REPORT

City of Chicago Fugitive Dust Study

March 2014

CDM Smith

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Executive Summary

The City of Chicago (City) has proposed regulations for the Handling and Storage of Bulk Material Piles to control potential emissions of dust from facilities that process and store bulk materials. This study evaluates the potential mechanisms of dust generation associated with bulk material piles, and is designed to inform the City concerning the importance of activities that, if unmitigated, could produce excessive dust and adversely affect ambient air quality. The study finds that bulk material piles can in general be significant sources of dust and contribute to localized exceedances of ambient air quality standards. Of the materials evaluated (petcoke, coal, Mesaba ore, and slag), potential emissions of petcoke were found to be highest. Factors important to fugitive dust generation include bulk material properties such as silt content, material handling procedures, and meteorological conditions such as dry weather and high winds.

Procedures developed by the U.S. Environmental Protection Agency (EPA) were implemented to estimate potential dust emissions from material handling and storage activities, including:

- material dropping operations (from truck dumping, front-end loader use, conveyors, etc.);
- bulldozing and grading;
- vehicle travel on paved roads and the unpaved surface of the storage pile; and
- surface wind erosion from stockpiles.

Dust emissions from many of these activities depend upon bulk material characteristics such as grain size (primarily silt content), moisture content, and bulk density. Per the request of the City, dust emissions were evaluated from four bulk materials:

- petroleum coke (petcoke);
- coal;
- Mesaba ore (enriched in copper and nickel); and
- slag.

Spreadsheet calculations were developed to estimate potential emissions of each bulk material from each source. A conceptual bulk material processing and storage facility was constructed using parameters from the City's draft regulations and knowledge of activities typical of bulk material handling. EPA's AP42 emission factor methods were implemented using material-specific parameters as appropriate. Mitigation efforts were not considered in order to estimate conservative worst-case dust emissions.

Results of the dust emission calculations are presented in Figure ES-1 (total dust), Figure ES-2 (PM_{10}, or particulate matter with aerodynamic diameter less than 10 μm), and Figure ES-3 ($PM_{2.5}$, or particulate matter with aerodynamic diameter less than 2.5 μm). Comparing between figures, total dust emissions are much higher than those of PM_{10} and $PM_{2.5}$, reflective of the nature of fugitive dust sources to release larger particle sizes. The highest emission estimates are for bulldozing operations, which depend strongly on the material silt content. Emission estimates from the travel of haul trucks on the paved access road and from grading the stockpile material are the same for all bulk materials as the calculation methods for these two activities do not depend on material properties. Overall, emission estimates are highest for the petroleum coke material. Estimates of wind erosion emissions from the stockpile, though lower than other sources on an annual basis, may be of elevated importance on an episodic basis as the emissions are assumed to occur over a very limited number of hours per year.

The fugitive dust emission estimates were subsequently used as input to the AERMOD dispersion model to predict the incremental concentrations of particulate matter in ambient air that could result from the activities at a bulk processing and storage facility. A key aspect of the calculations involved the linkage of hourly emission estimates to the meteorological data used in the dispersion modeling study. The predicted incremental concentrations of PM_{10} and $PM_{2.5}$ exceed the levels of National Ambient Air Quality Standards (NAAQSs) for a number of the emission sources considered. Since background levels of PM_{10} and $PM_{2.5}$ already account for substantial fractions of the NAAQSs, substantial mitigation efforts may be required on the part of operators of bulk material processing and storage facilities to ensure that fugitive dust emissions do not lead to localized exceedances of ambient air quality standards.

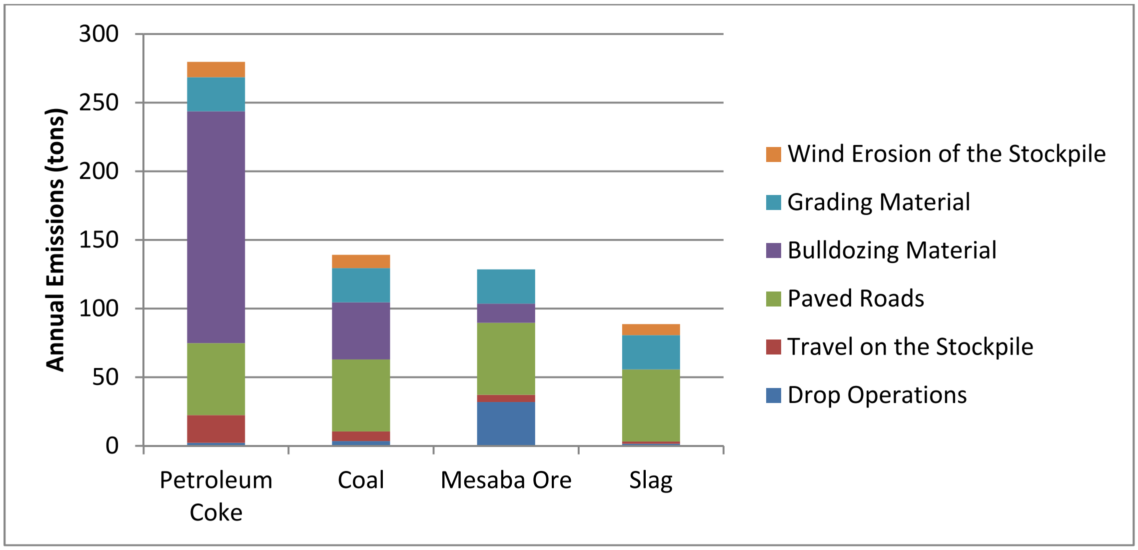


Figure ES-1 **Estimates of Total Dust Emissions**

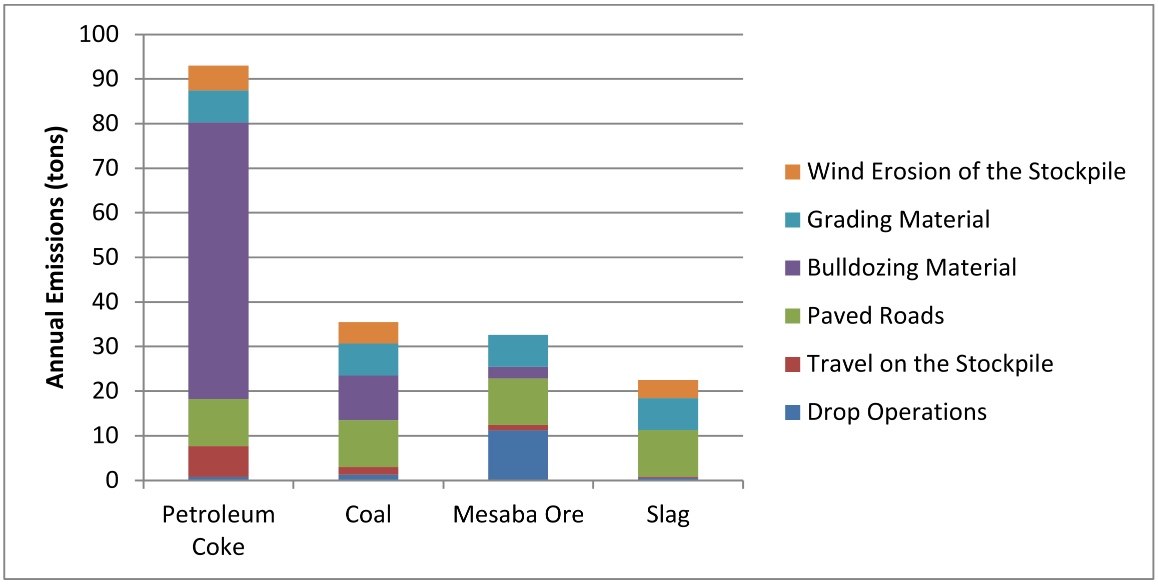


Figure ES-2 **Estimates of PM_{10} Emissions**

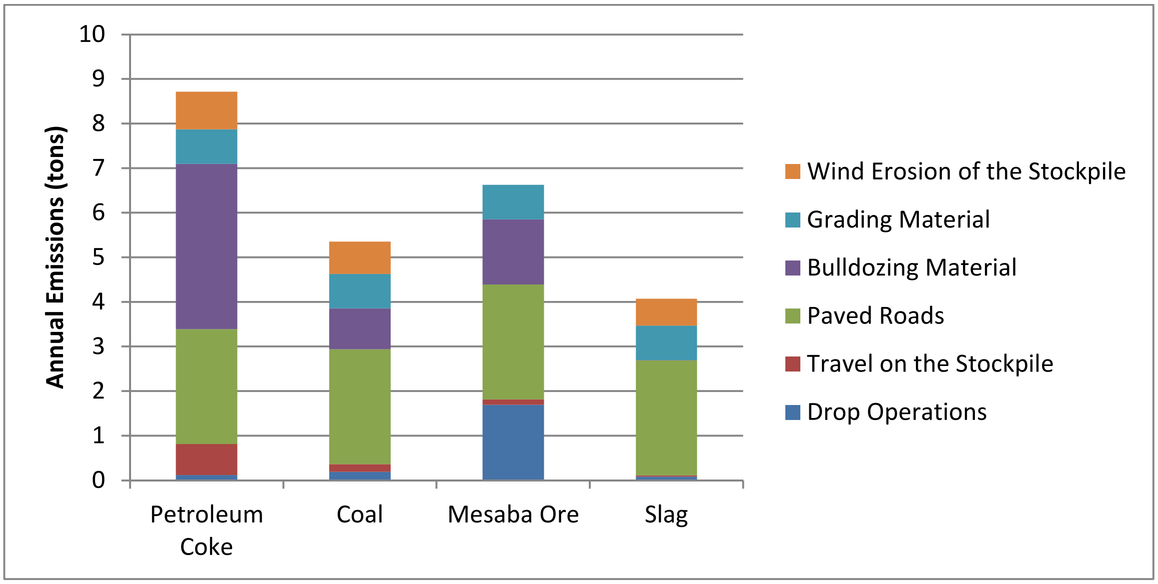


Figure ES-3 **Estimates of $PM_{2.5}$ Emissions**

Section 1

Introduction and Purpose

The presence and movement of bulk solid materials can lead to inadvertent, fugitive emissions of dust to the air. The City of Chicago has proposed regulations for the Handling and Storage of Bulk Material Piles to control potential emissions from facilities that process and store bulk materials.

This fugitive dust study evaluates the potential mechanisms of dust generation associated with bulk material piles. The study is designed to inform the City concerning the importance of activities that if unmitigated might produce dust and affect ambient air quality. Procedures developed by the U.S. Environmental Protection Agency are implemented to estimate potential dust emissions from material handling activities, including dropping operations (from truck dumping, front-end loader use, conveyors, etc.), bulldozing, vehicle travel on paved roads and the surface of the pile, and surface wind erosion from stockpiles. As dust emissions of many of these activities depend upon bulk material characteristics such as grain size and moisture content, several different bulk solid materials are evaluated. Predicted emissions are used in conjunction with air dispersion modeling to estimate potential levels of dust in ambient air that result from operation of a bulk solid material storage and processing facility.

Section 2

Conceptual Bulk Material Storage Facility

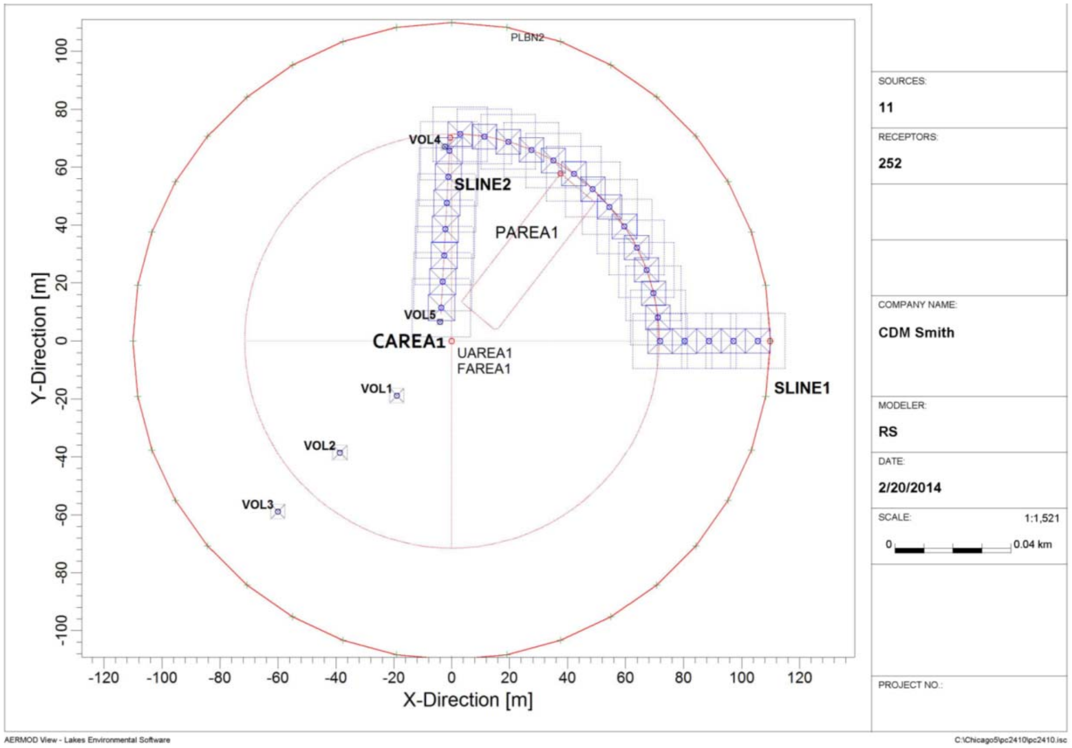
The fugitive dust study focuses on a generic but representative bulk material processing facility. The conceptual facility is not designed to represent a specific bulk solid materials processing facility, but rather is modeled after specifications in the City's draft regulations and includes a variety of processes capable of generating dust, some or all of which may be relevant to specific facilities.

For simplicity, a storage pile covering a circular areal footprint is assumed. The top of the pile is assumed to be conical frustum in shape, with side slopes leading to a flat top. The volume of material storage is assumed to be 100,000 cubic yards (yd^3), and 2,000 tons per day (tpd) of material is assumed to be processed for five days each week.

Figure 2-1 depicts the configuration of the conceptual bulk material storage facility. A paved access road is assumed to approach the facility from the east and run tangential to the outside of the pile. Haul trucks are assumed to traverse the access road and deposit loads of fresh material at the northern edge of the pile. A bulldozer and grader are assumed to move the bulk material and shape the pile. A front-end loader and an articulated truck are assumed to move material on the surface of the storage pile and facilitate the loading of a conveyor that places the bulk material on rail cars or barges for shipment out of the facility. The assumed equipment and operations are generic in construction, but are designed to represent the spectrum of activities typically found at bulk material storage facilities.

The size of the storage pile is determined by the assumed volume and shape of the pile. Based on an assumed ratio of 0.4 of the diameter of the top (flat) portion of the pile compared to its base and an assumed pile height of 30 feet, the based diameter of the pile is calculated to be 469 feet. The resulting exposed surface area (based on the assumed conical frustum shape) is 176,325 ft^2.

Four different bulk materials are examined to consider a range of characteristics that influence dust emissions. The bulk materials were selected in conjunction with discussions with the City of Chicago, and are selected to be representative of materials likely handled at local storage and processing facilities. Properties of the four materials, as gathered from sample analyses and information in the literature, are summarized in Table 2-1.



SOURCES:
11

RECEPTORS:
252

COMPANY NAME:
CDM Smith

MODELER:
RS

DATE:
2/20/2014

SCALE: 1:1,521

PROJECT NO.:

Legend for Sources

SLINE1	Line of 18 volume sources for paved road emissions (haul trucks)
SLINE2	Line of 6 volume sources for emissions from travel on the pile surface (articulated truck and front-end loader) for 24-hour modeling
UAREA1	Area source for emissions from travel on the pile surface (articulated truck and front-end loader) for annual modeling
PAREA1 FAREA1	Area sources for bulldozing and grading for 24-hour and annual modeling, respectively
CAREA1	Area source for wind erosion from stockpiles
VOL1 to VOL5	Drop sources from conveyor (1-3), haul truck dumping (4), and articulated truck loading (5)

Figure 2-1 **Conceptual Bulk Material Storage Facility Configuration of Area, Volume, and Line Volume Sources**

Table 2-1 Characteristics of Bulk Materials

Property	Material			
	Petcoke	Coal	Mesaba Ore	Slag
Silt (%)	21.2 (a)	4.6 (c)	3 (e)	0.55 (f)
Moisture (%)	6.7 (a)	4.8 (c)	1 (e)	8.69 (f)
Bulk Density (lb/ft^3)	50 (b)	50 (d)	135 (e)	60 (g)

Data sources:

(a) Average of measurements from two petcoke samples (Appendix A)

(b) http://www.petroleumhpv.org/docs/pet_coke/2000-08-30Pet%20Coke%20Robust%20Summary.pdf

(c) AP42 Table 13.2.4-1 values for coal in iron and steel industry

(d) Typical bituminous value, http://www.tapcoinc.com/content/product_data/Tapco_Catalog_09_p88-94.pdf

(e) http://s3.amazonaws.com/zanran_storage/www.isamill.com/ContentPages/2534118165.pdf#page=8

(f) Average of measurements from three slag samples obtained by CDPH from a local bulk material handling company (Appendix B)

(g) http://www.aqua-calc.com/page/density-table/substance/slag-coma-and-blank-furn-point--blank-granulated

Section 3

Emission Calculations

Fugitive dust emissions are estimated according to methods recommended by the U.S. Environmental Protection Agency (EPA) in its Compilation of Air Pollutant Emission Factors (AP42) document. AP42 has evolved to an on-line reference document that contains numerous chapters devoted to estimating fugitive dust emissions (http://www.epa.gov/ttn/chief/ap42/index.html).

The specific AP42 sections that are used to estimate potential fugitive dust emissions from bulk material storage facilities are described in subsequent sections. Some of the emission factors depend on wind velocities, and are hence tied to meteorological data (described in Section 4.2.3). Dust emissions are calculated on an hourly basis to complement subsequent air dispersion modeling. With the exception of wind erosion from stockpiles, emissions are estimated during assumed hours of facility operation from 7:00 AM through 5:00 PM (ten hours per day) for five days each week.

3.1 Drop Operations

Dust can be generated each time a material is transferred from one location to another via "dropping" operations. AP42 Section 13.2.4 provides the following equation to estimate these emissions:

$$E = k(0.0032)\frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

where the terms are:

E	Dust emission per unit of material handled (lb/ton);
k	Particle size multiplier (1 for total dust, 0.35 for PM_{10}, and 0.053 for $PM_{2.5}$);
U	Mean wind speed (mph); and
M	Moisture content of the bulk material (%).

Five drop operations are assumed to occur across the conceptual bulk material storage and processing facility:

- During the unloading of incoming haul trucks;
- During the loading of an articulated truck by the front-end loader; and
- At three points on a conveyor system (conveyor loading, an intermediate transfer point, and the loading of outgoing rail cars or barges).

A processing rate of 2,000 tons per day is assumed for each drop operation under the assumption of quasi-steady-state operation (equal material inflows and outflows). The processing rate is assumed to be distributed evenly over facility operating hours.

3.2 Travel on the Surface of the Pile

Dust can be generated when off-road vehicles travel directly across the surface of the bulk material storage pile. AP42 Section 13.2.2 provides the following equation to estimate these emissions:

$$E = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b}$$

where the terms are:

E	Dust emission per vehicle mile traveled (lb/VMT);
s	Silt content of the bulk material (%);
k	Particle size multiplier for industrial roads (4.9 lb/VMT for total dust, 1.5 lb/VMT for PM_{10}, and 0.15 lb/VMT for $PM_{2.5}$);
a	Particle size dependent constant (0.7 for total dust, 0.9 for PM_{10}, and 0.9 for $PM_{2.5}$);
b	Empirical constant equal to 0.45; and
W	Average weight of the vehicles traveling on the surface (tons).

Silt content is specific to the bulk material (see Table 2-1). Two vehicles are assumed to travel on the storage and processing pile:

- a front-end loader with a tare weight of 14.5 tons and bucket capacity of 6.5 cubic feet; and
- an articulated truck with a tare weight of 30 tons and carrying capacity of 40 tons.

Each vehicle is assumed to load or carry 2,000 ton/day of bulk material. The articulated truck is assumed to make trips across the pile, traversing a total of 8.9 miles per day. The front-end loader is assumed to travel half of this distance (4.45 miles per day). The average vehicle weight of 38.9-40.1 tons is estimated by weighting the average loaded and unloaded weights of the vehicles by the assumed travel distances (the value depends to a small extent on the bulk density of the material).

3.3 Paved Roads

Dust can also be generated by on-road vehicles that resuspend silted material from paved roadways. AP42 Section 13.2.1 provides the following equation to estimate these emissions:

$$E = k(sL)^{0.91}(W)^{1.02}$$

where the terms are:

E	Dust emission per vehicle mile traveled (lb/VMT);
k	Particle size multiplier (0.011 lb/VMT for total dust, 0.0022 lb/VMT for PM_{10}, and 0.00054 lb/VMT for $PM_{2.5}$);
sL	Road surface silt loading (g/m^2); and
W	Average weight of the vehicles traveling the road (tons).

The silt loading in this case is not specifically germane to the bulk material, but rather reflects the degree of fine dust covering the road due to all sources. A mid-range sL value of 70 g/m^2 is selected from values documented in AP42 Table 13.2.1-3, as developed from measurements in the sand and gravel processing industry. An average vehicle weight of 40 tons is assigned to W as the average loaded and unloaded weight of a haul truck with a tare weight of 30 tons carrying 20 tons of bulk material to the storage and processing facility. The one-way distance of travel assumed by a haul truck is 100 feet from the gate to the haul road plus 369 feet along the outside of the material pile (one quarter of the pile circumference). Allowing for double the distance to go in and out of the facility and the 100 trucks necessary to deliver bulk material, haul trucks are assumed to travel a total of 17.8 vehicle miles each day of facility operation.

3.4 Bulldozing and Grading

Bulldozers are likely to be used to move materials short distances, such as from the dump areas of haul trucks toward the storage pile or working limited areas of the pile. Graders are likely to be used to maintain the general shape of the entire pile. A bulldozer and grader are assumed to each operate 50% of the time at the conceptual bulk material facility. AP42 Section 11.9 (Table 11.9-1) provides the following equations for estimating dust emissions during the course of their operations. For the bulldozer, the emission factors are:

Total dust $E_{B=}\frac{\alpha(s)^{1.2}}{M^{1.3}}$

PM$_{10}$ $E_{B=}k_{10}\frac{\beta(s)^{1.5}}{M^{1.4}}$

PM$_{2.5}$ $E_{B=}k_{2.5}\frac{\alpha(s)^{1.2}}{M^{1.3}}$

where the terms are:

E_B	Dust emission per time (lb/hr);
α	Empirical constant of 78.4 lb/hr (petroleum coke and coal) or 5.7 lb/hr (Mesaba ore and slag);
β	Empirical constant of 18.6 lb/hr (petroleum coke and coal) or 1.0 lb/hr (Mesaba ore and slag);
s	Silt content of the bulk material (%);
M	Moisture content of the bulk material (%);
k_{10}	PM$_{10}$ particle size multiplier equal to 0.75; and
$k_{2.5}$	PM$_{2.5}$ particle size multiplier equal to 0.022 (petroleum coke and coal) or 0.105 (Mesaba ore and slag).

Emissions from grading operations are estimated as:

$$E_G = k\alpha(S)^{\beta}$$

where the terms are:

E_G	Dust emission per time (lb/VMT);
α	Empirical constant of 0.051 lb/VMT for PM$_{10}$ and 0.040 lb/VMT for total dust and PM$_{2.5}$;
β	Empirical constant of 2 for PM$_{10}$ and 2.5 for total dust and PM$_{2.5}$;
k	Particle size multiplier equal to 1 (total dust), 0.6 (PM$_{10}$), or 0.031 (PM$_{2.5}$);
S	Average speed of the grader (mph).

The average AP42 default median value of 7.1 mph is assumed for the average vehicle speed *S*. At this speed, the grader will travel 3.55 miles on the storage pile each hour if utilized half the time.

3.5 Wind Erosion from Stockpiles

Winds of sufficient strength can cause dust to blow off of storage piles, especially if the material is fine and dry. AP42 Section 13.2.5 provides the following equation for estimating dust emissions due to wind erosion from stockpiles:

$$P = k\left(58(u^* - u_t^*)^2 + 25(u^* - u_t^*)\right)$$

where the terms are:

P	Dust emission per unit area (g/m^2);
k	Particle size multiplier (1 for total dust, 0.5 for PM$_{10}$, and 0.075 for PM$_{2.5}$);
u^*	Friction velocity (m/s); and
$u_t{}^*$	Threshold friction velocity (m/s).

The equation for friction velocity applies only when the atmospheric friction velocity exceeds the threshold friction velocity. Additionally, wind erosion events typically occur under dry conditions over a pile that has recently experienced surface disturbance. Once fine materials have blown off the surface, the layer must be replenished before the next wind erosion event can occur.

Two calculations are performed to estimate the potential magnitude of emissions due to wind erosion from stockpiles. First, a worst-case assumption is made that one wind erosion event could occur each day (provided the friction velocity exceeds the threshold for at least one hour during the day). Such a situation might occur during periods of extended dryness while the storage pile remains active and the surface is routinely replenished. Second, the assumption is made that there could be on average one wind erosion event each month. The daily and monthly wind erosion models are thus designed to test the sensitivity of the wind erosion algorithms.

Hourly estimates of the friction velocity are available from the AERMET preprocessing program, which estimates u^* values in the course of preparing meteorological data for use by the AERMOD dispersion model. The threshold friction velocity $u_t{}^*$ depends on the particle size characteristics of the bulk material. AP42 Table 13.2.5-1 provides data from a field procedure for estimating $u_t{}^*$. A curve-fit of the data (R^2=0.9995) yields the equation for $u_t{}^*$ (in cm/s):

$$u_t^* = 64.43O^{0.4043}$$

where O is the midpoint opening size (in mm) of the sieves that indicate the statistical mode of an empirically-derived grain size distribution (following the method described in AP42 Section 13.2.5). Estimates of $u_t{}^*$ for the four bulk materials examined are:

- 47 cm/s for petroleum coke, based on an average estimate derived from grain size analyses of two samples (Appendix A);
- 54 cm/s to 112 cm/s for coal, based on specific values reported in AP42 section 13.2.5;
- 187 cm/s for Mesaba ore, based on data from a reported grain size analysis particle size distribution (http://s3.amazonaws.com/zanran_storage/www.isamill.com/ContentPages/2534118165.pdf#page=8); and
- 61 cm/s for slag, based on the results of a grain size analysis (Appendix B).

Over each daily period, the equation to predict event-based wind erosion is applied to the hour of the day with the highest hourly friction velocity. In addition, friction velocity estimates from the meteorological data are reduced by a factor of 0.9 to account for reduced wind speeds that would be expected to occur over a storage pile as it acts as a partial obstruction to surface winds (as described in AP42 Section 13.2.4).

3.6 Fugitive Dust Emission Estimates

The equations for fugitive dust emissions from the various sources were implemented in a spreadsheet in conjunction with hourly meteorological data for the 2008 calendar year. Emission estimates were derived for total suspended particulate (TSP, or total dust) and its subcomponents PM_{10} and $PM_{2.5}$. Summaries of the annual emission totals, in tons/year, are provided in Table 3-1 (TSP), Table 3-2 (PM_{10}), and Table 3-3 ($PM_{2.5}$).

The compiled emission estimates reflect the nature of the dependencies of the underlying factors that affect emissions. Emission estimates for the paved road and grading sources are the same for all four materials as there are no dependencies on bulk material properties in the constitutive model equations. Petroleum coke, due to its high silt content, generates the highest emission estimates for off-road vehicles traveling on the pile surface, bulldozing, and wind erosion from stockpiles. Mesaba ore produces the highest emission estimates for dropping operations (material handling) because of its low moisture content.[1] Stockpile wind erosion estimates are greatest for petroleum coke, and lowest (zero) for Mesaba ore (for which the threshold friction velocity is never exceeded in the hourly meteorological data). Stockpile wind erosion estimates for the monthly event model are a substantial fraction of those of the daily event model, reflective of the nature of the underlying non-linear model equation that predicts very high emissions under elevated wind conditions.

Total fugitive dust emissions are highest for the petroleum coke material, but can be substantial (of the order of 100 tons/year or more) for all materials. The generic assumptions regarding facility size, material handling practices, and equipment configuration and utilization can be expected to be different in practice at actual facilities, and facility-specific assessments may be useful in generating more accurate estimates of emissions.

The fugitive dust study does not explicitly consider dust control measures in order to highlight processes capable of producing dust emissions. Most fugitive dust emissions are amenable to control. For example, paved road emissions can be reduced through street sweeping and targeted application of water. Many estimates are also made with conservative assumptions designed to overestimate likely emissions (such as the premise that dry conditions will persist for long periods of time).

There are also uncertainties inherent to the estimation of fugitive dust emissions. The fugitive dust emission estimates must therefore be interpreted with caution. Some sense of the reliability of the methods is provided in the AP42 sections from which the predictive equations are taken, and readers are encouraged to review the U.S. EPA's descriptions.

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[1] The moisture content of the Mesaba ore (as taken from the literature) is notably lower than that for the other materials considered. As moisture content is expressed as a weight percentage and the ore has a higher bulk density, the volume fraction of water is higher than represented (relative to other materials). As the AP42 equation for material dropping emissions does not account for differences in bulk density, drop emission estimates for the Mesaba ore material may be overstated relative to the other materials.

The U.S. EPA AP42 emission factors are derived from empirical data to identify and capture the variables that most influence fugitive dust emissions. Many of the emission factors depend on bulk material properties. Since the same handling assumptions are used to evaluate each material, comparisons between materials indicate trends and tendencies based on the characteristics of the materials that can be influenced by facility-specific control and mitigation measures.

Table 3-1 TSP Emission Summary

	Petcoke	Coal	Mesaba Ore	Slag
Silt (%)	21.2	4.6	3	0.55
Moisture (%)	6.7	4.8	1	8.69
Threshold Friction Velocity (u^*_t, m/s)	0.47	0.54 to 1.12	1.88	0.62
Bulk Density (lb/ft^3)	50	50	135	60
Total Suspended Particulate (TSP) Emissions (tons/year)				
Drop operations	2.2	3.6	32.0	1.6
Travel on Pile Surface	20.2	6.9	5.2	1.6
Paved Roads	52.5	52.5	52.5	52.5
Bulldozing Material	168.8	41.6	13.9	0.1
Grading Material	24.9	24.9	24.9	24.9
Wind erosion from stockpiles (daily)	57.9	0.8 to 41.5	0	27.6
Wind erosion from stockpiles (monthly)	11.2	0.8 to 9.7	0	8.0
Total (daily wind erosion)	326	130 to 171	129	108
Total (once per month wind erosion)	280	130 to 139	129	89
Percentage hours greater than friction velocity threshold	37%	0.6% to 26%	0%	18%

Table 3-2 PM$_{10}$ Emission Summary

	Petcoke	Coal	Mesaba Ore	Slag
Silt (%)	21.2	4.6	3	0.55
Moisture (%)	6.7	4.8	1	8.7
Threshold Friction Velocity (u^*_t, m/s)	0.47	0.54 to 1.12	1.88	0.62
Bulk Density (lb/ft^3)	50	50	135	60
PM10 Emissions (tons/year)				
Drop operations	0.8	1.2	11.20	0.5
Travel on Pile Surface	6.9	1.7	1.2	0.3
Paved Roads	10.5	10.5	10.5	10.5
Bulldozing Material	62.1	10.0	2.5	0.01
Grading Material	7.2	7.2	7.2	7.2
Wind erosion from stockpiles (daily)	29.0	0.4 to 20.8	0	13.8
Wind erosion from stockpiles (monthly)	5.6	0.4 to 4.8	0	4.0
Total (daily wind erosion)	116	31 to 51	33	32
Total (once per month wind erosion)	93	31 to 35	33	22
Percentage hours greater than friction velocity threshold	37%	0.6% to 26%	0%	18%

Table 3-3 **$PM_{2.5}$ Emission Summary**

	Petcoke	Coal	Mesaba Ore	Slag
Silt (%)	21.2	4.6	3	0.55
Moisture (%)	6.7	4.8	1	8.69
Threshold Friction Velocity (u^{*}_{t}, m/s)	0.47	0.54 to 1.12	1.88	0.62
Bulk Density (lb/ft^3)	50	50	135	60
PM2.5 Emissions (tons/year)				
Drop operations	0.1	0.2	1.7	0.08
Travel on Pile Surface	0.7	0.2	0.1	0.03
Paved Roads	2.6	2.6	2.6	2.6
Bulldozing Material	3.7	0.9	1.5	0.01
Grading Material	0.8	0.8	0.8	0.8
Wind erosion from stockpiles (daily)	4.3	0.1 to 3.1	0	2.1
Wind erosion from stockpiles (monthly)	0.8	0.1 to 0.7	0	0.6
Total (daily wind erosion)	12	5 to 8	7	6
Total (once per month wind erosion)	9	5 to 5	7	4
Percentage hours greater than friction velocity threshold	37%	0.6% to 26%	0%	18%

Section 4

Dispersion Modeling

4.1 AERMOD References/Version

Dispersion modeling was conducted using the latest version of the U.S. EPA-approved AERMOD dispersion modeling system (AERMOD Version 13350) and the Lakes Environmental AERMOD View graphic user interface version 8.5.0. AERMOD is a computer-based mathematical dispersion model that can predict ambient concentrations of pollutants that result from releases to the atmosphere. AERMOD algorithms assume that:

- A source's plume is steady-state,
- The vertical and horizontal concentration distributions fit a Gaussian distribution in the stable boundary layer (SBL), and
- For the convective boundary layer (CBL), the horizontal concentration distribution is Gaussian and vertical distribution fits a bi-Gaussian probability density function.

AERMOD uses hour-by-hour meteorological data to predict the patterns of ambient concentrations of pollutants over time. Matched with hour-by-hour estimates of fugitive dust emissions, AERMOD is capable of predicting both short-term and long-term estimates of the impacts of bulk material processing and storage facilities on ambient air quality.

4.2 Modeling Setup

4.2.1 Terrain

Digital elevation model data was not required because the terrain surrounding the source was assumed to be flat.

4.2.2 Receptor Grid

A non-uniform polar receptor grid centered on the source consists of 36 radials (one every 10 degrees) that intersect six receptor rings at distances of 115, 140, 170, 220, 280 and 350 meters from the source. The grid consists of 216 receptors each assumed to be at ground-level (0.0 meters high).

Fenceline receptors were also included in the model and located every 10 meters along the virtual property boundary for a total of 36 receptors. The receptor grid is shown in Figure 4.1.

4.2.3 Meteorological Data and Land Use

As described in Section 3.4, hourly surface meteorological data for Midway Airport (Station ID 72534, base elevation 607 feet and 10 meter anemometer height), Chicago, IL, and upper air data from Lincoln, IL (Station ID 4833) for 2008 were obtained from a third party vendor. The data as purchased have undergone the quality assurance process required by EPA to identify and fill in missing data. The surface and upper air meteorological data were prepared for use in AERMOD using the AERMET meteorological data preprocessor and Lakes Environmental AERMET View Graphic User

Interface Version 8.50. Processing of the surface file indicated more than 99 percent data availability out of 8,711 records used.

Surface parameters (albedo, Bowen ratio and surface roughness) were determined using the AERSURFACE preprocessor and surface data from the National Land Cover Database for the state of Illinois based on the North American Datum 83. AERSURFACE evaluated 30 degree sectors over a full circle to generate 12 sets of the three parameters (one for each sector).

The meteorological data output from AERMET is summarized in the windrose shown in Figure 4.2. Winds most commonly originate from the south-southwest and westerly directions in general, though winds originate from all directions for at least some percentage of time. The average wind speed over the 8,711 available measurements[2] for calendar year 2008 was 9.7 mph (treating calm conditions as 0). Hourly average winds exceeded 15 mph 13% of the time and 20 mph 4% of the time.

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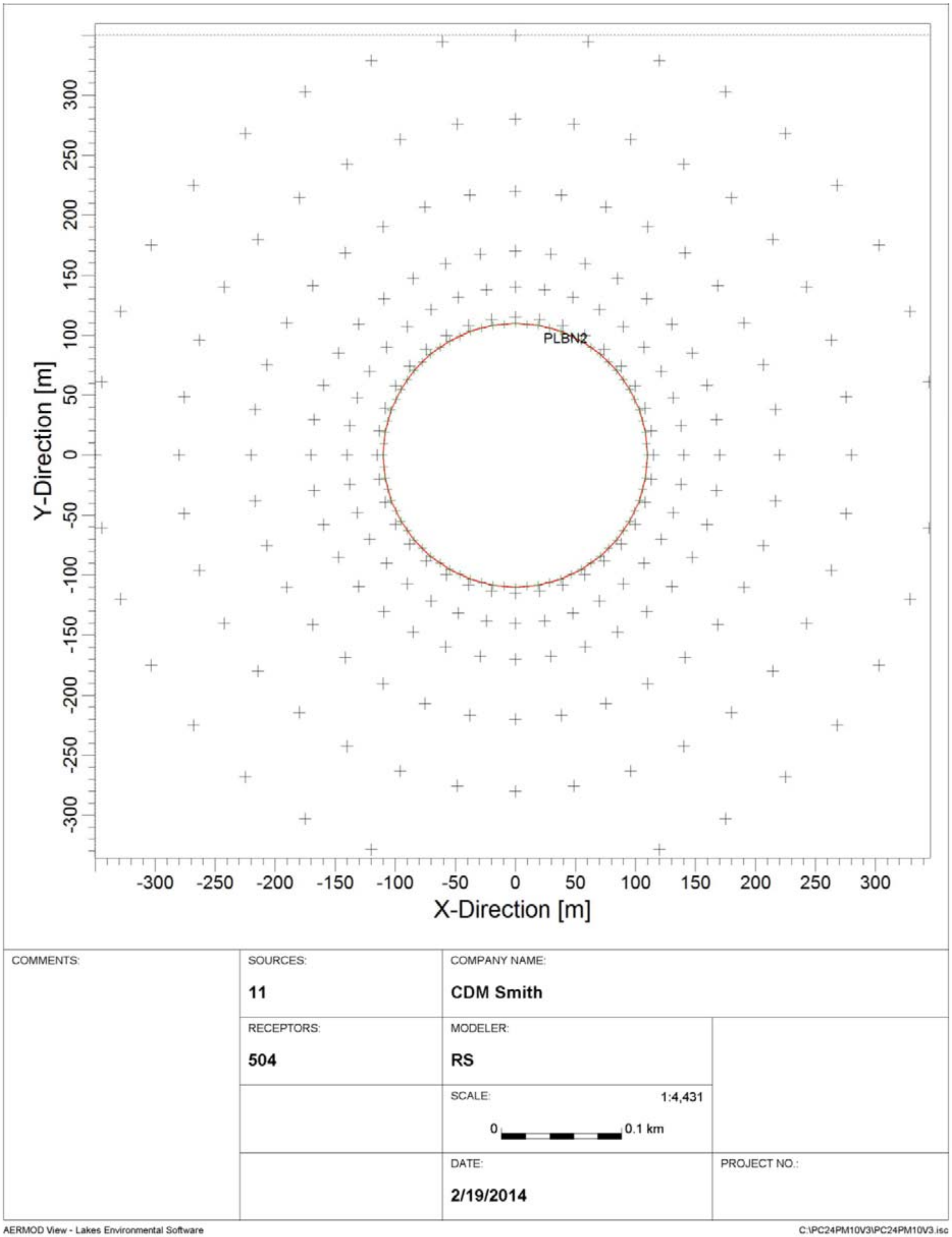
[2] Wind speeds were missing from 73 hours during the 2008 calendar year. These hours are assigned a code of 999 by AERMET and are ignored by AERMOD in dispersion modeling, as are 500 additional hours that are reported as calm conditions (with 0 wind speed). For the purpose of estimating annual emission totals, hours with missing wind speeds were assigned the average values of wind speeds of the previous and subsequent hours, and calm conditions were assigned a wind speed of 0.25 m/s (half of the lowest measureable wind speed).



COMMENTS:

SOURCES:
11

COMPANY NAME:
CDM Smith

RECEPTORS:
504

MODELER:
RS

SCALE: 1:4,431

DATE:
2/19/2014

PROJECT NO.:

AERMOD View - Lakes Environmental Software

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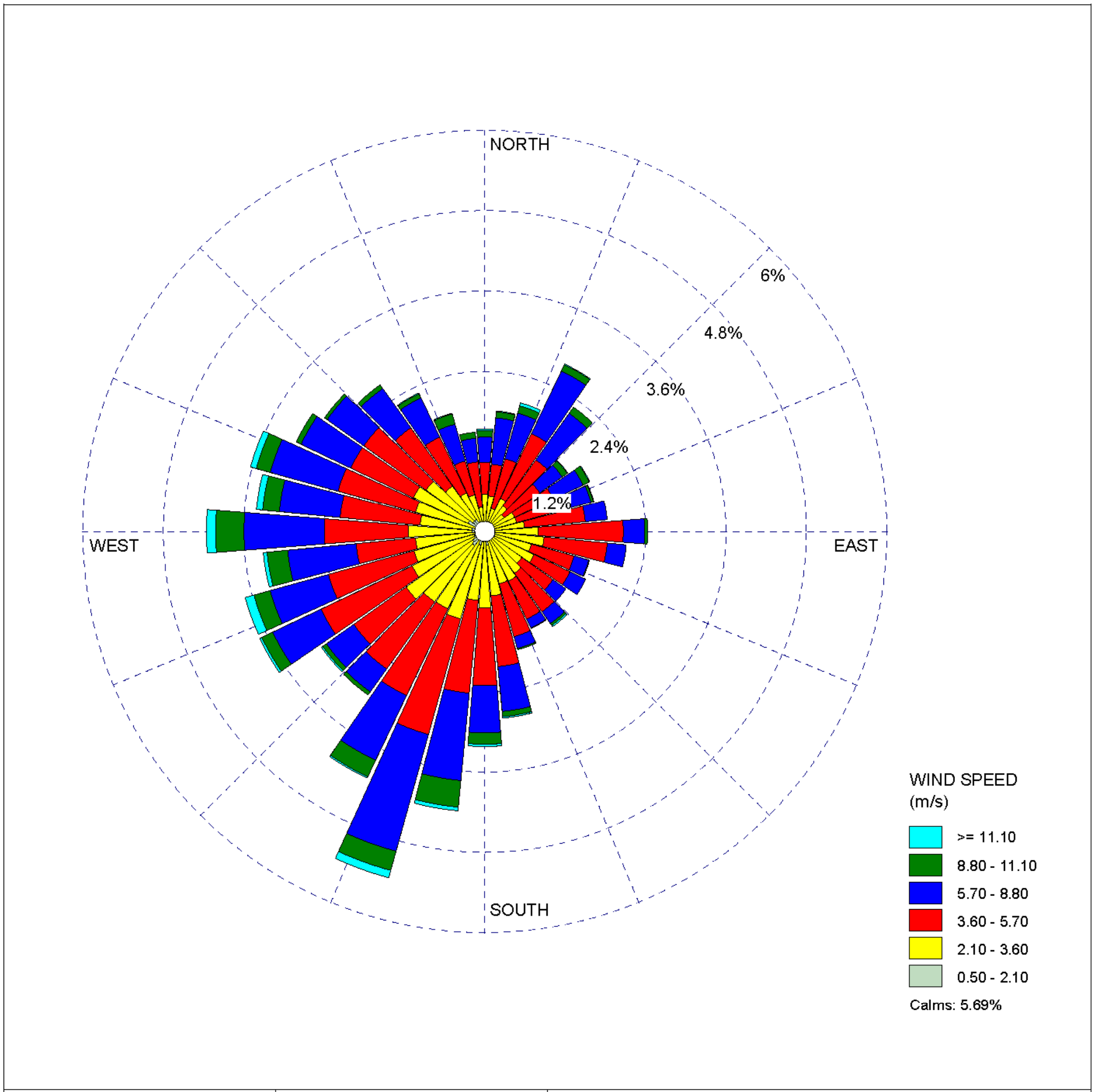
Figure 4-1 Polar and Fenceline Receptor Grid



COMMENTS:	DATA PERIOD: **Start Date: 1/1/2008 - 00:00** **End Date: 12/31/2008 - 23:00**	COMPANY NAME: **CDM Smith**	
		MODELER: **RS**	
	CALM WINDS: **5.69%**	TOTAL COUNT: **8711 hrs.**	
	AVG. WIND SPEED: **4.34 m/s**	DATE: **2/19/2014**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 4-2 Windrose for Chicago Midway Airport 2008 Surface Observations

4.2.4 Pollutants and Averaging Times

Modeling was conducted for emissions of particulate matter less than 10 micrometers aerodynamic diameter (PM_{10}) and particulate matter less than 2.5 micron aerodynamic diameter ($PM_{2.5}$) from petcoke and coal material handling operations. The sources that comprise the material handling operation are discussed in Section 4.3. Modeling of PM_{10} was conducted for a 24-hour averaging time for both petcoke and coal material handling operations in recognition of PM_{10}'s National Ambient Air Quality Standard (NAAQS). Similarly, modeling of $PM_{2.5}$ was conducted for annual and 24-hour averaging periods for petcoke and coal handling operations in recognition of $PM_{2.5}$'s NAAQSs. In addition, 1-hour average PM_{10} modeling was conducted to examine specific impacts of the wind erosion from stockpiles source for both petcoke and coal.

Particulate matter deposition using particle size data was not considered for any modeling runs, resulting in no removal of mass from the plume, and hence likely more conservative predictions of impacts to ambient air.

4.3 Emission Sources

4.3.1 Source Types

AERMOD has the capability of modeling various types of fugitive dust sources that include area sources, volume sources, and line sources as line volume sources.[3] Area sources are appropriate to model ground level releases with no plume rise such as storage piles. Volume sources apply to conveyors and other sources where a plume would be generated from a drop-like operation. Line sources include roadways. AERMOD can be used to model line sources as a series of adjacent volume sources.

Area sources were used for modeling any variations in area to the storage pile surface such as for bulldozer operations in a specific area. Area source emission rates are simply the equipment emission rate in mass per time divided by the total source area. For short-term modeling applications where a bulldozer would be working in a specific area of the storage pile, its emission rate would be distributed over that localized area, usually a fraction of the total area. For long-term modeling applications over a year or more where a bulldozer would be working over the entire face of the storage pile, the emission rate would appropriately be distributed by the total storage pile working face area. The release heights for area sources were assumed to be zero (ground-level).

For this evaluation, roadways, both paved and unpaved (traffic over the bulk material surface), were modeled as adjacent volume sources in accordance with EPA guidance.[4] The top of the source's plume height is given as 1.7 times the vehicle height and the source's plume release height is calculated as ½ of the top of the plume height. The recommended plume width is calculated as the vehicle width plus six meters for a single lane road, which is the approach used for this modeling evaluation. The initial vertical plume size is calculated as the plume height divided by a factor of 2.15, and the initial horizontal plume height is calculated as the plume width divided by 2.15.

---

[3] AERMOD as issued by EPA does not contain algorithms for line sources. The Lakes Environmental interface to AERMOD allows specification of line sources that are translated into series of adjacent volume sources.

[4] Volume II of the U.S. EPA User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (U.S. EPA, 1992).

4.3.2 Modeling Approach

The modeling approach considered a generic bulk material processing facility that includes various material handling operations and storage. Figure 2.1 shows the conceptual bulk material storage facility with the prime feature being a large storage pile shaped as a conical frustum. The material handling operations would include typical heavy equipment activity such as:

- Resupply of material to the storage pile via on-road haul truck activity;
- Preparation and maintenance of the storage pile with a bulldozer and grader;
- Material transport within the confines of the site and over the surface of the storage pile using a front-end loader and articulated dump truck;
- Conveyance of material for loading operations with a multi-segment conveyor system.

All of this equipment might not be used at every facility, but the goal of this study is to consider all possible means by which fugitive dust emissions might arise. With the exception of the storage pile itself, the emission sources are primarily defined by the use of heavy equipment and trucks at specific areas within confines of- and around- the site boundary. The sources and primary areas of operation used as inputs to the model are as follows:

- Wind erosion of the whole storage pile could occur annually as the surface is intermittently disturbed. The storage pile was modeled as an area source subject to wind erosion; therefore the emission rates input to the model were derived from wind erosion equations described in Section 3.5.
- A bulldozer and grader would likely operate in a nominal rectangular area to constantly reshape the storage pile as material is added and removed. Emissions from these activities would mainly be the dust from the bulldozer tracks and the grader blade. This source was modeled as rectangular area source located on the east side of the facility for short-term (daily) operations, but emissions were distributed over the full storage pile area for long-term projections. The emission rates input to the model were derived from equations described in Section 3.4.
- Haul trucks bringing new material to the facility for deposit and processing are assumed to travel on the paved perimeter road and dump material on the north side of the storage pile. The sources from this activity would be dust emissions mobilized from the pavement by truck tires and the dumping emissions where the material is unloaded at the north side of the pile. The paved roadway is assumed to originate from an east entrance and extend along the edge of the storage pile to the north where material unloading would occur. Emissions would include the round trip into and out of the site. The truck trip emissions were modeled as a line volume source, which is a series of nearly equal volume sources from the beginning of the route to the end. The emission rates for truck travel over paved road that were input to the model were derived from equations described in Section 3.3. The unloading of the new material at the north side of storage pile was modeled as a single volume source. The emission rates for truck unloading were derived from drop operation equations described in Section 3.1.
- An articulated dump truck and front-end loader operating on the face of the storage pile would travel along a makeshift unpaved road on the surface of the storage pile between the location

where the haul trucks unload and the center of the pile. The frontend loader would fill the articulated dump truck at the north side of the site and they would travel together to the center of the site where the dump truck would unload its material and the front-end loader would load material onto the conveyor inlet hopper. The loading of the articulated dump truck was modeled as a single volume source using emission rates derived from the drop equations described in Section 3.1. Travel-related emissions of the loader and dump truck on the unpaved road (bulk material surface) between the center of the pile and the north side of the pile were modeled using emission rates derived from unpaved road equations described in Section 3.2. The paved road was treated as a series of nominally equal volume sources. The articulated dump truck unloading near the conveyor was modeled as a single volume source using emission rates derived from the drop equations described in Section 3.1.

- The conveyor would be covered except at three positions in the system, the inlet, an intermediate segment change in conveyance and the outlet of the conveyor system. The two points where fugitive emissions would occur would be at the intermediate segment change and the outlet. The outlet is where barge and train car loading would occur. The conveyor system outlet and intermediate locations were modeled as single volume sources using emission rates derived from the drop equations described in Section 3.1.

Table 4-1 summarizes each of these activities and how they are defined for modeling purposes.

4.4 PM_{10} (24-hr) and $PM_{2.5}$ (Annual, 24-hr) Modeling Results

Petcoke and coal material handling operations were modeled for the maximum 24-hour average PM_{10} concentrations and the maximum annual-average and 24-hour average $PM_{2.5}$ concentrations. AERMOD was setup to allow the evaluation of individual and groups of fugitive emission sources. The modeling results are presented in the following sections.

4.4.1 Petcoke Material Handling Modeling Results

The petcoke material handling modeling results and corresponding figures that graphically summarize the modeling results are described in Table 4-2. Each modeling scenario is represented by a corresponding figure that is described in the table and included in Appendix C. Figures depicting the predicted impacts of all sources (summed together) are also included in this section.

As Shown in Table 4-2, predicted concentrations of 24-hour averaged PM_{10} and 24-hour average $PM_{2.5}$ greatly exceed National Ambient Air Quality Standards (NAAQSs). Among the source groups, bulldozer/grader operations are predicted to result in the maximum incremental concentration (4,899 $\mu g/m^3$ for PM_{10} and 317 $\mu g/m^3$ for $PM_{2.5}$, both at the same receptor). Substantial impacts are also predicted for the paved and unpaved road sources. For the annual averaging period, the total predicted concentration of $PM_{2.5}$ only modestly exceeded the level of the NAAQS. In terms of individual sources, paved road emissions dominate the total predicted annual-average $PM_{2.5}$ concentration and the source-specific maximum $PM_{2.5}$ concentration of 14 $\mu g/m^3$ would occur along the perimeter road. This concentration exceeds the NAAQS of 12 $\mu g/m^3$ and (as expected for a ground-level source) the predicted impacts rapidly drop off within a few meters further away from the perimeter road.

Table 4-1 Modeling Source Summary

Source Description/ Type	ID	Applicable Modeling Averaging Period	Height [m]	Diameter [m]	SigmaY [m]	SigmaZ [m]	Length_X [m]	Configuration	Line Volume Height [m]	Plume Width [m]	Line Volume Type
Wind Erosion from stockpiles/ AREA_CIRC	CAREA1	All averaging periods	0	71.5		2					
Bull-dozer/Grader operations over the entire storage pile surface/ AREA_CIRC	FAREA1	Annual Averaging period	2	71.5		2					
Bull-dozer/Grader/ AREA_POLY	PAREA1	Short term Averaging periods (24-hour)	2			2					
Paved Road Haul Trucks/ LINE_VOLUME	SLINE1 (HT000001 - HT000018)	All averaging periods						Adjacent	5.7	8.44	Surface Based
Unpaved Road Articulated Dump Truck & Front End Loader/ LINE_VOLUME	SLINE2 (L0000069 - L0000075)	Short term Averaging periods (24-hour)						Adjacent	5.18	9.05	Surface Based
Unpaved Road Articulated Dump Truck & Front End Loader/ AREA_CIRC	UAREA1	For the long-term averaging period, the emissions were spread-out over the entire area of the storage pile.	2	71.5		2					
Conveyor Drop 1/ VOLUME	VOL1	All averaging periods	5		1.163	1.163	5.0009				
Conveyor Drop 2/ VOLUME	VOL2	All averaging periods	5		1.163	1.163	5.0009				
Conveyor Drop 3/ VOLUME	VOL3	All averaging periods	5		1.163	1.163	5.0009				
On-Road Haul Truck Dump/ VOLUME	VOL4	All averaging periods	2.438		0.567	0.567	2.4381				
Articulated Dump Truck Loading/ VOLUME	VOL5	All averaging periods	3.048		0.425	0.567	1.8275				

Note: A base elevation of zero was used for all sources; emission rates were not included because an hourly emission rate source file that has more than one emission rate per source was used for each run. Lake Environmental AERMOD View uses single abbreviated source IDs to represent multiple volume sources (SLINE1 and SLINE2). Because the temperature of the sources are nearly ambient, fugitive dust emission plumes are modeled as not being buoyant.

Table 4-2 AERMOD Modeling Results Summary for Petcoke Material Handling

Material	Pollutant	Averaging Period	Source Group	Figure	Maximum Predicted Concentration (µg/m^3)	Coordinates (meters)	
						X	Y
Petcoke	PM$_{10}$	24-hour (NAAQS = 150 µg/m^3)	All	4.3, 4.3a	**5297**	70.71	84.26
			Dozer	4.3b	**4899**	70.71	84.26
			Drops	4.3c	69.6	-70.71	-84.26
			Paved Roads	4.3d	**450.3**	110	0
			Travel on Pile Surface	4.3e	**276.7**	37.62	103.37
			Wind Erosion from Stockpiles	4.3f	9.6	103.4	37.6
	PM$_{2.5}$	24-hour (NAAQS = 35 µg/m^3)	All	4.4, 4.4a	**390.5**	70.71	84.26
			Dozer	4.4b	**317.5**	70.71	84.26
			Drops	4.4c	10.5	-70.71	-84.26
			Paved Roads	4.4d	**110.5**	110	0
			Travel on Pile Surface	4.4e	27.7	37.62	103.37
			Wind Erosion from Stockpiles	4.4f	1.4	103.4	37.6
	PM$_{2.5}$	Annual (NAAQS = 12 µg/m^3)	All	4.5, 4.5a	**21.4**	108.3	19.1
			Dozer	4.5b	6.1	84.26	70.71
			Drops	4.5c	0.8	-70.71	-84.26
			Paved Roads	4.5d	**14.1**	108.3	19.1
			Travel on Pile Surface	4.5e	0.9	84.26	70.71
			Wind Erosion from Stockpiles	4.5f	0.1	37.62	103.37

4.4.2 Coal Material Handling Modeling Results

The coal material handling modeling results and corresponding figures that graphically summarize the modeling results are described in Table 4-3. Each modeling scenario is represented by a corresponding figure that is described in the table and included in Appendix C. Figures depicting the predicted impacts of all sources (summed together) are also included in this section.

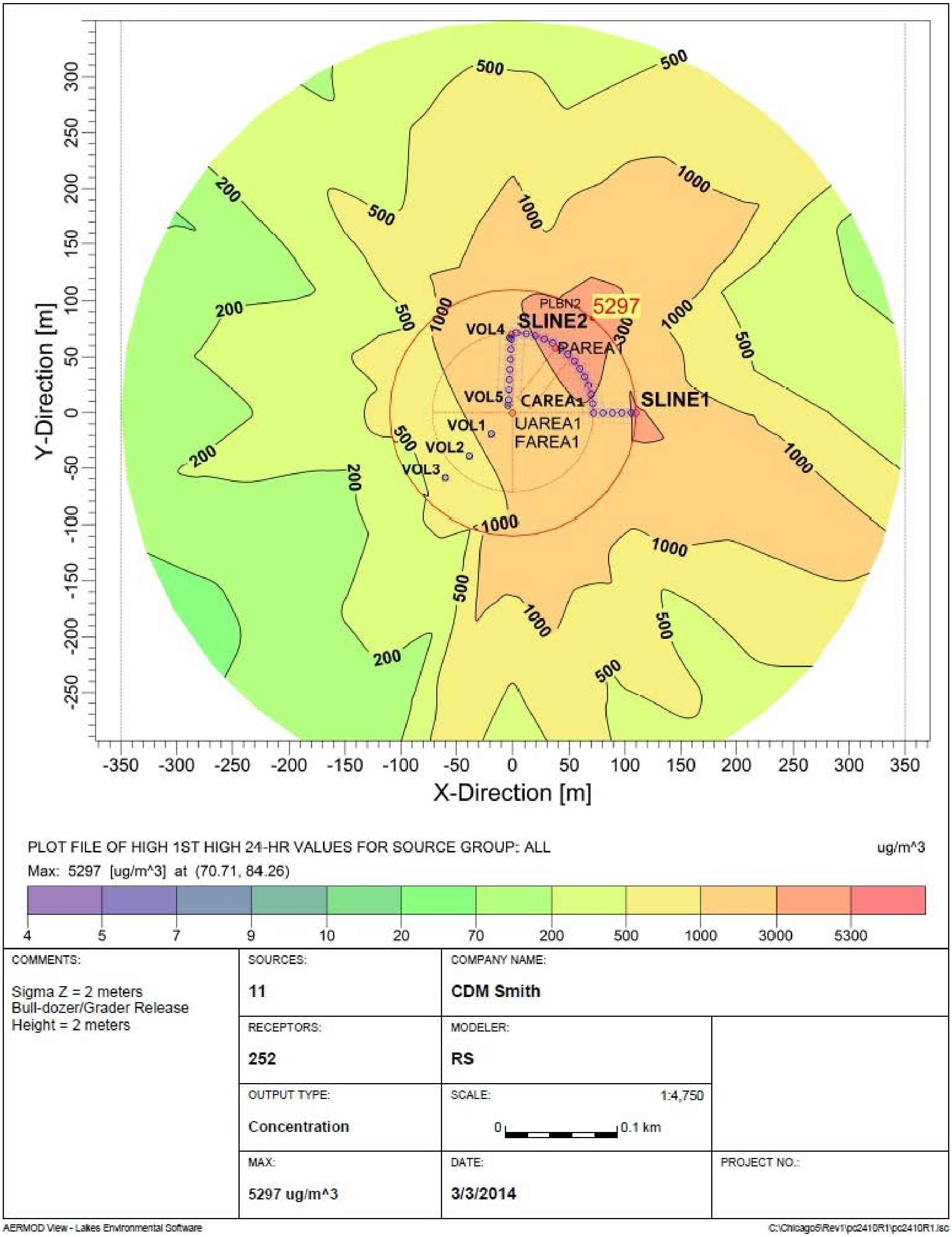
As shown in the table and similar to the modeling results for petcoke, AERMOD predicted for coal material handling operations that for the 24-hour averaging period, among all the source groups, bulldozer/grader operations would result in the maximum concentration of both PM$_{10}$ and PM$_{2.5}$ (at the same receptor in each case). Predicted maximum concentrations are lower than those for petcoke (by as much as a factor of 4, depending on the specific emission source), but still substantially larger than NAAQS. AERMOD also predicted that for the annual averaging period, paved road emissions would dominate the total predicted concentration.

Table 4-3 AERMOD Modeling Results Summary for Coal Material Handling

Material	Pollutant	Averaging Period	Source Group	Figure	Maximum Predicted Concentration (µg/m^3)	Coordinates (meters)	
						X	Y
Coal	PM$_{10}$	24-hour (NAAQS = 150 µg/m^3)	All	4.6, 4.6a	**1509**	70.71	84.26
			Dozer	4.6b	**1215**	70.71	84.26
			Drops	4.6c	111	-70.71	-84.26
			Paved Roads	4.6d	**450.3**	110	0
			Travel on Pile Surface	4.6e	70	37.62	103.37
			Wind Erosion from Stockpiles	4.6f	8.4	103.37	37.62
	PM$_{2.5}$	24-hour (NAAQS = 35 µg/m^3)	All	4.7, 4.7a	**186**	70.71	84.26
			Dozer	4.7b	**119.5**	70.71	84.26
			Drops	4.7c	16.8	-70.71	-84.26
			Paved Roads	4.7d	**110.5**	110	0
			Travel on Pile Surface	4.7e	7	37.62	103.37
			Wind Erosion from Stockpiles	4.7f	1.26	103.37	37.62
	PM$_{2.5}$	Annual (NAAQS = 12 µg/m^3)	All	4.8, 4.8a	**17.2**	108.3	19.1
			Dozer	4.8b	2.3	84.26	70.71
			Drops	4.8c	1.3	-70.71	-84.26
			Paved Roads	4.8d	**14.1**	108.3	19.1
			Travel on Pile Surface	4.8e	0.2	84.26	70.71
			Wind Erosion from Stockpiles	4.8f	0.08	37.62	103.37

4.4.3 Wind Erosion Modeling for the Petcoke and Coal Storage Piles

The specific effects of wind on each of a petcoke and coal storage pile were modeled by isolating the AERMOD modeling runs to only the PM$_{10}$ emission rate derived from the wind erosion from stockpiles equations. The modeling was performed for a 1-hour averaging period, corresponding to the emission algorithms that assume that material blows off the pile during the hour of the day with the highest wind speed. The results are graphically represented in Figures 4.9 and 4.10 for petcoke and coal dust, respectively and are included in Appendix C. The highest 1-hour concentrations are of the order of 200 µg/m^3, which, when averaged over a 24-hour period, would not likely lead to exceedance of the PM$_{10}$ NAAQS. However, given the high winds that accompany the predicted wind erosion events, the amount of material released during these events could be substantial relative to other emission sources.



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 5297 [ug/m^3] at (70.71, 84.26)

COMMENTS:

Sigma Z = 2 meters
Bull-dozer/Grader Release
Height = 2 meters

SOURCES:
11

COMPANY NAME:
CDM Smith

RECEPTORS:
252

MODELER:
RS

OUTPUT TYPE:
Concentration

SCALE:
1:4,750
0 0.1 km

MAX:
5297 ug/m^3

DATE:
3/3/2014

PROJECT NO.:

AERMOD View - Lakes Environmental Software

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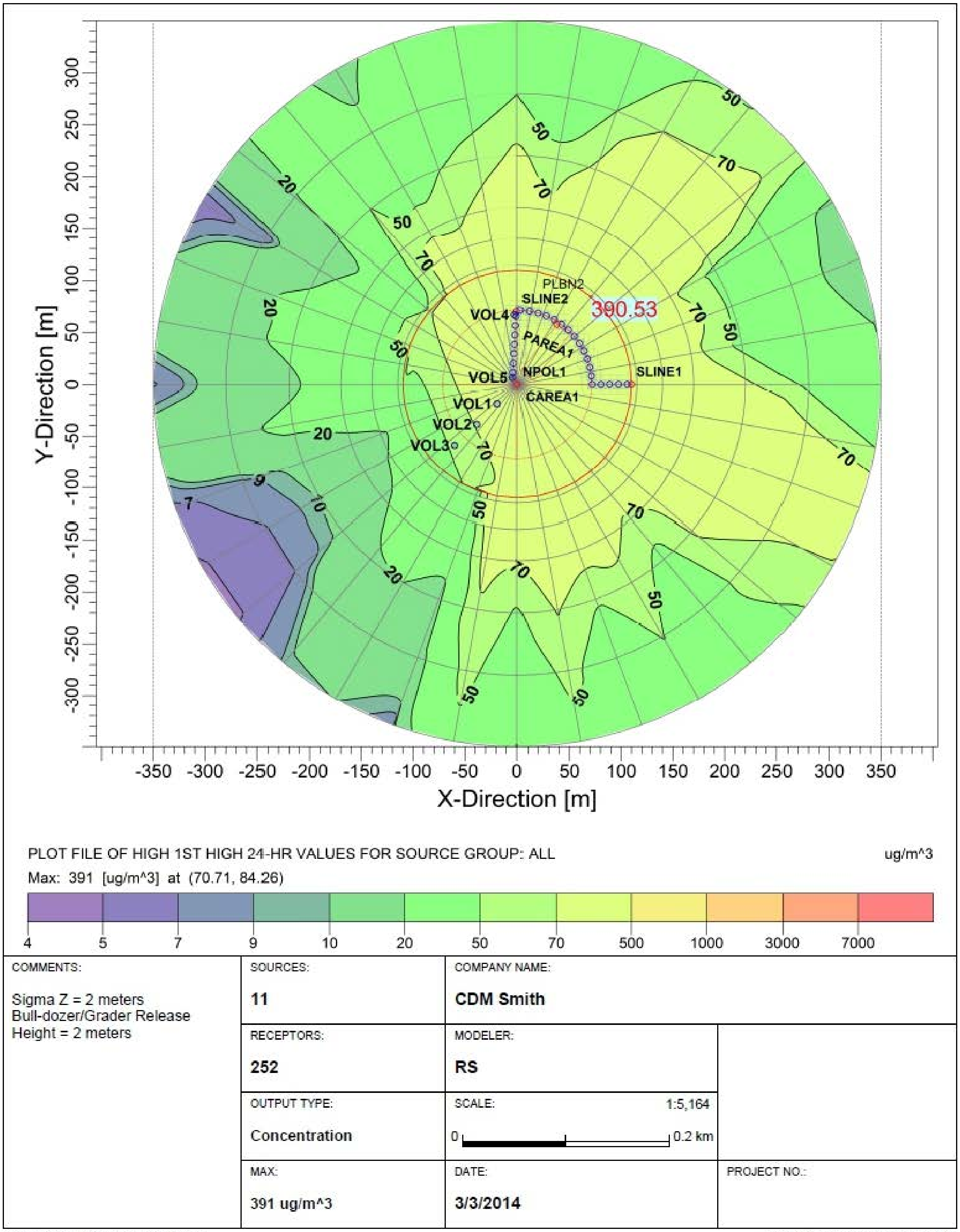
Figure 4-3 Highest 24-Hour Average PM_{10} Concentration Predictions for Petroleum Coke (All Sources)



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

ug/m^3

Max: 391 [ug/m^3] at (70.71, 84.26)

COMMENTS:

Sigma Z = 2 meters
Bull-dozer/Grader Release
Height = 2 meters

SOURCES: 11

COMPANY NAME: CDM Smith

RECEPTORS: 252

MODELER: RS

OUTPUT TYPE: Concentration

SCALE: 1:5,164

MAX: 391 ug/m^3

DATE: 3/3/2014

PROJECT NO.:

AERMOD View - Lakes Environmental Software

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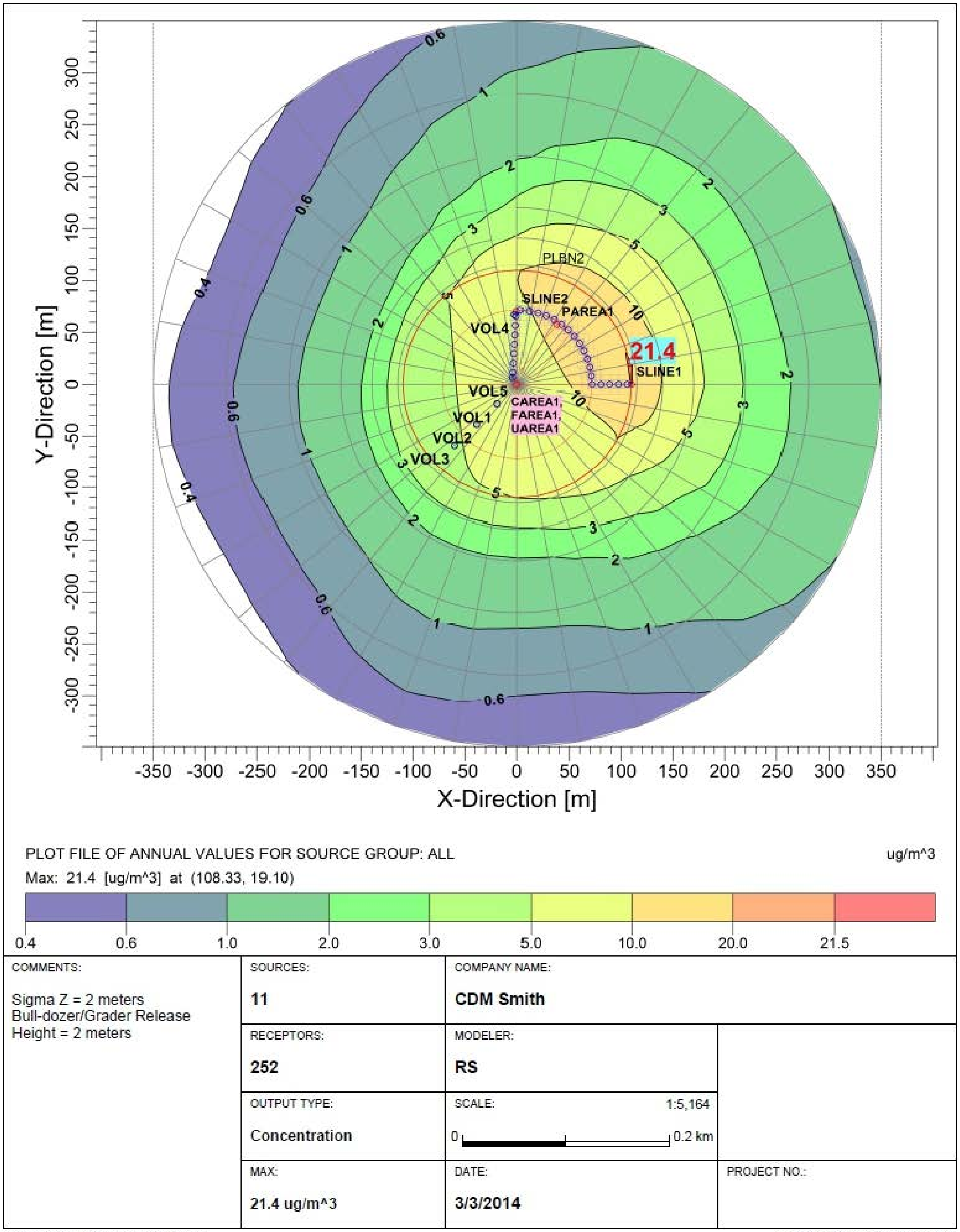
Figure 4-4 Highest 24-Hour Average $PM_{2.5}$ Concentration Predictions for Petroleum Coke (All Sources)



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: ALL

Max: 21.4 [ug/m^3] at (108.33, 19.10)

COMMENTS:

Sigma Z = 2 meters
Bull-dozer/Grader Release
Height = 2 meters

SOURCES:
11

COMPANY NAME:
CDM Smith

RECEPTORS:
252

MODELER:
RS

OUTPUT TYPE:
Concentration

SCALE:
1:5,164
0 — 0.2 km

MAX:
21.4 ug/m^3

DATE:
3/3/2014

PROJECT NO.:

AERMOD View - Lakes Environmental Software

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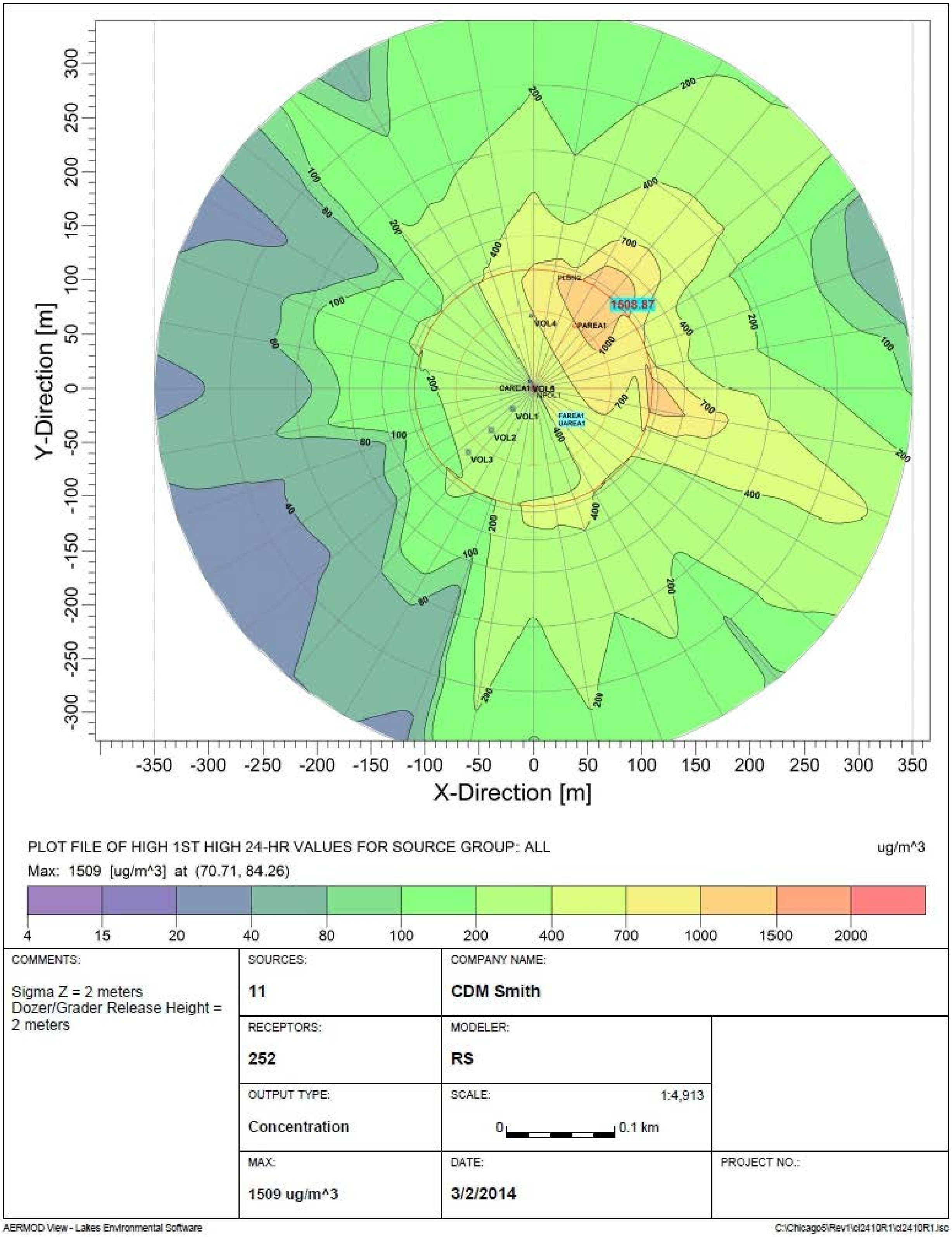
Figure 4-5 **Highest Annual Average $PM_{2.5}$ Concentration Predictions for Petroleum Coke (All Sources)**



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

Max: 1509 [ug/m^3] at (70.71, 84.26)

COMMENTS:

Sigma Z = 2 meters
Dozer/Grader Release Height = 2 meters

SOURCES:

11

COMPANY NAME:

CDM Smith

RECEPTORS:

252

MODELER:

RS

OUTPUT TYPE:

Concentration

SCALE: 1:4,913

0 0.1 km

MAX:

1509 ug/m^3

DATE:

3/2/2014

PROJECT NO.:

AERMOD View - Lakes Environmental Software

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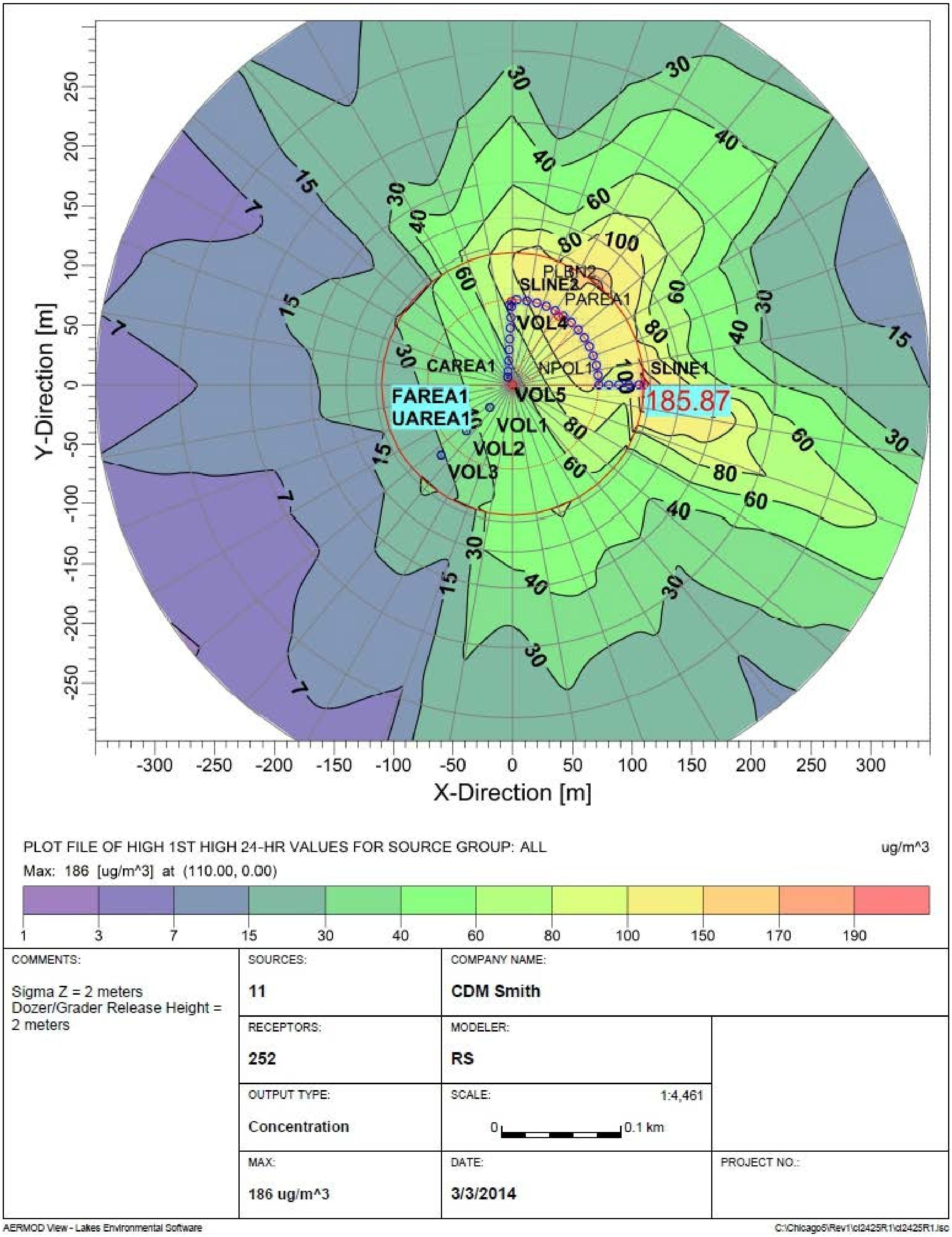
Figure 4-6 Highest 24-Hour Average PM_{10} Concentration Predictions for Coal (All Sources)



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

Max: 186 [ug/m^3] at (110.00, 0.00)

COMMENTS: Sigma Z = 2 meters Dozer/Grader Release Height = 2 meters	SOURCES: 11	COMPANY NAME: CDM Smith	
	RECEPTORS: 252	MODELER: RS	
	OUTPUT TYPE: Concentration	SCALE: 1:4,461 0 0.1 km	
	MAX: 186 ug/m^3	DATE: 3/3/2014	PROJECT NO.:

AERMOD View - Lakes Environmental Software

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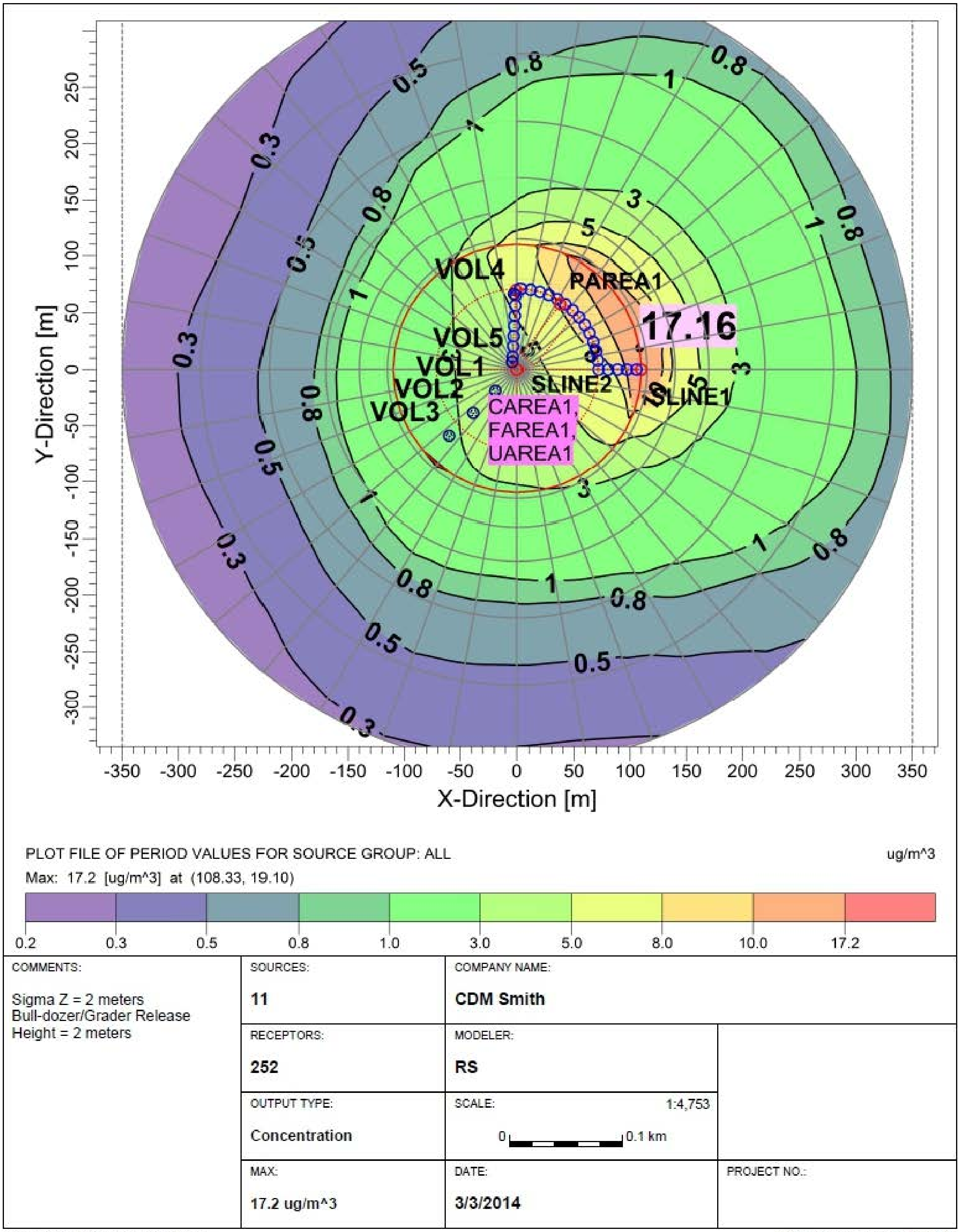
Figure 4-7 Highest 24-Hour Average $PM_{2.5}$ Concentration Predictions for Coal (All Sources)



PLOT FILE OF PERIOD VALUES FOR SOURCE GROUP: ALL

Max: 17.2 [ug/m^3] at (108.33, 19.10)

COMMENTS:

Sigma Z = 2 meters
Bull-dozer/Grader Release
Height = 2 meters

SOURCES: 11

COMPANY NAME: CDM Smith

RECEPTORS: 252

MODELER: RS

OUTPUT TYPE: Concentration

SCALE: 1:4,753

0 0.1 km

MAX: 17.2 ug/m^3

DATE: 3/3/2014

PROJECT NO.:

AERMOD View - Lakes Environmental Software

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Figure 4-8 Highest Annual Average $PM_{2.5}$ Concentration Predictions for Coal (All Sources)

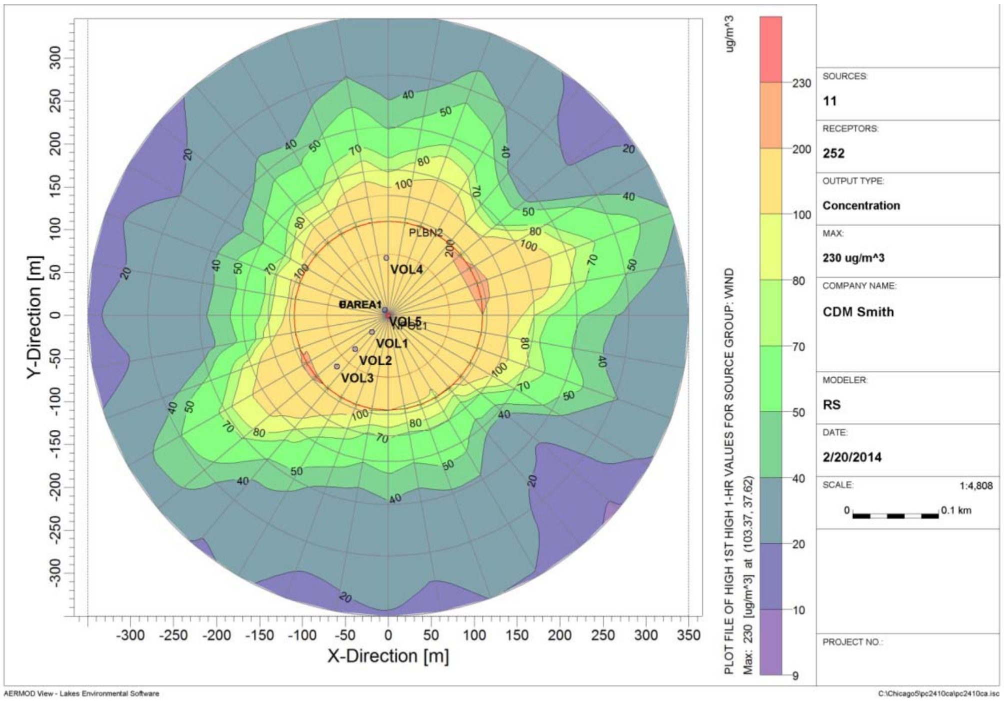


Figure 4-9 1-Hour Averaging Period PM10 Emissions Wind Erosion of a Petcoke Storage Pile

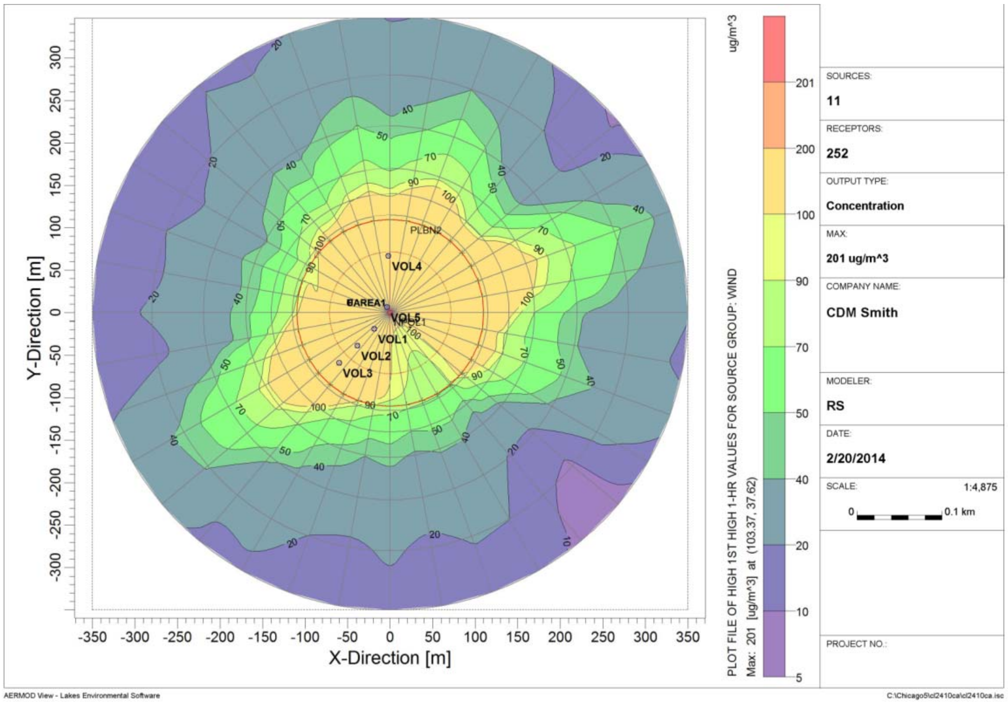


Figure 4-10 1-Hour Averaging Period PM10 Emission Rate Wind Erosion of a Coal Storage Pile

4.5 Interpretation of Model Predictions

Prediction of incremental PM_{10} and $PM_{2.5}$ concentrations greater than the NAAQS levels does not necessarily mean that air quality standards will in practice be exceeded as (1) fugitive dust emission factors may overpredict actual emissions, (2) facilities may not employ all of the sources considered, and/or in the manner considered, and (3) there has been no accounting of potential mitigation efforts designed to curb dust emissions. However, given the magnitude of incremental concentrations predicted for some emission sources, the potential exists for NAAQSs to be exceeded, especially at locations close to bulk material processing and storage facilities. Predicted concentrations are generally predicted to decrease rapidly with distance from the facility, characteristic of the dispersion of emissions from a ground-level source.

Based on modeling assumptions, the processes most likely to affect air quality are bulldozing/grading operations, paved road emissions, and unpaved road (bulk material surface) emissions. Predicted impacts from the paved road emission source are the same for petroleum coke and coal because the estimates are independent of material properties, depending principally on the amount of fine dust present on the roads available to be mobilized by vehicular traffic. The AP42-based value for road silt loading is based on older data collected from industrial facilities and may greatly overestimate values at facilities that employ street sweepers and dust suppression (watering). For the bulldozing/grading and unpaved road (bulk material surface) sources, modeling estimates for the petroleum coke material are substantially larger than those for coal, a result of the much higher silt content of the petcoke material that leads to higher predicted emissions. Uncertainty associated with the emissions estimates may be substantial, as reflected by low emission factor ratings in the AP42 database.

4.6 Comparison to Background Air Quality in Chicago

Chicago, like many urban areas, has many emission sources of particulate matter that contribute to significant background concentrations of $PM_{2.5}$ and PM_{10}. Data from the 2012 Illinois Air Quality Report (http://www.epa.state.il.us/air/air-quality-report/2012/air-quality-report-2012.pdf) indicate background concentrations are close to the levels of the National Ambient Air Quality Standards (NAAQS). Monitored annual average $PM_{2.5}$ concentrations are of the order of 12 $\mu g/m^3$, or approximately the same as the allowable NAAQS of 12 $\mu g/m^3$ (Figure 4-11). Measured 24-hour average $PM_{2.5}$ concentrations reach as high as 30 $\mu g/m^3$, or about 86% of the NAAQS of 35 $\mu g/m^3$ (Figure 4-12). The highest 24-hour average PM_{10} concentration of 106 $\mu g/m^3$ measured in 2012 represents 71% of the 150 $\mu g/m^3$ NAAQS (Figure 4-13). In all cases (and particularly for $PM_{2.5}$), incremental particulate matter concentrations due to emissions from bulk material processing and storage facilities must be small in order to avoid localized exceedances of the NAAQS. The model predictions of Table 4-2 and 4-3, however, indicate the potential impacts of bulk material facilities may be substantial. Given the levels of potential impacts and the limited gap between background levels and NAAQS, it may be difficult for bulk material facilities to avoid localized exceedances of air quality standards even if diligent mitigation measures are employed.

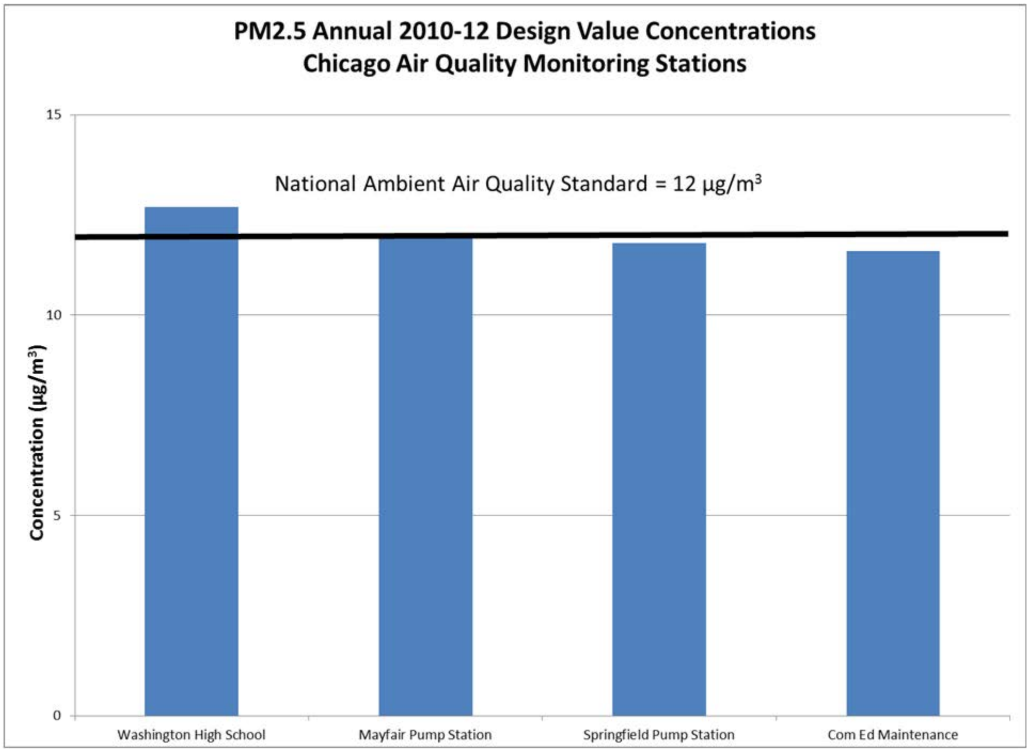


Figure 4-11 Annual Average $PM_{2.5}$ Concentrations at Monitoring Locations in Chicago

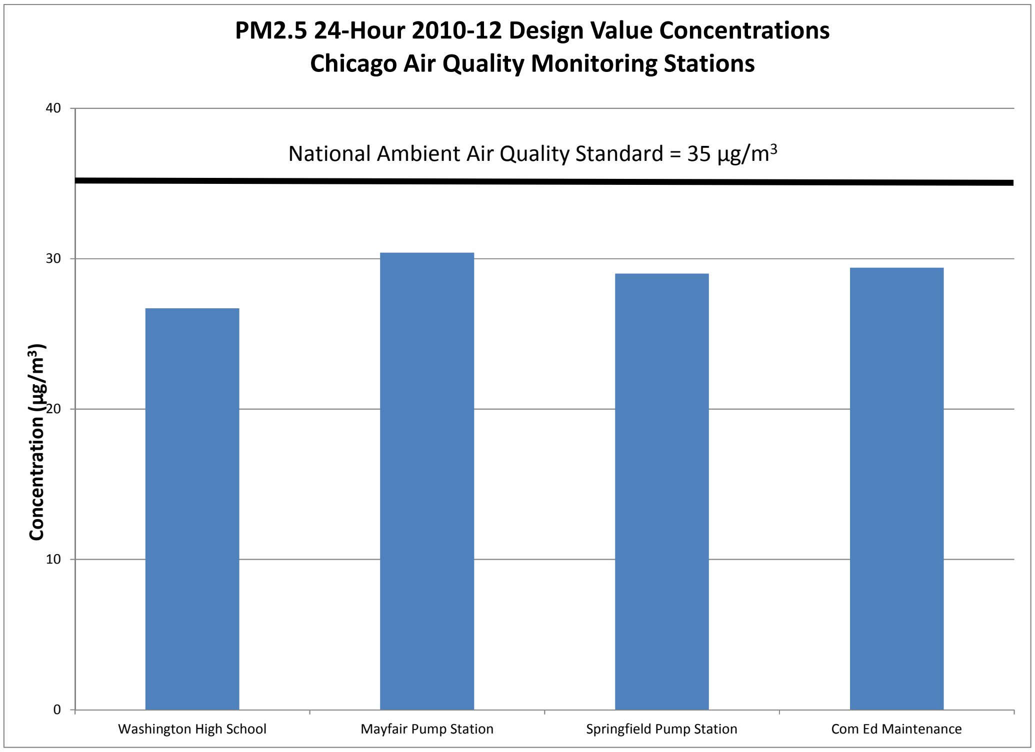


Figure 4-12 24-Hour Average $PM_{2.5}$ Concentrations at Monitoring Locations in Chicago

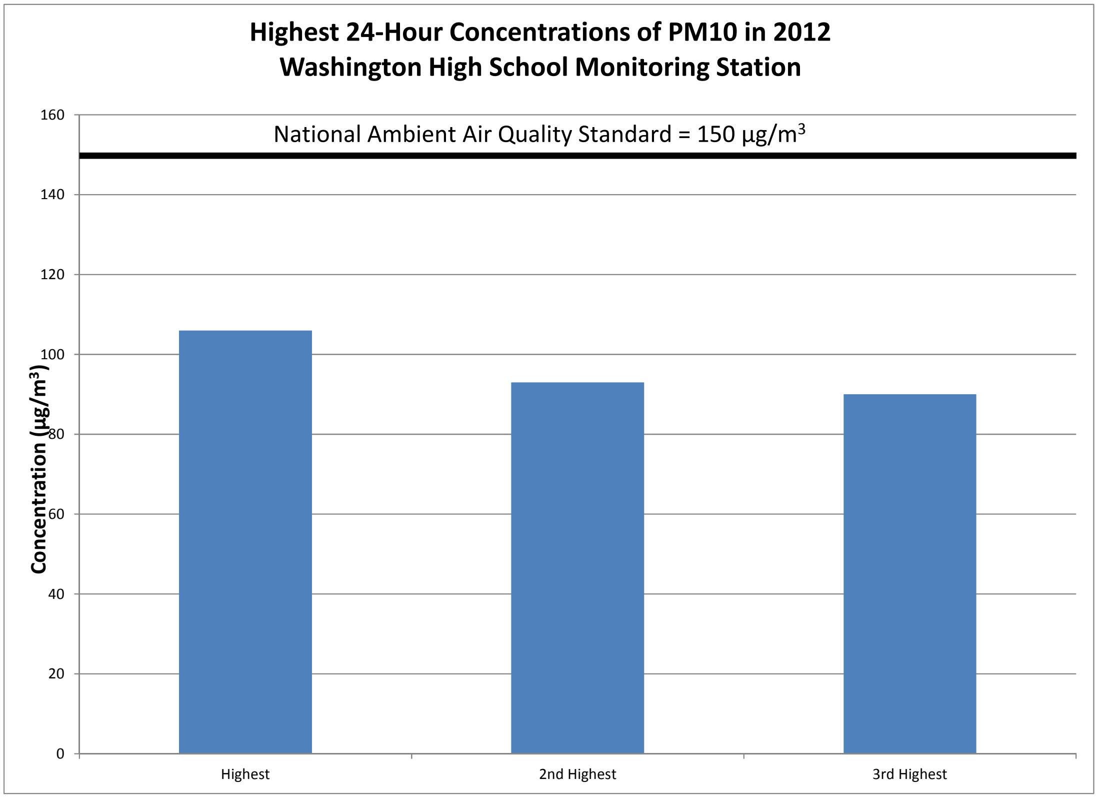


Figure 4-13 24-Hour Average PM_{10} Concentrations at Monitoring Locations in Chicago

Section 5

Conclusions

Calculations indicate that fugitive dust emissions from bulk material storage and handling facilities may be substantial enough to lead to localized exceedances of the National Ambient Air Quality Standards for PM_{10} and $PM_{2.5}$. The study does not account for use of mitigation methods to reduce fugitive dust emissions. Varying characteristics of bulk materials are likely to lead to differences in emissions among facilities. In particular, model equations predict greater emissions for materials with high silt contents. Thus, of the materials examined in this study, the highest overall emissions and air quality impacts are predicted for the petroleum coke material.

The various categories of emission sources are predicted to have differing levels of impacts to ambient air. The following are predicted impacts from various sources handling petcoke and coal:

- Drop operations from conveyor points and bulk material transfers are predicted to lead to modest increases in ambient dust concentrations. The fenceline increments of 111 μg/m^3 for 24-hour average PM_{10} and 16.8 μg/m^3 for 24-hour average $PM_{2.5}$ predicted for coal (Table 4-3), when combined with background, could contribute to exceedances of National Ambient Air Quality Standards (NAAQSs).

- Travel on the surface of the storage pile by off-road construction vehicles (an articulated truck and a front-end loader) are predicted to result in a worst-case incremental 24-hour average PM_{10} fenceline concentration of petcoke of 277 μg/m^3 that by itself exceeds the NAAQS.

- Haul trucks traveling on the paved access road are predicted to cause high localized impacts, with the worst-case incremental 24-hour average fenceline concentrations of 450 μg/m^3 (PM_{10}) and 110 μg/m^3 ($PM_{2.5}$) each about three times the level of the NAAQS. The modeled annual average $PM_{2.5}$ concentration of 14 μg/m^3 is also predicted to exceed the NAAQS. The dust level on the industrial roads, a key parameter used in the calculations, may be overestimated for local roads and current practices. Location of the haul road adjacent to the fenceline also contributes to the elevated impacts.

- Bulldozing operations are responsible for the highest incremental 24-hour average fenceline concentrations of 4,899 μg/m^3 (PM_{10}) and 317 μg/m^3 ($PM_{2.5}$) for the petcoke material (Table 4-2), each approximately an order of magnitude greater than the NAAQSs, A worst-case increment of 6 μg/m^3 to the annual $PM_{2.5}$ concentration (Table 4-2) is roughly half the level of the NAAQS.

- Wind erosion of the storage pile surface leads to the lowest predicted increments to ambient dust concentrations (Table 4-2 and Table 4-3). This in part results from the episodic nature of wind erosion, which is assumed to occur only once per day during the hour of the highest (and most dispersive) wind speed. Figure 4-9 and Figure 4-10, which depict potential 1-hour average dust concentrations due to storage pile wind erosion, indicate substantial short-term impacts are possible, especially in cases in which material is blown off the pile instantaneously.

The estimates may reflect conservative assumptions regarding vehicle utilization and facility-related activities. Given the study's inherent uncertainties and assumptions, the study results are best interpreted as indicating a potential for bulk material processing and storage facilities to adversely affect air quality. Use of best management practices can mitigate most fugitive dust impacts, but potential localized exceedances of National Ambient Air Quality Standards may still result, and air quality monitoring may be a useful tool to better evaluate facility impacts.

Appendix A

Petroleum Coke Data

STAT Analysis Corporation
2242 West Harrison St., Suite 200, Chicago, IL 60612-3766
Tel: (312) 733-0551 Fax: (312) 733-2386 STATinfo@STATAnalysis.com
Accreditation Numbers: IEPA ELAP 100445; ORELAP IL300001;AIHA 101160; NVLAP LabCode 101202-

February 25, 2014

CDM Smith Inc.
125 S. Wacker Drive, Suite 600
Chicago, IL 60606
Telephone: (312) 346-5000
Fax: (312) 346-5228

RE: PPT DOC STAT Project No 13120303

Dear John Grabs:

STAT Analysis received 2 samples for the referenced project on 12/13/2013 11:25:00 AM. The analytical results are presented in the following report.

All analyses were conducted at the University of Illinois at Chicago, Department of Civil Engineering under the supervision of Dr. Krishna Reddy. All analyses were performed in accordance with methods as referenced on the analytical report.

Thank you for the opportunity to serve you and I look forward to working with you in the future. If you have any questions regarding the enclosed materials, please contact me at (312) 733-0551.

Sincerely,

Craig Chawla
Project Manager

Client: CDM Smith Inc.
Project: PPT DOC
Lab Order: 13120303

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Tag Number	Collection Date	Date Received
13120303-001A	PPTDOC-KCBX-South		12/13/2013 10:00:00 AM	12/13/2013
13120303-002A	PPTDOC-KCBX-North		12/13/2013 10:15:00 AM	12/13/2013

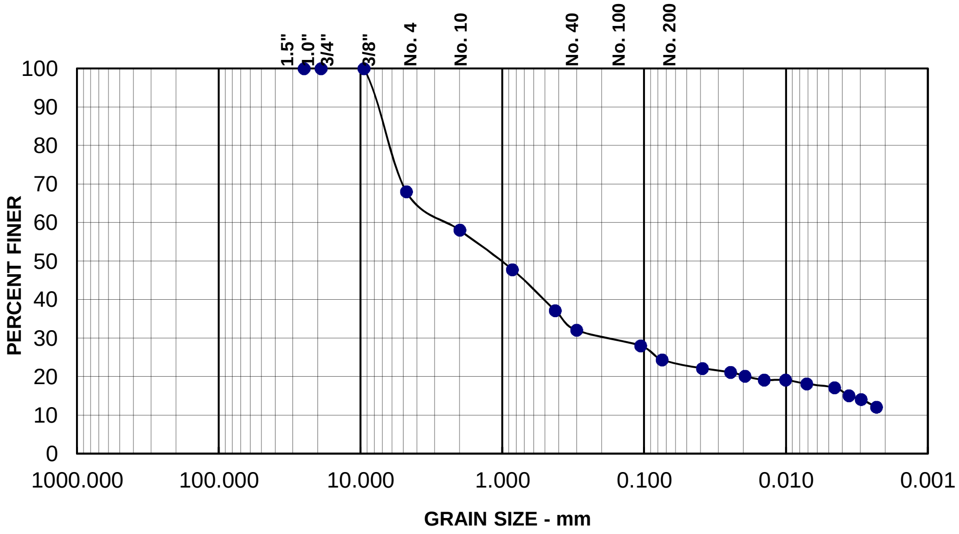
Report Date: February 25, 2014
Print Date: February 25, 2014

Client:	CDM Smith Inc.	**Client Sample ID:**	PPTDOC-KCBX-South
Lab Order:	13120303	**Tag Number:**	
Project:	PPT DOC	**Collection Date:**	12/13/2013 10:00:00 AM
Lab ID:	13120303-001A	**Matrix:**	Solid

Analyses	**Result**	**Qualifier**	**Units**	**Date Analyzed**
Grain Size	**D422**			Analyst: **SUB**
Clay Sized Particles	17.1	*	%	1/24/2014
Gravel Sized Particles	32.0	*	%	1/24/2014
Sand Sized Particles	43.6	*	%	1/24/2014
Silt Sized Particles	7.3	*	%	1/24/2014

	ND - Not Detected at the Reporting Limit	RL - Reporting / Quantitation Limit for the analysis
Qualifiers:	J - Analyte detected below quantitation limits	S - Spike Recovery outside accepted recovery limits
	B - Analyte detected in the associated Method Blank	R - RPD outside accepted recovery limits
	HT - Sample received past holding time	E - Value above quantitation range
	* - Non-accredited parameter	H - Holding time exceeded

GRAIN SIZE ANALYSIS (ASTM D422)	SAMPLE ID: PPTDOC-KCBX-South



% + 3"	% Gravel	% Sand	% Silt	% Clay
0.0	32.0	43.6	7.3	17.1

Sieve Size	Percent Passing
1"	100.0
3/4"	100.0
3/8"	100.0
#4	68.0
#10	58.0
#20	47.8
#40	37.2
#60	32.1
#140	28.0
#200	24.4

D60 (mm)	**D30** (mm)	**D10** (mm)	**Cu**	**Cc**
2.7	0.2			

Visual Soil Description:	Black coarse to fine sand-sized particles, and coarse to fine gravel-sized particles, some fines, moist
Soil Classification:	
System:	

Report Date: February 25, 2014
Print Date: February 25, 2014

Client:	CDM Smith Inc.	**Client Sample ID:**	PPTDOC-KCBX-North
Lab Order:	13120303	**Tag Number:**	
Project:	PPT DOC	**Collection Date:**	12/13/2013 10:15:00 AM
Lab ID:	13120303-002A	**Matrix:**	Solid

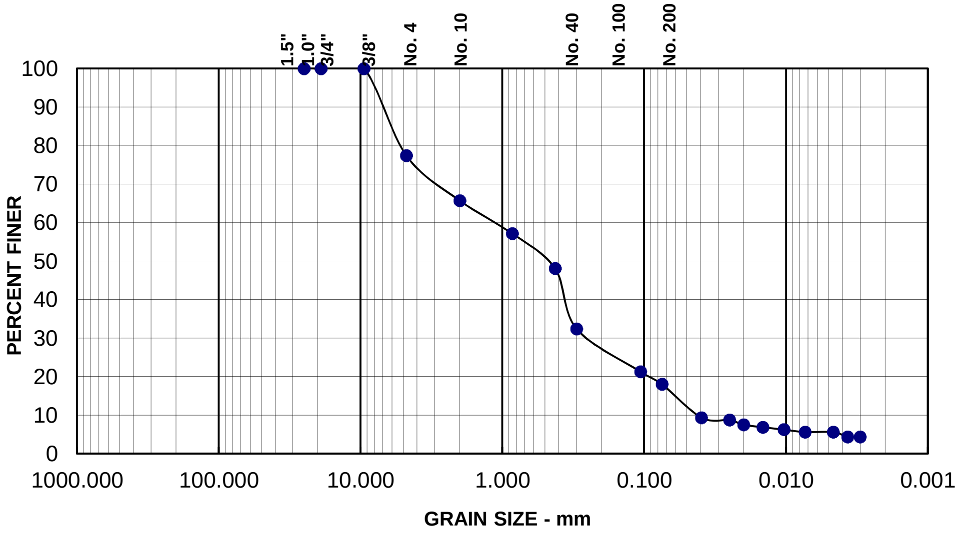
Analyses	**Result**	**Qualifier**	**Units**	**Date Analyzed**
Grain Size	**D422**			Analyst: **SUB**
Clay Sized Particles	5.6	*	%	1/24/2014
Gravel Sized Particles	22.6	*	%	1/24/2014
Sand Sized Particles	59.3	*	%	1/24/2014
Silt Sized Particles	12.4	*	%	1/24/2014

Qualifiers:

ND - Not Detected at the Reporting Limit	RL - Reporting / Quantitation Limit for the analysis
J - Analyte detected below quantitation limits	S - Spike Recovery outside accepted recovery limits
B - Analyte detected in the associated Method Blank	R - RPD outside accepted recovery limits
HT - Sample received past holding time	E - Value above quantitation range
* - Non-accredited parameter	H - Holding time exceeded

GRAIN SIZE ANALYSIS (ASTM D422)

SAMPLE ID: PPTDOC-KCBX-North



% + 3"	% Gravel	% Sand	% Silt	% Clay
0.0	22.6	59.3	12.4	5.6

Sieve Size	Percent Passing
1"	100.0
3/4"	100.0
3/8"	100.0
#4	77.4
#10	65.7
#20	57.1
#40	48.1
#60	32.4
#140	21.3
#200	18.0

D60 (mm)	**D30** (mm)	**D10** (mm)	**Cu**	**Cc**
1.12	0.27	0.0400	28.00	1.63

Visual Soil Description:	Black coarse to fine sand-sized particles, some coarse to medium gravel-sized particles, little fines, moist
Soil Classification:	
System:	

STAT Analysis Corporation
2242 W. Harrison, Suite 200, Chicago, Illinois 60612 Phone: (312) 733-0551 Fax: (312) 733-2386
e-mail address: STATinfo@STATAnalysis.com AIHA, NVLAP and NELAP accredited

CHAIN OF CUSTODY RECORD **Nº:** 843700 **Page :** ____ of ____

Company: CDM Smith
Project Number: PPTDOC Client Tracking No.:
Project Name:
Project Location:
Sampler(s): John Grobs
Report To: John Grobs Phone: 312/780-77
Fax:
QC Level: 1 ___ 2 ___ 3 ___ 4 ___ e-mail: grobsjc@cdmsmith.com

P.O. No.:
Quote No.:

Turn Around: 24-hr
Results Needed: / / am/pm

Client Sample Number/Description:	Date Taken	Time Taken	Matrix	Comp.	Grab	Preserv.	No. of Containers	TAL Metals	SVOCs	SPLP PAH	Remarks	Lab No.:
PPTDOC-KCBX-So	12/12/12	10:00	Solid	X			1	X	X	X		001
PPTDOC-KCBX-North		10:15	Solid	X			1	X	X	X		002

Relinquished by: (Signature) Date/Time: 12/13/12 11:25
Received by: (Signature) Date/Time: 12/13/12 11:25
Relinquished by: (Signature) Date/Time:
Received by: (Signature) Date/Time:
Relinquished by: (Signature) Date/Time:
Received by: (Signature) Date/Time:

Comments:

Preservation Code: [✓ A = None] B = HNO_3 C = NaOH D = H_2SO_4 E = HCl F = 5035/EnCore G = Other

Laboratory Work Order No.: 1312O303

Received on Ice: Yes ☒ No ☐

Temperature: 3.4 °C

STAT Analysis Corporation

Sample Receipt Checklist

Client Name CDM

Date and Time Received: 12/13/2013 11:25:00 AM

Work Order Number 13120303

Received by: EMLP

Checklist completed by: Signature 12/13/13 Date

Reviewed by: EMLP Initials 12/13/13 Date

Matrix:

Carrier name Client Delivered

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shippping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels/containers?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Container or Temp Blank temperature in compliance?	Yes ☑	No ☐	Temperature 3.4 °C
Water - VOA vials have zero headspace?	No VOA vials submitted ☐	Yes ☐	No ☐
Water - Samples pH checked?	Yes ☐	No ☐	Checked by:
Water - Samples properly preserved?	Yes ☐	No ☐	pH Adjusted?

Any No response must be detailed in the comments section below.

Comments:

Client / Person contacted:

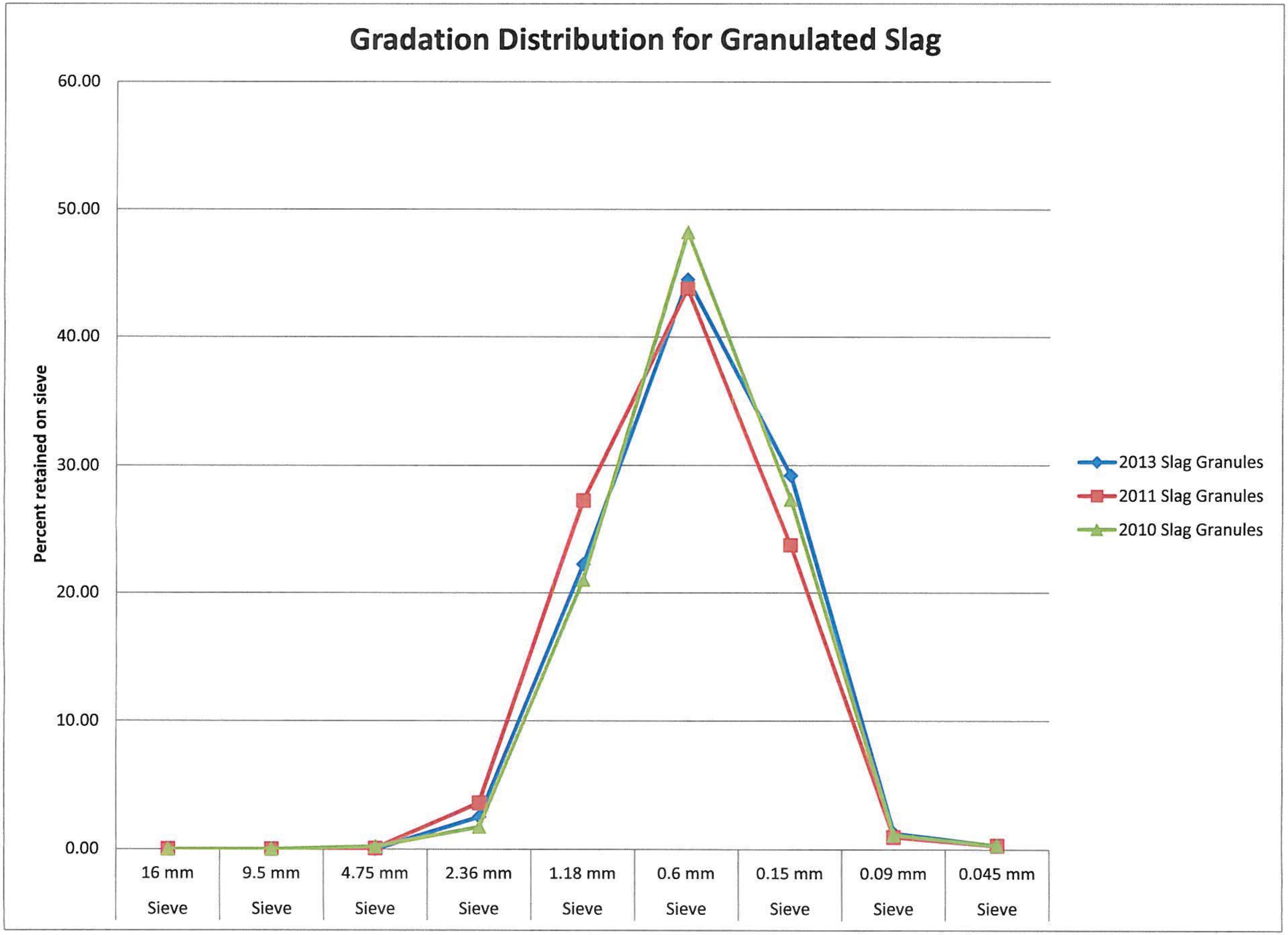
Date contacted:

Contacted by:

Response: PER JOHN GRABBS EMAIL TO CE 2/21/2014 1618, REPORT ONLY GRAIN SIZE RESULTS.

Appendix B

Slag Data


Gradation Distribution for Granulated Slag

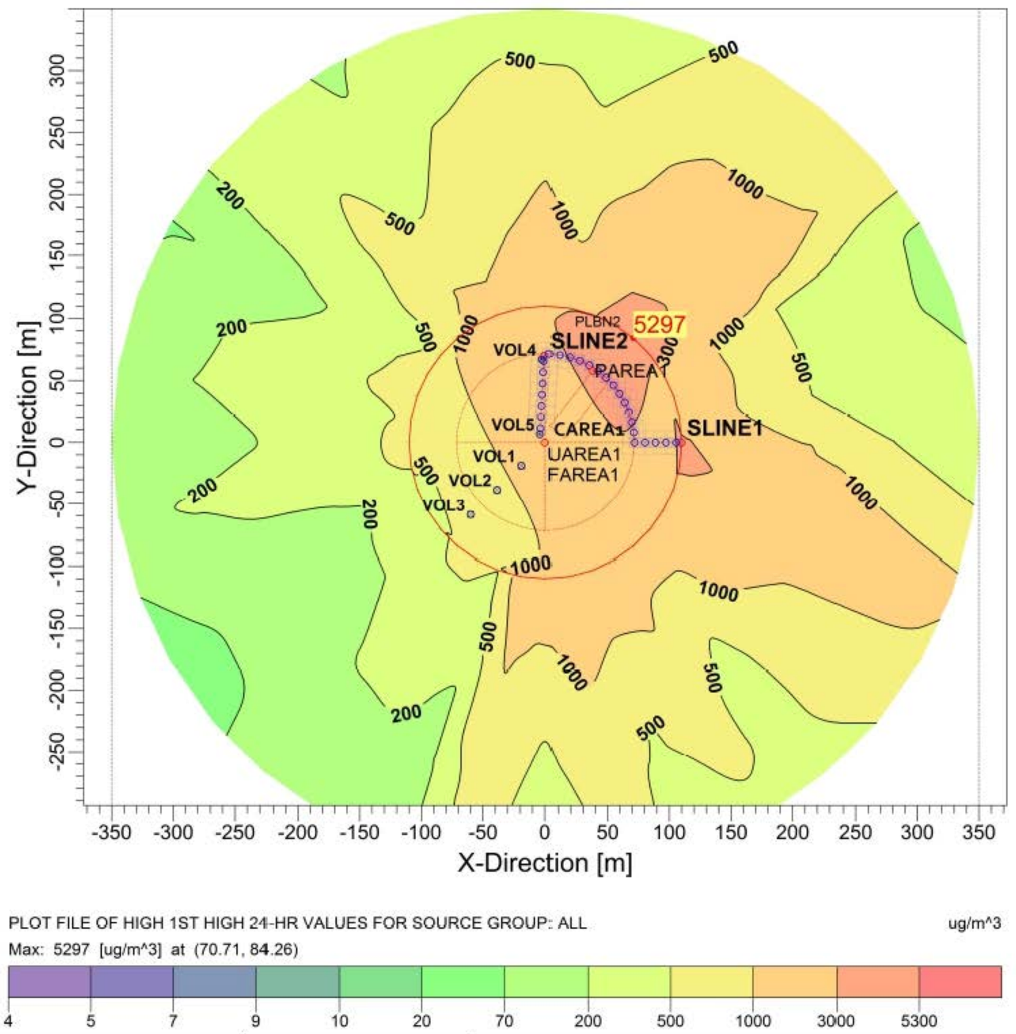
		Data represents percent retained on sieve								
Location	% Moisture	Sieve 16 mm	Sieve 9.5 mm	Sieve 4.75 mm	Sieve 2.36 mm	Sieve 1.18 mm	Sieve 0.6 mm	Sieve 0.15 mm	Sieve 0.09 mm	Sieve 0.045 mm
2013 Slag Granules	8.71	0.00	0.00	0.00	2.50	22.22	44.47	29.20	1.23	0.28
2011 Slag Granules	8.338	0.00	0.00	0.06	3.56	27.23	43.74	23.72	0.94	0.28
2010 Slag Granules	9.02	0.00	0.00	0.20	1.70	21.00	48.20	27.30	1.10	0.30

IN PERCENTAGE

Appendix C

Modeling Results Figures

Figure 4.3a 24-Hr Average Petcoke PM10 Emissions Modeling Group All Equipment Emissions



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

Max: 5297 [ug/m^3] at (70.71, 84.26)

COMMENTS:

Sigma Z = 2 meters
Bull-dozer/Grader Release
Height = 2 meters

SOURCES: 11

COMPANY NAME: **CDM Smith**

RECEPTORS: 252

MODELER: **RS**

OUTPUT TYPE: Concentration

SCALE: 1:4,750

0 — 0.1 km

MAX: 5297 ug/m^3

DATE: 3/3/2014

PROJECT NO.:

AERMOD View - Lakes Environmental Software

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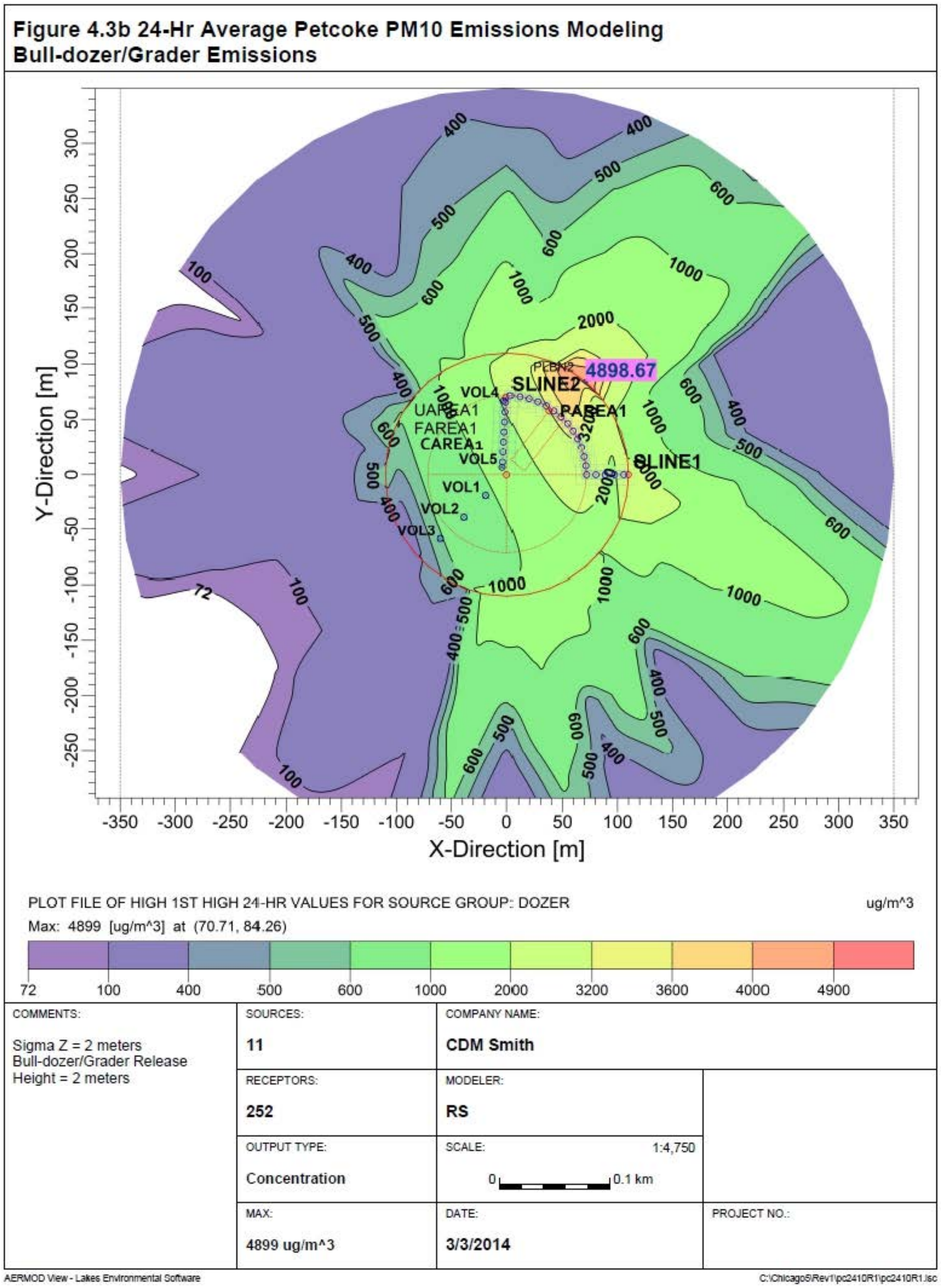

Figure 4.3b 24-Hr Average Petcoke PM10 Emissions Modeling
Bull-dozer/Grader Emissions

PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: DOZER

ug/m^3

Max: 4899 [ug/m^3] at (70.71, 84.26)

COMMENTS:
Sigma Z = 2 meters
Bull-dozer/Grader Release
Height = 2 meters

SOURCES:
11

COMPANY NAME:
CDM Smith

RECEPTORS:
252

MODELER:
RS

OUTPUT TYPE:
Concentration

SCALE:
1:4,750
0 0.1 km

MAX:
4899 ug/m^3

DATE:
3/3/2014

PROJECT NO.:

AERMOD View - Lakes Environmental Software

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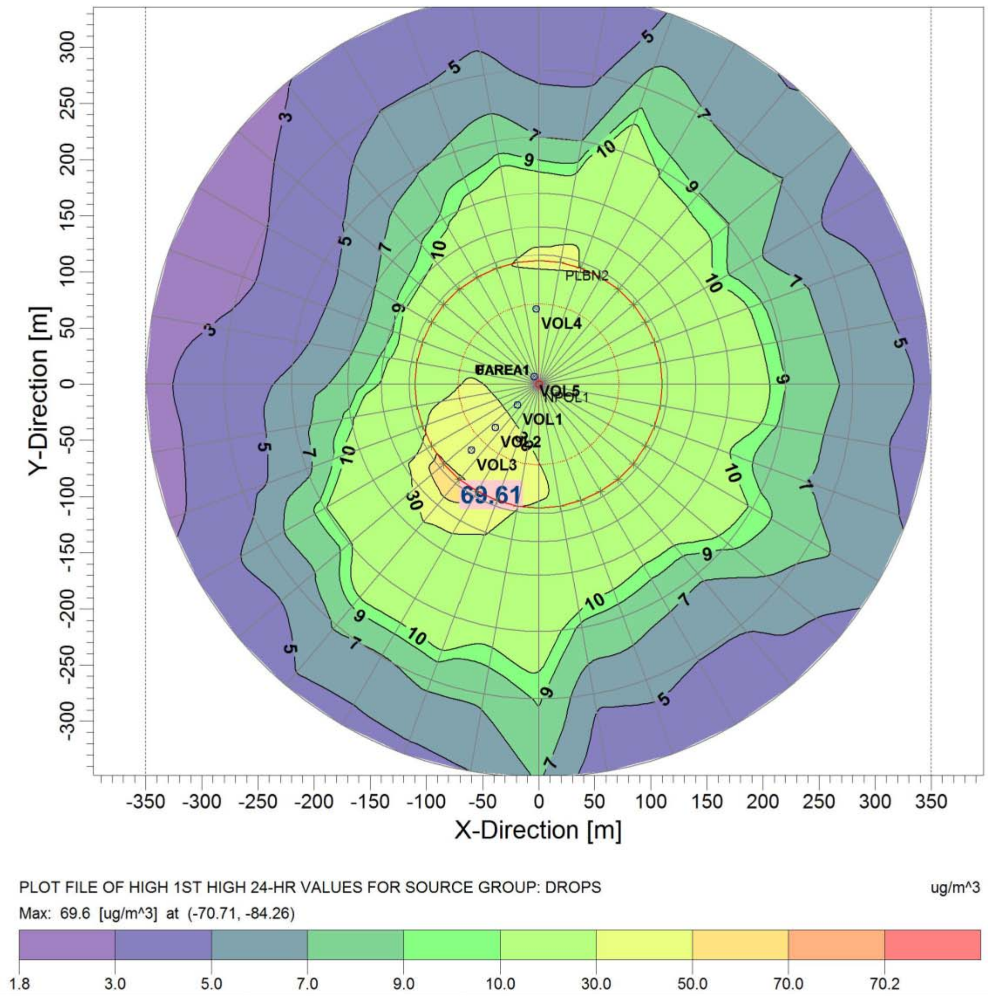
Figure 4.3c 24-Hr Average Petcoke PM10 Emissions Modeling Drop Emissions



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: DROPS ug/m^3

Max: 69.6 [ug/m^3] at (-70.71, -84.26)

COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,051 0 0.1 km	
	MAX: **69.6 ug/m^3**	DATE: **2/19/2014**	PROJECT NO.:

AERMOD View - Lakes Environmental Software

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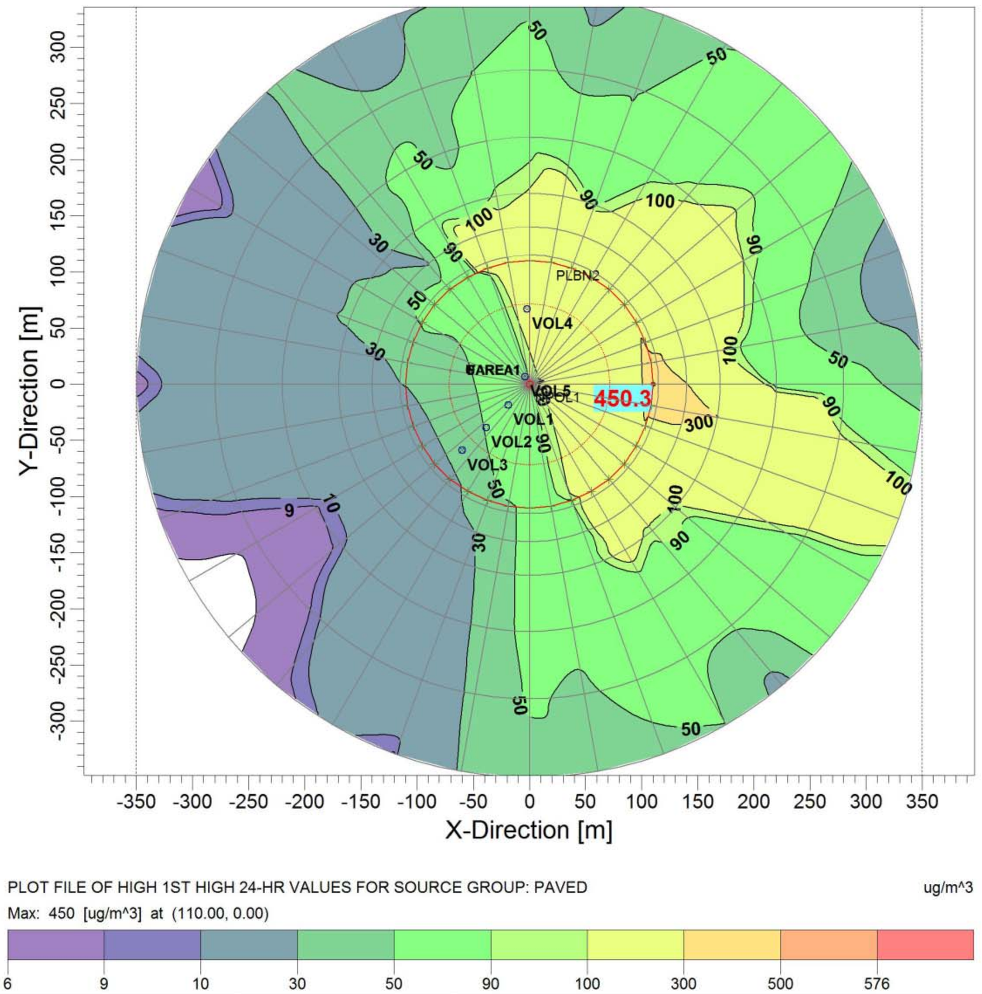
Figure 4.3d 24-Hr Average Petcoke PM10 Emissions Modeling
Paved Road Emissions



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: PAVED

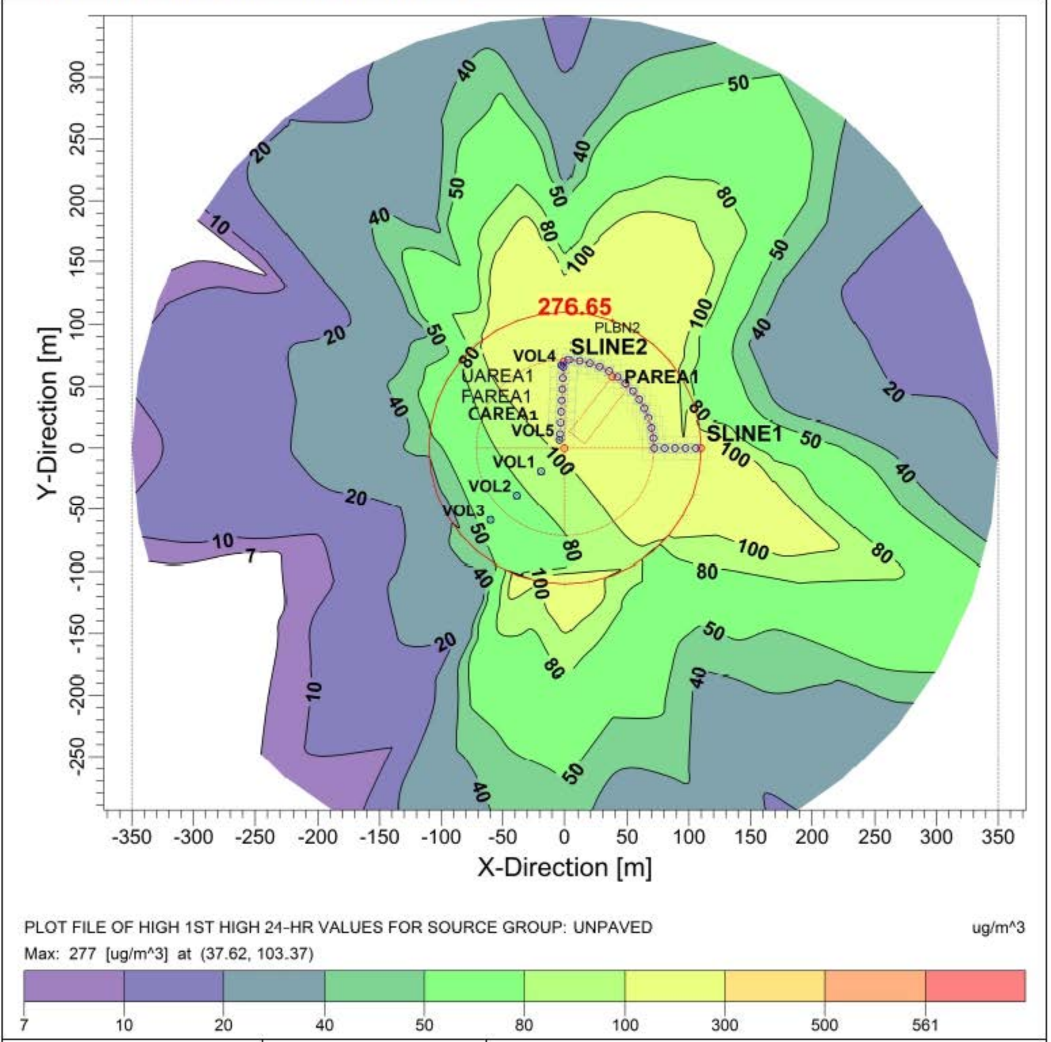
Max: 450 [ug/m^3] at (110.00, 0.00)

COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,051 0 0.1 km	
	MAX: **450 ug/m^3**	DATE: **2/19/2014**	PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Chicago5\pc2410\pc2410.isc

Figure 4.3e 24-Hr Average Petcoke PM10 Emissions Modeling Emissions from Travel on Pile Surface



COMMENTS:
Articulated Dump Truck & Loader

SOURCES:
11

COMPANY NAME:
CDM Smith

RECEPTORS:
252

MODELER:
RS

OUTPUT TYPE:
Concentration

SCALE: 1:4,750
0 0.1 km

MAX:
277 ug/m^3

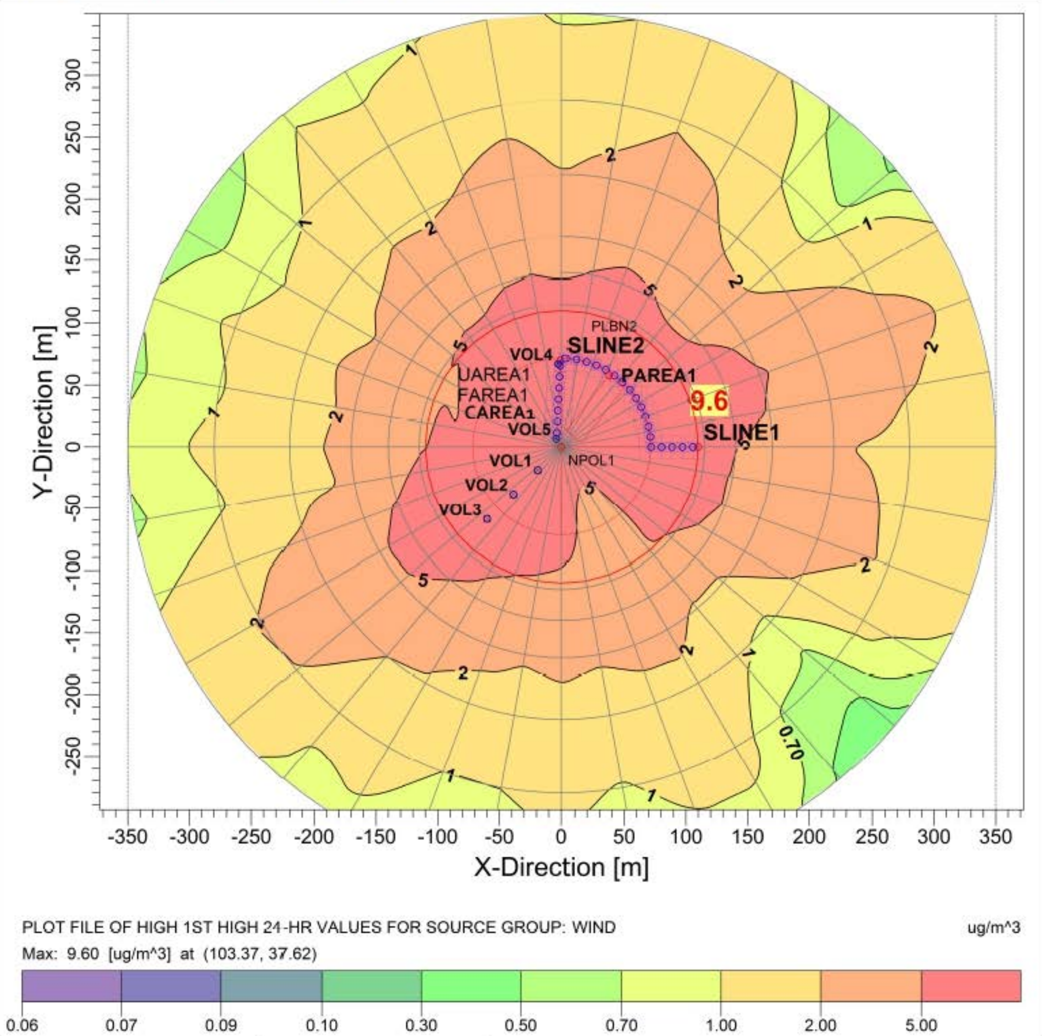
DATE:
3/3/2014

PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Chicago5\Rev1\pc2410R1\pc2410R1.isc

Figure 4.3f 24-Hr Average Petcoke PM10 Emissions Modeling Wind Erosion Emissions from Stockpile



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: WIND

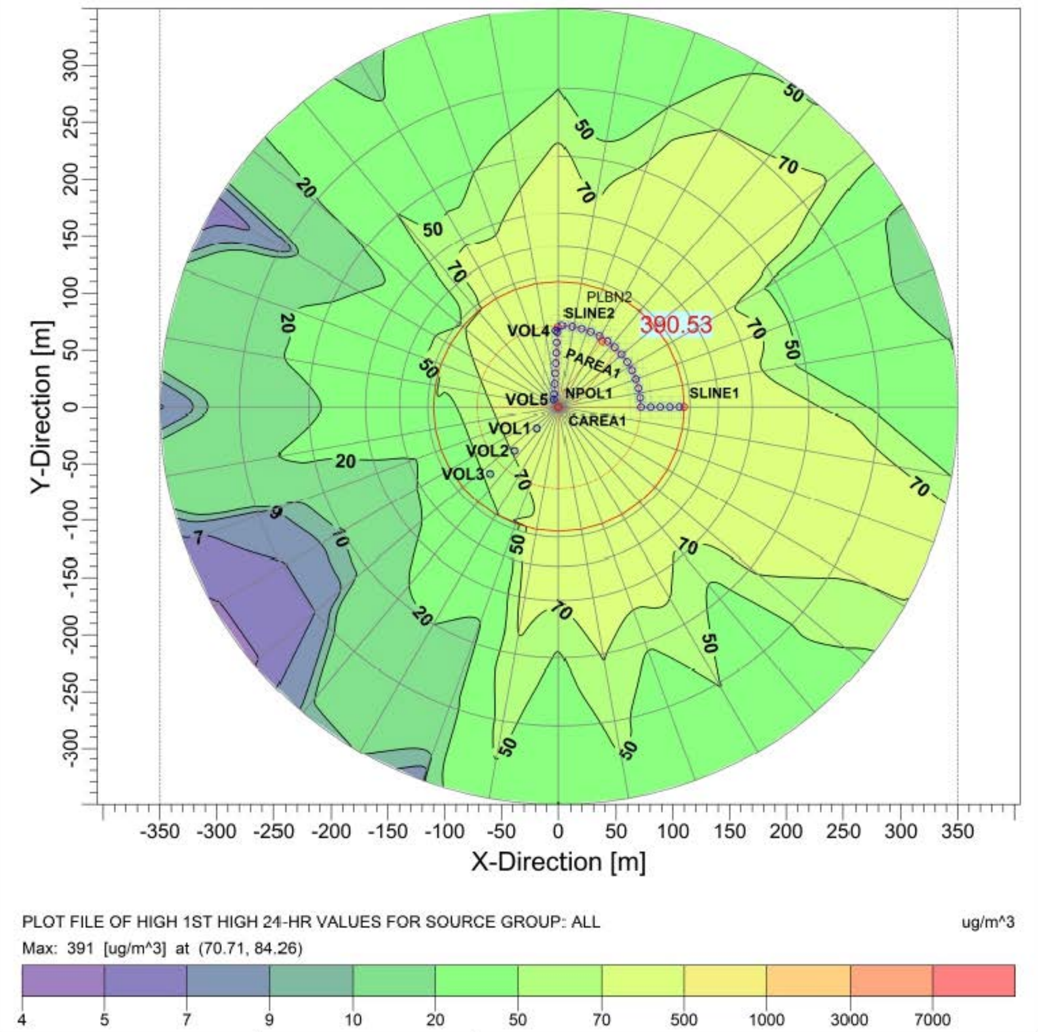
Max: 9.60 [ug/m^3] at (103.37, 37.62)

COMMENTS:	SOURCES: 11	COMPANY NAME: CDM Smith	
	RECEPTORS: 252	MODELER: RS	
	OUTPUT TYPE: Concentration	SCALE: 1:4,750 0 0.1 km	
	MAX: 9.60 ug/m^3	DATE: 3/3/2014	PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Chicago5\Rev1\pc2410R1\pc2410R1.isc

Figure 4.4a 24-Hr Average Petcoke PM2.5 Emissions Modeling Group All Equipment Emissions



COMMENTS: Sigma Z = 2 meters Bull-dozer/Grader Release Height = 2 meters	SOURCES: 11	COMPANY NAME: CDM Smith	
	RECEPTORS: 252	MODELER: RS	
	OUTPUT TYPE: Concentration	SCALE: 1:5,164 0 0.2 km	
	MAX: 391 ug/m^3	DATE: 3/3/2014	PROJECT NO.:

AERMOD View - Lakes Environmental Software

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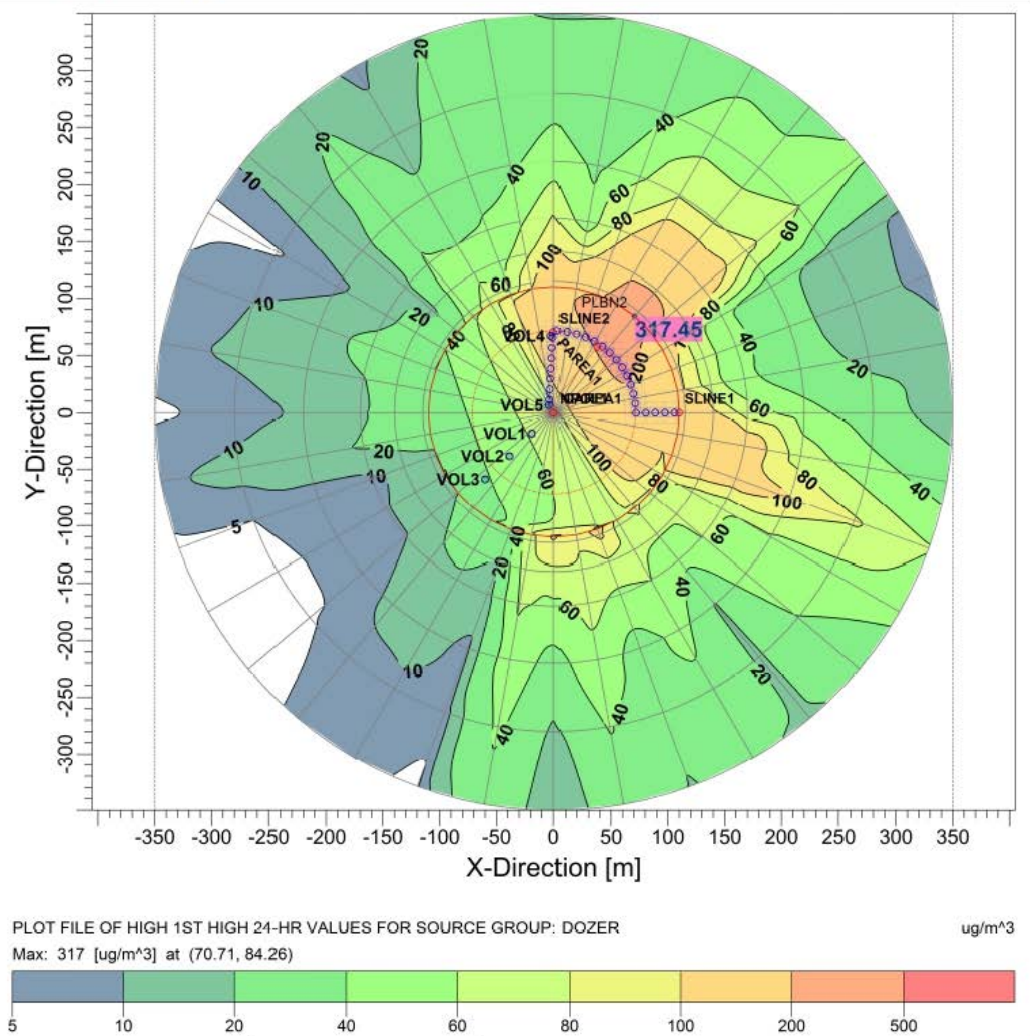
Figure 4.4b 24-Hr Average Petcoke PM2.5 Emissions Modeling Bull-dozer/Grader Emissions



COMMENTS: Sigma Z = 2 meters Bull-dozer/Grader Release Height = 2 meters	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,164 0 0.2 km	
	MAX: **317 ug/m^3**	DATE: **3/3/2014**	PROJECT NO.:

AERMOD View - Lakes Environmental Software

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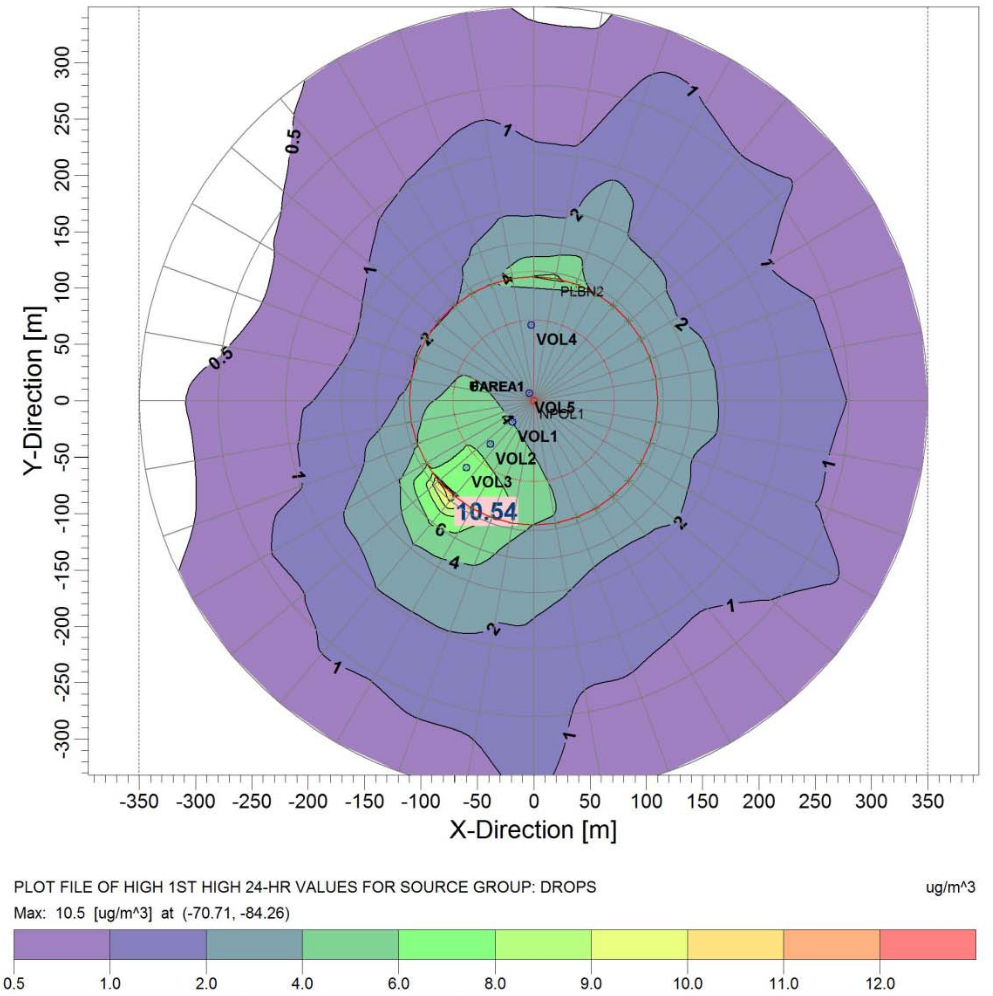
Figure 4.4c 24-Hr Average Petcoke PM2.5 Emissions Modeling Drop Emissions



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: DROPS

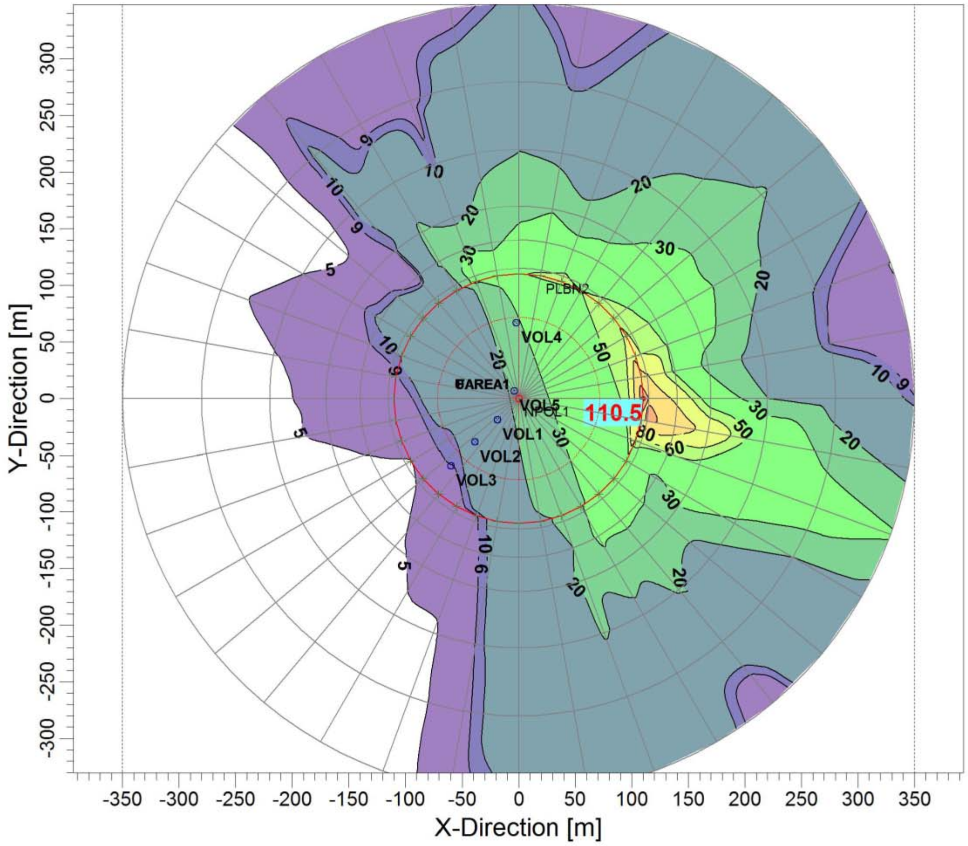
Max: 10.5 [ug/m^3] at (-70.71, -84.26)

COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,033 0 0.1 km	
	MAX: **10.5 ug/m^3**	DATE: **2/19/2014**	PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Chicago5\pc2425\pc2425.isc

Figure 4.4d 24-Hr Average Petcoke PM2.5 Emissions Modeling
Paved Road Emissions



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: PAVED

ug/m^3

Max: 111 [ug/m^3] at (110.00, 0.00)

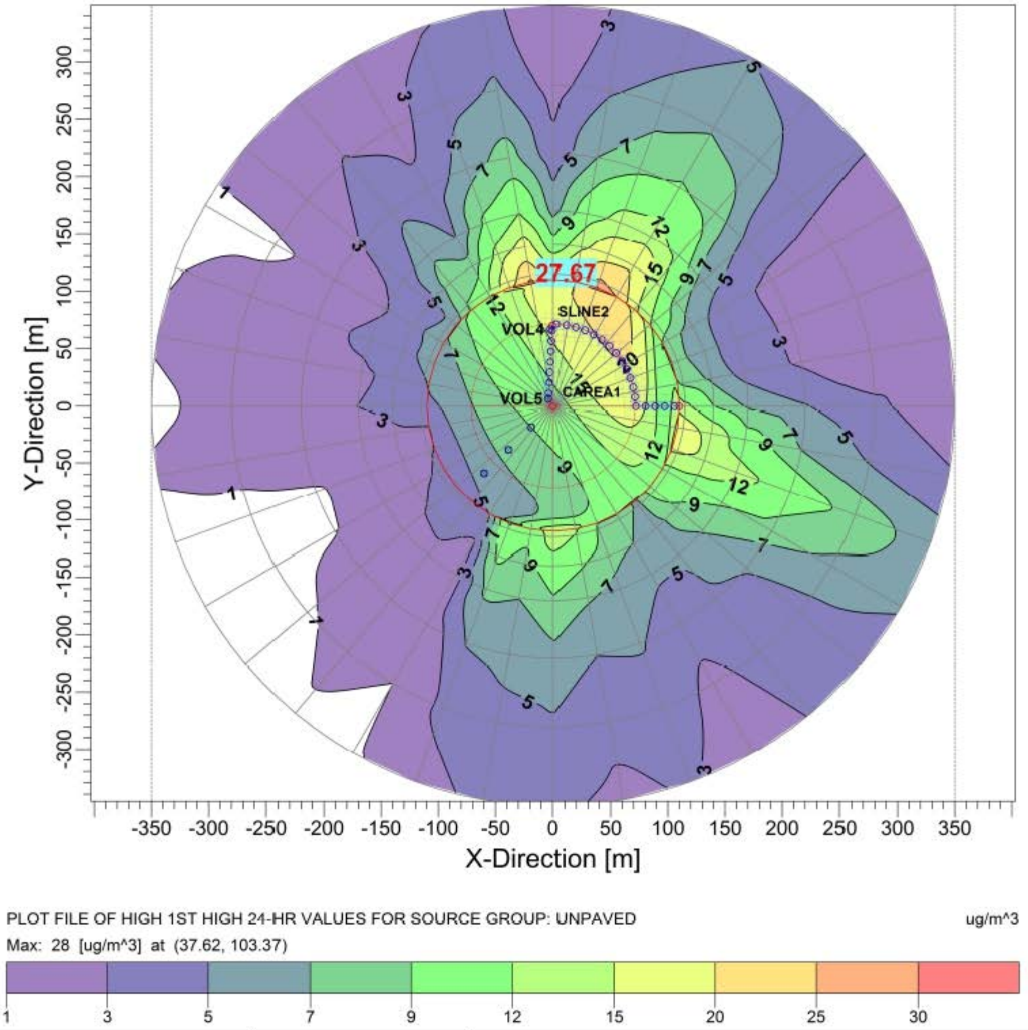
5 9 10 20 30 50 60 80 100 120

COMMENTS:	SOURCES: 11	COMPANY NAME: **CDM Smith**	
	RECEPTORS: 252	MODELER: RS	
	OUTPUT TYPE: Concentration	SCALE: 1:5,009 0 0.1 km	
	MAX: 111 ug/m^3	DATE: 2/19/2014	PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Chicago5\pc2425\pc2425.isc

Figure 4.4e 24-Hr Average Petcoke PM2.5 Emissions Modeling Emissions from Travel on Pile Surface

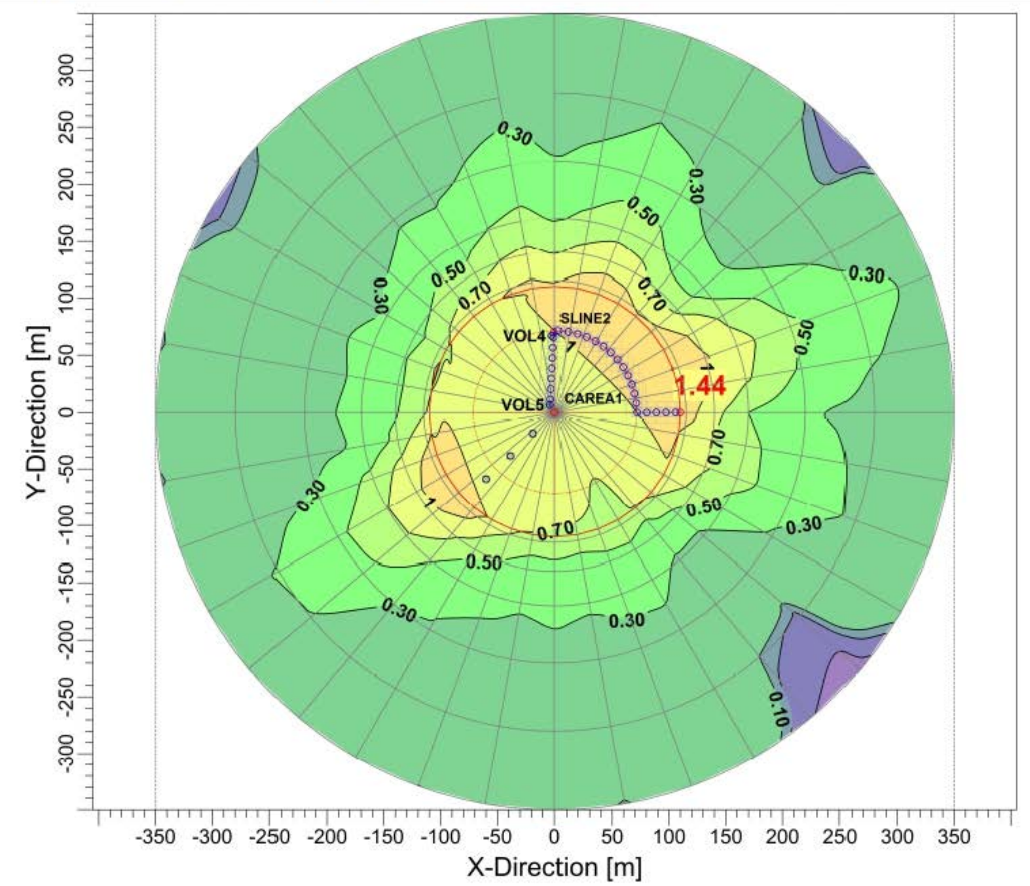


COMMENTS: Articulated Dump Truck & Loader	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: Concentration	SCALE: 1:5,136 0 0.2 km	
	MAX: 28 ug/m^3	DATE: 3/3/2014	PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Chicago5\Rev1\PC2425R1\PC2425R1.isc

Figure 4.4f 24-Hr Average Petcoke PM2.5 Emissions Modeling Wind Erosion Emissions from Stockpile



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: WIND ug/m^3

Max: 1.44 [ug/m^3] at (103.37, 37.62)

0.06 0.07 0.09 0.10 0.30 0.50 0.70 1.00 2.00 5.00

COMMENTS:	SOURCES: 11	COMPANY NAME: CDM Smith	
	RECEPTORS: 252	MODELER: RS	
	OUTPUT TYPE: Concentration	SCALE: 1:5,164 0 0.2 km	
	MAX: 1.44 ug/m^3	DATE: 3/3/2014	PROJECT NO.:

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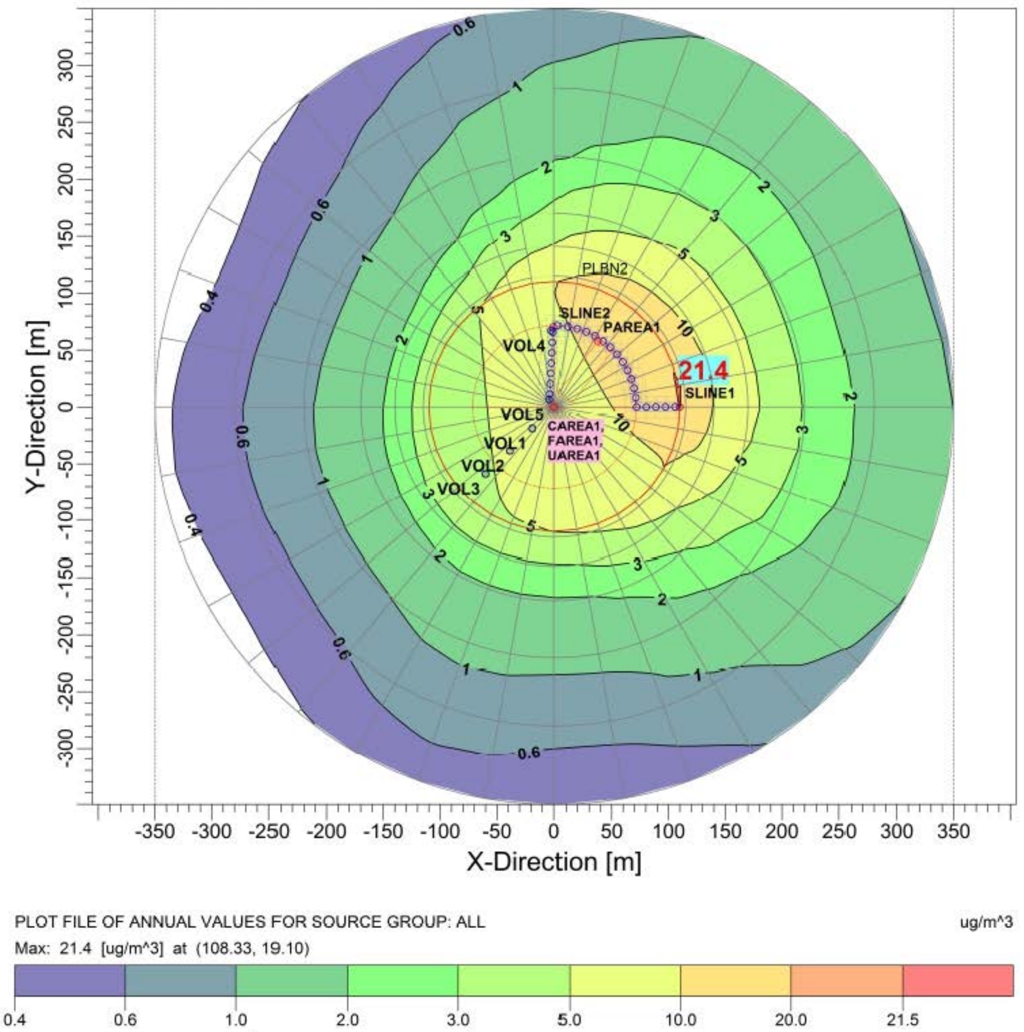
Figure 4.5a Annual Avg Petcoke PM2.5 Emissions Modeling Group All Equipment Emissions



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: ALL

Max: 21.4 [ug/m^3] at (108.33, 19.10)

COMMENTS:

Sigma Z = 2 meters
Bull-dozer/Grader Release
Height = 2 meters

SOURCES:

11

COMPANY NAME:

CDM Smith

RECEPTORS:

252

MODELER:

RS

OUTPUT TYPE:

Concentration

SCALE: 1:5,164

0 0.2 km

MAX:

21.4 ug/m^3

DATE:

3/3/2014

PROJECT NO.:

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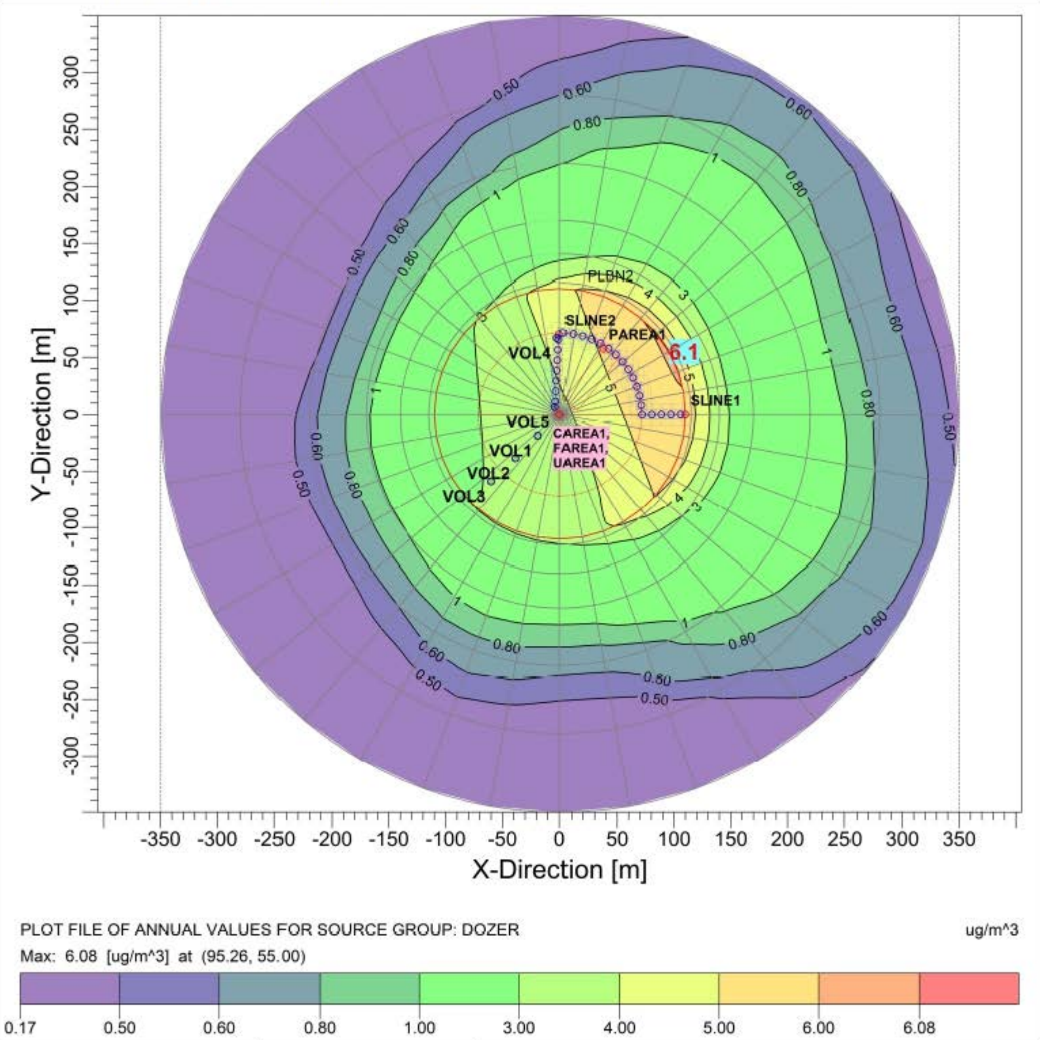
Figure 4.5b Annual Avg Petcoke PM2.5 Emissions Modeling Bull-dozer/Grader Emissions



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: DOZER

Max: 6.08 [ug/m^3] at (95.26, 55.00)

COMMENTS:

Sigma Z = 2 meters
Bull-dozer/Grader Release
Height = 2 meters

SOURCES:

11

COMPANY NAME:

CDM Smith

RECEPTORS:

252

MODELER:

RS

OUTPUT TYPE:

Concentration

SCALE:

1:5,164

0 0.2 km

MAX:

6.08 ug/m^3

DATE:

3/3/2014

PROJECT NO.:

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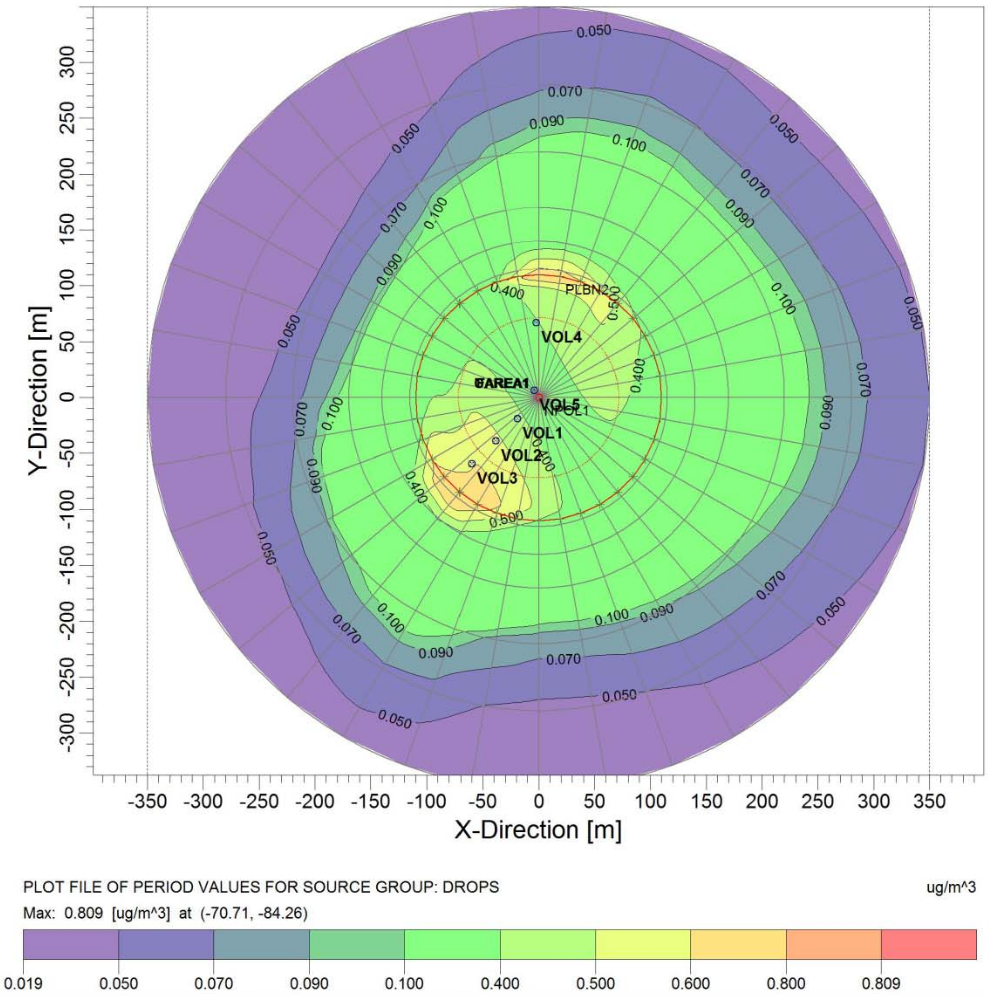
Figure 4.5c Annual Avg Petcoke PM2.5 Emissions Modeling Drop Emissions



PLOT FILE OF PERIOD VALUES FOR SOURCE GROUP: DROPS

Max: 0.809 [ug/m^3] at (-70.71, -84.26)

COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,076 0 0.1 km	
	MAX: **0.809 ug/m^3**	DATE: **2/19/2014**	PROJECT NO.:

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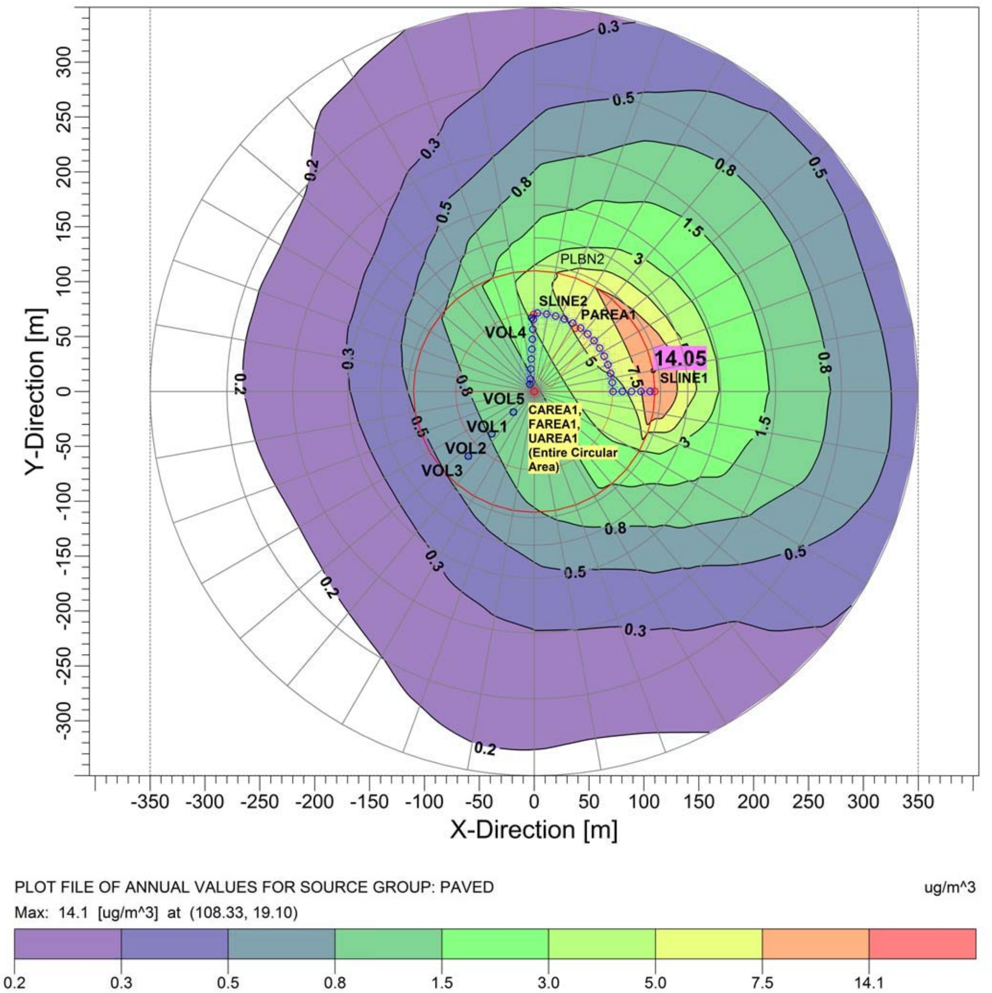
Figure 4.5d Annual Avg Petcoke PM2.5 Emissions Modeling Paved Road Emissions



COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,164 0 0.2 km	
	MAX: **14.1 ug/m^3**	DATE: **2/21/2014**	PROJECT NO.:

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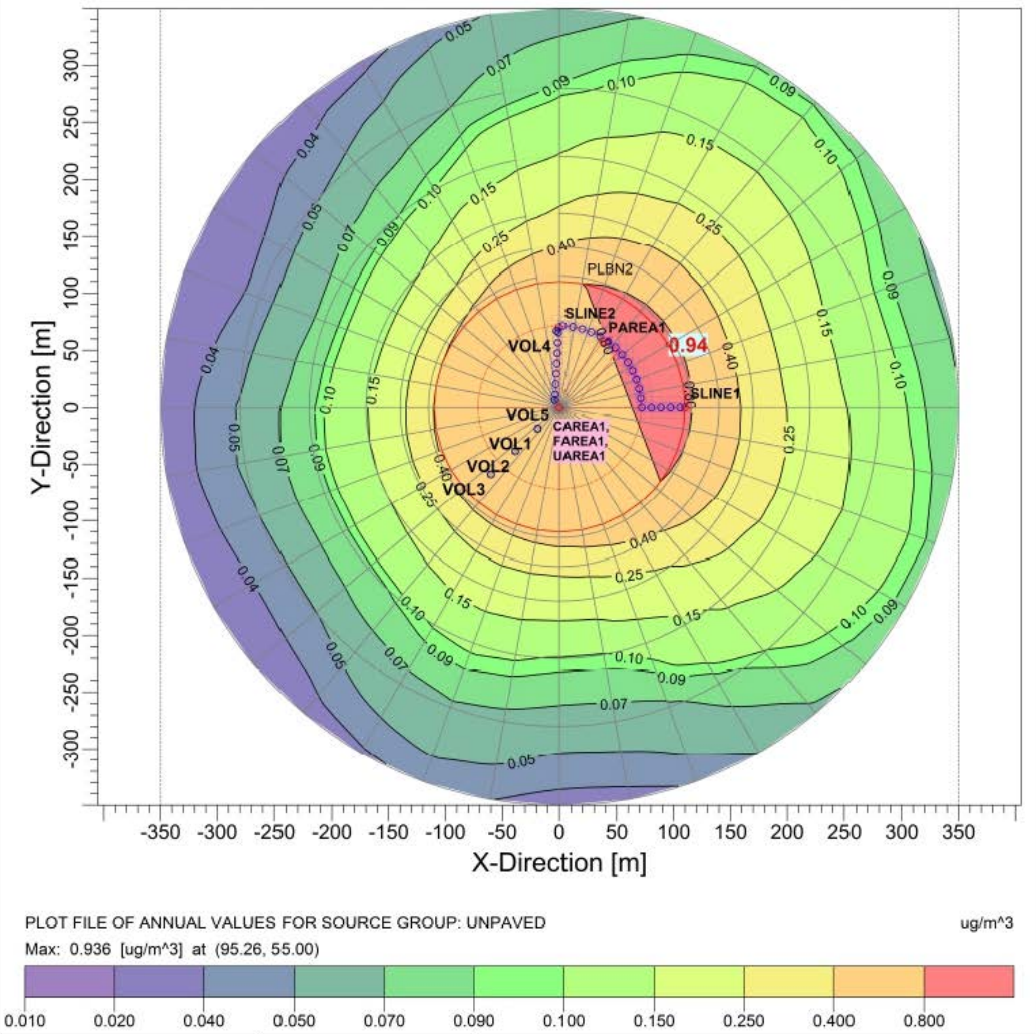
Figure 4.5e Annual Avg Petcoke PM2.5 Emissions Modeling Emissions from Travel on Pile Surface



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: UNPAVED

Max: 0.936 [ug/m^3] at (95.26, 55.00)

COMMENTS:
Articulated Dump Truck & Loader

SOURCES:
11

COMPANY NAME:
CDM Smith

RECEPTORS:
252

MODELER:
RS

OUTPUT TYPE:
Concentration

SCALE: 1:5,164
0 — 0.2 km

MAX:
0.936 ug/m^3

DATE:
3/3/2014

PROJECT NO.:

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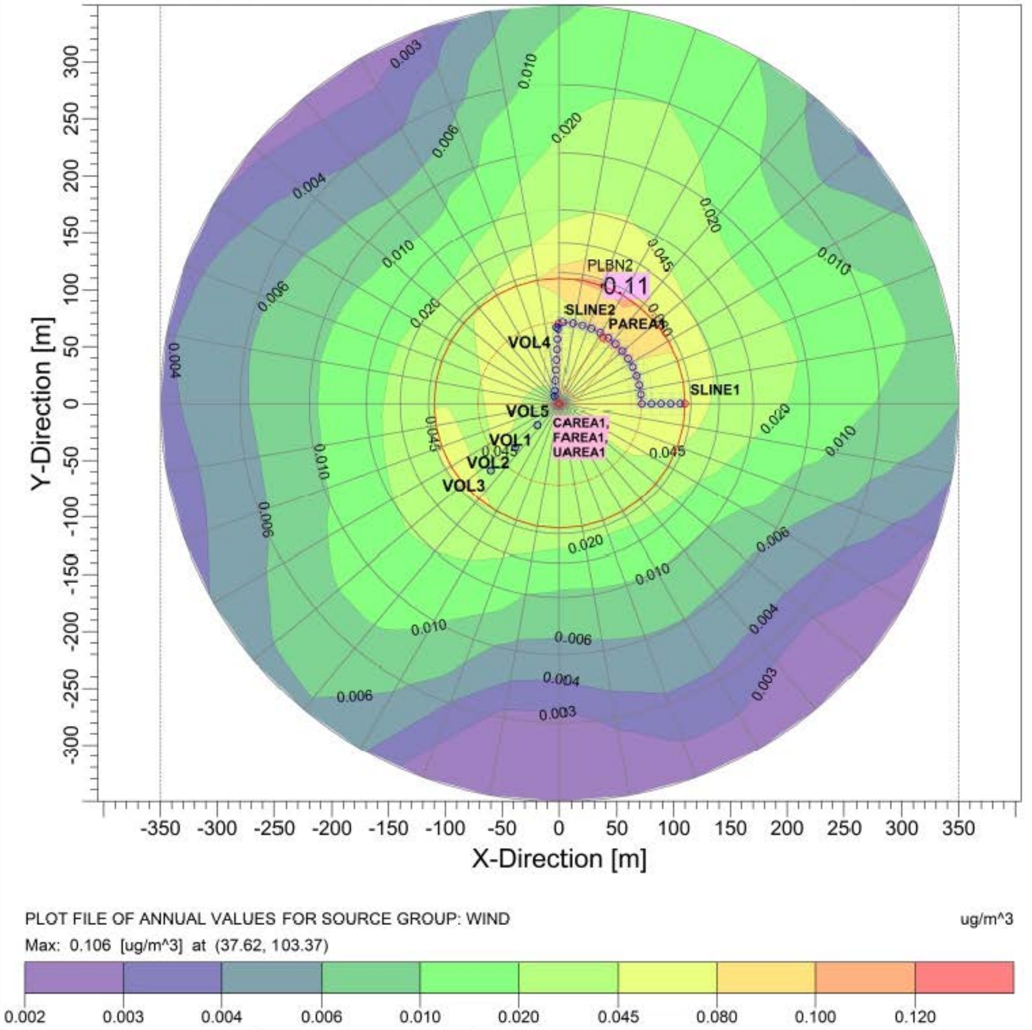
Figure 4.5f Annual Avg Petcoke PM2.5 Emissions Modeling Wind Erosion Emissions from Stockpile



PLOT FILE OF ANNUAL VALUES FOR SOURCE GROUP: WIND

Max: 0.106 [ug/m^3] at (37.62, 103.37)

COMMENTS:	SOURCES: 11	COMPANY NAME: **CDM Smith**	
	RECEPTORS: 252	MODELER: RS	
	OUTPUT TYPE: Concentration	SCALE: 1:5,164 0 0.2 km	
	MAX: 0.106 ug/m^3	DATE: 3/3/2014	PROJECT NO.:

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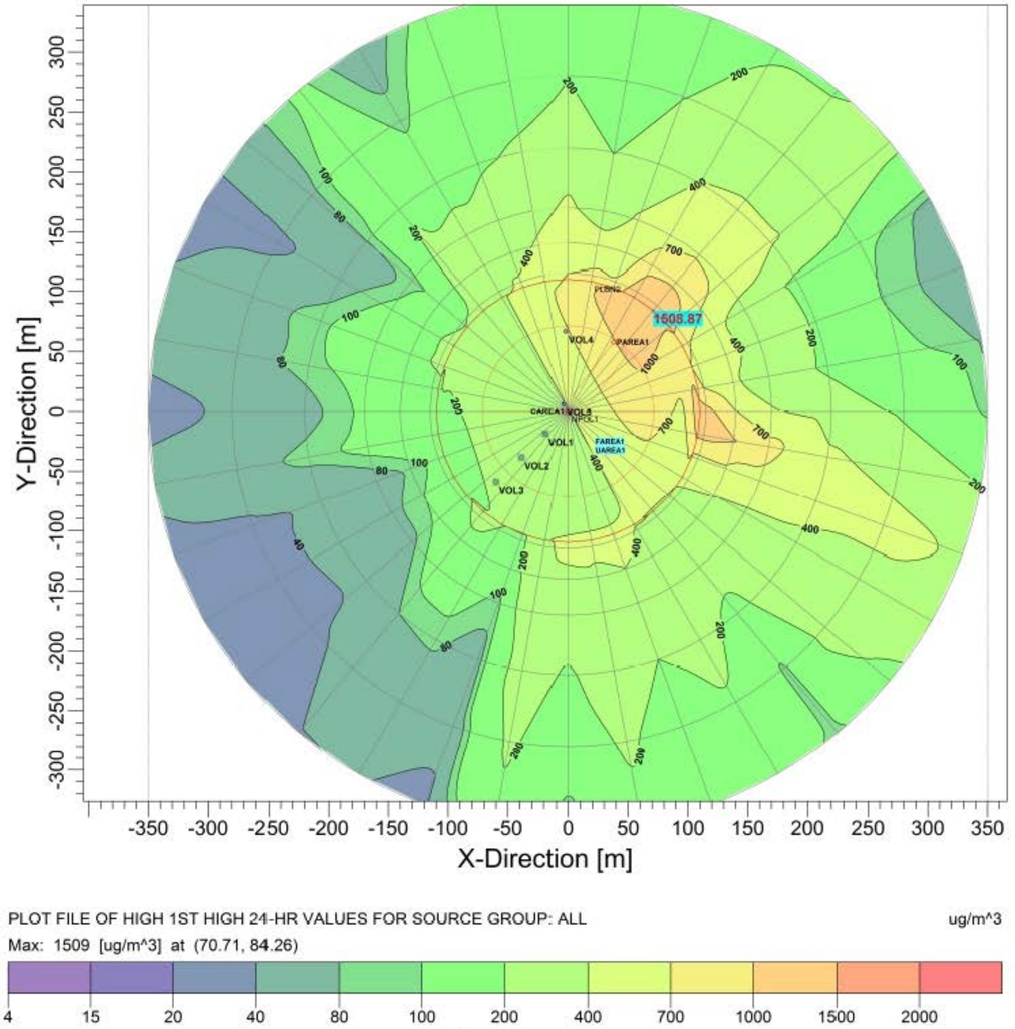
Figure 4.6a 24-Hr Average Coal PM10 Emissions Modeling Group All Equipment Emissions



COMMENTS:

Sigma Z = 2 meters
Dozer/Grader Release Height = 2 meters

SOURCES: **11**

RECEPTORS: **252**

OUTPUT TYPE: Concentration

MAX: 1509 ug/m^3

COMPANY NAME: **CDM Smith**

MODELER: **RS**

SCALE: 1:4,913
0 0.1 km

DATE: **3/2/2014**

PROJECT NO.:

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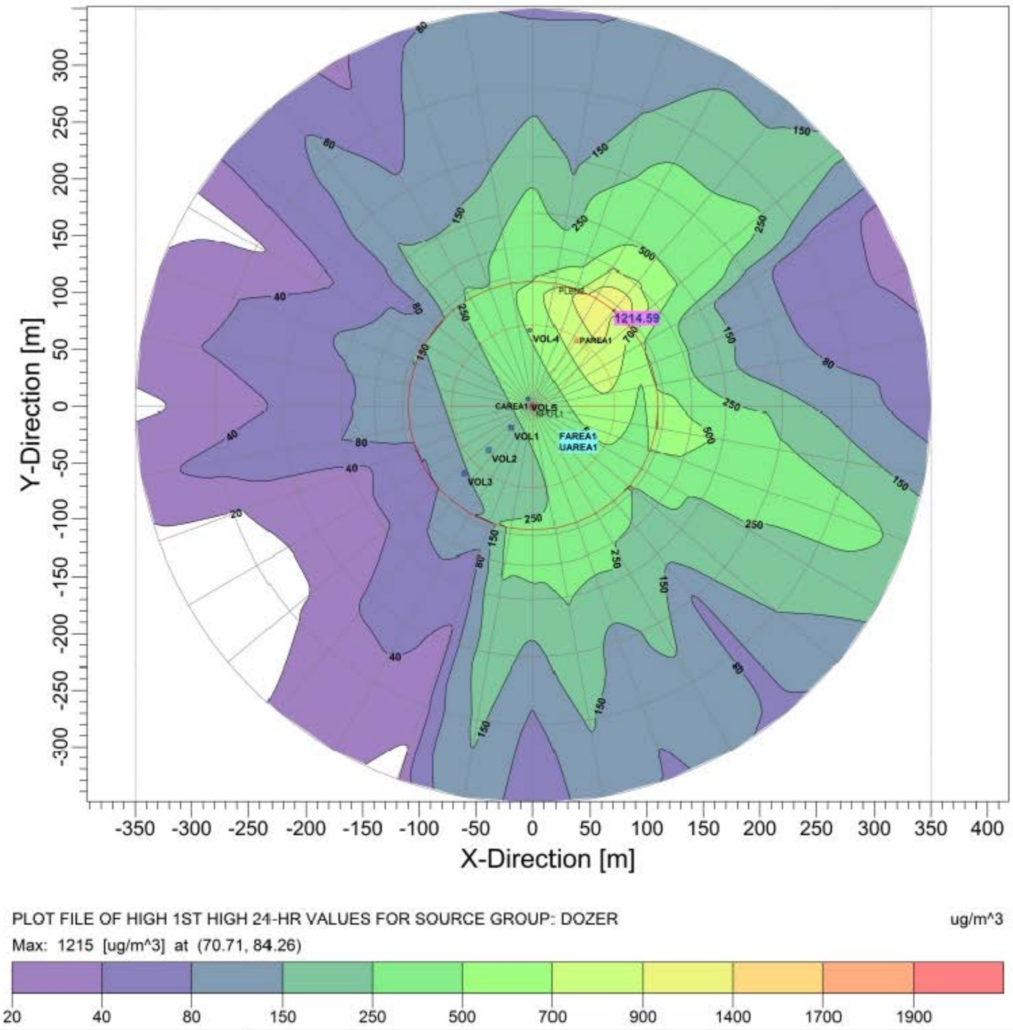
Figure 4.6b 24-Hr Average Coal PM10 Emissions Modeling Bull-dozer/Grader Emissions



COMMENTS: Sigma Z = 2 meters Dozer/Grader Release Height = 2 meters	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,170 0 0.2 km	
	MAX: **1215 ug/m^3**	DATE: **3/2/2014**	PROJECT NO.:

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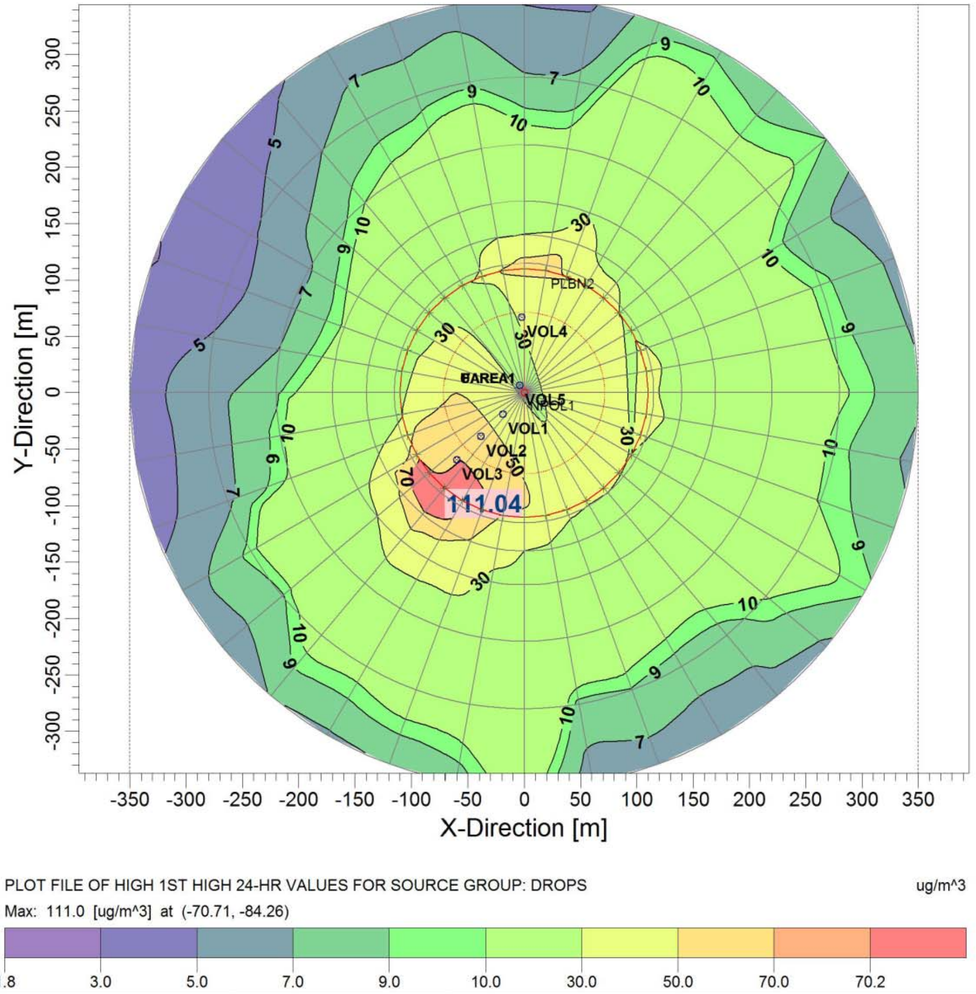
Figure 4.6c 24-Hr Average Coal PM10 Emissions Modeling Drop Emissions



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: DROPS

Max: 111.0 [ug/m^3] at (-70.71, -84.26)

COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,033 0 0.1 km	
	MAX: **111.0 ug/m^3**	DATE: **2/19/2014**	PROJECT NO.:

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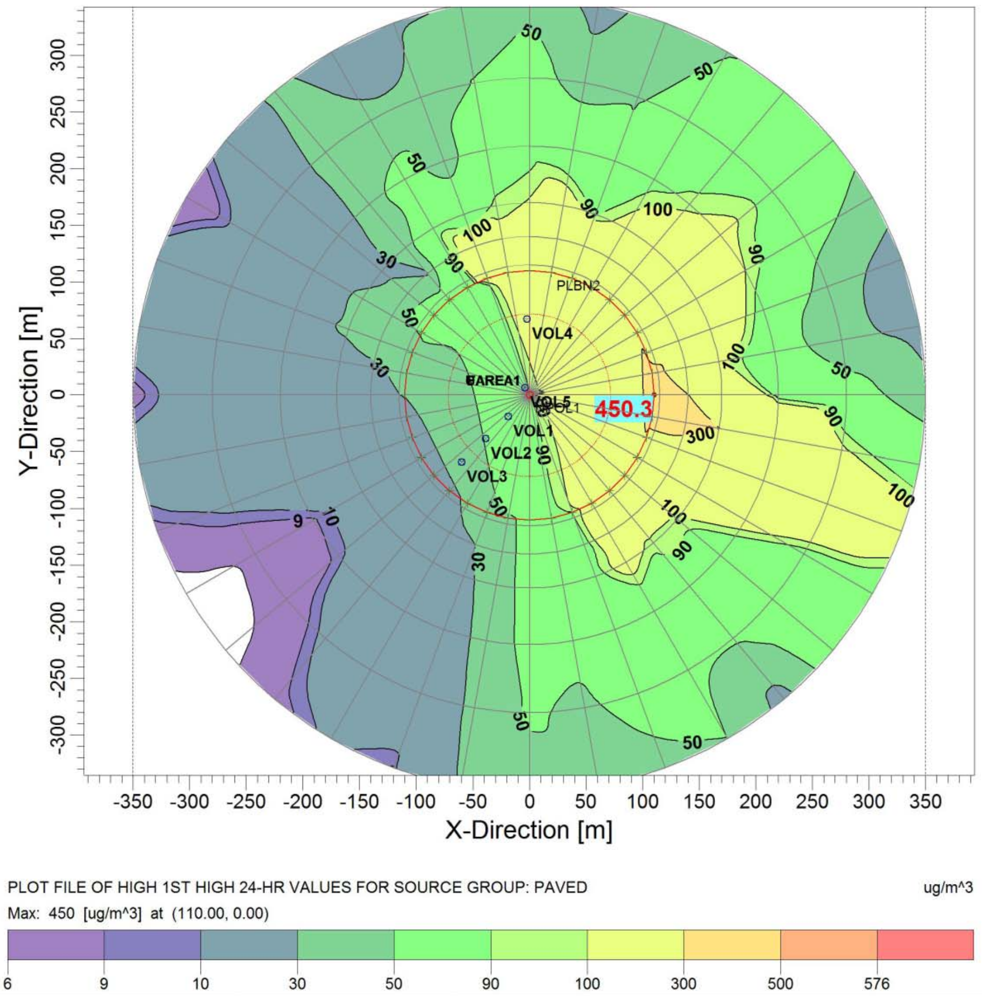
Figure 4.6d 24-Hr Average Coal PM10 Emissions Modeling Paved Road Emissions



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: PAVED

Max: 450 [ug/m^3] at (110.00, 0.00)

COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,009 0 0.1 km	
	MAX: **450 ug/m^3**	DATE: **2/19/2014**	PROJECT NO.:

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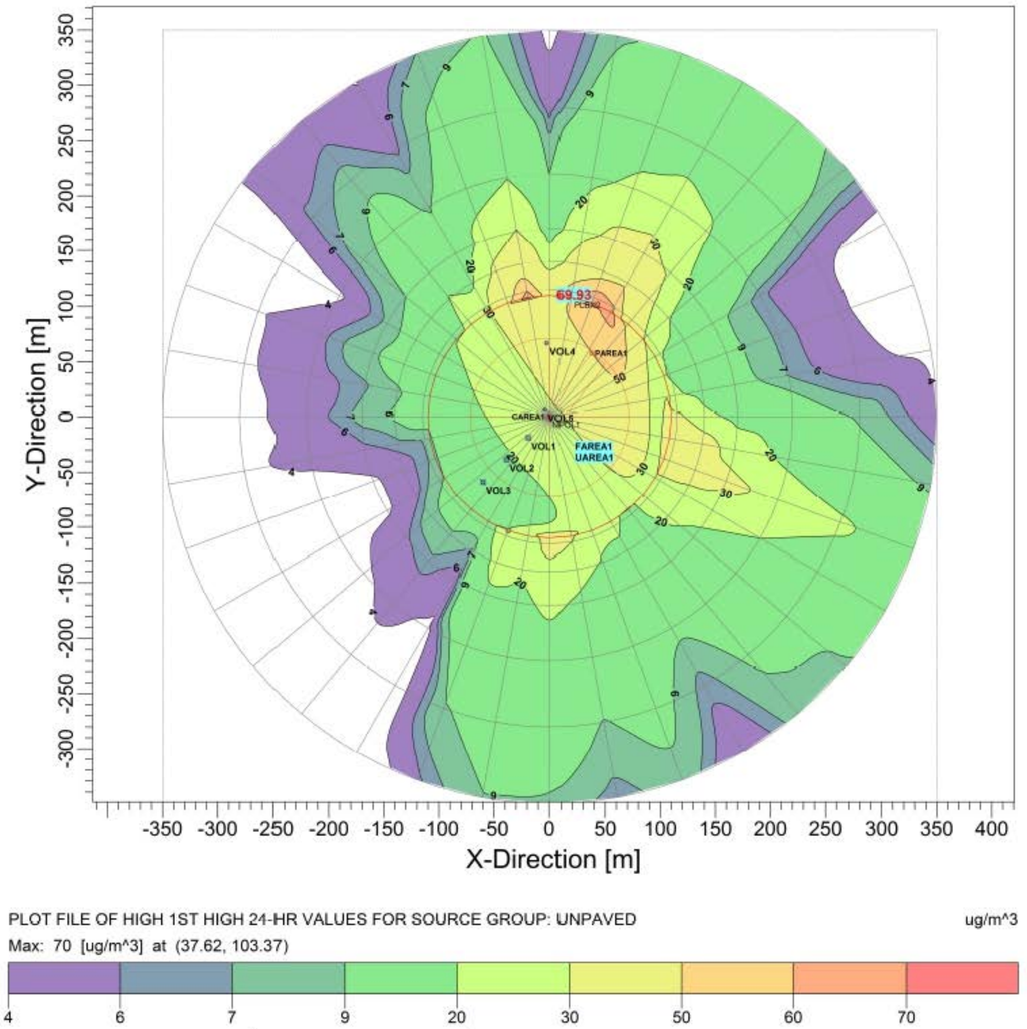
Figure 4.6e 24-Hr Average Coal PM10 Emissions Modeling Emissions from Travel on Pile Surface



COMMENTS:

Articulated Dump Truck & Loader

SOURCES:

11

COMPANY NAME:

CDM Smith

RECEPTORS:

252

MODELER:

RS

OUTPUT TYPE:

Concentration

SCALE: 1:5,315

0 0.2 km

MAX:

70 ug/m^3

DATE:

3/3/2014

PROJECT NO.:

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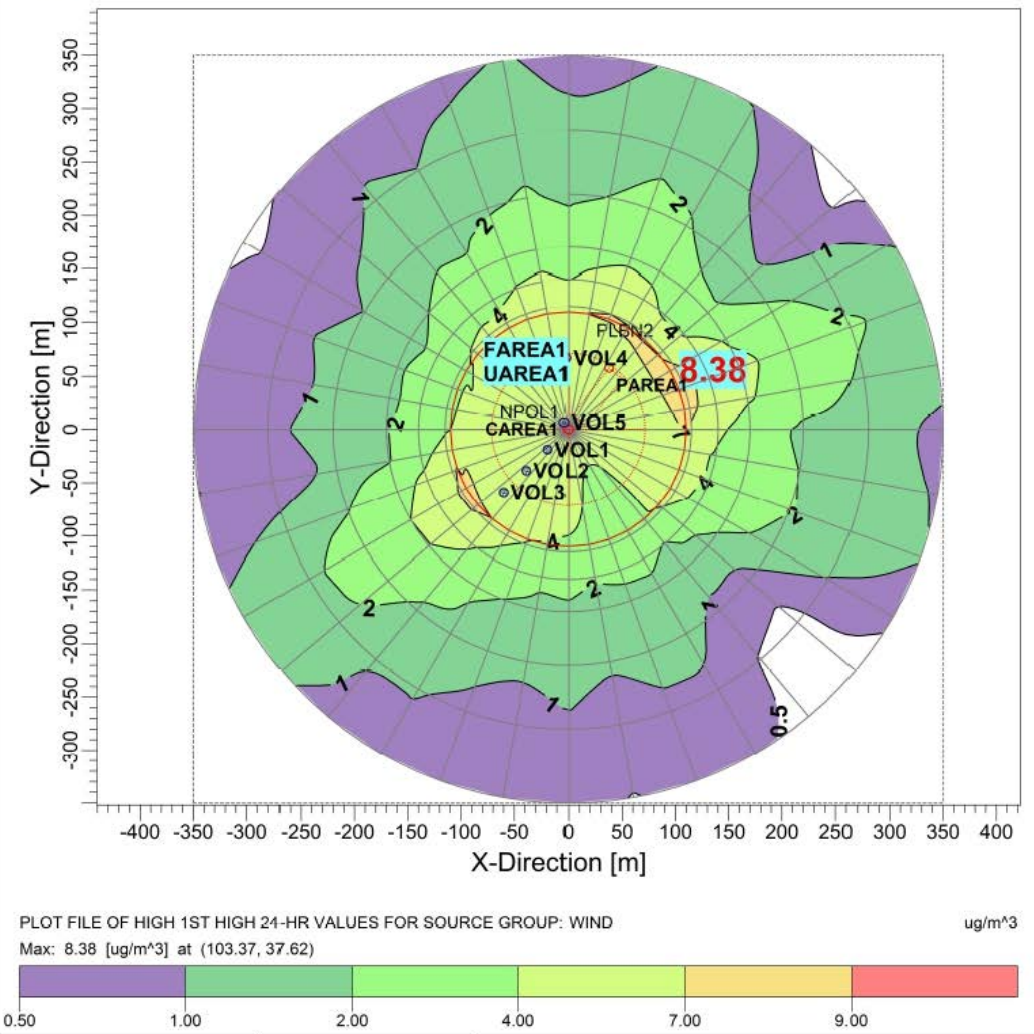
Figure 4.6f 24-Hr Average Coal PM10 Emissions Modeling Wind Erosion Emissions from Stockpiles



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: WIND

Max: 8.38 [ug/m^3] at (103.37, 37.62)

COMMENTS:

SOURCES: 11

COMPANY NAME: **CDM Smith**

RECEPTORS: 252

MODELER: **RS**

OUTPUT TYPE: Concentration

SCALE: 1:5,499

0 0.2 km

MAX: 8.38 ug/m^3

DATE: **3/3/2014**

PROJECT NO.:

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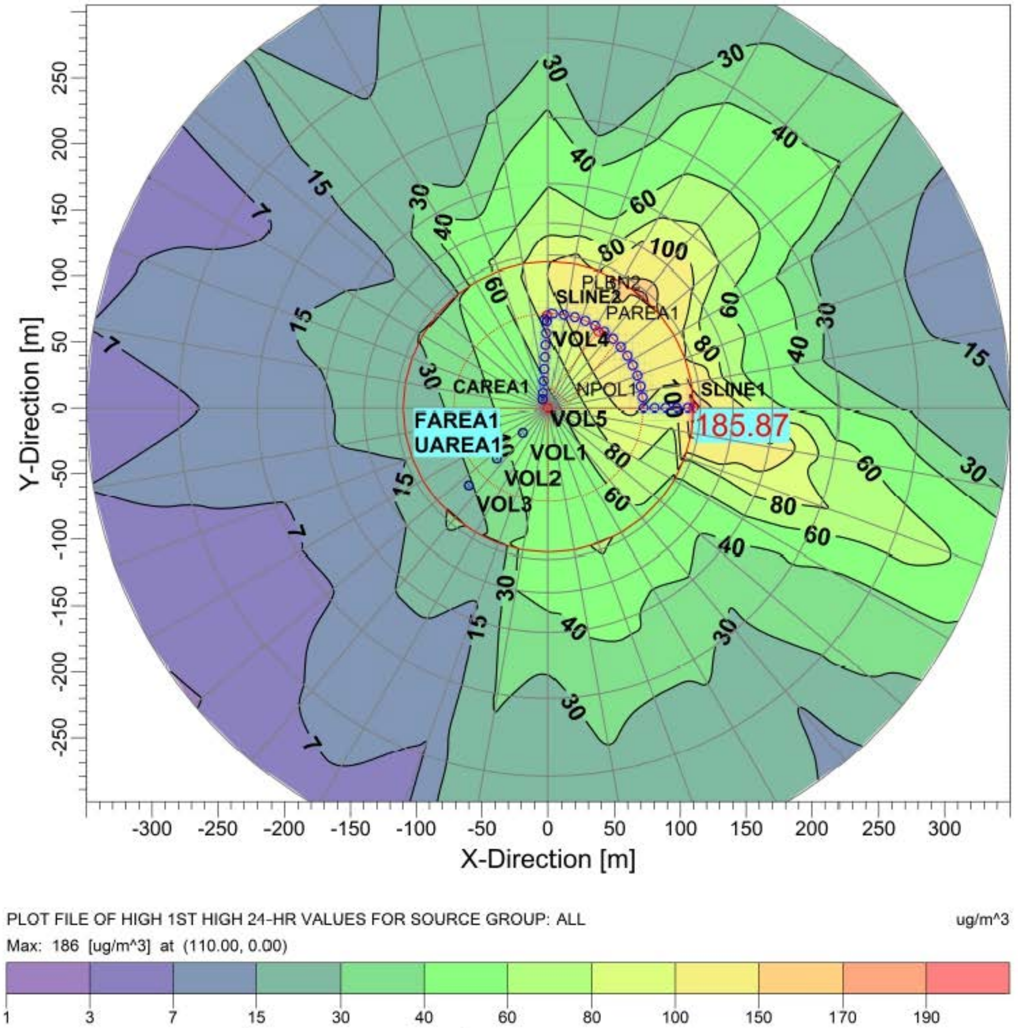
Figure 4.7a 24-Hr Average Coal PM2.5 Emissions Modeling Group All Equipment Emissions



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: ALL

Max: 186 [ug/m^3] at (110.00, 0.00)

COMMENTS: Sigma Z = 2 meters Dozer/Grader Release Height = 2 meters	SOURCES: 11	COMPANY NAME: CDM Smith	
	RECEPTORS: 252	MODELER: RS	
	OUTPUT TYPE: Concentration	SCALE: 1:4,461 0 ▬▬▬ 0.1 km	
	MAX: 186 ug/m^3	DATE: 3/3/2014	PROJECT NO.:

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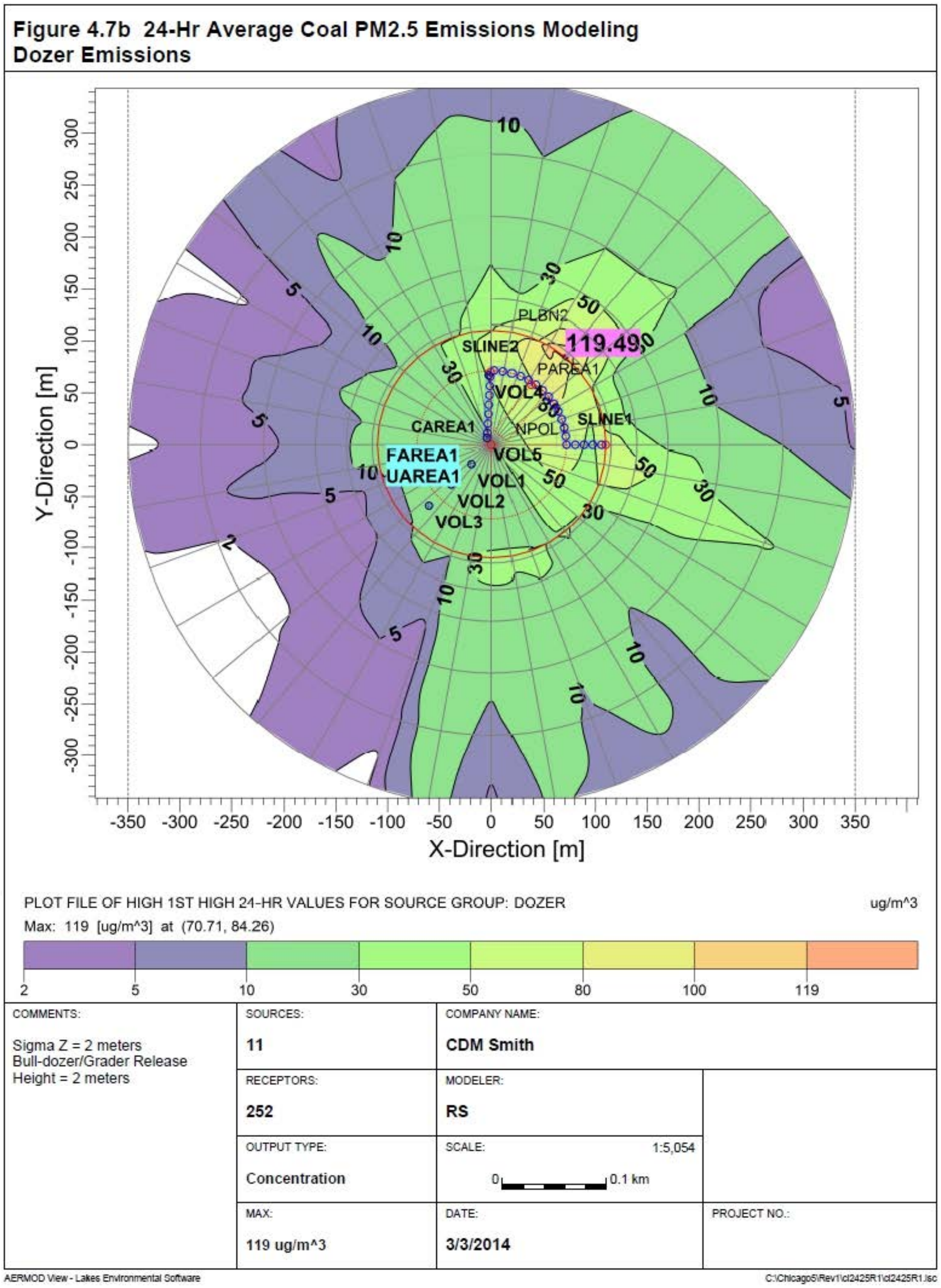

Figure 4.7b 24-Hr Average Coal PM2.5 Emissions Modeling Dozer Emissions

PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: DOZER

Max: 119 [ug/m^3] at (70.71, 84.26)

COMMENTS:

Sigma Z = 2 meters
Bull-dozer/Grader Release
Height = 2 meters

SOURCES: 11

COMPANY NAME: CDM Smith

RECEPTORS: 252

MODELER: RS

OUTPUT TYPE: Concentration

SCALE: 1:5,054

MAX: 119 ug/m^3

DATE: 3/3/2014

PROJECT NO.:

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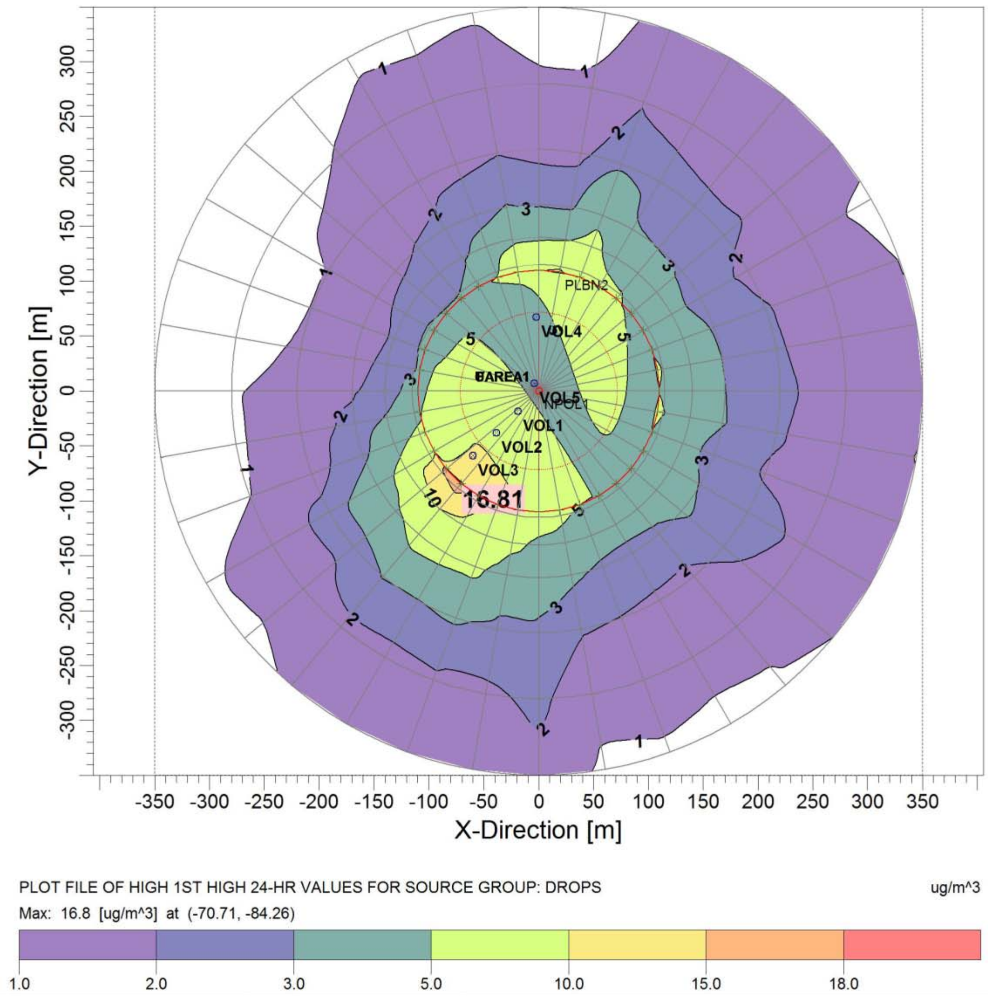
Figure 4.7c 24-Hr Average Coal PM2.5 Emissions Modeling Drop Emissions



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: DROPS ug/m^3

Max: 16.8 [ug/m^3] at (-70.71, -84.26)

COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,167 0 0.2 km	
	MAX: **16.8 ug/m^3**	DATE: **2/19/2014**	PROJECT NO.:

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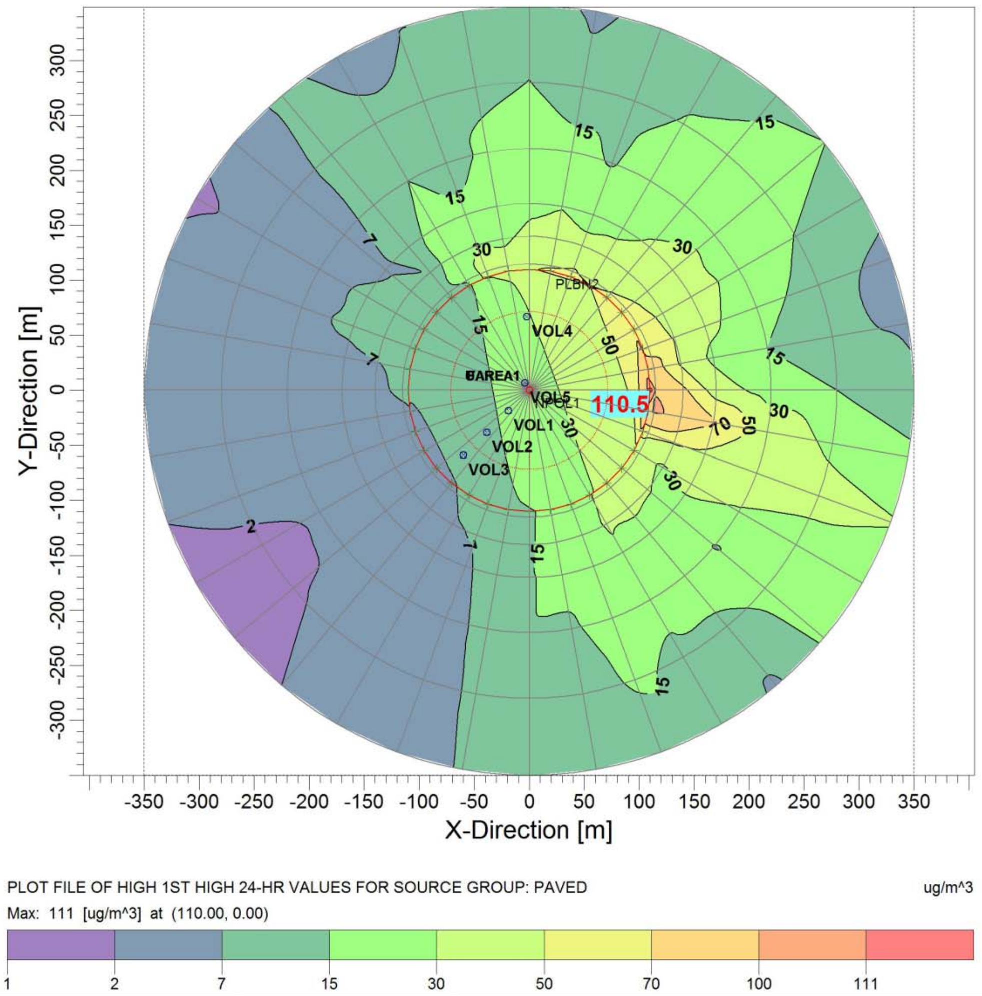
Figure 4.7d 24-Hr Average Coal PM2.5 Emissions Modeling Paved Road Emissions



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: PAVED

ug/m^3

Max: 111 [ug/m^3] at (110.00, 0.00)

COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,160 0 0.2 km	
	MAX: **111 ug/m^3**	DATE: **2/19/2014**	PROJECT NO.:

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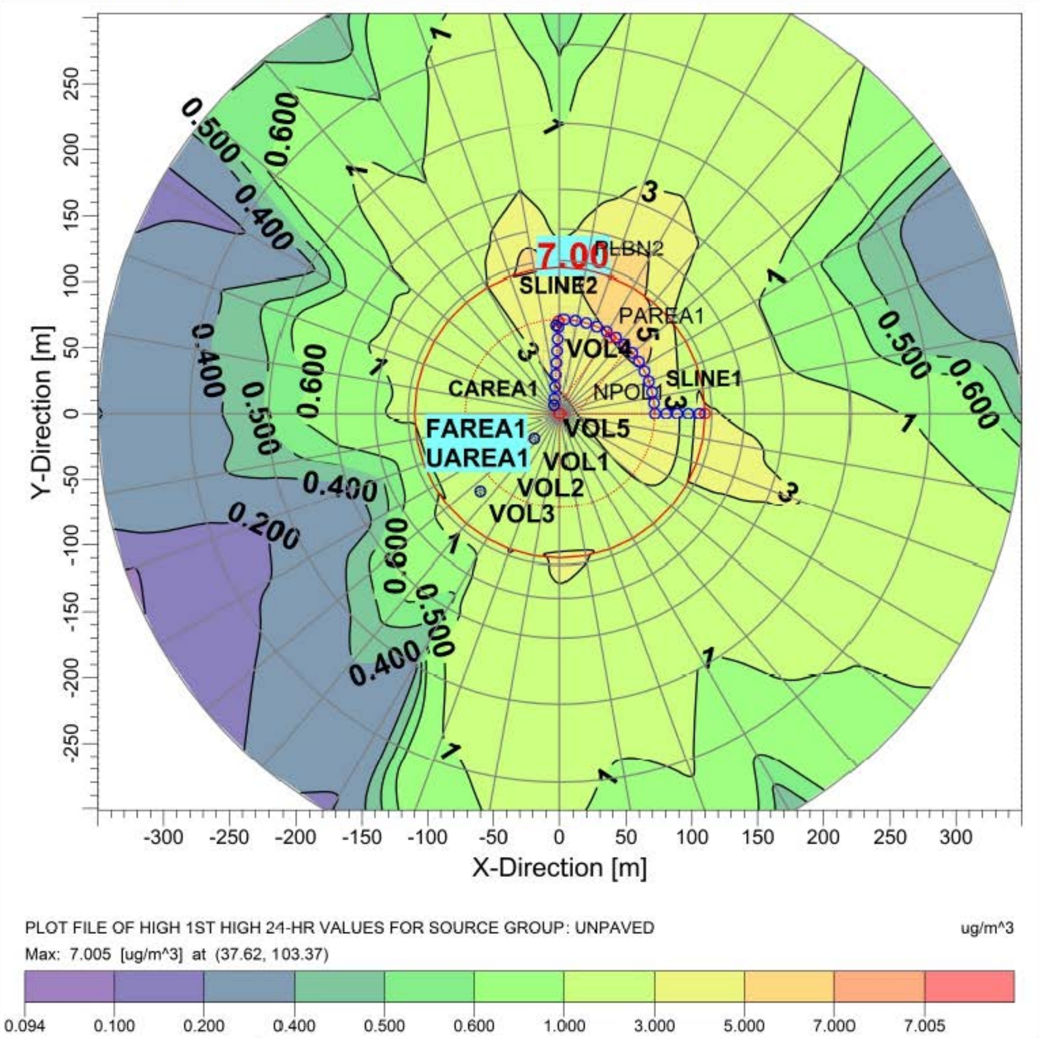
Figure 4.7e 24-Hr Average Coal PM2.5 Emissions Modeling Emissions from Travel on Pile Surface



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: UNPAVED

Max: 7.005 [ug/m^3] at (37.62, 103.37)

COMMENTS: Articulated Dump Truck & Loader	SOURCES: 11	COMPANY NAME: CDM Smith	
	RECEPTORS: 252	MODELER: RS	
	OUTPUT TYPE: Concentration	SCALE: 1:4,461 0 0.1 km	
	MAX: 7.005 ug/m^3	DATE: 3/3/2014	PROJECT NO.:

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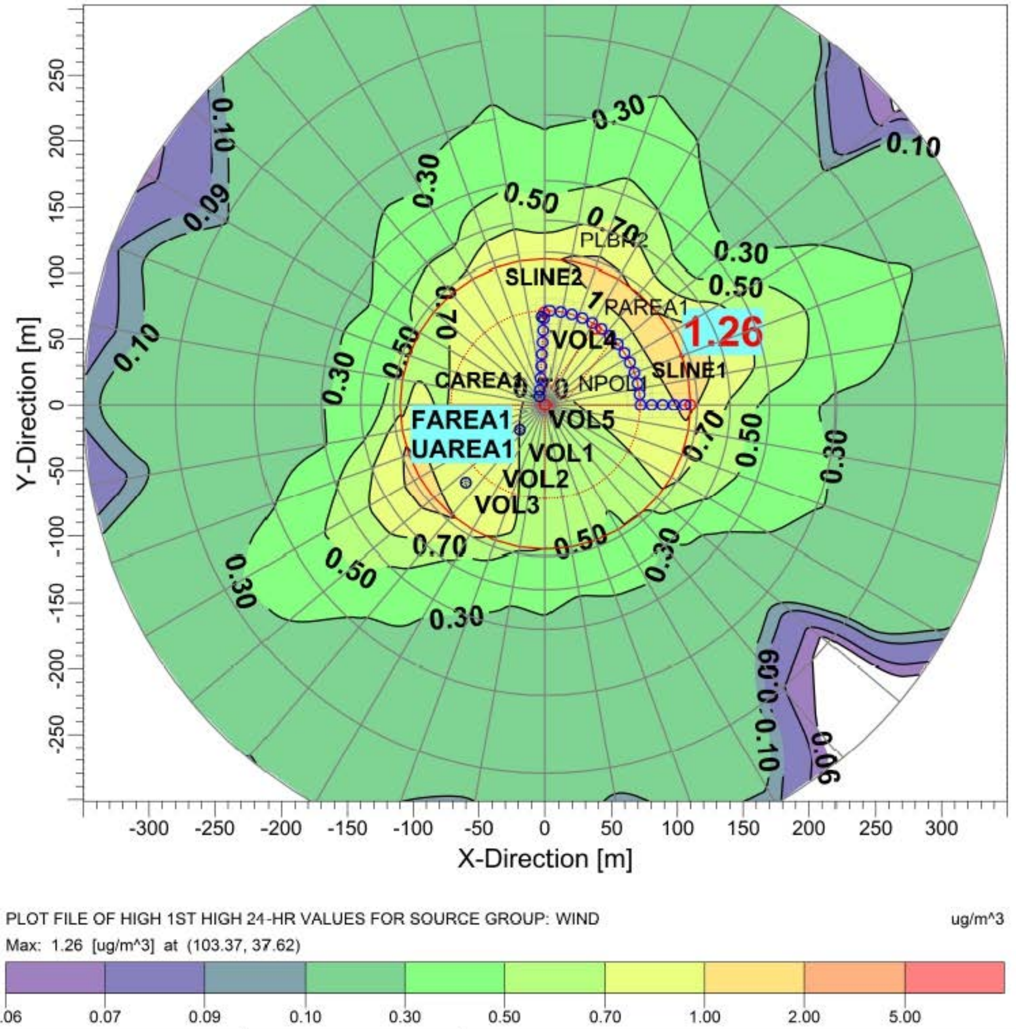
Figure 4.7f 24-Hr Average Coal PM2.5 Emissions Modeling Wind Erosion Emissions from Stockpile



PLOT FILE OF HIGH 1ST HIGH 24-HR VALUES FOR SOURCE GROUP: WIND ug/m^3

Max: 1.26 [ug/m^3] at (103.37, 37.62)

COMMENTS:	SOURCES: 11	COMPANY NAME: **CDM Smith**	
	RECEPTORS: 252	MODELER: **RS**	
	OUTPUT TYPE: Concentration	SCALE: 1:4,461 0 0.1 km	
	MAX: 1.26 ug/m^3	DATE: 3/3/2014	PROJECT NO.:

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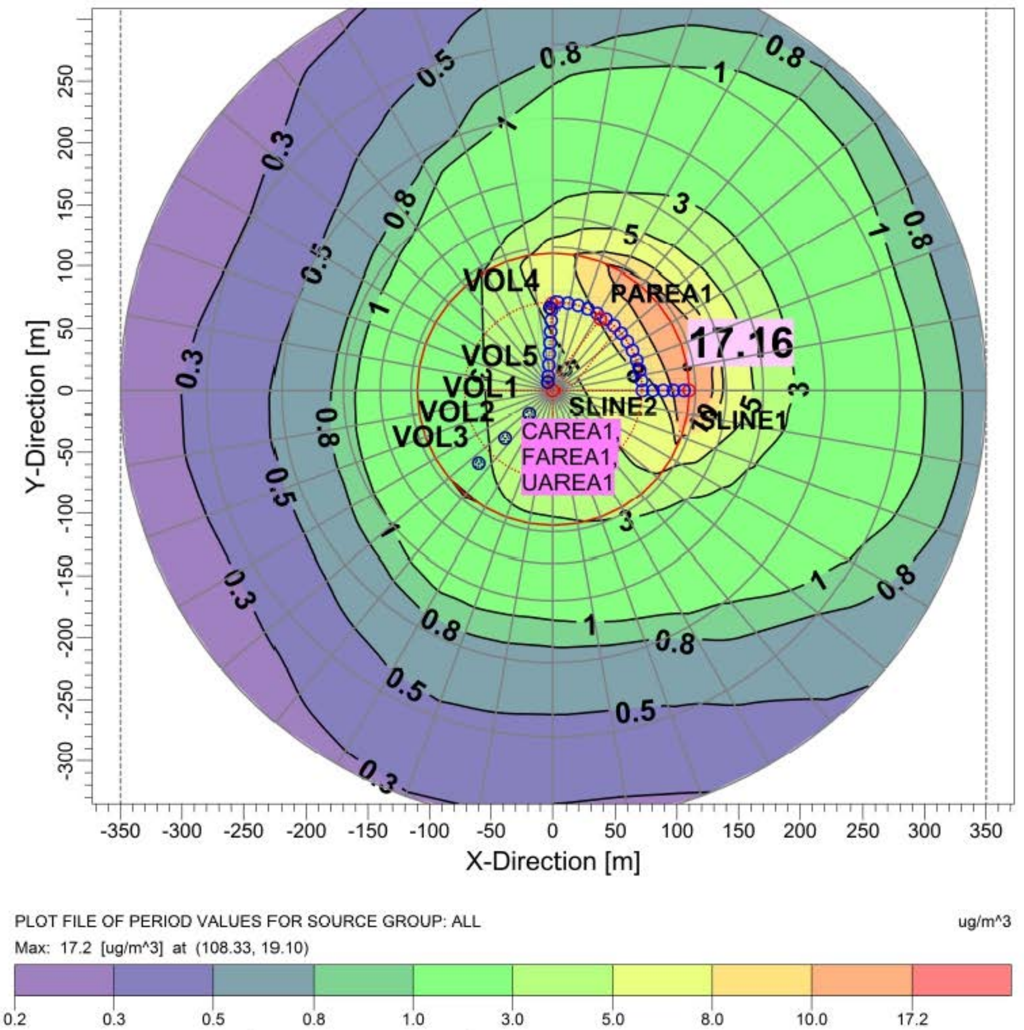
Figure 4.8a Annual Avg Coal PM2.5 Emissions Modeling Group All Equipment Emissions



COMMENTS: Sigma Z = 2 meters Bull-dozer/Grader Release Height = 2 meters	SOURCES: 11	COMPANY NAME: CDM Smith
	RECEPTORS: 252	MODELER: RS
	OUTPUT TYPE: Concentration	SCALE: 1:4,753 0 0.1 km
	MAX: 17.2 ug/m^3	DATE: 3/3/2014
		PROJECT NO.:

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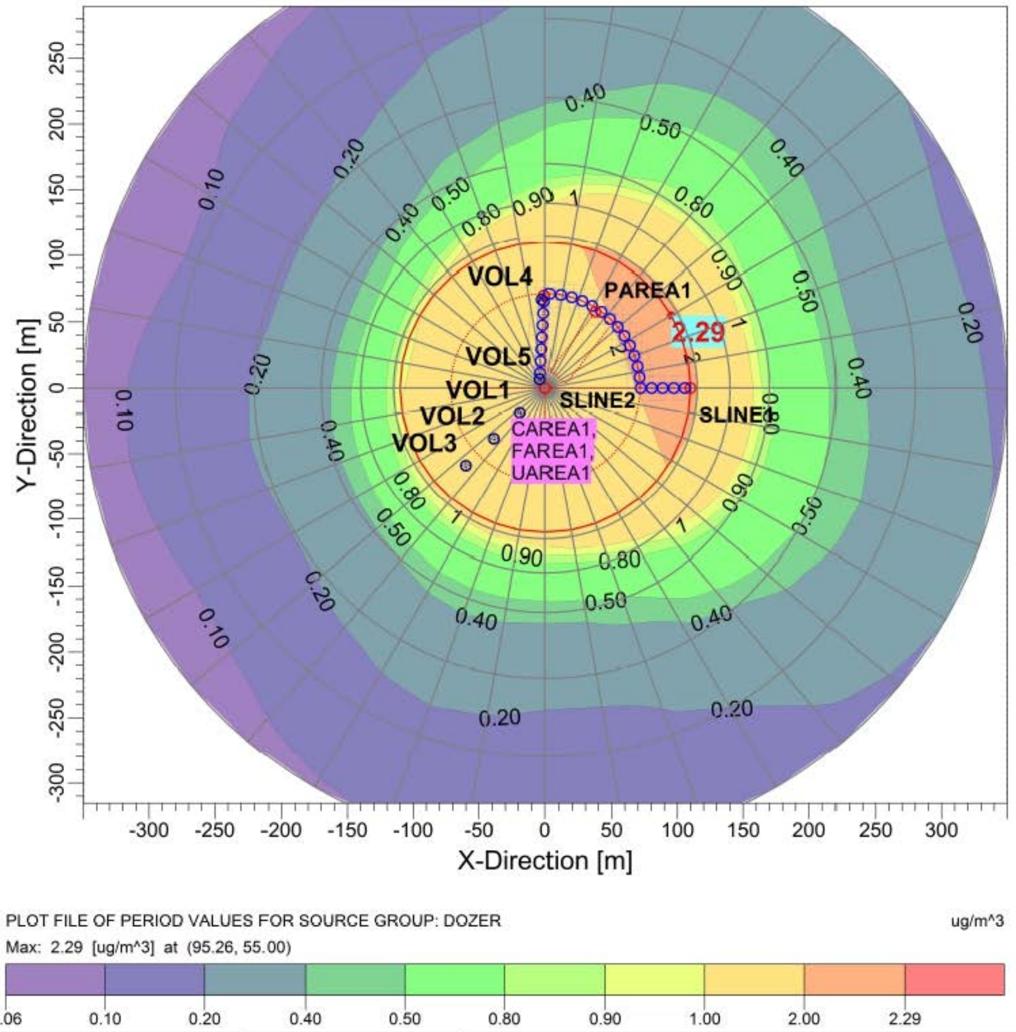
Figure 4.8b Annual Avg Coal PM2.5 Emissions Modeling Dozer Emissions



PLOT FILE OF PERIOD VALUES FOR SOURCE GROUP: DOZER

ug/m^3

Max: 2.29 [ug/m^3] at (95.26, 55.00)

COMMENTS:

Sigma Z = 2 meters
Bull-dozer/Grader Release
Height = 2 meters

SOURCES:

11

COMPANY NAME:

CDM Smith

RECEPTORS:

252

MODELER:

RS

OUTPUT TYPE:

Concentration

SCALE: 1:4,461

0 ▬▬▬ 0.1 km

MAX:

2.29 ug/m^3

DATE:

3/3/2014

PROJECT NO.:

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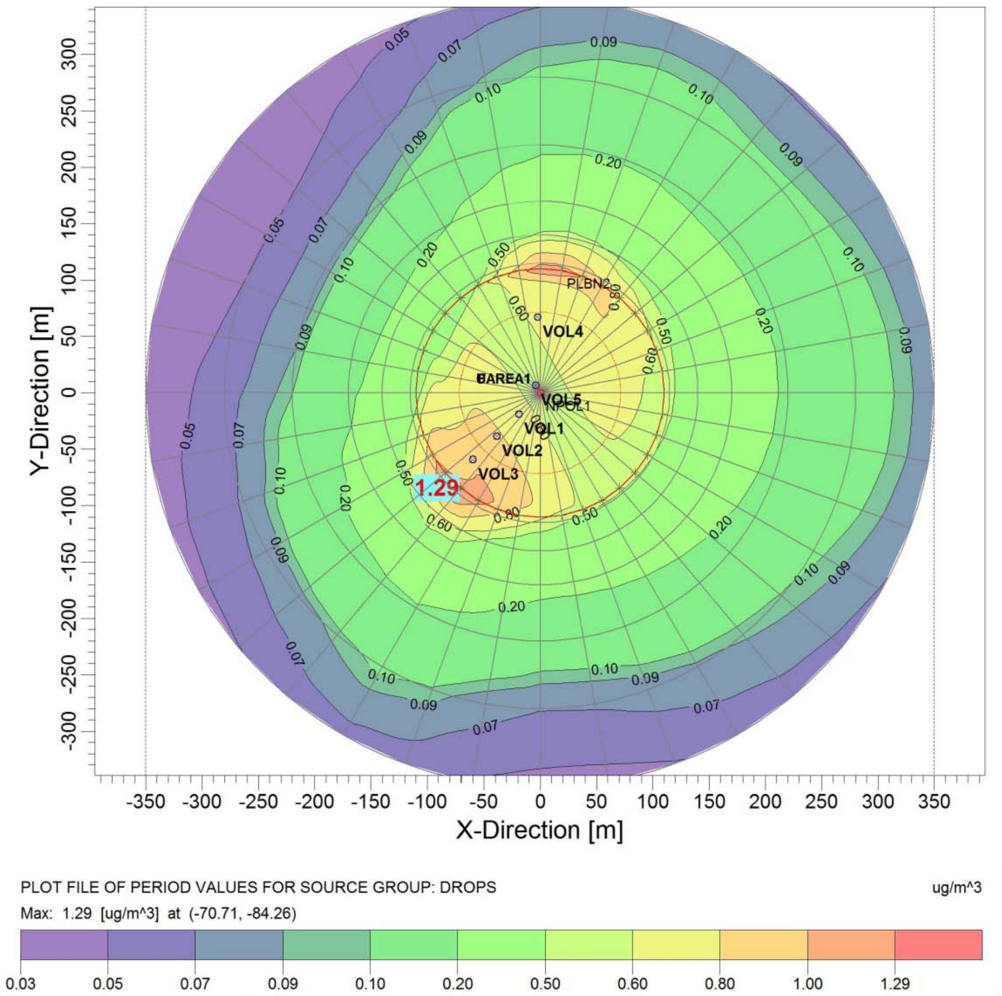
Figure 4.8c Annual Avg Coal PM2.5 Emissions Modeling Drop Emissions



PLOT FILE OF PERIOD VALUES FOR SOURCE GROUP: DROPS

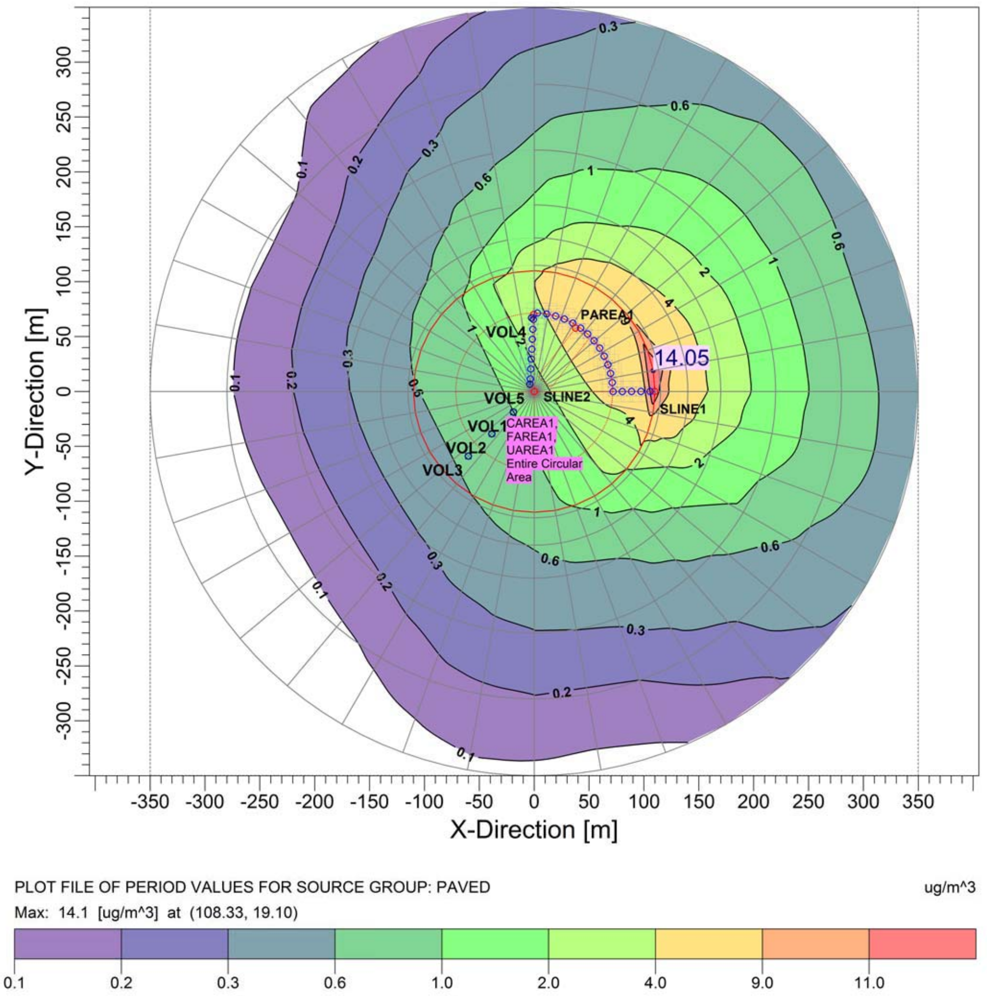
Max: 1.29 [ug/m^3] at (-70.71, -84.26)

COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,032 0 0.1 km	
	MAX: **1.29 ug/m^3**	DATE: **2/19/2014**	PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Chicago5\clan25\clan25.isc

Figure 4.8d Annual Avg Coal PM2.5 Emissions Modeling Paved Road Emissions



PLOT FILE OF PERIOD VALUES FOR SOURCE GROUP: PAVED

Max: 14.1 [ug/m^3] at (108.33, 19.10)

COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: **Concentration**	SCALE: 1:5,164 0 0.2 km	
	MAX: **14.1 ug/m^3**	DATE: **2/21/2014**	PROJECT NO.:

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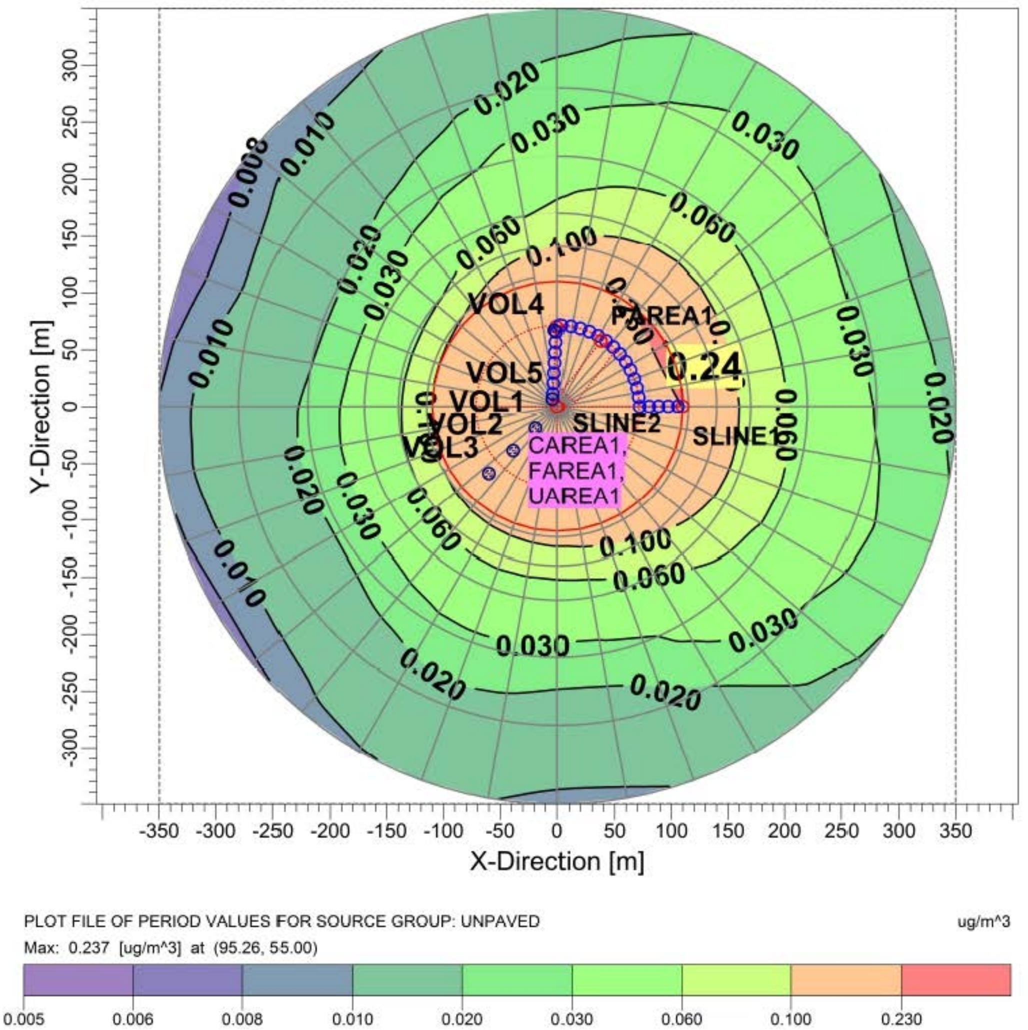
C:\Chicago5\clan25\clan25.isc

**Figure 4.8e Annual Avg Coal PM2.5 Emissions Modeling
Emissions from Travel on Pile Surface**



PLOT FILE OF PERIOD VALUES FOR SOURCE GROUP: UNPAVED

Max: 0.237 [ug/m^3] at (95.26, 55.00)

COMMENTS: Articulated Dump Truck and Loader	SOURCES: 11	COMPANY NAME: CDM Smith	
	RECEPTORS: 252	MODELER: RS	
	OUTPUT TYPE: Concentration	SCALE: 1:5,164 0 0.2 km	
	MAX: 0.237 ug/m^3	DATE: 3/3/2014	PROJECT NO.:

AERMOD View - Lakes Environmental Software

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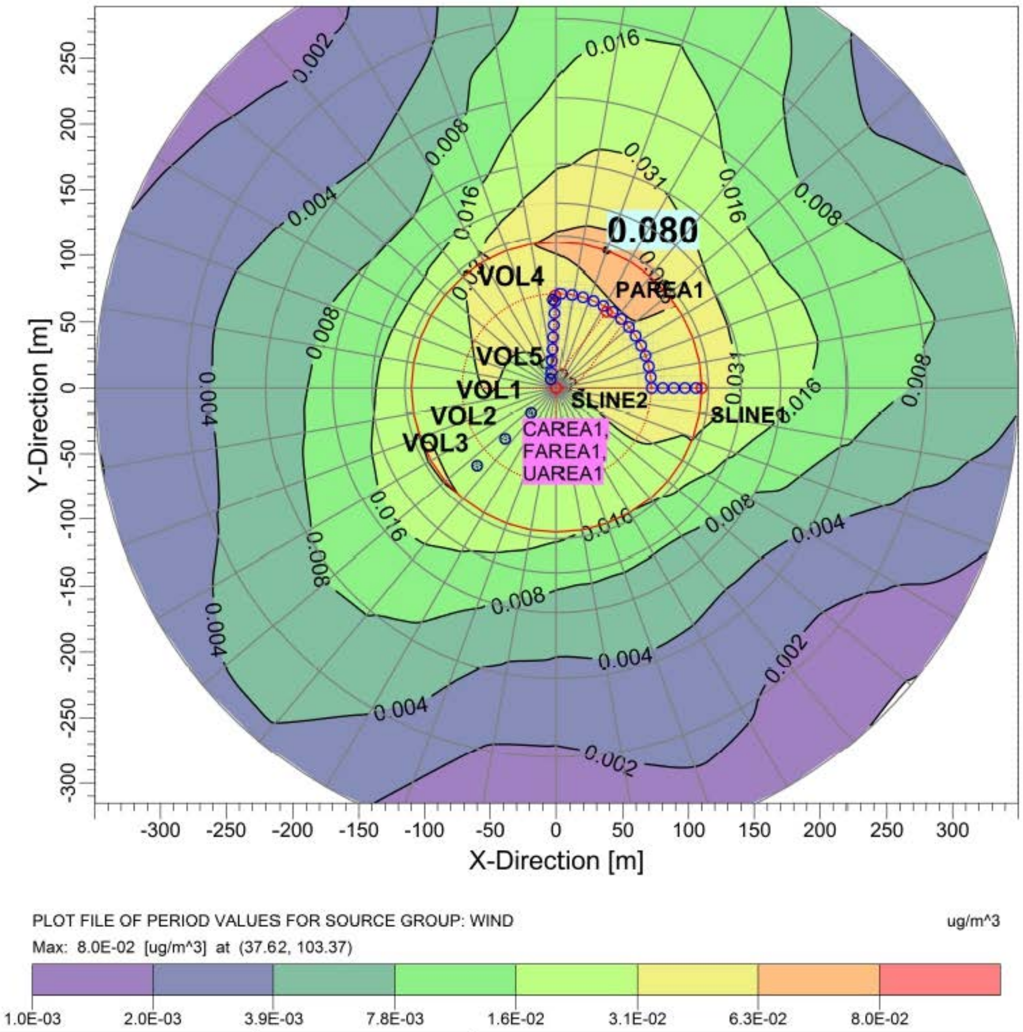
Figure 4.8f Annual Avg Coal PM2.5 Emissions Modeling Wind Erosion Emissions from Stockpile



COMMENTS:	SOURCES: **11**	COMPANY NAME: **CDM Smith**	
	RECEPTORS: **252**	MODELER: **RS**	
	OUTPUT TYPE: Concentration	SCALE: 1:4,461 0 0.1 km	
	MAX: 8.0E-02 ug/m^3	DATE: **3/3/2014**	PROJECT NO.:

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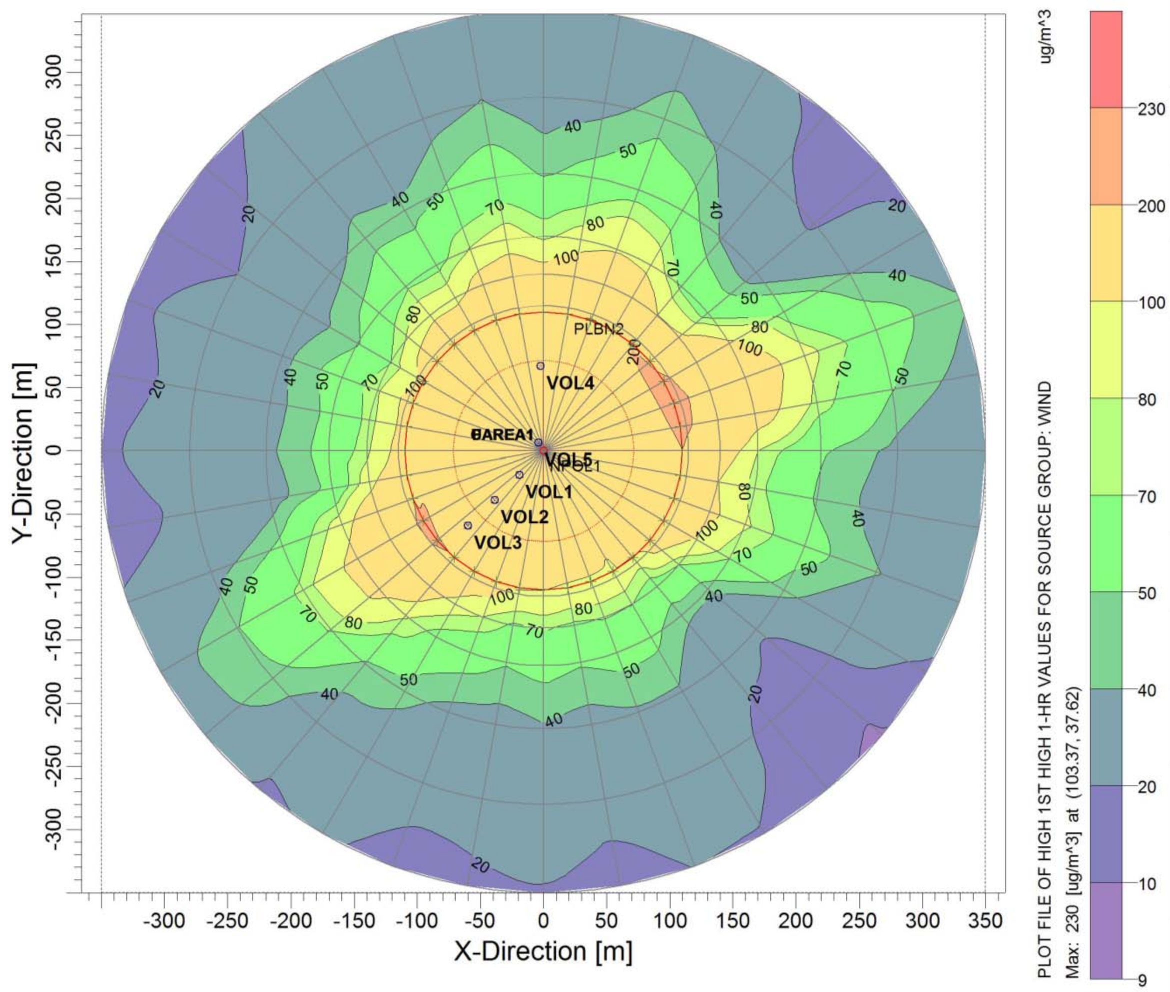
Figure 4.9 1-Hour Averaging Period PM10 Emissions
Wind Erosion of a Petcoke Storage Pile



PLOT FILE OF HIGH 1ST HIGH 1-HR VALUES FOR SOURCE GROUP: WIND
Max: 230 [ug/m^3] at (103.37, 37.62)

COMMENTS:

SOURCES:
11

RECEPTORS:
252

OUTPUT TYPE:
Concentration

MAX:
230 ug/m^3

COMPANY NAME:
CDM Smith

MODELER:
RS

DATE:
2/20/2014

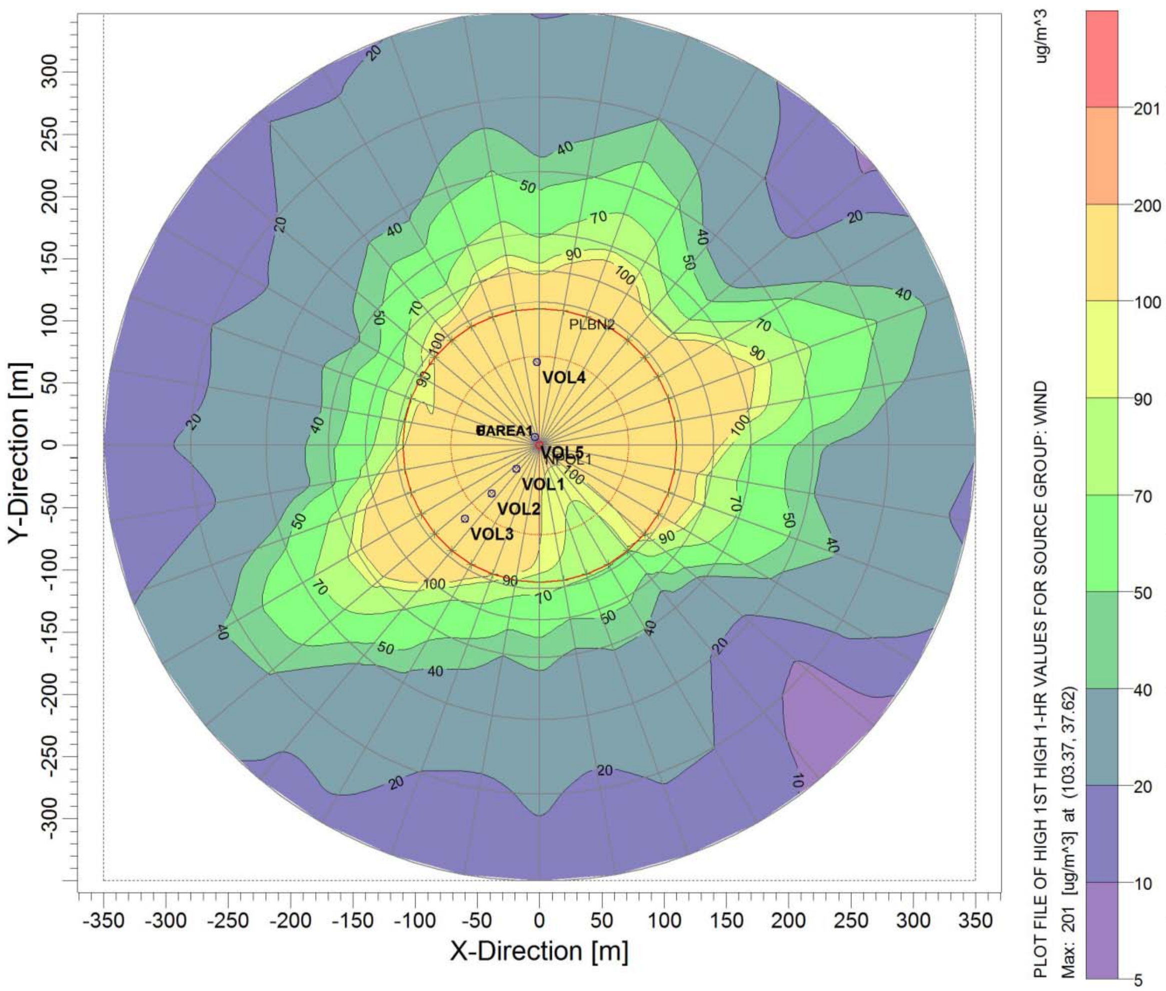
SCALE: 1:4,808
0 0.1 km

PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Chicago5\pc2410ca\pc2410ca.isc

Figure 4.10 1-Hour Averaging Period PM10 Emission Rate Wind Erosion of a Coal Storage Pile



COMMENTS:

SOURCES:
11

RECEPTORS:
252

OUTPUT TYPE:
Concentration

MAX:
201 ug/m^3

COMPANY NAME:
CDM Smith

MODELER:
RS

DATE:
2/20/2014

SCALE: 1:4,875

0 0.1 km

PROJECT NO.:

AERMOD View - Lakes Environmental Software

C:\Chicago5\cl2410ca\cl2410ca.isc

cdmsmith.com