SO_2 NAAQS Designations
Source-Oriented Monitoring
Technical Assistance Document

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Executive Summary

This document is one of two technical assistance documents being provided by the EPA to assist air agencies in the characterization of ambient air quality in areas with significant sulfur dioxide (SO_2) emission sources. The primary purpose of this Source-Oriented SO_2 Monitoring Technical Assistance Document (TAD) is to provide suggestions on how air agencies might appropriately and sufficiently monitor ambient air in proximity to an SO_2 emission source to create ambient monitoring data for comparison to the SO_2 National Ambient Air Quality Standards (NAAQS). This TAD presents recommended steps to prepare for the source-oriented SO_2 monitor site identification process that may proceed under an anticipated SO_2 data requirements rule, and discusses three different approaches air agencies might take to identify where a sufficient number of SO_2 monitors may be located to characterize the peak SO_2 concentrations that occur in an area around or impacted by an SO_2 emissions source. The three different potential approaches presented are to: 1) conduct new modeling to aid in monitoring site placement; 2) conduct exploratory monitoring to inform permanent monitor placement; and 3) take advantage of existing emissions data, existing monitoring data, and existing modeling, where possible, to determine permanent monitoring site placement.

This TAD does not impose binding and enforceable requirements or obligations on any person, and is not final agency action. It is intended to provide recommendations for others to consider as they develop information to be used in future separate final actions, such as area designations and other NAAQS implementation actions. The TAD is subject to change and does not represent the culmination of any agency proceeding or a final interpretation by the EPA of any pre-existing statutory or regulatory requirements.

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1. Introduction

1.1 Background

The traditional NAAQS implementation process begins with the area designations process described in section 107 of the Clean Air Act (CAA), which generally relies on air quality concentrations to be characterized by ambient monitoring data collected by state, local, and tribal air agencies to identify areas that are exceeding the relevant standard. The preamble to the final SO_2 NAAQS noted that although the current SO_2 ambient monitoring network included 400+ monitors nationwide, the scope of the network had certain limitations, and approximately two-thirds of the monitors are not located to characterize maximum concentration source-oriented impacts. It was observed that some areas without monitoring likely have concentrations violating the NAAQS. To address these potential public health impacts, the SO_2 NAAQS preamble and subsequent draft guidance issued in September 2011 recommended that air agencies submit substantive attainment demonstration state implementation plans (SIPs) based on air quality modeling by June 2013 [under Clean Air Act section 110(a)(1)] that would show how areas expected to be designated unclassifiable and have sources emitting over 100 tons of SO_2 per year would attain and maintain the NAAQS in the future.

A number of stakeholders expressed concern with this suggested implementation approach, particularly with the number of sources to be modeled (more than 1680 sources had emissions exceeding 100 tons in 2008), and the recommended SIP submission date for areas *without* monitoring being before the SIP due date for violating areas *with* monitoring data. In response, the EPA Assistant Administrator at that time, Gina McCarthy, sent letters to state Environmental Commissioners on April 12, 2012, indicating that the EPA wanted to further consult with stakeholders regarding how to best implement this standard and protect public health in an effective manner. The letters also stated that the agency would not expect air agencies to submit attainment demonstrations by June 2013 for areas not designated as "nonattainment" based on ambient monitoring data. The EPA developed a white paper on possible implementation approaches and proceeded to convene three stakeholder meetings in May- June 2012 with environmental group representatives; state, local, and tribal air agency representatives; and industry representatives. On July 27, 2012, the EPA also announced that it was extending the deadline for SO_2 NAAQS area designations by an additional year, to June 3, 2013, based on the unavailability of data.

1.2 Purpose

This draft Source-Oriented Sulfur Dioxide (SO_2) Monitoring Technical Assistance Document (TAD) is one of two TADs[1] being provided by the EPA to assist state, local, and tribal air agencies in the characterization of ambient air quality[2] in areas around or impacted by significant

[1] The companion document is the SO_2 NAAQS Designations Modeling Technical Assistance Document.
[2] Ambient air is defined in 40 CFR Part 50, 50.1 as that portion of the atmosphere, external to buildings, to which the general public has access.

SO_2 emission sources. This characterization is needed to support the implementation of the SO_2 NAAQS. This TAD provides technical background to an anticipated SO_2 data requirements rule which the EPA intends to propose to require states to characterize ambient air quality in areas around and impacted by the nation's larger SO_2 emission sources.

The purpose of this TAD is to provide suggestions on how state, local, and tribal air agencies might appropriately and sufficiently monitor ambient air in areas proximate to or impacted by an SO_2 emission source to create ambient monitoring data for comparison to the SO_2 NAAQS. Although there is already an SO_2 monitoring network, the EPA expects that some air agencies may consider using monitoring to provide additional air quality data that might be needed to satisfy the anticipated data requirements rule. The EPA expects monitoring conducted in response to the future data requirements rule to be targeted, source-oriented monitoring, for which the primary objective would be to identify peak SO_2 concentrations in the ambient air that are attributable to an identified emission source or group of sources. This TAD presents recommended steps to aid in identifying source-oriented SO_2 monitor sites. Three different potential approaches are presented that a state, local, or tribal air agency might consider when identifying where one or more SO_2 monitors may be needed to characterize the peak SO_2 concentrations that are occurring in an area around or impacted by an SO_2 emissions source or group of sources. The EPA notes that this monitoring effort can be carried out solely by air agencies, but may be most effective when there is collaboration among any affected air agencies and other stakeholders (e.g., industry and other parties). Such collaboration on this effort could potentially ease the burden on all parties during the collection of existing data on air quality, emissions, and other case-specific information, when designing a monitoring network, and during installation, operation, and maintenance of any ambient SO_2 monitors intended to satisfy the anticipated data requirements rule.

The approach taken by a state, local, or tribal air agency to determine where a sufficient number of SO_2 monitors may be sited to characterize ambient peak SO_2 concentrations should take into account as much available data as possible. Such data might include: all the available data with respect to relevant source emission profiles, existing air quality data, existing modeling results, meteorological data and analyses (e.g., wind roses), terrain, general knowledge of a source or sources and the surroundings, and general knowledge about an area with respect to monitoring site feasibility. This TAD presents methods by which a state might consider all the available information regarding the site selection process, and suggests three approaches that a state might use to find suitable source-oriented SO_2 monitoring sites. The three suggested approaches are: 1) conduct new modeling to aid in candidate site identification, and 2) conduct exploratory monitoring to inform permanent monitor placements, or 3) take advantage of existing emissions, monitoring, and modeling data to identify candidate monitor sites.

In the anticipated data requirements rule mentioned earlier, which the EPA expects to be proposed in 2014, the EPA envisions proposing requirements for air agencies to characterize SO_2 air quality conditions around and in areas impacted by an SO_2 emissions source. Any monitoring conducted by a state, local, or tribal air agency pursuant to the anticipated future requirements in the upcoming data requirements rule would be subject to EPA Regional Administrator approval. In the projected timeline included in the February 2013 EPA SO_2 Strategy Paper, the EPA suggested that it could propose any such monitoring could be included in the state's Annual Monitoring Network Plan due to be submitted July of 2016 or such other date determined in the future rule. Further, the EPA suggested that monitors could be expected to be operational by January 1, 2017, or other such date determined by the future rule. The EPA expects that in cases where monitoring is conducted in response to the future data requirements rule, monitors could also be eligible to satisfy monitoring required in 40 CFR part 58, Appendix D, Section 4.4.2, *Requirement for Monitoring by Population Weighted Emissions Index* (PWEI), if they are within an area subject to PWEI required monitoring. However, not all existing PWEI required monitors would necessarily satisfy the future data requirements rule. The EPA expects that those PWEI monitors that are source-oriented monitors, and in proximity to a source identified by the future data requirements rule, as currently envisioned, may be included in the consideration of what monitoring is necessary to appropriately and sufficiently characterize air quality around that identified source.

No matter what approach is used to site monitors to comply with the anticipated data requirements rule, the EPA expects to propose to require that the monitors be operated in a manner largely equivalent to those monitors operated elsewhere in the State and Local Air Monitoring Stations (SLAMS) network. Specifically, the EPA expects to propose that the monitors must be Federal Reference Methods (FRMs) or Federal Equivalent Methods (FEMs) and meet the requirements of 40 CFR part 58 Appendices A, C, and E. Further, the EPA intends to propose that resulting data be reported to the Air Quality Subsystem (AQS), be subject to annual data reporting and certification requirements listed in 40 CFR parts 58.15 and 58.16, and meet other requirements that may be specified by an EPA Regional Administrator.

2. Information Gathering to Support the Site Selection Process

This section is intended to guide the collection of existing information to support the source-oriented SO_2 monitor site selection process. The EPA suggests pursuing the acquisition and evaluation of each type of information presented here. Having as much of the suggested information as possible will increasingly ensure a thorough evaluation in the determination of a sufficient number of appropriately located source-oriented SO_2 monitoring sites. The review and synopsis of these data will provide support for a rationale of why a site or set of sites are appropriate when a state engages the EPA for future Annual Monitoring Network Plan approval.

2.1 SO_2 Emission Sources

It is anticipated that the forthcoming data requirements rule would propose to require the characterization of ambient air quality conditions around larger SO_2 emissions sources. These sources would likely be identified by a combination of: 1) emissions on a tons per year basis and 2) proximity to population. When those selection criteria are established through the rulemaking process, air agencies will be aware of which SO_2 sources and their surrounding or impacted areas must be characterized, and will be in a position to decide which areas would be appropriately characterized via monitoring.

The first recommended step in determining where and how many monitors will be needed to appropriately and sufficiently characterize ambient SO_2 air quality conditions in proximity to a SO_2 emission source is to evaluate the source itself. States should locate, collect, and review as much of the following types of information available about a source, including:

- Facility Name and owner
- Facility function (EGU, smelter, etc.)
- Fuel source or other information on SO_2 producing components and operations
- Emissions data (annual, sub-annual, etc., as available)
- Continuous Emissions Monitoring (CEM) data
- Stack testing results
- Long-term emissions trend data
- Emissions profile (plant operations 24 hours a day, diurnal, seasonal, on-demand, etc.)
- Emissions metrics (stack height(s), stack dimensions, emission temperatures, emission velocities, etc.)
- Emissions controls in place (also identify if control installations are planned, with committed timetable as available)
- Permit related data (which should include the identification of the existence of any Title V, PSD, or related modeling, permit limits, etc.)

Many of these data may be available in routinely produced Facility Level Reports and Process Level Reports which are submitted by states to the EPA on an annual basis for inclusion in the Emissions Inventory System (EIS). Data suggested for collection (above) which are not included in those reports most likely will be found in state-maintained permitting records, if available.

It is also important to understand the setting and surroundings of the SO_2 source. This would include determining if the source is isolated or in an area with multiple SO_2 sources of varying magnitudes, whether it is in a rural or urban setting, and characterizing the surrounding geography.

2.2 Existing Air Quality Data

In situations where existing air quality data are available in an area containing an SO_2 source, states should collect all the available data for review to assist in making reasoned decisions about monitor placement. The EPA believes this data collection activity should include those data from any nearby state, local, or tribal monitors, special purpose monitoring, non-regulatory monitoring, or prior field studies. In addition, any search for air quality data should include inquiries into industry or third party data sources that could be made available to air agencies. Although industry and third party monitoring data may not necessarily be appropriate for use in designation activities (e.g., they do not represent ambient air and/or they do not meet requirements in 40 CFR Part 58 Appendices A, C, and E), such data likely will be very valuable in aiding any process of determining where appropriate ambient air monitoring should be conducted.

It may be discovered that existing industry or third party monitoring infrastructure and monitoring operations could be modified to meet all necessary requirements to produce data of appropriate quality for comparison to the NAAQS and thus minimize the need for additional monitors. An example of such a situation might be an industry operated monitor sited at a location of expected maximum concentration, in ambient air, which only needs to be quality assured by a state (where the state could become the Primary Quality Assurance Organization [PQAO]). In any instance where industry or third party monitoring infrastructure is pursued for use to satisfy the anticipated data requirements rule, those monitors would need to meet 40 CFR part 58 Appendix A quality assurance requirements. In this example, collaboration between industry and the state could allow existing data collection activities to be used in characterizing ambient air quality that could help satisfy future requirements in the anticipated data requirements rule. Although the use of industry operated monitors may not always be an option, the EPA expects that there are opportunities to leverage industry or third party operated ambient air monitors to help satisfy the future data requirements rule requirements.

2.3 Existing Modeling

Large SO_2 sources likely to be identified in the forthcoming data requirements rule may have been modeled at some point in time, possibly in order to receive a state, Title V, and/or PSD related permit or as part of a SIP. It should be noted that relatively older sources could have been in operation before PSD rules were enacted, and as a result, there may be no modeling data for those 'grandfathered' sources if they have not significantly increased their net SO_2 emissions since PSD was introduced. However, for many sources, the EPA expects that there are modeling results available, and on public record. In those cases where older modeling data are available, the EPA recommends that those modeling results be considered in the monitor siting process, but used within the appropriate context. In some cases, older modeling may have been conducted for comparison to old primary or current secondary NAAQS averaging times (e.g., 24-hour averages, annual averages, and 3-hour averages), alternate purposes, used older versions of AERMOD, or executed with wholly different models. In such situations, care should be taken when interpreting where peak concentrations may be indicated. At a minimum, older modeling may still be informative of general pollutant dispersion patterns, if not appropriate for use to identify smaller or more specific areas of interest, where peak SO_2 concentrations could be occurring. The EPA strongly suggests that any existing modeling data used in the monitor siting process be documented to build the rationale behind a state, local, or tribal agency's network design choices.

2.4 Meteorological Data

Understanding the influence of meteorology on an SO_2 source is critical in understanding how SO_2 emissions may most often be dispersed and where the location or locations of maximum ground-level concentrations may be expected to occur. Therefore, the selection of meteorological data for analysis for monitoring site evaluations should be considered carefully.

The *Guideline on Air Quality Models*[3] published as 40 CFR part 51, Appendix W (Appendix W) offers guidance on selecting meteorological data for dispersion modeling and is relevant in the context of determining where monitoring sites might be most appropriate. The selection of meteorological data should be based on spatial and climatological (temporal) representativeness (Appendix W, Section 8.3). The representativeness of the data is based on: 1) the proximity of the meteorological monitoring site to the area under consideration, 2) the complexity of terrain, 3) the exposure of the meteorological site, and 4) the period of time during which data are collected. Spatial representativeness of the meteorological data can be adversely affected by large distances between the source and potential monitoring sites and any complex geographic characteristics of the area (Appendix W, Section 8.3.a and 8.3.c; and discussed in Section 2.5 of this TAD, respectively). While an identified SO_2 source and meteorological station may be in close proximity, there may be complex terrain between them such that conditions at the meteorological station may not be representative of conditions at the source. An example would be a source located on the windward side of a mountain chain with a meteorological station a few kilometers away on the leeward side of the mountains. When using data from a NWS station alone or in conjunction with site-specific or other data, it is important that the data be spatially and temporally representative of conditions in which the target SO_2 source is situated. Appendix W addresses spatial representativeness issues in Sections 8.3.a and 8.3.c.

There are a number of sources from which meteorological data might be obtained for the monitoring site evaluation process, including on-site data, the National Weather Service (NWS),

[3] http://www.epa.gov/ttn/scram/guidance/guide/appw_05.pdf

the Federal Aviation Administration (FAA), AQS, AIRNow-Tech, universities, and military facilities, among others. Of these data sources, the most valuable data for this application is meteorological data collected very nearby or even on the property of an identified SO_2 emitting facility (i.e., on-site or "site specific" data), if those data are of adequate quality. These data typically have very good spatial representativeness of the area in which the identified SO_2 source is situated, and thus, provide the best information to understand the actual conditions in which SO_2 emissions are being dispersed. Alternatively, meteorological data produced by the NWS is of high quality and is routinely collected at airports and other locations nationwide. NWS data are available from the National Climatic Data Center (NCDC) in many formats, with the most common format in recent years being the Integrated Surface Hourly data (ISH). Data from other sources mentioned above may be more varied in availability and format, but can be useful when routine data sources are not representative of the SO_2 source area or are unavailable, and may also be useful in augmenting available on-site or NWS data.

In the event that local or otherwise similar and suitable meteorological data sources are not available, there may be merit in considering installing instrumentation for a more localized data record going forward, for use in future evaluations of monitoring or modeling data. Regardless of the method by which air agencies determine where and how many SO_2 monitors are necessary to characterize air quality in areas around or impacted by an identified source, the consideration of meteorological influences is a must. In the siting process, the lack of use of such data can severely limit confidence in monitor siting exercises.

2.5 Geographic Influences

The geographic setting of an SO_2 source can have substantial impacts on emissions dispersion and thus on the appropriate location or locations of any source-oriented SO_2 monitors. States should evaluate both the immediate and larger scale geographic setting of each potential identified SO_2 source to understand if plume or emissions behavior are routinely subject to topographic, terrain, or water-body influenced air flows. For those SO_2 sources in relatively non-complex terrain, e.g., largely flat terrain or low relief topography and not near large water bodies, the pollutant dispersion will be largely dominated by the overarching synoptic meteorology (i.e., the prevailing wind flow and atmospheric stabilities). If the source is in complex terrain, such as in the midst of mountains and valleys, topographical influence becomes a much larger factor in pollutant transport and dispersion. The evaluation and investigation of topographical influence becomes especially important if no meteorological data are available within a valley where emissions originate. In those situations, the available meteorological data may not be locally representative. Rather, they could be representative of the larger synoptic scale regime or possibly a different and separate valley. The primary focus in understanding the topographical influences in complex terrain is to determine the differences between the broad synoptic winds that exist above ridges and the wind behavior below the ridges within a valley. Sources can also be in proximity to large water bodies, which can have a profound impact on pollutant dispersion. It is critical to understand these influences during any monitor site evaluation process. The following examples discuss how geographic and meteorologically coupled influences can affect pollutant dispersion in complex terrain or near large water bodies, including thermally driven winds (i.e., mountain/valley winds and sea/lake breezes), vertically coupled flow, pressure-induced channeling, and forced channeling. The examples are somewhat simplified and although we present them individually it is often the case for complex terrain that more than one of these physical influences can be in effect at once (, creating a complicated flow pattern in an area of interest. It is critical to understand these influences in determining proper placement of source-oriented SO_2 monitoring sites.

2.5.1 Thermally Driven Winds

Thermally driven winds are air circulations caused by air density and pressure gradients developed due to differential or uneven surface heating across an area (Whiteman and Doran, 1993; Arya, 1999; Birdwell, 2011). In basic effect, air is warmed as it sits over a heating surface area (due to surface insolation) and begins to expand. Adjacent air parcels, which are relatively cooler (due to less or a lack of heating), are denser than the warmer air parcel over the warming surface, leading to a density gradient between the two air parcels. As a consequence, the cooler, denser air will flow towards the area of warmer, less dense air, displacing the warmer air upwards. Aloft, the warmer air cools as it rises, and is often displaced in the horizontal towards the origination of the cooler air, where it eventually will sink back down to the surface and move to displace warming air, thus completing the thermally driven circulation. Thermally driven circulations or winds are typically diurnal, having day/night patterns, independent of synoptic air flow (e.g., the prevailing wind and/or those winds above the ridge lines in complex terrain), and are enhanced or otherwise least disrupted when synoptic winds are light and when surface heating potential is maximized with clear skies and/or a dry air mass (Weber and Kaufman, 1998; Stewart et al., 2002; Birdwell, 2011). These winds can be subdivided into a number of categories. This TAD will discuss several situations that may be most relevant to monitor siting processes in areas of complex terrain (mountain and valley winds) or in locations near large water bodies (lake/sea breezes).

In the case of mountain and valley winds, there are two circulations that may be in play: the slope or valley wall circulations and the flows that can develop along valley axes. Daytime thermally driven circulations are driven by daytime surface heating which causes up-slope and up-valley (along the valley axis) flow to develop throughout the day. Slope flows are particularly due to the temperature difference of air over the mountain slope compared to the air at the same altitude over the valley floor (Monti et al., 2002). As night falls, the pattern reverses, exacerbated by radiational cooling at the surface, causing down-slope and down-valley flow to develop as cooler air from aloft ‘fills’ back into the valley (Whiteman and Doren, 1993; Weber and

Kaufman, 1998; Arya, 1999). Notably, Whiteman and Doren, 1993, suggest that thermally driven up/down valley winds, which are generally along the valley axis, "…can be expected to be quite weak in shallow valleys because horizontal pressure differences depend strongly on valley depth." These mountain and valley winds are important to understand if a future identified SO_2 source is in a setting where these flows can often have significant influence on emission transport and dispersion throughout the diurnal flow cycle.

Lake or sea breezes can be influential on pollutant transport and dispersion in locations near large water bodies due to temperature differences between water bodies and the adjacent land. Water has a much larger thermal capacity than land, which can lead to sharp thermal contrasts between lake or sea surface temperatures and land surface temperature throughout the diurnal heating and cooling cycle. In particular, land heats more quickly than water during the day, and likewise cools more quickly at night. During the day, this leads to surface temperature differences which cause a shallow thermal low pressure area over the land as that air expands and begins to rise. The cooler air over the adjacent water body will begin to flow inland to replace the rising warmer air, creating what is known as a lake or sea breeze. Aloft, the risen warmer air will often move out over the water body where it can cool and sink, completing the thermal circulation. At night this circulation reverses when the land cools relative to the water body; however, the night-time land breeze circulation is typically not as strong as the daytime lake or sea breeze, as the difference in temperatures at night is typically not as large as during the day (Arya 1999; Laird et al., 2001; Sills et al., 2011). Arya, 1999, also notes that sea breezes are strongest in the afternoon when land surface temperatures are typically at a maximum, and in certain conditions, can extend several tens of kilometers inland in coastal regions. This diurnal circulation pattern is important to consider when siting monitors in coastal areas, as the lake or sea breeze may be a dominant influence on pollutant transport and dispersion.

2.5.2 Vertically Coupled Flow or Downward Momentum Transport

Vertically coupled flow is an effect of the downward transport of momentum from winds aloft directing or deflecting the in-valley air flow or circulation so that it is similar to the air flow above. This coupled flow is enabled or exacerbated during relatively unstable or neutral conditions and a well mixed boundary layer with stronger upper level winds (Whiteman and Doran, 1993; Birdwell, 2011). Whiteman and Doran, 1993, suggest vertically coupled flow might be expected more commonly in wide, flat-bottomed valleys with low sidewalls. The in-valley winds predominantly under the influence of vertically coupled flow would be expected to be roughly in the same direction of the upper air flow, except for a deflection of approximately 25° (Whiteman and Doren, 1993; Weber and Kaufman, 1998) or a range of 25° to 40° (Birdwell, 2011) due to increasing friction with decreasing altitude over the valley floor.

2.5.3 Pressure Driven Channeling

Pressure driven channeling can be described as the flow of air through a valley that is driven by differences in the larger, synoptic scale air pressures in a region (e.g., opposing high pressure and low pressure centers) where air flow within a valley is moving from areas of relatively high pressure towards those with relatively low pressure along the valley axis. Whiteman and Doran, 1993, suggest pressure driven channeling is a situation where winds in a valley below the ridge line are simply driven by the along-valley pressure gradient within that valley, balanced by friction from the valley floor and sidewalls, constrained by topography to blow along the valley's axis. Unlike forced channeling, which seems to be most prevalent in smaller, short and narrow valleys as noted above, pressure driven flows may have stronger potential influence in relatively wider valleys (on the order of tens of kilometers or more across), and possibly shallower valleys which are less subject to thermally driven wind influences, based on examples presented in literature by Gross and Wipperman, 1987; Whiteman and Doran, 1993; and Birdwell, 2011.

2.5.4 Forced Channeling

When wind is largely or solely re-directed by terrain, largely irrelevant of overlying pressure or thermal gradients, it can be characterized as forced channeling. Forced channeling is most prevalent in relatively smaller, short and narrow valleys (Weber and Kaufman, 1998; Kossman and Sturman, 2003). Depending on mesoscale or synoptic scale flow and valley axis orientation, air flow within a small valley affected by forced channeling can be deflected up to 90° from the direction of the prevailing winds in a generally neutrally buoyant atmosphere (Birdwell, 2011). The largest deflections can occur when prevailing winds are nearly perpendicular to the valley axis, where the winds have only two paths to follow, and the resulting wind is forced along the axis of the valley that is within 90° of the heading of the prevailing winds.

3. Approaches to Ambient Monitor Siting

The EPA suggests that the more data and analysis that goes into a source-oriented monitoring site evaluation process, the greater the confidence in how appropriate the resulting monitoring network proposal will be. It is anticipated that air agencies electing to use monitoring as a means of satisfying the anticipated data requirements rule would be expected to provide adequate reasoning in a monitoring network proposal. Such a network proposal would characterize an area around or impacted by an identified SO_2 source and include the identification of one or more locations where peak 1-hour SO_2 concentrations are expected to occur. This TAD is intended to provide options on how to identify locations where peak 1-hour SO_2 concentrations are expected to occur. The overarching intent is to encourage the use of all the available data, through one or more of the suggested approaches provided here, to formulate a proposal to site one or more monitors that would appropriately and sufficiently characterize air quality in areas around or impacted by a an SO_2 emission source. Whatever approach is taken to evaluate an area, the resulting options on what a sufficient number of source-oriented SO_2 monitors might be and where one or more sites should be located will be case specific. In light of this fact, this TAD will not recommend minimum criteria for a number of SO_2 monitors in a network or an area to characterize air quality in order to satisfy the anticipated data requirements rule. As noted earlier, specific elements of a network, including the appropriate number of monitors would be determined through analysis and subsequent discussion with the EPA for eventual approval by EPA Regional Administrators.

3.1 Modeling to Inform Monitor Placement

Modeling is a powerful tool that should be strongly considered to inform the identification of potential monitoring sites intended to satisfy the expected data requirements rule. Generally, this modeling can follow the recommendations of the SO_2 NAAQS Designations Modeling Technical Assistance Document (Modeling TAD)[4], which offers recommendations for modeling sources for designations. In general, the modeling TAD identifies the following suggested actions:

- Emissions data preparation, including sources to model, formatting of hourly emissions when available, and calculating temporally varying emissions
- Selection and processing of input meteorological data
- Source characterization including urban vs. rural treatment of sources in the modeling
- Design value calculations from model output

However, the difference between modeling to inform monitor placement and that conducted to model to determine attainment in order to satisfy the anticipated data requirements rule is that modeling to inform monitor placement can use normalized emissions. The modeling approach presented in the Modeling TAD uses the actual emissions from modeled sources. The use of normalized emissions can be used when modeling to inform monitor siting decisions because the goal of the modeling is not to determine the attainment status of an area, but to identify the location or locations of ambient SO_2 concentration maxima. The normalization of the emissions preserves the relative magnitude of emissions forecast at each receptor by the model and the spatial distribution of modeled normalized design values. To normalize the emissions, the input

[4] Please note that the SO2 NAAQS Designations Modeling TAD supersedes the EPA's March 2011 air quality modeling guidance intended for the designations process, which recommended the use of allowable emissions only to characterize air quality.

emissions could be initially calculated using the relevant sections of the Modeling TAD. Subsequently, all of the input emissions could be divided by a reference emission rate, which can be the overall highest emission rate or any alternative reference emission rate. In cases where multiple sources are included in an analysis, the same approach would be used, with all emission values being divided by the reference emission rate. The key is that all emissions would be divided by the same emission rate.

In general, the approach of modeling to inform monitor placement will likely provide high confidence information to inform the monitor siting process. In particular, modeling outputs can provide the location or locations of expected ambient, ground-level concentration maxima and the frequency of occurrence of any receptor having the highest concentration during the modeled period. These data can be then be utilized to rank which receptor locations might be the most desirable for monitoring, including the determination of whether one or more sites might be needed to adequately characterize peak concentrations around an identified source or set of sources. A detailed description and case-study example is provided in Appendix A and is intended to provide an optional template on how to use modeling to inform monitor placement.

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3.2 Using Exploratory Monitoring for Monitor Placement

State, local, and tribal air agencies may wish to conduct exploratory monitoring to either identify potential monitoring sites or more thoroughly evaluate potential monitoring sites identified through the other processes described in this TAD. In the case where exploratory monitoring is intended to be the main tool in informing where permanent SO_2 monitors should be established, a saturation study or a focused monitoring campaign considering existing data and local knowledge of an area is likely to be most appropriate. Exploratory monitoring should be viewed as a means to either identify potential permanent monitoring locations or to provide increased confidence of the legitimacy of candidate locations for permanent monitoring identified through other means (such as the evaluation of existing data). For example, if an agency used existing data to identify multiple areas where monitoring might be appropriate, they could use exploratory monitoring to bolster their evaluation and to aid in the prioritization of the candidate site or sites, including what number of sites might be most appropriate in the final network design. .

Saturation studies typically involve a large number of low-cost, portable samplers to “saturate” an area to identify the spatial variability of pollutant concentrations. In this case, the agency would deploy many samplers or devices at a number of locations around a source to determine which areas might have relatively higher pollutant levels. For example, saturation samplers could be distributed in a pattern similar to how receptors in a modeling exercise might be laid out. Although there could be variations in spacing and overall grid design due to logistical issues, the concept is a valid approach, particularly when there is little understanding or indication of where maximum concentrations might be expected to occur.

Focused exploratory monitoring could create data for comparison or evaluation at a specific number of sites, such as those derived from the evaluation of available data discussed in Section 2, or to further verify the highest priority candidate monitoring sites identified through the site selection processes discussed in Sections 3.1 (modeling) and 3.3(siting based on existing data). This focused monitoring approach may be more desirable when the resources to conduct the study are reduced or minimal as compared to the resources needed in a saturation study.

Two key considerations in exploratory monitoring are the method used and the timing and duration of the study. Stakeholders have the flexibility to use a variety of technologies and approaches to conduct exploratory monitoring. A key consideration is that the recently (2010) revised 1-hour SO_2 NAAQS is intended to protect public health by reducing exposure to high, short-term concentrations of SO_2. Therefore, exploratory monitoring conducted with highly time resolved data (i.e., data production on the order of minutes to hours) would likely be most useful. This suggests that continuous methods would be ideal in identifying short-term peak SO_2 concentrations because of the high time resolution data they provide. However, the problem with traditional fluorescent SO_2 continuous methods can be the cost and associated logistical burdens that they require to acquire, install, and operate. Recent technological advances in sensor and other sampler technology have introduced increasingly smaller and cheaper continuous measurement devices. These so-called “sensors” are not federal reference or equivalent methods, but have shown promise for use in a number of applications, including exploratory monitoring. In general, many of these new sensors may utilize electrochemical, spectroscopic, or metal oxide sensing principles. However, regardless of measurement technique, the overarching key issues in the use of these new sensor methods are detection limits and the assessment of the accuracy and precision of these new devices.

With regard to detection limits, it is believed that most sensors capable of measuring SO_2 have limits down towards 100ppb, with several potentially having detection limits down in the tens of ppb. Although having a high detection limit is problematic in typical ambient monitoring applications, any unit with detection limits in the tens of ppb still has potential in providing some insight to the locations where peak concentrations could be occurring in an area. For example, such sensors could be used only to show where peak concentrations are identified relative to non-detect responses elsewhere in time and space within the area under observation.

With regard to accuracy and precision, a modest effort in characterizing any sensors could be carried out through co-location exercises before, during, and/or after any study period, including comparisons amongst sensors and against better characterized methods such as an FEM. The EPA recognizes that there are many uncertainties associated with these new technologies, but views their potential use in this case as an alternative to other exploratory monitoring methods to aid in the site selection process.

Passive SO_2 methods that are commonly used for saturation studies and other field studies are commercially available, easy to use, and are relatively inexpensive. Passive methods are integrated samples traditionally collected over days to weeks and are excellent at determining long-term concentration trends, but they do not offer the same insight as continuous methods regarding where the short-term peak SO_2 concentrations may be occurring in an area. While passive SO_2 methods may not be the ideal method for conducting exploratory monitoring to aid in determining where to place source oriented SO_2 monitors, they still can be useful to the process. At a minimum, an adequately populated saturation study could still provide indications of what the spatial concentration gradient might be around an SO_2 source. It has also been suggested that passive sampler data could assist in "ground-truthing" concentration gradients predicted by modeling exercises.

In addition to method considerations, the other key issue in saturation or focused exploratory monitoring is the timing and duration of the study. The objective of the monitoring is to characterize peak, short-term SO_2 concentrations. However, exactly when and where these peaks are occurring is likely unknown. Therefore, a study should consider not only where to monitor, but also for how long. It is most logical to monitor throughout the course of a year, to gain at least some confidence that variations in facility operations (e.g., diurnal, seasonal, other emission profiles) and/or meteorological influences are reflected in the study data. If a particular season or time period, whether due to facility operations or meteorology, or both, is expected to be most likely to lead to peak SO_2 concentrations, then monitoring during those times could be an acceptable alternative to a year-round study. Finally, any exploratory monitoring would need to be completed in sufficient time such that the data from the study could be used to inform air agency decisions regarding network implementation in a timely manner.

3.3 Monitor Siting Based on Existing Data

In the event that a network designer has a sufficient amount and understanding of those data suggested in Section 2 (e.g., emissions data and source profile, air quality data, existing modeling data, meteorological data, topographical/terrain characterization), air agencies may be able to use those data to evaluate where source-oriented SO_2 monitors will be needed without conducting additional modeling and/or exploratory monitoring. The ultimate number and location of monitors that might be necessary to characterize air quality around an identified SO_2 source needs to be based on all available data and have a clear, technical rationale. The more that data are documented, considered, and explained, the more robust and supportable the resulting monitoring plan will be.

The EPA believes that this particular approach would not be robust without the use of one or both of existing ambient monitoring data (which could be SLAMS, Special Purpose Monitoring, industry, or third party data) and/or existing modeling data. With regard to monitoring data, historical data from a network or network components that have since been discontinued or relocated can be useful to help indicate where problem areas might have existed in the past, particularly when viewed with an understanding of an SO_2 facilities emissions trends over time. If there are one or more active monitor(s) around a source, the evaluation likely should turn towards the determination of whether the existing monitors are located where peak concentrations are expected to occur and whether site relocation or network augmentation is necessary.

With regard to existing modeling data, it is important to understand the context in which the modeling was conducted. As noted earlier in Section 2.3, existing or old modeling data may have been created for alternate purposes, using older versions of AERMOD, or with wholly different models. Therefore, the EPA believes that these modeling data can be useful in highlighting areas where ambient, peak 1-hour ground level concentrations might be expected to occur around a particular SO_2 source, within the context of the original modeling objectives and constraints. At a minimum, in situations where old modeling is increasingly questionable for use in the monitor siting process, the modeling may still be informative of general pollutant dispersion patterns.

Once the existing data are reviewed, one or more areas should be identified for a more detailed evaluation of other available data to determine where one or more monitor sites may be feasible (including considerations for access, permissions, and utilities). In the event that old monitoring or modeling data do not exist for an area with an identified source, the EPA encourages air agencies to strongly consider conducting modeling and/or exploratory monitoring to inform monitoring site selection as discussed above in Sections 3.1 and 3.2.

4. Source-oriented SO_2 Monitor Site Selection

State, local, and tribal air agencies are expected to use due diligence in acquiring or otherwise accessing space for monitoring in the location or locations that have been identified through one or more of the site identification approaches discussed in Section 3 above.. If one or more locations identified as appropriate for monitoring sites are not available due to logistical considerations, the air agency should be able to document why a preferred location was not selected or available. The EPA expects source-oriented SO_2 monitoring sites used to satisfy the anticipated data requirements rule should be SLAMS like, if not classified as SLAMS, and therefore subject to requirements in 40 CFR part 58 regarding data reporting and certification along with those included in Appendices A, C, and E. This is important when considering collaborating with third party monitoring. The EPA expects that there will be cases of industrial or other stakeholder monitoring in areas around or impacted by SO_2 sources, which may be ideal to aid in satisfying the anticipated data requirements rule. The EPA encourages the pursuit of partnerships between air agencies and other stakeholders wherever possible to use existing infrastructure, increase communication between stakeholders, and use available resources as efficiently as possible. In regard to the number of monitoring sites that could be in a network design, the EPA recognizes that increasing the number of monitoring sites around a single facility can present resource and logistical burdens. The primary objective is to place monitoring sites at the location or locations of expected peak concentrations. When multiple sites are under consideration, the secondary benefits should be recognized which can include increased spatial representation, increased understanding of concentration gradients, increased understanding or verification of the frequency at which certain locations see SO2 concentration maxima, and increased population exposure coverage or representation.

The process and outcome of determining how to appropriately and sufficiently characterize air quality conditions around an identified SO_2 source with ambient monitoring will be case specific. Air agencies should document the process they undertake to identify where one or more monitoring sites will be planned, installed, or modified (i.e., leveraging industry monitoring) with the explicit purpose of providing a rationale behind their monitoring network design decisions. These monitoring sites are expected to be included in state Annual Monitoring Network Plans that are due before the date by which monitoring is to begin and such plans would be subject to EPA Regional Administrator approval. The EPA plans to coordinate across Regions to ensure a reasonable degree of uniformity in how the Agency determines if network designs are adequate or not. A foundation of this coordination will be to reference this TAD, along with the modeling TAD, to accomplish this task. Beyond these common denominators, air agencies should engage their respective Region early in the process to minimize obstacles on the path to developing an appropriate network design that will gain Regional approval.

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Appendix A: Example of Modeling to Inform Monitoring Placement Using Normalized Emissions

As discussed in Section 3.1 of this TAD, modeling with normalized emission rates can be used to inform the identification of potential SO_2 monitoring sites. This appendix presents an example of using the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) to identify potential monitoring sites for an area influenced by a single source. Modeling procedures from the SO_2 NAAQS Designations Modeling Technical Assistance Document were followed with the exception of the layout of the receptor network and the used of normalized emissions.

A.1 Model setup

- The modeled source is a facility with three boilers located near a coastal region.
- 3 years of hourly boiler emissions were normalized using the maximum facility hourly rate.
- These hourly rates were modeled in AERMOD using concurrent meteorological data.
- The provided outputs do not provide an indication of NAAQS exceedances, just information on where maxima occur and the frequency of how often a receptor had the highest relative concentration per day.

A traditional Cartesian receptor grid was centered on the identified facility and extended to a distance of 20 km. The receptor spacing from the facility to 10 km was 250 meters and the spacing from 10 to 20 km was 500 meters. The full Cartesian receptor grid, typical of most modeling applications, can be seen in Figure 1. The SO_2 emission source is marked in the center of the receptor grid and the source of meteorological data used for the modeling exercise is denoted by the black triangle.

When modeling to inform monitor site placement, it would be unnecessary to have receptors located in areas or locations prohibitive to establishing fixed monitoring sites, such as open water, etc. It would also be unnecessary to have receptors within the fenced property of an SO_2 source or facility, as those locations are not likely to be representative of ambient air accessible to the public. These concepts are reflected in Figure 2, where receptors in locations prohibitive to ambient monitoring have been removed prior to running the model. Alternatively, an air agency could keep all receptors in a model run, and simply ignore receptors in prohibitive monitoring locations during the post-processing analysis.

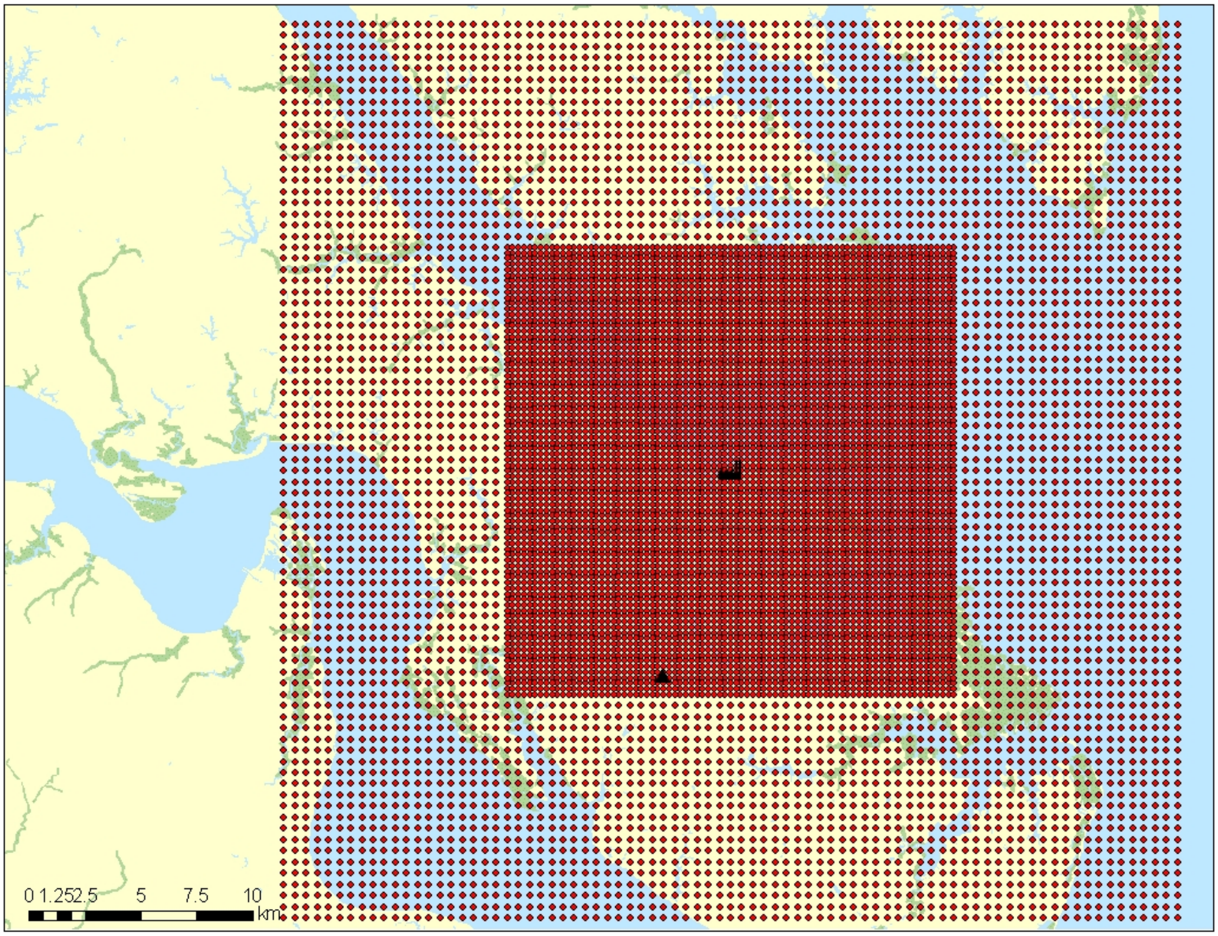

Figure 1. Traditional Cartesian receptor grid. This figure shows a traditional Cartesian receptor grid centered on an SO_2 facility in a coastal area. Grid spacing is 250 meters from the center to 10 kilometers out, and 500 meters from 10 to 20 kilometers out.

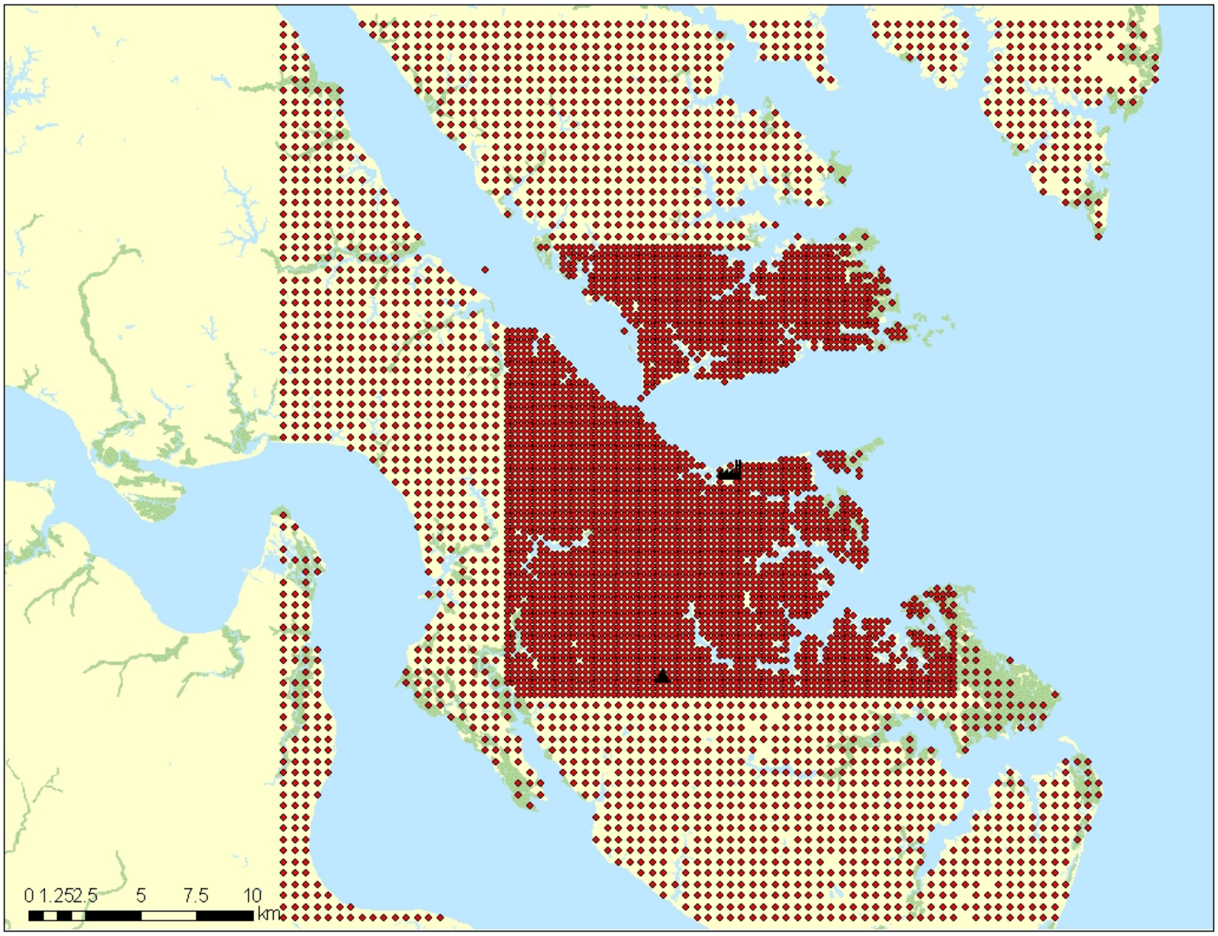

Figure 2. Receptor grid with receptors in locations prohibitive to ambient monitoring removed. This figure is a modification of Figure 1, illustrating the removal of receptors from locations which are not suitable for permanent SO_2 monitoring sites. In this case, such prohibitive locations would be those over water and any within the identified SO_2 source facility boundary.

A.2 Model results

Modeling the normalized hourly SO_2 emissions allows for the calculation of normalized design values (NDVs). NDVs do not indicate exceedance or compliance with the NAAQS, but provide a means to understanding the relative magnitude of ambient SO_2 concentrations across an area. In this example, the NDVs are the 3-year average of each year's 4^{th} daily highest 1-hour maximum concentration, which is an equivalent of the 99^{th} percentile of daily 1-hour maximum concentrations. NDVs for this example are shown in Figure 3, along with the 3-year wind rose of the meteorological station used for modeling. In Figure 3:

- Darker colors represent relatively higher concentrations.
- The dominant winds in this area are from the southwest.
- The overall highest normalized design value is denoted by the red circle, which is just west of the source facility.

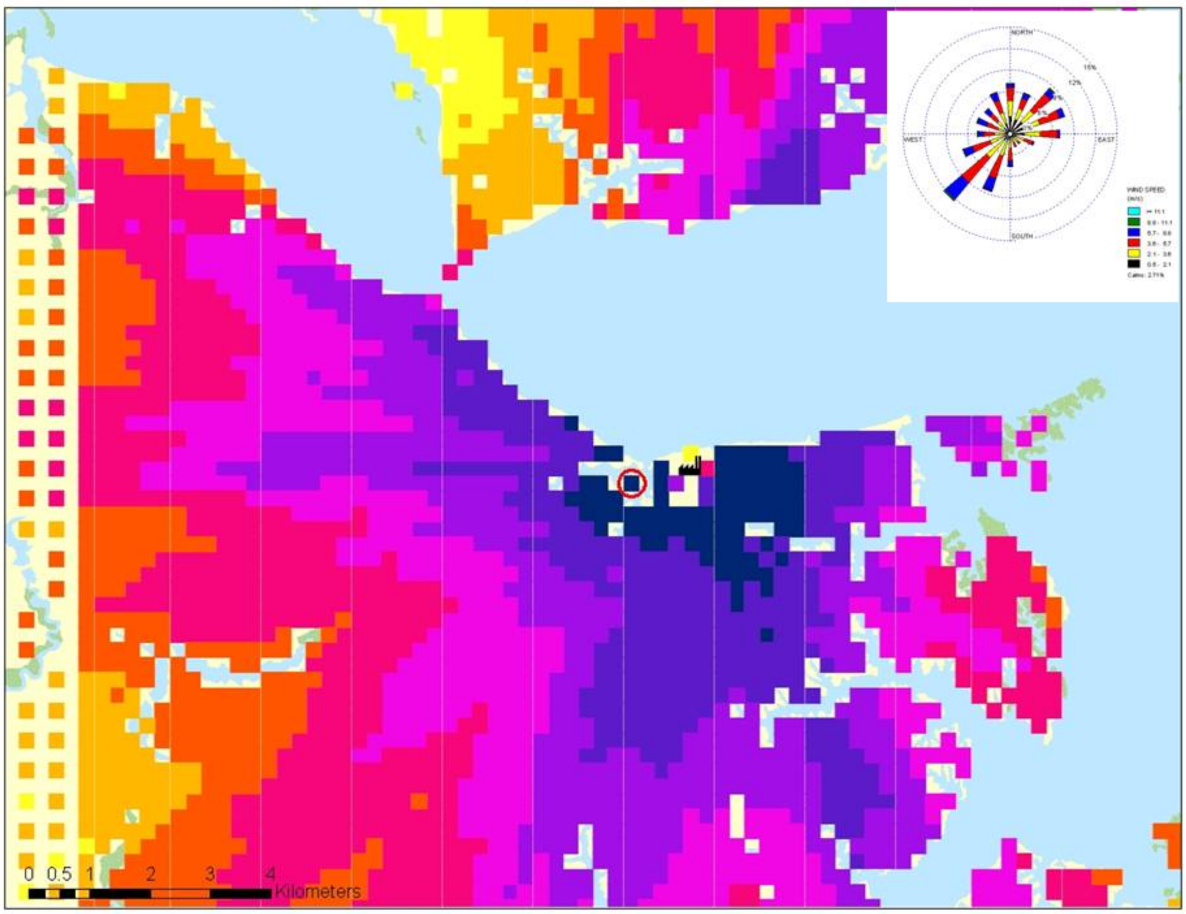

Figure 3. Normalized design values. This figure illustrates the NDV for each modeled receptor. The darker colors indicate relatively higher NDVs. The receptor with the highest overall NDV is circled, and is just west of the SO_2 emission source.

To better understand the relative difference between NDVs across modeled space, Figure 4 shows the ratio of the NDV of each individual receptor to that of the overall maximum NDV.

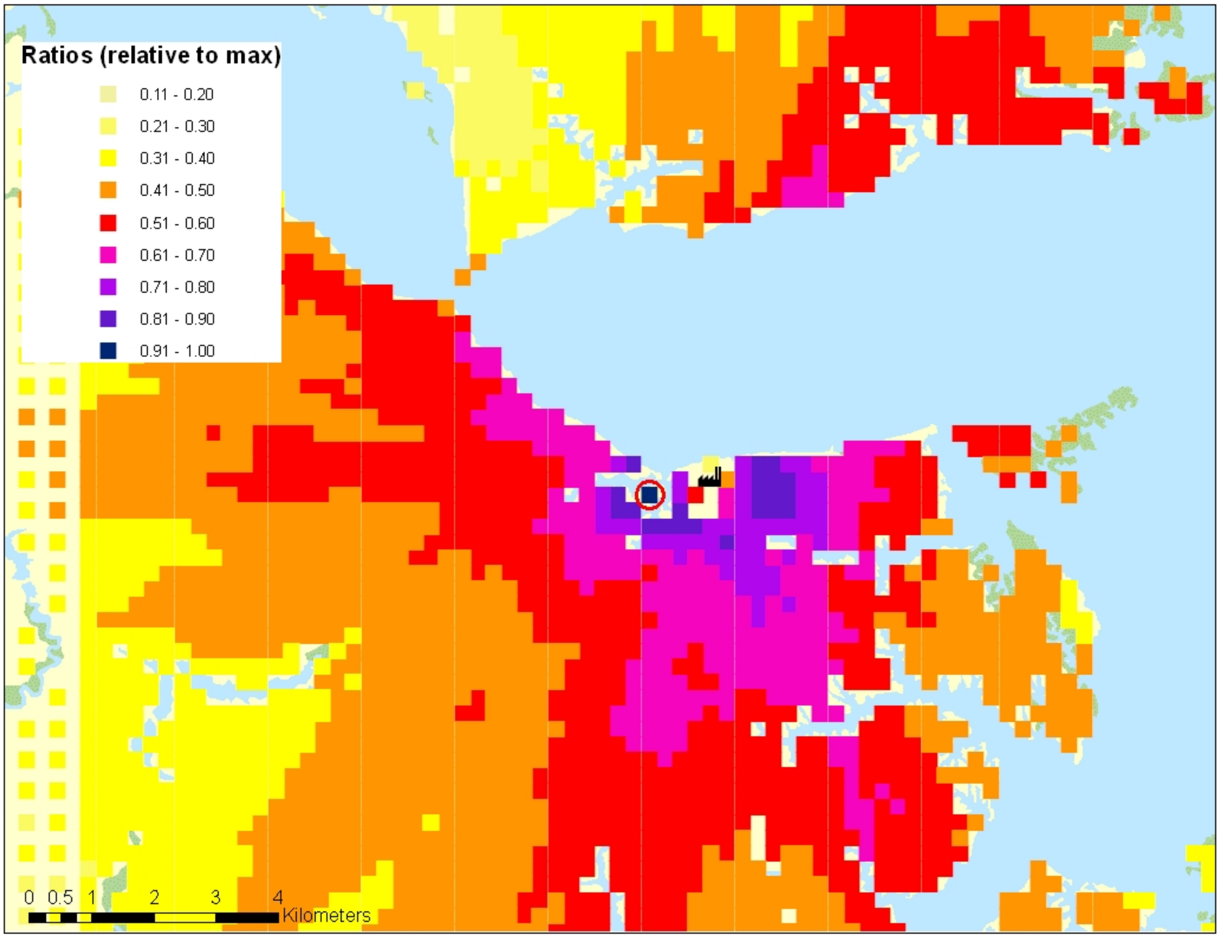

Figure 4. Ratios of individual receptor normalized design values NDVs to the overall maximum NDV. The receptor with the overall maximum NDV is circled in red.

As illustrated in Figures 3 and 4, the receptor with the highest overall NDV is just west of the SO_2 emissions source and is circled. That location, and those receptors denoted by the darkest colors, represents areas where further evaluation for potential monitoring sites might initially be focused. An additional analysis was performed to identify the receptors having the top 200, 100, 25, and 10 NDVs, which is presented in Figure 5.

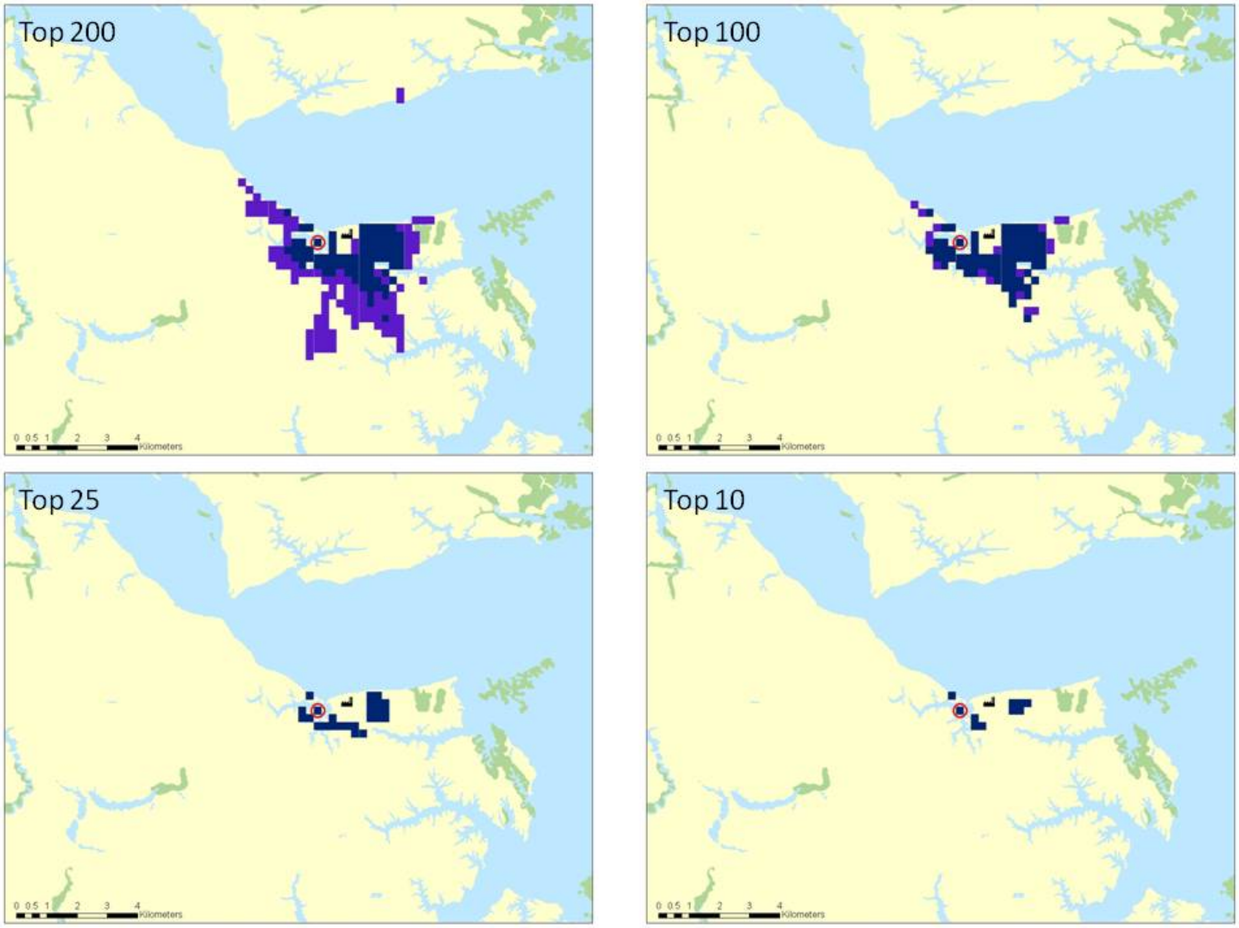

Figure 5. Locations of Top 200, 100, 25, and 10 normalized design values.

The analysis shown in Figure 5 prioritizes the locations that would likely be first evaluated to potentially establish a monitor. In this evaluation, the primary objective is to find a sufficient number of feasible locations with predicted peak and/or relatively high SO_2 concentrations where a permanent monitoring site might be located. However, the site selection process also needs to account for the frequency in which a receptor sees daily maximum concentrations. In order to assess the frequency of occurrence of concentration maxima at a given receptor, an analysis was performed on the top 200 receptors in AERMOD where the MAXDAILY option was used to output the maximum 1-hour concentration for each receptor for each day. This output was used to determine the number of days for which each receptor was the overall highest 1-hour concentration for the day for the 3 modeled years and is presented in Figure 6.

The receptor with the overall highest NDV, circled in Figures 3, 4, and 5, is also the receptor with the most days where it had the highest 1-hour concentration for the day (153 days) and is circled in Figure 6. Therefore, that receptor has the highest NDV and most often has the highest 1-hour concentration of all receptors. The receptors with the next highest frequency of having the daily 1-hour maximum concentrations are just to the east of the SO_2 source and also to the north-northeast, across the river. Those receptors just to the east of the SO_2 source also happen to have relatively high NDV (see Figures 3, 4, and 5). However, the two receptors across the river which had a relatively high number of 1-hour daily maxima do not have NDVs within the top 100 of all NDVs. As such, while frequently having 1-hour daily maxima, the sites across the river likely do not have relatively high concentrations on those days when they have the 1-hour daily maximum concentration among all receptors.

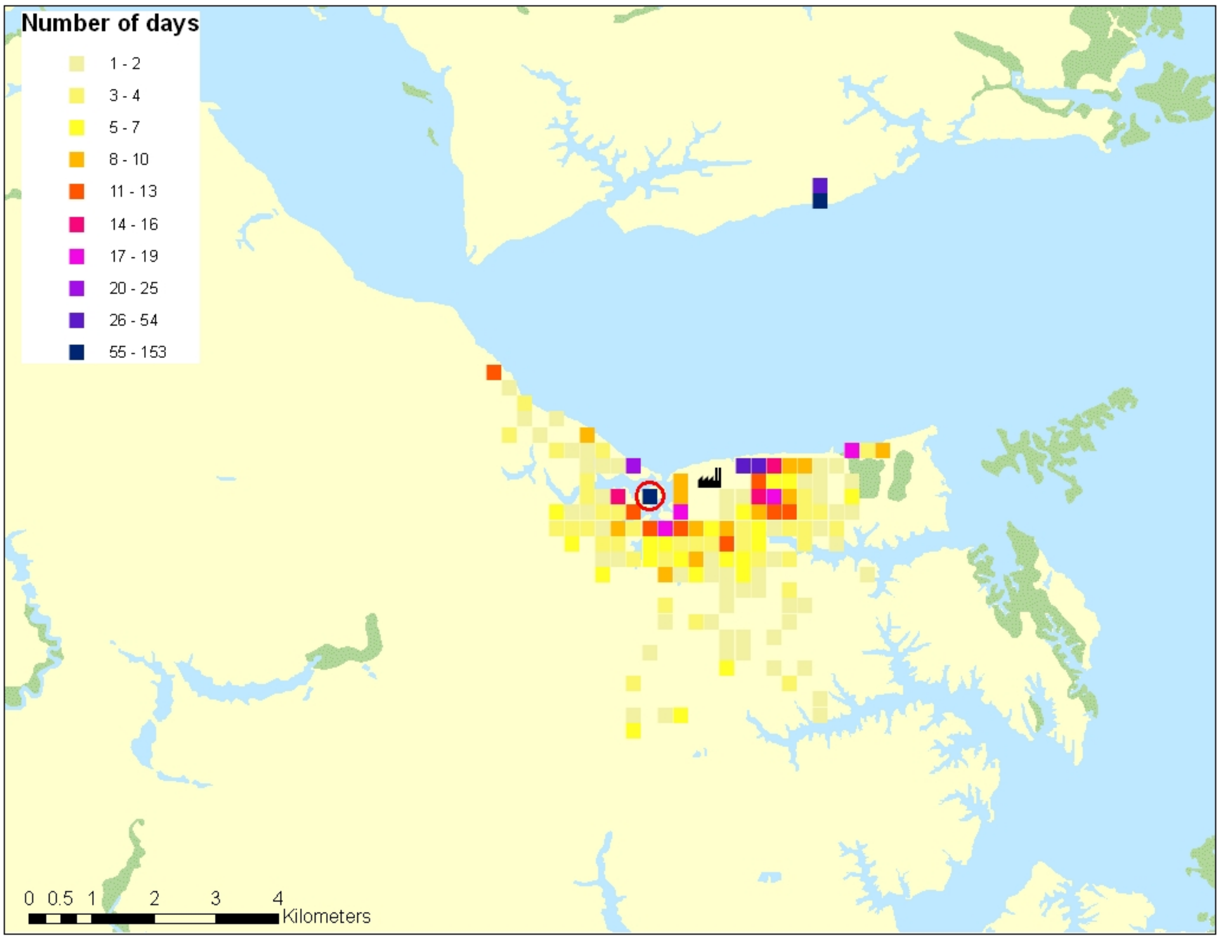

Figure 6. Cumulative number of days that an individual receptor had the 1-hour daily maximum concentration among all receptors. Darker colors indicate an increasing number of days that a receptor had the 1-hour daily maximum concentration.

Finally, it is an option to create a relative prioritized list of receptor locations for consideration of permanent monitoring sites using NDVs and frequency of having the 1-hour daily maximum concentration amongst all receptors. This scoring strategy can be conducted as follows:

1. Calculate the normalized design value at each receptor and rank from highest to lowest receptor. Rank of 1 means the highest design value

2. Using the MAXDAILY output option in AERMOD, determine each day's highest normalized concentration and receptor. The MAXDAILY option in AERMOD outputs each receptor's highest concentration for each modeled day.
3. Using the output from step 2, determine the number of days each receptor is the highest concentration for the day among all receptors.
4. Rank the results from step 3 from highest to lowest number of days. Rank of 1 means the highest number of days having the daily maximum value.
5. For each receptor, add the concentration rank and the day rank. The lowest possible score is 2, meaning the receptor was the highest overall normalized design value and also had the highest number of days where the receptor was the highest concentration for the day.

Using this strategy will provide a list of receptor locations, ranked in general order of desirability with regard to potentially siting permanent source-oriented SO2 monitors. Continuing with the case example in this Appendix, the following is an example output illustrating this scoring strategy:

x_rec	y_rec	dv_rank	ndays	ndays_rank	score1	score_rank
369401	**4119433**	**1**	**153**	**1**	**2**	**1**
371401	4119433	2	17	10	12	2
369151	4119933	6	25	6	12	3
369901	4119183	7	19	7	14	4
371151	4119433	5	15	12	17	5
371151	4119933	15	41	5	20	6
371151	4119683	3	12	19	22	7
368901	4119433	11	16	11	22	8
369651	4118933	16	18	8	24	9
371401	4119933	12	15	13	25	10

Where the variables are defined as:

Dv_rank - is the rank with regard to normalized DV (highest DV is rank 1).

Ndays - is the number of days that the receptor is the highest concentration for the day.

Ndays_rank - is the rank of the receptor with regards to ndays (sorted highest ndays to lowest)

Score1 - is the sum of dv_rank and ndays_rank

Score_rank - is the rank of the scores (lowest total score = rank 1)

Figure 7 illustrates the results of using this scoring strategy on the case example. In the figure, each receptor is color coded by calculated score (Score1), not the score ranking (score_rank).

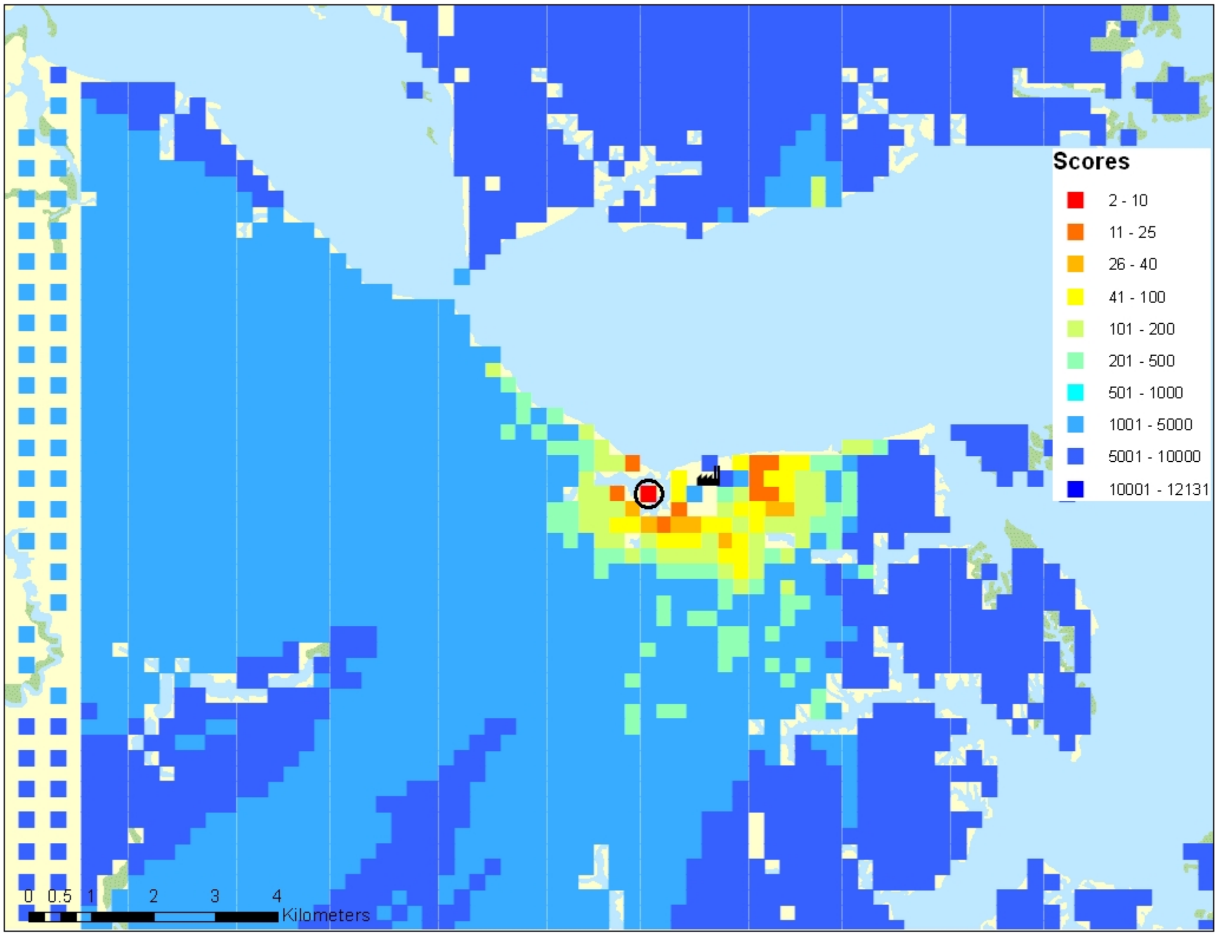

Figure 7. Receptors ranked by relative score reflecting NDV and frequency of having the 1-hour daily maxima amongst all receptors. Lower numerical scores indicate higher probability of experiencing peak 1-hour SO2 concentrations in the modeled domain.

A.3 Model Conclusions

In this example (and any other case where monitoring is elected to characterize air quality pursuant to the anticipated data requirements rule), at least one monitor would be expected to be sited and operated. The primary target for our example network design would be to first find a location at or very near the receptor having both the highest NDV and frequency of 1-hour daily maxima, indicated by a low score in the scoring strategy provided and illustrated above, which is just west of the SO_2 source. Additional monitors could also be considered in the area on the east side of the facility and possibly across the river to the north. The area to the east of the facility has relatively high NDVs in a different cardinal direction (i.e., a different wind direction) from the SO_2 source compared to the first potential site. The receptor locations on the north side of the river, while not having as high NDVs as areas immediately around the source, do appear to see some plume impacts on a higher frequency. This is not to say that one or both of these possible additional areas to the east and north should or would end up being feasible or otherwise warranted monitoring locations, but typical logistical issues not withstanding (i.e., access, power, safety concerns, etc.), their consideration should included in an evaluation. The EPA encourages air agencies to evaluate potential sites in this way, using the available model predictions, potential for population exposure, and other logistical metrics in laying out a rationale of why a certain number sites should be implemented.

In general, the example analyses presented here provides a potential template for using modeling to inform monitoring site placement. Following this procedure will provide air agencies with information to begin evaluating specific areas to determine where SO_2 monitors might be placed to characterize air quality around an SO_2 source. Further, there will be an expectation that due diligence will be carried out to get as close as possible to the location or locations anticipated to have the peak or otherwise highest NDVs available to them. The EPA expects air agencies to provide a rationale based on the available data on whether these monitoring sites are appropriate. As noted above in Section 3.1, the EPA recognizes that increasing the number of monitoring sites around a single facility can present resource and logistical burdens. However, the benefits of considering multiple monitor sites include increased spatial representation, increased population exposure coverage, and the potential to increasingly capture and characterize some portion of the emissions from the identified SO_2 source. Even in situations where the measured concentrations at any given monitor are not the peak values that would be driving the design values in the area, the characterization of SO_2 concentrations around the SO_2 source are enhanced, furthering the understanding of exposures and dispersion in that area. These data will allow for a more complete understanding of the likely SO_2 concentration gradients in an area, increased understanding of the frequency at which certain locations see SO_2 concentration maxima, and increased detail and confidence in any NAAQS determination activity.