AIR QUALITY ASSESSMENT IN SUPPORT OF THE SUMMIT PIT APPLICATION

MOUNTAIN ASH LIMITED PARTNERSHIP
SUMMIT PIT OPERATION
NW & SW 31-26-03-W5M
ROCKY VIEW COUNTY, ALBERTA

SLR Project No: 203.50207.00000
May 21, 2020

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SLR Project No: 203.50207.00000

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EXECUTIVE SUMMARY

SLR Consulting (Canada) was retained by Mountain Ash Group Ltd. (Mountain Ash) to provide an air quality assessment of emissions associated with the activities and operations of the proposed aggregate development, referred to as Summit Pit. Mountain Ash will apply for a Land Use Re-designation and Development permit to construct the aggregate pit northwest of the City of Calgary in Section 31, Township 26, Range 3 West of the 5th Meridian. The Summit Pit Project (Project) involves the production of over 0.5 million tonnes of aggregate per year when operating at peak capacity.

Project operations will result in emissions to the atmosphere. These emissions include diesel combustion products such as sulphur dioxide (SO_2), fine particulate matter with aerodynamic diameter less than 2.5 µm ($PM_{2.5}$), carbon monoxide (CO), oxides of nitrogen (NOx), and fugitive dust emissions from wheel entrainment and pit operations including total suspended particulates (TSP). These contaminants have the potential to be harmful to human health at sufficiently high ambient ground-level concentrations which should not exceed their prescribed Alberta Ambient Air Quality Objectives (AAAQOs).

Dispersion modelling was executed following the Alberta Environment and Parks (AEP) – and its predecessor organizations - dispersion modelling guidance (AESRD 20013b), using the CALMET and CALPUFF models with 5 years (2002-2006) of meteorological data.

To account for emissions from distant industrial facilities and non-industrial sources, background concentrations from the Caroline and Calgary Region Airshed Zone (CRAZ) air monitoring stations were added to predictions. Regional emissions from two active pits located within 5 km of the Project were modelled and added to predictions. Seven discrete (sensitive) receptors at nearby farms and residences were also included in this assessment.

Emission quantification accounts for emissions and dust from numerous project related activities and equipment such as aggregate excavating, loading and crushing, overburden stripping and bulldozing, transport of aggregate and overburden within pit, scrapers and loaders usage, stacking conveyors, watering, trucking of aggregate offsite and combustion emissions from engines. Additionally, it also accounts for wind-driven dust emissions.

Regional emissions from two active pits and one oil battery located within 5 km of the Project were added to predictions. Discrete(sensitive) receptors at nearby farms and residences were included in this assessment. Three individual pit activities were defined for the Project: overburden removal and backfill, aggregate mining/crushing, and sales (trucking). Maximum Daily Emission and Annual Average Emission cases were assessed. The Maximum Daily Emission Case assumed that all three pit activities overlap at their maximum respective emission rates, which were based on the number of working days and hours for each pit activity. However, for annual average predictions, emissions were spread over 24 hours and 365 days. To be conservative, precipitation was not considered, but may reduce total annual emissions of particulates.

The results at the Project boundary showed there were no predicted exceedances of AAAQOs for any modelled compounds and any averaging period. The predicted maximum concentrations at the sensitive receptors are all less than the AAAQOs for all modelling scenarios and all contaminants. Expected TSP concentrations will likely be lower, as the residences are surrounded by partially wooded areas and bushes which trap dust.

Some operating best-practice options were applied to reduce dust (TSP) emissions: the application of Calcium Chloride ($CaCl_2$) to unpaved roads for dust suppression, adding shrouds to conveyor drops and the application of watering on mine surfaces. Further, in order to avoid TSP exceedances along the property boundary,

crushers should be located at least 190 m from the east site boundary and 140 m from the other site boundaries.

In conclusion, operation of the Project is not expected to exceed ambient air quality objectives beyond the property boundary and, in particular, will have limited impact on air quality at the nearest residences, alone or in conjunction with emissions from other nearby operating industrial operations.

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1. INTRODUCTION

Mountain Ash Limited Partnership is applying for Land Use Re-Designation and a Development Permit for the development of the Summit Pit Operations (the Project) along Highway 567, northwest of the City of Calgary. The Project has a maximum capacity of producing approximately 0.5 million tonnes of aggregate per year.

Project operations will produce anthropogenic emissions and dust into the ambient air. Diesel combustion from engines on heavy trailer and haul trucks and other vehicles emit sulphur dioxide (SO_2), fine particulate matter with aerodynamic diameter below 2.5 micrometer ($PM_{2.5}$), carbon monoxide (CO), oxides of nitrogen (NOx). Additionally, fugitive dust emissions from wheel entrainment and pit operations produce suspended particulates (TSP). Since these contaminants can pose potential negative effect to human health at high ambient ground-level concentrations, they are regulated and should not exceed their prescribed Alberta Ambient Air Quality Objectives (AAAQOs).

SLR Consulting Ltd was retained by Mountain Ash Limited Partnership to carry out a dispersion modelling assessment related to the Project's estimated emissions. All standards and procedures outlined in the Alberta Environment and Parks (AEP) – and its predecessor organizations - dispersion modelling guidance (AESRD 20013b) are followed in the modelling work.

Five years of CALMET meteorological data (2002-2006) were used in the CALPUFF modelling. This report describes the project emission quantification approach, dispersion modelling configuration and an interpretation of the dispersion modelling results.

1.1 AIR QUALITY OBJECTIVES

Alberta's ambient air quality objectives AAAQOs) and guidelines are developed under the Alberta Environmental Protection and Enhancement Act (EPEA), and its objective is to protect Alberta's air quality. The AAAQOs shown in **Table 1-1** include SO_2, NO_2, CO, $PM_{2.5}$, TSP and the averaging periods for each pollutant varies from 1-hour to annual (AESRD 2013).

Table 1-1 Alberta Ambient Air Quality Objectives (AAAQOs)

Pollutant	Averaging Period	AAAQOs ($\mu g/m^3$)
SO_2	9^{th} Highest 1-hour	450
	Maximum 24-hour	125
	Maximum 30-day	30
	Annual	20
NO_2	9^{th} Highest 1-hour	300
	Annual	45
CO	9^{th} Highest 1-hour	15,000
	Maximum 8-hour	6,000
$PM_{2.5}$	Maximum 24-hour	29
TSP	Maximum 24-hour	100
	Annual	60

2. MODELLING APPROACH

The CALMET and CALPUFF models (version 7.1) were used for the air quality assessment, as recommended for refined regulatory air quality assessments (AESRD 2013). CALPUFF is an advanced non-steady-state meteorological and air quality modeling system consisting of three components: CALMET, CALPUFF, and CALPOST. CALMET is a diagnostic three-dimensional meteorological model, CALPUFF is an air quality dispersion model and CALPOST is a post processing package.

2.1 METEOROLOGY DATA

AEP provided five years (2002-2006) MM5 datasets as the standard input to CALMET, which has 12 km x 12 km horizontal resolution. The CALMET modelling domain covers 60 km x 60 km, and its south west corner is placed at UTM 646 km East and 5,653 km North. The adoption of horizontal grid cells of 1 km x 1 km resolution can both reduce expensive CPU run time cost and still capturing major terrain feature details and its influences on wind flow patterns as well. Geophysical parameters such as land use category, terrain elevation, roughness length, albedo, Bowen ratio and surface heat flux are interpolated from EPA provided datasets to CALMET defined grid cells. These parameters have seasonal variability and therefore influence CALPUFF modeling results. Specifically, four seasons were specified according to AEP model guideline (AESRD 2013b):

- Winter: November 15 to March 31 (ground could be snow-covered and/or frozen);
- Spring: April 1 to June 14 (snow melted, ground moisture is higher than average, there are no leaves on trees and bushes);
- Summer: June 15 to August 30 (leaves on bushes and trees; dry); and
- Fall: September 1 to November 14 (leaves fall from deciduous vegetation and ground moisture increases).

2.2 PROJECT LOCATION AND TOPOGRAPHY

The proposed project area is northwest of the City of Calgary in Section 31 and located south of Highway 567 (shown in **Figure 2-1**). The white rectangle encompasses the "Phase 3" project area, and the yellow filled areas are unpaved roads which haul trucks and other vehicles will use. The green shaded area shows the Project's full boundary and the blue line delineates the extraction boundary.

Topographic elevations for the terrain in CALMET and CALPUFF models 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 (approximately 23 meters) to a maximum 3 arc seconds (approximately 100 meters) for the 1:50,000 Canadian National Topographic System (NTS) tiles.

In this project CALPUFF model uses Universal Transverse Mercator (UTM) as its projection type its model center is located at UTM Coordinate 680,400 meters east and UTM Coordinate 5,682,600m north (NAD 83 UTM Zone 11N). The modelling study area has a north-south extent of 20 km and an east-west extent of 20 km.

2.3 RECEPTORS LAYOUT

The CALPUFF gridded receptors are designed using the following layout, per the AEP model guideline (AESRD 2013b).

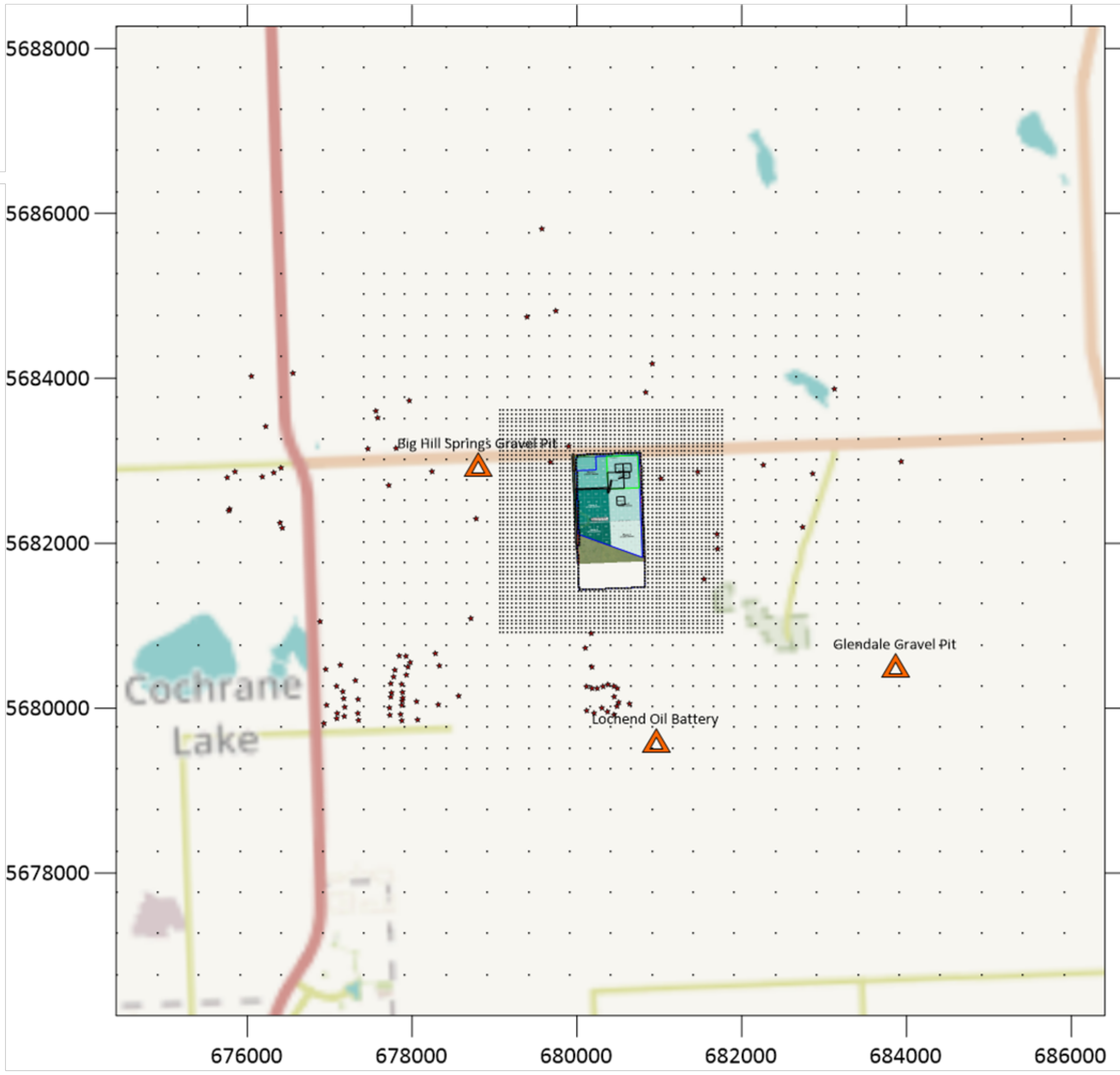
- Grid A = 20 x 20 km, 1,000 m spacing, centered on the model origin;

- Grid B = 10 x 10 km, 500 m spacing, centered on the model origin;
- Grid C = 4 x 4 km, 250 m spacing, centered on the model origin;
- Grid D = 1.8 x 1.8 km, 50 m spacing, centered on the model origin; and,
- Grid F = 20 m spacing along the Project boundary.

Additionally, a group of “sensitive” discrete receptors are purposely singled out as sensitive receptors group. Most of them are human-inhabited areas, sensitive ecosystems, or other important sites that are more susceptible to pollutant. **Figure 2-2** shows the layout of gridded receptors, as black dots, and discrete receptors, marked as red asterisks.

Considering cumulative effects, emissions from facilities within 5 km radius are included in the CALPUFF modelling. Two active pits, modelled as area sources, and one point source, are located within five kilometers distance of the Project and are modelled as existing nearby emissions sources. The first pit is Lafarge Big Hill Springs Gravel Pit, which is located approximately two kilometers northwest of the Project and the other is the Lafarge Glendale Gravel Pit, approximately 3.7 km southeast of the Project. The nearby point source emissions source is the Lochend Oil Battery, which is approximately 3.5 kilometers south of the Project (**Figure 2-2**).

Figure 2-1 Project Site Plan



MOUNTAIN ASH PROJECT	True North	Scale: N/A	METRES	SLR global environmental solutions
SUMMIT SITE, ALBERTA		Date: Apr 28, 2020	Rev 0.0	Figure No. 2.2
LAYOUT OF GRIDDED RECEPTORS (SMALL BLACK DOTS) AND RESIDENCE RECEPTOR (RED ASTERISKS). THREE BACKGROUND SOURCES ARE MARKED AS RED TRIANGLES		Project No. 203.50207.00000		

Figure 2-2 Layout of gridded receptors, as black dots, and discrete receptors, marked as red asterisks

3. EMISSION QUANTIFICATION

Emission quantification accounts for combustion and fugitive emissions from numerous project related activities, including:

- aggregate excavating,
- loading and crushing,
- overburden stripping and bulldozing,
- transport of aggregate and overburden within pit,
- scrapers and loaders usage,
- stacking conveyors,
- watering, and
- trucking of aggregate offsite, etc.

Additionally, it also accounts for wind-driven dust emissions.

Fuel combustion from operations is a primary source of SO_2, NO_X, CO, $PM_{2.5}$ and TSP. Fugitive emissions of particulate matters (PM) are mainly associated with wheel entrainment of dust on unpaved surfaces, crushing, overburden stripping, bulldozing, conveying and loading/unloading operations. Full details of emission estimate methods are provided in Appendix A.

3.1 PROJECT AREA SOURCE EMISSIONS DESCRIPTION

Project Phase 3 was determined as the worst-case phase due to using the most equipment, predominant westerly wind direction and the location of the sensitive receptors. Therefore, this assessment is based on the design of Phase 3 operation. For air quality modelling, all Project Phase 3 operations were represented by area sources and haul roads for modelling (as shown in Fig. 2.1):

- Mining area source (approximately 9,530 square meters) represents the aggregate extraction area during normal pit operations;
- Crusher area source (approximately 5,630 square meters) represents an operating area where all crushing activities take place;
- Stockpile area source (approximately 38,250 square meters) near the crusher location, represents stockpiles and aggregate loading for sales;
- Stripping area source (approximately 9,450 square meters) represents overburden stripping operation;
- Remediation area source (approximately 9,690 square meters) represents the backfill area, with overburden removal from stripping; and
- Conveyor area source (approximately 530 square meters) represents the conveyor transport area.

Additionally, the haul road was represented by:

- Paved Road - Aggregate Hauling, approximately 200 meters in length and 20 meters width; and

- Unpaved road - Aggregate hauling, approximately 600 meters in length and 18 meters in width. One area source for the un-paved portion of the haul road for aggregate sale (80 m in length).

3.2 COMBUSTION EMISSIONS

Combustion emissions for the operations fleet were based on U.S. EPA Tier 4 emission factors and load factors for non-road diesel engines, specifically the exhaust and crankcase emission factors for nonroad compression-ignition engines from the MOVES 2014b[1] emissions estimator. Emission factors for CO, NO_X, and $PM_{2.5}$ were extracted directly from MOVES 2014b and TSP was assumed to be equal to PM (total particulate matter defined in MOVES 2014b).

The load factor reflects equipment that work based on planned time and days (e.g., not full time). The MOVES 2014b model has equipment emission and load factor listings for various types of construction and mining equipment, including bulldozers, off-highway water trucks, quarry trucks, excavators, and loaders. **Table 3-1** summarizes the emissions parameters for the diesel-powered equipment. Detailed emissions estimates are provided in Appendix A.

EPA Tier 4 emission engines are expected to be operating in the pit, which provide the best efficiency and the lowest emissions. SO_2 emissions were based on a diesel fuel sulphur content of 15 ppm. The emissions from sales trucks were based on the maximum daily aggregate sale and the truck pay load.

Table 3-1 Parameters of the Diesel-Powered Equipment

OPERATION	EQUIPMENT	POWER RATING	TIER	HRS/DAY	DAYS	AVG FUEL	DIESEL SPECIFIC FUEL
		hp			Days/yr	L/hr	L/hr
Mining	CAT 374F Excavator	472	Tier 4	12	120	40	94
Mining & Crushing (Crusher feed load)	CAT 980M wheel Loaders	425	Tier 4	12	120	40	84
Crushing	Elrus Jaw Crusher	450	Tier 4	12	120	100	89
Crushing	1 MW crusher generator	1,341	Tier 4	12	120	150	266
Aggregate Sale	CAT966L Loader	278	Tier 4	7	302	30	55
Aggregate Sale	Peterbit Quad Trailer - Haul Truck	500	Tier 4	8	302	35	99
Overburden Stripping	Twin Engine 657G Motor Scraper	600	Tier 4	12	50	80	119
backfill/remediation	CAT D-7E dozer	238	Tier 4	6	50	30	47
Grader	CAT 14M grader	275	Tier 4	3	50	40	55

[1] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100UXEN.pdf

road, mining, stockpiles areas	Tandem Water Truck	550	Tier 4	12	240	13	109

3.3 EMISSION ASSUMPTIONS

The following key assumptions made up the Project's emissions estimates:

- Breaker/Crusher, water truck and diesel generator diesel engines, haul trucks, excavator, bulldozers, loaders, and scrapers meet Tier 4 EPA emissions standards;
- Crushing will operate 12 hours a day (between 7:00 am to 7:00 pm on Monday to Friday, and 7:00am to 5:00pm on Saturday), 120 days per year, from April 1 to October 31; in winter months (from November 1 to March 31), 10% of operation is considered in the modelling practice assuming a minimum maintenance activity is still required;
- Overburden stripping will operate 12 hours a day (between 7:00 am to 7:00 pm) except in winter months (from November 1 to March 31), 10% of operation is considered in the modelling practice;
- Sale will operate 12 hours a day (between 7:00 am to 7:00 pm) except in winter months (from November 1 to March 31), 5% of operation is considered in the modelling practice;
- Maximum aggregate extraction is 1,344,000 t/year, aggregate production is 1,200,000 t/year which will generate an estimated waste/reject material of approximately 161,280 t/year depending on the type of aggregate being produced;
- Mining/crushing emissions are reduced using "escape fractions", assuming the mining/crushing mostly operates in the sunken pit area 20 m below ground level. Conveyor on site is equipped with rubber shrouds to minimize drop height for dust control. The crushers will not be within 190 m from the east site boundary and 140m from all other boundaries;
- Aggregate silt and moisture contents are 3% and 4%, respectively; overburden silt and moisture contents are 2% and 12%, respectively, and haul road silt and moisture contents are 3% and 8%, respectively;
- During normal operation year, maximum overburden removal will be assumed as 450,000 t/year based on 50-day stripping per year;
- Assuming the dust suppressing technology with the application of Calcium Chloride ($CaCl_2$) on all unpaved roads, the facility will keep dust emission reduction to 89% on unpaved roads, according to U.S. EPA's AP-42 13.2.2 (U.S. EPA, 2006). Watering will be applied on off-road traffic areas including mine surface, crushing, stockpile, stripping and backfill/remediation;
- All stacking conveyors are uncovered but equipped with rubber shrouds to minimize the drop height, therefore the drop height is lowered to about 0.5 m in the CALPUFF modelling;
- The pit will be closed or operated on a minimal basis between December 1 and March 9 each year; and
- Windblown emissions are modelled during non-working hours from all actively disturbed areas, including uncovered conveyors. It was assumed that there was no wind driven emissions for wind speeds below 5.36 m/s at the height of the emitting surface, which is the threshold velocity for aggregate piles (EC 2009).

3.4 EMISSIONS BY ACTIVITY

3.4.1 CRUSHING

The major crushing activities including primary crushing, screening, conveyor transferring, secondary crushing, screening and conveyor transferring to drop points. Crushing rates are 12,096 t/day, and 1,344,000 t/year respectively. **Table 3-2** summarizes the emissions due to Crushing activities.

Table 3-2 Summary of Daily Emissions from Crushing Activities

CRUSHING ACTIVITIES (12 HRS/DAY)	PM2.5	TSP
	kg/day	kg/day
Primary Crushing (controlled)	0.6	7.3
Screening (controlled)	0.3	13.3
Conveyor transfer points (controlled)	0.1	0.8
Secondary crushing (controlled)	0.6	7.3
Screening (controlled)	0.3	13.3
Conveyor transfer points (controlled)	0.1	0.8
Sum	**2.0**	**42.8**

3.4.2 CONVEYOR DROP

A total of four conveyors are considered in operation. Stack Conveyors 1-3 transfer aggregate from crushers to stockpiles, and the fourth is a telescopic stacker to stockpile. The drop height is set to minimum at 0.5 m to reduce dust emissions. Emission factors are derived from U.S. EPA AP-42 11.19-2-1. **Table 3-3** summarizes PM emissions resulting from conveyor drop.

Table 3-3 PM Emissions from Conveyor Drop

CONVEYOR DROP (4 CONVEYORS, 12 HR/DAY)	$PM_{2.5}$	TSP
	kg/day	kg/day
	0.1	5.5

3.4.3 LOADING AND UNLOADING

Summit will sell aggregate from the pit throughout the year; however, most sales will likely be focused over the spring, summer, and fall period. During this activity, aggregate will be loaded from the stockpiles onto trucks and transported offsite. Aggregate sales may overlap with overburden removal and mining/crushing activities. Mitigation of fugitive dust with watering is proposed - 75% dust reduction has been applied in the air quality modelling. **Table 3-4** summarizes emissions from loading and unloading processes.

Table 3-4 Summary of Emissions from Loading and Unloading

LOADING AND UNLOADING (12HR/DAY)	QUANTIFY	$PM_{2.5}$	TSP
	t/hr	kg/day	kg/day
Aggregate Mined loading to crusher feeder	1,008	0.2	3.0
Aggregate Sale (load from pile to truck)	900	0.2	2.6
Overburden loading/unloading x2	750	0.1	0.9
Sum		**0.468**	**6.530**

3.4.4 WIND EROSION

Summit expects the overburden hauling and remediation area will be crusted or covered by vegetation or snow after overburden stripping and backfilling is complete. Crusting would occur if the area is not disturbed for a period of time, depending on aggregate soil types and moisture content. Any natural crusting of the surface binds the erodible material, thereby reducing the erosion potential (U.S. EPA 2006).

Table 3-5 summarizes wind erosion emissions from Summit Pit operations on a windy day, with wind speeds above 5.36 m/s in 24 hours; according to U.S. EPA AP 42. This is expected to be a conservative assumption to ensure wind driven model emissions are not under-estimated.

Even though wind driven emissions during the nighttime and winter would be much lower due to less operational disturbance, wind driven emissions from active aggregate pit area and stockpiles were modelled 24 hours each day for 365 days a year, with hourly wind speed as varying scaling factors. To conservatively assess wind driven emissions, precipitation was not considered to reduce annual wind driven emissions from the actively disturbed area.

Table 3-5 Summary of Emissions from Loading and Unloading

WIND EROSION		**PM2.5**	**TSP**
	Surface area (m²)	**kg/day**	**kg/day**
Mine face	10,000	0.8	3.8
Strip face	10,000	0.5	2.5
Backfill face	10,000	0.5	2.5
Conveyors	101	0.0	0.0
Unpaved road (onsite)	3,660	0.3	1.4
Unpaved Range Rd 40	5,310	0.4	2.0
Piles (stockpiles)	10,617	0.8	4.0
Sum	**49,688**	**3.28**	**16.38**

3.4.5 ROAD DUST

Road dust is one of the major emission source groups from the Project. It includes road dust emissions from moving vehicles on paved and unpaved roads, haul-trucks and water trucks for paved road and trucks for calcium chloride applications on unpaved road, etc. Road dust also includes emissions from off-road equipment and machines performing on-site activities, such as crushing, stripping, bulldozing and grading for remediation, backfilling, stockpiling, etc. **Table 3-6** summarizes emissions of road dust.

Table 3-6 Summary of Road Dust Emissions

ROAD DUST (12 HR/DAY)	**PM2.5**	**TSP**
	kg/day	**kg/day**
Mine	0.1	1.2
Crushing	0.003	0.05
Stockpile	0.1	0.9
Stripping	0.1	1.1
Backfill/remediation	0.3	1.5
Paved	0.03	0.7
Unpaved	1.6	31.7
Sum	**2.16**	**37.21**

3.5 BACKGROUND REGIONAL EMISSIONS

Two active pits (area sources) and one single point source are located within 5 km of the Project and are modelled as existing regional emission sources, as shown in **Figure 2.2**. The first pit is Lafarge Big Hill Springs Gravel Pit, which is located around 2 km northwest of the Project si and another one is Lafarge Glendale Gravel Pit, which is around 3.7 km southeast of the Project site. Emissions for the Glendale and Big Hill Springs Gravel Pits were taken from the air quality assessment for the Lafarge Hughes Gravel Pit (Lafarge 2014). The nearby point source emission is Lochend Oil Battery which is about 3.5 km south from the project site and its emissions are retrieved from NPRI report (NPRI 2017 database).

Table 3-7 summarizes regional maximum daily and annual emissions modelled for Glendale and Big Hill Springs Pits. Both active pits were modelled as area emission sources. The Lochend Oil Battery's emissions are from a flaring stack, which is treated as a point source in the modelling.

Table 3-7 Summary of Emissions from Nearby Facilities

Pollutant	Maximum Daily Emissions (kg/12-hr operating day)		Annual Emissions (t/year)
	Lafarge Glendale Pit	Lafarge Big Hill Springs	Lochend Oil Battery, 15-19-026-03W5, ORLEN Upstream Canada Ltd, NPRI ID: 29492
SO_2	0.39	0.1	-
NO_X	167.1	41.8	-
CO	49.8	12.4	-
$PM_{2.5}$	8.9	2.2	3.4
TSP	44.9	11.2	3.4

3.6 MONITORED BACKGROUND CONCENTRATIONS

According to model guideline (AESRD 2013b), for refined modelling projects, the 90th percentile value observations from the cumulative frequency distribution for all averaging periods should be added to model predictions. Since the Alberta Air Data Warehouse is temporarily out of work, the latest background concentration observation is not available during the period of this project and the observation data for earlier period(2009-2013) was adopted. For this Project, background concentrations of NO_X, $PM_{2.5}$ and SO_2 were obtained from the Caroline station, which is 77 km northwest of the Project. CO concentrations were obtained from the Calgary Northwest station because no CO measurement is available at Caroline. TSP and PM_{10} are measured only at Calgary Centre. Using data from Brook et al., (1997), TSP background concentrations were estimated by multiplying PM_{10} concentrations by a factor of 2. A summary of the background observations used in this assessment is provided in **Table 3-8**.

Table 3-8 Summary of Background Concentrations of Nearby Observation Sites (unit:µg/m3)

Pollutant	90th Percentile Hourly	90th Percentile 8-Hour	90th Percentile 24-Hour	90th Percentile Monthly	90th Percentile Annual	Monitoring sites and periods
SO_2	3.1	-	3.0	2.4	1.3	Caroline (2009-2013)
NOx	12	-	-	-	6.2	Caroline (2009-2013)
CO	355	355	-	-	-	Calgary Northwest (2009-2013)
$PM_{2.5}$	2.3	-	2.3	-	2.1	Caroline (2009-2013)
TSP	-	-	7.8	-	7.0	Caroline (2009-2013)*

*Based on Brook et al., (1997), TSP background concentrations were estimated by multiplying PM_{10} concentrations by a factor of 2.

4. DISPERSION MODEL PREDICTIONS

Based on the all the emissions sources described in section 3, three scenario predictions are made by CALPUFF model at all gridded and all desecrated (residence) receptors. These scenarios are:

- "Project-Only" Scenario: emissions include combustion and area sources emissions produced by the Project only. In this scenario, the Calcium Chloride ($CaCl_2$) dust suppression technology is considered, and two crushers are operating simultaneously;
- "Baseline" Scenario: emissions include only the two nearby area active pits and single point-source in the modelling domain; and
- "Application" Scenario: cumulative case created by merging "Project-Only" and "Baseline" scenario, with the addition of the natural background monitoring concentrations from Table 3.8. Results of this case are compared to AAAQOs.

4.1 MODELLING RESULTS

Modelled ground-level concentrations at discrete receptors for all modelling scenarios are presented in **Table 4-1**. The last column in the table shows the AAAQO for the different averaging periods, ranging from one hour to annual. All predicted maximum concentrations at discrete receptors are less than their respective AAAQOs for all modelling scenarios and all contaminants.

Table 4-1 Summary of Ground-Level Concentrations at Discrete Receptors

Pollutant	Averaging Period	Project-Only Scenario	Baseline Scenario	Application Scenario		AAAQO (µg/m³)
		Prediction (unit: µg/m³)	Prediction (unit: µg/m³)	Prediction (unit: µg/m³)	Percentage of AAAQO	
SO_2	9th Highest 1-hour	0.7	0.3	4.5	1.0%	450
	Maximum 24-hour	0.2	0.1	3.2	2.6%	125
	Maximum 30-day	0.1	0.1	2.5	8.3%	30
	Annual	0.1	0.1	1.4	7.0%	20
NO_2	9th Highest 1-hour	71	73	94	31.3%	300
	Annual	1	3	10.2	22.7%	45
CO	9th Highest 1-hour	747	39	1,107	7.4%	15,000
	Maximum 8-hour	226	26	582	9.7%	6,000
$PM_{2.5}$	Maximum 24-hour	4	2	6.3	21.7%	29
TSP	Maximum 24-hour	29	10	36.8	36.8%	100

Modelled maximum ground-level concentrations for the receptors grid are presented in **Table 4-2**, based on the best practice operational options (including mitigations) as mentioned below. It shows that all predicted maximum concentrations at the receptors within the study area are less than the AAAQOs for all modelling scenarios and all contaminants.

An analysis of source apportionment using CALPUFF modelling output tests indicated that the crushers are the largest contributors to TSP emissions. When crusher locations approach the property boundary, TSP exceedances may occur along and adjacent to the project boundary. Based on modelling tests, It is recommend as the best practice operation options that crushers are limited in their locations to minimum 190 m away from the eastern property boundary and 140 m away from all other boundaries.

Table 4-2 Summary of Ground-Level Concentrations at All Grids

Pollutant	Averaging Period	Project-Only Scenario	Baseline Scenario	Application Scenario		AAAQOs ($\mu g/m^3$)
		Prediction (unit:$\mu g/m^3$)	Prediction (unit:$\mu g/m^3$)	Prediction (unit:$\mu g/m^3$)	Percentage of AAAQOs	
SO_2	9th Highest 1-hour	1.7	1.8	4.9	1.1%	450
	Maximum 24-hour	0.6	0.6	3.6	2.9%	125
	Maximum 30-day	0.2	0.2	2.6	8.7%	30
	Annual	0.1	0.2	1.4	7.0%	20
NO_2	9th Highest 1-hour	82	149	161	53.7%	300
	Annual	3.7	31	37.2	82.7%	45
CO	9th Highest 1-hour	1,432	236	1,787	11.9%	15,000
	Maximum 8-hour	478	157	833	13.9%	6,000
$PM_{2.5}$	Maximum 24-hour	10	14	16.3	56.2%	29
TSP	Maximum 24-hour	86.1	68	90.0	90.0%	100
	Annual	15	19	26	43.3%	60

4.2 MITIGATION APPLIED

CALPUFF modelling results are based on following mitigation options taking place during Project operations. The recommended mitigation options are:

1) Apply $CaCl_2$ to all unpaved roads and apply water to mine operations where applicable; and
2) Crushers are limited in their locations to minimum 190 m from the eastern property boundary, and 140 m from all other boundaries.

There is no need for additional mitigation since modelling predictions are expected to be conservative (erring on the high side). Therefore, all predicted maximum concentrations are less than the AAAQOs for all modelling scenarios and all contaminants.

4.3 CONTOUR PLOTS

Contour plots for the Application scenario are generated to show model prediction for each of the average periods. Although CALPUFF modeled 5-year consecutively, only the worst-case year (with the highest concentration) of each pollutant are presented. Figure 4.1-4.2 show contour plots of 24-hr and annual TSP levels, respectively. Figure 4.3 is the contour plot for 24-hr $PM_{2.5}$ levels. Figure 4.4 – 4.7 represents ground level concentration contour plots for SO_2 in 1-hr, 24-hr, 30-day and annual maximum concentrations, respectively. Figure 4.8 - 4.9 show contour plots for 1-hr and annual maximum NO_2 concentrations, respectively. Figure 4.10 - 4.11 show contour plots for 1-hr and 8-hr maximum CO levels.

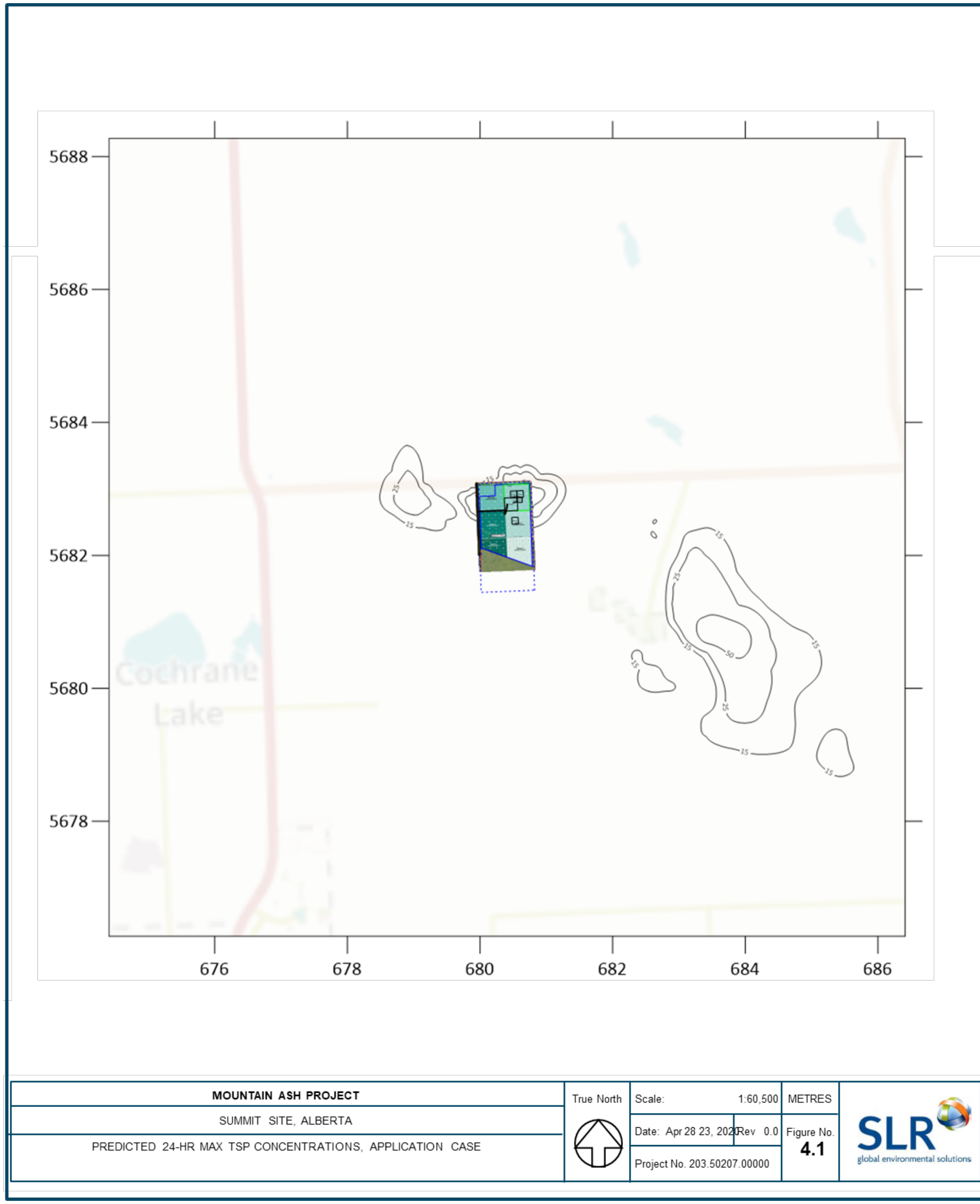
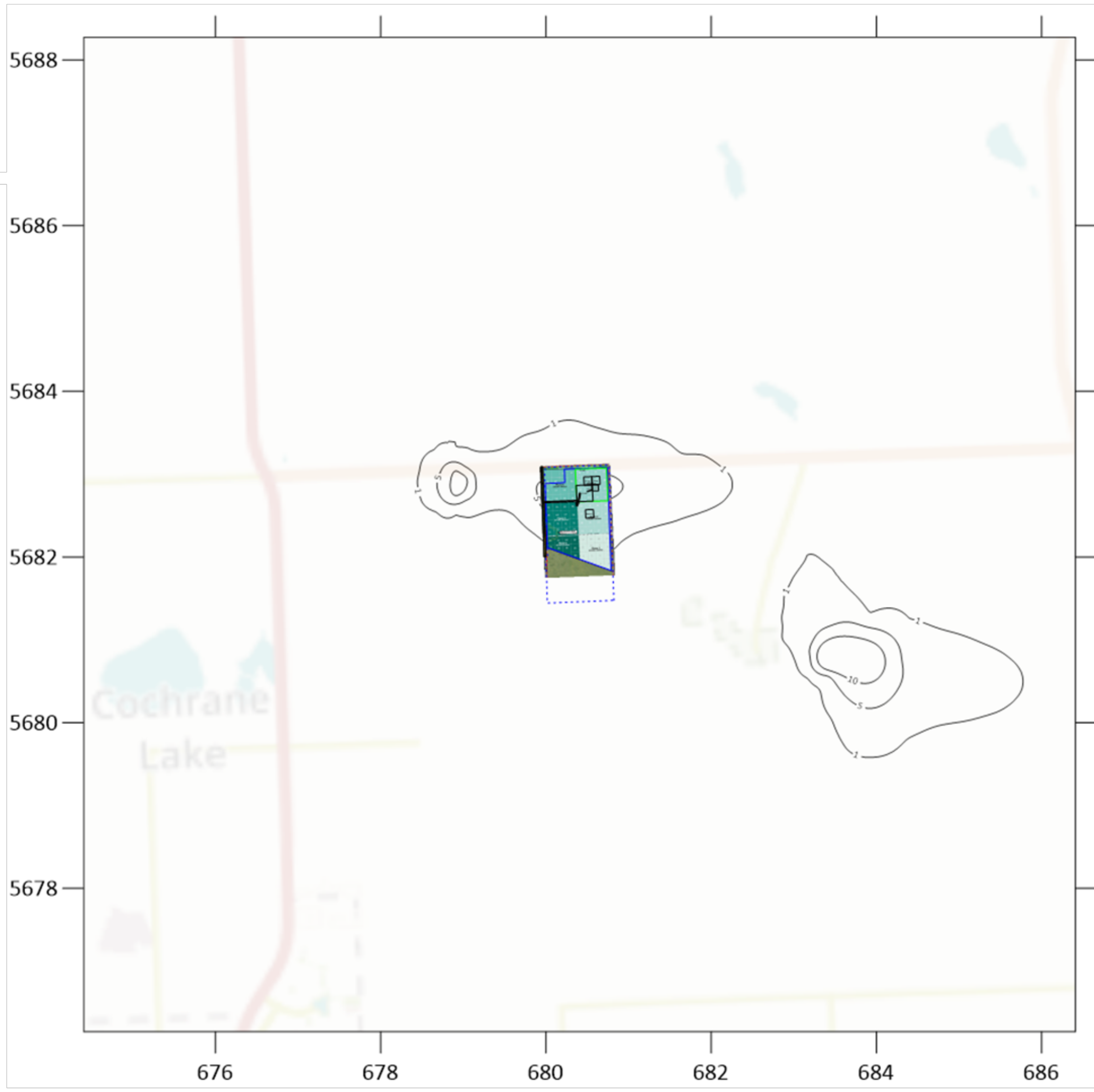


Figure 4-1 Predicted 24-HR MAX TSP Concentrations, APPLICATION CASE



MOUNTAIN ASH PROJECT	True North	Scale: 1:60,500	METRES	SLR global environmental solutions
SUMMIT SITE, ALBERTA		Date: Apr 28, 2020 / Rev 0.0	Figure No. 4.2	
PREDICTED ANNUAL MAX TSP CONCENTRATIONS, APPLICATION CASE (2005)		Project No. 203.50207.00000		

Figure 4-2 Predicted ANNUAL MAX TSP Concentrations, APPLICATION CASE (2005)

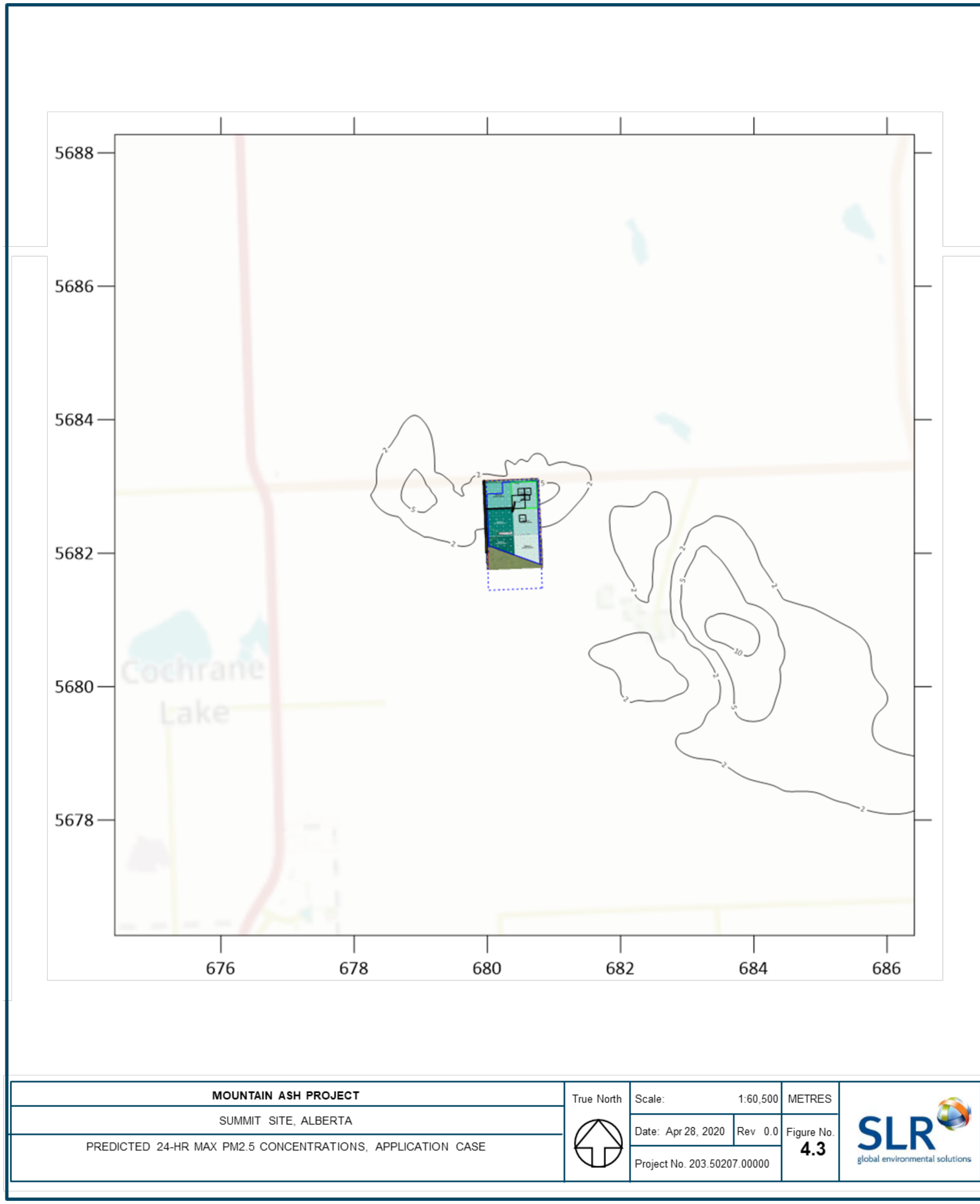
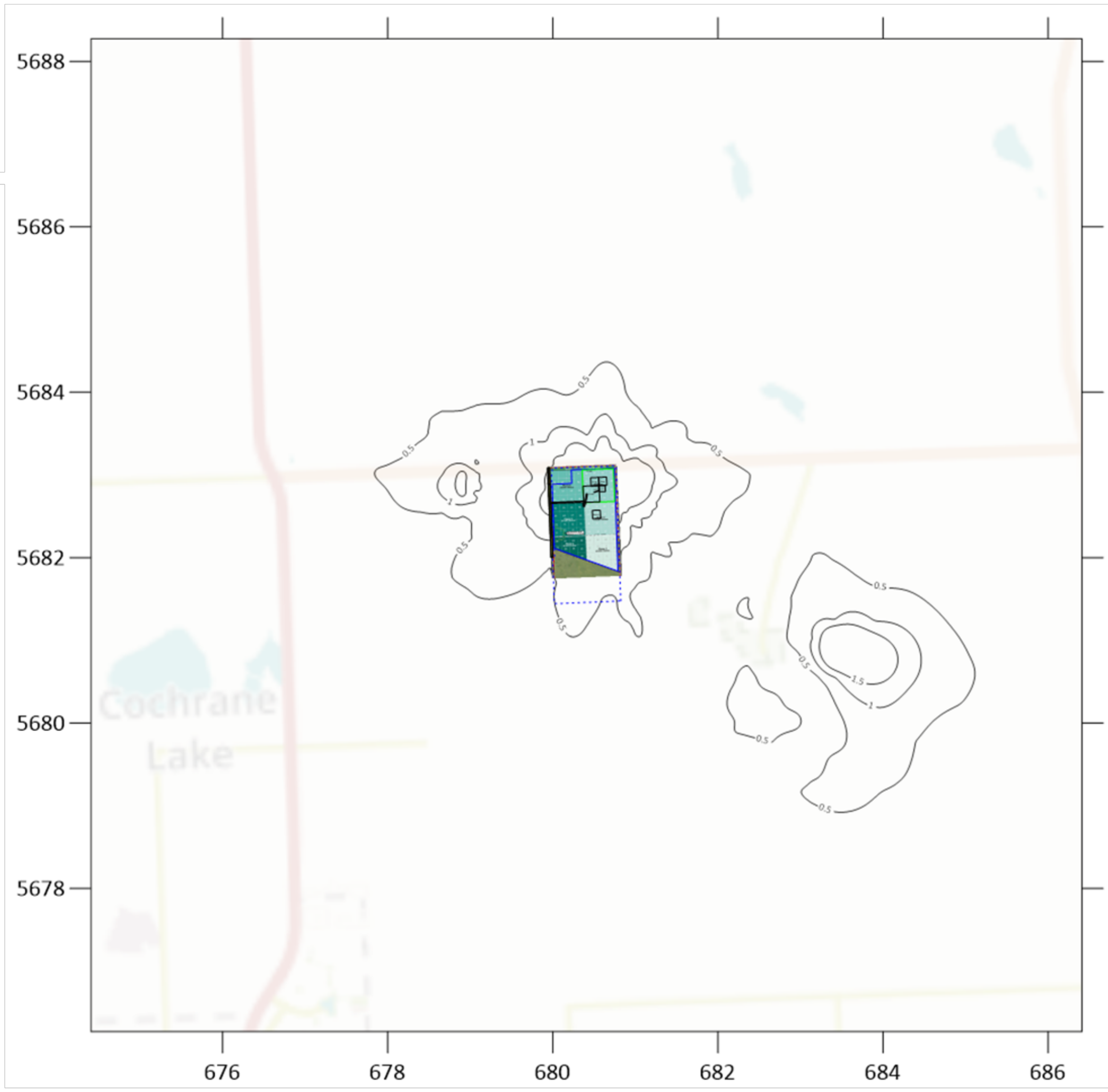
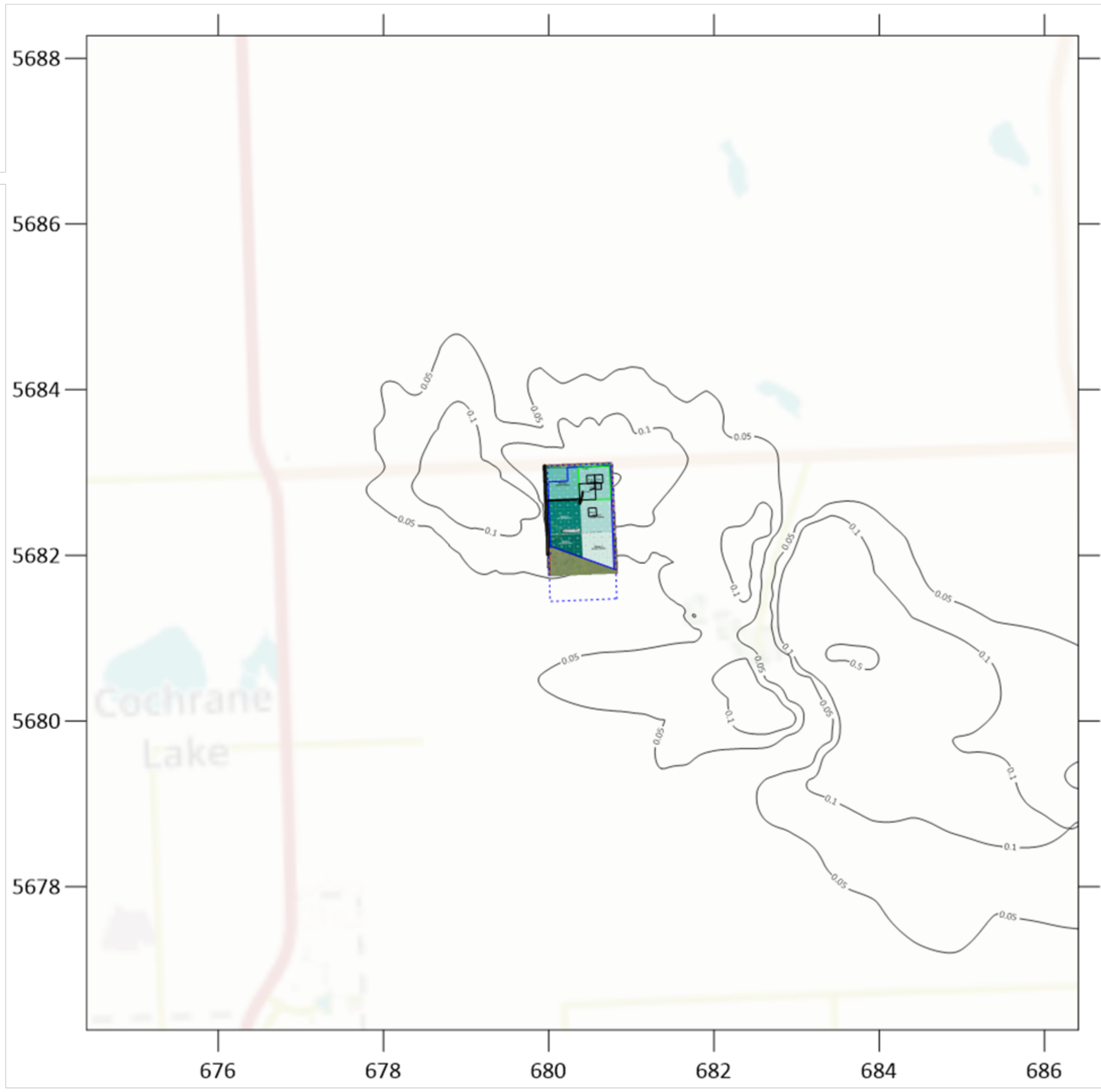


Figure 4-3 Predicted 24-hr MAX $PM_{2.5}$ Concentrations, APPLICATION CASE



MOUNTAIN ASH PROJECT	True North	Scale: 1:60,500		METRES	
SUMMIT SITE, ALBERTA		Date: Apr 28, 2020	Rev 0.0	Figure No. 4.4	
PREDICTED 1-HR MAX SO2 CONCENTRATIONS, APPLICATION CASE		Project No. 203.50207.00000			

Figure 4-4 Predicted 1-hr MAX SO_2 Concentrations, APPLICATION CASE

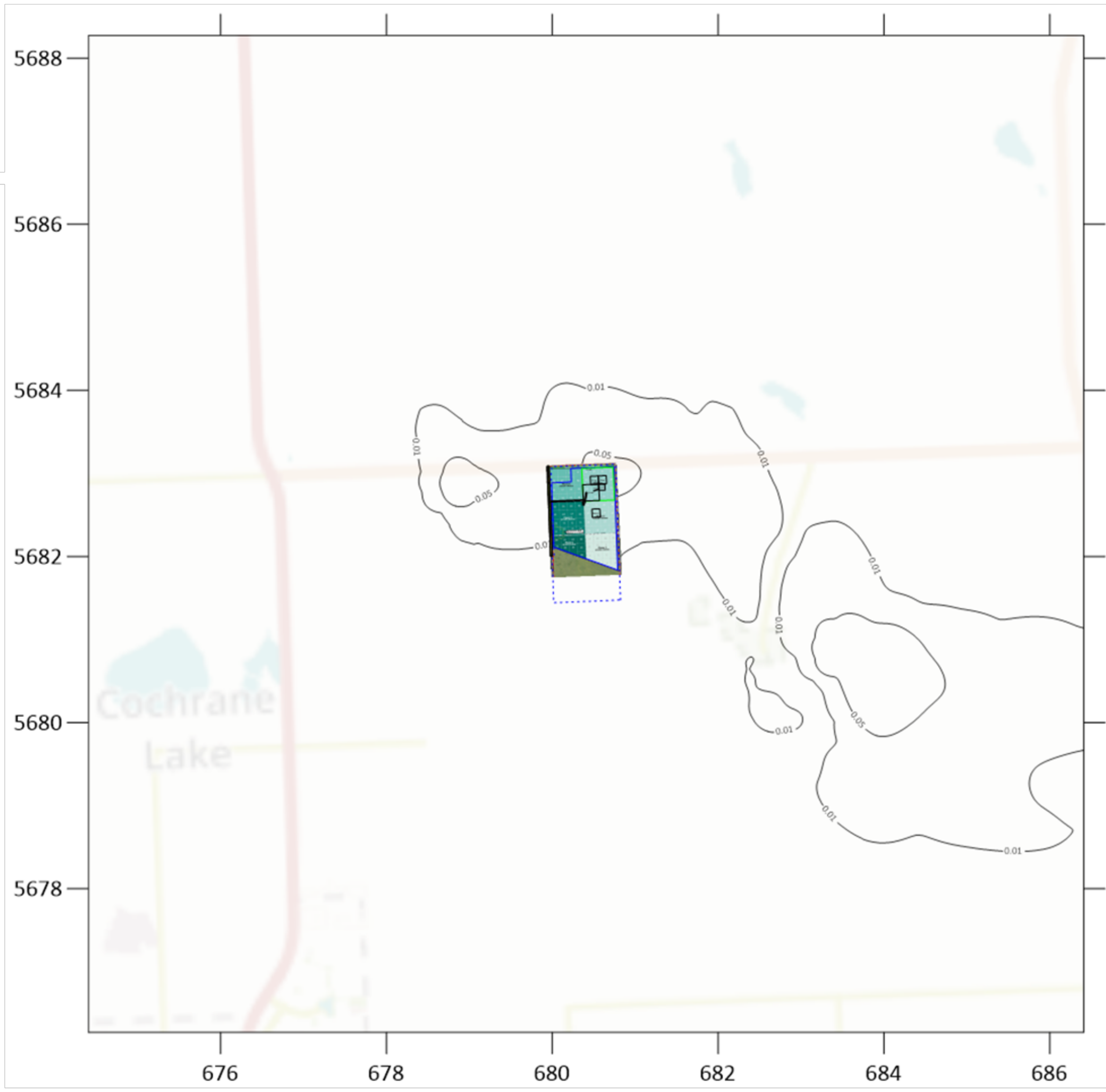


MOUNTAIN ASH PROJECT
SUMMIT SITE, ALBERTA
PREDICTED 24-HR MAX SO2 CONCENTRATIONS, APPLICATION CASE

True North | Scale: 1:60,500 METRES | Date: Apr 28, 2020 | Rev 0.0 | Figure No. 4.5 | Project No. 203.50207.00000

global environmental solutions

Figure 4-5 Predicted 24-hr MAX SO_2 Concentrations, APPLICATION CASE



MOUNTAIN ASH PROJECT	True North	Scale: 1:60,500	METRES	
SUMMIT SITE, ALBERTA		Date: Apr 28, 2020	Rev 0.0	Figure No. 4.6
PREDICTED 30-DAY MAX SO2 CONCENTRATIONS, APPLICATION CASE		Project No. 203.50207.00000		

Figure 4-6 Predicted 30-day MAX SO_2 Concentrations, APPLICATION CASE

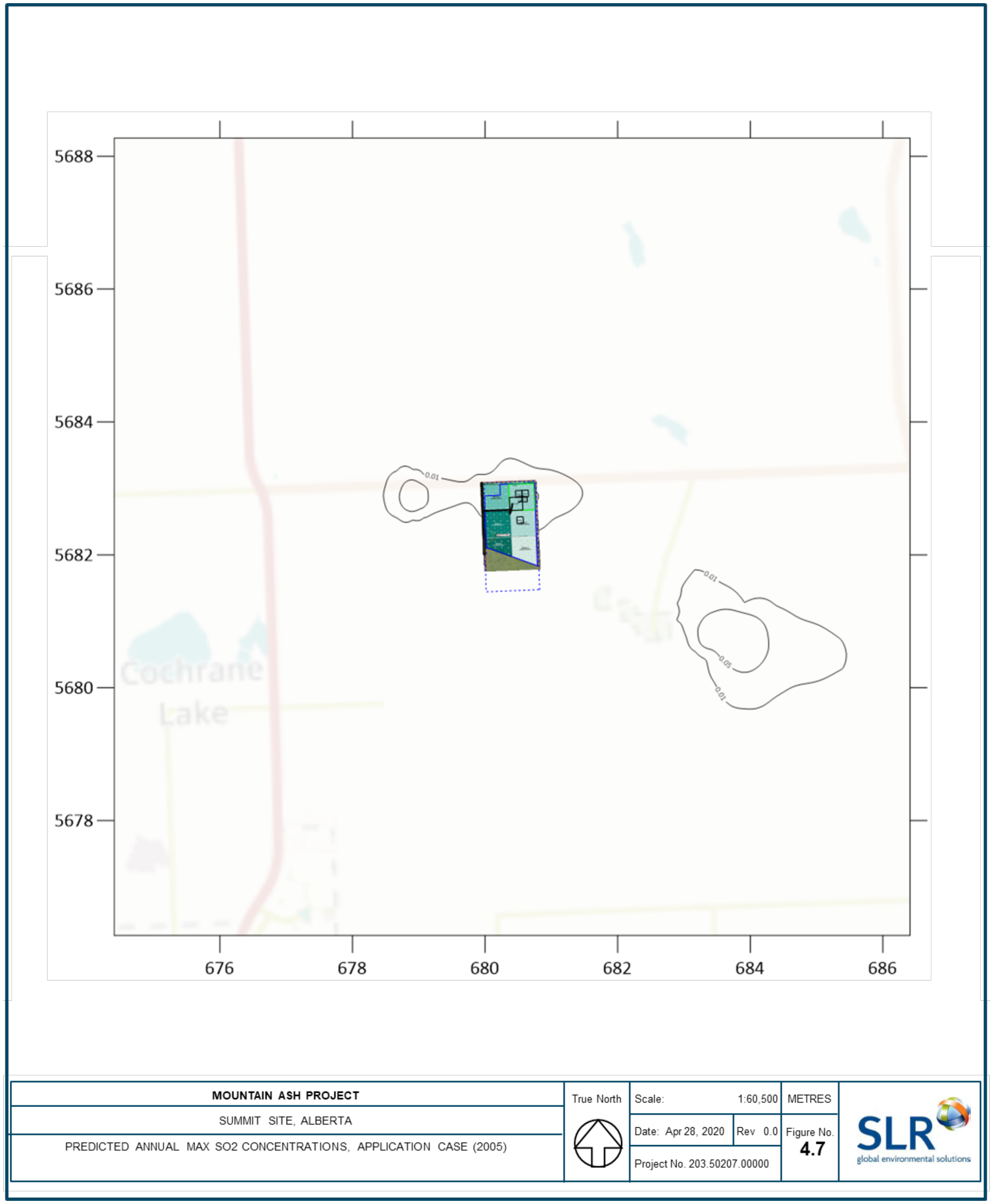


Figure 4-7 Predicted ANNUAL MAX SO_2 Concentrations, APPLICATION CASE (2005)

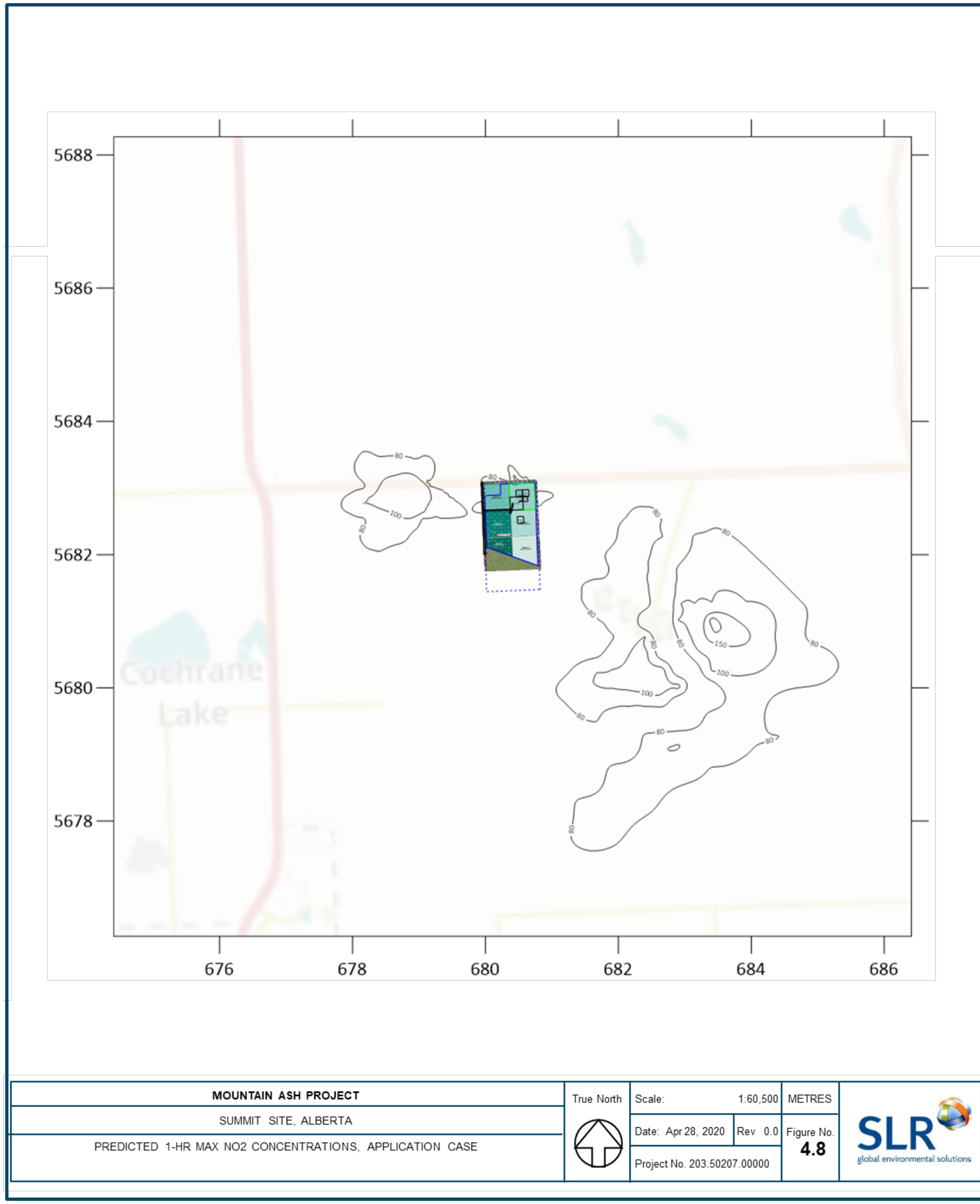
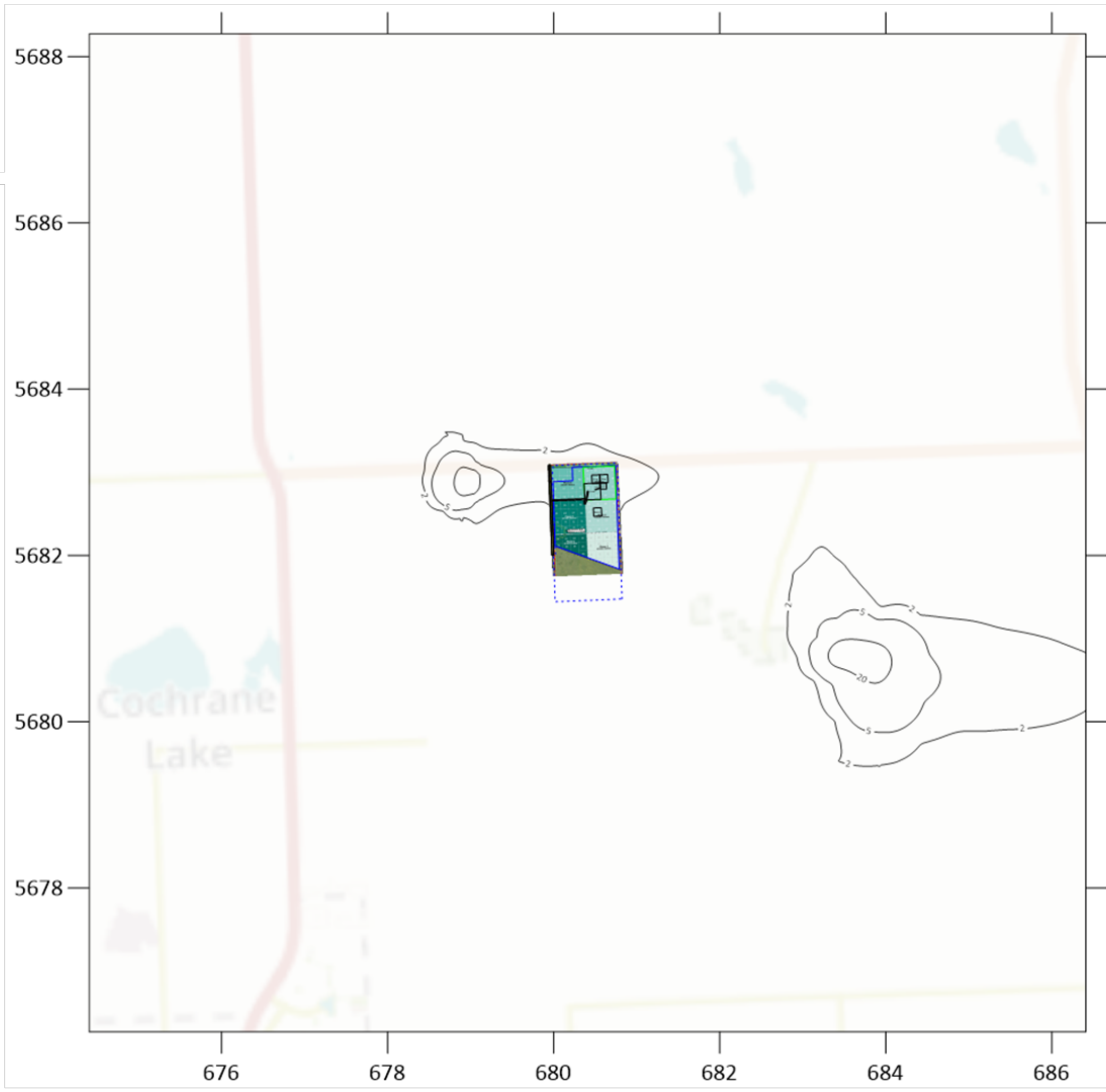


Figure 4-8 Predicted 1-hr MAX NO_2 Concentrations, APPLICATION CASE



MOUNTAIN ASH PROJECT	True North	Scale: 1:60,500	METRES	SLR global environmental solutions
SUMMIT SITE, ALBERTA		Date: Apr 28, 2020	Rev 0.0	Figure No. 4.9
PREDICTED ANNUAL MAX NO2 CONCENTRATIONS, APPLICATION CASE (2005)		Project No. 203.50207.00000		

Figure 4-9 Predicted ANNUAL MAX NO_2 Concentrations, APPLICATION CASE (2005)

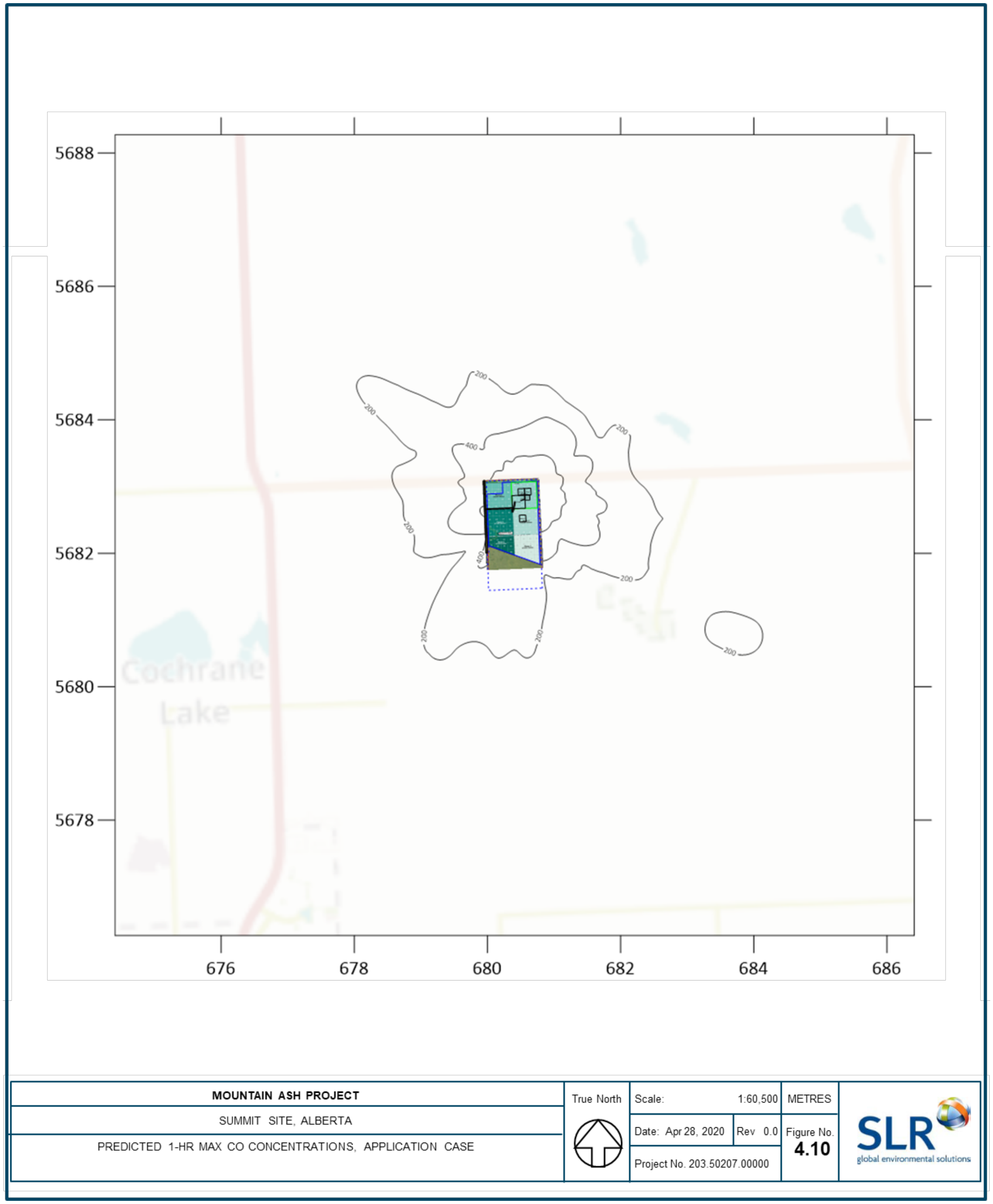


Figure 4-10 Predicted 1-hr MAX CO Concentrations, APPLICATION CASE

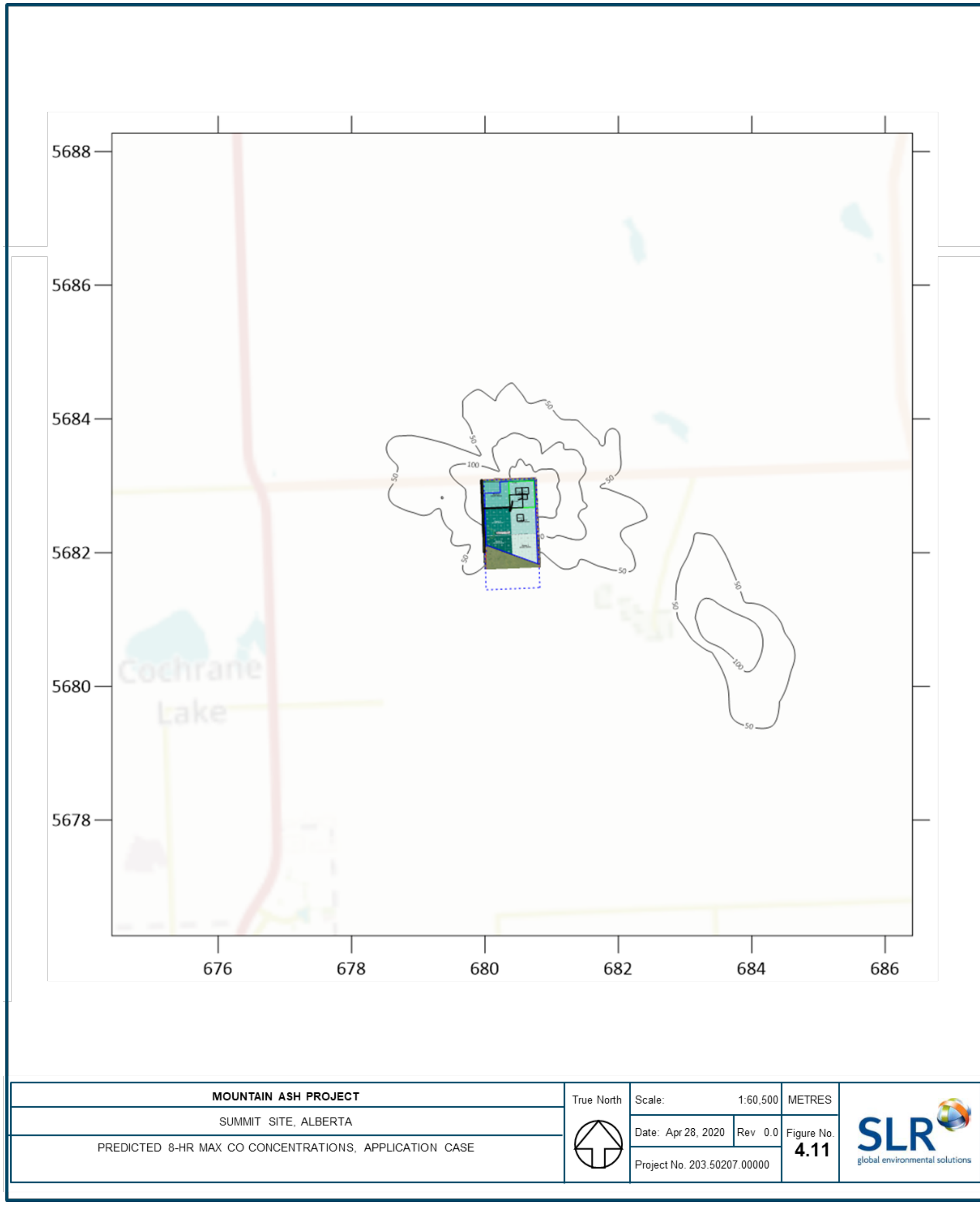


Figure 4-11 Predicted 8-hr MAX CO Concentrations, APPLICATION CASE

5. SUMMARY AND CONCLUSIONS

The CALPUFF dispersion model, incorporating five years (2002-2006) of CALMET meteorological data, was used to assess the dispersion of SO_2, NO_2, CO, $PM_{2.5}$, TSP emissions associated with the expected operation of Phase 3 of Summit Pit project.

Ambient background concentrations from the Caroline and CRAZ Calgary Northwest air monitoring stations were added to modelled predictions. Regional emissions from two active pits and one oil battery located within 5 km of the Project were included in the model.

Discrete receptors capturing nearby residences (and other identified sensitive locations) were included in this assessment along with the AEP-specified regional receptor grid.

Three key pit operations were defined for the Project: overburden removal and backfill, aggregate mining/crushing, and hauling/trucking. Maximum Daily Emission and Annual Average Emission cases were estimated. Maximum Daily Emissions assumed that all three pit activities overlap at their maximum respective emission rates, which were based on the number of working days and hours for each pit activity. For Annual Average Emissions predictions, emissions were spread over 24 hours and 365 days. To be conservative, precipitation was not considered to reduce annual dust emissions.

The results at the Project boundary showed there were no predicted exceedances of AAAQOs for any modelled compounds and any averaging period. The predicted maximum concentrations at residence receptors are all less than the AAAQOs for all modelling scenarios and all contaminants. Expected TSP concentrations will likely be lower, as the residences are surrounded by partially wooded areas and bushes which trap dust.

Some operating best-practice options were applied to reduce dust (TSP) emissions: the application of Calcium Chloride ($CaCl_2$) to unpaved roads for dust suppression, and the application of watering on mine surfaces. Further, in order to avoid TSP exceedances along the property boundary, crushers should be located at least 190 m from the east site boundary and 140 m from the other site boundaries.

In conclusion, operation of the Summit Pit is not expected to exceed ambient air quality objectives beyond the property boundary and, in particular, will have limited impact on air quality at the nearest residences, alone or in conjunction with emissions from other nearby operating industrial sources.

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APPENDIX A

EMISSION ESTIMATE METHODS

Table A.1 summarizes emission sources and the emission estimate methods. Emission sources are grouped into the following major categories:

- Off-road exhaust (diesel combustion sources);
- Road dust (due to truck runs);
- Material handling; and,
- Wind erosion.

Modelled pollutant emissions, other than TSP (dust), such as SO_2, NO_x, CO and $PM_{2.5}$ are mainly emitted from off-road exhaust sources. Particulate matter (PM) including $PM_{2.5}$ and TSP is the main emitted substance from the Project.

Table A.1 Summary of emissions sources and references for emission factors

Emission Sources	Equipment	substances	References for Emission Factors
Off road exhaust			
mine area	Excavator	CACs, PM	MOVES2014b offroad
mine area	Cat 980 wheel loaders (2)	CACs, PM	MOVES2014b offroad
crusher area	Crusher (2)	CACs, PM	MOVES2014b offroad
crusher area	diesel generator	CACs, PM	MOVES2014b offroad
aggregate sales area	Cat966 loader -aggregate to truck	CACs, PM	MOVES2014b offroad
paved+unpaved roads	Peterbilt Quad Trailer - trucks to transport aggregate offsite	CACs, PM	MOVES2014b offroad
strip/overburden	Twin Engine 657 Scraper (2)	CACs, PM	MOVES2014b offroad
remediation	CAT D-7 Dozer	CACs, PM	MOVES2014b offroad
remediation, unpaved road	cat 14m Grader	CACs, PM	MOVES2014b offroad
paved+unpaved roads+mine pit areas	Water Truck (Tandem Truck)	CACs, PM	MOVES2014b offroad
Road dust			
paved road	paved road (water truck, haul truck)	PM	AP-42 13.2.1 (paved)
unpaved road	unpaved road (water truck, haul truck)	PM	AP-42 13.2.2 (unpaved)
mine + stock pile area	traffic in mine pit (scraper, loaders)	PM	AP-42 11.9.2 (vehicle traffic - western surface coal mine)
backfill area	bulldozer operation (dozer), grader (backfill/grading)	PM	AP-42 11.9.2 (bulldozing - western surface coal mine)
Material handling			
crusher area	crushing (primary, secondary, screening) + conveyor transfer point	PM	AP-42 11.19.2 (Crushed stone processing)
Stacking conveyors (4)	conveyor drop (crusher to stockpiles)	PM	AP-42 11.9.2 (Dragline drop - western surface coal mines)

mine area	CAT 980 mine loader loading to crusher feeder	PM	AP-42 13.2.4 Aggregate handling (loading onto and loading out piles)
aggregate sales area	CAT 966 aggregate loading from stock pile to haul truck	PM	AP-42 13.2.4 Aggregate handling (loading onto and loading out piles)
overburden/stripping area	overburden load /unloader to dozer - by scrapers	PM	AP-42 13.2.4 Aggregate handling (loading onto and loading out piles)
Wind erosion			
mine area	mine face	PM	EC method - Wind Erosion of Stockpile surfaces
overburden/stripping area	striping area face	PM	EC method - Wind Erosion of Stockpile surfaces
backfill area	backfill area	PM	EC method - Wind Erosion of Stockpile surfaces
aggregate sales area	stock piles	PM	EC method - Wind Erosion of Stockpile surfaces
conveyors	uncovered conveyors	PM	EC method - Wind Erosion of Stockpile surfaces
unpaved road	unpaved road surface	PM	EC method - Wind Erosion of Stockpile surfaces

Emission factors for off-road exhaust are presented in Table A.2. Tier 4 engine ratings are applied to all equipment.

Table A.2 Off-road emission factors

EQUIPMENT	TIER	SO_2	NO_X	CO	$PM_{2.5}$	TSP
		g/L	g/hp-hr	g/hp-hr	g/hp-hr	g/hp-hr
CAT 374F Excavator	Tier 4	0.0252	0.3	2.6	0.01	0.01
CAT 980M wheel Loaders	Tier 4	0.0252	0.3	2.6	0.01	0.01
Elrus Jaw Crusher	Tier 4	0.0252	0.3	2.6	0.01	0.01
1 MW crusher generator	Tier 4	0.0252	0.5	2.6	0.02	0.02
CAT966L Loader	Tier 4	0.0252	0.3	2.6	0.01	0.01
Peterbit Quad Trailer - Haul Truck	Tier 4	0.0252	0.3	2.6	0.01	0.01
Twin Engine 657G Motor Scraper	Tier 4	0.0252	0.3	2.6	0.01	0.01
CAT D-7E dozer	Tier 4	0.0252	0.3	2.6	0.01	0.01
CAT 14M grader	Tier 4	0.0252	0.3	2.6	0.01	0.01
Tandem Water Truck	Tier 4	0.0252	0.3	2.6	0.01	0.01

Crushers are one major contributors to TSP emission sources. Emissions factors for crushers are derived from U.S. EPA's section AP42-11.19.2 "Crushed stone processing and Pulverized Mineral Processing". Table A.3 summarizes emission factors for crushing that were applied to the Project.

Table A.3 Crushed stone processing (kg/Mg)

SOURCES	TSP	TOTAL $PM_{2.5}$
Tertiary Crushing (controlled) (SCC 3-05-020-03)	0.0006	0.00005
Screening (controlled) (SCC 3-05-020-02, 03)	0.0011	0.000025
Fines Crushing (controlled) (SCC 3-05-020-05)	0.0015	0.000035
Conveyor Transfer Point (controlled) (SCC 3-05-020-06)	0.00007	6.50E-06

Conveyor loading and unloading result in dust emissions. Emission factor formulas for conveyor drop at the clean aggregate pile and reject material were taken from dragline emissions from AP-42 Table 11.9-2:

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

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

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

Where "M" is the moisture content and "d" is the drop height (m). A mean drop height of 0.5 m was used for unloading of material. Table A.4 summarizes conveyor drop emission factors.

Table A.4 Summary of conveyor drop emission factors

	$PM_{2.5}$	TSP
EF, kg/m3	1.372E-05	8.072E-04
EF, kg/tonnes	8.418E-06	4.952E-04

Emission factor formulas for loading of aggregate on conveyors and loading/un-loading of overburden onto (from) the excavator were taken from AP-42 (U.S. EPA 2006a) (Aggregate Handling and Storage Piles), which quantifies particulate emission factors for material dropping or dumping operations as:

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

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

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

Where "U "is average wind speed in this area (4.0 m/s) and "M" is moisture content. Calculated emission factors are for aggregate TSP 9.76E-04 kg/t, and for $PM_{2.5}$ 6.99E-05 kg/t; for overburden TSP 2.1E-04 kg/t, and for $PM_{2.5}$ 1.5E-05 kg/t.

Wind erosion also generates dust emissions ($PM_{2.5}$ and TSP). For wind driven emissions from active areas of operation (aggregate pits, overburden removal strip, unpaved haul roads, and from stockpiles), the emission factor formula below was obtained from Environment Canada Pits and Quarries Guidance (EC 2009):

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

Where "s" is the silt content (%), "f" is the percentage of time that the unobstructed wind speed exceeds 5.36 m/s. For the Project, "f" was assumed to be 100 (percent) as wind driven emissions were modelled with hourly wind speed as a varying scaling factor, 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 different material and location, measured on a 10-m tower (Table 13.2-5.2 in US EPA 2006b). This is expected to be a conservative assumption to ensure wind driven model emissions are not under-estimated.

Calculated emission factors of wind erosion are:

- for mining/aggregate/conveyor/unpaved road 3.81E-04 kg/m^2/day (TSP) and 7.62E-05 kg/m^2/day ($PM_{2.5}$); and,
- for overburden/backfill 2.54E-04 kg/m^2/day (TSP); and 5.08E-05 kg/m^2/day ($PM_{2.5}$).

Transportation emissions resulting from wheel entrainment on the paved portion of the haul road are based on equations taken from AP 42, Table 13.2.1-1 (U.S. EPA 2011):

$$PM_{2.5}\left(\frac{g}{vkt}\right) = \frac{0.15}{3.23} * TSP$$

$$PM_{10}\left(\frac{g}{vkt}\right) = \frac{0.62}{3.23} * TSP$$

$$TSP\left(\frac{g}{VKT}\right) = 3.23 * (sL)^{0.91} (W)^{1.02}$$

Where "sL" is the silt loading of the paved road surface (g/m2), and "W" is the average weight (in short tons) of the vehicle fleet on the road. Daily emissions were calculated by multiplying emission factors (in kg/VKT) by the total daily VKT.

Transportation dust emissions for the water truck and quarry trucks on unpaved, gravel roads, caused by wheel entrainment, are based on equations taken from historic version of AP 42 (U.S. EPA, 1998b). One of the EPA recommendations (e.g., U.S. EPA 2012) for decreasing dust emissions is to post a lower vehicle speed and enforce it. Summit will post a speed limit of 15 km/h within their property borders.

Applying Calcium Chloride ($CaCl_2$) to suppress dust emissions provides better efficiency than conventional watering. According to AP-42 Section 13.2.2 Unpaved road Emission Factor Document, the 90th percentile performance is about 89% reduction from uncontrolled emissions, which is more effective than watering (~75%). Table A.5 summaries emission factors based on Calcium Chloride application.

Table A.5 Summary of emission factors based on Calcium Chloride application

VEHICLE	UNIT	$PM_{2.5}$	TSP
water truck	EF, g/VKT	29	141
haul truck	EF, g/VKT	34	165

Overburden and aggregate bulldozing emissions were based on AP 42 Table 11.9-2 (Western Surface Coal Mines) (U.S. EPA 1998a):

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

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

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

Where " s " is silt content and "M " is moisture content. Calculated emission factors for aggregate are: 0.24 kg/hr for TSP, and 0.02 kg/hr for $PM_{2.5}$.