MARYLAND

DEPARTMENT OF THE ENVIRONMENT

2015 MARYLAND 5-YEAR NETWORK ASSESSMENT

Prepared for:

U.S. Environmental Protection Agency

Prepared by:

Ambient Air Monitoring Program
Air and Radiation Administration Management
Maryland Department of the Environment

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EXECUTIVE SUMMARY

As required in 40 CFR Part 58.10(d), state air quality monitoring agencies must conduct a network assessment once every five years. The goals of this assessment are as follows:

- Determine if the network meets the monitoring objectives of 40 CFR 58 Appendix D.
- Determine whether new sites are needed.
- Determine whether existing sites are no longer needed and can be terminated.
- Determine whether new technologies are appropriate for incorporation into the ambient air monitoring network.
- 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).
- For any sites that are being proposed for discontinuance, determine the effect on data users other than the agency itself, such as nearby States and Tribes or health effects studies.
- Identify needed changes to $PM_{2.5}$ population-oriented sites.

Following this requirement, MDE evaluated the current network and determined that the Maryland State network is efficient and effective at meeting all of the requirements of 40 CFR 58 Appendix D. MDE has also made the following specific findings and recommendations:

- The minimum number of monitors for all parameters is either met or exceeded.
- No SO_2, NO_2, PM_{10} or PAMS sites were found to be redundant.
- The Oldtown CO monitor could be removed since there are more CO monitors in the network than are required and all sites are measuring well below the NAAQS. Because the Maryland Maintenance Plan requires that Oldtown be operational until December 2015 [MDE, 2003], MDE therefore recommends terminating CO monitoring at this location beginning January 1, 2016, pending approval by the Regional Administrator.
- The Davidsonville ozone monitor was found to be redundant when compared with the PG Equestrian Center monitor. MDE recommends shutting down the site and moving the ozone monitor to Glen Burnie to capture possible ozone transport from the Washington, DC area into Baltimore as well. Before moving this monitor MDE will operate a portable ozone monitor, designated as an SPM, at Glen Burnie for the 2015 ozone season to determine whether the ozone concentrations are similar or higher.

- The Padonia monitor measures the 3rd lowest $PM_{2.5}$ design values in the state and since the Baltimore MSA monitoring requirements are being met and there are five other $PM_{2.5}$ monitors concentrated around Baltimore (Oldtown, Essex, Glen Burnie, Fire Dept. 20, and NW Police Station) this site could be moved to another location. The Frederick site would be a good location to move the $PM_{2.5}$ monitor because the western-central part of Maryland has fewer $PM_{2.5}$ monitors and this area has a growing population. The Frederick site is also located in a valley and this might be a good location to capture higher $PM_{2.5}$ concentrations than other nearby locations like South Carroll.

- Monitoring site objectives and representative scales for some monitor sites are recommended to be changed as follows:

    - The measurement scale at of the PM_{10} monitor at HU-Beltsville should be changed from urban to neighborhood, as urban scale is not applicable to PM_{10}.

    - Change the scale of the Howard County Near Road CO monitor from microscale to middle scale.

- Based on county level data it was determined that the $PM_{2.5}$ and ozone networks are adequately serving the sensitive populations of Maryland.

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ACRONYMS AND DEFINITIONS

AADT	Annual Average Daily Traffic
AQS	Air Quality System
CAMD	Clean Air Markets Divisions
CBSA	Core Based Statistical Area
CFR	Code of Federal Regulations
CMAQ	Community Multi-scale Air Quality Model
CSA	Combined Statistical Area
CO	Carbon Monoxide
DCDOE	District of Columbia Department of the Environment
VADEQ	Virginia Department of Environmental Quality
EGU	Electrical Generating Unit
FEM	Federal Equivalent Method typically used by local and state agency to measure particulate matter and determine NAAQS attainment status.
FIPS	Federal Information Processing Standards
FRM	Federal Reference Method typically used by local and state agency to measure particulate matter and determine NAAQS attainment status.
HAPS	Hazardous Air Pollutants
IMPROVE	Interagency Monitoring of PROtected Visual Environments
MDE	Maryland Department of the Environment
MSA	Metropolitan Statistical Area typically used by the EPA to study air quality trends in major metropolitan areas across the U.S.
NAA	Non-attainment Area
NAAQS	National Ambient Air Quality Standards used for determining attainment status.
NATTS	National Air Toxics Trend Station
NCore	National Core multi-pollutant monitoring stations
NESCAUM	Northeast States for Coordinated Air Use Management
NO	Nitrogen Oxide
NO_2	Nitrogen Dioxide
NO_X	Oxides of Nitrogen (ozone precursor)
NO_Y	Total Reactive Nitrogen Species (ozone precursor)
O_3	Ozone
PAMS	Photochemical Assessment Monitoring Station
PWEI	Population Weighted Emissions Index
Pb	Lead
$PM_{2.5}$	Particulate matter with an equivalent diameter less than or equal to 2.5 μm.
PM_{10}	Particulate matter with an equivalent diameter less than or equal to 10 μm.
SIP	State Implementation Plan
SLAMS	State or Local Air Monitoring Stations
SO_2	Sulfur Dioxide
SPM	Special Purpose Monitor
tpy	tons per year
US EPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

1. INTRODUCTION

The Maryland Department of the Environment (MDE) Ambient Air Monitoring Program is required by the U.S. Environmental Protection Agency (EPA) to conduct and submit a 5-year network assessment to the Regional Administrator by July 1, 2015. This document fulfills this requirement as set forth by the ambient air monitoring regulations, 40 CFR 58.10(d) as amended by the U.S. Environmental Protection Agency (EPA) and finalized on October 17, 2006. These amendments require state, or where applicable local, monitoring agencies to conduct a network assessment once every five years the first of which is due to the Regional Administrator by July, 2010. The text of 40 CFR 58.10(d) requirements is as follows:

"(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."

EPA decided to require a periodic assessment because, '*ambient air monitoring objectives have shifted over time—a situation which has induced air quality agencies to re-evaluate and reconfigure monitoring networks. A variety of factors contribute to these shifting monitoring objectives:*

- *Air quality has changed—for the better in most geographic areas—since the adoption of the federal Clean Air Act and National Ambient Air Quality Standards (NAAQS). For example, the problems of high ambient concentrations of lead and carbon monoxide have largely been solved.*
- *Populations and behaviors have changed. For example, the U.S. population has (on average) grown, aged, and shifted toward urban and suburban areas over the past four decades. In addition, rates of vehicle ownership and annual miles driven have grown.*
- *New air quality objectives have been established, including rules to reduce air toxics, fine particulate matter ($PM_{2.5}$) and regional haze.*
- *The understanding of air quality issues and the capability to monitor air quality have both improved. Together, the enhanced understanding and capabilities can be used to design more effective air monitoring networks'* [EPA, 2008].

As a result of the above factors, there is the potential that existing networks do not reflect current or new monitoring needs but rather the network may *have unnecessary or redundant monitors or ineffective and inefficient monitoring locations for some pollutants,* [EPA, 2008]. Doing a network assessment is an opportunity to discover how to refocus network resources to protect today's population and environment.

The State of Maryland, though the efforts of its various governmental agencies and programs has been measuring ambient air pollutant concentrations in the state for nearly 60 years. Currently it is the responsibility of the MDE Ambient Air Monitoring Program to measure ambient concentrations of air pollutants. A history of Maryland's monitoring sites is provided in Section 2. Throughout the years, the ambient air monitoring networks have changed in response to the factors listed previously. It is anticipated that one of the results of this assessment will be to help MDE determine if past changes to the networks have been sufficient to support current and/or proposed future monitoring needs. Several of the more important features that have shaped the monitoring networks are the state's climate, population density, and topography. These features have been known to contribute to the formation of some types of air pollutants and consequently have affected the states design of historical and existing ambient air monitoring networks.

MDE's approach to performing this 5-year assessment was to address every item required by 40 CFR 58.10(d) within the limitations of available data and analytical techniques. The analytical techniques used in this 5-year assessment required assembling and using a wide variety of data including but not limited to 2013 point source emissions estimates, air quality modeling results, meteorological data, population data, and ambient air pollutant monitoring data. The temporal scope was typically 2011-2013, and the spatial scope sometimes included data and information from the contiguous states around Maryland. When out-of-state information was used, its relevance to the 5-year assessment was explained. Some input data and the results generated by the analytical techniques are displayed on maps to help aid in visual analysis, interpretation, and presentation of the results. All results are reported based on the type of completed assessment and the confidence that can be attributed to the techniques and data used. A detailed explanation of all analytical techniques and data used is addressed in each section of this 5-year assessment.

The 5-year assessment was organized in such a way that Section 3 is comprised of separate subsections for each individual pollutant network (i.e., air toxics, carbon monoxide, lead, nitrogen dioxide, ozone, PAMS, particulate matter (PM_{10} and $PM_{2.5,}$) and sulfur dioxide), which make up Maryland's ambient air monitoring network. Section 4 addresses the requirement of determining if ozone and particulate monitors are appropriately located in areas with high populations of sensitive individuals. Section 5 examines new technologies that are available to measure ambient air pollutant concentrations. Section 6 summarizes the findings of the 5-year assessment and gives recommendations on how the networks might be modified in the next few years.

2. HISTORY OF AIR MONITORING NETWORK

Ambient air quality monitoring began in Maryland in 1955 following the passage of the Air Pollution Control Act of 1955, the first federal legislation involving air pollution. Early sampling was conducted using manual methods (mostly high volume samplers). Parameters measured included total suspended particulates (TSP), soiling index, dustfall, and sulfation rate (an indicator of sulfur dioxide concentrations). TSP filters were analyzed for benzene solubles and the trace metals lead, chromium, iron, manganese and nickel.

From 1957 to 1966 Maryland's air monitoring network grew to 32 sites. In 1967, monitoring was expanded to include carbon monoxide, photochemical oxidants, total hydrocarbons and fluorides. By 1970, there were over 90 sites. In 1971, analysis of TSP filters for manganese and nickel was discontinued and continuous monitoring for carbon dioxide and total oxidants began. The following year, continuous monitoring was expanded to include photochemical oxidants, sulfur dioxide, nitrogen dioxide, nitric oxide and total hydrocarbons. By 1975 there were 160 sites in the network and non-methane hydrocarbons and benzo-a-pyrene were added to the list of monitored parameters. Nitrogen oxides and cadmium were added in 1977 and the total number of sites at that time was 135. A chronological listing of the number of monitoring sites in Maryland from 1957 through 2014 is shown in Figure 2-1.

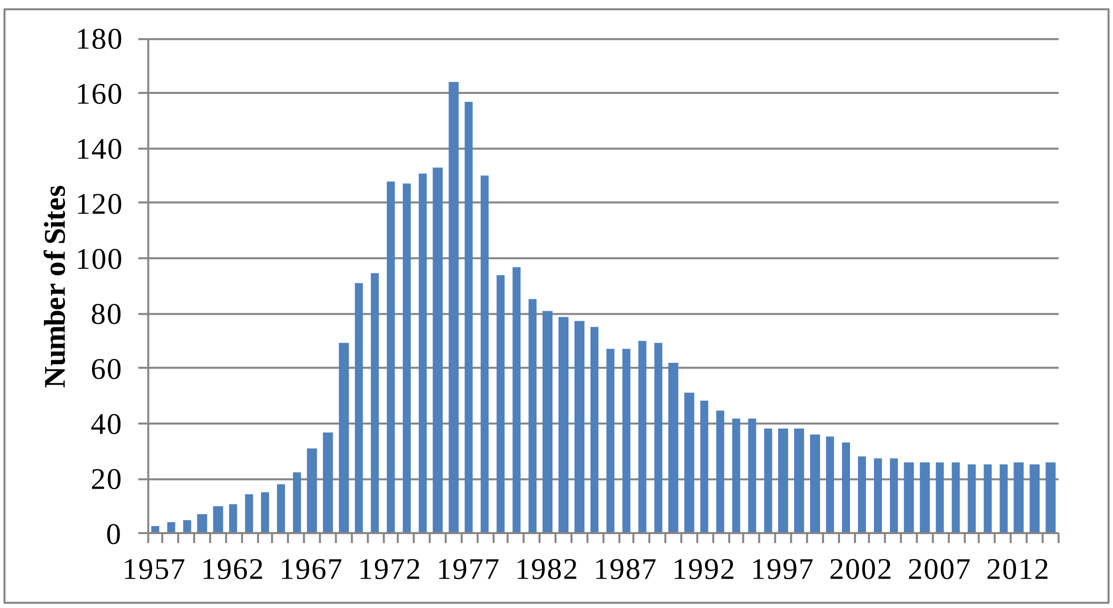

Figure 2-1 Evolution of the number of air monitoring sites in Maryland. These counts were determined from running AQS AMP500 report for the state of Maryland and querying all parameters. All sites were used except 240198001, which did not have any monitoring data in AQS.

In 1979, EPA promulgated uniform monitoring requirements establishing reference or equivalent monitoring methods, minimum numbers of required monitoring sites, public AQI reporting, annual monitoring network reviews, and quality assurance and quarterly and annual reporting of all data to EPA. With the establishment of these requirements and the discontinuation of monitoring using non-standard methods, the number of monitoring sites dropped to just below 100.

Maryland began measuring inhalable particulates in 1984 using high volume samplers with a 0-10 micron size selective inlet. In July 1987, EPA replaced TSP as the indicator for particulate matter with PM_{10} and by 1992 there were 26 PM_{10} monitoring sites. Concurrently, TSP monitoring was drastically reduced to support the lead NAAQS only. Other trace metal analyses were also discontinued at this time.

By 1989, the total number of sites state-wide had declined to 60. Beginning in 1955, monitoring was accomplished through the cooperative efforts of local agencies and the State of Maryland. Carroll, Dorchester, Howard, Washington, and Wicomico County Health Departments supplied personnel for the operation of state-owned air sampling stations located within their jurisdictions. In addition, the following health departments operated their own air sampling stations and assisted in the operation of State-owned stations: Allegany, Anne Arundel, Baltimore, Frederick, Montgomery and Prince George's Counties. Baltimore City maintained its own sampling network and did not operate any state-owned stations. Over the intervening years, as the local jurisdictions gradually divested themselves of ambient air monitoring responsibilities for a variety of reasons, including budgetary limitations, many sites were discontinued. By the early 1990's all ambient air monitoring activities were centralized in the Maryland Department of the Environment (MDE). The overall number of monitoring stations continued to decline throughout the 1990's as many single pollutant sites were either discontinued or consolidated as multipollutant sites.

By the late 1980's, Maryland had begun measuring air toxics at a handful of sites state-wide. Subsequent to the passage of the Clean Air Act Amendments of 1990, three enhanced ozone monitoring sites, referred to as Photochemical Assessment Monitoring Stations or PAMS, were established during 1993 and 1994 to collect detailed information on volatile organic ozone precursors, nitrogen dioxide and meteorological parameters.

Following promulgation of the $PM_{2.5}$ NAAQS in 1997, MDE implemented a network of 18 FRM $PM_{2.5}$ samplers in 1999 and 2000. The PM_{10} network was concurrently reduced. Two $PM_{2.5}$ chemical speciation sites were also established in 2000 to provide further information about the composition of $PM_{2.5}$ in Maryland. Semi-continuous monitoring for $PM_{2.5}$ with TEOM instruments began around the same time in order to provide near real-time data for AQI reporting and EPAs AirNow website. In recent years, MDE has discontinued the TEOMs and is now utilizing BAMM instruments for semi-continuous $PM_{2.5}$ monitoring.

In an effort to better understand the origin and nature of air pollution transported into Maryland from the Ohio River Valley and other areas to the west, MDE established a research monitoring station at Piney Run Reservoir in Garrett County in 2004. This site is outfitted with research grade instrumentation to monitor trace levels of SO_2 and CO, semi-continuous organic and elemental carbon $PM_{2.5}$, semi-continuous sulfate $PM_{2.5}$ (discontinued in 2014) and NO_y. Traditional semi-continuous BAMM $PM_{2.5}$, ozone and $PM_{2.5}$ chemical speciation are also measured. Similarly outfitted research sites were also established in Beltsville in 2004 (as part of the National Core Monitoring station network or NCORE) and Horn Point, on the Eastern Shore, in 2012.

The operating ranges of the current monitoring network are presented in Figure 2-2. The average site age is 25 years with a range of operation between 1 and 50 years. Most sites have been operating for more than 10 years.

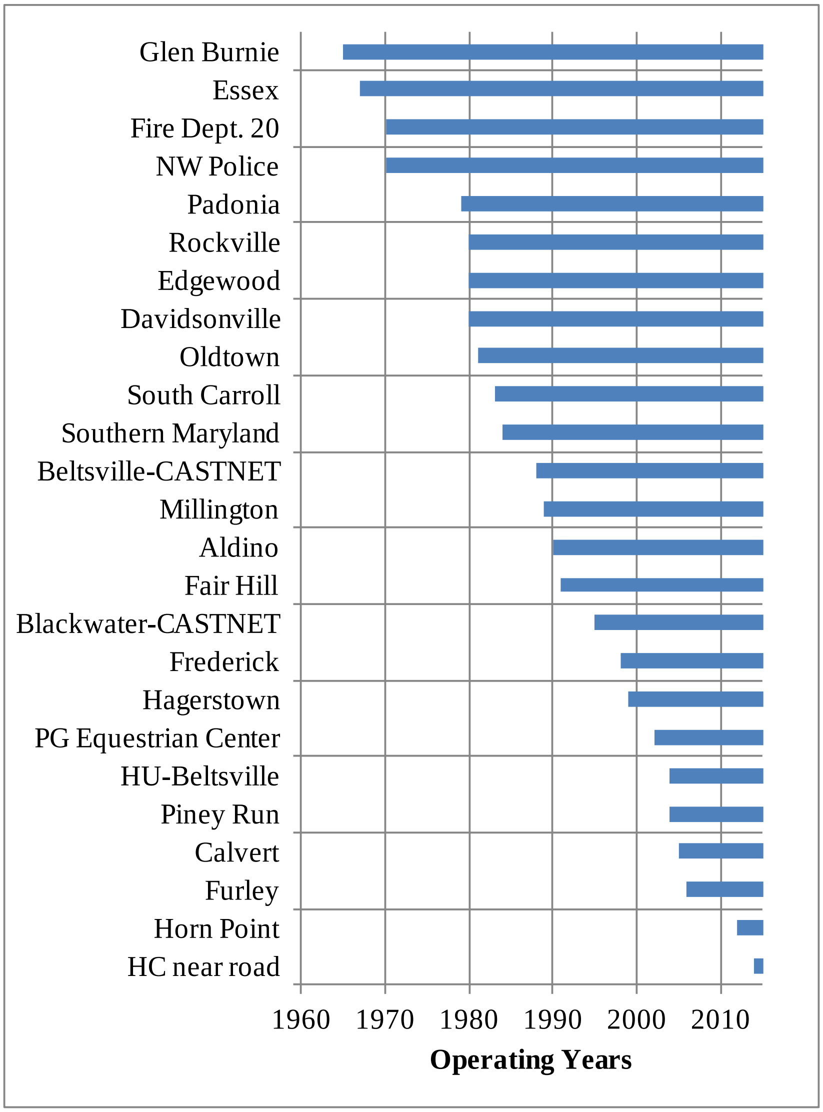

Figure 2-2 Operating ranges of currently operating sites in the Maryland Network.

Changes to the network since 2009

2009-2010

- FEM MetOne BAM–1020 continuous $PM_{2.5}$ monitors, collocated with $PM_{2.5}$ FRMs were installed at the following locations: Oldtown, Fair Hill, Rockville and HU-Beltsville.

2010-2011

- The continuous PM_{10} monitor at Essex was shut down.
- The co-located FRM $PM_{2.5}$ monitors at Fairhill and Rockville were removed.
- An FEM $PM_{2.5}$ monitor was installed at Piney Run.
- NOy measurements at Aldino were discontinued.
- PM coarse measurements were begun at Piney Run and Beltsville.

2011- 2012

- A low volume PM_{10} lead monitor was installed at the HU-Beltsville site.
- The Bladensburg VFD (240330025) $PM_{2.5}$ site was shut down.
- The NE Police station (245100006) $PM_{2.5}$ and air toxics site was shut down.
- The Horn Point site (240190004) on the Eastern Shore became operational.

2014-2015

- Howard County Near Road became operational in 2014 including NO_2, CO, $PM_{2.5}$ and air toxics.
- Two Ultrafine monitors were installed at the Howard County near road site. Once the collocation study period is over, one monitor will remain and one will be moved to HU-Beltsville.
- Two black carbon aethalometers were installed at the HU-Beltsville site. Once the collocation study period is over, one monitor will remain and one will be moved to Howard County Near Road.

3. SPECIFIC POLLUTANT NETWORKS

Ambient air monitoring networks are typically classified by the pollutant that they measure and usually consist of more than one monitoring site location. MDE operates several pollutant networks (e.g., an ozone network, a sulfur dioxide network, a $PM_{2.5}$ network, etc.). In addition, some of the networks measure groups of pollutants such as air toxics. In this section the assessment of network monitoring objectives and monitoring requirments, the identification of redundant monitoring sites, and the identification of new sites are addressed.

In 2009 EPA provided the states with software tools to identify redundant monitoring sites and to identify possible locations for new monitoring sites. The Lake Michigan Air Director's Consortium (LADCO) updated the tools for 2015 [Ladco, 2015]. To aid in the automation of analysis, MDE devised equivalent tools for use with the monitoring networks. As an aid to making decisions about current O_3 and $PM_{2.5}$ networks, a decision matrix approach for defining the relative value of each site in these networks was implemented following EPA's suggestions [Cavender, 2009].

To determine whether Maryland monitoring networks '*meet the monitoring objectives defined in appendix D*', MDE searched for inconsistencies in the monitoring objective types and the related scale of representation (scale) assigned to each monitor in each network. Inconsistencies can arise from the changes delineated above which may have occurred since the original assignment of scales and objectives. Inconsistencies can also arise from errors made in the original assignments. Six basic monitoring objectives with their AQS objective types have been defined in Appendix D to Part 58 1.1.1 as follows:

- Determine the highest concentration expected to occur in the area covered by the network (Highest Concentration)
- Measure typical concentrations in areas of high population density (Population Exposure)
- Determine the impact of significant sources or source categories on air quality (Source Oriented)
- Determine background concentration levels (General/Background)
- Determine the extent of regional pollutant transport among populated areas (Regional Transport)
- Measure air pollution impacts on visibility, vegetation damage, or welfare-based impact (Welfare Related Impacts)

'To clarify the nature of the link between general monitoring objectives, site types, and the physical location of a particular monitor, the concept of spatial scale of representativeness is defined. The goal in locating monitors is to correctly match the spatial scale represented by the sample of monitored air with the spatial scale most appropriate for the monitoring site type, air pollutant to be measured, and the monitoring objective. Thus, spatial scale of representativeness is described in terms of the physical dimensions of the air parcel nearest to a monitoring site throughout which actual pollutant concentrations are reasonably similar' [Appendix D to Part 58 1.2 (a) and Watson, 1997]. The scales of representativeness, as defined in Appendix D to Part 58 1.2 (b) for the monitoring site types described previously are as follows:

- **Micro** Concentrations in air volumes associated with area dimensions ranging from several meters up to about 100 meters.
- **Middle** Concentrations typical of areas up to several city blocks in size with dimensions ranging from about 100 meters to 0.5 kilometer.
- **Neighborhood** Concentrations within some extended area of the city that has relatively uniform land use with dimensions in the 0.5 to 4.0 kilometers range.
- **Urban** Overall, citywide conditions with dimensions on the order of 4 to 50 kilometers. This scale would usually require more than one site for definition.
- **Regional** Usually a rural area of reasonably homogeneous geography and extends from tens to hundreds of kilometers.
- **National/Global** Concentrations characterizing the nation and the globe as a whole.

Each of the previously mentioned scales is not appropriate for use with each pollutant. For example, '*urban scale and regional scale are of little relevance to PM_{10}, because of the short transport distances for PM_{10}, especially when emitted near ground level. In contrast, because $PM_{2.5}$ is a secondary pollutant, larger spatial scales are relevant, because monitors in such locations will reflect regional emissions trends and transport patterns*.'[CFR, 2006]. Each of the previously mentioned scales is not appropriate for use with each objective type. For example, population exposure is not an appropriate objective for characterizing regional scale sites, because to have regional scale, a site must be located away from population centers. Appropriate scales for each objective can be found in Table D-1 of Appendix D to Part 58. Note that different monitors located at the same site may have different objective and scales depending on the pollutant that they measure.

Here are some examples of how discrepancies in monitoring objectives and their related representative scales were found:

- To determine if a site was correctly assigned the 'Highest Concentration' objective, the site's design values were compared with the other sites in the network to determine if it did measure the highest concentration. Note that air quality modeling results were sometimes used to help locate new 'Highest Concentration' sites. Assigning the highest concentration objective for ozone monitors in Maryland has become less precise since the last network assessment, as extended high ozone episodes (multiple days with many monitors exceeding the NAAQS) have become less frequent and one day events at fewer or even individual monitors have tended to dominate on exceedance days.
- To determine if a site was correctly assigned 'Population Exposure' as an objective, land use in the area defined by the site's scale was considered. Areas that have mixed land use may not serve as the best population exposure sites.
- To determine if a site was correctly assigned the 'General/Background' objective, the site's design values were compared with other sites in the network to determine if it had one of the lowest values.
- Sites assigned the 'Population Exposure' or the' General/Background' objective should not be significantly influenced by nearby emissions sources. Maps identifying the locations of major point sources relative to the location of monitoring sites were used to identify which monitors were close to sources.

- Determining whether the scale was correctly assigned usually called for an appeal to the definition of scale: '… *throughout which actual pollutant concentrations are reasonably similar …*'. Inferences about the variation of pollutant concentrations were made by visual inspection of land use homogeneity, visual inspection of the location of major sources in relation to monitoring sites, and application of air quality modeling results.

3.1 Air Toxics Network

EPA Region III developed a regional air toxics network jointly with the state and local agencies in the late 1980's and early 1990's with the goal of characterizing ambient air toxics levels throughout Region III. There are four monitoring sites where air toxics samples are currently collected in Maryland. Two of these are urban sites (Oldtown, and Essex) which have operated for the last 20 years. The HU-Beltsville site is a suburban site and has operated for 11 years. The remaining site, Howard County Near Road, has been operational since April 2014. None of the sites are designated as National Air Toxics Trends Stations (NATTS) by EPA.

The Howard County Near Road site was not included in this assessment because of the limited amount of data collected to date. Assessment of the air toxics network was more difficult than the other networks due to the following:

- Thirty-two air toxics compounds needed to be assessed, not just one, as was the case with the other networks.

- Of the 32 air toxics compounds measured during 2011-2013, only ten species had median concentrations above their MDL and so statistical tests for redundancy could not be applied to these species.

- Most air toxics data follow highly skewed distributions making the use of statistical tests and statistical estimators, which assume a normal distribution of data, inappropriate for use with the air toxics data.

3.1.1 Compliance with Network Design Criteria

There are no federal or Maryland state regulations governing the design of air toxics networks. In addition, there are no NAAQS established for any of the measured air toxic compounds.

3.1.2 Assessment of Objective Types Assigned to Monitors

Although no design criteria exist for air toxics monitoring, MDE assigned scales and objective types to the currently operating air toxics monitors. Population exposure was the objective assigned to all air toxics monitors, and all were assigned neighborhood scale except for Oldtown, which was assigned middle scale because of its close proximity to a busy city intersection. Essex and Oldtown are located in densely populated areas in or around Baltimore City. Land use in the vicinity of HU-Beltsville is not as homogenous as the other urban sites. The immediate surroundings at the HU-Beltsville site consist primarily of open space on the research campus of the Howard University Physics Department. There is a commercial–industrial strip to the west along nearby Route 1 and low density residential neighborhoods to the north, east, and south. A chart showing the median concentrations of air toxics compounds from each of the air toxics sites is provided in Figure 3-1. Only air toxic compounds with annual median concentrations greater than the MDL are presented. Air toxics associated with mobile source emissions including benzene, toluene and m/p-xylene have higher concentrations at the Oldtown and Essex sites than what is measured at the HU-Beltsville site and this is likely due to location. The Essex site is located on a small but very active parking lot in Baltimore County and the Oldtown site is located at a busy Baltimore City intersection.

All of the air toxics monitoring sites are useful for characterizing ambient levels of air toxics within their respective communities as well as for determining trends and the effectiveness of specific emission reduction activities. In addition, the HU-Beltsville site is located less than 3 km from the terminus of the newly constructed Inter-County Connector (ICC) and these measurements may prove useful for evaluating the air quality impacts of the ICC and associated development.

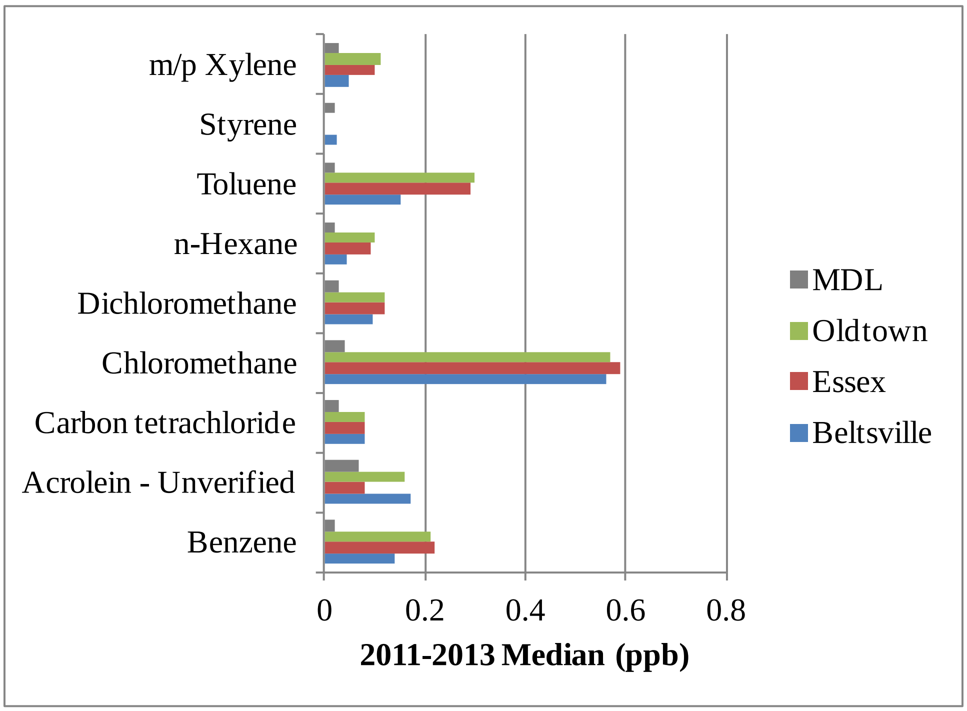

Figure 3-1 Median concentration profiles of selected air toxics parameters compared by site, 2011-2013. Air toxics shown above were the only species with values above the detection limit. Oldtown and Essex measure Styrene but the medians are below the minimum detection limit.

3.1.3 Identifying Redundant Sites

Following a similar evaluation method that was used to assess other pollutant networks, Spearman correlation coefficients were calculated for inter-site pairs of each air toxics pollutant evaluated to determine if there was a relationship between air toxics measurements at different sites (Spearman correlations were used instead of Pearson correlations, because the air toxics data does not follow a Gaussian distribution). Table 3-1 lists the Spearman correlation coefficients as well as the median relative differences. The median is a more appropriate measure of central tendency when the data is skewed. The median relative difference between site pairs X and Y was calculated as follows:

$$Median\ Relative\ Difference = 100 * Median \left[\frac{|X_1 - Y_1|}{\frac{X_1 - Y_1}{2}}, \quad \frac{|X_2 - Y_2|}{\frac{X_2 - Y_2}{2}}, \ldots \quad \frac{|X_n - Y_n|}{\frac{X_n - Y_n}{2}} \right]$$

Data collected from 2011-2013 were included in this analysis and only data in which each site pair measurement was above the MDL were used to calculate the correlation and median relative difference.

All correlations were small (less than 0.8) and the median relative differences between HU-Beltsville and Oldtown and between HU-Beltsville and Essex were much larger than the differences between Essex and Oldtown, likely related to the siting. The HU-Beltsville site is both far from the other air toxics sites and collects samples in an area characterized by mixed land use while the other sites are in areas characterized by residential land-use and higher population density. Nothing in these site pair results suggests that any of the site pairs were measuring redundant air toxic concentrations.

Table 3-1 Site pair Spearman correlations and median relative differences for air toxics with values larger than the MDL.

	Essex - HU Beltsville		**Essex - Oldtown**		**Oldtown - HU Beltsville**	
Species	Spearman	Median relative difference	Spearman	Median relative difference	Spearman	Median relative difference
Acrolein - Unverified	0.06	-63%	0.13	-57%	0.29	-6%
Benzene	0.66	50%	0.77	6%	0.66	43%
Carbon tetrachloride	0.77	0%	0.72	0%	0.67	0%
Chloromethane	0.56	6%	0.66	2%	0.56	4%
Dichloromethane	0.54	29%	0.58	0%	0.52	29%
m/p Xylene	0.49	58%	0.56	-7%	0.27	57%
n-Hexane	0.57	59%	0.49	0%	0.49	61%
Styrene	0.24	-29%	-0.17	0%	-0.17	-29%
Toluene	0.61	63%	0.67	0%	0.54	59%

3.1.4 Identifying New Sites Needed

EPA did not supply or develop any tools for identifying new air toxics site locations, and without any objective network design criteria, there is no clear cut approach for doing so. In general, the existing sites could be moved or additional air toxics monitoring sites could be established in order to characterize ambient air toxics levels in other areas of the state, provided adequate funding is available, although it is unlikely that concentrations of most air toxics would be any greater than those measured in the highly urban environment of Baltimore City or at the Howard County Near Road site.

MDE is considering the addition of a semi-continuous automated BTEX (benzene, toluene, ethylbenzene and xylene) analyzer to the Howard County Near Road site. This would provide hourly measurements of BTEX, allowing spikes in concentration to be discerned and correlated with traffic counts.

3.1.5 Effect of New or Proposed Network Design Regulations

None have been proposed for air toxics as of the time this report was written.

3.1.6 Recommended Network Changes

MDE recommends installation and operation of a semi-continuous automated BTEX analyzer at the Howard County Near Road monitoring site. Implementation of this recommendation is not contingent on EPA approval but is dependent on the availability of adequate resources and is not a high priority. It is also recommended that EPA Region III and the states should jointly reassess the goals and objectives of the regional air toxics network. A part of this assessment should focus on what air toxic compounds should be reported and whether existing sites should be continued as trends sites or moved to characterize other areas of the individual states.

3.2 CO Network

3.2.1 Compliance with Network Design Criteria

EPA revised the minimum monitoring requirements for CO on August, 12, 2011. One CO monitor is required to be collocated with a near-road NO_2 monitor in urban areas having a population of 1 million or more. MDE added a CO monitor to the Howard County Near Road NO_2 monitoring site at the Interstate 95 South (I-95S) rest area between MD-32 and MD-216. This monitor began collecting data April 1, 2014. Operation of the existing CO sites in Maryland is required until MDE requests discontinuation of a site in the Annual Network Plan and the EPA Regional Administrator approves the request. A summary of the monitoring requirements is provided in Table 3-2.

Table 3-2 Monitoring requirements for CO.

Requirement	Appendix D 40 CFR Part 58	Required in Maryland	Number of monitors active in Maryland
One CO monitor collocated with a Near Road NO_2 in urban area with a population >= 1 million	4.2.1	1	1
One CO monitor at each Type 2 PAMS site	5.3, Table D-6	1	1
One CO monitor at each NCore site	3(b)	2	2

Maryland has six CO monitoring sites and their type, objectives, and representative scales are summarized in Table 3-3. There are currently two primary NAAQS for CO, an 8-hr standard of 9 ppm and a 1-hr standard of 35 ppm. All CO monitoring sites meet the NAAQS (Table 3-3). The Howard County Near Road site does not have a valid design value for 2013, because this site did not begin operating until 2014.

Table 3-3 Monitoring details for the CO network.

Site Name	AQS ID	Monitor Scale	Monitor Objective	Type	2013 Design Value 1-hr (ppm)	2013 Design Value 8-hr (ppm)
Essex	240053001	Middle Scale Urban Scale	Highest Concentration Max Precursor Emissions Impact Population Exposure	SLAMS PAMS	2.2	1.4
Horn Point	240190004	Regional Scale	Population Exposure	SLAMS	0.4	0.3
Piney Run	240230002	Regional Scale	Regional Transport	NCORE	0.4	0.3
Howard County Near road	240270006	Middle Scale	Highest Concentration Source Oriented	SLAMS	*	*
HU-Beltsville	240330030	Urban Scale	General/Background	NCORE	1.0	0.9
Oldtown	245100040	Middle Scale	Highest Concentration	SLAMS	2.0	1.3

*Site operation started in 2014 and there is not enough data currently for a valid design value.

3.2.2 Assessment of Objective Types Assigned to Monitors

Essex, Oldtown, and the Howard County Near Road sites are assigned highest concentration objectives. The design values at Essex and Oldtown are the highest in the Maryland network (the Howard County Near Road site is expected to have a high design value but has not been operating long enough for a valid design value to be determined).

Micro scale and middle scale measurements are useful site classifications for SLAMS sites because most people have the potential for exposure at these scales. Appendix D to part 58 4.2.3.1 states that in certain cases, middle scale measurements may apply to areas that have a total length of several kilometers, such as "line" emission source areas. This type of emission source area would include air quality along a commercially developed street or shopping plaza, freeway corridors, parking lots, and feeder streets. Two SLAMS stations in Maryland, Essex and Oldtown, have the representative scale of middle (0.1-0.5 km). The Howard County Near Road site was previously designated as microscale, but it is recommended that this be changed to middle scale to better reflect the intended objective.

The HU-Beltsville site is an NCore site and its representative scale is urban. HU-Beltsville is located in a suburban area that is not close to large CO sources and this justifies the urban representative scale as well as the population exposure monitoring objective. Piney Run is an NCore site located in a rural area at high elevation (781 m above sea level) in Western Maryland. The site location justifies the regional representative scale. Horn Point is located in a rural area on the Eastern Shore of Maryland and this location justifies the regional representative scale.

3.2.3 Identifying Redundant Sites

Statistical relationships between site pairs were examined to determine redundant sites. Daily maximum CO data from each site were examined for 2011-2013. Pearson's correlation coefficients and average relative differences among site pairs are provided in Table 3-4. Average relative differences between site pairs (X and Y) were calculated with the following equation:

$$100 * \sum_{i=1}^{n} \frac{|X_i - Y_i|}{(X_i + Y_i)/2}$$

All correlations (r) are smaller than 0.77, suggesting that the site pairs are not well correlated. The distance between Essex and Oldtown is only 11 km and this pair shows the largest correlation (r = 0.77) and the second smallest difference (33%). However, the differences between the observations are large enough that the sites should not be considered redundant. Because Essex and Oldtown sites are close to each other and the monitoring requirements are being met, one site could be terminated. The design values for the two sites are similar, and since Essex has the larger design value and is required as part of the PAMS network, it is recommended that the Oldtown monitor be terminated in the future.

Table 3-4 Statistical relationships between CO site pairs.

X	Y	Distance (km)	r	n	Average Relative Difference
Oldtown	Essex	11	0.77	1029	33%
Oldtown	HU-Beltsville	36	0.64	1034	36%
HU-Beltsville	Essex	45	0.64	1022	40%
HU-Beltsville	Horn Point	82	0.27	606	60%
Oldtown	Horn Point	89	0.24	591	77%
Horn Point	Essex	86	0.22	604	71%
HU-Beltsville	Piney Run	197	0.15	1023	49%
Piney Run	Essex	222	0.14	1021	70%
Oldtown	Piney Run	212	0.13	1030	72%
Piney Run	Horn Point	277	0.11	593	22%

3.2.4 Identifying New Sites Needed

Given that CO concentrations at all sites are well below the NAAQS and the network requirements are being met, there is no pressing need to identify potential new sites.

3.2.5 Effect of New or Proposed Network Design Regulations

None have been proposed for CO as of the time this report was written.

3.2.6 Recommended Network Changes

MDE recommends changing the scale of the Howard County Near Road monitor from microscale to middle scale. The Oldtown CO monitor can be removed since there are more CO monitors in the network than are required and all sites are measuring well below the NAAQS. The Oldtown monitor was required to be operational as part of the CO Maintenance Plan through 2015 [MDE, 2003]. MDE therefore recommends that CO monitoring at Oldtown be terminated on January 1, 2016, pending approval by the Regional Administrator.

3.3 Lead Network

3.3.1 Compliance with Network Design Criteria

The latest revision to the lead (Pb) NAAQS was finalized on October 15, 2008, lowering the primary and secondary standards from 1.5 $\mu g/m^3$ to 0.15 $\mu g/m^3$. The final rule became effective on January 26, 2011 (Table 3-5). In 2011 MDE found one source emitting more than 0.5 ton per year but modeling showed that ambient concentrations were below the limit and MDE submitted a waiver for the unit (Maryland Annual Network Plan for Calendar Year 2012). The EPA Region III Regional Administrator approved the waiver. MDE reviewed data from the 2011 National Emissions Inventory (NEI) and did not find any source in Maryland that exceeded the 0.5 ton per year threshold for additional monitoring. EPA Region III and MDE review the Maryland lead inventory annually to see if any facilities exceed the criteria and need to be modeled and/or monitored.

Table 3-5 Lead Monitoring Requirements

Requirement	Appendix D 40 CFR Part 58	Required in MD
One source-oriented SLAMS site located to measure the maximum Pb concentration resulting from each non-airport Pb source which emits 0.50 or more tons per year	4.5(a)	0
One source-oriented SLAMS site located to measure the maximum Pb concentration resulting from airport which emits 1.0 or more tons per year	4.5(a)	0
Non-source oriented Pb monitoring at each required NCore site in a CBSA having a population of 500,000 or more	4.5(b)	1

Since there is only one lead monitoring station in Maryland and it is currently required, further assessment of the lead network is not necessary.

3.4 NO_2 Network

3.4.1 Compliance with Network Design Criteria

On January 22, 2010, EPA strengthened the health-based National Ambient Air Quality Standard (NAAQS) for nitrogen dioxide (NO_2) by setting a new 1-hour NAAQS at 100 ppb. The existing annual average NAAQS of 53 ppb has been retained as well. In addition to establishing a new 1-hour NO_2 NAAQS, EPA revised the NO_2 monitoring requirements in urban areas. A summary of the monitoring requirements are presented in Table 3-6.

Near Road Monitoring

There are three MSA's with populations greater than 2,500,000 that are either wholly in Maryland or that Maryland is a part of that each qualify for two near road NO_2 monitors. For the Baltimore-Towson, MD MSA, MDE is currently operating one near road NO_2 monitoring station, the Howard County Near Road site, located on I-95 S between Routes 32 and 216. A second site, the Baltimore County Near Road site, is currently being installed at the Maryland Transit Administration maintenance facility at the interchange of I-695 and I-795. Although this site was required to be operational by January 1, 2015, delays in securing permission to use the site and delays in developing the necessary infrastructure due to winter weather were encountered. It is anticipated that the site will be operational by August 1, 2015.

For the Washington-Arlington-Alexandria, DC-VA-MD-WV MSA, the requirements will be met by monitors installed in Washington, DC by the District of Columbia Department of the Environment (DDOE) and in Virginia by the Virginia Department of Environmental Quality (VaDEQ.) For the Philadelphia-Camden-Wilmington-Newark, PA-DE-MD MSA, the requirements will be met by monitors installed by the Pennsylvania Department of Environmental Protection (PADEP).

Community Wide Monitoring

There are three MSA's with populations greater than 1,000,000 that are either wholly in Maryland, or that Maryland is a part of, that each qualify for one community wide NO_2 monitor. MDE's NO_2 monitors at the Essex and Oldtown sites fulfill this requirement for the Baltimore-Towson, MD MSA.

For the Washington-Arlington-Alexandria, DC-VA-MD-WV MSA, the requirements will be met by monitors installed in Washington, DC by the District of Columbia Department of the Environment (DDOE) and in Virginia by the Virginia Department of Environmental Quality (VaDEQ). For the Philadelphia-Camden-Wilmington-Newark, PA-DE-MD MSA, the requirements will be met by monitors installed by the Pennsylvania Department of Environmental Protection (PADEP)

Sensitive and Vulnerable Populations

EPA Region III has not required MDE to install any additional monitors to meet this requirement.

Table 3-6 NO_2 monitoring requirements.

Requirement	Appendix D 40 CFR Part 58	Required in Maryland	Number of monitors active in Maryland
Near Road NO_2 monitoring in CBSA with a population >= 500,000	4.3.2(a)	1	0
Near Road NO_2 monitoring in CBSA with a population >= 2,500,000	4.3.2(a)	2	3 qualifying CBSA's
Area-wide monitoring in CBSA with population > 1 million	4.3.3	1	3 qualifying CBSA's
Regional Administrator required monitoring	4.3.4	Variable	0

Maryland has four NO_2 monitoring sites in Maryland and their type, objectives, and representative scale are summarized in Table 3-7. There are currently two primary standards for NO_2. The first primary standard is the annual average of 0.053 ppm. The second primary standard is an hourly standard where the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb. There is a secondary annual standard which is the same as the primary standard.

There are requirements for area-wide monitoring within the NO_2 network. 40 CFR 58 Appendix D 4.3.3 states that there must be one monitoring station in each CBSA to monitor a location of expected highest concentrations representing the neighborhood or larger spatial scales. PAMS sites collecting NO_2 data that are situated in an area of expected high NO_2 concentrations at the neighborhood or large spatial scale may be used to satisfy this minimum monitoring requirement when the NO_2 monitor is operated year round. The Essex site addresses this criterion (Table 3-7). Design values are presented in Table 3-7 for NO_2 monitoring sites. All locations have design values that are below both the annual and 1-hr NAAQS. Piney Run and Howard County Near Road were not operational until 2014 and do not yet have valid design values. The HU-Beltsville site began collecting NO_2 in 2012 and so there is not enough valid data to calculate the 1-hour design value which must be determined with three years of data. The annual design value is calculated with only one year of data and this is why there is an annual design value but not a 1-hour design value for HU-Beltsville.

Table 3-7 Monitoring details for NO_2 network.

Site Name	AQS ID	Representative Scale	Monitor Objective	TYPE	2013 Annual Design Value (ppb)	2011-2013 1-hr Design Value (ppb)
Essex	240053001	Neighborhood	Max Precursor Emissions Impact Population Exposure	Unofficial PAMS	11	44
Piney Run	240230002	Regional Scale	Regional Transport	SLAMS	*	*
Howard County Near road	240270006	Microscale	Highest Concentration Source Oriented	SLAMS	*	*
HU-Beltsville	240330030	Urban Scale	General/Background	SLAMS	8	*
Oldtown	245100040	Middle Scale	Highest Concentration	SLAMS	15	52

*Not enough data is available for a valid design value calculation.

3.4.2 Assessment of Objective Types Assigned to Monitors

The most important spatial scale for near-road NO_2 monitoring stations to effectively characterize the maximum expected hourly NO_2 concentrations due to mobile source emissions on major roadways is the microscale. The most important scales for other monitoring station characterizing maximum expected hourly NO_2 concentrations are the microscale and middle scale (40 CFR 58 Appendix D 4.3.5 a). The Howard County Near Road site has been assigned microscale and this is appropriate.

Middle scale sites represent air quality levels in areas up to several city blocks and may include locations of expected maximum concentrations due to proximity to major NO_2 point, area, and/or non-road sources. The Oldtown site has been assigned middle scale because this site is located on the corner of a busy intersection in downtown Baltimore with exposure to bus traffic.

Neighborhood scale sites represent air quality conditions throughout some relatively uniform land use areas ranging from 0.5-4 km. Emissions from stationary point and area sources may under certain plume conditions result in high NO_2 concentrations at the neighborhood scale (40 CFR 58 Appendix D 4.3.5 a.3). Essex has been assigned neighborhood scale because it is located in a parking lot that may experience some peaks in NO_2, but it typically measures values expected in an urban environment.

Urban scale sites represent concentrations throughout large portions of an urban area. These measurements are useful for assessing trends in area-wide air quality, and hence, the effectiveness of large scale air pollution control strategies. The HU-Beltsville site has been assigned the urban scale and this is appropriate because it is located in a suburban environment, not close to major NO_2 point sources.

Piney Run is located in Western Maryland and is directly in the path of transported aloft emissions of NO_2 from neighboring states; its representative scale is regional. Piney Run is located in a rural area at high elevation (781 m above sea level) not close to any large NO_2 sources which justifies the regional representative scale and the regional transport monitoring objective.

3.4.3 Identifying Redundant Sites

Statistical relationships between site pairs were examined to determine redundant sites. Daily maximum NO_2 data from each site were examined for 2011-2013. Because Piney Run and the Howard County Near Road site were not collecting data during this time period, they were not examined in this analysis. Pearson's correlation coefficients and average relative differences among site pairs are provided in Table 3-8. Average relative differences between site pairs (X and Y) were calculated with the following equation:

$$100 * \sum_{i=1}^{n} \frac{|X_i - Y_i|}{(X_i + Y_i)/2}$$

All correlations (r) are smaller than 0.78, suggesting that the site pairs are not well correlated. The average relative differences among site pairs ranged from 28-51% and are large enough that the sites should not be considered redundant. Using these statistical relationships no redundant sites were found.

Table 3-8 Statistical relationships between NO_2 site pairs.

X	Y	Distance (km)	r	n	Average Relative Difference
HU-Beltsville	Essex	45	0.78	692	37%
Oldtown	Essex	11	0.78	1007	28%
Oldtown	HU-Beltsville	36	0.66	669	51%

3.4.4 Identifying New Sites Needed

Because all sites are measuring below the NAAQS and all monitoring requirements are met, no new sites are considered at this time.

3.4.5 Proposed Regulations

There are currently no proposed changes to the regulations at this time.

3.4.6 Recommended Network Changes

There are no recommended changes to the network at this time.

3.5 Ozone Network

3.5.1 Compliance with Network Design Criteria

Ozone monitoring requirements are determined by the MSA population and design value, as specified in Table D-2 of 40 CFR Part 58 Appendix D. Table 3-9 shows that the MDE monitoring network meets or exceeds the minimum requirements. Since ozone levels decrease significantly in the colder periods of the year in many areas, ozone is only required to be monitored during the designated "ozone season". For Maryland, the ozone season is specified as April 1 through October 31. The monitoring objectives and spatial scales are discussed in greater detail in section 3.5.2.

Table 3-9 Number of ozone SLAMS sites required (based on Table D-2, Appendix D to 40CFR Part 58, Ozone minimum monitoring requirements).

MSA Name	Population	Monitors Deployed by State[A]						Total Monitors	Required ≥ 85% NAAQS
		DE	DC	MD	VA	WV	PA		
Baltimore-Towson, MD	2,753,149	0	0	7	0	0	0	7	4
Hagerstown-Martinsburg, MD-WV	256,278	0	0	1	0	1	0	2	1
Washington-Arlington-Alexandria, DC-VA-MD-WV	5,860,342	0	3	7	8	0	0	18	3
Philadelphia-Camden-Wilmington-Newark, PA-DE-MD	6,018,800	4	0	1	0	0	8	13	3
Salisbury, MD-DE	381,868	0	0	0	0	0	0	0	1
Total		4	3	16	8	1	8	40	12

A - Based on tables available at http://www.epa.gov/airtrends/values.html. All areas had their maximum site >= 85% Ozone NAAQS.

3.5.2 Assessment of Objective Types and Spatial Scales Assigned to Monitors

There are twenty ozone monitoring locations in Maryland and their objectives and representative scales are summarized in Table 3-10. There are four extra monitors in Table 3-10 than shown in Table 3-9 because these four monitors are not contained within an MSA (Piney Run, Millington, Blackwater-CASTNET, and Horn Point). The Blackwater and Beltsville sites are owned and operated by EPA Clean Air Markets Division as part of the Clean Air Status and Trends NETwork (CASTNET) but can be used by MDE in meeting EPA ozone network design requirements. These sites are therefore included in this assessment, but are not subject to any recommendations for closure or relocation.

Table 3-10 Monitoring objectives and scales for ozone.

Site Name	Monitor Objective	Measurement Scale	MSA
Davidsonville	Population Exposure	Urban Scale	Baltimore -Towson, MD
Padonia	Population Exposure	Neighborhood	Baltimore -Towson, MD
Essex	Population Exposure	Neighborhood	Baltimore -Towson, MD
Calvert	Population Exposure	Urban Scale	Washington-Arlington-Alexandria, DC-VA-MD-WV
South Carroll	Population Exposure	Urban Scale	Baltimore -Towson, MD
Fair Hill	Regional Transport	Urban Scale	Philadelphia-Camden-Wilmington, PA-DE-MD
Southern Maryland	General/Background	Regional Scale	Washington-Arlington-Alexandria, DC-VA-MD-WV
Horn Point	Population Exposure	Regional Scale	NA
Blackwater-CASTNET	Highest Concentration	Regional Scale	NA
Frederick	Population Exposure	Urban Scale	Washington-Arlington-Alexandria, DC-VA-MD-WV
Piney Run	Regional Transport	Regional Scale	NA
Edgewood	Highest Concentration	Urban Scale	Baltimore -Towson, MD
Aldino	Highest Concentration	Urban Scale	Baltimore -Towson, MD
Millington	Population Exposure	Urban Scale	NA
Rockville	Population Exposure	Urban Scale	Washington-Arlington-Alexandria, DC-VA-MD-WV
HU-Beltsville	Highest Concentration	Urban Scale	Washington-Arlington-Alexandria, DC-VA-MD-WV
PG Equestrian Center	Population Exposure	Urban Scale	Washington-Arlington-Alexandria, DC-VA-MD-WV
Beltsville-CASTNET	Highest Concentration	Regional Scale	Washington-Arlington-Alexandria, DC-VA-MD-WV
Hagerstown	Highest Concentration	Urban Scale	Hagerstown-Martinsburg, MD-WV
Furley	Population Exposure	Neighborhood	Baltimore -Towson, MD

The ozone monitoring rule (Appendix D to Part 58 4.1 b) states: "*Within an O_3 network, at least one O_3 site for each MSA, or CSA if multiple MSAs are involved, must be designed to record the maximum concentration for that particular metropolitan area. More than one maximum concentration site may be necessary in some areas*." Note that the AQS classifies maximum concentration monitors as highest concentration monitors (and will be referred to throughout the document as such). The Maryland ozone network has six monitors assigned highest concentration. Two of these monitors are in the Baltimore-Towson, MD MSA, two monitors are in the Washington-Arlington-Alexandria, DC-VA-MD-WV MSA, and one is in the Hagerstown-Martinsburg, MD-WV MSA. The Fair Hill monitor is the only ozone monitor in Maryland in the Philadelphia-Camden-Wilmington, PA-DE-MD MSA and the site is located in a rural area and representative of regional transport. The Clarksboro site (340150002) located in New Jersey and in the Philadelphia-Camden-Wilmington, PA-DE-MD MSA is classified with the objective of highest concentration.

The ozone monitoring rule requires that one of three scales be assigned to ozone monitor sites, including urban, neighborhood, and regional. Sites associated with these scales are shown in Table 3-10 and Figure 3-2. Neighborhood scale sites should be located to measure typical city concentrations and should not be near the influence of major NO_x sources. The map in Figure 3-2 shows no major NO_x sources within the spatial scales of the three neighborhood sites (Essex, Furley, and Padonia).

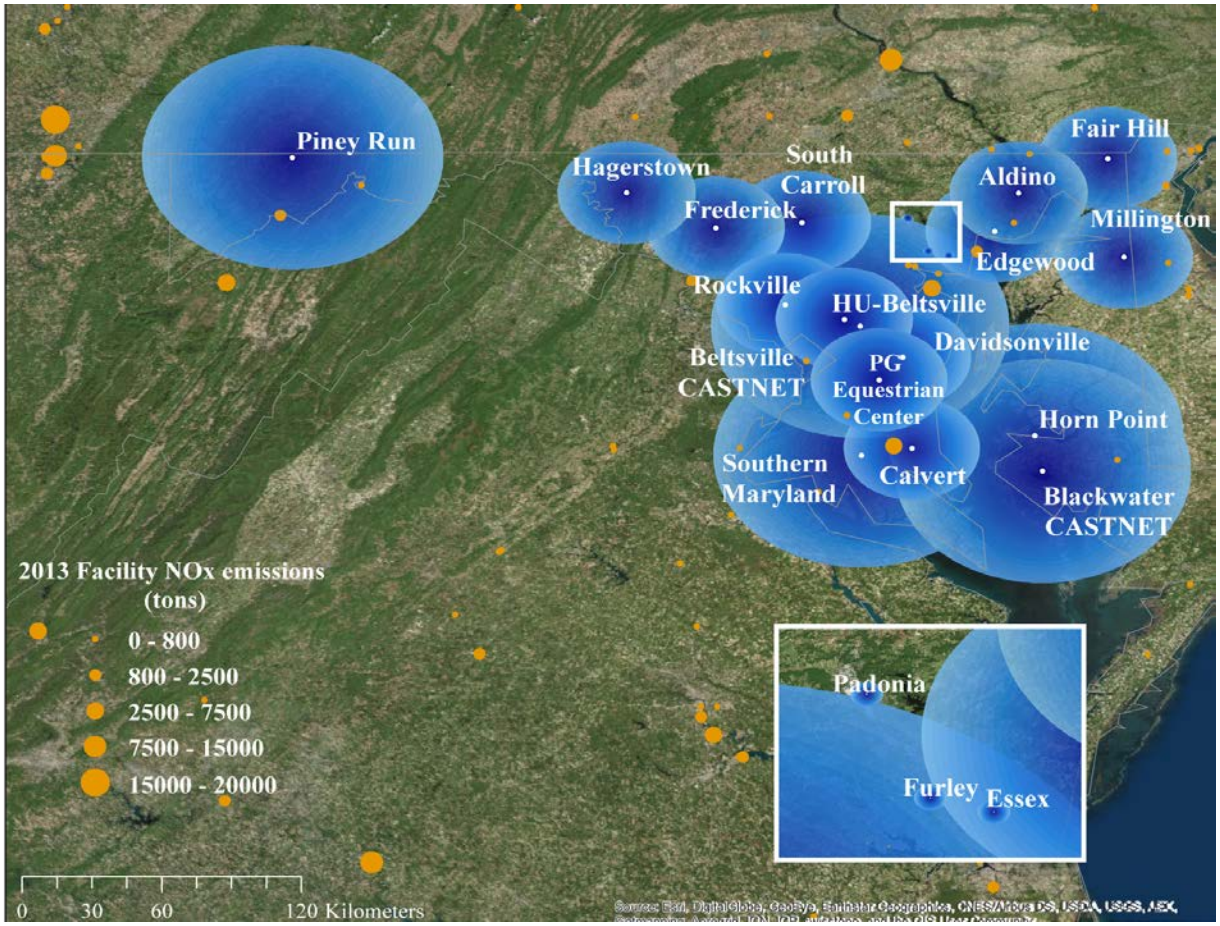

Figure 3-2 Locations of Maryland ozone monitors and large NO_x point sources. Also shown is the scale of the monitoring location. Regional scale monitors are shown with 50 km radius ellipses, urban scale monitors are shown with 23 km radius ellipses, and neighborhood scale monitors are shown with four km radius ellipses.

The Maryland ozone monitoring network objectives include population exposure, highest concentration, regional transport, and background. Population data were examined using EPA tools to assess the population exposure objective. CMAQ model output and monitored design values were utilized to assess the background objective and the highest concentration objective. The results of these assessments are described below.

Thirteen of the 20 ozone sites have population exposure designations as an objective. EPA developed a tool to calculate the population served by each monitor to assist states in developing network assessments (http://ladco.github.io/NetAssessApp/tools.html). This tool uses Voronoi polygons to show the area represented by a monitoring site. The shape and size of each polygon is dependent on the proximity of the nearest neighboring sites to any particular site. Data from the 2010 Decennial Census were used to determine which census tract centroids were within each polygon. The population represented by the polygon is calculated by summing the populations of these census tracts. The population density is determined by dividing the summed population by the area of the Voronoi polygon. Voronoi polygon population densities for the Maryland ozone monitoring network are shown in Figure 3-3. The population exposure sites are highlighted in red. Some of the population exposure sites are associated with much lower population densities but these include more rural areas of Maryland. Ultimately, all of the monitors represent some degree of population exposure, although it may not be the stated primary monitoring objective.

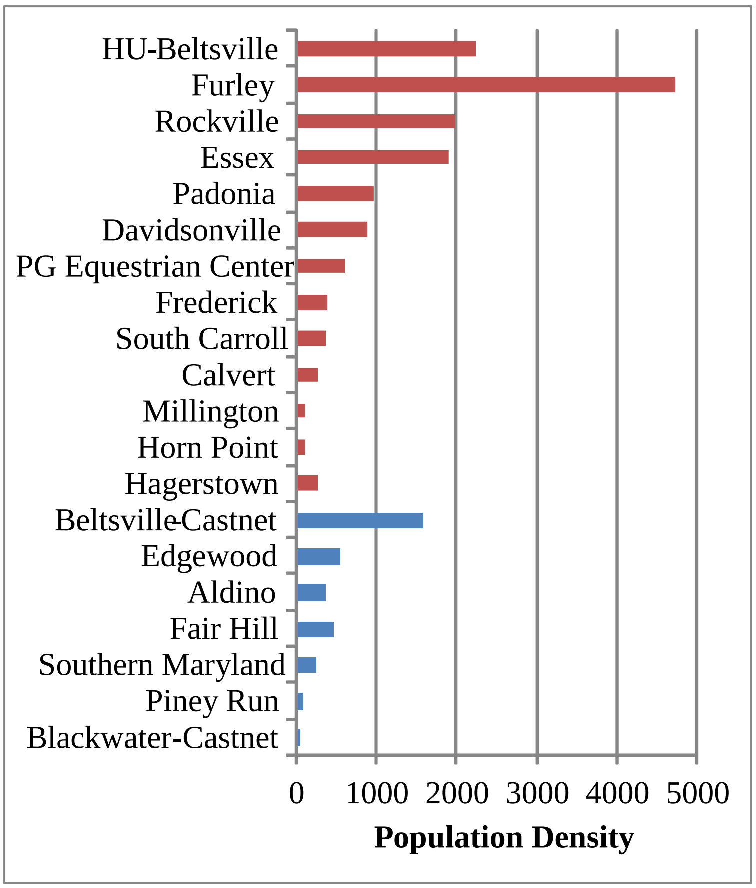

Figure 3-3 Population density for Maryland ozone monitors. Monitoring sites designated as population exposure sites are shaded in red, all other sites are shaded in blue.

CMAQ model output was examined as a method to assess the background monitoring objective and the highest concentration objective for the ozone network. Researchers at NASA-Goddard performed CMAQ modeling with 2011 emissions and 2011 meteorology [Loughner et al., 2014]. Figure 3-4 shows the number of ozone exceedance days in July from the CMAQ model run, overlaid with the measured number of exceedance days from surface monitors. Southern Maryland is classified as a background site and experiences fewer ozone exceedances, so this classification is appropriate. Blackwater-CASTNET, Aldino, Edgewood, HU-Beltsville,

Beltsville-CASTNET, and Hagerstown are classified as highest concentration monitors and these monitors do appear to measure the most ozone exceedances for the areas they represent.

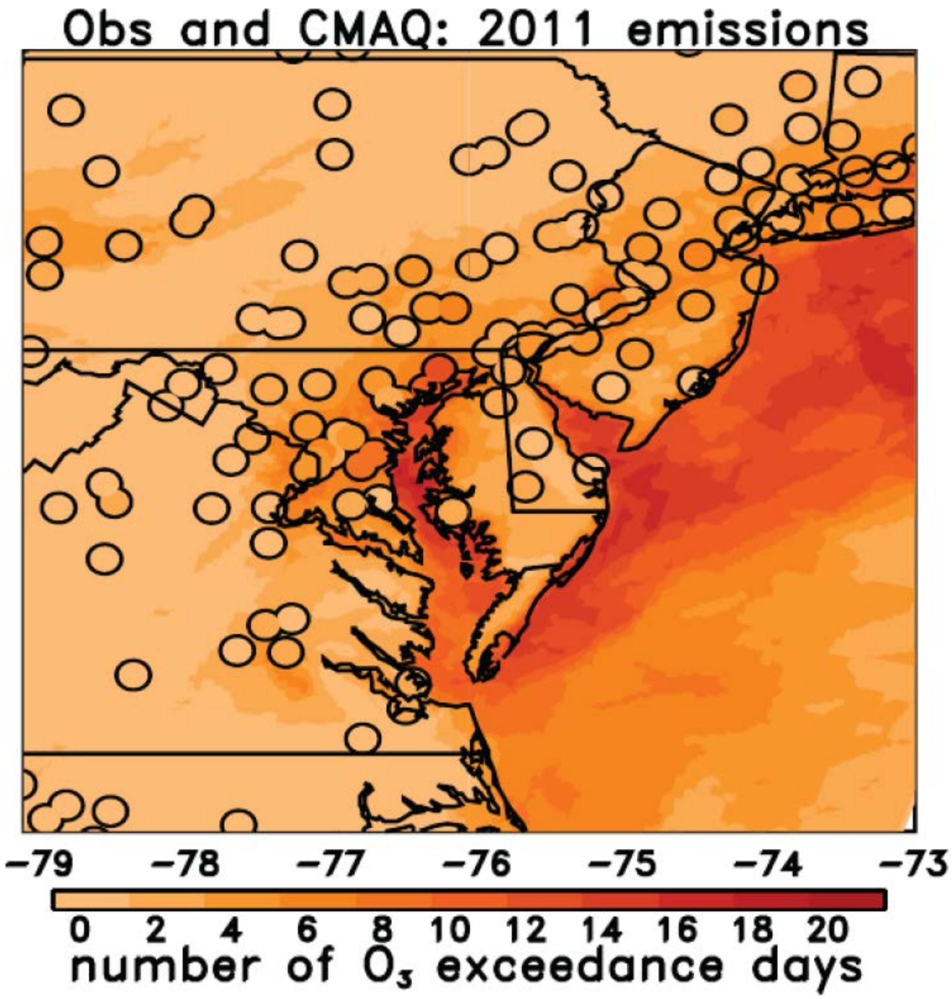

Figure 3-4 CMAQ modeled number of ozone exceedance days for July 2011. The number of measured exceedance days is overlaid in colored circles.

Monitored design values from 2012-2013 in each MSA were examined to assess the highest concentration and general/background monitoring objectives. These monitored design values are provided in Figure 3-5. The Edgewood and Aldino sites have the highest ozone design values in the Baltimore-Towson, MD MSA and this confirms their highest ozone monitoring objectives. HU-Beltsville and Beltsville-CASTNET are designated as highest concentration sites in the Washington-Arlington-Alexandria, DC-VA-MD-WV MSA. HU-Beltsville, Beltsville-CASTNET, and PG Equestrian Center have the highest design values in this MSA and so these sites seem to have the correct objectives. Assigning the highest concentration objective for ozone monitors in Maryland has become less precise since the last network assessment because extended high ozone episodes (multiple days with many monitors exceeding the NAAQS) have become less frequent and one day events at fewer or even individual monitors have tended to dominate on exceedance days. Southern Maryland is classified as a General/Background monitor and it has moderately high ozone design values. The scale is appropriate because the location is typically upwind of the greater DC metropolitan area and the I-95 corridor.

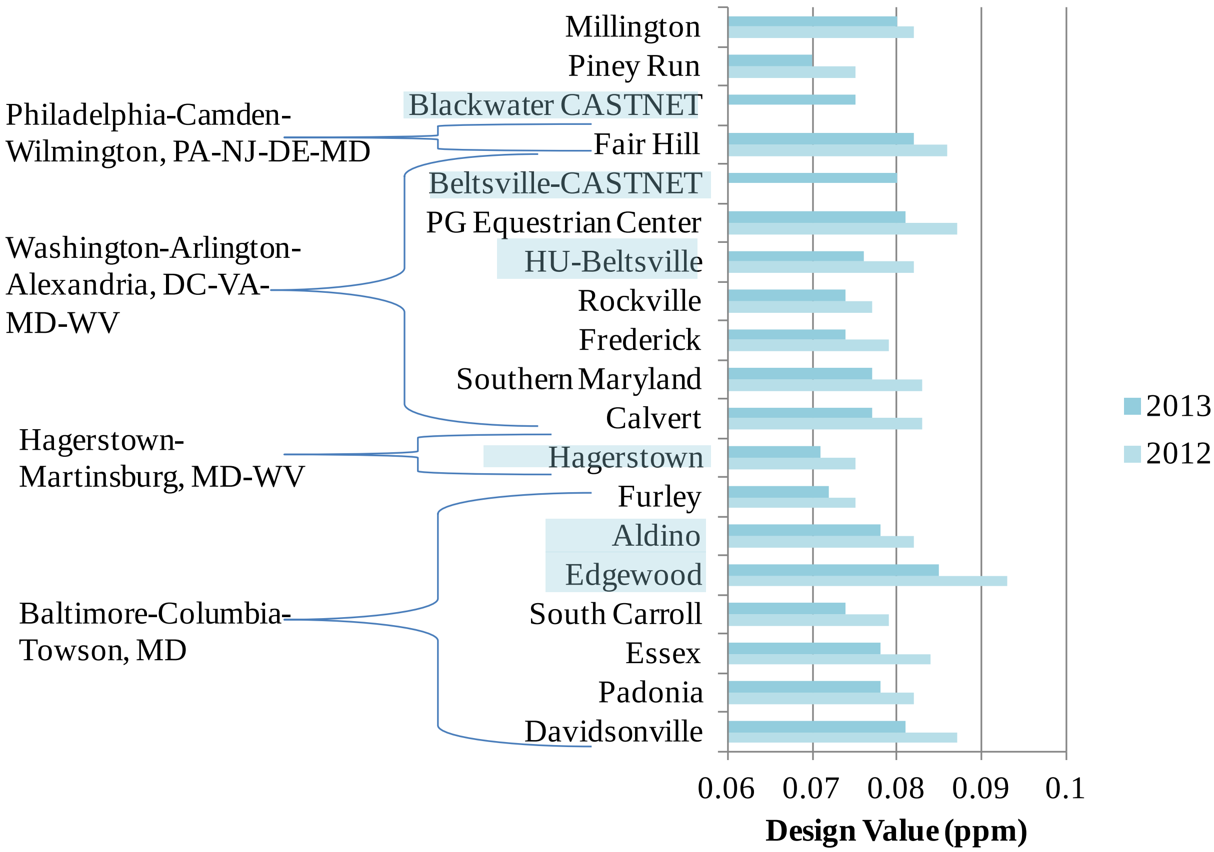

Figure 3-5 Ozone design values (DV) for Maryland ozone monitors for 2012 and-2013. MSAs are shown and monitors with the highest concentration monitoring objective are highlighted in teal.

3.5.3 Identifying Redundant Sites

To examine possible redundant sites an analysis examining correlations and percent differences between site pairs was performed. For each site in Maryland, daily maximum 8-hour ozone was tallied and paired with ozone data from sites within 50 km of the Maryland site (all sites included in this analysis are shown in Figure 3-6). Pearson correlation values (r-values) and average relative differences between site pairs (X and Y) were calculated with the following equation:

$$100 * \sum_{i=1}^{n} \frac{|X_i - Y_i|}{(X_i + Y_i)/2}$$

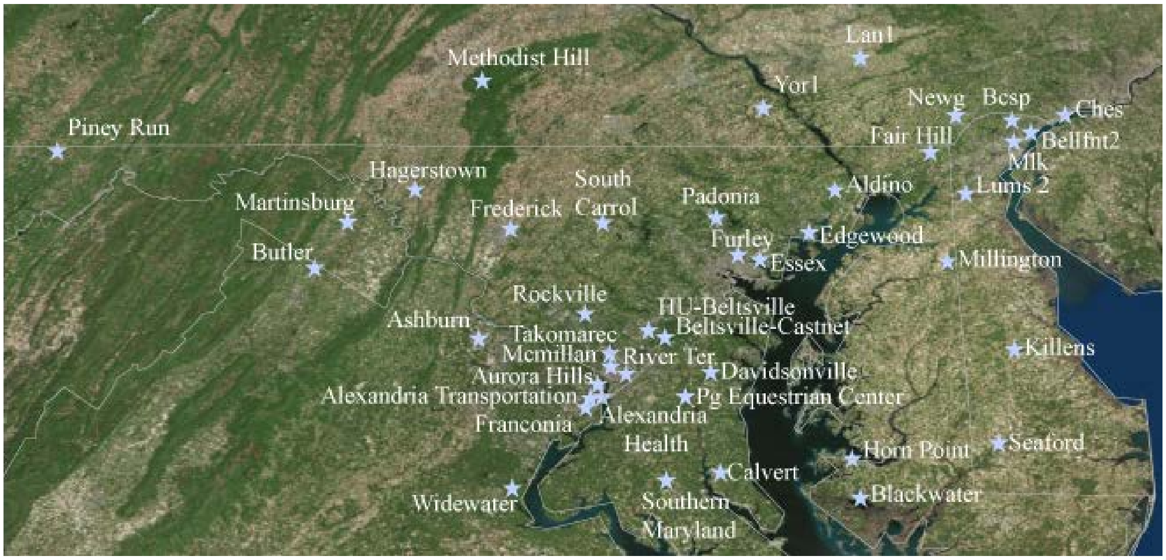

Figure 3-6 Ozone sites used in the redundant sites assessment.

Sites that measure nearly the same concentrations of ozone are those that are both highly correlated (large r) and have the smallest inter-site average relative differences. Sites with the top 20 highest correlations (r-values) are presented in Table 3-11. All site pairs have correlations of at least 0.9 and their average relative differences are between 6-15%.

The HU-Beltsville and Beltsville-CASTNET sites have the highest correlation and a small percent difference (7%), indicating that one may be redundant and a candidate for removal. HU-Beltsville is a required NCORE site operated by MDE and Beltsville is a CASTNET site, therefore they will not be considered for removal. The Blackwater and Horn Point site pair also had very high correlation and small percent difference (6%), but Horn Point is outfitted to measure meteorological influences on pollution on the eastern shore and Blackwater is also an EPA CASTNET site, so neither site will be considered for removal. PG-Equestrian Center and Davidsonville are also well correlated and have small percent differences. One of these sites may be redundant. Since Davidsonville does not monitor for any other pollutants this site is considered a good candidate for removal.

When considering possible removal, meteorology impacting the site must also be examined. Davidsonville is close enough to the Chesapeake Bay to be influenced by bay breezes. This can increase or decrease ozone values, depending on the day. If clean bay air from the bay breeze influences the monitor, the ozone values will presumably decrease. If the bay breeze moves inland and settles on Davidsonville, ozone values may increase greatly due to the convergence of polluted air. PG-Equestrian Center is influenced on occasion by the bay breeze, but is typically on the polluted side (the DC side).

The Southern Maryland and Calvert site pair also had high correlation and small percent differences. However, both monitors have shown independent behavior on high ozone days. Typically they do not observe significant ozone concentrations which may lead to similar readings on more background-type days and thus a high correlation. Therefore, removal of either Southern Maryland or Calvert will not be considered at this time.

Table 3-11 Top 20 correlated site pairs in the Maryland ozone network.

Site 1	Site 2	Distance (km)	r	n	Percent Difference
Beltsville-CASTNET	HU-Beltsville	6	0.985	834	7%
PG Equestrian Center	Davidsonville	13	0.980	611	6%
Blackwater	Horn Point	16	0.977	540	6%
Southern Maryland	Calvert	17	0.968	577	5%
Rockville	Takomarec	18	0.967	90	4%
Furley	Essex	7	0.966	568	12%
Horn Point	Seaford	46	0.966	567	6%
Edgewood	Essex	19	0.961	604	8%
Blackwater	Seaford	49	0.961	973	7%
Fair Hill	Newg	17	0.961	607	7%
Frederick	South Carroll	29	0.960	604	6%
HU-Beltsville	Mcmillan Reservoir	19	0.958	1024	11%
Hagerstown	Martinsburg	25	0.958	623	7%
Beltsville-CASTNET	Aurora Hills	28	0.957	541	8%
Hagerstown	Frederick	34	0.956	613	7%
Beltsville-CASTNET	Mcmillan Reservoir	21	0.956	860	14%
HU-Beltsville	Aurora Hills	27	0.955	603	8%
Horn Point	Calvert	42	0.955	367	7%
HU-Beltsville	Rockville	21	0.954	597	7%
Millington	Killens	41	0.954	604	8%

EPA developed tools in 2010 for the network assessment and LADCO modified them for 2015. One of these tools is the removal bias tool which is used to examine redundancies within the network [LADCO, 2015]. The bias estimation uses the nearest neighbors to each site to estimate the concentration at the location of the site, as if the site had never existed. This is done using the Voronoi Neighborhood Averaging algorithm with inverse distance squared weighting. The squared distance allows for higher weighting on concentrations at sites located closer to the site being examined. The bias was calculated for each day at each site by taking the difference between the predicted value from the interpolation and the measured concentration. A negative average bias suggests that the estimated concentration of the site is smaller than the actual measured concentration and high concentrations may not be appropriately captured [LADCO, 2015]. The mean removal bias ranged from -5.3 – 4.7 ppb (Table 3-12). Davidsonville was highly correlated with PG Equestrian Center and for this reason is being considered for possible removal. The average removal bias for Davidsonville was -1.2 ppb and this means that by removing the site ozone could be underestimated in that area.

Table 3-12 Mean removal bias for each site in Maryland's ozone network.

Site	Mean Removal Bias (ppb)
Piney Run	-5.3
Millington	-3.3
Padonia	-2.8
Fair Hill	-2.5
Beltsville-CASTNET	-2.1
Blackwater-CASTNET	-1.7
Edgewood	-1.5
Davidsonville	-1.2
Hagerstown	-0.8
Essex	-0.5
Frederick	-0.4
Southern Maryland	-0.1
Calvert	0
South Carroll	0
Aldino	0.3
PG Equestrian Center	0.3
Rockville	0.4
HU-Beltsville	0.6
Horn Point	1.6
Furley	4.7

3.5.4 Identifying New Sites Needed

EPA provided a tool for the 2010 network assessment to determine if new sites were needed for the ozone monitoring network, however no such tool was provided for the 2015 assessment. In 2010, MDE also examined CMAQ modeled output of days exceeding the ozone standard to identify areas that are likely to exceed the ozone NAAQS and do not have nearby monitors. Figure 3-4 shows the number of exceedance days in 2011 using emissions and meteorology for 2011 as input to the CMAQ model. The modeling indicates that there are no gaps in the ozone monitoring network and that additional monitors would not capture any ozone hot spots. Therefore, it is not recommended that any additional monitors be installed. However, MDE is considering closing the Davidsonville site and moving this ozone monitor to the Glen Burnie $PM_{2.5}$ monitoring site. This would allow measurement of intra-regional transport of ozone from the Washington, DC metropolitan area into Baltimore.

3.5.5 Proposed Changes to the Ozone NAAQS and Monitoring Rule

On November 25, 2014, the U.S. Environmental Protection Agency (EPA) proposed to strengthen the National Ambient Air Quality Standards (NAAQS) for ground-level ozone. EPA is proposing to update both the primary ozone standard, to protect public health, and the secondary standard, to protect the public welfare. Both standards would be 8-hour standards set within a range of 65 to 70 parts per billion (ppb). Elements of the proposal include: streamlining and modernizing the Photochemical Assessment Monitoring Stations (PAMS) network to use monitoring resources more efficiently, updating the Federal Reference Method for ozone, and lengthening the ozone season in certain areas (EPA, 2014). Any changes to the network necessary to meet these new requirements will be addressed in future MDE Annual Network Plans, pending final approval of the proposed rule.

3.5.6 Recommended Network Changes

Any changes to the ozone network, particularly site removals, must be considered in relation to the site's overall value to the ozone network. A decision matrix was used to determine the relative value of each site in the ozone network. The decision matrix ranks the sites according to a weighted score which is the sum of normalized, individual criterion scores multiplied by a subjectively determined weighting factor:

The score for each criterion was calculated with the following equation [Cavender, 2009]:

$$Score = 100 * weight * (V_i - V_{min}) / (V_{max} - V_{min})$$

Here V_i, V_{min} and V_{max} represent the value of the given criteria and the minimum and maximum values of criteria for all sites.

The criteria chosen for this network were:

- 2010 population and population density within Voronoi polygons associated with each site– important relative to the population oriented monitoring requirement.
- The number of parameters measured at the site.
- The site-average correlation coefficient among site pairs within 50 km of the site of interest (from section 3.5.3) – needed to quantify uniqueness of the concentrations measured relative to other sites/monitors.
- The site-average relative concentration difference (from section 3.5.3) – needed to quantify uniqueness of the concentrations measured relative to other sites/monitors.
- The site-specific 2013 design value (DV_{2013}) represented as a percentage of NAAQS.

The score for the correlation with other sites was calculated as follows:

$$Score = 100 * weight * (V_{max} - V_i) / (V_{max} - V_{min})$$

The weight for the correlation was calculated differently than the rest because the less correlated a site is with its neighbors the more unique and valuable it is.

The ozone DV % NAAQS was calculated as follows:

$$\text{Ozone DV ratio to NAAQS} = DV_{2013} / 75 \text{ ppb}$$

The results of the scoring are shown in Table 3-12. Horn Point and Blackwater-CASTNET had the lowest scores but since Horn Point is outfitted to measure meteorological influences on pollution on the Eastern Shore and Blackwater is part of CASTNET, these sites are not candidates for removal. Davidsonville has the fourth highest score and this was related to the design value being one of the higher values in the state. Because the design value at PG Equestrian Center is so similar and the ozone values measured at the two sites are often similar (as seen with their large positive correlation and small relative difference), this site still seems to be a good candidate for removal. MDE recommends terminating the site and moving the ozone monitor to Glen Burnie to capture possible ozone transport from the Washington DC area into Baltimore. Before moving this monitor MDE will operate a portable ozone monitor at Glen Burnie, designated as an SPM, for the 2015 ozone season to determine whether the ozone concentrations are similar or higher.

Table 3-13 Decision matrix for the ozone network.

Site	2013 Design Values (ppm)	2010 Population		2010 Population Density		Total Monitors		Average Correlation with other Sites		Average Relative Concentration Difference		Ozone DV ratio to NAAQS		Score
		Weight:	0.5	Weight:	0.50	Weight:	0.50	Weight:	1.00	Weight:	1.00	Weight:	1.00	
		raw	points	raw	points	raw	points	raw	points	raw	points	raw	points	
Horn Point		73926	2	117	1	5	11	0.97	0	0.06	0			13
Blackwater-CASTNET	0.075	47110	0	45	0	1	0	0.96	12	0.07	9	1.00	33	54
Frederick	0.074	218038	10	388	4	1	0	0.95	23	0.07	14	0.99	27	77
South Carroll	0.074	228961	11	371	3	1	0	0.94	35	0.09	32	0.99	27	108
Hagerstown	0.071	201132	9	267	2	2	3	0.93	60	0.09	29	0.95	7	110
Piney Run	0.07	156565	6	70	0	10	25	0.95	26	0.13	74	0.93	0	132
Calvert	0.077	158252	7	273	2	1	0	0.92	72	0.09	33	1.03	47	160
Aldino	0.078	128597	5	355	3	1	0	0.92	66	0.10	45	1.04	53	172
Essex	0.078	250736	12	1900	20	8	19	0.95	30	0.10	41	1.04	53	175
Padonia	0.078	439412	23	976	10	3	6	0.94	47	0.09	36	1.04	53	176
PG Equestrian Center	0.081	126228	5	622	6	3	6	0.93	57	0.09	30	1.08	73	177
Fair Hill	0.082	125139	5	447	4	2	3	0.94	49	0.10	44	1.09	80	185
Rockville	0.074	654249	36	1989	21	2	3	0.92	69	0.10	37	0.99	27	192
Beltsville-CASTNET	0.08	255543	12	1558	16	1	0	0.94	39	0.12	60	1.07	67	194
Millington	0.08	90477	3	124	1	2	3	0.92	76	0.11	54	1.07	67	203
Southern Maryland	0.077	150202	6	227	2	1	0	0.90	100	0.11	52	1.03	47	206
Edgewood	0.085	141420	6	528	5	2	3	0.93	55	0.10	43	1.13	100	212
Davidsonville	0.081	282645	14	883	9	1	0	0.92	67	0.11	49	1.08	73	212
HU-Beltsville	0.076	387322	20	2239	23	19	50	0.94	41	0.10	44	1.01	40	219
Furley	0.072	891912	50	4719	50	1	0	0.93	49	0.15	100	0.96	13	263

3.6 PAMS Network

3.6.1 Compliance with Network Design Criteria

Design criteria for the PAMS network are based on locations relative to ozone precursor source areas and predominant wind directions associated with high ozone events (40 CFR 58 Appendix D, 5.1). There are specific monitoring objectives associated with each location. The overall design should enable characterization of precursor emissions sources within ozone Non-Attainment Areas (NAA), transport of ozone and its precursors, and the photochemical processes related to ozone nonattainment. Specific monitoring objectives associated with each of these sites may result in four distinct site types:

Type 1 sites are intended to characterize upwind background and transported ozone and its precursor concentrations entering the area and will identify those areas which are subjected to transport.

Type 2 sites are intended to monitor the magnitude and type of precursor emissions in the area where maximum precursor emissions are expected to impact and are suited for the monitoring of urban air toxic pollutants.

Type 3 sites are intended to monitor maximum ozone concentrations occurring downwind from the area of maximum precursor emissions.

Type 4 sites are intended to characterize the downwind transported ozone and its precursor concentrations exiting the area and will identify those areas which are potentially contributing to overwhelming transport in other areas.

A Type 2 site is required for each PAMS area. Only two sites are required for each area, providing all chemical measurements are made. The PAMS network for the Baltimore NAA is described in Table 3-14. There are two PAMS monitoring stations in the Baltimore, MD NAA: the HU-Beltsville Type 1 site and Essex Type 2 site. The HU-Beltsville station also doubles as a Type 3 site for the Washington, DC NAA PAMS network. Note that the HU-Beltsville PAMS station serves different objectives for the Baltimore and Washington NAA's. The required PAMS monitoring locations and frequencies from the PAMS monitoring rule (40 CFR 58, Appendix D, Table D-6) are provided in Table 3-15. The requirements are all being met.

Table 3-14 Monitoring details for PAMS network

Site Name	PAMS Type	Parameters observed	Monitoring objective
Essex	Type 2	O_3	Population exposure
		VOCs	Maximum precursor emissions impact Population exposure
		NO_x	Maximum precursor emissions impact Population exposure
		CO	Maximum precursor emissions impact Highest concentration Population exposure
HU-Beltsville	Type 1/3	O_3	Highest concentration
		VOCs	Upwind background Population exposure
		NO_y, NOx	General/Background
		CO	General/Background

Table 3-15 Summary of required PAMS monitoring locations and frequencies

Measurement	Where required	Sampling frequency (all daily except for upper air meteorology)	Status
Speciated VOC	Two sites per area, one of which must be a Type 2 site	During the PAMS monitoring period: (1) Hourly auto GC, or (2) Eight 3-hour canisters, or (3) 1 morning and 1 afternoon canister with a 3-hour or less averaging time plus Continuous Total Non-methane Hydrocarbon measurement.	Met at Essex (Type 2, auto GC)) and HU-Beltsville (Type 1/ 3, canisters)
Carbonyl sampling	Type 2 site in areas classified as serious or above for the 8-hour ozone standard	3-hour samples every day during the PAMS monitoring period.	Met at Essex (Type 2)
NO_X	All Type 2 sites	Hourly during the ozone monitoring season.	Met at Essex (Type 2) and HU-Beltsville (Type 1/3)
NO_y	One site per area at the Type 3 or Type 1 site	Hourly during the ozone monitoring season.	Met at HU-Beltsville (Type 1/3)
CO (ppb level)	One site per area at a Type 2 site	Hourly during the ozone monitoring season.	Met at Essex (Type 2) and HU-Beltsville (Type 1/3)
Ozone	All sites	Hourly during the ozone monitoring season.	Met at Essex and HU-Beltsville
Surface met	All sites	Hourly during the ozone monitoring season.	Met at Essex and HU-Beltsville
Upper air meteorology	One representative location within PAMS area	Sampling frequency must be approved as part of the annual monitoring network plan required in 40 CFR 58.10.	Met at HU-Beltsville.

3.6.2 Assessment of Objective Types Assigned to Monitors

The Essex Type 2 site monitoring objective is to measure maximum precursor emissions impact for all PAMS parameters with the exception of ozone (Section 3.5.2). This location is, at times, immediately downwind of Baltimore City and industrial areas with relatively high ozone precursor emissions. The site is situated in a parking lot near a roadway and this may influence measured values of VOCs, NO_x, and CO, although fresh, well-mixed mobile emissions are prevalent throughout the area, especially during the morning rush hour.

HU-Beltsville is designated as a Type 1 site for the Baltimore NAA. The objective with respect to the Baltimore NAA is to measure background and transported ozone and precursor emissions. Originally, this Type 1 PAMS station was located at Fort Meade, approximately 5 km to the East-Northeast, but was moved in 2004 due to increased security measures implemented at the military base. Both locations have relatively similar land usage and emission characteristics, so significant differences in air quality are not likely. This location is ideally suited to measure transport between the Washington and Baltimore metropolitan area, given the right conditions. Washington and Baltimore are close together (only 25 km apart) and there has been an increase in development within the corridor which may distribute pollution homogenously throughout the area. These urban growth characteristics make it difficult to assess how well the HU-Beltsville site meets the upwind PAMS site objectives. Currently the monitoring objectives for VOC's at HU-Beltsville are population exposure and upwind background, which are appropriate for Type 1 PAMS sites.

HU-Beltsville is also designated as a Type 3 PAMS site for the Washington, DC NAA. The objective with respect to the Washington, DC NAA is to measure maximum ozone concentrations downwind of the area of maximum precursor emissions. HU-Beltsville currently does not observe the highest ozone concentrations in the Washington, DC NAA, although that does not necessarily mean it is not located downwind of maximum precursor emissions on high ozone days. As mentioned in the ozone section, assigning the highest concentration objective for ozone monitors in Maryland has become less precise since the last network assessment because extended high ozone episodes (multiple days with many monitors exceeding the NAAQS) have become less frequent and one day events at fewer or even individual monitors have tended to dominate on exceedance days. In addition, HU-Beltsville is located in a major traffic corridor (MD Route 29, I-95, and the Baltimore-Washington Parkway) between the two metropolitan areas, which could potentially suppress ozone levels. Virginia contributes a Type 1 site and DC contributes at Type 2 site to the Washington, DC NAA and these networks will be assessed in those states' 5-year Network Assessments.

3.6.3 Identifying Redundant Sites

The goals of the two PAMS sites are different and the distance between sites is far enough that these sites are not considered redundant.

3.6.4 Identifying New Sites Needed

The monitoring requirements for the minimum number of PAMS sites per PAMS area are currently being met. No additional sites are under consideration.

3.6.5 Effect of New or Proposed Network Design Regulations

On November 25, 2014 EPA proposed to strengthen the NAAQS for ground level ozone. Substantial revisions to the PAMS monitoring requirements were included in the proposal. These include requiring PAMS measurements at existing NCore sites in all O_3 non-attainment areas in lieu of the current PAMS network design requirements, and the development of an enhanced ozone monitoring plan for each non-attainment area. Proposed monitoring parameters includes hourly VOC sampling, carbonyl sampling (including formaldehyde, acetaldehyde and acetone), true $NO_{2,}$ and mixing height. Any changes to the network necessary to meet these new requirements will be addressed in future MDE Annual Network Plans, pending final approval of the proposed rule.

3.6.6 Recommended Network Changes

No changes to the PAMS network are recommended at this time.

3.7 $PM_{2.5}$ Network

3.7.1 Compliance with Network Design Criteria

The number of required $PM_{2.5}$ monitors in each MSA is determined by the MSA population and design value, as specified in Table D-5 of Appendix D to 40 CFR Part 58. Table 3-16 shows that the MDE monitoring network meets or exceeds the minimum requirements.

Table 3-16 Number of $PM_{2.5}$ SLAMS Sites (based on TABLE D–5 OF APPENDIX D TO PART 58. $PM_{2.5}$ Minimum Monitoring Requirements).

MSA Name	Population	Annual Design Value	Daily Design Value	Required SLAMS Monitors	Monitors Active in MD/Total[A,B]	Required ≥ 85% NAAQS
Baltimore-Towson, MD	2,753,149	10.5	26	3	8/8	3
Hagerstown-Martinsburg, MD-WV	256,278	10.7	27	1	1/2	1
Washington-Arlington-Alexandria, DC-VA-MD-WV	5,860,342	10.1	23	2	3/10	3
Philadelphia-Camden-Wilmington-Newark, PA-DE-MD	6,018,800	12.4	31	3	1/6	2
Salisbury, MD-DE	381,868	8.5	23	0	0/1	0

A - Based on tables available at http://www.epa.gov/airtrends/values.html.
B- Total number of monitors includes those located in other States.

Minimum Requirements for Collocated $PM_{2.5}$

Collocation requirements for $PM_{2.5}$ are based on the number of $PM_{2.5}$ monitors within a Primary Quality Assurance Organization (PQAO) and by measurement method (FRM or FEM) as specified in 40 CFR Part 58 Appendix A 3.2.5 and Appendix D 4.7.2. MDE is its own PQAO so all monitors in Maryland are counted in the collocation requirements. A minimum of 15% (round up) of the monitors must be collocated. MDE has 16 $PM_{2.5}$ monitors; therefore at least 2 must be collocated. MDE currently operates four collocated $PM_{2.5}$ monitors, three are FRM-FRM and one is FRM-FEM. At least one site where a FEM is designated as the primary monitor should be collocated with an FRM. This requirement is not currently being met in the network.

Requirements for Continuous $PM_{2.5}$ Monitoring

At least one-half (round up) of the minimum number of sites per MSA must operate continuous $PM_{2.5}$ monitors. MDE operates eight continuous $PM_{2.5}$ monitors, three in the Baltimore-Towson MD MSA, one in the Philadelphia-Camden-Wilmington-Newark, PA-DE-MD MSA, and one in the Hagerstown-Martinsburg, MD-WV MSA. The other three are in areas not designated as MSA's.

Requirements for Near Road $PM_{2.5}$ Monitoring

For MSA's with a population of one million or greater, at least one $PM_{2.5}$ monitor is to be located at a near road NO_2 station. The Howard County Near Road site fulfills this requirement for the Baltimore-Towson, MD MSA. MDE does not operate near road NO_2 stations in any other MSA.

Requirements for $PM_{2.5}$ Chemical Speciation

Each state shall continue to conduct chemical speciation monitoring and analyses at sites designated to be part of the $PM_{2.5}$ Speciation Trends Network (STN). MDE conducts chemical speciation monitoring at Essex and Howard U-Beltsville, and Howard U-Beltsville is designated as part of the STN.

Other Requirements for $PM_{2.5}$ Monitoring

The required monitoring sites must be located to represent area-wide air quality. These will typically be either neighborhood or urban scale, although micro or middle scale may be appropriate in some urban areas. At least one monitoring site must be neighborhood scale or greater in an area expected maximum concentration and one site must be sited in an area of poor air quality. Each State shall have at least one $PM_{2.5}$ site to monitor for regional background and at least one $PM_{2.5}$ site to monitor for regional transport. Each NCore station must operate a $PM_{2.5}$ monitor. Table 3-17 shows that MDE meets all of these additional requirements.

3.7.2 Assessment of Objective Types Assigned to Monitors

The site objective types required for $PM_{2.5}$ monitoring include highest/maximum concentration, population exposure, background, and transport. There are 16 $PM_{2.5}$ monitoring locations in Maryland and their objectives and scale of representativeness are summarized in Table 3-17. Maximum concentration sites are located to determine the highest concentrations. Population oriented sites have neighborhood or urban scales of representation, should not be influenced by single sources, and are located where large numbers of people live, work, or play [Watson,1997]. Background sites have urban or regional scales of representation, should measure the lower concentrations in the state/region, should not be along transport paths, and should be located away from major sources [Watson, 1997]. A map of the $PM_{2.5}$ monitoring locations along with spatial scales and large NO_x sources is provided in Figure 3-7.

MDE operates a transport site at Piney Run with an FEM $PM_{2.5}$ monitor. This site is located atop a local mountain peak at the Piney Reservoir, near other peaks on the Allegheny Plateau in Garrett County. The elevation of the Piney Run site is 781 meters above mean-sea-level. The purpose of this monitoring site is to track the impact of interstate pollutant transport on air quality in Maryland.

The Howard County Near Road and Oldtown sites are both designated highest concentration sites in the Baltimore-Towson, MD MSA. Hagerstown is designated a highest concentration monitor for the Hagerstown-Martinsburg, MD-WV MSA. River Terrace (110010041) and Haines Point (110010042), both located in Washington, DC, are designated highest concentration for the Washington-Arlington-Alexandria, DC-MD-VA MSA. There are five highest concentration monitors in the Philadelphia-Wilmington-Newark, PA-DE-MD MSA, with four located in Pennsylvania and one located in Delaware.

Table 3-17 Monitor Objective Types and scales assigned to monitors in the Maryland $PM_{2.5}$

Site Name	Measurement Scale	Monitor Objective	MSA
Oldtown	Middle Scale	Highest Concentration	Baltimore-Towson, MD
Howard County Near road	Microscale	Highest Concentration Source Oriented	Baltimore -Towson, MD
Glen Burnie	Neighborhood	Population Exposure	Baltimore -Towson, MD
Padonia	Neighborhood	Population Exposure	Baltimore -Towson, MD
Essex	Neighborhood	Population Exposure	Baltimore -Towson, MD
Edgewood	Neighborhood	Population Exposure	Baltimore -Towson, MD
NW Police	Neighborhood	Population Exposure	Baltimore -Towson, MD
Fire Dept. 20	Neighborhood	Population Exposure	Baltimore -Towson, MD
Hagerstown	Urban Scale	Population Exposure Highest Concentration	Hagerstown-Martinsburg, MD-WV
Fair Hill	Regional Scale	General/Background	Philadelphia-Camden-Wilmington, PA-DE-MD
Rockville	Neighborhood	Population Exposure	Washington-Arlington-Alexandria, DC-VA-MD-WV
HU-Beltsville	Urban Scale	Population Exposure	Washington-Arlington-Alexandria, DC-VA-MD-WV
PG Equestrian Center	Neighborhood	Population Exposure	Washington-Arlington-Alexandria, DC-VA-MD-WV
Horn Point	Regional Scale	Population Exposure	NA
Millington	Neighborhood	Population Exposure	NA
Piney Run	Regional Scale	Regional Transport	NA

Figure 3-7 Locations of $PM_{2.5}$ FRM and FEM monitors in Maryland with major point sources and scales.

All population exposure sites are assigned the proper spatial scales, either urban or neighborhood. Each state is required to install and operate at least one $PM_{2.5}$ site to monitor regional background and at least one $PM_{2.5}$ site to monitor regional transport. The background site for the network is Fair Hill in northeastern Maryland. The regional scale associated with Fair Hill does not appear to be compromised by nearby major sources (Figure 3-7). Fair Hill did not measure the lowest design values (Figure 3-8) but PG Equestrian Center did measure the lowest design values in 2012 and 2013. Fair Hill can also be influenced by transport from the Baltimore area to the Philadelphia area. Therefore, it is recommended to change the Fair Hill objective to population exposure and the PG Equestrian Center objective to general/background. Piney Run is designated the regional transport site for $PM_{2.5}$ and because of the mountaintop location in the westernmost portion of the state (typically upwind) this is an appropriate designation. The Padonia monitor measures the 3rd smallest design values in the state and since the Baltimore MSA monitoring requirements are being met and there are five other $PM_{2.5}$ monitors concentrated around Baltimore City (Oldtown, Essex, Glen Burnie, Fire Dept. 20, and NW Police Station) this site could be moved to another location. The Frederick site would be a good location to move the $PM_{2.5}$ monitor because the western-central part of Maryland has fewer

$PM_{2.5}$ monitors and this area has a growing population (Figure 3-9). This location will also provide for better near real-time mapping of $PM_{2.5}$ concentrations in Maryland.

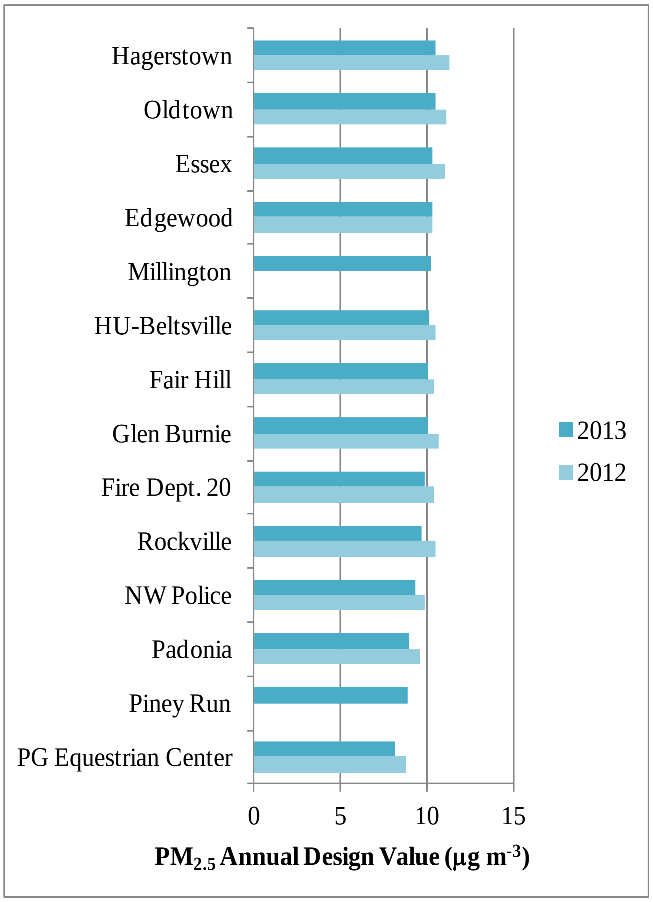

Figure 3-8 $PM_{2.5}$ Annual Design values for Maryland monitors for 2012 and 2013. The Howard County Near Road and the Horn Point sites are not included in this chart because they were not operational long enough to have valid design values for 2012 and 2013.

The population change in Maryland counties from 2010-2013 (Figure 3-9) was also examined using data from the US Census. County population changes range from -2 to 6% and most counties in Maryland have positive population growth. The largest growth occurs in Montgomery, Howard, Charles, and St. Mary's counties and MDE maintains $PM_{2.5}$ monitors in two of these counties (Montgomery and Howard). These changes in population do not necessitate any changes to the population-oriented sites.

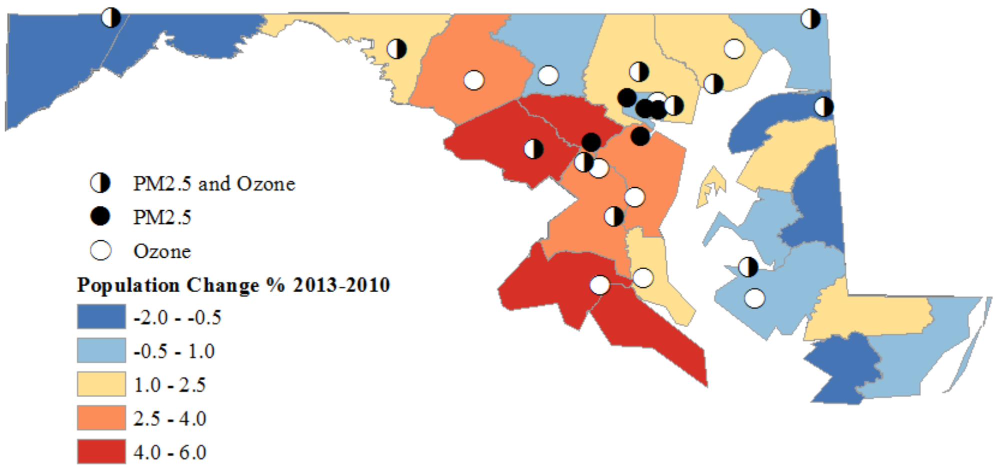

Figure 3-9 Percent change in Maryland population from 2010 - 2013, along with locations of monitoring sites. Note that percent change = (Pop2013 - Pop2010)/Pop2010

3.7.3 Identifying Redundant Sites

The methodology used to determine which existing $PM_{2.5}$ sites are candidates for relocation or removal is described in this section. Correlations and relative concentration differences among site pairs were used to determine if sites were measuring similar concentrations and thus considered redundant. The daily average $PM_{2.5}$ determined with the AQS report AMP435 (Daily Summary Report) for $PM_{2.5}$ parameter code 88101 (PM2.5 Local Conditions - FRM/FEM/ARM) was used in this analysis. $PM_{2.5}$ parameter code 88502 (Acceptable $PM_{2.5}$ AQI & Speciation Mass) was not included in the analysis. Data collected in Maryland, Pennsylvania, Virginia, West Virginia, Delaware, and the District of Columbia from 2011-2013 were used in the assessment (see Figure 3-10). For each $PM_{2.5}$ site in Maryland, site pairs within 50 km of that site were included in the analysis. Because there were no sites within 50 km of Piney Run, it was not included in this analysis and because the Howard County Near Road site was not operating during this time, it was also not included in this analysis. If a site has more than one monitor collecting $PM_{2.5}$ data, the daily average $PM_{2.5}$ concentration is the average of all valid results for that site on that date.

Data capture was satisfactory for most sites with 90% of the site comparisons including at least 285 days of data in the 2011-2013 time period. There were four site pairs with fewer than 200 days of data and these involved sites in Delaware and Virginia. These deficiencies were judged as not large enough to prevent their use in this part of the assessment.

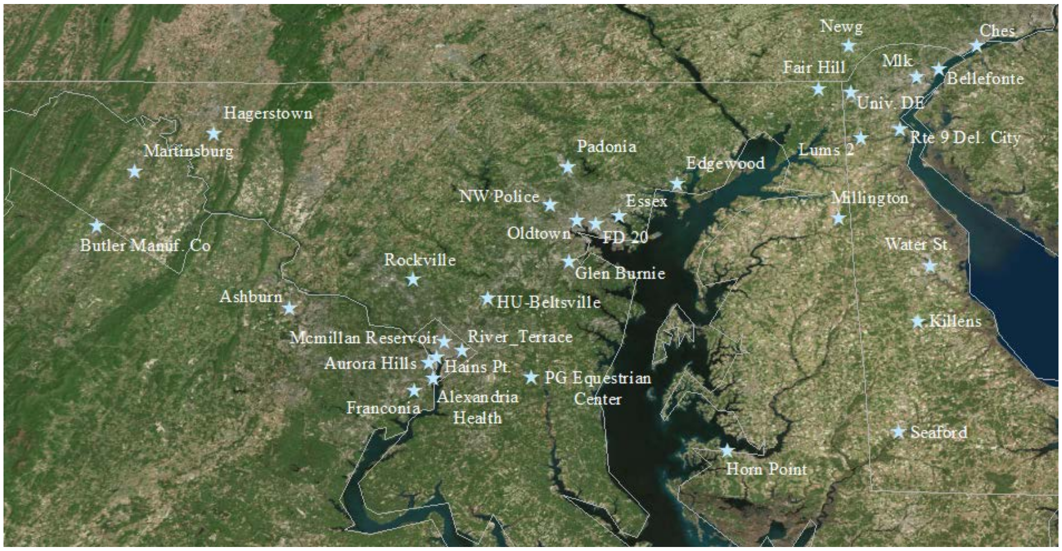

Figure 3-10 $PM_{2.5}$ sites used in the redundant sites assessment.

To examine possible redundant sites, an analysis examining correlations and percent differences between site pairs was performed. For each site in Maryland, daily average $PM_{2.5}$ was tallied and paired with $PM_{2.5}$ data from sites within 50 km of the Maryland site. Pearson correlation values (r-values) average relative differences between site pairs (X and Y) were calculated with the following equation:

$$100 * \sum_{i=1}^{n} \frac{\left| X_i - Y_i \right|}{\left(X_i + Y_i \right) / 2}$$

Sites that measure nearly the same concentrations of $PM_{2.5}$ are those that are both highly correlated (large r) and have the smallest inter-site average relative percent concentration differences. The site-pairs having the 20 highest correlations are listed in Table 3-18, together with their distances and relative percent concentration differences. All site pairs have correlations of at least 0.64 and the percent differences range from 9-34%. Glen Burnie appears as a member of four of the top six inter-site pair correlations. Because Glen Burnie is a collocated PM_{10} site it will not be considered for removal.

Table 3-18 Twenty most correlated site pairs in the Maryland $PM_{2.5}$ Network.

Site 1	Site 2	Distance (km)	r	n	Percent Difference
NW Police	Padonia	14	0.968	299	10%
Padonia	Glen Burnie	33	0.954	307	13%
Oldtown	FD 20	5	0.954	329	18%
Oldtown	Glen Burnie	14	0.951	341	18%
NW Police	Glen Burnie	20	0.951	309	13%
FD 20	Glen Burnie	15	0.947	307	12%
FD 20	Padonia	21	0.939	296	13%
FD 20	Essex	7	0.939	308	11%
Oldtown	Padonia	18	0.934	346	26%
Essex	Glen Burnie	21	0.928	310	12%
HU-Beltsville	Aurora Hills	27	0.918	301	17%
Rockville	Aurora Hills	29	0.918	284	20%
Oldtown	Edgewood	29	0.915	875	18%
Hagerstown	Butler Manuf. Co	44	0.913	336	21%
NW Police	HU-Beltsville	36	0.911	350	19%
PG Equestrian Center	Franconia	32	0.910	338	14%
Fair Hill	Newg	17	0.909	922	23%
Fair Hill	Lums 2	20	0.908	306	25%
Hagerstown	Martinsburg	25	0.907	336	21%
Rockville	Franconia	38	0.906	992	22%

The removal bias tool (developed by EPA and updated by LADCO) can be used to examine redundancies within the network [LADCO, 2015]. The bias estimation uses the nearest neighbors to each site to estimate the concentration at the location of the site, as if the site had never existed. This is done using the Voronoi Neighborhood Averaging algorithm with inverse distance squared weighting. The squared distance allows for higher weighting on concentrations at sites located closer to the site being examined. The bias was calculated for each day at each site by taking the difference between the predicted value from the interpolation and the measured concentration. A negative average bias suggests that the estimated concentration of the site is smaller than the actual measured concentration and high concentrations may not be appropriately captured [LADCO, 2015]. The mean removal bias ranged from -1.5 – 2.6 µg m-3 (Table 3-19). Glen Burnie has a small positive mean removal bias (0.2 µg m^{-3}) suggesting that removal of the $PM_{2.5}$ monitor would not impact Maryland's ability to measure maximum concentrations in that area. Since other measurements are collected at this site, it is not under consideration for removal.

Table 3-19 Mean removal bias for each site in Maryland's $PM_{2.5}$ network.

Name	Mean Removal Bias (μg m^{-3})
Oldtown	-1.5
Edgewood	-0.6
Millington	-0.6
Essex	-0.4
HU-Beltsville	-0.2
Glen Burnie	0.2
Hagerstown	0.2
Fair Hill	0.6
Rockville	0.6
Fire Dept. 20	0.8
Padonia	1.1
PG Equestrian Center	1.1
NW Police	1.2
Horn Point	1.5
Piney Run	2.6

3.7.4 Identifying New Sites Needed

EPA provided a tool for the 2010 network assessment to determine if new sites were needed for the $PM_{2.5}$ monitoring network, however no such tool was provided for the 2015 assessment. Because there is good correlation among most sites, small average percent differences among sites and all sites measure below the NAAQS, MDE does not recommend adding any new monitors to the network.

3.7.5 Effect of New or Proposed Network Design Regulations

None have been proposed for $PM_{2.5}$ as of this writing.

3.7.6 Recommended Network Changes

Modifications to the $PM_{2.5}$ network suggested up to this point in the network assessment need to be considered in relation to the candidate site's overall value to the $PM_{2.5}$ network, as well as, EPA regulations governing network design and System Modification, 40 CFR Part 58.14. A decision matrix was developed to determine the relative value of each site in the $PM_{2.5}$ network (Table 3-20). The decision matrix ranks the sites according to a weighted score which is the sum of normalized, individual criterion scores multiplied by a subjectively determined weighting factor.

The score for each criterion was calculated with the following equation [Cavender, 2009]:

$$Score = 100 * weight * (V_i - V_{min}) / (V_{max} – V_{min})$$

where V_i,V_{min}, and V_{max} represent the value of the given criteria and the minimum and maximum values of criteria for all sites. The score for the correlation with other sites was calculated as follows:

$$Score = 100 * weight * (V_{max} - V_i) / (V_{max} – V_{min})$$

The weight for the correlation was calculated different than the rest because the less correlated a site is with its neighbors the more unique and valuable it is. The $PM_{2.5}$ DV % NAAQS was calculated as follows:

$$PM_{2.5}\ DV\ ratio\ to\ NAAQS = DV_{2013} / 12\ \mu g\ m^{-3}$$

The criteria chosen for the network were:

- 2010 population and population density within Voronoi polygons associated with each site – important relative to the population oriented monitoring requirements.

- Percent of annual NAAQS – monitors that measure over or near the NAAQS are more important.

- Number of parameters measured at the site – relevant to decisions about site closure but not highly weighted, because the $PM_{2.5}$ monitor could be removed without closing the site.

- Site-average correlation coefficient and site-average relative percent concentration difference – needed to quantify uniqueness of the concentrations measured relative to other sites/monitors.

Because the Howard County Near Road site became operational in 2014, there were not enough data to calculate a design value, average correlation, or percent differences with other site pairs, so it was not included in the scoring.

Table 3-20 Decision Matrix for the $PM_{2.5}$ Network.

Site	2013 Design Values		Total Population 2010		Population density 2010		Number of Parameters		Average Correlation with other sites		Average Relative Concentration Difference		PM25 annual DV %NAAQS		Score
			weight:	0.5	weight:	0.5	weight:	0.5	weight:	1.0	weight:	1.0	weight:	1.0	
	24-hr	Annual	raw	points	raw	points	raw	points	raw	points	raw	points	raw	points	
Piney Run	20	8.9	199961	9	67	0	10	25					0.74		34
Padonia	21	9	232826	11	444	2	3	6	0.929	0	0.17	15	0.75	35	69
Fire Dept. 20	24	9.9	170983	7	4275	25	2	3	0.909	22	0.15	0	0.83	74	131
Glen Burnie	23	10	505294	29	1684	10	3	6	0.899	33	0.17	17	0.83	78	173
NW Police	22	9.3	597006	35	1983	12	1	0	0.871	65	0.18	20	0.78	48	179
Horn Point	*	*	163605	6	106	0	5	11	0.865	72	0.28	100	*	*	189
PG Equestrian Center	21	8.2	385689	21	404	2	3	6	0.840	100	0.23	63	0.68	0	191
Hagerstown	27	10.5	367425	20	302	1	2	3	0.910	21	0.21	48	0.88	100	192
Essex	26	10.3	216708	10	2007	12	8	19	0.884	50	0.17	13	0.86	91	196
Edgewood	25	10.3	237602	11	451	2	2	3	0.874	62	0.21	46	0.86	91	215
Fair Hill	25	10	117324	4	315	1	2	3	0.876	59	0.26	85	0.83	78	230
Rockville	23	9.7	834867	50	1230	7	2	3	0.868	69	0.23	62	0.81	65	255
Oldtown	26	10.5	360767	19	8390	50	6	14	0.904	28	0.21	50	0.88	100	261
Millington	24	10.2	63310	0	98	0	2	3	0.849	90	0.28	100	0.85	87	279
HU-Beltsville	23	10.1	487590	27	1998	12	19	50	0.857	80	0.21	44	0.84	83	296

*Not enough data available for a valid design value calculation.

Scores derived from the decision matrix, Table 3-20, range from a high of 296 at HU-Beltsville to a low of 34 at Piney Run. Piney Run's low score was influenced by the lack of nearby sites to compare with it for the correlation and average percent difference. Padonia and Fire Dept. 20 had the second and third lowest scores, and because $PM_{2.5}$ monitoring requirements are being met in the Baltimore MSA it is recommended that the Oldtown monitor be moved to Frederick. MDE also recommends changing the objective of Fair Hill to population exposure and the PG Equestrian Center to general/background.

3.8 PM_{10} Network

3.8.1 Compliance with Network Design Criteria

The number of required PM_{10} monitors in each CBSA is determined by the CBSA population and design value, as specified in Table D-5 of Appendix D to 40 CFR Part 58. Table 3-21 shows that the MDE monitoring network meets or exceeds the minimum requirements. A minimum of 15% (round up), or at least one, of the PM_{10} monitors must be collocated as specified in 40 CFR Part 58 Appendix A 3.3.1. MDE has 3 PM_{10} monitors and two are collocated, thereby meeting this requirement.

Table 3-21 Number of PM_{10} SLAMS Sites Required (based on Table D-4, Appendix D to 40 CFR Part 58, PM_{10} Minimum Monitoring Requirements).

MSA Name	Population	Monitors Required[A]	Active Monitors in MD/Total[B]
Baltimore-Towson, MD	2,753,149	2-4	3/3
Hagerstown-Martinsburg, MD-WV	256,278	0-1	0/0
Washington-Arlington-Alexandria, DC-VA-MD-WV	5,860,342	2-4	1/7
Philadelphia-Camden-Wilmington-Newark, PA-DE-MD	6,018,800	2-4	0/4
Salisbury, MD-DE	381,868	0-1	0/0

A – All of the listed MSA's have PM_{10} ambient concentrations well below 80% of the PM_{10} NAAQS.
B –Based on tables available at http://www.epa.gov/airtrends/values.html.

3.8.2 Assessment of Objective Types Assigned to Monitors

In contrast with design requirements for other pollutant networks, there are no required objectives or objective types for PM10 monitoring. Monitoring details for the PM10 network are provided in Table 3-22. Monitoring scales appropriate for PM_{10} include micro, middle, and neighborhood. Both of the PM_{10} monitors in the Baltimore, MD MSA, Glen Burnie and Fire Dept. 20, are assigned to the neighborhood scale with population exposure as the monitoring objective. The monitors located at these sites are operated on a one-in-six day schedule. Glen Burnie also has a co-located PM_{10} monitor operated on a one-in-twelve day schedule.

Table 3-22 Monitoring details for the PM_{10} network.

AQS code	Site Name	Measurement Scale	Monitor Objective	MSA
240031003	Glen Burnie	Neighborhood	Population Exposure	Baltimore -Towson, MD
245100008	Fire Dept. 20	Neighborhood	Population Exposure	Baltimore- Towson, MD
240330030	HU-Beltsville	Urban Scale	Population Exposure	Washington-Arlington-Alexandria, DC-VA-MD-WV

Two collocated monitors are operated at HU-Beltsville with population exposure objectives. The measurement scale is currently assigned urban scale and this should be changed to neighborhood. These monitors are manual FEM's operated on a one-in-three and one-in-six day schedule.

3.8.3 Identifying Redundant Sites

Because the minimum number of PM_{10} sites is operating in the Baltimore MSA, no sites can be removed. However, statistical relationships between site pairs were examined to determine possible redundant sites. Daily average PM_{10} data from each site were examined for 2011-2013. Pearson's correlation coefficients and average relative differences among site pairs are provided in Table 3-23. Average relative differences between site pairs (X and Y) were calculated with the following equation:

$$100 * \sum_{i=1}^{n} \frac{|X_i - Y_i|}{(X_i + Y_i)/2}$$

All correlations (r) are smaller than 0.80 suggesting that the site pairs are not well correlated. The average relative differences among site pair ranged from 19-29% and are large enough that the sites should not be considered redundant. Using these statistical relationships no redundant sites were found.

Table 3-23 Statistical relationships among PM_{10} site pairs.

X	Y	Distance (km)	r	n	Average Relative Difference
FD 20	HU-Beltsville	39	0.80	154	29%
HU-Beltsville	Glen Burnie	25	0.78	169	19%
FD 20	Glen Burnie	15	0.73	136	26%

3.8.4 Identifying New Sites Needed

Given that PM_{10} concentrations at all sites are well below the NAAQS and the network requirements are being met, there is no pressing need to identify potential new sites.

3.8.5 Proposed Changes to the PM_{10} NAAQS and Monitoring Rule

No changes to either the NAAQS or the monitoring rule have been proposed at this time.

3.8.6 Recommended Network Changes

It is recommended that the measurement scale at HU-Beltsville be changed from urban to neighborhood, as urban scale is not applicable to PM_{10}.

3.9 SO_2 Network

3.9.1 Compliance with Network Design Criteria

The minimum number of required SO_2 monitors in each MSA is proportional to the product of the total amount of SO_2 emissions in the MSA and its population, as specified in 40 CFR Part 58, Appendix D, Section 4.4. The resulting value is defined as the Population Weighted Emissions Index (PWEI). SO_2 emissions shown in Table 3-24 are from the 2011 National Emissions Inventory (NEI).

The Regional Administrator may require additional SO_2 monitoring stations above the minimum in areas where the minimum requirements are not deemed sufficient to meet monitoring objectives. There are no additional monitors required in Maryland by the Regional Administrator.

Each NCore station must operate a SO_2 monitor. This requirement is met at both the HU-Beltsville and Piney Run monitoring stations.

Table 3-24 SO_2 population weighted emissions index

MSA Name	Population	2011 NEI SO_2 (tons/year)	PWEI (millions of people-tons per year)	Monitors Required	Monitors Active in MD/Total[A]
Baltimore-Towson, MD	2,753,149	25,933	71,398	1	1/1
Hagerstown-Martinsburg, MD-WV	256,278	3,306	847	0	0/0
Washington-Arlington-Alexandria, DC-VA-MD-WV	5,860,342	21,513	126,074	2	1/5
Salisbury, MD-DE	381,868	10,772	4,114	0	0/0
Philadelphia-Camden-Wilmington-Newark, PA-DE-MD	6,018,800	22,647	136,310	2	0/11

A - Based on tables available at http://www.epa.gov/airtrends/values.html.

There are five SO_2 monitoring sites located in Maryland and their types, objectives, scales of representativeness, and design values are presented in Table 3-25. All sites are below the NAAQS 1-hour standard (75 ppb). The Beltsville-CASTNET and Horn Point monitoring sites have not been operational long enough (three years) for valid design values to be determined.

Table 3-25 Monitoring details for SO_2 network.

Site Name	AQS ID	Representative Scale	Monitor Objective	CBSA	TYPE	2011-2013 1-hr Design Value (ppb)
Essex	240053001	Neighborhood	Highest Concentration	Baltimore-Towson, MD	SLAMS	22
HU-Beltsville	240330030	Urban Scale	General/Background	Washington-Arlington-Alexandria, DC-VA-MD-WV	NCORE	10
Beltsville-CASTNET	240339991	Regional Scale	Highest Concentration	Washington-Arlington-Alexandria, DC-VA-MD-WV	CASTNET	12*
Horn Point	240190004	Regional Scale	Population Exposure	NA	SLAMS	NA
Piney Run	240230002	Regional Scale	Regional Transport	NA	NCORE	19*

*Does not meet completeness criteria

3.9.2 Assessment of Objective Types Assigned to Monitors

The appropriate scales for SO_2 SLAMS monitoring are the micro, middle, neighborhood, and urban scales. Essex was assigned the neighborhood scale because of its proximity to large SO_2 sources. The monitoring objective for Essex is highest concentration. Given the proximity of Essex to SO_2 sources and relative high design value compared to HU-Beltsville, the highest concentration objective is appropriate.

The HU-Beltsville site is an NCore site and its representative scale is urban. HU-Beltsville is located in a suburban area that is not close to large SO_2 sources and this justifies the urban representative scale as well as the general background monitoring objective. Piney Run is an elevated NCore site located in Western Maryland in the path of SO_2 emissions which can be transported from neighboring states; its representative scale is regional. Piney Run is located in a rural area at high elevation (781 m above sea level) not close to large SO_2 sources which justifies the regional representative scale and the regional transport monitoring objective. Horn Point is assigned a regional scale and population exposure monitoring objective. The regional scale is appropriate because this site is located in a rural area. The Beltsville-CASTNET site is not operated or owned by MDE and the representative scale and objectives are determined by EPA.

3.9.3 Identifying Redundant Sites

Statistical relationships between site pairs were examined to determine redundant sites. Daily maximum SO_2 data from each site was examined for 2011-2013. Pearson's correlation coefficients and average relative differences among site pairs are provided in Table 3-26. Average relative differences between site pairs (X and Y) were calculated with the following equation:

$$100 * \sum_{i=1}^{n} \frac{|X_i - Y_i|}{(X_i + Y_i)/2}$$

The HU-Beltsville and Beltsville-CASTNET monitors had the highest correlation, with r equal to 0.69 and an average relative difference of 49%. These metrics suggest that these two sites, which are only 6 km apart, are not well correlated and measure relatively different concentrations. All other correlations (r) are smaller than 0.30, suggesting that the site pairs are not well correlated. The average relative differences among the rest of the site pairs ranges from 63-91% and are large enough that the sites should not be considered redundant. Using these statistical relationships, no redundant sites were found.

Table 3-26 Statistical relationships between site pairs.

X	Y	Distance (km)	r	n	Average Relative Difference
Beltsville-CASTNET	HU-Beltsville	6	0.69	286	49%
HU-Beltsville	Piney Run	197	0.30	897	85%
HU-Beltsville	Essex	45	0.27	966	91%
HU-Beltsville	Horn Point	82	0.22	465	67%
Piney Run	Horn Point	277	0.16	413	81%
Piney Run	Essex	222	0.15	913	74%
Beltsville-CASTNET	Horn Point	76	0.13	242	63%
Beltsville-CASTNET	Piney Run	203	0.13	245	79%
Beltsville-CASTNET	Essex	43	0.08	314	82%
Horn Point	Essex	86	0.03	499	91%

3.9.4 Identifying New Sites Needed

MDE does not plan on installing any new SO_2 monitoring sites. Large sources of SO_2 can either perform dispersion modeling or conduct their own ambient air monitoring to determine whether they attain the SO_2 NAAQS. If any sources elect to monitor, the monitors must be operational by January 1, 2017. If any sources in Maryland wish to perform monitoring, MDE will work with those sources to determine the appropriate number and location of monitors that will be needed. Those issues will be addressed in the 2017 Annual Network Plan if necessary.

3.9.5 Recommended Network Changes

MDE does not recommend any changes to the network at this time.

4. SENSITIVE POPULATIONS

The Clean Air Act of 1990 set limits to protect public health, including the health of sensitive populations such as asthmatics, children and the elderly. The Air Quality Criteria Document for Ozone and related photochemical oxidants [U.S. EPA, 2006] states that the elderly population (>65 years of age) appears to be at increased risk of ozone-related mortality and hospitalizations, and children (<18 years of age) experience other potentially adverse respiratory health outcomes with increased ozone exposure. The Integrated Science Assessment for Particulate Matter [U.S. EPA, 2009] states that older adults have heightened responses for cardiovascular morbidity with PM exposure and children are at an increased risk of PM-related respiratory effects. It should be noted that the health effects observed in children could be initiated by exposures to PM that occurred during key windows of development, such as in utero. The term sensitive populations may extend to other populations [U.S. Census Bureau, 2010] but discussion of these populations is beyond the scope of this assessment.

The US census provides population counts in specific age groupings and these were used to examine populations of children and the elderly. The children and elderly populations are defined as the population with ages less than 18 and the populations with ages greater than 65, respectively. The populations composed of children and the elderly are presented Figure 4-1 [U.S. Census Bureau 2010]. The county populations are color-coded by percentiles and counties with the lowest sensitive population counts are shown with lighter colors while counties with the highest sensitive population counts are shown with darker colors. $PM_{2.5}$ and ozone monitors are also highlighted on the map. The largest sensitive populations in the state reside in Montgomery, Prince George's, and Baltimore counties and there are $PM_{2.5}$ and ozone monitors in each of these counties.

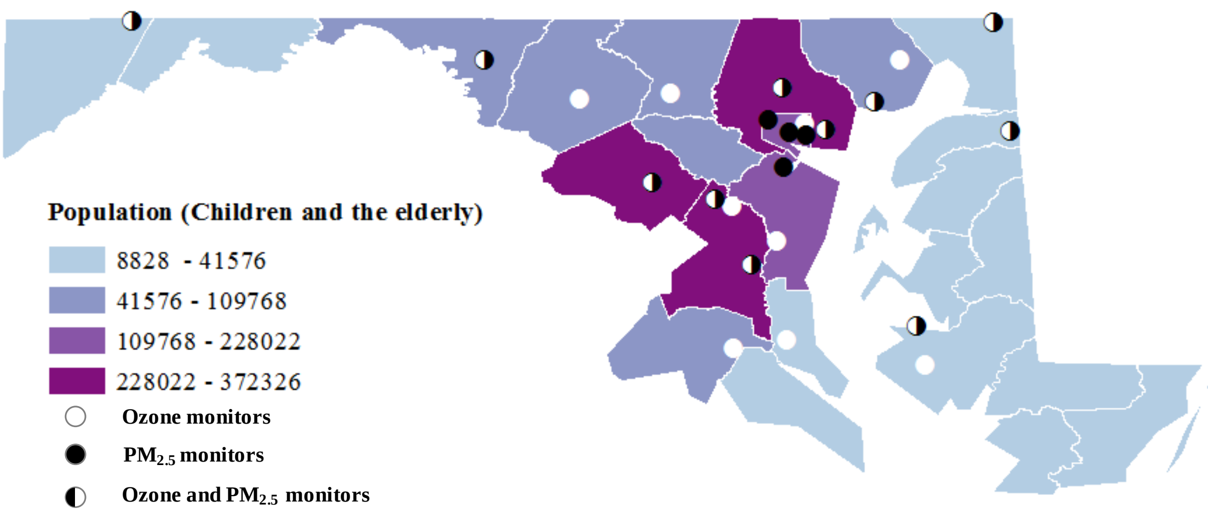

Figure 4-1 Maryland county level sensitive populations (children and the elderly from the 2010 census). Ozone and $PM_{2.5}$ monitor locations are also shown.

The Maryland Department of Health and Mental Hygiene maintains an environmental health public tracking website (http://eh.dhmh.md.gov/idehaweb/query.aspx). This site provides data on asthma hospital discharges by county and counts of hospital discharges are shown in Figure 4-2 [DHMH, 2009]. Sensitive populations as defined by asthma hospital discharges are color-coded by percentiles. The largest asthma hospital discharges in the state occur in Montgomery, Prince George's, Baltimore, Anne Arundel, and Harford counties, and Baltimore City and all contain both $PM_{2.5}$ and ozone monitoring sites.

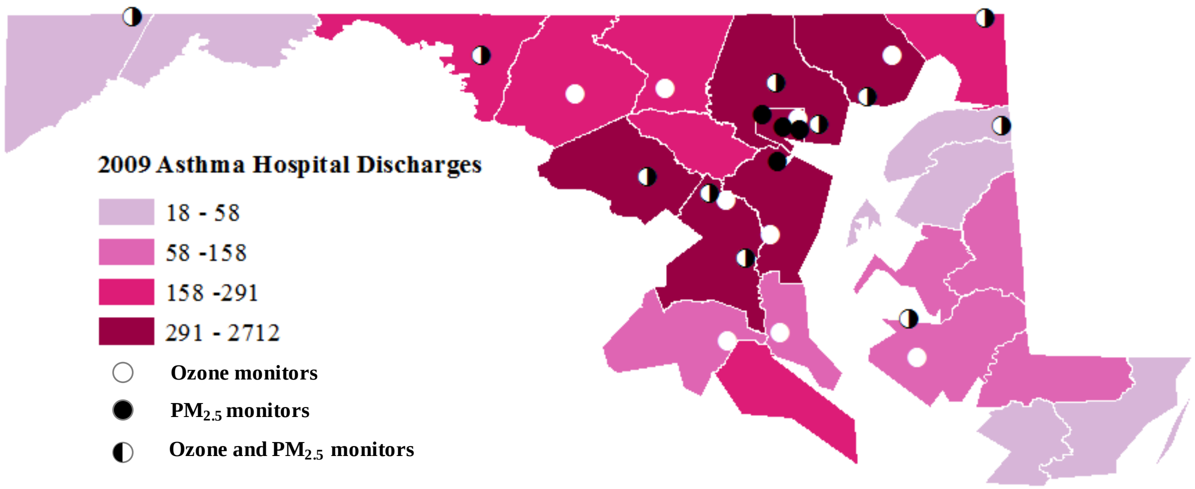

Figure 4-2 Maryland county level asthma hospital discharges (2009). Ozone and $PM_{2.5}$ monitor locations are also shown.

To determine how well the $PM_{2.5}$ and ozone monitoring networks provide coverage to areas where sensitive populations are most prevalent, the scales of the networks are overlaid on the county level asthma hospital discharges in Figure 4-3 and Figure 4-4. The spatial coverage of many of these monitors overlap counties with asthma hospital discharges of 158 and higher (between the 50th and 75th percentiles of asthma hospital discharge counts in the state). There is more spatial overlap of the monitoring scales in the ozone network than in the $PM_{2.5}$ network. When examining how well the network serves sensitive populations, the spatial variability of the pollutants must be considered. $PM_{2.5}$ concentrations are more homogeneous throughout the state than ozone concentrations and $PM_{2.5}$ design values are below the NAAQS. This indicates that the network provides adequate coverage for sensitive populations throughout the state.

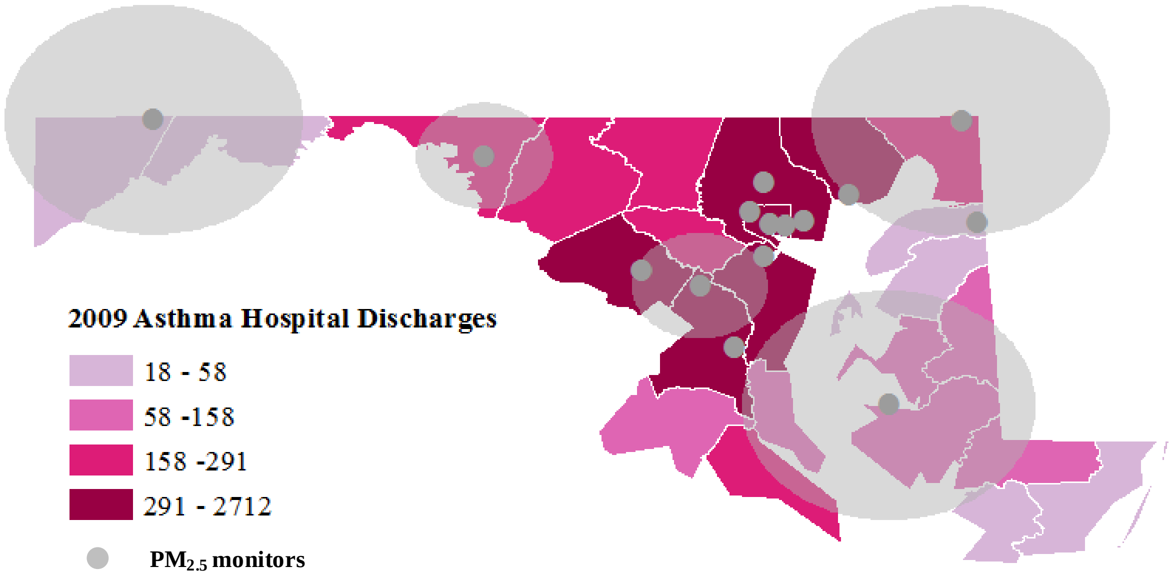

Figure 4-3 Maryland county level asthma hospital discharges with $PM_{2.5}$ monitors and spatial scales associated with those monitors. Only urban and regional scales are shown. The micro and neighborhood scales are too small for the map.

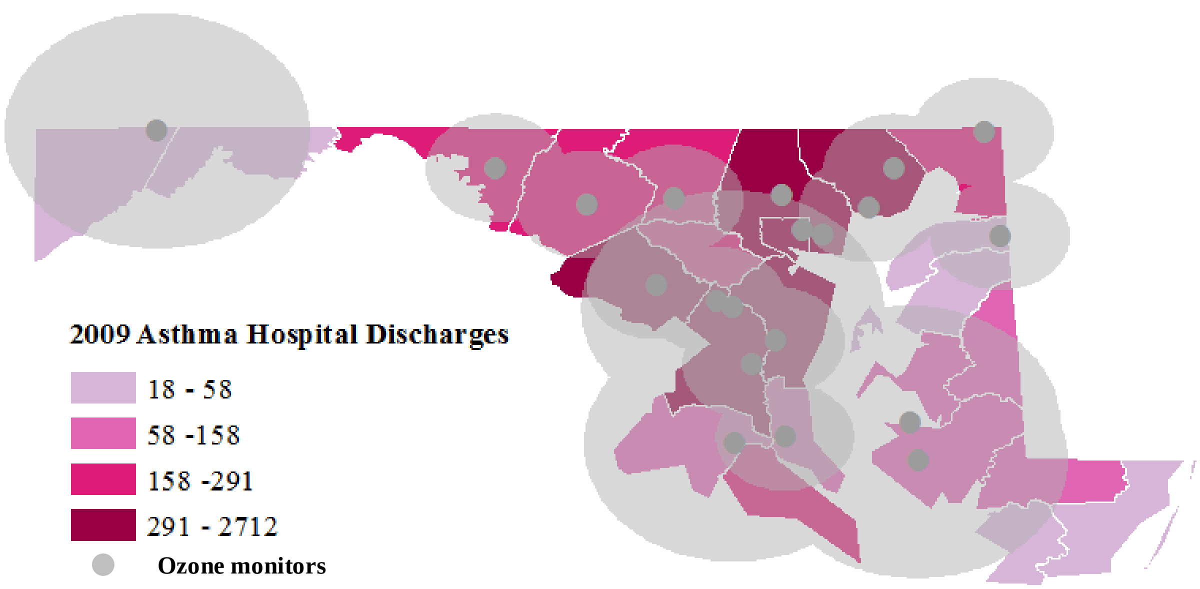

Figure 4-4 Maryland county level asthma hospital discharges with ozone monitors and spatial scales associated with those monitors. Only urban and regional scales are shown. The neighborhood scale is too small for the map.

5. TECHNOLOGY

Over the five years since the last network assessment, MDE has made great strides in upgrading almost all of its criteria monitoring instrumentation to incorporate trace level monitors, trace level multigas calibrators, trace level zero air source and semi-continuous PM2.5 monitors. Significant upgrades have also been made to the communications capabilities of the monitoring network. Cell phone modems are now used to transmit monitoring data to the central office, greatly improving MDE's ability to report data to EPA's AirNow and other near real-time air quality data mapping websites. Internet access is available at all of the monitoring shelters and virtual private network access to MDE's central servers has been provided to all field personnel.

MDE carefully tracks the age of the entire inventory of air monitoring instrumentation and equipment and maintains a formal replacement plan projecting five years into the future. Replacement goals are in broad groups and the actual replacement schedule is ultimately dependent on the availability of sufficient resources. The monitoring shelters generally are targeted after 15 years of service, continuous instruments (O3, CO, SO2, NOx) have 5 year targets and newer technologies are evaluated and incorporated when at all practicable. The PM2.5 semi-continuous FEM's are currently targeted for replacement at 10 years. Data loggers and associated devices are replaced every 3 years because computer technology is always evolving rapidly.

MDE air monitoring personnel stay abreast of new developments in monitoring technologies through building and maintaining strong relationships with vendors, acquiring loaner instruments to evaluate in the field alongside existing instrumentation, attendance at the National Air Monitoring Conferences and MARAMA Monitoring Committee meetings and participation in EPA/NACAA Monitoring Committee conference calls.

Recent major technological advance in the development of a wide variety of small, portable and lower-cost monitoring devices (generally referred to as air quality sensors, or just sensors) are of great interest to MDE. These devices have the potential to expand MDE's monitoring capabilities and supplement traditional ambient air quality and compliance monitoring. Sensors could prove very useful in locating new monitoring stations and in assessing the effectiveness of the existing network.

6. SUMMARY AND CONCLUSIONS

Recommendations from the assessment of each pollutant network are summarized by individual monitoring site in Table 6-1. It should be noted that some of these recommendations require approval of the EPA Regional Administrator and the availability of adequate resources prior to implementation.

Table 6-1 Summary of site specific network assessment recommendations

SITE NAME	POLLUTANT	RECOMMENDED CHANGES	QUALIFIER
Oldtown	CO	Discontinue measurement	Await approval of regional administrator and the end of the Maryland maintenance plan.
Davidsonville	O_3	Discontinue measurement and move monitor to Glen Burnie.	Decide after further analysis. Collect data at Glen Burnie for the 2014 ozone season and compare to Davidsonville.
Padonia	$PM_{2.5}$	Discontinue measurement and move monitor to Frederick.	Await approval of regional administrator
HU-Beltsville	PM_{10}	Change measurement scale from Urban to Neighborhood.	Implement now.
Howard County Near Road	CO	Change measurement scale from Microscale to Middle.	Implement now.

CFR40 58.10(d) requires MDE to assess the effect on data users of proposed site removals. The annual ambient air monitoring network plan, which this assessment is a part of, is posted on the web and made available for public comment as the primary means of disseminating information about network modifications to the general public and stakeholders. MDE also works closely with local universities, and disseminates news of site changes to the surrounding state and local air monitoring agencies at regional meetings and conference calls (i.e. MARAMA Annual Air Monitoring Committee meeting).

In general, this network assessment found Maryland’s air monitoring networks in compliance with most EPA regulations and fulfilling intended monitoring objectives. In some cases, the assigned monitoring scale and/or monitoring objective types were found to be in need of change and some sites were identified as good candidates for removal.

7. REFERENCES

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