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FIMISTON SOUTH PROJECT
AIR QUALITY IMPACT ASSESSMENT

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EXECUTIVE SUMMARY

Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM), a wholly owned subsidiary of Northern Star Resources Limited, operates the Fimiston Gold Mine Operations, located adjacent to the City of Kalgoorlie-Boulder in Western Australia. KCGM is proposing to develop the Fimiston South Project (FS Project), consisting of the Morrison (MO) and Southern Extension (SE) resources at the southern end of the existing Fimiston Open Pit (FOP). In support of the regulatory approval process for the proposed FS Project, Ramboll Australia Pty Ltd (Ramboll) has been engaged by KCGM to undertake an air quality assessment of the potential air quality impacts associated with the proposed changes at the Fimiston Operations including air dispersion modelling of emissions in order to compare current potential future impacts associated with the proposal.

The FS Project will be mined in the same manner as the GP Cutback, namely drilling and blasting the in-situ material and excavating and hauling via a conventional truck and shovel fleet. The primary sources and characteristics of atmospheric emissions generated as a result of the FS Project are expected to remain similar to KCGM's current operations. These include:

- Mining operations
  - Drilling and blasting;
  - Excavation of waste rock and ore;
  - Loading/unloading of haul trucks;
- Ore processing
  - Crushing;
  - Conveyor transfer points;
- Wheel generated dust emissions
  - Haul trucks and other vehicles travelling on unsealed roads; and
- Wind-blown dust emissions from exposed surface areas, such as the TSFs.

Dust emissions are actively managed via the Dust Monitoring and Management Programme (DMMP), a component of the Fimiston Air Quality Management Plan (FAQMP). The DMMP utilises real time PM_{10} and meteorological monitoring data, alarms for 0.5-hour, 1-hour, 6-hour and 24-hour averaging periods, back trajectory plots, and visual observations to identify periods where KCGM's operations may be contributing high concentrations of PM_{10} (particulate matter with an equivalent aerodynamic diameter of 10 microns or less) at the monitoring sites. In the event that any alarms are raised, the real time data is reviewed, including the back trajectory plots and the current mine site activities, to identify the operational areas that may have contributed to the alarms and instigate further dust management measures.

Air dispersion modelling was undertaken in order to provide a comparative analysis of current and proposed worst case emissions from KCGM once the FS Project is operational. Analysis of the predicted changes based on the results of air dispersion modelling shows that most significant changes to air quality are expected to occur within the pit and that impacts at sensitive receptor locations are not expected to change significantly. The cumulative results from the air dispersion modelling highlighted the importance of the effective implementation of controls and management to reduce emissions from KCGM operations. It is important to note although there is a level of uncertainty present with the utilisation of modelling, it is considered an effective tool to establish a basis for risk assessment.

Analysis of the historical data demonstrates that the FAQMP has proven to be an effective tool for the management of its particulate emissions and achievement of the FAQMP performance targets, within a framework of regular review and continuous improvement.

Given the proximity of the proposed FS Project to the City of Kalgoorlie-Boulder, the south-western expansion of the FOP is likely to have the greatest potential impact on ambient PM_{10} concentrations at the nearest monitoring locations (i.e. HOP, BSY and CLY). This will primarily be the case during construction works to realign the ENB and when mining activity is close to the surface, during the initial stages of the Project. It is anticipated that in-pit dumping of waste rock material as the project progresses will result in a reduction in wheel-generated dust emissions as the distances travelled by the haul trucks will be reduced. However, as the height of the in-pit waste rock dumps increase and material handling activities occur closer to the surface, the potential for fugitive dust emissions from the northern aspect of the FOP increases.

It is anticipated that continued implementation of the FAQMP, including regular review of data will facilitate the successful management of fugitive dust emissions from the proposed FS Project. It is recommended that the following dust management measures in particular, be applied during realignment of the Environmental Noise Bund (ENB) and near surface mining activities associated with FS Project:

- Restricting near surface activities (e.g. handling of oxide material, blasting) as a function of wind direction;
- Day time only mining near the surface such that any elevated dust concentrations from the Project will be clearly visible and have additional dust management measures applied;
- Continued continuous (24 hours a day, 7 days a week) real-time monitoring of PM_{10} concentrations and implementation of the reactive dust control strategy as required (i.e., dust alarm system);
- Restricting land clearing activities as a function of wind direction; and
- Use of water trucks and water cannons on areas that produce dust such as haul roads, service corridors and other active surfaces.

These measures should continue to be implemented alongside other components of the FAQMP, namely:

- Monitoring current and forecast weather conditions using daily forecasts and real time wind speed and direction monitoring data to plan work activities;
- Use of additional dust control measures where practical (e.g. a dust binding agent);
- Progressive rehabilitation to minimise exposed areas;
- Suspending work in a particular area or for a nominated activity as deemed necessary based on visual inspections, dust alarms, public feedback or prevailing wind conditions;
- Water sprays on crushers turned on when needed;
- Use of an alternative operational area if possible (e.g. use a different waste dump);
- Ensuring that all contractors and staff undertake site-specific inductions which include raising awareness of the importance of dust control;
- Ensuring dust monitoring is undertaken, that the data are assessed in real time, and the results of the monitoring are reviewed and reported on; and
- Ongoing consultation with stakeholders to determine the success of the dust management measures.

In addition to the above dust mitigation measures, Ramboll recommend consideration be given to the following:

- Investigate the use of chemical suppressant in open areas particularly prior to high-risk periods (i.e. ahead of Spring and Summer periods when higher proportion of easterlies occur) or when wind speeds are or are predicted to be above 6.3 m/s;
- Investigate the use of wind fences for periods with high dust transportation risk. For example, during realignment and construction of ENB; and
- Ramboll also recommend that KCGM approach the City of Kalgoorlie-Boulder to offer assistance with dust management measures (e.g., application of a surface binding agent, preventing vehicular access, or rehabilitation) of the open areas on the eastern side of the City with an initial focus on the areas in and around the PM_{10} monitoring locations with the objective of reducing fugitive particulate emissions.

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1. INTRODUCTION

1.1 Background

Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM), a wholly owned subsidiary of Northern Star Resources Limited, operates the Fimiston Gold Mine Operations, located adjacent to the City of Kalgoorlie-Boulder approximately 600 km east of Perth, Western Australia. The Fimiston Operations consist of the Fimiston Open Pit (FOP), the Fimiston Processing Plant, three Tailings Storage Facilities (TSFs), waste rock dumps (WRDs), run of mine, infrastructure corridors and workshop area (Figure 1). In support of the regulatory approval process for the proposed FS Project, Ramboll Australia Pty Ltd (Ramboll) has been engaged by KCGM to undertake an air quality assessment of the potential air quality impacts associated with the proposed FS Project.

Ministerial approval for the Fimiston Gold Mine Operations Extension (Stage 3) and Mine Closure Planning Public Environmental Review (PER) was granted in January 2009 under Ministerial Statement No. 782 (MS782). This allowed mining of a cutback along part of the western edge of the FOP, referred to as the 'Golden Pike (GP) Cutback', bringing mining closer to residential areas of Kalgoorlie-Boulder, and extending the life of the mine. Several amendments to MS782 have since been made allowing modifications to the Fimiston Operations, including an expansion of the FOP to facilitate mining of the Morrison and Brownhill areas (located on the southern and north-eastern boundaries of the FOP respectively). Conditional approval for the Morrison/Brownhill Project was received in January 2018, however the project was subsequently amended in October 2018 to comprise only the smaller Morrison Starter Pit (MOSP).

KCGM is now developing the Fimiston South (FS) Project at the southern end of the existing FOP (Figure 2). This consists consisting of the Morrison (MO) and Southern Extension (SE) resources. To facilitate the environmental approvals process, a number of studies are required for the proposed FS Project, including an air quality assessment. Air quality around the existing FOP is a critical management aspect for the mine and the implementation and regular review of an air quality management plan is a requirement of MS782 (see Conditions 7.1 to 7.3). Air quality management for the existing FOP is facilitated through the implementation of the Fimiston Air Quality Management Plan (FAQMP), the key focus of which is the management of dust emissions from mining operations.

1.2 Purpose of this Report

This report presents an air quality assessment of the potential particulate impacts associated with the proposed FS Project at the Fimiston Operations, including:

- Review of particulate monitoring data collected by KCGM;
- Review of KCGM's dust management and mitigation measures;
- Comparative assessment of current and proposed future operations using air dispersion modelling.

Figure 1: KCGM Mining Areas

Source: KCGM

Figure 2: Location of FOP Mining Areas

Source: KCGM

1.3 Project Description

KCGM's operations currently consist of the Fimiston Operations, Mt Charlotte Underground Mine (approximately 2 km north of the FOP), and the Gidji processing plant (approximately 20 km north of Kalgoorlie-Boulder). The active mining areas within the current FOP are the GP (starting 2010) and MOSP (starting 2018) laybacks, located on the western and southern sides of the pit respectively (Figure 1). The current FOP footprint extends approximately 1.5 km in width, 3.4 km in length and to a depth of approximately 640 m. The FOP hosts gold-bearing ores that are refractory in nature. The gold is associated with sulfides (mainly pyrite) and tellurides. Ore is processed through the Fimiston and Gidji process plants and includes crushing, milling, gravity separation, flotation, ultra-fine grinding (UFG) and cyanidation of the subsequent product streams. The majority of flotation concentrate is treated at the Gidji processing plant.

The proposed FS Project comprises expanding the existing pit to mine the MO and SE resources at the southern end of the existing FOP (Figure 2). The FS Project is an extension of the southern mineralisation and is consistent with previously mined ore bodies in Chaffers layback (completed in 2013) and the previously mined MO pit, which was completed in the late 1980s. The FS Project will be mined in the same manner as the GP Cutback, by drilling and blasting the in-situ material and excavating and hauling via a conventional truck and shovel fleet.

The maximum annual material movement will be approximately 96 Mt. A summary of the material movements for the proposed FS Project and KCGMs total operations are presented in Figure 3.

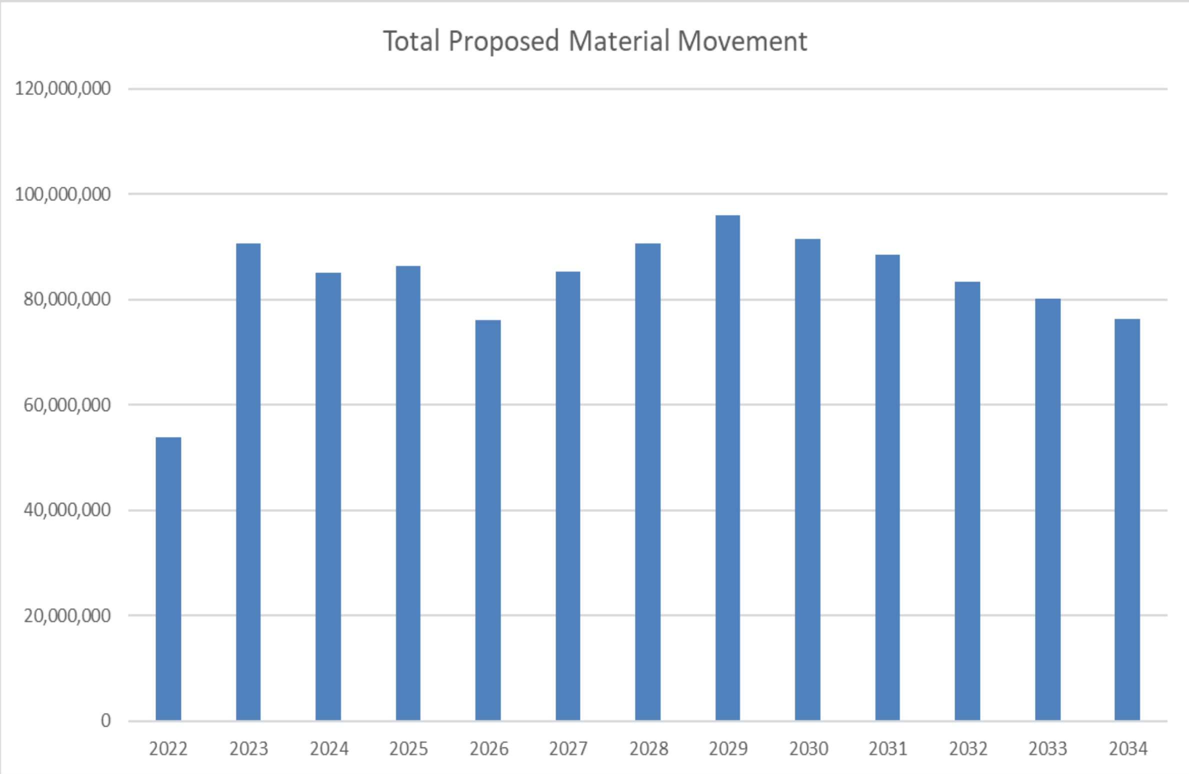


Figure 3: Summary of Total Material Movements

The FS Project is expected to begin operations at -70mRL (based on the final stages of the GP operations) and a maximum of 10 benches will be mined in a given year (bench heights being 10 m). During the initial stage of the FS Project, waste material will be hauled to the existing SE surface dumps. Upon completion of the GP Cutback, waste dumping will transition to in-pit deposition (Figure 4). Approximately 75% of the total waste material from the FS Project will be deposited in-pit. The proposed waste rock and mill haulage routes for the FS Project are shown in Figure 4.

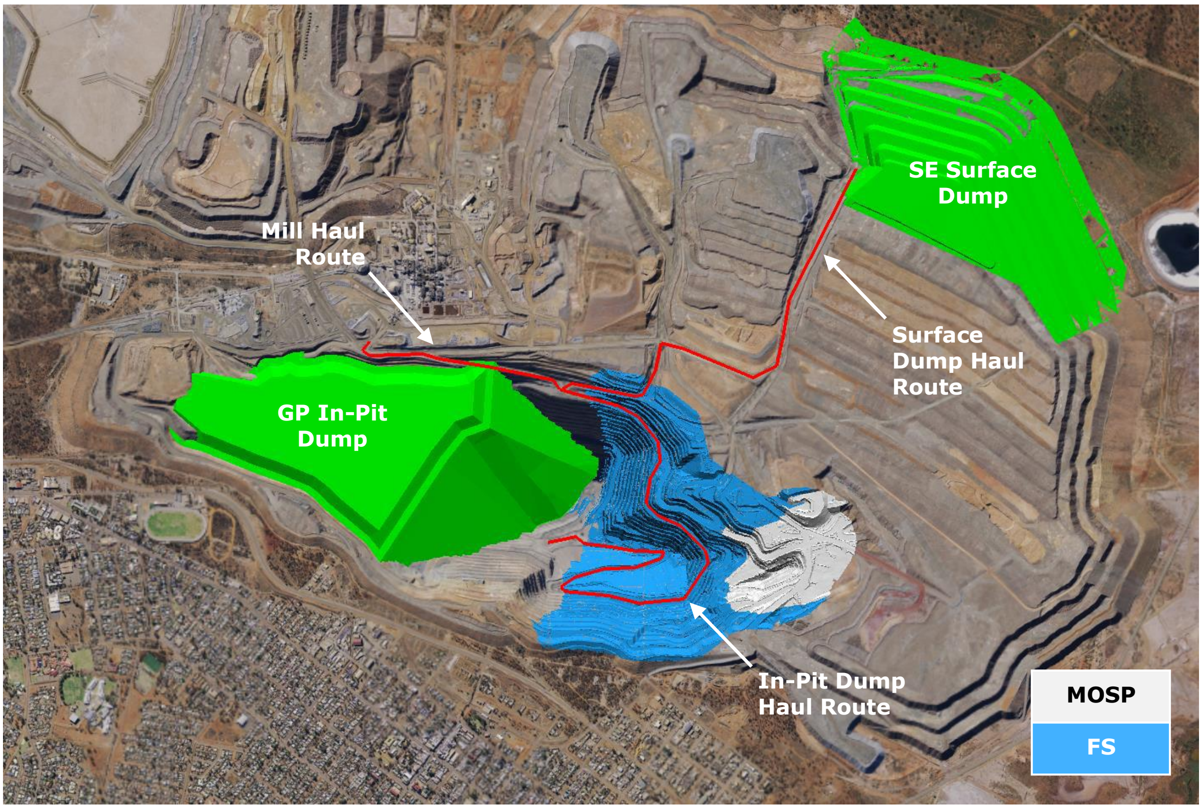


Figure 4: Proposed Haulage Routes for FS Project

Source: KCGM

As the proposed FS Project is a layback of the existing FOP, Ramboll understands the mineral and waste characteristics are expected to be consistent with the ore that has historically and is currently being mined and processed at the Fimiston and Gidji processing plants, and alternate processing routes will not be required.

The processing facility currently operates at a production rate of ~13.4 Mtpa through two parallel Semi-Autogenous Grinding and Ball Circuits (SABC): Mt Charlotte and Fimiston. The Mt Charlotte circuit comprises a three-stage crushing, Semi-Autogenous Grinding (SAG), ball milling, gravity concentration and flotation circuit. The Fimiston circuit comprises single-stage crushing, SAG, ball milling, gravity concentration and flotation circuit. The two circuits combine post flotation for concentrate to be treated via UFG and high-cyanide leach, primarily at the Gidji plant site, while the flotation tail is treated via a low-cyanide leach at Fimiston.

The only modification proposed for the existing ore processing stream to accommodate the FS project, is incremental tailings storage capacity. KCGM anticipate that the required tailings capacity for the FS Project can be achieved through progressive wall raises on the three existing TSFs servicing the Fimiston Plant (Fimiston I, Fimiston II and Kaltails) (refer to Figure 1). Progressively raising the walls of the three existing TSF's has commenced. KCGM is planning to construct a three-cell extension of the Fimiston II TSF. KCGM are also planning a 4th TSF called Fimiston III, to the north of Fimiston II to accommodate life of mine tailings storage requirements.

1.3.1 Proposed Project Footprint

MS782 includes conditions related to the setback for mining activities, namely that mining operations are not undertaken within 400 m of a residential property without the consent of the property owner and occupier. The proposed FS Project is expected to extend the footprint of the current FOP and in turn extend the footprint of the 400 m mining setback into the Boulder township, a predominantly industrial zone. As a result, there is established infrastructure that lies within the 400 m setback that will require modification or relocation.

A portion of the existing Environmental Noise Bund (ENB) that surrounds the western side of the FOP will need to be relocated as it lies within the working footprint of the proposed FS project. The ENB is an earthen bund built from waste rock, approximately 15 m in height. The ENB is designed to minimise the potential impacts of noise emissions from mining operations on the Kalgoorlie-Boulder community.

A public lookout to the FOP is provided by KCGM as a part of the Kalgoorlie-Boulder tourism initiative, located approximately 50 m from the southern boundary of the existing FOP. Ramboll understands relocation of the public lookout and access route is being considered as part of the proposed FS Project.

KCGM has also identified the potential requirement for relocation of ambient dust and meteorological monitoring stations (utilised within the FAQMP) located along the western side of the FOP, as the footprint of the FS Project extends west. Potential relocation of KCGM’s particulate monitoring locations is discussed in Section 2.1.

1.4 Atmospheric Emissions

Air quality issues for the Fimiston Operations have primarily been related to the management of fugitive dust from mining operations. Sources of fugitive dust emissions include the following activities:

- Mining operations
  - Drilling and blasting;
  - Excavation of waste rock and ore;
  - Loading/unloading of haul trucks;
- Ore processing
  - Crushing;
  - Conveyor transfer points;
- Wheel generated dust emissions
  - Haul trucks and other vehicles travelling on unsealed roads; and
- Wind-blown dust emissions from exposed surface areas, such as the WRDs.

KCGM employs a number of air quality control measures to minimise fugitive dust emissions associated with the above operations. These are discussed further in Section 2.3. There are also many natural and anthropogenic sources of particulate emissions in the Goldfields Region and it is not unusual to have regional dust storms that can result in significantly elevated ambient dust concentrations that can be visible over a wide area. KCGM commenced the Greening the Golden Mile rehabilitation project in 1991 which resulted in 730 ha of land being rehabilitated, resulting in a marked improvement in the visual amenity and environmental value of the area. The initiative significantly reduced dust emissions from areas that had been cleared by historical (pre-KCGM) mining activities. KCGM continues to progressively rehabilitate areas which further reduces potential dust emissions.

As the proposed FS Project will be mined and processed in the same way as the existing GP Cutback, the sources and characteristics of atmospheric emissions generated as a result of the FS Project are expected to remain the same as KCGM's current operations.

1.5 Ambient Particulate Guidelines

Particulate matter (PM) is generally defined as particles that can remain suspended in the air by turbulence for an appreciable length of time. PM can consist of a range of matter including crustal material, pollens, sea salts and smoke from combustion products. PM is commonly defined by the size of the particles including the following:

- Total suspended particulates (TSP), which is all particulate matter with an equivalent aerodynamic particle diameter below 50 µm diameter;
- PM_{10} is particulate matter below 10 µm in equivalent aerodynamic diameter; and
- $PM_{2.5}$ is particulate matter below 2.5 µm in equivalent aerodynamic diameter.

TSP contains PM_{10} and $PM_{2.5}$ fractions and is normally associated with amenity and nuisance impacts. PM_{10} and $PM_{2.5}$ are generally associated with the potential for health impacts as particles this size and below may enter the lungs. This study has focussed on predicted PM_{10} ambient air quality concentrations.

Table 1 contains the relevant criteria for particulate matter. The standards are based on the following guidelines:

- National Environment Protection Measure (NEPM) for Ambient Air Quality" by the National Environment Protection Council (NEPC, 2021);

Table 1: Relevant Air Quality Standards

Pollutant	Averaging Period	Unit[1]	Ambient Air Concentration Standard	Proposed Variation in2025	Reference
Particles as PM_{10}	24-Hour	µg/m³	50	-	(NEPC 2021)
	Annual	µg/m³	25	-	(NEPC 2021)

Note:

1. Reference temperature 0 °C

1.6 Regional Climate

The Kalgoorlie area is classified as semi-arid with warm to hot summers and cold to mild winters. Annual rainfall varies between 100 mm and 500 mm, with an average of 266 mm[1]. Generally,

[1] Source: Bureau of Meteorology Climate Statistics for Kalgoorlie-Boulder Airport 1939-2020 [http://www.bom.gov.au/climate/averages/tables/cw_012038_All.shtml]

more rain falls during the Winter months (June - August) as cold fronts bring widespread falls, although Summer (November - February) storm events occur regularly and often result in high intensity, short duration rainfall. Pan evaporation rates exceed average rainfall rates for every month of the year and the average annual pan evaporation is 2,646 mm, approximately 10 times the average annual rainfall. Average relative humidity is highest during the Winter months (up to 74% at 9:00 am and up to 48% at 3:00 pm) and lowest during the Summer (up to 57% at 9:00 am and up to 34% at 3:00 pm)[1].

Temperatures can range from maximums of 47°C in the Summer to minimums of -3°C in the Winter, with occasional frosts occurring. Winds are strongest during late Winter to early Spring, though they rarely exceed 40 km/hr and are predominately from the northeast or west. At other times of the year winds tend south-easterly. The 9:00 am and 3:00 pm wind roses based on data collected at the Kalgoorlie-Boulder Airport Bureau of Meteorology (BoM) between 1939 and 2020 are provided in Figure 5.

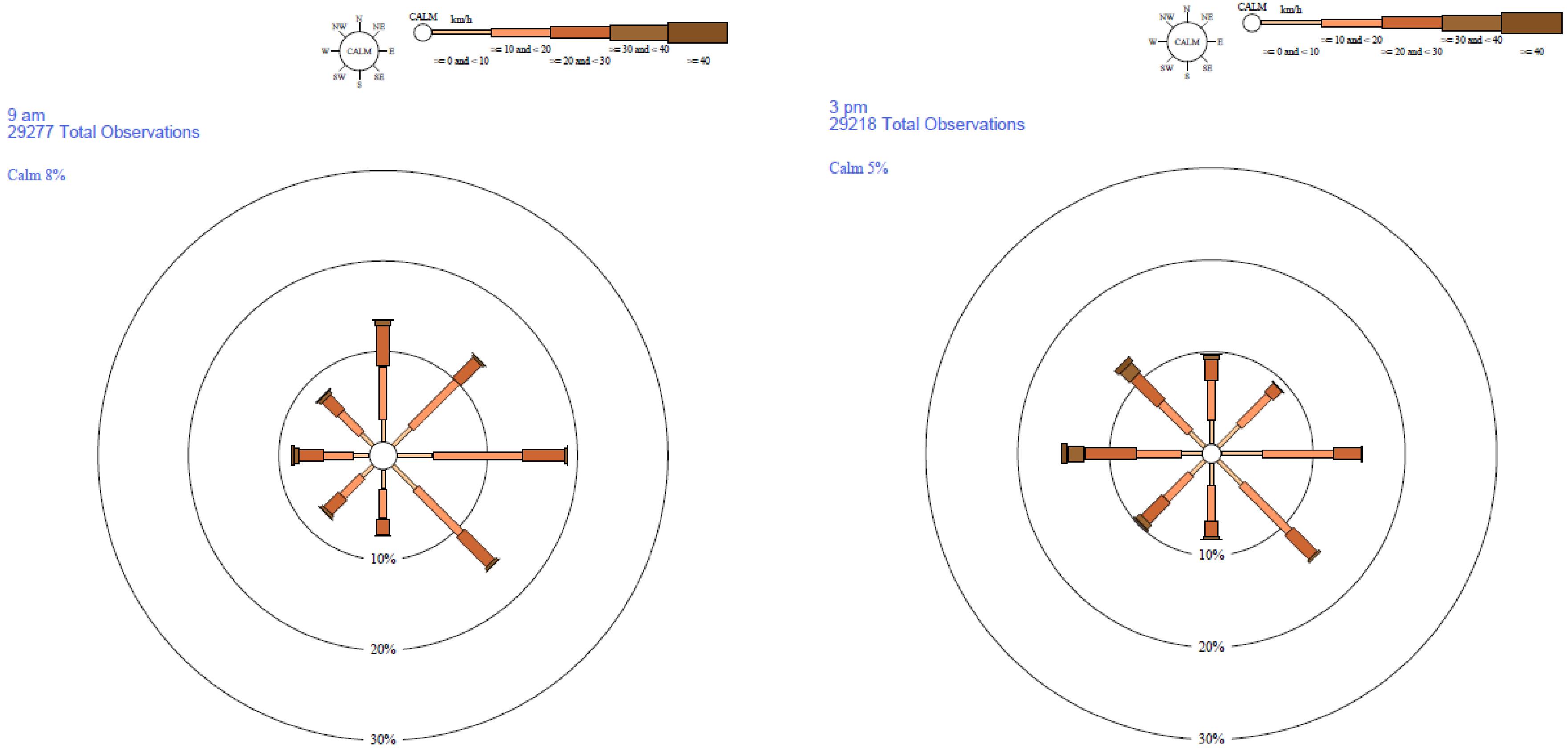


Figure 5: Kalgoorlie-Boulder Airport Wind Roses (1939-2020)

2. FIMISTON AIR QUALITY MANAGEMENT PLAN

The FAQMP was developed by KCGM in 2007 as part of the Fimiston Gold Mine Operations Extension (Stage 3) and Mine Closure Planning PER, the management plan became a formal requirement under conditions within Ministerial Statement 782 (MS782). The FAQMP comprises various components to addresses key air quality issues arising from the Fimiston Operations; namely dust emissions from the site.

Dust emissions are actively managed via the Dust Monitoring and Management Programme (DMMP) and Blasting Dust Management Programme (BDMP). While each of these plans are managed separately due to their different requirements and areas of application, the FAQMP ensures they are managed within a consistent and integrated framework. KCGM believes that the FAQMP provides best practices and procedures to enable the Fimiston Operations to continue to operate in a reasonable and practicable manner, while providing an acceptable air quality environment for the residents of the City of Kalgoorlie-Boulder.

The FAQMP is currently required to be formally reviewed and approved by the Environmental Protection Authority (EPA) services unit, on advice from the Department of Water and Environmental Regulation (DWER) and Department of Health (DoH), every three years.

A key performance target of the FAQMP (and specifically the DMMP) is to manage KCGM's operations such that there are no more than five events above the National Environmental Protection Measure (NEPM) 24-hour PM_{10} standard (i.e. 50 µg/m^3) at any dust monitoring site per annum, where KCGM is a significant contributor.

2.1 Monitoring Overview

The DMMP utilises a network of seven ambient PM_{10} monitoring stations, six of which are permanently located within the nearby residential and light industrial areas near the Fimiston Open Pit Operations (Figure 6). These comprise Boulder Shire Yard (BSY), Hewitt Street (HEW), Clancy Street (CLY), Hopkins Street (HOP), Mt Charlotte (MTC) and Metals Exploration Yard (MEX) sites. The seventh monitor, Hannan's Golf Course (HGC), is located north west of the Fimiston Operations and is considered representative of the local environment and the data collected at this location enables comparison of background levels with the other six monitoring sites. Meteorological monitoring stations are located at the MEX site and the Cassidy Headframe (CAS).

The HGC site is considered to be most representative of a compliance monitoring site as defined in the National Environment Protection (Ambient Air Quality) Measure (NEPM):

> "*Performance monitoring station(s) must be located in a manner such that they contribute to obtaining a representative measure of the air quality likely to be experienced by the general population in the region or sub-region*." National Environment Protection (Ambient Air Quality) Measure clause 13.2.

The BSY, HEW, CLY, HOP, MTC and MEX sites are not considered compliance monitoring sites as they are located in areas where peak concentrations are expected to be recorded.

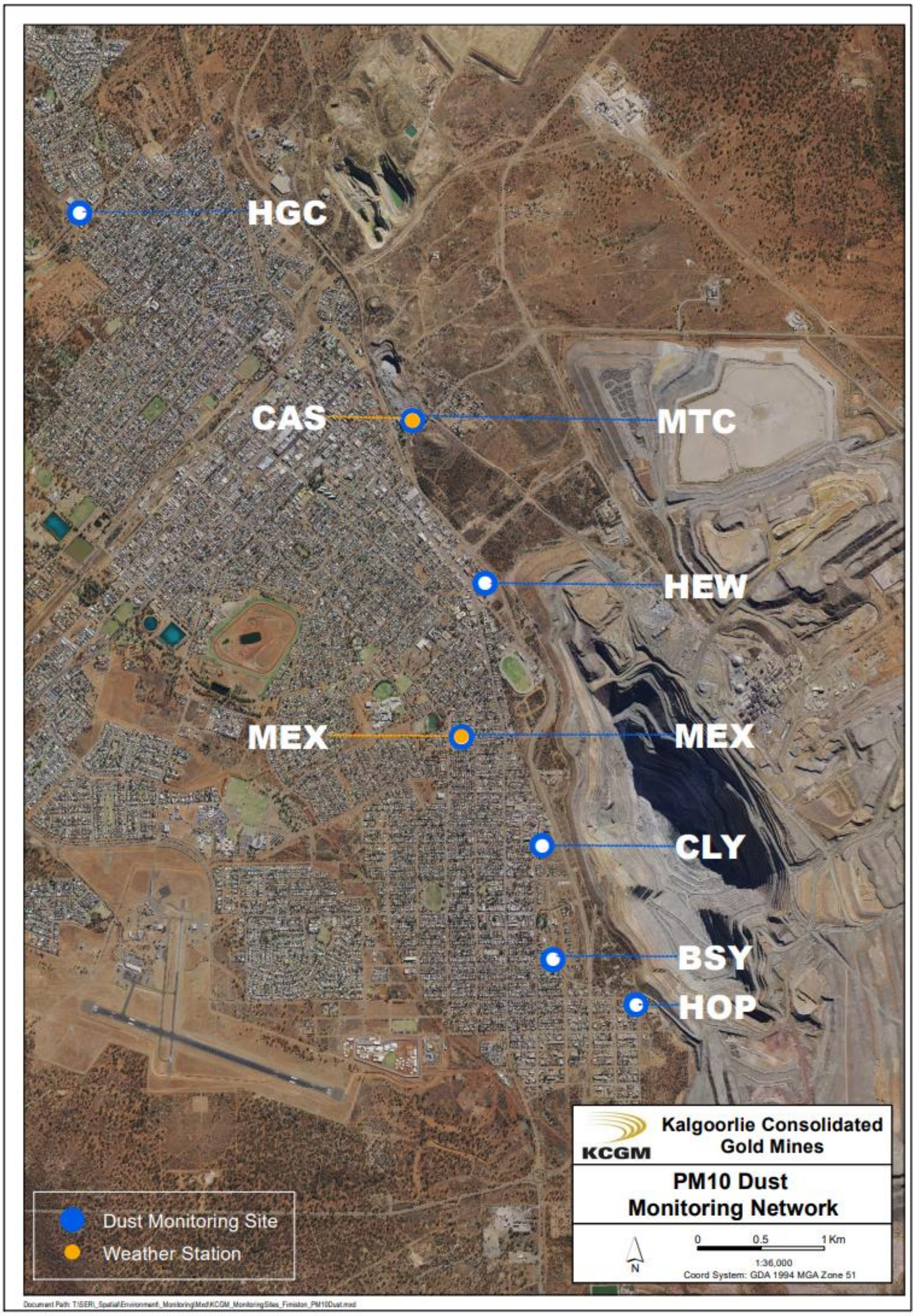


Figure 6: DMMP Monitoring Sites

The selection of ambient monitoring sites involves consideration of factors such as site access/ownership, mains power availability, communications, surrounding structures and vegetation, landforms, roads, land uses, as well as the objectives of the monitoring program. In selecting the location for the HEW, CLY, BSY and HOP sites, consideration was given to achieving a balance between the following key aspects:

1. Being located at a distance sufficiently far away from the ENB landform such that the potential impact of localised airflow changes caused by the ENB were minimised (i.e. nominally greater than 100 m);
2. Being located generally to the east of any residential property so that the peak residential, business and light industrial ambient concentrations under winds from the eastern sectors are known such that real-time responses can be instigated in the event of FAQMP generated alarms; and
3. The existence of cleared areas, unsealed roads, sealed roads (including the main bypass road), and tracks all located to the east of the monitoring sites that could impact on the measured ambient PM_{10} concentrations under winds from the eastern sector.

The primary objective of the PM_{10} monitoring program is to provide monitoring data that KCGM is able to use within the DMMP component of the FAQMP. Continuous real-time monitoring data from the monitoring sites are available to KCGM staff and the data is compared to site-specific Alert and Action levels that are designed to ensure there is a timely response in the event that elevated PM_{10} concentrations indicate additional dust mitigation measures may be required. Alert levels are set at values that are indicative of the possibility of on-site activities contributing to ambient concentrations that may approach key performance targets and where reasonable and practicable management measures could be implemented to reduce this risk. Action levels are set at values that indicate it is likely that on-site activities are contributing to ambient concentrations that may result in an exceedance of the DMMP target concentration and where reasonable and practicable, immediate management measures should be implemented to reduce this potential.

In the event that any alarms are raised, the KCGM staff at the dispatch hut will review the real time PM_{10} and meteorological monitoring data, back trajectory plots and the current mine site activities to identify the operational areas that may have contributed to the alarms and instigate further management measures as documented in the FAQMP.

Given the objective of the PM_{10} monitoring program, to provide monitoring data that KCGM is able to use within the DMMP component of the FAQMP, KCGM's desire was to have the monitoring sites located on the eastern side of Kalgoorlie-Boulder and as close to the western side of the Fimiston operations as could be reasonable achieved, making use of existing infrastructure as far as possible. Two of the monitoring sites (BSY and HGC [where HGC is largely considered to be a background monitoring site]) were established at existing ambient sulphur dioxide monitoring sites. A further three sites were established HEW, CLY and HOP. The last two PM_{10} monitoring site locations (MEX and MTC) were specified by the EPA as part of MS782; condition 7-6 states "*The proponent shall install two additional dust monitoring station, which are to be co-located with the existing wind speed and wind direction monitoring stations*".

The data collected from the monitoring sites can be impacted by non-KCGM related activities that occur in the vicinity of the monitoring sites. As an example, Figure 7 shows an aerial photograph of the area in the immediate vicinity of the BSY monitoring site. This figure shows that there are many cleared areas, sealed roads, unsealed roads/tracks and verges, and motorcycle tracks near the BSY monitoring site. Figure 9 presents a photograph from October 2012 showing non-KCGM related earthworks being undertaken immediately east of the BSY monitoring site that resulted in significant dust emissions. Factors like these make it difficult to determine contributing sources in the absence of visual observations. To this end, KCGM has installed video cameras at the HEW and CLY monitoring sites to assist in the post-event identification of dust created by non-KCGM related activities. A video camera has also been installed on top of the Cassidy Headframe (CAS) to assist in identification of fugitive dust emissions from the FOP travelling over the ENB.

Figure 7: BSY PM_{10} Monitoring Site and Surrounds

Figure 8: Location of HEW monitor

Figure 9: Non-KCGM Related Earthworks at BSY PM_{10} Monitoring Site – October 2012

While the monitoring sites would ideally be located to the east of any potential non-KCGM activity that may generate dust, the presence of the ENB, access issues, and power issues make this impractical. As such, the currently selected monitoring sites are considered suitable to meet the objectives of the FAQMP. However, the proposed FS Project will require relocation of a section of the ENB as it lies within the working footprint of the Project. The HOP site is located approximately 130 m west of the existing ENB and is likely to be impacted by the FS Project as the adjacent portion of the ENB is expected to be relocated as shown in Figure 10.

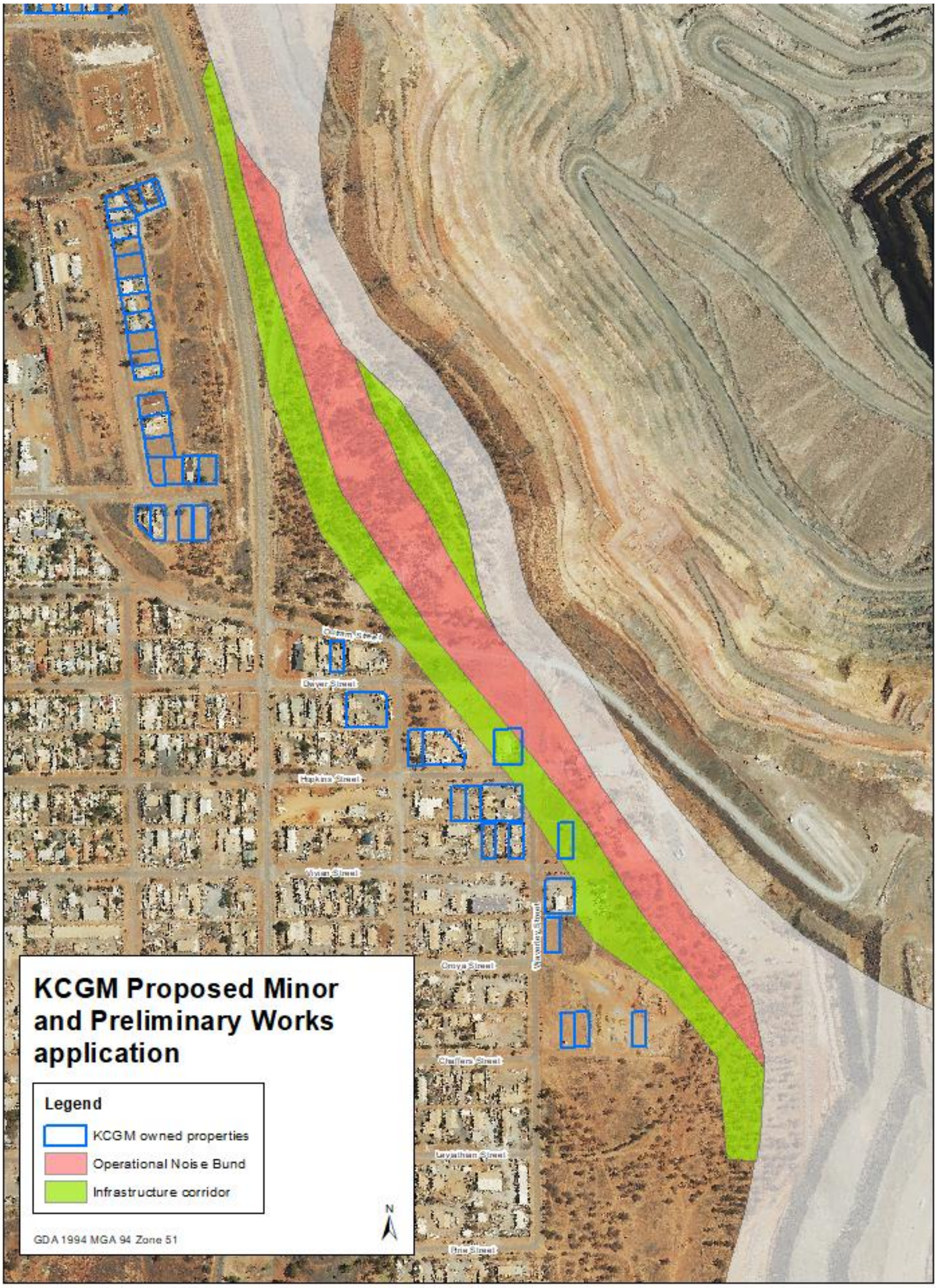


Figure 10: Proposed Noise Bund

Ramboll recommend the HOP monitor be relocated, maintaining a distance of approximately 100 m from the proposed ENB. This would require additional work to select a suitable location that complies with regulatory standards and maintains the principles used in the establishment of the current monitoring location. Selection of the new monitoring location will be dependent on factors including site access/ownership, availability of power and communications etc as previously outlined, but should also seek to remain east of any residential or industrial properties to enable real-time responses to ambient concentrations under winds from the eastern sector, in the event of an alarm. Unsealed surfaces (i.e. roads and tracks) that could impact on measured ambient PM_{10} concentrations under winds from the eastern sector should also be avoided where possible. It is recommended the re-located HOP monitor remain within the general proximity of the existing site to ensure the coverage of the DMMP captures potential impacts associated with activity within the southern extent of the FOP.

Selection of the new monitoring location should also give consideration to the requirements outlined in AS/NZS 3580.1.1:2016 *Methods for sampling and analysis of ambient air: Guide to siting air monitoring equipment*, including:

- The sampling inlet has a minimum clear sky angle of 120°;
- Avoiding sites affected by extraneous local emissions (e.g. adjacent to unsealed roads);
- The height of any nearby obstacle above the sampling unit should be less than or equal to half the distance between the sampling unit and nearest wall/supporting structure; and
- The sampling inlet should be located 10 m from any object with a height exceeding 2 m below the height of the sample inlet (for trees, the distance should be measured from the dripline).

A network of High-Volume Dust Samplers (Hi-Vols), primarily used to monitor fugitive dust emissions associated with blasting, were initially located in close proximity to the FOP at the BSY, CLY and HEW sites, and were only operated on days when blasting was undertaken. The Hi-Vol units at CLY and HEW were in time replaced by portable Beta Attenuation Mass (BAM) monitors (known as e-BAMS) and a third e-BAM was installed at the HOP site in 2004 to measure real-time fugitive dust emissions associated with the southern extension of the ENB. The HEW, CLY and HOP sites were upgraded to permanently established BAM units in 2012, following ongoing operational issues with the e-BAMs relating to moisture and heater switching. Two additional BAMs were subsequently installed at MEX and MTC.

Parameters currently monitored at each location in the network are shown in Table 2.

Table 2: Summary of Monitored Parameters

Site	Monitoring Parameters
BSY	PM_{10} BAM
CLY	PM_{10} BAM
HEW	PM_{10} BAM
HCG	PM_{10} BAM
HOP	PM_{10} BAM
MEX	PM_{10} BAM, wind speed, wind direction, ambient temperature
CAS	Wind speed, wind direction
MTC	PM_{10} BAM

BAMs are used to measure PM_{10}. This technique comprises a beta source and detector separated by a filter tape. Energy is absorbed from beta particles as they pass through the particulates captured on filter, which provide an indication of the mass on the filter. The instruments in use at KCGM are Thermo FH62 continuous BAMs, which use a source of Carbon-14. These instruments are classed as USA EPA Federal Equivalence Methods (FEM) so in accordance with Australian Standards (ASNZ 3580) are appropriate for reporting PM_{10} for regulatory purposes.

The instruments are maintained in climate-controlled enclosures or stations, and have heated inlets maintained between 5 and 8ºC above ambient temperature. The instruments are independently calibrated and serviced on a quarterly basis by Compliance Monitoring Pty Ltd. The service reports indicate the work is completed in accordance with the recommendations of the relevant Australian Standards.

A weekly validation process is undertaken at least once per week by KCGM. The checks include:

- Checking the date;
- Reviewing the data;
- Removal of erroneous negative spikes (<-20 µg/m³);
- Removal of calibration periods; and
- Recoding of errors codes.

2.2 Ambient PM_{10} Monitoring Data Review

The average PM_{10} concentrations recorded across all of the monitoring sites on a seasonal and annual basis from 2017 to 2021 are presented in Figure 11. This figure shows that the average PM_{10} concentrations tend to fluctuate from year to year generally as a function of variable climactic conditions such as regional annual rainfall.

The highest average concentrations typically occurring in Spring and Summer. This is attributable to the change in wind conditions that occur during the Spring being stronger and from an easterly direction. An exception to the general trend is apparent in the 2018 data, which shows the highest average concentration occurring in Autumn and the lowest average concentration occurring in Spring.

The increase in the 2018 Autumn average concentration was in part driven by a rock fall event within the Fimiston Open Pit that occurred on 14 May 2018. The dust impact from this event was reported to be associated with elevated 24-hour average PM_{10} concentrations recorded on 14, 15 and 24 May 2018 (the latter being attributed to the mobilisation of fine material within a safety exclusion zone following the rock fall, within which watercart access was restricted). Autumn 2018 was also characterised by below average rainfall (18 mm compared to a seasonal average of 63 mm) (Figure 12) and below average number of raindays (9 compared to a seasonal average of 15).

The highest average Summer and Spring PM_{10} concentrations were recorded in 2019 (Figure 11). These periods were also characterised by lower than average rainfall; 3 mm was recorded in Spring 2019 compared to a seasonal average of 57 mm, and 29 mm was recorded in Summer 2019 compared to a seasonal average of 103 mm (Figure 11). A number of regional bushfires and storm events occurred from late January through February 2019 and again from late November through December 2019, contributing to the elevated PM_{10} concentrations recorded during the Spring and Summer months of 2019.

The annual average PM_{10} concentrations for each of the monitoring sites from 2010 to 2021 is presented in Figure 13. This figure shows that the highest annual average concentrations are recorded at the BSY, HEW, HOP and CLY sites adjacent to KCGM operations.

Analysis of the monitoring data was undertaken to determine the wind speed threshold in the region. This is the wind speed where the velocity of the wind is sufficient to saltate and entrain particles of dust into the air. The analysis indicated that at wind speeds above 6.3 m/s (~23 km/hr) monitored dust concentrations began to increase. Winds above 9 m/s were often associated with exceedances of the short term NEPM guidelines. Ore stockpiles within the Fimiston Processing Plant are currently covered to mitigate dust. It is expected that any future new ore stockpiles will also be covered. Ramboll would recommend that increased dust control measures be undertaken when wind speeds are currently or are expected to exceed this threshold in any areas identified in the future where significant wind-blown dust is generated.

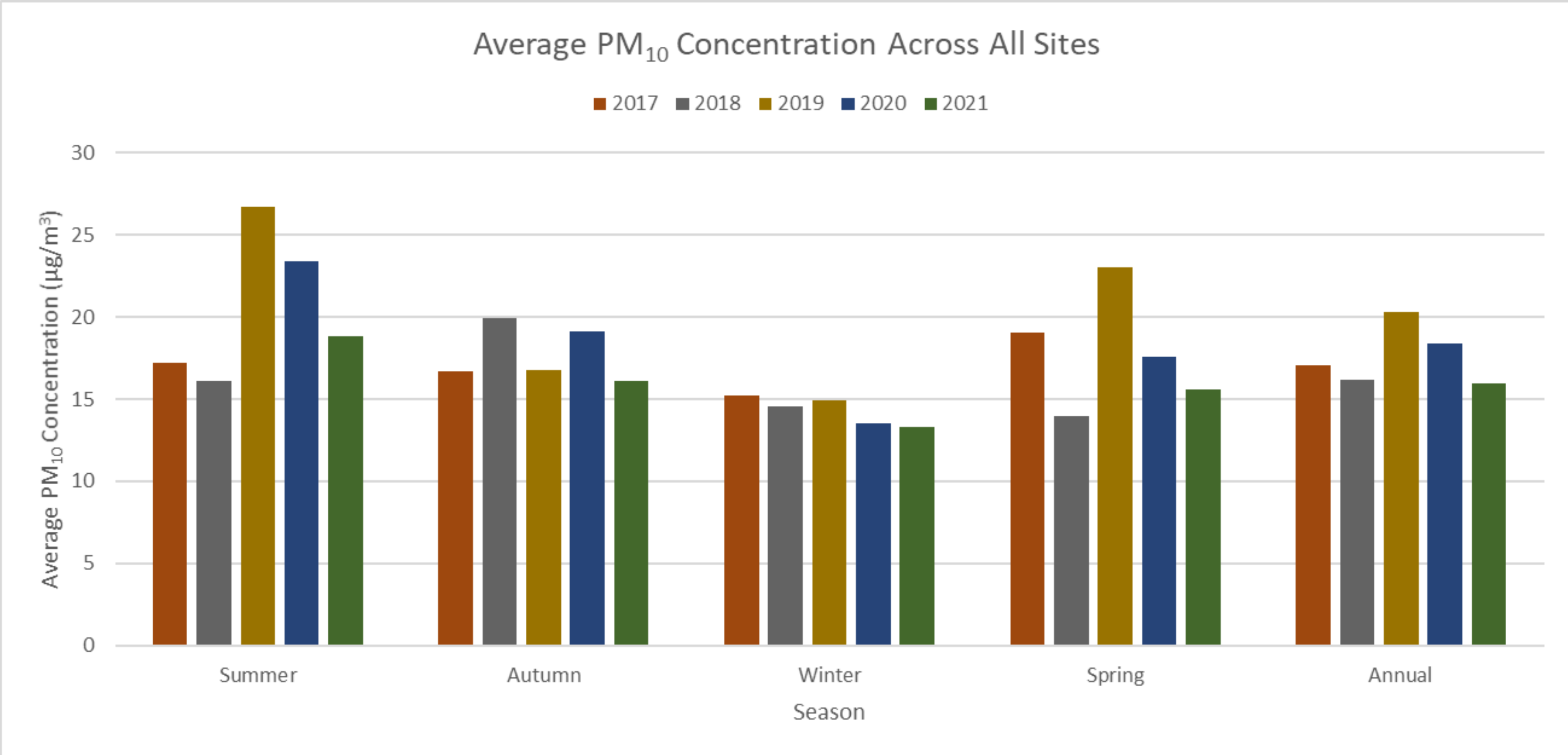


Figure 11: Average PM_{10} Concentration Across All Sites

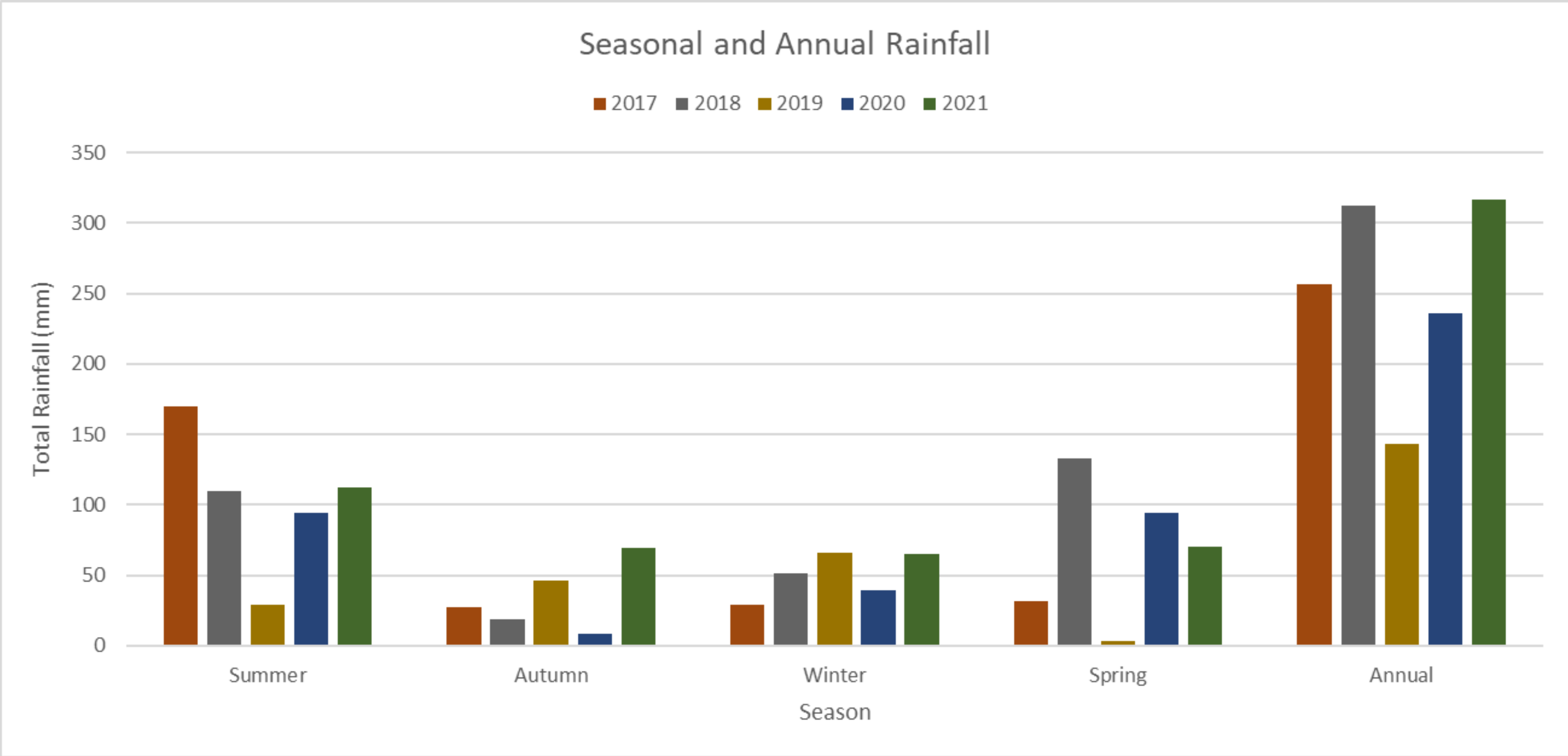


Figure 12: Seasonal and Annual Rainfall

Source: Bureau of Meteorology, Kalgoorlie-Boulder Meteorological Monitoring Station.

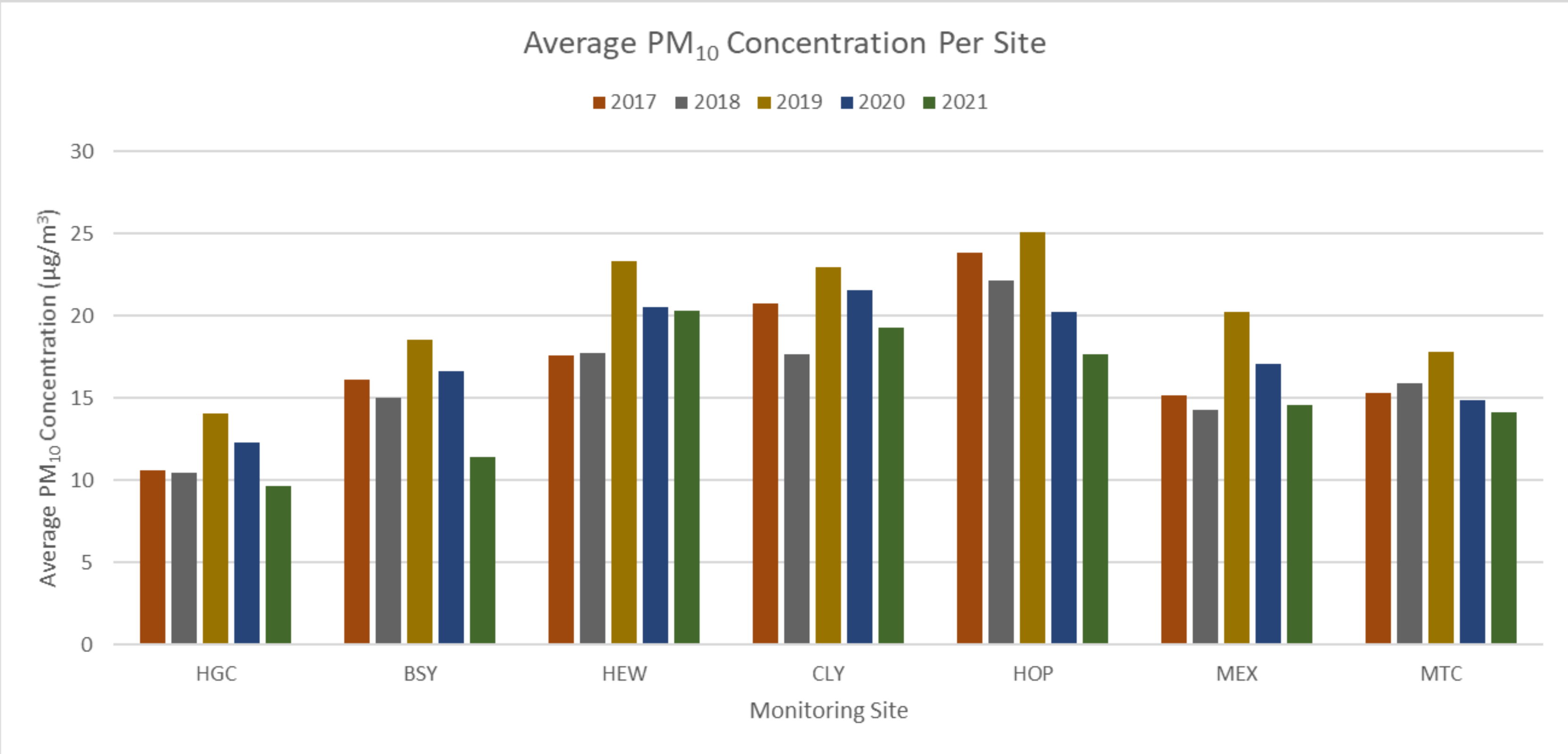


Figure 13: Annual Average PM_{10} Concentration for Each Monitoring Site

For each day where a PM_{10} concentration of greater than 50 µg/m^3 is recorded, KCGM reviews the data to determine if the Fimiston Operations may have been a significant contributor (using the procedure in the FAQMP). In brief, the procedure involves a review of the 5-minute average PM_{10} concentrations and meteorological monitoring data for the period in question to:

1. Determine the daily average concentration, if any, that was associated with wind directions that were within the arcs that align with KCGM's Fimiston Operations and use this value to calculate the ratio of the KCGM arc;
2. Based on an assessment of the winds that occurred, determine which ambient PM_{10} monitoring station is most likely to represent the "background" monitoring site (usually the HGC site) and the daily average "background" concentration recorded at that site;
3. Calculate the difference between the recorded daily average exceedance concentration and the daily average background concentration and determine the ratio of this difference and the recorded daily average exceedance concentration; and
4. If the ratios determined from steps 1 and 3 are both greater than 60% then KCGM is considered to be a potential significant contributor.

A summary of the last five years' average PM_{10} concentration across all monitors, winds within KCGM's arc and the number of reportable events by season is presented in Figure 14. It was observed that the 2021 PM_{10} 24-hour average concentrations were lower than in the two previous years (2020 and 2019), with the maximum average concentration for 2021 recorded in summer (18.8 µg/m^3).

The rainfall received in 2021 was slightly higher than in the two previous years in summer, autumn and winter, however, less rain was received in spring 2021 than in spring 2020. The seasonal maximum average temperature was generally lower than in previous years except for autumn with a maximum temperature of 27º C that only was recorded before in autumn 2018. The number of reportable events where KCGM was a significant contributor increased from the year before, as in 2021 two events occurred in summer and one in autumn.

It is not always possible to eliminate non-KCGM dust emission sources from the analysis particularly where the emissions may have occurred between the monitoring site and the Fimiston Operations. Ramboll considers that other non-KCGM related sources are also likely to be significant contributors for much of the time. These sources include smoke from wood heaters in winter, particulates from wind erosion of cleared areas, local non-KCGM earthworks, truck and car movement on sealed and unsealed roads and tracks, and motor cross bike generated dust from activity on nearby tracks. Where the contribution of these non-KCGM sources cannot be quantified (e.g. via photographic evidence), KCGM conservatively reports itself as a contributor. Therefore, the number of days presented in Figure 14 may be overstated.

The majority of 24-hour average PM_{10} concentrations greater than 50 µg/m^3 are related to non-KCGM dust sources. In 2019 for example, there were 36 days for which the 24-hour average PM_{10} concentration at any of the monitors was greater than 50 µg/m^3, however KCGM was determined to potentially be a significant contributor on only 5 of these occasions. In the Summer of that year there were 17 days for which the 24-hour average PM_{10} concentration was greater than 50 µg/m^3 with only one attributed to KCGM operations, reflecting the influence of regional dust sources during this period. The number of days for which KCGM has been identified as a potentially significant contributor to a 24-hour average PM_{10} concentrations greater than 50 µg/m^3 has remained relatively consistent.

The FAQMP has proven to be an effective tool for the management of its particulate emissions and achievement of the FAQMP performance targets, within a framework of regular review and continuous improvement. Compliance with the FAQMP performance targets at each of the PM_{10} monitoring sites is able to be demonstrated, even though a conservative approach has been adopted which potentially overstates the extent its operations contribute to ambient PM_{10} concentrations.

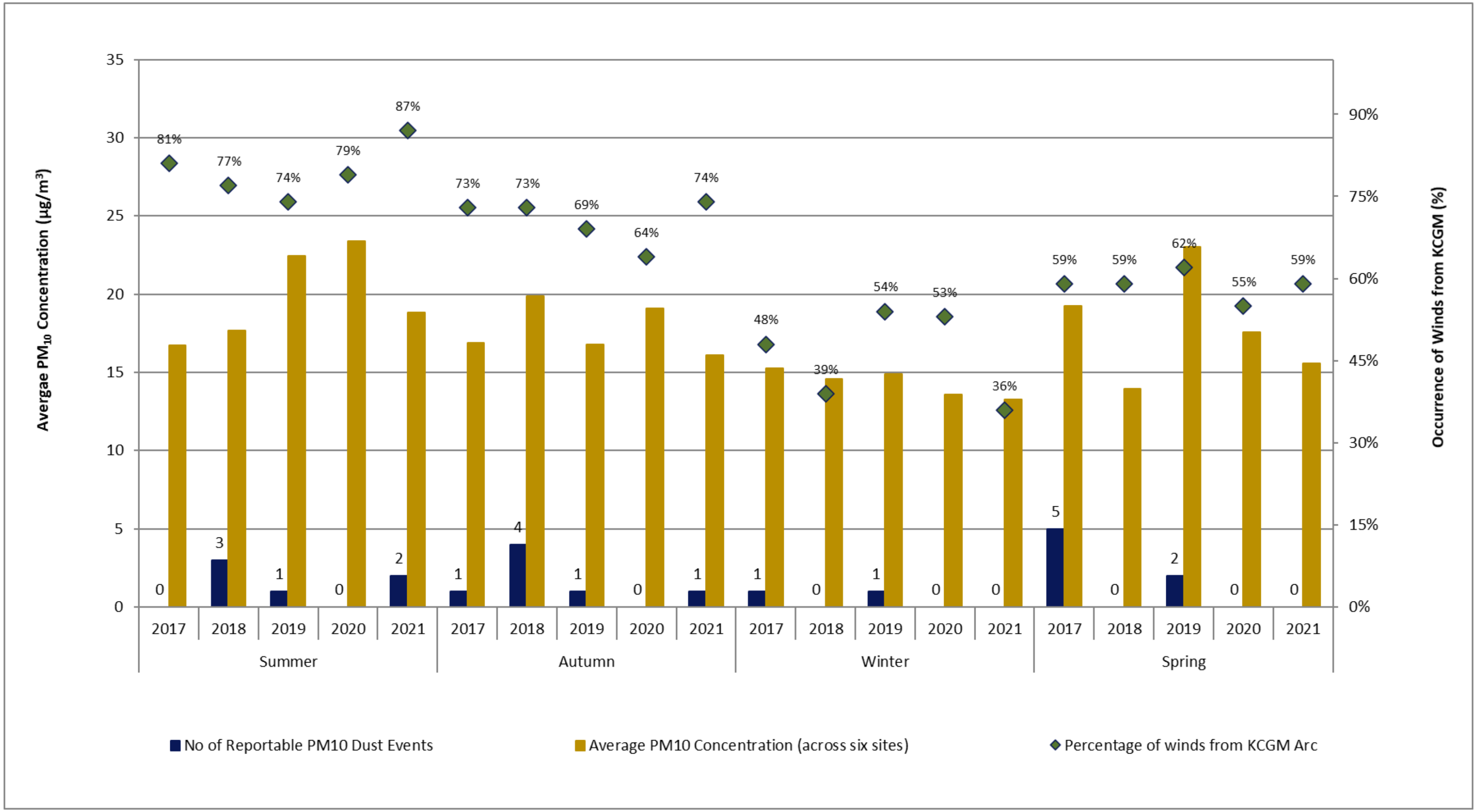


Figure 14 24-hour Average PM_{10} Concentrations, Number of Reportable Events and Percentage of Winds from KCGM Arc, by Season

2.2.1 Complaints

Northern Star KCGM Operations has a 24-hour Public Interaction Line (PIL) (established in 1993) which the community can use to speak directly with Northern Star representatives on specific matters they wish to discuss. It is an important avenue for capturing individual and community issues which require follow up and action. The PIL is promoted regularly in print and radio advertising, radio interviews, online mediums (website) and printed materials (Information Sheets). The PIL is supported by an electronic database, which enables the categorisation of queries and the automation of subsequent action allocation and follow-up. The database is also used to record stakeholder communications and engagement and enables data to be analysed and tracked with reference to areas of community concern.

During business hours, PIL enquiries are referred directly to the relevant department supervisor for appropriate action. Incoming calls received outside office business hours may be forwarded to the shift supervisor for immediate action or where appropriate will be followed up the next working day. Once an internal review has been completed, the caller is informed of actions taken or outcomes of their enquiry or complaint. Northern Star responds to all people who contact the PIL (and provide contact details) either by phone, in writing or meetings if required.

The highest number of dust related complaints (12) were received in 2012. A decrease was observed between 2014 (9) and 2016 (2), before increasing to 7 in 2017. Ramboll understands KCGM's investigation of each complaint was unable to identify the potential source of dust in three of these cases. A decrease in dust related complaints has since been recorded in 2018 (4) and 2019 (1). An increase in 2020 (3) and then increased again in 2021 (7) although four of the complaints were related to blasting on the same day. A summary of the dust complaints from the last three years is included in Table 3 below.

Table 3 shows that for the majority of the complaints, the recorded 24-hour average concentration of PM_{10} at any of the monitors was under the ambient air quality guideline. However, concentrations monitored at the HEW monitor on the 21st of January 2021 were well above the guideline. 24-hour average concentrations at all other monitors were well below the guideline (<30 µg/m^3). It is likely blasting occurring in the region significantly contributed to the exceedance at this monitor. KCGM operates a detailed control strategy around blasting (Section 2.3.1) and this incident is considered an isolated event although this event demonstrates that emissions from blasting need to be carefully controlled. Overall however, it is considered that the controls around blasting are sufficient to control potential impacts from this activity.

Table 3: Summary of Complaints

Date	Max 24 Hr PM_{10} Conc. at any Monitor	Summary of Complaint & KCGM Comment
17/01/2019	47 µg/m^3	Local resident complaint regarding fugitive dust from KCGM's Tailing Storage Facilities during high winds. KCGM's External Relations Advisor spoke with the complainant, providing them with information on aspects of KCGM's dust management practices (e.g. water carts and rehabilitation). The complainant was encouraged to continue to provide feedback. No further correspondence was received and the complaint status was 'resolved'.
21/09/2020	14 µg/m^3	Kalgoorlie Visitor Centre Manager complained regarding dust from the public access road to the Super Pit Lookout when operating the

Date	Max 24 Hr PM_{10} Conc. at any Monitor	Summary of Complaint & KCGM Comment
		tourist tram (tourist tram has open windows). A meeting was organised with the External Relations Superintendent and the Kalgoorlie Visitor Centre Manager to discuss the lookout road and steps going forward. The External Relations Superintendent mentioned that KCGM would not send water carts on a regular basis to the lookout road ahead of scheduled tourist tram visits, unless local residents were being affected by the dust. The Visitor Centre Manager said they would ask the City of Kalgoorlie-Boulder for regular water carts to visit the lookout ramp to minimise dust for tram visits. No further action noted.
9/11/2020	49 µg/m^3	Resident texted to advise of increased dust levels coming from MTC open pit conveyor. The Processing Department were notified and advised they would increase water carts in the area to suppress the dust. The resident was informed of the outcome, nothing further received.
29/12/2021	44 µg/m^3	Three complaints received from local residents regarding dust from open pit blast. External Relations Superintendent phoned all complainants to apologise and advise of blast, and blast taking place close to surface of pit.
11/01/2021	28 µg/m^3	Local resident contacted the PIL regarding dust coming from the Fimiston Waste Rock Dumps. It was identified that loader tipping activities were generating dust. Tipping activities were immediately stopped.
21/01/2021	71 µg/m^3	Four separate local residents contacted the PIL regarding generated dust from blasting. An External Relations Advisor contacted the residents and explain how potential impacts are managed via wind condition monitoring prior to blasting, as well as how we use several air quality monitoring stations throughout Kalgoorlie-Boulder and that our records are publicly available. No further correspondence was received.
29/01/2021	31 µg/m^3	Local resident contacted PIL regarding generated dust from mining operations. The resident raised concerns about dust blowing into his property. Extra watercarts were immediately sent to operational areas. The resident did not require further follow-up regarding the outcome.
05/08/2021	30 µg/m^3	Local resident contacted the PIL regarding generated dust coming from blasting. No further action required.
02/11/2021	25 µg/m^3	Local resident complaint regarding dust. A review was undertaken by KCGM, and it is likely that the dust was generated from a KCGM work area.
07/01/2022	49 µg/m^3	Local resident contacted the PIL regarding dust from blasting. No further correspondence has been received. An External Relations Advisor contacted the resident and explained the circumstances leading to the decision to blast.

Date	Max 24 Hr PM_{10} Conc. at any Monitor	Summary of Complaint & KCGM Comment
03/03/2022	25 µg/m^3	Local resident contacted KCGM concerned about significant increase in dust. Reached out via email on 10 March to meet with resident to better understand situation, waiting on response from resident and property address to organise a meeting.

2.3 Dust Control Measures

KCGM employs a suite of air quality control measures to minimise the impact of dust emissions from its operations. These include the following:

- Monitoring current and forecast weather conditions using daily forecasts and real time wind speed and direction monitoring data to plan work activities;
- Use of water trucks and water cannons in areas that produce dust such as haul roads, service corridors and other active surfaces (potable water is used on areas to be rehabilitated);
- Use of additional dust control measures where practical (e.g. a dust binding agent);
- Progressive rehabilitation to minimise exposed areas;
- Suspending work in a particular area or for a nominated activity as deemed necessary based on visual inspections, dust alarms, public feedback or prevailing wind conditions;
- Water sprays on crushers turned on when needed;
- Use an alternative operational area if possible (e.g. use a different waste dump);
- Ensuring that all contractors and staff undertake site-specific inductions which include raising awareness of the importance of dust control;
- Ensuring dust monitoring is undertaken, that the data are assessed in real time, and the results of the monitoring are reviewed and reported on; and
- Ongoing consultation with stakeholders to determine the success of the dust management measures.

The dust control measures are primarily implemented by Shift Supervisor and/or Project Supervisor and Environmental Advisor. Further, each employee and contractor are made aware of the potential impact of fugitive dust emissions and are obliged to implement dust control measures where required and report any notable visible dust coming from KCGM's operations to the Shift Supervisor, Project Supervisor or Environmental Advisor.

2.3.1 Blasting

Blasts that are undertaken in the upper benches of the FOP and/or have the potential to impact on residential areas are termed 'Wind Direction Dependent' blasts. Such blasts are managed using the KCGM Dust Programme. This is a visual tool utilising a graphical display of current wind speed and direction recorded at two weather monitoring stations (MEX and CAS). Once the blast location is selected and entered in this tool, it calculates and displays an acceptable wind arc within which the blast can be undertaken. Blasting proceeds only if the following conditions are met:

- At least four of the last six 5-minute average wind direction readings are within the acceptable wind arc;
- No more than one of the last three 5-minute wind direction readings are outside the acceptable wind arc;
- The 30-minute average wind direction reading is within the acceptable wind arc;

- The variation in the measured wind direction is narrow (<60°) and not reflective of large variations in the wind directions; and
- The 30-minute average wind speed is greater than 2 m/s.

It should however be noted that there may be instances when blasting would still occur despite the above restrictions due to safety reasons or where dust mitigating circumstances exist (e.g. rainfall, depth in pit).

2.3.2 Predictive, Reactive, Preventive and Adaptive Controls

For managing dust from its day-to-day operations, KCGM adopts a suite of predictive, preventative, reactive and adaptive control strategies.

The predictive control strategies incorporate the use of forecast weather conditions to manage dust emissions from blasting (as described in the preceding section) and earthmoving activities. Control measures adopted include delaying or suspending work and use of alternative operational areas if possible.

The preventive control strategies include:

- Progressive rehabilitation of bare ground areas to minimise the fugitive dust emissions from wind erosion;
- Use of water trucks and water cannons in areas that could produce dust such as haul roads, service corridors and other active surfaces. It is noted that the water used on site is hyper saline enabling better dust control than a standard watering practice;
- Partially enclosed Run off Mine (ROM) stockpile;
- Use of belt wash stations and belt scrapers in conveyors with material fallout regularly cleaned;
- Flue off-gas cleaning circuit on carbon kilns;
- Watering down ore/waste rock material prior to load and haul activities is undertaken as a standard practice;
- Watering down the surface of the blast prior to firing as required;
- Plan activities in high risk areas (e.g. digging/loading) during day shift when fugitive dust can be seen and managed where practicable; and
- Use of additional dust control measures (i.e. a dust binding agent) where necessary.

The reactive component includes a real-time dust alarm system which automatically activates an alarm based on pre-determined criteria, prompting a reactive response by KCGM to mitigate dust emissions, if the dust is likely to be from the Fimiston Operations. The alarm system is primarily based on trigger levels for each monitoring site to address the occurrence of short-term/high concentration events, although a longer-term/lower concentration alarm has also been integrated into the system. KCGM's reactive alert and action levels are further explained in Section 2.3.3.

Adaptive control measures implemented at KCGM include:

- Review of air quality monitoring data and trigger levels for dust alarms every three years or following any high dust event;
- Review of air quality management practices following an increase in complaints or repeated complaints from the same area; and
- Implementation of improved dust management practices where KCGM has been identified as a significant dust contributor.

2.3.3 FAQMP Action and Alert Levels

The FAQMP DMMP trigger levels have been determined for ambient PM_{10} concentrations over different time periods (i.e. moving 30-minute, 1-hour, and 6-hour averages) which are used in the alarm system. The objective is to have the trigger levels at low enough concentrations to allow adequate response time to reduce the risk of exceeding the 24-hour target concentration (i.e. 50 µg/m^3), but high enough to ensure that the triggers do not disrupt normal operations unnecessarily (without due cause).

The trigger levels have been determined by assessing the historical PM_{10} monitoring data for each of the PM_{10} monitoring sites, on days where the measured 24-hour average PM_{10} concentration was greater than 40 µg/m^3. For these days the analysis determined the peak 30-minute, 1-hour, and 6-hour average concentrations for use in the determination of the trigger levels as follows:

- the 'Alert' alarm levels for each averaging time were set as the average of the minimum and median values for each averaging time rounded to the nearest 5 µg/m^3; and
- the 'Action' alarm levels for each averaging time were set as the average values for each averaging time rounded to the nearest 5 µg/m^3.

The Alert and Action levels are reviewed on a regular basis, as more data become available at each monitoring station. The current trigger levels, developed as part of the triennial review of the FAQMP undertaken in 2019, are presented in Table 4. These were determined by assessing historical PM_{10} monitoring data, from January 2012 to April 2019. As the HGC site is used as a control monitoring site no trigger levels have been set for this site.

Table 4: Current FAQMP PM_{10} Alert and Action Levels

Alerts and Actions	Dust Monitoring Concentrations (µg/m^3)						
	HOP	CLY	HEW	BSY	MTC	MEX	HGC
1/2 hr Alert	160	135	155	155	175	165	N/A
1/2 hr Action	315	320	360	365	375	300	N/A
1 hr Alert	140	115	135	140	155	145	N/A
1 hr Action	270	250	285	285	325	235	N/A
6 hr Alert	75	65	75	80	90	90	N/A
6 hr Action	115	110	115	130	150	115	N/A

A reassessment of the trigger levels has been undertaken, incorporating the PM_{10} monitoring data available through to December 2022. The revised Alert and Action levels are presented in Table 5. Decreases to the current Alert and Action levels are highlighted blue and increases are highlighted green.

Table 5: Proposed Future FAQMP PM_{10} Alert and Action Levels (Decreases in the trigger levels are shaded light blue and increases are shaded light green)

Dust Monitor Concentrations (µg/m³)							
	HOP	**CLY**	**HEW**	**BSY**	**MTC**	**MEX**	**HGC**
1/2 hr Alert	155	130	165	160	190	170	N/A
1/2 hr Action	320	325	370	390	395	390	N/A
1 hr Alert	135	110	135	140	170	160	N/A
1 hr Action	270	255	290	300	340	295	N/A
6 hr Alert	75	65	80	80	95	85	N/A
6 hr Action	120	120	125	135	160	125	N/A

Based on the PM_{10} monitoring data available through to December 2022, increases in the Alert and Action levels are proposed across each averaging period for the MTC, BSY and HEW sites with the exception of the 1-hour Alert level (HEW and BSY) and 6-hour Alert level (BSY), which remains unchanged. Decreases in the 30-minute and 1-hour Alert levels are also proposed for HOP and CLY, with slight increases proposed for the 30-minute, 1-hour (BSY only) and 6-hour average Action levels. Increases in all Alert and Action levels are also proposed for the MEX site, with the exception of the decrease in 6-hour Alert level.

2.4 Comparative Literature Review

KCGM's current dust management and mitigation measures, as described in Section 2.3 were compared against similar dust management programs. The dust management programs considered in this review include the following:

- Port Hedland Port Authority (PPA) Leading Practice Dust Management Guidelines (PPA, 2011);
- NSW Coal Mining Best Management Practice (BMP) (Katestone, 2011);
- NSW Coal Mine PRP-U3 (PEL, 2014);
- Various documents for Mt Isa Mines (PEL, 2015) (Mount Isa Mines, 2020).

A brief overview of each of these documents follows below.

<u>PPA Leading Practice Dust Management Guidelines</u>

The PPA's leading practice guidelines detail dust control practices and technologies that are readily available and technically achievable, and recommends that each site consider them on a case by case basis. The guidelines have been based on the following key considerations:

- The nature and characteristics of the bulk material being handled. These include understanding of the chemical composition of the material, its hydrophobic or hydrophilic properties including dust extinction moisture and particle size distribution;
- The main sources of dust; and
- Practices adopted to manage the emissions or its source.

The key dust mitigation measures detailed in the guideline include suppression (water or chemical), extraction, barriers/wind breaks, enclosure, moisture content control, consideration of meteorology and sealing of surfaces. Additional mitigation measures are available for high-risk operations (i.e. activities due to their nature or temporal location that have a higher potential to impact sensitive receptors) and these include shielding conveyors or belt launders, minimising wind erosion using chemical product on stockpiles and open areas, reactive boundary monitors, use of wind fence at upwind and/or downwind of emission source, enclosure of stockpiles and worker education and training.

The guideline recommends the use of dust dispersion modelling to understand relative source contributions so that mitigation measures can be prioritised. It also recommends facilities undertake model verification every two to three years. The guidelines also place emphasis on a well-defined monitoring program with clearly defined objectives (e.g. purpose of the program could be either characterising emission rates from operations or compliance). It also recommends that boundary monitors be used to determine site contribution to high dust events at off-site receptor locations. The importance of stakeholder engagement early on in the project is emphasized and transparency of process is encouraged by making documents such as Dust Management Plans (DMPs) accessible to the public. The PPA also recommend an active complaints management system with well-defined roles and responsibilities for personnel together and annual reporting on compliance.

Further, the guideline recommends review of operational dust management plans as a minimum every 5 years after issue, and ideally every year or after a model verification study to capture changes to operations including consideration of recent developments in dust mitigation management techniques, changes to site operations and/or major sources.

NSW Coal Mining Best Management Practice (BMP)
The NSW Coal Mining BMP identifies best practice measures for controlling dust from specific activities in coal mines. It recommends the following items that are of relevance to the Project:

- Identification of site-specific best management practice and implementation of improvement through regulatory tools (e.g. environmental licence conditions);
- Use of opacity as an indicator for particulate matter fugitive emissions;
- Using a regional dispersion model to manage current and future emissions;
- Use of dust controls on operations, including:
  - Haul roads: reducing speed, surface improvements (paving or reducing silt loading) and surface treatments (water or chemical suppressants);
  - Stockpiles: use of water and/or chemical suppressants, enclosure and wind fences;
  - Open areas: use of water and/or chemical suppressants and rehabilitating land as they become available, use of wind fence;
  - Conveyors: water sprays, wind shielding, belt cleaning and reducing spillage, enclosure;
  - Bulldozing: minimising travel speed and distance travelled and/or application of water on travel routes;
  - Blasting: delaying shot to avoid unfavourable conditions and minimising area of blast;
  - Drilling: use of dry (fabric filter, cyclone) and wet collection systems;
  - Loading and unloading overburden: minimising drop height, irrigating work bench with water cart mounted cannon, pre-soaking blasted overburden with an agricultural sprinkler, fogging cannon on loading plume;
  - Loading and dumping Run of Mine (ROM) ore: bypass stockpiles, minimise drop height, water sprays; and
  - Real time air quality monitoring, proactive and reactive strategies that include forecasting and use of inversion tower data to predict strong inversions that inform operations (e.g., scheduling blasts).

Mt Isa Mines Various Documents
Mt Isa Mines (MIM) employs both real-time and predictive tools to minimise dust emissions from its operations. It maintains a document of best practice management measures for each potential

source of emissions particularly haul roads, open areas and process emissions. These are contained within the Trigger Action Response Plan (TARP) and include:

- Crushers: water sprays and wind fences around selected crushers;
- Transfer station: enclosure;
- Haul roads: sealing selected haul roads, watering and regular maintenance, implementing speed limits;
- Stockpiles: use of wind fence; and
- Open areas and waste dumps: progressive rehabilitation.

As part of their reactive management component, MIM utilise a web-based back trajectory to identify potential emission sources when elevated concentrations are recorded at the boundary monitors. This system also alerts environmental and operations personnel to the location of the monitor, possible sources and mitigation measures. The predictive management component uses forecast meteorology to inform management of emissions before its onset. For example, wetting of materials in advance of a high wind event and ensuring sealed roads are cleaned on a regular basis ahead of the dry season.

NSW Coal Mine PRP-U3

NSW Coal Mine PRP-U3 investigated best practice control measures for minimising dust emissions from disturbing and handling of overburden. The report concluded that pre-soaking blasted overburden prior to handling could result in a 40% dust control while irrigating work bench and spraying the plume from an excavator loading trucks using water cannon mounted on top of a water cart could achieve 70% reduction in dust levels.

A comparison of the current dust management practices implemented by KCGM at the Fimiston Operations against the dust management strategies recommended in the comparable dust management programs is presented in Table 6. In general, continued implementation of KCGM's existing management measures is expected to facilitate the successful management of fugitive dust emissions from the proposed FS Project. Recommendations for further consideration in relation to the FS Project have also been presented, within the context of continuous improvement.

Table 6: Review of Dust Management Practices at KCGM

Emission Source	Current Practice at KCGM	Strategies for Consideration
Haul roads	Watering when needed. The need for watering is also identified as part of the reactive strategy. The water used onsite is hyper saline enabling significantly better dust control.	Surface improvements on high risk areas. The high-risk areas may be determined based on spatial proximity to receptors or areas with high traffic. Scheduled maintenance of haul roads should be documented within onsite management systems.
Wind erosion from stockpiles	Water sprays are used to suppress dust when needed – identified based on the reactive strategy.	No further recommendations
Wind erosion from open areas	Water sprays are used to suppress dust when needed – identified based on the reactive strategy.	Investigate the use of chemical suppressant in open areas particularly prior to high risk periods (i.e. ahead of Spring and Summer periods when

Emission Source	Current Practice at KCGM	Strategies for Consideration
		higher proportion of easterlies occur) or before periods of high winds (>6.3 m/s). Investigate the use of wind fences for periods with high dust transportation risk. For example, during realignment and construction of ENB.
Conveyors	Conveyors are open but have belt wash stations and belt scrapers. Material fallout is regularly cleaned.	No further recommendations
Bulldozing	Suspension of work in a particular area as deemed necessary based on visual inspections, dust alarms or prevailing wind conditions.	Use predictive forecast to plan and schedule bulldozing of material. Include minimising travel speed and distance travelled where possible.
Blasting	Use of KCGM Dust Management Program (visual interface) that includes location of blast, acceptable wind arc and review of wind data recorded in the last 30-minutes for blasting to proceed.	No further recommendations.
Drilling	No cyclones or fabric filters. Water sprays are used when needed.	Consider use of cyclones or fabric filters.
Loading and unloading of overburden	Standard practice includes watering down the face area before material handling.	Integrate standard practices including minimising drop height, irrigating benches and pre-soaking blasted overburden and restrictions around handling of more dusty ore (e.g., oxide ore) into FAQMP and/or operational procedure for excavators etc. Use predictive forecast to identify the need for additional dust controls.
Screening and Crushing	Water sprays utilised throughout crushing circuit.	No further recommendations.
Loading and unloading of ROM	Reactive strategy is used to implement additional controls such as water carts along transport routes. ROM material itself not watered.	Use predictive forecast to identify the need for additional controls such as watering.
Reactive	Real-time monitoring data is used to set “Alert” and “Action” alarms. Back-trajectory module is used to identify potential sources and implementation of dust controls including use of water carts, suspend/delay operations, use	Document dust control options for each source within the FAQMP and/or operational procedures.

Emission Source	Current Practice at KCGM	Strategies for Consideration
	alternative operational area, contacting appropriate personnel if dust is from crushing operations and restricting haulage speeds.	
Predictive	Weather forecast systems are used to control fugitive dust emissions from blasting and earthmoving activities. Controls implemented include delaying/suspending work and use of alternate areas if possible.	Output from forecast system be used to apply additional dust controls ahead of an event. Examples include cleaning of sealed roads, applying dust suppressants on haul routes. Document control measures by source within the FAQMP and/or operational procedures.

It is recommended that KCGM document available dust control options in response to the predictive and reactive control strategy triggers within the FAQMP and the site's operational procedures. It is also recommended that KCGM ensure preventative actions undertaken that deliver benefits over the long term such as sealing certain sections of haul roads, rehabilitation of WRDs and use of rock armoury buttresses for TSFs, be documented within the FAQMP.

3. AIR QUALITY ASESSMENT OF PROPOSED OPERATIONS

3.1 Introduction

In order to assess potential changes associated with the implementation of the FS Project, an air dispersion modelling assessment to comparatively assess current and potential future operations was undertaken.

3.2 Potential Ambient Particulate Impacts

As outlined in Section 1.3, the FS Project will be mined in the same manner as the GP Cutback, with drilling and blasting of the in-situ material and excavating and hauling via a conventional truck and shovel fleet. The sources of fugitive dust emissions for the proposed FS Project are therefore expected to remain the same as the current operations.

Given the proximity of the proposed FS Project to the City of Kalgoorlie-Boulder, the south-western expansion of the FOP is likely to have the greatest potential impact on ambient PM_{10} concentrations at the nearest monitoring locations (i.e. HOP, BSY and CLY). This will primarily be the case during construction works to realign the ENB and when mining activity is close to the surface, during the initial stages of the Project.

Waste material from the FS Project will initially be hauled to the existing SE surface dumps, before in-pit deposition begins following completion of the GP Cutback (nominally within the first two years of the FS Project). The travel distance associated with in-pit deposition is expected to decrease compared to that of surface deposition, which in turn is expected to result in a decrease of wheel-generated dust emissions associated with the haulage of waste material. In-pit retention is also expected to contribute to the mitigation of fugitive dust emissions generated when unloading waste rock material within the pit. However, as the height of the in-pit waste rock dumps increases and material handling activities occur closer to the surface, the potential for fugitive dust emissions from the northern aspect of the FOP increases.

3.2.1 Background Dust Emissions

A review of historical ambient PM_{10} monitoring data has indicated that non-KCGM related dust sources are impacting the ambient PM_{10} concentrations recorded at sites located within close proximity to the Fimiston Operations (i.e., BSY, HOP, CLY and HEW). These sources include smoke from wood heaters in winter, particulates from wind erosion of cleared areas, local non-KCGM earthworks, truck and car movement on sealed and unsealed roads and tracks, and motor cross bike generated dust from activity on nearby tracks. The potential impacts and significance of these types of dust sources was similarly recognised in Port Hedland where the DoH recommended that part of the particulate exposure reduction plan should include:

> *"A coordinated approach to reduce dust from all sources not just industry is required. Various government sectors (planning, transport, energy) may be needed to develop and effectively develop and implement long-term policies and strategies that reduce exposure."* (DoH, 2016)

The Port Hedland Dust Management Taskforce 2016 report also recommended:

> *"The Town of Port Hedland works with key stakeholders to identify and mitigate dust from non-industry sources, with a focus on:*
> - *Identifying and implementing dust mitigation options for the spoil bank;*
> - *Sealing unsealed roads and undertaking regular and effective street sweeping operations;*

- *Considering greening options, including coastal dune revegetation and the establishment of a green belt around the port; and*
- *Reviewing and improving the efficacy of municipal services associated with dust control."* (Department of State Development, 2016)

In line with the type of recommendations made for Port Hedland, Ramboll recommends that KCGM approach the City of Kalgoorlie-Boulder to offer assistance with dust management measures (e.g., application of a surface binding agent, preventing vehicular access, or rehabilitation) of the open areas on the eastern side of the City with an initial focus on the areas in and around the PM_{10} monitoring locations with the objective of reducing fugitive particulate emissions.

Wheel generated dust emissions on the unsealed access road to the public lookout have been identified as an emission source contributing to elevated PM_{10} concentrations measured at the HOP site (see Section 2.2). KCGM has indicated that the public lookout is being relocated to a position south of the current location. Dust management during construction will be managed in accordance with the FAQMP. It is expected that these measures will result in a reduction of the PM_{10} concentrations measured at the monitoring locations.

3.3 Air Dispersion Modelling Methodology

3.3.1 Air Dispersion Model

The CALPUFF modelling system was utilised to undertake air dispersion modelling of current and proposed emissions. CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model. It utilises three-dimensional wind fields to simulate the effects of the temporal and spatial meteorological conditions on pollutant transport, transformation and removal. CALPUFF also allows for three-dimensional characterisation of land use and surface characteristics such as height and density of vegetation.

3.3.2 Modelling Year

Analysis of the past twelve years (2010-2021) indicates that 2019 was the year with the highest average monitored concentrations of PM_{10} in the region. This year was selected for use in the air dispersion modelling assessment. Emissions estimates derived from KCGM operations in 2019 were used to characterise the current operations.

Based on data provided by KCGM (Figure 3), 2029 is predicted to be the year with the highest total material movement (96 Mtpa) once operations for the FS Project commence however 2025 (86 Mtpa) was selected as the year to be modelled as this involved a higher level of activity located close to the town and a larger amount of material extracted from the pit and dumped externally and was therefore considered to represent a worst case assessment. Emissions estimates from this year were used to predict worst case impacts associated with the project using the meteorology from 2019.

3.3.3 Meteorological Data

Monitoring data was obtained for the region from the Kalgoorlie Bureau of Meteorology (BoM) station, the MEX meteorological monitoring station, and the Cassidy Headframe monitoring station. In the absence of site-specific meteorological monitoring parameters suitable for use in dispersion modelling, the TAPM prognostic meteorological was run for 2019 and used as input for the model.

3.3.4 Model Parameterisation

3.3.4.1 CALMET

The CALMET meteorological processor was used to develop a meteorological file for input into the CALPUFF model. CALMET is a diagnostic meteorological model that produces three-dimensional wind fields based on parameterised treatments of terrain effects such as slope flows and terrain blocking effects. Meteorological observations from the three regional meteorological monitors (BoM, MEX, CAS) were incorporated to determine the wind field in areas of the domain within which the observations are representative. Site specific terrain data was incorporated into the model ensuring fine scale terrain effects were determined by the diagnostic wind module in CALMET and is presented in Figure 15.

Comparison of the predicted meteorology with the monitored data is presented in Figure 16 at each of the monitoring sites for 2019. The figure shows that the model has reasonably predicted the meteorology at the locations of the monitoring.

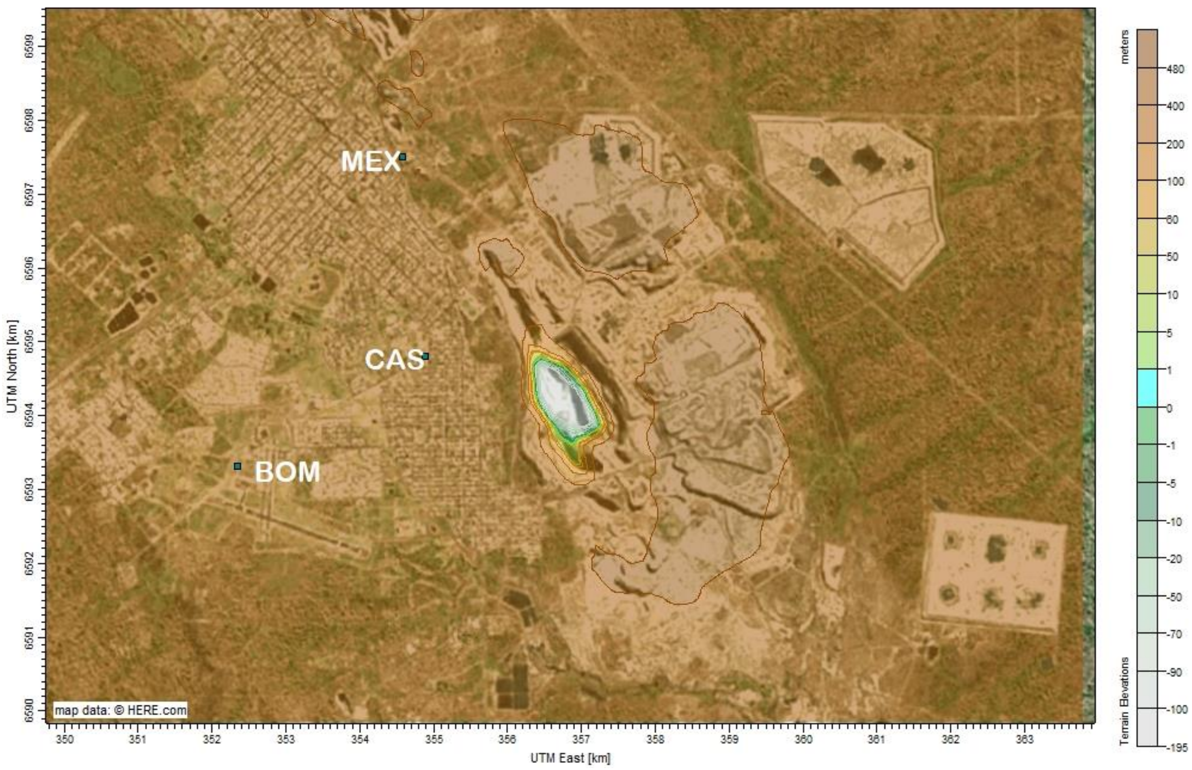
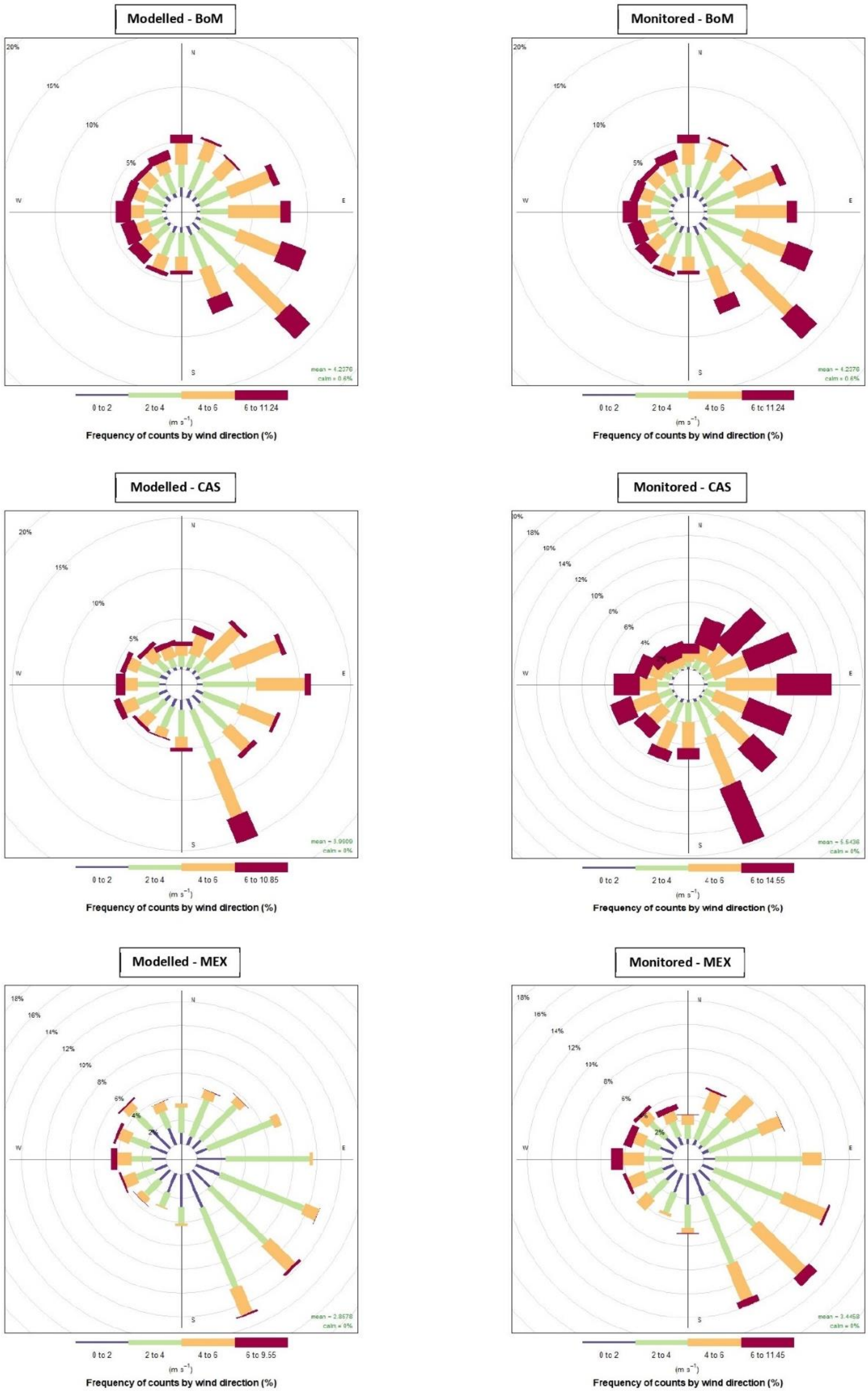


Figure 15: Modelled Area with Terrain Elevations and Meteorological Monitoring Stations

3.3.4.2 TAPM

The Air Pollution Model (TAPM) (Version 4.05) was used to generate a prognostic gridded meteorological dataset for the CALMET model domain. TAPM was developed by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) and consists of coupled prognostic meteorological and air pollution dispersion model components. The meteorological component of TAPM predicts the local-scale meteorological features, such as sea breezes and terrain-induced circulations, using the larger-scale synoptic meteorology as boundary conditions combined with other data including terrain, land use, soil and surface types. TAPM has been used extensively throughout Australia for generating site specific meteorological files for use in air dispersion modelling studies.



Confidential

Figure 16: Comparison of Monitored and modelled meteorology (2019) at Monitoring Locations

3.3.4.3 CALPUFF

The CALPUFF modelling system was used to predict ambient concentrations of particulates associated with fugitive particulate emissions from KCGM operations in isolation. CALPUFF provides a non-steady state modelling approach which evaluates the effects of spatial changes in the meteorological and surface characteristics and has been listed by the United Stated Environmental Protection Agency (USEPA) as an alternative model for situations involving complex terrain such as the Fimiston pit, where typical steady-state plume dispersion models (such as AERMOD) have limited capability.

3.3.4.4 CALPUFF Model Parameterisation

The following model set up options within CALPUFF were used:

- Computational grid of 15.75 km by 13.5 km encompassing the KCGM operations and the Kalgoorlie region, associated haul road, the processing facility and stockpiles, with meteorological grid spacings of 150 m;
- A sampling grid was utilised with grid spacings of approximately 150 m;
- Dry deposition;
- No chemical transformation; and
- Default partial plume path adjustment.

Each emission source was individually modelled in CALPUFF using a fixed emission rate and the resultant outputs for each source were scaled against the corresponding hourly variable emissions to generate predicted concentration for each hour of the year, at each model grid point within the associated region. The predicted concentrations rates for each source were then combined for each of the modelled scenarios.

3.3.4.5 Particle Size Distribution

Particle size distribution data used in the model for particles in the sub-fraction of the TSP emissions were based on the USEPA distributions for batch drop, wind erosion and vehicle emissions (USEPA, 2004a, b and c) as listed in Table 7. A distribution composite to all three USEPA distributions was adopted and applied for this study in the absence of actual data.

Table 7: Source Particle Size Distributions

<table>
<tr><th>Particle Size Range</th><th>Representative Particle Size</th><th colspan="4">Percentage of Particulate (%) in Various Size Ranges</th></tr>
<tr><th>µm</th><th>µm</th><th>USEPA Batch Drop</th><th>USEPA Wind Erosion</th><th>USEPA Unpaved Road</th><th>This Study</th></tr>
<tr><td><2.5</td><td>1.0</td><td>11</td><td>14.8</td><td>3.3</td><td>9</td></tr>
<tr><td>2.5 - 5.0</td><td>3.8</td><td>9</td><td rowspan="3">22.2</td><td rowspan="3">18.7</td><td>8</td></tr>
<tr><td>5.0 - 7.5</td><td>6.3</td><td rowspan="2">15</td><td>7</td></tr>
<tr><td>7.5 – 10</td><td>8.3</td><td>6</td></tr>
<tr><td>10 – 15</td><td>12.5</td><td>13</td><td>7</td><td rowspan="3">52</td><td>14</td></tr>
<tr><td>15 – 23</td><td>19</td><td rowspan="2">26</td><td rowspan="2">30</td><td>15</td></tr>
<tr><td>23 – 30</td><td>26</td><td>15</td></tr>
<tr><td>30 – 40</td><td>35</td><td rowspan="2">26</td><td rowspan="2">26</td><td rowspan="2">26</td><td>15</td></tr>
<tr><td>40 – 50</td><td>45</td><td>11</td></tr>
</table>

Notes

1. Particle sizes are equivalent aerodynamic size and not the physical size. The equivalent aerodynamic size relates to the aerodynamic properties of the particle as is used in dust sampling. For example PM_{10} samplers measure the dust below 10 μm equivalent aerodynamic size and not the physical size.
2. Wind erosion and vehicle emission size distributions are given for below 30 μm only but have been adjusted here to less than 50 μm based on assuming 74% of the particulate is less than 30 μm as per the batch drop distribution.

The particle sizes specified in Table 7 are based on the equivalent aerodynamic diameter and not the physical size. The equivalent aerodynamic diameter relates to the aerodynamic properties of the particle with a density of 1 g/cm^3 as is used in particulate matter sampling.

3.3.5 Emission Factors

Emission factors (EFs) and emission inventories have long been fundamental tools for air quality management. An EF is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g. kilograms of particulate emitted per tonne of iron ore mined). In most cases, these factors are simply averages of all available data of acceptable quality and are generally assumed to be representative of long-term averages for all similar facilities. However, there are inherent uncertainties associated with the use of EFs, as test data from representative sources may not always be of sufficient quantity or quality to calculate robust EFs and may not reflect the variability of actual emissions.

Data from source-specific emission tests or continuous emission monitors are typically preferred over the use of EFs to estimate source emissions as they provide the best representation of emissions from the tested source. However, in the absence of source-specific emission testing data, EFs are often the most appropriate or only method available for estimating emissions.

3.3.5.1 NPI Emissions Factors

The EFs proposed for use in the model are primarily based on the default EFs published in the Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) NPI Emissions Estimation Techniques (EET) Manual for Mining (2012) (NPI mining manual) (with the exception of wind erosion). In lieu of site-specific data, it is common practice for mining operations within Australia to utilise the default EFs from the NPI mining manual in order to estimate emissions.

The NPI mining manual was developed through a process of national consultation involving state and territory environmental departments and key industry stakeholders, including the Minerals Council of Australia (MCA) and the Clean Air Society of Australia and New Zealand (CASANZ). NPI EET manuals are updated on an ad-hoc basis, generally when key stakeholders indicate that the published EFs are no longer applicable. The current NPI mining manual (Version 3.1) was last updated in January 2012. This iteration incorporated a number of recommendations highlighted in the Improvement of NPI Fugitive Particulate Matter EET study undertaken by SKM (2005).

Many of the EFs from the NPI mining manual are derived from the United States Environment Protection Authority (USEPA) AP-42 EFs. The USEPA AP-42 represents a compilation of air pollutant EFs, published since 1972 as the primary repository for the USEPA's EFs information. The AP-42 EFs were developed and compiled from source test data, material balance studies and engineering estimates. Factor ratings are assigned to indicate the robustness, or appropriateness, of each AP-42 EF for estimating average emissions for a source activity. The ratings are based on the estimated reliability of the test data used to develop the factors, and on both the amount and the representative characteristics of those data. Factors based on many observations, or on more widely accepted test procedures, are generally assigned higher rankings.

The first step in assigning an EF rating is an assessment of the quality and reliability of the emissions data used to develop the factor. Data are rated A through D, according to the following criteria:

- **A** - Tests are performed by a sound methodology and are reported in enough detail for adequate validation.
- **B** - Tests are performed by a generally sound methodology but lacking enough detail for adequate validation.
- **C** - Tests are based on an unproven or new methodology or are lacking a significant amount of background information.
- **D** - Tests are based on a generally unacceptable method, but the method may provide an order-of-magnitude value for the source.

The second step is to assess the representativeness of a factor as an annual average EF for that source activity, and an overall rating is subsequently assigned:

- **A - Excellent -** Factor is developed from A and B rated source test data taken from many randomly chosen facilities in the industry population. The source category population is sufficiently specific to minimise variability.
- **B - Above average -** Factor is developed from A or B rated test data from a "reasonable number" of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with an A rating, the source category population is sufficiently specific to minimise variability.
- **C - Average** - Factor is developed from A, B, and/or C rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with the A rating, the source category population is sufficiently specific to minimise variability.
- **D - Below average** - Factor is developed from A, B and/or C rated test data from a small number of facilities, and there may be reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source population.
- **E - Poor** - Factor is developed from C and D rated test data, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry.

3.3.6 Emission Sources

To predict particulate rates in a realistic manner, hourly estimates of particulate emissions were determined from all major sources in the area. Factors which are important for particulate generation include:

- Ore type being handled - This is related to the size distribution of the material, shape and composition of the fines fraction;
- Moisture content - Increasing the moisture content decreases the dustiness of the ores with there normally being a moisture threshold above which particulate generation by material handling is negligible, known as practical extinction. This occurs as moisture acts to apply adhesive forces between particles;
- The operation occurring - Factors which are important are the drop height, the degree to which the falling ore is exposed to the wind such that winnowing can occur, and the particulate

control mechanism used. Control mechanisms may include enclosing the operation, the use of water sprays and particulate extraction to a bag filter or to a wet scrubber;
- Quantity of ore/overburden being moved and the number of movements;
- Size of stockpiles and level of activity;
- Level of vehicle traffic; and
- Ambient wind speed - For material handling operations exposed to the air, particulate emissions increase with increasing wind speed. For wind erosion, particulate emissions are negligible below a wind speed threshold, but increase rapidly above the threshold. Dust emissions from wind erosion are also dependent on the erodibility of the material which is dependent on the size distribution of the material and whether a crust has been developed.

3.3.6.1 Bulldozing

The emission rate for bulldozing can be estimated using Equation 1.

Equation 1: Bulldozing (PM_{10})

$$PM_{10}\ (\text{kg/hour}) = 0.34 \times (s^{1.5} / M^{1.4})$$

Where: S = default silt content of 10%
M = measured average moisture content of 3.52%

This equation is sourced from the NPI mining manual, which in turn references the AP-42 EFs (USEPA, 1998a). The USEPA (1998a) notes that the AP-42 dozer equation result in an emission rate (i.e. kg/hr) rather than an EF. The EF has been assigned a factor rating of D.

Figure 17 below outlines average daily soil moisture values for the location of proposed operations and shows and average moisture content of 3.52% for the area. This average value was utilised as the accepted moisture content in the estimation of emissions.

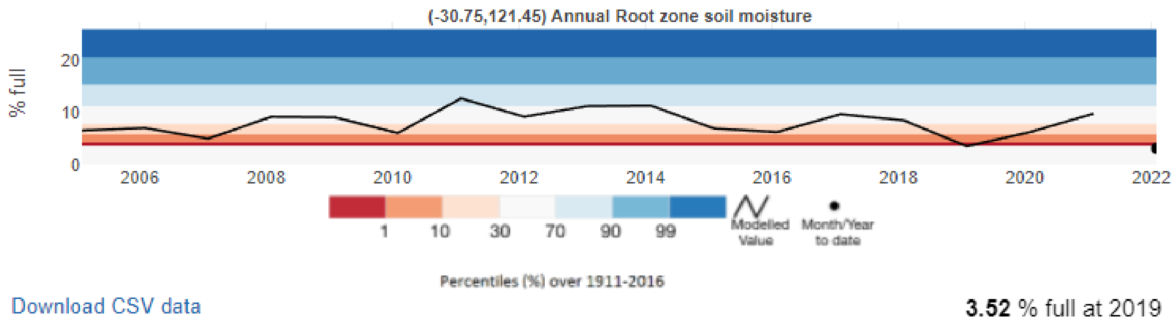


Figure 17: Average Daily Soil Moisture Content for Kalgoorlie (BoM, 2022)

3.3.6.2 Haul Roads

The emission factors for the haul roads can be estimated using Equation 2.

Equation 2: Haul Roads (PM_{10})

$$PM_{10}\ (\text{kg/VKT}) = (0.4536 / 1.6093) \times k \times (s/12)^{0.9} \times ((W \times 1.023)/3)^{0.45}$$

Where:

k = particle size multiplier (1.5 for PM_{10})
s = silt content (%) (NPI default of 10% to be applied)

W = vehicle gross mass in tonnes (262 tonnes to be adopted as the average of an empty and fully laden CAT793F haul truck)

This equation is sourced from the NPI mining manual, which in turn references the AP-42 EFs for miscellaneous sources (USEPA, 2006b). The USEPA (2006b) assigned this EF a factor rating of B.

KCGM has noted that it applies water to the haul roads using hypersaline water. The hypersaline water forms a crust on the haul roads binding the particles and assists in maintaining the moisture of the roads. This is a similar mechanism to the use of chemical suppressants and therefore for the purpose of this assessment it has been assumed that the control of particulate emissions from the roads using this water is similar to the use of chemical suppressants.

3.3.6.3 Loading and Unloading of Ore and Waste

The emissions factors for loading and unloading of ore and waste can be estimated using Equation 3 for use of excavators and front-end loaders on ore and overburden, and for truck dumping and general unloading as shown below. The USEPA batch drop equation was used to represent truck loading and truck dumping. The EF has been assigned a factor rating by the USEPA of A.

Equation 3: Loading Ore or Waste (PM_{10})

$$PM_{10} = 0.000388 \text{ kg/tonne}$$

3.3.6.4 Wind Speed Dependence for Material Handling

For all material handling processes exposed to the wind, increasing wind speed acts to increase dust emissions through winnowing of the particles from the falling ore. The USEPA batch drop equations (USEPA, 2004a) specify that the dust emission increases with the wind speed to the power of 1.3, as follows in Equation(s) 16:

Equation(s) 16: Wind Speed and Material Handling Emission Rate

$$E_{Actual} = E_{2.2}\,(WS/2.2)^{1.3}$$

Where:

- WS is the wind speed at the drop height;
- $E_{2.2}$ is the dust emission given for a wind speed of 2.2 m/s; and
- E_{Actual} is the final emission rate.

The average source height was assumed to be 5 m above the surface, with the 10 m wind speeds used to estimate the 5 m wind speeds using the 1/7 power law given by:

$$WS_5 = WS_{10}\,(5/10)^{(1/7)}$$

Where:

- WS_{10} is the wind speed at 10 m.
- WS_5 is the calculated wind speed at 5 m.

3.3.6.5 Wind Erosion

Dust emissions generated by wind are generally negligible below a wind speed threshold but increase rapidly when wind speeds exceed the threshold. Dust emissions from wind erosion are also dependent on the erodibility of the material which in turn is dependent on the size distribution of the material and whether a crust has developed. In general, material with a large

(>50%) fraction of non-erodible particles (generally particles greater than 1 mm to 2 mm) will not erode as the erodible fraction is protected by these particles. Fine ores are generally much more erodible by wind erosion, particularly if they have a large fraction of particles in the range from 0.1 mm to 0.25 mm which can be dislodged by wind and then rolled and skipped along the surface (saltation). These larger particles can then dislodge the smaller (<50 µm) dust fraction which can remain suspended in the air.

An analysis of the monitors was undertaken in the region for 2019 and the wind speed threshold was determined to be 6.3 m/s. An analysis of the data was also used to determine a wind speed dependency equation and an iterative modelling process whereby modelling results were compared to monitored data was undertaken to determine the emission rate. The equation used to represent wind erosion emissions is presented in Equation 17.

Equation 17: Wind Erosion

$$E_{wind} = 1.58E\text{-}05 * (EXP(0.5492*[WS])/EXP(0.5492*[WST])$$

Where:

WS_T is the threshold for wind erosion in m/s, taken to be 6.3 m/s; and
E_{wind} is the PM_{10} emissions ($g/m^2/s$).

3.3.6.6 Rainfall Dependence

To account for the effects of rainfall in reducing dust emissions, a simple scheme was adopted. With regards to wind erosion, rainfall was assumed to not only suppress dust emissions at the time rain was occurring, but to also result in a suppression of the dust emissions that gradually decreases over time as the areas dry out. Without stockpile activity, material can form a strong crust and be resistant to wind erosion for extended periods.

Dust emissions were taken to linearly return to a rainfall unaffected state within 400 hours of the rainfall evaporating if the rainfall event was greater than 25 mm. During the period when it was raining or if the rainfall had not evaporated, emissions were set to zero. The evaporation rate at the surface was assumed to be 1.25 times the amount from a Class A pan with a limit to the amount of water on/near the surface of 75 mm. Daily average evaporation rates for each month were obtained from the BoM for the Kalgoorlie monitoring station. This station is selected as this is the closest monitoring station to the project site operations that reports evaporation data, and no other monitoring station in a closer proximity to the site reports the evaporation data which is required for the emission estimations.

These time scales have been adopted from studies undertaken at iron ore mines in the Pilbara region of Western Australia (ENVIRON, 2004) and were originally based on observations of the time taken for high dust levels to return following a large rainfall event in the Pilbara region. The trend from the studies can similarly be applied for observations in the Wheatbelt region. It is noted that the return to dusty conditions is not just a function of the evaporation of the water but is determined more importantly from activity at exposed surface areas; fresh surfaces are created as a result of activities such as bulldozing, reclaiming and vehicle movement.

3.3.6.7 Summary of Estimated Emissions

A summary of emissions estimates is presented in Table 8 and Table 9 indicating predicted fugitive emissions for activities across mining operations for dry and wet scenarios.

Table 8: Summary of Fugitive Particulate Emission Estimates for Modelling of Current Operations (2019)

Description	Activity	EF Unit	PM_{10} EF	Activity Units	Activity Value	Control	Dust Cntl %	Pit %	Hours/ Year	PM_{10} g/s
FOP	Blasting	kg/blast	18.3	blast/Yr	196	No controls	0%	100%	196	2.54
Morrison	Blasting	kg/blast	18.3	blast/Yr	219	No controls	0%	100%	219	2.54
FOP	Drilling	kg/hole	0.307	hole/Yr	183,679	Fabric filters - NPI - 99%	99%	100%	8,760	0.01
Morrison	Drilling	kg/hole	0.307	hole/Yr	205,989	Fabric filters - NPI - 99%	99%	100%	8,760	0.01
Bulldozing	Bulldozing	kg/hour	1.76	hour/Yr	24,612	No controls	0%	0%	8,760	1.37
FOP	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	13,912,822	No controls	0%	100%	8,760	0.09
Morrison	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	15,602,737	No controls	0%	100%	8,760	0.096
Direct Feed	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	451,715	No controls	0%	0%	8,760	0.006
Ore Stockpile_1	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	3,310,918	No controls	0%	0%	8,760	0.041
In-Pit Dump	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	85,161	No controls	0%	0%	8,760	0.001
Morro Dump	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	7,104,561	No controls	0%	0%	8,760	0.044
North Dump	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	1,567,733	No controls	0%	0%	8,760	0.019
Trafalgar East	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	13,036,941	No controls	0%	0%	8,760	0.160
Trafalgar West	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	648,926	No controls	0%	0%	8,760	0.008
Ore Stockpile_2	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	3,310,918	No controls	0%	0%	8,760	0.041
Direct Feed Crushing	Primary Crushing	kg/tonne	0.004	tonne/Yr	9,475,701	Water sprays to keep ore wet - 50%	50%	0%	8,760	3.00
Direct Feed Crushing	Reclaimer	kg/tonne	0.03	tonne/Yr	9,475,701	Variable stack height - NPI - 25%	25%	0%	8,760	6.76
Main Pit out	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	190,995	Water Sprays with Hyper Saline	95%	0%	8,760	1.00

Description	Activity	EF Unit	PM_{10} EF	Activity Units	Activity Value	Control	Dust Cntl %	Pit %	Hours/ Year	PM_{10} g/s
Main Pit To Morrison Haul	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	131,105	Water Sprays with Hyper Saline	95%	0%	8,760	0.69
Morrison to Junction 1 Haul Road	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	78,740	Water Sprays with Hyper Saline	95%	0%	8,760	0.41
Junction to FAR / Trafalgar East Haul Road	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	86,403	Water Sprays with Hyper Saline	95%	0%	8,760	0.45
Junction1 to Junction 2	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	11,260	Water Sprays with Hyper Saline	95%	0%	8,760	0.06
Junction 1 to WST / Morrow Waste Haul Road	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	77,111	Water Sprays with Hyper Saline	95%	0%	8,760	0.40
Junction 2 to Junction 3	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	16,479	Water Sprays with Hyper Saline	95%	0%	8,760	0.09
Junction 3 to Ore Stockpile 1	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	4,799	Water Sprays with Hyper Saline	95%	0%	8,760	0.03
Junction 3 to Direct Feed	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	6,742	Water Sprays with Hyper Saline	95%	0%	8,760	0.04
Junction 2 to Ore Stockpile 2	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	18,911	Water Sprays with Hyper Saline	95%	0%	8,760	0.10
North Pit to Junction 4 Haul	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	5	Water Sprays with Hyper Saline	95%	0%	8,760	0.00003
Direct Feed to Junction 4 Haul	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	2,501	Water Sprays with Hyper Saline	95%	0%	8,760	0.01
Junction 4 to Northern Dump	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.3	VKT/Yr	10,812	Water Sprays with Hyper Saline	95%	0%	8,760	0.06
Main Pit out - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	190,995	Water Sprays with Hyper Saline	95%	0%	8,760	0.67
Main Pit To Morrison Haul - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	131,105	Water Sprays with Hyper Saline	95%	0%	8,760	0.46
Morrison to Junction 1 Haul Road - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	78,740	Water Sprays with Hyper Saline	95%	0%	8,760	0.27
Junction to FAR / Trafalgar East Haul Road - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	86,403	Water Sprays with Hyper Saline	95%	0%	8,760	0.30
Junction1 to Junction 2 - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	11,260	Water Sprays with Hyper Saline	95%	0%	8,760	0.04
Junction 1 to WST / Morrow Waste Haul Road - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	77,111	Water Sprays with Hyper Saline	95%	0%	8,760	0.27

Description	Activity	EF Unit	PM_{10} EF	Activity Units	Activity Value	Control	Dust Cntl %	Pit %	Hours/ Year	PM_{10} g/s
Junction 2 to Junction 3 - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	16,479	Water Sprays with Hyper Saline	95%	0%	8,760	0.06
Junction 3 to Ore Stockpile 1 - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	4,799	Water Sprays with Hyper Saline	95%	0%	8,760	0.02
Junction 3 to Direct Feed - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	6,742	Water Sprays with Hyper Saline	95%	0%	8,760	0.02
Junction 2 to Ore Stockpile 2 - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	18,911	Water Sprays with Hyper Saline	95%	0%	8,760	0.07
North Pit to Junction 4 Haul - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	5	Water Sprays with Hyper Saline	95%	0%	8,760	0.00003
Direct Feed to Junction 4 Haul - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	2,501	Water Sprays with Hyper Saline	95%	0%	8,760	0.01
Junction 4 to Northern Dump - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.2	VKT/Yr	10,812	Water Sprays with Hyper Saline	95%	0%	8,760	0.04

Table 9: Summary of Fugitive Particulate Emission Estimates for Modelling of Future Operations (2025)

Description	Activity	EF Unit	PM_{10} EF	Activity Units	Activity Value	Control	Dust Cntl %	Pit %	Hours/ Year	PM_{10} g/s
GB	Blasting	kg/blast	18.3	blast/Yr	146	No controls	0%	100%	146	2.54
GPN	Blasting	kg/blast	18.3	blast/Yr	89	No controls	0%	100%	89	2.54
IVH	Blasting	kg/blast	18.3	blast/Yr	226	No controls	0%	100%	226	2.54
OBH	Blasting	kg/blast	18.3	blast/Yr	183	No controls	0%	100%	183	2.54
GB	Drilling	kg/hole	0.307	hole/Yr	137,195	Fabric filters - NPI - 99%	99%	100%	8,760	0.007
GPN	Drilling	kg/hole	0.307	hole/Yr	84,023	Fabric filters - NPI - 99%	99%	100%	8,760	0.004
IVH	Drilling	kg/hole	0.307	hole/Yr	212,292	Fabric filters - NPI - 99%	99%	100%	8,760	0.010
OBH	Drilling	kg/hole	0.307	hole/Yr	171,521	Fabric filters - NPI - 99%	99%	100%	8,760	0.008
Bulldozing	Bulldozing	kg/hour	1.5	hours/Yr	38,213	No controls	0%	50%	8,760	2.57
GB	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	10,391,877	No controls	0%	100%	8,760	0.11
GPN	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	6,364,397	No controls	0%	100%	8,760	0.09
IVH	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	16,080,141	No controls	0%	100%	8,760	0.15
OBH	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	12,991,915	No controls	0%	100%	8,760	0.18
Direct Feed	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	3,532,832	No controls	0%	0%	8,760	0.10
Marginal	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	341,777	No controls	0%	0%	8,760	0.01
WST - Morro Dump	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	11,283,091	No controls	0%	100%	8,760	0.12
PAD 13 / CSI Subgrade / CSI Waste - North Dump	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	477,497	No controls	0%	0%	8,760	0.01
WST + FAR - Trafalgar East	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	28,550,408	No controls	0%	0%	8,760	0.66

Description	Activity	EF Unit	PM_{10} EF	Activity Units	Activity Value	Control	Dust Cntl %	Pit %	Hours/ Year	PM_{10} g/s
Sub Grade South - Ore Stockpile_2	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	1,490,756	No controls	0%	0%	8,760	0.04
Blackflag + Readymix	Materials Handling / Batch Drop	kg/tonne	0.000388	tonne/Yr	151,969	No controls	0%	0%	8,760	0.00
Direct Feed Crushing	Primary Crushing	kg/tonne	0.004	tonne/Yr	5,883,631	Water sprays to keep ore wet - 50%	50%	0%	8,760	0.80
Direct Feed Reclaiming	Reclaimer	kg/tonne	0.002	tonne/Yr	5,883,631	Variable stack height - NPI - 25%	25%	0%	8,760	0.60
Main Pit out	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	256,521	Water Sprays with Hyper Saline	95%	100%	8,760	1.52
IVH to GB Haul	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	322,364	Water Sprays with Hyper Saline	95%	100%	8,760	1.64
GB to Junction Haul Road	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	118,366	Water Sprays with Hyper Saline	95%	100%	8,760	0.59
Junction to FAR / Trafalgar East Haul Road	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	184,853	Water Sprays with Hyper Saline	95%	0%	8,760	1.84
Junction1 to Junction 2	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	7,542	Water Sprays with Hyper Saline	95%	0%	8,760	0.09
Junction 1 to WST / Morrow Waste Haul Road	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	118,222	Water Sprays with Hyper Saline	95%	0%	8,760	1.11
Junction 2 to Junction 3	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	13,446	Water Sprays with Hyper Saline	95%	0%	8,760	0.15
Junction 3 to Ore Stockpile 1	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	478	Water Sprays with Hyper Saline	95%	0%	8,760	0.01
Junction 3 to Direct Feed	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	13,424	Water Sprays with Hyper Saline	95%	0%	8,760	0.15
Junction 2 to Ore Stockpile 2	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	8,220	Water Sprays with Hyper Saline	95%	0%	8,760	0.09
Direct Feed to CSI Wate	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	2,365	Water Sprays with Hyper Saline	95%	0%	8,760	0.0252
OBH to Pit Haul	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	73,002	Water Sprays with Hyper Saline	95%	0%	8,760	0.87
Direct to Black-flag Northern	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 1	kg/VKT	3.34	VKT/Yr	1,205	Water Sprays with Hyper Saline	95%	0%	8,760	0.01
Main Pit out - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	256,521	Water Sprays with Hyper Saline	95%	100%	8,760	1.01

Description	Activity	EF Unit	PM_{10} EF	Activity Units	Activity Value	Control	Dust Cntl %	Pit %	Hours/ Year	PM_{10} g/s
IVH to GB Haul - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	322,364	Water Sprays with Hyper Saline	95%	100%	8,760	1.09
GB to Junction Haul Road - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	118,366	Water Sprays with Hyper Saline	95%	100%	8,760	0.39
Junction to FAR / Trafalgar East Haul Road - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	184,853	Water Sprays with Hyper Saline	95%	0%	8,760	1.22
Junction1 to Junction 2 - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	7,542	Water Sprays with Hyper Saline	95%	0%	8,760	0.06
Junction 1 to WST / Morrow Waste Haul Road - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	118,222	Water Sprays with Hyper Saline	95%	0%	8,760	0.74
Junction 2 to Junction 3 - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	13,446	Water Sprays with Hyper Saline	95%	0%	8,760	0.10
Junction 3 to Ore Stockpile 1 - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	478	Water Sprays with Hyper Saline	95%	0%	8,760	0.00
Junction 3 to Direct Feed - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	13,424	Water Sprays with Hyper Saline	95%	0%	8,760	0.10
Junction 2 to Ore Stockpile 2 - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	8,220	Water Sprays with Hyper Saline	95%	0%	8,760	0.06
Direct Feed to CSI Waste - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	2,365	Water Sprays with Hyper Saline	95%	0%	8,760	0.02
OBH to Pit Haul - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	73,002	Water Sprays with Hyper Saline	95%	0%	8,760	0.58
Direct to Black-flag Northern - Return Trip	Vehicle Wheel Generated Dust - Unpaved Roads - Haul 2	kg/VKT	2.21	VKT/Yr	1,205	Water Sprays with Hyper Saline	95%	0%	8,760	0.01

3.4 Modelling Results

3.4.1 Current Operations

Air dispersion modelling was completed based on current operations in 2019 in order to assess model performance using the monitored data and to provide the basis for a comparative analysis against the proposed future operations at the site. 2019 was selected as this was the year where the highest ambient air quality concentrations were recorded following several below average rainfall years.

The maximum predicted 24-hour and annual average concentrations from operations in 2019 at the monitoring locations for PM_{10} in isolation are presented in Table 10. Table 10 shows that on an annual basis, when concentrations from the HGC monitor (background monitor) are removed from the monitors near Fimiston operations, the predicted concentrations from KCGMs emissions are close to concentrations monitored at the BSY and HOP stations. The modelling underpredicted concentrations compared with monitored concentrations (with HGC removed) at the HEW, CLY, MEX and MTC monitors. The underprediction may be a function of the uncertainty in the emissions estimates or sources in this region in 2019. It may also be a function of other localised background sources (residential fireplaces, vehicle movements, local construction and industry etc.) impacting at these monitoring locations (See Section 2.1). The peak predicted 24-hour concentrations correlate relatively well with monitored values at these locations.

The results predicted peak 24-hour average concentrations exceeding the ambient air quality guidelines. Analysis of the results indicates that the peak concentrations were associated with wind erosion from exposed areas. It should be noted given the uncertainty associated with air dispersion modelling of fugitive dust sources, predictions of exceedances do not indicate that exceedances will occur, however the air dispersion modelling is useful to assess the potential risk of exceedances associated with the proposed upgrades.

Contour plots of the 24-hour average and annual average PM_{10} concentrations for current operations are presented in Figure 18 and Figure 19.

Table 10: Predicted and Monitored PM_{10} concentrations ($\mu g/m^3$) at Monitoring Locations for 2019 Operations

	PM_{10} ($\mu g/m^3$)						
	HGC	**BSY**	**HEW**	**CLY**	**HOP**	**MEX**	**MTC**
Monitored							
Max 24hr	77	103	93	91	95	91	131
Annual Av	14.1	18.5	23.3	23.0	25.0	20.2	17.8
Annual Av - Background (HGC) Removed	-	4.5	9.2	8.9	10.9	6.2	3.8
Predicted - KCGM Emissions Modelled in Isolation							
Max 24hr	1.7	91.8	142.9	113.1	93.9	97.4	21.6
Annual Av	0.2	5.1	5.3	4.9	10.1	3.0	1.4

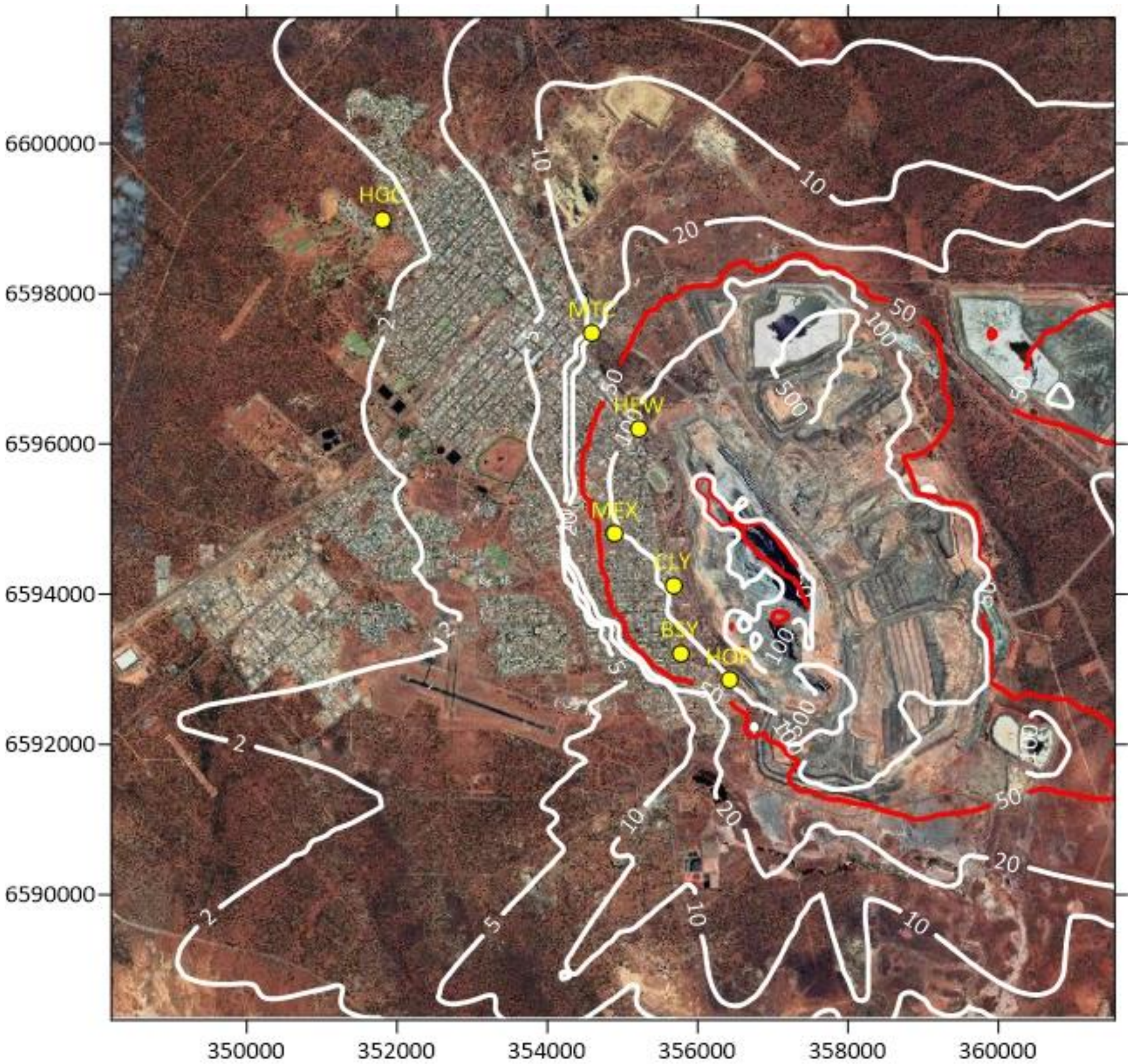


Figure 18: Predicted Maximum 24-hour Average Concentrations (µg/m³) of PM_{10} from current KCGM Operations in Isolation

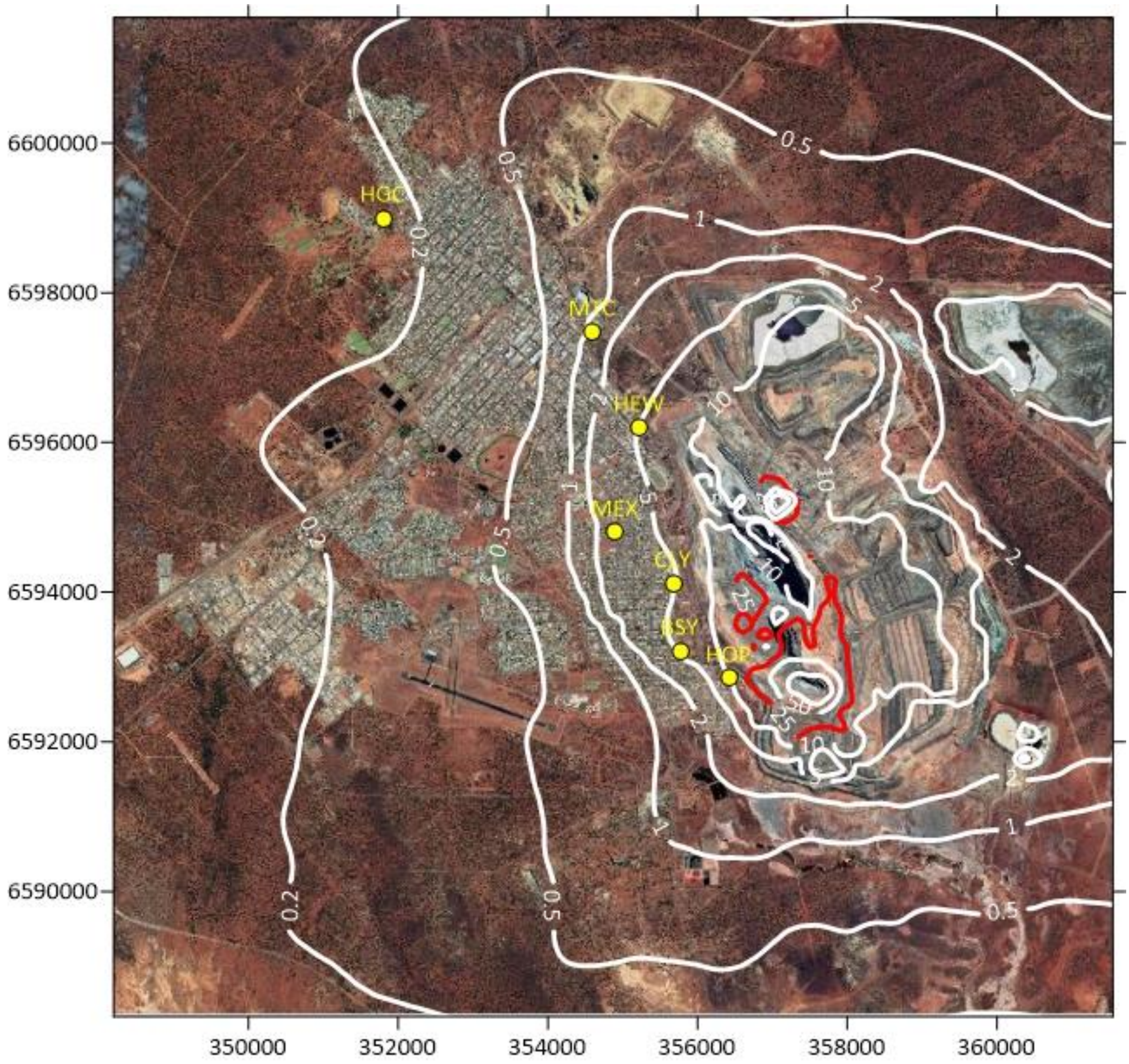


Figure 19: Predicted Annual Average Concentrations (µg/m³) of PM_{10} from current KCGM Operations in Isolation

3.4.2 Future Operations

In order to assess the potential impacts from the proposed FS Project, estimated emissions from operations in 2025 (The year with the highest material movement) were modelled in isolation. The results of the modelling in isolation are presented in Table 11 below. The table also presents the results from the current operational scenario in 2019 for ease of comparison.

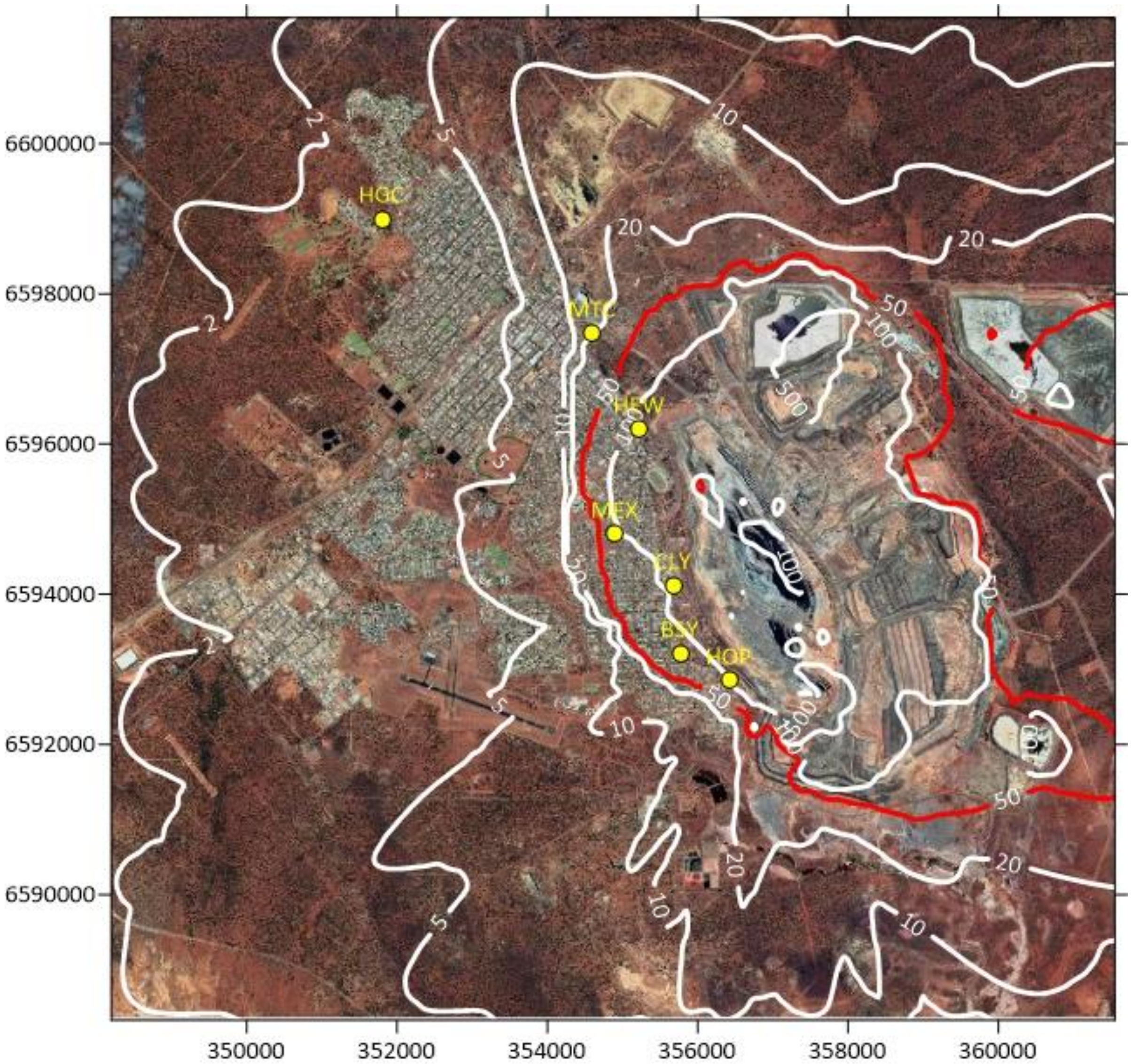


Figure 20: Predicted Maximum 24-hour Average Concentrations (μg/m³) of PM_{10} from future KCGM Operations in Isolation

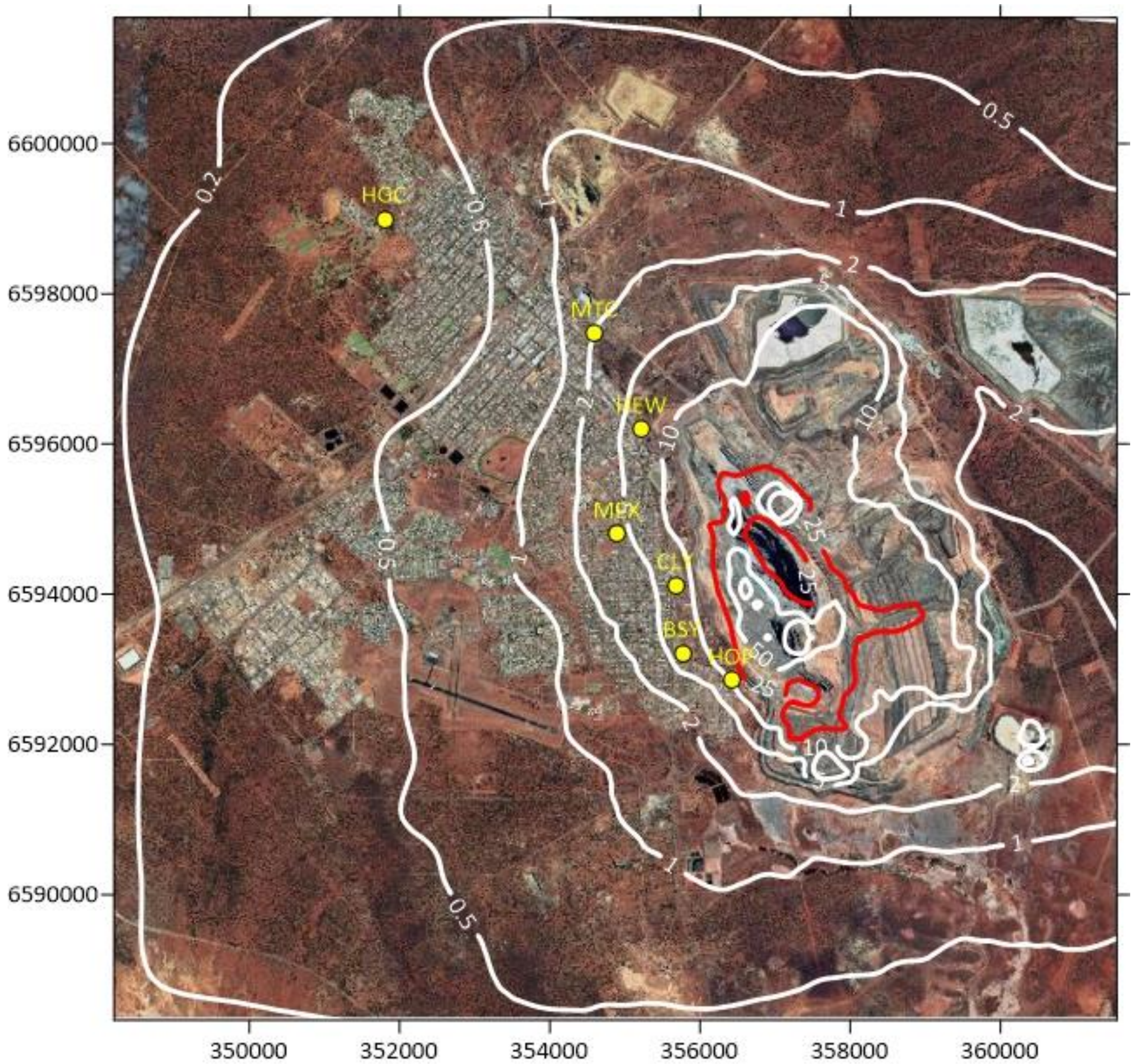


Figure 21: Predicted Annual Average Concentrations (µg/m^3) of PM_{10} from future KCGM Operations in Isolation

Table 11: Predicted PM_{10} Concentrations (µg/m³) at Monitoring Locations for Future and Current Scenario in Isolation

	PM_{10} (µg/m³)						
	HGC	BSY	HEW	CLY	HOP	MEX	MTC
Max 24-Hour Average							
Current	1.7	91.8	142.9	113.1	93.9	97.4	21.6
Future	2.3	91.8	142.9	114.3	93.9	97.4	21.6
Annual Average							
Current	0.2	5.1	5.3	4.9	10.1	3.0	1.4
Future	0.3	6.2	7.7	7.3	10.8	4.3	2.2

The difference in the predicted PM_{10} concentrations (maximum predicted 24-hour and annual average) between the proposed and current operations in isolation are presented in Table 12. They show that at the monitoring locations the modelling is predicting little difference between the current and future scenarios on an annual average and 24-hour average basis.

Analysis of the 24-hour average results indicates that the minimal change was because the peak concentrations at these locations were associated with wind erosion of open areas during high wind speed events and that these did not change due to the proposed operations.

Contour plots of the differences in 24-hour average and annual average PM_{10} concentrations for predicted and current operations are presented in Figure 22 and Figure 23. They show that significant differences are predicted within the pit but that increases associated with the future operations are unlikely to impact at sensitive receptor locations.

Table 12: Difference in Predicted PM_{10} concentrations (Proposed (2025) minus Current KCGM Operations) at Monitoring Locations (µg/m³)

	PM_{10} (µg/m³)						
	HGC	BSY	HEW	CLY	HOP	MEX	MTC
Max 24hr	0.6	<0.1	<0.1	1.2	<0.1	<0.1	<0.1
Annual Av	0.1	1.1	2.3	2.4	0.8	1.3	0.8

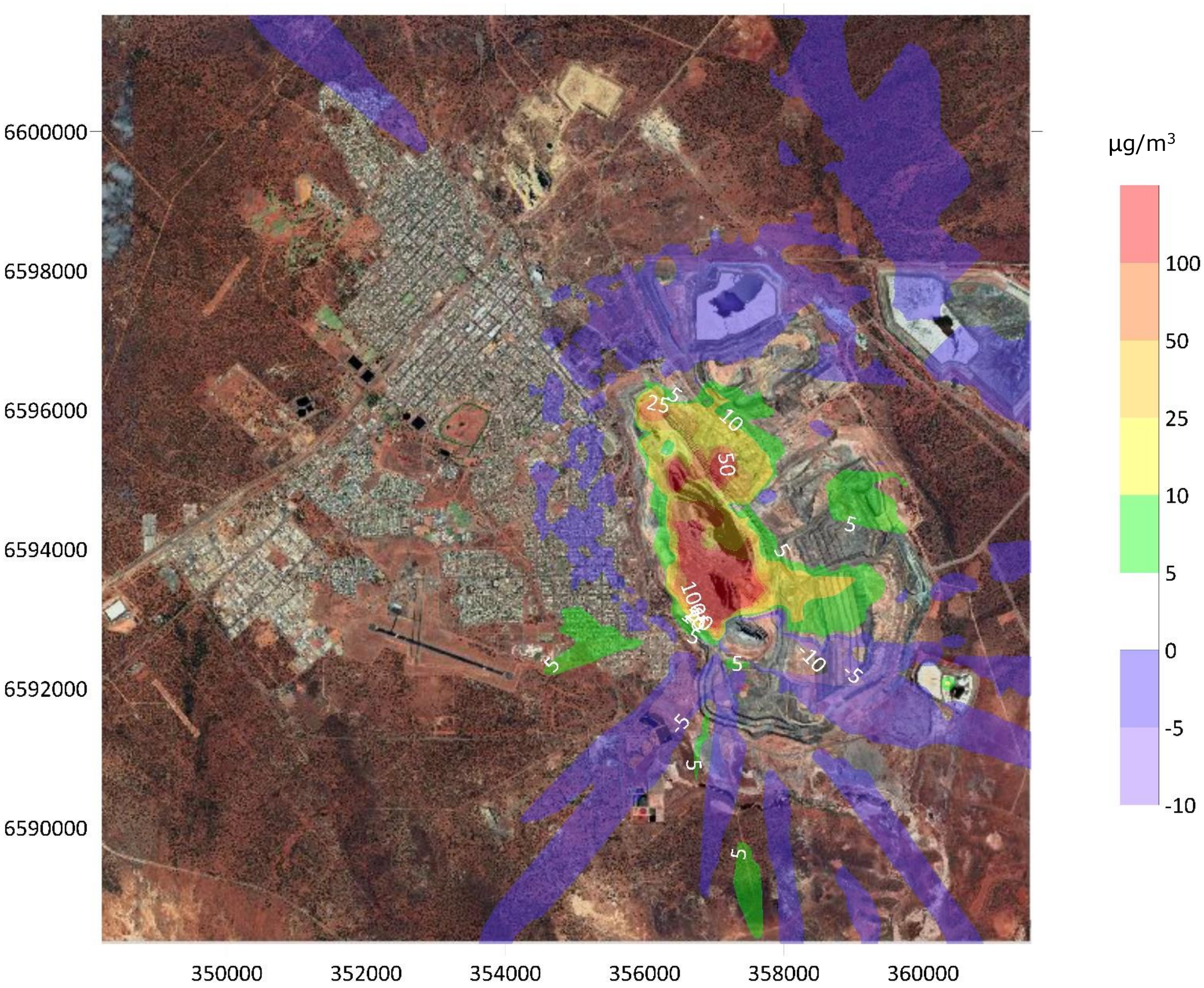


Figure 22: Predicted Difference in 24-hour Average Concentrations of PM_{10} (µg/m3) - Proposed (2025) minus Current KCGM Operations in Isolation

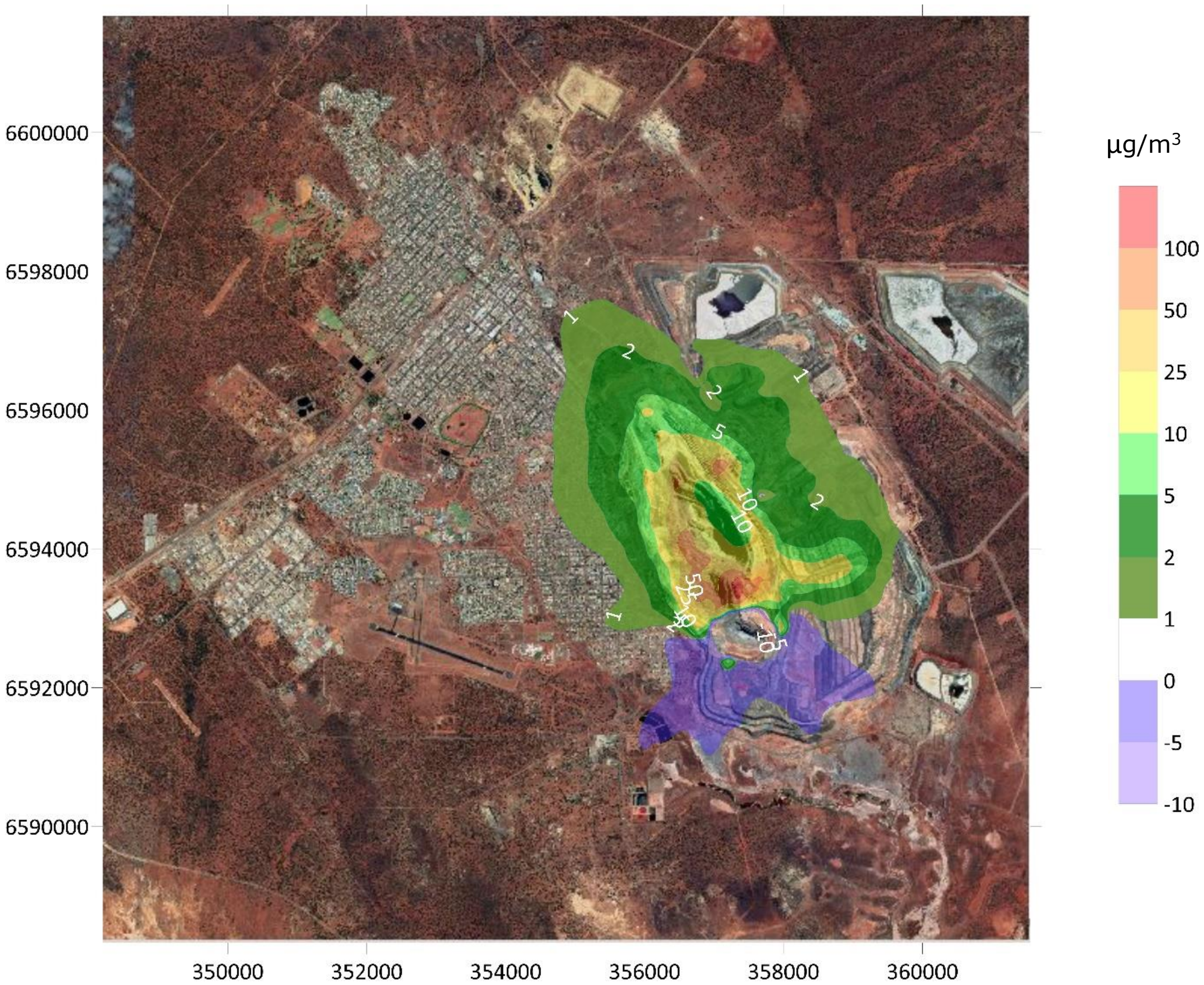


Figure 23: Predicted Difference in Annual Average Concentrations of PM_{10} (µg/m3) - Proposed (2025) minus Current KCGM Operations in Isolation

3.4.3 Cumulative Impacts

In order to assess potential cumulative impacts, the differences in the predicted concentrations from current and proposed operations as presented in Table 12 were added to the monitoring data from 2019 (Table 13) on an hour by hour basis.

The data shows that there were negligible differences in the maximum predicted 24-hour average concentrations at the monitoring locations. The number of predicted exceedances increased at some of the monitors. The modelling predicted a cumulative annual average concentration in exceedance of the ambient air quality criteria at the CLY, HEW and HOP monitors. The exceedances predicted at the monitors should be considered in the context of the following:

- These monitors are considered to be boundary monitors used in the management of emissions from KCGM operations rather than compliance monitors. The BSY, HEW, CLY, HOP, MTC and MEX sites are not considered to meet the definition of performance monitoring stations as they are specifically located in areas where peak concentrations are expected to be recorded and the application of the NEPM standard for PM_{10} (including the exclusion of allowable exceedances) is not applicable at these sites.

- The modelling was conservatively undertaken using data from the worst case monitored year (2019) where there was a long period of low rainfall and higher than average wind speeds, in conjunction with the year (2025) for the proposed future operations, which had the highest level of mining activity occurring close to the town using conservative assumptions to represent emissions from the operations.

However, the cumulative results from the modelling at these locations are useful to highlight the importance of the effective implementation of controls and management to holistically reduce emissions from KCGM operations.

Table 13: Monitored and Cumulative Predicted PM_{10} concentrations (µg/m^3) at Monitoring Locations for Proposed Future Operations

	PM_{10} (µg/m^3)						
	HGC	BSY	HEW	CLY	HOP	MEX	MTC
Monitored							
Max 24hr	77	103	93	91	95	91	131
Annual Av	14.1	18.5	23.3	23.0	25.0	20.2	17.8
# of Exceedances	4	9	16	21	18	10	11
Predicted - Monitored Plus Future Impacts							
Max 24hr	77	103	95	92	92	92	131
Annual Av	14.2	19.6	25.6	25.3	25.6	21.4	18.6
# of Exceedances	4	12	18	22	26	11	11

4. SUMMARY

KCGM is seeking to develop the FS Project, consisting of the MO and SE resources at the southern end of the existing FOP. In support of the regulatory approval process for the proposed FS Project, Ramboll has been engaged by KCGM to undertake an air quality assessment of the potential air quality impacts associated with the proposed changes at the Fimiston Operations including air dispersion modelling of emissions in order to compare current potential future impacts associated with the proposal.

The FS Project will be mined in the same manner as the GP Cutback, namely drilling and blasting the in-situ material and excavating and hauling via a conventional truck and shovel fleet. The maximum annual material movement will be approximately 96 Mt, in line with KCGM's current mining operations. As such, the primary sources and characteristics of atmospheric emissions generated as a result of the FS Project are expected to remain similar to KCGM's current operations. These include:

- Mining operations
  - Drilling and blasting;
  - Excavation of waste rock and ore;
  - Loading/unloading of haul trucks;
- Ore processing
  - Crushing;
  - Conveyor transfer points;
- Wheel generated dust emissions
  - Haul trucks and other vehicles travelling on unsealed roads; and
- Wind-blown dust emissions from exposed surface areas, such as the WRDs and the TSFs.

Dust emissions are actively managed via the DMMP, a component of the FAQMP. The DMMP utilises real time PM_{10} and meteorological monitoring data, alarms for 0.5-hour, 1-hour, 6-hour and 24-hour averaging periods, back trajectory plots, and visual observations to identify periods where KCGM's operations may be contributing high PM_{10} concentrations at the monitoring sites. In the event that any alarms are raised, the real time data is reviewed, including the back trajectory plots and the current mine site activities, to identify the operational areas that may have contributed to the alarms and instigate further dust management measures.

The PM_{10} monitors located in more urban or adjacent to rehabilitated areas (e.g. HGC, MEX and MTC) generally record lower longer term averages and a lower frequency of days with PM_{10} concentrations greater than 50 μg/m^3. While it could be concluded that KCGM is the primary contributor to the elevated PM_{10} concentrations for sites located closer to its Fimiston Operations (i.e., BSY, HOP, CLY and HEW), other non-KCGM related sources are also considered likely to be significant contributors for much of the time. These sources include smoke from wood heaters in winter, particulates from wind erosion of cleared areas, local non-KCGM earthworks, truck and car movement on sealed and unsealed roads and tracks, and motor cross bike generated dust from activity on nearby tracks.

Given the proximity of the proposed FS Project to the City of Kalgoorlie-Boulder, the south-western expansion of the FOP is likely to have the greatest potential impact on ambient PM_{10} concentrations at the nearest monitoring locations (i.e. HOP, BSY and CLY). This will primarily be the case during construction works to realign the ENB and when mining activity is close to the surface, during the initial stages of the Project. It is anticipated that in-pit dumping of waste rock material as the project progresses will result in a reduction in wheel-generated dust emissions as the distances travelled by the haul trucks will be reduced. However, as the height of the in-pit waste rock dumps increase and material handling activities occur closer to the surface, the potential for fugitive dust emissions from the northern aspect of the FOP increases.

Analysis of complaints indicates that particular attention must continue to be paid to ensuring the correct management of blasting operations which have the ability to cause exceedances of the ambient air quality guidelines and generate concern in the community. Peak concentrations are generally associated with wind erosion during high wind speeds also indicate that control measures must continue to be implemented and monitored during these periods.

Analysis of the predicted changes based on the results of air dispersion modelling shows that most significant changes to air quality are expected to occur within the pit and that impacts at sensitive receptor locations are increases outside of the pit are considered to be marginal. The predicted changes also indicate that wind erosion is the dominant source of elevated PM concentrations, as wind speeds did not change as a result of the proposed operations.

The cumulative results from the air dispersion modelling predicted marginal increases in concentrations at most monitoring locations and highlighted the importance of the effective implementation of controls and management to reduce emissions from KCGM operations.

It is important to note although there is a level of uncertainty present with the utilisation of modelling and therefore absolute conclusions should not be drawn from the outcome of the predicted results, it is considered an effective tool to establish a basis for risk assessment.

5. RECOMMENDATIONS

It is anticipated that continued implementation of the FAQMP, including regular review of data will facilitate the successful management of fugitive dust emissions from the proposed FS Project. It is recommended that the following dust management measures in particular, be applied during realignment of the ENB and near surface mining activities associated with FS Project:

- Start work meeting – Workers should undertake a detailed discussion on the first day of each swing regarding control of dust. The discussion should include potential issues with dust associated with upcoming operations. Workers should be reminded of their obligations to report and control any dust generated that is likely to impact at receptors offsite. Shorter, day-specific briefings and reminders should be provided daily at the start of each shift.
- Meteorology - Meteorological forecasts at hourly timesteps up to 7 days in advance should be supplied to all relevant parties and reviewed daily in advance of operations to allow identification of potential high-risk days for forward planning of operations. High risk activities where applicable should be scheduled when meteorological conditions are suitable. Meteorological conditions should be monitored with re-evaluation if there is a change to conditions or the wind arc. Re-evaluation should consist of visual inspections, assessment of boundary monitoring data or any other site-specific considerations.
- Excavation - Water carts should make regular passes at areas being excavated before loading into vehicles. This will reduce dust generated during tipping at the proposed noise bund.
- Moisture Control - Water spraying should be used at the bund construction area to minimise dust generated from newly placed waste rock.
- Bulldozers - Operations of bulldozers is considered a high-risk activity and should be risk assessed based on meteorological conditions. Areas where bulldozers will be operating should also be watered frequently during operations.
- Open areas - Where possible ground cover in the operational area should be retained or revegetated when not in use. Watering should be used to control particulate generation from operations and wind erosion of open areas.
- Wheel generated dust - All haul roads should be well maintained and watered regularly. If necessary, a chemical suppressant should also be applied to haul roads. Material that is tracked onto hard surfaces should be swept and removed.
- Visual inspection – All sources should be controlled where possible. If it is noted that dust continues to be visibly being generated and impacting at sensitive receptors offsite after mitigation measures a change to the work plan, such as standing down operations causing the dust, should be initiated.
- Boundary monitoring – Air quality monitors should be used at the boundary of the site to assess potential impacts from operations. This should include setting of appropriate, 10-minute, hourly, six hourly and 12 hourly average particulate concentration trigger alarms. These trigger values should be determined based on the distance between sources and receptors and potential worst case dispersion profiles. If the boundary monitoring alarm is triggered, sources of dust should be investigated and if it is determined that the source of the dust is related to operations at the noise bund, mitigation actions should be implemented. If the source cannot be controlled, a change to the work plan, such as standing down operations causing the dust, should be implemented.

Analysis of the historical PM_{10} monitoring data demonstrates that the FAQMP has proven to be an effective tool for the management of dust emissions from the GP Cutback and subsequent operations, within a framework of regular review and continuous improvement. KCGM should apply the same management measures during implementation of the proposed FS Project, including (but not limited to):

- Monitoring current and forecast weather conditions using daily forecasts from the Bureau of Meteorology and real-time wind speed and direction monitoring data to plan work activities;
- Restricting near surface mining activities (e.g. handling of oxide material, blasting) as a function of wind direction;
- Day time only mining near the surface (primarily for noise management) such that any elevated dust concentrations from the Project will be clearly visible and have additional dust management measures applied;
- Monitoring real-time PM_{10} concentrations and using the reactive dust control strategy as required (i.e., dust alarm system);
- Restricting land clearing activities as a function of wind direction;
- Using water trucks and water cannons on areas that produce dust such as haul roads, service corridors and other active surfaces;
- Visual inspections for dust generation in high risk areas (e.g., land clearing activities);
- Use of additional dust control measures where required and practical (e.g. a dust binding agent);
- Progressive rehabilitation to minimise exposed areas;
- Suspending work in a particular area or for a nominated activity as deemed necessary based on inspections, dust alarms, public feedback or prevailing wind conditions;
- Use of alternative operational areas if this is possible where the monitoring data or forecast data indicate increased risks (e.g. use a different waste dump);
- Ensuring that all contractors and staff undertake site-specific inductions which include raising awareness of the importance of dust control;
- Ensuring that the PM_{10} monitoring data are assessed in real time, and the results of the monitoring are reviewed and reported on with focus on continuous improvement; and
- Ongoing consultation with stakeholders to determine the success of the dust management measures.

Continued implementation of the FAQMP, including regular review of data is expected to facilitate the successful management of fugitive dust emissions from the proposed FS Project. In addition to the above dust mitigation measures, Ramboll recommend consideration be given to the following:

- Investigate the use of specific and appropriate controls in open areas particularly prior to high-risk periods (i.e. ahead of Spring and Summer periods when higher proportion of easterlies occur) or when wind speeds are or are predicted to be above 6.3 m/s; and
- Ramboll also recommend that KCGM approach the City of Kalgoorlie-Boulder to offer assistance with dust management measures (e.g., application of a surface binding agent, preventing vehicular access, or rehabilitation) of the open areas on the eastern side of the City with an initial focus on the areas in and around the PM_{10} monitoring locations with the objective of reducing fugitive particulate emissions. To this end, it is recommended that a sealed road surface or use of coarser road base material be considered by KCGM when relocating the public lookout access road, to reduce the percentage of fine particulates on the road surface that can be mobilised by vehicle movements.

6. REFERENCES

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