IB Operations Pty Ltd

North Star Magnetite Extension

Air Quality Assessment

June 2021

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Executive summary

IB Operations Pty Ltd operate the North Star magnetite mine located in Marble Bar, Western Australia and is currently developing Stage 2 of the project, approved under Ministerial Statement 993. IB Operations Pty Ltd plan to incorporate an extension of the mine through the development of additional deposits immediately south of North Star, known as North Star Extension (the Project), to be assessed under Section 38 of the *Environmental Protection Act 1986*. The Project will include full-depth mining from open pits and the development of the associated waste rock dump(s), with ore processing to be incorporated in the existing approved facilities.

This report provides results of an air quality assessment undertaken for the proposed extension of the mine (the Project) and includes dust dispersion modelling for the North Star mine Stage 2 proposal.

Dispersion modelling was undertaken for four operating scenarios representing approved Stage 2 operations (Scenario One), North Star Extension operations (Scenario Two), interim mining operations (Scenario Three) and North Star Extension operations with dust mitigation (Scenario Four). Dispersion modelling was carried out using the AERMOD dispersion model for particulate matter with an aerodynamic diameter of 10 microns (PM_{10}) or less, 2.5 microns or less($PM_{2.5}$), total suspended particulates (TSP) and dust deposition.

Dust emissions were estimated based on information provided by IB Operations Pty Ltd and methods described in the National Pollutant *Inventory Emission Estimation Technique Manual for Mining (Version 3.1).*

Dust concentrations were predicted at the nearby mine village (Japal Village) and were compared to the following dust criteria:

- *National Environment Protection (Ambient Air Quality) Measure*
- *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*
- *Environmental Protection (Kwinana) (Atmospheric Waste) Policy 1992*

For Scenario One, the predicted 24-hour TSP concentration exceeded the criterion by 21 percent. The dispersion modelling predicted a total of three exceedance days in the year for TSP.

For Scenario Two, the predicted 24-hour PM_{10} and TSP concentrations exceeded the criteria by 15 percent and 13 percent respectively. Dispersion modelling predicted a total of two exceedance days in the year for both 24-hour PM_{10} and TSP.

For Scenario Three, the predicted 24-hour PM_{10} and $PM_{2.5}$ concentrations exceeded the criteria by 564 percent and 114 percent respectively. Dispersion modelling predicted a total of 23 exceedance days in the year for 24-hour PM_{10} and only one exceedance day in the year for 24-hour $PM_{2.5}$. This scenario represents interim mining operations only.

For Scenario Four, the predicted 24-hour PM_{10} and TSP concentrations exceeded the criteria by six percent and four percent respectively. Dispersion modelling predicted a total of one exceedance day in the year for 24-hour PM_{10} and three exceedance days in the year for TSP.

List of abbreviations

Abbreviated term	Description
Air NEPM	National Environment Protection (Ambient Air Quality) Measure
Ambient Air SEP	State Environmental (Ambient Air) Policy 2009
AWS	Automatic weather station
BoM	Bureau of Meteorology
COS	Coarse ore stockpile
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DRL	Dry rejects landform
EPA	Environmental Protection Authority
GHD	GHD Pty Ltd
GLC	Ground level concentration
IBO	IB Operations Pty Ltd
Kwinana EPP	Environmental Protection (Kwinana) (Atmospheric Waste) Policy
LOM	Life of mine
Mt	Million tonnes
NCEP	National Centres for Environmental Protection
NEPC	National Environment Protection Council
NPI	National Pollutant Inventory
NSW AMMAAP	Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales
OPF	Ore processing facility
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 2.5 microns or less
PM_{10}	Particulate matter with an aerodynamic diameter of 10 microns or less
The Regulations	Environmental Protection (Kwinana) (Atmospheric Wastes) Regulations 1992
ROM	Run of mine
SO2	Sulphur dioxide
TAPM	The Air Pollution Model
TSP	Total suspended particulates
WRD	Waste rock dump

1. Introduction

1.1 Project description

IB Operations Pty Ltd (IBO) operate the North Star mine located in Marble Bar, Western Australia (Figure 2.1). IBO intend to continue the development and operations at the North Star mine beyond Stage 1, which commenced in late 2013. Stage 1 included the development of a processing plant, open pit, tailings facility and waste stockpile. Mining occurred throughout Stage 1 until 2016, and processing of stockpiled ore continued until early 2018.

Stage 2 of the North Star mine is approved under Ministerial Statement 993. IBO propose additional approvals and development to extend Stage 2 of the North Star mine by developing additional deposit(s) immediately to the south of approved operations, known as North Star Extension (the Project). The Project will include full-depth mining from open pits and the development of the associated waste rock dump(s), with ore processing to be incorporated in the existing approved facilities. Mining of Stage 2 is expected to commence in 2024 and first ore produced in late 2025. The initial expected life of mine is 20 to 25 years.

1.2 Purpose of this report

The purpose of this report is to undertake an air quality assessment for the Project including dust dispersion modelling for the North Star Extension to be assessed under Section 38 of *the Environmental Protection Act 1986*.

1.3 Scope of works

The scope of works includes the following:

- Characterisation of dust emissions associated with the Project
- Characterisation and location of sensitive receptors
- Air dispersion modelling to predict the potential dust impacts from the Project to sensitive receptors, including:
  - The use of site-specific emission estimates associated with the Project
  - Proposed dust controls
  - The use of recognised standards and accepted inputs and assumptions for dispersion modelling, and analyses to predict potential air impacts
  - Two operating scenarios representing highest throughput years for approved Stage 2 operations (year 2029) and North Star Extension operations (year 2041), a third operating scenario representing interim mining operations (year 2024), and a dust mitigation scenario (year 2041)
  - Predicted dust concentrations in the form of total suspended particulates (TSP), particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}), 2.5 microns or less ($PM_{2.5}$) and dust deposition

1.4 Approach

The approach taken to carry out the above scope of work is outlined below. Each point is discussed in further detail throughout the subsequent sections of this report.

- Desktop assessment to review Project background, including review of the previous air quality assessment undertaken by SKM (2012) (Section 2).

- Review of relevant legal framework and standards to use as assessment criteria for the predicted air quality concentrations (Section 3).
- Brief description of the existing environment in terms of topography, surrounding land use, climate, air quality and sensitive receptors (Section 4).
- Qualitative construction dust assessment (Section 5).
- Meteorological modelling undertaken to produce representative meteorological data to use as input into the air dispersion model (Section 6).
- Operational dust assessment including emissions estimation to be used as input into the air dispersion model, dispersion modelling methods and results for four operating scenarios (Section 7).
- Conclusions drawn from the above assessment (Section 8).

1.5 Limitations

This report has been prepared by GHD for IB Operations Pty Ltd and may only be used and relied on by IB Operations Pty Ltd for the purpose agreed between GHD and IB Operations Pty Ltd as set out in Section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than IB Operations Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer to Sections 1.6, 6 and 7 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by IB Operations Pty Ltd and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.6 Assumptions

This assessment assumes the following:

- All information provided by IBO, including operational parameters and project site layout is correct.
- All parameters used in the model and other relevant data are based on best estimates using information provided by IBO and other relevant sources.
- The meteorological data used and derived in this assessment is representative of the meteorology at the Project site.

2. Project overview

2.1 Background

Stage 2 of the North Star mine includes three approved open cut pits (North Star, Eastern Limb North and Eastern Limb Central). IBO are proposing to extend these operations through the development of two additional pits immediately to the south, referred to as Glacier Valley North and Glacier Valley South (Figure 2.1). Over the life of the mine (LOM) 835 million tonnes (Mt) of ore is expected to be removed from the Eastern Limb pits along with 430 Mt of waste material.

2.2 Project details

Load and haul techniques will transfer material from the run of mine (ROM) to two ROM pads, from which material will be processed through the proposed ore processing facility (OPF). Material will be fed into one of two crushing lines. Conveyors will transport material from primary crushing, to secondary crushing and to a radial stacker, which will feed a coarse ore stockpile (COS). From the COS, material is fed through a tertiary crusher and further processed via primary screening, grinding, magnetic separation and finally secondary grinding before wet processing begins. Figure 2.2 shows the process flow diagram for the proposed ore processing as part of North Star mine Stage 2 operations.

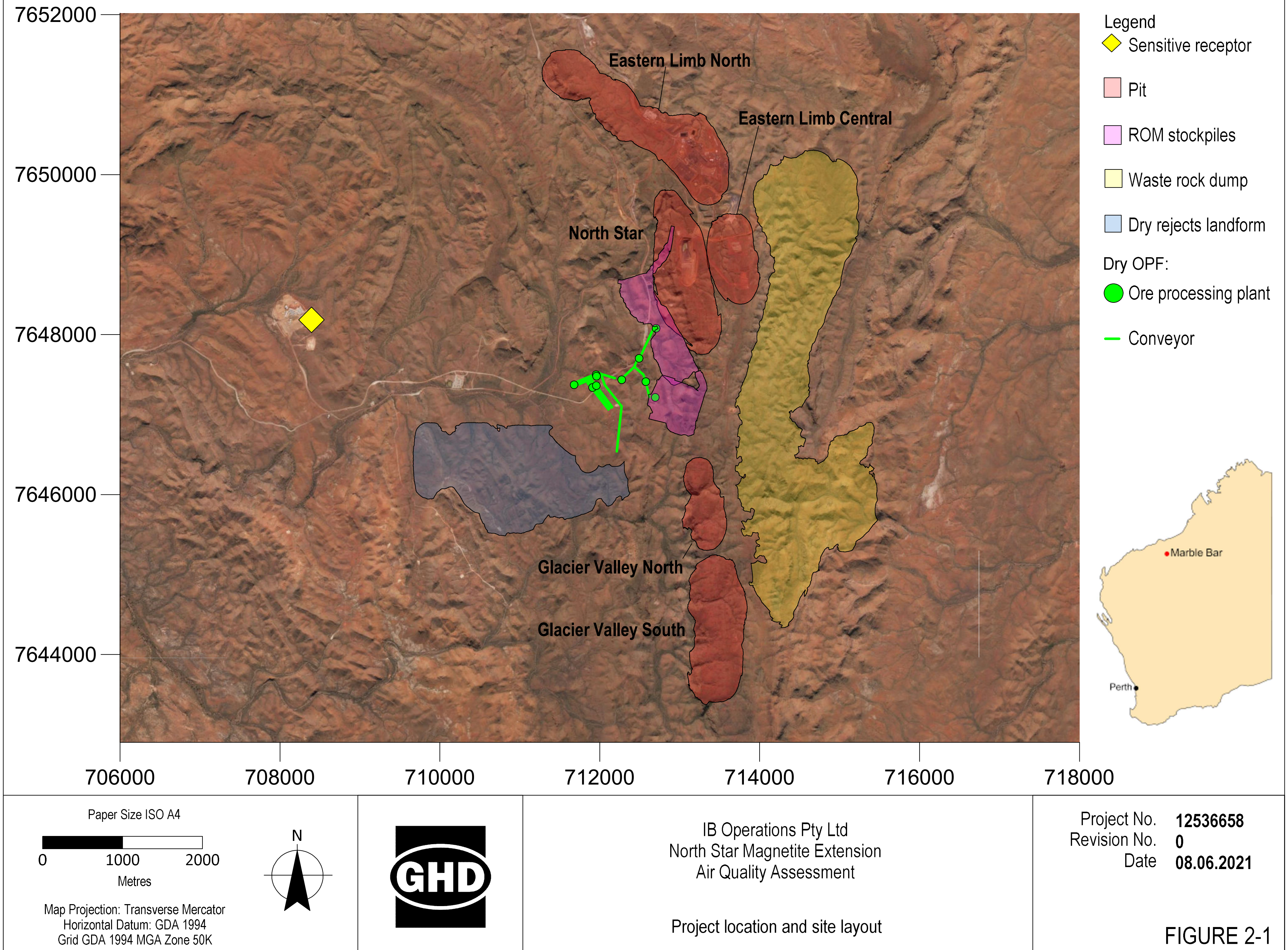
2.3 Key project elements

Key project elements associated with the Project will include the following:

- Five open cut mining pits (three approved and two proposed)
- Two ROM pads
- Waste rock dump
- Dry rejects landform (DRL)
- Stockpiles
- Conveyor infrastructure
- Ore processing plant including crushers, grinders and screens
- Haul trucks and light vehicles
- Front end loaders, dozers, graders and excavators
- Associated buildings, haul roads, access tracks and infrastructure

2.4 Operational schedule

The Project operating schedule will be 24 hourly, seven days per week. Blasting is expected to occur approximately four times per week.



IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Project location and site layout

Project No. 12536658
Revision No. 0
Date 08.06.2021

FIGURE 2-1

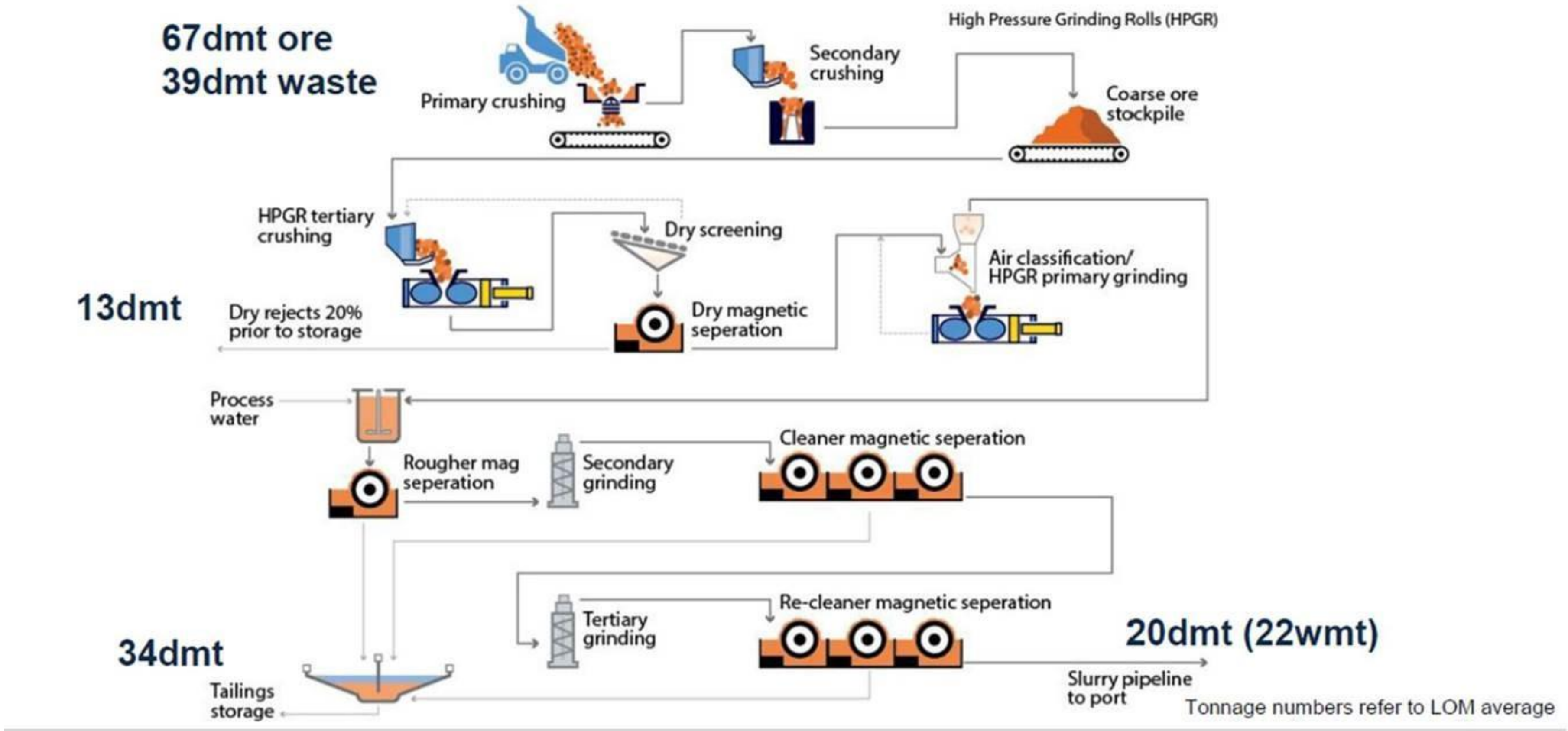


Figure 2.2 Process flow diagram for the proposed OPF as part of Stage 2 operations

3. Legal framework and standards

Air quality impacts are assessed by comparing model predictions (ground level concentrations (GLC)) with appropriate air quality criteria. The criteria referred to in this assessment include:

- *National Environment Protection (Ambient Air Quality) Measure*
- *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*
- *Environmental Protection (Kwinana) (Atmospheric Waste) Policy 1992*

3.1 National Environment Protection (Ambient Air Quality) Measure

The *National Environment Protection (Ambient Air Quality) Measure* (Air NEPM) was developed under Section 20 of the *National Environment Protection Council (Western Australia) Act 1996* to provide benchmark standards for ambient air quality to allow for "the adequate protection of human health and well-being" (National Environment Protection Council (NEPC) 2016). Air NEPM standards have been developed for nitrogen dioxide, carbon monoxide (CO), photochemical oxidants (as ozone), sulphur dioxide (SO_2), lead, PM_{10} and $PM_{2.5}$. A goal was introduced in 2015 to further reduce maximum concentrations of $PM_{2.5}$ to 20 µg/m^3 and 7 µg/m^3 for 24-hour and annual averaging periods respectively (NEPC 2016). Air NEPM standards for PM_{10} and $PM_{2.5}$ are provided in Table 3.1.

Table 3.1 Air NEPM standards

Pollutant	Averaging period	Maximum concentration (µg/m^3)
Particles as PM_{10}	24-hour	50
	Annual	25
Particles as $PM_{2.5}$	24-hour	25
	Annual	8

The draft *State Environmental (Ambient Air) Policy 2009* (Ambient Air SEP) gives effect to the Air NEPM standards and goals by establishing such standards as environmental quality criteria. The Ambient Air SEP states "environmental quality criteria should act as a trigger for investigation and management action when they are not met" (Government of Western Australia 2009).

Environmental quality criteria are applied across the whole State except where an Environmental Protection Policy exists, within the boundary of an industrial premise; within industrial buffer areas, within the boundary of a road, or where there are no sensitive receptors (Government of Western Australia 2009).

The proposed Project site does not contain sensitive receptors within the site boundary. Consistent with the application of environmental quality criteria, the Air NEPM standards have not been applied within the Project site boundary. However, as Japal Village is located within proximity to the Project area, Air NEPM standards have been applied at this location. Assessment of compliance with Air NEPM standards has been made at the maximum predicted value at the village location.

3.2 Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales

The *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW AMMAAP) provides “statutory methods for modelling and assessing emissions of air pollutants from stationary sources” (New South Wales Environmental Protection Authority (NSW EPA) 2017).

Although the criteria are designed to be used as a comparison for concentrations associated with stationary sources of air pollutants, the criteria for deposited dust have been adopted in this assessment in lieu of other appropriate criteria for deposited dust.

Assessment criteria for deposited dust from NSW AMMAAP are shown in Table 3.2.

Table 3.2 NSW AMMAAP impact assessment criteria

Pollutant	Averaging period	Impact assessment criteria
Deposited dust – Maximum increase	Annual	2 g/m^2/month
Deposited dust – Maximum total	Annual	4 g/m^2/month

3.3 Environmental Protection (Kwinana) (Atmospheric Waste) Policy 1992

The *Environmental Protection (Kwinana) (Atmospheric Waste) Policy 1992* (Kwinana EPP) sets out to provide “ambient air quality standards and ambient air quality limits for the concentration of atmospheric wastes in the relevant portion of the environment” (Environmental Protection Authority WA (EPA WA) 1999). Limits can be described as *concentrations of atmospheric waste that shall not be exceeded*, and standards can be described as *concentrations of atmospheric waste that should desirably not be exceeded*.

Concentrations for the limits and standards are provided in the *Environmental Protection (Kwinana) (Atmospheric Wastes) Regulations 1992* (EPA WA 2014) (the Regulations), which falls under the Kwinana EPP. The limits and standards set forth in the Regulations pertain to SO_2 and TSP. The limits and standards are divided into three categories, applying to three Areas based on geographical location. These are:

- Area A – Core heavy industrial area
- Area B – Buffer area beyond area A
- Area C – Beyond Areas A and B, predominately rural and residential

The predominant land use at Japal Village is considered to be residential for the purpose of this assessment. Therefore, Area C limits and standards (which are the most stringent) were adopted for this assessment. The limits and standards for TSP for Area C are displayed in Table 3.3.

Table 3.3 Kwinana EPP ambient air quality standards and limits for TSP (Area C)

Area	Averaging period	Standard ($\mu g/m^3$)	Limit ($\mu g/m^3$)
C	24-hour	90	150

3.4 Summary of adopted assessment criteria

Table 3.4 shows a summary of the adopted criteria used in this assessment.

Table 3.4 Adopted assessment criteria

Pollutant	Averaging period	Criteria	Source
PM_{10}	Maximum 24-hour	50 (µg/m^3)	Air NEPM
	Annual	25 (µg/m^3)	Air NEPM
$PM_{2.5}$	Maximum 24-hour	25 (µg/m^3)	Air NEPM
	Annual	8 (µg/m^3)	Air NEPM
TSP	Maximum 24-hour	150 (µg/m^3)	Kwinana EPP (Area C)
Deposited dust (TSP)	Annual	2 g/m^2/month	NSW AMMAAP
	Annual	4 g/m^2/month	NSW AMMAAP

4. Existing environment

4.1 Topography and geology

Situated within the North Pilbara terrain of the Pilbara Craton, the surrounding topography of the Project area is variable. Major landforms include hills, plateaux, ridges, stony plain, valleys and drainage channels. The main geological units surrounding the Project area are the Kangaroo Caves Formation, the Pincunah Hill Formation and the Corboy Formation, which are considered 2.5 to 3.5 billion years old (Van Vreeswyk, Payne, Leighton and Hennig 2004).

4.2 Surrounding land use

The land surrounding the Project area is predominantly used for grazing of stock, mining or is Unallocated Crown Land.

4.3 Climate

Climate of the Pilbara region is hot and arid, with very hot summers, mild winters and low, variable rainfall. The Australian-specific climate classification of a new modification of Köppen's classification of world climates (Stern *et al.* 2000) has the region around Marble Bar, and further west, as either Desert or Grassland – both have a subclassification of 'Hot (persistently dry)'. Maximum summer temperatures easily exceed 40 °C, and rainfall peaks in the months of summer and autumn. In winter, average temperatures are around 20 °C.

Tropical cyclones characterise the Pilbara climate, occurring in summer (the wet season) and can account for up to 21 percent of the annual rainfall (Government of Western Australia 2020).

Figure 4.1 shows the mean monthly temperature, rainfall and relative humidity recorded at Marble Bar automatic weather station (AWS) (station number 4106), operated by the Bureau of Meteorology (BoM) for the years 2000 to 2020 (BoM 2020).

Mean maximum temperature is highest in January and December, exceeding 40 °C. Mean maximum temperatures only fall below 30 °C in June and July. Mean minimum temperatures follow a similar trend, peaking in January and December at around 26 °C and falling below 20 °C in May through to September.

Relative humidity is variable, peaking in February, with secondary peaks in June/July before dropping in October and rising again in November/December. This pattern closely follows the variable monthly rainfall which reaches 50 mm in January and is very low throughout April to November.

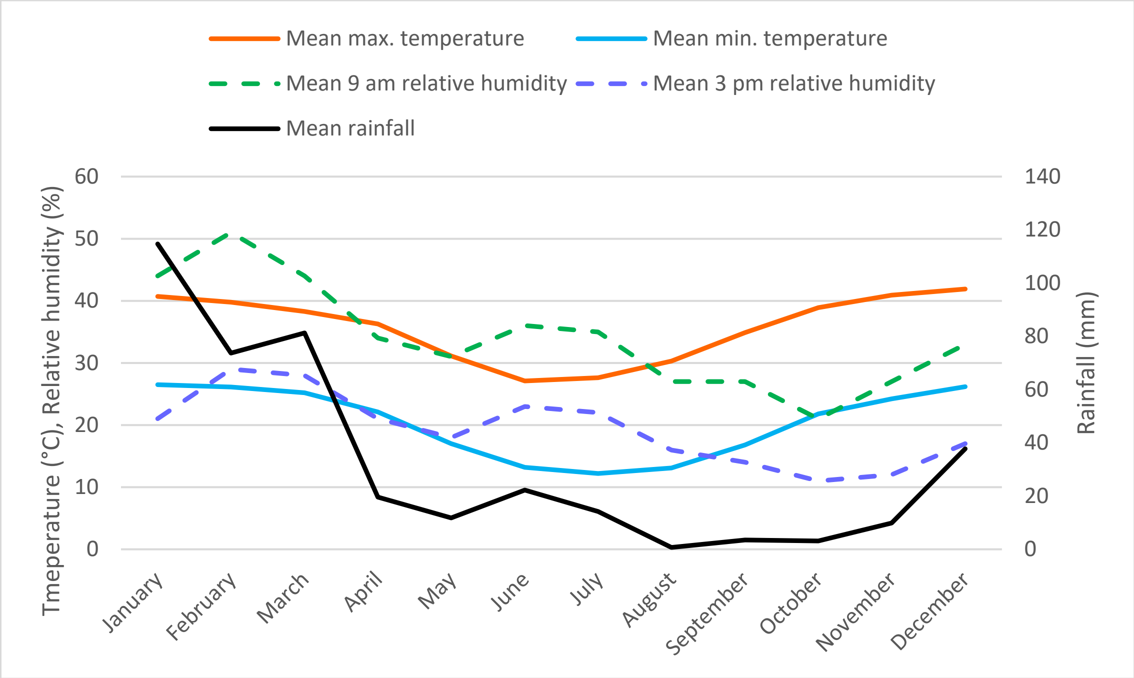


Figure 4.1 Mean monthly climate recorded at Marble Bar meteorological station for years 2000 to 2020

4.4 Existing ambient air quality

Due to the remote location of the Project, there is no nearby air quality data available.

Due to the inherent dusty environment of the Pilbara, background concentrations of particulate matter are relatively high in comparison to urban areas of Western Australia. However, background concentrations of particulate matter are not available for the Project site and have therefore been excluded from this assessment. A qualitative discussion regarding a cumulative assessment of particulate matter is included in Section 7.5.

4.5 Sensitive receptors

A desktop review of aerial imagery (Google Maps 2021) was undertaken to identify nearby sensitive receptors.

The closest sensitive receptor is the North Star Japal Village itself, approximately 3.5 km west of the proposed Project site. Only three other potential sensitive receptors were identified, all of which are located more than 15 km from the Project site:

- Abydos Mine Camp – approximately 17 km north of the proposed Project site
- Altura Mine Camp – approximately 27 km north-west of the proposed Project site
- Wodgina Mine Camp – approximately 39 km west of the proposed Project site

Abydos and Wodgina Mine Camps have both been closed since 2018 and 2017 respectively and were not included in this assessment. The Altura Mine Camp is currently operational, however as it is located more than 25 km from the Project site, impacts are not expected from the Project and it was excluded from this assessment.

5. Construction assessment

This section presents the qualitative assessment of air emissions likely to result during construction of the North Star extension.

Potential air quality impacts during construction and site establishment for the Project will be emission from heavy vehicle exhausts, dust generation from heavy equipment during earthworks and wind erosion from disturbed soil surfaces.

5.1 Heavy machinery and plant

Emissions from heavy vehicles and diesel-powered equipment may consist of products of combustion, including oxides of nitrogen, SO_2, CO, PM_{10} and volatile organic compounds. Emissions from heavy equipment will be minimised by ensuring all vehicles on-site are well maintained and operated in an efficient manner.

Ensuring vehicles are well maintained, and considering the nearest sensitive receptor is 3.5 km from the Project site, emissions from construction vehicles on-site are not considered to significantly impact air quality at the sensitive receptor.

5.2 Construction dust

The impacts of dust emissions fall under two distinct categories, being health and amenity.

Potential health impacts are attributable to the concentration of respirable particles in ambient air. Respirable particles of dust (PM_{10} or less), have maximum impact under light winds and stable atmospheric conditions. These conditions most frequently occur overnight and very early in the morning, and therefore, become more significant only if construction operations extend outside typical operating hours.

The presence of TSP greater than 35 microns is likely to affect amenity by way of reducing visibility (whilst suspended in the air column) and by soiling of materials via dust deposition. Amenity impacts are most likely to occur in high wind conditions, when large particles may be displaced and transported a significant distance before being deposited and soiling surfaces. Mitigation of amenity related dust impacts would in turn act to reduce health impacts due to dust emissions.

The following construction activities involve the movement and placement of soil, rock etc. and can be a source of dust emission:

- Mechanical disturbance: dust emissions resulting from the operation of construction equipment and vehicles.
- Wind erosion: dust emissions from exposed and disturbed soil surfaces under high wind speeds during construction.

The extent to which these emissions may impact the surrounding land uses would depend on a number of site-specific factors including type and number of construction equipment/machinery, soil characteristics, meteorology and shift times.

6. Meteorological modelling

The simulation of emission dispersion from the Project requires the use of meteorological data containing hourly data for a minimum of one year. Ideally, and as a first preference, much of these data would be obtained from onsite observations to provide a site-specific dataset. Such observations, however, are not available for the Project site. As an alternative, observed data from other representative locations may be used. Data are considered site representative if the meteorological trends, surrounding land uses and topographic features for the site of interest are similar to, or are expected to be similar to, those of the site at which the data were recorded.

The nearest available meteorological observations to the project site are recorded on an hourly basis at the BoM Marble Bar automatic weather station (AWS) (station number 004106). The Marble Bar AWS is located approximately 80 km east of the Project site and records air temperature, wind speed and wind direction.

Meteorological data available from the Marble Bar AWS is considered generally representative of the project site. However, there is a lack of representative cloud observation data that is required to calculate stability classes. The nearest station that collects suitable cloud observation data is Telfer Aero AWS (station number 013030) which is located approximately 340 km to the east of the Project site and therefore is not considered representative.

Where site representative data is not available, the alternative is to synthesise meteorological data for the site using diagnostic or prognostic 3D meteorological modelling. The Commonwealth Scientific and Industrial Research Organisation's (CSIRO) TAPM (The Air Pollution Model) was used to produce site representative hourly surface meteorological data for input to the AERMET pre-processor model. Environmental Protection Authority (EPA) Victoria Publication 1550 (EPA Victoria 2014) provides guidance on the use of TAPM as a prognostic model to generate site-representative data for AERMOD. The output from the AERMET model is input to the AERMOD dispersion model.

6.1 TAPM meteorological model

TAPM (v4.0.5) was developed by CSIRO's Division of Atmospheric Research. TAPM is a PC-based prognostic modelling system consisting of coupled prognostic meteorological and air pollution dispersion model components. It is suitable for use with complex geographic sites and/or for situations when the available site-representative meteorological data are not adequate.

The prognostic meteorological model predicts the meteorological conditions across the model domain based on synoptic scale meteorology, local topography and land surface characteristics (i.e., soil type and vegetation cover). The CSIRO's dataset of synoptic meteorological data was used as input into TAPM, along with terrain elevation and land surface characterisation data to generate a site-representative meteorological dataset. The synoptic meteorological data were derived from a global re-analysis dataset provided by CSIRO. The TAPM model then provides the link between the synoptic large-scale flows and local climatology, such as downslope drainage flows (katabatic winds), sea breeze influences (if any) and regional/local scale wind channelling around terrain features.

6.1.1 Model configuration

TAPM was configured with a nested model grid coverage designed to capture:

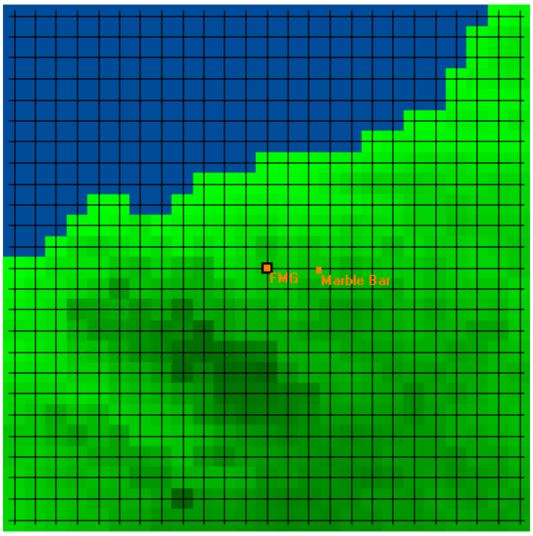
- Broad scale synoptic flows
- Regional and local wind channelling around terrain features

- Regional to local scale katabatic (downslope night-time drainage flow) and any sea breeze flows that may penetrate inland
- The influence of local land use

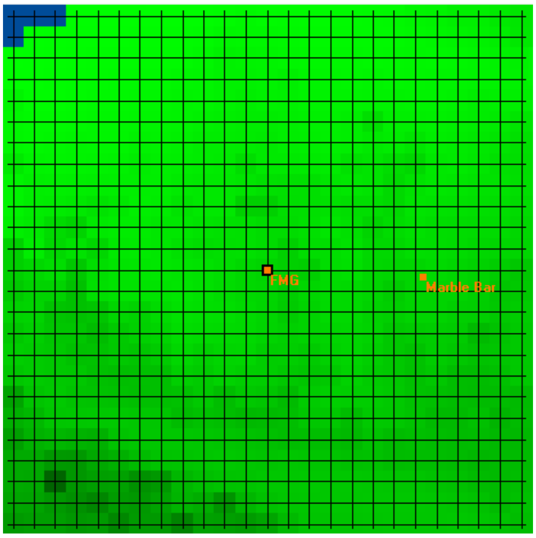
Nested grids were configured with the surface characteristics, such as terrain elevation; surface roughness/vegetation type; soil type and monthly varying deep soil moisture content. The synoptic analyses (derived from National Centres for Environmental Protection (NCEP) re-analysis) from 1 July 2019 to 30 June 2020 were used, which represents an average year (403 mm at Marble Bar compared to a long term mean of 403 mm and a median of 389 mm). The year was selected from a review of years 2015 to 2019 inclusive to avoid any tropical cyclones (Stan of 2015/16 and Joyce of 2017/18) and tropical lows crossing the region that produces extreme rainfall events. Similarly, the latter half of 2020 was avoided as a La Nina ENSO (El Nino - Southern Oscillation) phase was developing with the potential for an earlier than average Monsoon onset.

TAPM specific model settings were as follows:

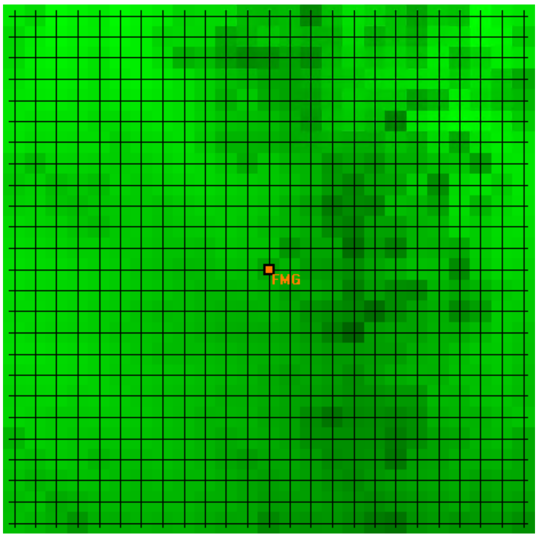
- Five nested meteorological grids with grid spacing of 30 km, 10 km, 3 km, 1 km and 300 m
- 25 x 25 grid points in the east-west and north-south direction respectively
- Grids centred at 21°29.5' S and 119°1' E at a local grid centred at 711684 m E and 7647456 m S (MGA94)
- Topography generated from the AUSLIG 9-second (250 m resolution) terrain elevation datasets provided with the model (Figure 6.1) shows topography three of the five nested meteorological grids
- Characterised vegetation and land use was determined from the datasets provided with the model
- Soil type information was derived from the United States geological datasets provided with the model
- 25 vertical levels
- Surface vegetation and precipitation processes included
- After TAPM was run, hourly wind direction, wind speed, temperature, relative humidity, net radiation and mixing height were extracted for the:
  - Project site to be used as input into AERMET (discussed below – consistent with the EPA Victoria Publication 1550 guidance)
  - For the Marble Bar AWS location to allow for validation against observed data



30 km domain



10 km domain



3 km domain

Figure 6.1 30 km, 10 km and 3 km nested meteorological grids

6.2 AERMET

AERMOD requires site representative meteorological data containing a minimum of one year of hourly data in the form of both a surface meteorological and file upper air file. This is essential to determine the general wind climate at the site in question, and to conduct dispersion modelling of emissions to air. TAPM can provide the data required directly from the run described above (Section 6.1.1), however certain parameters used to describe mixing of air within the stable boundary provide unreliable estimations. Therefore, a number of meteorological parameters (wind speed, wind direction, temperature, relative humidity, net radiation and mixing height) were taken from the TAPM run and used as input into AERMET.

AERMET is AERMOD's meteorological pre-processor, which provides the meteorological files for air dispersion modelling, in the format required by AERMOD.

AERMET was run in line with US EPA guidance in 'on-site' observation mode using the meteorological parameters provided by TAPM (discussed in Section 6.1.1). The option of ADJ_U* was used to better represent sources that have peak concentrations under low wind conditions (e.g., TSP). Appropriate values for albedo, Bowen ratio and surface roughness were input into AERMET to define the surface characteristics, which affect dispersion at the site.

These surface characteristics were determined using guidance from EPA Victoria (Publication 1550) and United States Environmental Protection Agency (US EPA) (2007).

Output from AERMET provided a surface meteorological file and upper air meteorological file to use as input into AERMOD.

6.3 Predicted meteorological data

This section describes the trends exhibited by the predicted meteorological parameters provided by TAPM and AERMET.

6.3.1 Wind distribution

The predicted annual average wind speed for the Project site is 2.5 m/s, with winter being the windiest (2.8 m/s) season and spring (2.3 m/s) the calmest.

The predicted annual and seasonal wind roses for the Project site are shown in Figure 6.2. Wind roses provide a graphical representation of the frequency distribution of winds of varying strength, from varying compass points. Figure 6.2 shows a strong seasonal cycle in wind direction, namely:

- South-east winds dominate throughout all seasons – consistent with the prevailing trade winds at these latitudes.
- North-west to south-east winds during spring, with the south-west winds subsiding and north-west winds more frequent during summer – the later as a monsoon influence is near or over the region.
- Dominant south-east winds in autumn.
- Increased frequency and strength of winds from the south-east during winter.

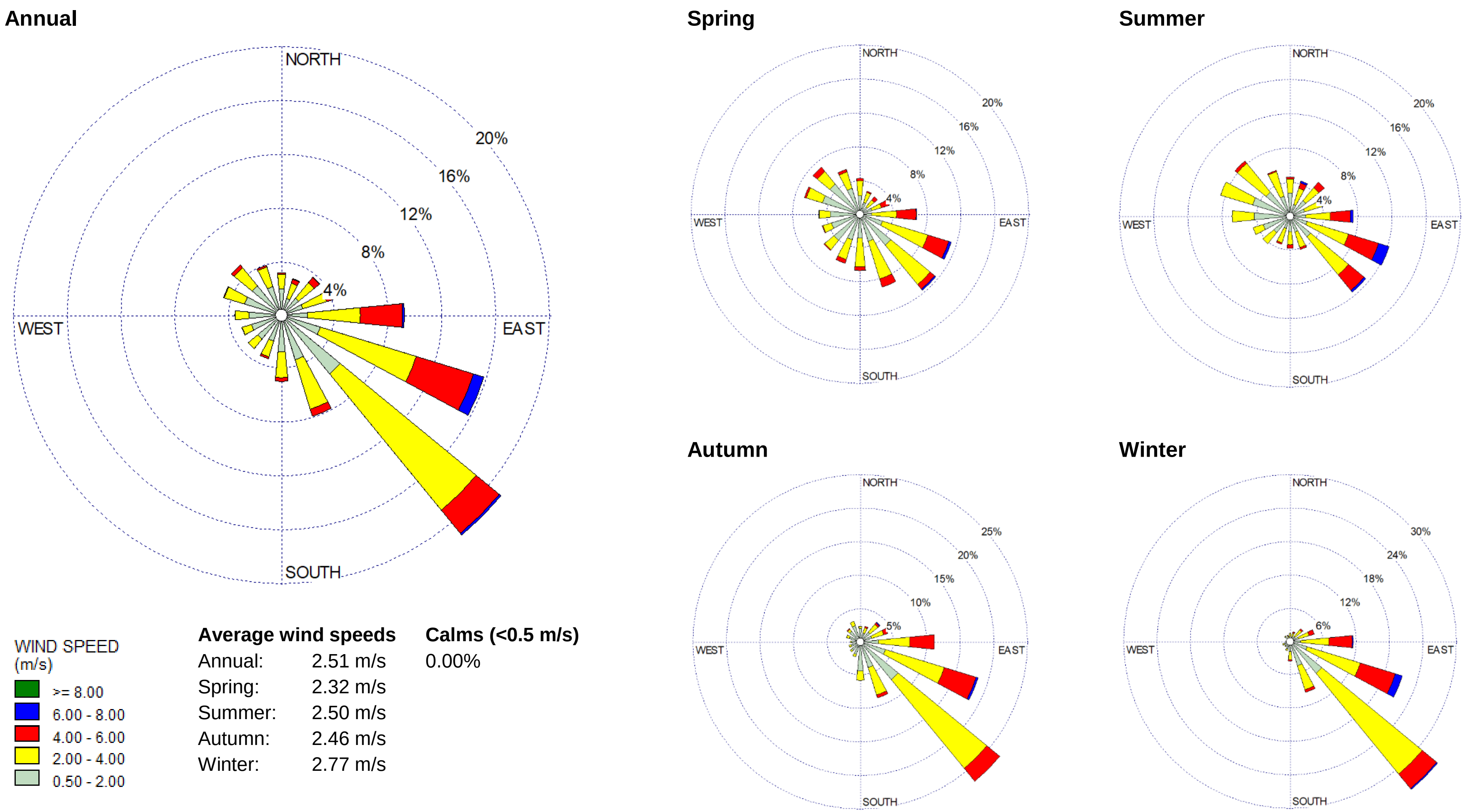


Figure 6.2 Annual and seasonal wind roses for TAPM-synthesised AERMET output at the Project site

6.4 Validation of predicted meteorological data

To validate hourly varying predictions, key parameters can be compared with observed data where available. Such comparisons typically include temperature with wind speed and direction. As previously mentioned, data from the BoM Marble Bar AWS meteorological site was available for comparison with predictions at the same location.

Key parameters were extracted from the relevant three-dimensional TAPM simulations for the BoM Marble Bar AWS location and compared with observed data from Marble Bar. This section provides comparison of the air temperature and wind speed and direction at Marble Bar.

6.4.1 Air temperature

Figure 6.3 and Figure 6.4 show the mean monthly 9:00 am and 3:00 pm air temperature, as predicted by TAPM and observed at Marble Bar AWS. The comparison between the predicted and observed data demonstrates TAPM underpredicts temperature by approximately 4 °C at 9:00 am and 2 °C at 3:00 pm but still follows the seasonal temperature patterns (correlation 97 percent). Typically, TAPM overestimates temperatures overnight and underestimates temperatures during the day but the morning and afternoon averages are close and follow the same seasonal pattern.

On a monthly basis, colder overall temperatures suggest TAPM will be somewhat conservative (in terms of dispersion modelling) in predicting plume penetration above temperature inversions and the cooler daytime temperatures lower the overall wind speed and mixing height (due to underdevelopment of convection) and hence daytime dispersion.

The strong correlation between predicted and recorded temperature indicates that the model is adequately calculating the surface energy balance, which, in turn, adds confidence to the predictions made for atmospheric stability.

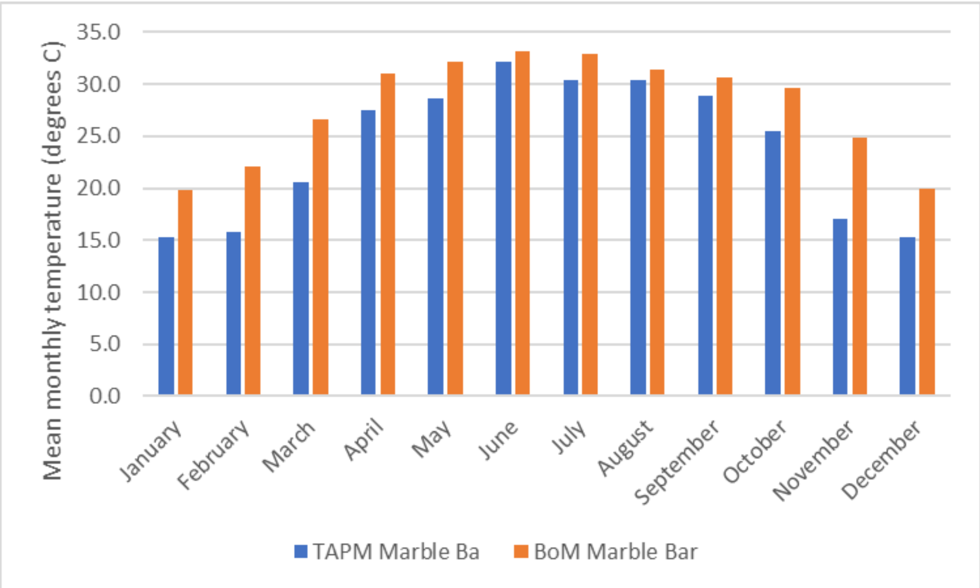


Figure 6.3 Average monthly 9:00 am TAPM-predicted and observed air temperature at Marble Bar AWS

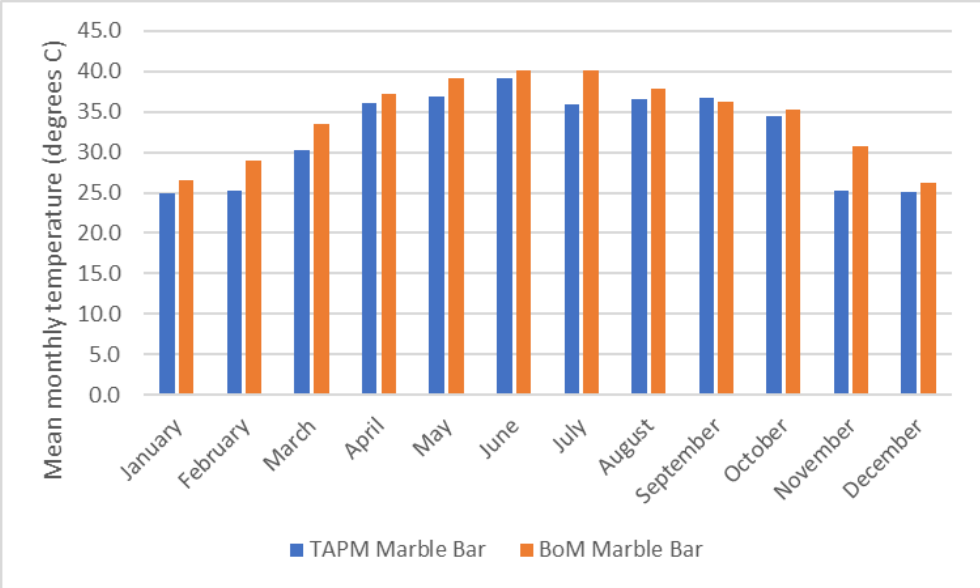


Figure 6.4 Average monthly 3:00 pm TAPM-predicted and observed air temperature at Marble Bar AWS

6.4.2 Wind distribution

For the purpose of comparison, Figure 6.5 shows the annual and seasonal predicted wind distribution at Marble Bar AWS, and Figure 6.6 shows the annual and seasonal wind distribution observed at the BoM Marble Bar AWS. Comparison of the wind roses shows the following:

- Slightly lower average annual wind speed (2.5 m/s) is predicted than observed (2.8 m/s).
- Both observed wind directions and TAPM-predicted wind directions are dominated by a south-east component, although the TAPM predictions over-predict the frequency of this direction compared to north-west directions.
- Both observed and TAPM-predicted winds are most evenly distributed in direction during spring and summer.

In view of the foregoing, it is considered that the predictions generally represent the wind climate of observed winds but tend to under predict wind speeds and frequency of north-west, monsoon-induced winds.

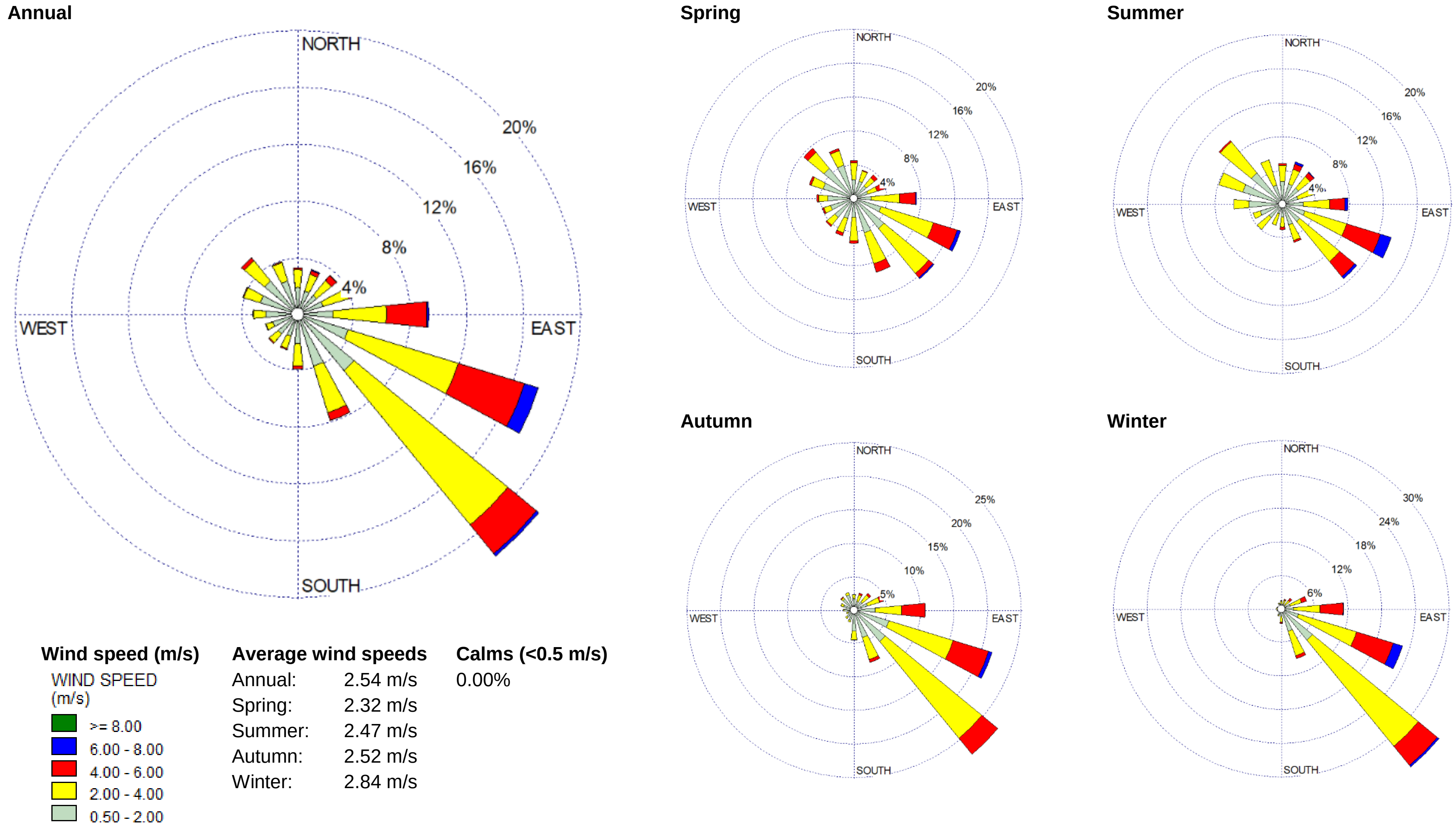


Figure 6.5 Annual and seasonal wind roses for TAPM predicted meteorological data at Marble Bar AWS

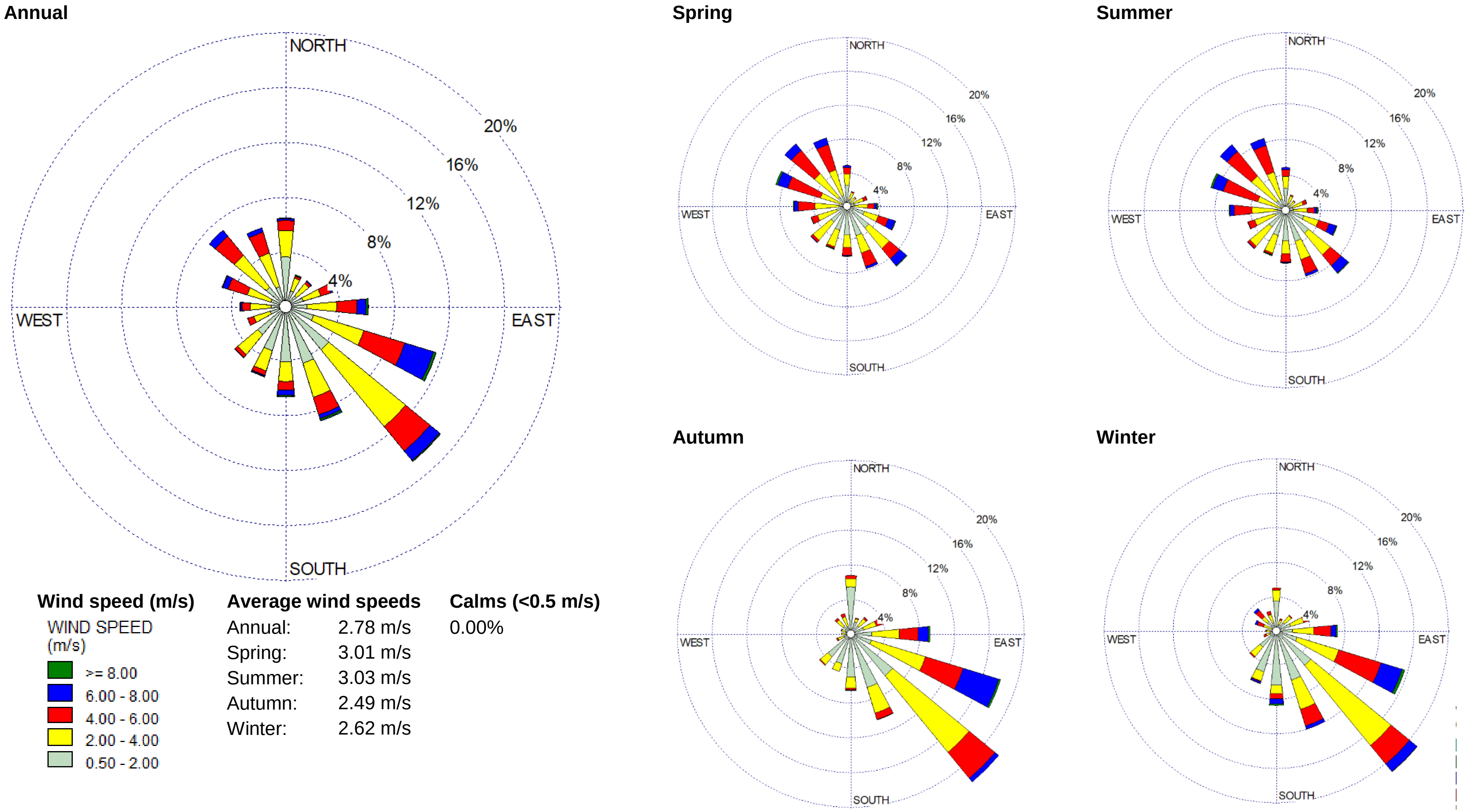


Figure 6.6 Annual and seasonal wind roses for observed meteorological data at Marble Bar AWS

7. Operational assessment

7.1 Modelling scenarios

Four air dispersion modelling scenarios were completed in this assessment to predict the impact of dust on local air quality associated with potential emissions from the Project. The modelling scenarios were as follows:

- Scenario One – Representing the highest throughput year for approved Stage 2 operations(year 2029)
- Scenario Two – Representing the highest throughput year for North Star Extension operations (year 2041)
- Scenario Three- Representing interim mining operations (year 2024). Specifically, in lieu of the use of the radial stacker for the dry rejects, a dozer and a loader will be utilised. Dry rejects will then be transported via truck from the OPF to the DRL instead of the conveyor system
- Scenario Four – Representing the highest throughput year for North Star Extension operations with dust mitigation included in the form of watering haul roads (Level 1 watering) (year 2041)

Assessment of PM_{10}, $PM_{2.5}$, TSP and dust deposition were included in the modelling.

7.2 Emission estimation

Dust emissions for the Project were used as input into the air dispersion model for each identified potential dust source associated with the Project. Emissions were estimated for TSP, PM_{10} and $PM_{2.5}$ using information provided by IBO and approved methods for emission estimation. Where required information or data were not available from IBO, appropriate default values were used, or informed assumptions were made.

Emission estimation was carried out in line with methods from the National Pollutant Inventory (NPI) *Emission Estimation Technique Manual for Mining (Version 3.1)* (NPI Mining) (Australian Government 2021).

The general equation used to estimate emissions to air is shown below.

Equation 7.1

$$E_{i\left(kg/_{yr}\right)} = \left[A_{\left(t/_{hr}\right)} \times OP_{\left(h/_{yr}\right)}\right] \times EF_{i\left(kg/_{t}\right)} \times \left[1 - \frac{CE_i}{100}\right]$$

Where:

$E_{i\left(kg/_{yr}\right)}$	= Emission rate of pollutant i (kg/yr)
$A_{\left(t/_{hr}\right)}$	= Activity rate (t/hr)
$OP_{\left(h/_{yr}\right)}$	= Operating hours (hr/yr)
$EF_{i\left(kg/_{t}\right)}$	= Uncontrolled emission factor of pollutant i (kg/t)
CE_i	= Overall control efficiency for pollutant i (kg/t)

Emission factors for each source included in the model were taken from the NPI (Mining) Table 2 and Table 3. Where proposed dust suppression techniques were provided by IBO, appropriate control factors were included in the emission estimation calculation using control efficiencies listed in Table 4 of the NPI (Mining). Factors used in the emission estimation for Scenario One, Scenario Two and Scenario Three are shown in the tables below, along with the resulting estimated emission rate for each source included in the dispersion modelling. The emission rate is shown in grams per second as this is required by AERMOD.

Scenario Four emissions were equal to those of Scenario Two, however emissions from haul trucks were halved, resulting from the addition of Level 1 watering on haul roads, as defined in the NPI (Mining) as 2 L/m^2/hour with an effectiveness of 50 percent dust emission control.

Table 7.1 Source emission rates for Scenario One (highest throughput year for approved Stage 2 operations (year 2029))

Source	Emission factor used	Activity rate per source (t/hr)	Control factors	Number of sources	TSP emission rate (g/s)	PM_{10} emission rate (g/s)	$PM_{2.5}$ emission rate (g/s)
Volume sources							
Primary crusher	Primary crushing (low moisture)	3596	Hooding with fabric filters Water sprays	2	17.0	1.70	0.17
Secondary crusher	Secondary crushing (low moisture)	3596	Hooding with fabric filters Water sprays	2	50.9	2.91	0.29
Tertiary crusher	Tertiary crushing (low moisture)	7191	Enclosure and use of fabric filters Water sprays	1	14.0	0.80	0.08
Radial stacker	Loading stockpiles	3596	Water sprays	1	2.0	0.85	0.25
Screen	Screening[1]	7191	Water sprays	1	12.5	4.29	0.43
Primary grinding	Dry grinding without air conveying or classification (low moisture)	3956	Enclosure and use of fabric filters Water sprays	2	6.0	0.80	0.08
Conveyor	Conveyor transfer point[1]	3596	Nil	3	1.5	0.55	0.05
Conveyor	Conveyor transfer point (controlled)[1]	3251	Enclosure	3	0.0	0.06	0.01
Excavator	Excavators/shovels/front end loaders (on overburden)	1750	Pit retention	7	6.1	5.54	0.02
Haul truck	Wheel generated dust from unpaved roads at industrial sites	N/A[2]	Pit retention	37	2.4	1.36	0.14
Front end loader	Excavators/shovels/front end loaders (on overburden)	4084	Pit retention	3	14.2	12.93	0.02
Dozer	Dozer on material other than coal	N/A	Pit retention	3	2.4	1.08	0.03
Grader	Graders	N/A[3]	Pit retention	6	0.3	0.22	0.03

Source	Emission factor used	Activity rate per source (t/hr)	Control factors	Number of sources	TSP emission rate (g/s)	PM_{10} emission rate (g/s)	$PM_{2.5}$ emission rate (g/s)
Loading material	Loading stockpiles	3596	Nil	2	4.0	1.70	0.25
Dumping material	Trucks (dumping overburden)	5173	Nil	1	17.2	6.18	0.93
Blasting	Blasting	Assume 1 hole per hour[4]	Nil	1	61.1	31.67	3.17
Drilling	Drilling	Assume 1 hole per hour[4]	Nil	1	0.2	0.09	0.00861
Source	**Emission factor used**	**Area exposed (hectares)**	**Control factors**	**Number of sources**	**TSP emission rate (g/s)**	**PM_{10} emission rate (g/s)**	**$PM_{2.5}$ emission rate (g/s)**
Area sources							
North Star pit 01[5]	Wind erosion	41	Pit retention	1	2.3	2.15	9.04E-08
North Star pit 02[5]	Wind erosion	29	Pit retention	1	1.6	1.52	1.15E-06
Eastern Limb North pit[5]	Wind erosion	29	Pit retention	1	1.6	1.54	1.27E-06
ROM stockpile north[5]	Wind erosion	38	Nil	1	4.2	2.11	2.71E-06
ROM stockpile south[5]	Wind erosion	45	Nil	1	4.9	2.47	3.49E-06
DRL stockpile[5]	Wind erosion	98	Nil	1	10.9	5.47	1.96E-06
WRD stockpile[5]	Wind erosion	68	Nil	1	3.7	1.87	6.70E-08

Note:

1. Emission factor taken from AP42: Compilation of Air Pollutant Emission Factors (US EPA 1995) in lieu of appropriate emission factor from the NPI (Mining)
2. Assumed to travel at 4.1 km/hr
3. Assumed to travel at 10 km/hr
4. Drilling and blasting were assumed to occur between 7:00 am and 8:00 am Monday to Thursday.
5. Assumed 40 percent of pit/stockpile is active at any one time

Table 7.2 Source emission rates for Scenario Two (highest throughput year for North Star Extension operations (year 2041))

Source	Emission factor used	Activity rate per source (t/hr)	Control factors	Number of sources	TSP emission rate (g/s)	PM_{10} emission rate (g/s)	$PM_{2.5}$ emission rate (g/s)
Volume sources							
Primary crusher	Primary crushing (low moisture)	3251	Hooding with fabric filters Water sprays	2	15.4	1.53	0.23
Secondary crusher	Secondary crushing (low moisture)	3251	Hooding with fabric filters Water sprays	2	46.1	2.63	0.39
Tertiary crusher	Tertiary crushing (low moisture)	6501	Enclosure and use of fabric filters Water sprays	1	12.6	0.72	0.11
Radial stacker	Loading stockpiles	3251	Water sprays	1	1.8	0.76	0.12
Screen	Screening[1]	6501	Water sprays	1	11.3	3.88	0.54
Primary grinding	Dry grinding without air conveying or classification (low moisture)	3251	Enclosure and use of fabric filters Water sprays	2	5.4	0.72	0.11
Conveyor	Conveyor transfer point[1]	3251	Nil	3	1.4	0.49	0.05
Conveyor	Conveyor transfer point (controlled)[1]	3251	Enclosure	3	0.02	0.06	0.01
Excavator	Excavators/shovels/front end loaders (on overburden)	1750	Pit retention	7	6.1	5.54	0.02
Haul truck	Wheel generated dust from unpaved roads at industrial sites	N/A[2]	Pit retention	31	3.8	2.11	0.32
Front end loader	Excavators/shovels/front end loaders (on overburden)	4084	Pit retention	3	14.2	12.93	0.02
Dozer	Dozer on material other than coal	N/A	Pit retention	3	2.4	1.08	0.02
Grader	Graders	N/A[3]	Pit retention	5	0.3	0.22	0.02

Source	Emission factor used	Activity rate per source (t/hr)	Control factors	Number of sources	TSP emission rate (g/s)	PM_{10} emission rate (g/s)	$PM_{2.5}$ emission rate (g/s)
Loading material	Loading stockpiles	3251	Nil	2	3.6	1.54	0.15
Dumping material	Trucks (dumping overburden)	5827	Nil	1	19.4	6.96	0.70
Blasting	Blasting	Assume 1 hole per hour[4]	Nil	1	61.1	31.67	3.17
Drilling	Drilling	Assume 1 hole per hour[4]	Nil	1	0.2	0.09	0.00861
Source	**Emission factor used**	**Area exposed (hectares)**	**Control factors**	**Number of sources**	**TSP emission rate (g/s)**	**PM_{10} emission rate (g/s)**	**$PM_{2.5}$ emission rate (g/s)**
Area sources							
North Star pit[5]	Wind erosion	5	Pit retention	1	0.3	0.27	9.04E-08
Eastern Limb Central pit[5]	Wind erosion	32	Pit retention	1	1.8	1.69	1.20E-06
Eastern Limb North pit[5]	Wind erosion	49	Pit retention	1	2.7	2.59	1.27E-06
Glacier Valley North pit[5]	Wind erosion	5	Pit retention	1	0.3	0.28	4.65E-07
Glacier Valley South pit[5]	Wind erosion	44	Pit retention	1	2.5	2.34	1.15E-06
ROM stockpile north[5]	Wind erosion	38	Nil	1	4.2	2.11	2.71E-06
ROM stockpile south[5]	Wind erosion	45	Nil	1	4.9	2.47	3.49E-06
DRL stockpile[5]	Wind erosion	98	Nil	1	10.9	5.47	1.96E-06
WRD stockpile[5]	Wind erosion	134	Nil	1	14.9	7.47	6.99E-08

Note:

1. Emission factor taken from AP42: Compilation of Air Pollutant Emission Factors (US EPA 1995) in lieu of appropriate emission factor from the NPI (Mining)
2. Assumed to travel at 6.4 km/hr
3. Assumed to travel at 10 km/hr
4. Drilling and blasting were assumed to occur between 7:00 am and 8:00 am Monday to Thursday.
5. Assumed 40 percent of pit/stockpile is active at any one time

Table 7.3 Source emission rates for Scenario Three (interim mining operations (year 2024))

Source	Emission factor used	Activity rate per source (t/hr)	Control factors	Number of sources	TSP emission rate (g/s)	PM_{10} emission rate (g/s)	$PM_{2.5}$ emission rate (g/s)
Volume sources							
Primary crusher	Primary crushing (low moisture)	3652	Hooding with fabric filters Water sprays	2	17.2	1.72	0.17
Secondary crusher	Secondary crushing (low moisture)	3652	Hooding with fabric filters Water sprays	2	51.7	2.96	0.30
Tertiary crusher	Tertiary crushing (low moisture)	7304	Enclosure and use of fabric filters Water sprays	1	14.2	0.81	0.08
Screen	Screening[1]	7304	Water sprays	1	12.7	4.36	0.44
Primary grinding	Dry grinding without air conveying or classification (low moisture)	3652	Enclosure and use of fabric filters Water sprays	2	6.1	0.81	0.08
Conveyor	Conveyor transfer point[1]	3652	Nil	3	1.5	0.56	0.06
Conveyor	Conveyor transfer point (controlled)[1]	3652	Enclosure	3	0.0	0.07	0.01
Excavator	Excavators/shovels/front end loaders (on overburden)	1750	Pit retention	7	6.1	5.54	0.55
Haul truck	Wheel generated dust from unpaved roads at industrial sites	N/A[2]	Pit retention	29	2.3	1.32	0.13
Front end loader	Excavators/shovels/front end loaders (on overburden)	4084	Pit retention	4	14.2	12.93	1.29
Dozer	Dozer on material other than coal	N/A	Pit retention	4	2.4	1.08	0.02
Grader	Graders	N/A[3]	Pit retention	6	0.3	0.22	0.02

Source	Emission factor used	Activity rate per source (t/hr)	Control factors	Number of sources	TSP emission rate (g/s)	PM_{10} emission rate (g/s)	$PM_{2.5}$ emission rate (g/s)
Loading material	Loading stockpiles	3652	Nil	2	4.1	1.72	0.26
Dumping material	Trucks (dumping overburden)	4595	Nil	2	15.3	5.49	0.82
Blasting	Blasting	Assume 1 hole per hour[4]	Nil	1	61.1	31.67	3.17
Drilling	Drilling	Assume 1 hole per hour[4]	Nil	1	0.2	0.09	0.00861
Source	Emission factor used	Area exposed (hectares)	Control factors	Number of sources	TSP emission rate (g/s)	PM_{10} emission rate (g/s)	$PM_{2.5}$ emission rate (g/s)
Area sources							
North Star pit[5]	Wind erosion	41	Pit retention	1	2.3	2.15	9.39E-07
Eastern Limb Central pit[5]	Wind erosion	32	Pit retention	1	1.8	1.69	1.20E-06
Eastern Limb North pit[5]	Wind erosion	29	Pit retention	1	1.6	1.54	5.20E-07
ROM stockpile north[5]	Wind erosion	38	Nil	1	4.2	2.11	2.71E-06
ROM stockpile south[5]	Wind erosion	45	Nil	1	4.9	2.47	3.49E-06
DRL stockpile[5]	Wind erosion	98	Nil	1	10.9	5.47	1.96E-06
WRD stockpile[5]	Wind erosion	68	Nil	1	3.7	1.87	2.96E-07

Note:

1. Emission factor taken from AP42: Compilation of Air Pollutant Emission Factors (US EPA 1995) in lieu of appropriate emission factor from the NPI (Mining)
2. Assumed to travel at 3.99 km/hr
3. Assumed to travel at 10 km/hr
4. Drilling and blasting were assumed to occur between 7:00 am and 8:00 am Monday to Thursday.
5. Assumed 40 percent of pit/stockpile is active at any one time

7.3 Dispersion modelling

This section describes the model used to predict GLCs associated with the operation of the proposed North Star extension based on meteorological data (Section 6) and derived emission rates (Section 7.2). This section provides further information on the model parameters selected for the dispersion model AERMOD.

AERMOD is a steady state model and assumes that over time, the average concentrations distribution within a plume, is Gaussian. AERMOD was used to predict the dispersion of TSP (including deposited dust), PM_{10} and $PM_{2.5}$ at the identified sensitive receptors (see Section 4.5). A sample AERMOD output file typical of those used in this assessment is presented in Appendix A. The main model options and assumptions used are listed below, and the AERMOD output file is provided in Appendix A.

7.3.1 Model configuration

Model configuration is summarised in Table 7.4.

Table 7.4 Model configuration

Parameter	Setting
Averaging times	1-hour, 8-hour 24-hour, monthly or annual
Model grid centre coordinates (m UTM)	712647.59 E, 7646994.34 S
Emission rate	Constant (see Section 7.2)
Topography	Default AERMAP databases used
Surrounding land use	Rural with land use as per the AERMET definition

7.3.2 Buildings included in the model

Buildings could affect the dispersion of air and hence the local dispersion of pollutants. This phenomenon is called building downwash and is characterised by the wake produced behind a building, which can draw pollutants in the air column to ground level. This effect may increase ground level concentrations of atmospheric pollutants produced by point sources such as stacks.

As there are no point sources included in the dispersion model, buildings were excluded from the assessment.

7.3.3 Grid system

A uniform cartesian grid system was used in the AERMOD model to predict concentrations of dust across an area of 15 km by 12 km. A grid resolution of 500 m was used.

7.3.4 Background concentrations

Background concentrations were not included in this assessment as background air quality monitoring data were not available for the Project area.

7.4 Results

This section presents the results of the air dispersion modelling across three modelling scenarios.

7.4.1 Scenario One

Scenario One represents the highest throughput for approved Stage 2 operations (year 2029). Predicted ground level dust concentrations at Japal Village from Scenario One are shown in Table 7.5.

Results for PM_{10} and $PM_{2.5}$ comply with the respective 24-hour and annual Air NEPM criteria.

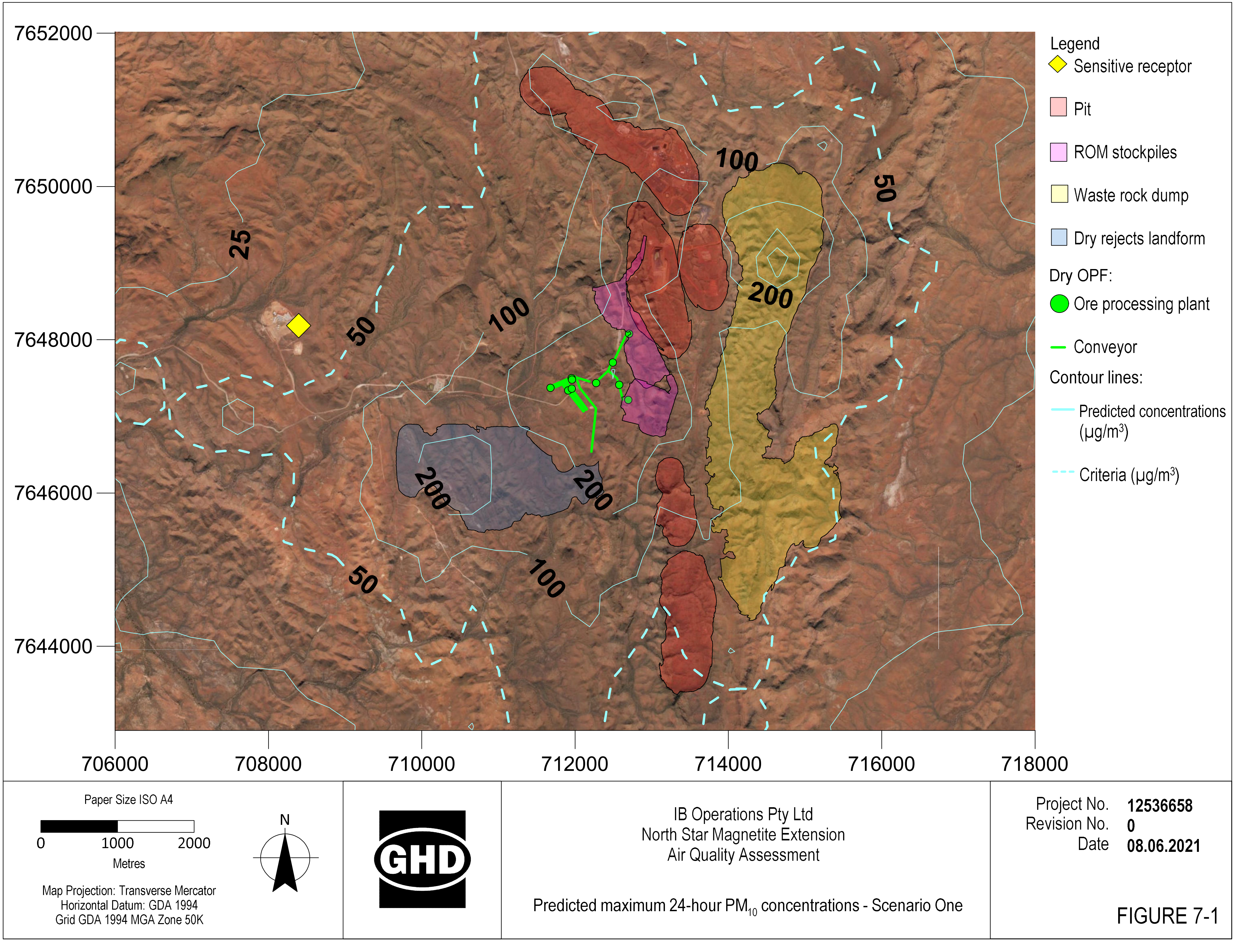
The predicted 24-hour TSP concentration at Japal Village exceeds the Kwinana EPP criterion by 21 percent. Analysis of subsequent highest predicted concentrations shows the three highest predicted 24-hour concentrations for TSP exceed the criteria, equating to three exceedance days in the year.

Predicted dust deposition at the mine village complies with the NSW AMMAAP criteria.

Contour figures for PM_{10}, $PM_{2.5}$ and TSP are shown in Figure 7.1 to Figure 7.5.

Table 7.5 Predicted concentrations at Japal Village for Scenario One

Pollutant	Averaging period	Criteria	Source	Predicted concentration (µg/m³)	Percent of criteria
PM_{10}	Maximum 24-hour	50 (µg/m³)	Air NEPM	48	97%
	Annual	25 (µg/m³)	Air NEPM	8	33%
$PM_{2.5}$	Maximum 24-hour	25 (µg/m³)	Air NEPM	6	24%
	Annual	8 (µg/m³)	Air NEPM	1	12%
TSP	Maximum 24-hour	150 (µg/m³)	Kwinana EPP (Area C)	182	121%
Deposited dust	Annual	2 g/m²/month	NSW AMMAAP	0.5	25%
	Annual	4 g/m²/month	NSW AMMAAP	0.5	12%



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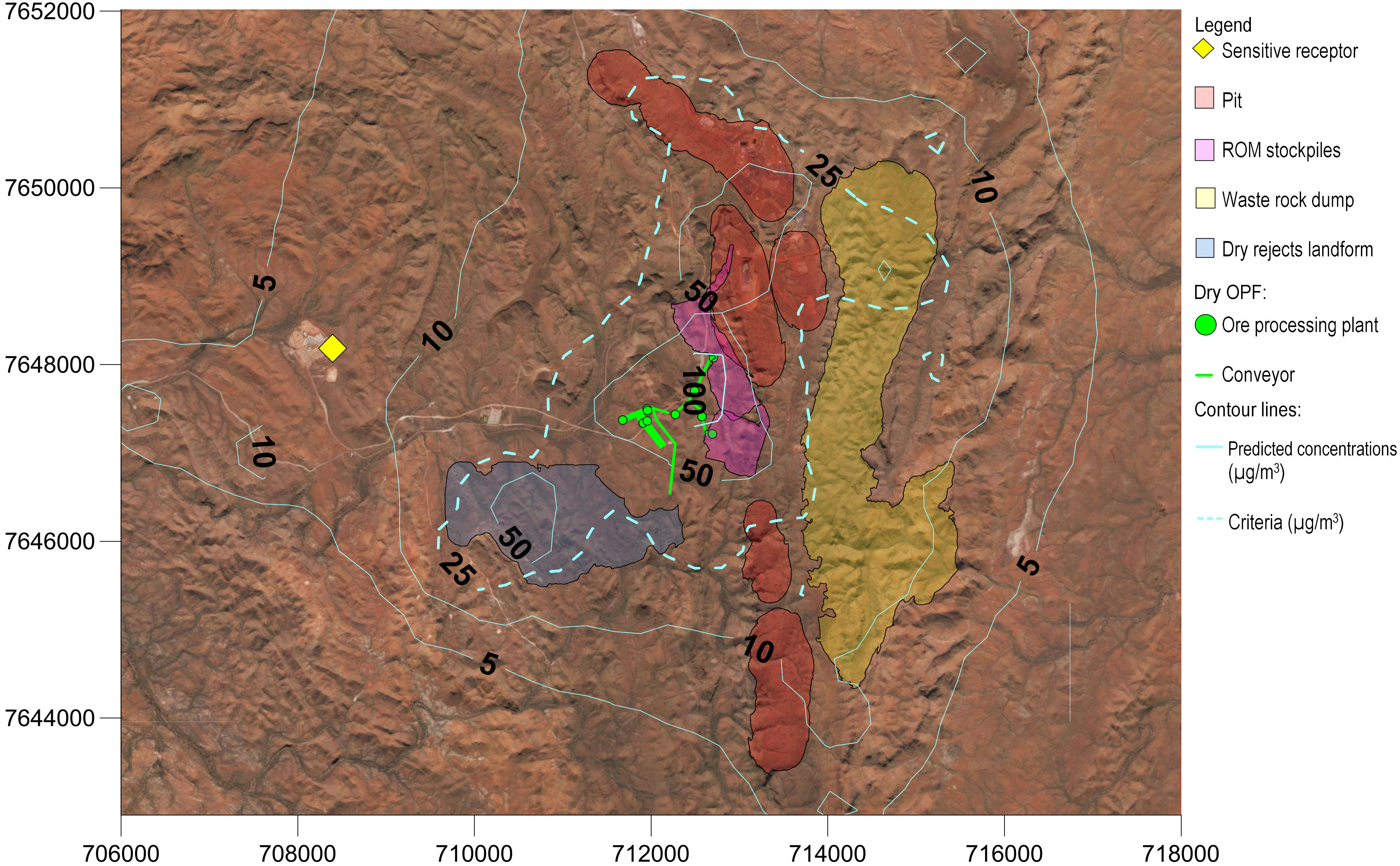
Air Quality Assessment

Predicted maximum 24-hour PM_{10} concentrations - Scenario One

Project No.	12536658
Revision No.	0
Date	08.06.2021

FIGURE 7-1



Paper Size ISO A4

0 1000 2000
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

N

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Air Quality Assessment

Predicted annual PM_{10} concentrations - Scenario One

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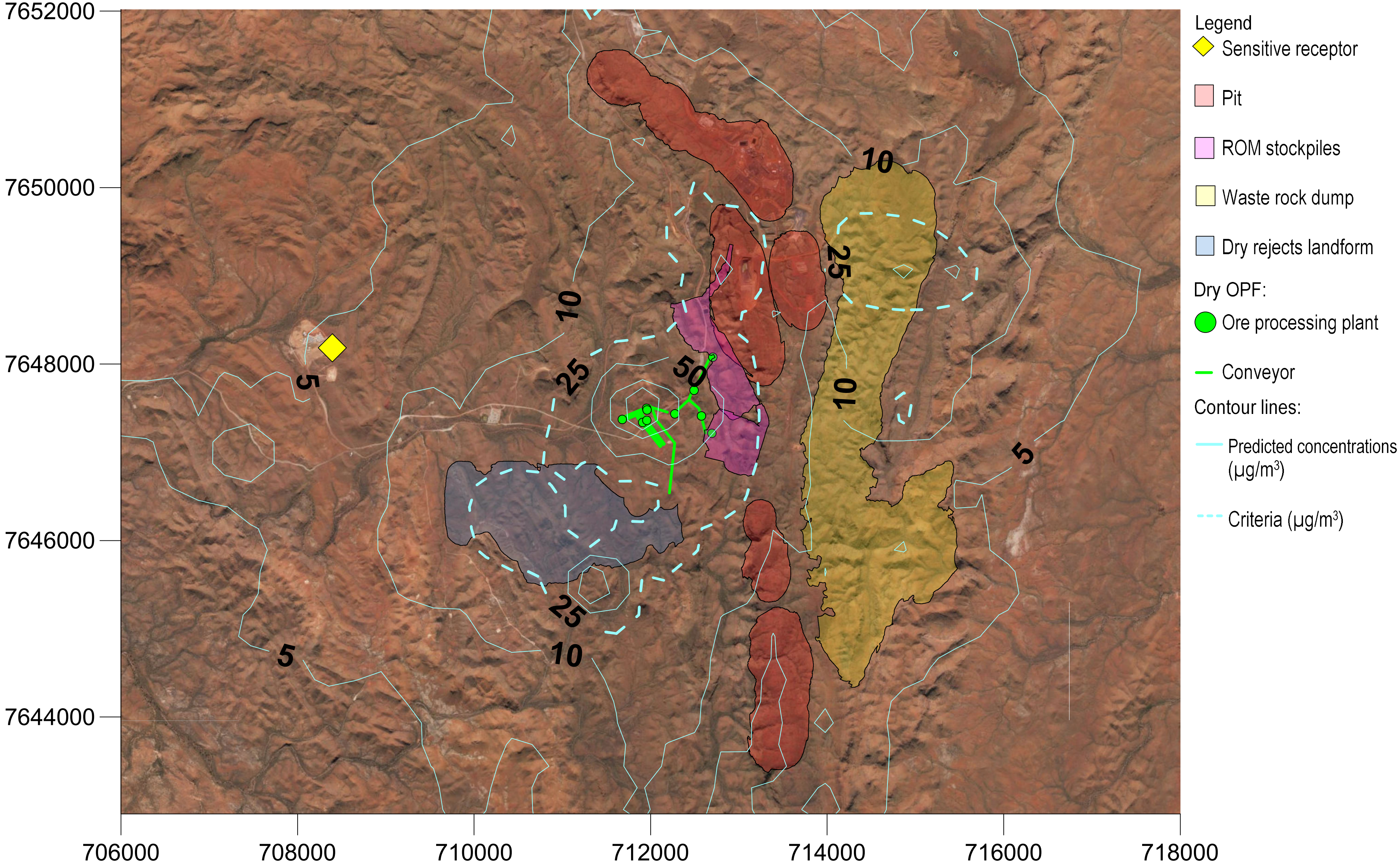
FIGURE 7-2



Paper Size ISO A4

0 1000 2000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

N

GHD

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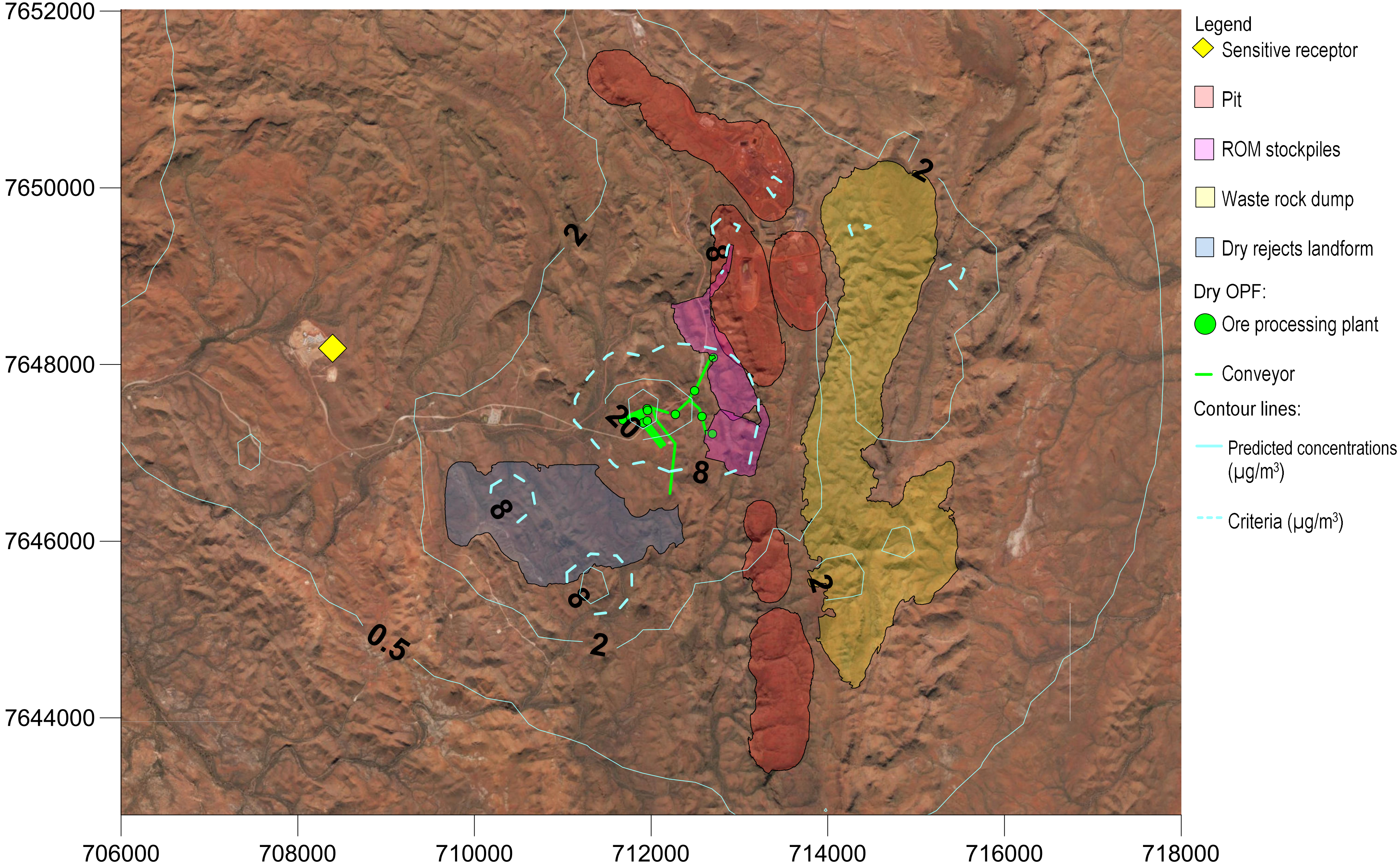
North Star Magnetite Extension
Air Quality Assessment

Predicted maximum 24-hour $PM_{2.5}$ concentrations - Scenario One

Project No. **12536658**
Revision No. **0**
Date **08.06.2021**

FIGURE 7-3



Paper Size ISO A4

0 1000 2000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

N

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Air Quality Assessment

Predicted annual $PM_{2.5}$ concentrations - Scenario One

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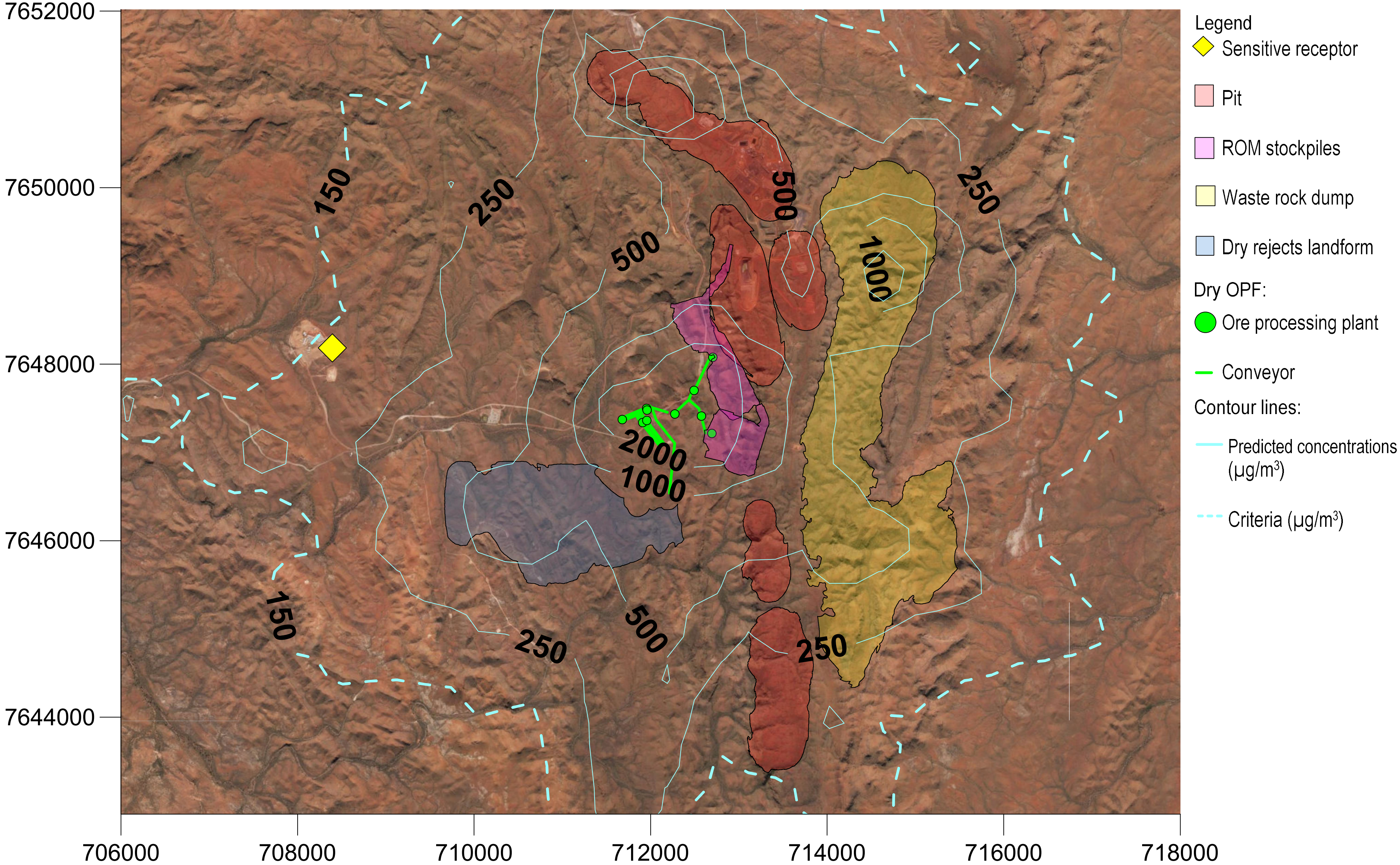
Date	**08.06.2021**

FIGURE 7-4



GHD

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Air Quality Assessment

Predicted maximum 24-hour TSP concentrations - Scenario One

Project No.	12536658
Revision No.	0
Date	08.06.2021

FIGURE 7-5

7.4.2 Scenario Two

Scenario Two represents the highest throughput for North Star Extension operations (year 2041). Predicted ground level dust concentrations at Japal Village from Scenario Two are shown in Table 7.6.

The predicted 24-hour PM_{10} concentration at Japal Village exceeds the Air NEPM criterion by 15 percent. Analysis of subsequent highest predicted concentrations shows the two highest predicted 24-hour concentrations for PM_{10} exceed the criteria, equating to two exceedance days in the year.

The predicted annual concentration for PM_{10}, and the predicted 24-hour and annual $PM_{2.5}$ concentrations comply with the respective Air NEPM criteria.

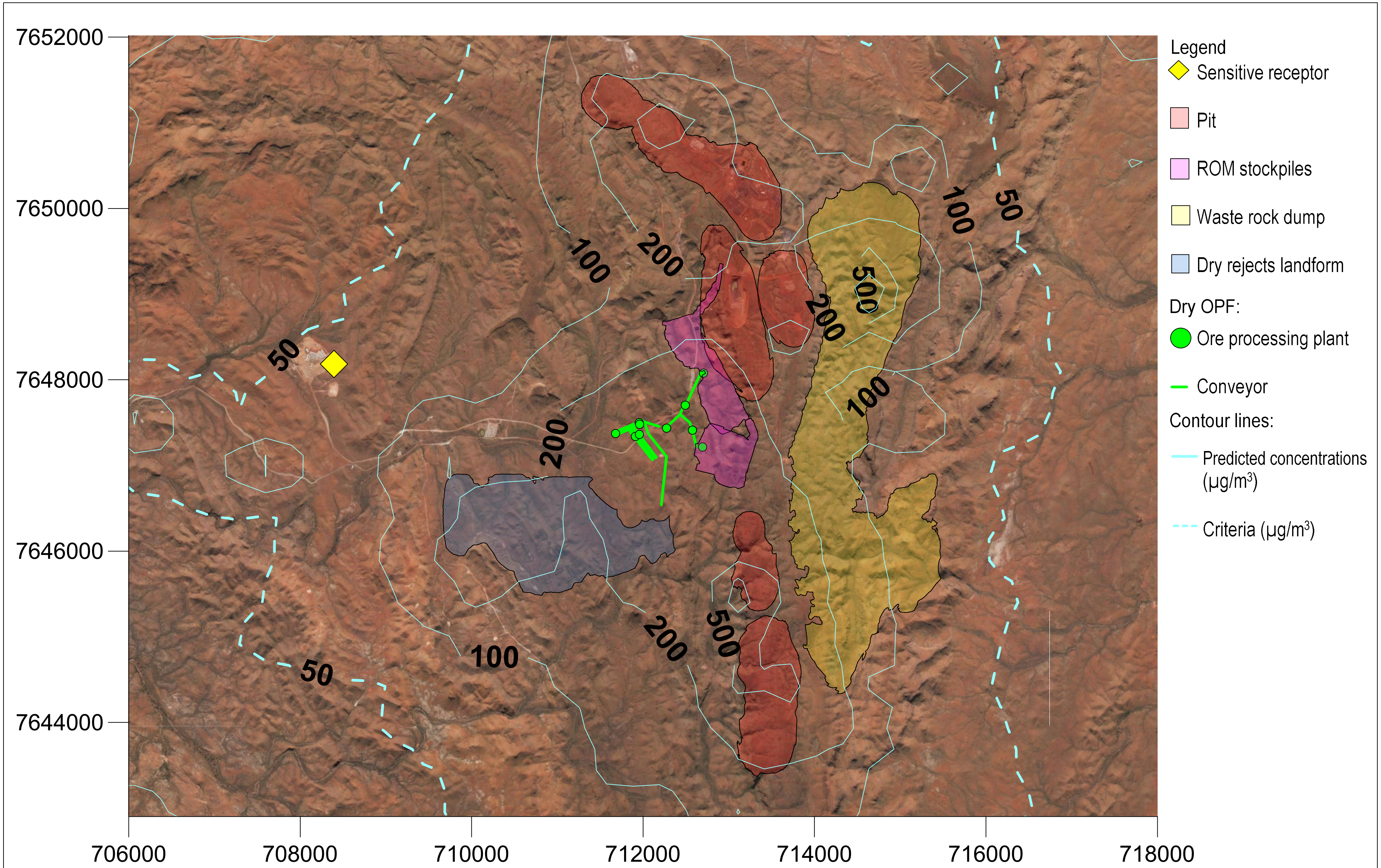
The predicted 24-hour TSP concentration at Japal Village exceeds the Kwinana EPP criterion by 13 percent. Analysis of subsequent highest predicted concentrations shows the two highest predicted 24-hour concentrations for TSP exceed the criteria, equating to two exceedance days in the year.

Predicted dust deposition at Japal Village comply with the NSW AMMAAP criteria.

Contour figures for PM_{10}, $PM_{2.5}$ and TSP are shown in Figure 7.6 to Figure 7.10.

Table 7.6 Predicted concentrations at Japal Village for Scenario Two

Pollutant	Averaging period	Criteria	Source	Predicted concentration (µg/m^3)	Percent of criteria
PM_{10}	Maximum 24-hour	50 (µg/m^3)	Air NEPM	58	115%
	Annual	25 (µg/m^3)	Air NEPM	12	49%
$PM_{2.5}$	Maximum 24-hour	25 (µg/m^3)	Air NEPM	8	31%
	Annual	8 (µg/m^3)	Air NEPM	2	19%
TSP	Maximum 24-hour	150 (µg/m^3)	Kwinana EPP (Area C)	169	113%
Deposited dust	Annual	2 g/m^2/month	NSW AMMAAP	0.6	29%
	Annual	4 g/m^2/month	NSW AMMAAP	0.6	15%



Paper Size ISO A4

0 1000 2000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

N

GHD

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Air Quality Assessment

Predicted maximum 24-hour PM_{10} concentrations - Scenario Two

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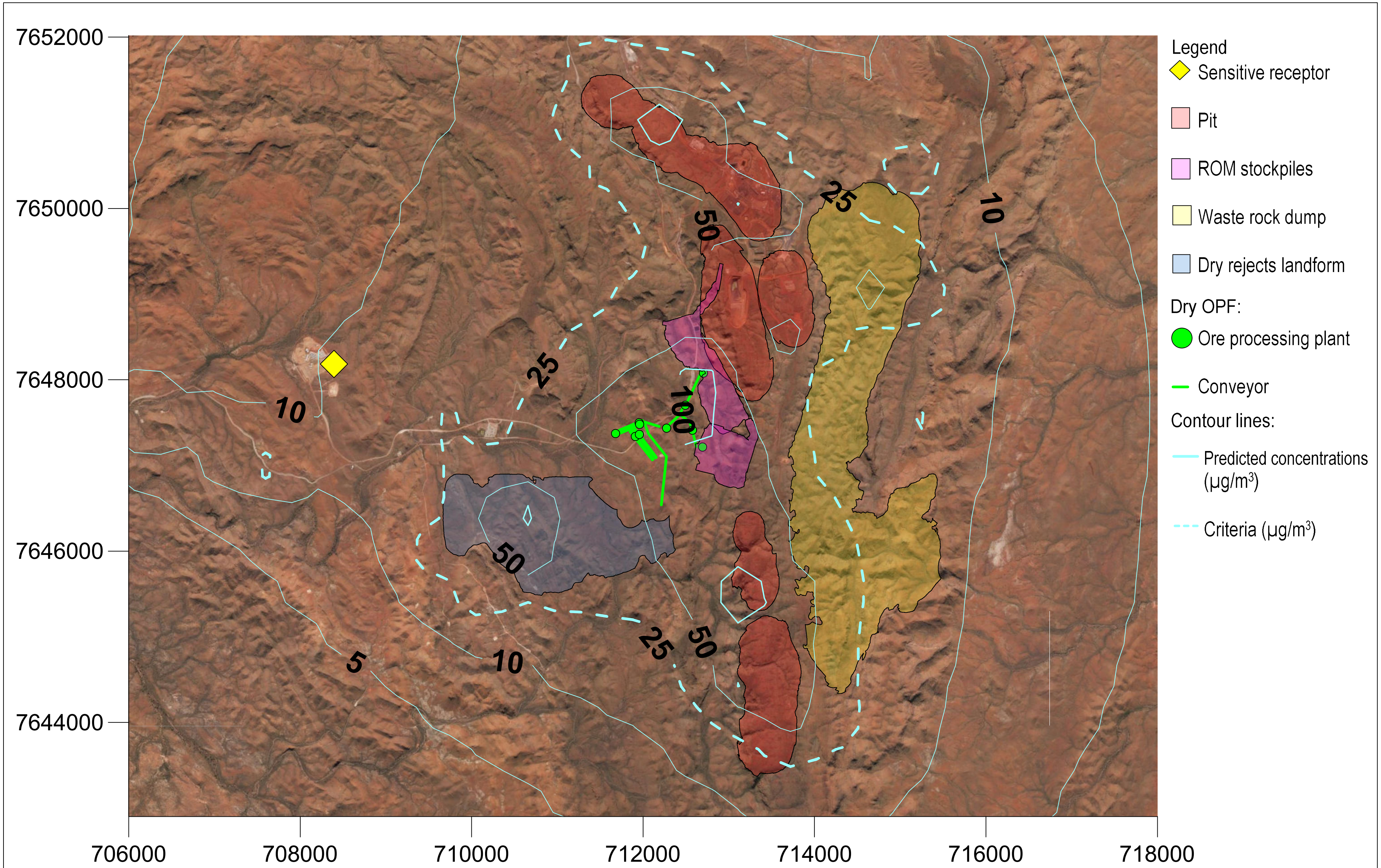
Revision No. **0**
Date **08.06.2021**

FIGURE 7-6



Paper Size ISO A4

0 1000 2000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

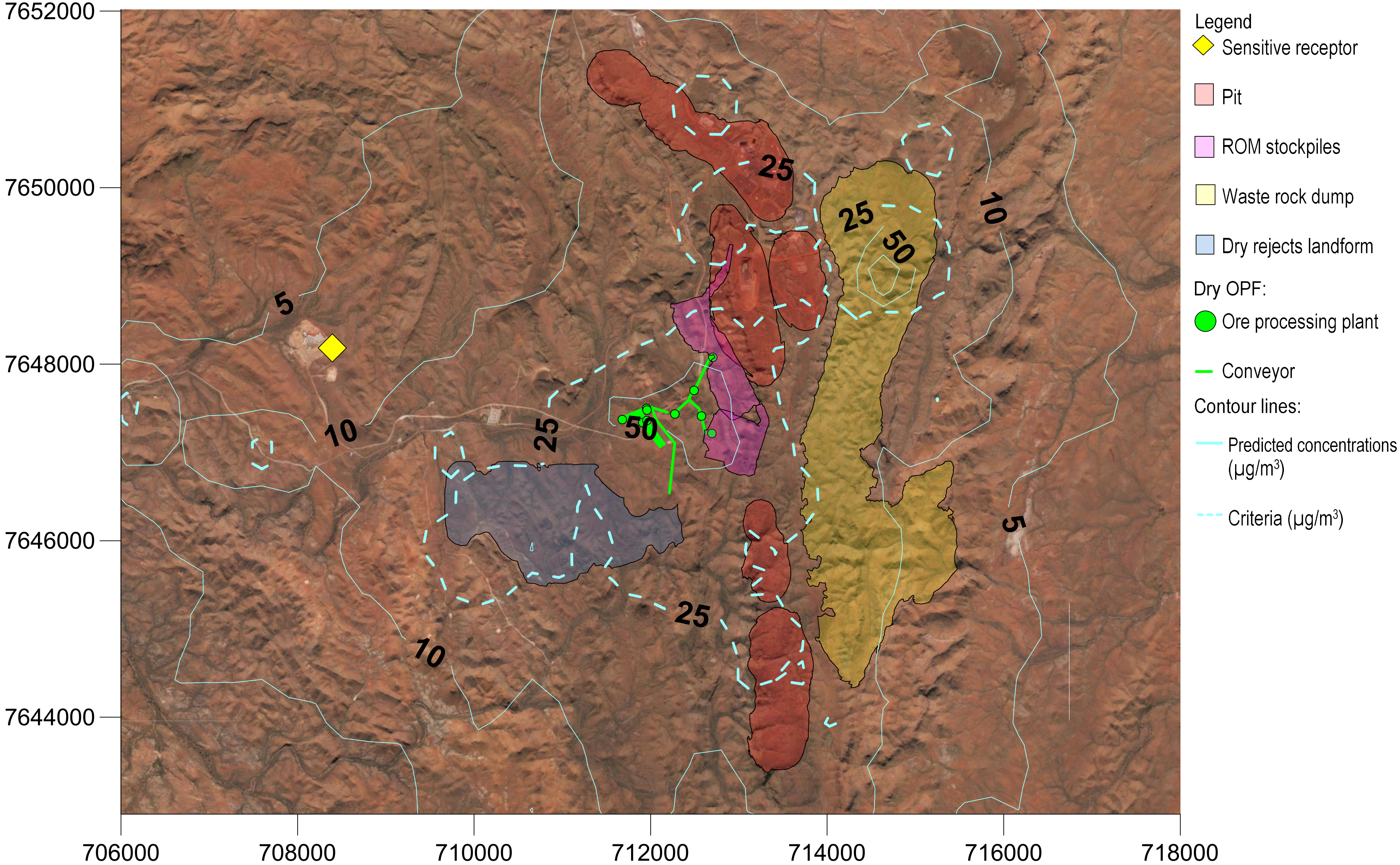
N

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted annual PM_{10} concentrations - Scenario Two

Project No. **12536658**
Revision No. **0**
Date **08.06.2021**

FIGURE 7-7



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

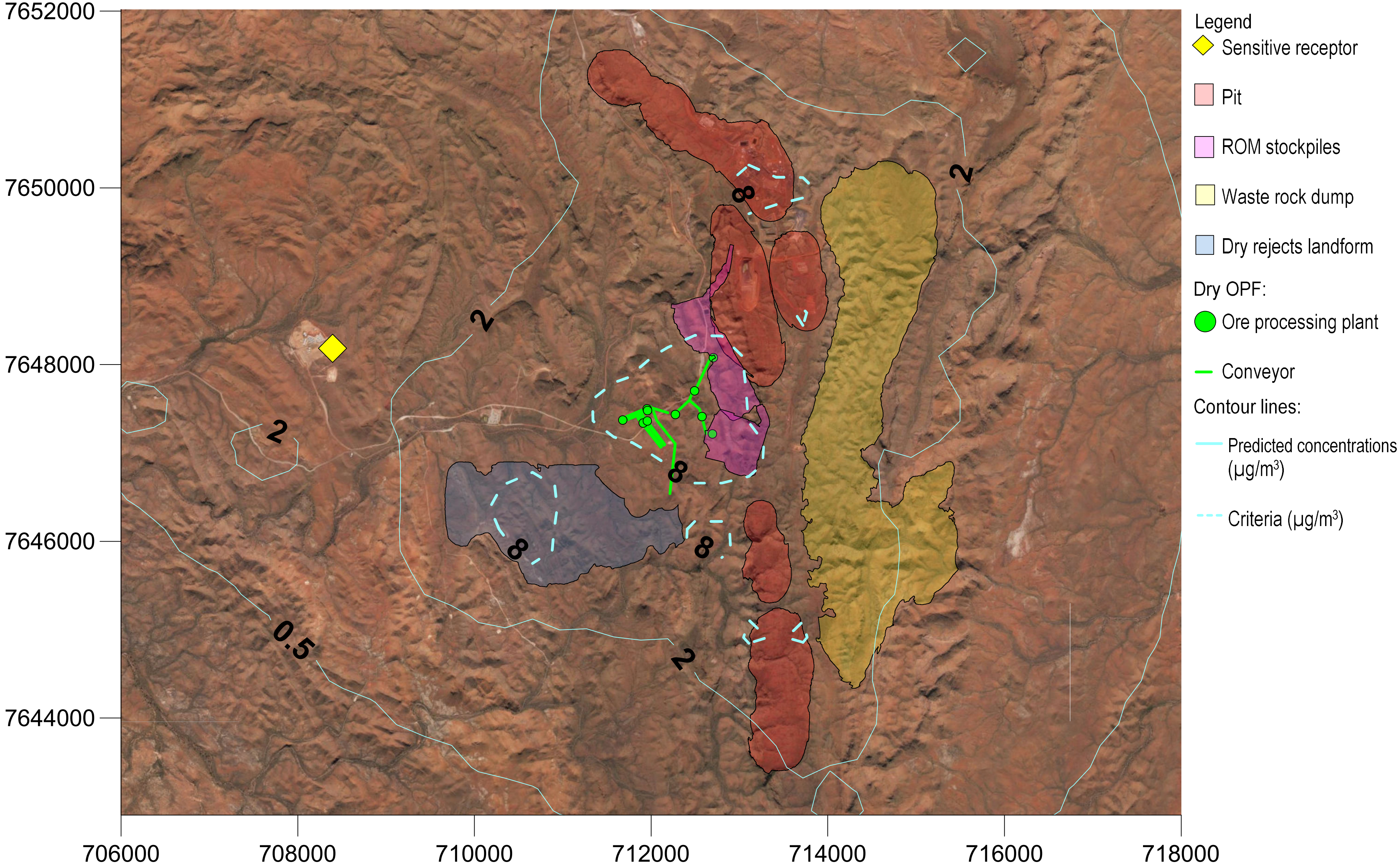
N

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted maximum 24-hour $PM_{2.5}$ concentrations - Scenario Two

Project No. **12536658**
Revision No. **0**
Date **08.06.2021**

FIGURE 7-8



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

N

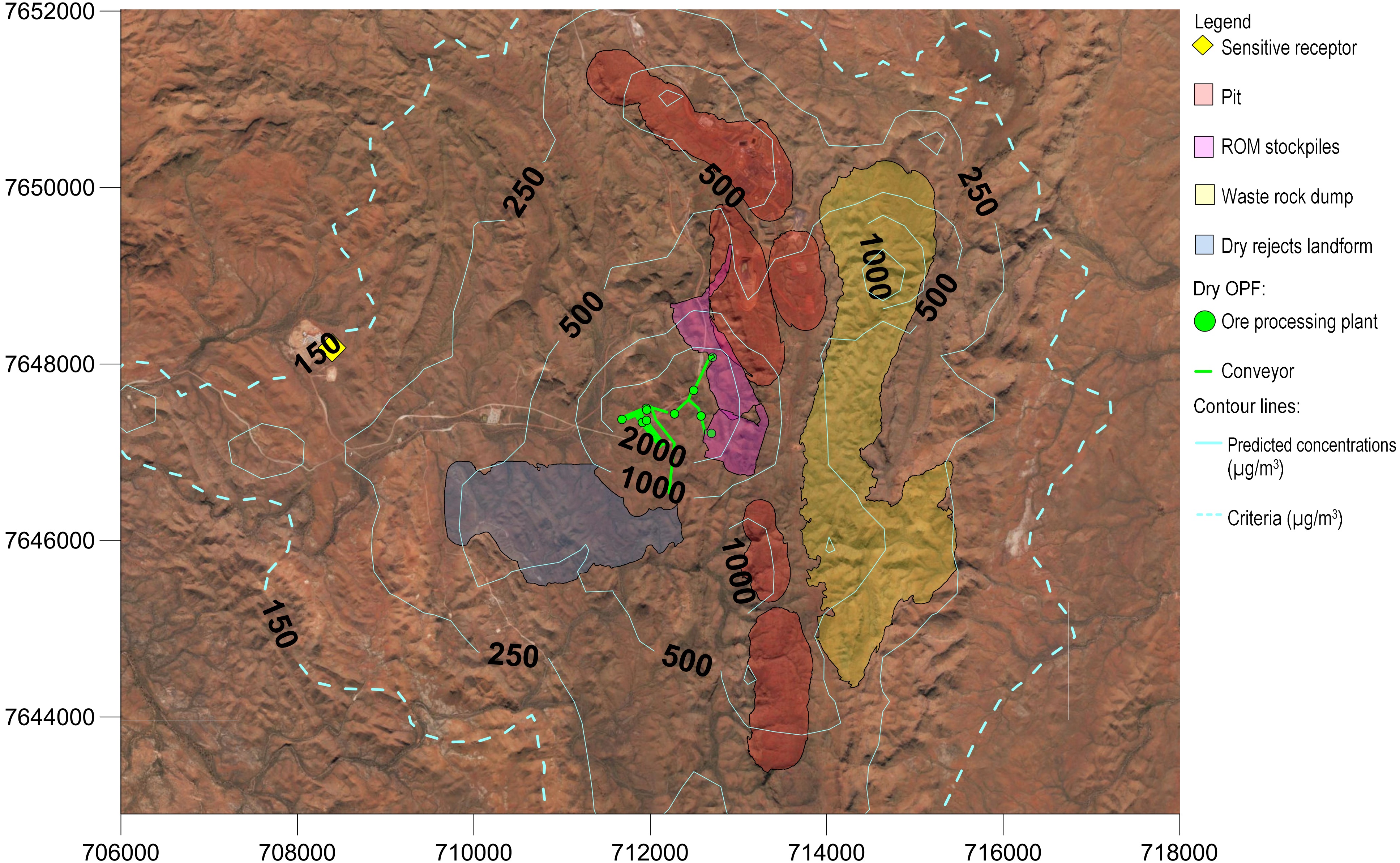
GHD

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted annual $PM_{2.5}$ concentrations - Scenario Two

Project No. **12536658**
Revision No. **0**
Date **08.06.2021**

FIGURE 7-9



Paper Size ISO A4

0 1000 2000
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

N

GHD

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted maximum 24-hour TSP concentrations - Scenario Two

Project No. **12536658**
Revision No. **0**
Date **08.06.2021**

FIGURE 7-10

7.4.3 Scenario Three

Scenario Three represents interim mining operations (year 2041). Predicted ground level dust concentrations at Japal Village from Scenario Three are shown in Table 7.7.

The predicted 24-hour PM_{10} and $PM_{2.5}$ concentrations at the mine village exceed the Air NEPM criteria by 564 percent and 114 percent respectively. Analysis of subsequent highest predicted concentrations shows the 23 highest predicted 24-hour concentrations for PM_{10} exceed the criteria, equating to 23 exceedance days in the year. The analysis shows only the maximum predicted 24-hour $PM_{2.5}$ concentration exceeds the criteria, equating to one exceedance day a year for $PM_{2.5}$.

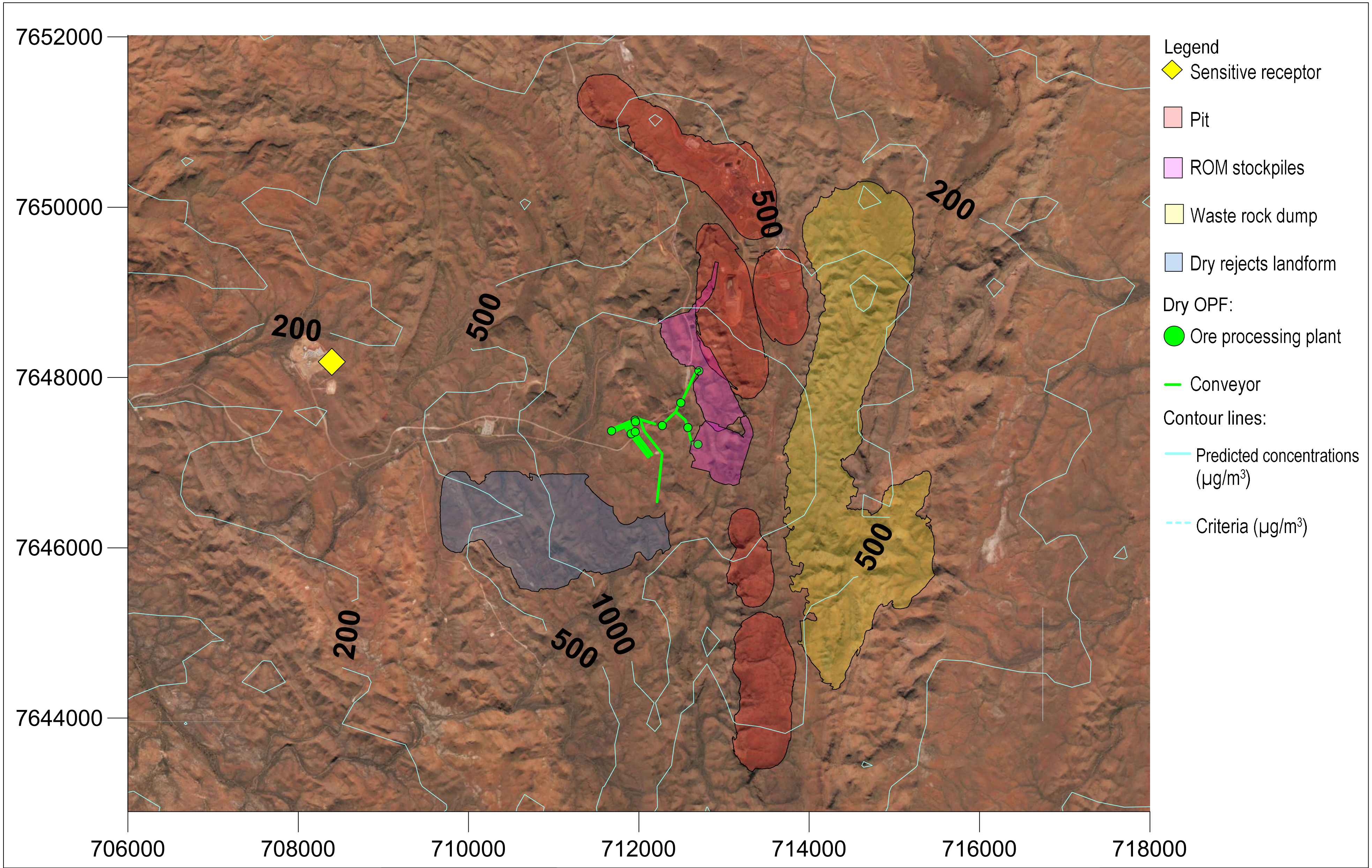
The predicted annual concentrations for PM_{10} and $PM_{2.5}$ comply with the respective Air NEPM criteria.

The predicted 24-hour TSP concentration at Japal Village complies with the Kwinana EPP criterion. Similarly, predicted dust deposition at Japal Village comply with the NSW AMMAAP criteria.

Contour figures for PM_{10}, $PM_{2.5}$ and TSP are shown in Figure 7.11 to Figure 7.15.

Table 7.7 Predicted concentrations at Japal Village for Scenario Three

Pollutant	Averaging period	Criteria	Source	Predicted concentration (µg/m^3)	Percent of criteria
PM_{10}	Maximum 24-hour	50 (µg/m^3)	Air NEPM	282	564%
	Annual	25 (µg/m^3)	Air NEPM	20	80%
$PM_{2.5}$	Maximum 24-hour	25 (µg/m^3)	Air NEPM	28	114%
	Annual	8 (µg/m^3)	Air NEPM	2	26%
TSP	Maximum 24-hour	150 (µg/m^3)	Kwinana EPP (Area C)	33	22%
Deposited dust	Annual	2 g/m^2/month	NSW AMMAAP	0.1	5%
	Annual	4 g/m^2/month	NSW AMMAAP	0.1	2%

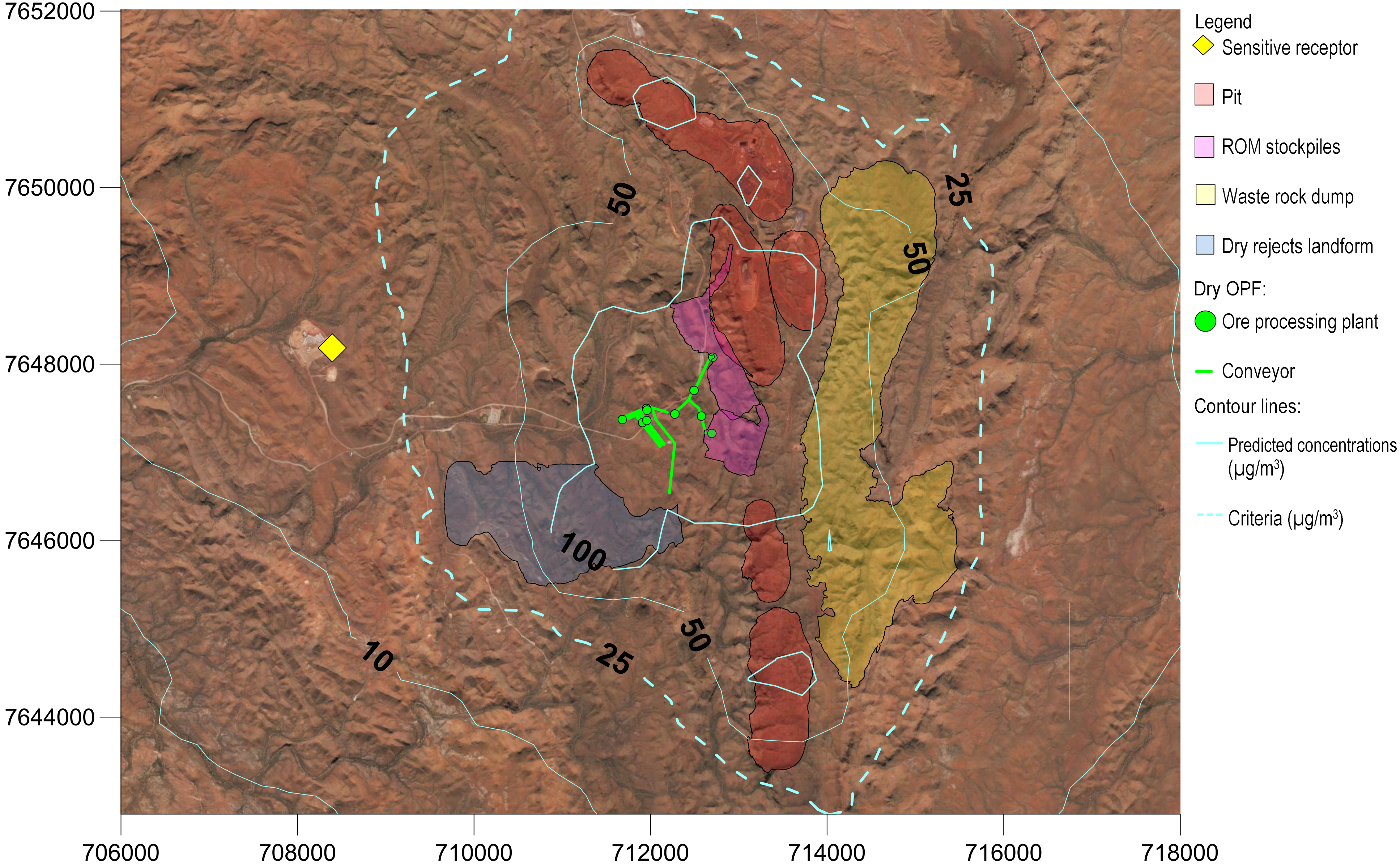


IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted maximum 24-hour PM_{10} concentrations - Scenario Three

Project No. **12536658**
Revision No. **0**
Date **08.06.2021**

FIGURE 7-11



Paper Size ISO A4

0 1000 2000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

N

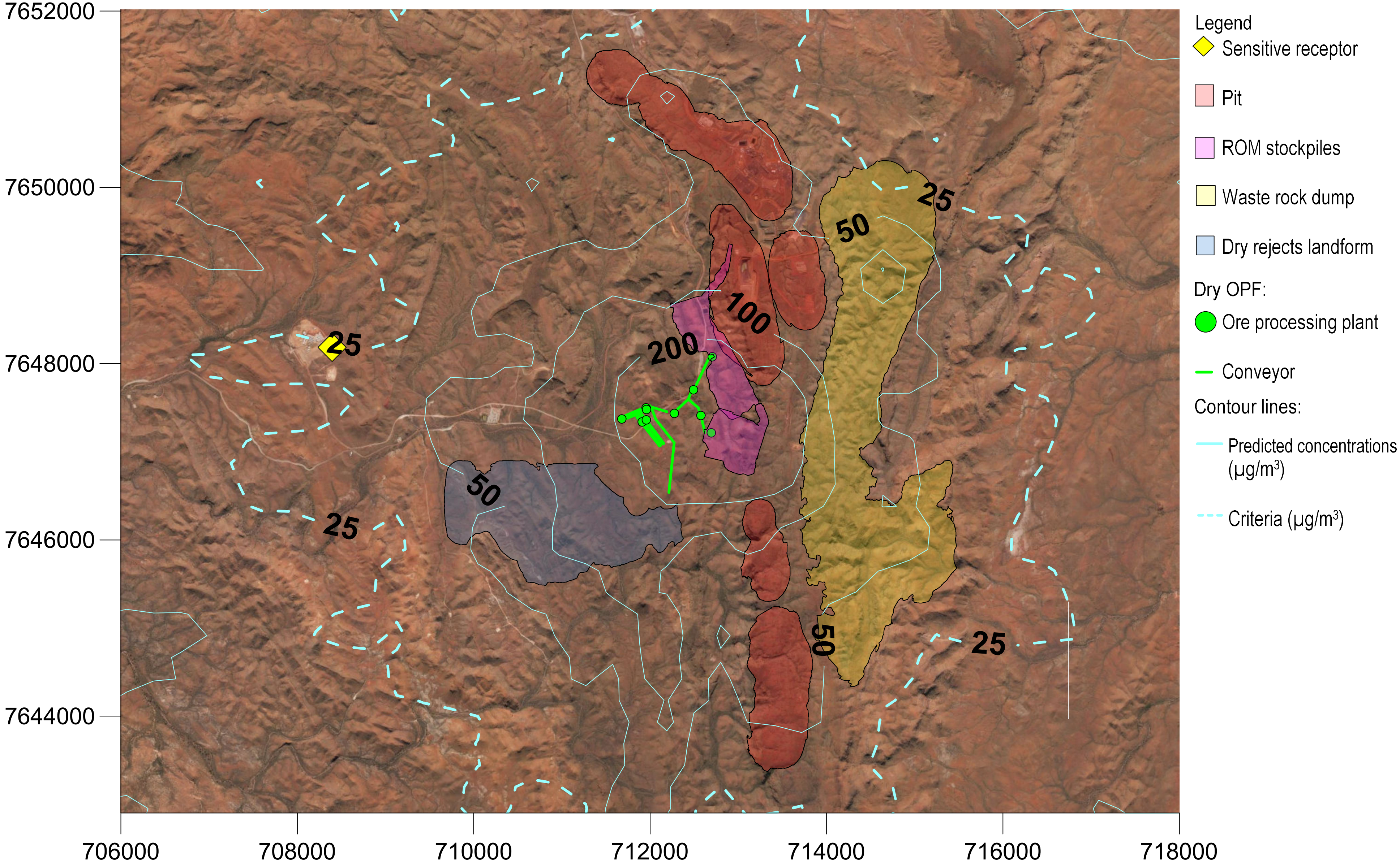
GHD

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted annual PM_{10} concentrations - Scenario Three

Project No.	**12536658**
Revision No.	**0**
Date	**08.06.2021**

FIGURE 7-12

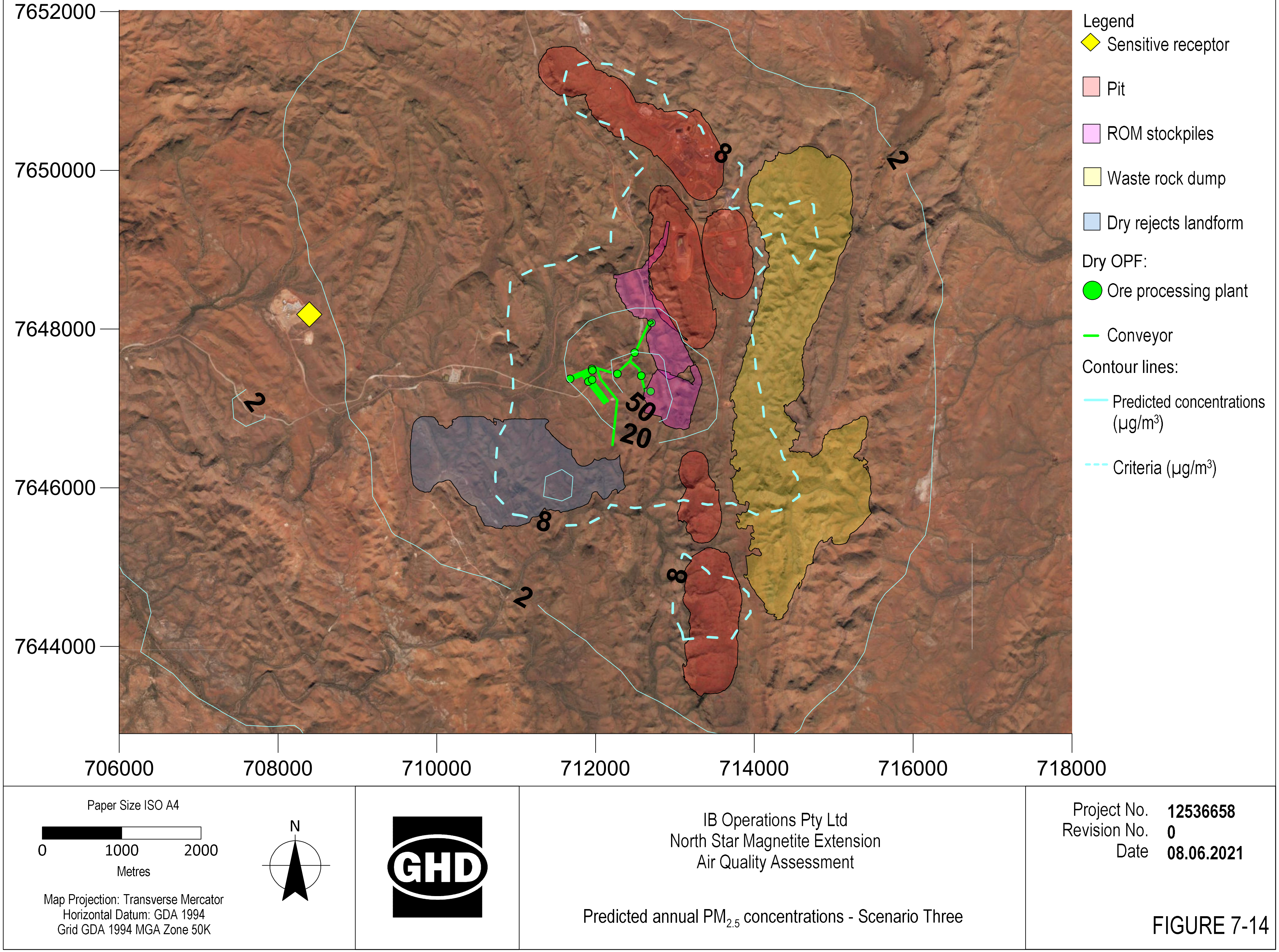


IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted maximum 24-hour $PM_{2.5}$ concentrations - Scenario Three

Project No.	12536658
Revision No.	0
Date	08.06.2021

FIGURE 7-13



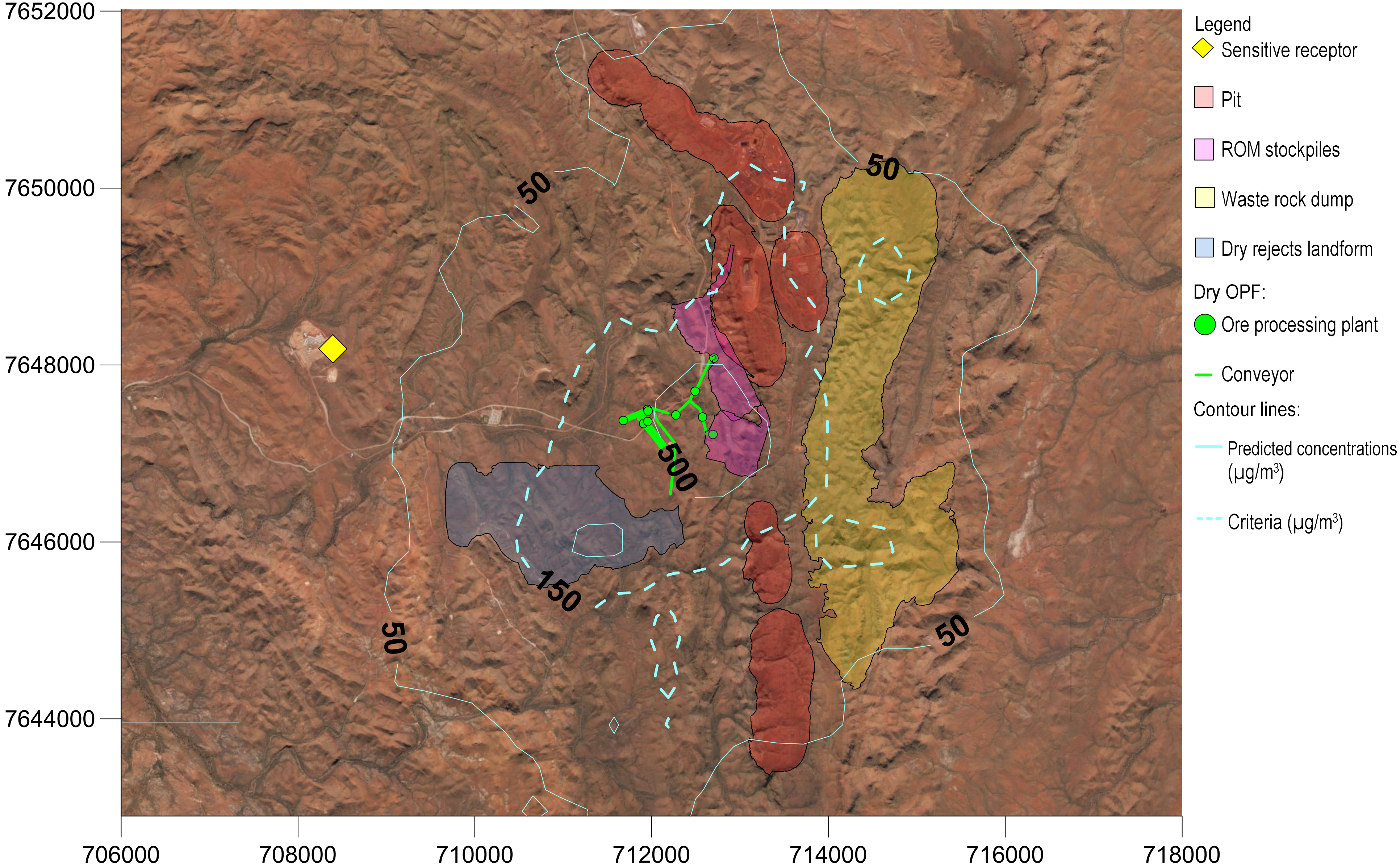
GHD

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted annual $PM_{2.5}$ concentrations - Scenario Three

Project No.	**12536658**
Revision No.	**0**
Date	**08.06.2021**

FIGURE 7-14



Paper Size ISO A4

0 1000 2000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

N

GHD

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted maximum 24-hour TSP concentrations - Scenario Three

Project No. **12536658**
Revision No. **0**
Date **08.06.2021**

FIGURE 7-15

7.4.4 Scenario Four

Scenario Four represents the highest throughput for North Star Extenasion operations (year 2041), with dust mitigation included. This is equivalent to Scenario Two, but with Level 1 watering on the haul roads. Predicted ground level dust concentrations at Japal Village from Scenario Four are shown in Table 7.8.

The predicted 24-hour PM_{10} concentration at Japal Village exceeds the Air NEPM criterion by six percent. Analysis of subsequent highest predicted concentrations shows only the maximum predicted 24-hour PM_{10} concentration exceeds the criteria, equating to one exceedance day a year for PM_{10}.

The predicted annual concentration for PM_{10}, and the predicted 24-hour and annual $PM_{2.5}$ concentrations comply with the respective Air NEPM criteria.

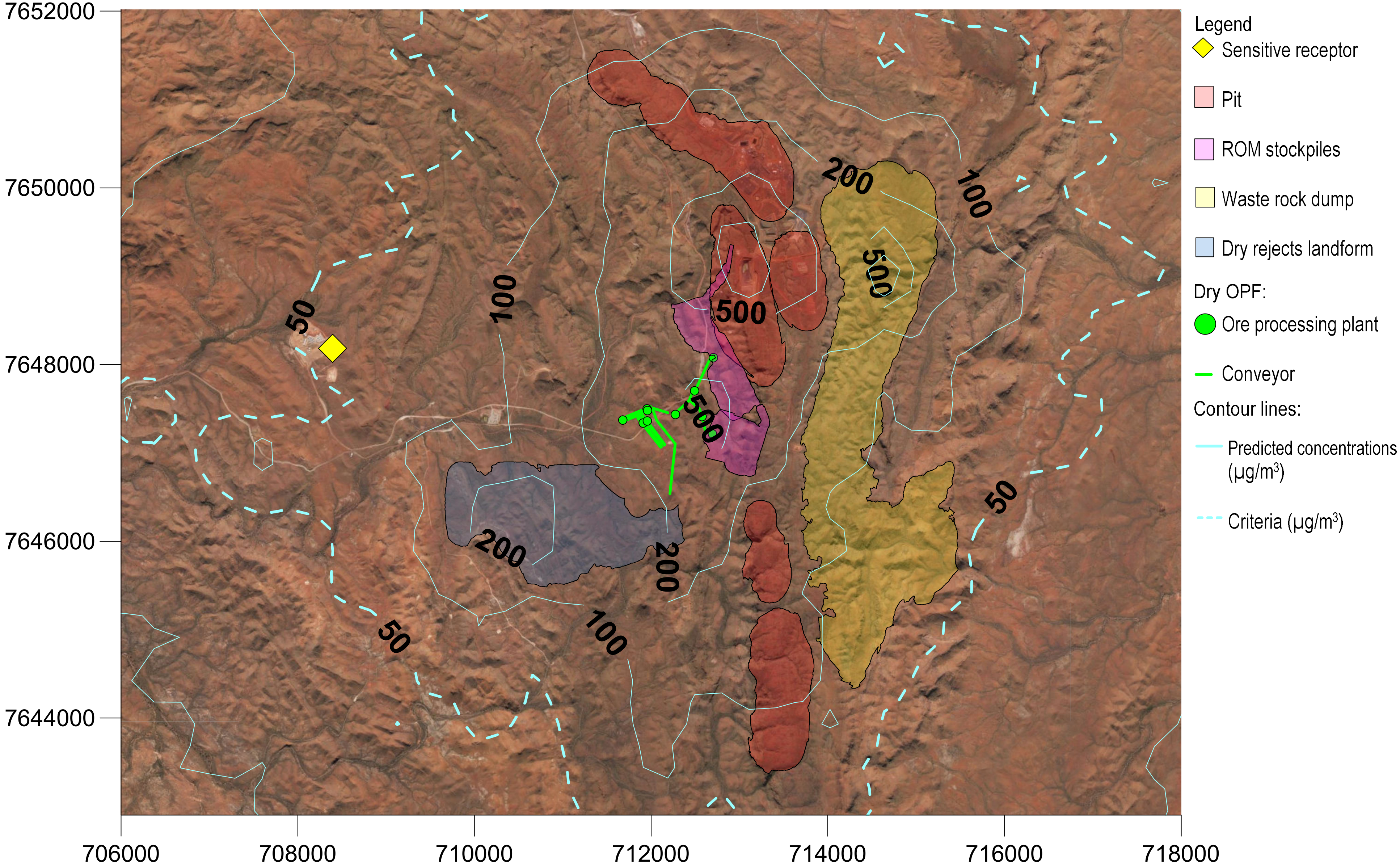
The predicted 24-hour TSP concentration at Japal Village exceeds the Kwinana EPP criterion by four percent. Analysis of subsequent highest predicted concentrations shows the three highest predicted 24-hour concentrations for TSP exceed the criteria, equating to three exceedance days in the year.

Predicted dust deposition at Japal Village comply with the NSW AMMAAP criteria.

Contour figures for PM_{10}, $PM_{2.5}$ and TSP are shown in Figure 7.16 to Figure 7.20.

Table 7.8 Predicted concentrations at Japal Village for Scenario Four

Pollutant	Averaging period	Criteria	Source	Predicted concentration (µg/m^3)	Percent of criteria
PM_{10}	Maximum 24-hour	50 (µg/m^3)	Air NEPM	53	106%
	Annual	25 (µg/m^3)	Air NEPM	8	32%
$PM_{2.5}$	Maximum 24-hour	25 (µg/m^3)	Air NEPM	7	26%
	Annual	8 (µg/m^3)	Air NEPM	1	14%
TSP	Maximum 24-hour	150 (µg/m^3)	Kwinana EPP (Area C)	157	104%
Deposited dust	Annual	2 g/m^2/month	NSW AMMAAP	0.5	26%
	Annual	4 g/m^2/month	NSW AMMAAP	0.5	13%



Paper Size ISO A4

0 1000 2000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

N

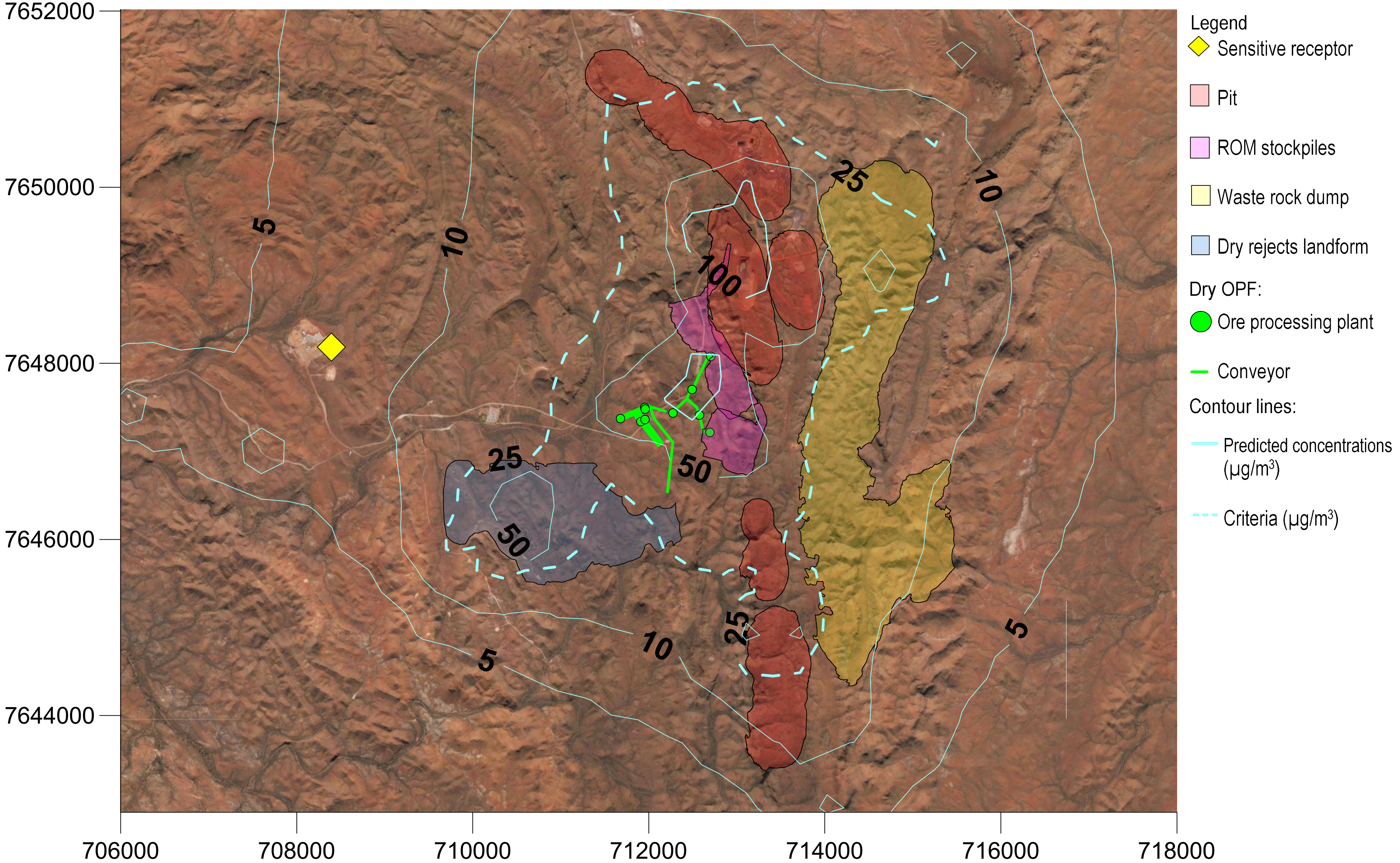
GHD

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted maximum 24-hour PM_{10} concentrations - Scenario Four

Project No.	**12536658**
Revision No.	**0**
Date	**08.06.2021**

FIGURE 7-16



Paper Size ISO A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

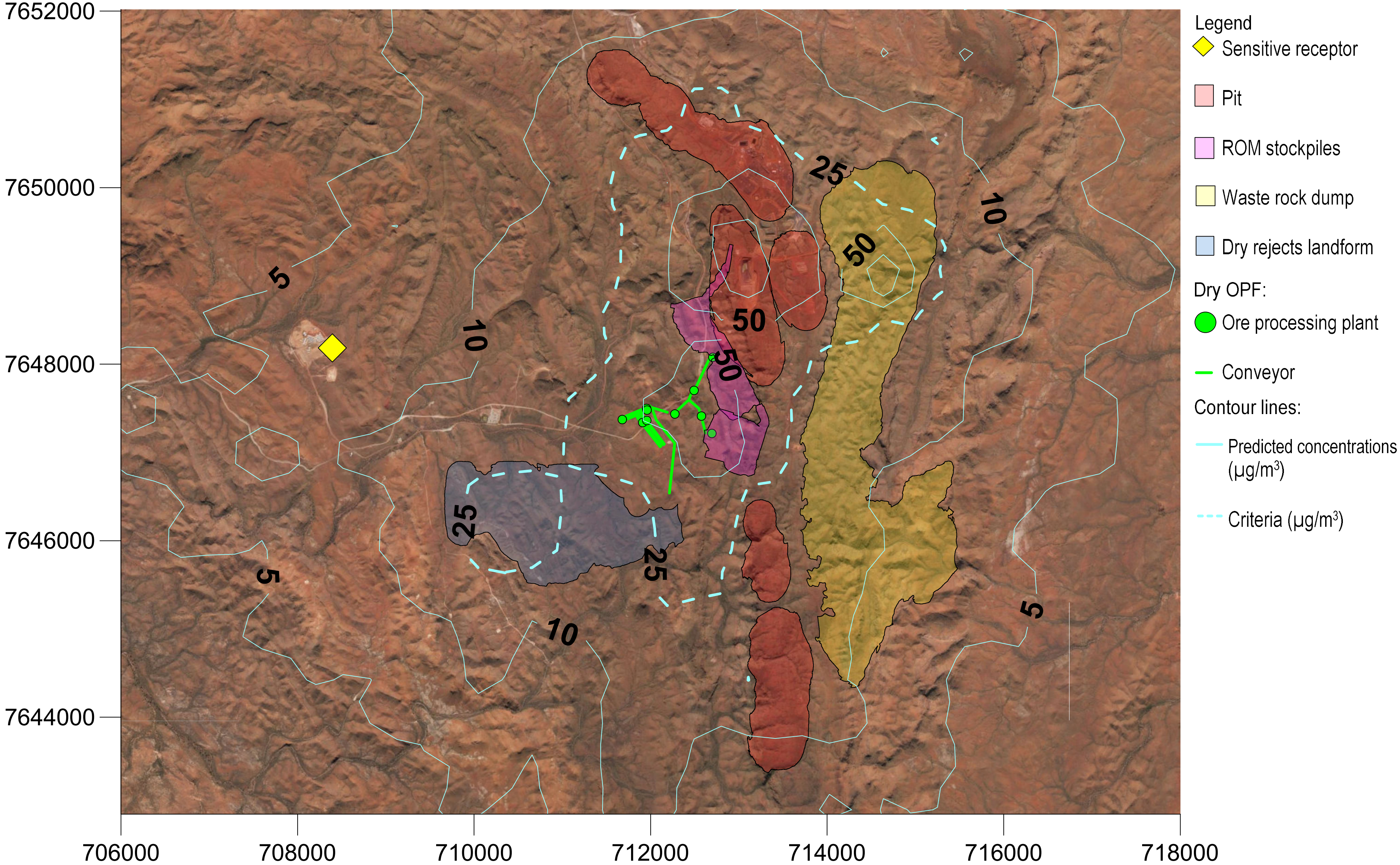
N

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted annual PM_{10} concentrations - Scenario Four

Project No. **12536658**
Revision No. **0**
Date **08.06.2021**

FIGURE 7-17



Paper Size ISO A4

0 1000 2000
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

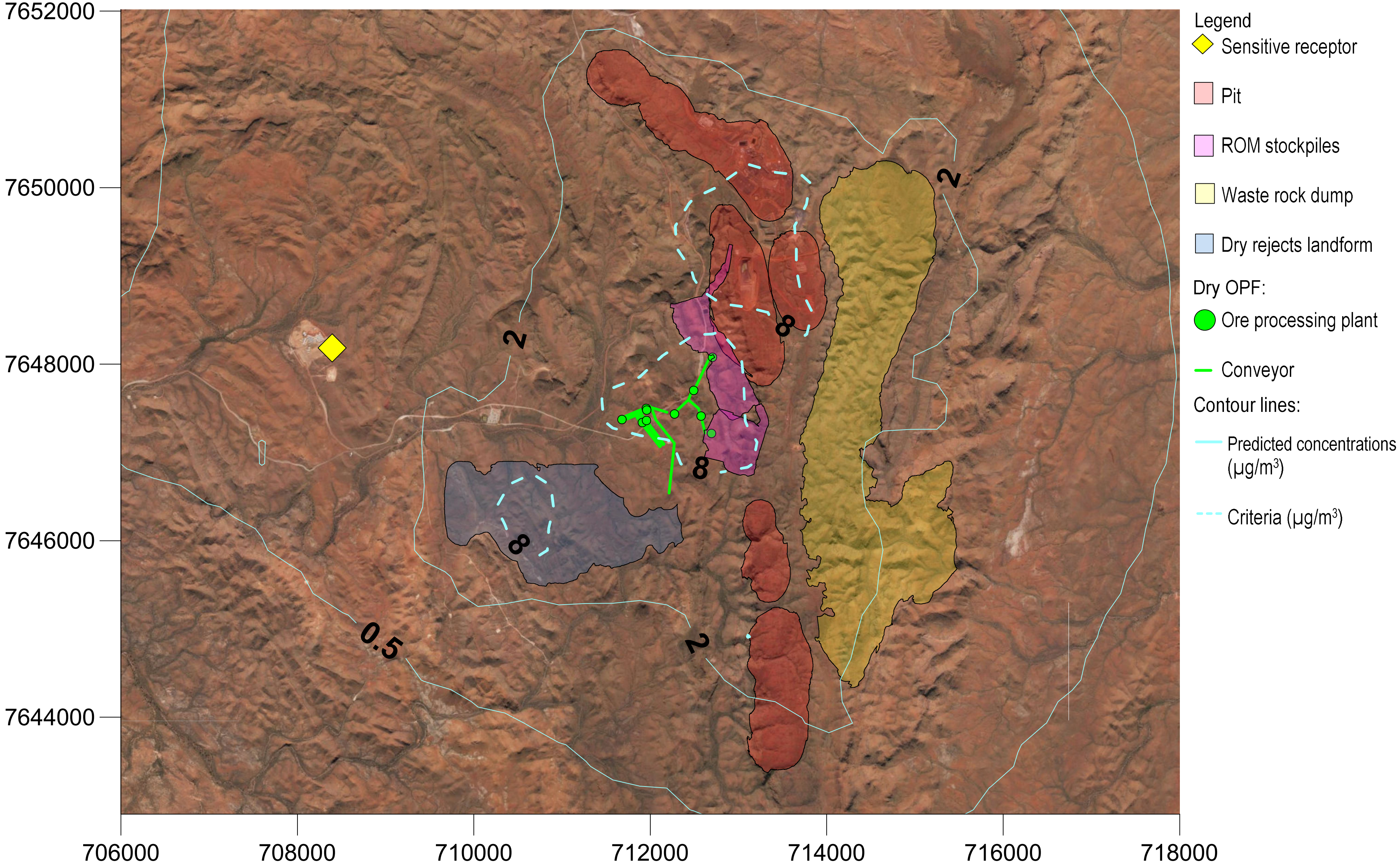
N

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted maximum 24-hour $PM_{2.5}$ concentrations - Scenario Four

Project No.	**12536658**
Revision No.	**0**
Date	**08.06.2021**

FIGURE 7-18



Paper Size ISO A4

0 1000 2000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

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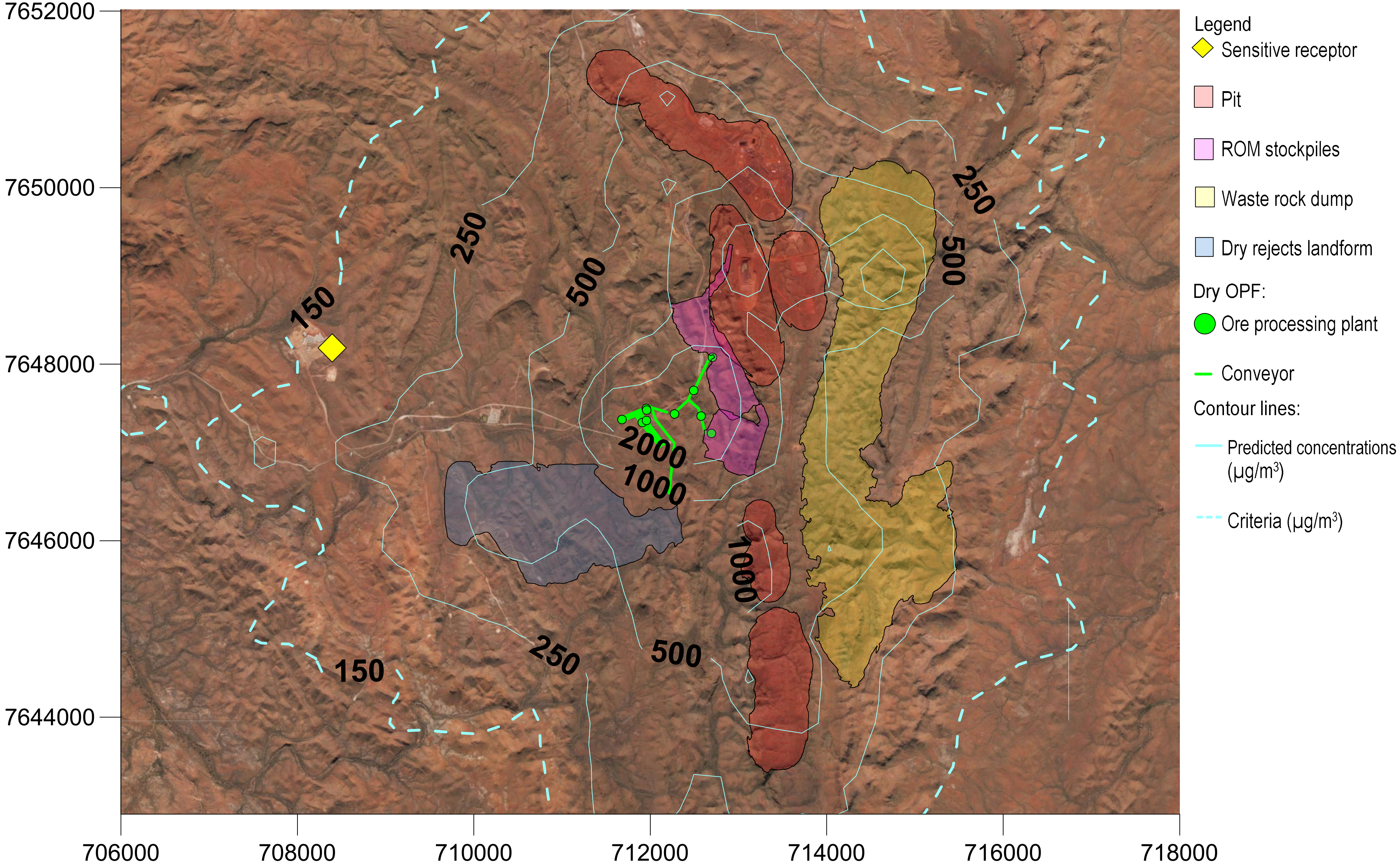
GHD

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted annual $PM_{2.5}$ concentrations - Scenario Four

Project No. **12536658**
Revision No. **0**
Date **08.06.2021**

FIGURE 7-19



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid GDA 1994 MGA Zone 50K

GHD

IB Operations Pty Ltd
North Star Magnetite Extension
Air Quality Assessment

Predicted maximum 24-hour TSP concentrations - Scenario Four

Project No. **12536658**
Revision No. **0**
Date **08.06.2021**

FIGURE 7-20

7.5 Cumulative assessment

As background dust concentrations were not available for the Project area, a quantitative cumulative assessment could not be undertaken as part of this assessment.

However, in each modelling scenario, at least one predicted concentration exceeded the relevant air quality criteria. It can therefore be concluded that a cumulative assessment would also result in exceedances of these air quality criteria.

8. Conclusion

8.1 Discussion

This report presents an air quality assessment for the North Star magnetite mine located in Marble Bar. Predicted dust impacts to local air quality from the proposed extension of Stage 2 of the mine have been assessed. The extension incorporates the development of a additional deposits immediately to the south of the existing approved Stage 2 pits. The Project is proposed to include full-depth mining from open pits, an ore processing facility, tailings dam and waste rock dump.

Four modelling scenarios were carried out as part of this assessment, using the AERMOD dispersion model. The modelling scenarios included the following:

- Scenario One – Representing the highest throughput year for approved Stage 2 operations (year 2029)
- Scenario Two – Representing the highest throughput year for North Star Extension operations (year 2041)
- Scenario Three- Representing interim mining operations (year 2024)
- Scenario Four – Representing the highest throughput year for North Star Extension operations with dust mitigation included in the form of watering haul roads (Level 1 watering) (year 2041)

TAPM was used to synthesize meteorological data for input into AERMOD. The modelling period used was 1 July 2019 to 30 June 2020 as this represents an average meteorological year at the Project site, without the influence of tropical cyclones or La Nina ENSO.

Emission estimation was carried out in line with methods from the National Pollutant Inventory Emission Estimation Technique Manual for Mining. Emission factors were taken from the same publication.

Dispersion modelling results at the Japal Village were compared to relevant local and national air quality criteria including:

- *National Environment Protection (Ambient Air Quality) Measure*
- *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*
- *Environmental Protection (Kwinana) (Atmospheric Waste) Policy*

For Scenario One, predicted concentrations of dust complied with the relevant air quality criteria at Japal Village, with the exception of the predicted 24-hour TSP concentration. This was 121 percent of the Kwinana EPP criterion. The dispersion modelling predicted a total of three exceedance days in the year for TSP.

For Scenario Two, predicted concentrations of dust complied with the relevant air quality criteria at Japal Village, with the exception of the predicted 24-hour PM_{10} and TSP concentrations. These were 115 percent of the Air NEPM criterion and 113 percent of the Kwinana EPP criterion respectively. Dispersion modelling predicted a total of two exceedance days in the year for both 24-hour PM_{10} and TSP.

For Scenario Three, predicted concentrations of dust complied with the relevant air quality criteria at Japal Village, with the exception of the predicted 24-hour PM_{10} and $PM_{2.5}$ concentrations. These were 564 percent and 114 percent of the Air NEPM criteria respectively. Dispersion modelling predicted a total of 23 exceedance days in the year for 24-hour PM_{10} and only one exceedance day in the year for 24-hour $PM_{2.5}$.

The reason for the high number of exceedances of 24-hour PM_{10} in Scenario Three is due to the increase in mechanical disturbance of the dry rejects. Until the year 2024, a dozer and loader will be used instead of a radial stacker. The dry rejects will then be transported via haul truck to the DRL instead of the conveyor, which will be utilised after 2024.

For Scenario Four, predicted concentrations of dust complied with the relevant air quality criteria at Japal Village, with the exception of the predicted 24-hour PM_{10} and TSP concentrations. These were 106 percent and 104 percent of the relevant criteria respectively. Dispersion modelling predicted a total of one exceedance day in the year for 24-hour PM_{10} and three exceedance days in the year for TSP.

8.2 Concluding remarks

A number of exceedances were predicted for each modelling scenario in this assessment, including the dust mitigation scenario. With the exception of Scenario Three, which represents increased handling and mechanical disturbance of the dry rejects and therefore higher emissions, exceedances of relevant air quality criteria were predicted to occur a maximum of three days per year.

9. References

Australian Government 2021, *National Pollutant Inventory Emission Estimation Technique Manual for Mining (Version 3.1),* Department of Sustainability, Environment, Water, Population and Communities, Canberra, January 2012.

Bureau of Meteorology (BoM) 2020, *Climate statistics for Australian locations, Summary statistics Marble Bar,* Accessed 25 January 2021 from http://www.bom.gov.au/climate/averages/tables/cw_004106.shtml, January 2021.

EPA Victoria 2014, *Guideline– Construction of Input Meteorological Data Files for EPA Victoria's Regulatory Air Pollution Model AERMOD,* Publication 1550 Revision 3, September 2014.

EPA WA (Environmental Protection Authority Western Australia) 1999, *Environmental Protection (Kwinana) (Atmospheric Waste) Policy,* Perth, 21 December 1999.

EPA WA 2014, *Environmental Protection (Kwinana) (Atmospheric Wastes) Regulations 1992,* Perth, 23 August 2014.

Google Maps 2021, *Satellite imagery of Marble Bar Western Australia and surrounds*, Google Maps, 2021, Accessed January 2020.

Government of Western Australia 2009, *State Environmental (Ambient Air) Policy 2009 - Draft Policy for Public and Stakeholder Comment*, Perth, June 2009.

NEPC (National Environment Protection Council) 2016, *National Environment Protection Measure for Ambient Air Quality*, Canberra, February 2016.

NSW EPA (New South Wales Environmental Protection Authority) 2017, *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales,* Sydney, January 2017.

SKM 2012, North Star Magnetite Project Air Quality Impact Assessment, Perth, June 2012.

Stern, H., de Hoedt, G. and Ernst, J 2000, *Objective classification of Australian climates*, Aust. Met. Mag., 49 (2000) 87-96.

US EPA 2007, Office of Air Quality Planning and Standards, *AERSURFACE User's Guide*, Research Triangle Park, North Carolina, EPA 454/B-08-00.

Van Vreeswyk, A., Payne, A., Leighton, K., and Hennig, P. 2004, *An Inventory and Condition Survey of the Pilbara Region, Western Australia,* Technical Bulletin, No. 92, Department of Agriculture, Government of Western Australia, South Perth, Western Australia, December 2004.

Appendices

Appendix A – AERMOD output file

*** MODELOPTs: RegDFAULT CONC ELEV RURAL ADJ_U*

*** MODEL SETUP OPTIONS SUMMARY ***

- -

**Model Is Setup For Calculation of Average CONCentration Values.

-- DEPOSITION LOGIC --

**NO GAS DEPOSITION Data Provided.

**NO PARTICLE DEPOSITION Data Provided.

**Model Uses NO DRY DEPLETION. DRYDPLT = F

**Model Uses NO WET DEPLETION. WETDPLT = F

**Model Uses RURAL Dispersion Only.

**Model Uses Regulatory DEFAULT Options:

1. Stack-tip Downwash.
2. Model Accounts for ELEVated Terrain Effects.
3. Use Calms Processing Routine.
4. Use Missing Data Processing Routine.
5. No Exponential Decay.

**Other Options Specified:

ADJ_U* - Use ADJ_U* BETA option for SBL in AERMET

CCVR_Sub - Meteorological data includes CCVR substitutions

TEMP_Sub - Meteorological data includes TEMP substitutions

**Model Assumes No FLAGPOLE Receptor Heights.

**The User Specified a Pollutant Type of: PM_10

**Model Calculates 1 Short Term Average(s) of: 24-HR
    and Calculates ANNUAL Averages

**This Run Includes: 84 Source(s);   1 Source Group(s); and   776 Receptor(s)

with: 0 POINT(s), including
           0 POINTCAP(s) and   0 POINTHOR(s)
and: 75 VOLUME source(s)
and: 9 AREA type source(s)
and: 0 LINE source(s)
and: 0 OPENPIT source(s)
and: 0 BUOYANT LINE source(s) with   0 line(s)

**Model Set To Continue RUNning After the Setup Testing.

**The AERMET Input Meteorological Data Version Date: 16216

**Output Options Selected:
    Model Outputs Tables of ANNUAL Averages by Receptor
    Model Outputs Tables of Highest Short Term Values by Receptor (RECTABLE Keyword)
    Model Outputs External File(s) of High Values for Plotting (PLOTFILE Keyword)
    Model Outputs Separate Summary File of High Ranked Values (SUMMFILE Keyword)

**NOTE: The Following Flags May Appear Following CONC Values: c for Calm Hours
    m for Missing Hours
    b for Both Calm and Missing Hours

**Misc. Inputs: Base Elev. for Pot. Temp. Profile (m MSL) =   10.00 ; Decay Coef. =   0.000   ; Rot. Angle =   0.0

Emission Units = GRAMS/SEC   ; Emission Rate Unit Factor = 0.10000E+07

Output Units   = MICROGRAMS/M**3

**Approximate Storage Requirements of Model =   5.0 MB of RAM.

**Detailed Error/Message File: PM10.err

**File for Summary of Results: PM10.sum

*** MODELOPTs: RegDFAULT CONC ELEV RURAL ADJ_U*

*** METEOROLOGICAL DAYS SELECTED FOR PROCESSING ***

(1=YES; 0=NO)

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1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

NOTE: METEOROLOGICAL DATA ACTUALLY PROCESSED WILL ALSO DEPEND ON WHAT IS INCLUDED IN THE DATA FILE.

*** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***

(METERS/SEC)

1.54, 3.09, 5.14, 8.23, 10.80,

*** MODELOPTs: RegDFAULT CONC ELEV RURAL ADJ_U*

*** UP TO THE FIRST 24 HOURS OF METEOROLOGICAL DATA ***

Surface file: ..\..\AERMET\FMGIB.SFC   Met Version: 16216

Profile file: ..\..\AERMET\FMGIB.PFL

Surface format: FREE

Profile format: FREE

Surface station no.:   0   Upper air station no.:   123

Name: UNKNOWN   Name: UNKNOWN

Year: 2019   Year: 2019

First 24 hours of scalar data

YR MO DY JDY HR   H0   U*   W* DT/DZ ZICNV ZIMCH M-O LEN   Z0 BOWEN ALBEDO REF WS   WD   HT REF TA   HT

- -

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19 07 01 182 02 -25.1 0.256 -9.000 -9.000 -999.   95.   72.1 0.15   6.07   1.00   1.40 142.   2.0 289.0   2.0

19 07 01 182 03 -27.0 0.275 -9.000 -9.000 -999.   97.   83.2 0.15   6.07   1.00   1.50 142.   2.0 288.5   2.0

19 07 01 182 04 -30.8 0.313 -9.000 -9.000 -999.   97.   107.9 0.15   6.07   1.00   1.70 147.   2.0 288.0   2.0

19 07 01 182 05 -34.7 0.351 -9.000 -9.000 -999.   97.   135.9 0.15   6.07   1.00   1.90 151.   2.0 286.9   2.0

19 07 01 182 06 -34.9 0.351 -9.000 -9.000 -999.   97.   135.9 0.15   6.07   1.00   1.90 153.   2.0 285.2   2.0

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19 07 01 182 08 -13.1 0.375 -9.000 -9.000 -999.   97.   363.2 0.15   6.07   0.49   2.00 152.   2.0 282.8   2.0

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285.1   2.0

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288.2   2.0

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19 07 01 182 17   0.1 0.278 0.097 0.005 332. 352. -8888.0 0.15   6.07   0.43   1.80 126.   2.0
296.5   2.0

19 07 01 182 18 -30.2 0.313 -9.000 -9.000 -999.   52.   108.0 0.15   6.07   1.00   1.70 140.   2.0
294.5   2.0

19 07 01 182 19 -30.5 0.313 -9.000 -9.000 -999.   83.   108.0 0.15   6.07   1.00   1.70 154.   2.0
291.0   2.0

19 07 01 182 20 -34.4 0.352 -9.000 -9.000 -999.   91.   136.0 0.15   6.07   1.00   1.90 161.   2.0
289.9   2.0

19 07 01 182 21 -34.5 0.352 -9.000 -9.000 -999.   97.   135.9 0.15   6.07   1.00   1.90 165.   2.0
289.2   2.0

19 07 01 182 22 -34.6 0.352 -9.000 -9.000 -999. 119.   135.9 0.15   6.07   1.00   1.90 163.   2.0
288.2   2.0

19 07 01 182 23 -34.7 0.352 -9.000 -9.000 -999. 141.   135.9 0.15   6.07   1.00   1.90 160.   2.0
287.2   2.0

19 07 01 182 24 -38.6 0.390 -9.000 -9.000 -999. 145.   167.1 0.15   6.07   1.00   2.10 157.   2.0
286.4   2.0

First hour of profile data

YR MO DY HR HEIGHT F WDIR   WSPD AMB_TMP sigmaA sigmaW sigmaV

19 07 01 01   2.0 1 140.   1.20   290.4   99.0 -99.00 -99.00

F indicates top of profile (=1) or below (=0)

*** MODELOPTs: RegDFAULT CONC ELEV RURAL ADJ_U*

*** THE SUMMARY OF MAXIMUM ANNUAL RESULTS AVERAGED OVER 1 YEARS ***

** CONC OF PM_10 IN MICROGRAMS/M**3 **

GROUP ID		AVERAGE CONC	RECEPTOR (XR, YR, ZELEV, ZHILL, ZFLAG)	NETWORK OF TYPE	GRID-ID
ALL	1ST HIGHEST VALUE IS	154.90716	AT (712647.59, 7647994.34, 0.00, 0.00, 0.00)	GC	UCART1
	2ND HIGHEST VALUE IS	132.56462	AT (712647.59, 7647494.34, 0.00, 0.00, 0.00)	GC	UCART1
	3RD HIGHEST VALUE IS	123.17338	AT (712147.59, 7647494.34, 0.00, 0.00, 0.00)	GC	UCART1
	4TH HIGHEST VALUE IS	117.30095	AT (710647.59, 7646494.34, 0.00, 0.00, 0.00)	GC	UCART1
	5TH HIGHEST VALUE IS	102.98239	AT (712647.59, 7649494.34, 0.00, 0.00, 0.00)	GC	UCART1
	6TH HIGHEST VALUE IS	98.04263	AT (713147.59, 7649994.34, 0.00, 0.00, 0.00)	GC	UCART1
	7TH HIGHEST VALUE IS	94.76320	AT (710647.59, 7645994.34, 0.00, 0.00, 0.00)	GC	UCART1
	8TH HIGHEST VALUE IS	93.83642	AT (712647.59, 7648994.34, 0.00, 0.00, 0.00)	GC	UCART1
	9TH HIGHEST VALUE IS	89.53075	AT (712647.59, 7646994.34, 0.00, 0.00, 0.00)	GC	UCART1
	10TH HIGHEST VALUE IS	85.21367	AT (713147.59, 7646994.34, 0.00, 0.00, 0.00)	GC	UCART1

*** RECEPTOR TYPES: GC = GRIDCART

GP = GRIDPOLR

DC = DISCCART

DP = DISCPOLR

*** MODELOPTs: RegDFAULT CONC ELEV RURAL ADJ_U*

*** THE SUMMARY OF HIGHEST 24-HR RESULTS ***

** CONC OF PM_10 IN MICROGRAMS/M**3 **

DATE NETWORK

GROUP ID AVERAGE CONC (YYMMDDHH) RECEPTOR (XR, YR, ZELEV, ZHILL, ZFLAG) OF TYPE GRID-ID

- -

ALL HIGH 1ST HIGH VALUE IS 1582.62999c ON 20012324: AT (714647.59, 7648994.34, 0.00, 0.00, 0.00) GC UCART1

HIGH 2ND HIGH VALUE IS 459.61832c ON 20050724: AT (712647.59, 7647994.34, 0.00, 0.00, 0.00) GC UCART1

HIGH 3RD HIGH VALUE IS 438.53684c ON 20012824: AT (712647.59, 7647994.34, 0.00, 0.00, 0.00) GC UCART1

HIGH 4TH HIGH VALUE IS 436.07343 ON 20011924: AT (712647.59, 7647994.34, 0.00, 0.00, 0.00) GC UCART1

HIGH 5TH HIGH VALUE IS 405.31432 ON 19111524: AT (712647.59, 7647994.34, 0.00, 0.00, 0.00) GC UCART1

HIGH 6TH HIGH VALUE IS 393.62810 ON 20032024: AT (712647.59, 7647994.34, 0.00, 0.00, 0.00) GC UCART1

HIGH 7TH HIGH VALUE IS 382.69733c ON 19090924: AT (712647.59, 7647994.34, 0.00, 0.00, 0.00) GC UCART1

HIGH 8TH HIGH VALUE IS 371.07449 ON 20042224: AT (712647.59, 7647994.34, 0.00, 0.00, 0.00) GC UCART1

HIGH 9TH HIGH VALUE IS 361.30303 ON 20062924: AT (712647.59, 7647994.34, 0.00, 0.00, 0.00) GC UCART1

HIGH 10TH HIGH VALUE IS 346.72604 ON 20040724: AT (712647.59, 7647994.34, 0.00, 0.00, 0.00) GC UCART1

*** RECEPTOR TYPES: GC = GRIDCART

GP = GRIDPOLR

DC = DISCCART

DP = DISCPOLR

*** MODELOPTs: RegDFAULT CONC ELEV RURAL ADJ_U*

*** Message Summary : AERMOD Model Execution ***

--------- Summary of Total Messages --------

A Total of 0 Fatal Error Message(s)
A Total of 2 Warning Message(s)
A Total of 27 Informational Message(s)

A Total of 8784 Hours Were Processed

A Total of 27 Calm Hours Identified

A Total of 0 Missing Hours Identified (0.00 Percent)

******** FATAL ERROR MESSAGES ********
*** NONE ***

******** WARNING MESSAGES ********
SO W320 206 APARM: Input Parameter May Be Out-of-Range for Parameter QS
ME W187 1291 MEOPEN: ADJ_U* Option for Low Winds used in AERMET

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12536658-74846-27/https://projectsportal.ghd.com/sites/pp18_01/northstarextensionai/ProjectDocs/12536658_REP-1_IBO North Star Extension Air Quality Assessment.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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