Virginia Department of Environmental Quality
Office of Air Quality Monitoring
Air Quality Monitoring Network Assessment

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Commonwealth of Virginia

Department of Environmental Quality

Office of Air Quality Monitoring

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This Network Assessment report covers the time period from calendar year 2010 to calendar year 2014

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Executive Summary

This document was developed to meet the requirements of 40 CFR Part 58.10 (d) which requires that all state air quality monitoring agencies must perform a network assessment once in five year. The last network assessment was done by VADEQ in 2010, and there have been some changes to the State-wide network which are discussed in this document. Per State regulations Virginia is divided into AQCRs and this assessment was done as regionally based to follow that requirement. The broad overall goals of this assessment are as follows:

- Evaluate if the existing network meets monitoring objectives of 40 CFR Part 58 Appendix D.
- Evaluate a need for new monitoring Sites by AQCR.
- Evaluate any redundancies in the network by pollutant within each AQCR.
- Identify any monitoring gaps.
- Identify proposed changes to the network and assess their impacts

VADEQ used the LADCO provided NetAssess application to do this network assessment (http://ladco.github.io/NetAssessApp/). The application was used to select areas of interest by pollutant for regional assessment. The monitoring sites within AQCRs were selected and the application defined the area-served polygons which bordered the monitoring sites based on their distances from the nearest neighboring sites. The application modeled outputs from these Sites assessment tools helped to analyze the areas served and populations served by the monitoring Sites. The NetAssess application used three-years of ambient air quality data (2011-2013) from AQS to determine the Site correlations and any network redundancies. This document also evaluates the other criteria pollutants, PAMS and Toxics but without any modeled outputs. These evaluations are based on the regulatory requirements for number, location and operation of these monitors along with information on recently gathered data from each of the sites.

From the results of the analyses performed as part of this Network Assessment the following recommendations/observations can be made:

1. The air monitoring network in the Commonwealth of Virginia meets the numeric expectations of the Regulatory requirements in 40 CFR Part 58.
2. The Nitrogen Dioxide network within the Commonwealth, while consistent with the area wide and susceptible populations regulatory requirements, still has to install two required additional near road sites to be consistent with 40 CFR Part 58 Appendix D paragraph 4.3.2; one in the Northern Virginia area (Washington DC MSA) and one in Virginia Beach (Hampton Roads MSA).
3. The Ozone Monitoring Network in Virginia continues to be robust and meets all regulatory requirements in terms of locations and minimum number of monitors. The trend for the Ozone values continues to demonstrate decreasing ambient ozone concentrations.
4. The PM2.5 Monitoring Network in Virginia continues to be robust and meets all regulatory requirements in terms of locations and minimum number of monitors.
5. Generally the long term air quality trends since 2004 for all criteria pollutants demonstrate decreasing ambient concentrations.

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LIST OF ACRONYMS

AADT	Annual Average Daily Traffic
AQM	Office of Air Quality Monitoring
AQS	Air Quality System
AQS ID	9-digit site identification number in AQS database
BAM	Beta Attenuation [Mass] Monitor-for measuring continuous particulate matter
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CASTNET	Clean Air Status and Trends Network
CBSA	Core Based Statistical Area
CFR	Code of Federal Regulations
CSA	Combined Statistical Area
CSN	Chemical Speciation Network
CO	Carbon Monoxide
EGU	Electrical Generating Unit
FE-AADT	Fleet Equivalent Annual Average Daily Traffic
FEM	Federal Equivalent Method-EPA approved method designated as equivalent to the Federal Reference Method (FRM) for a specific pollutant to compared to the applicable NAAQS
FID	Flame Ionization Detector
FRM	Federal Reference Method-EPA approved reference method necessary for a specific pollutant to be compared to the applicable NAAQS
GC	Gas Chromatograph
HAPS	Hazardous Air Pollutants
ICP-MS	Inductively Coupled Plasma Mass Spectroscopy
IMPROVE	Interagency Monitoring of Protected Visual Environments
LADCO	Lake Michigan Air Directors Consortium
MARAMA	Mid-Atlantic Regional Air Management Agency
MSA	Metropolitan Statistical Area
NAAQS	National Ambient Air Quality Standards-used for determining attainment status
NCore	National Core multi-pollutant monitoring stations

nm	Nanometer, an SI unit for measuring length; 1 nm equals 10^{-9} meter.
NO	Nitrogen Oxide
NO2	Nitrogen Dioxide
NOx	Oxides of Nitrogen (ozone precursor)
NOy	Total Reactive Nitrogen Species (ozone precursor)
O3	Ozone
OC/EC	Organic Carbon/Elemental Carbon
PAMS	Photochemical Assessment Monitoring Station
Pb	Lead
PM2.5	Particulate matter with an aerodynamic diameter less than or equal to 2.5 μm
PM10	Particulate matter with an aerodynamic diameter less than or equal to 10 μm Ambient Air Monitoring Network Plan for Calendar Year 2016 7
PM10-2.5	Particulate matter (“PM coarse”) with an aerodynamic diameter less than or equal to 10 μm minus particulate matter with an aerodynamic diameter less than or equal to 2.5 μm
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
SIP	State Implementation Plan
SLAMS	State or Local Air Monitoring Stations
SO2	Sulfur Dioxide
SPM	Special Purpose Monitor
PM2.5	Speciation Trends Network
TEOM	Tapered Element Oscillating Microbalance
TSP	Total suspended particulate μm Micrometer (10-6 meter)
$\mu g/m^3$	micrograms per cubic meter
UATM	Urban Air Toxics Monitoring
US EPA	United States Environmental Protection Agency
UV	Ultraviolet
VADEQ	Virginia Department of Environmental Quality
VOCs	Volatile Organic Compounds

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1. INTRODUCTION

The Commonwealth of Virginia Department of Environmental Quality (VADEQ) maintains a Statewide network of air quality monitoring Stations which includes SLAMS, SPM, NCore, Near-road and non-regulatory Special Studies monitoring Sites. As required by regulations (40 CFR Part 58) VADEQ prepares an annual Network Plan which describes any implemented and proposed changes to the monitoring network. In addition the Title 40 Code of Federal Regulations, Part 58.10(d) requires an evaluation of the Statewide network of air quality monitoring Sites every five years, and the first of the 5-year network assessment was done in 2010. The exact wording of the regulations is as follows:

§58.10(d)

(d) The State, or where applicable local, agency shall perform and submit to the EPA Regional Administrator an assessment of the air quality surveillance system every 5 years to determine, at a minimum, if the network meets the monitoring objectives defined in appendix D to this part, whether new sites are needed, whether existing sites are no longer needed and can be terminated, and whether new technologies are appropriate for incorporation into the ambient air monitoring network. The network assessment must consider the ability of existing and proposed sites to support air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma), and, for any sites that are being proposed for discontinuance, the effect on data users other than the agency itself, such as nearby States and Tribes or health effects studies. For PM2.5, the assessment also must identify needed changes to population-oriented sites. The State, or where applicable local, agency must submit a copy of this 5-year assessment, along with a revised annual network plan, to the Regional Administrator. The first assessment is due July 1, 2010.

This report describes the network of air quality monitoring stations operated by VADEQ and analyzes their effectiveness with regards to characterizing air quality within urban and rural areas in the Commonwealth of Virginia.

1.1 Background

The VADEQ has maintained a network of Air Monitoring Stations (SLAMS) in Virginia since 1980, as required by 40 CFR Part 58.30. The network was designed to meet the requirements of Appendix D to Part 58. A complete list of Sites in the Commonwealth is provided in Appendix A, which includes State and Local Monitoring Sites (SLAMS), Special Purpose Monitors (SPM), and IMPROVE Sites. For the purpose of Air Quality Planning, the State is divided into seven Air Quality Control Regions (AQCR) that are defined in the Virginia Air Quality Regulations 9VAC5-20-200. A description of the seven AQCRs along with the list of Sites within each of the Regions is given in Table 3.1.

VADEQ's Office of Air Quality Monitoring (AQM) maintains an extensive air quality monitoring network throughout the Commonwealth. Attached to this document is a list of all of Virginia's locations for the air monitoring sites for all criteria pollutants. Approximately 120 instruments at 39 sites monitored ambient air quality across Virginia during 2013 - 2014. All monitoring sites meet EPA's siting criteria (40 CFR Part 58, Appendices D and E), and all sites conform to EPA guidance documents and generally accepted air quality monitoring practices. AQM quality assures all data gathered from the Virginia air quality monitoring network in accordance with federal requirements (40 CFR Part 58, Appendix A). The

data are published annually in the Virginia Ambient Air Monitoring Data Report and are available from the VDEQ website at: http://www.deq.virginia.gov/Programs/Air/AirMonitoring/Publications.aspx.

The primary purpose of this 5-year network assessment is to evaluate if the current network is meeting the regulatory requirements, identify redundancies in the network, need for adding Sites, and recommend changes in locations of the monitoring Sites based upon demographic changes. The list of Sites in each of the AQCR has changed since the last 5-year assessment in 2010, and the Annual Network Monitoring Plan prepared by VADEQ by May 1 of each year lists the changes in the network.

1.2. Study Objectives

The network assessment is to evaluate if the monitoring objectives stated in 40 CFR Part 58 regulations are being met. As listed in Appendix D to 40 CFR Part 58 the key objectives for statewide air monitoring network are:

(a) provide air quality data to the general public in a timely manner.

(b) compliance with the NAAQS standards and support emissions reduction strategies by providing data for regional air quality models.

(c) provide support for air pollution research studies.

Section 1.3 gives a description of Virginia's air monitoring network, and Section 1.4 discusses the present state of Air Quality in Virginia.

1.3 Overview of Virginia's Air Monitoring Network

Virginia State regulations (9VAC5, Chapter 20) outline procedures for Virginia's Air Quality control, and the Code of Federal Regulations have been incorporated by reference. In regulation 9VAC5-2-200 for purposes of Air Quality Planning the Commonwealth has been divided into seven Air Quality Control Regions (AQCR) which are based on geographic boundaries and demographics. Table 3.1 gives a list of the AQCRs with air monitoring Sites within each Control Region.

1.3.1 Air Quality Control Region 1

AQCR 1 is defined in 9 VAC5-20-200 as the Eastern Tennessee-Southwest Virginia Interstate Air Quality Control region. The counties, independent cities and CBSA/MSA contained within this AQCR are described in Table 3.1 below. The combined population of the counties and independent cities in AQCR 1 as of the 2010 census was 401, 745 with an approximate land area of 15,400 square kilometers. AQCR 1 is served by the Southwest Regional Office located in the town of Abingdon in Washington County.

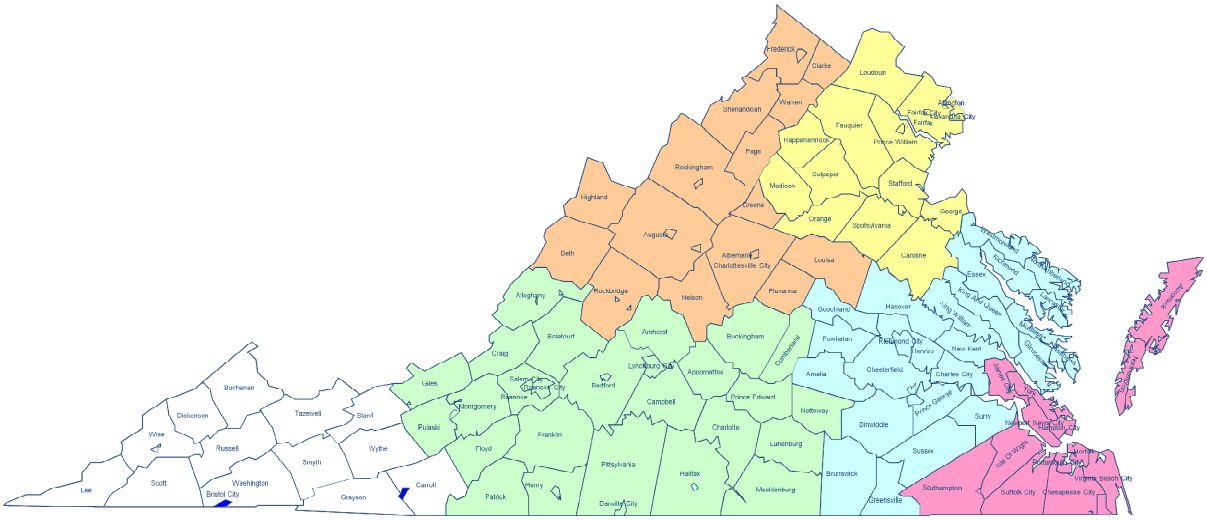

Figure 1.3.1 – AQCR 1 Tennessee-Southwest Virginia Interstate AQCR (shown in white)

1.3.2 Air Quality Control Region 2

AQCR 2 is defined in 9 VAC5-20-200 as the Valley of Virginia Intrastate Air Quality Control region. The counties, independent cities and CBSA/MSA's contained within this AQCR are described in Table 3.1 below. The combined population of the counties and independent cities based on the 2010 census in AQCR 2 is 961,929 with an approximate land area of 18,900 square kilometers. AQCR 2 is served by the Valley Regional Office located in the city of Harrisonburg and the Blue Ridge Regional Office located in the city of Roanoke.

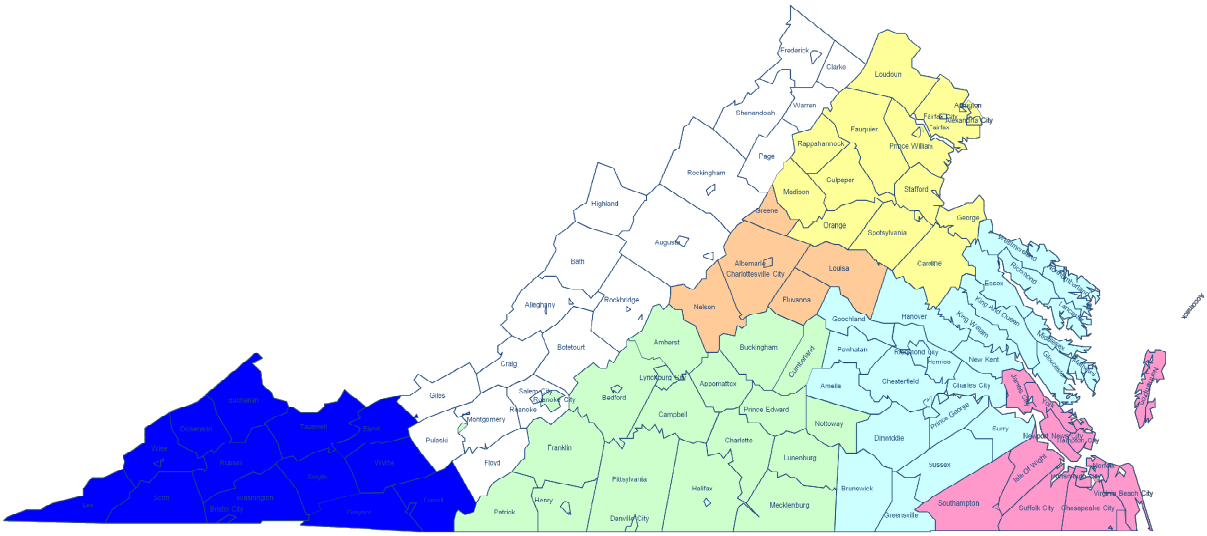

Figure 1.3.2 - Valley of Virginia Intrastate AQCR (shown in white)

Table 3.1 List of Air Quality Control Regions in Virginia

	Counties	Cities	Urban Areas	CBSA/MSA	Air Monitoring Sites	Pollutants
AQCR 1 - Southwest Virginia	Bland, Buchanan, Carroll, Dickenson, Grayson, Lee, Russell, Scott, Smyth, Tazewell, Washington, Wise, Wythe	Bristol, Galax, Norton	No	Kingsport-Bristol-Bristol, TN-VA	51-035-0001 (Carroll)	PM10
					51-197-0002 (Wythe)	O3
					51-520-0006 (Bristol)	PM2.5
AQCR 2 - Valley	Alleghany, Augusta, Bath, Botetourt, Clarke, Craig, Floyd, Frederick, Giles, Highland, Montgomery, Page, Pulaski, Roanoke, Rockbridge, Rockingham, Shenandoah, Warren	Buena Vista, Clifton Forge, Covington, Harrisonburg, Lexington, Radford, Roanoke, Salem, Staunton, Waynesboro, Winchester	Roanoke	Winchester, VA-WV; Roanoke, VA: Harrisonburg VA; Blacksburg-Christiansburg-Radford, VA; Staunton-Waynesboro VA	51-069-0010 (Frederick)	O3, PM2.5
					51-840-0002 (Winchester)	PM10
					51-113-0003 (Madison)	O3, PM2.5
					51-139-0004 (Page)	O3, PM2.5
					51-161-1004 (Roanoke)	O3, CO, NO2, SO2, PM2.5
					51-163-0003 (Rockbridge)	O3, PM2.5
					51-165-0003 (Rockingham)	O3, PM2.5, NO2, SO2
					51-775-0011 (Salem)	PM2.5
AQCR 3 - Central Virginia	Amelia, Amherst, Appomattox, Bedford, Brunswick, Buckingham, Campbell, Charlotte, Cumberland, Franklin, Halifax, Henry, Lunenburg, Mecklenburg, Nottoway, Patrick, Pittsylvania, Prince Edward	Bedford, Danville, Lynchburg, Martinsville, South Boston	Lynchburg, Campbell county	Lynchburg, VA; Martinsville, VA	51-680-0015 (Lynchburg)	PM2.5
					51-009-0007 (Amherst county)	TSP-Lead (source oriented)
AQCR 4 - Northeast Virginia	Accomack, Albemarle, Caroline, Culpepper, Essex, Fauquier, Fluvanna, Gloucester, Greene, King and Queen, King George, King William, Lancaster, Louisa, Madison, Mathews, Middlesex, Nelson, Northampton, Northumberland, Orange, Rappahannock, Richmond, Spotsylvania, Stafford, Westmoreland	Charlottesville, Fredericksburg	Charlottesville	Washington-Arlington-Alexandria, DC-VA-MD-WV; Richmond VA; Charlottesville, VA	51-033-0001 (Caroline co)	O3
					51-061-0002 (Fauquier co)	O3
					51-179-0001 (Stafford)	O3
					51-003-0001 (Albemarle)	O3, PM2.5
					51-630-0004 (Fredericksburg)	PM10
					51-101-0003 (West Point)	PM10

	Counties	Cities	Urban Areas	MSA/CBSA	Air Monitoring Sites	Pollutants
AQCR 5 - State Capital	Charles City, Chesterfield, Dinwiddie, Goochland, Greensville, Hanover, Henrico, New Kent, Powhatan, Prince George, Surry, Sussex	Colonial Heights, Emporia, Hopewell, Petersburg, Richmond	Richmond, Chesterfield, Hanover, Henrico	Richmond, VA	51-036-0002 (Charles City)	O3, SO2, NO2, PM2.5
					51-041-0003 (Chesterfield)	PM2.5
					51-041-0004 (chesterfield)	O3
					51-085-0003 (Hanover)	O3
					51-087-0014 (Henrico)	O3, CO, NO2, SO2, PM2.5, PM10, Pb, VOC, Carbonyls. Metals, PAH, Cr-6
					51-087-0015 (Henrico)	PM2.5
					51-670-0010 (Hopewell)	PM10, VOC, Carbonyls, metals
					51-760-0025 (Richmond)	NO2, CO
AQCR 6 - Hampton Roads	Isle of Wright, James city, Southampton, York	Chesapeake, Franklin, Hampton, Newport News, Norfolk, Poquoson, Portsmouth, Suffolk, Virginia Beach, Williamsburg	Hampton, Newport News, Norfolk, Portsmouth	Norfolk-VA Beach-Newport News	51-650-0008 (Hampton)	O3, CO, NO2, SO2, PM2.5, PM10
					51-710-0024 (Norfolk)	CO, NO2, SO2, PM2.5, PM10
					51-800-0004 (Suffolk)	O3
					51-800-0005 (Suffolk)	O3
					51-810-0008 (VA Beach)	PM2.5, VOC, Carbonyls, metals
AQCR 7 - Northern Virginia	Arlington, Fairfax, Loudoun, Prince William	Alexandria, Fairfax, Falls Church, Manassas, Manassas Park		Washington DC-MA-VA	51-013-0020 (Arlington)	O3, NO2, CO, PM2.5
					51-059-0030 (Fairfax)	O3, SO2, PM2.5, VOC, carbonyls, metals, PM10
					51-107-1005 (Loudoun)	O3, PM2.5, NO2
					51-153-0009 (Prince William)	O3, NO2
					51-510-0021 (Alexandria)	NO2, CO
					51-510-0020 (Alexandria)	PM10

1.3.3 Air Quality Control Region 3

AQCR 3 is defined in 9 VAC5-20-200 as the Central Virginia Intrastate Air Quality Control region. The counties, independent cities and CBSA/MSA's contained within this AQCR are described in Table 3.1 above. The combined population of the counties and independent cities based on the 2010 census in AQCR 3 is 686,605 with an approximate land area of 24,400 square kilometers. AQCR 3 is served by the Blue Ridge Regional Office located in the city of Roanoke.

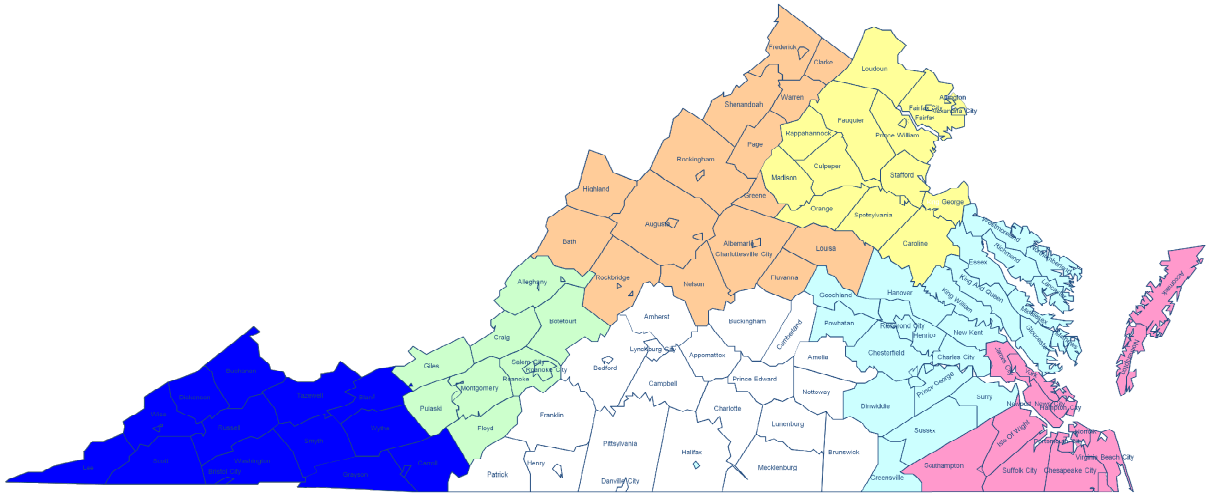

Figure 1.3.3 - Central Virginia Intrastate AQCR (Shown in white)

1.3.4 Air Quality Control Region 4

AQCR 4 is defined in 9 VAC5-20-200 as the Northeastern Virginia Intrastate Air Quality Control region. The counties, independent cities and CBSA/MSA's contained within this AQCR are described in Table 3.1 above. The combined population of the counties and independent cities based on the 2010 census in AQCR 4 is 915,347 with an approximate land area of 21,100 square kilometers. AQCR 4 is served by the Piedmont Regional Office located in the Glen Allen in the county of Henrico, the Valley Regional Office located in the city of Harrisonburg and the Northern Regional Office located in Woodbridge in Prince William County.

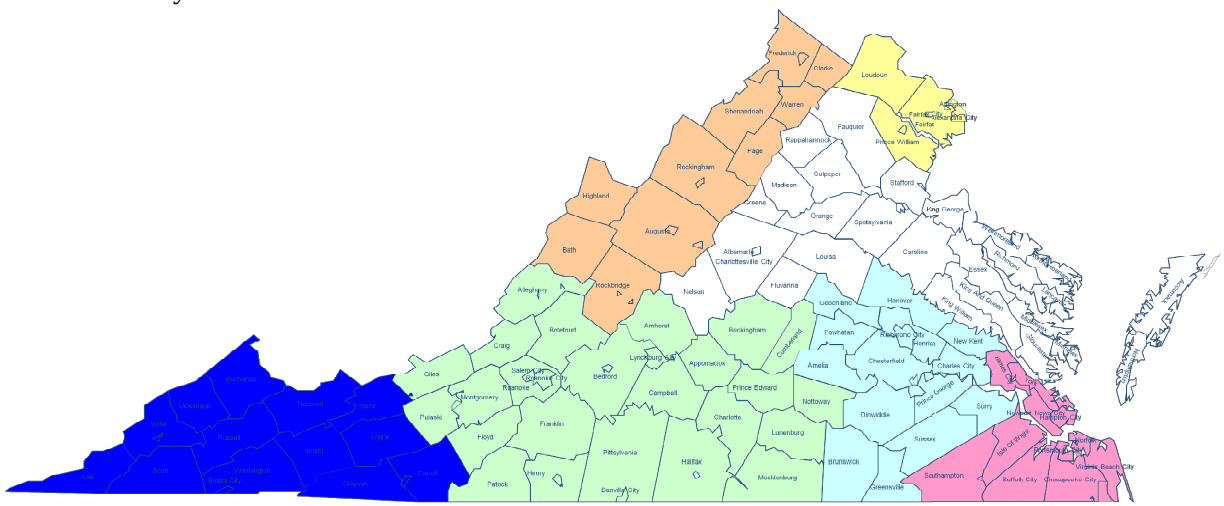

Figure 1.3.4 - Northeastern Virginia Intrastate AQCR (shown in white)

1.3.5 Air Quality Control Region 5

AQCR 5 is defined in 9 VAC5-20-200 as the State Capital Intrastate Air Quality Control region. The counties, independent cities and CBSA/MSA's contained within this AQCR are described in Table 3.1 above. The combined population of the counties and independent cities based on the 2010 census in AQCR 5 is 1,164,072 with an approximate land area of 10,300 square kilometers. AQCR 5 is served by the Piedmont Regional Office located in the Glen Allen in the county of Henrico.

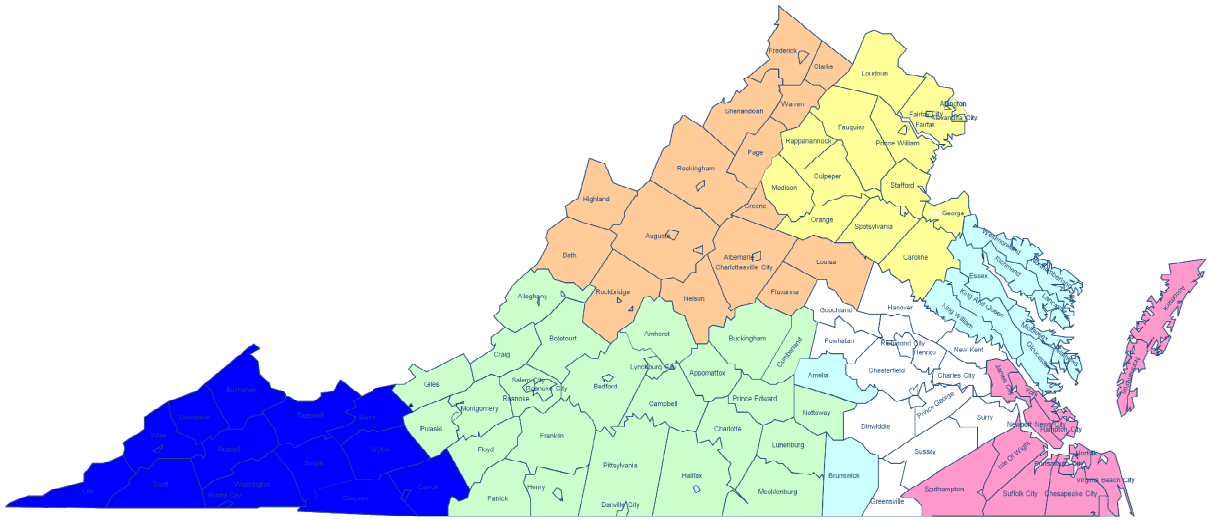

Figure 1.3.5 - State Capital Intrastate AQCR (Shown in white)

1.3.6 Air Quality Control Region 6

AQCR 6 is defined in 9 VAC5-20-200 as the Hampton Roads Intrastate Air Quality Control region. The counties, independent cities and CBSA/MSA's contained within this AQCR are described in Table 3.1 above. The combined population of the counties and independent cities based on the 2010 census in AQCR 6 is 1,622,394 with an approximate land area of approximately 5600 square kilometers. AQCR 6 is served by the Tidewater Regional Office located in the City of Virginia Beach.

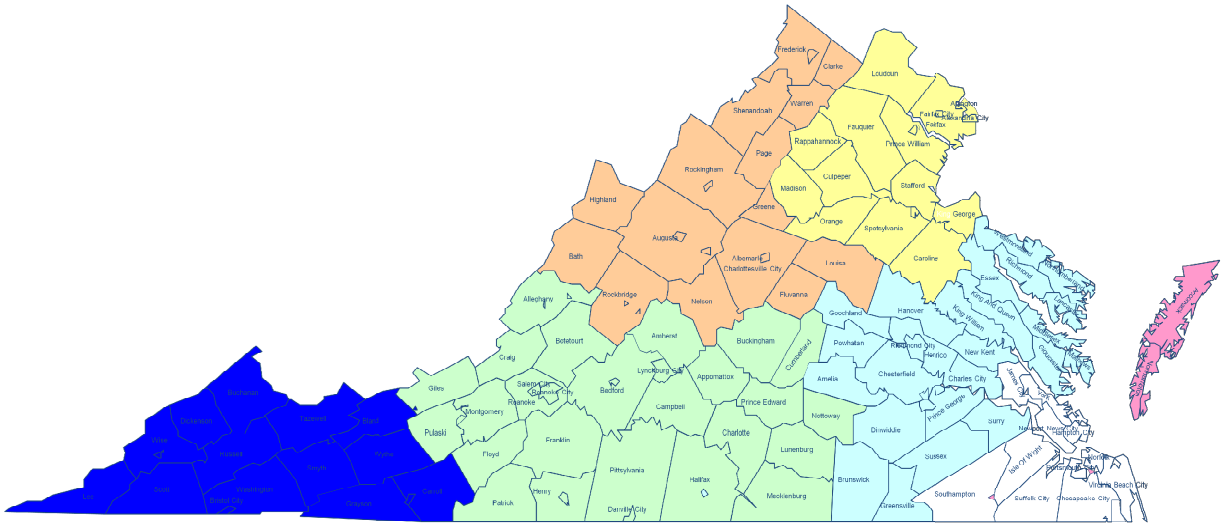

Figure 1.3.6 - Hampton Roads Intrastate AQCR (shown in white)

1.3.7 Air Quality Control Region 7

AQCR 7 is defined in 9 VAC5-20-200 as the National Capital Interstate Air Quality Control region. The counties, independent cities and CBSA/MSA's contained within this AQCR are described in Table 3.1 above. The combined population of the counties and independent cities in AQCR 7 is 2,230,623 with an approximate land area of 3300 square kilometers. AQCR 6 is served by the Northern Regional Office located in the Woodbridge in Prince William County.

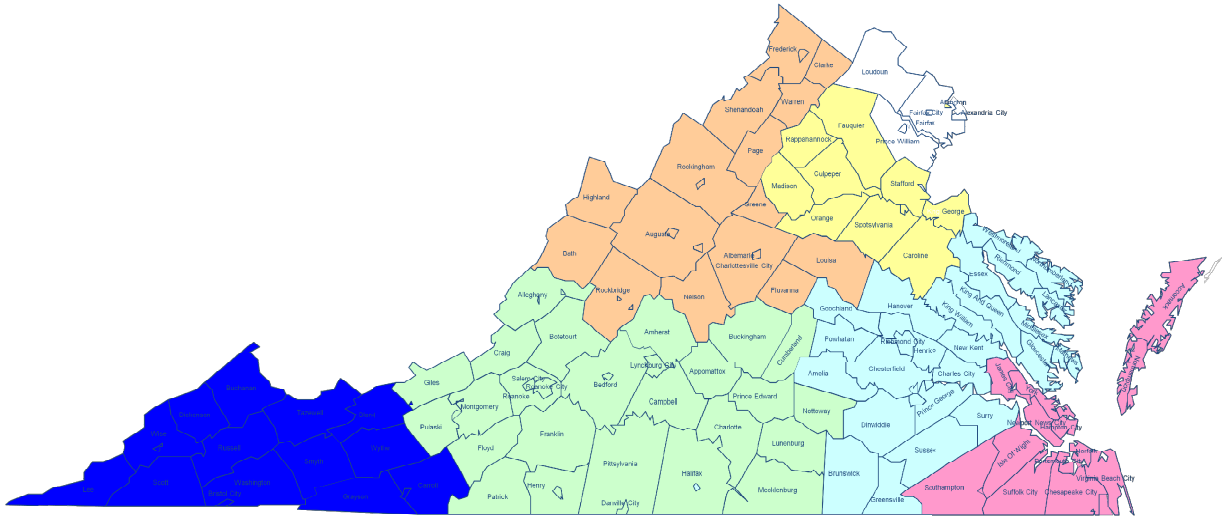

Figure 1.3.7 - National Capital Interstate AQCR (shown in white)

2. PRESENT STATE OF AIR QUALITY IN VIRGINIA

2.1 Ozone Air Quality Trends 2011 – 2013

The concentrations of ambient ozone measured throughout the Commonwealth of Virginia have generally been declining. The trends for all the Air Quality Control Regions within Virginia all have generally declining slopes indicating long term trends toward reduced ozone levels. The most recent design value calculations (2011 – 2013) for ozone are contained in table 2.1.1. Evaluation of the design values as depicted in the Table 2.1.1 indicate compliance with the 0.075 ppm standard at all sites except for Arlington County (51-013-0020) and Fairfax County (51-059-0030).

The design values displayed in Table 2.1.1 are the most recent information as of this writing. In terms of most recent trend information the data from the most recent ten year period (2004 – 2013) indicated a downward trend in the ambient ozone information across all monitoring sites. While two monitoring sites in the AQCR-7 show design values above the 0.075 ppm standard, Figure 2.1.1 below shows the results for the Northern Virginia Non-Attainment area which shows an overall downward trend in ozone concentrations across the region. This downward trend is generally representative of other air quality control regions in Virginia.

Table 2.1.1 Design Value Calculation for Ozone

2011-2013 Fourth-Highest Daily Maximum 8-Hour Ozone Averages (units parts per million)					
	Monitor Location (County/City)	**2011**	**2012**	**2013**	**3-Year Average (NAAQS = .075 ppm)**
Richmond Maintenance Area	Chesterfield Co.	.071	.074	.063	.069
	Henrico Co.	.078	.078	.065	.073
	Hanover Co.	.076	.076	.066	.072
	Charles City Co.	.084	.076	.061	.073
Hampton Roads Maintenance Area	Hampton City	.076	.074	.068	.072
	Suffolk City (TCC)	.076	.071	.065	.070
	Suffolk City (Holland)	.073	.067	.065	.068
Fredericksburg Maintenance Area	Stafford Co.	.074	.076	.064	.071
Northern Virginia Nonattainment Area	Loudoun Co.	.075	.073	.066	.071
	Prince William Co.	.071	.072	.066	.069
	Arlington Co.	.087	.084	.067	.079
	Fairfax Co. (Lee Park)	.087	.084	.067	.079
Shenandoah National Park Maintenance Area	Madison Co. (Big Meadows)	.072	.072	.063	.069
Areas Currently Designated Attainment	Wythe Co.	.064	.066	.059	.063
	Rockbridge Co.	.061	.061	.058	.060
	Rockingham Co.	.069	.067	.058	.064
	Frederick Co.	.067	.070	.060	.065
	Page Co.	.068	.068	.060	.065
	Albemarle Co.	.067	.068	.060	.065
	Roanoke Co.	.067	.070	.057	.064
	Fauquier Co.	.063	.061	.059	.061
	Caroline Co.	.072	.076	.065	.071

Indicates design values over the 0.075 ppm ambient standard

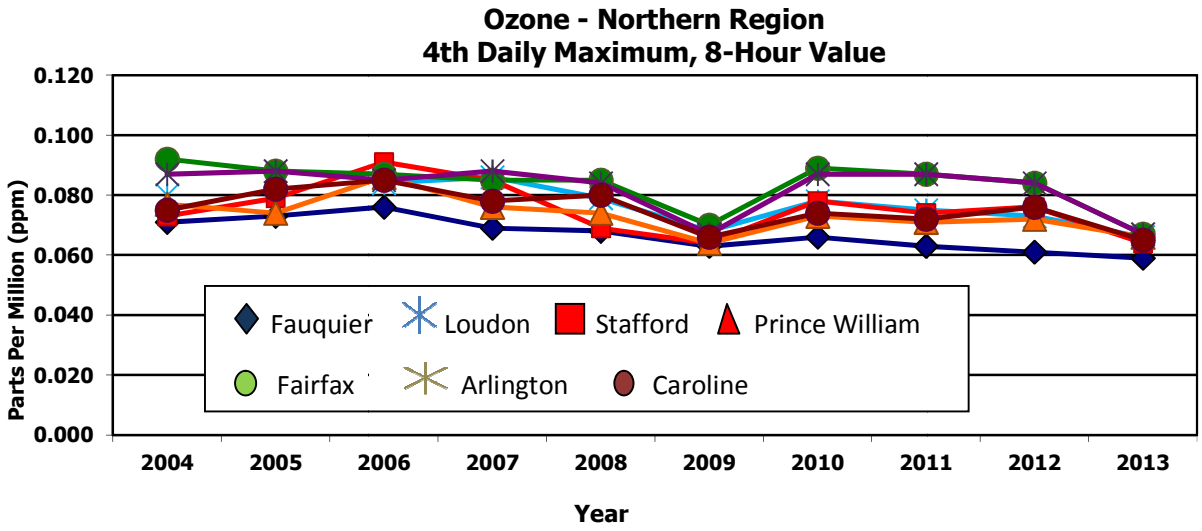

Figure 2.1.1 Ozone Trends 2004 – 2013, Northern Region

2.2 Carbon Monoxide Air Quality: Trends 2010-2014

The concentrations of ambient Carbon Monoxide (CO) measured throughout the Commonwealth of Virginia have generally been declining. The trends for all the Air Quality Control Regions within Virginia all have generally declining slopes indicating long term trends toward reduced CO levels. The most recent data (2013) for Carbon Monoxide are contained in table 2.2.1 below:

Table 2.2.1 Carbon Monoxide most recent year results

		2013			
		1-Hour Avg. (ppm)		8-Hour Avg. (ppm)	
Site	EPA ID No.	1st Max.	2nd Max.	1st Max.	2nd Max.
Vinton	51-161-1004	1.0	1.0	.9	.8
Henrico	51-087-0014	1.9	1.5	1.4	1.2
Richmond	51-760-0024	1.8	1.4	1.2	1.1
Hampton	51-650-0008	1.2	1.1	.9	.9
Norfolk	51-710-0024	2.1	2.0	1.5	1.1
Arlington Co.	51-013-0020	1.2	1.2	1.1	1.0
Alexandria	51-510-0021	5.7	4.9	4.1	3.1

The 2013 calculated values displayed in Table 2.2.1 are the most recent information as of this writing. In terms of most recent trend information the data from the most recent ten year period (2004 – 2013) indicated downward trends in the ambient ozone information. Figure 2.2.1 below shows the results for the Northern Virginia area which is generally representative of other areas of Virginia.

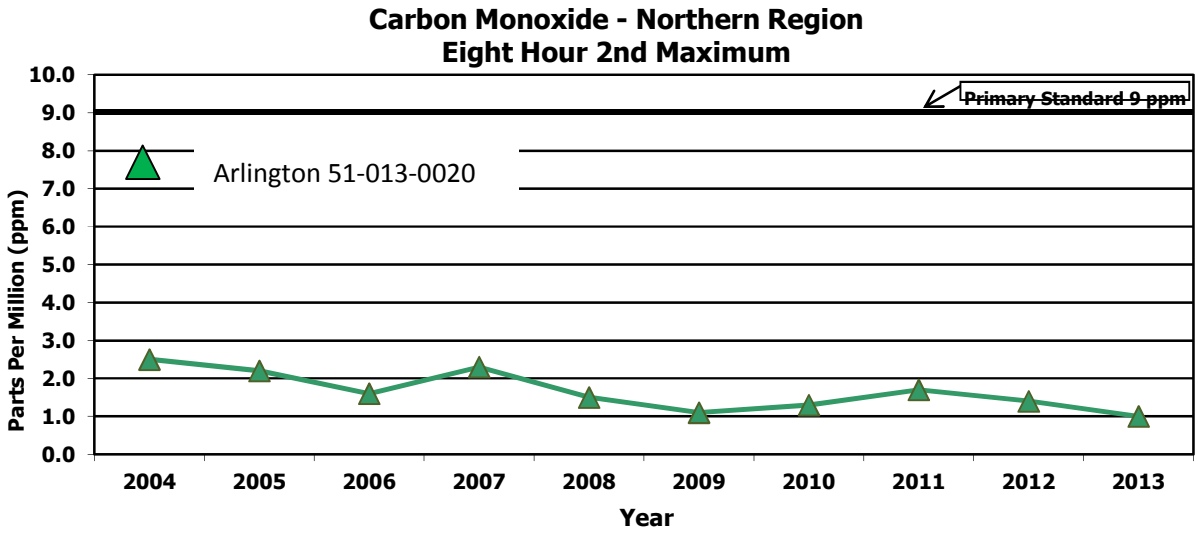

Figure 2.2.1 Carbon Monoxide Trend, 2004 – 2013, Arlington, Northern Region

2.3 Nitrogen Dioxide Air Quality: Trends 2010-2014

The concentrations of ambient Nitrogen Dioxide measured throughout the Commonwealth of Virginia have generally been staying steady for the 2011 – 2013 timeframe as demonstrated by Table 2.3.1 below. The trends for all the Air Quality Control Regions within Virginia all have generally been consistent with the exception of Charles City (51-036-0002) which has shown a strong decreasing trend as demonstrated in the table below.

Table 2.3.1 Nitrogen Dioxide Design Values

Nitrogen Dioxide 98th Percentile 1-Hour Daily Maximum Values (ppb)					
Site	**EPA ID No.**	**2011**	**2012**	**2013**	**3-Yr Avg. Design Value 2011-2013**
Rockingham Co.	51-165-0003	36	35*	40	37
Roanoke Co.	51-161-0003	38	37	35	36
Henrico Co.	51-087-0014	38	39	38	38
Charles City Co.	51-036-0002	55	46	41	47
Hampton	51-650-0008	31	28	28	29
Norfolk	51-710-0024	43	41	41	42
Loudoun Co.	51-107-1005	38	36	37	37
Prince William Co.	51-153-0009	29	25	29	28
Arlington Co.	51-013-0020	46	44	43*	44
Alexandria	51-510-0021			64	NA

*did not meet data completeness criteria

The 2013 design values displayed in Table 2.3.1 are the most recent information as of this writing. In terms of most recent trend information the data from the most recent ten year period (2004 – 2013) indicated downward trends in the ambient ozone information. Figure 2.3.1 below shows the results for the Northern Virginia area which is generally representative of other regions around the Commonwealth
.

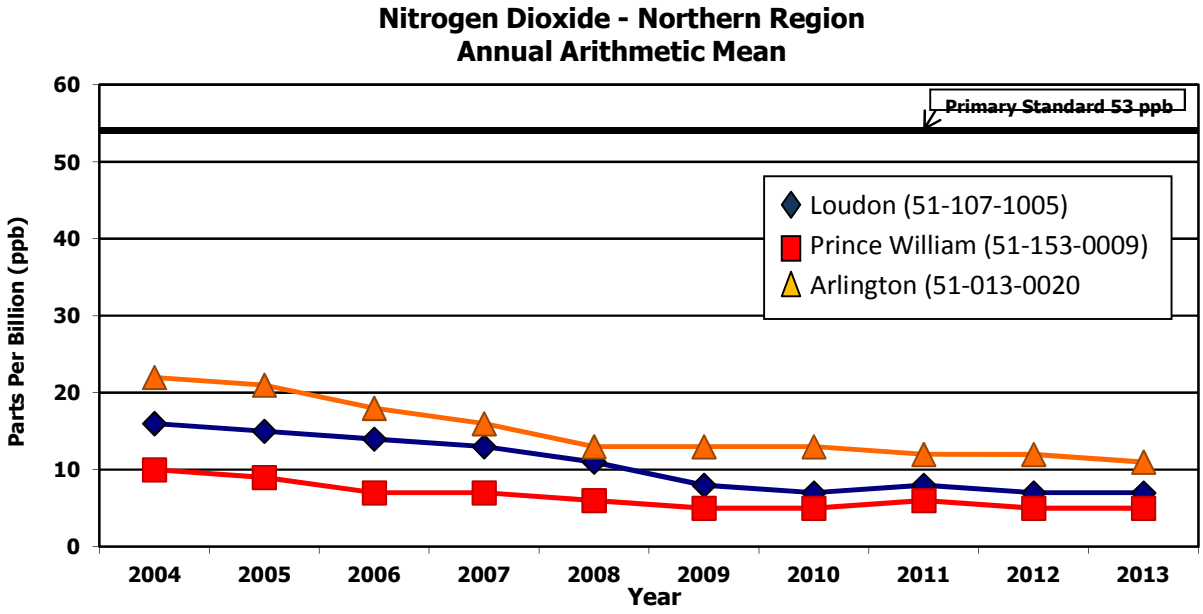

Figure 2.3.1 Nitrogen Dioxide trends 2004 - 2013

2.4. Sulfur Dioxide Air Quality: Trends 2010-2014

The concentrations of ambient Sulfur Dioxide (SO2) measured throughout the Commonwealth of Virginia have generally been declining. The trends for all the Air Quality Control Regions within Virginia all have generally declining slopes indicating long term trends toward reduced SO2 levels. The most recent design value calculations (2011 – 2013) for Sulfur Dioxide are contained in table 2.4.1 below:

Table 2.4.1 Sulfur Dioxide design value, 2011-2013

Sulfur Dioxide 99th Percentile 1-Hour Daily Maximum Values (ppb)					
City/County	**EPA ID No.**	**2011**	**2012**	**2013**	**3-Yr Avg Design Value 2011-2013**
Rockingham Co.	51-165-0003	6	4	4	5
Roanoke Co.	51-161-0003	9	5	6*	6
Henrico Co.	51-087-0014	21	8	6	11
Charles City Co.	51-036-0002	38	21	30	29
Hampton	51-650-0008	39	33	38	37
Norfolk	51-710-0024	54	56	52	54

In terms of most recent trend information the data from the most recent ten year period (2004 – 2013) indicated downward trends in the ambient Sulfur Dioxide data. Figure 2.4.1 below shows the results for the Piedmont Region (AQCR 5).

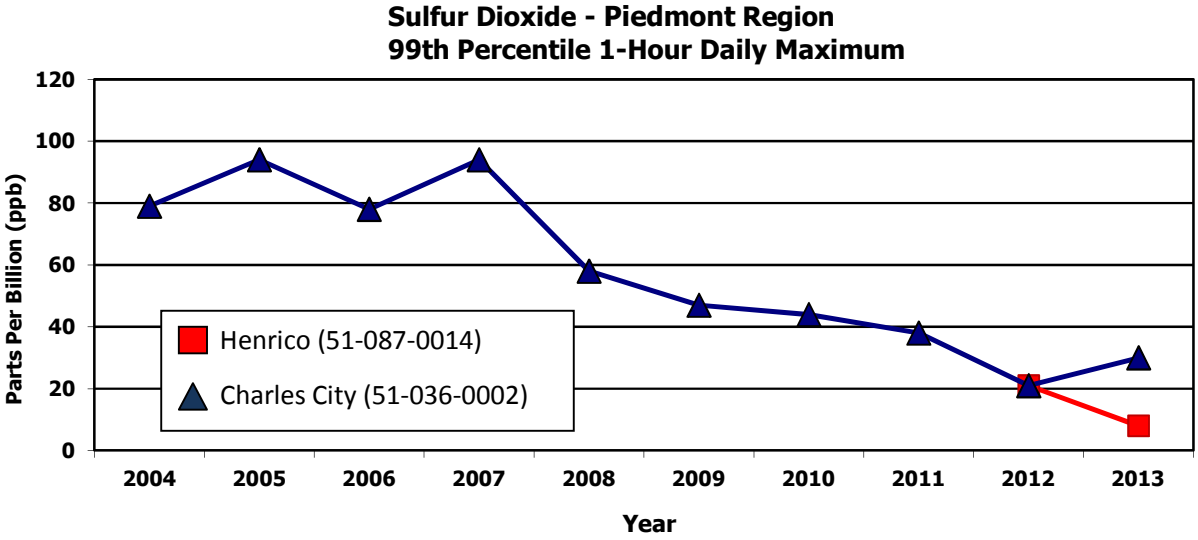

Figure 2.4.1 Sulfur Dioxide Trends 2004 – 2013, Piedmont Region

2.5. PM10 Air Quality: Trends 2010-2014

The concentrations of ambient PM10 measured throughout the Commonwealth of Virginia have generally been steady at levels that are well below the NAAQS standard. The most recent 3 years of data (2011 – 2013) for PM10 are contained in table 2.4.1 below:

Table 2.5.1 PM10 values 2011-2013

2011-2013 PM_{10} 24-Hour Average Concentrations (units in $\mu g/m^3$ STD)								
		2011		2012		2013		>150 $\mu g/m^3$
Site	EPA ID No.	1st Max	2nd Max	1st Max	2nd Max	1st Max	2nd Max	
Carroll Co.	51-035-0001	31	28	28	26	34	22	0
Winchester	51-840-0002	35	28	32	28	21	19	0
Roanoke	51-161-1004	65	39	38	31	62	45	0
Henrico Co.	51-087-0014	39	34	31	28	26	22	0
Hopewell	51-670-0010	38	32	31	27	23	19	0
King William Co.	51-101-0003	154*	40	30	29	27	22	1
Hampton	51-650-0008	67	35	34	32	22	19	0
Norfolk	51-710-0024	71*	58*	35	32	29	21	0
Fredericksburg	51-630-0004	36	28	34	29	29	21	0

* Dismal Swamp Wildfire, August 2011

2.6. PM2.5 Air Quality: Trends 2010-2014

The concentrations of ambient Particulate Matter less than 2.5 micrometers (PM2.5) measured throughout the Commonwealth of Virginia have generally been declining. The trends for all the Air Quality Control Regions within Virginia all have generally declining slopes indicating long term trends toward reduced PM2.5 levels. PM2.5 has both a 24 hour standard (35 µg/m3) and an annual standard (12 µg/m3). The most recent 3 year average value calculations (2011 – 2013) for the 24 hours standard are contained in table 2.6.1 below:

Table 2.6.1 PM2.5 most recent 3 year value (2011-2013)

2011-2013 $PM_{2.5}$ 24-hour Averages, 98th Percentile Values ($\mu g/m^3$, LC)					
Site	**EPA ID No.**	**2011**	**2012**	**2013**	**3-Year Average**
Bristol	51-520-0006	21.5	16.5	16.2	18
Rockingham Co.	51-165-0003	22.8	17.5	21.2	21
Frederick Co.	51-069-0010	23.8	22.6	23.5	23
Page Co.	51-139-0004	21.2	17.2	19.8	19
Albemarle Co.	51-003-0001	19.2	17.0	18.9	18
Salem	51-775-0011	21.5	16.4*	18.7*	19
Lynchburg	51-680-0015	18.3	15.7	18.2	17
Chesterfield Co.	51-041-0003	22.0	20.0	20.4*	21
Henrico Co.	51-087-0014	23.2	19.1	19.3	21
Henrico Co.	51-087-0015	18.6*	18.3	18.5	18
Charles City Co.	51-036-0002	21.6	20.0	18.2	20
Hampton	51-650-0008	25.0	20.9	15.9	21
Norfolk	51-710-0024	24.7	21.7	15.8	21
Va. Beach	51-810-0008	25.6	22.7	18.0	22
Loudoun Co.	51-107-1005	20.5	20.6	19.9	20
Arlington Co.	51-013-0020	21.2*	21.8	21.2	21
Fairfax Co.	51-059-0030	24.1	21.1	21.0	22

* Annual value did not meet completeness criteria

The annual standard for PM2.5 was revised and tightened in December of 2012. The standard was changed from 15 µg/m3 to 12 µg/m3. Table 2.6.2 below contains data to which the old 15 µg/m3 standard applies and to which the new standard applies. In all cases as demonstrated in Table 2.6.2 the PM2.5 newer annual standard has been met at all sites in the Commonwealth. The information in both tables are taken from the filter based sequential samplers at the sites designated in the tables. Virginia does maintain a network of continuous samplers but the measurement technology for these samplers has not been designated a Federal Equivalent Method (FEM) therefore they cannot be used for comparison with the NAAQS standards. These analyzers are used for the purpose of PM2.5 AQI forecasting.

Table 2.6.2 Annual PM2.5 data for 2011 – 2013

2011-2013 $PM_{2.5}$ Weighted Annual Arithmetic Means ($\mu g/m^3$, LC)					
Site	**EPA ID No.**	**2011**	**2012**	**2013**	**3-Year Average**
Bristol	51-520-0006	9.8	8.8	8.5	9.0
Rockingham Co.	51-165-0003	9.6	8.8	8.4	8.9
Frederick Co.	51-069-0010	10.0	9.8	8.8	9.5
Page Co.	51-139-0004	8.7	8.3	7.2	8.1
Albemarle Co.	51-003-0001	8.5	7.8	7.6	7.9
Salem	51-775-0011	9.9	8.9*	8.6*	9.1
Lynchburg	51-680-0015	8.4	7.6	7.4	7.8
Chesterfield Co.	51-041-0003	9.3	8.9	8.2*	8.8
Henrico Co.	51-087-0014	9.5	8.6	8.1	8.7
Henrico Co.	51-087-0015	8.6*	8.3	7.8	8.3
Charles City Co.	51-036-0002	8.8	8.1	7.6	8.2
Hampton	51-650-0008	8.8	7.7	7.1	7.9
Norfolk	51-710-0024	10.5	8.1	7.5	8.7
Va. Beach	51-810-0008	9.6	8.2	7.7	8.5
Loudoun Co.	51-107-1005	9.1	9.0	8.5	8.9
Arlington Co.	51-013-0020	9.9*	9.4	8.9	9.4
Fairfax Co.	51-059-0030	9.2	8.7	8.3	8.8

* Annual value did not meet completeness criteria

2.7. Lead Air Quality: Trends 2010-2014

The concentrations of ambient Lead (Pb) measured throughout the Commonwealth of Virginia are generally well below the ambient standard. The data for the Roanoke monitor (51-770-0011) is the one exception to this observation. Table 2.7.1 below provides the most recent results for the lead network in Virginia:

Table 2.7.1 2013 Lead monitoring results

2013 Pb 3-Month Averages (units in $\mu g/m^3$, LC)					
Site	**EPA ID No.**	**No. 24-Hour Observations**	**1st Max**	**2nd Max**	**>0.15 $\mu g/m^3$**
Buchanan Co.	51-027-0006	59	0.01	0.01	0
Roanoke*	51-770-0011	36	0.11	0.11	0
Amherst Co.	51-009-007	59	0.01	0.01	0
Henrico Co.	51-087-0014	59	0.00	0.00	0

* Incomplete data for 2013

2.8. Population Trends and Health Demographics

2.8.1 Population Trends

This report uses the most recent census data (2010) for the descriptive information about AQCR's within the Commonwealth for Section 1.3 above. The population changes can be projected based on US census information through 2014. Table 2.8.1 below summarizes these numbers. These numbers are only projections based on a 2010 baseline and expected growth patterns and should not be definitive.

Table 2.8.1 Projected population growth through 2014

Geographic Area	Baseline – 2010 Census	Projected – July 1, 2014	Percentage Change	Baseline Percent – total population	Projected Percent - total population
Commonwealth of Virginia	7,994,802	8,326,289	4.15		
AQCR 1 Eastern Tennessee – Southwestern Virginia	401,745	392,132	-2.39	5.0	4.7
AQCR 2 Valley of Virginia	961,929	983,923	2.20	12.0	11.8
AQCR 3 Central Virginia	686,605	688,905	0.33	8.6	8.3
AQCR 4 Northeast Virginia	915,347	955,993	4.44	11.4	11.5
AQCR 5 State Capital	1,176,159	1,225,143	3.18	14.7	14.7
AQCR 6 Hampton Roads	1,622,394	1,660,689	2.36	20.3	19.9
AQCR 7 National Capital	2,230,623	2,419,504	8.47	27.9	29.1

Generally, based on the projected information presented above, one can project that the population throughout the Commonwealth has generally increased in most AQC Regions through 2014. Table 2.8.1 demonstrates the high degree of variability among the Air Quality Control regions in terms of current population and projected growth rates. While the rate of population change varies for each AQCR the relative percentages stay proportionately constant with the exception of AQCR 7 which increases the relative percentage of population by 4%. The projected growth rates for all AQCRs within Virginia do not require an increase in the number of monitors strictly because of the population increase. Table 2.8.2 below provides a breakdown of the required monitors for each pollutant in each AQCR based on 1) the census data; 2) projected population and 3) other regulatory requirements and the actual number of monitors for the AQCR. Care must be taken in interpreting this table. In some cases the AQCR contains only a portion of a specific MSA. The required number of monitors for the AQCR in this case includes the requirements for the affected MSA but the total number of monitors applied includes all monitors in the MSA.

Table 2.8.2 Monitor coverage relative to regulatory and population requirements

Pollutant ⇨	Ozone				PM2.5				PM10				NO2				SO2				Lead (Pb)			
Population ⇨	Baseline		projected		Baseline		projected		Baseline		projected		Baseline		projected		Baseline		projected		Baseline		projected	
Monitors ⇨	Regs	Actual	Regs	Actual	Regs	Actual	Regs	Actual	Regs	Actual	Regs	Actual	Regs	Actual	Regs	Actual	Regs	Actual	Regs	Actual	Regs	Actual	Regs	Actual
AQCR 1	0	1	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	1	0	0
AQCR 2	2	6	0	6	0	4	0	4	0	1	0	1	0	2	0	2	0	2	0	2	1	1	1	1
AQCR 3	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
AQCR 4	4	4	4	4	0	1	0	1	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
AQCR 5	2	4	2	4	2	4	2	4	2	2	2	2	3	3	3	3	2	2	2	2	1	1	0	0
AQCR 6	2	3	2	3	2	3	2	3	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0
AQCR 7	2	4	2	4	2	3	2	3	2	2	2	2	2	2	2	2	3	5	3	5	0	0	0	0

These numbers include SO2 monitors located within the Washington MSA outside the Commonwealth of Virginia

These numbers include Ozone Monitors throughout affected MSAs not just in those counties included in the AQCR

These numbers do not include the Near Road sites that are required but not yet built

2.8.2 Health Demographic Data

The Virginia Department of Health (VDH) maintains the health statistics for the Commonwealth of Virginia. For the purposes of this report, DEQ looked only at asthma statistics as they relate to the entire Population of the Commonwealth and broken down by Region as defined by VDH. The Health regions were broken down into local Health district and the districts were associated with the appropriate AQCR. Those health districts for which no data was provided were not included in Table 2.8.4.

Table 2.8.3 Statewide Asthma statistics

Virginia BRFSS Online Reporting System		**2011**		**2012**		**2013**	
		Asthma percentage		**Asthma percentage**		**Asthma percentage**	
		Weighted Percent (%)	**C.I. (95%)**	**Weighted Percent (%)**	**C.I. (95%)**	**Weighted Percent (%)**	**C.I. (95%)**
***Virginia**	***State Total**	**8.7**	**7.7 -9.8**	**8.7**	**7.9 -9.6**	**8.7**	**7.9 -9.5**
Race/Ethnicity	**White/Non-Hispanic**	**9.0**	**7.8 -10.3**	**8.3**	**7.4 -9.3**	**8.4**	**7.5 -9.3**
	Black/Non-Hispanic	**8.9**	**6.6 -11.2**	**11.1**	**8.6 -13.7**	**11.4**	**8.9 -13.9**
	Hispanic	**- - -**	**- - -**	**6.4**	**3.4 -9.3**	**7.0**	**3.7 -10.3**
	Other	**11.1**	**5.9 -16.2**	**9.3**	**6.3 -12.2**	**7.3**	**4.4 -10.1**
Education	**< H.S.**	**12.8**	**9.5 -16.1**	**15.0**	**11.7 -18.3**	**11.6**	**8.7 -14.6**
	H.S. or G.E.D.	**8.2**	**6.3 -10.1**	**7.2**	**5.7 -8.7**	**9.5**	**7.9 -11.1**
	Some College	**8.2**	**6.4 -10.1**	**8.6**	**6.9 -10.2**	**8.4**	**6.8 -9.9**
	College Graduate	**8.0**	**6.1 -9.9**	**7.6**	**6.5 -8.8**	**7.4**	**6.2 -8.6**
Income	**$15,000 or less**	**20.0**	**15.2 - 24.8**	**16.5**	**12.7 -20.3**	**15.9**	**12.5 -19.3**
	$15,000 to less than $25,000	**8.9**	**6.4 -11.4**	**9.7**	**7.3 -12.1**	**11.9**	**9.5 -14.3**
	$25,000 to less than $35,000	**9.0**	**5.4 -12.6**	**10.4**	**6.7 -14.1**	**7.5**	**5.0 -9.9**
	$35,000 to less than $50,000	**7.2**	**4.6 -9.8**	**7.5**	**5.5 -9.5**	**7.9**	**5.6 -10.3**
	$50,000 or more	**6.9**	**5.4 -8.4**	**7.1**	**6.0 -8.3**	**6.7**	**5.6 -7.8**
Age	**Age 18 to 24**	**- - -**	**- - -**	**7.4**	**4.5 -10.4**	**10.2**	**7.2 -13.2**
	Age 25 to 34	**6.5**	**4.1 -8.9**	**9.0**	**6.6 -11.5**	**7.3**	**5.3 -9.2**
	Age 35 to 44	**9.7**	**7.1 -12.3**	**6.9**	**5.1 -8.8**	**8.0**	**6.1 -10.0**
	Age 45 to 54	**9.5**	**7.1 -11.9**	**9.7**	**7.5 -11.8**	**10.2**	**8.1 -12.2**
	Age 55 to 64	**10.7**	**8.2 -13.2**	**11.2**	**9.4 -13.0**	**9.9**	**8.2 -11.5**
	Age 65 or older	**8.1**	**6.5 -9.8**	**8.0**	**6.6 -9.4**	**7.2**	**5.8 -8.5**
Gender	**Female**	**12.3**	**10.6 - 14.0**	**11.3**	**10.0 -12.6**	**11.6**	**10.4 -12.9**
	Male	**5.0**	**4.0 -6.1**	**6.0**	**4.9 -7.2**	**5.6**	**4.7 -6.6**

The following caveats and explanations should be taken into account when evaluating Table 2.8.4. The Data source for the statistics below is the Virginia Department of Health, Division of Policy and

Evaluation, Behavioral Risk Factor Surveillance Survey, 2011. Weighted counts and weighted percents are weighted to population characteristics. The "- - -" replaces estimates when the unweighted sample size for the denominator was < 20 or the CI half width was > 10 for any cell. Responses of don't know/not sure, refused, or missing were removed from the numerator and denominator in all estimates. The VDH also stated that the user should use caution in interpreting sample sizes less than 50.

Table 2.8.4 Asthma statistics by VA department of Health districts

			2011		2012		2013	
			Asthma percentage		Asthma percentage		Asthma percentage	
		AQCR impacted	Weighted Percent (%)	C.I. (95%)	Weighted Percent (%)	C.I. (95%)	Weighted Percent (%)	C.I. (95%)
	*State Total		8.7	7.7 - 9.8	8.7	7.9 - 9.6	8.7	7.9 - 9.5
Central	*Region Total		9.1	6.5 -11.8	9.2	7.1 -11.3	9.2	7.3 -11.1
	Chesterfield	AQCR 5	- - -	- - -	- - -	- - -	10.9	6.7 -15.1
	Crater	AQCR 5	- - -	- - -	- - -	- - -	11.1	6.4 -15.7
	Henrico	AQCR 5	- - -	- - -	9.4	3.9 -14.8	- - -	- - -
	Piedmont	AQCR 3	- - -	- - -	- - -	- - -	7.0	3.2 -10.8
	Richmond City	AQCR 5	- - -	- - -	- - -	- - -	14.7	7.7 -21.8
Eastern	*Region Total		8.8	6.6 -11.0	8.5	6.6 -10.4	8.8	7.1 -10.5
	Chesapeake	AQCR 6	- - -	- - -	- - -	- - -	9.3	4.2 -14.4
	Norfolk City	AQCR 6	- - -	- - -	14.1	7.0 -21.2	- - -	- - -
	Peninsula	AQCR 6	- - -	- - -	7.1	3.4 -10.9	7.8	3.7 -11.8
	Virginia Beach	AQCR 6	- - -	- - -	- - -	- - -	7.8	4.6 -11.0
Northern	*Region Total		6.7	4.6 - 8.9	7.5	6.0 - 9.1	7.6	5.7 - 9.5
	Fairfax	AQCR 7	6.4	2.6 -10.1	8.1	5.9 -10.3	8.6	5.6 -11.7
	Prince William	AQCR 7	9.0	4.9 -13.1	8.1	4.7 -11.5	- - -	- - -
Northwestern	*Region Total		8.7	6.0 -11.3	9.8	7.5 -12.2	8.5	6.8 -10.2
	Rappahannock	AQCR 4	- - -	- - -	- - -	- - -	9.4	5.7 -13.0
	Rappahannock/ Rapidan	AQCR 4	- - -	- - -	- - -	- - -	12.1	6.7 -17.5
	Thomas Jefferson	AQCR 4	- - -	- - -	- - -	- - -	9.3	5.3 -13.2
Southwestern	*Region Total		10.7	8.6 -12.9	9.3	7.5 -11.2	9.8	7.9 -11.7
	Alleghany	AQCR 2	- - -	- - -	- - -	- - -	7.6	4.0 -11.2
	Cumberland Plateau	AQCR 1	17.7	8.9 -26.5	- - -	- - -	16.4	11.0 - 21.9
	Lenowisco	AQCR 1	- - -	- - -	11.9	6.0 -17.9	13.9	7.8 -20.0
	New River	AQCR 2	- - -	- - -	- - -	- - -	11.2	6.4 -16.0
	Pittsylvania/ Danville	AQCR 3	14.0	6.9 -21.1	- - -	- - -	- - -	- - -

3. Air Monitoring Network Analysis

3.1 Ozone Network

3.1.1 Southwest Virginia Ozone AQCR-1

There is a single ozone monitoring Site (51-197-0002) in Wythe, VA which covers the Southwest Virginia region identified as AQCR-1. The location of the Wythe Site is on the map shown in Figure 2.1.1. This region has 13 counties and two MSA which are the Bluefield WV-VA region and the Kingsport-Bristol-TN-VA region. The Wythe ozone monitor covers an area of 10,857 km^2 and this is approximately 70% of AQCR-1.

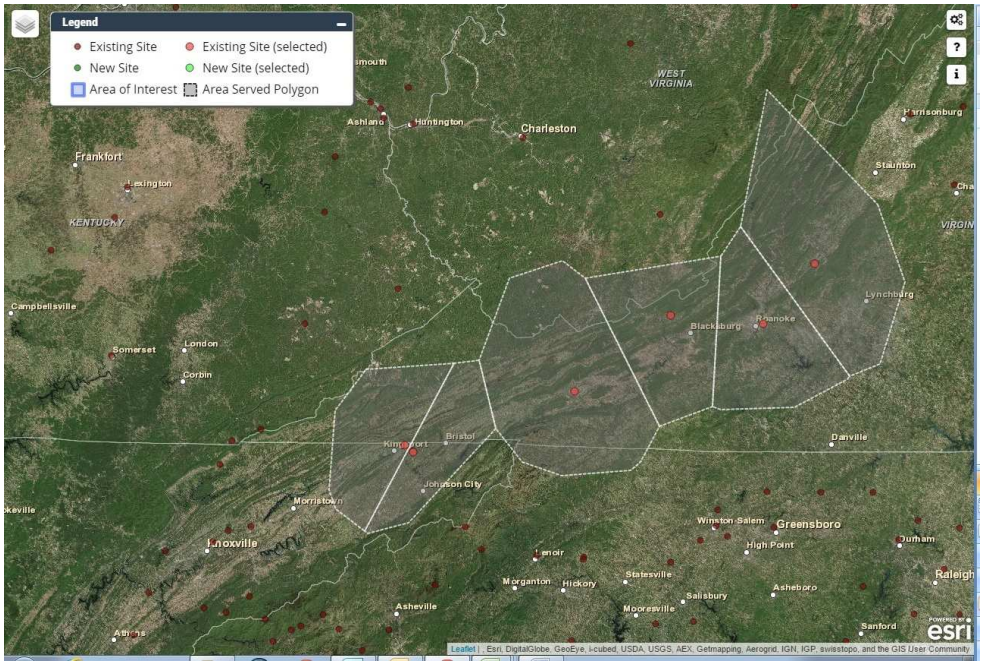

Figure 3.1.1. Ozone monitors in Southwest Virginia.

To evaluate if it would be beneficial to add another ozone monitoring Site in the Southwest Region, the 8-hour average ozone measurements at this Site were compared to the 8-hr average ozone measured at the closest monitors in the Valley Region (AQCR-2) and in the neighboring State of Tennessee. The analysis was done using the NetAssess tools for the correlation of Wythe Site with the ozone monitors closest in proximity and the results are shown in Figure 3.1.2. The list of these monitors with relevant information is given in Table 3.1.1. Two of the Sites are located in Tennessee (47-163-2003; 47-163-2002) and were selected since these Sites are nearest to the Kingsport-Bristol-TN-VA MSA.

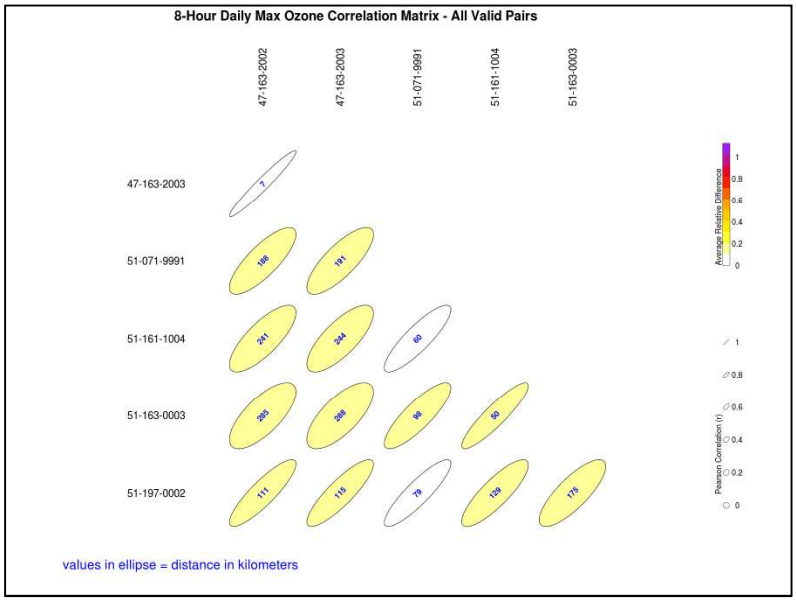

Figure 3.1.2 Pearson Correlations for the Ozone Sites in MSA/CBSA in Southwest Virginia

The Pearson's correlations using the 2011-2013 data show in Table 3.1.2 that the correlations for Wythe Site ranged from 0.801 to 0.884 which is a high degree of correlation. This indicates that the 8-hour average O_3 concentrations at this Site are similar to the ozone levels measured at the neighboring areas. The relative differences for this Site compared to the other 5 Sites ranges from 0.095 to 0.143, which is low and indicates that the ozone levels for this Site are very similar compared to the other Sites.

Table 3.1.1 Assessment of AQCR-1 Ozone Sites compared to nearby ozone monitors

Site ID	Location (county)	Area Served (km^2)	Population served	Ozone Design Value 2011	Ozone Design Value 2012	Ozone Design Value 2013	Ozone Probability of Exceeding 75 ppb
51-197-0002	Wythe	10857	267617	0.064	0.066	0.063	<25%
47-163-2002	Tennessee	3772	314729	0.07	0.074	0.071	25%-50%
47-163-2003	Tennessee	4714	230991	0.07	0.072	0.069	50%-70%
51-071-9991	Giles	6070	217929	NA	NA	0.063	25%-50%
51-161-0004	Roanoke	6065	334520	0.068	0.07	0.064	25%-50%
51-163-0003	Rockbridge	10152	298195	0.063	0.064	0.060	25%-50%

As the Southwest region is not densely populated and has few major sources of VOCs, hence chances are low that the ozone levels would exceed the NAAQS standard. This is reflected in the low ozone exceedance probability numbers seen in Table 3.1.1.

Table 3.1.2 Correlation between AQCR-1 Ozone Site compared to nearby ozone monitors

Site 1	Site 2	n	Correlation	Relative Difference	Distance
51-197-0002	47-163-2002	627	0.874	0.104	111
51-197-0002	47-163-2003	632	0.863	0.111	115
51-197-0002	51-071-9991	580	0.884	0.095	79
51-197-0002	51-161-1004	634	0.843	0.104	129
51-197-0002	51-163-0003	630	0.801	0.143	175

3.1.2 Valley Region AQCR-2

There are 6 ozone monitoring Sites in the Valley Region, and their locations are shown on the map in Figure 3.2.1. The region has 16 counties and four MSA/CBSAs in Winchester, Roanoke, Harrisonburg and Waynesboro-Staunton. Table 3.2.1 gives details on these Sites and the ozone design values for 2011-2013, and the probability of exceeding the current standard of 0.075 ppm. The exceedance probability is calculated by NetAssess based on historical data and it is highest for the northern most Site in Frederick County (51-069-0010) which is in the marginal ozone nonattainment area. All the Sites are located along the I-81 corridor which is the major highway in this region. The Big Meadows site in Madison County (51-113-0003) is approximately 3500 feet above sea level and is viewed more reflective of ozone transport concentrations.

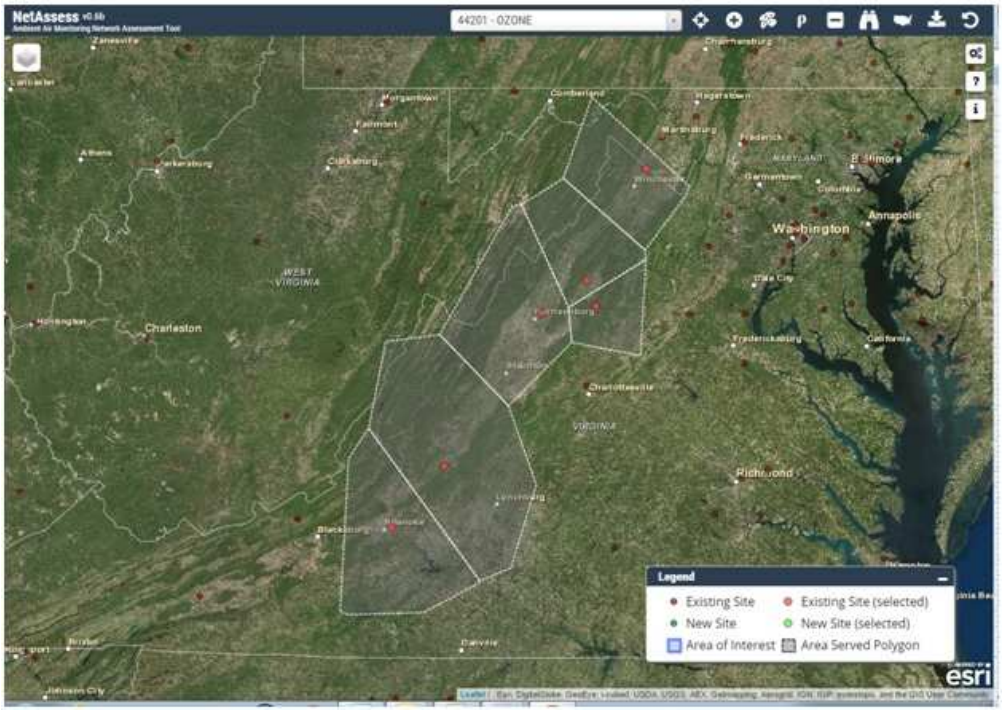

Figure 3.2.1 Ozone Sites in AQCR-2

To evaluate if the existing ozone Sites are providing adequate coverage, and if there were any redundancies, the Pearson's correlations between Sites was calculated using the NetAssess tool. Figure 3.2.2 shows the 8-hour average daily maximum correlation between the Sites, and Table 3.2.2 shows the data for correlation coefficients and relative differences between Sites.

Table 3.2.1 Assessment of Ozone Sites in AQCR-2

Site ID	Location (county)	Area Served (sq. km.)	Population served	Ozone Design Value 2011	Ozone Design Value 2012	Ozone Design Value 2013	Ozone Probability of Exceeding 75ppb
51-069-0010	Frederick	3596	199269	0.066	0.069	0.065	50%-70%
51-113-0003	Madison	1824	51653	0.071	0.072	0.069	25%-50%
51-139-0004	Page	3109	78872	0.066	0.068	0.065	25%-50%
51-161-1004	Roanoke	6065	334520	0.068	0.07	0.064	25%-50%
51-163-0003	Rockbridge	9608	293379	0.063	0.064	0.06	25%-50%
51-165-0003	Rockingham	5571	205660	0.066	0.068	0.064	25%-50%
Total		29,773	1,163,353				

Table 3.2.2 Correlations for the Ozone Sites in AQCR-2

Site 1	Site 2	n	Correlation	Relative Difference	Distance (km)
51-069-0010	51-113-0003	612	0.765	0.209	90
51-069-0010	51-139-0004	634	0.899	0.111	78
51-069-0010	51-161-1004	633	0.734	0.165	273
51-069-0010	51-163-0003	630	0.684	0.18	222
51-069-0010	51-165-0003	606	0.882	0.113	110
51-113-0003	51-139-0004	611	0.859	0.137	17
51-113-0003	51-161-1004	609	0.801	0.139	188
51-113-0003	51-163-0003	609	0.785	0.233	137
51-113-0003	51-165-0003	583	0.838	0.15	34
51-139-0004	51-161-1004	631	0.836	0.114	196
51-139-0004	51-163-0003	628	0.838	0.143	145
51-139-0004	51-165-0003	605	0.955	0.059	34
51-161-1004	51-163-0003	626	0.907	0.129	50
51-161-1004	51-165-0003	603	0.852	0.11	163
51-163-0003	51-165-0003	601	0.841	0.137	113

The correlations ranged from 0.684 to 0.955 and the relative difference between the Sites ranged from 0.06 to 0.23 which indicates that the Sites are very well correlated for their 8-hour average daily maximum ozone values. The highest correlation of 0.95 was between the Sites in Page county and Rockingham county as these Sites are within a distance of 34 km. The two Sites farthest apart in Frederick and Roanoke counties at a distance of 273 km were also well correlated (0.73) perhaps driven by similarities in ozone precursors levels during 2011-2013.

The 6 ozone Sites in this Region are providing coverage for over 100% of the land area in this region, the total land coverage for the 6 ozone monitors is 29,773 km^2. To evaluate redundancies in the ozone Sites the removal bias was evaluated using the NetAssess tool, which uses 2011-2013 data. The map in Figure 3.2.3 shows the removal bias in colored circles at the Site locations with red circles indicating a positive bias and blue circles indicating a negative bias. The removal bias is based on nearby Sites data and uses an inverse distance squared weighting. The bias is the difference between actual concentration and estimated concentration.

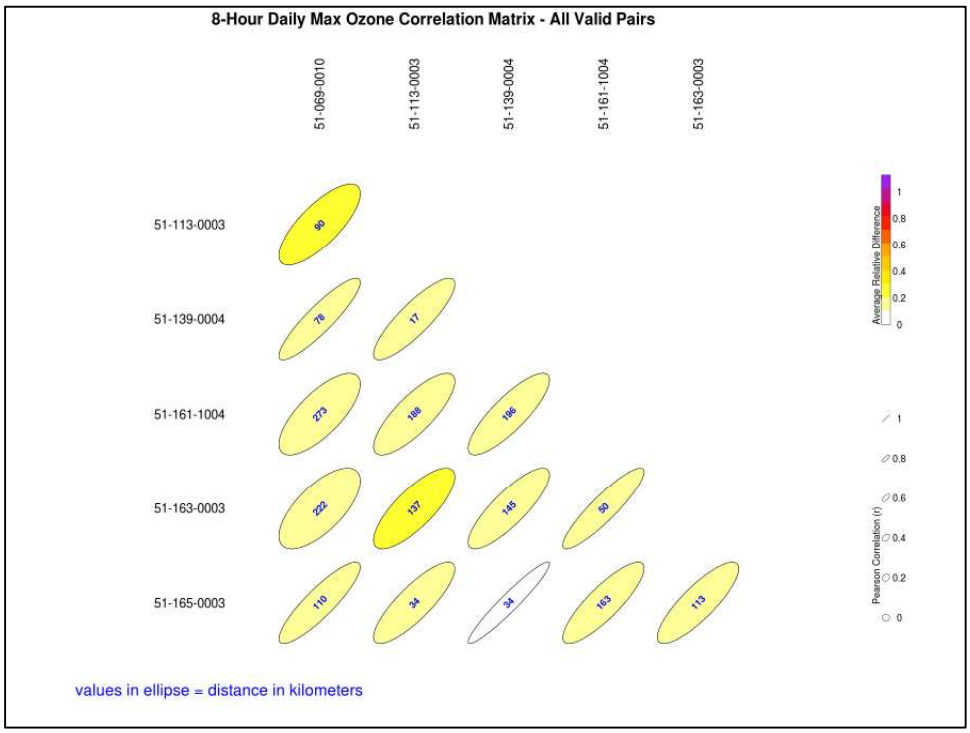

Figure 3.2.2 Correlations between Ozone Sites in AQCR-2

The removal bias data are shown in Table 2.2.3 and as seen the mean removal bias is lowest for the Site in Madison county which serves the smallest area (1,824 km^2) among all the 6 Sites. The Roanoke Site also has a negative mean removal bias, however since Roanoke is a MSA, hence an important location and would not be recommended for removal.

Table 3.2.3 Removal Bias for Ozone Sites in AQCR-2

Site ID	Location (county)	Neighbors	Mean Removal Bias (ppm)	Min Removal Bias (ppm)	Max Removal Bias (ppm)
51-069-0010	Frederick	5	0.002	-0.013	0.013
51-113-0003	Madison	4	-0.006	-0.036	0.005
51-139-0004	Page	6	0.004	-0.016	0.024
51-161-1004	Roanoke	7	-0.002	-0.015	0.017
51-163-0003	Rockbridge	7	0.004	-0.007	0.019
51-165-0003	Rockingham	6	0.002	-0.009	0.024
51-069-0010	Frederick	5	0.002	-0.013	0.013

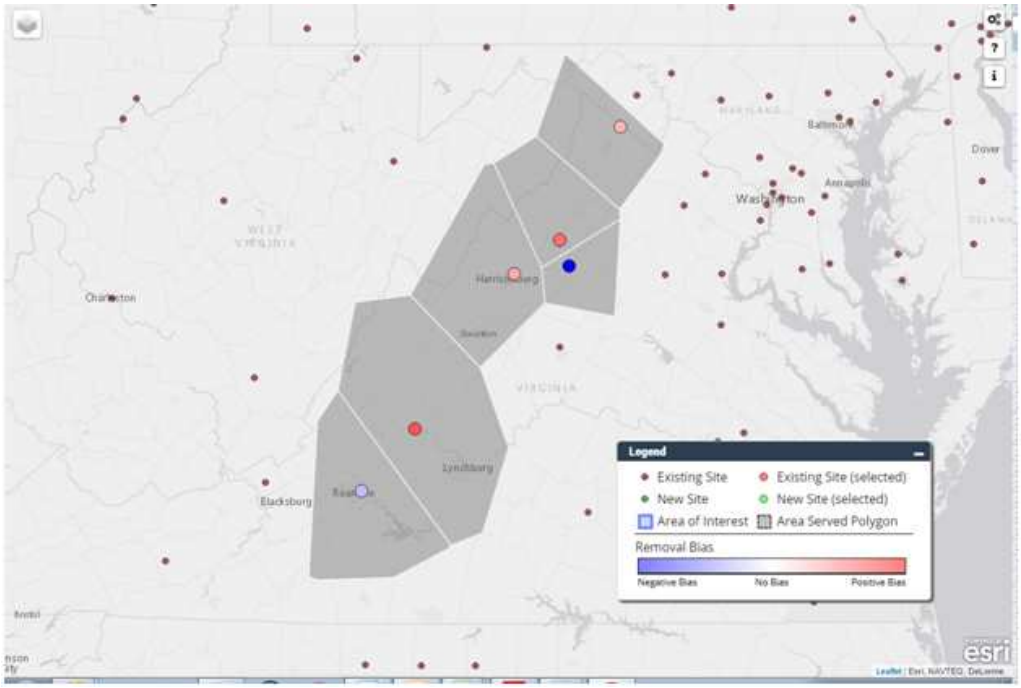

Figure 3.2.3 Removal Bias for Ozone Sites in AQCR-2

3.1.3 Central Virginia Region AQCR-3

At present there are no ozone monitoring Sites in Central Virginia. The AQCR-3 region has 18 counties and 2 metropolitan statistical areas in the cities of Lynchburg and Danville. To evaluate if the region would benefit from an ozone monitoring Site the NetAssess tool was used to evaluate the 8-hour average daily maximum ozone correlations between nearby 3 ozone monitoring Sites in neighboring counties in North Carolina close to Danville, and 3 ozone monitoring Sites near Lynchburg. These are shown in the map in Figure 3.3.1. Table 3.3.1 shows the locations of these Sites and the ozone design values from AQS for 2011-2013, and the probability of exceeding the current standard of 0.075 ppm. The exceedance probability is higher for the Sites in North Carolina closer to Danville, as compared to the 3 Sites in Virginia which are closer to Lynchburg. This is likely due to the fact that the Sites in NC are closer to more densely populated cities of Greensboro, Durham and Raleigh.

Table 3.3.1 Assessment of Ozone Sites in AQCR-3

Site ID	Location (county)	Area Served (sq. km.)	Population served	Ozone Design Value 2011	Ozone Design Value 2012	Ozone Design Value 2013	Ozone Probability of Exceeding 75ppb
51-147-9991	Prince Edward	9484	158377	NA	NA	0.062	25-50%
51-161-1004	Roanoke	6065	334520	0.068	0.070	0.064	25-50%
51-163-0003	Rockbridge	10149	298195	0.063	0.064	0.060	25-50%
37-033-0001	North Carolina	3202	259160	0.07	0.073	0.069	50-70%
37-145-0003	North Carolina	4032	104731	0.07	0.074	0.069	50-70%
37-157-0099	North Carolina	2623	166004	0.071	0.073	0.069	50-70%

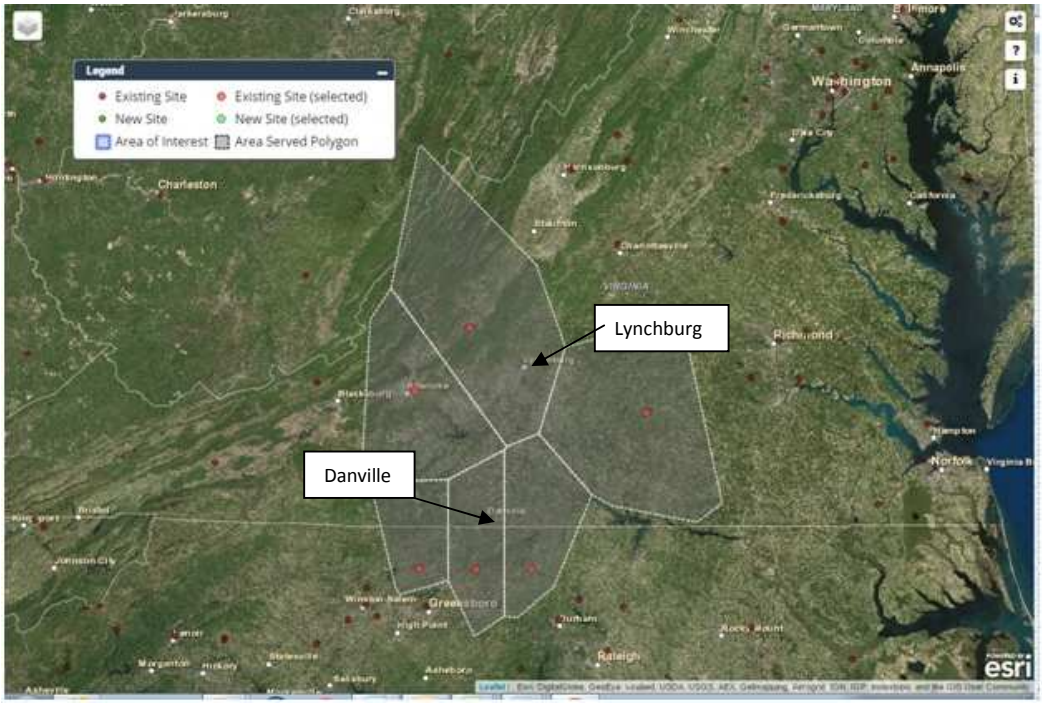

Figure 3.3.1 Ozone Sites nearby the AQCR-3

The Site-to-Site correlations are shown in Table 3.3.2 and figure 3.3.2, and they range from 0.811 to 0.953 which indicates that the 8-hour average daily maximums at these Sites are very similar for 2011-2013. Similarly the relative difference between these Sites is very low ranging from 0.068 to 0.165 which indicates these Sites are similar in the ozone levels being measured for the ozone season for 2011-2013.

Table 3.3.2 Pearson's Correlations for Ozone Sites near Central Virginia

Site 1	Site 2	n	Correlation	Relative Difference	Distance (km)
37-033-0001	37-145-0003	626	0.951	0.068	34
37-033-0001	37-157-0099	628	0.953	0.072	35
51-161-1004	51-163-0003	626	0.907	0.129	50
37-145-0003	37-157-0099	628	0.907	0.104	69
37-157-0099	51-161-1004	630	0.888	0.096	109
37-033-0001	51-161-1004	629	0.857	0.11	115
37-145-0003	51-147-9991	576	0.862	0.118	118
51-147-9991	51-163-0003	574	0.848	0.116	118
37-145-0003	51-161-1004	628	0.848	0.121	130
51-147-9991	51-161-1004	578	0.838	0.137	140
37-033-0001	51-147-9991	576	0.861	0.125	141
37-033-0001	51-163-0003	624	0.811	0.15	147
37-157-0099	51-163-0003	626	0.837	0.165	150
37-145-0003	51-163-0003	624	0.815	0.143	152
37-157-0099	51-147-9991	577	0.852	0.145	168

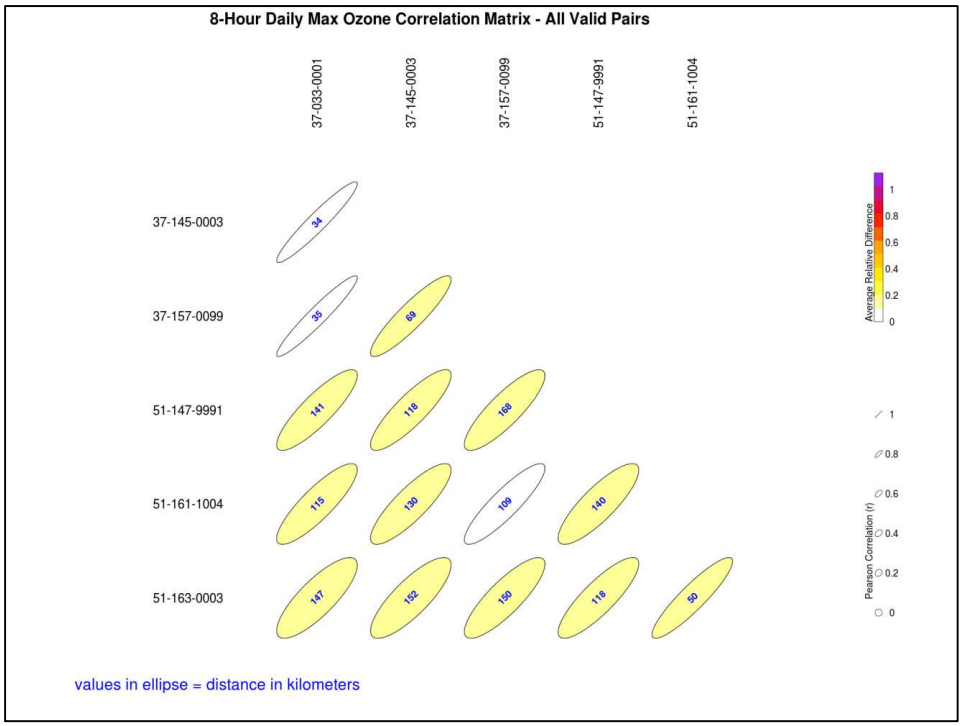

Figure 3.3.2 Pearson's Correlations for Ozone Sites near Central Virginia

Since the existing monitoring Sites near Danville and Lynchburg are measuring similar ozone levels in terms of the 8-hour averages, therefore the data indicates there would be no advantage gained by adding an ozone monitoring Site near either of the two MSAs in Lynchburg and Danville.

3.1.4 Northeast Virginia AQCR-4

There are four ozone monitoring Sites in the Northeast part of Virginia identified as the AQCR-4, and shown in the map in Figure 3.4.1. This region has 26 counties and two CBSAs which are the Charlottesville and the Fredericksburg areas. Table 3.4.1 shows the details for this region. Although the four ozone Sites are providing coverage for 25% of the land area, however these ozone monitors are located in the four highly populated counties and provide more than adequate coverage for the population in this area.

The NetAssess tools were used to calculate if there were any redundancies in the Sites in this region and two evaluations were done. First, the correlations between Sites were calculated and second the removal bias for each monitor was calculated. The four Sites are well correlated with each other as the correlation coefficients ranged from 0.87 to 0.96, and the data are shown in Table 3.4.2 and Figure 3.4.2. The removal bias data are shown in Table 3.4.3 and Figure 3.4.3. As evident from the data there are no redundancies in the ozone monitoring Sites in AQCR-4. Although the removal bias is neutral for the Sites in Caroline county and Stafford counties, these ozone monitors are essential for the ozone monitoring network in Virginia.

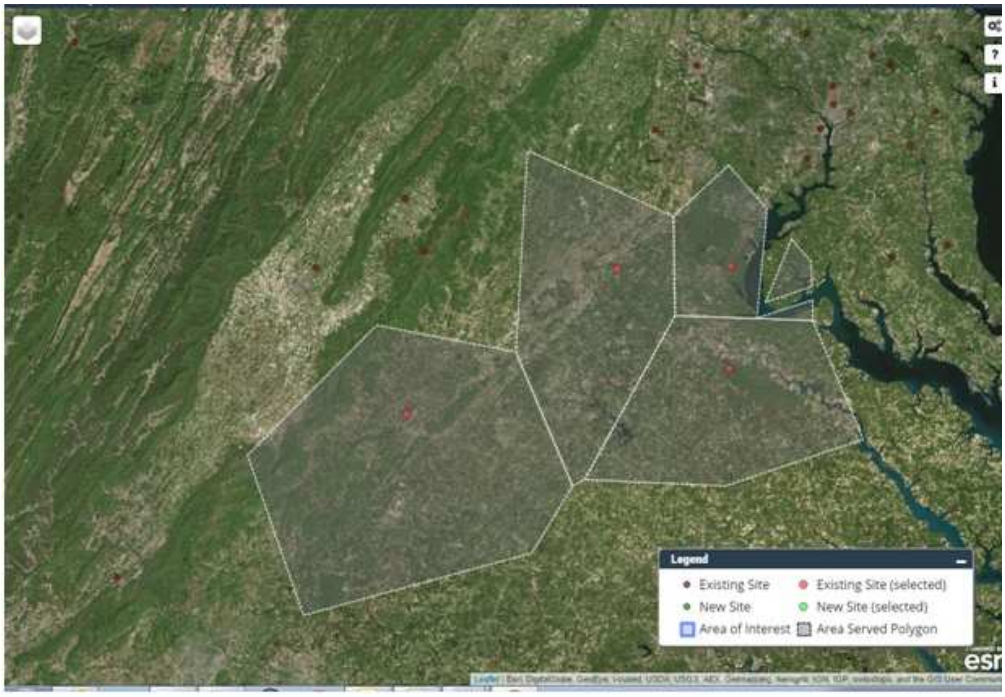

Figure 3.4.1 AQCR-4 Location of ozone Sites

Table 3.4.1 Site Description for ozone Sites in Northeast Virginia

Site ID	Location (county)	Area Served (km^2)	Population served	Ozone Design Value 2011	Ozone Design Value 2012	Ozone Design Value 2013	Ozone probability Exceeding 75 ppb
51-003-0001	Albemarle	2,286	259,859	0.067	0.068	0.065	25%-50%
51-033-0001	Caroline	1,181	209,303	0.07	0.074	0.071	80%-90%
51-061-0002	Fauquier	1,261	114,864	0.064	0.063	0.061	25%-50%
51-179-0001	Stafford	475	329,564	0.072	0.076	0.071	80%-90%
Total		5,203	913,590				

Table 3.4.2 Pearson's Correlation for Ozone Sites in AQCR-4

Site 1	Site 2	n	Distance (km)	Correlation	Rel. Diff
51-003-0001	51-033-0001	603	100	0.879	0.101
51-003-0001	51-061-0002	615	78	0.908	0.132
51-003-0001	51-179-0001	632	109	0.873	0.106
51-033-0001	51-061-0002	590	46	0.886	0.133
51-033-0001	51-179-0001	607	31	0.955	0.0645
51-061-0002	51-179-0001	620	35	0.904	0.134

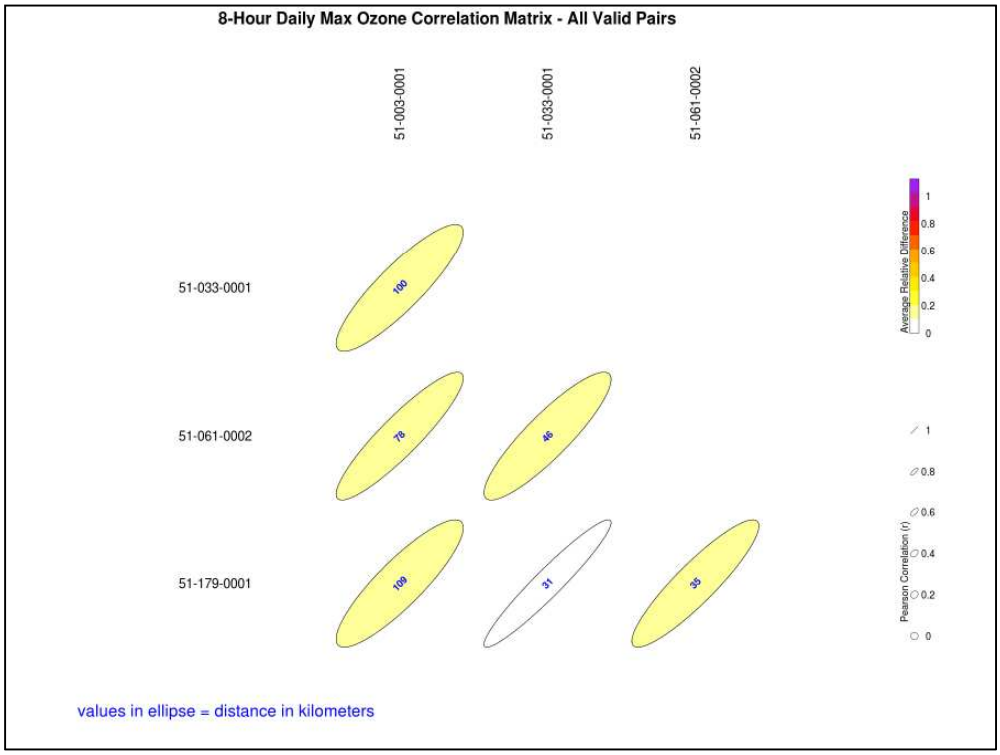

Figure 3.4.2 Correlation between ozone sites in AQCR-4

Table 3.4.3 Removal Bias for Ozone Sites in AQCR-4

Site ID	Mean Removal Bias (ppm)	Minimum Removal Bias (ppm)	Maximum Removal Bias (ppm)	Removal Bias St. Dev.	No. of neighbors
51-003-0001	0.0017	-0.0077	0.0228	0.0036	7
51-033-0001	-0.0001	-0.0137	0.035	0.0035	5
51-061-0002	0.0056	-0.0063	0.0214	0.0040	7
51-179-0001	-0.0003	-0.0119	0.013	0.0027	5

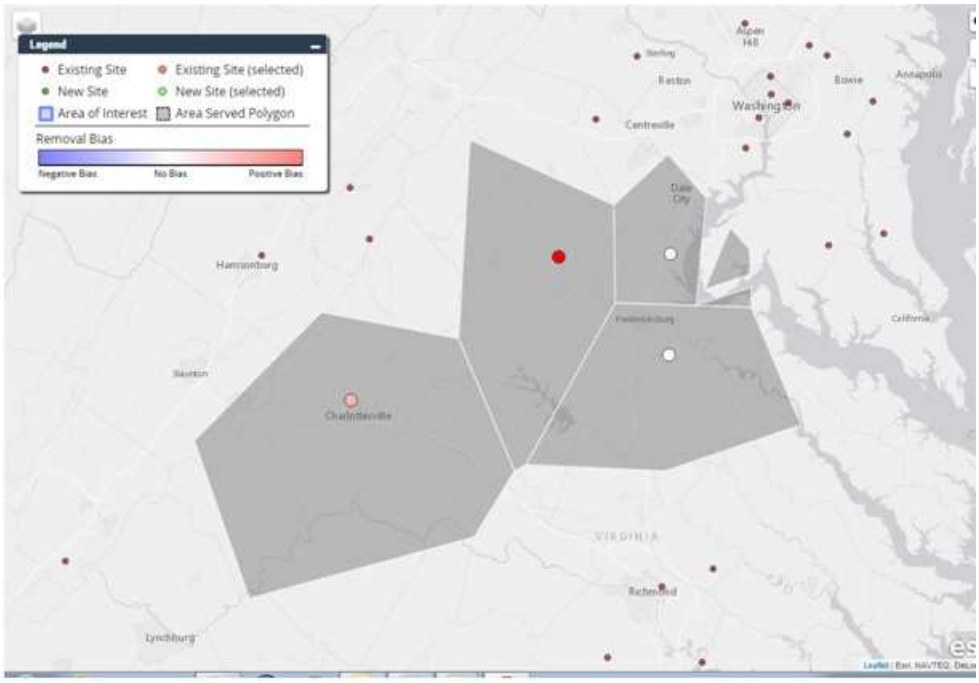

Figure 3.4.3 Removal Bias for the ozone Sites in Northeast Virginia.

3.1.5 Capitol Region AQCR-5

The State capitol Region is in the central part of Virginia and includes 12 counties, and the CBSA of Richmond. The map in Figure 3.5.1 shows the locations of these Sites. The total land area is approximately 10,000 km^2 and population is approximately 1 million. Table 3.5.1 provides details on the Ozone Sites coverage and design values. As evident from the Site coverage data the four ozone monitors provide coverage for over 100% of the area, and hence based on area coverage additional ozone monitors are not required.

Table 3.5.1 Ozone monitoring Sites in State Capital Region AQCR-5

Site ID	Location (county)	Area Served (km^2)	Population served	Ozone Design Value 2011	Ozone Design Value 2012	Ozone Design Value 2013	Ozone probability Exceeding 75 ppb
51-036-0002	Charles City	3328	184652	0.075	0.079	0.073	70%-80%
51-041-0004	Chesterfield	4780	343415	0.072	0.075	0.069	70%-80%
51-085-0003	Hanover	3482	95492	0.073	0.076	0.072	70%-80%
51-087-0014	Henrico	1670	606431	0.074	0.078	0.073	70%-80%
Total		13,260	1,229,990				

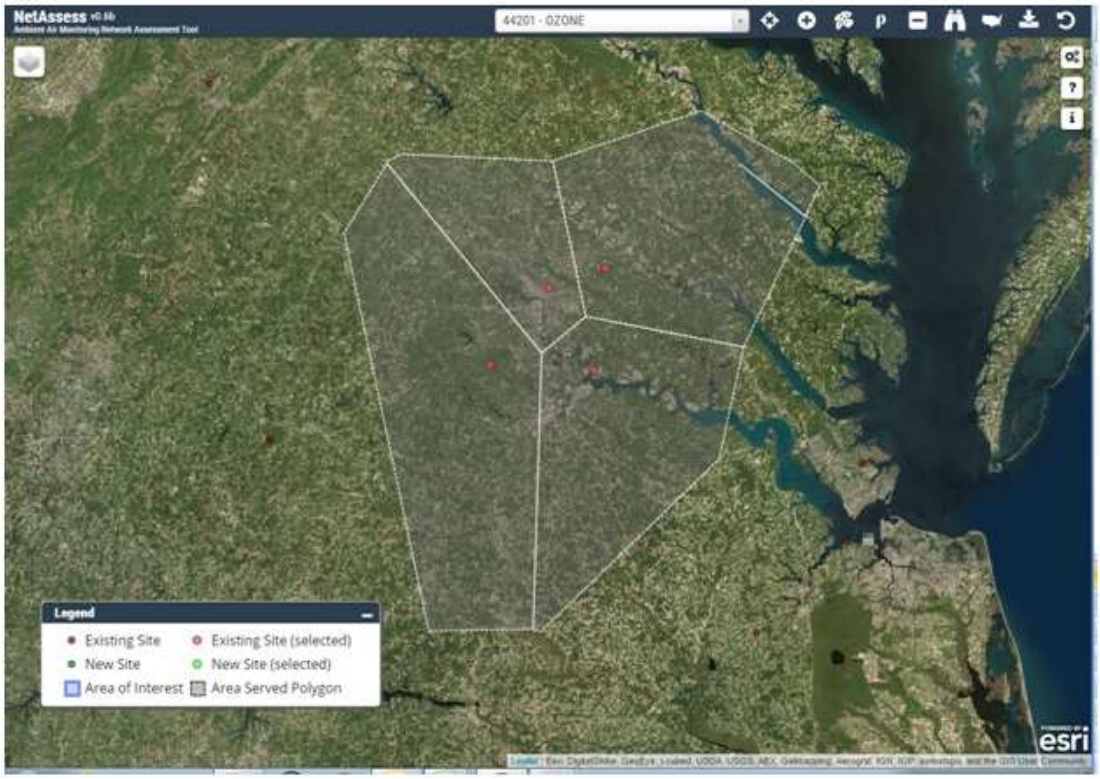

Figure 3.5.1 Ozone Sites in Capitol Region AQCR-5

To evaluate whether any of the ozone monitors in AQCR-5 were redundant, monitor to monitor correlations were calculated using NetAssess application. As seen from Figure 3.5.2 and Table 3.5.2 the four monitors are well correlated, with correlation coefficient ranging from 0.89-0.95, and the relative difference ranging from 0.074-0.104.

Table 3.5.2 Pearson's correlations for Ozone monitors in AQCR-5

Site 1	Site 2	N	Distance (km)	Correlation	Rel. Diff
51-036-0002	51-041-0004	596	30	0.887	0.0939
51-036-0002	51-085-0003	605	29	0.892	0.103
51-036-0002	51-087-0014	600	27	0.93	0.0897
51-041-0004	51-085-0003	598	43	0.878	0.104
51-041-0004	51-087-0014	594	28	0.912	0.0926
51-085-0003	51-087-0014	606	17	0.948	0.0742

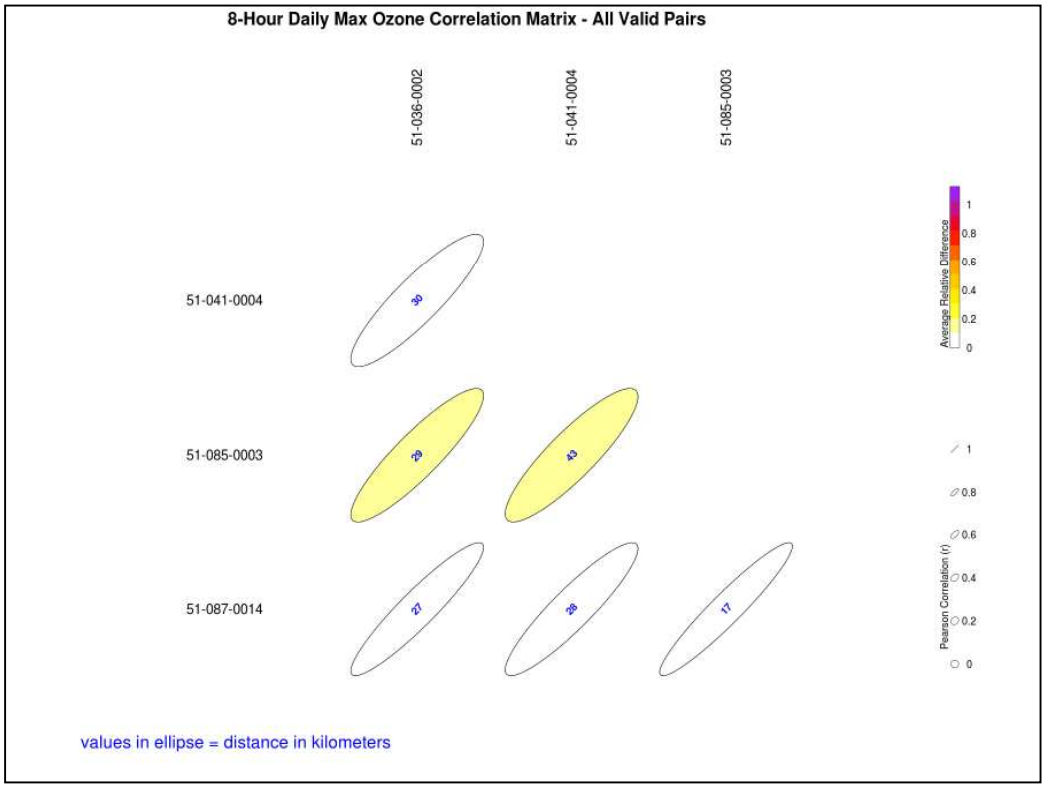

Figure 3.5.2 Monitor Correlations for Ozone Sites in AQCR-5

The NetAssess application was used to evaluate redundancy in the ozone Sites, and the map in Figure 3.5.3 illustrates the average removal bias at these Sites based on the daily 2011-2013 data. As seen from the data in Table 3.5.3, the average removal bias ranged from -0.0003 ppm for the Hanover Site to 0.0013 ppm for the Chesterfield Site. The red circles for both Chesterfield and Charles city indicate that these Sites are not redundant since based on the 2011-2013 data removing these Sites would have a positive bias on the daily maximum 8-hour average ozone values. The Henrico Site has a negative bias (-0.0011), however it is the NCORE Site and is a regulatorily required Site for Virginia.

Table 3.5.3 Removal Bias for Ozone Sites in AQCR-5

Site ID	Mean Removal Bias (ppm)	Minimum Removal Bias (ppm)	Maximum Removal Bias (ppm)	Removal Bias St. Dev.	No. of neighbors
51-036-0002	0.0012	-0.0273	0.0177	0.0046	6
51-041-0004	0.0013	-0.0198	0.0285	0.0048	5
51-085-0003	-0.0003	-0.0181	0.0156	0.0042	6
51-087-0014	-0.0011	-0.0222	0.0077	0.0035	6

The Hanover county Site has a negative removal bias of -0.0003, and it is very well correlated to the Henrico Site (correlation coefficient = 0.95) since they are nearby at a distance of 17 km. Their relative difference in daily 8-hour ozone max values is very low at 0.0742.

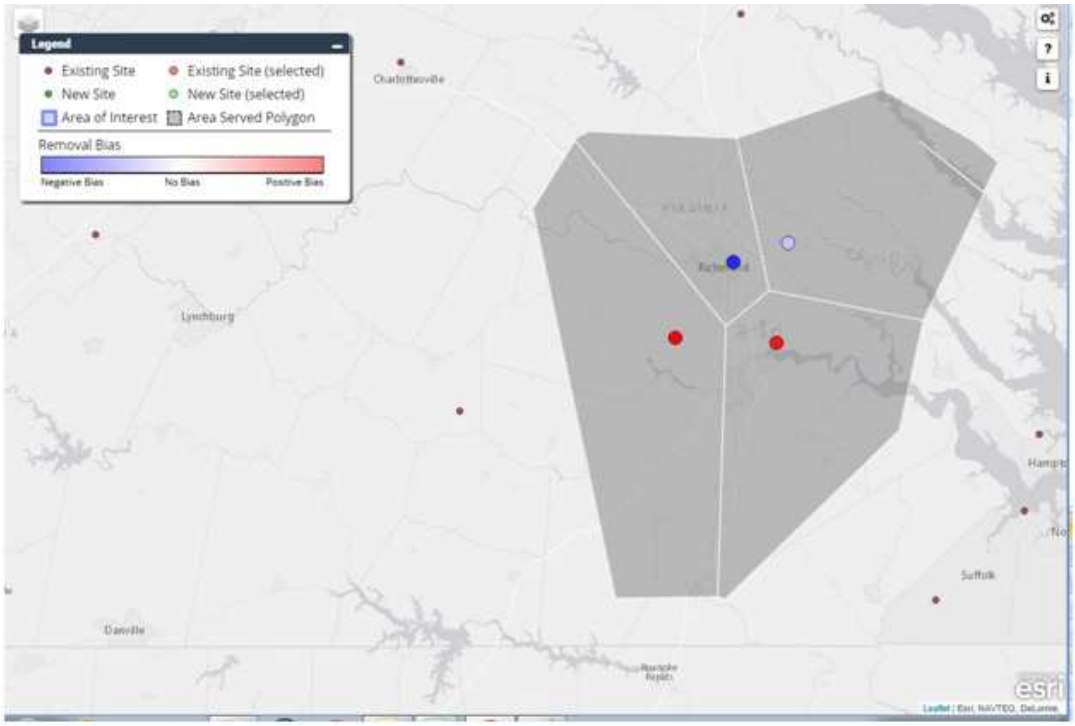

Figure 3.5.3 Removal Bias for Ozone Sites in State Capitol AQCR

3.1.6 Hampton Roads Region AQCR-6

The Hampton Roads Region is in the Eastern part of Virginia and includes 4 counties, and several cities, and the MSA of Norfolk-Virginia Beach-Newport News, VA-NC. It has 3 ozone monitoring Sites and their locations are shown on the map in Figure 3.6.1. The monitors were sited based on population densities and to comply with NAAQS standards and the requirements of 40 CFR Part 58 Appendix D. Details on area coverage and historical design values are in Table 3.6.1.

Table 3.6.1 Locations of ozone Sites in Hampton Roads Region

Site ID	Location	Area Served (km^2)	Population served	Ozone Design Value 2011	Ozone Design Value 2012	Ozone Design Value 2013	Ozone probability Exceeding 75 ppb
51-650-0008	Hampton city	1497	423623	NA	0.076	0.072	80%-90%
51-800-0004	Suffolk city	1692	969882	0.071	0.073	0.07	80%-90%
51-800-0005	Suffolk city	2489	167672	0.07	0.071	0.068	50%-70%
Total		5,678	1,561,177				

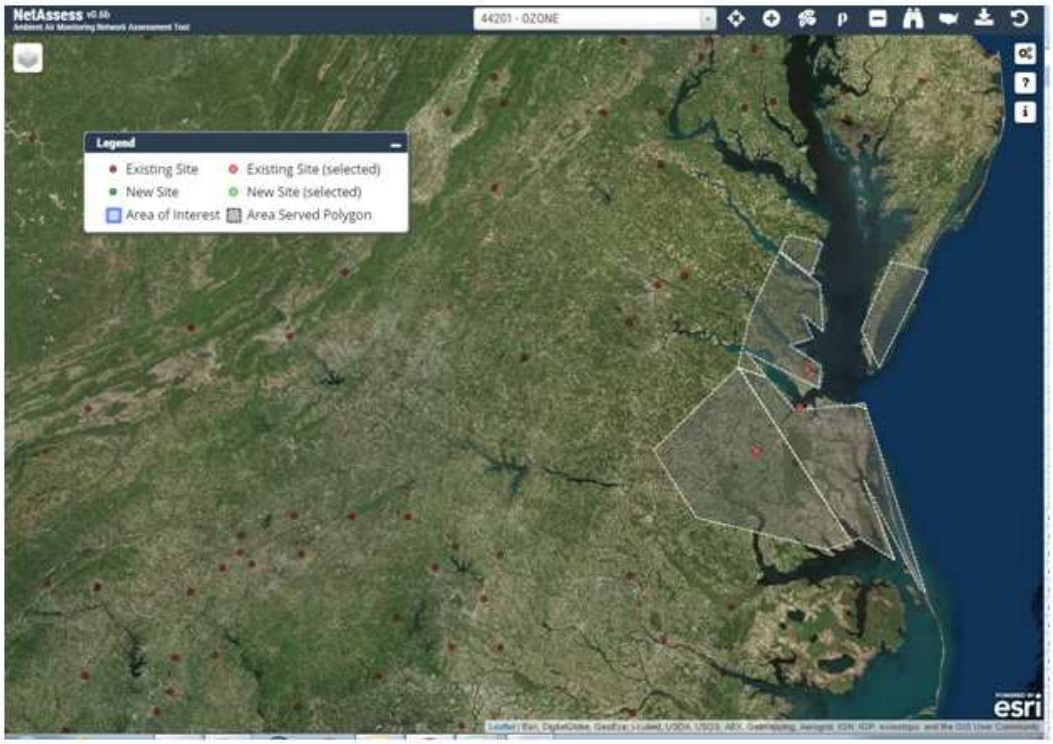

Figure 3.6.1 Ozone Sites in AQCR-6 Hampton Roads Region

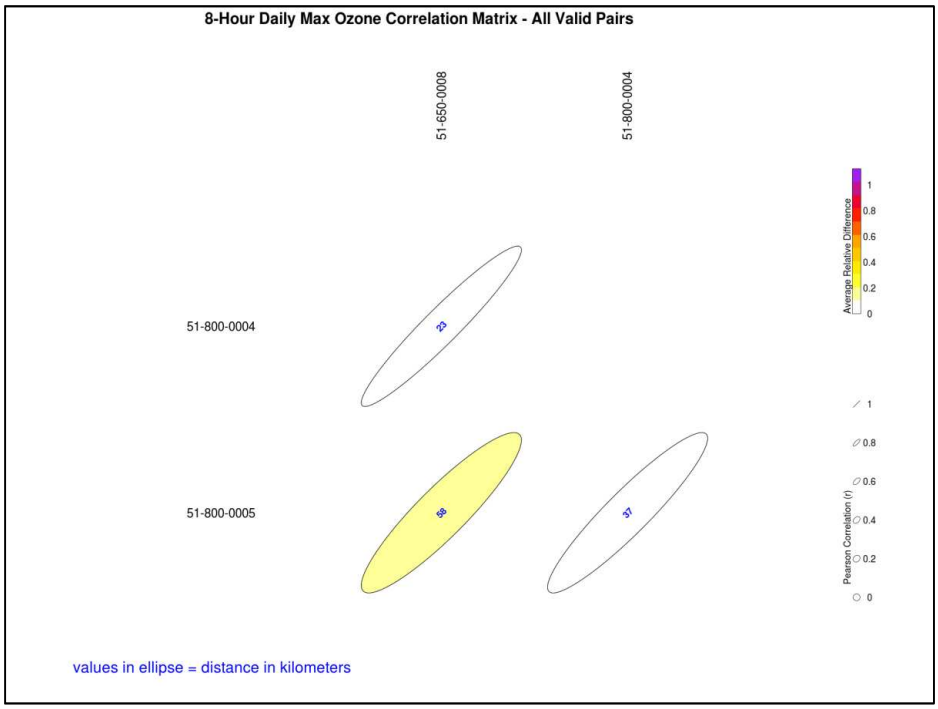

Figure 3.6.2 Pearson's Correlations for ozone monitors in AQCR-6

The correlations between the 3 ozone monitors in Hampton Roads area is excellent ranging from 0.91-0.95. The relative difference was also low ranging from 0.08-0.10 and this is expected based on proximity of the Sites.

Table 3.6.2 Pearson's Correlations for ozone monitors in AQCR-6

Site 1	Site 2	n	Distance (km)	Correlation	Rel. Diff
51-650-0008	51-800-0004	611	23	0.953	0.0932
51-650-0008	51-800-0005	615	58	0.906	0.101
51-800-0004	51-800-0005	630	37	0.929	0.0829

The removal bias for the ozone sites was estimated using the NetAssess tool, and the map in Figure 3.6.3 shows that the removal bias for the ozone 8-hour means with the colored circles at the Site locations indicating the bias also given in Table 3.6.3. The Hampton city Site has the lowest mean removal bias and hence it has a blue circle, however this is located in a high population density area and not a redundant Site. The 51-800-0004 Site in Suffolk is located at the Tidewater Community College and has a red circle indicating a positive bias and therefore not a redundant Site. The Suffolk (51-008-0005) Site is neutral and is also not a redundant Site.

Table 3.6.3. Removal bias for ozone Sites in AQCR-6 Hampton roads

Site ID	Mean Removal Bias (ppm)	Min Removal Bias (ppm)	Max Removal Bias (ppm)	Removal Bias Standard Deviation	Neighbors Included
51-650-0008	-0.0029	-0.0209	0.0081	0.0034	8
51-800-0004	0.0024	-0.0158	0.0161	0.0032	5
51-800-0005	0.0002	-0.0167	0.0246	0.0039	5

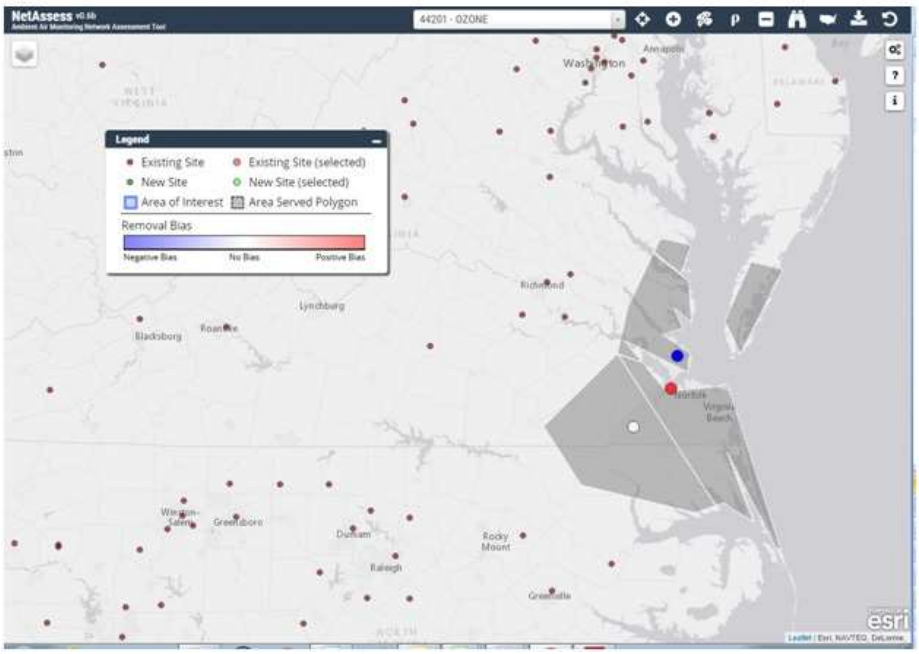

Figure 3.6.3 Removal bias for Ozone Sites in AQCR-6

3.1.7 Northern Virginia Region AQCR-7

The Northern Virginia Region includes 4 counties, and several cities, and the MSA of Washington-Arlington-Alexandria, DC-VA-MD-WV. It has 4 ozone monitoring Sites and their locations are shown on the map in Figure 3.7.1. The monitors were sited to comply with NAAQS based on population densities and comply with the requirements of 40 CFR Part 58 Appendix D. Details on area coverage and historical design values are in Table 3.7.1.

Figure 3.7.1 Location of ozone Sites in Northern Virginia

As shown in Table 3.7.1 the probability for exceeding the 8-hour NAAQS of 75 ppb is very high, primarily based on the historical design values in this region. To evaluate whether any of the ozone monitors in AQCR-7 were redundant, Site to Site correlations were calculated using NetAssess application. As seen from Figure 3.7.2 and Table 3.7.2 the four monitors are well correlated, with correlation coefficient ranging from 0.89-0.97, and the relative difference ranging from 0.06-0.13. This is not unexpected given the close proximity of the 4 Sites with the maximum distance between Sites being 50 km.

Table 3.7.1 Ozone Sites in Northern Virginia

Site ID	Location (county/city)	Area Served (km^2)	Population served	Design Value 2011	Design Value 2012	Design Value 2013	probability Exceeding 75 ppb
51-013-0020	Arlington	99	526595	0.08	0.086	0.079	80%-90%
51-059-0030	Fairfax	358	784708	0.082	0.086	0.079	80%-90%
51-107-1005	Loudoun	543	606376	0.073	0.075	0.071	80%-90%
51-153-0009	Prince William	701	298842	0.069	0.072	0.069	70%-80%
Total		1,701	2,216,521				

Table 3.7.2 Pearson's correlations for Ozone monitors in AQCR-5

Site 1	Site 2	n	Distance (km)	Correlation	Rel. Diff
51-013-0020	51-059-0030	628	10	0.97	0.061
51-013-0020	51-107-1005	632	42	0.926	0.095
51-013-0020	51-153-0009	629	50	0.894	0.121
51-059-0030	51-107-1005	629	44	0.92	0.092
51-059-0030	51-153-0009	625	47	0.904	0.108
51-107-1005	51-153-0009	630	23	0.963	0.058

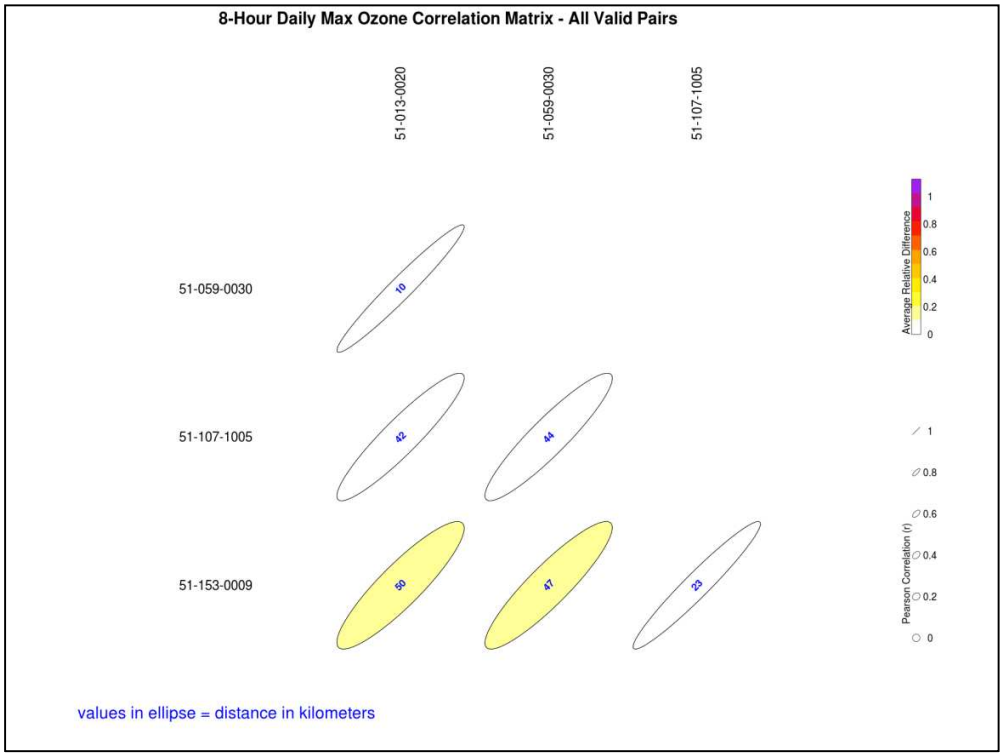

Figure 3.7.2. Correlations between ozone Sites in AQCR-7

The NetAssess application was used to evaluate redundancy in the ozone Sites, and the map in Figure 3.7.3 illustrates the average removal bias at these Sites based on the daily 2011-2013 data. As seen from the data in Table 3.7.3, the average removal bias ranged from -0.0007 ppm for the Fairfax Site to 0.0001 ppm for the Loudoun Site. Although three of the Sites have a neutral or negative mean removal bias, the maximum removal bias at these Sites (highest number being 17 ppb for Arlington) could be significant compared to the 8-hour ozone NAAQS of 75 ppb, hence all the four Sites are essential for the ozone network in the State.

Table 3.7.3 Removal Bias for Ozone Sites in AQCR-7

Site ID	Mean Removal Bias (ppm)	Minimum Removal Bias (ppm)	Maximum Removal Bias (ppm)	Removal Bias St. Dev.	No. of neighbors
51-013-0020	-0.0006	-0.009	0.017	0.003	6
51-059-0030	-0.0007	-0.021	0.008	0.003	7
51-107-1005	0.0001	-0.011	0.012	0.003	8
51-153-0009	-0.0001	-0.010	0.014	0.003	6

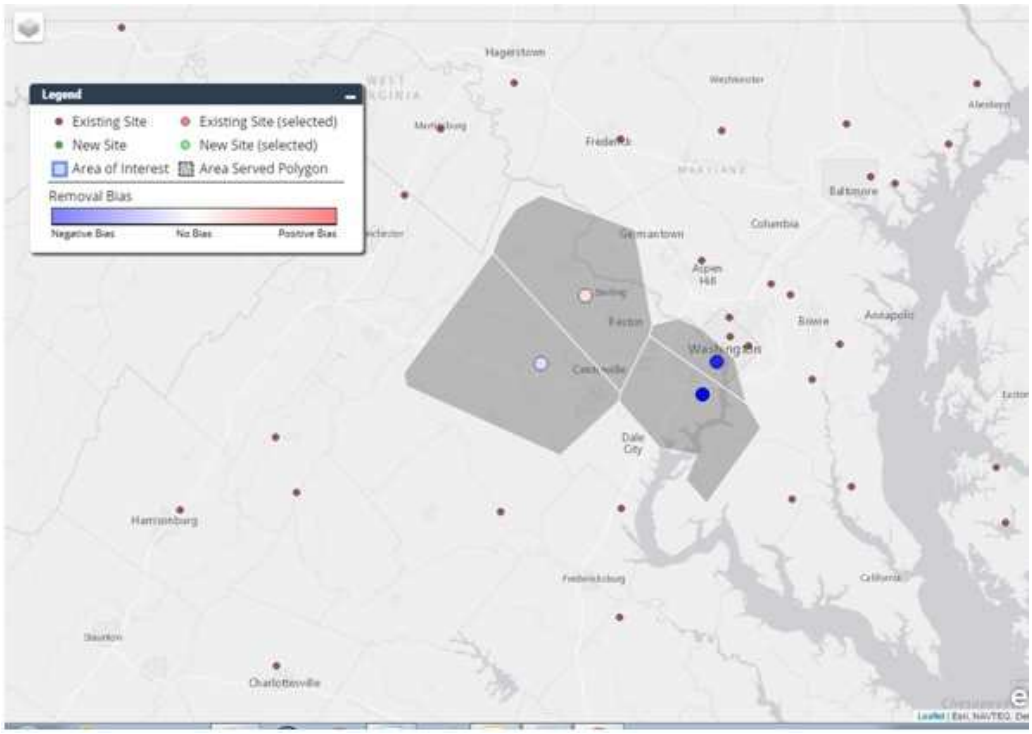

Figure 3.7.3 Removal bias for Ozone Sites in AQCR-7

3.1.8 PAMS Site

Currently VA DEQ maintains one PAMS site, located at the NCore site in Henrico County (51-087-0014). The PAMS site contains an automated Gas Chromatograph on site as well as an multi-port sampler as a back-up in case episodic sampling is needed. The PAMS site is collocated with the NCore site so the additional requirements for the PAMS beyond the speciated VOCs contained in Table D-6 in 40 CFR Part 58 Appendix D are met through the equipment included as part of the NCore suite. There is currently no upper air meteorological equipment in the PAMS area due to the shutdown of the Science Museum site in January of 2013. Figure 3.8.1 provides a view of the auto GC currently in use at the Henrico site.

Figure 3.8.1 Automated GC in operation at the Henrico County site

As part of the original UATM program, the VOC canisters were also analyzed for the PAMS pollutants. Virginia no longer performs the PAMS analysis on the VOC samples taken as part of the UATM program (or the NATTS program). As part of the PAMS program, a one in six day sample is taken at the Henrico County site where the Auto GC is located to establish baseline information. These samples are taken year round.

3.2 Carbon Monoxide Network Analysis

There are seven Carbon Monoxide monitoring sites throughout the Commonwealth of Virginia. The locations of these sites are primarily focused in the MSAs in the eastern part of Virginia, i.e. Washington DC MSA, Richmond MSA, and the Hampton Roads MSA. In addition there is one monitor located in the Roanoke MSA. Figure 3.2.1 below provides a map of the Commonwealth with the locations of these monitors.

Figure 3.9.1 Carbon Monoxide monitoring sites in Virginia

Table 3.9.1 below provides the demographic and historic data information for 2011 – 2013. Note that the Richmond Carbon Monoxide site (51-760-0025) is located at the near road site for the Richmond MSA. This monitor was originally located at the Science Museum (51-760-0024) site which was shutdown effective January 3, 2013 due to a property transfer. The Carbon Monoxide analyzer at the Alexandria site (51-510-0021) is currently designated a special purpose monitor due to the relocation to the Alexandria Transportation Department facility on Colvin Street. The Roanoke monitor (51-161-1004) was relocated to the site at Herman Horn Elementary School due to the shutdown of the Round Hill Site (51-770-0015) in March of 2013.

Table 3.9.1 Carbon Monoxide sites in Virginia

Site ID	Location	AQCR Region	Area Served (km2)	Population	Max 1 hour value 2011	Max 1 hour Value 2012	Max 1 hour Value 2013	1-hour Standard (ppm)
51-013-0020	Arlington	Northern VA	110	265,572	1.9	1.6	1.2	35
51-087-0014	Henrico	State Capitol	10,423	587,876	1.6	1.4	1.5	35
51-161-1004	Roanoke	Valley	48,362	1,515,271	1.5	1.5	1	35
51-510-0021	Alexandria	Northern VA	9,615	2,226,175	1.9	1.4	4.9	35
51-650-0008	Hampton	Hampton Roads	6,583	492,690	2.7	1.1	1.1	35
51-710-0024	Norfolk	Hampton Roads	22,847	1,269,010	4.2	1.5	2	35
51-760-0025	Richmond	State Capitol	18,727	1,155,972	2.2	2.2	1.4	35

3.3 Nitrogen Dioxide Network Analysis

There are eleven Nitrogen Dioxide monitoring sites throughout the Commonwealth of Virginia. The bulk of the analyzers are located in the MSAs in the eastern part of Virginia. In addition there is one monitor located in the Roanoke MSA (51-161-1004) and one located in Rockingham County (51-165-0003) in the Harrisonburg MSA. Figure 3.10.1 below provides a map of the Commonwealth with the locations of these monitors.

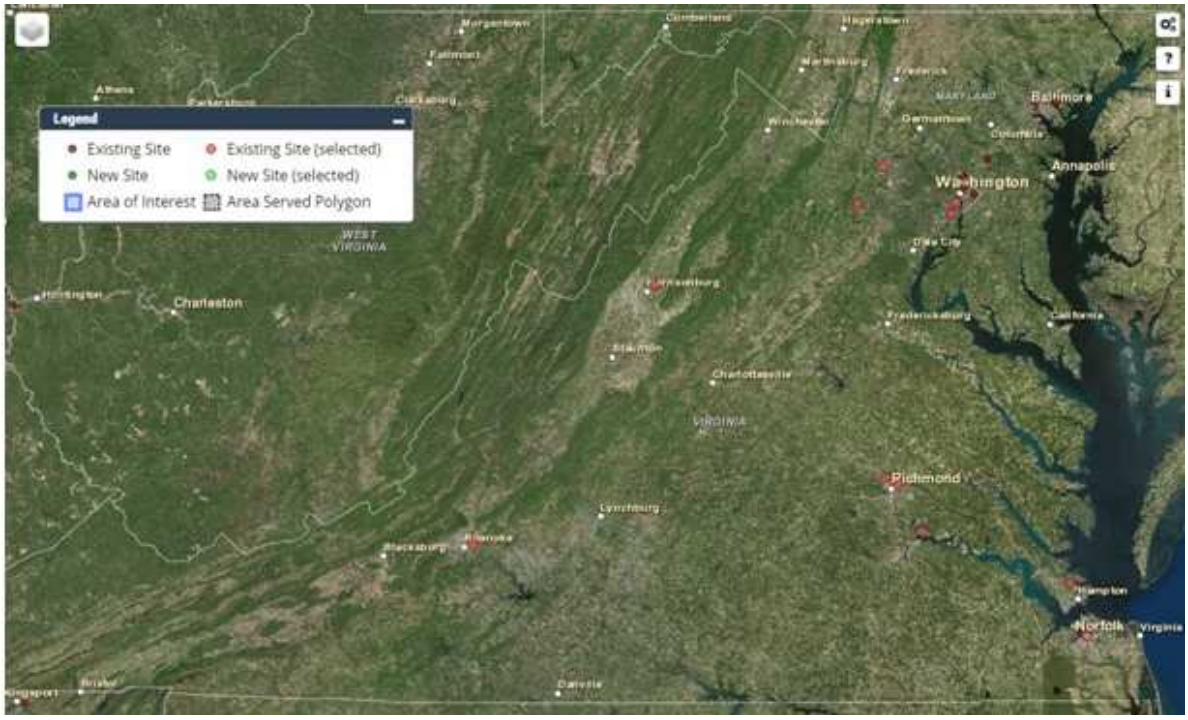

Figure 3.10.1 Nitrogen Dioxide Monitoring sites in Virginia

Table 3.10.1 below provides the demographic and historic data information for 2011 – 2013. Note that the Richmond Nitrogen Dioxide site (51-760-0025) is located at the near road site for the Richmond MSA. The near road site was started up in October of 2013 which explains the "NA" for the 3 years from 2011 – 2013. The Rockingham site (51-165-0003) experienced contamination issues with the QA system which caused a loss of data. The Hampton site (51-650-0008) data set was incomplete in 2011 and 2012 relocation from the site in Newport News to its current location. The Norfolk site (51-710-0024) was started up in 2013. The Alexandria site (51-510-0021) has been deemed a special purpose monitor.

3.3.1 Near Road NO2 monitoring

Paragraph 4.3.2 of Appendix D in 40 CFR Part 58 requires installation of Near Road Monitoring sites in the Washington DC MSA, Richmond MSA, and the Hampton Roads MSA. These locations are all phase 1 sites which required installation by January 1, 2014. Currently the

Richmond area is the first MSA for which a Near Road site has been installed. The Northern Virginia area has a site selected and a contractor has been selected. The site has been marked and Dominion Virginia Power has scheduled the electrical installation for the site. The Hampton Roads site has been selected and all approvals from the entities that hold the easements have been received. The projected completion date for both sites is December 31, 2015.

Table 3.10.1 Nitrogen Dioxide sites in Virginia

Site ID	Location	AQCR	Area Served (km2)	Population	Design Value 2011	Design Value 2012	Design Value 2013	1-hour Standard (ppb)
51-013-0020	Arlington	Northern	210	379970	49	47	44	100
51-036-0002	Charles City	State Capitol	12769	421548	55	52	47	100
51-087-0014	Henrico	State Capitol	3005	285454	41	41	38	100
51-107-1005	Loudoun	Northern	4188	1087585	41	39	37	100
51-153-0009	Prince William	Northern	8399	823035	28	28	28	100
51-161-1004	Roanoke	Valley	36109	1247231	39	39	36	100
51-165-0003	Rockingham	Valley	25954	656774	40	39*	37	100
51-510-0021	Alexandria	Northern	3385	1295551	52	49*	NA*	100
51-650-0008	Hampton	Hampton Roads	6043	471826	NA*	NA*	29	100
51-710-0024	Norfolk	Hampton Roads	24022	1345515	NA*	NA*	42	100
51-760-0025	Richmond	State Capitol	11907	825820	52	51	NA*	100

*Data completeness issues

3.4 Sulfur Dioxide Network Analysis

There are seven Sulfur Dioxide monitoring sites located throughout the Commonwealth of Virginia. The bulk of the analyzers are located in the MSAs in the eastern part of Virginia. The Charles City (51-036-0002) and Henrico (51-087-0014) monitors represent the population weighted emissions index monitors for the Richmond MSA as defined in 40 CFR Part 58 Appendix D Paragraph 4.4.2. The Hampton (51-650-0008) and the Norfolk (51-710-0024) monitors represent the PWEI monitors for the Hampton Roads MSA. The Washington DC MSA requires 3 PWEI monitors of which the (51-059-0030) Fairfax Monitor is one. Because the Washington DC MSA includes the District of Columbia and Maryland, the monitors in these jurisdictions also count towards the PWEI monitor totals. Virginia also runs Sulfur Dioxide Monitors in Roanoke (51-161-1004) and Rockingham (51-165-0003). The City of Alexandria at one time ran a Sulfur Dioxide monitor but this monitor was relocated to the VA DEQ Fairfax site. Figure 3.11.1 below displays a map with the Virginia Sulfur Dioxide monitors.

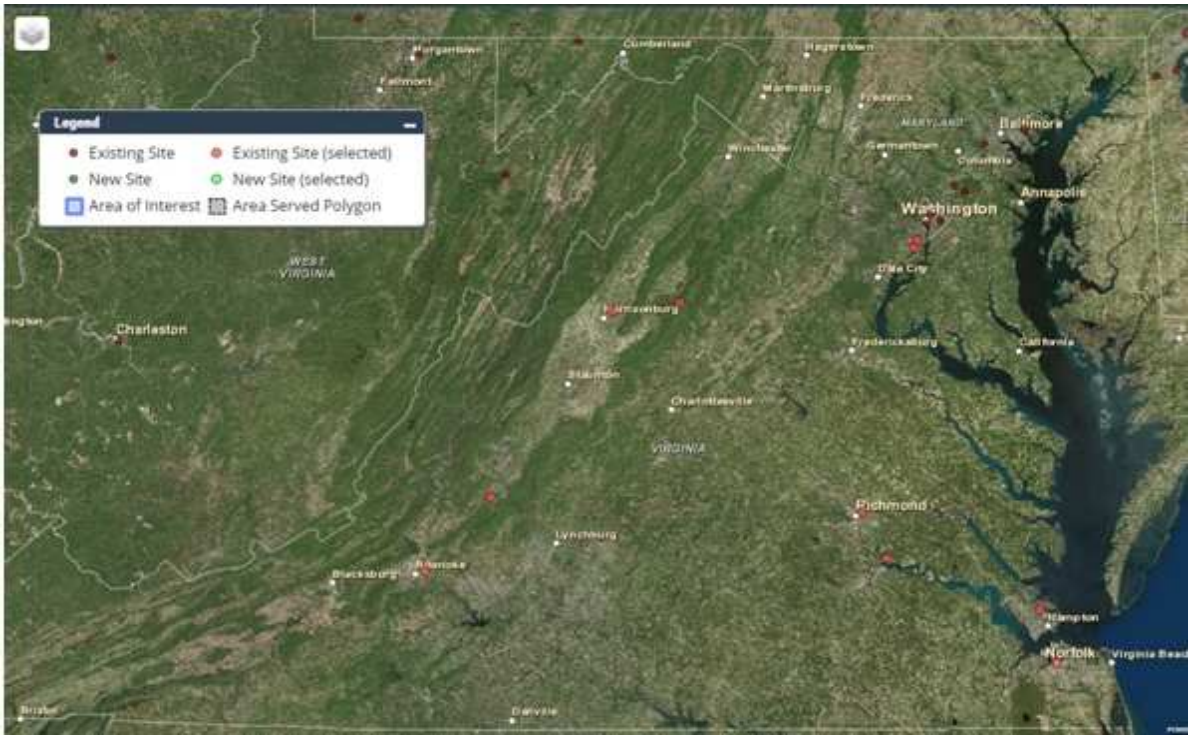

Figure 3.11.1 Sulfur Dioxide Monitoring Sites in Virginia

Table 3.11.1 below provides the demographic and historic data information for 2011 – 2013. Note that the Fairfax monitor (51-059-0030) has incomplete data listed for these years. This is due to the fact that the monitor was relocated from the Alexandria site in 2014. Note also that the Alexandria monitor (51-510-0021) does not display design values as well. This is due to the relocation of the monitor from the original site at the Alexandria Health Department to the new location at the Alexandria Transportation Department location on Colvin Street and also due to issues with the operational schedule performed by the City of Alexandria operator. Also the Hampton site (51-650-0008) displays no design values for 2011 and 2012 due to being relocated twice, once from the location at the Hampton School for the Blind to the Newport News Education Department annex on Hogan Street to its current location on the NASA Langley site in Hampton.

Not included with this table are the potential Sulfur Dioxide monitors that will likely be installed as a result of the revised Sulfur Dioxide standard. Currently Virginia has potentially up to 7 facilities that will select between a modeling and monitoring approach to demonstrate compliance with the new NAAQS standard. Where sources select the monitoring approach the monitors once approved by DEQ will be included in the Virginia Sulfur Dioxide air monitoring network. The proposed regulations required that the monitoring plans be included in the annual air monitoring network plan and will ultimately be included in the next version of this report in the form of a regulatory analysis and demonstration of compliance with the (then) final regulation.

Table 3.11.1 Sulfur Dioxide sites in Virginia

Site ID	Location	AQCR	Area in Square Kilometers	Total Population	Design Value 2011	Design Value 2012	Design Value 2013	Primary 1-hour standard
51-036-0002	Charles City	State Capitol	11508	395117	43	34	29	75 ppb
51-059-0030	Fairfax*	Northern	6487	1765411	NA	NA	NA	75 ppb
51-087-0014	Henrico	State Capitol	12360	1075086	NA	NA	11	75 ppb
51-161-1004	Roanoke	Valley	17065	683989	10	8	6	75 ppb
51-165-0003	Rockingham	Valley	7614	293998	9	6	5	75 ppb
51-650-0008	Hampton	Hampton Roads	5399	451867	NA	NA	37	75 ppb
51-710-0024	Norfolk	Hampton Roads	8164	1084627	NA	NA	54	75 ppb

***** relocated in 2014

3.5 PM10 Network Analysis

At present Virginia has ten PM10 monitoring Sites operating and their locations are shown on the map in Figure 3.12.1. The Sites collect samples on filters on a 1-in-6 days or 1-in-3 days schedule published by EPA. The samples are processed and weighed at the DEQ Office of Air Quality Monitoring in Glen Allen, VA and data are submitted to AQS. The NAAQS standard for PM10 is 24-hour average of 150 ug/m^3, and Virginia has not had any exceedances of the standard during 2011-2013 except for one exceedance at West Point Site that was due to the Great Dismal Swamp fire of 2011 which has been reported to EPA Region 3 as an exceptional event.

Figure 3.12.1 Virginia PM10 monitoring Sites

The locations and details on the present PM10 monitoring Sites are given in Table 3.12.1. The Table shows the 1st maximum and 2nd maximums for all Virginia Sites for 2011-2013. As seen the 24-hour average standard of 150 ug/m^3 was not violated anywhere except at the West Point location during 2011 which was an exceptional event triggered by the Great Dismal Swamp Wildlife Refuge Fire in August 2011. The 2011 1st and 2nd maximum PM10 data at Norfolk were also impacted by the Great Dismal Swamp Fire.

Table 3.12.1 PM10 Monitoring Sites in Virginia 2011-2013 Annual Maximum data

Site (AQS ID)	Area Served (km^2)	Population	2011 1st max	2011 2nd max	2012 1st max	2012 2nd max	2013 1st max	2013 2nd max
Carroll (51-035-0001)	28,038	941,910	31	28	28	26	34	22
Winchester (51-840-0002)	27,331	1,064,079	35	28	32	28	21	19
Roanoke (51-770-0011)	31,216	969,774	65	39	38	31	62	45
Richmond (51-087-0014)	10,815	1,013,399	39	34	31	28	26	22
Hopewell (51-670-0010)	11,906	361,878	38	32	31	27	23	19
West Point (51-101-0003)	6,618	249,202	154*	40	30	29	27	22
Hampton (51-650-0003)	5,249	391,948	67	35	34	32	22	19
Norfolk (51-710-0024)	16,646	1,169,048	71*	58*	35	32	29	21
Fredricksburg (51-630-0004)	10,405	717,559	36	28	34	29	29	21
Alexandria (51-510-0020)	4,170	2,333,283	44	35	35	33	34	28

* Great Dismal Swamp Fire

3.5.1 Southwest Region AQCR-1

There is a single PM10 monitor located in Carroll County (51-035-0001) and its location is shown on the map in Figure 3.13.1. The monitor is centrally located in AQCR-1 and provides area coverage for 28,038 km^2 according to the NetAssess application. It appears the monitor is providing adequate area-wide representation.

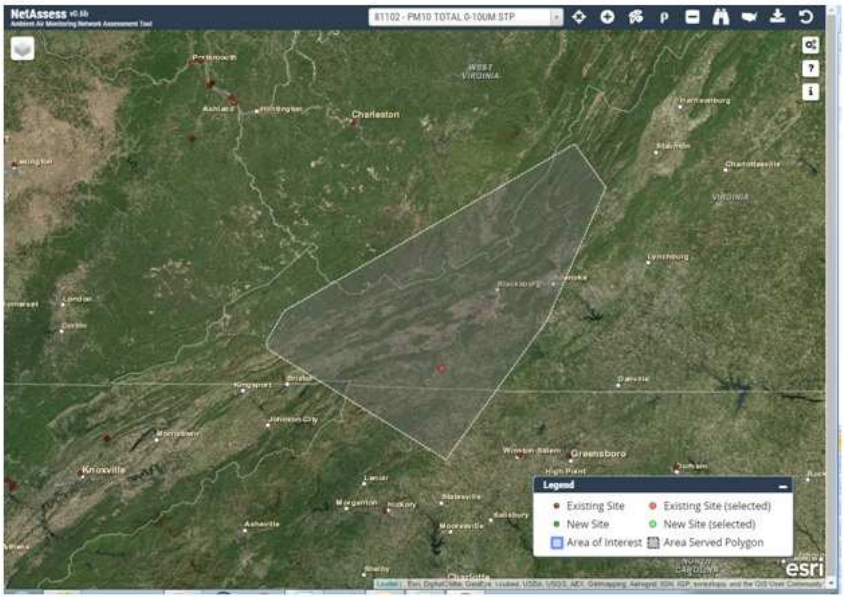

Figure 3.13.1 PM10 monitoring Site in Southwest Virginia

3.5.2. Valley Region AQCR-2

At present there is a single PM10 monitor in the Valley Region of Virginia located in Frederick County (51-840-0002) in Winchester as shown in Figure 3.14.1. This PM10 monitor is providing area-wide coverage for 27,331 km^2 according to the NetAssess application. There was second PM10 monitor located at Roanoke (51-770-0011) until September 2013 when it was shutdown and removed due to a request from the property owner that it be removed.

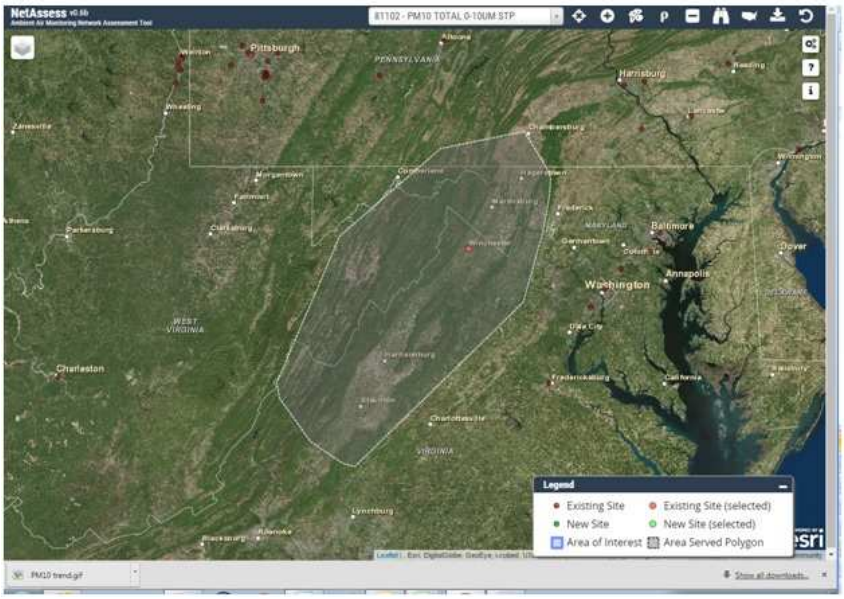

Figure 3.14.1 PM10 monitoring Site at Frederick in AQCR-2

3.5.3. Central Virginia AQCR-3

At present there is no PM10 monitor in AQCR-3 which is the Central Virginia Region primarily due to population considerations. The PM10 monitors in the Hampton Roads region and State Capitol Region are providing coverage for parts of Central Virginia as discussed in later Sections.

3.5.4. Northeast Virginia AQCR-4

The AQCR-4 Region has a total land area of 21,106 km^2, which includes 26 counties and 2 cities. The Northeast Virginia area presently has two PM10 monitors located in Fredericksburg and West Point (Figure 3.15.1) which provide area-wide coverage for 17023 km^2, and are providing adequate representation for this region. There was an additional PM10 monitor located in Culpeper (51-047-0002) which was removed in December 2012 due to being redundant. The first and second highest values were always low and compared well with the measurements at the nearby locations.

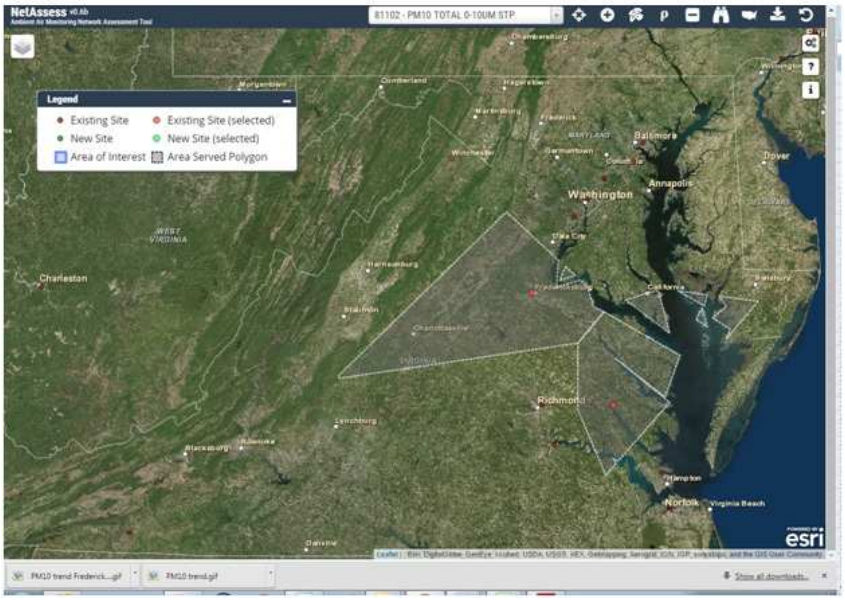

Figure 3.15.1 PM10 monitoring Sites in Northeast Virginia AQCR-4

3.5.5 Capitol Region AQCR-5

The AQCR-5 region includes 12 counties and 5 cities. There are two PM10 monitors in this Region located at Richmond (51-087-0014) and Hopewell (51-670-0010) as seen in Figure 3.16.1. The total area covered by these two is approximately 22,000 km^2 which also covers area in AQCR-3 as well.

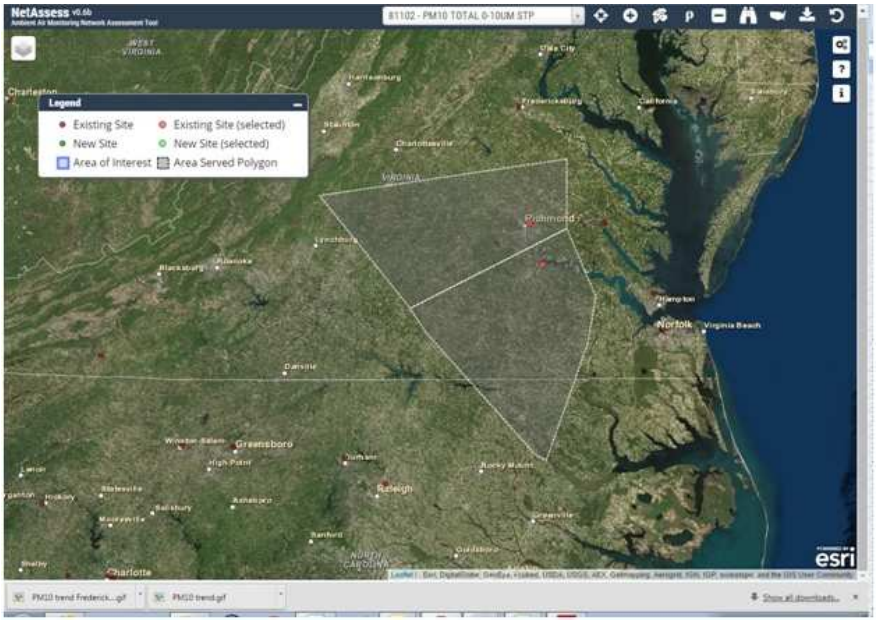

Figure 3.16.1 PM10 monitoring Sites in State Capitol AQCR-5

3.5.6 Hampton Roads Region AQCR-6

The AQCR-6 region includes 4 counties, and 8 cities and the land area is approximately 5,500 km^2. There are two PM10 monitors in this region located at Hampton (51-650-0003) and Norfolk (51-710-0024) and provide coverage for 21,895 km^2. As seen from the map in Figure 3.17.1 this includes regions in North Carolina across the State line that do not have any PM10 Sites.

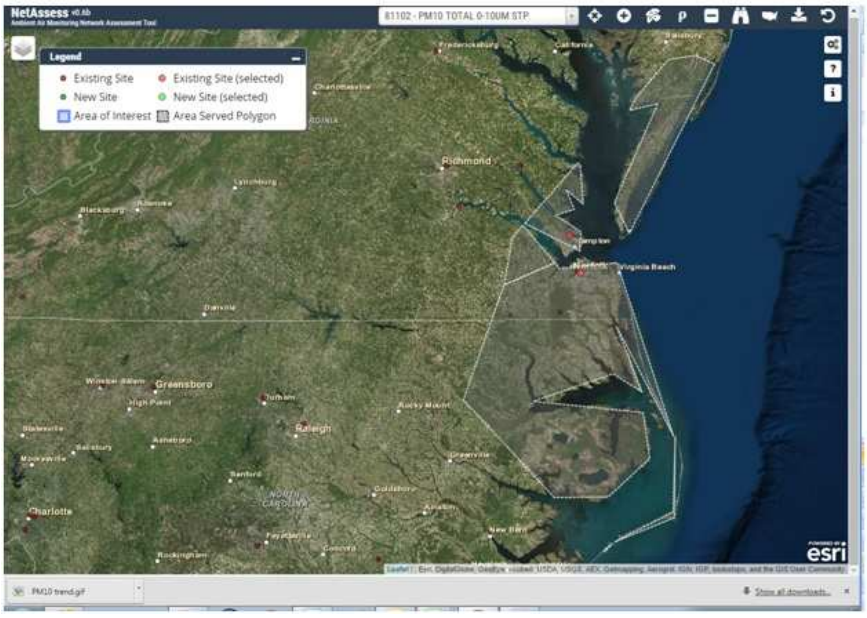

Figure 3.17.1 PM10 monitoring Sites in Hampton Roads AQCR-6

3.5.7 Northern Virginia AQCR-7

The Northern Virginia region has 4 counties and 5 cities and includes the MSA of Washington-Arlington-Alexandria, DC-VA-MD-WV. The region has a population of approximately 2.8 million, and the most densely populated region in the State (Figure 3.18.1). The region has two PM10 monitors; one is located at Alexandria (51-510-0020) and is considered a special purpose monitor; the second is located in the Fairfax County (51-039-0030) site. There was an additional PM10 monitor located in Alexandria (51-510-0009) which was removed in August 2012 due to The shutdown of the building in which it was located.

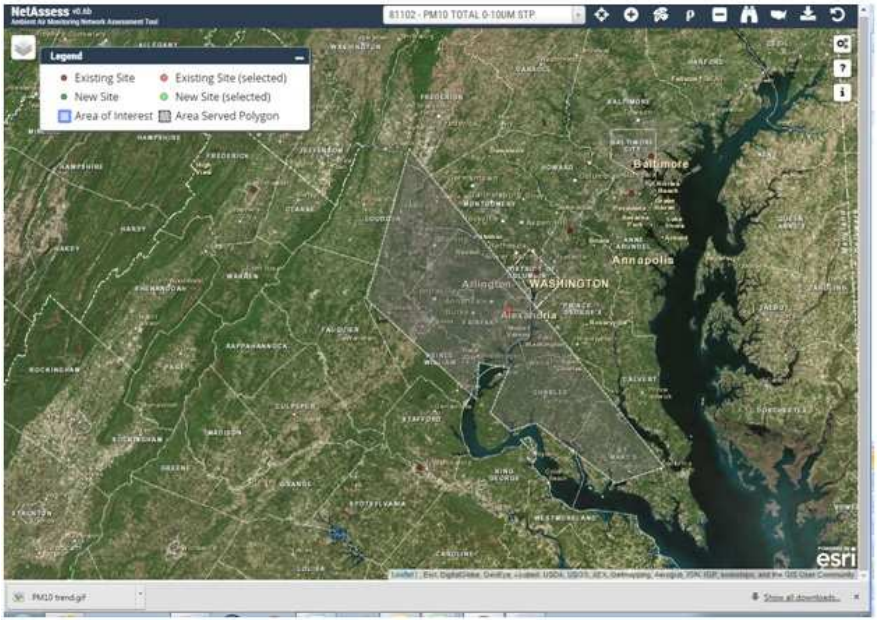

Figure 3.18.1 PM10 monitoring Site in Northern Virginia AQCR-7

3.6 PM2.5 Network in Virginia.

Virginia maintains a network of nineteen SLAMS FRM PM2.5 monitoring Sites in Virginia. Majority of the monitoring Sites are located in major metropolitan areas close to freeways and heavy traffic localities, since fuel combustion is one of the major sources of PM2.5 emissions (NEI 2011). The map in Figure 3.19.1 shows the locations of the PM2.5 monitors and as seen most of the monitoring Sites are near major freeways such as interstate 81, interstate 64, and near the Washington DC, Richmond and Hampton Roads Metropolitan statistical areas.

Figure 3.19.1 Virginia PM2.5 SLAMS Sites

3.6.1 Southwest Virginia AQCR-1

The Southwest Virginia is sparsely populated although it has 13 counties and two MSAs: Bluefield WV-VA region and the Kingsport-Bristol-TN-VA region. . AQCR-1 has one PM2.5 monitoring Site (51-520-0006) located in the city of Bristol in the MSA of Kingsport-Bristol-TN-VA. There have been no PM2.5 exceedances of the current annual NAAQS standard of 12 ug/m^3 over the 3 year period from 2011 - 2013.Figure 3.20.1 shows the long term PM2.5 trend at this Site comparing it to the annual standard of 12 ug/m^3. The annual standard was 15 ug/m^3 until Dec 2012 when it was revised to 12 ug/m^3.

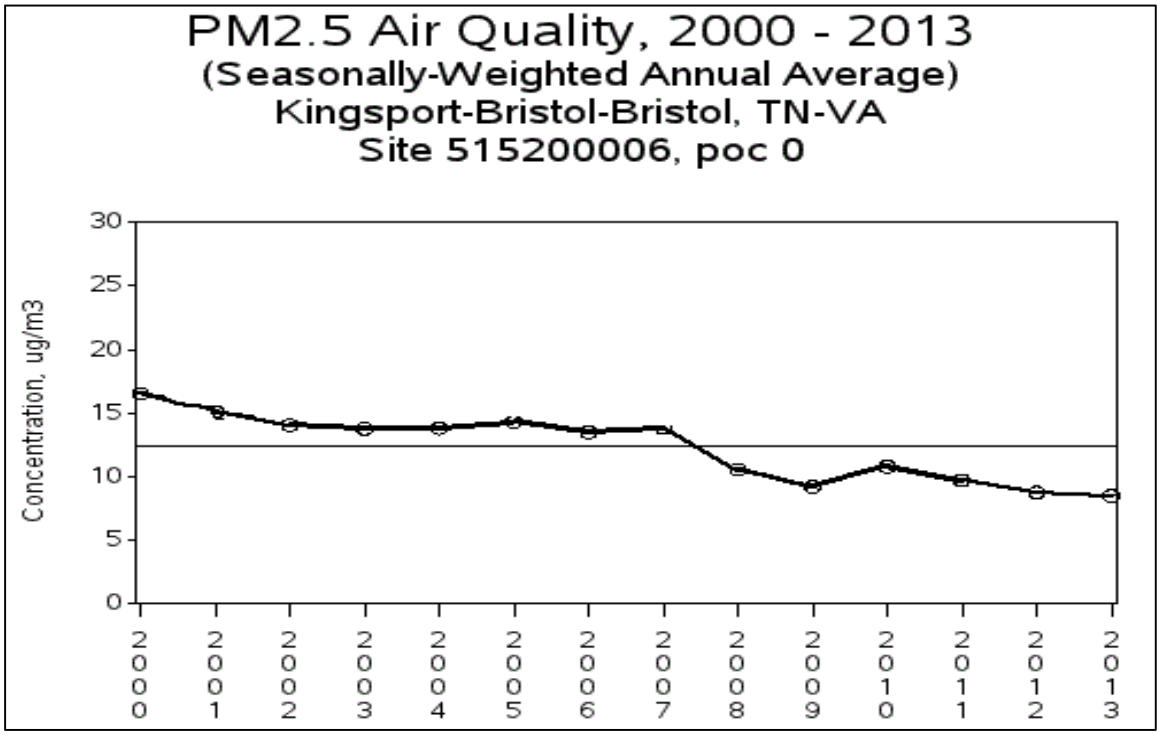

Figure 3.20.1 PM2.5 air quality trend at Bristol,VA Site

To evaluate if it would be beneficial to add another Site in Southwest Virginia the NetAssess application was used to evaluate the Site to Site correlations between the Bristol Site and three neighboring Sites in Virginia, Tennessee and North Carolina. The closest Sites are the Kingsport Site in Tennessee, Jefferson Road Site in North Carolina, and one Site in Salem, Virginia. The location of these Sites is shown in Figure 3.20.2.

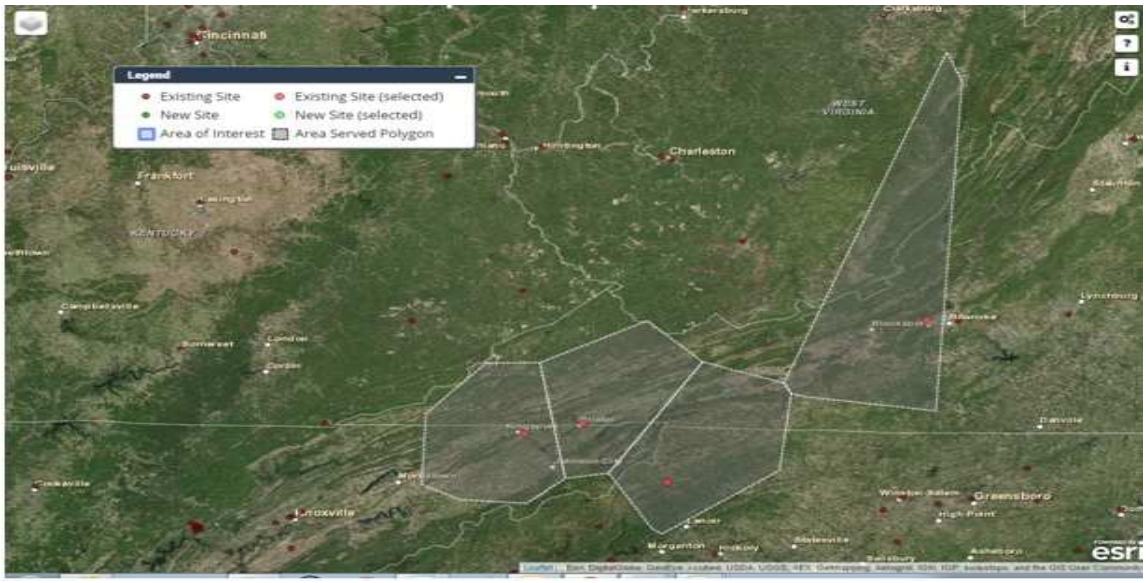

Figure 3.20.2 PM2.5 Sites in Southwest Virginia

Table 3.13.1 gives details of these Sites with historical design values for the 24-hour average NAAQS of 35 ug/m^3. The NetAssess application was used for comparing the PM2.5 levels at the Bristol Site to nearest neighboring Sites at Salem (VA), Boone (NC) and Kingsport (TN) and results are shown in Table 3.13.2 and Figure 3.20.3. NetAssess used the 2011-2013 data from AQS for this comparison. As any correlation above 0.6 is considered a high correlation therefore the PM2.5 24-hour averages at the Bristol Site are very similar to the levels at the other 3 Sites. Therefore it is unlikely there would be any advantage gained by adding an additional PM2.5 monitor in Southwest Virginia.

Table 3.13.1 Locations of PM2.5 monitors in Southwest Virginia

Site ID	Location (City/county)	Area Served (km^2)	Population served	24-hour Design Value 2011	24-hour Design Value 2012	24-hour Design Value 2013	Probability of Exceeding 35 ug/m^3
51-520-0006	Bristol, VA	5958	261,828	21	20	18	<25%
51-775-0011	Salem, VA	12,211	370,892	21	20	19	<25%
37-189-0003	Boone, NC	7,592	203,062	18	17	16	<25%
47-163-1007	Kingsport, TN	6,375	417,963	23	22	20	<25%

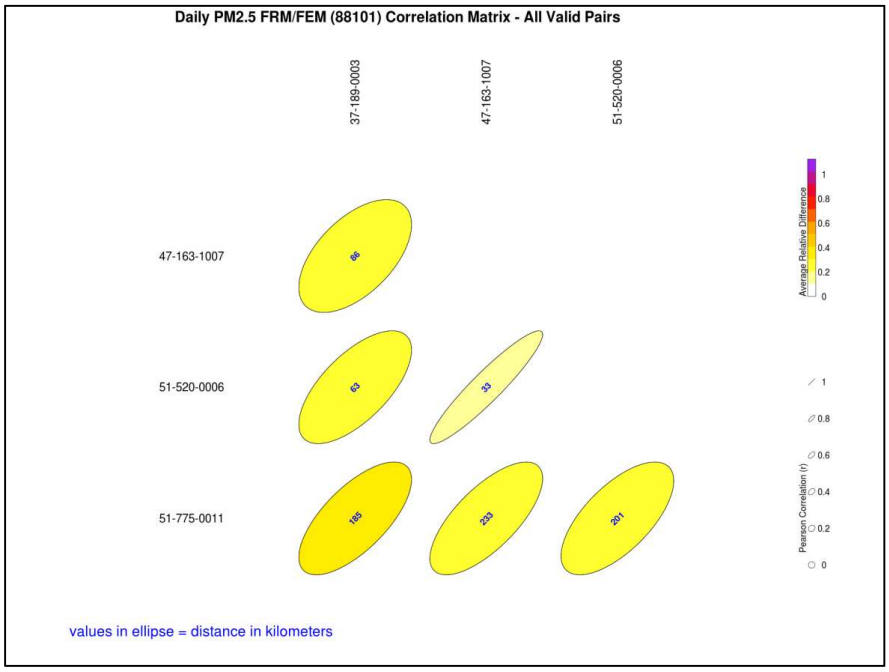

Figure 3.20.3 Site to Site Correlations for Southwest Virginia

Table 3.13.2 Pearson's correlations for AQCR-1

Site 1	Site 2	n	Distance (km)	Correlation	Rel. Diff
51-520-0006	37-189-0003	335	63	0.66	0.28
51-520-0006	47-163-1007	105	33	0.93	0.13
51-520-0006	51-775-0011	318	201	0.67	0.28

3.6.2 Valley Region of Virginia AQCR-2

The AQCR-2 region covers 16 counties and four MSA/CBSAs in Winchester, Roanoke, Harrisonburg and Waynesboro-Staunton. There are five PM2.5 FRM monitors in this region and Figure 3.21.1 shows the locations of these monitors. Table 3.14.1 gives their locations and details on the historical 24-hour average design values. The Roanoke Site (51-161-1004) was relocated several times and started operating in October 2013; hence it does not have historical design values calculations for the years of interest.

Table 3.14.1 PM2.5 FRM monitors in Valley Region

Site ID	Location (City/county)	Area Served (km^2)	Population served	24-hour Design Value 2011	24-hour Design Value 2012	24-hour Design Value 2013	Probability of Exceeding 35 ug/m^3
51-069-0010	Frederick	3,892	201,971	23	24	23	<25%
51-139-0004	Page	5,246	143,708	22	21	19	25%-50%
51-161-1004	Roanoke	5,893	252,086	22	21	NA	<25%
51-165-0003	Rockingham	9,225	235,350	23	22	21	25%-50%
51-775-0011	Salem	10,460	362,281	21	20	19	<25%
total		34,716	1,195,396				

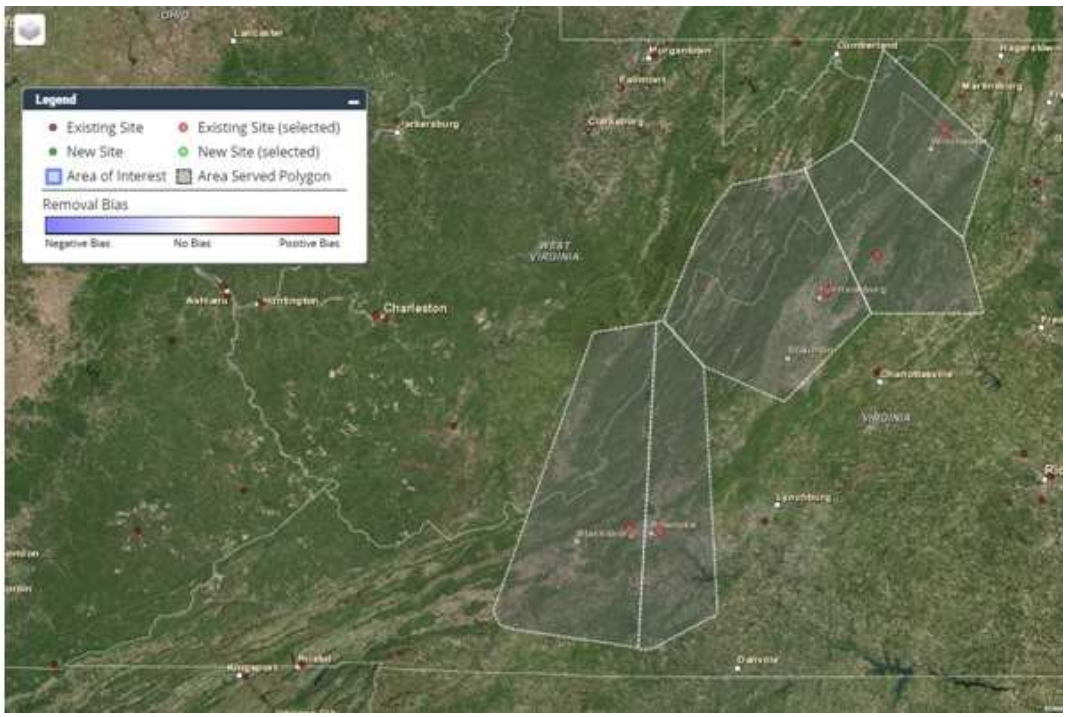

Figure 3.21.1 FRM PM2.5 Sites in Valley Region

To evaluate any redundancies in the locations of PM2.5 FRM Sites the NetAssess tool was used to calculate the Pearson's correlations between Sites. The data on the correlations are shown in Figure 3.21.2 and Table 3.14.2.

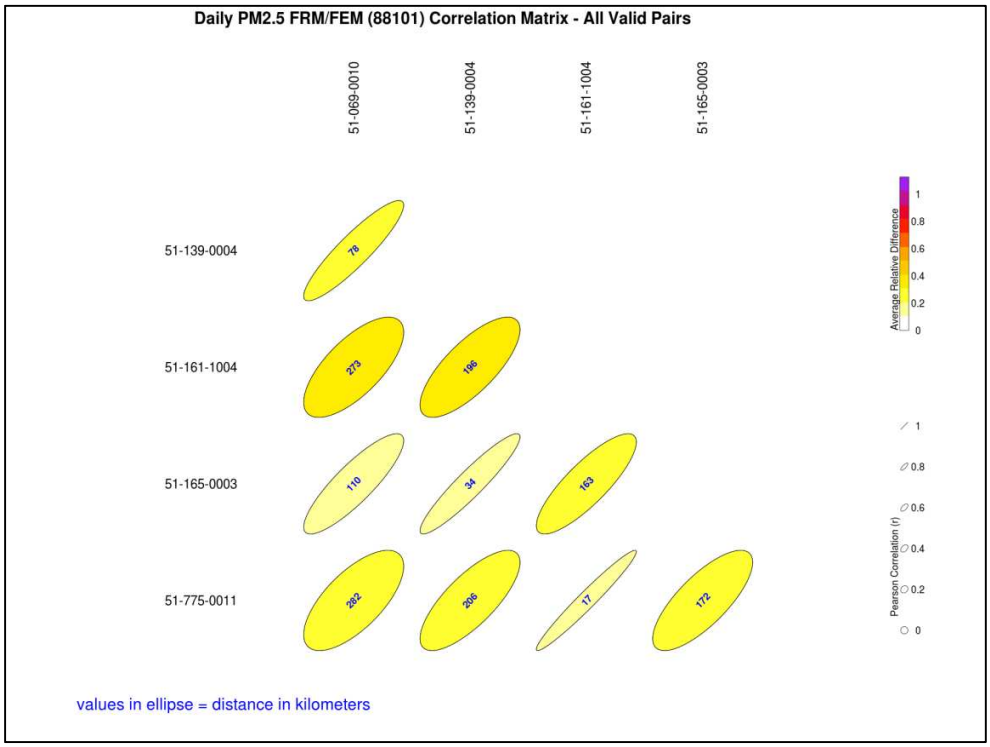

Figure 3.21.2 Pearson's correlations PM2.5 FRM Sites

Table 3.14.2 Site to Site Correlations for PM2.5 FRM Sites

Site 1	Site 2	n	Distance (km)	Correlation	Rel. Diff
51-069-0010	51-139-0004	348	78	0.91	0.21
51-069-0010	51-161-1004	61	273	0.70	0.31
51-069-0010	51-165-0003	347	110	0.86	0.20
51-069-0010	51-775-0011	319	282	0.68	0.29
51-139-0004	51-161-1004	60	196	0.75	0.32
51-139-0004	51-165-0003	352	34	0.93	0.16
51-139-0004	51-775-0011	323	206	0.76	0.27
51-161-1004	51-165-0003	60	163	0.83	0.22
51-161-1004	51-775-0011	58	17	0.97	0.14
51-165-0003	51-775-0011	320	172	0.76	0.23

The NetAssess application used the 2011-2013 PM2.5 24-hour averages data to compute the correlation coefficients and all the Sites correlate very well as the numbers are in the range of 0.68-0.97. In case of the Roanoke Site (51-161-1004) the number of valid data pairs available ranges from n=58 to n=61 since this Site started operating in October 2013.

The removal bias for these Sites was examined using NetAssess and the results are shown in Figure 3.21.3 and Table 3.14.3. The mean removal bias is positive for monitors in Frederick, Page and Roanoke indicating that these monitors are essential to the existing network, and although the mean removal bias for Rockingham and Salem is negative, these monitors are situated in densely populated MSAs of Harrisonburg and Roanoke and are also essential to the PM2.5 network.

Table 3.14.3 Removal bias for PM2.5 FRMs in Valley Region

Site ID	Neighbors Included	Mean Removal Bias (ug/m^3)	Minimum Removal Bias (ug/m^3)	Maximum Removal Bias (ug/m^3)	Removal Bias Standard Deviation
51-069-0010	4	0.83	-4.74	9.13	1.67
51-139-0004	5	0.67	-4.65	5.6	1.22
51-161-1004	7	1.11	-6.57	7.2	1.73
51-165-0003	8	-0.73	-13.5	3.56	1.58
51-775-0011	6	-0.69	-9.1	10.9	2.17

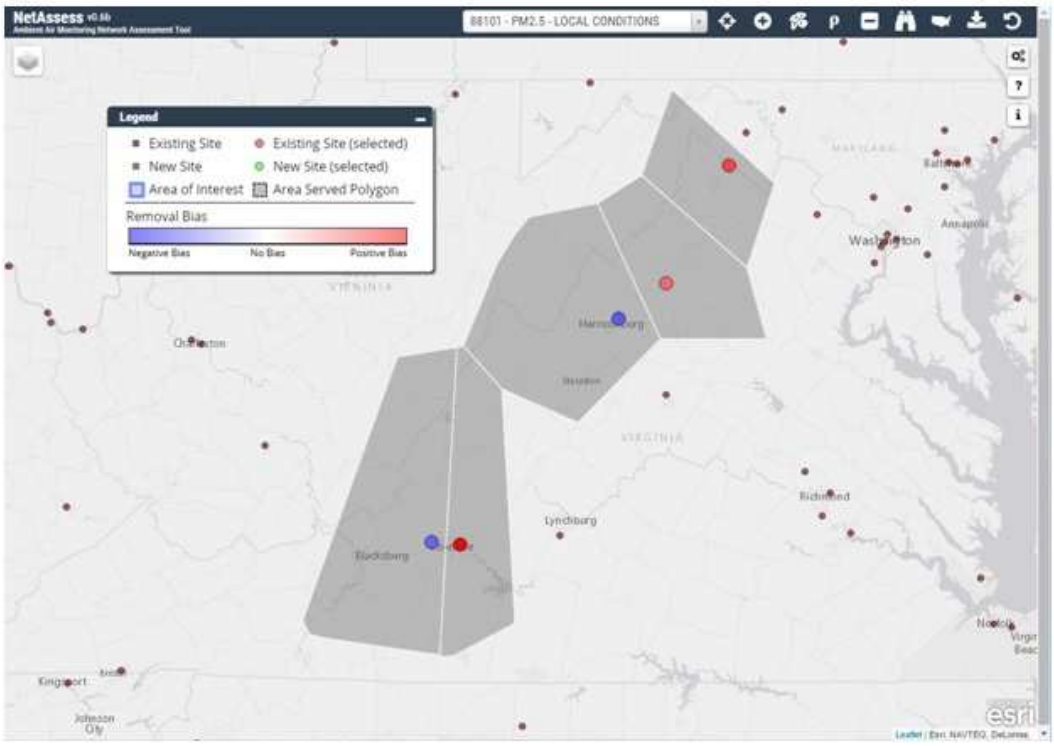

Figure 3.21.3 Removal Bias for PM2.5 FRMs in Valley Region

3.6.3 Central Virginia AQCR-3

The Central Virginia Region encompasses 18 counties with a land area of approximately 24,000 km^2 and population of approximately 560,000. The Region has one PM2.5 FRM which is located in Lynchburg (51-680-0015), and provides coverage for 11,504 km^2, as seen from the data in Table 3.15.1. Although the scale of the Lynchburg monitor does not project over the entire Central Virginia region, it serves a population of 324,590 which is approximately 60% of the region. The PM2.5 levels seen at this Site are very similar to the daily 24-hour average PM2.5 levels observed at the monitors nearby in Roanoke, Salem and Albemarle which are shown on the map in Figure 3.22.1. Details on these Sites with recent years design values and the correlations between the monitors are shown in Table 3.15.1 and Table 3.15.2. The PM2.5 monitor in Roanoke started operating in October 2013 hence it does not have the requisite data needed for the design value calculations.

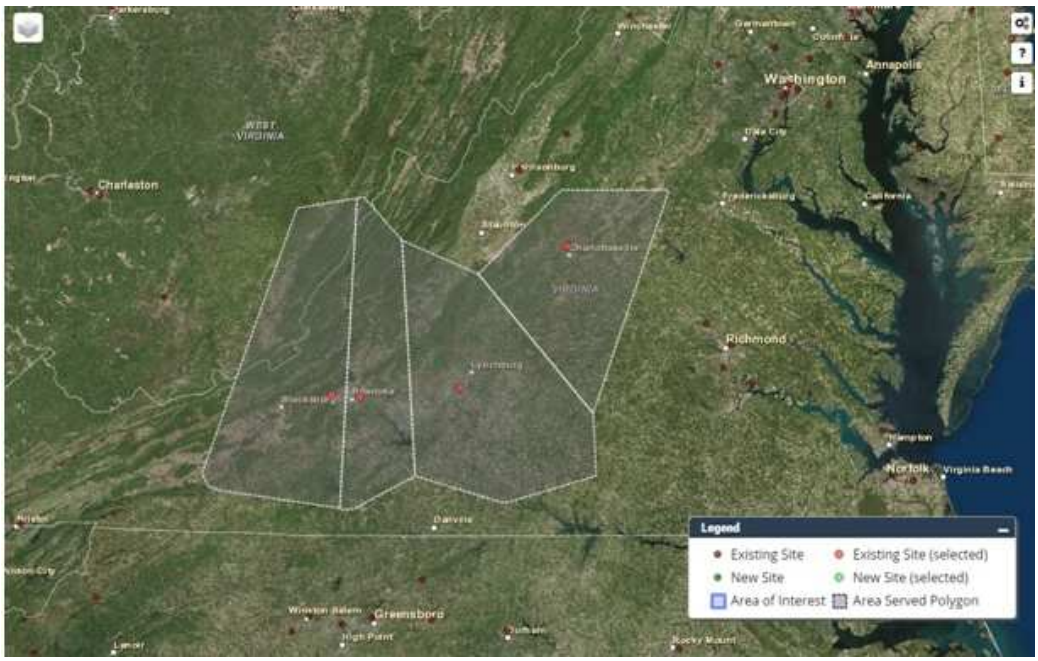

Figure 3.22.1 PM2.5 FRM monitors in Central Virginia.

Table 3.15.1 Location of PM2.5 FRM monitors in Central Virginia

Site ID	Location (City/county)	Area Served (km^2)	Population served	24-hour Design Value 2011	24-hour Design Value 2012	24-hour Design Value 2013	Probability of Exceeding 35 ug/m^3
51-680-0015	Lynchburg	11,504	324,590	19	18	17	<25%
51-003-0001	Albemarle	7,748	313,470	19	19	18	<25%
51-161-1004	Roanoke	5,893	252,086	22	21	NA	<25%
51-775-0011	Salem	10,460	362,281	21	20	19	<25%

Table 3.15.2 Site to Site Correlations for PM2.5 monitors in Central Virginia.

Site 1	Site 2	n	Distance (km)	Correlation	Rel. Diff
51-680-0015	51-003-0001	335	104	0.887	0.162
51-680-0015	51-161-1004	60	60	0.892	0.147
51-680-0015	51-775-0011	308	77	0.849	0.23

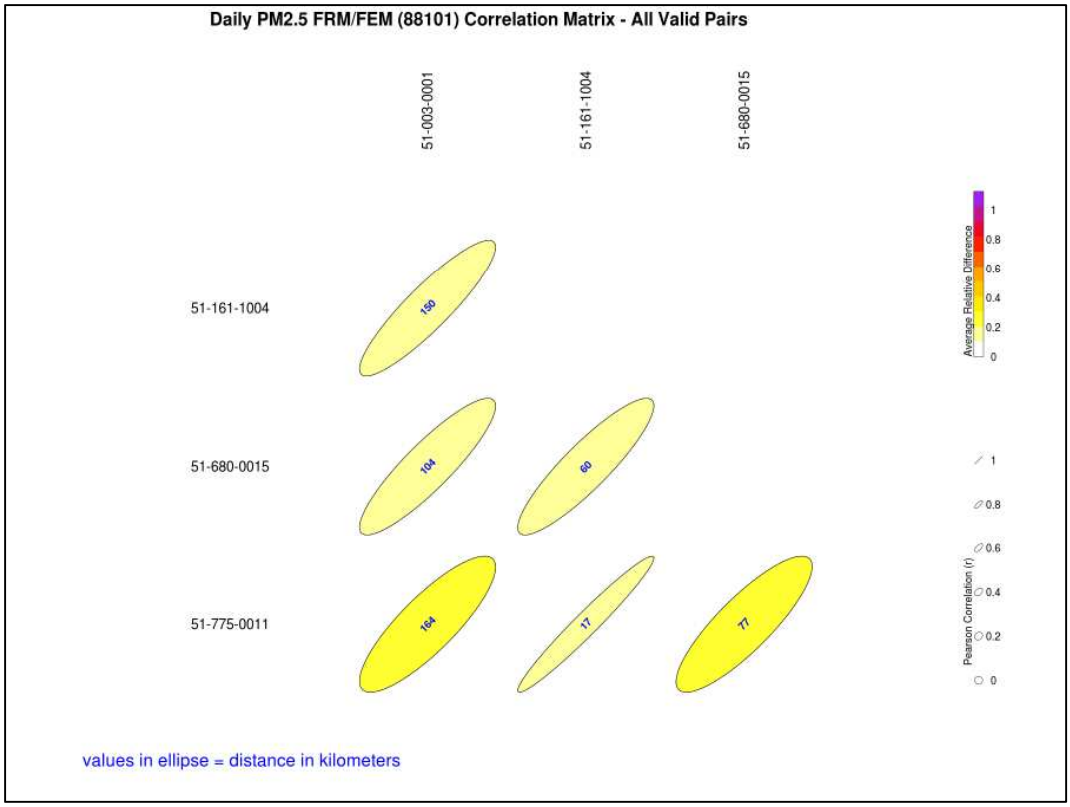

Figure 3.22.2 Pearson's correlations for PM2.5 FRMs in AQCR-3.

As seen from the 2011-2013 data in Table 3.22.2, the correlations ranged from 0.85-0.89 indicating the PM2.5 levels at these Sites was very similar. The same is indicated by the low numbers for their relative differences which are all less than 0.25. As the Roanoke monitor started operating in October 2013, the number of valid pairs of data for this monitor is small at n=60. Overall it can be concluded that the Lynchburg PM2.5 monitor is providing adequate representation for the PM2.5 levels and there would be no additional advantage from placing another PM2.5 FRM monitor in the Central Virginia area.

3.6.4. Northeast Virginia AQCR-4

This region has 26 counties and two CBSAs which are the Charlottesville and the Fredericksburg areas. . There is a single PM2.5 FRM monitor (51-003-0001) located in Albemarle County near the city of Charlottesville. The map in Figure 3.4.1 shows the location of this monitoring Site.

As visible from the map nearby PM2.5 monitors in Rockingham and Page counties and in the Richmond area also provide coverage and representation for the PM2.5 levels seen in this region.

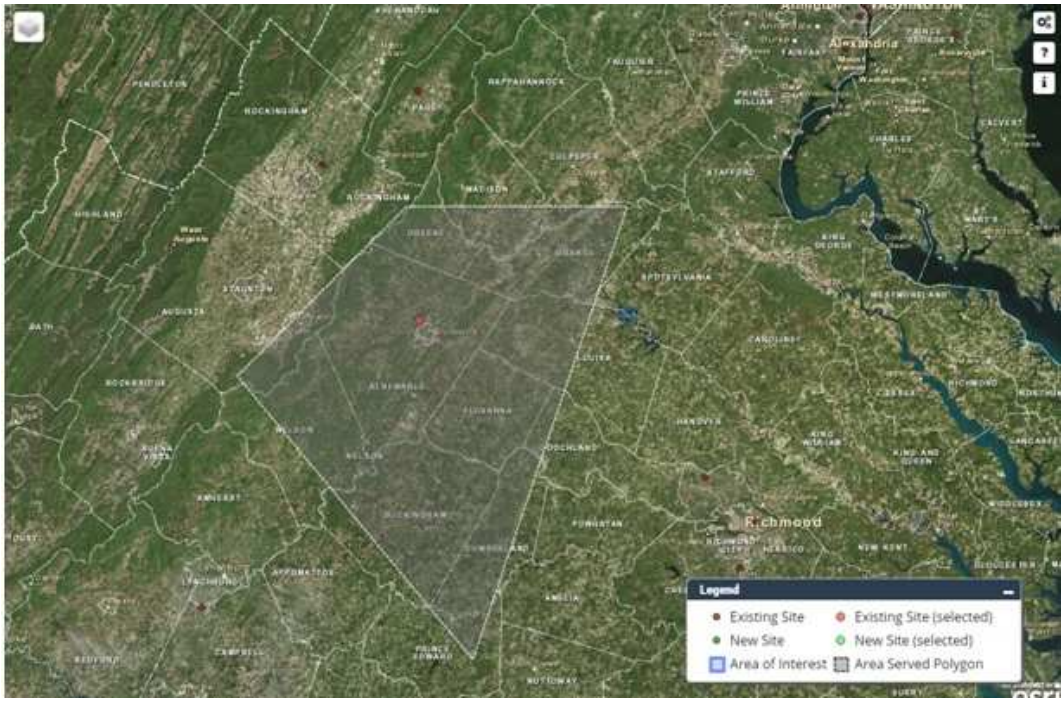

Figure 3.23.1 PM2.5 FRM monitoring Site in AQCR-4

In order to assess whether there is a need to add another PM2.5 FRM in this region, the 2011-2013 daily 24-hour PM2.5 averages at the Albemarle Site were compared to the levels at Rockingham, Page counties and Richmond area. The Site data with recent years design values and expected exceedance probability for the 24-hour NAAQS are shown in Table 3.16.1.

Table 3.16.1 PM2.5 FRM Sites in AQCR-4 Region

Site ID	Location (City/county)	Area Served (km^2)	Population served	24-hour Design Value 2011	24-hour Design Value 2012	24-hour Design Value 2013	Probability of Exceeding 35 ug/m^3
51-003-0001	Albemarle	7,748	313,470	19	19	18	<25%
51-165-0003	Rockingham	9,225	235,350	23	22	21	25%-50%
51-139-0004	Page	5,246	143,708	22	21	19	25%-50%
51-087-0015	Henrico	6,503	528,307	20	19	18	<25%

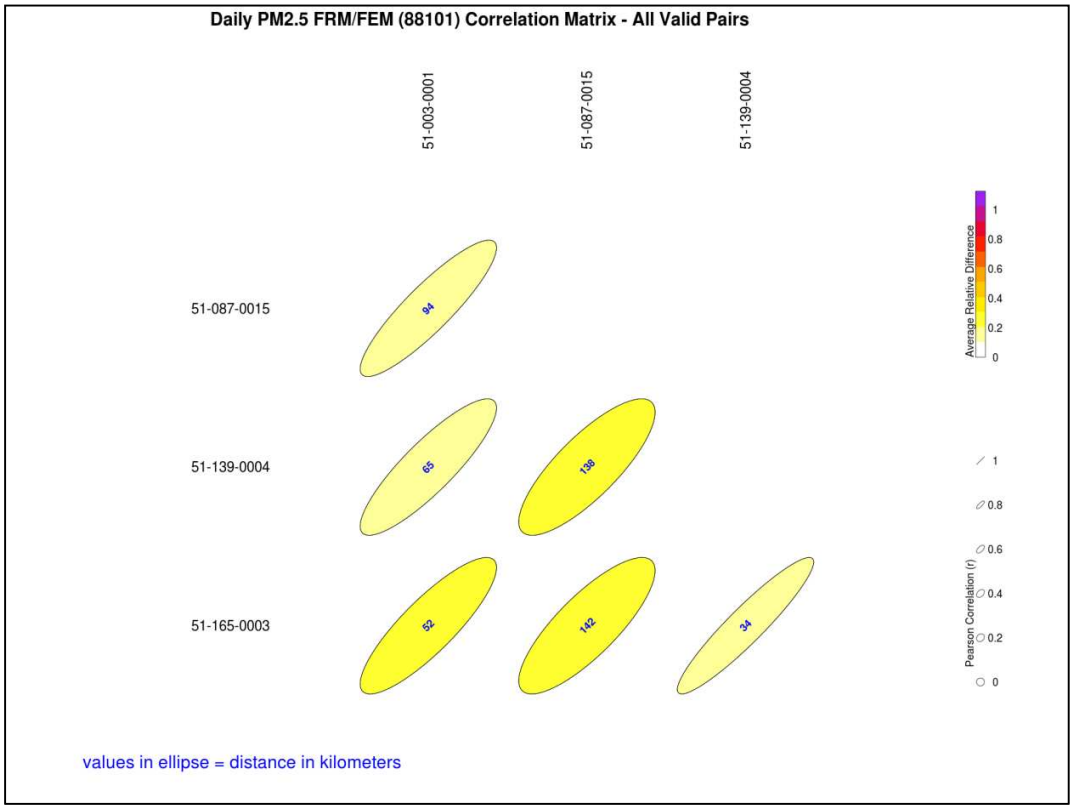

Figure 3.23.2 Pearson's correlations for PM2.5 FRM Sites in AQCR-4 region

Table 3.16.2 Site to Site Correlations for PM2.5 FRM Sites in AQCR-4 region

Site 1	Site 2	n	Distance (km)	Correlation	Rel. Diff
51-003-0001	51-087-0015	339	94	0.889	0.181
51-003-0001	51-139-0004	350	65	0.867	0.188
51-003-0001	51-165-0003	349	52	0.853	0.201

As seen from the reviewing the 2011-2013 data in Table 3.16.2, the correlations ranged from 0.85-0.89 indicating the PM2.5 levels at these Sites was very similar. The same is indicated by the low numbers for their relative differences which are all less than 0.25. Overall it can be concluded that the Albemarle PM2.5 monitor is adequately representing the PM2.5 levels and there would be no additional advantage from placing another PM2.5 FRM monitor in Northeast Virginia area.

3.6.5 State Capitol AQCR-5

The State Capitol Region of Virginia includes 12 counties and the CBSA of Richmond. The details about the Sites and PM2.5 air quality are given in Table 3.5.1 and a map in Figure 3.24.1 shows the locations of the Sites. As seen from the map total land area covered by the four PM2.5 monitors is much larger than the land area in AQCR-5 and as such these Sites are also providing coverage for the neighboring counties in AQCR-3 and AQCR-4.

Table 3.17.1 PM2.5 FRM Sites in the State Capitol Region

Site ID	Location (City/county)	Area Served (km^2)	Population served	24-hour Design Value 2011	24-hour Design Value 2012	24-hour Design Value 2013	Probability of Exceeding 35 ug/m^3
51-036-0002	Charles City	6648	242749	20	21	20	<25%
51-041-0003	Chesterfield	4915	382171	21	21	21	<25%
51-087-0014	Richmond	2790	330689	22	22	21	<25%
51-087-0015	Henrico	6503	528307	20	19	18	<25%
total		20,856	1,483,916				

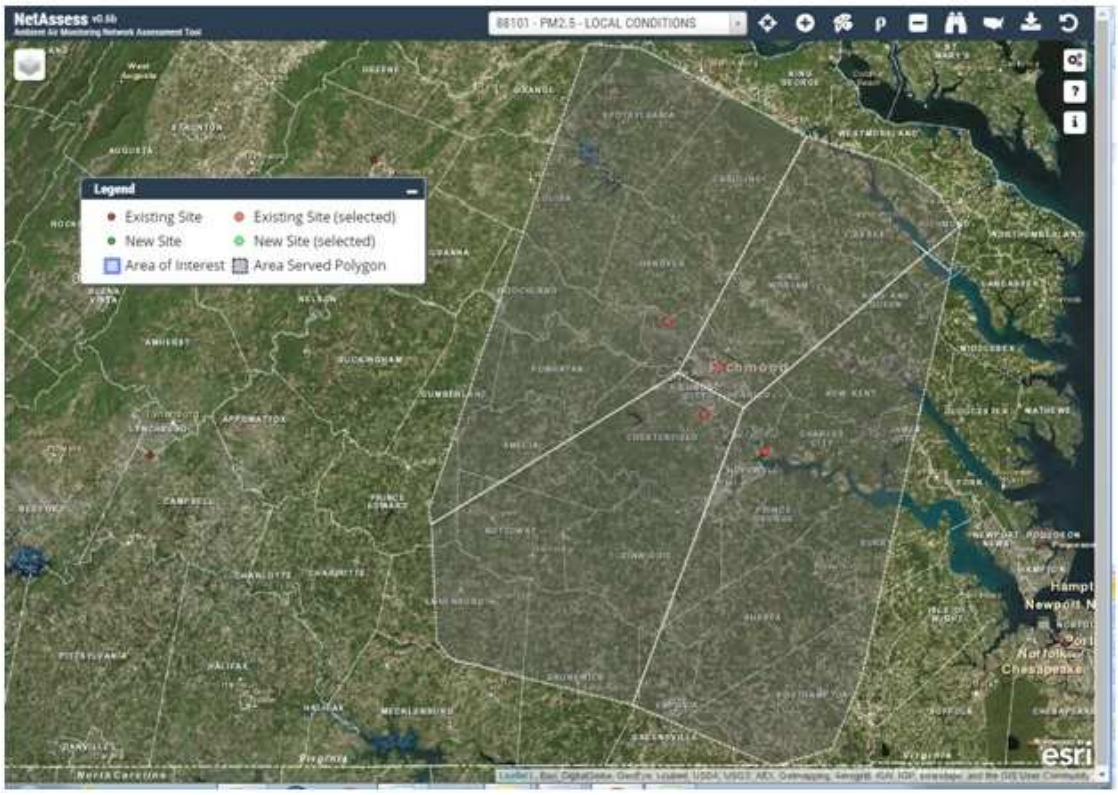

Figure 3.24.1 PM2.5 FRM Sites in State Capitol Region

In order to evaluate any redundancies in the PM2.5 monitors the NetAssess tool was used to calculate the Site to Site correlations, and the data are shown in Table 3.17.2 and Figure 3.24.2. As seen from this analysis the PM2.5 Sites are very well correlated since all the correlation coefficients are greater than 0.90, and their relative differences are very low at less than 0.25. To further evaluate if any of these Sites could potentially be redundant the NetAssess application was used to calculate the removal bias for these Sites.

Table 3.17.2 Site to Site Correlations for PM2.5 monitors in AQCR-5

Site 1	Site 2	n	Distance (km)	Correlation	Rel. Diff
51-036-0002	51-041-0003	318	20	0.92	0.15
51-036-0002	51-087-0014	349	27	0.95	0.12
51-036-0002	51-087-0015	326	45	0.94	0.14
51-041-0003	51-087-0014	341	14	0.98	0.08
51-041-0003	51-087-0015	320	28	0.96	0.11
51-087-0014	51-087-0015	357	19	0.97	0.10

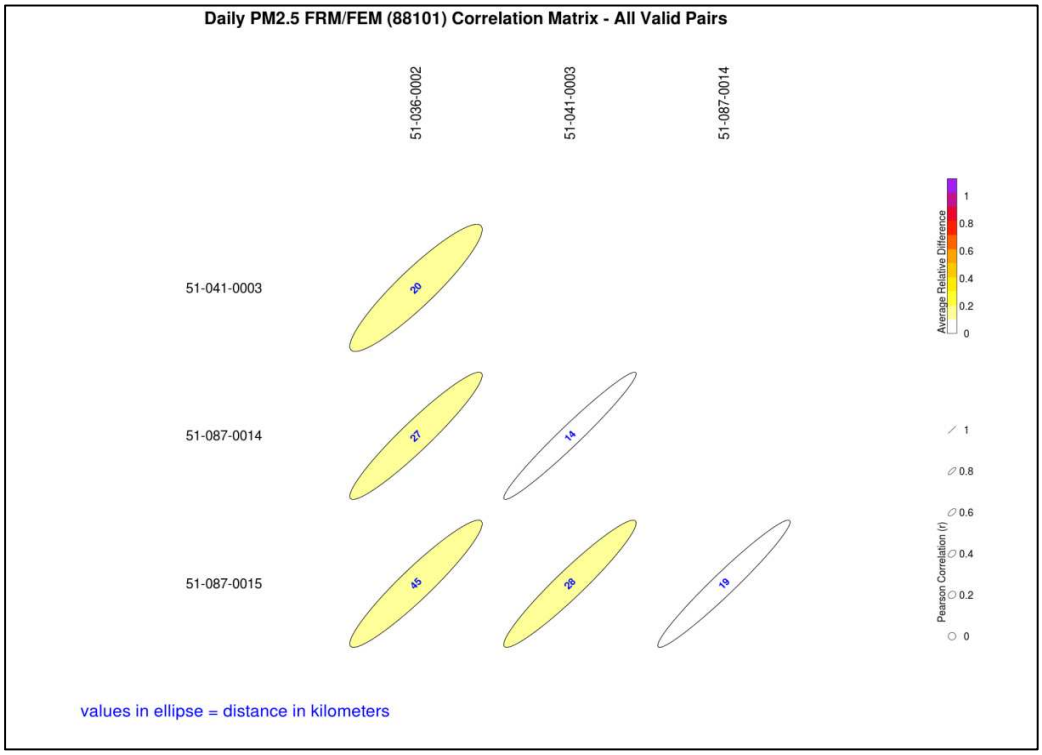

Figure 3.24.2 Pearson's Correlations for AQCR-5

The removal bias was evaluated using the NetAssess application and results are shown in Table 3.17.3 and Figure 3.24.3. In Figure 3.24.3 there are red circles at the Henrico and Charles City Sites due to a positive mean removal bias, and blue circles for the Richmond and Chesterfield Sites as there is a negative mean removal bias. However, there are no redundancies in the PM2.5 monitors in this region. The Richmond Site is an NCORE Site and the Chesterfield monitor is a downwind Site for the Hampton Roads area. These Sites are providing representation for the PM2.5 levels this region as well as for neighboring counties in AQCR-3 and AQCR-4 hence all four Sites are of high importance and cannot be removed or relocated.

Table 3.17.3 Removal Bias for PM2.5 monitors in AQCR-5

Site ID	Neighbors Included	Mean Removal Bias (ug/m3)	Minimum Removal Bias (ug/m3)	Maximum Removal Bias (ug/m3)	Removal Bias Standard Deviation
51-036-0002	7	0.57	-6.00	7.38	1.42
51-041-0003	7	-0.36	-6.08	2.92	1.07
51-087-0014	6	-0.19	-18.80	11.30	1.65
51-087-0015	6	0.42	-2.78	5.18	0.95

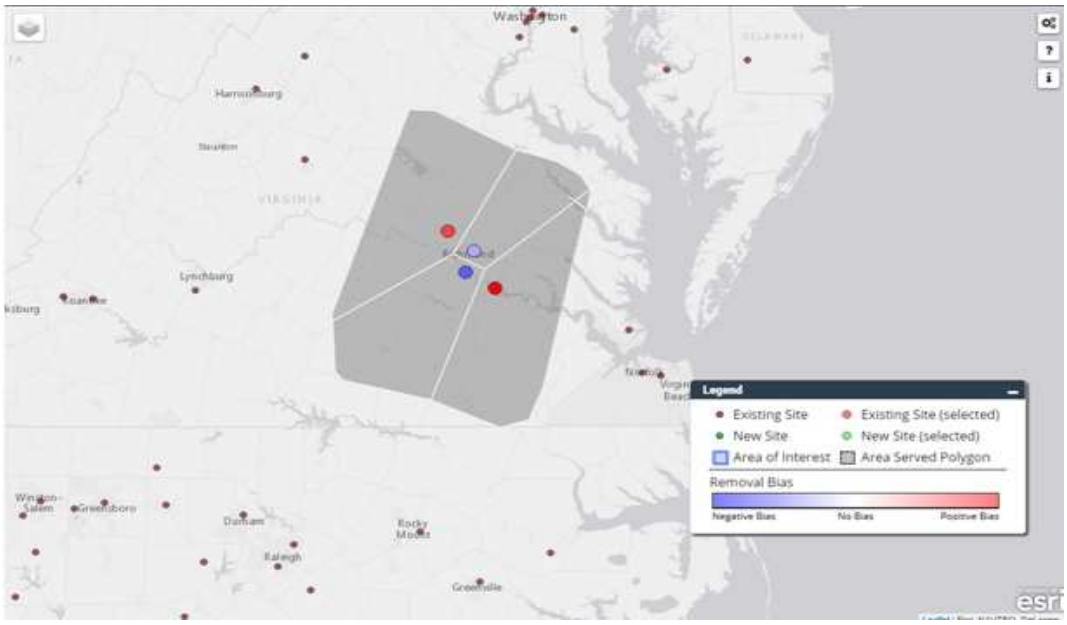

Figure 3.24.3 AQCR-5 Region with removal bias for PM2.5 monitors

3.6.6 Hampton Roads AQCR-6

The Hampton Roads Region is in the Eastern part of Virginia and includes 4 counties, and several cities, and the MSA of Norfolk-Virginia Beach-Newport News, VA-NC. There are three PM2.5 FRM monitors in this region and their locations are shown on the map in Figure 3.25.1. The details on these Sites and the PM2.5 24-hour design values for the recent years are in Table 3.18.1.

As seen from the Site correlations evaluation using NetAssess all three Sites are highly correlated and their relative differences are very low. This is also due to their close proximity as all three Sites are within 35 km of each other. To evaluate any redundancies in these Sites NetAssess was used to calculate the removal bias and results are shown in Table 3.18.2 and Figure 3.25.3.

Table 3.18.1 PM2.5 FRM Sites in Hampton Roads Region

Site ID	Location (City/county)	Area Served (km^2)	Population served	24-hour Design Value 2011	24-hour Design Value 2012	24-hour Design Value 2013	Probability of Exceeding 35 ug/m^3
51-650-0008	Hampton	5094	447674	NA	NA	21	<25%
51-710-0024	NOAA, Norfolk	3581	455438	26	27	21	<25%
51-810-0008	Virginia Beach	3784	614617	23	24	22	50%-70%
total		12,459	1,517,729				

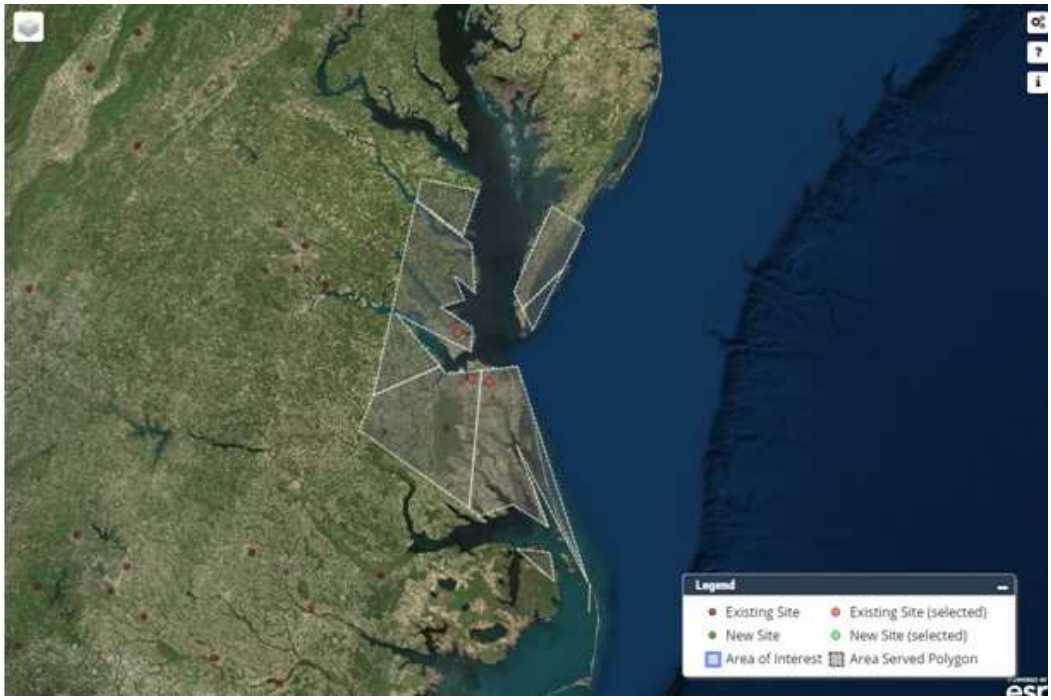

Figure 3.25.1 PM2.5 FRM Sites in Hampton Roads Region

Table 3.18.2 Site to Site Correlations for PM2.5 monitors in AQCR-6

Site 1	Site 2	n	Distance (km)	Correlation	Rel. Diff
51-650-0008	51-710-0024	350	29	0.89	0.13
51-650-0008	51-810-0008	340	34	0.77	0.16
51-710-0024	51-810-0008	350	11	0.85	0.11

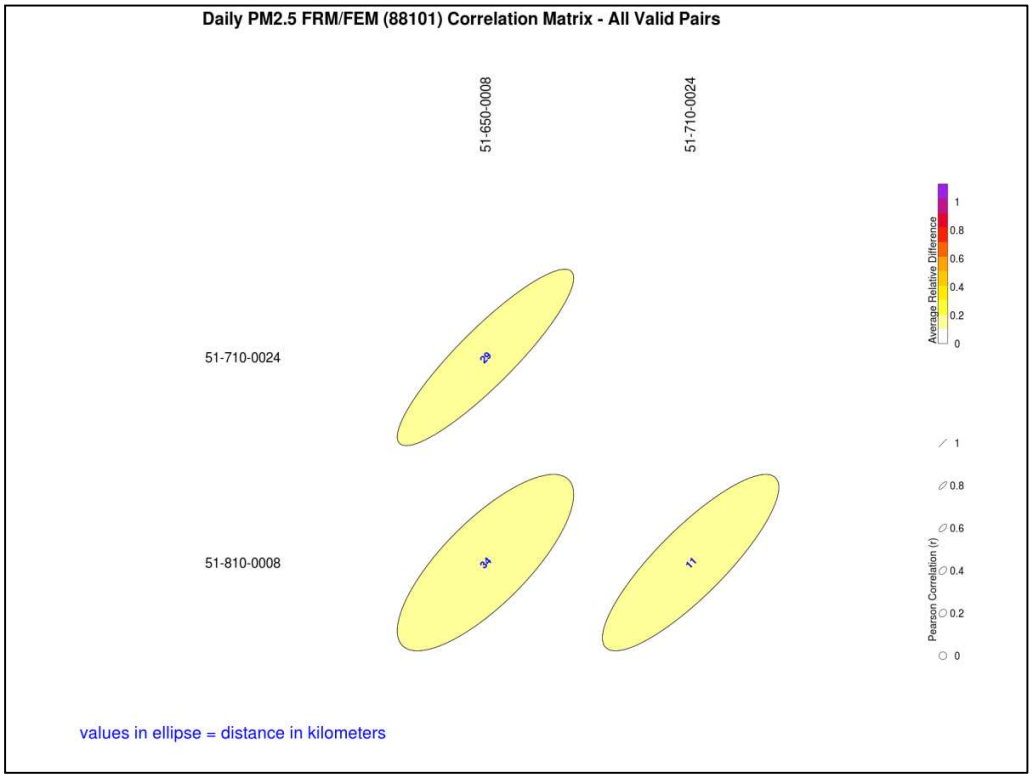

Figure 3.25.2 Pearson's Correlations for Hampton Roads Region

Table 3.18.3 Removal bias for PM2.5 FRM Sites in Hampton Roads

Site ID	Neighbors Included	Mean Removal Bias (ug/m3)	Minimum Removal Bias (ug/m3)	Maximum Removal Bias (ug/m3)	Removal Bias Standard Deviation
51-650-0008	5	0.71	-27.30	21.00	2.29
51-710-0024	4	-0.26	-32.00	13.50	2.55
51-810-0008	7	0.35	-16.70	38.30	3.19

As seen from the results of the removal bias calculation there are no redundancies in the PM2.5 Sites in the Hampton Roads region. The Hampton Site and Virginia Beach Site removal biases are positive indicating these are essential to the Region, and although the Norfolk Site has a negative mean removal bias this is a PM2.5 monitor at the NOAA facility and also essential for that Site and cannot be removed or relocated.

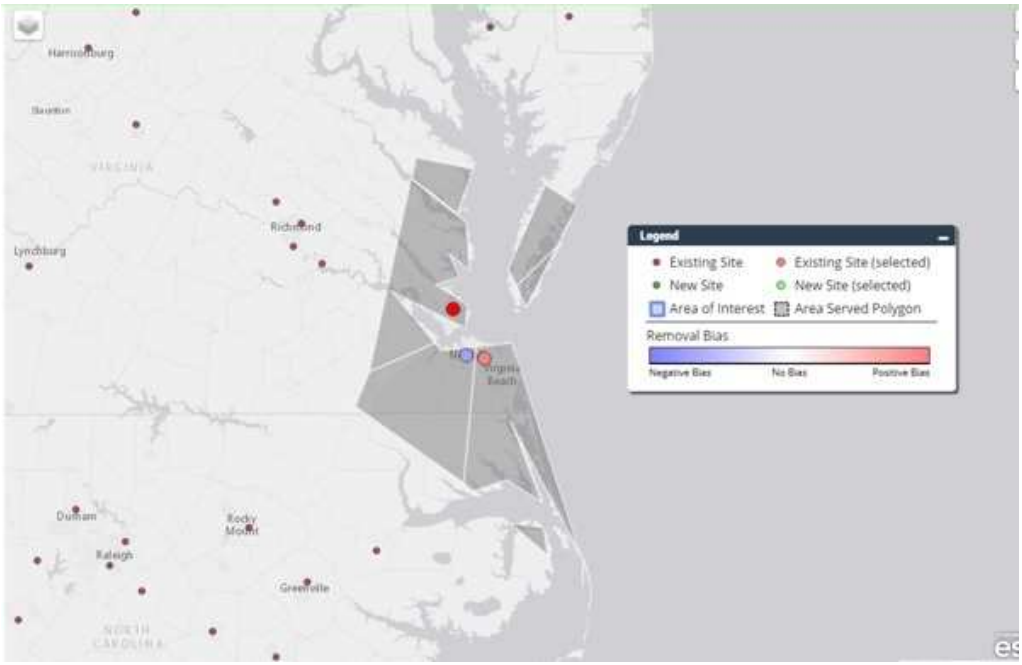

Figure 3.25.3 Removal bias for PM2.5 FRM Sites in Hampton Roads

3.6.7 Northern Virginia AQCR-7

The Northern Virginia Region includes 4 counties, and several cities, and the MSA of Washington-Arlington-Alexandria, DC-VA-MD-WV. The region has a population of approximately 2.8 million, and it is the most densely populated region in the State. The region has three PM2.5 FRM monitors and their locations and details on the Sites including the 24-hour average NAAQS design values are given in Table 3.19.1 and the map is in Figure 3.26.1. As seen from the Site coverage data in Table 3.7.1 the 3 Sites provide adequate coverage for the 4 counties in the Northern Virginia region. The Arlington Site PM2.5 monitor was non-operational from November 29, 2010 to July 2, 2011 due to the Site undergoing roof repair, hence there are no design value calculations for 2011, 2012 and 2013.

Table 3.19.1 PM2.5 FRM Sites in Northern Virginia Region

Site ID	Location (City/county)	Area Served (km^2)	Population served	24-hour Design Value 2011	24-hour Design Value 2012	24-hour Design Value 2013	Probability of Exceeding 35 ug/m^3
51-013-0020	Arlington (city)	231	464,058	20	22	21	25%-50%
51-059-0030	Fairfax	3,412	1,241,944	24	23	22	25%-50%
51-107-1005	Loudoun	4,226	950,986	20	20	20	<25%
total		7,869	2,656,988				

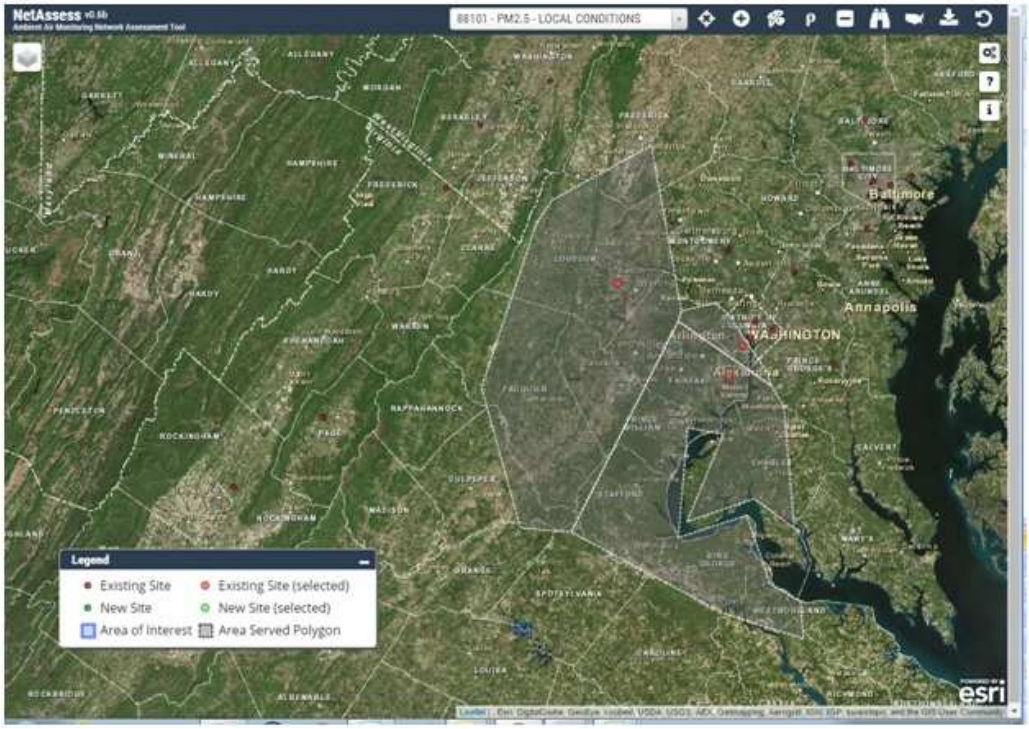

Figure 3.26.1 PM2.5 FRM Sites in Northern Virginia

To evaluate any redundancies in the PM2.5 Sites in this region the Site correlations and Site removal biases were calculated using NetAssess. As seen from Table 3.19.2 the PM2.5 24-hour averages were highly correlated. All correlation coefficients are greater than 0.9 and removal biases are less than 0.25. As seen from Table 3.19.3 the mean removal bias is positive for all three PM2.5 Sites indicating that all three Sites are non-redundant.

Table 3.19.2 Pearson's Correlations PM2.5 FRMs in Northern Virginia

Site 1	Site 2	n	Distance (km)	Correlation	Rel. Diff
51-013-0020	51-059-0030	290	10	0.966	0.106
51-013-0020	51-107-1005	278	42	0.943	0.13
51-059-0030	51-107-1005	328	44	0.953	0.114

Table 3.19.3 Removal bias for PM2.5 FRM Sites in Northern Virginia

Site ID	Neighbors Included	Mean Removal Bias (ug/m3)	Minimum Removal Bias (ug/m3)	Maximum Removal Bias (ug/m3)	Removal Bias Standard Deviation
51-013-0020	6	0.35	-9.76	10.40	1.84
51-059-0030	6	0.95	-14.30	26.90	2.40
51-107-1005	9	0.66	-2.67	5.64	1.30

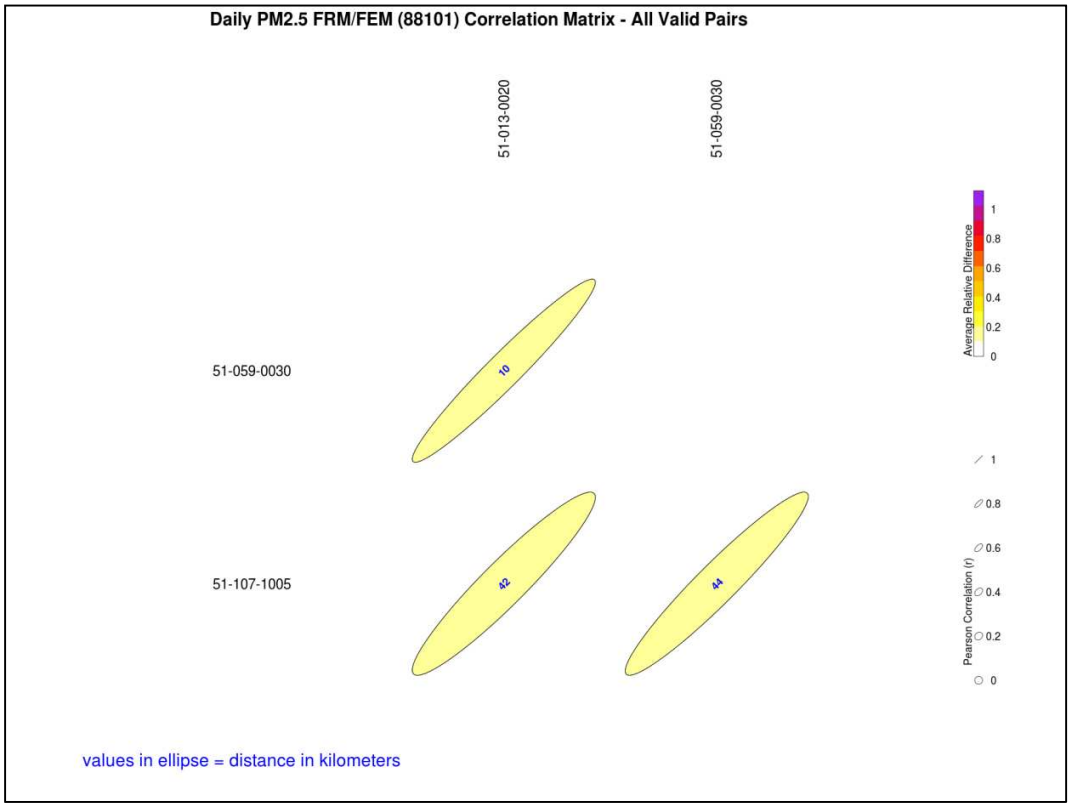

Figure 3.26.2 Pearson's Correlations for Northern Virginia Region

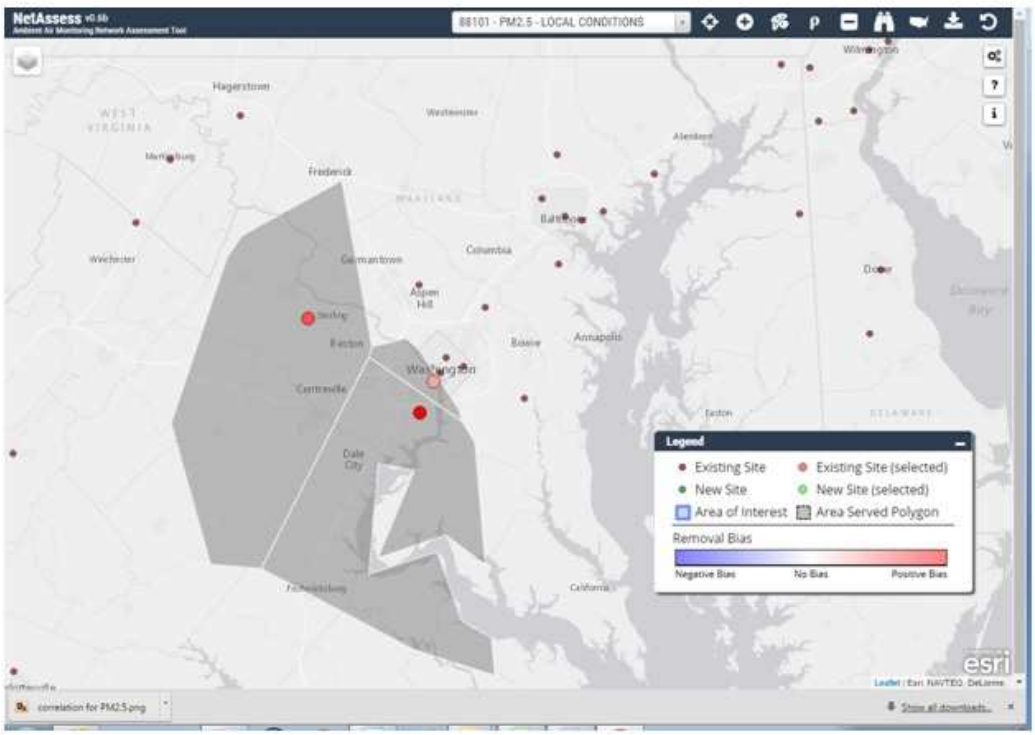

Figure 3.26.3 Removal bias for PM2.5 FRMs in AQCR-7

3.7 Lead (Pb) Monitoring Statewide

There are currently three Lead (Pb) monitoring sites throughout the Commonwealth of Virginia. These locations are determined by 40 CFR Part 58 Appendix D Paragraph 4.5. Originally there were three source specific locations in Virginia. The Buchanan site (51-027-0006) originally sited as a source specific monitor for the Jewell Coal and Coke facility located in Vansant, VA received a lead monitoring waiver dated June 17, 2014. The waiver was requested because the owner of the site planned to build on the site in a manner incompatible with the Pb monitor. The waiver was granted because 3 years worth of data demonstrated that the data was well below 50% of the NAAQS standard. Figure 3.7.1 below shows the locations of the Pb monitors in Virginia, including the Vansant monitor.

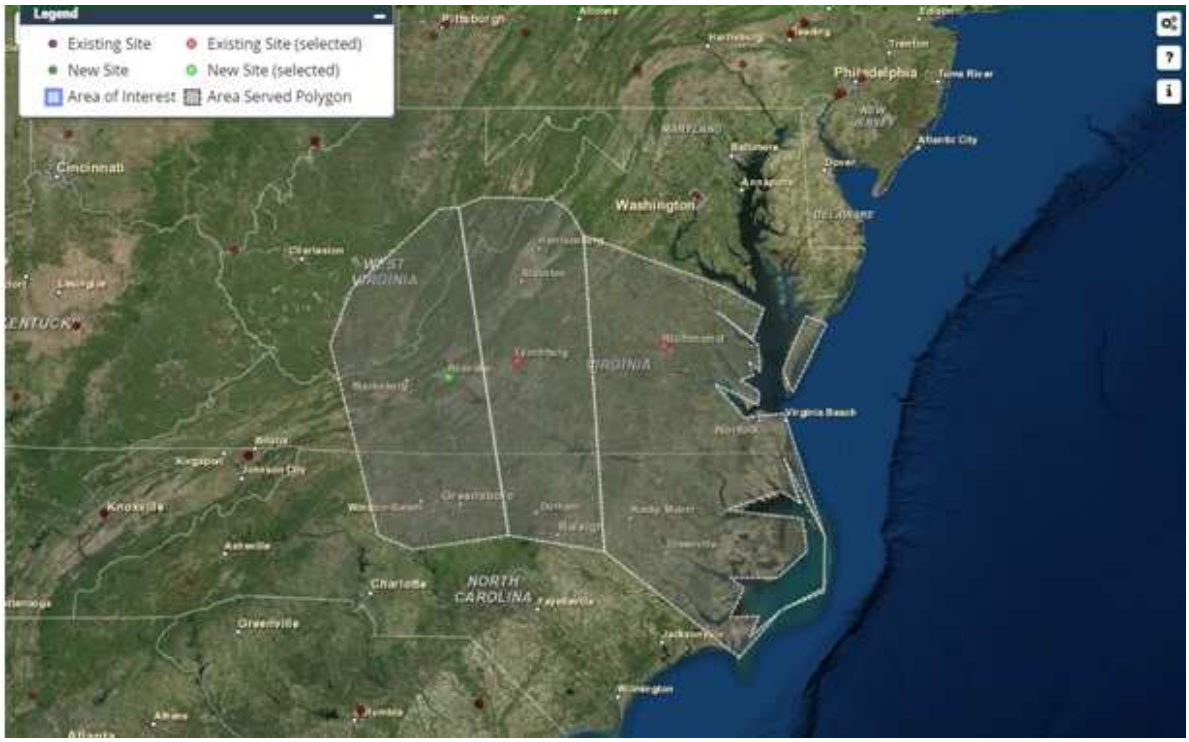

Figure 3.27.1 Lead (Pb) monitoring sites in Virginia

Table 3.7.1 below provides the demographic and historic data information for 2011 – 2013. For this table, note that there is very little information in the way of design value calculations. This is due to the fact that the Pb network is relatively new and most locations only began operating in 2011. The design value calculations require 3 years of data so the earliest DV calculations will be for 2013. I have included the information for Buchanan County to support the information provided for the waiver description above. There are two listings for the Roanoke site. This is due to the fact that the original site, 51-770-0011, was ultimately shutdown because the land upon which it was located was owned by the original source, Steel Dynamics /dba Roanoke Electric Steel, for which the Roanoke source specific monitor was required. DEQ-AQM has

installed the new site and it has been operating since fall of 2014. The Henrico Pb site (51-087-0014) is located at the NCore site.

Table 3.7.1 Lead (Pb) sites in Virginia

Site ID	Location	AQCR	Area Served (km2)	Population	Maximum Value 2013	Standard (ug/m3)	comments
51-009-0007	Amherst	Central Virginia	39459	2,331,007	0.01	0.15	
51-087-0014	Henrico	State Capitol	66184	3,977,672	0.00	0.15	
51-027-0006	Buchanan	Southwest			0.01	0.15	shutdown-EPA waiver
51-770-0011	Roanoke	Valley			0.11	0.15	Site removed
51-770-0016	Roanoke	Valley	43717	2,569,813	NA*	0.15	New Site Nov 2014

*Insufficient data to calculate the Design Value

4. NCORE SITE

40 CFR Part 58 §58.13(a) states that NCore sites must be established no later than January 1, 2011. Part 58 Paragraph §58.1 defines the NCore site as the National Core multi-pollutant monitoring stations. Monitors at these sites are required to measure particles ($PM_{2.5}$, speciated $PM_{2.5}$, $PM_{10-2.5}$), O_3, SO_2, CO, nitrogen oxides ($NO/NO_2/NO_y$), Pb, and basic meteorology. The Commonwealth of Virginia has met this requirement and currently operates an NCore site at their MathScience Innovation Center site in Eastern Henrico County (AQS No. 51-087-0014). Figure 4.1 below shows a picture of the NCore site.

Part 58 Appendix Paragraph 3.(b) requires that the NCore Site measure at a minimum the following pollutants: *$PM_{2.5}$ particle mass using continuous and integrated/filter-based samplers, speciated $PM_{2.5}$, $PM_{10-2.5}$ particle mass, speciated $PM_{10-2.5}$, O_3, SO_2, CO, NO/NO_y, wind speed, wind direction, relative humidity, and ambient temperature. NCore sites in CBSA with a population of 500,000 people (as determined in the latest Census) or greater shall also measure Pb either as Pb-TSP or Pb-PM_{10}.* The VA DEQ NCore site monitors the following Pollutants: Ozone, Trace CO, Trace SO2, PM2.5 FRM, PM2.5 Continuous (TEOM), PM2.5 Speciation, PM2.5 Carbon Sampler, NOy, NO_2 Trace, and Meteorological instrumentation including Wind Speed, Humidity, Temperature, Wind Direction, and Barometric Pressure. In addition the NCore site also monitors for Lead (Pb) as Pb-TSP.

Figure 4.1 Picture of NCore Site (From the South) Henrico County

The data from the NCore site is published on the DEQ public web page every hour and can also be displayed in monthly and annual reports. A sample report from the web page for the data that is displayed for public review is contained in Table 4.1 below.

Table 4.1 Public Web Page Data printout for June 5, 2015 (51-087-0014)

Parameter Measured	Morning												Afternoon											
	Mid	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	Noon	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
Ozone	26	25	25	23	23	21	21	21	20	***18***	20	26	25	27	**31**	31	29	28	24	23	19	19	21	22
PM-2.5	***0.1***	0.6	0.4	0.5	0.7	1.5	2	3.9	2.9	3.9	2.6	3.2	2.5	3.9	4.6	4.4	5.2	4.2	**6.4**	4.8	5.7	4.8	4	3.6
Carbon Monoxide	***0.1***	0.1	0.1	0.1	0.1	0.1	0.1	**0.2**	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Sulfur Dioxide	***0***	0	0	0	0	0	0	**0.1**	0.1	0.1	0.1	0.1	0	0.1	0.1	0.1	0.1	0	0.1	0.1	0.1	0.1	0.1	0
Nitric Oxide	***0***	0	0	0	0	0	0.2	0.4	0.3	0.7	**0.9**	0.5	0.3	0.6	0.5	0.3	0.3	0.2	0.2	0	0	0	0	0
Nitrogen Dioxide	***0.9***	1.1	1.1	1.2	1.7	2.3	2.7	2.9	2.7	2.9	2.2	1.7	1.8	2.7	2.4	2.4	3.2	3.2	6.4	6.2	**7.9**	7.3	5.6	4.5
Oxides of Nitrogen	***0.9***	1	1	1.2	1.6	2.2	2.8	3.2	2.9	3.5	3	2	2	3.2	2.8	2.6	3.3	3.3	6.5	6.1	**7.8**	7.2	5.6	4.5
Wind Speed	3.8	2.3	2.2	2	2.4	2.4	3.1	2.8	3.5	3.5	3.5	**4.2**	3.1	3	2.3	2.8	2.2	2.1	2.2	1.4	0.9	***0.7***	1.1	LIM
Wind Direction	***70.5***	102.9	84.1	105	182	158.2	144.1	170	170	172	133	152	106.5	213.7	198	203.4	169	254	282.4	264	281	**316**	245	LIM
Outdoor Temperature	***59.7***	59.7	59.8	60	60	60	59.9	60.5	60.9	61.3	63	66.2	66.5	67.1	68.5	**69.5**	69.1	68.9	68.4	67.9	67.7	67.4	67.2	66.1
Barometric Pressure	**1013**	1013	1012	1012	1012	1012	1012	1012	1013	1013	1012	1012	1011	1011	1010	1009	1009	1009	1009	1008	1008	1008	1008	***1008***

5. URBAN AIR TOXICS AND NATTS SITES

5.1 Network Description

The Urban Air Toxics Monitoring (UATM) program consists of three sites that are located at the Carter G. Woodson Middle School in Hopewell (51-670-0010); DEQ Tidewater Regional Office (TRO) in Virginia Beach (51-810-0008); and Lee District Park in Fairfax County (51-059-0030). Sampling at these sites consisted of Volatile Organic Compounds (VOC), Carbonyls, and Total Suspended Particulate (TSP) Metals. Each of the UATM sites had a sampling schedule consisting of 24-hour samples collected every 6th day. Data from these sites will be used to characterize air toxics concentrations in the respective urban areas. VADEQ also maintains a National Air Toxics Trend Site at the MathScience Innovation Center in Henrico County (51-087-0014). The sampling schedule is the same as the Urban Air Toxics sites. The suite of pollutants for the NATTS site includes VOCs and Carbonyls similar to the UATM program. The metals sampling is PM10 metals rather than the TSP metals. NATTS also includes sampling for hexavalent chrome (Cr+6) and for Polyaromatic Hydrocarbons (PAHs).

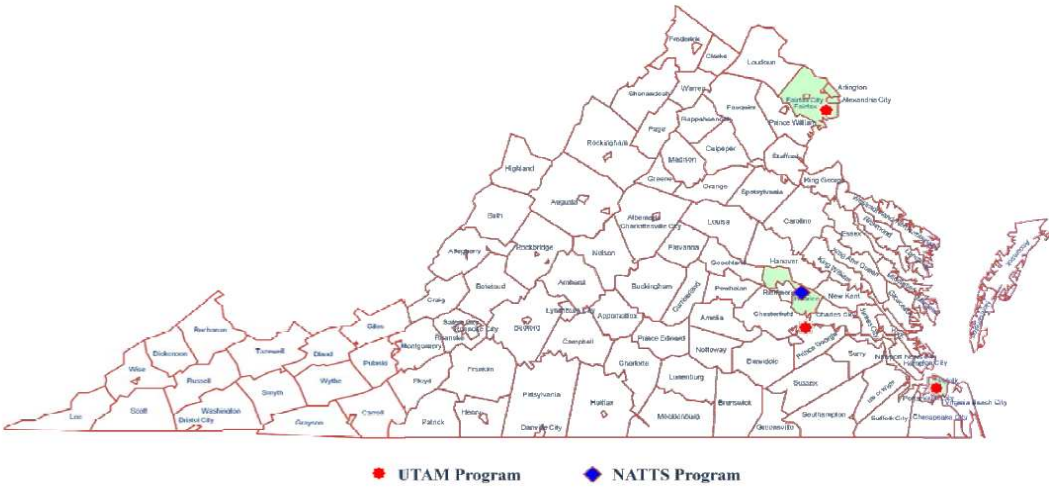

Figure 5.1 Map of the UATM sites and the NATTS site

AQM uses the manual method for collecting ambient air samples for VOC analysis (both UATM and NATTS). Whole air samples were collected using evacuated SilcoT or SUMMAT canisters and air samplers. The sample analysis for these samples was performed by the Maryland Department of the Environment but was taken over by Virginia Department of Consolidated Laboratory Services (DCLS) in 2014. DCLS uses Gas Chromatography equipped with a Mass Selective Detector, using a method designated as TO15. Carbonyls are collected on DNPH (2,4-Dinitrophenylhydrazine) treated sorbent tubes using cartridge samplers. Samples are analyzed by the Division of Consolidated Laboratory Services (DCLS), using a Liquid Chromatographic procedure designated as method TO11A. Metals samples are collected using a high volume Total Suspended Particulate (TSP) sampler in the case of the UATM program and a high volume PM10 sampler in the case of NATTS site. These filters are analyzed by DCLS using inductively coupled plasma mass spectrometry (ICP-MS) using an analytical method designated

as IO-3.1 and IO-3.5. Both CR+6 and PAH samples are analyzed by a federally contracted analytical lab. The results for the UATM and NATTS programs that are analyzed by DCLS are published in DEQ's Annual Air Monitoring report. The Cr+6 and PAHs results are published separately by the federal contract laboratory.

5.2 Network Siting

There are currently no federal or state design criteria for the design and implementation of air toxics sites. The NATTS site is part of the federal national air toxics trend network and the data generated from this site is included in the national Air Toxics trend report. Because the UATM sites are each located in a separate MSA there is no redundancy within the network. While both the NATTS site and the UATM site located in the City of Hopewell are both located within the Richmond Metropolitan statistical area, these sites are placed in these locations for separate and distinct reasons. As described earlier, the NATTS site is part of the national trends network. The UATM site is located in Hopewell due to the level of industrialization of the city.

5.3 Network Evaluation

The figures below provide a comparison of some of the compounds analyzed as part of the UATM program.

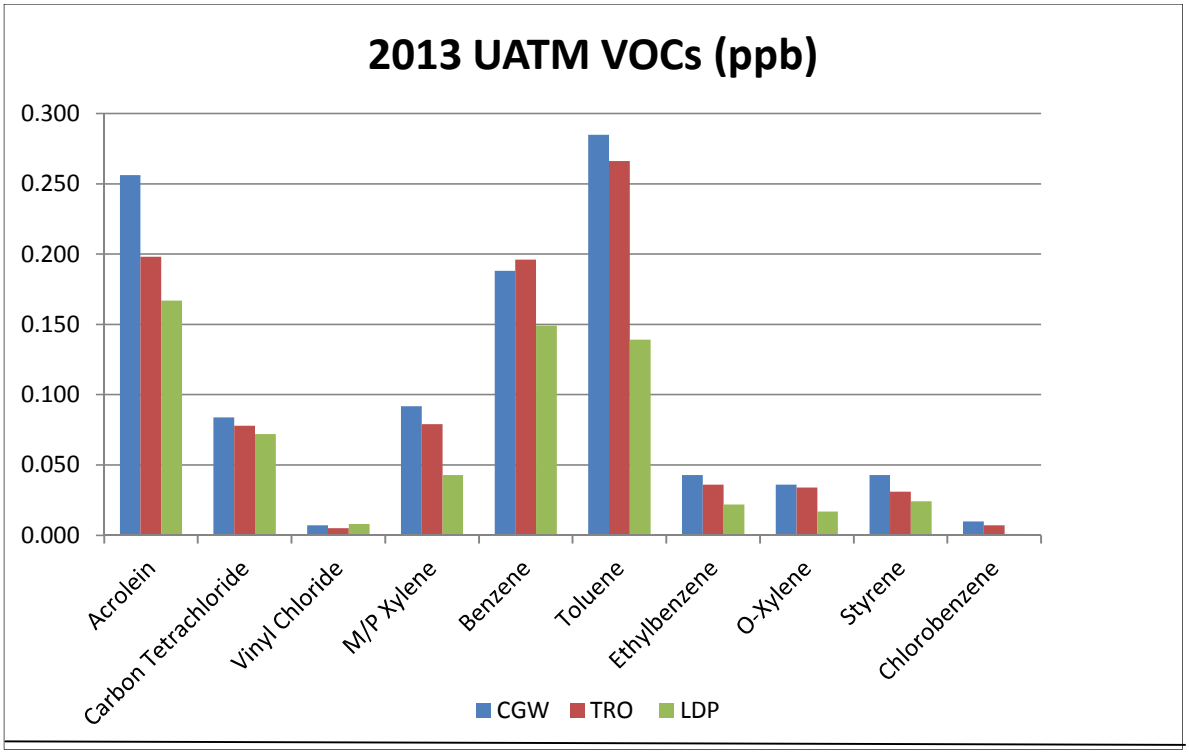

Figure 5.2 Comparison of UATM selected VOC results

Figure 5.2 provides a comparison of the results for selected Volatile Organic Compounds that are routine analyzed for as part of the TO-15 scan of pollutants. Generally the Hopewell site (CGW, 51-670-0010) has slightly elevated levels of the pollutants being compared. Please note that the measured levels are extremely low as the data is presented in parts per billion (ppb) by volume. For example, when evaluating Acrolein, the average measured concentration for CGW is 0.256

ppb versus 0.198 ppb for TRO (Tidewater Office, 51-810-0008) a difference of 0.058 ppb which is below the range of the method detection (MDL) for this pollutant.

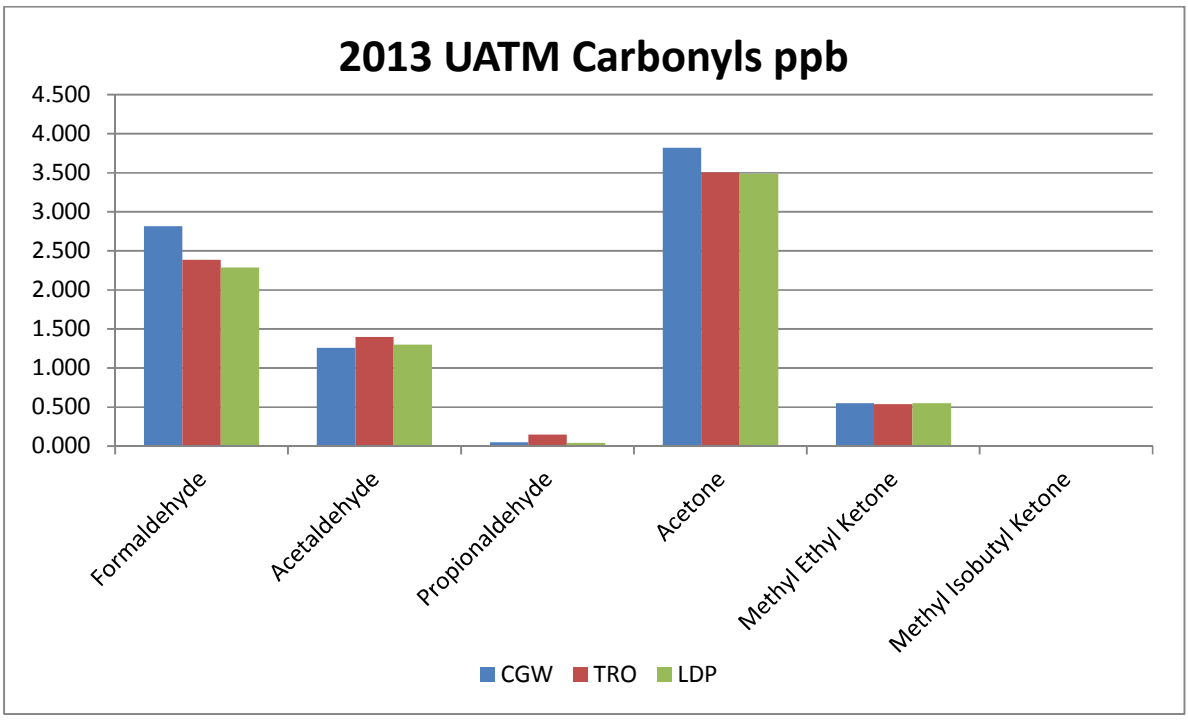

Figure 5.3 Comparison of UATM 2013 carbonyl results

Figure 5.3 provides a comparison of the full scan of carbonyl pollutants analyzed in the UATM program for 2013. The results are presented in ppb by volume. Note that the concentration levels are consistent across all of the sampling locations. For example, the mean formaldehyde concentration varies from 2.29 ppb at the Lee District Park site (Fairfax, 51-059-0030) to 2.82 ppb at the Hopewell site, a difference of less than 20%. Not shown is that median values at both sites which are 2.36 and 2.43 respectively.

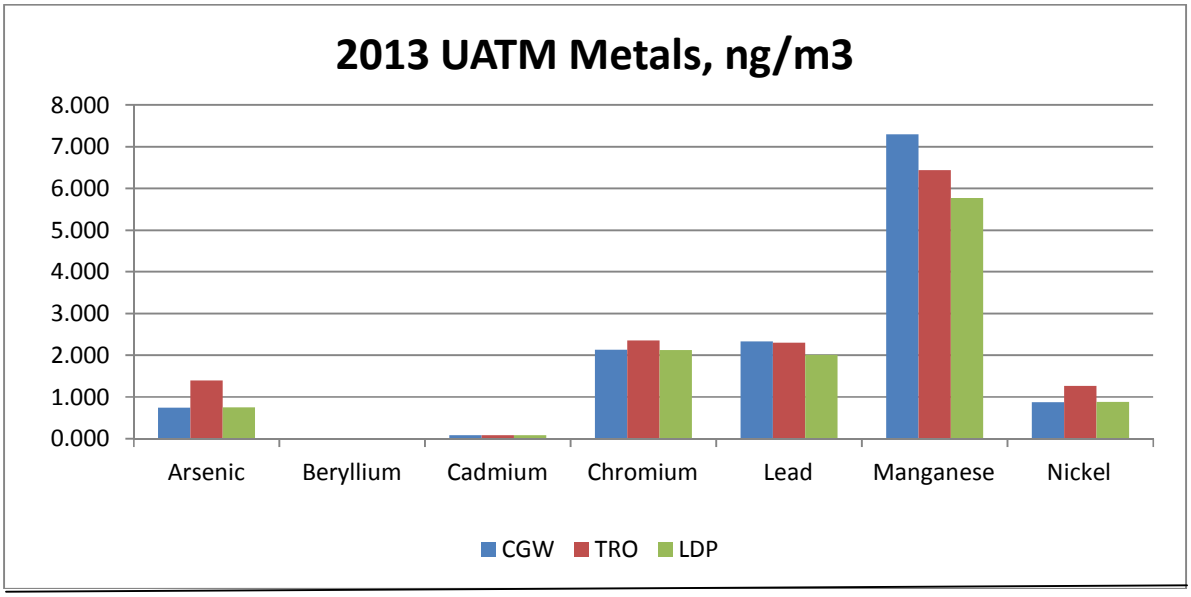

Figure 5.4 Comparison of UATM 2013 metals results

Figure 5.4 contains a comparison of the metals results for the UATM program. Please note that these results are reported in nanograms per cubic meter so the range and absolute results are extremely low. Manganese stands out as being more prevalent than the other metals analyzed for in UATM program. Manganese is ubiquitous in the atmosphere as it has many possible sources as an air pollutant, many of the sources being naturally occurring. Manganese is a common industrial and automotive pollutant as well.

6. **SUMMARY AND CONCLUSIONS**

6.1 Summary

Evaluation of the data in this report shows that the Virginia Department of Environmental Quality operates and maintains a regulatorily comprehensive air monitoring network. Since the 2010 Network Assessment there have been multiple changes to the network, primarily the installation of the near road site in the Richmond MSA, the relocation of the Alexandria monitoring site, the relocation of the Roanoke Lead monitoring site, the (twice) relocation of the Hampton Monitoring site, the closing of the Science Museum air monitoring site and the shutdown and relocation of the Round Hill site in Roanoke City to the Vinton site in Roanoke County. With all these multiple changes, the monitoring network continues to address most regulatory requirements. There is a need for two more near road sites; one in the Northern Virginia area (Washington DC MSA) and one in Virginia Beach (Hampton Roads MSA).

6.2 Conclusions

From the results of the analyses performed as part of this Network Assessment the following recommendations/observations can be made:

1. The air monitoring network in the Commonwealth of Virginia meets the numeric expectations of the Regulatory requirements in 40 CFR Part 58.
2. The Nitrogen Dioxide network within the Commonwealth, while consistent with the area wide and susceptible populations regulatory requirements, still has to install two required additional near road sites to be consistent with 40 CFR Part 58 Appendix D paragraph 4.3.2; one in the Northern Virginia area (Washington DC MSA) and one in Virginia Beach (Hampton Roads MSA).
3. The Ozone Monitoring Network in Virginia continues to be robust and meets all regulatory requirements in terms of locations and minimum number of monitors. The trend for the Ozone values continues to demonstrate decreasing ambient ozone concentrations.
4. The PM2.5 Monitoring Network in Virginia continues to be robust and meets all regulatory requirements in terms of locations and minimum number of monitors.
5. Generally the long term air quality trends since 2004 for all criteria pollutants demonstrate decreasing ambient concentrations.

APPENDIX A.
Virginia Air Monitoring Network Site Listing

VA DEQ, AQCR I SOUTHWEST VIRGINIA, 2014

SITE I.D.	POLLUTANT MEASURED	METHOD OR INSTRUMENT	SAMPLING INTERVAL	MONITORING OBJECTIVE	SCALE	BEGINNING DATE	MONITOR TYPE	LOCATION	LONGITUDE	LATITUDE	CBSAs/ MSAs	
51-035-0001 (23-A)	PM-10	SSI HI VOL	1/6	Population	Neighborhood	5/28/89	SLAMS	Carroll Co. - Gladeville Elem. School	-80.8798	36.7007	None	
51-197-0002 (16-B)	O3	UV Absorption	Continuous	Population	Regional	4/1/90	SLAMS	Rural Retreat - Wythe County Sewage Treatment Plant	-81.2542	36.8912	None	
51-520-0006 (101-E)	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	1/1/99	SLAMS	Bristol - Highland View Elem. Sch.	-82.1641	36.6080	28700/	Kingsport-Bristol-Bristol, TN-VA

There are no collocated monitors in AQCR I

VA DEQ, AQCR II VALLEY OF VIRGINIA, 2014

SITE I.D.	POLLUTANT MEASURED	METHOD OR INSTRUMENT	SAMPLING INTERVAL	MONITORING OBJECTIVE	SCALE	BEGINNING DATE	MONITOR TYPE	LOCATION	LONGITUDE	LATITUDE	CBSAs/ MSAs	
51-069-0010	O3	UV Absorption	Continuous	Population	Urban	4/1/91	SLAMS	Rest, Frederick County -	-78.0816	39.2810	49020/	Winchester, VA-WV
(28-J)	PM2.5 FRM	Sequential	1/3	Population	Urban	1/1/08	SLAMS	Lester Buildings				
	PM2.5	TEOM	Continuous	Background	Urban	1/1/08	SPM					
51-840-0002	PM-10	SSI HI VOL	1/6	Population	Neighborhood	9/13/89	SLAMS	Winchester -	-78.1631	39.1840	49020/	Winchester, VA-WV
(134-C)								Courts Bldg.				
51-113-0003	O3	UV Absorption	Continuous	Background	Regional		Nat'l Park	Madison County -	-78.4347	38.5231	None	
(N-35-A)	PM2.5	IMPROVE	1/3	Background	Regional		IMPROVE	Shenandoah Nat'l Park				
	PM2.5	TEOM	Continuous	Background	Regional	5/04	Nat'l Park	Big Meadows				
51-139-0004	O3	UV Absorption	Continuous	Population	Urban	7/21/99	SLAMS	Page County -	-78.5044	38.6637	None	
(29-D)	PM2.5 FRM	Sequential	1/3	Background	Regional	10/00	SLAMS	Luray Caverns Airport				
51-161-1004	NO2	Chemiluminescence	Continuous	Population	Neighborhood	1/1/81	SLAMS	Vinton - Roanoke Co.	-79.8845	37.2834	40220/	Roanoke, VA
(19-A6)	O3	UV Absorption	Continuous	Population	Neighborhood	8/81	SLAMS	Herman Horn ES				
	SO2	Fluorescence	Continuous	Population	Neighborhood	1/29/87	SLAMS					
	CO	Gas Filter Corr.	Continuous	Population	Neighborhood	4/04	SLAMS					
	PM2.5 FRM	Sequential	Daily	Population	Neighborhood	4/1/08	SLAMS					
	PM2.5	TEOM	Continuous	Background	Neighborhood	4/1/08	SPM					
51-163-0003	O3	UV Absorption	Continuous	Background	Regional	4/8/99	SLAMS	Rockbridge Co. -	-79.5126	37.6267	None	
(21-C)	PM2.5	IMPROVE	Continuous	Background	Regional		IMPROVE	Natural Bridge Station				
51-165-0003	SO2	Fluorescence	Continuous	Population	Neighborhood	9/22/97	SLAMS	Rockingham Co. -	-78.8195	38.4775	25500/	Harrisonburg, VA
(26-F)	NO2	Chemiluminescence	Continuous	Population	Neighborhood	4/04	SLAMS	VDOT				
	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	1/1/07	SLAMS					
	O3	UV Absorption	Continuous	Population	Neighborhood	4/1/07	SLAMS					
51-775-0011	PM2.5	Sequential	1/3	Population	Neighborhood	9/8/09	SLAMS	Salem -	-80.0810	37.2979	40220/	Roanoke, VA
(110-C)								Salem High School				
51-770-0011	TSP-Lead	Tisch Hi-Vol	1/6	Source	Neighborhood	11/1/14	SLAMS	Roanoke City	-79.9857	37.2749	40220/	Roanoke, VA
(109-N)		TSP Sampler		Oriented				Mario Industries				
								2502 Patterson Ave. SW				

There are no collocated monitors in AQCR II

VA DEQ, AQCR III CENTRAL VIRGINIA, 2014

SITE I.D.	POLLUTANT MEASURED	METHOD OR INSTRUMENT	SAMPLING INTERVAL	MONITORING OBJECTIVE	SCALE	BEGINNING DATE	MONITOR TYPE	LOCATION	LONGITUDE	LATITUDE	CBSAs/ MSAs	
51-680-0015 (155-Q)	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	4/1/03	SLAMS	Lynchburg - Water Tank	-79.2150	37.3327	31340/	Lynchburg, VA
51-009-007 (53-G)	TSP-Lead	Tisch Hi-Vol TSP Sampler	1/6	Source Oriented	Neighborhood	11/1/10	SLAMS	CVTC, Madison Heights Amherst Co.	-79.1162	37.4122	31340/	Lynchburg, VA

There is one collocated monitor in AQCR3. A collocated Hi-Vol TSP-lead monitor is located at 53-G Madison Heights and is designated H-53-G.

CC

VA DEQ, AQCR IV NORTHEAST VIRGINIA, 2014

SITE I.D.	POLLUTANT MEASURED	METHOD OR INSTRUMENT	SAMPLING INTERVAL	MONITORING OBJECTIVE	SCALE	BEGINNING DATE	MONITOR TYPE	LOCATION	LONGITUDE	LATITUDE	CBSAs/ MSAs	
51-033-0001	O3	UV Absorption	Continuous	Background	Regional	4/1/93	SLAMS	Caroline Co. -	-77.3774	38.2009	40060/	Richmond, VA
(48-A)	Meteorological	Wind Speed, Humidity	Continuous	Population	Neighborhood	6/1/02	SPM	USGS Geomagnetic				
	Instrumentation	Temp., Wind direction						Center				
		Barometric Pressure										
51-061-0002	O3	UV Absorption	Continuous	Background	Regional	9/1/81	SLAMS	Fauquier Co. -	-77.7677	38.4737	47900/	Washington-Arlington-Alexandria, DC-VA-MD-W
(37-B)								Phelps Wildlife				
								Area				
51-179-0001	O3	UV Absorption	Continuous	Population	Neighborhood	9/1/92	SLAMS	Stafford Co. -	-77.3704	38.4812	47900/	Washington-Arlington-Alexandria, DC-VA-MD-W
(44-A)								Widewater				
								Elem. School				
51-003-0001	O3	UV Absorption	Continuous	Population	Regional	4/1/08	SLAMS	Albemarle Co. -	- 78.5040	38.0766	16820/	Charlottesville, VA
33-A	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	4/1/08	SLAMS	Albemarle High				
	PM2.5	TEOM	Continuous	Background	Neighborhood	4/1/08	SPM	School				
51-630-0004	PM-10	SSI HI VOL	1/6	Population	Neighborhood	11/12/89	SLAMS	Fredericksburg -	-77.4871	38.3023	47900/	Washington-Arlington-Alexandria, DC-VA-MD-W
(130-E)								Mercer				
								Elem. School				

There are no collocated monitors in AQCR IV

VA DEQ, AQCR V STATE CAPITOL, 2014

SITE I.D. SITE I.D.	POLLUTANT MEASURED	METHOD OR INSTRUMENT	SAMPLING INTERVAL	MONITORING OBJECTIVE	SCALE	BEGINNING DATE	MONITOR TYPE	LOCATION	LONGITUDE	LATITUDE	CBSAs/ MSAs	
51-036-0002	O3	UV Absorption	Continuous	Population	Neighborhood	3/29/88	SLAMS	Charles City Co. -	-77.2593	37.3444	40060/	Richmond, VA
(75-B)	SO2	Pulsed Fluorescence	Continuous	Highest Concentration	Neighborhood	1/1/92	SLAMS	Route #608 Shirley Plantation				
	NO2	Chemiluminescence	Continuous	Population	Neighborhood	3/9/93	SLAMS					
	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	1/1/99	SLAMS					
51-041-0003	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	1/1/99	SLAMS	Chesterfield Co. -	-77.4512	37.4347	40060/	Richmond, VA
(71-D)								Bensley Armory				
51-041-0004	O3	UV Absorption	Continuous	Population	Neighborhood	4/80	SLAMS	Chesterfield Co. -	-77.5936	37.3575	40060/	Richmond, VA
(71-H)								Beach Rd. VDOT				
51-085-0003	O3	UV Absorption	Continuous	Highest Concentration	Urban	4/1/01	SLAMS	Hanover Co. -	-77.2188	37.6061	40060/	Richmond, VA
(73-E)								McClellan Road				
51-087-0014	O3	UV Absorption	Continuous	Population	Neighborhood	6/12/81	SLAMS	Henrico Co. -	-77.4003	37.5565	40060/	Richmond, VA
(72-M)	Trace CO	Gas Filter Correlation	Continuous	Population	Neighborhood	4/1/81	SLAMS	MathScience Center				
	Trace SO2	Pulsed Fluorescence	Continuous	Population	Neighborhood	8/29/13	SLAMS					
	PM2.5 FRM	Sequential	Daily	Population	Neighborhood	1/1/99	SLAMS					
	PM2.5	TEOM	Continuous	Population	Neighborhood	7/18/00	SPM					
	PM2.5	Speciation	1/3 Mini-Trends	Population	Neighborhood	1/1/04	SPM					
	PM2.5	Carbon	1/3 Mini-Trends	Population	Neighborhood	1/1/10	SPM					
	PM-10	SSI HI VOL	1/6	Population	Neighborhood	11/1/08	SLAMS					
	PM-10	Sequential	1/3	Population	Neighborhood	10/8/09	NCore					
	Metals	PM-10 LO VOL	1/6	Background	Neighborhood	11/1/08	NCore					
	Lead	TSP/ICPMS	1/6	Background	Neighborhood	11/1/08	NCore					
	Metals	TSP/ICPMS	1/6	Background	Neighborhood	11/1/08	NATTS					
	Carbonyl	TO-11A	1/6	Background	Neighborhood	11/1/08	NATTS					
	VOCs	TO-15	1/6	Background	Neighborhood	11/1/08	NATTS					
	PAH	TSP	1/6	Background	Neighborhood	11/1/08	NATTS					
	Hexavalent Chromium	TSP LO VOL	1/6	Background	Neighborhood	11/1/08	NATTS					
	NOy	Chemiluminescence	Continuous	Population	Neighborhood	5/1/05	NCore					
				Vulnerable and Susceptible								
	NO2 Trace	Chemiluminescence	Continuous	Population	Neighborhood	5/1/05	Ncore					
	Meteorological Instrumentation	Wind Speed, Humidity Temp., Wind direction Barometric Pressure	Continuous	Population	Neighborhood	7/1/10	NCore					
	VOC - PAMS	Automated GC	Continuous	Background	Regional	5/1/13	PAMS					
	VOC - PAMS episodic	TO-12	eight 3 hr. canisters	Background	Regional	5/1/13	PAMS					
51-087-0015	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	1/1/99	SLAMS	Henrico Co. -	-77.5666	37.6712	40060/	Richmond, VA
(72-N)								Piedmont DEQ				
51-101-0003	PM-10	SSI HI VOL	1/6	Population	Neighborhood	1/11/90	SLAMS	West Point -	-76.7953	37.5580	40060/	Richmond, VA
(82-C)								Elementary School				
51-670-0010	PM-10	PM10 SSI HI VOL	1/6	Population	Neighborhood	11/1/08	SLAMS	Hopewell -	-77.2918	37.2896	40060/	Richmond, VA
(154-M)	Metals	TSP/ICPMS	1/6	Population	Neighborhood	11/1/08	Urban Toxics	Carter G. Woodson				
	VOCs	TO-15	1/6	Population	Neighborhood	11/1/08	Urban Toxics	Middle School				
	Carbonyl	TO-11	1/6	Population	Neighborhood	11/1/08	Urban Toxics					
51-760-0025	NO2	Chemiluminescence	Continuous	Near Road	Microscale	10/1/13	SLAMS	City of Richmond -	77.4692	37.5911	40060/	Richmond, VA
(158-X)	CO	Gas Filter Correlation	Continuous	Near Road	Microscale	10/1/13	SLAMS	Joseph Bryan Park				
	PM2.5 FEM	Beta Attenuation	Continuous	Near Road	Microscale	10/1/14	SLAMS					

There are 3 collocated monitor in AQCR V. At Station 72-M, 510870014 - collocated PM2.5 FRM and Collocated Hi Vol PM10; Station 154-M Collocated VOC sampler

VA DEQ, AQCR VI HAMPTON ROADS, 2014

SITE I.D.	POLLUTANT MEASURED	METHOD OR INSTRUMENT	SAMPLING INTERVAL	MONITORING OBJECTIVE	SCALE	BEGINNING DATE	MONITOR TYPE	LOCATION	LONGITUDE	LATITUDE	CBSAs/ MSAs	
51-650-0008	O3	UV Absorption	Continuous	Population	Neighborhood	7/1/10	SLAMS	Hampton City -	-76.3870	37.1037	47260/	Virginia Beach-Norfolk-Newport News, VA-NC
(179-K)	SO2	Fluorescence	Continuous	Population	Neighborhood	7/1/10	SLAMS	NASA Langley				
	NO2	Chemiluminescence	Continuous	Population	Neighborhood	7/1/10	SLAMS	CAPABLE Site				
	CO	Gas Filter Corr.	Continuous	Population	Neighborhood	7/1/10	SLAMS					
	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	7/1/10	SLAMS					
	PM2.5	TEOM	Continuous	Population	Neighborhood	7/1/10	SPM					
	PM10	SSI HI VOL	1/6	Population	Neighborhood	7/1/10	SLAMS					
51-710-0024	SO2	Pulsed Fluorescence	Continuous	Population	Neighborhood	1/7/10	SLAMS	Norfolk City -	-76.3014	36.8556	47260/	Virginia Beach-Norfolk-Newport News, VA-NC
(181-A1)	NO2	Chemiluminescence	Continuous	Population	Neighborhood	1/7/10	SLAMS	NOAA Storage				
	CO	Gas Filter Corr.	Continuous	Population	Neighborhood	12/22/09	SLAMS	Facility				
	PM10	SSI HI VOL	1/6	Population	Neighborhood	6/21/97	SLAMS					
	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	1/1/99	SLAMS					
51-800-0004 (183-E)	O3	UV Absorption	Continuous	Population	Neighborhood	4/1/87	SLAMS	Suffolk City - Tidewater Community College	-76.4381	36.9012	47260/	Virginia Beach-Norfolk-Newport News, VA-NC
51-800-0005 (183-F)	O3	UV Absorption	Continuous	Population	Neighborhood	4/1/91	SLAMS	Suffolk City - Tidewater Research Station, Holland	-76.7304	36.6653	47260/	Virginia Beach-Norfolk-Newport News, VA-NC
51-810-0008	PM2.5 FRM	Sequential	Daily	Population	Neighborhood	1/1/99	SLAMS	VA Beach City -	-76.1812	36.8419	47260/	Virginia Beach-Norfolk-Newport News, VA-NC
(184-J)	VOC	TO-15	1/6	Background	Neighborhood	7/1/05	Urban Toxics	VA Beach DEQ Office				
	Carbonyl	TO-11A	1/6	Background	Neighborhood	7/1/05	Urban Toxics					
	Metals	TSP	1/6	Background	Neighborhood	8/2/05	Urban Toxics					

There are two collocated monitors in AQCR VI. Collocated PM10 and PM2.5 FRM are both at 181-A1, 517100024, the NOAA Storage Facility in Norfolk.

VA DEQ, AQCR VII NORTHERN VIRGINIA, 2014

SITE I.D.	POLLUTANT MEASURED	METHOD OR INSTRUMENT	SAMPLING INTERVAL	MONITORING OBJECTIVE	SCALE	BEGINNING DATE	MONITOR TYPE	LOCATION	LONGITUDE	LATITUDE	CBSAs/ MSAs	
51-013-0020	O3	UV Absorption	Continuous	Population	Neighborhood	8/1/79	SLAMS	Arlington -	-77.0592	38.8577	47900/	Washington-Arlington-Alexandria, DC-VA-MD-W
(47-T)	NO2	Chemiluminescence	Continuous	Population	Neighborhood	8/1/79	SLAMS	Aurora Hills				
	CO	Gas Filter Correlation	Continuous	Population	Neighborhood	4/1/81	SLAMS	Visitors Center				
	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	1/1/99	SLAMS					
51-059-0030	O3	UV Absorption	Continuous	Population	Neighborhood	7/1/98	SLAMS	Fairfax -	-77.1047	38.7734	47900/	Washington-Arlington-Alexandria, DC-VA-MD-W
(46-B9)	SO2	Pulsed Fluorescence	Continuous	Population	Neighborhood	8/29/13	SLAMS	Lee District park				
	PM2.5 FRM	Sequential	Daily	Population	Neighborhood	1/1/99	SLAMS					
	PM2.5	TEOM	Continuous	Population	Neighborhood	7/1/10	SPM					
	VOC	TO-15	1/6	Population	Neighborhood	6/1/02	Urban Toxics					
	Carbonyl	TO-11A	1/6	Population	Neighborhood	6/1/02	Urban Toxics					
	Metals	TSP	1/6	Population	Neighborhood	6/1/02	Urban Toxics					
	PM10	SSI HI VOL	1/3	Population	Neighborhood	5/1/15	SLAMS					
51-107-1005	O3	UV Absorption	Continuous	Population	Neighborhood	4/4/98	SLAMS	Loudoun Co. -	-77.4925	39.0247	47900/	Washington-Arlington-Alexandria, DC-VA-MD-W
(38-I)	NO2	Chemiluminescence	Continuous	Population	Neighborhood	4/4/98	SLAMS	Broad Run H.S.				
	PM2.5 FRM	Sequential	1/3	Population	Neighborhood	1/1/99	SLAMS					
51-153-0009	O3	UV Absorption	Continuous	Population	Urban	4/1/91	SLAMS	Prince Wm. Co. -	-77.6346	38.8529	47900/	Washington-Arlington-Alexandria, DC-VA-MD-W
(45-L)	NO2	Chemiluminescence	Continuous	Population	Urban	4/1/94	SLAMS	Long Park				
51-510-0021	NO2	Chemiluminescence	Continuous	Population	Neighborhood	8/29/13	SPM	Alexandria,	-77.0864	38.8065	47900/	Washington-Arlington-Alexandria, DC-VA-MD-W
(L-126-I)	CO	Gas Filter Correlation	Continuous	Population	Neighborhood	8/29/13	SPM	3200 Colvin St.				
51-510-0020	PM10	SSI HI VOL	1/3	Population	Neighborhood	6/4/06	SLAMS	Alexandria -	-77.1268	38.8050	47900/	Washington-Arlington-Alexandria, DC-VA-MD-W
(L-126-H)								Tucker Elem. Sch.				

There are 2 collocated monitors in AQCR VII. A collocated PM2.5 FRM is located at Station 47-T, 510130020, Aurora Hills Visitor Center, Arlington and TSP Metals located at station 46-B9, 510590030, Lee District Park, Fairfax.