NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

Appendix B

Modeling of Ozone Impacts from Well Pad Activities and Associated Truck Traffic and Compressor Stations for Future Peak Well Development Conditions in the Marcellus Shale Area of New York State

Final

Supplemental Generic Environmental Impact Statement

Response to Comments

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Modeling of Ozone Impacts from Well Pad Activities and Associated Truck Traffic and Compressor Stations for Future Peak Well Development Conditions in the Marcellus Shale Area of New York State

1.0 Introduction

Section 6.5.3 of the SGEIS presents projected regional emissions of ozone precursors (NO_X and VOCs) which are associated with well pad activities and related truck traffic during the time when the peak number of wells per year is expected to be drilled in the future. These estimates are based on industry's projections of these activities as described in the ALL/IOGA-NY report, referenced in the SGEIS.[1] The emissions estimates reflect worst case future operations wherein 2216 horizontal and 246 vertical wells could be drilled in a year and under a set of conservative assumptions listed in Section 6.5.3 of the SGEIS. These emissions calculations account for operational restrictions on certain of the equipment, such as time periods for the drilling and fracturing engines, but not on others such as dehydrators and line heaters which are presumed to be operated full year around. In addition to these regional well pad emissions, an estimate of ozone precursor emissions from truck traffic expected during the peak well drilling conditions were made in Section 6.5.3 of the SGEIS. For this purpose, industry provided an average Vehicle Miles Traveled (VMT) of about 20-25 miles for light and heavy duty trucks.[2] The Department used the average VMT to generate the necessary emissions of NO_X and VOC over the Marcellus Shale counties using EPA's MOVES model, as further described below.

As noted in Section 6.5.3 of the 2011 revised draft SGEIS, a screening level modeling assessment was to be undertaken prior to the Final SGEIS to determine the need for potential further mitigation measures and to guide the future needs of the Ozone modeling by the Department in its commitments to EPA for the ozone State Implementation Plan (SIP) process. The analysis carried out in this document serves as that first level screening assessment and serves to guide the future development of the ozone SIP modeling for New York. To project a more complete picture of the influence of gas development in New York, a rough estimate has also been made of the potential number of "typical" compressor station engines which might be required for the long term average amount of gas to be extracted for the peak number of wells to be developed. The emissions from these compressor station engines are calculated and the resultant incremental ozone levels are determined in conjunction with well drilling activity results to determine the maximum projected levels in the future years.

For the ozone modeling, the well pad emissions were distributed over the Marcellus Shale area in proportion to the expected number of wells to be drilled on a county-wide basis according to the Socio-Economic Impact Analysis Report prepared for the SGEIS.[3] Furthermore, for the modeling analysis, these emissions were assigned to specific "model cells" which, to the extent possible, avoided allocation of emissions in modeling cells in areas in which drilling would be prohibited. On the other hand, the truck emissions were distributed evenly over the Marcellus Shale area since no restrictions nor details were available on their movement over the region.

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1 ALL/IOGA-NY Industry Information Report, dated September 16, 2010.
2 ALL Consulting letter of March 16, 2011 from Daniel Arthur to Brad Gill of IOGA-NY.
3 Socio-economic Impact Analysis, Prepared by Ecology and Environment for the 2011 rdSGEIS. http://www.dec.ny.gov/docs/materials_minerals_pdf/rdsgeisecon0811.pdf

The details of the emission processing are provided in the next section. The compressor station engine emissions were distributed in the same manner as the well pad operations as described further below.

The estimated model ready emissions were then input to the EPA's Community Multiscale Air Quality (CMAQ) model for regional ozone modeling with all the other necessary information. The simulation requires meteorological data in the region which was generated mainly from a meteorological simulation model. The ozone projections were then made at a set of receptor locations on an appropriate modeling grid overlaid on the area of interest, including all of New York and neighboring states. The modeling methodologies are described in Section 3.

The CMAQ model projected daily maximum 8-hour Ozone levels associated with additional precursor emissions due to the peak well development were then superimposed over the region to depict the incremental impacts associated with the increased emissions from well drilling activities. The analysis was performed for a "baseline year" (2007) for projections relative to "current" conditions and a future year (2020) scenario which is more in line with the projected time frame for achieving the peak number of wells in the Socio-economic Impact Analysis report. The 2020 inventory was readily available as one of the inventories being currently tested for modeling assessments related to potential future ozone work for the SIP process. Since the industry projected emissions are based on worst case assumptions on some of the equipment which might not represent their actual use in the future, another CMAQ analysis was performed for a more likely emissions scenario associated with the future long term well development projections. This limited emissions scenario also incorporated certain emission reductions anticipated from the improvements in the drilling and fracturing engines emissions in future years as a result of recommended mitigation measures to be incorporated in the Final SGEIS and as a result of anticipated fleet turnover. The resultant impacts are presented in Section 4 for the two sets of increased emissions associated with the peak number of wells to be developed and the two sets of regional inventories. The compressor station emission calculation methods and the resultant ozone impacts are presented in Section 5.

The ozone impacts presented in this report are preliminary screening level impacts and cannot be used to project any compliance determinations for the current or potential future ozone standards, for the reasons discussed in Section 3. That assessment will be made in the ozone SIP process in cooperation with EPA region 2 following EPA defined procedures for such analysis. These EPA procedures account for the conservative nature of the model as well as of the "raw" projected concentrations over the modeling domain by adjusting the consequent total ozone levels at monitoring site concentrations. This leads to more realistic projection of potential future ozone levels at these sites. In addition, the screening modeling assessment is based on the estimated peak number of well to be developed in a ten year period after horizontal drilling is allowed, while the Socio-economic Impact Analysis report also presents an average and low development scenarios which could also be viable. The purpose of this particular analysis is to indicate the relative influence and significance of the gas development emissions on the future work to be undertaken by the Department during the long term timeframe projected to be necessary to reach the expected peak number of wells development in New York.

2.0 Emissions Processing Methods

In order to determine the impact of additional emissions associated with the proposed gas drilling in the Marcellus Shale area on local and regional ozone air quality, an emission inventory of drilling activities was developed and processed to create air quality model-ready emission files. Emission inventories for use in air quality modeling are typically developed for criteria pollutants at the county level and annual time resolution. It is then necessary to: 1) spatially allocate the county level emissions to the model grid cell level, 2) temporally allocate the annual emissions to the hour time resolution in order to predict hourly concentrations, and 3) chemically speciate the criteria pollutants to allow the use of chemical transformations built into the model for the species related to ozone formation. These steps were accomplished using EPA's Sparse Matrix Operator Kernel Emissions (SMOKE) model as described below. In the modeling analysis, emissions for well pad activities and truck traffic around the well pads and in the Marcellus Shale area were considered. The emissions from motor vehicles were calculated using EPA's Motor Vehicle Emission Simulator (MOVES) model using county level specific data developed from the most recent DOT/DMV data for New York instead of using "default" values in MOVES. Furthermore, emissions of ozone precursors from projected compressor station engines necessary to process the average total gas developed over a ten year period were made and modeled, as described in Section 5.0.

2.1 Total Shale Area Emissions and County Distribution

Total regional emissions of all activities except truck traffic from projected peak of 2462 wells per year were preferentially distributed among the counties where the shale is noted to have optimal thickness (see Figure 4-9 of the SGEIS). Using this criterion, Section 4 of the Socio-economic Impact Analysis report allocates the well development to four areas in the state, as follows:

- **Region A**: 50% of all new well construction would occur in Region A (Broome, Chemung, and Tioga counties);
- **Region B:** 23% of all new well construction would occur in Region B (Delaware, Otsego, and Sullivan counties);
- **Region C**: 5% of all new well construction would occur in Region C (Cattaraugus and Chautauqua counties); and
- **Remainder of the State:** 22% of new well construction would occur in other locations throughout the area covered by the Marcellus Shale and other low-permeability formations in New York State.

For the 22% of the wells in the "remainder of the state" category, the following distribution of wells was made in adjacent counties to those in Regions A to C based on the expected likelihood that the chosen areas will contribute to downwind Ozone formation in concert with the emissions from Regions A to C: rounded percentages of 3% each in Allegany and Steuben counties and 5% each in Tomkins, Chenango and Schuyler counties,.

The emissions associated with truck traffic used for the various activities necessary for the gas drilling and corresponding to the peak number of well drilling were equally assigned to each of the counties in the Marcellus Shale area. Since no information is available on the specific areas or routes on which this traffic would preferentially occur, this simple distribution was deemed adequate. Furthermore, as discussed in the SGEIS, the emissions of truck traffic are deemed small relative to both the emissions from all other well development activities, as well as relative to the existing mobile source emissions in the Marcellus Shale area.

Annual well pad emissions of NO_X and VOC for all other activities were estimated for the following activities: drilling, fracturing, flaring, venting, and production. The emissions were differentiated by these activities in order to assign SMOKE processing properly. Two emissions scenarios were considered in the modeling. The first scenario was based on the estimated NO_X and VOC emissions in the ALL-IOGA-NY 3/16/10 information report for the various well pad sources. These emissions accounted for the temporal operational restrictions on certain of the equipment, while other emissions were assumed to operate full year round. However, there are certain restrictions on the use of equipment such as the line heater and other likely modifications and restrictions to the engine use in the future years, when the peak emissions are to be realized, which also need to be considered. Thus, another scenario was developed to test the response of the modeled Ozone levels in an attempt to provide a range of potential impacts associated with future well development.

This second scenario started with the assumptions and emissions provided by industry and made the following modifications to the NO_X emissions:

1. The line heaters were assumed to only operate during the colder months and the emissions were prorated accordingly over the "ozone season" months;

2. It was assumed that not all wells would require a wellhead compressor as noted by industry. Thus, these emissions were reduced by 25% to allow for this likelihood in the production stage emissions;

3. The drilling and fracturing engine emissions were reduced to account for two possible conditions during the timeframes when the peak number of well would be drilled (as explained below). First, industry noted in the 3/16/10 information report that there will be limits on the number of engines available for drilling and fracturing due to the ongoing gas drilling in other shale plays. In addition, industry expects certain turnover of the older engines during this time span. In this analysis we are assuming that such a turnover would also be necessary in order for industry to demonstrate compliance with the 1-hour NO_2 ambient standard. Thus, the NO_X emissions are reduced from both drilling and fracturing engines by 25% as representing a likely minimum reduction scenario. It should be noted that in these latter calculations, it is assumed that Tier 4 engines would replace the tier 2 engines, the latter engines being assumed in industry's calculations of NO_X and VOC emissions in the 3/16/10 information report. Since for the fracturing engines the Tier 4 emission limit is only reduced by 40% from the Tier 2 limit, this factor was also incorporated in the NO_X emissions calculations. That is, account is taken of the fact that NO_X emissions from fracturing engines will still be contributing a significant portion to the non-road engines total emissions; and

4. No change is made to the flaring emissions since it is assumed that the flaring within the operational limitations described in the SGEIS may still be necessary to test the gas wells.

VOC emissions are essentially dominated by the glycol dehydrator emissions, with small contributions from the engines and very limited duration venting emissions pursuant to the permit restrictions discussed in the SGEIS. Since these latter emissions are relatively small and there is no information on whether fewer dehydrators would be used, no change was made to the VOC emissions for this scenario. It is also expected that any such emissions changes would not significantly alter the ozone impact results due to the lower overall VOC emissions and their contribution to ozone formation. Finally, no changes were made to the truck traffic emissions calculated from the weighted average VMT provided by industry.

Total estimated emissions for the shale area are shown in Table 1 for these two scenarios. For the VOC emissions, the drilling, fracturing and venting emissions were combined to simplify internal modeling assignments since these represent small fractions each of the total VOC emissions.

Table 1. Total Well Pad and Truck Traffic Emissions for Peak Number of Wells in the Shale Area.

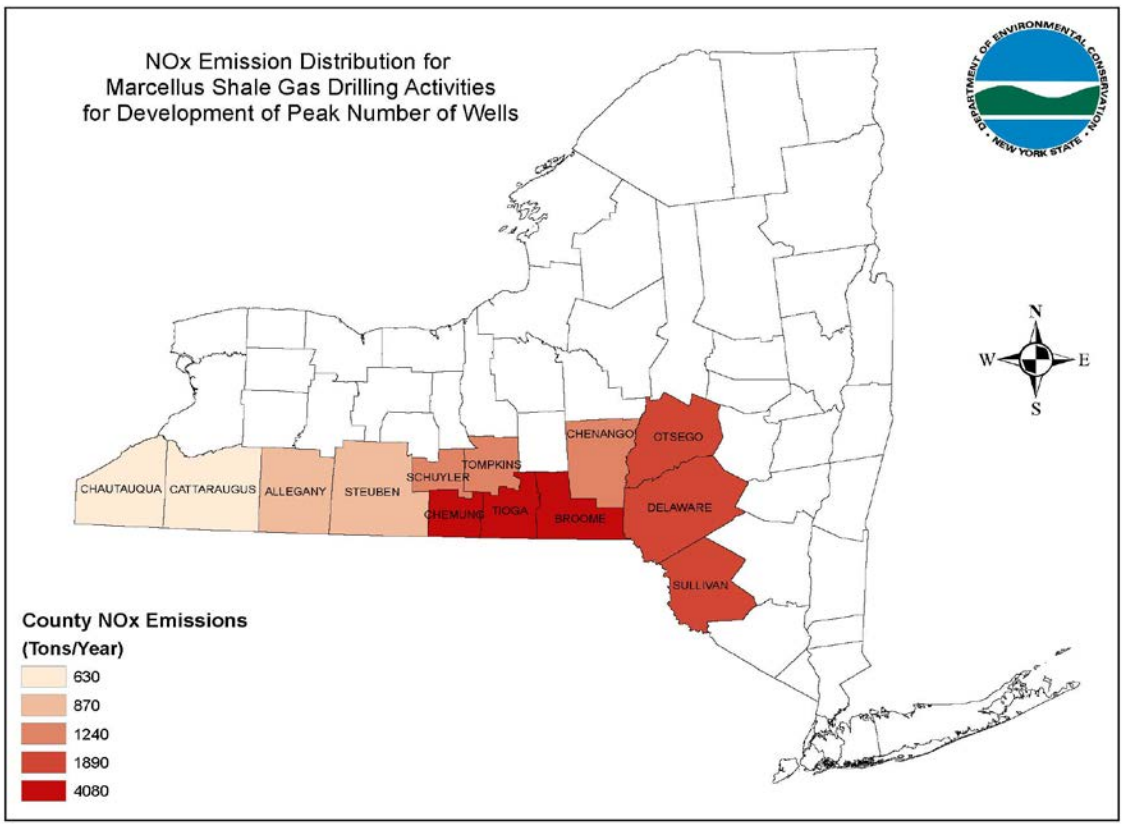
Activity	**Total NO_X Emissions (tpy)**		**Total VOC Emissions (tpy)**
	Peak Emissions Case	**Limited Emissions Case**	
Drilling	8785	6589	1296
Fracturing-NO_X/Venting-VOC	3235	2750	
Flaring	3013	3013	
Production	9274	5877	5974
Motor Vehicle Traffic	687	687	70

Using the percentages defined above from the Socio-economic Impact Analysis, the fractions of the total emissions were then allocated to each county as indicated in Table 2. The distribution of NO_X emissions is depicted in Figure 1 for the well pad activities. A similar distribution holds for VOC emissions. The higher emissions appear along the south central region where shale thickness is the largest.

Table 2. Fraction of Total Emissions of Well Pad Activities Assigned to Each County.

County	Fraction
Broome	0.1667
Chemung	0.1667
Tioga	0.1667
Delaware	0.0767
Otsego	0.0767
Sullivan	0.0767
Cattaraugus	0.0250
Chautauqua	0.0250
Allegany	0.0350
Steuben	0.0350
Tompkins	0.0500
Chenango	0.0500
Schuyler	0.0500

Figure 1. County Level Distribution of NO_X Emissions for Peak Emission Scenario for Well Pad Activities.



2.2 SMOKE Processing

Spatial and temporal allocation, as well as chemical speciation of emissions in SMOKE is largely accomplished using source classification codes (SCC). In order to process the emissions associated with gas drilling, SCC codes were assigned to more accurately represent drilling activities. This was possible since the source types for well drilling activities and the type of fuel these will use are known. For example, it is known that drilling and fracturing engines are internal combustion engines and will essentially use diesel fuel. This makes it possible to assign a higher level of association in the SCC assignment than at the "default" categories which would be otherwise used in SMOKE. In addition, much of the well pad emissions occur due to the use of internal combustion engines burning diesel fuel or natural gas. Thus, the following SCC codes were assigned to the well pad activities.

Table 3. Source Classification Code (SCC) Assignments for Gas Drilling Activities. (Updated 2012)

Activity	Device	Fuel	SCC
Drilling	Drilling Engine	Diesel	2102004000
Fracturing	Fracturing Engine	Diesel	2102004000
Flaring	Flare	Natural Gas	2310021500
Production	Line Heater/Gas Compressor Engine	Natural Gas	2102006002
On-road Truck Emissions	Primarily Diesel with some Gasoline Trucks	Diesel/Gasoline	2230070000

Applying the fractions from Table 2 to the total shale emission estimates in Table 1, county total emissions by SCC code were calculated as shown in Table 4. The VOC emissions in the "Drilling and Fracturing" column include the venting emissions from Table 1. These emissions represent the peak well drilling emissions scenario calculated from the ALL-IOGA-NY information report. The corresponding allocations for the alternative limited emissions scenario representative of likely conditions in the future case are not presented in the table, but were proportionately assigned the same way as for the peak emission scenario using the fractions in Table 2.

Table 4. County Total SCC Level Emission Estimates for Peak Well Pad Activity under **Peak Emissions Scenario.**

	Drilling & Fracturing SCC-2102004000		**Flaring** SCC-2310021500	**Production** SCC- 2102006002	
	NO_X	VOC	NO_X	NO_X	VOC
Broome	2003.7	216.0	502.3	1546.0	995.9
Chemung	2003.7	216.0	502.3	1546.0	995.9
Tioga	2003.7	216.0	502.3	1546.0	995.9
Delaware	921.9	99.4	231.1	711.3	458.2
Otsego	921.9	99.4	231.1	711.3	458.2
Sullivan	921.9	99.4	231.1	711.3	458.2
Cattaraugus	300.5	32.4	75.3	231.9	149.4
Chautauqua	300.5	32.4	75.3	231.9	149.4
Allegany	420.7	45.4	105.5	324.6	209.1
Steuben	420.7	45.4	105.5	324.6	209.1
Tompkins	601.0	64.8	150.7	463.7	298.7
Chenango	601.0	64.8	150.7	463.7	298.7
Schuyler	601.0	64.8	150.7	463.7	298.7

As part of New York's SIP development process, MOVES-based motor vehicle emissions were available for each county in the Marcellus Shale area. These emissions were generated by executing annual county-level MOVES runs using the most recently developed input data for 2007. A second set of runs were then performed using the same inputs, but increasing the emissions by the additional truck traffic VMT uniformly over the Marcellus Shale counties based on the industry provided traffic information. The difference in county-level NO_X and VOC emissions is attributed to increased truck traffic associated with drilling activities. The overall increase in emissions is indicated in the SGEIS to be 687 tons per year for NO_X and 70 tons per year for VOC. This is an average of 20 to 25 tpy NO_X and about 2.5 tpy VOC for each county in the drilling area.

2.3 Model Spatial Allocation of Well Pad Emissions

When emission inventories are processed through SMOKE, these are spatially allocated to individual grid cells for modeling purposes based on their assigned SCC code. The SCC codes are, in turn, linked to gridding surrogates, which represent the fraction of emissions for a particular activity in an individual grid cell. For example, the gridding surrogate of roadway miles would be used to locate emissions from motor vehicles, as it is assumed that driving activity would only occur on roadways and the emissions assigned to the grid cell would be proportional to the relative amount of roadway miles in that grid cell.

The surrogate code to SCC cross reference file used by SMOKE is developed by EPA at the national level. Since the SGEIS has identified areas in the Marcellus Shale where gas drilling would be prohibited (state parks, Primary Aquifers and surface water drinking supply watersheds), this cross reference file was overridden to avoid the possibility of placing emissions in these sensitive areas. Therefore, customized spatial allocation was used to place these emissions in model grid cells that did not contain any of these features or where these were minimally present. Although there are further distance restrictions from certain water bodies as identified in the SGEIS, this level of refinement was not made to the specific grids chosen for the modeling since such effects would be inconsequential to the projected ozone levels. Thus, this simplification is appropriate for the current purposes. Mobile source emissions were allocated using the typical gridding surrogate of roadways in SMOKE.

Figure 2 shows areas of the state where gas drilling would be prohibited and Figure 3 shows the selected grid cells where emissions were placed in order to avoid these general areas. These restrictions were applied to the well pad activities summarized in Table 4, except for the traffic emissions. As noted previously, the truck traffic emissions were allocated to each of the grid cells in the Marcellus Shale in accordance with the gridding surrogates in the SMOKE emissions processor.

Figure 2. Prohibited Gas Drilling Areas in the Marcellus Shale.

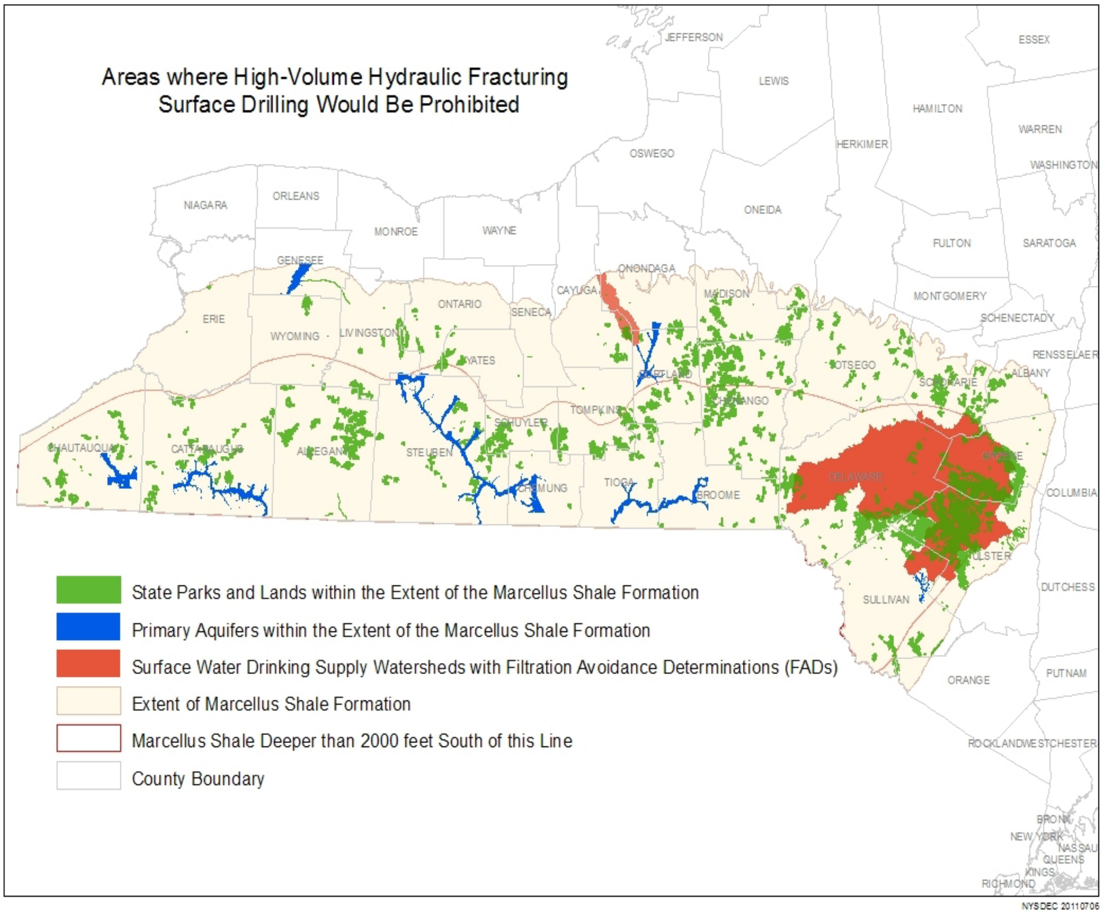
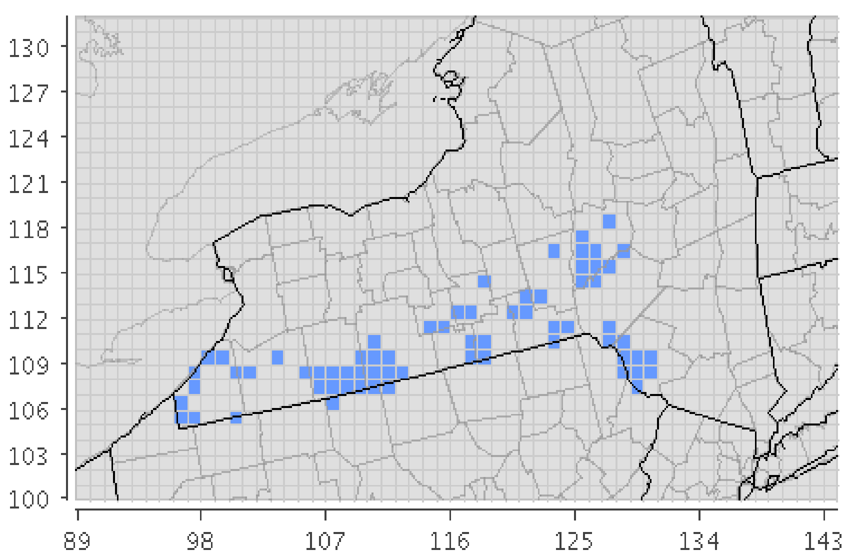


Figure 3. Modeling Grid Cells Selected to Locate Gas Drilling Emissions for the Well Pad Activities



2.4 Temporal Allocation

As with spatial allocation, SMOKE temporally allocates annual emissions to hourly values based on temporal profiles related to SCC codes. For this modeling exercise, it was assumed that drilling activities would occur during all months of the year, on weekdays and weekends, as well as all hours of the day. There is no indication from industry of any temporal restrictions on gas drilling. Therefore, monthly, weekly and hourly temporal allocation profiles were selected such that emissions from gas drilling would be evenly spread out over all hours of the year.

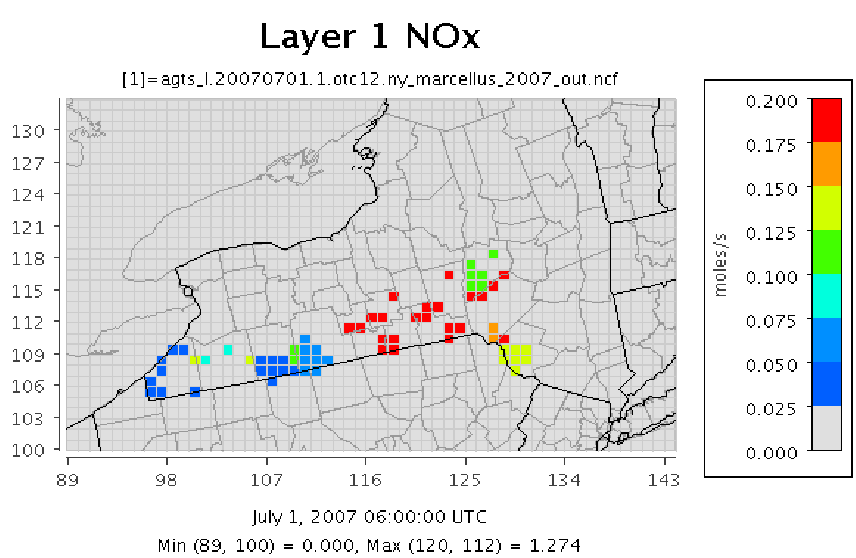
2.5 Chemical Speciation

Emission inventories are typically prepared for criteria pollutants which then must be chemically speciated to air quality model-ready species (i.e., $NO_X \rightarrow NO + NO2$; VOC → CB5 Species). This is again accomplished by applying speciation profiles to criteria pollutants based on source characteristics. Most of the well pad emissions come from natural gas or diesel powered internal combustion engines and, thus, the latest SMOKE default speciation profiles available for these SCC codes were utilized.

2.6 Results of Emission Processing

SMOKE was run for the entire year to generate daily files of hourly, gridded and chemically speciated model-ready inputs for the CMAQ air quality model. Figure 4 shows an example of the hourly NO_X emission values for July 1, 2007. As can be seen from this figure and Figure 1, NO_X emissions are highest where the shale thickness is greatest, but also are influenced by the number of grid cells in the available drilling areas.

Figure 4. Example Hourly NO_X Emissions Allocated in SMOKE for 7/1/07 Meteorological Data



3.0 Ozone Modeling Methodologies

Ozone concentrations were predicted using the state of-the-science EPA Community Multiscale Air Quality (CMAQ) model. Since ozone is formed from its precursors, NO_X and VOC, with chemical reactions under conducive meteorological condition days (i.e. high solar radiation), the simulation was limited to the "ozone season" which runs from April 15 through October 30. The model estimated the 8-hour ozone air quality impacts in accord with the averaging time of the national ambient air quality standard (NAAQS). Three modeling cases were performed to determine the incremental impacts of the estimated emission from the Marcellus Shale gas drill activities described in Section 2.0: i) impacts of the industry projected maximum additional emissions under peak well drilling activities relative to the baseline Ozone Transport Commission (OTC) 2007 emissions inventory platform used in modeling assessments in support of New York's Ozone SIP work, ii) the same Marcellus Shale emissions, except impacts relative to a projected 2020 emissions inventory scenario generated by OTC, and iii) a limited emissions scenario described in Section 2.0 relative to the 2020 emissions inventory scenario. The existing and future inventories are described further below.

The total ozone modeling system includes three major components: regional emission inventory modeling, meteorology modeling, and the ozone air quality modeling. The emission modeling prepares the emission data inputs, the meteorology modeling creates the meteorological data necessary for determining transport and dispersion, which are then input to CMAQ to calculate ozone impacts. The following subsections provide a brief description of each of these three components.

3.1 Baseline and Future Emissions Inventories

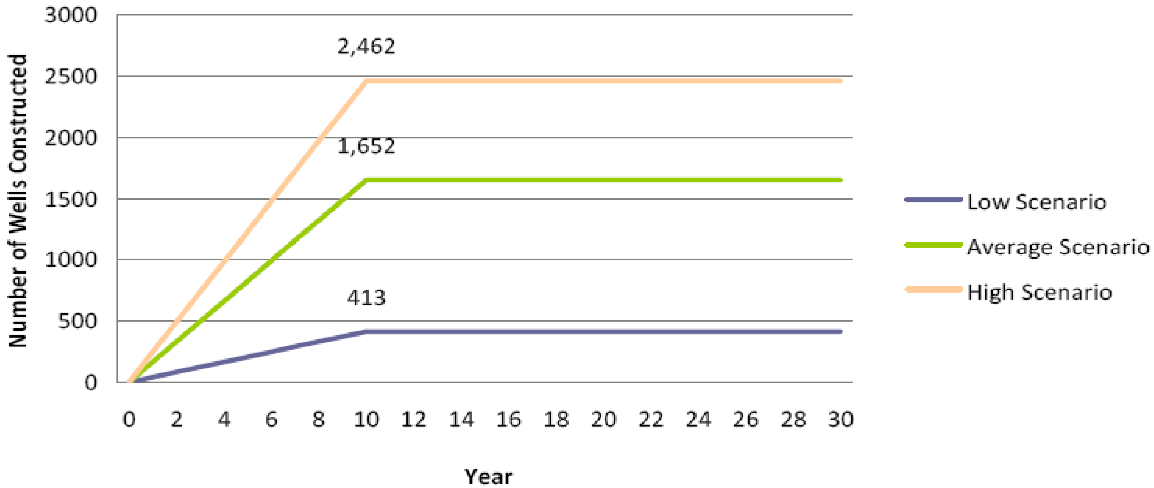
The inventory of the additional emissions associated with the peak number of wells to be drilled per year in the Marcellus Shale area were described in Section 2.0. In order to determine the consequence of these emissions on ozone levels, it is necessary to consider these emissions in concert with an inventory of either existing or future projected overall emissions of the precursors from all potential significant sources on a regional level. This is necessary because ozone, unlike most other criteria pollutants, is secondarily formed in the atmosphere as a result of a series of complex chemical reactions involving both anthropogenic and biogenic emissions under the influence of conducive meteorological conditions such as high solar radiation.

Thus, for the "baseline" situation, use is made of the detailed OTC 2007 Level 2 modeling emission inventory and platform which forms the basis of New York's current SIP modeling work. The base case 2007 Level 2 emissions include the following source types in the modeling region electric generating unit (EGU) point, Non-EGU point, on road mobile, non-road, area and biogenic emissions developed by The Mid-Atlantic Regional Air Management Association (MARAMA) for the year 2007 within the Mid-Atlantic/Northeast Visibility Union (MANE-VU) states. For the other Regional Planning Organizations (RPOs) in the modeling domain, the EPA NEI2008 inventories were used. A full description of the 2007 Level 2 emission inventory can be found at MARAMA's webpage.[4]

[4] See: http://www.marama.org/technical-center/emissions-inventory/2007-emissions-and-projections/2007-emissions-inventory

In addition to this base case, an additional future inventory scenario has been used to determine the impacts of gas drilling activities during the peak well development timeframe. According to Section 4 of the Socio-economic Impact Analysis, it is expected that gas development will proceed at a steady pace after drilling starts and will achieve the peak level of wells drilled per year in about ten years (see “Figure 4-1” repeated below from the study).

Annual Number of Wells Completed in New York State Under Each Development Scenario



Therefore, in order to determine the ozone impacts during this expected peak well development timeframe, a future emissions inventory was also modeled. As part of the OTC air quality modeling efforts by northeast state for future SIP planning activities, a 2020 “scenario 4” inventory was readily available and was used in this assessment. The 2020 projected inventory includes the following modifications by OTC to the 2007 inventory:

1) a domain-wide NO_X reduction of 65% from EGUs due to mainly the Cross State Air Pollution Rule (CSAPR);

2) a domain-wide NO_X reduction of 49% from non-road engines;

3) a domain-wide NO_X reduction of 70% from on-road mobile source turnover;

4) a domain-wide VOC reduction of 30% from EGUs and on-road mobile sources; and

5) an extra 5% NO_X reduction in the Ozone Transport Region emissions.

In this analysis, the additional Marcellus Shale drilling activity emissions were added to the OTC base 2007 Level 2 emission case and the 2020 “scenario 4” case and CMAQ was then applied to perform the simulation for the ozone season using the “baseline year” 2007 meteorological data. The incremental impacts due to the gas development activities alone were then determined relative to these two regional emissions scenarios as the difference in impacts in these inventories with and without the additional Marcellus Shale emissions. These incremental impacts are then use to determine the relative influence of the additional emissions.

3.2 Meteorological Processor

In order to simulate the transport and dispersion of ozone precursor emissions from the multitude of sources over the whole modeling domain, a set of meteorological parameters which affect these processes have to be developed from observations and simulation of atmospheric dynamics. This was accomplished for the base year of 2007 using the Weather Research Forecast (WRF) version 3.1 (Skamarock et al. 2008) model developed by the National Center of Atmospheric Research (NCAR). WRF is a state-of-the-art mesoscale numerical weather prediction system designed to serve both operational weather forecasting and atmospheric research needs. It has become widely used in the air quality modeling community to create meteorological fields used to drive air quality models. The WRF modeling was performed on two "nested" grids with 36 km covering the whole US continent and 12 km grids covering the eastern half of the US. Throughout the model simulations, WRF was "nudged" towards reanalysis of the meteorological fields (such as temperature, humidity, and wind) developed by the National Center for Environmental Prediction (NCEP) using four-dimensional data assimilation in order to reduce the potential bias caused by numerical simulations. The details of the 2007 WRF simulations and assessment of the simulations are available in the following two documents (Baker et al, 2010 and Sistla et al, 2010).

3.3 CMAQ Ozone Model

Ozone air quality impact simulations were performed with the CMAQ model, version 4.71 (Byun and Schere, 2006) developed by EPA. The model is applied with the carbon-bond 5 (CB-05) gas phase chemistry mechanism which accounts for 156 reactions involving 56 species (Yarwood, et.al. 2005). CMAQ is an Eulerian grid model that contains a set of dynamic equations to represent the transport, diffusion, deposition, and chemical reaction of the pollutants in the atmosphere. To solve the dynamic equations, both initial and boundary conditions are required which served as the initial time condition and influx of the pollutants into the modeling domain, respectively. CMAQ was run with a 12 km grid domain covering the Eastern half of US using climatological time invariant boundary conditions. CMAQ predicts hourly ozone concentrations at each of the modeled grid cells used in the simulation and then determines the corresponding 8-hour running averages at the grid cells. These are then used in order to calculate the overall maxima during the ozone season. In this analysis, the incremental ozone impacts due to the additional precursor emissions from the gas drilling activities were calculated to determine their potential consequence on the local and regional air quality.

<u>4.0 Results of the Modeling Simulations</u>

Ozone modeling for the two gas development scenarios was conducted in conjunction with a "current" baseline inventory and a future regional emission inventory cases using the input data and assumptions described in the previous sections. The main purpose of this modeling exercise was to determine whether the future peak level of well development in New York could pose a potential concern with Ozone levels such that future mitigation measures would need to be considered in New York's SIP planning work in association with EPA Region 2. To that end, the results are cast in terms of a range of potential incremental ozone impacts from emissions associated with future gas development in New York. These results are also contingent on the realization of the projected emissions and its future timeframes, as well as on the projected future emissions scenario which assumes expected reductions from certain source sectors in the 2020 timeframe. Thus, it is important that the results presented be viewed in their totality and are not misrepresented with respect to the Department's overall approach to use of the modeling exercise.

The results of CMAQ ozone predictions are presented first for the worst case emissions developed using industry's projections of the peak number of wells per year (2462). These results are presented relative to the "baseline" 2007 and future 2020 emission scenario cases to determine the range of the expected impacts. Guided by these results, the limited emissions scenario case, wherein reductions in well pad emissions due to more likely conditions associated with the future timeframes of peak well development conditions, are presented next relative to the future 2020 scenario. The additional modeling which accounts for estimated emissions due to compressor engines necessary to process the amount of gas during the peak well development timeframe are presented in Section 5.0.

4.1 Ozone Impacts under the Peak Emissions Scenario.

It is not certain that the projected emissions associated with the peak number of future well development depicted in Figure 4-1 of the Socio-Economic Impact Analysis would take about ten years to be achieved from the startup of well drilling. Thus, the increased emissions associated with these activities were modeled relative to both a 'baseline" 2007 case as representative of "current' conditions, as well as relative to the future 2020 scenario 4 emissions inventory reflecting conditions more likely to be used for the future New York ozone SIP work.

The increased emissions due to the gas development in the New York's portion of Marcellus Shale were added to the "baseline 2007" emissions and the CMAQ model used to predict daily maximum 8-hour impacts over the full grid cell and for the ozone season meteorological conditions. The model was also used to perform the same analysis for the "baseline" 2007 inventory only and then the difference in these projections was calculated to be the incremental impacts associated with the gas development emissions during peak well drilling conditions. The same process was followed with the future 2020 scenario. The results were then reviewed and presented both spatially and temporally to describe the consequent impacts.

To begin with, the incremental impacts of the daily maximum 8-hour ozone were found to increase and decrease when gas development emissions were added, with the latter occurring during periods of low ozone formation and due to the "scavenging" or titration effects of NO_X. That is, NO_X emissions have a tendency to initially reduce ozone concentrations at the local level. Examples of these effects are depicted in Figure 5 for a day (8/2/07) in which high ozone formation occurred and in figure 6 for another day (8/21/07) when the meteorological conditions were not conducive for photochemical reaction to form ozone. The results are presented for both the "baseline" 2007 scenario (A) and the 2020 future scenario (B). It is seen that the incremental ozone levels are confined on both modeled days to the general area of projected well drilling activity emissions depicted in Figure 1, with little impacts in the higher ozone regions along the coastal areas and, in particular, the New York City metropolitan area. The increased impacts are up to 9ppb while the reduced impacts (note the negative scale in figure 6) are up to 5 ppb on the respective days. One reason for the relatively "localized' maxima is the fact that the sources modeled have relatively low stacks and are "assigned" to the lowest layer of the CMAQ model (from the surface to 40m) in which these are transported and dispersed.

The overall daily maximum 8-hour impacts during the whole ozone season for the two emission inventories are depicted in Figure 7. Although the areal extent of the incremental increased impacts in ozone level has magnified relative to the single day depicted in figure 5, the higher ozone increases are still confined mainly to the areas where the drilling well activities are expected to occur. It is also seen that the maximum incremental impacts for the 2020 emissions scenario are slightly higher than for the 2007 inventory. This is mainly due to the fact that these impacts are calculated by taking a differences between the inventories with and without the Marcellus Shale activities, coupled with the fact that the future 2020 inventory and consequent total impacts are projected to be significantly lower than those for the 2007 inventory. The maximum projected impacts over the area are about 6 to10 ppb, with the higher impacts covering a larger area in the case of the 2020 future inventory.

In order to get an understanding of the level of increased impacts over the total area of the projected increases indicated in figure 7, the average ozone impacts over the areas depicted in Figure 7 were also calculated. Figure 8 is a "time series" of the average daily maximum 8-hour incremental ozone levels for the total areas impacted by the Marcellus Shale emissions, plotted for each of the ozone season days. The averages are presented for both the baseline 2007 and future 2020 regional inventories. In terms of the average ozone levels projected for the total affected area, the impacts are much lower than the "localized" maxima, with a maximum of about 1.2ppb. This is expected given the relatively small areas over which the higher impacts are projected to occur. These calculated averages, however, are not to be used to draw conclusions on the effects of the Marcellus Shale emissions with respect to future ozone assessments to be performed for SIP purposes which will rely on the form of the standard at the upper percentile of the 8-hour impacts.

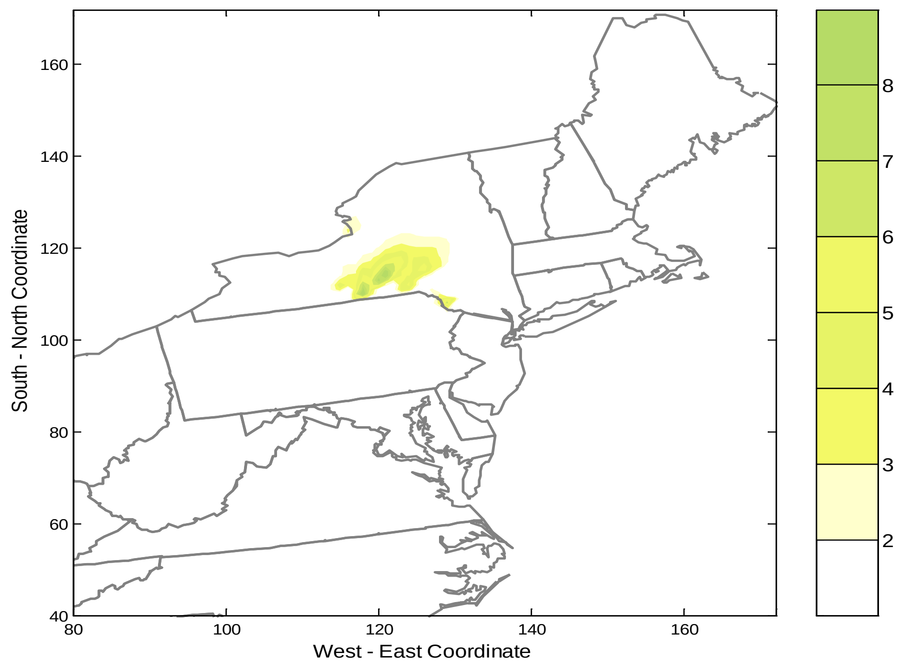
The projected incremental daily maximum 8-hour ozone impacts shown in figure 7 during peak well development timeframes are at levels which could have a potential to be significant. However, these predicted impacts alone do not form the basis of determinations of standards compliance for ozone. These projections have to be viewed within the context of how these are to be used in SIP demonstrations of future ozone standards compliance. Unlike the "permitting" modeling analyses where projections are added to background levels, such as those performed in Section 6.5.2 of the SGEIS, regional ozone modeling and standards compliance must follow established EPA guidance.[5] These established procedures to perform projected compliance calculations use the existing "design" concentrations at monitors and a relative response factor (RRF) approach to account for the conservative nature of the modeled projections. These procedures rely heavily on ozone predictions at the monitor locations. To that end, the incremental maximum 8-hour ozone levels during the whole season and for the "baseline" 2007 and 2020 future inventories are plotted in figure 9 at the existing ozone monitor within the Ozone Transport Region (OTR). It is seen that there are a limited number of monitors at which the

[5] See http://www.epa.gov/scram001/guidance_sip.htm

incremental impacts are relatively high, with only the Camp Georgetown monitor showing maximum impacts from 6 to 9ppb. Impacts at essentially all other monitors are less than 4 ppb.

Figure 5. Maximum Incremental 8-Hour Ozone Concentration for August 2, 2007 Meteorology (**high Ozone day**) due to Increased Emissions including Marcellus Shale Activities Minus (A) Impacts with 2007 Baseline Emissions and (B) 2020 Future Year Project Emissions.

(A)



(B)

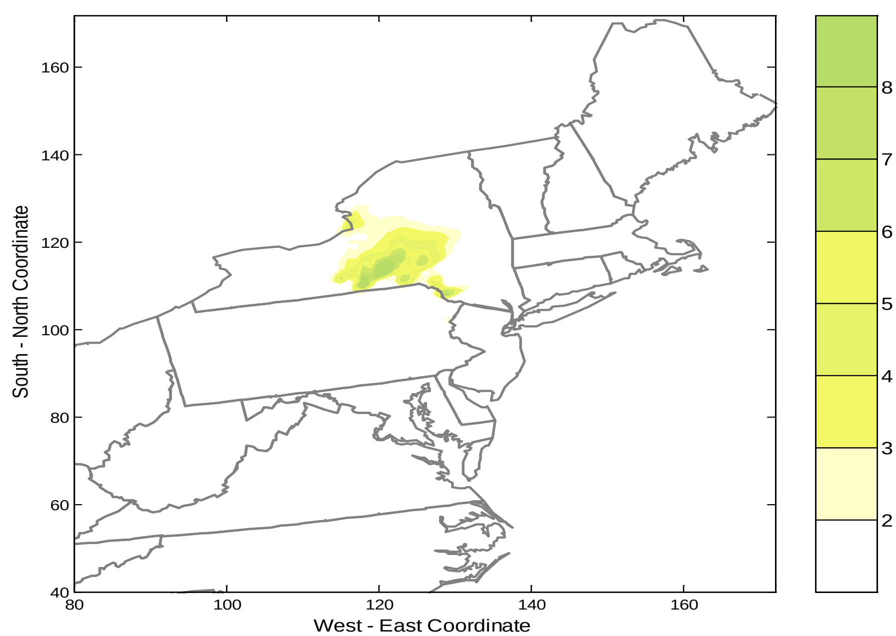
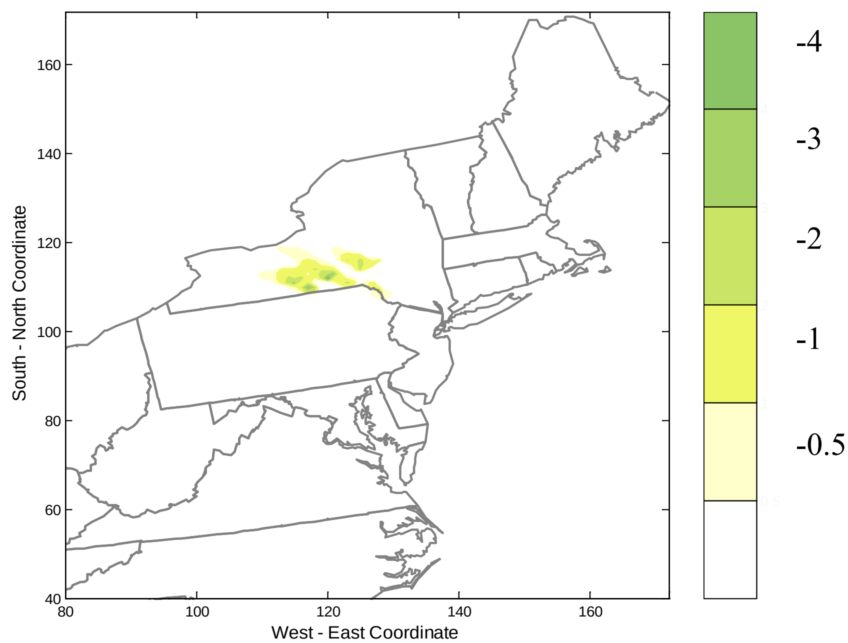


Figure 6. Maximum Incremental 8-Hour Ozone Concentration for August 21, 2007 Meteorology (**low Ozone day**) due to Increased Emissions Including Marcellus Shale Activities Minus (A) Impacts with 2007 Baseline Emission and (B) 2020 Future Year Project Emission.

(A)



(B)

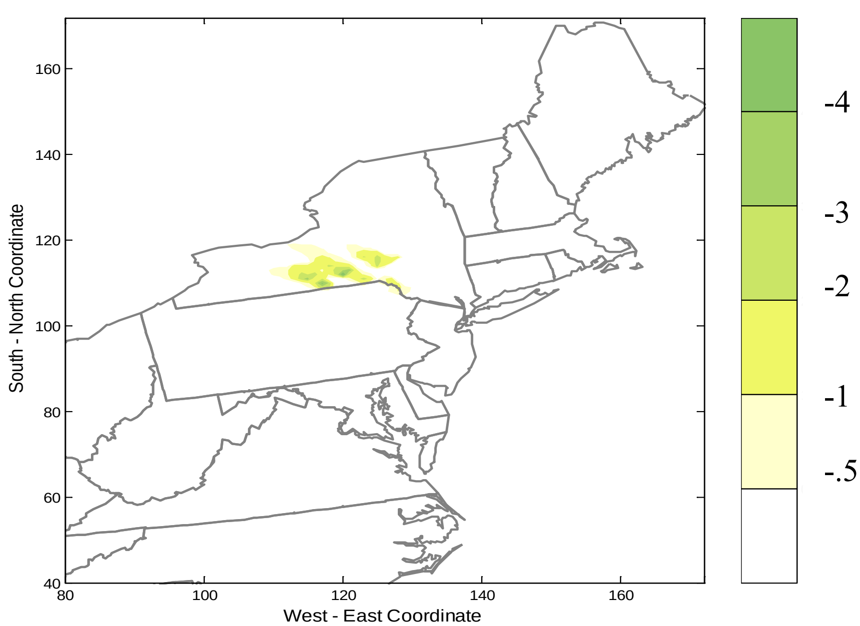
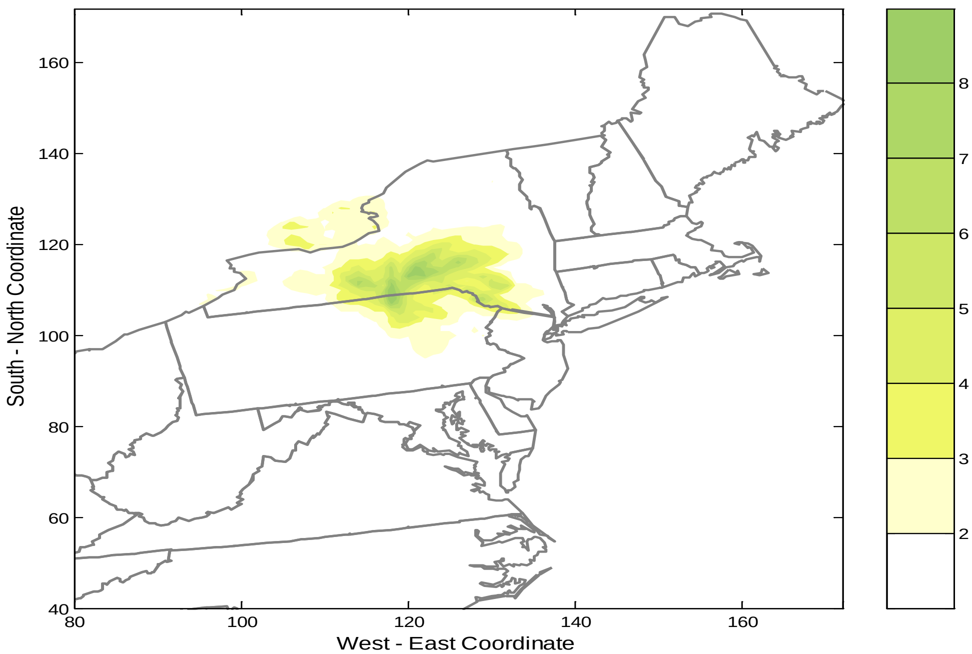


Figure 7. Incremental Daily Maximum 8-Hour Ozone Concentration for the Complete Ozone Season for the Additional Marcellus Shale Activities Under **Peak Emissions Scenario** and (A) Impacts with 2007 Baseline Emission and (B) 2020 Future Year Project Emission.

(A)



(B)

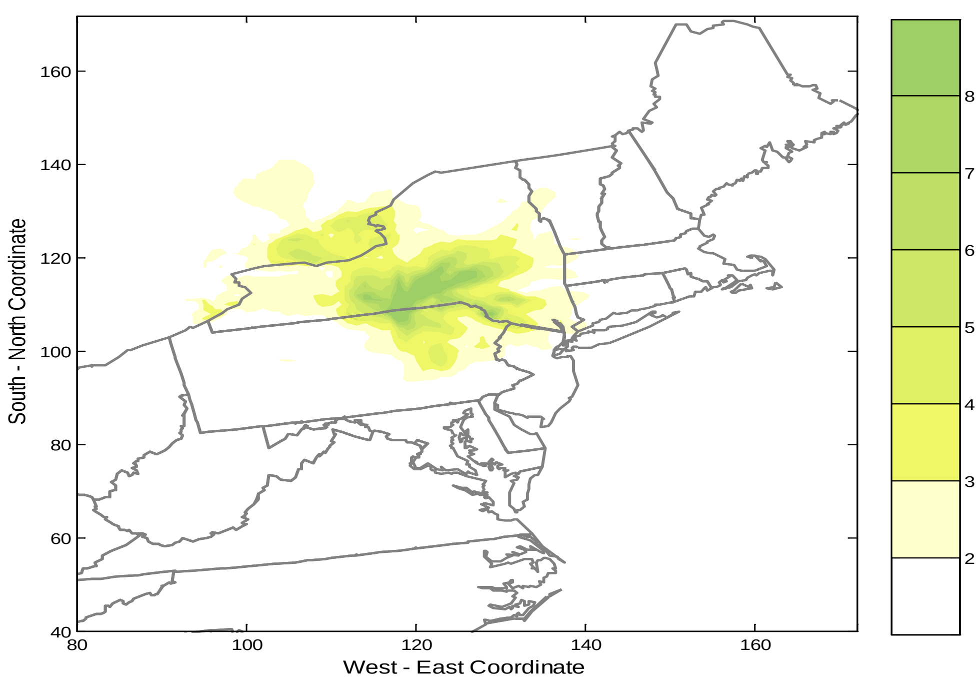
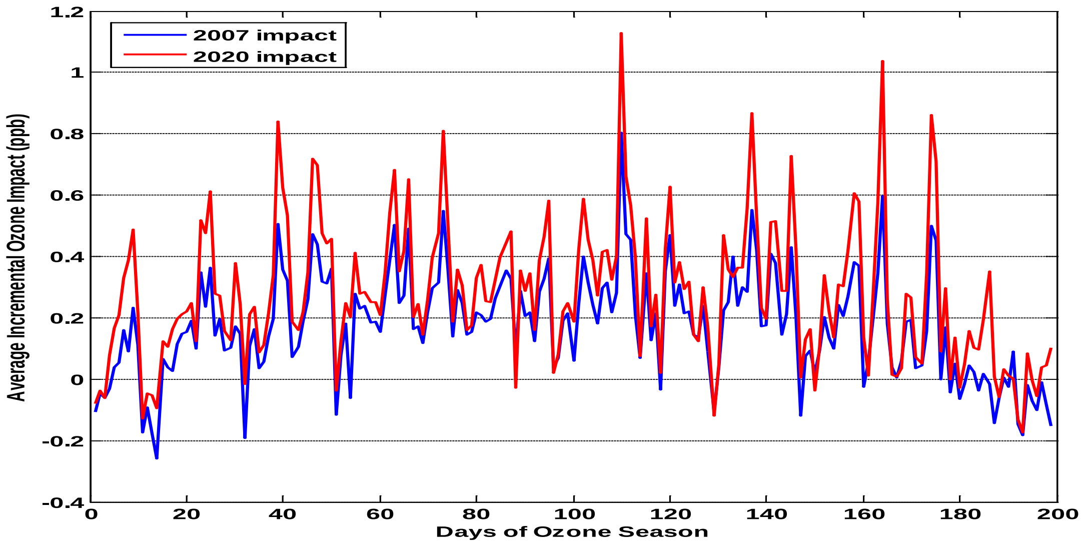


Figure 8. Time Series of the **Average** Modeling Maximum Daily 8-Hour Incremental Ozone in the Area Impacted by Marcellus Shale Drilling Activities for the Two Regional Inventory Cases (day 1 is April 15 while day 198 is October 30).

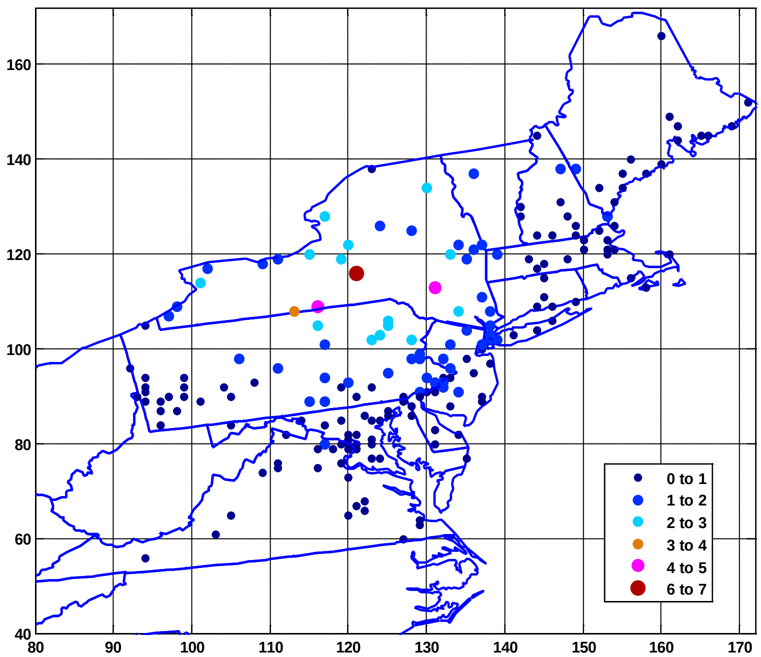


Coupled with the projected levels at the monitor locations, it is also very important to consider whether the higher incremental impacts due to well drilling activities are associated with times and locations of higher total predicted ozone levels. To that end, all the projected incremental daily maximum 8-hour ozone levels were plotted against the corresponding predicted ozone levels at the OTR monitors. The results are presented in Figure 10 for the two regional inventories. In these plots the incremental impacts are coupled with the total modeled impacts at the particular OTR monitor sites. The CMAQ modeling results indicate that the higher incremental impacts and total ozone levels essentially occur on the same days which are conducive to ozone formation. Thus, Figure 10 indicates that the higher incremental impacts have a tendency to occur at times and locations when the overall predicted concentrations are relatively lower for both inventory scenarios (in the range of 30 to 50ppb).

This is because the higher predictions due to the Marcellus Shale emissions occur in areas of New York with relatively lower predicted and observed ozone levels. On the other hand, some of the incremental daily maximum 8-hour ozone impacts due to the drilling activities are predicted to occur at locations where the total ozone levels are predicted to be at or around the current standard of 75 ppb. These occur mainly in the New York metropolitan area and along the eastern coastline. The incremental impacts in these areas are in the range of 1 to 3ppb. Although these impacts might seem relatively low, these must be cast within the EPA compliance demonstration procedures to determine whether these would affect the standard compliance in the areas where the current standard is currently approached or exceeded or is projected to be exceeded.

Figure 9. Incremental Daily Maximum 8-Hour Ozone Impacts at Ozone Monitors within OTR for the Entire Ozone Season and for the 2007 Inventory **(A)** and the 2020 Inventory **(B)**.

(A)



(B)

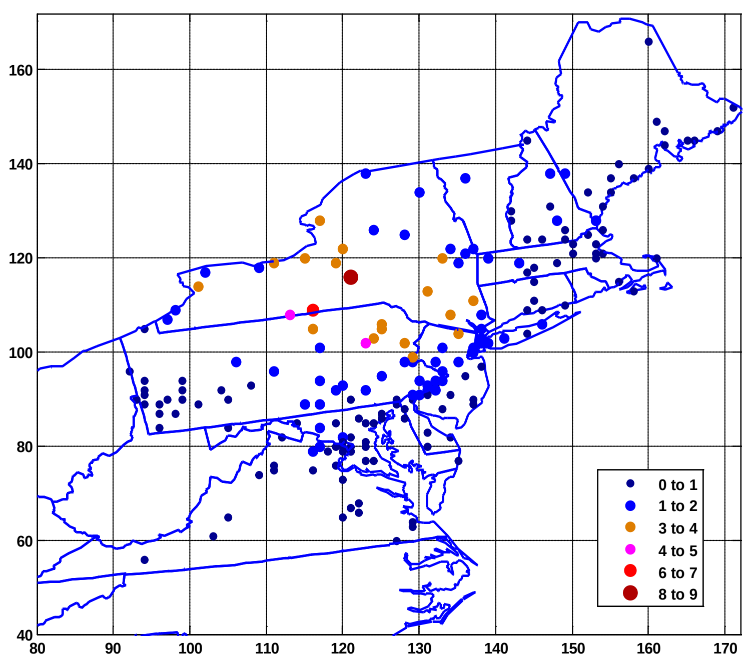
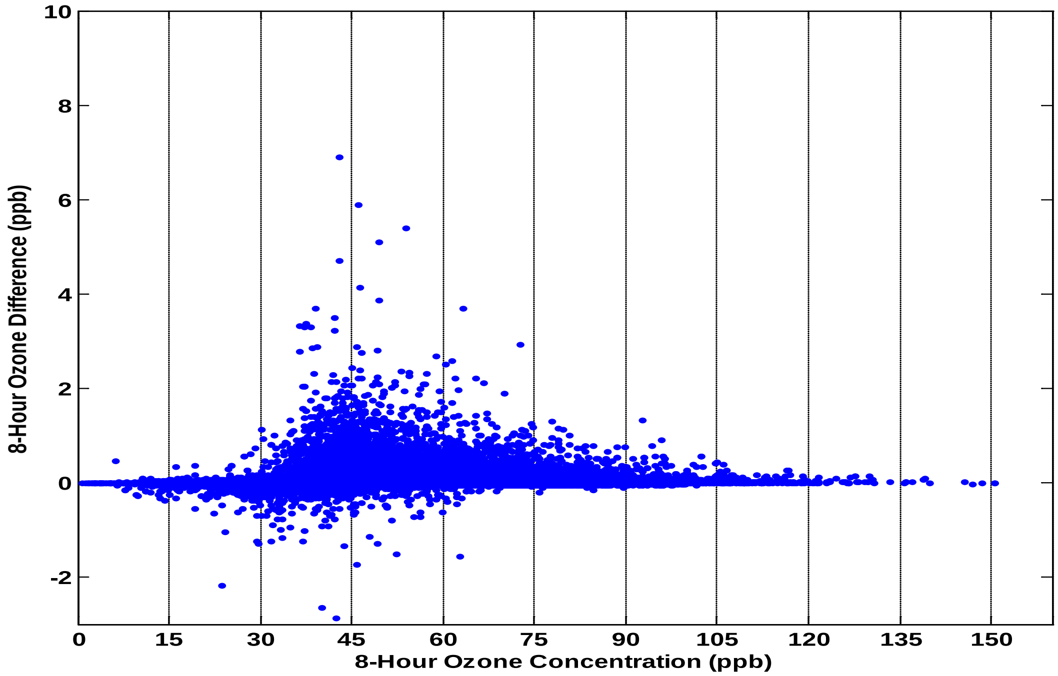
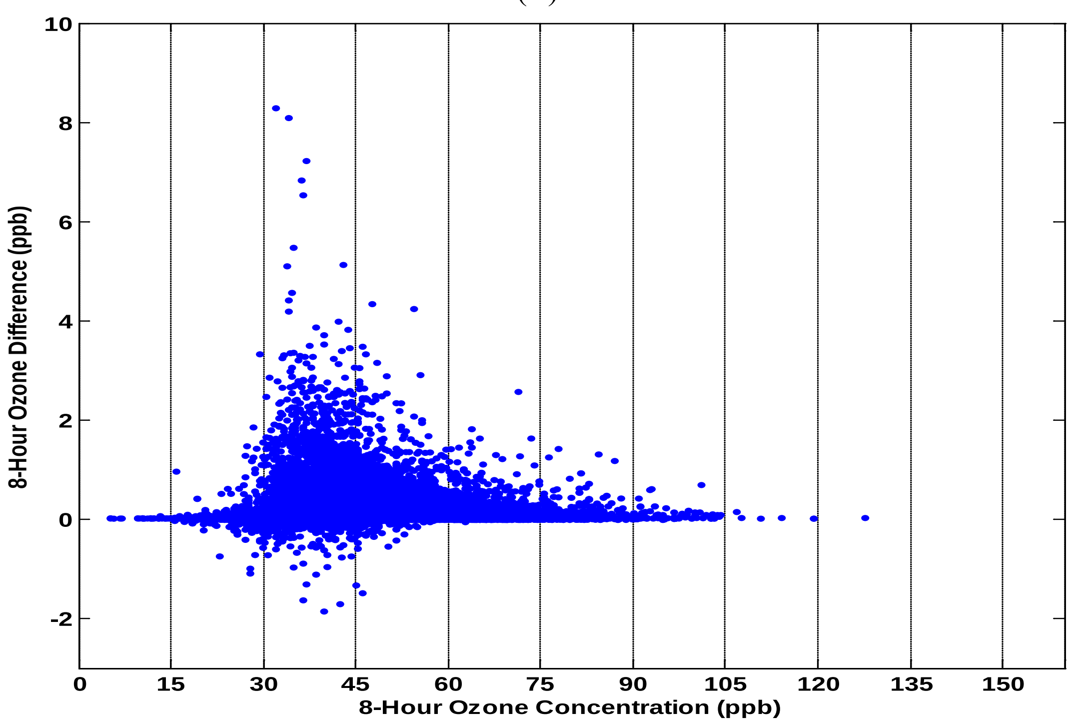


Figure 10. Incremental 8-Hour Ozone Impacts Versus Total Modeled 8-Hour Ozone at all Monitors within OTR with: **(A)** 2007 Baseline Emission Case, **(B)** Future 2020 Projected Emission Case.

(A)



(B)



Thus, it is critical to note that the incremental impacts and the projected total ozone levels cannot be used at this time to reach any conclusions on issues related to whether these incremental impacts will or will not result in standards compliance, for a number of reasons. First, there are specific EPA established calculation methodologies for ozone compliance demonstrations for future projections which must be performed to make such determinations for SIP purposes. However, it is premature to make such calculations at this time without a full understanding of: 1) how well the timeframes and levels of projected emissions from New York's portion of the well drilling activities as incorporated in this study will be actualized, 2) the potential future emissions expected from the full regional emissions associated with gas development, including those from neighboring states such as Pennsylvania and West Virginia, which have to be included in a final regional inventory to be relied upon by OTC states and EPA to make determinations. This inventory could differ from the 2020 inventory used in this analysis, and 3) the likely possibility that during the projected timeframes for gas development in New York and the SIP inventory development, EPA could act to revise the ozone standard.

The significant issue for item 1 which needs to be more fully explored is the level of emissions which are more likely to be representative of future gas development in the timeframes defined in the Socio-economic Impact Analysis. As discussed in Section 2.0, the peak emission projections for peak well development per year are likely an over prediction of future conditions due to the factors associated with the operational restrictions at the well pad and the non-road engine turnover which could occur in future years. To address this situation, the next section presents results of the alternative limited emissions scenario.

4.2 Ozone Impacts for the Limited Emissions Scenario.

The maximum projected emissions of NO_X assumed for the gas development during peak well development of 2462 wells per year were modified for this scenario to account for the expected limits on some of the production equipment (wellhead compressors and line heaters) and the future turnover of the older drilling and fracturing engines. Since limited amount of flaring will be allowed per well pad, no reduction was made to these emissions, although as gas lines are put in place, reduced emissions completions (i.e. green completion) could reduce the need for flaring. No reductions in VOC emissions were made in this scenario since these were mainly associated with glycol dehydrators, but for which no projected limitations were identified by industry. This limited emissions scenario should be viewed as the lower end emissions reductions relative to the worst case emissions and the likely conditions in the future if the well development was not to peak until ten years after it is initiated in New York.

Thus, the regional inventory which was used in conjunction with this scenario was limited to the future 2020 Scenario 4 from OTC as described the Section 2.0. This was deemed appropriate since the projected emissions assumptions used with future well development in New York under this limited emissions case would be realized only closer to the end of the approximate ten year timeframe to reach peak number of wells per year. In addition, the previous results for the peak emissions scenario indicated that the incremental impacts due to gas development are higher relative to this future scenario.

For the limited emissions scenario, not all of the results depicted in the peak emissions scenario need to be repeated. Figure 11 presents the incremental daily maximum 8-hour ozone impacts for the entire ozone season over the modeling grid. In comparison to the corresponding results in Figure 7(B), it is observed that the areal extent of the overall impacts, as well as the areas of the higher impacts, are significantly reduced. This is as expected since there is a significant reduction of approximately 25percent in NO_X emissions in this scenario versus the peak emission case. The corresponding incremental impacts at the OTR monitors are presented in Figure 12. Again, the areal extent and the larger impacts are reduced relative to the results for the peak emissions case in Figure 9(B). In particular, the maximum 8-hour ozone impacts in Figure 12 of 7ppb is about 77 percent of the 9ppb maximum in Figure 9(B), consistent with the reduced NO_X emissions. Furthermore, as in the case of the peak emissions scenario, the maxima for the limited emissions scenario occur at times and monitors where the total projected ozone levels for the 2020 emissions inventory are lower, as depicted in Figure 13. These impacts are now about 6ppb versus the 8ppb maximum for the peak emission case in figure 10(B). The incremental impacts associated with projected total ozone levels in the higher total ozone range of 60 to 75ppm are about 2ppb, reduced from the 3ppb maxima under the peak emissions case.

Figure 11. Incremental Daily Maximum 8-hour Ozone Concentration under the **Limited Emissions Scenario** for the Complete Ozone Season for the Additional Marcellus Shale Activities under the 2020 Future Year Project Emissions.

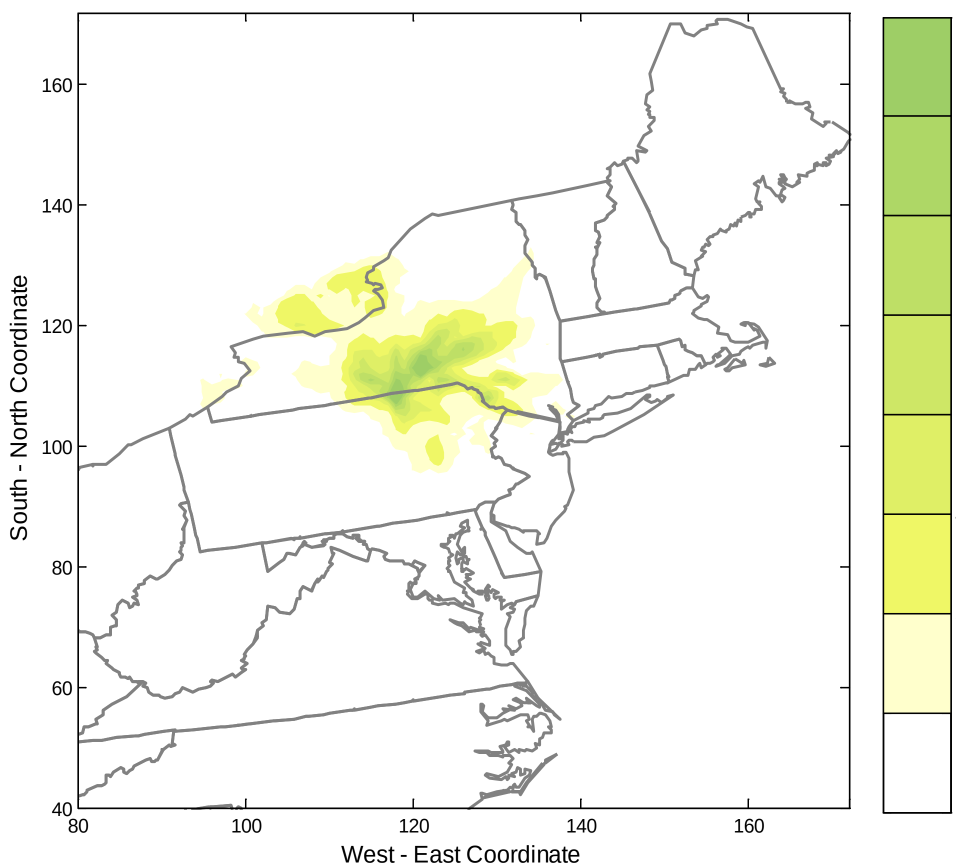


Figure 12. The Incremental Daily Maximum 8-Hour Impacts at Ozone Monitors within OTR for the **Limited Emissions Scenario** for the Ozone Season and for the 2020 Regional Inventory.

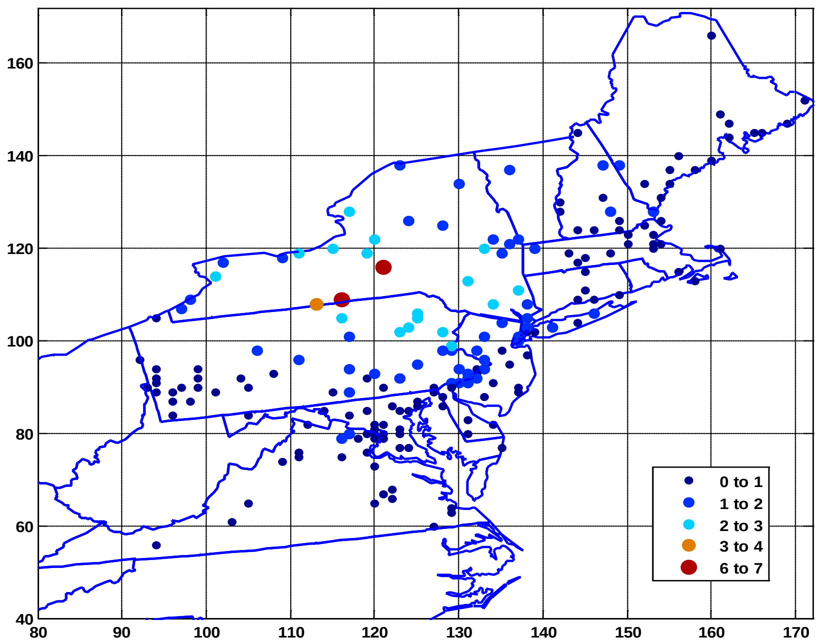
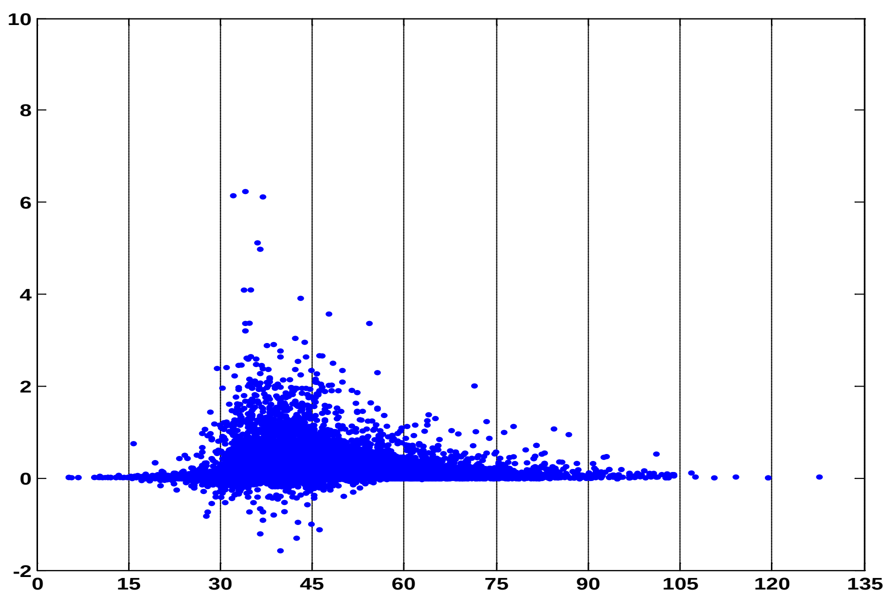


Figure 13. Incremental 8-Hour ozone impacts versus total modeled 8-Hour ozone at all monitors within OTR under the **limited emissions scenario** and with the future 2020 emission inventory.



5.0 <u>Impacts of Additional Compressor Station Emissions and the Marcellus Shale Limited Emissions Scenario.</u>

There are no projections of the number of compressor stations or processing plants which would be necessary to process the gas produced during the peak well development period described previously. It is possible that some of the existing stations could be used to a limited extent for this purpose, but it will be necessary to modify existing or to build new facilities in order to handle the projected amount of gas which is planned to be produced. The Department has already permitted some compressor stations and received applications for others along the border with Pennsylvania to process gas developed in the Marcellus Shale area of that state. Based on information in these permits and the Socio-economic Impact Analysis, it is possible to make a rough estimate of the number of compressor engines and associated emissions during the future peak well development time period. This information can then be used to determine the consequence of the additional increased ozone precursors due to the compressor facilities on projected incremental Ozone impacts previously discussed.

The next section presents the steps taken to estimate the potential NO_X and VOC emissions associated with the additional compressor stations using information from the Socio-Economic Impact Analysis and emission factors and rates from the ALL/IOGA responses to the Department's information request.[6] These factors and emission rates are also checked against similar information from a recently permitted compressor station or for which applications have been received in New York. Section 5.2 then presents the combined modeled incremental ozone impacts of the compressor stations and the limited emissions scenario relative to the 2020 future regional inventory. In addition, a preliminary assessment of total ozone levels for the 2020 future inventory case, with and without the Marcellus Shale emissions, are presented in Section 5.3 to allow a simple comparison of the regional effects of the additional emissions anticipated in future timeframes.

5.1 Emission Estimates for Compressor Engines.

To calculate the NO_X and VOC emissions from the potential number of engines which might be necessary to process the gas from the Marcellus Shale area during peak well development timeframes described in Section 2.0, the projected average amount of gas to be produced in the same timeframe was calculated. The gas production estimates for "high" and "low" conditions are provided in Section 4.1.3 of the Socio-economic Impact Analysis and in Section 5.16 of the Final SGEIS. For the current purposes, the gas estimates for the first ten years of production are used to calculate the weighted average gas production per well. The use of the ten year estimate also provides for a more appropriate value due to the considerable decrease in gas production after the ten years which could underestimate the average gas production value and the corresponding number of engines required. The projected "high" and "low" gas production rates are repeated below from the SGEIS Section 5.16:

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[6] ALL/IOGA Responses to DEC Information Request, dated October 14, 2009 which contains the report : *Horizontally Drilled/High-Volume Hydraulically Fractured Wells Air Emissions Data*, dated 8/26/09.

High Estimate:
Year 1: initial production rate of 8.72 million cubic feet per day (Mmcf/d), declining to 3.49Mmcf/d.
Years 2 to 4: initial production rate of 3.49Mmcf/d, declining to 1.25 Mmcf/d.
Years 5 to 10: initial production rate of 1.25 Mmcf/d, declining to 0.55 Mmcf/d.

Low Estimate:
Year 1: initial production rate of 3.26 Mmcf/d, declining to 1.14 Mmcf/d.
Years 2 to 4: initial production rate of 1.14 Mmcf/d, declining to 0.49 Mmcf/d.
Years 5 to 10: initial production rate of 0.49 Mmcf/d, declining to 0.29 Mmcf/d.

Using these values a weighted average (by years) gas production rate of 1.28 Mmcf/day is calculated per well produced over the first ten year of gas development. The total expected gas production is then simply the product of this rate and the estimated peak number of wells from the ALL/IOGA report of 2462 wells per year, or 3153 Mmcf/day. The "generic" compressor station engine modeled in Section 6.5.2 of the SGEIS is rated at 1775hp and is assumed to be able to process up to 40 Mmcf/day of gas (at 4 wells per year and maximum gas production of 10Mmcf/day from the ALL/IOGA August 26, 2009 report). To check on the appropriateness of this assumption, information from a recently permitted compressor station in New York was used. The Dunbar station will process an average of 235 Mmcf/day of gas using a number of engines with a total rating of about 10,060hp. Using this ratio of the Dunbar engine horsepower to the gas production, a level of gas production which corresponds to a 1775 hp engine was determined to be 41Mmcf/day. This matches the above value very well. Thus, the number of "generic" engines which would be necessary to process all of the average gas production in the ten year timeframe is calculated to be approximately 77 (3153 Mmcf/day divided by 41).

The next step in determining total NO_X and VOC emissions due to the estimated number of 77 "generic" engines was to use the emission rates from the ALL/IOGA emission report for the "generic" engines. It was noted in the report that the emission rates provided related to the emission factors of 0.7 and 0.27 gr/hp-hr for NO_X and VOC, respectively. The VOC factor corresponds to the use of an oxidation catalyst which will be required for essentially all these new engines per 40 CFR Part 63, Subpart ZZZZ (see Appendix 17). On the other hand, the NO_X emission factor is below the NSPS Subpart JJJJ factor of 2.0 g/hp-hr, but was noted by ALL/IOGA to be supported by the manufacturer's data. To check on these factors, the emissions from Dunbar and another compressor station for which a permit application has been received in New York were checked. In both these cases, the manufacturer's guarantee for NO_X is at 0.5 g/hp-hr, which confirms the factor used for the "generic" engine. For VOC, the factor for the "generic" source is essentially identical to the value used for these sources as well.

The corresponding emission rates of NO_X and VOC for the "generic" engines are 34 and 5 tons/year, respectively, from the ALL/IOGA report, as used in the modeling in Section 6.5.2 of the SGEIS. These rates are almost identical to the Dunbar facility values when adjusted for the horsepower differences. Thus, for the seventy seven "generic" sources, the total NO_X and VOC emissions are determined to be 2618 tons/year and 385 tons/year, respectively. These total emissions are 14 percent and 5 percent of the total NO_X and VOC emissions under the limited emissions scenario presented previously. These emissions were added to the limited emission scenario and the resultant incremental ozone impacts determined for the 2020 future regional inventory case which is the more likely scenario of future peak well development.

5.2 Ozone Impacts for the Marcellus Shale Development including the Compressor "Station" Engine Emissions.

The emissions from seventy seven "generic" 1775 hp engines estimated to process the gas under the peak well development scenario were calculated. Since the location of the compressor stations is unknown at this time, the emissions were spatially distributed as in the peak and limited emissions scenarios as described in Section 2.0. Furthermore, since these engines are associated with relatively low stacks with low plume rises due to likely downwash effects, the total emissions were "assigned" to the lowest layer of the CMAQ model which is from the surface to 40m and were assumed to be spread over the cells to which these were preferentially assigned as in Section 2.3 and Figure 3.

The calculated incremental daily maximum 8-hour ozone concentrations are depicted in Figure 14 for the Marcellus Shale limited emissions scenario plus the compressor station engines relative to the 2020 future regional emissions inventory. Figure 15 presents these incremental daily maxima at the OTR monitors, while Figure 16 presents each of the incremental 8-hour ozone impacts at these monitors against the total predicted ozone levels at the monitors. These results are consistent with previous depictions for the peak and limited emissions scenarios. To get an estimate of the contributions of the compressor engine emissions relative to the incremental impacts from other Marcellus Shale activities, a comparison of figures 14 to 16 can be made to the corresponding figures 11 to13 for the limited emissions scenario with the 2020 future inventory. This comparison indicates that the compressor engines are projected to result in a small addition to the overall incremental impacts of the order of 1ppb. This result is in line with the relatively small NO_X emissions associated with these compressor engines which were estimated at 14percent of the limited emissions scenario NO_X emissions. This, in turn, relates to the low NO_X emission factor expected from these new compressor stations which will service the Marcellus Shale gas development.

5.3 Preliminary Results for Total Daily Maximum 8-Hour Ozone Impacts

As discussed in Section 4.0, it is not possible, nor appropriate at this time, to project whether the emissions associated with gas development in the Marcellus Shale could affect the ozone standard compliance status in New York for a number of important reasons. These reasons were discussed in Section 4.1. However, it is possible to depict the incremental impacts associated with the additional NO_X and VOC emissions due to the gas development relative to the projected total impacts from the full 2020 inventory such that the relative influence on the concentration patterns can be ascertained. Similar information is already available to an extent from figures 13 and 16 where the incremental impacts are associated with the corresponding total impacts where the relative magnitudes of the incremental impacts versus the total ozone levels can be determined. Another way to depict this relationship is to show the ozone levels with and without the additional emissions from gas development. Since the incremental impacts were found to be larger for the 2020 future inventory and since this regional inventory is the more likely scenario than the 2007 inventory as far as the future timeframes for peak well development, the comparison is made of the 2020 future regional inventory ozone levels with and without the gas development emissions.

Figure 17 presents the predicted total daily maximum 8-hour ozone levels with the 2020 inventory with and without the additional Marcellus Shale emissions, including the compressor station engine emissions. The difference between these figures indicates the relative influence of the incremental impacts due to gas development with respect to the projected total ozone impacts expected in the future years. It is seen that the additional incremental impacts due to the Marcellus Shale associated emissions are not expected to change the total concentration patterns to a significant degree. However, the potential influence of these emissions at specific locations cannot be simply ascertained or dismissed, especially at monitor locations which are used for standard compliance demonstration, at some of which the observed levels are already high. The proper assessment must await the detailed analysis to be performed for the ozone SIP.

6.0 Conclusions

A screening level modeling analysis of regional ozone impacts due to estimated emissions from various well pad activities, associated truck traffic and compressor station engines was performed for assumed conditions under projected future peak well development. Some of the projections were based on the Socio-Economic Impact Analysis in support of the SGEIS, while other emissions and assumptions were made by the Department based on supplemental available information. Two well development emission scenarios were modeled using EPA's recommended CMAQ regional model which were coupled with two readily available regional emission inventories. The two Marcellus Shale emission scenarios represent the peak emissions and a limited NO_X emission scenarios, both associated with projected peak well development, but with the limited emission scenario, account for the likely future actual operations of some of the sources modeled. The regional inventories represented a "current" (2007) condition scenario and another future (2020) inventory scenario, both developed by the OTC, with the latter representing the anticipated timeframes when the peak well production is to occur.

The results of the modeling indicate that the incremental daily maximum 8-hour ozone impacts are maximized within the general region where the drilling activities are most likely to be the highest, with impacts reducing considerably with distance away from this limited area. The overall maximum incremental impacts are in the range of 6 to 10 ppb, but occur in areas where the predictions and observations of ozone are relatively low compared to the current standard. On the other hand, in areas with higher predicted and observed total ozone levels, the incremental ozone impacts from the gas development are low; in the range of 1 to 3ppb. While the overall maxima can be qualified as significant within the context of how that term is used in modeling relative to the corresponding standard (i.e. a few percent of the standard), this qualification cannot be used to translate to adverse effects within the context of this SGEIS. This is because the projected impacts must be further analyzed using EPA established procedures for compliance demonstrations within the SIP process.

That assessment, however, is premature at this time and must await the development of a more rigorous emission inventory for not only New York, but also for neighboring states which could impact New York's compliance determinations. Furthermore, it is essential that the proper future inventory (such as for 2020) which will be relied upon by EPA and the northeast states be finalized before such an analysis can be undertaken. Given that the peak well development is projected not to occur in New York for about ten years after horizontal drilling starts, the best approach to address the ozone projections and their consequences is to rely on the ozone SIP process which the Department must undertake in concert with EPA Region II to assure future compliance with the standard. This process will better quantify the resultant impacts and serve best to define any necessary control measures during the future timeframes when peak emissions might be reached. In addition, this process can better address the likelihood that EPA will revisit the ozone standard in this future timeframe.

The assumptions made in the modeling are based on viable options that if implemented by industry and the Department will assure that the above projected impacts have been properly quantified from the Marcellus Shale gas development activities. Specifically, two main aspects of the assumptions which should be assured to be implemented by industry and the Department will be mentioned. The modeling uses industry's projected regional emissions for drilling and fracturing engines which assumes an average emission factor from EPA Tier 2 engines. Thus, the above results are valid to the extent that the regional emissions projected are not significantly increased by the use of lower tier engines which could result in an inordinate increasing effect on the emissions. This is true even if the percentages of the lower tier engines are not large (see Table 6-20 of the Final SGEIS for the engine emission factors and percentages in use) since the lower tier engines have a significantly larger emission factor which can offset their lower percentages in the fleet of engines to be used for drilling and fracturing. In addition, the limited emissions scenario assumes that at least 25% of these engines will be replaced by the time peak well drilling conditions are realized over a ten year period. This assumption is consistent with the assumed non-road mobile source turnover in the OTC 2020 future inventory. This "turnover" emission reduction can be achieved in reality by the use of the newer Tier 4 engines which the manufacturers are in line to achieve starting in the 2014-5 timeframe, well before the peak emission conditions are projected to occur. In addition, cleaner fuel engines, such as natural gas and electric driven engines, might be more practically viable during this future time period. The other assumption which the Department will assure during the site specific permitting for the compressor stations is that the NO_X and VOC emission factors and rates used in this assessment would be imposed on compressor stations and would be representative of the proposed new facilities. Since these factors can be readily achieved and are in fact currently met by proposed facilities in New York through manufacturer's guarantees, the emissions imposed on new compressor stations will reflect the emission factors used in the modeling assessment.

Figure 14. Incremental Daily Maximum 8-Hour Ozone Levels for the **Compressor Station Engines Plus the Limited Emissions Scenario** for the Complete Ozone Season and the 2020 Future Inventory.

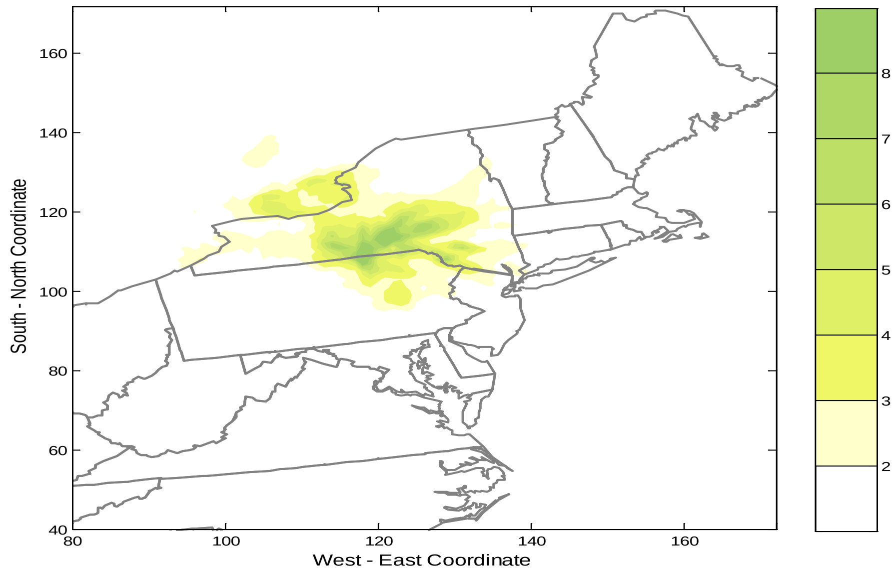


Figure 15. Incremental Daily Maximum 8-Hour Impacts at Ozone Monitors within OTR for the **Compressor Station Emissions Plus the Limited Emissions Scenario** for the Ozone Season and for the 2020 Regional Inventory.

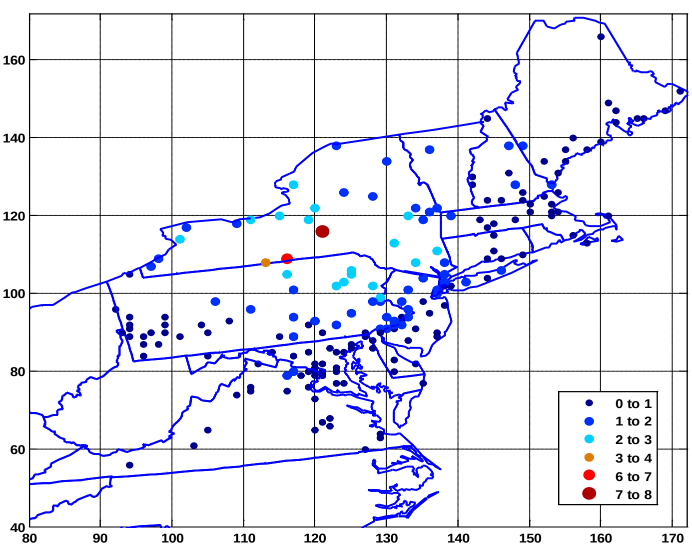


Figure 16. Incremental 8-Hour Ozone Impacts Versus Total Modeled 8-Hour Ozone at all Monitors within OTR for the **Compressor Stations Plus the Limited Emissions Scenario** and with the Future 2020 Emission Inventory.

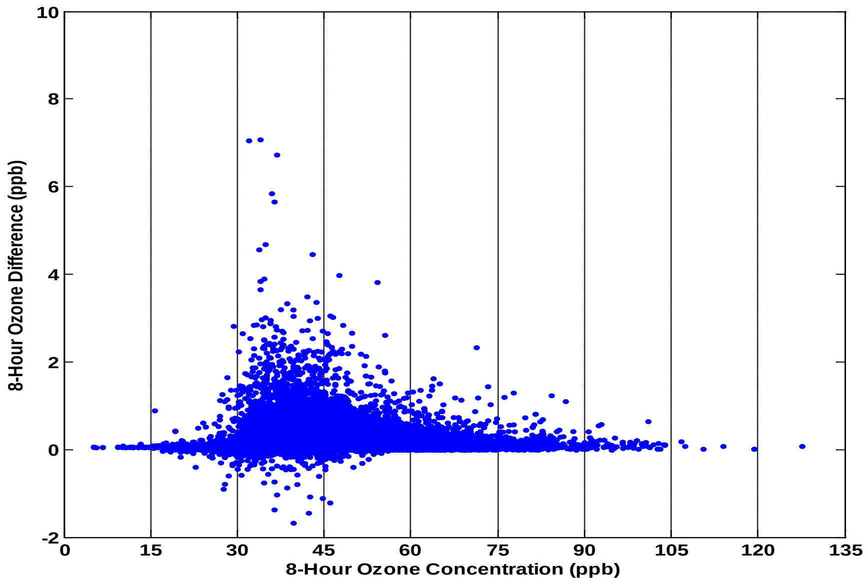
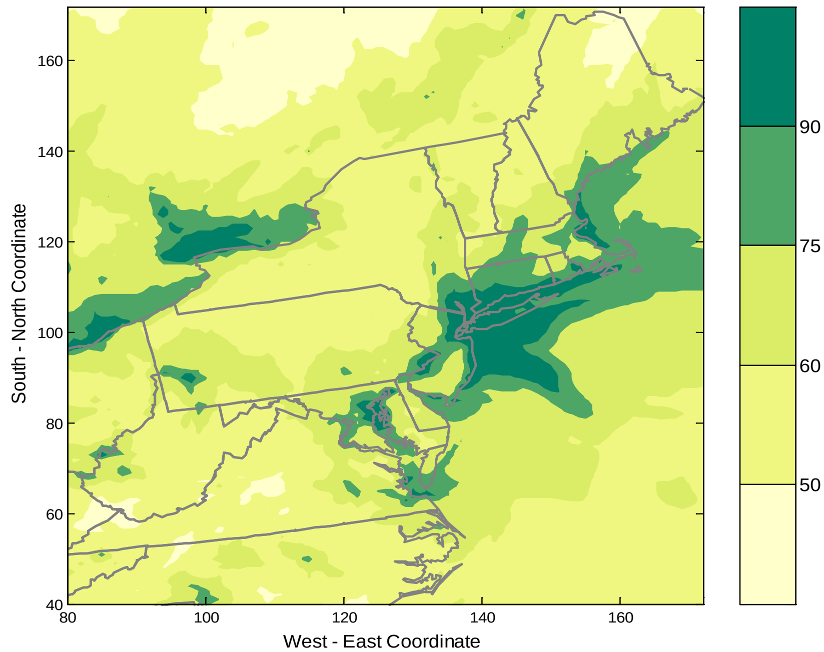
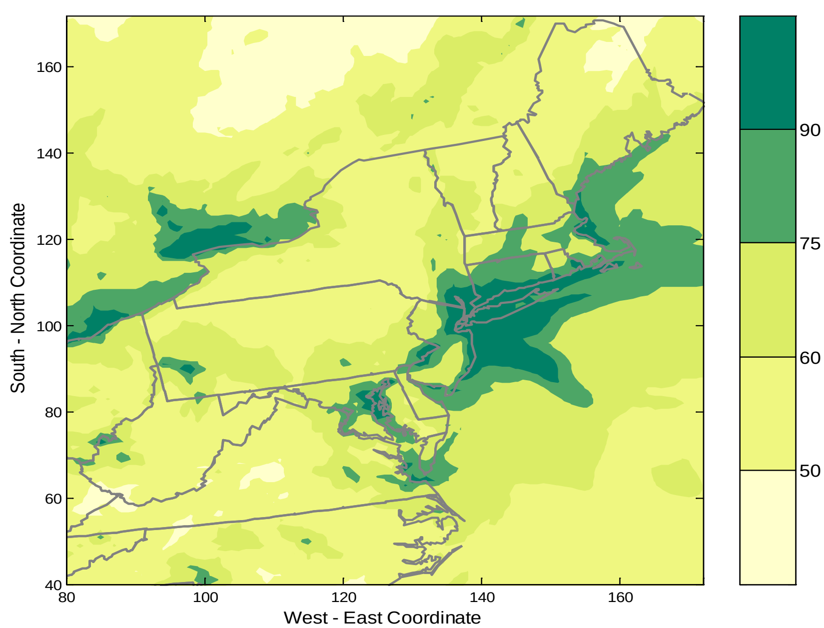


Figure 17. Total Daily Maximum 8-Hour Ozone Impacts for Future 2020 Inventory *without* (A) and *with* (B) Marcellus Shale Well Development Activities under the Limited Emissions Scenario Plus Compressor Station Engine Emissions.

(A)



(B)



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Baker, D. et al, 2010: Protocol for WRF Meteorological Modeling in Support of Regional SIP Air Quality Modeling in the OTR. Available at www.otc.org/

Byun, D.W. and K.L. Shere, 2006: Review of the governing equations, computational algorithms, and other components of the Model-3 Community Multiscale Air Quality (CMAQ) modeling system. Appl. Mech. Rev., 59, 51-77.

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Appendix C

Dispersion Modeling Input and Output Data, Sensitivity Analysis and Explanation of NAAQS and Toxics Threshold Establishment Process

Final

Supplemental Generic Environmental Impact Statement

Response to Comments

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This appendix contains two sections. Section I provides sample modeling input data and model sensitivity analysis to address issues raised about the building downwash dimensions used in the modeling analysis. In addition, sample concentration contours of PM2.5 and NO_2 impacts are presented to depict areas around the well pad where there is a potential for exceeding the 24 hour and 1 hour standards, respectively, for these pollutants. Section II presents a brief background on the procedures used by EPA to develop ambient air quality standards for criteria pollutants and those used by the Department to establish air guideline concentration thresholds.

I. Model Input Data and Sensitivity Analysis

This section provides the AERMOD model emission inputs data, the receptor grid plot and the revised source location on the well pad, wind roses, and sample contour plots for PM2.5 and NO2 impacts from the final set of model runs. In addition, the results of sensitivity analysis to address issues raised during the public comments on specific source input data have been included in the appendix. The emissions data used in the AERMOD modeling were taken for the most part from the ALL Consultant's document: *"Horizontally Drilled/HVHF Wells Air Emissions Data"*, dated 8/26/09. That report was contained in the ALL/IOGA October 14, 2009 responses to the Department's Information Request. The latter report also provided the findings of the independent Department staff review of the emission factors and rates some of which were subsequently modified for use in the modeling.

The appendix does not repeat all of the data from the 8/26/09 ALL report. Instead, only the PM and NO_2 modeling stack and emission rate data are detailed since these pollutants were found to exceed the short term NAAQS in the 2011 revised draft SGEIS modeling for which further refinements were made for the final SGEIS. The emissions for other pollutants and under average conditions used for the annual modeling can be found in the ALL Consulting report. The emissions input data used for PM were different from the NO_2 to the extent that the multiple drilling and compressor engines were represented as multiple point sources for the NO_2 modeling since the results of the modeling indicated potential exceedances of standards for the latter even with the Tier 2 engines. This is discussed in the Final SGEIS, Section 6.5.2.6. In addition, the engine tier level used in the PM versus NO_2 assessments were different, as detailed below, for the same reason.

PM Modeling Input Data

For the PM10 and PM2.5 standards compliance modeling, "Worst Case Drilling Emissions"-Table 8, "Worst Case Completion Emissions"-Table 15, "worst case emissions for the line heater"-Table 18, and the "maximum off-site compressor station emission"-Table24 from the ALL 8/26/09 report were used. The emissions of PM2.5 and PM10 were calculated by multiplying the total PM (given in the above tables) by EPA emission factors 0.69 and 0.89, respectively. In addition, per the ALL report, tier 1 emission rates were used for the drilling engines and tier 2 emissions for the compressor engines and the fracturing engines.

The specific source inputs in the AERMOD model are provided in Table 1 with: 15 fracturing engines (FRAC1 to FRAC15), 1 compressor engine (COMP), 1 drilling rig engine (RIGENG), 1 heater (HEATER), 1 flare (FLARE), and 1 off-site compressor (OFFCOMP). Each source was associated with its own "building" structure, except for the fracturing engine stacks which were divided between 2 "buildings" in separate 7 and 8 engines per set configuration. The structure heights were: 6ft for compressor engine and heater, 10 ft for the fracturing engines, 9 ft for the rig engine and 14 ft for the offsite compressor. Approximate lengths and widths for each structure were input to the BPIP model which in turn calculated the model projected structure width and length of each source for each 36 wind flow sector. The structure dimensions were approximate estimates from photographs. In addition, the flare "stack height" represents the minimum plume height estimated with the EPA SCREEN3 model using the heat release rate as explained in the SGEIS since AERMOD does not directly calculated the plume height for this source type.

Table 1. Stack/emission input parameters used in PM modeling scenarios.

Source	Stack height (m)	Stack Temp (K)	Stack Velocity (m/s)	Stack Diameter (m)	PM emission (lb/hr)	PM10 emission (lb/hr)	PM2.5 emission (lb/hr)
FRAC1	3.9624	616.48	57.912	0.3536	0.4400	0.3916	0.3036
FRAC2	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC3	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC4	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC5	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC6	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC7	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC8	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC9	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC10	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC11	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC12	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC13	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC14	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC15	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
COMP	3.048	616.48	100.584	0.1524	1.0000	0.8900	0.6900
RIGENG	3.048	616.48	100.584	0.1524	2.4000	2.1360	1.6560
HEATER	3.048	533.15	10.668	0.1015	0.0400	0.0356	0.0276
FLARE	150	293	0.01	0.1015	10.0000	8.9000	6.9
OFFCOMP	4.572	672.04	57.912	0.3557	0.1200	0.1068	0.0828

A 150x150m well pad was set up encompassing all the sources, except the off-site compressor was placed adjacent to the pad. The receptor grid was set up outside the fence out to 600m at 30m increments. Part of the receptor grid and the final source configuration of the fracturing engines are depicted in figure 1. There were no receptors inside the fence.

Modeling was done separately for drilling and fracturing scenarios since these operations will not occur simultaneously at a well pad. For the drilling scenarios all fracturing engine sources were removed from the model and for the fracturing scenarios, the drilling rig and compressor sources were removed from the model.

Model calculations were made for the maximum 24 hour concentration for PM10 and the 8th highest 24 hour concentration for PM2.5. The results were compared to their respective NAAQS, minus the respective background levels as described in Section 6.5.2 of the SGEIS.

NO_2 modeling Input Data

Emission and stack data for modeling of NO_2 were taken from the same reports and Tables noted above for PM. For the drilling rig engines, the emission rate was adjusted in these runs to be the tier 2 engine emission factor (tier1 times 0.695). Both the drilling and compressor engines were modeled as individual sets of 5 point sources for the NO_2 impacts as a refinement to the single source representation used for PM. Sources modeled for NO_2 are presented in Table 2. The stack parameters were the same as in Table 1, except as noted for the individual drilling and compressor engines representation. Also, structure dimensions were the same as for PM modeling, except the compressor structure height was adjusted to 10ft based on review of the photographs, while the offsite compressor building height was set to the 25ft which was determined to be the height necessary to eliminate the exceedances of the formaldehyde AGC.

Table 2. Stack/emission input parameters used in NO_2 modeling

Source	Stack Height (m)	Stack Temp. (K)	Stack Velocity (m/s)	Stack Diameter (m)	NO_2 Emission (lb/hr)
FRAC1	3.9624	616.48	57.912	0.3536	1.4
FRAC2	3.9624	616.48	57.912	0.3554	1.4
FRAC3	3.9624	616.48	57.912	0.3554	1.4
FRAC4	3.9624	616.48	57.912	0.3554	1.4
FRAC5	3.9624	616.48	57.912	0.3554	1.4
FRAC6	3.9624	616.48	57.912	0.3554	1.4
FRAC7	3.9624	616.48	57.912	0.3554	1.4
FRAC8	3.9624	616.48	57.912	0.3554	1.4
FRAC9	3.9624	616.48	57.912	0.3554	1.4
FRAC10	3.9624	616.48	57.912	0.3554	1.4
FRAC11	3.9624	616.48	57.912	0.3554	1.4
FRAC12	3.9624	616.48	57.912	0.3554	1.4
FRAC13	3.9624	616.48	57.912	0.3554	1.4
FRAC14	3.9624	616.48	57.912	0.3554	1.4
FRAC15	3.9624	616.48	57.912	0.3554	1.4
COMP1	3.048	616.48	100.584	0.1524	6.4
COMP2	3.048	616.48	100.584	0.1524	6.4
COMP3	3.048	616.48	100.584	0.1524	6.4
COMP4	3.048	616.48	100.584	0.1524	6.4
COMP5	3.048	616.48	100.584	0.1524	6.4
RIGENG1	3.048	616.48	100.584	0.1524	5.699
RIGENG2	3.048	616.48	100.584	0.1524	5.699
RIGENG3	3.048	616.48	100.584	0.1524	5.699
RIGENG4	3.048	616.48	100.584	0.1524	5.699

Source	Stack Height (m)	Stack Temp. (K)	Stack Velocity (m/s)	Stack Diameter (m)	NO_2 Emission (lb/hr)
RIGENG5	3.048	616.48	100.584	0.1524	5.699
HEATER	3.048	533.15	10.668	0.1015	0.2
FLARE	150	293	0.01	0.1015	34
OFFCOMP	7.6	672.04	57.912	0.3557	7.8

The same well pad and receptor configuration as in PM modeling was used. Based on a sensitivity analysis and the limited model evaluation results from EPA, the Ozone Limiting Method (OLM) with OLMGROUP ALL option in AERMOD was used in the final analysis of impacts. For the hourly background Ozone values, measurements from Elmira, NY was used.

The 1 hour NO_2 impacts were calculated for following source groups:

"Fracturing": 15 fracturing engines, heater, flare and off-site compressor
"Drilling": 5 compressor engines, 5 drilling rig engines, heater, flare and off-site compressor
"Compressor": 5 on-site compressors engines
"RigEngine": 5 drilling rig engines

The source groups allowed the determination of respective impacts from various operations and combination of sources. The resultant impacts were compared to the 1 hour NAAQS, minus the background values.

Meteorological data

The modeling performed for the SGEIS used meteorological data from 6 sites, as discussed in Section 6.5.2. These sites were: Albany, Syracuse, Binghamton, Jamestown, Buffalo and Montgomery County Airport. The wind roses for the two years of data used from each site are presented in Figure 2. The wind rose depicts the average annual percentages of wind direction (as direction from) in wind speed categories such that the annual "dominant" directions and the associated average wind speeds can be discerned for a given site.

Model Sensitivity Analysis for Building/Structure Heights

A concern raised during the public comment period related to the effects of choosing the building dimensions from photographs instead of actual data. A related concern was the potential effects of the building structures of a source on an adjacent source's impacts. The significance of these concerns was tested by performing sensitivity calculations by AERMOD to determine their consequences. Specifically, the placement of the off-site compressor station next to the well pad could have a significant contribution to maximum impacts of drilling and fracturing source groups. This is due to the fact that some of the building dimensions from BPIP for these latter sources were assigned the higher building height of the compressor building for a limited set of wind flows. However, these flows would result in impacts over the well pad, which were not considered in the standards compliance determinations.

To explicitly demonstrate this conclusion, the AERMOD model was rerun with the off-site compressor completely removed from the BPIP building dimension calculations and the resultant inputs parameters and Albany meteorological data used in the analysis. The maximum impacts for all pollutants, source groups and both years modeled were identical to those presented in previous Table 6.19 of the 2011 revised draft SGEIS (revised Table 6-20 of the Final SGEIS). This leads us to conclude that the off-site compressor did not impact our modeling results, nor the conclusions reached.

The other concern raised with the influence of the downwash effects by the structure dimensions was the use of approximate values from photographs. One of the concerns related to the new AERMOD model's approach to downwash calculations, as noted in a reference submitted with comments. However, the "new" AERMOD approach to downwash calculations only related to higher impacts noted for sources which have Good Engineering Practice (GEP) stack heights. Since none of the sources modeled for the SGEIS have GEP heights, the issue was not germane.

The use of approximate building dimensions in the modeling was due to lack of such actual data from the industry in the ALL Consulting emission reports. Furthermore, no such actual data was submitted during the public comments, nor was forthcoming from industry. Thus, a sensitivity analysis was performed with the fracturing engines to determine how the equipment dimensions influence modeled impacts. In the SGEIS modeling, the fracturing engine height ("building height") was set to 10ft. For the sensitivity study, the value was changed to 9ft and then to 11ft and BPIP was rerun. Then AERMOD was run with two years of Albany meteorological data and the results compared to the 10ft building height impacts.

For these sensitivity impacts, the fracturing engines were located in the middle of the well pad (as explained in Section 6.5.2 of the Final SGEIS) and AERMOD run with the three building heights. The results showed that the sensitivity of the impacts to a building height changes is within expectation and not as dramatic as was the basis of the concern raised. A 10% increase (decrease) in fracturing building height lead to a 6-11% increase (decrease) in maximum 24 hour impacts for PM2.5, while PM10 impacts changed 5-9%. In addition, the distances to where the concentrations fell below the critical value (NAAQS-background concentration) were similar for all three building heights; i.e. about 70m for PM2.5. For NO2, the same exercise was performed. In this instance, a 10% increase (decrease) in building height lead to 3-5% increase (decrease) in maximum 1-hour impacts. In this case also, the distances to where the concentrations fell below the critical value were the same as for the 10ft building height case. These results are the expected results of changing the stack height to envelop the likely heights expected for these sources.

Thus, it is concluded that the building dimensions used in the original analysis are adequate for the projections of standard compliance and other determinations for all of the engines. The additional modeling performed for the Final SGEIS removed the compressor engines from the AERMOD runs and also located the set of fracturing and drilling engines near the center of the well pad.

Concentration Contour Maps of PM2.5 and NO_2 Impacts

The additional modeling analysis performed in response to public comments on the 2011 revised draft SGEIS considered the placement of the drilling and completion engines near the center of the well pad and the cyclical nature of the completion engine operations. In order to determine the downwind distances where the maximum concentrations fall below the corresponding NAAQS- minus-background levels discussed in Section 6.5.2, concentration pattern maps were generated from the AERMOD results. For PM2.5, the impacts to below the standard were found to occur approximately right at or just beyond the well pad boundary. The concentration contour maps of the PM2.5 24 hour 8th highest impacts for the Buffalo 2007 meteorological data year for the completion engines, with and without accounting for the cycle operations, are presented in Figure 3. For the 1 hour NO_2 impacts, it was found that certain OLM contour plots did not provide a realistic drop-off of impacts in certain directions versus PVMRM maps. An example for the 8th highest daily maximum 1 hour concentration plots for the completion engines are presents in Figure 4 for the case of Albany, 2007 data with the OLM and PVMRM methods. A similar plot for the drilling engines and the Albany 2007 data with the PVMRM method is presented in Figure 5 and appears to be in line with expected patterns.

Figure 1. Well pad source layout for the set of final supplemental modeling runs and the surrounding near field receptor grid.

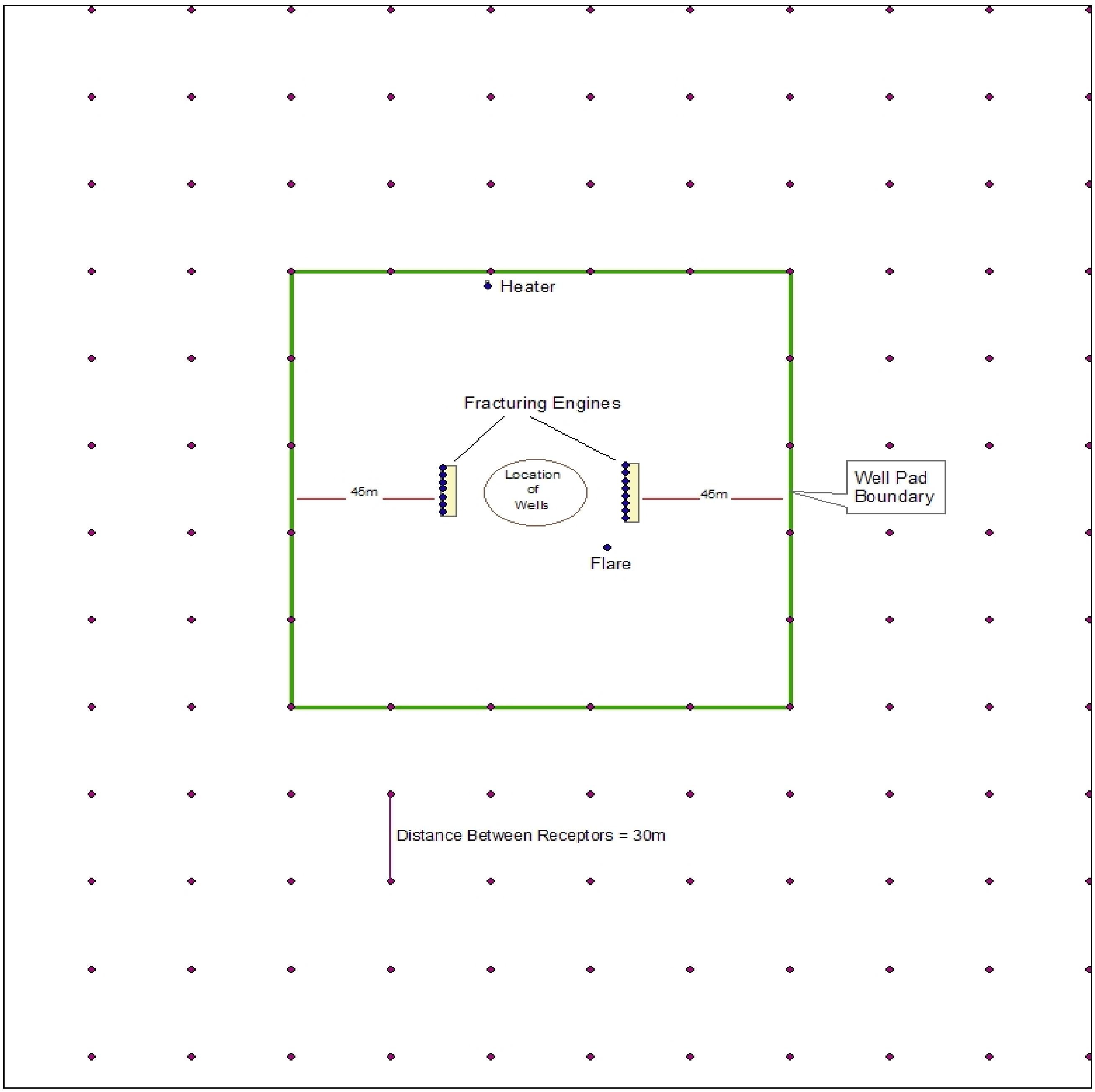
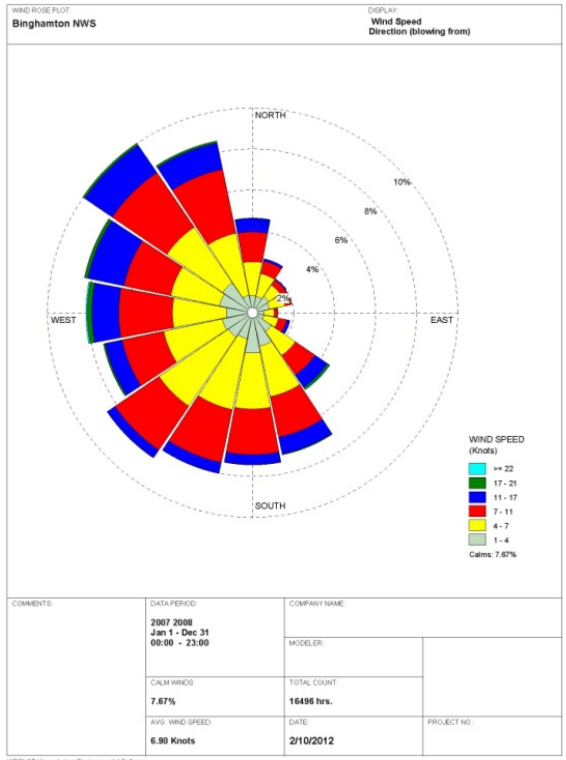
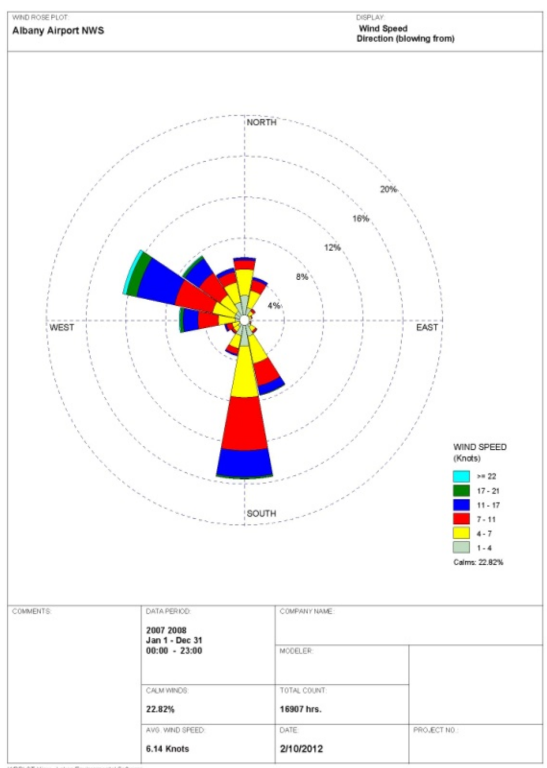
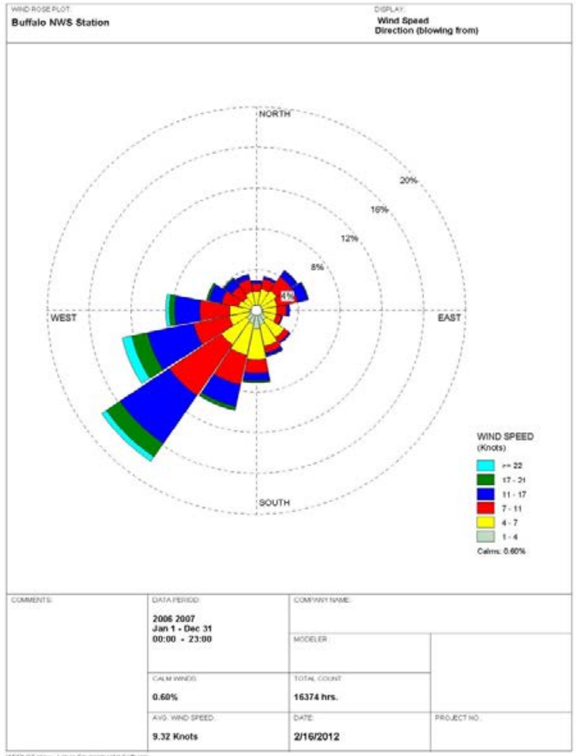


Figure 2. Wind Roses from Meteorological Data Sites






WIND ROSE PLOT:
Buffalo NWS Station
DISPLAY:
Wind Speed
Direction (blowing from)
NORTH
WEST
EAST
SOUTH
20%
16%
12%
8%
4%
WIND SPEED
(Knots)
>= 22
17 - 21
11 - 17
7 - 11
4 - 7
1 - 4
Calms: 0.60%
COMMENTS:
DATA PERIOD:
2006 2007
Jan 1 - Dec 31
00:00 - 23:00
COMPANY NAME:
MODELER:
CALM WINDS:
0.60%
TOTAL COUNT:
16374 hrs.
AVG. WIND SPEED:
9.32 Knots
DATE:
2/16/2012
PROJECT NO.:
WRPLOT View - Lakes Environmental Software

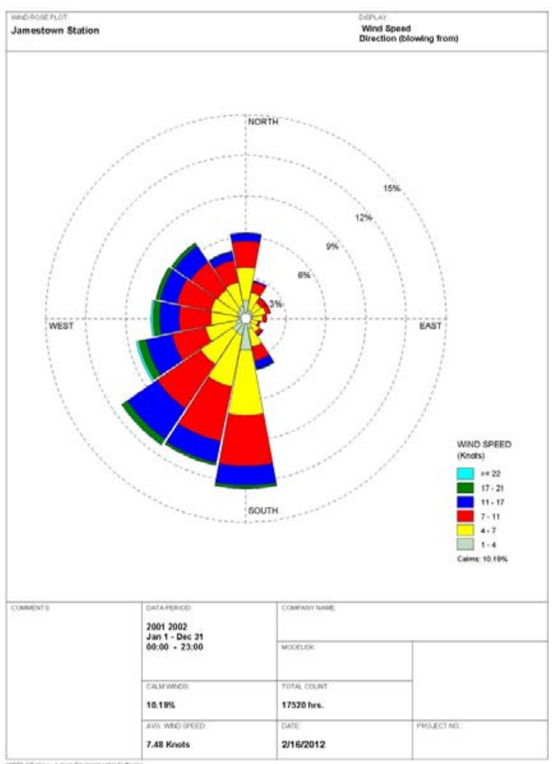
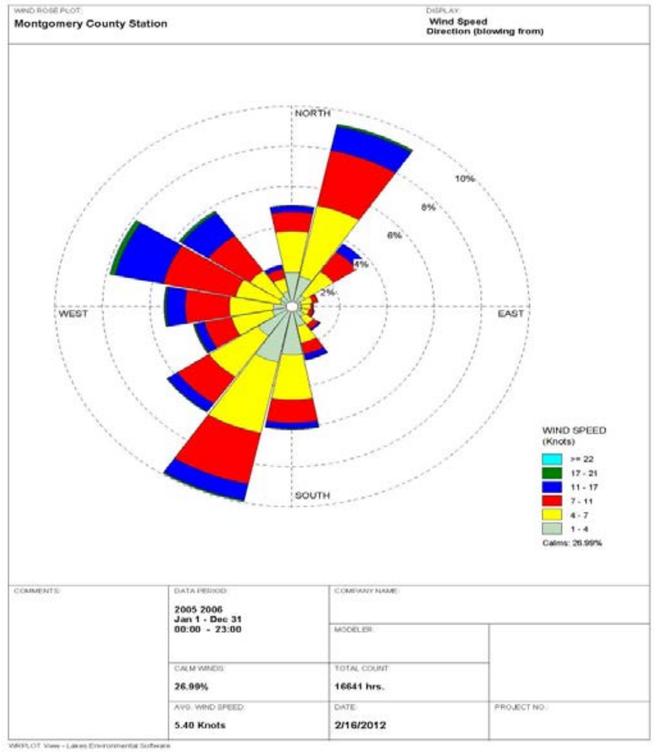

WIND ROSE PLOT:
Jamestown Station
DISPLAY:
Wind Speed
Direction (blowing from)
NORTH
WEST
EAST
SOUTH
15%
12%
9%
6%
3%
WIND SPEED
(Knots)
>= 22
17 - 21
11 - 17
7 - 11
4 - 7
1 - 4
Calms: 10.19%
COMMENTS:
DATA PERIOD:
2001 2002
Jan 1 - Dec 31
00:00 - 23:00
COMPANY NAME:
MODELER:
CALM WINDS:
10.19%
TOTAL COUNT:
17520 hrs.
AVG. WIND SPEED:
7.48 Knots
DATE:
2/16/2012
PROJECT NO.:
WRPLOT View - Lakes Environmental Software

Figure 2 (continued). Wind Roses from Meteorological Data Sites



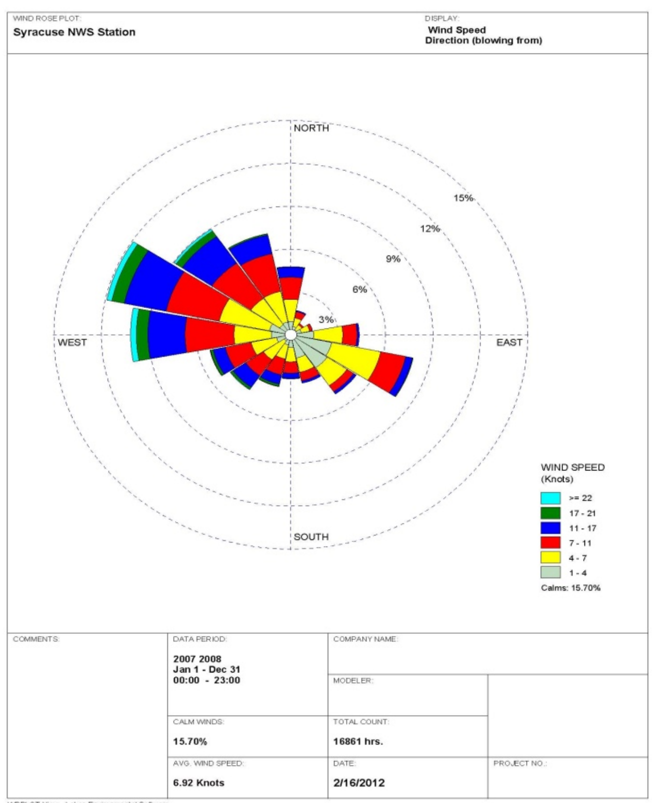
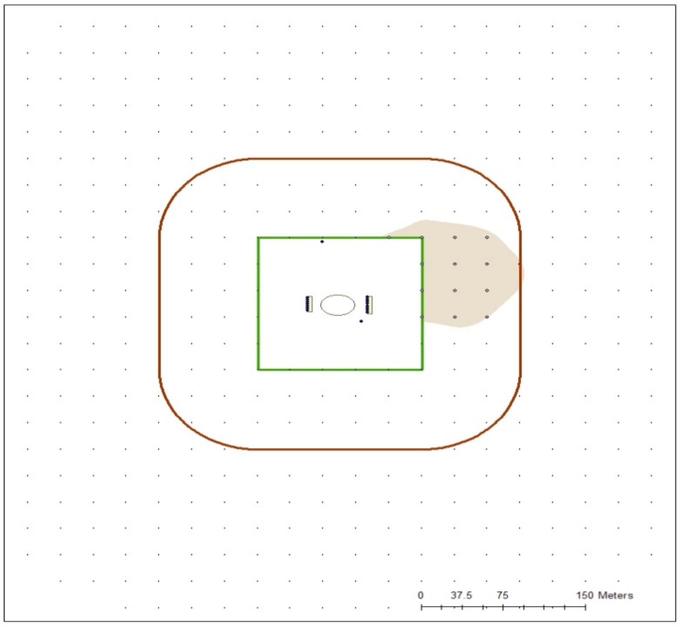


Figure 3. PM2.5 8th Highest 24 hour Impact Contours for the Completion Engines, Placed at the Well Pad Center and without (A) and with (B) the Cyclical Emissions for Albany 2007 Data.

(A)



(B)

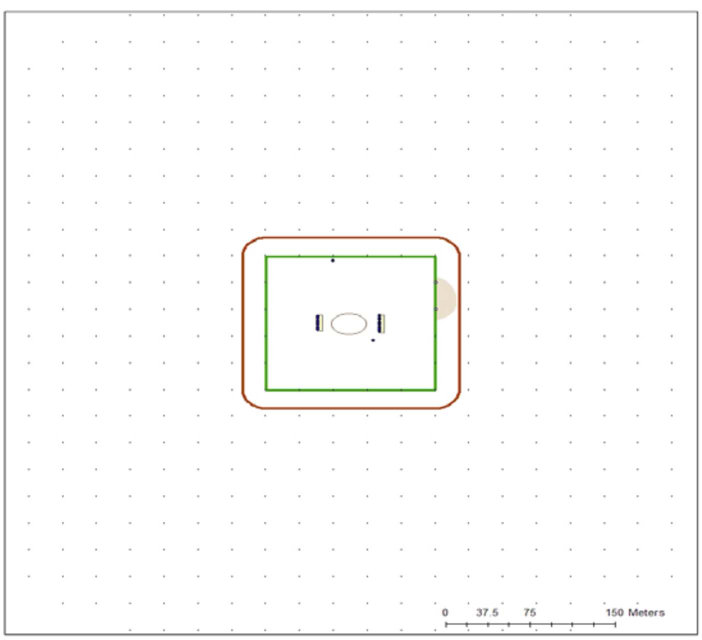
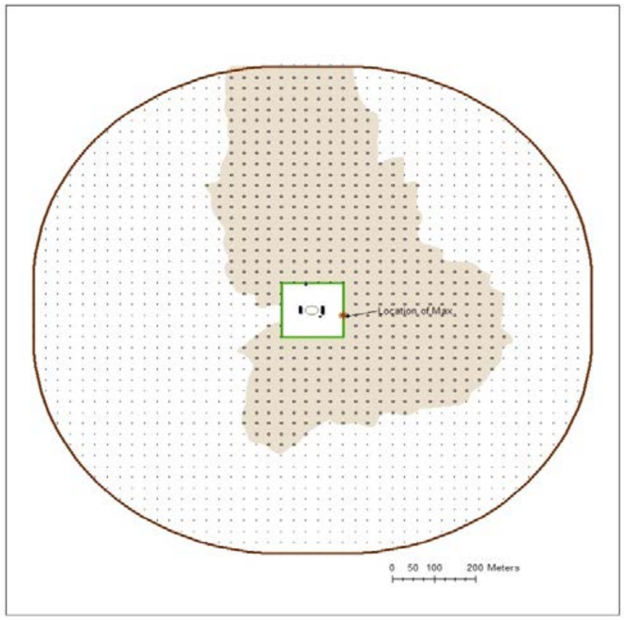
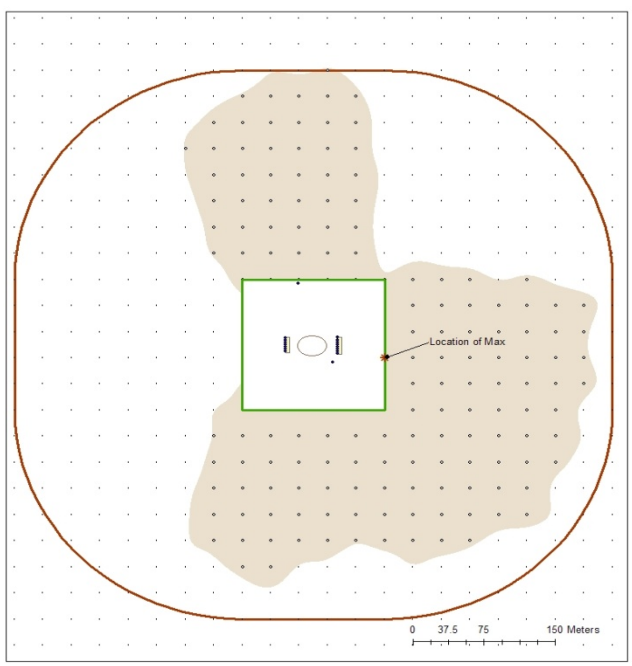


Figure 4. NO_2 8th Highest Daily Maximum 1-Hour Impacts for the Completion Engines with (A) OLM and (B) PVMRM using Albany 2007 Data.

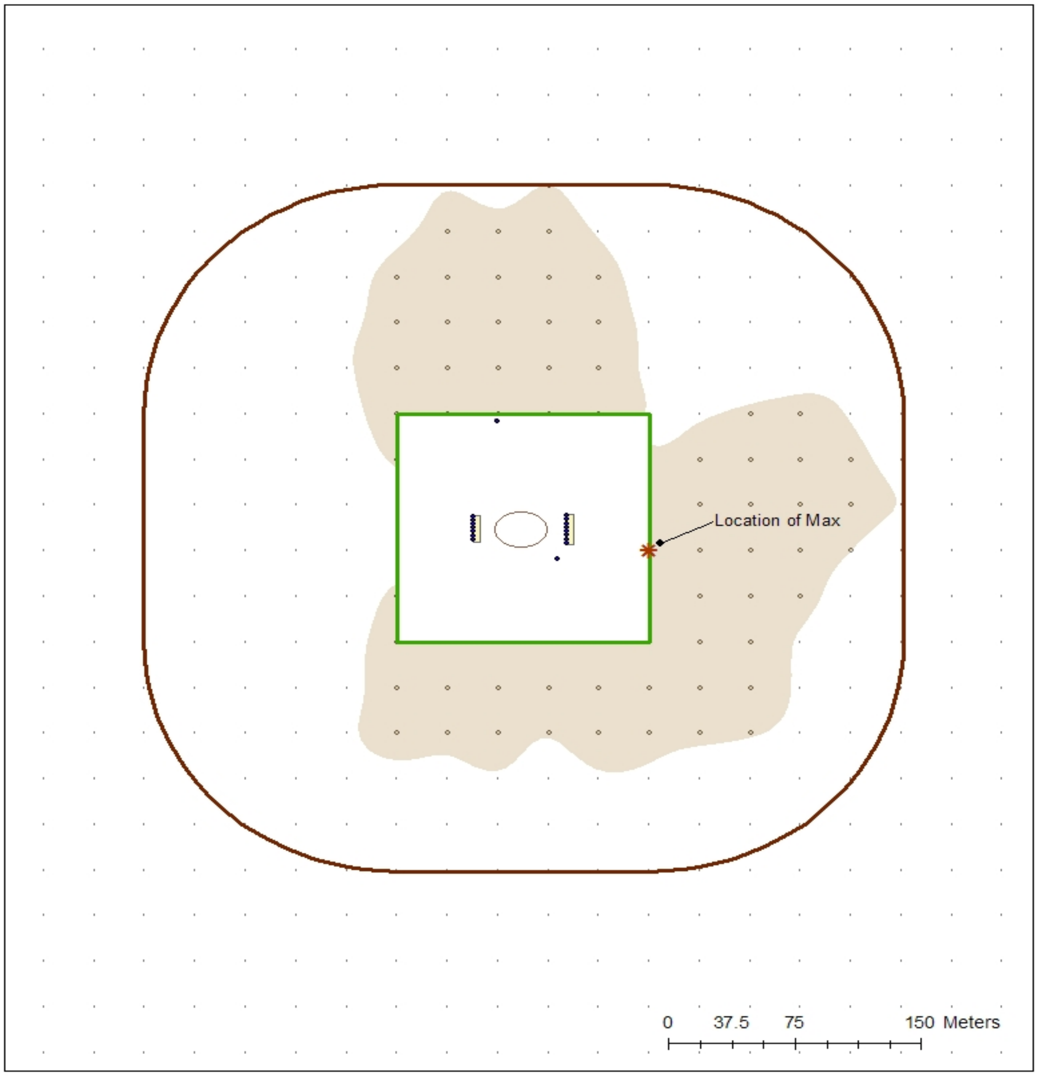
(A)





(B)

Figure 5. NO_2 8th Highest Daily Maximum 1-Hour Impacts for the Drilling Engines with PVMRM and Albany 2007 Data.



II. Summary of Procedures used by EPA to Establish National Ambient Air Quality Standards (NAAQS) for criteria pollutants and by the Department to establish Air Guideline Concentrations for Toxic Contaminants.

An area voiced by the public as a potential public health concern is air quality and whether the ambient standards and toxic thresholds used by the Department to determine the potential for adverse effects are adequately protective. The Department, along with other state and federal agencies, uses the national ambient air quality standards (NAAQS) to determine whether the public is exposed to acceptable ambient concentrations for the six criteria pollutants for which EPA has established NAAQS. Furthermore, the Department's Division of Air Resources (DAR) has established ambient air guideline concentrations (or thresholds) for non-criteria (or toxic) pollutants to determine the potential for adverse effects on public health (NYSDEC Air Guide- 1, DEC Program Policy DAR -1: *Guidelines for the Control of Toxic Ambient Air Contaminants*). These NAAQS and the toxic thresholds are routinely used for comparison to source impacts in order to determine the public's exposure by using actual observed monitoring data and/or model predicted concentrations.

For obvious reasons, a proposed source can only conduct a modeling analysis to determine the potential for adverse impacts under various future operational conditions. For the SGEIS, the Department undertook a comprehensive and detailed modeling analysis of all potential sources associated with gas drilling, completion and production activities related to well pad operations. All anticipated criteria and toxic pollutants from these sources were modeled under a set of conservative assumptions to predict worst case impacts. Details of the modeling approach and the results are presented in Section 6.5.2 of the Final SGEIS. The methodologies used in the modeling rely on EPA and Department recommended technical approaches and are, by their nature, formulated to predict impacts which are at or above the expected levels which could be observed in actuality. Thus, there is a level of conservatism in these predictions which further assures compliance with the NAAQS and toxic thresholds.

Using the NAAQS and toxic thresholds, the Final SGEIS recommends a set of mitigation measures to assure that predicted impacts which could exceed these levels are alleviated. These measures are discussed in Section 6.5.2 and summarized in Section 7.5 of the SGEIS in order to reduce air quality impacts below NAAQS and thresholds, including operational limits and equipment emission controls. The modeling analysis also incorporated existing conditions as determined by observed data for criteria pollutants at the Department's air quality monitoring network in the Marcellus Shale area. The current observations from all these monitors indicate attainment of all promulgated NAAQS currently in effect. As EPA promulgates new standards or revises existing ones, the Department will be required to assure compliance with these changes through its State Implementation Plan (SIP) and permitting process. For example, EPA finalized the 1 hour SO_2 and NO_2 standards after the release of the 2009 dSGEIS. These standards were then addressed in the 2011 rdSGEIS and necessary mitigation measures were recommended.

The issue which has arisen is whether the NAAQS and toxic guideline concentrations used by the Department to minimize public health effects due to air pollution from gas well activities are protective of public health. These levels have been established by the EPA and Department with a large margin of safety in order to protect even the most sensitive in the population. The steps taken to assure this level of protection are described below for the NAAQS established by EPA and for the toxic thresholds established by the Department.

NAAQS Development and Promulgation Process[1]

The Clean Air Act (CAA) governs the establishment and revision of National Ambient Air Quality Standards (NAAQS). The EPA has established NAAQS for six common air pollutants (lead, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter and ozone). The NAAQS are intended to accurately reflect the latest scientific knowledge about all the public health and environmental (welfare) effects associated with exposure to the specific air pollutant. Primary NAAQS are defined as the ambient air concentration that protects public health with an adequate margin of safety from adverse health effects of exposure. Secondary NAAQS are defined as the ambient air concentration that protects the public welfare from any known or anticipated adverse effects associated with the presence of the pollutant in ambient air.

The requirement that primary standards provide an adequate margin of safety was intended to address uncertainties associated with inconclusive scientific and technical information available at the time of standard setting. It was also intended to provide a reasonable degree of protection against hazards that research has not yet identified. When making a determination about an adequate margin of safety, the EPA is seeking not only to prevent pollution levels that have been demonstrated to be harmful but also to prevent lower pollutant levels that may pose an unacceptable risk of harm, even if the risk is not precisely identified as to nature or degree.

The CAA does not require the Administrator to establish a primary NAAQS at a zero-risk level or at “background” concentration levels, but rather at a level that reduces risk sufficiently so as to protect public health with an adequate margin of safety.

The Clean Air Act requires a comprehensive review of the latest scientific information on a five year basis to identify if the NAAQS should be revised. There are four phases of the NAAQS review process that guide the five year review process; 1) the preparation of plan for the review, 2) the preparation of an Integrated Science Assessment, 3) the preparation of a Risk/Exposure Assessment and 4) the preparation of a Policy Assessment.

During the planning phase, the EPA will convene science policy workshops to gather input from the scientific community and the general public to identify policy relevant issues associated with the specific NAAQS. Based on these workshops, EPA will prepare an integrated review plan that includes a schedule for the entire review process and identifies all the policy relevant issues that will be considered during the review process.

The next step involves preparation of an Integrated Science Assessment (ISA) document by EPA which is a comprehensive review, synthesis and evaluation of all the policy relevant science for

[1] For further detailed information see: Process of Reviewing the National Ambient Air Quality Standards, http://www.epa.gov/ttn/naaqs/review.html

the air pollutant. This document includes key scientific judgments that are important to inform the risk and exposure assessments.

The preparation of the Risk/Exposure Assessment (REA) document builds off the ISA to develop quantitative characterization of exposures and associated risk to human health and the environment that is associated with recent air quality, as well as, air quality that is estimated to just meet the current or alternative standard(s) under consideration. The uncertainty associated with these estimates is also characterized.

The final step is the preparation of a Policy Assessment document that includes the EPA staff's analysis of the scientific basis for alternative policy options for consideration by the EPA senior management prior to rulemaking. This document bridges the gap between the scientific assessments in the ISA and REA and the judgments required of the EPA Administrator in determining whether it is appropriate to retain or revise the NAAQS. This step facilitates the Clean Air Science Advisory Council (CASAC) advice to the Agency and recommendations to the Administrator on the adequacy of the existing standards or revisions that may be appropriate to consider. The Policy Assessment focuses on the information that is most pertinent to evaluating the basic elements of the NAAQS: indicator, averaging time, form and level.

The scientific review during the development of all these documents is thorough and extensive. The Clean Air Science Advisory Committee (CASAC) was established by the Clean Air Act and provides independent advice to the Administrator on the technical basis of all of EPA's NAAQS. CASAC critically reviews all of the above documents developed by the EPA and provides key recommendations about retaining or revising the standards. Drafts of all of these documents are also available to CASAC and the general public for review and comment before they are finalized by EPA.

After this entire process is complete, the EPA will take into consideration all of the final scientific information developed, the final policy assessment, and the advice of CASAC to develop and publish a notice of proposed rulemaking that communicates the Administrators proposed decision regarding the review of the NAAQS. A public comment period, which includes public hearings, follows the publication of the notice of proposed rulemaking. The EPA will issue a final rule after taking into account all of the comments received on the proposed rule.

Air Guide-1 Guideline Concentrations for the Assessment of Toxic Pollutant Impacts.

The Division of Air Resources relies upon the Department's Air Guide-1 (DEC Program Policy DAR -1) to assess the potential for adverse public health impacts from non-criteria pollutants. These are pollutants for which EPA has not established national ambient air quality standards (NAAQS), but have been, nonetheless, identified to pose potential public health concerns. Air Guide-1 analysis is a conservative public health risk screening tool created and used by the Department for the assessment of the risk posed from the inhalation of ambient air toxics. The Air Guide 1 process involves, among other steps, the identification and determination of the emission rates of air toxics from sources under review, the dispersion modeling of these air toxic emissions to predict long term (annual) and short-term (one hour) impacts, and the comparison of these predicted impacts to numerical guideline levels developed to be protective of public health.

The annual ambient guideline concentrations (AGCs) and Short-term Guideline Concentrations (SGCs) contained in Air Guide-1 were developed to be protective of public health and are based upon the most recent toxicological information available. These values were last updated after a comprehensive review by the Department and the New York State Department of Health (NYSDOH) in October 2010. The SGCs were developed to protect the general population from one hour exposures that can result in adverse acute health effects. The AGCs were developed to protect the general population from annual exposures which can result in adverse chronic health effects that include cancer and non-cancer endpoints. These guideline levels are conservative in that these are intended to protect the general public, including sensitive subpopulations, from adverse health effects that may be induced by exposure to ambient air contaminants by using degrees of safety factors. These factors depend on the toxicity of the specific pollutant and whether the effects are expected from short term or long term exposure, including potential for cancer causing effect. The procedures which are used by the Department to derive these guidelines are contained in Appendix C of the DEC Air Guide-1.

The AGCs are based on the most conservative cancer or non-cancer annual exposure limits. AGCs used to assess the risk for non-cancer effects are based on reference concentrations. USEPA has defined a reference concentration as an estimate of continuous inhalation exposure to the human population, including sensitive subgroups such as children, that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure. Certain of these reference concentrations have large uncertainties due to the nature and paucity of available data. On the other hand, the Air Guide-1 AGCs derived from cancer studies are defined as a chemical concentration in air that is associated with an estimated excess lifetime human cancer risk of one per one-million people (1×10^{-6}). A risk level of 1 in a million implies a likelihood that one person, out of one million equally exposed people, would contract cancer if exposed continuously (24 hours per day) to that specific concentration over 70 years (an assumed lifetime). This risk would be an excess cancer risk that is in addition to any cancer risk borne by a person not exposed to these air toxics.

As a comparison, the acceptable cancer risk used by the USEPA to make regulatory decisions about the need for further air pollution reductions for sources regulated under the 1990 Clean Air Act is 100-in-a-million (1×10^{-4}). The acceptable cancer risk used by the Department's Division of Air Resources to make regulatory permitting decisions about the need to consider further air pollution controls ranges from 1 to 10-in-a-million. Thus, the Department is using cancer risk values which are more protective than EPA. These decisions, however, are based on case specific information to assess the acceptability of proposed source's emissions during the permitting or SEQRA process, and are not just a bright line between air levels that cause health effects and those that do not.

Similarly, levels of "safety factors" are used by DAR's Air Guide 1 to derive 1 hour short term guideline concentrations (SGCs). For many of these SGCs, a minimum factor of about ten is used to drive the thresholds deemed acceptable in the general populations from the levels which have been determined acceptable to workers at facilities. This level of conservatism is used by the Department to also protect the sensitive in the population.