Appendix 11

Air Quality Impact Assessment

Appendix Section	Description
11 A	Air Quality Impact Assessment

Brandy Hill Expansion Project

Environmental Impact Statement

Appendix 11A

Air Quality Impact Assessment

Brandy Hill Expansion Project

Environmental Impact Statement

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Hanson Heidelberg Cement Group

Brandy Hill Quarry

Air Quality Assessment

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Brandy Hill Quarry
Air Quality Assessment

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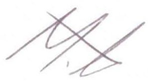
Author:  Date: 20 May2016
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EXECUTIVE SUMMARY

Vipac Engineers and Scientists Ltd (Vipac) was commissioned by Hanson Heidelberg Cement Group (Hanson) to prepare an air quality impact assessment for the proposed expansion of the Brandy Hill Quarry (BHQ), located near the town of Seaham, New South Wales.

This Level 2 assessment predicts air pollutant concentrations in accordance with NSW guidelines and is based on computational modelling and determines controls where needed. The modelling is based on activity information provided by Hanson. The emission rates for individual mining activities were calculated in accordance with the National Pollutant Inventory (NPI) - *Emissions Estimation Technique (EET) Manual for Mining.*

The main air emissions from BHQ operations are caused by wind-borne dust, vehicle usage, materials handling and transfers. A major source of dust will be from the construction of an 18 m high bund at the southern boundary of the quarry, but this will be a temporary activity. Once completed, the bund will provide long-term attenuation benefits by limiting the dispersal of the ground-borne particulate emissions, such as PM_{10} from the quarry.

In order to assess the impact of a quarry expansion on the receiving environment, the incremental impact is quantified and added to existing background pollutant concentrations. Vipac has used dust deposition monitoring results from BHQ as well as daily particulate monitoring data from NSW EPA site at Beresfield in the predictions.

The results of the modelling have shown that during all stages, the Total Suspended Particles (TSP), dust deposition and Respirable Crystalline Silica (RCS) predictions comply with the relevant criteria.

The exceedances of annual $PM_{2.5}$ concentrations are driven by the high background concentration which already exceeds the criterion of 8 $\mu g/m^3$. The results have shown that the proposed efficiency controls for the processing plant as modelled during Stage 4 significantly reduce the particulate emissions and impact on sensitive receptors. Frequency analysis has identified that during Stage 4, three receptors will exceed the PM_{10} criteria for a total of four days (i.e. for one or two days each per year).

The construction of an 18 m bund at the southern boundary of the future processing area will assist in limiting the dispersal of the ground-borne particulate emissions, such as PM_{10}. The height of the conveyors and other plant will not protrude above the bund and therefore the emissions are expected to be significantly reduced at sensitive receptors along Clarence Town Road.

Recommendations for the installation of a Tapered Element Oscillating Microbalance (TEOM) machine or a Dusttrack monitor capable of sampling particle sizes down to 10µm on a continual basis, or similar equipment (the capabilities of which should be discussed and minimum requirements agreed with NSW EPA/OEH in advance) and weather station at the fence-line of the quarry have been made. This would allow proactive dust controls measures to be enforced to reduce the likelihood of exceedances and complaints.

A greenhouse gas assessment has been undertaken for this project. This assessment determines the carbon dioxide equivalent (CO_2-e) emissions from the project according to international and Federal guidelines. Calculating the GHG emissions for the life of the BHQ, based on an extraction rate of 1.5 Mtpa for 30 years the following GHG emissions are expected:

- Scope 1 emissions: 296,072.5 tonnes CO_2-equivalent;
- Scope 2 emissions: 85,426.5 tonnes CO_2-equivalent; and
- Scope 3 emissions: 41,242.5 tonnes CO_2-equivalent.

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1 INTRODUCTION

Vipac Engineers and Scientists Ltd (Vipac) was commissioned by Hanson Heidelberg Cement Group (Hanson) to prepare an air quality impact assessment for the proposed expansion of the Brandy Hill Quarry (BHQ), located near the town of Seaham, New South Wales.

The purpose of this assessment is to evaluate the potential impacts of air pollutants generated from the construction and operational stages of the project and to provide recommendations to mitigate any potential impacts that might have an effect on nearby sensitive receptors.

2 PROJECT DESCRIPTION

2.1 Site Location

The quarry is located in Seaham, which is a suburb within the Port Stephens local government area in the Hunter Region of New South Wales. The quarry is located on a property that is approximately 554 hectares in area. The surrounding area is predominately zoned as rural landscape with minimal primary production.

Brandy Hill community lies to the south and is zoned as a large lot residential area. Seaham lies to the east and is zoned as a low density residential area. To the west and northwest of the BHQ extraction area, within the property boundary, the land is zoned as an environmental management area and will not be disturbed by the proposed development. To the north is a property zoned as an environmental conservation area. Road access to BHQ runs off Clarence Town Road at the intersection with Brandy Hill Drive.

2.2 Proposed Expansion

The proposed expansion will involve extending the life of the quarry to allow for extraction of additional resources up to 1.5 million tonnes per annum (Mtpa). The proposed extraction area extension includes resources beneath part of the existing quarry infrastructure area. In order to accommodate the proposed extraction area, it is proposed to relocate the existing plant infrastructure approximately 550 m south of the current location, as shown in ***Figure 2-1***.

It is also proposed to receive concrete washout waste from concrete batch plants in order to produce blended recycled aggregates and road base. Approximately 20,000 tonnes of washout material will be received by the concrete batch plants, through mainly the use of tipper trucks and directly using concrete agitator trucks. The material will be processed with the existing site material to process into recycled road base and other fill and drainage materials, the material will be processed within the existing quarrying operations.

2.2.1 Extraction boundaries

The proposed disturbance area associated with the quarry is approximately 54 hectares. The proposed quarry expansion includes relocating the existing plant and equipment into an area located to the south of the current quarry extraction area, as illustrated in ***Figure 2-1***.

The total resource available within the proposed extraction boundary is 78 million tonnes of hard rock.

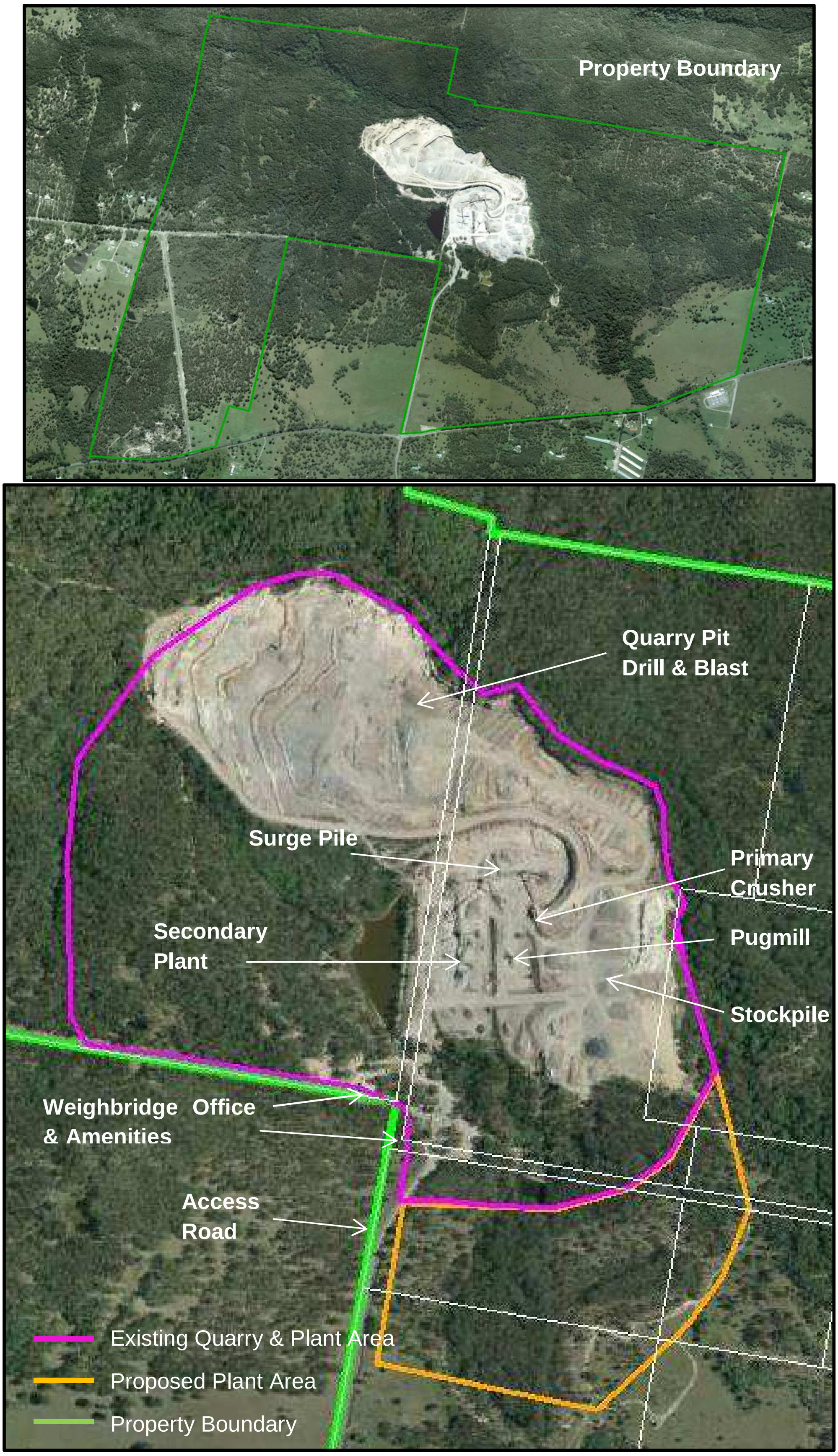


Figure 2-1: Current Infrastructure Area with Proposed Plant Infrastructure Area

The location of the existing plant infrastructure is illustrated in the aerial photograph shown above in ***Figure 2-1***. It should be noted that as part of the proposed quarry expansion plans, the existing plant infrastructure will be relocated to the area outlined above in orange (i.e. the Proposed Plant Area).

2.2.2 Expansion Stages

The planned development of BHQ has been broken into five stages:

- Stage 1 – The initial stage expands the western end of the quarry towards the south and extends existing benches running southwest to northeast and enlarges the quarry pit floor at RL 22m (AHD). Overburden from this area will be used to create a bund wall at the southern end of the final plant location. This will allow sufficient time to rehabilitate the area to act as a visual shield from residences and traffic along Clarence Town Road when the plant is moved during stage four
- Stage 2 – Stage 2 further expands the existing western end of the quarry southwards to the proposed expansion boundary and creates seven broad benches and the quarry pit floor at RL -m (AHD). Bench heights will typically be around 10-12 metres. Overburden from this area will again be used to build the bund wall at the southern end of the final plant location. Topsoil will also be used to rehabilitate the upper benches above RL 20m (AHD) as these benches will remain exposed upon completion of the quarry rehabilitation. Rehabilitation will be continual from stage two onwards and all final form areas will be planted with self-sustaining native vegetation communities and derived native grasslands.
- Stage 3 – Stage 3 expands the quarry along the southern extraction boundary towards the existing plant infrastructure. The western dam is removed and ten broad benches are created with the pit floor at RL -38m (AHD). Overburden will be used for finalising the bund wall and for rehabilitation of benches that have reached their final form. A water storage sump will be located on the quarry floor to replace the western dam upon its removal.
- Stage 4 – Stage 4 entails widening and deepening the benches towards the eastern extraction boundary. This stage will involve moving the existing fixed plant and stockpiles to the area allocated as the final plant location. The weighbridge, amenities and maintenance building will be relocated to suit the pit form. At this stage there will be twelve benches, some of which will be active and others at progressive or final stages of rehabilitation. The quarry pit floor at this stage will be RL -58m (AHD). This stage is the last stage where previously undisturbed land will be stripped to allow access to the resource material to make room for the fixed plant and stockpile area.
- Stage 5 – The final stage of the planned pit realises the final form of the quarry. This stage expands the quarry to the proposed extraction boundary at the eastern and southern end. The final pit will consist of fourteen benches and the quarry pit floor at RL -78m (AHD). Full rehabilitation can begin with the quarry being allowed to begin being filled through groundwater seepage and rain events up to RL 30m (AHD).

2.2.3 Infrastructure

Ancillary plant such as mobile pre-coat plant for asphalts will also form part of the proposed Project to assist in meeting industry demands for these products. The existing office block, quarry crib room, amenities block and transport crib room block have been on site for 20 years and are proposed to be replaced.

The proposal will also be incorporating a new concrete batch plant within the quarry site. The concrete plant will supply concrete within the local markets. The plant will produce approximately 15,000 m^3 of concrete each year and will have a fleet of approximately two twin steer trucks with average load-size of approximately 5.5 m^3. The batch plant will produce approximately 2,700 additional trips per annum.

The plant infrastructure will be constructed on a concrete hard stand area and water runoff will be managed on site. The plant would consist of an upright silo, incline conveyor belt, load bin, admixture bunded area, and batchroom amenities. The profile of the batch plant will be kept under the existing quarry infrastructure to minimise any visual impact.

The proponent is also seeking consent to receive unused concrete to be processed on site. No new infrastructure would be required to facilitate recycling the concrete as the fixed plant will crush the material to make the final product. The concrete material will be stockpiled on site until a suitable quantity is available, this will then be crushed along with quarry material to make a road base product. This can have additional cementitous material added as a binder to make different road base products to suit demand.

2.2.4 Current Equipment

Current quarry operations utilise the following mobile equipment:

- 2 x Komatsu WA500-6 front end loader;
- Volvo L250g front end loader;
- Caterpillar 773B dump truck and Caterpillar 773E dump truck;
- Komatsu PC600 excavator and Komatsu PC450 excavator; and
- Water cart

Current quarry operations utilise the following fixed plant:

- Jaques 48" x 42" double toggle jaw crusher and Jaques 4' gyratory crusher;
- Allis Chalmers 60" gyratory crusher;
- Kawasaki 1200 cone crusher;
- Rotorpactor MKII (barmac) crusher;
- Jaques 4' x 10' two deck, Jaques 6' x 16' two deck vibrating screen, Jaques 8' x 20' three deck vibrating screen;
- 2 x Malco 8' x 20' three deck vibrating screens;
- 28 conveyor belts;
- Pug mill and associated conveyors and cementitious material silos; and
- Pre coat and associated conveyors and oil storage.

2.3 Sensitive Receptors

A review of the area has identified several sensitive receptors within the locality of the BHQ. The approximate geographic coordinates of the closest sensitive receptors are presented in ***Table 2-1*** and ***Figure 2-2***.

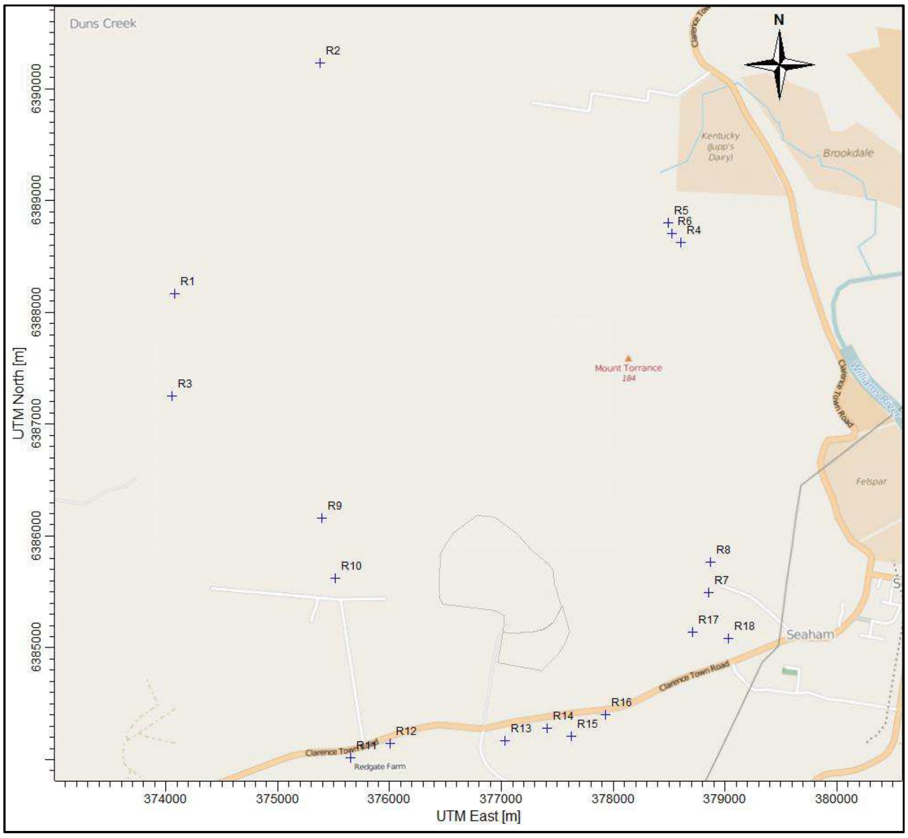


Figure 2-2: Sensitive Receptor Locations with the Quarry Boundary and Proposed Plant Area

Table 2-1: Sensitive Receptor Details

ID	Description	Universal Transverse Mercator Location (m)		Distance from Quarry (km)	Direction from Quarry (˚)
		X	Y		
R1	122B Dunns Creek Road	374075	6388164	3.2	310
R2	16 Uffington Road	375376	6390226	4.3	341
R3	60 Green Wattle Creek Road	374057	6387248	2.8	295
R4	34 Timber Top Road	378601	6388683	3.0	31
R5	35 Timber Top Road	378489	6388803	3.1	29
R6	36 Timber Top Road	378524	6388708	3.0	32
R7	13 Mooghin Road	378852	6385492	1.4	90
R8	14 Mooghin Road	378874	6385763	1.4	87
R9	13 Giles Road	375391	6386160	1.2	273
R10	13B Giles Road	375515	6385619	1.1	257
R11	866 Clarence Town Road	375653	6384015	2.0	231
R12	888 Clarence Town Road	376001	6384145	1.6	227
R13	994 Clarence Town Road	377028	6384170	1.1	188
R14	1034 Clarence Town Road	377412	6384283	1.0	176
R15	1060 Clarence Town Road	377624	6384207	1.0	173
R16	1094 Clarence Town Road	377933	6384401	0.8	153
R17	1189 Clarence Town Road	378709	6385138	1.2	96
R18	1203 Clarence Town Road	379027	6385084	1.5	97

2.4 Local Topography

The BHQ is situated is approximately 26 km from the coast and sits at the base of a mountain range. The local topography as modelled is presented in ***Figure 2-3***. The red dot shows the approximate location of BHQ.

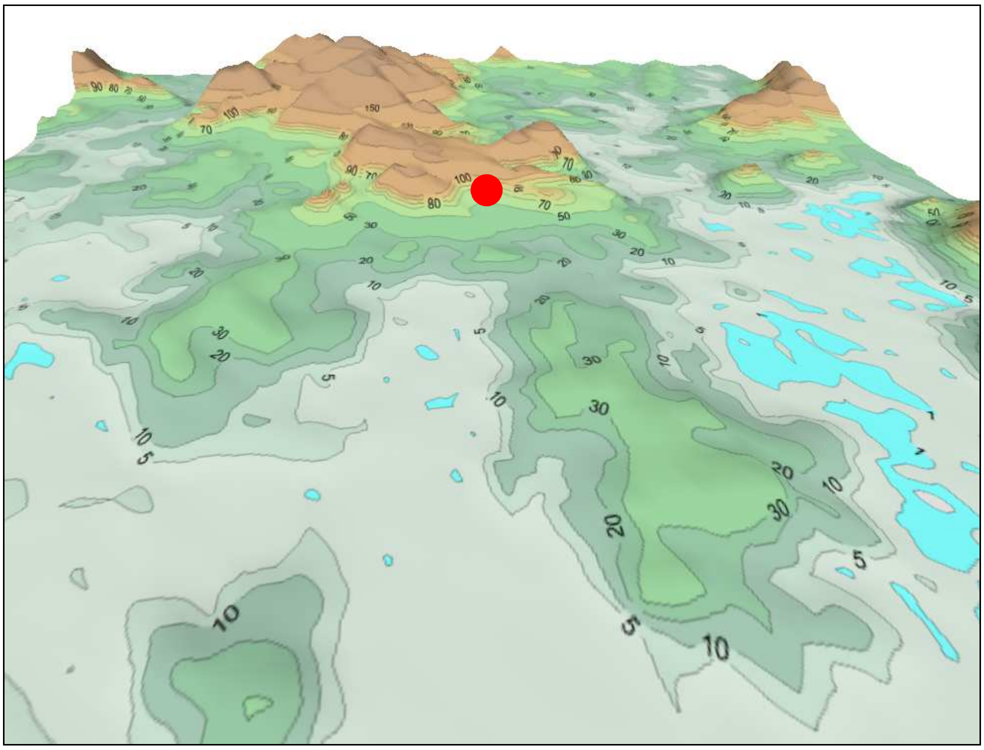


Figure 2-3: Local Topography Surrounding BHQ

3 POLLUTANTS OF CONCERN

The main emissions to air from quarrying operations are caused by wind-borne dust, vehicle usage, materials handling and transfers. Fugitive air emissions can be estimated using emission factors combined with site-specific information such as the silt and moisture content of material being handled.

Dust is a generic term used to describe fine particles that are suspended in the atmosphere. The dust emissions considered in this report are particulate matter in various sizes:

- Total Suspended Particles (TSP) - Particulate matter with a diameter up to 50 microns;
- PM_{10} - Particulate matter less than 10 microns in size;
- $PM_{2.5}$ - Particulate matter less than 2.5 microns in size;
- Respirable Crystalline Silica (RCS); and
- Dust Deposition – deposited matter that falls out of the atmosphere.

Crystalline silica is a basic component of sand (soil, granite and many other minerals). Quartz is the most common form of crystalline silica. Cristobalite and tridymite are two other forms of crystalline silica. Only the respirable particles (<7 µm in aerodynamic diameter those which are capable of reaching the gas exchange region of the lungs) are considered when determining health effects of crystalline silica.

Repeated and prolonged exposure to relatively high concentrations of crystalline silica can cause the disease known as silicosis. This respiratory disease is characterised by scarring and hardening of the lung tissue and it reduces the ability of the lungs to extract oxygen from the air.

4 REGULATORY FRAMEWORK

4.1 National Legislation

4.1.1 National Environment Protection Measure for Ambient Air Quality

Australia's first national ambient air quality standards were outlined in 1998 as part of the National Environment Protection Measure for Ambient Air Quality (National Environment Protection Council , 1998).

The Ambient Air Measure (referred to as Air NEPM) sets national standards for the key air pollutants; carbon monoxide, ozone, sulfur dioxide, nitrogen dioxide, lead and particles (PM_{10}). A revision to the Measure was issued in 2003 with the inclusion of advisory $PM_{2.5}$ standards. The Air NEPM requires the State's governments to monitor air quality and to identify potential air quality problems.

4.2 State Legislation and Guidelines

4.2.1 Department of Environment and Conservations (NSW) Approved Methods

The *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Department of Environment & Conservation, 2005) detail both the assessment methodology and criteria for air quality assessments. Due to the type of industry and proximity to sensitive receptors, the requirements for a Level 2 assessment have been followed.

The criteria within the Approved Methods have been used for this assessment with the exception of $PM_{2.5}$, which has been derived from the Air NEPM.

4.2.2 Protection of the Environment Operations (Clean Air) Regulation 2010

The *Protection of the Environment Operations (Clean Air) Regulation 2010 (Clean Air Regulation)* (NSW Government) provides regulatory measures to control emissions from wood heaters, open burning, motor vehicles and fuels and industry. The operation of BHQ does not trigger any regulatory emissions relating to industry; however the emission requirements for goods vehicles must be adhered to.

4.2.3 Action for Air

Action for Air (Environmental Protection Authority, 1998) seeks to provide long-term ongoing emission reductions, however it does not target acute and extreme exceedances from events such as bushfires. The aim of Action for Air includes:

- Meeting the national air quality standards for six pollutants as identified in the Ambient Air-NEPM; and
- Reducing the population's exposure to air pollution and the associated health costs.

The six pollutants in the Ambient Air-NEPM are CO, NO_2, SO_2, lead, ozone and PM_{10}. The pollutant from the BHQ expansion that is relevant to the Action for Air is PM_{10}. Action for Air aims to reduce air emissions to enable compliance with the Ambient Air-NEPM targets to achieve the aims described above, with a focus on motor vehicle emissions. The BHQ expansion would address the aims of the Action for Air Plan by implementing reasonable and feasible mitigation measures to reduce dust (e.g. PM_{10}) emissions and continue to implement an air quality monitoring plan to assess BHQ expansion against the Ambient Air-NEPM goals.

4.2.4 Respirable Crystalline Silica Guidelines

The NSW Office of Environment and Heritage (OEH) have not detailed an impact assessment criterion for Respirable Crystalline Silica (RCS). The Victorian EPA has adopted an annual average (as $PM_{2.5}$) ambient assessment criterion for mining and extractive industries of 3 $\mu g/m^3$ (EPA Victoria, 2007). This criterion has been adopted for this assessment.

4.3 Project Criteria

From all of the regulations the strictest applicable criteria have been selected for this assessment and are presented in ***Table 4-1***.

Table 4-1: Project Air Quality Goals

Pollutant	Basis	Criteria	Averaging Time	Source
TSP	Human Health	90 µg/m^3	Annual	Approved Methods
PM_{10}	Human Health	50 µg/m^3	24-hour	Approved Methods
	Human Health	30 µg/m^3	Annual	Approved Methods
$PM_{2.5}$	Human Health	25 µg/m^3	24-hour	Air NEPM
	Human Health	8 µg/m^3	Annual	Air NEPM
Dust deposition	Amenity	Maximum incremental increase of 2 g/m^2/month	Annual	Approved Methods
	Amenity	Maximum total of 4 g/m^2/month	Annual	Approved Methods
Silica	Human Health	3 µg/m^3	Annual	VIC EPA

5 METHODOLOGY

Computational modelling of air dispersion is used to predict the maximum levels of air pollutants based on the local topography, weather conditions and emission rates for the various sources of pollutants. The maximum levels are compared with criteria provided in ***Table 4-1***. Air quality controls are applied to reduce emission rates when non-compliance is predicted.

5.1 Emission Estimation

The emission rates for individual activities were obtained from the National Pollutant Inventory (NPI) - *Emissions Estimation Technique (EET) Manual for Mining.* (Department of Sustainability, Environment, Water, Population and Communities, 2012). The NPI emission factors are derived from the USEPA AP-42 (see ***Appendix B***).

Emission factors can be used to estimate emissions of TSP and PM_{10} to the air from various sources. Emission factors relate the quantity of a substance emitted from a source to some measure of activity associated with the source. Common measures of activity include distance travelled, quantity of material handled, or the duration of the activity (Department of Sustainability, Environment, Water, Population and Communities, 2012).

Emission factors are used to estimate a facility's emissions by the general equation:

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

Where:

$E_{i\,(kg/yr)}$ = Emission rate of pollutant

$A_{(t/h)}$ = Activity rate

$OP_{(h/yr)}$ = operating hours

$EF_{i\,I(kg/t)}$ = uncontrolled emission factor of pollutant

CE_i = overall control efficiency for pollutant

The equations and activity rates are presented in ***Appendix B***.

5.2 Air Dispersion Modelling

5.2.1 TAPM

A 3-dimensional dispersion wind field model, CALPUFF, has been used to simulate the impacts from BHQ. CALPUFF is an advanced non-steady-state meteorological and air quality modelling system developed and distributed by Earth Tech, Inc. The model has been approved for use in the '*Guideline on Air Quality Models*' (United States Environmental Protection Agency, 2005) as a preferred model for assessing applications involving complex meteorological conditions such as calm conditions.

To generate the broad scale meteorological inputs to run CALPUFF, this study has used the model The Air Pollution Model (TAPM), which is a 3-dimensional prognostic model developed and verified for air pollution studies by the CSIRO. The output from TAPM will be used to generate the appropriate meteorological data for the CALPUFF modelling system.

TAPM was configured as follows:-

- Centre coordinates – 32˚ 42.0 S, 151˚ 41.5 E;
- Dates modelled – 1st January 2013 to 31st December 2013;
- Four nested grid domains of 30 km, 10 km, 3 km and 1 km;
- 30 x 30 grid points for all modelling domains;
- 25 vertical levels from 10 m to an altitude of 8000 m above sea level; and
- The default TAPM databases for terrain, land use and meteorology were used in the model;

5.2.2 CALMET

CALMET is an advanced non-steady-state diagnostic three-dimensional meteorological model with micro-meteorological modules for overwater and overland boundary layers. The model is the meteorological pre-processor for the CALPUFF modelling system.

The CALMET simulation was run as No-Obs simulation with the gridded TAPM three-dimensional wind field data from the innermost grid. CALMET then adjusts the prognostic data for the kinematic effects of terrain, slope flows, blocking effects and three-dimensional divergence minimisation.

5.2.3 CALPUFF

CALPUFF is a non-steady-state Lagrangian Gaussian puff model. CALPUFF employs the three-dimensional meteorological fields generated from the CALMET model by simulating the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal.

Emission sources can be characterised as arbitrarily-varying point, area, volume and lines or any combination of those sources within the modelling domain.

The radius of influence of terrain features was set at 3 km while the minimum radius of influence was set as 0.1 km. The terrain data had a resolution of 3 arc-seconds (approximately 90 m). Most CALPUFF options remained at their default recommended values.

6 EXISTING CONDITIONS

6.1 Existing Sources of Air Pollutants

Aside from the existing quarry activities the surrounding land is forest with some commercial chicken farms located at Mooghin Road and south of Clarence Town Road.

6.2 Background Dust Deposition

Dust deposition monitoring is conducted at three locations as detailed in the Environment Protection Licence (number 1879 dated 29th April 2013). These locations are shown in ***Figure 6-1*** and the monthly results for insoluble solids are presented in ***Figure 6-2***.

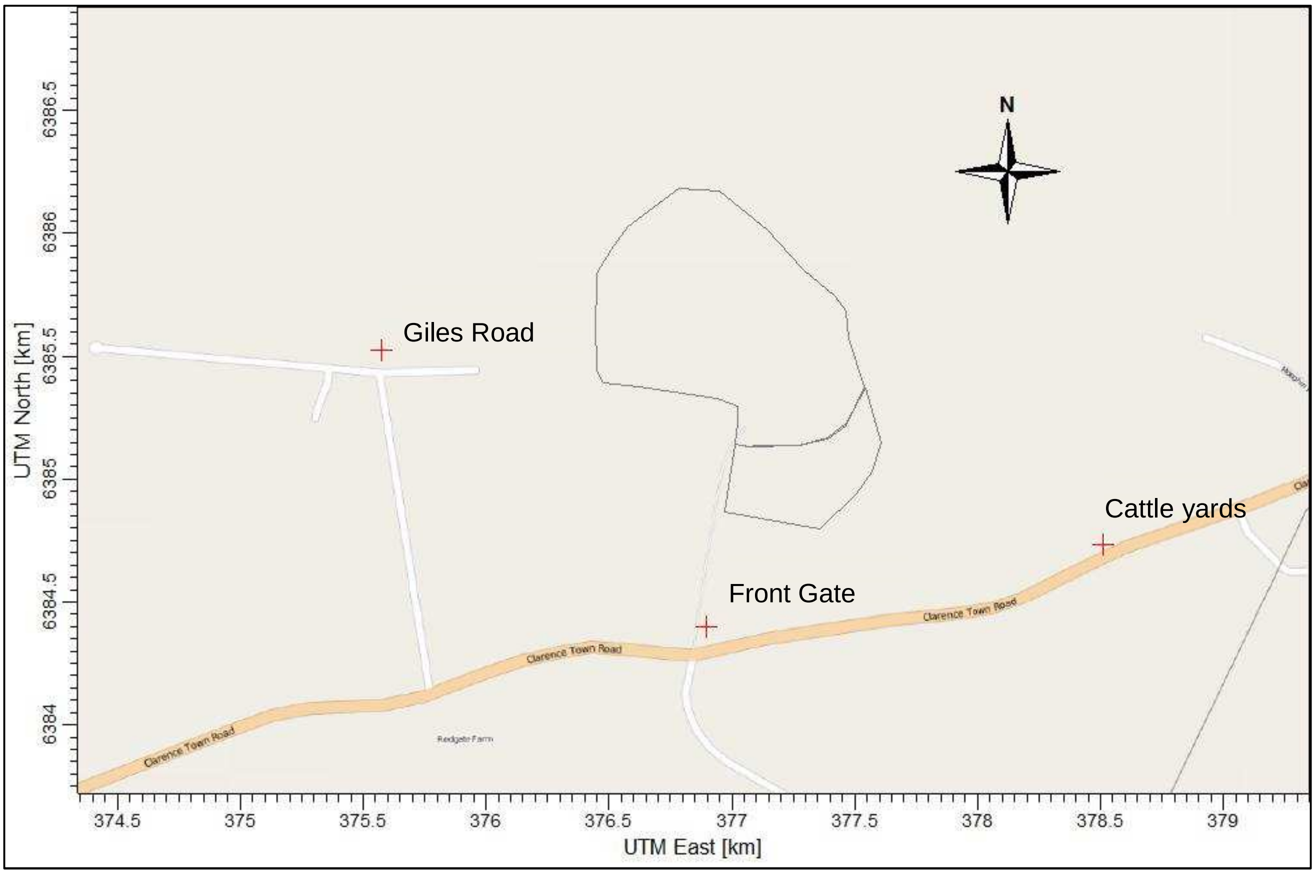


Figure 6-1: Approximate Dust Deposition Monitoring Locations [Hanson, 2014]

The dust deposition levels for the monitoring period Sept 2013 to August 2014 can be summarised as follows:

- Giles Road – the average deposition was 0.5 g/m^2/month with the highest monthly rate of 0.9 g/m^2/month, which occurred in January 2014 with a recorded rainfall of 42 mm;
- Front Gate – the average deposition was 2.1 g/m^2/month with the highest monthly rate of 6.3 g/m^2/month, which occurred in December 2013 with a recorded rainfall of 6 mm; and
- Cattle Yards – the average deposition was 0.5 g/m^2/month with the highest monthly rate of 6.0 g/m^2/month, which occurred in November 2013 with a recorded rainfall of 52 mm.

The dust deposition criterion is 4 g/m^2/month.

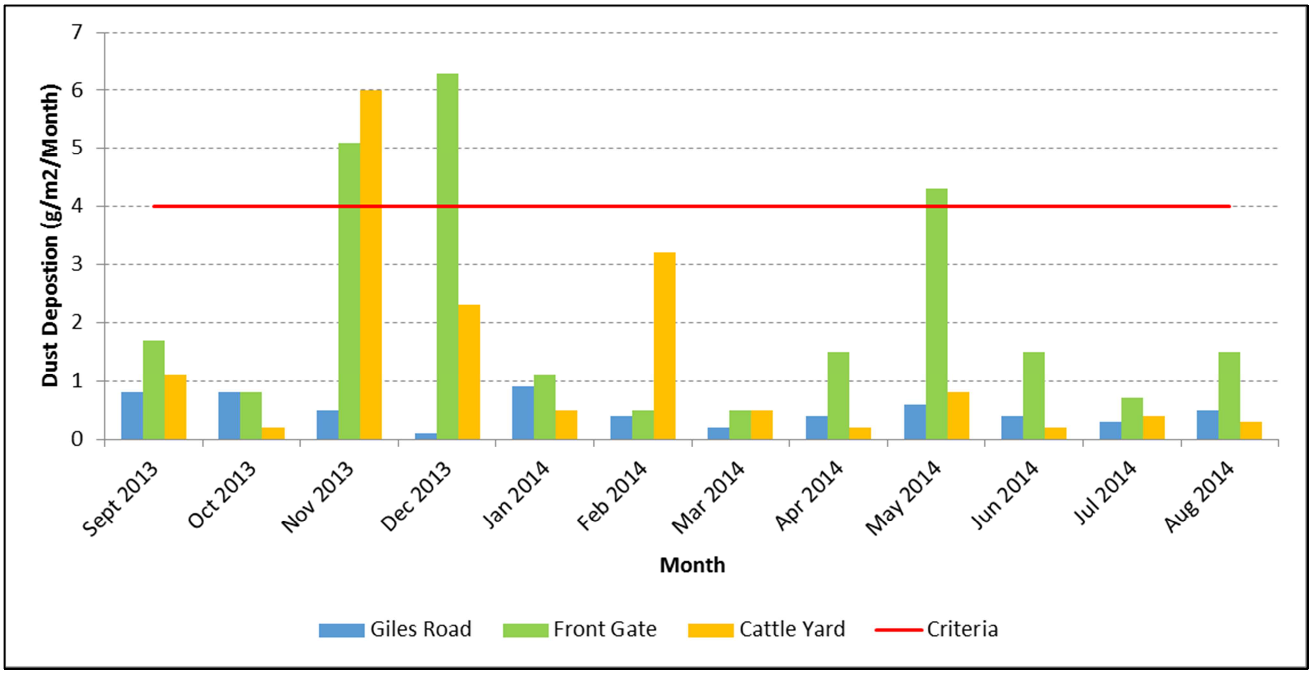


Figure 6-2: Dust Deposition (Insoluble Solids) Results [Hanson, 2014]

The dust deposition data presented in ***Figure 6-2*** is collected and managed by an external consultant. The dust values are usually accompanied with basic comments regarding the condition of the gauge if exceedances are detected. The commentary attributed to exceedances suggests that samples were affected by bird droppings or the gauge was compromised. There is no commentary relating to weather conditions or operational activities; therefore in the circumstances where no commentary is given, it is difficult to identify the corresponding operational or climatic drivers which may cause an exceedance of the criterion due to the month long exposure period.

It should also be noted that the local council uses the adjacent vacant land for stockpiling road construction material near the front of the Quarry, which may also elevate the levels on occasion.

The bottle located at the front gate is adjacent to the sealed entrance road (which is watered) which means there is limited wheel generated dust. The background concentrations discussed in Section 6.3 do not provide any information as dust deposition is a local issue. As such no conclusions can be drawn as to the origin or the spatial extent of these exceedances of the criterion; however it is noted that these exceedances appear to be infrequent in nature and over the annual averaging period, deposited dust readings are compliant.

6.3 Ambient Particulate Monitoring

6.3.1 PM_{10}

PM_{10} is not currently monitored for compliance in the vicinity of the BHQ site. As a substitute, data is available from the closest Office of Environment and Heritage's (OEH) Beresfield monitoring station. This air quality monitoring site is located at Francis Greenway High School, Beresfield, approximately 14.2 km SSW of the BHQ. Whilst this monitoring location is not wholly representative of the conditions of the local area surround BHQ, it is considered to be more representative than the other OEH monitoring stations. ***Figure 6-3*** illustrates the locations of the current Newcastle Air Monitors operated by OEH and it can clearly be seen that the Beresfield location is not only closer but also more representative of rural locations than the other stations.

In order to obtain an indication of likely PM_{10} concentrations in the region of the BHQ, the daily-varying (24-hour average) PM_{10} concentrations recorded at this station in 2013 has been analysed;

- The highest 24-hour concentration was 55.3 µg/m^3 on 17th and 18th October 2013, with five exceedances of the criteria during the year. The sixth highest value was 48.8 µg/m^3;
- The annual average excluding the exceedances was 20.9 µg/m^3; and
- The 90th percentile was 33.8 µg/m^3 and the 70th percentile was 23.8 µg/m^3.

Level 2 air quality assessments require ambient monitoring data for at least one year of continuous measurements be used in the dispersion modelling process (Department of Environment & Conservation, 2005). The 24-hour average PM_{10} concentrations recorded at the Beresfield monitoring station for the period 1st January 2013 to 31st December 2013 are presented in ***Figure 6-4***.

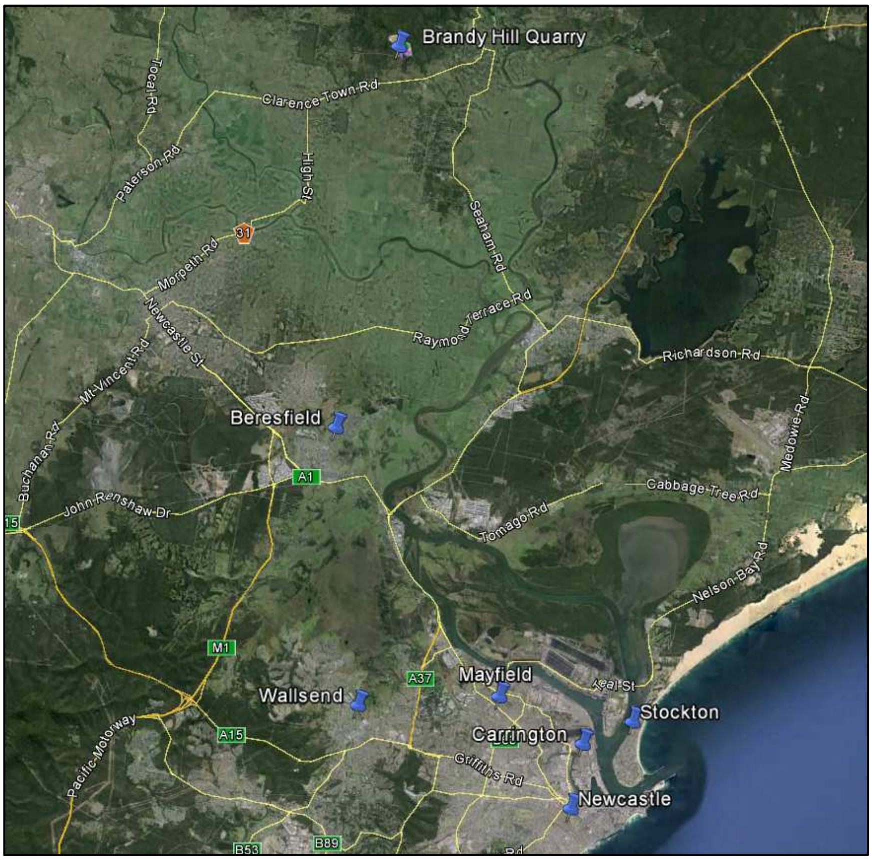


Figure 6-3: OEH Operated Air Monitoring Station Locations

6.3.2 $PM_{2.5}$

As with PM_{10}, $PM_{2.5}$ is not monitored in the vicinity of the BHQ site. As a substitute, data from the Beresfield monitoring station was used. In order to obtain an indication of likely $PM_{2.5}$ concentrations in the region of the BHQ, the daily-varying (24-hour average) PM_{10} concentrations recorded at this station in 2013 has been analysed;

- The highest 24-hour concentration was 38.4 µg/m^3 on the 18th October 2013, with one exceedance of the criteria during the year. The second highest 24-hour concentration was 23.6 µg/m^3;
- The annual average excluding the one exceedance was 8.1 µg/m^3, which exceeds the annual criterion of 8 µg/m^3; and

- The 90th percentile was 13.2 µg/m^3 and the 70th percentile was 9.5 µg/m^3.

The 24-hour average $PM_{2.5}$ concentrations recorded at the Beresfield monitoring station for the period 1st January 2013 to 31st December 2013 are presented in ***Figure 6-5***.

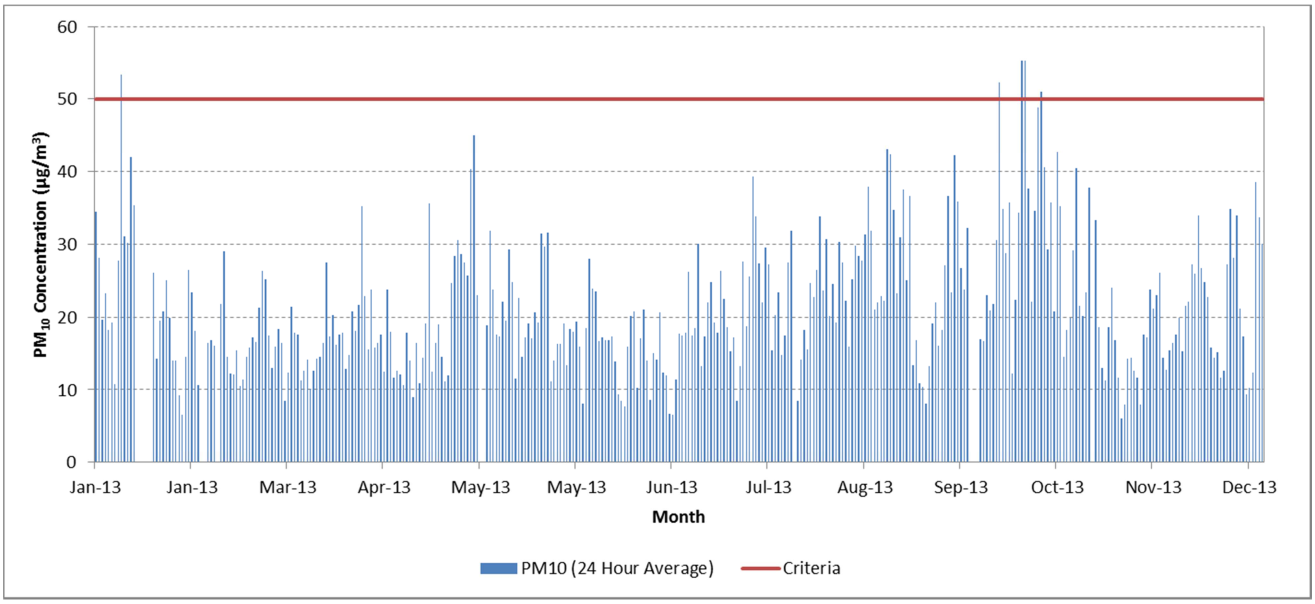


Figure 6-4: PM_{10} Concentrations at Beresfield [DECCW, 2014]

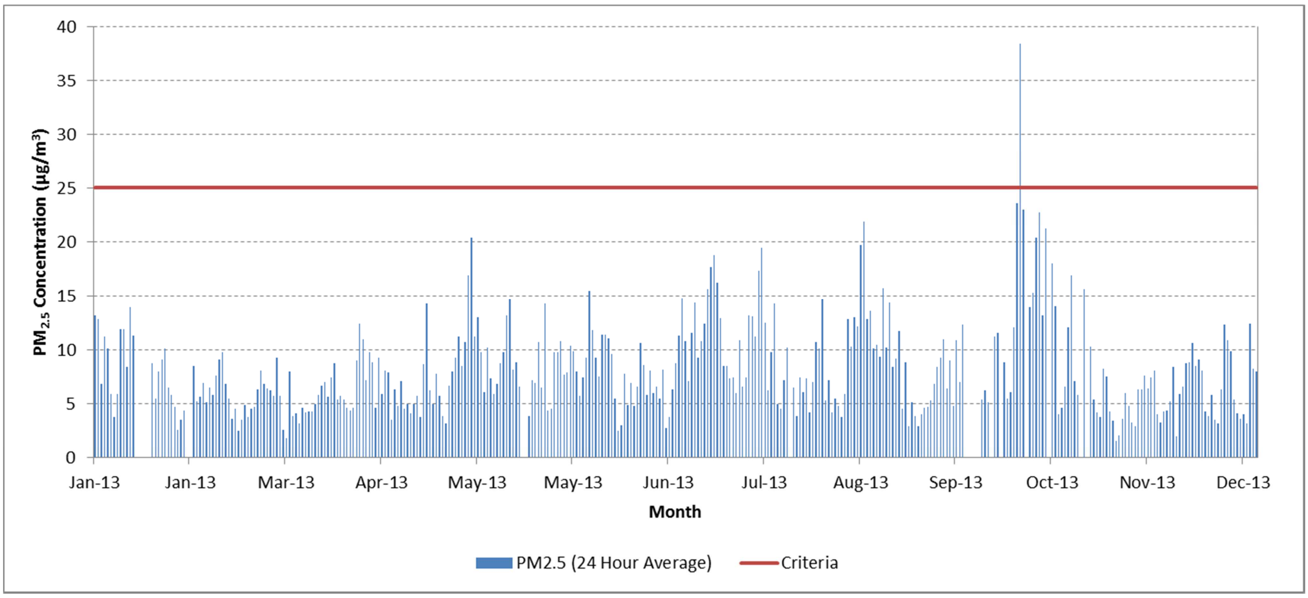


Figure 6-5: $PM_{2.5}$ Concentrations at Beresfield [DECCW, 2014]

Figure 6-6 shows the distribution of the 24 hour PM_{10} and $PM_{2.5}$ concentration monitoring data. It can be seen that the 27% of PM_{10} 24-hour concentrations are in the range 20-25 µg/m^3 whilst 46% of the $PM_{2.5}$ 24-hour concentrations are in the range 5-10 µg/m^3.

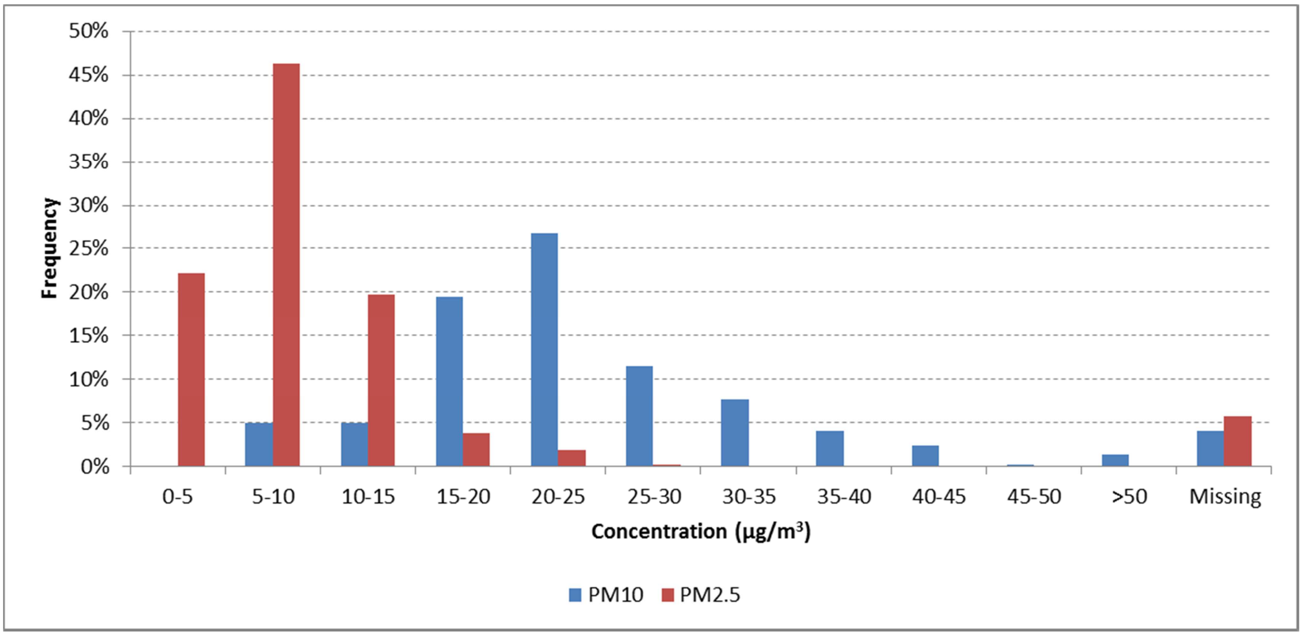


Figure 6-6: 24-Hour Average Particulate Concentration Distribution at Beresfield [DECCW, 2014]

6.3.3 TSP

TSP is not currently monitored in the vicinity of the BHQ. In this instance, TSP concentrations have been assumed to be twice those of the measured PM_{10} concentrations at Beresfield. It is noted that the PM_{10} sub-set is typically 50% of TSP mass in regions where road traffic is not the dominant particulate source (NSW Minerals Council, 2000).

6.4 Respirable Crystalline Silica

In lieu of any data of the silica content of the rock at Brandy Hill, Hanson has provided a report for another Hanson Project (Somersby in NSW) (SLR, 2012). The SLR report referenced a report by Toxikos (2005), which stated that data collected in Victoria estimated the respirable crystalline silica (RCS) annual average background concentration to be 0.7 µg/m^3. In the absence of any local data and in respect that this approach has been used previously in NSW, it has been assumed that the annual average background concentration of 0.7 µg/m^3 for RCS for the Project Site is both reasonable and representative.

6.5 Project Assigned Background Concentrations

A summary of the assigned background concentrations used in this study are presented in ***Table 6-1***. These background concentrations will be used to add to the predicted incremental impact from BHQ operation to derive total concentrations:

- Individual 24-hour average predicted PM_{10} and $PM_{2.5}$ concentration will be paired in time with the corresponding 24-hour concentration within the adopted 2013 monitoring dataset to obtain total impact at each receptor;
- The frequency distribution of predicted 24-hour average concentrations of PM_{10} and $PM_{2.5}$ will be compared with the corresponding frequency distribution of the monitoring dataset to provide an indication of the likelihood of elevated cumulative impacts occurring. It is considered that this method will be of significant use in determining the likely impact of expanded operations at the BHQ; and
- Annual average PM_{10}, $PM_{2.5}$, TSP and monthly dust deposition will be assessed through the addition of the dataset average concentrations.

Table 6-1: Assigned Project Background Concentrations

Parameter	Air Quality Objective	Period	Applied Background	Comments
TSP	90 µg/m^3	**Annual**	41.8 µg/m^3	Double annual average PM_{10}
PM_{10}	50 µg/m^3	**24 Hour**	Varies	Daily Beresfield Data for 2013
	30 µg/m^3	**Annual**	20.9 µg/m^3	Annual Average Beresfield Data
$PM_{2.5}$	25 µg/m^3	**24 Hour**	Varies	Daily Beresfield Data for 2013
	8 µg/m^3	**Annual**	8.1 µg/m^3	Annual Average Beresfield Data
Dust Deposition	4 g/m^2/month	**24 Hour**	2.1 g/m^2/month	BHQ data
Silica	3 µg/m^3	**Annual**	0.7 µg/m^3	No local data – VIC data used

It should be noted that the annual PM2.5 annual average already exceeds the 8 µg/m^3 criterion and the highest 24-hour PM10 concentration is 48.8 µg/m^3, which is just below the PM10 criterion of 50 µg/m^3.

7 METEOROLOGY

At the time this assessment was undertaken, there was no site specific meteorological data available for consideration.

Long term weather data has been obtained from the Bureau of Meteorology weather station Patterson (Tocal) Automatic Weather Station [AWS] Street (Site number 061250). The mean temperature range is between 6.2° and 29.8° with the coldest month being July and the hottest being January. The Rainfall in the region is variable, with most rainfall in the warmer months. On average, most of the annual rainfall is received between January and March. Rainfall is lowest between July and September, with a mean annual rainfall of 927.9 mm.

Table 7-1: Mean Long-term Weather Data for Patterson [BOM 1967-2014]

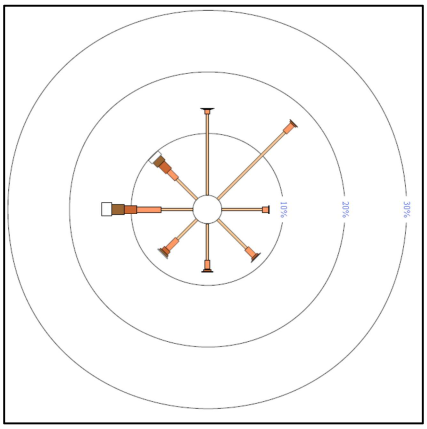
Month	Temperature		Rainfall (mm)	9 am Conditions			3 pm Conditions		
	Max (°C)	Min (°C)		Temp (°C)	RH (%)	Wind Speed (km/h)	Temp (°C)	Mean RH (%)	Wind Speed (km/h)
Jan	29.8	17.6	102.5	22.7	74	7.0	28.3	52	14.6
Feb	28.8	17.6	121.5	22.0	79	5.5	27.4	56	12.3
Mar	27.0	15.7	115.8	20.6	80	5.8	25.7	58	11.6
Apr	24.2	12.5	80.0	18.0	77	7.0	23.0	56	11.3
May	20.7	9.6	72.6	14.6	80	8.4	19.7	58	11.4
Jun	17.8	7.5	76.8	11.9	78	11.0	16.8	59	13.8
Jul	17.4	6.2	40.7	11.0	76	11.5	16.4	55	15.0
Aug	19.4	6.6	37.2	12.6	69	13.3	18.3	46	17.9
Sep	22.5	8.9	48.1	16.2	64	13.1	20.9	46	17.8
Oct	25.0	11.4	66.3	19.1	64	11.1	23.3	48	16.5
Nov	26.7	14.0	86.6	20.1	69	9.5	25.1	49	16.5
Dec	29.0	16.2	78.0	22.2	69	8.5	27.5	49	16.1
Annual	**24.0**	**12.0**	**927.9**	**17.6**	**73**	**9.3**	**22.7**	**53**	**14.6**

7.1 TAPM Meteorological Data

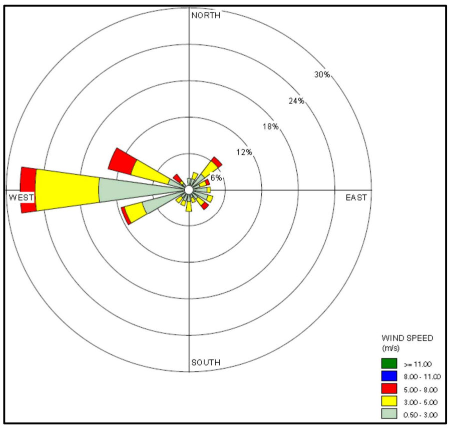
Meteorological data for the site was generated using meteorological data using The Air Pollution Model (TAPM) at the site for 2013. TAPM was configuration is presented in ***Section 5.2.1***.

A comparison of the AWS wind roses and the TAPM generated wind roses for 09:00 and 15:00 hours are presented in ***Figure 7-1***. The Patterson AWS is located approximately 10 km west and 4 km north of the Project site and is influenced by mountains immediately to the west and north-west. The TAPM wind roses were extracted from the 1 km grid, therefore the overall location does not align with the AWS location. The wind rose could not be extracted from CALMET as the grid did not extend wide enough.

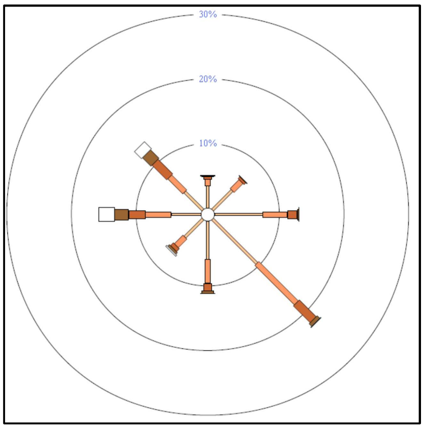
It can be seen from the figure that the 09:00 hour wind rose has more dominant winds from the west, however the 15:00 hours wind roses are very similar. The terrain between the AWS and the quarry is generally flat; however the quarry sits in a 'bowl' with the mountains on the west, north and east. Any differences in the wind fields will be addressed in the CALMET model.



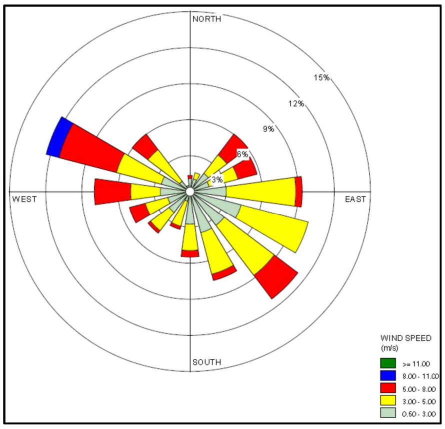
BOM Wind rose for Patterson 09:00 hours



TAPM extracted wind rose 09:00 hours



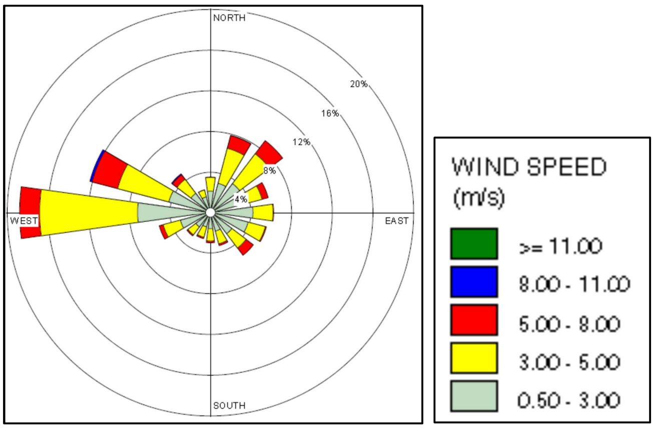
BOM Wind rose for Patterson 15:00 hours



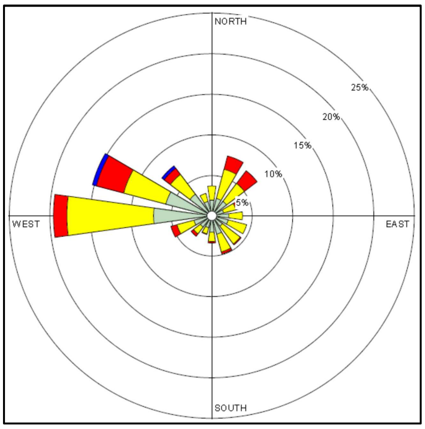
TAPM extracted wind rose 15:00 hours

Figure 7-1: Comparison of Patterson AWS Wind roses and TAPM Wind roses

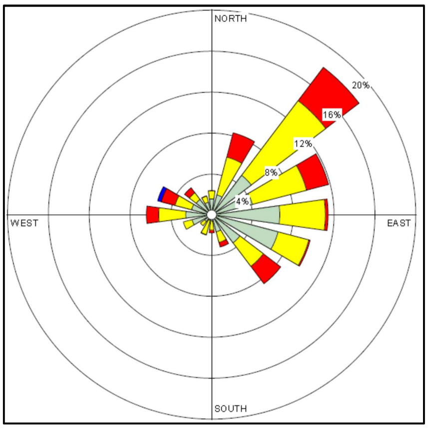
The wind roses are presented in ***Figure 7-2*** and show that winds blowing from the west are dominant during Spring, Autumn and Winter. These winds will carry the pollutants towards sensitive receptors R7, R8, R17 and R18. During the summer months, the receptors R11 to R16 are likely to be affected due to north easterly winds.



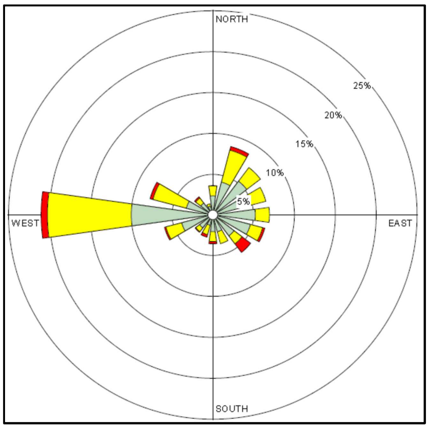
Annual (Calm – 1.37%)



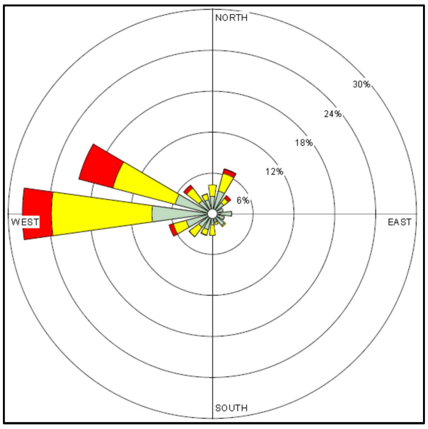
Spring (Calm – 1.01%)



Summer (Calm – 1.06%)



Autumn (Calm – 2.36%)



Winter (Calm – 1.04%)

Figure 7-2: Site-Specific Wind Roses by Season for 2013 [TAPM]

7.1.1 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Turner assignment scheme identifies six Stability Classes (Stability Classes A to F), to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions and are used as input into various air dispersion models. The frequency of occurrence for each stability class and the associated average wind speed the proposed development for 2013 is detailed in ***Table* 7-2**. The data identifies that Stability Class D is most common; this stability class is indicative of neutral conditions neither enhancing nor impeding pollutant dispersion.

Table 7-2: Annual Stability Class Distribution Predicted [TAPM, 2013]

Stability Class	Description	Frequency of Occurrence (%)	Average Wind Speed (m/s)
A	Very unstable low wind, clear skies, hot daytime conditions	1.95%	1.8
B	Unstable clear skies, daytime conditions	9.25%	2.6
C	Moderately unstable moderate wind, slightly overcast daytime conditions	14.83%	3.4
D	Neutral high winds or cloudy days and nights	38.15%	3.2
E	Stable moderate wind, slightly overcast night-time conditions	18.58%	3.3
F	Very stable low winds, clear skies, cold night-time conditions	17.24%	2.9

7.1.2 Mixing Height

Mixing height is defined as the height of the layer adjacent to the ground over which an emitted or entrained inert non-buoyant tracer will be mixed (by turbulence) within a time scale of about one hour or less.

Diurnal variations in mixing depths are illustrated in ***Figure 7-3***. As would be expected, an increase in the mixing depth during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and the growth of convective mixing layer.

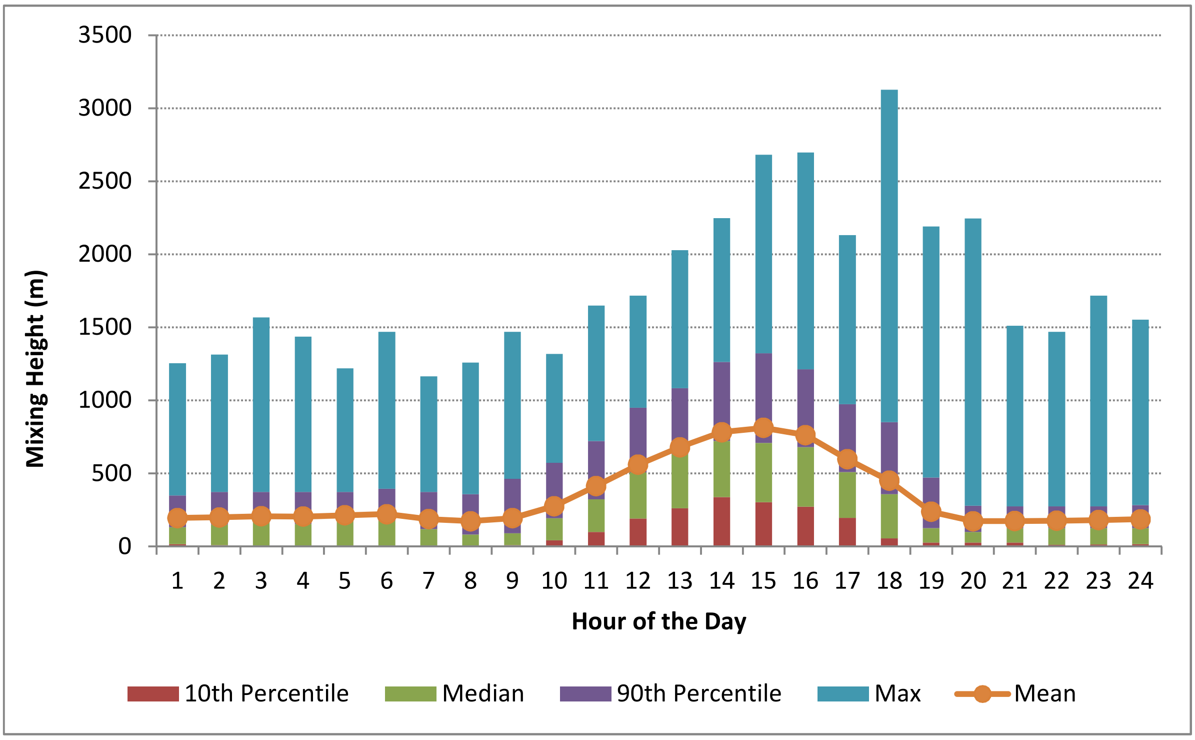


Figure 7-3: Mixing Height [TAPM, 2013]

8 SOURCES AND EMISSION ESTIMATION

Dust generation will be the main air quality issue associated with the Project; associated with the emissions from vehicles entering or leaving the site, mobile equipment exhaust emissions or blast fume. In general, the location of the mobile plant and blasting will be at a sufficient distance from the sensitive receptors, such that the pollutants, including blast fume will be dispersed fully and will not cause an impact. Additionally, the emissions from vehicles entering and leaving the site will potentially be double when compared to the existing situation; the vehicles will be using heavily trafficked roads and the increase in exhaust emissions associated with these vehicles will be negligible when compared to the existing traffic flows on these roads. This section provides information upon which the emission rates were derived using the equations and parameters detailed in ***Appendix B***.

8.1 Modelling Scenarios

For the purposes of accurate modelling predictions, the modelling will simulate different phases of the project as described below:

- Current - Current site operations with an annual production rate of 0.7 Mtpa;
- Stage 1 - Proposed site operations with an annual production rate of 1.5 Mtpa with the construction of the bund but without the concrete batching plant;
- Stage 2 - Proposed site operations with an annual production rate of 1.5 Mtpa including the construction of the bund and the concrete batching plant; and
- Stage 4 - Proposed site operations with an annual production rate of 1.5 Mtpa including the concrete batching plant and relocation of the fixed plant. At Stage 4, the bund to the southern boundary will be complete and stand 18 m high, however this bund has not been modelled in CALPUFF due to limitations of the software. As such Stage 4 is representative of the relocation of the processing plant with the proposed mitigation measures for the new fixed plant.

The Stages that will be assessed are representative of each production phase. ***Table 8-1*** compares the current and proposed operations at BHQ. It should be noted that the truck/traffic volumes presented in this table may differ from the noise impact assessment, however these values are not used in the air dispersion model; dust impacts from the trucks are calculated based on the capacity of the trucks and the production data from the quarry. The truck loads listed below relate to single truck movements associated with the proposed expansion operations and are based on estimates provided by Hanson. As outlined in ***Section 6.5*** of the Noise & Vibration Impact Assessment, the potential traffic generated from the proposed quarry expansion has not been confirmed at this stage. The Noise & Vibration Impact Assessment has assessed the potential noise impacts by considering the maximum number of truck movements that can be accommodated by Brandy Hill Drive, within the applicable noise criteria at the noise sensitive receivers located along Brandy Hill Drive.

Table 8-1: Comparison of Currently Approved Brandy Hill Quarry and the Proposed Project [Hanson, 2014]

Components	Current Operations	Proposed Operations
Quarry Life	No limit prescribed in existing consent. EIS states in excess of 30 years.	Approval is sought for 30 years.
Limits on Production	No Limit set by PSSC. Currently 0.7 Mtpa.	1.5 Mtpa
Quarry Footprint	Refer to ***Figure 2-1***	Extension of quarry pit and relocation of quarry infrastructure. Refer to ***Figure 8-1***
Operational Hours	No Limit set by PSSC	Sales, Production & Maintenance: 24 hours Mon. – Sun., Blasting: 8am - 5pm Mon - Fri.
Concrete Production	Not currently operating	15,000 m^3 per year
Concrete Recycling	Not currently operating	20,000 tonnes per year

Each modelling scenario incorporates the following activities:

- Open pit operations (drilling, blasting, mobile plant and haul truck movements);

- Processing operations (vehicle movements, material unloading, crushers, screening, material transfers, stockpiling of materials);
- Wind generated emissions from stockpiles; and
- Concrete batching plant emissions have been included for Stage 2 and Stages 4.

The following assumptions have been made:

- Continuous 24-hour plant operation, 365 days per year. In reality this situation is unlikely to occur;
- A site visit determined that the raw material unloading point is open, all crushers are enclosed and the screens have are also open;
- Watering of haul roads is Level 1;
- Throughputs for each crusher, screen, conveyor and stockpile were provided by Hanson for the current scenario. These have been adjusted for the future scenarios; and
- Conveyor height can vary but the conveyors are not enclosed (except Stage 4).

Additional assumptions and equations are presented in ***Appendix B***.

8.2 Location of Sources

Figure 2-1 presents the current quarry operations including the location of pit, stockpiles, processing area infrastructure. The location of each activity was based on this information for the current assessment scenario. The proposed processing area is also identified in ***Figure 2-1***; for the Stage 4 assessment scenarios the processing plant is relocated 550 m south of the current position. ***Figure 8-1*** shows the layout for the future scenarios for all sources. It should be noted that the concrete batching plant (CBP) is only in Stages 2 and 4, whilst the bund construction is only in Stages 1 and 2. The in-pit haul roads change location based on pit layout during each Stage. The haul road locations for each stage are presented in ***Appendix B***.

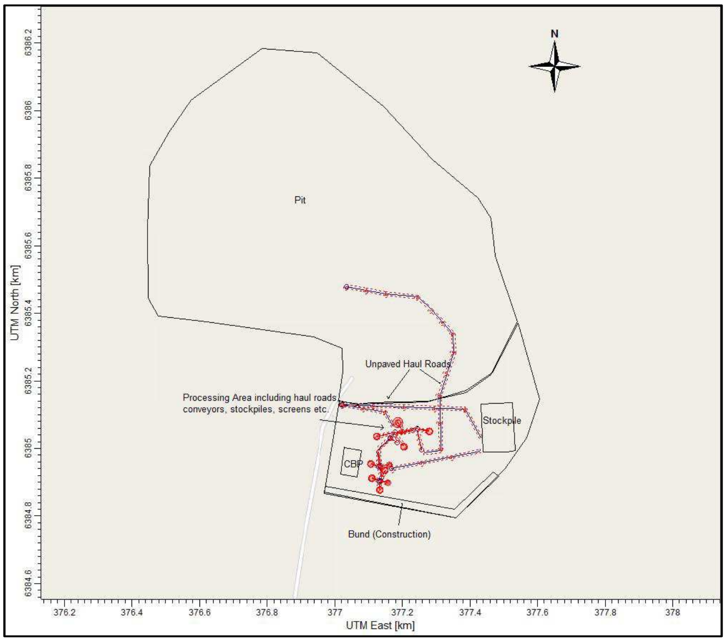


Figure 8-1: Location of Future Sources

8.3 Emissions by Source

As discussed in ***Section 5.1***, the emission estimation for individual activities has been derived from NPI Emission Estimation Technique manuals and US EPA AP42 documentation. Where calculation methods require site-specific parameters, these have been provided by Hanson, as detailed in ***Appendix B***. Emission rates for $PM_{2.5}$ are limited; so in order to derive the ratio of PM_{10} to $PM_{2.5}$, US EPA AP42 documentation and the Western Regional Air Partnership study (WRAP, 2006) has been used.

The annual calculated emissions for TSP, PM_{10} and $PM_{2.5}$ are presented in ***Table 8-2*** to ***Table 8-4*** for each source type and assessment stage. It should be noted that all sources are classed as fugitive and there are no point sources associated with this project.

Table 8-2: Calculated Annual TSP Emissions by Source for Each Assessment Stage (t/year)

Fugitive Source	Current	Stage 1	Stage 2	Stage 4
Drilling and Blasting	1.8	1.8	1.8	1.8
Mobile Plant	35.0	75.0	75.0	75.0
Haul Truck Movements	38.6	76.9	132.6	82.4
Raw Material Unloading	0.1	0.2	0.2	0.2
Stockpile Loading	0.1	0.2	0.2	0.2
Wind erosion	2.6	2.6	2.6	2.6
Crushers & Screens	37.5	80.3	80.3	0
Conveyors	23.7	50.7	50.7	0.5
Product Truck Movements	16.8	36.0	36.0	18.3
Bund Construction/Wind Erosion	-	1.8	1.8	<0.1
Concrete Plant	-	-	7.2	7.2

Table 8-3: Calculated Annual PM_{10} Emissions by Source for Each Assessment Stage (t/year)

Fugitive Source	Current	Stage 1	Stage 2	Stage 4
Drilling and Blasting	0.9	0.9	0.9	0.9
Mobile Plant	16.8	36.0	36.0	36.0
Haul Truck Movements	6.8	15.4	23.3	17.2
Raw Material Unloading	<0.1	0.1	0.1	0.1
Stockpile Loading	0.1	0.1	0.1	0.1
Wind erosion	0.8	0.8	0.8	0.8
Crushers & Screens	12.9	27.6	27.6	0
Conveyors	11.2	24.0	24.0	0.2
Product Truck Movements	3.0	6.3	6.3	3.2
Bund Construction/Wind Erosion	-	0.6	0.6	<0.1
Concrete Plant	-	-	3.6	3.6

Table 8-4: Calculated Annual $PM_{2.5}$ Emissions by Source for Each Assessment Stage (t/year)

Fugitive Source	Current	Stage 1	Stage 2	Stage 4
Drilling and Blasting	0.1	0.1	0.1	0.1
Mobile Plant	3.7	7.9	7.9	7.9
Haul Truck Movements	0.3	0.7	1.1	1.2
Raw Material Unloading	<0.1	<0.1	<0.1	<0.1
Stockpile Loading	0.0	0.0	0.0	<0.1
Wind erosion	0.1	0.1	0.1	0.1
Crushers & Screens	1.9	4.1	4.1	0
Conveyors	1.7	3.6	3.6	<0.1
Product Truck Movements	0.1	0.3	0.3	0.2
Bund Construction/Wind Erosion	-	0.1	0.1	0.0
Concrete Plant	-	-	0.5	0.5

The emissions of TSP, PM_{10} and $PM_{2.5}$ show the increase in production between the current operations and the proposed operations. During the construction of the bund (Stages 1 and 2), one item of mobile plant has been reallocated to the bund construction source rather than mobile plant source. It can be seen from ***Table 8-2*** to ***Table 8-4*** that the highest emissions of the total operations are mobile plant, crushers and screens, haul truck movements on unpaved roads and conveyors. During Stage 4, the processing plant will be new and will include best practice mitigation such as enclosed conveyors.

Emission rates for RCS were derived using the soil sizing and analysis report conducted by Amdel Limited (Toxikos, 2005) as reported in SLR (2012). The samples were from Somersby Quarry which is also operated by Hanson. The particle size distribution for the collected samples is listed in ***Table 8-5***.

Table 8-5: Calculated Size Distribution for Somersby Quarry [as reported by SLR, 2012]

Sample	Moisture Content (%)	Size Distribution (wt%)			Estimated Quartz Content of -4 µm Fraction (wt%)
		+63 µm “sand and gravel”	-63 µm + 4 µm “silt”	- 4 µm “clay”	
Stockpile	8.9	84	8	8	3.0
Haul Road	5.6	85	7	8	3.2

The estimated quartz content was based on the 4 µm fraction. For the purposes of this assessment, the 4 µm fraction is considered appropriate for estimating the quartz content as $PM_{2.5}$. The emission factors for PM_{10} have been used to estimate RCS. It is been assumed that all PM_{10} emissions contained 3.2% RCS.

It should be noted that the particle size distribution outlined in ***Table 8-5*** has only be used to derive a RCS value relative to the calculated PM_{10} emissions. In lieu of any site-specific particle size data, the standard particle parameters and emission ratios contained in the CALPUFF model and the NPI emission factors calculations have been used.

9 IMPACT ASSESSMENT

This section presents the results of the air quality impact assessment for predicted ground level concentrations of TSP, PM_{10}, $PM_{2.5}$, RCS and dust deposition for the proposed operations at varying Stages.

The results of the dispersion modelling include individual sensitive receptor and contour plots that are indicative of ground-level concentrations. This Level 2 impact assessment requires the predictions to be presented as follows:

- The incremental impact of each pollutant as per the criterion units and time periods;
- The total impact (incremental plus background) for the 100th percentile (i.e. maximum value) in units as per the criterion and time periods. For 24-hour average PM_{10} and $PM_{2.5}$ predictions, the contemporaneous concentrations are the predicted pollutant concentrations added to the daily monitoring results from Beresfield as discussed in ***Section 6.3***.

9.1 Impacts on Vacant Land

The extent of the property boundary with regard to the surrounding area of land under the ownership of Hanson is shown in ***Figure 2-1*** and illustrates the majority of land between the Quarry and nearby receptors is owned by Hanson. Vipac were advised that there are no third party sensitive receivers located on the parcel of land located to the southeast of the Quarry between the Quarry & Clarence Town Road. It is understood that the owner of this land parcel does not reside on the land parcel. Therefore there is no vacant land that is significantly closer to the air emissions than the sensitive prediction locations assessed in this report. Any emissions associated with the Quarry on Hanson's own property are assessable against occupational criteria to protect the health of employees.

9.2 TSP

The predicted incremental increase in annual average TSP is presented in **Table 9-1** for each assessment stage. It can be seen from **Table 9-1** that the incremental increase in annual average TSP will be no greater than 19 $\mu g/m^3$ at all sensitive receptor locations. When the annual average background concentration of 41.8 $\mu g/m^3$ is applied to the model productions, the total annual average TSP is predicted to be less than 61 $\mu g/m^3$, which is below the criterion of 90 $\mu g/m^3$. The highest incremental increases will occur at 1189 Clarence Town Road during Stage 2. High concentrations at receptors along Clarence Town Road during Stage 1 and 2 are driven by the emissions from the construction of the bund.

As such the TSP emissions from BHQ are not predicted to adversely impact upon the sensitive receptors. A contour plot is presented in ***Appendix C***.

Table 9-1: Predicted Annual Average Incremental TSP Concentrations (µg/m^3) [Criteria - 90 µg/m^3]

Receptor	Predicted Annual Average Incremental TSP Concentrations (µg/m^3)			
	Current	Stage 1	Stage 2	Stage 4
122B Duns Creek Road	0.2	0.3	0.4	0.1
16 Uffington Road	0.1	0.1	0.2	0.1
60 Green Wattle Creek Road	0.3	0.6	0.6	0.3
34 Timber Top Road	0.1	0.3	0.3	0.1
35 Timber Top Road	0.1	0.3	0.3	0.1
36 Timber Top Road	0.1	0.3	0.3	0.1
13 Mooghin Rd	2.3	4.8	5.0	2.2
14 Mooghin Rd	1.6	3.4	3.5	1.4
13 Giles Road	1.6	3.6	4.0	1.3
13B Giles Road	2.1	4.2	5.0	1.9
866 Clarence Town Road	2.0	4.1	4.6	2.8
888 Clarence Town Road	2.4	5.1	5.6	3.2
994 Clarence Town Road	2.1	4.6	5.5	5.9
1034 Clarence Town Road	2.3	4.9	5.7	5.7
1060 Clarence Town Road	2.1	4.5	5.2	4.7
1094 Clarence Town Road	1.8	3.9	4.7	4.6
1189 Clarence Town Road	8.5	17.1	19.0	6.7
1203 Clarence Town Road	7.0	14.2	15.5	6.1

9.3 PM_{10}

9.3.1 24-Hour Average

The daily PM_{10} results have been analysed in the following manner:

- Maximum total concentrations – these results are the overall maximum 24-hour concentrations at each receptor and associated number of exceedances of the criteria;
- Maximum incremental contemporaneous concentrations – these results are reviewed based on the highest impact from the quarry. The daily results are added to the corresponding background concentrations as detailed in ***Section 6.3***.

Maximum Concentrations

Analysis of the daily predictions has identified that the maximum 24-hour concentration at each receptors and the number of daily exceedances of the criteria. The results for each Scenario are presented in ***Table 9-2*** and ***Figure 9-1***.

The results show that during Stage 1 eight receptors exceed the criteria, during Stage 2 nine receptors exceed the criteria and during Stage 4 three receptors will exceed the criteria.

Table 9-2: Maximum 24-Hour Average PM_{10} Concentrations and Daily Exceedances (µg/m^3) [Criteria - 50 µg/m^3]

Receptor	Predicted Max 24-Hour PM_{10} Concentrations (µg/m^3) with Daily Exceedances							
	Current Scenario		Stage 1 Scenario		Stage 2 Scenario		Stage 4 Scenario	
	Total	No. of Exceedances	Total	No. of Exceedances	Total	No. of Exceedances	Total	No. of Exceedances
122B Duns Creek Road	48.8	0	48.8	0	48.8	0	48.8	0
16 Uffington Road	48.8	0	48.8	0	48.8	0	48.8	0
60 Green Wattle Creek Road	48.8	0	48.8	0	48.8	0	48.8	0
34 Timber Top Road	48.8	0	48.8	0	48.8	0	48.8	0
35 Timber Top Road	48.8	0	48.8	0	48.8	0	48.8	0
36 Timber Top Road	48.8	0	48.8	0	49.1	0	48.8	0
13 Mooghin Rd	48.9	0	49.1	0	49.0	0	48.9	0
14 Mooghin Rd	48.9	0	49.0	0	**55.6**	1	48.9	0
13 Giles Road	48.8	0	**54.8**	1	**51.7**	**1**	48.8	0
13B Giles Road	48.8	0	**51.2**	1	48.8	**0**	48.8	0
866 Clarence Town Road	48.8	0	48.8	0	**54.2**	1	48.8	0
888 Clarence Town Road	48.8	0	**54.2**	1	**54.1**	**1**	48.8	0
994 Clarence Town Road	**50.4**	**1**	**52.4**	**1**	**50.7**	**1**	**53.1**	2
1034 Clarence Town Road	49.4	0	**50.4**	1	**50.0**	**0**	**52.7**	1
1060 Clarence Town Road	49.2	0	49.9	0	52.4	2	49.9	0
1094 Clarence Town Road	49.5	0	**51.0**	2	**70.8**	**21**	**51.3**	1
1189 Clarence Town Road	49.4	0	**68.0**	18	**65.6**	**13**	49.4	0
1203 Clarence Town Road	49.3	0	**63.7**	10	**65.6**	**13**	49.1	0

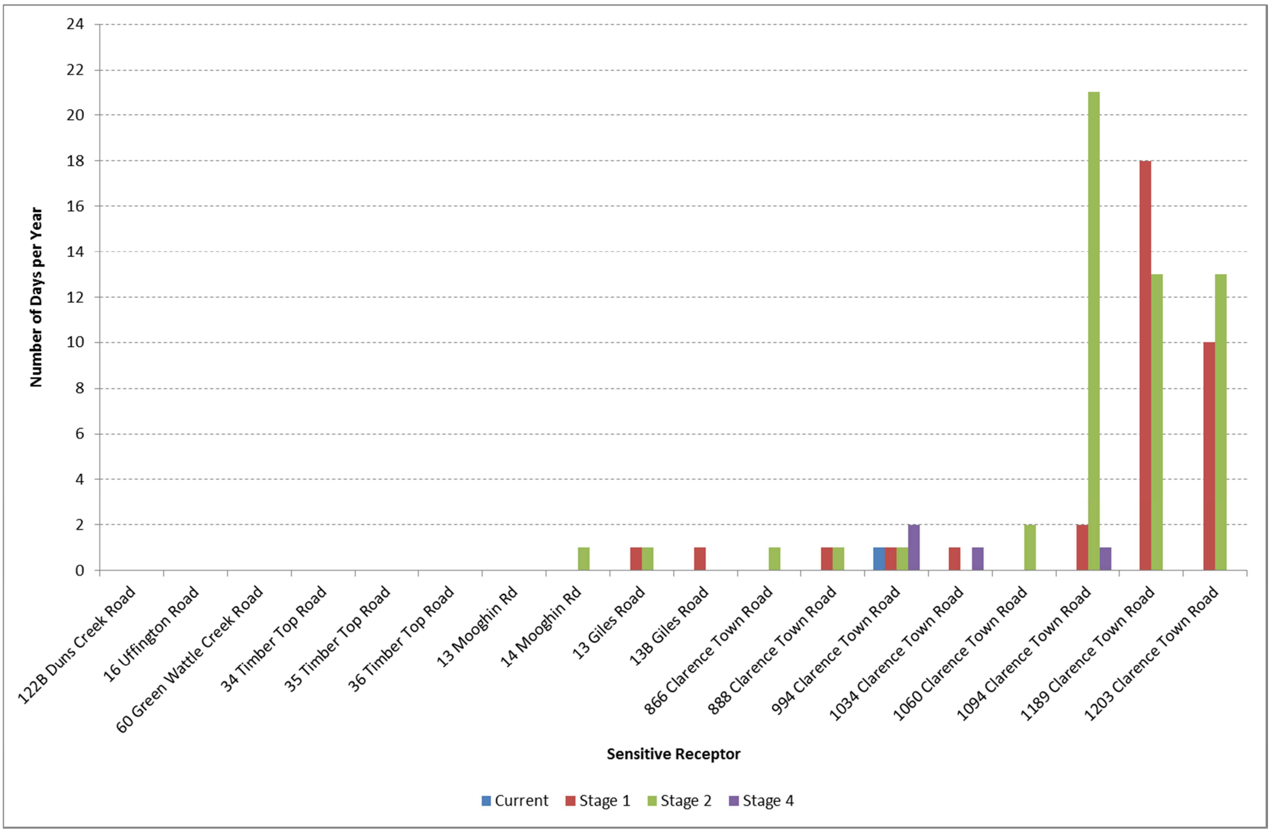


Figure 9-1: Number of Days the 24-Hour Average Incremental Predictions Exceed the PM_{10} Criteria

The receptor 1094 Clarence Town Road will experience the highest number of exceedances with 21 days during Stage 2. This corresponds to the creation of a dedicated haul road from the pit to the bund.

The maximum background concentration with exceedances removed (as discussed in ***Section 6.3***) was 48.8 µg/m^3, which occurred on 22/10/2013. As this high value is close to the criteria, a review of the incremental increases on this date has been undertaken:

- During Current operations one receptor is predicted to exceed the criteria, this exceedance occurs on 22/10/2013;
- During Stage 1 four of the eight receptors will exceed the criteria as a result of this high background concentration on 22/10/2013;
- During Stage 2 five of the nine receptors will exceed the criteria as a result of this high background concentration on 22/10/2013; and
- During Stage 4 all three receptors will exceed the criteria as a result of this high background concentration on 22/10/2013. Two receptors exceed for one day and one receptor exceeds for two days, for a total of four days.

Maximum Incremental Contemporaneous Results

The predicted contemporaneous 24-hour average PM_{10} is presented in **Table 9-3** for each assessment stage. The contemporaneous concentrations are the predicted pollutant concentrations added to the daily monitoring results from Beresfield as discussed in ***Section 6.3***. For each receptor location, the highest predicted concentration occurs at different times, therefore the background concentrations vary. The incremental increase for each sensitive receptor is presented in ***Table 9-5***.

Table 9-3: Maximum Contemporaneous 24-Hour Average PM_{10} Concentrations (µg/m^3) [Criteria - 50 µg/m^3]

Receptor	Predicted Max 24-Hour Contemporaneous PM_{10} Concentrations (µg/m^3) with Background Concentrations							
	Current Scenario		Stage 1 Scenario		Stage 2 Scenario		Stage 4 Scenario	
	Total	Background	Total	Background	Total	Background	Total	Background
122B Duns Creek Road	23.2	21.3	25.4	21.3	25.4	21.3	22.7	21.3
16 Uffington Road	7.2	6.1	8.6	6.1	8.7	6.1	7.2	6.1
60 Green Wattle Creek Road	19.2	16.6	22.4	16.6	22.6	16.6	14.7	11.7
34 Timber Top Road	17.2	15.4	12.0	8.0	20.1	15.4	17	15.4
35 Timber Top Road	9.6	8.0	11.5	8.0	11.9	8.0	9.3	8.0
36 Timber Top Road	9.7	8.0	11.8	8.0	12.2	8.0	9.3	8.0
13 Mooghin Rd	23.8	15.1	34.4	15.1	33.9	15.1	26.0	21.0
14 Mooghin Rd	23.2	11.4	36.4	11.4	38.3	11.4	26.1	21.0
13 Giles Road	22.7	6.7	44.0	6.7	46.1	6.7	15.9	6.7
13B Giles Road	37.4	28.1	32.5	12.0	36.7	12.0	22.5	12.0
866 Clarence Town Road	25.6	14.6	38.7	14.3	38.5	14.3	31.2	22.9
888 Clarence Town Road	20.9	10.5	33.4	10.5	33.4	10.5	21.5	12.1
994 Clarence Town Road	32.6	22.5	45.2	22.5	49.2	22.5	37.8	26.4
1034 Clarence Town Road	33.0	24.7	48.1	29.5	45.2	24.7	23.6	11.4
1060 Clarence Town Road	27.6	16.0	42.2	16.0	43.2	16.9	27.5	11.4
1094 Clarence Town Road	17.1	12.7	22.2	12.7	45.2	34.9	29.9	20.3
1189 Clarence Town Road	46.6	27.2	**68.0**	27.2	**70.8**	27.2	33.6	15.1
1203 Clarence Town Road	41.9	24.0	**63.3**	24.0	**64.0**	24.0	28.9	11.4

For each individual day the maximum concentrations at each sensitive receptor depend on the following:

- Daily varying background concentrations as presented in ***Section 6***; and
- Quarry emissions averaged over 24-hour periods based on wind speed, direction and other meteorological parameters.

In addition the differences between each scenario (i.e. addition/location of sources, different production rates etc.) may affect the day upon which the maximum concentration from the quarry operations are predicted at each receptor due to the weather conditions.

For example; the receptor 122B Dunns Creek Road is located approximately 3.3 km north-west of the quarry with significant terrain features between the quarry and the receptor. Due to the distance and location of the receptor, it is less likely to be affected by changes in the proposed quarry operations. A review of the results shown that for each scenario the maximum incremental increase (i.e. source only emissions) occurs on the same day (21st February), when the background concentration is 21.3 µg/m^3. For the current scenario, the incremental increase is 1.9 µg/m^3, therefore 1.9 (quarry emissions as detailed in ***Table 9-5***) + 21.3 (background as detailed in ***Section 6***) results in 23.2 µg/m^3 (total concentration).

By contrast one of the closest receptors, 1060 Clarence Town Road, has recorded different days upon which the maximum concentrations occur during each scenario as the proximity of the receptor to the quarry makes it more likely to be affected by any changes to the proposed operations. During the current and Stage 1 scenarios the background concentration of 16 µg/m^3 is recorded on the 01/6/2013. The backgrounds are recorded on the same day, as the only difference between the current scenario and Stage 1 scenario is the quarry production rate and construction of the bund, which is negligible. Stage 2 introduces concrete batching plant to the operations, which is closer to the receptor.

The day upon which the wind causes the maximum incremental increase is different and therefore the background concentration is different. For Stage 4 the sources have moved closer to the receptor, but have more emission controls (resulting in lower incremental increases) and once again the day upon which the wind causes the maximum incremental increase is different and therefore the background concentration is different.

Table 9-4: Changes in PM_{10} 24 hour Concentrations - Receptor 1060 Clarence Town Road example

Scenario	Max increment (Quarry Emissions Table 9-5)	Date of occurrence	Background (Section 6)	Total (Table 9-3)
Current	11.6	01/06/2013	16.0	27.6
Stage 1	26.2	01/06/2013	16.0	42.2
Stage 2	26.3	10/06/2013	16.9	43.2
Stage 4	16.1	01/07/2013	11.4	27.5

As outlined above, it should be noted that background concentrations for some receptors change due to the change in location of sources and the corresponding day when the maximum results are recorded (due to weather conditions).

Table 9-3 shows that two sensitive receptors exceed the 24-hour criterion of 50 µg/m^3, when the source and background concentrations are contemporaneously analysed.

The predicted incremental increase in 24-hour average PM_{10} is presented in ***Table 9-5*** for each assessment stage. It can be seen from ***Table 9-5*** that the highest 24-hour average incremental increase is 43.6 µg/m^3 at 1189 Clarence Town Road during Stage 2.

Whilst this incremental value is high in relation to the criterion, it occurs as a result of the construction of the 18m high bund, which when complete will protect the sensitive receptors from dust emissions. These dust emissions will be mitigated through water suppression; however this dust control was not modelled in order to provide a worst-case scenario. It should also be noted that working on the construction bund will not occur every day, therefore these activities can be managed to occur when wind is not blowing towards the receptors of concern. As the impacts will be temporary in nature and dust suppression and management techniques will be applied, the high PM_{10} levels are considered a worst-case concentration.

High concentrations at receptors along Clarence Town Road during Stage 1 and 2 are driven by the emissions from the construction of the bund whereas during Stage 4, the decreases are a result of the relocation of the processing plant with adopted mitigation measures.

Table 9-5: Predicted Max 24-Hour Incremental PM_{10} Concentrations (µg/m^3)

Receptor	Predicted 24-Hour Average Incremental PM_{10} Concentrations (µg/m^3)			
	Current	Stage 1	Stage 2	Stage 4
122B Duns Creek Road	1.9	4.1	4.1	1.4
16 Uffington Road	1.1	2.5	2.6	1.1
60 Green Wattle Creek Road	2.6	5.8	6.0	3.0
34 Timber Top Road	1.8	4.0	4.7	1.6
35 Timber Top Road	1.6	3.5	3.9	1.3
36 Timber Top Road	1.7	3.8	4.2	1.3
13 Mooghin Rd	8.7	19.3	18.8	5.0
14 Mooghin Rd	11.8	25.0	26.9	5.1
13 Giles Road	16.0	37.3	39.4	9.2
13B Giles Road	9.3	20.5	24.7	10.5
866 Clarence Town Road	11.0	24.4	24.2	8.3
888 Clarence Town Road	10.4	22.9	22.9	9.4
994 Clarence Town Road	10.1	22.7	26.7	11.4
1034 Clarence Town Road	8.3	18.6	20.5	12.2
1060 Clarence Town Road	11.6	26.2	26.3	16.1
1094 Clarence Town Road	4.4	9.5	10.3	9.6
1189 Clarence Town Road	19.4	40.8	43.6	18.5
1203 Clarence Town Road	17.9	39.3	40.0	17.5

9.3.2 Annual Average

The PM_{10} annual average criterion of 30 µg/m^3 has been adopted for this assessment. Table 9-6 presents the predicted total PM_{10} concentrations at sensitive receptors for each assessment stage. Background PM_{10} concentration of 20.9 µg/m^3 are included in the predictions.

Table 9-6: Predicted Total Annual Average PM_{10} Concentrations ($\mu g/m^3$) [Criteria - 30 $\mu g/m^3$]

Receptor	Predicted Total Annual Average PM_{10} Concentrations with Background Concentrations ($\mu g/m^3$)							
	Current Scenario		Stage 1 Scenario		Stage 2 Scenario		Stage 4 Scenario	
	Total	Background	Total	Background	Total	Background	Total	Background
122B Duns Creek Road	21.0	20.9	21.0	20.9	21.0	20.9	21.0	20.9
16 Uffington Road	20.9	20.9	21.0	20.9	21.0	20.9	20.9	20.9
60 Green Wattle Creek Road	21.0	20.9	21.1	20.9	21.1	20.9	21.0	20.9
34 Timber Top Road	21.0	20.9	21.0	20.9	21.0	20.9	20.9	20.9
35 Timber Top Road	20.9	20.9	21.0	20.9	21.0	20.9	20.9	20.9
36 Timber Top Road	20.9	20.9	21.0	20.9	21.0	20.9	20.9	20.9
13 Mooghin Rd	21.7	20.9	22.6	20.9	22.6	20.9	21.6	20.9
14 Mooghin Rd	21.5	20.9	22.2	20.9	22.2	20.9	21.4	20.9
13 Giles Road	21.4	20.9	22.1	20.9	22.2	20.9	21.4	20.9
13B Giles Road	21.5	20.9	22.3	20.9	22.5	20.9	21.5	20.9
866 Clarence Town Road	21.5	20.9	22.3	20.9	22.4	20.9	21.6	20.9
888 Clarence Town Road	21.6	20.9	22.6	20.9	22.7	20.9	21.7	20.9
994 Clarence Town Road	21.5	20.9	22.3	20.9	22.6	20.9	22.2	20.9
1034 Clarence Town Road	21.6	20.9	22.4	20.9	22.6	20.9	22.2	20.9
1060 Clarence Town Road	21.5	20.9	22.3	20.9	22.5	20.9	22.0	20.9
1094 Clarence Town Road	21.4	20.9	22.1	20.9	22.3	20.9	21.9	20.9
1189 Clarence Town Road	23.5	20.9	26.5	20.9	26.9	20.9	22.8	20.9
1203 Clarence Town Road	23.1	20.9	25.6	20.9	25.9	20.9	22.5	20.9

It can be seen from Table 9-6 that the total PM_{10} concentration will be less than the 30 µg/m^3 criterion at all sensitive receptor locations. The highest annual average PM_{10} concentration is 26.9 µg/m^3 which will occur at 1189 Clarence Town Road during Stage 2. **As such the annual PM_{10} emissions from BHQ are not predicted to adversely impact upon the sensitive receptors.** A contour plot is presented in ***Appendix C***.

9.4 $PM_{2.5}$

9.4.1 24-Hour Average

The daily $PM_{2.5}$ results have been analysis in the following manner:

- Maximum total concentrations – these results are the overall maximum 24-hour concentrations at each receptor and associated number of exceedances of the criteria;
- Maximum incremental contemporaneous concentrations – these results are reviewed based on the highest impact from the quarry. The daily results are added to the corresponding background concentrations as detailed in ***Section 6.3***.

Maximum Concentrations

Analysis of the daily predictions has identified that the maximum 24 hour concentration at each receptors and the number of daily exceedances of the criteria. The results for each Scenario are presented in ***Table 9-7.***

The results show that the only exceedances of the $PM_{2.5}$ criteria will occur during Stage 4 at three receptors.

Table 9-7: Maximum 24-Hour Average $PM_{2.5}$ Concentrations and Daily Exceedances (µg/m^3) [Criteria - 25 µg/m^3]

Receptor	Predicted Max 24-Hour $PM_{2.5}$ Concentrations (µg/m^3) with Daily Exceedances							
	Current Scenario		Stage 1 Scenario		Stage 2 Scenario		Stage 4 Scenario	
	Total	No. of Exceedances	Total	No. of Exceedances	Total	No. of Exceedances	Total	No. of Exceedances
122B Duns Creek Road	23.6	0	23.6	0	23.6	0	23.6	0
16 Uffington Road	23.6	0	23.6	0	23.6	0	23.6	0
60 Green Wattle Creek Road	23.6	0	23.6	0	23.6	0	23.6	0
34 Timber Top Road	23.6	0	23.6	0	23.6	0	23.6	0
35 Timber Top Road	23.6	0	23.6	0	23.6	0	23.6	0
36 Timber Top Road	23.6	0	23.6	0	23.6	0	23.6	0
13 Mooghin Rd	23.8	0	24.5	0	24.6	0	24.0	0
14 Mooghin Rd	24.0	0	24.2	0	24.2	0	23.9	0
13 Giles Road	23.6	0	23.6	0	23.6	0	23.6	0
13B Giles Road	23.6	0	23.6	0	23.6	0	23.6	0
866 Clarence Town Road	24.2	0	24.3	0	24.4	0	23.6	0
888 Clarence Town Road	24.0	0	23.8	0	23.9	0	23.8	0
994 Clarence Town Road	24.4	0	24.4	0	24.6	0	25.6	0
1034 Clarence Town Road	24.1	0	23.9	0	24.1	0	26.1	0
1060 Clarence Town Road	24.7	0	24.4	0	24.6	0	25.8	0
1094 Clarence Town Road	24.2	0	24.5	0	24.5	0	24.2	0
1189 Clarence Town Road	23.8	0	23.9	0	23.9	0	24.2	0
1203 Clarence Town Road	23.7	0	23.8	0	23.8	0	24.1	0

The maximum background concentration with exceedances removed (as discussed in ***Section 6.3***) was 23.6 µg/m^3, which occurred on 22/10/2013. As this high value is close to the criteria, a review of the incremental increases on this date has been undertaken. During Stage 4 two receptors will exceed the criteria as a result of this high background concentration on 22/10/2013 and the other receptor will exceed due a background concentration of 23 µg/m^3 on 24/10/2013.

At 1060 Clarence Town Road, the $PM_{2.5}$ predictions are higher for the current scenario than the Stage 1 results. A review of the sources has identified this is likely to be from the length of the haul road which is short for Stage 1. Additionally, the maximum concentrations occur on different days, as highlighted by the different background concentrations as **Table 9-8.**

Maximum Incremental Contemporaneous Results

The predicted contemporaneous 24-hour average $PM_{2.5}$ is presented in **Table 9-8** for each assessment stage. The contemporaneous concentrations are the predicted pollutant concentrations added to the daily monitoring results from Beresfield as discussed in ***Section 6.3***. For each receptor location, the highest predicted concentration occurs at different times, therefore the background concentrations vary. The incremental increase for each sensitive receptor is presented in ***Table 9-9***.

Table 9-8: Maximum Incremental Contemporaneous 24-Hour Average $PM_{2.5}$ Concentrations (µg/m^3) [Criteria - 25 µg/m^3]

Receptor	Predicted Max 24-Hour Average Contemporaneous $PM_{2.5}$ Concentrations with Background Concentrations (µg/m^3)							
	Current Scenario		Stage 1 Scenario		Stage 2 Scenario		Stage 4 Scenario	
	Total	Background	Total	Background	Total	Background	Total	Background
122B Duns Creek Road	7.2	6.3	7.4	6.3	7.3	6.3	6.8	6.3
16 Uffington Road	2.0	1.6	2.1	1.6	2.1	1.6	2.0	1.6
60 Green Wattle Creek Road	5.6	4.7	5.8	4.7	5.8	4.7	4.2	3.4
34 Timber Top Road	2.7	2.1	2.8	2.1	7.0	6.2	4.3	3.8
35 Timber Top Road	5.6	5.2	2.7	2.1	2.7	2.1	4.2	3.8
36 Timber Top Road	5.7	5.2	2.8	2.1	2.8	2.1	4.3	3.8
13 Mooghin Rd	12.6	9.8	11.1	7.8	10.1	6.9	10.6	8.6
14 Mooghin Rd	10.1	8.1	10.1	6.3	10.5	6.3	9.4	8.1
13 Giles Road	6.2	2.8	8.6	2.8	8.8	2.8	4.9	2.8
13B Giles Road	10.0	6.8	11.4	8.2	11.6	8.2	10.7	8.2
866 Clarence Town Road	9.2	5.8	8.7	5.0	8.7	5.0	15.5	11.0
888 Clarence Town Road	9.1	5.0	6.0	2.5	6.0	2.5	8.9	4.8
994 Clarence Town Road	16.8	12.9	16.6	12.9	17.2	12.9	16.5	9.6
1034 Clarence Town Road	15.4	11.4	14.3	11.4	11.1	8.0	16.7	8.0
1060 Clarence Town Road	14.0	8.0	12.5	8.0	12.5	8.0	13.4	10.2
1094 Clarence Town Road	14.9	12.3	10.4	8.9	10.5	8.9	15.6	10.9
1189 Clarence Town Road	15.0	8.8	15.3	8.8	15.8	8.8	14.5	8.1
1203 Clarence Town Road	13.8	8.8	21.1	15.5	21.3	15.5	13.3	8.1

It should be noted that background concentrations for some receptors change due to the change in location of sources and the corresponding day when the maximum results are recorded (due to weather conditions).

The predicted incremental increase in 24-hour average $PM_{2.5}$ is presented in ***Table 9-9*** for each assessment stage. It can be seen from ***Table 9-9*** that this highest 24-hour average incremental increase is 8.7 µg/m^3 at 1034 Clarence Town Road during Stage 4, when the processing plant has been relocated.

Table 9-9: Maximum 24-Hour Average Incremental $PM_{2.5}$ Concentrations (µg/m^3)

Receptor	Predicted 24-Hour Average Incremental $PM_{2.5}$ Concentrations (µg/m^3)			
	Current	Stage 1	Stage 2	Stage 4
122B Duns Creek Road	0.9	1.1	1.0	0.5
16 Uffington Road	0.4	0.5	0.5	0.4
60 Green Wattle Creek Road	0.9	1.1	1.1	0.8
34 Timber Top Road	0.6	0.7	0.8	0.5
35 Timber Top Road	0.4	0.6	0.6	0.4
36 Timber Top Road	0.5	0.7	0.7	0.5
13 Mooghin Rd	2.8	3.3	3.2	2.0
14 Mooghin Rd	2.0	3.8	4.2	1.3
13 Giles Road	3.4	5.8	6.0	2.1
13B Giles Road	3.2	3.2	3.4	2.5
866 Clarence Town Road	3.4	3.7	3.7	4.5
888 Clarence Town Road	4.1	3.5	3.5	4.1
994 Clarence Town Road	3.9	3.7	4.3	6.9
1034 Clarence Town Road	4.0	2.9	3.1	8.7
1060 Clarence Town Road	6.0	4.5	4.5	3.2
1094 Clarence Town Road	2.6	1.5	1.6	4.7
1189 Clarence Town Road	6.2	6.5	7.0	6.4
1203 Clarence Town Road	5.0	5.6	5.8	5.2

9.4.2 Annual Average

The $PM_{2.5}$ annual average criterion of 8 µg/m^3 has been adopted for this assessment. **Table 9-10** presents the predicted total $PM_{2.5}$ concentrations at sensitive receptors for each assessment stage. A background $PM_{2.5}$ concentration of 8.1 µg/m^3 is included in the predictions.

Table 9-10: Predicted Total Annual Average $PM_{2.5}$ Concentrations (µg/m^3) [Criteria - 8 µg/m^3]

Receptor	Predicted Total Annual Average $PM_{2.5}$ Concentrations with Background Concentrations (µg/m^3)							
	Current Scenario		Stage 1 Scenario		Stage 2 Scenario		Stage 4 Scenario	
	Total	Background	Total	Background	Total	Background	Total	Background
122B Duns Creek Road	8.12	8.1	8.13	8.1	8.13	8.1	8.12	8.1
16 Uffington Road	8.11	8.1	8.11	8.1	8.11	8.1	8.11	8.1
60 Green Wattle Creek Road	8.14	8.1	8.14	8.1	8.15	8.1	8.14	8.1
34 Timber Top Road	8.12	8.1	8.13	8.1	8.13	8.1	8.12	8.1
35 Timber Top Road	8.12	8.1	8.12	8.1	8.12	8.1	8.12	8.1
36 Timber Top Road	8.12	8.1	8.12	8.1	8.12	8.1	8.12	8.1
13 Mooghin Rd	8.44	8.1	8.56	8.1	8.56	8.1	8.37	8.1
14 Mooghin Rd	8.34	8.1	8.44	8.1	8.43	8.1	8.28	8.1
13 Giles Road	8.25	8.1	8.34	8.1	8.33	8.1	8.25	8.1
13B Giles Road	8.30	8.1	8.35	8.1	8.39	8.1	8.3.0	8.1
866 Clarence Town Road	8.34	8.1	8.36	8.1	8.39	8.1	8.37	8.1
888 Clarence Town Road	8.41	8.1	8.42	8.1	8.44	8.1	8.42	8.1
994 Clarence Town Road	8.35	8.1	8.37	8.1	8.41	8.1	8.65	8.1
1034 Clarence Town Road	8.35	8.1	8.36	8.1	8.39	8.1	8.56	8.1
1060 Clarence Town Road	8.33	8.1	8.33	8.1	8.36	8.1	8.47	8.1
1094 Clarence Town Road	8.31	8.1	8.3	8.1	8.34	8.1	8.51	8.1
1189 Clarence Town Road	8.99	8.1	9.19	8.1	9.24	8.1	8.67	8.1
1203 Clarence Town Road	8.86	8.1	9.0	8.1	9.03	8.1	8.56	8.1

It can be seen from **Table 9-10** that the highest incremental increase in $PM_{2.5}$ concentration is 1.1 µg/m^3 which will occur at 1189 Clarence Town Road during Stage 2. **As such the annual $PM_{2.5}$ emissions from BHQ are not predicted to adversely impact upon the sensitive receptors**. A contour plot is presented in ***Appendix C***.

9.5 Respirable Crystalline Silica

The RCS annual average criterion of 3 µg/m^3 has been adopted for this assessment. ***Table 9-4*** presents the predicted total RCS concentrations at sensitive receptors for each assessment stage. A background RCS of 0.7 µg/m^3 is included in the predictions.

Table 9-4: Predicted Total Annual Average RCS Concentrations (µg/m^3) [Criteria – 3 µg/m^3]

Receptor	Predicted Total Annual Average RCS Concentrations (µg/m^3)			
	Current	Stage 1	Stage 2	Stage 4
122B Duns Creek Road	0.70	0.70	0.70	0.70
16 Uffington Road	0.70	0.70	0.70	0.70
60 Green Wattle Creek Road	0.70	0.70	0.70	0.70
34 Timber Top Road	0.70	0.70	0.70	0.70
35 Timber Top Road	0.70	0.70	0.70	0.70
36 Timber Top Road	0.70	0.70	0.70	0.70
13 Mooghin Rd	0.71	0.72	0.71	0.71
14 Mooghin Rd	0.71	0.71	0.71	0.71
13 Giles Road	0.70	0.71	0.71	0.70
13B Giles Road	0.71	0.71	0.71	0.71
866 Clarence Town Road	0.71	0.71	0.71	0.71
888 Clarence Town Road	0.71	0.71	0.71	0.71
994 Clarence Town Road	0.71	0.71	0.71	0.72
1034 Clarence Town Road	0.71	0.71	0.71	0.71
1060 Clarence Town Road	0.71	0.71	0.71	0.71
1094 Clarence Town Road	0.71	0.71	0.71	0.71
1189 Clarence Town Road	0.73	0.74	0.74	0.72
1203 Clarence Town Road	0.72	0.73	0.73	0.71

It can be seen from ***Table 9-4*** that the highest predicted RCS concentration is 0.74 µg/m^3, which will occur during Stage 2 at 1189 Clarence Town Road.

Overall, the RCS concentration is below the criterion and is not expected to impact on the nearby sensitive receptors. A contour plot is presented in ***Appendix C***.

9.6 Dust Deposition

The predicted incremental increase in monthly average dust deposition is presented in ***Table 9-5*** for each assessment stage. The assessment criterion for dust deposition is a maximum incremental increase of 2 g/m^2/month. It can be seen from ***Table 9-5*** that the highest incremental increase in dust deposition is 0.78 g/m^2/month, which will occur at 13 Mooghin Road and 1189 Clarence Town Road during Stages 1, 2 and 4.

When the background dust deposition level of 2.1 g/m^2/month is applied to the predictions detailed in ***Table 9-5***, the highest dust deposition monthly average is 2.88 g/m^2/month, which complies with the total dust deposition criterion of 4 g/m^2/month.

Overall, the predicted levels comply with the incremental increase and the total dust deposition criteria and therefore dust is not expected to be a nuisance for sensitive receptors.

Table 9-5: Predicted Monthly Average Incremental Dust Deposition (g/m^2/month) [Criteria – 2 g/m^2/month]

Receptor	Predicted Annual Average Incremental Dust Deposition (g/m^2/month)			
	Current	Stage 1	Stage 2	Stage 4
122B Duns Creek Road	0.01	0.03	0.03	0.01
16 Uffington Road	0.01	0.02	0.02	0.01
60 Green Wattle Creek Road	0.01	0.03	0.03	0.02
34 Timber Top Road	0.02	0.05	0.05	0.02
35 Timber Top Road	0.02	0.04	0.04	0.02
36 Timber Top Road	0.02	0.04	0.05	0.02
13 Mooghin Rd	0.34	0.78	0.76	0.23
14 Mooghin Rd	0.27	0.61	0.61	0.16
13 Giles Road	0.07	0.17	0.18	0.06
13B Giles Road	0.03	0.06	0.07	0.02
866 Clarence Town Road	0.03	0.07	0.07	0.05
888 Clarence Town Road	0.04	0.08	0.09	0.05
994 Clarence Town Road	0.03	0.07	0.08	0.09
1034 Clarence Town Road	0.03	0.07	0.08	0.07
1060 Clarence Town Road	0.03	0.06	0.07	0.05
1094 Clarence Town Road	0.02	0.04	0.06	0.07
1189 Clarence Town Road	0.33	0.73	0.75	0.25
1203 Clarence Town Road	0.14	0.33	0.34	0.16

9.7 Summary of Results

The results of the modelling have shown that during all Stages, the TSP, dust deposition and RSC predictions comply with the relevant criteria and averaging periods.

For most sensitive receptors the maximum daily PM_{10} concentrations are driven by the background concentrations obtained from Beresfield monitoring station. A review of the incremental PM_{10} increases on the day of the highest background concentration has identified:

- During Current operations one receptor is predicted to exceed the criteria, this exceedance occurs on 22/10/2013;
- During Stage 1 four of the eight receptors will exceed the criteria as a result of this high background concentration on 22/10/2013;
- During Stage 2 five of the nine receptors will exceed the criteria as a result of this high background concentration on 22/10/2013; and
- During Stage 4 all three receptors will exceed the criteria as a result of this high background concentration on 22/10/2013. Two receptors exceed for one day and one receptor exceeds for two days, for a total of four days.

The exceedances of annual $PM_{2.5}$ concentrations are driven by the high background concentration which already exceeds the criterion of µg/m^3.

As discussed previously and in ***Section 10***, the modelling of Stage 4 does not take into consideration the 18 m high bund which will protect these receptors. The summary of results for all Stages is presented in ***Table 9-6*** and shows that compliance with the criteria is achieved for TSP, dust deposition (both total and incremental), RCS and the annual concentration of PM_{10}.

Table 9-6: Summary of Results for All Stages

Pollutant	Time Basis	Criteria	Maximum Predicted Concentrations at Any Receptor				Compliant
			Current	Stage 1	Stage 2	Stage 4	
TSP	Annual	90 µg/m^3	50.3	58.9	61.0	48.5	✓
PM_{10}	24 Hour	50 µg/m^3	50.4	68.0	70.8	53.1	×
	Annual	30 µg/m^3	23.5	26.5	26.9	22.8	✓
$PM_{2.5}$	24 Hour	25 µg/m^3	24.7	24.5	24.6	26.1	✓
	Annual	8 µg/m^3	8.4	9.2	9.2	8.67	×
Dust Deposition	Monthly Total	4 g/m^2/month	2.4	2.9	2.9	2.3	✓
	Monthly Increase	2 g/m^2/month	0.3	0.8	0.8	0.2	✓
RSC	Annual	3 µg/m^3	0.73	0.74	0.74	0.72	✓

10 BLAST FUME

The dust impacts from blasting have been assessed in ***Section 9***; however blasting activities have the potential to generate noxious gases such as NO_2 and CO as well as dust. Blast fume emissions can vary greatly depending on a number of factors but largely depend on the tendency of a particular blast (or holes within the shot) to generate significant NO_2 emissions.

Blasting operations at Brandy Hill are undertaken by Maxam Australia which use RIOFLEX MX 10000 as the explosive. The bulk load of explosive for Brandy Hill in the past 12 months is shown in ***Table 10-1***. The average blast is 12,035 kg per blast.

Table 10-1: Blasting History at Brandy Hill [Maxam Australia, 2016]

Date	Average of Quantity (kg)	Count of Count	Sum of Quantity (kg)
31/03/2015	6050	2	12100
30/04/2015	5739	1	5739
31/05/2015	6470	2	12940
30/06/2015	5067	2	10134
31/07/2015	3667	3	11000
31/08/2015	5460	1	5460
30/09/2015	6725	2	13450
31/10/2015	7764	3	23293
30/11/2015	5810	2	11620
31/12/2015	11080	1	11080
31/01/2016	8775	2	17549
29/02/2016	10058	1	10058
Average	6889	1.8	12035
Total	**82665**	**22**	**144423**

The NPI Emission Estimation Technique Manual for Explosives Detonation and Firing Ranges (Department of Sustainability, Environment, Water, Population and Communities, 2012) provides the following emission factors:

- NO_X – 0.2 kg/tonne of explosive; and
- CO – 17 kg/tonne of explosive.

It is assumed that the blasting requirements remain similar to the current situation; using the average quantity of explosives per blast (12,035kg) the resultant emissions are:

- NO_X –2,407 kg/blast or 28.9 tonnes/annum; and
- CO – 204,600 kg/blast or 2,455.2 tonnes/annum.

When these values are compared to the NSW EPA emissions inventory for the site postcode as presented in ***Figure 10-1***, it can be seen that similar values for the human emissions inventory for NO_X and CO are already included in the chart. It has been assumed that these emissions are from the existing operations at Brandy Hill as the quarry has been in operation since 1983, therefore an increase in NO_X or CO emissions is not expected.

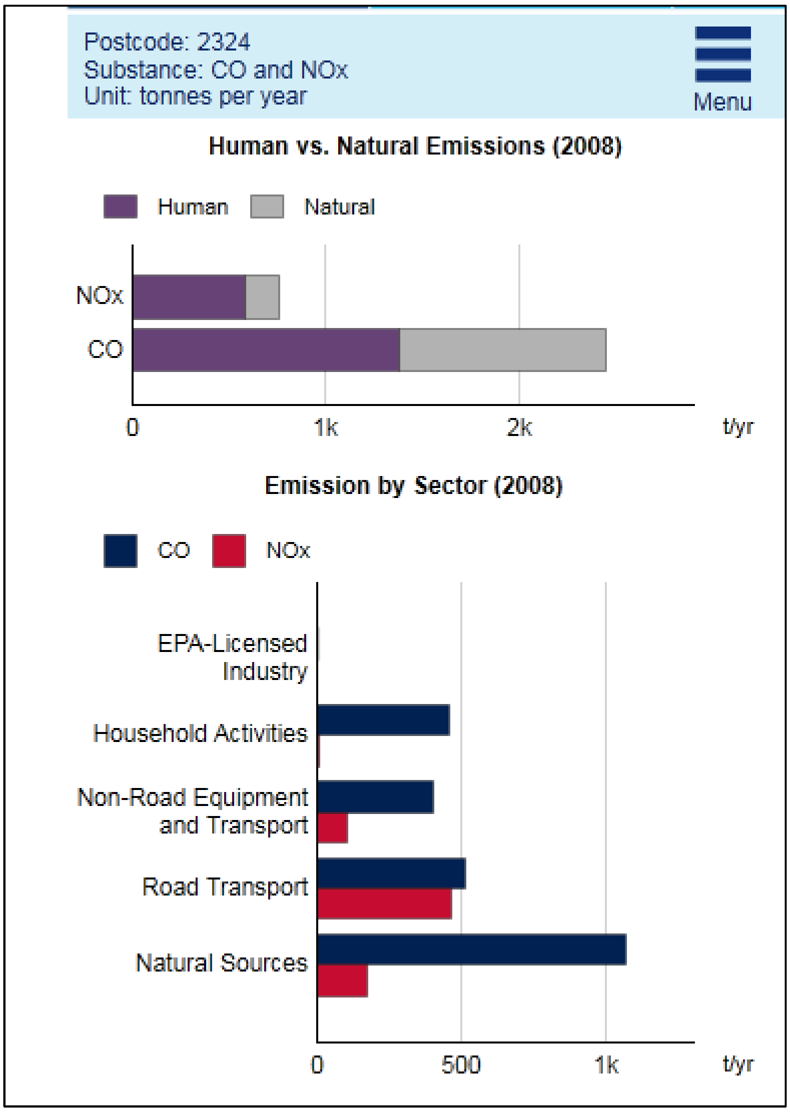


Figure 10-1: Emission Estimation for Postcode 2324

11 MITIGATION & MONITORING

11.1 Overview

Table 10-1 provides an overview of the mitigation measures considered as part of this Project. All operational mitigation and the future bund and air quality management plan are additional mitigation measures to limit the dust impacts. Hanson have committed to both the operational and future mitigation.

Table 11-1: Overview of Mitigation Measures

Mitigation Measures Considered	Modelled/proposed
Watering of haul roads	Modelled (see Appendix B3 for more information)
Enclosed Screens	Modelled (see Appendix B3 for more information)
Enclosed Crushers	Modelled (Stage 4 only)
Loading Stockpiles	Modelled (see Appendix B3 for more information)
Enclosed conveyors	Modelled (Stage 4 only)
Bund	Proposed
Air quality management plan (***Appendix D***)	Proposed procedures for on-going dust control

11.2 Dust Mitigation

Appendix B presents the emission controls applied as provided by Hanson. These controls include continual watering of the haul road, variable stacking height and enclosed crushing equipment. The future mitigation measures also include: fully enclosing the screen (Stage 4), pit retention (Stage 4), enclosed conveyors with filters (Stage 4) and revegetation of the bund (Stage 4). The mitigation measures are modelled for Stage 4 as this is when the Project is complete, as reflected in ***Table 11-2***.

From the Table it can be seen that crushers and screens and the conveyors were generating the significant emissions during the current, Stage 1 and Stage 2 phases. These sources are virtually eliminated through engineering controls specifically designed to control dust. As a result of controlling these dust sources, the contributions from vehicle movements (mobile plant, haul truck and product truck movements) become more significant. These emissions will be controlled through water suppression; with more frequent suppression occurring during dry weather conditions and when dust is visible.

Hanson is committed to limiting the dust emissions through water suppression and management (i.e. most truck movements will occur during the day when receptors are likely to be away from the house).

Table 11-2: Emissions Contributions by Source

Activity	Percentage of emissions			
	Current	Stage 1	Stage 2	Stage 4
Drilling and Blasting	1.8%	0.8%	0.7%	1.5%
Mobile Plant	32.1%	32.2%	29.2%	57.9%
Haul Truck Movements	12.9%	13.8%	18.9%	27.7%
Raw Material Unloading	0.1%	0.1%	0.1%	0.1%
Stockpile Loading	0.1%	0.1%	0.1%	0.2%
Wind erosion	1.5%	0.7%	0.6%	1.2%
Crushers & Screens	24.6%	24.7%	22.4%	0.0%
Conveyors	21.4%	21.5%	19.5%	0.4%
Product Truck Movements	5.6%	5.7%	5.1%	5.2%
Bund Construction	0.0%	0.5%	0.4%	0.0%
Concrete Plant	0.0%	0.0%	2.9%	5.8%
Total	**100%**	**100%**	**100%**	**100%**

The construction of an 18 m bund at the southern boundary of the future processing area will assist in limiting the dispersal of the ground-borne particulate emissions, as shown in ***Figure 11-1***. The height of the conveyors and the relocated quarry plant/equipment will not protrude above the bund and therefore the emissions are expected to be significantly reduced at sensitive receptors along Clarence Town Road. Due to the limitations of the CALPUFF software, the bund could not be modelled as a mitigation measure to prevent the dispersal of pollutants.

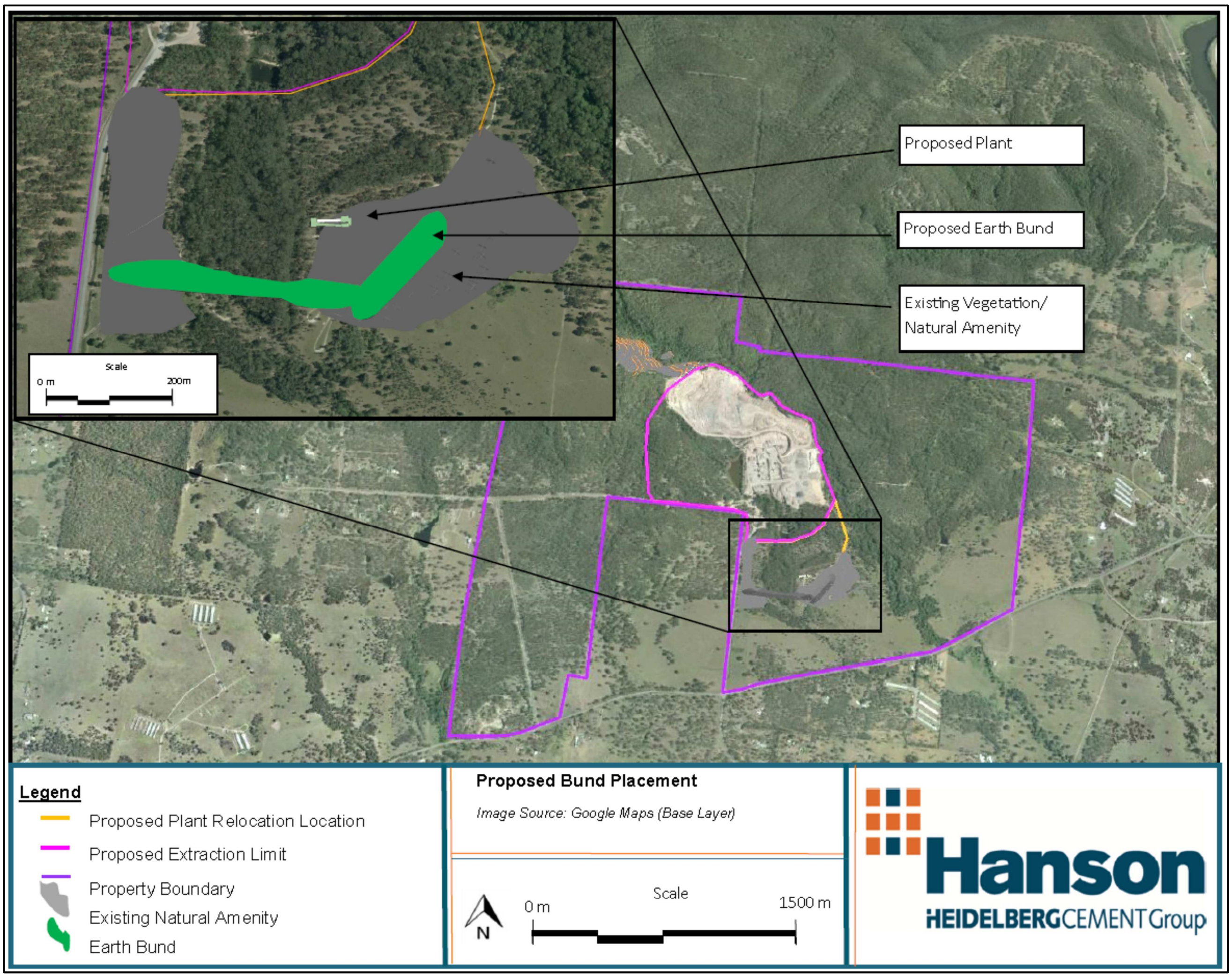


Figure 11-1: Proposed Bund Location [Hanson, 2014]

General dust control measures are currently employed by Hanson and these measures will continue. In addition it is recommended that the following measures are undertaken to reduce dust emissions:

- Minimise the potential for dust emissions from the construction of the bund by either watering, screening or revegetation;
- Minimise the potential for dust emissions from unpaved haul roads and exposed ground by watering a minimum of $2L/m^2/h$ during dry conditions or more frequently when required;
- Minimise the potential for dust emissions from stockpile wind erosion by watering where applicable;
- Maintain a wheel wash at the exit of BHQ to remove dust from vehicle wheels. This will reduce the likelihood of dust visibly accumulating on the road.

An air quality management plan is provided in ***Appendix D***; this management plan outlines general practices which will reduce dust emissions from the operation of BHQ.

11.3 Diesel Emissions

All vehicles and mobile plant are required to comply with the Protection of the Environment Operations (POEO) Act 1997 and the Clean Air Regulations (NSW EPA, 2013). This will be achieved through regular maintenance of vehicles, which when coupled with the distances between the Project site and the sensitive receptors, the overall impact will be negligible.

11.4 Air Monitoring Network

The current environment licence (licence number 1879 dated 29th April 2013) stipulates three dust deposition monitoring locations are sufficient.

In the Director General Requirements (DGR's) for this Project, the EPA state that they are moving away from dust deposition monitoring due to a more proactive real-time data collection methods for PM_{10}. The EPA has requested that the cost benefit analysis of Hi Volume Sampling and Tapered Element Oscillating Microbalance (TEOM) is undertaken, as shown in ***Table 11-3***. Additionally, dust deposition monitoring has also been included to outline the differences in measurement techniques.

Table 11-3: PM_{10} Measurement Technique Cost Benefit Analysis

Measurement Technique	Benefits	Disadvantages	Australian Standard
Hi Volume Sampler	The particulate concentration is calculated at a laboratory based on the total mass of the sample divided by the volume of air drawn through the filter paper. The filter can be analysed for further analysis such as RCS.	Time resolution is limited to 24 hour and the results are only available several days after the measurement. Estimated precision - ±2 µg/m^3	AS/NZS 3580.9.6:2003
TEOM	Provide real-time data with short resolution (<1 hour) that can be used for proactive particulate control. Estimated precision - ±0.5 µg/m^3	High capital costs.	AS/NZS 3580.9.8-2001
Dust Deposition Gauges	Low capital costs	30 day average deposition to determine nuisance	AS/NZS 3580.10.1-2003

Based on this assessment, consideration should be given to the installation of particulate monitoring equipment as recommended in the NSW Approved Methods for the Sampling and Analysis of Air Pollution or as otherwise agreed by the DP&E at the fence-line of the quarry (as close to Clarence Town Road as possible). Additionally, the installation of a meteorological station at BHQ would be beneficial to provide more accurate wind conditions at the site rather than using the Tocal AWS which is not considered to be representative of local wind conditions.

The installation of particulate monitoring equipment and weather station will allow proactive dust management techniques to be employed to reduce the likelihood of complaints and exceedances. Any equipment must be installed, maintained and sited in accordance with (Department of Environment & Conservation, 2007).

12 GREENHOUSE GAS

A greenhouse gas assessment has been undertaken for this project. This assessment determines the carbon dioxide equivalent (CO_2-e) emissions from the project according to international and Federal guidelines.

Greenhouse gases include water vapour, carbon dioxide (CO_2), methane, nitrous oxide and some artificial chemicals such as chlorofluorocarbons (CFCs). Water vapour is the most abundant greenhouse gas. These gases vary in effect and longevity in the atmosphere, but scientists have developed a system called Global Warming Potential to allow them to be described in equivalent terms to CO_2 (the most prevalent greenhouse gas) called equivalent carbon dioxide emissions (CO_2-e). A unit of one tonne of CO_2-e (t CO_2-e) is the basic unit used in carbon accounting. An emissions inventory, or 'carbon footprint', is calculated as the sum of the emission rate of each greenhouse gas multiplied by the global warming potential.

The Department of the Environment (DOE) monitors and compiles databases on anthropogenic activities that produce greenhouse gases in Australia. The DOE has published greenhouse gas emission factors for a range of anthropogenic activities. The DOE methodology for calculating greenhouse gas emissions is published in the National Greenhouse Accounts (NGA) Factors workbook ((Department of Environment, 2014). This workbook is updated regularly to reflect current compositions in fuel mixes and evolving information on emission sources.

The scope that emissions are reported, as defined by the NGA Factors Workbook is determined by whether the activity is within the organisation's boundary (Scope 1 – Direct Emissions) or outside the organisation's boundary (Scopes 2 and 3 – Indirect Emissions). Emission factors used in this assessment have been derived from either the Department of Environment, site-specific information or from operational details obtained from similar emission sources.

The purpose of this report is to evaluate the GHG emissions from the operation of BHQ. Calculating the GHG emissions for the life of the BHQ, based on an extraction rate of 1.5 Mtpa for 30 years the following GHG emissions are expected:

- Scope 1 emissions: 296,072.5 tonnes CO_2-equivalent;
- Scope 2 emissions: 85,426.5 tonnes CO_2-equivalent; and
- Scope 3 emissions: 41,242.5 tonnes CO_2-equivalent.

The full greenhouse gas assessment is presented in ***Appendix E***.

13 CONCLUSION

Hanson proposes to expand BHQ to a production rate of 1.5 Mtpa and relocate the processing plant. The purpose of this air quality assessment is to evaluate the potential impacts of pollutants generated from the proposed stages of the expansion and to provide recommendations to mitigate and minimise any potential impacts that might have an effect on nearby sensitive receptors.

The main air emissions from BHQ operations are caused by wind-borne dust, vehicle usage, materials handling and transfers. A major source of dust will be from the construction of an 18 m high bund at the southern boundary of the quarry, but this will be a temporary activity. Once completed, the bund will provide long-term attenuation benefits by limiting the dispersal of the ground-borne particulate emissions, such as PM_{10} from the quarry.

In order to assess the impact of a quarry expansion on the receiving environment, the incremental impact is quantified and added to existing background pollutant concentrations. Vipac has used dust deposition monitoring results from BHQ as well as daily particulate monitoring data from NSW EPA site at Beresfield in the predictions. For the purposes of accurate predictions, the modelling simulated different Stages of the project:

- Current - Current site operations with an annual production rate of 0.7 Mtpa;
- Stage 1 - Proposed site operations with an annual production rate of 1.5 Mtpa with the construction of the bund but without the concrete batching plant;
- Stage 2 - Proposed site operations with an annual production rate of 1.5 Mtpa including the construction of the bund and the concrete batching plant; and
- Stage 4 - Proposed site operations with an annual production rate of 1.5 Mtpa including the concrete batching plant and relocation of the fixed plant. At Stage 4, the bund to the southern boundary will be complete and will stand 18 m high.

The results of the modelling have shown that during all Stages, the TSP, dust deposition and RSC predictions comply with the relevant criteria. For most sensitive receptors the maximum daily and annual PM_{10} and $PM_{2.5}$ concentrations are driven by the background concentrations obtained from Beresfield monitoring station.

The exceedances of annual $PM_{2.5}$ concentrations are driven by the high background concentration which already exceeds the criterion of $\mu g/m^3$. The results have shown that the proposed efficiency controls for the processing plant as modelled during Stage 4 significantly reduce the particulate emissions and impact on sensitive receptors. Frequency analysis has identified that during Stage 4, three receptors will exceed the PM_{10} criteria for a total of four days. The modelling of Stage 4 does not take into consideration the 18 m high bund which will protect these receptors.

The construction of an 18 m bund at the southern boundary of the future processing area will assist in limiting the dispersal of the ground-borne particulate emissions. The height of the conveyors and other plant will not protrude above the bund and therefore the emissions are expected to be significantly reduced at sensitive receptors along Clarence Town Road.

Recommendations for the installation of particulate monitoring equipment as detailed in the NSW Approved Methods or as otherwise agreed by the DP&E and weather station have been made. This would allow proactive dust controls measures to be enforced to reduce the likelihood of exceedances and complaints.

A greenhouse gas assessment has been undertaken for this project. This assessment determines the carbon dioxide equivalent (CO_2-e) emissions from the project according to international and Federal guidelines. Calculating the GHG emissions for the life of the BHQ, based on an extraction rate of 1.5 Mtpa for 30 years the following GHG emissions are expected:

- Scope 1 emissions: 296,027.5 tonnes CO_2-equivalent;
- Scope 2 emissions: 85,426.5 tonnes CO_2-equivalent; and
- Scope 3 emissions: 41,242.5 tonnes CO_2-equivalent.

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Appendix A: GLOSSARY

Ambient Monitoring	Ambient monitoring is the assessment of pollutant levels by measuring the quantity and types of certain pollutants in the surrounding, outdoor air.
AWS	Automatic Weather Station
BHQ	Brandy Hill Quarry (project site)
BOM	Bureau of Meteorology
Carbon Dioxide Equivalent	A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (expressed as CO_2-e).
Conveyor	Mechanical handling equipment (which may include a belt, chain or shaker) used to move materials from one location to another.
Deforestation	Conversion of forested lands for non-forest uses.
Deposited Matter	Any particulate matter that falls from suspension in the atmosphere
Dust	Generic term used to describe fine particles that are suspended in the atmosphere. The term is nonspecific with respect to the size, shape and chemical composition of the particles.
Embodied energy	Energy consumed by all of the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery.
Emissions	Release of a substance (usually a gas) into the atmosphere.
Emissions Factor	Unique value for scaling emissions to activity data in terms of a standard rate of emissions per unit of activity (e.g., grams emitted per litre of fossil fuel consumed).
EPA	Environmental Protection Authority (NSW)
Fluorinated Gases	Powerful synthetic greenhouse gases such that are emitted from a variety of industrial processes.
Fluorocarbons	Carbon-fluorine compounds that often contain other elements such as hydrogen, chlorine, or bromine. Common fluorocarbons include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).
Fugitive Dust	Dust derived from a mixture of not easily defined sources. Dust is commonly derived from such non-point sources such as vehicular traffic on unpaved roads, materials transport and handling
Global Warming Potential	Measure of the total energy that a gas absorbs over a particular period of time (usually 100 years), compared to carbon dioxide.
Greenhouse Gas (GHG)	Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride.
Haul Roads	Roads used to transport extracted materials by truck around a mine/quarry site

Hydrocarbons	Substances containing only hydrogen and carbon. Fossil fuels are made up of hydrocarbons.
Hydrochlorofluorocarbons	Compounds containing hydrogen, fluorine, chlorine, and carbon atoms. Although ozone depleting substances, they are less potent at destroying stratospheric ozone than chlorofluorocarbons.
Hydrofluorocarbons (HFCs)	Compounds containing only hydrogen, fluorine, and carbon atoms. HFCs are emitted as by-products of industrial processes and are also used in manufacturing.
Methane (CH_4)	A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 25 times that of carbon dioxide (CO_2).
mg	Milligram (g × 10^{-3})
Micron	Unit of measure µm (metre × 10^{-6})
Nuisance Dust	Dust which reduces environmental amenity without necessarily resulting in material environmental harm. Nuisance dust generally comprises particles greater than 10 micrograms.
OEH	Office of Environment & Heritage (NSW)
Overburden	Material of any nature that overlies a deposit of useful materials
PM_{10}	Particulate matter less than 10 microns in size
$PM_{2.5}$	Particulate matter less than 2.5 microns in size
TSP	Total Suspended Particles is particulate matter with a diameter up to 50 microns
µg/m^3	Micrograms per cubic metre

Appendix B: EMISSION ESTIMATION

B.1 EMISSION ESTIMATION EQUATIONS

The major air emission from extraction activities is fugitive dust. Emission factors can be used to estimate emissions of TSP, PM_{10} and $PM_{2.5}$ to the air from various sources. Emission factors relate the quantity of a substance emitted from a source to some measure of activity associated with the source. Common measures of activity include distance travelled, quantity of material handled, or the duration of the activity.

The National Pollutant Inventory Emission Estimation Technique Manual for Mining (January 2012) provide the equations and emission factors to determine the emissions of TSP and PM_{10} from mining and quarrying activities. These emission factors incorporate emission factors published by the USEPA in their AP-42 documentation.

Excavation on Overburden

The default emission rates in the NPI EET for Mining have been used for this emission factor.

Material Unloading

Emission rate for dust from stockpile has been calculated using the following emission rates from AP42 11.19.2:

TSP = PM_{10} multiplied by 2

PM_{10} = default of 0.00005

$PM_{2.5}$ = 15% of PM_{10} is $PM_{2.5}$

Crushing and Screening

The default emission rates in the NPI EET for Mining and AP42 11.19.2 have been used.

Drilling

The default emission rates in the NPI EET for Mining and have been used for these emission factors. 10% PM_{10} is $PM_{2.5}$. Six holes per day is the estimated rate.

Blasting

The TSP emission rate for blasting has been calculated using the following equation:

$$Emissions_{\text{TSP}} = 0.00022 \ x \ Area \ blasted \ (m^2)^{1.5} \text{ kg /blast}$$

PM_{10} is TSP multiplied by 0.52 and 10% of PM_{10} is $PM_{2.5}$. Area blasted is 1225 m^2 with 25 blasts per year.

In-Pit Retention

The default reductions as detailed in the NPI EET for Mining were applied to one pit in Stage 4 only as the pit is more than RL -50 m:

TSP = 50% reduction

PM_{10} and $PM_{2.5}$ = 5% reduction

Haul Roads

The dust emission rate from haul roads has been calculated using the following equation:

$$Emissions = \left(\frac{0.4536}{1.6093}\right) x\ k\ x \left(\frac{s_{(\%)}}{12}\right)^{\alpha} x \left(\frac{W_{(t)}}{3}\right)^{0.45} \text{ kg /VKT}$$

Where:

k = 4.9 for TSP, 1.5 for PM_{10} and 0.15 for $PM_{2.5}$.

$s_{(\%)}$ = surface material silt content (provided by Hanson for different particulate sizes)

W = mean vehicle weight (tons converted to tonnes)

a = 0.7 for TSP, 0.9 for PM_{10} and $PM_{2.5}$

Conveyors

The dust emission rate from conveyor transfer points has been calculated using the following equation:

$$Emissions = k\ x\ 0.0016 \frac{(U/_{2.2})^{1.3}}{(M/_{2})^{1.4}} \text{ kg /transfer point}$$

Where:

k = 0.74 for TSP, 0.35 for PM_{10}. 15% of PM_{10} is $PM_{2.5}$

U = mean wind speed (m/s)

M = material moisture content (1%)

Stockpile Loading

Emission rate for dust from stockpile has been calculated using the following emission rates from AP42 11.19.2:

TSP = PM_{10} multiplied by 2

PM_{10} = 0.00005

$PM_{2.5}$ = 15% of PM_{10} is $PM_{2.5}$

Wind Erosion

The emission rate for dust from stockpile has been calculated using the following equation for TSP:

$$Emissions = 1.9\ x \left(\frac{s_{(\%)}}{1.5}\right) x\ 365\ x \left(\frac{365-p}{235}\right) x \left(\frac{f_{(\%)}}{15}\right) \text{ kg /ha /yr}$$

Where:

$s_{(\%)}$ = silt content (provided by Hanson for different particulate sizes).

P = number of days per year when rainfall is greater than 0.25 mm. A review of the TAPM metrological data has determined there are 216 days where rainfall is greater than 0.25 mm.

$f_{(\%)}$ = percentage of time that wind speed is greater than 5.4 m/s at the mean height of the stockpile. The frequency of wind speed >5.4 m/s has been determined to be 7.8%.

The fraction of PM_{10} in TSP is 50% and $PM_{2.5}$ is 15% of PM_{10}

Meteorological parameters for emission estimation as determined by TAPM:

- Mean wind speed is 3.11 m/s;
- Percentage of time when wind speed >5.4 m/s is 7.8%; and
- Number of days with rainfall >0.25 mm is 216.

B.2 ACTIVITY OVERVIEW

Operating Hours

Extraction and processing of material has been modelled as 24 hours per day whilst the construction of the bund has been modelled as 12 hours per day.

Extraction Rates

The current extraction rate is 0.7 Mtpa and this expansion proposes a future extraction rate of 1.5 Mtpa for Stages 1, 2 and 4.

Table B-2-14-1: Extraction Rates Modelled

Activity	Modelling Scenario			
	Current	Stage 1	Stage 2	Stage 4
Annual Extraction Rate (Mtpa)	0.7	1.5	1.5	1.5
Daily Extraction Rate (tonnes)	1,918	4,110	4,110	4,110

Bund Construction

The construction of bund will occur in Stages 1 and 2 only at a rate of 70 days over 10 years. This equates to 24,198 m^3 of overburden per annum moved to create the bund. One excavator will be active on the bund during construction.

Haul Roads

Haul road locations for each scenario were provided by Hanson and incorporated into the model.

Table B-2-14-2: Haul Road Lengths Modelled

Total Haul Road Length	Modelling Scenario			
	Current	Stage 1	Stage 2	Stage 4
Extraction Pit (km)	1.4	0.7	3.1	0.7
Processing Area (km)	1.8	1.8	1.8	0.9

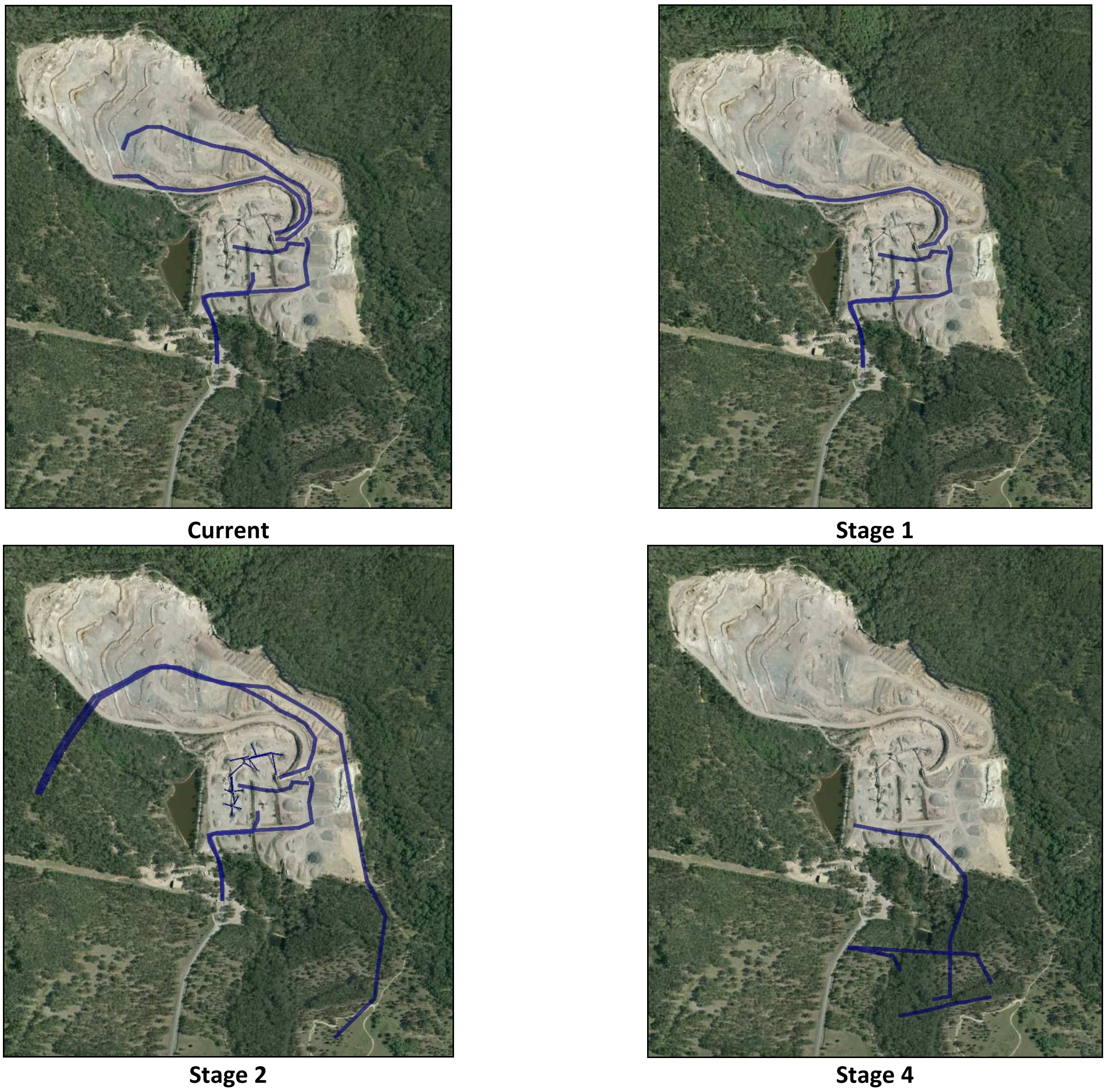


Figure B-2-14-1: Modelled Haul Road Locations [Hanson, February 2015]

Silt Content

Silt content data for Brandy Hill was provided by Hanson for particulates > 75 and < 2 um. Using the data the following silt content percentages were derived 7.5% for TSP, 4.5% for PM_{10} and 2% $PM_{2.5}$.

B.3 EMISSION CONTROLS APPLIED

The following control efficiencies were applied to each modelling scenario.

Table B-3-14-3: Control Efficiencies Applied to Emission Estimation

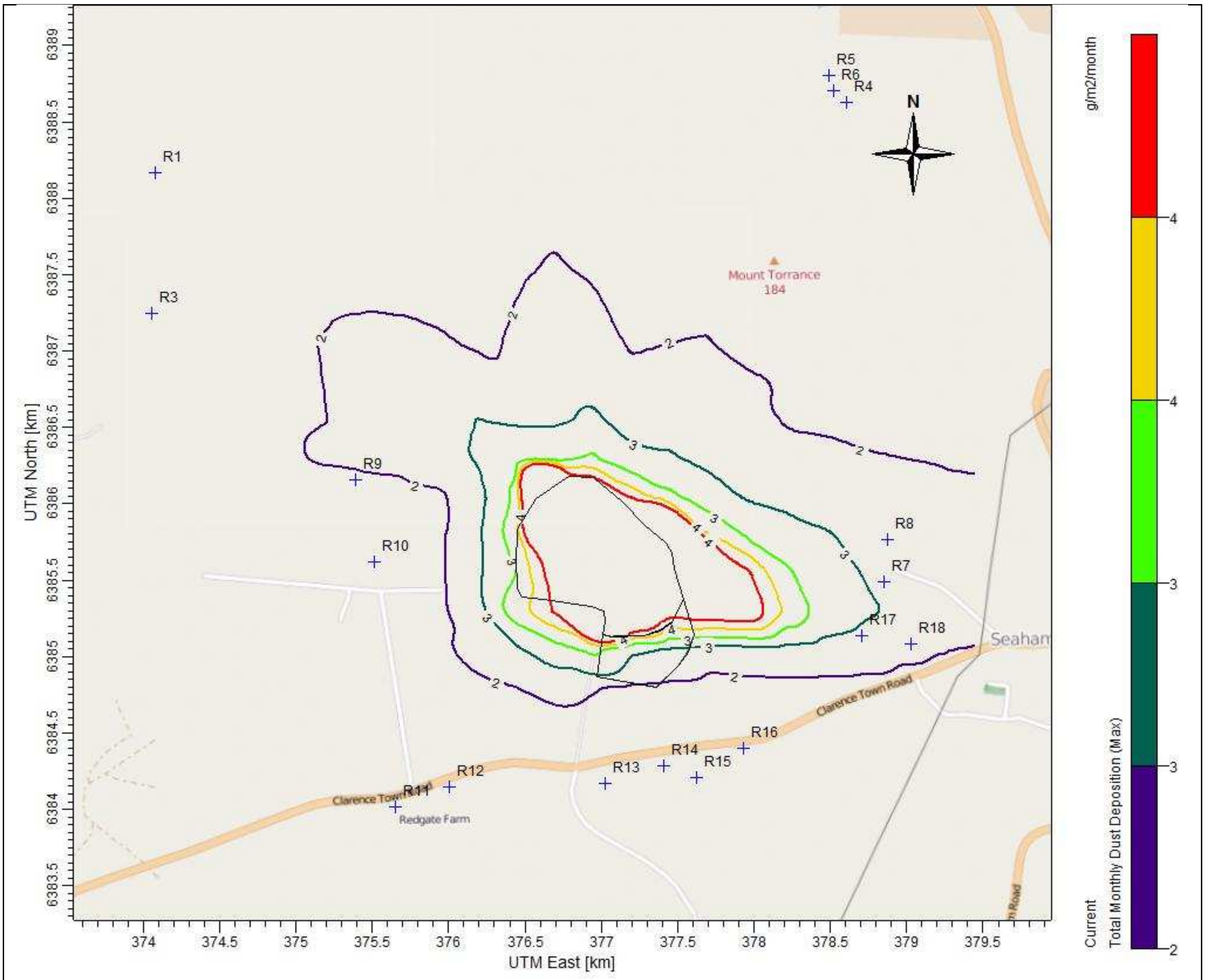
Activity	Modelling Scenario			
	Current	Stage 1	Stage 2	Stage 4
Haul Roads	Watering Level 1 (50%)	Watering Level 1 (50%)	Watering Level 1 (50%)	Watering Level 1 (50%)
Crushing	Enclosed (100%)	Enclosed (100%)	Enclosed (100%)	Enclosed (100%)
Screening	-	-	-	Enclosed (100%)
Loading Stockpiles	Variable Height Stacker (25%)	Variable Height Stacker (25%)	Variable Height Stacker (25%)	Variable Height Stacker (25%)
In-Pit Retention	-	-	-	NPI reductions
Conveyors	-	-	-	Enclosure and filters (99%)
Construction Bund Wind Erosion	-	-	-	Revegetation (99%)

Appendix C: CONTOUR PLOTS

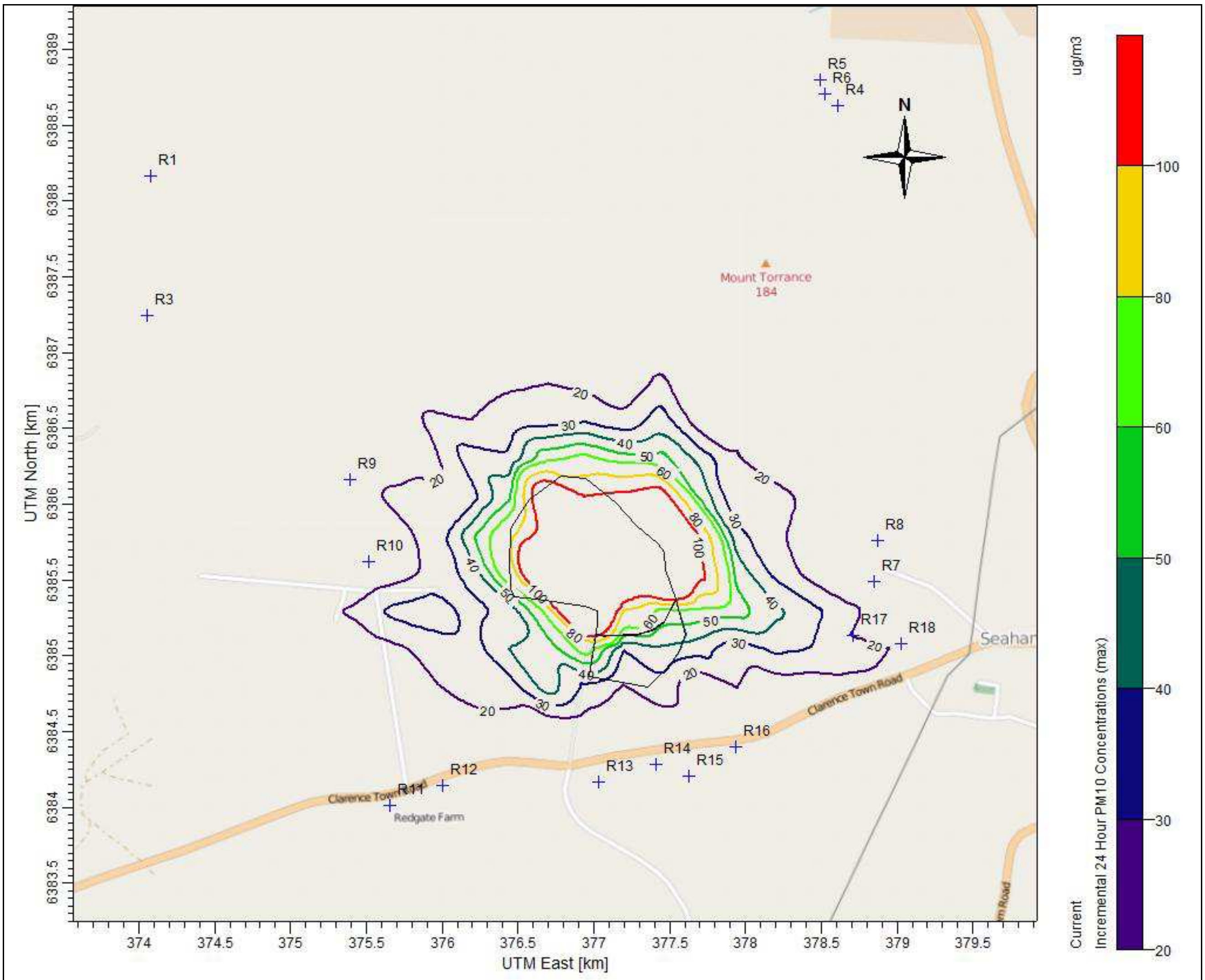
The contour plots are created from the predicted ground-level concentrations at the network of gridded receptors within the modelling domain at frequent intervals. These gridded values are converted into contours using triangulation interpolation in the CALPOST post-processing software within the CALPUFF View software (Version 7.2 - June 2014).

Contour plots illustrate the spatial distribution of ground-level concentrations across the modelling domain for each time period of concern. However, this process of interpolation causes a smoothing of the base data that can lead to minor differences between the contours and discrete model predictions.

C.1 CURRENT OPERATIONS

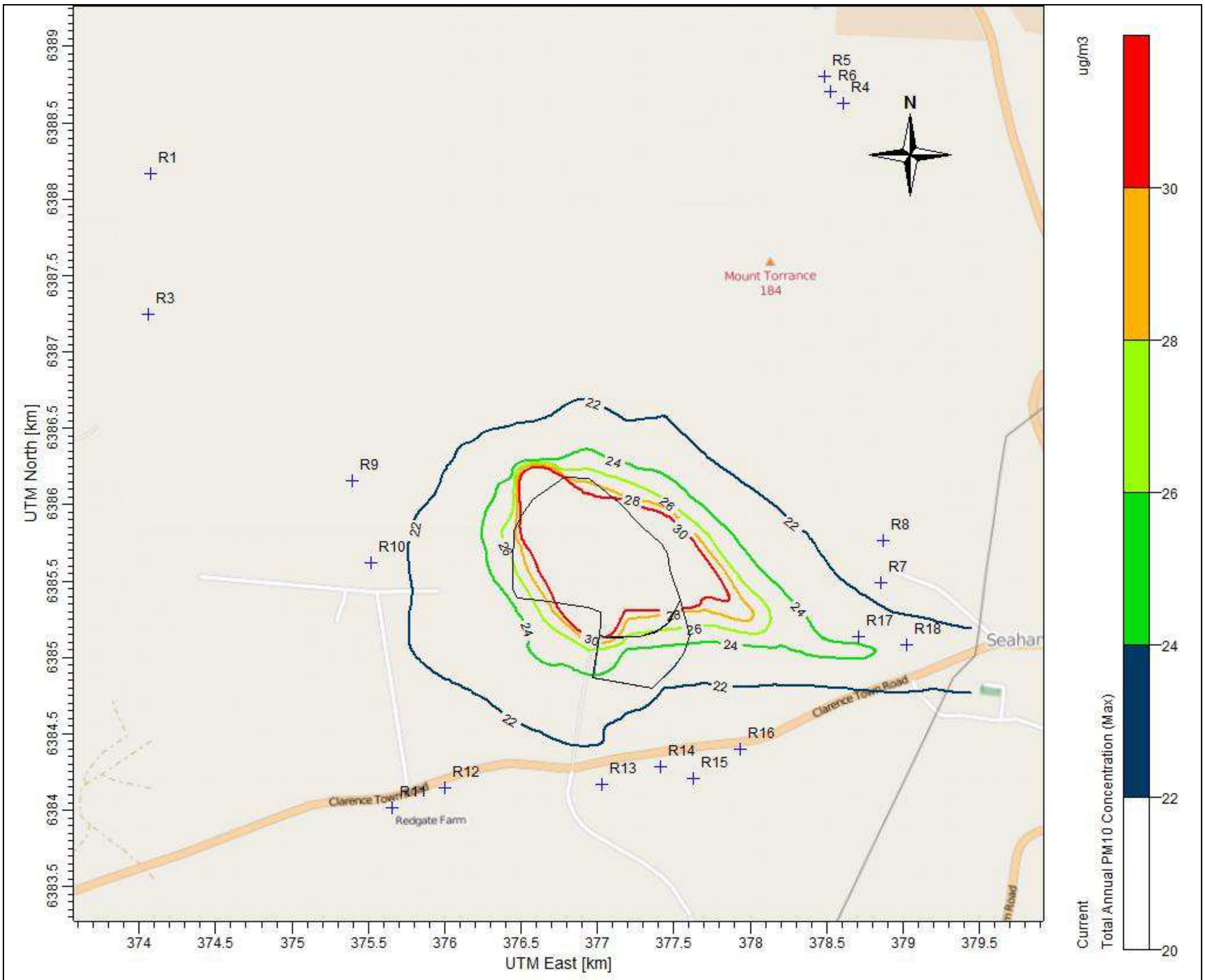


Pollutant: Dust Deposition	**Averaging Period:** Month	**Percentile:** 100th	**Criteria:** 4 g/m^2/month
Comment: Current operations in relation to the future quarry boundary and processing area. Includes background of 2.1 g/m^2/month			



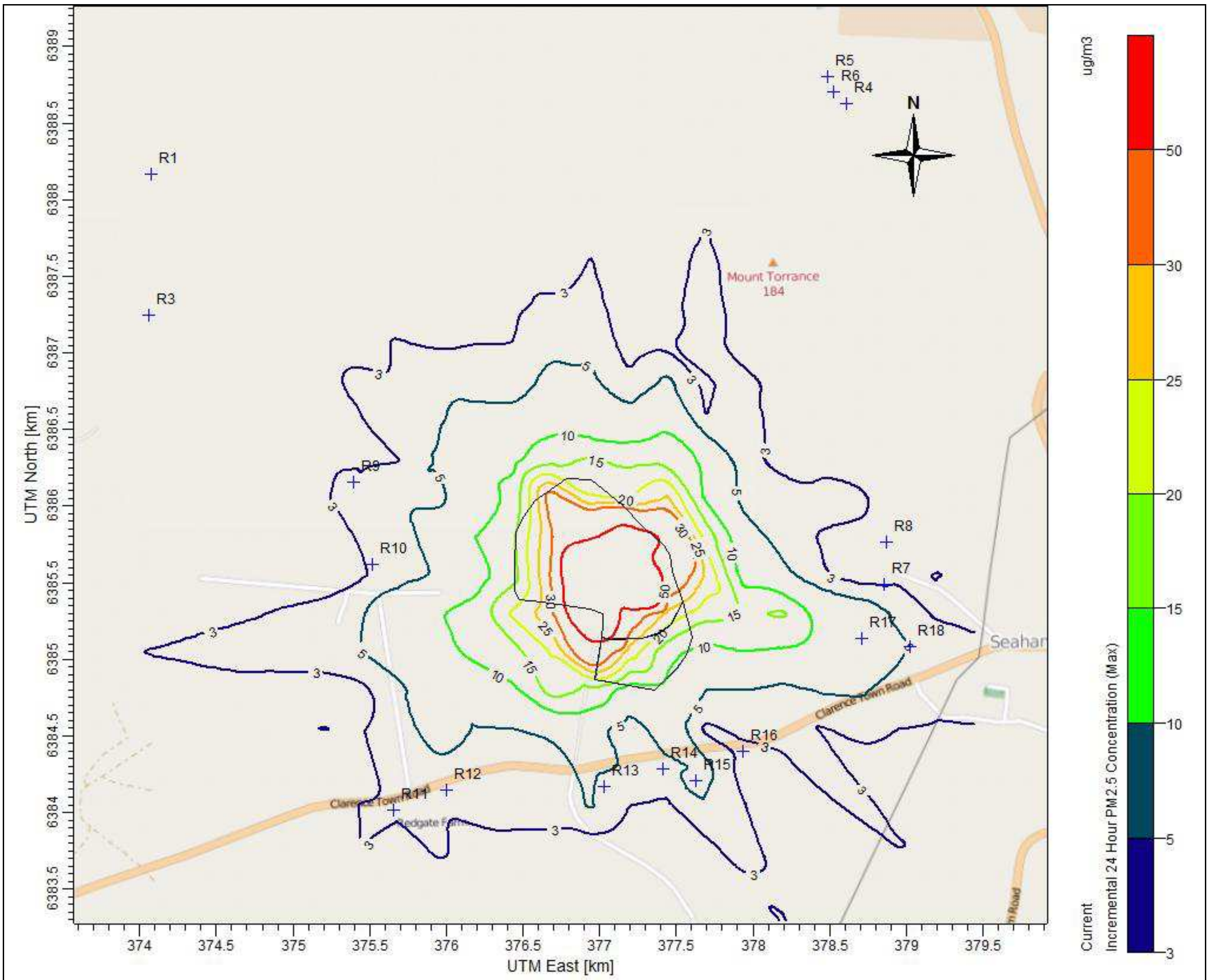
Pollutant: PM_{10} (Incremental)	**Averaging Period:** 24 hour	**Percentile:** 100^{th}	**Criteria:** 50 $\mu g/m^3$

Comment:
Current operations in relation to the future quarry boundary and processing area



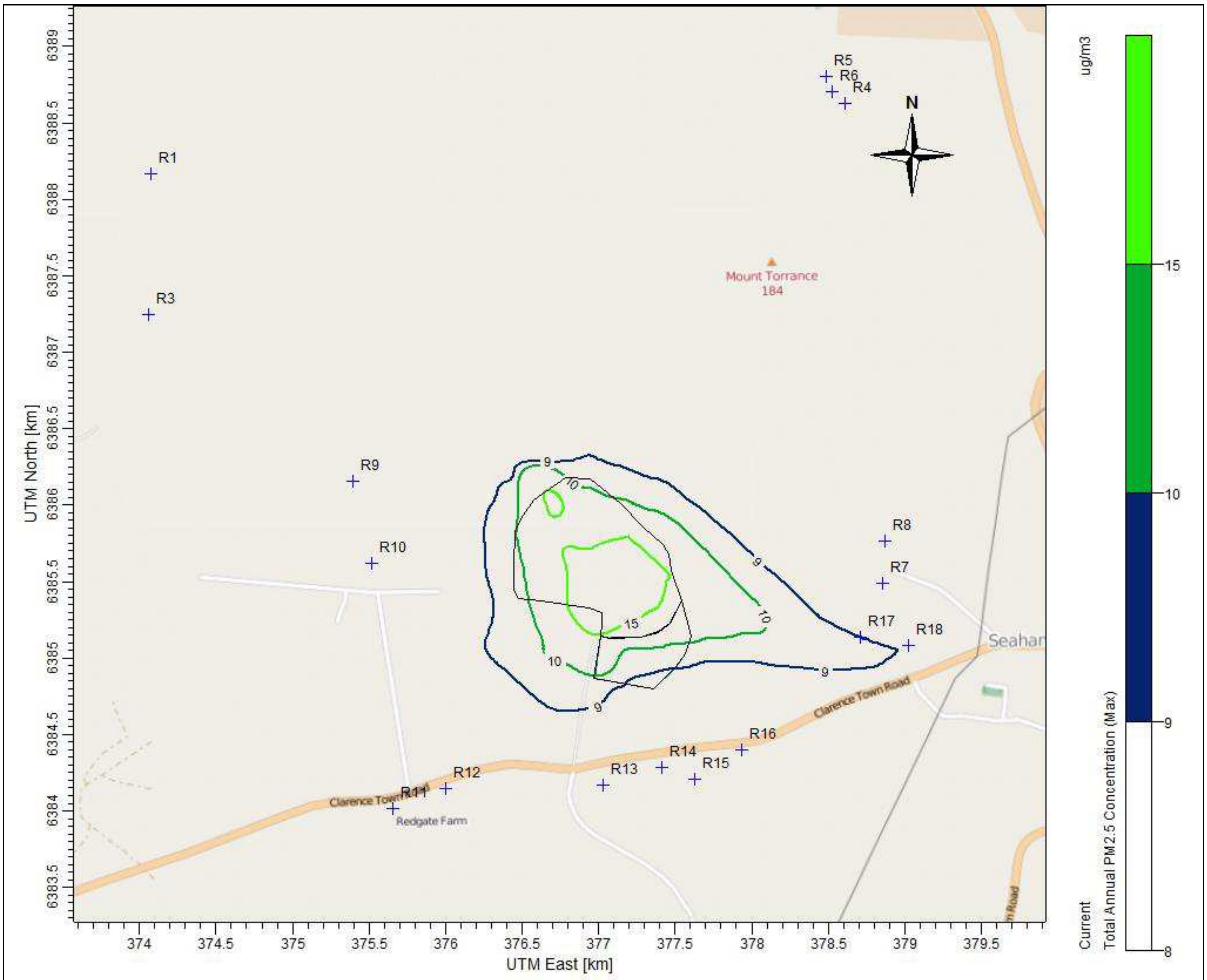
Pollutant:	Averaging Period:	Percentile:	Criteria:
PM_{10} (Total)	Annual	100^{th}	30 µg/m^3

Comment:
Current operations in relation to the future quarry boundary and processing area. Includes background of 20.9 µg/m^3



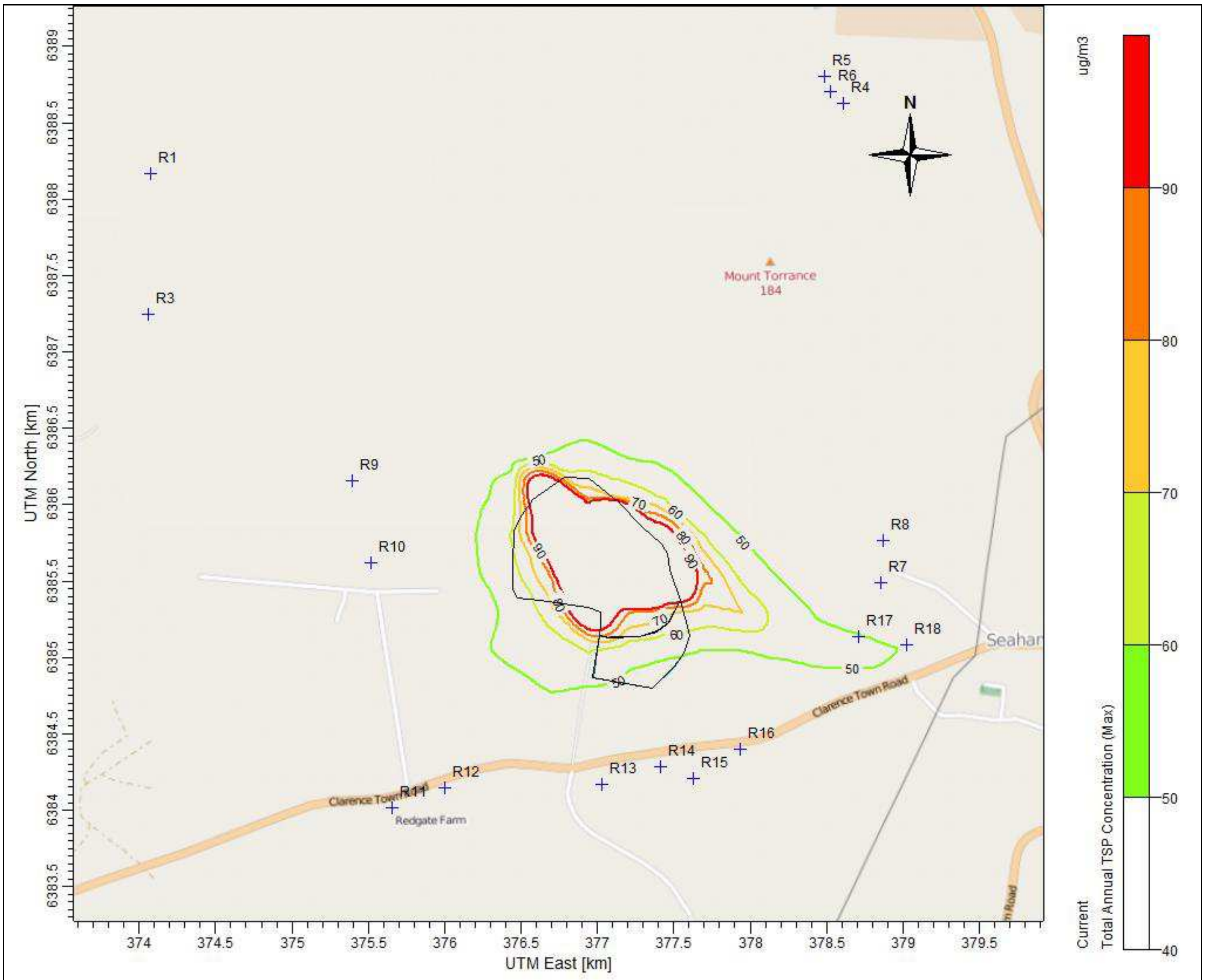
Pollutant: $PM_{2.5}$ (Incremental)	**Averaging Period:** 24 hour	**Percentile:** 100th	**Criteria:** 25 µg/m^3

Comment:
Current operations in relation to the future quarry boundary and processing area



Pollutant: PM$_{2.5}$ (Total)	**Averaging Period:** Annual	**Percentile:** 100th	**Criteria:** 8 µg/m^3

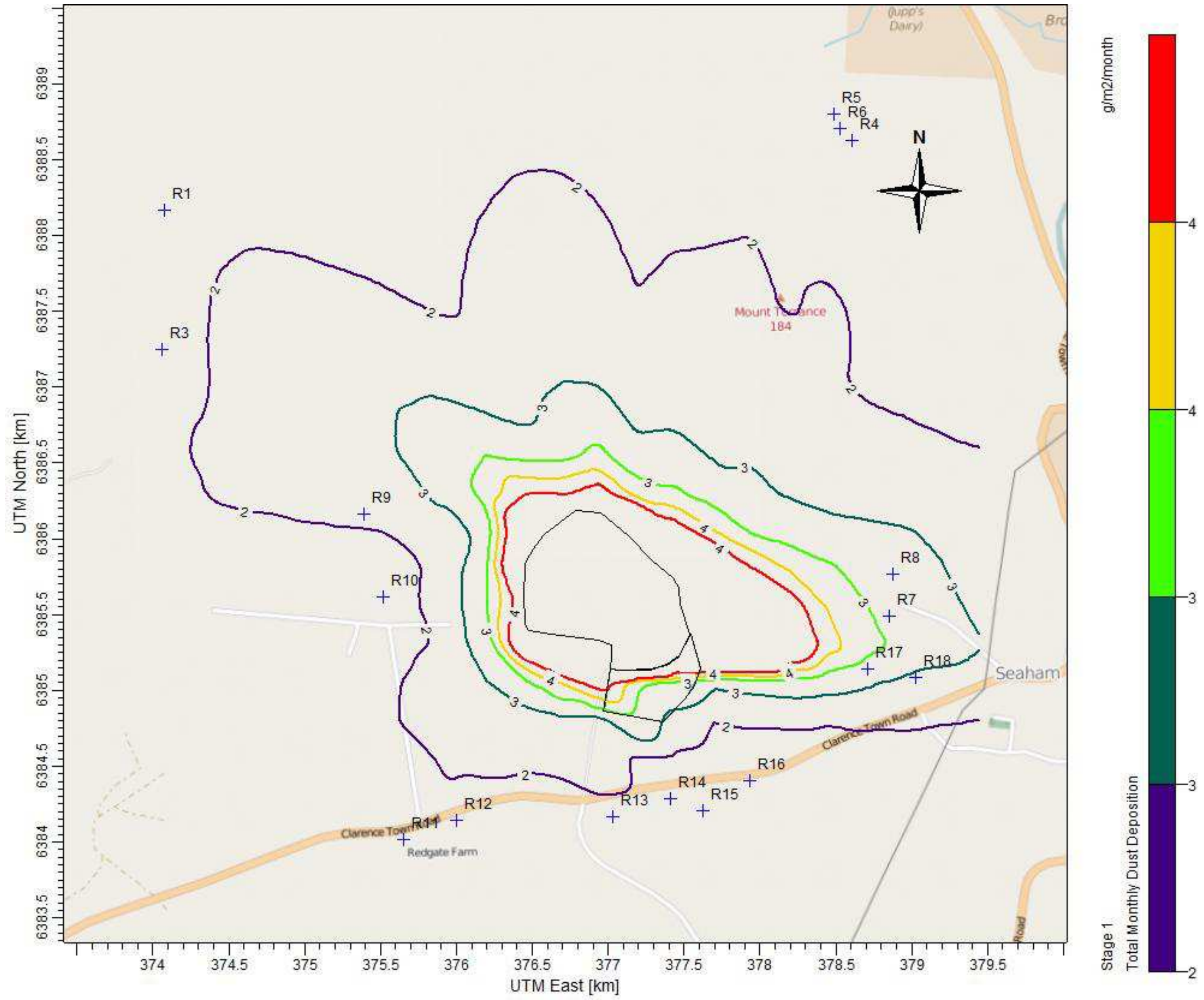
Comment:
Current operations in relation to the future quarry boundary and processing area.
Includes background concentration of 8.1 µg/m^3



Pollutant: TSP (Total)	**Averaging Period:** Annual	**Percentile:** 100th	**Criteria:** 90 µg/m^3

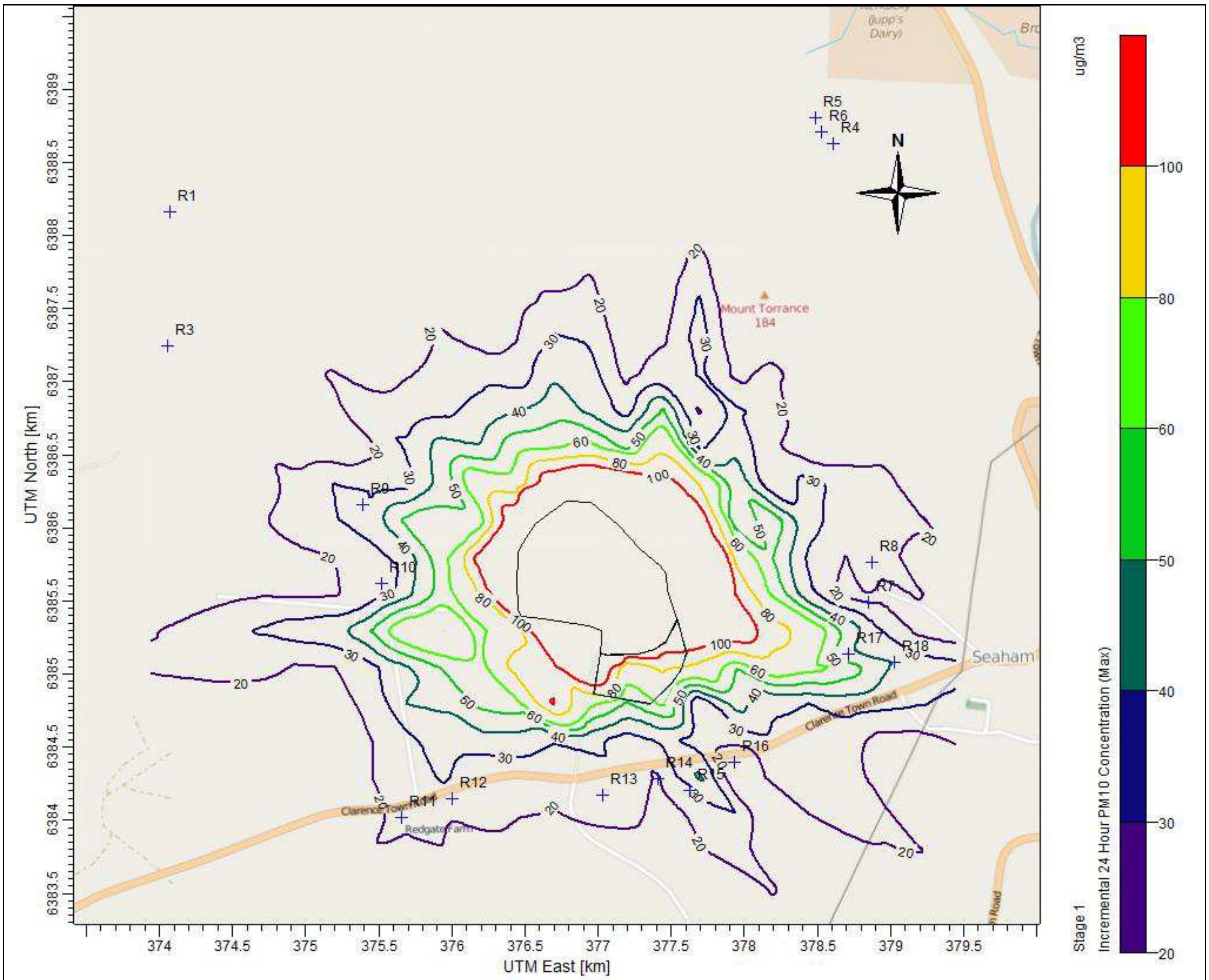
Comment:
Current operations in relation to the future quarry boundary and processing area.
Includes background concentration of 41.8 µg/m^3

C.2 STAGE 1



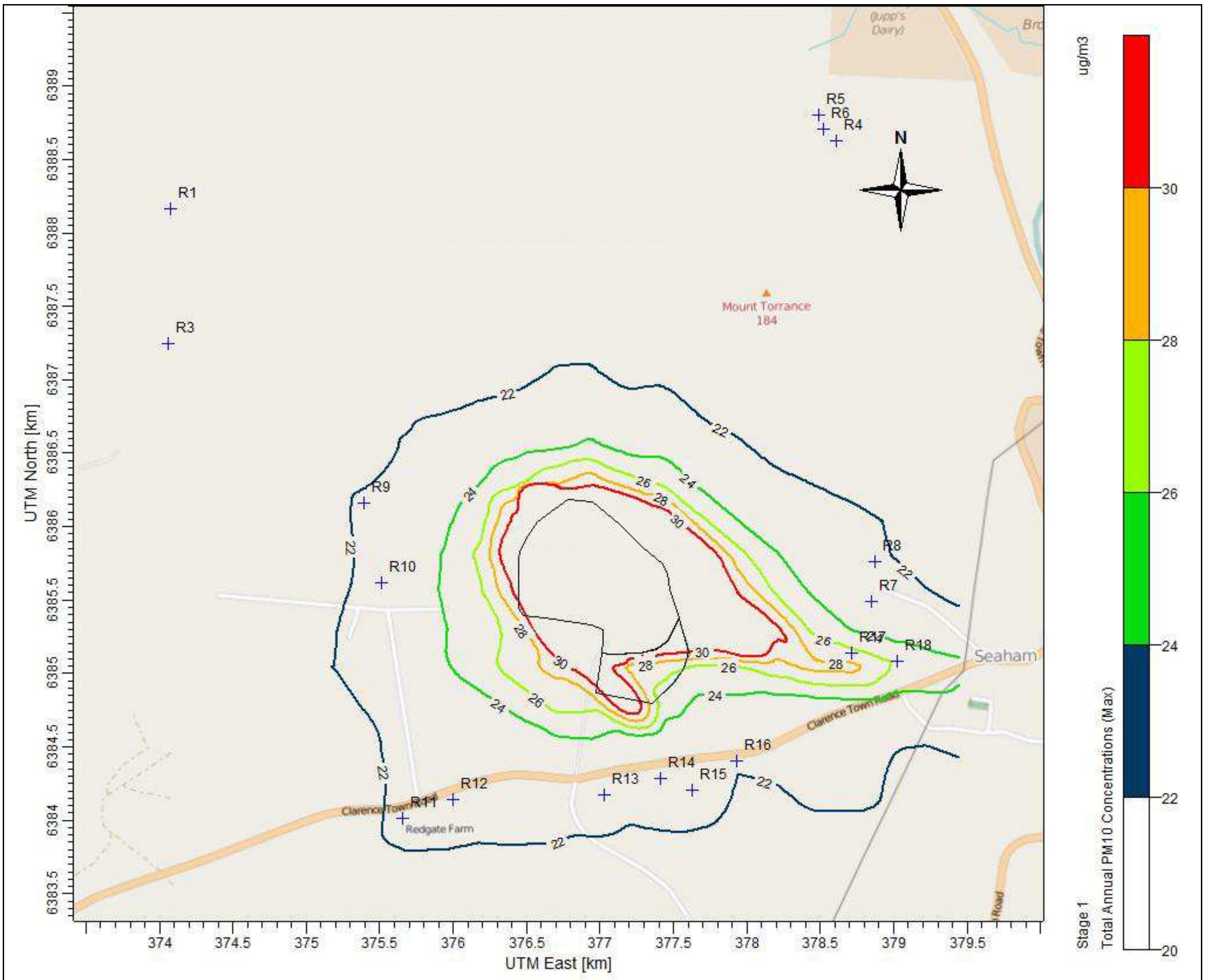
Pollutant: Dust Deposition	Averaging Period: Month	Percentile: 100th	Criteria: $4\ g/m^2/month$

Comment:
Stage 1 operations in relation to the future quarry boundary and processing area. Includes background of $2.1\ g/m^2/month$



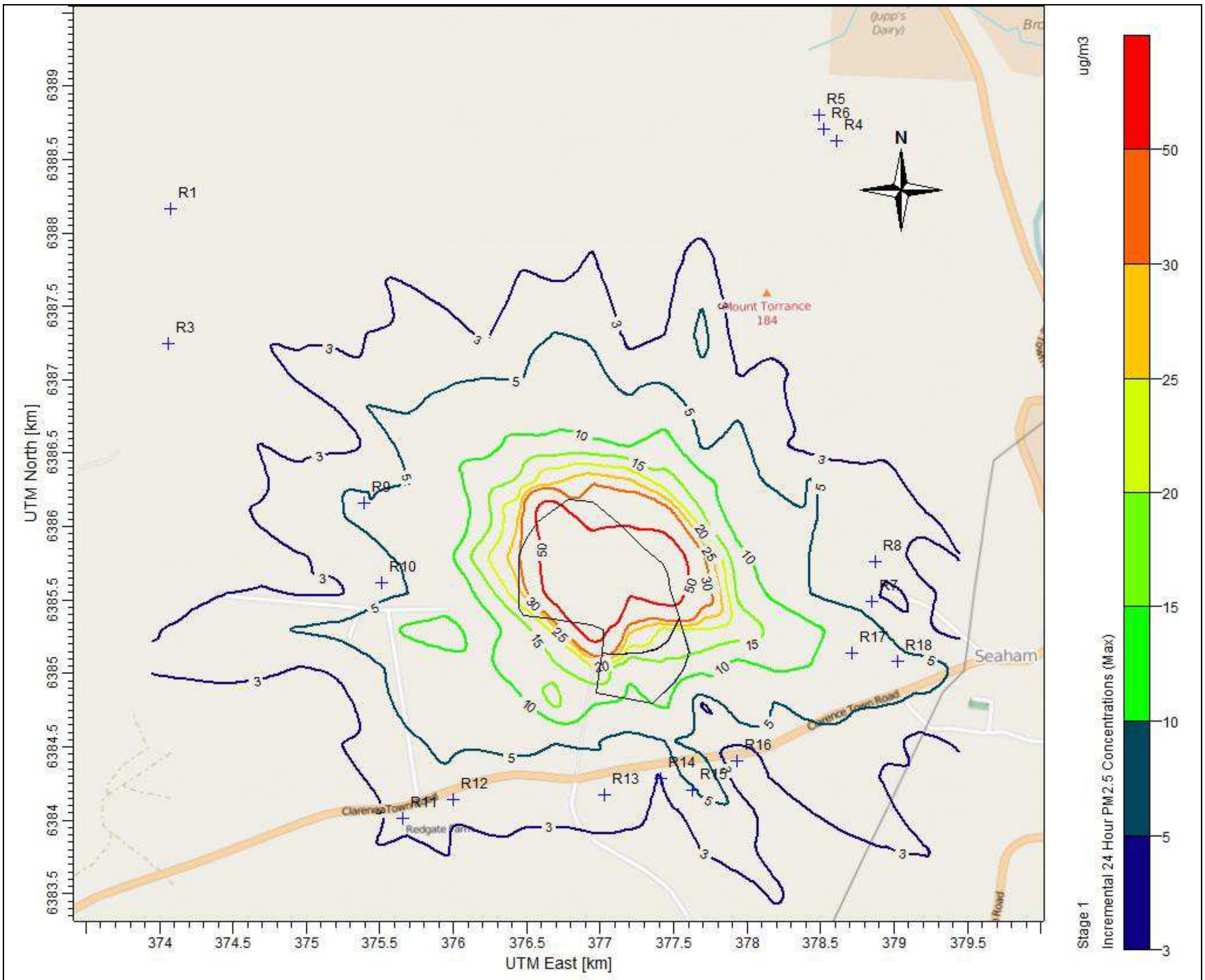
Pollutant:	Averaging Period:	Percentile:	Criteria:
PM_{10} (Incremental)	24 hour	100^{th}	50 µg/m^3

Comment:
Stage 1 operations in relation to the future quarry boundary and processing area



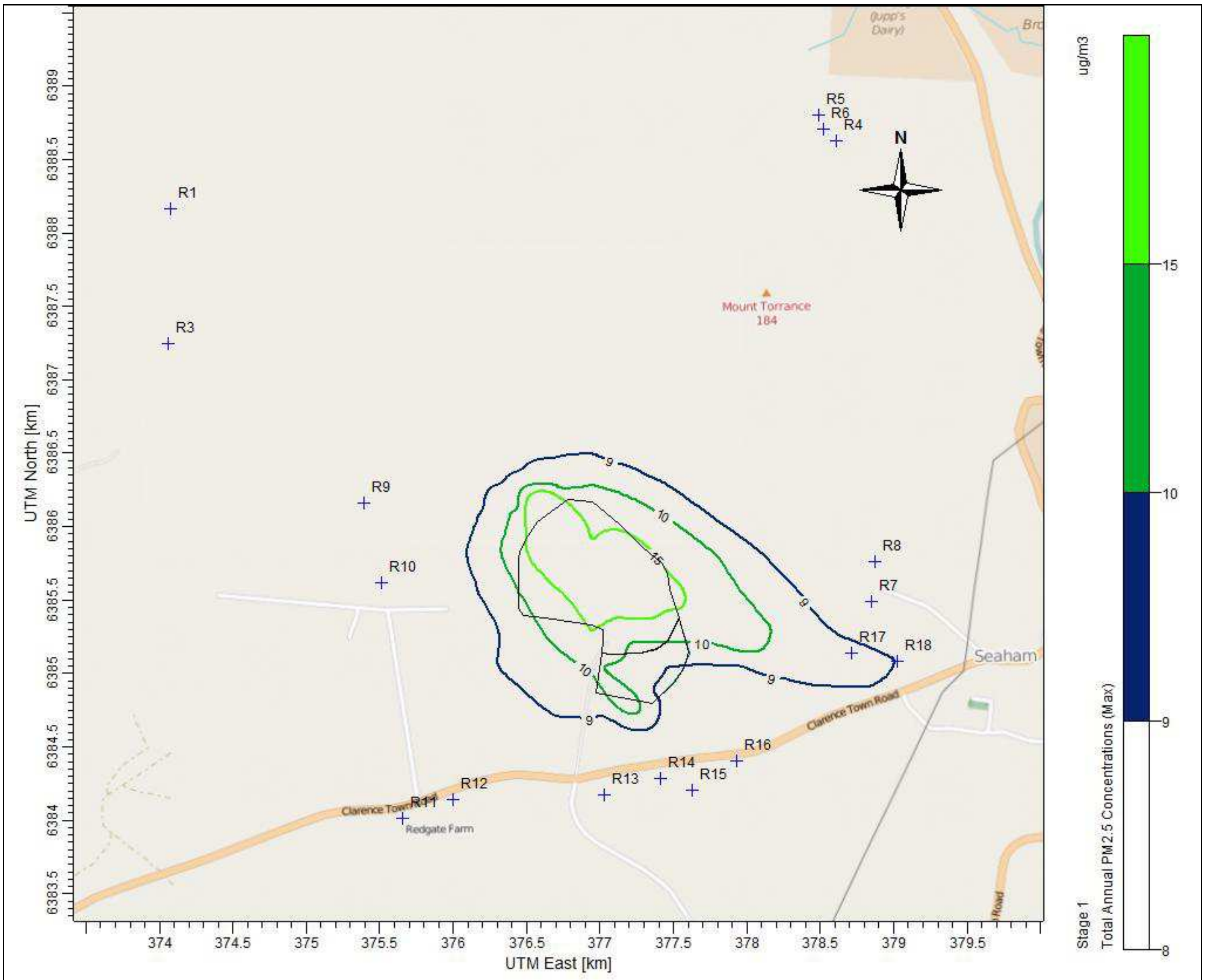
Pollutant:	Averaging Period:	Percentile:	Criteria:
PM_{10} (Total)	Annual	100^{th}	30 μg/m^3

Comment:
Stage 1 operations in relation to the future quarry boundary and processing area. Includes background concentration of 20.9 μg/m^3



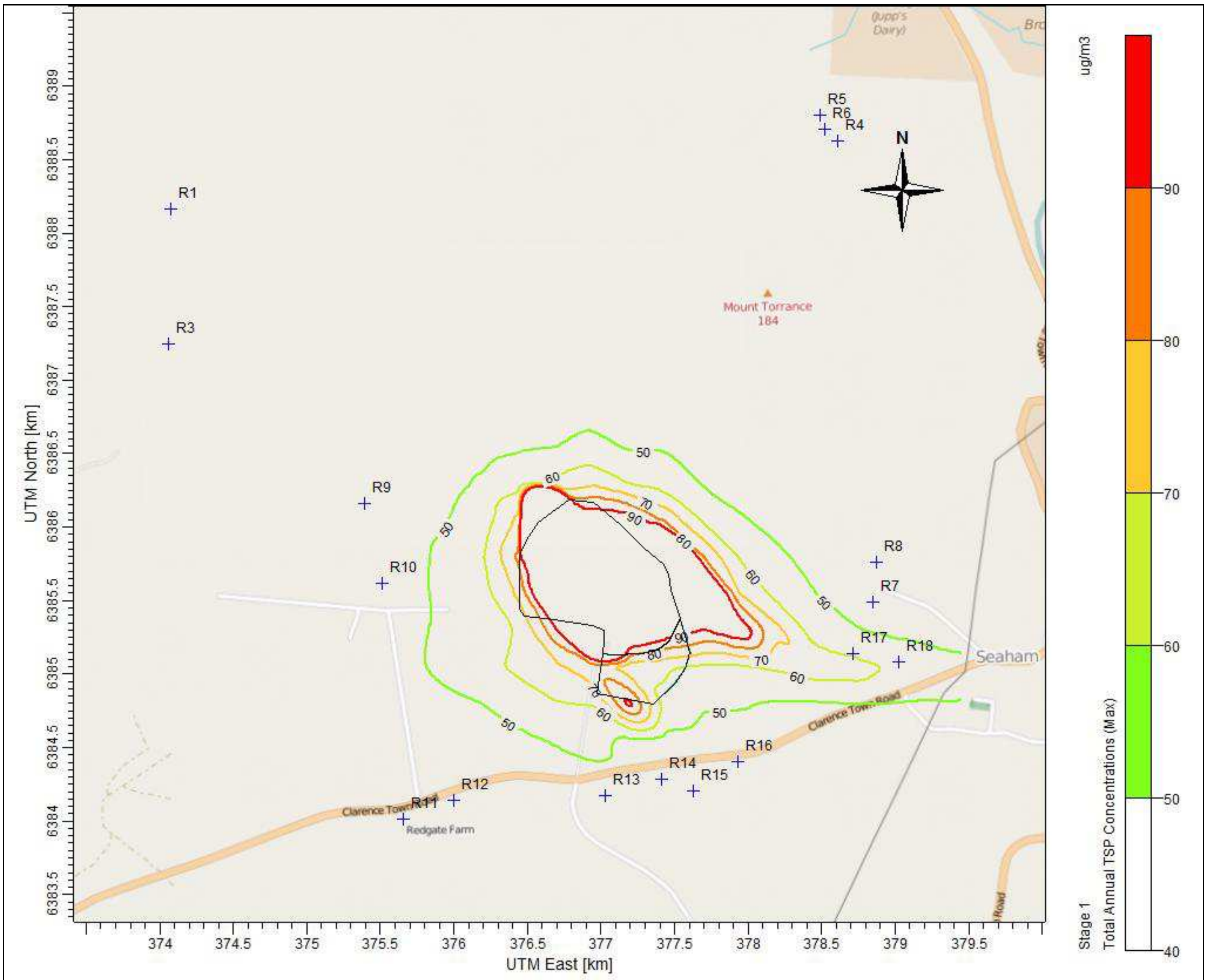
Pollutant:	Averaging Period:	Percentile:	Criteria:
$PM_{2.5}$ (Incremental)	24 hour	100^{th}	25 µg/m^3

Comment:
Stage 1 operations in relation to the future quarry boundary and processing area



Pollutant:	**Averaging Period:**	**Percentile:**	**Criteria:**
$PM_{2.5}$ (Total)	Annual	100th	8 µg/m^3

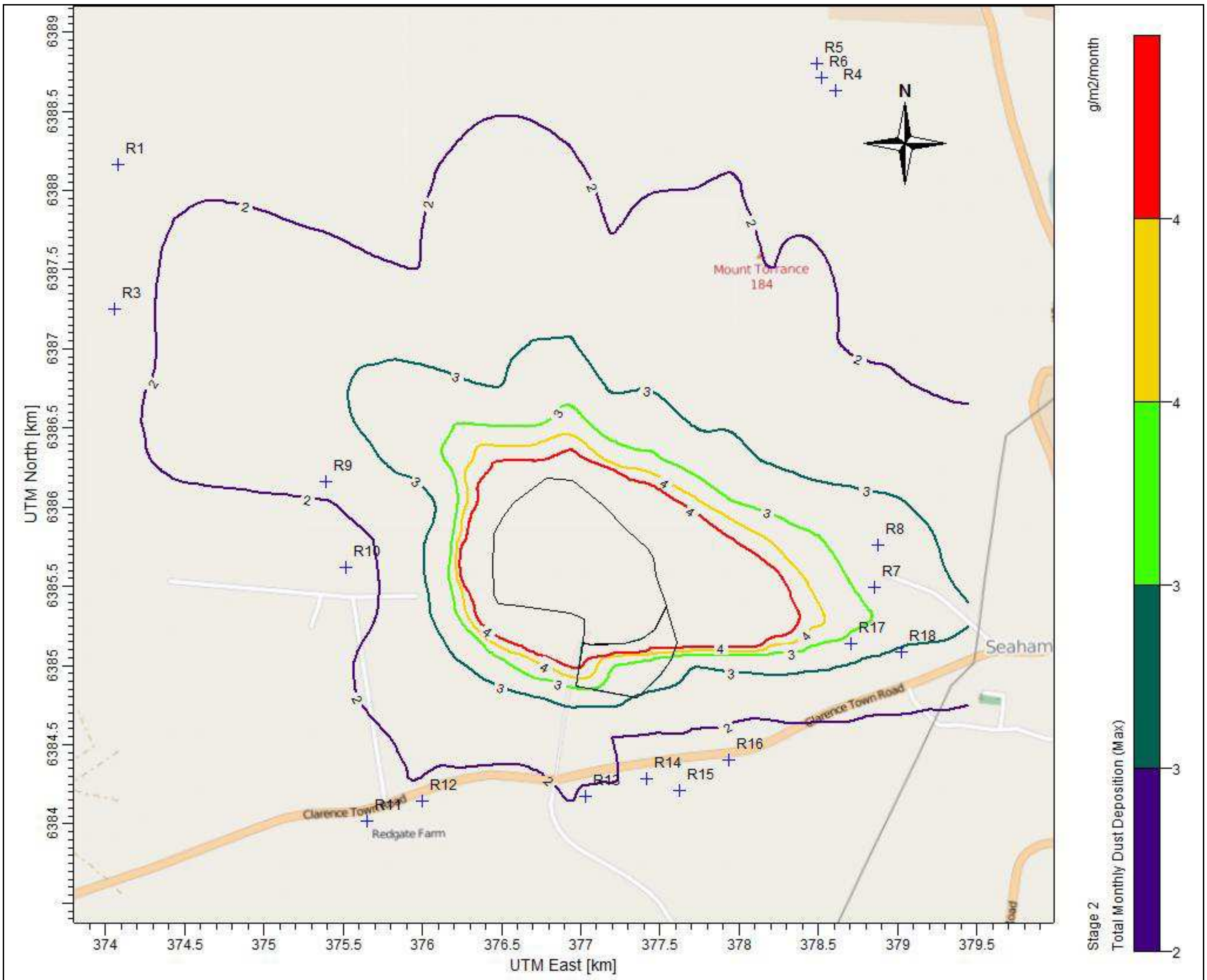
Comment:
Stage 1 operations in relation to the future quarry boundary and processing area.
Includes background concentration of 8.1 µg/m^3



Pollutant: TSP (Total)	**Averaging Period:** Annual	**Percentile:** 100th	**Criteria:** 90 µg/m^3

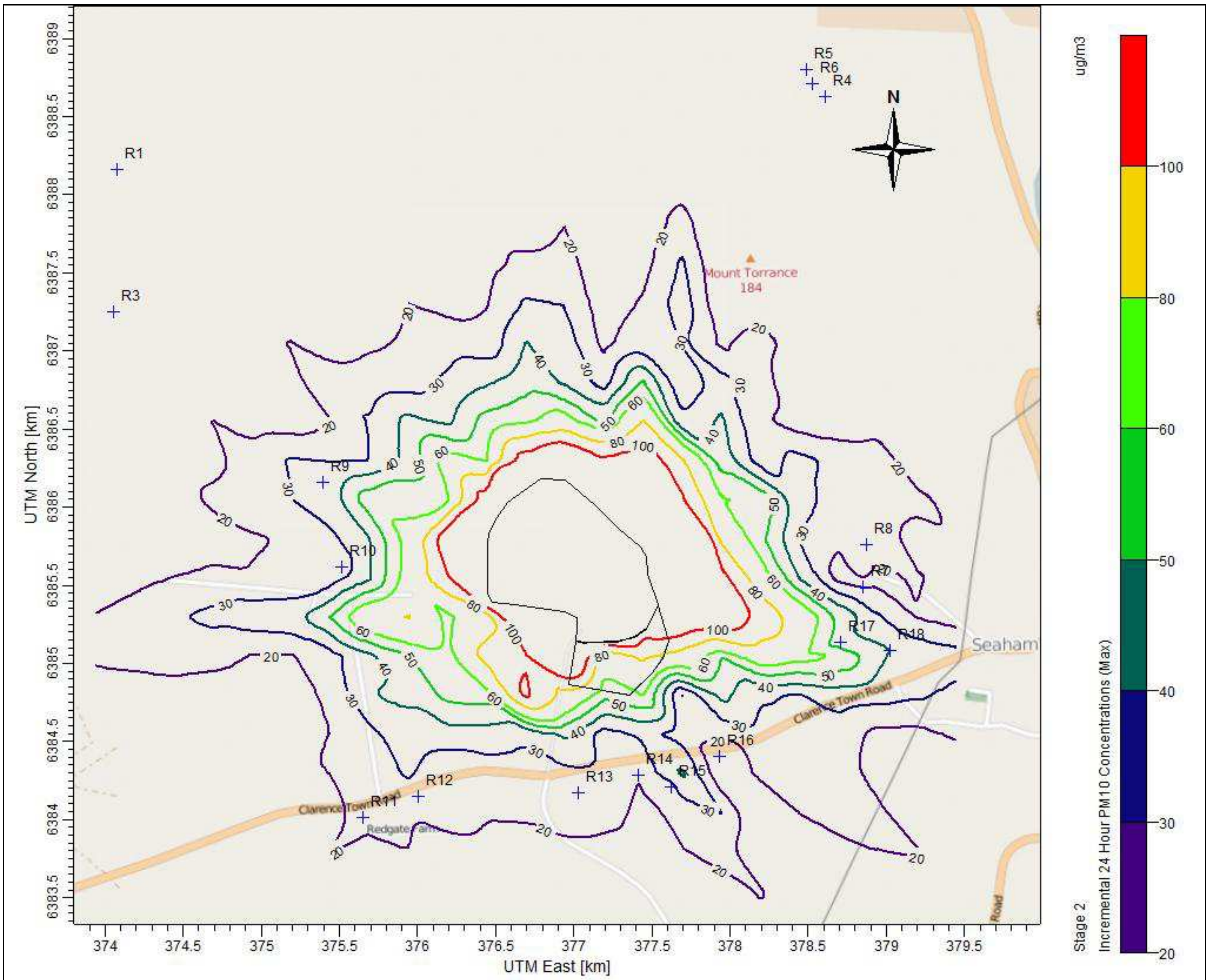
Comment:
Stage 1 operations in relation to the future quarry boundary and processing area.
Includes background concentration of 41.8 µg/m^3

C.3 STAGE 2



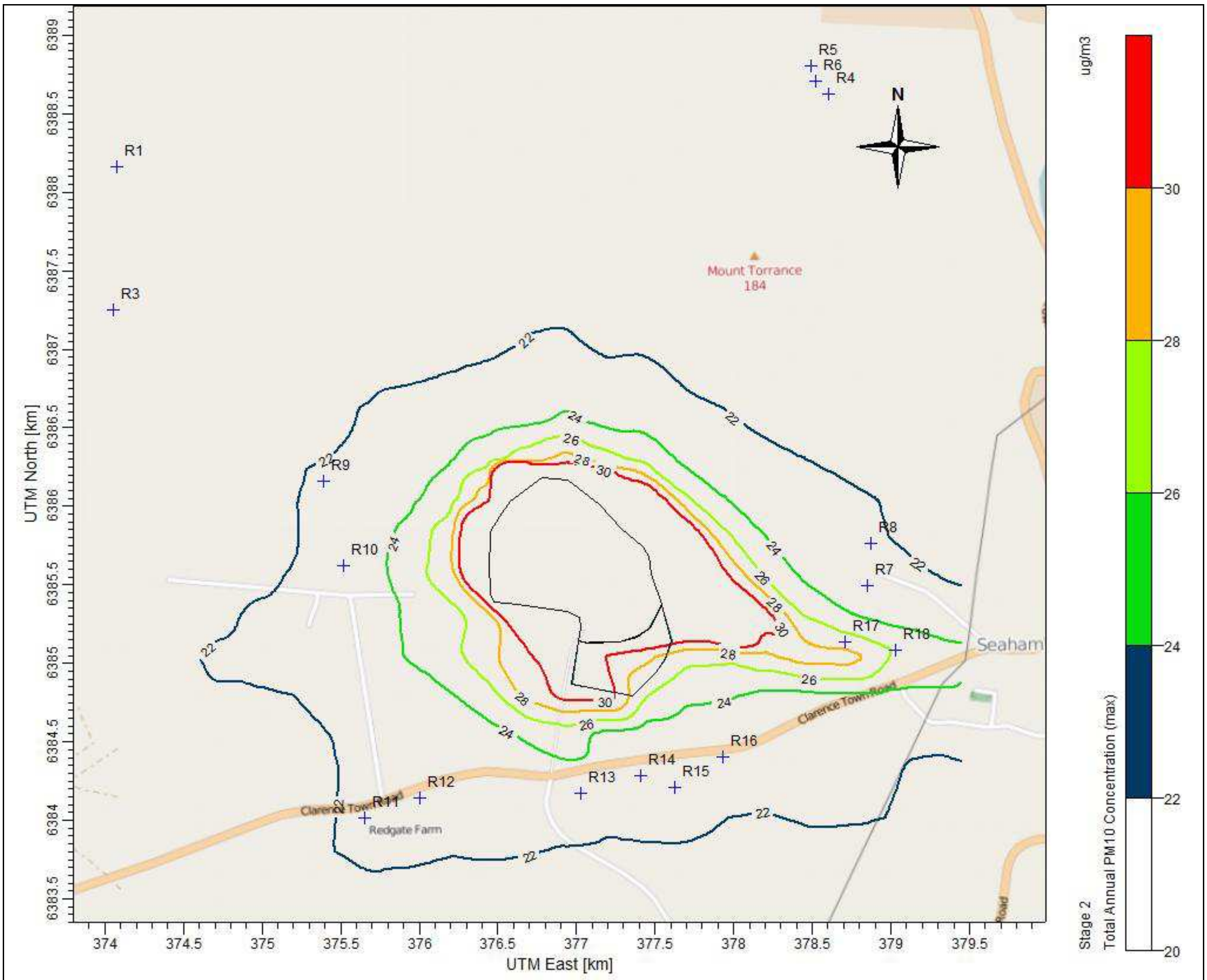
Pollutant: Dust Deposition	**Averaging Period:** Month	**Percentile:** 100th	**Criteria:** 4 g/m²/month

Comment:
Stage 2 operations in relation to the future quarry boundary and processing area. Includes background of 2.1 g/m²/month



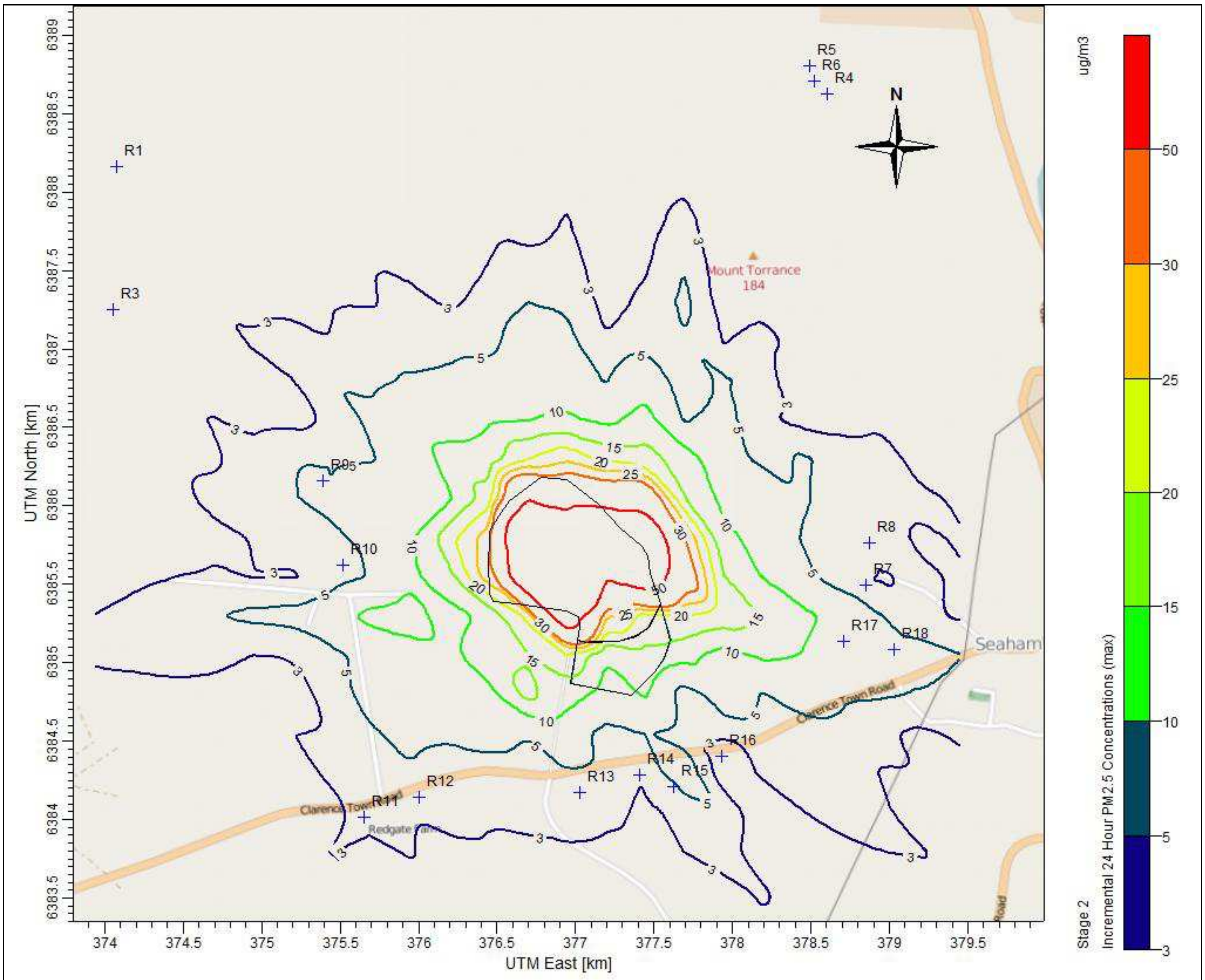
Pollutant: PM_{10} (Incremental)	Averaging Period: 24 hour	Percentile: 100th	Criteria: 50 µg/m^3

Comment:
Stage 2 operations in relation to the future quarry boundary and processing area



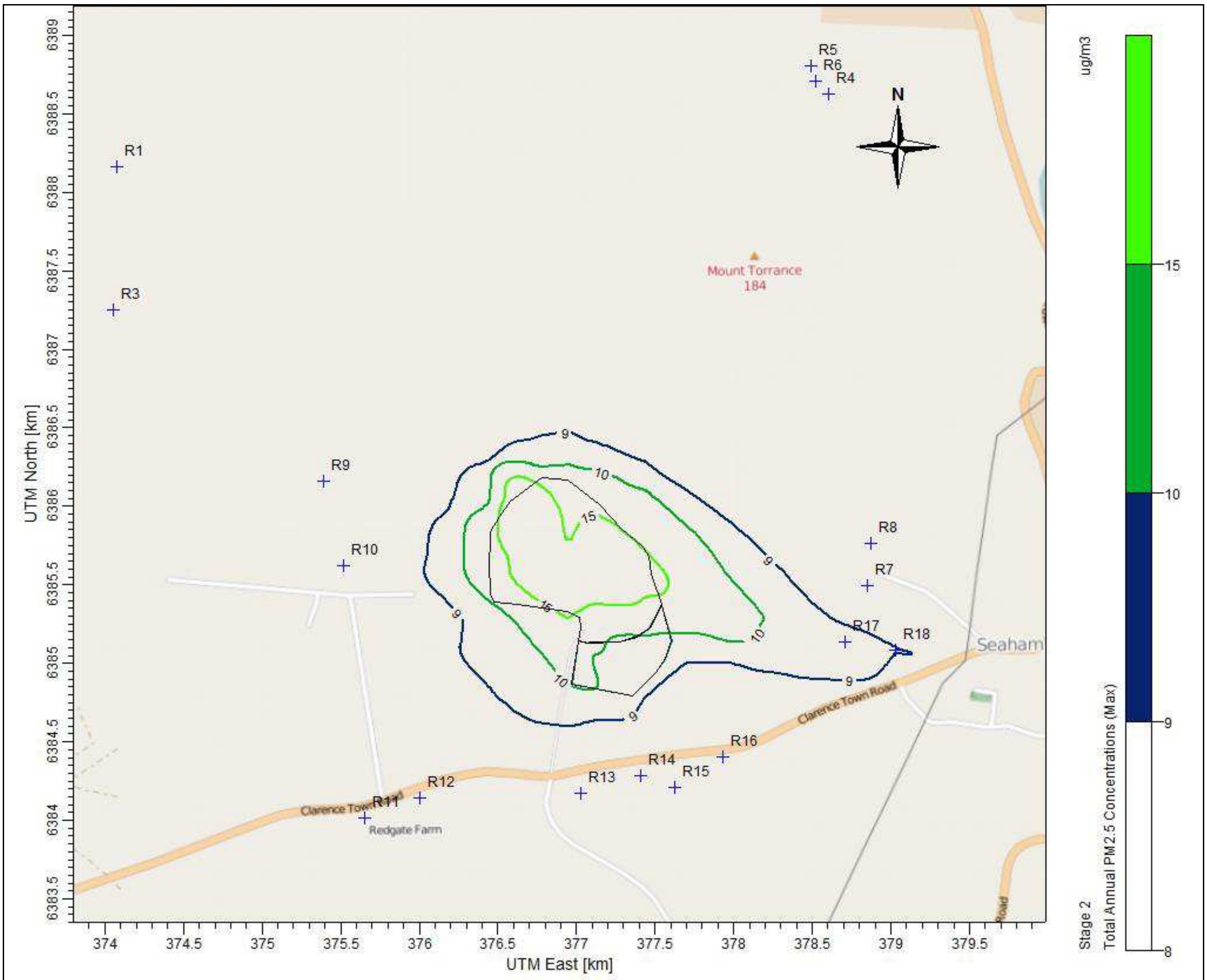
Pollutant: PM_{10} (Total)	**Averaging Period:** Annual	**Percentile:** 100^{th}	**Criteria:** 30 µg/m^3

Comment:
Stage 2 operations in relation to the future quarry boundary and processing area.
Includes background concentration of 20.9 µg/m^3



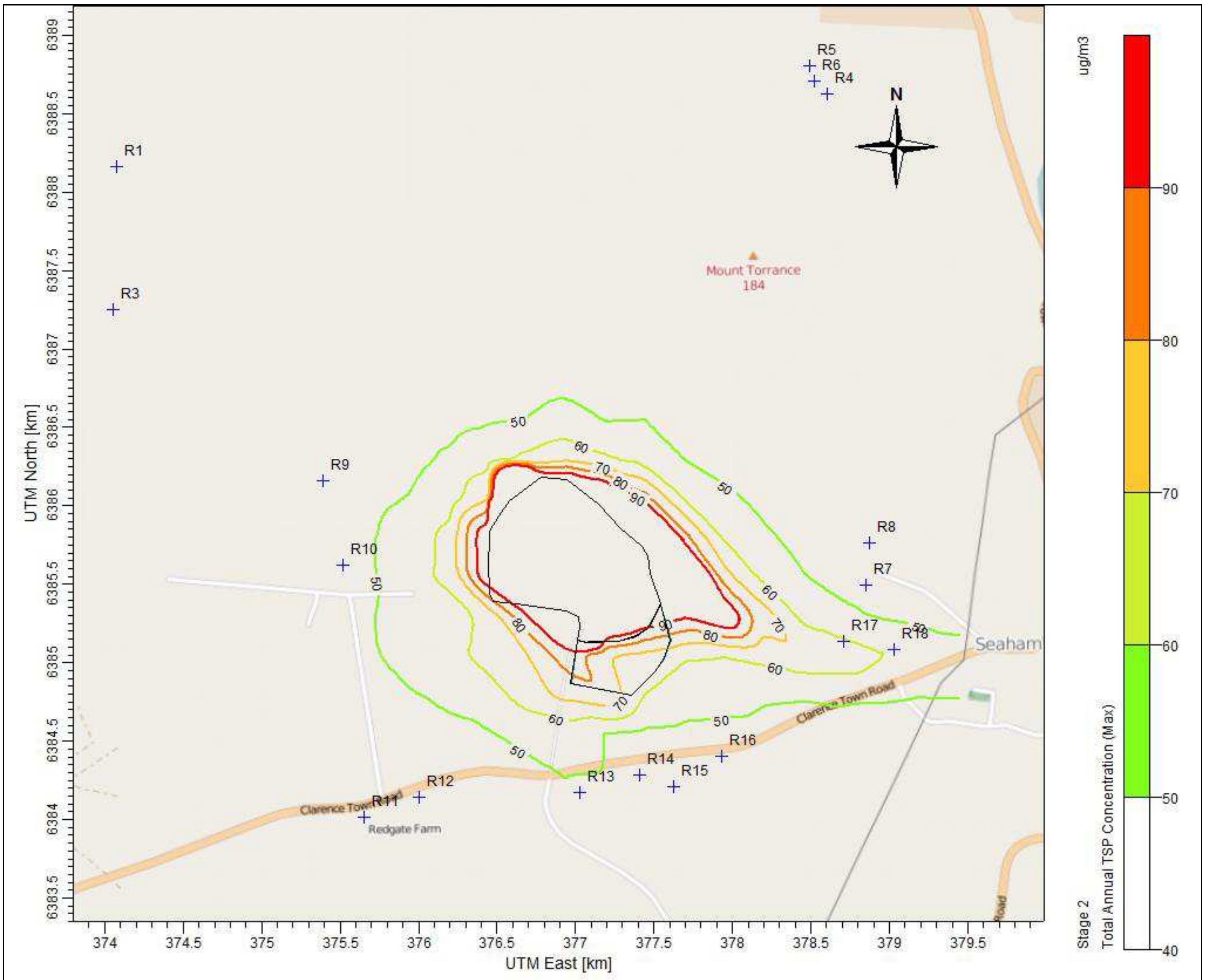
Pollutant:	Averaging Period:	Percentile:	Criteria:
$PM_{2.5}$ (Incremental)	24 hour	100th	25 µg/m^3

Comment:
Stage 2 operations in relation to the future quarry boundary and processing area



Pollutant: $PM_{2.5}$ (Total)	**Averaging Period:** Annual	**Percentile:** 100^{th}	**Criteria:** 8 μg/m^3

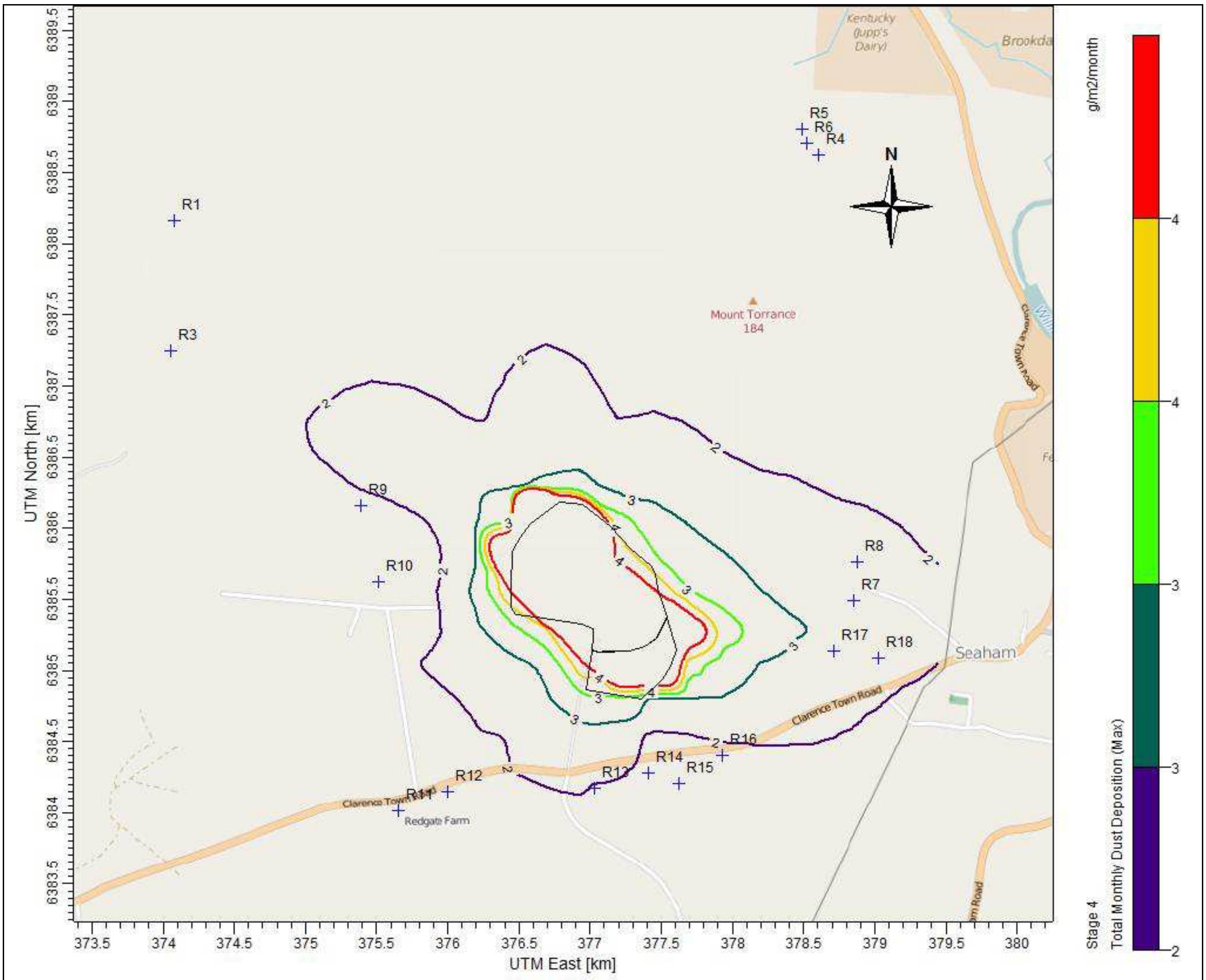
Comment:
Stage 2 operations in relation to the future quarry boundary and processing area.
Includes background concentration of 8.1 μg/m^3



Pollutant:	Averaging Period:	Percentile:	Criteria:
TSP (Total)	Annual	100th	90 µg/m^3

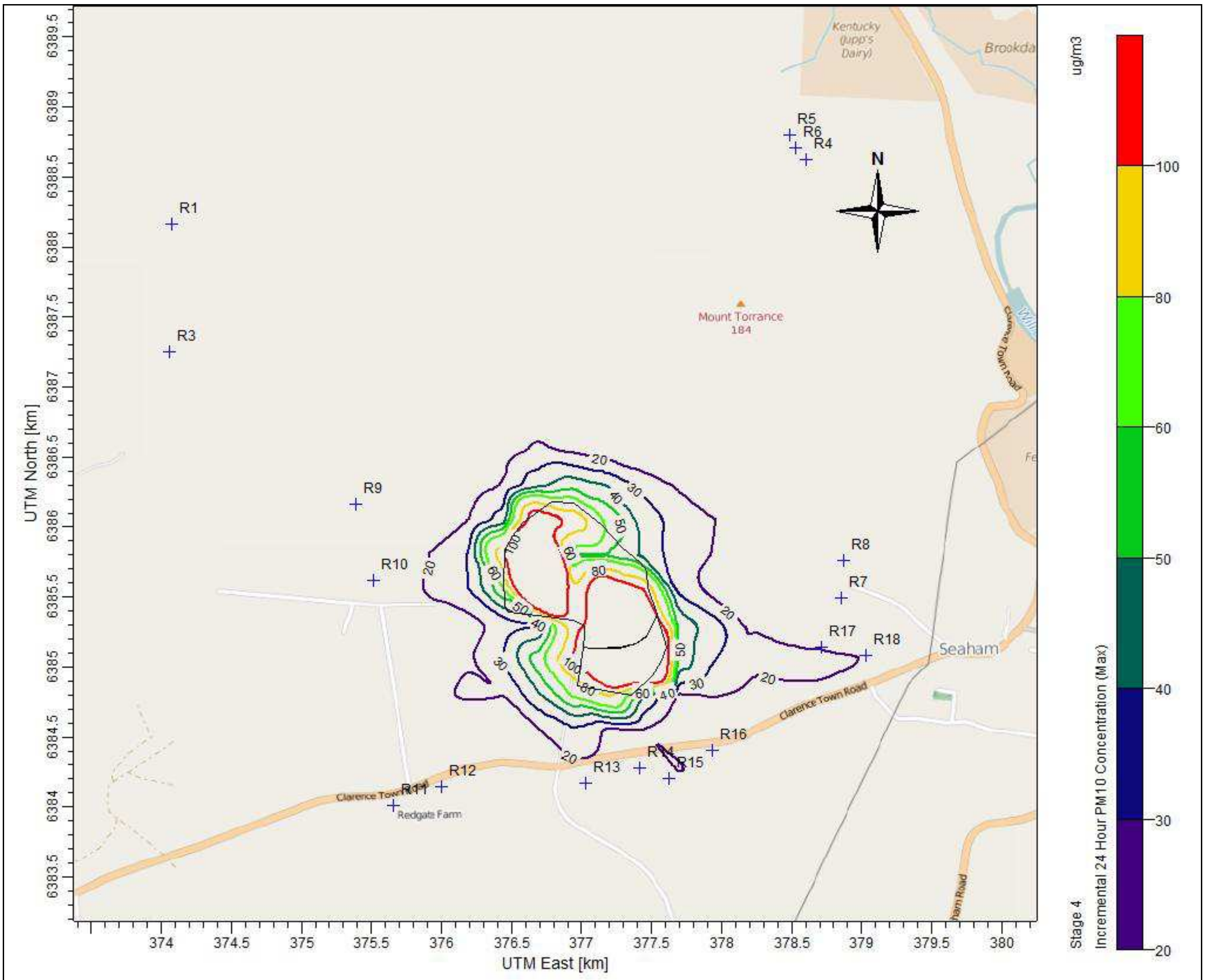
Comment:
Stage 2 operations in relation to the future quarry boundary and processing area.
Includes background concentration of 41.8 µg/m^3

C.4 STAGE 4



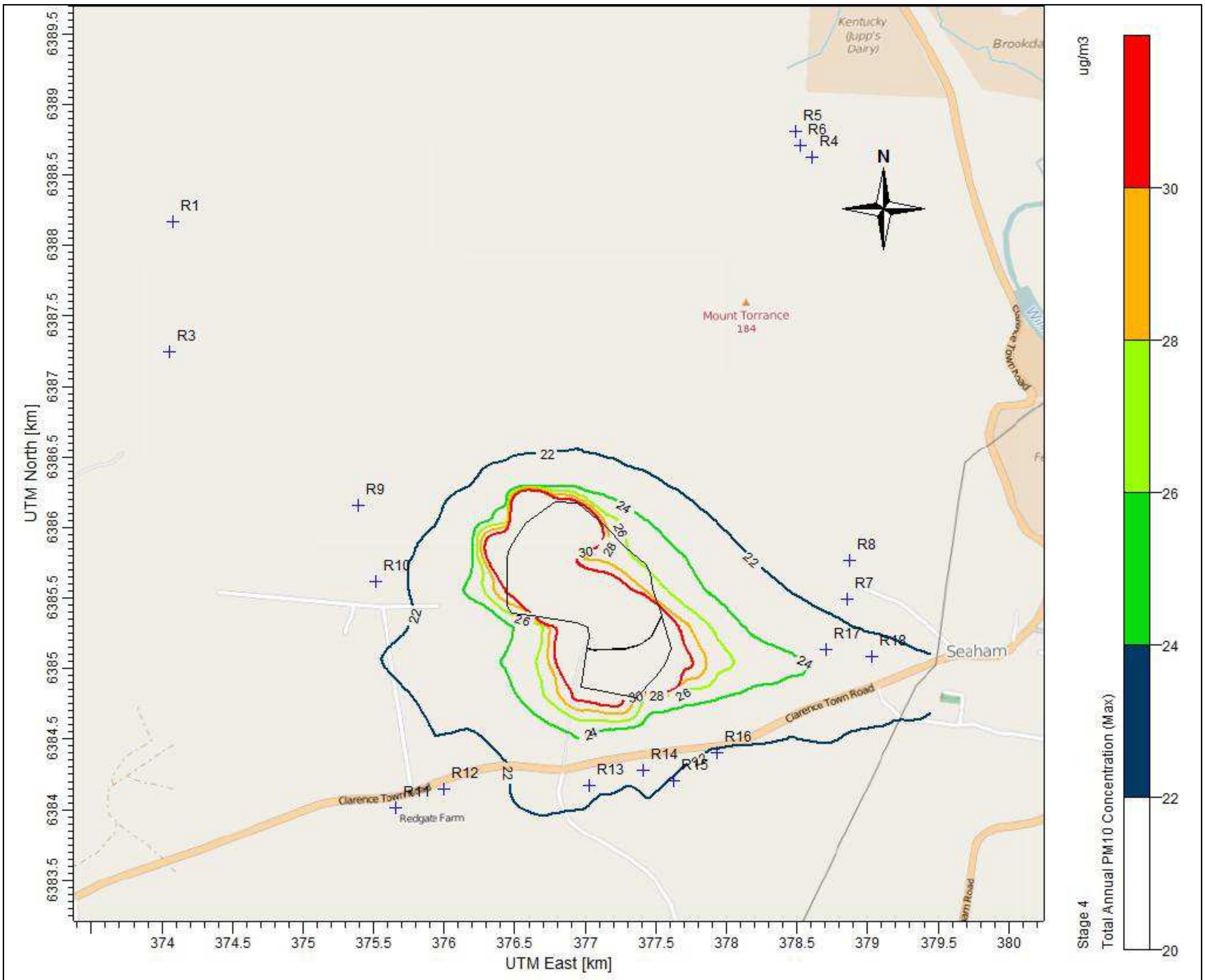
Pollutant: Dust Deposition	Averaging Period: Month	Percentile: 100th	Criteria: 4 g/m²/month

Comment:
Stage 4 operations in relation to the future quarry boundary and processing area. Includes background of 2.1 g/m²/month



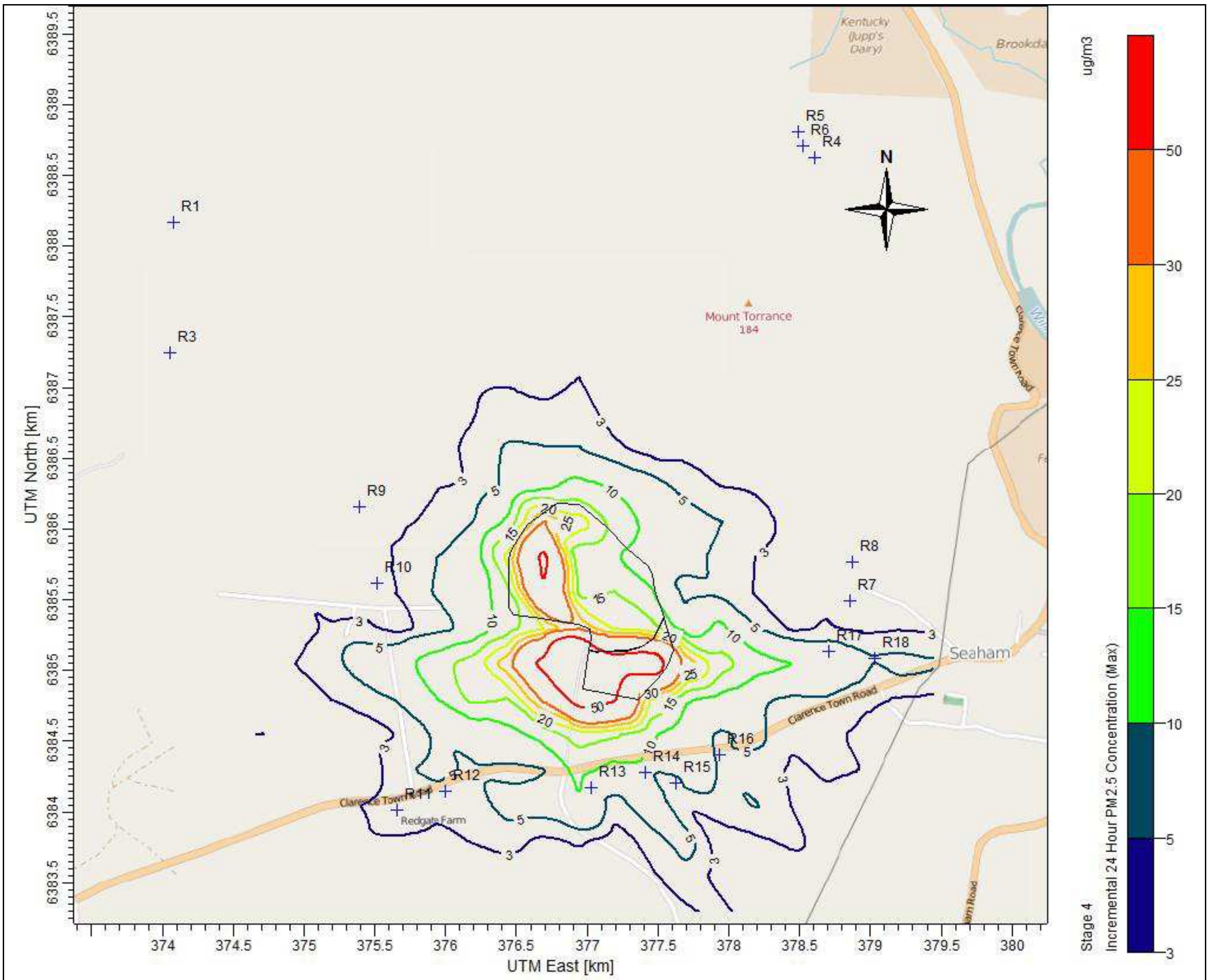
Pollutant:	**Averaging Period:**	**Percentile:**	**Criteria:**
PM_{10} (Incremental)	24 hour	100^{th}	50 µg/m^3

Comment:
Stage 4 operations in relation to the future quarry boundary and processing area



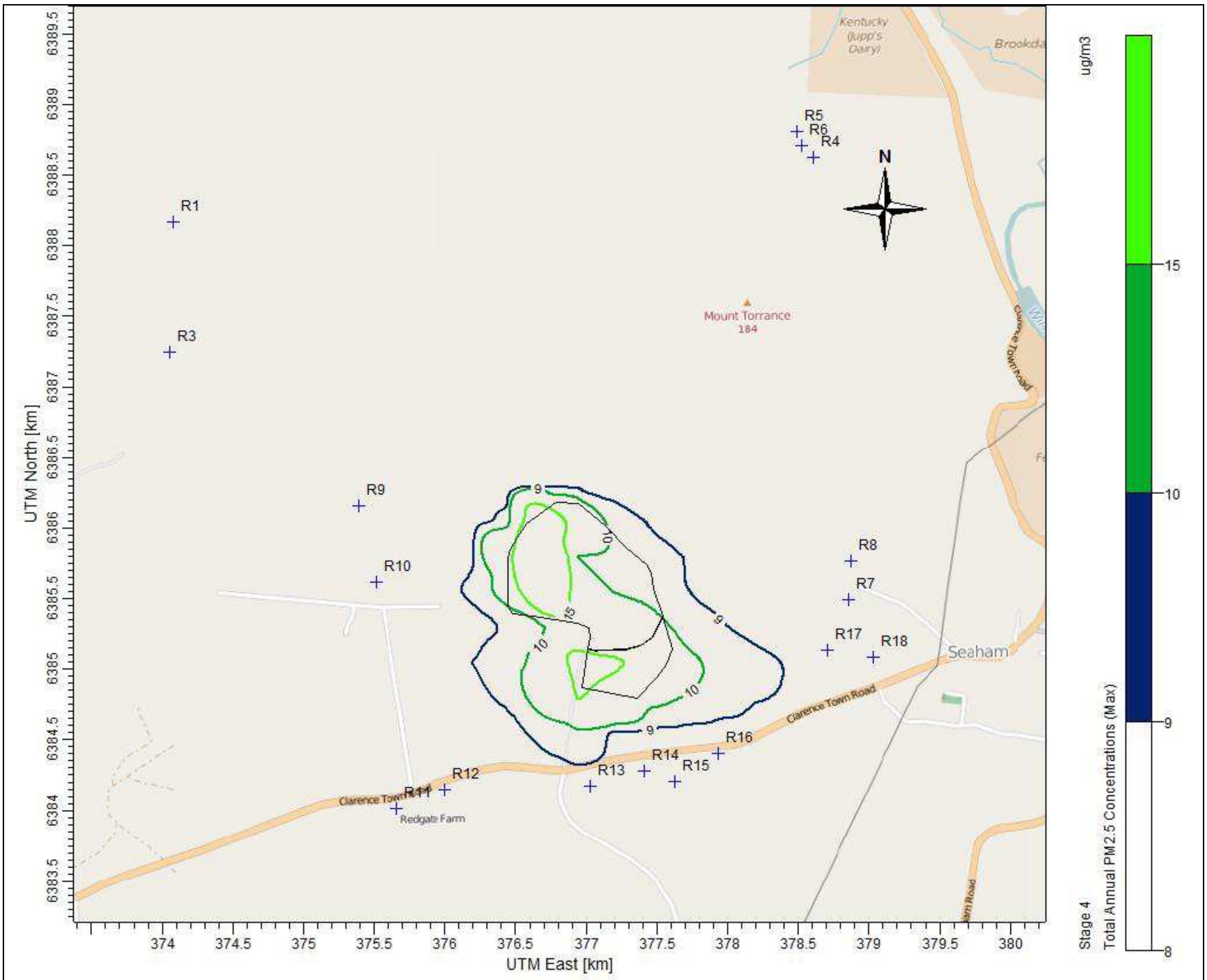
Pollutant:	Averaging Period:	Percentile:	Criteria:
PM_{10} (Total)	Annual	100^{th}	30 $\mu g/m^3$

Comment:
Stage 4 operations in relation to the future quarry boundary and processing area.
Includes background concentration of 20.9 $\mu g/m^3$



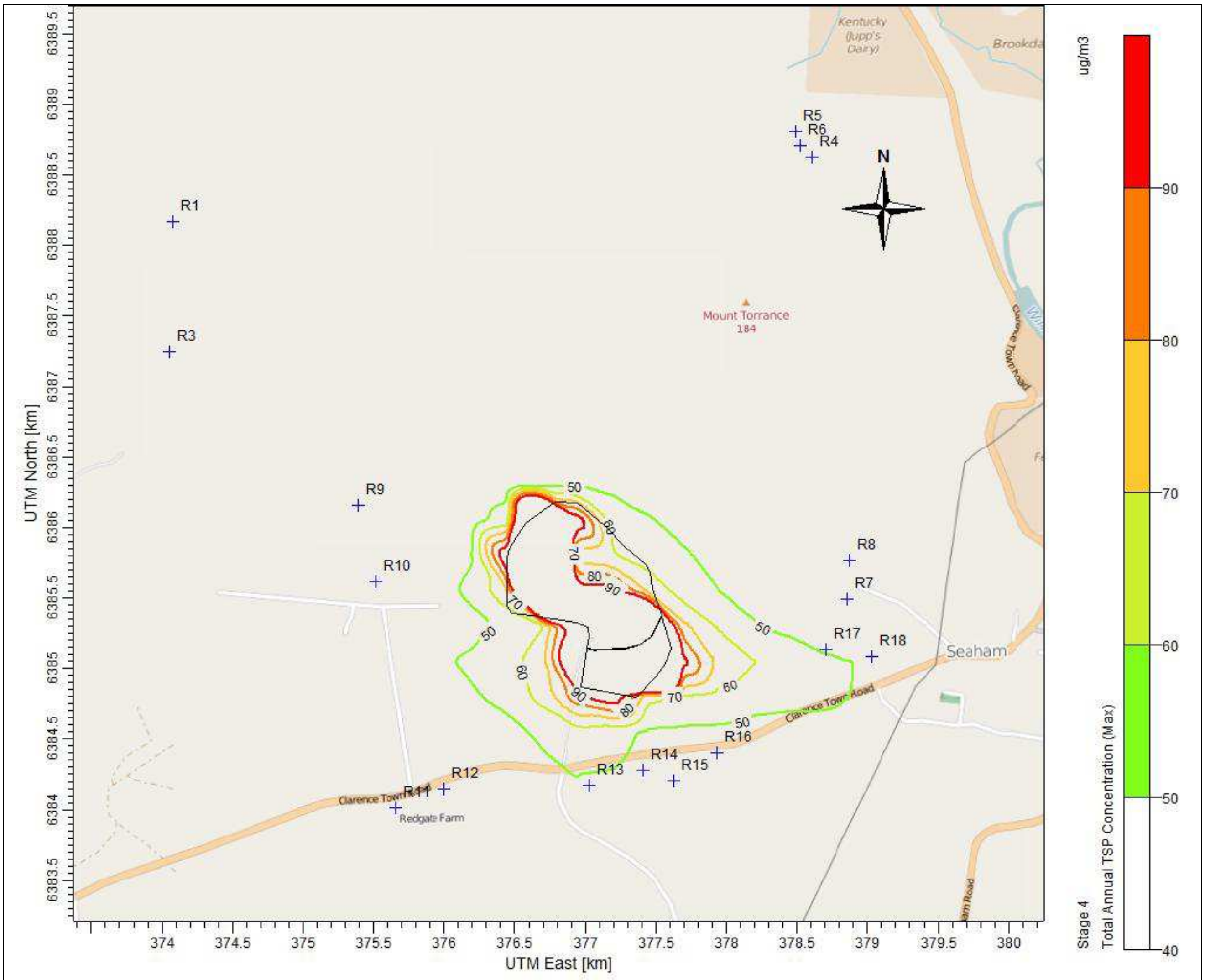
Pollutant: PM$_{2.5}$ (Incremental)	**Averaging Period:** 24 hour	**Percentile:** 100th	**Criteria:** 25 µg/m^3

Comment:
Stage 4 operations in relation to the future quarry boundary and processing area



Pollutant: $PM_{2.5}$ (Total)	**Averaging Period:** Annual	**Percentile:** 100^{th}	**Criteria:** 8 $\mu g/m^3$

Comment:
Stage 4 operations in relation to the future quarry boundary and processing area.
Includes background concentration of 8.1 $\mu g/m^3$



Pollutant:	Averaging Period:	Percentile:	Criteria:
TSP (Total)	Annual	100th	90 µg/m^3

Comment:
Stage 4 operations in relation to the future quarry boundary and processing area.
Includes background concentration of 41.8 µg/m^3

Appendix D: AIR QUALITY MANAGEMENT PLAN

Purpose & Scope

The purpose of the Plan is to:

- Comply with the expected conditions of the Approval;
- Provide a description of the measures to be implemented by Hanson to mitigate air quality impacts;
- To detail air quality monitoring requirements associated with BHQ;
- Provide a mechanism for assessing air quality monitoring results against the relevant air quality impact assessment criteria; and
- Provide employees with a clear and concise description of their responsibilities in relation to air quality management during the operation of BHQ.

Objectives

The Air Quality Management objectives of the Plan are to ensure that appropriate procedures and programs of work are in place to:

- Maintain an air quality monitoring system which can assess the air quality impact on surrounding sensitive receivers and performance against the legislative air pollution requirements;
- Detail the controls to be implemented to minimise dust generation from the site recognising that cumulative air quality is a key issue for the local community;
- Provide a mechanism to assess monitoring results against air quality impact assessment criteria to evaluate compliance;
- Manage air quality related community complaints in a timely and effective manner; and
- Provide management commitments and strategies for dealing with air quality related issues.

Compliance Assessment Protocol

In the event of an exceedance of the relevant pollutant criteria, Hanson will investigate and report the exceedance. Hanson will also implement mitigating measures for future air quality impacting activities as necessary and will monitor all activities for effectiveness and improvement opportunities. Air quality data will be collected and assessed in conjunction with meteorological data to determine the Hanson contribution to recorded dust events.

Community Complaints

Community complaints management includes receipt of complaints, investigation, implementation of appropriate remedial action, and feedback to the complainant as well as communication to site management or personnel and notification to external bodies, such as the OEH.

Accountabilities

Specific roles and accountabilities for employees and contractors in relation to Air Quality Management Plan are outlined below.

Person Responsible	Responsibilities
Operations Manager	• Approve appropriate resources for the implementation of this Plan. • Ensure the effective implementation of strategies designed to reduce air quality impacts from the operation. • Ensure air quality issues are reported in accordance with legal requirements. • Authorise internal reporting requirements of this plan
Environment and Community Manager/Officer	• Provide that sufficient resources are allocated for the implementation of this program. • Identify air quality risks and impacts to the environment and assess resources required to mitigate identified risks and impacts within the site. • Ensure that the air quality management controls are implemented in accordance with this Plan. • Ensure that the results of monitoring are evaluated and reported to senior management and to relevant personnel for consideration as part of ongoing planning. • Ensure any potential or actual air quality is reported in accordance with legal requirements and the corporate standard. • Provide visible and proactive leadership in relation to the air quality management. • Ensure that operational changes consider the potential air quality impacts to adjacent private landowners • Ensure all reporting requirements are met and complies with internal and external monitoring standards, protocols and regulations. • Coordinate progressive rehabilitation to minimise disturbed areas. • Manage and maintain the air quality monitoring programs. • Ensure monitoring equipment is operated in accordance with relevant industry standards and protocols.
Managers, Supervisor, & Task Coordinators	• Provide that sufficient resources are allocated for the implementation of this Plan, as required. • Ensure adequate resources are budgeted for in relation to air quality • Ensure that operational changes consider the potential impacts of dust emissions from BHQ on the surrounding environment. • Monitor team members and contractors carry out work appropriate monitoring and maintenance tasks. • Ensure any potential or actual air quality emissions are controlled. • Conduct daily inspections of the work area to monitor compliance with this plan. • Provide input to management on the adequacy and effectiveness of this plan. • Ensure the effective implementation of strategies designed to reduce air quality impacts from BHQ. • Provide visible and proactive leadership in relation to air quality management. • Ensure personnel working at the operation are aware of the air quality management obligations whilst working with Hanson.

Appendix E: GREENHOUSE GAS ASSESSMENT

INTRODUCTION

This assessment determines the carbon dioxide equivalent (CO_2-e) emissions from the expansion of the BHQ according to international and Federal guidelines.

BACKGROUND

Greenhouse gases (GHG's) are a natural part of the atmosphere; they absorb and re-radiate the sun's warmth, and maintain the Earth's surface temperature at a level necessary to support life. Human actions, particularly burning fossil fuels (coal, oil and natural gas), agriculture and land clearing, are increasing the concentrations of the greenhouse gases. This is the enhanced greenhouse effect, which is contributing to warming of the Earth.

Greenhouse gases include water vapour, carbon dioxide (CO_2), methane, nitrous oxide and some artificial chemicals such as chlorofluorocarbons (CFCs). Water vapour is the most abundant greenhouse gas. These gases vary in effect and longevity in the atmosphere, but scientists have developed a system called Global Warming Potential to allow them to be described in equivalent terms to CO_2 (the most prevalent greenhouse gas) called equivalent carbon dioxide emissions (CO_2-e). A unit of one tonne of CO_2-e (t CO_2-e) is the basic unit used in carbon accounting. An emissions inventory, or 'carbon footprint', is calculated as the sum of the emission rate of each greenhouse gas multiplied by the global warming potential.

LEGISLATION OVERVIEW

The National Greenhouse and Energy Reporting Act 2007 (NGER Act) established a national framework for corporations to report greenhouse gas emissions and energy consumption. Registration and reporting is mandatory for corporations that have energy production, energy use or greenhouse gas emissions that exceed specified thresholds.

METHODOLOGY

The Department of the Environment (DOE) monitors and compiles databases on anthropogenic activities that produce greenhouse gases in Australia. The DOE has published greenhouse gas emission factors for a range of anthropogenic activities. The DOE methodology for calculating greenhouse gas emissions is published in the National Greenhouse Accounts (NGA) Factors workbook (Department of Environment, 2014). This workbook is updated regularly to reflect current compositions in fuel mixes and evolving information on emission sources.

The scope that emissions are reported, as defined by the NGA Factors Workbook is determined by whether the activity is within the organisation's boundary (Scope 1 – Direct Emissions) or outside the organisation's boundary (Scopes 2 and 3 – Indirect Emissions). The scopes are described below:

- Scope 1 Emissions: Direct (or point-source) emission factors give the kilograms of carbon dioxide equivalent (CO_2-e) emitted per unit of activity at the point of emission release (i.e. fuel use, energy use, manufacturing process activity, mining activity, on-site waste disposal, etc.).
- Scope 2 Emissions: Indirect emissions from the generation of the electricity purchased and consumed by an organisation as kilograms of CO_2-e per unit of electricity consumed.
- Scope 3 Emissions: Indirect emissions for organisations that:
  a. Burn fossil fuels: to estimate their indirect emissions attributable to the extraction, production and transport of those fuels; or
  b. Consume purchased electricity: to estimate their indirect emissions from the extraction, production and transport of fuel burned at generation and the indirect emissions attributable to the electricity lost in delivery in the transmission and distribution network.

Scope 1 emissions include those from fuel use by vehicles, coal burnt in boilers and methane from wastewater systems. Scope 2 emissions are from any purchased electricity. Scope 3 emissions are from the emissions resulting from the energy required to manufacture products such as coal, diesel and equipment.

Emission factors used in this assessment have been derived from either the Department of Environment, site-specific information or from operational details obtained from similar emission sources.

The majority of the emission factors used in this report has been sourced from the NGA Factors Workbook (Department of Environment, 2014) as indicated in ***Table E1***.

Table E1: Emission Factors

Scope	Emission Source	Emission Factor	Source
1	Combustion emissions from petrol	1.08 t CO_2-e / kL	NGA Factors Workbook, 2014
	Combustion emissions from diesel (stationary)	2.68 t CO_2-e / kL	NGA Factors Workbook, 2014
	Combustion for transport (general)	2.69 t CO_2-e / kL	NGA Factors Workbook, 2014
2	Purchased electricity	0.87 kg/CO_2-e/kWh	NGA Factors Workbook, 2014
3	Purchased electricity	0.19 kg/CO_2-e/kWh	NGA Factors Workbook, 2014
	Diesel consumption	0.2 t CO_2-e/kL	NGA Factors Workbook, 2014
	Petrol consumption	0.2 t CO_2-e/kL	NGA Factors Workbook, 2014
	Ethanol fuel consumption	0.006 CO_2-e/kL	NGA Factors Workbook, 2014

QUANTIFICATION OF EMISSIONS

The operation of the BHQ will result in GHG emissions from power generation, mobile plant use, staff travel, and product transport fuel emissions.

ANFO

Scope 1 emissions are also produced by ANFO. The Mining Association of Canada provides an emission factor of 0.189 tonnes carbon dioxide per tonne. Based on information provided by Hanson relating to the amount of area blasted at Brandy Hill at present, it has been calculated that for 1.5 Mtpa, 8 tonnes of explosive will be used per annum. The calculated CO_2 emissions are 1.5 tonnes per annum and 45 tonnes CO_2 over the 30 year life of the quarry.

PURCHASED POWER

Data provided by Hanson details that the annual electricity usage for 2013 was 1,527,421 kWh. Using the State emission factors for Scope 2 (0.87 CO_2-e/kWh) and Scope 3 (0.19 CO_2-e/kWh). Annual Scope 2 and Scope 3 emissions of CO_2-equivalents from the consumption of purchased electricity are presented in ***Table E2***.

Table E2: Purchased Electricity Emissions

Production Rate	Scope	Annual Usage (kWh)	Annual Emissions (t CO_2-e)
0.7 Mtpa	2 (indirect)	1,527,421	1,328.9
	3 (embodied)	1,527,421	290.2
1.5 Mtpa	2 (indirect)	3,273,045	2,847.6
	3 (embodied)	3,273,045	621.9

It can be seen that the current CO_2-e emissions are 1,619.1 tonnes whilst the proposed expansion of BHQ is 3,469.4 tonnes.

EQUIPMENT FUEL

Annual fuel consumption for mobile plant for 2013 has been provided by Hanson. The calculated CO_2-e emissions for the current and future emissions are presented in ***Tables E3*** and ***E4***.

Table E3: Current Machine Equipment Fuel Emissions (CO_2-e tonnes)

Emission Source	Scope	Annual Usage (kL)	Annual Emissions (t CO_2-e)
Machine Fuel – Diesel	1 (direct)	408.3	1,095.4
	3 (embodied)	408.3	83.5
Machine Fuel – Petrol	1 (direct)	0.4	0.43
	3 (embodied)	0.4	0.08
Machine Fuel – E10	1 (direct)	0.02	0
	3 (embodied)	0.02	0
Annual CO_2-e Emissions (tonnes)			**1,179.4**

Table E4: Future Machine Equipment Fuel Emissions (CO_2-e tonnes)

Emission Source	Scope	Annual Usage (kL)	Annual Emissions (t CO_2-e)
Machine Fuel – Diesel	1 (direct)	807.97	2,347.3
	3 (embodied)	807.97	179.0
Machine Fuel – Petrol	1 (direct)	0.85	0.92
	3 (embodied)	0.85	0.17
Machine Fuel – E10	1 (direct)	0.04	0
	3 (embodied)	0.04	0
Annual CO_2-e Emissions (tonnes)			**2,527.4**

PRODUCT TRANSPORTATION AND STAFF TRAVEL

Data provided by Hanson determined that currently there are 150 truck movements relating to production per day. It has been assumed that the fuel consumption is 30 L/100 km and an average return journey is a distance of 80 km. Staff travel has been estimated based on current staff (22) travelling individually to site and a return journey of 40 km and a fuel consumption of 10 L/100 km. The expansion of the quarry will require approximately 30 staff.

The concrete plant will produce 15,000 tonnes per year and will require an additional 2,727 additional trips per annum.

Table E5: Current Transportation Emissions (CO_2-e tonnes)

Emission Source	Scope	Annual Usage (kL)	Annual Emissions (t CO_2-e)
Product Transport	1 (direct)	1,260	3,380.2
	3 (embodied)	1,260	257.8
Staff Travel	1 (direct)	32.12	73.7
	3 (embodied)	32.12	5.8
Annual CO_2-e Emissions (tonnes)			**3,717.5**

Table E6: Future Transportation Emissions (CO_2-e tonnes)

Emission Source	Scope	Annual Usage (kL)	Annual Emissions (t CO_2-e)
Product Transport	1 (direct)	2,700	7,243.3
	3 (embodied)	2,700	552.4
Staff Travel	1 (direct)	43.8	100.5
	3 (embodied)	43.8	7.9
Cement Plant Trucks	1 (direct)	65.5	175.6
	3 (embodied)	65.5	13.4
		Annual CO_2-e Emissions (tonnes)	**8,093.1**

SUMMARY

The purpose of this report is to evaluate the GHG emissions from the operation of BHQ. This assessment has found:

- Current CO_2-equivalent emissions are estimated to be 6,516 tonnes per year with the highest contribution from product transportation;
- Increasing production to 1.5 Mtpa will increase the estimated CO_2-equivalent emissions to 14,090 tonnes per annum.

A breakdown of the emissions per annum is presented in ***Table E7***.

Table E7: Annual Emissions Breakdown

Phase	Activity	CO_2-e Emissions (tonnes)
Current (0.7 Mtpa)	Machine Fuel	1,179.4
	Electricity	1,619.1
	Product and staff transportation	3,717.5
	Total	**6,516.0**
Future (1.5 Mtpa)	Machine Fuel	2,527.4
	Electricity	3,469.4
	Product and staff transportation	8,093.1
	Total	**14,089.9**

Calculating the GHG emissions for the life of the BHQ, based on an extraction rate of 1.5 Mtpa for 30 years the following GHG emissions are expected:

- Scope 1 emissions: 296,072.5 tonnes CO_2-equivalent;
- Scope 2 emissions: 85,426.5 tonnes CO_2-equivalent; and
- Scope 3 emissions: 41,242.5 tonnes CO_2-equivalent.

In 2012, the reported net GHG emissions for Australia was 558 Mt CO_2-e (Department of the Environment, 2013) are compared to the Scope 1 emissions from BHQ, the lifetime emissions from BHQ will represent approximately 0.0005% of total emissions.

A reduction in GHG emissions can be achieved through the reduction in consumption of fuel. This can be achieved through the consideration of haulage distances within the pit, mobile plant operational time and the amount of purchased electricity.

The potential installation and operation of more efficient plant during the relocation of the processing plant will assist in BHQ reducing their GHG emissions; however these potential reductions in energy consumption have not been calculated in this assessment as it is unclear if plant upgrades will occur.