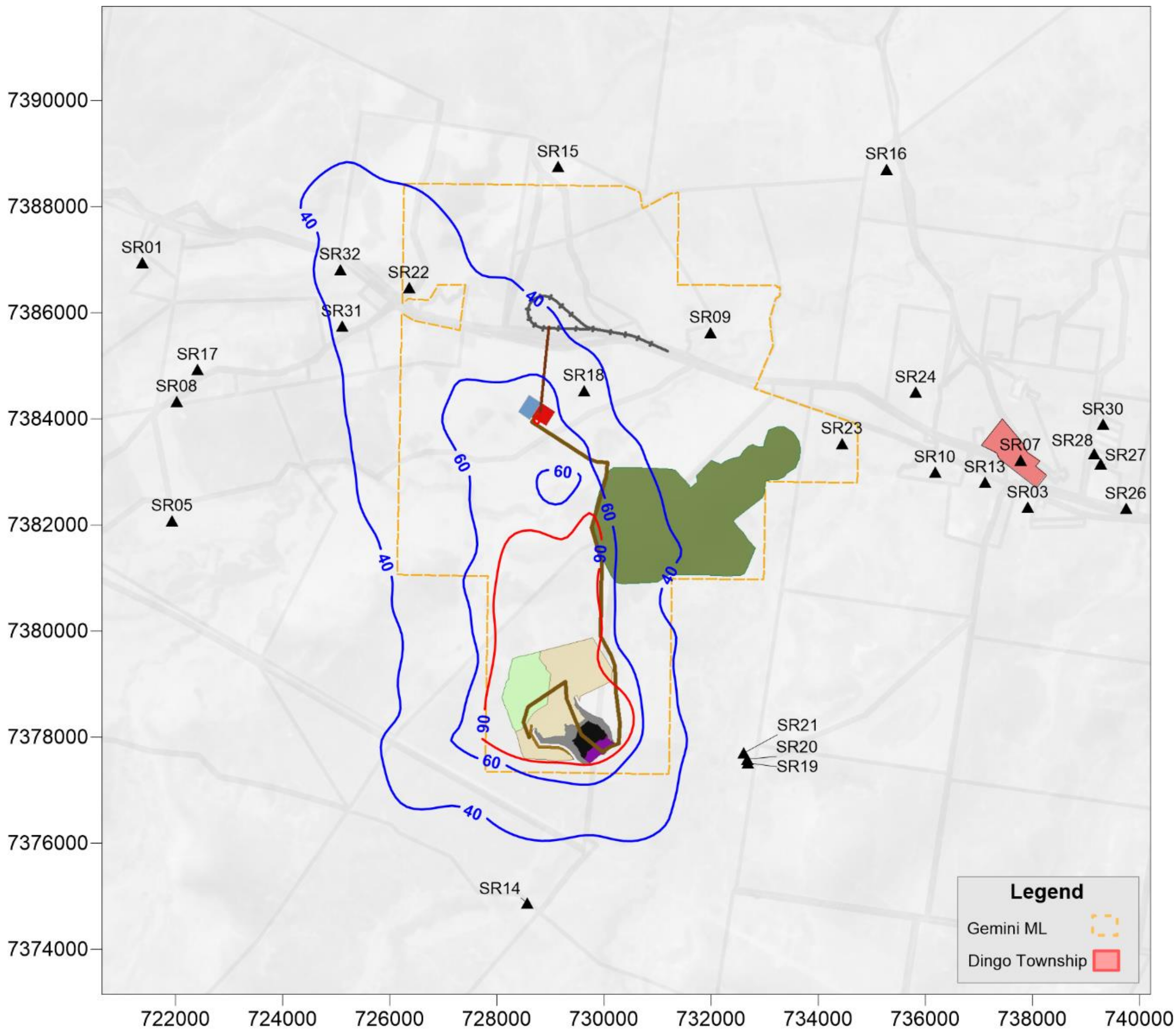

Plate 17	**Year 15 - Predicted annual average cumulative ground-level concentration of TSP using standard mitigation measures**		
Location: Gemini Project	**Averaging period:** 1 year	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 90 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

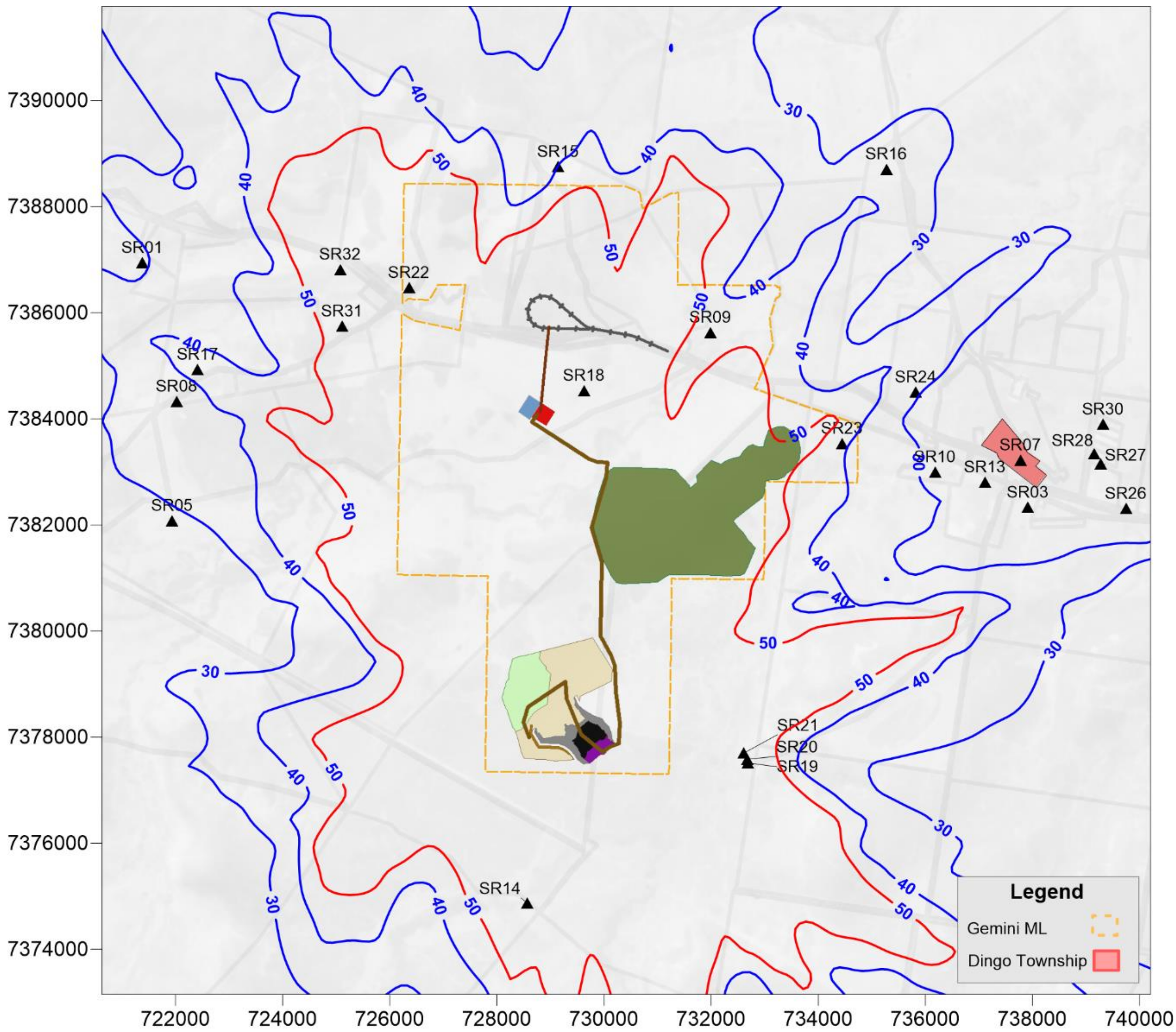

Plate 18	**Year 15 - Predicted maximum 24-hour average cumulative ground-level concentration of PM_{10} using standard mitigation measures**		
Location: Gemini Project	**Averaging period:** 24 hours	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 50 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

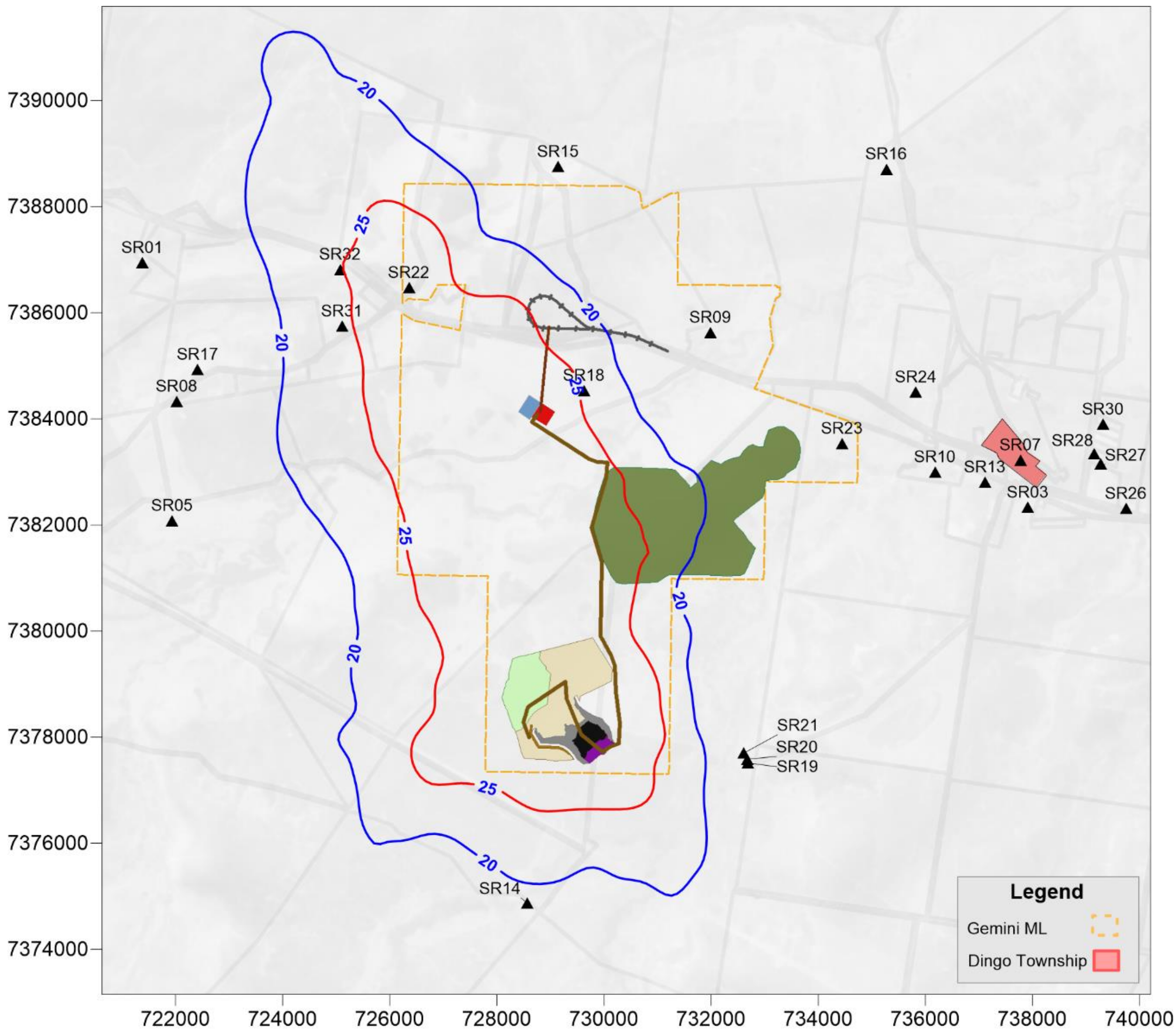

Plate 19	**Year 15 - Predicted annual average cumulative ground-level concentration of PM_{10} using standard mitigation measures**		
Location: Gemini Project	**Averaging period:** 1 year	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 25 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

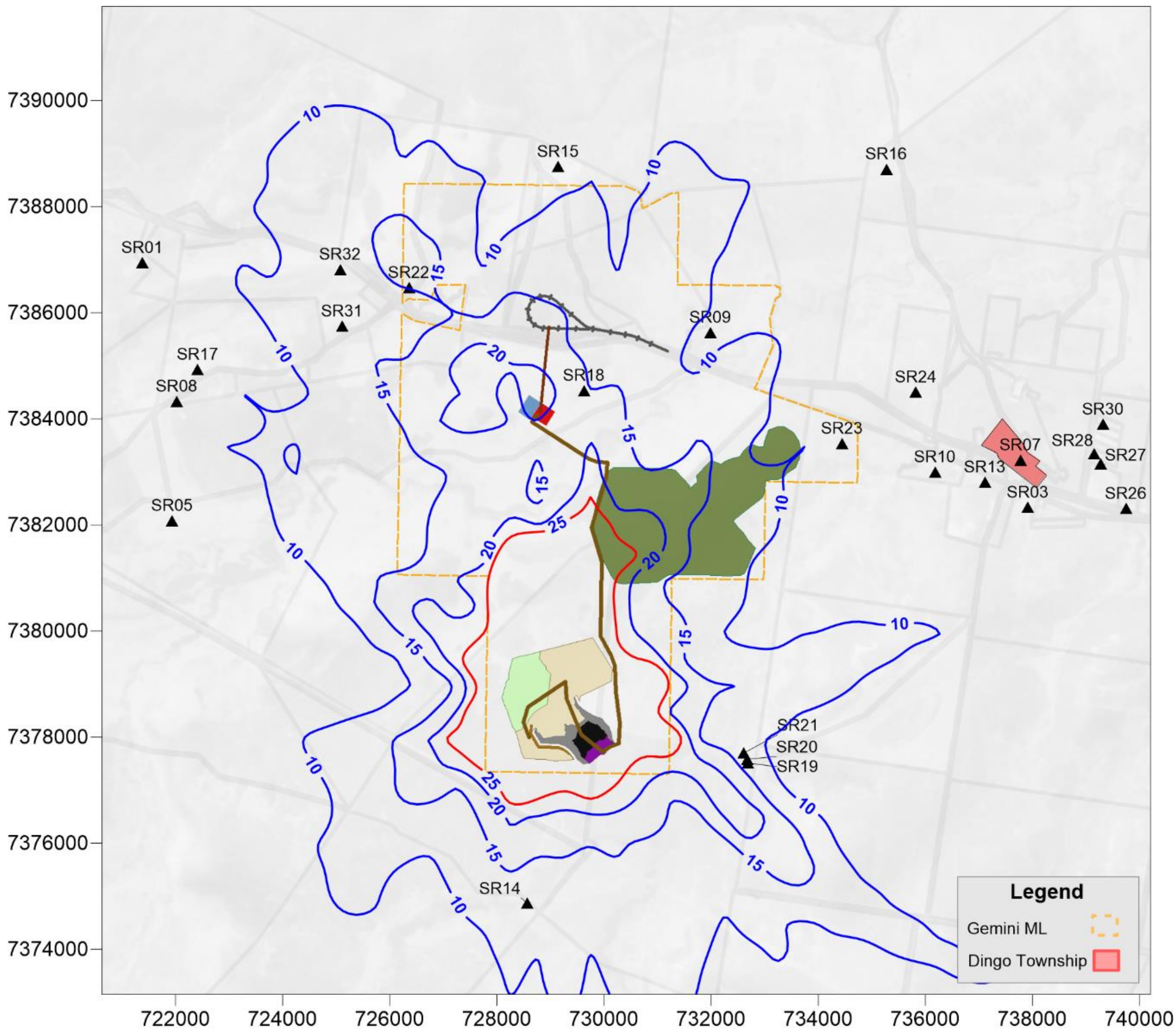

Plate 20 **Year 15 - Predicted maximum 24-hour average cumulative ground-level concentration of $PM_{2.5}$ using standard mitigation measures**

Location:	**Averaging period:**	**Data source:**	**Units:**
Gemini Project	24 hours	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Contour plot	25 µg/m³ (red)	Daniel Gallagher	September 2019

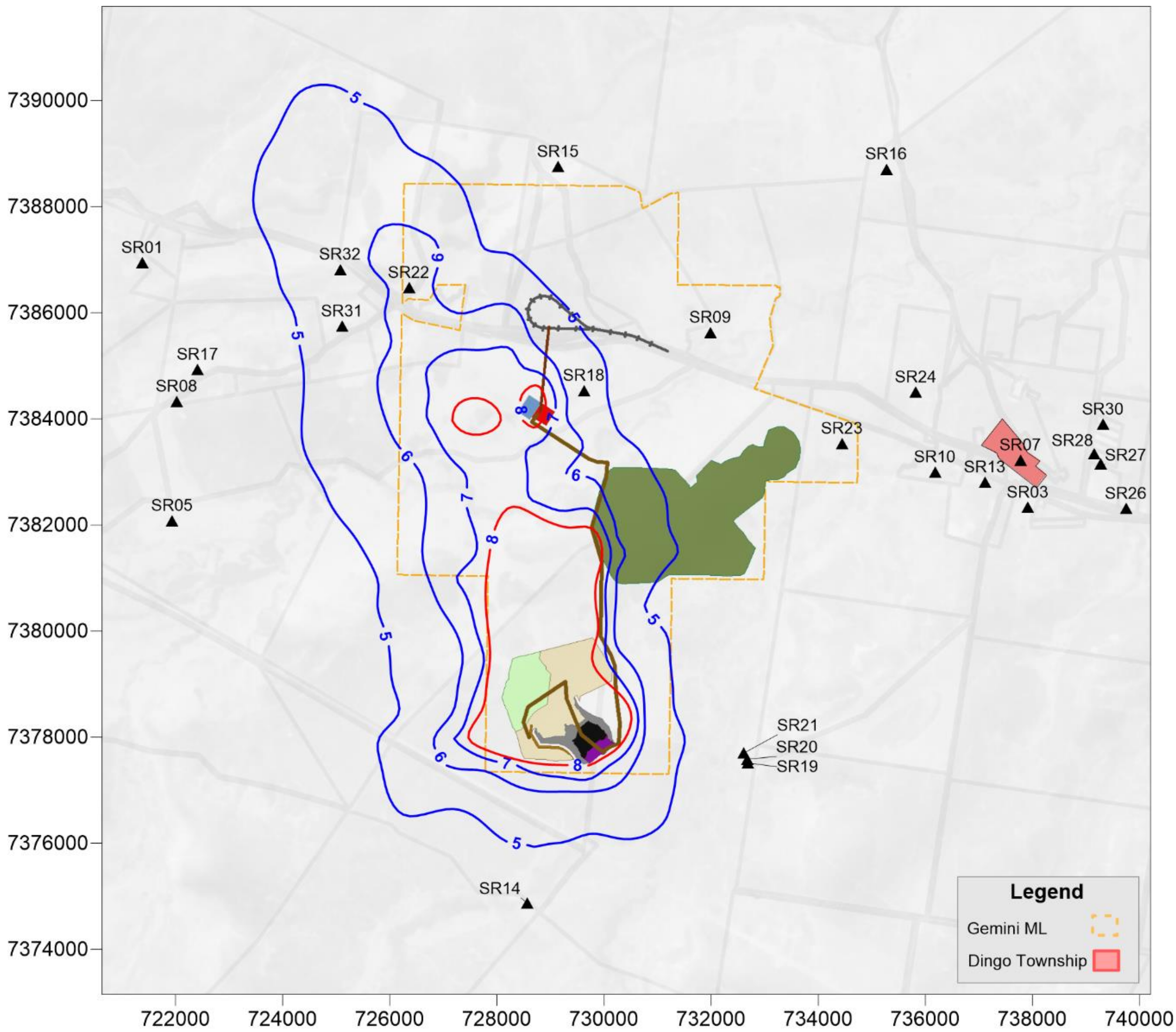

Plate 21	**Year 15 - Predicted annual average cumulative ground-level concentration of $PM_{2.5}$ using standard mitigation measures**		
Location: Gemini Project	**Averaging period:** 1 year	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 8 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

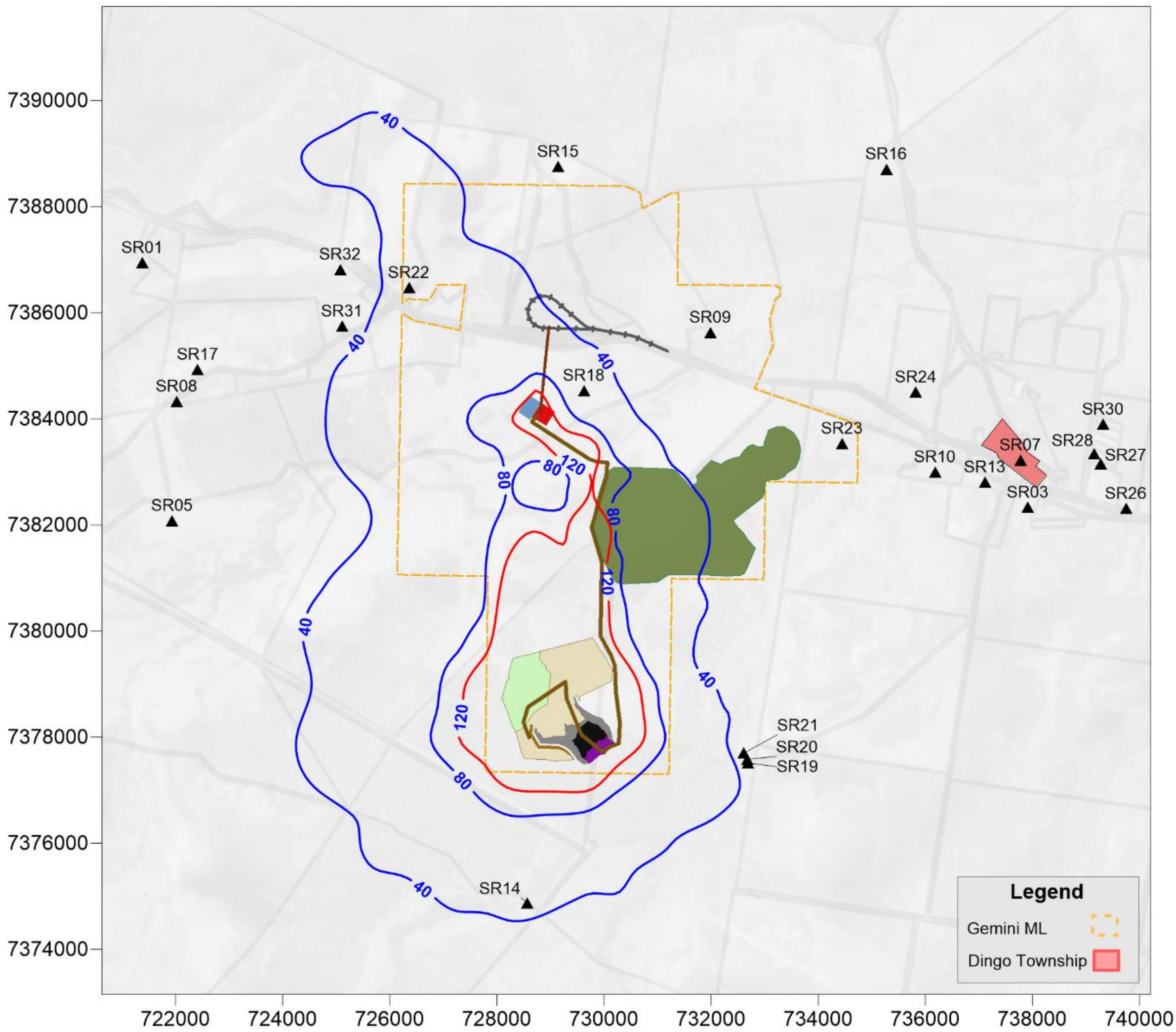

Plate 22	**Year 15 - Predicted maximum monthly cumulative dust deposition rate using standard mitigation measures**		
Location: Gemini Project	**Averaging period:** 1 month	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Guideline:** 120 mg/m²/day (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

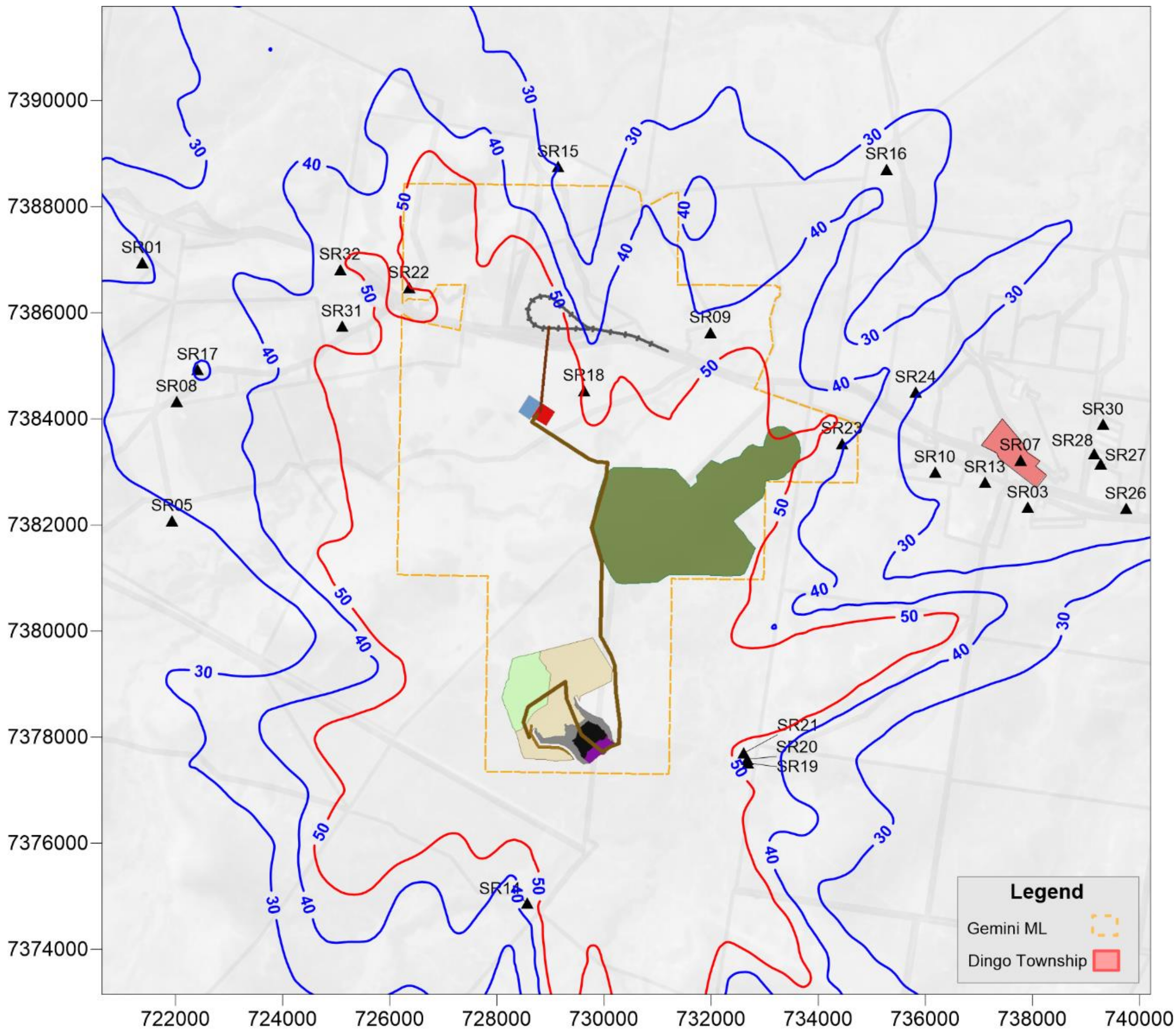

Plate 23	**Year 15 - Predicted maximum 24-hour average cumulative ground-level concentration of PM_{10} using standard mitigation measures and additional mitigation when necessary**

Location:	**Averaging period:**	**Data source:**	**Units:**
Gemini Project	24 hours	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Contour plot	50 µg/m³ (red)	Daniel Gallagher	September 2019

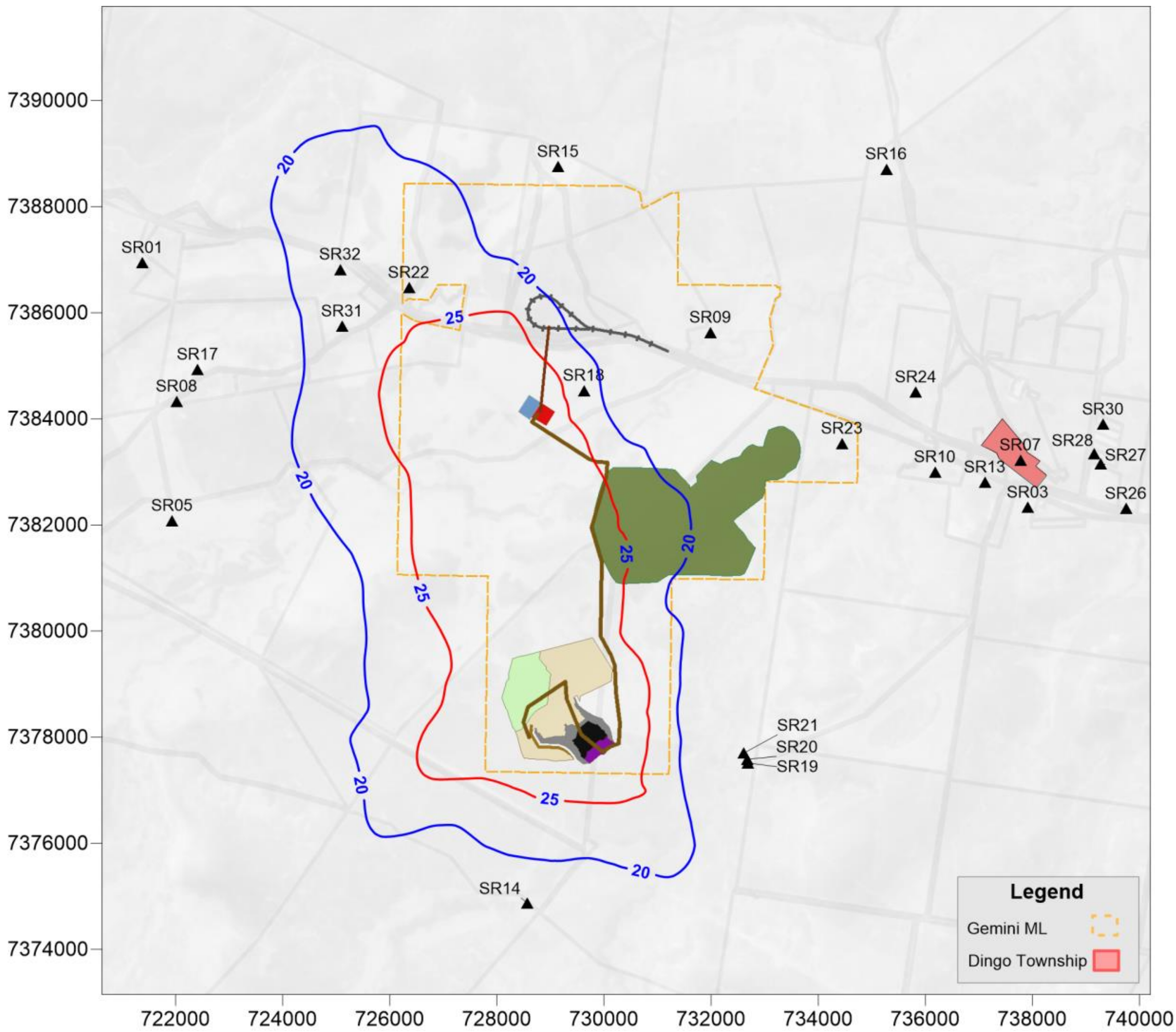

Plate 24	**Year 15 - Predicted annual average cumulative ground-level concentration of PM_{10} using standard mitigation measures and additional mitigation when necessary**		
Location: Gemini Project	**Averaging period:** annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Contour plot	**Objective:** 25 µg/m³ (red)	**Prepared by:** Daniel Gallagher	**Date:** September 2019

APPENDIX A MODELLING METHODOLOGY

A1 METEOROLOGY

A1.1 TAPM meteorological modelling

TAPM (The Air Pollution Model) was developed by the CSIRO and has been validated by the CSIRO, Katestone and others for many locations in Australia, in south-east Asia and in North America (CSIRO, 2008). Katestone has extensive experience with TAPM for sites throughout Australia and in parts of America, Bangladesh, New Caledonia and Vietnam. The model performs well in simulating regional wind patterns and has proven to be a useful tool for simulating meteorology in locations where monitoring data is unavailable.

TAPM is a prognostic meteorological model which predicts the flows important to regional and local scale meteorology, such as sea breezes and terrain-induced flows from the larger-scale meteorology provided by the synoptic analyses. TAPM solves the fundamental fluid dynamics equations to predict meteorology at a mesoscale (20 km to 200 km) and at a local scale (down to a few hundred metres). TAPM includes parameterisations for cloud/rain micro-physical processes, urban/vegetation canopy and soil, and radiative fluxes.

TAPM requires synoptic meteorological information for the region. This information is generated by a global model similar to the large-scale models used to forecast the weather. The data were supplied on a grid resolution of approximately 75km, and at elevations of 100m to 5km above the ground. TAPM uses this synoptic information, along with specific details of the location such as surrounding terrain, land-use, soil moisture content and soil type to simulate the meteorology of a region as well as at a specific location.

TAPM version 4.0.4 was configured with the following parameters:

- Modelling period from 1 January to 31 December 2016
- 50 x 50 grid point domain with nesting resolutions of 10 km, 3 km, and 10 km
- 25 vertical levels
- Grid centred on latitude -23° 39’, longitude 149° 15’
- Geoscience Australia 9 second DEM terrain data
- TAPM default land cover data and sea surface temperature
- Default options selected for advanced meteorological inputs.

A1.2 CALMET meteorological modelling

CALMET is an advanced non-steady-state diagnostic 3D meteorological model with micro-meteorological modules for overwater and overland boundary layers. It is the meteorological pre-processor for the CALPUFF modelling system. CALMET can read hourly meteorological data as data assimilation from multiple sites within the modelling domain; it can also be initialised with the gridded three-dimensional prognostic output from other meteorological models such as TAPM. This can improve dispersion model output, particularly over complex terrain as the near surface meteorological conditions are calculated for each grid point.

CALMET was used to simulate meteorological conditions in the region. The CALMET simulation was initialised with the gridded TAPM 3D wind field data from the 1 km grid. CALMET treats the prognostic model output as the initial guess field for the CALMET diagnostic model wind fields. The initial guess field is then adjusted for the kinematic effects of terrain, slope flows, blocking effects and 3D divergence minimisation.

CALMET version 6.5.0 was configured with default options and parameters, with the following exceptions:

- Modelling period from 1 January to 31 December 2016
- 94 x 94 grid point domain with 0.5 km resolution, nested within the TAPM inner domain
- 12 vertical levels at heights of 20, 60, 100, 150, 200, 250, 350, 500, 800, 1600, 2600 and 4600 metres
- Prognostic wind fields generated by TAPM input as MM5/3D.DAT at surface and upper air for “initial guess” field (no-observations mode)
- Gridded cloud cover from prognostic relative humidity at all levels
- No extrapolation of surface wind observations to upper layers
- Terrain radius of influence of 7 km
- Terrain radius of influence for temperature interpolation of 500 km.

A1.3 Analysis of dispersion meteorology

The following sections provide a description of the meteorological parameters that are important for dispersion of air pollutants in the atmosphere, namely wind speed and direction, atmospheric stability and mixing layer height. These parameters have been extracted from the TAPM/CALMET dataset at the Project site.

A1.3.1 Wind speed and wind direction

The annual, seasonal and diurnal distributions of winds predicted by TAPM/CALMET for 2016 are presented in Figure A1, Figure A2, and Figure A3 respectively. The winds are generally light to moderate and occur almost exclusively from the eastern quadrants with an average wind speed of 2.02 m/s (Figure A1). The distribution of winds is predominantly from the south-east (Figure A4). Winds are weaker during even hours (6 pm to 6 am), and stronger during daylight hours (6 am to 6 pm) (Figure A3).

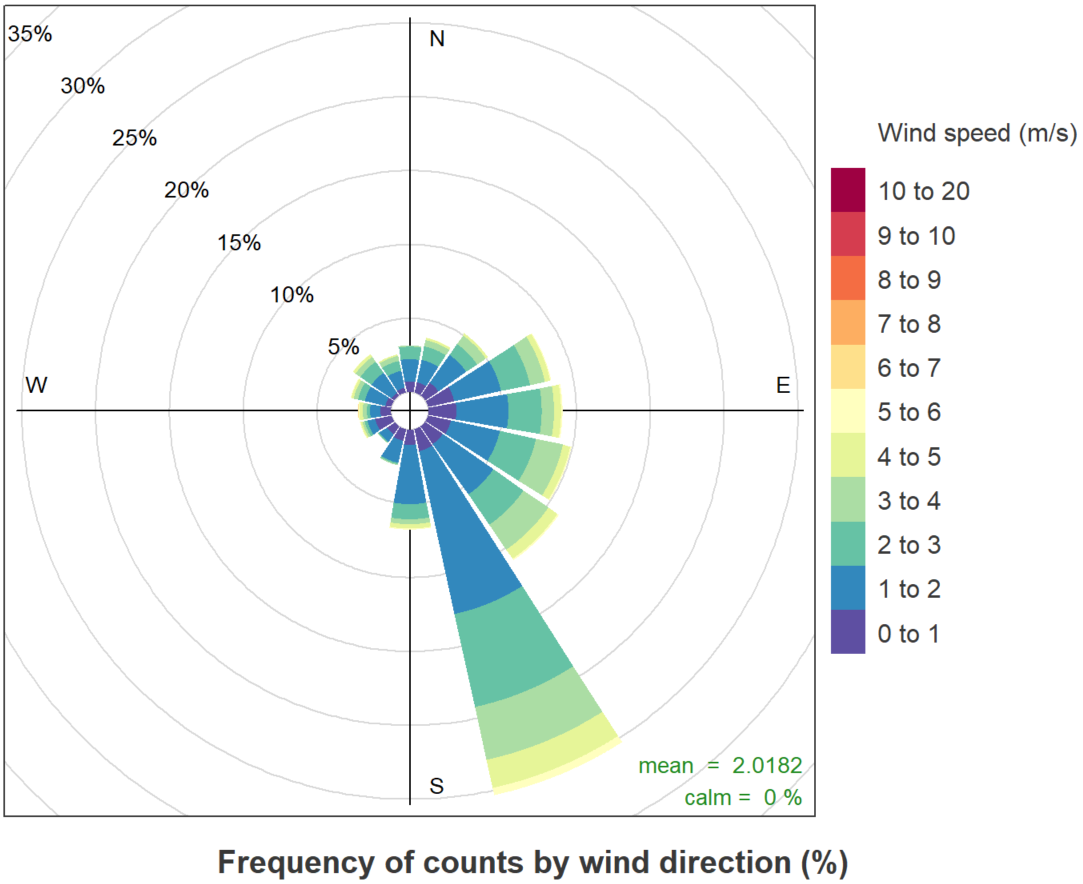

Figure A1 **Annual distribution of winds at the Project site predicted by TAPM/CALMET**

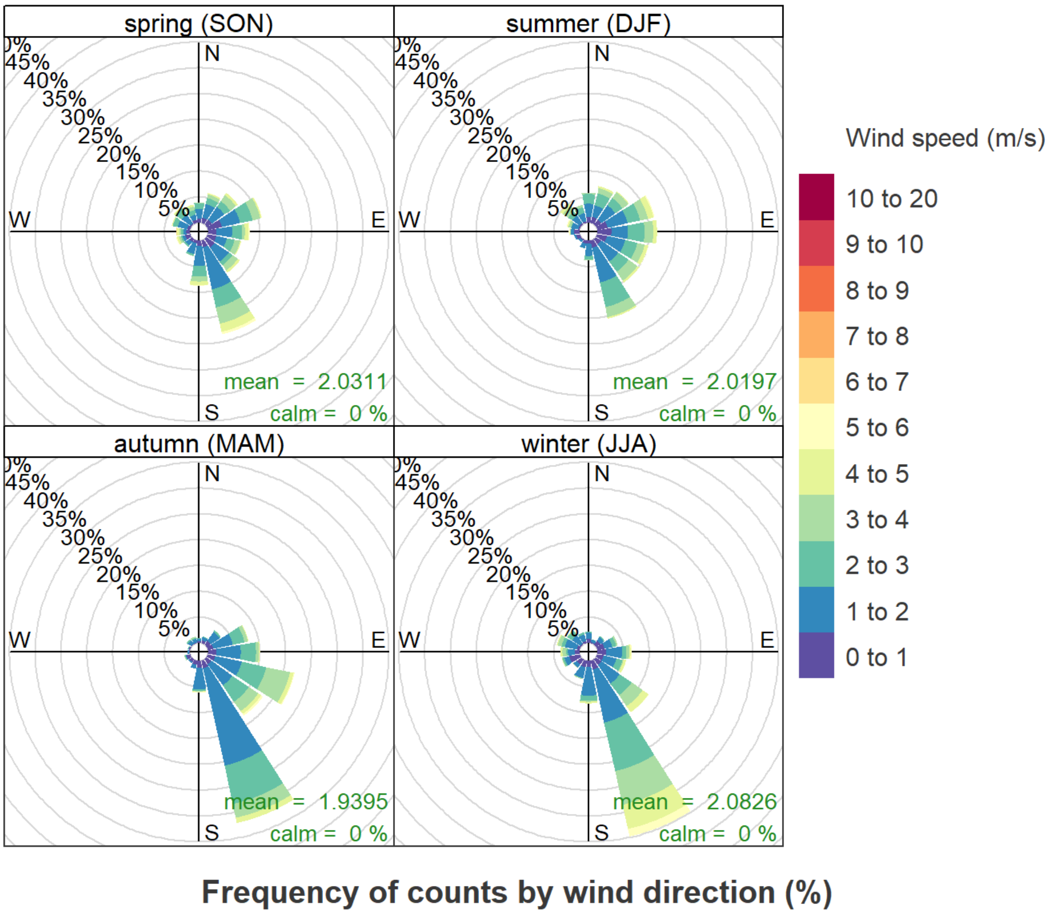

Figure A2 **Seasonal distribution of winds at the Project site predicted by TAPM/CALMET**

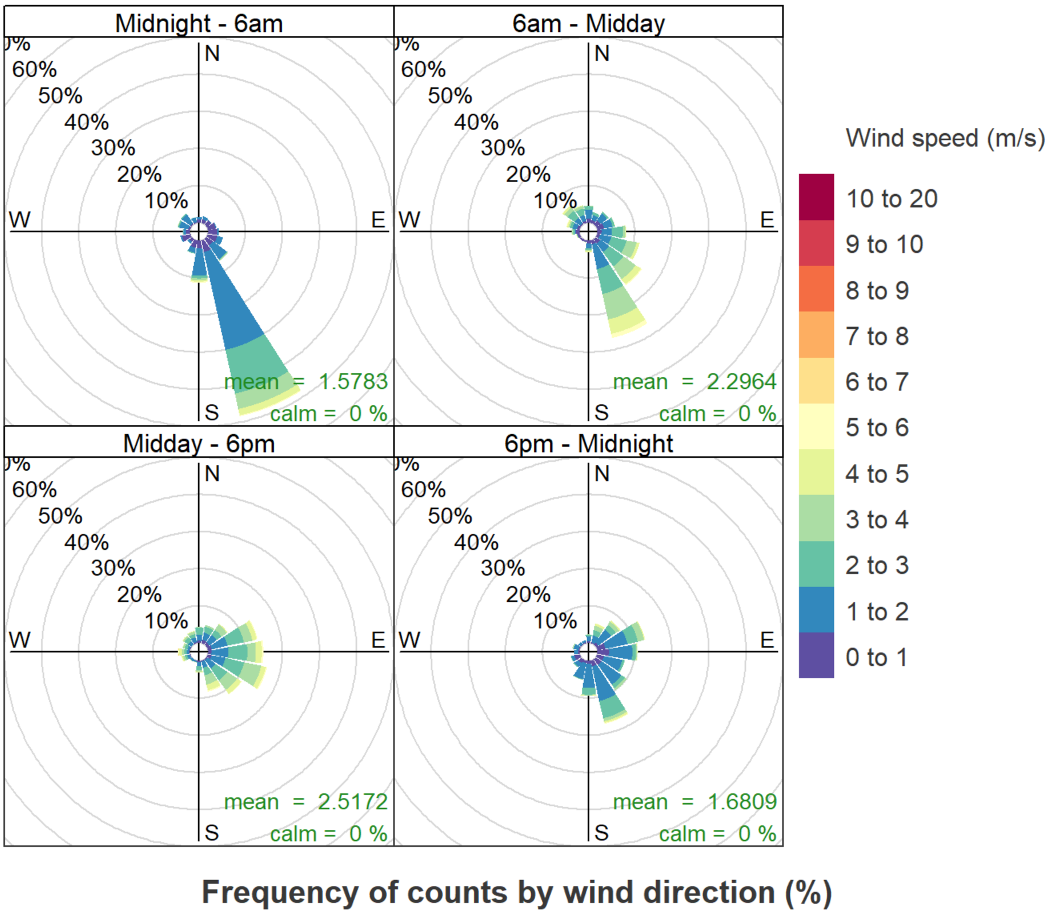

Figure A3 **Diurnal distribution of winds at the Project site predicted by TAPM/CALMET**

A1.3.2 Atmospheric stability

Stability classification is a measure of the stability of the atmosphere and can be determined from wind measurements and other atmospheric observations. The stability classes range from A Class, which represents very unstable atmospheric conditions that may typically occur on a sunny day, to F Class stability which represents very stable atmospheric conditions that typically occur during light wind conditions at night. Unstable conditions (Classes A to C) are characterised by strong solar heating of the ground that induces turbulent mixing in the atmosphere close to the ground. This turbulent mixing is the main driver of dispersion during unstable conditions. Dispersion processes for Class D conditions are dominated by mechanical turbulence generated as the wind passes over irregularities in the local surface. During the night, the atmospheric conditions are generally stable (often Classes E and F).

Figure A4 shows the distribution of stability classes at the Project site extracted from the TAPM/CALMET dataset, where Class A represents the most unstable conditions and Class F represents the most stable. Neutral (D class) conditions are present throughout the day. Very stable (F class) conditions are the next most frequent and only occur between 5 pm and 6 am.

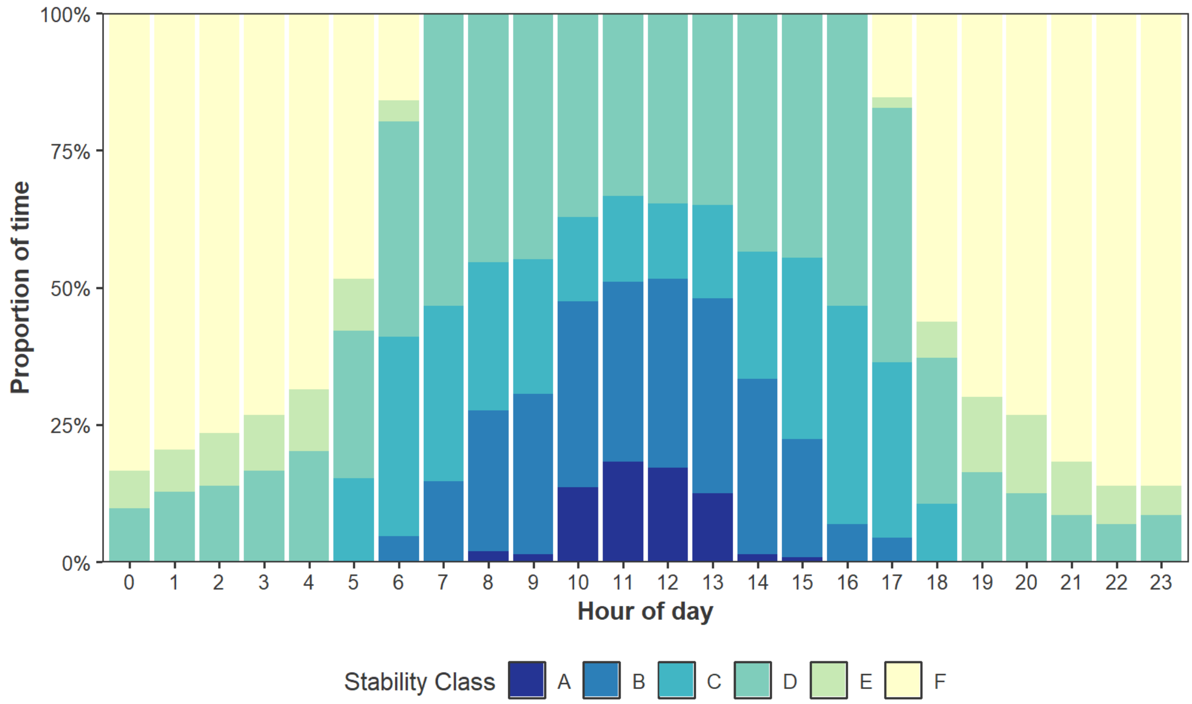

Figure A4 Diurnal stability class at the Project site predicted by TAPM/CALMET

A1.3.3 Mixing height

The mixing height defines the height of the mixed atmosphere above the ground (mixed layer), which varies diurnally. Particulate matter, or other pollutants released at or near the ground, will become dispersed within the mixed layer. During stable atmospheric conditions, the mixing height is often quite low and particulate dispersion is limited to within this layer. During the day, solar radiation heats the ground and causes the air above it to warm, resulting in convection and an increase to the mixing height. The growth of the mixing height is dependent on how well the warmer air from the ground can mix with the cooler upper level air and, therefore, depends on meteorological factors such as the intensity of solar radiation and wind speed. Strong winds cause the air to be well mixed, resulting in a high mixing height.

Mixing height information extracted from the TAPM/CALMET dataset at the Project site is presented in Figure A5 as a diurnal frequency (box and whisker) plot. The data shows that, on average, the mixing height develops around 6 am and peaks at 3-4 pm before descending rapidly until 6 pm.

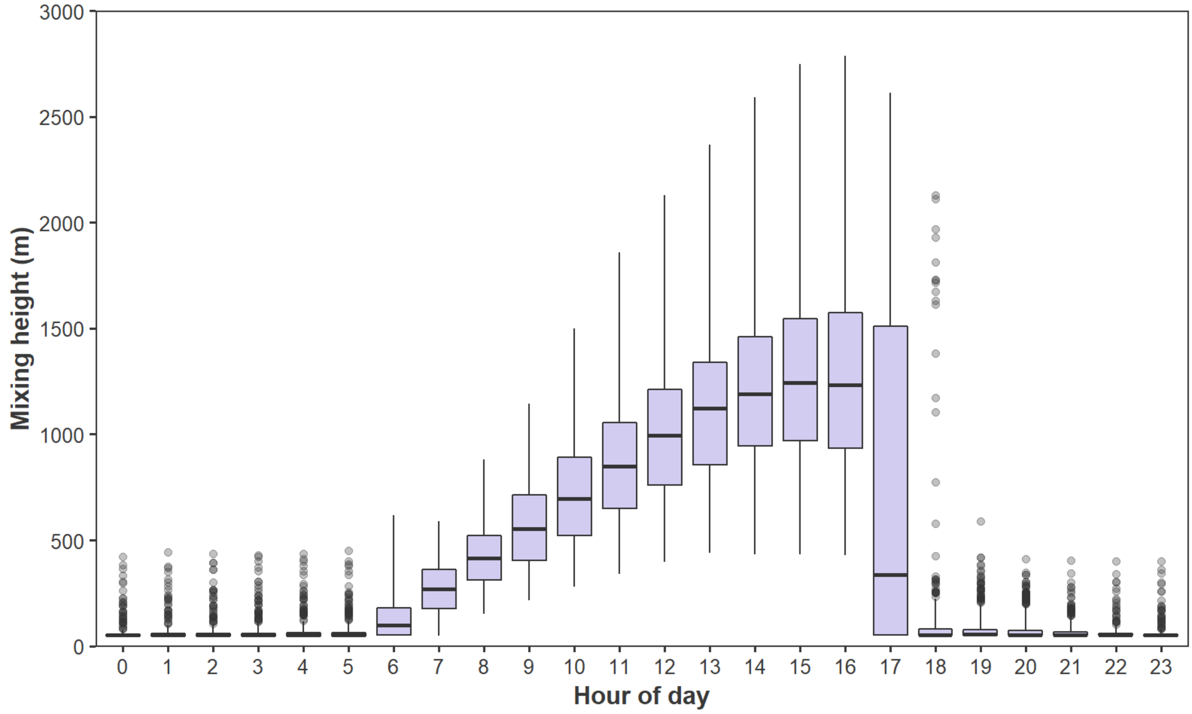

Figure A5 Diurnal mixing height at the Project site predicted by TAPM/CALMET

A2 CALPUFF DISPERSION MODELLING

CALPUFF simulates the dispersion of air pollutants to predict ground-level concentration and deposition rates across a network of receptors spaced at regular intervals, and at identified discrete locations. CALPUFF is a non-steady-state Lagrangian Gaussian puff model containing parameterisations for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation.

CALPUFF employs the 3D meteorological fields generated from the CALMET model by simulating the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal. CALPUFF takes into account the geophysical features of the study area that affects dispersion of pollutants and ground level concentrations of those pollutants in identified regions of interest. CALPUFF contains algorithms that can resolve near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub grid scale terrain interactions, as well as the long-range effects of removal, transformation, vertical wind shear, overwater transport and coastal interactions. Emission sources can be characterised as arbitrarily-varying point, area, volume and lines or any combination of those sources within the modelling domain.

CALPUFF version 7.2.1 was configured with default options and parameters, with the following exceptions:

- Modelling period from 1 January to 31 December 2016
- 94 x 94 grid point domain with 0.5 km resolution
- Gridded three-dimensional hourly-varying meteorological conditions generated by CALMET
- No chemical transformation or wet removal modelled
- PDF used for dispersion under convective conditions
- Dispersion coefficients calculated internally from sigma v and sigma w using micrometeorological variables.

A2.1 Source configuration

Emissions were modelled in CALPUFF using area sources with a constant, diurnal (blasting) or hourly-varying (wind erosion) profile. Source characteristics for the modelled activity classes are presented in Table A1.

Table A1 CALPUFF area source characteristics

Emission source	Effective height (m)	Initial vertical dispersion coefficient (σ_z)
Drilling and blasting	8.0	2.0
Material extraction	8.0	2.0
Dumping and bulldozing	10	2.5
Haulage	10.0	2.5
Rehabilitation activities	4.0	1.0
Wind erosion	1.0	0.25
CHPP and related activities	10.0	2.5

APPENDIX B ACTIVITY DATA

Operational parameters and activity data for the Project, used as input for the emissions calculations, are provided in Table B1.

Table B1 Summary of activity data used in emissions calculations

Activity	Values Year 2	Values Year 8	Values Year 15	Units	Information source
Operations					
Days per year	363	363	363	Days/year	MAGNETIC SOUTH
Standard hours of operation	24	24	24	hours/day	
Blasting hours	8	8	8	hours/day	
Hours on rehabilitation	8	8	8	hours/day	
Throughput					
Total ROM coal	900,000	1,830,000	1,800,000	tonnes	MAGNETIC SOUTH
Total product coal	673,000	1,383,000	1,383,000	tonnes	
Overburden - truck and shovel	29,093,000	29,869,000	28,638,000	tonnes	
Drilling and blasting					
Blasting frequency	53	40	37	blasts/year	MAGNETIC SOUTH
Holes drilled per blast (average)	313	313	313	holes/blast	
Blast area (average)	25,000	25,000	25,000	m^2	
Mine areas					
Active pit area	308,872	272,321	226,162	ha	Calculated
ROM stockpile	4	4	4	ha	MAGNETIC SOUTH
Product stockpile	1.5	1.5	1.5	ha	MAGNETIC SOUTH

Activity	Values Year 2	Values Year 8	Values Year 15	Units	Information source
Topsoil/Overburden dump area	1,948,563	1,077,910	1,935,996	ha	Calculated
Rehabilitating area	1,059,905	1,090,231	893,970	ha	
Rehabilitated area	NA	2,425,137	6,588,031	ha	
Pit shell	330,579	471,153	326,127	ha	
Transport					
ROM coal haulage to CHPP	91,440	240,748	289,108	VKT/year	Calculated
OB haulage to dump	1,035,646	937,676	1,285,363	VKT/year	
Rejects haulage to dump	19,812	63,278	58,143	VKT/year	
Bulldozing					
Number of dozers in operation	7	7	7	#	MAGNETIC SOUTH
Total hours of operation per vehicle per year	4,500	4,500	4,500	hr.op/year/vehicle	
Grading					
Number of graders in operation	2	2	2	#	MAGNETIC SOUTH
Grading speed (3500hrs/yr)	10	10	10	km/h	
Driving speed (1000hrs/yr)	30	30	30	km/h	
Total grader travel	130,000	130,000	130,000	VKT/year	Calculated
Conveying					
Length of enclosed conveyor	1.1	1.1	1.1	km	MAGNETIC SOUTH
Length of conveyor with windbreak	0.5	0.5	0.5	km	
Material characteristics					
ROM coal moisture content	10.4	10.4	10.4	%	AP42 Ch11.9 Table 11.9-4

Activity	Values Year 2	Values Year 8	Values Year 15	Units	Information source
ROM coal silt content	8.6	8.6	8.6	%	AP42 Ch11.9 Table 11.9-3
Overburden moisture content	7.9	7.9	7.9	%	AP42 Ch11.9 Table 11.9-3
Overburden silt content	6.9	6.9	6.9	%	AP42 Ch11.9 Table 11.9-3
Overburden density	2.3	2.3	2.3	%	MAGNETIC SOUTH
Pit haul road silt content	8.4	8.4	8.4	%	AP42 13.2.2-1
CHPP haul road silt content	8.4	8.4	8.4	%	AP42 13.2.2-1
Product moisture content	8.0	8.0	8.0	%	MAGNETIC SOUTH
Meteorology					
Mean onsite wind speed	2.018	2.018	2.018	m/s	TAPM/CALMET modelling