

# Ozone Advance Action Plan Caroline County, Virginia



1-30-2014

## **Summary**

This Ozone Advance Action Plan covers Caroline County, Virginia, which was designated by the United States Environmental Protection Agency as attaining the 2008 ozone National Ambient Air Quality Standards on May 21, 2012. To help ensure clean, healthy air into the future, the leaders from this jurisdiction have worked cooperatively with the Virginia Department of Environmental Quality (VDEQ) and a number of stakeholders to create this Action Plan, which details the numerous clean air programs that are in place and will be implemented to reduce ozone precursors. Many of these programs have the co-benefit of also reducing fine particulate matter precursors. Air quality in Caroline County will continue to improve through the implementation of these programs. Major stakeholders in this process include the Fredericksburg Area Metropolitan Planning Organization; Virginia Department of Mines, Minerals, and Energy; the Virginia Department of Transportation; Fort A.P. Hill; Dominion; Virginia Clean Cities Coalition; and GWRideConnect. Additionally, numerous outreach sessions provided stakeholders information on the development of this Action Plan, and VDEQ offered this Action Plan to the public for comment and review. Air quality in Caroline County has improved significantly in the last 15 years. The programs described in this Action Plan will continue to improve air quality well into the future.

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## Commonly Used Abbreviations

AEP	American Electric Power	kW	kilowatts
APMT	APM Terminal	kWh	kilowatt-hours
AQS	Air Quality System	lb	pound
ASIP	Association for Southeastern Integrated Planning	lb/hr	pounds/hour
BRAC	Base Realignment and Closure Act	lb/MWh	pound/megawatt - hour
CAA	Clean Air Act	LEAP	Local Energy Alliance Program
CAIR	Clean Air Interstate Rule	LEED	Leadership in Energy and Environmental Design
CAMD	Clean Air Markets Division	MACT	maximum achievable control technology
CASTNET	Clean Air Status and Trends Network	MAR	marine, air, and rail
CEDS	Comprehensive Environmental Data System	mmbtu	million British thermal units
CFR	Code of Federal Regulations	lbs/mmbtu	pounds/million British thermal units
CMAQ	Community Multiscale Air Quality model	$\mu\text{g}/\text{m}^3$	micrograms per cubic meter
CMAQ	Congestion, Mitigation, and Air Quality	MI/EMS	Mission Integrated Environmental Management System
CMPO	Crater Area Metropolitan Planning Organization	MOVES2010b	Motor Vehicle Emission Simulator version 2010b
CO	carbon monoxide	MRAQC	Metropolitan Richmond Air Quality Committee
DC	direct current	MW	megawatts
DMME	Virginia Department of Mines, Minerals, and Energy	MWh	megawatt-hours
EGU	electrical generating unit	NAAQS	National Ambient Air Quality Standard
EPA	United States Environmental Protection Agency	NBTP	NO <sub>x</sub> Budget Trading Program
EV	electric vehicles	NEV	neighborhood electric vehicles
FAMPO	Fredericksburg Area Metropolitan Planning Organization	NIT	Norfolk International Terminals
FGD	flue gas desulfurization unit	NMHC	nonmethane hydrocarbons
g/bhp-hr	grams/brake horsepower – hour	NMIM	National Mobile Inventory Model
g/kWh	grams/kilowatt – hour	NMOC	nonmethane organic compounds
g/MWh	grams/megawatt – hour	NNMT	Newport News Marine Terminal
GSHP	ground source heat pump	NO <sub>x</sub>	nitrogen oxides
GWAQC	George Washington Air Quality Committee	ORE	On Road Emissions Program
HAP	hazardous air pollutants	OTC	Ozone Transport Commission
HRAQC	Hampton Roads Air Quality Committee	OTR	Ozone Transport Region
HRTPO	Hampton Roads Transportation Planning Organization	PHEV	plug-in electric hybrid
IRP	Integrated Resource Planning	PJM	PJM Interconnection LLC
I/M	Vehicle Inspection and Maintenance Program	PM	particulate matter
ITS	Intelligent Transport System	PM <sub>2.5</sub>	fine particulate matter less than 2.5 angstroms in diameters
kg/day	kilograms/day	PM <sub>10</sub>	fine particulate matter less than 10 angstroms in diameter
km	kilometers	PMT	Portsmouth Marine Terminal

## Commonly Used Abbreviations, Continued

ppb	parts per billion
ppm	parts per million
PTE	potential to emit
PV	photovoltaic
REVi	Richmond Electric Vehicle Initiative
RMG	rail mounted gantry cranes
RREA	Richmond Regional Energy Alliance
SCC	State Corporation Commission
SCR	selective catalytic reduction
SF	square foot
SO <sub>2</sub>	sulfur dioxide
SPADP	Southeast Propane Autogas Development Program
TEU	twenty foot equivalent container units
TMP	Transportation Management Plan
tpy	tons per year
ULSD	ultra low sulfur diesel
VCC	Virginia Clean Cities, Inc.
VCU	Virginia Commonwealth University
VDEQ	Virginia Department of Environmental Quality
VDOT	Virginia Department of Transportation
VEMP	Virginia Energy Management Program
VIP	Virginia Inland Port
VOC	volatile organic compounds
VPA	Virginia Port Authority

# 1. Introduction

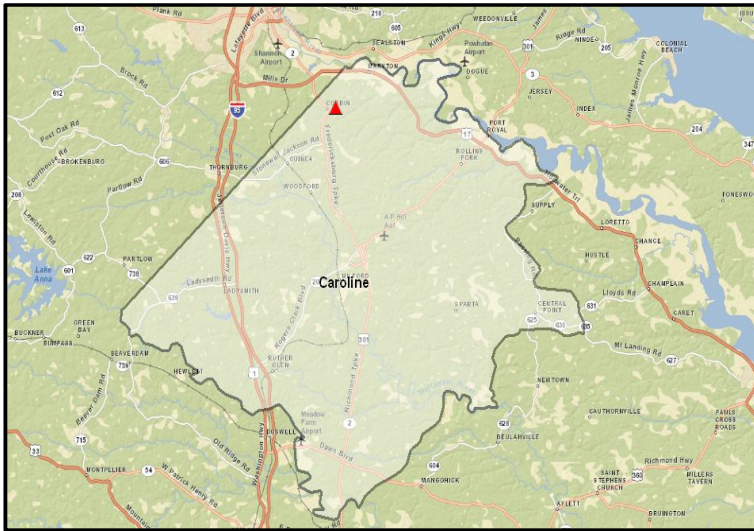
On May 21, 2012, the United States Environmental Protection Agency (EPA) designated Caroline County, Virginia as attaining the 2008 ozone National Ambient Air Quality Standard (NAAQS), based on 2009-2011 air quality monitoring data. To preserve and further improve air quality, the area's leaders decided to explore ways to facilitate additional reductions of nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOC), the precursor emissions for ozone formation, through the development of an Ozone Advance Action Plan. This Ozone Advance Action Plan provides background data, emission inventories, and modeling analyses. This information demonstrates that emissions in Caroline County will decrease between now and 2020, that emissions in the Commonwealth of Virginia will decrease significantly between now and 2020, and that ozone air quality in this area will improve significantly between now and 2020. This Plan discusses a number of new or on-going programs that will facilitate additional emission reductions to help further improve both ozone and fine particulate (PM<sub>2.5</sub>) air quality. This document will serve as a framework for the area to comply with any future NAAQS that may be promulgated, such as the next ozone NAAQS that is due to be promulgated in 2014, and it will help address any future violations of the 2008 ozone NAAQS quickly.

The air quality in Caroline County will benefit from significant upwind reductions in emissions of NO<sub>x</sub> and VOC in coming years. Upwind reductions are very important to the air quality in Caroline County since Caroline has only minimal emissions originating from within the county. Air quality modeling demonstrates that air quality will be well beneath the 2008 ozone NAAQS by 2020. The programs included in this Action Plan are generally not included in the area's overall emissions estimates and provide further air quality benefit beyond that predicted by the air quality modeling. Also, these programs often provide co-benefits in that they reduce emissions of sulfur dioxide (SO<sub>2</sub>), which is a precursor to PM<sub>2.5</sub>.

The programs in this Action Plan include regulatory programs that are federally enforceable and voluntary programs that are undertaken for air quality and other purposes such as energy or fuel savings. The stakeholders involved in this plan include the Virginia Department of Mines, Minerals, and Energy (DMME); the Virginia Department of Transportation (VDOT); the Fredericksburg Area Metropolitan Planning Organization (FAMPO); US Army Garrison - Fort A.P. Hill; Dominion; and Virginia Clean Cities (VCC). These stakeholders have worked together with the Virginia Department of Environmental Quality (VDEQ) to ensure that the Caroline County Ozone Advance Action Plan will help protect healthy air quality and continue to improve air quality into the future.



## 2. Background and Data



**Figure 1: Caroline County**

Caroline County is mainly rural in nature, with more than 51,000 acres of farmland and over 261,000 acres of commercial forestland. Figure 1 shows the location of this jurisdiction as well as that of the Caroline-Corbin ozone monitoring site, denoted by a red triangle. Caroline County is home to Fort A.P. Hill, which encompasses nearly 76,000 acres and is a regional military training center.

Since the 2000 census, Caroline has experienced a growth in population, which is expected to continue into the future. The County lies between two major metropolitan statistical areas (Richmond-Petersburg and Baltimore-Washington), and this central location is reflected in the commuting pattern of the citizenry. In 2000, surveys showed that nearly 58% of the working population commuted out of Caroline. Table 1 provides a summary of the 2010 socioeconomic data and the 2040 forecasts for this area.

**Table 1: Caroline County Socioeconomic Data, 2010 and 2040**

Households		Population		Employment		Autos	
2010	2040	2010	2040	2010	2040	2010	2040
10,456	19,070	28,545	46,600	9,896	16,615	23,944	43,670

*Data Source: Fredericksburg Area Metropolitan Planning Organization*

### 2.1. Ozone Air Quality

Caroline County has historically complied with all ozone NAAQS. On May 21, 2012 (77 FR 30160), EPA designated Caroline County as attainment for the 2008 ozone NAAQS. This standard was set at 0.075 ppm or 75 ppb. The attainment determination was made in large part on air quality monitoring data from 2009-2011. As shown in Figure 2, air quality in Caroline has significantly improved in the last 10 years. The data in Figure 2 is provided in Table 2. These data have been quality assured, certified, and provided to EPA's Air Quality System (AQS) database.

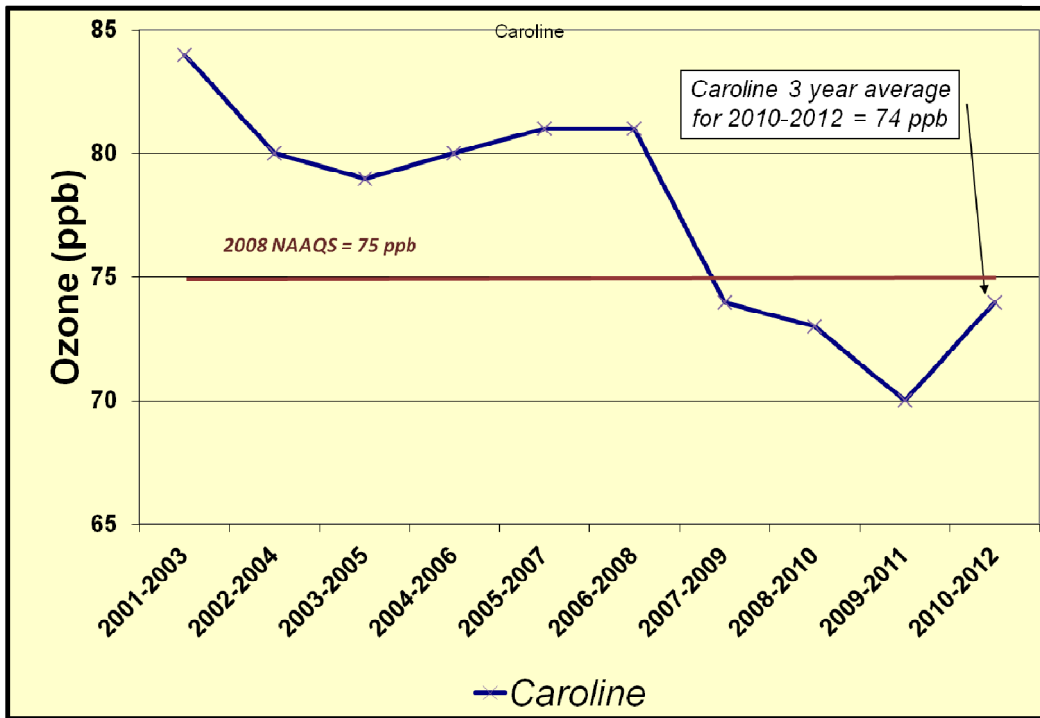


Figure 2: Caroline County Ozone Air Quality

Table 2: Caroline County 3-Year Monitoring Site Average, 4th Highest Values

3 Year Period	Caroline-Corbin 51-033-0001
2001-2003	84 ppb
2002-2004	80 ppb
2003-2005	79 ppb
2004-2006	80 ppb
2005-2007	81 ppb
2006-2008	81 ppb
2007-2009	74 ppb
2008-2010	73 ppb
2009-2011	70 ppb
2010-2012	74 ppb

Data Source: VDEQ-Air Quality Monitoring Division

## 2.2. PM<sub>2.5</sub> Air Quality

Caroline County does not host a PM<sub>2.5</sub> monitoring site since federal regulations do not require that the area monitor for this pollutant. However, all monitors in the Commonwealth of Virginia

demonstrate compliance with the 2012 PM<sub>2.5</sub> NAAQS of 35 µg/m<sup>3</sup> on a 24-hour basis and 12.0 µg/m<sup>3</sup> on an annual basis. Monitors across the Commonwealth show a strong trend toward improving PM<sub>2.5</sub> air quality, as demonstrated by Figure 3, Figure 4, and Table 3.

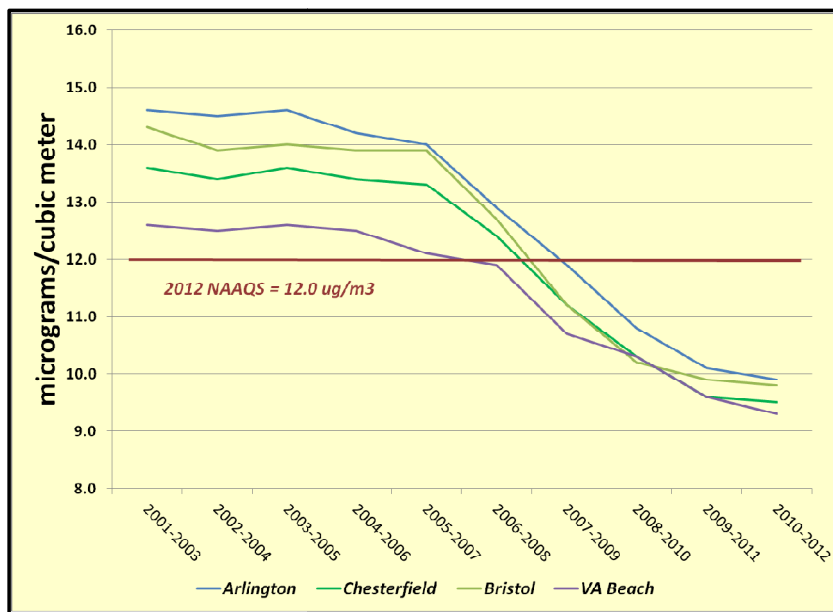


Figure 3: Annual PM<sub>2.5</sub> Air Quality Across Virginia

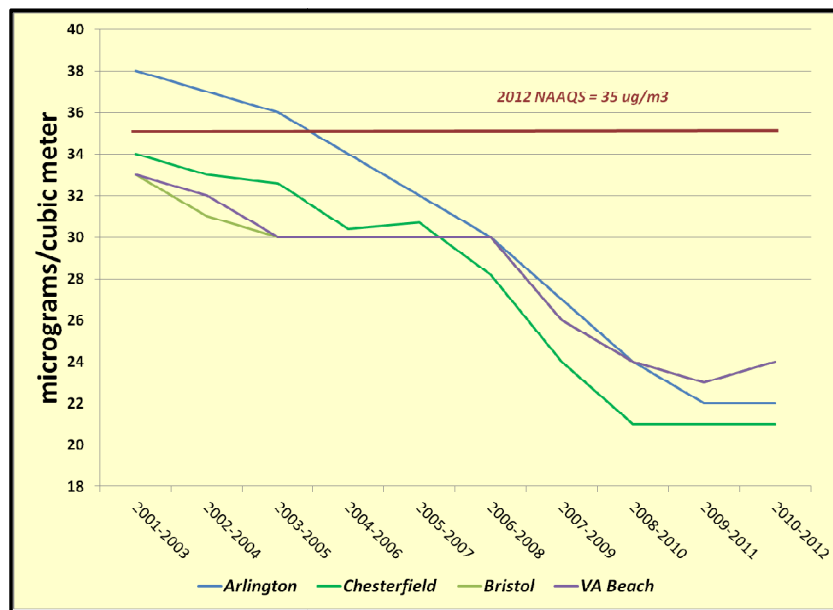


Figure 4: Daily PM<sub>2.5</sub> Air Quality Across Virginia

**Table 3: Annual and 24-Hour PM<sub>2.5</sub> 3-Year Averages Across the Commonwealth**

3 Year Period	Arlington 51-013-0020		Chesterfield 51-041-0003		Bristol 51-520-0006		Virginia Beach 51-810-0008	
	Annual	24-Hour	Annual	24-Hour	Annual	24-Hour	Annual	24-Hour
2001-2003	14.6 µg/m <sup>3</sup>	38 µg/m <sup>3</sup>	13.6 µg/m <sup>3</sup>	34 µg/m <sup>3</sup>	14.3 µg/m <sup>3</sup>	33 µg/m <sup>3</sup>	12.6 µg/m <sup>3</sup>	33 µg/m <sup>3</sup>
2002-2004	14.5 µg/m <sup>3</sup>	37 µg/m <sup>3</sup>	13.4 µg/m <sup>3</sup>	33 µg/m <sup>3</sup>	13.9 µg/m <sup>3</sup>	31 µg/m <sup>3</sup>	12.5 µg/m <sup>3</sup>	32 µg/m <sup>3</sup>
2003-2005	14.6 µg/m <sup>3</sup>	36 µg/m <sup>3</sup>	13.6 µg/m <sup>3</sup>	33 µg/m <sup>3</sup>	14.0 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>	12.6 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>
2004-2006	14.2 µg/m <sup>3</sup>	34 µg/m <sup>3</sup>	13.4 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>	13.9 µg/m <sup>3</sup>	31 µg/m <sup>3</sup>	12.5 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>
2005-2007	14.0 µg/m <sup>3</sup>	32 µg/m <sup>3</sup>	13.3 µg/m <sup>3</sup>	31 µg/m <sup>3</sup>	13.9 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>	12.1 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>
2006-2008	12.9 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>	12.4 µg/m <sup>3</sup>	28 µg/m <sup>3</sup>	12.7 µg/m <sup>3</sup>	28 µg/m <sup>3</sup>	11.9 µg/m <sup>3</sup>	30 µg/m <sup>3</sup>
2007-2009	11.9 µg/m <sup>3</sup>	27 µg/m <sup>3</sup>	11.2 µg/m <sup>3</sup>	24 µg/m <sup>3</sup>	11.2 µg/m <sup>3</sup>	25 µg/m <sup>3</sup>	10.7 µg/m <sup>3</sup>	26 µg/m <sup>3</sup>
2008-2010	10.8 µg/m <sup>3</sup>	24 µg/m <sup>3</sup>	10.3 µg/m <sup>3</sup>	21 µg/m <sup>3</sup>	10.2 µg/m <sup>3</sup>	22 µg/m <sup>3</sup>	10.3 µg/m <sup>3</sup>	24 µg/m <sup>3</sup>
2009-2011	10.1 µg/m <sup>3</sup>	22 µg/m <sup>3</sup>	9.6 µg/m <sup>3</sup>	21 µg/m <sup>3</sup>	9.9 µg/m <sup>3</sup>	21 µg/m <sup>3</sup>	9.6 µg/m <sup>3</sup>	23 µg/m <sup>3</sup>
2010-2012	9.9 µg/m <sup>3</sup>	22 µg/m <sup>3</sup>	9.5 µg/m <sup>3</sup>	21 µg/m <sup>3</sup>	9.8 µg/m <sup>3</sup>	20 µg/m <sup>3</sup>	9.3 µg/m <sup>3</sup>	24 µg/m <sup>3</sup>

Data Source: VDEQ-Air Quality Monitoring Division

Figure 5 provides the speciation data from the Henrico County Math and Science Center PM<sub>2.5</sub> speciation monitor. While this monitor is not located in Caroline County, the data is considered representative of the entire Commonwealth due to the regional nature of PM<sub>2.5</sub> air quality. Sulfates are a significant contributor to PM<sub>2.5</sub> concentrations throughout the Commonwealth. All areas of the Commonwealth have recently experienced significant SO<sub>2</sub> reductions, and these reductions are expected to continue into the future, as discussed in the following section. The sulfate portion of the PM<sub>2.5</sub> concentrations at all monitors in the Commonwealth should therefore continue to decrease, further improving air quality.

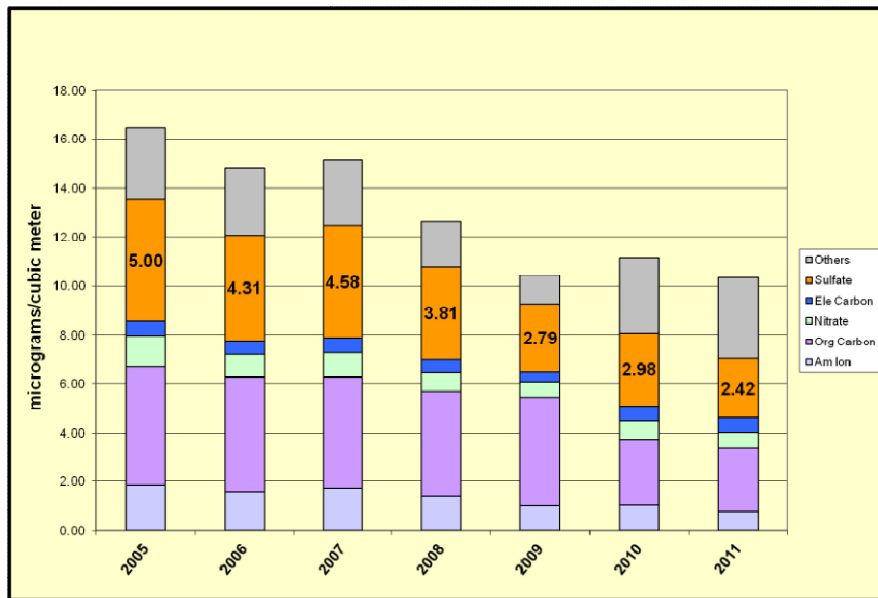


Figure 5: Henrico Speciation Data - VDEQ Air Quality Monitoring Division

All data provided in this section have been certified, quality-assured, and submitted to EPA via AQS.

### 2.3. Emission Inventories

This section presents the 2007, 2017, and 2020 emissions estimates for the Commonwealth of Virginia and for Caroline County. These estimates were developed using a variety of methods and data. Emissions of NO<sub>x</sub>, VOC, and carbon monoxide (CO), the precursors to ozone, are expected to decrease greatly between 2007 and 2017 and through 2020. Emissions of SO<sub>2</sub> are also expected to be significantly reduced. While SO<sub>2</sub> is not a factor in the formation of ozone, it is a precursor to PM<sub>2.5</sub>. Figure 6 and Figure 7 show the estimated emissions in tons/year (tpy) for the Commonwealth of Virginia. Figure 8 and Figure 9 show the estimated emissions in tpy for Caroline County. These figures provide data on emissions from the electrical generating unit (EGU) sector; the area source sector; the industrial sector (Point-NonEGU); the marine, air, and rail transport sector (MAR); the nonroad engine sector (NonRoad); and the on-road vehicle and truck sector (Mobile).

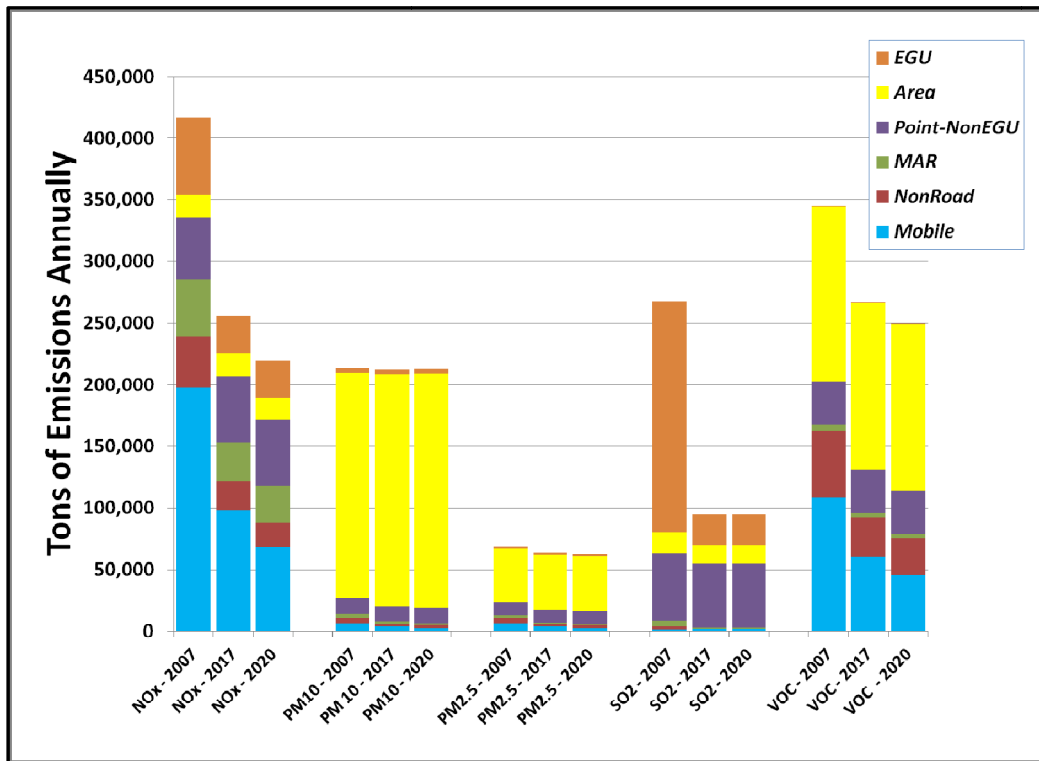


Figure 6: Virginia Emission Estimates

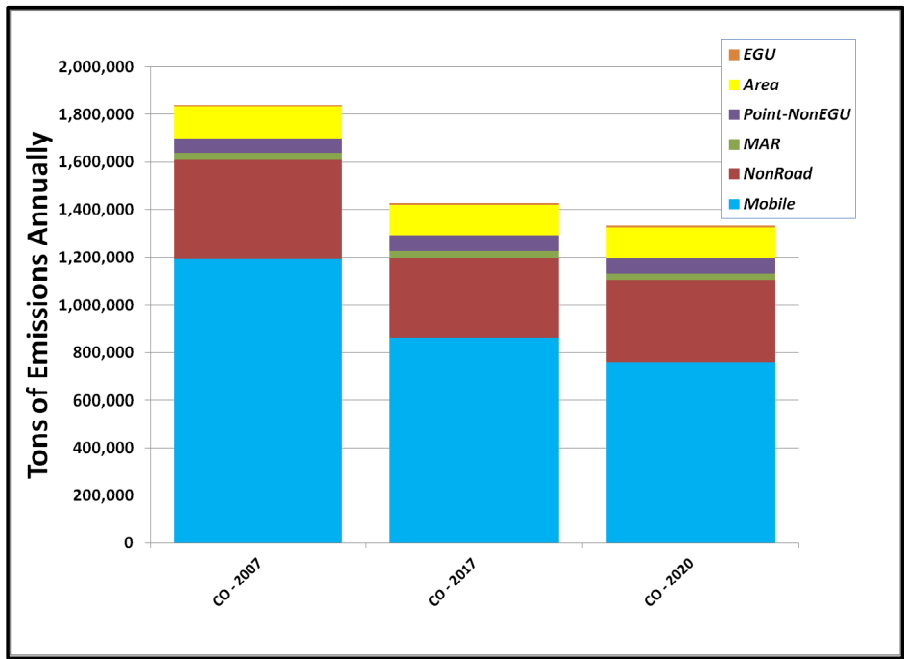


Figure 7: Virginia Emission Estimates, CO

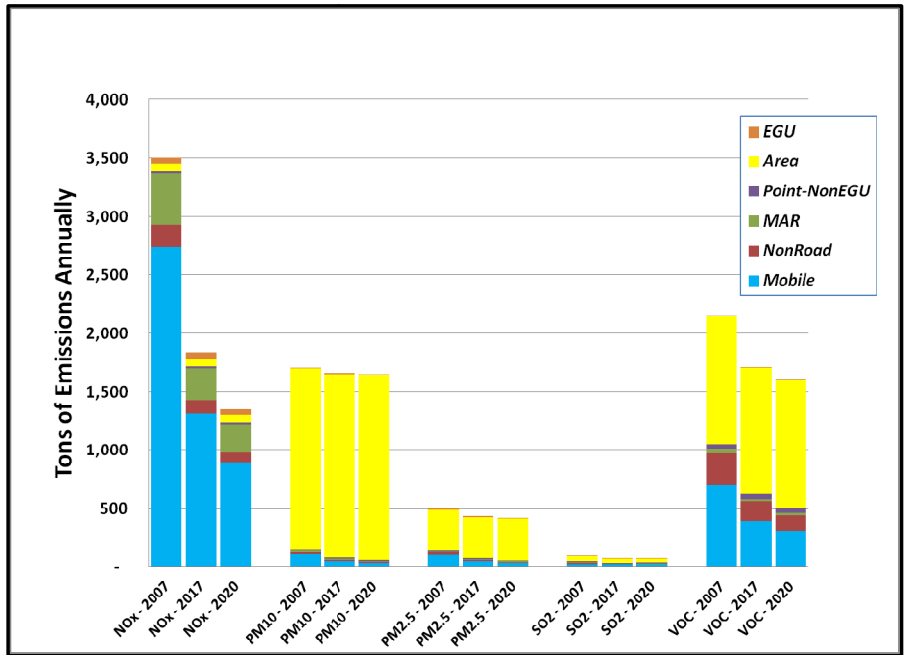


Figure 8: Caroline County Emission Estimates

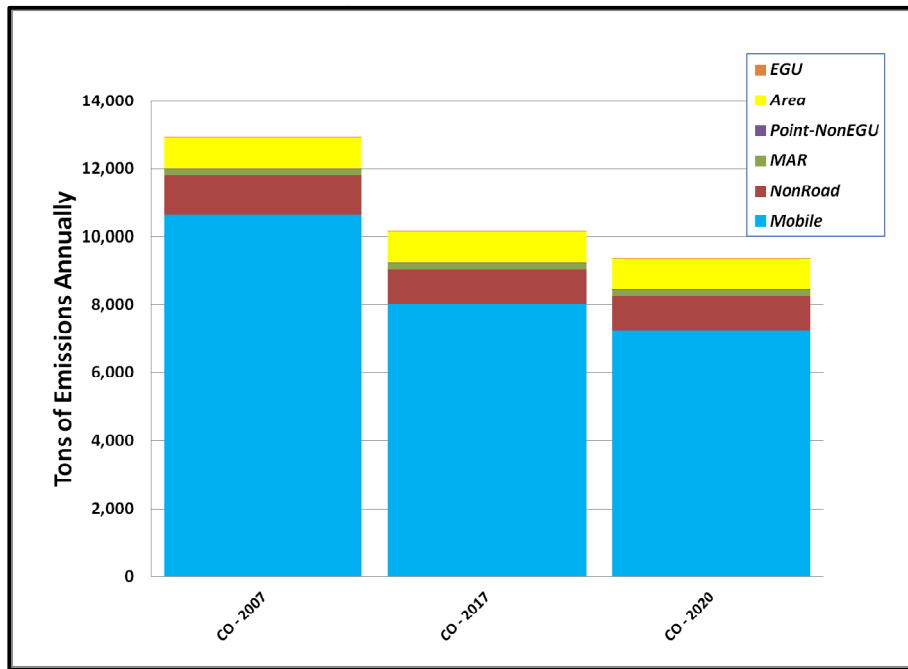


Figure 9: Caroline County Emission Estimates, CO

These figures demonstrate that Caroline County has very small emissions of air pollutants, as compared to the entire Commonwealth of Virginia. Since the area is rural in nature and not densely populated, Caroline does not generate a significant amount of ozone precursor emissions. The presence of I-95, a major thoroughfare on the east coast, inflates on-road emission estimates from Caroline beyond what might be expected from other jurisdictions with similar demographics. Due to the modest amounts of pollutants emitted from within Caroline, air quality in Caroline is largely influenced by upwind emissions. This fact makes the significant emission reductions expected across the Commonwealth especially important for maintaining and improving ozone air quality in Caroline County.

The reductions for the mobile and non-road sectors are generally attributable to several important federal measures that control total hydrocarbons, PM<sub>2.5</sub>, CO, and NO<sub>x</sub>. These measures are discussed in more detail in Section 2.3.2 and Section 2.3.3. These already-implemented federal control programs for vehicles, heavy duty diesel on-road engines, and non-road engines continue to provide air quality benefit due to equipment turnover. The phase-in of reduced sulfur content requirements for many types of fuels between 2007 and 2012 has been instrumental for reductions of SO<sub>2</sub> as well as NO<sub>x</sub>, CO, and PM<sub>2.5</sub> since reduced sulfur content in fuel allows control devices to function better. Reduced sulfur content in fuel also facilitates the use of state-of-the-art controls on new equipment.

Another factor that must be considered in long-range emission estimates is the reduced price of natural gas. Older, inefficient coal-fired power plants that are not economically viable for retrofit with control equipment are being converted to natural gas, which burns much more cleanly than coal. New, state-of-the-art combined cycle operations have been constructed in the Commonwealth, and more of these units are planned for construction to meet existing and future energy needs. These combined cycle operations, which have very low emission rates and produce electricity in a much more efficient manner than older, coal-fired units, are supplanting coal-based generation. Industrial facilities that need steam for manufacturing purposes are retiring coal-fired units and replacing them with new, low-emitting, natural gas units. Additionally, more residences are converting to natural gas, where available, and are using high efficiency furnaces and water heaters. These devices not only have lower emission factors per unit of fuel, they also are more efficient and consume less fuel in their operations.

### ***2.3.1. Point Source Emissions Sector***

Point source emissions originate from large facilities such as industrial manufacturing facilities. In Figures 6 through 9, the point source emissions sector is represented by the EGU estimates shown in orange and the point-nonEGU estimates shown in purple. The 2007 emissions data from this emissions source sector were gathered through Virginia's Comprehensive Environmental Data System (CEDS). Facilities reporting to VDEQ use a variety of methodologies to estimate emissions. These methodologies may include federal emission factor estimation techniques, models, throughput records, source-specific emissions testing, and continuous emissions monitors. Facility owners must certify their emissions data, and VDEQ staff quality-assures the data. For EGUs, hourly emissions of NO<sub>x</sub> and SO<sub>2</sub>, as well as heat input and gross load, are reported to EPA's Clean Air Markets Division (CAMD) on a quarterly basis.

The 2007 data have been extrapolated to 2017 and 2020 using different estimation techniques, depending on the type of industry or sector. Non-EGU point source emissions estimates are generally developed using factors that are specific to the type of industry represented. Factors that show a decline in emissions or decline in productivity have been updated to unity, so that 2017 and 2020 data are equivalent to 2007 data for those facilities. EGU point source emission estimates are extrapolated in this inventory using Energy Information Administration data from AEO2011. Since each EGU may have significant emissions, the EGU inventory has also been supplemented with changes based on known permit actions, enforcement orders, and information gleaned from planning documents submitted to the PJM Interconnection LLC (PJM) systems operator and the State Corporation Commission (SCC). For newly permitted facilities that have not yet been constructed, the inventory values included here represent maximum permitted limits. More information on EGU estimates may be found in Appendix A.

As Figure 8 shows, the point source sector is not a significant portion of the NO<sub>x</sub> emissions inventory for Caroline County.



### **2.3.2. Mobile Emissions Sector**

Mobile emissions are generated by vehicles and trucks that use the transportation system. The 2007 and 2020 mobile source sector emissions inventories were developed using EPA's most recent model for estimating on-road emissions, MOVES2010b. Mobile source sector emissions estimates for 2017 were developed using linear interpolation. In Figures 6 through 9, emission estimates for the mobile source emissions sector are shown in blue.

NO<sub>x</sub> emissions from the mobile sector constitute the largest portion of the overall NO<sub>x</sub> emissions inventory for both Caroline County and the Commonwealth as a whole. The mobile source sector emissions for Caroline County are higher than would be expected of a jurisdiction with similar demographics due to I-95's route through the area. Between 2007 and 2020, mobile emissions are expected to decrease, mainly due to the effect of two federal rules, the 2007 Heavy-Duty Diesel Highway Rule and the Tier 2 Vehicle and Gasoline Sulfur Program.

The 2007 Heavy-Duty Diesel Highway Rule (40 CFR Part 86, Subpart P) set a particulate matter (PM) emissions standard for new heavy-duty engines of 0.01 grams per brake-horsepower hour (g/bhp-hr), which took full effect for diesel engines in the 2007 model year. This rule also included standards for NO<sub>x</sub> and nonmethane hydrocarbons (NMHC) of 0.20 g/bhp-hr and 0.14 g/bhp-hr, respectively. These diesel engine NO<sub>x</sub> and NMHC standards were successfully implemented between 2007 and 2010. The rule also required that sulfur in diesel fuel be reduced to facilitate the use of modern pollution control technology on these trucks and buses. EPA required a 97% reduction in the sulfur content of highway diesel fuel -- from levels of 500 ppm to 15 ppm.

The Tier 2 Vehicle and Gasoline Sulfur Program (40 CFR Part 80, Subpart H; 40 CFR Part 85; 40 CFR Part 86) is a fleet averaging program for on-road vehicles and was modeled after the California LEV II standards. This program became effective in the 2005 model year. The Tier 2 program allows manufacturers to produce vehicles with emissions ranging from relatively dirty to very clean, but the mix of vehicles a manufacturer sells each year must have average NO<sub>x</sub> emissions below a specified value. Mobile emissions continue to benefit from this program as motorists replace older, more polluting vehicles with cleaner vehicles.

### **2.3.3. Non-Road Emissions Sector**

The non-road emissions sector includes estimates of emissions from equipment that contain various types of combustion engines, but these engines are not used to propel equipment on the roads and highways. Examples include pumps, generators, and turbines, as well as engines used for forklifts, earth-moving equipment, lawnmowers, marine transport, rail transport, and air transport.

The majority of the emissions from this source sector are estimated using EPA's National Mobile Inventory Model (NMIM). NMIM was used to estimate 2007, 2017, and 2020 emissions from this source category. While the population estimates for these equipment types increase over time, emissions decrease, due mainly to the Nonroad Diesel Emissions Program (40 CFR Part 89). EPA adopted these NO<sub>x</sub>, hydrocarbon, and CO emission standards for several groups of nonroad engines. The nonroad diesel rule set standards that reduced emissions by more than 90% from nonroad diesel equipment and, beginning in 2007, the rule reduced fuel sulfur levels by 99% from previous levels. The reduction in fuel sulfur levels applied to most nonroad diesel fuel in 2010 and applied to fuel used in locomotives and marine vessels in 2012.

Emissions from MAR are estimated using category-specific emission estimation tools and emission factors. In the figures above, the nonroad engine sector emissions estimates calculated using NMIM are shown in red, and the MAR sector emissions estimates are shown in green.

#### **2.3.4. Area Emissions Sector**

The area sector of the emissions inventory consists of categories where large populations of emitters exist, but each emitter has small emissions. In Figures 6 through 9, the area emissions sector is represented by the color yellow. This sector is heavily dependent on population and employment. In general, the reductions achieved by the control programs associated with the area emissions inventory sector are offset by growth in population and employment.

#### **2.3.5. Emissions Estimates**

Table 4 presents the Virginia-wide emissions estimates. Table 5 presents the emissions estimates for Caroline County. The estimates in these tables include the effects of the federal control programs described above as well as many other federally and state enforceable efforts. They do not include most of the additional reductions that are anticipated through the implementation of the programs described in this Action Plan. Where programs listed in the Action Plan are included within these inventories, the description of that program notes this information.

These tables demonstrate that Virginia and Caroline County are expected to experience significant drops in emissions of NO<sub>x</sub>, the most important ozone precursor in this area. These tables also demonstrate that Caroline County has only very small contributions to the overall emissions inventory for the Commonwealth. This area's air quality is dependent on transported emissions rather than on local emissions. Therefore, upwind reductions of ozone precursors are very important to ensuring that ozone air quality in Caroline County complies with the 2008 ozone NAAQS and makes progress toward meeting any future NAAQS.

**Table 4: Virginia Emission Estimates, 2007-2017-2020**

<b>Year</b>	<b>Mobile</b>	<b>NonRoad</b>	<b>MAR</b>	<b>Point- nonEGU</b>	<b>Area</b>	<b>EGU</b>	<b>Total:</b>
<b>CO, tpy</b>							
<b>2007</b>	1,195,237	415,093	28,444	63,079	132,098	7,255	1,841,208
<b>2017</b>	861,200	335,531	28,605	65,740	129,479	7,255	1,427,809
<b>2020</b>	760,988	341,458	29,183	66,212	128,937	7,255	1,334,034
<b>NO<sub>x</sub>, tpy</b>							
<b>2007</b>	197,822	41,325	45,600	50,265	19,056	62,309	416,376
<b>2017</b>	97,694	23,658	32,268	53,236	18,411	30,650	255,917
<b>2020</b>	67,656	20,189	29,495	53,591	18,520	30,271	219,721
<b>PM<sub>10</sub>, tpy</b>							
<b>2007</b>	6,798	4,132	2,402	13,028	183,341	3,375	213,076
<b>2017</b>	3,533	2,693	1,603	12,517	188,211	3,375	211,932
<b>2020</b>	2,553	2,317	1,498	12,602	190,097	3,375	212,443
<b>PM<sub>2.5</sub>, tpy</b>							
<b>2007</b>	6,499	3,937	2,074	10,296	44,102	1,812	68,719
<b>2017</b>	3,365	2,548	1,321	9,885	44,851	1,812	63,781
<b>2020</b>	2,424	2,184	1,222	9,947	45,216	1,812	62,804
<b>SO<sub>2</sub>, tpy</b>							
<b>2007</b>	1,434	2,329	4,674	54,486	17,098	187,671	267,692
<b>2017</b>	1,533	61	1,395	52,044	14,880	24,546	94,459
<b>2020</b>	1,562	63	1,214	52,338	14,616	24,600	94,394
<b>VOC, tpy</b>							
<b>2007</b>	108,001	55,135	4,312	35,018	142,218	689	345,373
<b>2017</b>	59,957	32,141	3,710	35,461	135,379	689	267,338
<b>2020</b>	45,543	29,303	3,622	35,593	135,002	689	249,753

**Table 5: Caroline County Emission Estimates, 2007-2017-2020**

<b>Year</b>	<b>Mobile</b>	<b>NonRoad</b>	<b>MAR</b>	<b>Point-NonEGU</b>	<b>Area</b>	<b>EGU</b>	<b>Total:</b>
<b>CO, tpy</b>							
<b>2007</b>	10,651	1,159	181	16	918	1	12,925
<b>2017</b>	8,039	1,000	182	16	909	1	10,146
<b>2020</b>	7,255	996	184	16	907	1	9,358
<b>NO<sub>x</sub>, tpy</b>							
<b>2007</b>	2,739	194	435	16	66	51	3,503
<b>2017</b>	1,316	115	265	17	65	59	1,836
<b>2020</b>	889	95	235	17	64	50	1,350
<b>PM<sub>10</sub>, tpy</b>							
<b>2007</b>	104	22	16	10	1,544	8	1,704
<b>2017</b>	48	12	8	10	1,572	8	1,659
<b>2020</b>	31	10	7	10	1,586	8	1,652
<b>PM<sub>2.5</sub>, tpy</b>							
<b>2007</b>	101	21	14	8	358	8	499
<b>2017</b>	46	12	7	8	357	8	437
<b>2020</b>	30	9	6	8	361	8	422
<b>SO<sub>2</sub>, tpy</b>							
<b>2007</b>	20	13	4	11	40	6	94
<b>2017</b>	22	0	0	11	35	4	73
<b>2020</b>	23	0	0	11	34	4	72
<b>VOC, tpy</b>							
<b>2007</b>	700	276	34	43	1,076	2	2,151
<b>2017</b>	394	163	23	43	1,081	2	1,706
<b>2020</b>	303	139	21	43	1,097	2	1,604

## 2.4. Ozone Air Quality Modeling

Air quality modeling for Caroline County was performed by the Ozone Transport Commission (OTC) and was conducted for a 2007 base year in addition to a 2020 future year. For 2020 this modeling study predicts air quality concentrations that are well beneath the 2008 ozone NAAQS for all monitoring locations within the Commonwealth. The future year modeling accounts for federal, state, and local control measures that are expected to occur prior to 2020 and are federally enforceable. However, most of the programs listed in this Action Plan are not included in the modeling. The emissions reductions resulting from the Action Plan programs will provide further air quality benefit beyond that predicted by this air quality modeling study.

### 2.4.1. Air Quality Model Configuration

This analysis used EPA's Models-3/ Community Multiscale Air Quality (CMAQ) modeling system. The configuration of the CMAQ modeling system was chosen based on the results of the model sensitivity testing performed during previous OTC ozone modeling efforts. Figure 10 displays the 36/12 kilometer (km) horizontal grid system used in this exercise, and Table 6 presents the CMAQ configuration. Appendix B provides details on the emissions inventories used in the modeling.

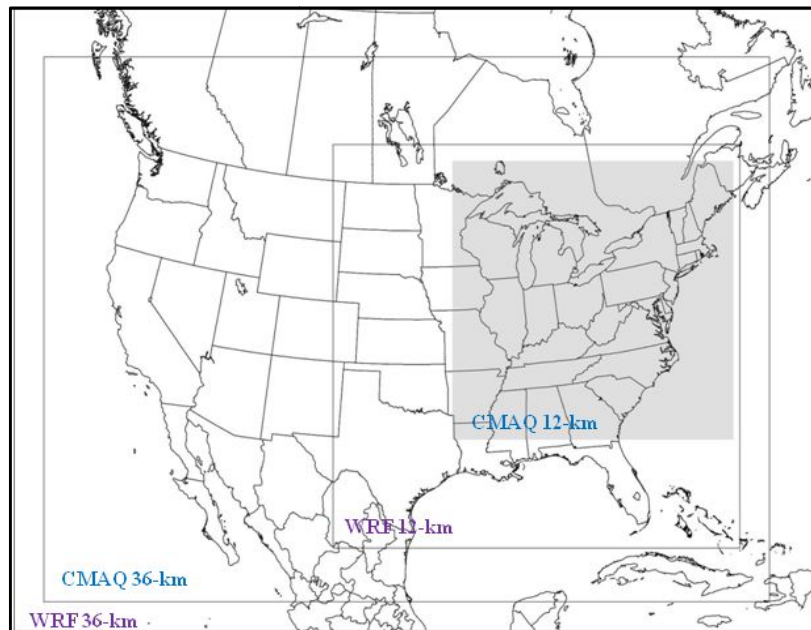


Figure 10: Modeling Grid

**Table 6: OTC Modeling CMAQ Configuration**

<b>Model Option</b>	<b>OTC Level 3 CMAQ Configuration</b>
Model Version	CMAQ 4.71
Horizontal Resolution	36/12 km
Vertical Spacing	34 layers
Emissions Inventories	MARAMA/OTC Level 3
Meteorology	WRF v3.1 OTC Modeling
Gas Phase Chemistry	CB05
Gas Phase Chemistry Solver	EBI
Aerosol Chemistry	AERO5
Aqueous Phase Chemistry	ACM
Horizontal Advection	Yamartino
Vertical Advection	Yamartino
Horizontal Diffusion	Eddy diffusivity dependent on grid
Vertical Diffusion	ACM2 (inline)
Boundary Conditions	36 km derived from 2007 GEOS-CHEM -- 12 km derived from 36 km
Initial Conditions	Default with 15 day spin-up

#### **2.4.2. Model Performance Evaluation**

To quantify model performance, several statistical measures were calculated and evaluated. The statistical measures selected were based on the recommendations outlined in “Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM<sub>2.5</sub>, and Regional Haze” (see <http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf>).

Model performance statistics were calculated for the Ozone Transport Region (OTR) and Virginia. The evaluation included 210 AQS monitoring sites and 20 Clean Air Status and Trends Network (CASTNET) monitoring sites. Figure 11 shows the locations of these AQS and CASTNET sites across the OTR and Virginia.

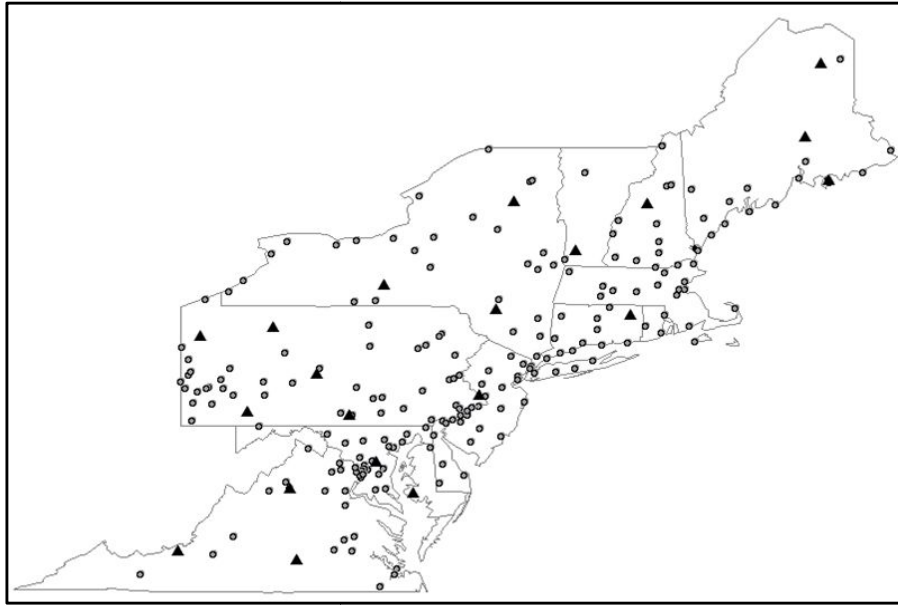


Figure 11: Locations of AQS (circles) and CASTNET (triangles) Monitoring Sites

The OTC CMAQ modeling platform performs well and within recommended modeling guidelines. Figure 12 compares predicted to observed average daily maximum 8-hour ozone concentrations for the OTR and Virginia. The model slightly over-predicts ozone but captures day-night and seasonal patterns very well. Figure 13 illustrates the average diurnal variation of ozone aggregated across the AQS (top panel) and CASTNET (bottom panel) sites within the OTR and Virginia.

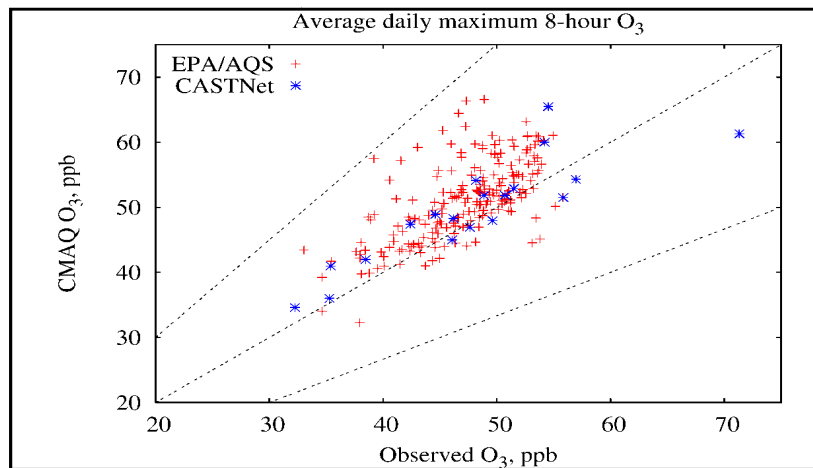


Figure 12: Predicted Versus Observed Average Daily Maximum 8-Hour Ozone

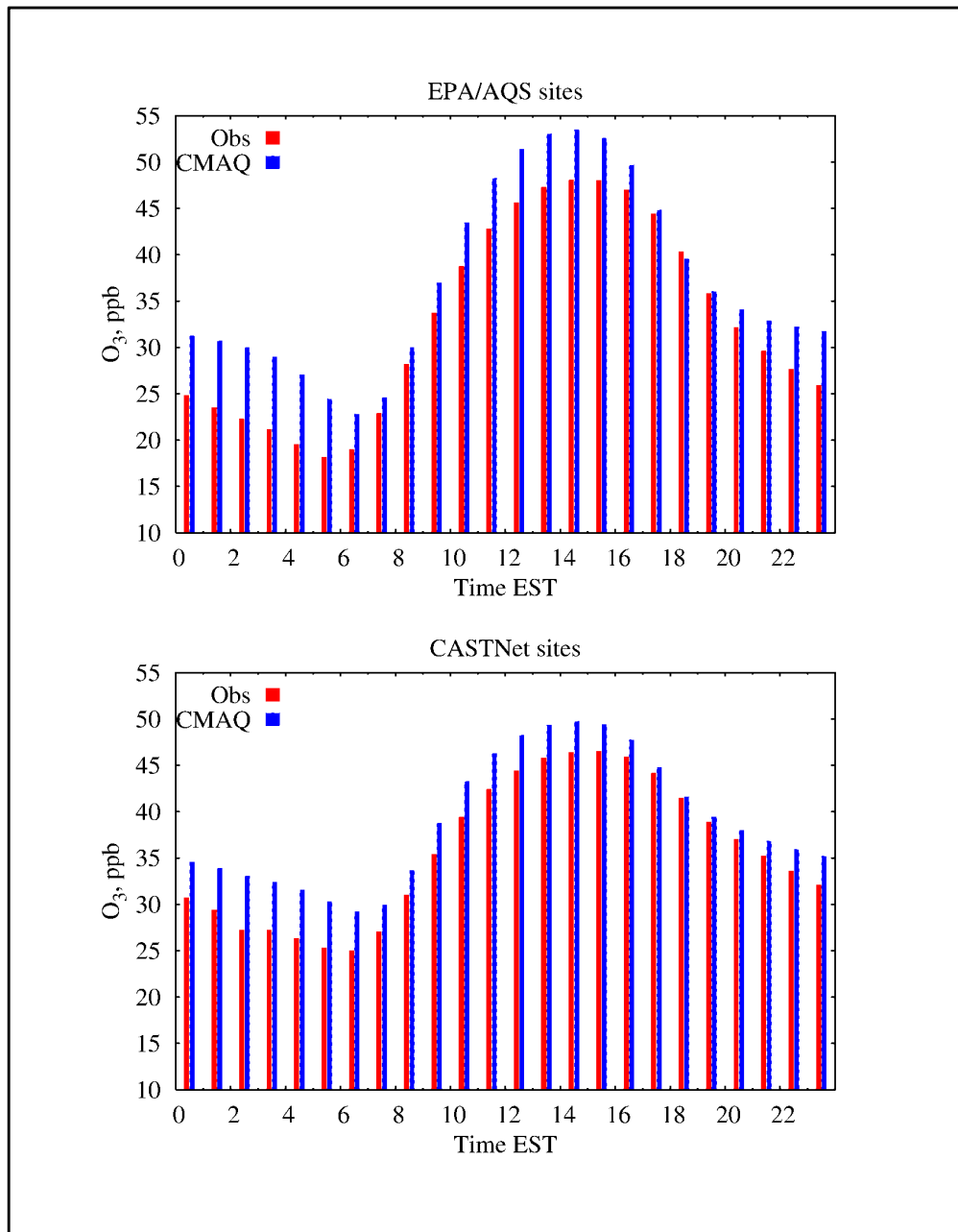


Figure 13: Average Diurnal Variation in Ozone

Appendix B provides additional statistical information on CMAQ ozone model performance for the 2007 base case.



### 2.4.3. Ozone Modeling Results for 2020

Figure 14 presents the air quality modeling results based on the 12-km grid modeling domain. These modeling results clearly demonstrate that the entire Commonwealth of Virginia, and the majority of the modeling domain, are projected to comply with the 2008 ozone NAAQS of 75 ppb by 2020. In addition, there is a significant margin of safety in Caroline County should the standard be lowered in the future.

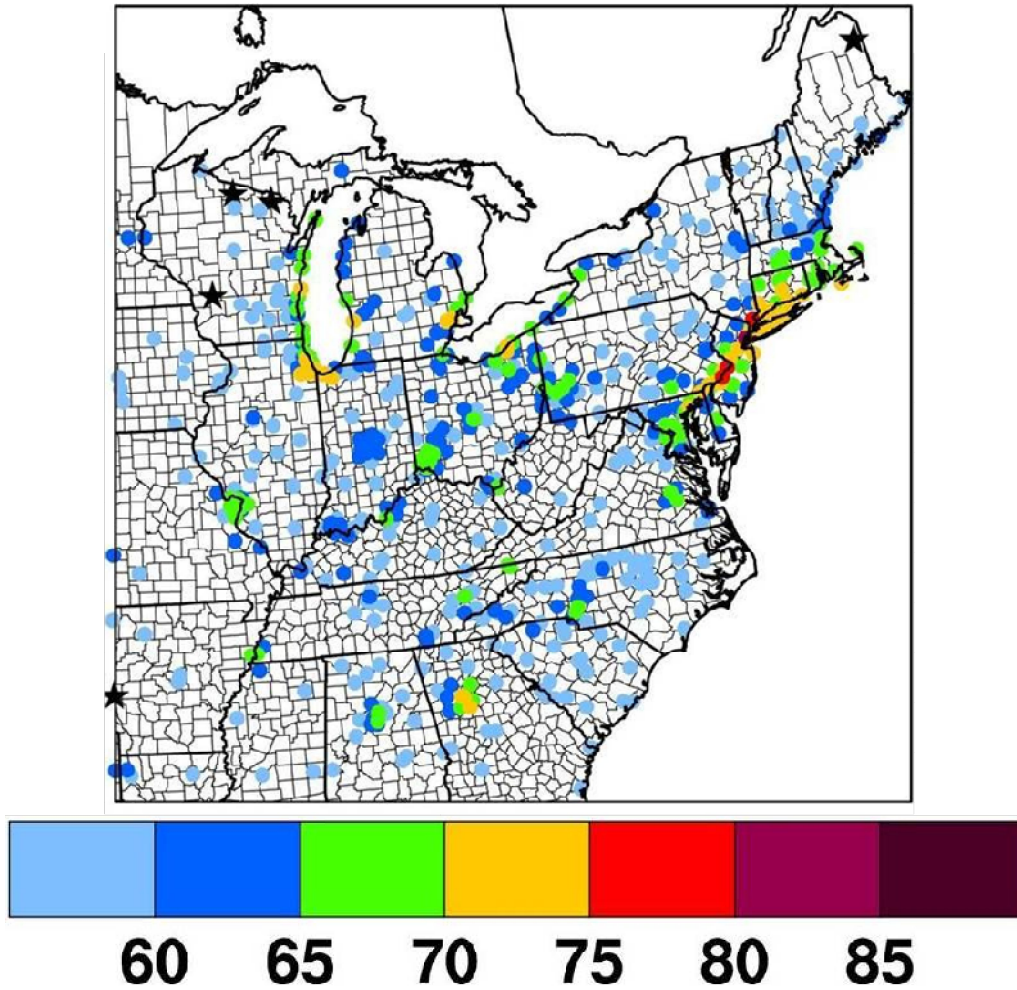


Figure 14: 2020 Ozone Modeling Results

Table 7 provides a summary of the 2007 base year and 2020 future year modeling results for Caroline County.

**Table 7: Caroline County Ozone Modeling Predictions**

AIRS LD.	Site Name	Latitude	Longitude	2007 Base Ozone Measurement	2020 Future Ozone Prediction
51-033-0001	Caroline-Corbin	38.2009	-77.3774	78.7 ppb	59 ppb

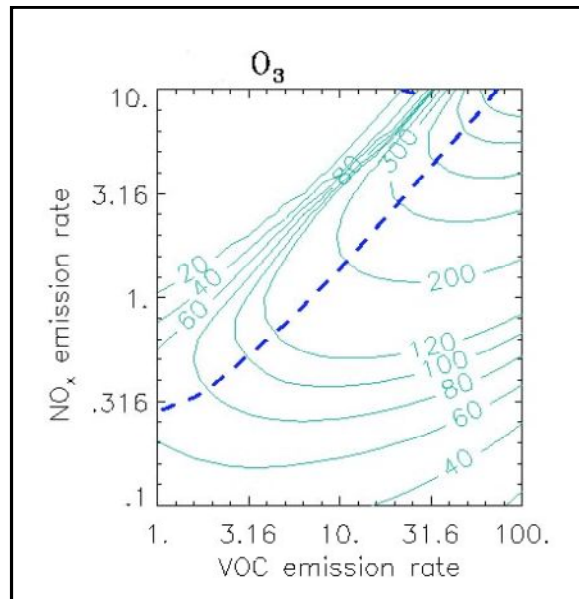
Many of the programs included in this Action Plan are not included in the area’s overall emissions estimates and will provide further air quality benefit beyond that predicted by the air quality modeling.

The modeling included in this Action Plan may be updated in the future or as part of the annual Action Plan report to reflect updated modeling platforms.

**2.5. Assessment of Relative Air Quality Impacts**

Ozone formation is driven by two major classes of directly emitted precursors: NO<sub>x</sub> and VOC. The relationship of peak ozone concentrations can be plotted as a function of VOC and NO<sub>x</sub> emission rates as illustrated in Figure 15.

This figure is a simplified illustration but shows that two distinct regimes exist with different ozone-NO<sub>x</sub>-VOC sensitivity. In the NO<sub>x</sub>-limited regime (with relatively low NO<sub>x</sub> and high VOC), ozone increases with increasing NO<sub>x</sub> and changes little in response to increasing VOC. The NO<sub>x</sub> saturated or VOC-limited regime has ozone decreases with increasing NO<sub>x</sub> and ozone increases with increasing VOC. The dotted line represents a local maximum for ozone versus NO<sub>x</sub> and VOC, separating the NO<sub>x</sub>-limited and VOC-limited regimes. The relationship between ozone, NO<sub>x</sub>, and VOC is driven by complex nonlinear photochemistry. No simple rule of thumb exists for distinguishing NO<sub>x</sub>-limited from VOC-limited conditions. Ozone-precursor sensitivity predictions are usually derived from 3-dimensional Eulerian chemistry/transport models such as CMAQ. CMAQ includes state-of-the-science capabilities for modeling multiple air quality issues, including tropospheric ozone formation, and accounts for the reactivity of the various VOC species.



**Figure 15: Peak Ozone Concentrations as a Function of VOC and NO<sub>x</sub> Emission Rates**

Studies in recent years have examined the sensitivity of surface ozone formation to precursor species concentrations of VOC and NO<sub>x</sub>. These studies have invariably concluded that peak ozone concentrations are more sensitive to NO<sub>x</sub> emissions over most of the United States. This conclusion is due in part to substantial decreases in NO<sub>x</sub> emissions, primarily from stationary sources and particularly over the last two decades, which have led to an additional reduction in the NO<sub>x</sub>-VOC emissions ratio. Another factor is that peak summertime ozone formation is more sensitive to changes in NO<sub>x</sub> with increasing temperature because emissions of highly reactive, biogenic isoprene increase with temperature and thus increase the total VOC emissions available for reaction. Very few exceptions exist to this rule. Only a few urban core areas such as Chicago and New York City have historically shown reductions in ozone due to the implementation of VOC emissions control measures.

Georgia Institute of Technology (Georgia Tech) conducted a series of emissions sensitivities in 2009 as part of the Association for Southeastern Integrated Planning (ASIP) project. The study examined the impact of NO<sub>x</sub> and VOC emission reductions on 8-hour ozone concentrations using CMAQ model

simulations for a summer ozone episode (June 1 – July 10, 2002). One of the sensitivity runs examined the effects of a 30% reduction in domain-wide anthropogenic VOCs on ozone formation. The impacts were then normalized by emissions. Figure 16 summarizes the results for Virginia.

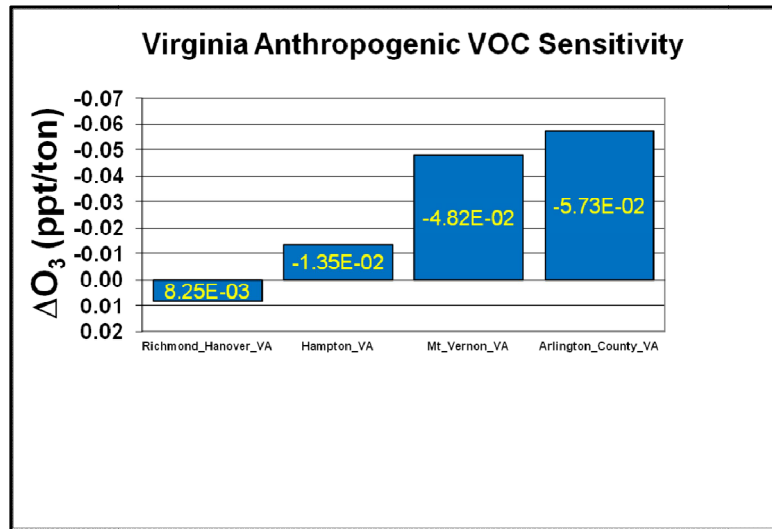


Figure 16: Ozone Response to Reductions in Anthropogenic VOC (Boylan, 2009)

A second sensitivity run examined the effects of a 30% reduction in ground level NO<sub>x</sub> for jurisdictions within Virginia on ozone formation. The impacts were then normalized by emissions. Figure 17 summarizes the results for the receptor locations in Virginia. The model response to ground level NO<sub>x</sub> reductions was two orders of magnitude (i.e., more than 100 times) greater than the response from anthropogenic VOC reductions.

Similarly, a third sensitivity run examined the effects of a 30% reduction in Virginia point source NO<sub>x</sub> on ozone formation. The impacts were again normalized by emissions. Figure 18 summarizes the results. The model response to point source NO<sub>x</sub> reductions was two to three orders of magnitude (i.e., more than 100-1,000 times) greater than the response from anthropogenic VOC reductions. The model response for this sensitivity was more variable and dependent on the location of the point source relative to the receptor locations as compared to the sensitivity run for ground level NO<sub>x</sub>.

These sensitivities demonstrate that NO<sub>x</sub> reductions are more efficacious than VOC reductions for improving ozone air quality in the Commonwealth.

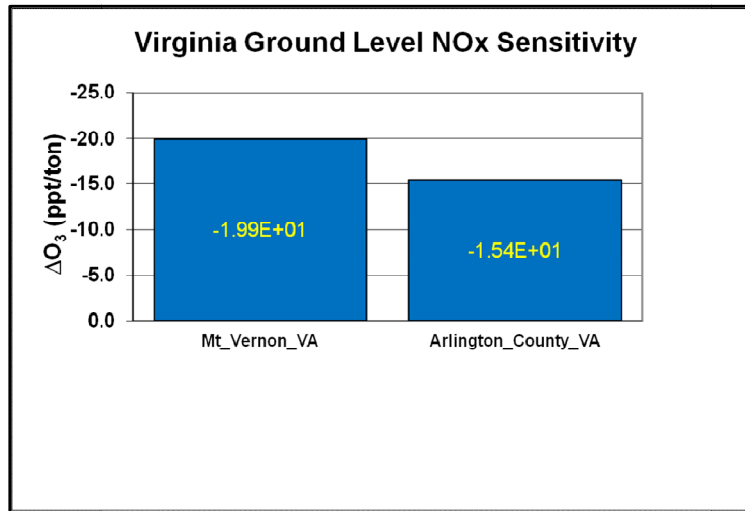


Figure 17: Ozone Response to Reductions in Ground Level NO<sub>x</sub> (Boylan, 2009)

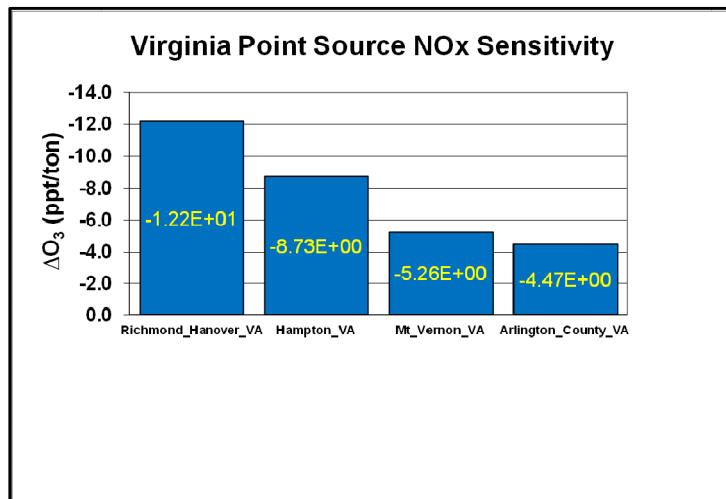


Figure 18: Ozone Response to Reductions in Point Source NO<sub>x</sub> (Boylan, 2009)

### 3. Action Plan Programs

This section provides detailed information on a number of new and ongoing programs that will provide additional emission reduction benefits to Virginia and Caroline County. These programs are directionally correct. They will reduce ozone precursors, and many of these programs will also reduce PM<sub>2.5</sub> precursors. The reductions from the programs are quantified, where possible, and the organizations responsible for the implementation of each program are provided. Timelines for implementation of each new program are also provided, where applicable. Each

program description specifically states if the reductions associated with the program or action have been included in the emissions inventories listed in Table 4 and Table 5.

### **3.1. Metropolitan Planning Efforts**

Caroline County, in partnership with FAMPO, has been proactive in establishing a strong planning effort aimed at reducing emissions from vehicle miles traveled. FAMPO has access to Congestion Mitigation and Air Quality (CMAQ) funding, which has been used for a wide variety of efforts designed to improve air quality between 2012 and 2017. These efforts will include improvements and construction of new bicycle paths, improvements to the commuter rail parking, and optimizing signal systems. More data on these programs may be found at <http://www.gwregion.org/transportation-planning/> and in Appendix C. Emission reductions from these efforts are not included in the estimates provided in Table 4 and Table 5.

### **3.2. GWRideConnect**

GWRideConnect is the ridesharing agency that serves the George Washington Regional Commission area. This region consists of the counties of Stafford, Spotsylvania, Caroline, and King George and the city of Fredericksburg. GWRideConnect promotes ridesharing and transportation demand management techniques to assist persons seeking transportation options to their workplaces and other destinations. The goals of the program are to promote, plan, and establish transportation alternatives to the use of single occupant vehicles; improve air quality; reduce congestion; and improve the overall quality of life for the citizens of the region. In addition to performing a wide range of daily travel demand management activities, GWRideConnect supports the largest vanpool fleet in Virginia and is an active partner in regional transit and transportation planning.

In 2000, 40% of employed George Washington Region residents traveled out of the region for work. In 2007, the “Virginia State of the Commute Survey” (Virginia Department of Rail and Public Transport, April 2009, see <http://www.drpt.virginia.gov/activities/stateofcommute.aspx>) estimated this figure had increased to 44%, the second highest percentage of any area in the Commonwealth. The region’s outbound commuters have an average one-way trip time of 64 minutes and distance of 45 miles, which are the longest average commute time and longest distance of any region in Virginia. These statistics, and the emissions inventory estimates provided for Caroline County in Table 5, highlight the importance of travel demand management programs. In fiscal year 2012, GWRideConnect facilitated the following reductions:

- 146,831,000 avoided vehicle miles traveled;
- 7,341,500 gallons of gasoline not consumed;
- 2,447,250 avoided work trips.



In fiscal year 2013, the program is expected to continue to grow. Goals include matching an additional 2,000 clients using the Free Rideshare Matching Program, forming an additional 50 vanpools, and forming 25 new carpools within the region.

This important, directionally correct program reduces or avoids air emissions from the on-road sector. These emission reductions from the programs offered by GWRideConnect are not included in the estimates provided in Table 4 and Table 5. See Appendix C for the “GWRideConnect Annual Work Plan FY2013.”

### 3.3. Fort A.P. Hill Sustainability Programs

Fort A.P. Hill is a regional training center that provides realistic joint and combined arms training, logistics, and support to America’s defense forces. This installation is situated in Caroline County, as shown in Figure 19, and maintains an all-purpose, year-round training facility that sits on 75,794 acres. The training facility serves active, reserve, and National Guard troops of the Army, Marine Corps, Navy, and Air Force as well as personnel from other government agencies.

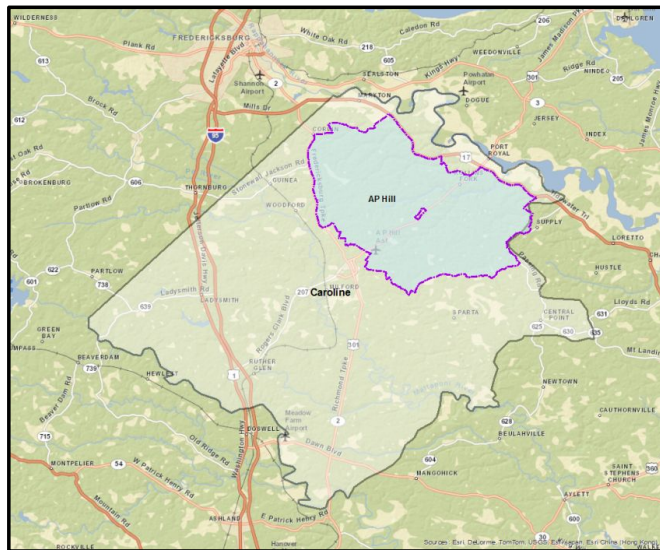


Figure 19: Fort A. P. Hill

Fort A.P. Hill has instituted several programs to reduce its impact on the environment. These programs reduce air emissions, as shown in Figure 20, and have other co-benefits, such as reducing dependence on foreign oil. These programs include the use of more efficient heating systems, use of ultra low sulfur diesel (ULSD) in all diesel-fired equipment, procurement of EPA-certified engine generators for any new construction or facility improvement, and the use of environmentally friendly and low-VOC alternatives to products used on the installation. Other programs reduce energy usage. For example, Fort A.P. Hill has recently completed a new facility that meets the requirements under Leadership in Energy and Environmental Design (LEED) Gold standards. Fort A.P. Hill has another building under construction that will meet LEED Silver standards. New buildings have also been equipped with highly efficient tankless hot water heaters and ground source heat pumps. These devices reduce the need for energy, avoiding air emissions and saving money on energy usage.

The main contributor to Fort A.P. Hill's reduction in NO<sub>x</sub> emissions is the transition from distillate oil-fired heating equipment to propane-fired equipment. Propane combustion creates much less NO<sub>x</sub> and SO<sub>2</sub> emissions than oil combustion, and reducing the amounts emitted of these pollutants will help to improve both ozone and PM<sub>2.5</sub> air quality. Figure 21 shows the outcomes from this transition, in terms of fuels used as well as NO<sub>x</sub> emissions.

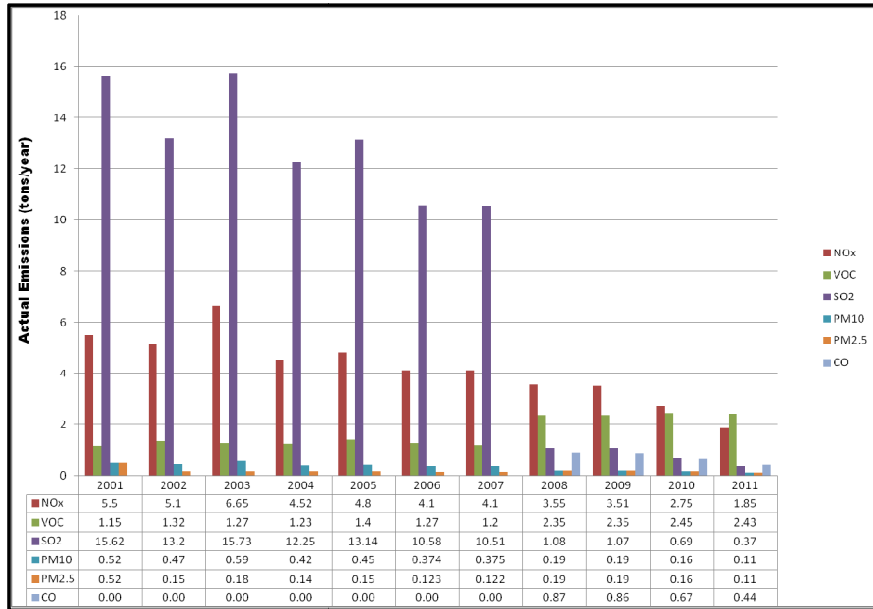


Figure 20: Fort A.P. Hill Emission Trends (Data Source: Fort A.P. Hill)

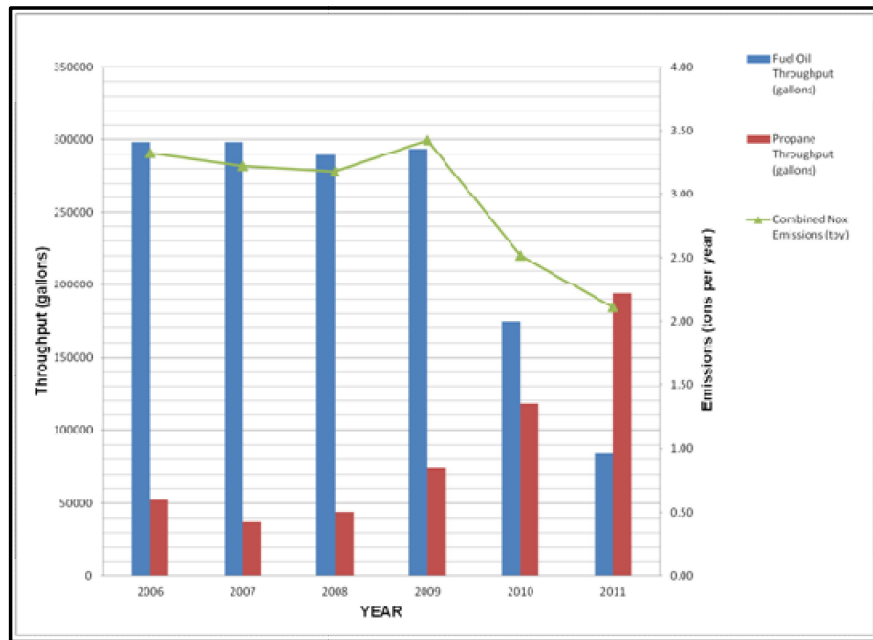


Figure 21: Fuel Consumption Comparison for Fort A.P. Hill (Data Source: Fort A.P. Hill)

The benefits associated with the programs instituted by Fort A.P. Hill have not been included in the overall emission estimates provided in Table 4.

### 3.4. Expansion of ORE Program

Vehicle inspection and maintenance programs (I/M) help improve air quality by identifying high-emitting vehicles in need of repair and causing them to be fixed as a prerequisite to vehicle registration. The CAA requires that I/M be implemented in certain portions of Virginia. The Virginia I/M program, called Air Check Virginia, is a decentralized I/M program that retains the convenience of having emissions inspections and repairs performed in the same stations but uses the latest accepted technology to determine which vehicles emit excessive pollutants. The jurisdictions in which Air Check Virginia must be implemented include the counties of Fairfax, Prince William, Loudoun, Arlington, and Stafford and the cities of Alexandria, Falls Church, Manassas, Manassas Park, and Fairfax. Vehicle owners in these jurisdictions, as well as regular commuters into the area and vehicles operating on federal installations in these jurisdictions, are subject to Air Check Virginia. These inspections must be performed every two years at a permitted emissions inspection station. If the vehicle does not pass the inspection, necessary repairs must be made.

As required by the CAA, each vehicle emissions inspection program must conduct remote sensing of vehicle emissions in the program area. In Air Check Virginia's On-

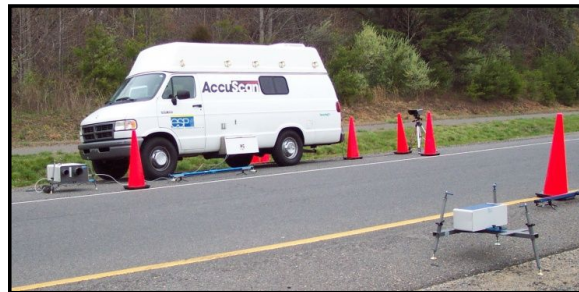


Figure 22: ORE Equipment

Road Emissions (ORE) monitoring program, equipment directing infrared and ultraviolet beams across one lane of traffic measure the concentrations of pollutants in the exhaust of vehicles as they drive by, as shown in Figure 22. These devices measure hydrocarbons, CO, and NO<sub>x</sub>. As the vehicle passes the equipment, a camera takes a picture of the vehicle's license plate while measurements are taken of the vehicle's exhaust. This process allows a large number of vehicles to be observed with little or no inconvenience to the vehicle operator. Vehicles that are garaged in the Northern Virginia area and that pollute excessively are required to make any necessary repairs. By identifying these "high emitters" immediately, instead of waiting until the next scheduled emissions inspection that could be many months away, repairs can be made to reduce the levels of harmful pollutants sooner. Vehicles that are garaged outside of Northern Virginia, that frequently commute into Northern Virginia, and that pollute excessively are also required to make necessary repairs. Since these vehicles are garaged outside of the Northern Virginia area and are only subject to the ORE program, vehicles needing repair would continue to pollute were it not for this program. An added benefit to recognition and repair of emissions problems is often improved fuel economy. Timely repairs may also help to prevent more expensive repairs



later. Owners of vehicles observed by remote sensing to be exceptionally clean are notified that their vehicle has received a “clean screen,” which constitutes an emission inspection pass.

The 2012 General Assembly passed legislation expanding the number of vehicles that may be eligible to participate in the ORE clean screen program. Some vehicle owners may find the use of the clean screen notification more convenient and efficient for meeting the emissions inspection requirement, and eventually up to 30% of the cleanest vehicles may be eligible. The State Air Pollution Control Board has amended its inspection and maintenance regulation (9VAC5 Chapter 91, effective December 15, 2012) to implement these statutory changes, which will increase the number of vehicle observations being performed by the ORE program in future years.

This expansion of the ORE program to identify clean vehicles will require that the program collect more vehicle observations. Additional vehicle observations will facilitate the identification of more vehicles that commute into the area and have excess emissions. Caroline County, as a bedroom community to Northern Virginia, will benefit in that more vehicles garaged in Caroline but operated frequently in Northern Virginia may be subjected to ORE testing. Such vehicles needing repairs will be required to do so, thereby reducing emissions in both areas of the Commonwealth.

The benefits from this program are difficult to quantify. However, in this area on-road emissions dominate the emissions inventory, and benefits from repairing high-emitting vehicles can only help to improve air quality. The expansion of the ORE program will take place in the 2014 timeframe.

Depending on future air quality concerns, VDEQ may also study the feasibility of using ORE data in other manners to benefit air quality.

### **3.5. DMME - Division of Energy Programs**

DMME’s Division of Energy serves as the state energy office and oversees a variety of programs that aim to reduce the consumption of energy throughout the Commonwealth of Virginia. These energy savings, which are facilitated in part by the programs described below, will have a beneficial effect on all facets of the Commonwealth’s environment. The generation of electricity is a significant contributor to the ozone precursor NO<sub>x</sub>. As these energy efficiency programs are developed and take full effect, the reduction in NO<sub>x</sub> emissions should help to improve ozone air quality in all parts of the Commonwealth. The emission reductions associated with the programs listed below have not been included in the inventory estimates listed in Table 4 and Table 5. More detail on the following programs, as well as other programs offered by DMME, may be found at [www.dmme.virginia.gov/divisionenergy.shtml](http://www.dmme.virginia.gov/divisionenergy.shtml).

### 3.5.1. Virginia Energy Management Program

The Virginia Energy Management Program (VEMP) was selected for expansion within DMME in response to Governor McDonnell's Executive Order 19, "Conservation and Efficiency in the Operation of State Government" (see <http://www.governor.virginia.gov/PolicyOffice/ExecutiveOrders/>). VEMP provides direction for Virginia's energy management program. The current staff of five employees has developed a roadmap to meet the Governor's order, which increases the scope of the public facilities energy efficiency retrofit program. The objectives of this program that relate directly to improving air quality are:

- Retrofitting 27 million square feet of public buildings by 2020,
- Reducing energy expenses by 20% at executive branch agencies and colleges by 2020,
- Deploying \$177 million of private capital between 2011 and 2020 in energy-efficiency improvements to Virginia's public buildings,
- Reducing peak demand by 88 megawatts (MW) no later than 2020.

Quantification of air quality benefits from the reduction of 88 MW of peak electrical demand can be estimated in a number of ways. One approach is to assume that avoided peak demand would have been supplied by demand response programs and therefore would have been generated primarily by diesel engines burning ULSD. Emissions from these types of engines can be approximated very conservatively through the manufacturer's engine certification for Tier 4 regulatory requirements, which mandate an emission rate of no more than 0.67 grams/kilowatt-hour (g/kWh) of NO<sub>x</sub>. The equation below demonstrates this methodology. This approach results in estimated emission reductions of 130 pounds/hour (lb/hr) of NO<sub>x</sub>.

$$88 \text{ MW} * 1,000 \frac{\text{kW}}{\text{MW}} * 0.67 \frac{\text{g}}{\text{kWh}} * 0.0022 \frac{\text{lb}}{\text{gram}} = 130 \frac{\text{lb NO}_x}{\text{hr}}$$

Another way to quantify the potential air quality benefit from the reduction of 88 MW at peak demand is to use PJM system mix information for summer months with high demand. This data is available on PJM's website (see <http://www.pjm-eiscom/reports-and-news/public-reports.aspx>). The PJM system mix for June and July of 2012 emitted approximately 1.1802 pounds/megawatt-hour (lb/MWh) of NO<sub>x</sub> and 3.6374 lb/MWh of SO<sub>2</sub>. As demonstrated by the equations below, this approach results in estimated emission reductions of approximately 103 lb/hr of NO<sub>x</sub> and 320 lb/hr of SO<sub>2</sub>.

$$88 \text{ MW} * 1.1802 \frac{\text{lb NO}_x}{\text{MWh}} = 103.9 \frac{\text{lb NO}_x}{\text{hr}}$$

$$88 \text{ MW} * 3.6374 \frac{\text{lb SO}_2}{\text{MWh}} = 320.1 \frac{\text{lb SO}_2}{\text{hr}}$$

These reductions are especially important since peak electrical demand hours often correspond with high ozone readings and poor air quality.

### **3.5.2. *Energize Virginia***

Energize Virginia is a revolving loan fund administered by DMME that supports qualifying energy efficiency and renewable energy projects and programs. The first request for proposals for this fund was issued December 5, 2011, and awards from this fund are expected to be approximately \$10,500,000. Loans from Energize Virginia may be used to finance renewable energy generation systems and energy conservation equipment, technology, controls, measures, and programs, including those that advance the goals of Governor McDonnell's Executive Order 19. Also eligible are differential costs for alternative fuel and advanced technology vehicles, alternative fuel refueling equipment, and vehicle energy conservation programs, including those that advance the goals of Executive Order 36, "Moving Toward Alternative Fuel Solutions for State-Owned Vehicles" (see <http://www.governor.virginia.gov/PolicyOffice/ExecutiveOrders/>). This program is directionally correct and will help improve air quality through the use of cleaner alternative fuels and the reduction in use of various fossil fuels.

### **3.6. Virginia Clean Cities Programs**

The mission of the Virginia Clean Cities, Inc. (VCC) is to increase national energy security; improve air quality and public health in Virginia, and develop economic, academic, and resource opportunities in the Commonwealth through petroleum reduction. VCC draws stakeholders from all levels of government, the commercial sector, and the manufacturing sector in its quest to cultivate an advanced transportation community in which citizens may learn about a wide range of options and technologies for on-road and off-road engines. The "2011 Annual Report for Virginia Clean Cities" (see <http://www.vacleancities.org/tools-resources/reports/>) estimates that in 2011, this program helped to reduce Virginia's reliance on petroleum products by the equivalent of over 8,700,000 gallons of gasoline. This directionally correct program is expanding every year to take on more challenges and will continue to provide air quality benefit for Caroline County as well as the rest of the Commonwealth by promoting clean, alternative fuels as well as energy efficiency improvements. The sections below provide information on a few of the notable projects facilitated by VCC. The emission benefits from these projects are not included in the emissions inventories presented Table 4 and Table 5. More information on this organization may be found at [www.vacleancities.org](http://www.vacleancities.org).

#### **3.6.1. *Virginia Get Ready Project***

VCC created and manages the Virginia Get Ready effort, which recently produced the Virginia Get Ready: Electric Vehicle Plan. The goal is to establish Virginia as a leader in the adoption of electric vehicles in order to reduce vehicle emissions, increase energy independence, and generate economic development for the Commonwealth. More information on this directionally correct program may be found at [www.virginiaev.org](http://www.virginiaev.org).

### **3.6.2. Southeast Propane Autogas Development Program**

VCC manages the Southeast Propane Autogas Development Program (SPADP). SPADP is a large-scale Recovery Act alternative fuel project aimed at building propane autogas infrastructure in the southeastern United States and encouraging public and private fleets in the region to adopt propane autogas. Propane fuel savings in the program exceed \$1.50 per gallon, and the fuel represents reductions of 20% in CO and of 40% in NO<sub>x</sub>. The program is converting over 1,200 vehicles from gasoline to propane autogas including 125 in Virginia, implementing propane autogas fueling stations along high-traffic routes with partner Alliance AutoGas, and deploying a wide-reaching communications campaign to increase awareness and usage of propane autogas. SPADP provides Virginia with a platform for the state fleet alternative fuel transition effort, which was initiated in October 2012. Although this program is not specific to Caroline County, the environmental benefits from this program should help to improve local area quality as well as air quality across the Commonwealth.

### **3.7. Regional Reductions**

Since air quality is not solely dictated by emissions within any particular area, but is heavily influenced in the case of the Commonwealth by transported emissions, this section describes other emission reduction efforts that are occurring outside of Caroline County. Depending on meteorological conditions on any summer day, the reductions described in this section could improve the air quality in Caroline County and may lessen the transported ozone and precursor load. The emission reductions associated with each of these upwind programs are considerable. With the exception of Section 3.7.4, these reductions have not been included in the summary of emissions for Virginia found in Table 4.

#### **3.7.1. Honeywell Hopewell SCR Installation**

Honeywell International Inc.-Hopewell Plant is a chemical manufacturing facility in Hopewell, Virginia. As a result of negotiations to resolve federal compliance issues, VDEQ issued a federally enforceable permit to this facility dated June 28, 2011, which requires the installation and operation of eight selective catalytic reduction (SCR) systems on eight of the ten largest-emitting units on site. Each SCR is expected to achieve NO<sub>x</sub> reductions of at least 95%. The permit requires installation of the SCR in a phased manner, where two SCR were required to begin operating on December 31, 2012. Others are required on a timeline such that all eight SCR are installed and operating by June 30, 2019.

Table 8 provides data on the actual emissions of these units from 2007 through 2011 and the expected emission rates after control, as listed in the June 28, 2011, permit. This table shows that the emissions from this equipment have historically been between 7,400 tpy and 8,100 tpy NO<sub>x</sub>.

After installation of controls, this equipment will be allowed to emit no more than 1,850 tpy of NO<sub>x</sub>. This program will provide reductions of at least 5,791.6 tpy of NO<sub>x</sub> by June 30, 2019, as

compared to actual 2011 annual emissions. The benefits from this program are not included in the overall NO<sub>x</sub> emission estimates listed in Table 4 and should help improve ozone air quality throughout the Commonwealth.

**Table 8: Honeywell Hopewell NO<sub>x</sub> Reductions**

	Actual Emissions of NO <sub>x</sub> , tpy					Permitted Limits of NO <sub>x</sub> , tpy			
	2007	2008	2009	2010	2011	6/30/13	6/30/15	6/30/2017	6/30/2019
<b>Nitrite Towers</b>									
A	969.4	1,151.6	1,305.3	1,228.7	1,152.3	1,673.0	1,673.0	117.0	117.0
B	863.6	881.4	855.1	971.7	938.4	1,844.0	123.0	123.0	123.0
C	949.2	1,129.9	1,090.1	1,055.5	1,001.4	102.0	102.0	102.0	102.0
D	366.3	435.5	451.8	420.8	332.2	600.0	600.0	600.0	33.0
E	426.6	495.0	541.0	454.4	422	600.0	600.0	600.0	600.0
<b>Disulfonate Towers</b>									
A	1,129.1	1,029.4	1,085.3	1,004.2	1,124.8	1,244.0	1,244.0	87.0	87.0
B	898.8	891.6	954.4	879.4	895.7	1,092	84.0	84.0	84.0
C	882.3	899.4	812.5	878.1	843.7	72.0	72.0	72.0	72.0
D	518.7	534.7	493.9	577.1	399.7	600.0	600.0	600.0	32.0
E	471.6	552.8	518.6	538.5	531.4	600.0	600.0	600.0	600.0
<b>Totals:</b>	<b>7,475.6</b>	<b>8,001.3</b>	<b>8,108.0</b>	<b>8,008.4</b>	<b>7,641.6</b>	<b>8,427.0</b>	<b>5,698.0</b>	<b>2,985.0</b>	<b>1,850.0</b>

Data Source: VDEQ-CEDS

### 3.7.2. *Invista*

Invista owns and operates a synthetic fiber production facility located in Waynesboro, Virginia. The facility has a powerhouse consisting of three boilers that predominantly use coal, with a total heat input of approximately 600 million British thermal units/hour (mmbtu/hr). Table 9 provides emissions information on the existing powerhouse for the facility.

**Table 9: Invista Powerhouse Emissions 2007-2011, SO<sub>2</sub> and NO<sub>x</sub>**

Year	Tons NO <sub>x</sub> /Year	Tons SO <sub>2</sub> /Year
2011	184.0	567.8
2010	198.5	629.1
2009	237.7	768.1
2008	275.7	843.2
2007	353.2	924.2

Data Source: VDEQ-CEDS

The facility received a federally enforceable permit from VDEQ to retire the existing boilers and in their place install two new, natural-gas fired boilers that use distillate oil and liquefied petroleum gas as back-up fuels. These new units are permitted at 33.8 tpy NO<sub>x</sub> and 2.3 tpy SO<sub>2</sub>. This change would reduce the NO<sub>x</sub> emissions by more than 100 tpy and the SO<sub>2</sub> emissions by more than 500 tpy, as compared to 2011 values. These reductions have not been included in the

Virginia-wide emissions estimates listed in Table 4. The facility commenced construction on these boilers in December of 2012.

**3.7.3. Celco**

Celanese Acetate, LLC (Celco) is a large manufacturing facility located in Giles County, Virginia. The facility primarily manufactures cellulose acetate flake and fiber using wood pulp and acetic acid as raw materials. The facility has a steam plant consisting of seven coal-fired boilers and two natural gas-fired boilers. The seven coal-fired boilers have a total capacity of approximately 1,400 mmbtu/hr heat input. The facility received a federally enforceable permit on December 6, 2012, allowing the construction of six natural gas-fired boilers that will be used in place of the seven coal-fired boilers. The retirement of the seven coal-fired boilers, which operate with minimal pollution control, and their subsequent replacement by natural gas-fired boilers with low NO<sub>x</sub> burners, will reduce emissions of SO<sub>2</sub> and NO<sub>x</sub> significantly from this facility. Table 10 provides the power house emissions since 2007 from this facility.

The total emissions from the new natural gas-fired boilers are limited to no more than 333 tpy of NO<sub>x</sub> and 6 tpy of SO<sub>2</sub>. Once these changes are made, the steam plant will emit 3,000 tons of NO<sub>x</sub> and 6,000 tons of SO<sub>2</sub> less than previous years. The estimated time frame for these changes to take effect is 2015. These reductions were not included in the overall emissions estimates provided in Table 4.

**Table 10: Celco Powerhouse Emissions 2007-2011, SO<sub>2</sub> and NO<sub>x</sub>**

Year	Tons NO <sub>x</sub> /Year	Tons SO <sub>2</sub> /Year
2011	3,539.9	6,540.2
2010	3,438.8	6,325.1
2009	3,775.9	6,551.1
2008	3,907.1	6,631.5
2007	3,609.2	6,499.9

*Data Source: VDEQ-CEDS*

**3.7.4. Dominion Generating Unit Retrofits, Retirements, and Fuel Conversions**

Dominion is one of the nation's largest producers and transporters of energy, with a portfolio of approximately 27,400 megawatts of generation; 11,000 miles of natural gas transmission, gathering, and storage pipeline; and 6,300 miles of electric transmission lines. Dominion has taken a number of steps over the last 15 years to reduce emissions from its electric generation fleet corporate wide and in Virginia. Since 1998, the company has reduced NO<sub>x</sub> and SO<sub>2</sub> emissions from its generation fleet that serves Virginia by 77% and 81%, respectively. In addition, mercury emissions have been reduced by about 65%. To meet new EPA regulations, over the next several years the company anticipates further reductions in emissions through coal

unit retirements, conversion from coal to other fuel sources including natural gas and biomass, and new transmission capacity. In addition, Dominion has a large number of programs designed to promote the use of alternative fuels and alternative fuel vehicles as well as energy conservation programs for its residential and business customers. It also offers its customers the option to voluntarily support renewable energy through its Dominion Green Power® Program.

As part of a federally-enforceable April 2003 Consent Decree between Dominion and EPA (United States v. Virginia Electric and Power Co., Civil Action No. 03-CV-517A, entered 10/10/2003), Dominion has installed SO<sub>2</sub> and/or NO<sub>x</sub> control devices on a number of coal-fired units in the Commonwealth. The Chesterfield Power Station, located in Chesterfield County, has had three of the four coal-fired units retrofitted with SCR for NO<sub>x</sub> control since 2002. These units have also been retrofitted for SO<sub>2</sub> control, with the fourth unit being tied into the SO<sub>2</sub> flue gas desulfurization (FGD) equipment in 2012. The FGD equipment at Chesterfield Power Station achieves approximately 95% reduction of SO<sub>2</sub> emissions, as well as significant emission reductions in other acid gases, mercury, and direct particulate matter.

As part of the same consent decree, Dominion has also installed control devices on a number of coal-fired units in the Hampton Roads area. The Chesapeake Power Station, located in the City of Chesapeake, retrofitted Units 3 and 4 with SCR for NO<sub>x</sub> control in 2003. Beginning in 2013, the Consent Decree requires year round operation of the SCRs.

Additionally, Dominion filed its annual Integrated Resource Plan (IRP) with the SCC on August 31, 2012. The IRP is a mandatory 15-year, forward-looking plan for matching generation, transmission, and demand-side management resources with expected demand. Information in the IRP is not a commitment to build any particular project or retire any particular unit but represents the company's evaluation to meet the expected electricity needs of its customers in a cost-effective manner over the next 15 years. This document notes that current plans call for the retirement of all four coal-fired units at the Chesapeake Energy Center as well as the retirement of Units 1 and 2 at the Yorktown Power Station, located in York County, in the 2015 timeframe. Dominion's IRP is available at <https://www.dom.com/about/integrated-resource-planning.jsp>.

Dominion also converted three formerly coal-fired power plants to biomass, a renewable energy source, and completed these projects in 2013. The current capacity of each of these facilities is 63 MW, and these power plants are located in the City of Hopewell, Southampton County, and Campbell County. The switch to biomass as the primary fuel should reduce emissions of NO<sub>x</sub>, SO<sub>2</sub>, and mercury from these facilities.

As required by a condition in the federally-enforceable construction permit issued by VDEQ to the Virginia City Hybrid Energy Center, which is located in southwest Virginia, Dominion plans to convert the Bremono Power Station to natural gas, pending SCC approval. Bremono Power Station

is a 222 MW coal-fired electrical generating facility consisting of two coal-fired units, Unit 3 and Unit 4, and is located in Fluvanna County. This conversion is expected to be completed in the 2014 time frame.

The emission benefits of the changes to these electrical generating units have been included in Table 4, and more information on these estimates may be found in Appendix A.

### 3.7.5. *American Electric Power Generating Unit Retirements and Retrofits*

American Electric Power (AEP) is the nation’s largest energy generator, serving customers across 11 states with a transmission network of nearly 39,000 miles. AEP operates two coal-fired facilities in western Virginia, Clinch River Power Station in Russell County and Glen Lyn Power Station in Giles County. These facilities house a total of six coal-fired EGUs, none of which operate with either FGD for SO<sub>2</sub> control or SCR for NO<sub>x</sub> control. Table 11 provides the emissions from Clinch River since 2007.

Table 12 provides the same data for Glen Lyn.

**Table 11: Clinch River SO<sub>2</sub> and NO<sub>x</sub> Emissions, 2007-2012**

Unit ID	Year	SO <sub>2</sub> (tpy)	NO <sub>x</sub> (tpy)
1	2007	8,710	2,569
2	2007	8,801	2,590
3	2007	9,164	2,673
2007 Total:		26,674	7,831
1	2008	6,483	2,081
2	2008	7,521	2,426
3	2008	7,132	2,002
2008 Total		21,136	6,509
1	2009	2,026	554
2	2009	1,149	310
3	2009	3,829	940
2009 Total		7,004	1,804
1	2010	3,421	61
2	2010	2,234	725
3	2010	1,110	261
2010 Total		6,765	1,048
1	2011	1,340	373
2	2011	2,281	639
3	2011	2,301	537
2011 Total		5,921	1,549
1	2012	2,035	454
2	2012	1,131	259
3	2012	715	160
2012 Total		3,771	873

*Data Source: EPA CAMD*



**Table 12: Glen Lyn SO<sub>2</sub> and NO<sub>x</sub> Emissions, 2007-2012**

Unit ID	Year	SO <sub>2</sub> (tpy)	NO <sub>x</sub> (tpy)
51	2007	1,956	557
52	2007	1,987	549
6	2007	7,548	2,346
2007 Total:		11,491	3,451
51	2008	1,323	397
52	2008	1,378	414
6	2008	7,465	2,325
2008 Total		10,166	3,137
51	2009	158	46
52	2009	169	52
6	2009	2,888	814
2009 Total		3,216	912
51	2010	83	25
52	2010	79	24
6	2010	1,552	431
2010 Total		1,715	480
51	2011	140	44
52	2011	146	43
6	2011	1,486	433
2011 Total		1,770	520
51	2012	36	15
52	2012	43	15
6	2012	534	170
2012 Total		613	200

*Data Source: EPA CAMD*

On May 3, 2013, AEP informed VDEQ as part of an extension request of their plans for these facilities. See Appendix A for the correspondence from AEP to VDEQ on this issue. AEP intends to retire the Glen Lyn Power Plant during the summer of 2015. At Clinch River Power Plant, AEP intends to retire Unit 3 and to switch Units 1 and 2 to natural gas. These changes will eliminate nearly all SO<sub>2</sub> emissions from these units and will significantly reduce NO<sub>x</sub> emissions from these units, providing additional upwind reductions for Caroline County. The reductions associated with these facility changes are included in Table 4.

#### **4. Ozone Advance Reporting and Checklist**

As part of the Action Plan process, VDEQ intends to report annually to EPA on the programs contained in this document. To facilitate the reporting process, VDEQ will coordinate with stakeholders and report to EPA using the checklist in Appendix D. This checklist is not intended to be prescriptive or a mandate. Rather, it provides a structure to the reporting process and

potential milestones for each program listed within this action plan. The checklist in Appendix D may also be used to report on other initiatives not included in this plan or future initiatives that are still being formulated.