6.0 Monitoring Network Design

The selection of a specific monitoring site includes four major activities:

1. Developing and understanding the monitoring objective and appropriate data quality objectives.
2. Identifying the spatial scale most appropriate for the monitoring objective of the site.
3. Identifying the general locations where the monitoring site should be placed.
4. Identifying specific monitoring sites.

This section describes the general concepts for establishing the SLAMS, NCore, STN, PAMS, and open path monitoring. Additional details can be found in 40 CFR Part 58, Appendix D [1] and the guidance information for the various monitor networks that can be found on AMTIC[2].

As described in Section 1, air quality samples are generally collected for one or more of the following purposes:

- To provide air pollution data to the general public in a timely manner.
- To judge compliance with and/or progress made towards meeting ambient air quality standards.
- To activate emergency control procedures that prevent or alleviate air pollution episodes.
- To observe pollution trends throughout the region, including non-urban areas.
- To provide a data base for research evaluation of effects: urban, land-use, and transportation planning; development and evaluation of abatement strategies; and development and validation of diffusion models.

Network information related to these 5 purposes is discussed below.

"Real-Time" Air Quality Public Reporting

The U.S. EPA, NOAA, NPS, tribal, state, and local agencies developed the AIRNow[3] Web site to provide the public with easy access to national air quality information. The Web site offers daily Air Quality Index (AQI):

Conditions- Nationwide and regional real-time ozone and $PM_{2.5}$ air quality maps covering 46 US States and parts of Canada. These maps are updated daily every hour. A click of a mouse brings up the U.S. map and a second click can bring up the AQI details of a region, state or local area within a state.

Forecasts - Nationwide daily air quality forecasts provided by monitoring organizations for over 300 major cities and areas in the U.S.

Federal requirements state that Metropolitan Statistical Areas (MSAs) with a population of more than 350,000 are required to report the AQI daily to the general public. The U.S. Office of Management and Budget defines MSAs according to the 2000 census. However, many other tribal, state and local monitoring organizations participate in AIRNow.

There are no specific network requirements or guidelines for reporting to AIRNow. Sites used for

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[1] http://www.epa.gov/ttn/amtic/40cfr53.html
[2] http://www.epa.gov/ttn/amtic/
[3] http://airnow.gov/

reporting to AIRNow are sites that have been set up for the other monitoring objectives discussed above. The air quality data used in these maps and to generate forecasts are collected using either federal reference or equivalent monitoring techniques or techniques approved by the monitoring organizations. Since the information needed to make maps must be as "real-time" as possible, the data are displayed as soon as practical after the end of each hour. Although some preliminary data quality assessments are performed, the data as such are not fully verified and validated through the quality assurance procedures monitoring organizations use to officially submit and certify data on the EPA AQS. Therefore, data are used on the AIRNow Web site only for the purpose of reporting the AQI. Information on the AIRNow web site is not used to formulate or support regulation, guidance or any other Agency decision or position.

Compliance Monitoring

The information required for selecting the number of samplers[4] and the sampler locations include isopleth maps, population density maps, and source locations. The following are suggested guidelines:

- the priority area is the zone of highest pollution concentration within the region; one or more stations should be located in this area;
- close attention should be given to densely populated areas within the region, especially when they are in the vicinity of heavy pollution;
- the quality of air entering the region is to be assessed by stations situated on the periphery of the region; meteorological factors (e.g., frequencies of wind directions) are of primary importance in locating these stations;
- sampling should be undertaken in areas of projected growth to determine the effects of future development on the environment;
- a major objective of compliance monitoring is the evaluation of progress made in attaining the desired air quality; for this purpose, sampling stations should be strategically situated to facilitate evaluation of the implemented control strategies; and
- some information of air quality should be available to represent all portions of the region of concern.

Some stations will be capable of fulfilling more than one of the functions indicated. For example, a station located in a densely populated area can indicate population exposures and can also document the changes in pollutant concentrations resulting from mitigation strategies used in the area.

Emergency Episode Monitoring

For episode avoidance purposes, data are needed quickly--in no less than a few hours after the pollutant contacts the sensor. While it is possible to obtain data rapidly by on-site manual data reduction and telephone reporting, there is a trend towards using automated monitoring networks. The severity of the problem, the size of the receptor area, and the availability of resources all influence both the scope and sophistication of the monitoring system.

It is necessary to use continuous air samplers because of the short durations of episodes and the control actions taken must be based on real-time measurements that are correlated with the decision criteria. Based on episode alert criteria and mechanisms now in use, 1-h averaging times are adequate for

[4] A “sampler” in this context refers to both continuous instruments that provide an ambient air concentration without additional preparation or analytical techniques as well as instruments that provide a sample needing additional analysis.

surveillance of episode conditions. Shorter averaging times provide information on data collecting excursions, but they increase the need for automation because of the bulk of data obtained. Longer averaging times (>6 hours) are not desirable because of the delay in response that these impose. After an alert is announced, data are needed quickly so that requests for information on the event can be provided.

Collection and analysis must be accomplished rapidly if the data are to be useful immediately. Collection instruments must be fully operable at the onset of an episode. For the instrument to be maintained in peak operating condition, either personnel must be stationed at the sites during an episode or automated equipment must be operated that can provide automatic data transmission to a central location.

Monitoring sites should be located in areas where human health and welfare are most threatened:

- in densely populated areas;
- near large stationary source of pollution;
- near hospitals;
- near high density traffic areas; and
- near homes for the aged.

A network of sites is useful in determining the range of pollutant concentrations within the area, but the most desirable monitoring sites are not necessarily the most convenient. Public buildings such as schools, firehouses, police stations, hospitals, and water or sewage plants should be considered for reasons of access, security and existing communications.

Trends Monitoring

Trends monitoring is characterized by locating a minimal number of monitoring sites across as large an area as possible while still meeting the monitoring objectives. The program objective is to determine the extent and nature of the air pollution and to determine the variations in the measured levels of the atmospheric contaminants in respect to the geographical, socio-economic, climatological and other factors. The data are useful in planning epidemiological investigations and in providing the background against which more intensive regional and community studies of air pollution can be conducted.

Urban sampling stations are usually located in the most densely populated areas of the region. In most regions, there are several urban sites. Non-urban stations encompass various topographical categories such as farmland, desert, forest, mountain and coast. Non-urban stations are not selected specifically to be “clean air” control sites for urban areas, but they do provide a relative comparison between some urban and nearby non-urban areas.

In interpreting trends data, limitations imposed by the network design must be considered. Even though precautions are taken to ensure that each sampling site is as representative as possible of the designated area, it is impossible to be certain that measurements obtained at a specific site are not unduly influenced by local factors. Such factors can include topography, structures, sources of pollution in the immediate vicinity of the site, and other variables; the effects which cannot always be accurately anticipated, but nevertheless, should be considered in network design. Comparisons among pollution levels for various areas are valid only if the sites are representative of the conditions for which the study is designed.

Research Monitoring

Air monitoring networks related to health effects are composed of integrating samplers both for determining pollutant concentrations for $\leq$24 hours and for developing long term ($\geq$24 hour) ambient air quality standards. The research requires that monitoring points be located so that the resulting data will represent the population group under evaluation. Therefore, the monitoring stations are established in the centers of small well-defined residential areas within a community. Data correlations are made between observed health effects and observed air quality exposures.

Requirements for aerometric monitoring in support of health studies are as follows:

- the station must be located in or near the population under study;
- pollutant sampling averaging times must be sufficiently short to allow for use in acute health effect studies that form the scientific basis for short-term standards;
- sampling frequency, usually daily, should be sufficient to characterize air quality as a function of time; and
- the monitoring system should be flexible and responsive to emergency conditions with data available on short notice.

6.1 Monitoring Objectives and Spatial Scales

With the end use of the air quality samples as a prime consideration, the national ambient air monitoring networks are designed to determine one of six basic monitoring objectives listed below:

1. Determine the highest concentration expected to occur in the area covered by the network.
2. Measure typical concentrations in areas of high population density.
3. Determine the impact of significant sources or source categories on air quality.
4. Determine background concentration levels.
5. Determine the extent of regional pollutant transport among populated areas; and in support of secondary standards.
6. Measure air pollution impacts on visibility, vegetation damage, or welfare-based impacts.

These six objectives indicate the nature of the samples that the monitoring network will collect that must be representative of the spatial area being studied. In the case of PAMS, the design criteria are site specific and, therefore, there are specific monitoring objectives associated with each location for which PAMS stations are required (see Table 6-4).

Sampling equipment requirements are generally divided into three categories, consistent with the desired averaging times:

1. **Continuous-** Pollutant concentrations determined with automated methods, and recorded or displayed continuously.
2. **Integrated-** Pollutant concentrations determined with manual or automated methods from integrated hourly or daily samples on a fixed schedule (i.e., manual $PM_{2.5}$).
3. **Static-** Pollutant estimates or effects determined from long-term (weekly or monthly) exposure to qualitative measurement devices or materials (i.e., passive monitoring[5])

[5] http://www.epa.gov/ttn/amtic/passive.html

Air monitoring sites that use automated equipment to continually sample and analyze pollutant levels may be classified as primary. Primary monitoring stations are generally located in areas where pollutant concentrations are expected to be among the highest and in areas with the highest population densities; thus, they are often used in health effects research networks. These stations are also designed as part of the air pollution episode warning system and used to report data to the public through AIRNow[6] and the air quality index (AQI).

The goal in siting stations is to correctly match the spatial scale represented by the sample of monitored air with the spatial scale most appropriate for the monitoring objective of the station. This achieves the goal of data quality indicator representativeness discussed in Section 3. The representative measurement scales of greatest interest are shown below:

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.

Table 6-1 illustrates the relationships among the four basic monitoring objectives and the scales of representativeness that are generally most appropriate for that objective. Appendix E provides more detailed spatial characteristics for each pollutant while Table 6-2 provides a summary for the various monitoring programs.

Table 6-1 Relationship Among Monitoring Objectives and Scales of Representativeness

Monitoring Objective	Appropriate Siting Scale
Highest Concentration	Micro, middle, neighborhood, sometimes urban
Population	Neighborhood, urban
Source impact	Micro, middle, neighborhood
General/background & Regional Transport	Urban/regional
Welfare-related	Urban/regional

There is the potential for using open path monitoring for microscale spatial scales. For microscale areas, however, siting of open path analyzers must reflect proper regard for the specific monitoring objectives. Specifically, the path-averaging nature of open path analyzers could result in underestimations of high pollutant concentrations at specific points within the measurement path for other ambient air monitoring situations. In open path monitoring, monitoring path lengths must be commensurate with the intended scale of representativeness and located carefully with respect to local sources or potential obstructions. For short-term/high-concentration or source-oriented monitoring, the monitoring path may need to be further restricted in length and be oriented perpendicular to the wind direction(s) determined by air quality modeling leading to the highest concentration, if possible. Alternatively, multiple paths may be used advantageously to obtain both wider area coverage and peak concentration sensitivity.

[6] http://airnow.gov/

Table 6-2 Summary of Spatial Scales for SLAMS, NCore, PAMS, and Open Path (OP) Sites

Spatial Scale	SLAMS Sites[1]							$PM_{10\text{-}2.5}$	NCore	STN	NATTs	PAMS	OP
	SO_2	CO	O_3	NO_2	Pb	PM_{10}	$PM_{2.5}$						
Micro	*	*			*	*	*	*					
Middle	*	*		*	*	*	*	*					*
Neighborhood	*		*	*	*	*	*	*	*	*	*	*	*
Urban			*	*	*		*		*	*	*	*	*
Regional			*		*		*		*		*		*

[1] SLAMS Site scales based on current listing in 40 CFR Part 58, Appendix D and do not include NCore spatial scale objective.

6.1.1 Monitoring Boundaries

The NAAQS refer to several boundaries that are defined below. These definitions are derived from the U.S. Office of Management and Budget (OMB).

Core-based Statistical Area (CBSA) – is defined by the OMB as a statistical geographic entity consisting of the county or counties associated with at least one urbanized area/urban cluster of at least 10,000 population, plus adjacent counties having a high degree of social and economic integration.

Metropolitan Statistical Area (MSA) - a category of CBSA with populations greater than 50,000[7].
Micropolitan Statistical Area - are a category of CBSA with populations between 10,000 and 50,000

Combined Statistical Area (CSA) - is defined by the OMB as a geographical area consisting of two or more adjacent Core Based Statistical Areas (CBSA) with employment interchange of at least 15 percent. Combination is automatic if the employment interchange is 25 percent and determined by local opinion if more than 15 but less than 25 percent[8].

New England city and town areas (NECTAs) - are analogous to CBSAs and are similarly classified as either metropolitan NECTAs (corresponding to MSAs) or micropolitan NECTAs (corresponding to micropolitan statistical areas). The principal difference between a CBSA and a NECTA is that NECTAs use New England towns as building blocks instead of counties. In the New England region, towns are a much more important level of government than counties. Because of this, NECTAs are usually a much closer approximation to metropolitan areas in New England than MSAs

Monitoring Planning Area (MPA) - means a contiguous geographic area with established, well defined boundaries, such as a CBSA, county or State, having a common area that is used for planning monitoring locations for $PM_{2.5}$. An MPA may cross State boundaries, such as the Philadelphia PA–NJ MSA, and be further subdivided into community monitoring zones. MPAs are generally oriented toward CBSAs or CSAs with populations greater than 200,000, but for convenience, those portions of a State that are not associated with CBSAs can be considered as a single MPA.

Community Monitoring Zone (CMZ) – means an optional averaging area with established, well defined boundaries, such as county or census block, within an MPA that has relatively uniform concentrations of annual $PM_{2.5}$ as defined by 40 CFR Part 50, Appendix N. Two or more community oriented SLAMS monitors within a CMZ that meet certain requirements as set forth in Appendix N may be averaged (spatial averaging) for making comparisons to the annual $PM_{2.5}$ NAAQS.

[7] *http://www.census.gov/population/estimates/metro-city/List1.txt*
[8] *http://www.census.gov/population/estimates/metro-city/List6.txt*

6.2 Monitoring Site Location

Four criteria should be considered, either singly or in combination when locating sites, depending on the sampling objective. Orient the monitoring sites to measure the following:

1. Impacts of known pollutant emission categories on air quality.
2. Population density relative to receptor-dose levels, both short and long term.
3. Impacts of known pollutant emission sources (area and point) on air quality.
4. Representative area-wide air quality.

To select locations according to these criteria, it is necessary to have detailed information on the location of emission sources, geographical variability of ambient pollutant concentrations, meteorological conditions and population density. Therefore, selection of the number, locations and types of sampling stations is a complex process. The variability of sources and their intensities of emissions, terrains, meteorological conditions and demographic features require that each network be developed individually. Thus, selection of the network will be based upon the best available evidence and on the experience of the decision team.

The sampling site selection process involves considerations of the following factors:

Economics - The amount of resources required for the entire data collection activity, including operators, instrumentation, installation, safety equipment, maintenance, data retrieval/data transfer, data analysis, quality assurance and data interpretation.

Security - Experience has shown that in some cases, a particular site may not be appropriate for the establishment of an ambient monitoring station simply due to problems with the security of the equipment in a certain area. If the problems cannot be remedied via the use of standard security measures such as lighting, fences, etc., then attempts should be made to locate the site as near to the identified sector as possible while maintaining adequate security.

Logistics - Logistics is the process of dealing with the procurement, maintenance and transportation of material and personnel for a monitoring operation. This process requires the full knowledge of all aspects of the data collection operation including:

Planning	*Staffing*
Reconnaissance	*Procurement of goods and services*
Training	*Communications*
Scheduling	*Inventory*
Safety	

Atmospheric considerations - Atmospheric considerations may include the spatial and temporal variability of the pollutants and its transport to the monitoring site. Effects of buildings, terrain, and heat sources or sinks on the air trajectories can produce local anomalies of excessive pollutant concentrations. Meteorology must be considered in determining not only the geographical location of a monitoring site but also such factors as height, direction, and extension of sampling probes. The following meteorological factors can greatly influence the dispersal of pollutants:

Wind speed affects the travel time from the pollutant source to the receptor and the dilution of polluted air in the downwind direction. The concentrations of air pollutants are inversely proportional to the wind speed.

Wind direction influences the general movements of pollutants in the atmosphere. Review of available data can indicate mean wind direction in the vicinity of the major sources of emissions.

Wind variability refers to the random motions in both horizontal and vertical velocity components of the wind. These random motions can be considered atmospheric turbulence, which is either mechanical (caused by structures and changes in terrain) or thermal (caused by heating and cooling of land masses or bodies of water). If the scale of turbulent motion is larger than the size of the pollutant plume, the turbulence will move the entire plume and cause looping and fanning; if smaller, it will cause the plume to diffuse and spread out.

If the meteorological phenomena impact with some regularity, data may need to be interpreted in light of these atmospheric conditions. Other meteorological conditions to consider are atmospheric stability and lapse rate (the decrease of an atmospheric variable with height).

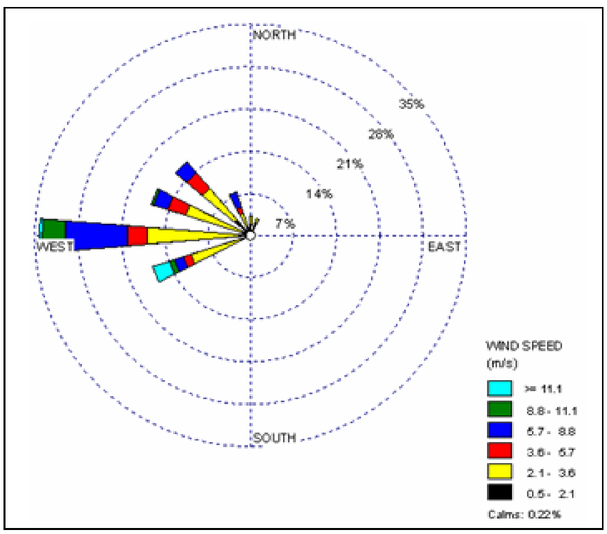

Figure 6.1 Wind rose pattern

A useful way of displaying wind data is a wind rose diagram constructed to show the distribution of wind speeds and directions. The wind rose diagram shown in Figure 6.1 represents conditions as they converge on the center from each direction of the compass. More detailed guidance for meteorological considerations is available[9]. Relevant weather information, such as stability-wind roses, is usually available from local National Weather Service stations. For PAMS monitoring, in many areas there are three types of high ozone days: overwhelming transport, weak transport (or mixed transport and stagnation) and stagnation. The wind rose concept to site monitors is only applicable to the transport types, but not applicable to the stagnation type. In general, transport types dominate north of 40^{o} N, stagnation types dominate the Ohio River Valley and northern Gulf Coast, and a mixture of the two is observed in the rest of the eastern United States. In areas where stagnation dominates the high ozone days, a well-defined primary wind direction (PWD) may not be available. If no well-defined PWD can be resolved, the major axes of the emissions sources should be used as substitutes for the PWDs and the PAMS monitors should be located along these axes.

Meteorological conditions, particularly those that can affect light transmission, should also be considered in selecting the location for open path analyzers (e.g., the influence of relative humidity on the creation of fog, the percentage of heavy snow, and the possible formation of haze, etc.). The percent fog, percent snow fall, percent haze, and hourly visibility (from nearest airport) may impact data completeness. Although sites with high relative humidity may have data capture rates around 90 percent, sites with relative humidity greater than 80 percent more than 20 percent of the time should be carefully assessed

[9] QA Handbook for Meteorological Measurements Volume IV http://www.epa.gov/ttn/amtic/met.html

for data completeness, or avoided. Similarly, severe fog, snow fall, or haze that affects visibility can affect data completeness and should be kept to less than 20 percent of the time. The time of day or season when such conditions occur should also be determined to ensure that representative data from various time periods and seasons are collected. No more than 20 percent of data in any time period should be lost as a result of the aforementioned meteorological conditions. Sometimes, high data capture at locations with frequent fog or other obscurant conditions can be enhanced by using a shorter path length of 50 to 100 meters. However, this can be done only for microscale sites. Meteorological data considerations therefore should include the following measurements: (1) hourly precipitation amounts for climatological comparisons, (2) hourly relative humidity, (3) percent haze, and (4) airport visibility.

Topography - Both the transport and the diffusion of air pollutants are complicated by topographical features. Minor topographical features may exert small influences; major features, such as deep river valleys or mountain ranges, may affect large areas. Before final site selection, review the topography of the area to ensure that the purpose of monitoring at that site will not be adversely affected. Table 6-3 summarizes important topographical features, their effects on air flow, and some examples of influences on monitoring site selection. Land use and topographical characterization of specific areas can be determined from U.S. Geological Survey (USGS) maps as well as from land use maps.

Table 6-3 Relationships of Topography, Air Flow, and Monitoring Site Selection

Topographical feature	Influence on air flow	Influence on monitoring site selection
Slope/Valley	Downward air currents at night and on cold days; up slope winds on clear days when valley heating occurs. Slope winds and valley channeled winds; tendency toward down-slope and down-valley winds; tendency toward inversions	Slopes and valleys as special sites for air monitors because pollutants generally are well dispersed; concentration levels not representative of other geographic areas; possible placement of monitor to determine concentration levels in a population or industrial center in valley
Water	Sea or lake breezes inland or parallel to shoreline during the day or in cold weather; land breezes at night.	Monitors on shorelines generally for background readings or for obtaining pollution data on water traffic
Hill	Sharp ridges causing turbulence; air flow around obstructions during stable conditions, but over obstructions during unstable conditions	Depends on source orientation; upwind source emissions generally mixed down the slope, and siting at foot of hill not generally advantageous; downwind source emissions generally down washed near the source; monitoring close to a source generally desirable if population centers adjacent or if monitoring protects workers
Natural or manmade obstruction	Eddy effects	Placement near obstructions not generally representative in readings

Pollutant Considerations - A sampling site or an array of sites for one pollutant may be appropriate for another pollutant species because of the configuration of sources, the local meteorology, or the terrain. Pollutants undergo changes in their compositions between their emission and their detection; therefore, the impact of that change on the measuring system should be considered. Atmospheric chemical reactions such as the production of O_3 in the presence of NO_x and hydrocarbons (HCs) and the time delay between the emission of NO_x and HCs and the detection peak of O_3 values may require either a sampling network for the precursors of O_3 and/or a different network for the actual O_3 measurement.

The success of the PAMS monitoring program is predicated on the fact that no site is unduly influenced by any one stationary emissions source or small group of emissions sources. Any significant influences would cause the ambient levels measured by that particular site to mimic the emissions rates of this source or sources rather than following the changes in nonattainment area-wide emissions as intended by the Rule. For purposes of this screening procedure, if more than 10% of the typical “lower end” concentration measured in an urban area is due to a nearby source of precursor emissions, then the PAMS site should be relocated or a more refined analysis conducted than is presented here. Detailed procedures can be found in the *PAMS Implementation Manual*[10].

None of the factors mentioned above stand alone. Each is dependent in part on the others. However, the objective of the sampling program must be clearly defined before the selection process can be initiated, and the initial definition of priorities may have to be reevaluated after consideration of the remaining factors before the final site selection. While the interactions of the factors are complex, the site selection problems can be resolved. Experience in the operation of air quality measurement systems; estimates of air quality, field and theoretical studies of air diffusion; and considerations of atmospheric chemistry and air pollution effects make up the required expertise needed to select the optimum sampling site for obtaining data representative of the monitoring objectives.

6.2.1 PAMS Site Descriptions

The PAMS network array for an area should be fashioned to supply measurements that will assist States in understanding and solving ozone nonattainment problems. Table 6-4 describes the five site types identified in the PAMS network. In 2007, EPA determined that the number of required PAMS sites could be reduced. Only one Type 2 site is required per area regardless of population; Type 4 sites would not be required; and only one Type 1 or one Type 3 site would be required per area.

Table 6-4 Site Descriptions of PAMS Monitoring Sites

Type #	Meas. Scale	Description
1	Urban	**Upwind and background characterization** to identify those areas which are subjected to overwhelming incoming transport of ozone. The #1 Sites are located in the predominant morning upwind direction from the local area of maximum precursor emissions and at a distance sufficient to obtain urban scale measurements. Typically, these sites will be located near the upwind edge of the photochemical grid model domain.
2	Neighborhood	**Maximum ozone precursor emissions impacts** located immediately downwind (using the same morning wind direction as for locating Site #1) of the area of maximum precursor emissions and are typically placed near the downwind boundary of the central business district (CBD) or primary area of precursor emissions mix to obtain neighborhood scale measurements.
2a	Neighborhood	**Maximum ozone precursor emissions impacts -second-most predominant morning wind direction**
3	Urban	**Maximum ozone concentrations** occurring downwind from the area of maximum precursor emissions. Locations for #3 Sites should be chosen so that urban scale measurements are obtained. Typically, these sites are located 10 to 30 miles from the fringe of the urban area
4	Urban	**Extreme downwind monitoring** of transported ozone and its precursor concentrations exiting the area and will identify those areas which are potentially contributing to overwhelming ozone transport into other areas. The #4 Sites are located in the predominant afternoon downwind direction from the local area of maximum precursor emissions at a distance sufficient to obtain urban scale measurements. Typically, these sites will be located near the downwind edge of the photochemical grid model domain.

There are three fundamental criteria to consider when locating a final PAMS site: sector analysis, distance, and proximate sources. These three criteria are considered carefully by EPA when approving or disapproving a candidate site for PAMS.

[10] http://www.epa.gov/ttn/amtic/pams.html

6.3 Monitor Placement

Final placement of the monitor at a selected site depends on physical obstructions and activities in the immediate area, accessibility/availability of utilities and other support facilities in correlation with the defined purpose of the specific monitor and its design. Because obstructions such as trees and fences can significantly alter the air flow, monitors should be placed away from obstructions. It is important for air flow around the monitor to be representative of the general air flow in the area to prevent sampling bias. Detailed information on urban physiography (e.g., buildings, street dimensions) can be determined through visual observations, aerial photography and surveys. Such information can be important in determining the exact locations of pollutant sources in and around the prospective monitoring site areas.

Network designers should avoid sampling locations that are unduly influenced by down wash or ground dust (e.g., a rooftop air inlet near a stack or a ground-level inlet near an unpaved road); in these cases, the sample intake should either be elevated above the level of the maximum ground turbulence effect or placed at a reasonable distance from the source of ground dust.

Depending on the defined monitoring objective, the monitors are placed according to exposure to pollution. Due to the various physical and meteorological constraints discussed above, tradeoffs will be made to locate a site in order to optimize representativeness of sample collection. The consideration should include categorization of sites relative to their local placements. Suggested categories relating to sample site placement for measuring a corresponding pollution impact are identified in Table 6-5.

Table 6-5 Monitoring Station Categories Relating to Sample Site Placement

Station Category	Characterization
A (ground level)	Heavy pollutant concentrations, high potential for pollutant buildup. A site 3 to 5 m (10-16 ft) from major traffic artery and that has local terrain features restricting ventilation. A sampler probe that is 3 to 6 m (10-20 ft) above ground.
B (ground level)	Heavy pollutant concentrations, minimal potential for a pollutant buildup. A site 3 to 15 m (15-50 ft) from a major traffic artery, with good natural ventilation. A sampler probe that is 3 to 6 m (10-20 ft) above ground.
C (ground level)	Moderate pollutant concentrations. A site 15 to 60 m (5-200 ft) from a major traffic artery. A sampler probe that is 3 to 6 m (10-20 ft) above ground.
D (ground level)	Low pollutant concentrations. A site 60 $\geq$ m ($\geq$200 ft) for a traffic artery. A sampler probe that is 3 to 6 m (10-20 ft) above ground.
E (air mass)	Sampler probe that is between 6 and 45 m (20-150 ft) above ground. Two subclasses: (1) good exposure from all sides (e.g., on top of building) or (2) directionally biased exposure (probe extended from window).
F (source-oriented)	A sampler that is adjacent to a point source. Monitoring that yields data directly relatable to the emission source.

6.4 Minimum Network Requirements

In 2007, the minimum network site requirements for the criteria pollutants CO, NO_2 and SO_2 were removed. Where SLAMS monitoring for these three criteria pollutants are ongoing, at least one site must be a maximum concentration sites for that area under investigation. Rather than place tables for minimum monitoring site requirements in the Handbook (since they have a tendency to change), the reader is directed to 40 CFR Part 58, Appendix D[11] of the most current regulation to find the appropriate minimum monitoring network requirements.

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[11] http://www.gpoaccess.gov/cfr/index.html or http://www.epa.gov/ttn/amtic/40cfr53.html

6.5 Operating Schedules

NOTE: The reader should check the most current version of 40 CFR Part 58 to ensure the schedules below have not changed.

For continuous analyzers, consecutive hourly averages must be collected except during:

1. periods of routine maintenance;
2. periods of instrument calibration; or
3. periods or monitoring seasons exempted by the Regional Administrator.

For Pb manual methods, at least one 24-hour sample must be collected every 6 days except during periods or seasons exempted by the Regional Administrator.

For PAMS VOC samplers, samples must be collected as specified in 40 CFR Part 58, Appendix D Section 5. Area specific PAMS operating schedules must be included as part of the PAMS network description and must be approved by the Regional Administrator.

For manual $PM_{2.5}$ samplers:

1. **Manual $PM_{2.5}$ samplers at SLAMS stations** other than NCore stations must operate on at least a 1-in-3 day schedule at sites without a collocated continuously operating $PM_{2.5}$ monitor. For SLAMS $PM_{2.5}$ sites with both manual and continuous $PM_{2.5}$ monitors operating, the monitoring agency may request approval for a reduction to 1-in-6 day $PM_{2.5}$ sampling at SLAMS stations or for seasonal sampling from the EPA Regional Administrator. The EPA Regional Administrator may grant sampling frequency reductions after consideration of factors, including but not limited to the historical $PM_{2.5}$ data quality assessments, the location of current $PM_{2.5}$ design value sites, and their regulatory data needs. Sites that have design values that are within plus or minus 10 percent of the NAAQS; and sites where the 24-hour values exceed the NAAQS for a period of 3 years are required to maintain at least a 1-in-3 day sampling frequency. Sites that have a design value within plus or minus 5 percent of the daily $PM_{2.5}$ NAAQS must have an FRM or FEM operate on a daily schedule. The national sampling schedule can be found on AMTIC[12].
2. **Manual $PM_{2.5}$ samplers at NCore stations** and required regional background and regional transport sites must operate on at least a 1-in-3 day sampling frequency.
3. **Manual $PM_{2.5}$ speciation samplers at STN stations** must operate on a 1-in-3 day sampling frequency.

For PM_{10} samplers, a 24-hour sample must be taken from midnight to midnight (local time) to ensure national consistency. The minimum monitoring schedule for the site in the area of expected maximum concentration shall be based on the relative level of that monitoring site concentration with respect to the 24-hour standard as illustrated in Figure 6.2. If the operating agency demonstrates by monitoring data that during certain periods of the year conditions preclude violation of the PM_{10} 24-hour standard, the increased sampling frequency for those periods or seasons may be exempted by the Regional Administrator and permitted to revert back to once in six days. The minimum sampling schedule for all other sites in the area remains once every six days.

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[12] http://www.epa.gov/ttn/amtic/calendar.html

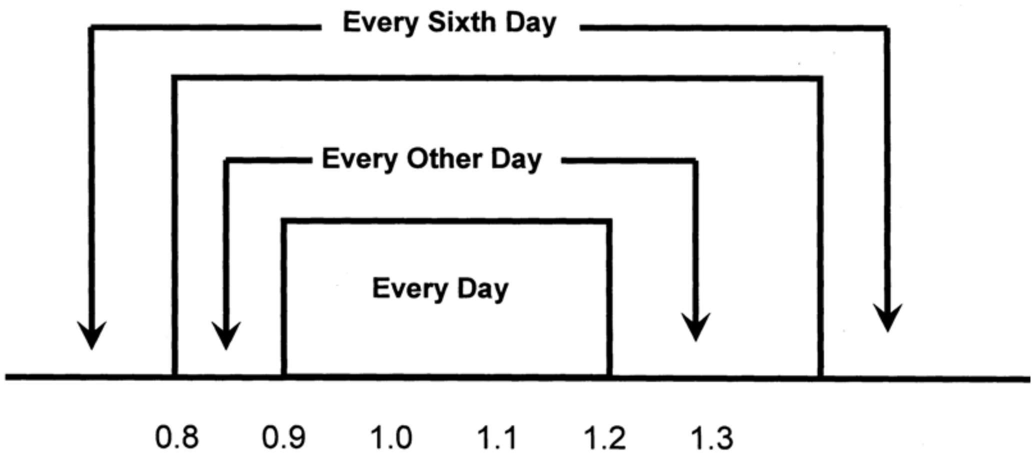

Figure 6.2 Sampling schedule based on ratio to the 24-hour PM_{10} NAAQS

For manual $PM_{10-2.5}$ samplers:

1. **Manual $PM_{10-2.5}$ samplers at NCore stations** must operate on at least a 1-in-3 day schedule at sites without a collocated continuously operating federal equivalent $PM_{10-2.5}$ method that has been designated in accordance with 40 CFR Part 53.
2. **Manual $PM_{10-2.5}$ speciation samplers** at NCore stations must operate on at least a 1-in-3 day sampling frequency.

For NATTS Monitoring, samplers must operate year round and follow the national 1-in-6 day sampling schedule.

6.5.1 Operating Schedule Completeness

Data required for comparison to the NAAQS have specific completeness requirements. These completeness requirements generally start from completeness at hourly and 24-hour concentration values. However, the data used for NAAQS determinations include 3-hour, 8-hour, quarterly, annual and multiple year levels of data aggregation. Generally, depending on the calculation of the design value, EPA requires data to be 75% complete. All continuous measurements come down to what is considered a valid hour and currently all 24-hour estimates based on sampling (manual PM, Pb, TSP) are based on a 24-hour sampling period. Table 6-6 provides the completeness goals for the various ambient air program monitoring programs.

The data cells highlighted in Table 6-6 refer to the standards that apply to the specific pollutant. Even though a highlighted cell lists the completeness requirement, CFR provides additional detail, in some cases, on how a design value might be calculated with less data than the stated requirement. Therefore, the information provided in Table 6-6 should be considered the initial completeness goal which should be attempted to be achieved. Completeness goals that are not highlighted, although not covered in CFR, are very important to the achievement of the CFR completeness goals. So, for example, even though there is only an 8-hour ozone standard, it's important to have complete 1-hour values in order to compare to the 8-hour standard.

Table 6-6 Completeness Goals for Ambient Air Monitoring Data

	Completeness Goals and Associated Standards (highlighted)					
Pollutants	**1-hour**	**3-hour**	**8-hour**	**24-hour**	**Quarterly**	**Annual**
CO	45, 1 min. values		75% of hourly values	75% of hourly values		75% of hourly values per quarter
O_3	45, 1 min. values		75% of hourly values			
SO_2	45, 1 min. values	All 3 hours 75% complete		75% of hourly values		75% of hourly values per quarter
NO_2	45, 1 min. values					75% of hourly values per quarter
PM_{10} Cont	45, 1 min. values			23 hours**		
$PM_{2.5}$ Cont.	45, 1 min. values			23 hours		
PM_{10} Manual				23 Hours**		
$PM_{2.5}$ Manual				23 hours	75% of samples	
Pb				23 Hours	75% of samples**	
PAMS				23 Hours		
NATTS				23 Hours		
STN				23 Hours		

**** not defined in CFR**

For continuous instruments, it is suggested that 45, 1-minute values be considered a valid hour. Therefore, it is expected that 1-minute concentration values would be archived for a period of time (see statute of limitations in Section 5). Since various QC checks take time to complete, (zero/span/1-point QC) it is suggested that they be implemented in a manner that spans two hours (e.g., at 11:45 PM to 12:15 AM) in order to avoid losing an hour's worth of data.

6.5.2 Monitoring Seasons

Most of the monitoring networks operate year round with the exception of PAMS and ozone monitoring.

PAMS - 40 CFR 58, Appendix D[10] stipulates that PAMS precursor monitoring must be conducted annually throughout the months of June, July and August (as a minimum) when peak O_3 values are expected in each area. Alternate precursor monitoring periods may be submitted for approval to the Administrator as a part of the annual monitoring network plan.

Ozone - Since O_3 levels decrease significantly in the colder parts of the year in many areas, O_3 is required to be monitored at SLAMS monitoring sites only during the ''ozone season'' as designated in the AQS files on a State-by-State basis and described in 40 CFR Part 58, Appendix D[13]. Deviations from the O_3 monitoring season must be approved by the EPA Regional Administrator, documented within the annual monitoring network plan, and updated in AQS.

[13] http://www.gpoaccess.gov/cfr/index.html