MILLENNIUM
EMS Solutions Ltd.

6111 91 Street
Edmonton, AB T6E 6V6
tel: 780.496.9048
fax: 780.496.9049

Suite 325, 1925 18 Avenue NE
Calgary, AB T2E 7T8
tel: 403.592.6180
fax: 403.283.2647

#106, 10920 84 Avenue
Grande Prairie, AB T8V 6H2
tel: 780.357.5500
fax: 780.357.5501

toll free: 888.722.2563
www.mems.ca

Air Quality Assessment

Grassy Mountain Coal Project

Prepared for:
Benga Mining Limited

Prepared by:
Millennium EMS Solutions Ltd.
Suite 325, 1925 18 Avenue NE
Calgary, Alberta
T2E 7T8

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1.0 INTRODUCTION

1.1 Project Overview

Benga Mining Limited (Benga) a wholly owned subsidiary of Riversdale Resources Limited (Riversdale) is proposing to build the Grassy Mountain Coal Mine and coal processing plant (the Project) located in southwestern Alberta within the Crowsnest Pass. With an extensive mining history dating back to the early 20th century, this area of the province is rich in coal resources.

The proposed mine and coal processing plant are approximately 7 km north of the community of Blairmore (Figure 2.3-1). The produced clean coal will be transported by conveyor to a rail load-out near Highway 3 (Figure 2.3-1) for transfer to train. The mine will supply high quality metallurgical coal to Asian markets.

This report is a part of an Environmental Impact Assessment, which is part of an application to the Alberta Energy Regulator (AER) and the Canadian Environmental Assessment Agency (CEAA) for the Grassy Mountain Coal Mine Permit and coal processing plant approval, and the acquisition of mine licences.

1.2 Terms of Reference

The final provincial terms of reference (ToR) and the federal CEAA guidelines are provided in the Project Application Appendices 1 and 2, respectively. The provincial final ToR relating to air quality are as follows:

3.2.5 Air Emissions Management

[A] Discuss the selection criteria used, options considered, and rationale for selecting control technologies to minimize air emission and for air quality management.

[B] Provide emission profiles (type, rate and source) for the Project's operating emissions including point and non-point sources and fugitive emissions (including mine faces), and for construction emissions. Consider both normal and upset conditions. Discuss:

a. odorous or visible emissions from the proposed facilities;

b. annual and total greenhouse gas emissions for all stages of the Project. Identify the primary sources and provide examples of calculations;

c. the Project's contribution to total provincial and national greenhouse gas emissions on an annual basis;

d. the Proponent's overall greenhouse gas management plans;

e. *the Proponent's plans to manage emissions from the mining fleet;*
f. *the amount and nature of Criteria Air Contaminant emissions; and*
g. *the amount and nature of acidifying emissions, probable deposition patterns and rates.*

4.1 Air Quality, Climate and Noise

4.1.1 Baseline Information

[A] Discuss the baseline climatic and air quality conditions including:

a. *the type and frequency of meteorological conditions that may result in poor air quality; and*
b. *appropriate ambient air quality parameters.*

4.1.2 Impact Assessment

[A] Identify components of the Project that will affect air quality, and:

a. *describe the potential for reduced air quality (including odours and visibility) resulting from the Project and discuss any implications of the expected air quality for environmental protection and public health;*
b. *estimate ground-level concentrations of appropriate air quality parameters;*
c. *discuss any expected changes to particulate deposition, nitrogen deposition or acidic deposition patterns;*
d. *identify areas that are predicted to exceed Potential Acid Input (PAI) critical loading criteria;*
e. *discuss interactive effects that may occur resulting from co-exposure of a receptor to all emissions; and*
f. *describe air quality impacts resulting from the Project, and their implications for other environmental resources, including habitat diversity and quantity, soil resources, vegetation resources, and water quality.*

[B] Identify stages or elements of the Project that are sensitive to changes or variability in climate parameters, including frequency and severity of extreme weather events. Discuss what impacts the change to climate parameters may have on elements of the Project that are sensitive to climate parameters.

CEAA Guidelines (Benga 2016, Appendix 2)

The following excerpts are specific to the air quality assessment:

6.1.1. Atmospheric Environment

- *ambient air quality in the project areas and, for the mine site, the results of a baseline survey of ambient air quality, including the following contaminants: total suspended particulates, fine particulates (PM2.5), particulate matters up to 10 micrometers in size (PM-10), sulfur oxide (SOx), volatile organic compounds (VOCs), and nitrogen oxide (NOx);*

- *historical records of monthly and total precipitation (rain and snow) and temperatures, including means, maximums, and minimums.*

6.2.1. Changes to the Atmospheric Environment

- *changes in air quality;*

2.0 ASSESSMENT APPROACH

2.1 Overview and Scope of Assessment

The Project will result in emissions to the atmosphere from fossil fuel combustion sources, fugitive emissions from processing equipment, soil handling, coal movement and wheel entrainment. At sufficiently high concentrations, these air emissions can have direct and indirect effects on humans, animals, vegetation, soil and water. The objectives of the air quality assessment are to address the Project provincial and federal ToR and Guidelines.

The methods used in the air quality assessments and the standards against which results are compared are presented in Section 2.0. Recent and current air quality in the area of the Project, as well as meteorological data relevant to atmospheric dispersion, is summarized in Section 3.0. An overview of Project emissions is presented in Section 4.0. Air quality predictions for chemicals of concern expected to be emitted by the Project, Baseline, and Application (*i.e.* Baseline + Project) Cases are discussed in Section 5.0.

This report is supported by Appendixes that describe the details that support this report. These include:

- Appendix A – details of emission estimation;
- Appendix B – detailed description of dispersion modelling methods and variances from provincial recommended guidance, if any; and
- Appendix C – detailed summaries of air quality, meteorological, and climate measurements relevant to the region.

2.1.1 Assessment Approach

Four assessment cases were considered in the air quality assessment:

1. **Baseline Case** – including all existing emissions from Highway 3 and four communities of Crowsnest Pass Sub-Division within the Air Quality Regional Study Area (RSA) – Coleman, Blairmore, Frank, and Bellevue (Figure 2.1-1) - and with the addition of ambient background concentrations. No active industrial facilities were located within RSA;
2. **Project-Only Case in Year 19** – including Project-only emissions from mining and waste stripping, north and south disposal areas, haul road emissions, coal processing facility emissions (Figure 2.1-1), and transportation emissions. This case does not include baseline emission sources or ambient background concentrations;
3. **Application Case for Year 19** – including Baseline and Project Case sources as defined above.
4. **Planned Development Case (PDC)** – identical to the Application Case, because no planned industrial developments were identified, and community and Highway 3 traffic emissions were assumed to be approximately unchanged.

Based on the mine plan provided by Benga in April 2016, Year 19 was identified as the year when reasonably worst-case emissions could be expected with approximately 47.5 million bank cubic metres (BCM) of overburden removal and comparatively long haul roads. The annual coal production in Year 19 was approximately 6.8 Mt of raw coal and 3.8 Mt of clean coal.

For air quality assessment purposes, maximum hourly and daily emissions were identified and modelled.

2.2 Scoping Results

2.2.1 Issue Scoping

A scoping exercise identified the following key potential issues for air quality:

- effects on air quality in the region, especially related to dust and particulates;
- effects of air emissions on deposition of acid-forming compounds and nitrogen;
- effects of changes in air quality on human health; and
- production of greenhouse gases (GHGs).

The scoping exercise identified the following chemicals of potential concern for the Project: sulphur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), ozone (O_3), Volatile Organic Carbons (VOC), Polycyclic Aromatic Hydrocarbons (PAH), particulate matter with a mean aerodynamic diameter of 2.5 µm or smaller ($PM_{2.5}$), with a mean aerodynamic diameter of 10 µm or smaller (PM_{10}), particulate with a mean aerodynamic diameter of about 30 µm or smaller (TSP), metals, and GHGs. The list of chemicals assessed exceeds the requirements of CEAA Section 6.1.1. The following sections examine the key issues.

2.2.2 Effects on Air Quality

2.2.2.1 Criteria Contaminants

Potential sources of the criteria air contaminants (CACs) SO_2, NO_X and CO from the Project include diesel-fired equipment emissions and ammonium nitrate and fuel oil (ANFO) used in overburden blasting.

Small amounts of fugitive VOCs and PAHs may be emitted by the diesel combustion equipment. Although total VOCs and PAHs are not regulated, specific compounds are regulated and are important in determination of the potential effects on health and ozone formation. Emissions of VOCs and PAHs from the Project were estimated on the basis of diesel combustion emission factors.

Potential particulate sources for the Project include fugitive dust emissions from wheel entrainment and mining and coal processing facility operations as well as from soil and coal handling activities. These emissions can be separated into fine particulate matter ($PM_{2.5}$, PM_{10}) and TSP. Fine particulates are also generated by diesel-fired equipment and are created in secondary atmospheric reactions. For the Baseline and Application/PDC Cases, other regional facilities were considered since they have combustion sources of $PM_{2.5}$, which is regulated in Alberta and under the Canadian Ambient Air Quality Standards (CAAQS). Of the particulate size ranges, $PM_{2.5}$ emissions are most closely linked to potential human health effects.

The Project will emit small amounts of VOCs and NO_X, which are precursors of O_3 formation. The Project incremental contribution to regional study area VOC and NO_X emissions and O_3 formation is estimated.

2.2.2.2 Metals

Specific metals are emitted in small quantities from diesel combustion equipment. Since soil and overburden contain small quantities of metals, metals in dust emissions were also accounted for in the assessment. Concentrations of specific metals are regulated and are components in determination of the potential effects on human health.

2.2.2.3 Deposition

The Alberta Environment and Parks (AEP) Air Quality Model Guideline (AESRD 2013b) requires that air quality assessments need to consider the impact of acid forming emissions. Modelling is needed if combined emissions of SO_2, NO_x, and NH_3 are greater than 0.175 t/d of H^+ equivalent.

$$[Total\ H+]_{eq} = 2 * \frac{[SO_2\ \left(\frac{t}{d}\right)]}{64} + 0.25 * \frac{[NO_x(\frac{t}{d})]}{46} + 1 * \frac{[NH_3(\frac{t}{d})]}{17}$$

(from AESRD 2013b)

$$[Total\ H+]_{eq} = 2 * \frac{0.018}{64} + 0.25 * \frac{2.72}{46} = 0.015\frac{t}{d}$$

The application of the 0.25 factor to NOx emissions is based on a recommendation by AENV (2007) and reflects that not all deposited nitrogen is acidifying. In this assessment, all nitrogen deposition in excess of 10 kg/ha/yr, and 25% of the first 10 kg/ha/yr of deposited nitrogen, was considered acidifying.

Total H^+ equivalent from all mine sources and haul trucks was estimated to be 0.015 t/d, using emissions for the maximum daily production (Table 4.2-5), which is about 9% of the threshold for modelling.

Nonetheless, nitrogen, PAI and TSP deposition were modelled in compliance with the provincial ToR and federal Guideline requirements.

2.2.2.4 Production of Greenhouse Gases

Greenhouse gases (*e.g.*, carbon dioxide [CO_2]) will be produced largely by combustion of diesel by equipment and fugitive methane emissions from surface coal mining. Emissions of GHGs, including indirect GHG emissions from electricity purchases, are estimated and compared to provincial and national totals in Section 4.3 of this report.

2.2.2.5 Visibility

Assessments of visibility are typically conducted on elevated plumes that may influence the ability to enjoy scenic vistas. Elevated plumes are often considered if they emit fine particulates, which can contribute to regional haze, or water vapour emissions that may obstruct a portion of the sky.

In the Project, plumes from combustion are primarily released at the exhaust pipe height of mine or haul vehicles, which is below the height of surrounding terrain and forest. Exhaust plumes are therefore considered to have negligible effect on visibility. Dust generated from haul vehicles can impair visibility on haul roads. This issue is one of safety and is addressed in operations management plans, rather than assessed as an environmental issue. Visibility is not considered further in this assessment. Particulate concentration in air and particulate deposition to vegetation are considered as part of the environmental assessment.

2.2.2.6 Odour

Benga has also examined the potential for odour associated with Project operations, as some VOC emissions from diesel combustion are odour causing. An assessment of odour is included.

2.2.2.7 Light Levels

An additional atmospheric effect considered here is related to the lighting of the project. This section discusses where lighting will be used on the project and how mitigation will reduce impacts.

2.3 Temporal and Spatial Scope

Observations of air quality and meteorology were provided to illustrate recent conditions and trends in the region. Air quality data were taken primarily from 2009 to 2013; focussed meteorological information is presented for the period of 2002 to 2006, as meteorological data from these years were used in dispersion modelling as required by AEP (AESRD 2013b). Emissions for regional communities were based on the most recently available and complete data from the National Pollutant Release Inventory (NPRI) (2014) or other available sources as identified.

2.3.1 Study Area Selection

Factors that influence the size and location of the air quality study areas include:

- emission source location and strength;
- potentially sensitive receptor locations; and
- terrain and distance scales associated with air quality processes.

For the Project, maximum concentrations from most sources are expected to occur adjacent to the main emission sources and decrease with increasing distance beyond this point, as emissions occur at or near ground level. The exception is O_3, a secondary product of combustion that may have maximum concentrations tens of kilometres from the source.

The Regional Study Area (RSA) and Local Study Area (LSA) for the Project are shown on Figure 2.3-1. The sizes and locations of the study areas were based on several factors and meet the requirements of AEP model guideline (AESRD 2013b). In particular, the RSA (30 km x 35 km) encompassed all project sources and concentrations from these sources reduced to 10% or less of maximum values at the RSA boundary. All identified, regional sources within the RSA were included in the assessment. The LSA was defined as the region immediately surrounding the Project development and was 12 km by 15 km. The LSA was designed to include all project developments and the nearest communities. The size of the LSA is largely arbitrary as the receptor grid spacing within the RSA is determined by the requirements of ESRD (2013).

An ambient background was added to all model predictions for Baseline and Application cases to account for the effects of distant and natural sources not within the RSA.

2.3.2 Topography

Terrain features such as hills and valleys affect the path followed by air emissions released into the atmosphere and the turbulence levels that result in the dilution of these emissions. These terrain effects depend on factors such as slope of the terrain feature, shape of the terrain feature, relative height of the emission plumes with respect to the terrain feature, and associated meteorological conditions. Step-like terrain features can cause complex re-circulating flow patterns in their immediate vicinity, while a valley can generate its own airflow independent of the winds above the valley. In some cases, depending on the meteorological conditions and terrain features, a plume will flow around the terrain feature; in other cases, the plume will flow over the terrain. In extreme cases, the plume may impinge directly on the terrain feature in its path. Terrain is especially important for low-level sources such as fugitive dust and exhaust from mining equipment.

Terrain elevation information is required by the dispersion models that are used to predict ambient air quality changes. Topographic elevations for the terrain were obtained from the Canadian Digital Elevation Data (CDED, Geobase 2014). The CDED dataset has a resolution of a minimum of 0.75 arc seconds to a maximum 3 arc seconds for the 1:50,000 NTS tiles.

The study area is nestled in the lee of the Rocky Mountains with rolling hills throughout the landscape. The coal processing plant area of the Project is located at a base elevation of approximately 1,550 m above sea level (asl). The terrain elevation for the mining area ranges from 1,550 to 2,000 m asl. Terrain within the vicinity of the proposed mining area slopes downhill about 400 m to the surrounding area. Terrain elevations within the RSA study area range from approximately 1,250 to 2,650 m asl (Figure 2.3-1). The highest elevations occur 5 km east of the Project mining area, on the eastern side of the LSA.

2.4 Air Quality Criteria

2.4.1 Ambient Air Quality Objectives and Guidelines

The Alberta Ambient Air Quality Objectives (AAAQO) and the Canadian Ambient Air Quality Standards (CAAQS) for relevant regulated compounds are presented in Table 2.4-1 (AESRD 2013a; CCME 2012). In the absence of AAAQOs and federal standards, British Columbia Ambient Air Quality Objective (BCAAQO) (BCMOE 2014) is applied for 24-hour PM_{10}.

The objectives refer to averaging periods ranging from one hour to one year. For modelling purposes, the hourly objectives are applied to the 9th highest hourly predictions (99.9th percentile) in each year, while 8-hour average, daily and annual objectives are applied to the highest prediction in each year (AESRD 2013c).

The AAAQO for $PM_{2.5}$ is 30 μg/m³ as a 24-hour average. Alberta has a 1-hour Ambient Air Quality Guideline (AAAQG) for $PM_{2.5}$. The AAAQG is not used to determine facility compliance, rather as a tool for airshed planning and management, and as a general performance indicator (AESRD 2013b). The 1-hour AAAQG for $PM_{2.5}$ is 80 μg/m³.

Starting in 2015 there are new 24-hour and annual $PM_{2.5}$ CAAQS (CCME 2012). The 24-hour $PM_{2.5}$ CAAQS is 28 μg/m³ based on the 98th percentile 24-hour value for a year (the 8th highest value), averaged over three consecutive years. The annual $PM_{2.5}$ CAAQS is 10 μg/m³ based upon a 3-year average of the annual average concentration. The CAAQS will become more stringent in 2020, with 24-hour and annual CAAQS of 27 μg/m³ and 8.8 μg/m³, respectively.

Table 2.4-1 Alberta Ambient Air Quality Objectives and Canada Ambient Air Quality Standards

Parameter	Period	AAAQO[a] [μg/m³]	CAAQS[b] [μg/m³]
SO_2	Annual	20	–
	30-day	30	–
	24-hour	125	–
	1-hour	450	–
NO_2	Annual	45	–
	1-hour	300	–
CO	8-hour	6,000	–
	1-hour	15,000	–
$PM_{2.5}$	Annual	–	10

Table 2.4-1 Alberta Ambient Air Quality Objectives and Canada Ambient Air Quality Standards

Parameter	Period	AAAQO[a] $[\mu g/m^3]$	CAAQS[b] $[\mu g/m^3]$
	24-hour	30	28[c]
	1-hour	80[d]	–
PM_{10}	24-hour	50[e]	–
TSP	Annual	60	–
	24-hour	100	–
Ozone	8-hour	–	124[f]
	1-hour	160	–
Benzene	Annual	3	–
	1-hour	30	–
Toluene	24-hour	400	–
	1-hour	1,880	–
Xylenes	24-hour	700	–
	1-hour	2,300	–
Formaldehyde	1-hour	65	–
Acetylaldehyde	1-hour	90	–
Benzo(a)pyrene	Annual	0.0003	–
Arsenic	1-hour	0.1	–
	Annual	0.01	–
Chromium	1-hour	1.0	–
Lead	1-hour	1.5	–
Manganese	1-hour	2.0	–
	Annual	0.2	–
Nickel	1-hour	6.0	–
	Annual	0.05	–
Particulate Deposition	30 days	53 [g] / 158 [h] (mg/cm^2)	–

[a] Source: AESRD 2013a.
[b] Source: CCME 2012.
[c] 98th percentile.
[d] Alberta Ambient Air Quality Guideline (AAAQG).
[e] Source: BCMOE 2014.
[f] 4th highest annually.
[g] For residential and recreation areas.
[h] For commercial and industrial areas.
– No air quality standard or guideline for this averaging period/parameter.

In Alberta (AENV 2002), the action triggers and actions for $PM_{2.5}$ compliance with the CAAQS are as follows:

- Where ambient concentrations are at the lowest levels, baseline monitoring, modelling and forecasting would occur. Results of baseline monitoring would indicate if there is any exceedance of the various trigger levels.
- At the "surveillance trigger" level of 15 μg/m^3, affected stakeholders in areas of concern would undertake pre-planning activities (for example, monitoring, source apportionment modelling, and detailed forecasting).
- Between the "planning trigger" of 20 μg/m^3 and the CAAQS, affected stakeholders will develop and implement a management plan. If this is not done within a certain time frame or by a specified level, AEP will impose a plan.
- When concentrations of $PM_{2.5}$ exceed the CAAQS, AEP will impose a mandatory plan to reduce ambient concentrations to below the CAAQS within a reasonable amount of time.

Although the CAAQS is a federal initiative, levels for surveillance and planning triggers would be set provincially, and development of regional management plans would take into account naturally occurring background levels.

For this assessment, all objectives and guidelines are taken to apply at and outside the mine permit boundary (MPB) and at any special receptor locations inside the MPB. The MPB is chosen as the defining location because access within the MPB must be controlled for safety reasons. Therefore, the public will not be allowed inside this area.

2.4.1.1 Triggers for the South Saskatchewan River Regional Plan

The Air Quality Management Framework (ESRD 2014a) for the South Saskatchewan River Regional Plan sets ambient air quality triggers and limits for NO2, PM2.5 and O3. They are of primary importance in the South Saskatchewan Region currently because of their contribution to urban smog (ESRD 2014b). Using the triggers and limits, the framework defines ambient air quality levels that help to guide long-term decision-making and air quality management. This approach, in conjunction with existing regulations and policies, contributes to the achievement of the desired regional objective for ambient air quality.

Comparison to triggers is based on measured values using the structure in Table 2.4-2. The limits identified in this table are listed in Table 2.4-3. In the region, five community stations report the ambient air concentrations for several substances including NO_2, O_3 and $PM_{2.5}$. The stations are managed by the Calgary Region Airshed Zone, the Palliser Airshed Society and AEMERA. These five stations are the framework's source of monitoring data.

In other words the triggers for regional management are based on changes to measured concentrations at the five stations. These stations are well outside the RSA.

Table 2.4-2 Annual Ambient Air Quality Level Descriptions (ESRD 2014b)

Level	Description	Management Intent
Level 4	Ambient air quality exceeding air quality limit	Improve ambient air quality to below the limit
Limit		
Level 3	Ambient air quality below but approaching the air quality limits	Proactively maintain air quality below the limit
Trigger into Level 3		
Level 2	Ambient air quality below air quality limits	Improve knowledge and understanding, and plan
Trigger into Level 2		
Level 1	Ambient air quality well below air quality limits	Apply standard regulatory and non-regulatory approaches

Table 2.4-3 Fine Particulate Matter and Ozone CAAQS (from ESRD 2014a)

Pollutant	Averaging time	Standards (concentration)		Metric
		2015	2020	
$PM_{2.5}$	24-hour (calendar day)	28 $\mu g/m^3$	27 $\mu g/m^3$	The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
$PM_{2.5}$	Annual (calendar year)	10.0 $\mu g/m^3$	8.8 $\mu g/m^3$	The 3-year average of the annual average concentrations
O_3	8-hour	63 ppb	62 ppb	The 3-year average of the annual 4th highest daily maximum 8-hour average concentrations

2.4.2 Acid Deposition Criteria

Deposition includes both wet and dry processes, and can result in the long-term accumulation of atmospheric emissions in aquatic and terrestrial ecosystems. Wet processes involve the removal of these atmospheric emissions by precipitation. Dry processes involve removal by direct contact with surface features (*e.g.,* vegetation, soils and surface water).

Both wet and dry deposition are expressed as a flux in units of kg/ha/yr. Where more than one acidifying chemical species is considered, the flux is often expressed in keq/ha/yr where 'keq' refers to hydrogen ion equivalents (1 keq = 1 kmol H^+). The deposition of sulphur and nitrogen compounds to these systems has been associated with changes in water and soil chemistry, and with the acidification of water and soil.

The Alberta Acid Deposition Management Framework recommends that 25% of nitrogen up to 10 kg N/ha/y, and 100% of nitrogen above 10 kg/ha/y, should be considered acidifying (AENV 2008). The threshold of 10 kg N/ha/y is equivalent to 0.714 keq H+/ha/y. The PAI is used as a deposition measure of acidification and is defined by:

$$PAI = \sum (SO_4^{2-}) + 0.25*\sum (NO_3^-) - \sum (\text{base cations}) \text{ for deposited nitrogen less than 10 kg/ha/y}$$

Where:

$\sum (SO_4^{2-})$ = total sulphur compound contribution (*i.e.*, SO_2 and SO_4^{2-}), expressed in keq/ha/yr

$\sum (NO_3^-)$ = total nitrogen compound contribution (*i.e.*, NO, NO_2, HNO_3, and NO_3^-), expressed in keq/ha/yr

$\sum$ (base cations) = primarily calcium (Ca^{2+}) and magnesium (Mg^{2+})

Critical, target and monitoring loads for management of acid deposition in Alberta were established on the basis of the work of the CASA Target Loading Subgroup (CASA 1999) as updated by Alberta Environment (AENV 2008). The loads were specifically based upon predictions of the Regional Lagrangian Acid Deposition (RELAD) model over 1° latitude by 1° longitude grid cells, and based upon the specific definitions of receptor sensitivity.

According to the receptor sensitivity map that is currently used for acid deposition assessment (AENV 2008, Figure 2), the Project is located in moderately sensitive ecological areas. The management levels adopted by CASA for moderately sensitive grid cells are:

Critical Load the highest load that will not lead to long-term, harmful changes to a receptor. The trigger level is 0.50 keq/ha/yr for moderately sensitive area.

Target load the level of deposition that consider the critical load and is practically and politically achievable. The trigger level is 0.45 keq/ha/yr for moderately sensitive areas.

Monitoring load the level of deposition predicted or estimated by dispersion and deposition models that trigger monitoring and/or research. The trigger level is 0.35 keq/ha/yr for moderately sensitive areas.

Use of the above critical, target, and monitoring loads uncoupled from RELAD modelling, and the definitions of receptor sensitivity (including the 5% level of protection) in a regional or Project-specific application is limited to the use of these values in the identification of areas potentially at risk of becoming acidified. Upon identifying such areas, actions towards confirming the acidification sensitivity of these areas are to be taken, and this may involve the use of models such as CALPUFF (AENV 2008). The provincial acid deposition management framework specifies that an exceedance of a target load at a local scale (*e.g.,* a project EIA) is not to be considered to be an exceedance of an environmental objective.

This assessment includes estimates of the areas above these thresholds, and the CASA monitoring, target and critical loads, based on CALPUFF modelling.

2.4.3 Nitrogen Deposition Criteria

Nitrogen is the limiting nutrient for plant growth in many natural ecosystems and the addition of nitrogen through atmospheric deposition has the potential to imbalance existing natural systems. The following paragraphs describe the method used to determine nitrogen deposition in assessment of the Project based on critical loads applicable in Europe (WHO 2000).

Deposition of nitrogen includes both wet (removal in precipitation) and dry (direct contact with surface features) processes. In the current approach, nitrate particulate was determined to be deposited by both wet and dry processes and was directly calculated by the dispersion model. NO_2 was assumed to be deposited by dry processes only, based on annual average predicted concentrations and a locally determined deposition velocity.

The deposited nitrogen was scaled by the molecular weights of the deposited species as follows:

$$N = \sum (14/46\ NO_2\ dry) + \sum (14/62\ NO_3^-\ dry) + \sum (14/62\ NO_3^-\ wet) + \sum (14/18\ NH_4\ dry)$$

This calculation is expected to result in conservative (*i.e.,* high) estimates of nitrogen leading to eutrophication as both acidifying and non-acidifying components are included.

Critical loads for nitrogen deposition were taken from WHO (2000). The lowest value is 5 kg/ha/yr and is applicable to softwater lakes, raised bogs and alpine heath. Acidic conifer forests have a critical load of 7 kg/ha/yr. For presentation purposes in Section 5, predictions above 5 kg/ha/yr were presented, along with those above 3.5 kg/ha/yr as a precautionary value.

2.4.4 Emission Standards

In 2011, Environment Canada adopted amendments to the Off-Road Compression-Ignition Engine Emission Regulations which align Canadian emission standards with the U.S. EPA Tier 4 standards for non-road engines, including the emission limits, testing methods and effective dates. Most of these requirements are defined by reference to the pertinent sections of the US regulations. The Canadian Tier 4 standards came into force in January 2012 and apply to engines of the 2012 and later model years.

2.5 Air Quality Analytical Approaches

2.5.1 Overview

AEP has periodically identified preferred dispersion modelling methods to be used for air quality impact assessments, most recently in the *Air Quality Model Guideline* (AESRD 2013b). While the methods are generic, they have been used as the basis for the preparation of the air quality assessment for the Project.

For the assessment, dispersion models were used to predict air quality changes for emissions from Project sources. The measurable parameters used in the baseline air quality assessment and the criteria used for assessment are summarized in Table 2.5-1. Key effects are examined at the maximum point of impingement (MPOI) in the RSA outside the disturbed area of the mine and at the MPB. In addition, predictions are made at several specific locations for use in the Human Health Risk Assessment included in Consultant Report (CR) #12 of this Project Application.

Table 2.5-1 Key Effects Assessment Summary

Key Effect	Environmental Component	Measurable Parameter	Criteria for Evaluating Effects Magnitude
Regional air quality	NO_2 concentration	Maximum hourly and annual average concentration	AEP NO_2 objectives for vegetative health (AESRD 2013a)
	SO_2 concentration	Maximum hourly, daily, 30-day and annual average concentration	AEP SO_2 objectives for human health (AESRD 2013a)
	CO concentration	Maximum hourly and 8-hour average concentration	AEP CO objectives for human health (AESRD 2013a)
	Particulate concentration	98th percentile daily and annual average concentration for $PM_{2.5}$	Canadian Ambient Air Quality Standards (CCME 2012)
		Maximum hourly average concentration for $PM_{2.5}$	AEP Ambient Air Quality Guideline (AAAQG) for $PM_{2.5}$ (AESRD 2013a)
		Maximum daily and annual average concentration	AEP $PM_{2.5}$ and TSP objectives for human health (AESRD 2013a), BCMOE objective for PM_{10} (BCMOE 2014)
	VOC concentration	Maximum concentration for a number of VOCs	AEP ambient objectives, where they exist (AESRD 2013a)
	PAH concentration	Maximum concentration for a number of PAHs	AEP ambient objectives, where they exist (AESRD 2013a)
	Metal Concentration	Maximum hourly and annual average concentrations	AEP ambient objectives, where they exist (AESRD 2013a)
Nitrogen Deposition	Nitrogen Deposition	Annual average nitrogen deposition	WHO deposition thresholds for ecosystem health (eutrophication) (WHO 2000)
Acid Deposition	Acid Deposition	Annual PAI deposition, area within 0.0.35 keq/ha/yr, 0.45 keq/ha/yr, 0.5 keq/ha/yr,	CASA deposition thresholds (AENV 2008). WHO deposition thresholds for ecosystem health (WHO 2000)

Table 2.5-1 Key Effects Assessment Summary

Key Effect	Environmental Component	Measurable Parameter	Criteria for Evaluating Effects Magnitude
Particulate Deposition	TSP Deposition	Annual maximum particulate deposition	AEP dust fall parameters (AESRD 2013a)
Greenhouse gas emissions	GHG emissions	GHG emission expressed as CO_2 equivalent	Relative change in Alberta and Canada GHG emissions
Regional ground-level concentration of ozone	Ozone concentration	Relative magnitude of precursor emissions (primarily NO_x)	Relative change in predicted ozone, compared to regional sources

2.5.2 Approach to Assessment

Evaluating the potential effects on an indicator requires the clear identification of thresholds or management objectives. For air quality, these thresholds are often ambient air quality objectives and guidelines that are referenced to particular averaging periods (hourly, daily, and annual are typical). The descriptors of the Project assessment are listed in Table 2.5-2. Comments relevant to the general descriptors are as follows:

- **Project Contribution/Direction:** Direction addresses the expected change, without regard to its magnitude. The direction is interpreted as being adverse (*i.e.* negative) if there are any increases in air quality parameters, neutral if there is no change, and positive if air quality parameters decrease.
- **Magnitude:** Predicted ambient air quality levels are usually compared to ambient air quality objectives. Magnitude ratings are classified as "negligible", "low", "moderate", or "high" based on the comparison to the ambient air quality objectives. A magnitude rating of "negligible" is assigned when the predicted change in concentration is less than or equal to 1% and does not result in any new exceedances of provincial objectives. A "low" rating is assigned to a prediction which the change in concentration is less than 10% and the concentration is below the applicable AAAQOs. A "moderate" rating is assigned to a prediction which the change in concentration is more than 10% and the concentration is below the applicable AAAQOs. The magnitude rating of "high" is assigned to predictions that exceed the provincial objectives and/or the federal standards. Magnitude refers to air quality during mitigated Project operation, not after operations end.
- **Geographic Extent:** Air quality changes typically decrease with increasing distance from the emission source. If the expected measurable changes are limited to the area immediately

surrounding the Project (the MPB), the geographic extent is interpreted as being local. If the expected measurable changes extend beyond the immediate project area, and are within the RSA, they are considered regional. If the expected changes extend beyond the RSA, such as the effects of greenhouse gas emissions, they may be interpreted as being provincial.

- **Duration and Frequency:** While emissions will occur for the full duration of the Project, changes in air quality will have temporal variability due to the natural fluctuations in meteorology (wind speed, wind direction, temperature), and short and long-term variability in emissions based on operational patterns. In addition, the highest concentrations typically occur for very short durations and there may be infrequent upset conditions.
- **Reversibility:** For all air emissions, the Project contribution to ambient concentration and direct deposition to receptors ceases when Project emissions cease.
- **Probability of Occurrence:** Most emissions occur continuously, but the combination of maximum emissions and meteorological conditions conductive to worst case predicted concentrations may not occur. At the same time, Project emission estimates are conservative. The indicator "probability of occurrence" integrates all these issues and determines the extent to which predicted concentrations/deposition will actually occur.
- **Confidence:** The level of confidence in predicted air quality changes depends on the representativeness of emission rates, the meteorological transport and dispersion, chemical transformation, and on dispersion model capability. The confidence rating is based on the assumption that dispersion models provide reasonable predictions for air quality assessment purposes given representative input data.
- **Significance:** An integrated assessment of the impact for each air quality parameter based on individual descriptors, summarizing the significance of Project impacts.

Table 2.5-2 Evaluation Criteria for Characterizing Residual Effects

Criteria	Criteria Definition	
Project Contribution / Direction	Neutral	No net change in air quality in the RSA
	Positive	Improved air quality in the RSA
	Negative	Poorer air quality in the RSA
Magnitude	Negligible	No change from background conditions anticipated after mitigation
	Low	The expected emission, ambient concentration, or deposition change is expected to be less than 10%

Table 2.5-2 Evaluation Criteria for Characterizing Residual Effects		
Criteria	**Criteria Definition**	
	Moderate	The expected emission, ambient concentration or deposition change is expected to be more than 10% but less than relevant thresholds
	High	The expected emission, ambient concentration or deposition change is greater than relevant thresholds
Geographic Extent of Impact	Project Area	Not generally applicable to air quality, but could be for near-ground level emissions associated with mining
	Local	Effects occurring mainly within the MPB
	Regional	Effects extending outside the air quality MPB but within the air quality RSA
	Provincial	Effects extending outside the air quality RSA
Duration of Impact	Short-term	Predicted impact ends after the construction phase of the Project
	Medium-term	Predicted impact persists to the end of the operational life of the Project
	Long-term	Predicted impact is measurable for more than two years beyond the end of the operational life of the Project
Frequency	Accidental	Effects occurring rarely over assessment period
	Isolated	Effects confined to a specified period (*e.g.* construction)
	Seasonal	Effects occurring seasonally
	Occasional	Effects occurring intermittently and sporadically over assessment period
	Periodic	Effects occurring intermittently but repeatedly over assessment period (*e.g.* routine maintenance activities)
	Continuous	Effects occurring continually over the duration of the Project
Reversibility (ability to recover)	Reversible in short-term	Effects which are reversible and diminish upon cessation of activities
	Reversible in long-term	Effects which remain after cessation of activities but diminish with time
	Irreversible	Effects which are not reversible and do not diminish upon cessation of activities and do not diminish with time
Probability of Occurrence	Low	Unlikely
	Medium	Possible or probable
	High	Certain
Confidence Rating	Low	Based on incomplete understanding of cause-effect relationships and incomplete data pertinent to study area

Table 2.5-2 Evaluation Criteria for Characterizing Residual Effects

Criteria	Criteria Definition	
	Moderate	Based on good understanding of cause-effect relationships using data from elsewhere or incompletely understood cause-effect relationship using data pertinent to study area
	High	Based on good understanding of cause-effect relationships and data pertinent to study
Impact Rating	Not Significant	Effects of the project are not predicted to cause irreversible changes to the integrity of the air quality
	Significant	Effects of the project are predicted to cause irreversible changes to the integrity of the air quality

2.5.3 Model Approach

2.5.3.1 Choice of Dispersion Model – CALPUFF

In accordance with recent modelling practice, the CALMET and CALPUFF models were used in the air quality assessment. These models are described in Scire *et al.* (2000) and Scire and Escoffier-Czaja (2004), and are recommended models by AEP (AESRD 2013b). The major reasons for the use of the CALMET/CALPUFF model set include the following:

- it is applicable to spatial scales ranging from a few kilometres to more than 100 km;
- it includes wet and dry removal processes (deposition);
- it includes both SO_2 and NO_X chemistry that is required to predict PAI;
- wind speed and wind direction vary in three spatial dimensions and time providing for a more realistic simulation of plume movement. To allow for this movement, the emissions are represented by a series of puffs;
- it is based on sound, openly documented physical principles that have undergone independent review; and
- the most recent version of the program was used for this assessment and incorporates the PRIME downwash algorithms.

Modelling parameters associated with CALPUFF and CALMET are presented in Appendix B.

2.5.3.2 General Approach

The model set applied in the Project is similar to those applied in recent and current assessments undertaken in Alberta. Some features of the modelling approach included the following:

- Receptor grid spacing ranged from 20 m to 1 km and was most dense near the Project emission sources following AEP model guidance (AESRD 2013b). One kilometre spacing was used in areas of the domain farther from the major sources. Twenty metre spacing was used along the Project pit limit. Receptors were removed within the pit limit, as it is expected that no public access would be available in this space. Predictions were made at receptors between the pit limit (*i.e.*, the edge of the disturbed area) and the MPB even though this area is subject to controlled access.
- 3-D meteorological data were provided in the form of Penn State Mesoscale Model version 5 (MM5) model output for the years 2002 to 2006, as provided by Alberta Environment.
- The dispersion model was applied to the four assessment scenarios. Predictions were made at specific locations in the region as listed in Table 2.5-3 and shown on Figure 2.3-1. Five special (R9 to R13) were located near Grassy Mine Permit Boundary and six special receptors (R1, R3, R6-R7, and R14) were located near communities. Maximum points of impingement (MPOI) concentration in the RSA and LSA were based on modelling within the grid of receptors.

Table 2.5-3 Location of Special Receptors

Receptor	Description	UTM-E [m]	UTM-N [m]
R1	Lost Lemon Campground	683,303	5,498,852
R2	Trapper's Cabin #1	685,018	5,514,269
R3	Residential #1	678,712	5,501,481
R4	Residential #2	693,350	5,519,213
R5	Residential #3	693,409	5,515,330
R6	Coleman	680,262	5,501,388
R7	Frank	687,770	5,497,670
R8	Blairmore North	684,940	5,498,786
R9	Aboriginal (traditional land use)	683,782	5,504,555
R10	Residential #4	687,336	5,507,081

Table 2.5-3 Location of Special Receptors

Receptor	Description	UTM-E [m]	UTM-N [m]
R11	Trapper's Cabin #2	687,682	5,510,209
R12	Residential #5	688,191	5,503,649
R13	Residential #6	687,984	5,505,267
R14	Blairmore Center	684,745	5,498,200

2.5.3.3 Approach for Nitrogen Oxides

Of several potential methods available for use, an ozone limiting approach estimated nitrogen dioxide (NO_2) concentrations from NO_X emissions.

Oxides of nitrogen (NO_X) are comprised of nitric oxide (NO) and nitrogen dioxide (NO_2). High temperature combustion processes primarily produce NO that in turn can be converted to NO_2 in the atmosphere through reactions with tropospheric ozone:

$$NO + O_3 \rightarrow NO_2 + O_2$$

Conversion of NO_X to NO_2 is estimated using the AEP recommended Ozone Limiting Method (OLM) (AESRD 2013b), which has been established through the consideration of lowest observable effect level on a sensitive receptor. This method states that if the ambient ozone concentration is greater than 90% of the predicted NO_X, then it is assumed that all the NO_X is converted to NO_2. Otherwise, the NO_2 concentration is equal to the sum of the ozone and 10% of the predicted NO_X concentration.

$$\text{That is: if } [O_3] > 0.9\ [NO_X]\text{, then } [NO_2] = [NO_X]$$

$$\text{Otherwise, } [NO_2] = [O_3] + 0.1\ [NO_X]$$

AEP's recommended hourly time-series ozone concentrations for rural locations were used in the conversion (AESRD 2013b). In this approach, NO_X background concentrations are added to the NO_X concentrations before they are converted to NO_2 using the OLM method and then compared to the AAAQOs.

AEP requires that if the OLM method is used, NO_2 concentration results assuming total conversion of NO_X to NO_2 also be presented.

2.5.4 Representative Model Predictions

The following comments are made with respect to representative predictions for this project:

- Modelling for the Project was performed on the basis of expected maximum emission rates. As such, predictions represent maximum expected concentration and deposition.
- Dispersion model results are typically viewed as reasonably replicating dispersion processes if concentrations are predicted within a factor of two, and if maximum concentrations are predicted under the same meteorological conditions that monitoring maximums are observed.
- Confidence in model predictions is considered reasonable if the maximum predicted concentration that may occur at a given time somewhere within a given area is within the 10% to 40% of the measured maximum value (U.S. EPA 2003a).
- Measured background concentrations were added to model predictions for CACs to represent the effect of distant industrial and all natural sources. Background values of PAI (Cheng 2009) were also added to model predictions to ensure conservative estimates were presented.
- Background values were also included for VOC, PAH and metal calculations. However, background measurements, which were available from locations influenced by industry and transportation, were not considered representative of naturally occurring sources near the Project (see Appendix C).
- While commonly accepted emission factors (*e.g.*, AP-42) are used for combustion emission estimates of VOCs and PAHs, emission factors are developed using a limited number of tests/observations under conditions which may vary from those of the Project operations. Similarly, many assumptions are employed in estimating fugitive metal emissions resulting in a higher level of uncertainty associated with the emissions.

Finally, dispersion models are generally designed to accurately but conservatively predict concentration and deposition so that practitioners can apply model results with the understanding that effects are unlikely to be underestimated. Appendix B provides switch settings of the CALMET and CALPUFF dispersion models.

2.5.5 Model Limitations

Dispersion models simplify the processes associated with atmospheric motions and turbulence. This simplification limits the capability of a model to replicate individual events. The predictive strength of the model lies in the capability to predict an ensemble average for a given set of meteorological conditions.

Factors that limit the predictive capability of a model to replicate observations are limitations in the input data and information used by the modeller.

3.0 SUMMARY OF AIR QUALITY AND METEOROLOGICAL OBSERVATIONS

3.1 Air Quality

Air quality observations at select stations in in the Calgary Regional Airshed Zone (CRAZ), the Alberta South Saskatchewan River Planning (SSRP) area and southeastern British Columbia are presented in Appendix C. These observations are summarized here to provide context for dispersion modelling results that form the basis of the baseline assessment.

Appendix C also compares measurements at other locations in Alberta that were considered to represent background conditions. These locations were largely downwind of other coal mines west of Edmonton, in the same way that the Project is downwind of coal mines in southeastern B.C. The comparison indicated that the measurements from southern Alberta and southeastern B.C. are similar to those west of Edmonton and therefore represent local baseline conditions as well as measurements west of Edmonton. Appendix C should be consulted for further details. Appendix C also provides initial results of the monitoring conducted by Benga near the Project and in the community in 2016.

Air contaminant concentrations measured in the region, and considered to reasonably represent background conditions in the Project area, are summarized in Table 3.1-1. The Devon Coleman station is located within the RSA, with the remaining stations located outside the modelling domain (Figure 2.3-1). The Devon station operated until October 2012. The Castlegar B.C. Zinio Place, Nelson B.C. Kutenai Place and Lethbridge stations are located approximately 195 km southwest, 225 km southwest and 100 km east of the Project, respectively. The Castlegar station is located within the primarily residential area of Castlegar, with air quality influenced by two pulp mills. The Nelson station is in a residential area of Nelson, with no industrial sources nearby. The Lethbridge station is positioned in the northwestern part of the city, surrounded mainly by food and agricultural processing facilities.

SO_2 measurements in Castlegar are higher than the two Alberta stations, potentially due to nearby industrial emissions. Maximum daily and 30-day concentrations were 10 times higher than measurements at Lethbridge and Devon Coleman, and both exceed AAAQOs. At Lethbridge, the 1-hour maximum O_3 values exceeded the AAAQO of 160 $\mu g/m^3$ once in the five year period. This O_3 exceedance occurred in September.

No exceedances of either the NO_2 or CO AAAQO were measured in the region. Maximum daily particulate ($PM_{2.5}$ and PM_{10}) values were high at all stations as the data reported includes measurements during periods of forest fire activity. The exceedances due to fire activity are summarized in Appendix C.

The ambient measurements which were used as background values are presented in Table 4.4-1. The Lethbridge air quality monitoring station was chosen based on its proximity to the Project and because it measures most parameters of interest. The Nelson station is expected to be representative of rural concentrations of $PM_{2.5}$ and PM_{10} distant from the mine location.

Table 3.1-1 Summary of Air Contaminant Concentrations Measured in the Region, 2009 to 2014

Compound	Devon Coleman	Lethbridge	Castlegar Zinio Place	Nelson Kutenai Place	AAAQO/ CAAQS [µg/m^3]
Province	**AB, within RSA**	**AB**	**BC**	**BC**	
Date Period[(a)]	Jan. 1, 2012 – Aug. 23, 2012	Jan. 1 2010 – Dec. 31, 2014	Jul. 2011 – Dec. 31, 2013	Jan. 1, 2009 – Dec. 31, 2013	
			SO_2		
1-hour Maximum	102	84	288	n/a	450
1-hour 90th Percentile	5.2	2.6	26	n/a	–
24-hour Maximum	11	11	128	n/a	125
24-hour 90th Percentile	5.4	2.1	24	n/a	–
30-day Maximum	3.1	2.7	38	n/a	30
30-day 90th Percentile	2.8	1.0	18	n/a	–
Annual Maximum	n/a	1.0	9.5	n/a	20
Annual 90th Percentile	n/a	0.9	9.4	n/a	–
			NO_X		
1-hour Maximum	n/a	495	n/a	n/a	–
1-hour 90th Percentile	n/a	32	n/a	n/a	–
Annual Maximum	n/a	17	n/a	n/a	–
Annual 90th Percentile	n/a	17	n/a	n/a	–
			NO_2		
1-hour Maximum	n/a	107	62	n/a	300

Table 3.1-1 Summary of Air Contaminant Concentrations Measured in the Region, 2009 to 2014

Compound	Devon Coleman	Lethbridge	Castlegar Zinio Place	Nelson Kutenai Place	AAAQO/ CAAQS [μg/m³]
Province	**AB, within RSA**	**AB**	**BC**	**BC**	
Date Period[(a)]	Jan. 1, 2012 – Aug. 23, 2012	Jan. 1 2010 – Dec. 31, 2014	Jul. 2011 – Dec. 31, 2013	Jan. 1, 2009 – Dec. 31, 2013	
1-hour 90th Percentile	n/a	24	25	n/a	–
Annual Maximum	n/a	11	12	n/a	45
Annual 90th Percentile	n/a	11	12	n/a	–
CO					
1-hour Maximum	n/a	2,634	1,489	n/a	15,000
1-hour 90th Percentile	n/a	344	573	n/a	–
8-hour Maximum	n/a	1,002	716	n/a	6,000
8-hour 90th Percentile	n/a	301	515	n/a	–
$PM_{2.5}$[(b)]					
1-hour Maximum	n/a	230	n/a	104	80
1-hour 90th Percentile	n/a	15	n/a	8.0	–
24-hour Maximum	n/a	115	n/a	49	30
24-hour 90th Percentile	n/a	12	n/a	6.8	–
Annual Maximum	n/a	7.8	n/a	4.1	10
Annual 90th Percentile	n/a	7.6	n/a	4.0	–
PM_{10}[(b)]					
24-hour Maximum	n/a	n/a	65	80	50
24-hour 90th Percentile	n/a	n/a	21	21	–
O_3					
1-hour Maximum	n/a	163	132	128	160
1-hour 90th Percentile	n/a	8 8	69	73	–
8-hour Maximum	n/a	131	59	56	–

Table 3.1-1 Summary of Air Contaminant Concentrations Measured in the Region, 2009 to 2014

Compound	Devon Coleman	Lethbridge	Castlegar Zinio Place	Nelson Kutenai Place	AAAQO/ CAAQS [μg/m³]
Province	**AB, within RSA**	**AB**	**BC**	**BC**	
Date Period[a]	Jan. 1, 2012 – Aug. 23, 2012	Jan. 1 2010 – Dec. 31, 2014	Jul. 2011 – Dec. 31, 2013	Jan. 1, 2009 – Dec. 31, 2013	
4th highest 8-hour	n/a	115	50	54	128

[a] Source: CASA 2014, NAPS 2014

[b] Maximum $PM_{2.5}$ and PM_{10} values include seasonal influence of forest fires.

– No air quality objective for this averaging period.

n/a Data not available for this monitoring station.

3.2 Key Meteorological Parameters

Meteorological observations in the RSA are presented in Appendix C. These observations are summarized here to provide context for dispersion modelling results that form the basis of the assessment.

Winds play an important role in determining air quality. Wind roses for 2002 to 2006 near the Project north mine area and south disposal area, based on the CALMET interpolation of MM5 winds, are shown on Figure 3.2-1. These winds were used in dispersion modelling and show that winds at the Project site are predominately from the west and northwest. In addition, Benga conducted field measurements of winds at two locations near the Project during the summer and fall of 2014. The wind roses from the two on-site locations (Appendix C) are shown in Figure 3.2-2. While the CALMET wind rose is not from the same measurement period, the comparison demonstrates that wind directions are determined by the terrain in the vicinity of the stations.

Atmospheric stability controls dispersion of plumes. Stable atmospheres, most common at night and in winter, limit dispersion and enhance the channelling effects of terrain on the low-level emissions associated with the Project. Unstable conditions result in greater mixing. Pasquill-Gifford (PG) stability classes A (very unstable) to E (very stable) are shown on Figure 3.2-3 and are based on the output from the CALMET meteorological model for the period 2002-2006. Unstable conditions occur most often in spring and summer, and during midday.

Mixing heights determine the extent to which emitted plumes are mixed in the vertical. Seasonal mixing heights derived from CALMET model output data near the Project are shown on Figure 3.2-4. Median mixing heights range from near 500 to 800 m during winter, to around 1,500 and 2,000 m during spring and summer afternoons respectively. Mixing heights show substantial diurnal variation in spring and summer, with the largest values in the afternoon due to thermal effects, and values near 200 m at night due to mechanical turbulence. These median mixing heights were assumed to be representative of the study area. Mixing heights are less important for near-surface emissions from the Project than they would be for tall stack sources.

4.0 SUMMARY OF EMISSIONS

4.1 Emissions Overview

The Project will produce average 4.5 million tonnes (Mt) of clean metallurgical coal annually for export overseas. The objective of the mine plan is to balance the removal of the overlying waste rock above the coal (overburden) with a continuous source of coal, economically over the life of the mine. The mine life for the Project is estimated to be 24 years (from 2019 to 2041).

Based on the mine plan provided by Benga, Year 19 of mining was chosen for modelling as it represents the highest emission potential, with approximately 47.5 million BCM overburden removal and comparatively long haul roads. The annual coal production in Year 19 was approximately 6.8 Mt of raw coal and 3.8 Mt of clean coal.

The mine will consist of a series of pits that will be developed to maintain the balance of overburden removal and production of coal. The proposed overburden mining was assessed using hydraulic waste shovels and end disposal area trucks. All overburden will require drilling and blasting, using ANFO as the primary blasting agent. The overburden material will be placed in disposal areas outside of the pit areas (both to the north and south of the main pit) and as well as in-pit disposal. Coal removal will also be conducted by diesel powered equipment consisting of dozers, backhoes and end dump trucks.

Coal from the open pit mining operations will be trucked to the run of mine (ROM) raw coal dump station at the Coal Handling Process Plant (CHPP) using large scale mining trucks. The CHPP will consist of the raw coal, reject coal, and product coal material handling components and a coal processing plant (CPP) module, where it will placed through a series of screening, cleaning, and mechanically dewatering. The CPP will be contained within a housed area and all coal material handling will be *via* covered conveyors. The reject material from the CPP will be dumped in an enclosed bin and later be trucked back into the mine for proper disposal.

The final coal product will be sent to the product coal stockpiles, where it will then be conveyed overland (*via* a covered conveyor) to the housed train load-out facility located near the existing Canadian Pacific (CP) railway track located near the Town of Blairmore, Alberta.

4.2 Project Criteria Air Contaminant Emissions

4.2.1 Basis of Emissions

Project emissions result from mining operations such as the combustion of fuel sources during drilling, blasting, bulldozing, loading and hauling; and dust generation from travel on haul roads:

- Two Coal Mining Areas – bulldozing and loading of coal;
- Two drilling Areas – drilling, blasting of rock;
- Three Waste Removal Areas –bulldozing, and loading of overburden;
- Two Waste Disposal area Areas – unloading and bulldozing of overburden;
- Three Overburden Hauling Roads – Two-way hauling of overburden from waste removal area to disposal area;
- Two Coal Hauling Roads – Two-way hauling of raw coal from coal mining area to Plant (including backhauling rejects);
- One Reclamation Area – loading topsoil from pile, unloading and bulldozing of topsoil at reclamation area;
- Plant Area – loading and unloading at raw coal pile, conveyor unloading and bulldozing at the clean coal pile;
- Train Loadout –unloading clean coal to train rail cars; and
- All open activity areas - wind driven emissions from the piles, mining and strip area, and haul roads.

Table 4.2-1 summarizes area emission sources for the Project.

Table 4.2-2 summarizes equipment which will be used in mines and coal processing facility operations. Equipment were based on information provided by Benga in April 2016. However, exhaust emissions were based on engine power rating and engine units required to meet estimated coal and waste volumes, and dust emissions were based on total annual coal production and waste volume. Slight differences in equipment will not change the conclusions of the assessment.

Table 4.2-1 Project Emission Sources

Location	Operations	Modelled Area Sources	Total Modelled Area (ha)
Mining Area			
Drilling	Drilling and blasting of overburden/rock	2	12
Waste Stripping	Bulldozing and loading of overburden	3	31.5
Coal Seam	Bulldozing and loading of coal	2	15
Overburden Haul Roads	Hauling of overburden to North and South Disposal areas	3	28
Coal Haul Road	Hauling of raw coal from coal seam to Plant ROM Pile and backhauling rejects	2	32
Waste Disposal area	Unloading and bulldozing of overburden from Waste Strip and coarse refuse from Plant	2	42.5
Reclamation Area			
Reclamation	Unloading and bulldozing of topsoil	1	20
Plant			
CHPP	Support diesel equipment at the plant site. No emissions from the housed CHPP module.	-	-
ROM Pile	Dumping of coal from haul trucks; wheel loader loading coal from ROM Pile to breaker feeder	1	4.5
Clean Coal Pile	Dumping of clean coal onto clean coal pile (stacker), and bulldozing of clean coal	1	4.8
Train Loadout			
Loadout	Loading of clean coal to train rail cars by conveyor	1	0.25

Table 4.2-2 Parameters of Diesel Powered Equipment

Equipment Category	Power Rating (hp)	Hours/ year/engine	Scheduled Fleet Units
Mine – Overburden/Waste Strip Fleet Area 1 (hauling to south dump)			
Blast Hole Drill	760	8,218	1
Backhoe (394t)	1,875	5,484	1
Haul Truck (220t)- to south dump	2,650	6,930	7
Bulldozer (664 kw)	850	6,465	2
Wheel dozer (49t) - at waste shovel	523	4,433	1
Water Truck	900	3,099	1
Mine – Overburden/Waste Strip Fleet Area 2 (hauling to south dump)			
Waste Shovel	2,520	5,828	1
Haul Truck (220 t) - to south dump	2,650	6,930	6
Bulldozer (664 kw)	850	6,465	1
Mine – Overburden/Waste Strip Fleet Area 3 (hauling to north dump)			
Blast Hole Drill	760	8,218	1
Waste Shovel	2,520	5,828	1
Haul Truck (220t)- to north dump	2,650	6,930	7
Bulldozer (664 kw)	850	6,465	2
Wheel dozer (49t) - at waste shovel	523	4,433	1
Motor Grader (7.5m) - between shovel and north dump	533	849	1
Blast Hole Drill	760	8,218	1
Mine – Coal Mining Fleet Area 1 (hauling to ROM stockpile)			
Backhoe (394t)	1,875	5,484	1
Haul Truck (220t) - hauling to ROM stockpile	2,650	6,930	6
Bulldozer (391 kw)	600	5,979	1
Motor Grader (7.5m)	533	849	1

Table 4.2-2 Parameters of Diesel Powered Equipment

Equipment Category	Power Rating (hp)	Hours/ year/engine	Scheduled Fleet Units
Mine – Coal Mining Fleet Area 2 (hauling to ROM stockpile)			
Backhoe (394t)	1,875	5,484	1
Haul Truck (220t) - hauling to ROM stockpile	2,650	6,930	6
Bulldozer (391 kw)	600	5,979	1
Water Truck - working between Coal Area 2 and ROM	900	3,099	1
Reclamation Area			
Backhoe (122t) - topsoil salvage in various locations	672	5,750	1
Articulated Trucks (37t) - hauling topsoil to/from stockpiles	489	161	2
Bulldozer (391 kW) salvaging topsoil	600	5,979	1
ROM/Clean Stockpile			
Haul Truck (220t) - unloading at stockpile, backhauling rejects	2650	6,930	1
Wheel Loader (218t) - at ROM stockpile	1765	5,753	1
Bulldozer (391 kW) at Clean Coal Pile	600	5,979	1
Train Load-out			
P42DC Locomotive at Train Load-out	4,250	2,832	1
Support Equipment/Other (throughout mine site)			
Lowboy - equipment hauler, no fixed location	2,100	471	1
Skid steer loader	73	5,783	1
Compactor	405	4,565	1
Portable Diesel Pumps	125	5,969	10
Rough Terrain Crane (250t)	550	2,344	1
Forklift(14t) - in shop area	164	1,126	1
Forklift(4t) - in shop area	100	1,126	1
Light Plant - nightshift only	12	2,637	10
Ford F-750 Fuel Truck	362	4,692	1
Mechanic/welding Truck	440	5,787	1
Heavy Duty Service Truck	440	4,889	2

Table 4.2-2 Parameters of Diesel Powered Equipment

Equipment Category	Power Rating (hp)	Hours/ year/engine	Scheduled Fleet Units
Light duty service truck	385	4,889	2
Pumpers Truck	440	8,208	2
Welding Machines	45	1,126	4
Crew Vehicle	255	2,722	4
Pickup - 7 Days/Week	365	3,911	22

4.2.2 Criteria Air Contaminant Emission Summary

The sources for emission factors used in this assessment are as following:

- SO_2 emission factors for diesel combustion were taken from U.S. EPA AP-42 – Table 3.4-1 (Large Stationary Diesel), (U.S. EPA 1996) and calculated using ultra low sulphur diesel (15 ppm). The SO_2 emission factor is independent of the engine age (Tier) and equipment and is 0.0055 g/hp-hr (0.0074 g/kWh), dependent only on the sulphur content in diesel.
- The diesel combustion emission factors for NO_x, CO and PM were taken from the NONROAD Engine Model (U.S. EPA 2010). Particulates emitted by diesel fired equipment are so small that PM_{10} and TSP emissions are equal, and assumed to be 103% of $PM_{2.5}$ emissions.
- Combustion and dust emissions from blasting were calculated using blasting emission factors (Roy *et al.*, 2010, NPI 2012, and NPI, 1999).
- Fugitive dust emissions from all other pit operations were estimated using AP-42 emission factors from Chapter 11 (Mineral Production Industry) and Chapter 13 (Miscellaneous Sources).

Details of emission equations and calculations as well as assumptions are presented in Appendix A. For the Project case, Maximum Hourly Emission and Maximum Daily Emission scenarios were assessed. Emissions from diesel combustion were estimated and modelled separately from dust emission from mine pit activities.

The Maximum Hourly Emission Scenario assumed that all Project activities overlap at the maximum hourly emissions:

- Hourly exhaust emissions of SO_2, NO_x, CO and $PM_{2.5}$ were based on engine power rating, load factor and number of engines.

- Dust emissions were based on total annual coal production and waste volume, and the number of annual working hours for each activity.

However, for daily and annual average predictions, emissions were spread over 24 hours and 354 days. To be conservative, precipitation was not considered to reduce annual fugitive dust emissions.

Table 4.2-3 summarizes maximum hourly and daily emissions from Project diesel fuel combustion. The table indicates that ANFO used in blasting is a major source of SO_2, NO_X, and CO emissions. Blasting was conservatively modelled each day; instead of on the 265 days per year, that blasting is expected in Year 19, to ensure worst-case meteorological conditions could occur simultaneously with blasting.

Table 4.2-4 summarizes maximum hourly and daily fugitive dust emissions generated from Project activities, except wind driven dust emissions. The table indicates that dust emission from wheel entrainment is a major source of PM emissions. Haul roads will be regularly watered in summer, reducing dust emissions from wheel entrainment by 80% (*e.g.* Luscar, 1999). Winter dust emissions from haul roads were reduced by 90% as the roads will be covered by snow and/or frozen. Thus, the dust emissions from haul roads in winter were modelled as 50% of the values listed Table 4.2-4. According to climatological data, periods of snow cover extend from October to April in the Project area.

It was assumed that, for all other sources, winter and summer emissions from mine operations are equal. Winter emission reduction effects (snow and freezing ground) were assumed to be insignificant for material excavated from the mine pit.

The use of escape fractions (fraction of particulate escaping from the pit to surroundings) will reduce dust PM emissions (Appendix A, Section A4.11). As mine pit and disposal area areas as well as haul roads of the Project will be located at higher elevations in comparison to surround area. Thus, to be conservative, escape fractions were not used to reduce PM dust emissions for the Project.

Table 4.2-5 summarizes Year 19 Project maximum hourly and daily CAC emissions, including both diesel fuel combustion and fugitive dust emissions.

Table 4.2-3 Maximum Hourly and Daily Emissions from Project Diesel Fuel Combustion								
Project Activity	**Maximum Hourly Emission (kg/h)**				**Maximum Daily Emission (kg/d)**			
	SO_2	**NO_x**	**CO**	**$PM_{2.5}$**	**SO_2**	**NO_x**	**CO**	**$PM_{2.5}$**
Coal Mining	0.05	8.6	0.56	0.10	0.8	164	10.2	1.9
Waste Removal	0.15	34	1.89	0.39	2.7	640	34	7.3
Haul Road	0.25	48	3.32	0.58	4.1	846	53	10.0
Disposal area	0.10	25	1.25	0.28	1.9	483	24	5.4
Reclamation	0.01	0.3	0.19	0.01	0.1	2.4	2.0	0.1
Plant	0.04	10	0.53	0.11	0.7	187	9.5	2.1
Train Loadout	0.02	0.89	1.6	0.01	0.2	7.1	13	0.1
Blasting	7.1	394	1,394	-	7.1	394	1,394	-
Total	**7.7**	**521**	**1,403**	**1.5**	**18**	**2,724**	**1540**	**27**

Table 4.2-4 Maximum Hourly and Daily Fugitive Dust Emissions from Project Activities						
Project Activity	**Maximum Hourly Emissions (kg/h)**			**Maximum Daily Emissions (kg/d)**		
	$PM_{2.5}$	**PM_{10}**	**TSP**	**$PM_{2.5}$**	**PM_{10}**	**TSP**
Coal Mining	0.3	1.6	4.7	5.0	29	83
Waste Removal	1.2	5.1	13.8	21	96	252
Haul Road	15	149	597	256	2,556	10,251
Disposal area	0.4	1.6	4.7	7.6	32	89
Reclamation	0.2	2.0	5.0	2.6	13	39
Plant	0.2	3.7	9.2	2.7	54	139
Train Loadout	0.03	1.0	2.0	0.3	7.6	16
Blasting	1.1	19	37	1.1	19	37
Total	**18**	**183**	**673**	**296**	**2,807**	**10,905**

Table 4.2-5 Summary of Project Daily CAC Emissions in Year 19

Sources	Emission Rate					
	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Maximum Hourly Emission (kg/h)						
Mine and Plant Operation	0.60	126	7.7	19	164	636
Train Loadout	0.02	0.89	1.6	0.05	0.97	2.0
Blasting	7.1	394	1,394	1.1	19	37
Total	7.7	521	1,403	20	185	675
Maximum Daily Emission (kg/d)						
Mine and Plant Operation	10.4	2,322	134	321	2,807	10,880
Train Loadout	0.2	7.1	13	0.4	7.7	16
Blasting	7.1	394	1,394	1.1	19	37
Total	18	2,724	1,540	323	2,834	10,933

Table 4.2-6 summarizes CAC annual emissions in Year 19 and total emissions over the life of the Project. Annual emissions in Year 19 are obtained by multiplying maximum daily emissions in Table 4.2-5 by the number of working days (354 days for mine and plant operations, 274 days for train loadout, and 265 blasting days in Year 19).

The assessed total overburden removal in Year 19 is 47.5 million BCM, about 5.7% of total overburden removal over the life of the Project which is expected to be 833.5 million BCM. Total CAC emissions over the life of the Project are scaled from annual CAC emissions in Year 19, based on the total overburden removal volume.

Table 4.2-6 Summary of Year 19 and Lifetime Project Emissions

Sources*	Emission (tonnes)					
	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Year 19 Emissions	5.6	929	420	114	1,001	3,866
Lifetime Emissions	98	16,304	7,378	2,003	17,578	67,880

*does not include wind driven emissions

4.2.3 Wind Driven Fugitive Emissions

For wind driven emissions from active areas of operation (aggregate pits, overburden removal strip, unpaved haul roads, and from stockpiles), the emission factor formula was obtained from Environment Canada Pits and Quarries Guidance (EC 2009). Table 4.2-7 summarizes wind driven emissions from Project operations on the worst windy day, with 24 hours of winds above 5.36 m/s. Wind driven emissions based on the approximate actively disturbed area for each operation. Details of emission calculations are presented in Appendix A, Section A4.9.

Table 4.2-7 Wind Driven Emissions on the Windiest Day in Five Years of Meteorological Data

	Disposal Area	Coal Mine Area	Waste Strip Area	Reclamation Area	Unpaved Haul Road	Coal Pile	Total
Actively Disturbed Area (ha)	4.3	1.5	4.4	2.0	18	4.7	35
Maximum Emissions (kg/24 hour day)							
$PM_{2.5}$	52	11	53	24	44	26	211
PM_{10}	129	29	132	61	110	66	527
TSP	258	57	264	122	220	132	1054

Even though wind driven emissions at night would be lower due to reduced operational activity (disturbance), wind driven emissions from active area and stock piles were modelled 24 hours each day for 365 days a year for hourly winds above 5.36 m/s.

To conservatively assess wind driven emissions, precipitation was not considered to reduce annual wind driven emissions from the actively disturbed area.

4.2.4 Construction Emissions

To comply with the terms of reference (ToR), construction emissions were determined by pro-rating the emission rates of CACs from the Project mine and plant operation emissions using the ratio of material moved during the plant construction to the material moved during the peak year of the Project.

The construction of mine and plant includes earthworks for following:

- CHPP earthworks includes platforms from ROM pad to product stockpile in CHPP;

- Mine access road includes access road from Highway 3 to the start of the mine/overland conveyor access road; and
- Mine/overland conveyor access road.

Including waste rock mined during construction phase, the total material handled during the plant construction is about 2.9 million BCM, based on information provided by Benga in April 2016. It was further assumed that the density of the material moved was equal to that of gravel, which is approximately 2.1 t/m^3. The total mass of the material moved during the plant construction is estimated to be 6.0 Mt, which is approximately 5.5% of the total 109 Mt annual waste overburden volume in Year 19 (Appendix A, Table A3-1). Therefore, the plant construction CAC emissions were scaled from maximum daily emissions from mine and plant operation in Year 19 (as shown in Table 4.2-5). Emissions for the rail loadout and blasting in Year 19 were excluded from the estimation of the construction emissions. Table 4.2-8 summarizes estimated total plant construction emission, comparing to operations emissions in Year 19.

The total mass of material handled is likely conservative since the density of gravel is higher than that of soil (1.4 to 1.7 t/m^3). However, it is anticipated this additional mass should cover any activities not accounted for in this estimate such as earthworks for culverts and ditches. These unaccounted activities are expected to be small compared to the total estimate listed below.

Table 4.2-8 Project Construction and Operations Emissions in Year 19 [(a)]

Description	SO_2	NO_X	CO	$PM_{2.5}$	PM_{10}	TSP
Operation Emissions in Year 19 (t)	5.6	929	420	114	1,001	3,866
Construction Emissions (t)[(b)]	0.2	45	2.6	6.3	55	213
Ratio of Construction to Operations [%]	3.6	4.9	0.6	5.5	5.5	5.5

[(a)]Wind driven emissions not included
[(b)]Scaled from maximum daily emissions from mine and plant operation in Year 19 (Table 4.2-5) with 5.5% ratio.

Haul roads are expected to undergo ongoing extension during operations. Haul road construction activities will take place concurrently with Project operations, and it is expected that operational vehicle activity indicators already include concurrent construction activities.

Reclamation emissions were assumed to be equal to construction emissions and also occur concurrently with mining activities and have already been accounted for in the emissions described in Table 4.2-5.

4.3 Project Greenhouse Gas Emissions

4.3.1 Operations

There are two primary sources of direct GHG emissions for the Project:

- Fugitive emissions of coal bed methane;
- Diesel combustion in the mine fleet and haul vehicles.

There is also propane combustion for space heating requirements but the contribution of this component to the total GHG emissions from the Project is negligible. As such, only the two primary direct GHG sources described were included, as well as indirect GHG emissions from electricity purchases.

Fugitive methane emissions from surface coal mining were estimated as 0.87 t/kt of coal production, using emission factors provided by the Intergovernmental Panel on Climate Change (IPCC 2006). GHG emission estimates for diesel combustion are based on the amount of fuel consumed and Environmental Canada emission factors. The GHG emissions associated with electricity consumption is based on the electricity generation intensity for Alberta of 930 g CO_2e/kWh (EC 2015). Further details about these emission factors along with sample calculations are provided in Appendix A, Section A8.0.

A summary of direct annual GHG emissions for the Project from both fugitive and combustion sources as well as electricity consumption is shown in Table 4.3-1.

Table 4.3-1 Project Total GHG Emissions in Year 19 and Over the Life of Project

Source	GHG Emissions in Year 19 (kt CO_2e)	Lifetime GHG Emissions (kt CO_2e)
Fugitive Methane	70	1,692
Diesel Combustion	172	4,139
Electricity Consumption	120	2,896
Total	362	8,727

The maximum equivalent CO_2 emissions from the Project were estimated to be 362 kt/year in Year 19. According to Environment Canada (2015), total national GHG emissions were 726 Mt in 2013 and Alberta's share was 36.8% or 267 Mt. Direct GHG emissions of the Project in Year 19 will be approximately 0.14% of 2013 Alberta GHG emissions and 0.05% of national emissions.

The total GHG emission over the life of the Project is 8,727 kt, also scaled from annual GHG emissions in Year 19, based on total coal production.

4.3.2 Construction

To estimate GHG emissions solely from construction activities, the same approach for construction CAC emissions in Section 4.2.4 was taken. That is, plant construction emissions were estimated by pro-rating the peak GHG emissions from the overall Project using the ratio of material handled during the construction to the material handled during the peak year of the Project.

The annual GHG emission during the plant construction is estimated to be 20 kt CO_2e, approximately 5.5% of the overall Project annual 362 kt CO_2e GHG emissions in Year 19.

Reclamation activities largely occur concurrently with mining activities and have already been accounted for in the GHG assessment for the peak operations of the Project (see previous discussion in Section 4.3.1).

4.4 Regional CAC Emissions

4.4.1 Industrial Emissions

The only industrial facility located within the RSA is the Devon Canada Coleman sour gas plant. According to information obtained from 2012 NPRI data (NPRI 2014), the gas plant ceased operations permanently in 2012 and as such was not included in modelling.

Emissions from facilities outside the RSA and facilities whose emissions are not reported to NPRI were accounted for using background concentrations added to model predictions.

4.4.2 Natural Background

This section presents the concentrations used as background for dispersion modelling purposes. In accordance with *Alberta Air Quality Model Guidelines*, this includes the 90^{th} percentile value from the cumulative frequency distribution for 1-hour and 24-hour predicted averaging periods (AESRD, 2013b). In cases where the 90^{th} percentile for the 1-hour and 24-hour periods were similar, the more conservative value (the 1-hour averaging period) was used as the background value.

For this assessment NO_x, SO_2 and CO from the Lethbridge air quality monitoring station between 2010 and 2014 were used to estimate the background concentrations. Measurements from the Nelson Kutenai station were used for $PM_{2.5}$ and PM_{10}, as this was the closest station with a similar rural setting and thus representative. Table 4.4-1 presents background values for Criteria Air Contaminants. Further details about natural background are provided in Appendix C.

Table 4.4-1 Ambient Background Concentrations for Modelled Criteria Air Contaminants (CACs)

Compounds	Hourly (µg/m³)	8-Hour (µg/m³)	24-Hour (µg/m³)	Monthly (µg/m³)	Annual (µg/m³)	Data Source
SO_2	2.6	-	2.1	1.0	0.9	Lethbridge, 2010-2014[(a)]
NO_x	32	-	-	-	17	Lethbridge, 2010-2014[(a)]
NO_2	24	-	-	-	11	Lethbridge, 2010-2014[(a)]
CO	344	301	-	-	-	Lethbridge, 2010-2014[(a]
$PM_{2.5}$	8.0	-	6.8	-	4.0	Nelson Kutenai, 2009-2013[(b)]
PM_{10}	-	-	21	-	13	Nelson Kutenai, 2009-2013[(b)]
TSP	-	-	42	-	26	2x PM_{10} Background Values

[(a)] CASA 2014
[(b)] NAPS 2014
- No AAAQO for this averaging period, therefore background concentration not required.

4.4.3 Public Road Emissions

Table 4.4-2 lists exhaust and dust emissions from Highway 3 for the Baseline case. Details of emission calculations are presented in Appendix A, Section A9.2.

The emission factor model MOBILE6.2C, which is the Canadian version of the U.S. EPA model (Environment Canada 2004; U.S. EPA 2003b), was used to calculate vehicle exhaust emissions of SO_2, CO, NO_X, as well as particulate matter emissions from vehicle exhaust, brake wear and tire wear.

Fugitive dust emissions were estimated separately using AP-42 emission factors (U.S. EPA 2011 – paved roads) to estimate particulate emissions from re-suspended road surface material. The emissions for each highway segment were calculated from the annual average daily traffic (AADT) counts from 2013 that were obtained from the Alberta Ministry of Transportation (2013, Internet site) and from the length of the individual segment. It was assumed that dust emissions from paved roads are reduced in winter by 90% due to snow and frozen road surfaces.

The assumptions of engine emissions for public roads are expected to be conservative, as more fuel efficient vehicles are expected in the future.

Table 4.4-2 Summary of Emissions from Highway 3

Sources	Emission Rate (kg/d)					
	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Exhaust Emissions from Mobiles Sources	0.84	551	1,865	11	11	11
Fugitive Dust Emissions	-	-	-	22	90	470
Total	**0.84**	**551**	**1,865**	**33**	**102**	**481**

4.4.4 Community Emissions

Four communities in the Crowsnest Pass Sub-Division lying within the RSA (Blairmore, Coleman, Bellevue and Frank) were modelled for the Baseline case. Table 4.4-3 lists total exhaust and road dust emissions from the four communities. Details of emission calculations are presented in Appendix A, Section A9.3.

Table 4.4-3 Summary of Emissions from Four Communities

Sources	Emission Rate (kg/d)					
	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Exhaust Emissions from Heating and Mobiles Sources	6.8	143	1,956	15	16	18
Fugitive Dust Emissions	-	-	-	49	203	1,058
Total	**6.8**	**143**	**1,956**	**64**	**219**	**1,076**

Exhaust emissions were calculated from 2010 NPRI Emissions in Alberta for commercial and residential heating and mobile sources. Assuming 1% of the total emissions in Alberta occurred in census Division No. 15, the community emissions were assigned to the individual communities in the Division No. 15 on the basis of population. Emissions per capita are expected to be lower in Crowsnest Pass Sub-Division as it has fewer commercial and industrial facilities.

Fugitive dust emissions from paved roads inside communities were also estimated using AP-42 emission factors (U.S. EPA 2011 – paved roads), based on the approximate mapped road lengths inside the communities. It was also assumed that fugitive dust emissions from paved roads are reduced in winter by 90% due to snow and frozen road surfaces.

4.4.5 Potential Future Emissions

No potential future industrial developments were identified in the RSA, and community and traffic emissions were assumed to be approximately unchanged.

4.5 VOC, PAH and Metal Emissions

4.5.1 Emission Factors

There are two processes leading to metal emissions from mine operations:

- diesel combustion (mine and plant equipment, hauling trucks, road maintenance);
- metals in overburden, rock, and coal re-suspended as a part of TSP.

Emissions of VOCs and PAHs from diesel combustion were calculated using emission factors taken from as AP-42 Table 3.4-1 (Large Stationary Diesel) (U.S. EPA 1996), as about 90% of diesel fuel is consumed by heavy-duty engines (larger than 600 hp). Combustion $PM_{2.5}$ sources were modelled separately from fugitive sources. Emissions of VOCs and PAHs were scaled from combustion $PM_{2.5}$ emission predictions, based on the multiplier of each species.

Metal emission factors for diesel combustion were based on Health Effects Institute (HEI) (2006). When HEI factors were not available, only the emissions from other sources were considered. Metal content in soil and overburden was measured for the Project. Predictions for metals were scaled from combustion $PM_{2.5}$ and fugitive TSP predictions separately and then summed together.

VOC, PAH, and trace metal emissions are presented in Table 4.6-2 to Table 4.6-4 of following section. Details of emission factors and calculations are presented in Appendix A, Section A6.0 (VOCs and PAHs) and Section A7.0 (Metals).

4.5.2 Natural Background

Background concentrations of VOC, PAH and metals were added to model predictions. However, background measurements, which were available from locations influenced by industry and transportation, were not representative of naturally occurring sources near the Project (see Appendix C).

Background concentrations for individual VOCs and PAHs were obtained from several sources including Alberta Health and Wellness (2003), Alberta Environment (2003, 2004a), *Canadian Environmental Protection Act* (2000, 2001), and the Fort Air Partnership (FAP 2004). VOC and PAH backgrounds are presented in Tables 4.5-1 and 4.5-2.

Averaged 24-hour maximum measurements from the Genesee and Powers stations in west-central Alberta were used as metal background concentration values for both the 1-hour and 24-hour averaging periods. Annual concentrations were derived from these values using the power law as recommended by OMOE (2004) (Table 4.5-3):

$$\text{Annual concentration} = \text{24-hour concentration}*(1/365)^{0.28}$$

Table 4.5-1 Ambient Background Concentrations for Volatile Organic Compounds (VOCs)

Compounds	Hourly (μg/m³)	24-Hour (μg/m³)	Annual (μg/m³)
Acetaldehyde	23.4	12.4	3.81
Acrolein	0.6	0.31	0.18
Benzene	2.34	2.2	0.58
Formaldehyde	27.5	14.6	4.48
Naphthalene	0.149	0.14	0.06
Toluene	11.1	10.4	1.86
Xylenes	0.55	0.52	0.3

Sources: AHW (2003), AENV (2003, 2004a), CEPA (2000, 2001), FAP (2004).

Table 4.5-2 Ambient Background Concentrations for Polycyclic Aromatic Hydrocarbons (PAHs)

Compounds	Hourly (μg/m³)	24-Hour (μg/m³)	Annual (μg/m³)
Acenaphthene	0.000906	0.00048	0.00034
Acenaphthylene	0.00193	0.00181	0.00105
Anthracene	0.000359	0.00019	0.00019
Benzo(a)anthracene	0.000302	0.00016	0.000052
Benzo(b)fluoranthene	0	0	0
Benzo(k)fluoranthene	0.000491	0.00026	0.00025
Benzo(g,h,i)perylene	0.000397	0.00021	0.00007
Benzo(a)pyrene	0.000127	0.000052	0.000010
Chrysene	0.000736	0.00039	0.00011
Dibenzo(a,h) anthracene	0.0000944	0.00005	0.000035
Dichlorobenzene	0.03	0.0159	0.015
Fluoranthene	0.000755	0.0004	0.00031

Table 4.5-2 Ambient Background Concentrations for Polycyclic Aromatic Hydrocarbons (PAHs)

Compounds	Hourly (μg/m³)	24-Hour (μg/m³)	Annual (μg/m³)
Fluorene	0.001	0.00053	0.00026
Indeno(1,2,3-cd)pyrene	0.000359	0.00019	0.000056
Phenanthrene	0.0054	0.00507	0.00294
Pyrene	0.00125	0.00117	0.00068

Sources: AHW (2003), AENV (2003, 2004a, 2004b), CEPA (2000, 2001), FAP (2004).

Table 4.5-3 Ambient Background Concentrations for Metals

Species	1-Hour[a] [μg/m³]	24-Hour[a][μg/m³]	Annual[b] [μg/m³]
Aluminum (Al)	0.502	0.502	0.0962
Antimony (Sb)	0.000797	0.000797	0.000153
Arsenic (As)	0.000653	0.000653	0.000125
Barium (Ba)	0.005985	0.005985	0.00115
Beryllium (Be)	0.000014	0.000014	0.0000027
Cadmium (Cd)	0.000382	0.000382	0.0000732
Cobalt (Co)	0.00739	0.00739	0.00142
Chromium (Cr)	0.00471	0.00471	0.000903
Copper (Cu)	0.0277	0.0277	0.00531
Mercury (Hg)	0.000021	0.000021	0.0000040
Manganese (Mn)	0.00776	0.00776	0.00149
Molybdenum (Mo)	0.000773	0.000773	0.000148
Nickel (Ni)	0.0436	0.0436	0.008357
Lead (Pb)	0.00436	0.00436	0.000836
Selenium (Se)	0.00072	0.00072	0.000138
Thallium(Tl)	0.0000475	0.0000475	0.0000091
Uranium(U)	0.0000225	0.0000225	0.0000043
Vanadium (V)	0.0012	0.0012	0.000230
Zinc (Zn)	0.0156	0.0156	0.00299

[a] Use averaged 24-hour maximum concentrations at Genesee and Power monitoring stations located southwest of Edmonton.
[b] Calculated using 24-hour average concentrations and using 0.28 power law

4.6 Summary of Project and Regional Sources

The emissions for, SO_2, NO_x, CO, $PM_{2.5}$, PM_{10}, and TSP in the three emission cases are summarized in Table 4.6-1, except wind driven dust emissions. VOCs, PAHs, trace metals emissions are presented in Table 4.6-2 to Table 4.6-4.

From the tables, the following observations are relevant:

- Hourly emissions of SO_2, NOx and CO from Baseline highway and communities were 4%, 6%, and 11%, respectively, of Project Maximum Hourly emissions.
- Daily emissions of TSP, PM_{10}, and $PM_{2.5}$ from Baseline highway and communities were 14%, 11%, and 30%, respectively, of Project Maximum Daily emissions.
- For VOCs and PAHs, Baseline emissions were similar magnitude to emissions associated with the Project.
- Dust-generated emissions from Project haul roads are the biggest source of most metals, except for aluminum and manganese which are the only two metals without on-site soil measurements. Hourly and daily emissions of most metals associated with the Project are 8 to 13 times higher than metal emissions from Baseline sources.

Table 4.6-1 Summary of Project and Regional CAC Emissions

Sources	Emission Rate					
	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Baseline Case						
Highway 3 Emission (kg/d)	0.84	551	1,865	33	102	481
Community Emission (kg/d)	6.8	143	1,956	64	219	1,076
Total	7.6	694	3,821	97	320	1,557
Project-only Case						
Maximum Hourly Emission (kg/h)	7.7	521	1,403	20	185	675
Maximum Daily Emission (kg/d)	18	2,724	1,540	323	2,834	10,933
Application/PDC Case						
Maximum Hourly Emission (kg/h)	8.0	550	1,562	24	198	740
Maximum Daily Emission (kg/d)	25	3,418	5,361	420	3,155	12,490

Table 4.6-2 Summary of Project and Regional VOC Emissions

Pollutant	Baseline Case	Project-only Case		Application/PDC Case	
	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)	Maximum Daily Emission (kg/d)
Benzene	423	24	435	42	858
Toluene	153	8.7	158	15	311
Xylenes	105	6.0	108	10	213
Propylene	1,520	87	1,565	150	3,085
Formaldehyde	43	2.5	44	4.2	87
Acetaldehyde	14	0.8	14	1.4	28
Acrolein	4.3	0.2	4.4	0.4	8.7

Table 4.6-3 Summary of Project and Regional PAH Emissions

Pollutant	Baseline Case	Project-only Case		Application/PDC Case	
	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)	Maximum Daily Emission (kg/d)	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)
Acenaphthene	2.6	0.15	2.6	0.25	5.2
Acenaphthylene	5.0	0.29	5.2	0.50	10.2
Anthracene	0.67	0.04	0.69	0.07	1.4
Benz(a)anthracene	0.34	0.02	0.35	0.03	0.69
Benzo(a)pyrene	0.14	0.01	0.14	0.01	0.28
Benzo(b)fluoranthene	0.60	0.03	0.62	0.06	1.2
Benzo(g,h,l)perylene	0.30	0.02	0.31	0.03	0.61
Benzo(k)fluoranthene	0.12	0.01	0.12	0.01	0.24
Chrysene	0.83	0.05	0.86	0.08	1.7

Table 4.6-3 Summary of Project and Regional PAH Emissions

Pollutant	Baseline Case	Project-only Case		Application/PDC Case	
	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)	Maximum Daily Emission (kg/d)	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)
Dibenz(a,h)anthracene	0.19	0.01	0.19	0.02	0.38
Fluoranthene	2.2	0.13	2.3	0.22	4.5
Fluorene	7.0	0.40	7.2	0.69	14
Indeno(1,2,3-cd)pyrene	0.2	0.01	0.2	0.02	0.5
Naphthalene	71	4.0	73	7.0	144
Phenanthrene	22	1.3	23	2.2	45
Pyrene	2.0	0.12	2.1	0.20	4.1

Table 4.6-4 Summary of Project and Regional Metal Emissions

Pollutant	Baseline Case	Project-only Case		Application/PDC Case	
	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)	Maximum Daily Emission (kg/d)	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)
Aluminum	11	0.6	11	1.1	22
Antimony	1.4	0.6	10	0.7	12
Arsenic	23	4.4	73	5.3	95
Barium	399	176	2,846	192	3,245
Beryllium	1.5	0.7	11	0.7	12
Cadmium	2.4	0.9	15	1.0	17
Chromium	12	4.2	68	4.7	80
Cobalt	11	4.8	77	5.2	88
Copper	47	17	282	19	329

Table 4.6-4 Summary of Project and Regional Metal Emissions

Pollutant	Baseline Case	Project-only Case		Application/PDC Case	
	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)	Maximum Daily Emission (kg/d)	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)
Lead	20	7.6	124	8.5	144
Manganese	1.9	0.1	2.0	0.2	3.9
Mercury	0.2	0.1	1.5	0.1	1.7
Molybdenum	2.4	1.1	17	1.2	20
Nickel	38	17	268	18	306
Selenium	1.8	0.8	13	0.9	15
Thallium	0.8	0.3	5.5	0.4	6.2
Uranium	3.1	1.3	22	1.5	25
Vanadium	47	16	265	18	311
Zinc	275	91	1,487	103	1,761

4.7 Estimates of Future Emissions

This section examines the need to include increased highway and railway traffic due to the Project as part of the cumulative effects assessment for air quality. It provides rationale as to why Highway 3 traffic emissions are not expected to increase over the life of the Project.

The traffic assessment for the EIA (Hatch Mott McDonald 2015) assumed traffic counts would increase by about 2.5% annually based on traffic count increases over the last 10 years. Figure 5 in Hatch Mott McDonald (2015) indicates the traffic counts over the last 7 years to be approximately constant. Based on the traffic assessment, mine operations will result in approximately 100 vehicle trips per day, with perhaps 60% travelling through the Blairmore access. The Project will result in an increase in traffic counts of about 1%.

At the same time, Canada released a draft regulation to limit GHG emissions from passenger cars and light trucks from model year 2011 to 2016, based on the latest U.S. standards. The Canadian government anticipates that the average GHG emission performance of the 2016 Canadian fleet of new cars and light trucks would average 153 g CO_2/km. This would represent an approximate 20%

reduction compared to the new vehicle fleet that was sold in Canada in 2007. Furthermore, the recent *Regulations Amending the Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* establish progressively more stringent GHG emission standards for Canadian vehicles of model years 2017 and beyond (Environment Canada 2014).

On balance, the combination of recent non-increasing vehicle counts on Highway 3, an insignificant increase in traffic due to Project operations, and projected decreases in vehicle emissions per kilometre results in near-neutral to decreasing total traffic emissions. Increased Alberta carbon taxes are expected to result in further optimization of vehicle use and these have not been factored into the forecast.

For this assessment to be conservative, it was assumed there would be no future decrease in vehicle emissions on Highway 3.

It is anticipated that the balance between future rail use and future decreases in emissions will also be near neutral given recently announced plans to federally regulate the emissions of diesel locomotives.

5.0 AIR QUALITY PREDICTIONS

The CALPUFF model was used to estimate the concentrations of the different COPCs that would occur for the assessment scenarios. The results have been provided for the RSA-MPOI (the maximum point of impingement outside the mine footprint), the Mine Permit Boundary maximum (MPB), as well as at 14 special receptors. The Project fenceline is considered to be the MPB, as public access within this area is completely restricted. Ambient background concentrations were added to the predictions for Baseline and Application cases.

The following assessment cases that were completed:

- "Project Only" predictions that result purely from Project emission sources;
- "Background" which is a measured value considered to represent the contribution of distant sources into the RSA;
- "Baseline Case" which includes the Background plus the effect of all existing emission sources in the RSA;
- "Application / PDC Case" which considers the effects of Project emissions added to the Baseline predictions; and
- "Application/PDC Case Increase Over Baseline" which represents the relative increase of the Application/PDC case effects compared to the Baseline case.

5.1 Sulphur Dioxide (SO_2)

The CALPUFF model was used to estimate the concentration of SO_2 which are summarized in Table 5.1-1.

Table 5.1-1 indicates that no exceedances of the AAAQO were predicted for any of the averaging periods, for any modelling case. The hourly SO_2 predictions for RSA-MPOI and MPB show a large relative increase in the Application Case over the Baseline, but the magnitude of the increase is low, and predictions are well below the AAAQO at all locations.

The change for maximum daily, monthly and annual average predictions in both RSA-MPOI and MPB as well as special receptors between the Baseline and Application Cases was negligible to small. Modeling predicted a slight increase in the ground-level SO_2 concentrations at fenceline receptors but the magnitude of the increase is very low.

The patterns of SO_2 concentration for the 9th highest hourly, maximum daily, monthly, and annual averages for the Baseline and Application cases are shown on Figures 5.1-1 to 5.1-8, respectively. On all figures, the location of the RSA-MPOI is shown, even though only concentrations at or outside the MPB (and all special receptors) are compared to ambient objectives. The hourly RSA-MPOI concentrations are 31 μg/m³ for the Application case and are located east of the pit boundary, reflecting emissions from pit operations.

Daily, monthly and annual RSA-MPOIs for Baseline and Application cases are located at Blairmore near Highway 3 primarily influenced by regional community and highway emissions. This trend is followed by all emissions in the Baseline case, not only SO_2, where the combination of community and highway emissions results in a regional maximum concentration in the absence of other existing industrial sources in the area.

Table 5.1-1 Predicted Sulphur Dioxide Ground-Level Concentration

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application /PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	73	2.6	8.8	75	753
Mine Permit Boundary Maximum	30	2.6	2.9	33	1027
Special Receptor Maximum	7	2.6	8.3	10	19
AEP AAAQO[(a)]	**n/a[(c)]**	**n/a[(c)]**	**n/a[(c)]**	**n/a[(c)]**	

Table 5.1-1 Predicted Sulphur Dioxide Ground-Level Concentration

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application /PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	29	2.6	8.0	32	299
Mine Permit Boundary Maximum	3.8	2.6	2.8	6.4	124
Special Receptor Maximum	2.0	2.6	7.5	7.5	0.0
AEP AAAQG[(a)(b)]	**450**	**450**	**450**	**450**	
24-Hour Maximum					
Overall Maximum (RSA-MPOI)	3.5	2.1	4.6	5.6	21
Mine Permit Boundary Maximum	0.7	2.1	2.2	2.9	31
Special Receptor Maximum	0.3	2.1	4.4	4.4	0.4
AEP AAAQO[(a)]	**125**	**125**	**125**	**125**	
30-Day Maximum					
Overall Maximum (RSA-MPOI)	0.6	1.0	2.1	2.1	0.3
Mine Permit Boundary Maximum	0.10	1.0	1.0	1.1	7.2
Special Receptor Maximum	0.07	1.0	2.0	2.0	0.3
AEP AAAQO[(a)]	**30**	**30**	**30**	**30**	
Annual Average					
Overall Maximum (RSA-MPOI)	0.3	0.9	1.8	1.8	0.4
Mine Permit Boundary Maximum	0.0	0.9	0.9	0.9	3.1
Special Receptor Maximum	0.05	0.9	1.6	1.6	0.2
AEP AAAQO[(a)]	**20**	**20**	**20**	**20**	

(a) Source: AESRD 2013a.
(b) The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).
Shaded Cells: AAAQOs are not applicable to predicted increases.

SO_2 ground-level concentrations for special receptors are also presented in Table 5.1-2. Project contributions at all locations are small in an absolute sense.

Table 5.1-2 Predicted Sulphur Dioxide Ground-Level Concentration at Special Receptors

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application /PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
R1-Campground	0.5	2.6	4.8	4.8	0.0
R2-Trapper's Cabin #1	1.0	2.6	2.6	3.6	38
R3-Residential #1	1.4	2.6	3.3	4.0	21
R4-Residential #2	0.4	2.6	2.6	3.1	19
R5-Residential #3	0.6	2.6	2.6	3.2	23
R6-Coleman	1.0	2.6	4.3	4.3	0
R7-Frank	0.7	2.6	3.8	3.8	0
R8-Blairmore North	0.9	2.6	6.8	6.8	0
R9-Aboriginal	1.1	2.6	2.7	3.7	36
R10-Residential #4	7.2	2.6	2.6	9.8	272
R11-Trapper's Cabin #2	6.3	2.6	2.6	8.9	240
R12-Residential #5	3.2	2.6	2.7	5.8	116
R13-Residential #6	5.2	2.6	2.7	7.8	192
R14-Blairmore Center	0.7	2.6	8.3	8.3	0
AEP AAAQO[a]	**n/a[b]**	**n/a[b]**	**n/a[b]**	**n/a[b]**	
9th Highest 1-Hour (99.9th Percentile)					
R1-Campground	0.2	2.6	4.5	4.5	0
R2-Trapper's Cabin #1	0.3	2.6	2.6	2.9	11
R3-Residential #1	0.1	2.6	3.2	3.3	3.1
R4-Residential #2	0.2	2.6	2.6	2.8	7.7
R5-Residential #3	0.2	2.6	2.6	2.8	7.7
R6-Coleman	0.2	2.6	4.1	4.1	0
R7-Frank	0.1	2.6	3.5	3.6	2.8
R8-Blairmore North	0.4	2.6	6.1	6.2	1.6
R9-Aboriginal	0.7	2.6	2.7	3.3	22
R10-Residential #4	2.0	2.6	2.6	4.6	76
R11-Trapper's Cabin #2	2.0	2.6	2.6	4.6	76
R12-Residential #5	0.4	2.6	2.7	3.0	11

Table 5.1-2 Predicted Sulphur Dioxide Ground-Level Concentration at Special Receptors					
Receptor Location	**Project Only [µg/m³]**	**Background [µg/m³]**	**Baseline Case [µg/m³]**	**Application /PDC Case [µg/m³]**	**Application/PDC Case Increase Over Baseline [%]**
R13-Residential #6	1.0	2.6	2.6	3.6	38
R14-Blairmore Center	0.1	2.6	7.5	7.5	0
AEP AAAQO[(a)]	**450**	**450**	**450**	**450**	
24-Hour Average					
R1-Campground	0.04	2.1	3.1	3.2	3.2
R2-Trapper's Cabin #1	0.05	2.1	2.1	2.2	4.8
R3-Residential #1	0.03	2.1	2.4	2.4	0
R4-Residential #2	0.02	2.1	2.1	2.1	0
R5-Residential #3	0.03	2.1	2.1	2.1	0
R6-Coleman	0.03	2.1	3.1	3.2	3.2
R7-Frank	0.03	2.1	2.7	2.7	0
R8-Blairmore North	0.09	2.1	4.0	4.1	2.5
R9-Aboriginal	0.17	2.1	2.1	2.3	9.4
R10-Residential #4	0.26	2.1	2.1	2.4	14
R11-Trapper's Cabin #2	0.29	2.1	2.1	2.4	14
R12-Residential #5	0.12	2.1	2.1	2.2	4.7
R13-Residential #6	0.13	2.1	2.1	2.2	4.7
R14-Blairmore Center	0.03	2.1	4.4	4.4	0
AEP AAAQO[(a)]	**125**	**125**	**125**	**125**	
30-Day Average					
R1-Campground	0.007	1.0	1.3	1.3	0
R2-Trapper's Cabin #1	0.005	1.0	1.0	1.0	0
R3-Residential #1	0.003	1.0	1.1	1.1	0
R4-Residential #2	0.001	1.0	1.0	1.0	0
R5-Residential #3	0.002	1.0	1.0	1.0	0
R6-Coleman	0.003	1.0	1.4	1.4	0
R7-Frank	0.004	1.0	1.2	1.3	8.0
R8-Blairmore North	0.037	1.0	1.7	1.8	5.8
R9-Aboriginal	0.037	1.0	1.0	1.0	0

Table 5.1-2 Predicted Sulphur Dioxide Ground-Level Concentration at Special Receptors					
Receptor Location	**Project Only [µg/m³]**	**Background [µg/m³]**	**Baseline Case [µg/m³]**	**Application /PDC Case [µg/m³]**	**Application/PDC Case Increase Over Baseline [%]**
R10-Residential #4	0.074	1.0	1.0	1.1	10
R11-Trapper's Cabin #2	0.021	1.0	1.0	1.0	0
R12-Residential #5	0.019	1.0	1.0	1.0	0
R13-Residential #6	0.015	1.0	1.0	1.0	0
R14-Blairmore Center	0.005	1.0	2.0	2.0	0
AEP AAAQO[(a)]	**30**	**30**	**30**	**30**	
Annual Average					
R1-Campground	0.004	0.9	1.1	1.1	0
R2-Trapper's Cabin #1	0.002	0.9	0.9	0.9	0
R3-Residential #1	0.001	0.9	0.9	0.9	0
R4-Residential #2	0.001	0.9	0.9	0.9	0
R5-Residential #3	0.001	0.9	0.9	0.9	0
R6-Coleman	0.002	0.9	1.2	1.2	0
R7-Frank	0.002	0.9	1.1	1.1	0
R8-Blairmore North	0.025	0.9	1.5	1.5	0
R9-Aboriginal	0.017	0.9	0.9	0.9	0
R10-Residential #4	0.047	0.9	0.9	0.9	0
R11-Trapper's Cabin #2	0.013	0.9	0.9	0.9	0
R12-Residential #5	0.012	0.9	0.9	0.9	0
R13-Residential #6	0.012	0.9	0.9	0.9	0
R14-Blairmore Center	0.003	0.9	1.6	1.6	0
AEP AAAQO[(a)]	**20**	**20**	**20**	**20**	

[(a)] Source: AESRD 2013a.

[(b)] The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

5.2 Nitrogen Dioxide (NO_2)

Using the Ozone Limiting Method (OLM) (as discussed in Section 2.5.3.3 of this report) the model predicted no exceedances of the AAAQOs of NO_2 for any of the assessment cases at any averaging period (Table 5.2-2). In compliance with the *Air Quality Model Guidelines* (AESRD 2013b), NO_2

ground-level concentrations, as predicted by the Total Conversion Method, are also presented in Table 5.2-1. Ambient background NO_X concentrations were added to the predictions for Baseline and Application cases. Data presented for the Project Only case did not include the measured ambient background. The discussion that follows refers to the results calculated using the OLM. NO_2 ground-level concentrations for special receptors are also presented in Table 5.2-3.

The patterns of NO_2 concentration for 9th highest 1-hour and annual average for the Baseline and Application cases are shown on Figures 5.2-1 to 5.2-4, respectively.

In the Baseline case, the RSA-MPOI predictions are 112 µg/m^3 for hourly average and 46 µg/m^3 for annual average, respectively. They are both located in the southwestern LSA and are the result of emissions from communities and the highway.

In the Application Case, the hourly RSA-MPOI prediction of 293 µg/m^3 is located east of the Project area, influenced by blasting activities, emissions from waste removal and vehicle traffic on the haul road. Blasting, during the hours when it is conducted, is the greatest contributor of NO_2 from the Project (Table 4.2-3). The hourly NO_2 predictions for all receptors show a large relative increase (Table 5.2-3) in the Application Case over the Baseline. However, all predictions with the OLM are well below AAAQOs.

The annual RSA-MPOI for Application case is also located at Blairmore, near Highway 3, primarily influenced by regional community and highway emissions. The change in annual average predictions at the RSA-MPOI, as well as at special receptors, between the Baseline and Application Cases is negligible.

An exceedance of the annual AAAQO is predicted at the RSA-MPOI in the Baseline case, with the Project contributing an additional 1.5% in the Application case. The Baseline prediction is due to local community and highway sources. The prediction may not be representative as it occurs within a model area source; the prediction is expected to overstate actual concentrations as a result. No exceedances are predicted outside the MPB, where Project sources would have the most influence.

Special receptors R1 and R8 are nearest the rail loadout Project source. At those locations, the Project contribution to NO_2 predictions was zero and there were no predicted exceedances of AAAQOs.

Table 5.2-1 Predicted Nitrogen Dioxide Ground-Level Concentration – Total Conversion Method

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application /PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	4,271	32	546	4,304	689
Mine Permit Boundary Maximum	2,005	32	71	2038	2,763
Special Receptor Maximum	484	32	542	542	0.1
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	1,663	32	454	1696	274
Mine Permit Boundary Maximum	462	32	63	494	680
Special Receptor Maximum	237	32	454	455	0.2
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
Annual Average					
Overall Maximum (RSA-MPOI)	76	17	69	92	33
Mine Permit Boundary Maximum	13	17	20	30	48
Special Receptor Maximum	14	17	68	69	2.2
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	

[(a)] Source: AESRD 2013a.

[(b)] The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.2-2 Predicted Nitrogen Dioxide Ground-Level Concentration – Ozone Limiting Method

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application /PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	668	24	131	671	414
Mine Permit Boundary Maximum	322	24	67	325	387
Special Receptor Maximum	119	24	130	130	0.0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	290	24	112	293	162
Mine Permit Boundary Maximum	110	24	61	113	86
Special Receptor Maximum	91	24	109	109	0.0
AEP AAAQO[(a)]	**300**	**300**	**300**	**300**	
Annual Average					
Overall Maximum (RSA-MPOI)	34	11	46	47	1.5
Mine Permit Boundary Maximum	12	11	20	28	39
Special Receptor Maximum	13	11	43	43	1.0
AEP AAAQO[(a)]	**45**	**45**	**45**	**45**	

(a) Source: AESRD 2013a.

(b) The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.2-3 Predicted Nitrogen Dioxide Ground-Level Concentration at Special Receptors – Ozone Limiting Method

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application /PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
R1-Campground	65	24	92	92	0
R2-Trapper's Cabin #1	85	24	36	88	148
R3-Residential #1	61	24	95	95	0
R4-Residential #2	44	24	34	72	113
R5-Residential #3	57	24	34	85	150
R6-Coleman	59	24	102	102	0
R7-Frank	56	24	94	94	0
R8-Blairmore North	64	24	130	130	0
R9-Aboriginal	97	24	49	101	106
R10-Residential #4	119	24	37	122	228
R11-Trapper's Cabin #2	106	24	35	110	210
R12-Residential #5	84	24	41	87	115
R13-Residential #6	102	24	38	105	175
R14-Blairmore Center	59	24	97	97	0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
R1-Campground	34	24	89	89	0
R2-Trapper's Cabin #1	47	24	34	61	78
R3-Residential #1	28	24	89	89	0
R4-Residential #2	17	24	33	49	49
R5-Residential #3	26	24	33	53	60
R6-Coleman	31	24	96	96	0
R7-Frank	25	24	87	87	0
R8-Blairmore North	29	24	109	109	0
R9-Aboriginal	91	24	44	94	113

Table 5.2-3 Predicted Nitrogen Dioxide Ground-Level Concentration at Special Receptors – Ozone Limiting Method

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application /PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
R10-Residential #4	87	24	36	91	155
R11-Trapper's Cabin #2	87	24	34	92	167
R12-Residential #5	59	24	39	76	95
R13-Residential #6	67	24	37	78	113
R14-Blairmore Center	27	24	94	94	0
AEP AAAQO(a)	**300**	**300**	**300**	**300**	
Annual Average					
R1-Campground	0.4	11	25	25	0
R2-Trapper's Cabin #1	0.6	11	16	17	6.1
R3-Residential #1	0.3	11	25	25	0
R4-Residential #2	0.2	11	16	17	6.1
R5-Residential #3	0.3	11	16	17	6.1
R6-Coleman	0.3	11	36	36	0
R7-Frank	0.3	11	29	29	0
R8-Blairmore North	1.6	11	43	43	0
R9-Aboriginal	4.6	11	17	21	23
R10-Residential #4	13	11	17	28	66
R11-Trapper's Cabin #2	2.8	11	16	19	18
R12-Residential #5	3.9	11	17	21	24
R13-Residential #6	3.4	11	17	20	18
R14-Blairmore Center	0.3	11	35	35	0
AEP AAAQO(a)	**45**	**45**	**45**	**45**	

(a) Source: AESRD 2013a.

(b) The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

5.3 Carbon Monoxide (CO)

Model predictions for CO are presented in Table 5.3-1. All data presented, except those for the Project Only case, include the measured ambient background. Table 5.3-1 indicates all predictions are well below AAAQOs for all averaging periods and modelling cases. The regional patterns of for hourly and 8-hour CO concentrations are presented in Figures 5.3-1 to 5.3-4, respectively.

In the Baseline case, the RSA-MPOI predictions are 2,241 µg/m³ for hourly and 1,638 µg/m³ for 8-hour averages, respectively. They are co-located in the southern LSA and are a result of emissions from communities and the highway.

The addition of the Project results in an increase in both the hourly (6,054 µg/m³), and 8-hour (2,835 µg/m³) predictions, and a shift in the location of the MPOI away from the community. In the Application Case, both hourly and 8-hour MPOIs occur east of the Project, and are primarily influenced by blasting activities. At the MPB, relative (percentage) increases in Table 5.3-1 are large. However, all predictions are well below AAAQOs.

Table 5.3-1 Predicted Carbon Monoxide Ground-Level Concentration

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application /PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	14,059	344	2,794	14,408	416
Mine Permit Boundary Maximum	5,910	344	509	6,257	1,130
Special Receptor Maximum	1,375	344	2,381	2,381	0.0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	5,708	344	2,241	6,054	170
Mine Permit Boundary Maximum	725	344	477	1,069	124
Special Receptor Maximum	386	344	2,014	2,014	0.0
AEP AAAQO[(a)]	**15,000**	**15,000**	**15,000**	**15,000**	
8-Hour Maximum					
Overall Maximum (RSA-MPOI)	2,530	301	1,638	2,835	73
Mine Permit Boundary Maximum	1,055	301	391	1,358	247
Special Receptor Maximum	314	301	1,574	1,574	0.0

Table 5.3-1 Predicted Carbon Monoxide Ground-Level Concentration					
Receptor Location	**Project Only [µg/m³]**	**Background [µg/m³]**	**Baseline Case [µg/m³]**	**Application /PDC Case [µg/m³]**	**Application/PDC Case Increase Over Baseline [%]**
AEP AAAQO[(a)]	**6,000**	**6,000**	**6,000**	**6,000**	

[(a)] Source: AESRD 2013a.

[(b)] The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.3-1 Predicted Carbon Monoxide Ground-Level Concentration at Special Receptors					
Receptor Location	**Project Only [µg/m³]**	**Background [µg/m³]**	**Baseline Case [µg/m³]**	**Application /PDC Case [µg/m³]**	**Application/PDC Case Increase Over Baseline [%]**
1-Hour Maximum					
R1-Campground	80	344	1,177	1,177	0
R2-Trapper's Cabin #1	176	344	360	522	45
R3-Residential #1	251	344	868	868	0
R4-Residential #2	86	344	352	432	23
R5-Residential #3	127	344	353	472	34
R6-Coleman	158	344	1,369	1,369	0
R7-Frank	126	344	964	964	0
R8-Blairmore North	147	344	2,381	2,381	0
R9-Aboriginal	201	344	435	547	26
R10-Residential #4	1,375	344	371	1,719	363
R11-Trapper's Cabin #2	1,195	344	362	1,541	326
R12-Residential #5	592	344	390	942	141
R13-Residential #6	990	344	377	1,338	255
R14-Blairmore Center	128	344	2,224	2,224	0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	

Table 5.3-1 Predicted Carbon Monoxide Ground-Level Concentration at Special Receptors

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application /PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
9th Highest 1-Hour (99.9th Percentile)					
R1-Campground	21	344	1,068	1,068	0
R2-Trapper's Cabin #1	61	344	356	407	14
R3-Residential #1	23	344	793	793	0.0
R4-Residential #2	28	344	350	374	6.9
R5-Residential #3	48	344	350	393	12
R6-Coleman	19	344	1,254	1,254	0
R7-Frank	21	344	860	860	0
R8-Blairmore North	32	344	2,014	2,014	0
R9-Aboriginal	61	344	402	429	6.6
R10-Residential #4	376	344	365	721	98
R11-Trapper's Cabin #2	386	344	358	731	104
R12-Residential #5	64	344	378	421	11
R13-Residential #6	167	344	369	512	39
R14-Blairmore Center	18	344	1,974	1,974	0
AEP AAAQO[(a)]	**15,000**	**15,000**	**15,000**	**15,000**	
Annual Average					
R1-Campground	19	301	877	877	0
R2-Trapper's Cabin #1	49	301	310	352	14
R3-Residential #1	38	301	659	659	0
R4-Residential #2	24	301	305	325	6.5
R5-Residential #3	39	301	307	343	12
R6-Coleman	25	301	1,030	1,030	0
R7-Frank	23	301	755	755	0
R8-Blairmore North	29	301	1,560	1,560	0
R9-Aboriginal	54	301	343	373	9.0
R10-Residential #4	314	301	319	618	94

Table 5.3-1 Predicted Carbon Monoxide Ground-Level Concentration at Special Receptors

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application /PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
R11-Trapper's Cabin #2	236	301	315	538	71
R12-Residential #5	128	301	330	432	31
R13-Residential #6	156	301	323	460	43
R14-Blairmore Center	23	301	1,574	1,574	0
AEP AAAQO[(a)]	**6,000**	**6,000**	**6,000**	**6,000**	

[(a)] Source: AESRD 2013a.

[(b)] The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

5.4 Particulate Matter Less Than 2.5 Microns ($PM_{2.5}$)

The CALPUFF model was used to estimate the concentration of ground-level $PM_{2.5}$ for each of the assessment cases. The secondary production of nitrates and sulphates within the dispersion model was included in the predicted results along with direct emissions. $PM_{2.5}$ concentrations were not depleted by deposition. Ambient background concentrations were added to the predictions for Application/PDC and Baseline cases.

The predicted $PM_{2.5}$ concentrations are presented in Table 5.4-1 and are compared to the AAAQO and CAAQS. The maximum daily and annual predicted concentrations are shown in Figures 5.4-1 to 5.4-4 for Baseline and Application cases. The predicted daily and annual $PM_{2.5}$ ground-level concentrations for special receptors are also presented in Table 5.4-2.

The main observations from the table and figures are that there are no exceedances of AAAQOs or CAAQSs in the Baseline case, and none in the Application/PDC case at the MPB or at special receptors. Further details follow.

The maximum daily RSA- MPOI prediction for the Baseline case is 24 μg/m³, lower than the AAAQO of 30 μg/m³. The maximum daily prediction at the RSA- MPOI increases to 50 μg/m³ in the Application case with the influence of the Project developments. The 98th percentile daily RSA-MPOI predictions are 32 μg/m³ for the Application case and 20 μg/m³ for the Baseline case. The maximum annual RSA-MPOI prediction is 12 μg/m³ for the Application case and 9.2 μg/m³ for the Baseline case.

The maximum RSA-MPOI prediction in the Baseline case for all averaging periods occurred at Blairmore as a result of emissions from the community and highway. In the Application case, the RSA-MPOI location for both daily and annual averaging periods shifts to the eastern pit boundary, as a result of dust emissions from the haul road which is near the boundary of the pit area.

The Application case predictions of $PM_{2.5}$ concentration at receptors R1 and R8 nearest the rail loadout increase by at most 0.7% as a result of the Project. All predictions at these locations are less than the AAAQO and CAAQS.

Table 5.4-1 Predicted $PM_{2.5}$ Ground-Level Concentration

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application /PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	205	8.0	68	214	213
Mine Permit Boundary Maximum	83	8.0	13	91	584
Special Receptor Maximum	33	8.0	59	59	0.1
AEP AAAQO(a)	**n/a(c)**	**n/a(c)**	**n/a(c)**	**n/a(c)**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	167	8.0	56	175	214
Mine Permit Boundary Maximum	44	8.0	12	52	334
Special Receptor Maximum	17	8.0	52	52	0.0
AEP AAAQG(a)(b)	**80**	**80**	**80**	**80**	
24-Hour Maximum					
Overall Maximum (RSA-MPOI)	43	6.8	24	50	108
Mine Permit Boundary Maximum	13	6.8	8.1	20	142
Special Receptor Maximum	5.7	6.8	22	22	0.7
AEP AAAQO(a)	**30**	**30**	**30**	**30**	
8th Highest 24-Hour (98th Percentile)					
Overall Maximum (RSA-MPOI)	25	6.8	20	32	58
Mine Permit Boundary Maximum	6.2	6.8	7.9	13	66
Special Receptor Maximum	3.5	6.8	19	19	0.6
CAAQS(d)	**28**	**28**	**28**	**28**	
Annual Average					
Overall Maximum (RSA-MPOI)	7.5	4.0	9.2	12	26

Table 5.4-1 Predicted $PM_{2.5}$ Ground-Level Concentration

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application /PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
Mine Permit Boundary Maximum	1.0	4.0	4.3	5.0	17
Special Receptor Maximum	1.2	4.0	8.3	8.3	0.3
CAAQS[(d)]	**10**	**10**	**10**	**10**	

[(a)] Source: AESRD 2013a.
[(b)] Alberta Ambient Air Quality Guideline (AAAQG), not Objective: (AESRD 2013a).
[(c)] The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).
[(d)] CCME 2012
Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.4-2 Predicted $PM_{2.5}$ Ground-Level Concentration at Special Receptors

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application /PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
24-Hour Maximum					
R1-Campground	0.7	6.8	13.2	13.2	0.5
R2-Trapper's Cabin #1	0.7	6.8	6.9	7.5	10
R3-Residential #1	0.7	6.8	10.7	10.8	0.2
R4-Residential #2	0.3	6.8	6.8	7.1	4.5
R5-Residential #3	0.4	6.8	6.8	7.2	5.4
R6-Coleman	0.8	6.8	18.5	18.5	0
R7-Frank	0.6	6.8	12.3	12.3	0
R8-Blairmore North	0.7	6.8	21.7	21.8	0.7
R9-Aboriginal	2.5	6.8	7.3	9.4	28
R10-Residential #4	5.7	6.8	7.0	12.6	81
R11-Trapper's Cabin #2	2.8	6.8	6.9	9.7	40
R12-Residential #5	1.5	6.8	7.1	8.4	19
R13-Residential #6	1.5	6.8	7.0	8.4	19
R14-Blairmore Center	0.6	6.8	21.2	21.2	0
AEP AAAQO[(a)]	**30**	**30**	**30**	**30**	

Table 5.4-2 Predicted $PM_{2.5}$ Ground-Level Concentration at Special Receptors					
Receptor Location	**Project Only [µg/m³]**	**Background [µg/m³]**	**Baseline Case [µg/m³]**	**Application /PDC Case [µg/m³]**	**Application/PDC Case Increase Over Baseline [%]**
8th Highest 24-Hour (98th Percentile)					
R1-Campground	0.2	6.8	12.3	12.3	0
R2-Trapper's Cabin #1	0.4	6.8	6.8	7.3	6.0
R3-Residential #1	0.2	6.8	9.8	10.0	1.4
R4-Residential #2	0.2	6.8	6.8	7.0	2.4
R5-Residential #3	0.2	6.8	6.8	7.1	3.4
R6-Coleman	0.2	6.8	16.0	16.0	0
R7-Frank	0.2	6.8	11.1	11.1	0
R8-Blairmore North	0.3	6.8	18.5	18.6	0.6
R9-Aboriginal	1.5	6.8	7.2	8.5	18
R10-Residential #4	3.5	6.8	6.9	10.3	49
R11-Trapper's Cabin #2	2.0	6.8	6.9	8.8	29
R12-Residential #5	0.8	6.8	7.0	7.7	10
R13-Residential #6	0.9	6.8	7.0	7.8	11
R14-Blairmore Center	0.2	6.8	18.1	18.3	0.9
CAAQS[(b)]	**28**	**28**	**28**	**28**	
Annual Average					
R1-Campground	0.03	4.0	5.3	5.3	0.5
R2-Trapper's Cabin #1	0.06	4.0	4.0	4.1	1.5
R3-Residential #1	0.03	4.0	4.7	4.8	0.5
R4-Residential #2	0.02	4.0	4.0	4.0	0.5
R5-Residential #3	0.03	4.0	4.0	4.0	0.7
R6-Coleman	0.03	4.0	7.4	7.5	0.3
R7-Frank	0.02	4.0	5.4	5.5	0.4
R8-Blairmore North	0.07	4.0	8.2	8.3	0.8
R9-Aboriginal	0.25	4.0	4.1	4.3	5.8
R10-Residential #4	1.2	4.0	4.0	5.2	30

Table 5.4-2 Predicted $PM_{2.5}$ Ground-Level Concentration at Special Receptors

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application /PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
R11-Trapper's Cabin #2	0.27	4.0	4.0	4.3	6.7
R12-Residential #5	0.18	4.0	4.1	4.2	4.3
R13-Residential #6	0.21	4.0	4.0	4.2	5.2
R14-Blairmore Center	0.02	4.0	8.3	8.3	0.3
CAAQS[(b)]	**10**	**10**	**10**	**10**	

[(a)] Source: AESRD 2013a.

[(b)] CCME 2012

Shaded Cells: AAAQOs are not applicable to predicted increases.

5.5 Particulate Matter Less Than 10 Microns (PM_{10})

In Table 5.5-1, the predicted PM_{10} concentrations are compared to the BCAAQO (BCMOE 2014). An ambient background concentration of 21 μg/m³ was added to the predictions for Baseline and Application cases. The spatial distribution of daily PM_{10} predictions is presented in Figures 5.5-1 to 5.5-2 for Baseline and Application cases.

For the Baseline case, the predicted maximum daily concentrations are 72 μg/m³ at the RSA-MPOI and 64 μg/m³ at the special receptors maximum. Both predictions are higher than the BCAAQO of 50 μg/m³, and occurred in Blairmore as a result of emissions from the community and highway which is completely independent and outside of the influence of the Project.

The maximum daily prediction at the RSA-MPOI increases to 314 μg/m³ in the Application case with the influence of the Project. The RSA-MPOI in the Application case is located at the eastern pit boundary, a result of dust emissions from the haul road near the boundary of the pit.

The maximum daily PM_{10} prediction at the MPB is 105 μg/m³ for Application case, and at that location, there are 66 days in the 5-year period (3.6 % of the time) when predictions are above the BCAAQO. These predictions occur in an area outside the MPB of about 5 km². Exceedances were spread throughout the year, roughly divided between winter months with poorer dispersion meteorology in winter and those with increased emissions in summer. All exceedances outside the MPB occurred with wind speeds less than 4 m/s and the highest concentrations were associated with low wind speeds (less than 2 m/s), no matter the time of year – low wind speeds limit the dilution of dust plumes. The highest concentration was predicted in December, when wind speeds in a 24-hour period averaged about 0.85 m/s (very low) and when modelled emissions were reduced by snow cover. This suggests that further mitigation of dust emissions, beyond the means already planned, is not the solution to further reductions in effects.

Maximum daily PM_{10} predictions at three special receptors in Blairmore and Coleman – R6, R8 and R14 - exceed the BCAAQO of 50 µg/m^3 in both Baseline and Application cases (as noted earlier, predictions within model area sources are unlikely to be representative of actual conditions). However, the change due to the addition of the Project at these three special receptors ranged from zero to 2.5%. The increases at R1 and R8 in Blairmore, which are mostly likely due to the effects of the rail loadout, were at most 2.5%.

The maximum daily PM_{10} prediction at R10, the special receptor inside the MPB, increased from 21 µg/m^3 in the Baseline case to 55 µg/m^3 in the Application/PDC case due to Project emissions. At that location, there are 3 days in the 5-year period (less than 0.2 % of the time) when predictions are above the BCAAQO. The highest concentration was predicted to occur in January, and the other two in September. Winds were near or less than 2 m/s. The effects of terrain irregularities and coniferous vegetation were not considered to reduce concentrations (Appendix A suggests reductions would be the order of 25% from these factors). R10 is inside the MPB where no public access will be allowed. Therefore, it is expected that predicted concentrations are higher than will be expected and will not be experienced by people.

As discussed in Appendix A, Section A4.5, dust trapped by vegetation and in small terrain irregularities settles out quickly. The forested region west of the mine may have the effect of reducing particulate emissions by 80% to 100% (applying the method of Pace 2005) while the less vegetated area east of the mine could reduce the near-field predicted concentrations by 25% or more. If the mitigating influence of vegetation had been considered, PM_{10} predictions would less than the BCAAQO at R10. Predictions in Table 5.5-1 are unmitigated by vegetation but include the effects of road watering as well as snow cover and frozen ground in winter.

Table 5.5-1 Predicted PM_{10} Ground-Level Concentration					
Receptor Location	**Project Only [µg/m³]**	**Background [µg/m³]**	**Baseline Case [µg/m³]**	**Application /PDC Case [µg/m³]**	**Application/PDC Case Increase Over Baseline [%]**
24-Hour Maximum					
Overall Maximum (RSA-MPOI)	293	21	72	314	335
Mine Permit Boundary Maximum	84	21	24	105	335
Special Receptor Maximum	34	21	64	66	2.7
R1-Campground	2.3	21	38	39	1.6
R2-Trapper's Cabin #1	2.9	21	21	24	13
R3-Residential #1	2.4	21	30	31	1.9
R4-Residential #2	1.2	21	21	22	5.9
R5-Residential #3	1.9	21	21	23	8.9
R6-Coleman	2.1	21	56	56	0
R7-Frank	1.7	21	37	37	0
R8-Blairmore North	3.3	21	64	66	2.7
R9-Aboriginal	12	21	22	33	51
R10-Residential #4	34	21	21	55	158
R11-Trapper's Cabin #2	16	21	21	37	74
R12-Residential #5	6.0	21	22	27	25
R13-Residential #6	8.5	21	21	30	38
R14-Blairmore Center	1.8	21	62	62	0
BC AAAQO[(a)]	**50**	**50**	**50**	**50**	

[(a)] Source: BCMOE 2014.

Shaded Cells: BC AAQOs are not applicable to predicted increases.

It is also expected that overall turbulence levels in the area have been under-estimated by the modelling approach used. As identified in Appendix B (Section 3.6.1) roughness length used in modelling is based on land cover (*e.g.* trees) as required by AESRD (2013b), not on variations in the height of land that occur in mountains and foothills. A general increase in turbulence levels will increase dispersion and reduce predicted concentrations.

To summarize, it is expected that PM_{10} predictions are conservative for the following reasons:

- The worst-case year of emissions was assessed. These emissions would not be representative of all years of mine operations
- The mitigative effects of vegetation and small scale terrain features to physically trap dust have been ignored. Predicted concentrations off the mine site are expected to be more than 25% lower than predicted for this reason.
- The effects of generally enhanced turbulence in mountainous areas have not been included. These effects tend to increase dilution of dust plumes and reduce concentrations.

PM_{10} is weakly correlated with human health. $PM_{2.5}$ concentrations, presented in Section 5.4, are better indicators of potential health effects.

5.6 Total Suspended Particulate Matter (TSP)

The predicted maximum daily and annual TSP concentrations are presented in Table 5.6-1 and are compared to the AAAQOs. Ambient background concentrations of 42 µg/m^3 for daily average and 26 µg/m^3 for annual average were added to the predictions for Baseline and Application cases. The patterns of TSP concentration for maximum daily and annual averages are shown in Figures 5.6-1 to 5.6-4 for Baseline and Application cases, respectively. TSP ground-level concentrations for special receptors are also presented in Table 5.6-2.

The maximum daily RSA-MPOI prediction for the Baseline case was 220 µg/m^3 and occurred in Blairmore as a result of emissions from the community and highway. As noted earlier, this prediction is likely overstated because the prediction occurred within the bounds of a model area source.

For the Application case, RSA-MPOI location for 24-hour concentrations shifted to the eastern side of the pit, as a result of dust emissions from the haul road which is near the boundary of the pit. The maximum daily TSP prediction at the MPB is 232 µg/m^3, above the AAAQO of 100 µg/m^3. At this location, the AAAQO is exceeded 107 days in a 5-year period (5.9% of the time). The area outside the MPB within which exceedances are predicted is about 3 km^2. In a manner similar to PM_{10}, all 24-hour TSP exceedances occur with wind speeds less than 4 m/s with the highest predictions occurring with wind speeds less than 2 m/s. Winds blew from west to southwest directions aligning haul road, pit and waste dump source activities. Exceedances were predicted throughout the year. The highest concentrations were predicted in September (2 m/s wind speeds) and December (1 m/s winds and reduced emissions due to snow cover). If the trapping effects of vegetation and small-scale terrain irregularities had been applied, the concentrations would have been reduced further, by amounts ranging upwards of 25% depending on the vegetation cover (Appendix A). In particular, all 24-hour predictions at R10 would be less than the AAAQO, and the nuisance effects of TSP would be reduced everywhere.

For maximum daily predictions at R1 and R8, the nearest special receptors to the loadout, the increase in predicted concentrations due to Project sources was 1.2%.

The maximum annual RSA-MPOI prediction was 69 µg/m³ for the Baseline case and occurred within Blairmore. This prediction exceeds the AAAQO of 60 µg/m³. The maximum annual Application case prediction at the MPB was 41 µg/m³. The maximum annual TSP prediction at special receptors was 59 µg/m³ for the Baseline and Application cases, just below the AAAQO. For annual average predictions at R1 and R8, the increase was 2.2% - the predicted impact of the loadout from TSP in the community is small.

According to air quality modelling guidelines, annual TSP predictions are to be reduced by the frequency of days on which trace or greater amounts of precipitation occur. The effects of trace or greater amounts of precipitation, which occur on 117 days per year at the Connelly Creek climate station (Appendix C, Section C4.5), would be expected to reduce annual average TSP concentrations by about one-third to 105 µg/m³ at all locations, and perhaps by more at higher elevations.

Table 5.6-1 Predicted TSP Ground-Level Concentration

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application /PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
24-Hour Maximum					
Overall Maximum (RSA-MPOI)	623	42	220	665	202
Mine Permit Boundary Maximum	190	42	46	232	407
Special Receptor Maximum	60	42	182	184	1.2
AEP AAAQO[(a)]	**100**	**100**	**100**	**100**	
Annual Average					
Overall Maximum (RSA-MPOI)	128	26	69	153	124
Mine Permit Boundary Maximum	15	26	27	41	53
Special Receptor Maximum	13	26	59	59	0.9
AEP AAAQO[(a)]	**60**	**60**	**60**	**60**	

[(a)] Source: AESRD 2013a.

Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.6-2 Predicted TSP Ground-Level Concentration at Special Receptors

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application /PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
24-Hour Maximum					
R1-Campground	4.0	42	80	80	0.8
R2-Trapper's Cabin #1	4.2	42	42	46	10
R3-Residential #1	4.3	42	60	61	0.8
R4-Residential #2	1.7	42	42	44	3.8
R5-Residential #3	3.2	42	42	45	7.3
R6-Coleman	3.2	42	145	145	0
R7-Frank	1.9	42	90	91	0
R8-Blairmore North	4.4	42	182	184	1.2
R9-Aboriginal	23	42	43	66	52
R10-Residential #4	60	42	42	102	141
R11-Trapper's Cabin #2	27	42	42	69	63
R12-Residential #5	9.5	42	43	52	21
R13-Residential #6	13	42	43	56	31
R14-Blairmore Center	2.6	42	182	182	0
AEP AAAQO[(a)]	**100**	**100**	**100**	**100**	
Annual Average					
R1-Campground	0.2	26	32	32	0.8
R2-Trapper's Cabin #1	0.3	26	26	26	1.3
R3-Residential #1	0.2	26	29	29	0.7
R4-Residential #2	0.1	26	26	26	0.3
R5-Residential #3	0.2	26	26	26	0.6
R6-Coleman	0.2	26	51	51	0.3
R7-Frank	0.2	26	36	36	0.4
R8-Blairmore North	1.3	26	58	59	2.2
R9-Aboriginal	2.7	26	26	29	10
R10-Residential #4	13	26	26	39	52

Table 5.6-2 Predicted TSP Ground-Level Concentration at Special Receptors					
Receptor Location	**Project Only [μg/m³]**	**Background [μg/m³]**	**Baseline Case [μg/m³]**	**Application /PDC Case [μg/m³]**	**Application/PDC Case Increase Over Baseline [%]**
R11-Trapper's Cabin #2	2.1	26	26	28	8.2
R12-Residential #5	1.7	26	26	28	6.6
R13-Residential #6	1.9	26	26	28	7.3
R14-Blairmore Center	0.2	26	59	59	0.3
AEP AAAQO[(a)]	**60**	**60**	**60**	**60**	

[(a)] Source: AESRD 2013a.

Shaded Cells: AAAQOs are not applicable to predicted increases.

It is also expected that overall turbulence levels in the area have been under-estimated by the modelling approach used, as per the discussion in Appendix B (Section 3.6.1). A general increase in turbulence levels will increase dispersion and reduce predicted concentrations.

To summarize, it is expected that TSP predictions are conservative for the following reasons:

- The worst-case year of emissions was assessed. These emissions would not be representative of all years of mine operations
- The mitigative effects of vegetation and small scale terrain features to physically trap dust have been ignored. Predicted concentrations off the mine site are expected to be more than 25% lower than predicted for this reason.
- The effects of generally enhanced turbulence in mountainous areas have not been included. These effects tend to increase dilution of dust plumes and reduce concentrations.
- Annual predictions have not been reduced by the fraction of days with precipitation, which reduces emissions from all activities.

Finally, TSP is considered for its nuisance effects, not for health effects on humans or the environment.

5.7 TSP Deposition

In accordance with the ToR, TSP deposition was estimated using CALPUFF. Predictions are presented in Table 5.7-1 and compared to AEP dustfall guidelines.

The maximum 30-day TSP deposition for the Baseline Case was 54 kg/ha and occurred in Blairmore as a result of emissions from the community and highway. The maximum prediction is just above the AEP dustfall guidelines for residential and recreational areas of 53 kg/ha per 30 day period.

The maximum 30-day TSP deposition for the Application Case was 203 kg/ha, occurring east of the pit boundary, as a result of dust emissions from the haul road which is close to the boundary of the pit. In the model, dust deposition is a function of dust concentration, and so would occur under the same conditions as the highest TSP concentrations do. Increases at special receptors near the operating mine (Table 5.7-2) are large in a relative sensitive but are not large in an absolute sense, with Application predictions less than the AAQG for residential locations. In general, the greatest effects of TSP deposition are found near unpaved road sources.

The maximum 30-day TSP deposition at the MPB and the most-affected special receptor for the Application Case was 22 kg/ha and 40 kg/ha, respectively; both predictions are less than the AEP dustfall guideline. The difference between Baseline and Application case predictions at special receptors R1 and R8 in Blairmore is near zero, indicating the impact of the loadout on 30-day TSP deposition in the community is negligible.

Table 5.7-1 Maximum 30-day Predicted TSP Deposition

Receptor Location	Project Only [kg/ha]	Percentage of AAQO [%]	Baseline Case [kg/ha]	Application/PDC Case [kg/ha]	Application Case Increase Over Baseline [%]
Based on 30-Day Maximum					
Overall Maximum (RSA-MPOI)	203	383	54	203	275
Mine Permit Boundary Maximum	22	41	0.3	22	730
Special Receptor Maximum	40	75	40	40	0
AEP Guideline – Residential and Recreational Areas (per 30 days) [(a)]	**53**		**53**	**53**	
AEP Guideline – Commercial and Industrial Areas (per 30 days) [(a)]	**158**		**158**	**158**	

[(a)] Source: AESRD 2013a.

Shaded Cells: AAAQGs are not applicable to predicted increases.

Table 5.7-2 Maximum 30-day Predicted TSP Deposition at Special Receptors

Receptor Location	Project Only [kg/ha]	Percentage of AAQG for Residential [%]	Baseline Case [kg/ha]	Application/PDC Case [kg/ha]	Application Case Increase Over Baseline [%]
Based on 30-Day Maximum					
R1-Campground	0.2	0.4	5.0	5.1	3
R2-Trapper's Cabin #1	0.3	0.6	0.01	0.4	2,292
R3-Residential #1	0.3	0.5	2.0	2.2	14
R4-Residential #2	0.1	0.2	0.01	0.1	1,465
R5-Residential #3	0.2	0.4	0.01	0.2	1,836
R6-Coleman	0.3	0.6	40	40	0
R7-Frank	0.2	0.4	11	11	0
R8-Blairmore North	0.7	1.4	32	32	0
R9-Aboriginal	2.3	4.3	0.1	2.3	3,028
R10-Residential #4	20	37	0.02	20	81,777
R11-Trapper's Cabin #2	2.5	4.7	0.02	2.5	13,701
R12-Residential #5	1.0	1.9	0.05	1.1	1,901
R13-Residential #6	2.2	4.1	0.03	2.2	6,944
R14-Blairmore Center	0.2	0.3	36	36	0
AEP Guideline – Residential and Recreational Areas (per 30 days)	**53**		**53**	**53**	
AEP Guideline – Commercial and Industrial Areas (per 30 days)[a]	**158**		**158**	**158**	

[a] Source: AESRD 2013a.

Shaded Cells: AAAQGs are not applicable to predicted increases.

5.8 Nitrogen Deposition

Deposition of nitrogen can lead to eutrophication in water bodies or changes in growth rates of terrestrial vegetation, and its calculation includes both wet (removal in precipitation) and dry (direct contact with surface features) processes. In the current approach, nitrate particulate was determined to be deposited by both wet and dry processes and was directly calculated by the dispersion model.

Based on RELAD modelling (Cheng 2009), the nitrogen deposition was 0.087 keq/ha/yr in the RSA. The nitrogen deposition background used for the Project is 0.11 keq/ha/yr (including both wet and dry deposition) estimated from the closest precipitation station (Kananaskis), located 145 km northwest of the Project in the lee of the Rocky Mountains.

The results of CALPUFF modelling are listed in Table 5.8-1, indicating that the RSA-MPOI predicted nitrogen deposition was 6.5 kg/ha/yr for Baseline and 9.4 kq/ha/yr for Application and PDC cases. The pattern of deposition is presented in Figure 5.8-1 to 5.8-2, and is similar to the NO_2 contour pattern.

Maximum predicted nitrogen deposition at the MPB was 1.9 kg/ha/yr for Baseline and 3.0 kq/ha/yr for Application and PDC cases. Outside the MPB, the Project increases the area of deposition above the 5 kg/ha/yr threshold for the most sensitive ecosystem (see Section 2.4.3) by 0.1 km^2.

Table 5.8-1 Predicted Annual Nitrogen Deposition

Parameter	Project Only	Baseline Case	Application / PDC Case	Application/PDC Case Increase Over Baseline [%]
RSA Nitrogen Deposition (kg/ha/yr)				
Overall Maximum (RSA-MPOI)	9.4	6.5	9.4	45
Mine Permit Boundary Maximum	3.0	1.9	3.0	60
RSA Nitrogen Deposition Load Areas (km^2) Outside of Mine Permit Boundary				
N - Deposition > 3.5 kg/ha/yr	0.0	8.0	8.5	5.9
N - Deposition > 5 kg/ha/yr	0.0	0.6	0.7	15

5.9 Potential Acid Input (PAI)

Precursor emissions for PAI include NO_X and SO_2. Based on RELAD modelling (Cheng 2009), the PAI deposition was zero in the RSA. The PAI background for this assessment, however, is 0.015 keq/ha/yr, estimated from the closest precipitation station at Kananaskis. The results of

CALPUFF modelling in the RSA are shown in Table 5.9-1. The pattern of PAI is presented in Figures 5.9-1 to 5.9-2.

The predicted maximum annual PAI at the RSA-MPOI is approximately 0.11 keq/ha/yr in the Baseline and 0.18 keq/ha/yr in Application/PDC cases, both below the threshold of 0.35 keq/ha/yr for moderately sensitive ecological areas.

Predicted annual PAI at the MPB was 0.02 keq/ha/yr for Baseline and 0.04 keq/ha/yr for Application and PDC cases, both well below the threshold of 0.35 keq/ha/yr. Outside the MPB, there is no deposition above the threshold of 0.17 keq/ha/yr for sensitive soil.

Predicted annual RSA-MPOIs for PAI in the Baseline case are located near Highway 3 and the community of Blairmore, primarily influenced by regional community and highway emissions.

Table 5.9-1 Predicted Maximum Annual Potential Acid Input

Parameter	Project Only	Baseline Case	Application / PDC Case	Application/PDC Case Increase Over Baseline [%]
RSA PAI Deposition (keq/ha/yr)				
Overall Maximum MPOI)	0.18	0.11	0.18	66
Mine Permit Boundary Maximum	0.04	0.02	0.04	98
RSA PAI Deposition Load Areas [km²] Outside of Mine Permit Boundary				
Sensitive Soil Monitoring Load > 0.17 keq/ha/yr	0.0	0.0	0.0	-

PAI is commonly evaluated in latitude/longitude grid cells to assist in the regional evaluation of potential acidification (Cheng 2009). As the Project encompasses an area less than one 1º by 1º grid cell, only the average deposition within a grid cell encompassing the project was evaluated (Table 5.9-2). In this calculation, areas outside the influence of the Project were assumed to have PAI at background levels. The average deposition in the grid cell is 0.03 keq H^+/ha/yr for Project-only and Application cases, much less than the monitoring level for moderately sensitive ecosystems.

Table 5.9-2 Average Potential Acid Input Predicted by CALPUFF in 1º by 1º Grid Cells[(a)]

Latitude [°]	Longitude [°]	Project Only Case [keq H^+/ha/yr]	Baseline Case [keq H^+/ha/yr]	Application / PDC Case [keq H^+/ha/yr]	Application/PDC Case Increase Over Baseline [%]
49	**114**	**0.03**	**0.02**	**0.03**	**86**

[(a)] Coordinates denote the SW corner of the grid cell
Bold indicates cell in which the Project is located.

5.10 Volatile Organic Compounds (VOCs) and Polycyclic Aromatics (PAHs)

The Project will generate trace chemical compounds from combustion of fuel for vehicles and mine equipment. The chemical compounds assessed have been identified as those emitted by the proposed Project that may potentially have a deleterious effect on human health if present in air in sufficient concentration, and whose concentrations are subject to AAAQOs.

There is limited availability of local ambient measurements for some VOC and PAH concentrations, so measurements from outside the RSA were used (sources of background concentrations are presented in Appendix C). For all species, this resulted in very conservative predictions as the modelling predictions (for all cases) were often much smaller than the background values. Ambient measurements were added to predictions for Baseline and Application cases, but not the Project-Only case.

Predictions of Chemicals of Potential Concern (COPCs) at the RSA-MPOI, MPB and special receptors near the Project, for chemicals subject to AAAQOs, are presented in Tables 5.10-1 to 5.10-6. No exceedances of AAAQOs were predicted for any COPC and, in most cases, the concentrations for the Project case at the MPOIs were many orders of magnitude below the AAAQOs. For most chemicals, the Project contribution was negligible at all locations.

Effects from COPCs are further considered in the human health risk assessment included in this EIA.

Table 5.10-1 Predicted Acetaldehyde Concentration

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application/PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	8.5E-03	23	23	23	0.0
Mine Permit Boundary Maximum	2.6E-03	23	23	23	0.0
Special Receptor Maximum	1.4E-03	23	23	23	0.0
AEP AAAQO(a)	**n/a(b)**	**n/a(b)**	**n/a(b)**	**n/a(b)**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	6.7E-03	23	23	23	0.0
Mine Permit Boundary Maximum	2.0E-03	23	23	23	0.0
Special Receptor Maximum	1.0E-03	23	23	23	0.0
AEP AAAQO(a)	90	90	90	90	

(a) Source: AESRD 2013a.

(b) The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.10-2 Predicted Benzene Concentration

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application/PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	0.26	2.3	2.6	2.6	0.0
Mine Permit Boundary Maximum	0.08	2.3	2.4	2.4	0.0
Special Receptor Maximum	0.04	2.3	2.6	2.6	0.0
AEP AAAQO(a)	**n/a(b)**	**n/a(b)**	**n/a(b)**	**n/a(b)**	

Table 5.10-2 Predicted Benzene Concentration

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application/PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	0.21	2.3	2.6	2.6	0.0
Mine Permit Boundary Maximum	0.06	2.3	2.4	2.4	0.0
Special Receptor Maximum	0.03	2.3	2.5	2.5	0.0
AEP AAAQO[(a)]	**30**	**30**	**30**	**30**	
Annual Average					
Overall Maximum (RSA-MPOI)	0.010	0.58	0.62	0.62	0.0
Mine Permit Boundary Maximum	0.002	0.58	0.58	0.58	0.0
Special Receptor Maximum	0.002	0.58	0.61	0.61	0.0
AEP AAAQO[(a)]	**3.0**	**3.0**	**3.0**	**3.0**	

(a) Source: AESRD 2013a.

(b) The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.10-3 Predicted Benzo[a]pyrene Concentration

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application/PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
Annual Average					
Overall Maximum (RSA-MPOI)	3.4E-06	1.0E-05	2.2E-05	2.2E-05	0.0
Mine Permit Boundary Maximum	5.5E-07	1.0E-05	1.1E-05	1.1E-05	0.0
Special Receptor Maximum	6.3E-07	1.0E-05	2.0E-05	2.0E-05	0.0
AEP AAAQO[(a)]	**3.0E-04**	**3.0E-04**	**3.0E-04**	**3.0E-04**	

(a) Source: AESRD 2013).

(b) The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.10-4 Predicted Formaldehyde Concentration

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application/PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	2.7E-02	27.5	27.5	27.5	0.0
Mine Permit Boundary Maximum	8.1E-03	27.5	27.5	27.5	0.0
Special Receptor Maximum	4.3E-03	27.5	27.5	27.5	0.0
AEP AAAQO[a]	**n/a[b]**	**n/a[b]**	**n/a[b]**	**n/a[b]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	2.1E-02	27.5	27.5	27.5	0.0
Mine Permit Boundary Maximum	6.2E-03	27.5	27.5	27.5	0.0
Special Receptor Maximum	3.3E-03	27.5	27.5	27.5	0.0
AEP AAAQO[a]	**65**	**65**	**65**	**65**	

[a] Source: AESRD 2013a.

[b] The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.10-5 Predicted Toluene Concentration

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application/PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	0.10	11.1	11.2	11.2	0.0
Mine Permit Boundary Maximum	0.03	11.1	11.1	11.1	0.0
Special Receptor Maximum	0.02	11.1	11.2	11.2	0.0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	0.07	11.1	11.2	11.2	0.0
Mine Permit Boundary Maximum	0.02	11.1	11.1	11.1	0.0
Special Receptor Maximum	0.01	11.1	11.2	11.2	0.0
AEP AAAQO[(a)]	**1,880**	**1,880**	**1,880**	**1,880**	
24-Hour Maximum					
Overall Maximum (RSA-MPOI)	0.030	10.4	10.4	10.4	0.0
Mine Permit Boundary Maximum	0.011	10.4	10.4	10.4	0.0
Special Receptor Maximum	0.004	10.4	10.4	10.4	0.0
AEP AAAQO[(a)]	**400**	**400**	**400**	**400**	

(a) Source: AESRD 2013a.

(b) The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.10-6 Predicted Xylene Concentration

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application/PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	0.07	0.55	0.62	0.62	0.0
Mine Permit Boundary Maximum	0.02	0.55	0.56	0.57	2.7
Special Receptor Maximum	0.01	0.55	0.61	0.61	0.0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	0.05	0.55	0.61	0.61	0.0
Mine Permit Boundary Maximum	0.02	0.55	0.55	0.57	2.0
Special Receptor Maximum	0.01	0.55	0.60	0.60	0.0
AEP AAAQO[(a)]	**2,300**	**2,300**	**2,300**	**2,300**	
24-Hour Maximum					
Overall Maximum (RSA-MPOI)	0.021	0.52	0.55	0.55	0.0
Mine Permit Boundary Maximum	0.007	0.52	0.52	0.53	1.1
Special Receptor Maximum	0.003	0.52	0.54	0.54	0.0
AEP AAAQO[(a)]	**700**	**700**	**700**	**700**	

(a) Source: AESRD 2013a.

(b) The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

5.11 Metals

Sources of metals include exhaust emissions from diesel combustion and fugitive emissions from the re-suspension of road dust and material handling in pit operations. Not all metals have associated diesel combustion emission factors and if there were no emission factors available for a particular species, then the primary emission source would be from the soil/dust component (Appendix A Section A7).

In addition, there is limited availability of background ambient measurements for metals so measurements from outside the RSA were used. Ambient measurements (summarized in Appendix C) tend to be available from areas with higher levels of industrialization than the Project area, so the background concentrations introduce additional conservatism to the predictions.

No exceedances of the AAAQOs were predicted for any metal, for any averaging period (Tables 5.11-1 to 5.11-5). At some locations, the relative (percent) increase over the Baseline is large. However, the actual magnitude of the increase is small, and is well below the AAAQO. Model results indicated a larger relative increase in the Application predictions at the RSA-MPOI and MPB. However, the change due to the addition of the Project at all special receptors was small or negligible.

Table 5.11-1 Predicted Arsenic Concentration

Receptor Location	Project Only [μg/m³]	Background [μg/m³]	Baseline Case [μg/m³]	Application/PDC Case [μg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	2.2E-02	6.5E-04	1.3E-02	2.3E-02	83
Mine Permit Boundary Maximum	7.2E-03	6.5E-04	1.4E-03	7.8E-03	458
Special Receptor Maximum	2.8E-03	6.5E-04	1.1E-02	1.1E-02	0.0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	1.8E-02	6.5E-04	1.0E-02	1.8E-02	84
Mine Permit Boundary Maximum	5.3E-03	6.5E-04	1.3E-03	6.0E-03	372
Special Receptor Maximum	1.7E-03	6.5E-04	9.3E-03	9.3E-03	0.0
AEP AAAQO[(a)]	**0.1**	**0.1**	**0.1**	**0.1**	
Annual Maximum					
Overall Maximum (RSA-MPOI)	1.0E-03	1.3E-04	1.6E-03	1.6E-03	0.3
Mine Permit Boundary Maximum	1.3E-04	1.3E-04	1.9E-04	2.7E-04	43
Special Receptor Maximum	1.4E-04	1.3E-04	1.4E-03	1.4E-03	0.2
AEP AAAQO[(a)]	**0.01**	**0.01**	**0.01**	**0.01**	

(a) Source: AESRD 2013a.
(b) The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).
Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.11-2 Predicted Chromium Concentration

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application/PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	2.0E-02	4.7E-03	1.0E-02	2.5E-02	146
Mine Permit Boundary	5.9E-03	4.7E-03	4.9E-03	1.1E-02	115
Special Receptor Maximum	2.1E-03	4.7E-03	9.7E-03	9.7E-03	0.0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	1.5E-02	4.7E-03	8.7E-03	2.0E-02	129
Mine Permit Boundary	4.4E-03	4.7E-03	4.9E-03	9.1E-03	86
Special Receptor Maximum	1.1E-03	4.7E-03	8.5E-03	8.5E-03	0.0
AEP AAAQO[(a)]	**1.0**	**1.0**	**1.0**	**1.0**	

[(a)] Source: AESRD 2013a.

[(b)] The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.11-3 Predicted Lead Concentration

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application/PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	3.8E-02	4.4E-03	1.3E-02	4.2E-02	220
Mine Permit Boundary	1.1E-02	4.4E-03	4.7E-03	1.5E-02	218
Special Receptor Maximum	3.6E-03	4.4E-03	1.2E-02	1.2E-02	0.0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	2.8E-02	4.4E-03	1.1E-02	3.2E-02	200
Mine Permit Boundary	7.9E-03	4.4E-03	4.6E-03	1.2E-02	166

Table 5.11-3 Predicted Lead Concentration

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application/PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
Special Receptor Maximum	1.9E-03	4.4E-03	1.0E-02	1.0E-02	0.0
AEP AAAQO[(a)]	**1.5**	**1.5**	**1.5**	**1.5**	

[(a)] Source: AESRD 2013a.
[(b)] The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).
Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.11-4 Predicted Manganese Concentration

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application/PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	1.2E-03	7.8E-03	9.1E-03	9.1E-03	0.0
Mine Permit Boundary	3.7E-04	7.8E-03	7.9E-03	8.1E-03	3.6
Special Receptor Maximum	1.9E-04	7.8E-03	8.9E-03	8.9E-03	0.0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	9.4E-04	7.8E-03	8.8E-03	8.8E-03	0.0
Mine Permit Boundary	2.8E-04	7.8E-03	7.8E-03	8.0E-03	2.6
Special Receptor Maximum	1.5E-04	7.8E-03	8.7E-03	8.7E-03	0.0
AEP AAAQO[(a)]	**2.0**	**2.0**	**2.0**	**2.0**	
Annual Maximum					
Overall Maximum (RSA-MPOI)	4.7E-05	1.5E-03	1.7E-03	1.7E-03	0.0
Mine Permit Boundary	7.7E-06	1.5E-03	1.5E-03	1.5E-03	0.1
Special Receptor Maximum	8.7E-06	1.5E-03	1.6E-03	1.6E-03	0.0
AEP AAAQO[(a)]	**0.2**	**0.2**	**0.2**	**0.20**	

[(a)] Source: AESRD 2013a.
[(b)] The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).
Shaded Cells: AAAQOs are not applicable to predicted increases.

Table 5.11-5 Predicted Nickel Concentration

Receptor Location	Project Only [µg/m³]	Background [µg/m³]	Baseline Case [µg/m³]	Application/PDC Case [µg/m³]	Application/PDC Case Increase Over Baseline [%]
1-Hour Maximum					
Overall Maximum (RSA-MPOI)	8.4E-02	4.4E-02	5.9E-02	1.3E-01	117
Mine Permit Boundary	2.2E-02	4.4E-02	4.4E-02	6.6E-02	50
Special Receptor Maximum	7.5E-03	4.4E-02	5.7E-02	5.7E-02	0.0
AEP AAAQO[(a)]	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	**n/a[(b)]**	
9th Highest 1-Hour (99.9th Percentile)					
Overall Maximum (RSA-MPOI)	6.0E-02	4.4E-02	5.5E-02	1.0E-01	90
Mine Permit Boundary	1.7E-02	4.4E-02	4.4E-02	6.0E-02	37
Special Receptor Maximum	3.9E-03	4.4E-02	5.4E-02	5.4E-02	0.0
AEP AAAQO[(a)]	**6.0**	**6.0**	**6.0**	**6.0**	
Annual Maximum					
Overall Maximum (RSA-MPOI)	3.1E-03	8.4E-03	9.3E-03	1.1E-02	23
Mine Permit Boundary	3.6E-04	8.4E-03	8.4E-03	8.7E-03	4.1
Special Receptor Maximum	3.3E-04	8.4E-03	9.1E-03	9.1E-03	0.2
AEP AAAQO[(a)]	**0.05**	**0.05**	**0.05**	**0.05**	

(a) Source: AESRD 2013a.

(b) The hourly AAAQO is to be applied to the 99.9th percentile hourly predictions (AESRD 2013b).

Shaded Cells: AAAQOs are not applicable to predicted increases.

5.12 Odour

5.12.1 Approach

In this section, the maximum predicted concentrations for compounds are compared with established odour thresholds. As odour can be perceived within a short time span, the air concentration used in the comparison was based on a three-minute averaging period. The 9th highest hourly predictions for the compounds were converted to a three-minute average using the following equation:

$$C_3 = C_{60} \times (60 \text{ minutes} / 3 \text{ minutes})^a$$

Where:

C_3 is the three-minute peak concentration derived from hourly predictions;

C_{60} is the predicted 9th highest one-hour concentration; and

^{a} is a stability dependent exponent, which is 0.5 for neutral atmospheres, as recommended by the AEP model guideline (AESRD 2013c).

The frequency of exceedance reported is the maximum annual frequency predicted in the five years that were modelled. Only those emissions with established odour thresholds were assessed. Predicted concentrations were compared to mean odour thresholds found in the literature.

Establishing air quality criteria for odours is challenging as odour detection, recognition and nuisance thresholds for compounds vary from individual to individual. Odour threshold were reviewed from the literature (Amoore and Hautala 1983; Ruth 1986; and van Gemert 1999); however, lower odour detection thresholds as recommended by Nagata (2003) were used in the odour assessment. The odour thresholds for air emissions from the proposed project are presented in Table 5.12-1. Because odour thresholds are not relevant for particulate matter and also not available for most PAHs with the exception of naphthalene and acenaphthene, those species are not addressed in the odour assessment. No background concentrations were included in the odour assessment.

5.12.2 Assessment Results

5.12.2.1 Individual Chemical Approach

A summary of the chemicals included in the odour assessment is presented in Table 5.12-1, and indicates that the mean odour detection thresholds were not exceeded by the 3-minute predictions, except for NO_2.

The results of the odour assessment for these chemicals are presented in Table 5.12-2. The exceedances of the odour threshold for NO_2 were predicted to occur on the eastern Project boundary, mainly influenced by blasting activities which were modelled to occur once each day.

Predicted 3-minute NO_2 concentrations at special receptors and frequency of exceedance at all special receptors are presented in Table 5.12-3. The table indicates that the highest Baseline NO_2 odour detection frequency was 44% at R8 near Highway 3. The highest Application case frequency of exceedance at special receptors influenced by the mine operation was 14% at R10 inside the MPB where the concentrations would be largely influenced by blasting emissions. The odour thresholds used in this assessment are detection thresholds. They do not represent concentration levels at which nuisance would be noted.

The change due to the addition of the Project at special receptors in or near communities was negligible to small.

Table 5.12-1 Odour Assessment and Predicted Exceedances

Chemical Modelled	Project Only			Baseline			Application		
	RSA-MPOI	Mine Permit Boundary	Special Receptors	RSA-MPOI	Mine Permit Boundary	Special Receptors	RSA-MPOI	Mine Permit Boundary	Special Receptors
Acenaphthene	-	-	-	-	-	-	-	-	-
Acetaldehyde	-	-	-	-	-	-	-	-	-
Acrolein	-	-	-	-	-	-	-	-	-
Benzene	-	-	-	-	-	-	-	-	-
Formaldehyde	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	-	-	-	-	-	-
Nitrogen Dioxide	√	√	√	√	√	√	√	√	√
Sulphur Dioxide	-	-	-	-	-	-	-	-	-
Propylene									
Toluene	-	-	-	-	-	-	-	-	-
Xylenes	-	-	-	-	-	-	-	-	-

√ 3-minute predicted concentrations exceed odour threshold;

- Mean odour threshold not exceeded

Table 5.12-2 Predicted 3-Minute Concentration of Odourants

Compound	Receptor Location	Predicted 3-Minute Concentration (μg/m³)			Odour Threshold (μg/m³)	Percentage of Odour Threshold (%)		
		Project Only Case	Baseline Case	Application Case		Project Only Case	Baseline Case	Application Case
Benzene	Overall Maximum (RSA-MPOI)	0.92	1.04	1.04	8,621	0.0	0.0	0.0
	Mine Permit Boundary Maximum	0.27	0.07	0.27	8,621	0.0	0.0	0.0
	Special Receptor Maximum	0.14	0.93	0.93	8,621	0.0	0.0	0.0
Toluene	Overall Maximum (RSA-MPOI)	0.33	0.38	0.38	1,243	0.0	0.0	0.0
	Mine Permit Boundary Maximum	0.10	0.03	0.10	1,243	0.0	0.0	0.0
	Special Receptor Maximum	0.05	0.34	0.34	1,243	0.0	0.0	0.0
Xylenes	Overall Maximum (RSA-MPOI)	0.23	0.26	0.26	4,773	0.0	0.0	0.0
	Mine Permit Boundary Maximum	0.07	0.02	0.07	4,773	0.0	0.0	0.0
	Special Receptor Maximum	0.04	0.23	0.23	4,773	0.0	0.0	0.0
Propylene	Overall Maximum (RSA-MPOI)	3.30	3.73	3.73	22,360	0.0	0.0	0.0
	Mine Permit Boundary Maximum	0.98	0.26	0.99	22,360	0.0	0.0	0.0
	Special Receptor Maximum	0.52	3.35	3.35	22,360	0.0	0.0	0.0
Formaldehyde	Overall Maximum (RSA-MPOI)	0.09	0.11	0.11	614	0.0	0.0	0.0
	Mine Permit Boundary Maximum	0.03	0.01	0.03	614	0.0	0.0	0.0
	Special Receptor Maximum	0.01	0.09	0.09	614	0.0	0.0	0.0

Table 5.12-2 Predicted 3-Minute Concentration of Odourants

Compound	Receptor Location	Predicted 3-Minute Concentration (µg/m³)			Odour Threshold (µg/m³)	Percentage of Odour Threshold (%)		
		Project Only Case	Baseline Case	Application Case		Project Only Case	Baseline Case	Application Case
Acetaldehyde	Overall Maximum (RSA-MPOI)	0.03	0.03	0.03	2.7	1.1	1.2	1.2
	Mine Permit Boundary Maximum	0.01	0.00	0.01	2.7	0.3	0.1	0.3
	Special Receptor Maximum	4.7E-03	0.03	0.03	2.7	0.2	1.1	1.1
Acrolein	Overall Maximum (RSA-MPOI)	9.3E-03	1.1E-02	1.1E-02	8.2	0.1	0.1	0.1
	Mine Permit Boundary Maximum	2.8E-03	7.4E-04	2.8E-03	8.2	0.0	0.0	0.0
	Special Receptor Maximum	1.5E-03	9.5E-03	9.5E-03	8.2	0.0	0.1	0.1
Naphthalene	Overall Maximum (RSA-MPOI)	0.15	0.17	0.17	440	0.0	0.0	0.0
	Mine Permit Boundary Maximum	0.05	0.01	0.05	440	0.0	0.0	0.0
	Special Receptor Maximum	0.02	0.16	0.16	440	0.0	0.0	0.0
Sulphur Dioxide	Overall Maximum (RSA-MPOI)	131	36	143	2,278	5.8	1.6	6.3
	Mine Permit Boundary Maximum	17	13	28	2,278	0.7	0.6	1.2
	Special Receptor Maximum	9.1	34	34	2,278	0.4	1.5	1.5
Nitrogen Dioxide	Overall Maximum (RSA-MPOI)	1,295	499	1,309	226	573	221	579
	Mine Permit Boundary Maximum	492	272	507	226	218	120	224
	Special Receptor Maximum	405	488	488	226	179	216	216

Table 5.12-3 Predicted 3-Minute NO_2 Concentration at Special Receptors

Receptor Name	Predicted 3-Minute Concentration (µg/m³)			Odour Threshold from Nagata[a] (µg/m³)	Percentage of Odour Threshold (%)			Frequency of Exceedance (%)		
	Project Only Case	Baseline Case	Application Case		Project Only Case	Baseline Case	Application Case	Project Only Case	Baseline Case	Application Case
R1-Campground	153	397	397	226	68	176	176	0	9.2	9.4
R2-Trapper's Cabin #1	209	152	271	226	92	67	120	0	0	0.4
R3-Residential #1	126	398	398	226	56	176	176	0	9.8	10
R4-Residential #2	76	147	219	226	34	65	97	0	0	0
R5-Residential #3	116	149	238	226	51	66	105	0	0	0
R6-Coleman	139	430	430	226	62	190	190	0	28	28
R7-Frank	111	389	390	226	49	172	172	0	13	14
R8-Blairmore North	131	488	488	226	58	216	216	0	44	44
R9-Aboriginal	405	197	420	226	179	87	186	2.5	0	6.2
R10-Residential #4	387	161	409	226	171	71	181	3.6	0	14
R11-Trapper's Cabin #2	389	154	411	226	172	68	182	1.2	0	3.0
R12-Residential #5	262	173	339	226	116	77	150	0.04	0	2.6
R13-Residential #6	298	164	350	226	132	73	155	0.1	0	2.1
R14-Blairmore Center	121	420	420	226	54	186	186	0	25	25

5.12.2.2 Additive Approach

Odour detection potential was assessed using an additive odour approach (Kim and Park 2008, Adamache and Spink 2012). In this approach, the sum of the concentration of each constituent divided by the odour detection threshold is determined. A sum greater than one indicates a potential for odour detection. This approach is conservative because it considers only positive synergistic effects, not potential masking effects.

The Nagata (2003) odour thresholds refer to the levels at which half a population can just detect an odour. The odour potential presented here is therefore not a nuisance threshold, which would occur at higher concentrations.

The odour detection potential is shown in Table 5.12-4 and was almost entirely determined by NO_2 concentrations, with minor contributions from SO_2. The Project does not contribute to odour potential in communities. At the nearest special receptor (R10) inside the MPB, there is potential for odour to be detected.

Table 5.12-4 Odour Detection Potential

Receptor Location	Odour Detection Potential from Predicted 3-Minute Concentrations		
	Project Only Case	Baseline Case	Application Case
Overall Maximum (RSA-MPOI)	5.8	2.2	5.9
Mine Permit Boundary Maximum	2.2	1.2	2.3
Special Receptor Maximum	1.8	2.2	2.2

5.13 Ozone

Surface O_3 can be formed through photochemical production from emissions of anthropogenic NO_x, anthropogenic VOCs, and biogenic VOC compounds. The potential is greatest during summer periods characterized by high ambient temperatures (*i.e.* above 30°C) and stagnant weather conditions (*i.e.* low wind speeds).

Observations of O_3 at three air monitoring stations near the study area – Lethbridge, Castlegar, and Nelson - have been summarized in Appendix C (Section C3.4) for 2009-2014. The 1-h maximum observation at Castlegar was substantially higher than at other stations, but lower percentile values were substantially lower and for these percentiles and averaging times, Lethbridge values were consistently higher. The 4th highest 8-h average values at all three stations were lower than the CAAQS of 63 ppb (124 µg/m^3).

Photochemical models can be used to predict the secondary formation of O_3 based on precursor emissions and meteorological conditions. These models have been applied in Alberta to determine the potential for O_3 formation due to future changes in precursor emissions.

Fox and Kellerhaus (2008) used the CMAQ model to estimate future O_3 concentration throughout Alberta that could result from foreseeable emission increases. Of the source sectors considered in the study, those most applicable to the Project area were oil and gas and on-road emissions; future emission increases in oil and gas were estimated to be negligible in the province. On-road emission changes were also negligible and are likely to decline with new vehicle emission reduction advances. With these emission assumptions, Fox and Kellerhaus predicted future increases in ozone concentrations (4th highest 8-h average values) of between zero and 1% in the region of the Project.

According to Tables 4.2-5, 4.4-2, and 4.4-3, Project NOx emissions are about five times total RSA baseline emissions of NOx of 0.69 t/d, resulting from highway and community sources. Thus the Project contribution would correspond to about a less-than 5% increase in 4th highest 8-h average O_3 concentrations.

5.14 Climate Change

This section qualitatively identifies impacts to air quality on all stages of the Project from projected changes in climate factors. Climate change may affect construction, operation, decommissioning, and reclamation stages of the Project.

The climate change assessment for the Project included the following elements:

- determine projections for climate parameters during the Project lifetime;
- identify potential effects of climate change on Project stages; and
- identify implications that climate change may have on the Project.

5.14.1 Projected Climate Change

A large number of institutions have developed global climate models (GCM) that address a wide range of potential climate change scenarios based on various global growth and technology implementation approaches (IPCC 2001; Nakicenovic and Swart, 2000). The effects of global warming on climate variables in Alberta have been assessed by the Prairie Adaptation Research Collaborative (PARC) using IPCC growth scenarios and various international GCMs (Barrow and Yu, 2005).

More recent predictions are available from the Prairie Climate Center (PCC) which is a collaboration of the University of Winnipeg and the International Institute for Sustainable Development (http://climateatlas.ca/home.html). The primary source of PCC climate model data is the Pacific Climate Impacts Consortium (pacificclimate.org). The dataset was statistically downscaled to produce 10-km scale predictions for the M.D. of Pincher Creek from 12 global climate models (ACCESS1.0, CanESM2, CCSM4, CNRM-CM5, CSIRO-Mk3-6.0, GFDL-ESM2G, HadGEM2-CC, HadGEM2-LR, INM-CM4, MPI-ESM-LR, MRI-CGCM3, MIROC5), for two emissions scenarios (RCP4.5 and RCP8.5) that reflect "high" and "low" carbon futures.

PCC predictions for Alberta include temperatures (maximum and minimum) and total precipitation at 10 km resolution for the prairie provinces, for the period 1950-2100. Average predictions from the 12 GCMs from the recent past and the year 2050 are presented, the latter for high and low carbon futures.

The existing and projected changes to the selected climate parameters are provided for the region near the Project. The selected parameters are:

- number of warm and cold days;
- seasonal precipitation; and
- frost free days.

Predicted changes in the 2050s for these parameters near the expected end of the Project lifetime are listed in Table 5.14-1. The changes are largely independent of which emission scenario is used: a substantial increase in the number of hot days and a decrease in the number of cold days, a 3% increase in precipitation with an increase in spring and a decrease in summer, and a 15% increase in the frost-free period.

Table 5.14-1 Projected Climate Parameters near Pincher Greek based on the Average of 12 GCMs (PCC 2016)

Parameter	Baseline Value (1961 – 1990)	High Carbon Prediction, 2050s	Low Carbon Prediction, 2050s
Number of Days above 30 °C	7.6	17.2	15.2
Number of Days below -30 °C	3.0	0.6	0.9
Precipitation (mm)	474.7	487.0	489.2
Total Winter	76.6	79.4	82.2
Total Spring	134.8	151.3	150.8

Table 5.14-1 Projected Climate Parameters near Pincher Greek based on the Average of 12 GCMs (PCC 2016)

Parameter	Baseline Value (1961 – 1990)	High Carbon Prediction, 2050s	Low Carbon Prediction, 2050s
Total Summer	175.4	164.1	165.5
Total Fall	87.9	92.2	90.7
Frost Free Days	114.3	133.2	129.9

5.14.2 General Influences on Air Quality

Air quality is strongly dependent on specific weather variables and could therefore be sensitive to climate change. Generally, and not necessarily applicable to the RSA, the future climate is expected to be more stagnant due to a weaker global circulation and the currently decreasing frequency of mid-latitude cyclones. The observed correlation between surface ozone and temperature in polluted regions points to a detrimental effect of warming. Warmer temperatures will increase summertime surface ozone in regions with anthropogenic emissions (Jacob and Winner, 2009); at the same time, increased water vapour in the future climate is expected to decrease the ozone background, so these two parameters have opposite sensitivities to climate change.

The effect of climate change on particulates is more complicated and uncertain than for ozone. Precipitation frequency is an important factor in mitigation, and increased storminess is predicted.

5.14.3 Sensitivity to Climate Change

5.14.3.1 Construction

Construction on the Project is largely limited to new haul road corridors in stages throughout the Project life, the Plant and the conveyor system. Extreme weather conditions may affect fugitive dust emissions and the frequency of windblown dust. The impact is expected to be low, occurring either prior to the beginning of operations (for construction of the conveyors, Plant and the main haul road) or during operations for construction of secondary haul roads within the various mine segments. Any increases in dust can be readily managed with appropriate dust control. The impact of climate change on construction is expected to be minor.

5.14.3.2 Operations

An increase in mean temperature will have no impact on the Plant, as it is designed for operation in a wide range of temperatures. There may be a small effect on ozone and VOC concentrations, depending on the seasonality of the temperature changes. Biogenic VOC emissions may increase slightly if the temperature increases occur in summer, resulting in slightly higher background concentrations. Increased VOCs could increase the rate of ozone formation. In addition, ozone production increases quickly with increased temperature and solar radiation.

Increases in the frequency of extreme temperature will result in an increased frequency of high ozone concentrations, as a result of the increase in temperature/radiation and possibly through increases in biogenic emissions of precursors.

At the same time, increases in degree days could likely cause additional drying. Mitigation by road watering could adapt to changes as they occur. $PM_{2.5}$ emissions, which arise largely from combustion, are not expected to change as much as those of coarser particulate.

5.14.3.3 Decommissioning and Reclamation

For the decommissioning phase of the Project, climate change may impact reclamation and re-vegetation activities, potentially increasing fugitive dust emissions as evidenced by increases in the number of hot days in summer and reduction in summer precipitation in the 2050s. These impacts are anticipated to be low and can be readily managed with appropriate dust control.

Overall, the change in climate will have low to no impact on air quality associated with the Project as potential increases in fugitive dust can be managed through adaptive road watering practices.

5.15 Assessment for Start-Up/Upset Emissions

As explained in Section 4.2-4, emission estimations for construction of haul roads and mines are much lower than total emissions for the mines and haul roads during regular operations. Construction activities occur concurrently with mining activities, and operational vehicle activity indicators already include concurrent construction activities. The emissions calculated for the Project are not additional or incremental to the emissions for construction of haul roads and mines. Rather, the emissions for haul roads and mines construction have already been accounted for in the emissions for the Project.

The following sections identify impacts from potential upset scenarios. At this point, no estimates are available for the probability that these upsets could occur.

5.15.1 Large Wall Failure

Dust emissions for the large wall failure upset case are calculated based on the total volume of fallen rock and emission factors described in AP 42 Section 11.19.2 (U.S. EPA 2004) (Crushed Stone Processing and Pulverized Mineral Processing). According to this document, the PM_{10} emission factor for unloading fragmented stone is 8.0E-06 kg/t.

If the material size distribution of this upset case is assumed to be the same as that of AP42 Section 13.2.4 (U.S. EPA 2006a) for aggregate handling and storage (TSP/PM_{10}=0.74/0.35, $PM_{2.5}$/PM_{10}=0.053/0.35), the emission factor is 1.7E-05 kg/t for TSP and 1.2E-06 kg/t for $PM_{2.5}$. This assumption is expected to be conservative, as much larger pieces of stone are expected to be formed in the failure case than in the aggregate handling case, which would overstate the emission factor.

The estimated total volume for the large wall failure is roughly 2 million cubic metres, approximately 4.4 million tonnes. Using the above emission factors, the estimated dust emission due to this failure would be 5.3 kg $PM_{2.5}$, 35 kg PM_{10} and 74 kg TSP (Table 5.15-1). It is expected these emissions would occur for a time interval of a few minutes.

To put the estimated emissions from this upset case into perspective, maximum hourly fugitive dust emissions generated from Project activities, including blasting, were 20 kg/h $PM_{2.5}$, 185 kg/h PM_{10} and 675 kg/h TSP (Table 4.2-4). Therefore dust emissions generated from the event of a large wall failure would be 11% to 27% of total hourly dust emissions from Project activities.

Table 5.15-1 Wall Failure Upset Emissions

	$PM_{2.5}$	PM_{10}	TSP
Emission Factor for Unloading Fragmented Stone (kg/t) (AP42 Table 11.19.2-1)	1.2E-06	8.0E-06	1.7E-05
Total Dust Emission (kg) from Large Wall Failure with 4.4 Million Tonnes Volume	5.3	35	74
Total Dust Emission from Grassy Project Activities (kg/h)	20	185	675
Percentage of Wall Failure Emissions over Total Project Emissions	**27%**	**19%**	**11%**

The wall failure could occur inside an open sunken pit about 300 m below the surface. It is reasonable to expect that only a fraction of the fugitive dust generated during the wall failure at the pit floor escapes to the pit surface where it then may be transported to the mine boundaries. Applying the escape factor (described in Appendix A, Section A4.11) would reduce emissions by an additional 25% to 50% for PM_{10} and 80 % for TSP. These additional reductions are not included in the table above.

Even though the upset emissions would originate over a single area in the centre of the operating mine, they are much less than normal emissions from Project activities spread over a larger area. It is expected that air quality impacts would be reduced in accordance with the reduction in emissions.

5.15.2 Rock Disposal Area Failure

The estimated total volume for a rock disposal area failure is 200,000 to 400,000 cubic metres - approximately 0.44 to 0.88 million tonnes (Mt). The rock displaced by this failure could be expected to run–out as far as 600 to 1,100 m from the disposal area. The event would last a few minutes. The rock in the disposal area is previously blasted rock with an average size of 40 cm.

The same emission factors described for the large wall failure were used to estimate the dust emissions from the rock disposal area failure. Estimated dust emissions due to this failure with 0.88 Mt volume rock would be 1.1 kg $PM_{2.5}$, 7.0 kg PM_{10} and 15 kg TSP. Again, the application of aggregate size distributions to 40 cm stone pieces is expected to result in a conservative emission estimate.

Maximum hourly fugitive dust emissions generated from Project activities, including blasting, were 20 kg/h $PM_{2.5}$, 185 kg/h PM_{10} and 675 kg/h TSP (Table 4.2-4). Therefore dust emissions generated from the event of rock disposal area failure would be 2% to 6% of total hourly dust emissions from Project activities.

Furthermore, a portion of the fugitive dust potential from the failure will already have been blown away during the initial blasting, material handling, and due to windblown removal. Therefore, the actual emission during the rock disposal area failure could be less than calculated.

5.15.3 Coal Train Derailment

It is extremely unlikely that all the cars in the entire train would empty all their contents. For this upset assessment, it was assumed that 40 cars derailed during a train accident, resulting in spilling 4,000 tonnes of clean coal.

According to the emission factor provided in AP 42 Table 11.9-4 (U.S. EPA 1998), the TSP emission factor for end-dump truck unloading of coal (batch drop) is 0.004 kg/t. If the same size distribution (TSP/PM_{10}=0.74/0.35, $TSP/PM_{2.5}$=0.74/0.053) as that of AP42 Section 13.2.4 (U.S. EPA 2006a) is used, the emission factors are 2.9E-04 kg/t for $PM_{2.5}$ and 1.9E-03 kg/t PM_{10}. The estimated dust emissions due to this worst-case train derailment with 4000 tonnes of clean coal would be 1.1 kg $PM_{2.5}$, 7.6 kg PM_{10} and 16 kg TSP.

To put the estimated emissions from this upset case into perspective, maximum hourly fugitive dust emissions generated from the train loadout under normal operations were 0.04 kg/h $PM_{2.5}$, 1.1 kg/h PM_{10} and 2.3 kg/h TSP (Table 4.2-4), based on 2,000 tonnes of clean coal per hour unloading from conveyor onto rail cars. Therefore, dust emissions generated from the train derailment event would be about 29 times the hourly dust emissions from normal train load-out operations for $PM_{2.5}$ and seven times for PM_{10} and TSP (Table 15.5-2).

Table 5.15-2 Coal Train Derailment Upset Emissions

	$PM_{2.5}$	PM_{10}	TSP
Emission Factor for End Dump Truck Unloading Coal (kg/t) (AP42 Table 11.9-4)	2.9E-04	1.9E-03	0.004
Total Particulate Emission (kg) from Coal Train Derailment with 4000 Tonnes of Clean Coal	1.1	7.6	16
Total Particulate Emission from Normal Train Load-out (kg/h)	0.04	1.1	2.3
Ratio of Train Derailment Upset Emissions to Normal Load-out Emissions	**29**	**6.9**	**6.9**

According to detailed model predictions, the 9th highest hourly $PM_{2.5}$ prediction at model grid points outside the load-out during normal operations was about 1.9 µg/m³ at receptor R8 resulting from normal train load-out emissions only. Based on the CALPUFF modelling results for this train derailment event only, the 9th highest hourly $PM_{2.5}$ prediction was about 20 µg/m³, 25% of the 1-hour AAAQG of 80 µg/m³. The MPOI for normal and upset events occurred at grid points about 600 m northwest of the train load-out. Compared to the normal train load-out, the $PM_{2.5}$ prediction is 10 times higher for the train derailment event. It is expected that increase of air quality impact for PM_{10} and TSP would be much smaller than $PM_{2.5}$ based on the emission comparison in the above table.

5.16 Light Levels

Responding to CEAA Guideline requirements, this section includes a description of existing ambient night-time light levels at the project site and at any other areas where project activities could have an effect on light levels or the visibility of Project operational activities during the day. It also includes a summary of expected light level changes at night.

5.16.1 Approach

The proposed Project is in an area without current light sources.

The proposed Project activities may be visible to the public at a number of locations, including the rail load-out, access road and conveyor corridor, and the CHPP, all of which are fixed. Activities will also occur at pits, waste disposal areas, and haul roads, whose locations vary with time. The types of activities that may be visible include CHPP and rail load-out structures, and street lights along the access road and rail loop area.

As such, the assessment of potential changes in night-time light levels was conducted by considering four Project locations would that would require night-time illumination:

- Rail loadout area;
- CHPP;
- the connecting access road/conveyor route (although lights along this route were not modelled); and
- the highest elevation accessed during development of the waste disposal areas as representative of the worst case location during mining operations.

The assessment assumed that a light source 15 m above ground would be placed at each of the locations, and would be viewed from a 2 m individual. The assessment considered the line of sight from these locations to other locations within about 20 km of each location. This 20 km radius is a very conservative distance as it is not expected that Project related illumination or activities would be visible at a distance of 20 km.

5.16.2 Results

The results of the assessment are shown in Figures 5.16-1 to 5.16-3. The locations from which project activities (as represented by a light source 15 m above ground) could be seen are shaded. The shaded areas in the figures do not represent locations at which lights would be annoying or intense. They simply represent line of sight positions, at which the light sources could be visible, if they were intense enough.

The main emphasis of the discussion is on potential impacts to community residents. The main observations from the assessment are:

- given the nature of the terrain in the area, activities at the rail loadout could be seen by residents in Coleman and Blairmore and along several kilometres of Highway 3 (Figure 15.6-1). However, this assessment does not consider the built-up nature of the communities and that, from some locations within them, views to the loadout would be blocked by intervening buildings. Lights at this location would not be generally visible from the Forestry Trunk Road because of intervening terrain;
- lighted activities at the plant site would be seen by no residents in the communities in the valley or along Highway 3 (Figure 15.6-2); and
- activities in the area of mining operations as represented by the waste disposal area (Figure 15.6-3) are likely to be visible over broader areas, but mostly from higher elevations. Activities would not be visible in any of the communities.

Benga will undertake the following mitigations to reduce changes to night-time light levels from the Project:

- use of low visibility spectrum lights on CHPP and rail loadout structures;
- use of low visibility spectrum lights in light stands, designed with directional shades to minimize illumination above the lights horizontal line and to direct light to the illuminated feature (*e.g.*, the waste disposal area);
- implementation of an on-demand and adaptive light management strategy (*i.e.*, activated when needed) at the rail loadout during times a train set is not onsite for loading during night time hours;
- where possible, minimize the amount of train loading during night time hours;
- light-duty vehicles along the access road will be kept to a minimum;
- the overland conveyor system will not be equipped with any additional lighting structures, as lighting would be provided by the associated access road lights;
- existing vegetation (mature trees) will not be cleared along areas requiring night-time illumination to reduce total viewshed;
- mobile lighting set ups on the waste rock disposal area(s) would only be used when needed, and will be equipped with low visibility spectrum lights; and
- mobile lighting set ups would be positioned (where possible) at the base of existing high points (such as the noise mitigation berm) to reduce their associated viewshed.

Given the distance of the lighting sources from the communities, and the mitigation measures proposed by Benga, it is expected that the visibility of operations will be low and the overall impact will be not significant.

6.0 SUMMARY OF ASSESSMENT RESULTS

6.1 Introduction

The assessment of air quality impacts consisted of identifying key air quality concerns and parameters resulting from the proposed mine development project, including sulphur dioxide (SO_2), oxides of nitrogen (NO_x), carbon monoxide (CO), particulate matter ($PM_{2.5}$, PM_{10} and TSP), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), metals and particulate deposition.

Four assessment cases were considered in the air quality assessment:

1. **Baseline Case**– including all existing emissions from Highway 3 and community emissions, with the addition of the ambient background concentrations. No active industrial facilities were located within RSA. The potential effects of natural sources to the Baseline Case are identified in Appendix C.

2. **Project-Only Case** in Year 19 – including Project only emissions from mining and waste stripping, north and south disposal area, haul road emissions, and coal processing facility emissions. This case does not include baseline emission sources and ambient background concentrations.
3. **Application Case** in Year 19 – including Baseline and Project Case sources as defined above.
4. **Planned Development Case (PDC)** – identical to the Application Case, because no new industrial developments were identified, and future community and traffic emissions were assumed to be approximately unchanged.

By conducting dispersion modelling that includes the effects of all industrial sources in the RSA, as well as community and transportation sources and a regional background concentration, and considering the potential new industrial development in the area, Benga has met the CEAA (2015) Section 6.6.3 requirements of an air quality cumulative effects assessment.

For the Project Case, Year 19 was identified as the year when the mine will be at full production with 47.5 million BCM of overburden removal and the haul roads will be long and located near the boundary of the mine permit boundary. At that time, the annual production will be approximately 6.8 Mt and 3.8 Mt of raw and clean coal, respectively. For air quality assessment purposes, maximum hourly and daily emissions were used.

Dispersion modelling for each of the scenarios was conducted with CALPUFF in accordance with the AEP model guideline (AESRD 2013b). Predictions were made over a grid of receptors, and maximum values were presented at the RSA-MPOI and Mine Permit Boundary, as well as at specific receptors for input to the human health risk assessment.

6.2 Project Contribution to Regional Emissions

The Project will be developed in an airshed that has other emission sources. Table 6.2-1 lists key emissions for each of the assessment cases and shows the contribution of the Project to the Baseline case in the study area.

For most CAC emissions, except CO, emissions associated with the Project are larger than Baseline regional missions. Uncertainties in emission estimates from communities and Highway 3 traffic are expected to be larger than those associated with Project combustion emissions. Uncertainties associated with fugitive and windblown dust are larger than uncertainties in combustion emissions.

Table 6.2-1 Summary of Annual Average Emissions

Scenario	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Baseline Emissions (t/year)	2.8	253	1,395	35	117	568
Project (t/year)	5.6	929	420	114	1,001	3,866
Application/PDC (t/year)	8.4	1,182	1,815	149	1,118	4,434
Application/PDC increase relative to Baseline (%)	201	367	30	322	856	680

6.3 Air Quality Predictions

A summary of air quality model predictions at the RSA-MPOI, MPB and special receptors is presented in Table 6.3-1 to Table 6.3-3, respectively. Comparisons to ambient objectives are made at or beyond the MPB, or at special receptors. The predictions are summarized below:

- blasting resulted in large relative increases in predicted maximum 1-hour concentrations of combustion emissions (SO_2, NO_2, and CO) on the eastern pit boundary. For longer averaging periods, the actual and relative increases due to the Project were negligible. The AAAQOs were met for all averaging periods for SO_2, NO_2 and CO at and beyond the MPB in all three assessment cases, and also at special receptors;
- the 24-hour $PM_{2.5}$ AAAQO or CAAQS was not exceeded at or beyond the MPB or at any special receptors in Application/PDC and Project-only cases. The Project (rail load-out) increased predicted concentrations at the nearest special receptor in Blairmore by less than 1%;
- PM_{10} daily predictions exceeded the BCAAQO in Blairmore in the Baseline case as a result of community and highway emissions. Exceedances were predicted at the MPB in the Application/PDC assessment cases where exceedances were predicted 3.6% of the time over a small area as a result of fugitive dust emissions from the haul road located very close to the boundary of the pit. The Project (rail load-out) increased predicted concentrations at the nearest special receptor in Blairmore by 2.7%;
- predicted TSP concentrations were above the AAAQOs at Blairmore in the Baseline case. In the Application case, predictions were also above the AAAQOs east of the pit at the MPB, occurring up to 5.9% of the time over a small area. Exceedances of the daily AAAQO were also predicted at a number of special receptors in both Application and Baseline cases, while the Project contribution was negligible. The Project (rail load-out) increased predicted concentrations at the nearest special receptor in Blairmore by 1.2%;

- predicted concentrations of all VOCs, PAHs and metals were less than AAAQOs at and beyond the MPB in Baseline and Application cases; and
- odours from NO_2 were predicted to be detectable in communities in the Baseline case, up to 44% of the time. The Project did not change those frequencies in the community and added a new location with detectable odour on the MPB in the Application case, likely the result of blasting.

Table 6.3-1 Summary of Key Predicted Air Quality Concentrations at the RSA-MPOI

Contaminant	Averaging Period	Project-Only		Baseline	Application/ PDC	Application/ PDC Case Increase Over Baseline [%]	AAQO (μg/m³)
		Prediction (μg/m³)	Percentage of AAQO	Prediction (μg/m³)	Prediction (μg/m³)		
SO_2	9th Highest 1-hour	29	6.5	8	32	299	450
	Maximum 24-hour	3.5	2.8	4.6	5.6	21	125
	Maximum 30-day	0.6	1.9	2.1	2.1	0	30
	Maximum Annual	0.3	1.5	1.8	1.8	0	20
NO_2	9th Highest 1-hour	290	97	112	293	162	300
	Maximum Annual	34	76	46	47	2	45
CO	9th Highest 1-hour	5,708	38	2,241	6,054	170	15,000
	Maximum 8-hour	2,530	42	1,638	2,835	73	6,000
$PM_{2.5}$	Maximum 24-hour	43	144	24	50	108	30
	98th Percentile 24-hour	25	89	20	32	58	28
	Maximum Annual	7.5	75	9.2	11.6	26	10
PM_{10}	Maximum 24-hour	293	586	72	314	335	50
TSP	Maximum 24-hour	623	623	220	665	202	100
	Maximum Annual	128	213	69	153	124	60

Table 6.3-2 Summary of Key Predicted Air Quality Concentrations at Mine Permit Boundary

Contaminant	Averaging Period	Project-Only		Baseline	Application/ PDC	Application/ PDC Case Increase Over Baseline [%]	AAQO (µg/m³)
		Prediction (µg/m³)	Percentage of AAQO	Prediction (µg/m³)	Prediction (µg/m³)		
SO_2	9th Highest 1-hour	3.8	0.8	2.8	6.4	124	450
	Maximum 24-hour	0.7	0.6	2.2	2.9	31	125
	Maximum 30-day	0.1	0.3	1.0	1.1	7.2	30
	Maximum Annual	0.05	0.2	0.92	0.95	3.1	20
NO_2	9th Highest 1-hour	110	37	61	113	86	300
	Maximum Annual	12	27	20	28	39	45
CO	9th Highest 1-hour	725	5	477	1,069	124	15,000
	Maximum 8-hour	1,055	18	391	1,358	247	6,000
$PM_{2.5}$	Maximum 24-hour	13	43	8.1	20	142	30
	98th Percentile 24-hour	6.2	22	7.9	13	66	28
	Maximum Annual	1.0	10	4.3	5.0	17	10
PM_{10}	Maximum 24-hour	84	168	24	105	335	50
TSP	Maximum 24-hour	190	190	46	232	407	100
	Maximum Annual	15	24	27	41	53	60

Table 6.3-3 Summary of Key Predicted Air Quality Concentrations at Special Receptors

Contaminant	Averaging Period	Project-Only		Baseline	Application/ PDC	Application/ PDC Case Increase Over Baseline [%]	AAQO (μg/m³)
		Prediction (μg/m³)	Percentage of AAQO	Prediction (μg/m³)	Prediction (μg/m³)		
SO_2	9th Highest 1-hour	2.0	0.5	7.5	7.5	0	450
	Maximum 24-hour	0.3	0.2	4.4	4.4	0	125
	Maximum 30-day	0.07	0.2	2.0	2.0	0	30
	Maximum Annual	0.05	0.2	1.6	1.6	0	20
NO_2	9th Highest 1-hour	91	30	109	109	0	300
	Maximum Annual	13	29	43	43	1.0	45
CO	9th Highest 1-hour	386	2.6	2,014	2,014	0	15,000
	Maximum 8-hour	314	5.2	1,574	1,574	0	6,000
$PM_{2.5}$	Maximum 24-hour	5.7	19	22	22	0.7	30
	98th Percentile 24-hour	3.5	12	19	19	0.6	28
	Maximum Annual	1.2	12	8.3	8.3	0.3	10
PM_{10}	Maximum 24-hour	34	68	64	66	2.7	50
TSP	Maximum 24-hour	60	60	182	184	1.2	100
	Maximum Annual	13	22	59	59	0.9	60

6.4 Impact Ratings

6.4.1 Fugitive Dust

The following comments apply specifically to predictions of PM_{10} and TSP concentration which at some locations exceed ambient objectives in Baseline and Application cases. The magnitude of residual impacts was high for fugitive dust (PM_{10} and TSP) when accounting for the effects of road watering and winter snow but not for any mitigative effects of vegetation or trapping by small terrain features. Predictions in the Baseline case were above ambient air quality objectives; predictions increased with the addition of the Project while the locations of the maxima shifted to nearer the

Project. Project predictions were due to the particular configuration of mining and haul roads during Year 19 and are not necessarily indicative of a long-term impact. Predictions at the permit boundary are relevant for comparison to ambient objectives because access within the boundary is controlled.

TSP is not associated with effects on human health. It is considered to represent the potential nuisance effects of dust emissions. Even though AAAQOs for TSP remain, the parameter is no longer measured by provincial monitoring networks. In this assessment, Benga used TSP as an indicator of its dust mitigation efficacy.

There is no AAAQO for PM_{10} and PM_{10} is not monitored in Alberta airshed networks. There are also no federal standards for PM_{10} concentration. As an indicator of effects on human health, PM_{10} was superseded by $PM_{2.5}$. There are no Project-related exceedances of the AAAQO or CAAQS for $PM_{2.5}$. All $PM_{2.5}$ concentrations at the mine permit boundary are less than AAAQO or CAAQS.

The predicted exceedances of PM_{10} and nuisance TSP occur relatively infrequently (at the mine permit boundary, at most 3.6% of the time for 24-hour PM_{10} and 5.9% of the time for 24-hour TSP). There was no exceedance of the AAAQO for annual TSP predictions at the mine permit boundary. The areas within which exceedance were predicted to occur occasionally were small – restricted to 5 km^2 for PM_{10} and 3 km^2 for TSP. Thus, the effects are very localized.

Only one special receptor (R10) is marginally affected by a PM_{10} and TSP exceedance under worst-case emissions and meteorology. The predicted frequencies of exceedance were 0.2% and 1.2% for PM_{10} and TSP, respectively, at this location. R10 is inside the mine permit boundary where no public access will be allowed during operation of the mine.

Measured concentrations are likely to be less than predicted because of the presence of small scale terrain features that trap dust and that are not accounted for in modelling. In addition, vegetation on the west side of the mine, based on satellite photos and field reconnaissance, would likely result in a factor of two reduction in actual measurements compared to predictions, based on information in Appendix A. On the east side, vegetation is smaller and less dense and a 25% reduction compared to predictions would be expected. Application of these adjustments would completely eliminate exceedances west of the ridge. On the east side, TSP exceedances at R10 would be eliminated.

Finally, it is expected that atmospheric turbulence and the parameterization of the roughness length Zo has been underestimated in current modelling. Zo values in mountainous terrain are typically more than three times higher than the values prescribed for modelling by AEP which are based on land use only, not on the complexity of terrain features (see Appendix B). Larger Zo values are expected to reduce predicted concentrations.

For these reasons, the predicted effects of PM_{10} and TSP are considered not to be significant.

6.4.2 Other Comments

Table 6.5-1 summarizes air quality impact ratings for Project residual effects. In the table, Project residual effects are those associated with maximum (daily) Project emissions or annual average emissions as appropriate. Project emissions cease after operations cease. For most air quality emissions associated with mining operations, effects are largest at the source and decrease with distance and are therefore local not regional in nature. Impact ratings are typically based on effects at the point of maximum prediction (on the mine permit boundary) because maximum concentrations there are usually associated with Project facilities.

The following observations relate to Project impacts of other emissions (as determined by comparison of Application and Baseline cases):

- all Project air quality impacts were considered to be local in extent, continuously occurring (most emissions are continuous), and long lasting (for the life of the Project) but reversible after project operations cease. All impacts were negative in direction;
- in most cases, because Project impacts were local, and regional emissions were near ground-level and confined to Highway 3 and communities, the cumulative impacts were also considered to be local;
- the magnitude of residual impacts was low for combustion-related emissions including SO_2, NO_2, CO, $PM_{2.5}$, VOCs, PAHs, metals, and nitrogen and acid deposition. For these parameters, actual increases in concentration or deposition were low even when relative increases were large given the isolated nature of the project. The approach used to assess the magnitude of impact was based on the increase over the Baseline value, for a specific air quality indicator, and is not an indicator of overall air quality (Section 2.5.2);
- confidence ratings were generally high for Project contribution predictions, with the exception of fugitive emissions and deposition which are considered to have higher emission and modelling uncertainties, notwithstanding a tendency for CALPUFF to predict conservatively; and
- overall, residual air quality impacts (significance) relevant to the Project were considered to be not significant.

6.5 Recommended Monitoring Program

Benga established a monitoring program in spring 2016, comprised of passive monitoring of SO_2, NO_X and O_3 near the proposed plant site. A network of 6 dustfall monitoring stations was also implemented, one at the plant site and five in other locations in the communities. Initial monitoring results are provided in Appendix C.

Benga proposes to establish an ambient air quality monitoring program to document the potential, localized, fugitive dust impacts due to Project operation. The measurement program for dustfall will be extended, with details of the required monitoring a function of the operational configuration at any time. As such, the dustfall monitoring program will need to be further developed when the mine plan is established and operations begin, and then modified as mining progresses.

Benga commits to developing a more detailed monitoring program when the mine plan is more advanced than it is now, and commits to reviewing its adequacy periodically in future. Benga will provide the draft monitoring plan to AER 6 months before planned start-up and to implement the program 3 months or more prior to the beginning of construction.

6.6 Air Quality Mitigation & Management

The primary sources of $PM_{2.5}$, PM_{10} and TSP emissions are dust from haul road activity and material handling. Benga has introduced mitigative measures to reduce particulate emissions along their private haul roads and for pit activities. All of these measures were incorporated into emission estimation and dispersion modelling:

- the mine fleet is regularly upgraded and by Year 19, equipment will be newer and more efficient than assumed in emission estimation. Exhaust emissions from the U.S. EPA Tier 4 (2010) standards were used in Project emission estimates and it is likely that off-road standards will be more stringent by Year 19;
- water is systematically applied to haul roads and to the plant access road to minimize dust using a water truck dedicated to this purpose. An emission control efficiency of 80% during the summer months is expected from this measure;
- snow cover is retained on the road as a mitigative measure during the winter months, unless the cover would compromise the safety of vehicle operations. Winter ground is frozen and, since the soil and overburden have elevated moisture contents, there is a reduction of dust emissions at that time;
- gravel or crushed rock is used on the haul roads. Gravel is observed to produce less dust than clay and sandy surfaces;
- use of a grader to maintain the active surface of the road. This procedure is expected to reduce the effective silt content of the portion of the road where the wheels of the haul trucks travel. The grader blade would tend to move the silt particles to the inactive portion (side) of the road or cover the active portion with coarser material;
- the mined areas are reclaimed promptly and backfilled with overburden and soil from pre-strip areas, and then covered by vegetation which reduces windblown fugitive dust emissions from exposed land;

- trees and bushes will be preserved around mines and plant, because they effectively trap dust emissions from mining activities and reduce dust concentrations farther from mining activities;
- the coal processing plant module will be contained within an enclosed area and all coal material handling will be *via* covered conveyors;
- dust generation from transferring coal from the conveyor to the stock pile will be minimized by the use of luffing stackers (those that can lower and raise their boom) which will minimize the drop height and drop time of the coal; and
- fugitive dust generation will be minimized at the rail load-out, with full cladding on the sides of the load-out structure to create a wind shelter, and with the movable discharge chute of the bin located as close as practical to the coal within the rail cars.

Mitigation measures for NOx emissions include the use of Tier 4 engines in heavy duty mine equipment. Benga will also investigate alternative ANFO formulations that reduce NOx emissions during blasting.

Table 6.5-1 Summary of Impact Significance on Air Quality

Measurable Parameter	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Effect	Geographic Extent[a]	Duration[b]	Frequency[c]	Reversibility[d]	Magnitude[e]	Project Contribution[f]	Confidence Rating[g]	Probability of Occurrence[h]	Significance[j]
1. NO_2 Concentration												
	Potential human health effects	Section 6.3	Project Residual	Local	Medium	Continuous	Reversible in short term	Moderate (blasting)	Negative	High	High	Not significant
			Cumulative	Local	Medium	Continuous	Reversible in long term	Low (localized impact of blasting)	Negative	Moderate	Medium	Not significant
2. SO_2 Concentration												
	Potential human health and vegetation effects	Section 6.3	Project Residual	Local	Medium	Continuous	Reversible in short term	Moderate	Negative	High	High	Not significant
			Cumulative	Local	Medium	Continuous	Reversible in long term	Low	Negative	Moderate	Medium	Not significant
3. $PM_{2.5}$ Concentration												
	Potential human health effects and visibility impairment	Section 6.3	Project Residual	Local	Medium	Continuous	Reversible in short term	Moderate (localized on mine permit boundary)	Negative	Moderate (greater uncertainty in PM secondary formation and fugitive component)	High	Not significant
			Cumulative	Local	Medium	Continuous	Reversible in long term	Low	Negative	Moderate	Medium	Not significant

Table 6.5-1 Summary of Impact Significance on Air Quality

Measurable Parameter	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Effect	Geographic Extent[(a)]	Duration[(b)]	Frequency[(c)]	Reversibility[(d)]	Magnitude[(e)]	Project Contribution[(f)]	Confidence Rating[(g)]	Probability of Occurrence[(h)]	Significance[(j)]
4.TSP Concentration												
	Nuisance effects	Section 6.3	Project Residual	Local	Medium	Continuous	Reversible in short term	High. Would be reduced by the effects of precipitation and vegetation.	Negative	Low (more uncertainty in fugitive emissions). Mitigative effects of vegetation not considered.	High	Not significant
			Cumulative	Local	Medium	Continuous	Reversible in long term	High (localized exceedances at special receptors). Would be reduced by the effects of precipitation and vegetation.	Negative	Low	Medium	Not significant
5. CO Concentration												
	Potential human health effects	Section 6.3	Project Residual	Local	Medium	Continuous	Reversible in short term	Moderate (localized impact of blasting)	Negative	High	High	Not significant
			Cumulative	Local	Medium	Continuous	Reversible in long term	Low	Negative	Moderate	Medium	Not significant

Table 6.5-1 Summary of Impact Significance on Air Quality

Measurable Parameter	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Effect	Geographic Extent[a]	Duration[b]	Frequency[c]	Reversibility[d]	Magnitude[e]	Project Contribution[f]	Confidence Rating[g]	Probability of Occurrence[h]	Significance[j]
6. PAI Deposition												
	Potential acidification of sensitive soils, water bodies and vegetation	Based on management of precursors as identified in Section 6.3	Project Residual	Local	Medium	Continuous	Reversible in short term	Low	Negative	Moderate (more uncertainty in deposition estimates)	Medium	Not significant
			Cumulative	Local	Medium	Continuous	Reversible in long term	Low (localized)	Negative	Low	Low	Not significant
7. Nitrogen Deposition												
	Potential eutrophication of sensitive ecosystems	Based on management of precursors as identified in Section 6.3	Project Residual	Local	Medium	Continuous	Reversible in short term	Low (some double counting of impact)	Negative	Moderate (more uncertainty in deposition estimates)	Medium	Not significant
			Cumulative	Local	Medium	Continuous	Reversible in long term	Low (localized)	Negative.	Low	Low	Not significant
8. Particulate Deposition												
	Potential nuisance effects	Section 6.3	Project Residual	Local	Medium	Continuous	Reversible in short term	Moderate	Negative	Moderate (more uncertainty in deposition estimates)	Medium	Not significant
			Cumulative	Local	Medium	Continuous	Reversible in long term	Low (localized)	Negative.	Low	Low	Not significant

Table 6.5-1 Summary of Impact Significance on Air Quality

Measurable Parameter	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Effect	Geographic Extent[a]	Duration[b]	Frequency[c]	Reversibility[d]	Magnitude[e]	Project Contribution[f]	Confidence Rating[g]	Probability of Occurrence[h]	Significance[j]
9. Ozone Concentration												
	Potential human health effects	Based on management of precursors as identified in Section 6.3	Project Residual	Regional	Medium	Continuous	Reversible in short term	Low	Negative	High	High	Not significant
			Cumulative	Regional	Medium	Continuous	Reversible in long term	Low	Negative	Low	Medium	Not significant
10. VOC, PAH and Metal Concentration												
	Potential human health effects	Section 6.3	Project Residual	Local	Medium	Continuous	Reversible in short term	Low in an absolute sense (Moderate in relative sense)	Negative	Moderate	Medium	Not significant
			Cumulative	Local	Medium	Continuous	Reversible in long term	Low	Negative	Low future (regional emissions less certain)	Medium	Not significant
11. Odour												
	Potential nuisance effects	Section 6.3	Project Residual	Local	Medium	Continuous	Reversible in short term	High (localized exceedances of detection thresholds)	Negative	Moderate	Medium	Not significant
			Cumulative	Local	Medium	Continuous	Reversible in long term	Moderate (exceedances of detection thresholds at some special receptors; also in Baseline)	Negative	Low future (regional emissions less certain)	Medium	Not significant

Table 6.5-1 Summary of Impact Significance on Air Quality

Measurable Parameter	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Effect	Geographic Extent(a)	Duration(b)	Frequency(c)	Reversibility(d)	Magnitude(e)	Project Contribution(f)	Confidence Rating(g)	Probability of Occurrence(h)	Significance(j)
12. Greenhouse Gas												
	Potential ecological effects	Section 6.3	Project Residual and Cumulative	Regional	Long	Continuous	Reversible in long term	Low	Negative	Moderate (information on indirect emissions is more uncertain)	Medium	Not significant
13. Lighting												
	Potential nuisance effects	Section 5.16.2	Project Residual	Local	Medium	Periodic (night time)	Reversible in long term	Low	Negative	Moderate	High	Not significant

(a) Local, Regional, Provincial, National, Global

(b) Short, Long, Extended, Residual

(c) Continuous, Isolated, Periodic, Occasional

(d) Reversible in short term, Reversible in long term, Irreversible - rare

(e) Negligible, Low, Moderate, High

(f) Neutral, Positive, Negative

(g) Low, Moderate, High

(h) Low, Medium, High

(i) Significant, Not significant

7.0 REFERENCES

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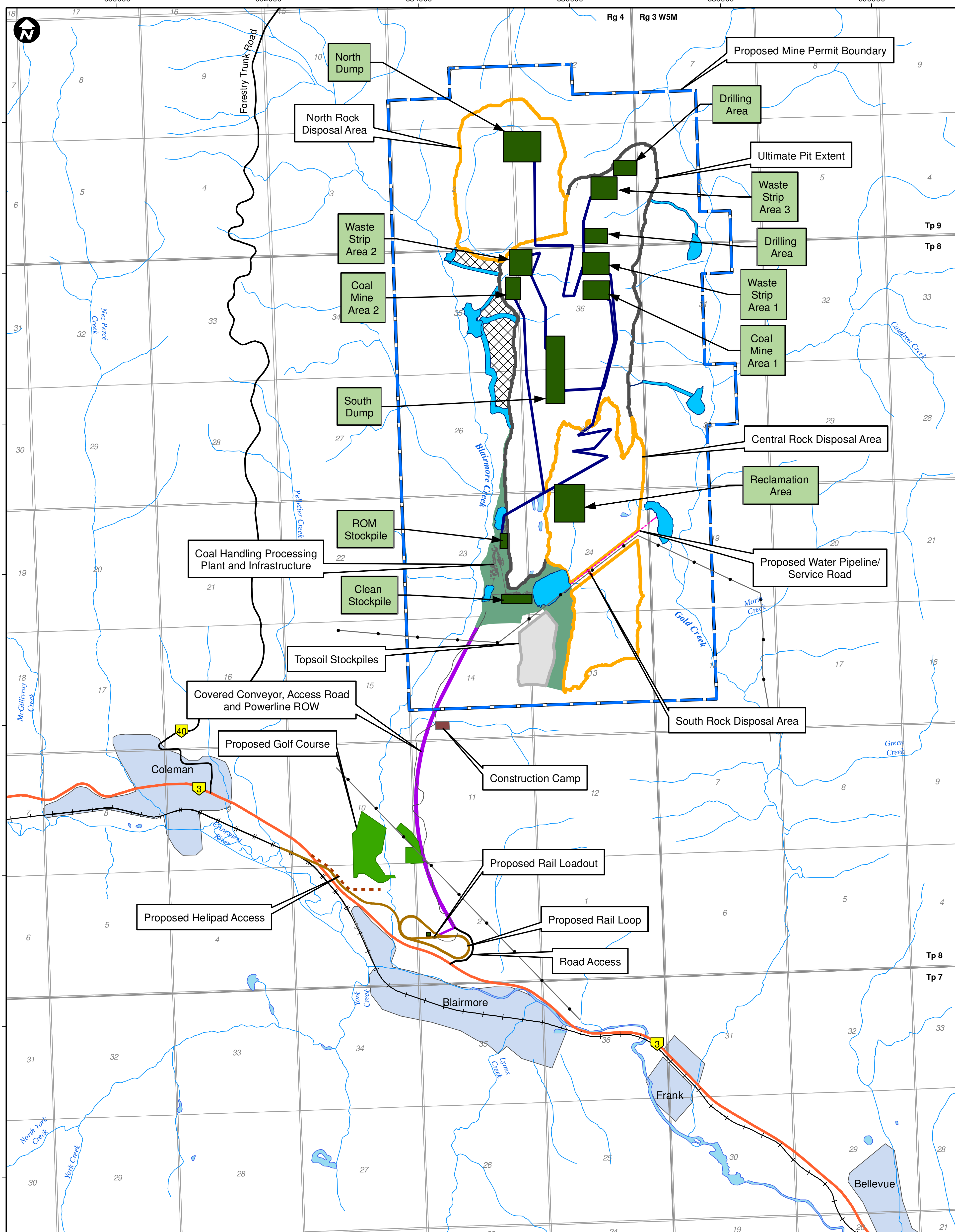
FIGURES



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Existing Access Road
- Existing Powerline
- CHPP Facilities
- Proposed Water Pipeline/Service Road
- Railway Loop
- Proposed Helipad Access
- Modelled Haul Road
- Modelled Operation Area
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Coal Handling Processing Plant and Infrastructure
- Covered Conveyor, Access Road and Powerline ROW
- Proposed Golf Course Area
- Undisturbed Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

BASELINE AND PROJECT ONLY CASE EMISSIONS SOURCES

NOTES

AltaLIS, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

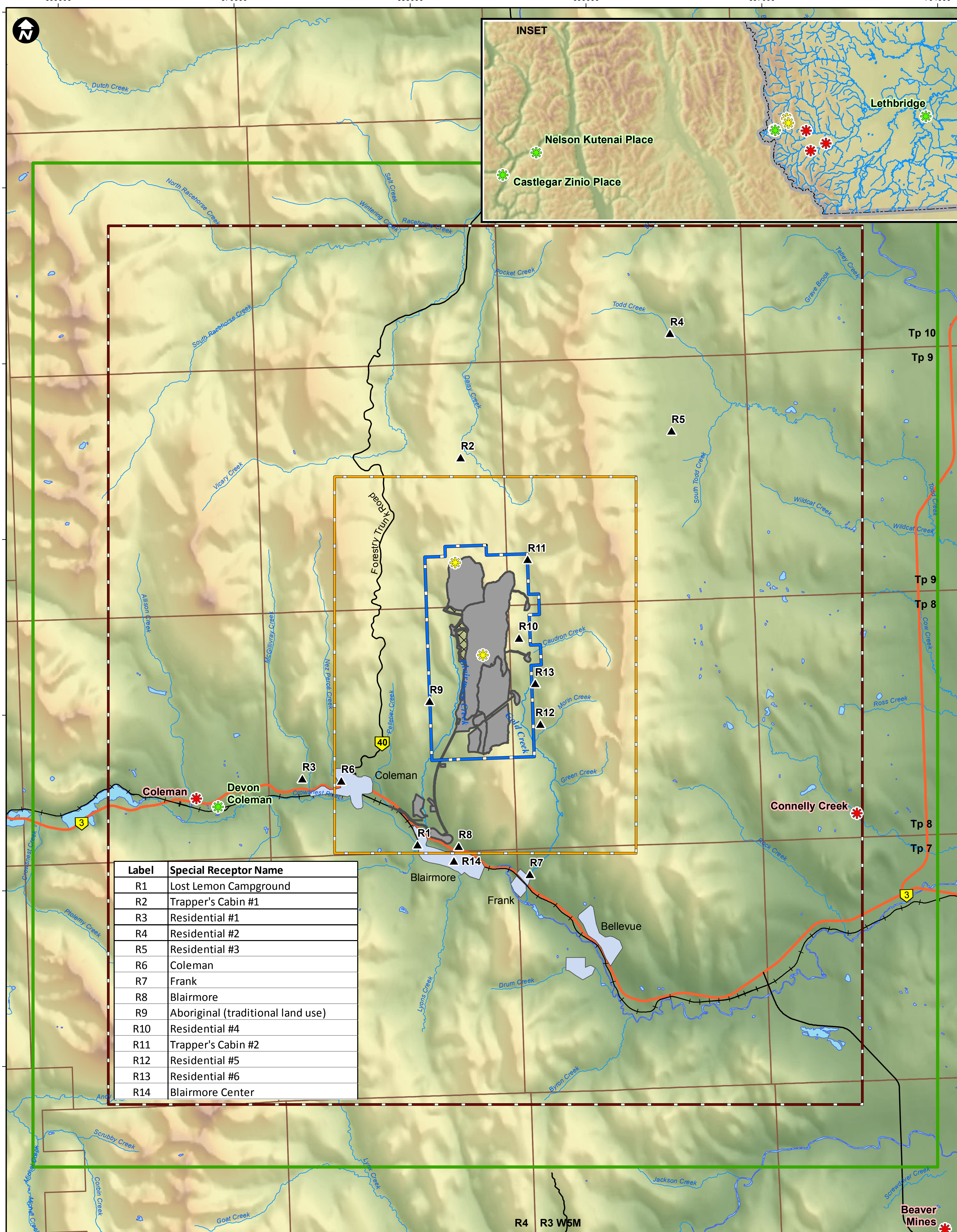
0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE

2.1-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 2.1-1 Baseline and Project Only Case Emissions Sources.mxd



Label	Special Receptor Name
R1	Lost Lemon Campground
R2	Trapper's Cabin #1
R3	Residential #1
R4	Residential #2
R5	Residential #3
R6	Coleman
R7	Frank
R8	Blairmore
R9	Aboriginal (traditional land use)
R10	Residential #4
R11	Trapper's Cabin #2
R12	Residential #5
R13	Residential #6
R14	Blairmore Center

LEGEND

- ▲ Special Receptor
- AQ Monitoring Station
- EC Meteorological Station
- Focus Monitoring Stations
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area
- Model Domain

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

LOCAL AND REGIONAL STUDY AREAS

NOTES

AltaLIS, 2016; GeoBase, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC/SL
CHECKED BY: JS
DATE: JUNE 28, 2016

FIGURE
2.3-1

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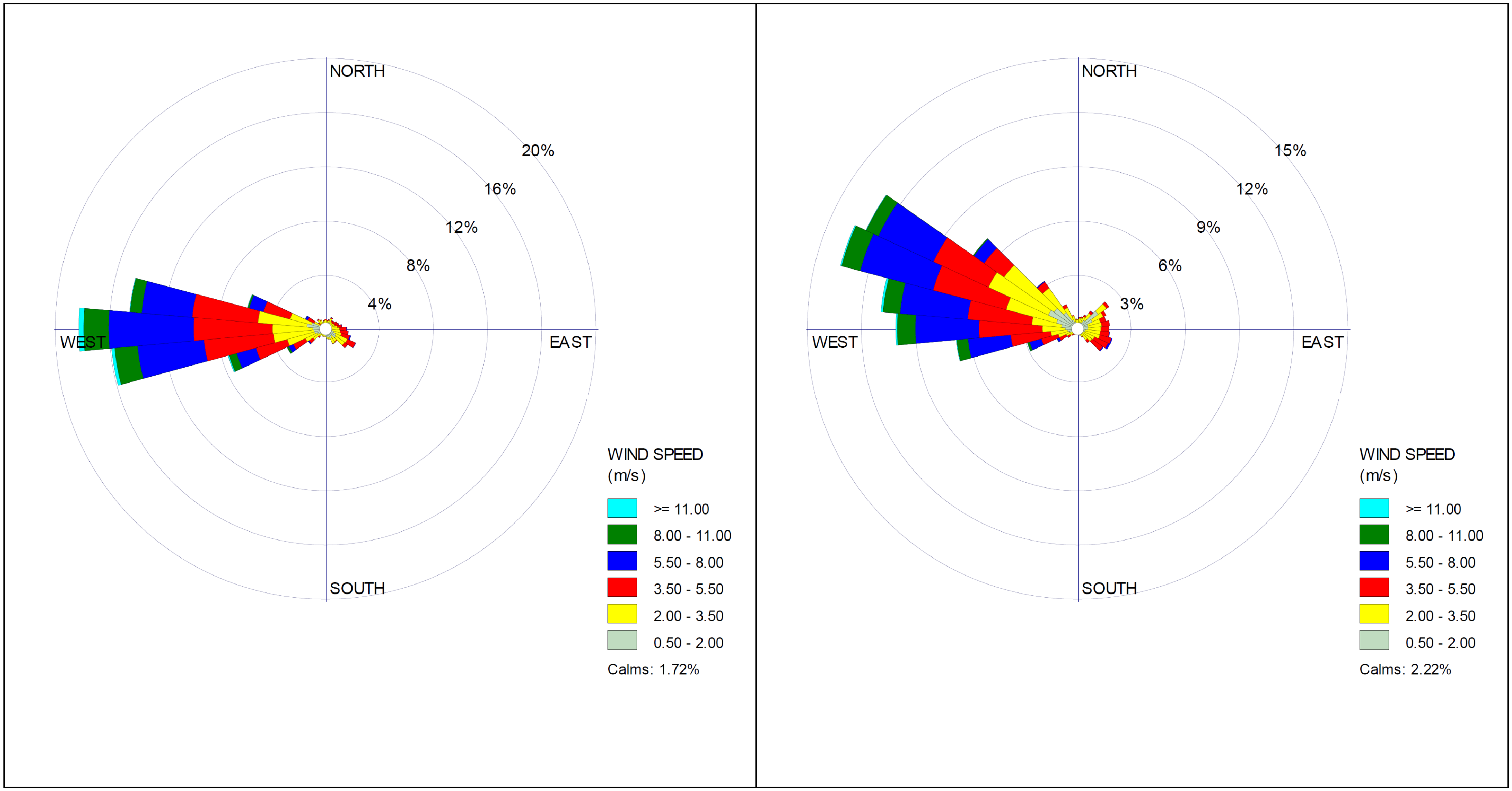


PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

WIND ROSES FROM CALMET MODEL OUTPUT AT PROJECT NORTH (LEFT) AND SOUTH (RIGHT) LOCATIONS, 2002 TO 2006

PROJECT: 14-00201-01
DRAWN BY: SL
CHECKED BY: RR
DATE: AUGUST 4, 2016

NOTES

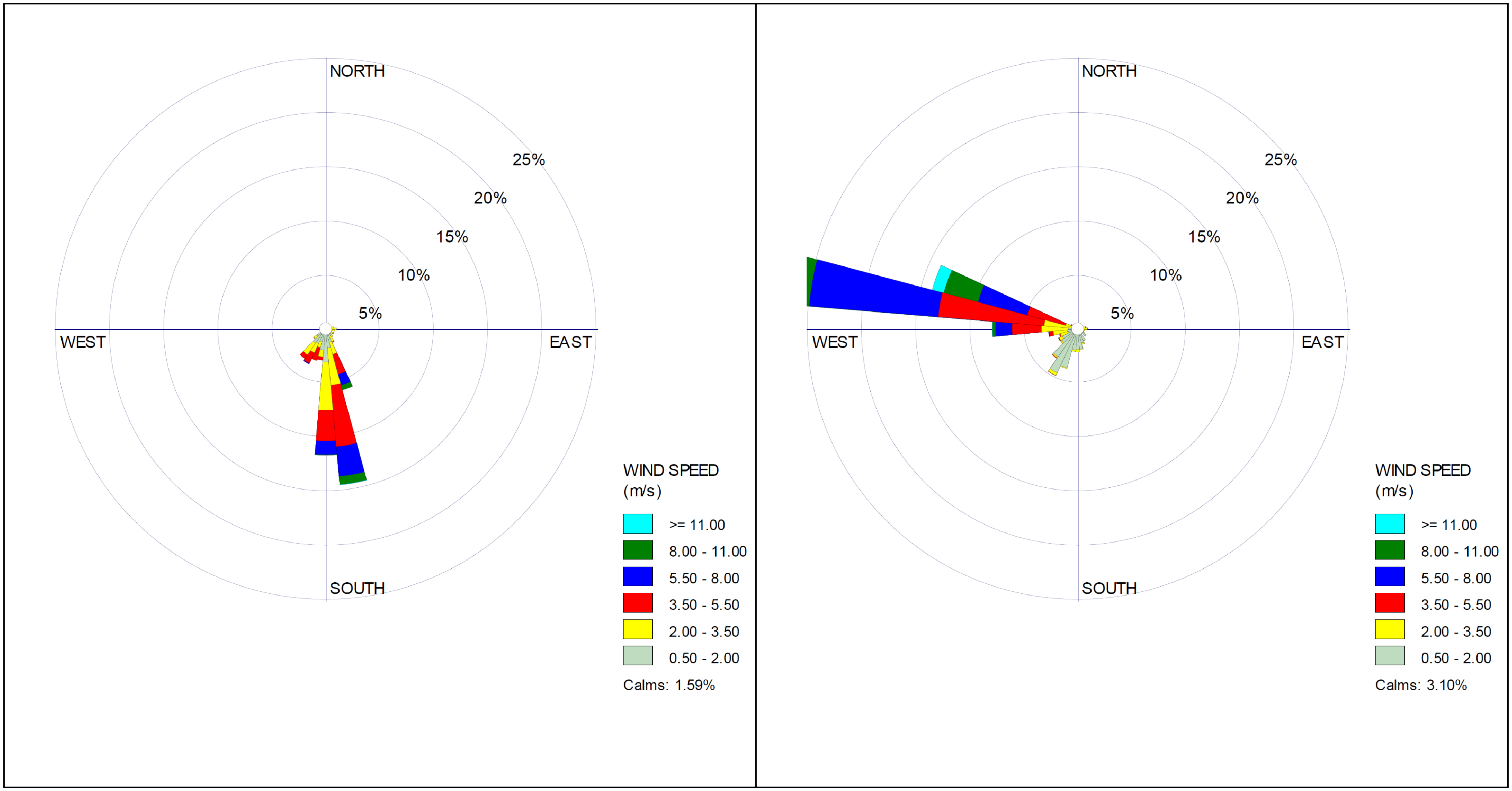
MEMS, 2016

SCALE: N/A

FIGURE

3.2-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 3.2-1 Wind Roses CALMET Model Output.mxd



PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

WIND ROSES AT THE ON-SITE AIR MONITORING NORTH (LEFT) AND SOUTH (RIGHT) STATIONS, 2014

PROJECT: 14-00201-01

DRAWN BY: SL

CHECKED BY: RR

DATE: AUGUST 4, 2016

NOTES

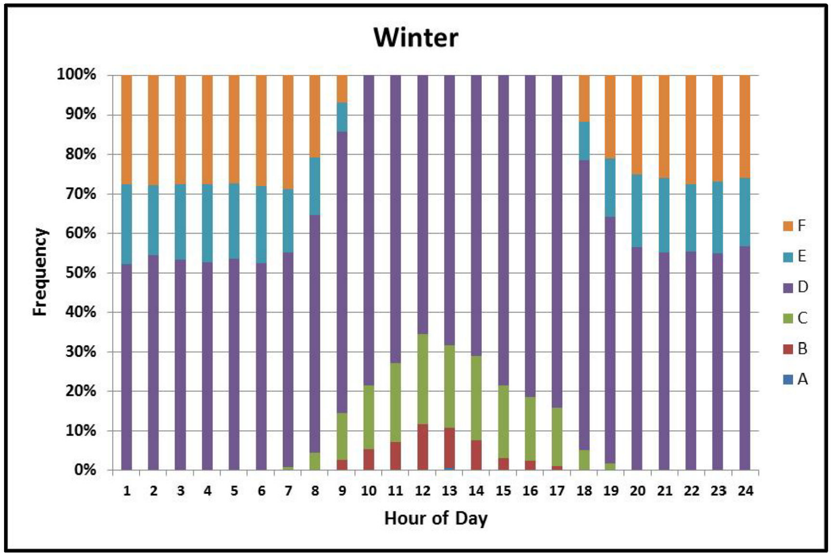
MEMS, 2016

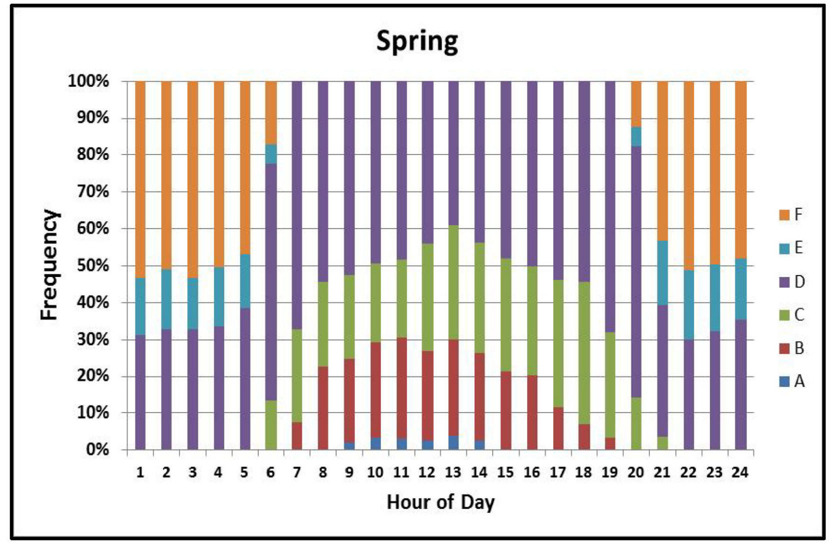
SCALE: N/A

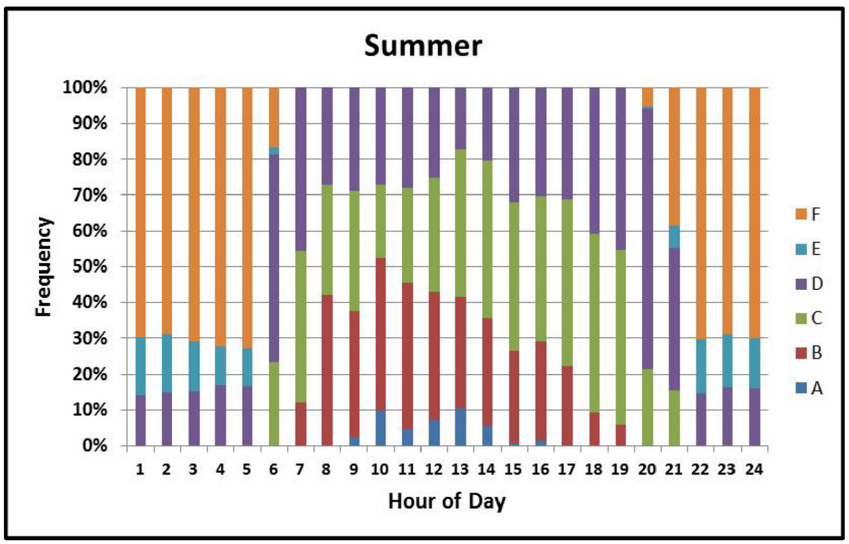
FIGURE

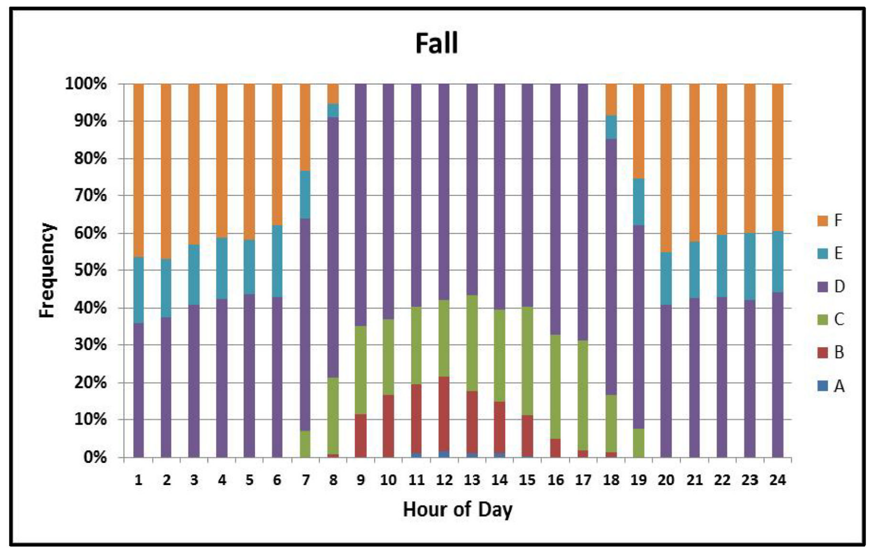
3.2-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 3.2-2 Wind Roses On-Site Air Monitoring.mxd









PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEASONAL STABILITY CLASS DISTRIBUTION NEAR THE PROJECT BASED ON CALMET OUTPUT, 2002-2006

PROJECT: 14-00201-01

DRAWN BY: SL

CHECKED BY: RR

DATE: AUGUST 4, 2016

NOTES

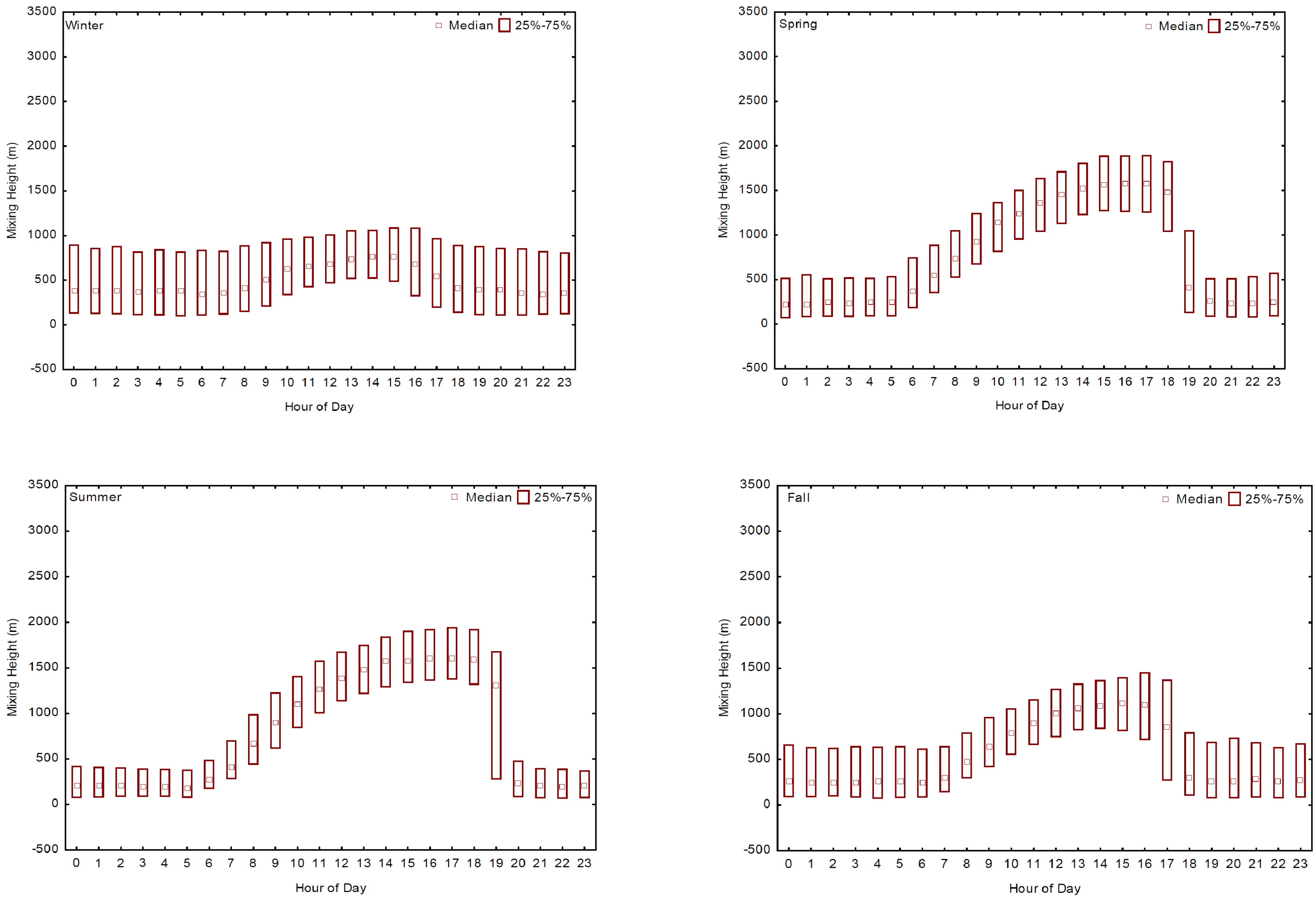
MEMS, 2016

SCALE: N/A

FIGURE

3.2-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 3.2-3 Seasonal Stability Class Distribution.mxd



PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEASONAL MIXING HEIGHT DISTRIBUTION NEAR THE PROJECT BASED ON CALMET MODEL OUTPUT, 2002-2006

PROJECT: 14-00201-01

DRAWN BY: SL

CHECKED BY: RR

DATE: AUGUST 4, 2016

NOTES

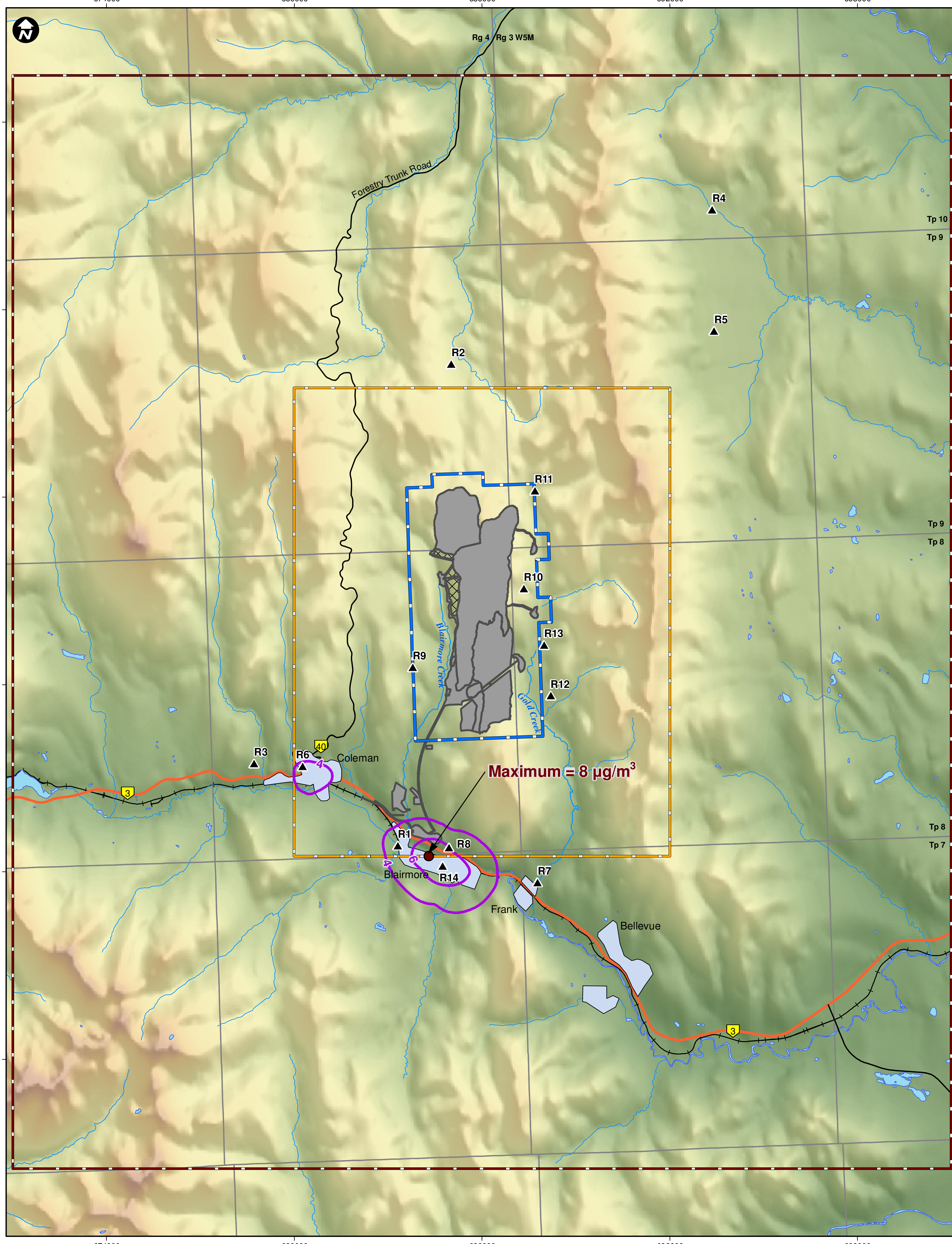
MEMS, 2016

SCALE: N/A

FIGURE

3.2-4

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 3.2-4 Seasonal Mixing Height Distribution.mxd



LEGEND

- Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 9th HIGHEST 1-HOUR SO_2 CONCENTRATION ($\mu g/m^3$) – BASELINE CASE

NOTES

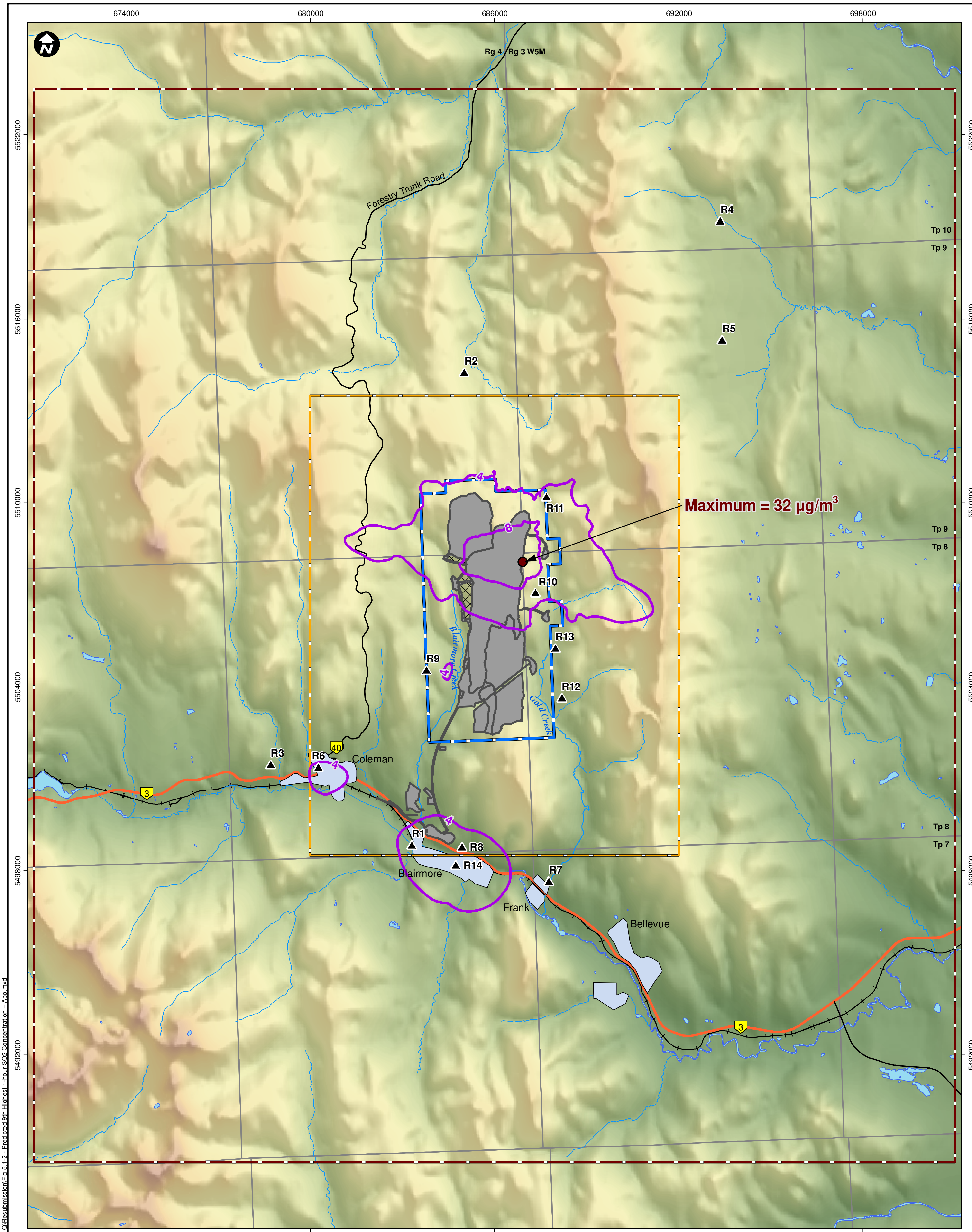
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE
5.1-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.1-1 - Predicted 9th Highest 1-hour SO2 Concentration – Base.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 9th HIGHEST 1-HOUR SO_2 CONCENTRATION (µg/m³) – APPLICATION CASE

NOTES

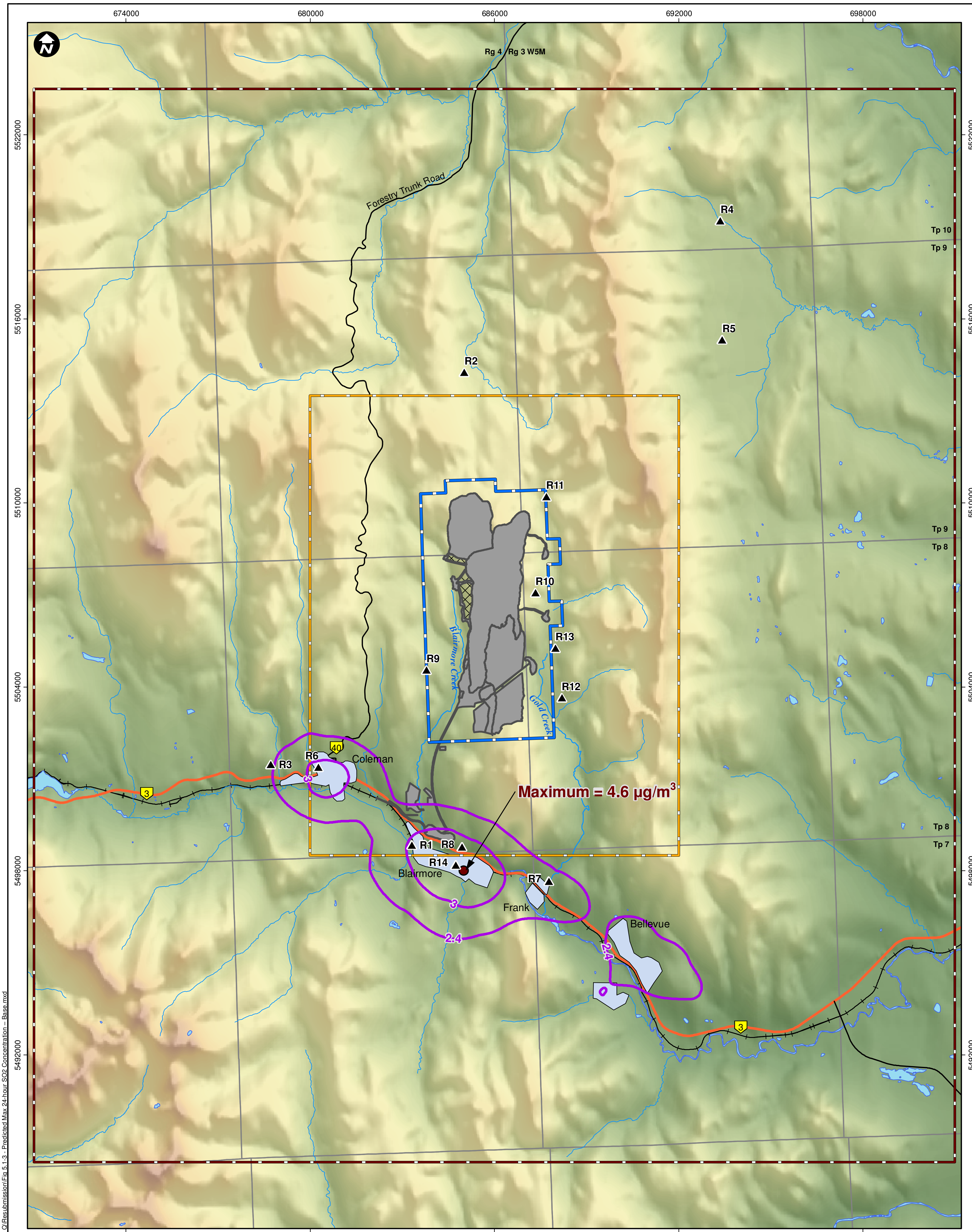
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE

5.1-2



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED MAXIMUM 24-HOUR SO_2 CONCENTRATION ($\mu g/m^3$) – BASELINE CASE

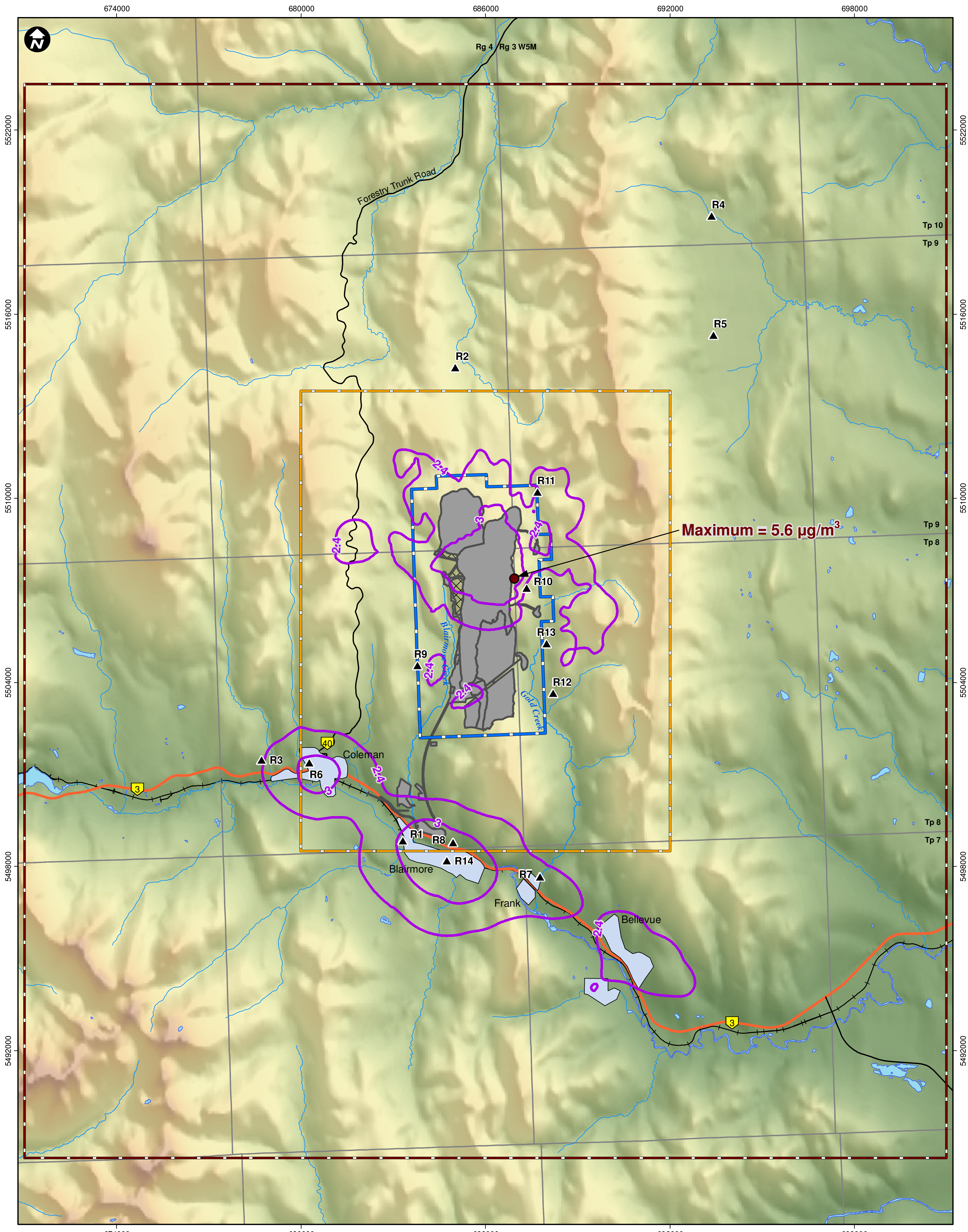
NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE
5.1-3



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED MAXIMUM 24-HOUR SO_2 CONCENTRATION ($\mu g/m^3$) – APPLICATION CASE

NOTES

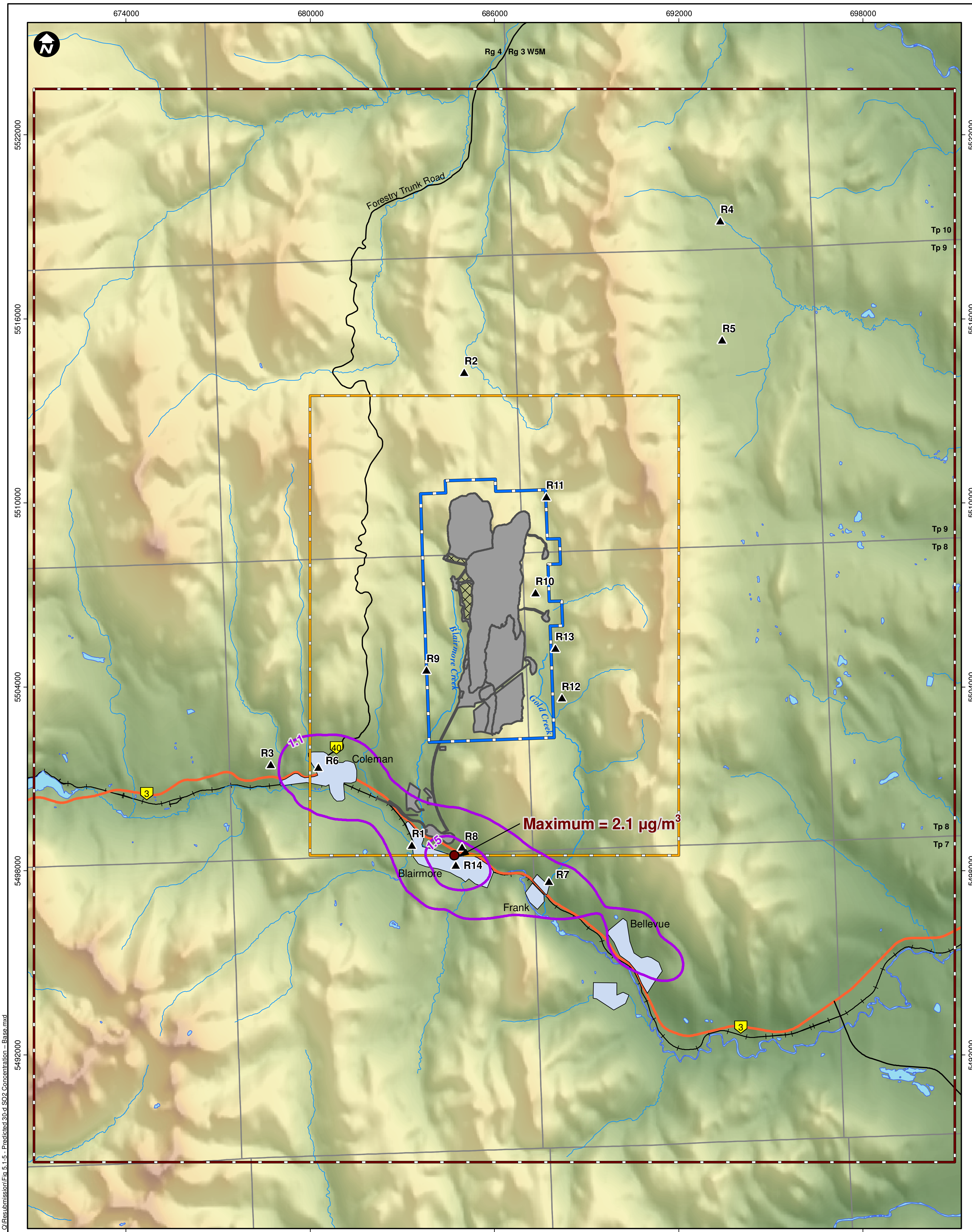
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE
5.1-4

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.1-4 - Predicted Max 24-hour SO2 Concentration – App.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 30-DAY SO_2 CONCENTRATION ($\mu g/m^3$) – BASELINE CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016

Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10

Kilometres

PROJECT: 14-00201-01

DRAWN BY: CP/JDC

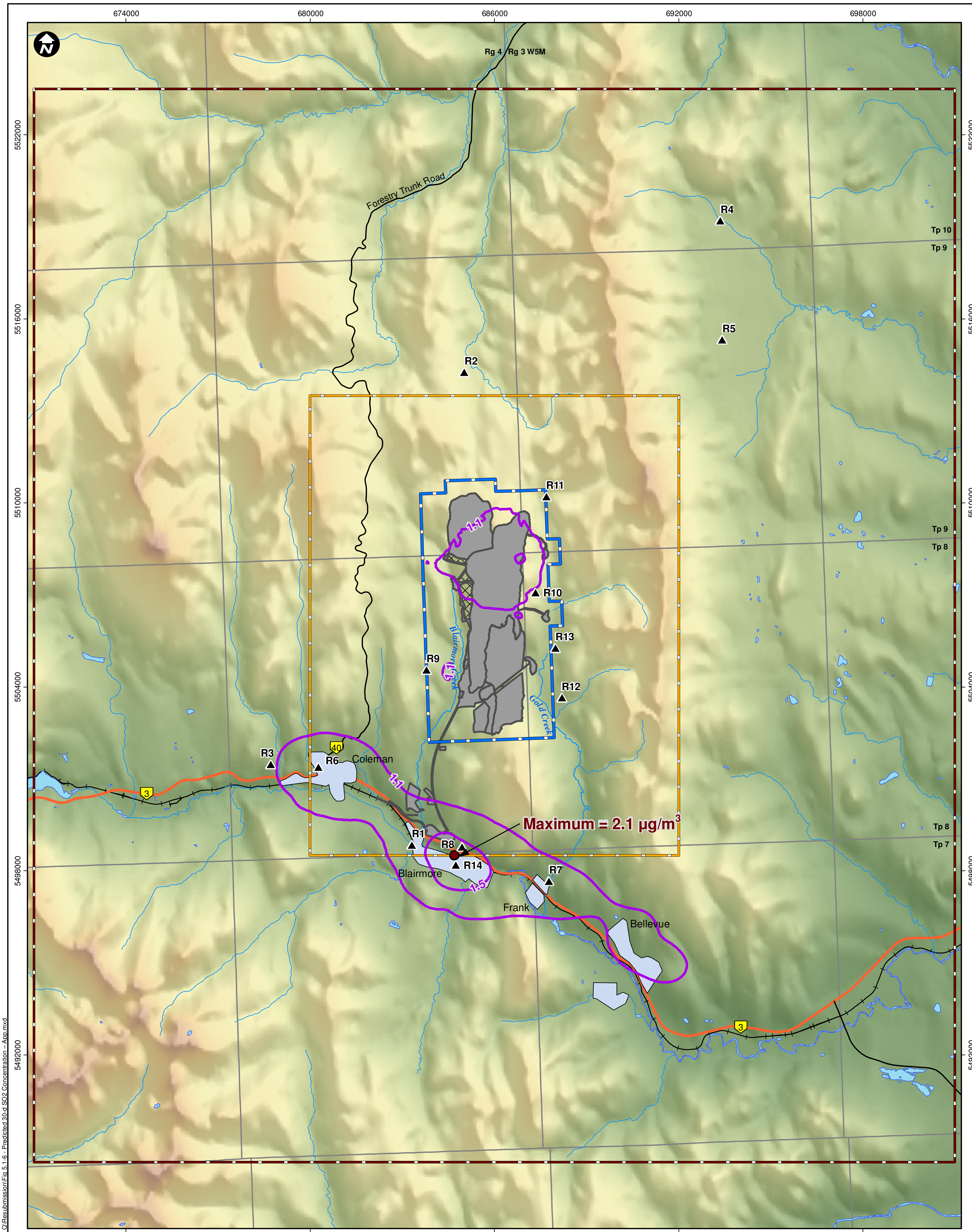
CHECKED BY: JS

DATE: JUNE 16, 2016

FIGURE

5.1-5

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.1-5 - Predicted 30-d SO2 Concentration – Base.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 30-DAY SO_2 CONCENTRATION ($\mu g/m^3$) – APPLICATION CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01

DRAWN BY: CP/JDC

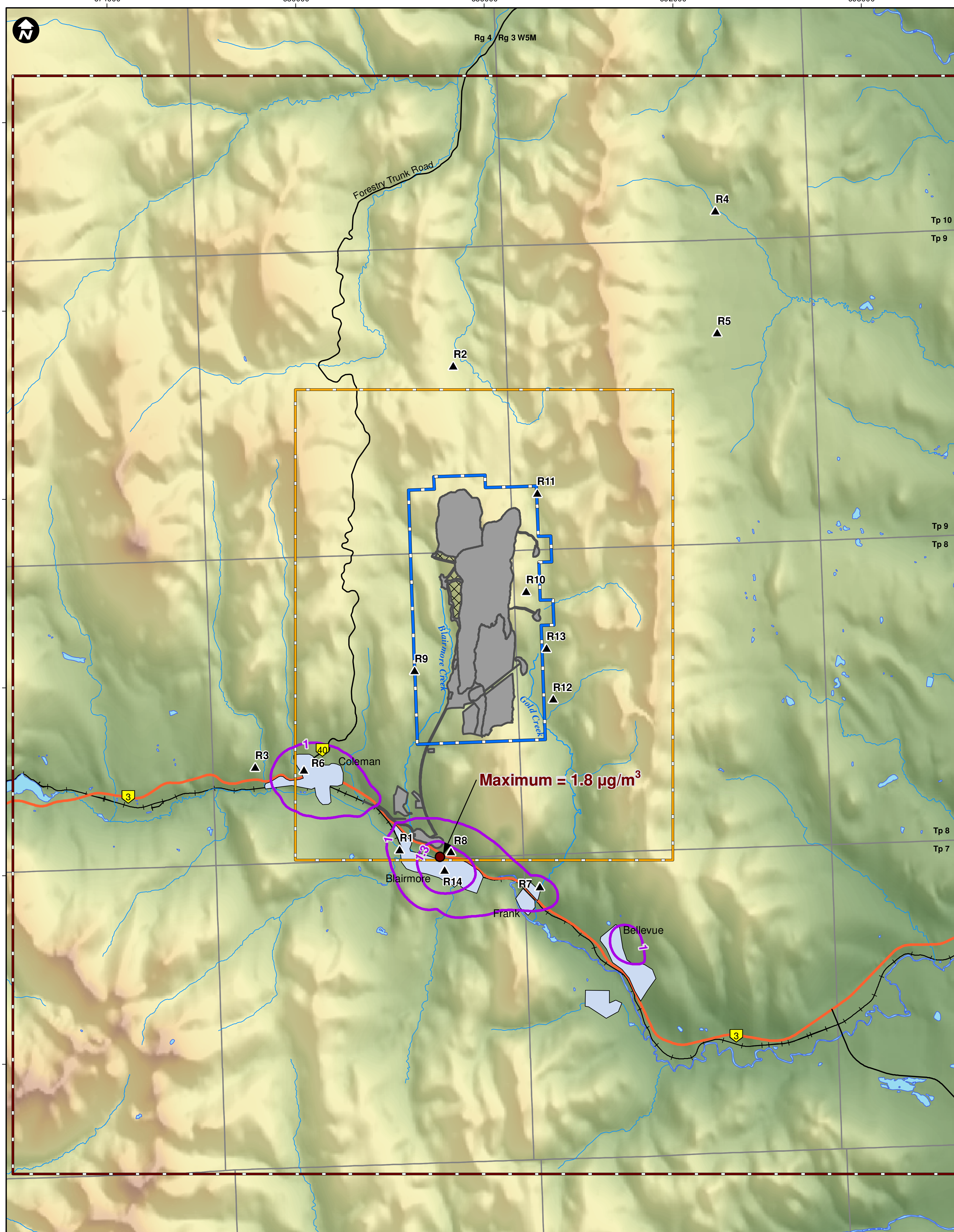
CHECKED BY: JS

DATE: JUNE 16, 2016

FIGURE

5.1-6

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.1-6 - Predicted 30-d SO2 Concentration – App.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL SO_2 CONCENTRATION ($\mu g/m^3$) – BASELINE CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

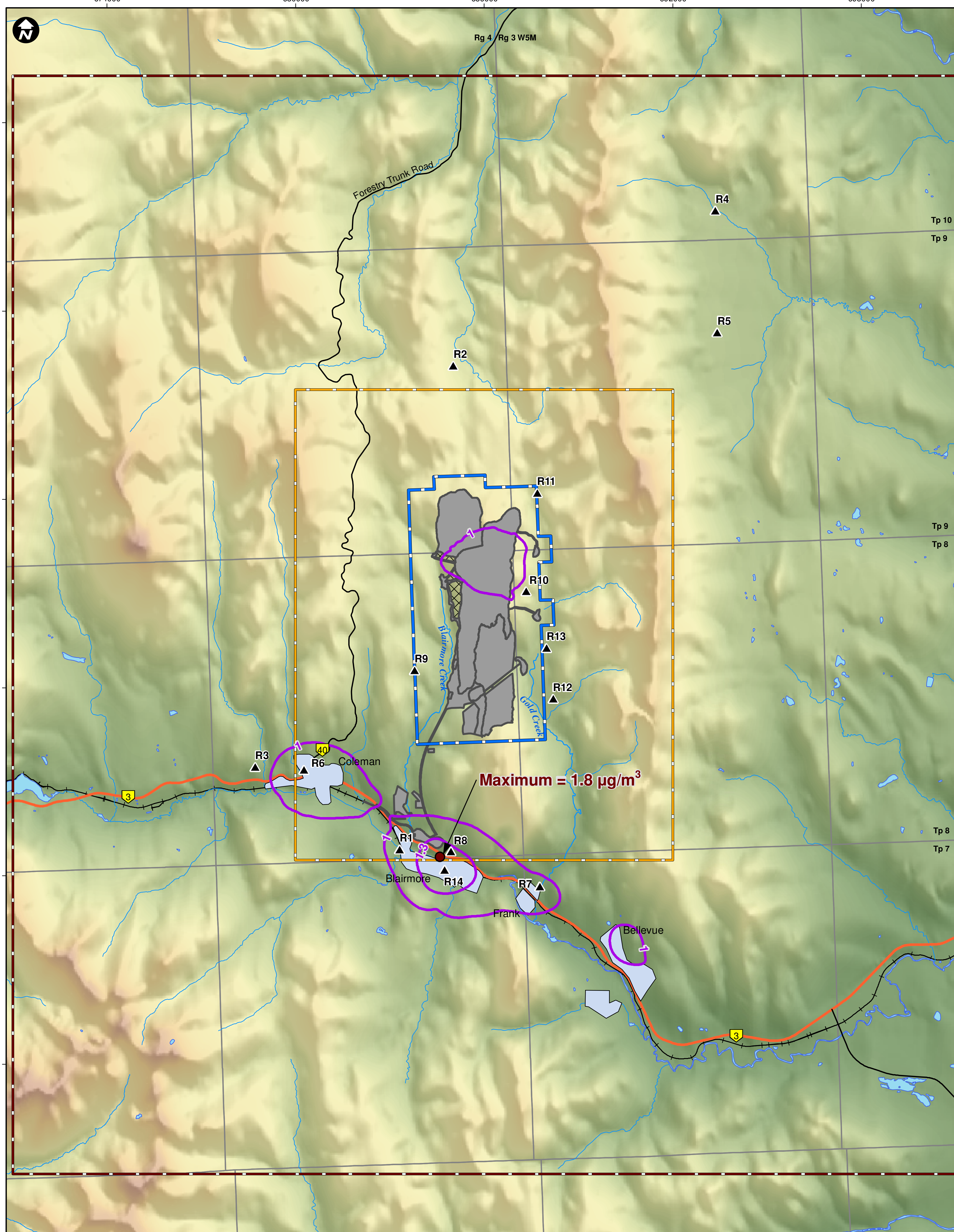
0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE

5.1-7

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.1-7 - Predicted Annual SO2 Concentration – Base.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL SO_2 CONCENTRATION (µg/m³) – APPLICATION CASE

NOTES

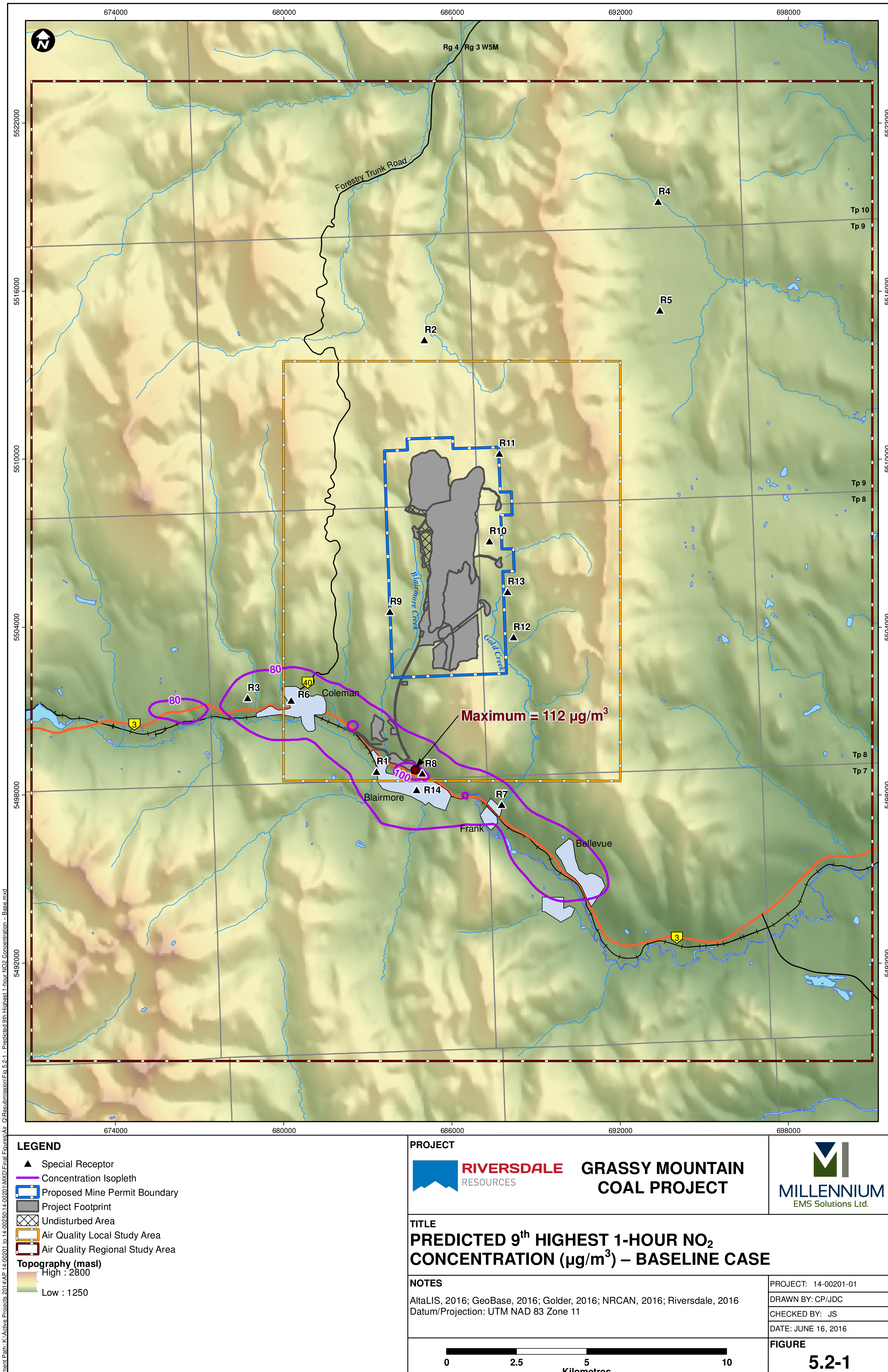
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE

5.1-8



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 9th HIGHEST 1-HOUR NO_2 CONCENTRATION ($\mu g/m^3$) – BASELINE CASE

NOTES

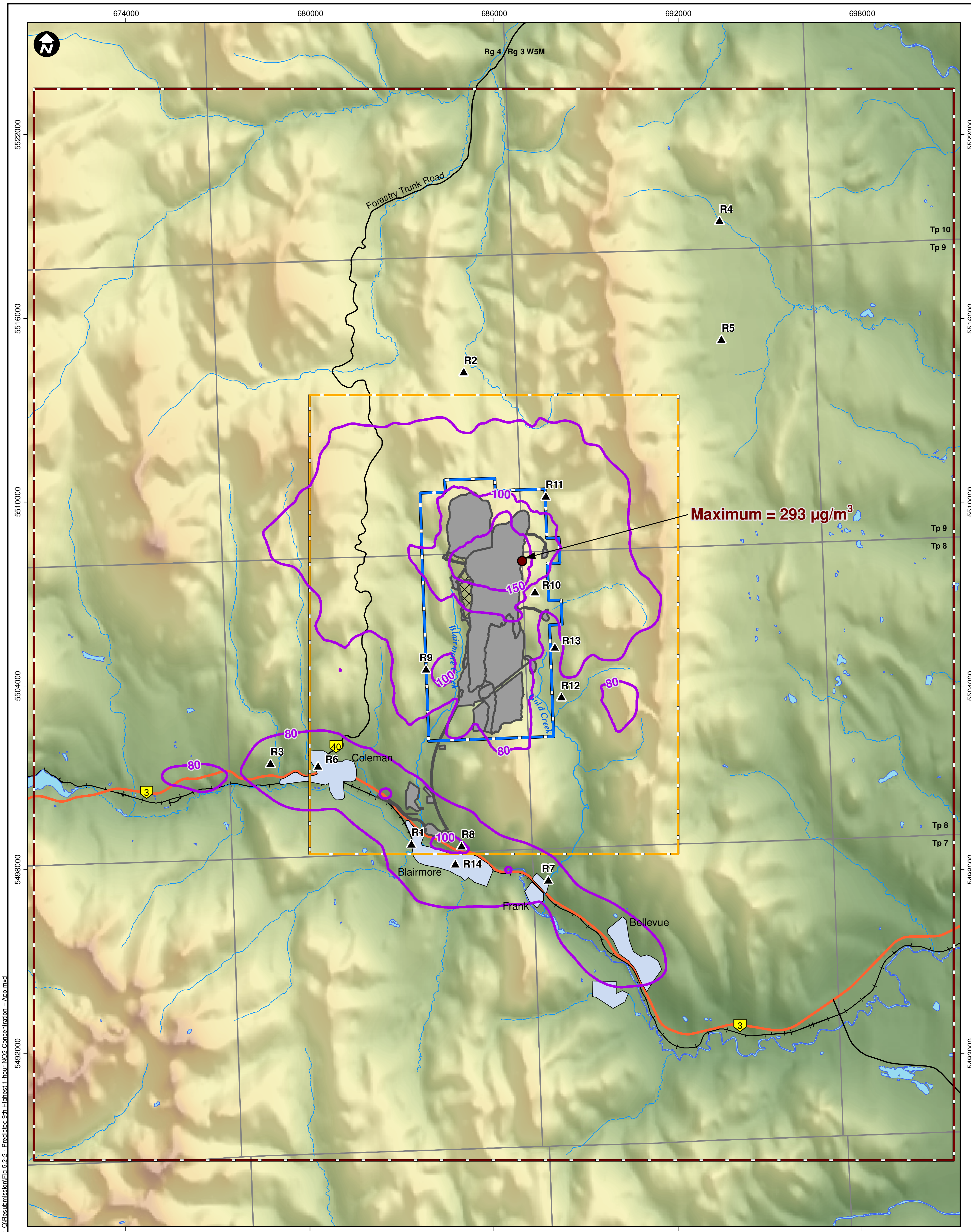
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE

5.2-1



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 9th HIGHEST 1-HOUR NO_2 CONCENTRATION ($\mu g/m^3$) – APPLICATION CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01

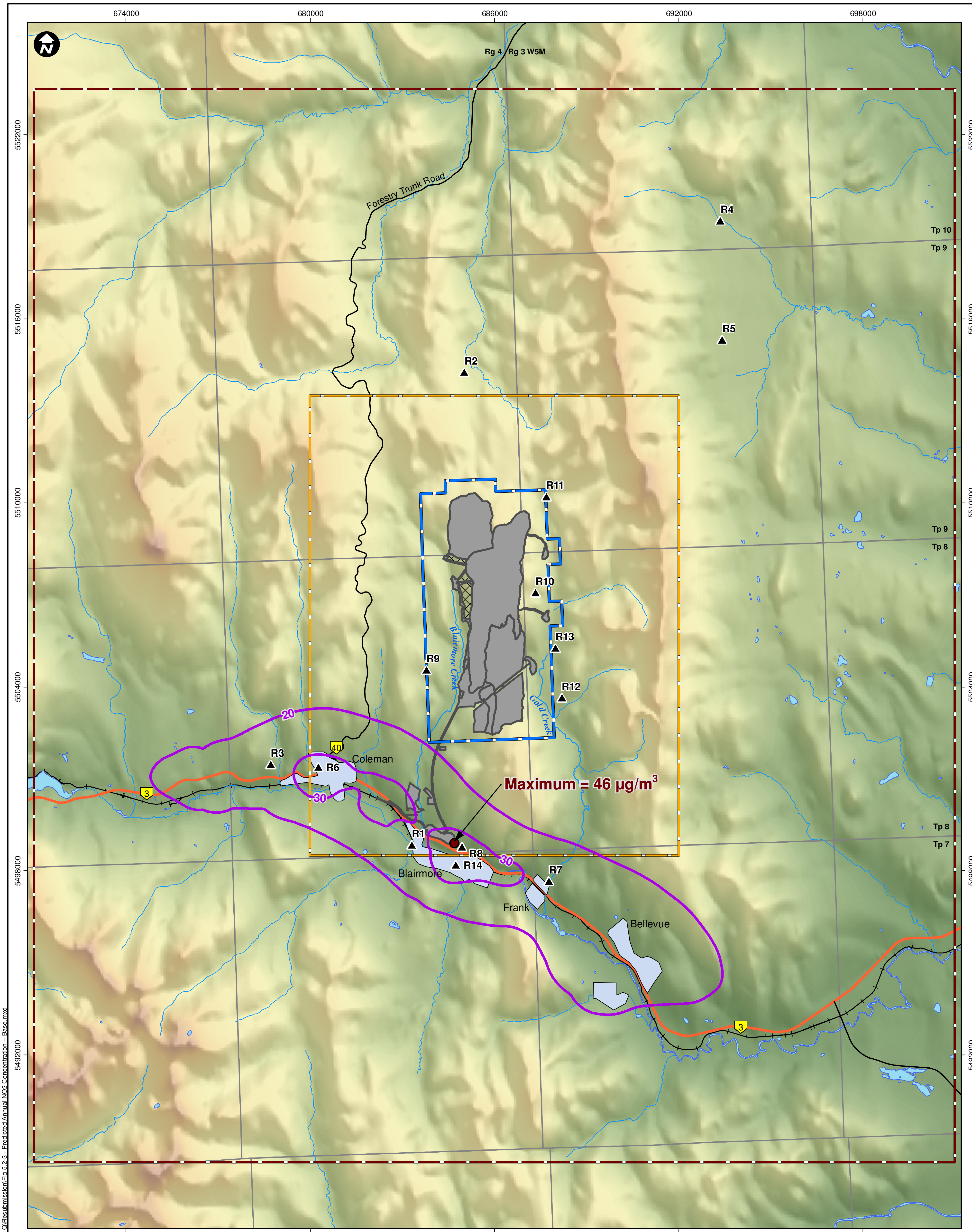
DRAWN BY: CP/JDC

CHECKED BY: JS

DATE: JUNE 16, 2016

FIGURE

5.2-2



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL NO_2 CONCENTRATION ($\mu g/m^3$) – BASELINE CASE

NOTES

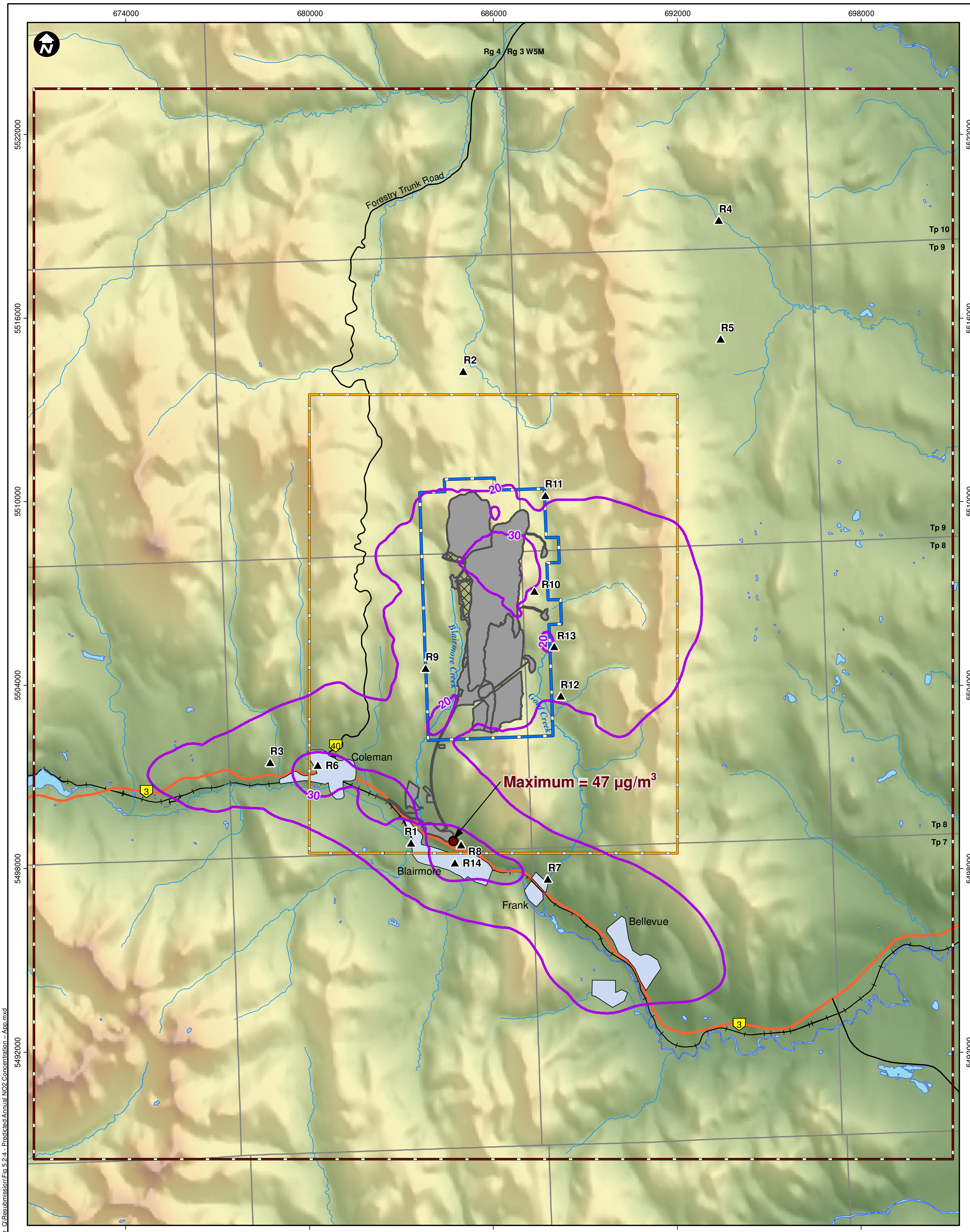
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE
5.2-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.2-3 - Predicted Annual NO2 Concentration – Base.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL NO_2 CONCENTRATION ($\mu g/m^3$) – APPLICATION CASE

NOTES

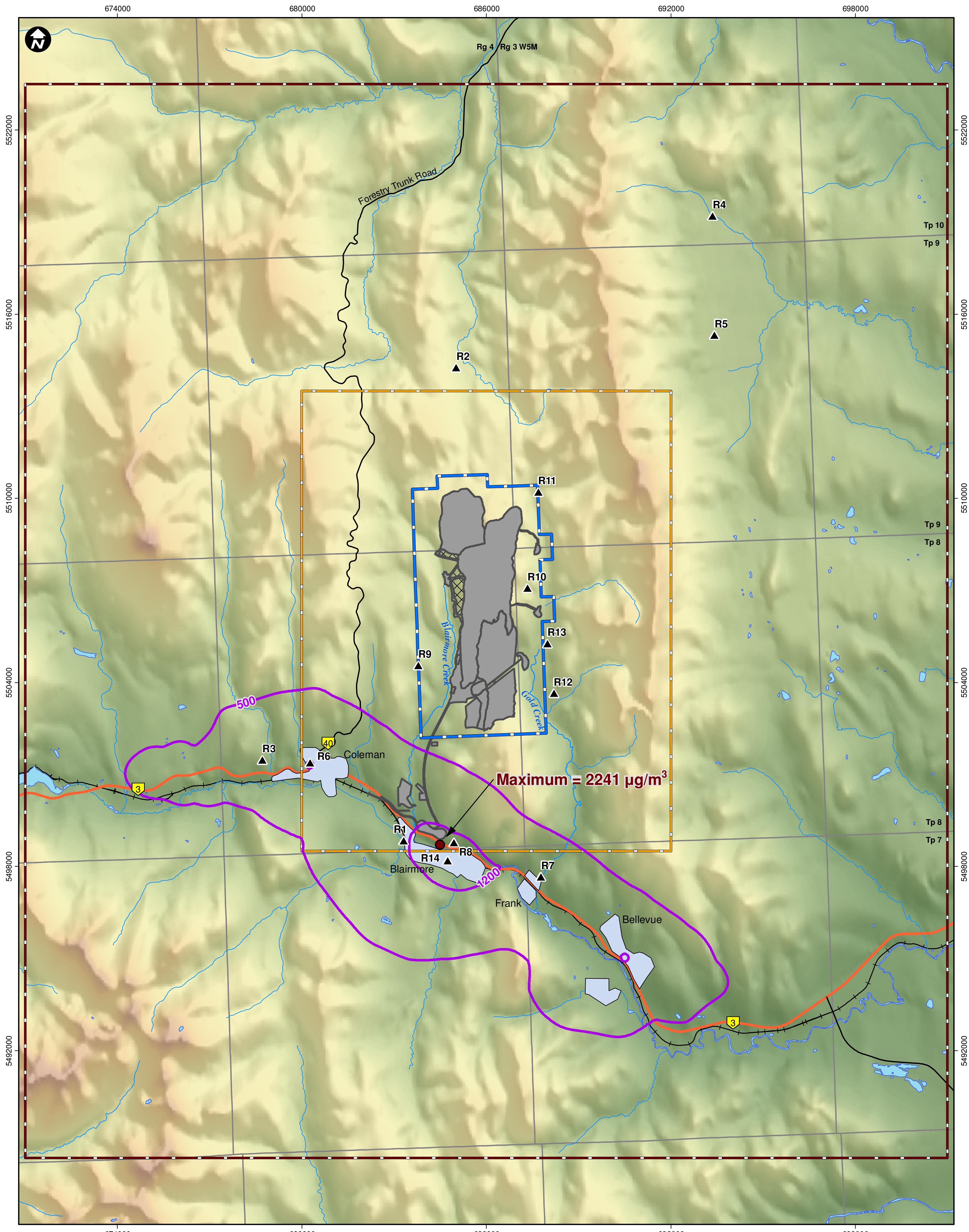
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE
5.2-4

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.2-4 - Predicted Annual NO2 Concentration – App.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 9th HIGHEST 1-HOUR CO CONCENTRATION (μg/m^3) – BASELINE CASE

NOTES

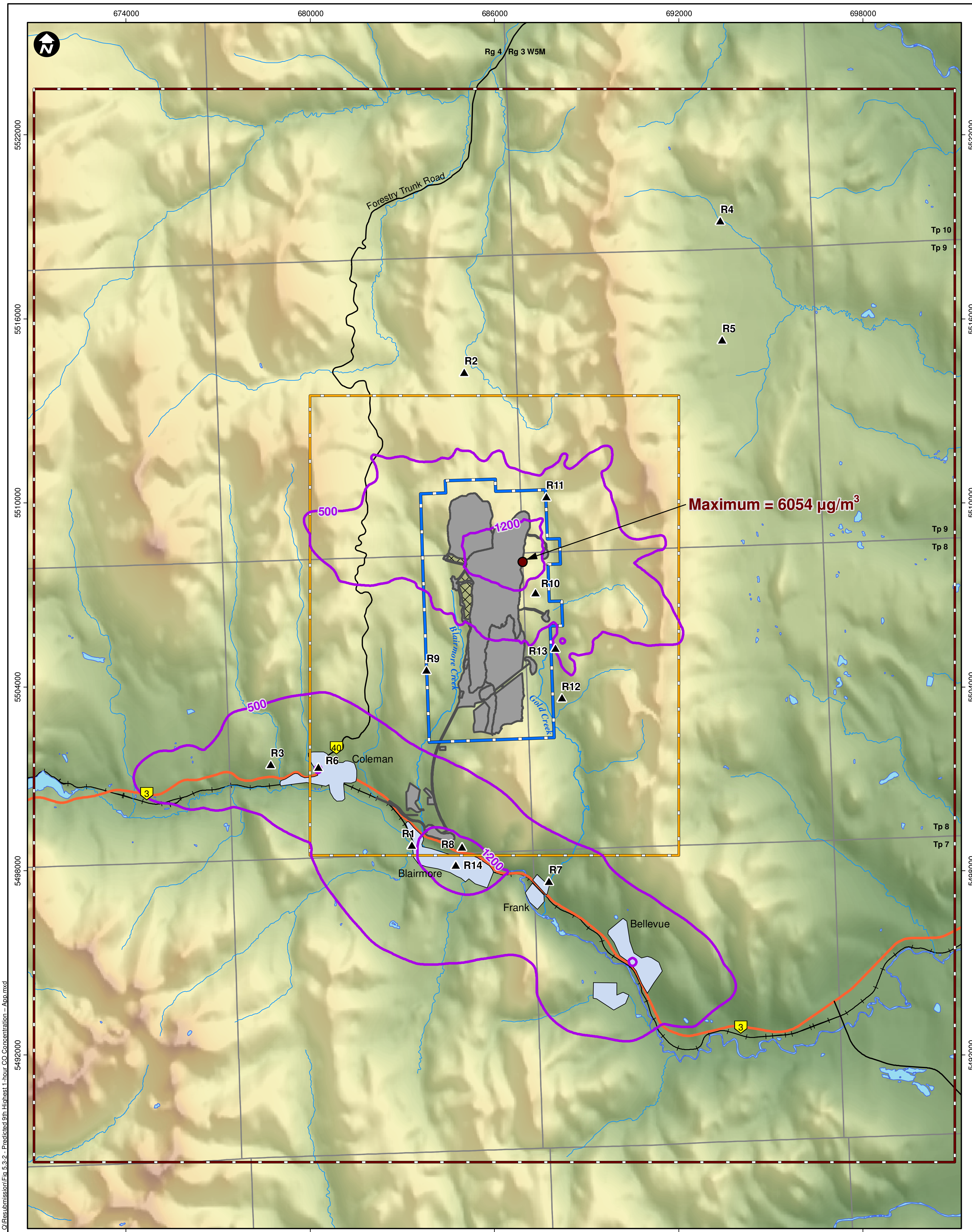
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE

5.3.-1



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 9th HIGHEST 1-HOUR CO CONCENTRATION (µg/m³) – APPLICATION CASE

NOTES

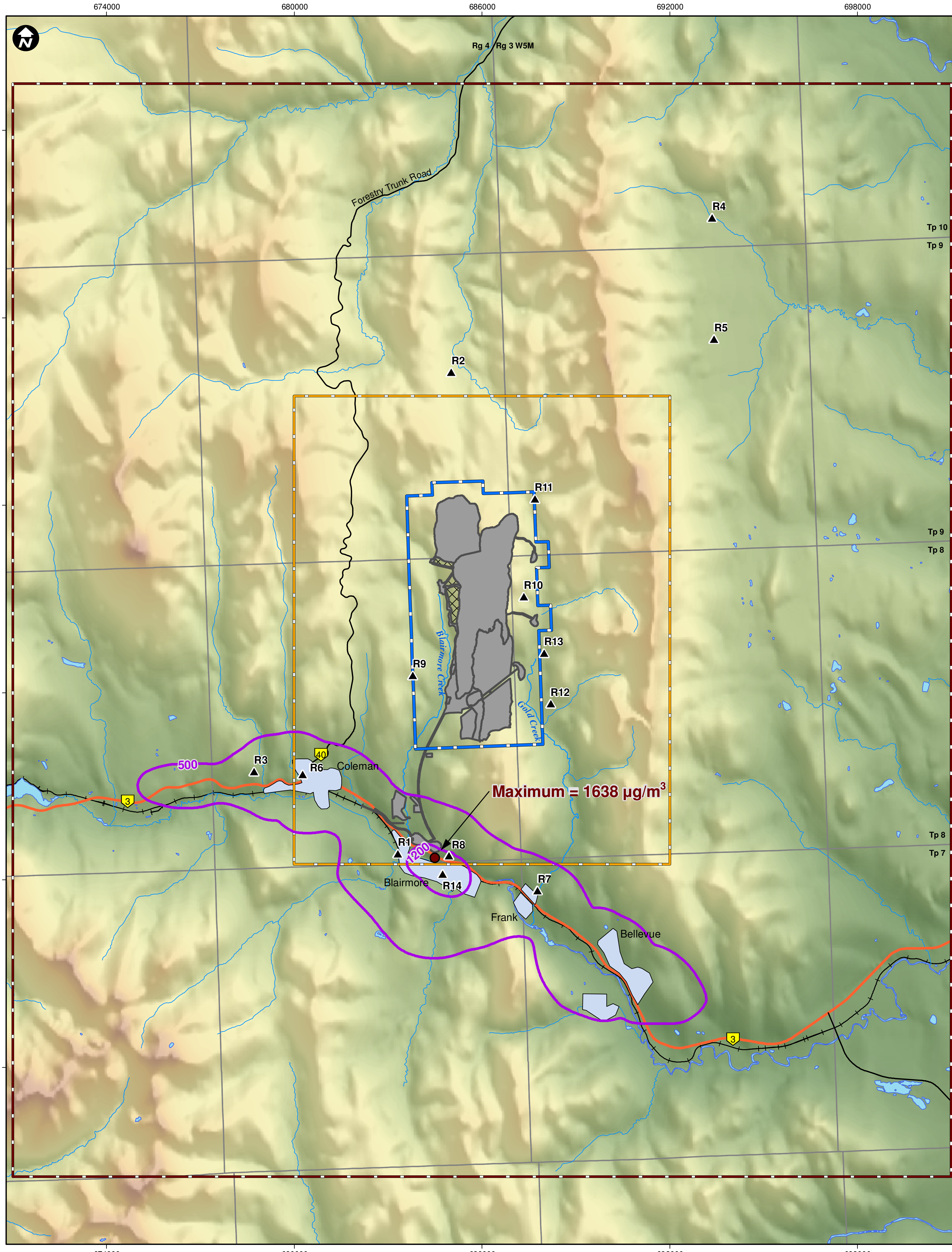
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE

5.3-2



LEGEND

- Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 9th HIGHEST 1-HOUR CO CONCENTRATION (µg/m³) – BASELINE CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

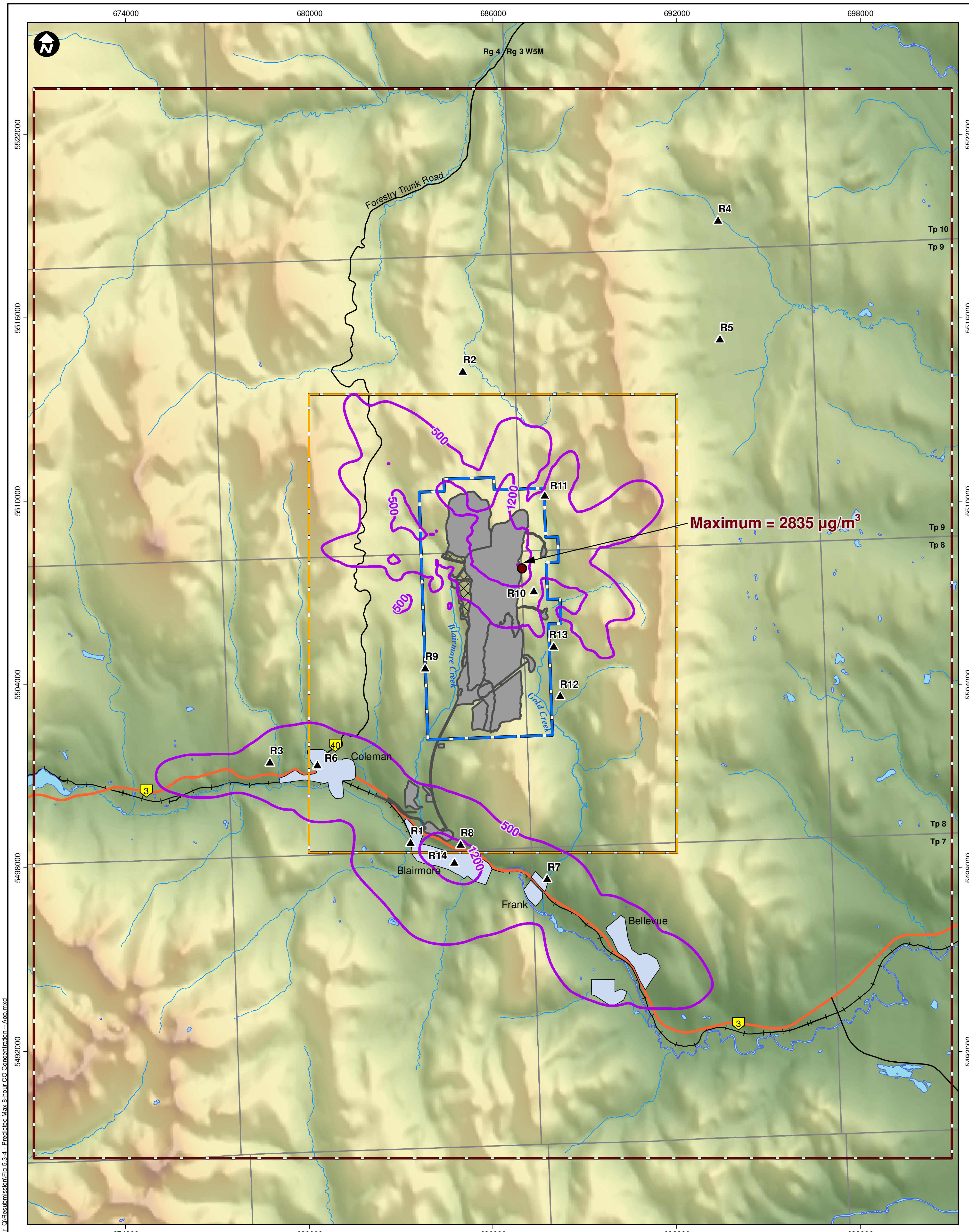
0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE

5.3-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.3-3 - Predicted Max 8-hour CO Concentration – Base.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 9th HIGHEST 1-HOUR CO CONCENTRATION (µg/m^3) – APPLICATION CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

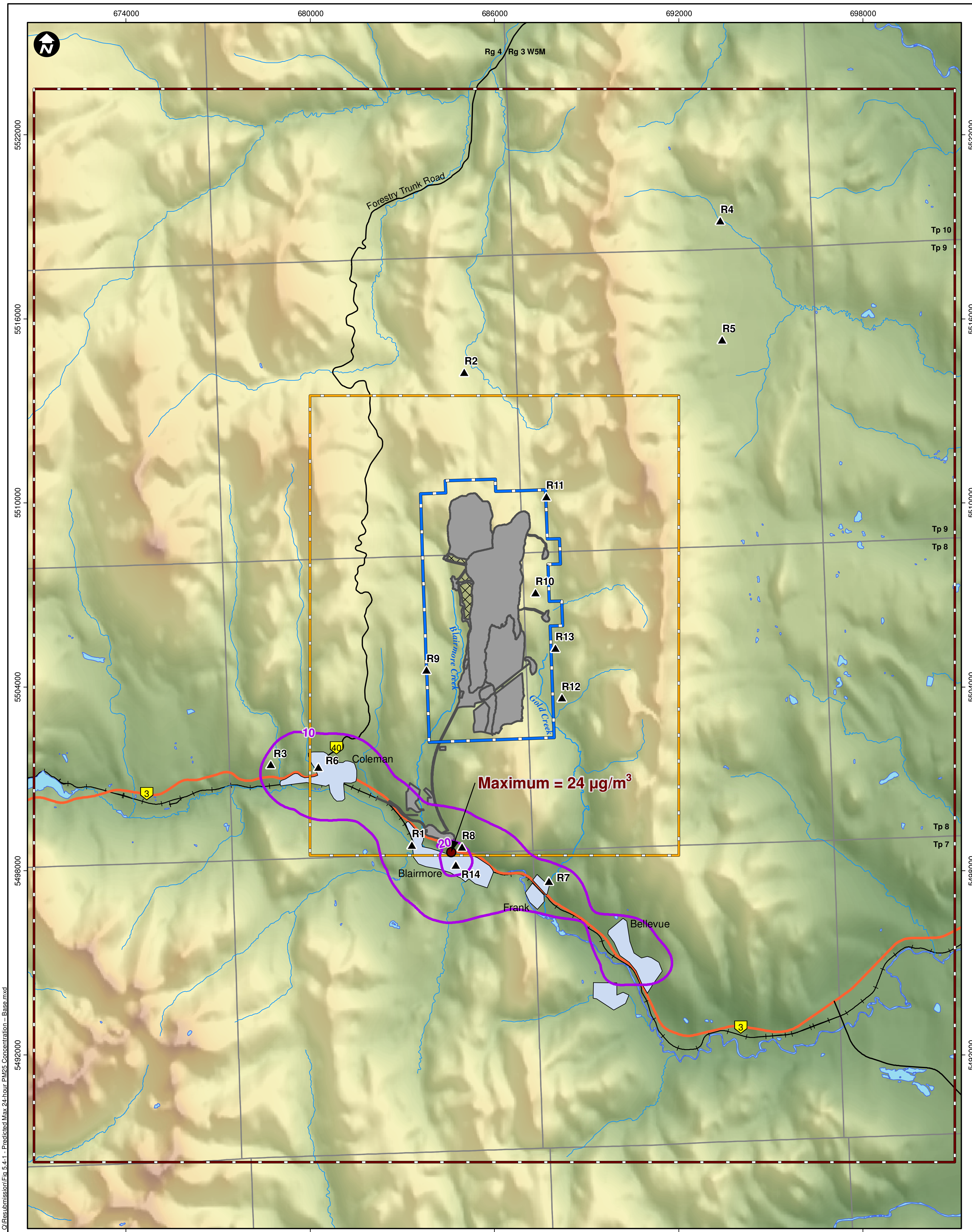
0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE

5.3-4

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.3-4 - Predicted Max 8-hour CO Concentration – App.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED MAXIMUM 24-HOUR $PM_{2.5}$ CONCENTRATION ($\mu g/m^3$) – BASELINE CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

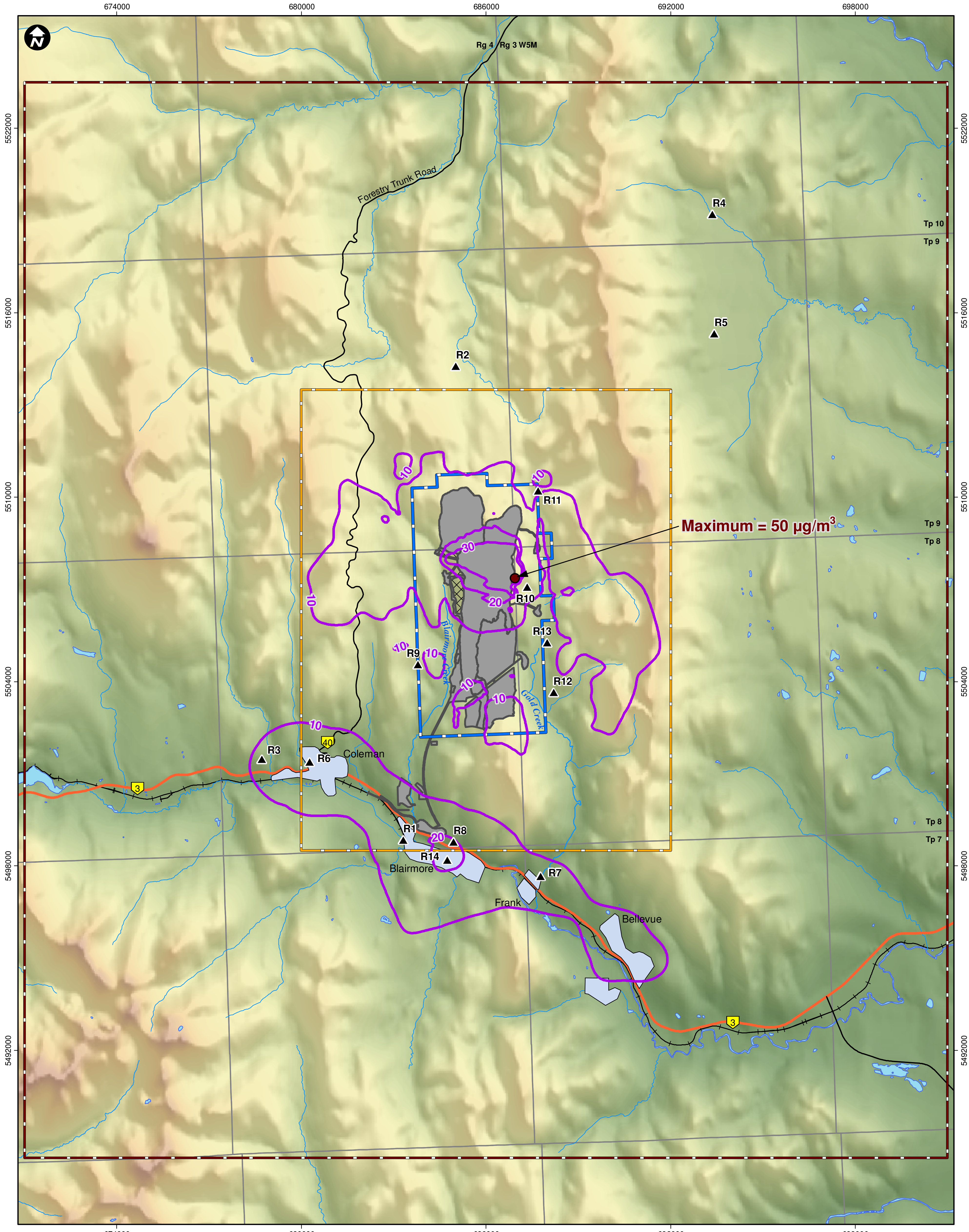
0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE

5.4-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.4-1 - Predicted Max 24-hour PM25 Concentration - Base.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED MAXIMUM 24-HOUR $PM_{2.5}$ CONCENTRATION ($\mu g/m^3$) – APPLICATION CASE

NOTES

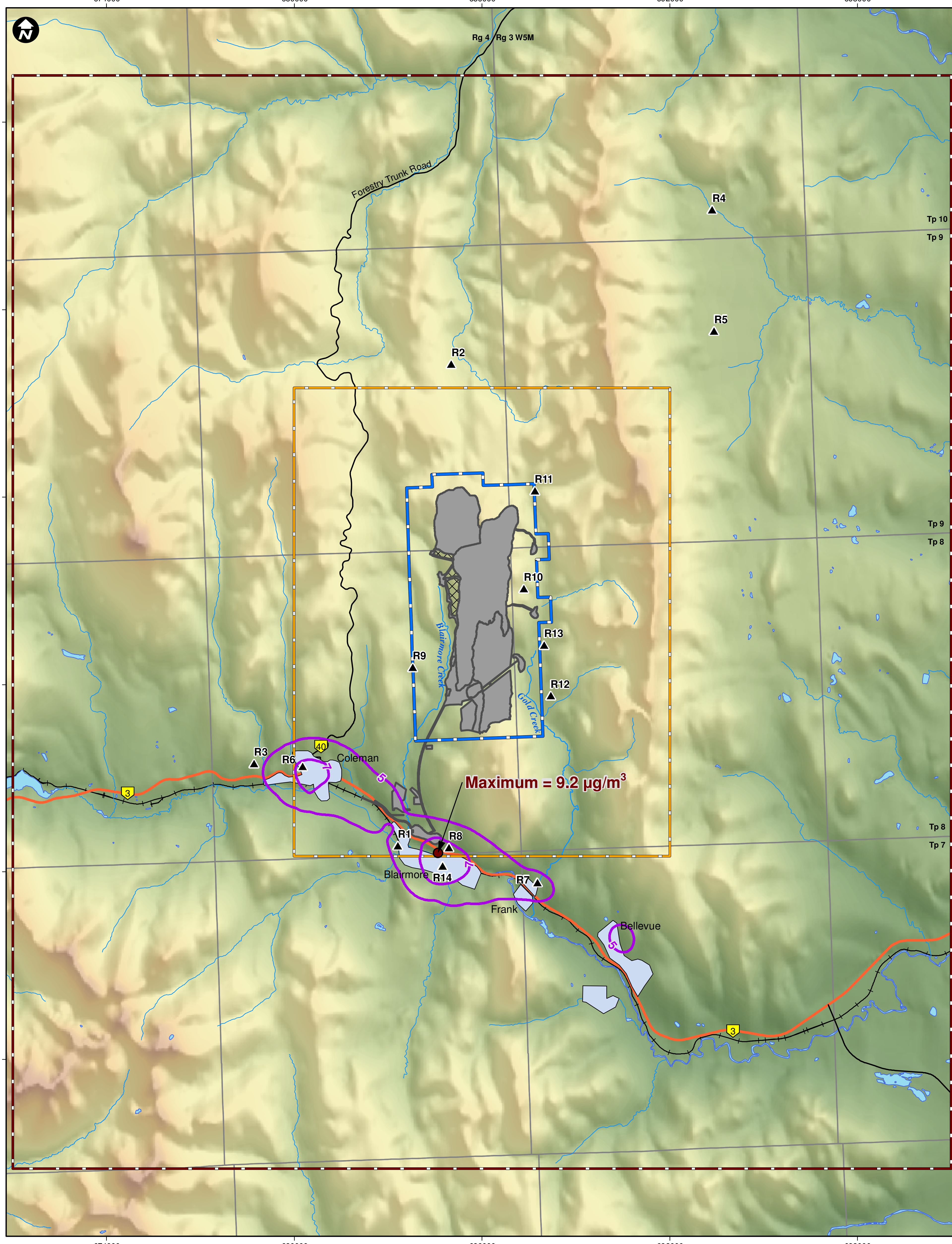
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE
5.4-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.4-2 - Predicted Max 24-hour PM25 Concentration - App.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL $PM_{2.5}$ CONCENTRATION ($\mu g/m^3$) – BASELINE CASE

NOTES

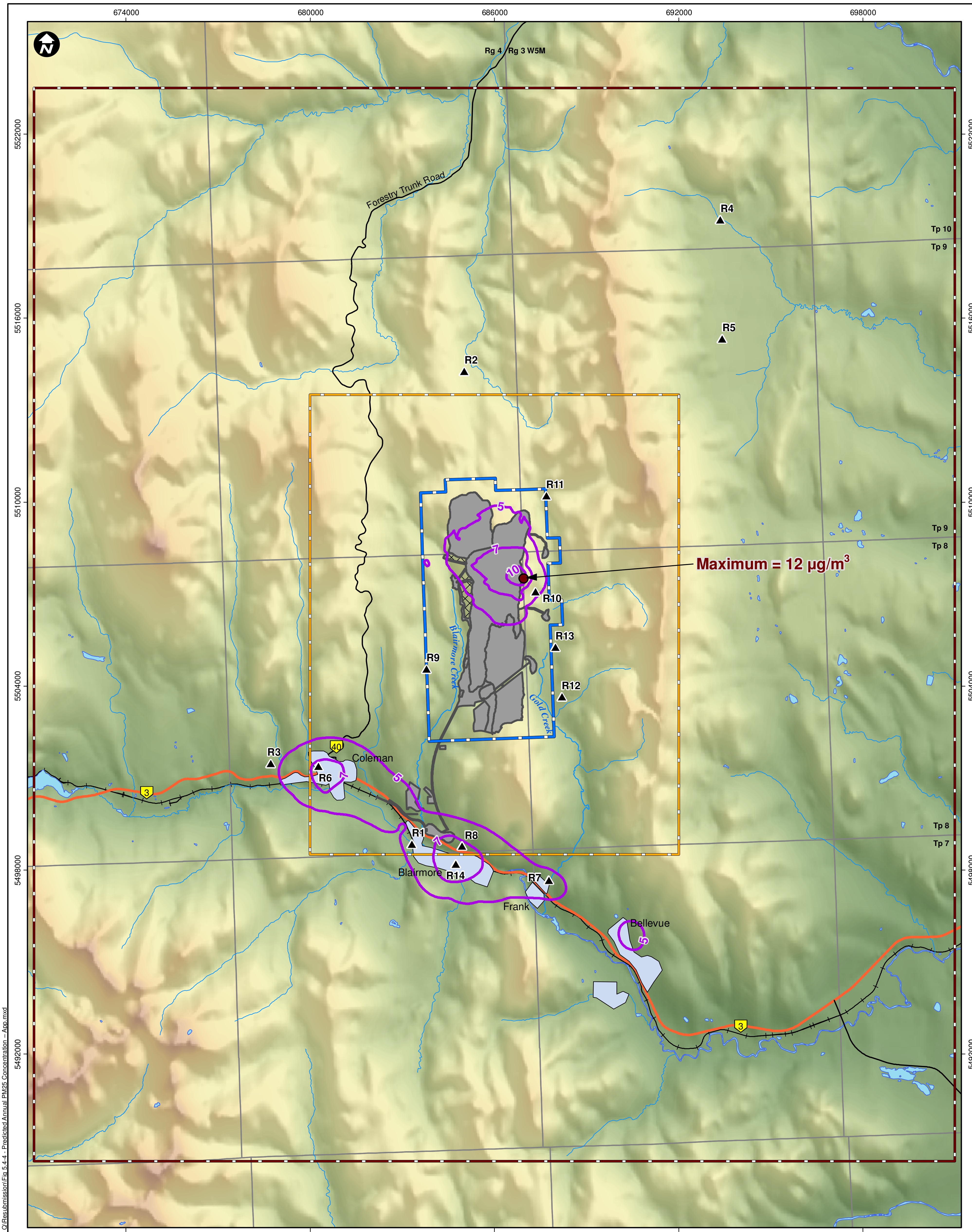
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE

5.4-3



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL $PM_{2.5}$ CONCENTRATION ($\mu g/m^3$) – APPLICATION CASE

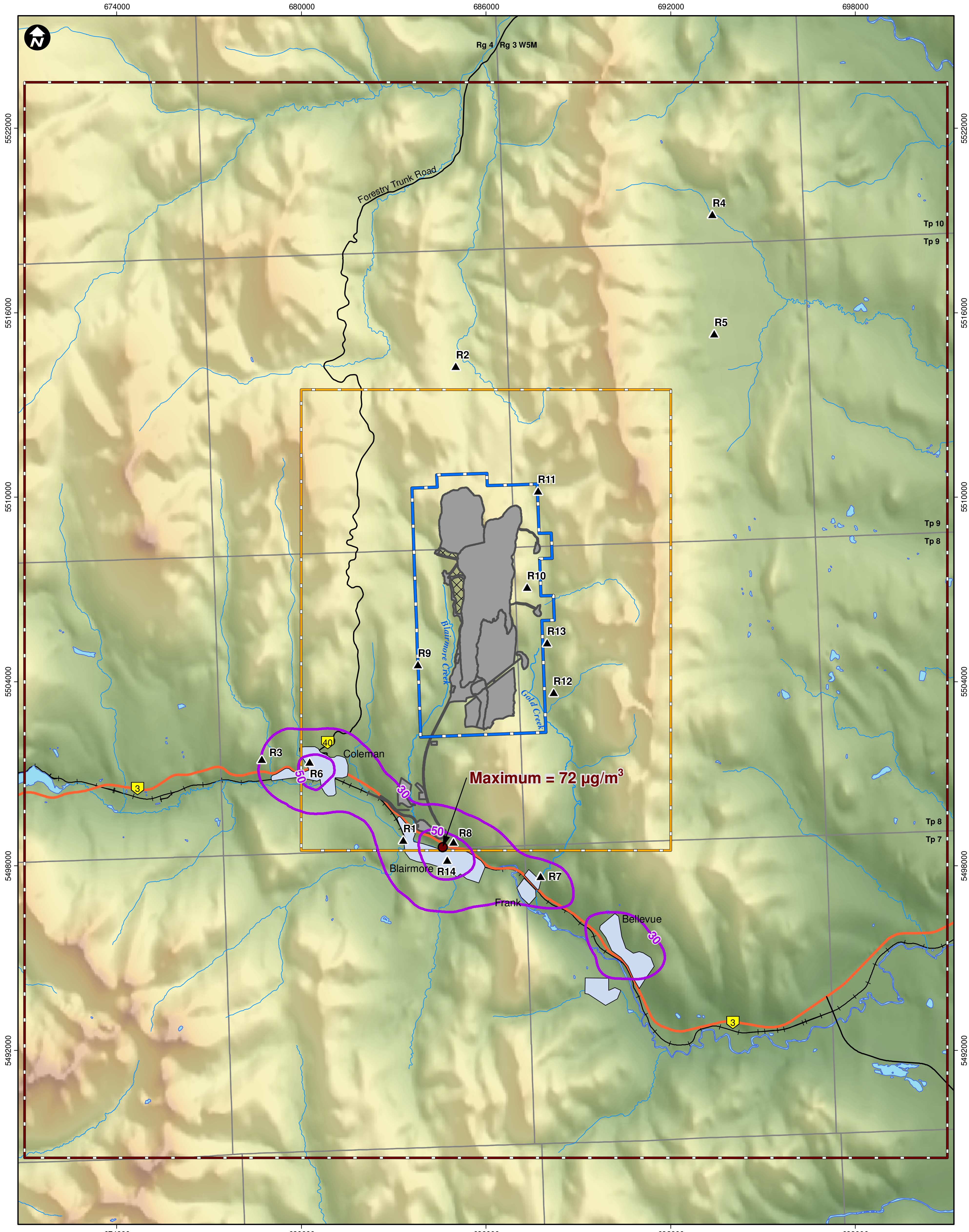
NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT:	14-00201-01
DRAWN BY:	CP/JDC
CHECKED BY:	JS
DATE:	JUNE 17, 2016
FIGURE	5.4-4

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.4-4 - Predicted Annual PM25 Concentration – App.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED MAXIMUM 24-HOUR PM_{10} CONCENTRATION ($\mu g/m^3$) – BASELINE CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

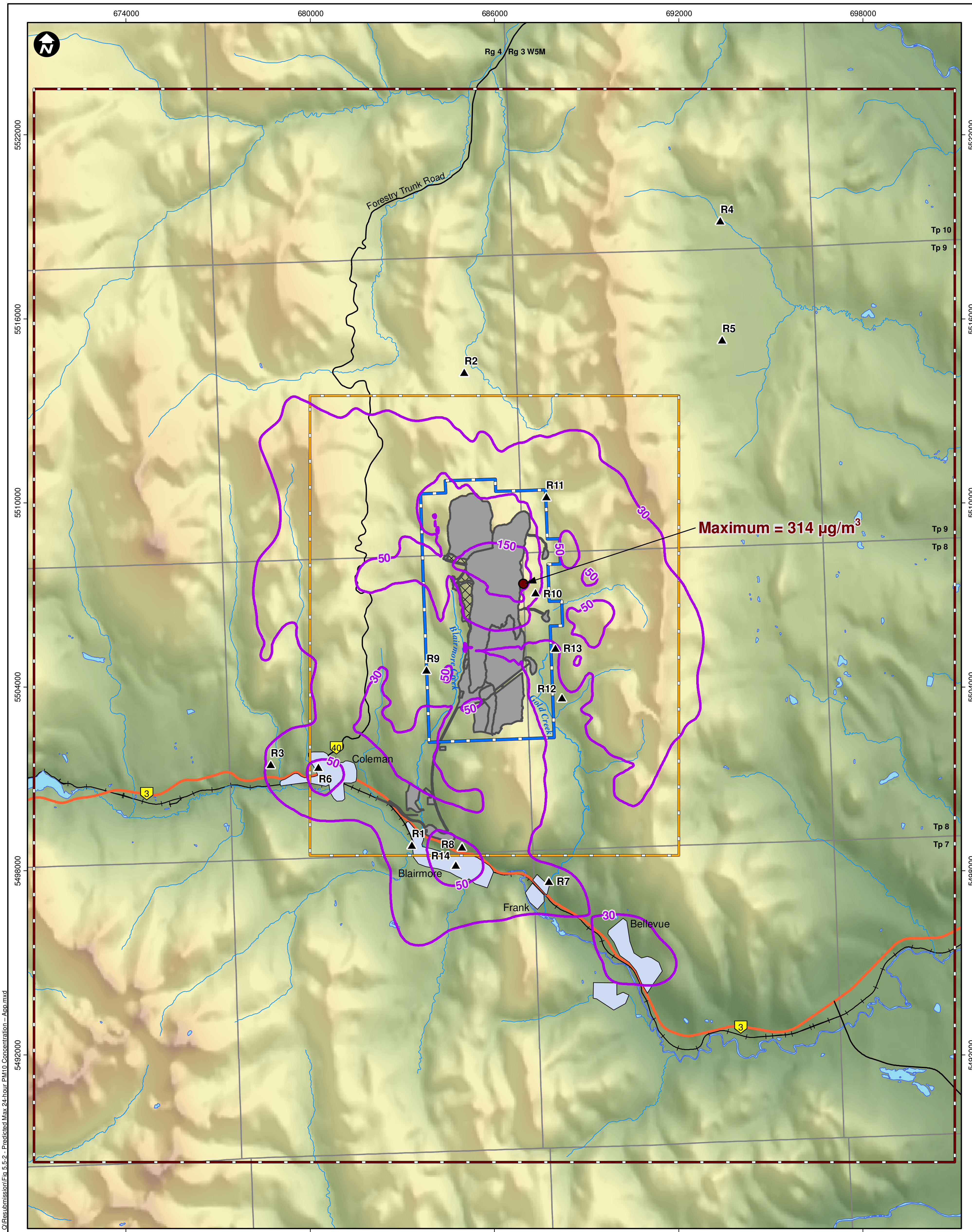
0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE

5.5-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.5-1 - Predicted Max 24-hour PM10 Concentration - Base.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED MAXIMUM 24-HOUR PM_{10} CONCENTRATION ($\mu g/m^3$) – APPLICATION CASE

NOTES

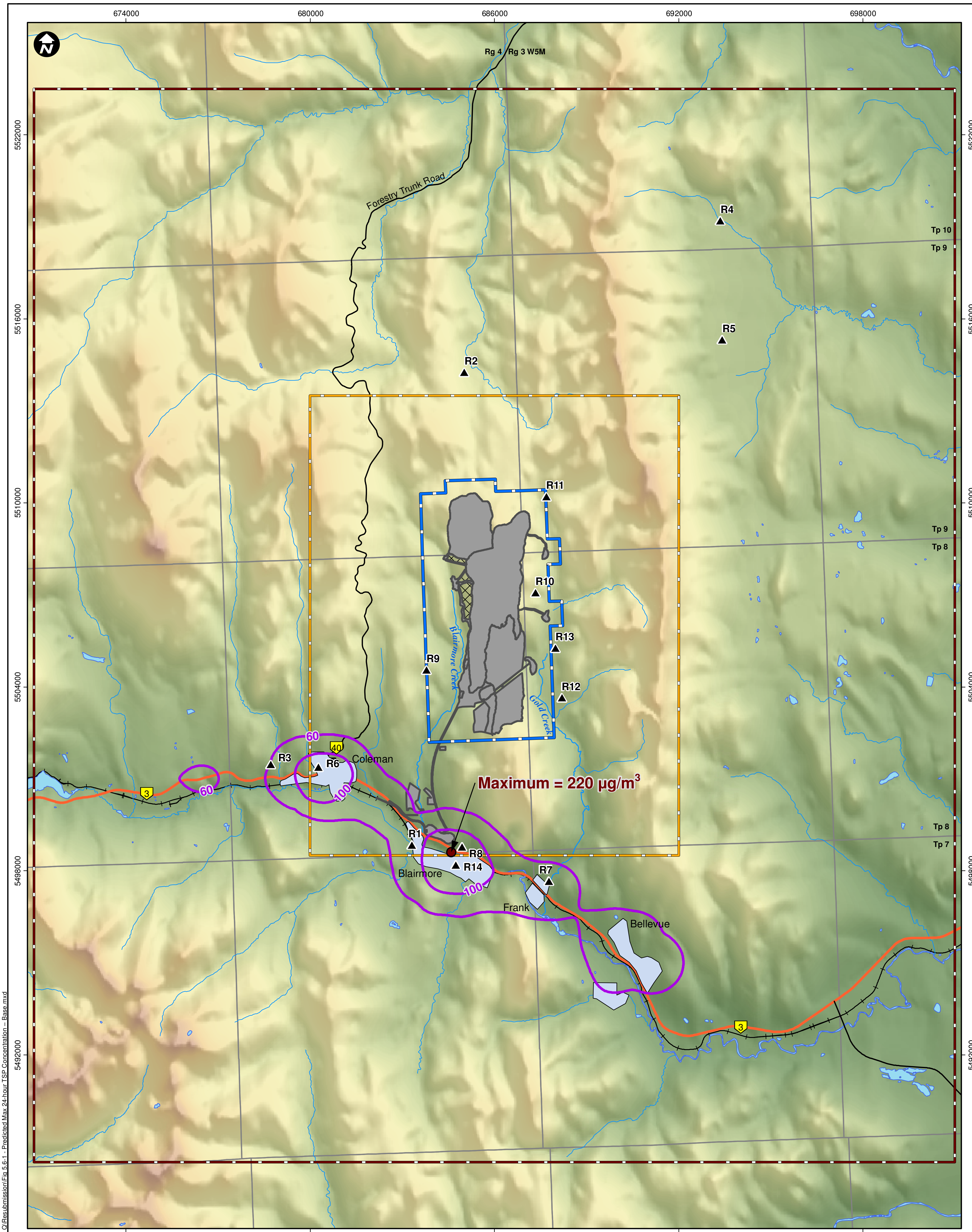
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE

5.5-2



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED MAXIMUM 24-HOUR TSP CONCENTRATION (µg/m³) – BASELINE CASE

NOTES

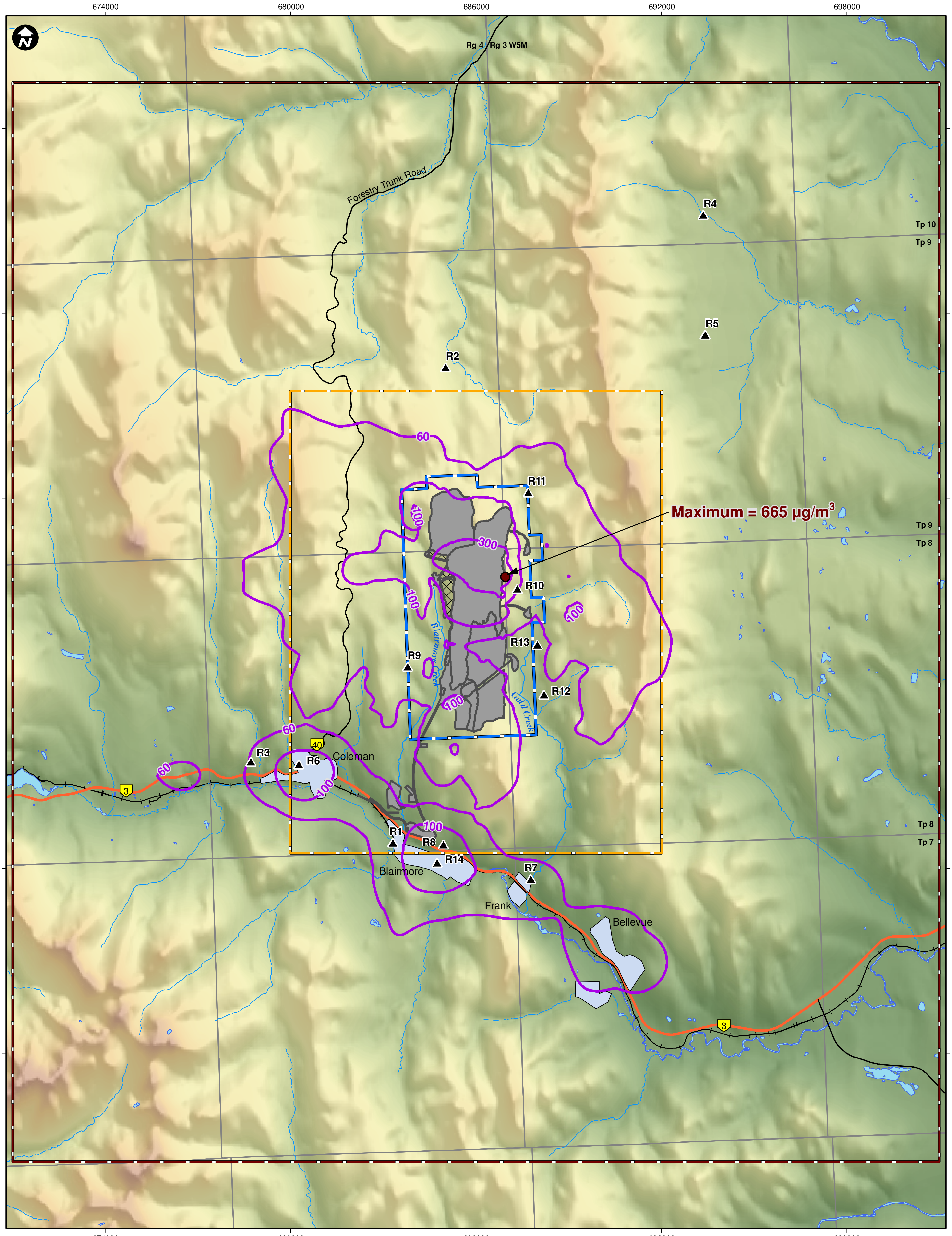
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE
5.6-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.6-1 - Predicted Max 24-hour TSP Concentration – Base.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED MAXIMUM 24-HOUR TSP CONCENTRATION (µg/m³) – APPLICATION CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

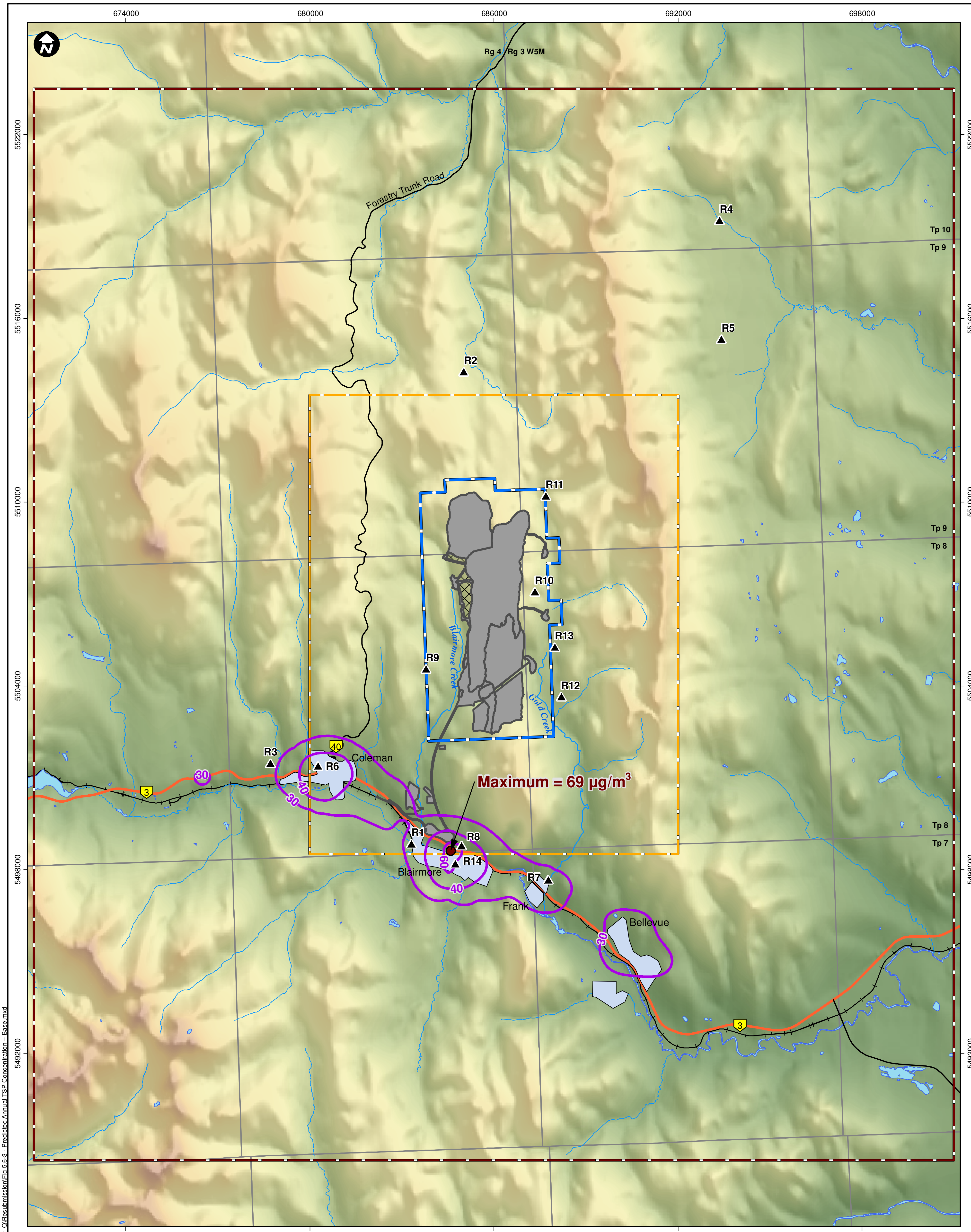
0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE

5.6-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.6-2 - Predicted Max 24-hour TSP Concentration – App.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL TSP CONCENTRATION (µg/m^3) – BASELINE CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

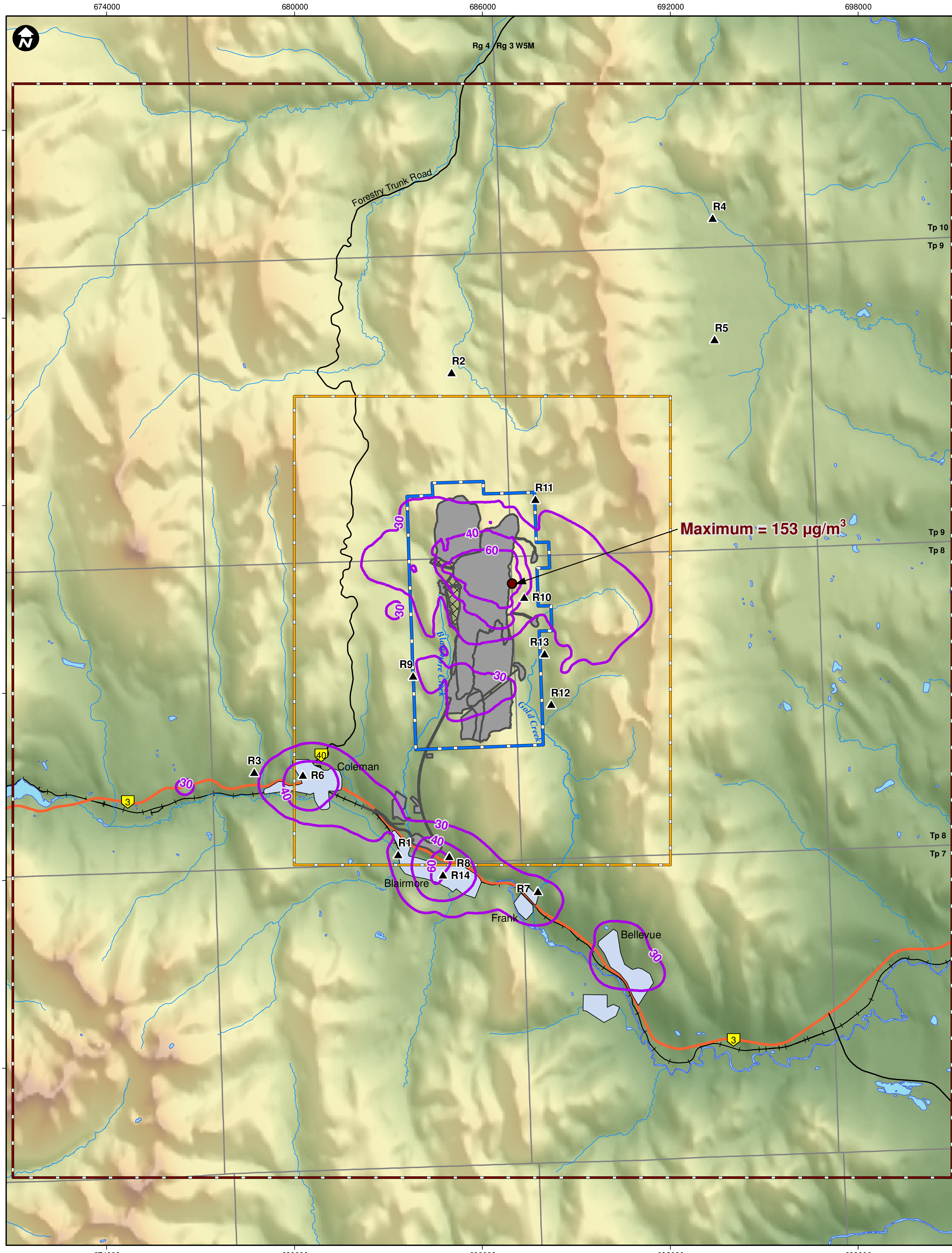
0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE

5.6-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.6-3 - Predicted Annual TSP Concentration – Base.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL TSP CONCENTRATION ($\mu g/m^3$) – APPLICATION CASE

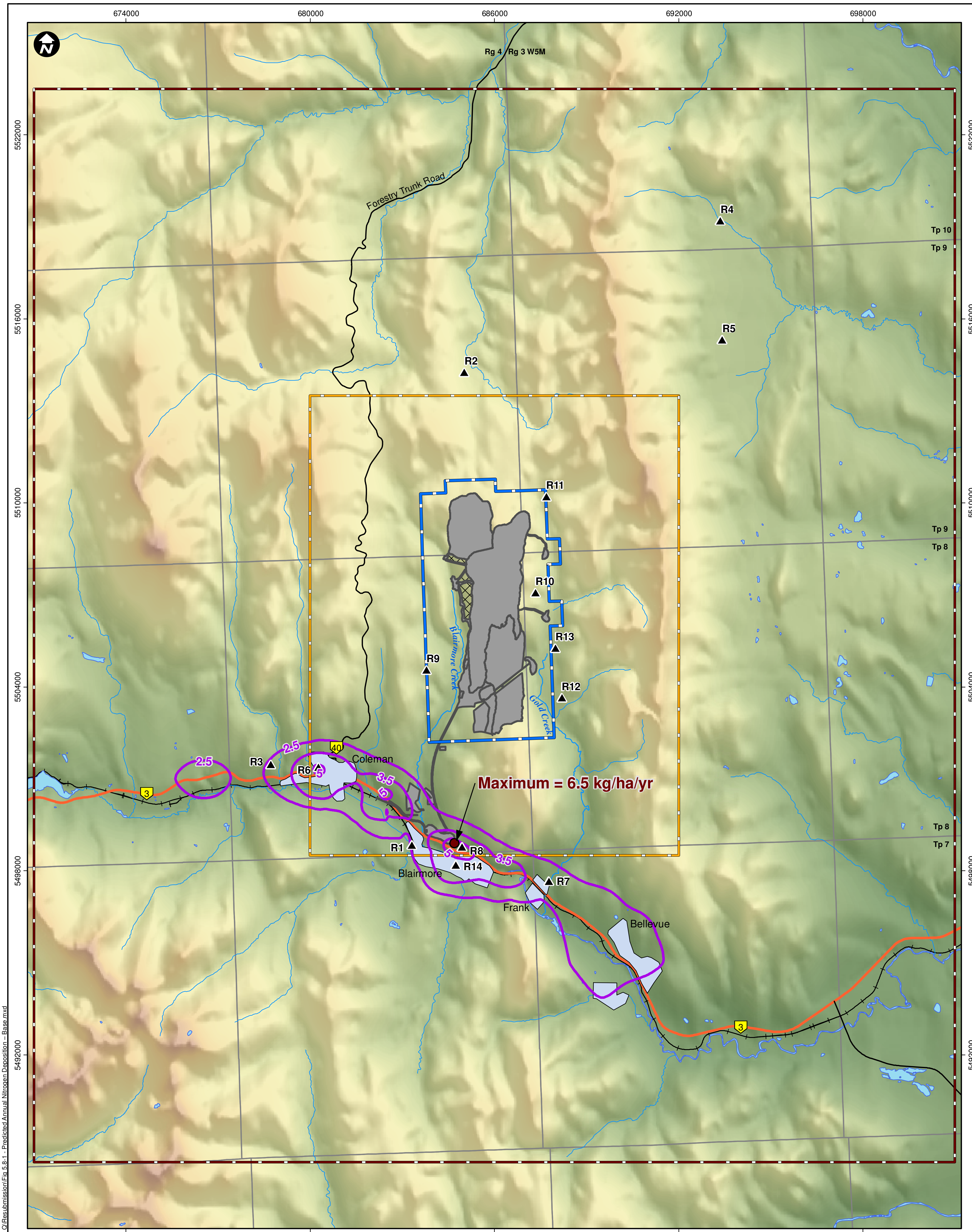
NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 17, 2016

FIGURE
5.6-4



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL NITROGEN DEPOSITION (kg/ha/yr) – BASELINE CASE

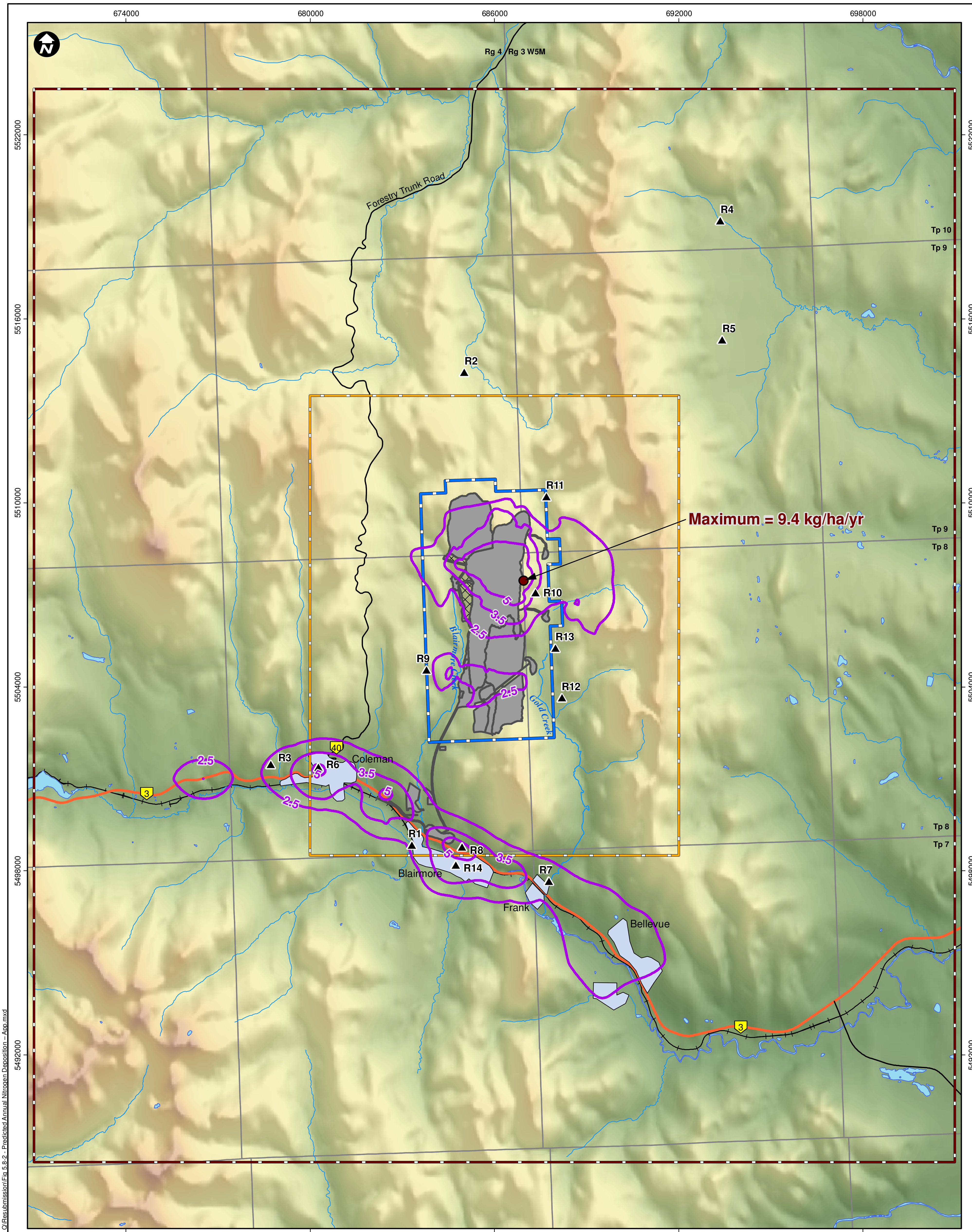
NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JULY 3, 2016

FIGURE
5.8-1



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL NITROGEN DEPOSITION (kg/ha/yr) – APPLICATION CASE

NOTES

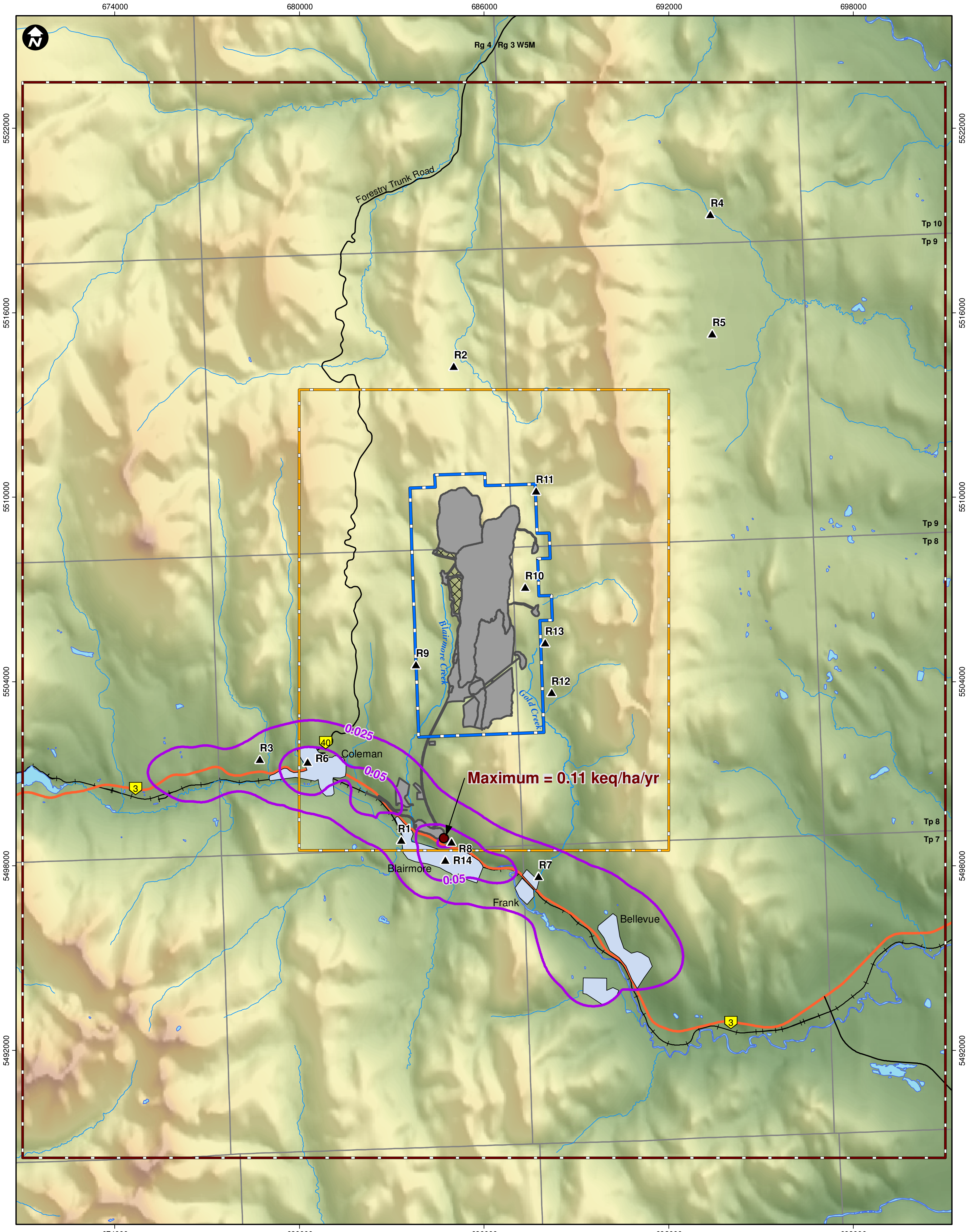
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JULY 3, 2016

FIGURE

5.8-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.8-2 - Predicted Annual Nitrogen Deposition – App.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL POTENTIAL ACID INPUT DEPOSITION (keq/ha/yr) – BASELINE CASE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

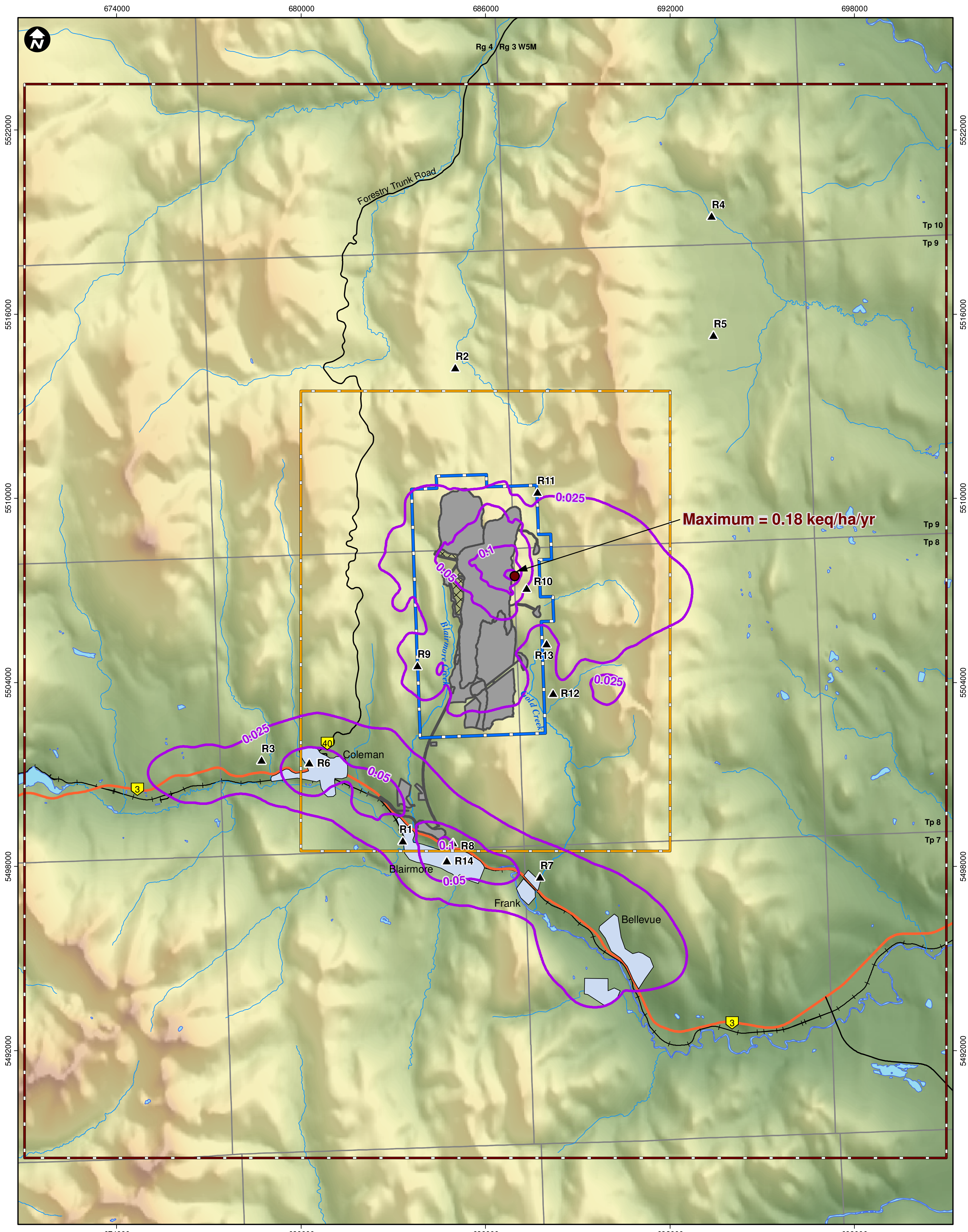
0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JULY 3, 2016

FIGURE

5.9-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.9-1 - Predicted Annual Potential Acid Input Deposition – Base.mxd



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED ANNUAL POTENTIAL ACID INPUT DEPOSITION (keq/ha/yr) – APPLICATION CASE

NOTES

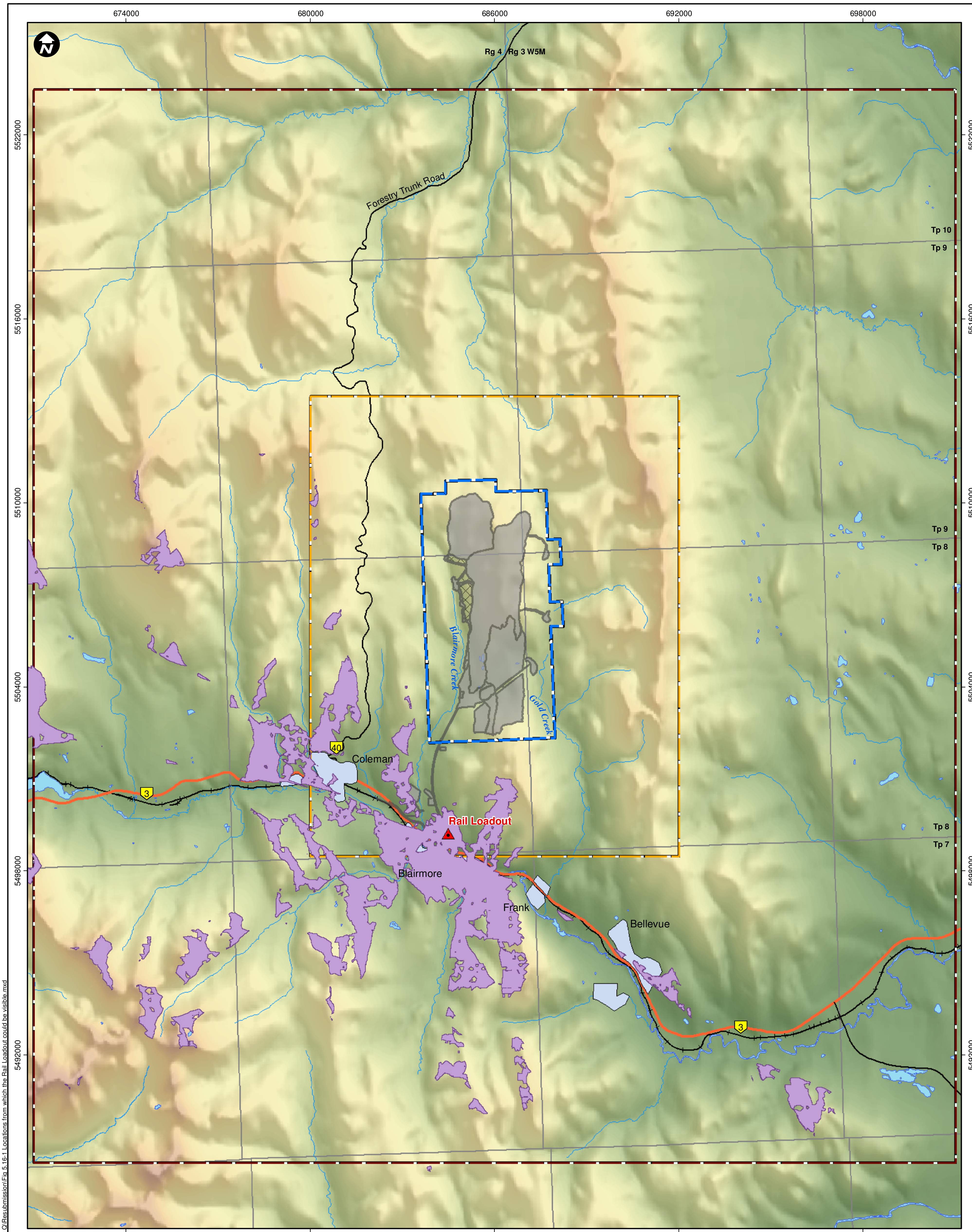
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JULY 3, 2016

FIGURE

5.9-2



LEGEND

- Rail Loadout
- Viewshed
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

LOCATIONS FROM WHICH THE RAIL LOADOUT COULD BE VISIBLE

NOTES

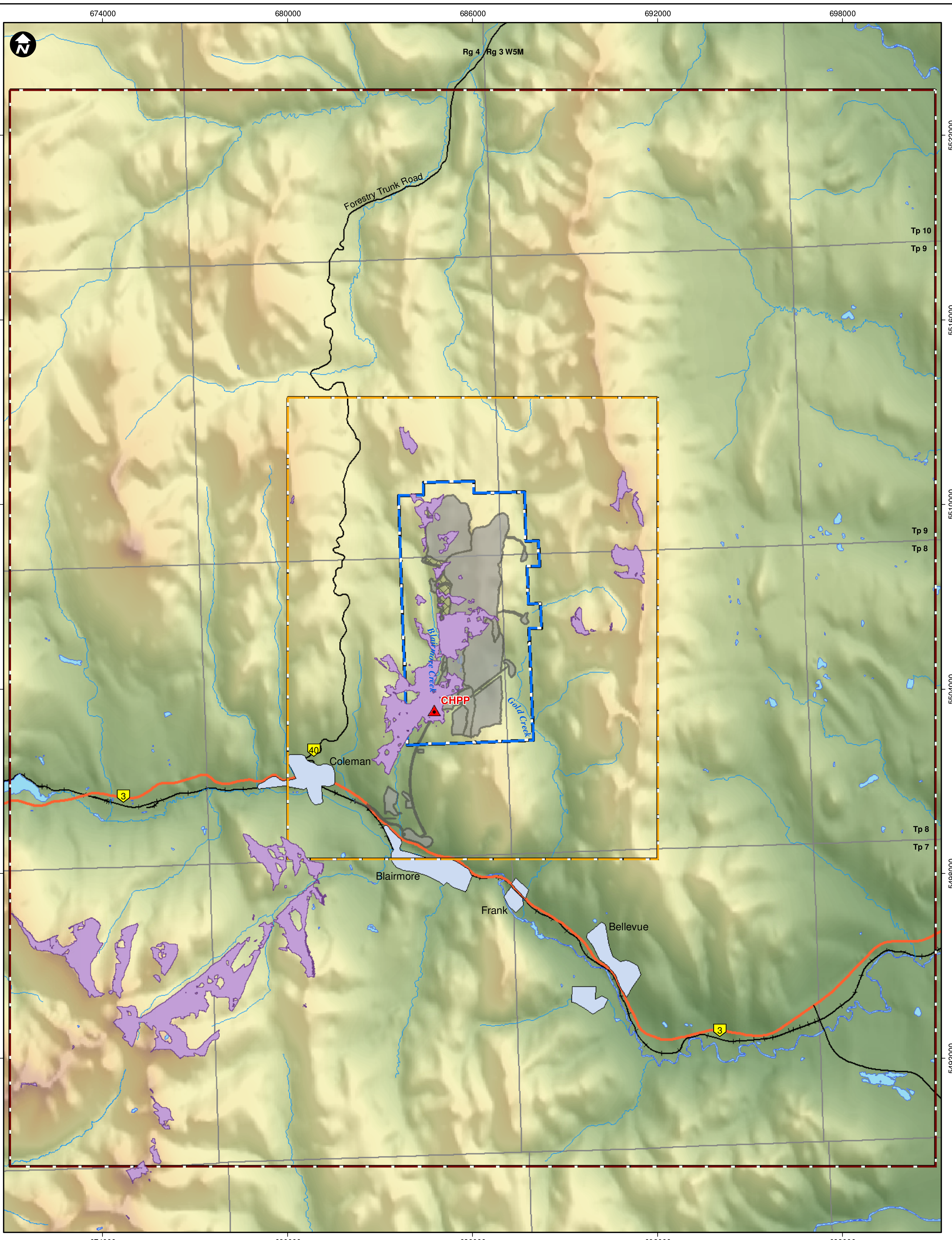
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JULY 4, 2016

FIGURE
5.16-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.16-1 Locations from which the Rail Loadout could be visible.mxd



LEGEND

- CHPP
- Viewshed
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)
High : 2800
Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

LOCATIONS FROM WHICH THE CHPP COULD BE VISIBLE

NOTES

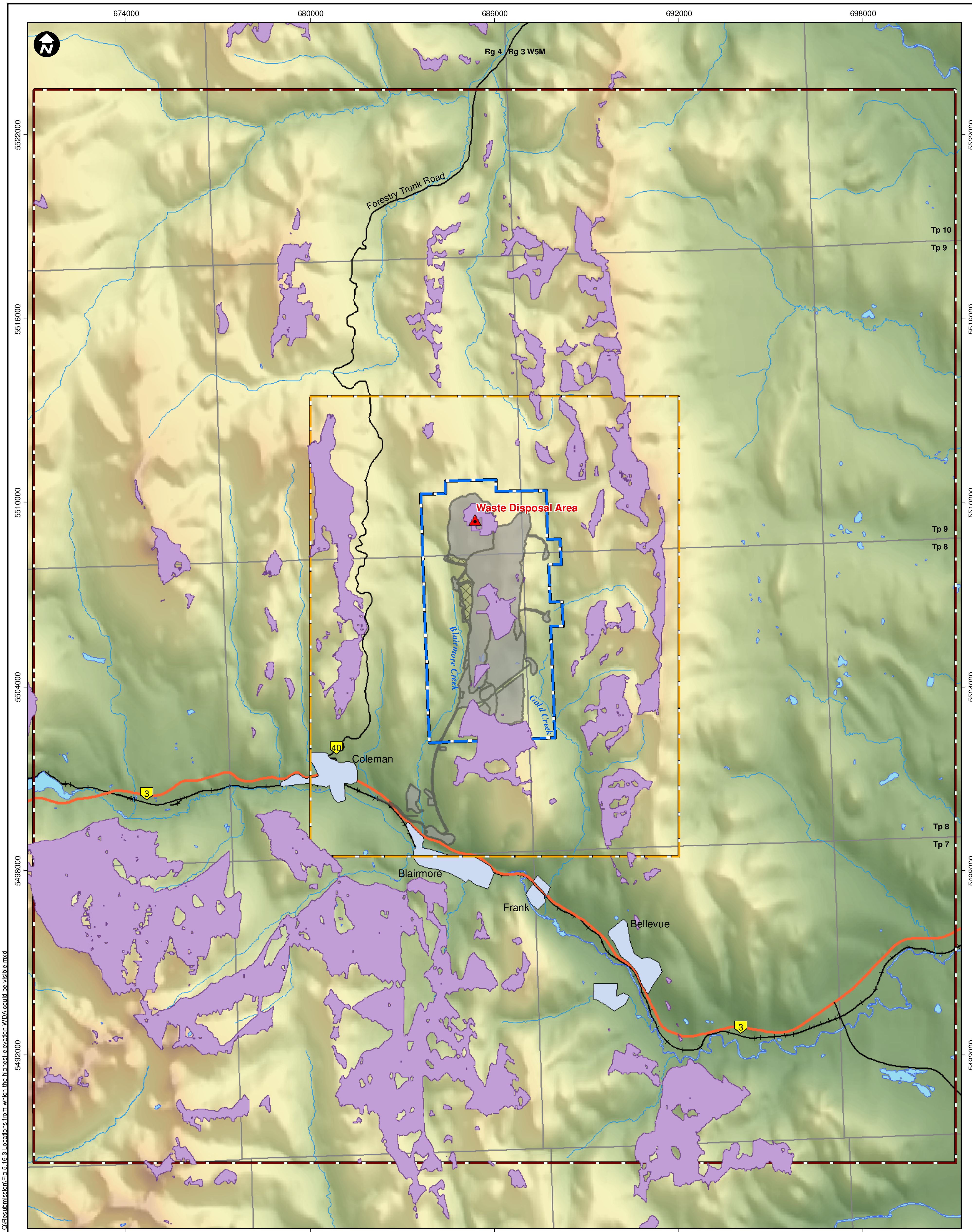
AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JULY 4, 2016

FIGURE
5.16-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.16-2 Locations from which the CHPP could be visible.mxd



LEGEND

- Waste Disposal Area
- Viewshed
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area

Topography (masl)

High : 2800

Low : 1250

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

LOCATIONS FROM WHICH THE HIGHEST-ELEVATION WASTE DISPOSAL AREA COULD BE VISIBLE

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JULY 5, 2016

FIGURE

5.16-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 5.16-3 Locations from which the highest-elevation WDA could be visible.mxd

APPENDIX A: DETAILS OF EMISSION ESTIMATION AND MITIGATION

Table of Contents

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List of Tables

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A1 INTRODUCTION

To assess the effect of the Project on the regional air quality, an air quality regional study area (RSA) was defined. All known industrial and non-industrial emissions sources within the RSA were collected or estimated and input to the CALPUFF dispersion model. Details of the emission calculations and related assumptions are summarized in this Appendix.

A2 PROJECT EMISSION SOURCES

The Grassy Mountain Coal Mine plans to produce from 2.0 to 4.0 million tonnes (Mt) of clean metallurgical coal annually for export overseas. The objective of the mine plan is to balance the removal of the overlying waste rock above the coal (overburden) with a continuous source of coal, economically over the life of the mine. The mine life for the Project is estimated to be 23 years (from 2019 to 2041).

Based on the mine plan provided by Benga, Year 19 was identified as the year when reasonably worst case emissions could be expected with 47.5 million BCM of overburden removal and comparatively long haul roads. The annual coal production in Year 19 was approximately 6.8 Mt of raw coal and 3.8 Mt of clean coal.

The mine will consist of a series of pits that will be developed to maintain the balance of overburden removal and release of coal. The overburden was assumed to be mined using hydraulic waste shovels and end dump trucks. It is assumed that all of the overburden will require drilling and blasting, using ammonium nitrate and fuel oil (ANFO) as the primary blasting agent. Initially, the overburden material will be placed in disposal areas outside the pit areas; later, there will be in-pit disposal. Coal will be removed by diesel powered equipment consisting of dozers, backhoes and end dump trucks.

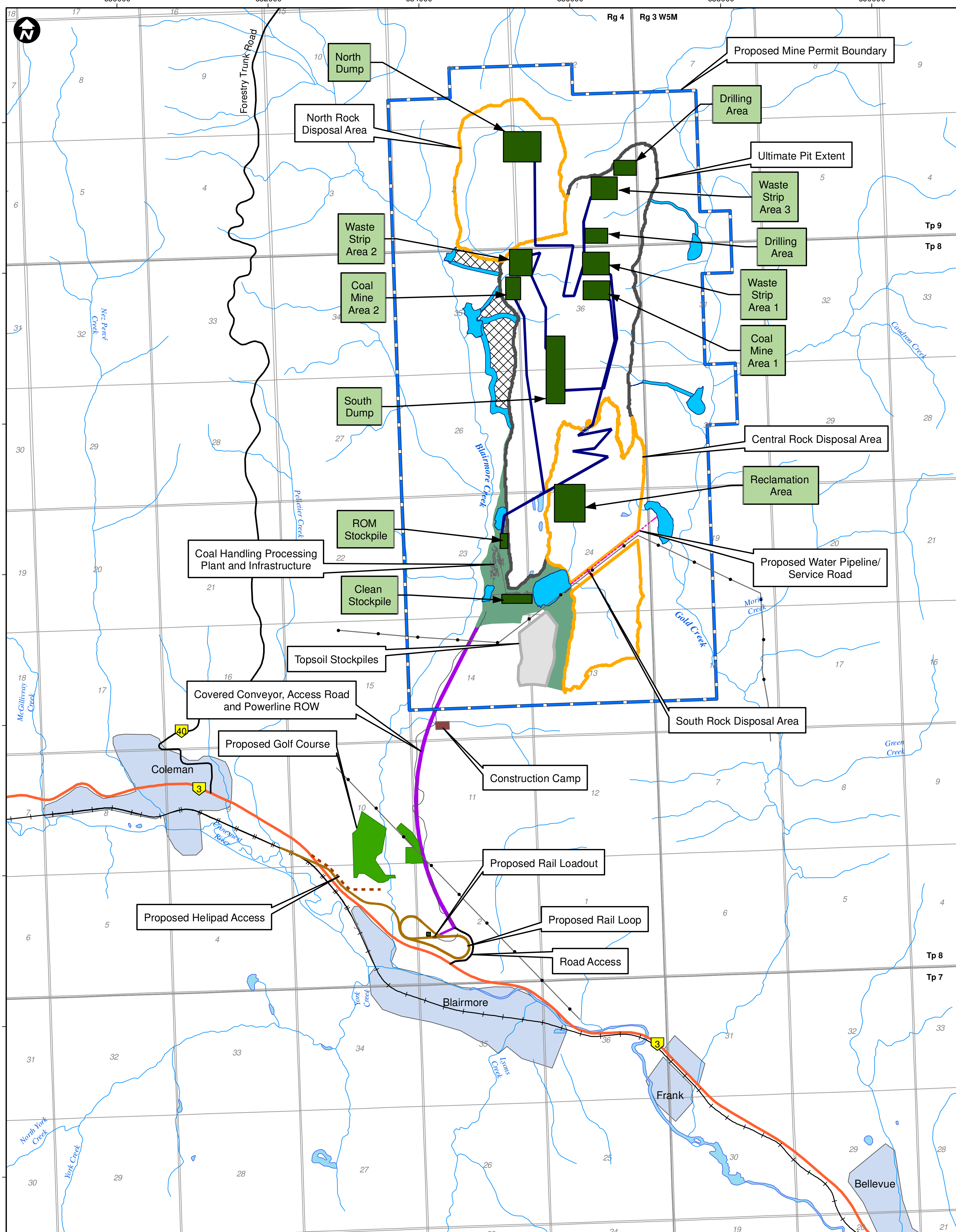
Coal from the open pit mining operations will be trucked to the run of mine (ROM) raw coal dump station at the Coal Handling Process Plant (CHPP) using large-scale mining trucks. The CHPP will consist of the raw coal, reject coal, and product coal material handling components and two coal processing plant (CPP) modules, where the coal will undergo screening, washing, and mechanical dewatering. The two CPP modules will be contained within a housed area and all coal material handling will be via covered conveyors. The reject material from the CPP will be stored in an enclosed bin and later trucked back into the mine for disposal.

The final coal product will be sent to the product coal stockpiles, from where it will be conveyed overland (via a covered conveyor) to the housed train load-out facility located near the existing Canadian Pacific Railway track located in Blairmore, Alberta.

Table A2-1 summarizes emission sources modelled for the Project. Figure A2-1 shows the modelled operational areas.

Table A2-1 Emission Sources for Project Operations

Location	Operations	Modelled Area Sources	Total Modelled Area (ha)
Mining Area			
Drilling	Drilling, blasting of overburden/rock	2	12
Waste Stripping	Bulldozing, and loading of overburden	3	31.5
Coal Seam	Bulldozing and loading of coal	2	15
Overburden Hauling Roads	Hauling of overburden to North and South Disposal areas	3	28
Coal Hauling Road	Hauling of raw coal from coal seam to Plant ROM Pile and backhauling rejects	2	32
Waste Disposal area	Unloading and bulldozing of overburden from Waste Strip and coarse refuse from Plant	2	42.5
Reclamation Area			
Reclamation	Unloading and bulldozing of topsoil	1	20
Plant			
CHPP	Support diesel equipment at the plant site. No emissions will be present from the two housed CPP modules.	-	-
ROM Pile	Dumping of coal from Coal seam, wheel loader loading coal from Pile to breaker feeder	1	4.5
Clean Coal Pile	Disposal of clean coal on clean coal pile (stacker), and bulldozing of clean coal	1	4.8
Train Load Out			
Load out	Conveyor loading of clean coal to train rail cars	1	0.25



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig A2-1 Operation Areas Modelled for Grassy Mountain Coal Project.mxd

LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Existing Access Road
- Existing Powerline
- CHPP Facilities
- Proposed Water Pipeline/Service Road
- Railway Loop
- Proposed Helipad Access
- Modelled Haul Road
- Modelled Operation Area
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Coal Handling Processing Plant and Infrastructure
- Covered Conveyor, Access Road and Powerline ROW
- Proposed Golf Course Area
- Undisturbed Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

OPERATION AREAS MODELLED FOR GRASSY MOUNTAIN COAL PROJECT

NOTES

AltaLIS, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE

A2-1

A3 SUPPORTING DATA USED IN EMISSION CALCULATIONS

A3.1 Hours of Operation

It was assumed that pits and truck traffic (from active pits to waste dumps and plant) and the Plant (including ROM) will operate 24 hours a day, 354 days a year (excluding statutory holidays). It was assumed that the loading of clean coal will occur for 8 hours each day and there will be approximately 274 trains loaded in a typical year, each carrying 14,000 t of clean coal.

A3.2 Material Balance and Properties

Waste overburden volume, raw coal extraction material, reject material, and clean coal production values for Year 19 were based on information provided by Benga in April 2016 (Table A3-1).

Table A3-1 Summary of Maximum Daily Material Balance for the Project in Year 19

Material		Annual Activity	Maximum Daily Activity	Annual Days of Operation
Waste Volume	m^3	47,465,000	134,082	354
	tonnes	109,169,500	308,388	
ROM Coal Total (tonnes)		6,836,000	19,311	354
Clean Coal Production (tonnes)		3,840,000	10,847	354
Clean Coal Train Load out		3,840,000	14,000	274
Reject from Plant back to the pit		3,139,000	8,867	354
Stripped Soil (m^3)		100,000	3,333	30

The material properties assumed in the study are presented in Table A3-2. Coal and overburden moisture data were provided by Benga. The silt content for overburden was based on measurements at the Grassy Mountain site. The silt content for raw coal and clean coal were based on Table 13.2.4-1 in AP-42 (US EPA 2006a). Clean coal has lower silt content than the other materials since the fine fractions are removed.

Table A3-2 Material Properties			
Material	**Density (kg/m^3)**	**Moisture Content (%)**	**Silt Content (%)**
Overburden	2,300	13	7.2
Raw Coal	1,500	5.0	4.6
Clean Coal	1,400	10	2.2

A3.4 Diesel Powered Equipment

Table A3-3 summarizes parameters of the diesel powered equipment by the operation area for the Project in Year 19. It was assumed that all heavy-duty equipment will meet Tier 4 final engine emission standards.

Table A3-3 Parameters of Diesel Powered Equipment			
Equipment Category	**Power Rating (hp)**	**Hours/ year/engine**	**Scheduled Fleet Units**
Mine – Overburden/Waste Strip Fleet Area 1 (hauling to south dump)			
Blast Hole Drill	760	8,218	1
Backhoe (394 t)	1,875	5,484	1
Haul Truck (220 t) – to south dump	2,650	6,930	7
Bulldozer (664 kw)	850	6,465	2
Wheel dozer (49 t) – at waste shovel	523	4,433	1
Water Truck	900	3,099	1
Mine – Overburden/Waste Strip Fleet Area 2 (hauling to south dump)			
Waste Shovel	2,520	5,828	1
Haul Truck (220 t) – to south dump	2,650	6,930	6
Bulldozer (664 kw)	850	6,465	1
Mine – Overburden/Waste Strip Fleet Area 3 (hauling to north dump)			
Blast Hole Drill	760	8,218	1
Waste Shovel	2,520	5,828	1
Haul Truck (220 t)- to north dump	2,650	6,930	7

Table A3-3 Parameters of Diesel Powered Equipment

Equipment Category	Power Rating (hp)	Hours/ year/engine	Scheduled Fleet Units
Bulldozer (664 kw)	850	6,465	2
Wheel dozer (49 t) – at waste shovel	523	4,433	1
Motor Grader (7.5 m) – between shovel and north dump	533	849	1
Blast Hole Drill	760	8,218	1
Mine – Coal Mining Fleet Area 1 (hauling to ROM stockpile)			
Backhoe (394 t)	1,875	5,484	1
Haul Truck (220 t) – hauling to ROM stockpile	2,650	6,930	6
Bulldozer (391 kw)	600	5,979	1
Motor Grader (7.5 m)	533	849	1
Mine – Coal Mining Fleet Area 2 (hauling to ROM stockpile)			
Backhoe (394 t)	1,875	5,484	1
Haul Truck (220 t) – hauling to ROM stockpile	2,650	6,930	6
Bulldozer (391 kw)	600	5,979	1
Water Truck – working between Coal Area 2 and ROM	900	3,099	1
Reclamation Area			
Backhoe (122 t) – topsoil salvage in various locations	672	5,750	1
Articulated Trucks (37 t) – hauling topsoil to/from stockpiles	489	161	2
Bulldozer (391 kW) salvaging topsoil	600	5,979	1
ROM/Clean Stockpile			
Haul Truck (220 t) – unloading at stockpile, backhauling rejects	2650	6,930	1
Wheel Loader (218 t) – at ROM stockpile	1765	5,753	1
Bulldozer (391 kW) at Clean Coal Pile	600	5,979	1
Train Load-out			
P42DC Locomotive at Train Load-out	4,250	2,832	1

Table A3-3 Parameters of Diesel Powered Equipment			
Equipment Category	**Power Rating (hp)**	**Hours/ year/engine**	**Scheduled Fleet Units**
Support Equipment/Other (throughout mine site)			
Lowboy - equipment hauler, no fixed location	2,100	471	1
Skid steer loader	73	5,783	1
Compactor	405	4,565	1
Portable Diesel Pumps	125	5,969	10
Rough Terrain Crane (250 t)	550	2,344	1
Forklift(14 t) - in shop area	164	1,126	1
Forklift(4 t) - in shop area	100	1,126	1
Light Plant - nightshift only	12	2,637	10
Ford F-750 Fuel Truck	362	4,692	1
Mechanic/welding Truck	440	5,787	1
Heavy Duty Service Truck	440	4,889	2
Light duty service truck	385	4,889	2
Pumpers Truck	440	8,208	2
Welding Machines	45	1,126	4
Crew Vehicle	255	2,722	4
Pickup – 7 Days/Week	365	3,911	22

A3.5 Haul Road Data

Haul road emissions were estimated using the following fleet categories:

- two-way Overburden hauling;
- two-way Coal hauling (including backhauling reject); and
- haul road maintenance: water trucks and other service vehicles.

Table A3-4 is a detailed listing of vehicle parameters related to fugitive dust emissions generated by wheel entrainment.

For coal and waste haul, daily maximum two-way trips were calculated as the daily maximum coal or waste handled divided by the average pay-load of haul trucks. The total hourly vehicle kilometres travelled (VKT) were, for the purpose of emission estimation, the daily maximum number of two-way trips multiplied by two-way distance.

The hourly VKT per service vehicle was estimated as 12.5 km/h, assuming 50% hourly operation on haul roads with an average vehicle speed of 25 km/h. The total hourly VKTs were based on the hourly VKT per vehicle multiplied by the number of vehicles. The total fugitive dust emissions from all service vehicles were averaged over all haul roads. Although not all service vehicles will be working for 24 hours a day, to be conservative, it was assumed that all service vehicles operated simultaneously at maximum hourly emissions.

Fugitive dust emissions generated by wheel entrainment from graders on haul roads were based on an average 15 km/h vehicle speed, for vehicles working throughout the hour. Dust emissions generated by wheel entrainment from wheel loaders and articulated trucks on site were based on an average 5 km/h vehicle speed, while total hourly VKTs were based on the number of two-way trips per hour with an average payload.

Vehicle speeds are estimates of expected maximum speeds, on haul roads or mine areas. Speed limits will be posted on haul roads and speeds will be monitored by shift foremen.

Table A3-4 Parameters of Vehicle Operation

Equipment Category	Average Vehicle Weight (short tons)*	Average Pay-Load (tonnes)	Hours /Day /Engine	Maximum Two-Way Trips / Day	Two-Way Distance (km)	Total Hourly VKT (km/h)
Waste Haul from Waste Area 3 to North Dump 1						
Haul Truck (220 t)	309	220	19.6	467	7.6	181
Motor Grader (7.5 m)	-	-	16.3	-	-	15
Waste Haul from Waste Area 2 to South Dump						
Haul Truck (220 t)	309	220	19.6	467	3.8	91
Waste Haul from Waste Area 1 to South Dump						
Haul Truck (220 t)	309	220	19.6	467	4.7	113
Water Truck	128	96	8.8	-	-	15
Coal Haul from Coal Seam 1 to ROM						
Haul Truck (220 t)	369	254	19.6	44	7.2	16
Motor Grader (7.5 m)	-	-	16.3	-	-	15
Coal Haul from Coal Seam 2 to ROM						
Haul Truck (220 t)	369	254	19.6	44	11.1	25
Water Truck	128	96	8.8	-	-	15
Reclamation Area						
Articulated Trucks (37 t)	-	-	5.4	-	-	19.3
Service Vehicles						
Tractor & Lowboy Trailer	254	-	1.3	-	-	12.5
Skid Steer	1.7	-	16.3	-	-	12.5
Compactor	40	-	12.9	-	-	12.5
Fuel Truck	19	-	13.3	-	-	12.5
Mechanic/Welding Truck	8	-	16.3	-	-	12.5
Heavy Duty Service Truck	8	-	13.8	-	-	25
Light Duty Service Truck	8	-	13.8	-	-	25
Pumpers Truck	19	-	23.2	-	-	25
Crew Vehicle	19	-	7.7	-	-	50
Pickup Truck	2.2	-	11.0	-	-	275

* 1 Short Ton [US] = 0.907 Metric Tons [Tonnes]

A4 FUGITIVE PARTICULATE EMISSIONS

The following section outlines the approach taken to estimate particulate emissions generated by equipment at the coal and waste mine pit and haul road such as material loading, unloading and bulldozing, and wheel entrainment from aggregate transport.

A4.1 Blasting and Drilling Operations

A4.1.1 Emission Estimates

The emission volumes generated by the detonation of the explosives were estimated based on the amount and the type of the explosives that will be used. ANFO and emulsion were used onsite for blasting.

The TSP emissions from blasting were calculated using an approach and the equations developed by Environment Australia as they reflect recent practices in blasting (Roy *et al.*, 2010). Multipliers for PM_{10} and $PM_{2.5}$ were taken from AP-42 Table 11.9-2 (U.S. EPA 1998a):

$$TSP(kg / Blast) = 344 * (A)^{0.8} * (M)^{-1.9} * (D)^{-1.8}$$

$$PM_{10}(kg / Blast) = 0.52 * TSP$$

$$PM_{2.5}(kg / Blast) = 0.03 * TSP$$

where:

A = blasted area of overburden,

M = moisture content in percentage (%); and

D = depth of the blast hole (m).

Emissions from drilling were calculated using an emission factor of 0.59 kg TSP/hole developed for rock drilling and taken from AP-42 Table 11.9-4 (U.S. EPA 1998a). If the same size distribution is that of U.S. EPA (2006a) for aggregate handling and storage (PM_{10}/TSP=0.47, $PM_{2.5}$/TSP=0.072), the emission factor is 0.279 kg/hole for PM_{10} and 0.042 kg/hole for $PM_{2.5}$.

Environment Canada (2009) considers VOC and other trace gas emissions from blasting to be negligible, and particulate emissions from ANFO to be included in those from the rock material shattering.

Table A4-1 summarizes the approximate number of holes drilled per blast, area for each blast and the number of blasts per year. The number of holes drilled per day was based on the assumption that the mine operates 354 days a year. For modelling, it was assumed that there will be no more than one blast per day for each pit during the operating years.

Table A4-1 Details of Overburden Drilling and Blasting

	Volume (BCM*/year)	Hole Depth (m)	Area per hole (m^2)	Holes per blast	Area per blast (m^2)	Blasts/ Year	Drilled Holes/day
Overburden	48,064,000	15	81	150	12,113	265	112

*Bank Cubic Metre

A4.1.2 Rationale for Roy *et al* Emission Factors

Current U.S. EPA AP42 emission factors have not been used to estimate particulate emissions for blasting. Instead, emission factors from Roy et al., 2010 were used, which were the same as pre-1998 U.S. AP42 emission factors. The pre-1998 equation had been recommended for all blasting from coal, overburden and other un-fractured rock blasting. However, the updated equation was considered by the stone processing industry to overestimate the emissions due to the strong moisture dependence of the equation and the much lower moistures in the stone processing industry. In response to the concern of over-estimation, the U.S. EPA developed a new equation for use in the crushed stone industry, which is now also applied to the coal industry, based on the original surface coal data, that only includes the area blasted (SKM 2005).

The updated equation was developed from 14 coal and four overburden blasts at three western surface coal mines. Also, the blast area in the updated AP42 estimate ranges from approximately 700 to 8,000 m^2, while blasting in the current operation is over 20,000 m^2 (SKM 2005).

The older equation was used in the current assessment as it includes moisture and blast-hole depth dependences and both of these variables are known for the proposed coal mining operation, presumably leading to a more accurate emission estimate.

Currently there are no other equations available to estimate particulate emissions from blasting.

A4.2 Loading and Unloading Operations

Dust emissions for loading (un-loading) of overburden and coal onto (from) the trucks using backhoes and shovels were calculated based on the maximum annual production rates and emission estimation methodology described in AP 42, Section 13.2-4 (U.S. EPA 2006a) (Aggregate Handling and Storage Piles). According to this document, particulate emission factors for material dropping or dumping operations are:

$$TSP\left(\frac{kg}{tonne}\right)=\frac{0.74*0.0016*\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

$$PM_{10}\left(\frac{kg}{tonne}\right)=0.35/0.74*TSP$$

$$PM_{2.5}\left(\frac{kg}{tonne}\right)=0.053/0.74*TSP$$

Where:

U = average wind speed in this area (m/s); and,

M = moisture content in percentage (%).

The mean wind speed used in the calculations was 3.9 m/s, which was calculated based on 2002 to 2006 CALMET predictions at the site location. The moisture contents used in the calculations are outlined in Table A3-2.

A4.3 Conveyor Drop Operations

Emission factor formulas for ROM coal truck loading/unloading, conveyor drop at the clean coal pile and train railcars were taken from dragline emissions of AP-42 Table 11.9-2 (U.S. EPA 1998a):

$$TSP\left(\frac{kg}{m^3}\right)=\frac{0.0046*d^{1.1}}{(M)^{0.3}}$$

$$PM_{10}\left(\frac{kg}{m^3}\right)=\frac{0.75*0.0029*d^{0.7}}{(M)^{0.3}}$$

$$PM_{2.5}\left(\frac{kg}{m^3}\right)=0.017*TSP$$

Where:

M = moisture content in percentage (%); and,

d = drop height (m).

This dust generation is minimised by the use of luffing stackers (those that can lower and raise their boom) which will minimise the drop height of the coal piling onto the stockpile, and will also minimise the drop time. A mean drop height of 1 m was used for conveyor drop at the clean coal pile and train railcars.

Emissions from the load-out were based on 274 trains/year and railcars being loaded 8 h/day between 8:00 am and 4:00 pm. Each rail car carried 91.5 t of coal (14,000 t of coal/train) which is equivalent to 152 rail cars per train.

Fugitive dust generation is minimised during this process with full cladding on the sides of the train load-out structure, and with the discharge chute of the bin being situated as close as practical to the train railcars. Train load-out emissions were modelled with 30% emission reduction from these mitigating features.

A4.4 Bulldozing Operations

The particulate emissions associated with bulldozing of overburden, waste rock and coal were estimated based on methodology described in AP-42, Section 11.9 (U.S. EPA 1998a). The bulldozing emission factors are expressed as kilograms of particulate emissions per hour of dozer operation.

Emission factor formulas for overburden, soil, and rock bulldozing were based on following equations, and assuming operations were conducted throughout the entire hour:

$$TSP\left(\frac{kg}{hr}\right) = \frac{2.6 * (s)^{1.2}}{(M)^{1.3}}$$

$$PM_{10}\left(\frac{kg}{hr}\right) = \frac{0.45 * 0.75 * (s)^{1.5}}{(M)^{1.4}}$$

$$PM_{2.5}\left(\frac{kg}{hr}\right) = 0.105 * TSP$$

The dozer at the clean coal pile was used to push the pile after it is built. Clean coal bulldozing emission factors were based on following equations and assuming bulldozing operations were conducted 10% of the time:

$$TSP\left(\frac{kg}{hr}\right) = \frac{35.6 * (s)^{1.2}}{(M)^{1.3}}$$

$$PM_{10}\left(\frac{kg}{hr}\right)=\frac{8.44*0.75*(s)^{1.5}}{(M)^{1.4}}$$

$$PM_{2.5}\left(\frac{kg}{hr}\right)=0.022*TSP$$

Where:

s = silt content of the road surface in percentage (%); and,

M = moisture content in percentage (%).

The moisture and silt contents used in the calculations are outlined in Table A3-2.

A4.5 Transport Operations on Unpaved Roads

Particulate emissions will be generated when mining vehicles (haul trucks, water trucks and service vehicles) travel on the unpaved haul roads. Transport emissions on unpaved roads, caused by wheel entrainment are based on equations taken from AP-42, Table 13.2.2-2 (U.S. EPA 2006b):

$$TSP\left(\frac{kg}{VKT}\right)=4.9*0.2819\left(\frac{s}{12}\right)^{0.7}\left(\frac{W}{3.0}\right)^{0.45}$$

$$PM_{10}\left(\frac{kg}{VKT}\right)=1.5*0.2819\left(\frac{s}{12}\right)^{0.9}\left(\frac{W}{3.0}\right)^{0.45}$$

$$PM_{2.5}\left(\frac{kg}{VKT}\right)=0.15*0.2819\left(\frac{s}{12}\right)^{0.9}\left(\frac{W}{3.0}\right)^{0.45}$$

Where:

s = silt content of the road surface in percentage (%); and,

W = mean weight (in short tons) of the vehicle under consideration.

The silt content of the haul road was assumed to be 4.3%, taken from AP-42 Table 11.9-3. The mean vehicle weights are outlined in Table A3-4. Hourly emissions were calculated by multiplying emission factors (in kg/VKT) by their total hourly VKTs (Table A3-4).

A4.6 Grader and Loader Transport Emissions

Emission factors for grader and wheel loader were derived from AP-42, Table 11.9-2 (U.S. EPA 1998a):

$$TSP\left(\frac{kg}{VKT}\right) = 0.0034 * (S)^{2.5}$$

$$PM_{10}\left(\frac{kg}{VKT}\right) = 0.6 * 0.0056 * (S)^{2.0}$$

$$PM_{2.5}\left(\frac{kg}{VKT}\right) = 0.031 * TSP$$

Where:

S = mean vehicle speed (km/h)

The mean vehicle speed was assumed to be 15 km/h for graders and 5 km/h for loaders. Hourly emissions were calculated by multiplying the emission factor (kg/VKT) by the total hourly kilometres travelled.

The total hourly VKT used in the calculations are outlined in Table A3-4. The same equations were used to estimate emissions from articulated trucks transporting soil from stockpiles to the reclamation area.

A4.7 Road Surface Material Moisture and Effect of Watering

It was assumed that dust was reduced by 80% in the summer due to frequent watering of, or application of $CaCl_2$, to, the haul roads. This reduction was used in previous air quality assessments for mine operations in Alberta (*e.g.* Luscar, 1999; Coalspur, 2012), and was increased to 90% in winter due to the presence of frozen ground or snow on the ground.

Table A4-2 summarizes emission reduction data presented by AP-42 Section 13.2.2 U.S. EPA (1998b) from a number of studies, with average emission reductions of 76% by road watering. Other studies conducted for the iron and steel industry (U.S. EPA 1983a), in North Dakota, New Mexico, Ohio and Missouri showed control efficiencies from watering ranging from 69 to 88% (median 81%). Similar emission reductions are obtained for chemical suppressants. Cowherd *et al.* (1986) reviewed major unpaved road dust suppressants and found control efficiency for chemical suppressants ranged from 24 to 100% (median value about 75%).

Table A4-2 Emission Reduction Achieved by Road Watering

	Industry	Emission Reduction of PM_{10} (%)	Average Moisture Content (%)	Range of Moisture Content (%)
Michigan(a)	Power plant	72	Watered 4.56 Uncontrolled 1.70	2.30 – 8.70 1.7
Wyoming(b)	Coal mines	53	Watered 4.10 Uncontrolled 2.02	1.29 – 12.30 0.68 – 5.11
California(c)	Road construction	81	Watered 7.41 Uncontrolled 4.92	7.41 4.14 – 5.69
Ohio(d)	Steel and iron	83(e)	n/a	n/a
Missouri(f)	Steel and iron	92	n/a	n/a
Median		81	n/a	n/a

(a) MRI 1985.
(b) U.S. EPA 1994.
(c) South Coast AQMD 1996.
(d) U.S. EPA 1983a.
(e) Based on TSP and $PM_{2.5}$ data presented.
(f) U.S. EPA 1983b.

Frozen or snow-covered road surfaces in winter may further reduce road dust emissions, as evidenced by comparing summer and winter data from the static dust fall station located on the west side of the Smoky River north of the Grande Cache Coal processing plant and the H.R. Milner generating plant areas, just off the Sheep Creek haul road. The average readings for November to April were about 43% lower than for the rest of year (Grande Cache Coal, 2004). Occasionally this proportion was even lower, especially in December and January. For this reason, it was assumed that during winter months road emissions were suppressed by 90% (the result of multiplication of summer emission reduction to 25% by 0.43). According to climatological data from Coleman, periods of snow cover extend from October to April.

Additional dust reduction may be considered by using the approach outlined in Air Control Techniques (1997), which recommended to the U.S. EPA that emissions would be negligible when daily rainfall exceeds 0.25 mm and when roads are covered by snow or ice. The average number of days with measurable precipitation from Coleman was 133 days, which is about 36% of days in the year. To be conservative, precipitation was not considered to reduce annual emissions in this assessment.

A4.8 Summary of Dust Emissions

For the Project case, Maximum Hourly Emission and Maximum Daily Emission scenarios were assessed. The Maximum Hourly Emission Scenario assumed that all Project activities overlap at maximum hourly emission rates. Hourly dust emissions were based on total annual coal production and waste volume, and the number of annual working hours for each activity, while for daily and annual average predictions, emissions were spread over 24 hours and 354 days. To be conservative, precipitation was not considered to reduce annual emissions.

Table A4-3 summarizes maximum hourly and daily fugitive dust emissions generated from Project activities, except wind driven dust emissions. Wind driven emissions are discussed in the following section. Dust emissions from haul roads in winter were modelled as 50% of the values listed Table A4-3. The table indicates that dust emission from wheel entrainment is a major source of particulate matter (PM) emissions. Of these activities, haul road emissions account for about 85% of maximum hourly emissions and 90% of maximum daily emissions.

Table A4-3 Summary of Maximum Hourly and Daily Fugitive Dust Emissions from Project Activities

Compound	Maximum Hourly Emissions (kg/h)			Maximum Daily Emissions (kg/d)		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Coal Mining	0.3	1.6	4.7	5.0	29	83
Waste Removal	1.2	5.1	13.8	21	96	252
Haul Road	15	149	597	256	2,556	10,251
Dump	0.4	1.6	4.7	7.6	32	89
Reclamation	0.2	2.0	5.0	2.6	13	39
Plant	0.2	3.7	9.2	2.7	54	139
Train Load out	0.03	1.0	2.0	0.3	7.6	16
Blasting	1.1	19	37	1.1	19	37
Total	**18**	**183**	**673**	**296**	**2,807**	**10,905**

A4.9 Wind Driven Emissions

For wind driven emissions from active areas of operation (aggregate pits, overburden removal strip, unpaved haul roads, and from stockpiles), the emission factor formula was obtained from Environment Canada Pits and Quarries Guidance (EC 2009).

$$TSP(kg/day/ha) = (1.9)\left(\frac{s}{1.5}\right)\left(\frac{f}{15}\right)$$

$$PM_{10}(kg/day/ha) = 0.5 * TSP$$

$$PM_{2.5}(kg/day/ha) = 0.02 * TSP$$

Where:

s = silt content of the road surface in percentage (%); and,

f = percentage of time that the unobstructed wind speed exceeds 5.36 m/s.

"*f*" was assumed to be 100 (%) for these calculations as wind driven emissions were modelled assuming there is no wind driven emission at wind speeds below 5.36 m/s (19.3 km/h). According to U.S. EPA AP 42, the corresponding threshold velocities for piles ranged from 11 to 27 m/s depending on material and location, measured on a 10-m tower (Table 13.2-5.2 in U.S. EPA 2006b). The current approach is conservative to ensure wind driven model emissions are not under-estimated. Precipitation was not considered as a mitigating factor in this calculation.

It is expected the overburden hauling and remediation area will be crusted or covered by vegetation or snow after overburden stripping is complete. Crusting would occur if the area is not disturbed for a period of time. Any natural crusting of the surface binds the erodible material, thereby reducing the erosion potential (U.S. EPA 2006b). Thus, wind driven emissions were estimated based on the approximate actively disturbed area for each operation.

The total modelled mining and stripping area is 121 ha. About 10% of the total area is assumed to be active for wind driven emission calculations. The total unpaved hauling road is 60 ha and 30% of the area is assumed to be actively disturbed. The area of stockpiles for ROM and clean coal was estimated as 4.5 ha each, with 100% of the surface area of each actively disturbed. Total active areas used for wind driven emission estimation were 35 ha.

Table A4-4 summarizes wind driven emissions from all Project operations on the windiest day, with 24 hours with winds above 5.36 m/s. Even though wind driven emissions at night would be lower due to reduced operations, wind driven emissions from active areas and stock piles were modelled 24 hours each day for 365 days a year, for hourly winds above 5.36 m/s.

Table A4-4 Maximum Wind Driven Daily Emissions on the Windiest Day in Five Years of Meteorological Data

	Dump Area	Coal Mine Area	Waste Strip Area	Reclamation Area	Unpaved Haul Road	Coal Pile	Total
Actively Disturbed Area (ha)	4.3	1.5	4.4	2.0	18	4.7	35
Emissions (kg/24 hour day)							
$PM_{2.5}$	52	11	53	24	44	26	211
PM_{10}	129	29	132	61	110	66	527
TSP	258	57	264	122	220	132	1054

A4.10 Effect of Vegetation Cover

AP-42 emission factors have a tendency to over-predict fugitive dust emissions. The atmospheric dispersion models used for regulatory compliance assessment also lead to over-prediction of air quality impacts of fugitive dust sources, in the "factor of 4" range (Cowherd 2008). Mechanisms that result in near-source plume loss, which are not properly represented in prevalent regulatory dispersion models, include:

- tribocharging of dust particulates in highly turbulent fugitive dust clouds, and resultant particle agglomeration and enhanced deposition on the ground;
- representation of haul trucks as moving points sources rather than continuously emitting volume source in the model; and
- pit trapping of fugitive dust in terrain cavities.

Pace (2005) showed that an area covered by forest (18 to 20 m tall) effectively traps dust; reducing emissions by 80 to 100% (see Table A4-5). The area surrounding the mines, coal processing facility, and many sections of the haul road, are covered by coniferous and deciduous trees, which should mitigate dust emissions beyond those modelled. Studies by Cowherd *et al*. (2003) and Etyemezian *et al*. (2003), on which Pace's estimates of capture fraction were based in part, were conducted for heavy vehicles travelling on dry roads in the south-western U.S. Cowherd *et al*. (2006) showed capture efficiencies were similar for PM_{10} and $PM_{2.5}$.

To account for the mitigating influences of forested vegetation, the Project emissions of particulate could have been reduced by up to a factor of four, the minimum recommended by Pace (2005). However, no vegetative effects were incorporated into current modelling.

Table A4-5 Recommended Capture Fraction (CF) (%) for Five Land Cover Types (from Pace 2005)

Land Cover Type	Average Height (m)	Recommended CF (%)	Estimated CF Range (%)	Comment
Forest	18-20	100%	80 to 100%	Forested areas will capture dust effectively
Urban	5 – 50+	50%	25 to 75%	Structures are interspersed with open areas
Scrub, Sparsely Wooded & Grasses	1 – 2	25%	10 to 40%	Portion of plume is below sparse vegetation
Agricultural	1 - 2	25%	10 to 40%	Portion of plume is below crop (seasonally)
Barren / Water	0	0%	0 to 10%	Impediment-free surfaces are ineffective to capture dust

A4.11 Escape Fraction from Mine Pits

The ISCST3 model includes an algorithm to model open-pit sources, which is a modelling option not currently available to CALPUFF. Modelling mine pits as sunken area sources is an alternative approach designed to more accurately reflect physical reality.

Another way to improve the modelling of open mine pit sources is to incorporate into the model an escape fraction (fraction of particulate escaping from the pit to surroundings) for the emissions of particulate matter to account for the partial retention of particulate emissions in open mine pits.

Details of the derivation of the escape fraction from open pit sources can be found in Reed (2005). According to Cole and Fabrick (1984), the escape fraction from the mine can be calculated based on the gravitational settling velocity, diffusivity and depth of the pit. Escape fractions for $PM_{2.5}$, PM_{10}, and TSP are also based on particulate size distribution and incremental size ranges.

As mine pit and dump areas as well as haul roads of the Project will be located at higher elevations compared to the surrounding receptors and countryside, escape fractions were not used to reduce PM dust emissions for the Project. This approach is conservative.

A4.12 Summary of Emission Reduction Factors

This section summarizes the emission reduction factors assumed in modelling in table form for ease of review. It also identifies other factors that could have been applied, or that have been applied in other coal mine modelling exercises, but were not applied in this assessment.

Table A4-6 Summary of Emission Discount Factors

Emission	Discount Feature	Factor	Report Section	Rationale
Road dust	Road watering effectiveness	80%	A4.7	See references in Section A4.7
	Precipitation	Up to 100% during rainfall events		Not applied
	Snow cover	90%	A4.7	See references in Section A4.7
Rail loadout	Reduction due to partial enclosure	30%	A4.3	See rationale in Section A4.3
Vegetation cover	Inability of models to account for dust collection by vegetation	Typically a factor of 4	A4.10	See references in Section A4.10. Not applied.
Mine fugitive dust	Escape fraction	Range depending on particle size and depth of pit		Not applied

A5 EXHAUST AND BLASTING EMISSIONS

Exhaust emissions of $PM_{2.5}$, PM_{10}, TSP, SO_2, CO, and NO_x are considered. There are two processes leading to these emissions:

- diesel combustion (mine and plant equipment, haul trucks, road maintenance); and
- blasting using ANFO.

The following section outlines the approach taken to estimate emissions generated by diesel combustion and blasting.

A5.1 Diesel Exhaust Emissions of $PM_{2.5}$, PM_{10}, TSP, SO_2, CO, and NO_x

SO_2 emission factors for diesel combustion were taken from EPA AP-42 – Table 3.4-1 (Large Stationary Diesel), (U.S. EPA 1996) and calculated using ultra low sulphur diesel (15 ppm). The SO_2 emission factor is independent of the engine age (Tier) and equipment and is 0.0055 g/hp-h (0.0074 g/kWh), dependent only on the sulphur content in diesel.

The diesel combustion emission factors for NO_x, CO and PM_{10} were taken from the NONROAD Engine Model (U.S. EPA 2010). Particulates emitted by diesel fired equipment are small such that PM_{10} and TSP emissions are equal. $PM_{2.5}$ emissions were assumed to be 97% of PM_{10}. Emission factors are summarized in Table A5-1.

Hourly exhaust emissions of SO_2, NO_x, CO and PM were obtained by the following equation:

$$\text{Emission (g/hr)} = LF * EF * PR * EN$$

Where:

LF	Load Factor (Table A5.1)
EF	Emission Factor (g/hp-h) (Table A5.1)
PR	Engine Power Rating (hp) (Table A3.3)
EN	Number of Engines (Table A3.3)

The load factor reflects that equipment does not always work at full power. According to the NONROAD model, the load factor for most equipment is 0.59 (average emissions are 59% of maximum emissions for maximum equipment load). Shovels and backhoes have a load factor of 0.21; drills and cranes have a load factor of 0.43.

It was assumed that one 4,250 hp locomotive engine will be used to shunt rail cars during loading. Emission factors for a typical locomotive (P42DC) were taken from U.S. EPA (2009) (Table 2 – Switch Emission Factors).

Table A5-1 Exhaust Emission Factors (from Diesel Combustion) of SO_2, NO_x, CO, and PM from all Mine and Plant Equipment (Final Tier 4)

Equipment	Load Factor	Emission Factors (g/hp-h)					
		SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Mine Fleet							
Backhoe (122 t)	0.21	0.0055	0.28	0.34	0.0089	0.0092	0.0092
Waste Backhoe (394 t)	0.21	0.0055	2.39	0.20	0.0268	0.0276	0.0276
Blast Hole Drill	0.43	0.0055	2.39	0.08	0.0268	0.0276	0.0276
Articulated Trucks (37 t) Wheel dozer (49 t) Motor Grader (7.5 m)	0.59	0.0055	0.28	0.13	0.0089	0.0092	0.0092
Bulldozer (391 kw)	0.59	0.0055	0.28	0.20	0.0089	0.0092	0.0092
Wheel Loader (218 t) Haul Truck (220 t) Bulldozer (664 kw) Waste Shovel	0.59	0.0055	2.39	0.12	0.0268	0.0276	0.0276
Train Load-out							
P42DC Locomotive	0.21	0.0055	1.00	1.83	0.015	0.015	0.015
Support Equipment							
Skid steer loader	0.21	0.0055	0.28	0.61	0.0089	0.0092	0.0092
Compactor for new road Rough Terrain Crane (250 t)	0.43	0.0055	0.28	0.08	0.0089	0.0092	0.0092
Lowboy - equipment hauler	0.59	0.0055	2.39	0.12	0.0268	0.0276	0.0276
Crew Vehicle	0.59	0.0055	0.28	0.11	0.0089	0.0092	0.0092
Others	0.59	0.0055	0.28	0.13	0.0089	0.0092	0.0092

A5.2 Gaseous Emissions from Blasting

Table A5-2 summarizes blast areas and ANFO usage used to calculate blasting emissions.

Table A5-2 Details of ANFO for Blasting

	Volume (BCM/year)	Blasts/year	Powder Factor (kg/BCM)	Explosives (t)	ANFO/Blast (t)
Overburden	48,064,000	265	0.65	31,242	118

Emission factors, summarized in Table A5-3 for ANFO containing 5.8-8% fuel oil, were based on the average of emission factors for various ANFO compositions (NPI, 2012). The controlled NOx emission factor ranged from 1.4 kg/t to 3.8 kg/t of ANFO and the CO emission factor ranged from 8 kg/t to 21 kg/t of ANFO. It was assumed that ultra-low sulphur diesel (15 ppm sulphur content) is used in the ANFO mixture.

Particulates are produced as well, but the quantities are expected to be negligible compared to the particulate generated in shattering rock and displacing earth.

Blasting was conservatively modelled each day instead of on the 265 days per year that blasting is expected in Year 19, to ensure worst case meteorological conditions could occur simultaneously with blasting. Blasting was modelled as an elevated volume source with effective height E_h = 25 m, an initial vertical spread of 25 m and an initial horizontal spread of 50 m.

Table A5-3 ANFO Emissions from Blasting

Compound	Emission Factors (kg/t of ANFO)	Emission Factors (kg/blast)
SO_2	0.06	7.1
NO_x	3.34	394
CO	11.8	1394

A5.3 Summary of Exhaust Emissions

Table A5-4 summarizes maximum hourly and daily emissions from Project diesel fuel combustion and blasting. PM_{10} and TSP emissions emitted by diesel fired equipment are equal, and assumed to be 103% of $PM_{2.5}$ emissions. The table indicates that ANFO used in blasting is a major source of SO_2, NO_X, and CO emissions.

Table A5-4 Summary of Maximum Hourly and Daily Emissions from Project Diesel Fuel Combustion and Blasting

Compound	Maximum Hourly Emission (kg/h)				Maximum Daily Emission (kg/d)			
	SO_2	NO_x	CO	$PM_{2.5}$	SO_2	NO_x	CO	$PM_{2.5}$
Coal Mining	0.05	8.6	0.56	0.10	0.8	164	10.2	1.9
Waste Removal	0.15	34	1.89	0.39	2.7	640	34	7.3
Haul Road	0.25	48	3.32	0.58	4.1	846	53	10.0
Dump	0.10	25	1.25	0.28	1.9	483	24	5.4
Reclamation	0.01	0.3	0.19	0.01	0.1	2.4	2.0	0.1
Plant	0.04	10	0.53	0.11	0.7	187	9.5	2.1
Train Load out	0.02	0.89	1.6	0.01	0.2	7.1	13	0.1
Blasting	7.1	394	1394	-	7.1	394	1394	-
Total	**7.7**	**521**	**1403**	**1.5**	**18**	**2724**	**1540**	**27**

A6 EXHAUST EMISSIONS OF VOCS AND PAHS

Emissions of PAHs and VOCs from diesel combustion were calculated using emission factors taken from as AP-42 Table 3.4-1 (Large Stationary Diesel) (U.S. EPA 1996), as about 90% of diesel fuel is consumed by heavy-duty engines (larger than 600 hp).

Tables A6-1 and A6-2 summarize VOC and PAH emission factors and calculated multipliers for diesel combustion. The multiplier for each species was calculated by dividing its AP-42 emission factor by $PM_{2.5}$ emission factor. Combustion $PM_{2.5}$ sources were modelled separately from fugitive sources.

Table A6-1 Summary of VOC Emission Factor and Multipliers (g/g) for Diesel Combustion

Compound	EF Large Engines > 600 hp (lb/MMBtu) [(a)]	Multiplier for Diesel Combustion (g/g of gas $PM_{2.5}$)
$PM_{2.5}$	4.79E-02	1
Benzene	7.76E-04	1.62E-02
Toluene	2.81E-04	5.87E-03
Xylenes	1.93E-04	4.03E-03
Propylene	2.79E-03	5.82E-02
Formaldehyde	7.89E-05	1.65E-03
Acetaldehyde	2.52E-05	5.26E-04
Acrolein	7.88E-06	1.65E-04

[(a)] US EPA (1996)

Table A6-2 Summary of PAH Emission Factor and Multipliers (g/g) for Diesel Combustion $PM_{2.5}$

Compound	EF Large Engines > 600 hp (lb/MMBtu) [(a)]	Multiplier for Diesel Combustion (g/g of gas $PM_{2.5}$)
$PM_{2.5}$	4.79E-02	1
Acenaphthene	4.68E-06	9.77E-05
Acenaphthylene	9.23E-06	1.93E-04
Anthracene	1.23E-06	2.57E-05
Benz(a)anthracene	6.22E-07	1.30E-05
Benzo(a)pyrene	<2.57E-07	5.37E-06
Benzo(b)fluoranthene	1.11E-06	2.32E-05
Benzo(g,h,i)perylene	<5.56E-07	1.16E-05
Benzo(k)fluoranthene	<2.18E-07	4.55E-06
Chrysene	1.53E-06	3.19E-05
Dibenzo(a,h)anthracene	<3.46E-07	7.22E-06
Fluoranthene	4.03E-06	8.41E-05
Fluorene	1.28E-05	2.67E-04

Table A6-2 Summary of PAH Emission Factor and Multipliers (g/g) for Diesel Combustion $PM_{2.5}$

Compound	EF Large Engines > 600 hp (lb/MMBtu) [(a)]	Multiplier for Diesel Combustion (g/g of gas $PM_{2.5}$)
Indo(1,2,3-cd)pyrene	<4.14E-07	8.64E-06
Naphthalene	1.30E-04	2.71E-03
Phenanthrene	4.08E-05	8.52E-04
Pyrene	3.71E-06	7.75E-05

[(a)] US EPA (1996)

Propane will be used to heat the plant and its use is seasonal (no heating is summer). Emissions from propane combustion were assumed to be negligible compared to other sources (*e.g.*, Coalspur 2012).

A7 EMISSIONS OF METALS

There are two processes leading to metal emissions from Grassy Mountain Coal Mine operations:

- diesel combustion (mine and plant equipment, hauling trucks, road maintenance); and
- metals in overburden, rock, and coal re-suspended as a part of TSP.

Metal emission factors for diesel combustion were based on Health Effects Institute (HEI) (2006). For metals for which HEI factors were not available, only non-combustion emission sources were modelled.

The main source of TSP emissions is material hauling, through wheel entrainment. Metal content in soil and overburden was measured for the Project. Further details about soil sample measurements are provided in the soil assessment included in this EIA.

Table A7-1 summarizes metal emission multipliers in g/g for $PM_{2.5}$ emissions from diesel combustion and TSP emissions from soil and overburden fugitive emissions.

Table A7-1 Summary of Metal Emission Multipliers (g/g) for Diesel Combustion $PM_{2.5}$ and Soil TSP Emissions

Compound	Multiplier for Diesel Combustion (g/g of $PM_{2.5}$)	Multiplier for Soil Emissions (g/g of TSP)
Aluminum	4.17E-04	n/a
Antimony	1.90E-07	9.45E-07
Arsenic	5.65E-04	5.26E-06
Barium	6.58E-06	2.61E-04
Beryllium	n/a	1.00E-06
Cadmium	1.54E-05	1.30E-06
Chromium	1.23E-04	5.91E-06
Cobalt	n/a	7.08E-06
Copper	3.21E-04	2.51E-05
Lead	1.37E-04	1.10E-05
Manganese	7.43E-05	n/a
Mercury	n/a	1.39E-07
Molybdenum	0.00E+00	1.59E-06
Nickel	n/a	2.46E-05
Selenium	n/a	1.21E-06
Thallium	n/a	5.00E-07
Uranium	0.00E+00	2.00E-06
Vanadium	4.28E-04	2.32E-05
Zinc	2.97E-03	1.29E-04

A8 EMISSIONS OF GREENHOUSE GASES

A8.1 Sources of GHG

Direct project emissions for GHG come from the following main sources:

- fugitive emissions of coal bed methane; and
- diesel combustion in the mine fleet and haul vehicles.

There is also some propane combustion for space heating but the contribution of this component to the total GHG emissions from the Project is negligible. As such, only the two primary direct GHG sources described were included, as well as indirect GHG emissions from electricity purchases.

A8.2 GHG Emissions Estimation

Greenhouse gas emissions are expressed in carbon dioxide equivalents (CO_2e). The global warming potential factors used in estimating GHG emissions are 1 for CO_2, 21 for CH_4, and 310 for N_2O emissions, based on a 100-year time horizon (U.S. EPA 2005).

Total equivalent CO_2 emissions were calculated using the following formula:

$$CO_2e = CO_2 + 310(N_2O) + 21(CH_4)$$

Fugitive methane emissions from surface coal mining were estimated using emission factors provided by the Intergovernmental Panel on Climate Change (IPCC 2006). The IPCC provides a range of emission factors that depend on the overburden depth of the mine. In the absence of overburden information, or country-specific emission factors, the IPCC considers it good practice to use the average emission factors of 1.2 m^3 CH_4 /t coal production for surface mining and 0.1 m^3 CH_4 /t coal production for post-mining (for an overall emission factor of 1.3 m^3/t).

Using the IPCC recommended methane density of 0.67×10^{-6} kg/m^3; the resulting emission factor is calculated to be 0.87 t CH_4/ kt of coal production. The estimated GHG emissions from fugitive methane are 70 kt CO_{2e} per year for Year 19 based on 3,840 kt annual coal production.

GHG emissions from diesel-fuelled vehicles and equipment were based on the annual average fuel consumption and Environmental Canada (2011) emission factors. The amount of diesel fuel consumed in Year 19 was 63,675,000 L, based on engineering estimates provided by Benga. Environment Canada GHG emission factors used for combustion sources are summarized in Table A8-1.

Table A8-1 GHG Emission Factors for Diesel Combustion

Compound	Diesel Engines ≤ 600 hp[a] (kg/1000 l)	Diesel and Gasoline Engines > 600 hp[a] (kg/1000 l)
CH_4	0.068	0.14
N_2O	0.21	0.082
CO_2	2,663	2,663

[a] Environment Canada (2011)

The GHG emissions associated with electricity consumption are based on the electricity generation intensity for Alberta of 930 g CO_2e/kWh (EC 2015). The estimated electricity consumption for Year 19 will be 129,145,600 kWh.

A summary of direct annual GHG emissions for the Project from both fugitive and combustion sources as well as electricity consumption is shown in Table A8-2. Sample calculations using these emission factors are shown in following section.

Table A8-2 Project Total GHG Emissions in Year 19 and Over the Life of Project

Source	GHG Emissions in Year 19 (kt CO_2e)	Lifetime GHG Emissions (kt CO_2e)
Fugitive Methane	70	1,692
Diesel Combustion	172	4,139
Electricity Consumption	120	2,896
Total	**362**	**8,727**

The maximum equivalent CO_2 emissions from the Project were estimated to be 362 kt in Year 19. According to Environment Canada (2015), total national GHG emissions were 726 Mt in 2013 and Alberta's share was 36.8% or 267 Mt. Therefore, GHG emissions of the Project in Year 19 will be approximately 0.14% of 2013 Alberta GHG emissions and 0.05% of national emissions.

The total coal production over the life of the Project will be approximately 92.6 Mt. The total GHG emission over the life of the Project will be 8,727 kt, scaled from annual GHG emissions in Year 19, based on total coal production.

A8.2 Sample Calculations of GHG Emissions

A sample calculation for fugitive GHG emissions from surface mining is shown below. The estimated annual coal production for the Project year 19 is 3,840 kt/a.

CH_4 emissions = (0.87 t CH_4/kt coal produced x 3,840 kt/year coal produced)
= 3,340 t/year

CO_2e emissions = 3,340 t CH_4/year x 21
= 70,152 t CO_2e/year
= 70 kt CO_2e/year

A sample calculation for the largest component of GHG emissions from diesel combustion is shown below. Emission factors, as listed in Table A8-1, were used. The annual diesel fuel consumption for activities performed at the mine operations has been estimated to be 63,675,000 L. About 90% of the diesel fuel for the mine operations will be consumed by trucks and equipment with engines larger than 600 hp.

For large engines (larger than 600 hp):

CH_4 emissions = 0.140 g/L x 63,675,000L /year x 0.9 ÷ 354 days/year = 22.7 kg/d
N_2O emissions = 0.082 g/L x 63,675,000L /year x 0.9 ÷ 354 days/year = 13.3 kg/d
CO_2 emissions = 2663 g/L x 63,675,000L /year x 0.9 ÷ 354 days/year = 431,103 kg/d

For small engines (smaller than 600 hp):

CH_4 emissions = 0.068 g/L x 63,675,000L /year x 0.1 ÷ 354 days/year = 1.22 kg/d
N_2O emissions = 0.210 g/L x 63,675,000L /year x 0.1 ÷ 354 days/year = 3.8 kg/d
CO_2 emissions = 2663 g/L x 63,675,000L /year x 0.1 ÷ 354 days/year = 47,900 kg/d

Therefore, total GHG emissions from the mine operations are as follows:

CH_4 emissions = 22.7 kg/d + 1.22 kg/d = 23.9 kg/d
N_2O emissions = 13.3 kg/d + 3.8 kg/d = 17.1 kg/d
CO_2 emissions = 431,103 kg/d + 47,900 kg/d = 479,003 kg/d
CO_2e emissions = (23.9 kg CH_4/d x 21) + (17.1 kg N_2O/d x 310) + (479,003 kg CO_2/d x 1)
= 484,791 kg/d
= 172 kt CO_2e/year

A9 REGIONAL EMISSIONS

A9.1 Regional Industrial Emissions

All approved and existing industrial facilities within RSA were considered for modelling. The only facility located within the RSA is the Devon Canada Coleman sour gas plant. According to information obtained from 2012 NPRI data (NPRI 2014), the gas plant ceased operations permanently in 2012 and as such was not included in modelling. In addition, there are four small batteries and compressor stations in the RSA. As these have comparatively low emissions, their contribution to air quality in the RSA was taken into account through background ambient concentrations, which are given in Appendix C.

A9.2 Public Road Emissions

A9.2.1 Traffic Exhaust Emissions

The emission factors for traffic exhaust from Highway 3 due to all vehicles are listed in Table A9-1. The emission factor model MOBILE6.2C, which is the Canadian version of the U.S. EPA model (Environment Canada 2004; U.S. EPA 2003), was used to calculate vehicle exhaust emissions of SO_2, CO, and NO_X, as well as particulate matter emissions from vehicle exhaust, brake wear and tire wear. Sulphur content in gasoline and diesel fuel was assumed to meet ultra-low standards. The sulphur content was assumed to be 25 ppm for gasoline and 15 ppm for diesel.

The MOBILE6.2C model was also used to calculate average road emissions for two months: January and July. The difference in emission factors between the summer and winter season is related to the difference in the average vehicle speed (seasonal driving conditions) and the seasonal differences in ambient temperatures.

The average vehicle weight (8 t) assumed 70% of the vehicles on Highway 3 are passenger cars (LDGV in MOBILE6; average weight of 1.5 tonnes), 3% are buses (HDDBT) and RVs (HDGV7 - average weight of 13 t); 15% are single unit trucks (HDDV8A - 21 tonnes) and 12% are tractor trailer units (HDDV8B - 30 t).

Table A9-1 Fleet-average Highway Exhaust Emission Factors from MOBILE E6.2C

	Emission Factor (g/VMT)			Emission Factor (g/VKT)
	Summer	Winter	Average	
$PM_{2.5}$	0.109	0.118	0.114	0.071
SO_2	0.009	0.009	0.009	0.005
CO	13.7	24.8	19.2	12.0
NO_X	5.6	5.8	5.7	3.53

VMT: Vehicle Miles Travelled VKT: Vehicle Kilometres Travelled

The emissions for each highway segment were calculated from the annual average daily traffic (AADT) from 2013 that were obtained from the Alberta Ministry of Transportation (2013, Internet site) and from the length of the individual road segments as follows. Table A9-2 lists modelled highway exhaust emissions for the Baseline scenario.

The highway emission sources were area sources with an effective release height of 2.5 m and initial dispersion sigma z of 2.5 m.

The assumptions of engine emissions for public roads are expected to be conservative, as more fuel efficient vehicles are expected in the future.

Table A9-2 Modelled Highway 3 Exhaust Emissions (kg/d) for the Baseline Scenario

Highway Segment	AADT	Length (km)	AADT × Length	Emission Rate (kg/d)			
				SO_2	NO_X	CO	$PM_{2.5}$
Section West of Coleman	4,520	4.7	21,054	0.11	74.4	252	1.5
Coleman Section West of Highway 40 at Crowsnest Pass	8,200	2.9	23,389	0.13	82.7	280	1.7
Section East of Highway 40 to Blairmore 107 St	9,240	2.9	26,365	0.14	93.2	315	1.9
Section of Blairmore 107 St to 20 Ave	7,810	2.7	20,925	0.11	73.9	250	1.5
Section Blairmore 20 Ave to Frank	9,640	2.0	18,905	0.10	66.8	226	1.3
Section East of Frank	7,870	5.8	45,392	0.24	160.4	543	3.2
Total	47,280	20.8	156,030	**0.84**	**551**	**1865**	**11**

NOTE: AADT is the Average Annual Daily Traffic (2013).

A9.2.2 Fugitive PM Emissions from Road Dust

Transportation emissions, caused by wheel entrainment on paved Highway 3, are based on equations taken from AP 42, Table 13.2.1-1 (U.S. EPA 2011):

$$PM_{2.5}\left(\frac{kg}{vkt}\right) = \frac{0.15}{3.23} * TSP$$

$$PM_{10}\left(\frac{kg}{vkt}\right) = \frac{0.62}{3.23} * TSP$$

$$TSP\left(\frac{kg}{VKT}\right) = 3.23 * (sL)^{0.91}(W)^{1.02}$$

Where:

sL = silt loading of the paved road surface (g/m^2); and,

W = average weight (in short tons) of the vehicle fleet on the road.

The silt loading parameter of 0.9% was the average of the recommended default winter and summer values for roads for AADT categories between 5,000 to 10,000 AADT (Table 13.2.1-2 in AP-42; U.S. EPA 2011). The average weight of the vehicle fleet on the road was assumed to be 8 short tons (7.3 t).

Calculated emission factors from road dust were: TSP 3.01 g/VKT; PM_{10} 0.58 g/VKT; and $PM_{2.5}$ 0.14 g/VKT.

Table A9-3 lists modelled highway fugitive dust emissions for the Baseline scenario. The dust suppression factor was assumed to 90% in winter due to the presence of frozen ground or snow on the ground.

Table A9-3 Modelled Highway 3 Fugitive Dust Emissions (kg/d) for the Baseline Scenario

Highway Segment	AADT	Length (km)	AADT × Length	Emission Rate (kg/d)		
				$PM_{2.5}$	PM_{10}	TSP
Section West of Coleman	4,520	4.7	21,054	2.9	12.2	63.4
Coleman Section West of Highway 40 at Crowsnest Pass	8,200	2.9	23,389	3.3	13.5	70.4
Section East of Highway 40 to Blairmore 107 St	9,240	2.9	26,365	3.7	15.2	79.4
Section of Blairmore 107 St to 20 Ave	7,810	2.7	20,925	2.9	12.1	63.0
Section Blairmore 20 Ave to Frank	9,640	2.0	18,905	2.6	10.9	56.9
Section East of Frank	7,870	5.8	45,392	6.3	26.2	136.7
Total	47,280	20.8	156,030	**21.8**	**90.2**	**469.8**

NOTE: AADT is the Average Annual Daily Traffic (2013).

A9.3 Community Emissions

A9.3.1 Exhaust Emissions

Annual heating and mobile source emissions for Alberta obtained from the NPRI are summarized in Table A9-4 for 2010. Heating emissions are comprised of commercial and residential fuel combustion emissions.

Based on Cheminfo (2007) which examined Alberta emissions on a regional basis, approximately 1% of the total emissions in Alberta were assumed to occur in census Division No. 15. Individual community emissions were assigned based on population; 2011 census data showed the total population was 35,983 for Division No. 15 and 5,665 for Crowsnest Pass Sub-Division (Government of Alberta, 2014).

Table A9-4 Annual NPRI Heating and Mobile Source Emissions (t) for Alberta and Division No. 15, 2010

Sectors	Year 2010					
	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Commercial Fuel Combustion	1,488	4,914	3,911	471	520	554
Residential Fuel Combustion	425	7,367	3,456	743	863	1,305
Residential Fuel Wood Combustion	45	312	20,809	3,369	3,380	3,551
Total Heating Emissions in Alberta	**1,957**	**12,593**	**28,176**	**4,583**	**4,763**	**5,410**
Heavy-duty gasoline trucks	23	4,619	22,058	57	67	69
Light-duty diesel trucks	15	1,163	1,011	87	94	94
Light-duty diesel vehicles	1	71	102	6	7	7
Light-duty gasoline trucks	120	17,558	357,907	92	112	116
Light-duty gasoline vehicles	64	9,735	216,814	45	49	51
Motorcycles	1	204	3,167	3	4	4
Total Traffic Emissions in Alberta	**223**	**33,351**	**601,058**	**289**	**333**	**340**
Total Community Emissions in Division No. 15	**22**	**459**	**6,292**	**49**	**51**	**57**

Four communities of Crowsnest Pass Sub-Division within the RSA were modelled for the Baseline scenario (Table A9-5). Emissions from smaller communities, populaces, and individual dwellings were taken into account through the use of background ambient concentrations, described in

Appendix C. The community emission sources were modelled as area sources with an effective release height of 3 m and initial dispersion sigma z of 5 m. Emissions per capita are expected to be lower in Crowsnest Pass Sub-Division as it has fewer commercial and industrial facilities.

Table A9-5 Modelled Exhaust Emissions from Four Communities in the Crowsnest Pass

		Blairmore	Coleman	Bellevue	Frank	Total
Location (NAD83/UTM zone 11N)	UTM E (m)	684,743	680,286	690,390	687,291	
	UTM N (m)	5,498,200	5,501,077	5,495,357	5,497,697	
Elevation (m)		1,295	1,320	1,290	1,293	
Population in 2011*		2,021	1,031	777	255	
Area (km^2)		2.37	2.66	1.39	0.36	
Daily Emission (kg/d)						
SO_2		3.4	1.7	1.3	0.4	**6.8**
NO_X		70.7	36.1	27.2	8.9	**143**
CO		968	494	372	122	**1,956**
$PM_{2.5}$		7.5	3.8	2.9	0.9	**15**
PM_{10}		7.8	4.0	3.0	1.0	**16**
TSP		8.8	4.5	3.4	1.1	**18**

*Scaled from 2006 Census data for each individual community

A9.3.2 Fugitive PM Emissions from Road Dust

Transportation emissions, caused by wheel entrainment on paved roads inside communities, were calculated based on equations listed in Section A9.2.2 and the approximate mapped road lengths. Table A9-6 lists modelled summer fugitive dust emissions within communities for the Baseline scenario. Winter emissions were modelled as 10% of the values listed Table A9-6.

Table A9-6	**Modelled Baseline Fugitive Dust Emissions from Four Communities in the Crowsnest Pass**					
		Blairmore	**Coleman**	**Bellevue**	**Frank**	**Total**
Location (NAD83/UTM zone 11N)	UTM E (m)	684,743	680,286	690,390	687,291	
	UTM N (m)	5,498,200	5,501,077	5,495,357	5,497,697	
Elevation (m)		1,295	1,320	1,290	1,293	
AADT 2103*		9,240	8,200	7,870	9,640	
Estimated Road Length (km)		14.5	14.4	8.7	3.2	
Daily Emission (kg/d)						
$PM_{2.5}$		18.7	16.5	9.6	4.3	**49**
PM_{10}		77.4	68.2	39.6	17.8	**203**
TSP		403	356	206	92.9	**1,058**

*obtained from the Alberta Ministry of Transportation (2013, Internet site)

A10 SUMMARY OF PROJECT AND REGIONAL EMISSIONS

The air quality impact assessment included the following sources, by assessment Case:

Baseline Case:

- Highway 3 – paved road from Coleman to Bellevue (only segments located within the RSA were included in the assessment); and
- communities – four communities of Crowsnest Pass Sub-Division within the RSA: Coleman, Blairmore, Frank, and Bellevue.

Project-Only Case in Year 19:

- Two Drilling Areas – drilling and blasting overburden and rock;
- Two Coal Mining Areas – bulldozing and loading coal;
- Three Waste Removal Areas – bulldozing, and loading overburden;
- Two Waste Dump Areas – unloading and bulldozing overburden;
- Three Overburden Hauling Roads – Hauling overburden from waste removal area to dump area;
- Two Coal Hauling Roads – Hauling raw coal from coal mining area to Plant;
- One Reclamation Area – loading topsoil from pile, unloading and bulldozing topsoil at reclamation area;
- Plant Area – loading and unloading at raw coal pile, conveyor unloading and bulldozing at the clean coal pile;
- Train Loadout – unloading clean coal from conveyor onto train rail cars; and
- All open activity areas – wind driven emissions from the storage piles, mining and strip area, and haul roads.

For the Project case, Maximum Hourly Emission and Maximum Daily Emission scenarios were assessed.

Application Case for Year 19:

- baseline + Project-Only Case for Year 19.

Planned Development Case (PDC):

- Identical to the Application Case, because no planned industrial developments were identified, and community and traffic emissions were assumed to be approximately unchanged.

The emissions of SO_2, NO_x, CO, $PM_{2.5}$, PM_{10}, and TSP in the three emission cases are summarized in Table A10-1, except wind driven dust emissions. VOC, PAH, and trace metals emissions are presented in Table A10-2 to Table A10-4.

From the tables, the following observations are relevant:

- Hourly emissions of SO_2, NOx and CO from Baseline highway and communities were 4%, 6%, and 11%, respectively, of Project Maximum Hourly emissions.
- Daily emissions of TSP, PM_{10}, and $PM_{2.5}$ from Baseline highway and communities were 14%, 11%, and 30%, respectively, of Project Maximum Daily emissions.
- Baseline emissions of VOCs and PAHs were of similar magnitude to emissions associated with the Project.
- Dust-generated emissions from Project haul roads are the biggest source of most metals, except for aluminum and manganese, which are the only two metal species without on-site soil measurements. Hourly and daily emissions of most metals associated with the Project are 8 to 13 times higher than metal emissions from Baseline sources.

Table A10-1 Summary of Project and Regional Criteria Air Contaminant Emissions

Sources	Emission Rate					
	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Baseline Case						
Highway 3 Emission (kg/d)	0.84	551	1,865	33	102	481
Community Emission (kg/d)	6.8	143	1,956	64	219	1,076
Total	7.6	694	3,821	97	320	1,557
Project-only Case						
Maximum Hourly Emission (kg/h)	7.7	521	1,403	20	185	675
Maximum Daily Emission (kg/d)	18	2,724	1,540	323	2,834	10,933
Application/PDC Case						
Maximum Hourly Emission (kg/h)	8.0	550	1,562	24	198	740
Maximum Daily Emission (kg/d)	25	3,418	5,361	420	3,155	12,490

Table A10-2 Summary of Project and Regional VOC Emissions

Pollutant	Baseline Case	Project-only Case		Application/PDC Case	
	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)	Maximum Daily Emission (kg/d)
Benzene	423	24	435	42	858
Toluene	153	8.7	158	15	311
Xylenes	105	6.0	108	10	213
Propylene	1,520	87	1,565	150	3,085
Formaldehyde	43	2.5	44	4.2	87
Acetaldehyde	14	0.8	14	1.4	28
Acrolein	4.3	0.2	4.4	0.4	8.7

Table A10-3 Summary of Project and Regional PAH Emissions					
Pollutant	Baseline Case	Project-only Case		Application/PDC Case	
	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)	Maximum Daily Emission (kg/d)	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)
Acenaphthene	2.6	0.15	2.6	0.25	5.2
Acenaphthylene	5.0	0.29	5.2	0.50	10.2
Anthracene	0.67	0.04	0.69	0.07	1.4
Benz(a)anthracene	0.34	0.02	0.35	0.03	0.69
Benzo(a)pyrene	0.14	0.01	0.14	0.01	0.28
Benzo(b)fluoranthene	0.60	0.03	0.62	0.06	1.2
Benzo(g,h,l)perylene	0.30	0.02	0.31	0.03	0.61
Benzo(k)fluoranthene	0.12	0.01	0.12	0.01	0.24
Chrysene	0.83	0.05	0.86	0.08	1.7
Dibenz(a,h)anthracene	0.19	0.01	0.19	0.02	0.38
Fluoranthene	2.2	0.13	2.3	0.22	4.5
Fluorene	7.0	0.40	7.2	0.69	14
Indeno(1,2,3-cd)pyrene	0.2	0.01	0.2	0.02	0.5
Naphthalene	71	4.0	73	7.0	144
Phenanthrene	22	1.3	23	2.2	45
Pyrene	2.0	0.12	2.1	0.20	4.1

Table A10-4 Summary of Project and Regional Metal Emissions

Pollutant	Baseline Case	Project-only Case		Application/PDC Case	
	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)	Maximum Daily Emission (kg/d)	Maximum Daily Emission (kg/d)	Maximum Hourly Emission (kg/h)
Aluminum	11	0.6	11	1.1	22
Antimony	1.4	0.6	10	0.7	12
Arsenic	23	4.4	73	5.3	95
Barium	399	176	2,846	192	3,245
Beryllium	1.5	0.7	11	0.7	12
Cadmium	2.4	0.9	15	1.0	17
Chromium	12	4.2	68	4.7	80
Cobalt	11	4.8	77	5.2	88
Copper	47	17	282	19	329
Lead	20	7.6	124	8.5	144
Manganese	1.9	0.1	2.0	0.2	3.9
Mercury	0.2	0.1	1.5	0.1	1.7
Molybdenum	2.4	1.1	17	1.2	20
Nickel	38	17	268	18	306
Selenium	1.8	0.8	13	0.9	15
Thallium	0.8	0.3	5.5	0.4	6.2
Uranium	3.1	1.3	22	1.5	25
Vanadium	47	16	265	18	311
Zinc	275	91	1,487	103	1,761

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APPENDIX B: AIR QUALITY MODEL SETTINGS

Table of Contents

List of Tables

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B1 INTRODUCTION

CALMET and CALPUFF models, versions 6.334 and 6.42, respectively, were used for the air quality assessment. Both of the models are described in detail by Exponent (Exponent, 2011) and are recommended by Alberta Environment and Parks (AEP) for regulatory air quality assessments (AESRD 2013).

The purpose of this appendix is to present the technical information associated with the air dispersion modeling that was completed for the Grassy Mountain Coal Project (the Project).

B2 MODELLING DOMAIN, REGIONAL AND LOCAL STUDY AREAS

Various regions for the air quality assessment were defined as follows:

- The region over which the air quality predictions were applied is defined as the **modelling domain**. Within the modelling domain, the emission sources were quantified and used in the air quality predictions.
- The region over which the graphical results of the air quality modelling were presented and over which air effects were evaluated is the **regional study area** (RSA).
- The **local study area** (LSA) was located in the immediate vicinity of the Project, and within which the majority of Project air quality effects occurred.

Factors that influence the size and location of the air quality study areas include:

- emission source location and strength;
- potentially sensitive receptor locations; and
- terrain and distance scales associated with air quality processes.

For the Project, maximum concentrations from most sources are expected to occur adjacent to the main emission sources and decrease with increasing distance beyond this point, because emissions occur at or near ground level from mining activities. The exception is O_3, a secondary product of combustion that may have maximum concentrations tens of kilometres from the source.

The modelling domain, RSA and LSA are shown on Figure B2-1. The UTM coordinates of the northeast (NE) and southwest (SW) corner are listed in Table B2-1. The sizes and locations of the study areas were based on several factors and meet the requirements of AEP model guideline (AESRD 2013). In particular, the RSA (30 km x 35 km) encompassed all project sources and concentrations from these sources reduced to 10% or less of maximum values at the RSA boundary. All identified, regional sources within the RSA were included in the assessment.

Table B2-1 Modelling Domain, Regional and Local Study Areas

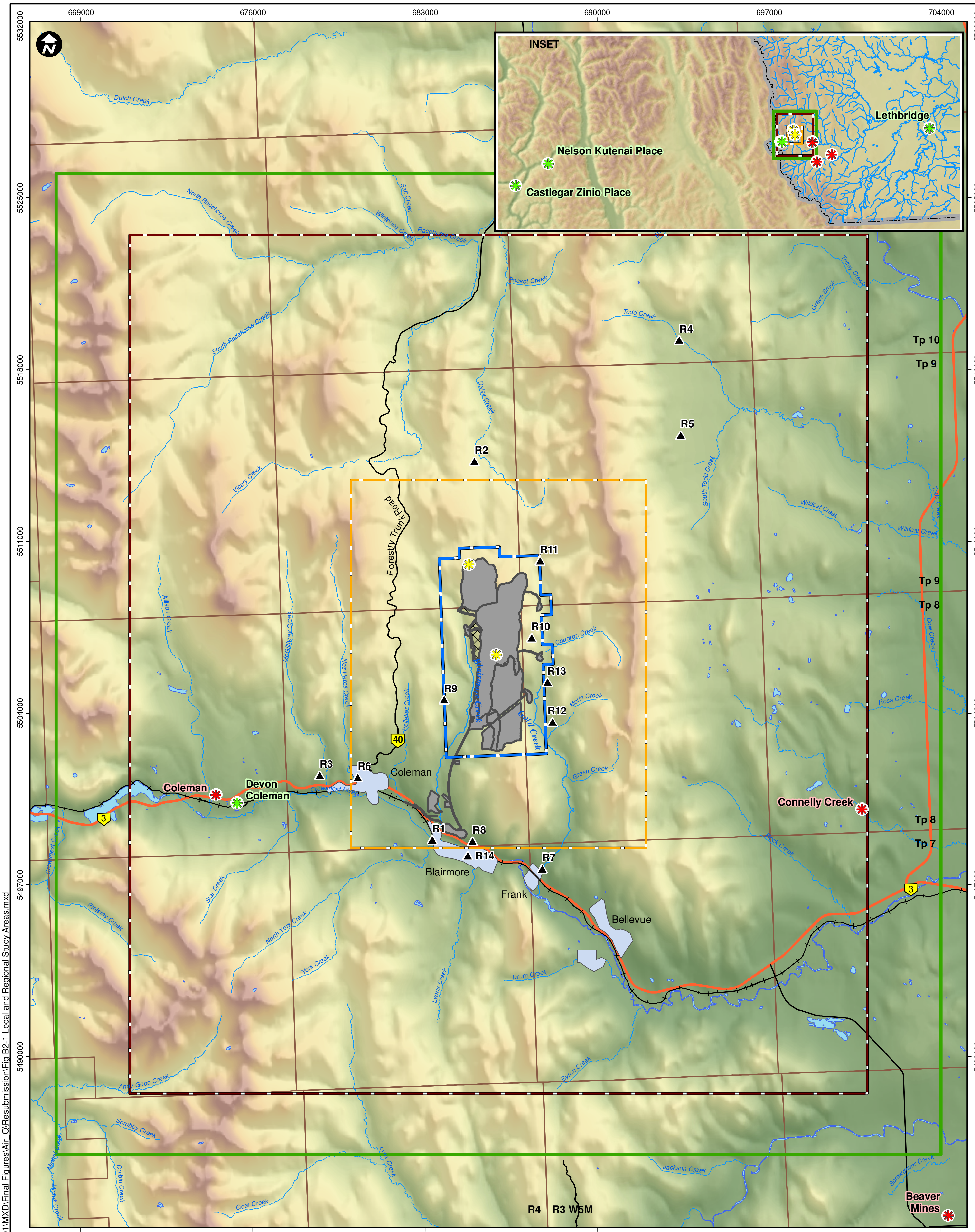
Domain	Corner	UTM Coordinates (NAD83/UTM zone 11N)	
		UTM E (m)	UTM N (m)
CALMET Modelling Domain (36 km x 40 km)	NE	704,000	5,526,000
	SW	668,000	5,486,000
RSA (30 km x 35 km)	NE	701,000	5,523,500
	SW	671,000	5,488,500
LSA (12 km x 15 km)	NE	692,000	5,513,500
	SW	680,000	5,498,500

B3 CALMET MODEL OPTIONS

AEP guidelines were followed for all model switches as defined in the *Air Quality Model Guideline* (AESRD, 2013). This section defines variables relevant to computational methods of CALMET that are not defined by AEP Guidelines. For all model switches not covered by the AEP guideline and not defined below, CALMET model defaults were used. Model switches with more than one allowable option according to the AEP guideline are also defined here.

B3.1 Grid Setting

The base CALMET computational grid was 36 km west to east and 40 km north to south. Horizontal grid cells 2 km × 2 km were adopted for the modelling (Grid A). A second CALMET grid with 0.5 km × 0.5 km horizontal grid spacing was nested (Grid B) to provide greater resolution near the Project in the LSA. The nested area was 12 km × 15 km. Most CALMET settings were kept constant between the two grids.



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig B2-1 Local and Regional Study Areas.mxd

LEGEND

- ▲ Special Receptor
- AQ Monitoring Station
- EC Meteorological Station
- Focus Monitoring Stations
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area
- Model Domain

Topography (masl)

High : 2500

Low : 1300

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

LOCAL AND REGIONAL STUDY AREAS

NOTES

AltaLIS, 2016; GeoBase, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE

B2-1

Table B3-1 Map Projection and Grid Control Parameters (Input Group 2)

Parameter	Default	Coarse Grid A	Fine Grid B	Description
IUTMZN	-	11	11	UTM Zone (1 to 60)
DATUM	WGS-84	NAR-B	NAR-B	NIMA Datum Region - Canada
NX	-	18	24	Number of X grid cells in meteorological grid
NY	-	20	30	Number of Y grid cells in meteorological grid
DGRIDKM	-	2.0	0.5	Grid spacing (km)
XORIGKM	-	668.0	680.0	Reference X coordinate for SW corner of grid cell (1,1) of meteorological grid (km)
YORIGKM	-	5,486.0	5,498.5	Reference Y coordinate for SW corner of grid cell (1,1) of meteorological grid (km)

B3.2 Wind Field Options (Input Group 5)

Within the CALMET model, there are a number of options for calculating the modelling domain wind field. Similarity theory is used to extrapolate surface winds to upper layers.

The maximum overland radius of influence for the surface layer and for upper layers is 24 km. This was calculated as twice the resolution of the AEP provided meteorological dataset. The radius of influence is set to 5 km for terrain features (TERRAD). The relative weighting of the first guess field and observations is 6 km; half the resolution of the AEP provided meteorological dataset.

B3.3 Meteorological Data Options (Input Group 4 and 6)

The radius of influence for temperature interpolation is 24 km; twice the resolution of the AEP provided meteorological dataset.

The following identifies and provides rationale for the use of non-default model parameters:

- IPROG = 14: MM5 data were used.
- IEXTRP = 4; similarity theory was used in the project as surface stations are used.
- ICLOUD = 4; gridded cloud cover from prognostic relative humidity at all levels. This option was used as MM5 data was employed and the surface station does not provide cloud cover data.
- NOOBS = 1; surface stations were included in Grid A and Grid B.

- ITPROG = 1; surface stations data were used, while MM5/3D.DAT is employed for upper air data.
- NSSTA = 1; one surface stations were included.
- NPSTA = 1; MM5 precipitation data was used.
- JWAT1/JWAT2 = 999; temperature interpolation over water was disabled as it was not needed for this assessment.

B3.4 Surface Meteorology

Surface meteorology from one climate station, Crowsnest Pass, was used by the CALMET model.

Table B3-2 Surface Meteorological Station Parameters

Name	UTM Coordinates (NAD83/UTM zone 11N)		Time Zone	Anemometer Height (m)
	UTM E (m)	UTM E (m)		
Crowsnest Pass	681,973	5500,543	7	10

B3.5 Fifth Generation NCAR/Penn State Mesoscale Model (MM5)

The fifth generation NCAR/Penn State Mesoscale Model (MM5) was developed jointly by the National Center for Atmospheric Research (NCAR) and Pennsylvania State University (PSU). It is a prognostic model that computes horizontal and vertical velocity components, pressure, temperature, relative humidity and vapour, cloud, rain, snow, ice, and graupel mixing ratios. The MM5 dataset used for this assessment is the AEP-provided meteorological dataset.

B3.6 Geophysical Parameters

B3.6.1 Land Use

To determine meteorological parameters in the boundary layer, the CALMET model requires a physical description of the ground surface. The geophysical parameters for this assessment include land use category, terrain elevation, roughness length, albedo, Bowen ratio, surface heat flux parameter, anthropogenic heat flux and leaf area index (LAI). Values for all land use parameters except land use category and elevation were determined for the following periods:

- Winter – January 1 to March 31 and November 15 to December 31;
- Spring – April 1 to June 14;
- Summer – June 15 to August 31; and

- Fall – September 1 to November 14.

The geophysical parameters for all periods are summarized in Table B3-3 below.

Table B3-3 Surface Variables Associated with Land Use Characteristics

Land Use Categories		Geophysical Parameters					
CALMET (USGS Land Use Classification System)	**GeoBase (NRCAN)**	**Surface Roughness Length (m)**	**Albedo**	**Bowen Ratio**	**Heat Flux [a] (W/m^2)**	**Anthropogenic Heat Flux [a] (W/m^2)**	**Leaf Area Index [a]**
WINTER							
10 – Urban or Build-Up Land	34 - Developed	1.00	0.35	1.50	0.25	30.0	0.20
20 – Agricultural Land - Unirrigated	52 – Shrub Low 121 – Agriculture Annual Cropland	0.01	0.60	1.50	0.15	0.0	0.50
30 - Rangeland	100 – Herb 110 – Grassland 122 – Agriculture Pasture/Forage	0.001	0.60	1.50	0.15	0.0	0.20
41 – Deciduous Forest Land	51 – Shrub Tall 221 – Broadleaf dense 222 – Broadleaf Open 223 – Broadleaf Sparse	0.50	0.50	1.50	0.15	0.0	0.50
42 – Evergreen Forest Land	211 – Coniferous Dense 212 - Coniferous Dense 213 – Coniferous Sparse	1.30	0.35	1.50	0.15	0.0	4.00
43 – Mixed Forest Land	231 – Mixedwood Dense 232 – Mixedwood Open 233 – Mixedwood Sparse	0.90[a]	0.43[a]	1.50[a]	0.15	0.0	2.30
50 - Water	20 - Water	0.0001	0.20	1.50	1.00	0.0	0.00
61 – Forested Wetland	81 – Wetland-Treed 82 – Wetland – Shrub 11 – Cloud 12 - Shadow	0.90[a]	0.43[a]	1.50[a]	0.15	0.0	1.2
62 – Non-forested Wetland	83 – Wetland - Herb	0.05	0.30	1.50	0.15	0.0	0.2

Table B3-3 Surface Variables Associated with Land Use Characteristics

Land Use Categories		Geophysical Parameters					
CALMET (USGS Land Use Classification System)	**GeoBase (NRCAN)**	**Surface Roughness Length (m)**	**Albedo**	**Bowen Ratio**	**Heat Flux [a] (W/m²)**	**Anthropogenic Heat Flux [a] (W/m²)**	**Leaf Area Index [a]**
70 – Barren Land	32 – Rock/Rubble 33 – Exposed/Barren Land	0.05[a]	0.45[a]	1.50[a]	0.15	0.0	0.00
SPRING							
10 – Urban or Build-Up Land	34 - Developed	1.00	0.14	1.00	0.25	15.0	0.20
20 – Agricultural Land - Unirrigated	52 – Shrub Low 121 – Agriculture Annual Cropland	0.03	0.14	0.30	0.15	0.0	1.00
30 - Rangeland	100 – Herb 110 – Grassland 122 – Agriculture Pasture/Forage	0.05	0.18	0.40	0.15	0.0	0.30
41 – Deciduous Forest Land	51 – Shrub Tall 221 – Broadleaf dense 222 – Broadleaf Open 223 – Broadleaf Sparse	1.00	0.12	0.70	0.15	0.0	1.00
42 – Evergreen Forest Land	211 – Coniferous Dense 212 - Coniferous Dense 213 – Coniferous Sparse	1.30	0.12	0.70	0.15	0.0	4.00
43 – Mixed Forest Land	231 – Mixedwood Dense 232 – Mixedwood Open 233 – Mixedwood Sparse	1.15[a]	0.12[a]	0.70[a]	0.15	0.0	2.50
50 - Water	20 - Water	0.0001	0.12	0.10	1.00	0.0	0.00
61 – Forested Wetland	81 – Wetland-Treed 82 – Wetland – Shrub 10 – Unclassified 11 – Cloud 12 - Shadow	1.15[a]	0.12[a]	0.70[a]	0.15	0.0	1.30
62 – Non-forested Wetland	83 – Wetland - Herb	0.20	0.12	0.10	0.15	0.0	0.30

Table B3-3 Surface Variables Associated with Land Use Characteristics

Land Use Categories		Geophysical Parameters					
CALMET (USGS Land Use Classification System)	GeoBase (NRCAN)	Surface Roughness Length (m)	Albedo	Bowen Ratio	Heat Flux [(a)] (W/m^2)	Anthropogenic Heat Flux [(a)] (W/m^2)	Leaf Area Index [(a)]
70 – Barren Land	32 – Rock/Rubble 33 – Exposed/Barren Land	0.05[(a)]	0.30[(a)]	1.00[(a)]	0.15	0.0	0.00
SUMMER							
10 – Urban or Build-Up Land	34 - Developed	1.00	0.16	2.00	0.25	10.0	0.30
20 – Agricultural Land - Unirrigated	52 – Shrub Low 121 – Agriculture Annual Cropland	0.20	0.20	0.50	0.15	0.0	3.00
30 - Rangeland	100 – Herb 110 – Grassland 122 – Agriculture Pasture/Forage	0.10	0.18	0.80	0.15	0.0	1.00
41 – Deciduous Forest Land	51 – Shrub Tall 221 – Broadleaf dense 222 – Broadleaf Open 223 – Broadleaf Sparse	1.30	0.12	0.30	0.15	0.0	3.50
42 – Evergreen Forest Land	211 – Coniferous Dense 212 - Coniferous Dense 213 – Coniferous Sparse	1.30	0.12	0.30	0.15	0.0	4.00
43 – Mixed Forest Land	231 – Mixedwood Dense 232 – Mixedwood Open 233 – Mixedwood Sparse	1.30[(a)]	0.12[(a)]	0.30[(a)]	0.15	0.0	3.80
50 - Water	20 - Water	0.0001	0.10	0.10	1.00	0.0	0.00
61 – Forested Wetland	81 – Wetland-Treed 82 – Wetland – Shrub 10 – Unclassified 11 – Cloud 12 - Shadow	1.30[(a)]	0.12[(a)]	0.30[(a)]	0.25	0.0	2.00
62 – Non-forested Wetland	83 – Wetland - Herb	0.20	0.14	0.10	0.25	0.0	1.00

Table B3-3 Surface Variables Associated with Land Use Characteristics							
Land Use Categories		**Geophysical Parameters**					
CALMET (USGS Land Use Classification System)	**GeoBase (NRCAN)**	**Surface Roughness Length (m)**	**Albedo**	**Bowen Ratio**	**Heat Flux [a] (W/m²)**	**Anthropogenic Heat Flux [a] (W/m²)**	**Leaf Area Index [a]**
70 – Barren Land	32 – Rock/Rubble 33 – Exposed/Barren Land	0.05[a]	0.30[a]	1.00[a]	0.15	0.0	0.00
FALL							
10 – Urban or Build-Up Land	34 - Developed	1.00	0.18	2.00	0.25	15.0	0.20
20 – Agricultural Land - Unirrigated	52 – Shrub Low 121 – Agriculture Annual Cropland	0.05	0.18	0.70	0.15	0.0	1.50
30 - Rangeland	100 – Herb 110 – Grassland 122 – Agriculture Pasture/Forage	0.01	0.20	1.00	0.15	0.0	1.00
41 – Deciduous Forest Land	51 – Shrub Tall 221 – Broadleaf dense 222 – Broadleaf Open 223 – Broadleaf Sparse	0.80	0.12	1.00	0.15	0.0	2.00
42 – Evergreen Forest Land	211 – Coniferous Dense 212 - Coniferous Dense 213 – Coniferous Sparse	1.30	0.12	0.80	0.15	0.0	4.00
43 – Mixed Forest Land	231 – Mixedwood Dense 232 – Mixedwood Open 233 – Mixedwood Sparse	1.05[a]	0.12[a]	0.90[a]	0.15	0.0	3.00
50 - Water	20 - Water	0.0001	0.14	0.10	1.00	0.0	0.00
61 – Forested Wetland	81 – Wetland-Treed 82 – Wetland – Shrub 10 – Unclassified 11 – Cloud 12 - Shadow	1.05[a]	0.12[a]	0.90[a]	0.25	0.0	1.50
62 – Non-forested Wetland	83 – Wetland - Herb	0.20	0.16	0.10	0.25	0.0	0.70

Table B3-3 Surface Variables Associated with Land Use Characteristics

Land Use Categories		Geophysical Parameters					
CALMET (USGS Land Use Classification System)	GeoBase (NRCAN)	Surface Roughness Length (m)	Albedo	Bowen Ratio	Heat Flux [(a)] (W/m^2)	Anthropogenic Heat Flux [(a)] (W/m^2)	Leaf Area Index [(a)]
70 – Barren Land	32 – Rock/Rubble 33 – Exposed/Barren Land	0.05[(a)]	0.28[(a)]	1.00[(a)]	0.15	0.0	0.00

[(a)] Non-default values

The CALMET modelling domain was described using seven land use categories. A category was assigned to each 500 m x 500 m grid cell based on the most prevalent land use type according to those described by Cihlar and Beaubien (1998). These descriptive categories were then grouped into broader classifications, which were provided by CALMET. The Land Use Categories were defined using land cover information from the Canadian Council on Geomatics Geobase (Geobase, 2014). The Cover Classification data originates from Landsat 5 and Landsat 7 ortho-images.

The albedo and Bowen ratio values follow the AEP modelling guidelines. For the other geophysical parameters not covered by AEP guidelines, parameters used were largely values recommended by PCRAMMET (U.S. EPA 1995).

The surface roughness length, Zo, values used in the assessment also followed AEP guidelines, with a maximum value of 1.3 m. However, these guidelines result in substantial underestimation of Zo in the rough terrain of the Project area. There is ample evidence that mountainous terrain increases Zo above the "classical" values adopted by AEP. For example, Wieringa (1998) notes Zo values > 2 m for large forested areas with clearings. Thompson (1978) measured Zo values of 35 m in an area with mountain heights of 180 m (above the valley bottom), and quotes other sources with Zo estimates of 3.5 m in a Tennessee river valley with heights 100-150 m above the valley floor. In a more extreme case, Han et al (2014) derived Zo values of about 70 m in the Tibetan plateau with peak heights 500-750 m above the valley.

There is also likely to be enhanced lateral dispersion generated by flow over mountains, hills and obstacles. This will tend to increase turbulence and mixing, leading to lower concentrations.

B3.6.2 Terrain

Terrain data were obtained from Canadian Digital Elevation Data (1 arc second or roughly ~ 30 m) found on the GeoBase website (Geobase 2014). The terrain heights for meteorological grid points, receptors, and sources are processed through pre-processor program. The CALMET pre-processor program, TERREL, was used to extract and format terrain data.

Terrain within the mine footprint was modified to reflect the expected elevations in the modelled year of mine operations.

B3.6.2.1 Sensitivity to TERRAD

Model guidance is that TERRAD should be some multiple of CALMET's horizontal grid spacing (which is 2 km in the regional study area), roughly ranging from 5 to 10 times. Therefore a TERRAD value of 10 km is consistent with the large scale terrain features in the regional study area and with the grid spacing.

In the local study area the CALMET grid spacing is 0.5 km. Here, a TERRAD value in the 3-5 km range would be appropriate. The range in multipliers (i.e., 5-10 times grid spacing) is only approximate.

To gauge the sensitivity of TERRAD in this project, the CALMET model was run in the LSA with a TERRAD value of 2 and 10, which is smaller than the recommended range and should provide a worse case example of the effects of the parameter. Wind roses in the LSA were examined at 8 locations and are plotted in Figure B3-1 below, with some locations in the Crowsnest Valley, some on site, and some up and downwind of planned operations.

Differences in windrose patterns (Figure B3-2) between the TERRAD 10 and 2 windroses were considered negligible at all but three locations – the South Dump, and locations R11 and R12. At all three locations, the effect of the TERRAD reduction was to slightly increase the frequency of winds from west and reduce the northwest wind frequency, with no changes in wind speeds. The effect was less pronounced in daytime conditions than at night when terrain influences on wind (drainage flows and channelling) are enhanced. Overall, the changes in wind roses with TERRAD are expected to be within natural variability.

The effects of the TERRAD value, in the 2-10 km range examined, on dispersion and predicted concentrations are expected to be negligible to minor. Slight differences in wind direction are expected to have no influence in concentrations at offsite receptors or in communities, although the location of maximum predictions may change slightly. With a general trend to slightly fewer calms (or no change in frequency), the effect on dispersion is expected to be negligible. For combustion parameters largely associated with blasting emissions (*e.g.*, CO, SO2, NOx), no differences in predicted maximum hourly concentrations are expected as blasting occurs during daytime hours when no changes in windrose were observed. Predicted concentrations of particulate are compared to 24-hour objectives; these predictions would be influenced by daytime contributions which are unaffected by TERRAD changes and nighttime contributions where the effect of changes is small – the overall change is expected to be minor.

Overall, the effects of TERRAD values ranging from 2 to 10 are expected to be negligible in most of the locations examined, and small in others, and supports the value of 5 km used in modelling. The effect on maximum predicted concentrations is expected to be negligible.

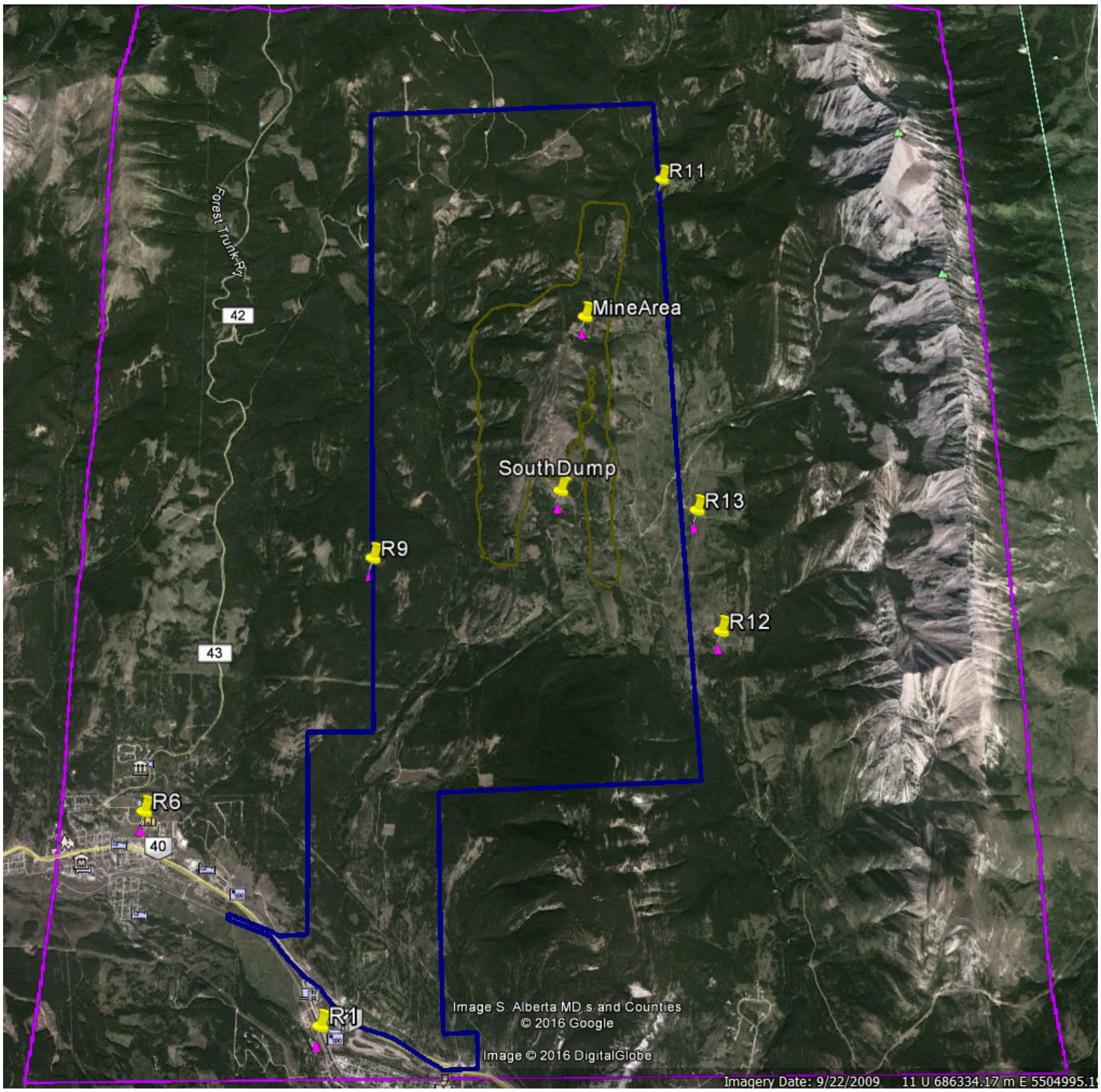


Figure B3-1 Windrose Comparison Locations

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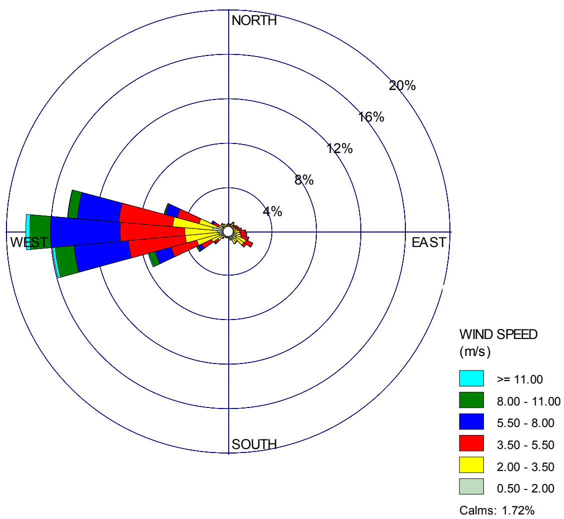
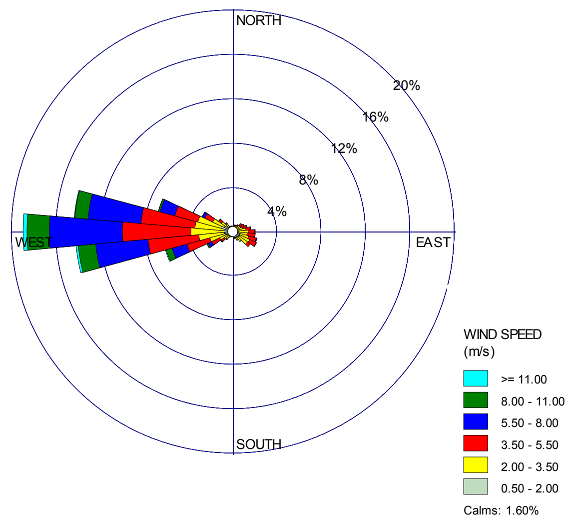
<tr><td>North Mine Area terrain elevation = 1976 m asl</td><td>
</td><td>
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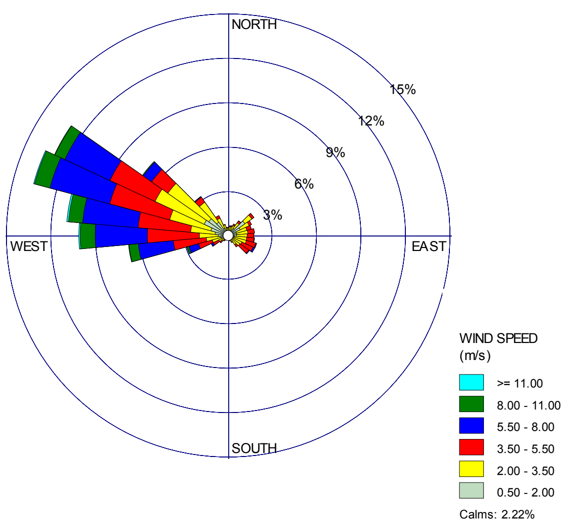
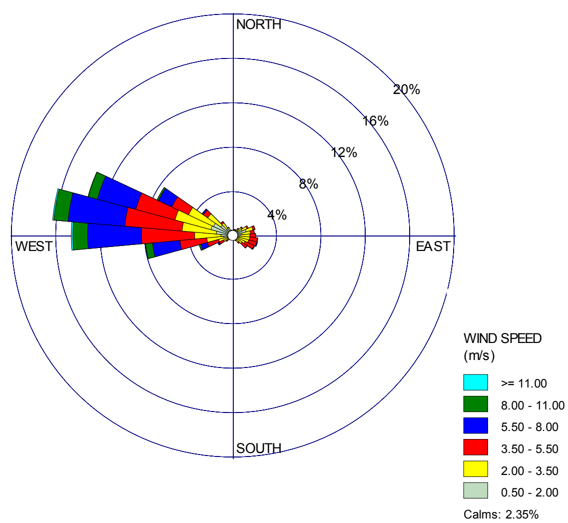
<tr><td>South Dump Area terrain elevation = 1620 m asl</td><td>
</td><td>
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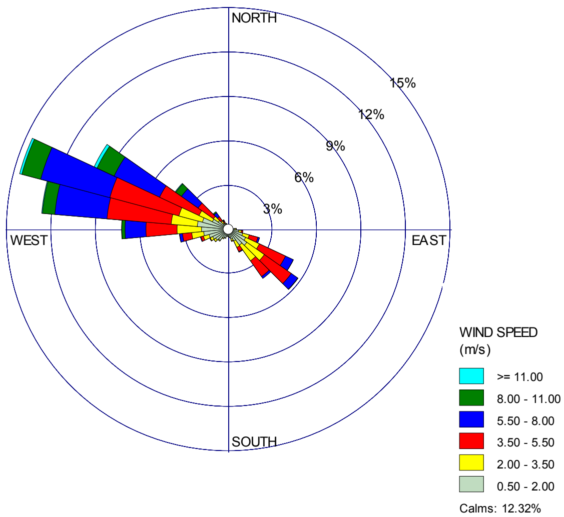
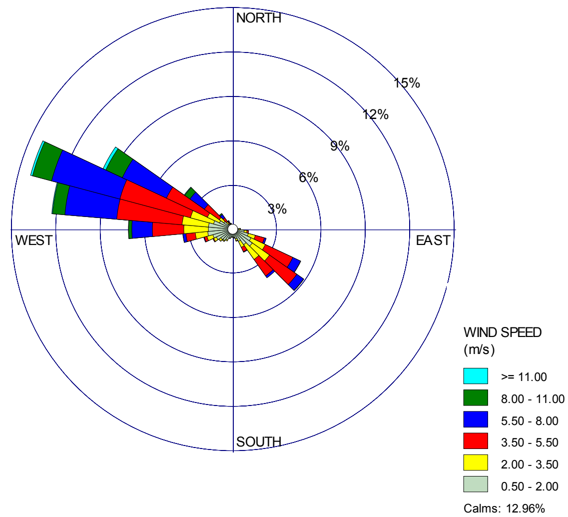
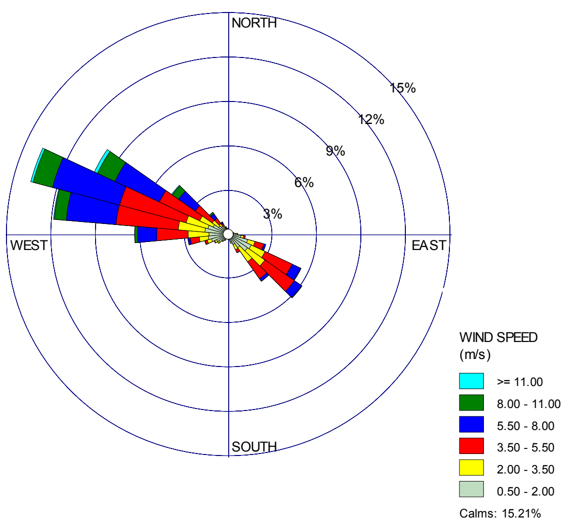
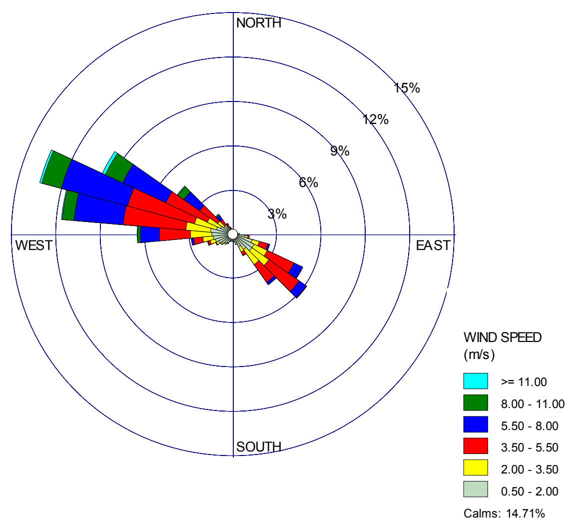
R1 terrain elevation = 1310 m asl



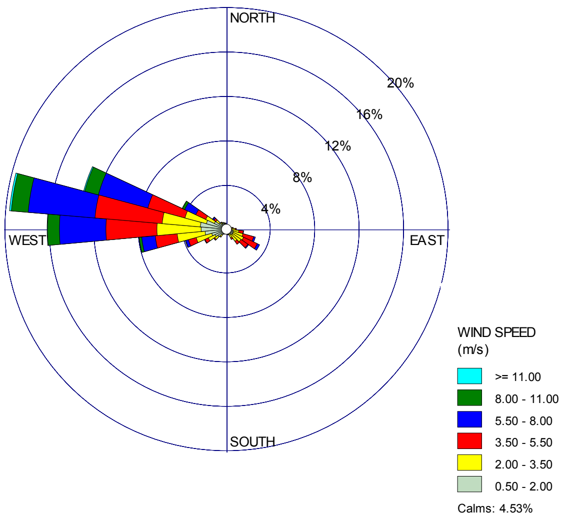


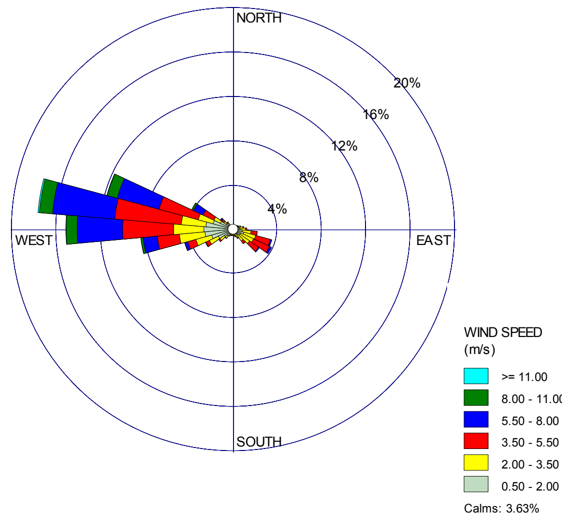
R6 terrain elevation = 1351 m asl



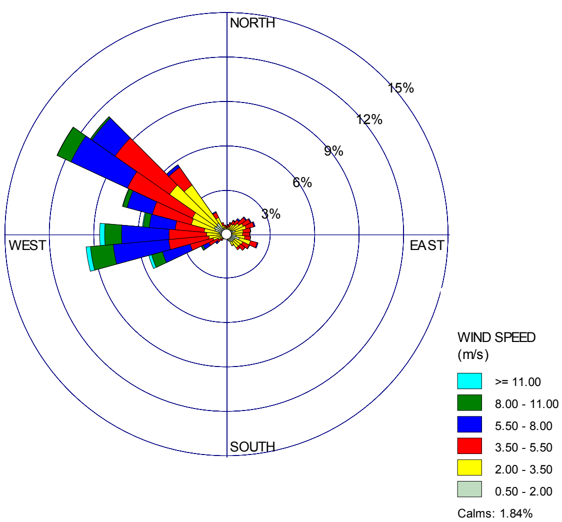


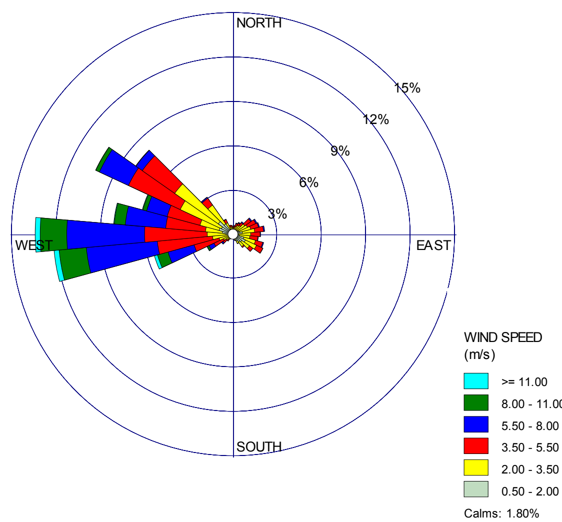
R9 terrain elevation = 1590 m asl





R11 terrain elevation = 1715 m asl





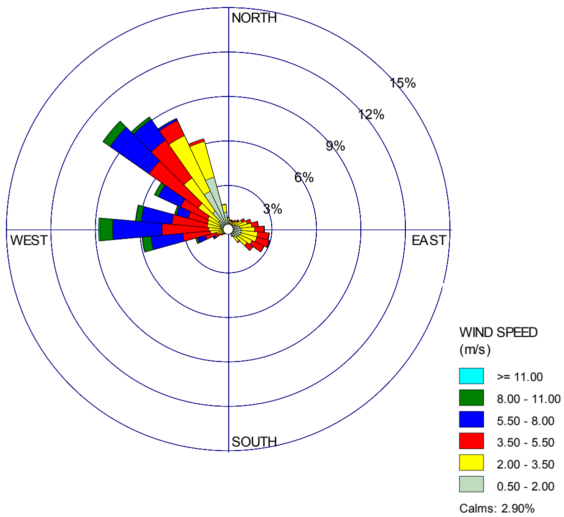
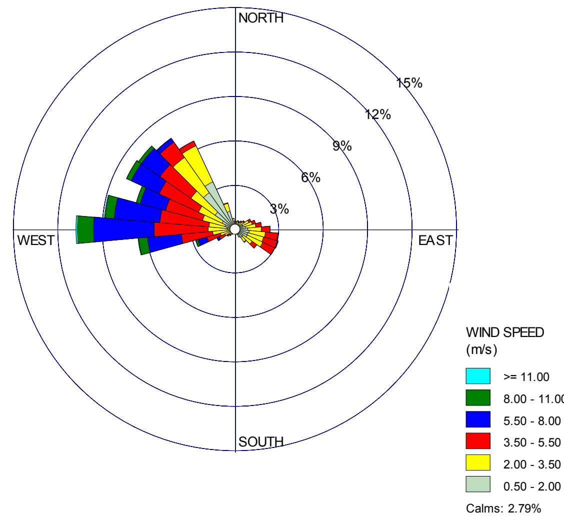
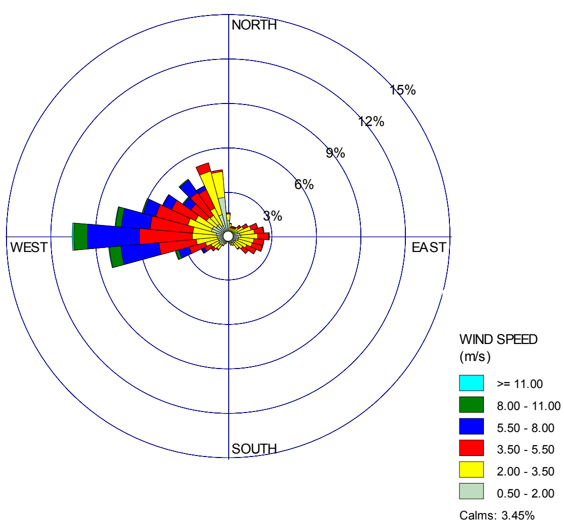
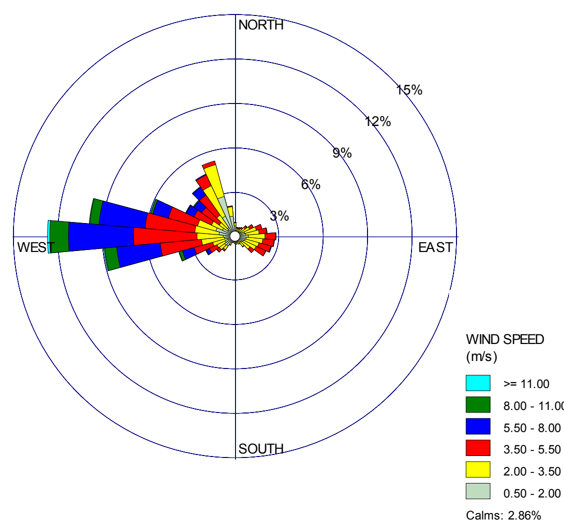
R12 terrain elevation = 1524 m asl		
R13 terrain elevation = 1550 m asl		

Figure B3-2 Wind Roses from CALMET Model Output (2002 to 2006)

B3.6.2.2 Sensitivity to Terrain Elevation at the Mine Site

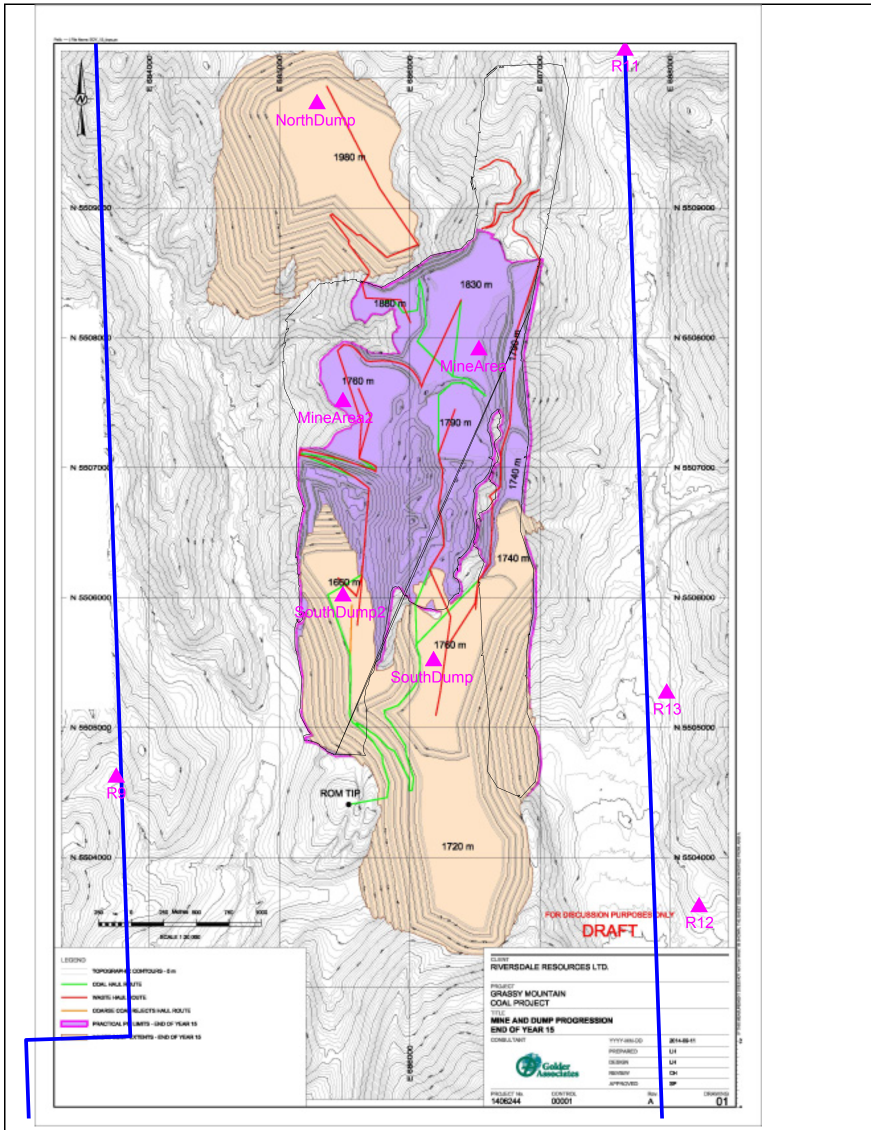
Windflow in CALMET is modelled to be parallel to terrain. Mining sources in CALPUFF are placed atop the terrain or within it for pit sources. As terrain is gradually mined down, or as waste areas are gradually built up, the flow would remain parallel to the terrain. The flows immediately around these features will vary as the mine evolves. However, as the main focus of the EIA is the prediction of concentrations at special receptors and communities, the effect of near-source flow changes is expected to be negligible at these off-site locations.

In the air quality assessment, the emission sources were placed on the mine-altered surface of the terrain. The digital terrain file used in modelling was modified to resemble the mine plan in the year of interest. The elevation of mined areas was decreased as pits were mined down and the elevation of waste dump areas was increased as low-lying areas were filled in. To test how flows would change in the presence of native terrain, differences in windroses between native and mined landscapes were compared at 5 locations within the disturbed area and 4 locations outside it. The differences in windroses in the two landscapes were examined for TERRAD values of 10 and 2.

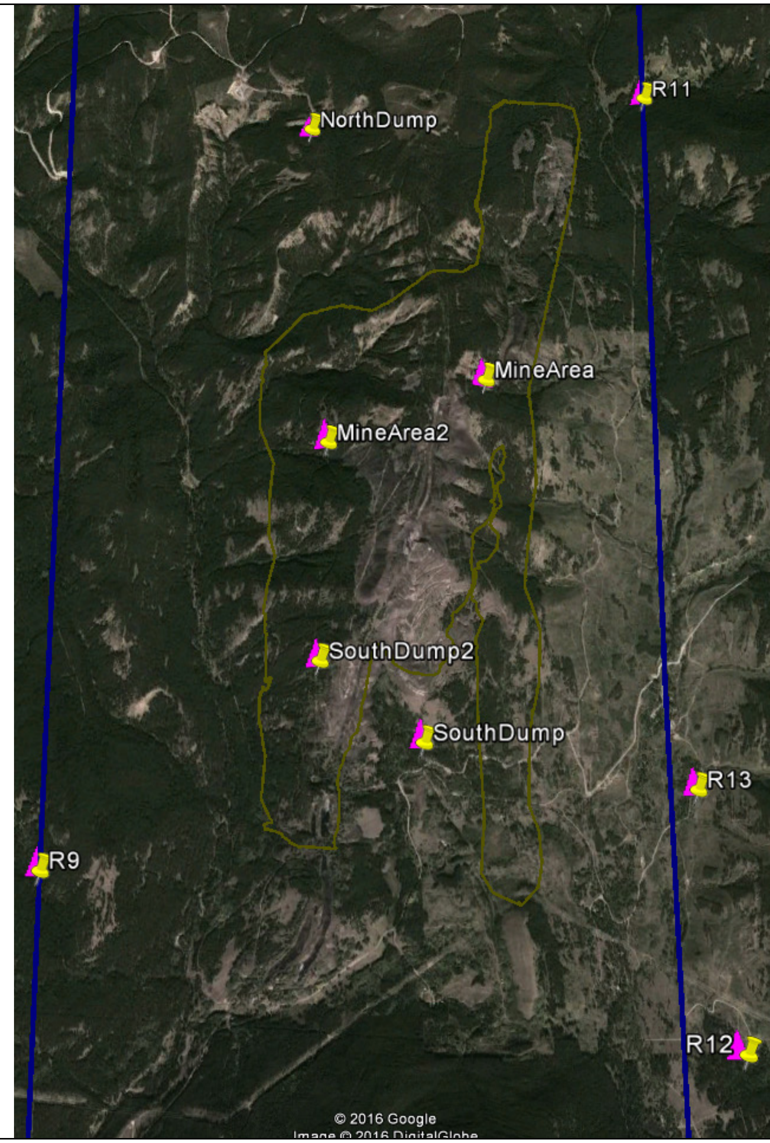
The locations of the windrose sites in native and mined landscapes are shown in Figure B3-3. The windrose comparisons are shown in Figure B3-4 for sites within the disturbed area and in Figure B3-5 for locations outside the disturbance. The comparisons broadly indicate:

- Windroses in the two landscapes are virtually identical at sites outside the disturbed area. This suggests changes in flow, and in predicted air quality, would be localized to the disturbed area only.
- Windroses in the disturbed area with TERRAD=2 are insensitive to changes in the shape and elevation of the landscape.
- Differences in windroses with TERRAD=10 are larger, with more variation in direction. In mine areas where the terrain elevation is decreased, wind speeds are generally slightly lower (more calms); in dump areas where elevation has increased, wind speeds are slightly higher.

Overall, the wind rose differences in the two landscapes remain small. It is expected that concentrations outside the disturbed areas will be insensitive to the landscape used in modelling.

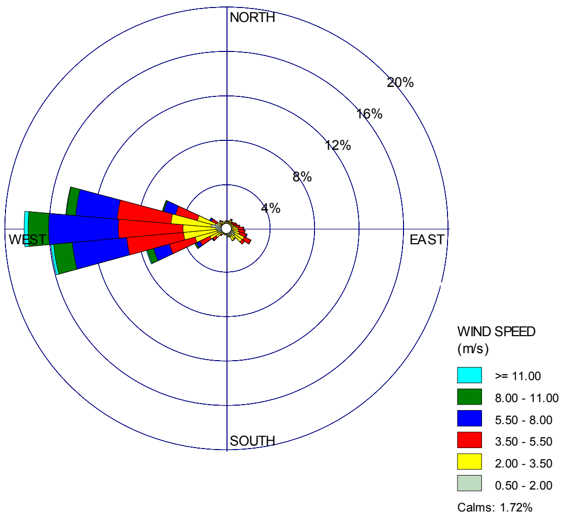
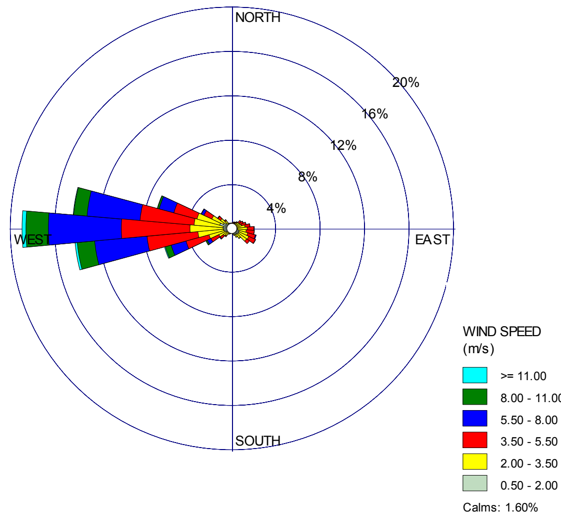


Mined Terrain



Original Terrain

Figure B3-3 Locations of windrose comparisons in native and mined landscapes

<table>
<tr><th>North Mine Area</th><th>Terrad=10</th><th>Terrad=2</th></tr>
<tr><td>Original terrain elevation = 1976 m asl</td><td>
</td><td>
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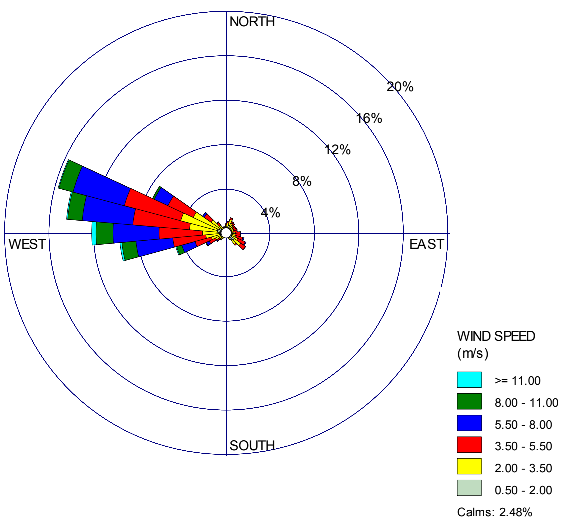
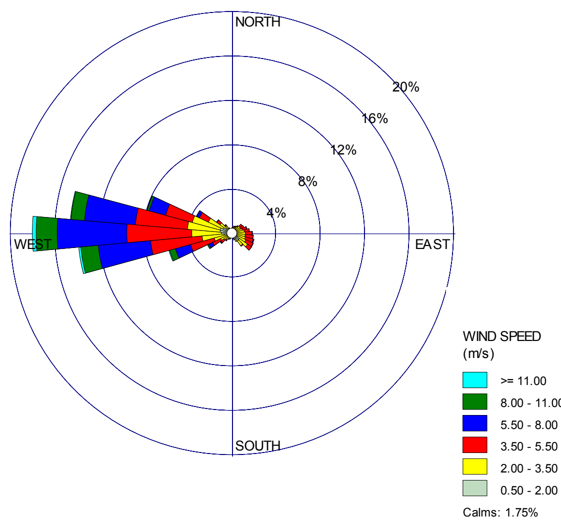
<tr><td>Mined terrain elevation = 1830 m asl</td><td>
</td><td>
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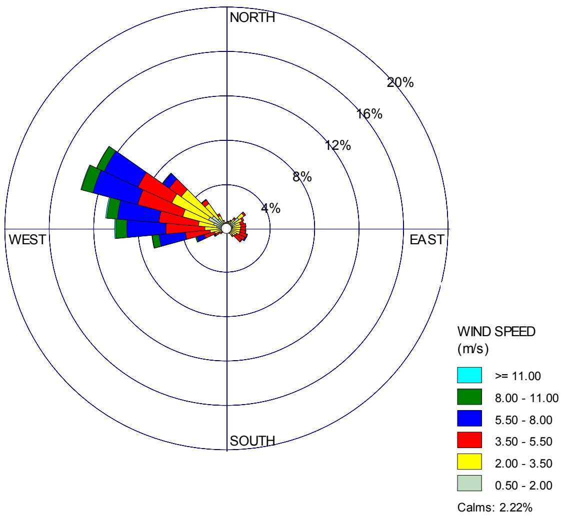
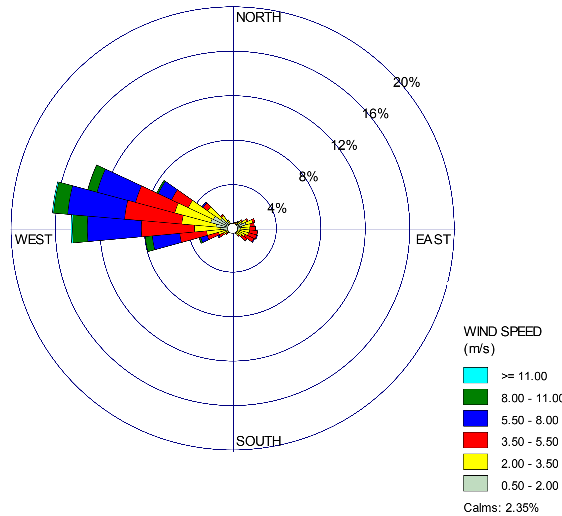
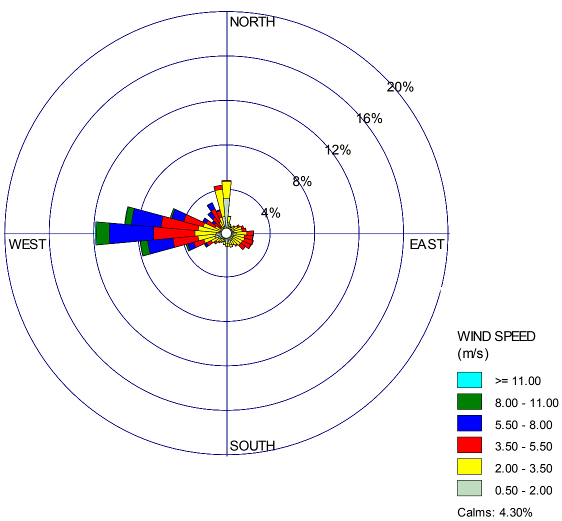
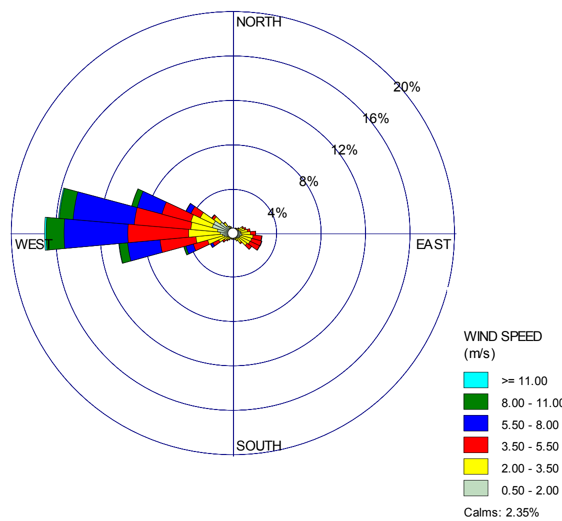
South Dump Area	Terrad=10	Terrad=2
Original terrain elevation = 1620 m asl		
Mined terrain elevation = 1760 m asl		

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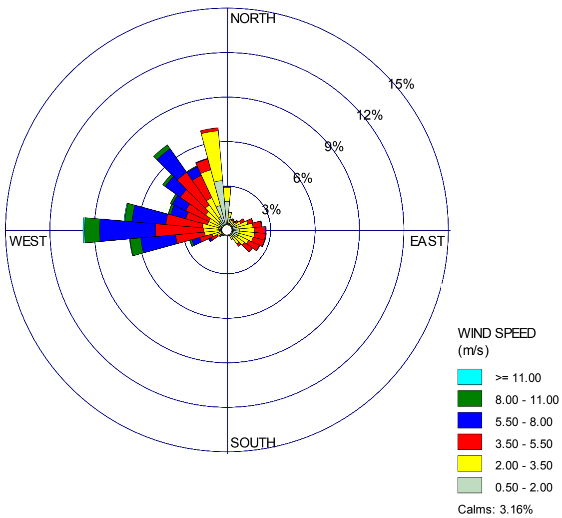
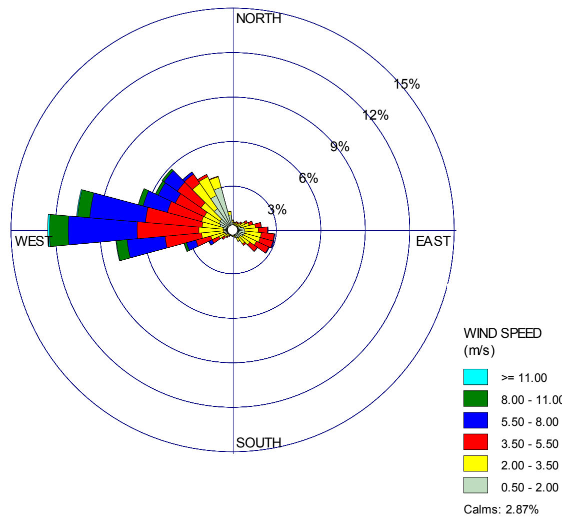
<tr><th>South Dump Area2</th><th>Terrad=10</th><th>Terrad=2</th></tr>
<tr><td>Original terrain elevation = 1700 m asl</td><td>
</td><td>
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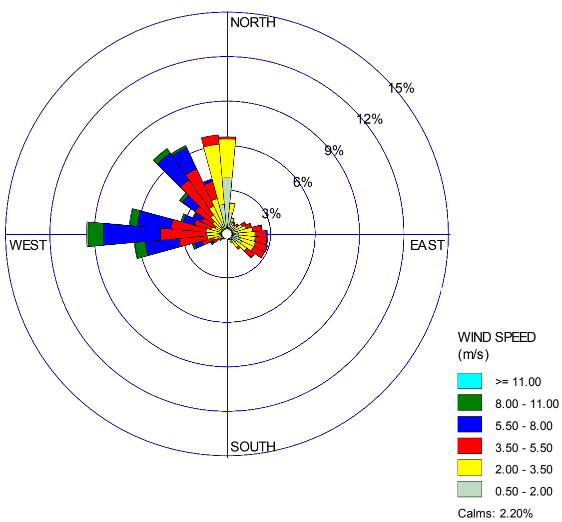
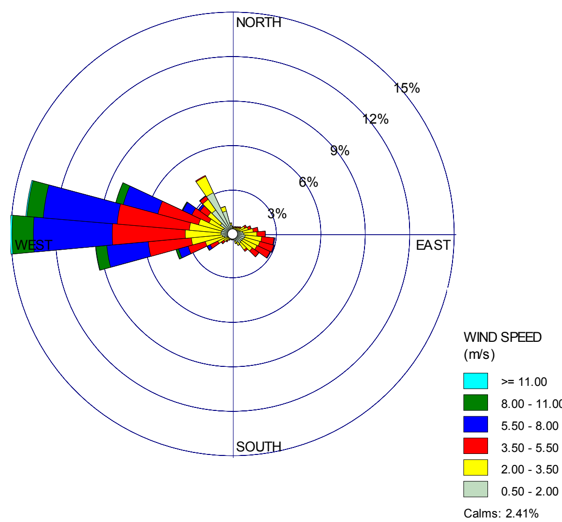
<tr><td>Mined terrain elevation = 1660 m asl</td><td>
</td><td>
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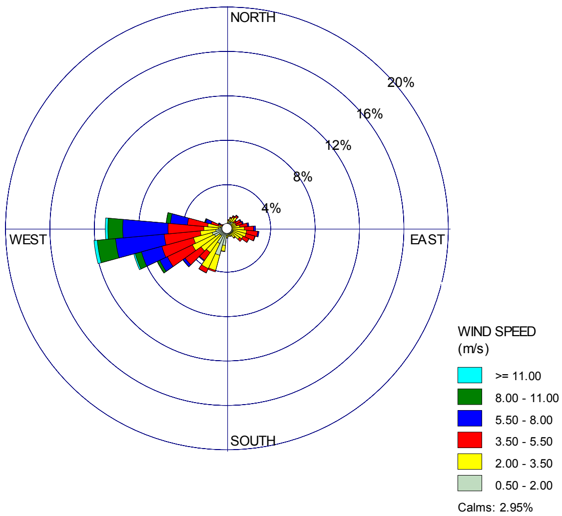

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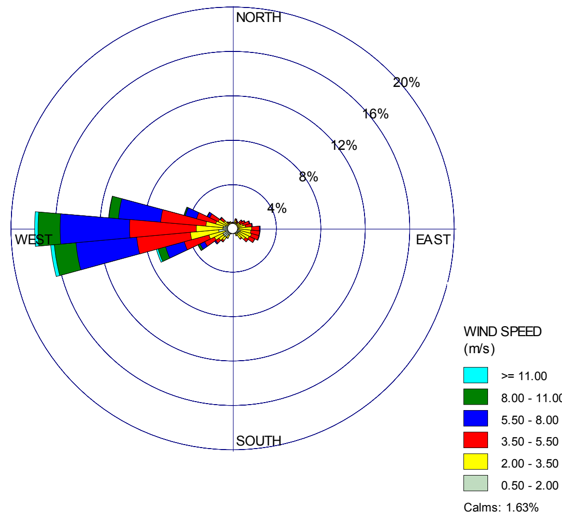

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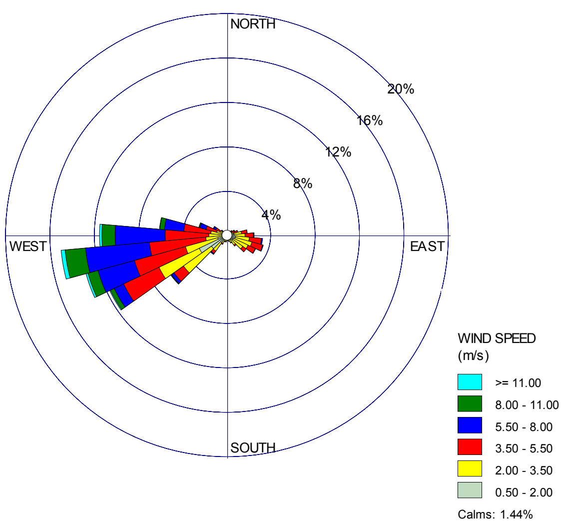

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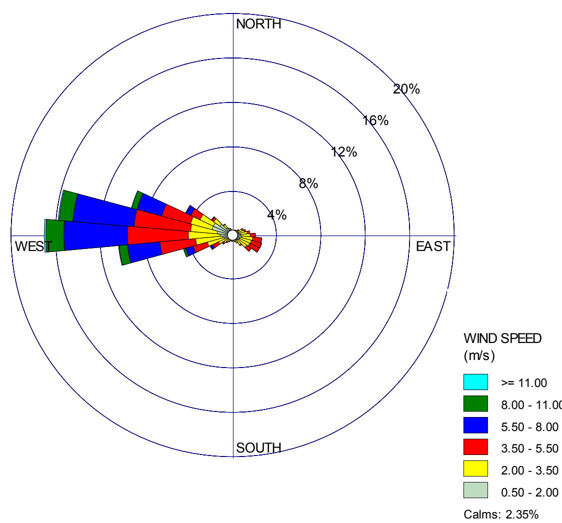

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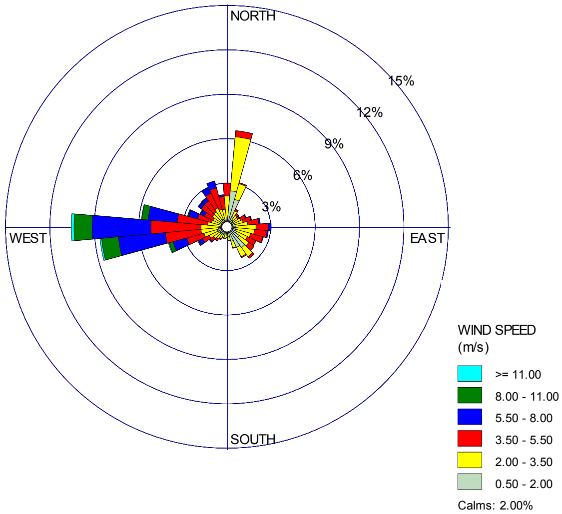
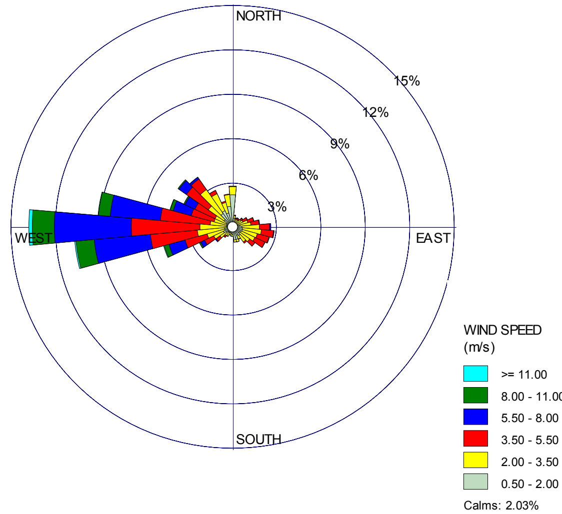
<tr><td>Original terrain elevation = 1800 m asl</td><td>
</td><td>
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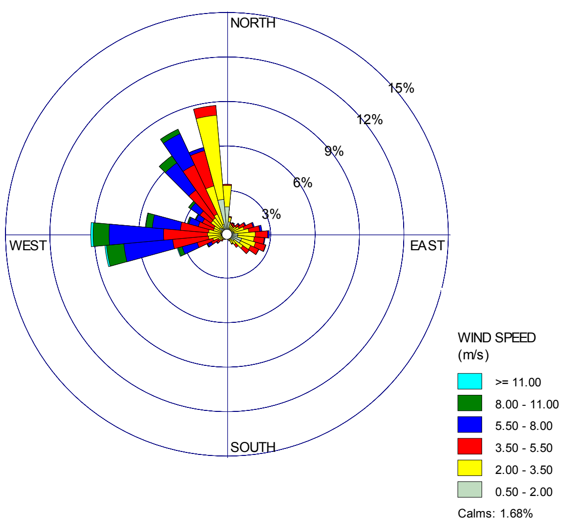
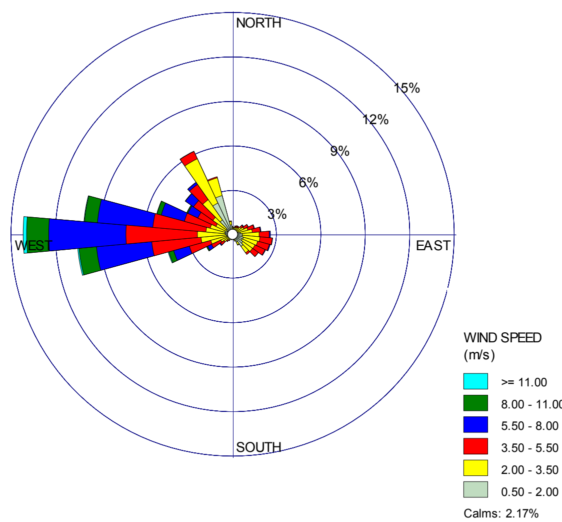
<tr><td>Mined terrain elevation = 1760 m asl</td><td>
</td><td>
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Figure B3-4 Windrose Comparisons at Sites within the Disturbed Landscape

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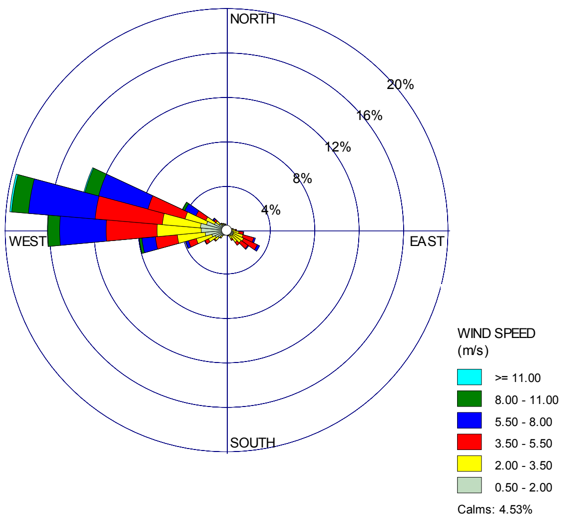
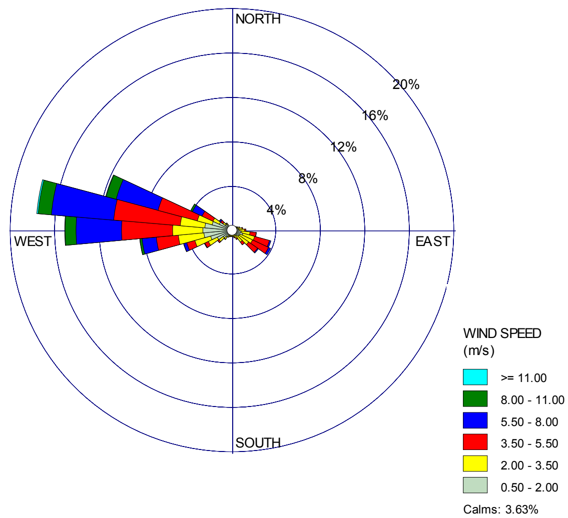
<tr><td>Original Terrain</td><td>
</td><td>
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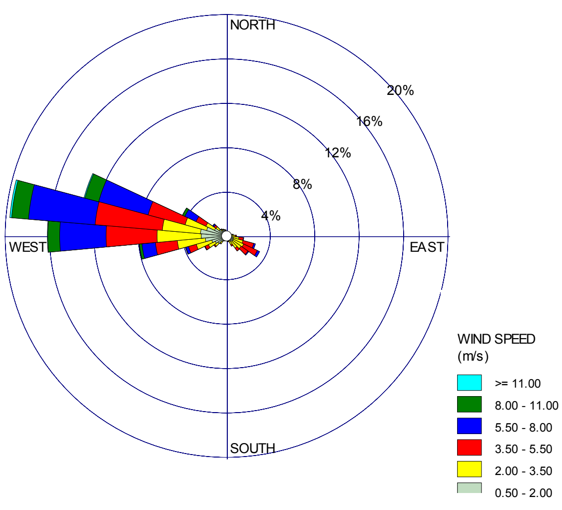
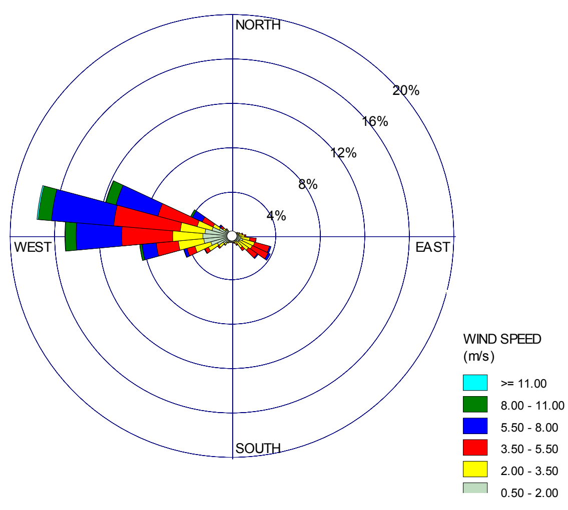
<tr><td>Mined Terrain</td><td>
</td><td>
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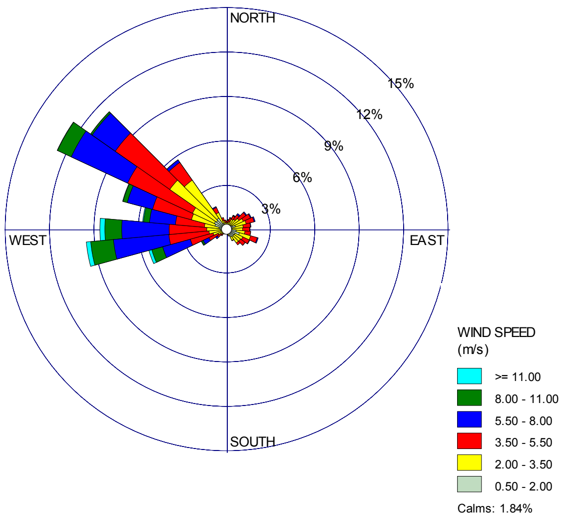
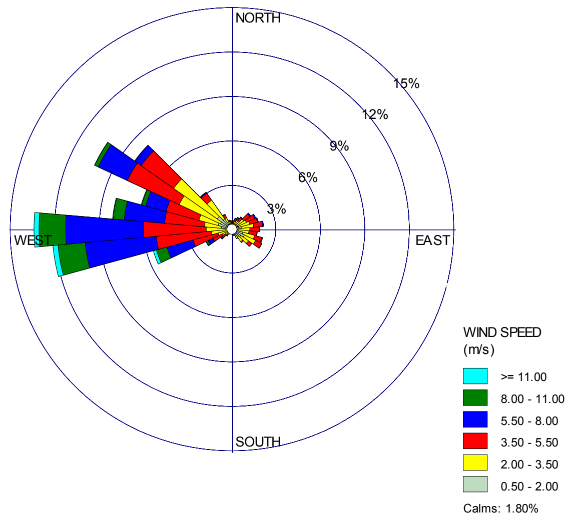
<tr><td>Original Terrain</td><td>
</td><td>
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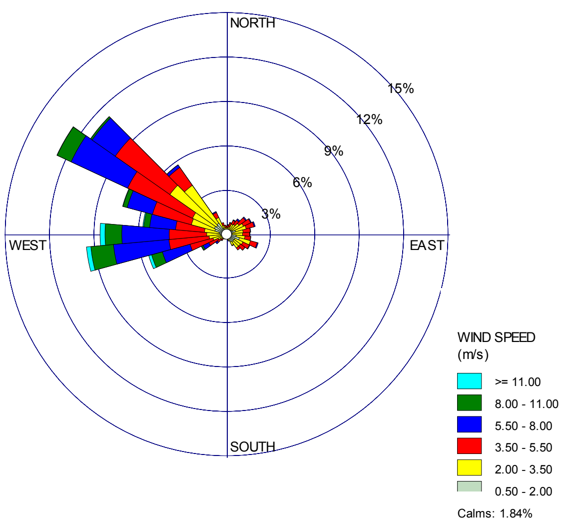
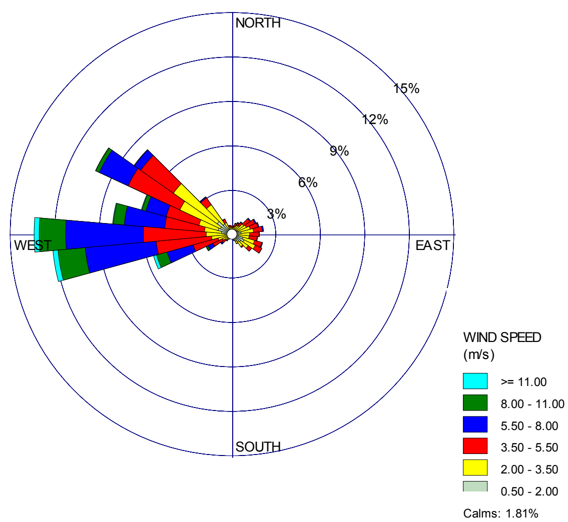
<tr><td>Mined Terrain</td><td>
</td><td>
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<table>
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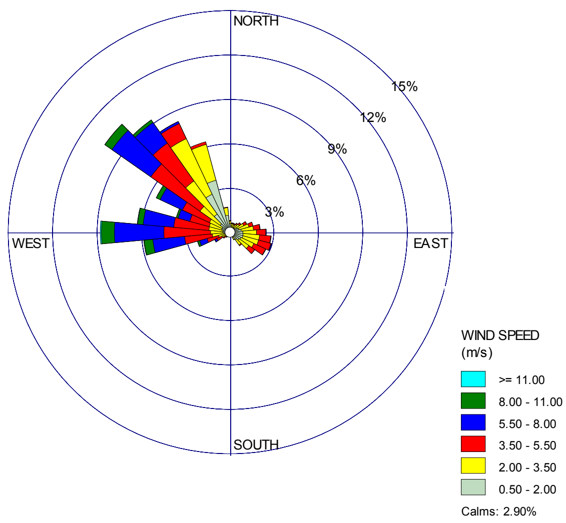
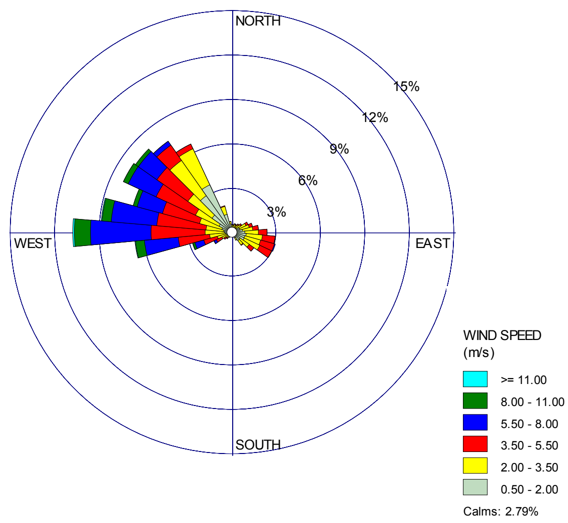
<tr><td>Original Terrain</td><td>
</td><td>
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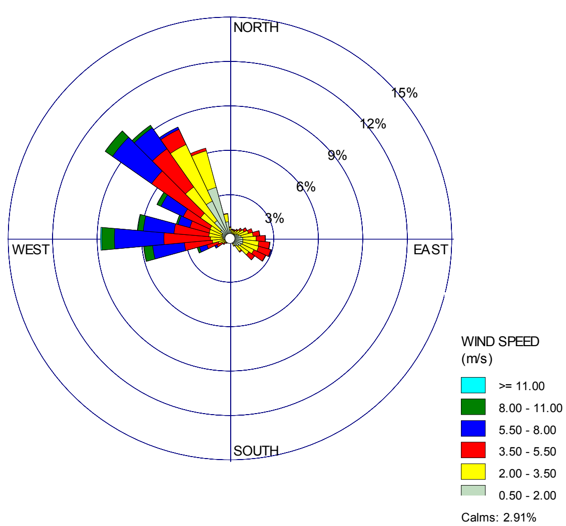
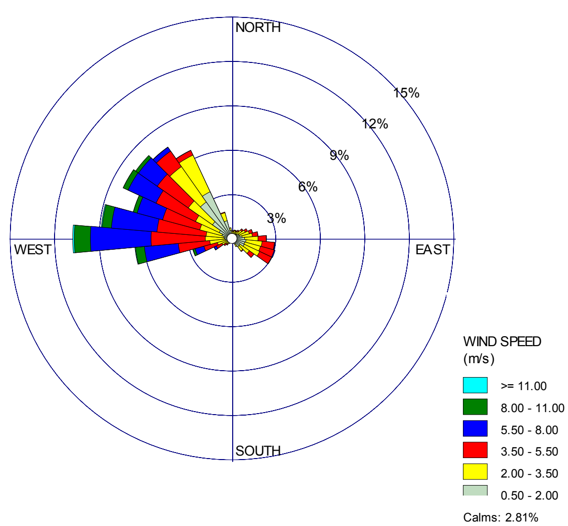
<tr><td>Mined Terrain</td><td>
</td><td>
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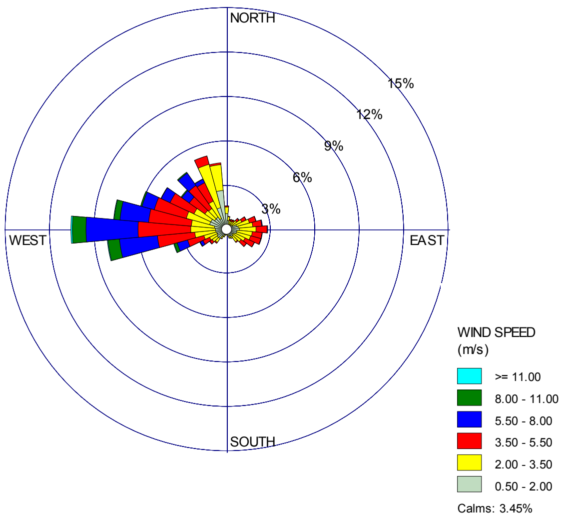
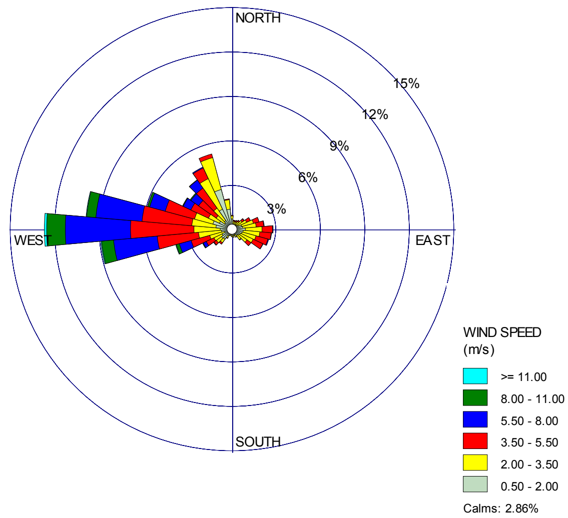
<tr><td>Original Terrain</td><td>
</td><td>
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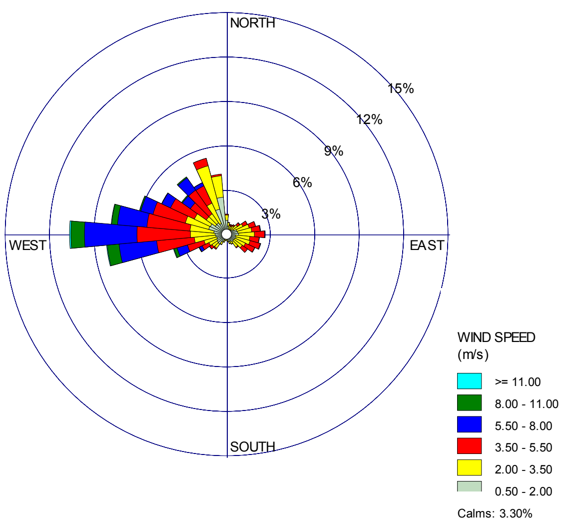
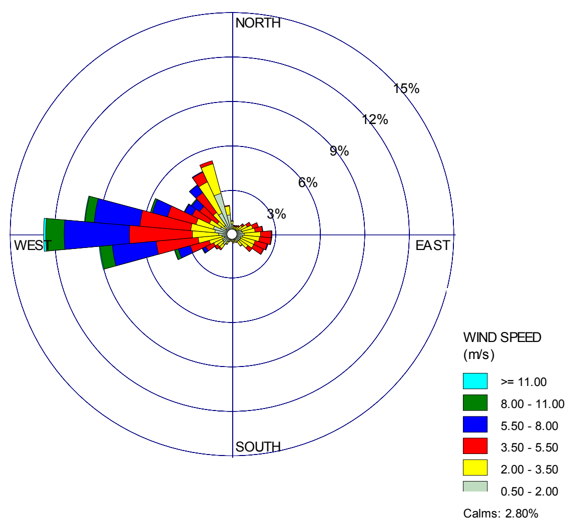
<tr><td>Mined Terrain</td><td>
</td><td>
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Figure B3-5 Windrose Comparisons at sites Beyond the Disturbed Landscape

B4 CALPUFF MODEL OPTIONS

B4.1 Modelling Approach and Configuration

Some features of the modelling approach included the following:

- For air quality assessment purposes, maximum hourly and daily emissions were identified and modelled separately.
- Emissions from diesel combustion were estimated and modelled separately from fugitive dust emission from mine pit activities.
- All Project activities, excepting blasting, were modelled as area sources with an effective release height of 6 m and initial dispersion sigma z of 5.5 m, which were based on 7 m average height for mining equipment and vehicles. All activities were modelled for 24 hours each day for 365 days each year.
- Blasting was conservatively modelled each day instead of on the 120 days per year that blasting is expected in Year 14, to ensure worst case meteorological conditions could occur simultaneously with blasting. Blasting was modelled as an elevated volume source with effective height E_h = 25 m, an initial vertical spread of 25 m and an initial horizontal spread of 50 m.
- The community and highway emission sources were modelled as area sources emitting on a continuous basis with an effective release height of 3 m and initial dispersion sigma z of 5 m.
- Even though wind driven emissions during the nighttime would be lower due to reduced operations, wind driven emissions from active areas and stock piles were modelled 24 hours each day for 365 days a year, for hourly winds above 5.36 m/s.
- The dust suppression factor was assumed to be 90% in winter for fugitive dust emissions from roads as well as wind driven emissions, due to the presence of frozen ground or snow on the ground. It was assumed that, for all other sources, winter and summer emissions from mine operations are equal.
- VOCs and PAHs were scaled from diesel combustion $PM_{2.5}$ emission predictions, based on the multiplier of each species. Predictions for metals were scaled from combustion $PM_{2.5}$ and fugitive TSP predictions separately, based on the multiplier of each species, and then summed. The multiplier for each species was calculated using emission factors taken from AP-42 (U.S. EPA, 1996) divided by the $PM_{2.5}$ emission factor, as about 90% of diesel fuel is consumed by heavy-duty engines (larger than 600 hp).

B4.2 Receptors

Two types of receptors within the RSA were defined: nested Cartesian grid points, and discrete locations (Figure B4-1). The CALPUFF receptor grids described below were considered in this assessment as per AEP model guideline (AESRD 2013). The model origin was centered at UTM Coordinate 684,000 m east, UTM Coordinate 5,503,100 m north (NAD 83 UTM Zone 11N). Receptor grids were set according to the following spacing:

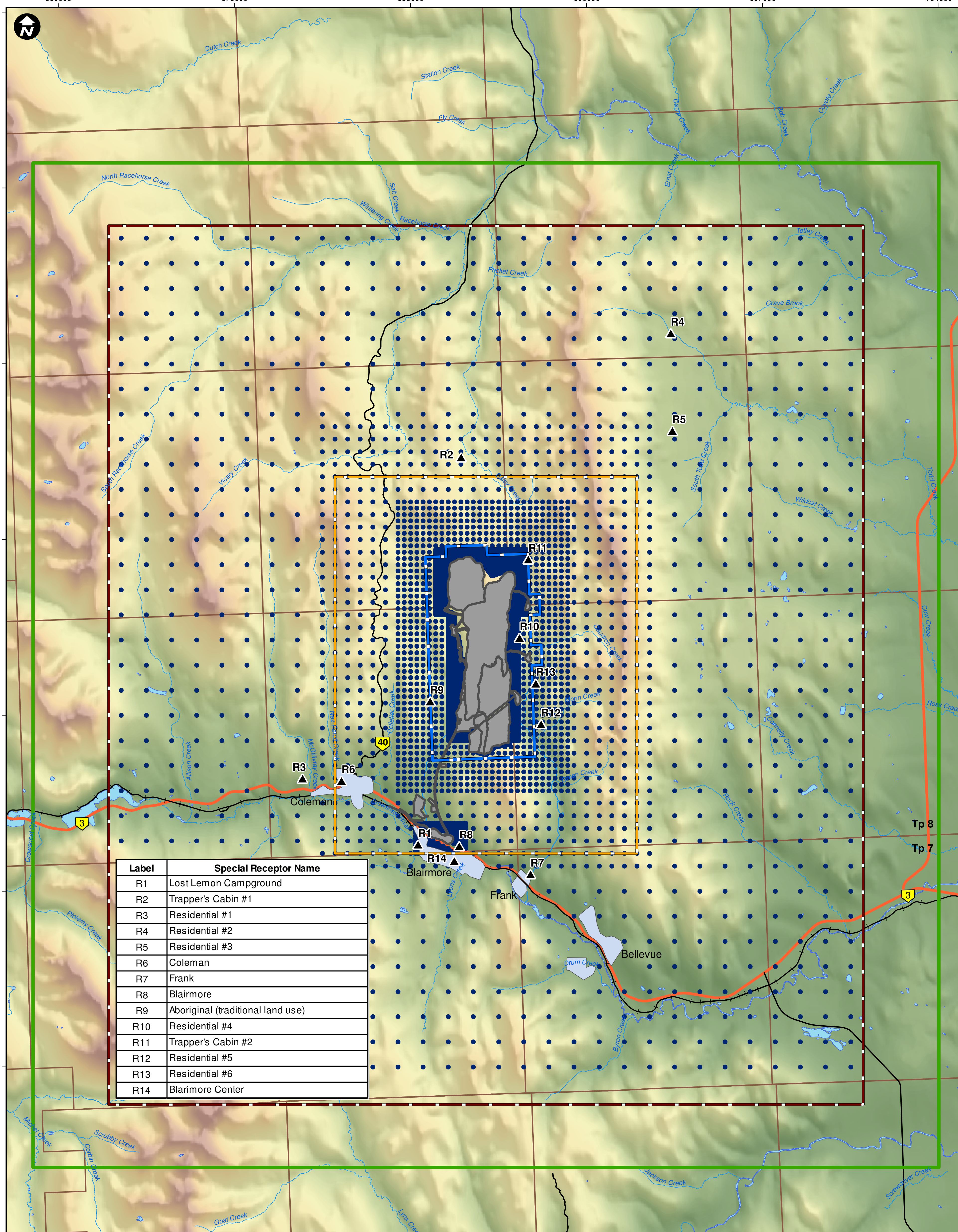
- Grid A = 30 x 34 km, 1,000 m spacing, centered on the model origin;
- Grid B = 14 x 18 km, 500 m spacing, centered on the model origin;
- Grid C = 8 x 12 km, 250 m spacing, centered on the model origin;
- Grid D = 4 x 8 km, 50 m spacing, centered on the model origin;
- Grid F = 50 m spacing along the Mine Permit Boundary; and
- Grid G = 20 m spacing along the Project boundary.

Receptors were removed within the Project pit boundary, as it is expected that no public access would be available in this space.

In addition, 13 discrete receptor locations (Table B4-1) were included in the assessment. These locations represent human health locations (aboriginal, community, recreation, *etc.*).

Table B4-1 Location of Special Receptors

Receptor	Description	UTM-E [m]	UTM-N [m]
R1	Lost Lemon Campground	683,303	5,498,852
R2	Trapper's Cabin	685,018	5,514,269
R3	Cabin	678,712	5,501,481
R4	AP	693,350	5,519,213
R5	Cabin	693,409	5,515,330
R6	Coleman	680,262	5,501,388
R7	Frank	687,770	5,497,670
R8	Blairmore	684,940	5,498,786
R9	First Nations Hunting/Gathering Site	683,782	5,504,555
R10	MDRL006	687,336	5,507,081
R11	MDRL011 – Trapper's Cabin	687,682	5,510,209
R12	MDRL009	688,191	5,503,649
R13	MDRL010	687,984	5,505,267



Label	Special Receptor Name
R1	Lost Lemon Campground
R2	Trapper's Cabin #1
R3	Residential #1
R4	Residential #2
R5	Residential #3
R6	Coleman
R7	Frank
R8	Blairmore
R9	Aboriginal (traditional land use)
R10	Residential #4
R11	Trapper's Cabin #2
R12	Residential #5
R13	Residential #6
R14	Blarimore Center

LEGEND

- Receptor
- Special Receptor
- Proposed Mine Permit Boundary
- Project Footprint
- Air Quality Local Study Area
- Air Quality Regional Study Area
- Model Domain

Topography (masl)

High : 2500

Low : 1300

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

RECEPTORS CONSIDERED IN THE DISPERSION MODELLING

NOTES

AltaLIS, 2016; GeoBase, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE

B4-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig B4-1 Receptors Considered in the Dispersion Modelling.mxd

B4.3 Settings for Regional Model

The CALPUFF input parameters were selected according to AEP Guidelines. For parameters not covered by the guidelines, default CALPUFF values (Exponent, 2011) were selected with some exceptions, as follows. Only parameters related to the computational methods are included.

Table B4-2 Map Projection and Grid Control Parameters (Input Group 4)

Parameter	Default	Current	Description
IUTMZN	-	11	UTM Zone (1 to 60)
DATUM	WGS-84	NAR-B	NIMA Datum Region - Canada
NX	-	18	Number of X grid cells in meteorological grid
NY	-	20	Number of Y grid cells in meteorological grid
NZ	-	12	Number of vertical layers in meteorological grid
DGRIDKM	-	2.0	Grid spacing (km)
XORIGKM	-	668.0	Reference X coordinate for SW corner of grid cell (1,1) of meteorological grid (km)
YORIGKM	-	5,486.0	Reference Y coordinate for SW corner of grid cell (1,1) of meteorological grid (km)
IBCOMP	-	1	X index of lower left corner of the computational grid
JBCOMP	-	1	Y index of lower left corner of the computational grid
IECOMP	-	18	X index upper right corner of the computational grid
JECOMP	-	20	Y index upper right corner of the computational grid
LSAMP	T	F	Sampling grid is not used

B4.3.1 Modelling for Diesel Combustion Emissions

For the chemical method, the RIVAD/ARM3 was chosen from the choices recommended by AEP Guidelines (AEP 2013). Rural hourly ozone background concentrations provided by AEP were used. Table B4-3 shows the species modelled for diesel combustion emissions in CALPUFF.

Table B4-3 Species List-Chemistry Options (Subgroup 3a) – Diesel Combustion Emissions				
CSPEC	**Modelled (0=no, 1=yes)**	**Emitted (0=no, 1=yes)**	**Dry deposition (0=none, 1=computed gas, 2=computed particle, 3=user-specified)**	**Output group Number**
SO_2	1	1	1	0
SO_4^{-2}	1	0	2	0
NO	1	1	1	0
NO_2	1	1	1	0
HNO_3	1	0	1	0
NO_3^-	1	0	2	0
$PM_{2.5}$	1	1	2	0
CO	1	1	1	0

B4.3.2 Modelling for Fugitive Dust Emissions

The chemistry option was switched off for the modelling runs for fugitive dust emissions. Table B4-4 shows the species modelled in CALPUFF. Particulates were modelled in three size fractions (Table B4-5), based on the particulate size distribution for $PM_{2.5}$, PM_{10}, and TSP, which taken from Watson and Chow (2000).

Table B4-4 Species List-Chemistry Options (Subgroup 3a)- Fugitive Dust emissions				
CSPEC	**Modelled (0=no, 1=yes)**	**Emitted (0=no, 1=yes)**	**Dry deposition (0=none, 1=computed gas, 2=computed particle, 3=user-specified)**	**Output group Number**
AER	1	1	2	0
DPM10	1	1	2	0
DTSP	1	1	2	0

Table B4-5 Size Parameters for Dry Deposition of Particles (Input Group 8)			
Species	**Default**	**Current**	**Description**
AER	0.48	0.48	Geometric mass mean diameter of $PM_{2.5}$ [μm]
AER	1.5	1.5	Geometric standard deviation of $PM_{2.5}$ [μm]
DPM10	-	6.0	Geometric mass mean diameter of PM_{10} [μm]
DPM10	-	1.5	Geometric standard deviation of PM_{10} [μm]
DTSP	-	20	Geometric mass mean diameter of TSP [μm]
DTSP	-	1.5	Geometric standard deviation of TSP [μm]

B5 REFERENCES

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APPENDIX C: AIR QUALITY AND METEOROLOGICAL OBSERVATIONS

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C1.0 INTRODUCTION

This appendix summarizes air quality baseline information for the proposed Riverside Grassy Mountain Coal Mine Project (the Project). It is the basis for the environmental impact assessment to be completed as part of the project approval process. The baseline information is derived from representative monitoring programs and provides appropriate background concentrations to which predicted concentrations resulting from Project activities are added (AESRD 2013a).

The information reflects the current understanding of baseline conditions near the Project and is based on information available as of December 2014.

C2.0 METHODS TO OBTAIN BACKGROUND CONCENTRATIONS

C2.1 Air Quality Indicators

The project will result in emissions to the atmosphere from diesel combustion in mine operation and haul fleets, as well as fugitive sources of dust. While primary combustion products are carbon dioxide (CO_2) and water vapour (H_2O), trace amounts of oxides of nitrogen (NO_x), particulate matter with diameter less than 2.5 µm ($PM_{2.5}$), particulate matter less than 10 µm (PM_{10}) and volatile organic compounds (VOC) are also produced.

Trace amounts of SO_2, carbon monoxide (CO) and polycyclic aromatic hydrocarbons (PAH) emissions will occur. A portion of particulate is comprised of metals and those associated with combustion of diesel are considered. At sufficiently high concentrations, these air emissions can have direct and indirect effects on humans, animals, vegetation, soil and water. Ammonia (NH_3) may also be present in the background air and is thus considered in this report.

C2.2 Air Quality Objectives

Table C2-1 presents the Alberta Ambient Air Quality Objectives (AAAQO) and the Canadian Ambient Air Quality Standards (CAAQS) for regulated compounds. The objectives refer to averaging periods ranging from one hour to one year.

When assessing monitoring data, the maximum values in any averaging period are compared to the relevant objectives and standards.

For modelling purposes, the hourly objectives are applied to 99.9th percentile hourly predictions and daily, monthly and annual objectives are applied to the highest daily prediction. For monitoring purposes, objectives are compared to maximum observations. The AAAQOs are updated occasionally and the current values at time of preparation of this report are presented.

Table C2-1 Alberta Ambient Air Quality Objectives and Canada Wide Standards

Species	Period	Alberta Objectives(a) (µg/m3)	CAAQS(b) (µg/m3)
SO_2	Annual	20	-
	30-day	30	-
	24-hour	125	-
	1-hour	450	-
NO_2	Annual	45	-
	1-hour	300	-
CO	8-hour	6,000	-
	1-hour	15,000	-
Ozone	8-hour	-	124, 122(c)
	1-hour	160	-
$PM_{2.5}$	24-hour	30	28, 27(c)
	1-hour	80(e)	-
	Annual	-	10, 8.8(c)
PM_{10}	24-hour	50(d)	-
TSP	Annual	60	-
	24-hour	100	-
Arsenic	Annual	0.01	-
	1-hour	0.1	-
Lead	1-hour	1.5	-
Manganese	Annual	0.2	-
	1-hour	2	-
Nickel	Annual	0.05	-
	1-hour	6	-
Ammonia	1-hour	1,400	-
Benzene	Annual	3	-

Table C2-1 Alberta Ambient Air Quality Objectives and Canada Wide Standards

Species	Period	Alberta Objectives(a) (µg/m3)	CAAQS(b) (µg/m3)
	1-hour	30	
Formaldehyde	1-hour	65	-
Acetylaldehyde	1-hour	90	-
Benzo(a)pyrene	Annual	0.0003	-
Toluene	1-hour	1,880	-
	24-hour	400	-
Xylenes	1-hour	2,300	-
	24-hour	700	-

(a) Source: AESRD 2013b
(b) Source: Canadian Ambient Air Quality Standards (CCME 2012)
(c) CAAQS implemented in 2015 and to be implemented in 2020.
(d) British Columbia Air Quality Guideline (BCE, 2009)
(e) Guideline, not regulatory objective

C2.3 Spatial and Temporal Study Area Boundaries

Mining activities for the proposed Riverside Grassy Mountain Coal Mine Project are planned to occur about 10 to 15 km north of the communities of Coleman, Blairmore and Frank. The produced clean coal will be transported by conveyor to a Rail load-out for transfer to rail.

Based on air emissions generated from other mining and industrial operations, the maximum concentrations of substances that could be emitted are expected to occur within a few hundred metres of the emission sources and will decrease with distance from there. The exception may be O_3, which, due to the atmospheric reactions involved, may reach maximum concentrations further from the project area.

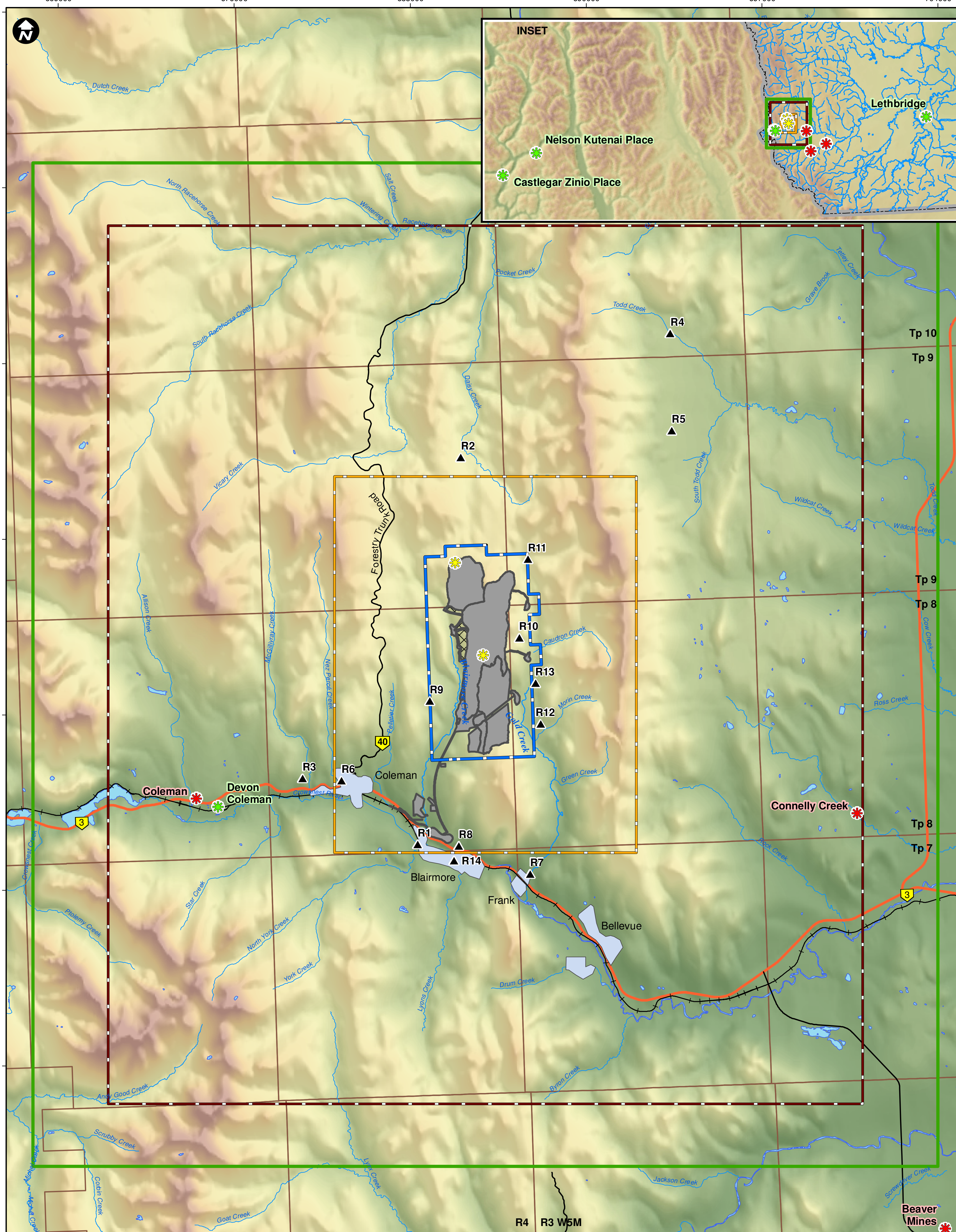
The rationale for determining the size and location of the study area for examining observed air quality is based on several factors:

- the location and strength of project emission sources. Project sources are largely limited to mine and haul fleets which result in near-surface releases. Dust from haul roads will be a large contributing factor to particulate emissions. The largest concentrations will be therefore immediately adjacent to sources;

- the location of potentially sensitive receptors including nearby residences and communities, parks and campgrounds;
- the study area just east of the Rocky Mountains includes elevation changes and several valleys which will influence dispersion through airflow channeling; and
- background concentrations from representative monitoring sites were added to model predictions.

Figure C2-1 shows the region of the project and the locations of monitoring stations in area surrounding the facility that provided background data.

The background data are temporally bounded by the end of the calendar year in which data are most recently available. At time of writing, the last complete year of available data was 2014. Five years of data are typically presented to provide an indication of recent trending, and data from 2006 – 2010 is utilized, where available.



LEGEND

- ▲ Special Receptor
- AQ Monitoring Station
- EC Meteorological Station
- Focus Monitoring Stations
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area
- Model Domain

Topography (masl)
High : 2500
Low : 1300

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

STUDY AREA AND BACKGROUND METEOROLOGICAL AND AIR QUALITY STATIONS

NOTES

AltaLIS, 2016; GeoBase, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

PROJECT:	14-00201-01
DRAWN BY:	JDC
CHECKED BY:	JS
DATE:	JUNE 16, 2016

0 2.5 5 10
Kilometres

FIGURE
C2-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air Q\Resubmission\Fig C2-1 Study Area and Background Meteorological and Air Quality Stations.mxd

C2.4 Air Quality, Meteorological and Climate Data Sources

C2.4.1 Data Sources near the RSA

Regional air quality and meteorological data has been summarized in this report. The following are the major sources of air quality information used in the preparation of this document:

- Table C2-2 and Figure C2-1 provide the locations of the air quality stations in the Calgary Regional Airshed Zone (CRAZ), the Alberta South Saskatchewan River Planning Area and southeastern British Columbia, and the type of measurements made at each station. The Coleman site was expected to be most representative based on proximity the Project; however, the number of air quality parameters measured at this station is limited. The Castlegar Zinio Place and Nelson Kutenai Place Stations are expected to be representative of rural concentrations, similar to the mine location. The parameters measured at each station are listed in Table C2-2. The information was obtained from the Clean Air Strategic Alliance Data Warehouse (CASA 2014, internet site) and from the National Air Pollution Survey Network (NAPS, 2014), central repositories for ambient air quality data collected in Alberta and Canada, respectively. CRAZ, Environment Canada (EC) and the respective station operators are responsible for performing quality control of the data.
- Climate normals and maximums for the thirty-year period from 1981 to 2010 were available from Coleman and Connelly Creek (Environment Canada 2010).
- Precipitation data was collected from 2004 to 2011 at Connelly Creek and Pincher Creek (Environment Canada, 2014, internet site). Data was not available past 2011.
- Precipitation speciation data from 2007 to 2011 at Kananaskis were used for the deposition calculations as it was the nearest available location (CASA 2014).
- Background data for CACs were available from a number of continuous air monitoring stations, as detailed in Table C2-2.

The EC Coleman and Connelly Creek stations are located with the Project Regional Study Area (RSA). The EC Beaver Mines and Pincher Creek Stations are located approximately 2.5 km south and 17 km east, respectively, of the modelling domain. The Pincher Creek station is within the town of Pincher Creek and Beaver Mines Station is located near sparsely distributed settlements.

The Devon Coleman AQ Monitoring Station is located with the RSA, with the remaining AQ stations located outside of the modelling Domain. The Devon station was set up to monitor a Gas Plant, which operated until October 2012. The Castlegar Zinio Place, Nelson Kutenai Place and Lethbridge stations are located approximately 195 km southwest, 225 km southwest and 100 km west, respectively. Castlegar Zinio Place station is located within the primarily residential area of Castlegar, B.C. The only major industrial source is Castlegar Sawmill located 5 km away. The Nelson

Kutenai Places station is in residential area of Nelson, B.C. with no industrial sources nearby.
The Lethbridge station is positioned in the northwest of the city of Lethbridge, surrounded mainly by food and agricultural processing facilities.

Table C2-2 Summary of Continuous Ambient Air Quality Stations in the Study Area, 2009 - 2014

Parameter	Devon Coleman-Savanna Creek	Lethbridge	Castlegar Zinio Place	Nelson Kutenai Place
Province	AB	AB	BC	BC
UTM E (m)	675369	370201	451922	478608
UTM N (m)	5500340	5508634	5462984	5482032
Data Period	2012	2010-2014	2011-2013	2009-2013
Wind Speed	√	√		
Wind Direction	√	√		
Air Temperature		√		
Relative Humidity		√		
Ground-level ozone (O_3)		√	√	√
Carbon Monoxide (CO)		√	√	
Nitrogen Oxides (NO_x)		√		
Nitrogen Oxide (NO)		√	√	
Nitrogen dioxide (NO_2)		√	√	
Particulates ($PM_{2.5}$)		√		√
Particulates (PM_{10})			√	√
Sulphur dioxide (SO_2)	√	√	√	
Total Reduced Sulphur (TRS)				

Source: CASA 2014, NAPS 2014

C2.4.2 Data Sources Downwind of Alberta Coal Mines

In addition to considering representative monitoring data from southern Alberta and southeastern B.C., Benga also reviewed measurements made downwind of coal mines in Alberta, regardless of location. The intent of this review was to determine how concentrations in the RSA located might be affected by mine operations near Sparwood, approximately 30 km west of the RSA.

To test this concept, monitoring stations of an equivalent distance downwind of coal mines in Alberta were analyzed. The three stations chosen for this comparative analysis are the Edson Station, located 67 km east of the Coal Valley Obed Mine, the Steeper Station located 22 km northeast of the Teck Coal Cheviot Mine and 55 km southeast of the Coal Valley Obed Mine and the Wagner Station, located 10 km southeast of the Capital Power Genesee Mine and 15 km northwest of the Transalta Highvale Mine. These stations are situated downwind of their respective coal mines listed in Table C2-3.

The results of the comparison are listed in Section C2.9.

Table C2-3 Summary of Continuous Ambient Air Quality Stations nearby to Coal Mines in Alberta, 2010 - 2014

Parameter	Edson	Steeper	Wagner
Province	AB	AB	AB
Airshed	WCAS	WCAS	WCAS
UTM E (m)	540189	493904	674420
UTM N (m)	5938479	5887014	5922676
Nearest Coal Mine	Coal Valley Obed Mine	Teck Coal Cheviot Mine/ Coal Valley Obed Mine	Capital Power Genesee Mine/ TransAlta Highvale Mine
Distance Relative to Coal Mine	67 km E	22 km NE/ 55 km SE	10 km SE/ 15 km NW
Data Period	2010-2014	2010-2014	2010-2014
Wind Speed	√	√	√
Wind Direction	√	√	√
Air Temperature	√	√	√
Relative Humidity		√	

Table C2-3 Summary of Continuous Ambient Air Quality Stations nearby to Coal Mines in Alberta, 2010 - 2014

Parameter	Edson	Steeper	Wagner
Ground-level ozone (O_3)	√	√	
Carbon Monoxide (CO)		√	
Nitrogen Oxides (NO_x)	√	√	√
Nitrogen dioxide (NO_2)	√	√	√
Particulates ($PM_{2.5}$)	√	√	
Particulates (PM_{10})			
Sulphur dioxide (SO_2)	√		√
Total Reduced Sulphur (TRS)			

Source: CASA 2016

WCAS – West Central Airshed Society

C3.0 AIR QUALITY MONITORING RESULTS

C3.1 Sulphur Dioxide

Table C3-1 summarizes measured SO_2 concentrations at air monitoring stations near the study area during recent years. Diurnal and seasonal fluctuations in SO_2 concentration based on 1-h measurements are shown in Figure C3-1 and Figure C3-2, respectively. The results indicate the following:

- Maximum 1-h SO_2 concentrations at the three air monitoring stations ranged from 84 μg/m^3 (Lethbridge) to 288 μg/m^3 (Castlegar Zinio), and were below the AAAQO of 450 g/m^3.
- The 24-h SO_2 concentrations ranged from 11 μg/m^3 (Lethbridge) to 128 μg/m^3 (Castlegar Zinio). Values at Castlegar Zinio exceeded the AAAQO of 125 μg/m^3 a total of 55 times during the five-year period. The concentrations at the other stations remain well below the AAAQO.
- The 30-day SO_2 concentrations ranged from 2.7 μg/m^3 (Lethbridge) to 38 μg/m^3 (Castlegar Zinio). Values at Castlegar Zinio exceeded the AAAQO of 30 μg/m^3 once during the five-year period, while the other stations remain well below the AAAQO.

- All the annual (median) SO_2 concentrations were about 10% or less of the AAAQO of 20 μg/m$^{3.}$
- SO_2 concentrations showed characteristic diurnal variations (Figure C3-1) at all stations with peak concentrations in the mid-day to early afternoon and minimums after midnight.
- SO_2 concentrations showed seasonal variations (Figure C3-2) at three stations with peak concentrations in the Winter.

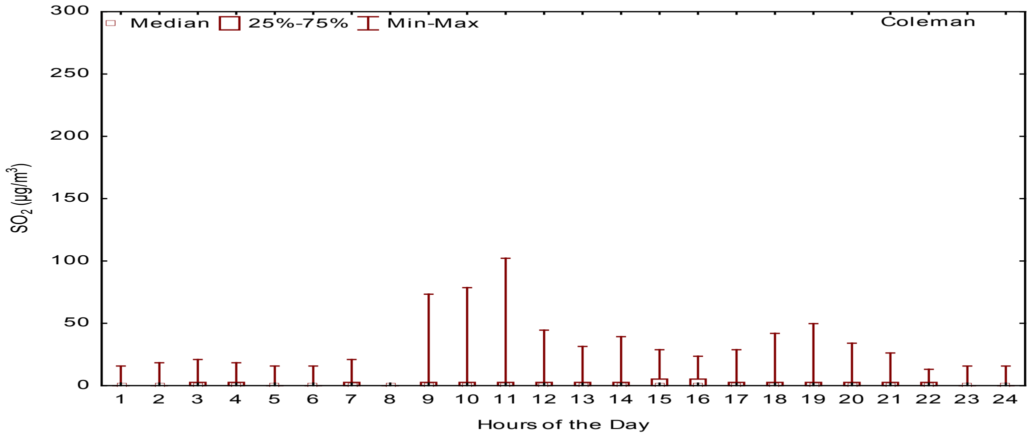
In accordance with Alberta Environment and Parks (AEP) for a detailed assessment, 90th percentile hourly and daily and annual average measurements are added to model predictions (AESRD 2013b). These concentrations form the background air quality for dispersion modelling.

While the Coleman station is nearest to the Project area, its measurements were likely influenced by the operation of the Devon gas plant, which is no longer in service. Therefore, the more rural Lethbridge site is expected to be most representative of the current Project area.

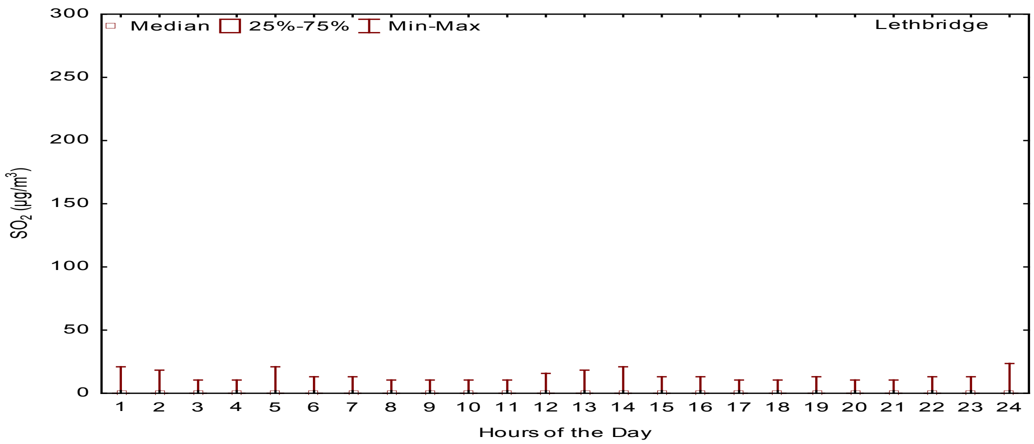
Table C3-1 SO_2 Concentrations (μg/m^3) Measured at Air Monitoring Stations, 2010-2014

Averaging Period	Devon Coleman[(b)]	Lethbridge	Castlegar Zinio Place[(c)]	Nelson Kutenai Place	AAAQO[(a)]
1-h Maximum	102	84	288	n/a	450
1-h 99th percentile	21	5.2	85	n/a	–
1-h 90th percentile	5.2	2.6	26	n/a	–
24-h Maximum	11	11	128	n/a	125
24-h 99th percentile	8.9	4.1	58	n/a	-
24-h 90th percentile	5.4	2.1	24	n/a	–
30-day Maximum	3.1	2.7	38	n/a	30
Annual Maximum	0.0	1.0	9.5	n/a	20
Annual 90th percentile	0.0	0.9	9.4	n/a	-

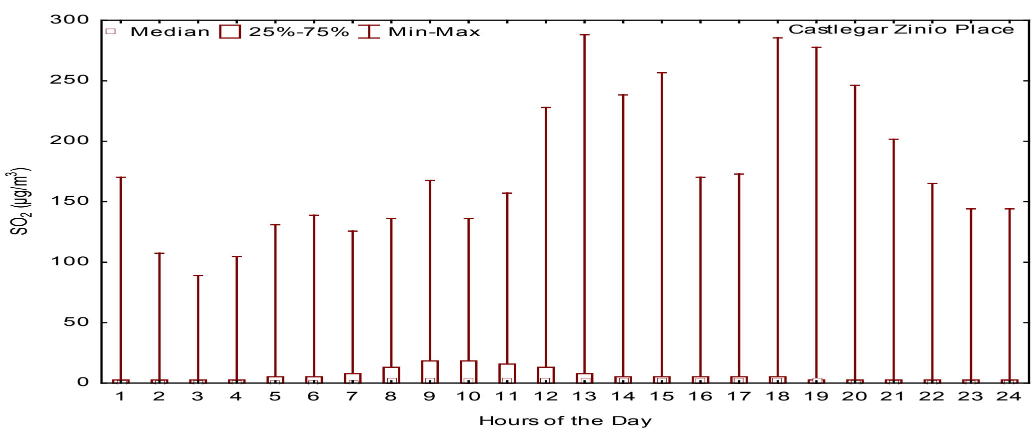
Data Source: CASA 2014
(a) Source: AESRD 2013b
(b) January 1, 2012 – August 23, 2012
(c) July 2011 – December 31, 2013
n/a Species not measured at this station
- No AAAQO for this averaging period.



Coleman, January 1, 2012 – August 31 2012

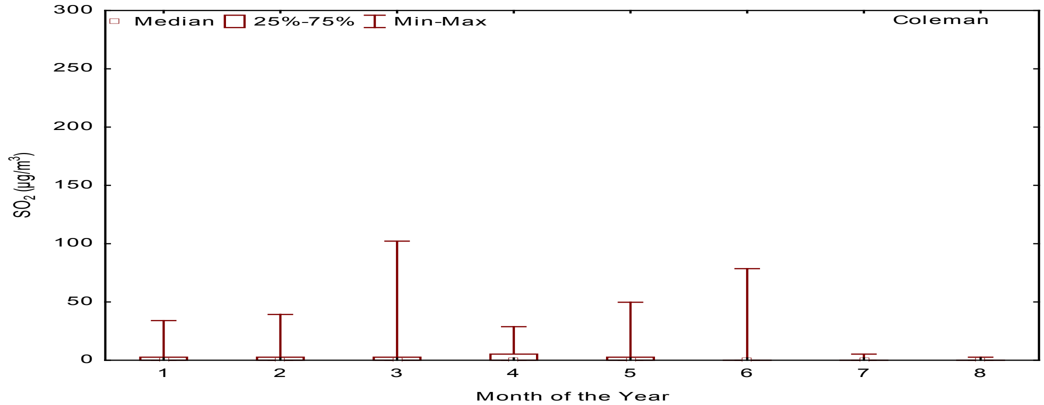


Lethbridge, January 1, 2010 –December 31, 2014

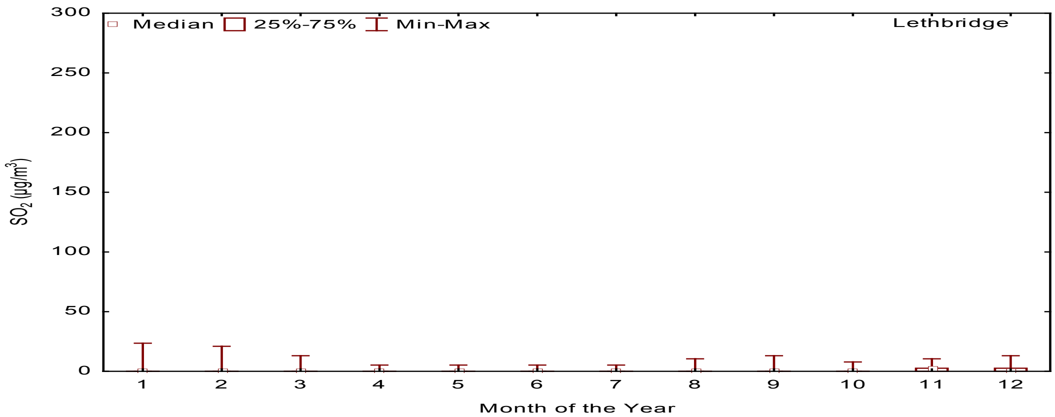


Castlegar Zinio Place, July 1, 2011 – December 31, 2013

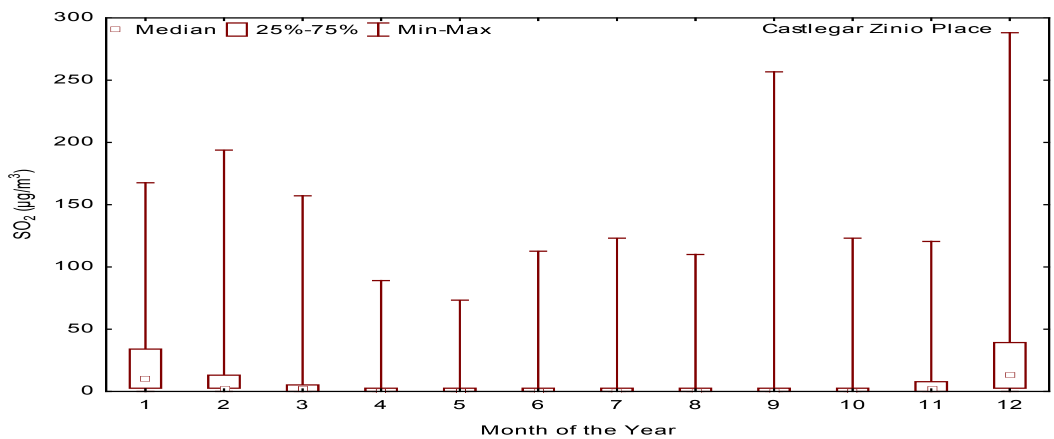
Figure C3-1 Diurnal Variation in SO_2 Concentration at Three Air Monitoring Stations, 2010-2014. Data Source: CASA 2014, NAPS 2014.



Coleman, January 1, 2012 – August 31 2012



Lethbridge, January 1, 2010 – December 31, 2014



Castlegar Zinio Place, July 1, 2011 – December 31, 2013

Figure C3-2 Seasonal Variation in SO_2 Concentration at Three Air Monitoring Stations, 2010-2014. Data Source: CASA 2014, NAPS 2014.

C3.2 Nitrogen Oxides

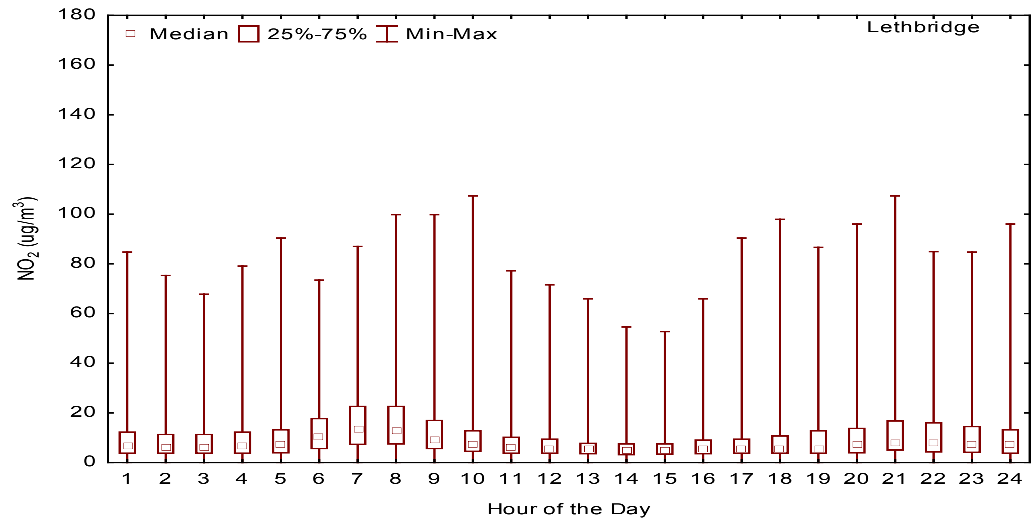
Table C3-2 summarizes measured NO_2 concentrations from Lethbridge and Castlegar Zinio, the two stations nearest to the project that measure NO_2. Data are presented from 2010 to 2014. Diurnal fluctuations in NO_2 concentration based on 1-h measurements are shown in Figure C3-3, while seasonal trends are presented in Figure C3-4. The results indicate the following:

- Maximum 1-h NO_2 concentrations are 62 µg/m³ (Castlegar Zinio) and 107 µg/m³ (Lethbridge), which are both below the AAAQO of 300 g/m³.
- Annual maximum NO_2 concentrations are 12 µg/m³ (Castlegar Zinio) and 11 µg/m³ (Lethbridge) and are all below the AAAQO of 45 µg/m³.
- At Castlegar Zinio, the diurnal variation of NO_2 concentration peaked in the morning and the afternoon. At Lethbridge, the diurnal peak concentrations occurred in the morning and the evening. Minimums occurred in early afternoon at both locations.
- NO_2 concentrations were highest during winter months at Castlegar Zinio Place, with peaks in May and October. NO_2 concentrations were highest during January and November at Lethbridge.

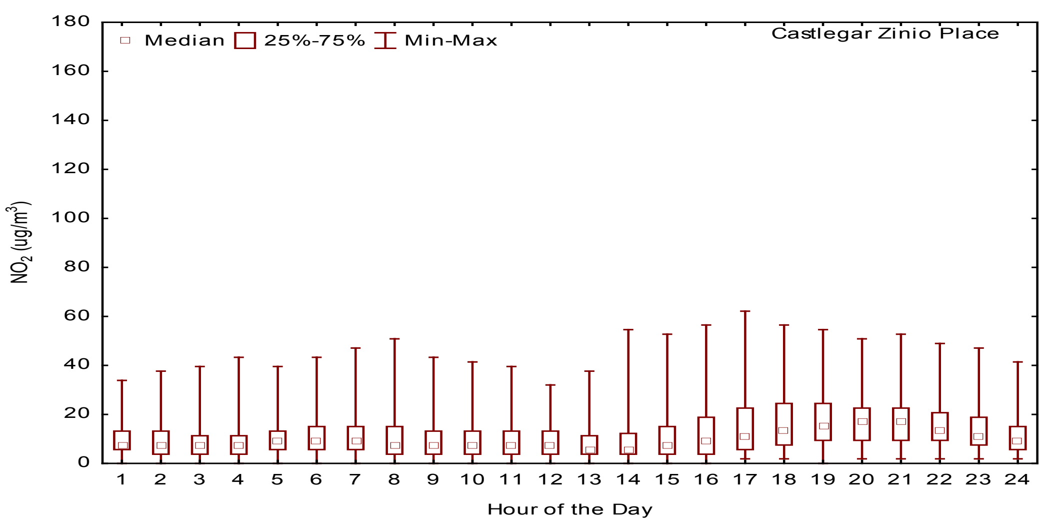
Table C3-2 NO_2 and NO_x Concentrations (µg/m³) Measured at Air Monitoring Stations, 2007-2010

Averaging Period	NO_x Lethbridge	NO_x AAAQO[(a)]	NO_2 Lethbridge	NO_2 Castlegar Zinio Place[(b)]	NO_2 AAAQO[(a)]
1-h Maximum	495	–	107	62	300
1-h 99th percentile	104	–	57	40	–
1-h 90th percentile	32	–	24	25	–
Annual Maximum	17	–	11	12	45
Annual 90th percentile	17	–	11	12	-

Data Source: CASA 2014
(a) Source: AESRD 2013
(b) July 2011 – December 31, 2013
n/a Species not measured at this station
- No AAAQOs for this averaging period.

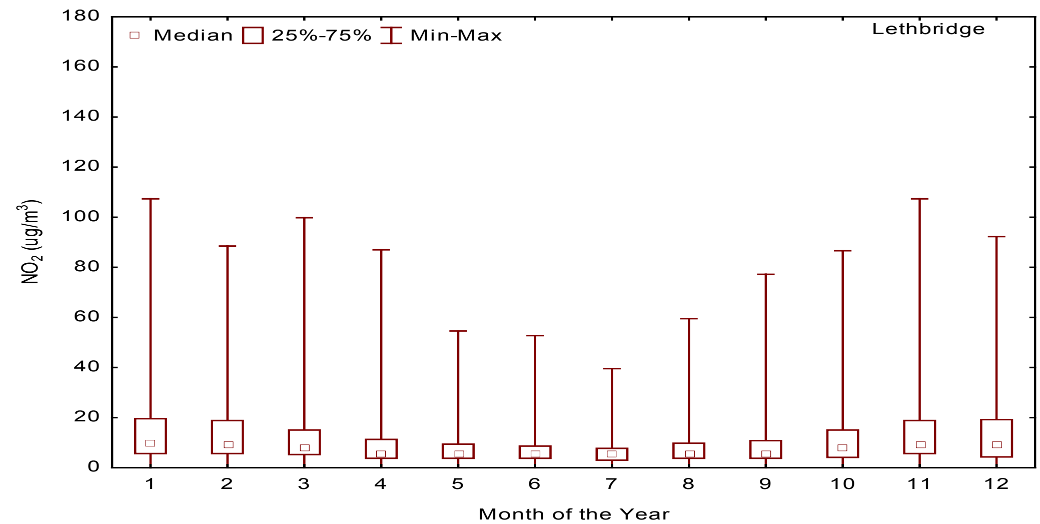


Lethbridge, January 1, 2010 – December 31, 2014

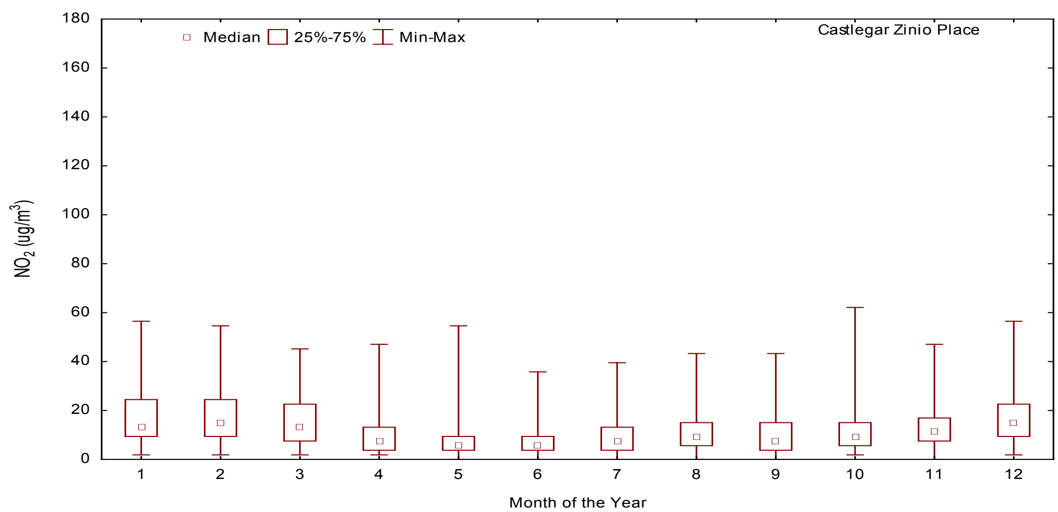


Castlegar Zinio Place, April 3, 2012 – December 31, 2013

Figure C3-3 Diurnal Variation of NO_2 at Two Air Monitoring Stations. Data Source: CASA 2014, NAPS, 2014.



Lethbridge, January 1, 2010 – December 31, 2014



Castlegar Zinio Place, April 3, 2012 – December 31, 2013

Figure C3-4 Seasonal Variation of NO_2 at Two Air Monitoring Stations. Data Source: CASA 2014, NAPS, 2014.

C3.3 Particulate Matter Smaller than 2.5 µm – $PM_{2.5}$

Table C3-3 summarizes $PM_{2.5}$ concentrations measured at the Lethbridge and Nelson Kutenai Place stations, as the Devon Coleman and Castlegar Zinio stations do not measure $PM_{2.5}$. Nelson Kutenai Place and Lethbridge $PM_{2.5}$ measurements were taken using a tapered element oscillating microbalance (TEOM) system. Diurnal and seasonal fluctuations in $PM_{2.5}$ concentration based on 1-hour measurements are shown in Figure C3-5 and Figure C3-6, respectively. The results indicate:

- The hourly maximum observed concentration was 230 µg/m³ at Lethbridge and 104 µg/m³ at Nelson Kutenai. High values are listed in Table C3-4, and can be attributed to the August 2010 fire.
- The maximum 24-h concentrations ranged from 49 µg/m³ (Nelson Kutenai) to 115 µg/m³ (Lethbridge), above the AAAQO of 30 µg/m³. As shown in Table C3-4, the majority of these exceedances occurred from August 20 to 21, 2010, and can be attributed to forest fire activity.
- The 24-h 90th percentile value was 12 µg/m³ at Lethbridge and 6.8 µg/m³ at Nelson.
- Diurnal variations in $PM_{2.5}$ levels (Figure C3-5) at Lethbridge result in peak concentrations occurring during in the morning and evening. At Nelson Kutenai peak concentrations occur in the morning and at night.
- Seasonal fluctuations in $PM_{2.5}$ levels at Nelson Kutenai (Figure C3-6) indicated that the highest concentrations occurred generally in July and August. This correlates well with seasonal increases in brush fire activity and dry unpaved road conditions. Peak concentrations for Lethbridge occurred from July to November.

Analysis to support the conclusion that fires are an important source of PM2.5 has been conducted by AEP (AENV 2009). AEP states on p. 17, "Fine particulate matter levels in northern Alberta are largely driven by forest fire smoke influence, with many episodes being backed out of the analysis for this reason." Regarding winter exceedances, AEP states "Anthropogenic sources (industrial activity in the area) influence $PM_{2.5}$ levels in the wintertime during periods of stagnant winds." This statement was valid for the period of data reviewed for the current assessment, as wintertime exceedances were observed in periods of lower speed or calm winds.

The frequency of fire events is shown in Figure C3-7 for 2009 to 2013 taken from the BC Wildfire website (BC WFM, 2014). The 2009 image shows wildfires which occurred in close proximity to the Nelson Kutenai Station. The Nelson Kutenai $PM_{2.5}$ data obtained from EC had no data from July 1 to July 23 2009. Table C3-6 shows most high $PM_{2.5}$ observations occurred in August 2010. There was an increase in forest fire activity in central BC over that time period in 2010 according to the BC Wildfire Location database.

The Nelson station montane setting is expected to be more representative of the Project location than the prairie Lethbridge site.

Table C3-3 PM2.5 Concentrations (µg/m³) Measured at Air Monitoring Stations, 2010-2014

Averaging Period	Lethbridge	Nelson Kutenai Place(c)	AAAQO(a)
1-h Maximum	230	104	80(b)
1-h 90th percentile	15	8.0	80(b)
24-h Maximum	115	49	30
24-h 99th percentile	25	12	30
24-h 90th percentile	12	6.8	–
Annual Maximum	7.8	4.1	–
Annual 90th percentile	7.6	4.0	–

Data Source: CASA 2014
(a) Source: AESRD 2013
(b) AEP guideline, not AAAQO
(c) January 1, 2009 – December 31, 2013
n/a species not measured at this station
- No AAAQOs for this averaging period.

Table C3-4 Highest $PM_{2.5}$ Values, 2010-2014

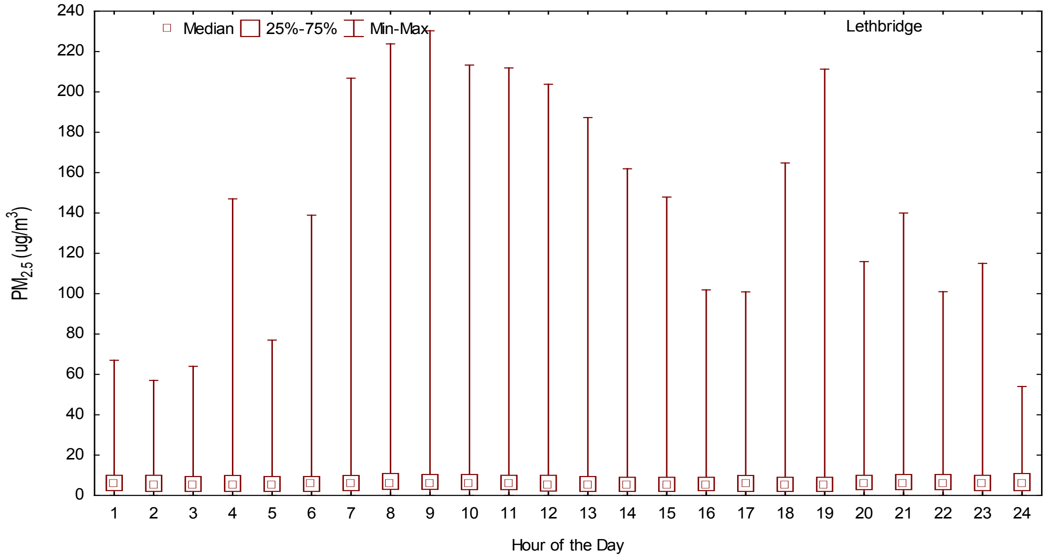
Averaging Period	Criteria	Lethbridge	Nelson Kutenai Place[c]
Hourly (> 80 µg/m3)(a,b)	**Number of Exceedances**	25	8
	Period	15 h: Aug 20, 2010 1 h: Aug 21, 2010 3 h: Nov 27, 2011 1 h: Sept 23, 2012 3 h: Oct 14, 2012 2 h: Apr 27, 2013	7 h: Aug 2, 2009 1 h: Jul 29, 2010
Daily (> 30 µg/m3)(a)	**Number of Exceedances**	6	1
	Period	2 d: Aug 20-21, 2010 2 d: Dec 2-3, 2010 1 d: Sep 23, 2012 1 d: Jul 13, 2014	1h: Aug 2, 2009

Data Source: CASA 2014

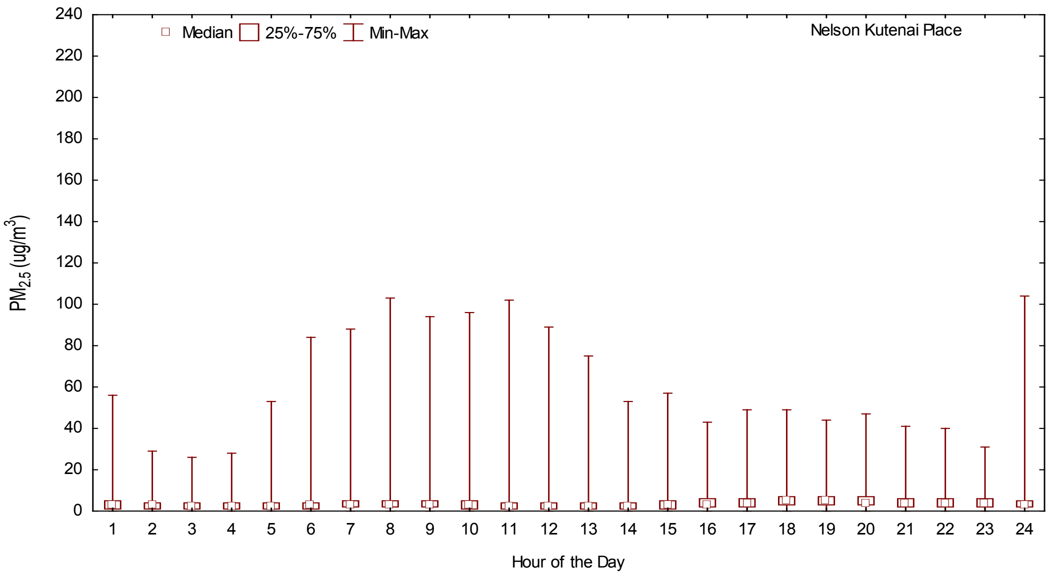
[a] Source: AESRD 2013

[b] AEP guideline, not AAAQO

[c] January 1, 2009 – December 31, 2013

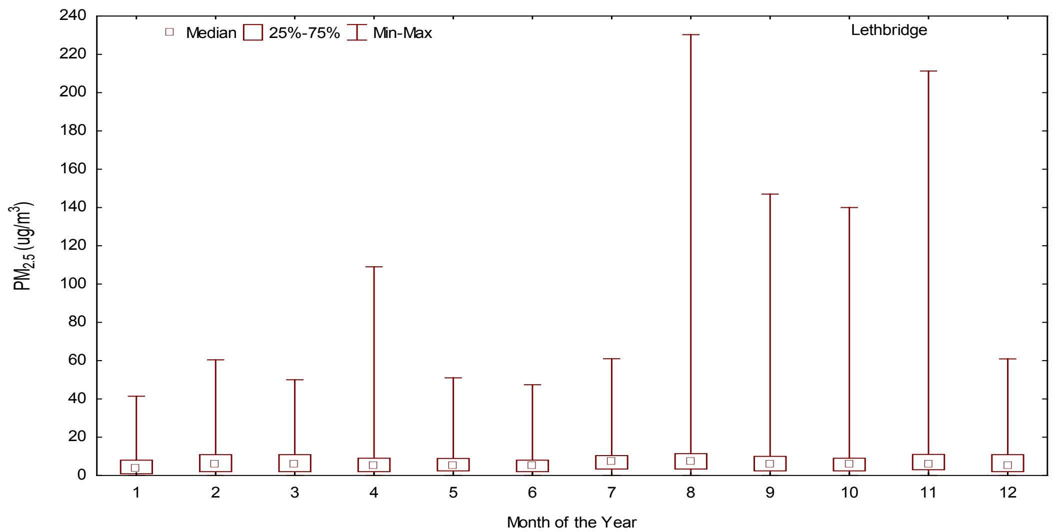


Lethbridge, January 1, 2010 – December 31, 2014

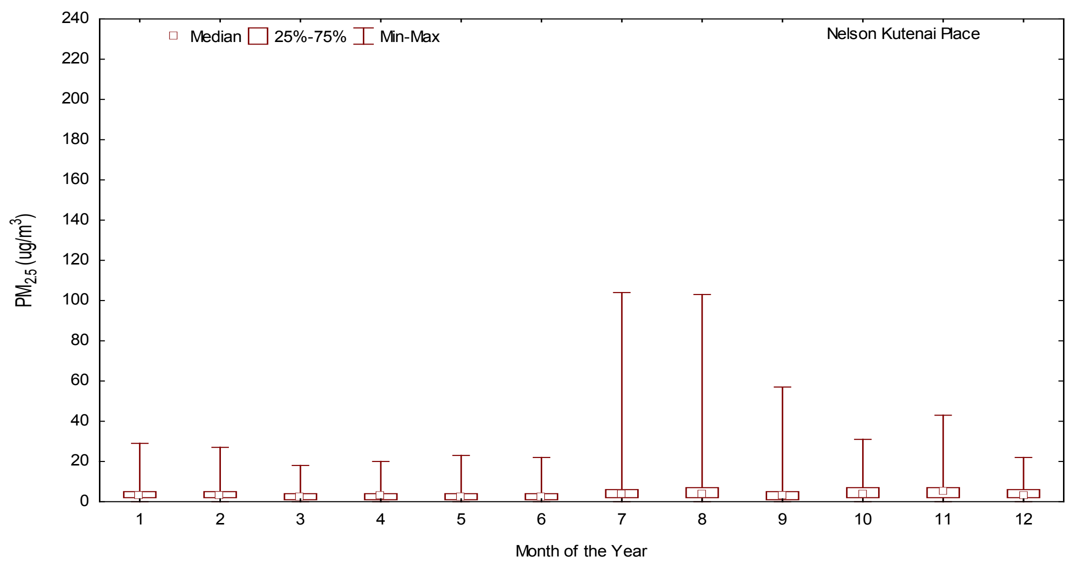


Nelson Kutenai Place, January 1, 2009 – December 31, 2013

Figure C3-5 Diurnal Variation of $PM_{2.5}$ at Two Air Monitoring Stations. Data Source: CASA 2014, NAPS, 2014.



Lethbridge, January 1, 2010 – December 31, 2014



Nelson Kutenai Place, January 1, 2009 – December 31, 2013

Figure C3-6 Seasonal Variation of PM2.5 at Two Air Monitoring Stations. Data Source: CASA 2014, NAPS, 2014.

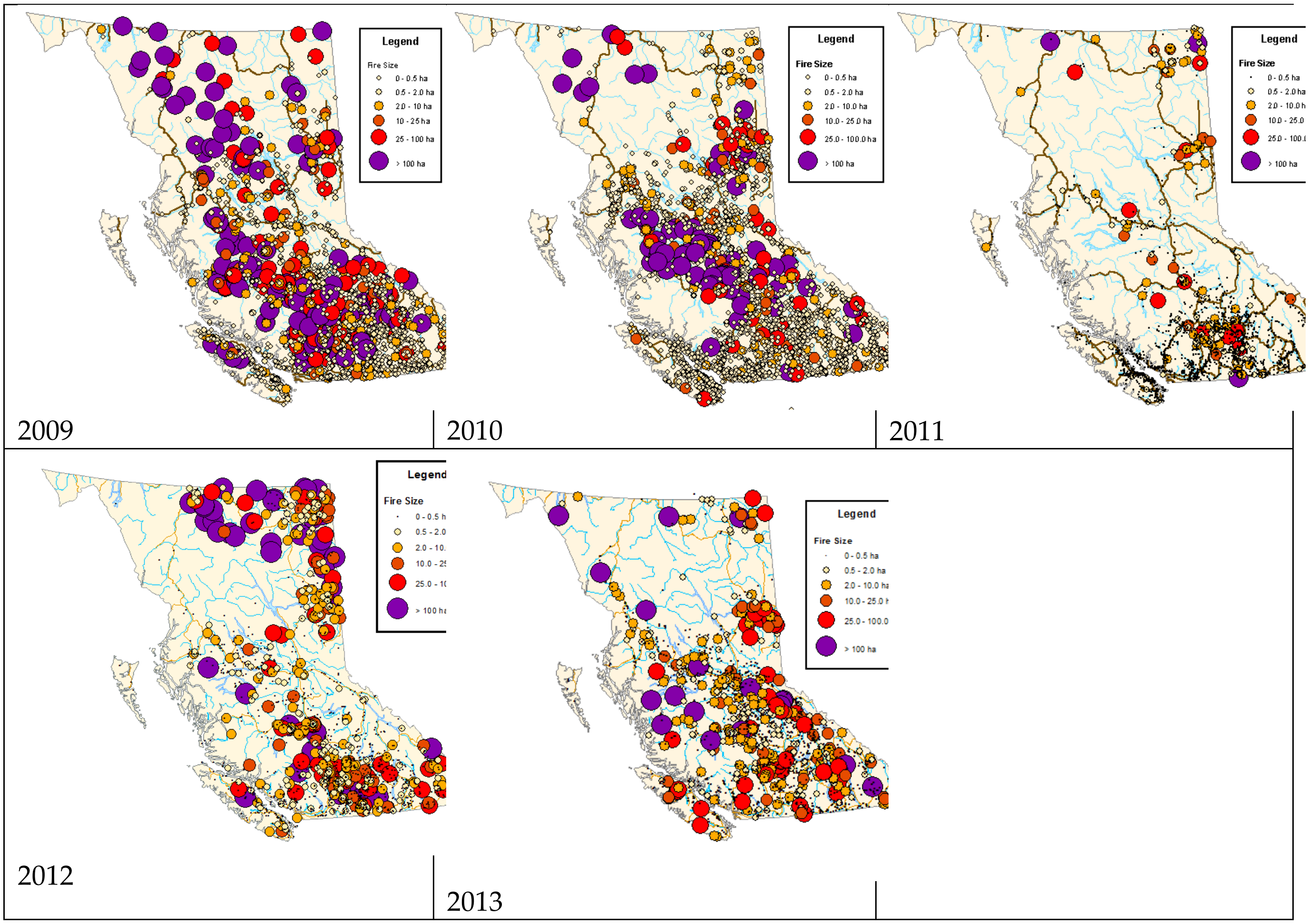


Figure C3-7 Forest Fire Hotspots for 2009 – 2013 (BC WMB, 2014).

C3.4 Particulate Matter Smaller than 10 µm – PM_{10}

Table C3-5 summarizes PM_{10} concentrations measured at the stations included in this analysis. There are no AAAQOs for PM_{10}, although British Columbia has a standard of 50 µg/m^3 for the maximum 24-hour concentration. This information is presented for a benchmark for PM_{10} predictions.

Seasonal fluctuations in PM_{10} concentration based on 1-h measurements are shown in Figure C3-7. The results indicate:

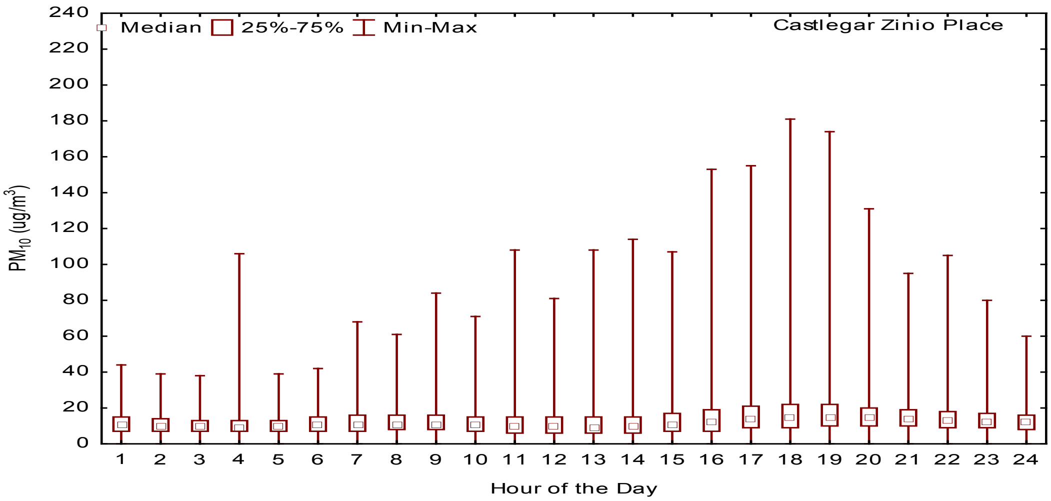
- The hourly maximum observed concentrations were 181 µg/m^3 and 183 µg/m^3 at Castlegar Zinio and Nelson Kutenai, respectively.
- Maximum 24-hour concentrations ranged from 65 µg/m^3 (Castlegar Zinio) to 80 µg/m^3 (Nelson Kutenai). The 24-hour BC standard was exceeded 41 times at Castlegar Zinio, and 81 times at Nelson Kutenai.
- Figure 3-8 shows peak concentrations occur in the evening at Castlegar Zinio and in morning to evening at Nelson Kutenai.
- Seasonal peak concentrations (Figure 3-9) appeared in February-March at Castlegar Zinio and in February-March and August-October at Nelson Kutenai. It is expected the Nelson Kutenai values in the fall are the result of forest fire activity.

Table C3-5 PM_{10} Concentrations (μg/m³) Measured at Air Monitoring Stations, 2010 -2014

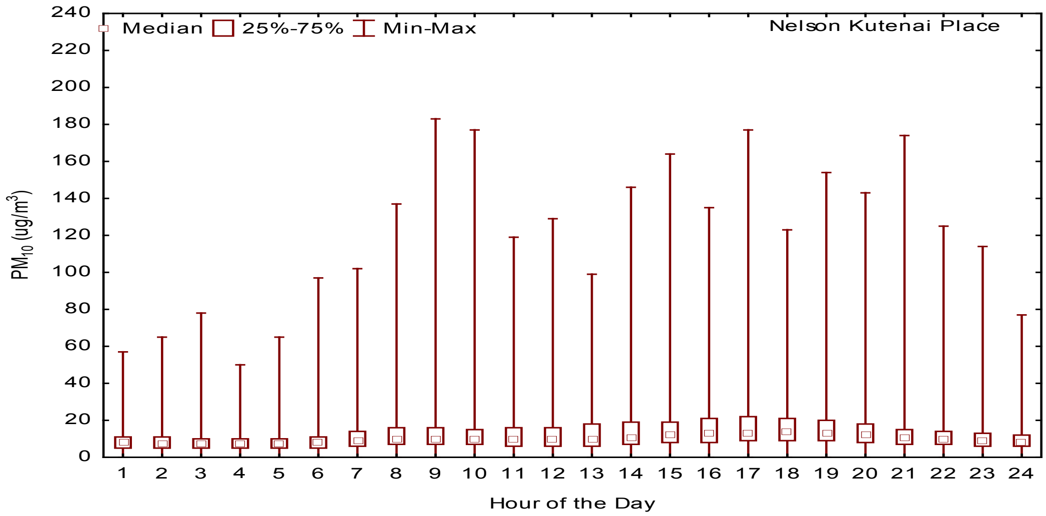
Averaging Period	Castlegar Zinio Place[c]	Nelson Kutenai Place[d]	AAQG[a]
1-h Maximum	181	183	-
1-h 90th percentile	23	23	-
24-h Maximum	65	80	30
24-h 99th percentile	33	39	-
24-h 90th percentile	21	21	-
Annual Maximum	14	13	-
Annual 90th percentile	14	13	-

Data Source: CASA 2014, NAPS 2014
[a] British Columbia Air Quality Guideline (BCE, 2009)
[b] CCME 2012
[c] June 11, 2011 – December 31, 2013
[d] January 1, 2009 – December 31, 2013

- No AAAQOs for this averaging period.

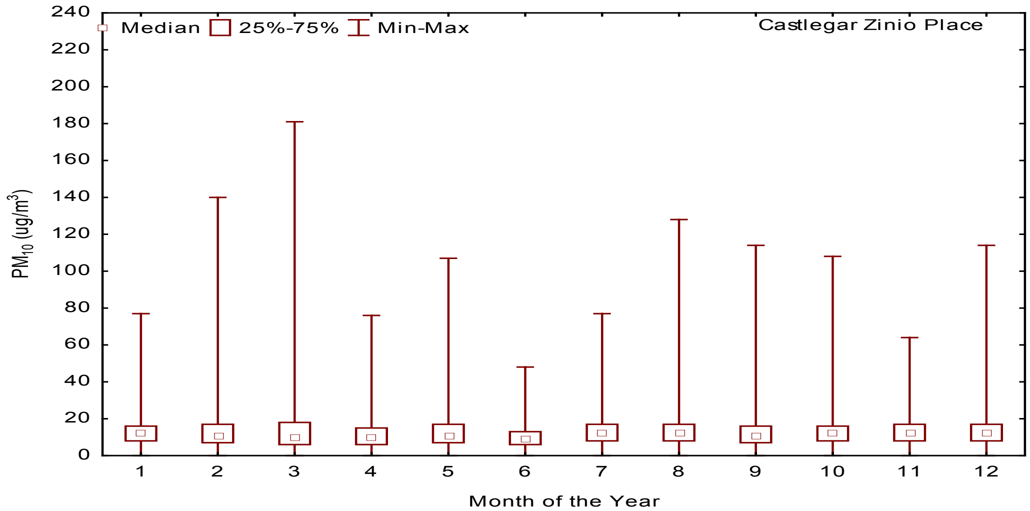


Castlegar Zinio Place, July 11, 2011 – December 31, 2013

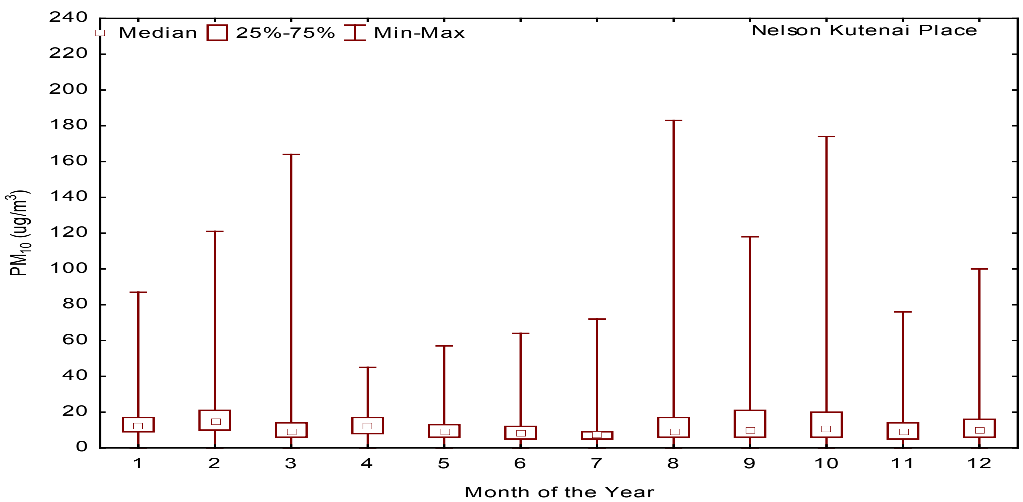


Nelson Kutenai Place, January 1, 2009 – December 31, 2013

Figure C3-8 Diurnal Variation of PM_{10} Concentrations at Two Air Monitoring Stations, 2006-2010. Data Source: NAPS 2014.



Castlegar Zinio Place, July 11, 2011 – December 31, 2013



Nelson Kutenai Place, January 1, 2009 – December 31, 2013

Figure C3-9 Seasonal Variation of PM_{10} Concentrations at Two BC Air Monitoring Society Stations, 2006-2010. Data Source: NAPS, 2014.

C3.4 Ozone

Table C3-6 summarizes measured O_3 concentrations at three air monitoring stations near the study area. These measurements are presented for information purposes as AEP (AESRD 2013a) requires that standard values be used in modelling.

Diurnal fluctuations in O_3 concentration based on 1-h measurements are shown in Figure C3-10, while seasonal trends are presented in Figure C3-11. The results indicate the following:

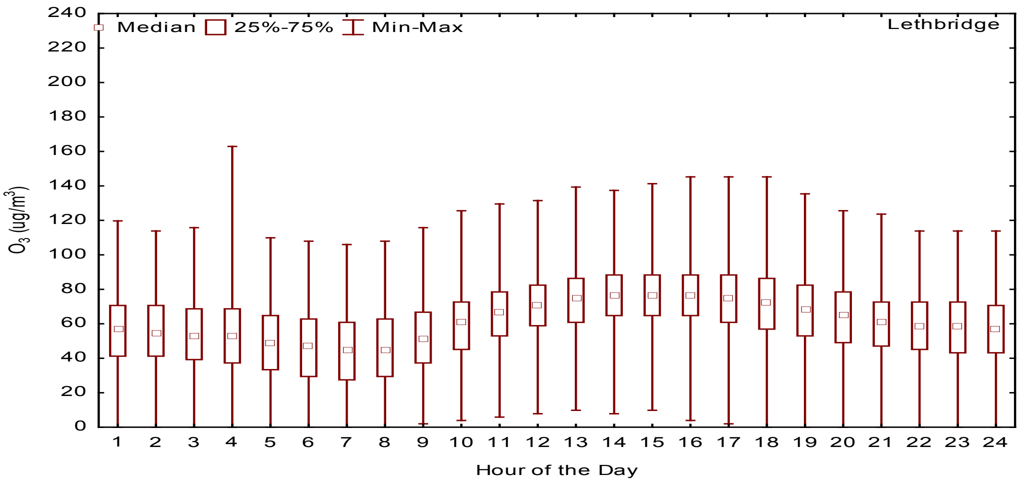
- At Lethbridge, the 1-h maximum O_3 values exceeded the AAAQO of 160 µg/m^3 once in the five year period. This exceedance occurred in September. July peak values at all stations are likely due to photochemical production.
- At Castlegar Zinio Place, the 1-h maximum O_3 values exceed the AAAQO of 160 µg/m^3 16 times over the five year period. All but one occurrences occurred in 2013, with thirteen occurring in December 2013.
- Median O_3 concentrations peak in mid-afternoon (about 16:00). The lowest concentrations occur in early morning (about 06:00). These ground level ozone trends correlate well with the daily solar maximum which is responsible for initiating the photo-chemical reactions necessary to form ozone.

Ozone was not modelled in the assessment but the potential impact of the project was determined by comparison of Project precursor emissions to regional emissions.

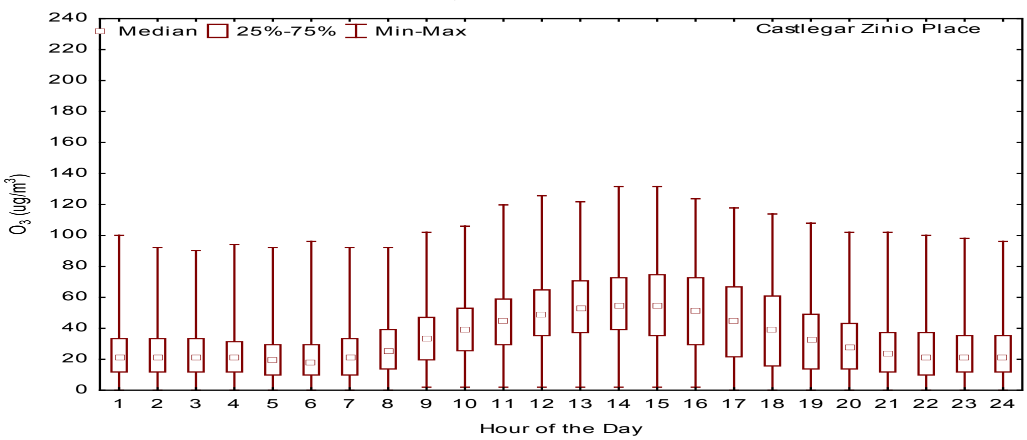
Table C3-6 O_3 Concentrations (µg/m^3) Measured at Air Monitoring Stations, 2010-2014

Averaging Period	Lethbridge	Castlegar Zinio Place[(b)]	Nelson Kutenai Place[(c)]	AAAQO/CAAQS[(a)]
1-h Maximum	163	288	128	160
1-h 99th percentile	112	85	94	–
1-h 90th percentile	88	26	73	–
8-h Maximum	131	24	71	124, 122[(d)]
8-h 90th percentile	85	7.9	58	-

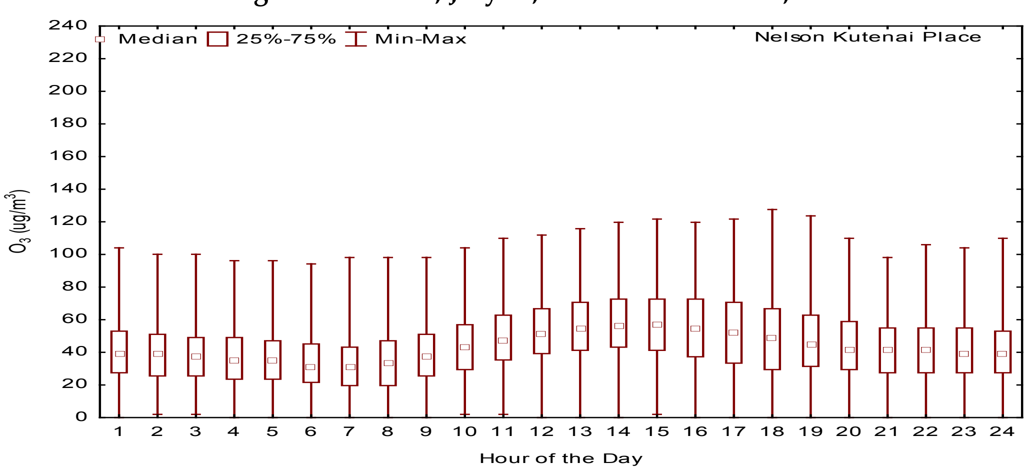
Data Source: CASA 2014, NAPS 2014
(a) AESRD 2013
(b) July 11, 2011 – December 31, 2013
(c) January 1, 2010 – December 31, 2013
(d) CAAQS implemented in 2015 and to be implemented in 2020.
- No AAAQO/CAAQS for this averaging period.



Lethbridge, January 1, 2010 – December 31, 2014

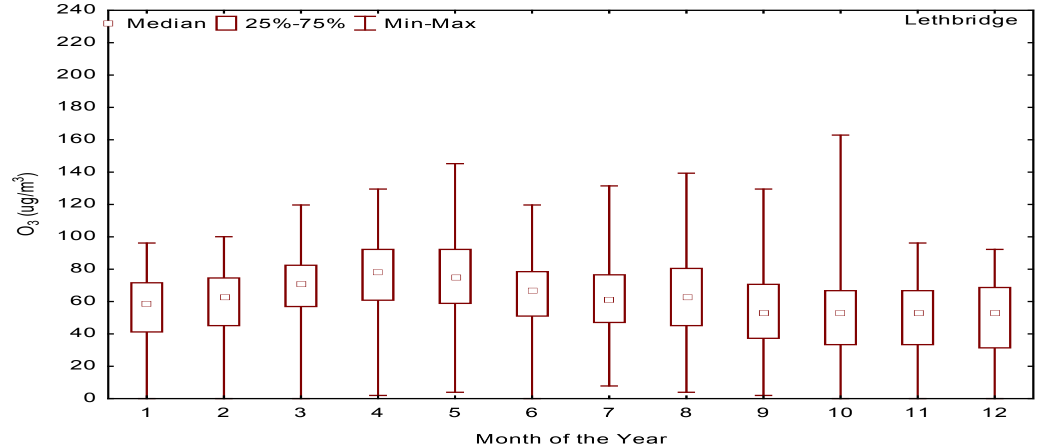


Castlegar Zinio Place, July 11, 2011 – December 31, 2014

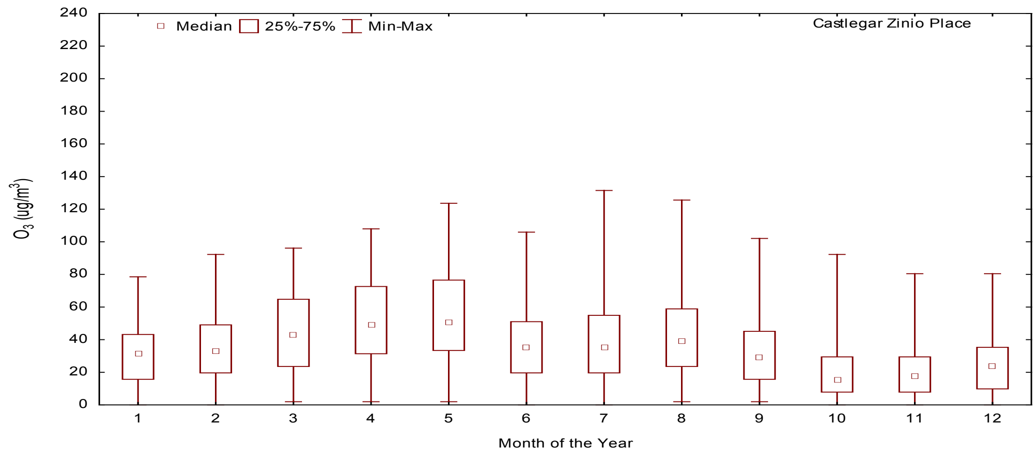


Nelson Kutenai Place, January 1, 2010 – December 31, 2013

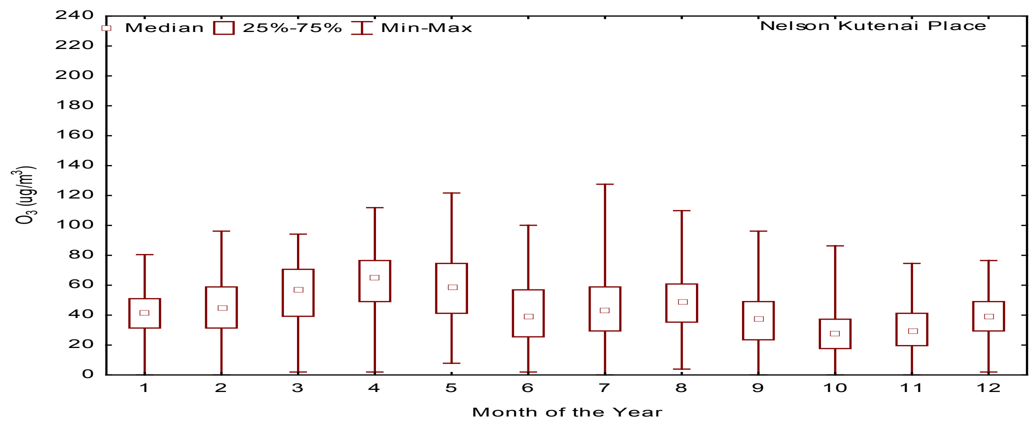
Figure C3-10 Diurnal Variation in O_3 Concentrations at Air Monitoring Stations. Data Source: CASA 2014, NAPS 2014.



Lethbridge, January 1, 2010 – December 31, 2014



Castlegar Zinio Place, July 11, 2011 – December 31, 2014



Nelson Kutenai Place, January 1, 2010 – December 31, 2013

Figure C3-11 Seasonal Variation of O_3 Concentrations at Three Air Monitoring Stations. Data Source: CASA 2014, NAPS 2014.

C3.5 Carbon Monoxide

CO concentrations were measured at the Lethbridge station and Castlegar Zinio Place Station. These data are presented in Table C3-7, and all measurements are below the hourly AAAQO of 15,000 µg/m^3.

Because measured concentrations are low relative to AAAQOs, seasonal and diurnal plots are not presented.

Table C3-7 Carbon Monoxide (CO) Concentrations Measured at Air Monitoring Station

Averaging Period	Lethbridge	Castlegar Zinio Place[b]	Nelson Kutenai Place	AAAQO[a]
1-hour Maximum	2,634	1,489	n/a	15,000
1-hour 99th percentile	573	687	n/a	-
1-hour 90th percentile	344	573	n/a	-
8-hour Maximum	1,002	716	n/a	-
8-hour 99th percentile	515	652	n/a	-
8-hour 90th percentile	301	515	n/a	8,000

Data Source: CASA, 2014, NAPS, 2014.
[a] Source: AENV, 2009b
[b] July 2011 – December 31, 2013
n/a Species not measured at this station

C3.6 Ammonia

Ammonia is not a Project emission. Ammonia contributes to secondary particulate formation and to deposited nitrogen and potential acid input. Ambient ammonia monitoring data near the project area were available at Lethbridge. Because of agricultural emissions in the Lethbridge area, ammonia concentrations are expected to be much lower in the Project area. As shown in Table C3-8, the maximum hourly concentration observed in both areas was significantly less than the AAAQO of 1400 µg/m^3.

Monitoring data (Table C3-8) from the Lethbridge area were used as model inputs in the determination of nitrogen chemistry.

Table C3-8 Ammonia Concentrations (μg/m³) Measured at Lethbridge Station

Averaging Period	Lethbridge	AAAQO[a]
Maximum 1-hour	140	1400
Average 1-hour	22	1400
Median 1-hour	1.4	1400

Data Source: CASA, 2014, NAPS, 2014.

[a] Source: AESRD, 2013

[b] July 2011 – December 31, 2013

C3.7 Acid Deposition

Acid deposition estimates in the following sections are inferred from measurements in the region, not from direct measurements. Estimates were made from stations in the CRAZ and Southern Alberta region and are representative of possible deposition seen in the area of the project. These deposition estimates are compared to precipitation data from the Kananaskis passive monitoring station in Section C3.7.4.

C3.7.1 Dry Deposition of Sulphate and Nitrate

The SO_2 and SO_4^{2-} deposition during 2007 to 2014, calculated from continuous measurements at Lethbridge station, and from 2007 to 2014 for passive measurements at three CRAZ and Southern Alberta stations are summarized in Table C3-9.

Sulphate and nitrate deposition were calculated as the product of a dry deposition velocity and average ground-level air concentrations. Calculations assume a deposition velocity of 0.58 cm/s based on average estimates in the Fort McMurray region (EPCM 2002).

Table C3-9 Period Average Sulphur Dioxide Measurements and Sulphate Dry Deposition Estimates, 2007 to 2014

Location	Measurement Type	SO_2 Concentration [μg/m³]	SO_2 Deposition [kg/ha/yr]	SO_4^{2-} Deposition [kg/ha/yr]	SO_4^{2-} Equivalent Deposition [keq/ha/yr]
Kananaskis Village[(a)]	Passive	0.84	1.5	2.3	0.048
Pincher Creek Airport[(b)]	Passive	0.55	1.0	1.5	0.031
Wild Rose Colony[(c)]	Passive	0.92	1.7	2.5	0.053
Lethbridge	Continuous	0.48	0.88	1.3	0.027

Data Source: CASA 2014

[(a)] Valid Measurements at Kananaskis Village are from 2011 to 2014

[(b)] Valid Measurements at Pincher Creek Airport are from 2007 to 2009

[(c)] Valid Continuous Measurements at Wild Rose Colony are from 2011 to 2014

The NO_2 and NO_3^- deposition during 2007 to 2011, as calculated from continuous measurements at Lethbridge Station, and from 2003 to 2012 for passive measurements, are summarized in Table C3-10. Calculations assume a deposition velocity of 0.19 cm/s based on estimated regional averages (EPCM 2002). Average concentrations based on continuous measurements are typically higher than passive concentrations, although part of the explanation for the difference may be that data periods are not identical.

Pippus (2012) examined sources of uncertainty in the Lakeland Industry and Community Association network by comparing passive and continuous measurements of SO_2 and NO_2 as well as co-located duplicate passive measurements from 2009 to 2011. The results of the Pippus study indicated that passive and continuous measurements exhibited the same trends, even when the actual values were statistically significantly different, and that the disparities between passive and continuous results were not consistent for all pollutants. For H_2S and SO_2 results, passive samplers were consistently higher than the reported values from continuous monitors with the discrepancy increasing as concentrations increased. Conversely, NO_2 results from passive samplers demonstrated consistently lower reported values than collocated continuous monitors.

A more comprehensive study by Curran *et al.*, (2012) examined over 1000 passive measurements in five airshed zones in relatively low concentration environments in Alberta and compared them to continuous measurements. The study concluded that the passive monitors generally followed the same trends as the continuous monitors. Like the Pippus (2012) study, the Curran *et al.*, (2012) study found that relative to continuous measurements, NO_2 concentrations are under-estimated (by about

40% on average) and SO_2 concentrations are over-estimated (by about 60% to 70%) by passive monitors.

Both studies found, relative to continuous measurements, passive NO_2 concentrations are under-estimated and SO_2 concentrations are over-estimated. The impact on PAI estimates will vary depending on the proportion of these two constituents in the air at any particular monitoring location.

Table C3-10 Period Average Nitrogen Dioxide and Nitrate Dry Deposition Estimates, 2007 to 2014

Location	Measurement Type	NO_2 Concentration [μg/m³]	NO_2 Deposition [kg/ha/yr]	NO_3- Deposition [kg/ha/yr]	NO_3- Equivalent Deposition [keq/ha/yr]
Kananaskis Village[(a)]	Passive	1.2	0.71	0.96	0.015
Pincher Creek Airport[(b)]	Passive	1.8	1.1	1.5	0.023
Wild Rose Colony[(c)]	Passive	2.0	1.2	1.6	0.026
Lethbridge	Continuous	11	6.6	8.82	0.142

Data Source: CASA 2013

(a) Valid Measurements at Kananaskis Village are from 2011 to 2014

(b) Valid Measurements at Pincher Creek Airport are from 2007 to 2009

(c) Valid Continuous Measurements at Wild Rose Colony are from 2011 to 2014

C3.7.2 Wet Deposition

Precipitation chemistry measurements are made periodically throughout the year at Kananaskis. Kananaskis, the closest precipitations station, is about 145 km from the Project. Annual precipitation rates were used to calculate wet deposition. The precipitation chemical composition from 2007 to 2011 at Kananaskis, taken from the CASA data warehouse (CASA 2014), are summarized in Table C3-11 (precipitation data past 2011 is not available at this station).

Table C3-11 Wet Deposition Rates (kg/ha/yr) in Precipitation at Kananaskis, 2007 to 2011

Year	Sulphate SO_4^{2-}	Nitrate NO_3^-	Ammonium NH_4^+	Sodium Na^+	Potassium K^+	Calcium Ca^{2+}	Magnesium Mg^{2+}
2007	3.13	2.94	1.12	0.13	0.54	0.98	0.19
2008	4.89	3.53	1.67	0.22	0.34	1.26	0.27
2009	2.33	2.13	0.77	0.11	0.15	1.20	0.21
2010	2.37	2.32	0.68	0.08	0.20	0.87	0.16

Table C3-11 Wet Deposition Rates (kg/ha/yr) in Precipitation at Kananaskis, 2007 to 2011

Year	Sulphate SO_4^{2-}	Nitrate NO_3^-	Ammonium NH_4^+	Sodium Na^+	Potassium K^+	Calcium Ca^{2+}	Magnesium Mg^{2+}
2011	2.24	2.24	0.62	0.19	0.18	0.74	0.11
Average	**2.99**	**2.63**	**0.97**	**0.15**	**0.28**	**1.01**	**0.19**

Data Source: CASA 2014

The equivalent rates of wet deposition calculated from the precipitation chemistry measurements are summarized in Table C3-12. Although ammonia (NH_4^+) is a cation, once in the soil it oxidizes with oxygen into nitrate that will acidify the soil (this is the so-called "nitrification process").

Potential Acid Input (PAI) from wet (or dry) deposition is calculated by the following equation:

$$\text{PAI (keq/ha/yr)} = 2\frac{[SO_4^{2-}]}{96} + \frac{[NO_3^-]}{62} + \frac{[NH_4^+]}{18} - \left(\frac{[K^+]}{39} + \frac{[Na^+]}{23} + 2\frac{[Ca^{2+}]}{40} + 2\frac{[Mg^{2+}]}{24}\right)$$

The average wet PAI deposition during 2007 to 2011 at Kananaskis was 0.079 keq/ha/yr.

Table C3-12 Wet Deposition Rates (keq/ha/yr) at Kananaskis, 2007 to 2011

	Sulphate SO_4^{2-}	Nitrate NO_3^-	Ammonium NH_4^+	Sodium Na^+	Potassium K^+	Calcium Ca^{2+}	Magnesium Mg^{2+}	PAI Wet Deposition
2007	0.065	0.047	0.062	0.006	0.014	0.049	0.016	0.091
2008	0.102	0.057	0.093	0.010	0.009	0.063	0.022	0.149
2009	0.048	0.034	0.043	0.005	0.004	0.060	0.017	0.040
2010	0.049	0.037	0.038	0.004	0.005	0.043	0.013	0.060
2011	0.047	0.036	0.035	0.008	0.005	0.037	0.009	0.058
Average	**0.063**	**0.043**	**0.055**	**0.006**	**0.007**	**0.051**	**0.016**	**0.079**

Note: Based on the assumption that 100% of nitrogen deposition contributes to PAI.
Data Source: CASA 2014

C3.7.3 Dry Deposition of Cations

Eder and Dennis (1990) developed a general linear regression method to estimate surface-level air concentrations of sodium, calcium, magnesium, and potassium base cations (Na^+, Ca^{2+}, Mg^{2+}, and K^+) from precipitation concentrations. Monthly measured air concentrations at Beaverlodge and Esther from 1991 to 1999 were then used to develop a regression to be used in western Canada by Chaikowsky (2001). The equations and their regression correlation values for the relationship between air concentrations (in μg/m^3) of Na^+, Ca^{2+}, Mg^{2+}, and K^+ and precipitation concentrations (in mg/L) are listed in Table C3-13.

Table C3-13 Alberta (Beaverlodge and Esther) Linear Regression Equations

Cation	Linear Regression Equations	Correlation
Sodium (Na^+)	Air Concentration = 0.5414(Precipitation Concentration) + 0.0279	0.84
Calcium (Ca^{2+})	Air Concentration = 0.1906(Precipitation Concentration) + 0.1166	0.32
Magnesium (Mg^{2+})	Air Concentration = 0.3459(Precipitation Concentration) + 0.0147	0.86
Potassium (K^+)	Air Concentration = 0.2958(Precipitation Concentration) + 0.0285	0.35

Data Source: Chaikowsky 2001

The mean precipitation chemistry data for 2007 to 2011 at Kananaskis was obtained from CASA and is listed in Table C3-14. The air concentration of cations estimated by the Alberta regression equation (Table C3-13) and their dry deposition rates are listed in Table C3-15. The dry deposition rates are estimated by multiplying the air concentration of cations with the dry deposition velocity, and the resulting deposition rate is expressed in units of keq/ha/yr. Because of the large variation in deposition velocities, a typical deposition velocity of 0.01 m/s, as suggested by Eder and Dennis (1990), was used for all cations. The average dry cation deposition during 2007 to 2011 at the Kananaskis station was 0.044 keq/ha/yr.

Table C3-14 Mean Precipitation Cation Composition (mg/L) at Kananaskis, 2007 to 2011

	Sodium Na^{+}	Calcium Ca^{2+}	Magnesium Mg^{2+}	Potassium K^{+}
2007	0.035	0.190	0.051	0.104
2008	0.032	0.186	0.049	0.053
2009	0.039	0.340	0.059	0.057
2010	0.033	0.231	0.043	0.052
2011	0.053	0.182	0.029	0.053
Average	**0.038**	**0.225**	**0.046**	**0.064**

Data Source: CASA 2014

Table C3-15 Dry Cation Concentration and Deposition Rates at Kananaskis, 2007 to 2011

	Sodium Na^{+}	Calcium Ca^{2+}	Magnesium Mg^{2+}	Potassium K^{+}	Total Dry Cation
Concentration (μg/m³)					
2007	0.047	0.153	0.032	0.059	0.291
2008	0.045	0.152	0.032	0.044	0.273
2009	0.049	0.181	0.035	0.045	0.310
2010	0.046	0.161	0.030	0.044	0.280
2011	0.057	0.151	0.025	0.044	0.277
Dry deposition (keq/ha/yr)					
2007	0.006	0.024	0.008	0.005	0.044
2008	0.006	0.024	0.008	0.004	0.042
2009	0.007	0.029	0.009	0.004	0.048
2010	0.006	0.025	0.008	0.004	0.043
2011	0.008	0.024	0.006	0.004	0.042
Average	0.007	0.025	0.008	0.004	0.044

Data Source: CASA 2014

C3.7.4 Potential Acid Input

Potential acid input (PAI) deposition rates are estimated from continuous Lethbridge measurements from 2007 to 2014 and passive measurements from 2007 to 2014, as well as Kananaskis precipitation chemistry data from 2007 to 2014. Data from both the continuous and passive measurements are provided in Table C3-16. Data within this table is based on information provided in Tables C3-9 to C3-10, modified as follows:

- Dry NO_2 deposition doubled to account for nitric acid deposition (Kindzierski *et al*., 2006), which is meant to be applicable near major emission sources but has been applied to all measurements.

The PAI levels from CRAZ and Southern Alberta in Table C3-16 are similar to the PAI and Cation levels seen at Kananaskis in Table C3-12 and Table C3-15.

Table C3-16 Average Potential Acid Input Estimates From Measurements

Location	Measurement Type	Nitrate	Sulphate	PAI	Cations	Total PAI
		Dry Deposition [keq/ha/yr]	Dry Deposition [keq/ha/yr]	Wet Deposition [keq/ha/yr]	Dry Deposition [keq/ha/yr]	Deposition [keq/ha/yr]
Kananaskis Village	Passive	0.015	0.048	0.079	0.044	0.100
Pincher Creek Airport	Passive	0.023	0.031	0.079	0.044	0.091
Wild Rose Colony	Passive	0.026	0.053	0.079	0.044	0.115
Lethbridge	Continuous	0.142	0.027	0.079	0.044	0.206

[(a)] Data Source: CASA (2014).

C3.8 Volatile Organic Compounds (VOCs) and Polycyclic Aromatic Hydrocarbons (PAHs)

To our knowledge, speciated PAH and VOC measurements have not been made in the region, and background estimates were based on data from a variety of sources including the Fort Air Partnership (FAP, 2005), other publically available air quality assessments and monitoring reports (Luscar, 2006; AENV 2002, 2004b), Hazardous Substance Database (HSDB, 2004, 2006). This information is included in the Section C5.0, which summarizes the background concentrations used in the air dispersion modelling. Background concentrations based on these data sources are expected to be conservatively high.

Short-term, occasional PAH measurements from the AEP Mobile Air Monitoring Laboratory (MAML) were available for a representative region downwind of coals and are presented in Table C3-17. The majority of the readings collected by MAML in the Edson/Hinton Area were below the equipment detection limit of 0.003 μg/m^3 which results in a median value below the detection limit. Of the available data, the average reading was 0.003 μg/m^3. No VOC data was available through MAML.

Table C3-17 1-hour Average Total PAH Concentration (μg/m^3) Measured through AEP's Mobile Air Monitoring Laboratory

Averaging Period	Town of Edson	Edson Area	Town of Hinton	AAAQO[(a)]
Maximum 1-hour	0.034	b/d	0.038	0.034
Average 1-hour	0.004	0.003	0.004	0.004
Median 1-hour	b/d	b/d	b/d	b/d
Total Hours of Monitoring	44	32	76	

[(a)] Measurements taken at 5 area locations between November 2004 and October 2007.
[(b)] Measurements taken at 18 area sites between September 1999 and June 2000.
[(c)] AENV 2011
- No AAAQO for this species or averaging period
b/d – below detection limit.

C3.9 Ambient Metal Concentrations

Ambient metal concentrations measured at the Genesee Air Monitoring Station were obtained for 2005 – 2009. The maximum 24-hour concentration over the five year period is reported in Table C3-18.

None of the maximum measured metal concentrations were above the AAAQOs, the Texas Effects Screening Levels (TCEQ, 2010) or the Ontario Ambient Air Quality Standards (OMOE, 2005). In the absence of measured percentiles, maximum 1-hour and 24-hour observed concentrations were used as modelling background.

Table C3-18 Ambient Metal Concentrations at the Genesee Monitoring Station

Species	24-hour Maximum Concentration at Genesee Monitoring (µg/m³)	24-hour Maximum Concentration at Powers Monitoring[(a)] (µg/m³)	Average of Genesee and Powers Station Measurements – Used for Background (µg/m³)[(b)]	Alberta Objectives [µg/m³] [(c)]		TCEQ Effects Screening Levels [µg/m³] [(d)]		Ontario Standards [µg/m³] [(e)]	
				Short-term (1-hour)	Long-term (annual)	Short-term (1-hour)	Long-term (annual)	Short-term (1/2 hour)	Long-term (24-hour)
Aluminum (Al)	0.502	n/a	0.502	-	-	50	5	-	-
Antimony (Sb)	0.000797	n/a	0.000797	-	-	5	0.5	-	-
Arsenic (As)	0.000773	0.000533	0.000653	0.1	0.01	0.1	0.01	1	0.3
Barium (Ba)	0.00820	0.00377	0.005985	-	-	5	0.5	-	-
Beryllium (Be)	0.000014	n/a	0.000014	-	-	0.02	0.002	0.03	0.01
Cadmium (Cd)	0.000554	0.000209	0.000382	-	-	0.1	0.01	5	2
Cobalt (Co)	0.00739	n/a	0.00739	-	-	0.2	0.02	0.3	0.1
Chromium (Cr)	0.00471	n/a	0.00471	1	-	1	0.1	5	1.5
Copper (Cu)	0.0277	n/a	0.0277	-	-	10	1	100	50
Mercury (Hg)	0.000021	0.000021	0.000021	-	-	0.25	0.025	5	2
Manganese (Mn)	0.0112	0.00432	0.00776	2	0.2	2	0.2	7.5	2.5
Molybdenum (Mo)	0.000773	n/a	0.000773	-	-	50	5	100	120
Nickel (Ni)	0.0436	n/a	0.0436	6	0.05	0.15	0.015	5	2
Lead (Pb)	0.00377	0.00495	0.00436	1.5	-	1.5	-	6	2

Table C3-18 Ambient Metal Concentrations at the Genesee Monitoring Station

Species	24-hour Maximum Concentration at Genesee Monitoring (µg/m³)	24-hour Maximum Concentration at Powers Monitoring[a] (µg/m³)	Average of Genesee and Powers Station Measurements – Used for Background (µg/m³)[b]	Alberta Objectives [µg/m³] [c]		TCEQ Effects Screening Levels [µg/m³] [d]		Ontario Standards [µg/m³] [e]	
				Short-term (1-hour)	Long-term (annual)	Short-term (1-hour)	Long-term (annual)	Short-term (1/2 hour)	Long-term (24-hour)
Selenium (Se)	0.000803	0.000636	0.00072	-	-	2	0.2	20	10
Thallium (Tl)	0.0000475	n/a	0.0000475	-	-	1	0.1	-	-
Uranium (U)	0.0000225	n/a	0.0000225	-	-	0.5[f]	0.05[g]	-	-
Vanadium (V)	0.00120	n/a	0.0012	-	-	0.5	0.05	5	2
Zinc (Zn)	0.0156	n/a	0.0156	-	-	0.5	0.05	100	120

n/a Monitoring data not available at this station for specified metal
- No AAAQO for this metal.
(a) Data available for 2006 only
(b) If no data was available for the Powers station, the measurement from the Genesee station was used.
(c) AESRD 2013b
(d) TCEQ, 2010
(e) OMOE, 2005
(f) For Uranium, soluble compounds
(g) For Uranium, soluble compounds

C3.10 Comparison of Background Concentrations at Other Potential Locations

Section C2.4.2 identified three stations downwind of coal mines west of Edmonton that might yield representative background concentrations for use in the Project air quality assessment.

Tables C3.19 to C3.22 compare 90th percentile observations from the background station used in the air quality assessment to the three stations. The difference in background values relative to the AAAQO of the downwind stations, Steeper, Edson and Wagner when compared to the assessment stations, Lethbridge and Nelson Kutenai, are typically between -6% to +6%. For annual NO_2 and $PM_{2.5}$, larger percentage differences (20% and 27%) are observed due to the lower magnitude of values being compared, but the absolute differences are small. There was not a full year of PM_{10} data available for the 2010 to 2014 period.

Based on this comparison, there is no compelling information that suggests the data from stations west of Edmonton are more representative for the RSA than the southern stations used in the assessment. In all cases, the values are similar in percentage or absolute terms compared to the AAAQO.

Table C3.19 Comparison of Background to Other Air Monitoring Stations Downwind of Coal Mines for SO_2

Averaging Period	Background – Lethbridge (ug/m³)	Edson (ug/m3)	Wagner (ug/m3)	AAAQO (ug/m3)
1-h 90th percentile	2.6	2.6	5.2	450
24-h 90th percentile	2.1	1	0.7	125
Monthly	2.7	1.1	0.96	30
Annual 90th percentile	0.9	0.58	0.31	20

Table C3.20 Comparison of Background to Other Air Monitoring Stations Downwind of Coal Mines for NO_2

Averaging Period	Background - Lethbridge (ug/m3)	Edson (ug/m3)	Steeper (ug/m3)	Wagner (ug/m3)	AAAQO (ug/m3)
1-h 90th percentile	24	39	7.5	23	300
Annual 90th percentile	11	12	2.2	8.6	45

Table C3.21 Comparison of Background to Other Air Monitoring Stations Downwind of Coal Mines for $PM_{2.5}$

Averaging Period	Background – Nelson Kutenai (ug/m3)	Edson (ug/m3)	Steeper (ug/m3)	AAAQO (ug/m3)
1-h 90th percentile	8	10	6	80
24-h 90th percentile	6.8	5.4	3.1	28
Annual 90th percentile	4	3.5	1.6	8.8

Table C3.22 Comparison of Background to Other Air Monitoring Stations Downwind of Coal Mines for CO

Averaging Period	Background – Lethbridge (ug/m3)	Steeper (ug/m3)	AAAQO (ug/m3)
1-hour 90th percentile	344	229	15000
8-hour 90th percentile	301	229	6000

C3.11 Comparison of Background Concentrations to Local Measurements

Benga has begun collection of limited air quality data on site and in the community. The following information is collected:

- SO_2, NO_2 and ozone using passive samplers at the planned processing plant site. Data are 30-day averages. Apart from SO_2, these averaging periods do not correspond to averaging periods of the AAAQOs.
- Dustfall (total and fixed) at six locations including one at the planned processing plant site and five in the community. The information is directly comparable to AAAQGs.

Sampling locations are listed in Table C3.23 and Figure C3.10-2. Dustfall 5 and the passive sampler are located near the proposed processing plant site.

Table C3.23 Dustfall and Passive Measurement Locations, April 2016

Name	Easting	Northing	Location
Dustfall 1	682973	5500233	residence
Dustfall 2	683368	5498825	campground
Dustfall 3	683674	5498978	Hospital
Dustfall 4	685186	5498202	residence
Dustfall 5	685876	5504877	Plant Site
Dustfall 6	688604	5499204	residence
Passive	685878	5504877	Plant Site

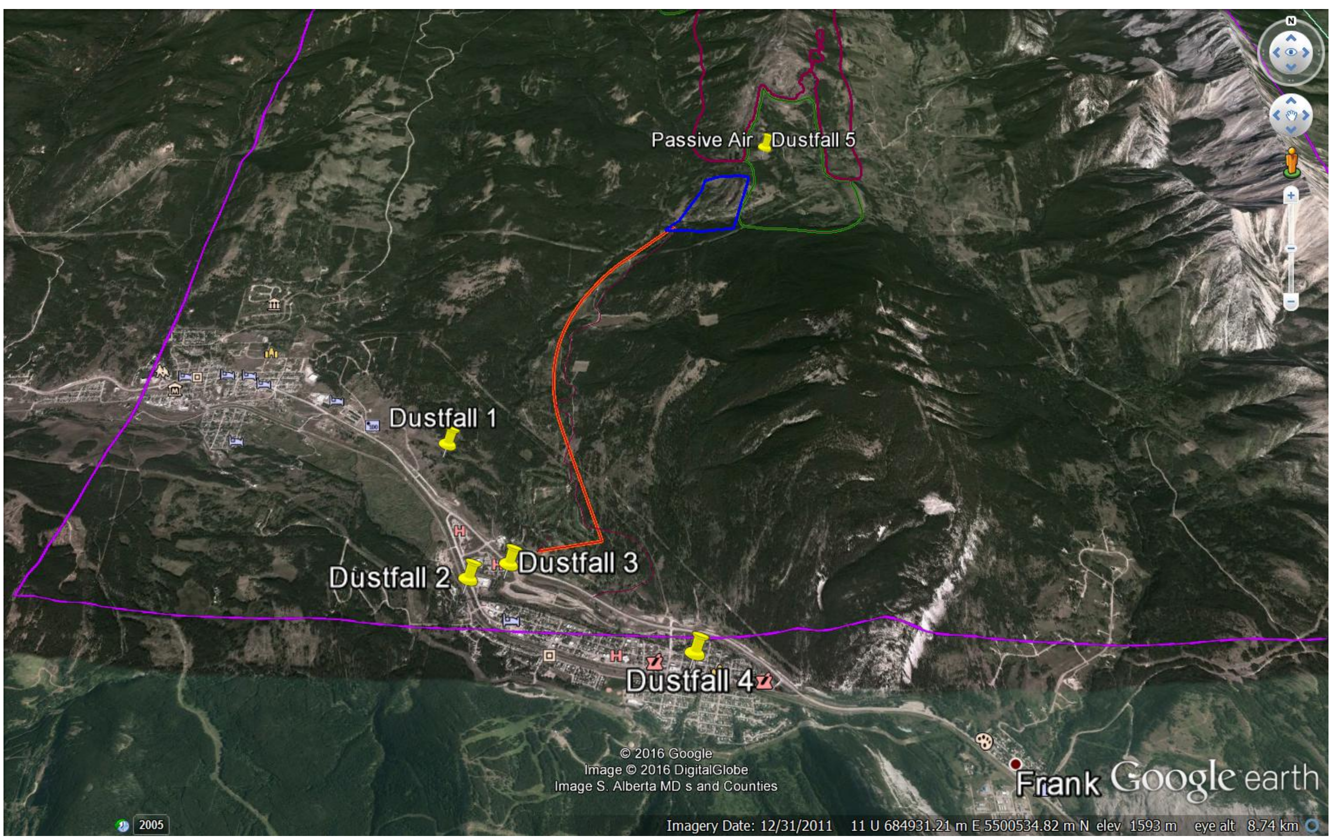


Figure C3.10-1 Benga sampling locations for dustfall and passive SO_2, NO_2, and O_3.

Two months of dustfall observations are currently available. These are summarized in Table C3.24 which indicates that the dustfall at the proposed plant site location, at the side of a dirt road, is higher than at other sites. The 2nd highest measurements are on the 1st floor roof of a condo building staircase in the back alley. Dustfall measurements at all locations could be compared to the residential AAAQG of 58 mg/100 cm^2/30 days.

Table C3.24 Dustfall Measurement Results, May-June 2016

	DF – 1	DF – 2	DF – 3	DF – 4	DF – 5	DF – 6
	mg/100 cm^2/30day					
April	3	6	10	33	113	6
May	20	21	37	53	99	34
AAAQG						
Resident	53	53	53	53	53	53
Industrial	158	158	158	158	158	158

Two months of passive data are also available and summarized in Table C3.25. SO_2 measurements (0.1 ppb or 0.04 μg/m^3) are well below the 30-day AAAQO of 11 ppb and below the 30-day background level of 1.0 μg/m^3 in Table C5-1. Similarly, the observed 30-day NO_2 concentration of 0.3 ppb (0.6 μg/m^3) is well below the annual NOx background of 11 μg/m^3. With only two months of data available, and no measurements at the averaging time of most AAAQOs, it can't be determined to what extent local measurements are comparable to the background values in Section C5.

Table C3.25 Passive Sampling Results, May-June 2016

Parameter	Units	AAAQO	April	May
NO_2	ppb	n/a	0.3	0.2
O_3	ppb	n/a	37.1	30.3
SO_2	ppb	11	<0.1	0.1

C4.0 METEOROLOGY AND CLIMATOLOGY MEASUREMENTS

C4.1 Winds

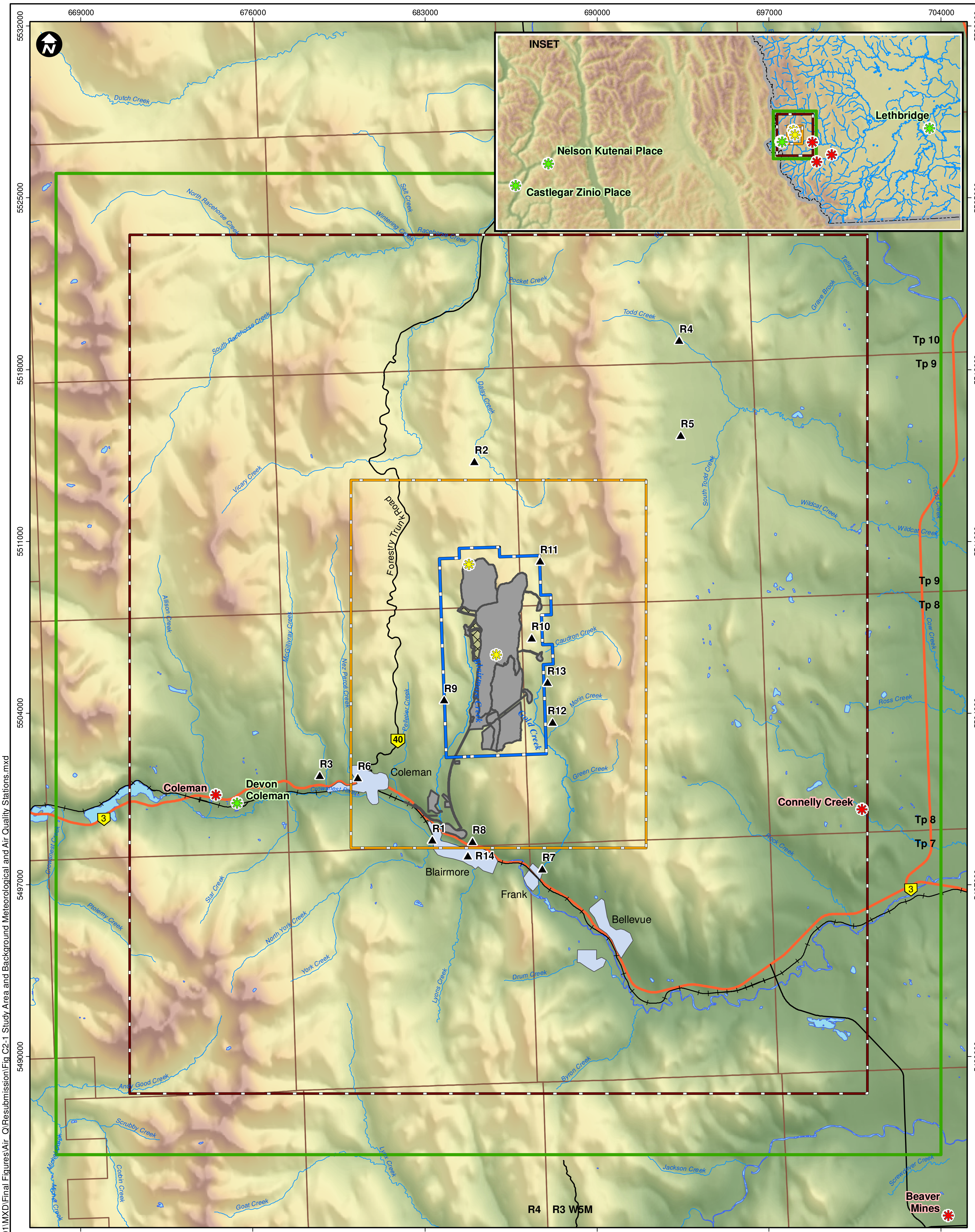
Riversdale conducted field measurements of winds at two locations near the Project, as shown in Figure C4-1. Measurements were made at a height of 2 m and were conducted from June 6, 2014 to November 12, 2014. Figure C4-2 is a wind rose showing the frequency of hourly average winds for the period. In this period of record, wind directions are completely determined by the surrounding terrain in the immediate vicinity of the stations.

Figure C4-3 shows 10-m wind roses at the town of Crowsnest and Beaver Mines based on data from Environment Canada. These wind roses also show that wind directions are fully determined by the terrain in the vicinity of the stations. Wind directions broadly from the west are consistent with First Nations observations that "prevailing winds are from the west through Crowsnest Pass (blowing toward Brocket)" (Piikani Nation 2015).

Calms are defined as wind speeds less than about 0.5 m/s. More frequent calms may result in high concentrations, but also in lower emissions due to windblown dust. The frequency of calms varies in the region from a low of 1.4% to 3.1% at Crowsnest and the South stations, respectively.

Figure C4-4 shows the overall frequency distribution of wind speeds and Figure C4-5 shows diurnal variation of wind speeds at the stations. The figures indicate the following:

- Median wind speeds are higher during the early to mid-afternoon, while maximum wind speed gusts can occur at any time.
- Wind gusts are strongest at the South site and the Beaver Mines station.



LEGEND

- ▲ Special Receptor
- AQ Monitoring Station
- EC Meteorological Station
- Focus Monitoring Stations
- Proposed Mine Permit Boundary
- Project Footprint
- Undisturbed Area
- Air Quality Local Study Area
- Air Quality Regional Study Area
- Model Domain

Topography (masl)
High : 2500
Low : 1300

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

STUDY AREA AND BACKGROUND METEOROLOGICAL AND AIR QUALITY STATIONS

NOTES

AltaLIS, 2016; GeoBase, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 2.5 5 10
Kilometres

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: JS
DATE: JUNE 16, 2016

FIGURE
C2-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig C2-1 Study Area and Background Meteorological and Air Quality Stations.mxd

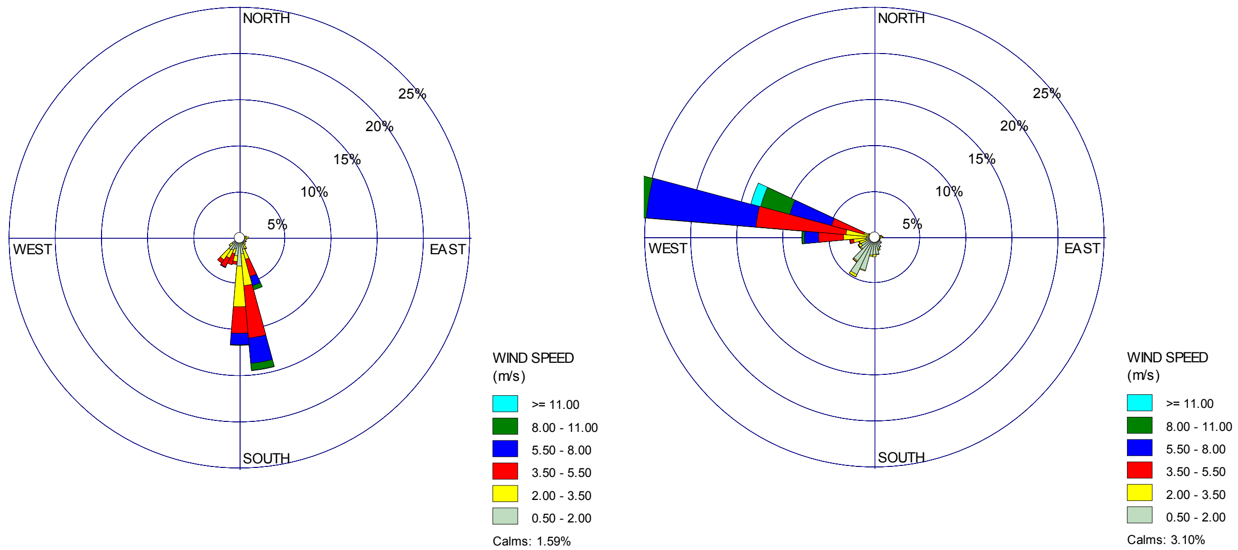


Figure C4-2 Wind Roses at the On-Site Air Monitoring North (left) and South (right) Stations, 2014.

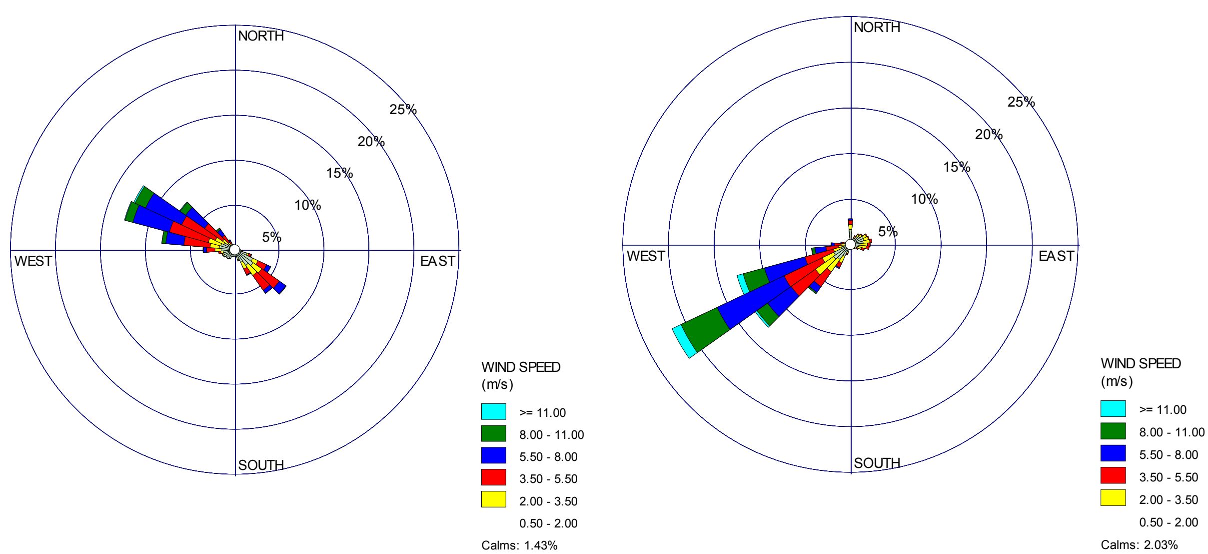
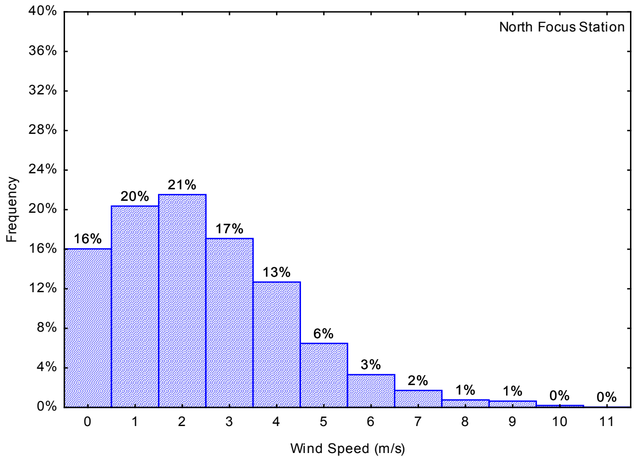
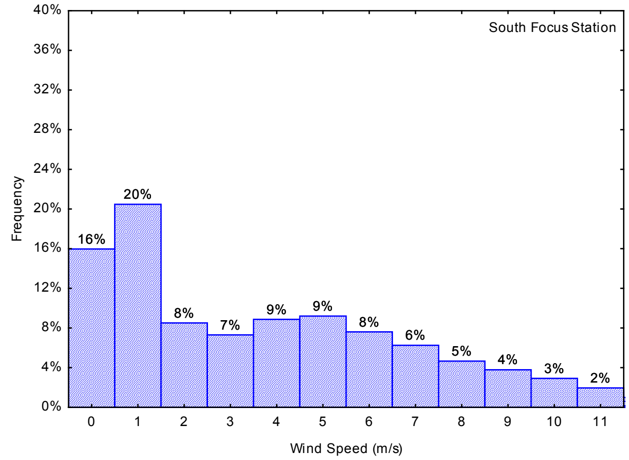


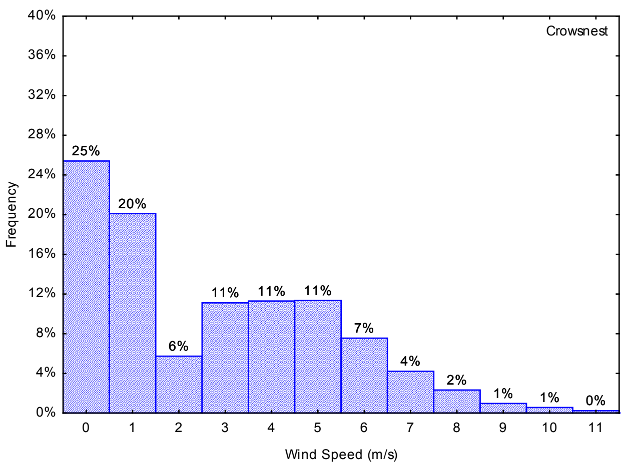
Figure C4-3 Wind Rose at Crowsnest and Beaver Mines, Environment Canada Air Monitoring Stations, 2010-2014. Data Source: Environment Canada 2014.



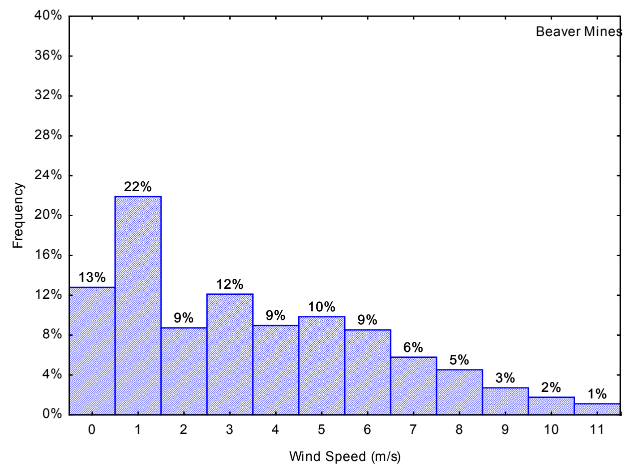
North Station, July 30, 2014 – November 12, 2014



South Station, June 6, 2014 – November 12, 2014

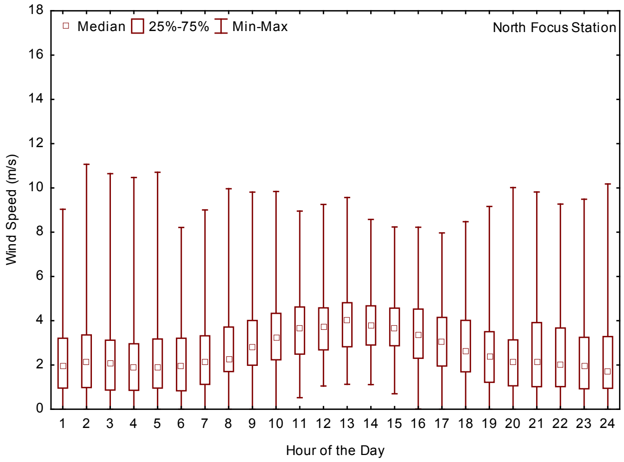


Crowsnest Station, January 1, 2010 – December 31, 2014

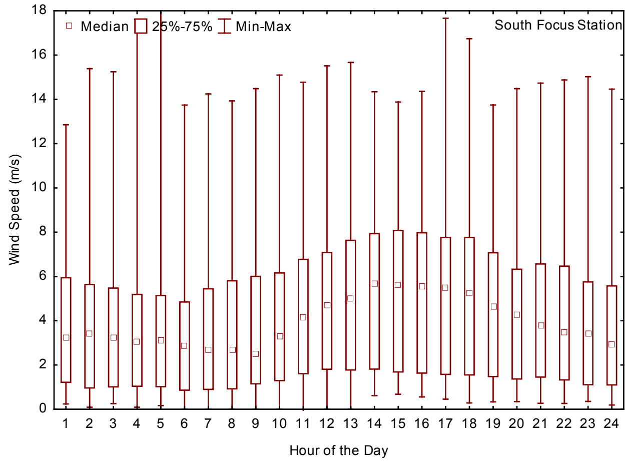


Beaver Mines Station, February 1, 2012 – December 31, 2014

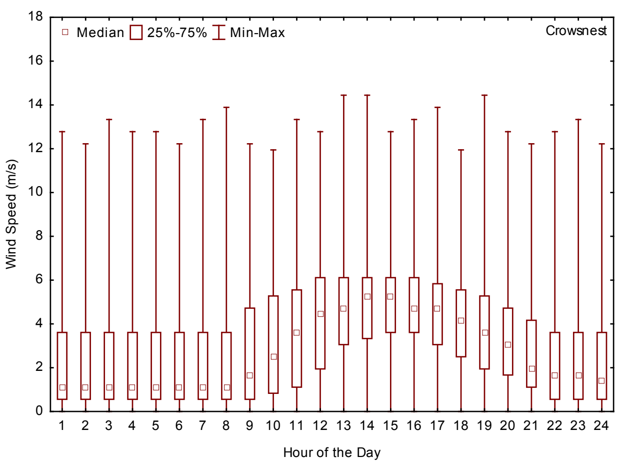
Figure C4-4 Frequency Distribution of Windspeeds at Four Air Monitoring Stations. Data Source: Environment Canada (2014) for Crowsnest and Beaver Mines.



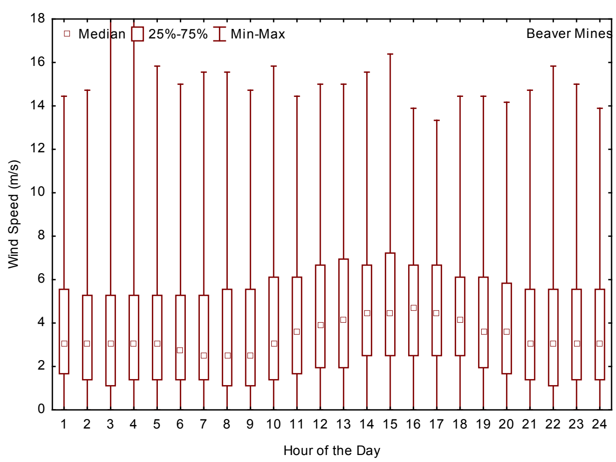
North Station, July 30, 2014 – November 12, 2014



South Station, June 6, 2014 – November 12, 2014



Crowsnest Station, January 1, 2010 – December 31, 2014



Beaver Mines Station, February 1, 2012 – December 31, 2014

Figure C4-5 Diurnal Variation in Wind Speeds at Four Air Monitoring Stations. Data Source: Environment Canada 2014.

C4.2 Ambient Temperature

Ambient air temperatures recorded at the two EC stations are summarized in Table C4-1. The minimum temperatures were -39°C and the maximum temperature was 33°C. The average annual temperature for the two stations was 4.0 to 5.5°C.

Table C4-1 Ambient Temperatures Measured at Air Monitoring Stations, 2008-2013

Station	Temperature (ºC)			
	Average	Median	Minimum	Maximum
Crowsnest	4.0	3.9	-39.2	33.1
Beaver Mines	5.5	5.7	-38.5	32.6

Data Source: NAPS 2014

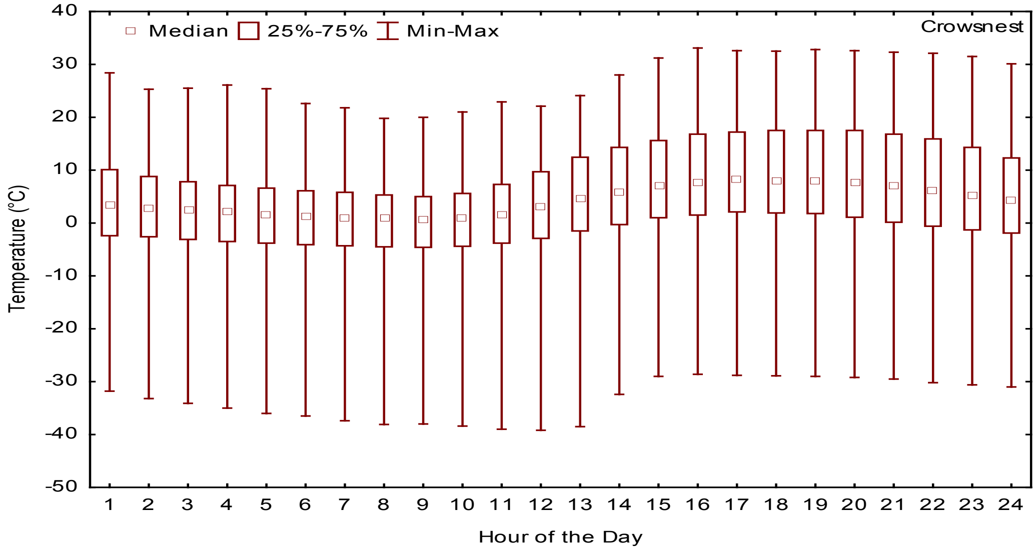
The diurnal and seasonal temperature variations are presented in Figures C4-6 and C4-7. The results indicate the following:

- Median hourly temperatures were highest in mid-afternoon as a result of solar heating; and temperatures were lowest before sunrise (07:00 to 08:00).
- Median temperatures ranged from about -3°C in February/March to about +15°C in July.

Table C4-2 summarizes the maximum, average, and minimum daily and extreme temperatures for each month from 1981 to 2010 at Coleman (the available climate normal data closest to the Project). The data indicate that:

- Daily average temperature ranges from about -6°C in January to +14°C in July.
- Temperature extremes can reach as high as 35°C in July and as low as -41°C in December.

Long-term temperatures at the Project should be similar to those observed at Coleman (perhaps slightly cooler because of the increased elevation), where climate normal data are available from Environment Canada.



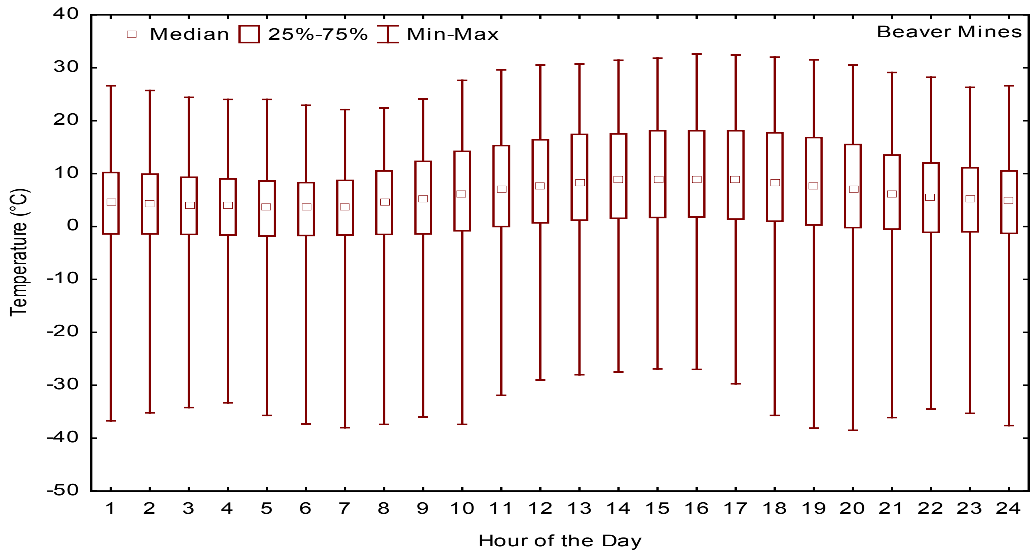


Figure C4-6 Diurnal Variation of Hourly Temperature at Two EC Air Monitoring Stations. Data Source: NAPS 2014.

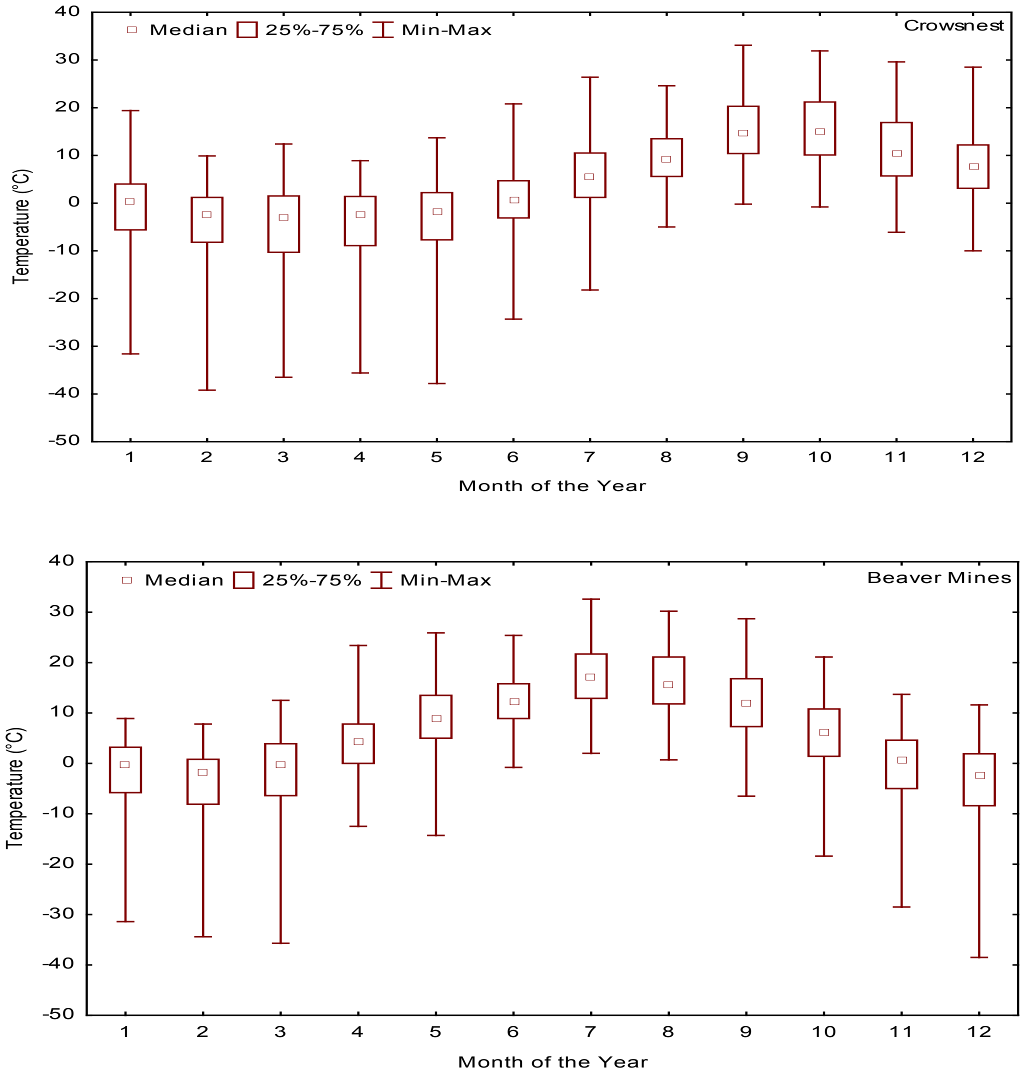


Figure C4-7 Seasonal Variation of Hourly Temperature at Two EC Air Monitoring Station. Data Source: NAPS 2014.

Table C4-2	Canadian Climate Normals– Coleman, 1981-2010												
Temperature													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Daily Average (°C)	-6.4	-5.0	-0.8	3.6	7.9	11.8	14.3	14.3	9.5	4.6	-2.7	-7.4	3.6
Standard deviation	3.9	4.1	2.5	1.6	1.3	1.4	1.5	1.4	2.0	1.7	3.8	4.1	1.2
Daily Max (°C)	-1.6	0.1	4.6	9.5	14.4	18.7	22.1	22.8	17	10.2	1.4	-3	9.7
Daily Min (°C)	-11.3	-10.1	-6.2	-2.4	1.3	4.9	6.5	5.7	2	-1.1	-6.8	-11.9	-2.4
Extreme Max (°C)	11.5	13.9	18.3	25.6	29.0	30.0	35.0	34.0	32.0	26.0	16.0	13.5	11.5
Extreme Min (°C)	-39.4	-37.5	-37.2	-24.4	-8.3	-5.6	-3.3	-7.0	-11.0	-27.0	-37.0	-41.1	-39.4

Data Source: Environment Canada, 2014

C4.3 Atmospheric Stability

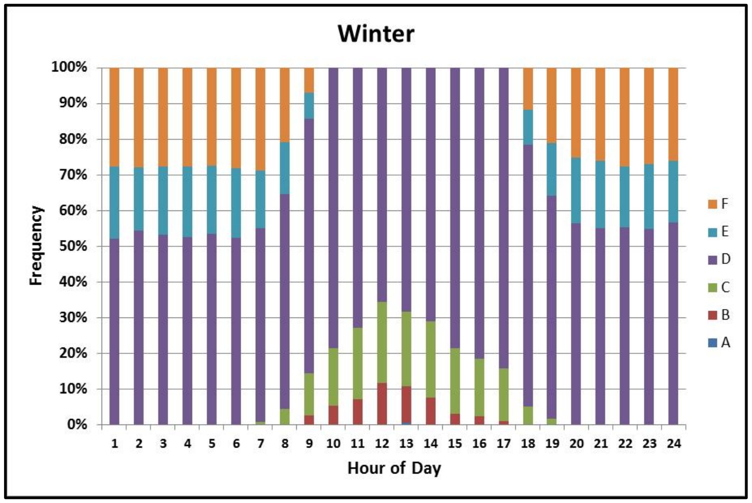
Pasquill-Gifford (PG) stability classifications are useful to describe the amount of turbulence present in the atmosphere. These classes range from unstable (classes A, B, C) through neutral (D) to stable (E, F). Unstable conditions are primarily associated with daytime heating conditions that result in enhanced turbulence. Stable conditions occur during night-time cooling and indicated suppressed turbulence. Neutral conditions occur in cloudy or windy conditions.

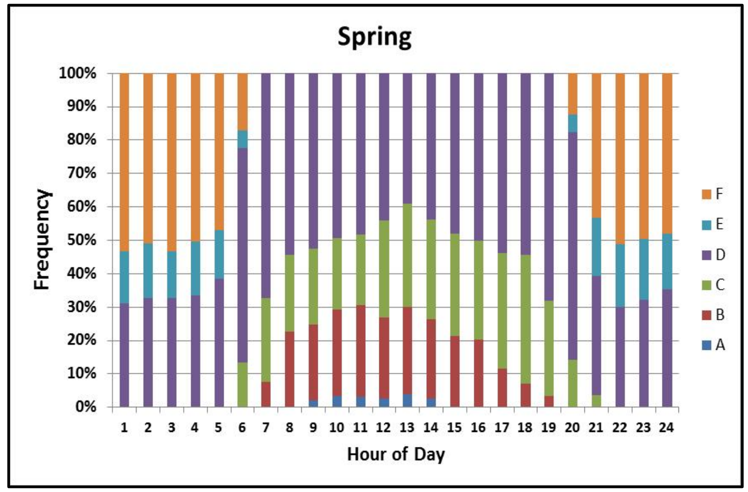
Stability class was derived following the approach of U.S. EPA where the final stability class changes are limited to one category per hour. For this reason, the final PG stability classes can include a few hours with stable conditions occurring in daylight hours, and or unstable conditions in evening hours.

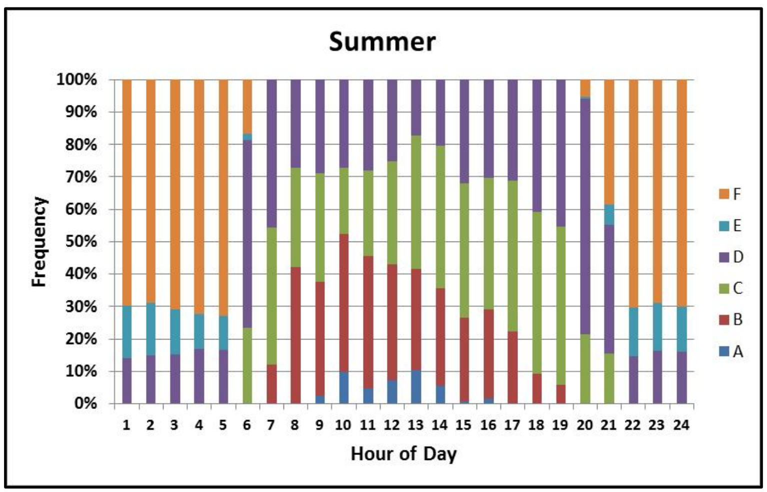
Figure C4-8 presents PG stability classes as functions of time of day for the period 2002-2006 (the period that corresponds with the CALMET data used for dispersion modeling) at the Project location. The information indicates:

- Neutral conditions (Stability Class D) can occur at any hour of the day and occur about one-quarter of the time.

- Unstable stability classes (A, B, and C) are limited to daytime hours and occur about one-third of the time.
- Stable classes (E and F) occur during night-time hours (except as indicated above) and occur almost one-half of the time.
- Spring and summer have the largest percentage of stability Class A (very unstable) that can occur up to 6% of daylight hours. Winter and fall have the least stability Class A values as this class is associated with strong daytime heating.







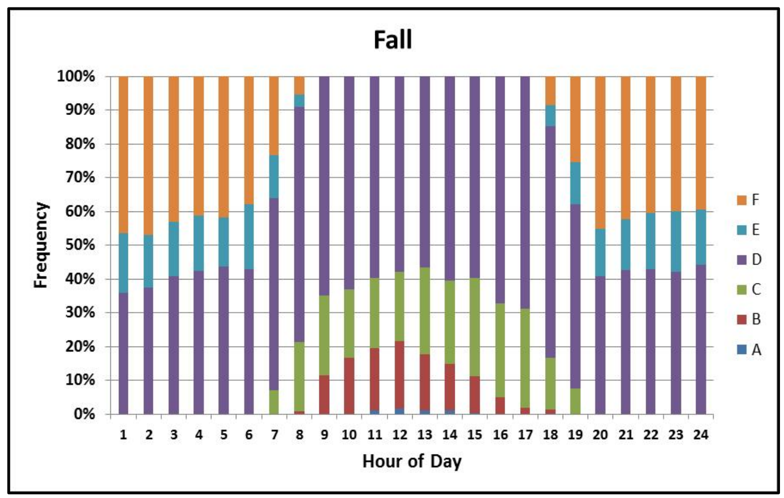


Figure C4-8 Seasonal Stability Class Distribution near the Project based on CALMET Output, 2002-2006.

C4.4 Mixing Height

A temperature increase with height is referred to as an inversion. The base of the temperature inversion may be ground-based or elevated. In the latter case, a two-layered atmosphere is created. The lower layer tends to be well mixed and is characterized by neutral or unstable conditions. The depth of this lower layer is referred to as the mixing height. The upper layer tends to be characterized by stable conditions. The vertical transfer of mass between these two layers is minimal. Mixing heights are not explicitly used as inputs to the CALPUFF model. However, an examination of them is useful to aid in understanding observed and predicted plume dispersion.

During the night, the mixing height is determined by the mechanical interaction of the wind with surface features. Maximum mixing layer depths tend to be a few hundred metres and can be less in winter.

After sunrise, solar heating usually determines the depth of the mixing layer. Typical depths increase from the mechanical mixing height at sunrise to heights of up to a few thousand metres by mid-afternoon. Median mixing depths for the study area were obtained from CALMET model out for the 2002 to 2006 period at a grid cell near the Project location (see Figure C4-9).

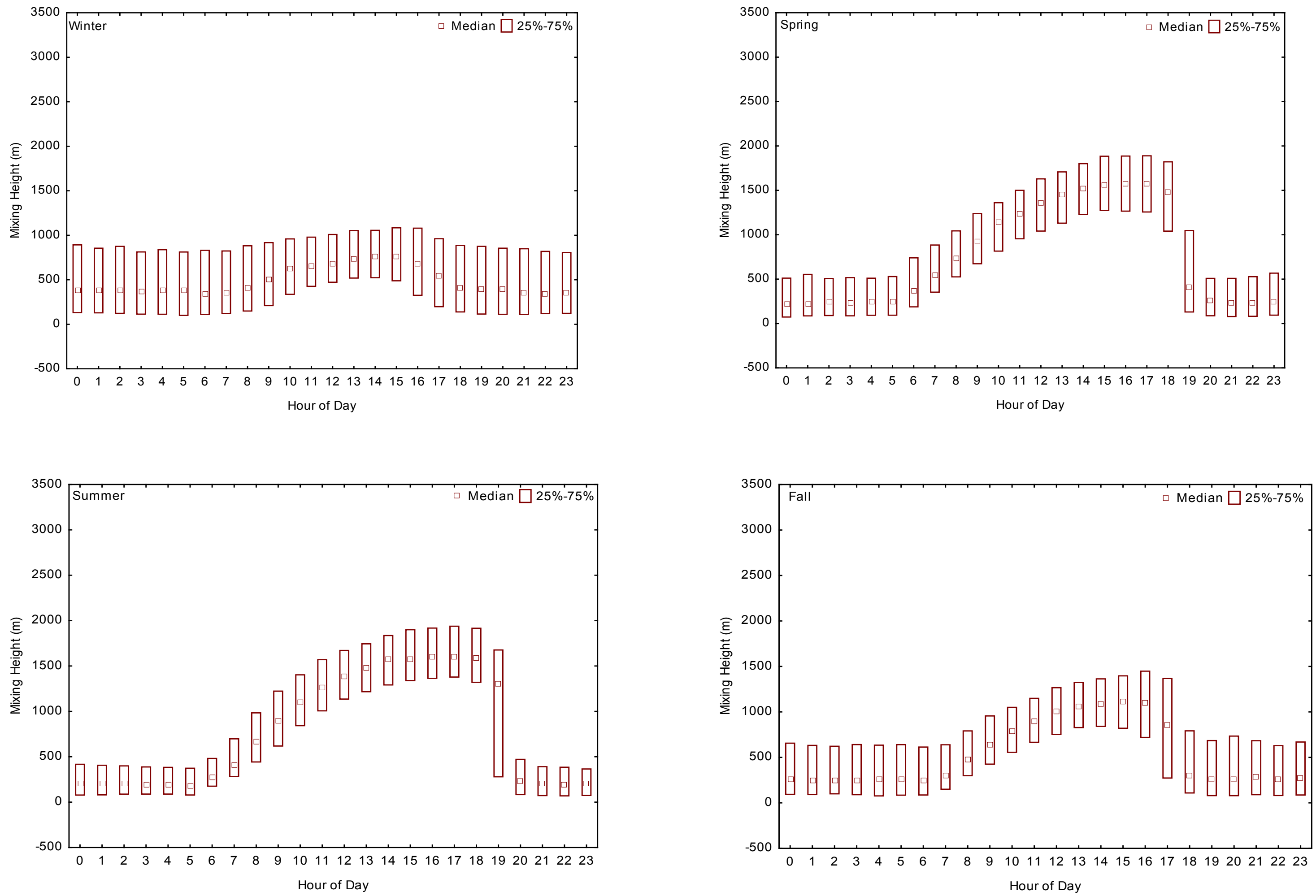


Figure C4-9 Seasonal Mixing Height Distribution near the Project based on CALMET Model Output, 2002-2006.

C4.5 Precipitation

Tables C4-3 and C4-4 shows average monthly rainfall, snowfall and total precipitation observed at Connelly Creek from 2002 - 2006 and 2007-2011, respectively. Figure C4-10 displays this data visually. Connelly Creek was selected as the data set available from Environment Canada was more complete than at Coleman. The precipitation climate normals for Coleman and Connelly Creek are shown in Tables C4-5 and C4-6, respectively. It is anticipated that long-term climate patterns will be similar (for air quality purposes) in Connelly Creek and Coleman.

Most of annual rainfall during the modelling period (Table C4-3) occurs during May to September – June has the highest total. Most of annual snowfall occurs during November to March. The highest recent total precipitation of about 273 mm/month at Connelly Creek occurred in June 2005. The 5-year period used in dispersion modelling (2002-2006) has a precipitation rate of about 595 mm/year, with an inter-year standard deviation of 106 mm. The average precipitation is about 2% lower than the climate normal precipitation at Coleman (Table C4-3).

Table C4-3 Total Precipitation (Rain and Snow) at Connelly Creek, 2002 - 2006

Month	2002 (mm)	2003 (mm)	2004 (mm)	2005 (mm)	2006 (mm)
January	53.4	17.8	53.6	22	26.6
February	50.8	41.4	2.4	33.1	43.2
March	69.8	71.2	15.5	56	19.4
April	55.2	101	22	26.8	52.2
May	93.8	61.2	85	37	61
June	154	41	105	273	71.4
July	20.5	8.2	25.4	12.2	26.1
August	43	10.9	111	81.2	18.2
September	102	34.2	30.2	51.2	40
October	22.8	29.2	40	39.2	46.8
November	7.2	63	18.4	58	99.6
December	35.6	18.8	31.8	22.6	12
Total	708	498	540	712	517

Source: Environment Canada 2014

Table C4-4 Total Precipitation (Rain and Snow) at Connelly Creek, 2007 - 2011

Month	2007 (mm)	2008 (mm)	2009 (mm)	2010 (mm)	2011 (mm)
January	14.2	44.6	14.3	25.6	61.9
February	36	39.4	54.4	5.8	53.6
March	38	17.8	54.8	18.4	29.8
April	23.2	18.4	38	70.6	75.2
May	91.2	55.2	18.7	122	110
June	31.8	57.8	48.6	59.9	97
July	1.6	33.6	114	48.9	49.6
August	9.2	15.8	68.2	42.4	22.8
September	60.4	36.9	2.8	88.2	6
October	24.8	2.2	55.6	6.7	95.6
November	26.6	14.6	19.6	56	33.8
December	23.6	42.2	32.6	32.6	5.6
Total	381	379	522	577	641

Source: Environment Canada 2014

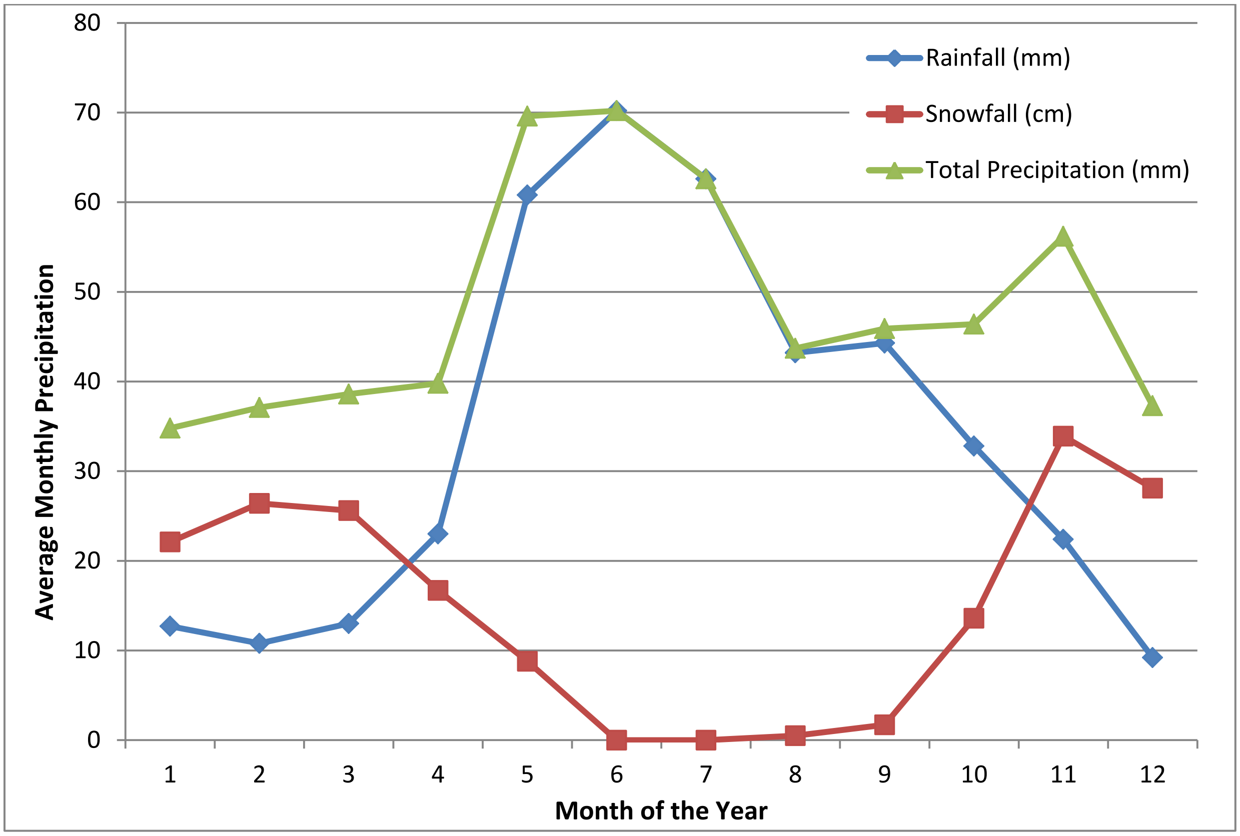


Figure C4-10 Average Monthly Rainfall, Snowfall and Total Precipitation Values at Coleman, 1981-2010. Data Source: Environment Canada 2010.

Table C4-5 summarizes the average monthly rainfall, snowfall, and precipitation at Coleman from 1981 to 2010 (the most recent climate normal data available). The table indicates that:

- The average monthly snowfall ranges from 14 to 34 cm during winter.
- The precipitation ranges from 40 to 70 mm during summer.
- The total average annual precipitation is 582 mm.

Table C4-6 summarizes the average monthly precipitations at Connelly Creek from 1981 to 2010. The table indicates that:

- The average monthly snowfall ranges from 21 to 42 cm during winter.
- The precipitation ranges from 40 to 75 mm during summer.
- The total average annual precipitation is 568 mm.

The precipitation ranges for the Climate Normals for Coleman and Connelly Creek are very similar. As seen in Figure C2-1, the two stations are positioned west and east of the RSA.

Table C4-5 Canadian Climate Normals– Coleman, 1981-2010

Precipitation													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Rainfall (mm)	12.7	10.8	13	23	60.8	70.2	62.6	43.2	44.3	32.8	22.4	9.2	404.8
Snowfall (cm)	22.1	26.4	25.6	16.7	8.8	0	0	0.5	1.7	13.6	33.9	28.1	177.3
Precipitation (mm)	34.8	37.1	38.6	39.8	69.6	70.2	62.6	43.7	45.9	46.4	56.2	37.3	582.1

Data Source: Environment Canada, 2014

Table C4-6 Canadian Climate Normals– Connelly Creek, 1981-2010

Precipitation													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Rainfall (mm)	3.6	2.2	3.2	13.8	62.2	88.8	46.8	39	41.2	13.6	8.9	1.9	325.2
Snowfall (cm)	30.7	33.5	41.3	33.2	12.2	0	0	1.3	5.9	21.3	34.9	28.3	242.6
Precipitation (mm)	34.3	35.7	44.5	47	74.3	88.8	46.8	40.3	47.2	34.9	43.8	30.2	567.8

Data Source: Environment Canada, 2014

C4.6 Other Meteorological Data

Other meteorological variables of interest include relative humidity and limited visibility events since they may have a potential impact on the design, construction, and operation of industrial developments. Figures C4-11 and C4-12 present the climatological values, based on observations at Crowsnest and Pincher Creek stations from 1981 to 2010 (Environment Canada, 2010), the most recent periods during which these observations were routinely available and reported.

Relative Humidity

Figure C4-11 shows the monthly relative humidity for selected times during the day at Crowsnest. The highest relative humidity values tend to occur in the early morning hours in May through August. The lowest values tend to occur in the afternoon in July. Overall, the lower daytime relative humidity values are associated with the warmer temperatures that occur during the day.

Visibility Reductions

Figure C4-12 shows the average frequency of visibility at Pincher Creek. Data relating visibility reductions to specific events was not available. Periods with visibility less than 1 km can be the result of fog or smoke haze events in the spring through fall and from blowing snow or fog during the winter. Winter visibility reductions were most common in the area.

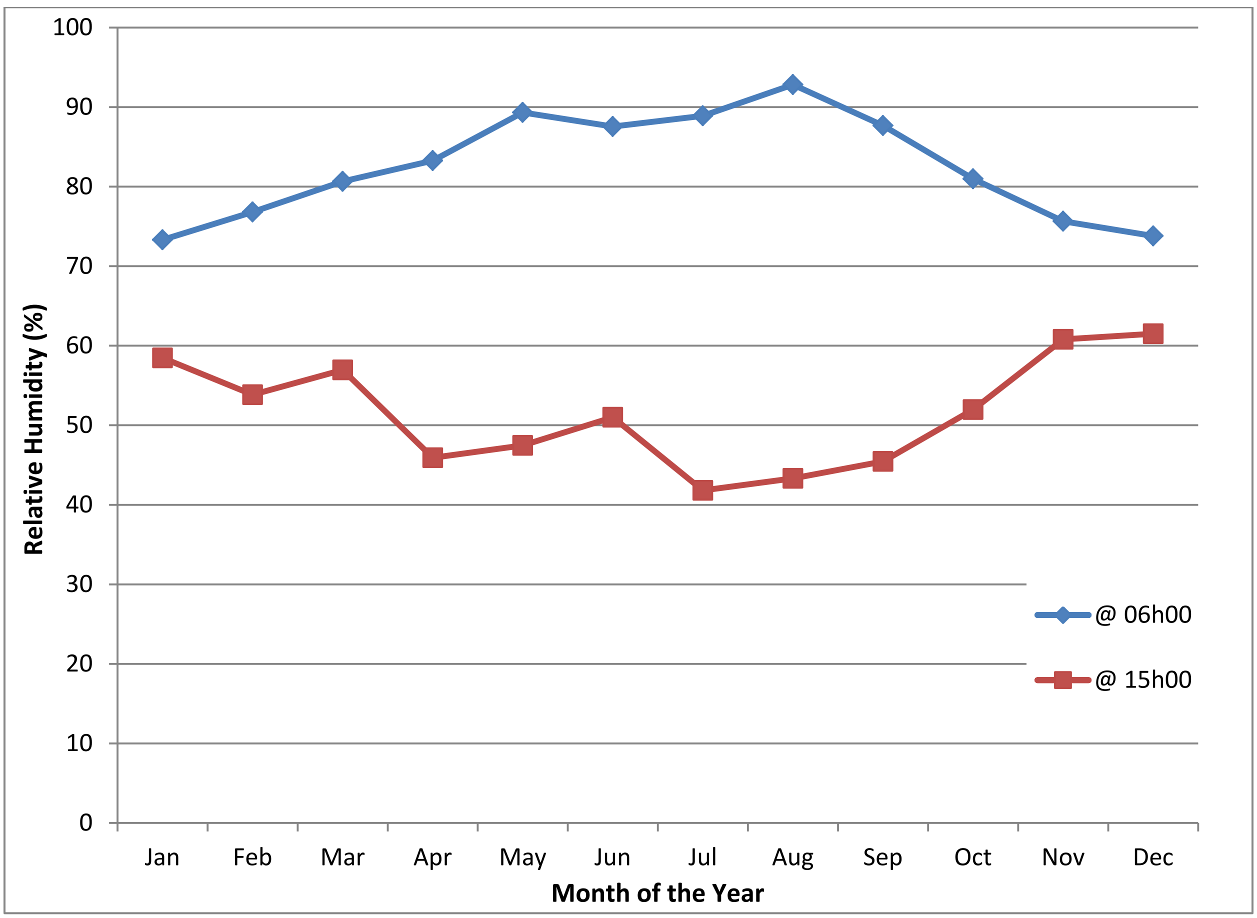


Figure C4-11 Monthly Relative Humidity at Crowsnest, 2010-2014. Data Source: Environment Canada 2015.

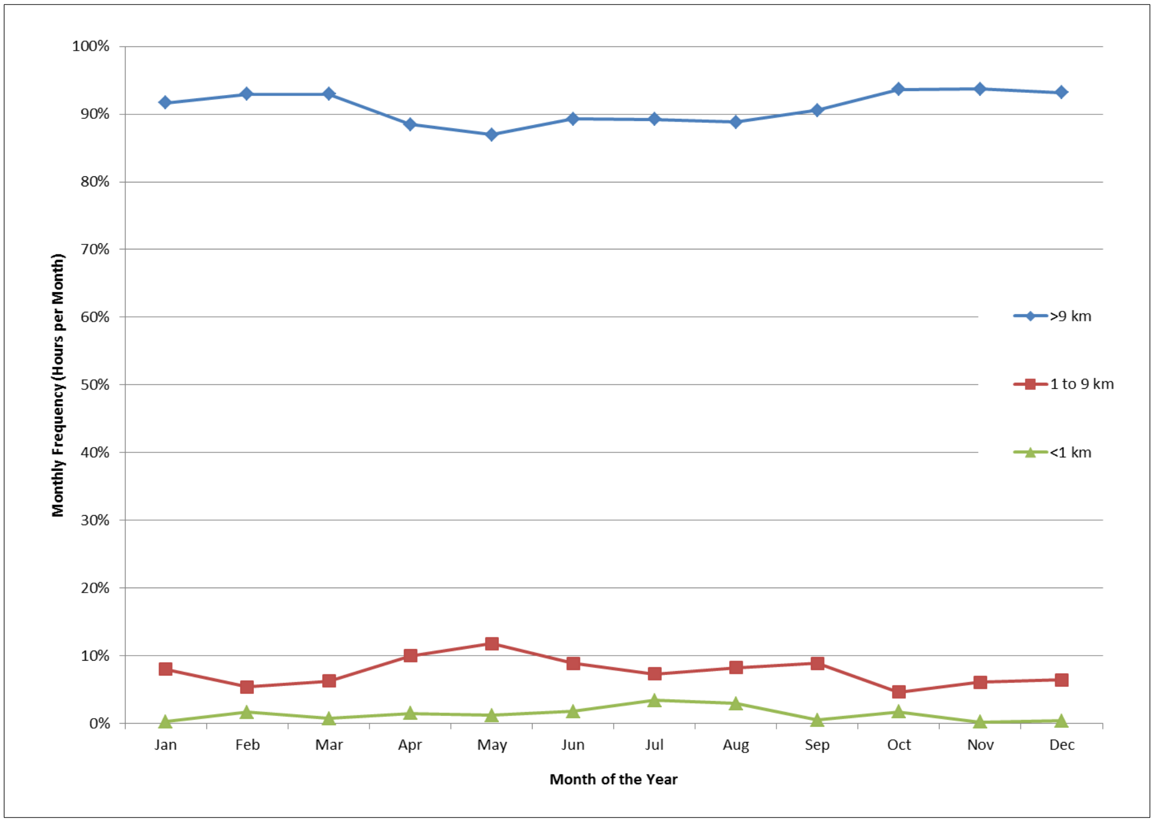


Figure C4-12 Monthly Frequency of Visibility at Pincher Creek, 2007-2011. Data Source: Environment Canada 2014.

C4.7 Climate Summary

The climate can be inferred from observations in the regional area. A review of observations expected to be relevant to the Project area indicates the following:

- Winds in the area are a function of terrain.
- Median temperatures range from a low of about -6°C in January to a high of about +14°C in July.
- Median afternoon mixing heights range from a few hundred metres in winter to about 1,500 m in summer. Night-time mixing heights are typically in the 200 to 400 m range.
- Most precipitation occurs during the May to September period (with peak precipitation occurring in June) and average annual precipitation is around 570 mm. Average monthly snowfall is expected to be at approximately 20 cm during the winter.
- Mean relative humidity varies from a minimum of about 40 percent during spring day-time periods to a maximum of about 90 percent during late summer/early fall night-time periods.

C5.0 BACKGROUND AIR QUALITY FOR DISPERSION MODELLING

This section presents the concentrations used as background for dispersion modelling purposes. In accordance with *Alberta Air Quality Model Guidelines*, this includes the 90th percentile value from the cumulative frequency distribution for 1-hour and 24-hour predicted averaging periods (AESRD, 2013). In cases where the 90th percentile for the 1-hour and 24-hour periods were similar, the more conservative value (the 1-hour averaging period) was used as the background value. For this assessment NO_x, SO_2 and CO from the Lethbridge air quality monitoring station between 2010 and 2014 were used to estimate the background concentrations. Measurements from Nelson Kutenai were used for $PM_{2.5}$ and PM_{10}, as this was the closest station with a similar rural setting and thus representative. Table C5-1 presents background values for Criteria Air Contaminants.

For the modelling of acid deposition, total PAI was calculated from measurements at the Kananaskis Village station, as this station closest station which was representative of the Project setting. Calculated deposition rates are presented in Table C5-2.

Background concentrations for the speciated VOCs and PAHs were obtained from several sources including Alberta Health and Wellness (2003), Alberta Environment (2004a), Canadian Environmental Protection Act (2000, 2001), and the Fort Air Partnership (FAP 2004). VOC and PAH backgrounds are presented in Tables C5-3 and C5-4.

Averaged 24-hour maximum metal measurements from the Genesee and Powers stations in west-central Alberta were used as background concentration values for both the 1-hour and 24-hour averaging periods. Annual concentrations were derived from these values using the power law as recommended by OMOE (2005) (Table C5-5):

- Annual concentration = 24-hour concentration*(1/365)*0.28

Table C5-1 Ambient Background Concentrations for Modelled Criteria Air Contaminants (CACs)

Compounds	Hourly (μg/m³)	8-Hour (μg/m³)	24-Hour (μg/m³)	Monthly (μg/m³)	Annual (μg/m³)	Data Source
SO_2	2.6	-	2.1	1.0	0.9	Lethbridge, 2010-2014[(a)]
NO_x	32	-	-	-	17	Lethbridge, 2010-2014[(a)]
NO_2	24	-	-	-	11	Lethbridge, 2010-2014[(a)]
$PM_{2.5}$	8.0	-	6.8	-	4.0	Nelson Kutenai, 2009-2013[(b)]

Table C5-1 Ambient Background Concentrations for Modelled Criteria Air Contaminants (CACs)

Compounds	Hourly (µg/m³)	8-Hour (µg/m³)	24-Hour (µg/m³)	Monthly (µg/m³)	Annual (µg/m³)	Data Source
PM_{10}	-	-	21	-	13	Nelson Kutenai, 2009-2013[b]
TSP	-	-	42	-	26	2x PM_{10} Background Values
CO	344	301	-	-	-	Lethbridge, 2010-2014[a

[a] CASA 2014
[b] NAPS 2014
- No AAAQO for this averaging period, therefore background concentration not required.

Table C5-2 Average Potential Acid Input Estimates From Measurements

Location	Measurement Type	Nitrate	Sulphate	PAI	Cations	Total PAI
		Dry Deposition [keq/ha/yr]	Dry Deposition [keq/ha/yr]	Wet Deposition [keq/ha/yr]	Dry Deposition [keq/ha/yr]	Deposition [keq/ha/yr]
Kananaskis Village	Passive	0.015	0.048	0.079	0.044	0.100

[a] Data Source: CASA (2014).

Table C5-3 Ambient Background Concentrations for Volatile Organic Compounds (VOCs)

Compounds	Hourly (µg/m³)	24-Hour (µg/m³)	Annual (µg/m³)
Acetaldehyde	2.34E+01	1.24E+01	3.81E+00
Acrolein	6.00E-01	3.10E-01	1.80E-01
Benzene	2.34E+00	2.20E+00	5.80E-01
Formaldehyde	2.75E+01	1.46E+01	4.48E+00
Naphthalene	1.49E-01	1.40E-01	6.00E-02
Toluene	1.11E+01	1.04E+01	1.86E+00
Xylenes	5.50E-01	5.20E-01	3.00E-01

Sources: AHW (2003), AENV (2003, 2004a), CEPA (2000, 2001), FAP (2004).

Table C5-4 Ambient Background Concentrations for Polycyclic Aromatic Hydrocarbons (PAHs)			
Compounds	**Hourly (μg/m³)**	**24-Hour (μg/m³)**	**Annual (μg/m³)**
Acenaphthene	9.06E-04	4.80E-04	3.40E-04
Acenaphthylene	1.93E-03	1.81E-03	1.05E-03
Anthracene	3.59E-04	1.90E-04	1.90E-04
Benzo(a)anthracene	3.02E-04	1.60E-04	5.20E-05
Benzo(b)fluoranthene	0.00E+00	0.00E+00	0.00E+00
Benzo(k)fluoranthene	4.91E-04	2.60E-04	2.50E-04
Benzo(g,h,i)perylene	3.97E-04	2.10E-04	7.00E-05
Benzo(a)pyrene	1.27E-04	5.20E-05	1.00E-05
Chrysene	7.36E-04	3.90E-04	1.10E-04
Dibenzo(a,h) anthracene	9.44E-05	5.00E-05	3.50E-05
Dichlorobenzene	3.00E-02	1.59E-02	1.50E-02
Fluoranthene	7.55E-04	4.00E-04	3.10E-04
Fluorene	1.00E-03	5.30E-04	2.60E-04
Indeno(1,2,3-cd)pyrene	3.59E-04	1.90E-04	5.60E-05
Phenanthrene	5.40E-03	5.07E-03	2.94E-03
Pyrene	1.25E-03	1.17E-03	6.80E-04

Sources: AHW (2003), AENV (2003, 2004a, 2004b), CEPA (2000, 2001), FAP (2004).

Table C5-5 Ambient Background Concentrations for Metals			
Species	**1-Hour[(a)] [μg/m³]**	**24-Hour[(a)] [μg/m³]**	**Annual[(b)] [μg/m³]**
Aluminum (Al)	5.02E-01	5.02E-01	9.62E-02
Antimony (Sb)	7.97E-04	7.97E-04	1.53E-04
Arsenic (As)	6.53E-04	6.53E-04	1.25E-04
Barium (Ba)	5.99E-03	5.99E-03	1.15E-03
Beryllium (Be)	1.40E-05	1.40E-05	2.70E-06
Cadmium (Cd)	3.82E-04	3.82E-04	7.32E-05
Cobalt (Co)	7.39E-03	7.39E-03	1.42E-03

Table C5-5 Ambient Background Concentrations for Metals			
Species	**1-Hour[(a)] [μg/m³]**	**24-Hour[(a)] [μg/m³]**	**Annual[(b)] [μg/m³]**
Chromium (Cr)	4.71E-03	4.71E-03	9.03E-04
Copper (Cu)	2.77E-02	2.77E-02	5.31E-03
Mercury (Hg)	2.10E-05	2.10E-05	4.00E-06
Manganese (Mn)	7.76E-03	7.76E-03	1.49E-03
Molybdenum (Mo)	7.73E-04	7.73E-04	1.48E-04
Nickel (Ni)	4.36E-02	4.36E-02	8.36E-03
Lead (Pb)	4.36E-03	4.36E-03	8.36E-04
Selenium (Se)	7.20E-04	7.20E-04	1.38E-04
Thallium(Tl)	4.75E-05	4.75E-05	9.10E-06
Uranium(U)	2.25E-05	2.25E-05	4.30E-06
Vanadium (V)	1.20E-03	1.20E-03	2.30E-04
Zinc (Zn)	1.56E-02	1.56E-02	2.99E-03

[(a)] Use averaged 24-h maximum concentrations at Genesee and Power monitoring stations.

[(b)] Calculated using 24- h average concentrations and using 0.28 power law

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MILLENNIUM
EMS Solutions Ltd.

6111 91 Street
Edmonton, AB T6E 6V6
tel: 780.496.9048
fax: 780.496.9049

Suite 325, 1925 18 Avenue NE
Calgary, AB T2E 7T8
tel: 403.592.6180
fax: 403.283.2647

#106, 10920 84 Avenue
Grande Prairie, AB T8X 6H2
tel: 780.357.5500
fax: 780.357.5501

toll free: 888.722.2563
www.mems.ca

Air Quality Assessment of Loadout Emissions

Grassy Mountain Coal Project

Prepared for:
Benga Mining Limited

Submitted by:
Millennium EMS Solutions Ltd.
Suite 325, 1925 – 18th Avenue NE
Calgary, Alberta
T2E 7T8

July 2016

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1.0 INTRODUCTION

The development of the Grassy Mountain Coal Project (the Project) as presented in the Environmental Impact Assessment (EIA) plans to ship its coal product to market via the Canadian Pacific Railway (CPR). A rail loadout facility is required to transfer the final produced metallurgical coal onto railcars where it can then be transported via existing rail-connected ports on the west coast of British Columbia to send to off-shore markets. The rail loadout facility is planned on the present site of the Crowsnest Pass Golf & Country Club, located just north of Highway 3 (Figure 1.0-1).

The purpose of this document is to provide an air quality assessment specific to the loadout operation as a standalone component of the Project as it is the closest Project activity to the community and has been a key topic of discussion throughout the stakeholder engagement program. The proposed Grassy Mountain Coal Project, which includes the mining development and Coal Handling and Processing Plant (CHPP), is located approximately 7 km north of Blairmore. Coal from the mine will be transported by a covered overland conveyor to a rail siding and loadout facility located immediately north of Highway 3 in Blairmore. The most significant components of the rail siding and loadout that have potential air and dust emissions are:

- enclosed overland conveyor;
- 300 tonne surge bin that transfers coal with a vibratory feeder to the loadout bin (loadout); and
- rail siding with locomotives hauling train cars.

2.0 AIR QUALITY OBJECTIVES

The Alberta Ambient Air Quality Objectives (AAAQO) and the Canadian Ambient Air Quality Standards (CAAQS) are standards against which air quality is compared (AESRD 2013a; CCME 2012). The British Columbia Ambient Air Quality Objective (BCAAQO) (BCMOE 2014) is also applied, to daily PM_{10} predictions.

The AAAQO for $PM_{2.5}$ is 30 μg/m^3 as a daily average. Alberta also has an hourly Ambient Air Quality Guideline (AAAQG) for $PM_{2.5}$ which is 80 μg/m^3.

Air quality objectives are compared to model predictions in Section 6 of this report.

3.0 ASSESSMENT APPROACH

The air quality study for the entire Project (CR#1a) covered an area of about 30 km x 35 km. This report presents the dispersion model results in a zoomed-in area, centered on the rail siding and loadout, covering three communities (Coleman, Blairmore and Frank) (Figure 1.0-1).

As winds play an important role in determining air quality, Figure 3.0-1 shows the wind rose used in modelling, which are very similar to winds measured by Environment Canada in the Crowsnest Valley. Wind directions are aligned with the orientation of the valley, with prevailing winds from the west through the Crowsnest Pass.

Three cases were modelled:

1. **Baseline** – includes all existing emissions from Highway 3 and four communities of Crowsnest Pass Sub-Division - Coleman, Blairmore, Frank, and Bellevue and with the addition of estimated background concentrations. This reflects the current conditions.
2. **Loadout** – includes only the emissions from the loadout operation, including dust and diesel locomotive exhaust emissions. This predicts the emissions only from the operations of the loadout.
3. **Regional** – includes the existing communities and highway, the predicted contributions of the loadout and rail facility, the predicted emissions from the other mine operations, and any emissions from other projects in the region. The mine emissions are those expected from the highest-emission year of operations. This is meant to capture all regional emissions that might have an impact of air quality.

For each of the three scenarios that were modeled, five local receptors were also considered in the assessment:

- R1 – Lost Lemon Campground;
- R6 – Coleman;
- R7 – Frank;
- R8 – Blairmore; and
- R14 – the centre of Blairmore (represented as Blairmore Centre in figures).

4.0 EMISSIONS SOURCE OVERVIEW

4.1 Mine Emission Mitigation

Fugitive dust emissions will be minimized at the rail load-out, as rail cars will be loaded within an enclosed structure and any external load-out components will have full cladding on the sides to prevent exposure to wind. In addition, the movable discharge chute of the coal bin will be located as close as practical to the coal within the rail cars to minimize the drop height of the coal, reducing opportunities for wind to disperse dust during the fall and reducing breakage when the coal lands in the rail car. After loading, within the enclosed structure, tackifier is sprayed onto the coal surface of the loaded rail cars to prevent wind-blown dusting during transport.

The primary sources of $PM_{2.5}$, PM_{10} and TSP emissions for the Project are dust from haul road activity and material handling. Benga has introduced mitigative measures to reduce particulate emissions along their private haul roads and for pit activities. All of these measures were incorporated into emission estimation and dispersion modelling:

- The mine fleet is regularly upgraded and by Year 19, equipment will be newer and more efficient than assumed in emission estimation. Exhaust emissions from the U.S. EPA Tier 4 (2010) standards were used in Project emission estimates and it is likely that off-road standards will be more stringent by Year 19.
- Water is systematically applied to haul roads and to the plant access road to minimize dust using a water truck dedicated to this purpose. An emission control efficiency of 80% during the summer months is expected from this measure.
- Snow cover is retained on the road as a mitigative measure during the winter months, unless the cover would compromise the safety of vehicle operations. Winter ground is frozen and, since the soil and overburden have elevated moisture contents, there is a reduction of dust emissions at that time.
- Gravel or crushed rock is used on the haul roads. Gravel is observed to produce less dust than clay and sandy surfaces.
- Grader is used to maintain the active surface of the road. This procedure is expected to reduce the effective silt content of the portion of the road where the wheels of the haul trucks travel. The grader blade would tend to move the silt particles to the inactive portion (side) of the road or cover the active portion with coarser material.
- The mined areas are reclaimed promptly and backfilled with overburden and soil from pre-strip areas, and then covered by vegetation which reduces windblown fugitive dust emissions from exposed land.

- Trees and bushes will be preserved around mines and plant facilities, because they effectively trap dust emissions from mining activities and reduce dust concentrations farther from mining activities.
- The coal processing plant will be contained within an enclosed area and all coal material handling will be via covered conveyors.
- Dust generation from transferring coal from the conveyor to the stock pile will be minimized by the use of luffing stackers (those that can lower and raise their boom) which will minimize the drop height and drop time of the coal.

Mitigation measures for NOx emissions from diesel engines include the use of Tier 4 technology in heavy duty mine equipment. Benga will also investigate alternative ANFO formulations that reduce NOx emissions during blasting.

4.2 Regional Emissions

Existing emissions from Highway 3 and the communities of Coleman, Blairmore, Frank, and Bellevue are provided in Table 4.2-1. They are also compared to expected worst-case emissions from the overall Project.

Table 4.2-1 Summary of Regional Emissions

Sources	Emission Rate (kg/d)					
	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Baseline						
Highway 3	0.84	551	1,865	33	102	481
Communities	6.8	143	1,956	64	219	1,076
Total Baseline	**7.6**	**694**	**3,821**	**97**	**320**	**1,557**
Grassy Mountain Mine Sources						
Mine and Plant	10.4	2,322	134	321	2,807	10,880
Loadout	0.2	7.1	13	0.4	7.7	16
Blasting	7.1	394	1,394	1.1	19	37
Total Mine	**18**	**2,724**	**1,540**	**323**	**2,834**	**10,933**

4.3 Loadout Emissions

The loadout infrastructure includes a connection to the CPR, a length of loading track loop and associated rail, access road, and infrastructure. The loadout is sized to accommodate a unit train at 152 cars.

At full production, the Project will average 4.5 million tonnes (4.5 Mt) of clean coal per year. All of the coal will be transported from the clean coal stockpiles at mine site to the rail loadout through a covered conveyor. There will be approximately 320 trains loaded in a typical year, each carrying 14,000 t of clean coal. The loading of clean coal to railcars will normally occur for 8 hours each day. One locomotive engine car will be used to shunt rail cars during loading.

Emissions from the activities at the loadout (locomotive operation and coal car loading), which are provided in more detail in CR#1a (Section 4.2, and Table 4.2-1), account for a small fraction of total Project emissions, ranging from 0.1% for $PM_{2.5}$ to 1.1% of SO_2. In other words, emissions from the loadout are substantially smaller than emissions from the rest of the mine located farther from the community.

Table 4.3-1 separates the loadout emissions from the overall Project and directly compares them to the existing baseline (community and Highway 3 emissions).

Table 4.3-1 Comparison of Baseline and Loadout Emissions

Sources	Emission Rate (kg/d)					
	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP
Loadout	**0.2**	**7.1**	**13**	**0.4**	**7.7**	**16**
Total Baseline	**7.6**	**694**	**3,821**	**97**	**320**	**1,557**
Highway 3[1]	0.84	551	1,865	33	102	481
Communities[1]	6.8	143	1,956	64	219	1,076

[1] as part of baseline

5.0 BACKGROUND CONCENTRATIONS

In addition to modelling all the known emission sources in the region, background concentrations were added to the model results. This background is meant to account for natural sources and unidentified, possibly distant sources. The background is based on 90th percentile measurements from a site that is thought to be representative of the mine area.

There are no long-term air quality monitoring stations in the Crowsnest Valley. Five years of measurements from Lethbridge were used for diesel combustion emissions. Measurements from Nelson BC were used for particulates (dust). Measurements from both locations are expected to be higher than the area near the Project, due to the larger populations. Further details are provided in CR#1a regarding background concentrations, including the background values (CR#1a, Section 4.4), and rationale for choosing representative monitoring stations (CR#1a, Section 3.1, Appendix C, C.2.4).

6.0 DISPERSION MODEL PREDICTIONS

Maximum predicted concentrations near the community are listed in Table 6.0-1 and shown in Figures 6.0-1 to 6.0-4 for NO_2 and the three sizes of dust particles. The maximum predictions are determined as the sum of model predictions from Baseline sources plus model predictions from mine sources plus measured background concentrations. Predictions from the loadout (locomotive plus dust) are shown separately. All predictions shown are the highest predictions that may occur in five years within the study area.

In Table 6.0-1, we compare predicted concentrations from loadout emissions to Baseline concentrations, and then show the impact in the community from all mine sources as well. All figures indicate where the maximum concentrations are predicted to occur within the small study area surrounding the loadout and within the limitations of modelling. Key modelling results include:

- The model predicts that the Baseline concentrations, from existing community and Highway 3 sources, are near or above AAAQOs for annual average NO_2, annual average $PM_{2.5}$, daily average PM_{10}, and daily and annual average TSP. There are no measurements of air quality in the community to confirm these predictions, but there is an expectation that the model may over-predict. Regardless, the model results provide a useful benchmark to compare to the effects of the loadout and the entire mine.

- The loadout contributions to air quality in the community are generally small fractions of Baseline concentrations and small fractions of the AAAQOs.

- The maximum predictions in the community from all Regional Sources are virtually identical to maximum Baseline predictions; therefore, the mine sources, including the loadout, have minimal contribution to the maximum predictions in the community. Of this minimal contribution, the loadout only provides a very small percentage to the maximum predictions.

Table 6.0-1 Summary of Maximum Predicted Ground-Level Concentrations

Contaminant	Averaging Period	Baseline	Loadout		All Regional Sources	AAQO (μg/m³)
		Prediction (μg/m³)	Prediction (μg/m³)	% of AAQO	Prediction (μg/m³)	
SO_2	9th Highest 1-hour	8.0	2.5	0.5%	8.0	450
	Maximum 24-hour	4.6	0.3	0.3%	4.7	125
	Maximum 30-day	2.1	0.04	0.1%	2.1	30
	Maximum Annual	1.8	0.01	0.1%	1.8	20
NO_2	9th Highest 1-hour	112	58	19%	112	300
	Maximum Annual	46	0.7	1.6%	47	45
CO	9th Highest 1-hour	2,241	173	1.2%	2,241	15,000
	Maximum 8-hour	1,638	70	1.2%	1,638	6,000
$PM_{2.5}$	Maximum 24-hour	24	0.7	2.3%	24	30
	98th Percentile 24-hour	20	0.3	1.2%	20	28
	Maximum Annual	9.2	0.03	0.3%	9.2	10
PM_{10}	Maximum 24-hour	72	13	27%	73	50
TSP	Maximum 24-hour	220	25	25%	221	100
	Maximum Annual	69	0.9	1.5%	69	60

In summary, loadout operation is expected to produce very little in the way of air quality impacts. It will not result in additional predicted exceedances of ambient air quality objectives beyond those predicted in the Baseline Case.

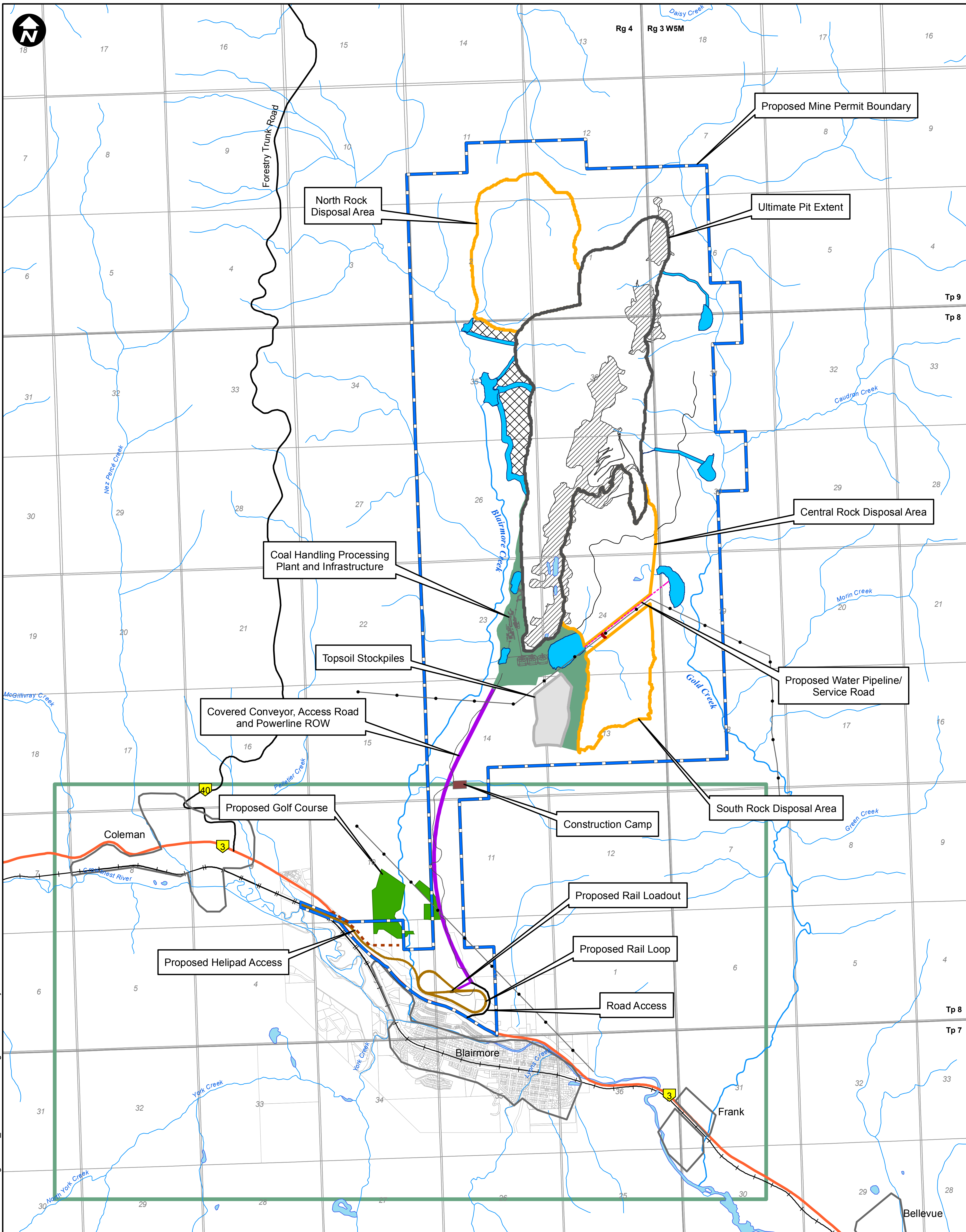
7.0 REFERENCES

Alberta Environment and Sustainable Resources Development (AESRD) 2013a. Alberta Ambient Air Quality Objectives and Guidelines Summary. Issued August 2013: http://environment.gov.ab.ca/info/library/5726.pdf

British Columbia Ministry of Environment (BCMOE) 2013. British Columbia Ambient Air Quality Objectives. Prepared by Environmental Standard Branch, updated August 12, 2013.

Canadian Council of Ministers of the Environment (CCME). 2012. Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone. PN1483.

FIGURES



LEGEND

- Primary Highway
- Secondary Highway
- Existing Railway
- Existing Access Road
- Existing Powerline
- CHPP Facilities
- Proposed Water Pipeline/ Service Road
- Railway Loop
- Proposed Helipad Access
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Topsoil Storage
- Construction Camp
- Ponds and Ditches
- Coal Handling Processing Plant and Infrastructure
- Covered Conveyor, Access Road and Powerline ROW
- Proposed Golf Course Area
- Undisturbed Area
- Legacy Mine Disturbance
- Load-out Study Area

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

AIR QUALITY LOAD-OUT ASSESSMENT STUDY AREAS

NOTES

AltaLIS, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

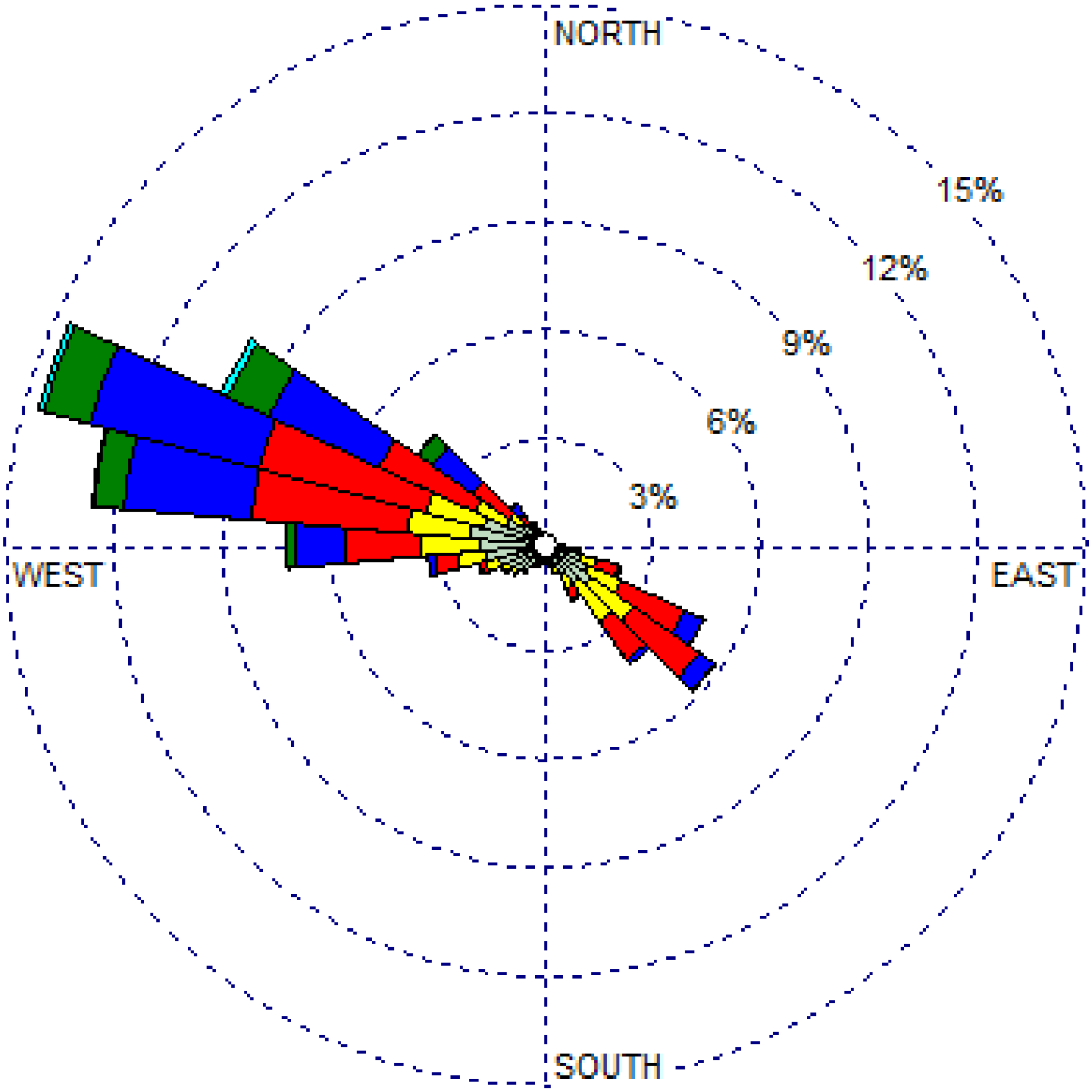
0 1 2 4
Kilometres

PROJECT: 14-00201-01
DRAWN BY: SL/JL
CHECKED BY: DM
DATE: JULY 12, 2016

FIGURE

1.0-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 1.0-1 Air Quality Loadout Assessment.mxd



LEGEND

WIND SPEED (m/s)

- >= 11.00
- 8.00 - 11.00
- 5.50 - 8.00
- 3.50 - 5.50
- 2.00 - 3.50
- 0.50 - 2.00

Calms: 12.32%

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

MODEL WINDS AT LOAD-OUT

NOTES

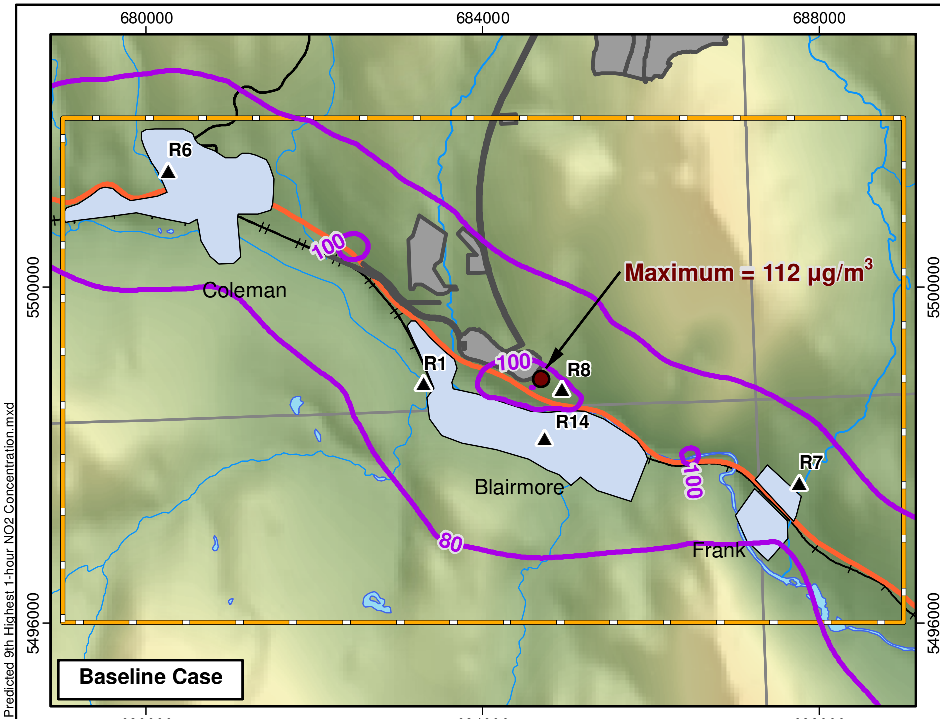
AltaLIS, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

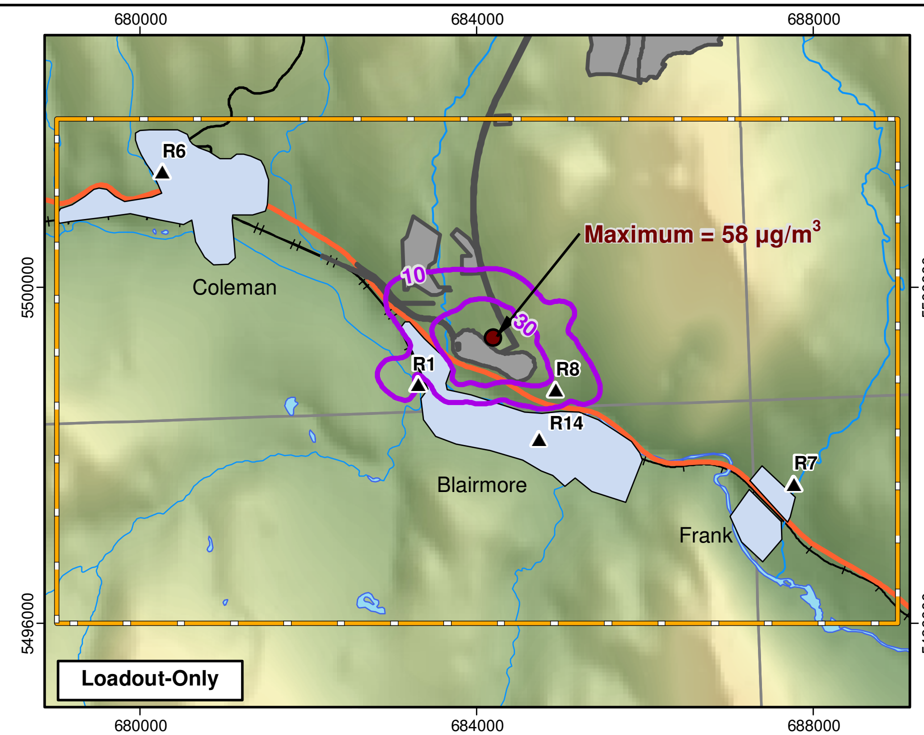
PROJECT: 14-00201-01
DRAWN BY: JL
CHECKED BY: MB
DATE: JULY 12, 2016

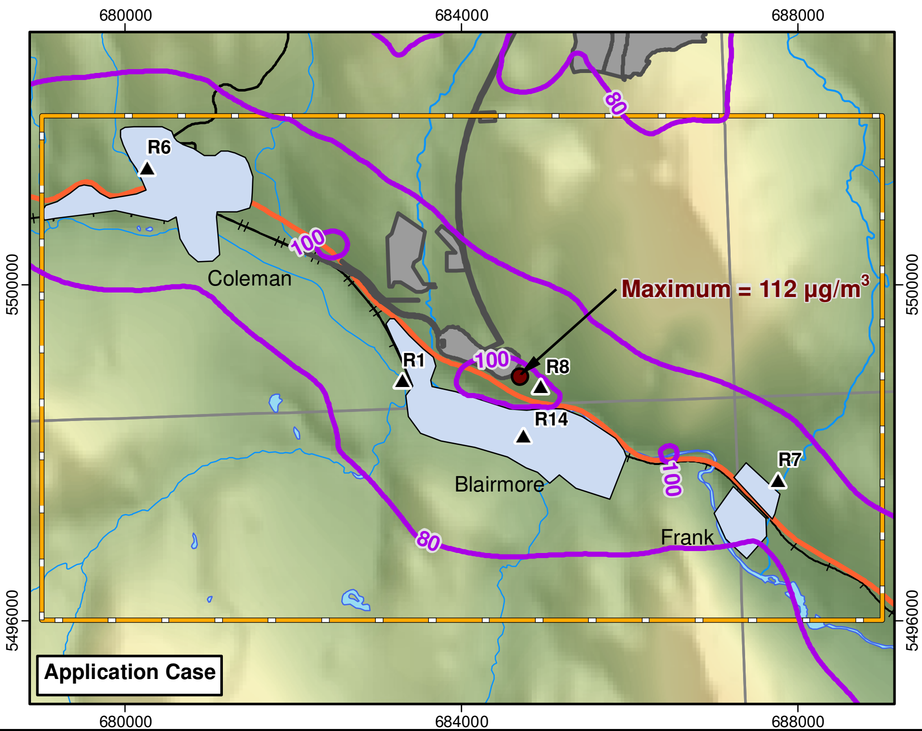
FIGURE

3.0-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Air_Q\Resubmission\Fig 3.0-1 Model Winds at Loadout.mxd







LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Study Area
- Project Footprint
- High : 2800
- Low : 1250

Label	Name
R1	Lost Lemon Campground
R6	Coleman
R7	Frank
R8	Blairmore
R14	Blairmore Centre

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED 9th HIGHEST 1-HOUR NO_2 CONCENTRATION (μg/m³)

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: JS/RR
DATE: JULY 7, 2016

NOTES
AltaLIS, 2016; GeoBase, 2016; Golder, 2016;
NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 0.5 1 2
Kilometres

FIGURE
6.0-1

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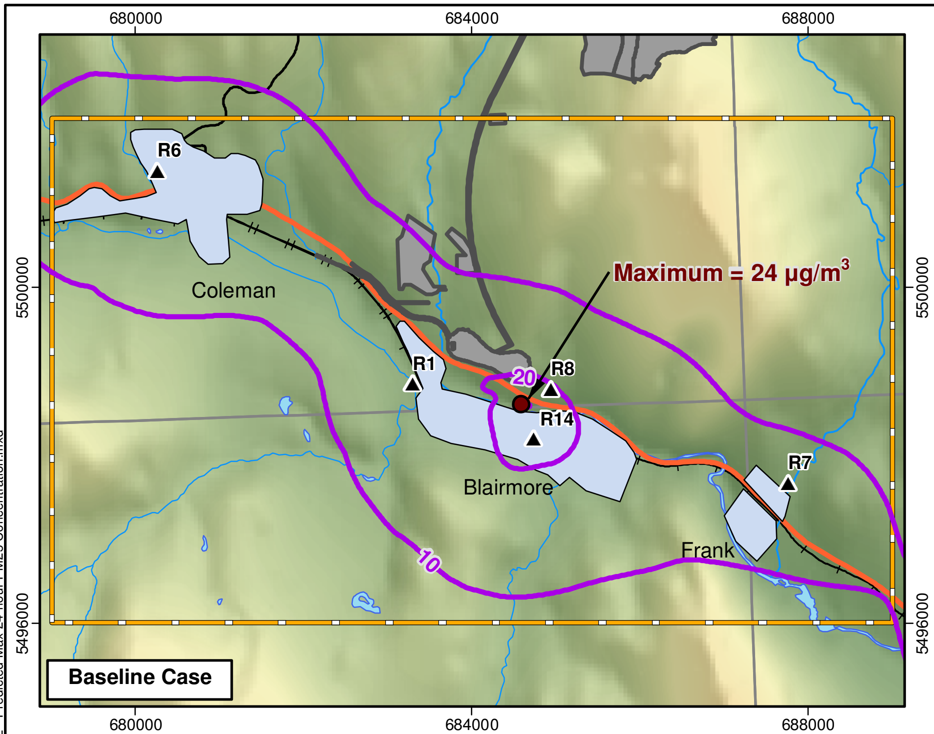

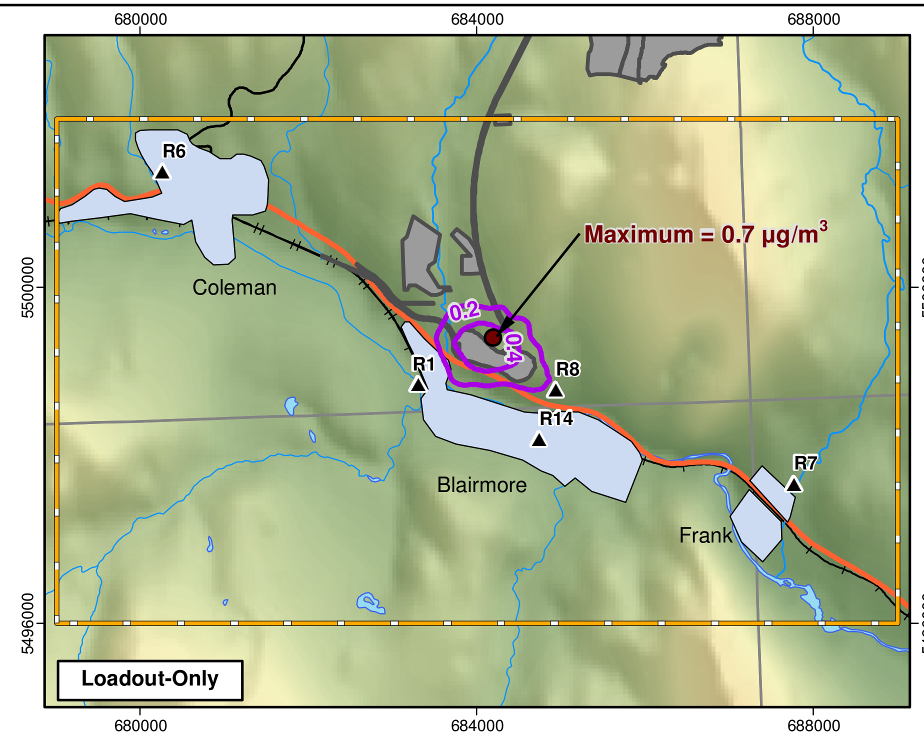

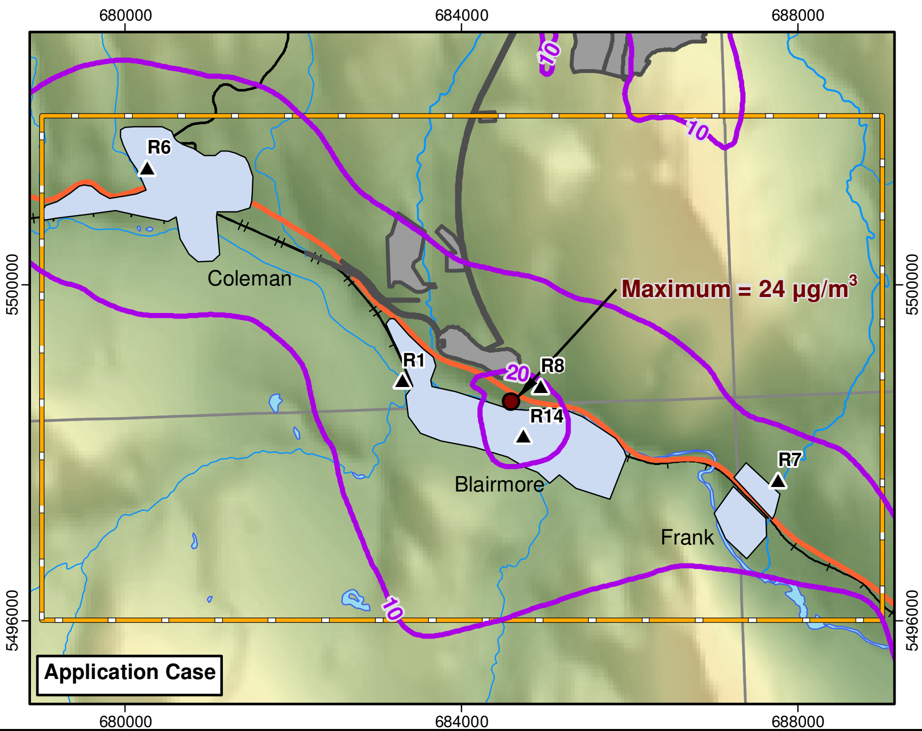

LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Study Area
- Project Footprint
- High : 2800
- Low : 1250

Label	Name
R1	Lost Lemon Campground
R6	Coleman
R7	Frank
R8	Blairmore
R14	Blairmore Centre

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: JS/RR
DATE: JULY 7, 2016

TITLE

PREDICTED MAXIMUM 24-HOUR $PM_{2.5}$ CONCENTRATION ($\mu g/m^3$)

NOTES
AltaLIS, 2016; GeoBase, 2016; Golder, 2016;
NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 0.5 1 2
Kilometres

FIGURE
6.0-2

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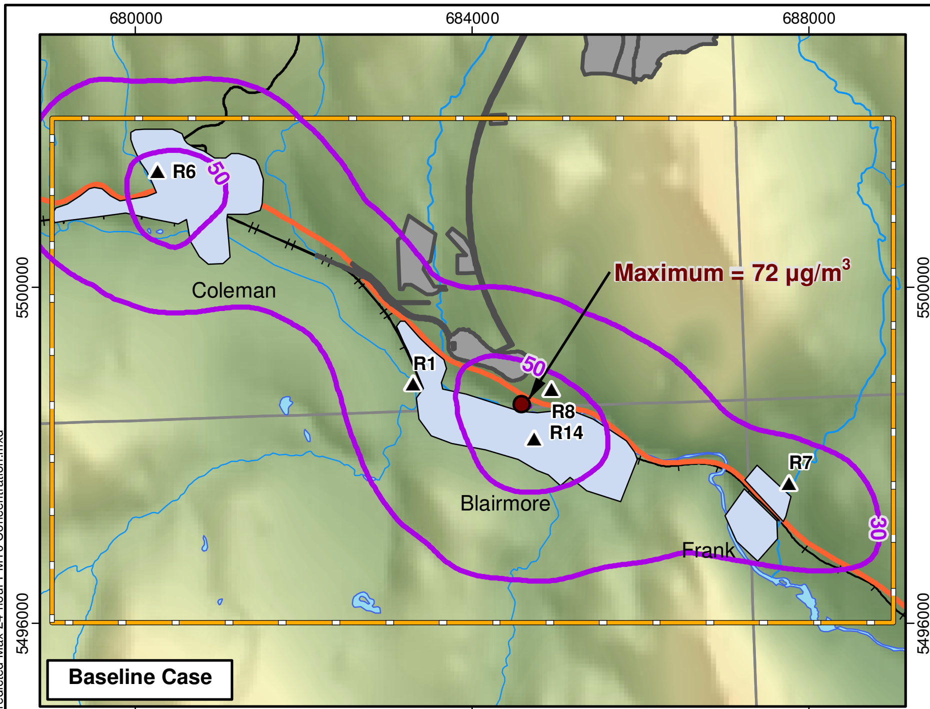
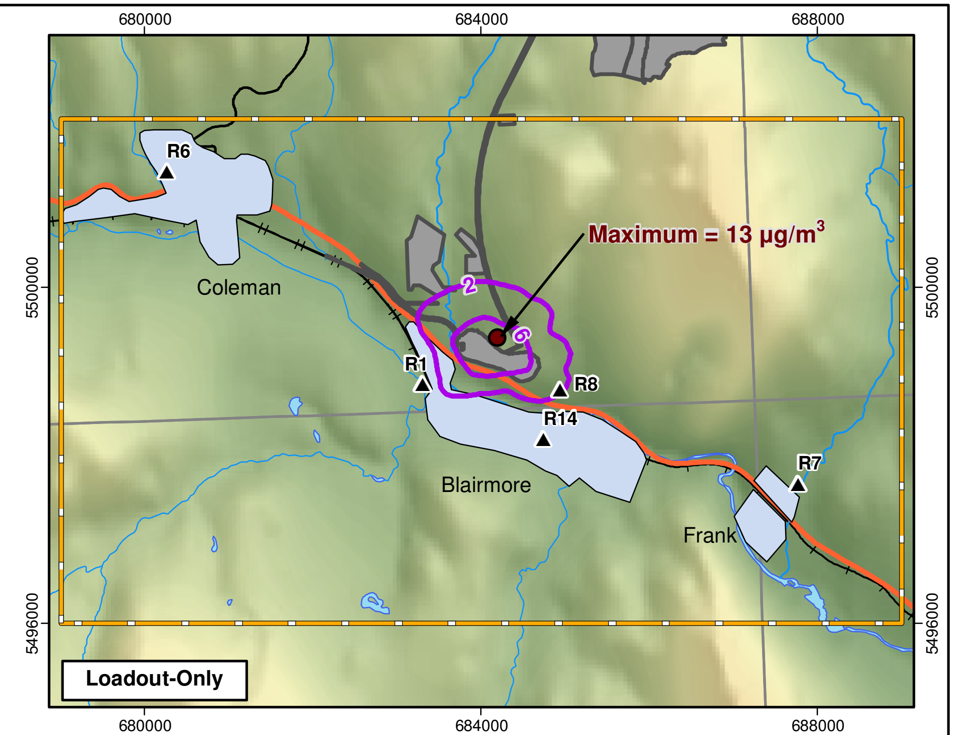
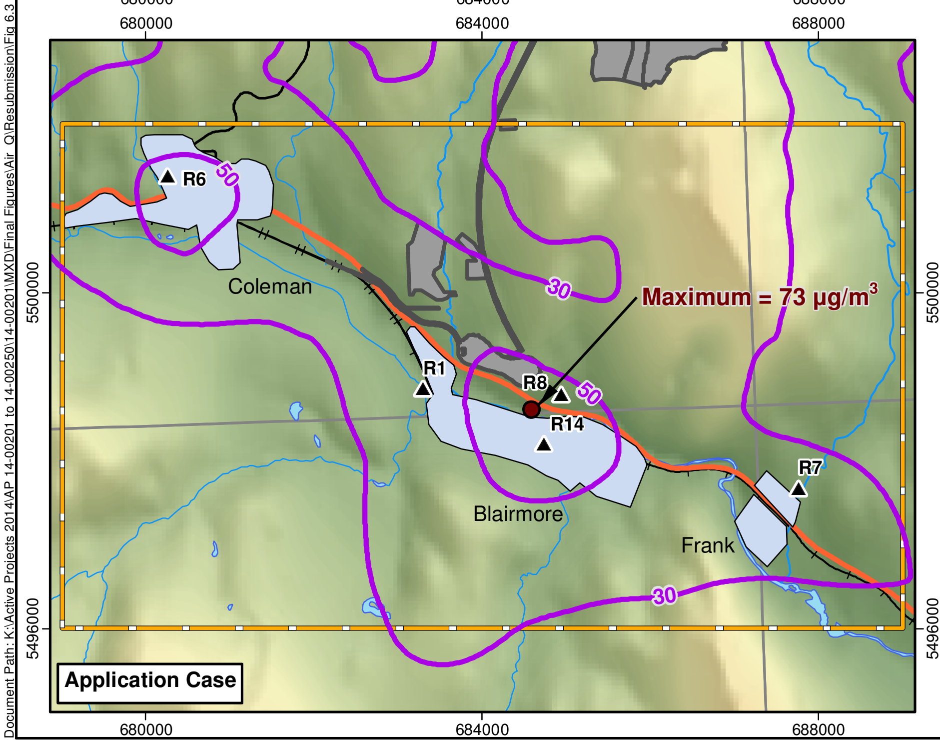






LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Study Area
- Project Footprint
- High : 2800
- Low : 1250

Label	Name
R1	Lost Lemon Campground
R6	Coleman
R7	Frank
R8	Blairmore
R14	Blairmore Centre

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

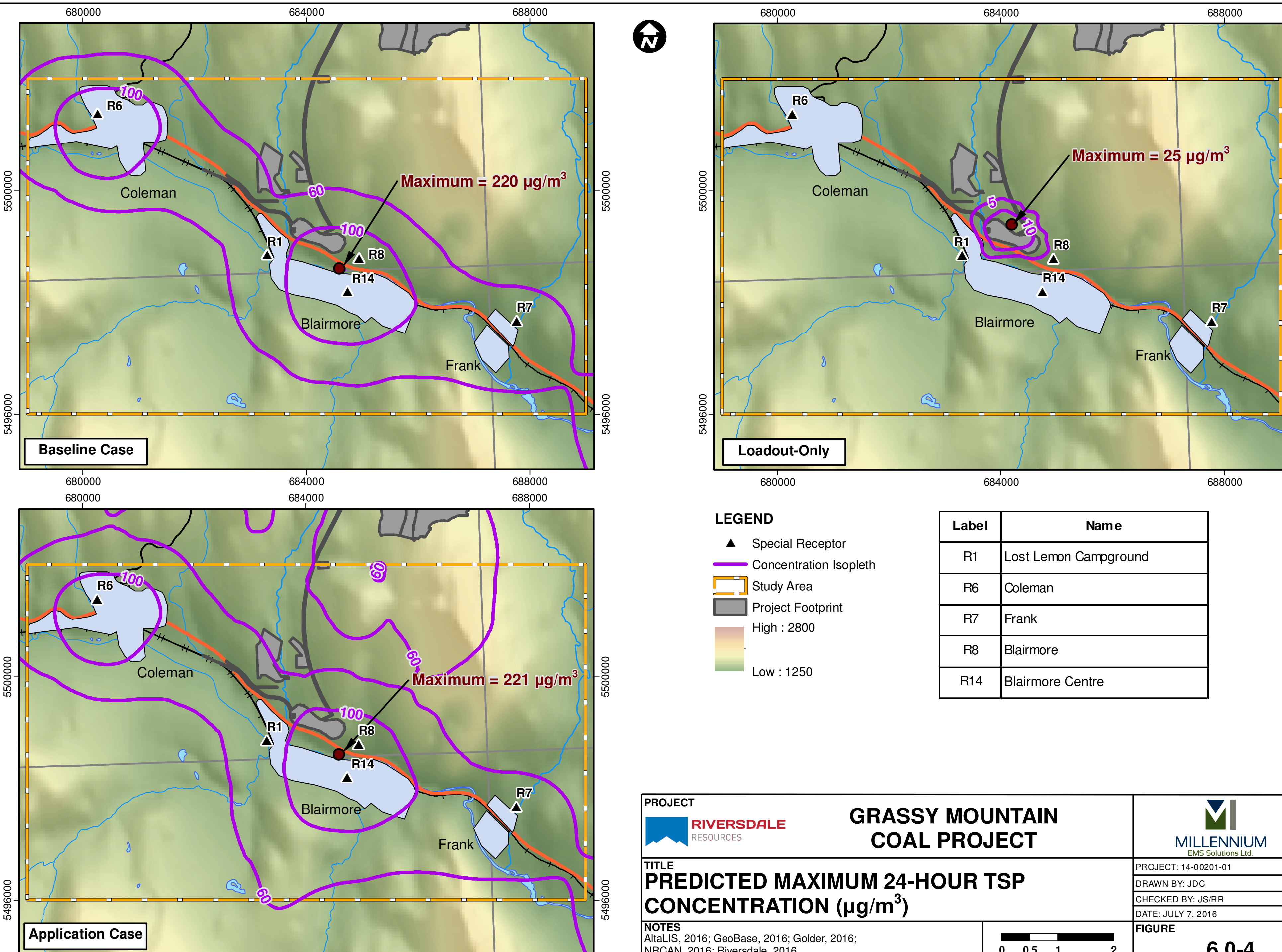
PREDICTED MAXIMUM 24-HOUR PM_{10} CONCENTRATION ($\mu g/m^3$)

PROJECT: 14-00201-01
DRAWN BY: JDC
CHECKED BY: JS/RR
DATE: JULY 7, 2016

NOTES
AltaLIS, 2016; GeoBase, 2016; Golder, 2016;
NRCAN, 2016; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 0.5 1 2
Kilometres

FIGURE
6.0-3



LEGEND

- ▲ Special Receptor
- Concentration Isopleth
- Study Area
- Project Footprint
- High : 2800
- Low : 1250

Label	Name
R1	Lost Lemon Campground
R6	Coleman
R7	Frank
R8	Blairmore
R14	Blairmore Centre

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PREDICTED MAXIMUM 24-HOUR TSP CONCENTRATION (μg/m³)

PROJECT: 14-00201-01

DRAWN BY: JDC

CHECKED BY: JS/RR

DATE: JULY 7, 2016

NOTES

AltaLIS, 2016; GeoBase, 2016; Golder, 2016; NRCAN, 2016; Riversdale, 2016

Datum/Projection: UTM NAD 83 Zone 11

0 0.5 1 2 Kilometres

FIGURE

6.0-4

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