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Memorandum

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Subject: **Middletown Technology Center**
Refined Air Quality Modeling Results

Date: June 14, 2016

CC: Pat Wright, TRC

Project No.: 252909

TRC has completed a refined air quality dispersion modeling analyses to assess the Middletown Technology Center's (MTC) generator engine emissions' potential for modeled compliance with the National Ambient Air Quality Standards (NAAQS). The modeling results are based upon the anticipated locations of the specific generator sets (gensets) and the permitted emission estimates as provided to DNREC in the air permit application.

Selection of Sources for Modeling

The emission sources responsible for potential emissions from the MTC facility are the five (5) 10MW reciprocating engine generator sets and five (5) 2.5MW reciprocating engine generator sets. These units were collectively included in and are the main focus of the modeling analyses. The modeling includes the operation of all 10 gensets simultaneously in steady-state operation, and also assess the startup emissions of all 10 gensets starting within a single hour (and combinations of various gensets starting within the same hour).

Emission Rates and Exhaust Parameters

The dispersion modeling analysis was conducted with emission rates and flue gas exhaust characteristics (flow rate and temperature) that were provided by the vendor of the proposed natural gas fired engines. The modeled emissions and exhaust parameters have been provided to DNREC as an emissions workbook, as part of the air permit application. Tables 1 and 2 summarize the stack parameters and emission rates that were used in the modeling for the generator engines. The 10 MW gensets exhaust stacks were located at their respective design locations. The stacks for the 2.5 MW

gensets were co-located (at the same modeled location) as these units will be placed fairly close together and the dispersion would benefit from the merging of the exhaust plumes. The startup modeling analysis examined multiple scenarios of combinations of the 10 MW and 2.5 MW gensets starting within the same hour. The startup modeling initially examined individually, all five of the 2.5 MW gensets and various combinations of the 10 MW gensets (i.e., 1, 2, 3, 4 and 5 units) starting in the same hour. In as much as the 10 MW units will be the primary generators, the startup analysis also included the assessment of five 10 MW units plus incrementally starting the 2.5 MW gensets, until the impact of all 10 units being started within the same hour is assessed.

Model Selection

The latest version of US EPA's AERMOD model (Version 15181) was used in the analysis. AERMOD is a refined, steady state, multiple-source, Gaussian dispersion model. It was selected because it is US EPA's preferred model for nearfield analysis of industrial sources and is appropriate for assessing the air quality impacts from point source facilities such as MTC. AERMOD was applied with the regulatory default options and 5-years (2005-2009) of hourly meteorological data described below.

Meteorological Data

AERMOD modeling analyses require the use of meteorological data that has been collected at either an onsite location or a location with similar, representative land use and topographic features to the proposed site. The meteorological data used in this analysis were processed in the AERMOD pre-processor AERMET and were provided to TRC by Environmental Consulting & Technology, Inc. The dataset consists of years 2005 through 2009 derived from surface data observed at the Dover Air Force Base, Delaware meteorological station (WBAN #13707) and upper air data collected from Phillips Air Force Base, Maryland upper air sounding station (WBAN #13701). This data is considered representative of the study area for which this refined modeling analysis is being prepared, due to the proximity of the data source to the site and the similarity of the terrain at both locations which is generally flat coastal plain at elevations of 50 to 100 feet above mean sea level.

Background Concentrations

Ambient air quality data for the MTC study area (northern Delaware including New Castle County) was obtained from the USEPA AirData web site (https://www3.epa.gov/airdata/) last visited May, 2016. Monitoring data results were downloaded for Delaware and if absent, from Maryland monitors, for the period years 2013, 2014, 2015.) The background concentrations are presented in Table 3. The highest of the three recorded values were selected as representative and conservative estimates of the background air quality within the air shed with the exception of obtaining a representative background for the air regime around MTC, which is located away from the anticipated high NO2 area of Wilmington. To obtain a reasonably representative background concentration for 1-hour NO2, all of the highest 98th percentile concentrations measured in Delaware for 2013, 2014 and 2015 were averaged, and the actual stations (with seven monitoring values) used

are shown in italics in Table 3. This value is considered more representative of the background concentrations of NO2 for the air quality in the vicinity of the MTC facility. These values are presented for comparison to the National Ambient Air Quality Standards (NAAQS) presented in Table 4.

Receptor Grid

The AERMOD model requires receptor data consisting of location coordinates and ground-level elevations. The receptor generating program, AERMAP (Version 11103), was used to develop a complete receptor grid to a minimum distance of 10 kilometers from the proposed facility. AERMAP uses National Elevation Dataset (NED) data obtained from the USGS. AERMAP was run to determine the representative elevation for each receptor using 1/3 arc second NED files that were obtained for an area covering at least 10 kilometers in all directions from the proposed facility.

The following rectangular (i.e. Cartesian) receptors were used to assess the air quality impact of the proposed facility:

- Property line receptors were spaced at 25 meters;
- Fine grid receptors (50 meter spacing) from the property line to 2 kilometers;
- Course grid receptors (250 meter spacing) from 2 kilometers to 5 kilometers;
- Course grid receptors (500 meter spacing) from 5 kilometers to 10 kilometers.

Note that these grid distances are squared and the actual distances from the center of the facility are about 40% greater to the receptors on the diagonals.

The facility will have a security fence that will preclude public access to the site. Ambient air is therefore defined as the area at and beyond the fence. The modeling receptor grid includes receptors spaced at 25-meter intervals along the entire fence line. Any Cartesian receptors located within the fence line were removed.

GEP Stack Height Analysis

The 10 emission units at the facility were evaluated in terms of their proximity to nearby structures for the purpose of assessing the downwash of the plumes from those structures. The US EPA modeling guidance requires that stacks with a height less than the Good Engineering Practice (GEP) stack height should be further evaluated for determining air quality impacts associated with downwash. Because the stacks have a height less than the GEP stack height, further evaluation was required.

The US EPA GEP stack height regulations specify that the GEP stack height be calculated in the following manner:

$$H_{GEP} = H_B + 1.5L$$

where: H_B = the height of adjacent or nearby structure(s) measured from the ground-level elevation at the base of the stack, and

L = the lesser dimension (height or projected width) of the adjacent or nearby structure(s).

The direction-specific building dimensions that were used as input to the AERMOD model were calculated using the latest version of the Building Profile Input Program BPIP-PRIME (version 04274). The largest structure is the MTC building itself at 35 feet above grade. The formula GEP height at the facility is approximately 75 feet based upon the dimensions of the proposed building as calculated by BPIP PRIME. As such, all of the exhaust stacks are subject to downwash and the downwash parameters from the BPIP program were included in the AERMOD analysis.

NO2 modeling options

Whereas modeled concentrations of PM10, PM2.5, SO2, and CO match the pollutant being emitted, NO_X emissions are modeled differently because of how the pollutant chemically reacts in the atmosphere and because of the form of the NAAQS. When a fuel source (e.g., natural gas) is combusted, oxides of nitrogen (NO_X) are emitted, which initially comprises of approximately 30% NO2 and 70% nitrogen oxide (NO) for natural gas-fired engines like those at the MTC. Over time due to photochemical reactions in the ambient atmosphere where NO converts to NO2, the NO-NO2 ratio will settle out to the ambient atmospheric ratio, which is 80% NO2 on a one-hour basis and 75% NO2 on an annual basis per US EPA guidance. Because the NAAQS is for NO2, only modeled concentrations of NO2 should calculated for comparison to the NAAQS.

To amend the discontinuity between the pollutant emissions (i.e., grams per second [g/s] of NO_X) and pollutant concentrations (i.e., micrograms per cubic meter [$\mu g/m^3$] of NO2), the US EPA guidance outlines a three-tiered modeling approach. In the Tier 1 approach, all NO_X emissions are conservatively assumed to be NO2, so the total modeled concentrations are in terms of NO2. If the Tier 1 modeled concentrations are greater than the NAAQS design values, the Tier 2 approach may be used. This approach is often called the Ambient Ratio Method (ARM) because the ambient atmospheric ratio is applied to modeled concentrations of NO_X, where 80% are assumed to be NO2 concentrations on a one-hour basis and 75% are assumed on an annual basis. If Tier 2 modeled concentrations are greater than the NAAQS design values, the more refined Tier 3 approach (i.e., the Plume Volume Molar Ratio Method [PVMRM] or the Ozone Limiting Method [OLM]) may be used with consent from the State Regulatory Agency for non-PSD air dispersion modeling as these are non-default modeling options.

Two key model inputs for PVMRM are the source-specific in-stack ratios of $NO2/NO_x$ emissions and hourly ambient background O_3 concentrations. Initially, PVMRM takes into account that some NO_2 is formed during the combustion process and emitted directly to the atmosphere. Therefore, to account for this initial component of NO2, PVMRM as implemented in AERMOD uses a specified in-stack ratio for each source in addition to the NOx emission rate. The remaining fraction of NOx

emissions are assumed to be NO and available for conversion to NO2. The PVMRM computations are performed on an hourly basis and therefore require a representative data base of hourly ozone concentrations concurrent with the meteorological data input to AERMOD. As O_3 is required for the conversion of NO to NO2 in the model, higher O_3 concentrations for a given hour mean there is a greater potential that a larger fraction of the NO emitted will be converted to NO2.

The refined modeling analysis was conducted using the Tier 2 approach which results in conservative modeled NO2 concentrations. However, even with the modeled conservatism, the NO2 concentrations plus background will still achieve the NAAQS during startup conditions for all 10 engines starting during the same hour. A discussion for the potential use of the Tier 3 approach for reducing the modeled conservatism is included in the modeling results section as follows.

Refined Modeling Results

The refined modeling results are presented in Table 5 added to the representative background and compared to the applicable NAAQS. These values represent the ground level concentrations from the emissions of all 10 engines in steady state operation. Note that the NOx concentrations are adjusted by the Tier 2 recommendation of 80%. As shown, all pollutants are below the applicable NAAQS, however, PM2.5 concentrations when added to background approach the NAAQS. This is entirely due to the very high background concentrations which constitute 80 percent of the standard, and the MTC facility emissions adding only an additional 16 percent of the 24-hour value. As such, it is demonstrated through the refined modeling analysis that the steady state operation of the MTC facility with all 10 engines will not exceed any of the applicable NAAQS.

Additionally, the modeling analysis examined the potential air quality impact of the startup emissions. During startup the CO and NOx control technologies take as long as a half an hour to achieve design emissions control. As such, the emissions are uncontrolled for a portion of the hour during the start. The startup emissions were modeled with increased emissions representing uncontrolled emissions during the first 15 minutes followed by partial control for the next 15 minutes.

In as much as the primary pollutants of concern during startup are CO and NOx the results of the startup refined modeling for all 10 generators for these two pollutants are provided in Table 6. This table highlights the individual units starting up within the same hour, adding in additional units in order to show the cumulative concentrations when all 10 units are started in the same hour. The maximum modeled impacts are also added to representative background air quality concentrations for comparison to the NAAQS. The maximum modeled NO2 concentrations occur on the facility property line nearest the exhaust stacks from the gensets. The maximum NO2 concentrations (as Tier 1 values) are plotted by distance from the facility are illustrated in Figure 1, which also shows a very rapid decrease in concentrations within a kilometer from the facility, falling to less than 10% of the maximum concentration at 2 kilometers from the facility, and below the SIL of 7.5 $\mu g/m^3$ at about 1.5 kilometers.

As shown in Table 6, the modeling results indicate the proposed 5 x 2.5MW and 5 x 10MW MTC engines can be started simultaneously within the same hour and will achieve the 1-hour NO2 NAAQS (taking into account the Tier 2 80% adjustment). Note that due to the spatial separation of the 10MW and 2.5MW engines, there is little overlap of individual concentrations that contribute to the maximum combined concentrations. As mentioned earlier in this report, the use of Tier 3 (PVMRM) adjustment would likely result in a substantial decrease in the modeled NO2 concentrations over the values presented in this analysis, and would remove much of the conservatism that the 1-hour modeling analysis applies to these results. In such a case, the combined concentrations of all gensets starting simultaneously and added to a representative background concentration would achieve the NO2 NAAQS with a large margin of safety.

Note that all maximum NO2 concentration values are above the Significant Impact Level of 7.5 $\mu g/m^3$. If this facility was considered a major source then a cumulative NAAQS analysis would be performed to determine the combined impact of existing major sources within the study area in combination with the concentrations resulting from the MTC facility emissions. In as much as this facility is a State Synthetic Minor source and there are no major sources within the immediate study area (approximately 10 kilometers), it is assumed that any cumulative source contribution is captured by the conservative background concentrations being used. As such, a cumulative NAAQS analysis is not necessary.

Conclusion

In summary, the refined modeling indicates that the current facility design is in compliance with the NAAQS for all 10 generating units operating in steady state conditions. Similarly, the CO NAAQS is maintained if all 10 units are started within the same hour. Starting all 10 units likewise will achieve the 1-hour NO2 NAAQS when just the Tier 2 NO2 adjustment is made. Further analysis using the Tier 3 approach with PVMRM would likely reduce the total concentration to well below the 1-hour NO2 NAAQS and the MTC facility emissions would achieve the NAAQS for both steady state and startup operations with a substantial margin of safety.

Table 1: Stack Parameters and Emission Rates –10 MW Generators

Parameter		**Values**				
Unit		Engine #1	Engine #2	Engine #3	Engine #4	Engine #5
Stack Height (m)		15.24	15.24	15.24	15.24	15.24
Stack Diameter (m)		1.12	1.12	1.12	1.12	1.12
Exhaust Velocity (m/s)		27.51	27.51	27.51	27.51	27.51
Exhaust Temperature (K)		590.9	590.9	590.9	590.9	590.9
Pollutant Emissions (g/s)	NOx	0.0633	0.0633	0.0633	0.0633	0.0633
	CO	0.0732	0.0732	0.0732	0.0732	0.0732
	SO2	0.0534	0.0534	0.0534	0.0534	0.0534
	PM10/PM2.5	0.0541	0.0541	0.0541	0.0541	0.0541

Table 2: Stack Parameters and Emission Rates –2.5 MW Generators

Parameter		Values				
Unit		Engine #6	Engine #7	Engine #8	Engine #9	Engine #10
Stack Height (m)		15.24	15.24	15.24	15.24	15.24
Stack Diameter (m)		0.51	0.51	0.51	0.51	0.51
Exhaust Velocity (m/s)		35.28	35.28	35.28	35.28	35.28
Exhaust Temperature (K)		663.7	663.7	663.7	663.7	663.7
Pollutant Emissions (g/s)	NOx	0.0216	0.0216	0.0216	0.0216	0.0216
	CO	0.0382	0.0382	0.0382	0.0382	0.0382
	SO2	0.0143	0.0143	0.0143	0.0143	0.0143
	PM10/PM2.5	0.0135	0.0135	0.0135	0.0135	0.0135

Table 3: Background Concentrations

Pollutant(1)	State	County	City	Site ID	Average	Value (μg/m³)
NO2	DE	New Castle	Wilmington	100032004	1-hour 98%ile	66(2)
	DE	*New Castle*	*Wilmington*	*100032004*	*1-hour 98%ile*	*88*
	DE	*New Castle*	*Not in a City*	*100031010*	*1-hour 98%ile*	*66*
	DE	*New Castle*	*Wilmington*	*100032004*	*1-hour 98%ile*	*85*
	DE	*Sussex*	*Lewes*	*100051003*	*1-hour 98%ile*	*41*
	DE	*New Castle*	*Not in a City*	*100031010*	*1-hour 98%ile*	*64*
	DE	*New Castle*	*Wilmington*	*100032004*	*1-hour 98%ile*	*86*
	DE	*Sussex*	*Lewes*	*100051003*	*1-hour 98%ile*	*34*
NO2	DE	New Castle	Wilmington	100032004	Annual	23
CO	DE	New Castle	Delaware City	100031008	1-hour highest	2519
	DE	New Castle	Delaware City	100031008	1-hour 2nd Highest	2176
	DE	New Castle	Wilmington	100032004	8-hour highest	1489
	DE	New Castle	Wilmington	100032004	8-hour 2nd Highest	1374
SO2	DE	New Castle	Wilmington	100032004	1-hour 99%ile	39
PM10	MD	Anne Arundel	Glen Burnie	240031003	24-hour highest	34
	MD	Anne Arundel	Glen Burnie	240031003	24-hour 2nd highest	33
PM2.5	DE	New Castle	Wilmington	100032004	24-hour 98%ile	28(3)
	DE	New Castle	Wilmington	100032004	Annual	11
(1) Years of observation: 2013, 2014, 2015						
(2) Average of seven Delaware NO2 1-hour values to develop a representative regional background concentration.						
(3) Average of four monitors at this location						

Table 4: National Ambient Air Quality Standards

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm (10,000 μg/m^3)	Not to be exceeded more than once per year
			1 hour	35 ppm (40,000 μg/m^3)	
Nitrogen Dioxide (NO_2)		primary	1 hour	100 ppb (188 μg/m^3)	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb (1) (100 μg/m^3)	Annual Mean
Particle Pollution (PM)	$PM_{2.5}$	primary	1 year	12.0 μg/m^3	annual mean, averaged over 3 years
		secondary	1 year	15.0 μg/m^3	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 μg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24 hours	150 μg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1 hour	75 ppb (2) (197 μg/m^3)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm (1,300 μg/m^3)	Not to be exceeded more than once per year

(1) The level of the annual NO2 standard is 0.053 ppm (100 μg/m^3). It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(2) The previous SO2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2)any area for which implementation plans providing for attainment of the current (2010) standard have not been submitted and approved and which is designated nonattainment under the previous SO2 standards or is not meeting the requirements of a SIP call under the previous SO2 standards (40 CFR 50.4(3)), A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the require NAAQS.

Table 5: AERMOD Refined Modeling Concentrations (µg/m³)

	NO_2		CO		SO_2				PM_{10}	$PM_{2.5}$	
	1-Hour	**Annual**	**1-Hour**	**8-Hour**	**1-Hour**	**3-Hour**	**24-Hour**	**Annual**	**24-Hour**	**24-Hour**	**Annual**
	H8H[a]	--	H2H	H2H	H4H[a]	H2H	H2H	--	H2H	H8H[b]	--
MTC Modeled Impacts	23.4	0.34	28.9	22.6	20.2	18.3	14.6	0.28	14.8	5.5	0.24
Background (µg/m³)	66	23	1489	1374	39	39	10	3	33	28	11
MTC Modeled Impacts + BG	89.4	23	1,517	1,397	59	57	25	3	48	33	11
NAAQS	188	100	40,000	10,000	196	1,300	365	80	150	35	12
Percent (%) of NAAQS	48%	23%	4%	14%	30%	4%	7%	4%	32%	95%	90%

Greater than the 90% NAAQS

Notes:

a - Maximum daily 99th percentile (H4H) averaged over 5 years

b - Maximum daily 98th percentile (H8H) averaged over 5 years

c - Averaged over 5 years

Table 6: Facility Maximum Modeled Concentrations During Startup

Source Group Description	NO_2		CO	
	1-Hour		1-Hour	
	H1H[a]	H8H[b]	H1H	H2H
Five (5) 2.5 MW Engines Only	26.9	21.2	110.4	109.7
One (1) 10 MW Engines Only	41.6	35.5	34.2	34.0
Two (2) 10 MW Engines Only	78.5	69.5	66.4	65.0
Three (3) 10 MW Engines Only	105.6	101.5	86.2	85.9
Four (4) 10 MW Engines Only	131.6	125.7	108.2	107.2
Five (5) 10 MW Engines Only	131.7	125.9	108.2	107.2
Five (5) 10 MW Engines with One (1) 2.5 MW Engine	131.7	125.9	108.2	107.2
Five (5) 10 MW Engines with Two (2) 2.5 MW Engines	131.7	125.9	108.8	107.2
Five (5) 10 MW Engines with Three (3) 2.5 MW Engines	131.7	125.9	110.9	109.2
Five (5) 10 MW Engines with Four (4) 2.5 MW Engines	131.7	125.9	110.7	110.7
Five (5) 10 MW Engines with Five (5) 2.5 MW Engines	131.7	125.9	110.4	109.7
Maximum of any engine combination and applying Tier2 80% Adjustment[c]	105.3	100.7	110.9	110.7
Background (µg/m³)	--	66	--	1489
MTC Modeled Impacts plus BG		166.7		1599
SIL/NAAQS	7.5	188	2,000	40,000

Greater than the SIL

a - Maximum daily concentration averaged over 5 years

b - Maximum daily 98th percentile (H8H) averaged over 5 years

c- Applied Tier 2 1-hour NO2 adjustment of 80% per EPA guidance.
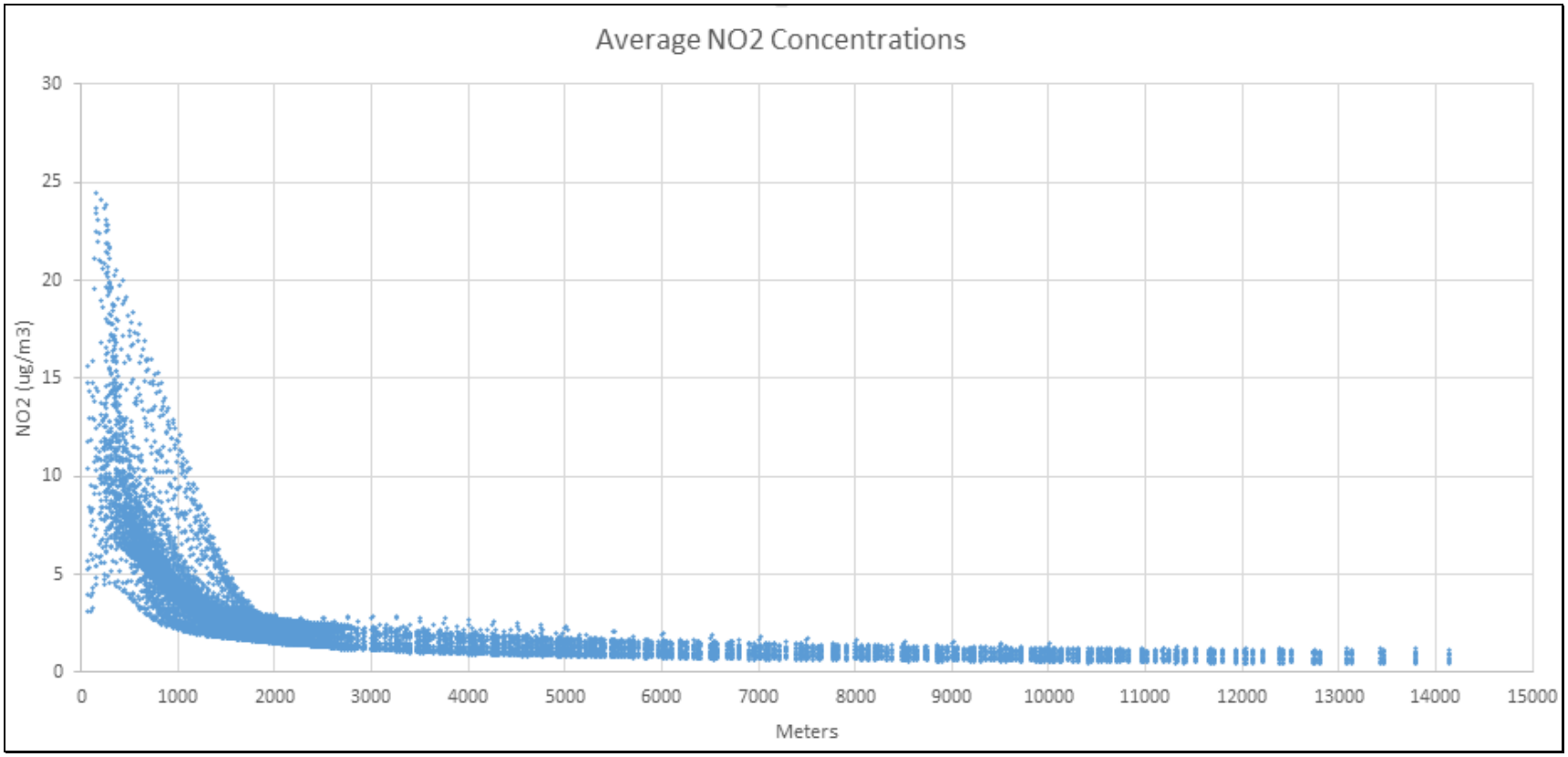
Figure 1: Average NO2 Tier 1 Concentrations with Distance