

Alaska Department of Environmental Conservation
Air Permit Program

Review of
Teck Alaska, Inc.'s
Lead Emissions Ambient Demonstration
for the
Red Dog Mine

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1. INTRODUCTION

This report summarizes the Alaska Department of Environmental Conservation's (Department's) findings regarding the ambient demonstration submitted by Teck Alaska, Inc. (Teck) for the Red Dog Mine. This modeling analysis was performed in support of the Department's request to renew the waiver for the 2025 State and Local Air Monitoring Stations (SLAMS) lead (Pb) monitoring requirement at the Red Dog Mine ambient air quality boundary. Teck demonstrated that operating the Red Dog Mine emissions units (EUs) as described in this report will not contribute to an ambient Pb concentration equal to or greater than 50 percent of the three-month National Ambient Air Quality Standard (NAAQS). Therefore, the modeling analysis supports the Department's request to renew a monitoring waiver for the mine.

In 2016, the Department performed a modeling analysis in support of the original Pb waiver request. This request was approved by the U.S. Environmental Protection Agency Region 10 (EPA R10) on August 11, 2016. In 2020, the Department performed another modeling analysis supporting a renewal of the Pb waiver request. This waiver request was renewed by EPA R10 on December 7, 2021. The Department's previous modeling effort is discussed in the October 21, 2021 report, *2021 Teck Red Dog Mine Lead Waiver Modeling Review*. Teck's present modeling analysis, discussed in this report, has many aspects in common with the Department's 2021 analysis; therefore, today's report focuses mainly on those items that have changed subsequent to the previous analysis, or that otherwise warrant discussion.

2. PROJECT BACKGROUND

The following sub-sections provide additional background on the proposed project and application materials.

2.1. Project Location and Description

Red Dog Mine, an existing stationary source, is a Pb and zinc (Zn) surface mining and ore processing facility located in the Delong Mountain Range of northwest Alaska. The mine facility is a Prevention of Significant Deterioration (PSD) major stationary source, having potential to emit greater than 250 tons per year (TPY) of a regulated New Source Review (NSR) pollutant.

2.2. Waiver Requirements

The ambient monitoring requirement for assessing Pb impacts from the Red Dog Mine came into effect through the revised Pb NAAQS rule finalized November 12, 2008. The revisions amended Appendix D to 40 CFR part 58, and allow EPA Regional Administrators to waive the requirement to conduct monitoring near Pb sources if the applicable State agency can demonstrate that the source will not contribute to a Pb impact in excess of 50% of the NAAQS. The level of this NAAQS is 0.15 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$); thus, the modeling demonstration must result in an ambient impact of less than $0.075 \mu\text{g}/\text{m}^3$.

Red Dog Mine is located in a remote area above the Arctic Circle, in the Northwest Arctic Borough. Providing electrical power would require the installation of several miles of

distribution line from the mine site. The Department, therefore, considers monitoring at or near the ambient air quality boundary of the mine is infeasible due to the high expense of access and electrical power.

The Department performed a modeling analysis and requested a monitoring waiver in 2016, which was issued by EPA R10 on August 11, 2016. Teck performed a modeling analysis in 2020 to support the Department's waiver renewal in 2020. After response to comments by the EPA, Teck revised the modeling analysis and the Department requested a monitoring waiver renewal in November, 2021. The monitoring waiver renewal was issued by EPA R10 on December 7, 2021. 40 CFR 58, Appendix D, Section 4.5(a)(ii), requires the waiver to be renewed as part of Alaska's five-year Air Monitoring Network Assessment, which is required to be submitted on July 1, 2025. The Department requested that Teck provide an additional modeling analysis to support the renewal of the monitoring waiver.

2.3. Modeling Protocol & Analysis Submittal

Teck submitted a modeling protocol on January 24, 2020. SLR International Corporation (SLR), prepared the protocol on their behalf. The Department approved the protocol, with comment, on March 10, 2020. Teck submitted their modeling demonstration for the 2025 modeling report on April 25, 2025. After the Department's initial comments regarding open pit orientation and volume source parameters, Teck submitted a revised modeling demonstration on June 10, 2025.

3. SOURCE IMPACT ANALYSIS

Teck used computer analysis (modeling) to predict the ambient Pb air quality impacts. SLR performed the modeling analysis on their behalf. The Department's findings regarding Teck's analysis are discussed below.

3.1. Approach

Teck performed a modeling analysis of the Red Dog Mine Pb-emitting EUs and compared the modeled impacts to the three-month Pb NAAQS. Modeled results showing impacts less than 50% of the Pb NAAQS were considered sufficient demonstration for renewal of the Pb monitoring waiver.

3.2. Model Selection

There are a number of air dispersion models available to applicants and regulators. EPA lists these models in their *Guideline on Air Quality Models* (Guideline), which the Department has adopted by reference in 18 AAC 50.040(f). Teck used EPA's AERMOD Modeling System (AERMOD) for their ambient analysis. AERMOD is an appropriate modeling system for this permit application.

The AERMOD Modeling System consists of three major components: AERMAP, used to process terrain data and develop elevations for the receptor grid and EUs; AERMET, used to process the meteorological data; and the AERMOD dispersion model, used to estimate the ambient pollutant concentrations. Teck used the current version of each component in their

2025 ambient analysis: AERMAP version 24142, AERMET version 24142, and AERMOD version 24142.

3.3. Modeling Domain

The modeling domain is used to help establish and limit the receptor grid and offsite emissions inventory. Teck used a reasonable modeling domain for their ambient demonstration. The modeling domain is described and illustrated in *Figure 4* of their modeling report.

3.4. Meteorological Data

AERMOD requires hourly meteorological data to estimate plume dispersion. A *minimum* of one-year of site-specific data, or five years of representative National Weather Service (NWS) data is required, per Section 8.4 of the Guideline. When modeling with site-specific data, the Guideline states that up to five years should be used, when available, to account for year-to-year variation in meteorological conditions.

Teck collected four years of site-specific surface data from October 1, 2011 through September 30, 2014; and from October 1, 2015 through September 30, 2016. All years and measured parameters met the PSD quality assurance requirements, with the following exceptions:

- Relative humidity during 2012-2013;
- Relative humidity during 2013-2014;
- Precipitation during 2012-2013; and
- Barometric pressure during 2013-2014.

Teck collected the meteorological data for each year at two meteorological monitoring stations: a 10-meter tower known as Bons Creek station, and a 33.5-meter tower known as the Mill Site station. The parameters from each monitoring site, as listed in Table 1, were paired to form a single dataset.

Table 1. Monitored Parameters at Each Meteorological Station

Bons Creek	Mill Site
Ambient 2-meter temperature	Horizontal wind speed
Ambient 10-meter temperature	Horizontal wind direction
Vertical temperature difference	Standard deviation of horizontal wind direction
Solar radiation	
Relative humidity	
Barometric pressure	
Precipitation	

The Department finds the use of these paired datasets to be acceptable.

Teck used the four years of surface data, along with concurrent upper air data from Barrow and Kotzebue airports, for their ambient demonstration. Kotzebue is geographically closer to

Red Dog Mine than Barrow; however, the Kotzebue upper air data was not used for the year October 1, 2011 through September 30, 2012 due to significant data gaps. Therefore, Barrow data was used for the first model year, and data from Kotzebue was used for the remainder of the model years.

Teck's meteorological data provides the surface meteorological parameters required under Section 8.4 of the Guideline and represents the plume transport conditions of the Red Dog Mine EUs. The use of all four years of available data is appropriate. Additional details regarding their data are provided below.

3.4.1. Quality Assurance Review

Site-specific meteorological data must meet the PSD quality assurance requirements outlined in EPA's *Meteorological Monitoring Guidance for Regulatory Modeling Applications* per 18 AAC 50.215(a)(3). The October 2011 through September 2013 met datasets – which were used in the 2016 lead modeling analysis -- were both previously reviewed by Enviroplan Consulting on behalf of the Department, and accepted as PSD-quality.

Teck submitted their October 2013 - September 2014 data on January 12, 2015; the Department accepted the data as PSD-quality on September 15, 2015. The October 2015 – September 2016 data was submitted by Teck on February 10, 2017 and accepted by the Department on May 4, 2017. Teck reprocessed the same data used in their 2020 lead modeling analysis for use in the 2025 modeling analysis.

3.4.2. Surface Characteristics

AERMET requires the area surrounding the meteorological tower to be characterized with regard to the following three surface characteristics: noon-time albedo, Bowen ratio, and surface roughness length. EPA has provided additional guidance regarding the selection and processing of values for these surface characteristics in their *AERMOD Implementation Guide*.

Teck continued in 2025 to utilize the values used in their 2016 analysis. The approved values are provided in Table 2.

Table 2. Approved AERMET Surface Parameters for Red Dog Mine

Surface Parameter	Spring	Summer	Winter	Autumn
Albedo				
Open Water/Ice	0.600	0.100	0.100	0.700
Dwarf Birch/Grasses/Mosses	0.180	0.180	0.190	0.570
Quarries/Open Mine/Gravel	0.200	0.200	0.200	0.600
Bowen Ratio				
Average Conditions				
Open Water/Ice	0.500	0.100	0.100	0.500
Dwarf Birch/Grasses/Mosses	0.500	0.780	0.940	1.100
Quarries/Open Mine/Gravel	1.500	1.500	1.500	0.500
Wet Conditions				
Open Water/Ice	0.500	0.100	0.100	0.500
Dwarf Birch/Grasses/Mosses	0.360	0.440	0.520	0.500
Quarries/Open Mine/Gravel	1.000	1.000	1.000	0.500
Dry Conditions				
Open Water/Ice	0.500	0.100	0.100	0.500
Dwarf Birch/Grasses/Mosses	1.200	1.900	2.000	1.400
Quarries/Open Mine/Gravel	3.000	3.000	3.000	0.500
Surface Roughness Length (m)				
Open Water/Ice	0.050	0.050	0.050	0.050
Dwarf Birch/Grasses/Mosses	0.074	0.110	0.056	0.043
Quarries/Open Mine/Gravel	0.002	0.001	0.001	0.002

Table Note: Spring is defined as May; Summer is defined as June, July and August; Autumn is defined as September; and winter is defined as October through April for purposes of processing Red Dog Mine data with AERMET.

3.5. Coordinate System

Air quality models need to know the relative location of the EUs, structures (if applicable), and receptors, in order to properly estimate ambient pollutant concentrations. Therefore, applicants must use a consistent coordinate system in their modeling analysis.

Teck used the Universal Transverse Mercator (UTM) grid for their coordinate system. This is the most commonly used approach in AERMOD assessments. The UTM system divides the world into 60 zones, extending north-south, and each zone is 6 degrees wide in longitude. The modeled EUs, structures, and receptors are all located in UTM Zone 3. Teck used the North American Datum of 1983 reference for each UTM coordinate.

3.6. Terrain

Terrain features can influence the dispersion of exhaust plumes from EUs and the resulting ambient air concentrations of the pollutants being emitted. Digitized terrain elevation data is, therefore, generally included in a modeling analysis. AERMOD's terrain preprocessor, AERMAP, uses terrain data to obtain the base elevations for the modeled EUs, buildings, and receptors; and to calculate a "hill height scale" for each receptor.

Teck used National Elevation Dataset (NED) files for their terrain analysis. NED is the current terrain elevation dataset provided by the United States Geological Survey.

3.7. EU Release Parameters

The assumed emission rates and characterization of how the emissions enter the atmosphere will significantly influence the modeled results. Therefore, the modeling must include the correct release parameters for each source.

3.7.1. Emission Rates

To determine the emission rates for Red Dog Mine EUs, Teck used similar methodologies as in the 2016 and 2020 analyses, but updated their calculations to reflect present-day (2023) mine operations. The Department continues to find Teck's emission rate calculation methodology to be appropriate, and generally found Teck's modeled emission rates to be consistent with the known conditions at Red Dog Mine.

Bulldozing operations warrant additional discussion. While Teck calculated the 2021 Pb emission rates for most EUs assuming the maximum 24-hour emissions, they opted to take a more realistic approach for characterizing bulldozer emissions. Teck determined the historical maximum hours of operation, prorated on a three-month basis, at each location within Red Dog Mine. The emissions values that Teck developed based on these assumptions were then multiplied by a safety factor of 1.5 to obtain the final emission rates used for modeling. The Department finds this approach to be acceptable for characterizing bulldozer operations.

The June revision to the 2025 modeling included prorating of loader, drilling, and road maintenance activities' emission rates. Like the dozer prorating, the loader and drill 24-hour emission rates were prorated for a three-month averaging timespan using the

actual operating hours recorded for each location of the respective operations. The road maintenance emission factor was prorated to the length of road associated with the open pit. This was performed because grader operations, which drive the road maintenance emissions for the open pits, were previously being calculated from grader mileage and hours of operation across the entire site. The new prorated road maintenance emission factors are based on grader operation on the road lengths solely associated with the open pits. Each prorated emission rate was then multiplied by a safety factor of 1.5 for final modeling emission rates.

The prorating affected both volume source emission rates as well as open pit emission rates. Each open pit emission rate was developed from the sum of loader operations, drilling, loading and dumping ore, road maintenance, unpaved road dust, and the prorated dozer operations emission rates for that pit, which was then divided by the area of the pit.

3.7.2. Particle Deposition and Lead Mass Fractions

AERMOD contains two optional algorithms for simulating the gravitational settling and dry/wet deposition that occurs as a particulate plume travels downwind. The “Method 1” approach may be applied under the *regulatory default* option of AERMOD, i.e. the use of Method 1 is allowed in a regulatory modeling analysis. The “Method 2” approach is considered a non-Guideline method and, therefore, requires case-specific approval from the Department and EPA under the alternative modeling procedures of the Guideline. Teck used the Method 1 deposition option within AERMOD to improve the accuracy of their estimated Pb concentrations.

The Method 1 algorithm requires data that reflects the particle size distribution for each activity with particulate emissions. The user essentially categorizes the emissions by particle size and then provides AERMOD the mass-mean aerodynamic particle diameter, mass fraction, and particle density for each category. Teck used the particle size distribution parameters listed in Table 4, below.

Table 4. Lead Particulate Deposition Parameters

Particle Diameter (µm)	Mass Fraction	Density (g/cm ³)
1.6	0.021	2.65
3.9	0.073	2.65
7.8	0.176	2.65
12.7	0.147	2.65
17.6	0.115	2.65
25.3	0.467	2.65

Teck used a particle density of 2.65 g/cm³, whereas lead has a density of 11.3 g/cm³. The Department found this to be a conservative characterization, as the effects of deposition would increase with greater density, which would in turn result in less particle dispersion.

In the June revision to the 2025 modeling analysis, Teck adjusted the lead mass fraction for both loader and drilling (drilling and blasting) operations. Loader mass fractions while operating within the open pits were revised from using measurements from outside the pit to measurements from inside the pit. Loader operations outside the pits were updated to use mass fractions from waste rock. Drilling operations mass fractions were updated to reflect the lead mass fraction of both ore *and* waste rock, rather than only ore as used previously. This resulted in new emission rates for the dozer and drilling activities, which are used in both the open pit sources and additionally volume sources (Section 3.7.5). Ore mass fractions were taken from 2014 Aqqaluk pit lab testing and 2020 Qanaiyaq pit assay. Waste rock mass fractions were taken from 2020 assay on typical waste rock lead content. These revisions provided more representative estimates of lead content dispersed during the provided applications. The 2014 Aqqaluk results (4.37%) remained in line with the average mass fraction (4.3%) from the most recent 2019-2023 summary reports. The Department finds these mass fraction revisions acceptable.

3.7.3. Non-Modeled EUs

Similar to the Department's 2016 analysis, Teck omitted fuel-burning EUs that were determined to have negligible amounts of Pb emissions. The Department continues to find this approach acceptable.

3.7.4. Point Source Parameters

In addition to the previously discussed emission rates, the model must include appropriate values for the stack height, diameter, location, base elevation, exhaust plume exit velocity, and exhaust temperature for each EU characterized as a point source. The Department generally found the modeled stack parameters to be an appropriate representation of the point sources at Red Dog. Point source emission rates in 2025 were modified from the 2020 analysis. MD3 and MD4 both decreased, while MD6, MD9, and MI3 moderately increased. MD8 had a significant increase from 2.21 E-05 to 1.34 E-03. The parameters used to model point sources are listed below, in Table 3.

Table 3. Point Source Parameters

EU Description	Model ID	Emission Rate (g/s)	Stack Height (m)	Exhaust Temp (K)	Exhaust Velocity (m/s)	Stack Dia. (m)
Primary Jaw Crusher Baghouse	MD1	2.43E-05	7.32	299.8	0.50	0.210
Coarse Ore Conveyor A Scrubber	MD2	1.22E-03	23.47	299.8	35.66	0.457
Coarse Ore Conveyor B Scrubber	MD3	7.68E-04	23.47	299.8	35.66	0.457
Assay Lab & Bucking Room Baghouse	MD4	1.26E-04	12.19	299.8	7.12	0.559
Gyratory Crusher Baghouse	MD6	1.59E-04	33.53	299.8	18.19	0.610
Jaw Crusher Dump Pocket Baghouse	MD7	7.37E-05	16.71	299.8	19.64	1.016

Gyratory Crusher Dump Pocket Baghouse	MD8	1.34E-03	17.60	299.8	19.43	1.067
Coarse Ore Storage Building Baghouse	MD9	7.18E-04	3.92	299.8	17.22	1.321
Incinerator	MI2	9.10E-04	7.62	672.0	3.38	0.914
Incinerator	MI3	4.65E-04	8.43	1144.3	5.11	0.711

Capped stacks or horizontal releases generally lead to higher impacts in the immediate near-field than what would occur from uncapped, vertical releases. The presence of non-vertical stacks or stacks with rain caps therefore requires special handling in an AERMOD analysis. EPA describes the proper approach for characterizing these types of stacks in their *AERMOD Implementation Guide*.¹ EPA has also developed an option in AERMOD that will automatically revise the stack and exhaust parameters for any stack identified as horizontal (using the POINTHOR keyword) or capped (using the POINTCAP keyword).

Teck used the POINTHOR option to characterize the coarse ore storage building baghouse (model ID MD9) as having a horizontal, uncapped release. They characterized all other EUs as having uncapped, vertical releases.

3.7.5. Open Pit Parameters

AERMOD has an *open pit* option for characterizing particulate or gaseous releases that occur below grade. Examples of where this option could be used include open pit mines and gravel quarries. Irregularly-shaped pit areas must be characterized by a rectangle of equal area when using the open pit option. Applicants who use this option must therefore provide AERMOD with the length of each side, the pit volume, and the average release height of the emissions activities within the pit, in addition to the pit location and base elevation. If warranted, the user may also provide an orientation angle of the pit in degrees from the North. If particulate emissions are modeled, the applicant must also provide the same particle size information as needed to account for particle deposition.

Teck used the OPENPIT option to characterize the particulate emissions from within the Aqqaluk and Qanaiyaq open pits. This is a reasonable option for characterizing these below grade emission activities.

The dimensions and activities in mine pits obviously change during the life of the mine. Teck used updated information to account for these changes since the original 2016 modeling. Specifically, they included activities from the Qanaiyaq Pit as well as updating the parameters of the previously-modeled Aqqaluk Pit to reflect current conditions.

In their 2020 modeling analysis, Teck increased the depth of the Aqqaluk pit to 290 meters, compared to 98 meters in their 2016 modeling, based on the anticipated

¹ *AERMOD Implementation Guide* (EPA-454/B-24-009); November 2024.

maximum pit depth during the life of the mine. EPA R10 commented that modeling this increased, future depth may not be representative of the maximum impacts from that source at shallower depths. In response, Teck submitted new modeling in 2021 with updated source parameters for the Aqqaluk Pit. They also discovered that the dozer operations emissions reflected in the Aqqaluk pit were based on a conservative maximum 24-hour emission rate, rather than the three-month average used for other dozer emissions. Their updated modeling reflected these changes as well.

The Department noted in the initial 2025 modeling that the Aqqaluk and Qanaiyaq area pit sources were each rotated at a negative angle from true north instead of positive to match where the pits were located in the report memo. Teck revised the Qanaiyaq area pit to align with the location in the report memo. Teck re-evaluated the Aqqaluk pit geometry and orientation to better determine the representative pit location and parameters. The Aqqaluk Pit was ultimately modeled centered at the same location of the report memo, but rotated to better align with the pit rim shape. This change is demonstrated in the pit angle parameter, changing 90 degrees from -20 to 70 degrees from true north.

Originally, the 2025 modeling saw an increased Aqqaluk Pit volume and marginally increased emission rates. After the June revision, the parameters were modified by recalculating pit volumes, initial dimensions, and pit angle according to geographic imagery and new elevation measurements. In particular, the Aqqaluk pit volume had a small decrease from 73.7 million to 64.7 million cubic meters, while the Qanaiyaq pit volume decreased from 59.1 million to 15.6 million cubic meters. This decrease is predominately a result of remeasuring the pit bottom elevation. The pit geometries were also changed to a square opening instead of rectangular. The Department finds these revisions to the pit parameters following updated measurements to be acceptable.

The Department finds Teck's modeled open pit parameters – shown in Table 5, below -- to be acceptable.

Table 5. Open Pit Source Parameters

EU Location	Model ID	Emission Rate (g/s/m ²)	Release Ht. (m)	X _i (m)	Y _i (m)	Pit Vol. (m ³)	Angle (deg.)
Aqqaluk Pit	AQQL PIT	2.00E-07	5.0	820.0	820.0	64,658,000	70.0
Qanaiyaq Pit	QANA PIT	2.88E-07	5.0	560.0	560.0	15,567,000	42.0

3.7.6. Volume Source Parameters

The volume source option is frequently used to characterize fugitive emissions that have initial lateral and vertical spread near the point of release. Examples include the fugitive dust associated with construction activities or dirt roads, and wind-blown dust from storage piles. Applicants who characterize an EU or emissions activity as a volume source must provide AERMOD with the initial lateral and vertical dimensions of the volume, the release height (volume center), location and base elevation, in addition to the previously discussed emissions rate.

Unlike the 2016 analysis which relied primarily upon area sources, Teck characterized their loading, dumping, bulldozing, grading, and blasting operations as volume sources in the 2020 analysis. Teck continued this characterization in the 2025 analysis. Teck also characterized fugitive Pb emissions from vehicle traffic on unpaved roads as multiple volume sources. This is consistent with the approach recommended by the Haul Road Workgroup of EPA/State/Local Modelers.² The Department found Teck's volume source parameters to be acceptable. While the release height, initial lateral, and initial vertical (σ_Y and σ_Z) dimensions remained the same, the volume source 24-hour emission rates decreased slightly from the 2020 analysis. Phase 3 bulldozing had zero reported operating hours and was therefore modeled as a 0.00 emission rate. Those parameters can be found in Table 6, below.

Table 6. Volume Source Parameters

EU Location	Model ID	24-hour Emission Rate (g/s)	Release Ht. (m)	Sigma Y (m)	Sigma Z (m)
Loading					
Ore Stockpile	ORESLOAD	1.67E-03	2.74	35.44	2.55
Methanol Pad	METHLOAD	5.31E-05	2.74	17.72	2.55
New Shifters Pad	NEWSLOAD	9.79E-06	2.74	24.81	2.55
Phase 3	PHASLOAD	3.61E-05	2.74	15.95	2.55
Loading/Dumping					
Ore Stockpile	ORE_DUMP	6.02E-03	3.05	35.44	2.84
Copper Ore Stockpile	COPPDUMP	2.65E-05	3.05	30.48	2.84
Methanol Pad	METHDUMP	1.64E-04	3.05	17.71	2.84
New Shifters Pad	NEWSDUMP	1.23E-04	3.05	24.81	2.84
Phase 3	PHASDUMP	1.47E-05	3.05	15.95	2.84
Main Waste Dump	MAINDUMP	5.20E-05	3.05	53.16	2.84
Cover Waste Dump	COVRDUMP	3.41E-07	3.05	19.49	2.84
Oxide Waste Dump	OXIDDUMP	6.40E-06	3.05	17.72	2.84
Bulldozing					
Ore Stockpile	ORE_DOZE	9.16E-03	2.44	35.44	2.27
Main Waste Dump	MAINDOZE	2.03E-04	2.44	53.16	2.27
Copper Ore Stockpile	COPPDOZE	4.00E-05	2.44	30.48	2.27
Cover Waste Dump	COVRDOZE	2.62E-06	2.44	19.49	2.27
Methanol Pad	METHDOZE	2.87E-04	2.44	17.72	2.27
New Shifters Pad	NEWSDOZE	1.03E-03	2.44	24.81	2.27
Oxide Waste Dump	OXIDDOZE	5.08E-05	2.44	37.21	2.27
Phase 3	PHASDOZE	0.00E+00	2.44	15.95	2.27
Grading					
Ore Stockpile	ORE_GRAD	8.47E-05	1.83	35.44	1.70
New Shifters Pad	NEWSGRAD	5.24E-05	1.83	24.81	1.70
Oxide Waste Dump	OXIDGRAD	5.35E-05	1.83	37.21	1.70
Cover Waste Dump	COVRGRAD	1.72E-05	1.83	19.49	1.70

² EPA Memorandum from Randy Robinson, EPA Region 5 and Mick Daye, EPA Region 7 to Tyler Fox, *Haul Road Workgroup Final Report*; December 6, 2011.

Main Waste Dump	MAINGRAD	6.13E-05	1.83	53.16	1.70
Blasting					
Aqqaluk Pit	AQQ BLST	1.85E-03	76.20	21.27	70.88
Qanaiyaq Pit	QAN BLST	7.01E-04	76.20	21.27	70.88

3.8. Downwash

Downwash refers to the situation where local structures influence the plume from an exhaust stack. Downwash can occur when a stack height is less than a height derived by a procedure called "Good Engineering Practice" (GEP), which is defined in 18 AAC 50.990(42). It is a consideration when there are receptors relatively near the applicant's structures and exhaust stacks.

EPA developed the "Building Profile Input Program – PRIME" (BPIPPRM) program to determine which stacks could be influenced by nearby structures and to generate the cross-sectional profiles needed by AERMOD to determine the resulting downwash. Teck used the current version of BPIPPRM, version 04274, to determine the building profiles needed by AERMOD.

Teck included all of the modeled point sources in their downwash analysis. The Department used a proprietary 3-D visualization program to review Teck's characterization of the exhaust stacks and structures. The characterization matches the known conditions at Red Dog Mine. Teck appropriately accounted for downwash in their modeling analysis. BPIPPRM indicated that the modeled exhaust stacks are within the GEP stack height requirements.

3.9. Ambient Air Boundary

The NAAQS only apply in *ambient air* locations, which has been defined by EPA as, "*that portion of the atmosphere, external to buildings, to which the general public has access.*"³ Applicants may, therefore, exclude areas that they own or lease from their ambient demonstration if public access is precluded. They conversely need to model that portion of their property/lease that has no such restriction, or where there is an easement or public right-of-way. Natural features, such as dense vegetation or topographical features, can provide adequate barriers to public access, although the adequacy of the given features must be evaluated on a case-specific basis.

Teck continued to use the ambient air boundary used in their 2020 and 2016 lead analyses, as well as previous PSD permit applications. The Department continues to find this ambient air boundary acceptable.

³ The term "ambient air" is defined in 40 CFR 50.1. The Alaska Legislature has also adopted the definition by reference in AS 46.14.90(2).

3.10. Worker Housing

Teck needs to house their workers on-site due to the project's remote location. Worker housing areas must be treated as ambient air, except under the conditions described in the Department's *Ambient Air Quality Issues at Worker Housing* policy.⁴ The conditions are:

- 1) the worker housing area is located within a secure or remote site;
- 2) the worker housing area is for official business/worker use only; and
- 3) the operator has a written policy stating that the on-site workers are on 24-hour call.

Teck did not treat the worker housing area as ambient air for the reasons explained in Section 2.3 of their 2020 ambient analysis. The Department agrees that their housing plan meets the conditions listed in its worker housing policy for taking this approach. The location is remote, which meets the first condition; the housing complex will be for business purposes only – family visitors will not be permitted, which meets the second condition; and Teck has a written policy that all personnel are on 24-hour call while on-site, which meets the third condition.

3.11. Receptor Grid

A dispersion model will calculate the concentration of the modeled pollutant at locations defined by the user. These locations are called receptors. Designated patterns of receptors are called receptor grids.

Teck used a rectangular receptor grid of decreasing resolution with distance from the ambient boundary. The receptor resolutions are:

- 50 m along the ambient boundary;
- 100 m from the ambient boundary to a distance of 500 m; and
- 500 m from 500 m to 2 km.

Like in 2021, to ensure that the grid resolution is sufficient to capture the maximum concentrations, Teck also performed a “hot spot” analysis by performing an additional iteration of their modeling analysis in which they added a finer receptor grid (with 25-m spacing) over the areas of maximum modeled impacts. This area was directly west of the ambient boundary across from the Red Dog Mine tailings pond.

3.12. Modeled Design Concentrations

EPA allows applicants to use modeled concentrations that are consistent with the form of the standard as the modeled design concentration.

Teck reported the maximum three-month average Pb concentration for each modeled year. They did not determine the three-month average concentrations spanning the end and beginning of adjacent years; however, only one year of site-specific data is required under the Guideline. Reporting maximum three-month concentrations from four individual years

⁴ Policy and Procedure 04.02.108: *Ambient Air Quality Issues at Worker Housing*; October 8, 2004.

is, therefore, a conservative approach, and the Department finds the reported results to be an acceptable demonstration.

The three-month concentration was obtained using EPA's post-processing tool, LEADPOST, version 13262. This is the current version of the software. Teck's use of LEADPOST is appropriate.

4. RESULTS AND DISCUSSION

The maximum modeled three-month average Pb impacts are presented in Table 7, below. The Pb NAAQS is also presented, as well as the modeled percentage and the concentration corresponding to 50% of the Pb NAAQS, for comparison.

Table 7. Modeled Three-Month Average Pb Levels

Pb NAAQS ($\mu\text{g}/\text{m}^3$)	0.150
50% of Pb NAAQS ($\mu\text{g}/\text{m}^3$)	0.075
Modeled Pb Design Concentration ($\mu\text{g}/\text{m}^3$)	0.070
Ratio of Modeled Concentration to NAAQS (%)	47.0%

5. CONCLUSION

The Department concludes that Red Dog Mine will not cause ambient air quality impacts greater than 50% of the Pb NAAQS. Therefore, Teck's modeling analysis is sufficient to demonstrate that the SLAMS Pb monitoring requirements may be waived for Red Dog.



Red Dog Mine Lead Emissions Dispersion Modeling Analysis

**ADEC Requested Lead Modeling Demonstration under
40 CFR Part 58, Appendix D, section 4.5(a)**

Teck Alaska Inc

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SLR Project No.: 105.021323.00001

Client Reference No: 0001

April 25, 2025

Revision: 00

Revision Record

Revision	Date	Prepared By	Checked By	Authorized By
00	April 25, 2025	M Marinucci	T Grosch	T Damiana



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Appendices

- Appendix A 2020 Lead Emissions Dispersion Modeling Analysis**
- Appendix B Amendment 1 to 2020 Lead Emissions Dispersion Modeling Analysis**



1.0 Purpose and Scope

This technical report describes an analysis conducted to predict ambient air lead (Pb) impacts from the Red Dog Mine (Mine), which is a Pb and zinc surface mining and ore processing facility. **Figure 1** shows a topographic map of the region including the Mine, Delong Mountain Transportation System (DMTS), and DMTS Port all located in the Northwest Arctic Borough above the Arctic Circle. This analysis has been conducted to demonstrate ambient air quality monitoring should not be needed to assess the regional attainment status of the Pb National Ambient Air Quality Standards (NAAQS).

An ambient air monitoring requirement for assessing ambient air impacts due to Mine Pb emissions came into effect through the revised final Pb NAAQS rule, promulgated on November 12, 2008 (40 CFR Parts 50, 51, 53, and 58 National Ambient Air Quality Standards for Lead; Final Rule). The 2008 Pb NAAQS established new thresholds for air quality monitoring around sources which emit 1.0 or more tons per year (tpy) of Pb. Revisions to the Lead Ambient Air Monitoring Requirements, Final Rule, lowered the source emission threshold from 1.0 tpy to 0.5 tpy (75 FR 81127). Red Dog Mine emissions exceed this criteria.

According to the rule, monitoring agencies may request a waiver for ambient monitoring requirements if the agency can demonstrate through a modeling analysis that the maximum modeled Pb concentration will not exceed 50 percent of the Pb NAAQS. The level of the Pb NAAQS is 0.15 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) and is in the form of a 3-month rolling average. Therefore, 50 percent of the level of the Pb NAAQS is 0.075 $\mu\text{g}/\text{m}^3$.

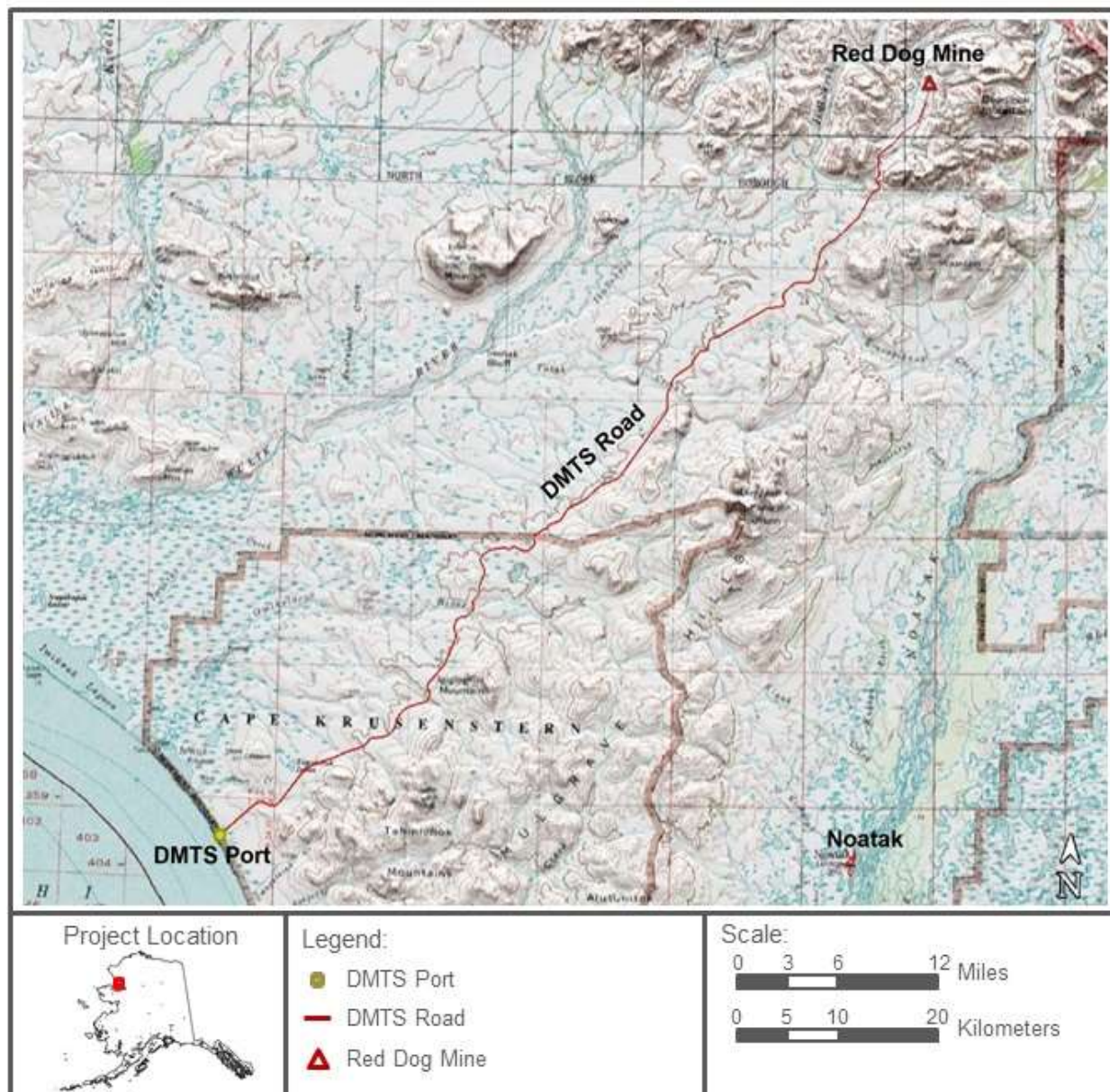
The Alaska Department of Environmental Conservation (ADEC) completed the original Pb ambient air quality impact analysis demonstration during 2015 and 2016 in support of a monitoring waiver issued on August 11, 2016 by the USEPA Region 10. Pursuant to 40 CFR Part 58, Appendix D, section 4.5(a)(ii), the waiver must be renewed every five years as part of the Alaska 5-year Air Monitoring Network Assessment.

The 2020 Lead Emissions Dispersion Modeling Analysis submitted in support of the monitoring waiver issued on December 7, 2021 by the USEPA Region 10 is included as **Appendix A**. Amendment 1 to the 2020 Lead Emissions Dispersion Modeling Analysis is included as **Appendix B**. This analysis was prepared to support the request for renewal of the Pb monitoring waiver, which should be renewed by July 1, 2025.

Except for incorporating the most current dispersion model versions and latest actual emission rates, the approaches and simulation used to conduct this 2025 Lead Emissions Dispersion Modeling Analysis are identical to those used to support the 2020 Lead Emissions Dispersion Modeling Analysis detailed in **Appendix A** and **Appendix B**.



Figure 1: Project Location Map



2.0 Modeling Overview

The dispersion modeling analysis was conducted in accordance with U.S. EPA Guideline on Air Quality Models: Enhancements to the AERMOD Dispersion Modeling System - 40 CFR Part 51, Appendix W, (Revised November 2024). The analysis is based on the latest version of the EPA-approved AERMOD air dispersion model (version 24142). AERMOD is a steady-state, Gaussian dispersion model developed to simulate dispersion of emissions at distances within 50 kilometers (km) of the source. The latest version of AERMET (version 24142) was used to prepare meteorological data and atmospheric stability parameter inputs for use in AERMOD. Terrain elevations from National Elevation Dataset (NED) files acquired from the U.S. Geological Survey (USGS) were processed in the latest version of AERMAP (version 24142) to



develop the receptor terrain elevations and corresponding hill height scales required by AERMOD. In addition, the most recent version of the Building Profile Input Program with Plume Rise Model Enhancements (BPIPPEM, version 04272) was used to model the effects of building downwash on the dispersion of emissions from modeled point sources.

Surface characteristics used as inputs to AERMET were developed as part of the 2020 Lead Emissions Dispersion Modeling Analysis without the benefit of AERSURFACE. The same parameters were used when reprocessing the meteorological data for this analysis.

2.1 Model Emission Inventory

Fundamentally, Mine operations and source locations have not changed since the last time this assessment was conducted. The Mine includes two open pit mines, ore crushing equipment, waste rock disposal sites, stockpiles, a mill and concentrator, and wastewater treatment facilities. Supporting equipment includes fuel-fired generator engines, boilers, heaters and small, remote incinerators. Mobile equipment operated at the mine includes haul trucks, bulldozers, graders, and loaders. Emissions of fugitive particulate matter containing Pb originate from drilling, blasting, bulldozing, grading, material handling, and vehicle traffic on unpaved roads at the Mine. A description of the model source inventory is in **Appendix A** with updates provided in the addendum provided in **Appendix B**. These descriptions are still applicable to the current analysis. The focus of this effort was to update Mine emission rates based on current actual operation. Modeled Pb emissions and operational information used to simulate Pb emissions from Mine activities are provided in a comprehensive workbook transmitted electronically with this document¹.

As discussed, the modeled point, volume, and open pit source inventory has not changed from 2020. A full description of each source, input parameters and plume depletion and deposition can be found in Sections 2.1.1 through 2.1.4 of **Appendix A** with changes to the Aqqaluk Pit described in **Appendix B**. Source details, input parameters, and emission rates can be found in the workbook transmitted electronically with this analysis². **Figure 2** and **Figure 3** provide a visual representation of the modeled source layout overlaid on recent aerial photography to show that the modeled source locations are representative of the current Mine activities they simulate.

2.2 AERMET Meteorological Data

The meteorological data used to support the 2020 Lead Emissions Dispersion Modeling Analysis was reprocessed with the current version of AERMET (24142) with no changes to the inputs. See Section 2.2 of **Appendix A** for a full description of the meteorological data.

2.3 Model Receptors and Terrain

The receptor grid horizontal locations used to support the 2020 Lead Emissions Dispersion Modeling Analysis were used to support the current analysis after reprocessing with the current version of AERMAP. Receptors were positioned every 50 meters along the Mine ambient air boundary. Additional receptors were placed at intervals of 100 meters from the ambient

¹ Refer to the workbook called "Red Dog Mine Lead Emissions for 2025 Assessment 2025-04-8 to ADEC.xlsx"

² Ibid. 1



boundary out to 500 meters, and at intervals of 500 meters from 500 meters to 1,500 meters. AERMAP processed these receptors to determine their elevations and hill height scales, which are required parameters for AERMOD when modeling in regions with complex terrain. For a full description of the model receptors and terrain details see Section 2.3 in **Appendix A. Figure 4** displays the location of the receptors in relation to modeled sources.

3.0 Modeling Analysis Results

USEPA's lead post-processing tool, LEADPOST (version 13262), was used to calculate the 3-month rolling average (Pb) concentrations for each modeled year. The highest modeled concentration, based on the full field receptor grid shown in **Figure 4**, was 0.070 $\mu\text{g}/\text{m}^3$ at a receptor located in the near-field grid to the west-southwest of the Mine. To better capture the maximum ambient Pb impact, a hot-spot analysis was conducted using a finer receptor grid with 25-meter spacing, focused on the area of the highest modeled concentrations. **Figure 5** shows the locations of these hot-spot receptors.

Table 1 provides a summary of the maximum modeled 3-month rolling average Pb concentrations for each modeled period along with the ratio of the maximum modeled impact to the 3-month Pb NAAQS. These maximums all occur within the area of hot-spot receptors. The table shows that the maximum modeled 3-month rolling average Pb concentration occurred during the November 2012 through January 2013 period (model year 2) and is 0.0706 $\mu\text{g}/\text{m}^3$ which is 47.1 percent of the Pb standard making the Red Dog Mine stationary source eligible for an ambient monitoring waiver.

Figure 6, Figure 7, Figure 8, and Figure 9 show the maximum 3-month rolling average Pb concentrations at all model receptors as a heat map for modeled years 1, 2, 3, and 4, respectively. For all years, the maximum model-predicted impact can clearly be seen occurring to the west-southwest of the Mine with year 2 showing the highest overall impacts.

Table 1: Maximum Modeled 3-Month Rolling Average Pb Concentrations Including Hot-Spot Receptor Locations

Meteorological Model Year	Maximum 3-Month Average Pb Level ($\mu\text{g}/\text{m}^3$)	3-Month Averaging Period	Percent of Maximum Impact to Pb NAAQS
1	0.0671	Oct. 2011 – Dec. 2011	44.7%
2	0.0706	Nov. 2012 – Jan. 2013	47.1%
3	0.0532	Jan. 2014 – Mar. 2014	35.5%
4	0.0666	Nov. 2015 – Jan. 2016	44.4%



Figure 2: Mine Activity Model Source Locations

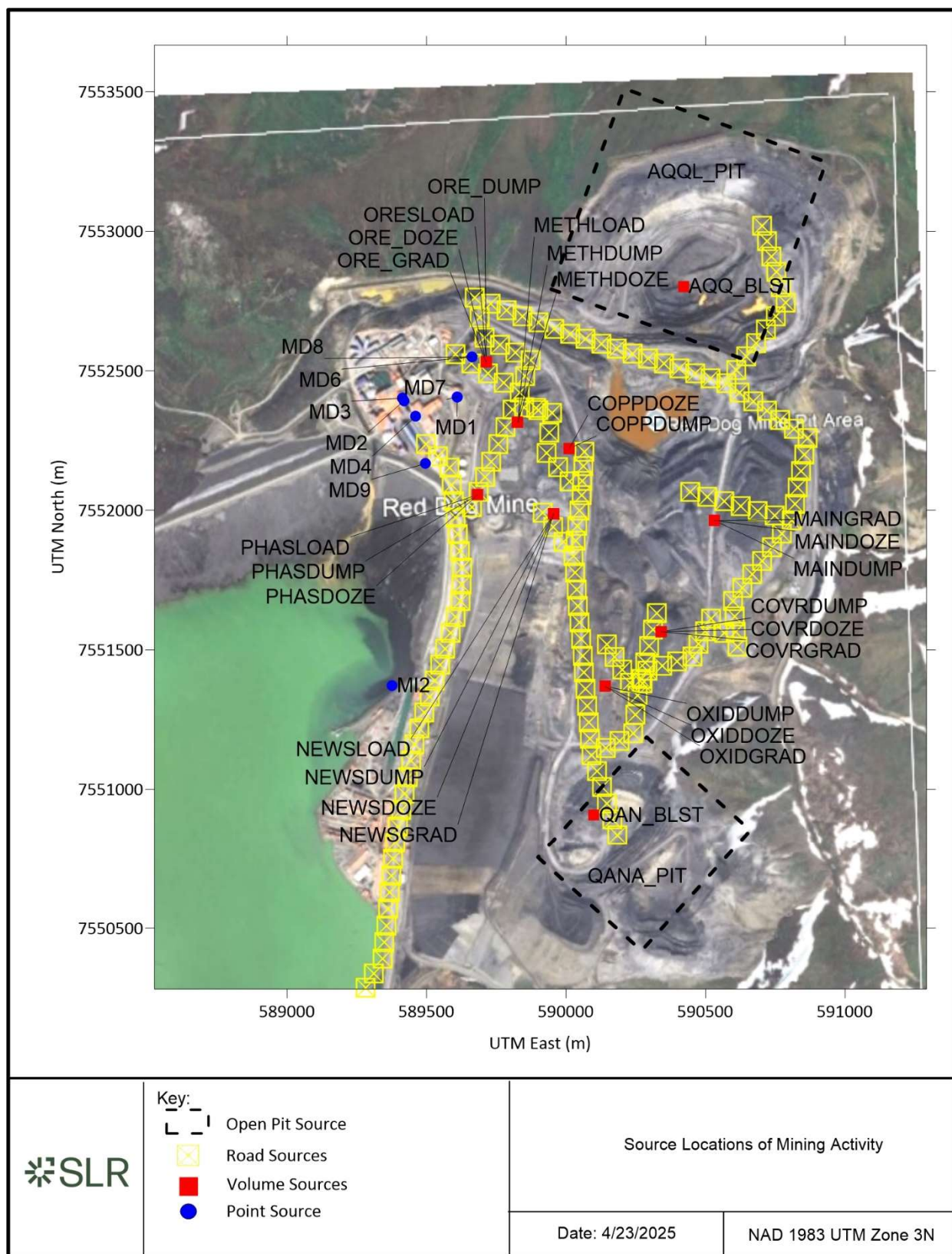


Figure 3: All Source Locations

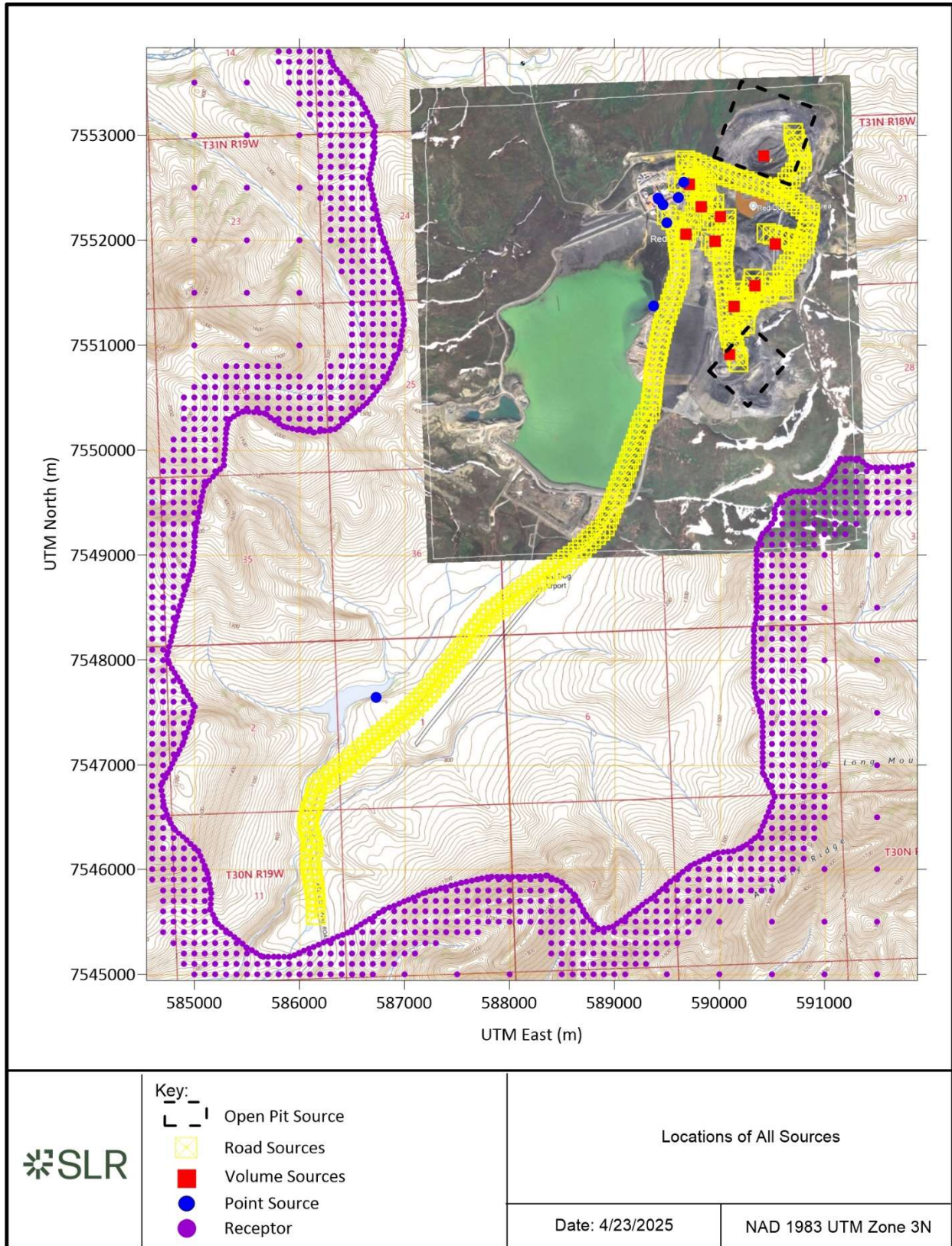


Figure 4: Full Receptor Field and Sources

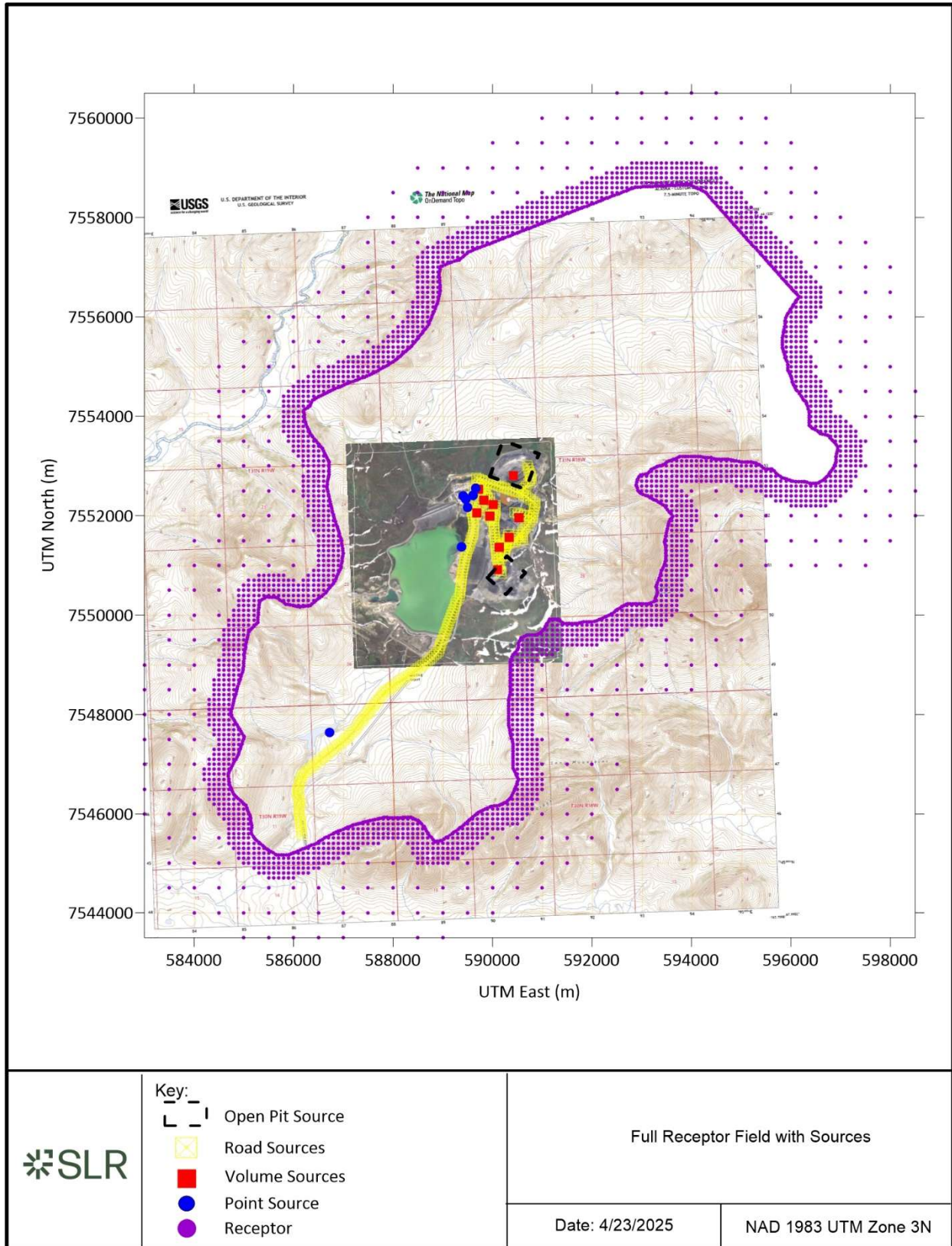


Figure 5: Location of Hotspot Receptors

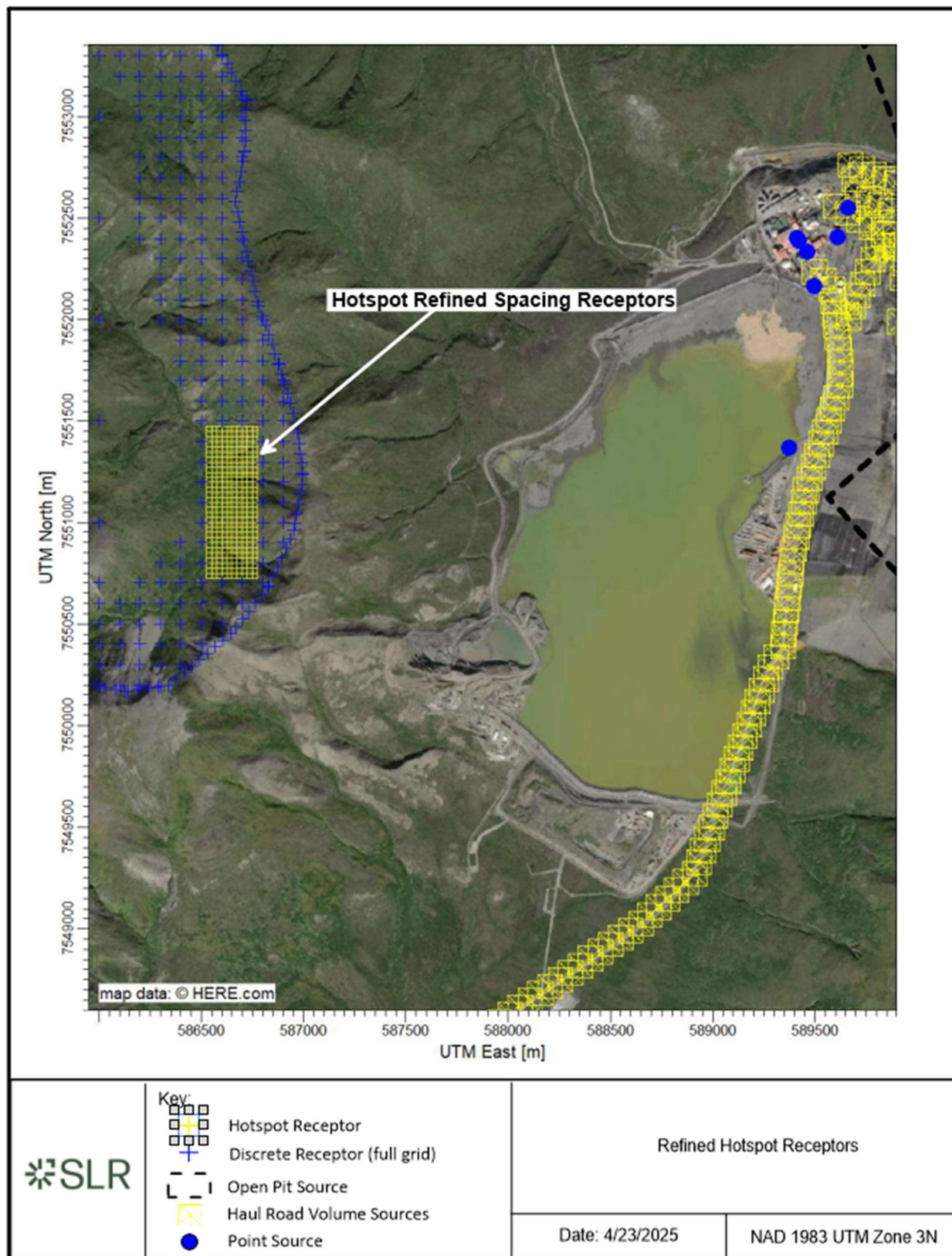


Figure 6: Year 1 - Maximum Rolling 3-Month Pb Average Concentration Heat Map

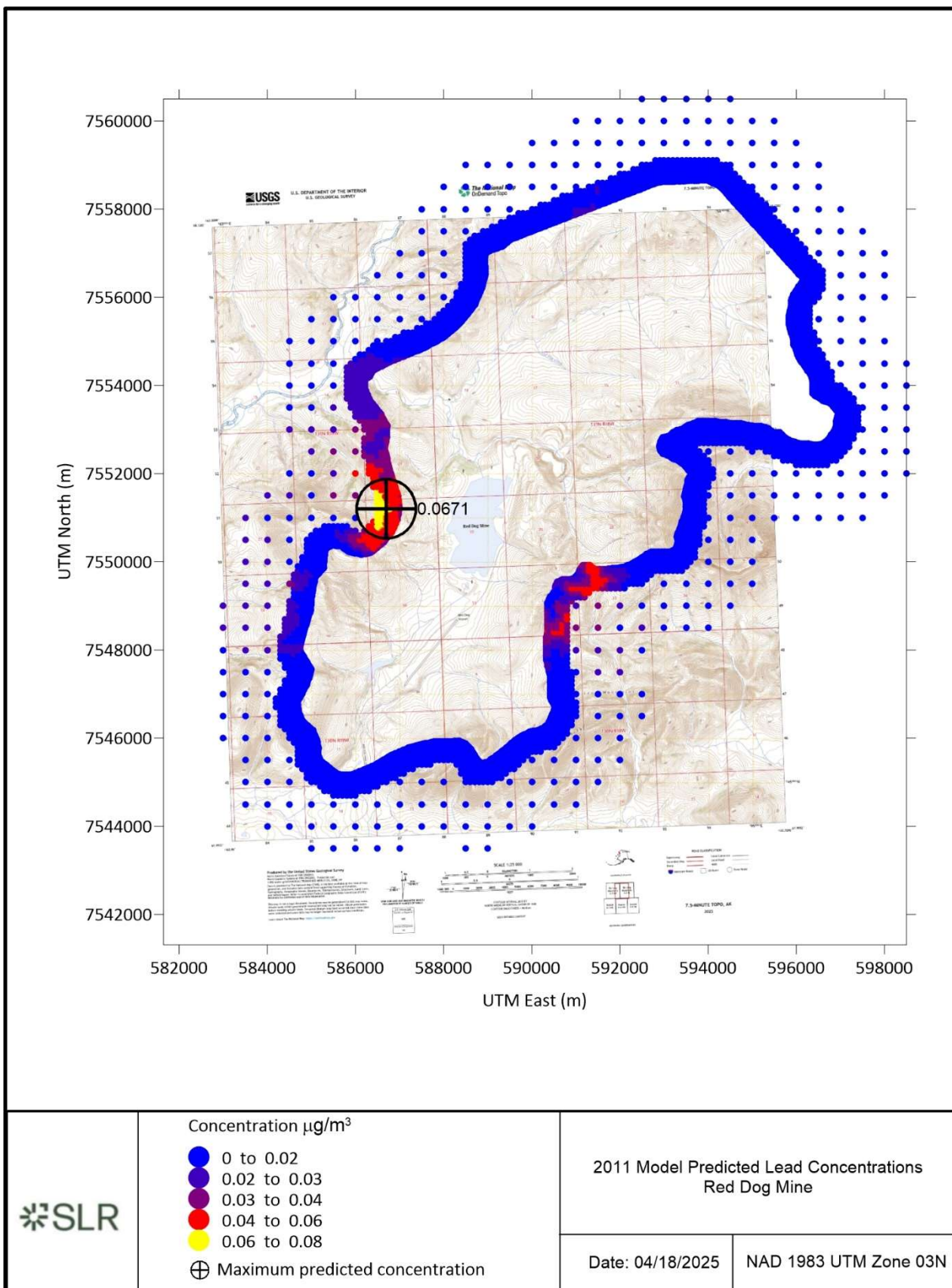


Figure 7: Year 2 - Maximum Rolling 3-Month Pb Average Concentration Heat Map

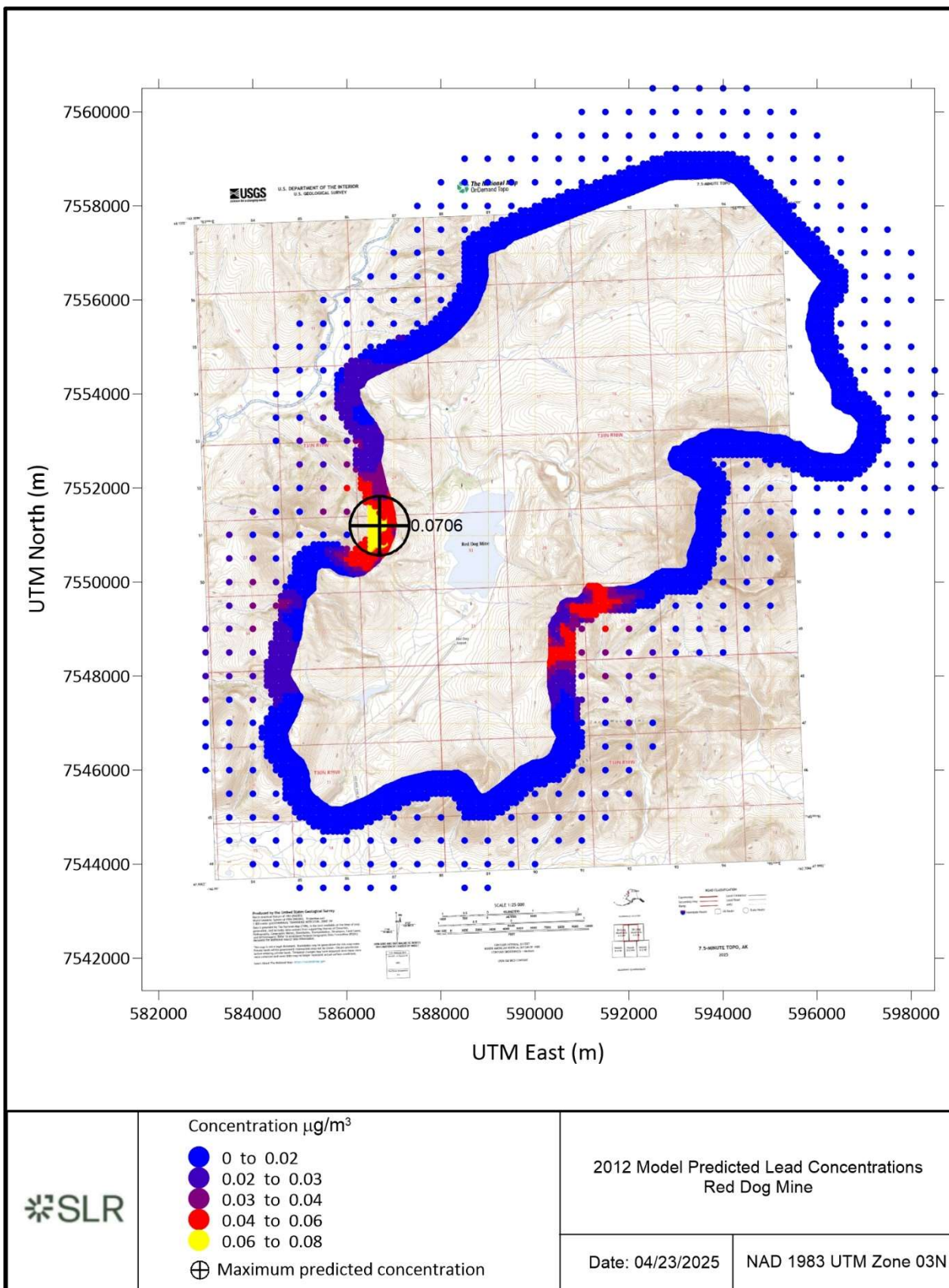


Figure 8: Year 3 - Maximum Rolling 3-Month Pb Average Concentration Heat Map

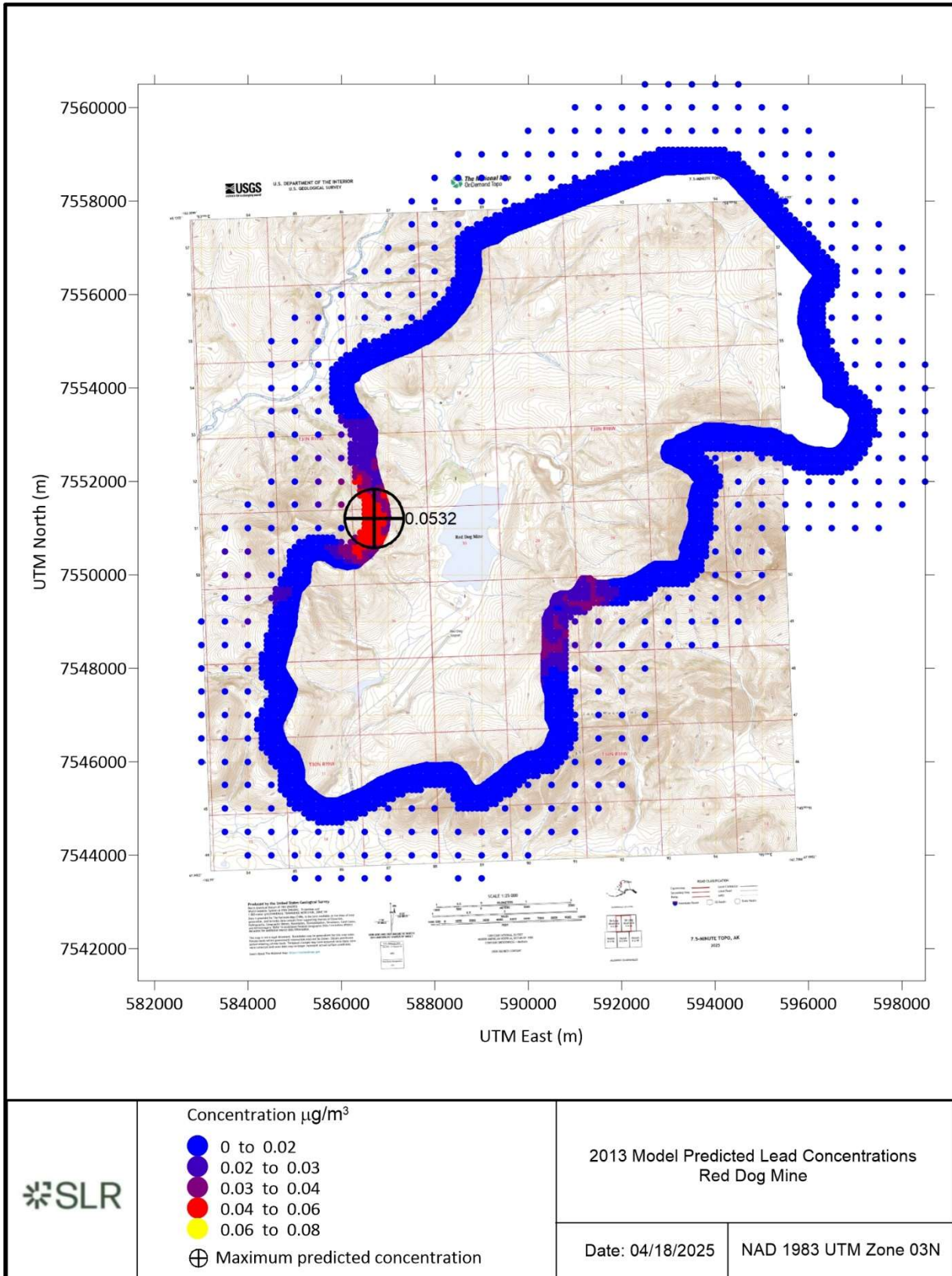
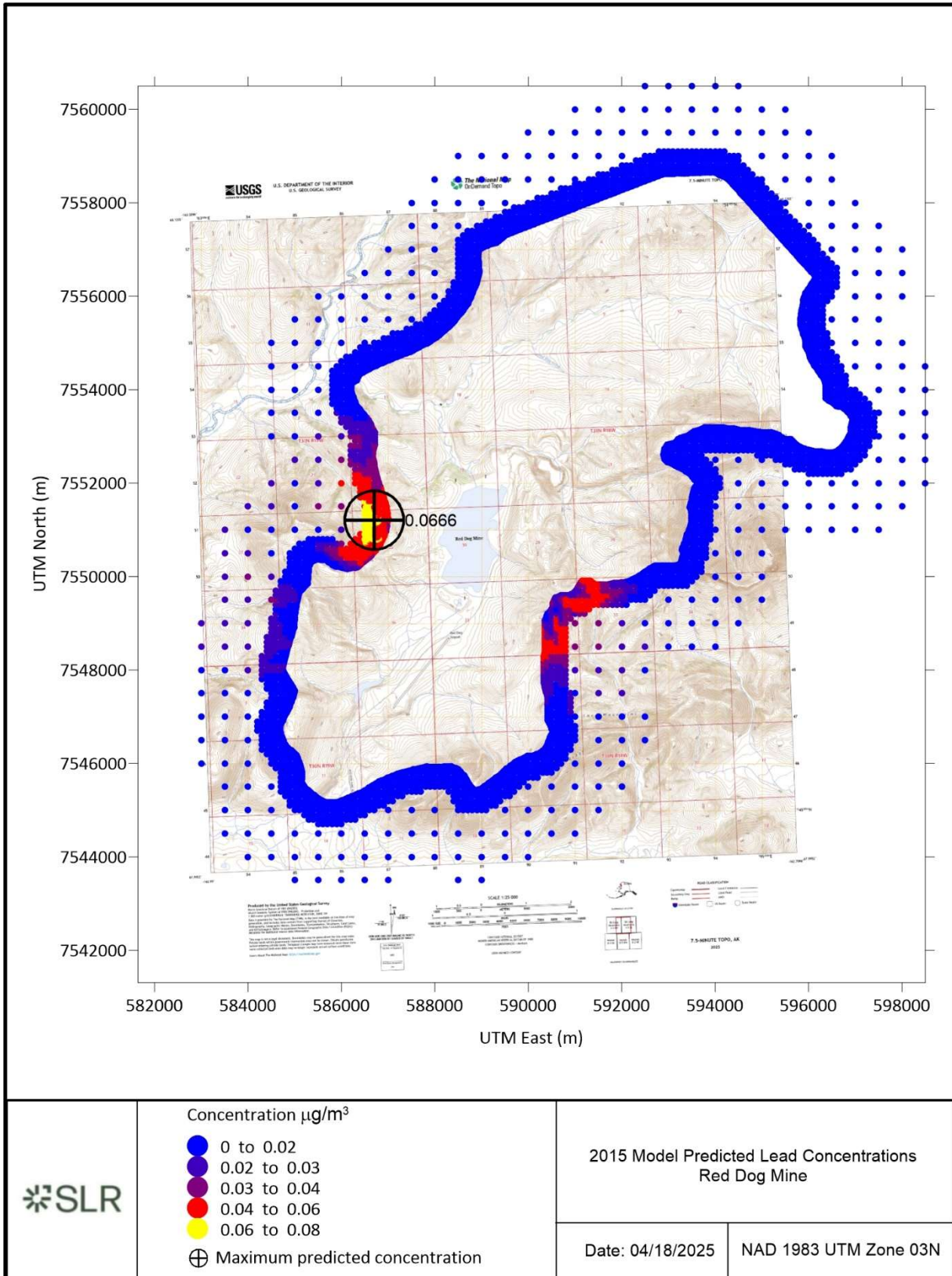
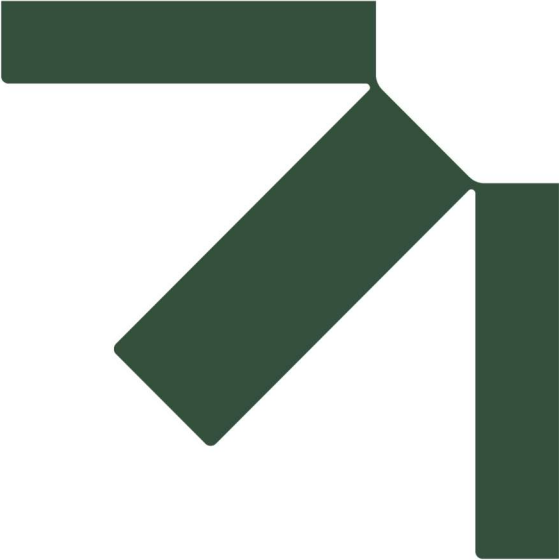


Figure 9: Year 4 - Maximum Rolling 3-Month Pb Average Concentration Heat Map





Appendix A 2020 Lead Emissions Dispersion Modeling Analysis

Red Dog Mine Lead Emissions Dispersion Modeling Analysis

ADEC Requested Lead Modeling Demonstration under 40 CFR Part 58, Appendix D,
section 4.5(a)

Teck Alaska Inc

SLR Project No.: 105.021323.00001

April 25, 2025



**Lead Emissions Dispersion
Modeling Analysis**
for the
**ADEC Requested Lead Modeling
Demonstration under 40 CFR Part 58,
Appendix D, section 4.5(a)**
Red Dog Mine

May 2020

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2700 Gambell Street, Ste 200
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Appendix A Emission Calculations and Electronic Modeling Files

Appendix B PSD Meteorological Data Final Findings Reports

Executive Summary

The Teck Alaska Incorporated (Teck) Red Dog Mine is a source of lead (Pb) emissions exceeding 0.5 tons per year and triggers ambient Pb monitoring requirements as specified in Title 40 Code of Federal Regulations (40 CFR) Part 58, Appendix D, section 4.5(a). According to 40 CFR Part 58, Appendix D, section 4.5(a)(ii), the U.S. Environmental Protection Agency (EPA) Regional Administrator may waive the requirement for Pb source monitoring if the state can demonstrate that the source will not contribute to a maximum Pb concentration in ambient air in excess of 50 percent of the Pb National Ambient Air Quality Standard (NAAQS).

This report describes the Pb dispersion modeling methods conducted for the Red Dog Mine in accordance with the recommendations and requirements put forth in 40 CFR Part 51, Appendix W, and recommendations in EPA and Alaska Department of Environmental Conservation (ADEC) guidance documents. The results of the dispersion modeling analysis described in this report demonstrate that the Red Dog Mine will not contribute to a maximum Pb concentration in ambient air in excess of 50 percent of the Pb NAAQS. Therefore, the modeling demonstration results can be used to support the Alaska Department of Environmental Conservation request to the EPA Region 10 Administrator for a monitoring waiver for the Red Dog Mine.

1.0 Purpose and Scope

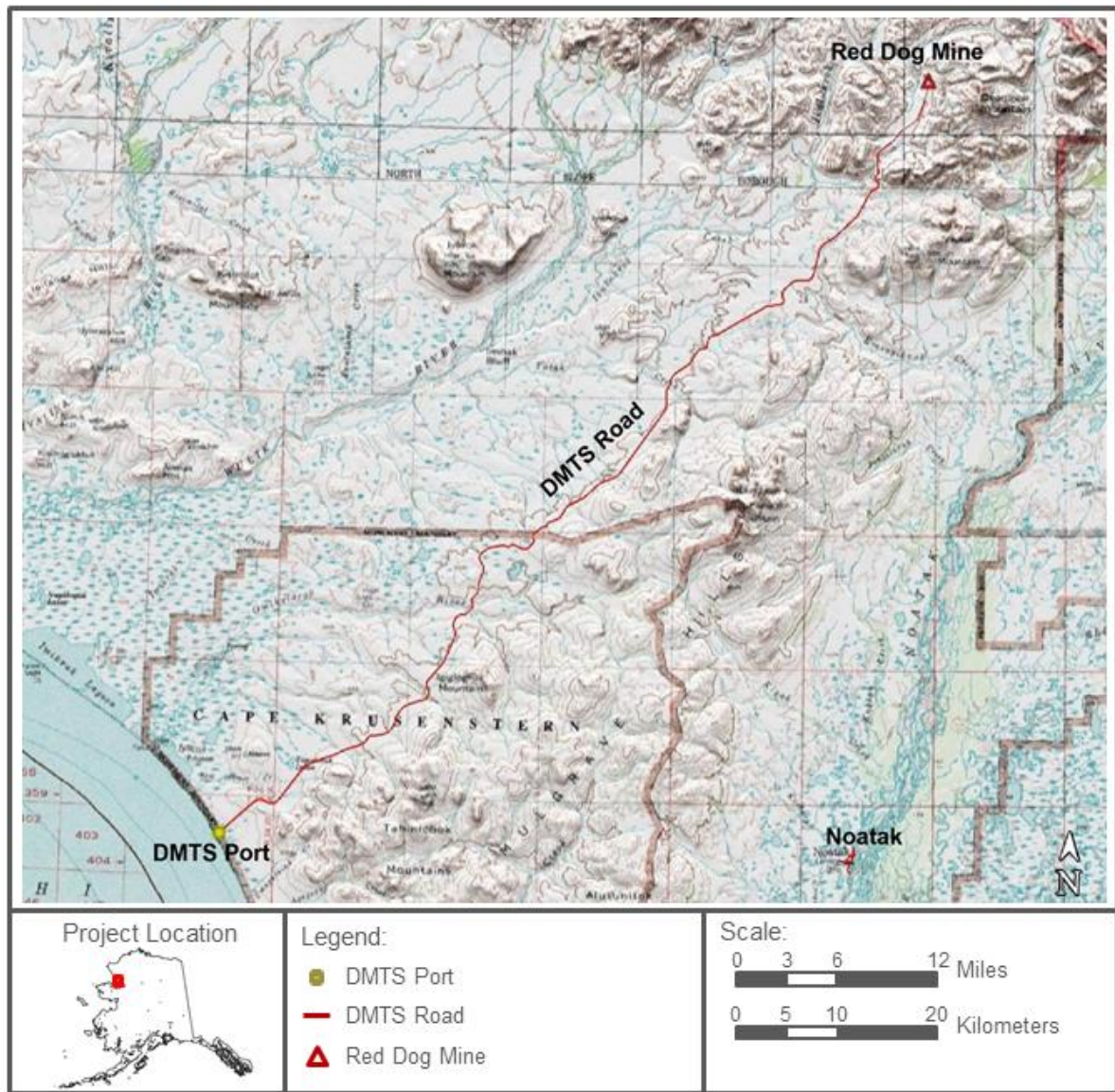
This modeling report describes the modeling methodology for quantifying ambient air Pb impacts from the Red Dog Mine (Mine), which is a Pb and zinc (Zn) surface mining and ore processing facility. Figure 1-1 shows a topographic map of the Mine, Delong Mountain Transportation System (DMTS), and DMTS Port located in the Northwest Arctic Borough above the Arctic Circle.

An ambient air monitoring requirement for assessing ambient air impacts due to Pb emission at the Mine came into effect through the revised final Pb NAAQS rule, promulgated on November 12, 2008 (40 CFR Parts 50, 51, 53, and 58 National Ambient Air Quality Standards for Lead; Final Rule). The 2008 Pb NAAQS established new thresholds for air quality monitoring around sources which emit 1.0 or more tpy of Pb. Revisions to the Lead Ambient Air Monitoring Requirements, Final Rule, lowered the source emission threshold from 1.0 tpy to 0.5 tpy (75 FR 81127). The Red Dog Mine is the only stationary source in Alaska that meets this criterion.

According to the rule, monitoring agencies may request a waiver for ambient monitoring requirements if the agency can demonstrate through a modeling analysis that the maximum modeled Pb concentration will not exceed 50 percent of the Pb NAAQS. The level of the Pb NAAQS is 0.15 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) and is in the form of a 3-month rolling average. Therefore, fifty percent of the level of the Pb NAAQS is $0.075 \mu\text{g}/\text{m}^3$.

ADEC completed a Pb modeling demonstration during 2015 and 2016 (2016 ADEC analysis) in support of a monitoring waiver issued on August 11, 2016 by the EPA Region 10. Pursuant to 40 CFR Part 58, Appendix D, section 4.5(a)(ii), the waiver must be renewed every five years as part of the Alaska 5-year Air Monitoring Network Assessment. This modeling analysis was prepared to support the renewal of the Pb monitoring waiver, which must be renewed by July 1, 2020.

Figure 1-1. Project Location Map



2.0 Modeling Overview

The dispersion modeling analysis was conducted in accordance with the following guidance documents:

- U.S. EPA *Guideline on Air Quality Models*, 40 CFR Part 51, Appendix W, (Revised January 2017).
- U.S. EPA *User's Guide for the AMS/EPA Regulatory Model (AERMOD)*, EPA-454/B-19-027, August 2019.
- U.S. EPA *User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*, EPA-454/B-19-028, August 2019.
- U.S. EPA *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)*, EPA-454/B-18-004, April 2018.
- U.S. EPA *User's Guide to the Building Profile Input Program (BPIP)*, EPA-454/R-93-038, April 2004.
- ADEC Guidance: *re AERMET Geometric Means, How to Calculate the Geometric Mean Bowen Ratio and the Inverse-Distance Weighted Geometric Mean Surface Roughness Length in Alaska*, June 2009.

The analysis is based on the latest version of the EPA-approved AERMOD (version 19191) air dispersion model. AERMOD is a steady-state, Gaussian dispersion model developed for the dispersion of emissions at distances within 50 kilometers (km) of the source. The latest version of AERMET (version 19191) was used to prepare meteorological data and atmospheric stability parameter inputs for use in AERMOD. Terrain elevations from National Elevation Dataset (NED) files acquired from the U.S. Geological Survey (USGS) were processed in the latest version of AERMAP (version 18081) to develop the receptor terrain elevations and corresponding hill height scales required by AERMOD. In addition, the most recent version of the Building Profile Input Program with Plume Rise Model Enhancements (BPIP-PRM, version 04272) was used to model the effects of building downwash on the dispersion of emissions from modeled point sources.

2.1 Model Emission Inventory

The Mine includes two open pit mines, ore crushing equipment, waste rock disposal sites, stockpiles, a mill and concentrator, and wastewater treatment facilities. Supporting equipment includes fuel-fired generator engines, boilers, heaters and small, remote incinerators. Mobile equipment operated at the mine includes haul trucks, bulldozers, graders, and loaders. Emissions of fugitive particulate matter (PM) containing Pb originate from drilling, blasting, bulldozing, grading, material handling, and vehicle traffic on unpaved roads at the Mine.

The modeled Pb emissions and information used to simulate Pb emissions from Mine activities are provided in Appendix A. The Pb emission estimates are based on similar calculation methodologies and input parameters as used for the 2016 ADEC analysis, except that updates

have been made to the Pb emission estimates to reflect recent Mine operations and additional, more recent meteorological observations. A variety of sources, including EPA AP-42 emission factors, source test data, and actual analyses of Pb concentrations in Mine materials, was used to develop the Pb emissions inventory. The Pb content in the fugitive PM emissions from activities at the different Mine locations are based on soil samples analyzed for Pb content performed in 2014.

Mine Pb emissions sources were characterized in AERMOD as either point sources, volume sources, or open pit sources. All modeled source locations were referenced to the Universal Transverse Mercator (UTM) Zone 3, North American Datum 1983 (NAD83) coordinate system. Figure 2-1 shows an aerial image of the Mine site and depicts the locations of the modeled Mine activity sources. Figure 2-2 provides an expanded aerial image of all modeled sources.

Figure 2-1. Mine Activity Model Source Locations

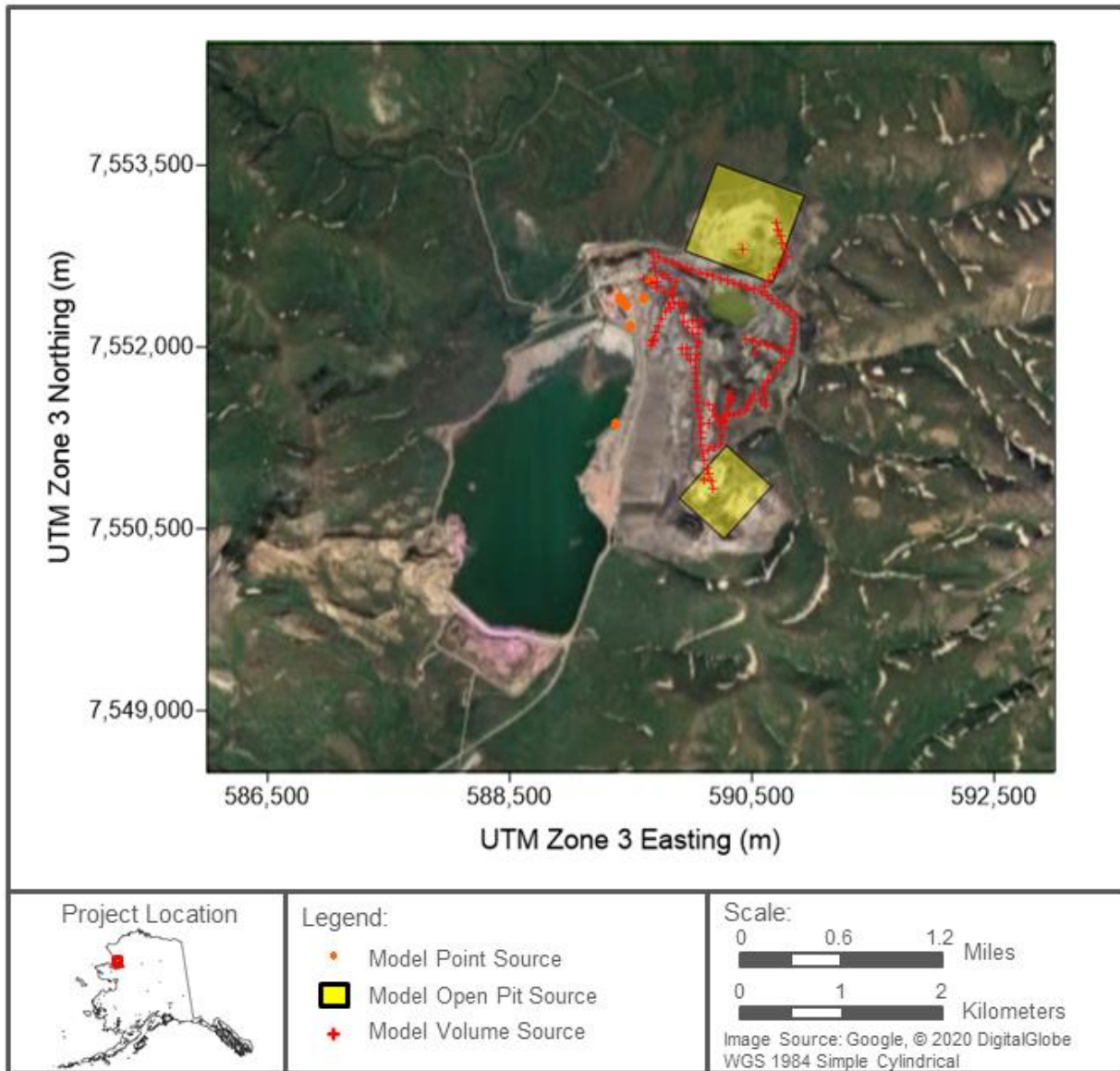
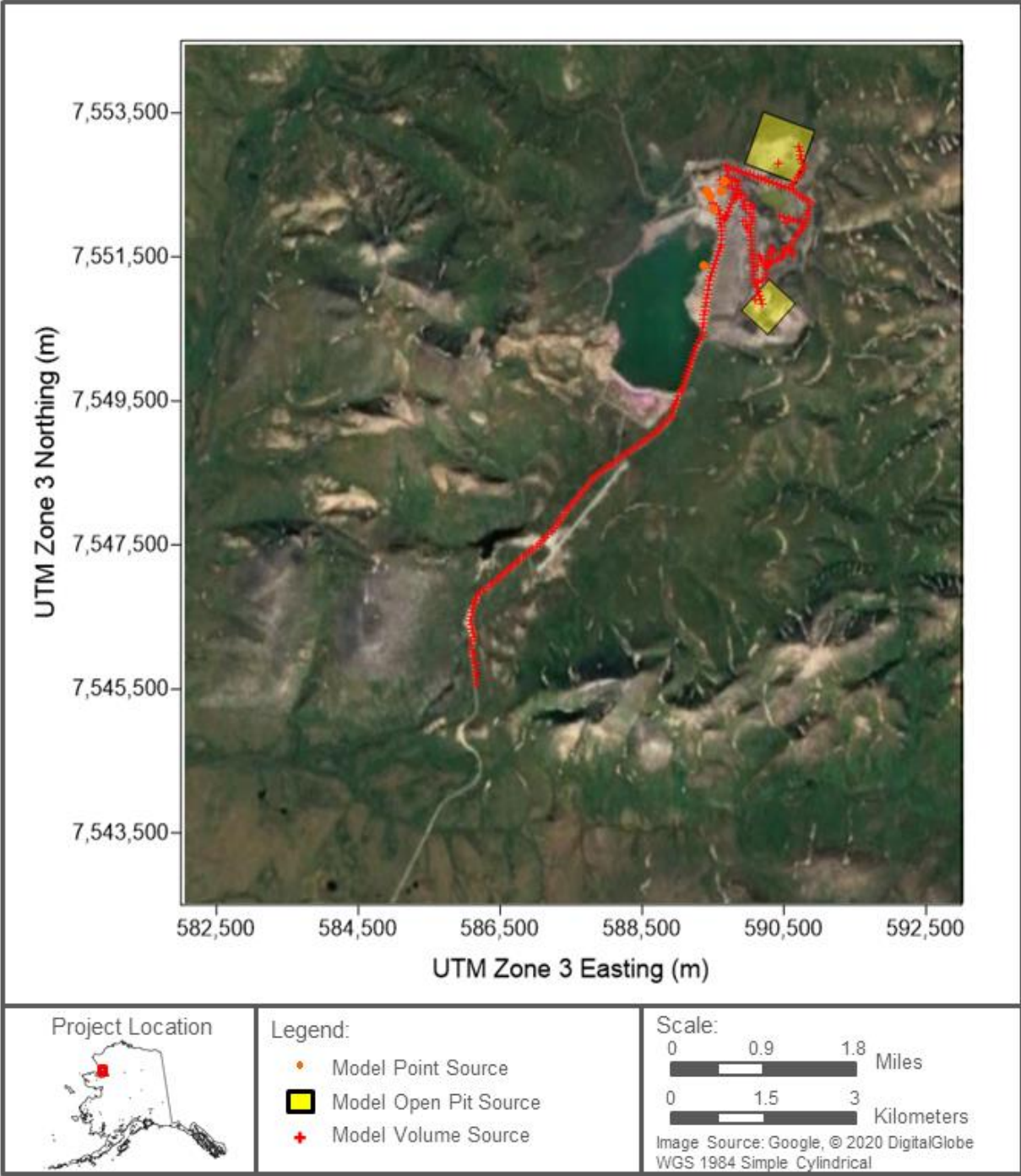


Figure 2-2. All Model Source Locations



2.1.1 Point Sources

Table 2-1 provides coordinates, emission rates, and exhaust parameters for the modeled point source inventory. The modeled point source inventory includes baghouses, conveyer wet scrubbers and incinerators. All point sources were modeled as vertical, uncapped point sources except for the Coarse Ore Storage Building Baghouse (Model ID MD9), which was modeled as a horizontal, uncapped point source. The effects of plume downwash from facility structures was considered for all point sources following the guidance provided in the EPA *Guidelines for Determination of Good Engineering Practice Stack Height* (EPA-450/4-80-023R, June 1985). Direction-specific building downwash dimensions for use as modeling inputs were calculated using BPIPPRM, version 04274. Building coordinates and heights for each structure that could influence a modeled EU were entered into BPIPPRM and the output dimensions were used to provide the direction-specific downwash dimensions to the AERMOD model.

Table 2-1. Modeled Point Source Input Parameters

Emissions Units		Coordinates (UTM Zone 3)			Exhaust Parameters				
Description	Model ID	Easting (km)	Northing (km)	Elevation (m)	Emission Rate (g/s)	Stack Height (m)	Exhaust Temp. (K)	Exhaust Velocity (m/s)	Stack Diameter (m)
Primary Jaw Crusher Baghouse	MD1	589.610	7,552.406	304.8	2.47E-05	7.32	299.8	0.50	0.210
Coarse Ore Conveyor A Wet Scrubber	MD2	589.419	7,552.392	304.8	1.24E-03	23.47	299.8	35.66	0.457
Coarse Ore Conveyor B Wet Scrubber	MD3	589.413	7,552.401	300.2	1.20E-03	23.47	299.8	35.66	0.457
Assay Lab, Bucking Room Baghouse	MD4	589.461	7,552.337	300.2	1.05E-04	12.19	299.8	7.12	0.559
Gyratory Crusher Baghouse	MD6	589.662	7,552.549	291.1	3.69E-05	33.53	299.8	18.19	0.610
Jaw Crusher Dump Pocket Baghouse	MD7	589.610	7,552.406	304.8	6.31E-05	16.71	299.8	19.64	1.016
Gyratory Crusher Dump Pocket Baghouse	MD8	589.662	7,552.549	291.1	2.21E-05	17.60	299.8	19.43	1.067
Coarse Ore Storage Building Baghouse	MD9	589.497	7,552.168	296.6	2.71E-04	3.92	299.8	17.22	1.321
Incinerator	MI2	589.375	7,551.372	304.8	9.13E-04	7.62	672.0	3.38	0.914
Incinerator	MI3	586.729	7,547.643	289.6	8.17E-05	8.43	1,144.3	5.11	0.711

2.1.2 Volume Sources

The ADEC 2016 analysis relied primarily on characterizing non-point sources as area sources. However, the approach used for this analysis is primarily based on volume source emissions type parameters applied to activities associated with quarry rock crushing operations, drilling, blasting, bulldozing, material handling, grading, and unpaved road traffic. The approach to model these activities as volume sources, instead of as area sources, is consistent with the guidance in the EPA memorandum, *Haul Road Workgroup Final Report Submission to EPA-OAQPS* (March 2, 2012) and the AERMOD User's Guide.

Table 2-2 provides the volume source model input parameters, including emission rates for most of the Pb emission volume sources. The physical dimensions of the volume source activity were used to determine the applicable model input parameters, such as the initial lateral and vertical dispersion coefficients (i.e. Sigma Y and Sigma Z). These parameters were calculated based on the methodologies provided in the AERMOD User's Manual and the EPA *Haul Road Workgroup Final Report Submission to EPA-OAQPS* memorandum. Fugitive Pb emissions from vehicle traffic on unpaved roads was modeled using a series of volume sources placed over different roadway segments. The model volume source parameters for the unpaved road sources are provided in Appendix A.

Lead emissions estimates for the volume source type activities used a similar approach as that used for 2016 ADEC analysis. The updated emissions inputs are based on appropriate EPA AP-42 emissions equations for the specified activity along with other relevant information, such as the Pb mass fraction, in order to calculate respective maximum daily and maximum annual Pb emission rates. The majority of Pb emissions calculated are associated with materials handling in the active mining areas, such as the ore stockpile areas.

While the Pb NAAQS is based on a rolling 3-month average concentration, the 2016 ADEC analysis used annual average Pb emission rates as model source inputs. Because this approach could result in underestimating the 3-month average Pb impacts, the updated modeling analysis is based on estimated maximum 24-hour average Pb emission rates provided in Attachment A. While the approach to use the maximum 24-hour average Pb emission rates provides a more robust estimate of Pb impacts than using annual average Pb emission rates, this approach proved to be overly conservative for the bulldozing source category. For example, the maximum annual hours of operation for bulldozing activities at the Mine is 765 hours at the Main Waste Dump, which is equivalent to continuous bulldozing for 32 days, or approximately 33 percent of a 3-month average period. Therefore, more realistic, conservative model emissions rates were developed for bulldozing activities. Specifically, model emission rates for bulldozing activities were based on the actual annual hours of bulldozing at a given location and pro-rated on a 3-month basis and then multiplied by a 1.5 factor to provide a conservative estimate of the Pb emission rates from the bulldozing activities.

Table 2-2. Modeled Volume Source Input Parameters

Emissions Source			Coordinates (UTM Zone 3)			Source Parameters			
Location	Description	Model ID	Easting (km)	Northing (km)	Elevation (m)	Emission Rate (g/s)	Release Height (m)	Sigma Y (m)	Sigma Z (m)
Materials Handling									
Ore Stockpile	Ore Stockpile - Loading	ORESLOAD	589.714	7,552.531	314.20	5.41E-03	2.74	35.44	2.55
Methanol Pad	Methanol Pad - Loading	METHLOAD	589.827	7,552.315	336.87	7.59E-05	2.74	17.72	2.55
New Shifters Pad	New Shifters Pad - Loading	NEWSLOAD	589.955	7,551.987	350.22	1.74E-05	2.74	24.81	2.55
Phase 3	Phase 3 - Loading	PHASLOAD	589.683	7,552.055	306.34	5.16E-05	2.74	15.95	2.55
Ore Stockpile	Ore Stockpile - Load/Dump	ORE_DUMP	589.714	7,552.531	314.20	1.85E-02	3.05	35.44	2.84
Copper Ore Stockpile	Copper Ore Stockpile - Load/Dump	COPPDUMP	590.011	7,552.221	352.93	4.05E-04	3.05	30.48	2.84
Methanol Pad	Methanol Pad - Load/Dump	METHDUMP	589.827	7,552.315	336.87	4.62E-04	3.05	17.72	2.84
New Shifters Pad	New Shifters Pad - Load/Dump	NEWSDUMP	589.955	7,551.987	350.22	9.09E-04	3.05	24.81	2.84
Phase 3	Phase 3 - Load/Dump	PHASDUMP	589.683	7,552.055	306.34	7.22E-04	3.05	15.95	2.84
Main Waste Dump	Main Waste Dump - Load/Dump	MAINDUMP	590.532	7,551.963	215.35	3.11E-04	3.05	53.16	2.84
Cover Waste Dump	Cover Waste Dump - Load/Dump	COVRDUMP	590.340	7,551.565	392.91	9.20E-07	3.05	19.49	2.84
Oxide Waste Dump	Oxide Waste Dump - Load/Dump	OXIDDUMP	590.140	7,551.369	411.28	1.52E-04	3.05	17.72	2.84
Bulldozing									
Ore Stockpile	Ore Stockpile - Bulldozing	ORE_DOZE	589.714	7,552.531	314.20	8.93E-03	2.44	35.44	2.27
Main Waste Dump	Main Waste Dump - Bulldozing	MAINDOZE	590.532	7,551.963	215.35	6.80E-04	2.44	53.16	2.27
Copper Ore Stockpile	Copper Ore Stockpile - Bulldozing	COPPDOZE	590.011	7,552.221	352.93	1.76E-04	2.44	30.48	2.27

Table 2-2 (Continued). Modeled Volume Source Input Parameters

Emissions Source			Coordinates (UTM Zone 3)			Source Parameters			
Location	Description	Model ID	Easting (km)	Northing (km)	Elevation (m)	Emission Rate (g/s)	Release Height (m)	Sigma Y (m)	Sigma Z (m)
Bulldozing (continued)									
Cover Waste Dump	Cover Waste Dump - Bulldozing	COVRDOZE	590.340	7,551.565	392.91	2.01E-06	2.44	19.49	2.27
Methanol Pad	Methanol Pad - Bulldozing	METHDOZE	589.827	7,552.315	336.87	2.03E-04	2.44	17.72	2.27
New Shifters Pad	New Shifters Pad - Bulldozing	NEWSDOZE	589.955	7,551.987	350.22	2.13E-03	2.44	24.81	2.27
Oxide Waste Dump	Oxide Waste Dump - Bulldozing	OXIDDOZE	590.140	7,551.369	411.28	3.34E-04	2.44	37.21	2.27
Phase 3	Phase 3 - Bulldozing	PHASDOZE	589.683	7,552.055	306.34	5.88E-04	2.44	15.95	2.27
Grading									
Ore Stockpile	Ore Stockpile - Grading	ORE_GRAD	589.714	7,552.531	314.20	9.52E-05	1.83	35.44	1.70
New Shifters Pad	New Shifters Pad - Grading	NEWSGRAD	589.955	7,551.987	350.22	5.89E-05	1.83	24.81	1.70
Oxide Waste Dump	Oxide Waste Dump - Grading	OXIDGRAD	590.140	7,551.369	411.28	6.02E-05	1.83	37.21	1.70
Cover Waste Dump	Cover Waste Dump - Grading	COVRGRAD	590.340	7,551.565	392.91	1.93E-05	1.83	19.49	1.70
Main Waste Dump	Main Waste Dump - Grading	MAINGRAD	590.532	7,551.963	215.35	6.90E-05	1.83	53.16	1.70
Blasting									
Aqqaluk Pit	Aqqaluk Pit - Blasting	AQQ_BLST	590.421	7,552.802	343.63	7.13E-03	76.20	21.27	70.88
Qanaiyaq Pit	Qanaiyaq Pit - Blasting	QAN_BLST	590.100	7,550.907	429.62	9.63E-03	76.20	21.27	70.88

2.1.3 Open Pit Sources

The Mine includes two open pit mines, the Aqqaluk Pit and the Qanaiyaq Pit and, as such, Pb emissions activities at these two sources were modeled using the AERMOD Open Pit option. Table 2-3 provides emission rates and physical parameters for the open pit sources, which includes grading, material handling, and fugitive Pb emissions from vehicle traffic.

2.1.4 Plume Depletion and Deposition

The AERMOD model allows for the calculation of deposition and plume depletion as a result of dry and wet deposition that may occur during plume transport. This deposition can be an important consideration for fugitive Pb emissions, which would cause the emitted material to fall from the plume near the emission source.

A second consideration is the deposition or scavenging of air pollutants during precipitation events. The AERMOD model uses the AERMET hourly precipitation information to determine when precipitation events occur and the magnitude of those events. AERMOD uses this information to calculate the amount of air pollutants that would be removed through the processes of wet deposition and scavenging.

To complete the calculations of dry and wet deposition and plume depletion, AERMOD requires information regarding the particle size, mass fraction, and density. The deposition parameters in Table 2-4 were used for particle diameter, mass fraction, and density inputs and are site-specific values that are consistent with the values used for the 2016 ADEC analysis.

Table 2-3. Modeled Open Pit Source Input Parameters

Emissions Source		Coordinates (UTM Zone 3)			Source Parameters					
Description	Model ID	Easting (km)	Northing (km)	Elevation (m)	Emission Rate (g/s/m ³)	Release Height (m)	X _i (m)	Y _i (m)	Pit Volume (m ³)	Angle (deg)
Aqqaluk Pit	AQQL_PIT	589.947	7,552.792	378.59	1.48E-07	5.00	765.5	770.0	170,195,864	-20.0
Qanaiyaq Pit	QANA_PIT	589.899	7,550.754	398.40	2.55E-07	5.00	582.6	500.0	59,133,773	-42.0

Table 2-4. Summary of Total Suspended Particulate Deposition Parameters

Particle Diameter (µm)	Mass Fraction	Density (g/cm ³)
1.6	0.021	2.65
3.9	0.073	2.65
7.8	0.176	2.65
12.7	0.148	2.65
17.6	0.115	2.65
25.3	0.467	2.65

2.2 AERMET Meteorological Data

The latest version of AERMET (19191) was used to process meteorological data used for atmospheric boundary layer and meteorology parameters used in the AERMOD algorithms. AERMET requires a minimum of hourly surface observations of wind speed, wind direction, temperature, and cloud cover and corresponding twice-daily upper air meteorological soundings collected by the National Weather Service (NWS). Four years of representative site-specific meteorological data were used to estimate Pb impacts, which is consistent with EPA modeling requirements to use at least one-year of site-specific meteorological data (40 CFR 51, Appendix W).

The modeling analysis uses hourly site-specific surface meteorological data collected at the Red Dog Mine collected during the following time periods:

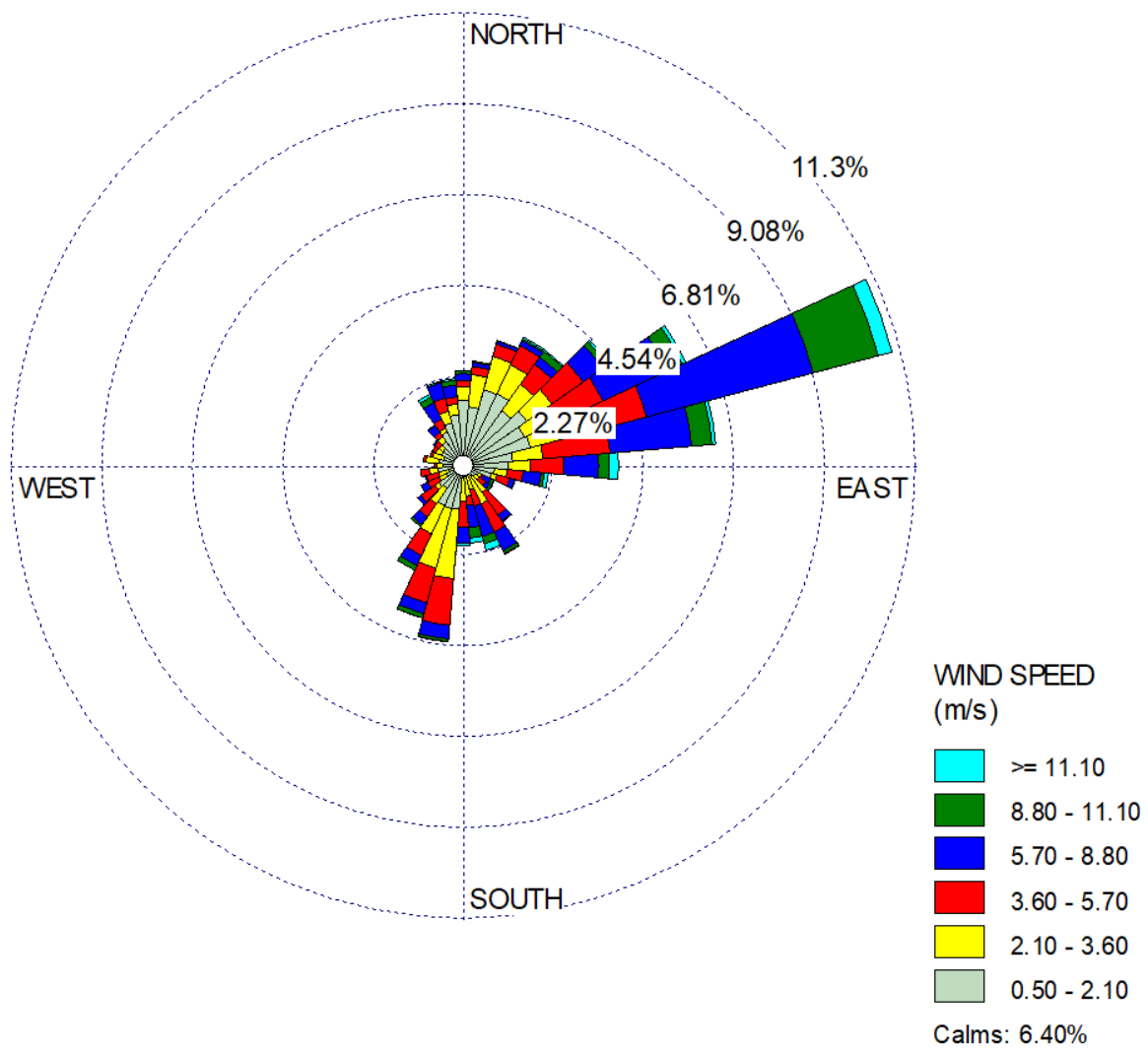
- October 1, 2011 through September 30, 2014 (Model Years 1 through 3), and
- October 1, 2015 through September 30, 2016 (Model Year 4).

The on-site data are comprised of hourly averages of Prevention of Significant Deterioration (PSD) meteorological monitoring parameters collected at two Red Dog Mine meteorological stations: Bons Creek and Mill Site stations. The paired data sets include horizontal wind speed, horizontal wind direction, and standard deviation of the horizontal wind direction (sigma-theta) from the Mill monitoring site and ambient 2-meter temperature, ambient 10-meter temperature, vertical temperature difference (10-meter temperature minus 2-meter temperature, "Delta T"), solar radiation, relative humidity, barometric pressure, and precipitation from the Bons Creek monitoring site. Each one-year meteorological data set was found by ADEC to meet all PSD meteorological data standards except for relative humidity parameters during Model Years 2 and 3, precipitation parameters during Model Year 2, and barometric pressure parameters during Model Year 3.

Figure 2-3 through Figure 2-6 depict wind roses of the respective site-specific wind data sets collected during Model Years 1 through 4 and show that the predominant winds at the Mine are from the east north-east. This wind pattern facilitates the transport of emissions primarily to the west south-west of the Mine activity area.

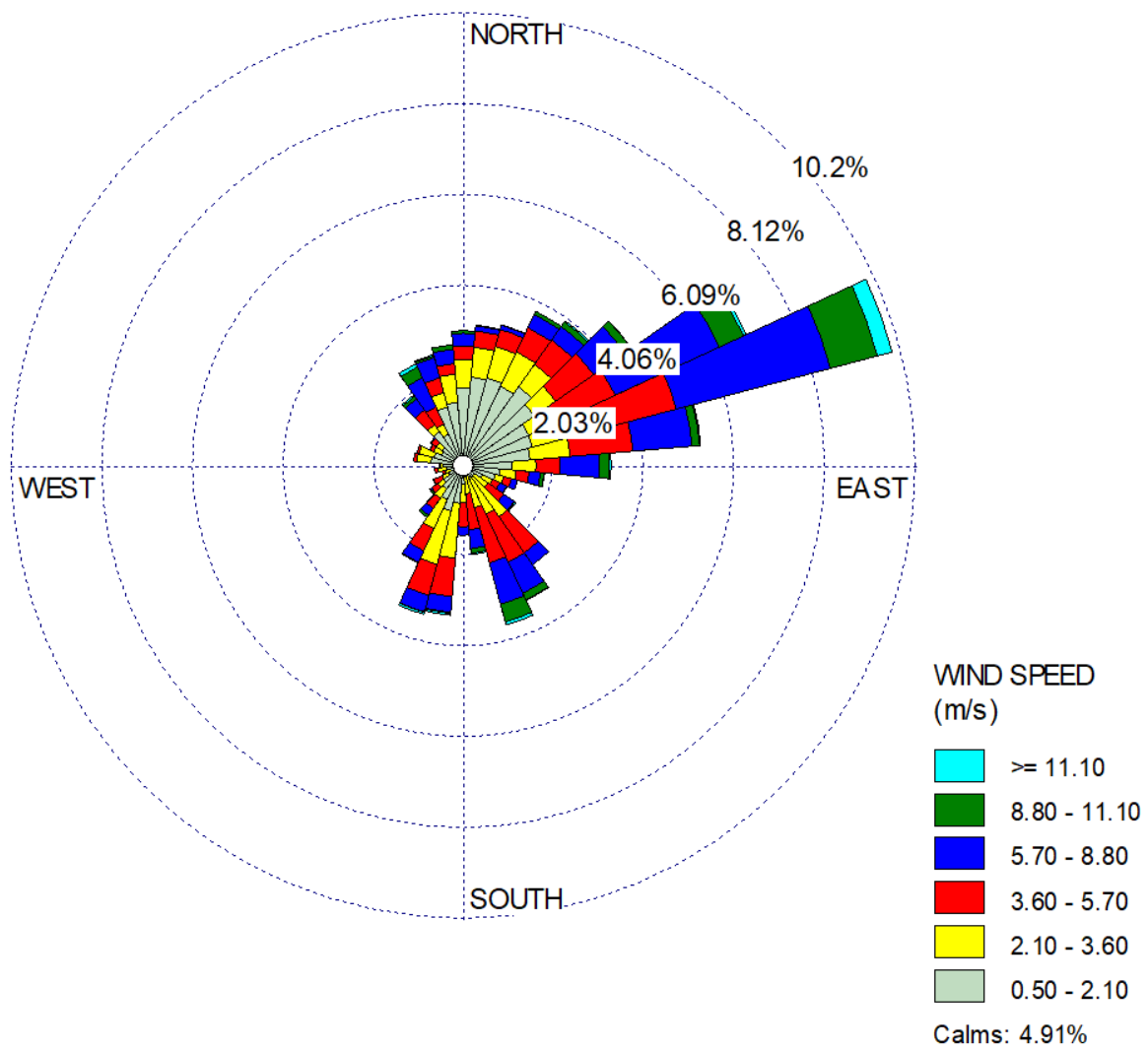
Concurrent twice-daily upper-air meteorological data collected by the NWS at either Barrow, Alaska or Kotzebue, Alaska was input with the site-specific meteorological data parameters. The Kotzebue station is closer to the Red Dog Mine than the Barrow station and was used for the modeling analysis for Model Years 2 through 4. However, the Kotzebue upper-air data set was not used for Model Year 1 because the upper-air data set for this period is composed of 474 soundings, which indicates the NWS Kotzebue upper-air data set for this time period contains significant data gaps. As a result, concurrent NWS upper-air data collected at Barrow, Alaska was used in lieu of the Kotzebue upper-air data set for Model Year 1. This approach is consistent with the approach used for the 2016 ADEC Analysis.

Figure 2-3. Mill Site Monitoring Station Wind Rose – Model Year 1



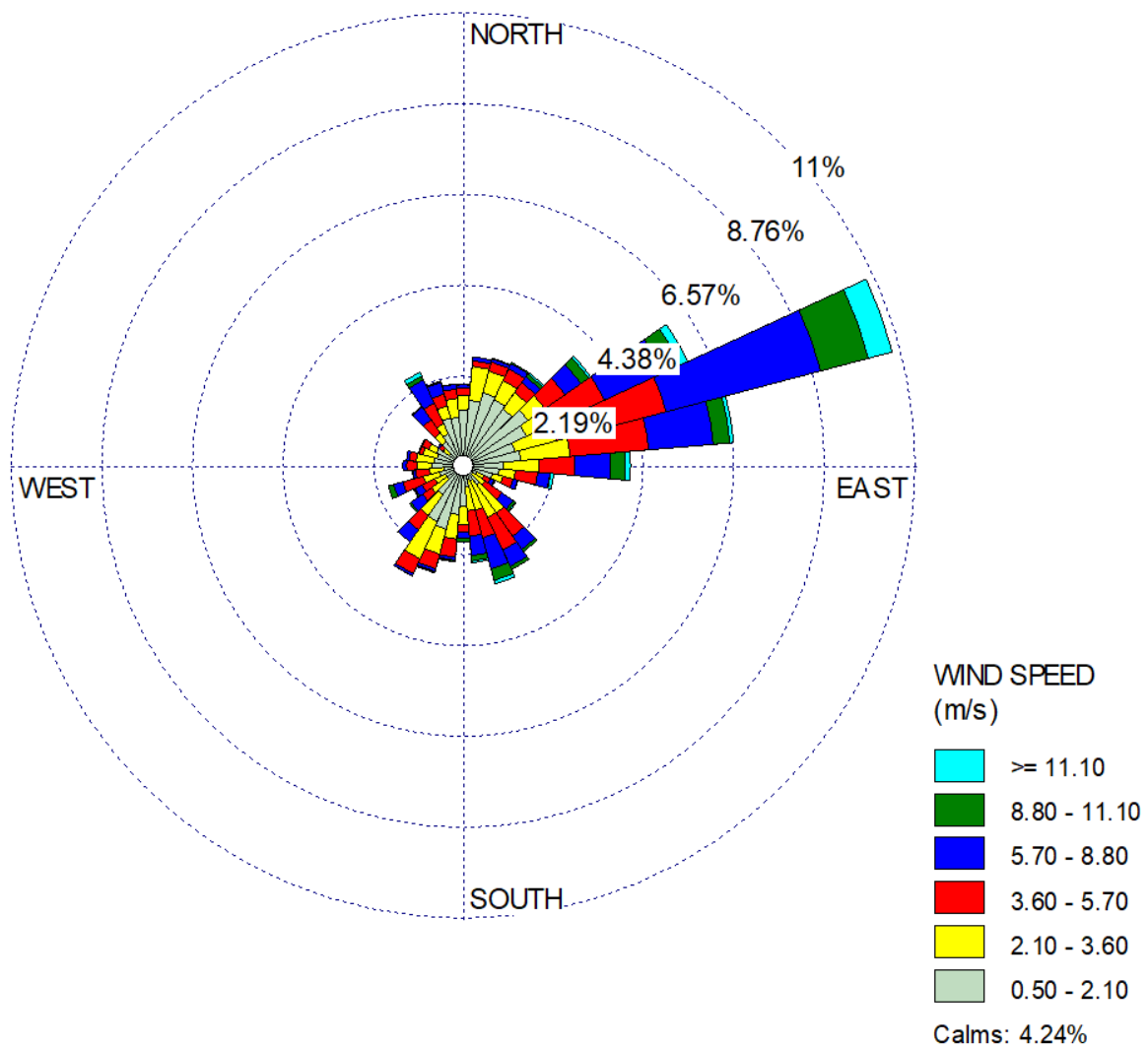
October 1, 2011 through September 30, 2012

Figure 2-4. Mill Site Monitoring Station Wind Rose – Model Year 2



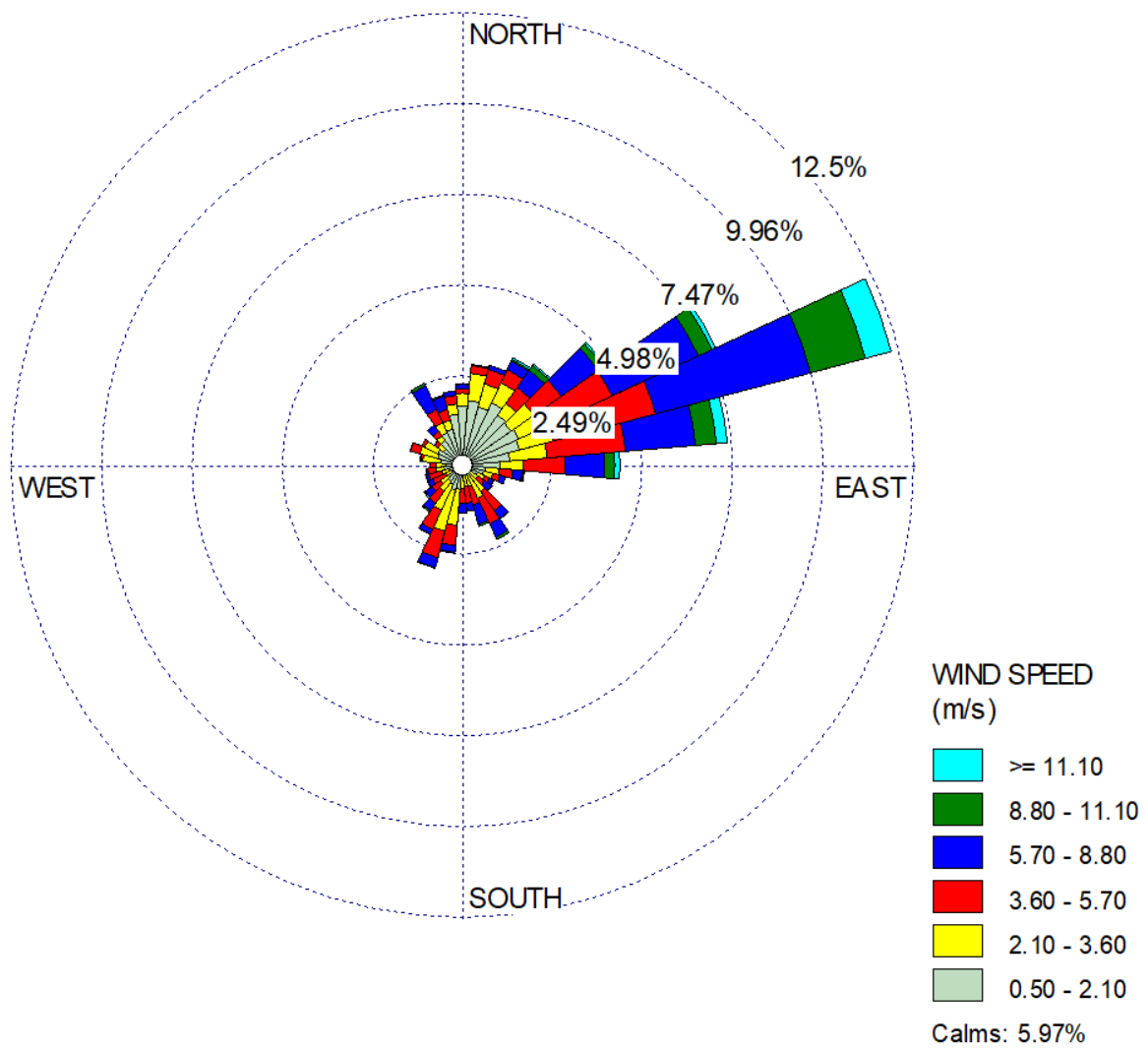
October 1, 2012 through September 30, 2013

Figure 2-5. Mill Site Monitoring Station Wind Rose – Model Year 3



October 1, 2013 through September 30, 2014

Figure 2-6. Mill Site Monitoring Station Wind Rose – Model Year 4



October 1, 2015 through September 30, 2016

AERMET uses upper air and surface meteorological data with site-specific geophysical inputs to calculate the atmospheric boundary layer parameters supplied to AERMOD for use in the air dispersion model algorithms. The geophysical input parameters are albedo, Bowen ratio, and surface roughness length. The procedures used to determine these input parameters are outlined in the EPA *AERMOD Implementation Guide* and the ADEC *AERMET Geometric Means, How to Calculate the Geometric Mean Bowen Ratio and the Inverse-Distance Weighted Geometric Mean Surface Roughness Length in Alaska* (June 2009). The recommendations for determining the geophysical input parameters are summarized below.

- Albedo is based on a simple un-weighted arithmetic mean for a representative domain defined by a 10 km by 10 km grid with a resolution of 1 km² and centered on the surface measurement site.
- Bowen Ratio is based on a simple un-weighted geometric mean for the same representative domain that is used to define the site-specific albedo.
- Surface Roughness Length is based on an inverse-distance weighted geometric mean for a default upwind distance of 1 km relative to the surface meteorological measurement site. Surface roughness length may be varied by sector to account for variations in land cover near the measurement site. The sector widths should be no smaller than 30 degrees.

In addition to the dependency on land-use classifications, the AERMET geophysical input parameters are also seasonally dependent. AERMET uses a different definition of the monthly composition of the seasons than that of northwestern Alaska. Therefore, geophysical input parameters are provided on a monthly basis to reflect more representative seasonal patterns experienced at the Mine. The following definitions of the seasons are based on Kotzebue, Alaska climate data and used for this air quality analysis:

- Spring (May): vegetation is emerging or partially green, the period when the mean monthly temperatures rise above 32 °F.
- Summer (June, July, and August): vegetation is most lush, daylight hours are at annual maximum, and daily low temperatures are typically above 32 °F.
- Autumn (September): below-freezing temperatures are common, deciduous plants transition from shedding leaves to becoming leafless, grasses are brown, and little or no snow is present.
- Winter (October, November, December, January, February, March, and April): mean daily high temperatures rarely exceed 32 °F, lakes and streams are frozen, and ground is covered with snow and ice.

Additionally, monthly surface moisture conditions at the site were used to determine Bowen ratio values per EPA guidance. Monthly precipitation values during the meteorological data period were compared with a 30-year climatological record collected at the Kotzebue, Alaska Airport from 1987 through 2016; this record includes the on-site meteorological data collection time period.

Following EPA recommendations, “wet” conditions are used when monthly precipitation is in the upper 30th-percentile, “dry” conditions are used if precipitation is in the lower 30th-percentile, and “average” conditions are used if precipitation is in the middle 40th-percentile.

Table 2-5 provides the seasonal values for applicable land cover use in the analysis area.

Table 2-5. AERMET Stage 3 Geophysical Input Parameters for the Mill Site

Land Use Classification	Season			
	Spring	Summer	Autumn	Winter
Albedo				
Open Water/Ice	0.600	0.100	0.100	0.700
Dwarf Birch/Grasses/Mosses	0.180	0.180	0.190	0.570
Quarries/Open Mine/Gravel	0.200	0.200	0.200	0.600
Bowen Ratio				
Average Conditions				
Open Water/Ice	0.500	0.100	0.100	0.500
Dwarf Birch/Grasses/Mosses	0.500	0.780	0.940	1.100
Quarries/Open Mine/Gravel	1.500	1.500	1.500	0.500
Wet Conditions				
Open Water/Ice	0.500	0.100	0.100	0.500
Dwarf Birch/Grasses/Mosses	0.360	0.440	0.520	0.500
Quarries/Open Mine/Gravel	1.000	1.000	1.000	0.500
Dry Conditions				
Open Water/Ice	0.500	0.100	0.100	0.500
Dwarf Birch/Grasses/Mosses	1.200	1.900	2.000	1.400
Quarries/Open Mine/Gravel	3.000	3.000	3.000	0.500
Surface Roughness Length (m)				
Open Water/Ice	0.050	0.050	0.050	0.050
Dwarf Birch/Grasses/Mosses	0.074	0.110	0.056	0.043
Quarries/Open Mine/Gravel	0.002	0.001	0.001	0.002

2.3 Model Receptors and Terrain

EPA defines ambient air as that portion of the atmosphere, external to buildings, to which the general public has access. For the purpose of modeling source emissions, the area to which Teck controls public access is not ambient air. Therefore, model receptors were placed only along, and outside of, the Mine ambient air boundary. No receptors were placed over worker housing or camp areas because all workers will be active and “on-call” at all times.

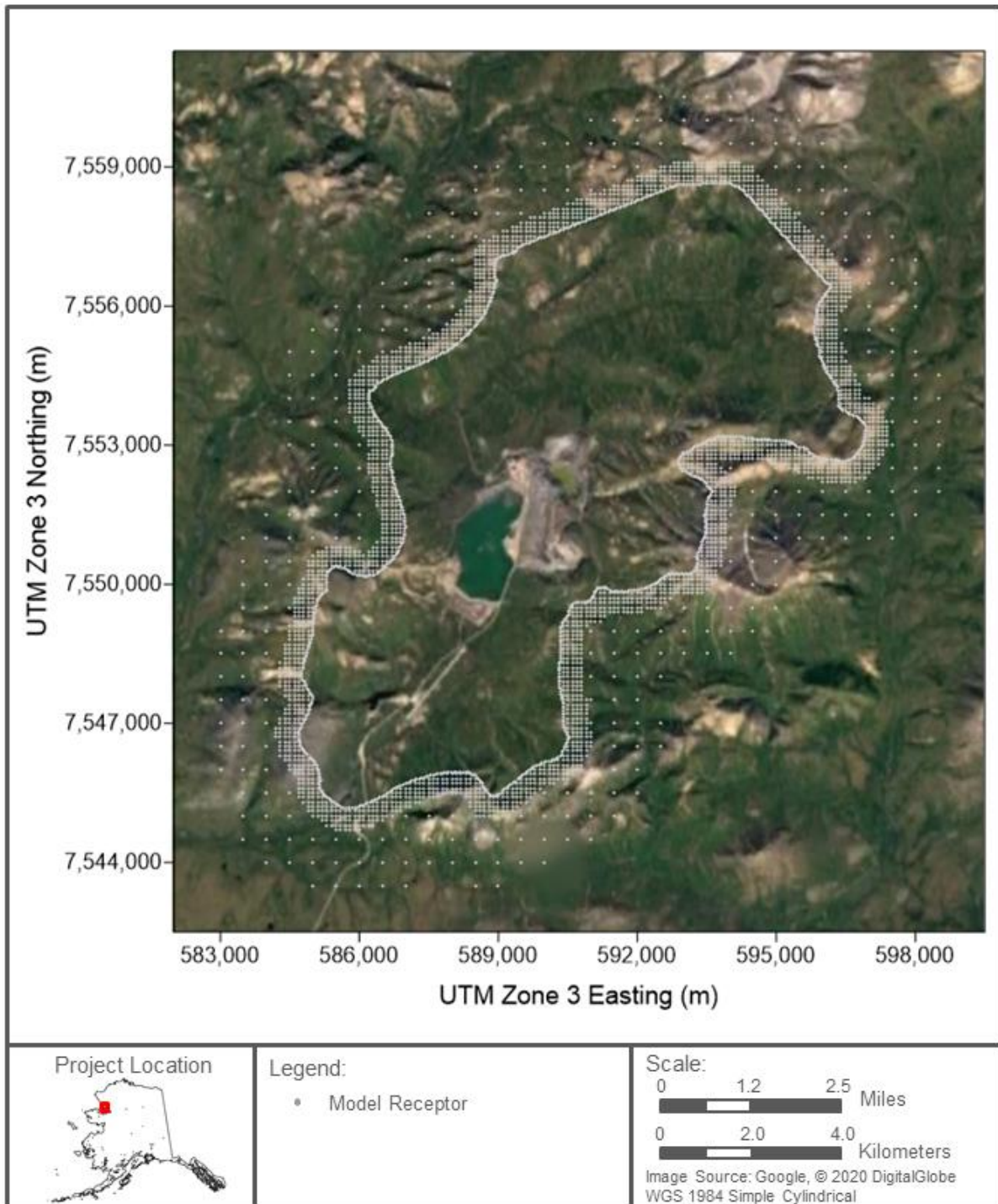
Figure 2-7 shows the full field receptor grid used for the analysis, which is a more refined receptor grid than that used for the 2016 ADEC Analysis.

All receptors placed along the ambient air boundary are separated by no more than 50 meters from adjacent receptors. Other receptor grids utilized for the modeling analysis include:

- A near field receptor grid consisting of receptors spaced 100 meters apart from adjacent receptors and located between the ambient air boundary and 500 meters outward from the Mine ambient air boundary.
- A far field receptor grid consisting of receptors placed in an area outside of the near field receptor grid and within 2,000 meters from the Mine ambient air boundary. Receptors in the far field grid are spaced apart by 500 meters from adjacent receptors.

Terrain elevations from USGS NED were input to AERMAP with the receptor locations, referenced to the UTM Zone 3, NAD83 coordinate reference system for processing receptor elevations and corresponding hill height scales inputs.

Figure 2-7. Full Receptor Field



3.0 Lead Modeling Analysis Results

The EPA Pb model post-processing tool, LEADPOST (version 12114), was used to calculate the 3-month rolling average Pb concentrations for each model year. The maximum modeled impact using the full field receptor grid shown in Figure 2-7 is 0.070 $\mu\text{g}/\text{m}^3$ at a receptor located in the near field receptor grid to the west-southwest of the Mine site. To ensure that the maximum modeled ambient Pb impact was characterized, an additional hot-spot analysis using a finer 25-meter spacing receptor grid centered over the area of the maximum modeled impacts was utilized.

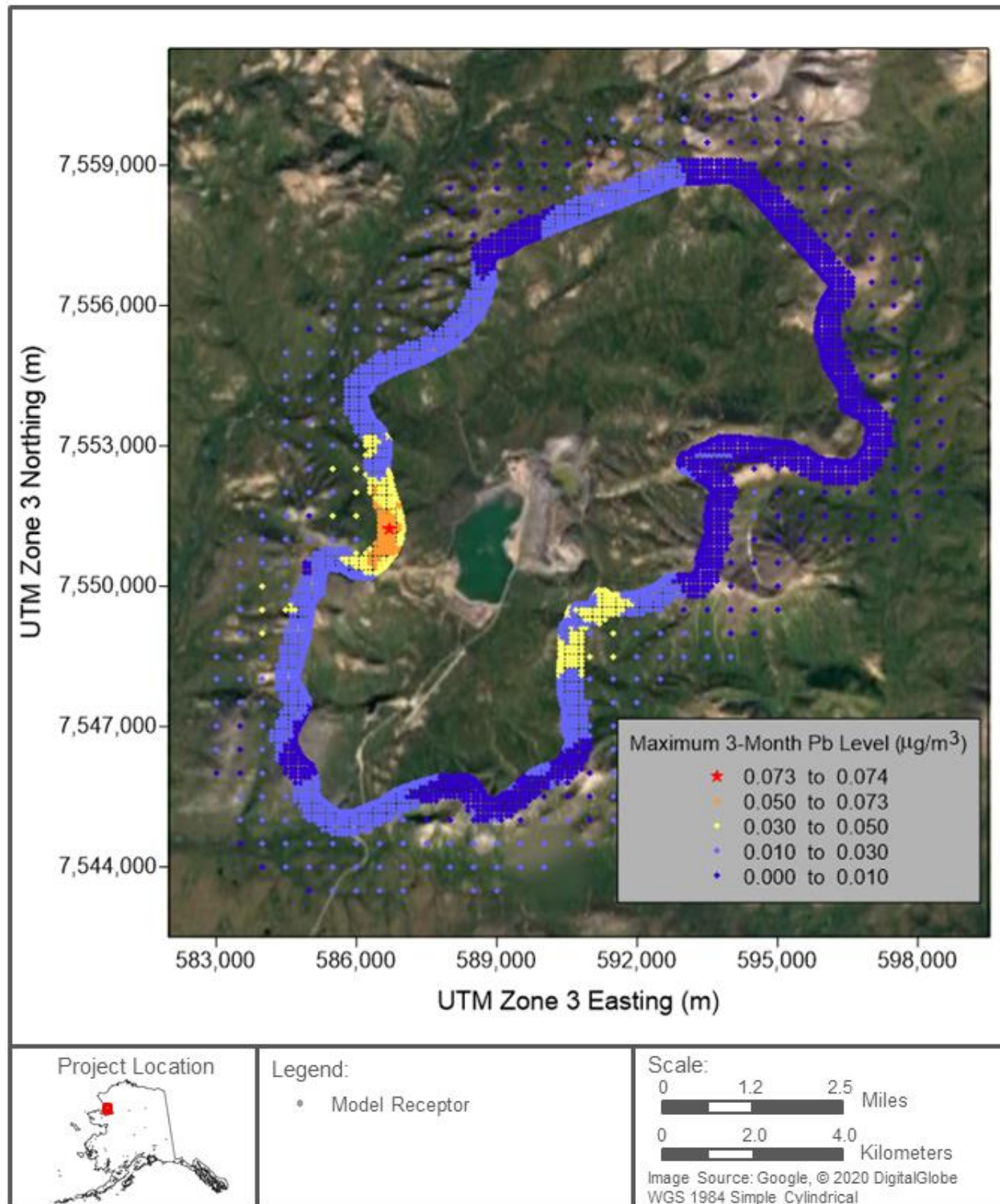
Table 3-1 provides a summary of the maximum modeled rolling 3-month average Pb concentrations for each model year and shows the ratio of the maximum modeled impact to the 3-month Pb NAAQS for comparison. Table 3-1 shows that the maximum modeled 3-month average Pb concentration is 0.074 $\mu\text{g}/\text{m}^3$ during November, 2012 through January, 2013 during Model Year 2 and is 49.3 percent of the Pb NAAQS.

Figure 3-1 is an aerial image that shows the maximum rolling 3-month average Pb levels at all model receptors and shows that the maximum modeled impacts are located to the west-southwest of the Mine site, which is consistent with the predominant wind direction at the Mine as indicated in Figure 2-3 through Figure 2-6.

Table 3-1. Maximum Modeled Rolling 3-Month Average Pb Levels

Meteorological Model Year	Maximum 3-Month Average Pb Level ($\mu\text{g}/\text{m}^3$)	3-Month Averaging Period	Ratio of Maximum Impact to Pb NAAQS
1	0.071	Oct. 2011 – Dec. 2011	47.3%
2	0.074	Nov. 2012 – Jan. 2013	49.3%
3	0.055	Jan. 2014 – Mar. 2014	36.6%
4	0.069	Oct. 2015 – Dec. 2015	46.0%

Figure 3-1. Location of Maximum 3-Month Average Pb Concentrations



4.0 References

- ADEC, *AERMET Geometric Means, How to Calculate the Geometric Mean Bowen Ratio and the Inverse-Distance Weighted Geometric Mean Surface Roughness Length in Alaska*, Revision 2, June 2009.
- EPA, *Guidelines for Determination of Good Engineering Practice Stack Height*, EPA-450/4-80-023R, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., June 1985.
- EPA, *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, EPA-454/R-99-005, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., February 2000.
- EPA, *Haul Road Workgroup Final Report Submissions to EPA-OAQPS*, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., March 2, 2012.
- EPA, *Revisions to the Guideline on Air Quality Models: Enhancements to the AERMOD Dispersion Modeling System and Incorporation of Approaches to Address Ozone and Fine Particulate Matter; Final Rule*, 40 CFR Part 51, Appendix W, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., January 17, 2017.
- EPA, *User's Guide for the AERMOD Terrain Preprocessor (AERMAP)*, EPA-454/B-18-004, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., April 2018.
- EPA, *AERMOD Implementation Guide*, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., August 2019.
- EPA, *User's Guide for the AMS/EPA Regulatory Model (AERMOD)*, EPA-454/B-19-027, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., August 2019.
- EPA, *User's Guide for the AERMOD Meteorological Preprocessor (AERMET)*, EPA-454/B-19-028, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., August 2019.

Appendix A

Emission Calculations and Electronic Modeling Files

Appendix B

PSD Meteorological Data Final Findings Reports

**Final Findings Report
Meteorological Data and Annual Report Review
for the Teck Alaska, Inc. Red Dog Mine Meteorological Monitoring Program
for the Period October 1, 2011 through September 30, 2012**

Prepared for:
State of Alaska
Department of Environmental Conservation
Division of Air Quality

ADEC Contract No. 18-6004-16
NTP-18-6004-16-89A

Prepared by
Enviroplan Consulting
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Enviroplan Consulting Project No. 7115.08
April 26, 2013

EXECUTIVE SUMMARY

This report provides Enviroplan Consulting's (Enviroplan) recommended findings regarding the October 1, 2011 through September 30, 2012 meteorological data submitted by Teck Alaska, Inc. (TAK) for their Red Dog Mine (RDM) monitoring program. The Alaska Department of Environmental Conservation (ADEC) received TAK's submittal on January 22, 2013. Enviroplan reviewed the data under contract to the Department to determine whether it meets the quality assurance requirements of the U.S. Environmental Protection Agency's (EPA's) Prevention of Significant Deterioration (PSD) program.

The RDM monitoring program consists of two stations, the Bons Creek and Mill sites. The Bons Creek site continuously monitors and records surface meteorological parameters that include 10-meter horizontal wind speed, 10-meter horizontal wind direction and standard deviation of the horizontal wind direction (sigma-theta, σ_θ), 2-meter and 10-meter temperatures, and differential (or delta) temperature (i.e., 10-meter temperature minus 2-meter temperature), solar radiation, relative humidity, barometric pressure and precipitation. The Mill site continuously monitors and records 10-meter horizontal wind speed, 10-meter horizontal wind direction and standard deviation of the horizontal wind direction (sigma-theta, σ_θ).

TAK conducted a comparison study of the wind speed and wind direction data collected at the Bons and Mill sites. The study determined that the wind speed and wind direction data collected at the Bons site was not representative of the meteorological conditions at the Mill site. Therefore, the wind speed and wind direction data collected at the Mill site, and the non-wind parameters collected at the Bons Creek site will be used in the event that an ambient air quality analysis study is required to support future air permitting or in the preparation of an Environmental Impact Statement or Environmental Assessment. The wind data from the Bons Creek site are not reported as part of this monitoring project, and are for internal use only. This method of data collection and archiving is consistent with the Department approved Quality Assurance Project Plan (QAPP) for the RDM monitoring program.

Enviroplan finds that the measured and calculated meteorological parameters submitted by TAK for the Bons Creek and Mill sites meet all the requirements set forth under the PSD monitoring program. Enviroplan recommends the Department determine these parameters to be PSD quality for all four quarters and for the October 1, 2011 through September 30, 2012 monitoring year.

Table E-1 presents the PSD Data Quality Determination summary for the Bons Creek and Mill meteorological monitoring site by parameter and data collection period (quarter and full annual period).

TABLE E-1: PSD Data Quality Determination for the RDM Bons Creek and Mill Sites' Meteorological Parameters Submitted by TAK for October 2011-September 2012^a

Parameter ^b	Jul-Sep 2011	Oct-Dec 2011	Jan-Mar 2012	Apr-Jun 2012	Jul 2011-Jun 2012
10-m Horizontal Wind Speed	Yes	Yes	Yes	Yes	Yes
10-m Horizontal Wind Direction	Yes	Yes	Yes	Yes	Yes
10-m Standard Deviation of the Horizontal Wind Direction (σ_θ)	Yes	Yes	Yes	Yes	Yes
10-m Temperature	Yes	Yes	Yes	Yes	Yes
2-m Temperature	Yes	Yes	Yes	Yes	Yes
10-m minus 2-m (Delta) Temperature	Yes	Yes	Yes	Yes	Yes
Solar Radiation	Yes	Yes	Yes	Yes	Yes
Relative Humidity	Yes	Yes	Yes	Yes	Yes
Barometric Pressure	Yes	Yes	Yes	Yes	Yes
Precipitation	Yes	Yes	Yes	Yes	Yes

Table Notes:

^a: 'Yes' in Table E-1 means the data is PSD-Quality for the specified data collection period.

^b: The horizontal wind speed, horizontal wind direction and standard deviation of the horizontal wind direction data are collected at the Mill site. All non-wind parameters are monitored at the Bons Creek site.

Enviroplan has prepared an AERMET support table pertaining to the subject annual meteorological data. The AERMET support table (Table E-2 below) provides monitoring information that Department staff would need should the data from this project be used in a future AERMET run as part of an AERMOD modeling analysis.

TABLE E-2: AERMET Support Information for the RDM Meteorological Monitoring Program

Anemometer Starting Threshold for Horizontal Wind Speed	Anemometer Height for Horizontal Wind Direction	Convention Used to Calculate Ambient Delta Temperature	10-m Tower Location (Latitude, Longitude & Base Elevation) *
<i>Mill Meteorological Monitoring Site</i>			
0.4 m/s	10 meters	NA	Latitude: 68.073333333333° N Longitude: -162.85422222222° W Elevation: 300 meters above sea level
<i>Bons Creek Meteorological Monitoring Site</i>			
NA	NA	T-10 minus T-2	Latitude: 68.027277778° N Longitude: -162.920388889° W Elevation: 290 meters above sea level

*Taken from Appendix C-2 of TAK's October 2011 Technical Systems Audit report (contained in Appendix C of the TAK Bons Creek and Mill Annual Report). Wind data recorded at the Bons Creek site are for internal use only, and have not been reported or reviewed as part of this report.

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1. INTRODUCTION

The RDM facility is a surface zinc and lead ore mining operation located in northwest Alaska, approximately 90 miles north of Kotzebue, Alaska. The DeLong Mountain Transportation System (DMTS) Port site, also owned by TAK and used to stockpile mined materials, is located about 50 miles south of the RDM. The RDM meteorological monitoring program consists of two stations: the Bons Creek meteorological monitoring station and the Mill meteorological monitoring station. Horizontal wind speed and horizontal wind direction data collected at the Mill site, and all non-wind parameters collected at the Bons Creek site, serve as the official parameters for the RDM meteorological monitoring program. Wind data collected by TAK at the Bons Creek site are for internal use only, and such data have not been evaluated in this review. The overall purpose of the TAK monitoring program (RDM and DMTS Port monitoring programs) is to collect PSD quality surface meteorological data to use in dispersion modeling to support possible future air quality permitting projects, as well as to comply with regulatory requirements. This review pertains only to the RDM monitoring program.

TAK's data submittal for the RDM Bons Creek and Mill monitoring sites is for the period October 1, 2011 through September 30, 2012. TAK submitted this information to ADEC on January 22, 2013. ADEC retained Enviroplan to review the meteorological data set and related report for this annual period in order to determine whether the data meet the EPA's established PSD criteria for acceptability.

Enviroplan reviewed the above referenced meteorological data set and annual. This Findings Report provides the results of the data quality review of TAK's data set and annual report performed by Enviroplan.

2. REVIEW OF METEOROLOGICAL MONITORING DATA

Enviroplan reviewed the TAK RDM October 2011 – September 2012 Annual Data Report for the Bons Creek and Mill sites to confirm that the data contains all the information required to support the quality of the data collected per the Department’s report format requirements (<http://dec.alaska.gov/air/am/index.htm>). Enviroplan also conducted a review of the corresponding meteorological data set to ensure the data comply with EPA’s requirements as found in their *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA-454/R-99-005); the Department’s regulatory provisions in 18 AAC 50.215(a) for meteorological monitoring; the Department’s Quality Assurance Project Plan (QAPP) for the State of Alaska Air Monitoring and Quality Assurance Program (as amended February 23, 2010); and the project QAPP approved by the Department on May 24, 2011.

The following sections of this report provide Enviroplan’s findings in relation to the review of the TAK meteorological data and the annual report for the subject monitoring period and station locations.

2.1 Discussion of Meteorological Data Review

This review includes the meteorological data reported by TAK from the RDM Bons Creek and Mill monitoring stations. TAK collected the data continuously between October 1, 2011 and September 30, 2012.

As contained in TAK’s December 2012 dated report, Tables 2-1 and 2-2 below respectively summarize the measurement methods TAK used for meteorological parameter data collection.

Table 2-1: Measurement Methods for the TAK, RDM Bons Creek and Mill Meteorological Monitoring Sites

Parameter ¹	Manufacturer Model	Measurement Method	Manufacturer's Specified Accuracy	EPA Required Accuracy	EPA Required Resolution	Sampling Frequency	Averaging Period
BONS CREEK SITE							
Ambient Temperature and Vertical Temperature Difference Primary and Secondary	RM Young 41342 RTD	Precision Platinum RTD Thermistor	±0.1 °C	±0.5 °C (Ambient Temperature) ±0.1 °C (Vertical Temperature Difference)	0.1 °C (Ambient Temperature) 0.02 °C (Vertical Temperature Difference)	1 minute	1 hour
Relative Humidity	Campbell CS215	Thin Polymer Capacitor	±4%	1.5°C or 7% RH	0.1°C or 5% RH	1 minute	1 hour
Barometric Pressure	Campbell CS105	Silicon Capacitive Sensor	±3 mb	±3 mb	0.5mb	1 minute	1 hour
Solar Radiation	Eppley PSP	Precision Thermopile Pyranometer	±5%	±5% of the mean observed interval (≥200W/m ²)	10 W/m ²	1 minute	1 hour
Precipitation Primary	Belfort 5915	Weighing Bucket Rain Gauge	±0.5% of full scale (±1.5 mm)	10% of observed or ±0.5 mm	0.3 mm	1 minute	1 hour
MILL SITE							
Horizontal Wind Speed Primary and Secondary	RM Young Co. 05305-AQ	Propeller-type anemometer	±0.2 m/s	±0.2 m/s, ±5% of observed	0.1 m/s	1 second	1 hour
Horizontal Wind Direction Primary and Secondary	RM Young Co. 05305-AQ	Precision Potentiometer	±3 degrees	±5 degrees	1.0 degree	1 second	1 hour

Table Notes:

¹ The purpose of the horizontal wind and ambient temperature secondary sensors is for data substitution if the primary sensor data were unavailable due to suspect data or during times of sensor failure.

Table 2-2 presents Enviroplan’s detailed review findings, including those findings that do not affect data validity. Except as indicated, Enviroplan determined that all measured and calculated meteorological parameters submitted by TAK for the RDM Bons Creek and Mill sites meet the requirements set forth by EPA under the PSD program for all four quarters and for the monitoring year. Also, the findings below include recommended clarifications that TAK should make in future data reports.

Table 2-2: Enviroplan’s Findings on the October 2011-September 2012 Meteorological Data Review for TAK, RDM Bons Creek and Mill

Invalid Data Periods	There were no additional periods of invalid data identified by Enviroplan.
Completeness	All meteorological parameters meet the 90% completeness requirement for all four quarters and for the monitoring year.
Precision	N/A
Calibration	Meteorological calibrations at the Bons Creek and Mill sites were performed three times during the October 2011 – September 2012 monitoring year. The solar radiation sensor failed the August 2011 calibration due to a programing error. The program was corrected and the sensor passed the subsequent re-calibration on September 29, 2011 which was performed prior to the start of the monitoring year. No data were lost.
Accuracy	Audits of the meteorological sensors were performed three times during the October 2011 – September 2012 monitoring year. The solar radiation sensor failed the September 12, 2011 audit due to a programming error. The program was corrected and the sensor passed the subsequent re-audit which was performed in October. No data were lost.
Equipment Certifications	Certifications found to be complete and within acceptable limits
Miscellaneous	There were no variations of the QAPP during the October 2011 – September 2012 monitoring year.

2.2 Discussion of Annual Report Review

Table 2-3 presents ADEC's reporting format requirements and the results of Enviroplan's review of TAK's annual report with respect to these requirements. For future annual reports submitted by TAK, Enviroplan included recommended changes that TAK should make in order to clarify or correct the report element such that it is consistent with the requisite ADEC PSD reporting format.

Table 2-3: Enviroplan's Findings on the TAK, RDM Bons Creek and Mill July 2011 - June 2012 Annual Data Report Review for ADEC PSD Quality Reporting Compliance

ADEC PSD Quality Reporting Requirements for Annual Reports	Content Satisfies ADEC Report Format	Comments
Cover Letter/Transmittal Letter to ADEC	Yes	
Title Page:		
Permittee Name	Yes	
Stationary Source Name (or location of monitoring effort)	Yes	
Air Permit Number, Permit Revision Number and Permit Issue Date (as applicable)	N/A	
Monitoring Project Name	Yes	
Monitoring Period	Yes	
Name of Agency/Contractor Who Prepared Report	Yes	
Email Address and Phone Number of Agency/Contractor for Report Preparation	Yes	
Report Issue Date	Yes	
Table of Contents	Yes	
Executive Summary:		
Maximum 2 Pages (not including tables)	Yes	
Quarterly Maximum Concentrations Table	N/A	
Annual Maximum Concentration Table, Including AAAQS	N/A	
Meteorological Data Capture Table	Yes	
QAPP Variation Table	Yes	
Introduction:		
Project Summary	Yes	
Measurement Methods Table	Yes	
Variations from QAPP	Yes	
Station Performance Summary:		
Significant Project Events	Yes	
Missing, Invalid and Adjusted Data	Yes	
Network Data Completeness		

ADEC PSD Quality Reporting Requirements for Annual Reports	Content Satisfies ADEC Report Format	Comments
Data Completeness Table	Yes	
Precision Statistics		
Monitoring Network Precision Statistics	N/A	
Monitoring Network Precision Table	N/A	
Analytical Laboratory Precision Statistics (Particulate Samples)	N/A	
Analytical Laboratory Precision Statistics (Lead)	N/A	
Accuracy Statistics		
Instrument Calibration Statistics	Yes	
Independent Quality Assurance Audits		
Performance Audit Accuracy Table	Yes	
Monitoring Data Network Summary:		
Air Quality Data Summary		
Project specific quarterly and annual summary and analysis presented in table format with a specific written summary for each parameter measured	N/A	
Pollutant concentrations for each parameter and how they compare to the NAAQS and AAAQS	N/A	
Statistical and graphical representation and interpretation of the data	N/A	
Meteorological Data Summary		
Project specific meteorological data presented in table format with a specific written summary for each parameter measured	Yes	
Wind Speed and Wind Direction Climatology	Yes	
Annual Wind Rose	Yes	
Annual Wind Rose Analysis Table	Yes	
Wind Rose Superimposed Over Site and/or Topographical Map (including map source locations and monitoring locations)	Yes	
Stability Class Frequency Distribution Graph	N/A	
Temperature Climatology	Yes	
Temperature Climatology Table	Yes	
Temperature Climatology Graph	Yes	
Appendices (Relative Sections)		
Appendix A:		
Data Recovery Percentage	Yes	
Data Bias Correction	Yes	
Estimation of Pasquill-Gifford Stability Categories	N/A	
Appendix B:		

ADEC PSD Quality Reporting Requirements for Annual Reports	Content Satisfies ADEC Report Format	Comments
Precision Data	N/A	
Appendix C:		
Accuracy Data Methods	Yes	
Calibration Data	Yes	
Quality Control (QC) Data	Yes	
Assessment Reports	Yes	
Appendix D:		
Validated Continuous Data	Yes	

3. CONCLUSIONS

Enviroplan reviewed the surface meteorological data submitted by TAK for the RDM monitoring program, i.e., Bons Creek and Mill monitoring sites. The data submitted by TAK for the Bons Creek and Mill monitoring stations covers the monitoring period October 1, 2011 through September 30, 2012.

Enviroplan finds that all measured and calculated meteorological parameters submitted by TAK for the Bons Creek and Mill sites meet all the requirements set forth by the EPA under the PSD monitoring program and are PSD quality for all four quarters and for the October 1, 2011 through September 30, 2012 monitoring year. Enviroplan recommends these data be accepted as valid and of PSD quality.

**Final Findings Report
Meteorological Data and Annual Report Review
for the Teck Alaska, Inc. Red Dog Mine Meteorological Monitoring Program
for the Period October 1, 2012 through September 30, 2013**

Prepared for:
State of Alaska
Department of Environmental Conservation
Division of Air Quality
ADEC Contract No. NTP-18-9006-14-05
NTP-18-9006-14-05-10 (ANCP036)

Prepared by
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Enviroplan Consulting Project No. 209997.15
April 16, 2014

EXECUTIVE SUMMARY

This report provides Enviroplan Consulting's recommended findings regarding the October 1, 2012 through September 30, 2013 meteorological data submitted by Teck Alaska, Inc. (TECK) for their Red Dog Mine (RDM) monitoring program. The Alaska Department of Environmental Conservation (ADEC) received TECK's submittal on January 7, 2014. Enviroplan reviewed the data under contract to the Department to determine whether it meets the quality assurance requirements of the U.S. Environmental Protection Agency's (EPA's) Prevention of Significant Deterioration (PSD) program.

The RDM monitoring program consists of two stations, the Bons Creek and Mill sites. The Bons Creek site continuously monitors and records surface meteorological parameters that include 10-meter horizontal wind speed, 10-meter horizontal wind direction and standard deviation of the horizontal wind direction (sigma-theta, σ_θ), 2-meter and 10-meter temperatures, and differential (or delta) temperature (i.e., 10-meter temperature minus 2-meter temperature), solar radiation, relative humidity, barometric pressure and precipitation. The Mill site continuously monitors and records horizontal wind speed, horizontal wind direction and standard deviation of the horizontal wind direction (sigma-theta, σ_θ) at a 110 foot (33.5 meter) tower level.

TECK conducted a prior comparison study of the wind speed and wind direction data collected at the Bons and Mill sites. The study determined that the wind speed and wind direction data collected at the Bons site was not representative of the meteorological conditions at the Mill site. Therefore, the wind speed and wind direction data collected at the Mill site, and the non-wind parameters collected at the Bons Creek site will be used in the event that an ambient air quality analysis study is required to support future air permitting or in the preparation of an Environmental Impact Statement or Environmental Assessment. The wind data from the Bons Creek site are not reported as part of this monitoring project, and are for internal use only. This method of data collection and archiving is consistent with the Department approved Quality Assurance Project Plan (QAPP) for the RDM monitoring program.

Enviroplan finds that the relative humidity, barometric pressure and precipitation data reported from the Bons Creek station do not meet all the requirements set forth under the PSD monitoring program, and are not PSD quality for all four quarters and for the October 1, 2012 through September 30, 2013 monitoring year. Enviroplan further finds that the measured and calculated meteorological parameters submitted by TECK for the Bons Creek and Mill sites, including the 10-meter horizontal wind speed, 10-meter horizontal wind direction and standard deviation of the horizontal wind direction, 2-meter and 10-meter temperatures, and differential temperature, and solar radiation, do meet all the requirements set forth under the PSD monitoring program. Enviroplan recommends the Department determine these parameters to be PSD quality for all four quarters and for the October 1, 2012 through September 30, 2013 monitoring year.

Enviroplan also agrees with TECK's notation in Table E-1: QAPP Variation Table of their annual report wherein the relative humidity is determined not to be PSD quality due to a failed calibration and audit which was performed on September 26, 2013. TECK has elected to retain the data in the annual report for "informational purposes only". TECK is not requesting approval by the Department for this data to be used for PSD permitting projects.

The barometric pressure and precipitation data were invalid due to instrument malfunction. PSD completeness objectives were not met for barometric pressure for the July-September 2013 monitoring period. Precipitation did not meet PSD completeness objectives for the January-June 2013 monitoring period.

Table E-1 presents the PSD Data Quality Determination summary for the Bons Creek and Mill meteorological monitoring site by parameter and data collection period (quarter and full annual period).

TABLE E-1: PSD Data Quality Determination for the RDM Bons Creek and Mill Sites' Meteorological Parameters Submitted by TECK for October 2012-September 2013¹

Parameter ²	Oct-Dec 2012	Jan-Mar 2013	Apr-Jun 2013	Jul-Sep 2013	Oct 2012-Sep 2013
33.5-m Horizontal Wind Speed	Yes	Yes	Yes	Yes	Yes
33.5-m Horizontal Wind Direction	Yes	Yes	Yes	Yes	Yes
33.5-m Standard Deviation of the Horizontal Wind Direction (σ_θ)	Yes	Yes	Yes	Yes	Yes
10-m Temperature	Yes	Yes	Yes	Yes	Yes
2-m Temperature	Yes	Yes	Yes	Yes	Yes
10-m minus 2-m (Delta) Temperature	Yes	Yes	Yes	Yes	Yes
Solar Radiation	Yes	Yes	Yes	Yes	Yes
Relative Humidity	Yes	No	No	No	No
Barometric Pressure	Yes	Yes	Yes	No	No
Precipitation	Yes	No	No	Yes	No

Table Notes:

¹: 'Yes' in Table E-1 means the data is PSD-Quality for the specified data collection period.

²: The horizontal wind speed, horizontal wind direction and standard deviation of the horizontal wind direction data are collected at the 33.5 meter (110 foot) tower located at the Mill site. All non-wind parameters are monitored at the Bons Creek site.

Enviroplan has prepared an AERMET support table pertaining to the subject annual meteorological data. The AERMET support table (Table E-2 below) provides monitoring information that Department staff would need should the data from this project be used in a future AERMET run as part of an AERMOD modeling analysis.

TABLE E-2: AERMET Support Information for the RDM Meteorological Monitoring Program

Anemometer Starting Threshold for Horizontal Wind Speed ¹	Anemometer Height for Horizontal Wind Direction	Convention Used to Calculate Ambient Delta Temperature	Meteorological Tower Location (Latitude, Longitude & Base Elevation) ²
<i>Mill Meteorological Monitoring Site</i>			
0.4 m/s	33.5 meters	NA	Latitude: 68.073333333333° N Longitude: -162.854222222222° W Elevation: 300 meters above sea level
<i>Bons Creek Meteorological Monitoring Site</i>			
NA	NA	T-10 minus T-2	Latitude: 68.027277778° N Longitude: -162.920388889° W Elevation: 290 meters above sea level

Notes:

1. The table value reflects the horizontal wind direction (vane) starting threshold value, as the greater of the horizontal wind speed and horizontal wind direction starting threshold values.
2. Taken from Appendix C-2 of TECK's October 2013 Technical Systems Audit report (contained in Appendix C of the TECK Bons Creek and Mill Annual Report). Wind data recorded at the Bons Creek site are for internal use only, and have not been reported or reviewed as part of this report.

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1. INTRODUCTION

The RDM facility is a surface zinc and lead ore mining operation located in northwest Alaska, approximately 90 miles north of Kotzebue, Alaska. The DeLong Mountain Transportation System (DMTS) Port site, also owned by TECK and used to stockpile mined materials, is located about 50 miles south of the RDM. The RDM meteorological monitoring program consists of two stations: the Bons Creek meteorological monitoring station and the Mill meteorological monitoring station. Horizontal wind speed and horizontal wind direction data collected at the Mill site, and all non-wind parameters collected at the Bons Creek site, serve as the official parameters for the RDM meteorological monitoring program. Wind data collected by TECK at the Bons Creek site are for internal use only, and such data have not been evaluated in this review. The overall purpose of the TECK monitoring program (RDM and DMTS Port monitoring programs) is to collect PSD quality surface meteorological data to use in dispersion modeling to support possible future air quality permitting projects, as well as for environmental assessments and studies, and facility design and engineering. This review pertains only to the RDM monitoring program.

TECK's data submittal for the RDM Bons Creek and Mill monitoring sites is for the period October 1, 2012 through September 30, 2013. TECK submitted this information to ADEC on January 7, 2014. ADEC retained Enviroplan to review the meteorological data set and related report for this annual period in order to determine whether the data meet the EPA's established PSD criteria for acceptability.

Enviroplan reviewed the above referenced meteorological data set and annual report. This Findings Report provides the results of the data quality review of TECK's data set and annual report performed by Enviroplan.

2. REVIEW OF METEOROLOGICAL MONITORING DATA

Enviroplan reviewed the TECK RDM October 2012 – September 2013 Annual Data Report for the Bons Creek and Mill sites to confirm that the data contains all the information required to support the quality of the data collected per the Department's report format requirements (<http://dec.alaska.gov/air/am/index.htm>). Enviroplan also conducted a review of the corresponding meteorological data set to ensure the data comply with EPA's requirements as found in their *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA-454/R-99-005); the Department's regulatory provisions in 18 AAC 50.215(a) for meteorological monitoring; the Department's Quality Assurance Project Plan (QAPP) for the State of Alaska Air Monitoring and Quality Assurance Program (as amended February 23, 2010); and the project QAPP approved by the Department on May 24, 2012.

The following sections of this report provide Enviroplan's findings in relation to the review of the TECK meteorological data and the annual report for the subject monitoring period and station locations.

2.1 Discussion of Meteorological Data Review

This review includes the meteorological data reported by TECK from the RDM Bons Creek and Mill monitoring stations. TECK collected the data continuously between October 1, 2012 and September 30, 2013.

As contained in TECK's December 2013 dated report, Tables 2-1 and 2-2 below respectively summarize the measurement methods TECK used for meteorological parameter data collection.

Table 2-1: Measurement Methods for the TECK, RDM Bons Creek and Mill Meteorological Monitoring Sites

Parameter ¹	Manufacturer Model	Measurement Method	Manufacturer's Specified Accuracy	EPA Required Accuracy	EPA Required Resolution	Sampling Frequency	Averaging Period
BONS CREEK SITE							
Ambient Temperature and Vertical Temperature Difference Primary and Secondary	RM Young 41342 RTD	Precision Platinum RTD Thermistor	±0.1 °C	±0.5 °C (Ambient Temperature) ±0.1 °C (Vertical Temperature Difference)	0.1 °C (Ambient Temperature) 0.02 °C (Vertical Temperature Difference)	1 minute	1 hour
Relative Humidity	Campbell CS215	Thin Polymer Capacitor	±4%	1.5°C or 7% RH	0.1°C or 5% RH	1 minute	1 hour
Barometric Pressure	Campbell CS105	Silicon Capacitive Sensor	±3 mb	±3 mb	0.5mb	1 minute	1 hour
Solar Radiation	Eppley PSP	Precision Thermopile Pyranometer	±5%	±5% of the mean observed interval (≥200W/m ²)	10 W/m ²	1 minute	1 hour
Precipitation (through 3/22/13)	Belfort 5915	Weighing Bucket Rain Gauge	±0.5% of full scale (±1.5 mm)	10% of observed or ±0.5 mm	0.3 mm	1 minute	Instantaneous readings summed hourly
Precipitation (after 3/22/13)	Geonor T-200B	Weighing Bucket Rain Gauge	±0.1% of full scale (±0.6 mm)	10% of observed or ±0.5 mm	0.3 mm	1 minute	Instantaneous readings summed hourly
MILL SITE							
Horizontal Wind Speed Primary and Secondary	RM Young Co. 05305-AQ	Propeller-type anemometer	±0.2 m/s	±0.2 m/s, ±5% of observed	0.1 m/s	1 second	1 hour
Horizontal Wind Direction Primary and Secondary	RM Young Co. 05305-AQ	Precision Potentiometer	±3 degrees	±5 degrees	1.0 degree	1 second	1 hour

Table Notes:

¹ The purpose of the horizontal wind and ambient temperature secondary sensors is for data substitution if the primary sensor data were unavailable due to suspect data or during times of sensor failure.

Table 2-2 presents Enviroplan’s detailed review findings, including those findings that do not affect data validity. Except as indicated, Enviroplan determined that all measured and calculated meteorological parameters submitted by TECK for the RDM Bons Creek and Mill sites meet the requirements set forth by EPA under the PSD program for all four quarters and for the monitoring year. Also, the findings below include recommended clarifications that TECK should make in future data reports.

Table 2-2: Enviroplan’s Findings on the October 2012-September 2013 Meteorological Data Review for TECK, RDM Bons Creek and Mill Sites

Invalid Data Periods	Enviroplan determined there were no additional periods of invalid data found for this annual reporting period.
Completeness	Relative humidity, barometric pressure and precipitation reported from the Bons Creek site did not meet the 90% completeness requirement and are not PSD quality for all four quarters and for the monitoring year. All other calculated and measured parameters reported from the Bons Creek and Mill sites meet the 90% completeness requirement for all four quarters and for the monitoring year and are considered PSD quality.
Precision	N/A
Calibration	Meteorological calibrations at the Bons Creek and Mill sites were performed three times during the October 2012 – September 2013 monitoring year. The relative humidity sensor failed the September 26, 2013 calibration. Data for PSD quality determination are considered invalid for the period beginning March 21, 2013 through the time of the calibration on September 26, 2013.
Accuracy	Audits of the meteorological sensors were performed three times during the October 2012 – September 2013 monitoring year. The relative humidity sensor failed the September 26, 2013 audit. Data for PSD quality determination are considered invalid for the period beginning March 21, 2013 through the time of the calibration on September 26, 2013.
Equipment Certifications	Certifications found to be complete and within acceptable limits
Miscellaneous	Enviroplan reviewed the data, calibration and audit results and agrees with TECK that the relative humidity reported from the Bons Creek site is not PSD quality as the monitor failed the September 2013 calibration and audit. Data is invalid beginning March 21, 2013 through the time of the calibration and audit on September 26, 2013. TECK elected to retain the relative humidity data in the annual report for “informational purposes” only. TECK is not requesting Department approval for this data to be used for PSD permitting projects.

2.2 Discussion of Annual Report Review

Table 2-3 presents ADEC's reporting format requirements and the results of Enviroplan's review of TECK's annual report with respect to these requirements. For future annual reports submitted by TECK, Enviroplan included recommended changes that TECK should make in order to clarify or correct the report element such that it is consistent with the requisite ADEC PSD reporting format.

Table 2-3: Enviroplan's Findings on the TECK, RDM Bons Creek and Mill October 2012 - September 2013 Annual Data Report Review for ADEC PSD Quality Reporting Compliance

ADEC PSD Quality Reporting Requirements for Annual Reports	Content Satisfies ADEC Report Format	Comments
Cover Letter/Transmittal Letter to ADEC	Yes	
Title Page:		
Permittee Name	Yes	
Stationary Source Name (or location of monitoring effort)	Yes	
Air Permit Number, Permit Revision Number and Permit Issue Date (as applicable)	N/A	
Monitoring Project Name	Yes	
Monitoring Period	Yes	
Name of Agency/Contractor Who Prepared Report	Yes	
Email Address and Phone Number of Agency/Contractor for Report Preparation	Yes	
Report Issue Date	Yes	
Table of Contents	Yes	
Executive Summary:		
Maximum 2 Pages (not including tables)	Yes	
Quarterly Maximum Concentrations Table	N/A	
Annual Maximum Concentration Table, Including AAAQS	N/A	
Meteorological Data Capture Table	Yes	
QAPP Variation Table	Yes	
Introduction:		
Project Summary	Yes	
Measurement Methods Table	Yes	
Variations from QAPP	Yes	
Station Performance Summary:		
Significant Project Events	Yes	
Missing, Invalid and Adjusted Data	Yes	
Network Data Completeness		

ADEC PSD Quality Reporting Requirements for Annual Reports	Content Satisfies ADEC Report Format	Comments
Data Completeness Table	Yes	
Precision Statistics		
Monitoring Network Precision Statistics	N/A	
Monitoring Network Precision Table	N/A	
Analytical Laboratory Precision Statistics (Particulate Samples)	N/A	
Analytical Laboratory Precision Statistics (Lead)	N/A	
Accuracy Statistics		
Instrument Calibration Statistics	Yes	
Independent Quality Assurance Audits		
Performance Audit Accuracy Table	Yes	
Monitoring Data Network Summary:		
Air Quality Data Summary		
Project specific quarterly and annual summary and analysis presented in table format with a specific written summary for each parameter measured	N/A	
Pollutant concentrations for each parameter and how they compare to the NAAQS and AAAQS	N/A	
Statistical and graphical representation and interpretation of the data	N/A	
Meteorological Data Summary		
Project specific meteorological data presented in table format with a specific written summary for each parameter measured	Yes	
Wind Speed and Wind Direction Climatology	Yes	
Annual Wind Rose	Yes	
Annual Wind Rose Analysis Table	Yes	
Wind Rose Superimposed Over Site and/or Topographical Map (including map source locations and monitoring locations)	Yes	
Stability Class Frequency Distribution Graph	N/A	
Temperature Climatology	Yes	
Temperature Climatology Table	Yes	
Temperature Climatology Graph	Yes	
Appendices (Relative Sections)		
Appendix A:		
Data Recovery Percentage	Yes	
Data Bias Correction	Yes	
Estimation of Pasquill-Gifford Stability Categories	N/A	
Appendix B:		

ADEC PSD Quality Reporting Requirements for Annual Reports	Content Satisfies ADEC Report Format	Comments
Precision Data	N/A	
Appendix C:		
Accuracy Data Methods	Yes	
Calibration Data	Yes	
Quality Control (QC) Data	Yes	
Assessment Reports	Yes	
Appendix D:		
Validated Continuous Data	Yes	

3. CONCLUSIONS

Enviroplan reviewed the surface meteorological data submitted by TECK for the RDM monitoring program, i.e., Bons Creek and Mill monitoring sites. The data submitted by TECK for the Bons Creek and Mill monitoring stations covers the monitoring period October 1, 2012 through September 30, 2013.

Enviroplan finds that the relative humidity, barometric pressure and precipitation parameters submitted by TECK for the Bons Creek and Mill sites do not meet all the requirements set forth by the EPA under the PSD monitoring program and are not PSD quality for all four quarters and for the October 1, 2012 through September 30, 2013 monitoring year. The measured and calculated meteorological parameters submitted by TECK for the Bons Creek and Mill sites, including the 10-meter horizontal wind speed, 10-meter horizontal wind direction and standard deviation of the horizontal wind direction, 2-meter and 10-meter temperatures, and differential temperature, and solar radiation, do meet all the requirements set forth under the PSD monitoring program. Enviroplan recommends the Department determine these parameters to be PSD quality for all four quarters and for the October 1, 2012 through September 30, 2012 monitoring year.

**Alaska Department of
Environmental Conservation
Findings
Regarding the**

**Teck Alaska Inc. (Teck)
2013-2014 Red Dog Mine Meteorological (RDM) Data**

**Alaska Department of Environmental Conservation
Division of Air Quality
619 East Ship Creek Avenue
Anchorage, Alaska 99501**

September 9, 2015

Abbreviations/Acronyms

AAC	Alaska Administrative Code
ADEC.....	Alaska Department of Environmental Conservation
ADR.....	Annual Data Report
Avg.	Average
EPA.....	United States Environmental Protection Agency
NA.....	Not Applicable
NAAQS	National Ambient Air Quality Standards
PSD	Prevention of Significant Deterioration
QA.....	Quality Assurance
QAPP.....	Quality Assurance Project Plan
QC.....	Quality Check
RDM	Red Dog Mine
SLR.....	SLR International Corporation, Anchorage Alaska
Teck.....	Teck Alaska Incorporated
W/D.....	Wind Direction
WD–Sigma	Wind Direction Standard Deviation
W/S.....	Wind Speed

Units and Measures

m.....	meter
m/s	meters per second

EXECUTIVE SUMMARY:

The Alaska Department of Environmental Conservation (ADEC) reviewed the 2013-2014 Red Dog Mine meteorological monitoring data collected by Teck Alaska Inc. (Teck) to determine whether it meets the quality assurance requirements of the Prevention of Significant Deterioration (PSD) program.

The Teck Red Dog Mine Meteorological Monitoring Program (RDM) is comprised of two monitoring stations, Bons Creek and Mill sites. ADEC finds the Bons Creek Station measured and calculated meteorological parameters including; 2-meter and 10-meter temperatures, delta temperature, solar radiation, barometric pressure and precipitation to be PSD quality data. ADEC finds the Mill Station measured parameters including; horizontal wind speed and horizontal wind direction, and wind direction standard deviation to be PSD quality data. The Bons Creek Station relative humidity data were not submitted for review.

The Teck RDM Monitoring Program monitoring stations are located in northwest Alaska, approximately 105 miles north of Kotzebue. This report specifically addresses meteorological data collected at the Bons Creek and Mill stations for the period of October 1, 2013 – September 30, 2014.

Teck measured/calculated the following meteorological parameters at the RDM monitoring stations:

TABLE 1: Teck RDM Monitoring Parameters

RDM Monitoring Stations	
Bons Creek Station Meteorological Parameters	Mill Station Meteorological Parameters
• 2 m Temperature • 10 m Temperature • Delta Temperature (10 m – 2 m) • Solar Radiation • Barometric Pressure • Precipitations • Relative Humidity	• Horizontal Wind Speed at 10 m • Horizontal Wind Direction at 10 m • Wind Direction Standard. Deviation. (WD Sigma) at 10 m

BACKGROUND:

Teck established the Meteorological Monitoring Program to collect PSD quality meteorological data suitable for use in the AERMOD Modeling System to support possible future permitting needs. On behalf of Teck, SLR International Corporation (SLR) prepared the meteorological data report. SLR completed QC calibrations with assistance from Teck and AMS Tech LLC. (AMS). Independent audits were performed by AMS.

Teck submitted a Quality Assurance Project Plan (QAPP) entitled *Teck Alaska Incorporated Red Dog Mine Meteorological Monitoring and Quality Assurance Plan May 2011, Revision 1.1* for the RDM station that was approved by the Department on May 24, 2011. Teck previously submitted data collection years 2011-2012 and 2012-2013 for the RDM stations. The Department found both data sets to be PSD quality data.

Teck submitted the 2013 – 2014 data on January 12, 2015. The Annual Data Report (ADR) states SLR collected the 2013-2014 data in accordance with the approved QAPP with no variations.

During the review process additional information was requested and received on August 18, 2015 and August 26, 2015.

FINDINGS:

ADEC performed this review on adherence to the procedures and requirements described by the current Teck Red Dog Mine QAPP. In addition, meteorological data were screened based on criteria from EPA's *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, EPA-454/R-99-005, per 18 AAC 50.215(a)(3). ADEC also considered the following guidance and documents during its review:

- ADEC's Quality Assurance Guidance Documents posted at http://dec.alaska.gov/air/am/am_airqual&guidQA.htm and
- Results of the Teck RDM 2013-2014 routinely scheduled quality control (QA/QC) checks to assess methods, record completeness, and timeliness.

ADEC determined the following:

- The Teck RDM 2013-2014 data is PSD quality for most meteorological parameters, for all four quarters and for the monitoring year.
 - Relative humidity data failed to meet PSD accuracy criteria and as such, were not submitted for Departmental review.
- All calibration and audit forms, certificates, and dates are complete and within acceptable parameters in regards to EPA's standards.

The monitoring-related information needed to perform an AERMOD analysis is provided in Table 2.

Table 2: AERMET Support Information Teck Sites

Mill Station			
Threshold Wind Speed ^a	Anemometer Height ^b	Ambient Delta Temperature	Tower Location ^c
0.5 m/s	10 m	10 m T minus – 2 m T	Latitude: 68.073333 N Longitude: 162.854222 W Base Elevation: 300 meters
Bons Creek Station			
0.5 m/s	10 m	10 m T minus – 2 m T	Latitude: 68.027278 N Longitude: 162.920389 W Base Elevation: 290 meters

- a. The table value reflects the horizontal wind direction (vane) starting threshold value, as the greater of the horizontal wind speed and horizontal wind direction starting threshold values.
- b. Verified in the Red Dog Mine, May 2011 QAPP
- c. Found in Red Dog Mine 2013-2014, Annual Data Report, verified in Red Dog Mine, May 2011 QAPP.

ADEC performed a thorough review of the calibration and audit records. Table 3 contains the dates of every calibration and audit performed for the 2013-2014 data period.

Table 3: Calibration and Audit Records: Completeness and Timeliness for Teck 2013-2014 collection year

Bons Creek Station Calibration/Audit						
Calibration				Audit		
Date	9/26/13	4/7/14	9/25/14	4/6/14	4/6/14	9/25/14
Data Logger	Pass	Pass	Pass	Pass	Pass	Pass
Primary						
2m Temp SN 19883	Pass	Pass	Pass	Pass	Pass	Pass
10 M temp SN 19881	Pass	Pass	Pass	Pass	Pass	Pass
S Radiation SN PY74191	Pass	Pass (new PY38397)	Pass	Pass	Pass	Pass
Backup						
2m Temp SN 19884	Pass	Pass	Pass	Pass	Pass	Pass
10 M temp SN 19882	Pass	Pass	Pass	Pass	Pass	Pass
S Radiation SN PY74192	Pass	Pass	Pass	Pass	Pass	Pass
S Radiation SN 37005F3	Pass	Pass	Pass	Pass	Pass	Pass
Optional for AERMET						
Barometric Pressure SN W0150011	Pass	Pass (new 4794700)	Pass	Pass	Pass	Pass
Relative Humidity SN E6180	Fail	Pass (new E10414)	Pass	Fail	Pass	Fail
Precipitation SN 40006	Pass	Pass	Pass	Pass	Pass	Pass
Mill Station Calibration / Audit						
Primary						
Date	9/26/13	4/7/14	9/25/14	9/26/13	4/7/14	9/25/14
W/S SN 121821	Pass	Pass (new 132872)	Pass	Pass	Pass	Pass
W/D SN 121821	Pass	Pass	Pass	Pass	Pass	Pass
Backup						
W/S SN 121819	Pass	Pass (new 132873)	Pass	Pass	Pass	Pass
W/D SN 121819	Pass	Pass	Pass	Pass	Pass	Pass

^a Relative Humidity did not meet calibration and audit requirements. As such they are not PSD quality data and were submitted for informational purposes only. Review was not requested.

Table 4 summarizes which meteorological parameters are PSD quality on a quarterly and annual basis.

Table 4: Meteorological PSD Data Quality Determination

2013-2014 Teck RDM PSD Determination					
Bons Creek					
Parameter	Oct – Dec Quarter 1	Jan - March Quarter 2	April - June Quarter 3	July - Sep Quarter 4	Oct - Sep 2013 ^b -2014
10 m Temperature	Yes ^a	Yes	Yes	Yes	Yes
2 m Temperature	Yes	Yes	Yes	Yes	Yes
Delta Temperature (10 m – 2 m)	Yes	Yes	Yes	Yes	Yes
Solar Radiation	Yes	Yes	Yes	Yes	Yes
Barometric Pressure	No	Yes	Yes	Yes	No
Precipitation	Yes	Yes	Yes	Yes	Yes
Red Dog Mine					
10 m Horizontal Wind Speed	Yes	Yes	Yes	Yes	Yes
10 m Horizontal Wind Direction	Yes	Yes	Yes	Yes	Yes
W/D-Sigma ^c	Yes	Yes	Yes	Yes	Yes

- 'Yes' means the data is PSD-Quality for the specified data collection period
- PSD-quality meteorological monitoring standards require data capture of 90 percent or greater per quarter for four consecutive quarters according to EPA's *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, adopted by reference in 18 AAC 50.035(a)(4)
- There are no PSD screening criteria written for standard deviation of horizontal wind direction, as such parameter was reviewed for 90% capture requirements, calibration and audit completeness.

ADEC would like to acknowledge SLR's work in preparing a well-organized and very thorough data summary report. The detail required to document a PSD monitoring program is voluminous. ADEC did request additional information from SLR to clarify some review items. SLR addressed each ADEC comment and provided a well-organized revision.

Meteorological Data Review Performed by:

Elizabeth Nakanishi
Environmental Program Technician I
ADEC, Division of Air, Permits Program

(907) 269-6953

Mike Gravier
Environmental Program Specialist IV
ADEC, Division of Air, Air Monitoring and Quality Assurance
Program

(907) 269-7676

**Alaska Department of
Environmental Conservation
Findings
Regarding the**

**Teck Alaska Inc. (Teck)
2015-2016 Red Dog Mine Meteorological Monitoring Program Data**

**Alaska Department of Environmental Conservation
Division of Air Quality
555 Cordova St.
Anchorage, Alaska 99501**

May 4, 2017

Abbreviations/Acronyms

AAC	Alaska Administrative Code
ADEC.....	Alaska Department of Environmental Conservation
ADR.....	Annual Data Report
Avg.	Average
EPA.....	United States Environmental Protection Agency
NA.....	Not Applicable
NAAQS	National Ambient Air Quality Standards
PSD	Prevention of Significant Deterioration
QA.....	Quality Assurance
QAPP.....	Quality Assurance Project Plan
QC.....	Quality Check
SLR.....	SLR International Corporation, Anchorage Alaska
Teck.....	Teck Alaska Inc.
VWS-Sigma	Vertical Wind Speed Standard Deviation
W/D.....	Wind Direction
WD-Sigma	Wind Direction Standard Deviation
W/S.....	Wind Speed

Units and Measures

m.....	meter
m/s	meters per second

EXECUTIVE SUMMARY:

The Alaska Department of Environmental Conservation (ADEC) reviewed the 2015-2016 meteorological monitoring data collected by Teck Alaska Inc. (Teck) at their Red Dog Mine, Bons Creek and Mill monitoring stations to determine whether the data meets the quality assurance requirements of the Prevention of Significant Deterioration (PSD) program.

The Teck Red Dog Mine Meteorological Monitoring Program is comprised of two monitoring stations, Bons Creek and Mill. The Bons Creek and Mill sites are located at the Red Dog Mine about 105 miles northwest of Kotzebue. Teck measured/calculated the meteorological parameters listed in Table 1 at the Bons Creek and Mill monitoring stations. Teck intends to combine the data into a single data set for purposes of representing the plume transport conditions at the Mill site.

The Mill station includes primary and back up sensors for wind speed/direction. The Bons Creek station includes primary and back up sensors for temperature, and solar radiation. Teck also operated an anemometer at the Bons Creek station, but they are no longer reporting wind speed/direction from the Bons Creek station since it would not be used in an air quality modeling analysis of the mining operations.

This report specifically addresses the meteorological data submitted by Teck for the period of October 1, 2015 - September 30, 2016. ADEC finds the Bons Creek/Mill data to be PSD quality data for all meteorological parameters collected, for all four quarters during the 2015-2016 monitoring year.

TABLE 1: Teck, Red Dog Mine Monitoring Parameters

Bons Creek Monitoring Station	Mill Monitoring Station
Meteorological Parameters	
• 2 m Temperature • 10 m Temperature • Delta Temperature (10 m – 2 m) • Relative Humidity • Solar Radiation • Barometric Pressure • Precipitation	• Horizontal Wind Speed at 33.5 m • Horizontal Wind Direction at 33.5 m • Wind Direction Standard. Deviation. (WD Sigma) at 33.5 m
Back up Sensors	
• 2 m Temperature • 10 m Temperature • Solar Radiation	• Horizontal Wind Speed at 30 m • Horizontal Wind Direction at 30 m

BACKGROUND:

The objective of the Red Dog Mine Meteorological Monitoring Program is to collect meteorological data that could be used in the event that an ambient air quality analysis is required to support future air permitting or an Environmental Impact Statement or Environmental Assessment.

The Bons Creek monitoring site is located near the Red Dog Mine airport, 20 m N of the Red Dog Mine road. The Mill monitoring site is approximately 230 m NE of the mill building, consists of a 33.5 m tower and collects only wind speed and wind direction. The Bons Creek and Mill sites are approximately 7.2 Kilometers apart. The selected sites were chosen to meet the PSD criteria for meteorological data and are combined to make the Red Dog Mine Meteorological Monitoring Program

SLR submitted the Red Dog Mine Meteorological Monitoring Quality Assurance Project Plan (QAPP) (Revision 1.1) for the Teck Red Dog Mine Monitoring Program on March 1, 2011. ADEC approved the May 2011 Red Dog Mine QAPP (Revision 1.1) version on May 24, 2011.

SLR prepared and submitted the 2015-2016 data and data report on behalf of Teck and the Red Dog Mine Monitoring Program on February 10, 2017. The Annual Data Report (ADR) states that the 2015-2016 data was collected in accordance with the approved QAPP with no variations. ADEC found a minor variation which is listed in Table 2.

During the review process additional information was requested and received on March 15, 2017 and April 7, 2017.

Table 2: QAPP Variation Table

Item /Procedure	QAPP Variation	Reason for Variation
	SLR reported no variations from the approved procedures and criteria specified in the Red Dog Mine Meteorological Monitoring Program QAPP Revision 1.1. ADEC notes that the QAPP includes an anemometer at the Bons Creek station, and that wind speed/direction data would be checked and reported which did not occur for this monitoring period. While ADEC finds the lack of reporting to be a variation from the QAPP, it is a non-substantive variation since the wind data would not be used for modeling of the Mill area emissions units.	

FINDINGS:

ADEC performed this review on adherence to the procedures and requirements described by the Teck Red Dog Mine QAPP. In addition, ADEC also considered the following guidance and documents during this review:

- EPA's *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, EPA-454/R-99-005, per 18 AAC 50.215(a)(3).
- The Department's regulatory provisions in 18 AAC 50.215(a) for meteorological and ambient pollutant monitoring;
- ADEC's Quality Assurance Guidance Documents posted at http://dec.alaska.gov/air/am/am_airqual-guidQA.htm, and
- The results of the Red Dog Mine 2015-2016 monitoring program's routinely scheduled quality control (QA/QC) checks to assess methods, record completeness, and timeliness.

ADEC determined the following:

- The reported Bons Creek and Mill 2015-2016 data are PSD quality for all meteorological parameters, for all four quarters and for the monitoring year.
- All calibration and audit forms, certificates, and dates are complete and within acceptable parameters in regards to EPA's standards.

Tables 3a and 3b presents the PSD Data Quality Determination summary for the Bons Creek and Mill monitoring sites by meteorological parameter and data collection period (quarter and full annual period).

Table 3a: Meteorological PSD Data Quality Determination

2015-2016 Bons Creek Station PSD Determination					
Parameter	Oct-Dec Quarter 1	Jan-Mar Quarter 2	Apr-June Quarter 3	Jul-Sep Quarter 4	Oct-Sep 2015 ^b -2016
2 m Temperature	Yes ^a	Yes	Yes	Yes	Yes
10 m Temperature	Yes	Yes	Yes	Yes	Yes
Delta Temperature (10 m – 2 m)	Yes	Yes	Yes	Yes	Yes
Solar Radiation	Yes	Yes	Yes	Yes	Yes
Barometric Pressure	Yes	Yes	Yes	Yes	Yes
Precipitation	Yes	Yes	Yes	Yes	Yes
Relative Humidity	Yes	Yes	Yes	Yes	Yes

- a. 'Yes' means the data is PSD-Quality for the specified data collection period
- b. PSD-quality meteorological monitoring standards require data capture of 90 percent or greater per quarter for four consecutive quarters according to EPA's *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, adopted by reference in 18 AAC 50.035(a)(4)

Table 3b: Meteorological PSD Data Quality Determination

2015-2016 Mill Station PSD Determination					
Parameter	Oct-Dec Quarter 1	Jan-Mar Quarter 2	Apr-June Quarter 3	Jul-Sep Quarter 4	Oct-Sep 2015 ^b -2016
33.5 m Horizontal Wind Speed	Yes	Yes	Yes	Yes	Yes
33.5 m Horizontal Wind Direction	Yes	Yes	Yes	Yes	Yes
WD-Sigma	Yes	Yes	Yes	Yes	Yes

- a. 'Yes' means the data is PSD-Quality for the specified data collection period
- b. PSD-quality meteorological monitoring standards require data capture of 90 percent or greater per quarter for four consecutive quarters according to EPA's *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, adopted by reference in 18 AAC 50.035(a)(4)

ADEC performed a thorough review of the calibration and audit records. Tables 4a and 4b contain the dates of every calibration and audit reported to have been performed for the Teck Red Dog Mine stations for the data collection year of 2015-2016.

Table 4a: Calibration and Audit Records: Completeness and Timeliness for the Bons Creek 2015-2016 collection year

Bons Creek 2015-2016 Monitoring Year						
Calibration				Audit		
Date	9/18/15	5/6/16	10/14/16	9/17/15	5/5/16	10/13/16
Data Logger	Pass	Pass	Pass	Pass	Pass	Pass
Primary						
2m Temp A SN 19883	Pass	Pass	Pass	Pass	Pass	Pass
10 M temp A SN 19881	Pass	Pass	Pass	Pass	Pass	Pass
Delta T	Pass	Pass	Pass	Pass	Pass	Pass
Precipitation SN 40006	Pass	Pass	Pass	Pass	Pass	Pass
S Radiation A SN 89064	Pass	Fail	Pass	Pass	Pass	Pass
Barometric Pressure SN 4794700	Pass	Pass	Pass	Pass	Pass	Pass
Relative Humidity SN 13853	Pass	Pass	Pass	Pass	Pass	Pass

Bons Creek 2015-2016 Monitoring Year cont.						
Calibration				Audit		
Backup Sensors						
2m Temp B SN 19884	Pass	Pass	Pass	Pass	Pass	Pass
10 M temp B SN 19882	Pass	Pass	Pass	Pass	Pass	Pass
Delta T	Pass	Pass	Pass	Pass	Pass	Pass
S Radiation Q SN 74193	Pass	Pass	Pass – new PY89490	Pass	Pass	Pass – New PY89490
S Radiation E SN 37005F3	Pass	Pass	Pass	Pass	Pass	Pass

Table 4b: Calibration and Audit Records: Completeness and Timeliness for the Mill 2015-2016 collection year

Mill 2015-2016 Monitoring Year						
Calibration				Audit		
Primary Sensors						
Date	9/19/15	5/7/16	10/15/16	9/17/15	5/5/16	10/14/16
W/S A SN 143785	Pass	Pass	Pass	Pass	Pass -	Pass
W/D A SN 143785	Pass	Pass	Pass	Pass	Pass	Pass
Backup Sensors						
W/S B SN 132873	Pass	Pass	Pass	Pass	Pass	Pass
W/D B SN 132873	Pass	Pass	Pass	Pass	Pass	Pass

ADEC prepared an AERMET support table pertaining to the subject annual meteorological data. The AERMET support information is provided in Tables 5a and 5b.

Table 5a: AERMET Support Information

Bons Creek Site			
Threshold Wind Speed ^a	Anemometer Height	Ambient Delta Temperature	Tower Location ^c
N/A ^a	N/A	10 m T minus – 2 m T	Latitude: 68.027278 N Longitude: 162.920389 W Base Elevation: 290 m

- a. Teck did not include Bons Creek wind data in the 2015 – 2016 ADR.
- b. Verified in the 2016 Teck Red Dog Mine Technical Systems Audit Report.

Table 5a: AERMET Support Information

Mill Site			
Threshold Wind Speed ^a	Anemometer Height ^b	Ambient Delta Temperature ^c	Tower Location ^c
0.5 m/s	33.5 m	N/A	Latitude: 68.07333 N Longitude: 162.854222 W Base Elevation: 300 m

- a. The table value reflects the horizontal wind direction (vane) starting threshold value, as the greater of the horizontal wind speed (0.4 m/s) and horizontal wind direction (0.5 m/s) starting threshold values.
- b. Verified in the 2016 Teck Red Dog Mine Technical Systems Audit Report.
- c. The Mill site does not collect temperature data.

ADEC would like to acknowledge SLR work in preparing a well-organized and very thorough data summary report. The detail required to document a PSD monitoring program is voluminous. ADEC did request additional information from SLR to clarify some review items. SLR provided prompt communications and/or detailed responses for each request, addressing each ADEC communication.

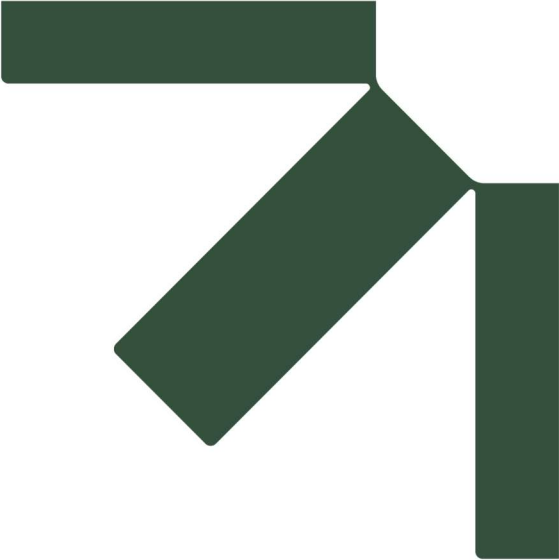
Meteorological Data Review Performed by:

Elizabeth Nakanishi
Environmental Program Technician I
ADEC, Division of Air, Permits Program

(907) 269-6953

Mark Smith
Environmental Program Specialist IV
ADEC, Division of Air, Air Monitoring and Quality Assurance Program

(907) 269-7676



Appendix B Amendment 1 to 2020 Lead Emissions Dispersion Modeling Analysis

Red Dog Mine Lead Emissions Dispersion Modeling Analysis

ADEC Requested Lead Modeling Demonstration under 40 CFR Part 58, Appendix D, section 4.5(a)

Teck Alaska Inc

SLR Project No.: 105.021323.00001

April 25, 2025



**Lead Emissions Dispersion
Modeling Analysis
for the
Teck Alaska, Inc. Red Dog Mine

Amendment 1**

October 2021

prepared by:

SLR International Corporation

**2700 Gambell Street, Ste 200
Anchorage, Alaska 99503**

EXECUTIVE SUMMARY

In May 2020, Teck Alaska Incorporated (Teck) submitted an ambient air quality impact analysis to the Alaska Department of Environmental Conservation (ADEC)¹. That analysis referred to as the 2020 RDM Pb Ambient Analysis demonstrated that the lead (Pb) emissions from the Red Dog Mine will not contribute to a maximum Pb concentration in excess of 50 percent of the Pb National Ambient Air Quality Standard (NAAQS). Since that time ADEC and USEPA Region 10 have been reviewing the analysis and asked Teck to confirm the depth of the Aqqaluk pit used in the modeling². While confirming the depth, Teck also reviewed all other Aqqaluk pit modeled parameters and determined that in addition to the pit depth, the pit base elevation, and emissions should be revised to better reflect the current operations. Recommended revisions to the modeling are described in this document.

The revised impacts predicted with the amended parameters demonstrate that the Pb emissions from the Red Dog Mine will not contribute to a maximum Pb concentration in excess of 50 percent of the Pb NAAQS. See Summary Table below.

Summary Table: Maximum Predicted Impacts per Model Year

Meteorological Model Year	Maximum 3-Month Average Pb Level (µg/m³)	3-Month Averaging Period	Ratio of Maximum Impact to Pb NAAQS
1	0.069	Oct. 2011 – Dec. 2011	46%
2	0.072	Nov. 2012 - Jan. 2013	48%
3	0.053	Jan. 2014 - Mar. 2014	35%
4	0.066	Nov. 2015 - Jan. 2016	44%

¹ Red Dog Mine Lead Emissions Dispersion Modeling Analysis for the ADEC Requested Lead Modeling Demonstration under 40 CFR Part 58, Appendix D, section 4.5(a). prepared by SLR International Corporation. May 2020.

² July 13, 2021, email from: Jack, Jesse R (ADEC) to Ann Mason & Rebecca Hager (Teck). Subject: FW: Red Dog Mine waiver follow-up questions.

1.1 REVISED AQQALUK PIT DIMENSIONS

Emissions from Aqqaluk pit activities were simulated using the open pit algorithm in AERMOD invoked with the OPENPIT keyword. Among several input parameters, that algorithm requires estimates of the pit opening area, the pit rim elevation (base elevation), and the pit depth. Determining these parameters is not simple for the Aqqaluk Pit because the rim is not at a constant elevation. A schematic of the current pit is shown in **Figure 1**. Since the Aqqaluk pit opening is tilted and the OPENPIT source can only handle a single base elevation and depth, these values were set using the average elevation of the rim which is 316 meters with a pit depth of 125 meters. **Table 1** shows the recommended revised modeled OPENPIT parameters.

Figure 1: Schematic of the Current Aqqaluk Pit Volume

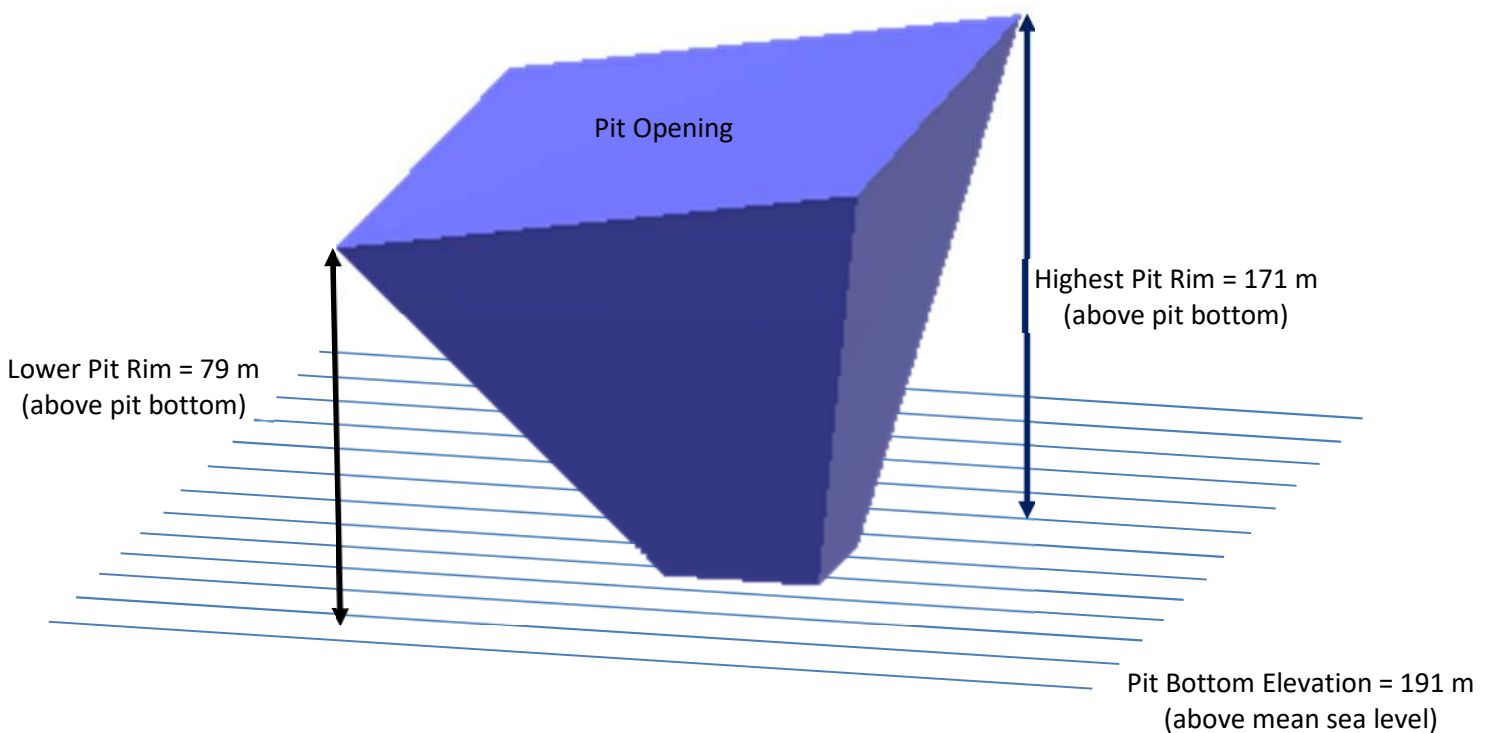


Table 1: Revised Aqqaluk Pit Source Simulation

Parameter	Value	Description ^(a)
Source ID	AQQL_PIT	No Change
Emission Rate [g/(s*m ²)]	0.11100E-06	Decreased from 0.14800E-06. Reference the discussion in Section 1.2 and Table 2 below.
UTMx	589947.0	No Change
UTMy	7552792.0	No Change
Base Elevation (m)	316	Decreased from 378.16 meters as part of the reevaluation. Revised value is equal to the average pit rim elevation, or [(171+79)/2 + 191].
Release Height (m)	5.0	No Change
Pit X-Dimension (m)	765.5	No Change
Pit Y-Dimension (m)	770.0	No Change
Orientation of Pit (deg)	-20.0	No Change
Volume of Pit (m ³)	0.73679E+08	Decreased from 170,200,000 m ³ as a result of revising the pit depth. Volume = [Pit Depth] * [Pit X-Dimension] * [Pit Y-Dimension] 73,679,375 = [(79+171)/2] * [765.5] * [770.0]

^a The basis for values that did not change can be found in Section 2.1.3, Table 2-3 of the 2020 RDM Pb Ambient Analysis.

1.2 REVISED AQQALUK PIT EMISSIONS

The Aqqaluk pit source emission rate is a combination of the emissions from the activities shown in **Table 2**. Upon closer review, it was discovered that Dozer Operations emissions reflected a conservative maximum 24-hour emission rate rather than an emission rate pro-rated on a 3-month basis like all the other dozer sources. This prorating protocol is described in Section 2.1.2 of the 2020 RDM Pb Ambient Analysis as follows: "...model emission rates for bulldozing activities were based on the actual annual hours of bulldozing at a given location and pro-rated on a 3-month basis and then multiplied by a 1.5 factor to provide a conservative estimate of the Pb emission rates from the bulldozing activities.". **Table 2** provides the recalculated Aqqaluk pit emission rate after pro-rating the dozer operations emissions.

Table 2: Aqqaluk Pit Source Emission Rate

Activity	Short-Term Emission Rate (g/s)	Discussion ^(a)
Loader Operations	2.32E-02	No Change
Dozer Operations	5.99E-03	Decreased from 2.74E-02 g/s. The emission rate was recalculated consistent with all other bulldozing source emissions.
Drilling	2.95E-03	No Change
Ore/Waste Loading/Dumping	7.90E-03	No Change
Road Maintenance	7.03E-05	No Change
Unpaved Road Dust	2.55E-02	No Change
Total =	6.56E-02	The modeled emission rate is the total short-term emission rate (g/s) divided by the pit area determined shown in Table 1 , or $[6.56E-02 / (765.5 * 770.0)] = 0.11100E-06 \text{ g}/(\text{s} * \text{m}^2)$.

^a The basis for values that did not change can be found in Section 2.1.3, Table 2-3 of the 2020 RDM Pb Ambient Analysis Appendix A.

2. REVISED LEAD MODELING ANALYSIS RESULTS

Impacts were predicted with the revised inputs described above. As before, predicted monthly impacts were post-processed using LEADPOST to determine the 3-month rolling average Pb concentrations for each model year. The maximum modeled impact using the initial full field receptor grid is $0.068 \mu\text{g}/\text{m}^3$. As before, this impact occurred in a coarse receptor grid located to the west-southwest of the site. To ensure that the maximum modeled ambient Pb impact was characterized, an additional hot-spot analysis using a finer 25-meter spacing receptor grid centered over the area of the maximum modeled impact was utilized.

Table 3 provides a summary of the maximum modeled rolling 3-month average Pb concentrations predicted for each model year. These impacts were all predicted within the additional refined 25-meter receptor grid and shows the ratio of the maximum modeled impact to the 3-month Pb NAAQS for comparison. **Table 3** shows that the maximum modeled 3-month average Pb concentration is $0.072 \mu\text{g}/\text{m}^3$ occurring in the period November 2012 through January 2013 during Model Year 2 and is 48 percent of the Pb NAAQS.

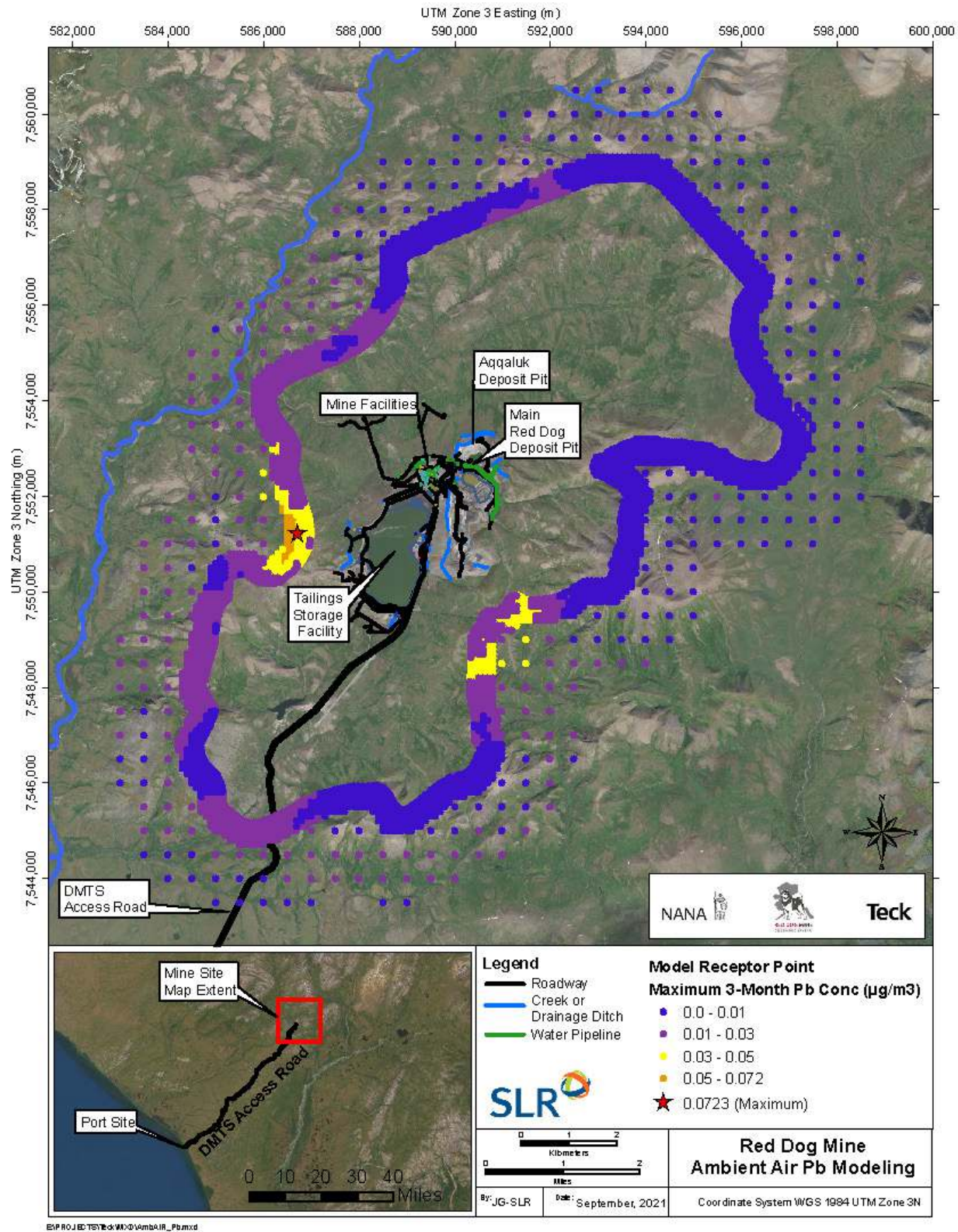
Figure 2 is an aerial image that shows the maximum rolling 3-month average Pb levels at all model receptors. Maximum modeled impacts are located to the west-southwest of the Mine site, which is consistent with the predominant wind direction at the Red Dog Mine.

Table 3: Revised Maximum Modeled Rolling 3-Month Average Pb Levels

Meteorological Model Year	Maximum 3-Month Average Pb Level ($\mu\text{g}/\text{m}^3$)	3-Month Averaging Period	Ratio of Maximum Impact to Pb NAAQS
1	0.069	Oct. 2011 – Dec. 2011	46%
2	0.072	Nov. 2012 - Jan. 2013	48%
3	0.053	Jan. 2014 - Mar. 2014	35%
4	0.066	Nov. 2015 - Jan. 2016	44%

These values supersede those shown in Section 3.0, Table 3-1 of the 2020 RDM Pb Ambient Analysis.

Figure 2: Location of Maximum 3-Month Average Pb Concentrations



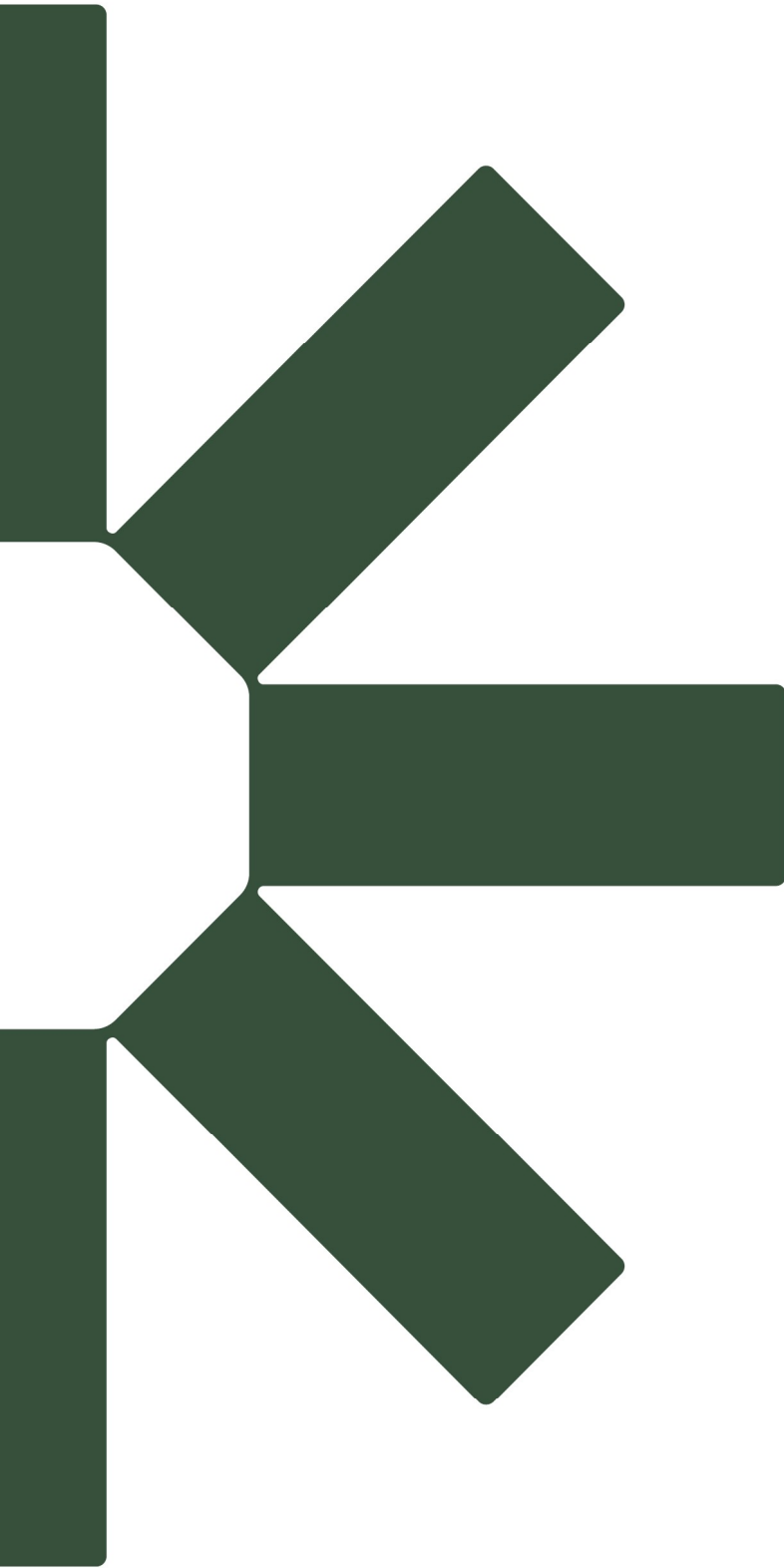
ATTACHMENT A

EMISSION CALCULATIONS AND ELECTRONIC MODELING FILES

(TRANSMITTED ELECTRONICALLY)

Reference Files:

- **Red Dog Lead Model Emissions v1-1 (2021.10.01).xlsx**
- **Attachment_A-Modeling_Files_2021.10.01.zip**



Making Sustainability Happen

Response to RFI



To: Zach Boyden
From: Tom Damiana
Company: Alaska Department of Environmental Conservation
SLR International Corporation
cc: Ann Mason (Teck Alaska)
James Renovatio (ADEC)
James Plosey (ADEC)
TJ Brado (ADEC)
Date: June 10, 2025
Morgan Marinucci (SLR)
Jackson Duvall (SLR)
Chris Lindsey (SLR)

**RE: Response 2 to the 2025-05-08 ADEC Request for Information (RFI)
Red Dog Mine Lead Emissions Dispersion Modeling Analysis**

The information presented in this document is supplementing an initial May 15, 2025 response to an RFI sent by email on May 8, 2025 by the Alaska Department of Environmental Conservation (ADEC) related to the Red Dog Mine Lead Emissions Dispersion Modeling Analysis dated April 25, 2025. This is to supplement the response to request item 1b. The ADEC request along with the previous May 15, 2025 response is provided in **Table 1**. The response to this request has resulted in revising the modeling simulation. The amendment to the dispersion modeling analysis is included as **Attachment A** to this response.

Please do not hesitate to contact me if you have questions related to **Attachment A** or the files transmitted with it.

Regards,

SLR International Corporation

A handwritten signature in blue ink that reads "T. DAMIANA".

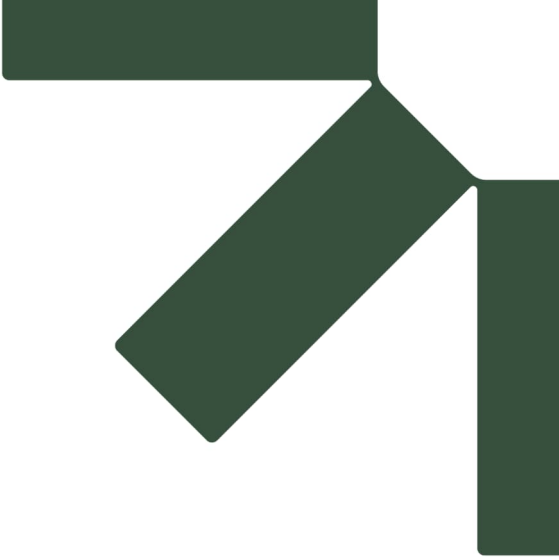
Tom Damiana
Principal Engineer Air Quality
tdamiana@slrconsulting.com
970 817 3172

Attachments: Attachment A – Amendment 1 to the Red Dog Mine Lead Emissions Dispersion Modeling Analysis dated April 25, 2025.

Table 1: Response to the 2025-05-08 ADEC RFI's Item 1b

Request	May 15, 2025 Response
Could you clarify if the model inputs for the Aqqaluk Pit and Qanaiyaq Pit are correct, or if Figures 2 and 3 in the SLR report are correct?	The model inputs for the Aqqaluk Pit and Qanaiyaq Pit are as they were intended; however, they are not in the proper location and do not match the SLR Report. This is because the negative rotation angles specified in the model input files should be positive. This same negative rotation angle is a carryover from the model input files used to support the 2020 ADEC Requested Lead Modeling Demonstration under 40 CFR Part 58, Appendix D, Section 4.5(a) and had gone unnoticed. The simulation has been corrected, and an amended dispersion modeling analysis will be submitted.





Attachment A

Amendment 1 to the Red Dog Mine Lead Emissions Dispersion Modeling Analysis dated April 25, 2025

June 10, 2025



1.0 Background and Simulation Revisions

In April 2025, Teck Alaska Incorporated (Teck) submitted an ambient air quality impact analysis to the ADEC. That analysis referred to as the 2025 RDM Pb Ambient Analysis demonstrated that lead (Pb) emissions from the Red Dog Mine will not contribute to a maximum Pb concentration more than 50 percent of the Pb National Ambient Air Quality Standard (NAAQS). Since that time, ADEC has been reviewing the analysis and asked Teck to confirm several modeling inputs and figures for both the Aqqaluk and Qanaiyaq pits. It was confirmed that the negative rotation angles used to simulate both pits should have been positive and needed to be corrected.

As part of revising the dispersion modeling simulation to correct the rotation, several other Aqqaluk and Qanaiyaq pit model input parameters were revised such as pit dimensions, pit orientation, mass fractions from emissions associated with pit activities, and prorating emissions from intermittent activities. During the process of revising inputs, an error was discovered and corrected related to the dimensions of the non-road volume source parameters. Revisions to the modeling are described in **Section 2.0** of this document along with updated predicted impacts using the revised parameters provided in **Section 3.0**. As described in **Section 3.0**, the result of the revised ambient analysis demonstrates that Pb emissions from the Red Dog Mine will not contribute to a maximum Pb concentration more than 50 percent of the Pb NAAQS.

2.0 Revisions to the Dispersion Modeling Simulations

2.1 Revised Aqqaluk and Qanaiyaq Pit Dimensions and Orientation

Emissions from the Aqqaluk and Qanaiyaq pit activities were simulated using the open pit algorithm in AERMOD invoked with the OPENPIT keyword. Among several input parameters, that algorithm requires estimates of the pit lateral dimensions, the pit rim elevation (base elevation), the pit depth, and an orientation angle. Determining these parameters is not simple for the Red Dog Mine open pits because the pit openings are quite irregular, and in the case of the Aqqaluk pit, the rim is not at a uniform elevation.

Because better geographic tools are readily available, and to simplify model inputs and future re-evaluation; the process used to determine the dimensions of both pits was standardized resulting in minor adjustments to pit dimensions and orientation. The following process was used to determine new pit dimensions:

- 1) Map the exact rim of the pit using an irregular polygon and determine the area; maximum elevation, minimum elevation, and average elevation of that polygon.
- 2) Simulate the pit opening as a square with sides equivalent to the square root of the area of the polygon as previously determined in step 1.
- 3) Position the square pit opening over the pit and determine the southwest corner coordinate and rotation angle from true north.
- 4) Obtain the elevation of the pit bottom.
- 5) Calculate the pit volume assuming it is an inverted, truncated, square pyramid with 1) a depth equal to the difference between the average elevation of the polygon defining the pit rim, and 2) side slopes of 1.25 horizontal to 1.0 vertical.
- 6) Add all revised inputs into the AERMOD input file.



Revised Aqqaluk pit and Qanaiyaq pit model input parameters are detailed in **Table 1** and **Table 2**, respectively, and a depiction of the revised source layout of the pit area is shown in **Figure 1**.

2.2 Revised Aqqaluk and Qanaiyaq Pit Lead Mass Fractions

The emission rates for both open pits are a combination of the emissions from Loader Operations, Dozer Operations, Drilling, Ore/Waste Loading/Dumping, Road Maintenance, and Unpaved Road Dust. While revisiting the Aqqaluk and Qanaiyaq pit source parameters, some of these individual source emissions were adjusted to be calculated using a more consistent and accurate lead mass fraction.

Dozer Operations emissions were calculated using two lead mass fractions based on source rock sampling in 2020. One value representing movement of ore, and one value for movement of waste rock. Although the loaders are operating at roughly the same location as the dozers within the pits, Loader Operations emissions representing fugitive dust generated from loader movement within the Aqqaluk/Qanaiyaq pit (AP-42, Section 13.2.2 Unpaved Roads, Equation 2 (control related to precipitation)) were previously calculated using a lead mass fraction based on sampling results taken from locations outside the pit around various stockpiles. Based on that methodology, if the loader was filling a truck bound for the New Shifters Pad stockpile, the loader fugitive emissions were calculated assuming mass fractions from sampling conducted around the New Shifters pad and not the pit. Because of these inconsistencies, mass fractions used to calculate Loader Operations within the pit were adjusted to represent either ore from the Aqqaluk/Qanaiyaq pit, or waste rock consistent with dozer operations. Updated mass fractions for Loader Operations are apparent in “Red Dog Mine Lead emissions for 2025 Assessment to ADEC for Response 2.xlsx”, worksheet “Fug. Emissions by Type”, cell range T78:T101. See **Section 4** for a link to download this revised version of the workbook.

Similarly, Drilling Operations (drilling and blasting) emissions occurring in the Aqqaluk/Qanaiyaq pit were also adjusted. Initially, all emissions were associated with lead mass fractions representative of only ore, when it is more accurate to include both ore and waste rock. Therefore, the lead mass fraction used for fugitive dust from drilling operations was adjusted to be a weighted average of the waste and ore source rock lead mass fractions. The weighting was based on the apportionment between the number of blasts associated with ore versus waste. These updated mass fractions for Drilling Operations are apparent in “Red Dog Mine Lead emissions for 2025 Assessment to ADEC for Response 2.xlsx”, worksheet “Fug. Emissions by Type”, cell range H159:H170. See **Section 4** for a link to download this revised version of the workbook.

Consistent with the discussions above, lead mass fractions associated with these activities have been revised to have either one of the four values shown in **Table 3**. In addition, all changes to Lead Mass Fractions have been detailed in **Table 4**.



Figure 1: June 2025 Simulation Main Mine Area Source Layout

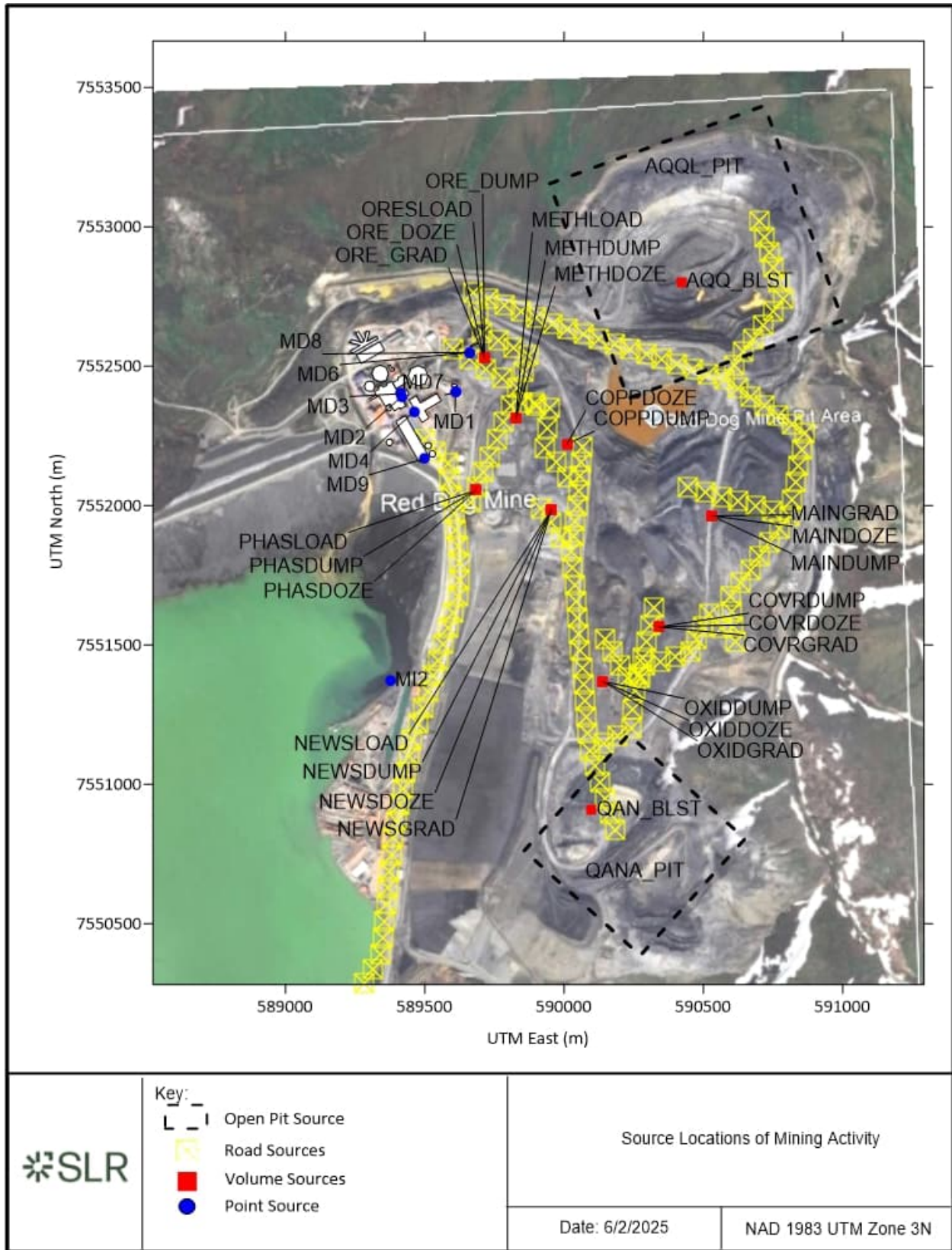


Table 1: Revised Aqqaluk Pit Source Parameters

Parameter	April 2025 Value	June 2025 Value	Description
Source ID	AQQL_PIT	AQQL_PIT	No Change
Elevation of Pit Bottom (m asl)	191	150	Revised based on information obtained from operations during the re-evaluation.
UTMx	589,947	589,948	Adjusted for a better match to aerial photography after re-evaluation.
UTMy	7,552,792	7,553,155	Adjusted for a better match to aerial photography after re-evaluation.
Base Elevation (m)	316	316	No Change
Release Height (m)	5	5	No Change
Pit X-Dimension (m)	765.5	820	Dimension adjusted because of simulating the source opening as a square rather than a rectangle.
Pit Y-Dimension (m)	770.0	820	Dimension adjusted because of simulating the source opening as a square rather than a rectangle.
Area of Pit Opening (m ²)	589,435	672,400	Minimal change following new procedures articulated in this document.
Orientation of Pit (deg)	-20	70	Adjusted for a better match to aerial photography after re-evaluation.
Volume of Pit (m ³)	170,195,864	64,658,000	Decreased because of revising the pit depth.



Table 2: Revised Qanaiyaq Pit Source Parameters

Parameter	April 2025 Value	June 2025 Value	Description
Source ID	QANA_PIT	QANA_PIT	No Change
Elevation of Pit Bottom (m asl)	unknown	330	Revised based on information obtained from operations during the re-evaluation.
UTMx	589,899	589,857	Adjusted for a better match to aerial photography after re-evaluation.
UTMy	7,550,754	7,550,762	Adjusted for a better match to aerial photography after re-evaluation.
Base Elevation (m)	398	398	No Change
Release Height (m)	5	5	No Change
Pit X-Dimension (m)	582.6	560	Dimension adjusted because of simulating the source opening as a square rather than a rectangle.
Pit Y-Dimension (m)	500	560	Dimension adjusted because of simulating the source opening as a square rather than a rectangle.
Area of Pit Opening (m ²)	291,296	313,600	Minimal change following new procedures articulated in this document.
Orientation of Pit (deg)	-42	42	Adjusted for a better match to aerial photography after re-evaluation.
Volume of Pit (m ³)	59,133,773	15,567,000	Decreased because of revising the pit depth.



Table 3: Lead Mass Fractions used for Aqqaluk/Qanaiyaq Pit Activities

Location	Material Handled	Lead Mass Fraction	Discussion
Aqqaluk Pit	Ore	0.0432	Lab results from material sampled in 2014 near the Aqqaluk Pit and equivalent to the values used for ore dozing operations within the Aqqaluk Pit. This value is also approximately equal to typical material fed to the mill crusher.
	Waste	0.0154	Typical waste rock lead content based on a 2020 assay.
Qanaiyaq Pit	Ore	0.0591	Ore lead content based on a 2020 Qanaiyaq pit assay. This value is higher than material fed to the mill crusher.
	Waste	0.0154	Typical waste rock lead content based on a 2020 assay.



Table 4: Updated Mass Fractions for Loader and Drilling Operations

Operation / Area	Location	April 2025 Lead Mass Fraction	June 2025 Lead Mass Fraction
Loader Operations Aqqaluk Pit	to Ore Stockpile	0.0437	0.0432
	to Copper Dump	0.0617	0.0154
	to Methanol Pad	0.0684	0.0154
	to New Shifters Pad	0.0283	0.0154
	to Phase 3	0.0386	0.0154
	to Main Waste Dump	0.0154	
	to Cover Waste Dump	0.0006	0.0154
Loader Operations Qanaiyaq Pit	to Ore Stockpile	0.0591	0.0591
	to Copper Dump	0.0617	0.0154
	to Methanol Pad	0.0684	0.0154
	to New Shifters Pad	0.0283	0.0154
	to Main Waste Dump	0.0154	
	to Oxide Waste Dump	0.1255	0.0154
Loader Operations Ore Stockpile	to Gyro Crusher	0.0467	0.0154
	to Methanol Pad	0.0684	0.0154
	to Main Waste Dump	0.0154	
Loader Operations Methanol Pad	to Ore Stockpile	0.0340	0.0432
	to Main Waste Dump	0.0154	
Loader Operations New Shifters Pad	to Ore Stockpile	0.0340	0.0432
	Rehandling within Pad	0.0633	0.0154
Loading Operations Phase 3	to Ore Stockpile	0.0340	0.0432
	to Methanol Pad	0.0684	0.0154
	to Main Waste Dump	0.0154	
Drilling Operations Aqqaluk Pit	Ore Drilling	0.0437	
	Waste Drilling	0.0437	0.0154
	Drilling Total	0.0437	0.0146 ^(a)
	Blasting Ore	0.0437	
	Blasting Waste	0.0437	0.0154
	Blasting Total	0.0437	0.0140 ^(a)
Drilling Operations Qanaiyaq Pit	Ore Drilling	0.0591	
	Waste Drilling	0.0591	0.0154
	Drilling Total	0.0591	0.0130 ^(a)
	Blasting Ore	0.0591	
	Blasting Waste	0.0591	0.0154
	Blasting Total	0.0591	0.0116 ^(a)

a Weighted average of the waste and ore source rock lead mass fractions based on the apportionment between the number of blasts associated with ore versus waste.



2.3 Prorated Aqqaluk and Qanaiyaq Pit Emission Rates, Contributions, and Totals

The Aqqaluk and Qanaiyaq pit source emission rates are a combination of the emissions from the activities shown in **Table 4**. As described in September 2021 in an amendment to the prior modeling, several of the components reflected a conservative maximum 24-hour emission rate rather than an emission rate prorated on a 3-month basis. At that time, only the Aqqaluk and Qanaiyaq Pit Dozer Operations emissions components were revised even though the same refinement could have been made to the Loader Operations and Drilling components. Therefore, model emission rates for these components have been revised by prorating 24-hour emissions to make them applicable to modeling a 3-month averaging period based on the actual operating hours at a given location, and finally multiplying by a factor of 1.5 to provide a conservative estimate of the Pb emission rates just as was done with the bulldozing activities.

Road Maintenance was also prorated; however, it was done using road length. Previously, the hours used to calculate emissions from this component were calculated using grader speed and the total road length throughout the entire lease area (refer to the “Red Dog Mine Lead emissions for 2025 Assessment to ADEC for Response 2.xlsx”, worksheet “Fug. Emissions by Type”, cells G244 and S247). First, the total hours of each grader operations were estimated using both the Annual Average Mileage of each grader divided by the average grader speed. Originally, the open pits modeled the short-term 24-hour emission rates even though during a 3-month period, the grader operations only maintain a very small portion of roads for a very small number of hours in the vicinity of the open pits. Therefore, the 24-hour emission rate was prorated using the number of hours attributable to time spent near the open pits. These hours were calculated by taking the total hours of operations for graders and multiplying by the ratio of miles associated with the open pit to the total miles maintained by the graders. These hours were used to prorate the short-term 24-hour emission rate into a 3-month emission appropriate for modeling. **Table 5** summarizes the effects of these revisions noting that 1) changes to emissions shown also include the effect of adjusting Lead Mass Fractions as described in **Section 2.2**, and 2) no adjustments were made to the Dozer Operations emissions, as the prorating refinement had already been incorporated into the final 2020 assessment modeling. Additionally, the Lead Mass Fractions assigned to this component remained accurate and did not require further modification.

2.4 Revised Volume Source Inputs - 24-hour Emissions

Due to the Lead Mass Fraction updates for the loading and drilling operations, the modeled emission rates from various stockpiles modeled as volume sources were revised as a direct result of connections within the calculations workbook. The Model ID, description of the volume source, and a comparison of the 24-hour Lead Emission Rates are shown in **Table 6**.



Table 5: Updated 24-Hour Lead Emission Rates for Open-Pit Sources as a Result of Prorating

Area	Component	April 2025 Lead 24-Hour Emission Rate (g/s)	June 2025 Lead 24-Hour Emission Rate (g/s)
Aqqaluk Pit	Loader Operations	6.68E-02	3.85E-02
	Dozer Operations	8.17E-03	
	Drilling	3.70E-03	1.24E-03
	Ore/Waste Loading/Dumping	2.05E-03	
	Road Maintenance	7.96E-05	1.10E-05
	Unpaved Road Dust (VOL SRCS 1-11)	3.68E-02	
	Total	1.18E-01	8.68E-02
Qanaiyaq Pit	Loader Operations	4.02E-02	1.23E-02
	Dozer Operations	3.01E-03	
	Drilling	6.12E-04	4.46E-04
	Ore/Waste Loading/Dumping	2.02E-03	6.12E-04
	Road Maintenance	4.95E-05	4.99E-06
	Unpaved Road Dust (VOL SRCS 1-11)	3.79E-02	
	Total	8.38E-02	5.43E-02

Table 6: Revised 24-hour Emission Rates for Volume Source Inputs

Model ID	Description	April 2025 Lead 24-Hour Emission Rate (g/s)	June 2025 Lead 24-Hour Emission Rate (g/s)
ORESLOAD	Ore Stockpile - Loading	4.86E-03	1.67E-03
METHLOAD	Methanol Pad - Loading	4.24E-05	5.31E-05
NEWSLOAD	New Shifters Pad - Loading	1.63E-05	9.79E-06
PHASLOAD	Phase 3 - Loading	2.84E-05	3.61E-05
AQQ_BLST	Aqqaluk Pit - Blasting	7.13E-03	1.851E-03
QAN_BLST	Qanaiyaq Pit - Blasting	9.63E-03	7.01E-04



3.0 Revised Lead Modeling Analysis Results

Impacts were predicted using the revised inputs described above. As with previous modeling, predicted monthly impacts were post processed using LEADPOST to determine the 3-month rolling average Pb concentrations for each model year. **Table 7** provides a summary of the maximum modeled rolling 3-month average Pb concentrations predicted for each model year. These impacts were all predicted within the supplemental refined 25-meter receptor grid and shows the ratio of the maximum modeled impact to the 3-month Pb NAAQS for comparison. The maximum 3-Month Average Pb cumulative impact modeled was found to be below 50% of the Pb NAAQS.

Figure 2 is a topographic map of the Red Dog Mine that shows the maximum rolling 3-month average Pb levels at all model receptors. Maximum modeled impacts are located to the west-southwest of the Mine site, which is consistent with the predominant wind direction at the Red Dog Mine.

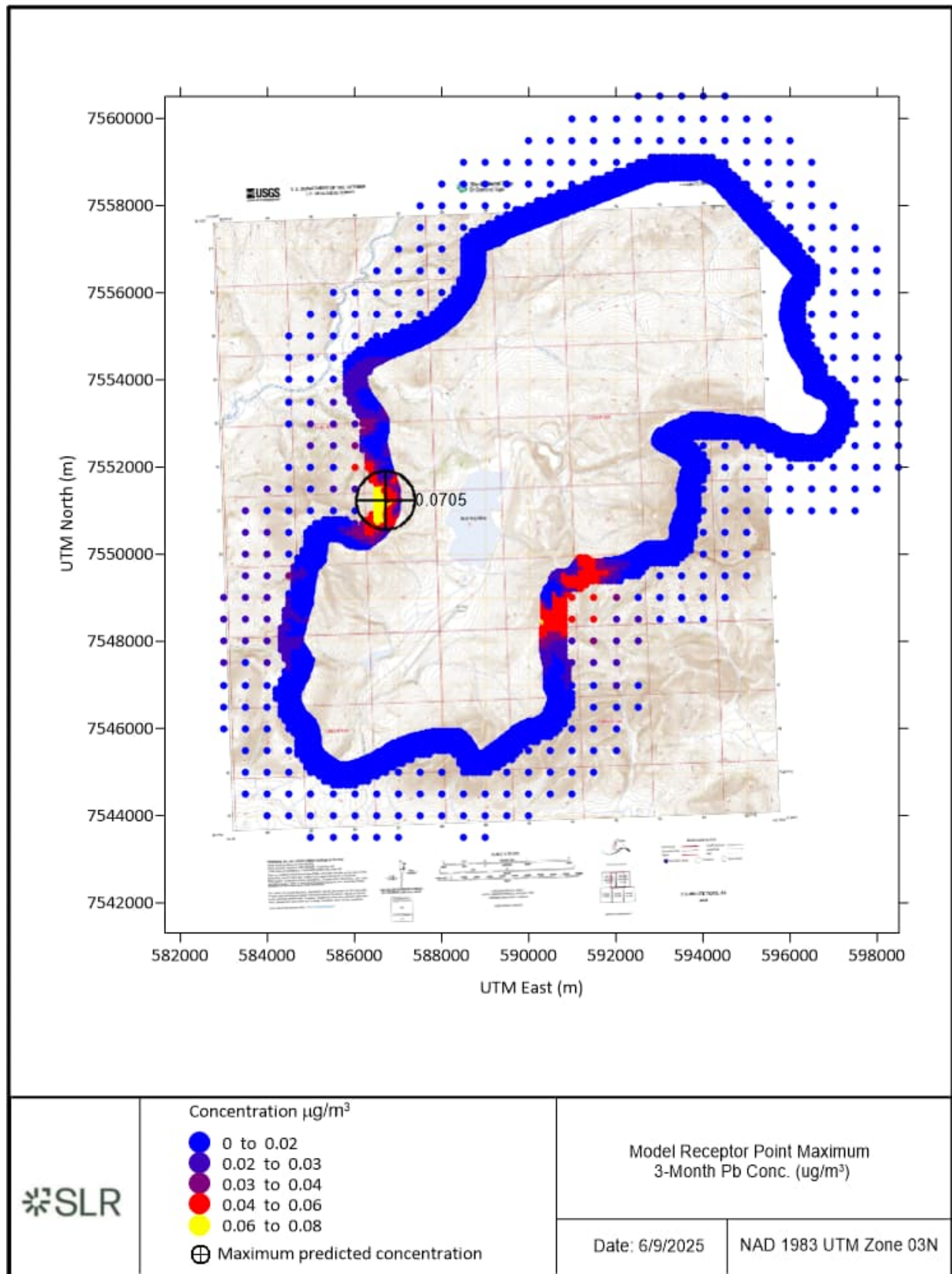
Table 7: Revised Maximum Modeled Rolling 3-Month Average Pb Levels

Meteorological Model Year	Maximum 3-Month Average Pb Level ($\mu\text{g}/\text{m}^3$)	3-Month Averaging Period	Ratio of Maximum Impact to Pb NAAQS
1	0.067	Oct. 2011 – Dec. 2011	45%
2	0.070	Nov. 2012 - Jan. 2013	47%
3	0.052	Dec. 2013 - Feb. 2014	34%
4	0.066	Nov. 2015 - Jan. 2016	44%

These values supersede those shown in Section 3.0, Table 3-1 of the Red Dog Mine Lead Emissions Dispersion Modeling Analysis transmitted April 25, 2025.



Figure 2: Location of Maximum 3-Month Average Pb Concentrations



4.0 Emission Calculations and Electronic Modeling Files

The following links which are active for 30-days will allow the download of the current emissions calculation workbook and final model output files and post-processing as follows:

- **Red Dog Mine Lead emissions for 2025 Assessment to ADEC for Response 2.xlsx**
 - o <https://filetransfer.slrconsulting.com/link/qloJmYs3U32aB3yK9ttHkT>
- **TAK Lead Modeling Files for ADEC 2025-06-09.zip**
 - o <https://filetransfer.slrconsulting.com/link/vJ1lPjmRJz5vRI9Uf6zyGA>

