



# Gunlake Quarry Extension Project

3

Environmental Impact Statement

Prepared for Gunlake Quarries Pty Limited | April 2016



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Intended for  
**EMM Consulting Pty Ltd**

Document type  
**Final**

Date  
**February 2016**

# **GUNLAKE QUARRY AIR QUALITY IMPACT AND GREENHOUSE GAS ASSESSMENT**

**GUNLAKE QUARRY  
AIR QUALITY IMPACT AND GREENHOUSE GAS  
ASSESSMENT**

Revision	Date	Made by	Checked by	Approved by	Signed
Final	11/02/2016	S Fishwick	R. Kellaghan	S.Fishwick	

Ref AS121885

Ramboll Environ Australia Pty Ltd  
Level 3  
100 Pacific Highway  
PO Box 560  
North Sydney  
NSW 2060  
Australia  
T +61 2 9954 8100  
F +61 2 9954 8150  
[www.ramboll-environ.com](http://www.ramboll-environ.com)

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## EXECUTIVE SUMMARY

The Gunlake Quarry has been operating since 2009 under project approval 07-0074 issued by the Minister for Planning in September 2008. The proposed extension project seeks to progressively increase the rate of extraction from 750,000 tonnes per annum (tpa) to a maximum of 2 million tpa.

Ramboll Environ Australia Pty Ltd (Ramboll Environ) has been commissioned by EMM Consulting Pty Limited (EMM) to conduct an air quality and greenhouse gas assessment of the proposed extension project.

The existing Quarry is located in a rural setting, approximately 5 km to the northwest of Marulan town. The site is surrounded by scattered rural residential properties, the closest of which are located to the southeast, along Brayton Road.

An onsite meteorological station indicates that the dominant winds are from the west-southwest to west, with lower wind speeds from the east and northeast also experienced. Existing air quality monitoring (PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition) indicates that ambient air quality is generally good.

Particulate matter (PM) emissions inventories have been developed for current operations and three future scenarios for the proposed expansion. To explicitly account for the potential impacts from the nearby Lynwood and Johnniefields Quarry sites, emissions from these two sites have been quantified for inclusion in the dispersion modelling.

Dispersion model predictions for the proposed Gunlake Quarry extension project show that the proposed changes to operations would not result in any exceedances of the impact assessment criteria for key pollutants, including PM<sub>10</sub>, PM<sub>2.5</sub>, Total Suspended Particulates, Respirable crystalline silica and dust deposition.

The closest receptor locations (R1, R2, R3 and R6) are the most impacted by emissions from the Gunlake Quarry. The predicted concentrations and deposition rates increase as the Gunlake Quarry expands with peak production predicted to have the highest impacts.

Cumulative predictions are presented for worst case operations, taking into account emission from neighbouring quarry operations and existing ambient background concentrations. Cumulative annual average PM<sub>10</sub>, PM<sub>2.5</sub> and TSP were all below the applicable assessment criteria and the risk of additional days over the 24-hour average PM<sub>10</sub> and PM<sub>2.5</sub> assessment criteria is minimal.

The dispersion modelling presented in this report assumes a number of dust controls. Existing controls should continue to be implemented for the extension project as production increases.

It is recommended that the existing monitoring regime is maintained with the need for additional monitoring determined on an annual basis, as production ramps up.

In addition to air quality impacts, a greenhouse gas (GHG) quantification assessment was undertaken for the proposed Gunlake Quarry extension project. Relative to existing operations, the proposed modification will result in an increase in annual GHG emissions, due primarily to the related increase in diesel fuel consumption (on-site and product transportation) and electricity demand for processing.

At maximum production, GHG emissions will increase by approximately three fold from current operations. The annual Scope 1 and Scope 3 emissions at full production represent approximately 0.03% of total GHG emissions for NSW and 0.008% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2013.

# 1. INTRODUCTION

Gunlake Quarry is a hard rock quarry operated by Gunlake Quarries Pty Ltd (Gunlake). It is located approximately 5 kilometres (km) north-west of Marulan in the Goulburn Mulwaree local government area (LGA), shown in **Figure 1-1**. Gunlake Quarry has been operating since 2009 under New South Wales (NSW) project approval 07-0074 issued by the Minister for Planning in September 2008 under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

The proposed Gunlake Quarry Extension Project (the extension project) seeks to enable an increased rate of extraction at Gunlake Quarry to assist to meet the identified demand for construction materials, including quarried aggregate, for the local area and Sydney. The extension project includes the production of 2 million tonnes per annum (Mtpa) of saleable product for 30 years. Therefore, Gunlake seeks a new development consent that allows:

- 2 Mtpa of saleable products to be produced;
- an increase in truck movements to an average of 440 movements per day;
- extension of the quarry pit footprint to approximately 49 hectares (ha);
- 24 hour per day primary crushing;
- additional overburden emplacement (approximately 10 ha) to accommodate the increase in production; and
- blasting twice weekly.

In addition, Gunlake seeks to maintain the approval for all aspects of the existing operations for Gunlake Quarry under NSW Project Approval 07-0074.

Ramboll Environ Australia Pty Ltd (Ramboll Environ) has been commissioned by EMM Consulting Pty Limited (EMM) on behalf of the Gunlake to conduct an air quality and greenhouse gas assessment of the proposed extension project.

This air quality assessment provides:

- characterisation of the existing environment, specifically the existing air quality, prevailing meteorology and regulatory context;
- review of potential emission sources and mitigation measures;
- calculation of annual particulate matter emissions from the Gunlake Quarry;
- atmospheric dispersion modelling of emissions for proposed operations at Gunlake Quarry site to predict potential particulate matter impacts at the surrounding sensitive receptor locations; and
- quantification of greenhouse gas emissions from the current and proposed future operations at the Gunlake Quarry.

## 1.1 Study objectives

The objective of the study is to identify the potential air quality and greenhouse gas related impacts associated with the project, satisfy the Secretary's Environmental Assessment Requirements (SEARs) and to make recommendations for additional mitigation and management measures if required.

## 1.2 Secretary's Environmental Assessment Requirements

The SEARs for the extension project are as follows:

- **Air Quality** – including a quantitative assessment of potential:
  - Construction and operational impacts, with a particular focus on dust emissions including PM<sub>10</sub> and PM<sub>2.5</sub>;
  - Dust generation from blasting and processing, as well as diesel emissions and dust generated from the transportation of quarry products;
  - Reasonable and feasible mitigation measures to minimise dust and diesel emissions; and
  - Monitoring and management measures, in particular, real-time air quality monitoring.

- **Greenhouse gases** – including an assessment of the likely greenhouse gas emissions of the development.

The air quality requirements are specifically addressed in **Section 6, 7, 8** and **0** of the report with the earlier Sections providing the baseline information and study methodology. The greenhouse gas requirements are specifically addressed in **Section 10** of the report.

The air quality assessment is guided by the NSW Environment Protection Authority (NSW EPA) Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (“the Approved Methods for Modelling”, (NSW EPA, 2005).

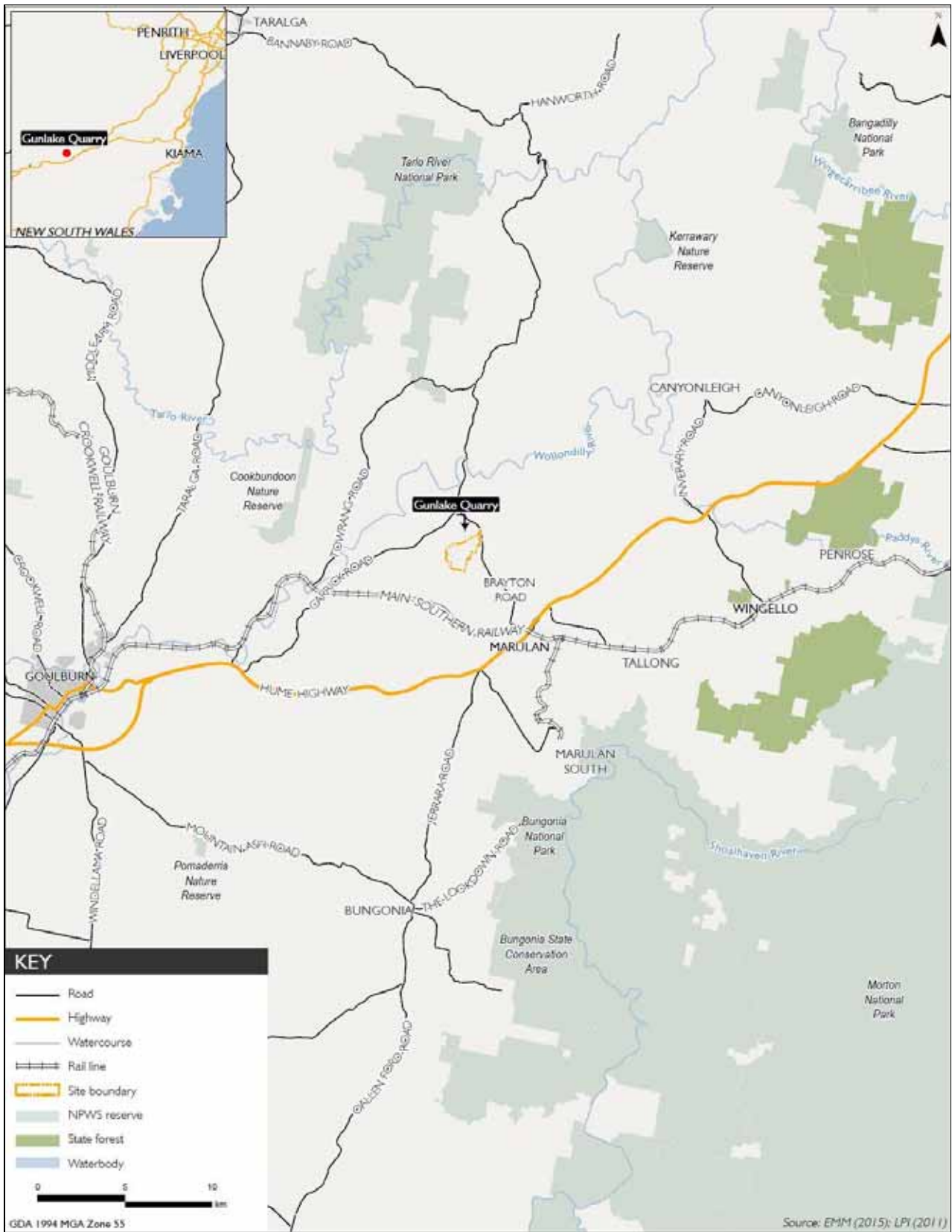


Figure 1-1: Site location map

Source: EMM (2015)

## 2. PROJECT DESCRIPTION AND LOCAL SETTING

### 2.1 Existing operations

#### 2.1.1 Resource

The rock resource is within the Bindook Volcanic Complex of the Devonian Age. The Complex comprises a north-northeast trending series of volcanic units located north of the intrusive Marulan Granite. Gunlake Quarry is located on a proven rock resource of approximately 180 Mt of tuffaceous rhyodacite. The igneous rock deposit continues well over 100 m below the surface.

The hard rock is suitable for uses in a range of quarry products including concrete and sealing aggregates, rail ballast, manufactured sand and road bases.

To date, only a small proportion (0.9 Mt) of the 180 Mt of hard rock identified on the site has been quarried at Gunlake Quarry.

#### 2.1.2 Quarry components

Gunlake Quarry supplies the local region and the greater Sydney Metropolitan area with hard rock. Gunlake Quarry has approval for up to 750,000 tonnes of saleable product and is a significant supplier of heavy construction materials for the New South Wales (NSW) construction industry. Key components of the existing quarry include:

- a quarry pit providing hard rock resources;
- overburden emplacement and excess product stockpile areas;
- drilling and blasting to release the rock material;
- crushing and screening of the quarried rock;
- truck loading and transport of hard rock; and
- ancillary infrastructure to support operations including offices, amenity buildings and other minor infrastructure.

#### 2.1.3 Soil stockpiling

Topsoil and subsoil within the quarry pit is stripped and replaced directly onto completed sections of the final landform. Where this is impractical and stockpiling is necessary, topsoil and subsoil is stockpiled separately.

#### 2.1.4 Soil and overburden removal

Overburden is removed by an excavator loading to 50-tonne dump trucks. In the quarry pit, overburden is removed progressively in front of the quarry bench. This occurs about two months in advance of the drilling in preparation for rock production blasting.

#### 2.1.5 Overburden emplacement bund

An overburden emplacement bund has been constructed to provide a permanent location for the overburden material. The overburden for the bund was obtained from the processing and quarry pit development to date. It will be extended to the north and south.

The overburden emplacement bund has been located to maximise its acoustic and visual screening properties.

#### 2.1.6 Rock extraction

Following the removal of overburden, conventional drill and blast techniques are used to quarry the rock faces that are up to approximately 13 m high. Quarrying started at the northern end of the quarry pit and is proceeding south.

Drilling in preparation for blasting is undertaken using a hydraulic drill and approximately 30,000 tonnes of hard rock is prepared for each blast. Blasting occurs approximately once a fortnight.

#### 2.1.7 Rock processing

Following extraction, quarried rock is transported north-east of the quarry pit to the rock processing area via haul roads. The rock processing area contains the following components:

- primary crusher;

- secondary crushers and screens;
- tertiary crushers and screens;
- main screen;
- interconnecting conveyors; and
- product stockpiles.

The processing area has a prepared hard surface of crushed rock material. It is used for stockpiling various products and for load out by a front end loader into road haul trucks for delivery to markets.

The processing plant contains atomised water dust suppression systems at all discharge points.

#### 2.1.8 Site infrastructure and equipment

The existing site infrastructure includes the following:

- site office;
- toilet and ablution facilities;
- weighbridge;
- truck wash;
- crib hut;
- hardstand and truck parking area;
- light vehicle parking area;
- bunded fuel bay;
- maintenance workshop and wash bay; and
- light vehicle parking facilities.

Gunlake Quarry operates the following equipment:

- face loader (Cat 988);
- two 50-tonne dump trucks (Cat 773);
- front end loader (Cat 980);
- front end loader (Cat 988);
- drilling rig (Atlas Copco Hydraulic rig);
- excavator (Caterpillar 345BL);
- grader (Caterpillar 12H);
- tip truck;
- maintenance trucks; and
- water truck.

#### 2.1.9 Quarry products

Rock extracted at Gunlake Quarry is processed by crushing and screening within the processing area to form saleable products. The material produced at Gunlake quarry is suitable for use in the following products:

- concrete and sealing aggregates;
- rail ballast;
- manufactured sand; and
- road base.

Typical finished products from the processing plant include aggregates with diameters less than 20 mm, 14 mm, 10 mm and 7 mm.

## 2.2 The Extension Project proposal

As stated in **Section 1**, Gunlake seeks a new development consent that allows:

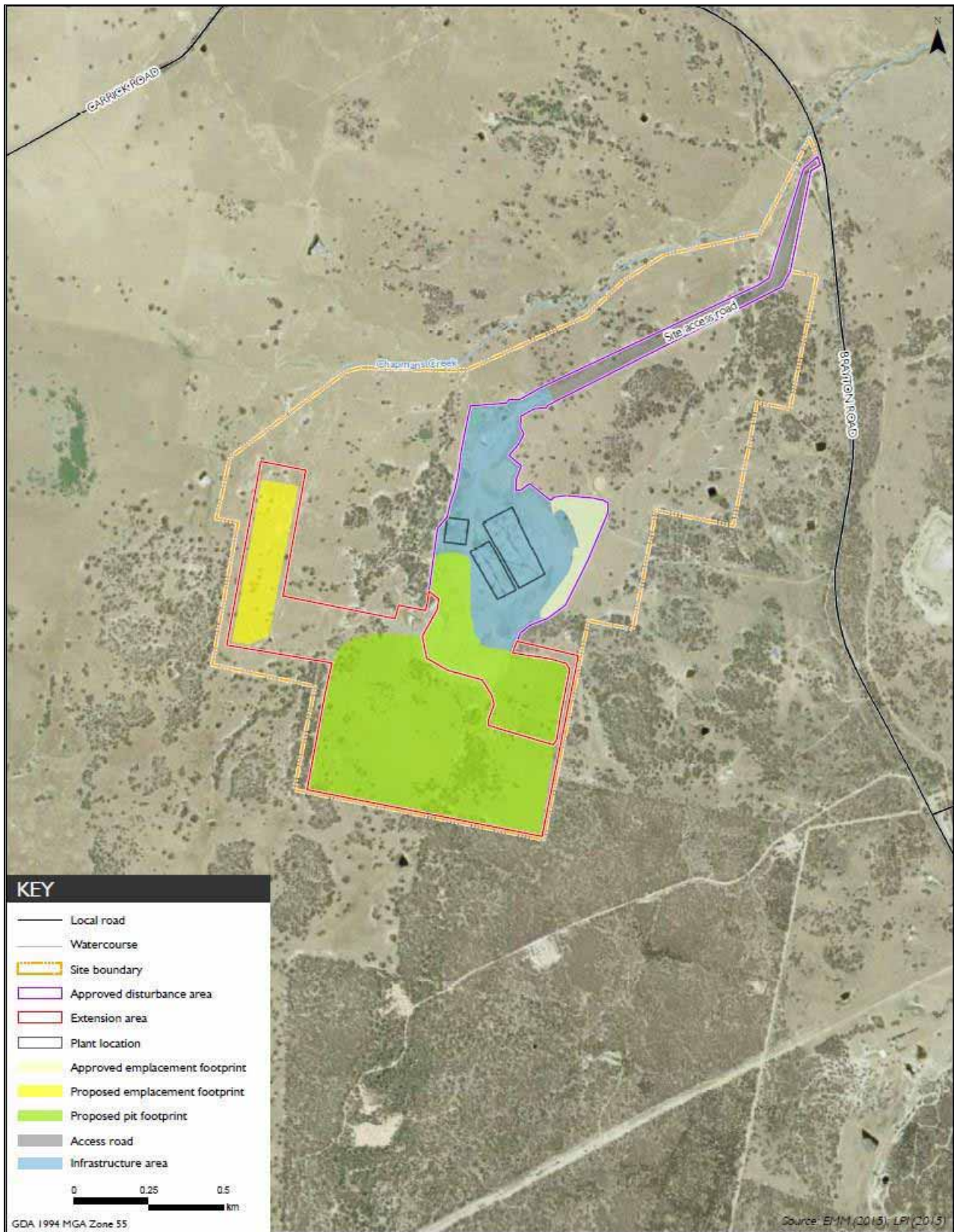
- 2 million tonnes per annum (Mtpa) of saleable products to be produced;
- an increase in truck movements to an average of 440 movements per day;
- extension of the quarry pit footprint by 150 percent to approximately 63 ha;
- 24 hour per day primary crushing;
- additional overburden emplacement to accommodate the increase in production; and

- blasting twice weekly.

In addition, Gunlake seeks to maintain the approval for all aspects of the existing operations for Gunlake Quarry under Project Approval 07-0074. The proposed extension area is shown in **Figure 2-1**. The proposed progression of the Gunlake Quarry is illustrated in **Figure 2-2**.

A summary of the Extension Project is provided in **Table 2-1**.

<b>Table 2-1: Project description</b>		
<b>Project element</b>	<b>Currently approved</b>	<b>Proposed change</b>
Quarrying method	Hard rock quarrying by open cut methods.	No change.
Resource	Approximately 180 million tonnes	No change.
Disturbance area	As shown in <b>Figure 2-1</b> .	Extension of pit footprint to approximately 63 ha (shown in <b>Figure 2-1</b> ).
Saleable product	750,000 tonnes per annum (tpa)	Increase to 2 Mtpa.
Quarry life	30 years	30 years from approval. There is sufficient resource (180 Mt) for quarrying to continue at 2 Mtpa for 90 years.
Beneficiation	Onsite crushing and stockpiling of quarried rock	No change.
Infrastructure	As outlined in <b>Section 2.1.8</b>	Upgrade infrastructure as required to produce 2 Mtpa of products
Product transport	An average of 164 truck movements per day.	Increase truck movements to an average of 440 movements per day
Operational workforce	25 on-site employees and 25 to 38 truck drivers (full-time equivalent)	Increase of approximately 27 on-site employees and truck drivers.
Hours of operation	6:00 am Monday to 6:00 pm Saturday, including crushing between 7:00 am and 6:00 pm, Monday to Saturday and maintenance at any time, Monday to Saturday.	Modify existing hours of operation to allow crushing 24 hours a day (except Sundays and public holidays) and maintenance anytime (including Sundays and public holidays).



**Figure 2-1: Site elements**

Source: EMM (2016)

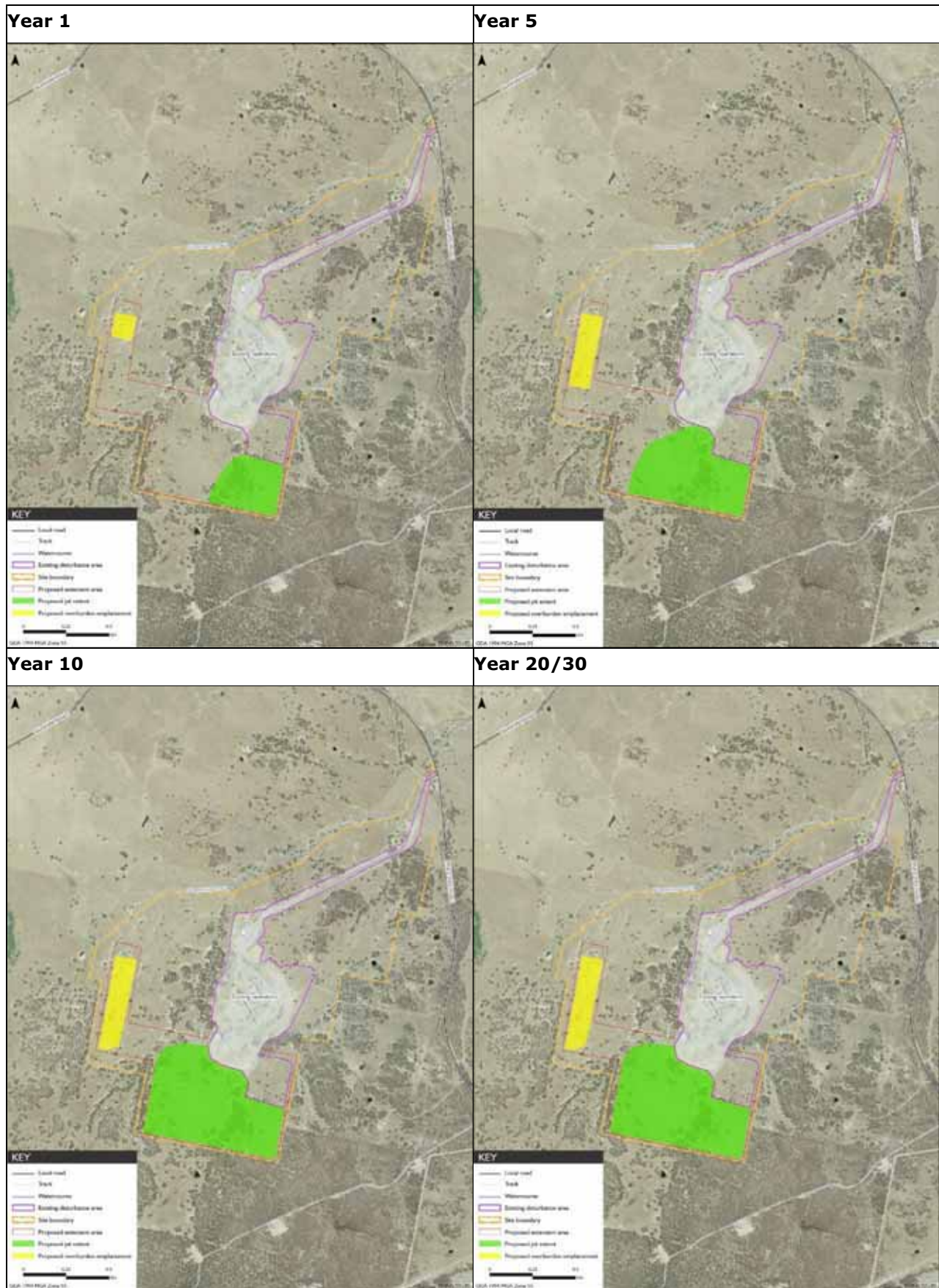


Figure 2-2: Proposed quarry progression

Source: EMM (2015)

### 2.3 Surrounding land use and topography

The Gunlake Quarry is located in a rural setting, approximately 5 km to the northwest of Marulan town. The site is surrounded by agricultural lands and existing extractive industry, including the Holcim Johnniefelds Quarry, approximately 1 km to the east and the Holcim Lynwood Quarry – approximately 1.5 km to the south.

The Gunlake Quarry site is situated at an elevation of approximately 620m Australian Height Datum (AHD) at its north-eastern boundary to approximately 700m at its southern boundary. An elevated ridgeline exists to the northwest, extending to a height of between 800m and 900m AHD. A three-dimensional representation of the local topographic features is illustrated in **Figure 2-3**.

The Gunlake Quarry site is surrounded by scattered rural residential properties. The majority of closest receptor locations are located to the southeast of the Gunlake Quarry along Brayton Road. Receptor locations R1 and R3 are owned by Gunlake, but are retained within this assessment for completeness. The selected receptor locations are presented in **Table 2-2** and illustrated in **Figure 2-4**.

Receptor ID	Location (m, MGA55S)		Elevation (m, AHD)
	Easting	Northing	
1*	772856	6159435	653
2	772842	6159055	679
3*	772686	6158639	674
4	771054	6160526	671
5	773015	6158957	678
6	773363	6158287	659
7	773293	6158087	657
8	773966	6157901	646
9	773943	6157467	662
10	774114	6157288	651
11	774786	6156906	642
12	775012	6156979	632

Note \*: Gunlake Quarries-owned residence

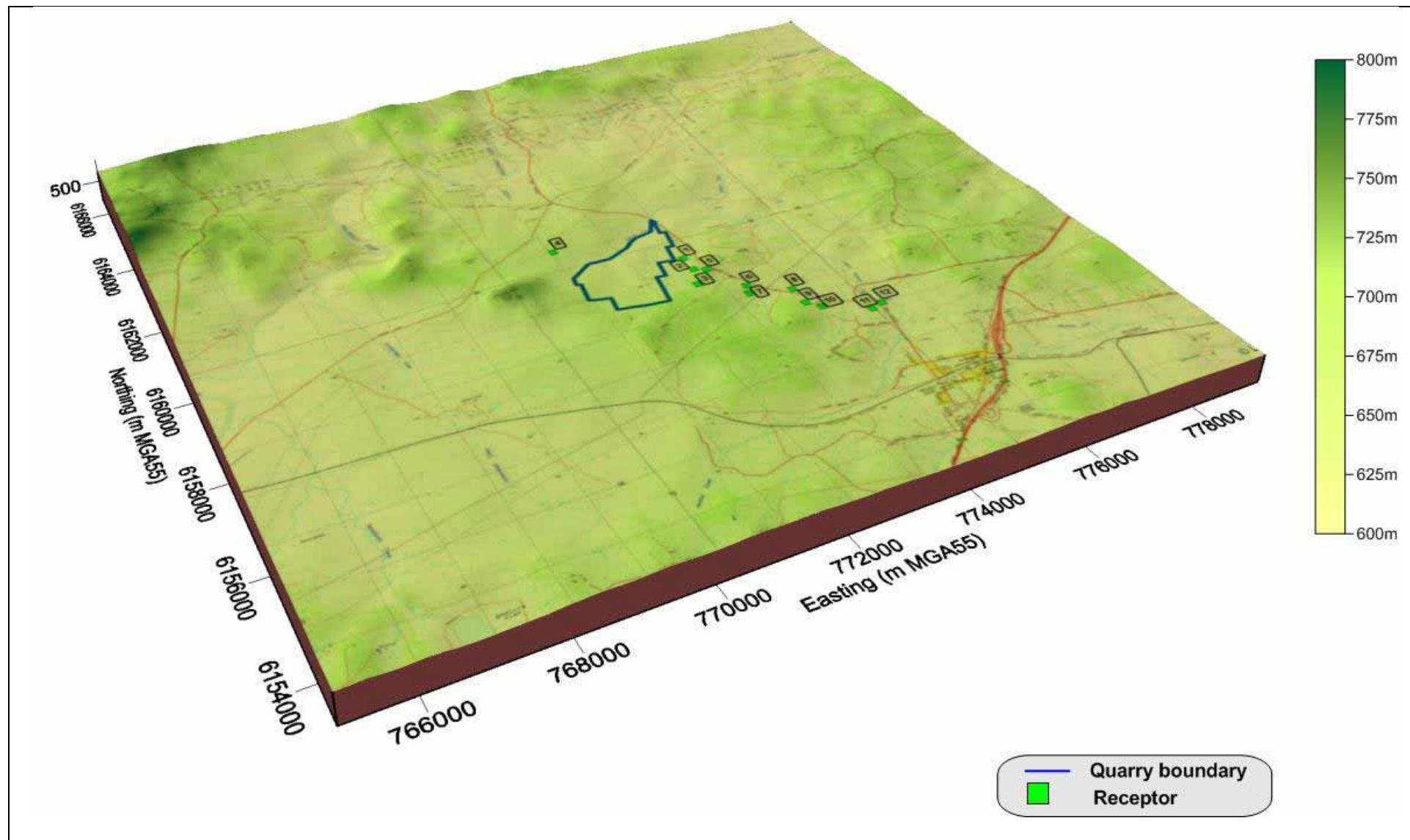


Figure 2-3: Local topographic features

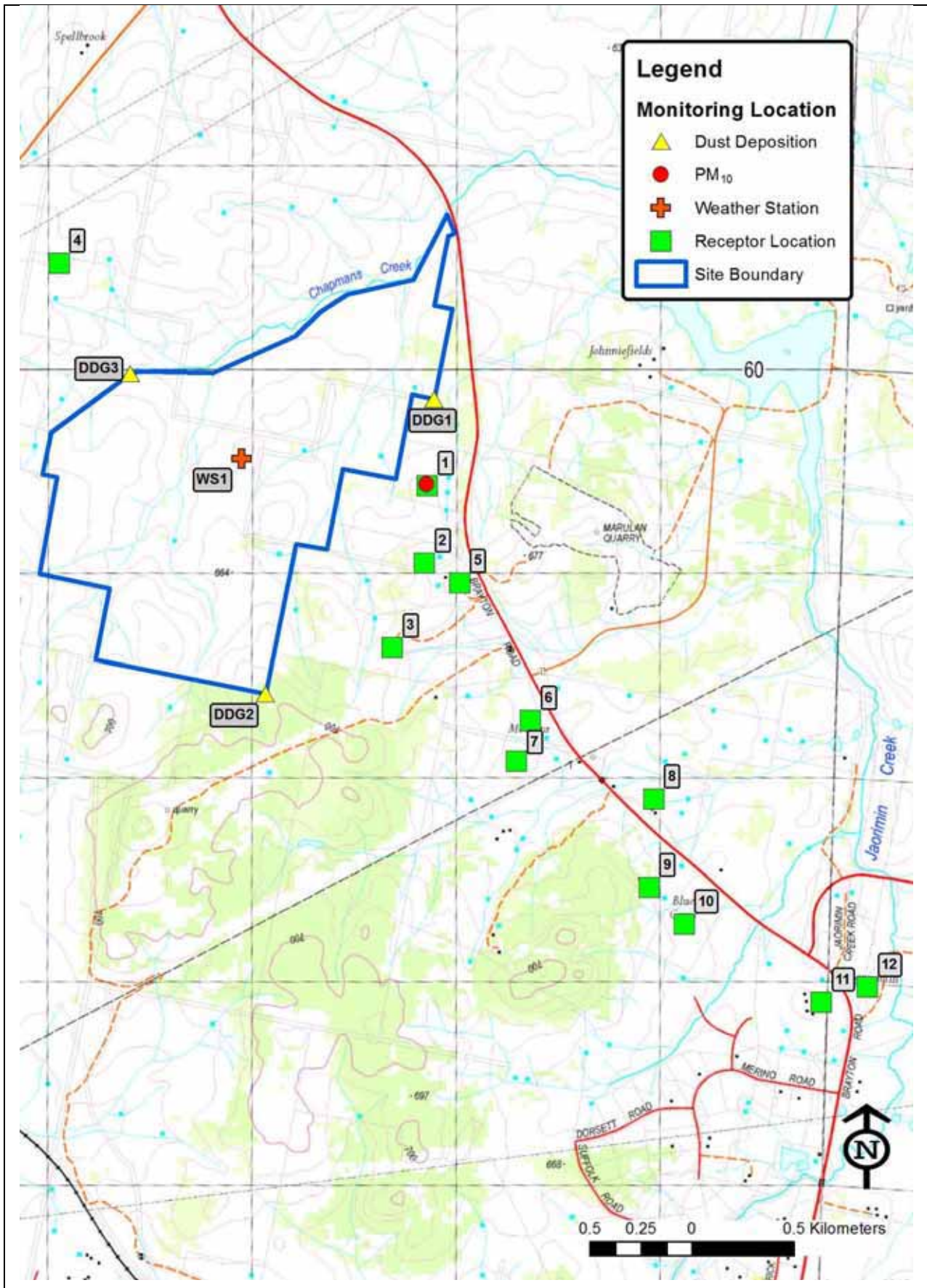


Figure 2-4: Surrounding sensitive receptor and monitoring locations

### 3. AIR QUALITY ASSESSMENT CRITERIA

The Gunlake Quarry must demonstrate compliance with the impact assessment criteria outlined in the Approved Methods for Modelling (NSW EPA, 2005). The impact assessment criteria are designed to maintain ambient air quality that allows for the adequate protection of human health and well-being.

The Approved Methods for Modelling specifies that the impact assessment criteria for 'criteria pollutants' are applied at the nearest existing or likely future off-site sensitive receptor and compared against the 100<sup>th</sup> percentile (i.e. the highest) dispersion modelling prediction. Both the incremental and cumulative impacts need to be presented, requiring consideration of existing ambient background concentrations for the criteria pollutants assessed. Methodology for the assessment of cumulative impacts is detailed in **Section 8**.

In accordance with the SEARs, focus has been given to the emissions of primary particulate matter (PM), including total suspended particulate matter (TSP) and particulate matter with an equivalent aerodynamic diameter of less than 10 microns (PM<sub>10</sub>) and 2.5 microns (PM<sub>2.5</sub>). Dust deposition, as a result of the TSP emissions, is also assessed.

#### 3.1 Goals applicable to airborne particulate matter

Air quality limits for PM are typically given for various particle size metrics, including TSP, PM<sub>10</sub> and PM<sub>2.5</sub>. PM<sub>10</sub> and PM<sub>2.5</sub> require specific consideration due to their health impact potential.

The impact assessment criteria for TSP and PM<sub>10</sub> are prescribed in the Approved Methods for Modelling, however PM<sub>2.5</sub> is not included. Reference is therefore made to the PM<sub>2.5</sub> advisory reporting standards issued by the National Environmental Protection Council (NEPC) (NEPC, 2003).

The National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) PM<sub>2.5</sub> advisory reporting standards were published in 2003 for the purpose of supporting the monitoring and evaluation of ambient PM<sub>2.5</sub> concentrations ahead of the setting ambient air quality standards for this pollutant.

On 29 April 2014, Ministers signalled their intention to vary the AAQ NEPM for particles, to reflect the latest scientific understanding on health risks. An impact statement was published in July 2014 which outlined the options considered in the variation (NEPC, 2014). The draft varied NEPM seeks to establish a more stringent reporting standard for 24-hour PM<sub>10</sub>, introduce a reporting standard for annual average PM<sub>10</sub> and formalise the advisory reporting standards for PM<sub>2.5</sub><sup>2</sup>. This assessment has applied the existing AAQ NEPM PM<sub>2.5</sub> advisory reporting standards.

The air quality criteria applied for PM in this assessment are presented in **Table 3-1**.

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<sup>1</sup> 'Criteria pollutants' is used to describe air pollutants that are commonly regulated and typically used as indicators for air quality. In the Approved Methods the criteria pollutants are TSP, PM<sub>10</sub>, NO<sub>2</sub>, SO<sub>2</sub>, CO, ozone (O<sub>3</sub>), deposition dust, hydrogen fluoride and lead.

<sup>2</sup> <http://www.environment.gov.au/system/files/pages/dfe7ed5d-1eaf-4ff2-bfe7-dbb7ebaf21a9/files/aaq-nepm-varied.pdf>

<b>Pollutant</b>	<b>Averaging Period</b>	<b>Concentration (<math>\mu\text{g}/\text{m}^3</math>)</b>	<b>Reference</b>
TSP	Annual	90	NSW EPA <sup>(1)(2)</sup>
PM <sub>10</sub>	24 hours	50	NSW EPA <sup>(1)</sup>
	24 hours	50 <sup>(4)</sup>	NEPM <sup>(3)</sup>
	Annual	30	NSW EPA <sup>(1)</sup>
PM <sub>2.5</sub>	24 hours	25	NEPM <sup>(5)</sup>
	Annual	8	NEPM <sup>(5)</sup>

Note 1: NSW EPA, 2005 *Approved Methods for Modelling*

Note 2: NSW EPA impact assessment criterion based on the subsequently rescinded National Health and Medical Research Council (NHMRC) recommended goal

Note 3: NEPC, 2003, *National Environment Protection (Ambient Air Quality) Measure*, as amended

Note 4: Provision made for up to five exceedances of the standard per year

Note 5: Advisory reporting goal issued by the NEPC (NEPC, 2003)

### 3.2 Dust deposition criteria

Nuisance dust deposition is regulated through the stipulation of maximum permissible dust deposition rates. The NSW EPA impact assessment goals for dust deposition are given in **Table 3-2**. These are the allowable increment in dust deposition rates above ambient (background) and cumulative (increment + background) dust deposition rates which would be acceptable to avoid dust nuisance.

<b>Averaging Period</b>	<b>Maximum Increase in Deposited Dust Level</b>	<b>Maximum Total Deposited Dust Level</b>
Annual	2 g/m <sup>2</sup> /month	4 g/m <sup>2</sup> /month

Source: Approved Methods for Modelling, EPA 2005

### 3.3 Respirable Crystalline Silica

Crystalline silica is present in abundance on the earth's crust. The most common form of crystalline silica is quartz, which is a basic component of sand, stone, granite and many other minerals (United States Branch of Industrial Minerals, 1992).

Based on information provided by Gunlake, the indicative silica content of the extracted material is estimated to be between 5% and 7%.

Inhalation of respirable crystalline silica (RCS) particles has long been known to cause silicosis, an inflammation and scarring in the lungs reducing the capacity to absorb oxygen from air depending on the level of exposure. The International Agency for Research on Cancer has classified crystalline silica as a human carcinogen (United States Department of Health and Human Services, 2011).

While the NSW EPA does not provide assessment criteria for RCS, the Victorian Environment Protection Authority (VEPA) has developed an assessment criteria based on California regulations for RCS of 3 $\mu\text{g}/\text{m}^3$  for mining and extractive industries (VEPA, 2007). The VEPA criterion represents an annual average applied to RCS in the PM<sub>2.5</sub> fraction.

In the current assessment, the Victorian annual average criterion of 3 $\mu\text{g}/\text{m}^3$  has been used to assess potential impacts from RCS. Further discussion on the assessment of RCS is presented in **Section 6.5**.

## 4. CLIMATE AND DISPERSION METEOROLOGY

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. Emission generation rates are particularly dependent on wind energy and on the moisture budget, which is a function of rainfall and evaporation rates.

A combination of onsite monitoring, regional observational data and meteorological modelling techniques were used to understand the meteorological characteristics of the study area. Details regarding the meteorological modelling are presented in **Section 4.1**.

The following data were used in the meteorological analysis:

- 1-hour average meteorological data from the meteorological monitoring station located at the Gunlake Quarry (see **Figure 2-4**).
- 1-hour average meteorological data and historical climate data from the BoM Automatic Weather Station (AWS) locations at Goulburn Airport (Station Number 070330) and Moss Vale (Station Number 068239), located approximately 26km west-southwest and 45km east-northeast of the Gunlake Quarry respectively.

### 4.1 Overview of meteorological modelling

Section 4.1 of the Approved Methods for Modelling specifies that meteorological data should cover a period of at least one year with a percentage completeness of at least 90%. From the onsite meteorological monitoring station, the calendar year of 2014 contains the most complete and current continuous twelve months of data at the time of reporting. The 2014 calendar year has therefore been used as the baseline for this assessment.

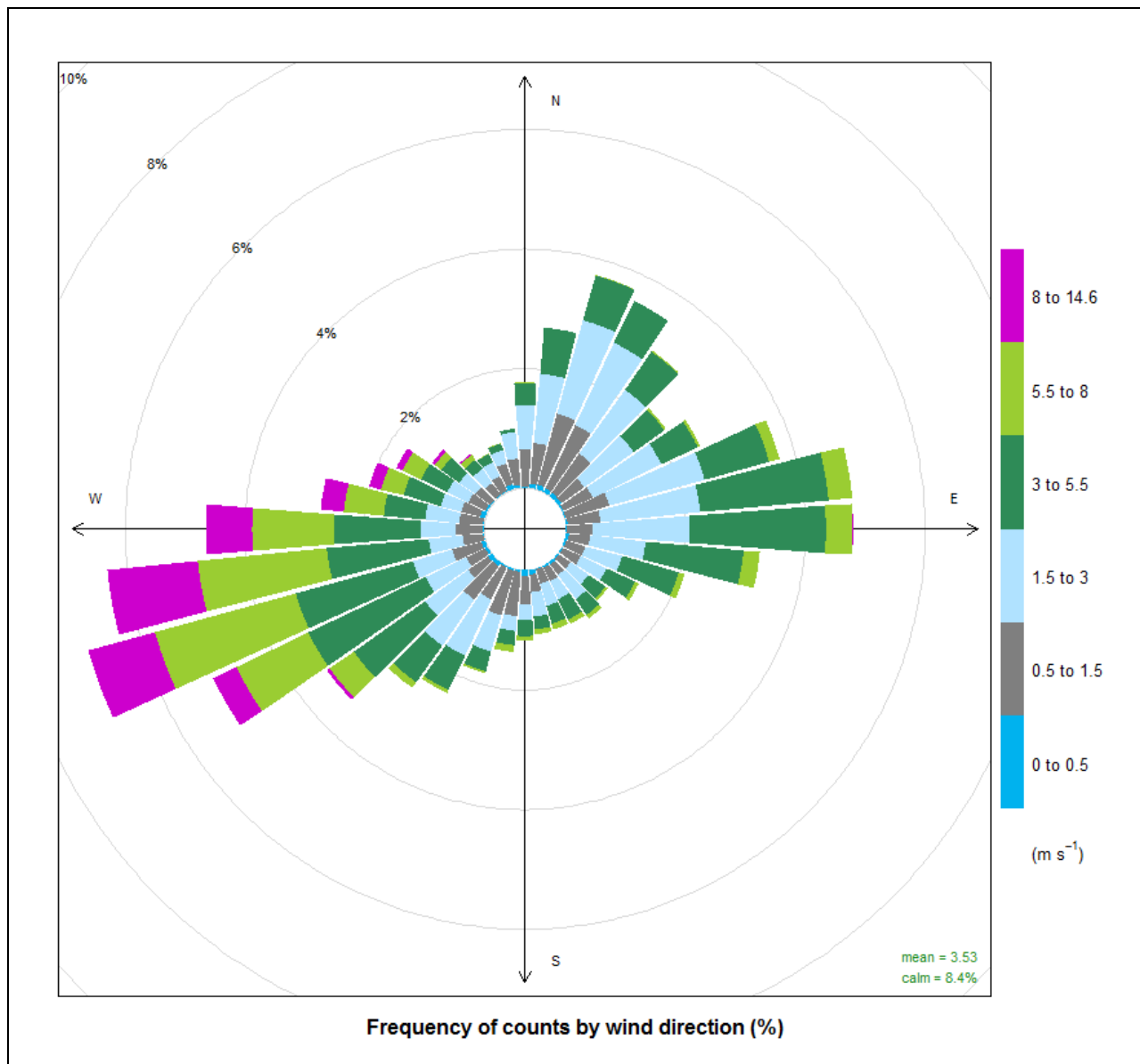
Data from the onsite meteorological station were supplemented with cloud observations from the Moss Vale BoM AWS. The CSIRO meteorological model TAPM was used to generate the vertical temperature profile and to fill gaps in the monitoring dataset. TAPM was configured and run in accordance with the Section 4.5 of the Approved Methods for Modelling, with the following refinements:

- Modelling to 300 m grid cell resolution (beyond 1 km resolution specified).
- Inclusion of high resolution (90 m) regional topography (improvement over default 250 m resolution data).

The TAPM generated Quarry site vertical temperature profile was adjusted for every hour by first substituting the predicted 10 m above ground temperature with hourly recorded temperature at 10 m. The vertical layer temperature difference predicted by TAPM was then adjusted relative to the 10 m observation temperature for each hour. This modified vertical profile was used in combination with the ambient air temperature throughout the day to calculate convective mixing heights between sunrise and sunset

### 4.2 Prevailing wind regime

A wind rose showing wind speed and direction data recorded by the onsite meteorological monitoring station at the Gunlake Quarry is presented in **Figure 4-1**. The annual recorded wind pattern is dominated by west-southwest to westerly airflow, with lower wind speeds from the east and northeast also experienced. The highest wind speeds are most frequently experienced from the west-southwest to west. The average recorded wind speed for 2014 was 3.5 m/s, with a frequency of calm conditions (wind speeds less than 0.5 m/s) occurring in the order of 8% of the time.



**Figure 4-1: Annual Average Wind Rose – Quarry Station – 2014**

Seasonal and diurnal (dividing the day into night and day) wind roses for the meteorological dataset are presented within **Appendix 1**. Seasonal variation in wind speed and direction is evident in the recorded data from the Gunlake Quarry station. While present in all seasons, the west-southwest to westerly airflow is most dominant between late autumn and early spring, peaking in winter. The easterly and northeasterly airflow is most common in the summer months. Average wind speed is lowest during autumn and peaks in winter. The incidence of calm conditions is greatest in autumn.

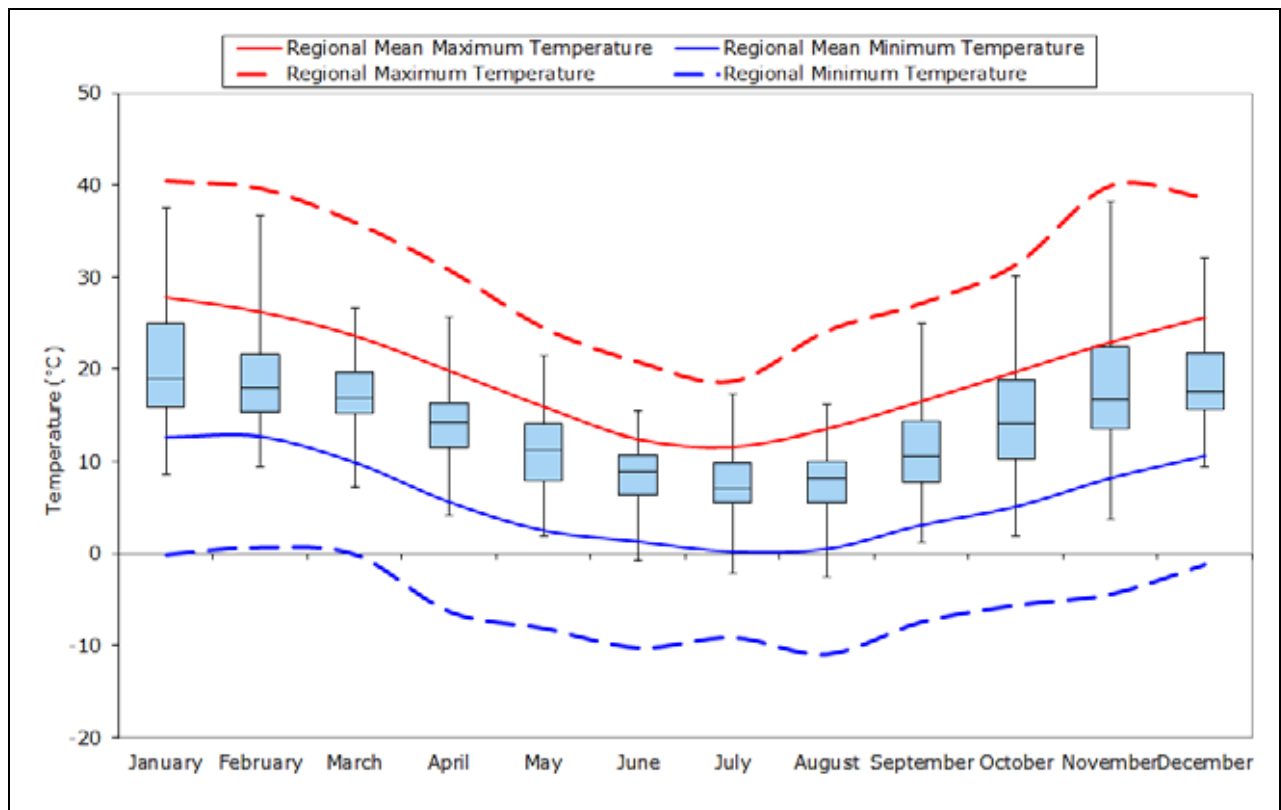
Diurnal variation is notable in both wind speed and direction. Winds are more commonly from the west-southwest to west and higher in velocity during the daylight hours. Wind speeds are notably lower during night hours.

**4.3 Ambient temperature**

Monthly mean minimum temperatures are in the range of 0°C to 13°C, with mean maxima of 12°C to 28°C, based on the long-term average record from the BoM Goulburn Airport AWS. Peaks occur during summer months with the highest temperatures typically being recorded between November and March. The lowest temperatures are usually experienced between June and August.

The 2014 Quarry station temperature dataset has been compared with long-term trends recorded at the Goulburn Airport climate station to determine the representativeness of the dataset.

**Figure 4-2** presents the monthly variation in recorded temperature during 2014 compared with the mean, minimum and maximum temperatures from Goulburn Airport. There is good agreement between temperatures recorded during 2014 and the recorded historical trends, indicating that the dataset is representative of conditions likely to be experienced in the region.



**Figure 4-2: Temperature Comparison between Quarry 2014 dataset and Historical Averages (1988-2015) – Goulburn Airport**

Note: 2014 data from the Gunlake Quarry station are illustrated by the 'box and whisker' indicators. Boxes indicate 25<sup>th</sup>, median and 75<sup>th</sup> percentile temperature values while upper and lower whiskers indicate maximum and minimum values. Maximum and minimum temperatures from long-term measurements at Goulburn Airport are depicted as line graphs.

**4.4 Rainfall**

Precipitation is important to air pollution studies since it impacts on dust generation potential and represents a removal mechanism for atmospheric pollutants.

Based on historical data recorded at Goulburn Airport, the area is characterised by low to moderate rainfall, with a mean annual rainfall of approximately 540mm, and an annual rainfall range between 320mm and 860mm. Rainfall is lowest during the autumn months and greatest in June and the months between November and February. According to the long term records, an average of 124 rain days occur per year.

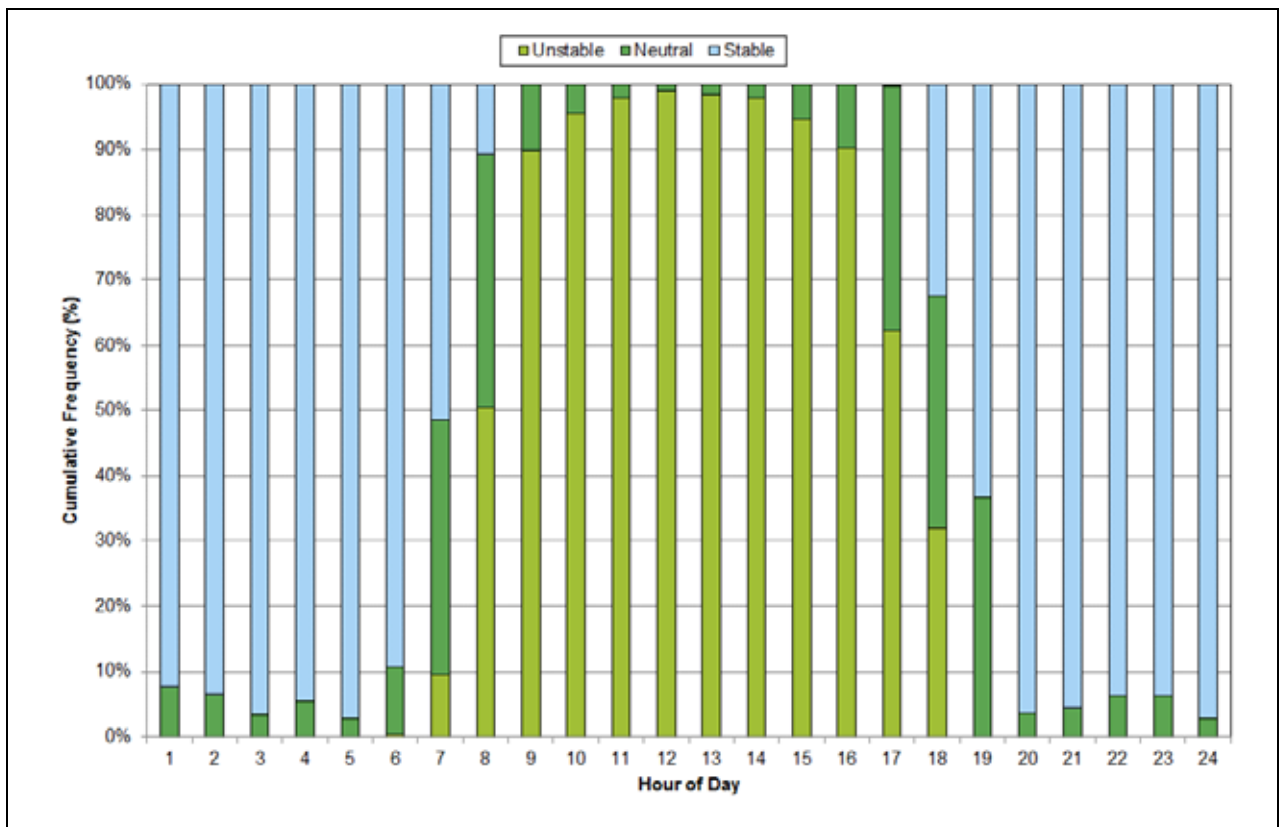
To provide a conservative (upper bound) estimate of the airborne particulate matter concentrations occurring due to the Gunlake Quarry, wet deposition (removal of particles from the air by rainfall) was excluded from the dispersion modelling simulations undertaken in this report.

**4.5 Atmospheric stability**

Atmospheric stability refers to the degree of turbulence or mixing that occurs on the atmosphere and is a controlling factor in the rate of atmospheric dispersion of pollutants.

The Monin-Obukhov length (L) provides a measure of the stability of the surface layer (i.e. the layer above the ground in which vertical variation of heat and momentum flux is negligible; typically about 10% of the mixing height). Negative L values correspond to unstable atmospheric conditions, while positive L values correspond to stable atmospheric conditions. Very large positive or negative L values correspond to neutral atmospheric conditions.

**Figure 4-3** illustrates the seasonal variation of atmospheric stability derived from the Monin-Obukhov length calculated by AERMET for the Gunlake Quarry site. The diurnal profile presented illustrates that atmospheric instability increases during daylight hours as convective energy increases, whereas stable atmospheric conditions prevail during the night-time. This profile indicates that the potential for atmospheric dispersion of emissions would be greatest during day time hours and lowest during evening through to early morning hours.

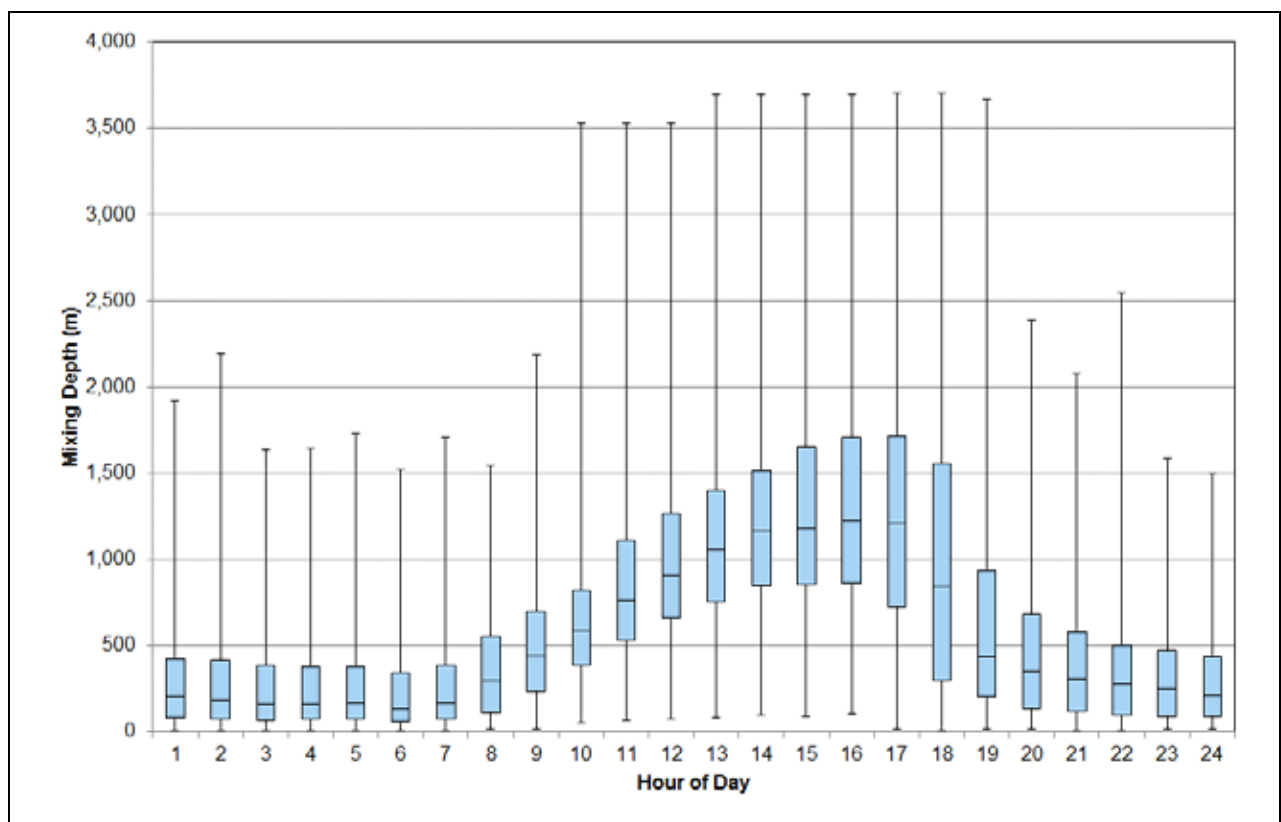


**Figure 4-3: AERMET-Calculated Diurnal Variation in Atmospheric Stability– Gunlake Quarry Site 2014**

### 4.6 Mixing depth

Hourly-varying atmospheric boundary layer depths were generated for the Gunlake Quarry site by AERMET, the meteorological processor for the AERMOD dispersion model (see **Section 7.1** for further information), using a combination of surface observations at the Gunlake Quarry, sunrise and sunset times and adjusted TAPM-predicted upper air temperature profile.

The variation in average boundary layer depth by hour of the day for the Gunlake Quarry is illustrated in **Figure 4-4**. It can be seen that greater boundary layer depths are experienced during the day time hours, peaking in the mid to late afternoon. Higher day-time wind velocities and the onset of incoming solar radiation increases the amount of mechanical and convective turbulence in the atmosphere. As turbulence increases so does the depth of the boundary layer, generally contributing to higher mixing depths and greater potential for atmospheric dispersion of pollutants.



**Figure 4-4: AERMET-Calculated Diurnal Variation in Atmospheric Mixing Depth – Gunlake Quarry Site**

Note: Boxes indicate 25<sup>th</sup>, Median and 75<sup>th</sup> percentile of AERMET-calculated mixing height data while upper and lower whiskers indicate maximum and minimum values.

## 5. EXISTING AIR QUALITY ENVIRONMENT

The quantification of cumulative air pollution concentrations and the assessment of compliance with ambient air quality limits necessitate the characterisation of baseline air quality. Given that particulate matter emissions represent the primary pollutant of concern generated by the proposed Gunlake Quarry, it is important that existing sources and ambient air concentrations of these pollutants are considered.

### 5.1 Existing local sources of atmospheric emissions

Review of the National Pollutant Inventory (NPI) database and NSW EPA Environment Protection Licence (EPL) register lists the following sources of air pollution emissions in the surrounding 15km from Quarry:

- Holcim Marulan (Johnniefields) Quarry – approximately 1km east of the Gunlake Quarry;
- Holcim Lynwood Quarry – approximately 1.5km south of the Gunlake Quarry; and
- Boral Resources Marulan South Limestone Mine and Peppertree Quarry – approximately 10km south-southwest of the Gunlake Quarry.

In addition to the above operations, it is considered that the following background sources contribute to particulate matter emissions in the vicinity of the Gunlake Quarry site:

- Dust entrainment due to vehicle movements along unsealed and sealed public roads;
- Petrol and diesel emission from vehicle movements along public roads;
- Wind generated dust from exposed areas within the surrounding region;
- Episodic emissions from local vegetation burning (e.g. grass and bush fires);
- Seasonal emissions from household wood burning fires.

More remote sources which contribute episodically to suspended particulates in the region include dust storms and bushfires. Whereas dust storms predominately contribute primary particulates from mechanical attrition, bushfires are a source of fine particulates including both primary particulates and secondary particulates formed by atmospheric gas to particle conversion processes.

To account for these existing sources of air pollution emissions in the cumulative assessment of project impacts, a combination of air quality monitoring datasets (**Section 5.2**) and modelling predictions for neighbouring sources (see **Section 5.3**) will be utilised.

### 5.2 Characterisation of baseline air quality

The following monitoring resources have been referenced for this study:

- PM<sub>10</sub> and dust deposition monitoring data from the Gunlake Quarry air quality monitoring network;
- PM<sub>10</sub> monitoring data from two locations at the Holcim Lynwood Quarry;
- PM<sub>10</sub> and PM<sub>2.5</sub> monitoring data from the NSW Office of Environment and Heritage (OEH) air quality monitoring stations at Bargo and Camden (68 km northeast and 96 km northeast of the Gunlake Quarry respectively); and
- PM<sub>10</sub> and PM<sub>2.5</sub> monitoring data from the ACT Government Monash air quality monitoring station (115km southwest of the Gunlake Quarry).

Both the Gunlake Quarry and Lynwood Quarry PM<sub>10</sub> monitoring results are recorded by high volume air sampler (HVAS) on a one-in-six day schedule. Monitoring results of PM<sub>10</sub> from the Gunlake Quarry station are available from December 2014 onwards. There are no PM<sub>2.5</sub> air quality monitoring results available in the public domain for the Marulan area.

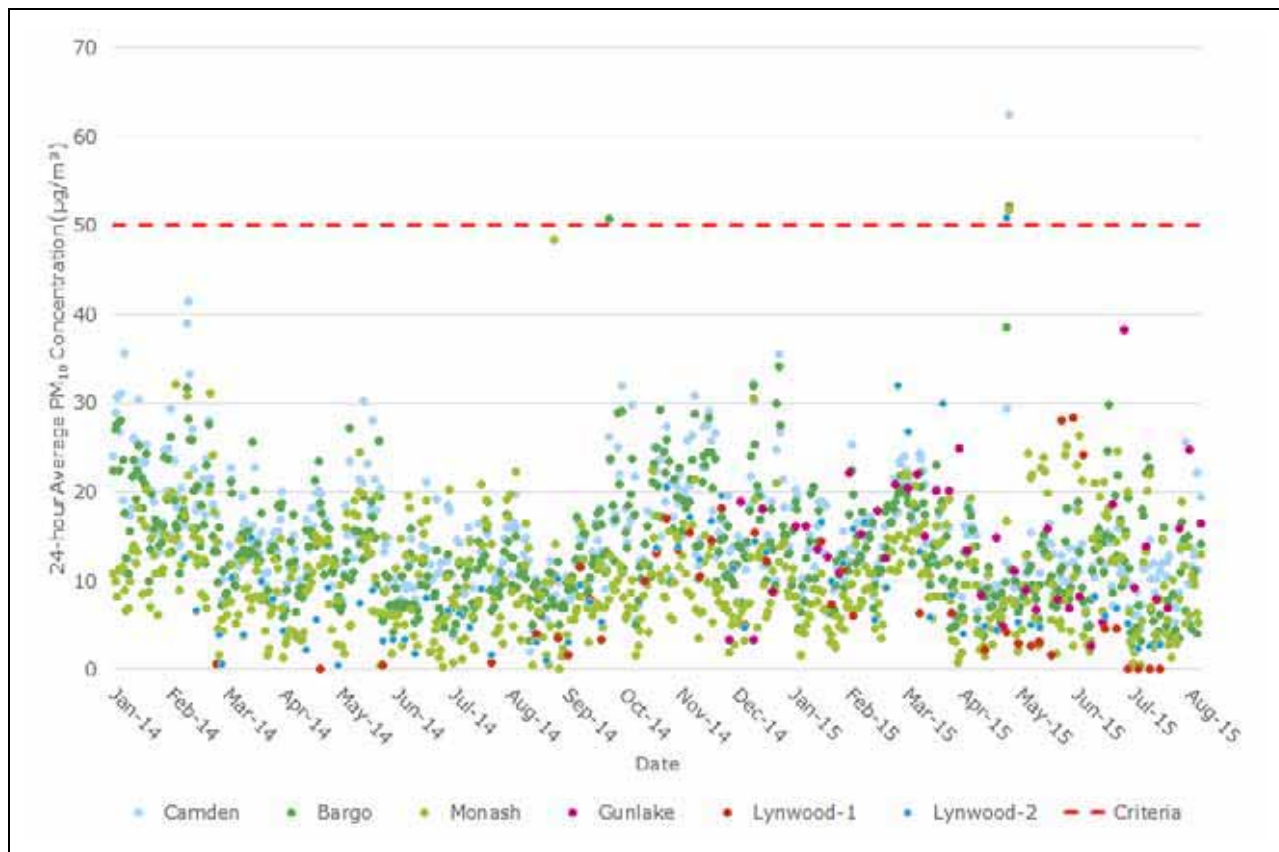
To provide a greater understanding of ambient PM<sub>10</sub> and PM<sub>2.5</sub> concentrations across the region, daily-varying PM<sub>10</sub> and PM<sub>2.5</sub> concentrations from the NSW OEH and ACT Government recorded between January 2014 and August 2015 were referenced.

### 5.2.1 Ambient PM<sub>10</sub>

The daily varying (24-hour average) PM<sub>10</sub> concentrations recorded at the air quality monitoring stations listed in **Section 5.2** are illustrated in **Figure 5-1**.

The 24-hour average PM<sub>10</sub> concentrations at all locations fluctuate throughout the period presented. Exceedances of the 24-hour average NSW EPA assessment criterion (50 µg/m<sup>3</sup>) occur at the majority of monitoring locations presented (Gunlake and Lynwood-1 excluded). These exceedances are attributed to emissions from hazard reduction burns.

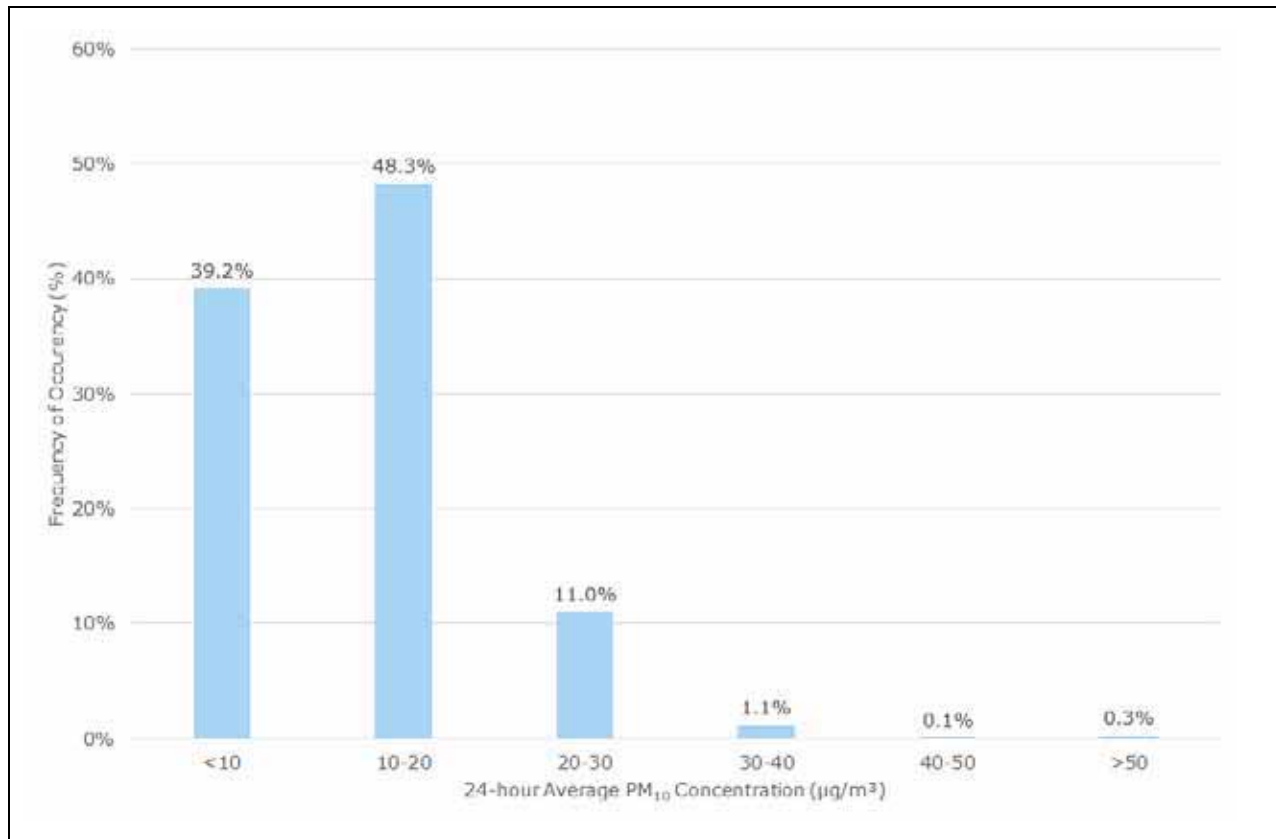
There is good agreement between the local stations (Gunlake and Lynwood) with regional monitoring stations, despite the distance between the locations. This suggests that the ambient particulate matter concentrations are strongly influenced by regional emission sources.



**Figure 5-1: Time-series of 24-hour Average PM<sub>10</sub> Concentrations – January 2014 and August 2015**

The frequency distribution of recorded PM<sub>10</sub> concentrations between January 2014 and August 2015 at the six monitoring stations collated is illustrated in **Figure 5-2**. It can be seen that approximately 88% of PM<sub>10</sub> concentrations recorded are below 20 µg/m<sup>3</sup>. The frequency of concentrations in exceedance of the NSW EPA impact assessment criterion of 50 µg/m<sup>3</sup> is 0.3%, equating to approximately 1 day per 365 days.

The average PM<sub>10</sub> concentration for the analysed period across the six sites is 12.5µg/m<sup>3</sup>.



**Figure 5-2: Frequency distribution of 24-hour average PM<sub>10</sub> concentrations – All Sites – January 2014 to August 2015**

#### 5.2.2 Ambient PM<sub>2.5</sub>

In the absence of publicly available PM<sub>2.5</sub> monitoring datasets for the Marulan area, reference is made to regional PM<sub>2.5</sub> monitoring data (NSW OEH Camden and ACT Government Monash stations) to analyse likely ambient PM<sub>2.5</sub> concentrations in the vicinity of the Gunlake Quarry. The daily varying (24-hour average) PM<sub>2.5</sub> concentrations recorded at the NSW OEH Camden and ACT Government Monash air quality monitoring stations are illustrated in **Figure 5-1**.

The recorded 24-hour average PM<sub>2.5</sub> concentrations at both monitoring locations fluctuate throughout the period presented. Exceedances of the 24-hour average NEPM advisory reporting goal (25µg/m<sup>3</sup>) occur at the Monash air quality monitoring station. Similar to PM<sub>10</sub> concentrations, the illustrated exceedances are attributed to emissions from hazard reduction burns. During the winter months, recorded PM<sub>2.5</sub> concentrations are typically higher at the Monash air quality monitoring location in comparison with data from the Camden station. ACT Health commissioned a study in 2009 (Bridgeman, 2009) investigating the air quality of the Tuggeranong Valley (within which the Monash station is located). This report that found that domestic wood heating during winter months significantly influenced particulate matter concentrations experienced in the area. Given the higher density of residential dwellings in the vicinity of the Monash air quality monitoring station relative to the Gunlake Quarry site area, it is considered that the use of the above data represents a conservative estimate of ambient PM<sub>2.5</sub> concentrations at Marulan.

The frequency distribution of recorded PM<sub>2.5</sub> concentrations between January 2014 and August 2015 at the two monitoring stations is illustrated in **Figure 5-4**. It can be seen that approximately 94% of PM<sub>2.5</sub> concentrations recorded are below 15µg/m<sup>3</sup>. The frequency of concentrations in exceedance of the NEPM advisory reporting goal of 25µg/m<sup>3</sup> is 1.2%, equating to approximately 4.4 days per 365 days. The average PM<sub>2.5</sub> concentration for the analysed period across the two monitoring sites is 6.7µg/m<sup>3</sup>.

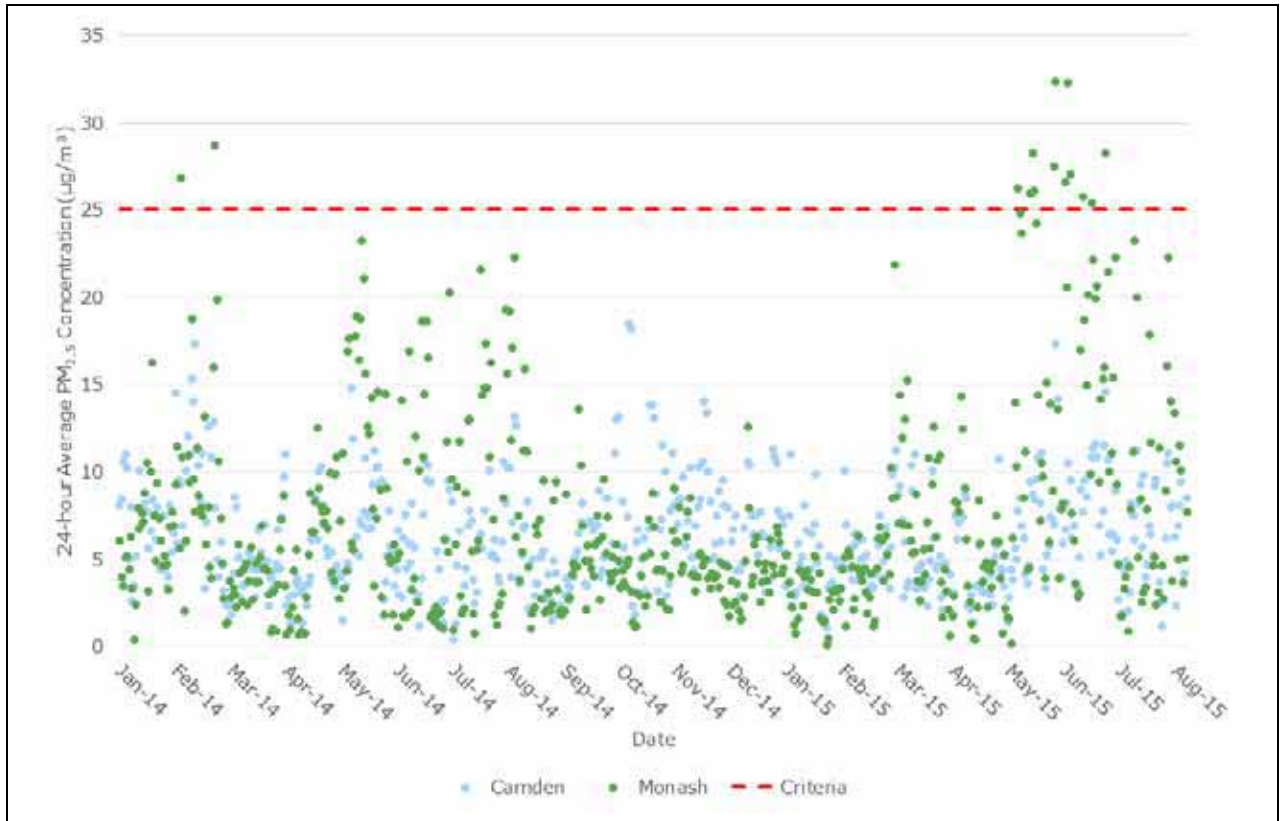


Figure 5-3: Time-series of 24-hour Average PM<sub>2.5</sub> Concentrations – January 2014 and August 2015

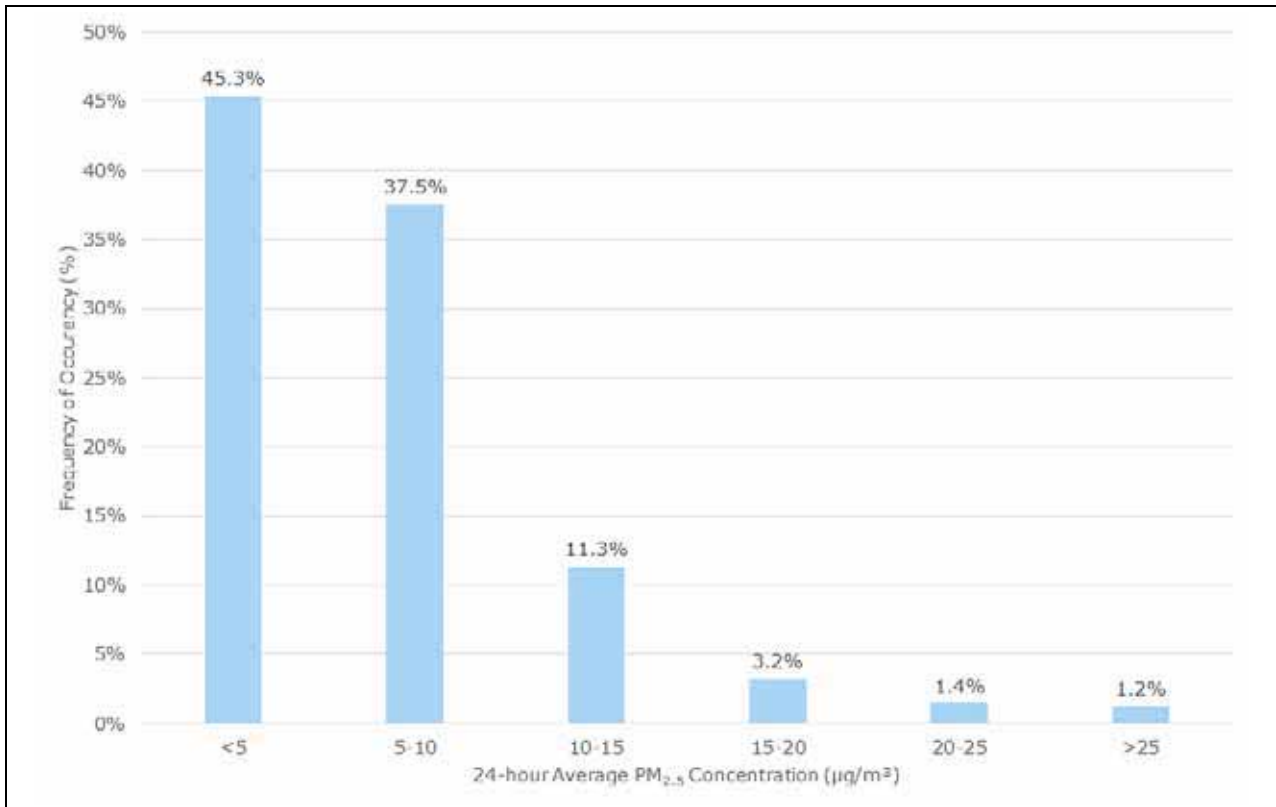


Figure 5-4: Frequency distribution of 24-hour average PM<sub>2.5</sub> concentrations – Camden and Monash – January 2014 to August 2015

### 5.2.3 Background TSP

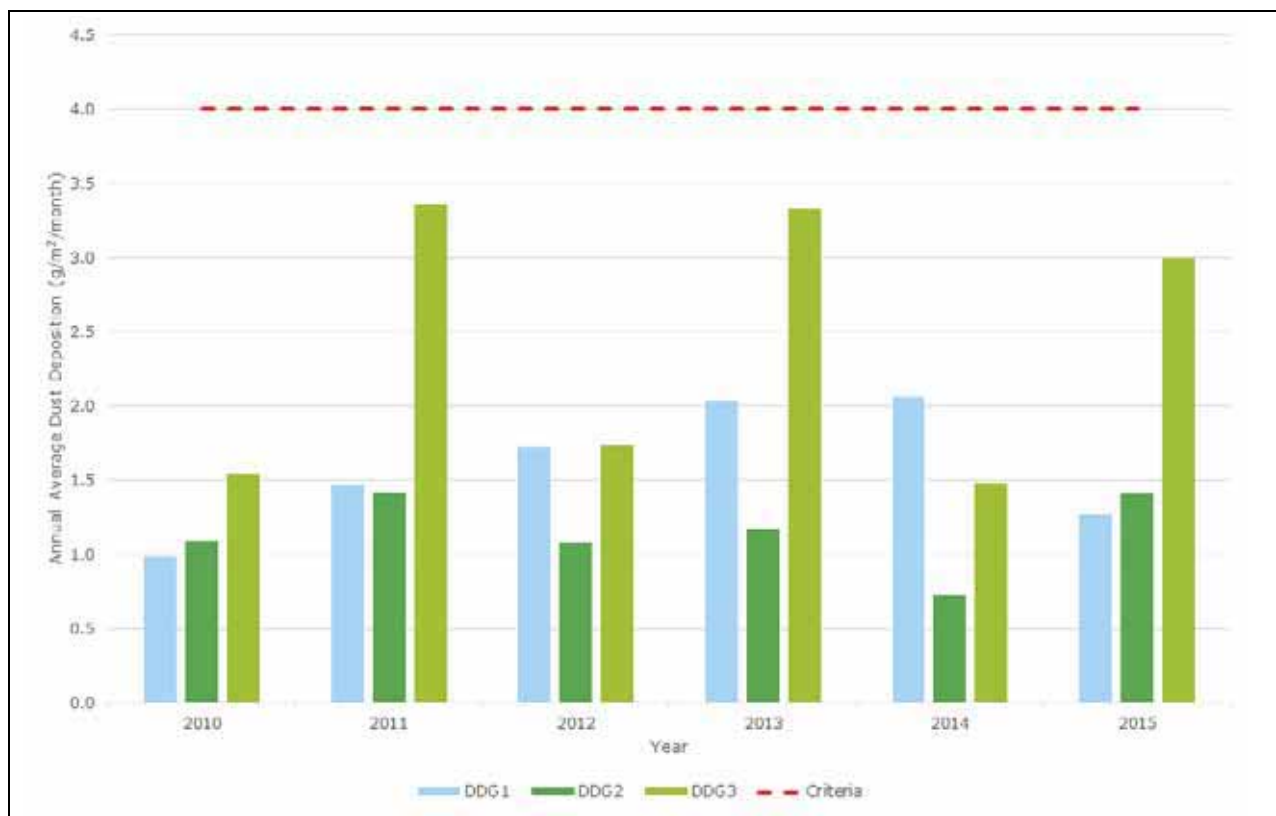
No local TSP monitoring data is available for the Marulan area. Rural/semi-rural areas (such as the study area), typically experience a PM<sub>10</sub>/TSP ratio of 0.4 (ENVIRON, 2009). This ratio has been applied to the adopted annual average PM<sub>10</sub> concentration (12.5 µg/m<sup>3</sup>) to derive a representative TSP background concentration. The annual average TSP concentration adopted as background is therefore 31.3 µg/m<sup>3</sup>.

### 5.2.4 Background dust deposition

Dust deposition monitoring is conducted at three locations around the Gunlake Quarry boundary (see **Figure 2-4**). Annual average dust deposition levels recorded at the three locations between 2010 and 2015 are illustrated in **Figure 5-5**.

At all sites and across all years, the annual average dust deposition levels recorded are below the NSW EPA assessment criterion of 4 g/m<sup>2</sup>/month. It is noted that DDG3 experiences higher dust deposition levels than the other two locations. Review of the samples collected at DDG3 highlighted that samples recorded at this location had a low ratio of soil material (indicative of dust from the Gunlake Quarry) to biogenic material (including material such as leaf matter and organisms), indicating that the primary influencing sources of deposition levels at this location are not Quarry-related.

The average dust deposition level for the analysed period across the three monitoring sites is 1.7g/m<sup>2</sup>/month.



**Figure 5-5: Annual average dust deposition levels – Quarry site monitoring network – January 2010 to August 2015**

## 5.3 Contribution from neighbouring sources

In order to explicitly account for the potential impacts from the nearby Lynwood and Johnniefields Quarry sites, emissions from these two sites have been included in the atmospheric dispersion modelling configured for the Gunlake Quarry. The locations of the two neighbouring quarries in relation to the Gunlake Quarry are illustrated in **Figure 5-6**.

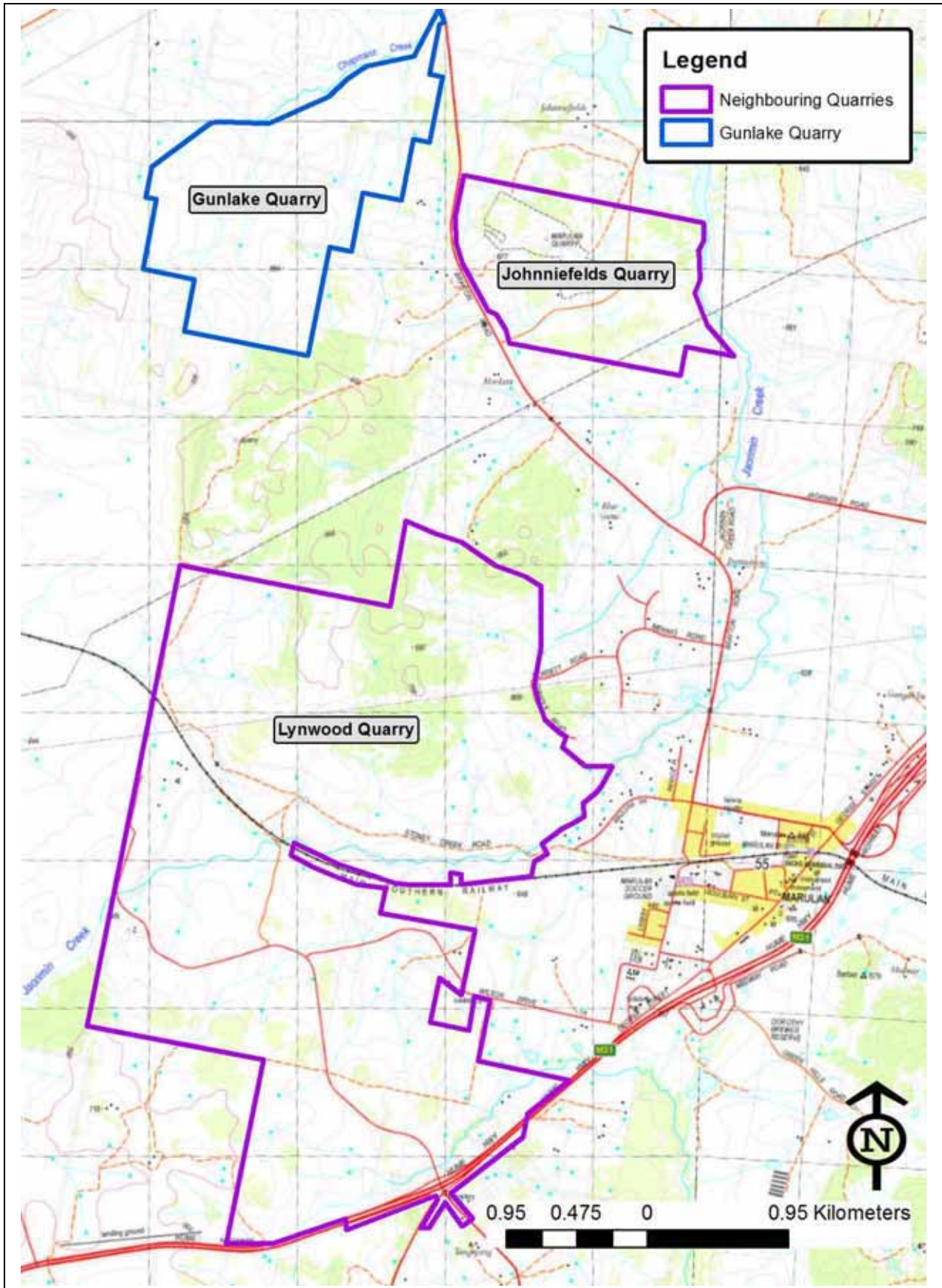


Figure 5-6: Neighbouring quarry operations

Emissions from the two sites have been quantified for inclusion in the dispersion modelling. For the Lynwood Quarry, annual emissions for future (Year 30) operational scenario were taken from the 2010 air quality impact assessment completed for that project (PAE Holmes, 2010).

The Johnniefelds Quarry is licenced to quarry up to 500,000 tpa (extracted, processed or stored). On the basis that the Lynwood Quarry is approved for the extraction and processing of up to 5 Mtpa, 10% of calculated emissions from the Lynwood Quarry assessment (PAE Holmes, 2010) have been assumed for the Johnniefelds Quarry. This approach is considered appropriate in the absence of a publicly available air quality assessment for that quarry.

A summary of adopted emissions from the two quarry sites is presented in **Table 5-1**.

<b>Table 5-1: Adopted annual emissions – Neighbouring quarry operations</b>		
<b>Pollutant</b>	<b>Annual Emissions (kg/annum)</b>	
	<b>Lynwood Quarry</b>	<b>Johnniefelds Quarry</b>
TSP	1,374,311	137,431
PM <sub>10</sub>	537,081	53,708
PM <sub>2.5</sub>	64,318	6,432

At the time of modelling, the 2010 Lynwood Quarry assessment (PAE Holmes, 2010) represented the most recently available resource for quantifying emissions from that operation. Since that time, the EIS for Lynwood Quarry Modification 4 was listed on the NSW Department of Planning and Environment (DPE) public register, including an accompanying air quality impact assessment (PEL, 2015). Review of the maximum annual emissions presented in the two Lynwood Quarry air quality impact assessments highlights that calculated peak annual emissions are significantly higher in the 2010 Lynwood Quarry assessment. For peak annual TSP emissions, the 2010 Lynwood Quarry assessment total is 1,374,311 kg/annum vs 388,180 kg/annum for the 2015 Lynwood Quarry assessment.

Consequently, it is considered that the use of emissions calculations from the 2010 Lynwood Quarry assessment will conservatively account for the future emissions contribution from that site operation. Model source configuration and emissions within this study is consistent with the 2010 Lynwood Quarry assessment.

Predicted concentrations from the two neighbouring quarry operations are presented in **Table 5-2**. In order to assess cumulative impacts, model predictions of concentrations from the Gunlake Quarry have been paired with the predictions for neighbouring quarries and the baseline air quality monitoring data. Further details on the cumulative assessment approach is given in **Section 8**.

<b>Table 5-2: Predicted Concentrations – Neighbouring quarry operations</b>						
<b>Receptor</b>	<b>Predicted Concentration (<math>\mu\text{g}/\text{m}^3</math>)</b>					<b>Annual Average Dust Deposition (<math>\text{g}/\text{m}^2/\text{month}</math>)</b>
	<b>Annual Average TSP</b>	<b>Maximum 24-hour <math>\text{PM}_{10}</math></b>	<b>Annual Average <math>\text{PM}_{10}</math></b>	<b>Maximum 24-hour <math>\text{PM}_{2.5}</math></b>	<b>Annual Average <math>\text{PM}_{2.5}</math></b>	
R1*	1.6	5.6	0.6	0.7	0.1	0.2
R2	1.9	6.9	0.7	0.8	0.1	0.2
R3*	1.4	7.2	0.5	0.9	0.1	0.1
R4	0.3	1.6	0.1	0.2	<0.1	0.0
R5	2.2	7.6	0.9	0.9	0.1	0.3
R6	1.9	5.5	0.8	0.7	0.1	0.2
R7	1.9	6.1	0.7	0.7	0.1	0.2
R8	1.8	4.7	0.7	0.6	0.1	0.2
R9	2.4	5.2	0.9	0.6	0.1	0.3
R10	2.7	6.5	1.0	0.8	0.1	0.3
R11	3.0	9.7	1.2	1.2	0.1	0.4
R12	2.7	8.9	1.0	1.1	0.1	0.4

Note \*: Gunlake Quarries-owned residence

## 6. EMISSIONS ESTIMATION

### 6.1 Introduction

Emissions to air associated with the operation of the Gunlake Quarry would primarily comprise fugitive dust in each of the particle size metrics described in **Section 3** (TSP, PM<sub>10</sub> and PM<sub>2.5</sub>). Fine particulate emissions generated by the combustion of diesel fuel in plant and equipment has been accounted for in this assessment. Minor emissions of nitrogen dioxide, sulphur dioxide, carbon monoxide and assorted volatile organic compounds would be generated by the combustion of diesel fuel and detonation of explosives about the Gunlake Quarry site, however emissions and impacts from these pollutants have not be assessed within this report.

Sources of fugitive dust at the Gunlake Quarry include:

- Removal, handling, hauling and dumping of topsoil and waste rock/overburden;
- Removal, handling, hauling and dumping of hard rock product, including drilling and blasting in the quarry pit;
- Product processing (crushing, screening and conveying);
- Wind erosion from stockpiles and exposed surfaces; and
- Transportation (hauling) of product along unpaved internal roads, the paved site access road and paved public roads.

Emission factors developed by the US EPA<sup>3</sup> have been applied to estimate the amount of dust produced by each activity. Emissions were quantified for each particle size fraction, with the TSP size fraction also used to predict dust deposition rates. It is noted that fugitive emission factors are also provided in the National Pollution Inventory (NPI) Emission Estimation Technique Manual for Mining (DSEWPC, 2012), however these are typically based on, or the same as, those presented in the US EPA AP-42.

Emission from diesel combustion are estimated using emission factors for diesel industrial vehicles provided in the NPI Emission Estimation Technique Manual for Combustion Engines (DEWHA, 2008). Further information on the assumptions and inputs for emission estimation are provided in **Appendix 2**.

### 6.2 Emission scenarios

Particulate matter emissions inventories have been developed for current operations and three future scenarios for the proposed quarry expansion. The emissions and modelling scenarios are summarised as follows:

- Current operations – representative of existing approved production rate of 750,000 tpa and processing at two existing processing plants.
- Scenario 2 – ramping up of production to 1,000,000 tpa and the introduction of a third processing plant.
- Scenario 3 – continued expanded production of 1,500,000 tpa with all three processing plants operating.
- Scenario 4 - quarrying at a maximum expanded production rate of 2,000,000 tpa with all three processing plants operating.

### 6.3 Emission controls

Emission reductions were applied to the emissions estimates to account for controls that are currently in place and those proposed for expanded operations. The emission reductions applied in the emission inventories are described in **Table 6-1**.

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<sup>3</sup> United States Environmental Protection Agency (US EPA) AP-42 Compilation of Air Pollutant Emission Factors (US EPA, 1998, US EPA, 2004, US EPA, 2006)

<b>Table 6-1: Emission controls</b>			
<b>Activity</b>	<b>Scenario</b>	<b>Measure</b>	<b>% Control</b>
Hauling on unpaved roads	Existing and Future	Level 2 watering (DSEWPC, 2012) plus maintaining vehicle speeds below 40 km/hr (Countess Environmental, 2006)	86% (75% and 44%)
Loading stockpiles	Existing and Future	Carry-over of high moisture content from water sprays earlier in the process (DSEWPC, 2012)	50%
Truck unloading to hopper	Existing and Future	Water spraying	50%
Material re-handle	Existing and Future	Water spraying	50%
Primary screening	Existing and Future	Water spraying	50%
Secondary screening	Existing and Future	Water spraying	50%
Primary crushing	Existing and Future	Water spraying	50%
Secondary crushing	Existing and Future	Water spraying	50%
Conveyor transfer Plant 1	Existing and Future	Water spraying	50%
Conveyor transfer Plant 2	Existing and Future	Water spraying	50%

#### 6.4 Summary of estimated emissions

A summary of annual emissions by source type for each scenario is presented in **Table 6-2**, **Table 6-3**, **Table 6-4** and **Table 6-5**.

The contribution of various source groups to annual emissions is presented in **Figure 6-1**. For both existing and proposed future operations, the most significant source of emissions are hauling (unpaved and paved roads) and wind erosion.

<b>Table 6-2: Annual emissions by source for current operations</b>			
<b>Emissions Source</b>	<b>Calculated Emissions (tpa) by Source</b>		
	<b>TSP</b>	<b>PM<sub>10</sub></b>	<b>PM<sub>2.5</sub></b>
Overburden removal - bulldozer	1.56	0.28	0.16
OB loading to trucks - excavator	0.03	0.01	0.00
OB haulage - unsealed	2.70	0.77	0.08
OB trucks unloading	0.03	0.01	0.00
OB dump management - bulldozer	1.56	0.28	0.16
Truck loading in pit - raw material	0.21	0.10	0.02
Raw material haulage - unsealed	12.62	3.59	0.36
Truck unloading to hopper	0.11	0.05	0.01
Raw material rehandle	0.01	0.00	0.00
Scalping screen	4.69	1.61	0.01
Screen 1	4.69	1.61	0.01
Screen 2	3.66	1.26	0.01
Screen 3	3.66	1.26	0.01
Primary crusher	1.01	0.45	0.08
Secondary crusher	0.79	0.35	0.07
Tertiary cone crushers	0.79	0.35	0.07
Tertiary crusher	0.79	0.35	0.07
Existing Plant 1 - conveyor transfer points (3 points)	1.69	0.62	0.17
Existing Plant 1 - stockpile loading	0.12	0.05	0.01
Plant 2 - conveyor transfer points (8 points)	3.51	1.29	0.36
Plant 2 - stockpile loading	0.44	0.16	0.05
Upgraded Plant 1 - conveyor transfer points (10 points)	N/A	N/A	N/A
Upgraded Plant 1 - stockpile loading	N/A	N/A	N/A
Loading to product trucks - Existing Plant 1	0.03	0.01	0.00
Loading to product trucks - Plant 2	0.09	0.04	0.01
Loading to product trucks - Upgraded Plant 1	N/A	N/A	N/A
Unpaved - product transportation - Existing Plant 1 to weighbridge	2.42	0.67	0.07
Unpaved - product transportation - Plant 2 to weighbridge	10.29	2.84	0.28
Unpaved - product transportation - Upgraded Plant 1 to weighbridge	N/A	N/A	N/A
Paved - product transportation - weighbridge to site entry	4.00	0.77	0.18
Brayton Road - product transportation	21.32	4.09	0.97
Drill	1.69	0.89	0.13
Blast	0.03	0.02	<0.01
Wind Erosion - exposed surfaces and stockpiles	22.10	11.05	1.66
Diesel combustion	3.42	3.42	3.135
<b>Total</b>	<b>110.0</b>	<b>38.2</b>	<b>8.1</b>

NA – Upgrade section of Plant 1 would occur in future scenarios only.

Emissions Source	Calculated Emissions (tpa) by Source		
	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>
Overburden removal - bulldozer	1.56	0.28	0.16
OB loading to trucks - excavator	0.10	0.05	0.01
OB haulage - unsealed	19.47	5.54	0.55
OB trucks unloading	0.10	0.05	0.01
OB dump management - bulldozer	1.56	0.28	0.16
Truck loading in pit - raw material	0.28	0.13	0.02
Raw material haulage - unsealed	16.83	4.78	0.48
Truck unloading to hopper	0.14	0.07	0.01
Raw material rehandle	0.01	0.00	0.00
Scalping screen	6.25	2.15	0.01
Screen 1	6.25	2.15	0.01
Screen 2	1.63	0.56	0.00
Screen 3	1.63	0.56	0.00
Primary crusher	1.35	0.60	0.11
Secondary crusher	0.35	0.16	0.03
Tertiary cone crushers	0.35	0.16	0.03
Tertiary crusher	0.35	0.16	0.03
Existing Plant 1 - conveyor transfer points (3 points)	2.25	0.83	0.23
Existing Plant 1 - stockpile loading	0.17	0.06	0.02
Plant 2 - conveyor transfer points (8 points)	1.56	0.57	0.16
Plant 2 - stockpile loading	0.20	0.07	0.02
Upgraded Plant 1 - conveyor transfer points (10 points)	3.90	1.43	0.40
Upgraded Plant 1 - stockpile loading	0.39	0.14	0.04
Loading to product trucks - Existing Plant 1	0.04	0.02	0.00
Loading to product trucks - Plant 2	0.04	0.02	0.00
Loading to product trucks - Upgraded Plant 1	0.08	0.04	0.01
Unpaved - product transportation - Existing Plant 1 to weighbridge	3.24	0.89	0.09
Unpaved - product transportation - Plant 2 to weighbridge	3.83	1.06	0.11
Unpaved - product transportation - Upgraded Plant 1 to weighbridge	9.20	2.54	0.25
Paved - product transportation - weighbridge to site entry	5.36	1.03	0.24
Brayton Road - product transportation	28.60	5.49	1.30
Drill	2.30	1.21	0.18
Blast	0.05	0.02	0.00
Wind Erosion - exposed surfaces and stockpiles	57.46	28.73	4.31
Diesel combustion	5.76	5.76	5.28
<b>Total</b>	<b>182.58</b>	<b>67.54</b>	<b>14.28</b>

<b>Table 6-4: Annual emissions by source for scenario 3</b>			
<b>Emissions Source</b>	<b>Calculated Emissions (tpa) by Source</b>		
	<b>TSP</b>	<b>PM<sub>10</sub></b>	<b>PM<sub>2.5</sub></b>
Overburden removal - bulldozer	1.56	0.28	0.16
OB loading to trucks - excavator	0.12	0.05	0.01
OB haulage - unsealed	26.18	7.44	0.74
OB trucks unloading	0.12	0.05	0.01
OB dump management - bulldozer	1.56	0.28	0.16
Truck loading in pit - raw material	0.42	0.20	0.03
Raw material haulage - unsealed	43.27	12.30	1.23
Truck unloading to hopper	0.21	0.10	0.02
Raw material rehandle	0.01	0.00	0.00
Scalping screen	9.38	3.23	0.02
Screen 1	9.38	3.23	0.02
Screen 2	2.44	0.84	0.00
Screen 3	2.44	0.84	0.00
Primary crusher	2.03	0.90	0.17
Secondary crusher	0.53	0.23	0.04
Tertiary cone crushers	0.53	0.23	0.04
Tertiary crusher	0.53	0.23	0.04
Existing Plant 1 - conveyor transfer points (3 points)	3.38	1.24	0.35
Existing Plant 1 - stockpile loading	0.25	0.09	0.03
Plant 2 - conveyor transfer points (8 points)	2.34	0.86	0.24
Plant 2 - stockpile loading	0.29	0.11	0.03
Upgraded Plant 1 - conveyor transfer points (10 points)	5.85	2.15	0.61
Upgraded Plant 1 - stockpile loading	0.59	0.21	0.06
Loading to product trucks - Existing Plant 1	0.05	0.02	0.00
Loading to product trucks - Plant 2	0.06	0.03	0.00
Loading to product trucks - Upgraded Plant 1	0.12	0.06	0.01
Unpaved - product transportation - Existing Plant 1 to weighbridge	4.84	1.33	0.13
Unpaved - product transportation - Plant 2 to weighbridge	5.71	1.58	0.16
Unpaved - product transportation - Upgraded Plant 1 to weighbridge	13.72	3.78	0.38
Paved - product transportation - weighbridge to site entry	7.99	1.53	0.36
Brayton Road - product transportation	42.63	8.18	1.93
Drill	2.76	1.45	0.22
Blast	0.15	0.08	0.01
Wind Erosion - exposed surfaces and stockpiles	68.85	34.43	5.16
Diesel combustion	8.1	8.1	7.425
<b>Total</b>	<b>268.20</b>	<b>95.59</b>	<b>19.81</b>

<b>Table 6-5: Annual emissions by source for scenario 4</b>			
<b>Emissions Source</b>	<b>Calculated Emissions (tpa) by Source</b>		
	<b>TSP</b>	<b>PM<sub>10</sub></b>	<b>PM<sub>2.5</sub></b>
Overburden removal - bulldozer	1.56	0.28	0.16
OB loading to trucks - excavator	0.01	0.00	0.00
OB haulage - unsealed	2.16	0.62	0.06
OB trucks unloading	0.01	0.00	0.00
OB dump management - bulldozer	1.56	0.28	0.16
Truck loading in pit - raw material	0.56	0.27	0.04
Raw material haulage - unsealed	72.12	20.51	2.05
Truck unloading to hopper	0.28	0.13	0.02
Raw material rehandle	0.01	0.01	0.00
Scalping screen	12.50	4.30	0.03
Screen 1	12.50	4.30	0.03
Screen 2	3.25	1.12	0.01
Screen 3	3.25	1.12	0.01
Primary crusher	2.70	1.20	0.22
Secondary crusher	0.70	0.31	0.06
Tertiary cone crushers	0.70	0.31	0.06
Tertiary crusher	0.70	0.31	0.06
Existing Plant 1 - conveyor transfer points (3 points)	4.50	1.65	0.47
Existing Plant 1 - stockpile loading	0.33	0.12	0.03
Plant 2 - conveyor transfer points (8 points)	3.12	1.14	0.32
Plant 2 - stockpile loading	0.39	0.14	0.04
Upgraded Plant 1 - conveyor transfer points (10 points)	7.80	2.86	0.81
Upgraded Plant 1 - stockpile loading	0.78	0.29	0.08
Loading to product trucks - Existing Plant 1	0.07	0.03	0.01
Loading to product trucks - Plant 2	0.08	0.04	0.01
Loading to product trucks - Upgraded Plant 1	0.17	0.08	0.01
Unpaved - product transportation - Existing Plant 1 to weighbridge	6.49	1.79	0.18
Unpaved - product transportation - Plant 2 to weighbridge	7.67	2.11	0.21
Unpaved - product transportation - Upgraded Plant 1 to weighbridge	18.40	5.07	0.51
Paved - product transportation - weighbridge to site entry	10.72	2.06	0.49
Brayton Road - product transportation	57.19	10.98	2.59
Drill	4.60	2.42	0.36
Blast	0.21	0.11	0.02
Wind Erosion - exposed surfaces and stockpiles	68.85	34.43	5.16
Diesel combustion	10.44	10.44	9.57
<b>Total</b>	<b>316.18</b>	<b>110.71</b>	<b>23.81</b>

### 6.5 Respirable crystalline silica

As stated in **Section 3.3**, the indicative silica content of the extracted material at the Gunlake Quarry is estimated to be between 5% and 7%. To estimate RCS emissions from existing and future operations, the annual calculated PM<sub>2.5</sub> emissions for each scenario have been multiplied by 7%. As the annual PM<sub>2.5</sub> emissions include emissions from overburden removal, unpaved

road movements and diesel combustion, it is considered that this approach will provide a conservative estimation of annual RCS emissions from Gunlake Quarry operations. Annual RCS emissions are calculated as follows:

- Scenario 1 – 0.6 tpa;
- Scenario 2 – 1.0 tpa;
- Scenario 3 – 1.4 tpa; and
- Scenario 4 – 1.7 tpa.

## **6.6 Construction phase**

The proposed expansion would involve minor construction activities, for example ground preparation for the additional processing plan, re-alignment of internal roads or modification / augmentation of existing erosion and sediment control. Construction emissions would be short term and on an annual basis the emissions intensity would be significantly less than quarry operations. Therefore no additional quantitative construction scenario was considered necessary.

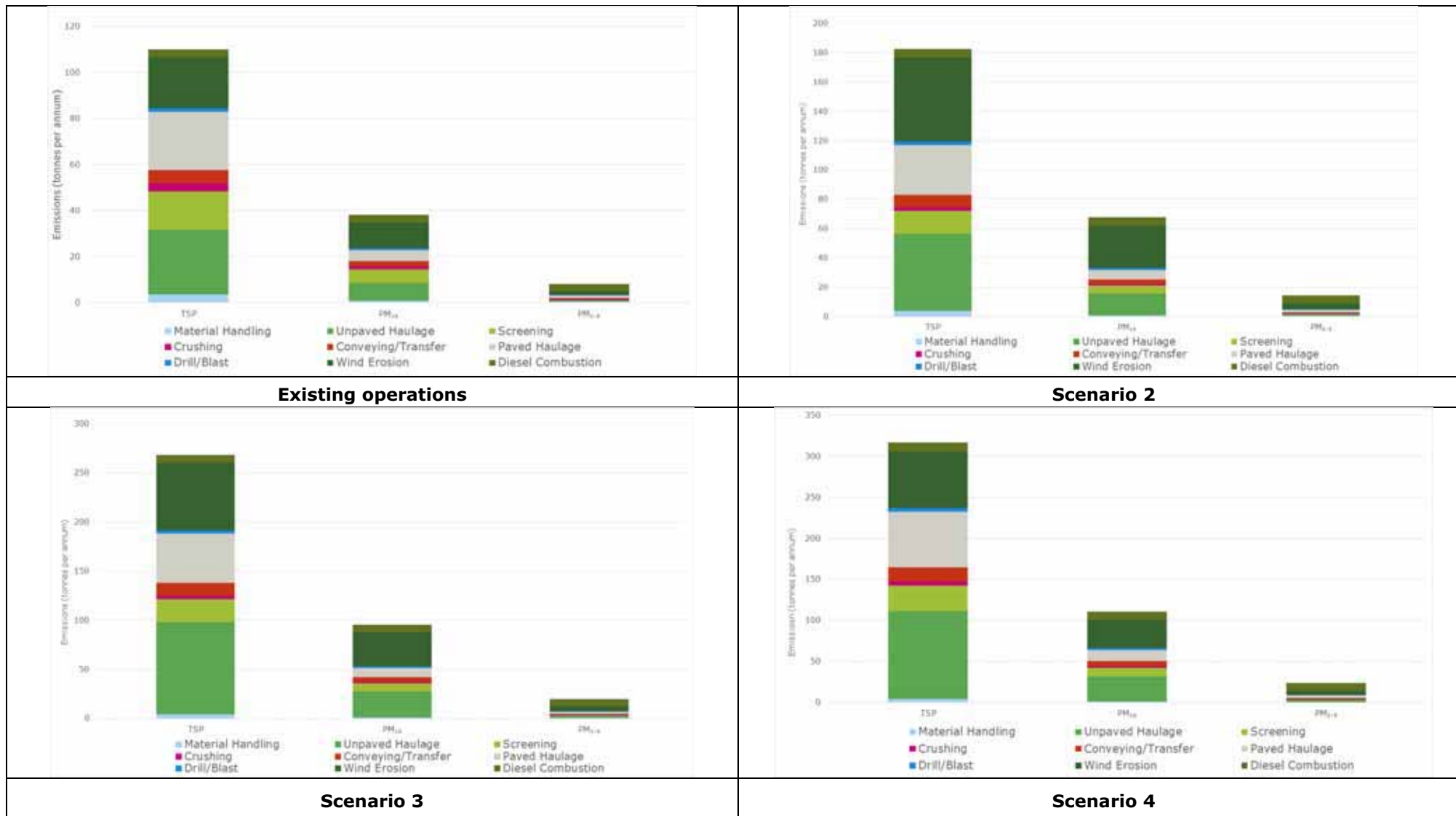


Figure 6-1: Comparison of calculated annual TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions by source group

## 7. ASSESSMENT METHODOLOGY

### 7.1 Dispersion model selection and application

The atmospheric dispersion modelling completed within this assessment used the AMS/US-EPA regulatory model (AERMOD) (US-EPA, 2004). AERMOD is designed to handle a variety of pollutant source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain. AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006 as it is considered to provide more realistic results with concentrations that are generally lower and more representative of actual concentrations compared to the ISC model. Compared to ISC, AERMOD represents an advanced new-generation model which requires additional meteorological and land-use inputs to provide more refined predictions.

Predicted concentrations were calculated at three levels:

- An outer Cartesian receptor grid covering a 15km by 15km computational domain centred over the Gunlake Quarry site, with a grid resolution of 500m applied;
- An inner Cartesian receptor grid covering a 6km by 6km computational domain centred over the Gunlake Quarry site, with a grid resolution of 200m applied; and
- The 12 sensitive receptor locations listed in **Table 2-2**.

Simulations were undertaken for the 12 month period of 2014 using the AERMET-generated file based on the onsite meteorological monitoring dataset as input (see **Section 4** for description of input meteorology).

### 7.2 Modelling scenarios

As identified in **Section 6**, four emission scenarios have been developed to estimate the staged increase in operational emissions of TSP, PM<sub>10</sub> and PM<sub>2.5</sub> from the Gunlake Quarry. The air dispersion modelling has predicted ground-level concentrations and deposition rates for each scenario.

### 7.3 Source and emissions data

The methodology and results of the emissions inventory developed for this study are presented in **Section 6** and **Appendix 2**. The spatial allocation of emissions for each scenario is presented in **Appendix 2**. Material handling and wind erosion emissions were varied by wind speed, with higher emissions occurring during periods of higher wind speed.

### 7.4 Presentation of model results

Dispersion simulations were undertaken to predict the concentrations of TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, RCS and dust deposition. Incremental Gunlake Quarry-related concentrations and deposition rates occurring due to the proposed operations across the Gunlake Quarry Site were modelled. Model results are expressed as the maximum predicted concentration for each averaging period at the selected assessment locations over the 2014 modelling period.

The results are presented in the following formats:

- Tabulated results of particulate concentrations and dust deposition rates from the Gunlake Quarry at the selected assessment locations are presented and discussed in **Section 8**.
- Cumulative impacts with neighbouring quarry operations and ambient background concentrations are presented in **Section 8.2** and **Section 8.3** respectively;
- Isopleth plots, illustrating spatial variations in Gunlake Quarry-related incremental TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and RCS concentrations and dust deposition rates are provided in **Appendix 3**. Isopleth plots of the maximum 24-hour average concentrations presented in **Appendix 3** do not represent the dispersion pattern on any individual day, but rather illustrate the maximum daily concentration that was predicted to occur at each model calculation point given the range of meteorological conditions occurring over the 2014 modelling period.

## 8. DISPERSION MODELLING RESULTS

### 8.1 Quarry-only incremental results

The predicted Gunlake Quarry-only incremental concentrations and deposition rates at each of the selected receptor locations for each emissions scenario are presented in **Table 8-1**.

All concentrations and deposition rates are below the applicable impact assessment criteria. The criteria in **Table 8-1** are applicable to cumulative concentrations (discussed in **Section 8.3**), and these predictions are incremental only.

The predicted concentrations and deposition rates increase with each scenario, reflective of the increase in quarry production. Receptor locations R1, R2, R3 and R6 are the most impacted by emissions from the Gunlake Quarry and Scenario 4 (highest production) has the highest impacts.

<b>Table 8-1: Predicted Quarry-only incremental concentrations and deposition rates</b>							
<b>Receptor ID</b>	<b>Annual TSP</b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>10</sub></b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>2.5</sub></b>	<b>Annual RCS</b>	<b>Annual Dust Deposition</b>
<b>Unit</b>	<b>µg/m<sup>3</sup></b>						<b>g/m<sup>2</sup>/month</b>
<b>Criteria</b>	<b>90</b>	<b>50</b>	<b>30</b>	<b>25</b>	<b>8</b>	<b>3</b>	<b>2</b>
<b>Scenario 1</b>							
1*	2.4	9.7	0.9	1.5	0.2	0.013	0.4
2	1.0	6.7	0.4	1.1	0.1	0.005	0.2
3*	0.5	3.3	0.2	0.7	<0.1	0.003	0.1
4	0.2	1.4	0.1	0.3	<0.1	0.001	<0.1
5	0.9	4.9	0.3	0.8	0.1	0.004	0.1
6	0.5	1.4	0.1	0.2	<0.1	0.002	0.1
7	0.3	1.2	0.1	0.2	<0.1	0.001	<0.1
8	0.7	1.3	0.1	0.2	<0.1	0.002	0.1
9	0.3	0.7	0.1	0.1	<0.1	0.001	<0.1
10	0.2	0.6	0.1	0.1	<0.1	0.001	<0.1
11	0.1	0.5	<0.1	0.1	<0.1	0.001	<0.1
12	0.1	0.5	<0.1	0.1	<0.1	0.001	<0.1
<b>Scenario 2</b>							
1*	3.1	11.3	1.2	1.8	0.2	0.016	0.5
2	2.4	11.4	1.0	1.8	0.2	0.013	0.4
3*	1.4	9.4	0.6	1.5	0.1	0.008	0.2
4	0.3	1.8	0.1	0.4	<0.1	0.002	<0.1
5	2.1	9.7	0.8	1.5	0.1	0.010	0.3
6	0.8	4.4	0.2	0.7	0.1	0.004	0.1

<b>Table 8-1: Predicted Quarry-only incremental concentrations and deposition rates</b>							
<b>Receptor ID</b>	<b>Annual TSP</b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>10</sub></b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>2.5</sub></b>	<b>Annual RCS</b>	<b>Annual Dust Deposition</b>
<b>Unit</b>	<b>µg/m<sup>3</sup></b>						<b>g/m<sup>2</sup>/month</b>
<b>Criteria</b>	<b>90</b>	<b>50</b>	<b>30</b>	<b>25</b>	<b>8</b>	<b>3</b>	<b>2</b>
7	0.5	3.2	0.1	0.5	<0.1	0.002	<0.1
8	0.9	2.6	0.2	0.4	<0.1	0.003	<0.1
9	0.4	1.6	0.1	0.2	<0.1	0.002	<0.1
10	0.3	1.3	0.1	0.2	<0.1	0.001	<0.1
11	0.2	1.0	0.0	0.2	<0.1	0.001	<0.1
12	0.2	1.2	0.1	0.2	<0.1	0.001	<0.1
<b>Scenario 3</b>							
1*	4.5	15.0	1.7	2.3	0.3	0.022	0.7
2	3.4	14.5	1.3	2.3	0.2	0.017	0.5
3*	1.9	11.5	0.8	1.8	0.1	0.010	0.3
4	0.5	2.4	0.2	0.5	<0.1	0.003	<0.1
5	2.9	12.1	1.0	1.9	0.2	0.013	0.5
6	1.2	5.6	0.3	0.9	0.1	0.005	0.2
7	0.7	4.1	0.2	0.6	<0.1	0.003	0.1
8	1.4	3.4	0.3	0.6	0.1	0.005	0.2
9	0.5	2.0	0.1	0.3	<0.1	0.002	0.1
10	0.5	1.7	0.1	0.3	<0.1	0.002	0.1
11	0.3	1.3	0.1	0.2	<0.1	0.001	<0.1
12	0.3	1.5	0.1	0.3	<0.1	0.001	<0.1
<b>Scenario 4</b>							
1*	5.3	16.5	2.0	2.5	0.4	0.026	0.8
2	3.7	13.8	1.4	2.2	0.3	0.018	0.6
3*	2.0	11.1	0.8	1.7	0.1	0.010	0.3
4	0.4	2.8	0.2	0.7	<0.1	0.003	<0.1
5	3.3	11.1	1.1	1.8	0.2	0.015	0.6
6	1.5	6.0	0.4	0.9	0.1	0.006	0.2
7	0.8	4.2	0.2	0.7	0.1	0.004	0.1
8	1.8	3.8	0.4	0.7	0.1	0.006	0.3
9	0.6	2.1	0.2	0.3	<0.1	0.003	0.1
10	0.6	1.9	0.2	0.3	<0.1	0.003	0.1

<b>Table 8-1: Predicted Quarry-only incremental concentrations and deposition rates</b>							
<b>Receptor ID</b>	<b>Annual TSP</b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>10</sub></b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>2.5</sub></b>	<b>Annual RCS</b>	<b>Annual Dust Deposition</b>
<b>Unit</b>	<b>µg/m<sup>3</sup></b>						<b>g/m<sup>2</sup>/month</b>
<b>Criteria</b>	<b>90</b>	<b>50</b>	<b>30</b>	<b>25</b>	<b>8</b>	<b>3</b>	<b>2</b>
11	0.3	1.5	0.1	0.3	<0.1	0.001	<0.1
12	0.3	1.8	0.1	0.3	<0.1	0.001	<0.1

Note \*: Gunlake Quarries-owned residence

## 8.2 Quarry and neighbouring quarry operations incremental results

The maximum concentrations and deposition rates predicted from the combination of Quarry-only and neighbouring quarry operations (Lynwood and Johnniefields) at each of the selected receptor locations for each emissions scenario are presented in **Table 8-2**.

For the Gunlake Quarry and neighbouring quarry operations in combination, predicted concentrations and deposition rates are below the applicable impact assessment criteria. It is reiterated that these criteria, with the exception of dust deposition, are applicable to cumulative concentrations accounting for ambient conditions and these predictions are incremental only. Cumulative impact assessment is presented in **Section 8.3**.

When compared with the Gunlake Quarry -only incremental concentrations presented in **Section 8.1**, the increase in maximum 24-hour average PM<sub>10</sub> and PM<sub>2.5</sub> concentrations is negligible at the at closest receptor locations to the Gunlake Quarry (R1, R2, R3, R4 and R6). This is attributable to the prevailing east-west aligned wind regime (**Section 4**) and demonstrates that daily impacts from the Lynwood and Johnniefields Quarry operations generally do not affect these receptors on the same days as the Gunlake Quarry.

<b>Table 8-2: Predicted Quarry plus neighbouring quarry operations incremental concentrations and deposition rates</b>							
<b>Receptor ID</b>	<b>Annual TSP</b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>10</sub></b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>2.5</sub></b>	<b>Annual RCS</b>	<b>Annual Dust Deposition</b>
<b>Unit</b>	<b>µg/m<sup>3</sup></b>						<b>g/m<sup>2</sup>/month</b>
<b>Criteria</b>	<b>90</b>	<b>50</b>	<b>30</b>	<b>25</b>	<b>8</b>	<b>3</b>	<b>2</b>
<b>Scenario 1</b>							
1*	4.0	9.9	1.6	1.5	0.3	0.018	0.5
2	2.9	7.1	1.1	1.1	0.2	0.012	0.4
3*	1.9	7.4	0.7	0.9	0.1	0.007	0.2
4	0.6	2.0	0.2	0.4	<0.1	0.002	0.0
5	3.2	7.8	1.2	1.0	0.2	0.012	0.4
6	2.5	5.6	0.9	0.7	0.1	0.009	0.2
7	2.2	6.2	0.8	0.7	0.1	0.008	0.2
8	2.4	4.9	0.8	0.6	0.1	0.008	0.3

<b>Table 8-2: Predicted Quarry plus neighbouring quarry operations incremental concentrations and deposition rates</b>							
<b>Receptor ID</b>	<b>Annual TSP</b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>10</sub></b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>2.5</sub></b>	<b>Annual RCS</b>	<b>Annual Dust Deposition</b>
<b>Unit</b>	<b>µg/m<sup>3</sup></b>						<b>g/m<sup>2</sup>/month</b>
<b>Criteria</b>	<b>90</b>	<b>50</b>	<b>30</b>	<b>25</b>	<b>8</b>	<b>3</b>	<b>2</b>
9	2.6	5.2	1.0	0.6	0.1	0.009	0.3
10	2.9	6.5	1.1	0.8	0.1	0.010	0.4
11	3.1	9.7	1.2	1.2	0.1	0.010	0.4
12	2.8	8.9	1.1	1.1	0.1	0.009	0.4
<b>Scenario 2</b>							
1*	4.7	11.5	1.9	1.8	0.3	0.022	0.6
2	4.3	11.5	1.7	1.8	0.3	0.019	0.6
3*	2.8	9.5	1.1	1.5	0.2	0.012	0.3
4	0.7	2.3	0.2	0.4	0.0	0.003	0.1
5	4.3	9.8	1.7	1.6	0.3	0.018	0.6
6	2.8	5.7	1.0	0.7	0.1	0.010	0.3
7	2.4	6.2	0.9	0.8	0.1	0.008	0.2
8	2.7	5.0	0.9	0.6	0.1	0.009	0.3
9	2.7	5.2	1.0	0.6	0.1	0.009	0.3
10	3.0	6.5	1.1	0.8	0.1	0.010	0.4
11	3.2	9.7	1.2	1.2	0.2	0.011	0.4
12	2.9	8.9	1.1	1.1	0.1	0.010	0.4
<b>Scenario 3</b>							
1*	6.1	15.0	2.3	2.3	0.4	0.028	0.9
2	5.3	14.5	2.1	2.3	0.3	0.023	0.8
3*	3.3	11.5	1.3	1.8	0.2	0.014	0.4
4	0.8	2.4	0.3	0.5	0.1	0.004	0.1
5	5.2	12.1	1.9	1.9	0.3	0.021	0.8
6	3.1	5.6	1.1	0.9	0.2	0.011	0.4
7	2.6	4.1	1.0	0.6	0.1	0.009	0.3
8	3.1	3.4	1.0	0.6	0.2	0.011	0.4
9	2.9	2.0	1.1	0.3	0.1	0.010	0.4
10	3.2	1.7	1.2	0.3	0.2	0.011	0.4

<b>Table 8-2: Predicted Quarry plus neighbouring quarry operations incremental concentrations and deposition rates</b>							
<b>Receptor ID</b>	<b>Annual TSP</b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>10</sub></b>	<b>Maximum 24-hour PM<sub>10</sub></b>	<b>Annual PM<sub>2.5</sub></b>	<b>Annual RCS</b>	<b>Annual Dust Deposition</b>
<b>Unit</b>	<b>µg/m<sup>3</sup></b>						<b>g/m<sup>2</sup>/month</b>
<b>Criteria</b>	<b>90</b>	<b>50</b>	<b>30</b>	<b>25</b>	<b>8</b>	<b>3</b>	<b>2</b>
11	3.2	1.3	1.2	0.2	0.2	0.011	0.4
12	3.0	1.5	1.1	0.3	0.1	0.010	0.4
<b>Scenario 4</b>							
1*	6.9	16.7	2.6	2.6	0.4	0.031	1.0
2	5.5	14.0	2.1	2.2	0.3	0.024	0.8
3*	3.4	11.2	1.3	1.8	0.2	0.015	0.4
4	0.8	3.2	0.3	0.7	0.1	0.004	0.1
5	5.5	11.3	2.0	1.8	0.3	0.022	0.8
6	3.4	6.1	1.1	0.9	0.2	0.012	0.4
7	2.7	6.2	1.0	0.8	0.1	0.010	0.3
8	3.5	5.2	1.1	0.7	0.2	0.012	0.5
9	3.0	5.2	1.1	0.6	0.1	0.010	0.4
10	3.3	6.5	1.2	0.8	0.2	0.011	0.4
11	3.3	9.7	1.3	1.2	0.2	0.011	0.5
12	3.0	8.9	1.1	1.1	0.1	0.010	0.4

Note \*: Gunlake Quarries-owned residence

### 8.3 Cumulative impacts from Gunlake Quarry, neighbouring quarries plus background

#### 8.3.1 Cumulative 24-hour average concentrations

As described in **Section 8.1** and **Section 8.2**, maximum predicted 24-hour average concentrations occur at all receptors during Scenario 4 operations of the Gunlake Quarry. Therefore Scenario 4 is used to assess maximum cumulative impacts (Gunlake Quarry + neighbouring quarry operations + ambient air quality levels) at surrounding receptors.

Cumulative impacts for 24-hour PM<sub>10</sub> and PM<sub>2.5</sub> have been evaluated using a statistical approach which presents the likelihood of the Gunlake Quarry causing additional exceedances of the 24-hour average assessment criterion of 50µg/m<sup>3</sup> and 25µg/m<sup>3</sup> for PM<sub>10</sub> and PM<sub>2.5</sub> respectively. To provide an analysis of the likelihood of compliance with the NSW EPA assessment criterion for 24-hour average PM<sub>10</sub> (50 µg/m<sup>3</sup>) and NEPM advisory reporting goal for PM<sub>2.5</sub> (25 µg/m<sup>3</sup>), every predicted 24-hour average concentration (365 individual concentrations) has been paired with every recorded 24-hour average concentration detailed in **Section 5.2.1** for PM<sub>10</sub> (1,930 individual concentrations) and **Section 5.2.2** for PM<sub>2.5</sub> (1,182 individual concentrations).

Each combination of model prediction and recorded concentration (704,450 potential combinations for PM<sub>10</sub>; 431,430 potential combinations for PM<sub>2.5</sub>) has been collated. The process assumes that any background value from the data set could occur on any given day of the Gunlake Quarry operation. In using all available background values from the analysed

monitoring stations (with monitoring stations located locally, in southwest Sydney and in Canberra), an extensive range of potential background conditions are assessed.

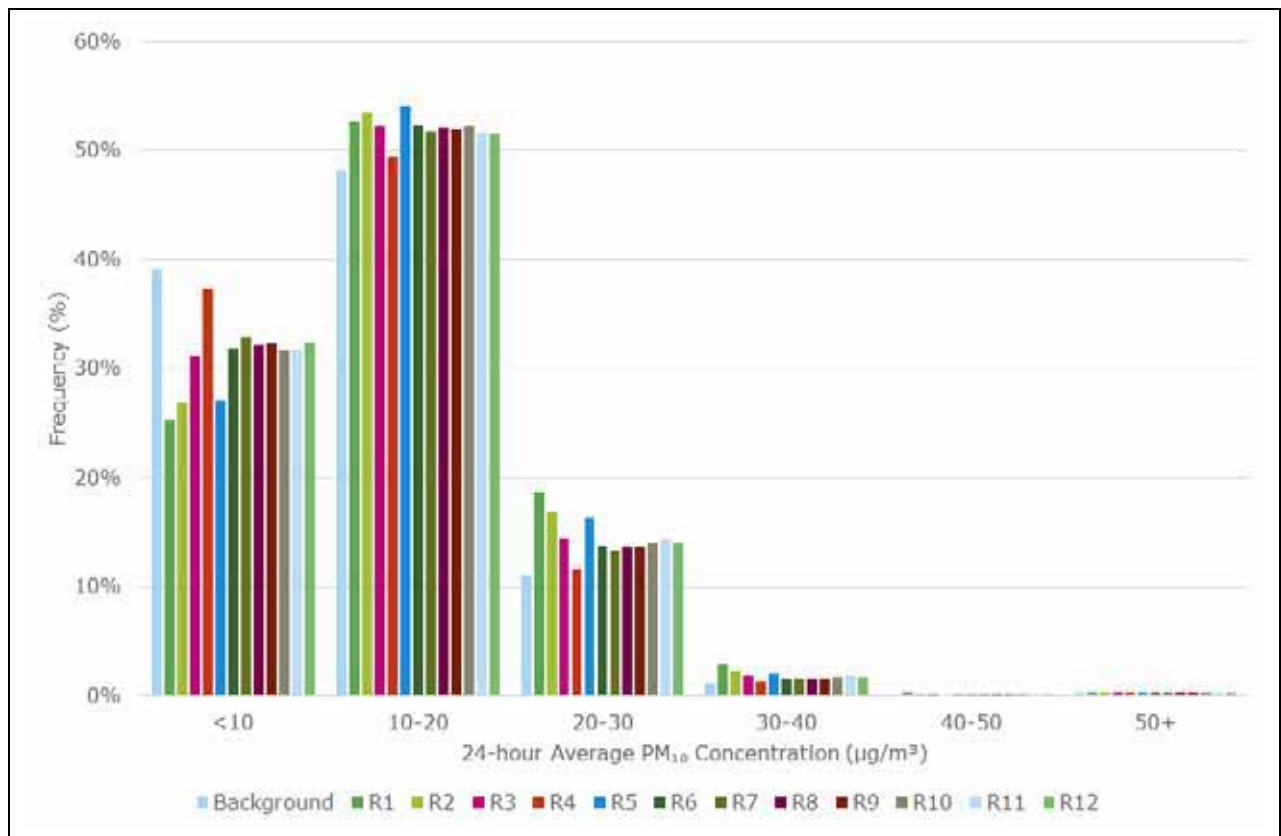
For each receptor location, a frequency distribution of cumulative concentrations has been derived. Frequency histogram plots for cumulative 24-hour average PM<sub>10</sub> and PM<sub>2.5</sub> concentrations are presented in **Figure 8-1** and **Figure 8-2** respectively.

The frequency histogram profiles presented in **Figure 8-1** and **Figure 8-2** demonstrate that the most notable change from the “background” frequency occurs in the lower concentration bands (less than 30µg/m<sup>3</sup> for PM<sub>10</sub> and less than 15µg/m<sup>3</sup> for PM<sub>2.5</sub>).

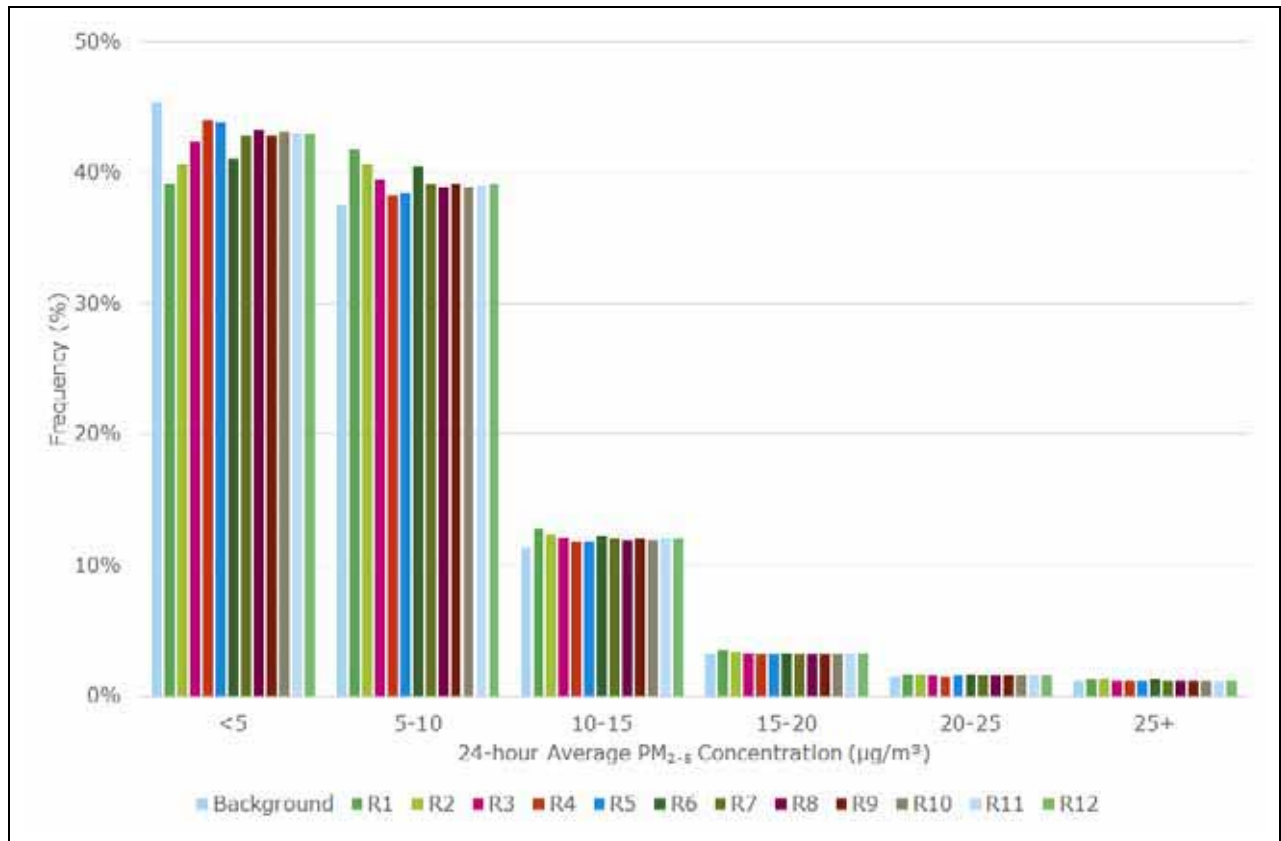
For 24-hour average PM<sub>10</sub>, the frequency of potential cumulative concentrations greater than 50µg/m<sup>3</sup> across all receptors remains at 0.3%, consistent with the background PM<sub>10</sub> dataset. Similarly, the frequency of potential cumulative 24-hour average PM<sub>2.5</sub> concentrations greater than 25µg/m<sup>3</sup> across all receptors ranged between 1.2% and 1.3%, relative to an exceedance frequency of 1.2% in the background dataset. Consequently, the frequency analysis demonstrates that the likelihood of an additional day exceedance is negligible for both 24-hour average PM<sub>10</sub> and PM<sub>2.5</sub>.

On the basis of this cumulative analysis, it is concluded that there is a very low probability that worst case emissions from the Gunlake Quarry, combined with emissions from neighbouring quarry operations and background, will result in additional exceedances of the 24-hour average PM<sub>10</sub> or PM<sub>2.5</sub> criteria at surrounding receptors, beyond those that would occur in the absence of the Gunlake Quarry.

Maximum incremental 24-hour average PM<sub>10</sub> concentration isopleth plots for existing and proposed operations are presented in **Appendix 3**.



**Figure 8-1: Frequency histogram of cumulative 24-hour average PM<sub>10</sub> concentrations – Scenario 4 Quarry + neighbouring quarries + ambient concentrations**



**Figure 8-2: Frequency histogram of cumulative 24-hour average PM<sub>2.5</sub> concentrations – Scenario 4 Quarry + neighbouring quarries + ambient concentrations**

8.3.2 Cumulative annual average concentrations and deposition rates

The predicted annual average concentrations from Quarry emissions, neighbouring quarry operations plus background are presented in **Table 8-3**. The results show that all cumulative annual average concentrations and deposition levels are below the applicable impact assessment criteria for all modelling scenarios across all sensitive receptor location.

<b>Table 8-3: Cumulative annual average TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition</b>				
<b>Receptor ID</b>	<b>Annual TSP</b>	<b>Annual PM<sub>10</sub></b>	<b>Annual PM<sub>2.5</sub></b>	<b>Annual Dust Deposition</b>
<b>Unit</b>	<b>µg/m<sup>3</sup></b>			<b>g/m<sup>2</sup>/month</b>
<b>Criteria</b>	<b>90</b>	<b>30</b>	<b>8</b>	<b>4</b>
<b>Scenario 1</b>				
1*	35.3	14.1	7.0	2.2
2	34.2	13.6	6.9	2.1
3*	33.2	13.2	6.8	1.9
4	31.9	12.7	6.7	1.7
5	34.5	13.7	6.9	2.1
6	33.8	13.4	6.8	1.9
7	33.5	13.3	6.8	1.9
8	33.7	13.3	6.8	2.0
9	33.9	13.5	6.8	2.0
10	34.2	13.6	6.8	2.1
11	34.4	13.7	6.8	2.1
12	34.1	13.6	6.8	2.1
<b>Scenario 2</b>				
1*	36.0	14.4	7.0	2.3
2	35.6	14.2	7.0	2.3
3*	34.1	13.6	6.9	2.0
4	32.0	12.7	6.7	1.8
5	35.6	14.2	7.0	2.3
6	34.1	13.5	6.8	2.0
7	33.7	13.4	6.8	1.9
8	34.0	13.4	6.8	2.0
9	34.0	13.5	6.8	2.0
10	34.3	13.6	6.8	2.1
11	34.5	13.7	6.9	2.1
12	34.2	13.6	6.8	2.1
<b>Scenario 3</b>				
1*	37.4	14.8	7.1	2.6

<b>Table 8-3: Cumulative annual average TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and dust deposition</b>				
<b>Receptor ID</b>	<b>Annual TSP</b>	<b>Annual PM<sub>10</sub></b>	<b>Annual PM<sub>2.5</sub></b>	<b>Annual Dust Deposition</b>
<b>Unit</b>	<b>µg/m<sup>3</sup></b>			<b>g/m<sup>2</sup>/month</b>
<b>Criteria</b>	<b>90</b>	<b>30</b>	<b>8</b>	<b>4</b>
2	36.6	14.6	7.0	2.5
3*	34.6	13.8	6.9	2.1
4	32.1	12.8	6.8	1.8
5	36.5	14.4	7.0	2.5
6	34.4	13.6	6.9	2.1
7	33.9	13.5	6.8	2.0
8	34.4	13.5	6.9	2.1
9	34.2	13.6	6.8	2.1
10	34.5	13.7	6.9	2.1
11	34.5	13.7	6.9	2.1
12	34.3	13.6	6.8	2.1
<b>Scenario 4</b>				
1*	38.2	15.1	7.1	2.7
2	36.8	14.6	7.0	2.5
3*	34.7	13.8	6.9	2.1
4	32.1	12.8	6.8	1.8
5	36.8	14.5	7.0	2.5
6	34.7	13.6	6.9	2.1
7	34.0	13.5	6.8	2.0
8	34.8	13.6	6.9	2.2
9	34.3	13.6	6.8	2.1
10	34.6	13.7	6.9	2.1
11	34.6	13.8	6.9	2.2
12	34.3	13.6	6.8	2.1

Note \*: Gunlake Quarries-owned residence

## 9. MITIGATION AND MONITORING

**Section 6.3** lists the mitigation measures and practices, current and proposed, to manage particulate matter emissions during operations at the Gunlake Quarry. These controls were incorporated into the modelling wherever an appropriate emission reduction factor was available. Existing controls should continue and proposed controls should be progressively implemented for the extension project as production increases.

The modelling predictions presented in the report indicate that the risk of adverse air quality impacts from the extension project are low. The highest predicted impacts occur at full production and at receptor locations R1, R2, R3 and R6. Gunlake Quarries own receptors R1 and R3.

The existing monitoring network for the Gunlake Quarry is described in **Section 5**, which includes PM<sub>10</sub> monitoring using a HVAS at R1. Based on the modelling results and prevailing winds, this is the most suitable location for monitoring.

It is recommended that the existing monitoring network is retained for the proposed extension. Monitoring results should be reviewed on an annual basis, in accordance with the EPL and approval conditions, and the need for additional monitoring determined on an annual basis, as production ramps up.

## 10. GREENHOUSE GAS ASSESSMENT

### 10.1 Introduction

The estimation of greenhouse gas (GHG) emissions for the Gunlake Quarry is based on the National Greenhouse Accounts Factors (NGAF) workbook (DoE, 2014). The methodologies in the NGAF workbook follow a simplified approach, equivalent to the "Method 1" approach outlined in the National Greenhouse and Energy Reporting (Measurement) Technical Guidelines (DoE 2014a). The Technical Guidelines are used for the purpose of reporting under the National Greenhouse and Energy Reporting Act 2007 (the NGER Act).

For accounting and reporting purposes, GHG emissions are defined as 'direct' and 'indirect' emissions. Direct emissions (also referred to as Scope 1 emissions) occur within the boundary of an organisation and as a result of that organisation's activities. Indirect emissions are generated as a consequence of an organisation's activities but are physically produced by the activities of another organisation (DoE, 2014). Indirect emissions are further defined as Scope 2 and Scope 3 emissions. Scope 2 emissions occur from the generation of the electricity purchased and consumed by an organisation. Scope 3 emissions occur from all other upstream and downstream activities, for example the downstream extraction and production of raw materials or the upstream use of products and services.

Scope 3 is an optional reporting category and should not be used to make comparisons between organisations (WBCSD, 2004), for example in benchmarking GHG intensity of products or services. Typically, only major sources of Scope 3 emissions are accounted and reported by organisations. Specific Scope 3 emission factors are provided in the NGAF workbook for the consumption of fossil fuels and purchased electricity, making it straightforward for these sources to be included in a GHG inventory, even though they are a relatively minor source.

### 10.2 Estimated emissions

The GHG emissions sources included in this assessment are presented in **Table 10-1** representing the most significant sources associated with the Gunlake Quarry. Emission are estimated using the methodologies outlined in the NGAF workbook, using fuel energy contents and scope 1, 2 and 3 emission factors for diesel, gasoline and electricity generation in NSW.

<b>Table 10-1: GHG emission sources</b>		
<b>Scope 1</b>	<b>Scope 2</b>	<b>Scope 3</b>
Direct emissions from fuel combustion (diesel) by onsite plant and equipment	Indirect emissions associated with the consumption of purchased electricity	Indirect upstream emissions from the extraction, production and transport of diesel fuel.
		Indirect upstream emissions from electricity lost in delivery in the transmission and distribution network.
		Indirect downstream emissions generated from off-site transportation of product
		Indirect emissions generated from employee travel

The activity data for the emission estimates is presented in **Table 10-2**. The annual on-site diesel fuel consumption and electricity usage was provided by the client for existing operations and maximum production (Scenario 4). An estimate of the diesel and electricity consumption for the intermediate scenarios (2 and 3) is based on an assumption of linear increase from existing to maximum production.

An estimate of diesel consumption from product transportation has been made based on the NSW average fuel consumption rate for articulated trucks of 56.9 L/ 100 km (ABS, 2015<sup>4</sup>). An upper

<sup>4</sup> <http://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0>

estimate of annual vehicle kilometres travelled (VKT) is based on a return trip distance to Sydney (300 km) and the number of trips estimated based on a truck capacity of 30 tonnes.

An estimate of diesel consumption from employee travel is based on the NSW average fuel consumption rate for passenger vehicles of 10.7 L/ 100 km (ABS, 2015). An upper estimate of annual vehicle kilometres travelled (VKT) is based on commute distance of 30 km, 288 workdays per annum and the number of on-site employee progressively rising from 25 (current) to 52 at maximum production.

Scenario	Production (tonnes/annum)	On-site Diesel (kL/annum)	Electricity (kWh/annum)	Product Transport Diesel (kL/annum)	Employee Travel Fuel (kL/annum)
1	750,000	950	127,000	4,268	216
2	1,000,000	1,600	137,583	5,690	259
3	1,500,000	2,250	148,167	8,535	346
4	2,000,000	2,900	158,750	11,380	449

The estimated annual GHG emissions for each source is presented in **Table 10-3**. The proposed modification will result in an increase in annual GHG emissions, as a result of increased fuel consumption (on-site and product transportation) and an increase in electricity demand for processing.

At maximum production, GHG emissions will increase by approximately three fold from current operations. The annual Scope 1 and Scope 3 emissions at full production represent approximately 0.03% of total GHG emissions for NSW and 0.008% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2013<sup>5</sup>.

Scenario	Scope 1 emissions	Scope 2 emissions	Scope 3 emissions				Total
	On-site Diesel	Electricity	On-site Diesel	Electricity	Product Transport (Diesel)	Employee Travel	
1	2,549	109	194	17	12,387	553	13,152
2	4,292	118	327	18	16,516	664	17,526
3	6,036	127	460	19	24,775	885	26,140
4	7,780	137	593	21	33,033	1,151	34,798

Note: GHG emissions are reported in tonnes of carbon dioxide equivalents (t CO<sub>2</sub>-e). Non-CO<sub>2</sub> gases are converted to CO<sub>2</sub>-e by multiplying the quantity of the gas by its Global Warming Potential (GWP) – see Table 26 of the NGAF workbook.

<sup>5</sup> <http://ageis.climatechange.gov.au/>

## 11. CONCLUSION

Dispersion model predictions for the proposed Gunlake Quarry extension project show that the proposed changes to operations would not result in any exceedances of the impact assessment criteria for key pollutants, including PM<sub>10</sub>, PM<sub>2.5</sub>, TSP, RSC and dust deposition.

Four emission scenarios were assessed to account for a staged increase from currently approved (750,000 tpa) to maximum production (2 Mtpa). The predicted concentrations and deposition rates increase with each scenario and Scenario 4 (highest production) has the highest impacts. The closest receptor locations (R1, R2, R3 and R6) are the most impacted by emissions from the Gunlake Quarry, noting that receptors R1 and R3 are owned by Gunlake Quarries.

Cumulative predictions are presented for worst case operations, taking into account emission from neighbouring quarry operations and existing ambient background concentrations. Cumulative annual average PM<sub>10</sub>, PM<sub>2.5</sub> and TSP were all below the applicable assessment criteria and the risk of additional days over the 24-hour average PM<sub>10</sub> and PM<sub>2.5</sub> assessment criteria is minimal.

The dispersion modelling presented in this report assumes a number of dust controls. Existing controls should continue to be implemented for the extension project as production increases.

It is recommended that the existing monitoring regime is maintained with the need for additional monitoring determined on an annual basis, as production ramps up.

A greenhouse gas quantification assessment was undertaken for the proposed Gunlake Quarry extension project. Relative to existing operations, the proposed modification will result in an increase in annual GHG emissions, due primarily to the related increase in diesel fuel consumption (on-site and product transportation) and electricity demand for processing.

At maximum production, GHG emissions will increase by approximately three fold from current operations. The annual Scope 1 and Scope 3 emissions at full production represent approximately 0.03% of total GHG emissions for NSW and 0.008% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2013.

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## 13. GLOSSARY OF TERMS

AEMR	Annual Environmental Monitoring Report
AHD	Australian Height Datum
Approved Methods for Modelling of Air Pollutants in NSW	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW
AWS	Automatic Weather Station
BoM	Australian Bureau of Meteorology
CO <sub>2</sub>	Carbon dioxide
CO <sub>2</sub> -e	CO <sub>2</sub> equivalent
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCCEE	Department of Climate Change and Energy Efficiency
DEC	NSW Department of the Environment and Conservation
DoE	Department of Environment
EMM	EMM Consulting
EPL	Environmental Protection Licence
GHG	Greenhouse Gas
LGA	Local government area
µg	Microgram (g x 10 <sup>-6</sup> )
µm	Micrometre or micron (metre x 10 <sup>-6</sup> )
m <sup>3</sup>	Cubic metre
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NGAF	National Greenhouse Accounts Factors
NPI	National Pollutant Inventory
PM <sub>10</sub>	Particulate matter less than 10 microns in aerodynamic diameter
PM <sub>2.5</sub>	Particulate matter less than 2.5 microns in aerodynamic diameter
OEH	Office of Environment and Heritage
Ramboll Environ	Ramboll Environ Australia Pty Ltd
RCS	Respirable crystalline silica
SEARs	Secretary's Environmental Assessment Requirements
TAPM	"The Air Pollution Model"
tpa	Tonnes per annum
TSP	Total Suspended Particulate
US-EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
VKT	Vehicle Kilometres Travelled

## **APPENDIX 1 SEASONAL AND DIURNAL WIND ROSES**

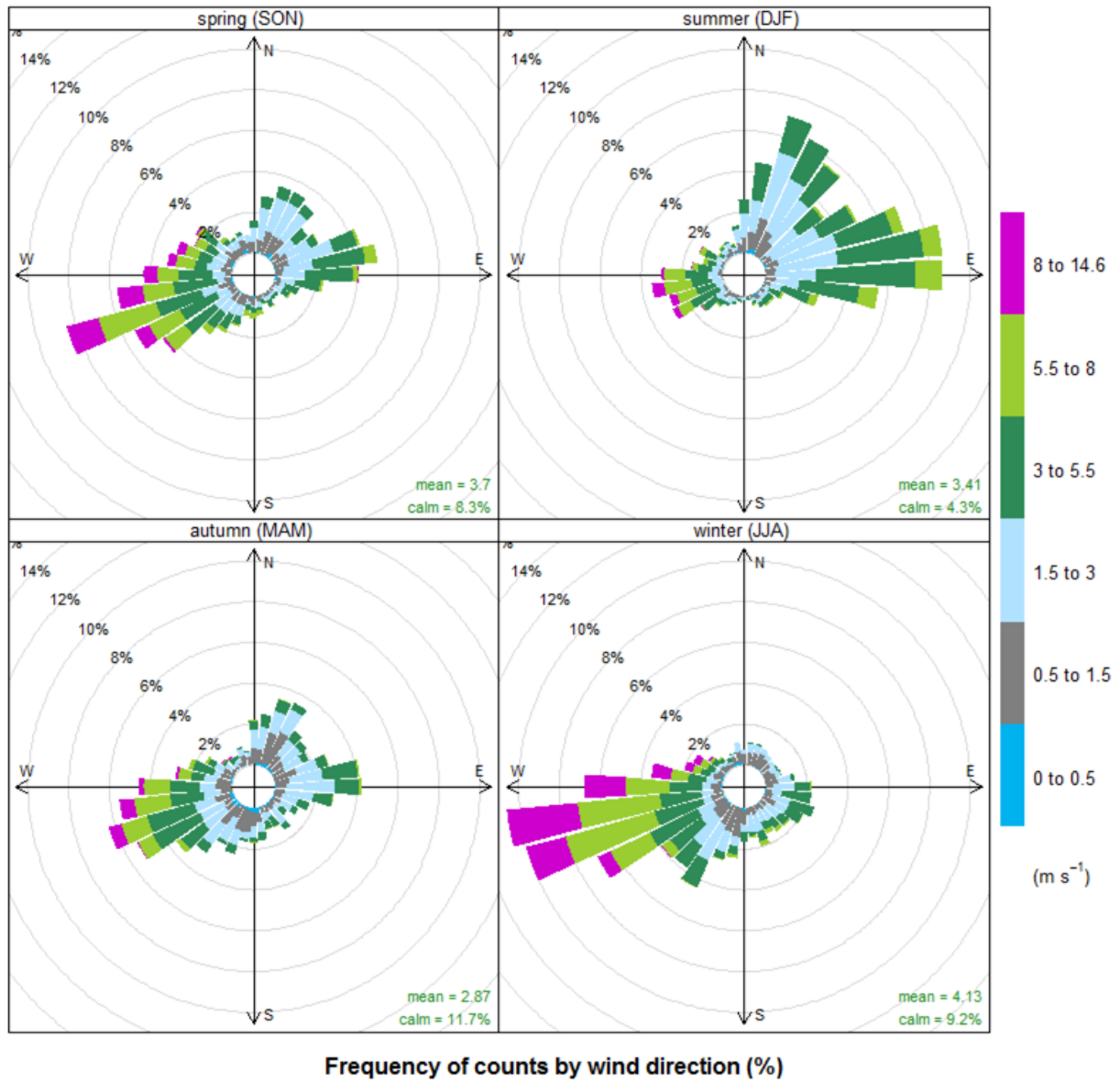


Figure A1-1: Seasonal wind roses – Quarry Site - 2014

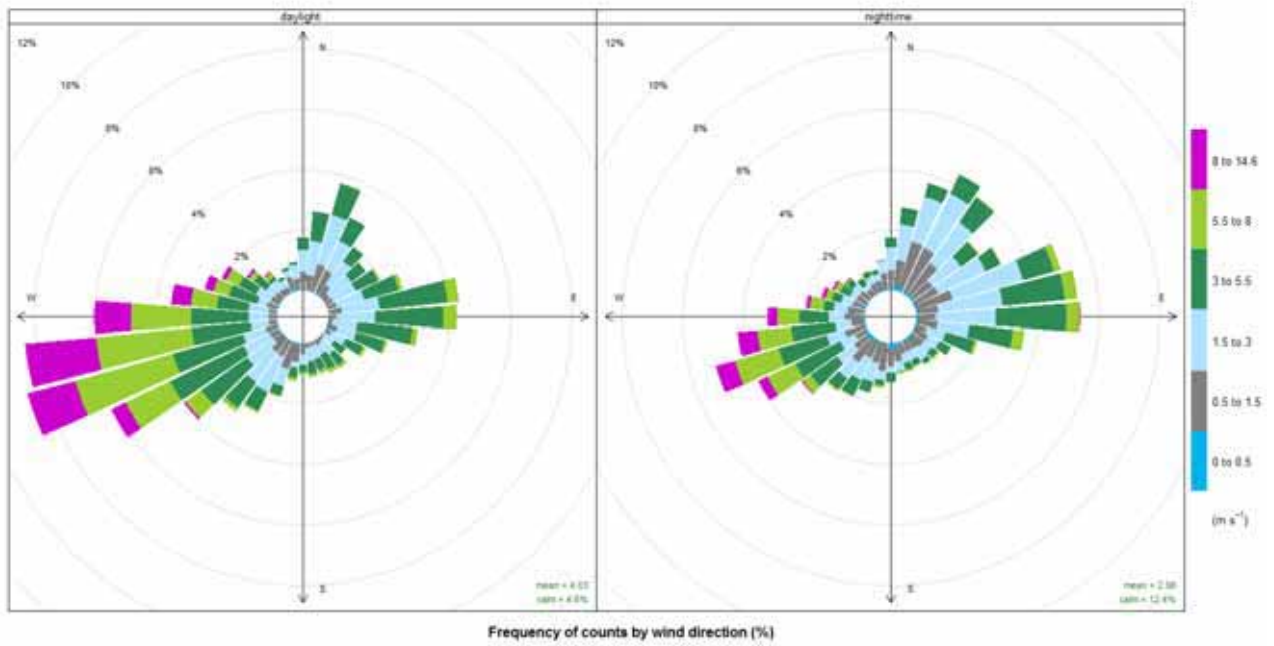


Figure A1-2: Diurnal wind roses – Quarry Site - 2014

## **APPENDIX 2 EMISSION INVENTORY ASSUMPTIONS AND INPUTS**

## Introduction

Emissions are inventoried for the following sources of fugitive PM at the Gunlake Quarry:

- Removal, handling, hauling and dumping of topsoil and waste rock/overburden;
- Removal, handling, hauling and dumping of hard rock product, including drilling and blasting in the quarry pit;
- Product processing (crushing, screening and conveying);
- Wind erosion from stockpiles and exposed surfaces; and
- Transportation (hauling) of product along unpaved internal roads, the paved site access road and paved public roads.

Emission factors developed by the United States Environmental Protection Agency (US-EPA AP-42) and National Pollution Inventory (NPI) are referenced, as follows:

- NPI Emission Estimation Technique Manual for Mining (DSEWPC, 2012).
- NPI Emission Estimation Technique Manual for Combustion Engines (DEWHA, 2008).
- AP-42 Chapter 11.19.2 – Crushed Stone Processing and Pulverized Mineral Processing (US-EPA, 2004).
- AP-42 Chapter 13.2.2 – Unpaved Roads (US-EPA 2006a).
- AP-42 Chapter 13.2.4 – Aggregate Handling and Storage Piles (US-EPA 2006b).
- AP-42 Chapter 11.9 – Western Surface Coal Mining (US-EPA 1998).

Emissions were quantified for each particle size fraction, with the TSP size fraction also used to predict dust deposition rates. Fine particles (PM<sub>10</sub> and PM<sub>2.5</sub>) were estimated using ratios for the different particle size fractions available within the literature (principally the US EPA AP-42).

Emission from diesel combustion are estimated based on fuel usage (kL/annum) and emission factors for diesel industrial vehicles (kg/kL) (DEWHA, 2008).

## Emission inventory development

The following steps are used to develop annual emission estimates for each activity listed above. Silt and moisture contents (%) are identified for each material handled at the Gunlake Quarry. The material properties (**Table A2.1**) are used as input to the various emission factor equations listed in **Table A2.3** to derived site specific uncontrolled emission factors for each source (**Table A2.2**). The activity data presented in **Table A2.4** is then used to estimate annual emission totals for each scenario.

<b>Table A2.1 Material properties</b>			
<b>Properties</b>	<b>Units</b>	<b>Value</b>	<b>Source of Information</b>
Silt Content of Unpaved Roads internal haul roads	%	8.3	Silt Content for Quarrying - Haul Road to/from pit AP42 13.2.2
Silt Content of Unpaved Roads Product transportation	%	7.1	Silt Content for Sand and Gravel Processing - Material Storage Area AP42 13.2.2
Silt loading for paved roads	g/m <sup>2</sup>	0.6	Silt Loading (g/m2) for road <500 trucks/day
Silt Content of Overburden	%	7.0	US-EPA AP42 (1998) mean value for "overburden"
Silt Content of raw material	%	6.0	Client provided
Silt Content of product	%	3.0	Client provided
Moisture Content of Overburden	%	15	Client provided
Moisture Content of raw material	%	8	Client provided
Moisture Content of product	%	12	Client provided

Activity	Units	TSP emission factor equation	PM <sub>10</sub> emission factor equation	PM <sub>2.5</sub> emission factor equation	Variables
Material handling	kg/t	$0.74 \times 0.0016 \times \left( \frac{U}{2.2} \right)^{1.3} \left( \frac{M}{2} \right)^{1.4}$	$0.35 \times 0.0016 \times \left( \frac{U}{2.2} \right)^{1.3} \left( \frac{M}{2} \right)^{1.4}$	$0.053 \times 0.0016 \times \left( \frac{U}{2.2} \right)^{1.3} \left( \frac{M}{2} \right)^{1.4}$	U = mean wind speed (m/s) M = material moisture content (%)
Dozers	kg/hr	$2.6 \times \frac{s^{1.2}}{M^{1.3}}$	$0.45 \times \frac{s^{1.5}}{M^{1.4}}$	0.15 × PM <sub>10</sub>	s = material silt content (%) M = material moisture content (%)
Wheel generated dust	kg/VKT	$\left( \frac{0.4536}{1.6093} \right) \times 4.9 \times \left( \frac{s}{12} \right)^{0.7} \times \left( \frac{W \times 1.1023}{3} \right)^{0.45}$	$\left( \frac{0.4536}{1.6093} \right) \times 1.5 \times \left( \frac{s}{12} \right)^{0.9} \times \left( \frac{W \times 1.1023}{3} \right)^{0.45}$	$\left( \frac{0.4536}{1.6093} \right) \times 1.5 \times \left( \frac{s}{12} \right)^{0.9} \times \left( \frac{W \times 1.1023}{3} \right)^{0.45}$	s = surface material silt content (%) W = mean vehicle weight (tonnes)
Blasting	kg/blast	0.00022(A) <sup>1.5</sup>	TSP × 0.52	PM <sub>10</sub> × 0.15	A= horizontal area (m <sup>2</sup> ) with blasting depth ≤ 21.

Emission Source	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Unit	Source of Factor
Overburden Removal - Bulldozer	0.7946	0.1411	0.0834	kg/hour	AP-42 11.9 - Bulldozer on Material Other Than Coal
OB Loading to trucks - excavator	0.0001	0.0001	0.0000	kg/tonne	AP-42 13.2.4 - Materials Handling Equation / NPI Mining Equation 10
OB Haulage - Unsealed	4.2926	1.2207	0.1221	kg/VKT	AP-42 13.2.2 - Unpaved Road Equation
OB Trucks unloading	0.0001	0.0001	0.0000	kg/tonne	AP-42 13.2.4 - Materials Handling Equation / NPI Mining Equation 10
OB Dump management - bulldozer	0.7946	0.1411	0.0834	kg/hour	AP-42 11.9 - Bulldozer on Material Other Than Coal
Truck Loading in Pit - raw material	0.0003	0.0001	0.0000	kg/tonne	AP-42 13.2.4 - Materials Handling Equation / NPI Mining Equation 10
Raw Material Haulage - Unsealed	4.29	1.22	0.12	kg/VKT	AP-42 13.2.2 - Unpaved Road Equation
Truck Unloading to Hopper	0.0003	0.0001	0.0000	kg/tonne	AP-42 13.2.4 - Materials Handling Equation / NPI Mining Equation 10
Raw material rehandle	0.0003	0.0001	0.0000	kg/tonne	AP-42 13.2.4 - Materials Handling Equation / NPI Mining Equation 10

<b>Table A2.2 Site specific emission factors</b>					
<b>Emission Source</b>	<b>TSP</b>	<b>PM<sub>10</sub></b>	<b>PM<sub>2.5</sub></b>	<b>Unit</b>	<b>Source of Factor</b>
Scalping Screen	0.0125	0.0043	0.0000	kg/tonne	USEPA AP-42 11.19.2 - Screening Factor
Screen 1	0.0125	0.0043	0.0000	kg/tonne	USEPA AP-42 11.19.2 - Screening Factor
Screen 2	0.0125	0.0043	0.0000	kg/tonne	USEPA AP-42 11.19.2 - Screening Factor
Screen 3	0.0125	0.0043	0.0000	kg/tonne	USEPA AP-42 11.19.2 - Screening Factor
Primary Crusher	0.0027	0.0012	0.0002	kg/tonne	USEPA AP-42 11.19.2 - Tertiary Crushing Factor
Secondary Crusher	0.0027	0.0012	0.0002	kg/tonne	USEPA AP-42 11.19.2 - Tertiary Crushing Factor
Tertiary Cone Crushers	0.0027	0.0012	0.0002	kg/tonne	USEPA AP-42 11.19.2 - Tertiary Crushing Factor
Tertiary Crusher	0.0027	0.0012	0.0002	kg/tonne	USEPA AP-42 11.19.2 - Tertiary Crushing Factor
Existing Plant 1 - Conveyor Transfer Points (3 Points)	0.0015	0.0006	0.0002	kg/tonne	USEPA AP-42 11.19.2 - Conveyor Transfer
Existing Plant 1 - Stockpile Loading	0.0015	0.0006	0.0002	kg/tonne	USEPA AP-42 11.19.2 - Conveyor Transfer
Plant 2 - Conveyor Transfer Points (8 points)	0.0015	0.0006	0.0002	kg/tonne	USEPA AP-42 11.19.2 - Conveyor Transfer
Plant 2 - Stockpile Loading	0.0015	0.0006	0.0002	kg/tonne	USEPA AP-42 11.19.2 - Conveyor Transfer
Upgraded Plant 1 - Conveyor Transfer Points (10 points)	0.0015	0.0006	0.0002	kg/tonne	USEPA AP-42 11.19.2 - Conveyor Transfer
Upgraded Plant 1 - Stockpile Loading	0.0015	0.0006	0.0002	kg/tonne	USEPA AP-42 11.19.2 - Conveyor Transfer
Loading to Product Trucks – Existing Plant 1	0.0002	0.0001	0.0000	kg/tonne	AP-42 13.2.4 - Materials Handling Equation / NPI Mining Equation 10
Loading to Product Trucks - Plant 2	0.0002	0.0001	0.0000	kg/tonne	AP-42 13.2.4 - Materials Handling Equation / NPI Mining Equation 10
Loading to Product Trucks - Upgraded Plant 1	0.0002	0.0001	0.0000	kg/tonne	AP-42 13.2.4 - Materials Handling Equation / NPI Mining Equation 10
Unpaved - Product Transportation – Existing Plant 1	3.17	0.87	0.09	kg/VKT	AP-42 13.2.2 - Unpaved Road Equation
Unpaved - Product Transportation - Plant 2	3.17	0.87	0.09	kg/VKT	AP-42 13.2.2 - Unpaved Road Equation
Unpaved - Product Transportation - Upgraded Plant 1	3.17	0.87	0.09	kg/VKT	AP-42 13.2.2 - Unpaved Road Equation

<b>Table A2.2 Site specific emission factors</b>					
<b>Emission Source</b>	<b>TSP</b>	<b>PM<sub>10</sub></b>	<b>PM<sub>2.5</sub></b>	<b>Unit</b>	<b>Source of Factor</b>
Paved - Product Transportation	0.05	0.01	0.00	kg/VKT	AP-42 13.2.1 - Paved Road Equation
Brayton Road - Product Transportation	0.05	0.01	0.00	kg/VKT	AP-42 13.2.1 - Paved Road Equation
Drill	0.59	0.31	0.05	kg/hole	AP-42 11.9 - Drilling factor
Blast	1.14	0.59	0.09	kg/blast	AP-42 11.9 - Blasting Equation
Wind Erosion - Exposed surfaces and stockpiles	850.0	425.0	63.8	kg/ha/y	AP-42 11.9 - Wind erosion of exposed areas factor

**Table A2.4 Activity rates**

Process	Unit	Activity rate			
		Existing	Sc2	Sc3	Sc4
Overburden removal - bulldozer	Hours/year	1,963	1,963	1,963	1,963
OB loading to trucks - excavator	Tonnes/year	225,000	900,000	990,000	75,000
OB haulage - unsealed	Annual VKT	4500	32400	43560	3600
OB trucks unloading	Tonnes/year	225,000	900,000	990,000	75,000
OB dump management - bulldozer	Hours/year	1,963	1,963	1,963	1,963
Truck loading in pit - raw material	Tonnes/year	750,000	1,000,000	1,500,000	2,000,000
Raw material haulage - unsealed	Annual VKT	21,000	28,000	72,000	120,000
Truck unloading to hopper	Tonnes/year	750,000	1,000,000	1,500,000	2,000,000
Raw material rehandle	Tonnes/year	37,500	50,000	75,000	100,000
Scalping screen	Tonnes/year	750,000	1,000,000	1,500,000	2,000,000
Screen 1	Tonnes/year	750,000	1,000,000	1,500,000	2,000,000
Screen 2	Tonnes/year	585,000	260,000	390,000	520,000
Screen 3	Tonnes/year	585,000	520,000	780,000	1,040,000
Primary crusher	Tonnes/year	750,000	1,000,000	1,500,000	2,000,000
Secondary crusher	Tonnes/year	585,000	260,000	390,000	520,000
Tertiary cone crushers	Tonnes/year	585,000	520,000	780,000	1,040,000
Tertiary crusher	Tonnes/year	585,000	520,000	780,000	1,040,000
Existing Plant 1 - conveyor transfer points (3 points)	Tonnes/year	2,250,000	3,000,000	4,500,000	6,000,000
Existing Plant 1 - stockpile loading	Tonnes/year	165,000	220,000	330,000	440,000
Plant 2 - conveyor transfer points (8 points)	Tonnes/year	4,680,000	2,080,000	3,120,000	4,160,000
Plant 2 - stockpile loading	Tonnes/year	585,000	260,000	390,000	520,000
Upgraded Plant 1 - conveyor transfer points (10 points)	Tonnes/year	0	5,200,000	7,800,000	10,400,000
Upgraded Plant 1 - stockpile loading	Tonnes/year	0	520,000	780,000	1,040,000
Loading to product trucks - Existing Plant 1	Tonnes/year	165,000	220,000	330,000	440,000
Loading to product trucks - Plant 2	Tonnes/year	585,000	260,000	390,000	520,000
Loading to product trucks - Upgraded Plant 1	Tonnes/year	0	520,000	780,000	1,040,000
Unpaved - product transportation - Existing Plant 1 to weighbridge	Annual VKT	5,448	7,308	10,896	14,617
Unpaved - product transportation - Plant 2 to weighbridge	Annual VKT	23,179	8,637	12,877	17,274
Unpaved - product transportation - Upgraded Plant 1 to weighbridge	Annual VKT	0	20,729	30,905	41,459

Process	Unit	Activity rate			
		Existing	Sc2	Sc3	Sc4
Paved - product transportation – weighbridge to site entry	Annual VKT	74,292	99,660	148,584	199,320
Brayton Road - product transportation	Annual VKT	396,224	531,520	792,448	1,063,040
Drill	Holes/blast	110	150	180	150
Blast	Blasts/year	26	26	26	52
Wind Erosion - exposed surfaces and stockpiles	Area (ha)	26	67.6	81	81
Diesel combustion	Litres/year	950,000	1,600,000	2,250,000	2,900,000
Blast area	m <sup>2</sup>	300	400	900	700
Average vehicle mass (haul trucks)	tonnes	46.3	46.3	46.3	46.3
Average vehicle mass (product truck)	tonnes	31.5	21.5	21.5	31.5

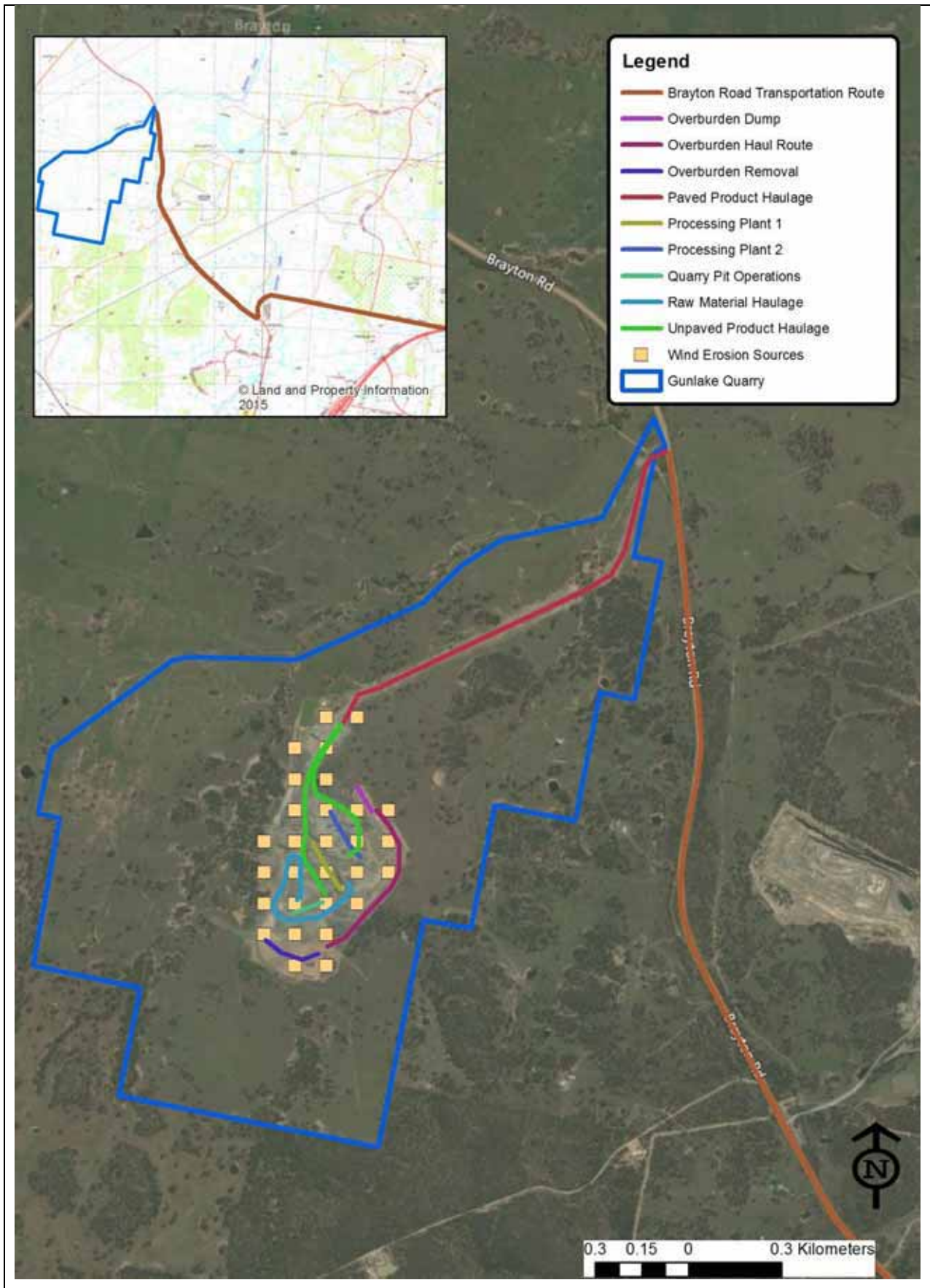


Figure A2-1: Scenario 1 Model Emission Source Locations

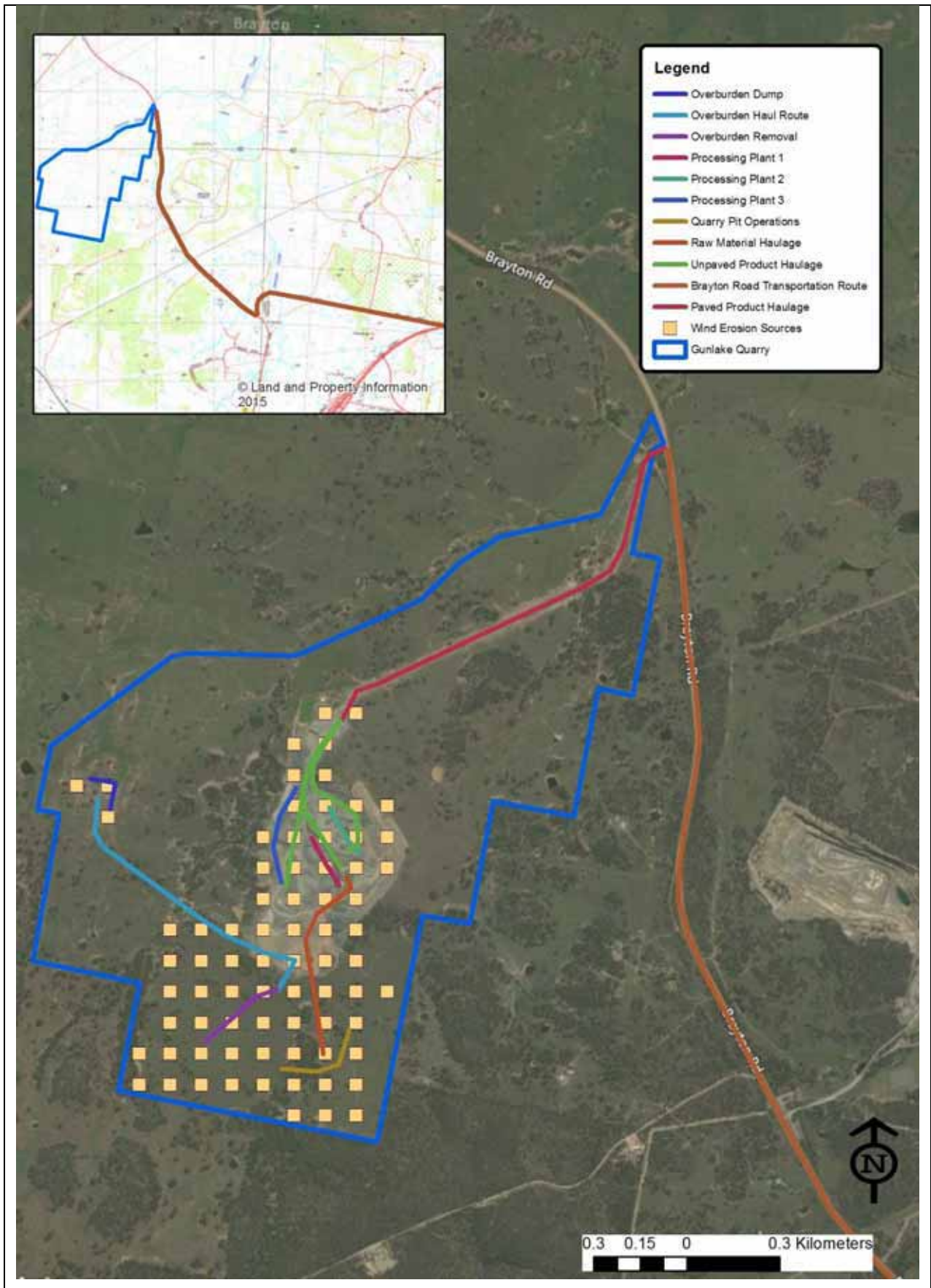


Figure A2-2: Scenario 2 Model Emission Source Locations

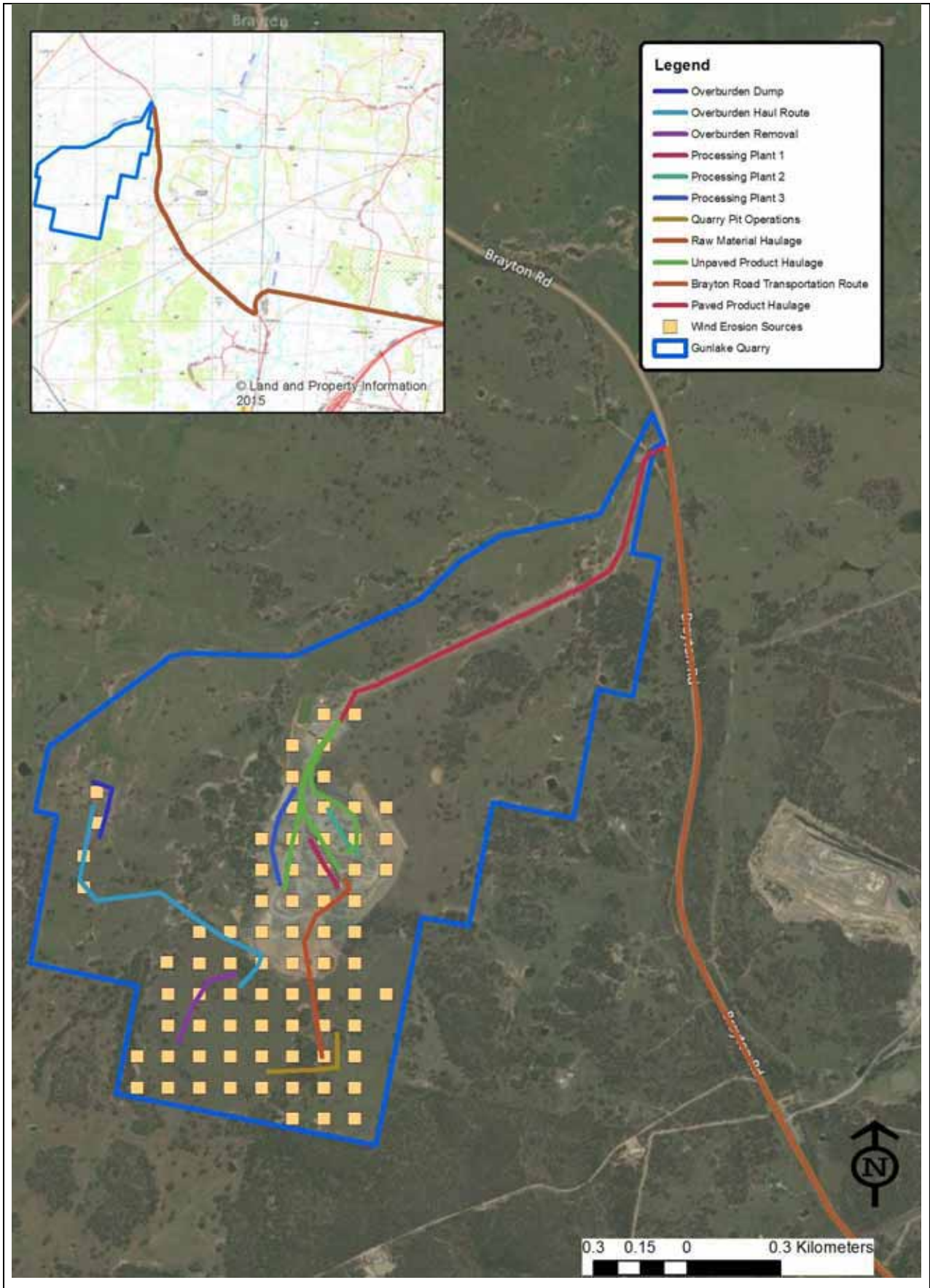


Figure A2-3: Scenario 3 Model Emission Source Locations

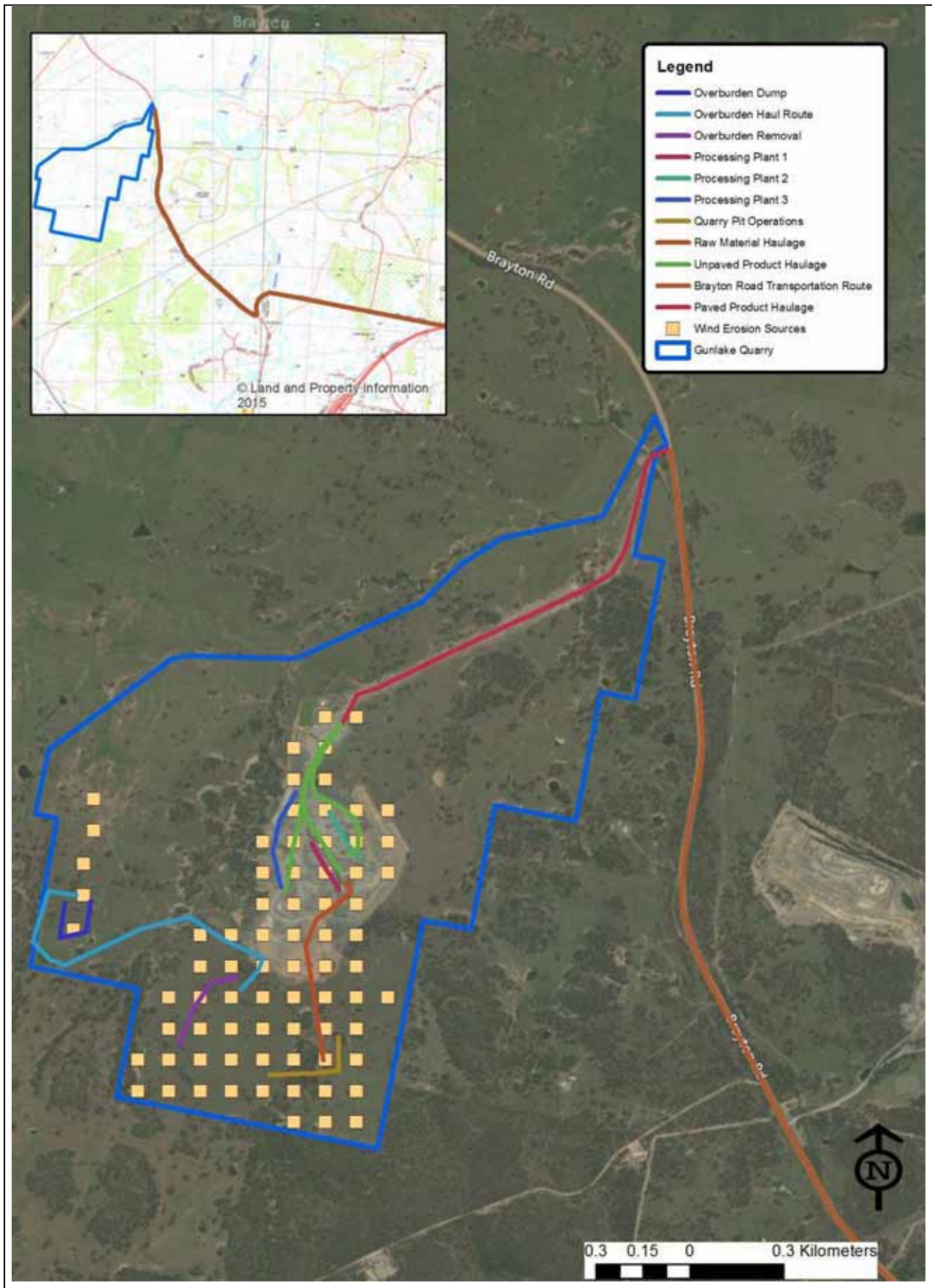


Figure A2-4: Scenario 4 Model Emission Source Locations

## **APPENDIX 3 CONTOUR PLOTS FOR INCREMENTAL MODELLING RESULTS**

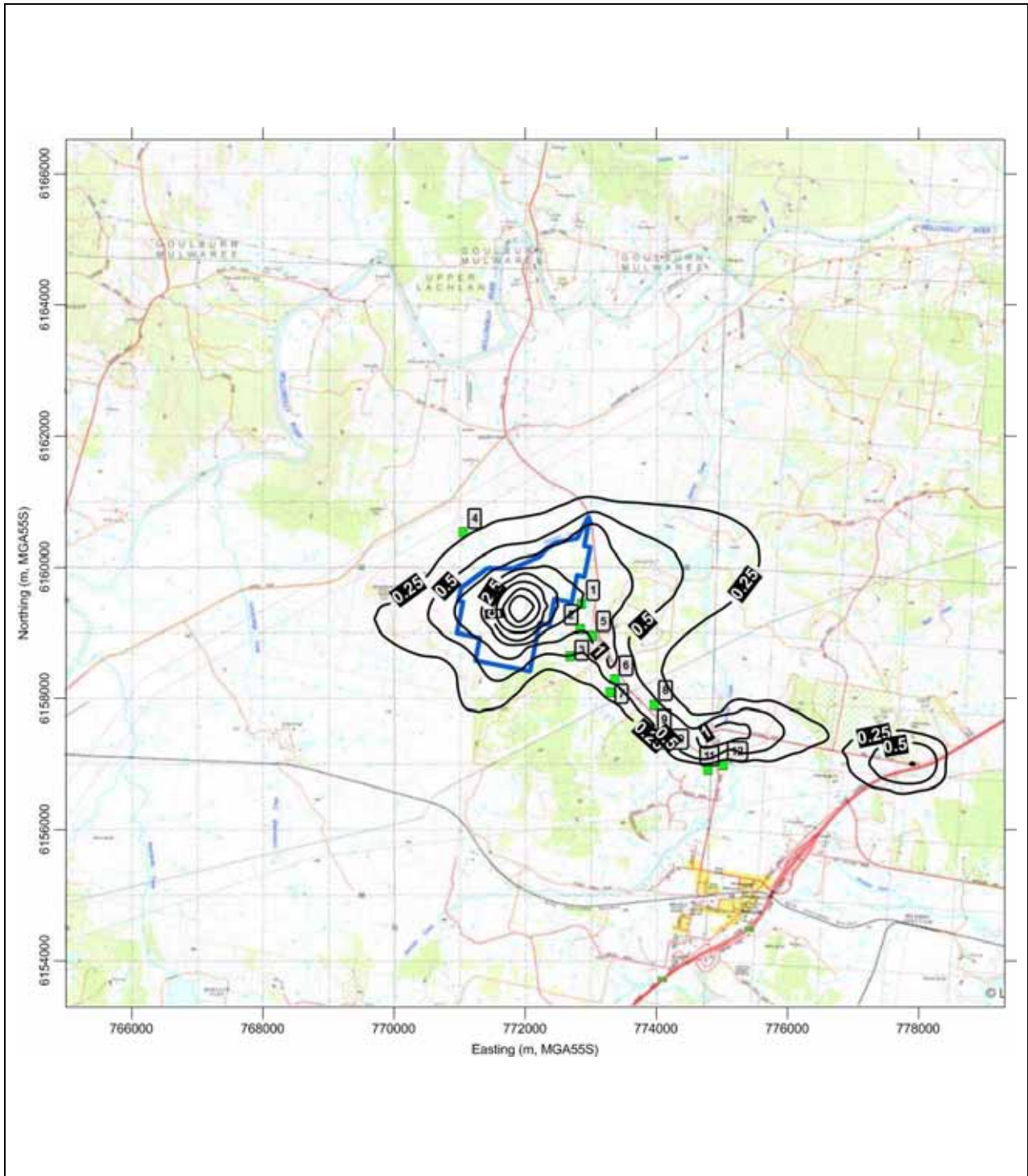
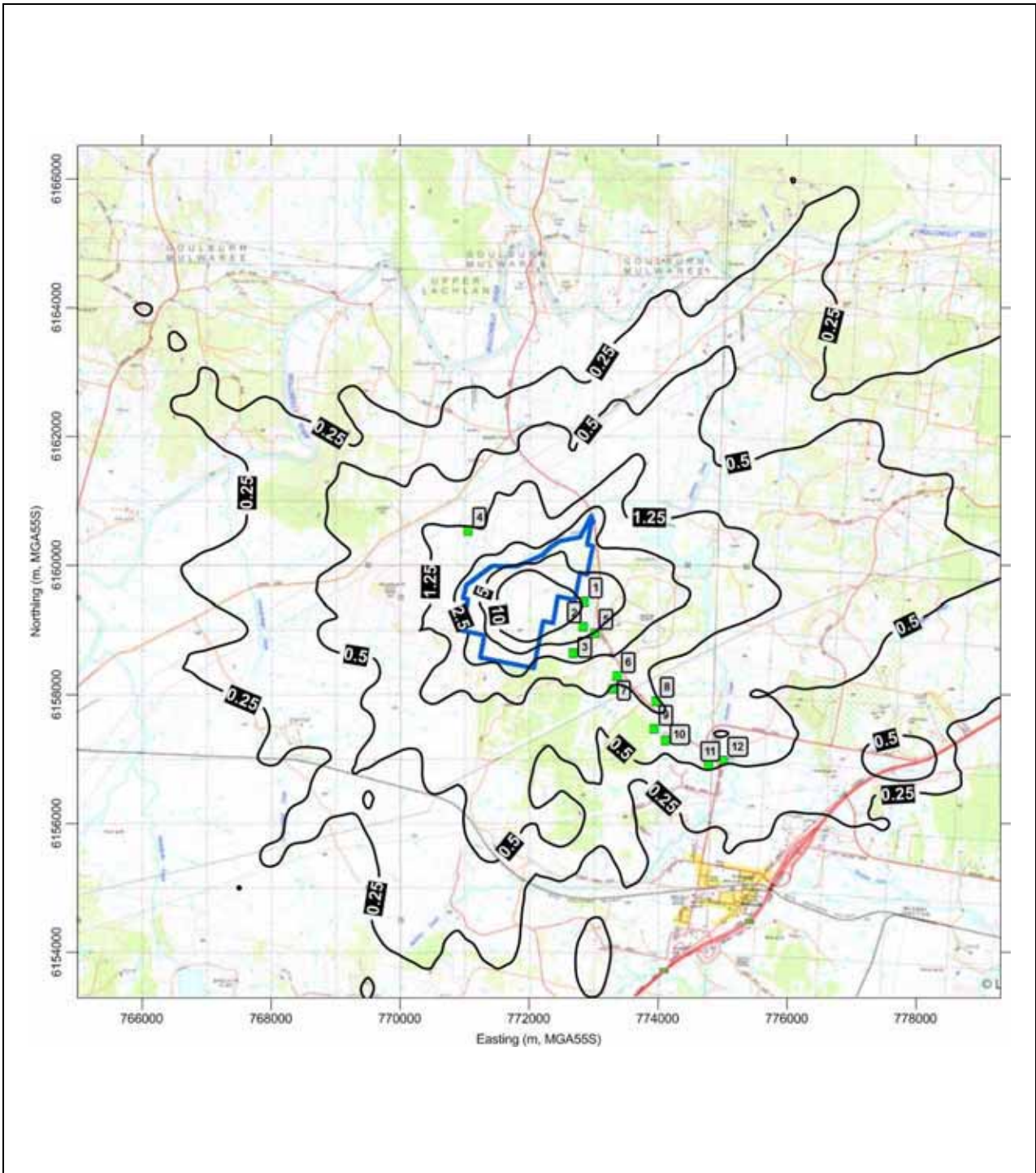


Figure A3-1: Predicted annual average TSP concentrations (µg/m³) – Gunlake Quarry Only – Scenario 1



**Figure A3-2: Predicted maximum 24-hour average PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 1**

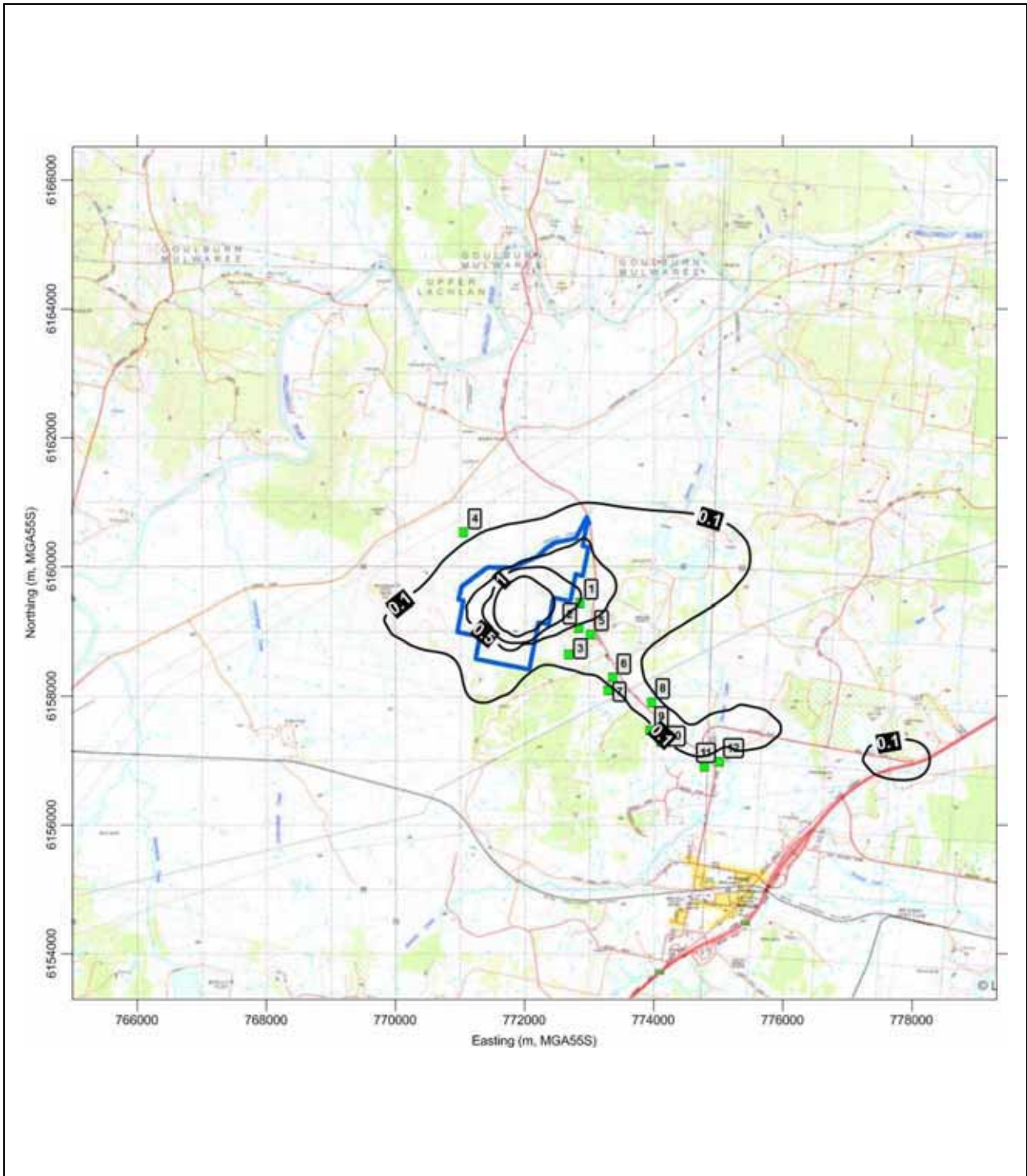
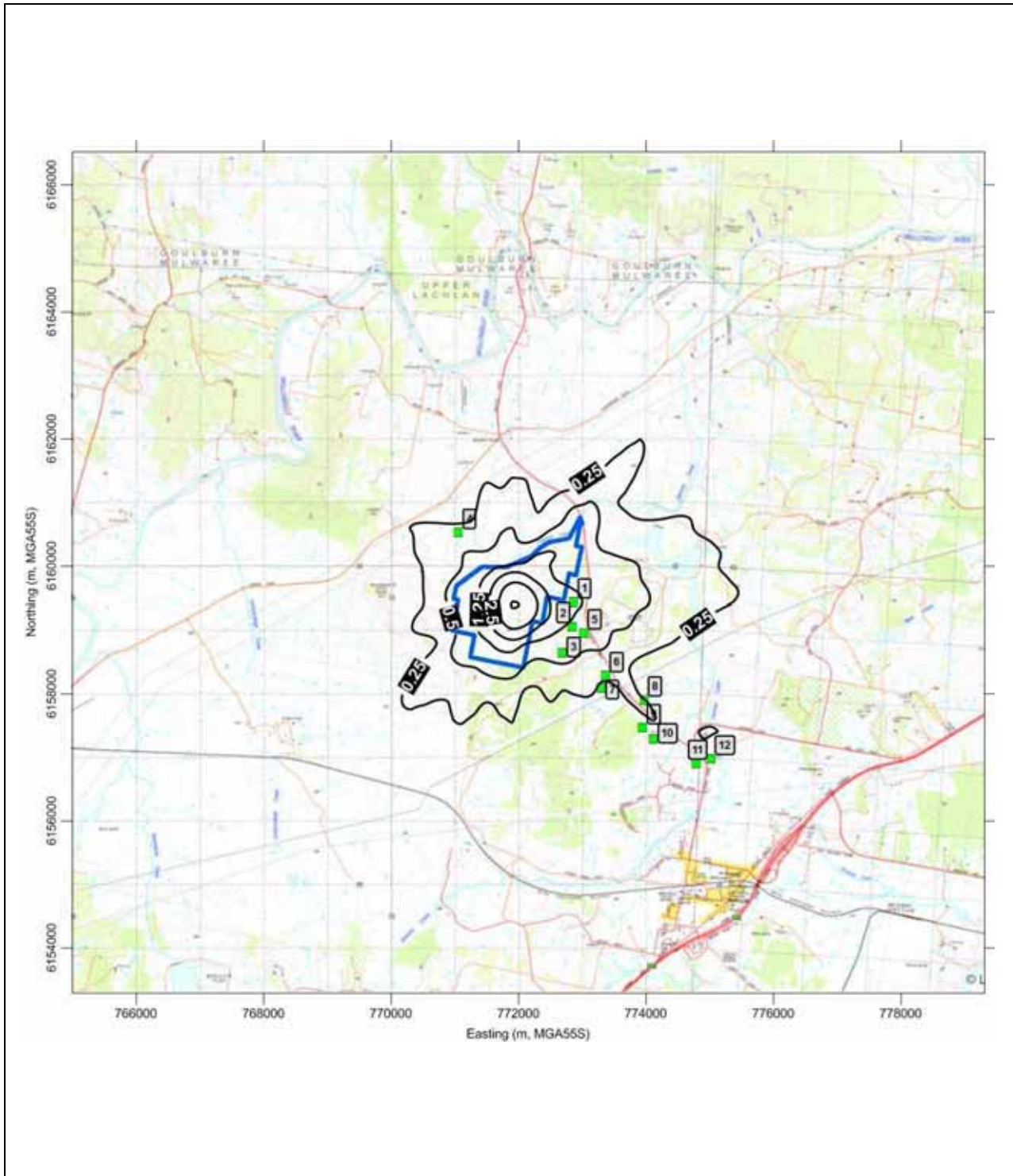


Figure A3-3: Annual average PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 1



**Figure A3-4: Predicted maximum 24-hour average PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 1**

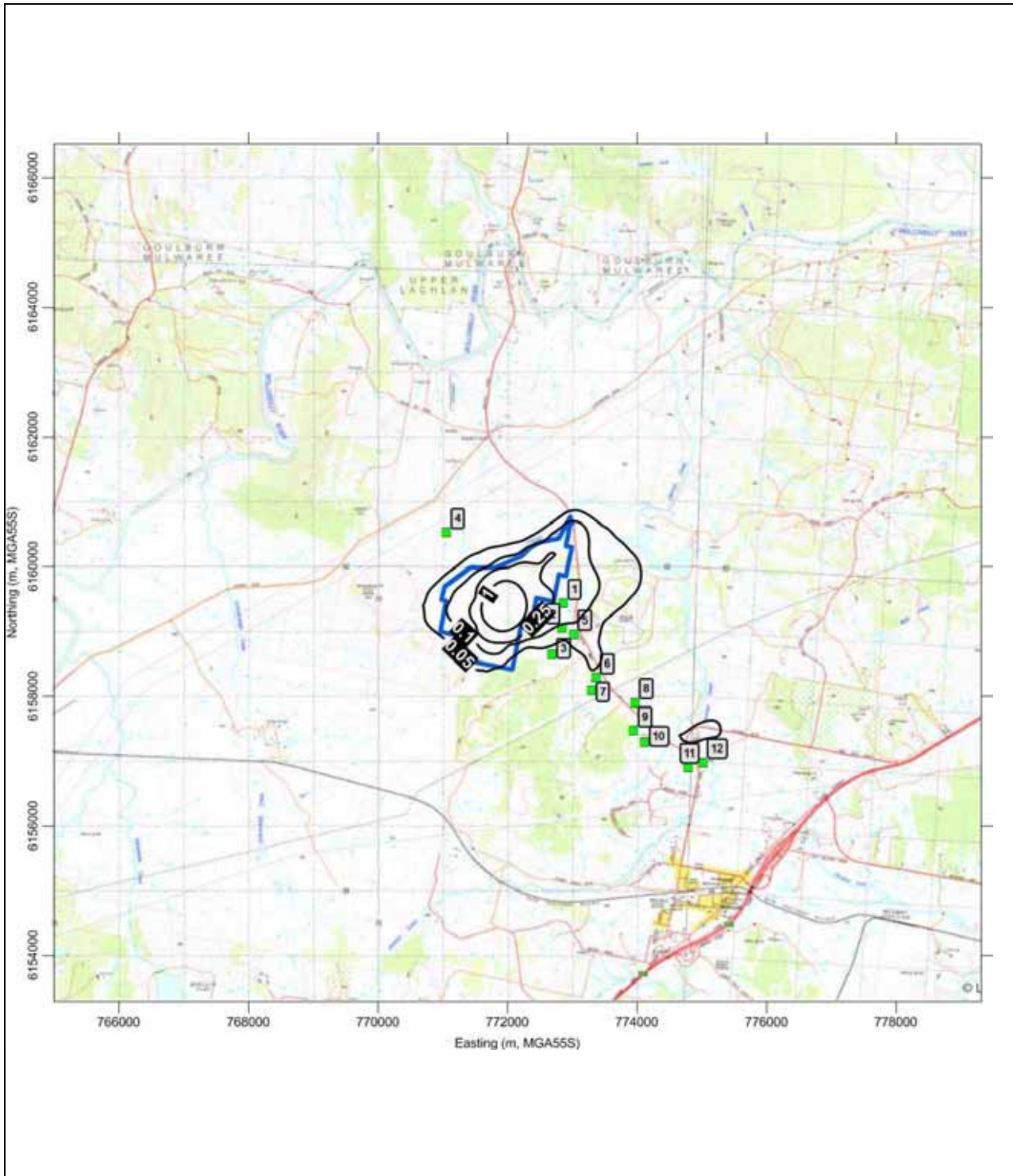


Figure A3-5: Annual average PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 1

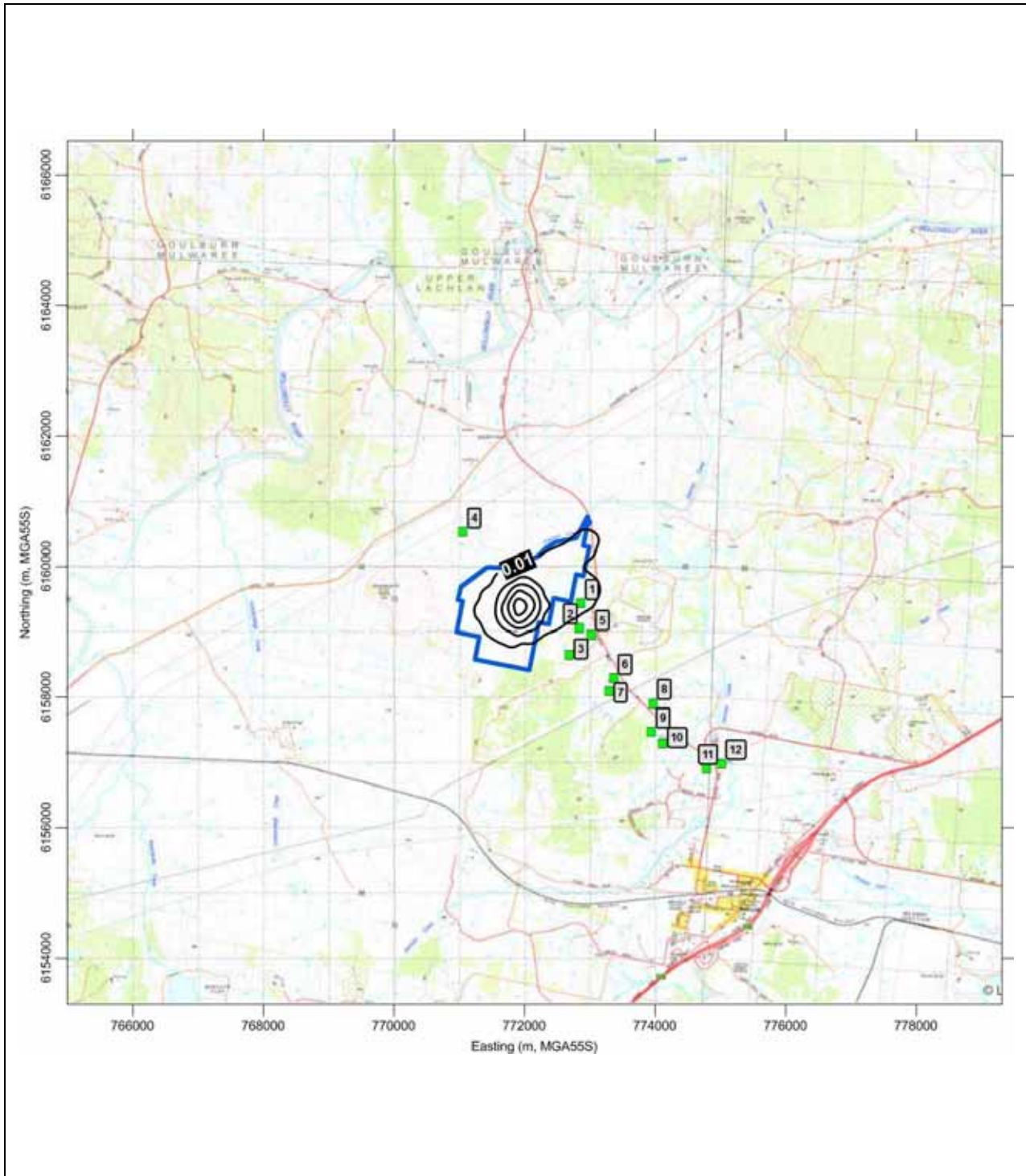


Figure A3-6: Annual average RCS concentrations ( $\mu\text{g}/\text{m}^3$ ) – Gunlake Quarry Only – Scenario 1

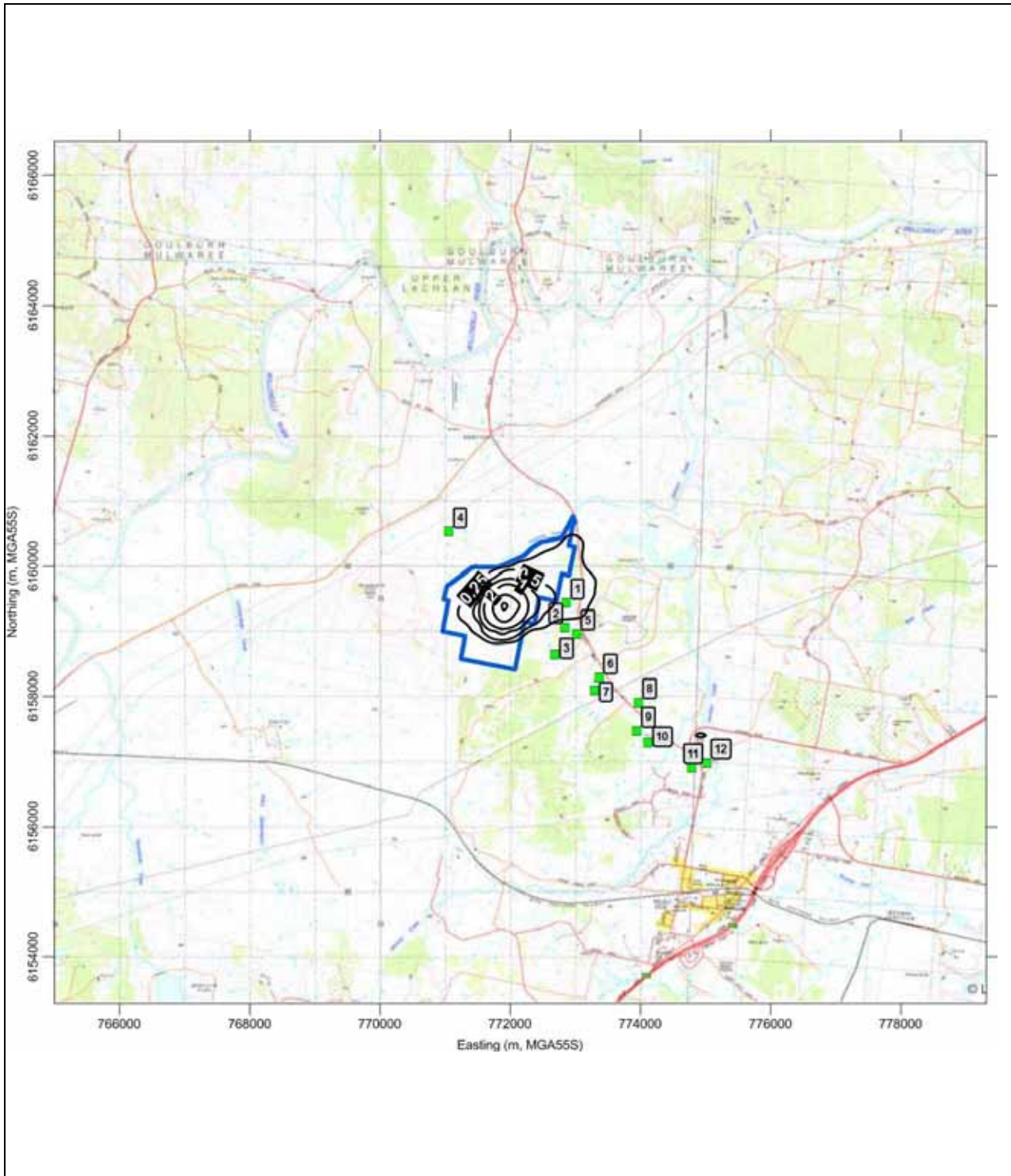


Figure A3-7: Annual average dust deposition levels (g/m<sup>2</sup>/month) – Gunlake Quarry Only – Scenario 1

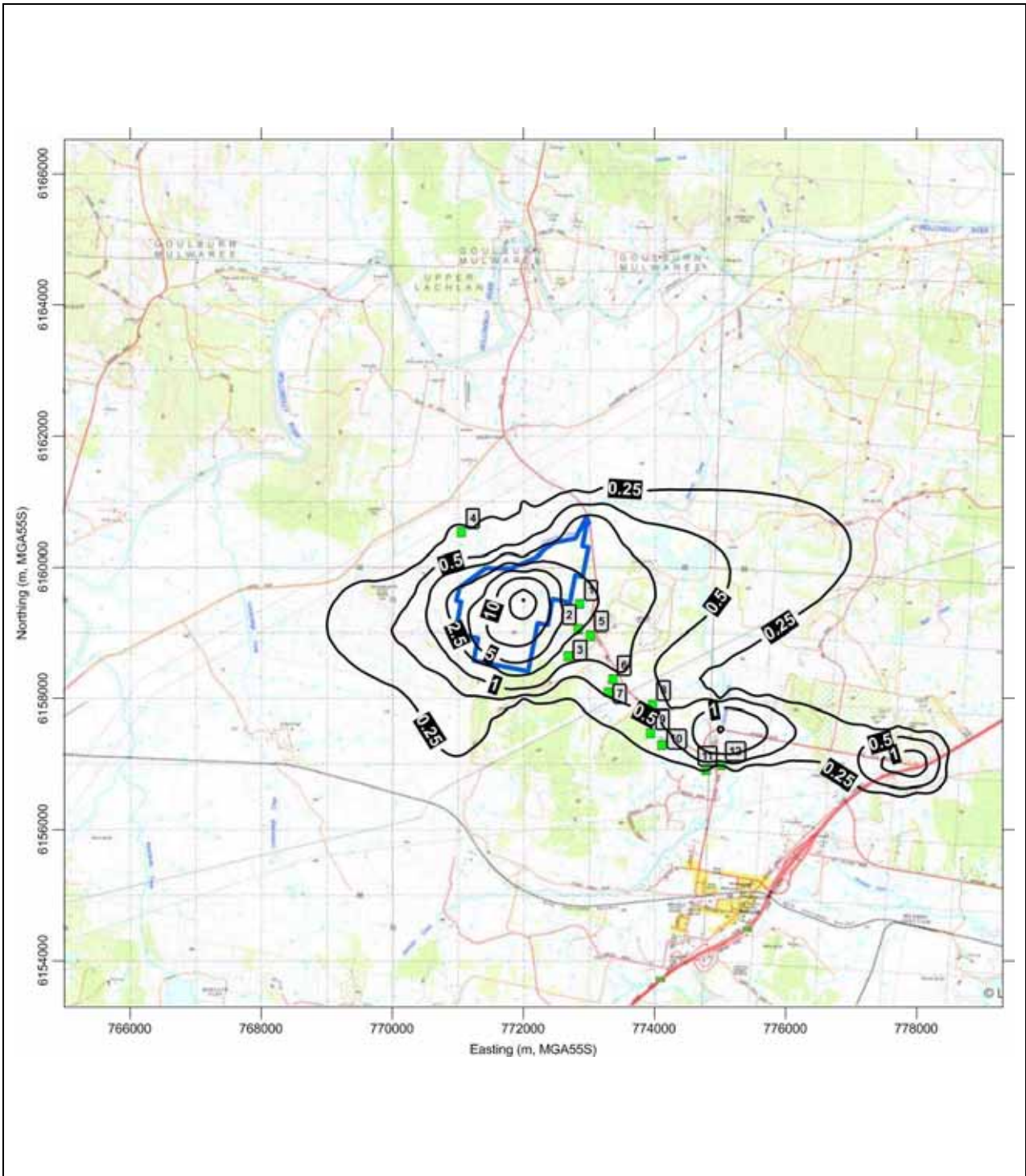
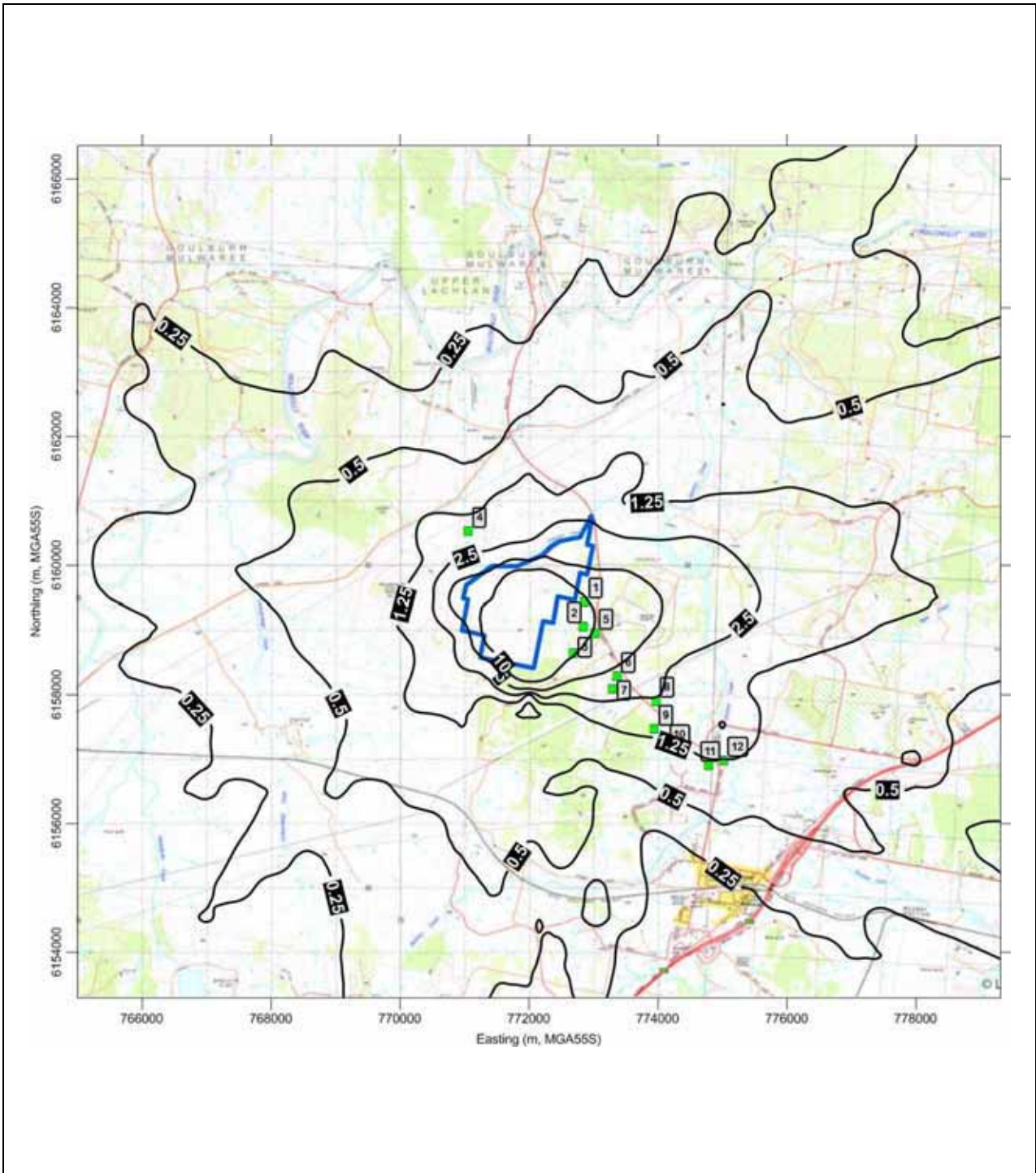


Figure A3-8: Predicted annual average TSP concentrations ( $\mu\text{g}/\text{m}^3$ ) – Gunlake Quarry Only – Scenario 2



**Figure A3-9: Predicted maximum 24-hour average PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 2**

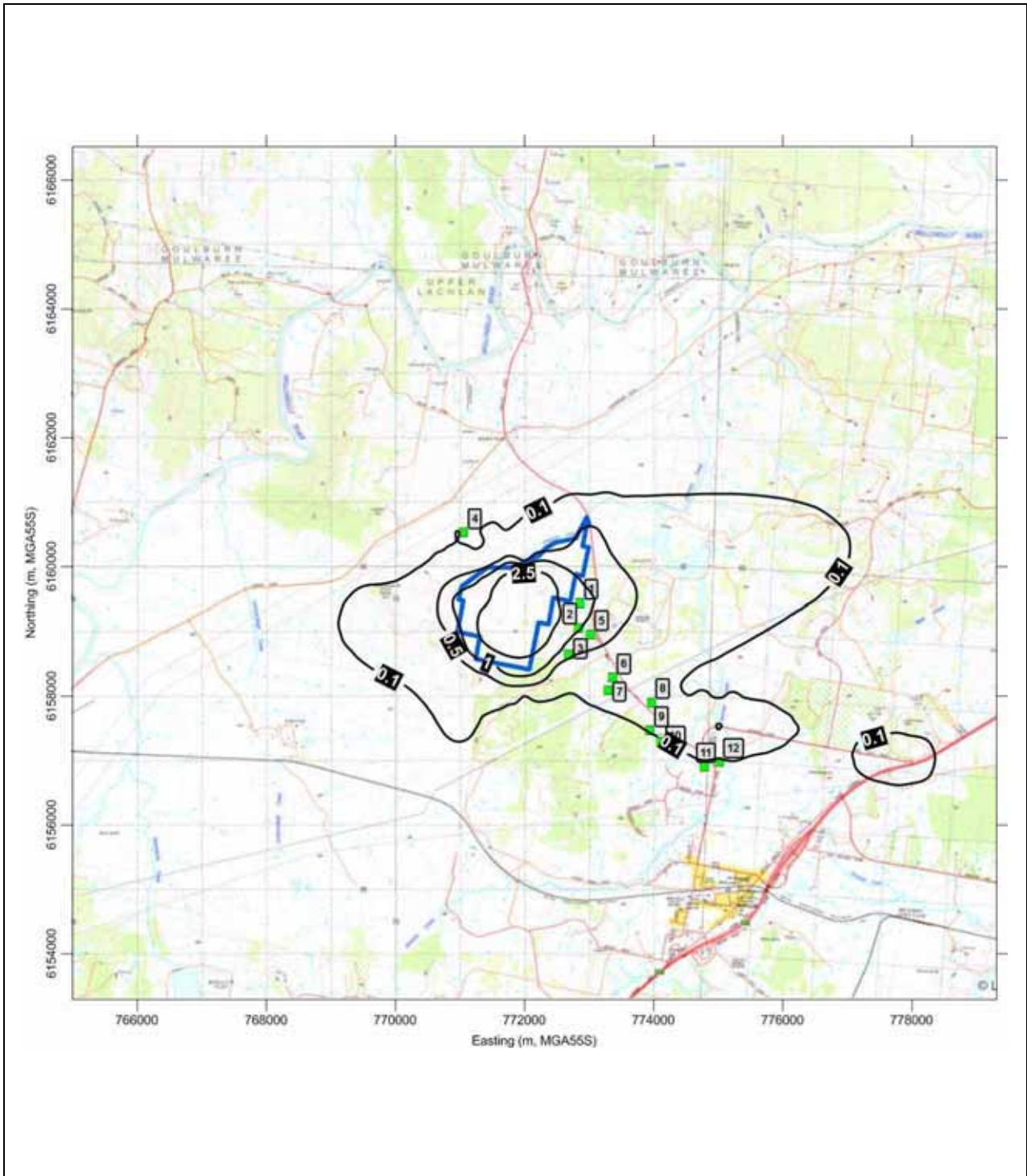


Figure A3-10: Annual average PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 2

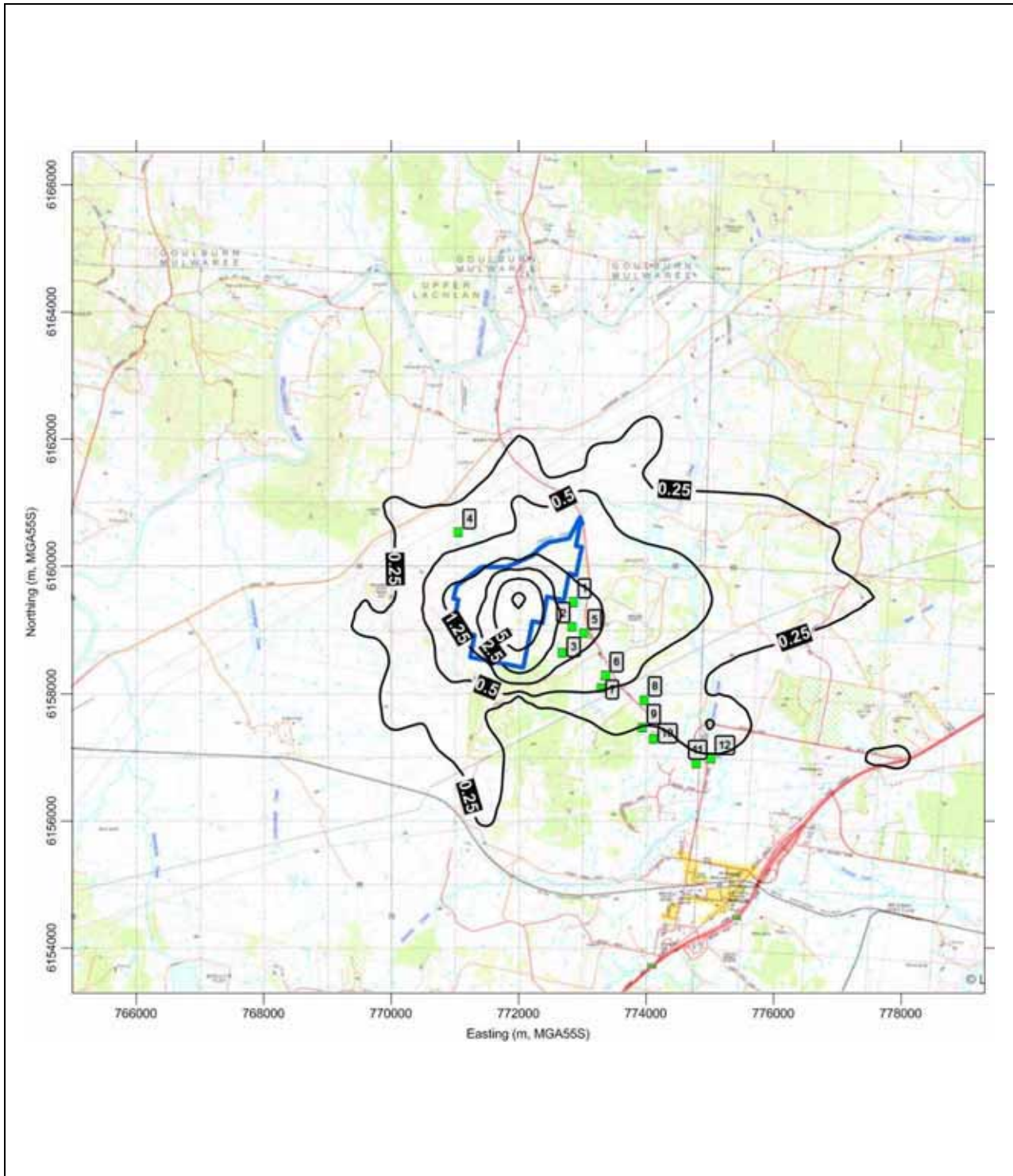


Figure A3-11: Predicted maximum 24-hour average PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 2

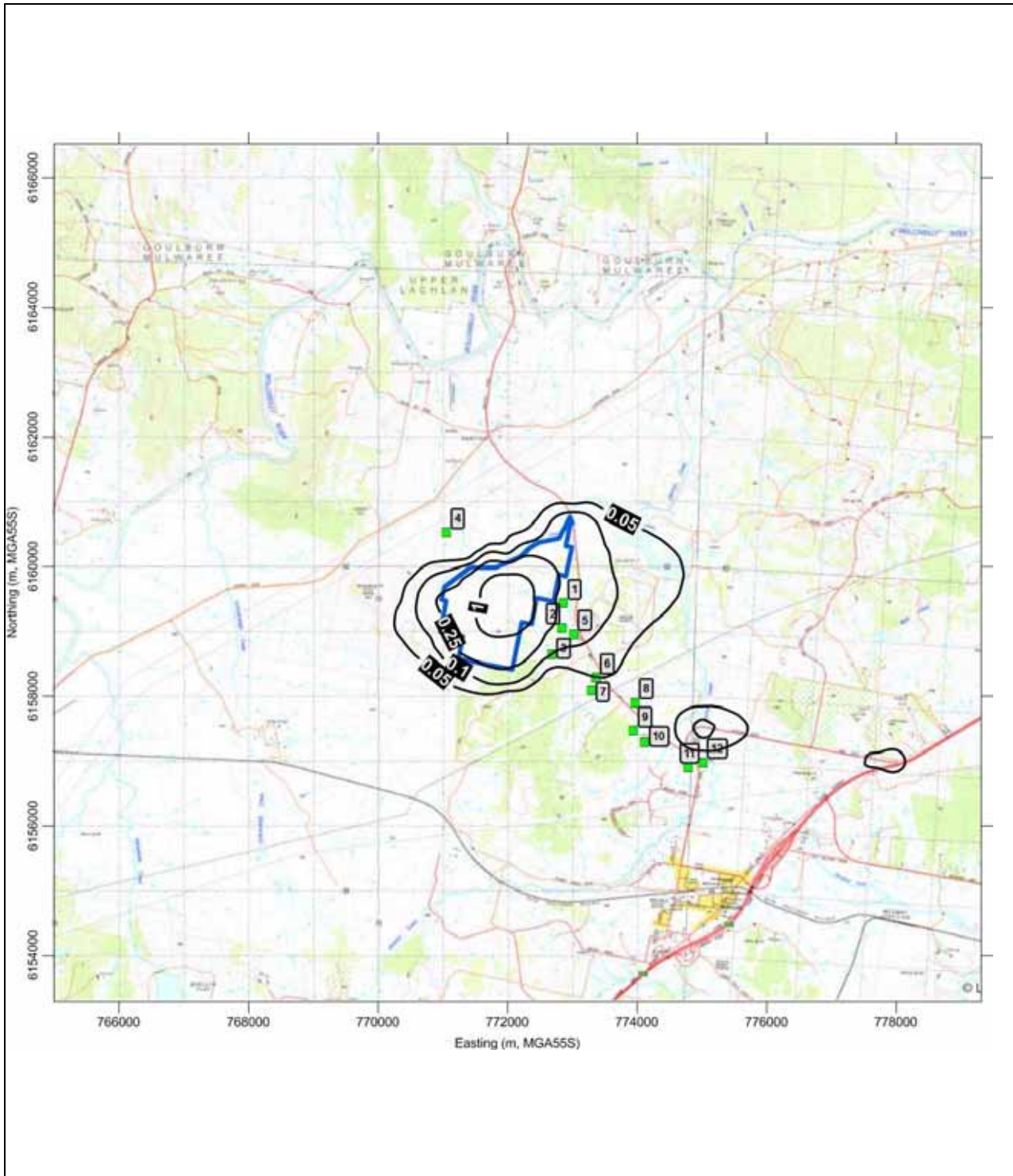


Figure A3-12: Annual average PM<sub>2.5</sub> concentrations ( $\mu\text{g}/\text{m}^3$ ) – Gunlake Quarry Only – Scenario 2

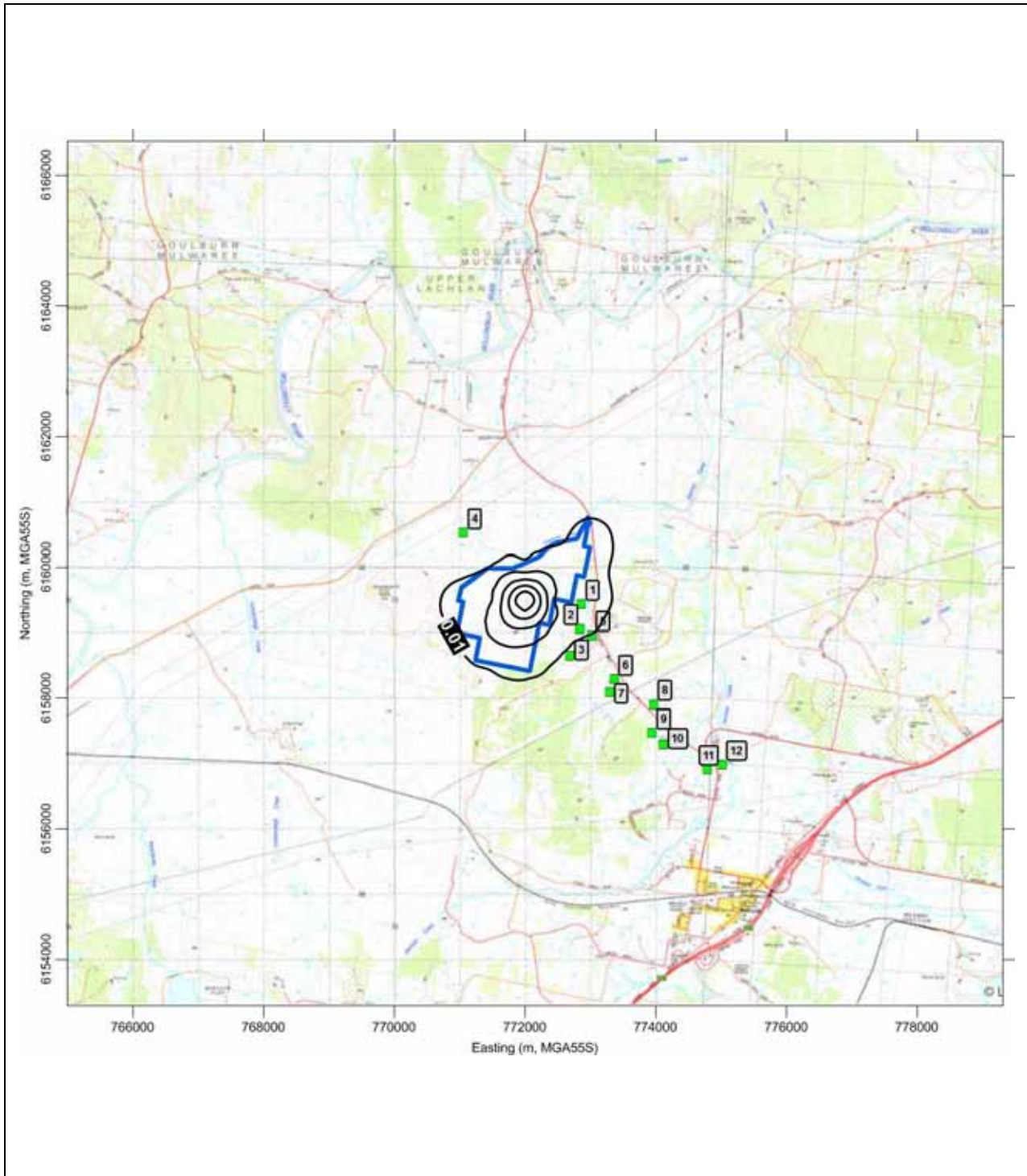


Figure A3-13: Annual average RCS concentrations (µg/m³) – Gunlake Quarry Only – Scenario 2

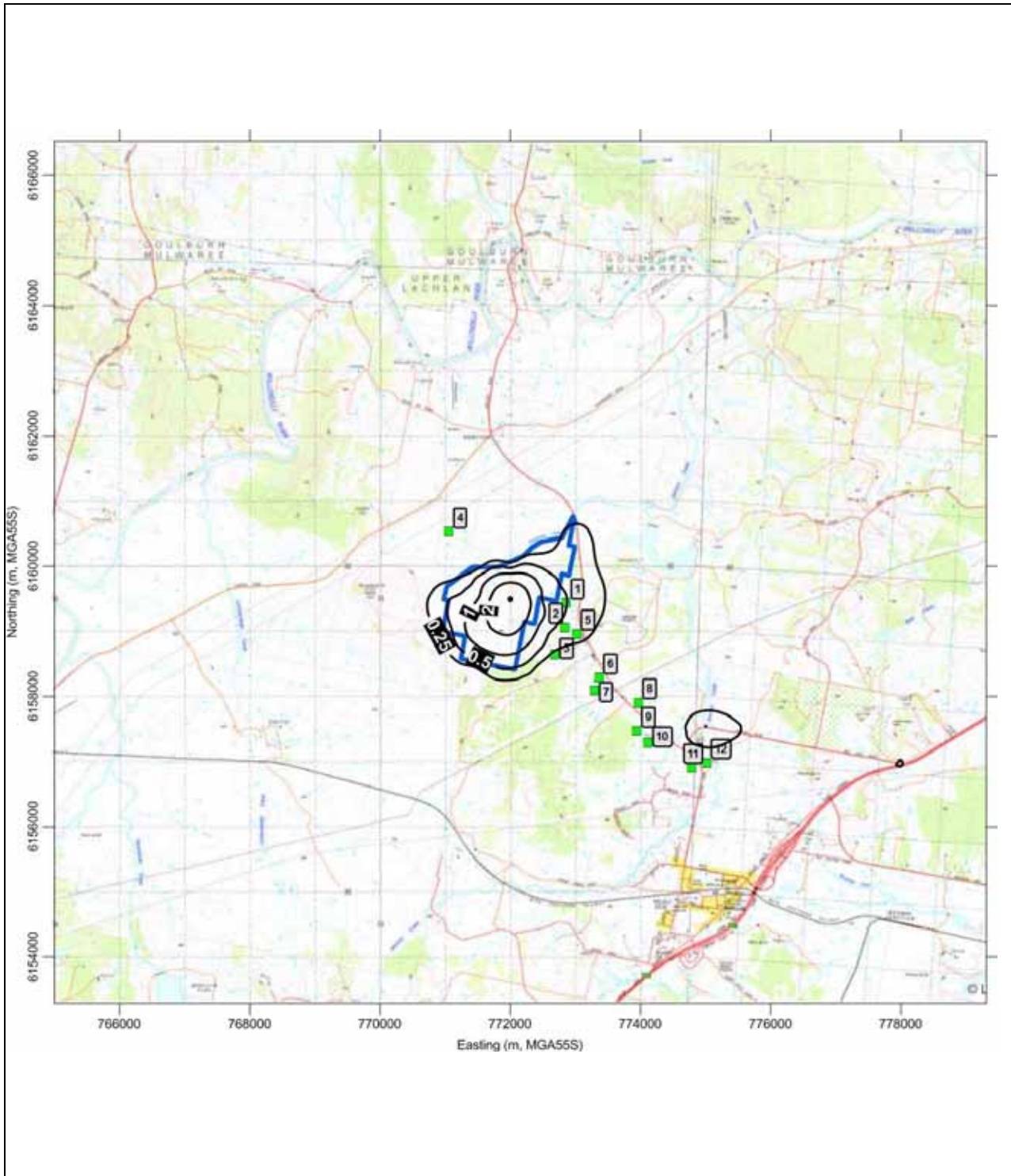


Figure A3-14: Annual average dust deposition levels (g/m<sup>2</sup>/month) – Gunlake Quarry Only – Scenario 2

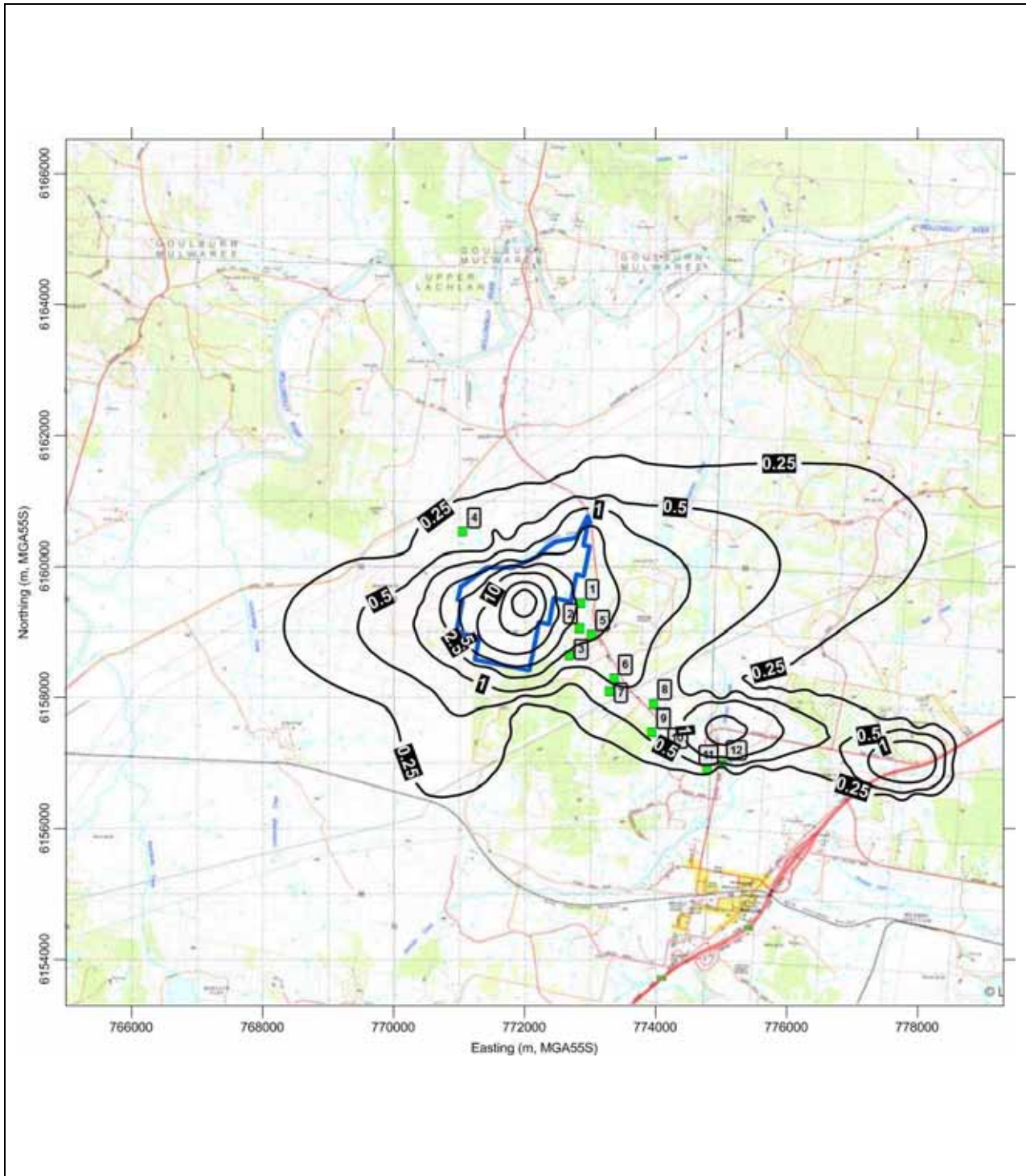
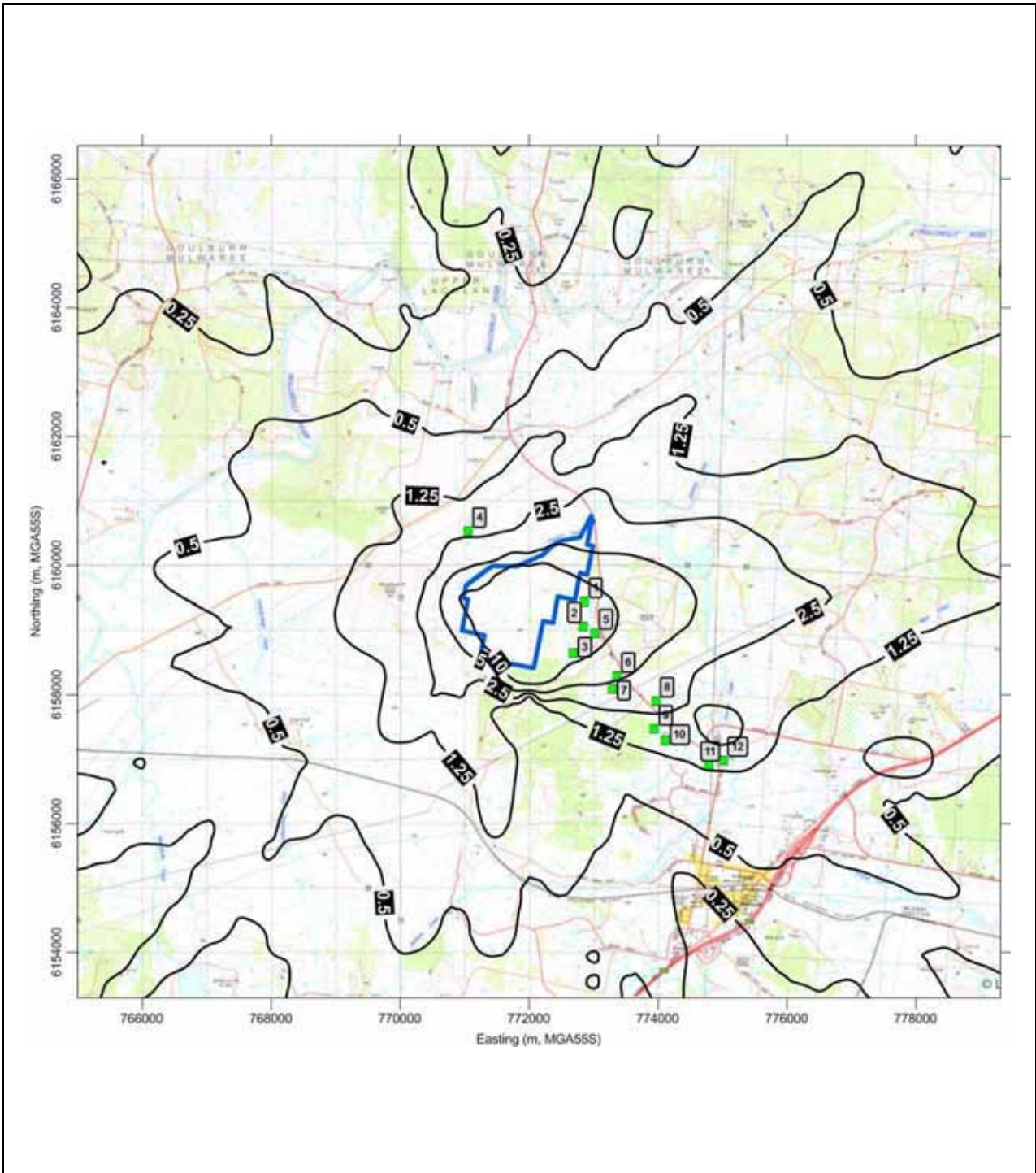


Figure A3-15: Predicted annual average TSP concentrations ( $\mu\text{g}/\text{m}^3$ ) – Gunlake Quarry Only – Scenario 3



**Figure A3-16: Predicted maximum 24-hour average PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 3**

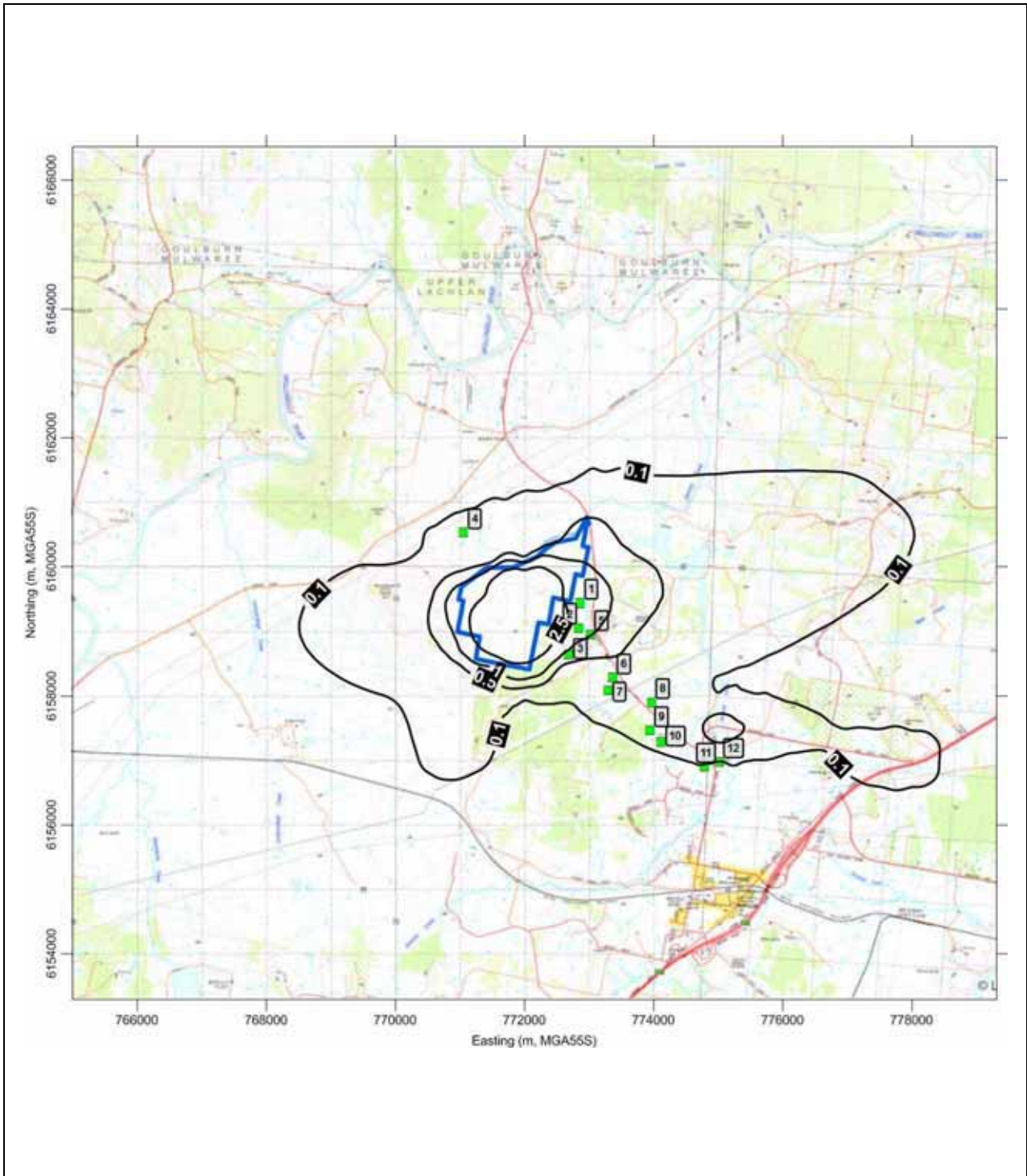


Figure A3-17: Annual average PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 3

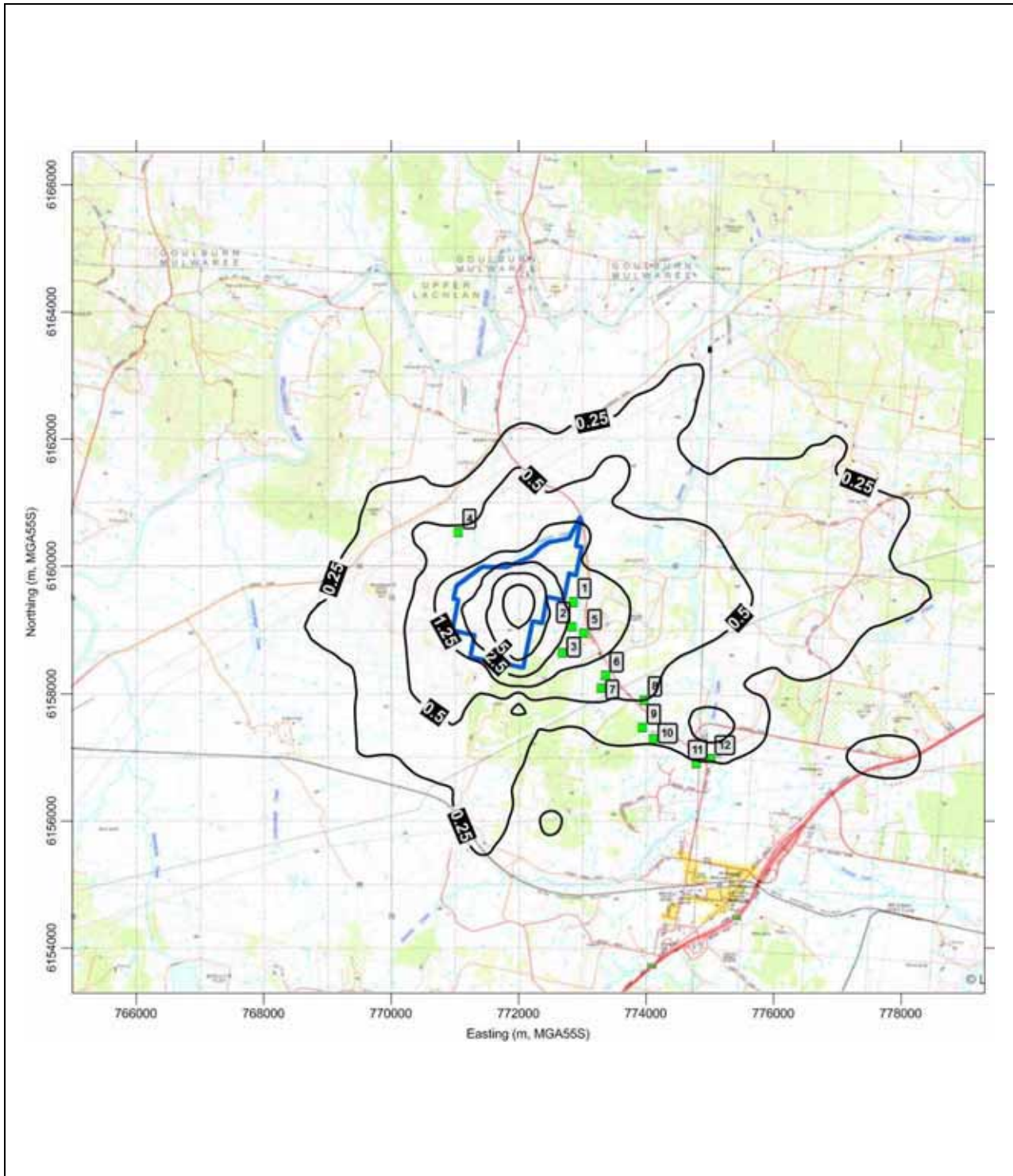


Figure A3-18: Predicted maximum 24-hour average PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 3

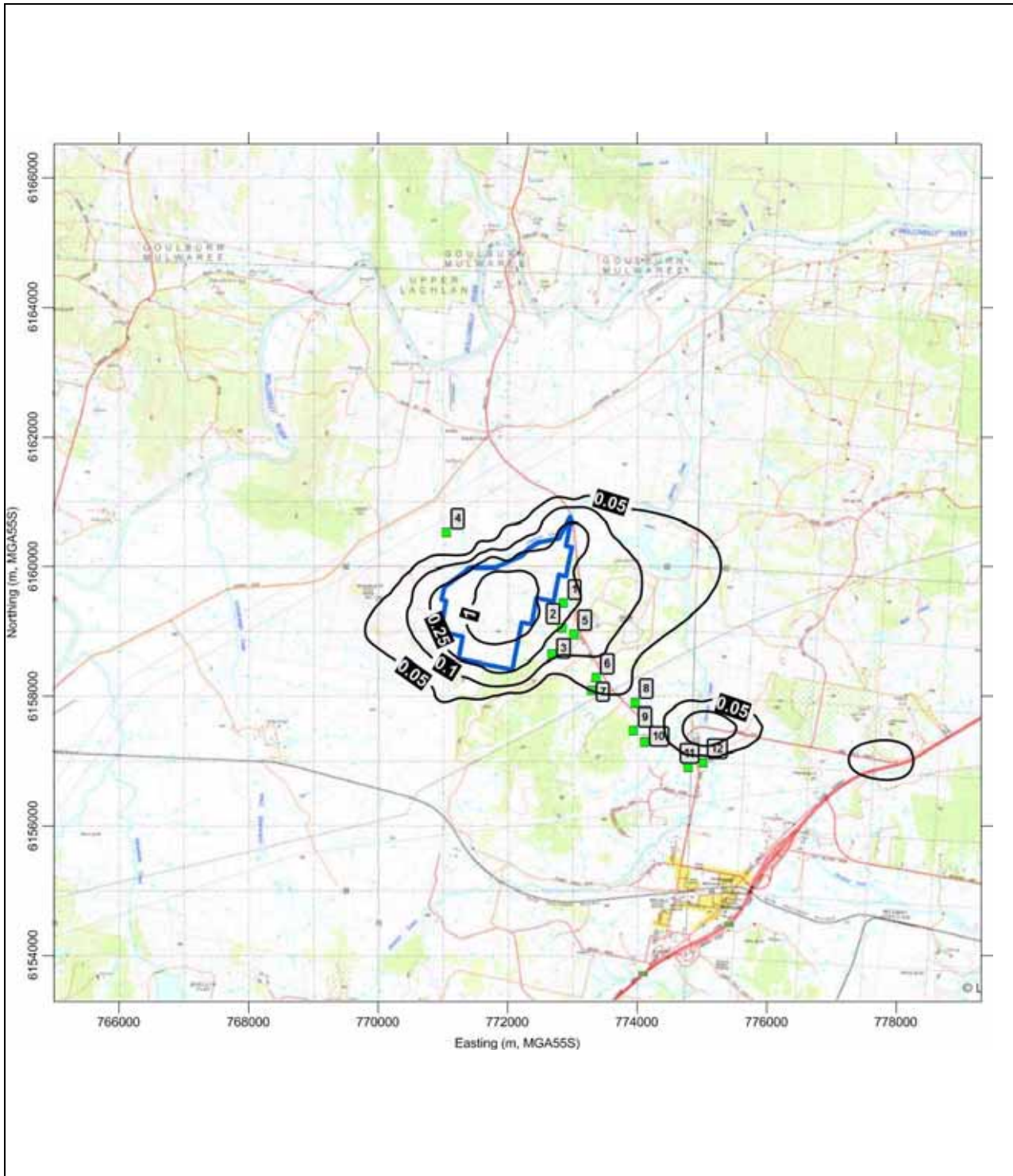


Figure A3-19: Annual average PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 3

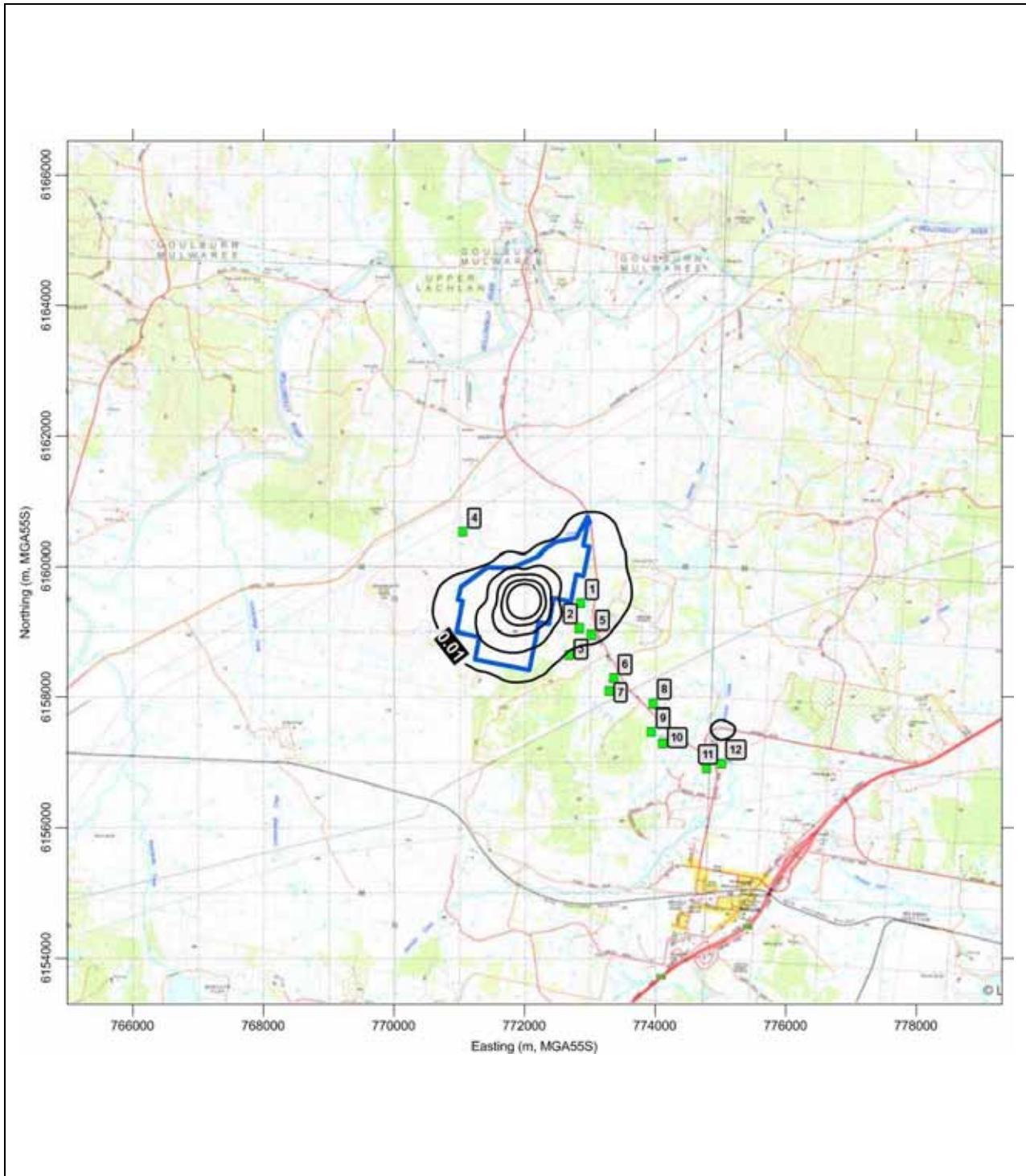


Figure A3-20: Annual average RCS concentrations ( $\mu\text{g}/\text{m}^3$ ) – Gunlake Quarry Only – Scenario 3

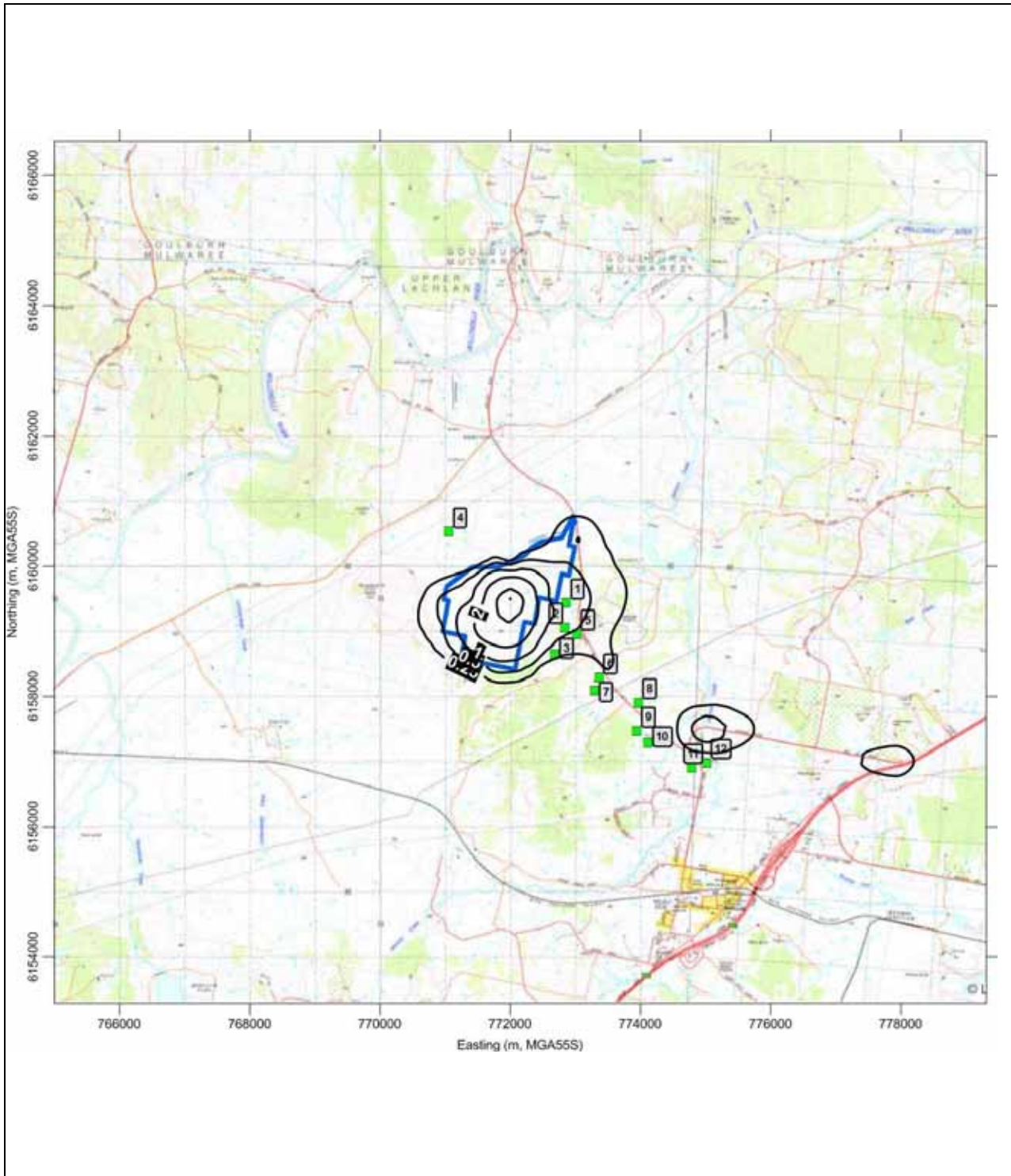


Figure A3-21: Annual average dust deposition levels (g/m<sup>2</sup>/month) – Gunlake Quarry Only – Scenario 3

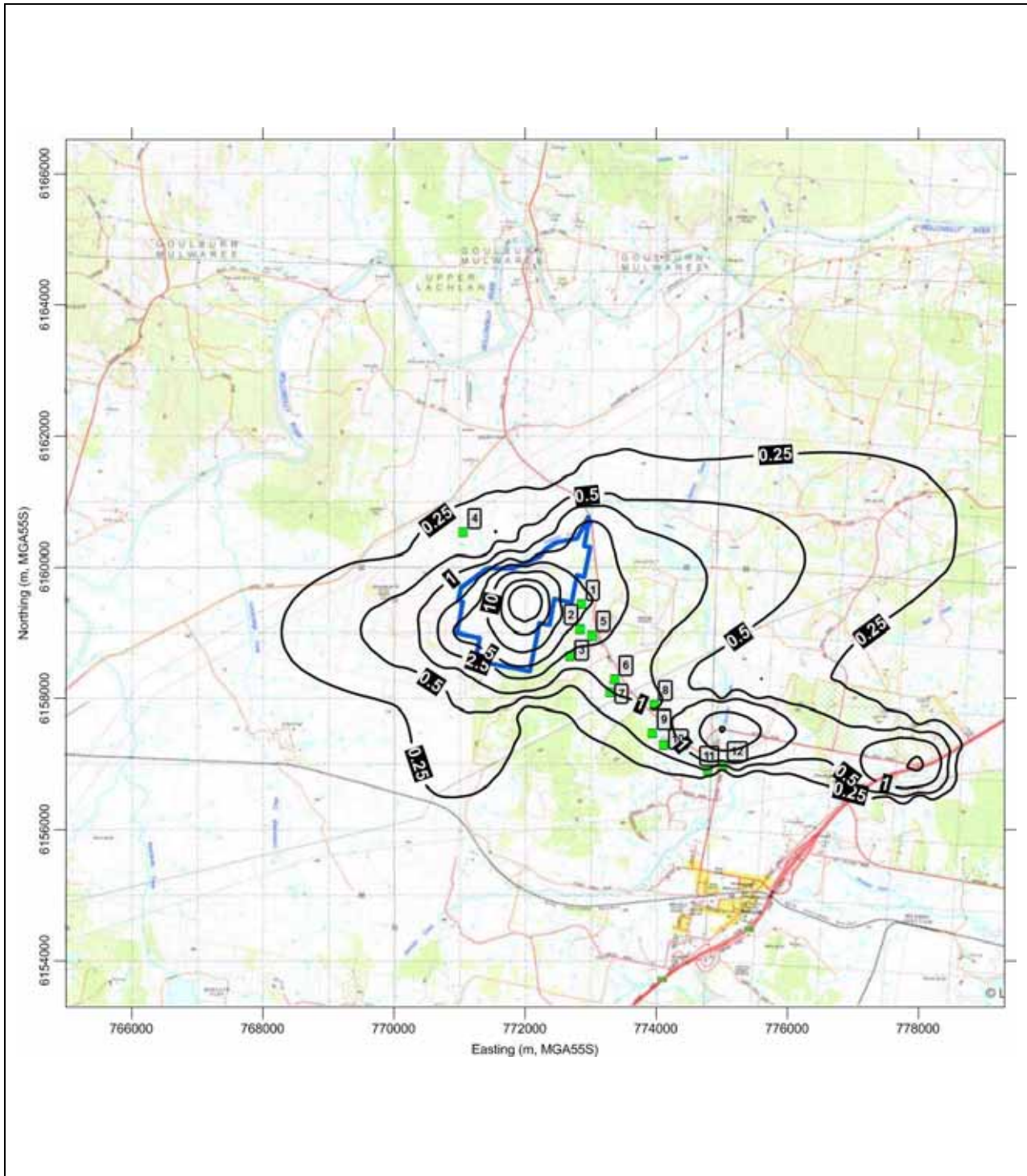


Figure A3-22: Predicted annual average TSP concentrations ( $\mu\text{g}/\text{m}^3$ ) – Gunlake Quarry Only – Scenario 4

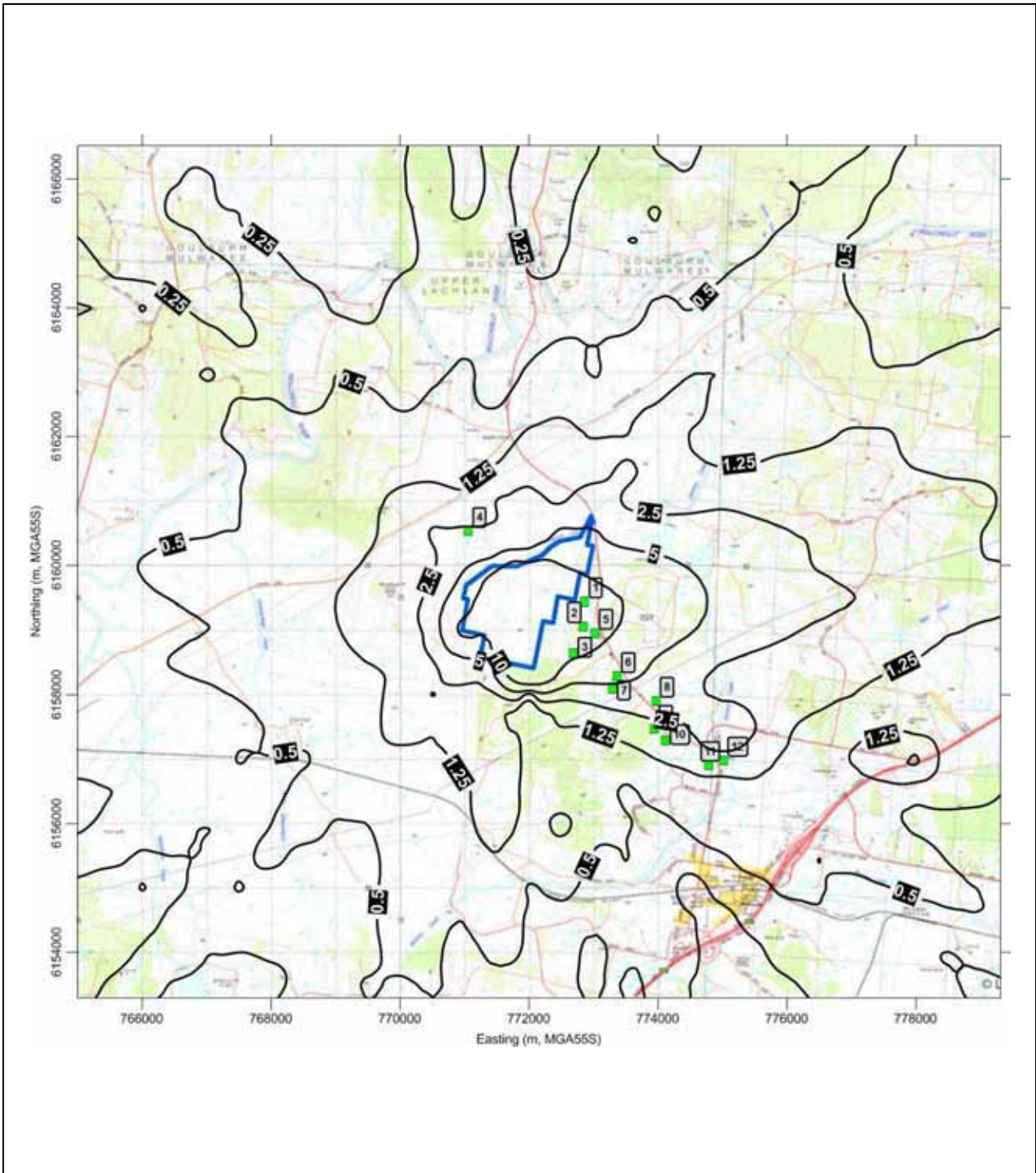


Figure A3-23: Predicted maximum 24-hour average PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 4

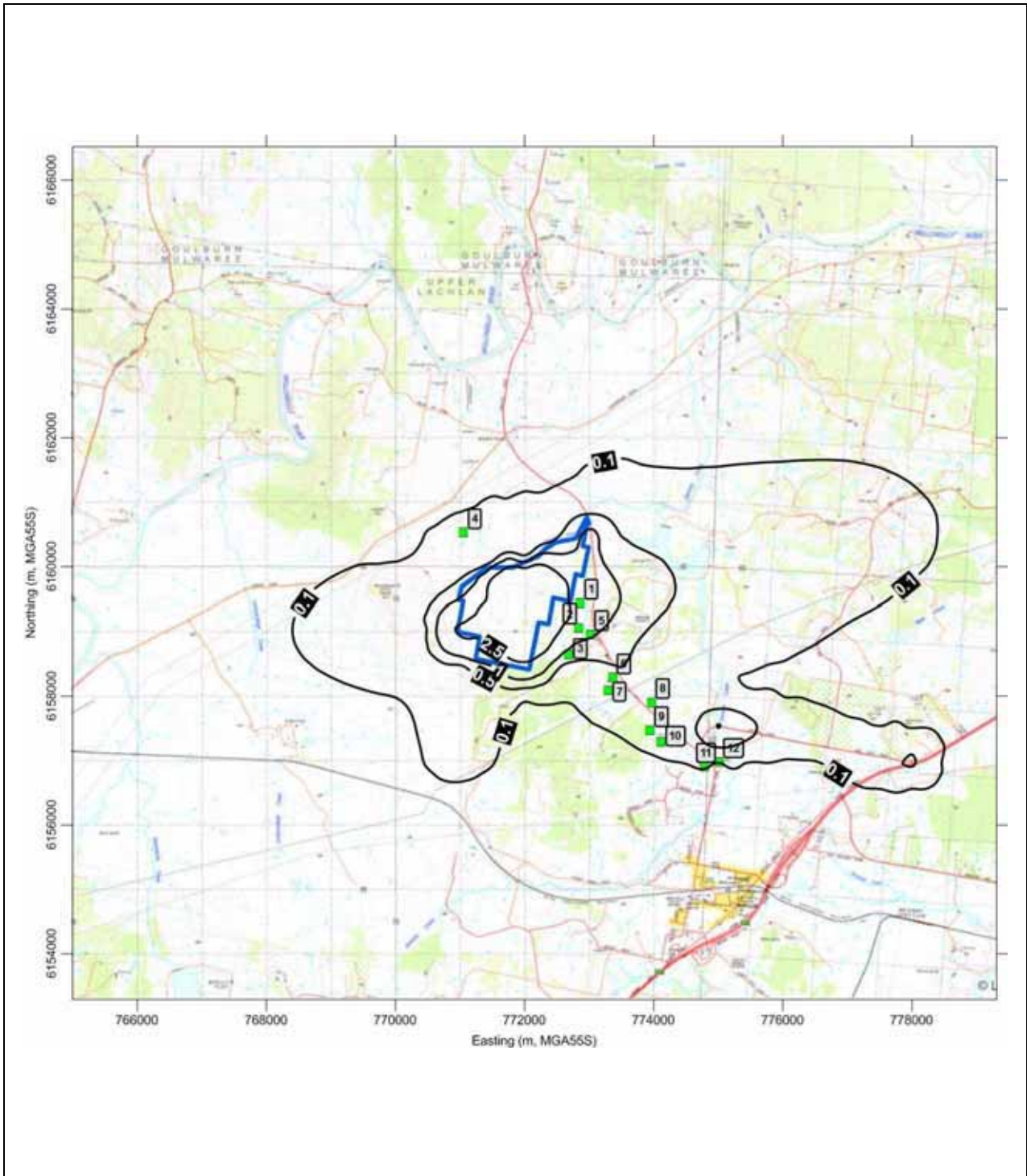


Figure A3-24: Annual average PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 4

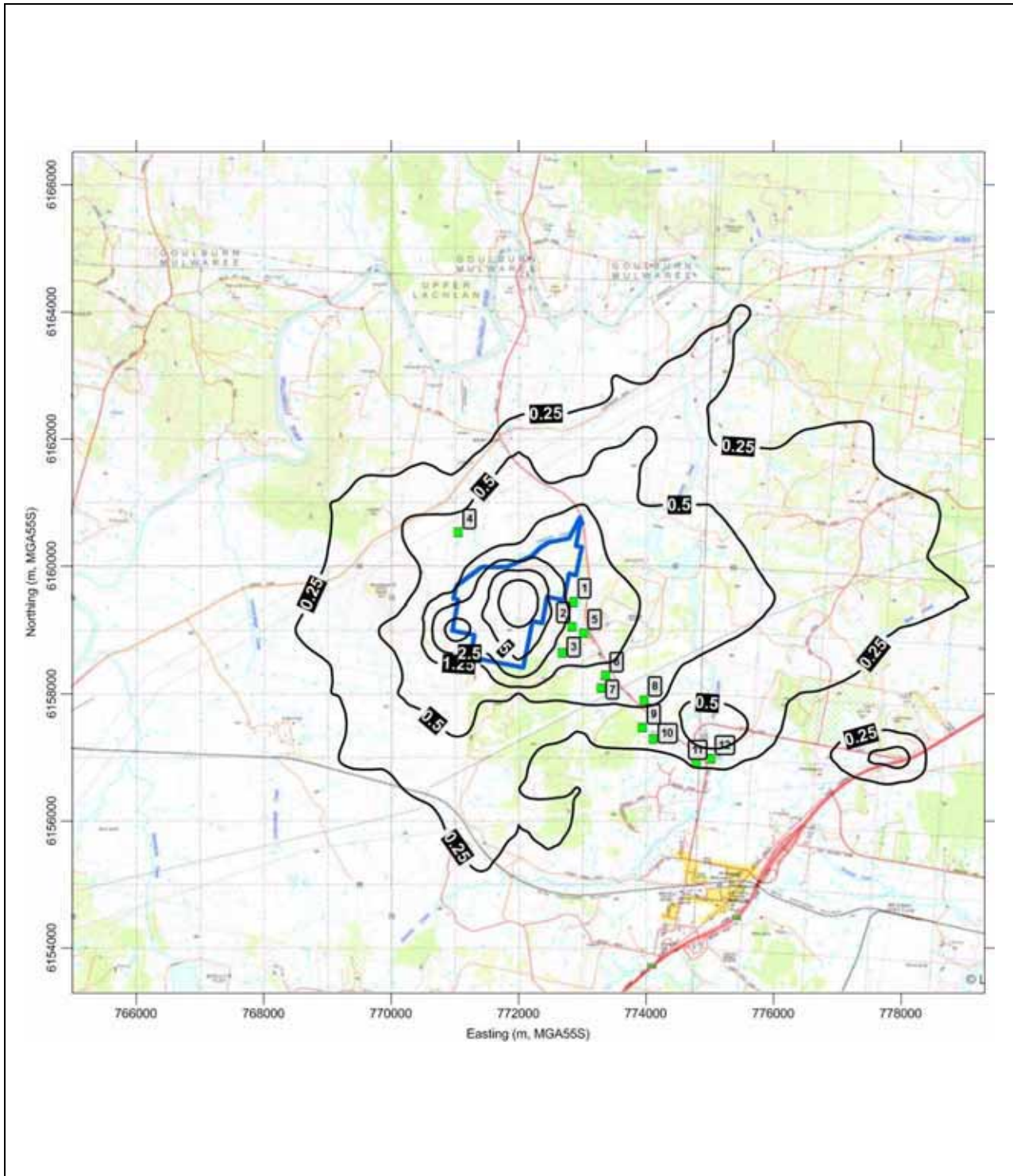


Figure A3-25: Predicted maximum 24-hour average PM<sub>2.5</sub> concentrations ( $\mu\text{g}/\text{m}^3$ ) – Gunlake Quarry Only – Scenario 4

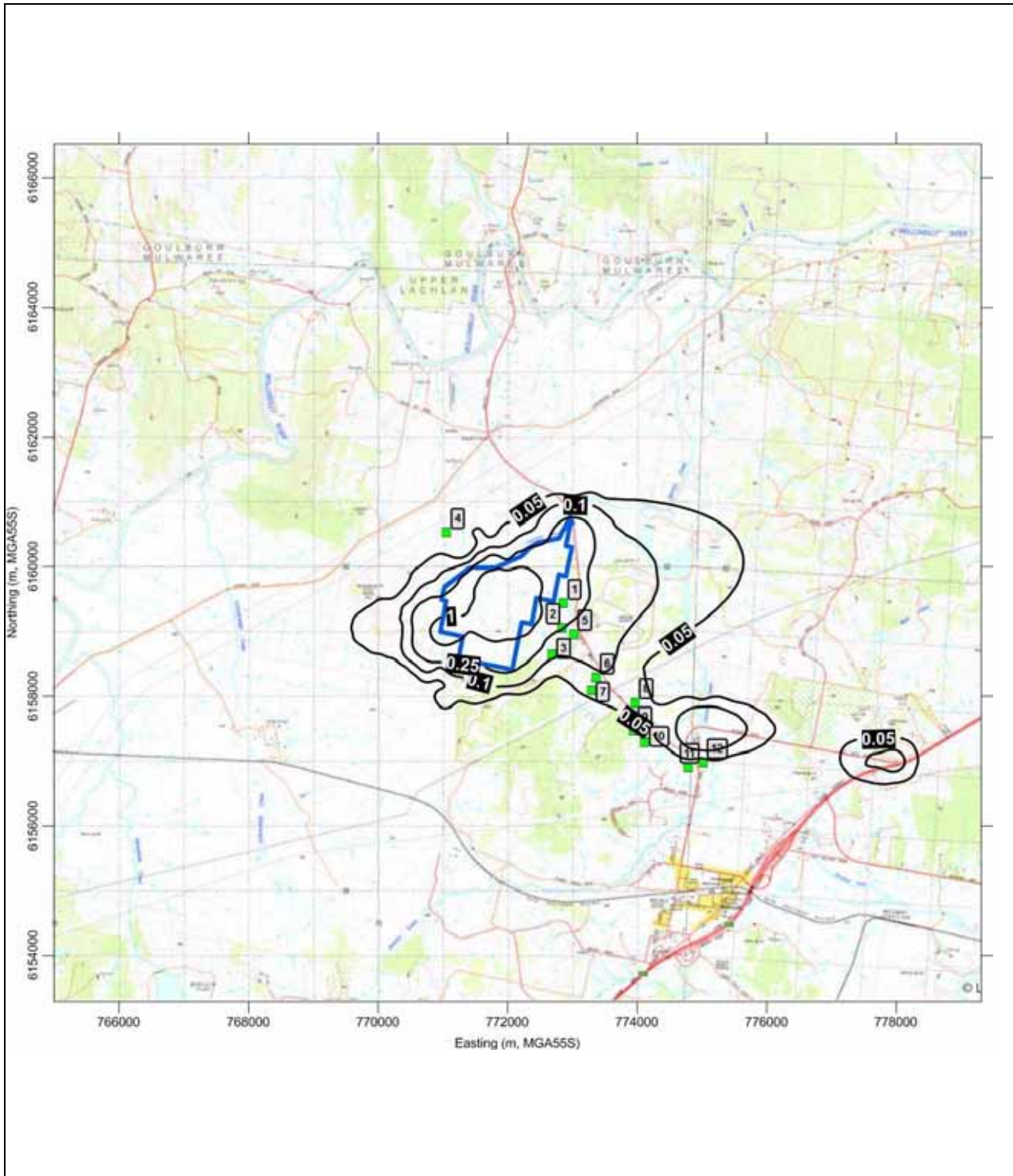


Figure A3-26: Annual average PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) – Gunlake Quarry Only – Scenario 4

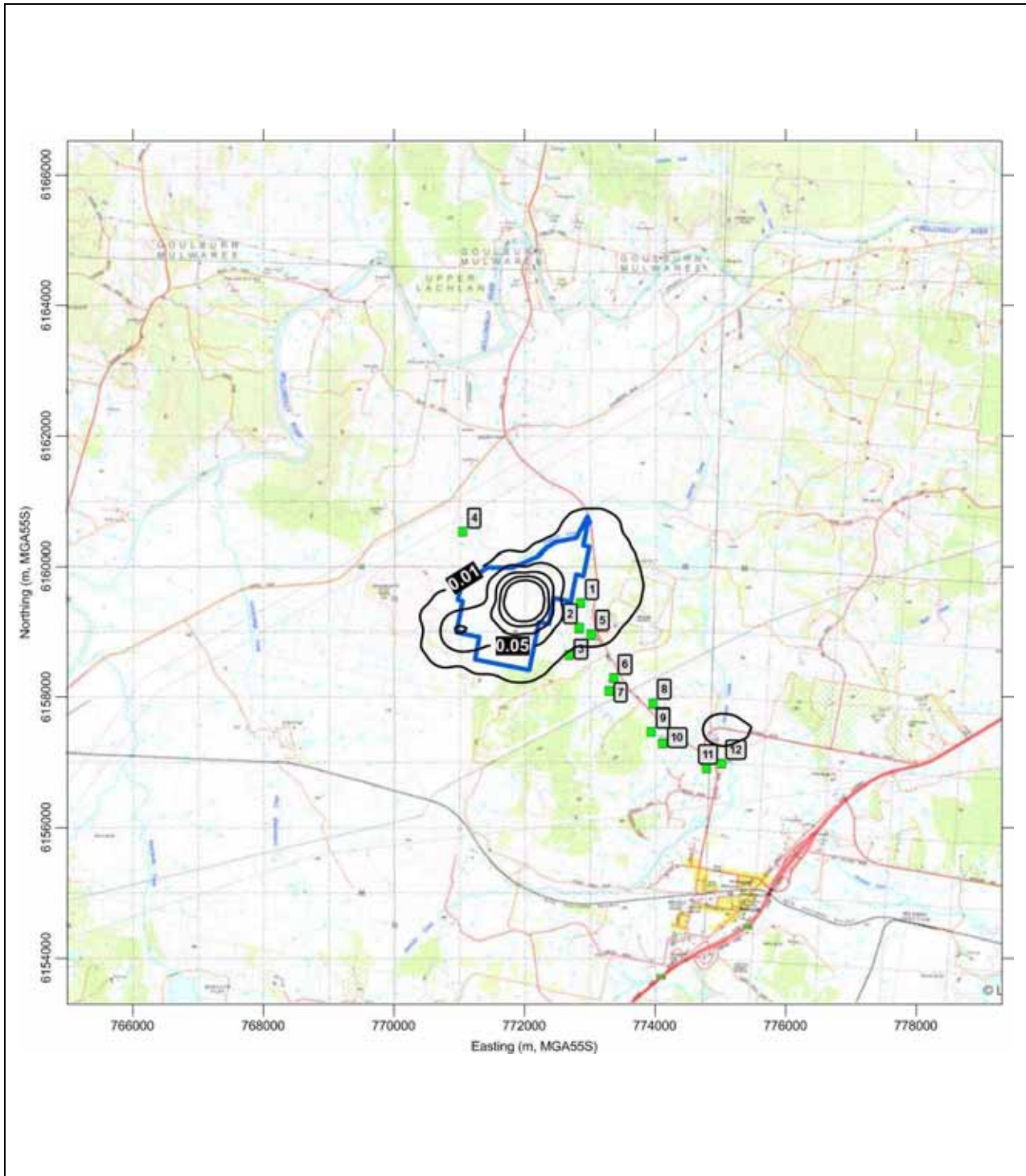


Figure A3-27: Annual average RCS concentrations ( $\mu\text{g}/\text{m}^3$ ) – Gunlake Quarry Only – Scenario 4

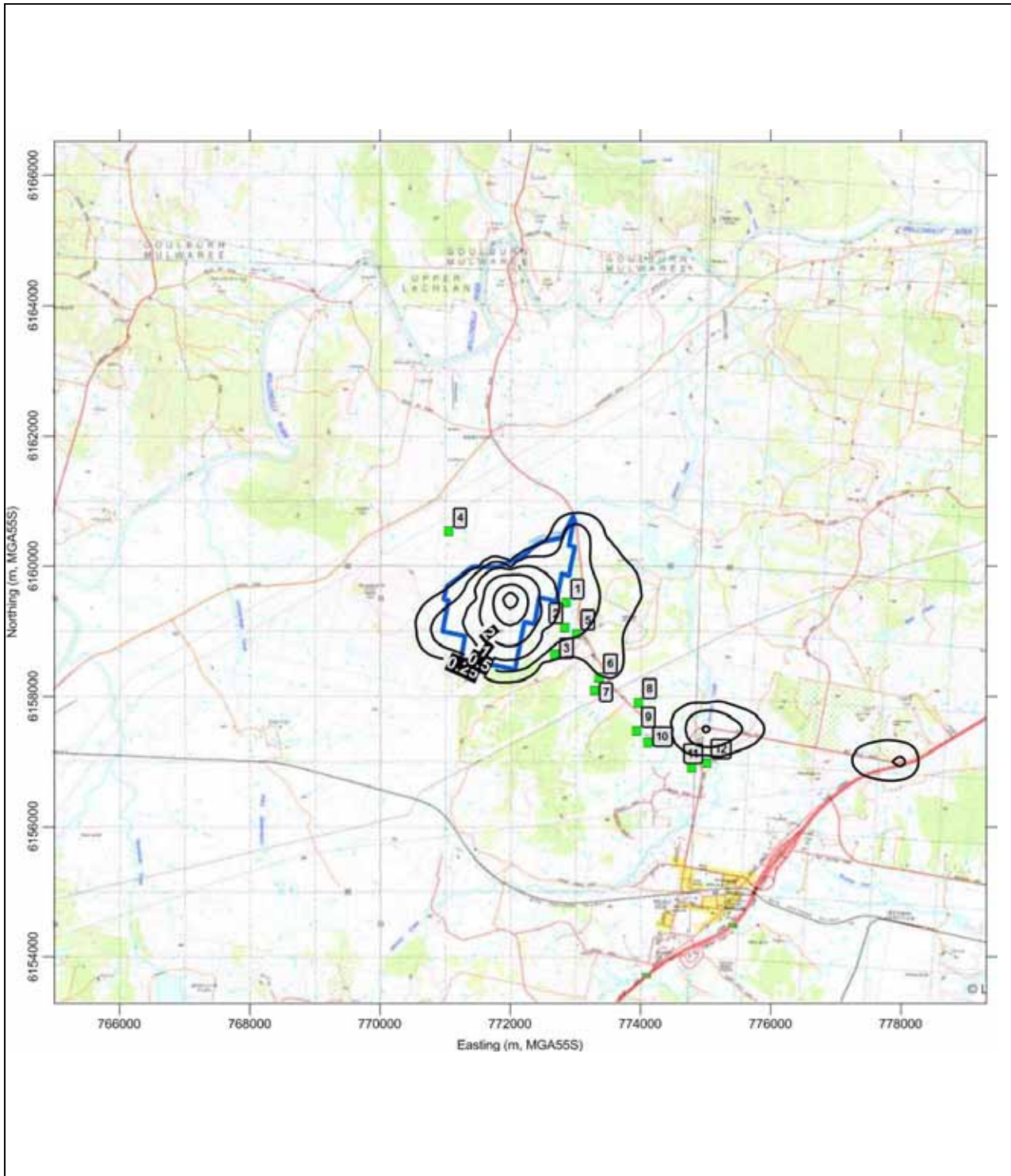


Figure A3-28: Annual average dust deposition levels (g/m<sup>2</sup>/month) – Gunlake Quarry Only – Scenario 4