2015 AIR MONITORING NETWORK ASSESSMENT

Sacramento Metropolitan Air Quality Management District

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2015 AIR MONITORING NETWORK ASSESSMENT
SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT

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EXECUTIVE SUMMARY

A network assessment was performed for Sacramento Metropolitan Air Quality Management District (SMAQMD) to determine if the monitoring network is meeting the required objectives, which are:

(1) to establish regulatory compliance with ambient air quality standards;
(2) to develop a scientific understanding of air quality, including spatial and temporal distribution of emissions, historical trends in air quality, identification and quantification of emission source contributions, input to and evaluation of air quality models, population exposure to poor air quality, and design and evaluation of the effectiveness of control strategies; and
(3) to provide the public with air quality information that includes air quality forecasts, air quality episodes that affect public health, and current air quality conditions.

These objectives, and the technical qualities of the monitoring network, were assessed using two primary methods: site-to-site and bottom-up, as presented in EPA's Ambient Air Monitoring Network Assessment Guidance, Analytical Techniques for Technical Assessment of Ambient Air Monitoring Networks. The overall approach when performing each analysis method was to rank the sites from high to low that best met the specified objectives for each analysis technique. The results of each analysis were evaluated and viewed in aggregate in light of the overall monitoring objectives.

Each pollutant monitor was analyzed for importance based on the site-by-site analysis technique. Individual monitors were ranked based on the relevant metrics for each monitor/site. For each analysis technique, each monitor was given a score, the scores were summed, and the monitors were ranked based on these scores. Monitors with the lowest ranking were examined carefully to identify network redundancies or possible relocation.

Site-to-Site Assessment Methodology

Summarized below are the analyses performed for the site-to-site assessment.

- **Area-Served** - The purpose of the area-served analysis was to estimate the spatial coverage of each monitoring site to identify potential spatial gaps or redundancies in the network. Thiessen polygons were applied as a standard technique to assign a zone of influence surrounding a given point (monitoring sites for this analysis). Monitors with the largest areas of influence were ranked highest.
- **Population-Served** - The purpose of the population-served analysis was to determine the population coverage represented by each monitoring site and to identify the sites surrounded by high population densities. Monitors serving the largest population were ranked highest. Likewise, monitors that served the largest sensitive or vulnerable populations were ranked highest.
- **Population Change** - High rates of population increase are associated with increased potential emissions activity and exposure. Population change was calculated as the difference between the five-year (2009 through 2013) American Community Survey (ACS) population estimate and the 2010 Census at the block-group level. Monitors with the largest net increase in population were ranked highest.
- **Emissions-Served Analysis** - The emissions-served analysis examined the quantity of pollutants emitted within each monitor's area of influence. Spatially resolved emission inventory data from 2012 for the Sacramento nonattainment area were used to determine how emissions relate to monitors. Monitors were ranked on the average emissions-served, with the highest emissions

values being ranked highest. Seasonal emissions were analyzed for ozone (summer) and 24-hour $PM_{2.5}$ (winter).

- **Measured Concentration -** The objective of the measured concentration analysis was to identify the location of the maximum concentration. Individual monitors within SMAQMD's network were ranked according to the pollutant concentrations measured. Design values for each monitor were calculated utilizing monitoring data from 2005 through 2014. Monitors with higher design values were ranked highest.
- **Deviation from NAAQS -** The deviation from the National Ambient Air Quality Standard (NAAQS) analysis provided an indication of which sites were important for monitoring NAAQS compliance. Sites which measured concentrations (design values) that were very close to NAAQS were considered more important for determining attainment status than sites that were well above or well below the NAAQS. Monitors with design values closest to the NAAQS were ranked highest, with those above the standard being higher ranked than those below the standard.
- **Trend Impact -** The trend analysis assessed the historical record of monitors located within the network. Monitors with a long historical record of data were considered to be more valuable to the network for tracking pollutant trends and control strategy effectiveness. In this analysis, monitoring sites within SMAQMD's network were ranked based on the number of years of continuous measurement for each pollutant measured. Monitoring sites with the longest active historical record were ranked highest.
- **Monitor-to-Monitor Correlation -** The monitor-to-monitor correlation technique determined the temporal correlation between monitors through a regression analysis. Raw data from 2005 through 2014 for each SMAQMD pollutant monitor were compared, using the Pearson correlation coefficient, to other monitoring sites within the network or outside the network but representing a portion of Sacramento County. Monitors were ranked on a cumulative score of maximum correlation value with any one monitor in the network and average correlation values with all monitors in the network, with lowest correlation values being highly ranked.
- **Removal Bias -** Removal bias sensitivity analysis determined monitor importance by the change in spatial concentrations interpolated across the SMAQMD area as each monitor was removed. The Natural Neighbor gridding technique was utilized to interpolate the most recent design values between monitor locations. Monitors having the highest change in concentration when removed from the network were ranked highest in importance.

Sites not included in any analyses listed above (due, for example, to limited operational history) were given a rank half of the number of monitors being analyzed to be used in the cumulative ranking.

Bottom-up Assessment Methodology

The bottom-up method examined the phenomena that are thought to contribute to or cause high pollutant concentrations and/or population exposure, such as meteorology, emissions, and population density. Multiple data sets were combined using spatial analysis techniques to determine optimum site locations. These optimum site locations were compared to the current network to identify deficiencies in the network. Suitability modeling was performed which identified suitable monitoring locations based on monitoring objectives and determine locations for potential additional monitoring sites or to assess existing monitor locations.

Many of the analyses (measured concentration, deviation from NAAQS, and removal bias) required the calculation of pollutant design values. A design value is the mathematically determined pollutant concentration at a particular site that must be reduced to, or maintained at or below, the NAAQS to assume attainment. Calculation methods for each pollutant and averaging period were found in 40 CFR Part 50, Appendices A through U.

Site-Specific Assessments

SMAQMD's ambient air monitoring network was evaluated for ozone (O_3), particulate matter less than or equal to 2.5 microns ($PM_{2.5}$), particulate matter less than or equal to ten microns (PM_{10}), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), lead (Pb), meteorological, and Photochemical Assessment Monitoring Stations (PAMS) measurements. There are a total of 12 ambient air monitoring sites (including SMAQMD's Bercut Drive, which started data collection in November 2015) located within Sacramento County. Table E-1 lists each monitoring site and the pollutants measured within the SMAQMD network. Conclusions regarding the monitors for each pollutants follow Table E-1.

Table E-1 SMAQMD Monitoring Network and Parameters Measured

#	Site Name	Criteria Pollutant							Met.	PAMS
		O_3	$PM_{2.5}$	PM_{10}	NO_2	CO	SO_2	Pb		
1	Sacramento-Branch Center Rd.			X						
2	Sacramento-Bercut Dr.		X[1]		X	X			X	
3	Elk Grove-Bruceville Rd.	X	X		X				X	X
4	Sacramento-Del Paso Manor	X	X	X	X	X	X	X	X	X
5	Folsom-Natoma	X	X		X				X	X
6	Sacramento-Goldenland Ct.	X		X	X	X			X	X
7	North Highlands-Blackfoot Way	X		X	X	X				
8	Rancho Seco		X							
9	Sloughhouse	X	X						X	
10	Sacramento-Health Department		X	X						
11	Sacramento-T Street	X	X	X	X				X	
12	Walnut Grove Tower	X							X	

[1]$PM_{2.5}$ will be added to the site winter 2016.

Ozone

There are eight ozone monitoring stations located within the SMAQMD network. Six of the monitoring sites (Elk Grove-Bruceville Rd., Sacramento-Del Paso Manor, Folsom-Natoma, Sacramento-Goldenland Ct., North Highlands-Blackfoot Way, Sacramento-Health Department) operate under the State and Local Air Monitoring Stations (SLAMS) designation while one monitoring site, Walnut Grove Tower, is designated as a Special Purpose Monitor (SPM) tasked to measure the vertical distribution of ozone concentrations. The Sacramento-T Street monitor is operated by the California Air Resources Board (CARB). Spatial analysis techniques (area-served, population-served, emissions-served, and removal bias) were applied to all of these monitors.

Results of the suitability modeling and site-by-site analysis for the ozone monitoring network were combined to evaluate monitor placement. T-Street, Del Paso Manor, Goldenland Court, and Elk Grove-Bruceville were the top four locations for ozone monitor placement. Although having low rankings for the site-to-site analysis, Sloughhouse and Folsom-Natoma are considered important to the network based on the concentration design values being monitored at the sites. Ozone forms through photochemical reactions in the presence of precursor pollutants and sunlight. These photochemical reactions take time and the air masses typically get transported away from emission sources before ozone forms. Both sites are located downwind of the urban core, providing sufficient time for photochemical reactions to occur and resulting in high concentrations of ozone. Because those two sites have the highest concentrations in the county, the attainment status of the county currently depends on those stations.

SMAQMD's ozone monitoring network was found to meet federal requirements and adequately supports SMAQMD monitoring objectives. One site, Goldenland Court, was found to reproduce redundant data with other monitors in the network and is recommended for removal.

$PM_{2.5}$

There are a total of eight $PM_{2.5}$ monitoring stations located within Sacramento County. Six of the monitoring sites (Sacramento-Bercut Drive, Elk Grove-Bruceville Rd., Sacramento-Del Paso Manor, Folsom-Natoma, Sloughhouse, Sacramento-Health Department) operate under the SLAMS designation while one monitoring site, Ranch Seco, is designated as an SPM which measures seasonal particulate concentrations. A near-road monitor is expected to be installed at the Bercut Drive monitoring site in 2016.

With the exception of the Sacramento-Health Department site, all sites operate a continuous monitor which is important for determining the Air Quality Index (AQI) and disseminating real-time particulate data to the public.

The results of the suitability modeling and site-by-site analysis for the $PM_{2.5}$ monitoring network showed Sacramento-Health Department, Del Paso Manor, and Elk Grove-Bruceville were the top three locations for $PM_{2.5}$ monitor placement. Sacramento-Health Department was the highest scoring in terms of monitor placement and the third highest rank for the site-by-site analysis. However, $PM_{2.5}$ and PM_{10} are the only pollutants being measured at the Health Department site, and results of the correlation analysis show that measurements made at the site may be redundant with T Street and Del Paso Manor. Due to the potential redundancies and the importance of T Street to the O_3 and NO_2 monitoring networks, the Health Department $PM_{2.5}$ monitor is recommended for removal.

The current $PM_{2.5}$ monitoring network meets all federal requirements and adequately supports SMAQMD's monitoring objectives and the suggested removal of the Health Department site is the only change recommended for the network.

PM_{10}

There are a total of six PM_{10} monitoring stations located within Sacramento County. Each monitoring site operates as part of the SLAMS network. Two sites—Goldenland Court and Sacramento-Health Department—operate continuous monitors which are important for determining the AQI and disseminating real-time particulate data to the public. All sites operate filter-based Federal Reference Method (FRM) monitors. Del Paso Manor also measures coarse fraction particulate ($PM_{10-2.5}$).

Results of suitability modeling and site-by-site analyses for the PM_{10} monitoring network showed Health Department, T Street, and Branch Center Road were the highest ranked locations for PM_{10} monitor placement. However, the area of influence from these sites extends to the south end of the county with the next nearest site located in Stockton, California. Thus, it is being recommended that a PM_{10} monitor be installed at the Elk Grove-Bruceville monitoring site to measure regional background concentrations. The Goldenland Court and Health Department PM_{10} monitors are recommended for removal due to redundant measurements with T Street and Del Paso Manor. Continuous monitors at these sites should also be considered for relocation for AQI and public information purposes. As it stands, the PM_{10} network meets all federal requirements and adequately supports SMAQMD's monitoring objectives.

NO_2 Network

There are a total of seven NO_2 monitoring stations located within Sacramento County. SMAQMD recently installed the seventh monitoring station, Sacramento-Bercut Drive, which started collecting NO_2 data in November 2015. Suitability modeling and site-by-site analysis results for the NO_2 monitoring network showed Sacramento-T Street and Del Paso Manor were the top two locations for NO_2 monitor placement for characterizing air quality in the county. Monitor-to-monitor correlation tests between Goldenland Court and T Street show the two sites are making redundant measurements.

SMAQMD currently operates one NO_2 near-road monitor at the Bercut Drive site. Annual Average Daily Traffic (AADT) counts from 2014 show Sacramento County has triggered the 250,000 AADT threshold for a second near-road monitoring site to be installed within the Sacramento Core Based Statistical Area (CBSA).

Recent changes to the ozone NAAQS require National Core (NCore) sites in CBSAs with a population greater than 1,000,000 people to make PAMS measurements. As it pertains to NO_2, the NCore site is required to monitor for true or direct NO_2. EPA believes the methods developed to measure true or direct NO_2 provide very accurate readings of NO_2 without issues characteristic of analyzers which measure NO_2 using the difference method. Del Paso Manor is part of the NCore monitoring network and is currently configured to measure NO_2 using an analyzer capable of measuring true NO_2. Thus, the Del Paso Manor monitoring site is already meeting the requirement to measure true NO_2.

The current NO_2 monitoring network adequately supports SMAQMD's monitoring objectives. The Goldenland Court NO_2 monitor is recommended for removal since the analyses showed it to be making redundant measurements with T Street. As previously discussed, SMAQMD should consider the addition of a second near-road monitor to the network.

CO Network

There are four CO monitoring stations located within Sacramento County including the Bercut Drive near-road monitoring station which began monitoring for CO in November 2015. Site-to-site and suitability modeling results showed Del Paso Manor and Bercut Drive to be the highest ranking locations for CO monitor placement. No sites in the network have measured an exceedance of the current NAAQS over the past 10 years. Measurements of CO are required at Del Paso Manor (NCore) and Bercut Drive (near-road monitor). The CO monitor at Goldenland Court is recommended for removal since this site is not required for CO, and (as noted above) the site makes redundant measurements of ozone, PM_{10}, and NO_2. Otherwise, the CO monitoring network meets federal requirements and adequately addresses SMAQMD's monitoring objectives.

SO_2 Network

There is only one site in the SMAQMD network, Sacramento-Del Paso Manor, which monitors SO_2. All NCore stations, like Sacramento-Del Paso Manor, are required to measure SO_2. Low county-wide emissions and low monitored concentrations suggest there is not a need for additional SO_2 monitors to be added to the network. The SO_2 network meets federal requirements and adequately supports SMAQMD's monitoring objectives.

Lead (Pb) Monitoring Network

As of 2014, there is only one site, Sacramento-Del Paso Manor, in the SMAQMD network monitoring characterizing Pb pollution with respect to the NAAQS in the Sacramento Metropolitan Statistical Area (MSA). Low monitored concentrations and a lack of emission sources triggering source-oriented monitoring requirements suggest no additional monitors are required to be added to the network. The Pb monitoring network meets federal requirements and supports SMAQMD's monitoring objectives.

Meteorological Monitoring Network

Meteorological data collected throughout the network adequately support SMAQMD monitoring objectives. Meteorological towers and sensors are properly located at ambient air monitoring sites to determine pollutant transport. The Goldenland Court monitoring station is recommended for removal based on redundant measurements of ozone, PM_{10}, and NO_2; the meteorological tower at Goldenland Court may be considered for relocation to the North Highlands-Blackfoot monitoring site to aid in the understanding of pollutant transport at this station. Additional meteorological measurements are required as part of the Del Paso Manor NCore site design to support photochemical modeling and PAMS monitoring objectives.

PAMS Monitoring Network

There are four ambient air monitoring sites (Sacramento-Del Paso Manor, Elk Grove-Bruceville, Folsom-Natoma, and Sacramento-Goldenland Court) that make PAMS measurements in Sacramento County. These sites have historically supported photochemical modeling and research efforts for understanding ozone formation. With recent updates to the PAMS monitoring requirements, the Del Paso Manor PAMS monitoring site is now the only site required to be a part of the federal PAMS monitoring network. However, retaining other stations to make PAMS measurements may be valuable in terms of air quality and meteorological modeling applications.

Conclusion

The network as it is currently configured is sufficient for characterizing general background, regional transport, and urban air quality while meeting all federal requirements and SMAQMD monitoring objectives. Monitoring sites are properly positioned to capture maximum concentrations of stable pollutants (CO, NO_x, PM, and SO_2) near emission sources and are properly located in areas where maximum concentrations of pollutants formed through photochemical reactions (O_3, $PM_{2.5}$) are captured. Ambient air quality is sufficiently characterized in areas with high population as well as areas with a high occurrence of sensitive and vulnerable populations, and the public has access to real-time and historical air quality and meteorological data through SMAQMD's *Spare the Air* website.

As presented above, a few recommendations, based on the analyses performed, are made in this assessment to further support the monitoring objectives of SMAQMD and to satisfy current regulation.

1.0 INTRODUCTION

In October 2006[1], the U.S. Environmental Protection Agency (EPA) finalized an amendment to the ambient air monitoring regulations. The goal of the amendments was to enhance ambient monitoring networks to better serve current and future air quality management and research needs. As part of the amendment, EPA required that states or local air monitoring agencies conduct a network assessment once every five years to determine, at a minimum, if the monitoring network meets the monitoring objectives as defined in Title 40 Code of Federal Regulations (CFR) Part 58, Appendix D. This requirement is an outcome of implementing the 2005 National Ambient Air Monitoring Strategy (NAAMS). The purpose of the NAAMS is to optimize monitoring networks to achieve the best possible scientific value and protection of public and environmental health and welfare utilizing limited resources.

Per Appendix D, the network assessment must consider the ability of existing and proposed sites to support air quality characterization for areas with relatively high populations of sensitive or susceptible individuals (children, asthmatics, disadvantaged communities) and, for any sites that are being proposed for discontinuance, the effect on data users other than the agency itself. This network assessment included (1) re-evaluation of the network, including whether it meets monitoring objectives and whether existing sites are still needed; (2) evaluation of the network's effectiveness in meeting the monitoring objectives for areas with high populations of sensitive individuals; (3) evaluation of the effect of proposed closures on users of monitoring data, such as nearby states, tribes, and health effect studies; and (4) development of recommendations for network reconfigurations and improvements, including whether new technologies are appropriate for incorporation into the ambient air monitoring network.

To satisfy the requirements of 40 CFR Part 58.10(e), EPA's network assessment mandate, the Sacramento Metropolitan Air Quality Management District (SMAQMD) contracted with Trinity Consultants to perform an assessment of the SMAQMD air and meteorological monitoring networks. The work activities, methodology, and techniques used in the assessment, as agreed upon by SMAQMD and Trinity, are a subset of the analysis methods prescribed in EPA's network assessment guidance document[2].

1.1 Background

Since ambient monitoring objectives, regulatory requirements, and demographics change over time, air agencies need to reevaluate and potentially reconfigure their monitoring networks to address these changes. Several factors contribute to the ever-evolving monitoring objectives, which include the following:

- Changes in air quality monitoring objectives,
- Improvements in air quality,
- Changes in population and behaviors, and
- Advances in scientific understanding of air quality.

[1] US EPA Revisions to Ambient Air Monitoring Regulations; Final Rule, FR Vol. 71, No. 200, October 17, 2006.
[2] US EPA Ambient Air Monitoring Network Assessment Guidance, Analytical Techniques for Technical Assessments of Ambient Air Monitoring Networks, EPA-454/D-07-001, February 2007.

As a result of these changes, air monitoring networks in some areas may have unnecessary or redundant monitors or may be placed at ineffective monitoring locations for some pollutants, while other regions may lack the necessary monitors altogether. Changes to the National Ambient Air Quality Standards (NAAQS), such as the lowering of the 8-hour ozone (O_3) standard, motivate air agencies to examine their monitoring activities and to refocus monitoring resources on pollutants of interest, such as O_3 and its precursors, particulate matter less than or equal to $PM_{2.5}$ microns in size ($PM_{2.5}$), and certain air toxics.

Agencies are also more cognizant in designing networks which protect the public and the environment while maintaining the ability to understand long-term historical air quality trends. Air monitoring agencies can also take advantage of improved scientific understanding of air quality issues as well as implement new air monitoring technologies into their monitoring networks.

Monitoring networks should be designed to address multiple, interrelated air quality issues and to support other types of air quality assessments, such as emission inventory assessments or photochemical modeling. Reconfiguring air monitoring networks to meet the needs of current air quality issues or research enhances their value to the general public, stakeholders, and scientists.

1.2 Network Assessment Objectives

Sacramento County is located in the middle of California's Central Valley and at the southern end of the Sacramento Valley. The objectives of the SMAQMD air monitoring stations are to collect ambient air quality and meteorological data to be used for several purposes, including the following:

- To establish regulatory compliance with ambient air quality standards;
- To develop a scientific understanding of air quality, including spatial and temporal distribution of emissions, historical trends in air quality, identification and quantification of emission source contributions, input to and evaluation of air quality models, population exposure to poor air quality, and design and evaluation of the effectiveness of control strategies; and
- To provide the public with air quality information that includes air quality forecasts, air quality episodes that affect public health, and current air quality conditions.

The goal of the SMAQMD monitoring network is to ensure that its network is capable of effectively characterizing air quality and meteorology in the region and that it meets its monitoring objectives.

1.3 Network Overview

The SMAQMD is the public agency responsible for development, implementation, monitoring, and enforcement of air pollution control strategies in Sacramento County, including its incorporated cities. SMAQMD is part of a larger area, called the Sacramento Federal Ozone Non-Attainment Area (SFNA). The SFNA is designated by the EPA as a "severe" non-attainment area for the eight-hour O_3 standard. In addition to the Sacramento Air District, the SFNA includes all or parts of four other districts: El Dorado County Air Quality Management District, Feather River Air Quality Management District, Placer County Air Pollution Control District, and Yolo-Solano Air Quality Management District. After meeting the PM_{10} air quality standard since 2002, U.S. EPA designated Sacramento County as a PM_{10} attainment area in 2013. Sacramento County is in non-attainment for the 24-hour and annual particulate matter 2.5 microns or less ($PM_{2.5}$) standards. Sacramento County is in attainment for the federal carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) standards. The California Air Resources Board (CARB) has recommended to EPA that Sacramento County be designated as unclassified for the 2008 federal lead (Pb) standard.

The primary focus of the current ambient air monitoring network is the collection of O_3 and photochemical pollutant precursors such as oxides of nitrogen (NO_x), volatile organic compounds (VOC), and $PM_{2.5}$. These data are used to support state implementation plan (SIP) development, attainment/non-attainment decisions, air quality modeling efforts, and public notification.

SMAQMD has established a website (*Spare The Air* - www.sparetheair.com) in which the public have access to real-time and historical air quality and meteorological data. The Sacramento Regional Air Quality Index (AQI) and AQI forecast are available on SMAQMD's *Spare The Air* website as well as EPA's AirNow website (www.airnow.gov). Historical air quality and meteorological data collected by the network can also be accessed by the public through EPA's AirData website (www.epa.gov/airdata).

Each SMAQMD monitoring site has monitors that belong to one or more national monitoring networks. State and Local Air Monitoring Stations (SLAMS) are used for supplying general monitoring data for criteria pollutants and determining compliance with the NAAQS. The SLAMS are long-term stations that must meet and follow specific quality assurance, monitoring methodology, sampling objectives and siting requirements. The SMAQMD SLAMS stations have been established with the purpose of determining compliance with NAAQS for the protection of public health.

SMAQMD operates one of the 80 National Core (NCore) Multi-Pollutant Monitoring Stations and one of 132 nation-wide $PM_{2.5}$ Chemical Speciation Network (CSN) monitors. 40 CFR Part 58, Appendix D2 defines NCore criteria as the following: *"The NCore multipollutant sites are sites that measure multiple pollutants in order to provide support to integrated air quality management data needs. NCore sites include both neighborhood and urban scale measurements in general, in a selection of metropolitan areas and a limited number of more rural locations."*

In addition to the criteria pollutants, SMAQMD operates four (4) Photochemical Assessment Monitoring Stations (PAMS) due to the severity of ozone non-attainment classification in Sacramento Metropolitan Statistical Area (MSA). Currently, there is one of each PAMS type I, II, and III sites. There is also a secondary type II site.

Special Purpose Monitoring (SPM) stations are also part of SMAQMD's monitoring network. SPM stations provide additional information needed by state and local air quality agencies to support air program activities and fulfill the objectives of the air monitoring network.

There are ten (10) air monitoring sites currently operated by SMAQMD. An eleventh monitoring site, referred to as the Bercut Drive station, started operation on November 8, 2015. One site, Sacramento-T Street, is currently operated by CARB. Two SMAQMD stations, Walnut Grove tower and Rancho Seco, are exclusively SPM stations tasked for public information and research purposes. The Walnut Grove tower, which collects ozone and meteorological measurements at four levels, is used to understand upper air transport. Rancho Seco measures seasonal $PM_{2.5}$ concentrations for research and forecasting purposes. Data collected from both of these sites are not used in an official capacity, but the locations of the sites were evaluated for placement of official monitoring stations. Table 1-1 presents the current and proposed stations located within SMAQMD's network. Figure 1.1 presents the locations of the stations within the County. Table 1-1 also provides site type (purpose), main site objective(s), and station start date. Table 1-2 presents, by station, the air quality and meteorological parameters measured at each site.

Table 1-1 List of SMAQMD Monitoring Stations, Site Type, and Established Date

#	Site Name	AQS ID	Latitude (˚)	Longitude (˚)	Site Type					Date Established
					SLAMS	PAMS	CSN	NCORE	SPM	
1	Sacramento-Branch Center Rd.	06-067-0284	38.55351	-121.33714	X					04/01/2006
2	Sacramento-Bercut Dr.	06-067-0015	38.59333	-121.50373	X					11/08/2015
3	Elk Grove-Bruceville Rd.	06-067-0011	38.30263	-121.42085	X	X				07/01/1992
4	Sacramento-Del Paso Manor	06-067-0006	38.61380	-121.36801	X	X	X	X	X	01/01/1980
5	Folsom-Natoma	06-067-0012	38.68330	-121.16446	X	X				06/01/1996
6	Sacramento-Goldenland Ct.	06-067-0014	38.65072	-121.50665	X	X				08/12/2008
7	North Highlands-Blackfoot Way	06-067-0002	38.71209	-121.38109	X				X	01/01/1980
8	Rancho Seco	SPM-RS	38.34381	-121.10998					X	11/01/2008
9	Sloughhouse	06-067-5003	38.49448	-121.21113	X				X	07/01/1997
10	Sacramento-Health Department	06-067-4001	38.55633	-121.45850	X					01/01/1985[2]
11	Sacramento-T St.	06-067-0010	38.56844	-121.49311	X		X			12/01/1988
12	Walnut Grove Tower	SPM-WG	38.26444	-121.49056					X	07/19/2009

[1]Sacramento-Bercut Dr. started data collection of carbon monoxide (CO), nitrogen dioxide (NO_2), meteorological parameters, and Black Carbon in November 2015. $PM_{2.5}$ is anticipated to be monitored at the site starting in 2016.

[2]Documentation suggests this station has been operational since the late 1950s. However, the earliest monitor start date in EPA's AQS database is January 1, 1985.

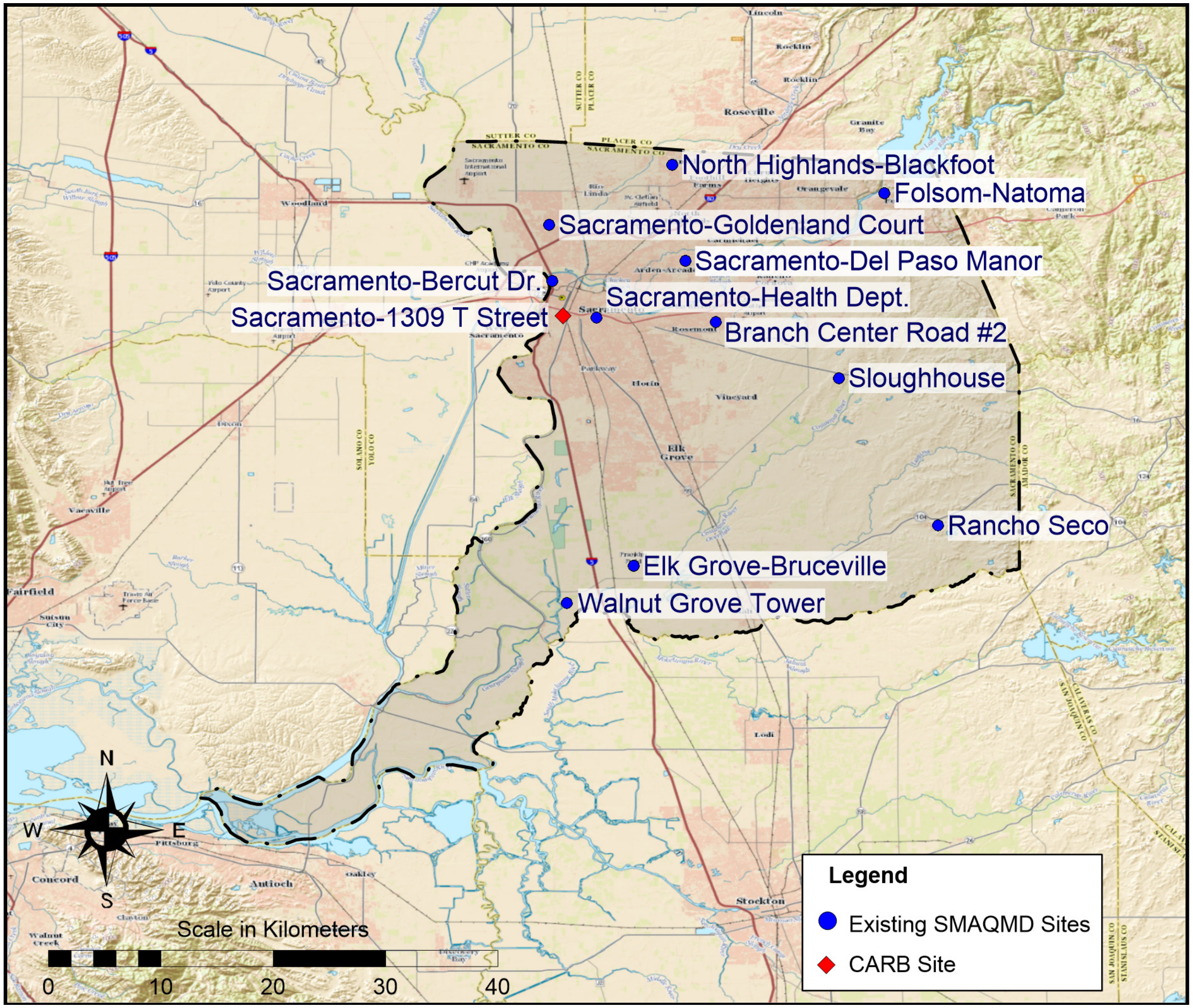

Figure 1.1 Locations of SMAQMD Monitoring Stations

Table 1-2 Parameters Measured at SMAQMD Monitoring Stations

#	Site Name	Parameters
1	Sacramento-Branch Center Rd.	PM_{10}
2	Sacramento-Bercut Dr.	CO, NO_2, BC, T, RH, WS, WD, $PM_{2.5}$ (to be added in 2016)
3	Elk Grove-Bruceville Rd.	O_3, NO_2, Total NMHC, Speciated VOC, $PM_{2.5}$, T, RH, BP, PR, SR, UV, WS, WD, UA Profiler
4	Sacramento-Del Paso Manor	O_3, CO, NO_2, NO_y, SO_2, Total NMHC, SVOC, Carbonyl, PM_{10}, $PM_{2.5}$, Speciated $PM_{2.5}$, Pb, BC, Scattering Coefficient, T, RH, SR, WD, WS
5	Folsom-Natoma	O_3, NO_2, NO_y, Total NMHC, Speciated VOC, $PM_{2.5}$, T, RH, SR, WS, WD
6	Sacramento-Goldenland Ct.	O_3, CO, NO_2, Total NMHC, PM_{10}, T, RH, SR, WS, WD
7	North Highlands-Blackfoot Way	O_3, CO, NO_2, PM_{10}
8	Rancho Seco	$PM_{2.5}$ (Seasonal)
9	Sloughhouse	O_3, $PM_{2.5}$ (Seasonal), WS, WD
10	Sacramento-Health Department	PM_{10}, $PM_{2.5}$
11	Sacramento-T St.	O_3, NO_2, PM_{10}, $PM_{2.5}$, Speciated $PM_{2.5}$, T, RH, BP, WS, WD
12	Walnut Grove Tower	O_3 (five vertical levels), T, WS, WD (five vertical levels), (NO_x to be added in 2016)

2.0 TECHNICAL APPROACH

The overall technical approach for the network assessment of the SMAQMD's criteria pollutant, meteorological, and PAMS monitoring networks was centered on two areas. The first portion of the assessment focused on the ambient air monitoring and meteorological network; the second portion of the assessment focused on the PAMS network. The results of the air monitoring and meteorological analyses as well as the PAMS network assessment were reviewed and evaluated by station, then for the network in its entirety. Recommendations for adjustments to the overall network are presented in Section 4 of this assessment. PAMS network recommendations, also presented in Section 4, follow EPA guidance as found in the final rule for the Ozone NAAQS, signed on October 1, 2015.[3]

A list of network assessment analyses utilized to address the monitoring objectives discussed in Section 1.2 is presented in Table 2-1. The analysis methods listed in Table 2-1 are presented in EPA's Ambient Air Monitoring Network Assessment Guidance, Analytical Techniques for Technical Assessments of Ambient Air Monitoring Networks, February 2007. Objectives listed in Table 2-1 reflect 40 CFR Part 58, Appendix D monitoring requirements based upon MSA/Core Based Statistical Areas (CBSAs).

Two methods—site-to-site and bottom-up analyses—were utilized for assessing the technical qualities of the monitoring network. Site-to-site analyses rank individual monitors based on a particular metric. For the site-to-site comparisons, each monitor for each analysis technique was given a score and the scores were summed and the monitors ranked based on these scores. The monitors with the lowest ranking were examined carefully to identify network redundancies or possible relocation.

The bottom-up method examined the phenomena that are thought to contribute to or cause high pollutant concentrations and/or population exposure, such as meteorology, emissions, and population density. Multiple data sets were combined using spatial analysis techniques to determine optimum site locations. These optimum site locations were compared to the current network to identify deficiencies in the network.

Several analysis methods that address specific objectives and network design requirements were evaluated in the network assessment. These included:

- Does the agency have a preferred method that supports AQI forecasting and reporting?
- Does SMAQMD have the information to answer whether ozone exceedances are NO_x and VOC limited?
- Describe the PAMS data used or that will be used to assess progress in control programs.

The overall approach when performing each analysis method was to rank the sites from high to low that best met the specified objectives for each analysis technique. The results of each analysis were evaluated and viewed in aggregate in light of the overall monitoring objectives. Recommendations in Section 4 of this document were made based on the aggregated results.

[3] http://www.gpo.gov/fdsys/pkg/FR-2015-10-26/pdf/2015-26594.pdf

Table 2-1 Summary of Analyses to be Performed and the Monitoring Objectives Addressed

	Site-by-Site Analyses									Bottom-up Analyses
Parameters Analyzed	Number of Parameters Measured	Trends Impact	Measured Concentrations	Deviation from NAAQS	Area Served	Monitor-to-Monitor Correlation	Removal Bias	Population Served/ Population Change	Emissions Served	Suitability Modeling
Criteria Pollutant Monitors & Meteorology	X	X	X	X	X	X	X	X	X	X
PAMS Sites	X	X	X					X	X	X
Analysis Objectives										
Are air pollutant data disseminated to the public in a timely manner? (i.e. data are available for AQI and forecasting objectives)	X				X	X		X		
Are sites located to measure the highest pollutant concentrations expected to occur in area covered by network?			X	X			X			
Are sites located to measure typical concentrations in areas of high population density?	X							X		
Are sites located appropriately to determine the impact of significant sources on air quality?					X				X	X
Are sites located to determine general background concentrations?			X					X	X	X
Are sites located to determine the extent of regional pollutant transport among populated areas?			X					X	X	X
Are sites located appropriately to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts to support secondary standards?			X		X		X			
Are sites in locations with sensitive populations?	X	X	X	X				X		
Is the meteorological network adequate for characterizing regional surface and upper-air meteorology?	X				X	X				
Which sites provide the most value of pollutants measured, the length of data record, dedicated use?	X	X		X			X			
Are there redundant sites? Are there locations where new monitors could be placed?					X	X	X	X	X	X
Do these data support air pollution research studies? Are data available to researchers to conduct health based studies?	X				X			X	X	

Each pollutant monitor was analyzed for importance based on the site-by-site analysis techniques presented in Table 2-1 above. Below is a list of the analyses included in the site-to-site assessment and how each monitor was ranked.

- Area-Served - Monitors with the largest areas of influence were ranked highest.
- Population-Served - Monitors serving the largest population were ranked highest. Likewise, monitors which had the largest sensitive or vulnerable populations were ranked highest.
- Population Change - Monitors with the largest net increase in population were ranked highest.
- Emissions-Served Analysis - Monitors were ranked on the average emissions-served with the highest emissions values being ranked highest. Seasonal emissions were analyzed for ozone (summer) and 24-hour $PM_{2.5}$ (winter).
- Measured Concentration - Monitors with higher design values were ranked highest.
- Deviation from NAAQS - Monitors closest to the NAAQS were ranked highest with those above the standard being higher ranked than those below the standard.
- Trend Impact - Monitoring sites with the longest active historical record were ranked highest.
- Monitor-to-Monitor Correlation - Monitors were ranked on a cumulative score of maximum correlation value with any one monitor in the network and average correlation values with all monitors in the network, with lowest correlation values being highly ranked.
- Removal Bias - Monitors having the highest change in concentration when removed from the network were ranked highest in importance.
- Sites not included in any analyses listed above were given a rank half of the number of monitors being analyzed.

2.1 Minimum Monitoring Requirements

Federal minimum monitoring requirements (40 CFR, Part 58, Appendix D) were evaluated for the Sacramento–Roseville–Arden-Arcade MSA (Sacramento MSA) which, according to the 2010 census, has a population of approximately 2.2 million persons. SMAQMD's jurisdiction is Sacramento County, which is part of the Sacramento MSA, with a population of approximately 1.4 million persons.

Minimum Requirements for Ozone

A CBSA with a population between 350,000 and 4,000,000 with the most recent three-year design value greater than 85 percent of the ozone NAAQS must have a minimum of two active ozone monitors. Furthermore, at least one ozone site within the MSA must be designed to record the maximum concentration for that particular area. SMAQMD currently has seven (7) SLAMS monitors within its network.

Minimum Requirements for $PM_{2.5}$

CBSAs with a population above 1,000,000 and the most recent three-year design value above 85% of the $PM_{2.5}$ NAAQS must have a minimum of three active $PM_{2.5}$ monitors. SMAQMD currently has three active $PM_{2.5}$ FRM monitors (Del Paso Manor, Health Department, and T Street); one station (Folsom-Natoma) has FEM-designated continuous $PM_{2.5}$ monitors. Five stations (Elk Grove-Bruceville, Del Paso Manor, Rancho Seco, Sloughhouse, and T Street) have non-FEM-designated continuous $PM_{2.5}$ monitors whose data are used for public information and research purposes. An additional $PM_{2.5}$ monitor is anticipated to start collecting data in December 2016 and will be located at the Sacramento-Bercut Drive near-road NO_2 monitoring site.

Minimum Requirement for PM_{10}

CBSAs with a population above 1,000,000 and ambient PM_{10} concentrations less than 80 percent of the PM_{10} NAAQS must have a minimum of two active PM_{10} monitors. There are currently six (6) active PM_{10} monitors located in SMAQMD's network. Two of these sites operate a collocated continuous monitor.

Minimum Requirement for NO_2

Federal regulations require that a minimum of one monitor be placed in any urban area with a population greater than 1,000,000 people to assess area-wide NO_2 concentrations. There are six (6) NO_2 monitoring sites currently operational in SMAQMD's network to characterize area-wide NO_2.

CBSAs with a population above 500,000 are required to place a monitor near a major roadway where maximum concentrations are expected to occur. Additional near-road NO_2 monitoring stations are required for any CBSA with a population of 2,500,000 persons or more, or in a CBSA with a population of 500,000 or more persons that has one or more roadway segments with an Annual Average Daily Traffic (AADT) count of 250,000 or greater. Sacramento-Bercut Drive became operational in November 2015 and has been sited to meet the population-based microscale near-road NO_2 monitoring requirement in 40 CFR 58, Appendix D, Section 4.3.2.

AADT data for Sacramento County from 2014 were obtained from the California Department of Transportation. In 2014, an AADT count of 251,000 was registered along State Route 50 near Junction Route 160 between 15th and 16th Street. This traffic count locations show AADT values are greater than the 250,000 AADT threshold presented in 40 CFR 58, Appendix D, Section 4.3.2(a), requiring a second near-road monitoring site to be located within the Sacramento CBSA.

Minimum Requirement for CO

One CO monitor is required to operate co-located with a required near-road NO_2 monitor in CBSAs having populations greater than 1,000,000. In addition, NCore sites are required to monitor CO. SMAQMD currently operates three (3) CO monitoring locations, with a fourth CO monitor collocated with the Sacramento-Bercut Drive near-road NO_2 monitor. CBSAs required to have a second near-road monitor are required to have only one CO monitor.

Minimum Requirement for SO_2

SO_2 monitoring requirements are determined based on a combination of population and emissions. The Population Weighted Emissions Index (PWEI) is calculated by multiplying the population of each CBSA by the total amount of SO_2 (in tons per year) emitted within the CBSA area, then dividing the resulting product by one million. CBSAs with a calculated PWEI (in million persons-ton per year) greater than 1,000,000 require three (3) SO_2 monitoring sites. A PWEI between 100,000 and 1,000,000 requires a minimum of two (2) monitoring sites, and CBSAs with a PWEI between 5,000 and 100,000 require a minimum of one (1) SO_2 monitoring site. The PWEI for the Sacramento MSA is 2,331 million persons-tons per year, which is based on 1,085 tons of SO_2 emissions[4] obtained from the 2011 National Emission Inventory and the 2010 Census population count of 2,149,127 persons within the Sacramento-Roseville-Arden-Arcade, CBSA. SMAQMD operates one SO_2 monitor at the Sacramento-Del Paso Manor site to satisfy NCore requirements.

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[4] 2011 National Emissions Inventory

Minimum Requirement for Pb

Federal regulations require a lead monitor at NCore sites in CBSAs with more than 500,000 people. Source-oriented monitors are also required for non-airport sources which emit more than 0.5 tons per year or airports which emit more than 1.0 ton per year. There are no emission sources greater than 0.5 tons in Sacramento County. SMAQMD operates one Pb monitor at the Sacramento-Del Paso Manor site to satisfy NCore requirements. There are no sources that trigger source-oriented monitors within Sacramento County.

Minimum Requirement for PAMS and Enhanced Ozone Monitoring

According to 40 CFR Part 58 Appendix D Section 5, state and local monitoring agencies are required to collect and report PAMS measurements at each NCore site in a CBSA with a population of 1,000,000 or more. States with moderate and above 8-hour O_3 nonattainment areas shall develop and implement an Enhanced Monitoring Plan (EMP) detailing enhanced O_3 and O_3 precursor monitoring activities to be performed. The EMP shall be submitted to the EPA Regional Administrator no later than October 1, 2019, or two years following the effective date of a designation to a classification of moderate or above O_3 nonattainment, whichever is later. The EMP will include monitoring activities deemed important to understanding the O_3 problems in the area. Such activities may include, but are not limited to, the following:

1. Additional O_3 monitors beyond the minimally required under paragraph 4.1 of 40 CFR Part 58 Appendix D;
2. Additional NO_x or NO_y monitors beyond those required under 4.3 of 40 CFR Part 58 Appendix D;
3. Additional speciated VOC measurements including data gathered during different periods other than required June, July, and August PAMS monitoring period or at locations other than the NCore station; and
4. Enhanced upper air measurements of meteorology or pollution concentrations.

Currently, SMAQMD has four (4) active PAMS monitoring sites that met the 2006 PAMS monitoring[5] requirements.

2.2 Gather Network, Air Quality, Emissions, Population, and Other Necessary Information for Use in the Network Assessment

For this network assessment, a variety of different data sources and products to evaluate SMAQMD's ambient air monitoring network were utilized. The data products presented are typically illustrated in a graphical format to aid the reader's understanding. Data obtained in support of this network assessment include the following:

- Criteria pollutant concentration monitoring data for each SMAQMD network monitor;
- Meteorological monitoring data for each SMAQMD meteorological station and National Weather Service (NWS) stations located within the District;
- PAMS monitoring data;
- Annual Average Daily Traffic (AADT);
- Gridded emission inventory data for the Sacramento MSA; and
- Population data.

[5] US EPA Revisions to Ambient Air Monitoring Regulations; Final Rule, FR Vol. 71, No. 200, October 17, 2006.

2.2.1 Sources of Data

Ambient monitoring, meteorological, emissions, and population data were obtained from several sources, including SMAQMD, National Climatic Data Center (NCDC), Census Bureau, and EPA. The primary data source for monitoring stations within SMAQMD's network monitoring station data was EPA's Air Quality System (AQS) database, which was accessed through EPA's AirData website. Raw data[6] for all criteria, PAMS (ozone, NO_y, speciated VOC, and total non-methane hydrocarbon [TNMHC]), and air toxic pollutants for each SMAQMD monitoring station were downloaded from AQS for 2005 through 2014. Meteorological data used in the network assessment were obtained from AQS for years 2005 through 2014 as well as from the NCDC[7] for comparison purposes.

Gridded emission inventory data, representing seasonal periods when monitored pollutant concentrations are highest (wintertime for PM and summertime for ozone and NO_x), were provided by the CARB Air Quality Planning & Science Division.

To evaluate total population, population density, and sensitive and vulnerable populations within Sacramento County, spatially resolved population data (at the block level) were obtained from the United States Census Bureau's master address file (MAF)/TIGER database[8]. Sensitive and vulnerable population demographic data were acquired from EPA's EJSCREEN: Environmental Justice Screening and Mapping Tool[9].

2.3 Data Analyses

Data analyses were critical components for determining the effective use of the SMAQMD's monitoring network resources. A comprehensive statistical analysis of the monitoring data obtained in Section 2.2 from 2005 through 2014 was performed to identify potential redundancies of the monitoring data and/or to determine the adequacy of the existing monitoring sites. These analyses consisted of (1) an evaluation of air quality concentrations measured by the network; (2) a monitor-to-monitor correlation and spatial analysis to determine site redundancy; (3) data completeness; (4) a pollutant-by-pollutant comparison to NAAQS; and (5) pollutant-specific summaries assessing individual pollutant objectives.

Many of the analyses (measured concentration, deviation from NAAQS, and removal bias) required the calculation of pollutant design values. A design value is the mathematically determined pollutant concentration at a particular site that must be reduced to, or maintained at or below, the NAAQS to assume attainment. Calculation methods for each pollutant and averaging period are found in 40 CFR Part 50, Appendices A through U. The period that was evaluated for this assessment was the ten-year period from 2005 through 2014. Section 3 of this report includes tables providing the design value(s) for each pollutant, by averaging period and monitoring site. Many of the standards are based on a three-year average (e.g., 2005-2007, 2006-2008, 2007-2009, 2008-2010, 2009-2011, 2010-2012, 2011-2013, 2012-2014). A list of the current NAAQS is found on EPA's NAAQS website[10] and is summarized in Table 2-2.

[6] Data to be found at https://ofmext.epa.gov/AQDMRS/aqdmrs.html.
[7] Data to be found at http://ncdc.noaa.gov/oa/ncdc.html.
[8] Data to be found at http://www.census.gov/geo/maps-data/data/tiger-line.html.
[9] Data to be found at http://www2.epa.gov/ejscreen/download-ejscreen-data.
[10] www.epa.gov/ttn/naaqs/criteria.html

Table 2-2 National Ambient Air Quality Standards

Criteria Pollutant	Averaging Period	NAAQS	Form
Carbon Monoxide (CO)	1-hour	35 ppm	Not to be exceeded more than once per year
	8-hour	9 ppm	
Lead (Pb)	Rolling 3-month Average	0.15 µg/m³	Not to be exceeded
Nitrogen Dioxide (NO_2)	1-hour	100 ppb	98th percentile of 1-hr daily maximum concentration averaged over 3 years
	Annual	53 ppb	Annual mean
Ozone	8-hour	0.070 ppm	Annual fourth-highest daily maximum 8-hr concentration averaged over 3 years
Particulate Matter ($PM_{2.5}$)	24-hour	35 µg/m³	98th percentile averaged over 3 years
	Annual (Primary)	12 µg/m³	Annual mean averaged over 3 years
	Annual (Secondary)	15 µg/m³	
Particulate Matter (PM_{10})	24-hour	150 µg/m³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)	1-hour	75 ppb	99th percentile of 1-hr daily maximum concentration averaged over 3 years
	3-hour (Secondary)	0.5 ppm	Not to be exceeded more than once per year

2.3.1 Number of Parameters Monitored

According to the network assessment guidance, air quality monitoring sites hosting monitors collocated with other measurements are likely more valuable than sites where fewer parameters are measured. Sites were ranked by the number of parameters collected at a particular site. The metric addresses two aspects of monitor value. First, collocated measurements of several pollutants are valuable for many air quality analyses, such as source apportionment, model evaluation, and emission inventory reconciliation. Second, a single site with multiple measurements is more cost-effective to operate than monitors located at several sites.

2.3.2 Measured Concentrations

The objective of the measured concentration analysis was to identify the location of the maximum concentration. Individual monitors within SMAQMD's network were ranked according to the pollutant concentrations measured. Design values for each monitor were calculated utilizing monitoring data from 2005 through 2014 downloaded in October 2015 from the AQS database (as described in Section 2.2 above). Monitors were ranked by design value, with larger design value concentrations ranking higher than smaller design value concentrations.

The results of this analysis were used to determine whether each monitoring site was meeting its objective(s). Monitors with higher design values than the NAAQS were considered more valuable from a compliance and public health standpoint. The measured concentration analysis falls under the site-to-site comparison method and results of this analysis were combined with rankings from other site-to-site analysis techniques at the end of the network assessment for an overall determination of site importance within the network.

A data completeness analysis for each pollutant (by monitoring station), based on the total number of expected samples, was performed and is presented in Appendix A. Substitution methods, as found in 40 CFR Part 50, Appendices N, P, R, S, and T were utilized. Data completeness was calculated by dividing the actual number of reported samples by the expected total number of samples.

2.3.3 Deviation from NAAQS

The deviation from NAAQS analysis provided an indication of which sites were important for monitoring NAAQS compliance. Sites which measured concentrations (design values) that were very close to NAAQS were considered more important for determining attainment status than sites that were well above or well below the NAAQS (see Table 2-2). Thus, design value concentrations close to the standard were ranked highest in this analysis.

The design values for each pollutant were calculated as they impact regulatory compliance. For pollutants with more than one standard, monitors were scored for each standard using the absolute value of the difference between the measured design value and the NAAQS. Ranking was based on the value that was most restrictive. Monitors with the smallest absolute difference were ranked highest. Monitors with higher design values than the NAAQS were considered more valuable from a compliance and public health standpoint than those with design values lower than the standard but with a similar absolute difference.

The deviation from NAAQS analysis falls under the site-to-site comparison method and results of this analysis were combined with rankings from other site-to-site analysis techniques at the end of the network assessment for an overall determination of site importance within the network.

2.3.4 Trend Analyses

The trend analysis assessed the historical record of monitors located within the network. Monitors with a long historical record of data were considered to be more valuable to the network for tracking pollutant trends and control strategy effectiveness. In this analysis, monitoring sites within SMAQMD's network were ranked based on the number of years of continuous measurement for each pollutant measured.

As part of the trend analysis, each monitoring site was evaluated to determine if there was a less than 10% probability that the monitor would exceed 80% of the applicable NAAQS during the next three years based on concentrations, trends, and variability observed during the data period. Exceedance probability was calculated by site for each pollutant and averaging period for applicable NAAQS.

Equation 1 from Section 4 of EPA's Ambient Air Monitoring Network Assessment Guidance was used to calculate the exceedance probability for the trend analysis and is as follows:

$$\bar{X} + \frac{t * s}{\sqrt{n}} < 0.8 * NAAQS \quad (1)$$

where $\bar{X}$ is the average design value for 2005 through 2014, t is the student's t value for the n-1 degrees of freedom at the 90% confidence level, s is the standard deviation of the design values, n is the number of design values, and NAAQS was the standard of interest.

The 90% upper confidence intervals for each pollutant and averaging period were compared to 80% of the applicable NAAQS to assist SMAQMD in its decision-making process.

The trend analysis fell under the site-to-site comparison method and results of this analysis were combined with rankings from other site-to-site analysis techniques at the end of the network assessment for an overall determination of site importance within the network.

2.3.5 Monitor-to-Monitor Correlation

The monitor-to-monitor correlation technique determined the temporal correlation between monitors through a regression analysis. Raw data from 2005 through 2014 for each SMAQMD pollutant monitor were compared, using the Pearson correlation coefficient, to other monitoring sites within the network or outside the network but representing a portion of Sacramento County. Pearson correlation coefficient was used to measure the linear correlation between two variables. The square of the correlation coefficient (R^2) was calculated for each monitoring pair.

Concentration plumes may travel between monitors, leading to similar maximum daily concentrations while the temporal relationship is unique. For example, two monitors in the network could have the same maximum daily concentration though the measured maximum occurred at different times of the day. For this reason, pollutant comparisons were based on the highest sampling frequency reported in EPA's AQS database (hourly or, in the case of filter-based PM monitors, 24-hour). For pollutants reporting hourly concentrations, pollutant comparisons were based on hour-by-hour measurements. At PM sites which have continuous FEM monitors, correlations were evaluated on an hour-by-hour basis with other continuous monitors. At sites with continuous PM FEM monitors as the primary monitor for collecting particulate data, 24-hour concentrations were also evaluated.

Monitoring pairs with a correlation coefficient near one were considered to be highly correlated, while monitor pairs with a correlation coefficient near zero were considered to exhibit unique temporal concentration variation relative to other monitors and were important for assessing local emissions, transport, and spatial coverage. Those monitor pairs that correlated well were considered to be less important to retain (EPA guidance[11] suggests monitors with an R^2 value greater than 0.75 may be redundant).

The monitor-to-monitor correlation analysis fell under the site-to-site comparison method and results of this analysis were combined with rankings from other site-to-site analysis techniques at the end of the network assessment for an overall determination of site importance within the network.

2.3.6 Meteorological Analysis

A meteorological data analysis was performed and meteorological records from the monitoring network were examined. This analysis focused on data from 2005 through 2014 collected throughout the monitoring network.

Annual and seasonal average wind and pollutant roses were constructed for each site to aid in the understanding of wind speed, direction, and frequency. May through October represent the ozone season and November through February represent the particulate season. Wind and pollutant rose plots were generated using Grapher software. These plots show the frequency of wind directions as petal positions around a 16-point compass using color shading to represent speed and pollutant concentration

[11] *Ambient Techniques for Technical Assessments of Ambient Air Monitoring Networks.* February 2007.

distributions. Rose plots were placed on a topographic relief map to illustrate monitoring location, spatial coverage, relationship to nearby datasets, as well as potential influences from topographical features.

The meteorological analysis also examined the transport of pollutants over monitor locations throughout the District. Trajectory analyses were prepared for four days (January 9, 2012; July 12, 2012; August 11, 2012; and December 15, 2013). These days represent periods of elevated concentrations during a typical work day and weekend day (not associated with exceptional events such as fire or holidays) for the winter (elevated PM) and summer (elevated ozone) seasons. The trajectory analyses were performed using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model program developed by the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL).

HYSPLIT was run to generate ten backward trajectories per location. Back trajectories trace the origin of an air parcel in relation to the location where it is currently being measured. Backward trajectories, with a duration of 48 hours, were generated from the origin of each monitoring location and elevation above mean sea level (msl). A total of ten 48-hour backward trajectories were generated every three hours (i.e., 2400, 1800, 1500, etc.) from the end of the day of interest. These trajectories aid the reader in understanding the origin of a parcel of air for the days leading up to arrival at a monitor location. Modeling parcel transportation with HYSPLIT was conducted using Eta Data Assimilation System (EDAS) dataset, which consisted of 40 kilometer (km) gridded data. All layers within the EDAS dataset were utilized and the model default was used for vertical motion.

2.3.7 Area-Served Analysis

The purpose of the area-served analysis was to estimate the spatial coverage of each monitoring site to identify potential spatial gaps or redundancies in the network. Thiessen polygons were applied as a standard technique to assign a zone of influence surrounding a given point (monitoring sites for this analysis). The polygons are a simple quantitative method to determine the areas closest to each monitoring site, of which the nearest site may be a monitor not operated by SMAQMD. A map of the SMAQMD air quality sites and monitoring sites of other agencies adjacent to Sacramento County was compiled and Thiessen Polygons were generated with the GIS software (MapViewer 8). Thiessen polygon boundaries were limited to the boundaries of the jurisdiction of the District.

Thiessen polygons do not take into account terrain within the area of influence. Air quality measured by a monitor may not represent air quality at a location at a much higher elevation within the monitor's area of influence. However, there were no areas within Sacramento County excluded as being represented by a monitor due to complex terrain.

Using the Thiessen polygon technique, some monitors outside of SMAQMD's network were found to be representative of a portion of Sacramento County. Although SMAQMD does not have control over the continued operation of these monitors, non-District monitors were included as part of the assessment if the area of influence was at least half of one percent of the total area of the District (2575.26 km^2). Sites were then ranked based on their area of coverage. Figure 2.1 presents an example of Thiessen polygons developed for the monitoring network. Table 2-3 presents a list of monitors (and pollutants) which were included as part of the assessment.

The area-served analysis fell under the site-to-site comparison method and results of this analysis were combined with rankings from other site-to-site analysis techniques at the end of the network assessment for an overall determination of site importance within the network.

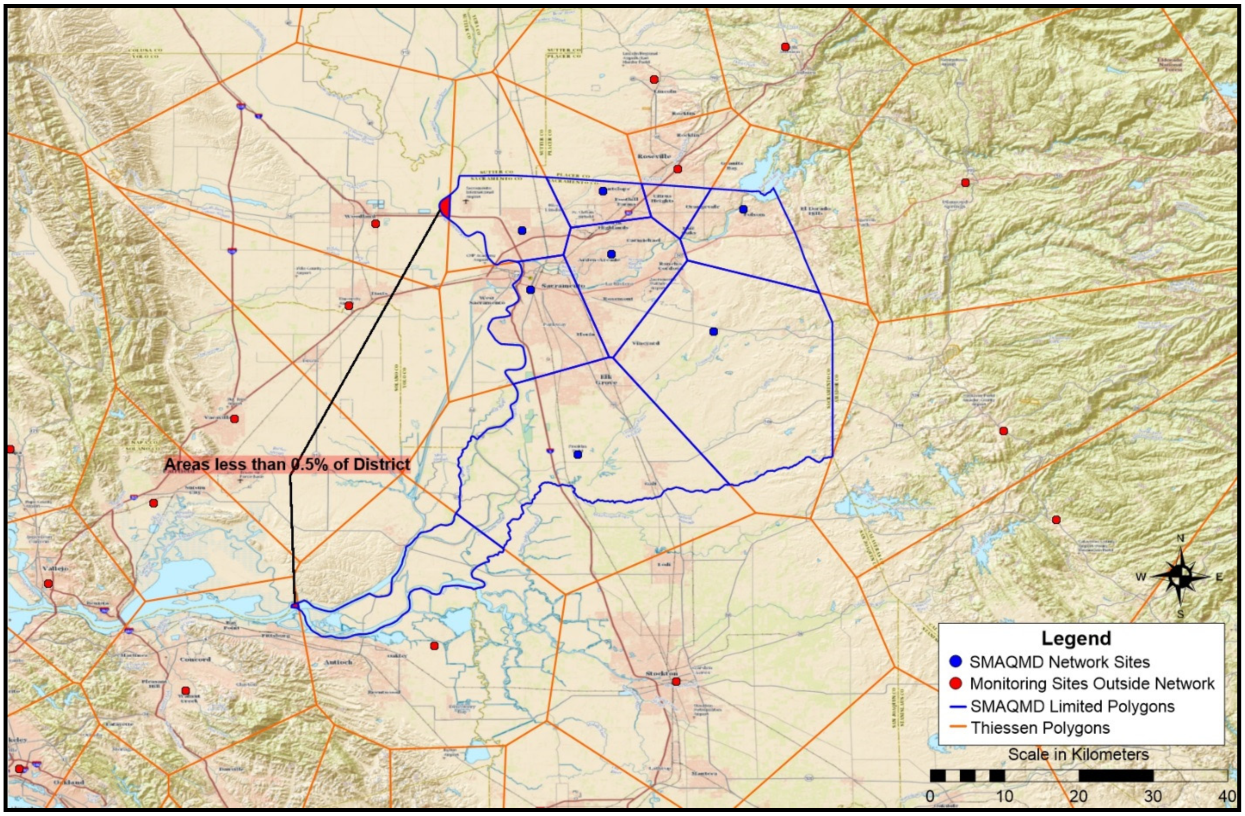

Figure 2.1 Example Area-Served Analysis

Table 2-3 List of Monitoring Stations to be Included in Area-Served Analysis (By Pollutant)[a]

#	Site Name	AQS ID	Latitude (˚)	Longitude (˚)	Criteria Pollutant						
					O_3	$PM_{2.5}$	PM_{10}	NO_2	CO	SO_2	Pb
1	Sacramento-Branch Center Rd.	06-067-0284	38.55351	-121.33714			X				
2	Sacramento-Bercut Dr.	06-067-0015	38.59333	-121.50373		X		X	X		
3	Elk Grove-Bruceville Rd.	06-067-0011	38.30263	-121.42085	X	X		X			
4	Sacramento-Del Paso Manor	06-067-0006	38.61380	-121.36801	X	X	X	X	X	X	X
5	Folsom-Natoma	06-067-0012	38.68330	-121.16446	X	X		X			
6	Sacramento-Goldenland Ct.	06-067-0014	38.65072	-121.50665	X		X	X	X		
7	North Highlands-Blackfoot Way	06-067-0002	38.71209	-121.38109	X		X	X	X		
8	Rancho Seco	SPM-RS	38.34381	-121.10998		X					
9	Sloughhouse	06-067-5003	38.49448	-121.21113	X	X					
10	Sacramento-Health Department	06-067-4001	38.55633	-121.45850		X	X				
11	Sacramento-T St.	06-067-0010	38.56844	-121.49311	X	X	X	X			
12	Walnut Grove Tower	SPM-WG	38.26444	-121.49056	X						
13	Bethel Island	06-013-1002	38.00631	-121.64192	X		X	X	X	X	
14	Concord	06-013-0002	37.93601	-122.02615		X					
15	Stockton-Hazelton	06-077-1002	37.95074	-121.26852					X		
16	Stockton-Wagner/Holt	06-077-3011	38.02963	-121.35403			X				
17	Roseville-N Sunrise Blvd.	06-113-2001	38.74573	-121.26631	X	X	X	X			
18	Woodland-Gibson Road	06-113-1003	38.66121	-121.73269		X	X				

[a] Sites included in this list may monitor other parameters; the sites and pollutants in this list are sites that represent more than half of one percent of Sacramento County's total geographical footprint.

2.3.8 Population-Served Analysis

The purpose of the population-served analysis was to determine the population coverage represented by each monitoring site and to identify the sites surrounded by high population densities. Those sites identified with the greatest populations were ranked highest.

Census data were super-imposed on the area-served polygons. Total population within the areas were extracted and population density was calculated for each monitor's area of influence. The results of this analysis were used to identify areas of high population and the potential need for new monitors, or where population growth has encroached on a monitoring site.

The population-served analysis fell under the site-to-site comparison method and results of this analysis were combined with rankings from other site-to-site analysis techniques at the end of the network assessment for an overall determination of site importance within the network.

A primary objective of the network should be the inclusion of sites located to protect susceptible and vulnerable populations such as asthmatics, children, and disadvantaged communities. EPA developed the EJScreen tool, which evaluates area demographics at a block-group level. The 2015 EJScreen Supplementary Demographic Index (SDI) evaluates demographic characteristics from the American Community Survey (ACS) 2008 through 2012 summary file to represent the "social vulnerability" of a disadvantaged population. SDI is an average of six demographic indicators (% minority, % low-income, % less than high school education, linguistic isolation, % of individuals under age 5, and % individuals over age 64). Not included in this list are asthmatics which do not meet the demographics within the SDI.

Asthmatic persons not covered under the EJScreen demographics were included as part of the vulnerable and disadvantaged population by multiplying the population not covered under the SDI by the percent of active asthma prevalence for ages 5 to 64 (persons below age 5 and above age 64 are included in the EJScreen SDI). The equation below demonstrates how the asthmatic population was included in the modified SDI (MSDI). An example of the calculation is presented in Appendix B.

$$MSDI = SDI + (1 - SDI) * AP_{5-64}$$

Where: AP_{5-64} = is the percent of total population with active asthma for ages 5 to 64.

The California Breathing program within the California Department of Public Health's Environmental Health Investigations Branch has published asthma prevalence data in 2011 through 2012[12] by age, by county. These data show the rate of active prevalent asthma is an average of 9.2% for ages 5 to 64 in Sacramento County. Thus, the number of susceptible, vulnerable, and disadvantaged (SVD) individuals within a block group would be the total population of the block group multiplied by the MSDI with AP_{5-64} equating to 9.2% in the equation above. The MSDI was multiplied by the population (on a block group level) to estimate the number of sensitive or vulnerable persons within each block group.

The U.S. Census Bureau estimates that, in 2014, Sacramento County had a population of 1,482,026. Sacramento County's population in 2013 (concurrent with the latest ACS data) was estimated to be 1,435,207. Figure 2.2 presents the population density (persons/km^2) as well as the sensitive/vulnerable population index (MSDI) by block group.

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[12] Sacramento County Asthma Profile http://www.californiabreathing.org/asthma-data/county-asthma-profiles/sacramento-county-asthma-profile.

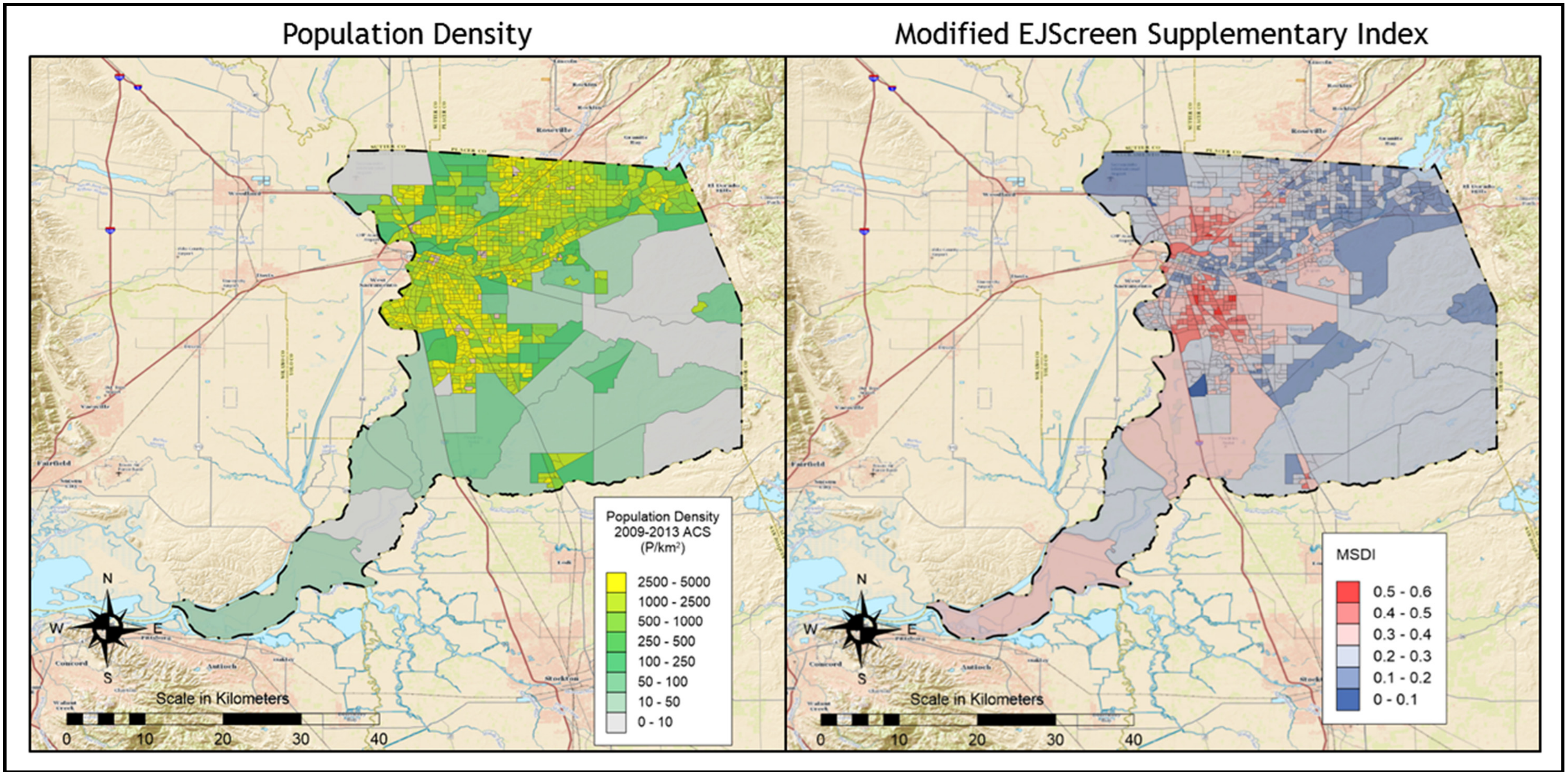


Figure 2.2 Population Density and MSDI by Block Group in Sacramento County

2.3.9 Population Change

High rates of population increase are associated with increased potential emissions activity and exposure. Population change was calculated as the difference between the five-year (2009 through 2013) ACS population estimate and the 2010 Census at the block-group level. Figure 2.3 presents the population change, in persons, between 2010 through 2013 by block group.

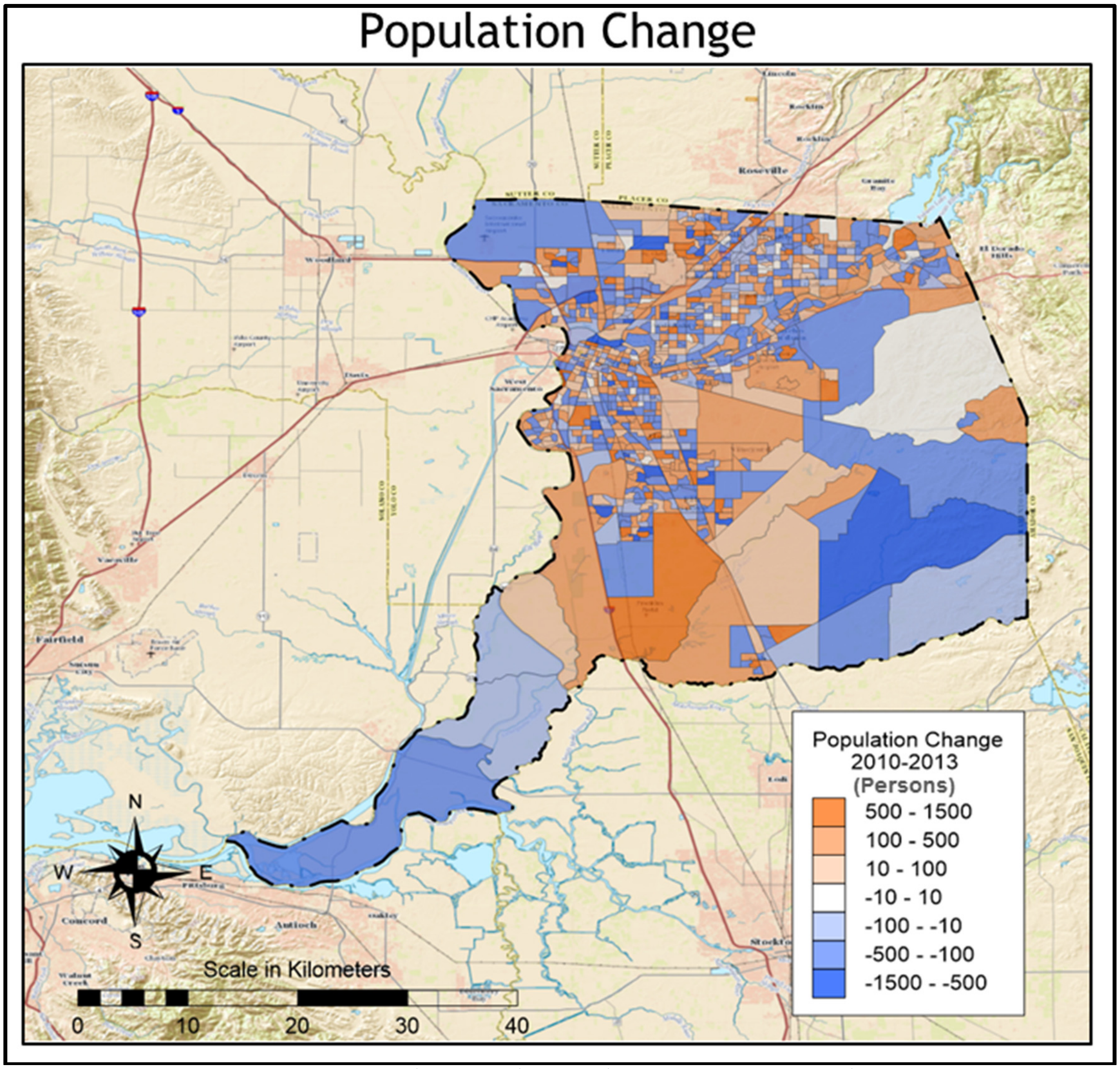


Figure 2.3 Population Change between 2010 and 2013

Similar to the population-served analysis above, change in population was calculated for each monitor's area of representation. Sites were ranked based on total population change within the area of representation determined in the area-served analysis described in Section 2.2.7 (by pollutant monitor). Population change was also evaluated at the block-group level to identify any areas of rapid growth which could be considered as potential locations for new monitors.

2.3.10 Emissions-Served Analysis

The emissions-served analysis examined the quantity of pollutants emitted within each monitor's area of influence. Spatially resolved emission inventory data from 2012 for the Sacramento nonattainment area were used to determine how emissions relate to monitors. These data were used in the Community Multi-scale Air Quality System (CMAQ) by CARB's Air Quality Planning & Science Division for SIP modeling efforts.

CMAQ emissions data were provided for a typical work day and weekend day for the winter (elevated PM) and summer (elevated ozone) seasons. Figure 2.4 presents a map showing the CMAQ gridded $PM_{2.5}$ emission inventory for a typical wintertime weekday and gridded NO_x emissions inventory for a typical summer weekday.

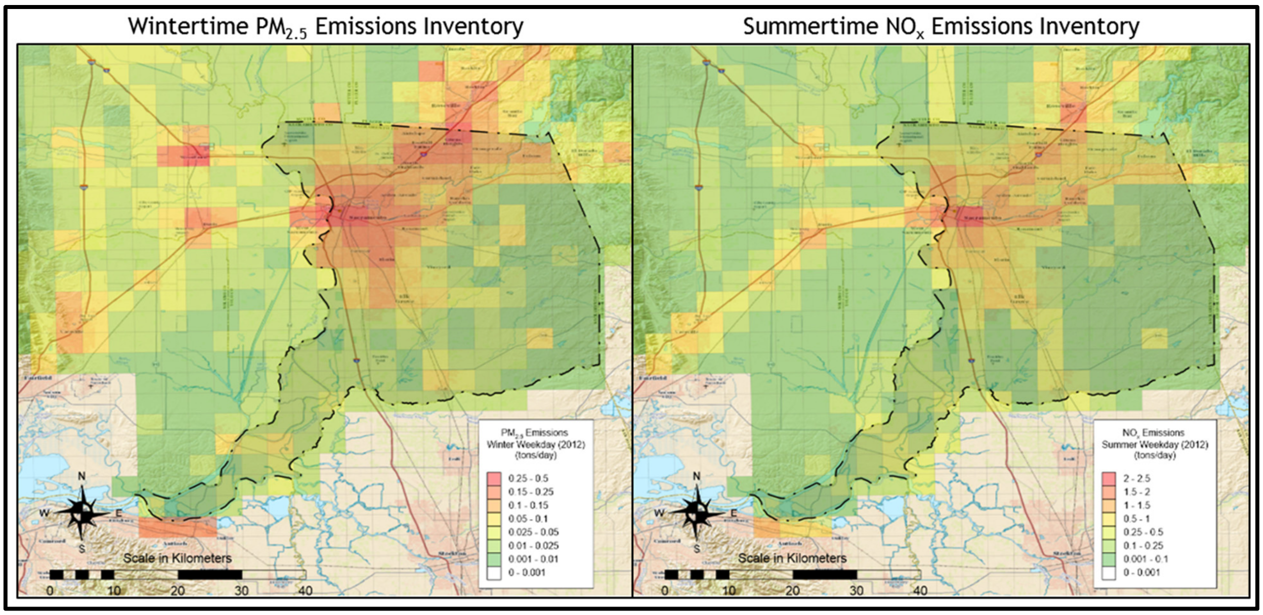


Figure 2.4 Example of Spatially Resolved Emission Inventory

Available spatially resolved gridded emissions data were overlaid onto the area of influence for each monitor to determine potential emissions impacts at each monitoring site. Monitors were ranked by total emissions within the area of influence by each monitor with the highest total emissions being highly ranked.

2.3.11 Removal Bias

Removal bias sensitivity analysis determined monitor importance by the change in spatial concentrations interpolated across the SMAQMD area as each monitor was removed. The Natural Neighbor gridding technique was utilized to interpolate the most recent design values between monitor locations. This technique uses a weighted average of the neighboring observations and generates contours from data sets containing dense data in some areas and sparse data in other areas.

GIS software used in this analysis (MapViewer and/or Surfer) performed mathematical functions between interpolation grids. Interpolations were compared, with and without data from specific monitors, to determine either the bias or uncertainty that results from the removal of those monitors. Greater bias or uncertainty indicated a more important site for developing interpolations to represent concentrations across the domain. Those sites with a low bias indicated that the site was redundant. The sites were ranked by importance. Figure 2.5 presents an example of the removal bias technique showing interpolated design values for all monitors and subtracting the regenerated interpolation grid without one of the monitors.

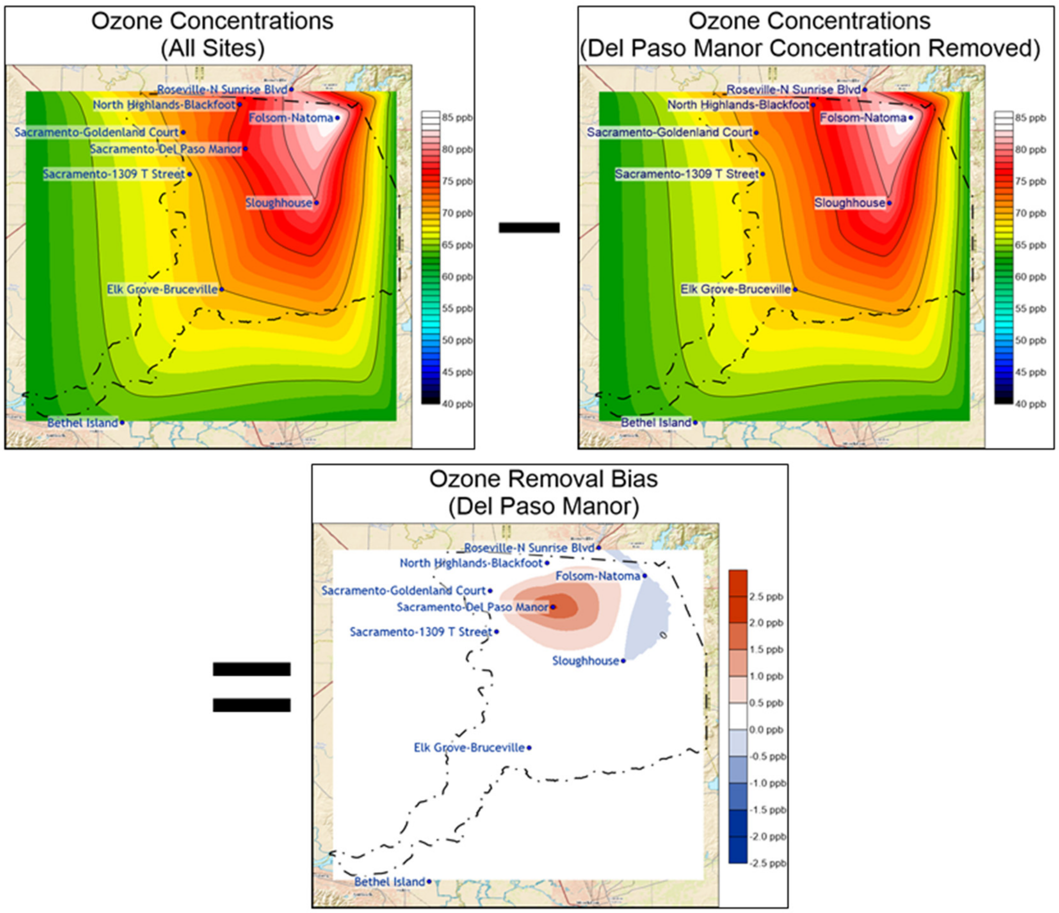


Figure 2.5 Example Removal Bias Analysis

2.3.12 Suitability Modeling

Suitability modeling is a method for identifying suitable monitoring locations based on monitoring objectives. Suitability modeling was used to determine locations for potential additional monitoring sites or to assess existing monitor locations.

This network review utilized GIS software (ArcGIS, MapViewer, and/or Surfer) to combine spatial data layers. Each dataset was gridded to provide a spatial representation of the data. Data layers that were included in the suitability modeling and associated gridding methods are provided in Table 2-4.

Table 2-4 Data Layers and Gridding Methods for Suitability Modeling

Data Layers	Gridding Method	Gridding Method Description
Population Density	Minimum Curvature	Minimum Curvature produces a grid by repeatedly applying an equation over the grid in an attempt to smooth the grid; each pass over the grid is counted as a single iteration. Grid node values are recalculated until successive changes in the values are less than the Maximum Residuals value, or the maximum number of iterations is reached.
Sensitive/Vulnerable Population	Minimum Curvature	
Emission Inventory	CMAQ 4km Grid Cell	Grid nodes will be centered on the centroid of CMAQ grid cells provided by CARB.
Population Change	Natural Neighbor	Natural Neighbor technique uses a weighted average of the neighboring observations and generates contours from data sets containing dense data in some areas and sparse data in other areas.
Measured Concentration	Natural Neighbor	
Deviation from NAAQS	Natural Neighbor	
Exceedance Probability	Natural Neighbor	

Each data grid was normalized (dividing each grid node by the maximum value within the grid) and averaged within the respective category (population, emissions, concentrations). The three categories were then summed to provide an index of 0 to 3 showing ideal locations for potential monitoring and/or whether existing monitors are properly located to characterize pollutants. An index of 0 had the lowest ranking and an index of 3 had the highest ranking.

2.4 PAMS Network Assessment

The PAMS network was developed specifically to characterize upwind, new emissions, and downwind pollutant concentrations within a region for the purpose of understanding ozone precursor emissions, chemical transformation, geospatial ozone patterns, and transport. The objective of a PAMS network is to obtain measurements which will assist States in understanding and addressing ozone nonattainment problems.

EPA has determined that the minimum network that will provide data sufficient to satisfy four (4) monitoring objectives should consist of (1) an upwind and background characterization site; (2) a maximum ozone precursor emissions impact site; (3) a maximum ozone concentration site: and (4) an extreme downwind monitoring site. A PAMS site typically monitors 56 target hydrocarbons and 2 carbonyl compounds, ozone, NO_x and/or NO_y, and meteorological measurements. EPA Region 9 (which consists of California, Arizona, Nevada, and Hawaii) has the most severe ozone areas in the country. SMAQMD has four active PAMS monitoring sites, which are included in Table 1-1.

Several of the analysis techniques presented in Section 2.3 were performed as part of the PAMS network assessment. These included the number of parameters monitored, trend analysis, emission inventory, population change and population served, and suitability modeling. Population-served, emissions-served, and suitability modeling analyses were used to determine if PAMS monitoring sites within the network were properly located to evaluate population exposure to air toxics and to characterize precursor emission sources within the PAMS area and the transport of ozone and precursors into the District.

The trend analysis for the PAMS network consisted of hydrocarbon (VOC and TNMHC) concentrations. Trend analyses for other PAMS monitoring parameters (ozone, nitrogen dioxide, and meteorological) are discussed in Section 2.3.4. Without a specific design value for hydrocarbons, concentrations were averaged over the ozone season (May through September) and grouped by hydrocarbon category (i.e., olefins, paraffins, isoparaffins, oxygenates, naphthalenes, and aromatics). VOC concentrations presented for the ozone season were graphically displayed by year for 2005 through 2014.

On October 17, 2006, EPA established PAMS network requirements which include one Type II site to measure maximum precursor emissions and either a Type I site to characterize air upwind of ozone nonattainment areas or a Type III site to measure maximum ozone. SMAQMD currently operates four PAMS sites to satisfy the 2006 PAMS network requirements. The SMAQMD PAMS network includes a Type I site (Elk Grove), two Type II sites (Del Paso Manor and Goldenland Court), and a Type III site (Folsom-Natoma). One of the key focuses of this assessment was the designated maximum ozone concentration (Type III) site to determine if the site was still capturing maximum ozone concentrations given changes in population and emission sources over time.

On October 1, 2015, the EPA Administrator signed the final rule for the NAAQS for ground-level ozone. The revised eight-hour ozone standard is 0.070 parts per million (ppm) or 70 parts per billion (ppb). As part of the new standard, EPA made revisions to the PAMS network requirements. As found in the October 26, 2015 Federal Register Volume 80, No. 206 (beginning at page 65420), EPA recommends five main areas of assessment. These areas are summarized as follows:

1. Moving PAMS measurements to existing NCore sites. For the SMAQMD, the existing NCore site is located at Sacramento-Del Paso Manor.
2. Preparing an enhanced monitoring plan to be included in the annual monitoring network plan to improve monitoring of O_3, NO_x/NO_y, VOC, and meteorology.
3. Using automatic gas chromatographs (GCs) for the determination of speciated VOCs.
4. Enhancing meteorological stations to collect wind speed, wind direction, temperature, relative humidity, barometric pressure, precipitation, solar and ultraviolet radiation data.
5. Measuring mixing height at the required PAMS monitoring site.

3.0 FINDINGS

An evaluation of SMAQMD's ambient air monitoring was conducted by parameter (O_3, $PM_{2.5}$, PM_{10}, NO_2, CO, SO_2, Pb, meteorological, and PAMS measurements). Each section below provides explanations pertaining to monitoring objectives and spatial scales as well as the determination of the redundancy of sites or the need for additional sites in Sacramento County. The network is designed to meet three basic monitoring objectives: (1) provide air pollution data to the general public in a timely manner; (2) support compliance with ambient quality standards and emissions strategy development; and (3) support air pollution research studies.

3.1 Parameters Measured Analysis

There are a total of 12 ambient air monitoring sites (including SMAQMD's Bercut Drive, which started data collection in November 2015) located within Sacramento County. Each station is categorized as SLAMS, PAMS, CSN, NCore, and/or SPM. Table 3-1 lists the number of parameters, categorized by pollutant type and meteorology, measured at each site within the SMAQMD network. In addition, each station's ranking based on the number of parameters measured is presented.

Table 3-1 Number of Parameters Measured at Each Monitoring Site Located in Sacramento County

Site	Number of Parameters	Rank	Criteria[a]	PAMS	Spec. $PM_{2.5}$	HAPS	Met.	Other
Sacramento-Del Paso Manor	150	**1**	14	49	40	26	8	13
Folsom-Natoma	71	**2**	6	48	0	11	4	2
Sacramento-T Street	59	**3**	9	0	36	10	4	0
Walnut Grove Tower	25	**4**	10[c]	0	0	0	15	0
Elk Grove-Bruceville Road	13	**5**	5	1	0	0	7	0
Sacramento-Goldenland Court	12	**6**	7	1	0	0	4	0
Sacramento-Bercut Drive	7	**7**	2[b]	0	0	0	4	0
North Highlands-Blackfoot Way	6	**8**	6	0	0	0	0	0
Sloughhouse	4	**9**	2	0	0	0	2	0
Sacramento-Health Department	3	**10**	2	0	0	0	1	0
Sacramento-Branch Center Rd.	1	**11**	1	0	0	0	0	0
Rancho Seco	1	**12[d]**	1	0	0	0	0	0

[a] Count includes measurements made by duplicate analyzers.
[b] SMAQMD plans to add $PM_{2.5}$ and Black Carbon to Sacramento-Bercut Dr. in 2017.
[c] SMAQMD plans to add NO_x monitoring to the Walnut Grove tower in 2016.
[d] Rancho Seco and Sacramento Branch Center Rd. each measure only one parameter ($PM_{2.5}$ and PM_{10}, respectively). Rancho Seco was given a lower rank because the monitor is classified as a SPM and measures $PM_{2.5}$ only seasonally.

Monitoring sites collocating measurements of several pollutants are valuable for many air quality analyses, such as source apportionment, model evaluation, and emission inventory reconciliation. Also, a single site with multiple measurements is more cost-effective to operate than monitors located at several sites. Based on the number of parameters measured at each site, Del Paso Manor, Folsom-Natoma, and T Street are the most important monitors within the network.

3.2 Ozone Network

There are a total of eight (8) ozone monitoring stations located within Sacramento County. Seven of the monitoring sites operate under the SLAMS designation while one monitoring site, Walnut Grove Tower, is designated as a SPM tasked to measure the vertical distribution of ozone concentrations at four levels (30 feet, 400 feet, 800 feet, and 1600 feet). Ozone data collected by the Walnut Grove Tower are not used in an official capacity for determination of NAAQS attainment. Thus, Walnut Grove ozone data were excluded from design value calculations and related assessment analyses. Spatial analysis techniques (area-served, population-served, emissions-served, and removal bias) were evaluated to determine the potential for a permanent site.

3.2.1 Ozone Network Spatial Analyses

Thiessen polygons, as described in Section 2.3.7, were generated to determine the spatial representation of each ozone monitoring station located in and adjacent to Sacramento County. Ten (10) ozone monitors were identified as representing a portion of Sacramento County. The following sections present the findings for area, population, and emissions served analyses for the ozone network.

3.2.1.1 Ozone Network Area- and Population-Served Analyses

The population within Sacramento County represented by each monitoring site was counted within the Thiessen polygons using 2009 through 2013 ACS data. Area- and population-served analyses, including sensitive and vulnerable populations, are presented in Table 3-2. Figure 3.1 presents a map showing the location, area of influence, and served population for each ozone monitor.

Table 3-2 Area and Population Served by Ozone Monitors Serving Sacramento County

Site	2013 Population Estimate (Persons)	Population Change from 2010 to 2013 (Persons)	Sensitive/ Vulnerable Population (Persons)[a]	Area (km^2)
North Highlands-Blackfoot	147,903	4,417	39,784	92.96
Sacramento-Del Paso Manor	303,974	1,178	82,400	217.71
Sacramento-1309 T Street	411,171	5,448	141,477	218.44
Elk Grove-Bruceville	157,462	2,939	41,859	476.82
Folsom-Natoma	125,087	445	24,810	202.94
Sacramento-Goldenland Court	143,387	971	44,662	190.82
Sloughhouse	70,062	978	17,863	762.88
Walnut Grove Tower	3,276	-31	979	225.73
Bethel Island	*1,594*	*-390*	*513*	*150.05*
Roseville-N Sunrise Blvd	*71,291*	*464*	*16,234*	*36.93*

Sites located outside Sacramento County are italicized.
[a] Summation of sensitive/vulnerable persons located within the monitor's area of influence.

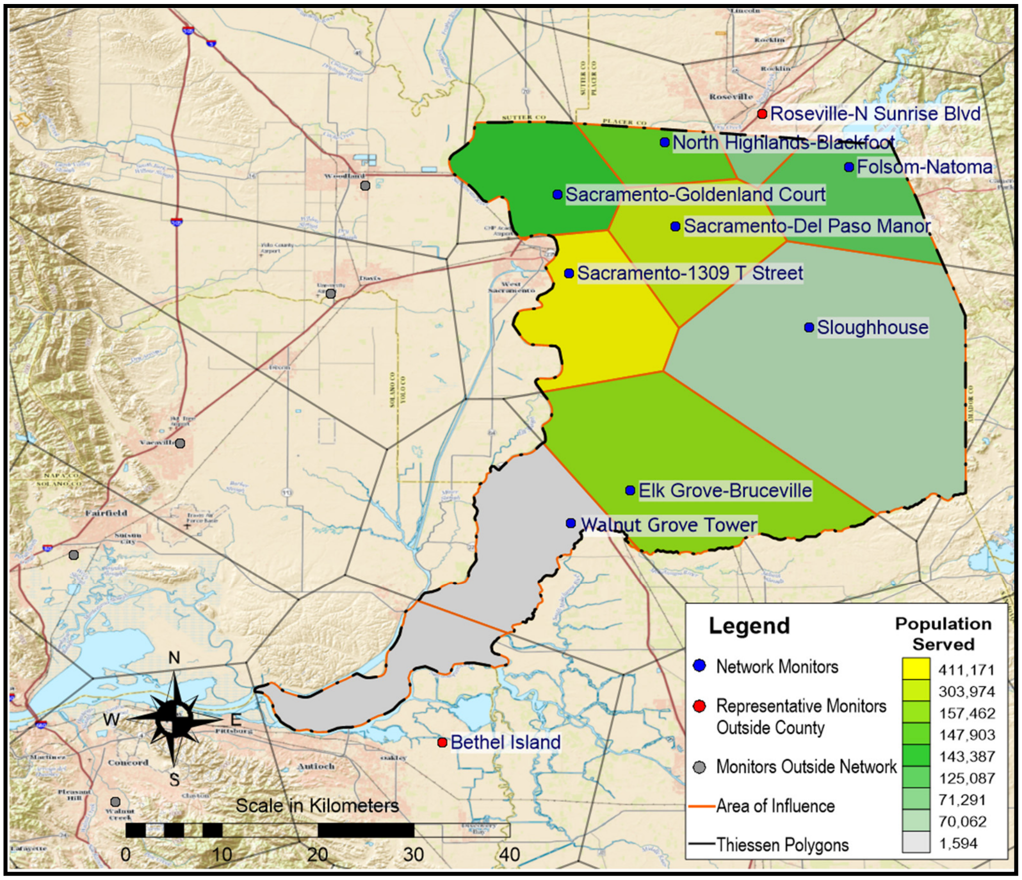


Figure 3.1 Ozone Network Area and Population Served

Sloughhouse was found to be the most important ozone site based only on area of influence; however, the population served by Sloughhouse is rather small. T street, Del Paso Manor, and Elk Grove-Bruceville serve the majority of the population as well as the majority of the Environmental Justice population within the county. Population is increasing the fastest in areas served by the T Street, North Highlands, and Elk Grove-Bruceville ozone monitors.

3.2.1.2 Ozone Network Emissions-Served Analysis

Ozone forms through photochemical reactions between NO_x and VOCs. For Sacramento County, high ozone concentrations are typically observed in summer when solar radiation and temperature are strongest. To evaluate the emissions served by each monitor, 2012 gridded modeled emissions of ozone precursors from a typical summer weekday and weekend day were obtained from CARB and summed within each monitor's area of influence. Table 3-3 presents the emissions-served analysis results for the ozone monitoring network in tons per day (tpd). Figures 3.2 and 3.3 present the emissions served by each monitoring area.

Table 3-3 Emissions Served by Ozone Monitors Representing Sacramento County

Site	Summer Weekday NO_x Emissions (tpd)	Summer Weekend NO_x Emissions (tpd)	Summer Weekday VOC Emissions (tpd)	Summer Weekend VOC Emissions (tpd)
North Highlands-Blackfoot	4.04	3.33	6.42	6.04
Sacramento-Del Paso Manor	10.21	8.38	14.99	14.06
Sacramento-1309 T Street	14.97	12.74	20.00	19.97
Elk Grove-Bruceville	5.39	4.57	12.66	15.47
Folsom-Natoma	4.04	3.37	6.34	6.86
Sacramento-Goldenland Court	4.31	3.61	4.21	4.58
Sloughhouse	2.69	2.27	17.79	22.21
Walnut Grove Tower	2.17	2.60	5.09	11.00
Bethel Island	*0.96*	*1.07*	*1.47*	*3.10*
Roseville-N Sunrise Blvd	*2.53*	*2.02*	*3.73*	*3.48*

Sites located outside Sacramento County are italicized.

Ground-level ozone forms through photochemical reactions in the atmosphere and requires time for the reactions to occur. Over the time that it takes for ozone to form, air masses transport ozone precursors out of the area where they were emitted before ozone has a chance to form. Although summertime emissions of ozone precursors (VOC and NO_x) were highest in areas served by T Street, Del Paso Manor, and Sloughhouse, these areas may not be the most important areas for monitoring ozone, but are important for monitoring ozone precursors.

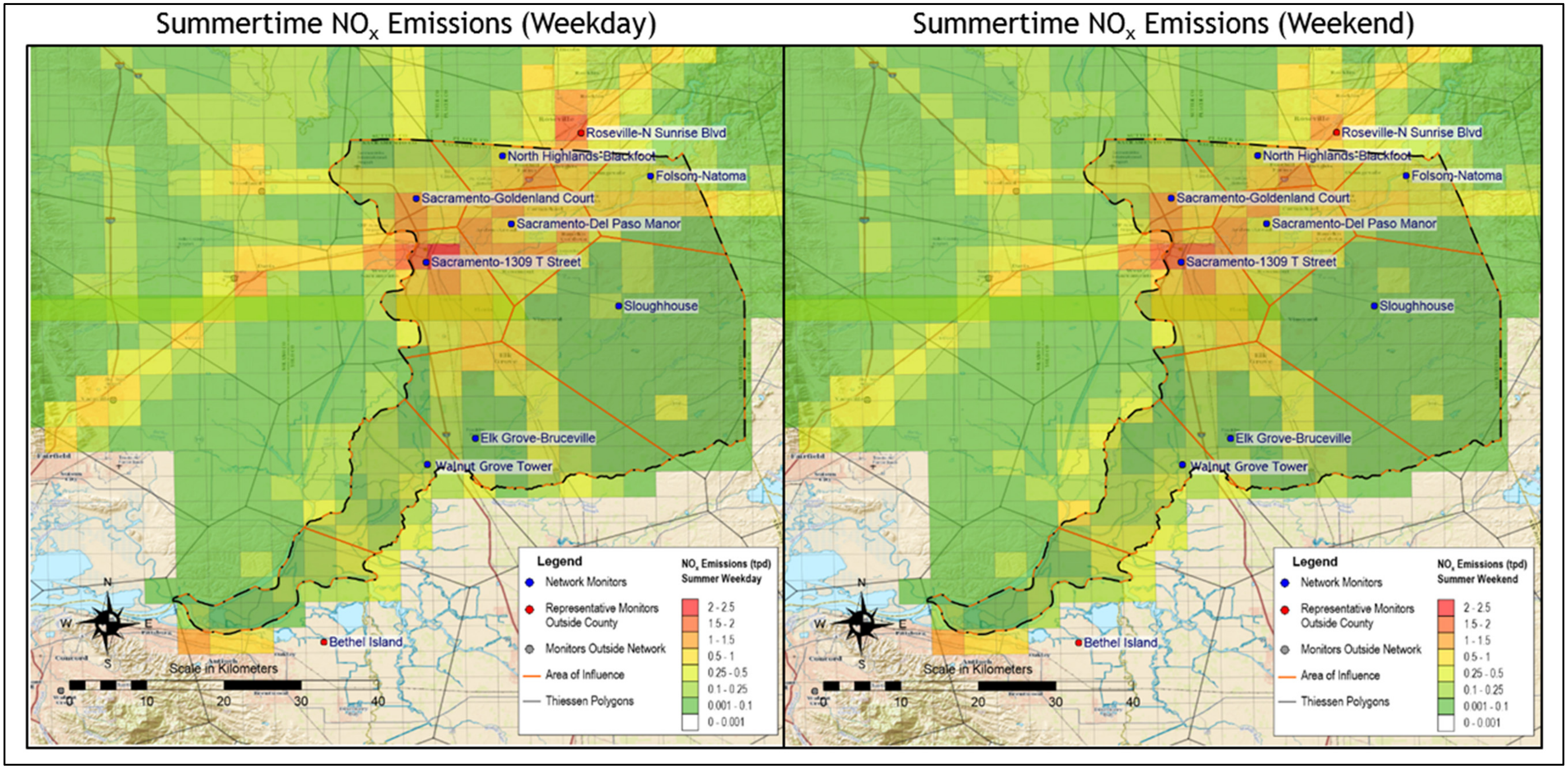


Figure 3.2 Ozone Network Emissions Served (Summertime NO_x)

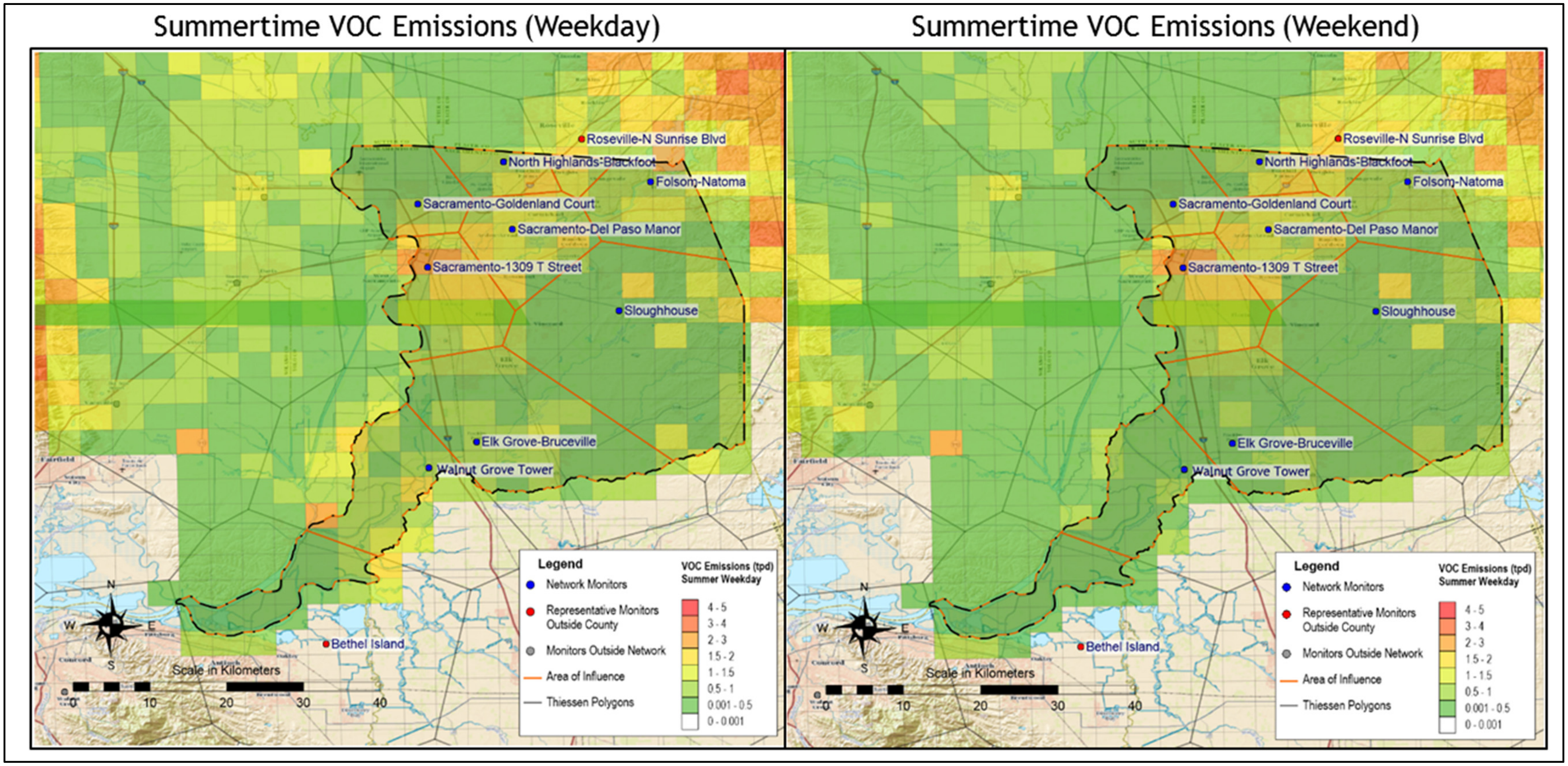


Figure 3.3 Ozone Network Emissions Served (Summertime VOC)

3.2.2 Ozone Data Analyses

The ozone data analysis conducted was used to determine the importance of a site based on measured concentrations, deviation from NAAQS, monitor-to-monitor correlation, trend impact, and removal bias.

3.2.2.1 Measured Concentration, Deviation from NAAQS, and Trend Analysis

The eight-hour ozone NAAQS of 70 ppb, as revised on October 1, 2015, was utilized for the exceedance probability calculations. This level matches the 8-hour ozone California Ambient Air Quality Standard (CAAQS). California has maintained a 1-hour standard of 90 ppb. Monitors within SMAQMD's ambient air monitoring network shown to have high levels of ozone, design values close to the standard, and with long historical record were considered to be of high value for characterizing pollution in an area. Table 3-4 presents 8-hour ozone design value concentrations for 2005 through 2014, deviation from NAAQS for the 2012 through 2014 monitoring period, and the exceedance probability in percent calculated with the design values from 2005 through 2014. Figure 3.4 presents the 2005 through 2014 maximum 8-hour concentrations, by year, and the design values for ozone monitors serving Sacramento County.

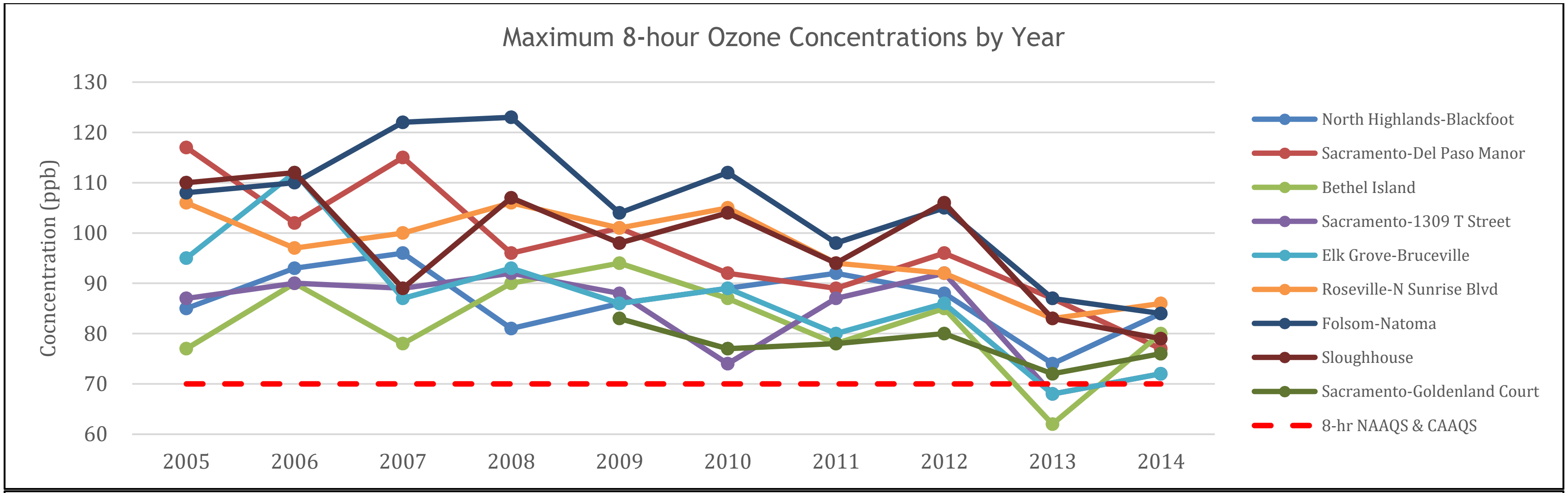
Of monitoring stations located within Sacramento County, Folsom-Natoma, Sloughhouse, and Del Paso Manor had the highest concentrations and exceedance probability. As previously mentioned, ozone forms through photochemical reactions in the presence of precursor pollutants and sunlight. These photochemical reactions take time and the air masses typically get transported away from emission sources before ozone forms. Folsom-Natoma and Sloughhouse are located outside the urban core of the county where many of the ozone precursors are emitted. Daytime wind patterns transport the air mass where ozone is forming to Folsom-Natoma and Sloughhouse where the high ozone concentrations are monitored. Section 3.9 provides a meteorological analysis and provides a summertime snapshot of 24-hour wind transport during a typical summer day.

The deviation from NAAQS analysis shows Folsom-Natoma and Sloughhouse having the lowest ranking. From the definition, these sites do have the largest differential from the NAAQS level of 70 ppb; however, the value at both stations is greater than the level of the NAAQS. For the county to attain the standard, both of these sites would need to measure design values below the level of the standard. Thus, for ozone, the measured concentration is a more important metric than the ranking for deviation from NAAQS.

Table 3-4 Concentration Analysis for Ozone Monitors Serving Sacramento County

Site	Length of Record (Years)	Three-year Calculated Design Values (ppb)								Deviation from NAAQS (ppb)[a]	Exceedance Probability
		2005-07	2006-08	2007-09	2008-10	2009-11	2010-12	2011-13	2012-14		
North Highlands-Blackfoot	36	80	76	75	77	77	77	76	75	5	110.9%
Sacramento-Del Paso Manor	35	90	87	86	85	81	78	77	77	7	122.5%
Sacramento-1309 T Street	27	78	79	77	75	71	71	69	69	1	108.8%
Elk Grove-Bruceville	24	83	82	79	77	76	77	73	70	0	114.0%
Folsom-Natoma	20	98	102	100	102	95	95	90	85	15	142.3%
Sacramento-Goldenland Court	7	--	--	--	--	69	69	70	71	1	101.0%
Sloughhouse	19	93	95	91	92	87	88	84	80	10	131.3%
Bethel Island	*35*	*73*	*76*	*74*	*74*	*73*	*72*	*67*	*64*	*6*	*105.9%*
Roseville-N Sunrise Blvd	*23*	*89*	*90*	*89*	*90*	*86*	*85*	*81*	*81*	*11*	*126.8%*

Sites located outside Sacramento County are italicized.
[a] Based on 2014 through 2014 monitoring design values.



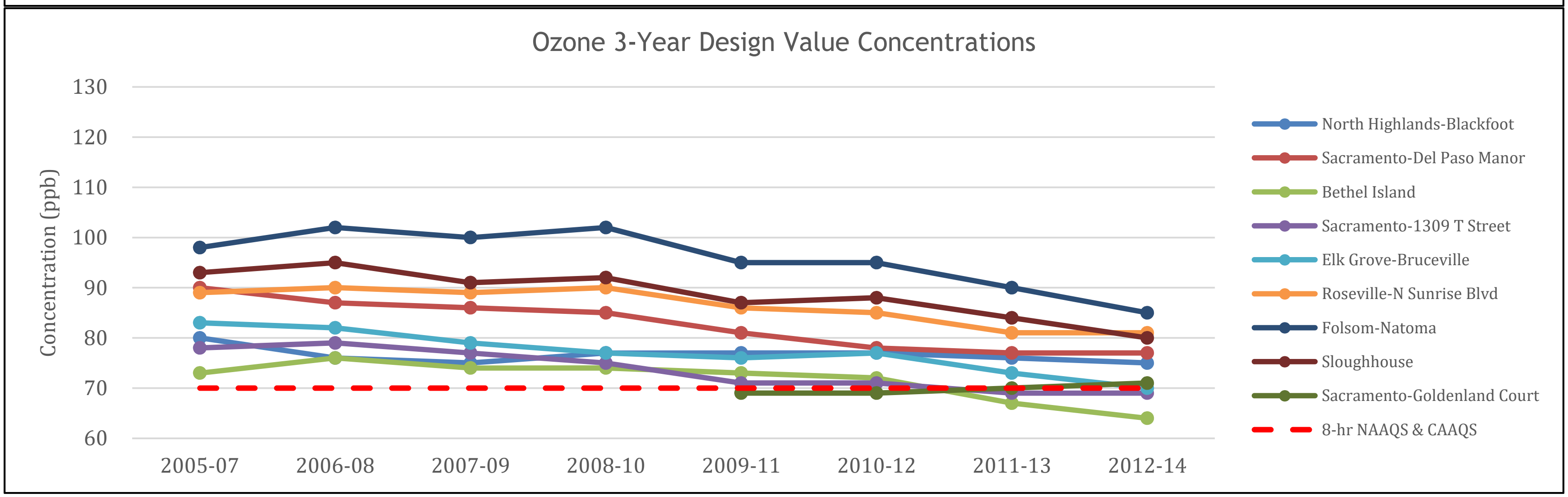


Figure 3.4 Ozone Annual Maximum 8-hour and 3-year Design Value Concentrations

3.2.2.2 Monitor-to-Monitor Correlation Analysis

Available hourly ozone concentrations for 2005 through 2014 were compared for redundancy using the square of the Pearson correlation coefficient (R^2). Monitor-to-monitor correlation analysis found that eight of the nine monitors representing a portion of Sacramento County were highly correlated (>80%) with at least one other monitor. As can be expected, monitors closer in proximity correlated better than those that were further apart. Tables 3-5 and 3-6 present the correlation statistics and distance.

Table 3-5 Correlation (R^2)/Distance (km) Analysis for Ozone Monitors Serving Sacramento County

Site ID	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Elk Grove-Bruceville	Folsom-Natoma	Sacramento-Goldenland Court	Sloughhouse	Bethel Island	Roseville-N Sunrise Blvd
North Highlands-Blackfoot									
Sacramento-Del Paso Manor	0.861								
Sacramento-1309 T Street	0.809	0.900							
Elk Grove-Bruceville	0.735	0.831	0.816						
Folsom-Natoma	0.702	0.759	0.696	0.702					
Sacramento-Goldenland Court	0.911	0.918	0.935	0.840	0.717				
Sloughhouse	0.695	0.749	0.698	0.780	0.869	0.730			
Bethel Island	*0.627*	*0.698*	*0.710*	*0.758*	*0.590*	*0.693*	*0.633*		
Roseville-N Sunrise Blvd	*0.769*	*0.824*	*0.747*	*0.723*	*0.840*	*0.767*	*0.751*	*0.592*	

Sites located outside Sacramento County are italicized.

Distance (km)								
90	80	70	60	50	40	30	20	10

Table 3-6 Distance (km)/Correlation (R^2) Analysis for Ozone Monitors Serving Sacramento County

Site ID	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Elk Grove-Bruceville	Folsom-Natoma	Sacramento-Goldenland Court	Sloughhouse	*Bethel Island*	*Roseville-N Sunrise Blvd*
North Highlands-Blackfoot									
Sacramento-Del Paso Manor	11.0								
Sacramento-1309 T Street	19.7	12.5							
Elk Grove-Bruceville	45.7	34.9	29.1						
Folsom-Natoma	19.1	19.3	31.8	47.9					
Sacramento-Goldenland Court	12.9	12.8	10.4	39.5	30.0				
Sloughhouse	28.4	19.1	25.6	28.1	21.4	31.1			
Bethel Island	*81.8*	*71.7*	*62.8*	*38.2*	*86.1*	*72.7*	*66.1*		
Roseville-N Sunrise Blvd	*10.6*	*17.1*	*28.7*	*51.1*	*11.3*	*23.4*	*28.4*	*88.6*	

Sites located outside Sacramento County are italicized.

Correlation (R^2)								
0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.50

Ozone measurements made at Goldenland Court for 2005-2014 were exceptionally correlated (R^2 values above 90 percent) with three other stations (Del Paso Manor, North Highlands-Blackfoot, T Street). Del Paso Manor was exceptionally correlated with Goldenland Court and T Street. Extreme correlation with multiple sites may be an indication that measuring the pollutant at each site is redundant.

3.2.2.3 Ozone Monitor Removal Bias Analysis

Each monitor was analyzed to determine the change in spatial concentrations interpolated across Sacramento County if the monitor was removed. Table 3-7 presents the results of the removal bias analysis and the maximum change in ozone concentrations in Sacramento County if each ozone monitor in SMAQMD's network was individually removed.

The change in concentration at a site indicates the bias which may be observed if the individual monitor were removed. Table 3-7 below indicates that removal of the T Street ozone monitor could introduce a large bias in concentration interpolation.

Table 3-7 SMAQMD Ozone Monitoring Network Removal Bias Results

Site	2012-2014 Design Value (ppb)	Change in Concentration (ppb)
North Highlands-Blackfoot	75	0.9
Sacramento-Del Paso Manor	77	2.1
Sacramento-1309 T Street	69	11.6
Elk Grove-Bruceville	70	1.1
Folsom-Natoma	85	1.6
Sacramento-Goldenland Court	71	6.5
Sloughhouse	80	1.8

3.2.3 Ozone Site-to-Site Analysis

The ozone monitoring network site-to-site analysis ranked sites based on spatial representation, measured concentrations, monitor-to-monitor correlation, trend impact and removal bias. Table 3-8 presents the results and ranking of each site from the site-to-site analysis for the ozone monitoring network. These results, and a discussion of their meaning, are combined with the suitability modeling in the next section.

Table 3-8 Results and Ranking of Each Site from the Ozone Network Site-to-Site Analysis

Site	Area Served	Pop. Served[b]	MSDI Pop.[b]	Pop. Change[b]	Emissions Served	Measured Conc.	Deviation from NAAQS	Corr.	Removal Bias	Total	Rank by Importance
North Highlands-Blackfoot	9	4	5	2	7	5	4	9	7	52	7
Sacramento-Del Paso Manor	5	2	2	4	2	4	6	7	3	35	2
Sacramento-1309 T Street	4	1	1	1	1	8	2	8	1	27	1
Elk Grove-Bruceville	2	3	4	3	4	7	1	5	6	35	3
Folsom-Natoma	6	6	6	8	6	1	9	3	5	50	6
Sacramento-Goldenland Court	7	5	3	6	8	6	3	6	2	46	5
Sloughhouse	1	8	7	5	3	3	7	2	4	40	4
Walnut Grove Tower	3	9	9	9	5	5[a]	5[a]	5[a]	5[a]	55	8
Bethel Island	*8*	*10*	*10*	*10*	*10*	*9*	5	*1*	*5*[a]	*68*	*10*
Roseville-N Sunrise Blvd	*10*	*7*	*8*	*7*	*9*	*2*	8	*4*	*5*[a]	*60*	*9*

Sites located outside Sacramento County are italicized.
[a] Monitor not included in analysis technique, was substituted with 5.
[b] Population within Sacramento County

3.2.4 Ozone Suitability Modeling

The suitability modeling aimed to find the most appropriate locations for monitor placement. Gridded data layers, categorized by population, emissions inventory, and measured concentrations, were combined to determine the most appropriate locations for ozone monitor placement. The grids used in the ozone network suitability modeling are listed below and graphical representations of these grids are provided in Appendix C.

- Typical summertime weekday NO_x emissions from CMAQ model
- Typical summertime weekend NO_x emissions from CMAQ model
- Typical summertime weekday VOC emissions from CMAQ model
- Typical summertime weekend VOC emissions from CMAQ model
- 8-hour ozone design values
- Exceedance probability of ozone monitors
- Population density
- Population change
- Sensitive and vulnerable population index (MSDI)

Table 3-9 presents the model output score at the location of each monitor within Sacramento County. Figure 3.5 presents the output of the suitability modeling.

Table 3-9 SMAQMD Ozone Monitoring Network Suitability Modeling Results

Site	Suitability Modeling Output	Suitability Modeling Rank	Site-by-Site Rank	Sum of Rankings	Final Rank
Sacramento-1309 T Street	1.8	1	1	2	1
Elk Grove-Bruceville	1.25	3	3	6	2
Sacramento-Del Paso Manor	1.2	5	2	7	3
Sacramento-Goldenland Court	1.46	2	5	7	4
North Highlands-Blackfoot	1.23	4	7	11	5
Sloughhouse	1.01	8	4	12	6
Folsom-Natoma	1.05	7	6	13	7
Walnut Grove Tower	1.14	6	8	14	8

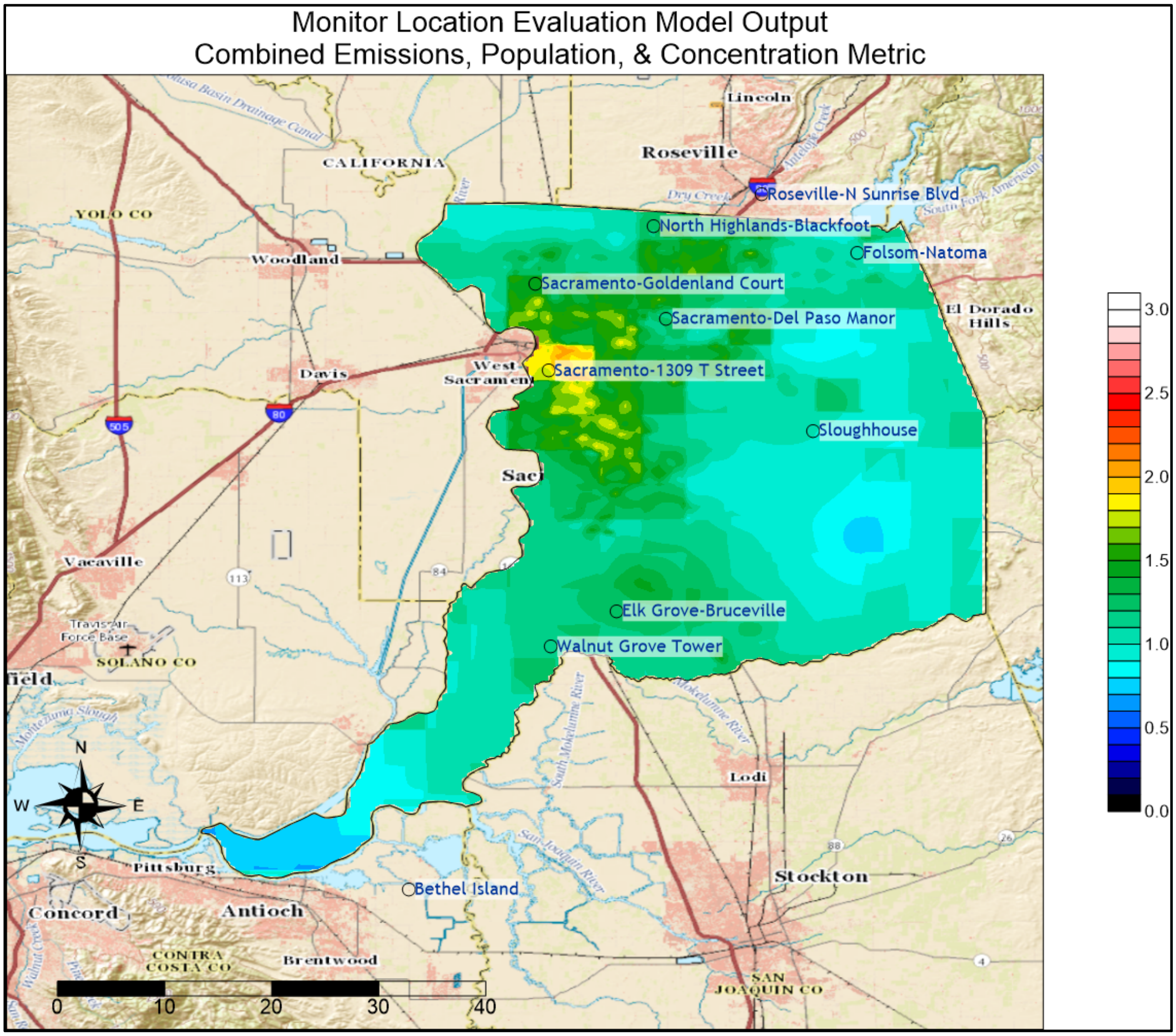


Figure 3.5 Ozone Monitoring Network Suitability Modeling Output

Results of the suitability modeling and site-by-site analysis for the ozone monitoring network were combined to evaluate monitor placement. T-Street, Del Paso Manor, Goldenland Court, and Elk Grove-Bruceville were the top four locations for ozone monitor placement. The metrics in the suitability modeling generally focus on concentration, emissions, and population. Ozone forms through photochemical processes in the presence of precursor pollutants and sunlight. The limitation in the suitability modeling is transport from where precursor pollutants are being emitted and where ozone is actually monitored.

Although ranking 6 and 7, respectively, based on the analyses, Sloughhouse and Folsom-Natoma are important to the network based on the concentration design values being monitored at the sites. Both sites are located downwind of the urban core, providing sufficient time for photochemical reactions to occur and resulting in high concentrations of ozone. Having the highest concentrations in the county, the attainment of the county currently depends on those two stations.

3.3 $PM_{2.5}$ Network

There are a total of seven $PM_{2.5}$ monitoring stations located within Sacramento County. Six of the monitoring sites operate under SLAMS while one monitoring site, Rancho Seco, is designated as a SPM which measures seasonal particulate concentrations. All sites, with the exception of the Health Department, operate a continuous monitor which is important for determining the AQI and disseminating real-time particulate data to the public.

$PM_{2.5}$ data collected by Rancho Seco are not used in an official capacity for compliance determination. Thus, $PM_{2.5}$ data collected at Rancho Seco were excluded from design value calculations and related assessment analyses. However, spatial analysis techniques were evaluated for the Rancho Seco location to determine the potential for a permanent site. SMAQMD is planning a new monitoring station, Bercut Drive, and it is anticipated that this station would begin collecting $PM_{2.5}$ data in 2017.

3.3.1 $PM_{2.5}$ Network Spatial Analyses

Thiessen polygons were generated to determine the spatial representation of each $PM_{2.5}$ monitoring station located in and adjacent to Sacramento County. Eleven $PM_{2.5}$ monitors were identified as representing a portion of Sacramento County. The following sections present the findings for area-, population-, and emissions-served analyses for the $PM_{2.5}$ network.

3.3.1.1 $PM_{2.5}$ Network Area- and Population-Served Analyses

The population within Sacramento County represented by each monitoring site was counted within the Thiessen polygons using 2009 through 2013 ACS data. Area- and population-served analyses, including sensitive and vulnerable populations, are presented in Table 3-10. Figure 3.6 presents a map showing the location, area of influence, and served population for each $PM_{2.5}$ monitor.

Table 3-10 Area and Population Served by $PM_{2.5}$ Monitors Serving Sacramento County

Site	2013 Population Estimate (Persons)	Population Change from 2010 to 2013 (Persons)	Sensitive/ Vulnerable Population (Persons)[a]	Area (km^2)
Sacramento-Del Paso Manor	385,462	5,410	105,936	274.714
Sacramento-1309 T Street	120,120	1,680	35,905	71.437
Elk Grove-Bruceville	159,271	2,414	42,161	694.104
Folsom-Natoma	113,679	154	22,502	204.746
Sacramento-Health Department	326,002	4,596	115,875	170.196
Sloughhouse	42,323	1,521	9,956	456.383
Rancho Seco	4,450	(1,076)	957	364.994
Sacramento-Bercut Dr.	152,549	1,589	48,102	187.892
Concord	-	-	-	*69.891*
Roseville-N Sunrise Blvd	*131,351*	*131*	*29,187*	*65.156*
Woodland-Gibson Road	-	-	-	*15.748*

Sites located outside Sacramento County are italicized.
[a]Summation of sensitive/vulnerable persons located within the monitors area of influence.

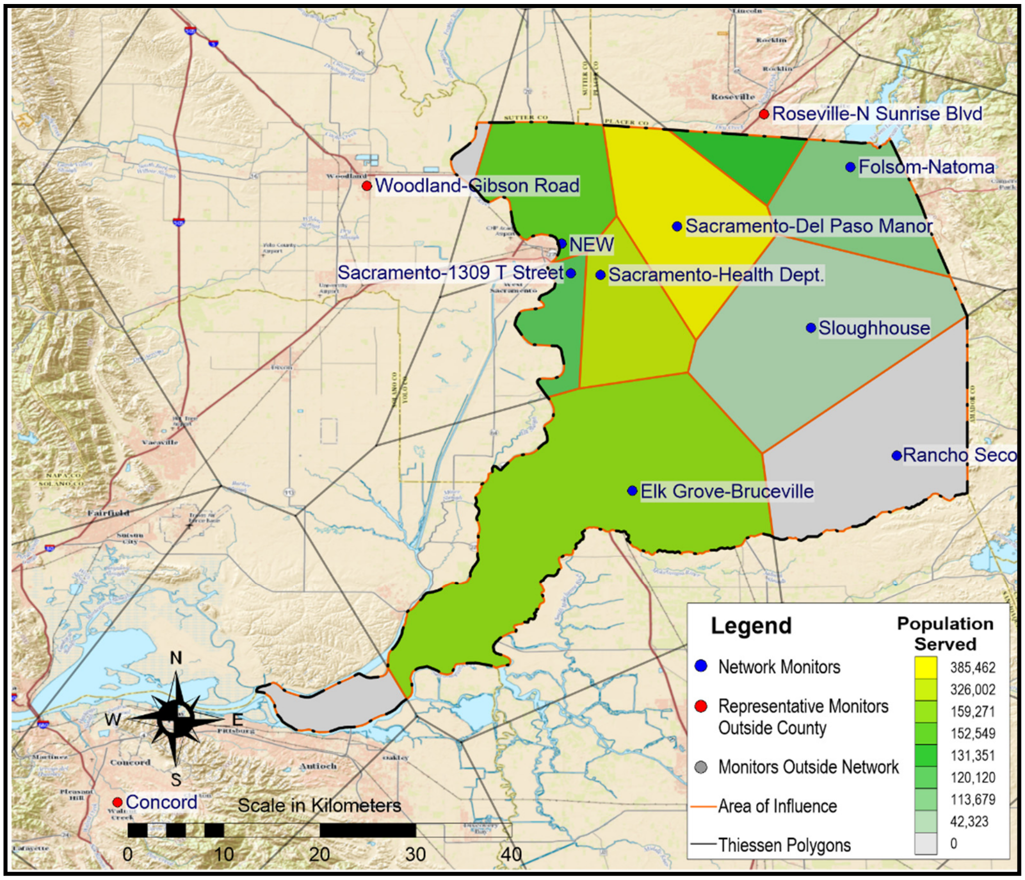


Figure 3.6 $PM_{2.5}$ Network Area and Population Served

Elk Grove-Bruceville was found to be the most important site in the $PM_{2.5}$ network based only on area of influence. Del Paso Manor, Health Department, and Elk Grove-Bruceville serve the majority of the population as well as the majority of the Environmental Justice population within the county. The largest population growth in the county was in areas served by these three monitors.

3.3.1.2 $PM_{2.5}$ Network Emissions-Served Analysis

In addition to emissions of direct $PM_{2.5}$, the emissions-served analysis included emissions of VOCs and NO_x due to the importance of these pollutants reacting chemically in the atmosphere to form $PM_{2.5}$. There are two air quality standards for $PM_{2.5}$, 24-hour and annual, which can be found in Table 2-2. For Sacramento County, 24-hour concentrations of $PM_{2.5}$ are typically higher in the winter.

Emissions served by each monitor were evaluated utilizing 2012 gridded emissions of direct $PM_{2.5}$, NO_x, and VOCs. Table 3-11 presents typical weekday and weekend emissions of $PM_{2.5}$, NO_x, and VOC for both winter and summer, for each $PM_{2.5}$ monitor. Monitors were ranked for each $PM_{2.5}$ standard according to the quantity of $PM_{2.5}$, NO_x, and VOCs emissions within each monitor's area of representation. The ranking for 24-hour $PM_{2.5}$ was based on wintertime emissions; annual $PM_{2.5}$ was ranked based on the average of the summer and winter emissions. Figures 3.7 through 3.12 present the winter and summer emissions served by each monitoring area, respectively.

Table 3-11 Emissions Served by $PM_{2.5}$ Monitors Representing Sacramento County

Site	Weekday $PM_{2.5}$ (tpd)	Weekend $PM_{2.5}$ (tpd)	Weekday NO_x (tpd)	Weekend NO_x (tpd)	Weekday VOC (tpd)	Weekend VOC (tpd)
Winter Emissions						
Sacramento-Del Paso Manor	4.158	4.034	30.797	25.196	35.957	33.270
Sacramento-1309 T Street	1.051	0.920	8.817	7.227	8.559	7.924
Elk Grove-Bruceville	2.089	2.129	14.858	12.087	17.026	17.716
Folsom-Natoma	1.381	1.349	9.730	7.896	9.529	8.863
Sacramento-Health Dept.	3.144	3.003	22.668	18.693	25.384	23.399
Sloughhouse	1.093	1.054	4.471	3.563	12.839	12.802
Rancho Seco	0.466	0.523	1.004	0.878	2.965	3.116
Sacramento-Bercut Dr.	1.806	1.764	14.192	11.794	11.166	10.449
Concord	*0.122*	*0.137*	*0.293*	*0.305*	*0.385*	*0.560*
Roseville-N Sunrise Blvd	*1.396*	*1.427*	*8.607*	*7.095*	*9.440*	*8.952*
Woodland-Gibson Road	*0.066*	*0.059*	*1.027*	*0.833*	*0.364*	*0.361*
Summer Emissions						
Sacramento-Del Paso Manor	1.538	1.191	25.621	20.995	38.687	36.332
Sacramento-1309 T Street	0.458	0.367	7.544	6.388	9.570	9.904
Elk Grove-Bruceville	1.010	1.262	16.149	15.359	34.012	51.421
Folsom-Natoma	0.511	0.431	8.096	6.766	14.101	15.579
Sacramento-Health Dept.	1.420	1.135	18.726	15.758	27.181	26.047
Sloughhouse	0.392	0.235	4.306	3.472	21.724	25.890
Rancho Seco	0.156	0.137	1.545	1.436	15.078	20.294
Sacramento-Bercut Dr.	0.699	0.633	12.454	10.763	13.618	15.290
Concord	*0.084*	*0.148*	*0.392*	*0.698*	*0.892*	*2.594*
Roseville-N Sunrise Blvd	*0.523*	*0.398*	*6.757*	*5.449*	*9.686*	*8.993*
Woodland-Gibson Road	*0.034*	*0.030*	*0.991*	*0.840*	*0.829*	*1.189*

Sites located outside Sacramento County are italicized.

Del Paso Manor, Health Department, and Elk Grove-Bruceville were the highest ranking sites for both wintertime emissions, when 24-hour $PM_{2.5}$ is typically highest, as well as overall emissions (summer and winter) for monitoring for the annual $PM_{2.5}$ standard.

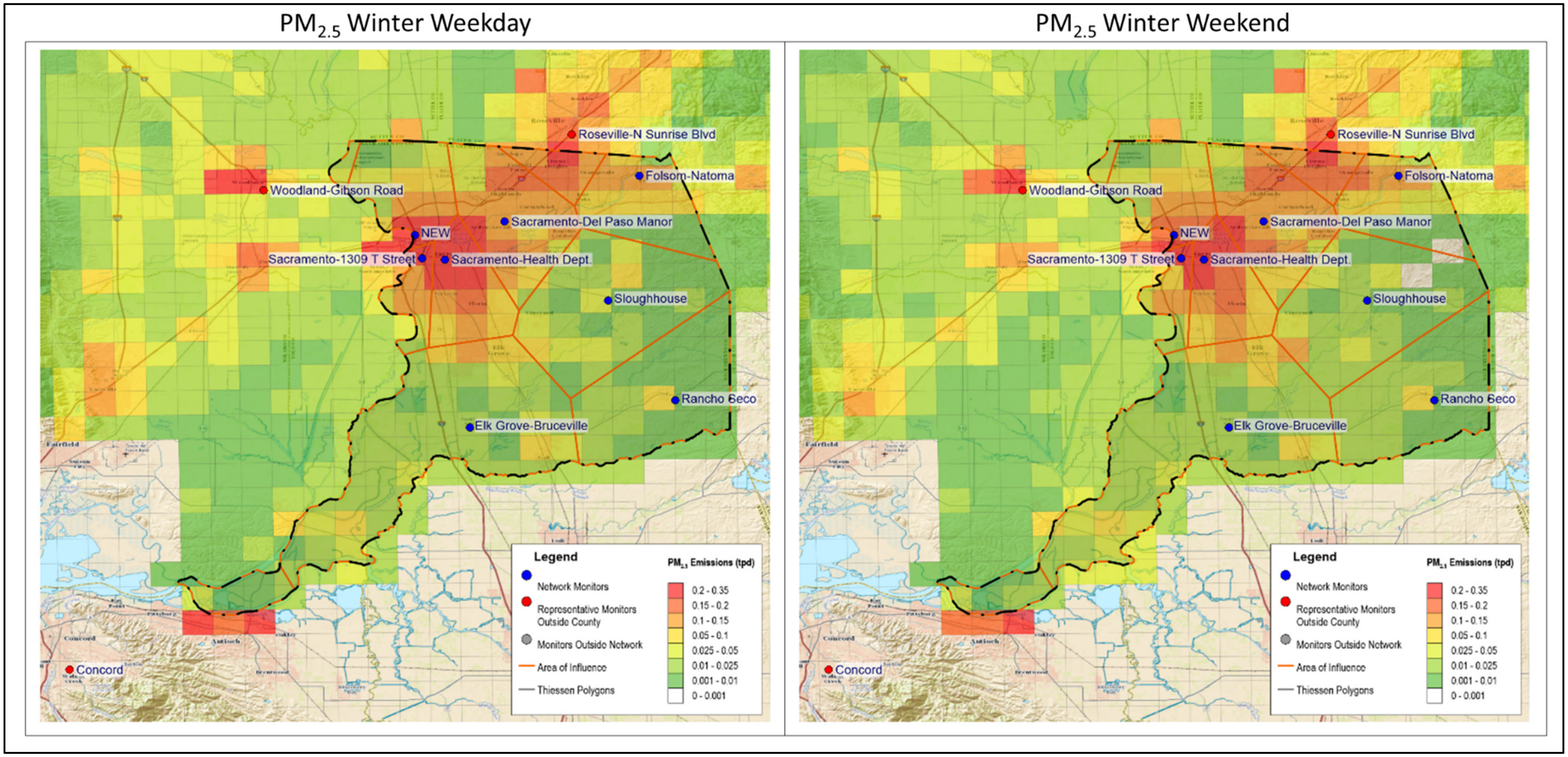


Figure 3.7 $PM_{2.5}$ Network Wintertime Emissions Served ($PM_{2.5}$)

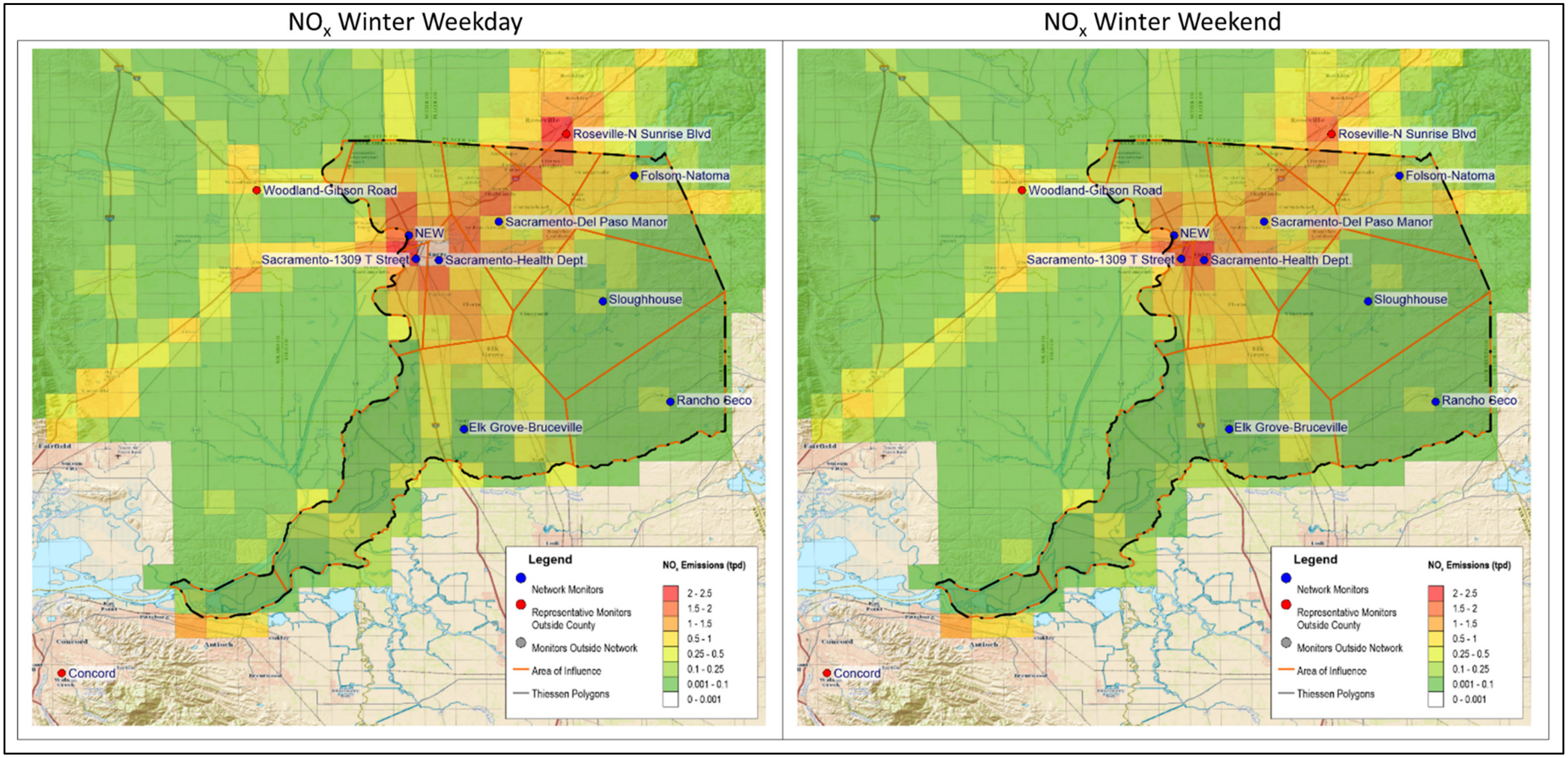


Figure 3.8 $PM_{2.5}$ Network Wintertime Emissions Served (NO_x)

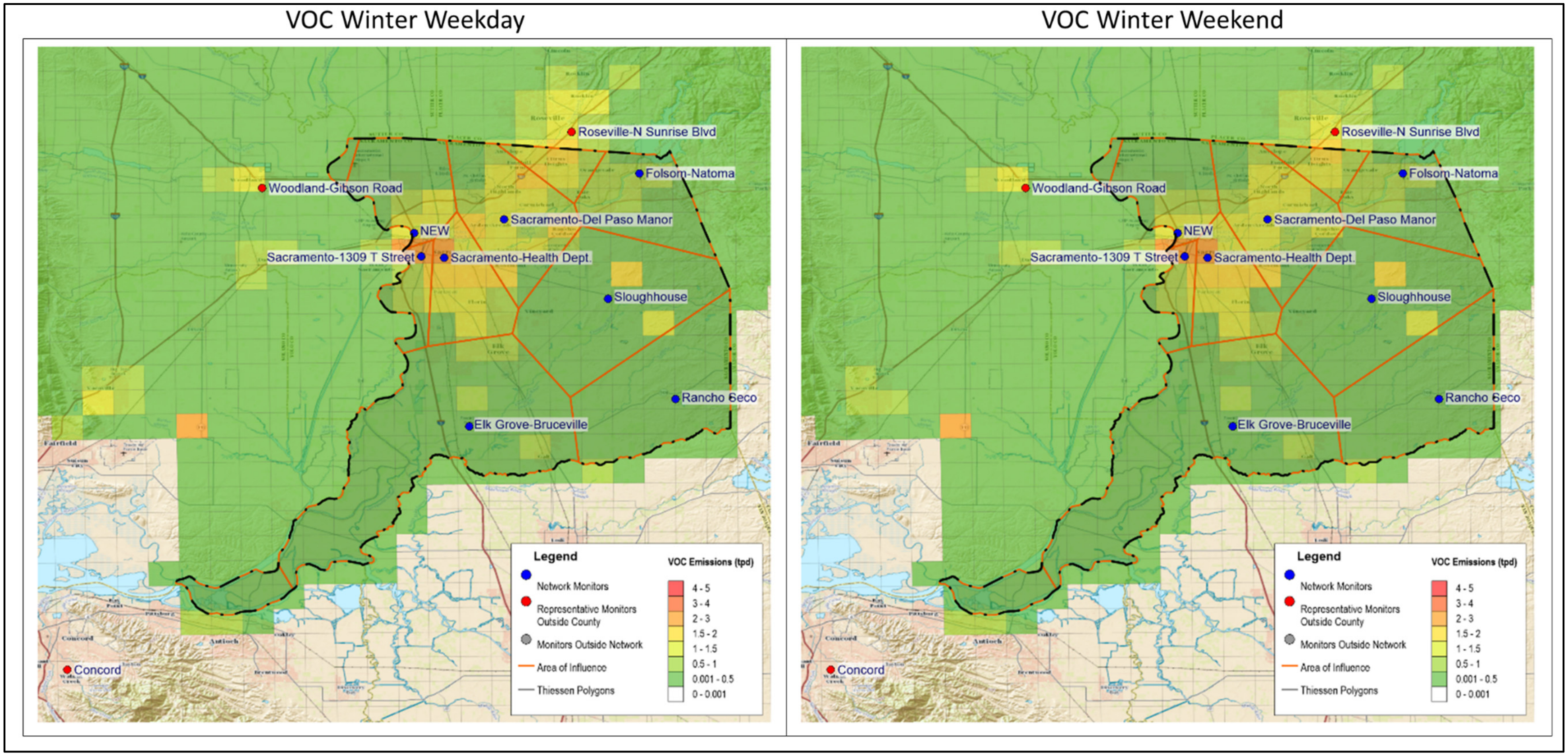


Figure 3.9 $PM_{2.5}$ Network Wintertime Emissions Served (VOC)

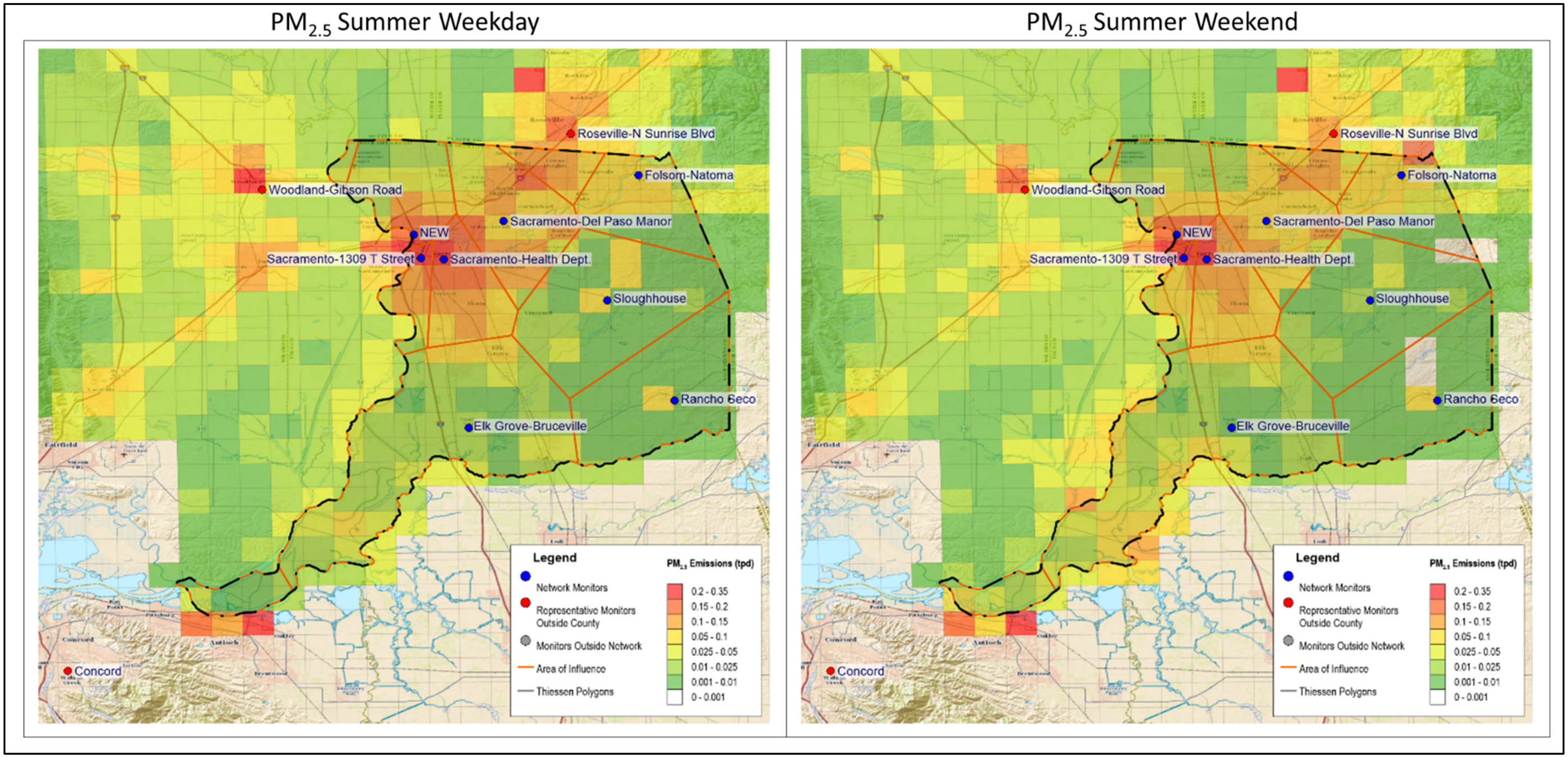


Figure 3.10 $PM_{2.5}$ Network Summertime Emissions Served ($PM_{2.5}$)

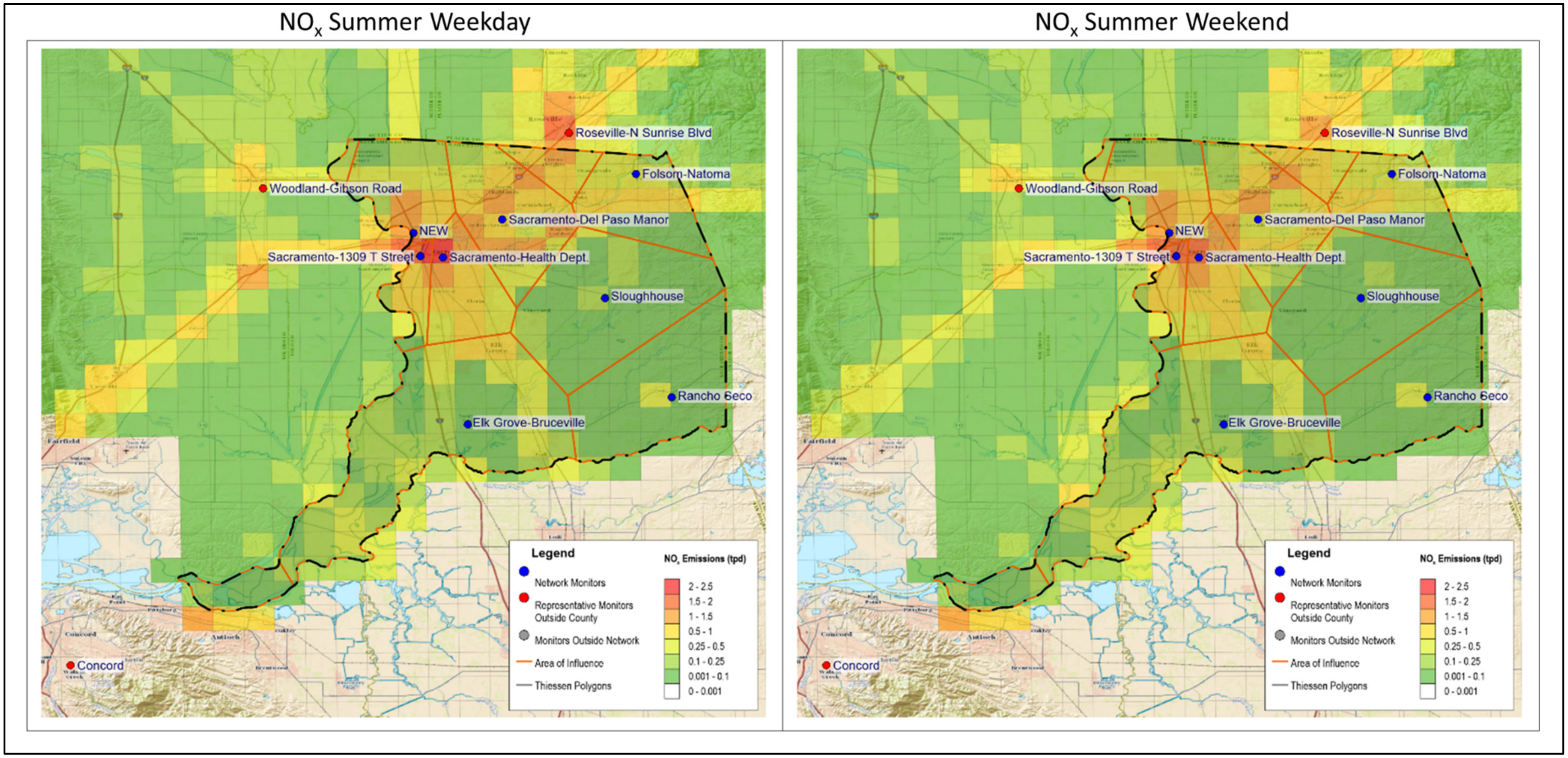


Figure 3.11 PM$_{2.5}$ Network Summertime Emissions Served (NO$_x$)

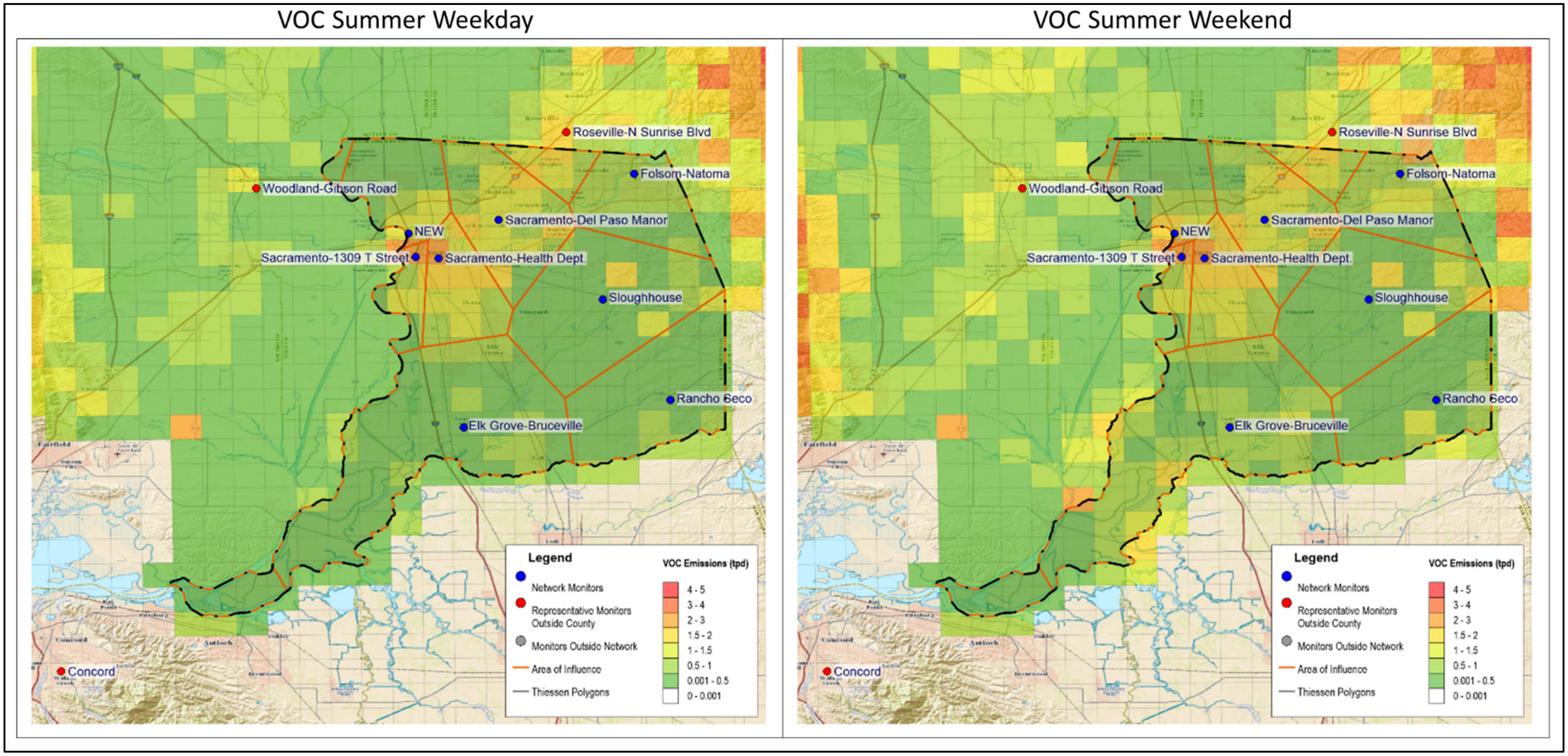


Figure 3.12 $PM_{2.5}$ Network Summertime Emissions Served (VOC)

3.3.2 $PM_{2.5}$ Data Analyses

The data analysis conducted was used to determine the importance of a site based on measured concentrations, deviation from NAAQS, monitor-to-monitor correlation, trend impact, and removal bias.

3.3.2.1 $PM_{2.5}$ Measured Concentration, Deviation from NAAQS, and Trend Analysis

Monitors within SMAQMD's ambient air monitoring network shown to have high concentrations of $PM_{2.5}$, design values close to the standard, and with a long historical record were considered to be of high value for characterizing pollution in an area. Tables 3-12 and 3-13 present the 24-hour and annual design value concentrations for 2005 through 2014, deviation from NAAQS for the 2012-2014 monitoring period, and the exceedance probability using values from 2005 through 2014. Figure 3.13 presents the 2005 through 2014 maximum 24-hour concentrations by year and the 24-hour design values for $PM_{2.5}$ monitors serving Sacramento County. Figure 3.14 presents the annual standard design value for $PM_{2.5}$ monitors serving Sacramento County. The exceedance probability in Tables 3-12 and 3-13 is presented as percent of the standards (35 µg/m^3 for 24-hour and 12 µg/m^3 for annual).

Del Paso Manor had the highest concentration in both the 24-hour and annual averaging periods for all monitors representing a portion of the county. Within the network, Del Paso Manor, T Street, Elk Grove-Bruceville, and Health Department had the most complete record for calculating design values and exceedance probability. All stations in the network show a probability to exceed the 24-hour standard, and only Elk Grove-Bruceville shows a probability to exceed the annual standard.

Table 3-12 24-hour Concentration Analysis for $PM_{2.5}$ Monitors Serving Sacramento County

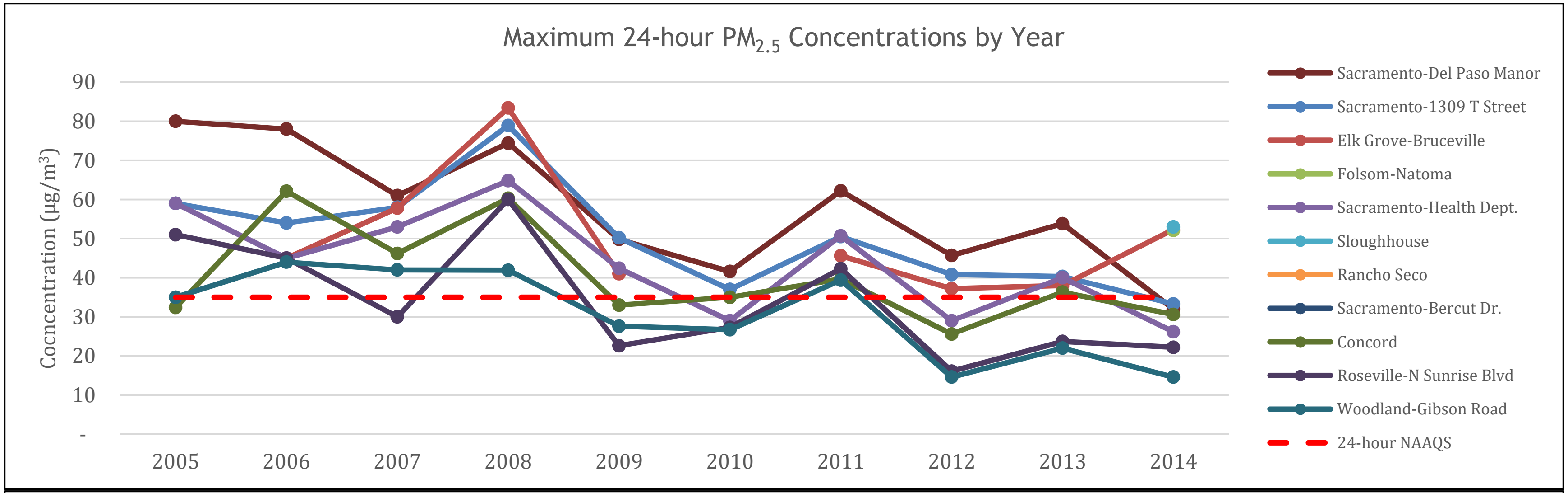
Site	Length of Record (years)	Design Values (µg/m³)								Deviation from NAAQS (µg/m³)	Exceedance Probability
		2005-07	2006-08	2007-09	2008-10	2009-11	2010-12	2011-13	2012-14		
Sacramento-Del Paso Manor	17	61.7	57.6	51.2	40.2	33.6	29.8	34	31.6	-3.4	143.8%
Sacramento-1309 T Street	18	43.0	42.8	38.9	33.6	33.2	31.0	32.9	25.9	-9.1	111.1%
Elk Grove-Bruceville	16	--	41.5	39.6	--	--	--	29.2	25.7	-9.3	119.6%
Folsom-Natoma	3	--	--	--	--	--	--	--	--	--	--
Sacramento-Health Dept.	17	44.3	44.9	43.2	36.3	35.4	30.6	33.7	26.8	-8.2	117.4%
Sloughhouse	3	--	--	--	--	--	--	--	--	--	--
Rancho Seco	8	--	--	--	--	--	--	--	--	--	--
Sacramento-Bercut Dr.	0*	--	--	--	--	--	--	--	--	--	--
Concord	*3*	*35.8*	*35.8*	*31.2*	*26.3*	*25.1*	*23.2*	*22.8*	*20.4*	*-14.6*	*89.5%*
Roseville-N Sunrise Blvd	*18*	*30.3*	*29.9*	*25.0*	*22.7*	*21.5*	*19.4*	*18.9*	*18.1*	*-16.9*	*74.9%*
Woodland-Gibson Road	*17*	*33.2*	*31.8*	*28.9*	*21.9*	*23.9*	*19.5*	*20.7*	*16.5*	*-18.5*	*81.0%*

Sites located outside Sacramento County are italicized. "*" anticipated start date in winter 2016.

Table 3-13 Annual Concentration Analysis for $PM_{2.5}$ Monitors Serving Sacramento County

Site	Length of Record (years)	Design Values (µg/m³)								Deviation from NAAQS (µg/m³)	Exceedance Probability
		2005-07	2006-08	2007-09	2008-10	2009-11	2010-12	2011-13	2012-14		
Sacramento-Del Paso Manor	17	12.3	12.9	12.1	11.0	10.0	9.5	10.4	9.8	-2.2	98.4%
Sacramento-1309 T Street	18	11.7	11.8	10.9	9.6	9.3	8.9	9.5	8.8	-3.2	90.2%
Elk Grove-Bruceville	16	--	16.7	15.5	13.7	12.0	11.0	9.2	9.0	-3.0	120.6%
Folsom-Natoma	3	--	--	--	--	--	--	--	--	--	--
Sacramento-Health Dept.	17	10.7	11.3	11.0	9.9	9.2	8.7	9.3	8.7	-3.3	87.5%
Sloughhouse	3	--	--	--	--	--	--	--	--	--	--
Rancho Seco	8	--	--	--	--	--	--	--	--	--	--
Sacramento-Bercut Dr.	0*	--	--	--	--	--	--	--	--	--	--
Concord	*3*	*8.8*	*8.9*	*8.8*	*8.3*	*7.8*	*7.1*	*7.3*	*6.9*	*-5.1*	*70.8%*
Roseville-N Sunrise Blvd	*18*	*9.7*	*9.6*	*9.0*	*8.3*	*7.9*	*7.2*	*7.6*	*7.3*	*-4.7*	*74.6%*
Woodland-Gibson Road	*17*	*8.7*	*9.4*	*8.7*	*7.8*	*6.9*	*6.6*	*7.2*	*6.7*	*-5.3*	*70.1%*

Sites located outside Sacramento County are italicized. "*" anticipated start date in winter 2016.



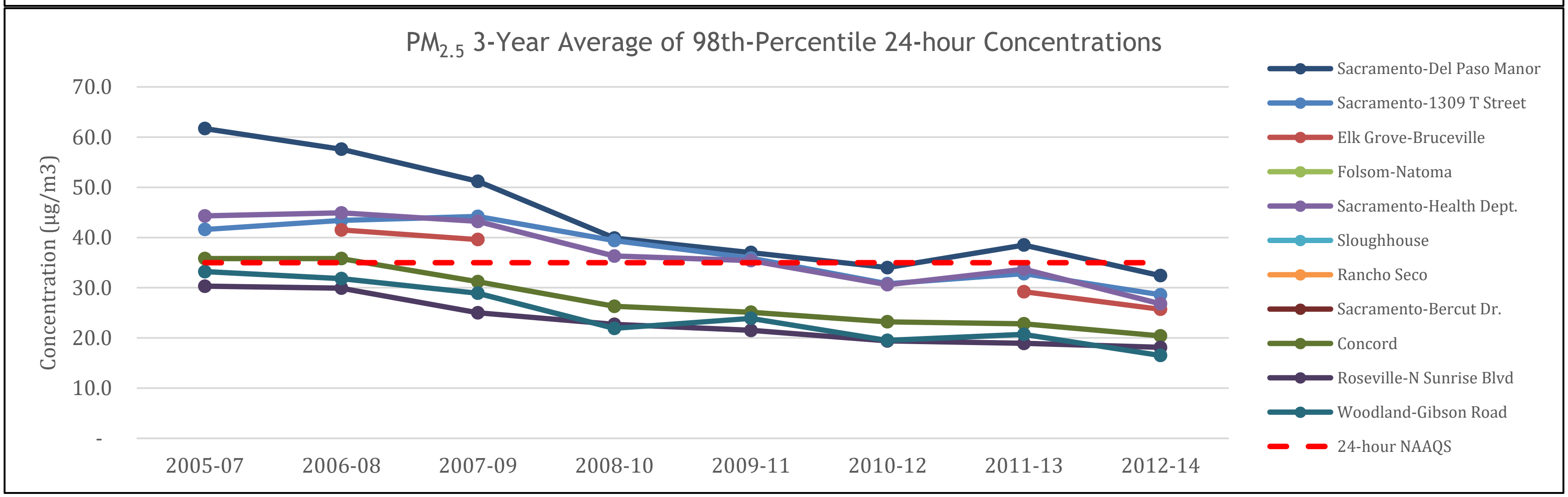


Figure 3.13 24-hour $PM_{2.5}$ Maximum and Design Value Concentrations

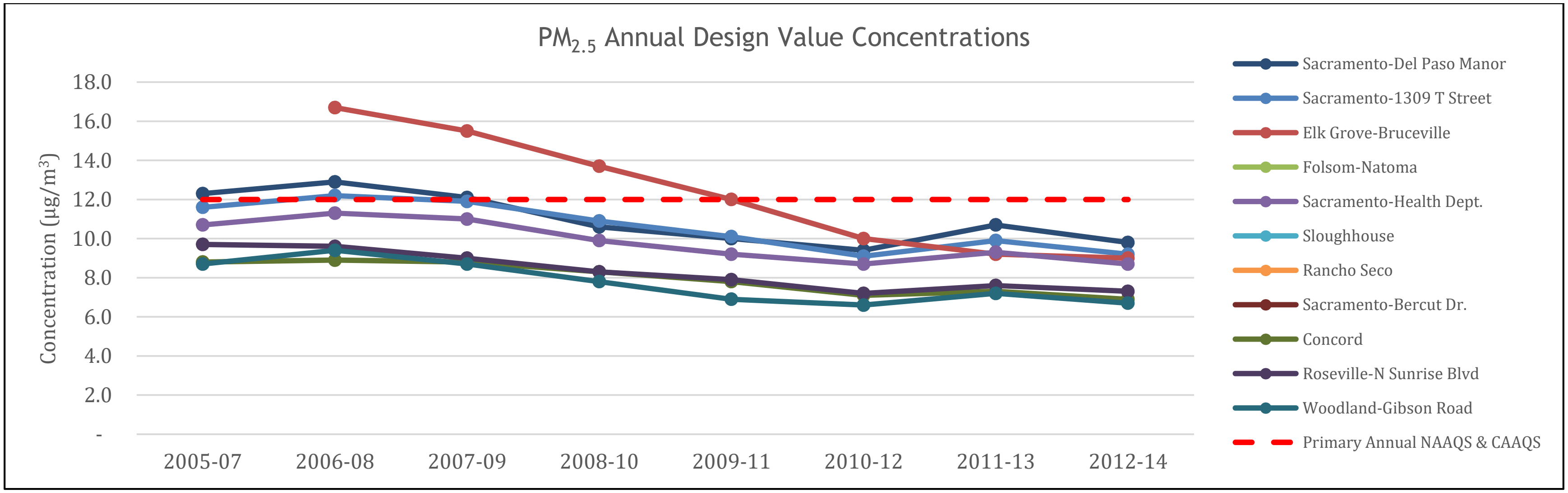


Figure 3.14 Annual PM$_{2.5}$ Design Value Concentrations

3.3.2.2 Monitor-to-Monitor Correlation Analysis

Daily $PM_{2.5}$ concentration data collected between 2005 through 2014 from nine monitors were compared for redundancy using the square of the Pearson correlation coefficient (R^2). Monitor-to-monitor correlation analysis found that three of the nine monitors representing a portion of Sacramento County were highly correlated (>80%) with at least one other monitor. As can be expected, monitors closer in proximity correlated better than those that were further apart. Tables 3-14 and 3-15 present the correlation statistics compared to distance.

$PM_{2.5}$ monitoring sites with continuous monitors were also evaluated for redundancy using hourly $PM_{2.5}$ data. The correlation analysis for continuous monitors showed monitors to be relatively unique in hour-to-hour comparisons. Tables 3-16 and 3-17 present the correlation statistics for hourly concentrations compared to distance.

Table 3-14 Correlation (R^2)/Distance (km) Analysis for 24-hour $PM_{2.5}$ Data from Monitors Serving Sacramento County

Site ID	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Elk Grove-Bruceville	Folsom-Natoma	Sacramento-Health Department	Sloughhouse	*Concord*	*Roseville-N Sunrise Blvd*	*Woodland-Gibson Road*
Sacramento-Del Paso Manor									
Sacramento-1309 T Street	0.822								
Elk Grove-Bruceville	0.541	0.653							
Folsom-Natoma	0.386	0.409	0.327						
Sacramento-Health Dept.	0.903	0.944	0.646	0.306					
Sloughhouse	0.469	0.535	0.332	0.365	0.534				
Concord	0.571	0.579	0.459	0.279	0.622	0.332			
Roseville-N Sunrise Blvd	0.713	0.711	0.529	0.600	0.741	0.548	0.496		
Woodland-Gibson Road	0.661	0.795	0.594	0.604	0.772	0.593	0.607	0.650	

Sites located outside Sacramento County are italicized.

Distance (km)								
90	80	70	60	50	40	30	20	10

Table 3-15 Distance (km)/Correlation (R^2) Analysis for 24-hour $PM_{2.5}$ Data from Monitors Serving Sacramento County

Site ID	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Elk Grove-Bruceville	Folsom-Natoma	Sacramento-Health Department	Sloughhouse	*Concord*	*Roseville-N Sunrise Blvd*	*Woodland-Gibson Road*
Sacramento-Del Paso Manor									
Sacramento-1309 T Street	12.5								
Elk Grove-Bruceville	34.9	29.1							
Folsom-Natoma	19.3	31.8	47.9						
Sacramento-Health Dept.	10.1	3.0	28.4	29.2					
Sloughhouse	19.1	25.6	28.1	21.4	22.6				
Concord	*94.9*	*83.5*	*66.9*	*112.2*	*85.0*	*94.6*			
Roseville-N Sunrise Blvd	*17.1*	*28.7*	*51.1*	*11.3*	*26.9*	*28.4*	*111.9*		
Woodland-Gibson Road	*32.1*	*23.8*	*48.3*	*49.4*	*26.6*	*49.0*	*84.7*	*41.6*	

Sites located outside Sacramento County are italicized.

Correlation (R^2)								
0.95	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20

Table 3-16 Correlation (R^2)/Distance (km) Analysis for Hourly $PM_{2.5}$ Data from Monitors Serving Sacramento County

Site ID	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Elk Grove-Bruceville	Folsom-Natoma	Sloughhouse	*Concord*
Sacramento-Del Paso Manor						
Sacramento-1309 T Street	0.547					
Elk Grove-Bruceville	0.231	0.368				
Folsom-Natoma	0.203	0.178	0.117			
Sloughhouse	0.161	0.104	0.110	0.143		
Concord	0.244	0.269	0.209	0.107	0.107	

Sites located outside Sacramento County are italicized.

Distance (km)								
90	80	70	60	50	40	30	20	10

Table 3-17 Distance (km)/Correlation (R^2) Analysis for Hourly $PM_{2.5}$ Data from Monitors Serving Sacramento County

Site ID	Sacramento-Del Paso Manor	Sacramento- T Street	Elk Grove-Bruceville	Folsom-Natoma	Sloughhouse	*Concord*
Sacramento-Del Paso Manor						
Sacramento-1309 T Street	12.5					
Elk Grove-Bruceville	34.9	29.1				
Folsom-Natoma	19.3	31.8	47.9			
Sloughhouse	19.1	25.6	28.1	21.4		
Concord	94.9	83.5	66.9	112.2	94.6	

Sites located outside Sacramento County are italicized.

Correlation (R^2)								
0.95	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20

Measurements of 24-hour $PM_{2.5}$ made at Health Department for 2005-2014 were exceptionally correlated (R^2 values above 90 percent) with Del Paso Manor and T Street. Extreme correlation with multiple sites may be an indication that measuring the pollutant at each site is redundant.

3.3.2.3 $PM_{2.5}$ Monitor Removal Bias Analysis

Each monitor was analyzed to determine the change in spatial concentrations interpolated across Sacramento County if the monitor were removed. Table 3-18 presents the results of the removal bias analysis and the maximum change in $PM_{2.5}$ concentrations (both 24-hour and annual) in Sacramento County if each $PM_{2.5}$ monitor in SMAQMD's network were individually removed.

The change in concentration at a site indicates the bias that may be observed if the individual monitor were removed. Results in Table 3-18 indicate that removal of the Elk Grove-Bruceville and Folsom-Natoma $PM_{2.5}$ monitors could introduce a large bias in concentration interpolation.

Table 3-18 SMAQMD $PM_{2.5}$ Monitoring Network Removal Bias Results

Site	24-hour $PM_{2.5}$ 2012-2014 Design Value (µg/m^3)	Change in 24-hour $PM_{2.5}$ Concentration (µg/m^3)	Annual $PM_{2.5}$ 2012-2014 Design Value (µg/m^3)	Change in Annual $PM_{2.5}$ Concentration (µg/m^3)
Sacramento-Del Paso Manor	31.6	9.0	9.8	1.6
Sacramento-1309 T Street	25.9	3.1	8.8	0.7
Elk Grove-Bruceville	25.7	2.5	9.0	1.0
Folsom-Natoma	--	--	--	--
Sacramento-Health Dept.	26.8	2.4	8.7	0.6
Sloughhouse	--	--	--	--

3.3.3 $PM_{2.5}$ Site-to-Site Analysis

The $PM_{2.5}$ monitoring network site-to-site analysis ranked sites based on the analyses in spatial representativeness, measured concentration, monitor-to-monitor correlation, trend impact, and removal bias. As previously mentioned, $PM_{2.5}$ has two standards (24-hour and annual). The site-by-site analysis was performed for each standard. Tables 3-19 and 3-20 present the results of the site-to-site analysis for the $PM_{2.5}$ monitoring network based on the 24-hour and annual standards, respectively. These results, and a discussion of their meaning, are combined with the suitability modeling in the next section.

Table 3-19 Results of the $PM_{2.5}$ Network Site-to-Site Analysis for the 24-hour Standard

Site	Area Served	Pop. Served[b]	MSDI Pop.[b]	Pop. Change[b]	Emissions Served	Measured Conc.	Deviation from NAAQS	Corr.	Removal Bias	Total	Rank by Importance
Sacramento-Del Paso Manor	4	1	2	1	1	1	1	7	1	19	1
Sacramento-1309 T Street	8	6	5	4	8	2	2	9	2	46	5
Elk Grove-Bruceville	1	3	4	3	3	4	4	4	3	29	2
Folsom-Natoma	5	7	7	7	5	5[a]	5[a]	1	5[a]	47	6
Sacramento-Health Dept.	7	2	1	2	2	3	3	8	4	32	3
Sloughhouse	2	8	8	6	7	5[a]	5[a]	2	5[a]	48	7
Rancho Seco	3	9	9	11	9	5[a]	5[a]	5[a]	5[a]	61	9
Sacramento-Bercut Dr.	6	4	3	5	4	5[a]	5[a]	5[a]	5[a]	42	4
Concord	*9*	*10*	*10*	*9*	*11*	*5*	*5*	*3*	*5[a]*	*67*	*10*
Roseville-N Sunrise Blvd	*10*	*5*	*6*	*8*	*6*	*6*	*6*	*5*	*5[a]*	*57*	*8*
Woodland-Gibson Road	*11*	*10*	*10*	*9*	*10*	*7*	*7*	*6*	*5[a]*	*75*	*11*

Sites located outside Sacramento County are italicized.
[a] Monitors not included in analysis technique, were substituted with 5.
[b] Population within Sacramento County

Table 3-20 Results of the $PM_{2.5}$ Network Site-to-Site Analysis for the Annual Standard

Site	Area Served	Pop. Served[b]	MSDI Pop.[b]	Pop. Change[b]	Emissions Served	Measured Conc.	Deviation from NAAQS	Corr.	Removal Bias	Total	Rank by Importance
Sacramento-Del Paso Manor	4	1	2	1	1	1	1	7	1	19	1
Sacramento-1309 T Street	8	6	5	4	7	2	2	9	3	46	5
Elk Grove-Bruceville	1	3	4	3	3	3	3	4	2	26	2
Folsom-Natoma	5	7	7	7	6	5[a]	5[a]	1	5[a]	48	7
Sacramento-Health Dept.	7	2	1	2	2	4	4	8	4	34	3
Sloughhouse	2	8	8	6	5	5[a]	5[a]	2	5[a]	46	6
Rancho Seco	3	9	9	11	9	5[a]	5[a]	5[a]	5[a]	61	9
Sacramento-Bercut Dr.	6	4	3	5	4	5[a]	5[a]	5[a]	5[a]	42	4
Concord	*9*	*10*	*10*	*9*	*11*	*6*	*6*	*3*	*5*[a]	*69*	*10*
Roseville-N Sunrise Blvd	*10*	*5*	*6*	*8*	*8*	*5*	*5*	*5*	*5*[a]	*57*	*8*
Woodland-Gibson Road	*11*	*10*	*10*	*9*	*10*	*7*	*7*	*6*	*5*[a]	*75*	*11*

Sites located outside Sacramento County are italicized.
[a] Monitors not included in the analysis technique or without a 2014 design value, were substituted with 5.
[b] Population within Sacramento County.

3.3.4 $PM_{2.5}$ Suitability Modeling

The suitability modeling aimed to determine the most appropriate locations for monitor placement. Gridded data layers, categorized by population, emissions inventory, and measured concentrations, were combined to determine the most appropriate locations for $PM_{2.5}$ monitor placement. Since $PM_{2.5}$ has two standards, a suitability modeling analysis was conducted for each standard. The grids used in the $PM_{2.5}$ network suitability modeling are listed below and graphical representations of these grids are provided in Appendix C. Figures 3.15 and 3.16 present the output of the suitability modeling for the $PM_{2.5}$ network. Table 3-21 presents the model output score at the location of each $PM_{2.5}$ monitoring location within Sacramento County.

- Typical weekday $PM_{2.5}$ emissions from CMAQ model
  - Winter emissions for 24-hour analysis
  - Average of summer and winter emissions for annual analysis
- Typical weekend $PM_{2.5}$ emissions from CMAQ model
  - Winter emissions for 24-hour analysis
  - Average of summer and winter emissions for annual analysis
- Typical weekday NO_x emissions from CMAQ model
  - Winter emissions for 24-hour analysis
  - Average of summer and winter emissions for annual analysis
- Typical weekend NO_x emissions from CMAQ model
  - Winter emissions for 24-hour analysis
  - Average of summer and winter emissions for annual analysis
- Typical weekday VOC emissions from CMAQ model
  - Winter emissions for 24-hour analysis
  - Average of summer and winter emissions for annual analysis
- Typical weekend VOC emissions from CMAQ model
  - Winter emissions for 24-hour analysis
  - Average of summer and winter emissions for annual analysis
- $PM_{2.5}$ design values (24-hour and annual)
- Exceedance probability of $PM_{2.5}$ monitors (24-hour and annual)
- Population density
- Population change
- Sensitive and vulnerable population index (MSDI)

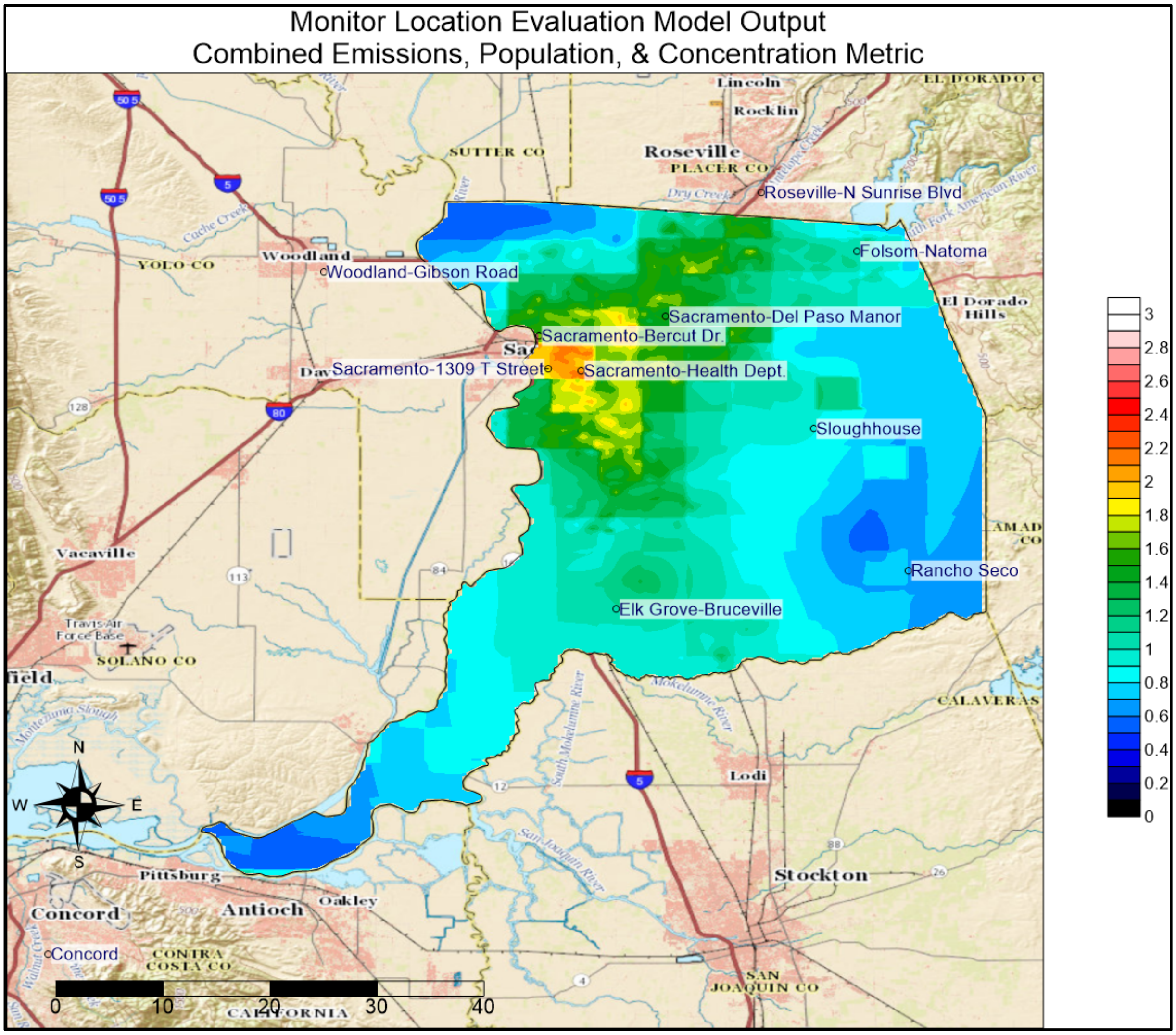


Figure 3.15 $PM_{2.5}$ (24-hour) Monitoring Network Suitability Modeling Output

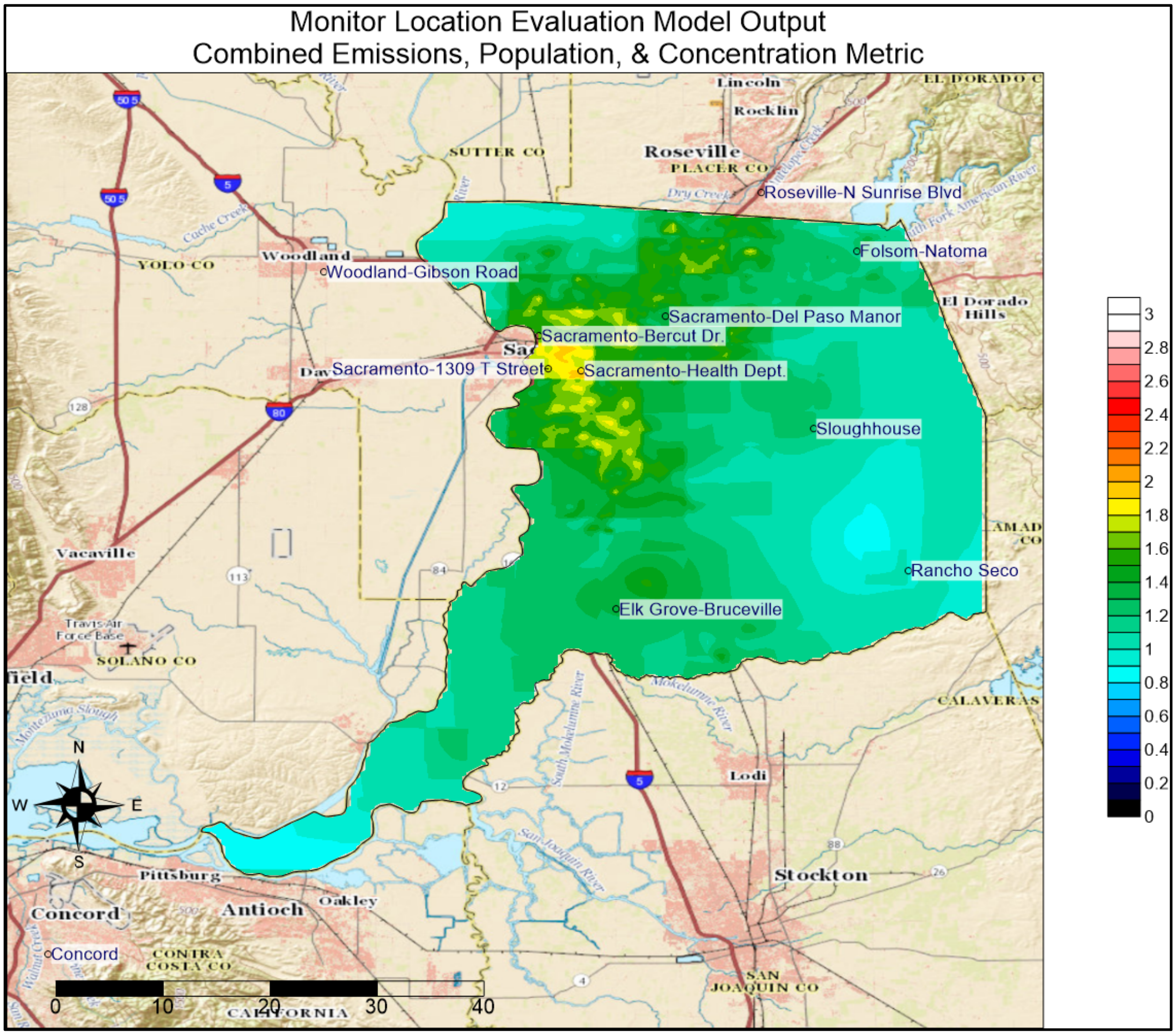


Figure 3.16 PM$_{2.5}$ (Annual) Monitoring Network Suitability Modeling Output

Table 3-21 SMAQMD $PM_{2.5}$ Monitoring Network Suitability Modeling Results

Site	Suitability Modeling Output		Suitability Modeling Rank		Site-by-Site Rank		Sum of Rankings	Final Rank
	24-hour	Annual	24-hour	Annual	24-hour	Annual		
Sacramento-Health Dept.	2.12	1.91	1	1	3	3	8	1
Sacramento-Del Paso Manor	1.48	1.36	4	4	1	1	10	2
Sacramento-1309 T Street	1.92	1.76	2	2	5	5	14	3
Elk Grove-Bruceville	1.09	1.32	5	5	2	2	14	4
Sacramento-Bercut Dr.	1.64	1.62	3	3	4	4	14	5
Folsom-Natoma	1.03	1.2	6	7	6	7	26	6
Sloughhouse	0.92	1.21	7	6	7	6	26	7
Rancho Seco	0.71	0.98	8	8	9	9	34	8

The results of the suitability modeling and site-by-site analysis for the $PM_{2.5}$ monitoring network were combined to evaluate monitor placement. Sacramento-Health Department, Del Paso Manor, and Elk Grove-Bruceville were the top three locations for $PM_{2.5}$ monitor placement.

Sacramento-Health Department was the highest scoring in terms of monitor placement and the third highest rank for the site-by-site analysis. However, $PM_{2.5}$ and PM_{10} are the only pollutants being measured at the Health Department and results of the correlation analysis show that 24-hour concentrations measured between 2005 and 2014 are exceptionally correlated (R^2 greater than 0.9) with T-Street and Del Paso Manor. EPA indicates in its network assessment guidance that monitors with concentrations that correlate well (e.g., $R^2 > 0.75$) with concentrations at another monitor may be redundant.

The Health Department monitor is located only 3 kilometers from the T Street monitoring site, which serves much of the same population and emission sources. If the Health Department particulate monitors were removed, the T Street monitor would be the most important site in the network for monitoring fine particulates.

3.4 PM_{10} Network

There are a total of six PM_{10} monitoring stations located within Sacramento County. Each monitoring site operates as part of the SLAMS network. Two sites, Goldenland Court and the Sacramento-Health Department, operate continuous monitors which are important for determining the AQI and disseminating real-time particulate data to the public. All sites operate filter-based FRM monitors, with Del Paso Manor also measuring coarse fraction particulate ($PM_{10-2.5}$).

3.4.1 PM_{10} Network Spatial Analyses

Thiessen polygons were generated to determine the spatial representation of each PM_{10} monitoring station located in and adjacent to Sacramento County. Ten PM_{10} monitors were identified as representing a portion of Sacramento County. The following sections present the findings for area-, population-, and emissions-served analyses for the PM_{10} network.

3.4.1.1 PM_{10} Network Area- and Population-Served Analyses

The population within Sacramento County represented by each monitoring site was counted within the Thiessen polygons using 2009 through 2013 ACS data. Area- and population-served analyses, including sensitive and vulnerable populations, are presented in Table 3-22. Figure 3.17 presents a map showing the location, area of influence, and served population for each PM_{10} monitor.

Table 3-22 Area and Population Served by PM_{10} Monitors Serving Sacramento County

Site	2013 Population Estimate (Persons)	Population Change from 2010 to 2013 (Persons)	Sensitive/ Vulnerable Population (Persons)[1]	Area (km²)
North Highlands-Blackfoot	147,903	4,417	39,784	93.02
Sacramento-Del Paso Manor	216,510	1,364	57,524	136.18
Sacramento-1309 T Street	123,995	2,114	37,532	147.59
Sacramento-Goldenland Court	135,274	878	42,080	183.88
Branch Center Road	246,970	4,206	68,031	1,131.76
Sacramento-Health Dept.	334,021	3,757	113,597	245.24
Bethel Island	3,329	(519)	941	270.62
Roseville-N Sunrise Blvd	*186,931*	*158*	*39,282*	*176.55*
Stockton-Wagner/Holt	*25,590*	*(59)*	*7,272*	*176.52*
West Sacramento-Fire Station	*14,684*	*103*	*4,538*	*13.90*

Sites located outside Sacramento County are italicized.
[1]Summation of sensitive/vulnerable persons located within the monitors area of influence.

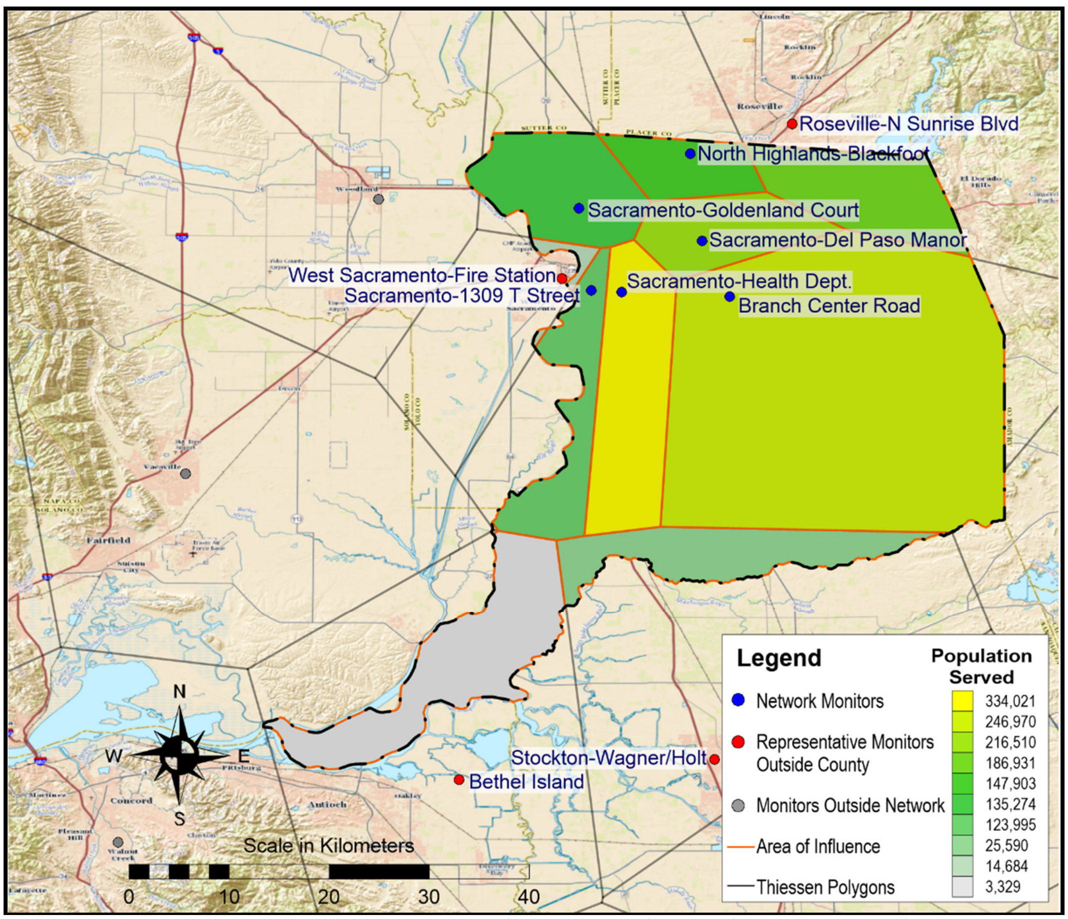


Figure 3.17 PM_{10} Network Area and Population Served

Branch Center Road was found to be the most important site in the PM_{10} network based only on area of influence. This is primarily due to a lack of PM_{10} monitoring south of Highway 50 and State Road 16. Del Paso Manor, Health Department, and Branch Center Road combine to serve the majority of the population as well as the majority of Environmental Justice population within the county. The largest population growth in the county were in areas served by Health Department, Branch Center Road and North Highlands-Blackfoot.

3.4.1.2 PM_{10} Network Emissions-Served Analysis

PM_{10} emissions served by each monitor were evaluated with 2012 gridded modeled emissions provided by CARB. Table 3-23 presents a typical weekday or weekend day during the summer and winter of PM_{10} emissions for each monitor. Monitors were ranked according to the quantity of PM_{10} emissions within each monitor's area of representation. Figures 3.18 and 3.19 present maps with the emissions served by each monitoring area.

Table 3-23 PM_{10} Emissions Served by Monitors Representing Sacramento County

Site	Winter Weekday PM_{10} Emissions (tpd)	Winter Weekend PM_{10} Emissions (tpd)	Summer Weekday PM_{10} Emissions (tpd)	Summer Weekend PM_{10} Emissions (tpd)
North Highlands-Blackfoot	2.084	1.496	2.282	1.326
Sacramento-Del Paso Manor	2.713	1.965	2.945	1.758
Sacramento-1309 T Street	1.147	0.793	1.383	0.883
Sacramento-Goldenland Court	1.427	1.201	1.461	1.074
Branch Center Road	5.314	3.846	6.262	3.550
Sacramento-Health Dept.	5.505	4.138	6.025	3.942
Bethel Island	*1.243*	*1.191*	*1.374*	*1.532*
Roseville-N Sunrise Blvd	*3.148*	*2.386*	*3.254*	*1.995*
Stockton-Wagner/Holt	*0.744*	*0.655*	*0.853*	*0.811*
West Sacramento-Fire Station	*1.364*	*0.950*	*1.532*	*0.993*

Sites located outside Sacramento County are italicized.

Health Department and Branch Center Road were the highest ranking sites for PM_{10} emissions within their respective area of influence. As can be seen in the following figures, there seems to be a lack of PM_{10} monitoring south of these sites, which extends their respective areas of influence to areas that may not accurately represent these emission sources.

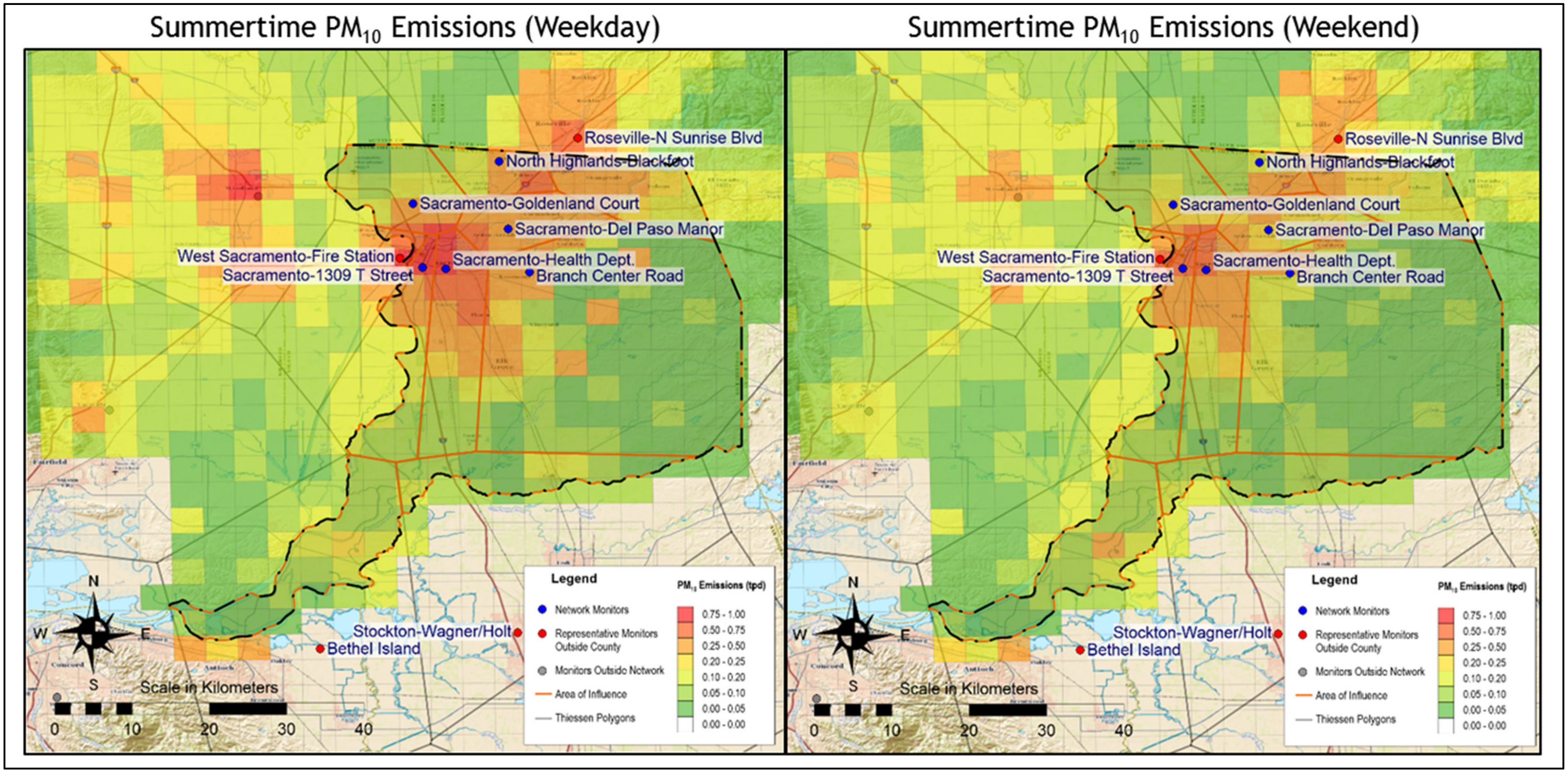


Figure 3.18 PM_{10} Network Summer Emissions Served

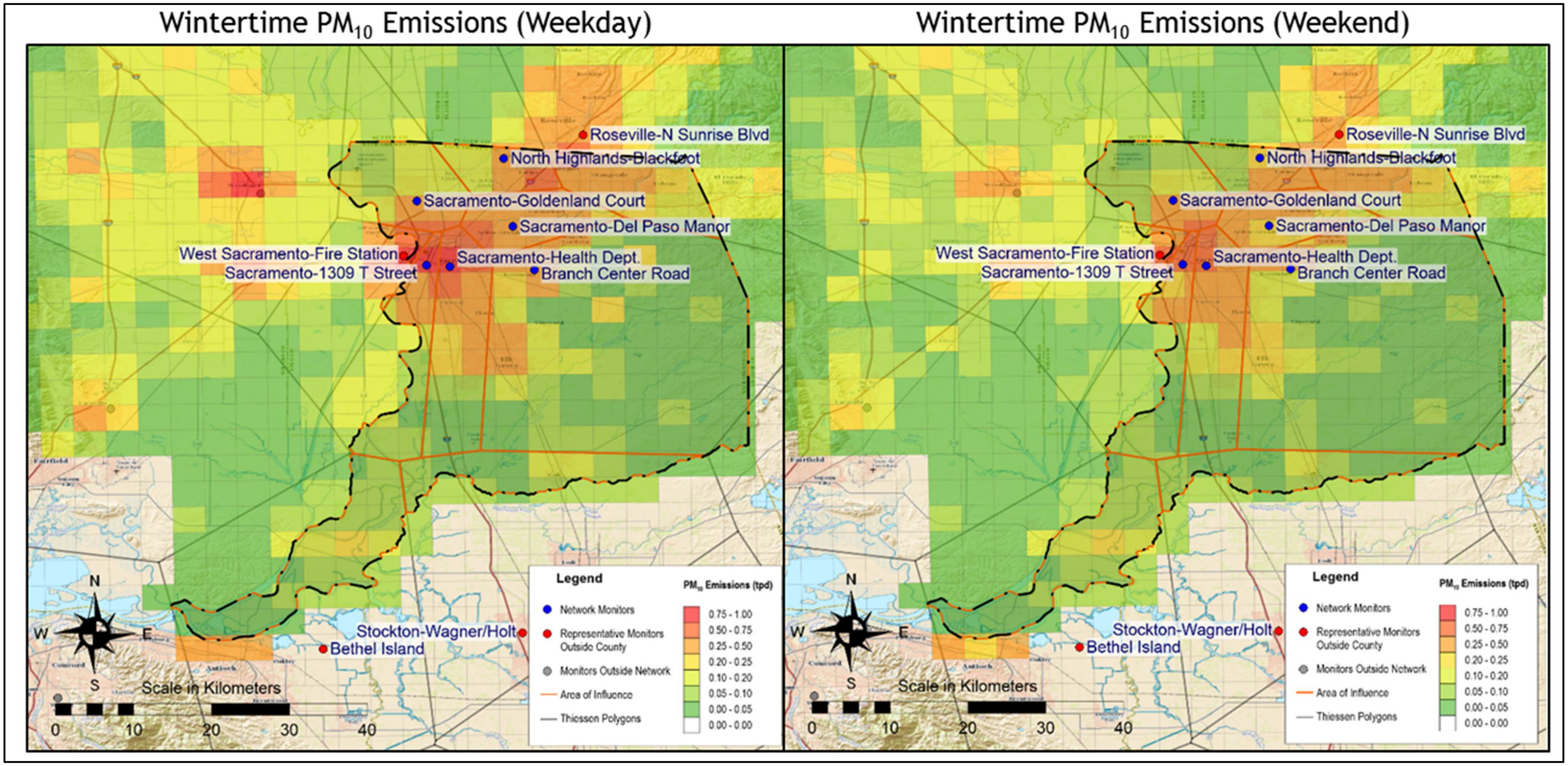


Figure 3.19 PM$_{10}$ Network Winter Emissions Served

3.4.2 PM_{10} Data Analyses

The data analysis conducted for PM_{10} was used to determine the importance of a site based on measured concentrations, deviation from NAAQS, monitor-to-monitor correlation, trend impact, and removal bias. Unlike $PM_{2.5}$, PM_{10} has only a 24-hour NAAQS.

3.4.2.1 PM_{10} Measured Concentration, Deviation from NAAQS, and Trend Analysis

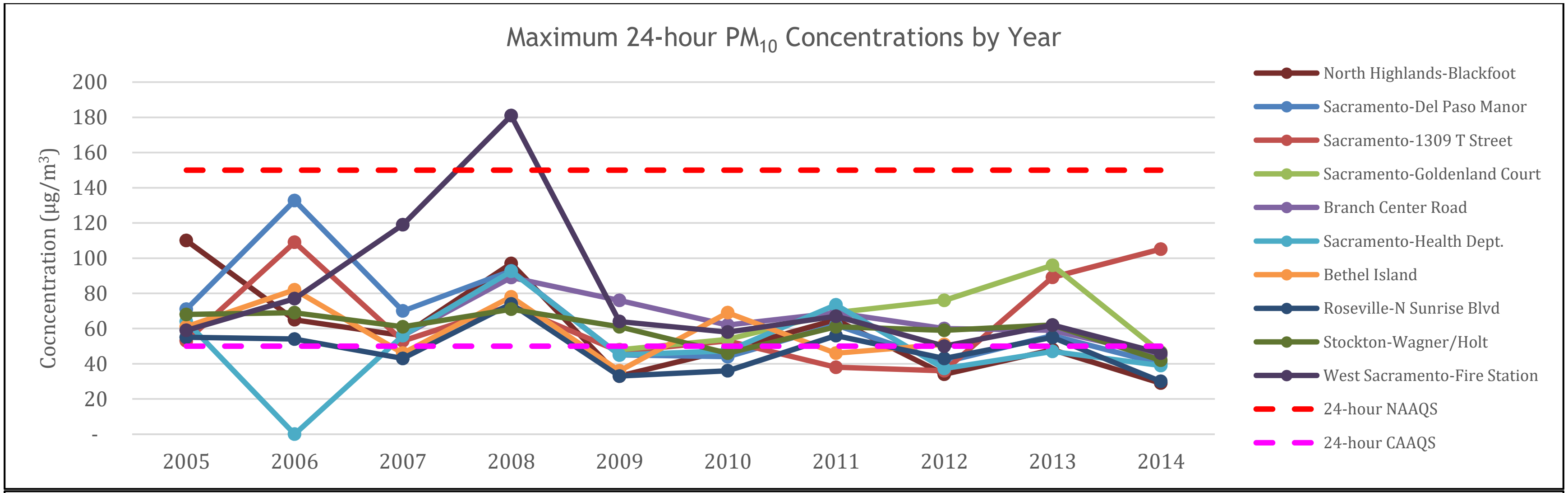
Monitors within SMAQMD's ambient air monitoring network that have high levels of PM_{10}, design values close to the standard, and with a long historical record were considered to be of high value for characterizing pollution in an area. Table 3-24 presents the 24-hour design value concentrations for 2005 through 2014, deviation from NAAQS for 2014, and the exceedance probability using data from 2005 through 2014. Figure 3.20 presents the 2005 through 2014 maximum 24-hour concentrations by year and the 24-hour design values for PM_{10} monitors serving Sacramento County. The exceedance probability in Table 3-24 is presented as percent of the standard (150 $\mu g/m^3$).

In 2014, T Street had the highest concentration of all sites representing a portion of the county. No monitors within the network have a probability to exceed the standard in the next three years based on EPA's exceedance probability calculation.

Table 3-24 Concentration Analysis for PM_{10} Monitors Serving Sacramento County

Site	Length of Record (years)	24-hour Design Values (µg/m³)										Deviation from NAAQS (µg/m³)[a]	Exceedance Probability
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
North Highlands-Blackfoot	27	67	57	54	76	33	37	39	31	46	28	-122.0	37.1%
Sacramento-Del Paso Manor	30	64	92	66	90	39	36	58	30	42	36	-114.0	45.1%
Sacramento-1309 T Street	26	52	68	53	66	41	43	36	33	66	83	-66.8	42.1%
Sacramento-Goldenland Court	8	--	--	--	--	43	46	63	43	68	33	-116.8	39.7%
Branch Center Road	10	--	--	56	86	74	54	57	58	48	39	-111.0	45.5%
Sacramento-Health Dept.	30	54	102	51	88	45	45	60	34	46	37	-113.0	45.5%
Bethel Island	*30*	*42*	*47*	*46*	*59*	*31*	*45*	*44*	*29*	--	--	--	*32.5%*
Roseville-N Sunrise Blvd	*23*	*40*	*50*	*35*	*40*	*29*	*33*	*30*	*28*	*36*	*29*	*-121.0*	*25.9%*
Stockton-Wagner/Holt	*20*	*62*	*62*	*61*	*67*	*43*	*41*	*49*	*45*	*58*	*38*	*-112.0*	*38.9%*
West Sacramento-Fire Station	*26*	*49*	*65*	*60*	*109*	*54*	*48*	*52*	*38*	*55*	*44*	*-106.0*	*45.5%*

Sites located outside Sacramento County are italicized.
[a] Based on 2014 data



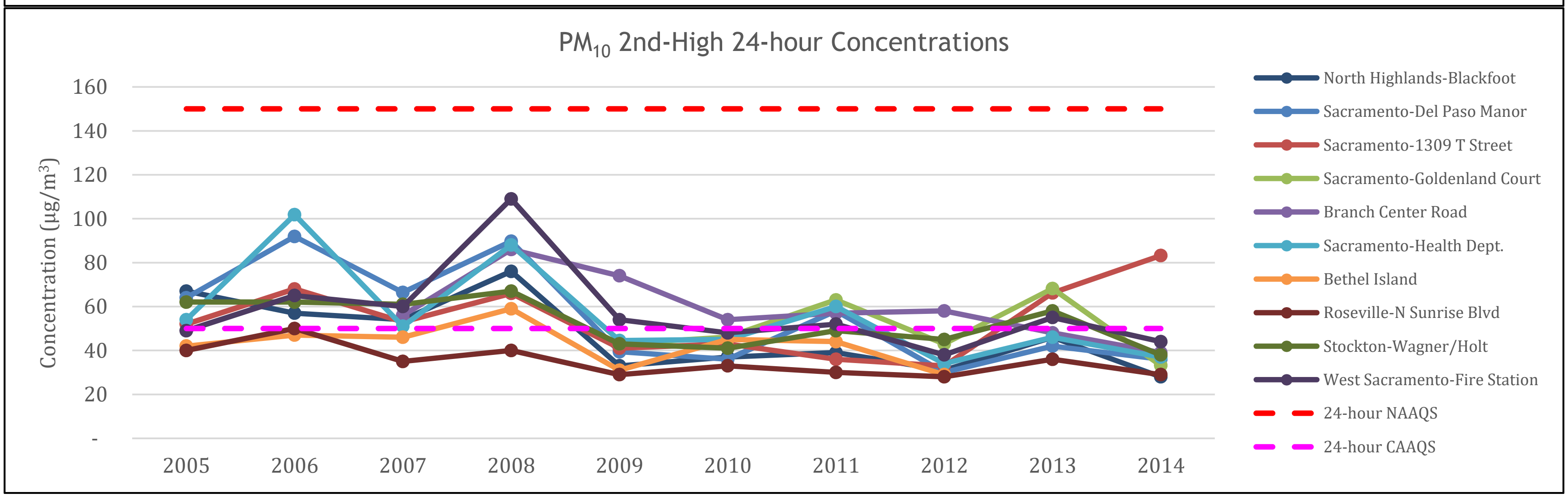


Figure 3.20 PM_{10} 24-hour Maximum and Design Value Concentrations by Year

3.4.2.2 Monitor-to-Monitor Correlation Analysis

Daily PM_{10} concentration data collected between 2005 through 2014 from the ten monitors were compared for redundancy using the square of the Pearson correlation coefficient (R^2). Monitor-to-monitor correlation analysis found that of the ten monitors representing a portion of Sacramento County, four were highly correlated (>80%) with at least one other monitor. As can be expected, monitors close in proximity correlated better than those that were further apart. Tables 3-25 and 3-26 present the correlation statistics compared to distance.

Table 3-25 Correlation (R^2)/Distance (km) Analysis for PM_{10} Monitors Serving Sacramento County

Site ID	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Sacramento-Goldenland Court	Branch Center Road	Sacramento-Health Dept.	*Bethel Island*	*Roseville-N Sunrise Blvd*	*Stockton-Wagner/Holt*	*West Sacramento – Fire Station*
North Highlands-Blackfoot										
Sacramento-Del Paso Manor	0.509									
Sacramento-1309 T Street	0.478	0.768								
Sacramento-Goldenland Court	0.879	0.723	0.569							
Branch Center Road	0.567	0.523	0.564	0.687						
Sacramento-Health Dept.	0.557	0.814	0.851	0.845	0.595					
Bethel Island	*0.442*	*0.570*	*0.713*	*0.646*	*0.481*	*0.666*				
Roseville-N Sunrise Blvd	*0.568*	*0.665*	*0.679*	*0.705*	*0.577*	*0.685*	*0.540*			
Stockton-Wagner/Holt	*0.440*	*0.638*	*0.683*	*0.608*	*0.449*	*0.670*	*0.627*	*0.537*		
West Sacramento-Fire Station	*0.551*	*0.448*	*0.550*	*0.769*	*0.480*	*0.534*	*0.536*	*0.464*	*0.441*	

Sites located outside Sacramento County are italicized.

Distance (km)								
90	80	70	60	50	40	30	20	10

Table 3-26 Distance (km)/Correlation (R^2) Analysis for PM_{10} Monitors Serving Sacramento County

Site ID	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Sacramento-Goldenland Court	Branch Center Road	Sacramento-Health Dept.	*Bethel Island*	*Roseville-N Sunrise Blvd*	*Stockton-Wagner/Holt*	*West Sacramento – Fire Station*
North Highlands-Blackfoot										
Sacramento-Del Paso Manor	11.0									
Sacramento-1309 T Street	19.7	12.5								
Sacramento-Goldenland Court	12.9	12.8	10.4							
Branch Center Road	18.3	7.5	13.6	18.5						
Sacramento-Health Dept.	18.6	10.1	3.0	11.3	10.6					
Bethel Island	*81.8*	*71.7*	*62.8*	*72.7*	*66.3*	*63.3*				
Roseville-N Sunrise Blvd	*10.6*	*17.1*	*28.7*	*23.4*	*22.5*	*26.9*	*88.6*			
Stockton-Wagner/Holt	*76.0*	*65.0*	*60.1*	*70.4*	*58.1*	*59.3*	*25.4*	*80.1*		
West Sacramento-Fire Station	*20.1*	*14.5*	*3.2*	*9.0*	*16.6*	*6.1*	*63.7*	*29.8*	*62.2*	

Sites located outside Sacramento County are italicized.

Correlation (R^2)								
0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.50

Monitoring sites that are highly correlated (R^2 values above 80 percent) with more than one site may be an indication of a redundant site. Both Health Department and Goldenland Court had PM_{10} monitoring data that were highly correlated with two or more monitoring sites. The Health Department was highly correlated with Del Paso Manor, T Street, and Goldenland Court. In addition, Goldenland Court was highly correlated with measurements made at the North Highlands-Blackfoot monitoring station.

3.4.2.3 PM_{10} Monitor Removal Bias Analysis

Each monitor was analyzed to determine the change in spatial concentrations interpolated across Sacramento County if the monitor were removed. Table 3-27 presents the results of the removal bias analysis and the maximum change in PM_{10} concentrations in Sacramento County if each monitor in SMAQMD's network were individually removed.

The change in concentration at a site indicates the bias that may be observed if the individual monitor were removed. Results in Table 3-27 indicate that removal of the Health Department and Branch Center Road PM_{10} monitors could introduce a large bias in concentration interpolation. This is due to the lack of PM_{10} monitoring south of these two sites and the large areas they represent.

Table 3-27 SMAQMD PM_{10} Monitoring Network Removal Bias Results

Site	2014 Design Value (µg/m³)	Change in Concentration (µg/m³)
North Highlands-Blackfoot	28.0	9.2
Sacramento-Del Paso Manor	36.0	3.3
Sacramento-1309 T Street	83.2	8.0
Sacramento-Goldenland Court	33.2	2.2
Branch Center Road	39.0	34.7
Sacramento-Health Dept.	37.0	37.5

3.4.3 PM_{10} Site-to-Site Analysis

The PM_{10} monitoring network site-to-site analysis ranked sites based on spatial representation, measured concentrations, deviation from NAAQS, and trend analysis. Table 3-28 presents the results of the site-to-site analysis for the PM_{10} monitoring network. These results, and a discussion of their meaning, are combined with the suitability modeling in the next section.

Table 3-28 Results of the PM_{10} Network Site-to-Site Analysis

Site	Area Served	Pop. Served[b]	MSDI Pop.[b]	Pop. Change[b]	Emissions Served	Measured Conc.	Deviation from NAAQS	Corr.	Removal Bias	Total	Rank by Importance
North Highlands-Blackfoot	9	5	5	1	5	9	9	6	3	52	6
Sacramento-Del Paso Manor	8	3	3	5	4	6	6	5	5	45	3
Sacramento-1309 T Street	7	7	7	4	9	1	1	7	4	47	4
Sacramento-Goldenland Court	4	6	4	6	7	7	7	9	6	56	8
Branch Center Road	1	2	2	2	2	3	3	1	2	18	1
Sacramento-Health Dept.	3	1	1	3	1	5	5	8	1	28	2
Bethel Island	*2*	*10*	*10*	*10*	*6*	*5*[a]	*5*[a]	*4*	*5*[a]	*57*	*10*
Roseville-N Sunrise Blvd	*5*	*4*	*6*	*7*	*3*	*8*	*8*	*3*	*5*[a]	*49*	*5*
Stockton-Wagner/Holt	*6*	*8*	*8*	*9*	*10*	*4*	*4*	*2*	*5*[a]	*56*	*9*
West Sacramento-Fire Station	*10*	*9*	*9*	*8*	*8*	*2*	*2*	*0*	*5*[a]	*53*	*7*

Sites located outside Sacramento County are italicized.
[a]Monitors not included in analysis technique, were substituted with 5.
[b]Population within Sacramento County

3.4.4 PM_{10} Suitability Modeling

The suitability modeling aimed to determine the most appropriate locations for monitor placement. Gridded data layers, categorized by population, emissions inventory, and measured concentrations, were combined to determine the most appropriate locations for PM_{10} monitor placement. The grids used in the PM_{10} network suitability modeling are listed below and graphical representations of these grids are provided in Appendix C. Figure 3.21 presents the output of the suitability modeling. Table 3-29 presents the model output score at the location of each monitor within Sacramento County.

- Typical summertime weekday PM_{10} emissions from CMAQ model
- Typical summertime weekend PM_{10} emissions from CMAQ model
- Typical wintertime weekday PM_{10} emissions from CMAQ model
- Typical wintertime weekend PM_{10} emissions from CMAQ model
- 24-hour PM_{10} design values
- Exceedance probability of PM_{10} monitors
- Population density
- Population change
- Sensitive and vulnerable population index (MSDI)

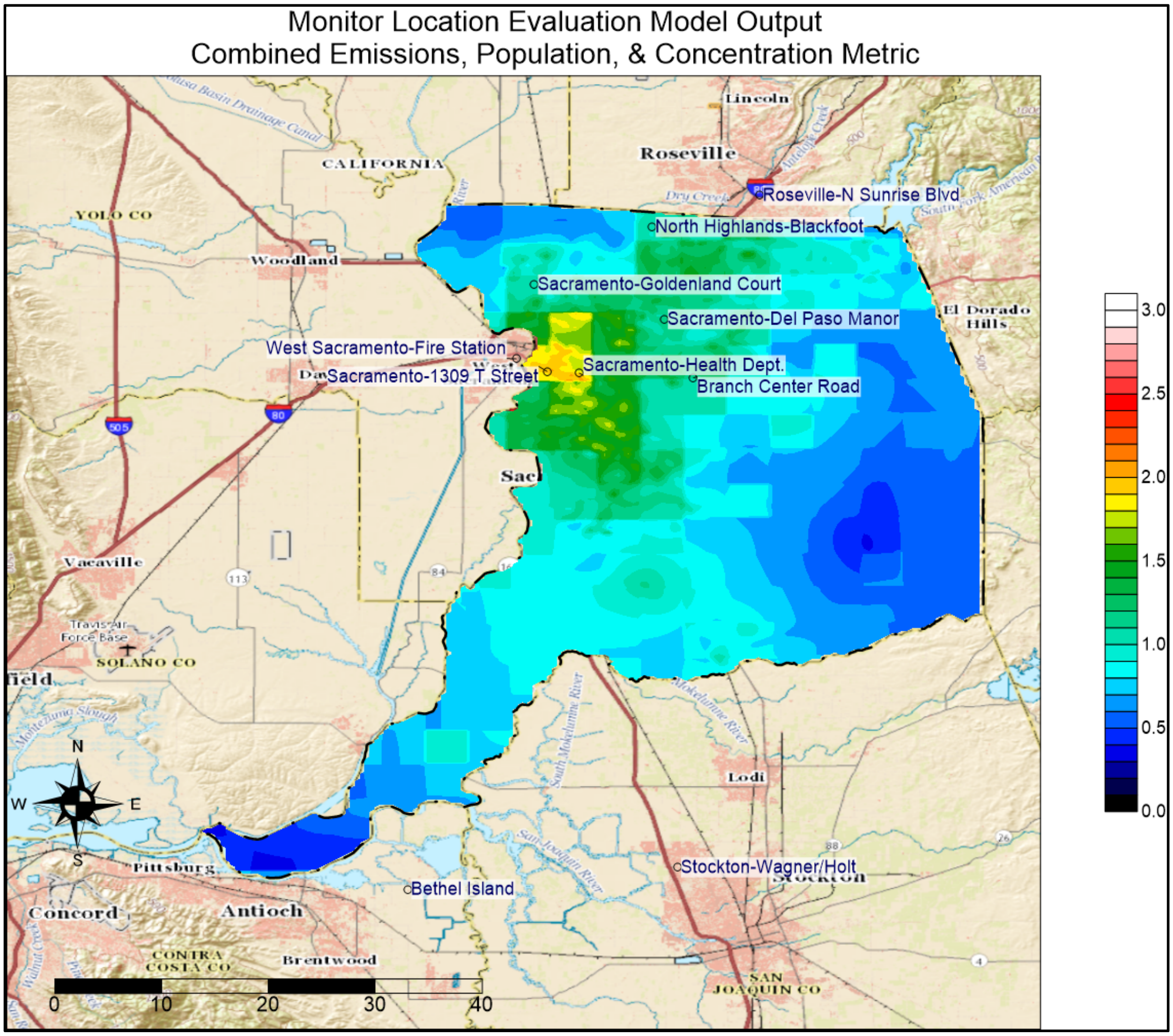


Figure 3.21 PM_{10} Monitoring Network Suitability Modeling Output

Table 3-29 SMAQMD PM_{10} Monitoring Network Suitability Modeling Results

Site	Suitability Modeling Output	Suitability Modeling Rank	Site-by-Site Rank	Sum of Rankings	Final Rank
Sacramento-Health Dept.	1.87	2	2	4	1
Sacramento-1309 T Street	1.96	1	4	5	2
Branch Center Road	1.11	4	1	5	3
Sacramento-Del Paso Manor	1.13	3	3	6	4
North Highlands-Blackfoot	1.02	5	6	11	5
Sacramento-Goldenland Court	0.87	6	8	14	6

The results of the suitability modeling and site-by-site analyses for the PM_{10} monitoring network were combined to evaluate monitor placement. The Health Department, T Street, and Branch Center Road sites were the highest ranked locations for PM_{10} monitor placement. The area of influence from these sites extends to the south end of the county, with the next nearest site located in Stockton, CA. Although the final analysis shows the Health Department is the most important site based on the analytical techniques, the site is located only 3 kilometers from the T Street site and they serve much of the same population and emission sources, which is reflected in the correlation analysis.

3.5 NO_2 Network

There are a total of six (6) NO_2 monitoring stations located within Sacramento County. SMAQMD has installed a new monitoring station, Sacramento-Bercut Drive, which started collecting NO_2 data November 2015.

3.5.1 NO_2 Network Spatial Analyses

Thiessen polygons were generated to determine the spatial representation of each NO_2 monitoring station located in and adjacent to Sacramento County. Nine (9) NO_2 monitors were identified as representing a portion of Sacramento County. The following sections present the findings for area-, population-, and emissions-served analyses for the NO_2 network.

3.5.1.1 NO_2 Network Area- and Population-Served Analyses

The population within Sacramento County represented by each monitoring site was counted within the Thiessen polygons using 2009 through 2013 ACS data. Area- and population-served analyses, including sensitive and vulnerable populations, are presented in Table 3-30. Figure 3.22 presents a map showing the location, area of influence, and served population for each NO_2 monitor.

Table 3-30 Area and Population Served by NO_2 Monitors Serving Sacramento County

Site	2013 Population Estimate (Persons)	Population Change from 2010 to 2013 (Persons)	Sensitive/ Vulnerable Population (Persons)[a]	Area (km^2)
North Highlands-Blackfoot	142,237	4,683	38,548	86.12
Sacramento-Del Paso Manor	343,673	3,554	93,377	383.91
Sacramento-1309 T Street	375,361	4,911	129,455	187.03
Elk Grove-Bruceville	193,401	2,432	52,001	894.72
Folsom-Natoma	123,544	149	24,548	564.97
Sacramento-Goldenland Court	105,427	928	32,177	174.17
Sacramento-Bercut Dr.	53,897	-151	18,540	36.98
Bethel Island	*2,241*	*-481*	*691*	*196.13*
Roseville-N Sunrise Blvd	*95,426*	*394*	*21,244*	*51.24*

Sites located outside Sacramento County are italicized.
[a] Summation of sensitive/vulnerable persons located within the monitor's area of influence.

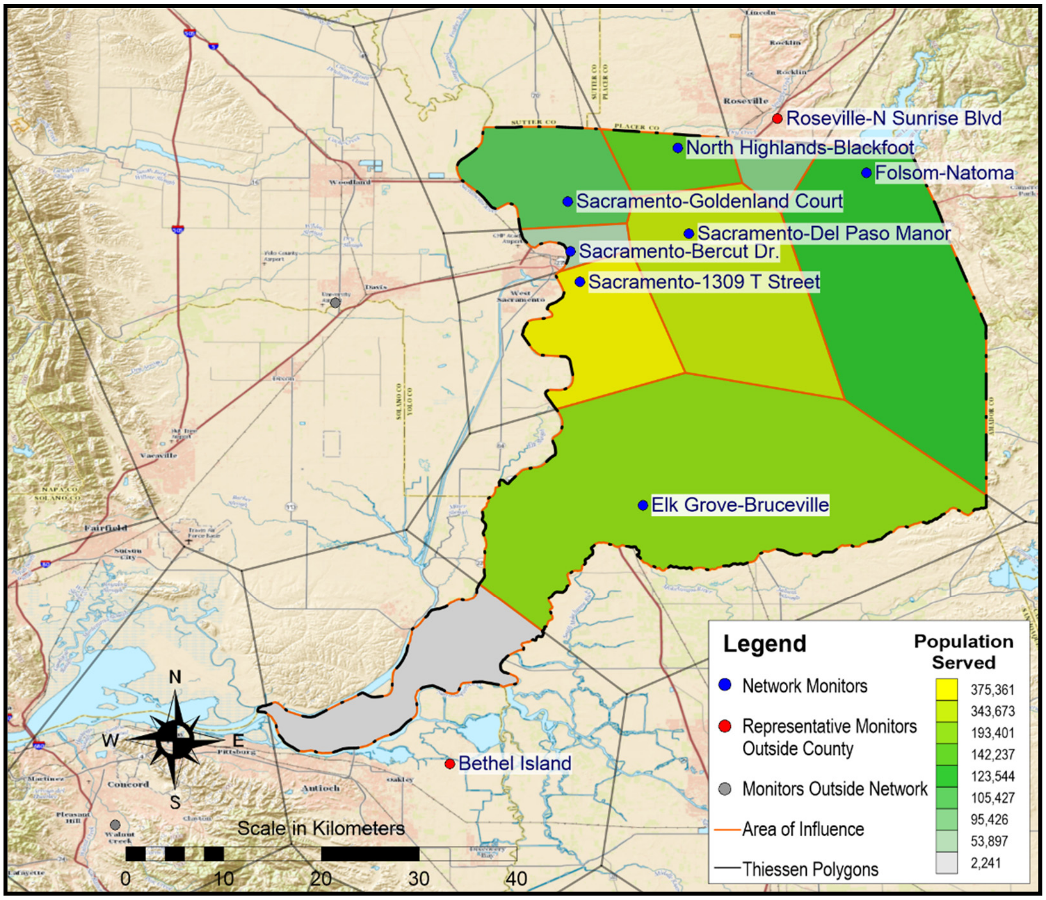


Figure 3.22 NO_2 Network Area and Population Served

Elk Grove-Bruceville was found to be the most important site in the NO_2 network based only on area of influence. T Street, Del Paso Manor, and Elk Grove-Bruceville combine to serve the majority of the population as well as the majority of the Environmental Justice population within the county. The largest population growth in the county was in areas served by these three monitors and North Highlands-Blackfoot.

3.5.1.2 NO_2 Network Emissions Served Analysis

Emissions served by each monitor were evaluated with 2012 gridded modeled emissions of summertime and wintertime NO_x. Table 3-31 presents NO_x emissions for each NO_2 monitor based on a typical weekday or weekend in winter and summer. Monitors were ranked on the average of the summer and winter emissions. Figures 3.23 and 3.24 present maps with the emissions served by each monitoring area.

Table 3-31 Emissions Served by NO_2 Monitors Representing Sacramento County

Site	Winter Weekday NO_x Emissions (tpd)	Winter Weekend NO_x Emissions (tpd)	Summer Weekday NO_x Emissions (tpd)	Summer Weekend NO_x Emissions (tpd)
North Highlands-Blackfoot	4.80	3.99	3.93	3.24
Sacramento-Del Paso Manor	15.29	12.46	12.82	10.53
Sacramento-1309 T Street	13.38	11.01	11.19	9.44
Elk Grove-Bruceville	7.04	5.76	7.50	6.92
Folsom-Natoma	5.64	4.57	4.89	4.10
Sacramento-Goldenland Court	4.96	4.11	4.41	3.70
Sacramento-Bercut Dr.	2.65	2.20	2.31	2.10
Bethel Island	*1.22*	*1.00*	*1.70*	*1.91*
Roseville-N Sunrise Blvd	*3.26*	*2.67*	*2.53*	*2.02*

Sites located outside Sacramento County are italicized.

Del Paso Manor, Health Department, and Elk Grove-Bruceville were the highest ranking sites in terms of overall emission sources located within their respective areas of influence.

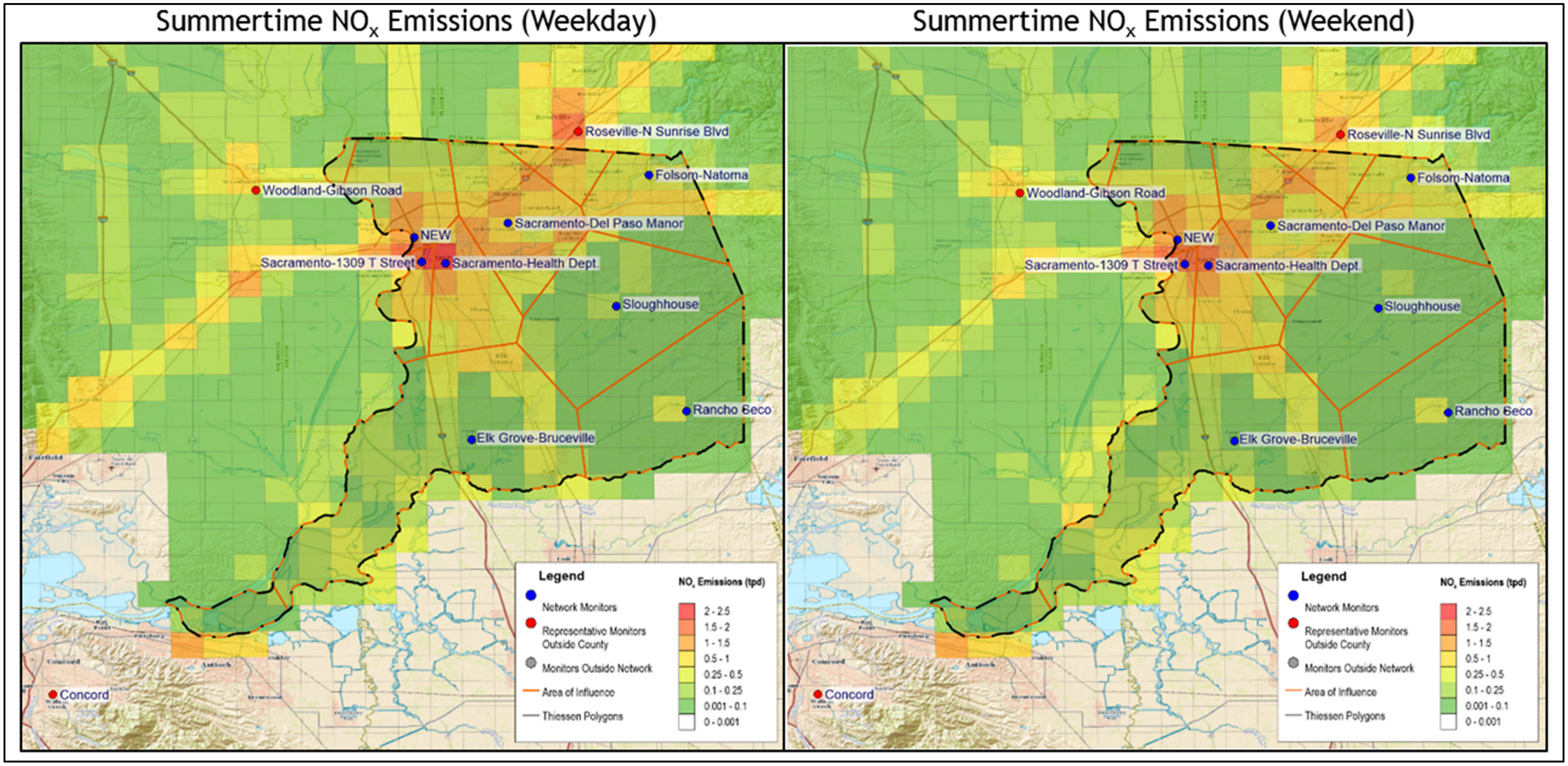


Figure 3.23 NO_2 Network Summer Emissions Served

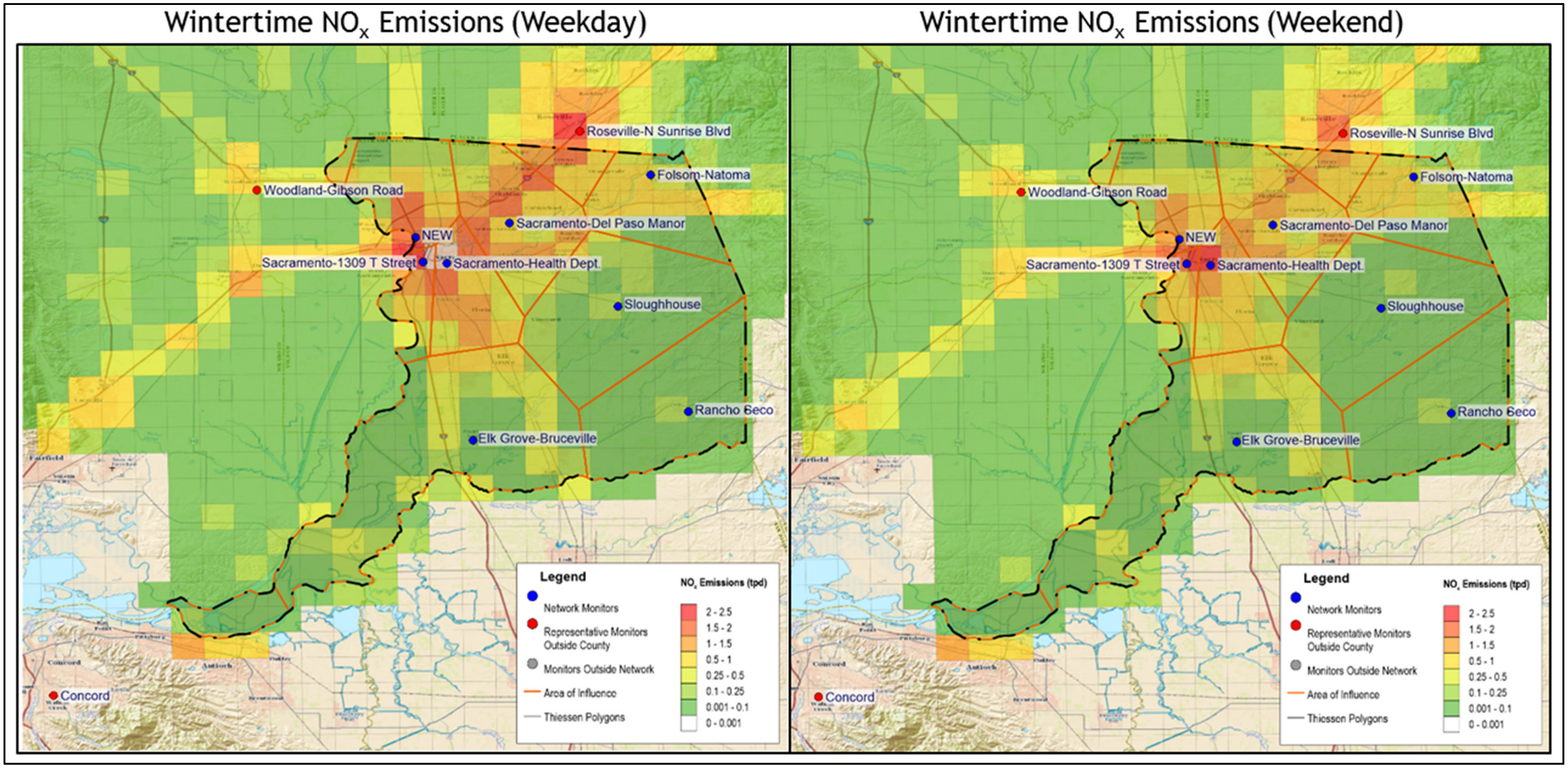


Figure 3.24 NO_2 Network Winter Emissions Served

3.5.2 NO_2 Data Analyses

The data analysis conducted was used to determine the importance of a site based on measured concentrations, deviation from NAAQS, monitor-to-monitor correlation, trend impact, and removal bias. Near-road NO_2 requirements are presented in the minimum requirements discussion in Section 2.1.

3.5.2.1 NO_2 Measured Concentration, Deviation from NAAQS, and Trend Analysis

Monitors within SMAQMD's ambient air monitoring network shown to have high levels of NO_2, design values close to the standard, and with a long historical record were considered to be of high value for characterizing pollution in an area. Tables 3-32 and 3-33 present the 1-hour and annual design value concentrations for 2005 through 2014, deviation from NAAQS for the 2012-2014 monitoring period, and the exceedance probability using values from 2005 through 2014. Figure 3.25 presents the 2005 through 2014 maximum 1-hour concentrations, by year, and the 1-hour design values for NO_2 monitors serving Sacramento County. Figure 3.26 presents the annual standard design values for NO_2 monitors serving Sacramento County. The exceedance probability is presented in percent of the standards (100 ppb for 1-hour and 53 ppb for annual, Table 2-2) in Tables 3-32 and 3-33.

T Street had the highest NO_2 concentrations for both the 1-hour and annual averaging periods for all monitors representing a portion of the county. No monitors within the network have a probability to exceed either the 1-hour or annual standards in the next three years based on EPA's exceedance probability calculation.

Table 3-32 1-hour Concentration Analysis for NO_2 Monitors Serving Sacramento County

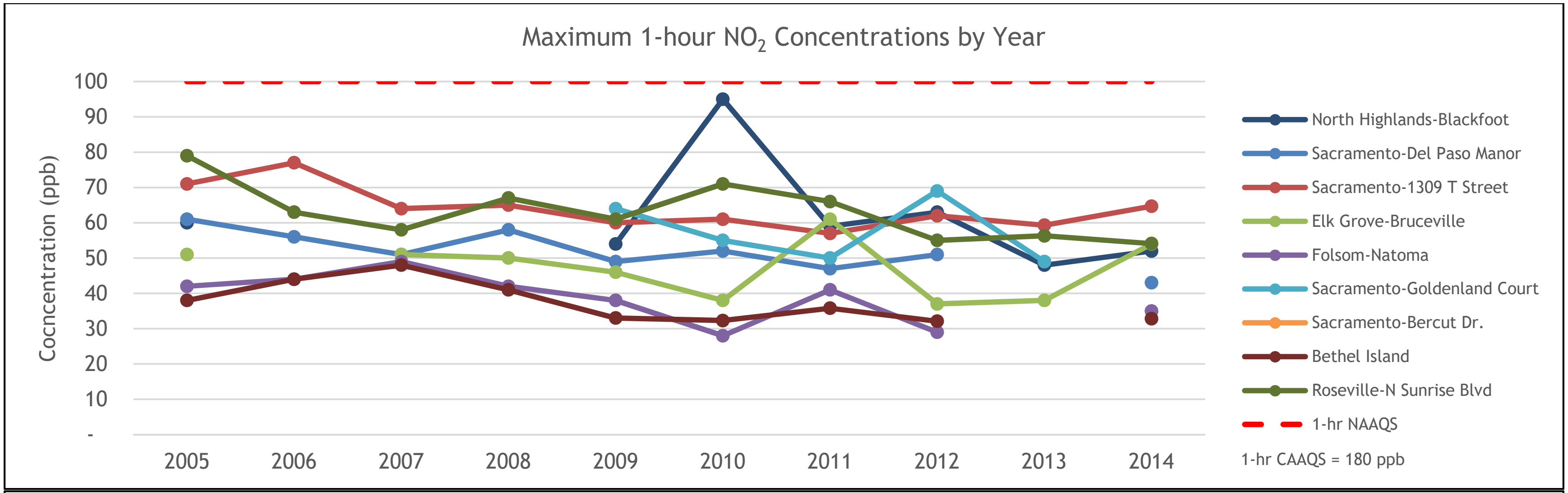
Site	Length of Record (years)	1-hour Design Values (ppb)								Deviation from NAAQS (ppb)	Exceedance Probability
		2005-07	2006-08	2007-09	2008-10	2009-11	2010-12	2011-13	2012-14		
North Highlands-Blackfoot	37	--	--	--	--	44	44	43	44	56	44.3%
Sacramento-Del Paso Manor	36	47	47	45	43	40	39	--	--	--	46.1%
Sacramento-1309 T Street	27	54	55	54	53	50	50	51	52	48	53.6%
Elk Grove-Bruceville	24	--	--	35	33	32	32	33	31	69	33.7%
Folsom-Natoma	20	35	34	32	29	28	26	--	--	--	33.3%
Sacramento-Goldenland Court	8	--	--	--	--	46	45	45	--	--	46.1%
Sacramento-Bercut Dr.	0	--	--	--	--	--	--	--	--	--	--
Bethel Island	*35*	*33*	*33*	*31*	*27*	*27*	*27*	--	--	--	*31.9%*
Roseville-N Sunrise Blvd	*23*	*57*	*57*	*53*	*53*	*50*	*51*	*49*	*48*	*52*	*54.4%*

Sites located outside Sacramento County are italicized.

Table 3-33 Annual Concentration Analysis for NO_2 Monitors Serving Sacramento County

Site	Length of Record (years)	Annual Design Values (ppb)										Deviation from NAAQS (ppb)	Exceedance Probability
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
North Highlands-Blackfoot	37	11	--	12	--	10	9	9	8	10	8	45	10.5%
Sacramento-Del Paso Manor	36	11	12	11	10	10	7	9	8	8	6	47	10.3%
Sacramento-1309 T Street	27	16	16	15	15	13	12	12	12	12	11	42	14.4%
Elk Grove-Bruceville	24	8	9	8	8	6	6	6	5	6	5	48	7.5%
Folsom-Natoma	20	7	7	7	7	6	4	5	4	--	3	50	6.5%
Sacramento-Goldenland Court	8	--	--	--	--	11	9	9	8	9	--	--	10.1%
Sacramento-Bercut Dr.	0	--	--	--	--	--	--	--	--	--	--	--	--
Bethel Island	*35*	*7*	*7*	*7*	*7*	*6*	*5*	*6*	*6*	--	--	*48*	*6.7%*
Roseville-N Sunrise Blvd	*23*	*13*	*13*	*12*	*12*	*10*	*9*	*10*	*10*	*10*	*5*	*45*	*11.6%*

Sites located outside Sacramento County are italicized.



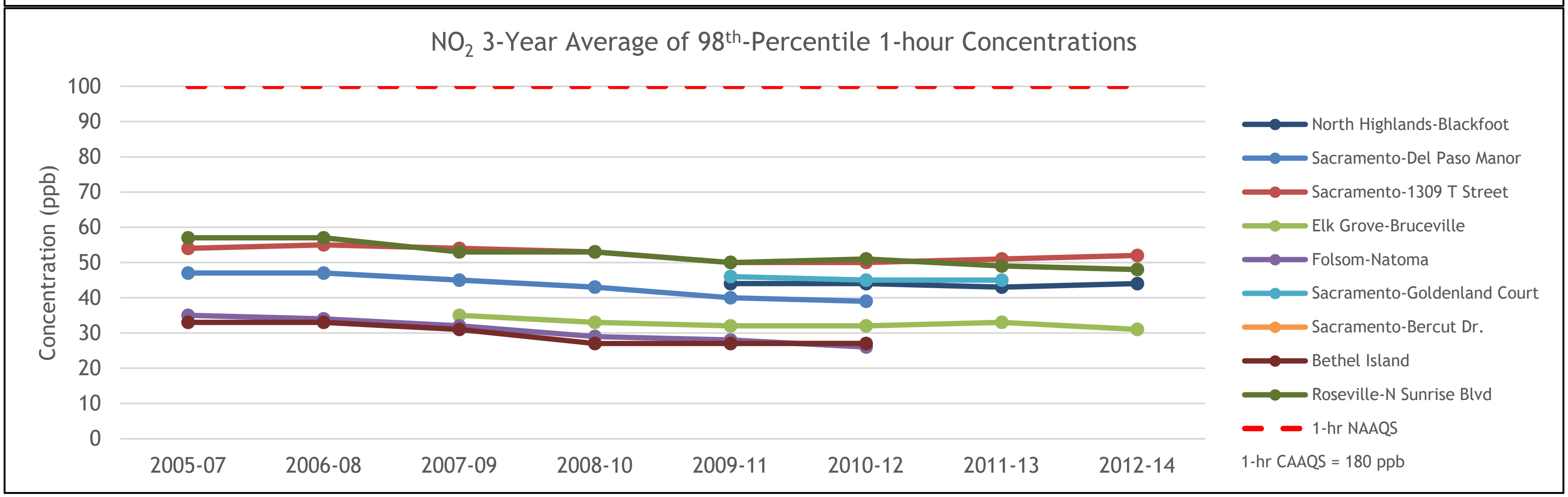


Figure 3.25 1-hour NO_2 Maximum and Design Value Concentrations

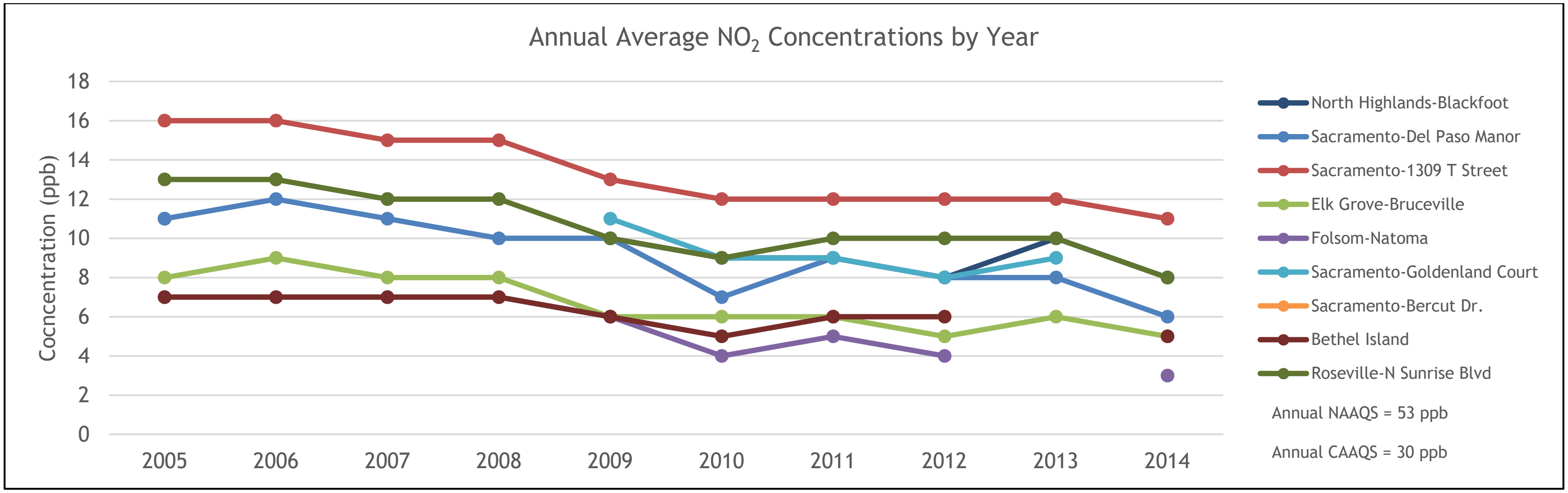


Figure 3.26 Annual NO_2 Design Value Concentrations

3.5.2.2 Monitor-to-Monitor Correlation Analysis

Hourly NO_2 concentration data collected between 2005 through 2014 from eight monitors were compared for redundancy using the square of the Pearson correlation coefficient (R^2). Sacramento-Bercut Drive was excluded as the station is anticipated to start data collection in 2016. Monitor-to-monitor correlation analysis found that none of the monitors representing a portion of Sacramento County were highly correlated (>80%). As can be expected, monitors close in proximity correlated better than those that were further apart. Table 3-34 and 3-35 present the correlation statistics compared to distance.

Table 3-34 Correlation (R^2)/Distance (km) Analysis for 1-hour NO_2 Data from Monitors Serving Sacramento County

Site ID	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Elk Grove-Bruceville	Folsom-Natoma	Sacramento-Goldenland Court	*Bethel Island*	*Roseville-N Sunrise Blvd*
North Highlands-Blackfoot								
Sacramento-Del Paso Manor	0.655							
Sacramento-1309 T Street	0.598	0.735						
Elk Grove-Bruceville	0.376	0.520	0.516					
Folsom-Natoma	0.289	0.404	0.301	0.271				
Sacramento-Goldenland Court	0.741	0.673	0.754	0.404	0.292			
Bethel Island	*0.455*	*0.490*	*0.531*	*0.473*	*0.248*	*0.491*		
Roseville-N Sunrise Blvd	*0.293*	*0.539*	*0.395*	*0.369*	*0.409*	*0.272*	*0.259*	

Sites located outside Sacramento County are italicized.

Distance (km)								
90	80	70	60	50	40	30	20	10

Table 3-35 Distance (km)/Correlation (R^2) Analysis for 1-hour NO_2 Data from Monitors Serving Sacramento County

Site ID	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Elk Grove-Bruceville	Folsom-Natoma	Sacramento-Goldenland Court	*Bethel Island*	*Roseville-N Sunrise Blvd*
North Highlands-Blackfoot								
Sacramento-Del Paso Manor	11.0							
Sacramento-1309 T Street	19.7	12.5						
Elk Grove-Bruceville	45.7	34.9	29.1					
Folsom-Natoma	19.1	19.3	31.8	47.9				
Sacramento-Goldenland Court	12.9	12.8	10.4	39.5	30.0			
Bethel Island	*81.8*	*71.7*	*62.8*	*38.2*	*86.1*	*72.7*		
Roseville-N Sunrise Blvd	*10.6*	*17.1*	*28.7*	*51.1*	*11.3*	*23.4*	*88.6*	

Sites located outside Sacramento County are italicized.

Correlation (R^2)								
0.95	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20

Of the six monitors located in the network, Goldenland Court had the lowest rank in terms of correlation, having two of the highest correlation pairs in the network with North Highlands-Blackfoot and T Street (74.1percent and 75.4 percent, respectively). The only other pair with a correlation above 70 percent was Del Paso Manor and T Street at 73.5 percent.

3.5.2.3 NO_2 Monitor Removal Bias Analysis

Each monitor was analyzed to determine the change in spatial concentrations interpolated across Sacramento County if the monitor were removed. Monitors with missing 2012 through 2014 design values were replaced with the most recent design value. Table 3-36 presents the results of the removal bias analysis and the maximum change in NO_2 concentration's (both 1-hour and annual) in Sacramento County if each NO_2 monitor in SMAQMD's network were individually removed.

The change in concentration at a site indicates the bias that may be observed if the individual monitor were removed. Results in Table 3-36 indicate that removal of the T Street NO_2 monitor could introduce a large bias in concentration interpolation.

Table 3-36 SMAQMD NO_2 Monitoring Network Removal Bias Results

Site	1-hour NO_2 2012-2014 Design Value (ppb)	Change in 1-hour NO_2 Concentration (ppb)	Annual NO_2 2014 Design Value (ppb)	Change in Annual NO_2 Concentration (ppb)
North Highlands-Blackfoot	44	2.5	8	0.5
Sacramento-Del Paso Manor	39	3.1	6	1.6
Sacramento-1309 T Street	52	12.6	11	3.8
Elk Grove-Bruceville	31	5.8	5	1.7
Folsom-Natoma	26	5.3	3	2.3
Sacramento-Goldenland Court	45	3.5	9	1.1

3.5.3 NO_2 Site-to-Site Analysis

The NO_2 monitoring network site-to-site analysis ranked sites based on the area, population, and emissions served; measured concentration; deviation from NAAQS; and trend analyses. NO_2 has two standards (1-hour and annual), and the site-by-site analysis was performed for each standard. Tables 3-37 and 3-38 present the results of the site-to-site analysis for the NO_2 monitoring network based on the 1-hour and annual standards, respectively. These results, and a discussion of their meaning, are combined with the suitability modeling in the next section.

Table 3-37 Results of the NO_2 Network Site-to-Site Analysis for the 1-hour Standard

Site	Area Served	Pop. Served[b]	MSDI Pop.[b]	Pop. Change[b]	Emissions Served	Measured Conc.	Deviation from NAAQS	Corr.	Removal Bias	Total	Rank by Importance
North Highlands-Blackfoot	7	4	4	2	6	5	3	5	6	42	5
Sacramento-Del Paso Manor	3	2	2	3	1	4	5[a]	8	5	33	3
Sacramento-1309 T Street	5	1	1	1	2	2	1	7	1	22	1
Elk Grove-Bruceville	1	3	3	4	3	6	4	4	2	30	2
Folsom-Natoma	2	5	6	7	4	7	5[a]	1	3	40	4
Sacramento-Goldenland Court	6	6	5	5	5	3	5[a]	6	4	45	6
Sacramento-Bercut Dr.	9	8	8	8	8	5[a]	5[a]	5[a]	5[a]	61	9
Bethel Island	*4*	*9*	*9*	*9*	*9*	*8*	*5[a]*	*2*	*5[a]*	*60*	*8*
Roseville-N Sunrise Blvd	*8*	*7*	*7*	*6*	*7*	*1*	*2*	*3*	*5[a]*	*46*	*7*

Sites located outside Sacramento County are italicized.
[a] Monitors not included in analysis technique, were substituted with 5.
[b] Population within Sacramento County

Table 3-38 Results of the NO_2 Network Site-to-Site Analysis for the Annual Standard

Site	Area Served	Pop. Served[b]	MSDI Pop.[b]	Pop. Change[b]	Emissions Served	Measured Conc.	Deviation from NAAQS	Corr.	Removal Bias	Total	Rank by Importance
North Highlands-Blackfoot	7	4	4	2	6	2	2	5	6	38	4
Sacramento-Del Paso Manor	3	2	2	3	1	4	4	8	4	31	2
Sacramento-1309 T Street	5	1	1	1	2	1	1	7	1	20	1
Elk Grove-Bruceville	1	3	3	4	3	5	5	4	3	31	3
Folsom-Natoma	2	5	6	7	4	7	7	1	2	41	5
Sacramento-Goldenland Court	6	6	5	5	5	5[a]	5[a]	6	5	48	7
Sacramento-Bercut Dr.	9	8	8	8	8	5[a]	5[a]	5[a]	5[a]	61	9
Bethel Island	*4*	*9*	*9*	*9*	*9*	*5*	*5*	*2*	*5[a]*	*57*	*8*
Roseville-N Sunrise Blvd	*8*	*7*	*7*	*6*	*7*	*2*	*2*	*3*	*5[a]*	*47*	*6*

Sites located outside Sacramento County are italicized.
[a] Monitors not included in analysis technique, were substituted with 5.
[b] Population within Sacramento County

3.5.4 NO_2 Suitability Modeling

The suitability modeling aimed to determine the most appropriate locations for monitor placement. Gridded data layers, categorized by population, emissions inventory, measured concentrations, were combined to determine the most appropriate locations for NO_2 monitor placement. Since NO_2 has two NAAQS (1-hour and annual), a suitability modeling analysis was conducted for each standard. The grids used in the NO_2 network suitability modeling are listed below and graphical representation of these grids are provided in Appendix C. Figures 3.27 and 3.28 present the output of the suitability modeling for the NO_2 network. Table 3-39 presents the model output score at the location of each NO_2 monitoring location within Sacramento County.

- Typical summertime weekday NO_x emissions from CMAQ model
- Typical summertime weekend NO_x emissions from CMAQ model
- Typical wintertime weekday NO_x emissions from CMAQ model
- Typical wintertime weekend NO_x emissions from CMAQ model
- NO_2 design values (1-hour and annual)
- Exceedance probability of NO_2 monitors (1-hour and annual)
- Population density
- Population change
- Sensitive and vulnerable population index (MSDI)

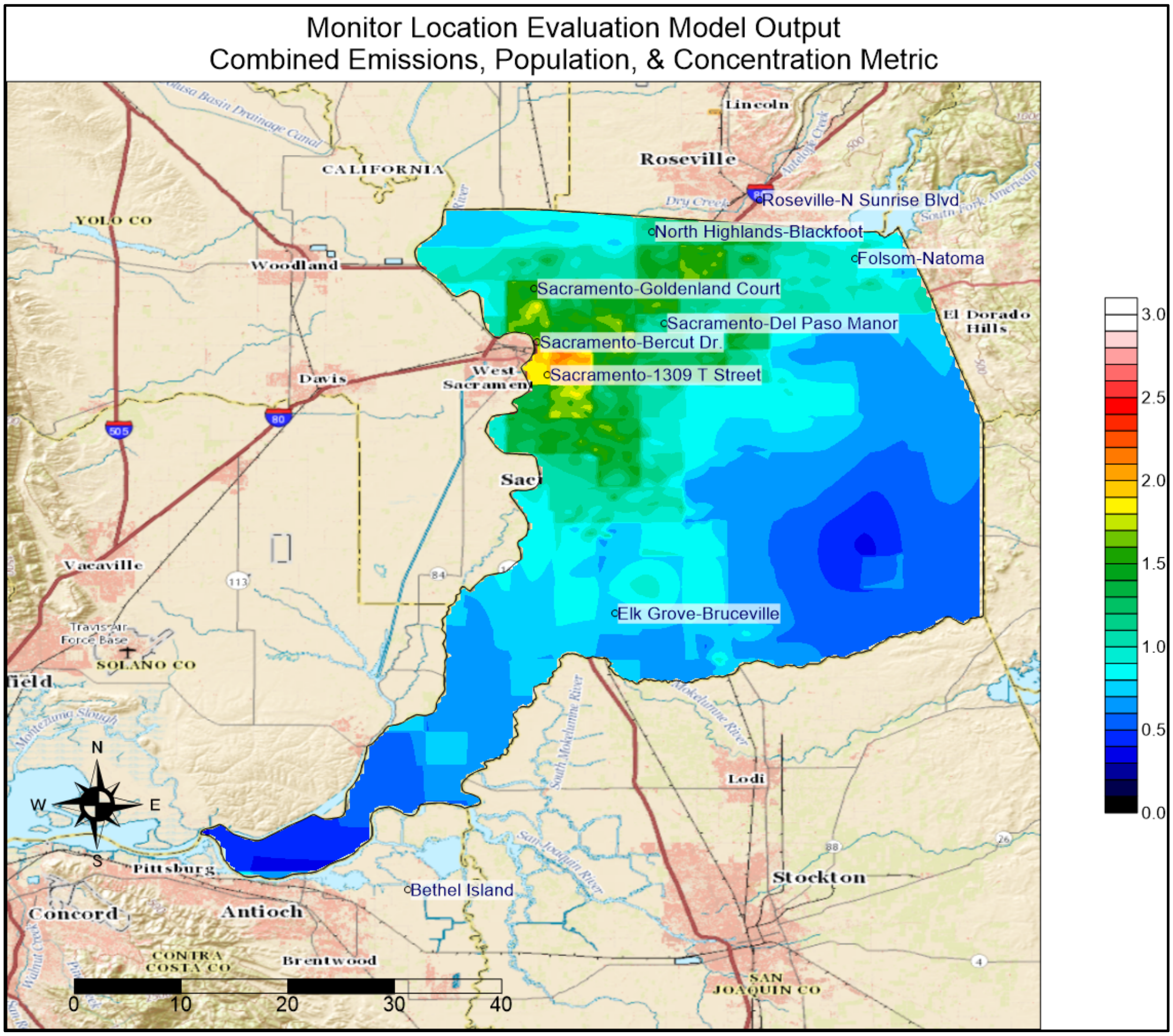


Figure 3.27 NO_2 (1-hour) Monitoring Network Suitability Modeling Output

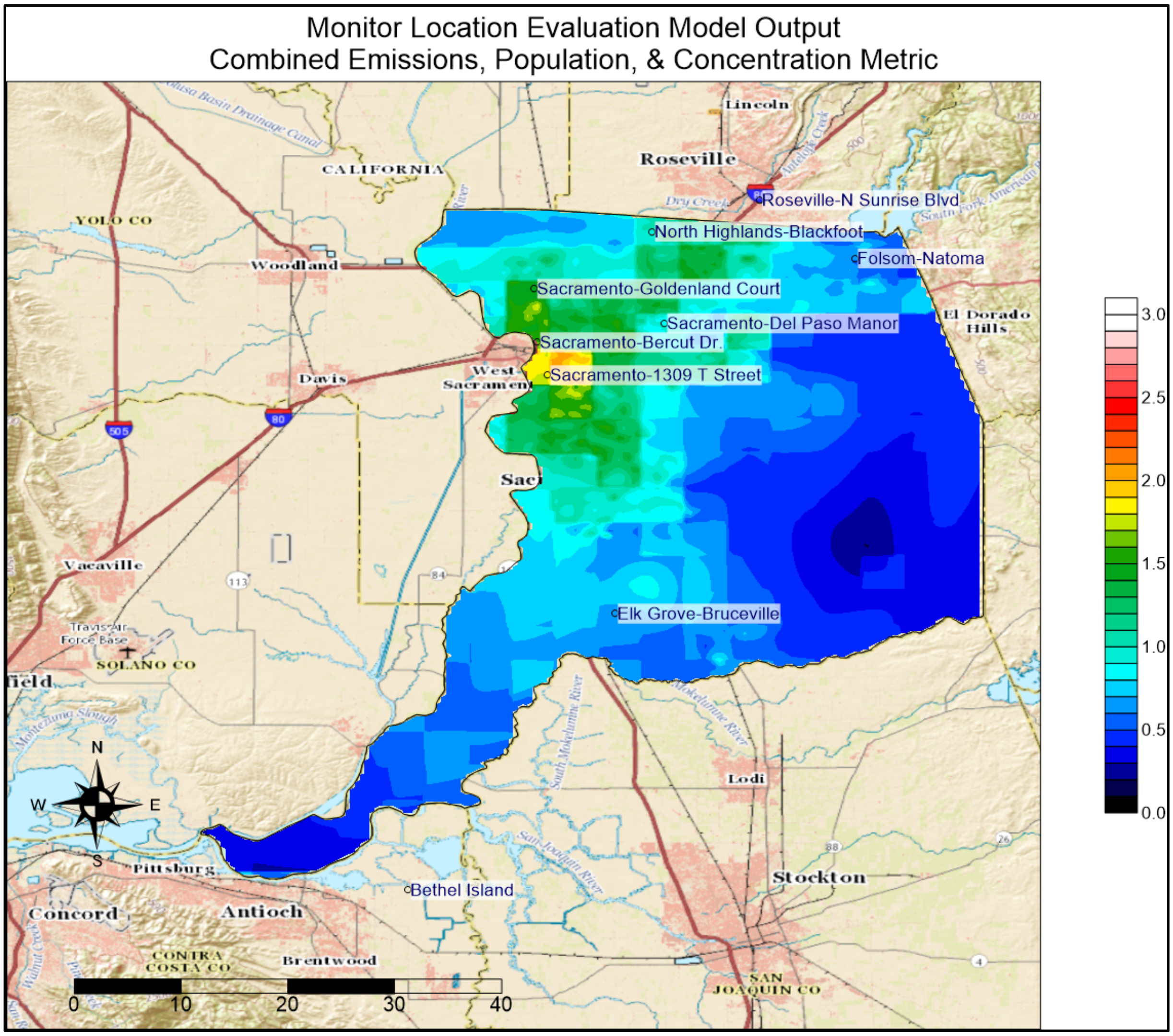


Figure 3.28 NO_2 (Annual) Monitoring Network Suitability Modeling Output

Table 3-39 SMAQMD NO_2 Monitoring Network Suitability Modeling Results

Site	Suitability Modeling Output		Suitability Modeling Rank		Site-by-Site Rank		Sum of Rankings	Final Rank
	1-hour	Annual	1-hour	Annual	1-hour	Annual		
Sacramento-1309 T Street	1.86	1.83	1	1	1	1	4	1
Sacramento-Del Paso Manor	1.1	0.89	4	5	3	2	14	2
Elk Grove-Bruceville	0.74	0.67	7	6	2	3	18	3
North Highlands-Blackfoot	1.08	0.98	5	4	5	4	18	4
Sacramento-Goldenland Court	1.51	1.44	3	3	6	7	19	5
Folsom-Natoma	0.93	0.63	6	7	4	5	22	6
Sacramento-Bercut Dr.	1.66	1.6	2	2	9	9	22	7

The results of the suitability modeling and site-by-site analysis for the NO_2 monitoring network were combined to evaluate monitor placement. Sacramento-T Street and Del Paso Manor were the top two locations for NO_2 monitor placement. The Bercut Drive site ranked the lowest based on the analysis techniques and metrics measured. However, the Bercut Drive site is required based on near-road monitoring requirements where monitors are considered a source-oriented monitor representing a micro-scale spatial coverage. The analysis techniques in this network assessment are tailored to analyze monitors meant for more spatial coverage (neighborhood, urban, or regional scale monitors).

3.6 CO Network

There are a total of three (3) CO monitoring stations located within Sacramento County. SMAQMD has plans for a fourth monitoring station, Sacramento-Bercut Drive, which is anticipated to start collecting CO data in 2016.

3.6.1 CO Network Spatial Analyses

Thiessen polygons were generated to determine the spatial representation of each CO monitoring station located in and adjacent to Sacramento County. Six (6) CO monitors were identified as representing a portion of Sacramento County. The following sections present the findings for area-, population-, and emissions-served analyses for the CO network.

3.6.1.1 CO Network Area- and Population-Served Analyses

The population within Sacramento County represented by each monitoring site was counted within the Thiessen polygons using 2009 through 2013 ACS data. Area- and population-served analyses, including sensitive and vulnerable populations, are presented in Table 3-40. Figure 3.29 presents a map showing the location, area of influence, and served population for each CO monitor.

Table 3-40 Area and Population Served by CO Monitors Serving Sacramento County

Site	2013 Population Estimate (Persons)	Population Change from 2010 to 2013 (Persons)	Sensitive/ Vulnerable Population (Persons)[a]	Area (km^2)
North Highlands-Blackfoot	233,744	5,138	58,671	146.90
Sacramento-Del Paso Manor	616,233	7,388	164,141	1,367.65
Sacramento-Goldenland Court	105,427	928	32,177	174.19
Sacramento-Bercut Dr.	448,083	3,551	146,526	408.19
Hazelton, Stockton	*26,850*	*-165*	*7,574*	*155.50*
Bethel Island	*4,870*	*-421*	*1,492*	*322.84*

Sites located outside Sacramento County are italicized.
[a]Summation of sensitive/vulnerable persons located within the monitors area of influence.

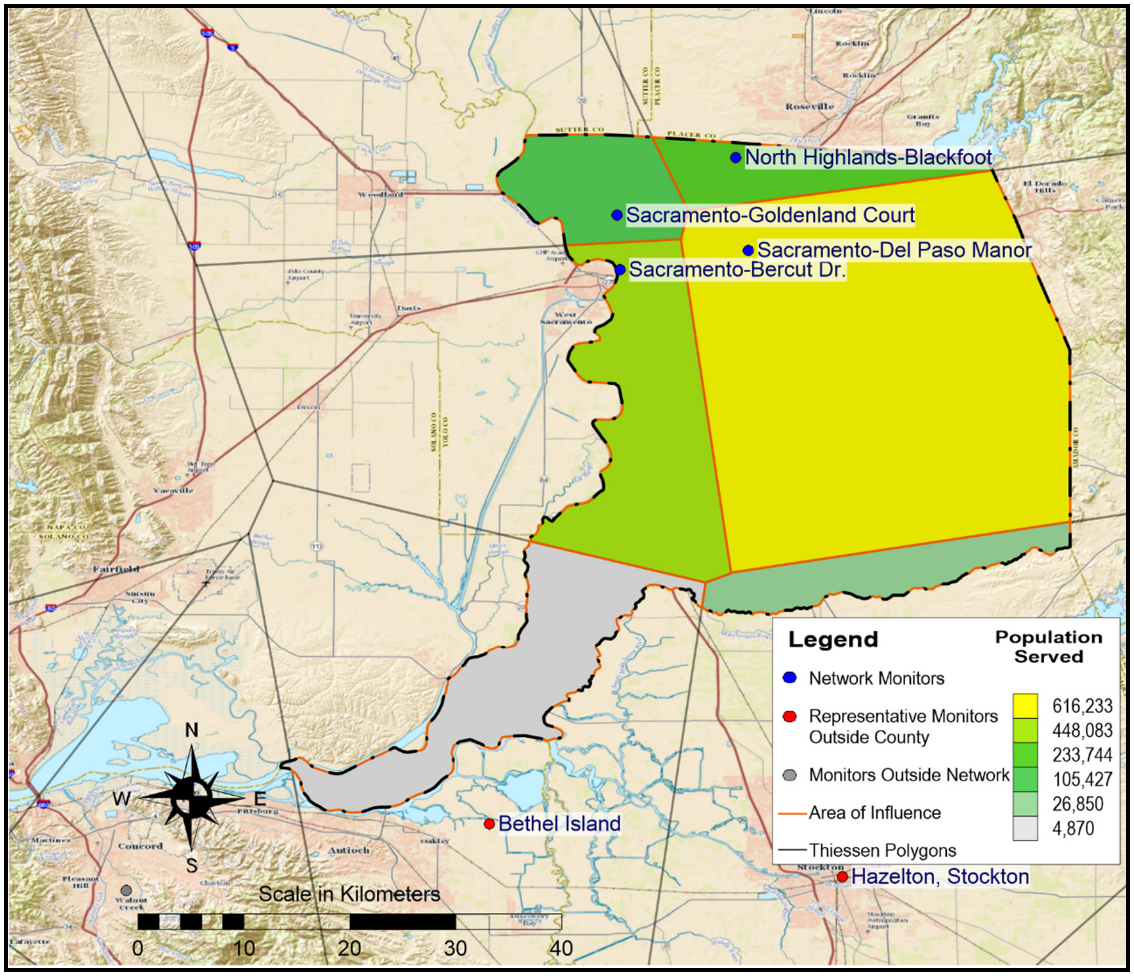


Figure 3.29 CO Network Area and Population Served

Del Paso Manor was found to be the most important site in the CO network based only on area of influence and population metrics (population, population change, and Environmental Justice population).

3.6.1.2 CO Network Emissions-Served Analysis

Emissions served by each monitor were evaluated based on 2012 gridded modeled emissions of summertime and wintertime CO. Table 3-41 presents CO emissions for each CO monitor based on a typical weekday or weekend day in winter and summer. Monitors were ranked based on the average of the summer and winter emissions. Figures 3.30 and 3.31 present maps with the emissions served by each monitoring area.

Table 3-41 Emissions Served by CO Monitors Representing Sacramento County

Site	Winter Weekday CO Emissions (tpd)	Winter Weekend CO Emissions (tpd)	Summer Weekday CO Emissions (tpd)	Summer Weekend CO Emissions (tpd)
North Highlands-Blackfoot	31.45	33.32	28.78	32.79
Sacramento-Del Paso Manor	107.13	108.66	100.45	114.05
Sacramento-Goldenland Court	19.02	18.29	17.60	18.34
Sacramento-Bercut Dr.	61.44	60.95	58.28	70.61
Hazelton, Stockton	4.20	6.50	10.34	32.13
Bethel Island	2.70	2.93	2.77	3.29

Sites located outside Sacramento County are italicized.

Del Paso Manor and Bercut Drivee were the highest ranking sites in terms of overall emission sources located within their respective areas of influence. The following maps show the CO monitors are located in the areas with the highest CO emissions in the county. The maps also show that areas extending south of Bercut Drive and Del Paso Manor also show concentrated areas of CO emissions. As will be discussed in Section 3.6.1, design value concentrations and exceedance probability calculations show the existing network is not at risk of exceeding the current NAAQS (Table 2-2).

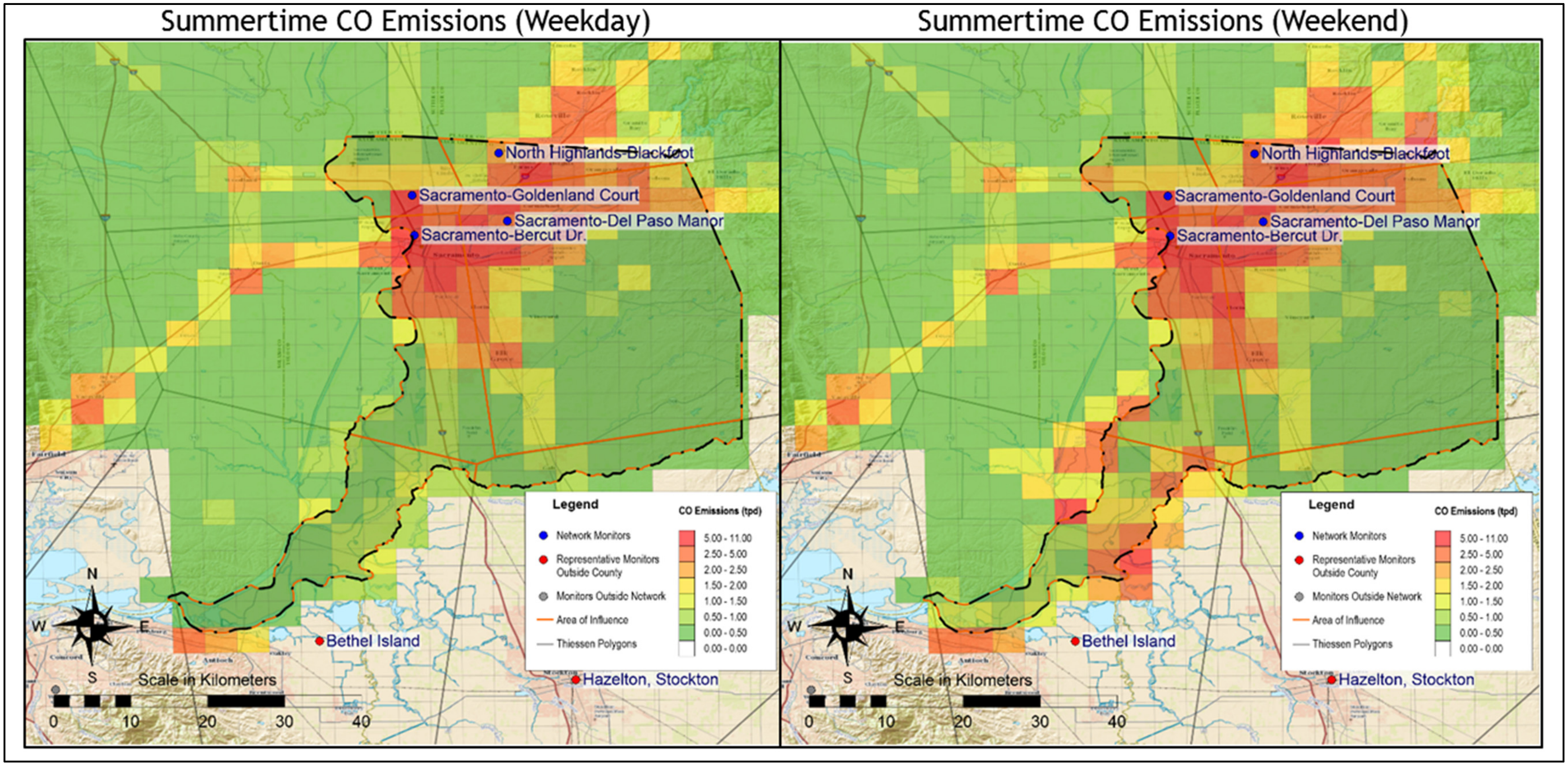


Figure 3.30 CO Network Summer Emissions Served

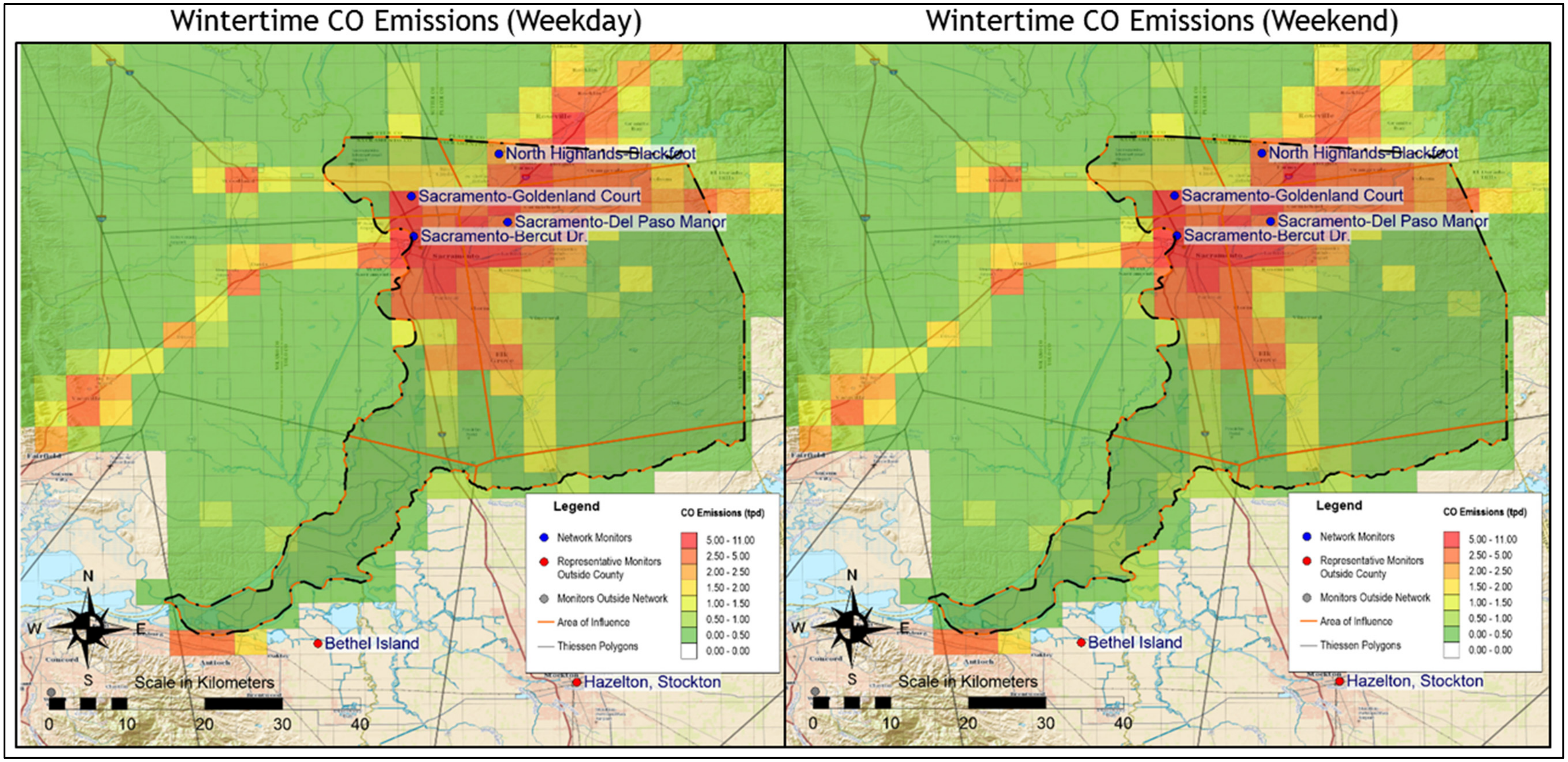


Figure 3.31 CO Network Winter Emissions Served

3.6.2 CO Data Analyses

The data analysis conducted was used to determine the importance of a site based on measured concentrations, deviation from NAAQS, monitor-to-monitor correlation, trend impact, and removal bias.

3.6.2.1 CO Measured Concentration, Deviation from NAAQS, and Trend Analysis

Monitors within SMAQMD's ambient air monitoring network shown to have high levels of CO, design values close to the standard, and with a long historical record were considered to be of high value for characterizing pollution in an area. Tables 3-42 and 3-43 present the 1-hour and 8-hour design value concentrations for 2005 through 2014, deviation from NAAQS for the 2014 monitoring year, and the exceedance probability using data from 2005 through 2014. Figure 3.33 presents the 2005 through 2014 maximum 1-hour concentrations and the 1-hour design values, by year, for CO monitors serving Sacramento County. Figure 3.34 presents the maximum 8-hour concentrations and 8-hour standard design values, by year, for CO monitors serving Sacramento County. Tables 3-42 and 3-43 present the exceedance probability as percent of the standards (35 ppm for 1-hour and 9 ppm for 8-hour, Table 2-2).

All stations representing a portion of the county and within SMAQMD's network are measuring concentrations well below the NAAQS and do not show a probability to exceed the standard in the next three years based on EPA's exceedance probability calculation.

Table 3-42 1-hour Concentration Analysis for CO Monitors Serving Sacramento County

Site	Length of Record (years)	1-hour Design Values (ppm)										Deviation from NAAQS (ppm)[a]	Exceedance Probability
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
North Highlands-Blackfoot	37	6.6	7.3	5.1	2.3	2.1	1.8	2.2	2.1	1.7	1.7	33.3	12.8%
Sacramento-Del Paso Manor	35	3.9	4.2	3.2	2.7	3.0	1.9	2.5	2.4	2.3	1.9	33.1	9.2%
Sacramento-Goldenland Court	8	--	--	--	1.7	2.3	1.5	1.8	1.9	1.9	1.7	33.3	5.7%
Sacramento-Bercut Dr.	0	--	--	--	--	--	--	--	--	--	--	--	--
Hazelton, Stockton	*53*	*4.2*	*4.3*	*3.6*	*3.0*	*2.9*	*2.4*	*3.1*	*2.5*	*2.5*	*2.7*	*32.3*	*10.0%*
Bethel Island	*35*	*1.1*	*1.2*	*1.0*	*1.5*	*1.2*	*1.0*	*1.3*	*1.1*	*1.0*	*0.9*	*34.1*	*3.5%*

Sites located outside Sacramento County are italicized.
[a] Based on 2014 data

Table 3-43 8-hour Concentration Analysis for CO Monitors Serving Sacramento County

Site	Length of Record (years)	8-hour Design Values (ppm)										Deviation from NAAQS (ppm)[a]	Exceedance Probability
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
North Highlands-Blackfoot	37	2.8	2.6	1.7	1.9	1.6	1.2	1.9	1.7	1.4	1.4	7.6	23.4%
Sacramento-Del Paso Manor	35	3.5	3.5	2.9	2.4	2.8	1.6	2.2	2.0	2.1	1.7	7.3	31.6%
Sacramento-Goldenland Court	8	--	--	--	1.2	1.9	1.2	1.5	1.6	1.6	1.3	7.7	18.3%
Sacramento-Bercut Dr.	0	--	--	--	--	--	--	--	--	--	--	--	--
Hazelton, Stockton	*53*	*2.8*	*2.2*	*2.3*	*1.8*	*2.3*	*1.6*	*2.1*	*1.8*	*1.7*	*2.0*	*7.0*	*25.1%*
Bethel Island	*35*	*0.9*	*1.0*	*0.8*	*1.1*	*0.9*	*0.8*	*0.9*	*0.9*	*0.8*	*0.7*	*8.3*	*10.5%*

Sites located outside Sacramento County are italicized.
[a] Based on 2014 data

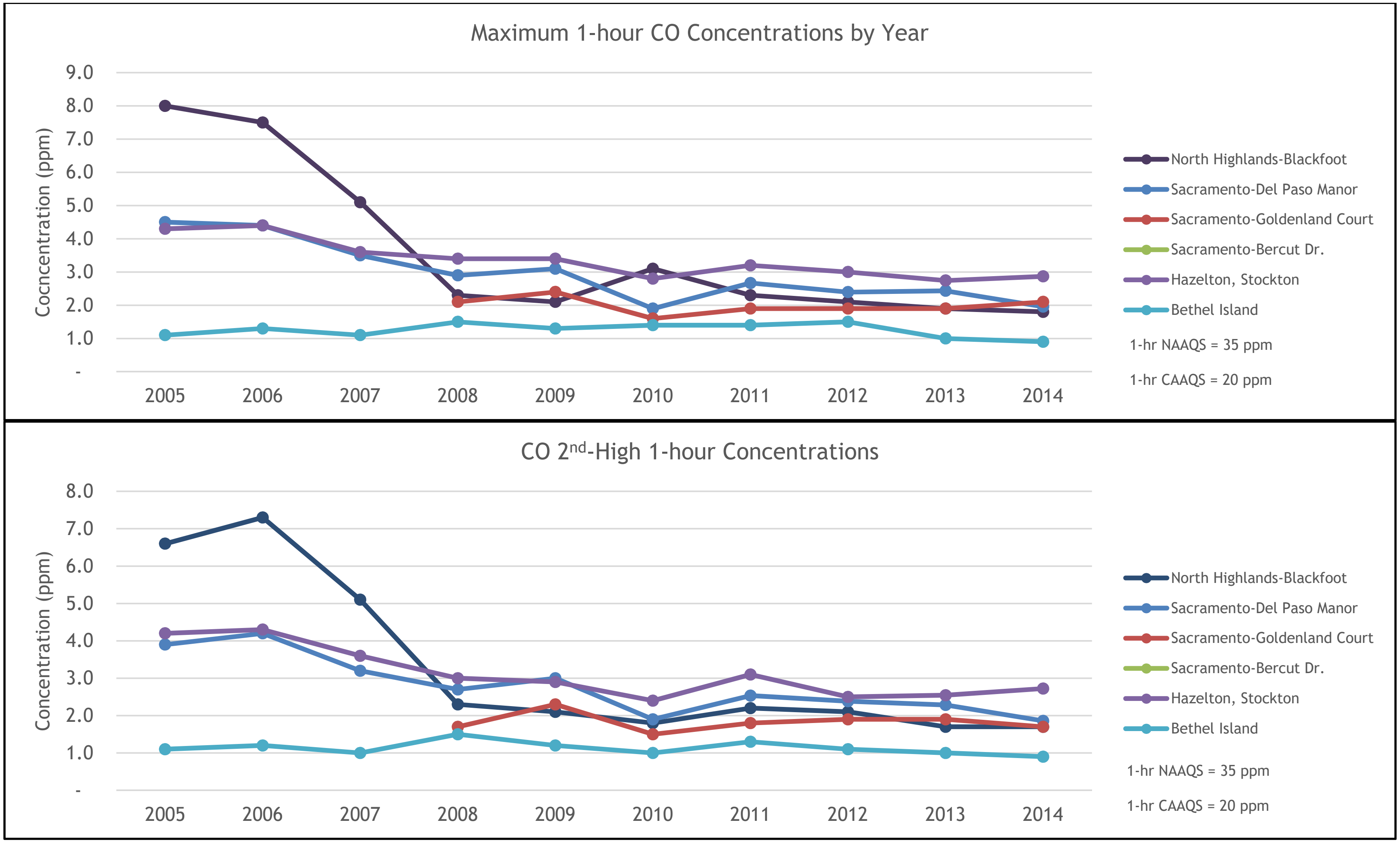
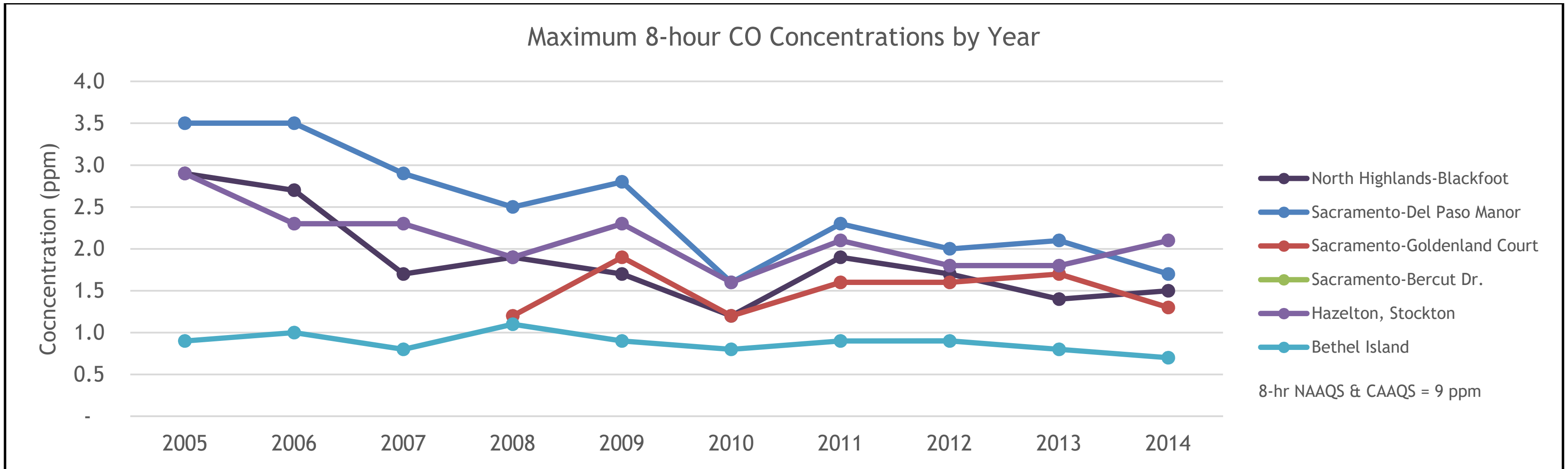


Figure 3.32 1-hour CO Maximum and Design Value Concentrations



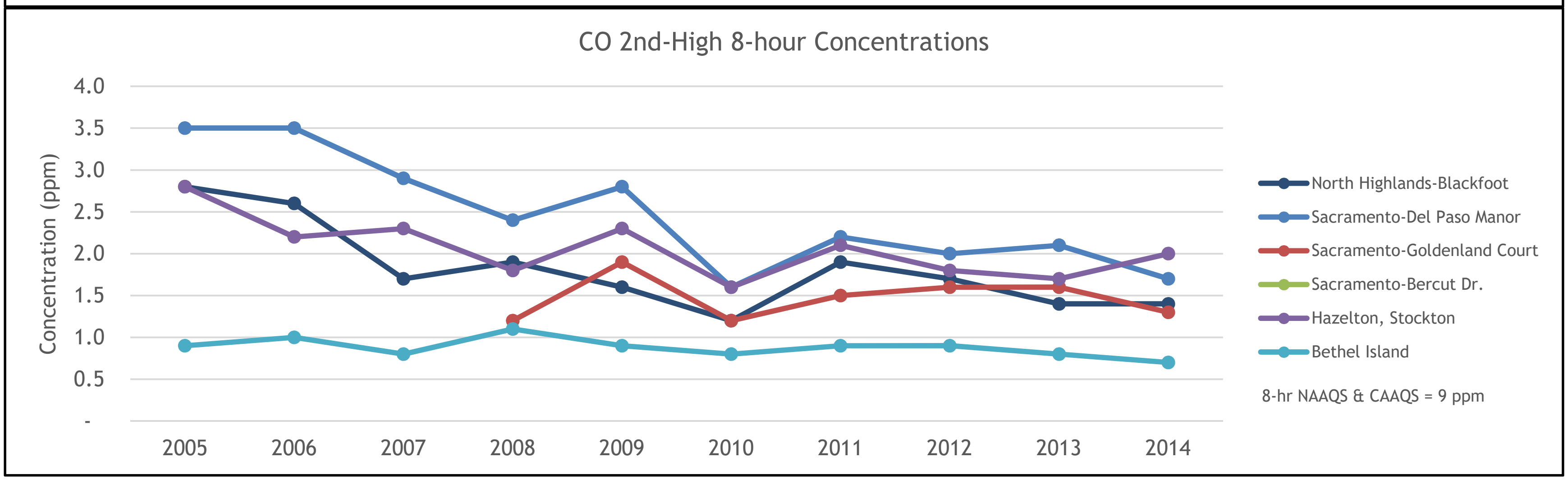


Figure 3.33 8-hour CO Maximum and Design Value Concentrations

3.6.2.2 Monitor-to-Monitor Correlation Analysis

Hourly CO concentration data collected between 2005 through 2014 from five monitors were compared for redundancy using the square of the Pearson correlation coefficient (R^2). Sacramento-Bercut Drive was excluded as the station started data collection in November 2015. Monitor-to-monitor correlation analysis found that none of the monitors were highly correlated (>80%). Monitors close in proximity to one another correlated better than those that are further apart. Tables 3-44 and 3-45 present the correlation statistics compared to distance.

Table 3-44 Correlation (R^2)/Distance (km) Analysis for 1-hour CO Data from Monitors Serving Sacramento County

Site ID	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-Goldenland Court	*Hazelton, Stockton*	*Bethel Island*
North Highlands-Blackfoot					
Sacramento-Del Paso Manor	0.512				
Sacramento-Goldenland Court	0.421	0.455			
Hazelton, Stockton	*0.317*	*0.396*	*0.224*		
Bethel Island	*0.181*	*0.275*	*0.180*	*0.175*	

Sites located outside Sacramento County are italicized.

Distance (km)								
90	80	70	60	50	40	30	20	10

Table 3-45 Distance (km)/Correlation (R^2) Analysis for 1-hour CO Data from Monitors Serving Sacramento County

Site ID	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-Goldenland Court	*Hazelton, Stockton*	*Bethel Island*
North Highlands-Blackfoot					
Sacramento-Del Paso Manor	11.0				
Sacramento-Goldenland Court	19.7	12.5			
Hazelton, Stockton	45.7	34.9	29.1		
Bethel Island	19.1	19.3	31.8	47.9	

Sites located outside Sacramento County are italicized.

Correlation (R^2)								
0.95	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20

None of the stations correlate very well when comparing hourly concentrations, which is likely due to the nature of CO and its more localized exposure potential. As EPA confirms in 40 CFR 58, Appendix D Section 4.2.2, most people have the potential to be exposed to CO in micro- or middle spatial scale.

3.6.2.3 CO Monitor Removal Bias Analysis

Each monitor was analyzed to determine the change in spatial concentrations interpolated across Sacramento County if the monitor were removed. Table 3-46 presents the results of the removal bias analysis and the maximum change in CO concentrations (both 1-hour and 8-hour) in Sacramento County if each CO monitor in SMAQMD's network were individually removed.

Table 3-46 SMAQMD CO Monitoring Network Removal Bias Results

Site	1-hour CO 2014 Design Value (ppm)	Change in 1-hour CO Concentration (ppm)	8-hour CO 2014 Design Value (ppm)	Change in Annual CO Concentration (ppm)
North Highlands-Blackfoot	1.7	0.61	1.4	0.54
Sacramento-Del Paso Manor	1.9	0.28	1.7	0.46
Sacramento-Goldenland Court	1.7	0.14	1.3	0.07

3.6.3 CO Site-to-Site Analysis

The CO monitoring network site-to-site analysis ranked sites based on the area, population, and emissions served; measured concentration; deviation from NAAQS; and trend analyses. As previously mentioned, CO has a 1-hour and 8-hour NAAQS and the site-by-site analysis was performed for each standard. Tables 3-47 and 3-48 present the results of the site-to-site analysis for the CO monitoring network based on the 1-hour and 8-hour standards, respectively. These results, and a discussion of their meaning, are combined with the suitability modeling in the next section.

Table 3-47 Results of the CO Network Site-to-Site Analysis for the 1-hour Standard

Site	Area Served	Pop. Served[b]	MSDI Pop.[b]	Pop. Change[b]	Emissions Served	Measured Conc.	Deviation from NAAQS	Corr.	Removal Bias	Total	Rank by Importance
North Highlands-Blackfoot	6	3	3	2	3	3	3	4	1	28	3
Sacramento-Del Paso Manor	1	1	1	1	1	2	2	5	2	16	1
Sacramento-Goldenland Court	4	4	4	4	4	3	3	3	3	32	4
Sacramento-Bercut Dr.	2	2	2	3	2	3[a]	3[a]	3[a]	3[a]	23	2
Hazelton, Stockton	*5*	*5*	*5*	*5*	*5*	*1*	*1*	*2*	*3[a]*	*32*	*5*
Bethel Island	*3*	*6*	*6*	*6*	*6*	*5*	*5*	*1*	*3[a]*	*41*	*6*

Sites located outside Sacramento County are italicized.
[a]Monitor not included in analysis technique, substituted with 3.
[b]Population within Sacramento County

Table 3-48 Results of the CO Network Site-to-Site Analysis for the 8-hour Standard

Site	Area Served	Pop. Served[b]	MSDI Pop.[b]	Pop. Change[b]	Emissions Served	Measured Conc.	Deviation from NAAQS	Corr.	Removal Bias	Total	Rank by Importance
North Highlands-Blackfoot	6	3	3	2	3	3	3	4	1	28	3
Sacramento-Del Paso Manor	1	1	1	1	1	2	2	5	2	16	1
Sacramento-Goldenland Court	4	4	4	4	4	4	4	3	3	34	5
Sacramento-Bercut Dr.	2	2	2	3	2	3[a]	3[a]	3[a]	3[a]	23	2
Hazelton, Stockton	*5*	*5*	*5*	*5*	*5*	*1*	*1*	*2*	*3[a]*	*32*	*4*
Bethel Island	*3*	*6*	*6*	*6*	*6*	*5*	*5*	*1*	*3[a]*	*41*	*6*

[a]Monitor not included in analysis technique, substituted with 3.
[b]Population within Sacramento County

3.6.4 CO Suitability Modeling

The suitability modeling aimed to determine the most appropriate locations for monitor placement. Gridded data layers, categorized by population, emissions inventory, and measured concentrations, were combined to determine the most appropriate locations for CO monitor placement. The suitability modeling analysis was conducted for the one-hour and eight-hour standards. The grids used in the CO network suitability modeling are listed below and graphical representations of these grids are provided in Appendix C. Figures 3.34 and 3.35 present the output of the suitability modeling for the CO network. Table 3-49 presents the model output score at the location of each CO monitoring location within Sacramento County.

- Typical summertime weekday CO emissions from CMAQ model
- Typical summertime weekend CO emissions from CMAQ model
- Typical wintertime weekday CO emissions from CMAQ model
- Typical wintertime weekend CO emissions from CMAQ model
- CO design values (1-hour and 8-hour)
- Exceedance probability of CO monitors (1-hour and 8-hour)
- Population density
- Population change
- Sensitive and vulnerable population index (MSDI)

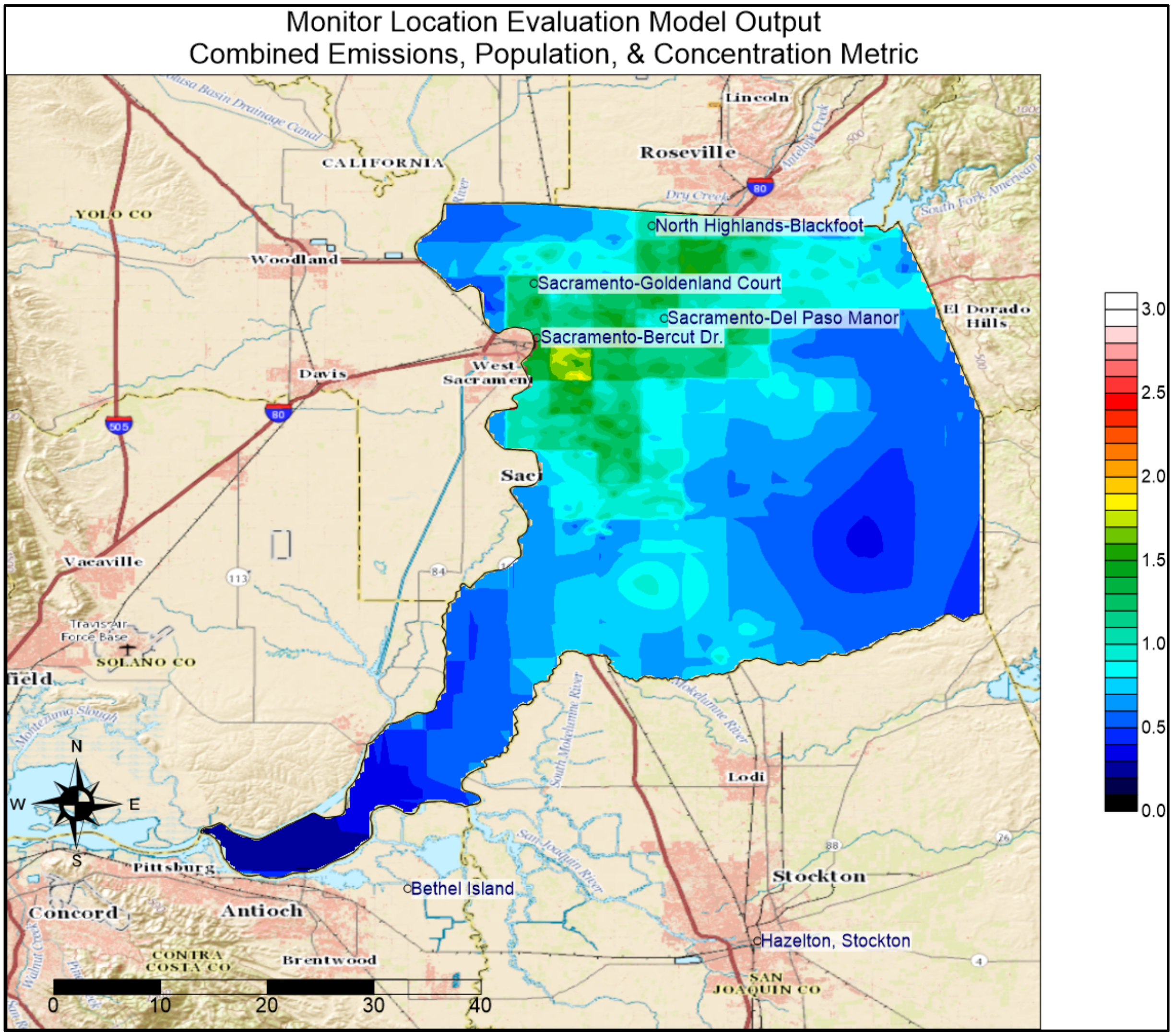


Figure 3.34 CO (1-hour) Monitoring Network Suitability Modeling Output

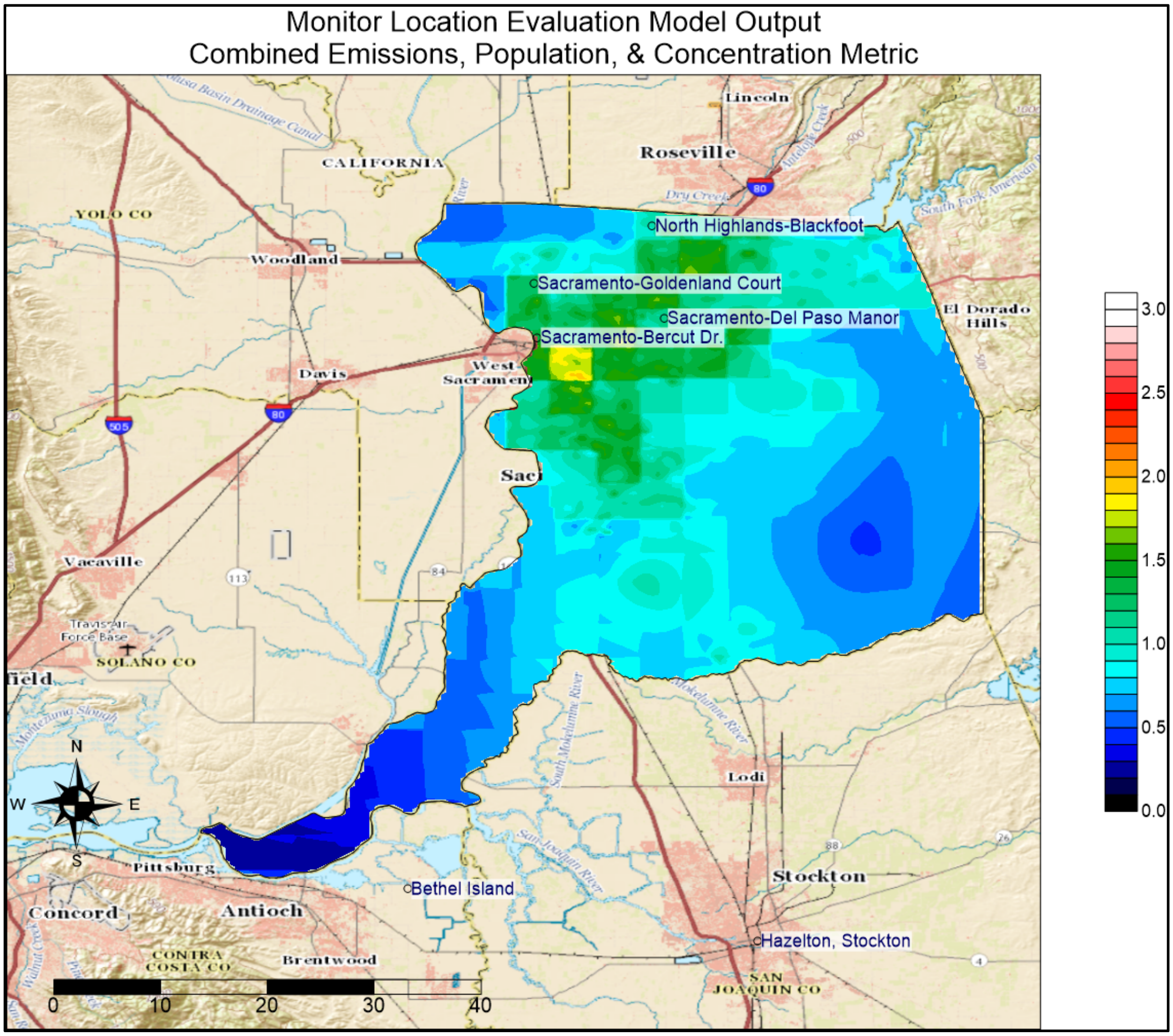


Figure 3.35 CO (8-hour) Monitoring Network Suitability Modeling Output

Table 3-49 SMAQMD CO Monitoring Network Suitability Modeling Results

Site	Suitability Modeling Output		Suitability Modeling Rank		Site-by-Site Rank		Sum of Rankings (Rank)[a]	Final Rank
	1-hour	8-hour	1-hour	8-hour	1-hour	8-hour		
Sacramento-Bercut Dr.	1.28	1.37	1	1	2	2	6	1
Sacramento-Del Paso Manor	0.97	1.15	4	3	1	1	9	2
Sacramento-Goldenland Court	1.17	1.24	2	2	4	5	13	3
North Highlands-Blackfoot	1.04	1.01	3	4	3	3	13	4

[a]Ties between sites with the same overall value are broken by the number of parameters measured at the site.

Results of the suitability modeling and site-by-site analysis for the CO monitoring network were combined to evaluate monitor placement. Sacramento-Bercut Drive and Del Paso Manor were the top two locations for CO monitor placement, and North Highlands-Blackfoot scored the worst. However, suitability modeling showed all locations scored within 30 percent of each other. From an emissions and population perspective, all monitors currently in the network (including the near-road monitor at Bercut Drive) are located in the areas where the population is most susceptible to exposure to CO.

3.7 SO_2 Network

There is only one site, Sacramento-Del Paso Manor, in the SMAQMD network which monitors SO_2.

3.7.1 SO_2 Network Spatial Analyses

Thiessen polygons were generated to determine the spatial representation of the SO_2 monitoring stations located in and adjacent to Sacramento County. Two SO_2 monitors were identified as representing a portion of Sacramento County. The following sections present the findings for area-, population-, and emissions-served analyses for the SO_2 network.

3.7.1.1 SO_2 Network Area- and Population-Served Analyses

The population within Sacramento County represented by each monitoring site was counted within the Thiessen polygons using 2009 through 2013 ACS data. Area- and population-served analyses, including sensitive and vulnerable populations, are presented in Table 3-50. Figure 3.36 presents a map showing the location, area of influence, and served population for each SO_2 monitor.

Table 3-50 Area and Population Served by SO_2 Monitors Serving Sacramento County

Site	2013 Population Estimate (Persons)	Population Change from 2010 to 2013 (Persons)	Sensitive/ Vulnerable Population (Persons)[a]	Area (km^2)
Sacramento-Del Paso Manor	1,423,361	16,783	406,863	2,166.97
Bethel Island	*11,846*	*-64*	*3,718*	*408.29*

Sites located outside Sacramento County are italicized.
[a]Summation of sensitive/vulnerable persons located within the monitors area of influence.

The SO_2 monitor at Del Paso Manor represents the vast majority of area and population within Sacramento County.

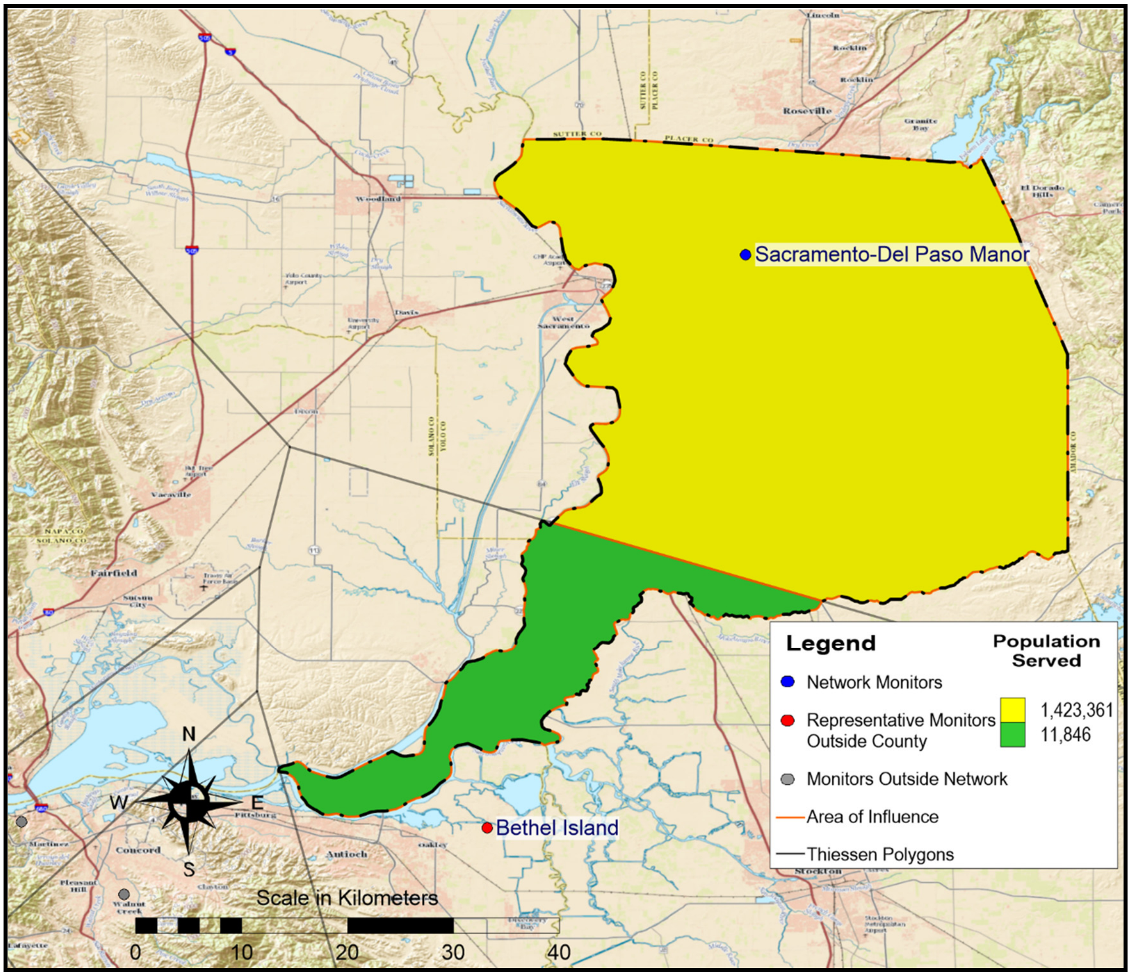


Figure 3.36 SO_2 Network Area and Population Served

3.7.1.2 SO_2 Network Emissions-Served Analysis

Emissions served by each monitor were evaluated with 2012 gridded emissions of summertime and wintertime SO_2. Table 3-51 presents SO_2 emissions for each SO_2 monitor based on a typical weekday or weekend day in winter and summer. Monitors were ranked based on the average of the summer and winter emissions. SO_2 emissions in the county are fairly low and additional monitors beyond the NCore requirement would likely not add value to the network. Figures 3.37 and 3.38 present maps with the emissions served by each monitoring area.

Table 3-51 Emissions Served by SO_2 Monitors Representing Sacramento County

Site	Winter Weekday SO_2 Emissions (tpd)	Winter Weekend SO_2 Emissions (tpd)	Summer Weekday SO_2 Emissions (tpd)	Summer Weekend SO_2 Emissions (tpd)
Sacramento-Del Paso Manor	0.86	0.61	0.94	0.53
Bethel Island	*0.01*	*0.01*	*0.01*	*0.01*

Sites located outside Sacramento County are italicized.

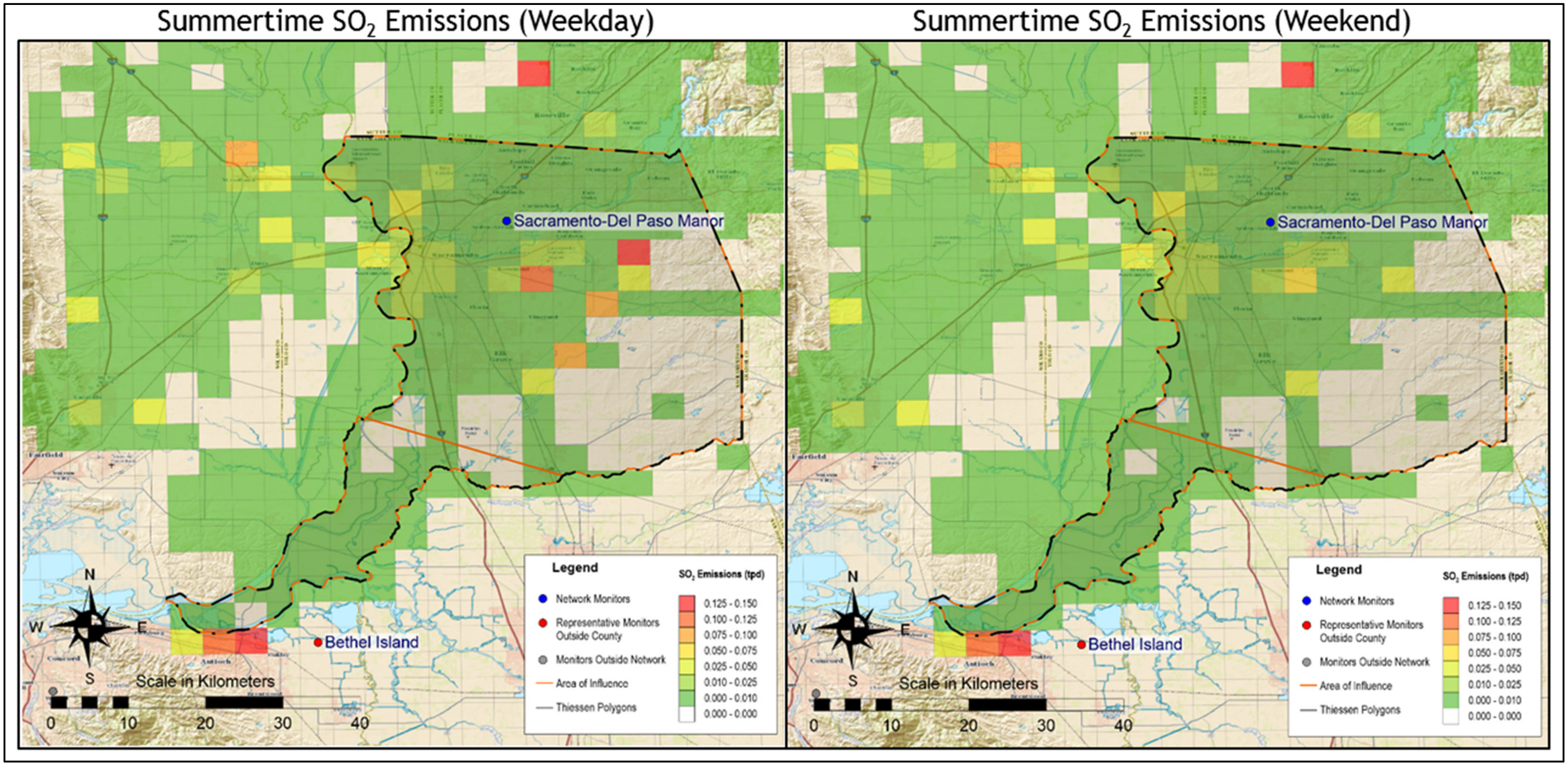


Figure 3.37 SO_2 Network Summer Emissions Served

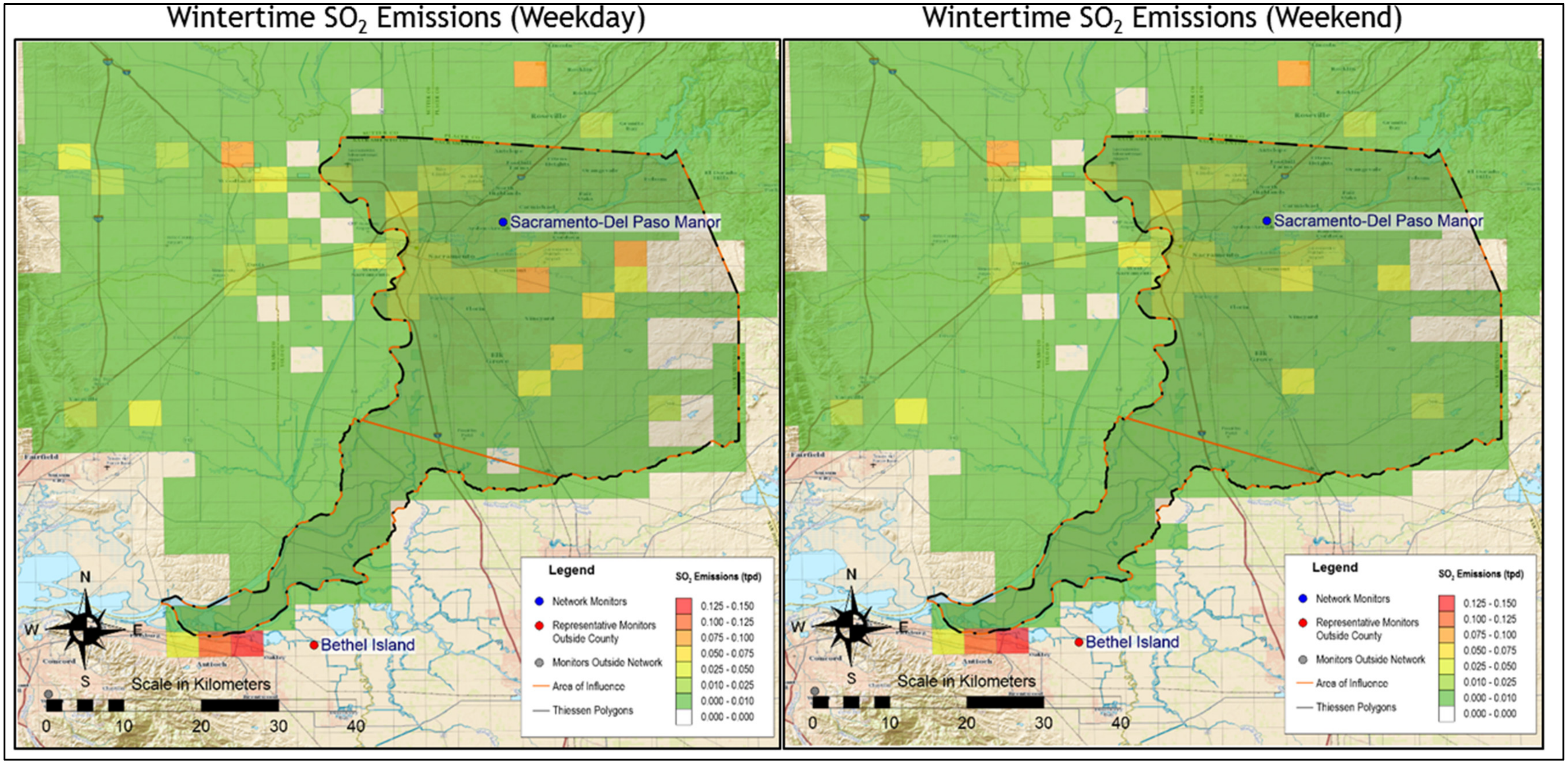


Figure 3.38 SO_2 Network Winter Emissions Served

3.7.2 SO_2 Data Analyses

The data analysis conducted was used to determine the importance of a site based on measured concentrations, deviation from NAAQS, monitor-to-monitor correlation, trend impact, and removal bias.

3.7.2.1 SO_2 Measured Concentration, Deviation from NAAQS, and Trend Analysis

Monitors within SMAQMD's ambient air monitoring network shown to have high levels of SO_2, design values close to the standard, and with a long historical record were considered to be of high value for characterizing pollution in an area. Table 3-52 presents the 1-hour design value concentrations for 2005 through 2014, deviation from NAAQS for the 2012-2014 monitoring period, and the exceedance probability using values from 2005 through 2014. Figure 3.39 presents the 2005 through 2014 maximum 1-hour concentrations, by year, and the 1-hour design values for SO_2 monitors serving Sacramento County. The exceedance probability, as a percent of the standard (75 ppb) is presented in Table 3-52.

Design values for the secondary 3-hour SO_2 standard were calculated for the past 10 years. Rounding conventions for the secondary standard are to the nearest tenth of a ppm per 40 CFR Part 50.5(a), with concentrations equal to or greater than 0.05 ppm being rounded up. Neither Del Paso Manor nor Bethel Island registered a 3-hour block concentration over 0.02 ppm.

Table 3-52 1-hour Concentration Analysis for SO_2 Monitors Serving Sacramento County

Site	Length of Record (years)	1-hour Calculated Design Values (ppb)								Deviation from NAAQS (ppb)	Exceedance Probability
		2005-07	2006-08	2007-09	2008-10	2009-11	2010-12	2011-13	2012-14		
Sacramento-Del Paso Manor	36	5.6	--	--	--	2.0	1.7	2.4	3.4	71.6	5.8%
Bethel Island	*35*	*12.3*	*11.0*	*8.3*	*6.3*	*5.1*	*4.3*	--	--	--	*13.8%*

Sites located outside Sacramento County are italicized.

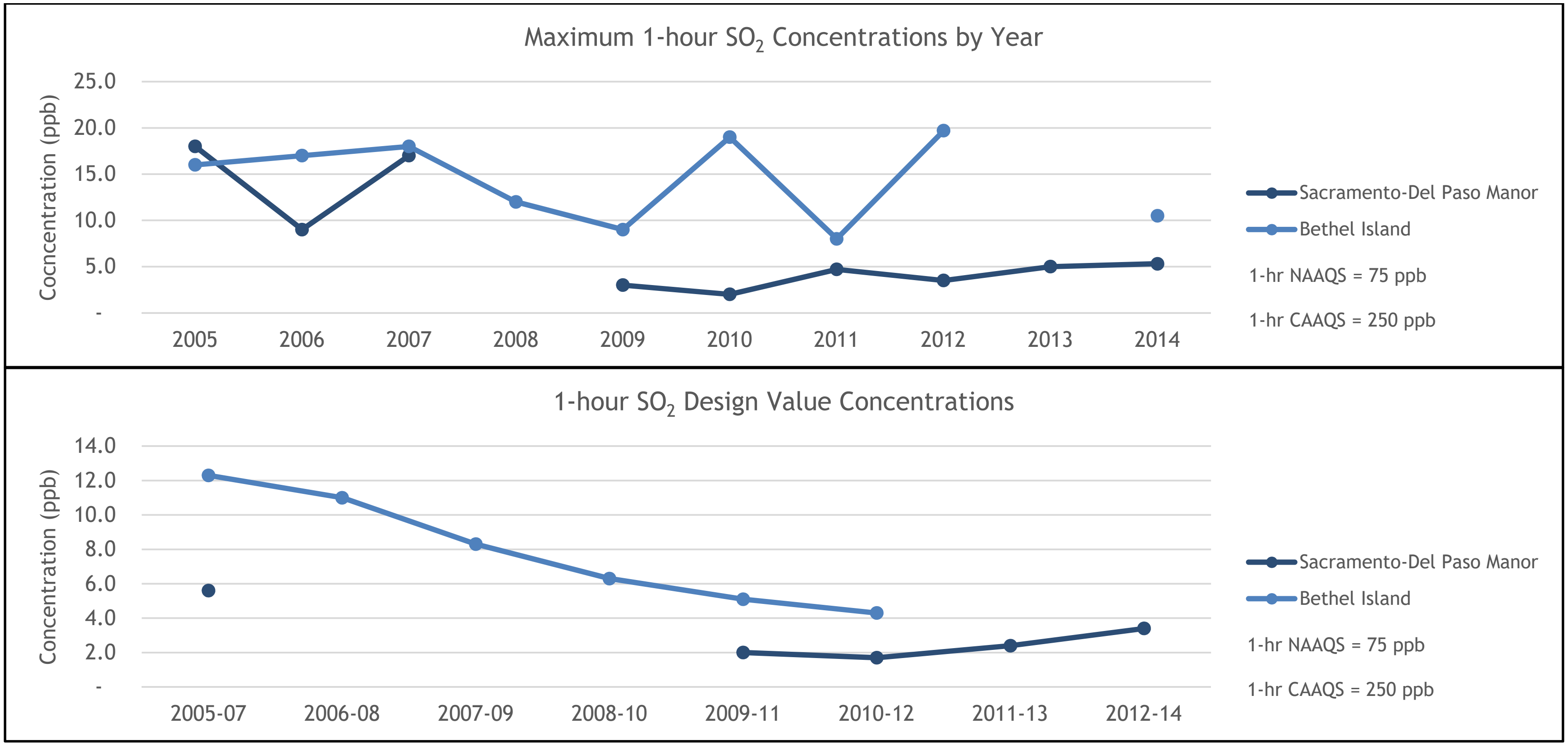


Figure 3.39 1-hour SO_2 Maximum and Design Value Concentrations

3.7.2.2 Monitor-to-Monitor Correlation Analysis

Hourly SO_2 concentration data collected between 2005 through 2014 from Sacramento-Del Paso Manor and Bethel Island were compared for redundancy using the square of the Pearson correlation coefficient (R^2). Monitor-to-monitor correlation analysis found that these two monitors did not correlate. Table 3-53 presents the correlation and distance between the two monitors.

Table 3-53 SO_2 Correlation (R^2)/Distance (km) Statistics

Sacramento-Del Paso Manor/ Bethel Island	
Correlation (R^2)	0.018
Distance between monitors	71.7

3.7.2.3 SO_2 Monitor Removal Bias Analysis

With Sacramento-Del Paso Manor being the only monitor within SMAQMD's network, the removal bias was not evaluated.

3.7.3 SO_2 Site-to-Site Analysis

Based on the network area, population, emissions served, measured concentration, deviation from NAAQS, and trend analyses, the Sacramento-Del Paso Manor monitoring station was the primary SO_2 monitor for characterizing SO_2 concentrations in Sacramento County.

3.7.4 SO_2 Suitability Modeling

The suitability modeling aimed to determine the most appropriate locations for monitor placement. Gridded data layers, categorized by population, emissions inventory, and measured concentrations, were combined to determine the most appropriate locations for SO_2 monitor placement. The grids used in the SO_2 network suitability modeling are listed below and graphical representations of these grids are provided in Appendix C. Figure 3.40 presents the output of the suitability modeling for the SO_2 network.

- Typical summertime weekday SO_2 emissions from CMAQ model
- Typical summertime weekend SO_2 emissions from CMAQ model
- Typical wintertime weekday SO_2 emissions from CMAQ model
- Typical wintertime weekend SO_2 emissions from CMAQ model
- SO_2 design values
- Exceedance probability of SO_2 monitors
- Population density
- Population change
- Sensitive and vulnerable population index (MSDI)

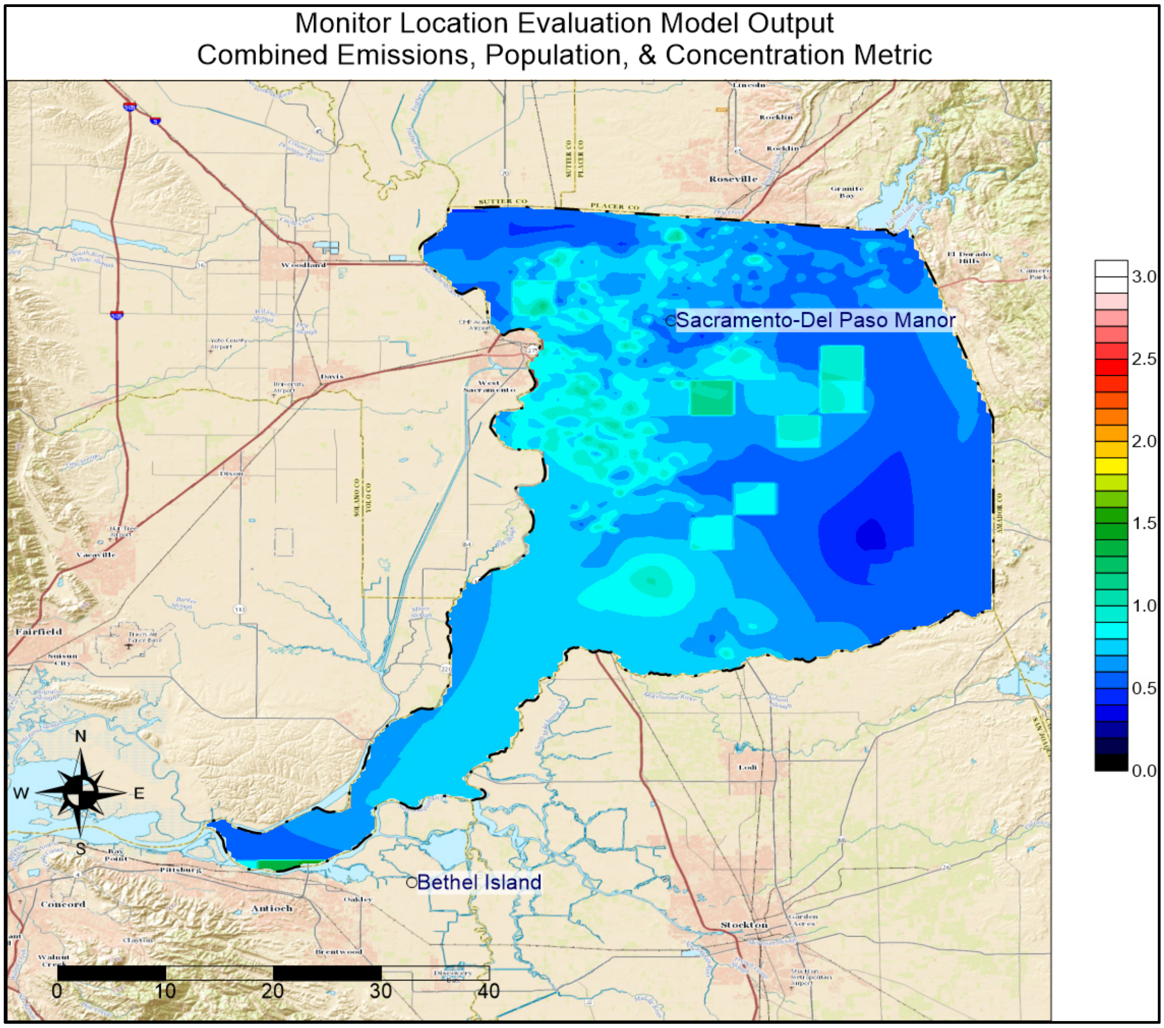


Figure 3.40 SO_2 Monitoring Network Suitability Modeling Output

Results of the suitability modeling for the SO_2 monitoring network show that the Sacramento-Del Paso Manor monitor is not located at the highest scoring location within the county. However, a combination of low county-wide emissions and very low monitored concentrations suggests the site is a regional monitor and only required to satisfy NCore monitoring requirements.

3.8 Lead (Pb) Monitoring Network

As of 2014, there is only one site, Sacramento-Del Paso Manor, in the SMAQMD network monitoring characterizing Pb pollution in the Sacramento MSA with respect to the NAAQS.

3.8.1 Pb Network Spatial Analyses

Thiessen polygons were generated to determine the spatial representation of the Pb monitor located in Sacramento County. However, the Sacramento-Del Paso Manor monitor was the only ambient monitoring site found to represent Sacramento County.

3.8.1.1 Pb Network Area- and Population-Served Analyses

As the only monitor representing Sacramento County, population and demographic statistics for the monitor represent Sacramento County as a whole. Table 3-54 presents the area- and population-served analyses, including sensitive and vulnerable populations.

Table 3-54 Area and Population Served by Pb Monitor Serving Sacramento County

Site	2013 Population Estimate (Persons)	Population Change from 2010 to 2013 (Persons)	Sensitive/ Vulnerable Population (Persons)[a]	Area (km^2)
Sacramento-Del Paso Manor	1,435,207	16,419	410,581	2,575.26

[a] Summation of sensitive/vulnerable persons located within the County.

3.8.1.2 Pb Network Emissions-Served Analysis

2011 Pb emissions were obtained from EPA's 2011 National Emission Inventory (NEI). The emissions presented in the 2011 NEI present facility-reported Pb emissions. County-wide emissions of Pb for 2011 were reported to be 0.71 tons per year.

3.8.2 Pb Data Analyses

A statistical analysis of Pb data was conducted to determine the measured concentrations, deviation from NAAQS, and trend impact from the Pb monitor.

3.8.2.1 Pb Measured Concentration, Deviation from NAAQS, and Trend Analysis

Monthly, rolling 3-month Pb concentrations, and rolling 3-month design values for April 2012 through December 2014 are presented in Table 3-55. Figure 3.41 presents the monthly mean, rolling 3-month concentrations, and the rolling 3-month design values for the Pb monitor serving Sacramento County for April 2012 through December 2014.

Table 3-55 Concentration Analysis for the Pb Monitor Serving Sacramento County

Month	Monthly Concentrations (μg/m³)	Rolling 3-month Concentrations (μg/m³)	Rolling 3-month Design Values (μg/m³)
Apr-2012	0.00100	--	--
May-2012	0.00060	--	--
Jun-2012	0.00060	0.00073	0.00
Jul-2012	0.00100	0.00073	0.00
Aug-2012	0.00083	0.00081	0.00
Sep-2012	0.00480	0.00221	0.00
Oct-2012	0.00200	0.00254	0.00
Nov-2012	0.00233	0.00304	0.00
Dec-2012	0.00150	0.00194	0.00
Jan-2013	0.00360	0.00248	0.00
Feb-2013	0.00300	0.00270	0.00
Mar-2013	0.00200	0.00287	0.00
Apr-2013	0.00060	0.00187	0.00
May-2013	0.00080	0.00113	0.00
Jun-2013	0.00080	0.00073	0.00
Jul-2013	0.00080	0.00080	0.00
Aug-2013	0.00060	0.00073	0.00
Sep-2013	0.00100	0.00080	0.00
Oct-2013	0.00283	0.00148	0.00
Nov-2013	0.00380	0.00254	0.00
Dec-2013	0.00400	0.00354	0.00
Jan-2014	0.00260	0.00347	0.00
Feb-2014	0.00100	0.00253	0.00
Mar-2014	0.00080	0.00147	0.00
Apr-2014	0.00060	0.00080	0.00
May-2014	0.00040	0.00060	0.00
Jun-2014	0.00060	0.00053	0.00
Jul-2014	0.00060	0.00053	0.00
Aug-2014	0.00000	0.00040	0.00
Sep-2014	0.00020	0.00027	0.00
Oct-2014	0.00140	0.00053	0.00
Nov-2014	0.00340	0.00167	0.00
Dec-2014	0.00080	0.00187	0.00

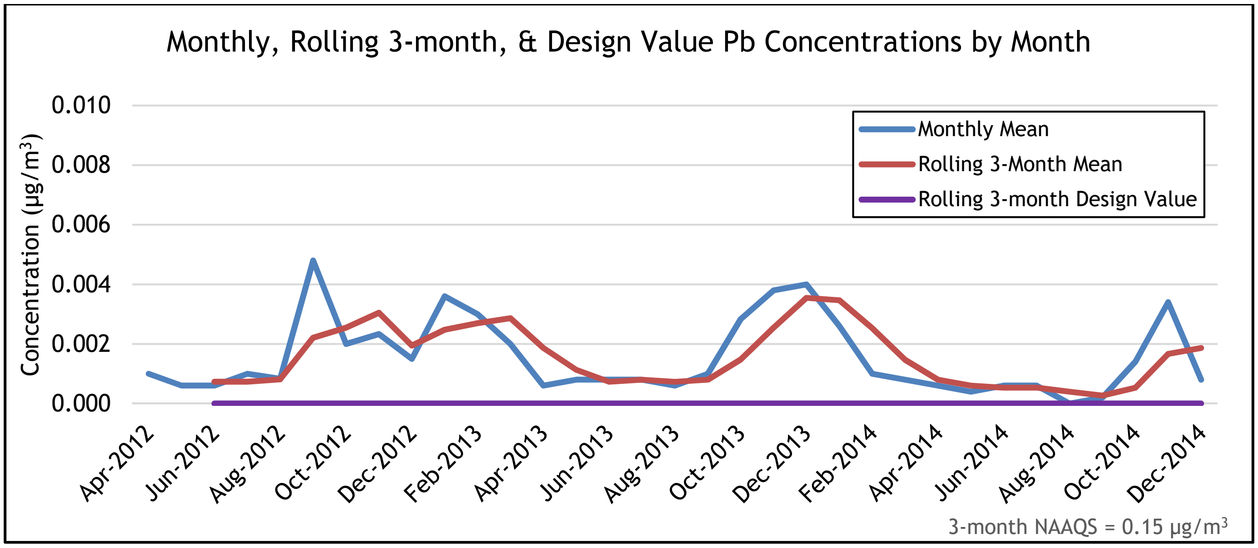


Figure 3.41 Monthly, Rolling 3-month, and Design Value Pb Concentrations

3.8.2.2 Monitor-to-Monitor Correlation Analysis

With Sacramento-Del Paso Manor being the only Pb monitor characterizing Pb concentrations in Sacramento County, monitor-to-monitor correlation was not evaluated.

3.8.2.3 Pb Monitor Removal Bias Analysis

With Sacramento-Del Paso manor being the only monitor within SMAQMD's network, removal bias was not evaluated.

3.8.3 Pb Site-to-Site Analysis

Sacramento-Del Paso Manor monitoring station is the primary monitor for characterizing Pb concentrations in Sacramento County.

3.8.4 Pb Suitability Modeling

Suitability modeling was not performed for Pb monitors since Pb monitoring is required only at NCore stations, near non-airport sources with emissions greater than 0.5 tons per year, or near airports emitting more than 1.0 tons per year.

3.9 Meteorological Network

Surface meteorological measurements are currently being collected at six monitoring sites within SMAQMD's network, with surface meteorology to be measured at the planned Sacramento-Bercut Drive microscale near-road station. Table 3-56 presents the meteorological parameters currently being measured at each monitoring site.

Table 3-56 Meteorological Parameters Currently Measured in SMAQMD's Network

Site	Elk Grove-Bruceville	Sacramento-Del Paso Manor	Folsom-Natoma	Sacramento-Goldenland Court	Sloughhouse	Sacramento-T Street
Wind Speed/ Direction	X	X	X	X	X	X
Temperature	X	X	X	X	X	X
Relative Humidity	X	X	X	X		X
Solar Radiation	X	X	X	X		
UV Radiation	X					
Barometric Pressure	X					
Precipitation	X					
Upper Air Meteorology	X					

3.9.1 Meteorological Network Windrose and Pollutant Rose Analysis

Data from 2005 through 2014 were used to compile windrose plots for an average annual distribution, average summer (using May through October to align with historical ozone season) distribution, and average winter (using November through February to align with historical PM season) distribution of wind transport in the county. Figures 3.42 through 3.44 present maps with annual, summer, and winter windrose plots, respectively, at SMAQMD monitors.

Annual windrose plots (Figure 3.42) show that predominant wind flow at T Street, Goldenland Court, and Del Paso Manor follows the orientation of the Central Valley (north-northwest to south and south-southeast). Elk Grove-Bruceville and Walnut Grove Tower show predominant winds out of the west-southwest, where air masses are flowing through the Carquinez Strait into the Central Valley and Sacramento County. Wind data collected at Sloughhouse show three sectors of primary wind flow (northwest, southwest, and east). The location of the Sloughhouse monitoring station may be influenced by diurnal wind patterns with canyon drainage during the night and Central Valley flow during the day.

Summer wind patterns (Figure 3.43) show a much stronger daytime upslope influence, with stronger southerly winds for Del Paso Manor, T Street, Goldenland Court, and Folsom-Natoma. Elk Grove, Walnut Grove Tower, and Sloughhouse all have stronger southwesterly flow out of the Strait.

Winter wind patterns (Figure 3.44) have a more evenly distributed diurnal pattern for all sites following the orientation of the Central Valley. Sloughhouse has a higher frequency of easterly winds which are associated with canyon drainage from the east.

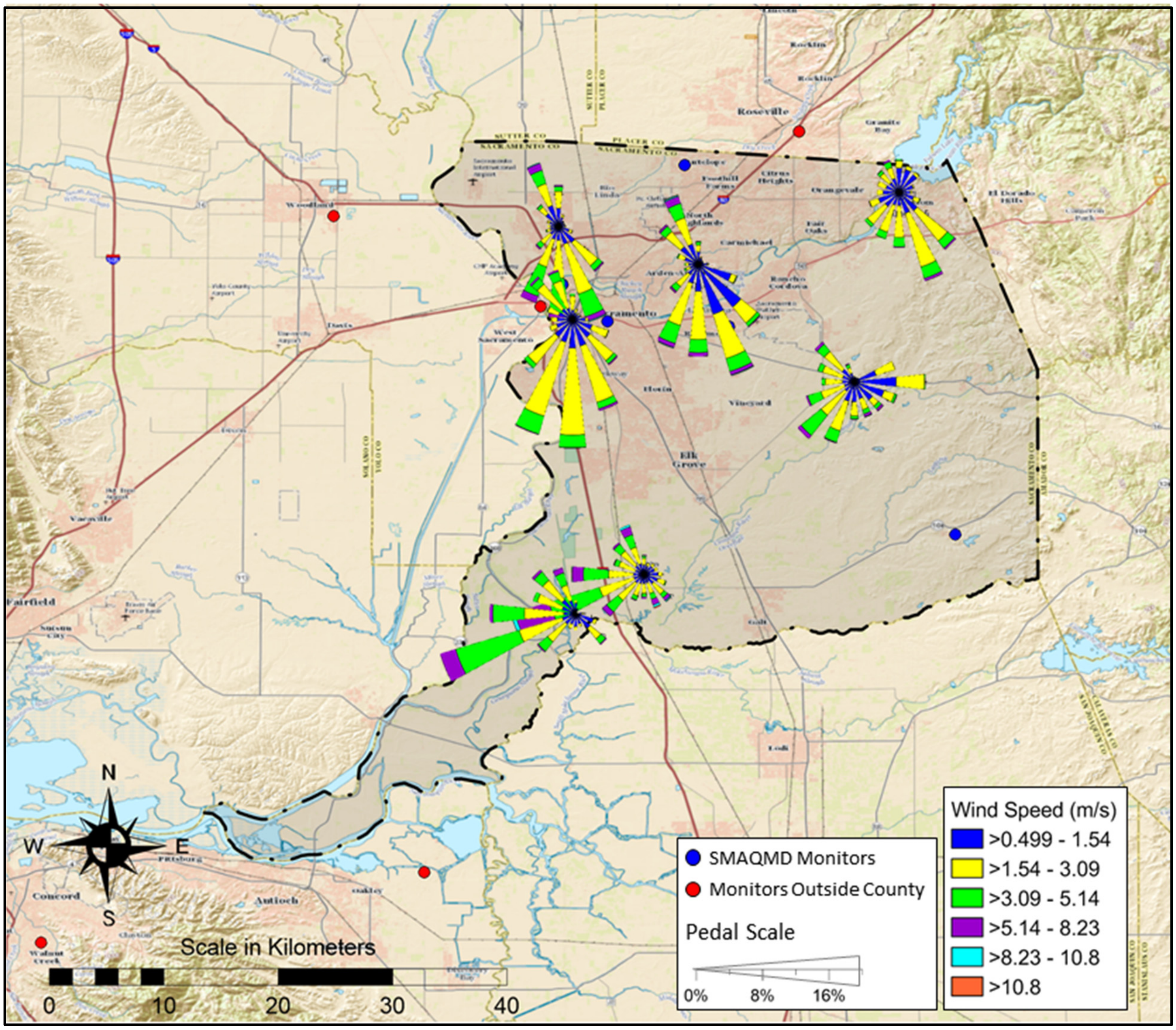


Figure 3.42 SMAQMD Meteorological Network Windrose Plots (2005-2014 Annual Average)

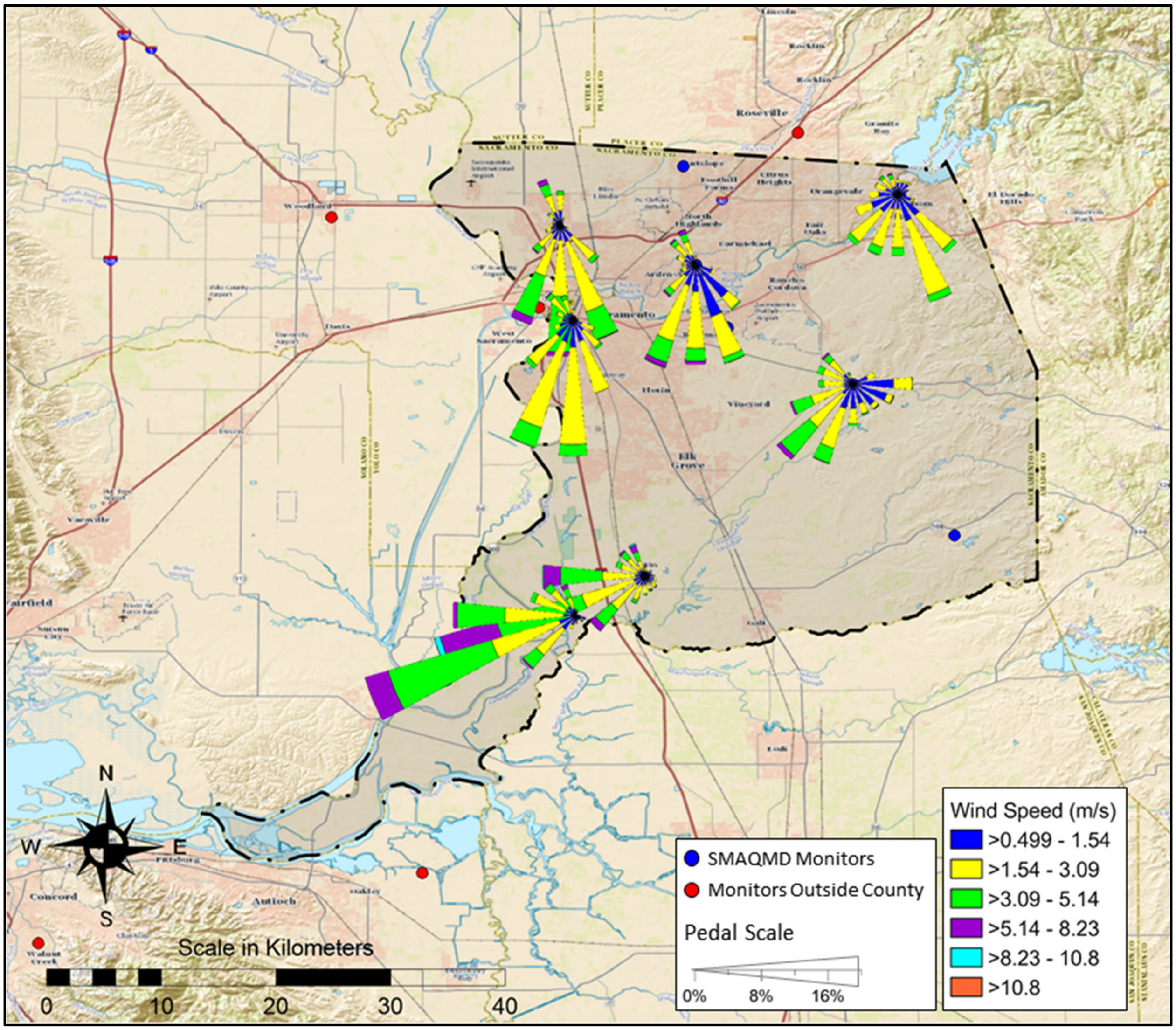


Figure 3.43 SMAQMD Meteorological Network Windrose Plots (2005-2014 Summer Average)

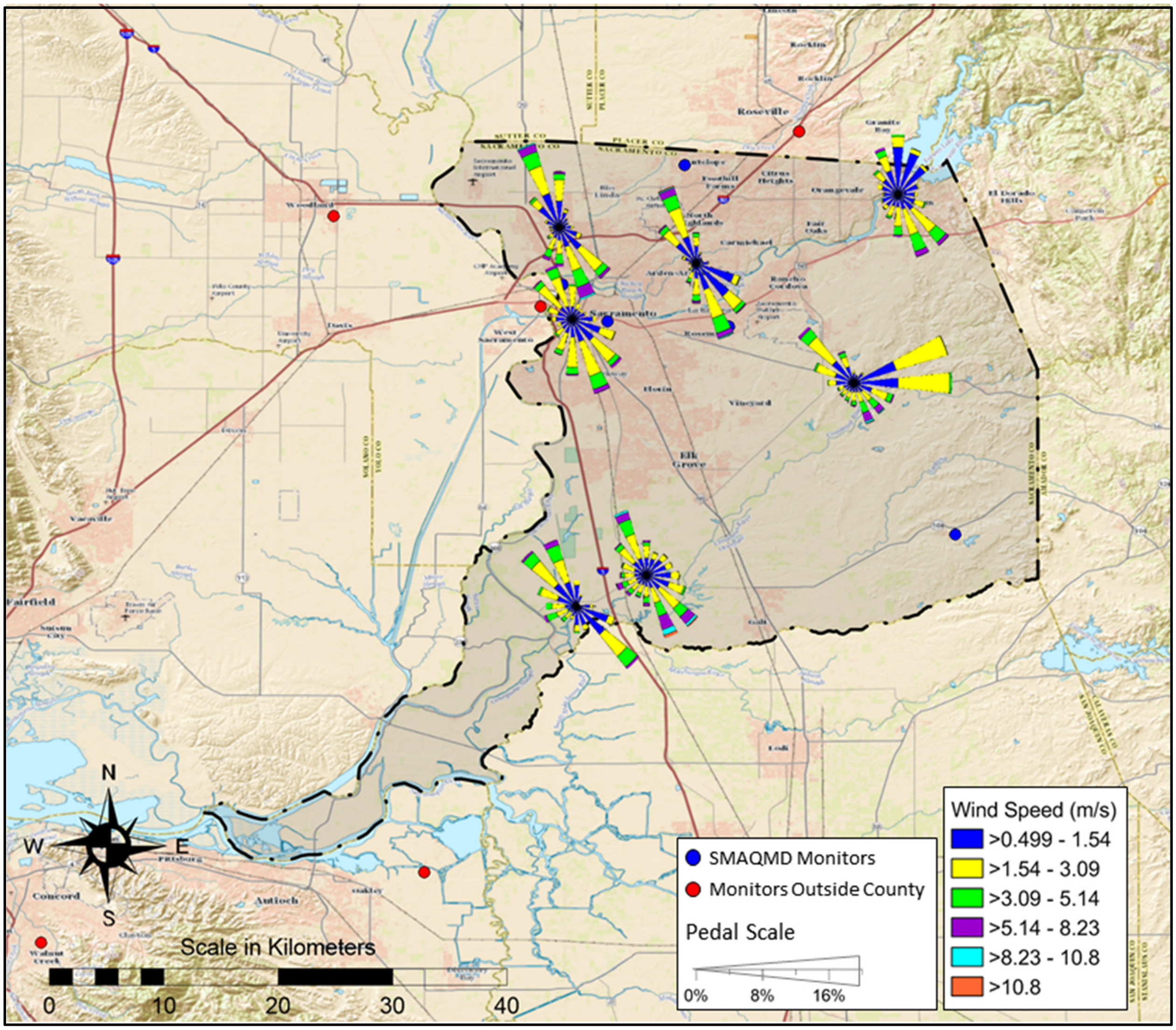


Figure 3.44 SMAQMD Meteorological Network Windrose Plots (2005-2014 Winter Average)

Meteorological data are important for analyzing the transport of pollutants. Wind direction data and concentration data in SMAQMD's network were paired to develop pollutant roses which are useful for understanding what direction the wind was blowing from when concentration data were collected. Similar to the windrose plots, pollutant roses were generated for each pollutant using available data from 2005 through 2014 on an annual average basis, and for the summer and winter seasons.

Exceedance probability tests show ozone and $PM_{2.5}$ have the greatest potential for exceeding the NAAQS. In Sacramento County, elevated concentrations of ozone are typically observed in the summer months while elevated $PM_{2.5}$ is typically observed in the winter. Figures 3.45 and 3.46 present the annual and summertime average pollutant roses for ozone; Figures 3.47 and 3.48 present the annual and wintertime average pollutant roses for $PM_{2.5}$. Annual, summer, and winter pollutant roses for all pollutants can be found in Appendix D.

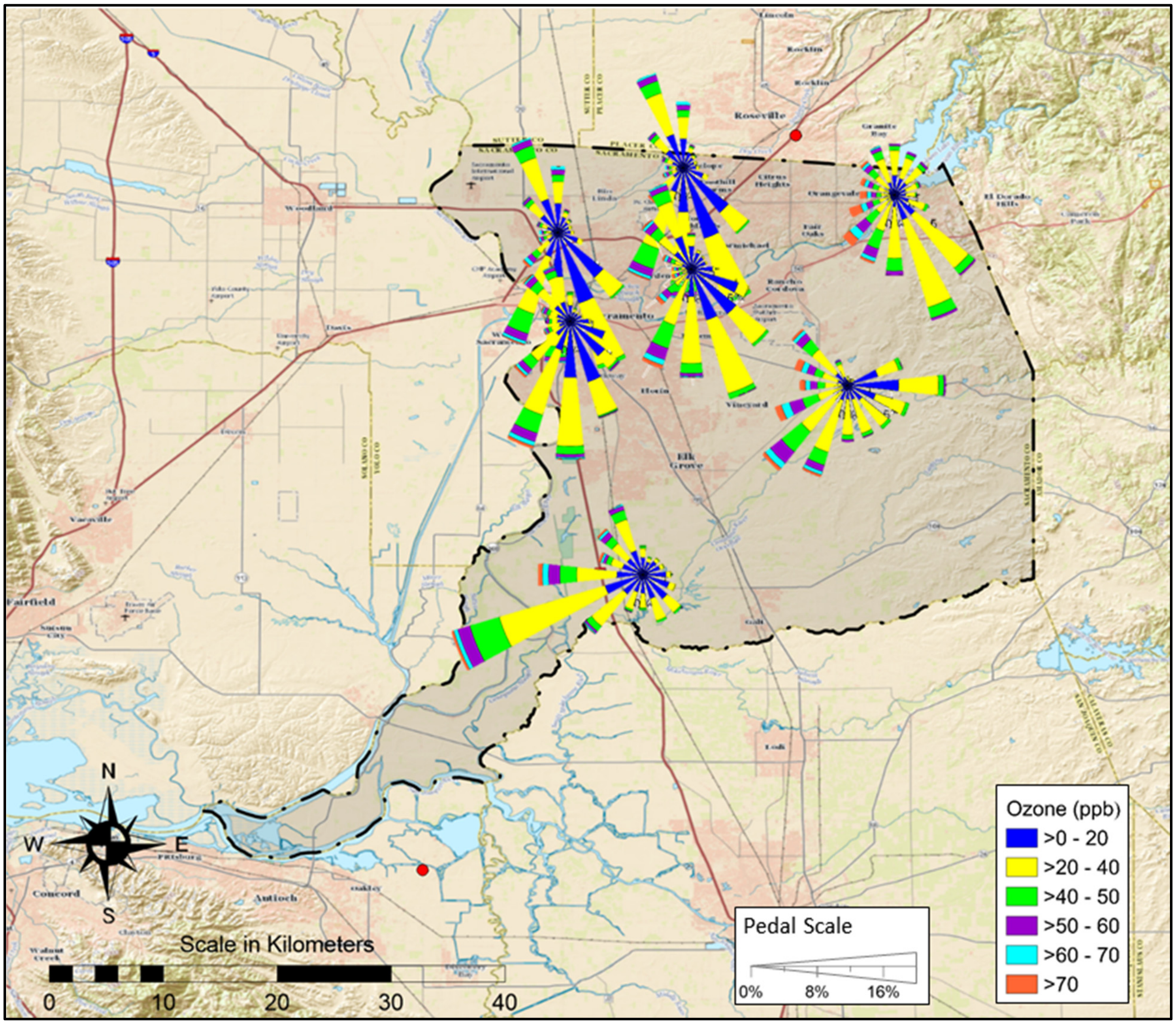


Figure 3.45 SMAQMD Ozone Pollutant Rose Plots (2005-2014 Annual Average)

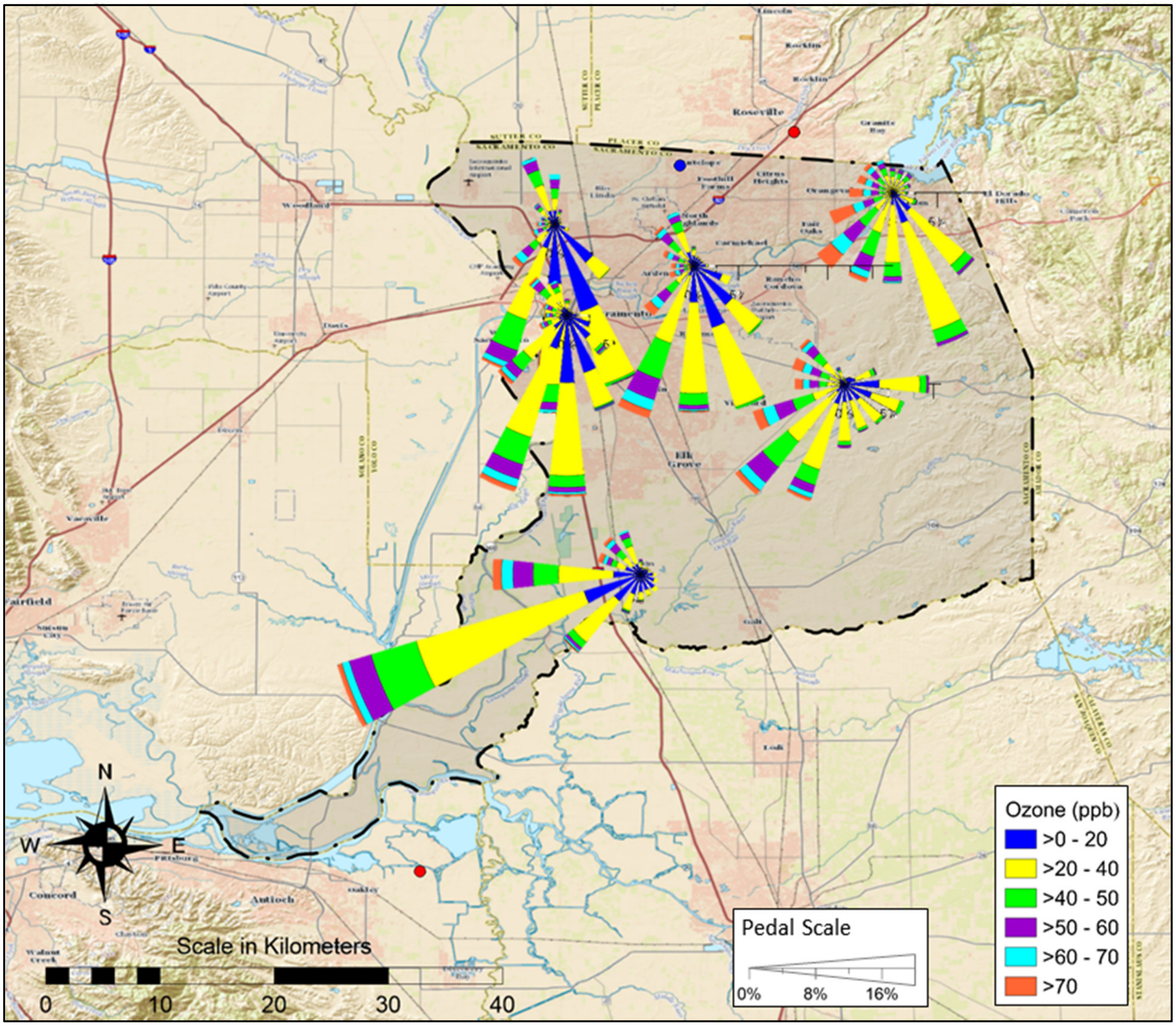


Figure 3.46 SMAQMD Ozone Pollutant Rose Plots (2005-2014 Summer Average)

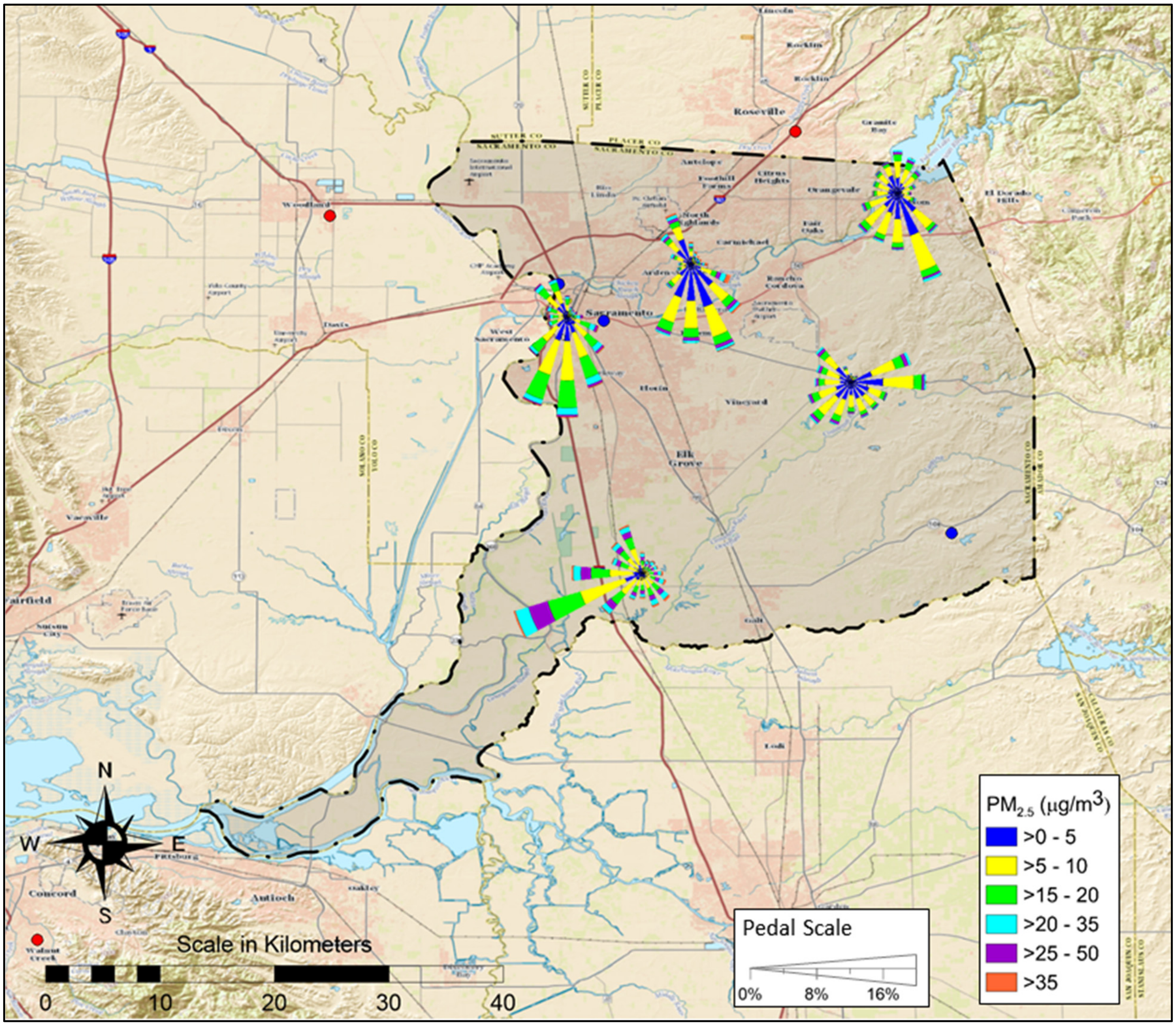


Figure 3.47 SMAQMD $PM_{2.5}$ Pollutant Rose Plots (2005-2014 Annual Average)

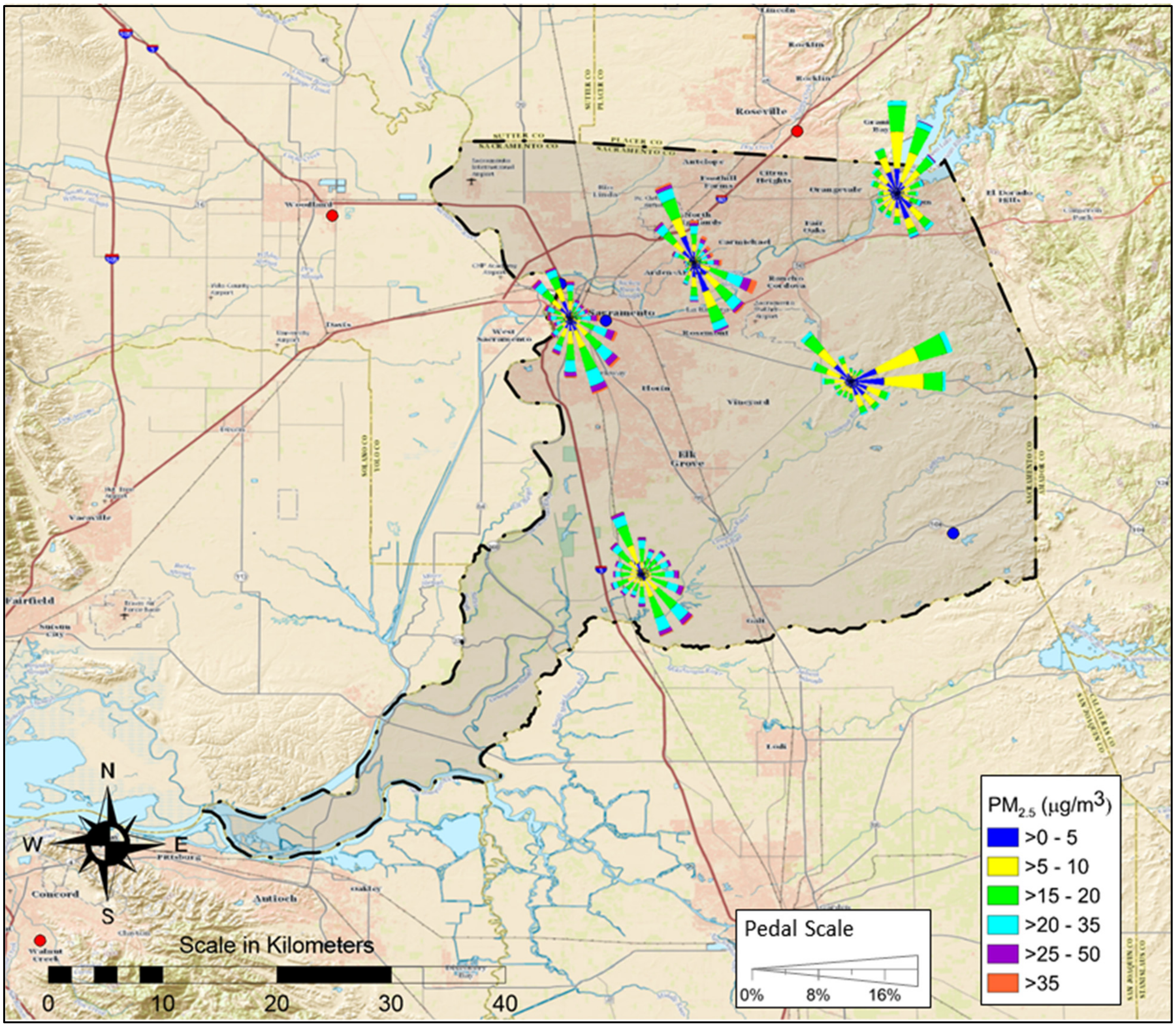


Figure 3.48 SMAQMD $PM_{2.5}$ Pollutant Rose Plots
(2005-2014 Winter Average)

Ozone pollutant roses indicate that high ozone concentrations observed in the summer are originating from the west and southwest at many of the ozone monitoring sites. Folsom-Natoma (which has the highest design value of ozone) shows most of the concentration data above 70 ppb are originating from the southwest to west-northwest sectors. Sloughhouse, located approximately 14 miles south of Folsom-Natoma, observes most of its measured concentrations above 70 ppb from the west-southwest to west-northwest sectors. As discussed in Section 3.2, ozone is not directly emitted by pollution sources but is formed through photochemical processes in the presence of precursor emissions and sunlight. Emissions from the urban core are being transported to Folsom-Natoma and Sloughhouse, where the highest concentrations of ozone in the county are being monitored.

Elk Grove and Walnut Grove also measure high concentrations of ozone originating from the west-southwest or outside the county. Air masses carrying the elevated concentrations of ozone are being transported through the Carquinez Strait into the southern portion of Sacramento County.

Pollutant roses for $PM_{2.5}$ show highest concentrations in the wintertime originate in the urban areas of the county with monitoring sites on the valley floor observing the highest concentrations within the network from all directions.

3.9.2 Meteorological Network HYSPLIT Analysis

Back trajectories were created using NOAA's HYSPLIT[13] model for periods of elevated ozone and $PM_{2.5}$. The model can be found and run on-line at the Air Resources Laboratory's (ARL) HYSPLIT webpage.[14] Back trajectories are meant to provide a snapshot of wind transport during individual days with high concentrations of ozone and $PM_{2.5}$.

Inputs to the model runs used in this report are listed below.

- Select "1" for number of source locations
- Select "Normal" for type of trajectory selection
- Select "EDAS 40km" for archived data source
- Input latitude and longitude of each site location
- Input appropriate archived data file for each site location for use by HYSPLIT
- Select "Backward" for Trajectory direction
- Select "Model vertical velocity" for vertical motion
- Input appropriate year, month, day, and hour for start time for each site location
- Select "48" for total run time
- Select "3" for Start a new trajectory every
- Select "10" for maximum number of trajectories
- Select "10" and "meters AGL" for level 1 height of trajectory

The output trajectories for each station and date were saved as a Google Earth® .kmz file.

Figures 3.49 and 3.50 present back trajectories for each site when elevated concentrations of ozone were observed throughout the network on a weekday and weekend day, respectively. These figures confirm what the summertime pollutant roses show, that air masses containing ozone precursors are originating south and southwest of the sites. Many of the sites in the southern portion of the county have air masses originating in the San Francisco Bay area and transported through the Carquinez Strait. Sites in the northern portion of Sacramento County measure high ozone concentrations from air masses that originate within the Central Valley and move over the Sacramento urban core, capturing ozone precursor emissions.

Figures 3.51 and 3.52 present back trajectories for each site when elevated concentrations of $PM_{2.5}$ were observed through the network on a weekday and weekend day, respectively. Most sites are located on the floor of the Central Valley, where particulate emissions are emitted or collect during inversions where cool air pools in the lower elevations. The Hysplit model shows that Folsom-Natoma and Sloughhouse have periods when airflow is originating from the east, which is due to canyon drainage.

The HYSPLIT model runs were run with a coarse 40 km grid spacing. The model output is only to provide a broad understanding of where pollutants may have originated during the selected high pollution days.

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[13] Air Resources Laboratory's Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) Model http://www.arl.noaa.gov/HYSPLIT_info.php
[14] IBID

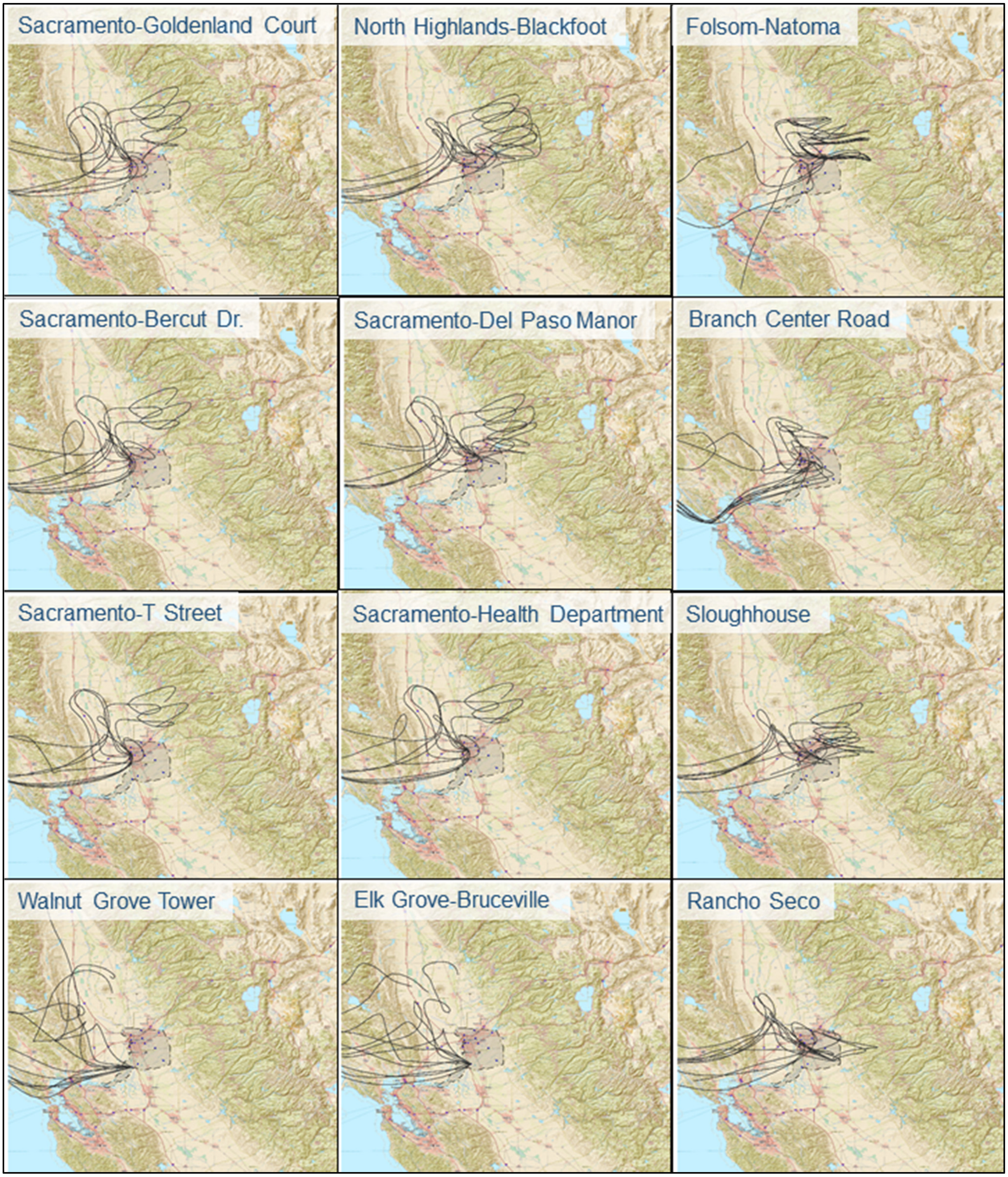


Figure 3.49 Summer Weekday Back Trajectory Analysis (Thursday, July 12, 2012)

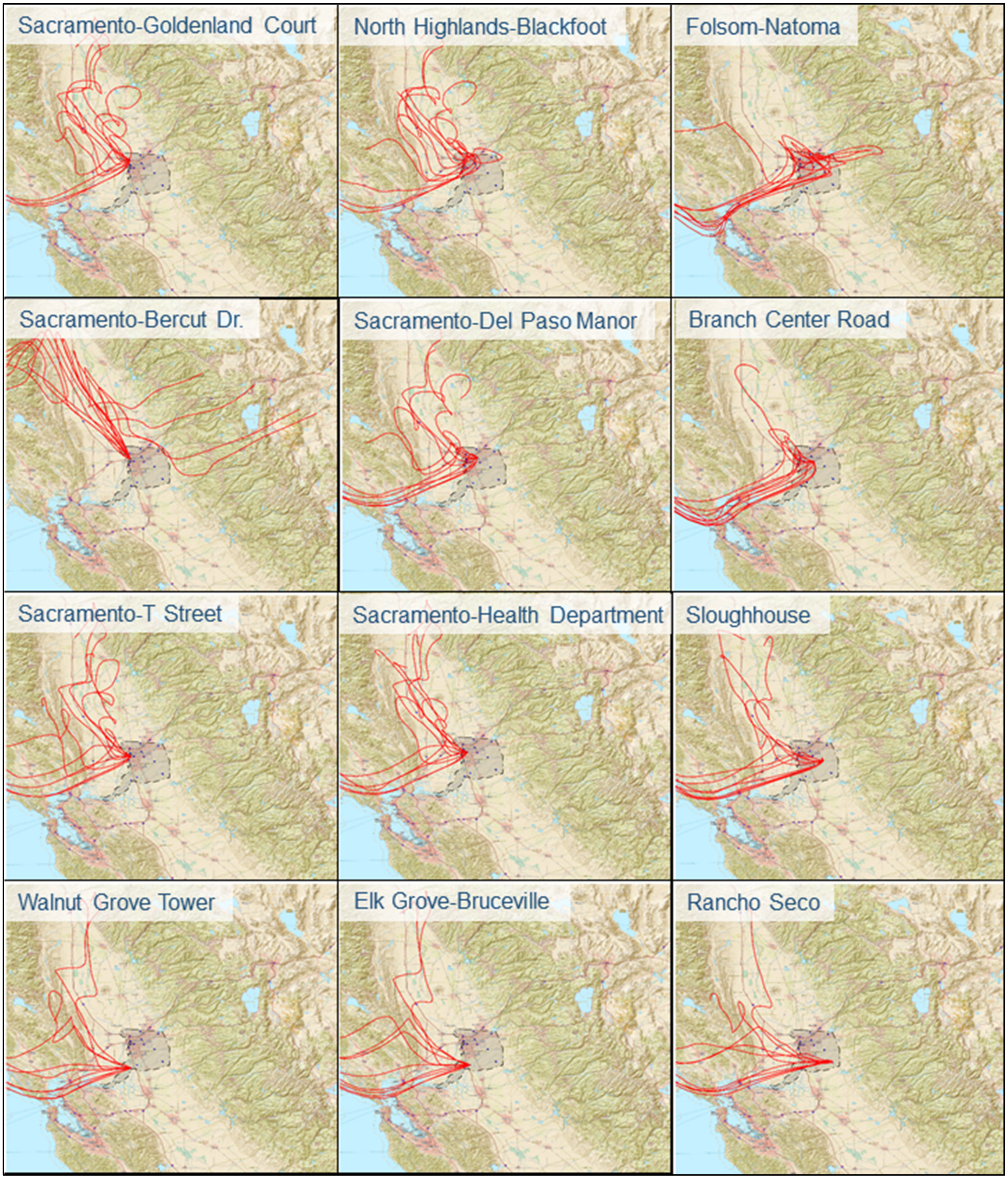


Figure 3.50 Summer Weekend Back Trajectory Analysis (Saturday, August 11, 2012)

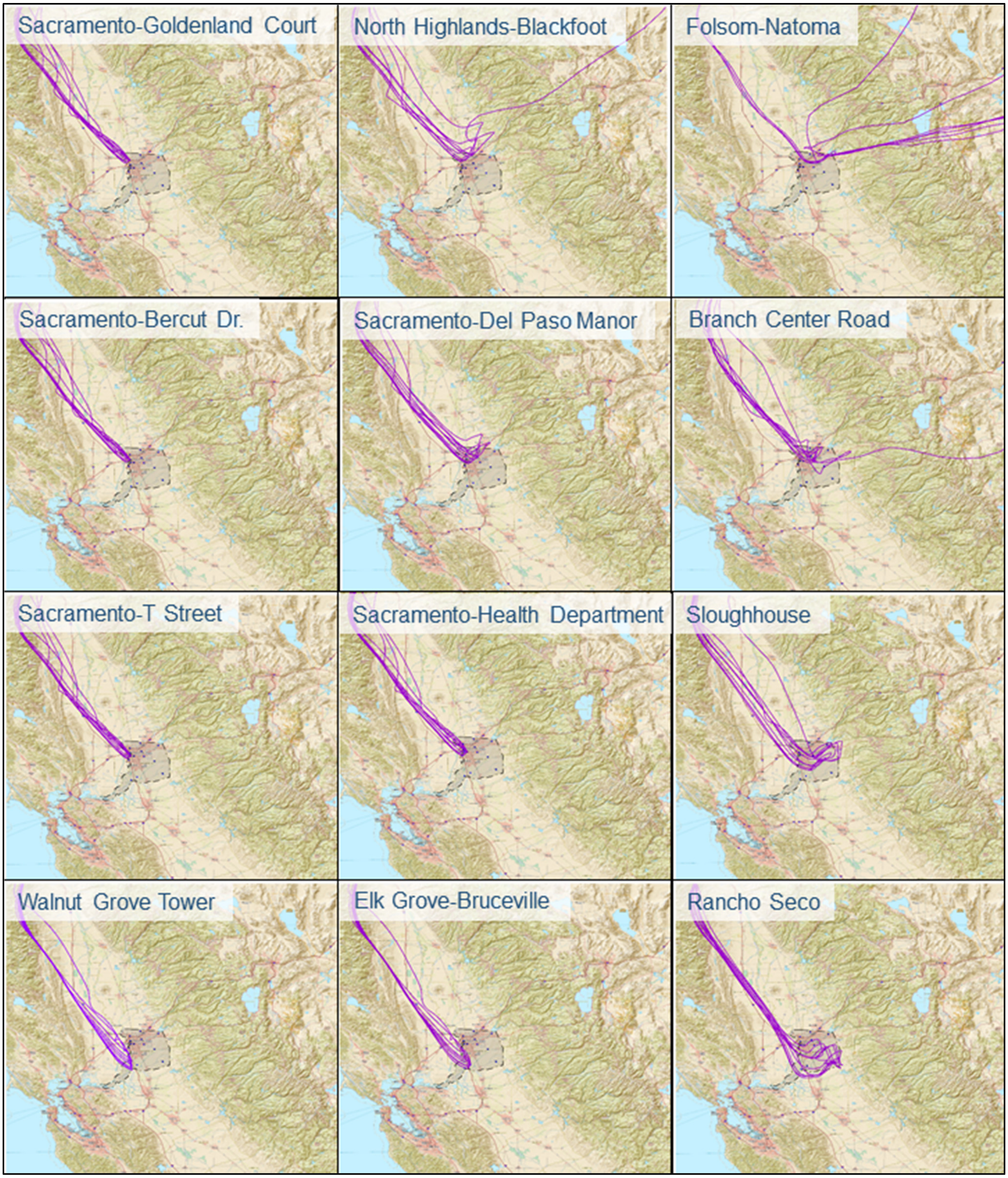


Figure 3.51 Winter Weekday Back Trajectory Analysis (Monday, January 9, 2012)

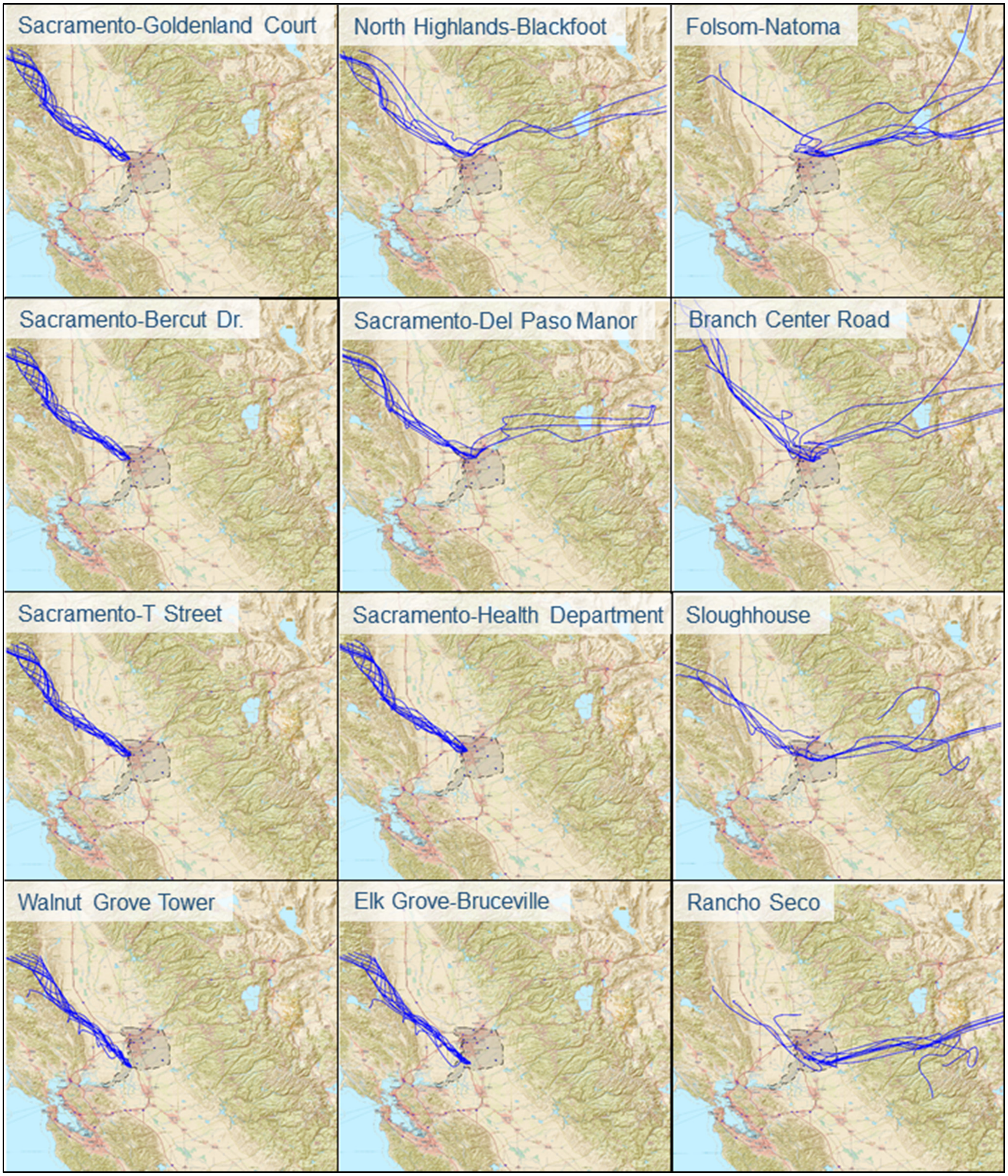


Figure 3.52 Winter Weekend Back Trajectory Analysis (Sunday, December 15, 2013)

3.10 PAMS Network

There are four ambient air monitoring sites (Sacramento-Del Paso Manor, Elk Grove-Bruceville, Folsom-Natoma, and Sacramento-Goldenland Court) which are part of the PAMS monitoring network within Sacramento County. Spatial analysis techniques (area-served, population-served, emissions-served) and the concentration trend analysis were evaluated for the current PAMS network.

3.10.1 PAMS Network Measured Parameters

The SMAQMD PAMS network consists of four monitoring stations which monitor ozone precursor emissions as required under the 2006 PAMS monitoring requirements. Table 3-57 presents the parameters being measured at each PAMS monitoring site.

Table 3-57 PAMS Network Parameters Monitored

Site Name	Elk Grove-Bruceville	Sacramento-Del Paso Manor	Sacramento-Goldenland Court	Folsom-Natoma
Site Type	Type I	Type II	Type II (secondary)	Type III
O_3	X	X	X	X
NO_x	X	X	X	X
NO_y	X	X[a]		X
CO	X	X	X	
Speciated VOC	X	X		X
Carbonyl		X		
Surface Meteorology	X	X	X	X
Upper Air Meteorology	X			

[a] Sacramento-Del Paso Manor collects NO_y data to satisfy NCore requirements and does not count toward the PAMS monitoring requirement.

As discussed in Section 2.4 of this document, on October 1, 2015, EPA finalized the new ozone NAAQS which included updates to the national PAMS network design. As part of the rule, EPA made several changes to the PAMS monitoring network requirements; these are outlined below.

1. Final network design requires PAMS measurements are to be made at all NCore sites in CBSA areas with a population of at least 1 million people, irrespective of ozone attainment status. SMAQMD operates an existing NCore site (Sacramento-Del Paso Manor).
2. Automatic gas chromatographs (GCs) for the determination of speciated VOCs are to be utilized.
3. Carbonyl samples using TO-11A cartridge sampling during the PAMS season on a 1-in-3 day schedule with three 8-hour samples collected per sample day are required. However, EPA added the option to allow continuous (hourly) formaldehyde measurements as an alternate to the TO-11A sample method.
4. Measurements of nitrogen oxides require true NO_2 in addition to NO and NO_y. NCore sites are not required to measure NO_2. With this rule, measurements of true NO_2 should be made with a photolytic NO_2 analyzer or an analyzer that directly measures NO_2 without using the common difference method between NO and NO_x.
5. Enhancing PAMS meteorological stations to collect wind speed, wind direction, temperature, relative humidity, barometric pressure, precipitation, solar, and ultraviolet radiation data is required. NCore sites are required to measure all but barometric pressure, precipitation, solar radiation, and ultra-violet radiation.

6. Mixing height is now a required parameter to be measured at PAMS monitoring sites. EPA cites the importance of mixing height to ozone modeling and the technological advances of ceilometers to measure mixing height at a reasonable cost to require mixing height at required PAMS monitoring locations. However, EPA has included a waiver option, to be approved by the Regional Administrator, which allows a state to obtain mixing height measurements from existing nearby sites. This includes mixing height measurements from wind profilers.

3.10.2 PAMS Network Spatial Analyses

Thiessen polygons were generated to determine the spatial representation of each PAMS monitoring station located in Sacramento County. The following sections present the findings for area-, population-, and emissions-served analyses for the PAMS network.

3.10.2.1 Ozone Network Area- and Population-Served Analyses

The population within Sacramento County represented by each monitoring site was counted within the Thiessen polygons using 2009 through 2013 ACS data. Area- and population-served analyses, including sensitive and vulnerable populations, are presented in Table 3-58. Table Figure 3.53 presents a map showing the location, area of influence, and served population for each ozone monitor.

Table 3-58 Area and Population Served by Ozone Monitors Serving Sacramento County

Site	2013 Population Estimate (Persons)	Population Change from 2010 to 2013 (Persons)	Sensitive/ Vulnerable Population (Persons)[a]	Area (km^2)
Sacramento-Del Paso Manor	754,356	11,973	229,516	592.46
Elk Grove-Bruceville	225,511	1,714	62,659	1,215.66
Folsom-Natoma	183,342	570	37,728	480.58
Sacramento-Goldenland Court	271,998	2,162	80,678	286.57

[a]Summation of sensitive/vulnerable persons located within the monitors area of influence.

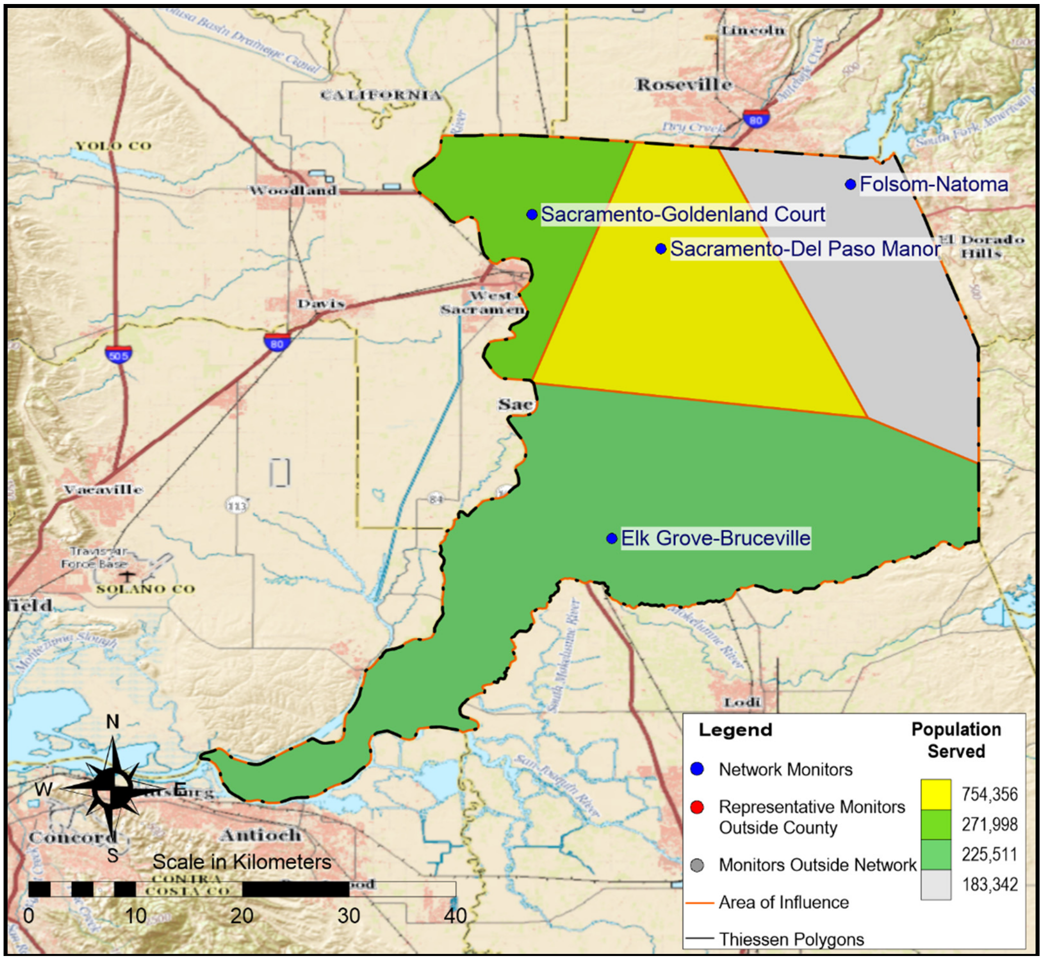


Figure 3.53 PAMS Network Area and Population Served

3.10.2.2 PAMS Network Emissions-Served Analysis

The PAMS network monitors ozone and ozone precursors. For Sacramento County, high ozone concentrations are typically observed in summer when solar radiation and temperature are strongest. To evaluate the emissions served by each monitor, 2012 gridded emissions of ozone precursors from a typical summer weekday and weekend day were obtained from CARB and summed within each monitor's area of influence. Table 3-59 presents the emissions-served analysis for the PAMS monitoring network. Monitors were ranked according to the amount of NO_x and VOC emissions within each monitor's area of representation. Figures 3.54 and 3.55 present maps with the emissions served by each monitoring area for summertime NO_x and summertime VOC.

Table 3-59 Emissions Served by PAMS Monitors Within Sacramento County

Site	Summer Weekday NO_x Emissions (tpd)	Summer Weekend NO_x Emissions (tpd)	Summer Weekday VOC Emissions (tpd)	Summer Weekend VOC Emissions (tpd)
Sacramento-Del Paso Manor	20.48	16.92	31.71	30.84
Elk Grove-Bruceville	10.58	10.03	27.04	39.23
Folsom-Natoma	7.18	5.92	18.53	20.60
Sacramento-Goldenland Court	13.05	11.09	15.41	16.10

Del Paso Manor and Goldenland Court are located in areas where the majority of ozone precursors are being emitted. As can be seen in Figures 3.54 and 3.55, Folsom is situated between emission maxima locations for NO_x (emitted in urban areas) and VOCs (naturally emitted biogenic VOCs in forested areas)., although there is a second maxima of anthropogenic VOCs located in the urban core of the county.

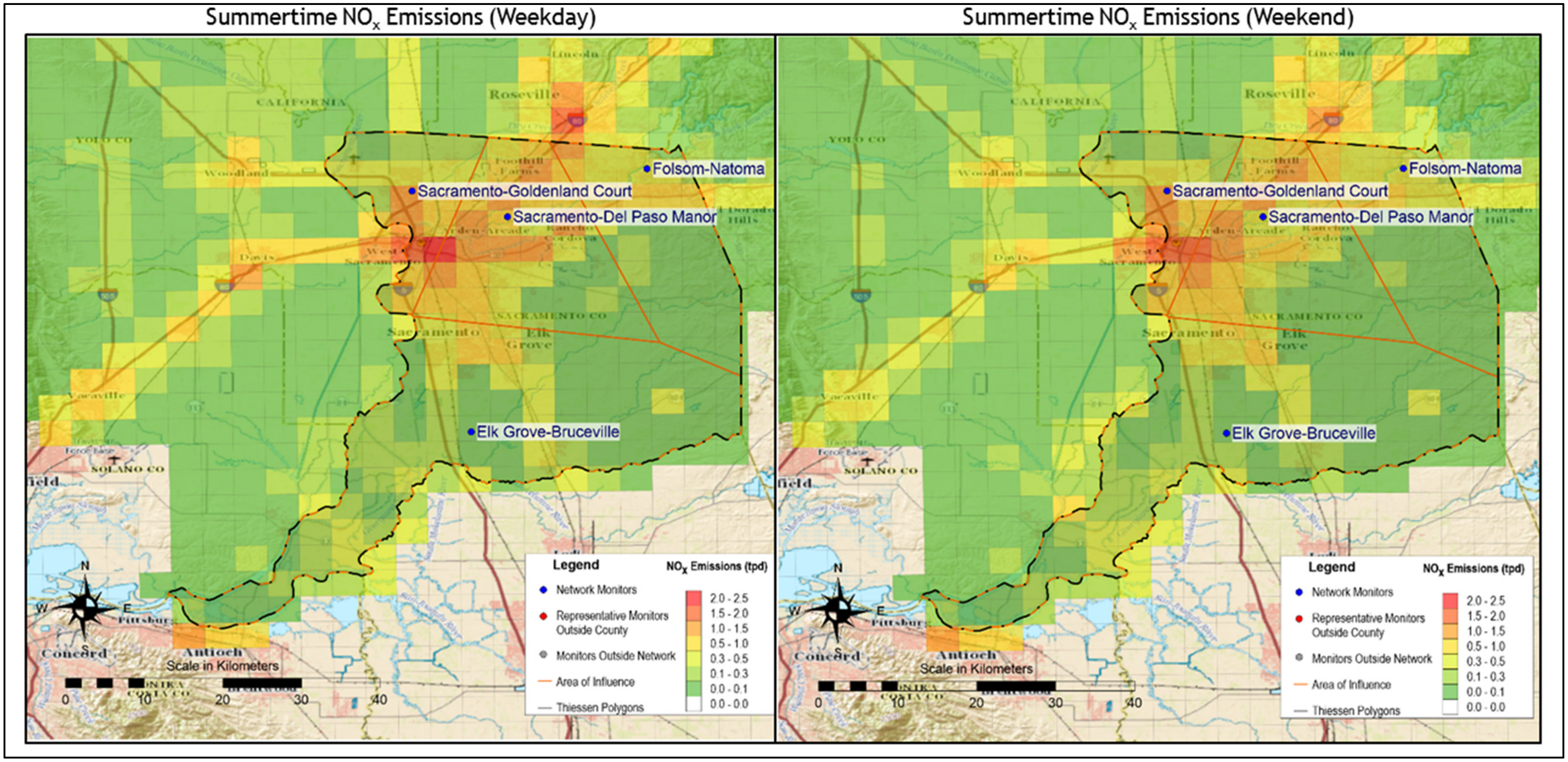


Figure 3.54 PAMS Network Emissions Served (Summertime NO_x)

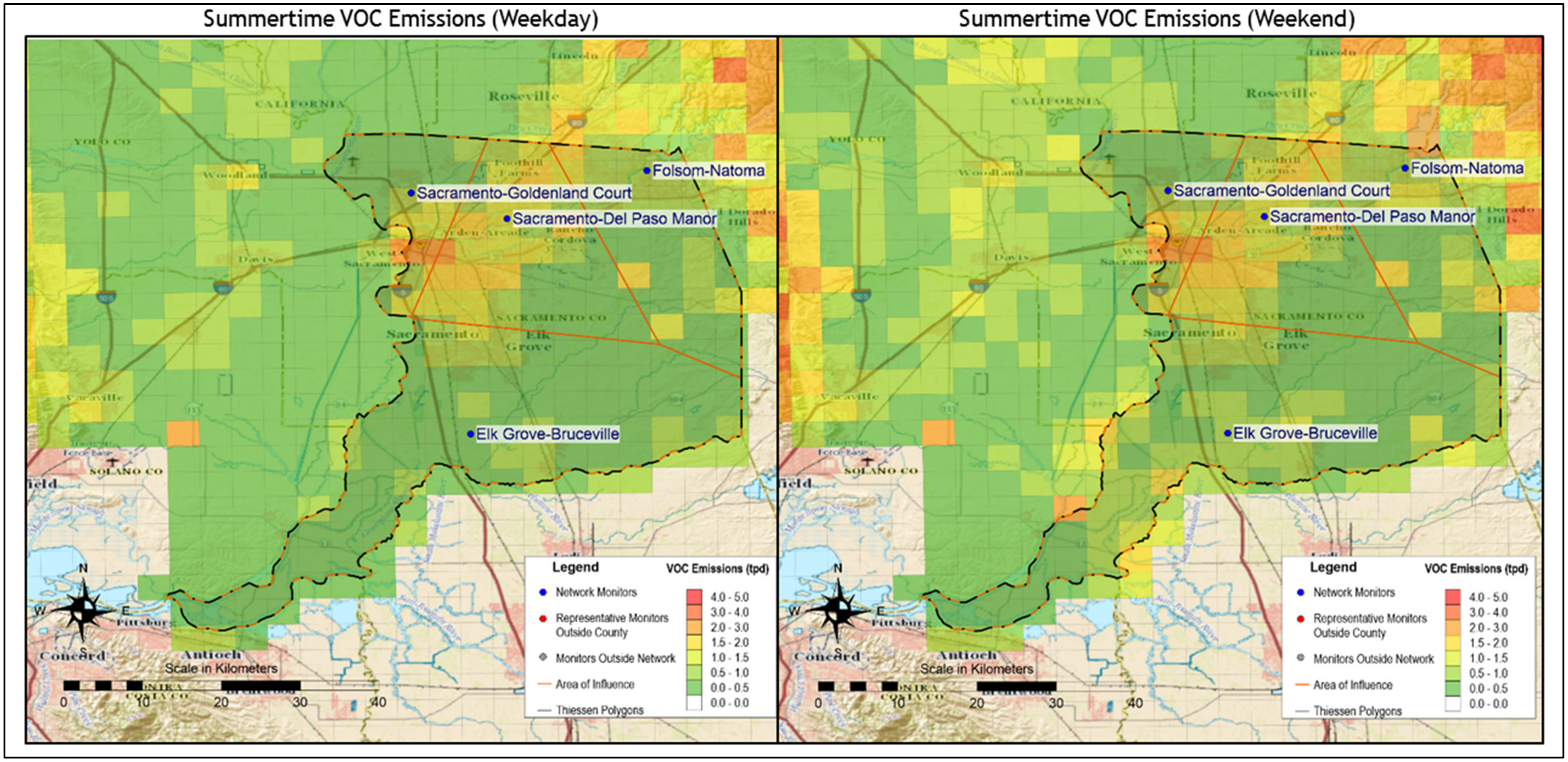


Figure 3.54 PAMS Network Emissions Served (Summertime VOC)

3.10.3 PAMS Data Analyses

A data analysis was conducted to determine the importance of each site based on measured concentrations and trend impact.

3.10.3.1 Measured Concentration and Trend Analysis

Monitors within SMAQMD's PAMS monitoring network shown to have high concentrations of ozone precursors and with a long historical record were considered to be of high value for characterizing pollution in the area. Table 3-60 presents the annual fourth-high ozone concentrations, annual average NO_y concentrations, annual average TNMHC concentrations, and average VOC concentrations (sampled July through September) for 2005 through 2014. Figures 3.56 and 3.57 present the 2005 through 2014 concentrations, by year, for PAMS monitors serving Sacramento County.

Speciated VOC data collected in 2008 at Del Paso Manor showed a large spike for one canister sample that was three orders of magnitude higher than any concentration measured in the 10-year period being analyzed. This sample was omitted from the plots to allow the reader to view concentration trends. Starting in 2010, canister sample analyses included oxygenate compound class at the Del Paso Manor site only.

Table 3-60 Concentration Analysis for PAMS Monitoring Network Serving Sacramento County

Site	Length of Record (years)	Pollutant	Concentration[a]									
			2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sacramento-Del Paso Manor	35	Ozone	96	93	81	87	92	77	75	83	75	75
	5	NO_y	--	--	--	--	--	--	15.63	12.24	17.78	12.92
	22	TNMHC	42.86	41.07	24.40	14.54	62.60	45.65	58.01	55.79	93.61	55.60
	22	VOC	40.14	45.19	45.52	42.29	32.52	55.16	38.26	42.93	41.52	33.55
Elk Grove-Bruceville	24	Ozone	84	87	78	82	78	73	79	79	62	69
	--	NO_y	--	--	--	--	--	--	--	--	--	--
	20	TNMHC	77.03	67.56	60.26	55.65	2.42	0.14	10.88	4.81	8.13	11.62
	20	VOC	14.01	19.20	26.88	20.90	--	17.01	14.01	17.46	22.51	--
Folsom-Natoma	20	Ozone	102	102	90	114	96	96	94	97	79	81
	5	NO_y	--	--	--	--	--	--	8.47	5.23	5.18	4.30
	20	TNMHC	62.11	54.87	28.30	3.14	46.14	14.62	23.84	--	--	--
	20	VOC	33.32	36.66	31.10	29.29	28.37	29.00	25.45	31.74	24.02	24.77
Sacramento-Goldenland Court	8	Ozone	--	--	--	--	77	64	67	77	68	70
	--	NO_y	--	--	--	--	--	--	--	--	--	--
	8	TNMHC	--	--	--	--	59.69	45.92	61.44	54.49	65.02	56.31
	--	VOC	--	--	--	--	--	--	--	--	--	--

[a]Ozone and NO_y in ppb; TNMHC and VOC in ppbC.

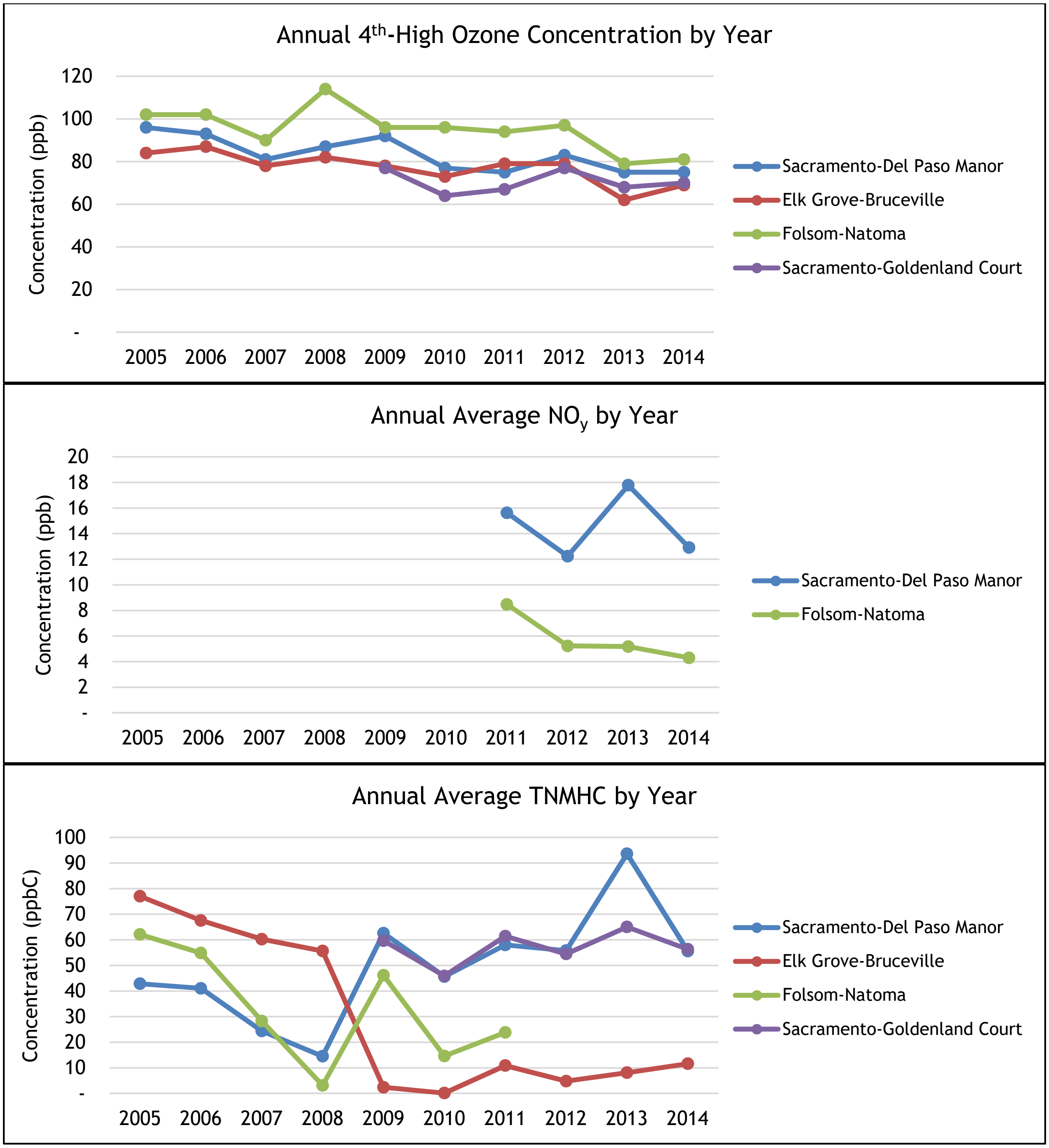
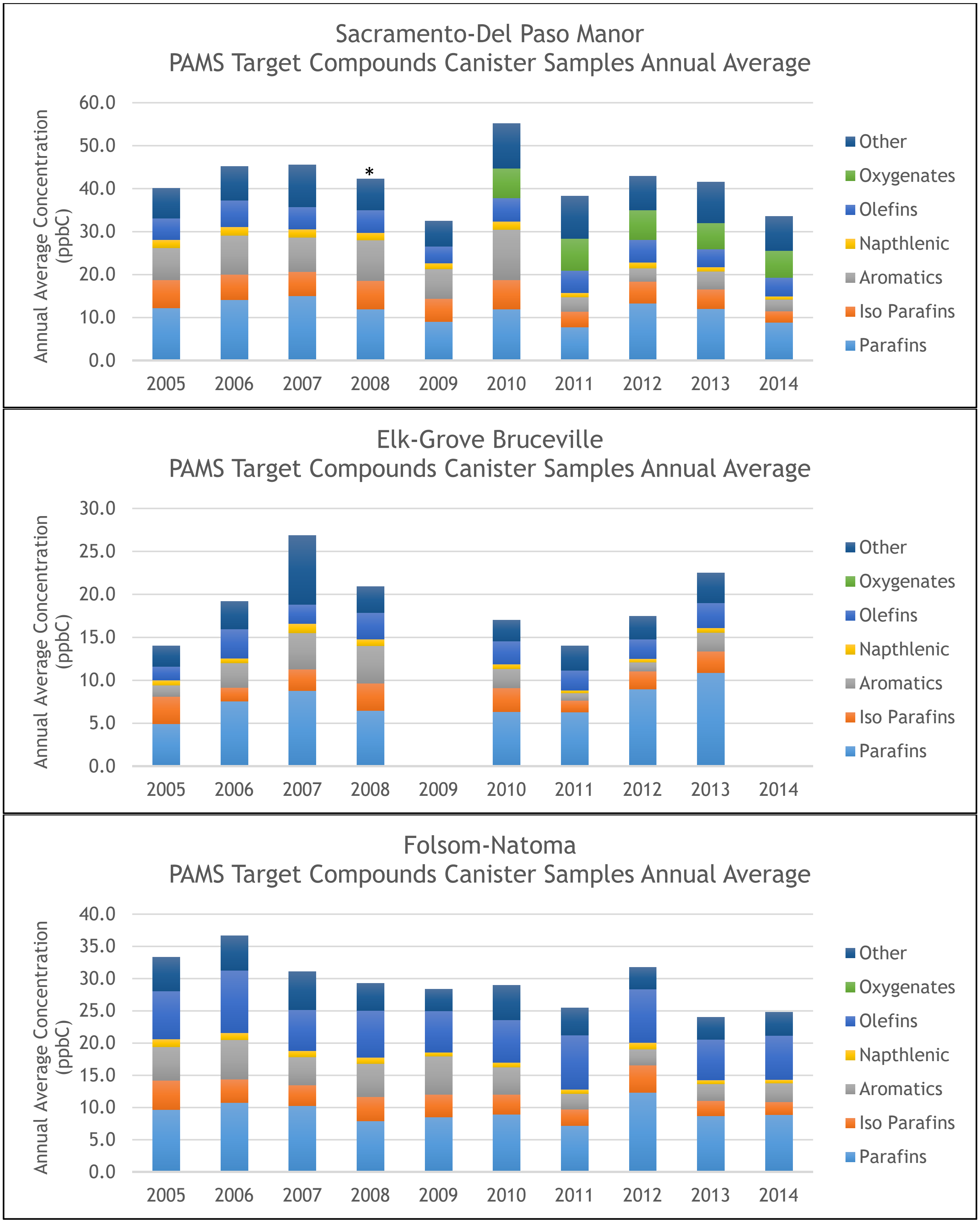


Figure 3.56 Fourth-High Ozone, Annual Average NOy, and Annual Average TNMHC by Year



*Outlier concentration measured on 9/26/2008 at 23:00 was not included in data

Figure 3.57 July through September Average VOC Concentration by Year

3.10.4 PAMS Suitability Modeling

The suitability modeling aimed to determine the most appropriate locations for ozone precursor monitor placement. Gridded data layers, categorized by population, emissions inventory, measured concentrations, were combined to determine the most appropriate locations for ozone monitor placement. The grids used in the ozone network suitability modeling are listed below and graphical representation of these grids are provided in Appendix C. Figure 3.58 presents the output of the suitability modeling. Table 3-61 presents the model output score at the location of each monitor within Sacramento County.

- Typical summertime weekday NO_x emissions from CMAQ model
- Typical summertime weekend NO_x emissions from CMAQ model
- Typical summertime weekday VOC emissions from CMAQ model
- Typical summertime weekend VOC emissions from CMAQ model
- 8-hour ozone design values for 2012-2014
- 2014 Annual Average TNMHC concentrations
- July through September 2014 Average VOC concentrations
- Exceedance probability of ozone monitors
- Population density
- Population change
- Sensitive and vulnerable population index (MSDI)

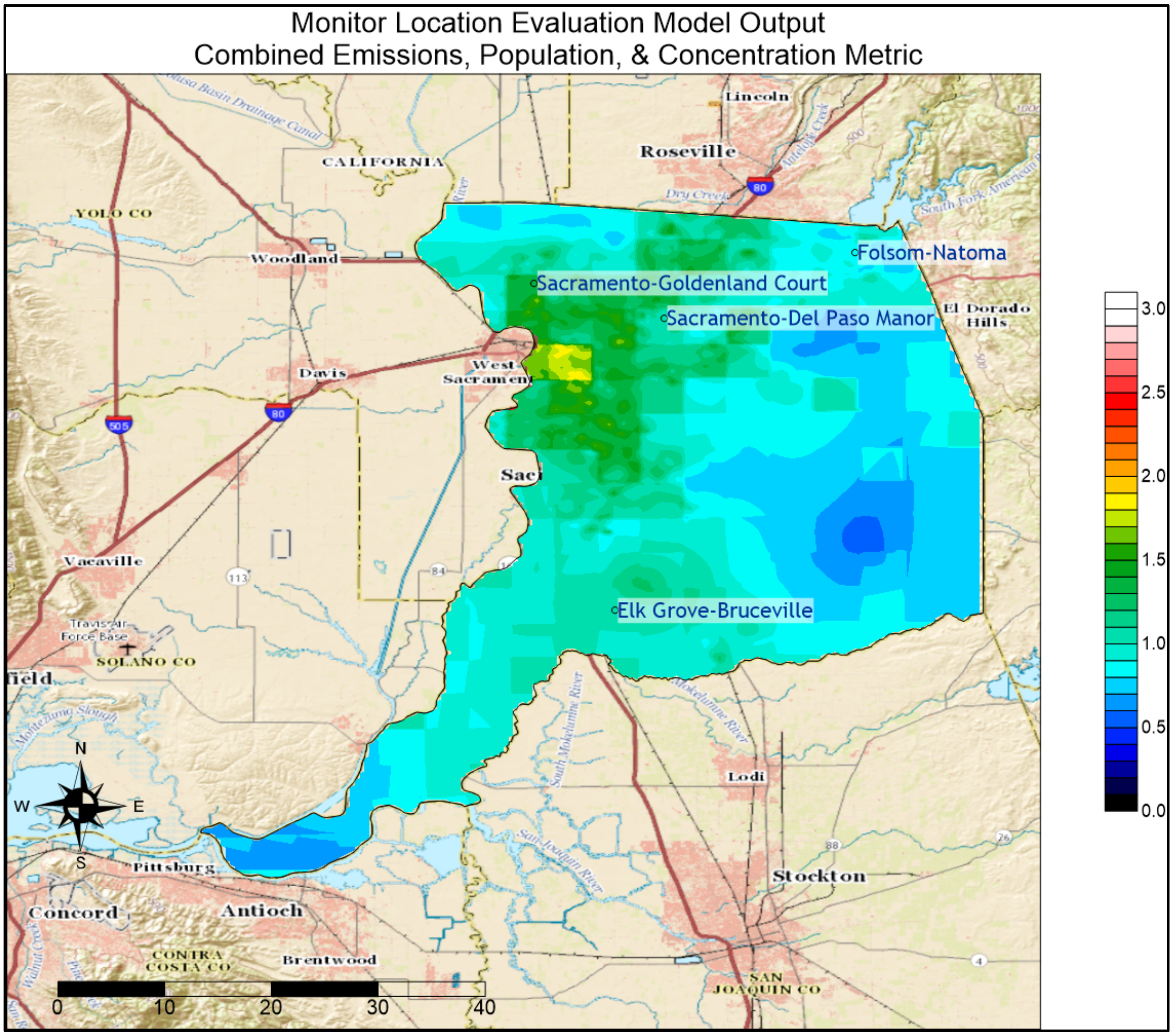


Figure 3.58 Ozone Monitoring Network Suitability Modeling Output

Table 3-61 SMAQMD PAMS Monitoring Network Suitability Modeling Results

Site	Suitability Modeling Output
Sacramento-Del Paso Manor	1.07
Elk Grove-Bruceville	1.05
Folsom-Natoma	0.84
Sacramento-Goldenland Court	1.34

Results of the suitability modeling for the PAMS monitoring network show Sacramento-Goldenland Court having the highest model output index of the four PAMS monitor locations. The metrics in the suitability model generally focused on concentration, emissions, and population. A limitation in the suitability model is the model does not take into account transport of air masses.

Ground-level ozone photochemically forms in the atmosphere through chemical reactions in the presence of precursor pollutants and sunlight. Time is required for the reactions to occur and while ozone is being chemically formed, air masses are transported out of the area where precursor pollutants were emitted. The suitability model shows Folsom-Natoma as having the lowest model output although the site measures the highest concentrations of ozone. The model is showing that Del Paso Manor, Goldenland Court, and Elk Grove-Bruceville monitors are important for measuring ozone precursor pollutants from the source before the chemical reactions have time to complete. Retaining Folsom-Natoma as an ozone precursor site may be important for understanding the spatial distribution of precursor pollutants remaining in the atmosphere after air masses have had time for chemical reactions to produce high levels of ozone. In addition, the site may also prove important for continued historical trends of ozone precursors which may change due to population and source migration as well as measuring effectiveness of pollution policy changes.

3.10.5 PAMS Meteorological Measurements

Each PAMS site measures surface meteorology, with Elk Grove-Bruceville also collecting upper air data to support ozone modeling input data.

3.10.5.1 Surface Meteorology

The final ozone rule is requiring all NCore sites to make PAMS measurements including surface meteorological measurements of wind direction, wind speed, temperature, humidity, atmospheric pressure, precipitation, solar radiation, and UV radiation. Currently, the Elk Grove-Bruceville monitoring site is the only station making all of these measurements. All four sites which are currently considered part of SMAQMD's PAMS monitoring network collect wind speed, wind direction, outdoor temperature, relative humidity, and solar radiation.

3.10.5.2 Upper Air Meteorology

At the Elk Grove-Bruceville site, SMAQMD operates a Radian 915 MHz LAP-3000 wind profiler equipped with a radio acoustic sounding system (RASS). This profiler has been in operation at the site since June 1, 1996.

The profiler collects a profile of upper air measurements of wind speed, direction, and temperature. and is capable of providing mixing height measurements for ozone modeling applications. The profiler located at the Elk Grove-Bruceville site is almost 20 years old, which makes it susceptible to costly maintenance and low data recovery. This site was chosen at the time to reduce the amount of urban interference on the profiler and acoustical nuisance of the RASS system which sends out a sound pulse to make its measurements.

Site selection for mixing height was evaluated to determine if continued measurement of mixing height at the profiler location would suffice or if another location within the network would be preferable if the profiler were to be decommissioned. The Elk Grove-Bruceville site is located in the southern portion of Sacramento County. The site is situated in the middle of the Central Valley in a fairly flat and rural portion of the county surrounded by agriculture. The Carquinez Strait is located west-southwest of the site and the foothills of the Sierra Mountains are located east of the site. Figure 3.59 presents a map showing the location of the sites (Elk Grove-Bruceville and Sacramento Del Paso Manor NCore) and the surrounding topographical and geographical features.

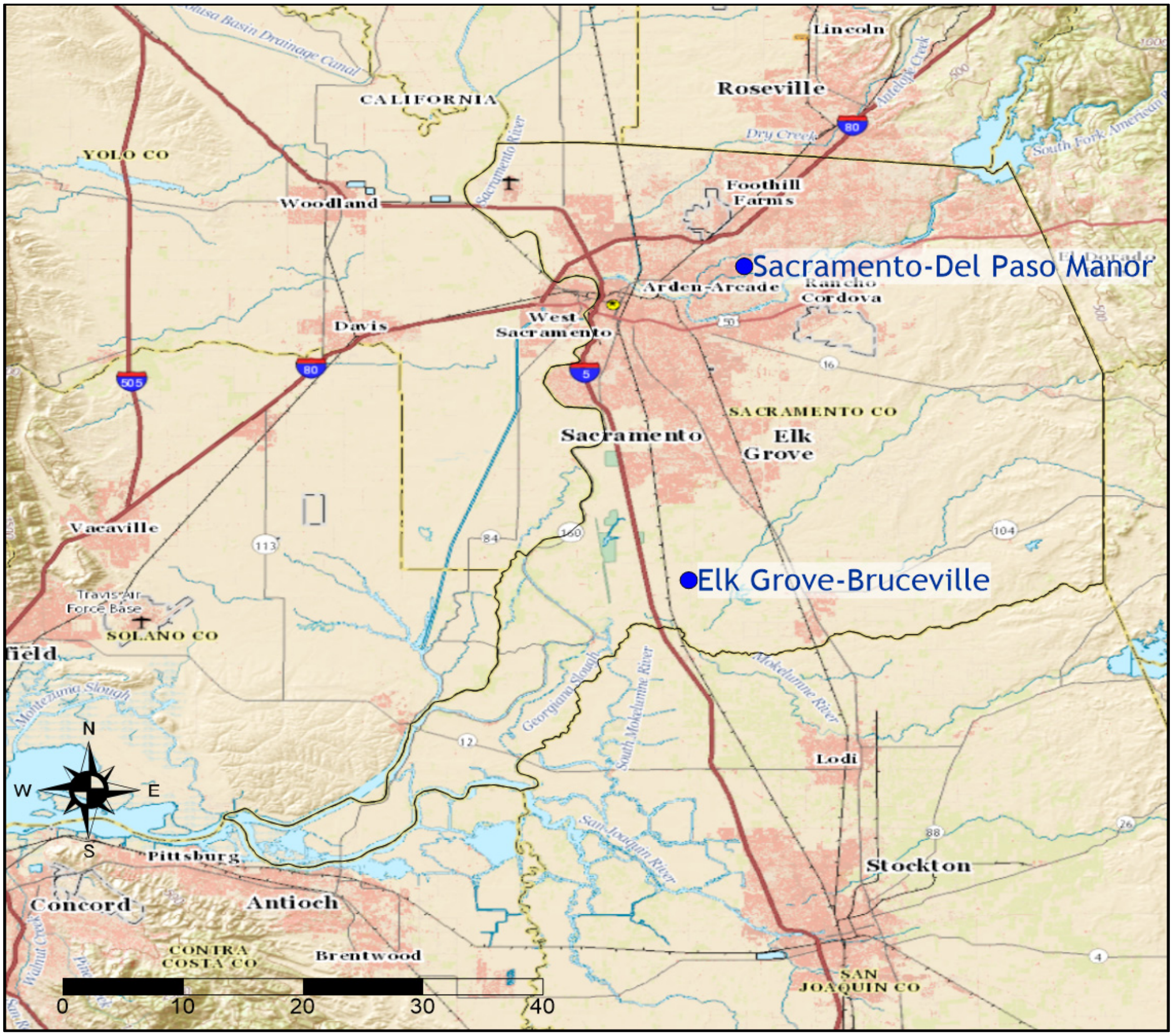


Figure 3.59 Profiler Location

One of the main concerns with the current location of the profiler is the representativeness of the location for making mixing height measurements. The highest ozone concentrations being measured in the SMAQMD network are located in the northern, more urbanized, areas of the county. It is well documented that man-made surfaces create an urban heat island which can increase the depth of the mixing height when compared to surrounding rural areas[15]. The meteorological analysis above showed that predominant wind flow observed at the site during the summer ozone season was from the west-southwest (sea breeze from the San Francisco Bay area). The sea breeze carries marine air which suppresses the air temperature at the site. Average temperatures for the ozone season measured at each site support this, as shown in Table 3-62 below. Seasonal average temperatures at Elk Grove-Bruceville regularly have the lowest temperatures in the network.

[15] Angevine et al. 2003

Table 3-62 Average June through October (Ozone Season) Temperatures by Site and Year

Site	Temperature (˚C)									
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sacramento-Del Paso Manor	21.7	22.0	21.2	22.1	21.4	20.6	21.1	21.9	21.6	22.2
Sacramento-T Street	21.5	21.9	21.0	21.9	21.0	20.6	21.0	21.1	21.3	23.5
Elk Grove-Bruceville	20.3	20.8	20.4	21.1	20.3	21.3	19.8	20.3	20.3	21.3
Folsom-Natoma	23.9	24.6	23.5	24.9	24.4	23.4	24.1	24.9	24.6	25.2
Sacramento-Goldenland Court	--	--	--	--	22.3	23.4	23.1	23.7	23.5	24.6

Complex terrain can also affect mixing height by creating turbulence as air masses move over the terrain. Night-time canyon drainage also generates localized turbulent eddies, affecting local mixing height in areas influenced by drainage. The center of the Central Valley is likely a good location for mixing height to be measured.

The Sacramento-Del Paso Manor NCore site is located in the valley floor of the Central Valley. Meteorological analysis showed little to no influence from canyon drainage and the site is located in the heart of the urbanized area of Sacramento County. The NCore site is a preferred location in EPA's latest revisions to the PAMS network design and the site is relatively free of external interference known to exist for modern ceilometers.

4.0 SUMMARY AND RECOMMENDATIONS

This section summarizes the findings of the technical approach of the network assessment and evaluates the overall monitoring objectives defined in 40 CFR Part 58 Appendix D. The network is designed to meet three basic monitoring objectives: (1) provide air pollution data to the general public in a timely manner; (2) support compliance with ambient quality standards and emissions strategy development; and (3) support air pollution research studies.

4.1 Station Summaries

This section provides a brief discussion on the importance and recommendations for each monitoring site.

The network assessment evaluated existing sites within SMAQMD's ambient monitoring network to support air quality characterization based on population (including areas with relatively high populations of sensitive or susceptible individuals), population change, and emissions within each site's area of influence and each pollutant being monitored. Other factors evaluated for each site include measured concentrations, concentration trends, and the potential redundancy of each site through correlation and removal bias techniques. Results of the site-to-site and suitability modeling analyses were ranked for each site, by pollutant measured, and provide cumulative results of representative area, population-served, emissions-served, monitored concentrations, deviation from NAAQS, and redundancy.

The current monitoring network adequately supports SMAQMD's and EPA's stated monitoring objectives and meets all but a few recently promulgated federal ambient air monitoring requirements. To address network deficiencies, measurements made at the NCore site should be upgraded to meet the PAMS monitoring requirements established in the Final Ozone NAAQS signed October 1, 2015, and a second near-road NO_2 monitoring site should be added.

4.1.1 Sacramento-Del Paso Manor

Sacramento-Del Paso Manor began operation in 1979 and is the most complete site (Section 3.1) within SMAQMD's ambient monitoring network and the Sacramento Valley air basin. This station is part of several national networks, including SLAMS, CSN, Speciation Trends Network, and NCore multi-pollutant network. The purpose of this site is to measure criteria and speciated precursor pollutant concentration data representative of the Sacramento urban area for NAAQS comparison, population exposure, public information, and research purposes. Parameters measured at the site include O_3, CO (trace-level) NO_2, NO_y, SO_2 (trace level), TNMHC, speciated VOC, carbonyl, PM_{10} (primary and collocated), $PM_{2.5}$ FRM (primary and collocated), continuous $PM_{2.5}$ (for AQI), speciated $PM_{2.5}$ (Spiral Aerosol Speciation Sampler [SASS]), coarse fraction ($PM_{10-2.5}$), black carbon, scattering coefficient, wind speed and direction, ambient temperature, relative humidity, and total solar radiation.

Site-to-site and suitability modeling analyses for each criteria pollutant and PAMS parameters measured at the site show Del Paso Manor is consistently ranked as an important site for characterizing air quality based on population, local emissions, and concentrations monitored. Del Paso Manor is strategically placed in an urbanized area of Sacramento County on the valley floor of the Central Valley east of downtown Sacramento. The surrounding area is densely populated, including a higher percentage of sensitive and vulnerable population, and has a high amount of nearby emissions relative to other stations in the network (see sections 3.2.1.1, 3.2.1.2, 3.3.1.1, 3.3.1.2, 3.4.1.1, 3.4.1.2, 3.5.1.1, 3.5.1.2, 3.6.1.1, 3.6.1.1, 3.6.1.2, 3.7.1.1, and 3.7.1.2). Redundancy tests show Del Paso Manor is highly correlated (R^2 greater than

0.75) for O_3 (section 3.2.2.2), $PM_{2.5}$ (section 3.3.2.2), and PM_{10} (section 3.4.2.2) with several nearby stations (North Highlands-Blackfoot, T Street, Goldenland Court, and Health Department) located in the urbanized area of the county. Results of the redundancy tests demonstrate that this site is representative of the contiguous urbanized areas within the county (urban scale).

Under the recently promulgated revised ozone standard, this site is required to make technological upgrades and additional measurements for PAMS monitoring are required, as addressed in Section 4.2. These recommendations include additional and improved measurements of surface and upper air meteorological parameters; continuous monitoring of speciated VOC data with an automated gas chromatograph (auto-GC); and continued measurement of carbonyl parameters, taking into consideration continuous measurements of these parameters.

4.1.2 Sacramento-1309 T Street

Established in 1989, the Sacramento-1309 T Street SLAMS monitoring site is operated by the CARB Monitoring and Laboratory Division – Special Purpose Monitoring Section. The site is located in an urbanized area of the county south of downtown Sacramento. Thiessen polygons in the area-served analysis show the site represents an area which is densely populated with higher percentage of sensitive and vulnerable population and has a high amount of nearby emissions relative to other stations in the network (see sections 3.2.1.1, 3.2.1.2, 3.3.1.1, 3.3.1.2, 3.4.1.1, 3.4.1.2, 3.5.1.1, and 3.4.1.2). The purpose of the monitor is to measure concentration data representative of the Sacramento urban area for NAAQS comparison, population exposure, public information, and research purposes. The site measures ambient concentrations of O_3, NO_2, continuous PM_{10}, $PM_{2.5}$ FRM, continuous $PM_{2.5}$, and speciated $PM_{2.5}$, as well as wind speed and direction, temperature, and relative humidity.

With the exception of $PM_{2.5}$ and PM_{10}, site-to-site and suitability modeling analyses for each criteria pollutant measured at the site show T Street is consistently ranked as an important site relative to other sites in the network. Redundancy tests show T Street was highly correlated with several nearby stations in the network (Del Paso Manor, North Highlands-Blackfoot, Goldenland Court, and Elk Grove-Bruceville) for O_3 (section 3.2.2.2), $PM_{2.5}$ (section 3.3.2.2), PM_{10} (section 3.4.2.2), and NO_2 (section 3.5.2.2). Particulate concentration data (for both PM_{10} and $PM_{2.5}$) were exceptionally correlated (R^2 greater than 0.85) with monitors located at the Sacramento-Health Department, with 24-hour concentration data over the past 10 years having R^2 values of 0.851 for PM_{10} and 0.944 for $PM_{2.5}$. EPA's network assessment guidance suggests R^2 values above 0.75 may indicate redundant measurements. Results of the redundancy tests also demonstrate that this site is representative of the contiguous urbanized areas within the county.

Spatial analysis techniques (area, population, and emissions served) for evaluating site importance showed T Street had a small area of influence for characterizing PM. T Street serves an area with many of the same population and emission sources as the Health Department monitor, which is evident in suitability modeling results presented in Figures 3.15, 3.16, and 3.21 and the exceptional correlation between the two sites. In 2014, T Street measured the highest concentrations of PM_{10} in the county, and spatial analysis tests for O_3 and NO_2 show this site is important for characterizing air quality in the area. If Health Department were removed from the spatial analysis, results of the site-by-site analysis would show T Street to be the most important site in the network for characterizing particulate concentrations.

It is recommended that Sacramento-1309 T Street monitoring site remain in operation as currently configured.

4.1.3 Elk Grove-Bruceville

Elk Grove-Bruceville was established in 1992 and is located in a rural portion of the southern part of Sacramento County with limited population and emissions in the immediate vicinity of the station. The site is tasked with measuring background concentrations of O_3, continuous $PM_{2.5}$, NO_2, speciated VOC (episodic only), and TNMHC. The station also collects wind speed and direction, ambient temperature, relative humidity, solar radiation, precipitation, barometric pressure, and ultraviolet radiation. Adjacent to the monitoring site, SMAQMD operates a Radian 915 MHz LAP-3000 wind profiler equipped with a radio acoustic sounding system (RASS) for upper air measurements in support of photochemical modeling.

The nearest ambient monitoring station north of Elk Grove-Bruceville is T Street, at a distance of 29 kilometers (18 miles). Census data show the largest population growth in the county is occurring between Elk Grove-Bruceville and the T Street monitor, as shown previously in Figure 2.3. Thus, the Elk Grove-Bruceville site does represent a generous percentage of the population within the county due to the lack of monitors between T Street and Elk Grove-Bruceville. The monitoring purposes of these two sites are drastically different: Elk Grove-Bruceville monitors data in a rural part of the county as a regional monitor, while T Street characterizes urban air quality on an urban scale. As the population expands southward, emissions from associated traffic and industrial growth are expected to occur. This population growth may indicate that Elk Grove-Bruceville may not be suitable for characterizing general background concentrations for the area in the future. The T Street monitoring site characterizes urban air quality. The spatial scale of an urban monitor (4 to 50 km) marks the T Street monitor as appropriate for characterizing air quality in the area of population growth (urbanization) between the Elk Grove-Bruceville and T Street monitoring sites.

With the latest updates to the Ozone NAAQS, PAMS measurements made at the Elk Grove-Bruceville site are no longer explicitly required as part of federal regulation. However, ongoing monitoring of these parameters may be useful for research and SIP planning and modeling purposes, which should be considered before retiring the measurements. Section 4.2 provides a discussion on how PAMS measurements may be used in research and photochemical modeling studies for model verification and setup.

Site-to-site and suitability modeling analyses for each criteria pollutant measured at the site show Elk Grove-Bruceville is consistently ranked as an important monitoring site within the network. Located in a fairly rural portion of the county, redundancy tests in sections 3.3.2.2 ($PM_{2.5}$) and 3.5.2.2 (NO_2) show the site is making a fairly unique characterization of air quality within the county. Ozone (3.2.2.2) is the only pollutant measured at the site that is highly correlated (R^2 greater than 0.75) with other stations in the network (Del Paso Manor, T Street, Goldenland Court, and Sloughhouse). The site also represents a spatially large portion of the county and is placed to measure pollutant transport from areas south and west of Sacramento County, including emissions from the San Francisco Bay area.

It is recommended that the Elk Grove-Bruceville monitoring site remain in operation for characterizing air quality in the southern portion of the county. Although monitors throughout the network show there is less than a 10% chance that PM_{10} measurements made in the county will exceed NAAQS, the six monitors comprising the PM_{10} network are located only in the northern portion of the county, with Branch Center Road being the southernmost monitor in the network. Adding PM_{10} measurements to Elk Grove-Bruceville will provide a regional-scale background concentration.

4.1.4 Folsom-Natoma

Folsom-Natoma has been in operation since 1996. The air monitoring site is located approximately 20 miles east-northeast of downtown Sacramento and routinely measures high ozone concentrations and has the highest ozone design value concentrations in the network (section 3.2.2.1). Folsom-Natoma measures O_3, NO_2, continuous $PM_{2.5}$ FEM, TNMHC, speciated VOC, wind speed and direction, ambient temperature, relative humidity, and solar radiation.

Site-by-site and suitability modeling results show Folsom-Natoma ranking in the interquartile range (low- to mid-range) of stations within the network in terms of importance (sections 3.2.4, 3.3.4, and 3.5.4). Lower rankings in the spatial analysis tests are due to a combination of lower population density, lower incidence of sensitive and vulnerable population, and lower emission density in the areas surrounding the site relative to sites in more urbanized areas of the county. The site is considered to be very important for characterizing ozone concentrations in the county. High ozone concentrations measured at the site are due to the chemical formation processes for ozone in the atmosphere. Ozone forms through photochemical reactions in the presence of precursor emissions and sunlight. These photochemical reactions take time, and the air masses typically get transported away from the urban core where precursor pollutants are emitted. Daytime wind patterns transport the air masses east, and ozone is formed before reaching the Folsom-Natoma and Sloughhouse monitoring sites.

As mentioned previously, Folsom-Natoma is an important monitoring site for characterizing ozone concentrations in the county. Continued operation of the monitoring site and measurement of ozone precursor emissions (NO_x, speciated VOC, and TNMHC) is recommended for NAAQS comparison, measurement of public exposure, and research purposes. The site is also located on the edge of the county, which is useful for understanding transport of pollutants that originate from the Sacramento urban core as well as areas north and east of the county.

4.1.5 Sacramento-Goldenland Court

The Sacramento-Goldenland Court ambient air monitoring site was established on August 12, 2008, and collects criteria pollutant data for ozone, PM_{10} (FRM and FEM), NO_2, and CO. In addition, this site measures surface meteorological data and TNMHC for ozone formation studies.

Site-by-site and suitability modeling analyses show this site is ranked in the interquartile range based on importance for all pollutants monitored. This site is characterizing air quality representative of urbanized areas within the county and is tasked as a secondary (redundant) PAMS monitoring site. The site is in close proximity to North Highlands-Blackfoot (13 km northeast), Del Paso Manor (12.8 km southeast), T Street (10.3 km southwest), and the recently installed Bercut Drive near-road monitoring site (6.9 km). Redundancy tests throughout the network assessment show that Goldenland Court is exceptionally correlated for ozone (section 3.2.2.2) with North Highlands-Blackfoot, Del Paso Manor, and T Street. The site is also highly or exceptionally correlated with at least one other pollutant (PM_{10} [section 3.4.2.2] or NO_2 [section 3.5.2.2]) at the aforementioned sites. Both Del Paso Manor and T Street have been shown to adequately characterize ambient concentrations within the contiguous urbanized areas of the county. The site was evaluated for removal because the analysis showed that the site is redundant with multiple sites in the network.

The October 17, 2006 amendments to the national monitoring regulations added a requirement that a state or local agency seek the Regional Administrator's approval prior to shutting down a SLAMS monitor. Four tests were recommended for agencies to evaluate when seeking termination of a site. Goldenland

Court was evaluated based on the metrics defined in 40 CFR 58.14(c) for SLAMS monitor station discontinuation.

Below are the EPA's recommended tests for removal.

1. *Monitor shows attainment during the previous five years.*

   Since inception, the site has shown attainment of all criteria pollutants measured. However, the ozone design value for 2014 was 71 ppb, which is above the revised ozone standard of 70 ppb.

   Goldenland Court fails this test for removal; however, as was shown in Section 3.2.2.2, ozone levels measured over the past 10 years show Goldenland Court is exceptionally well correlated with North Highlands Blackfoot (R^2 = 0.911), Del Paso Manor (R^2 = 0.918), and T Street (R^2 = 0.935), which suggests concentrations measured by the monitor are not unique to the site and surrounding monitors would satisfy characterization of the area.

2. *The exceedance probability test shows a monitor has less than a 10% probability to exceed 80 percent of the NAAQS in the next three years.*

   With the exception of ozone, all criteria pollutants show less than 10% probability of exceeding 50 percent of the respective standards. The exceedance probability test for ozone showed greater than a 10% probability the site will exceed the NAAQS in the next three years.

   Although this requirement is not met for ozone, this site is well correlated with other sites and is considered to be making redundant measurements in the area.

3. *The monitor is not specifically required in an attainment or a maintenance plan.*

   This site was established as a replacement for the former Airport Road monitoring site and is currently a secondary (redundant) PAMS Type II site. Thus, the site is not specifically required in an attainment or a maintenance plan.

4. *The monitor is not the last monitor in a nonattainment or maintenance area in which the attainment or maintenance plan contains a contingency trigger for a measured concentration.*

   The site is not the last monitor in the ozone nonattainment or PM_{10} maintenance area. Through this analysis, the site appears to be well correlated with other nearby sites within the network. Thus, the site is not unique in its characterization of air quality in the area.

Based on EPA's four tests for removal, Goldenland court does not meet the concentration-centric metrics in 40 CFR 58.14(c) for ozone because the site has measured concentrations above the current NAAQS and has an exceedance probability to exceed 80 percent of the NAAQS in the next three years. However, Goldenland Court is making redundant measurements with the nearby monitors Del Paso Manor, T Street, and North Highlands-Blackfoot, which qualifies the site for removal.

4.1.6 North Highlands-Blackfoot

Established in 1979, the North Highlands-Blackfoot ambient monitoring site was originally designed to collect data in support of a proposed power plant project at McClellan Air Force Base. The site does not collect meteorological data but collects ambient O_3, PM_{10} FRM, NO_2, and CO data. The purpose of the site is to collect representative air pollution data for population exposure (NAAQS comparison) and research on a neighborhood scale.

Site-by-site and suitability modeling analyses show this site is ranked in the lower interquartile range based on importance for all pollutants monitored (sections 3.2.4, 3.4.4, 3.5.4, and 3.6.4). The lower rankings are likely due to North Highlands-Blackfoot's proximity to other sites in the network: Del Paso Manor is 11 km south of the site, Goldenland Court is 13 km southwest, and the Roseville monitoring site 10 km northeast. The close proximity to other sites limits the spatial coverage of the site to a neighborhood-scale site, which translates to a limited number of population and emissions within its area of influence. Monitor-to-monitor correlation tests for ozone show North Highlands-Blackfoot is highly correlated (R^2 greater than 0.75) with the T Street station and exceptionally correlated (R^2 greater than 0.85) with Del Paso Manor (R^2 of 0.861) and Goldenland Court (R^2 of 0.911). PM_{10} correlation tests show North Highland-Blackfoot is also exceptionally correlated with Goldenland Court (R^2 of 0.879).

Redundancy tests show the site may be redundant based on correlation and removal bias. The site is exceptionally correlated with Goldenland Court, which is being recommended for removal in section 4.1.5 due to its redundancy with multiple sites in the network. If Goldenland Court is removed, the network would be deficient of meteorological data collected in the area. If siting requirements can be met, adding basic meteorological parameters (wind speed and direction, ambient temperature, and relative humidity) to North Highlands-Blackfoot is recommended for understanding pollutant transport into the county.

4.1.7 Sacramento-Health Department

Records indicate that the Sacramento-Health Department ambient air monitoring site has been in existence since the late 1950s. The site measures PM_{10} FRM, continuous PM_{10}, and $PM_{2.5}$ FRM.

Site-by-site and suitability modeling analyses show this site is highly ranked for measuring particulate data based on population emissions and concentration data. Redundancy tests in sections 3.3.2 and 3.4.2 show the station is exceptionally correlated ($PM_{2.5}$ $R^2 = 0.944$ and PM_{10} $R^2 = 0.851$) with the T Street monitor (located 3 km west) and the Del Paso Manor site ($PM_{2.5}$ $R^2 = 0.903$ and PM_{10} $R^2 = 0.814$). Both Del Paso Manor and T Street have been established to characterize air quality in the contiguous urbanized areas of the county. Based on the exceptional correlation with T Street and Del Paso Manor, Health Department was evaluated for removal.

The October 17, 2006 amendments to the national monitoring regulations added a requirement that a state or local agency seek the Regional Administrator's approval prior to shutting down a SLAMS monitor. Four tests were recommended for agencies to evaluate when seeking termination of a site. Health Department was evaluated based on the metrics defined in 40 CFR 58.14(c) for SLAMS monitor station discontinuation.

Below are the EPA's recommended tests for removal.

1. *Monitor shows attainment during the previous five years.*

   The site has shown attainment of the PM_{10} (Table 3-24 in section 3.4.2.1) and annual $PM_{2.5}$ (Table 3-13 in Section 3.3.2.1) standards over the past five years. As can be seen in Table 3-12 in Section 3.3.2.1, three-year design values of 24-hour $PM_{2.5}$ in 2010 and 2011 were above the current standard of 35 μg/m^3. Over the past three years, design values have shown attainment of the 24-hour $PM_{2.5}$ NAAQS.

2. *The exceedance probability test shows a monitor has less than a 10% probability to exceed 80 percent of the NAAQS in the next three years.*

   The exceedance probability test shows PM_{10} has less than a 10% probability of exceeding 80 percent of the NAAQS in the next three years.

   Health Department was unable to pass the exceedance probability test for both the annual and 24-hour $PM_{2.5}$ standards (see Table 3-12 and 3-13 in Section 3.3.2.1 for exceedance probability test results). The correlation analyses for $PM_{2.5}$ and PM_{10} both show Health Department is exceptionally well correlated with measurements made at the T Street monitoring site, with Pearson correlation coefficients of 0.944 ($PM_{2.5}$) and 0.851 (PM_{10}). This can be interpreted as indicating that measurements being taken at the Health Department are redundant with the T Street monitoring site.

3. *The monitor is not specifically required in an attainment or a maintenance plan.*

   This site is not required for an attainment or a maintenance plan.

4. *The monitor is not the last monitor in a nonattainment or maintenance area in which the attainment or maintenance plan contains a contingency trigger for a measured concentration.*

   The site is not the last monitor in the network or CBSA. The site has exceptional correlation (R^2 of 0.944) with the nearby site Sacramento-T Street, located 3 km to the east, and Del Paso Manor (R^2 of 0.903), located 10 km tot the northeast. Thus, this site is not unique in characterizing air quality in the area.

With the exceptions of attaining the 24-hour $PM_{2.5}$ standard for the past five years and exceedance probability tests for both annual and 24-hour $PM_{2.5}$, the Health Department passes all removal test criteria defined in 40 CFR 58.14(c). The stated purpose of the site is to determine population exposure representative of an urban area, which is the same goal as the T Street monitoring site. $PM_{2.5}$ measurements at the Health Department are made with a filter-based system (FRM), which is incapable of providing timely data for public dissemination and AQI determination. Thus, the only purpose for the monitor is for NAAQS comparison, which is a duplicate effort redundant to the nearby T Street monitor. Thus, it is recommended that Sacramento-Health Department be removed.

4.1.8 Sloughhouse

Established in 1997, the Sloughhouse monitoring site is located in a rural area of the county 16.5 miles southeast of Downtown Sacramento and measures O_3, $PM_{2.5}$, and wind speed and direction. The site was initially designed as a special-purpose monitor to cover data gaps in the ozone monitoring network and measured seasonal ozone concentrations being transported from the urban core of the county. Beginning in 2011, the site was reclassified as a SLAMS site and ozone measurements are now collected throughout the year. In 2013, a non-FEM BAM was installed at the site for special-purpose monitoring of $PM_{2.5}$.

The Sloughhouse monitoring site represents a geographically large area of the county for the ozone (Table 3-2) and $PM_{2.5}$ (Table 3-10) networks. Population and emissions within the station's area of influence are relatively small compared to other stations in the network. The site regularly measures high concentrations of ozone (3.2.2.1) in the summertime, which makes the site important to retain. Similar to Folsom-Natoma, Sloughhouse measures high levels of ozone, which is formed through photochemical reactions in the presence of precursor pollutants and sunlight. The precursor emissions are being emitted in the urban area of the county and photochemically react in the atmosphere while being transported to the site. It is recommended that Sloughhouse be retained in the network for characterizing ozone within the county.

4.1.9 Sacramento-Branch Center Road

Sacramento-Branch Center Road was established in April 2006 for NAAQS comparison and public information. The site measures PM_{10} on a neighborhood scale. According to site-to-site and suitability modeling analytical results (Table 3-29), this site is the third highest ranked site of six monitors in the network. A large portion of the high ranking is due to the area of influence based on the Thiessen polygons. The Branch Center Road PM_{10} monitor is the southernmost monitor in the network, representing a large rural area. Concentration data show the site measured the second-highest concentration in the network, and redundancy tests (section 3.4.2.2) show the site profile differs from other sites in the county with no site well correlated over the past 10 years. It is recommended that this site be retained to measure PM_{10} concentration data based on the relatively high concentrations in the network and the uniqueness of the measurements being made.

4.1.10 Sacramento-Bercut Drive

The Sacramento-Bercut drive monitoring station was established on November 8, 2015 to meet federally required near-road monitoring for NO_2, CO, and $PM_{2.5}$. The station currently monitors NO_2, CO, black carbon, wind speed, wind direction, and ambient temperature with $PM_{2.5}$ expected to be installed in winter 2016. AADT counts from 2014 suggest a second near-road monitor is required within the Sacramento CBSA.

4.1.11 Rancho Seco

Established in 2008, this site is a SPM located in the southeast portion of the county. The site only measures seasonal $PM_{2.5}$ for public information; data from Rancho Seco are therefore not submitted to EPA's AQS database. The only metric within the network assessment in which Rancho Seco ranked highly was area served. The site is located in a rural part of the county with limited population or emissions sources in the surrounding area. The nearest stations to the site include Sloughhouse to the north-northeast (18.9 km) and Elk Grove-Bruceville to the west (27 km). Because the site is located in a rural and fairly homogenous portion of the county, the site may be suitable as a regional background monitoring site. The only other sites located in the southern portion of the county are Elk Grove-Bruceville and Walnut Grove Tower, which are adjacent to one another.

4.1.12 Walnut Grove Tower

The Walnut Grove Tower is located southwest of the Elk Grove-Bruceville monitoring station in a fairly rural portion of the county. The Tower's purpose is to support research for understanding the vertical profile and transport of ozone into the county. Measurements made at the tower include O_3, wind speed and direction, and ambient temperature at five levels. In 2016, SMAQMD plans to start making NO_2 measurements at all five levels, which will assist researchers in evaluating the vertical profile of NO_2 as an ozone precursor. The Walnut Grove Tower is important for supporting ozone research and could also serve as a location for monitoring general background concentrations.

4.2 PAMS Monitor Location Recommendation

Per the ozone NAAQS rule, PAMS monitoring is required at all NCore sites located in CBSAs of 1 million people regardless of ozone attainment.

SMAQMD's Sacramento-Del Paso Manor ambient monitoring site is part of the NCore network and is classified as a PAMS Type II monitor. It is recommended that SMAQMD make several upgrades to the site, as detailed below, to meet the new PAMS measurement requirements.

- Enhance the surface meteorological station to satisfy new PAMS monitoring requirements. This includes adding measurements of barometric pressure, precipitation, and ultraviolet radiation.
- Upgrade the mixing height measurement technology. SMAQMD currently operates an upper air profiler at the Elk Grove-Bruceville site to satisfy PAMS upper air measurement requirements; however, the profiler is almost 20 years old, which makes it susceptible to costly maintenance and low data recovery. Adding a ceilometer to the Sacramento-Del Paso NCore site will allow photochemical models to use the more appropriate urban mixing height data.
- NO_2 monitoring of "true" or direct NO_2 measurements do not contain the inherent bias of NO_2 values from standard NO_x analyzers. The site is already equipped with an analyzer capable of measuring true concentrations of NO_2.
- Add hourly speciated VOC measurements using an auto-gas chromatograph (auto-GC). Adding an auto-GC to Sacramento-Del Paso will satisfy the new requirement to collect hourly speciated VOC data at NCore stations required to make PAMS measurements.
- Consider adding continuous (hourly) monitoring of formaldehyde. Aldehyde measurements using Method TO-11A are required at NCore/PAMS monitoring sites. Continuous monitoring of formaldehyde may reduce lab costs associated with cartridge analysis.

The revisions to the PAMS network requirements reduce the burden of operating multiple PAMS monitoring sites, with the stipulation that monitoring agencies are required to develop an enhanced monitoring plan (EMP) that allows agencies to design the network based on unique situations within their nonattainment area. Thus, PAMS measurements at Folsom-Natoma, Sacramento-Goldenland Court, and Elk Grove-Bruceville are no longer required; however, if the measurements are used to address the specific needs for planning purposes, the measurement may be rolled into the EMP.

Some considerations should be made when developing the EMP in terms of how PAMS measurements being made at Folsom-Natoma, Sacramento-Goldenland Court, and Elk Grove-Bruceville could be beneficial for research, SIP development, and public protection.

PAMS measurements made at these additional monitor sites may provide value in terms of air quality and meteorological modeling applications. Specifically, concentrations of aerosol and gaseous pollutants as well as meteorological conditions may serve as model inputs, model performance checks, and unmonitored area analysis inputs. Model inputs may take the form of initial and boundary conditions (IC/BC) for concentrations of pollutants or various meteorological variables. Depending on the monitor data available and the modeling application, these IC/BCs may be processed for either a photochemical model, dispersion model, or prognostic meteorological model. Model performance assessments of both the meteorological modeling and the air quality model are expected elements of attainment modeling.[16] Data from PAMS monitors could serve as checks against modeled values in calculating the mean fractional

[16] *Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*, US EPA, Office of Air Quality Planning and Standards, December 2014 (http://www.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf)

bias and error values for various meteorological variables and pollutant concentrations provided by the monitor. These model validations could also extend to assessing the modeled versus actual reactivity of VOC and NO_x in producing ozone or the reactivity of $PM_{2.5}$ precursors in forming secondary $PM_{2.5}$. The current draft guidance on attainment modeling includes a test of unmonitored area analysis (UMAA). This test relies on blending of interpolated monitor data and modeled concentrations of criteria pollutants. Monitors in the PAMS network can be used to contribute to the UMAA process improving the interpolated monitor data fields.

Currently, there are no guidelines defining what an acceptable EMP may contain. EPA is crafting technical guidance for developing and reviewing EMPs.

4.3 Technology Assessment

EPA is continuously working with state, tribal, and local agencies to improve ambient air monitoring networks. Part of the improvement includes an assessment of available and future monitoring technology.

For $PM_{2.5}$, EPA is currently working with agencies to phase in the operation of near-road $PM_{2.5}$ monitors established in the December 2012[17] final rulemaking. SMAQMD currently plans to install a $PM_{2.5}$ monitor at the Bercut Dr. near-road monitoring site. EPA is also suggesting the replacement of filter-based monitoring systems with approved FEM continuous $PM_{2.5}$ monitoring systems, with the exception of the FRMs required for QA and NCore monitoring. Currently, FRM monitors are located only at Del Paso Manor (NCore requirement), T Street, and Health Department. T Street is paired with a continuous monitor meeting the network's QA requirement, and the FRM at Health Department is the lone $PM_{2.5}$ monitor at the site.

EPA is working on a pilot program with a small number of monitoring agencies to characterize speciation of PM data on a daily basis using a combination of continuous and filter-based systems.

Most technological improvements for gaseous pollutants recommended by EPA include high sensitivity measurements of CO, SO_2, and NO/NO_y at NCore monitoring stations. This movement is part of the multi-pollutant strategy to support the characterization of ozone and PM precursors. These improvements are also tied in to the expanded requirement for NCore sites to host PAMS monitoring, as discussed in Section 4.2.

4.4 Network Objectives Summary

Are air pollutant data disseminated to the public in a timely manner? (i.e., data are available for AQI and forecasting objectives)

Yes, SMAQMD has established a website (*Spare The Air* - www.sparetheair.com) in which the public have access to real-time and historical air quality and meteorological data. In addition to the meteorological and gaseous pollutant concentration data, several sites have incorporated continuous particulate monitors which provide real-time particulate data for public information. The Sacramento Regional AQI and AQI forecast are available on SMAQMD's *Spare The Air* website as well as EPA's AirNow website (www.airnow.gov). Historical air quality and meteorological data collected by the network can also be accessed by the public and air quality research scientists through EPA's AirData website (www.epa.gov/airdata).

[17] Federal Register Vol. 78, No. 10, January 15, 2013

Are sites located to measure the highest pollutant concentrations expected to occur in the area covered by network?

Yes, the network is sufficiently dense in areas where emissions are emitted to capture maximum concentrations of stable pollutants (CO, NO_x, PM, and SO_2). Pollutants formed through photochemical processes (ozone and $PM_{2.5}$) are being collected at several locations downwind of sources which emit precursory pollutants. Several monitors within the network are close enough to the county border to capture pollutants transported into Sacramento County from emission sources located outside the county.

Are sites located to measure typical concentrations in areas of high population density?

Yes, the existing network sufficiently measures typical ambient pollutant concentrations in high population areas. Most of the population in Sacramento County is located in the northwest portion of the County north of Lincoln Highway, west of Elk Grove Florin Road, and north of Elk Grove Boulevard.

For all monitored pollutants, the Sacramento-Del Paso Manor monitoring station ranks as one of the top locations for population served as well as sensitive or vulnerable population served. The station is part of the national NCore network and provides representative concentrations of a variety of pollutants expected throughout the metropolitan area. The site could be considered an urban scale monitoring site, which is defined by EPA as representing concentrations in a city-like area on the order of 4 to 50 kilometers.

Recent data on population change suggest there is population growth occurring near Vineyard and Elk Grove. Elk Grove-Bruceville, Sloughhouse, and Sacramento-T Street are the closest monitors, with each monitor located within 15 km (9 miles) of these locations with population growth. Elk Grove-Bruceville and Sloughhouse are located outside of the urbanized areas of the county in reasonably homogenous geography and could be considered regional-scale monitors within the network representing the less developed areas in the southern and southeastern portions of the county. T Street and Del Paso Manor collect air quality data representative of more congruent urbanized areas near Vineyard and Elk Grove.

Are sites located appropriately to determine the impact of significant sources on air quality?

An evaluation of spatially resolved gridded modeled emissions and population data showed monitors within SMAQMD's network are generally positioned to properly determine the impacts and population exposure of emissions sources located in Sacramento County. SMAQMD started collecting data at the Sacramento-Bercut Drive monitoring station in November 2015, which will serves as a source-oriented monitor collecting near-road concentration data of NO_2, CO, and $PM_{2.5}$. Average Annual Daily Traffic (AADT) data show the Sacramento CBSA requires a second near-road NO_2 monitor.

Are sites located to determine general background concentrations?

The Elk Grove-Bruceville and Rancho Seco SPMs are tasked with collecting general background concentration data within Sacramento County. These two sites are located in fairly rural parts of the county.

The Elk Grove-Bruceville monitoring site collects background concentration for ozone, $PM_{2.5}$, NO_2, and PAMS measurements (VOC and TNMHC). Census data show the largest growth within the county is occurring north of the Elk Grove-Bruceville station. Should the population and associated emission sources continue to expand south of the urban core, the Elk Grove-Bruceville monitoring site may be less suitable for regional background.

Rancho Seco currently collects $PM_{2.5}$ data only on a seasonal basis; however, the site is located in a more rural and homogenous area of the county with few emissions sources or population and could be a prime location to establish a regional-scale background monitor.

The Walnut Grove Tower is located southwest of the Elk Grove-Bruceville monitoring station, which is also fairly rural. The Walnut Grove Tower could also serve as a location for monitoring general background concentrations.

Are sites located to determine the extent of regional pollutant transport among populated areas?

As previously mentioned, several monitors within the network are close enough to the county border to capture pollutants transported into Sacramento County from emission sources located outside the county. The meteorological analysis in Section 3.9 included annual and seasonal pollutant roses and HYSPLIT model runs to demonstrate where pollutants were originating during periods of monitored elevated concentrations.

Elk Grove-Bruceville and the Walnut Grove Tower are situated in locations that are able to monitor pollutant transport from the southwest through the Carquinez Strait. Surface meteorology and air quality measurements could be added to Rancho Seco to better understand pollutant transport between Sacramento County and emission sources located south and east of the county.

Folsom-Natoma and Sloughhouse, located in the eastern portion of the county, have a dual purpose of measuring ozone which is formed through photochemical processes and transported from the urban core. These two sites also measure pollutants being transported from the Sierra Nevada mountains located east of the sites. Pollutant roses in Section 3.9 show the distribution of high pollutant concentrations being transported from the urban core, with nighttime drainage from the Sierra Nevada's east of the site locations.

Are sites located appropriately to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts to support secondary standards?

The network has some value in characterizing welfare-based impacts in support of secondary standards. Sites such as Elk Grove-Bruceville, Rancho Seco, Walnut Grove Tower, and Sloughhouse are located in more rural parts of Sacramento County and pollutants measured could be used to characterize vegetation impacts. Del Paso Manor is the only monitoring location for SO_2 in the network; however, Section 3.7 shows there is no impact at the monitoring site for the secondary standard. Visibility is often affected by particulate in the atmosphere. PM_{10}, $PM_{2.5}$, and black carbon are all measured throughout the network and can be used to characterize visibility in Sacramento County.

Are sites in locations with sensitive populations?

Yes, sites were evaluated for sensitive and vulnerable populations utilizing EPA's Environmental Justice as well as Sacramento County Asthma profile data from the California Department of Health's Environmental Health Investigations Branch. Sacramento-Del Paso Manor and Sacramento-T Street were found to consistently serve the highest percentage of sensitive or vulnerable population. These sites could be considered urban-scale monitors representing concentrations within congruent urbanized areas with a spatial representation of 4 to 50 kilometers.

Is the meteorological network adequate for characterizing regional surface and upper-air meteorology?

Overall, placement of meteorological stations is adequate for characterizing surface and upper-air meteorology. EPA revised the ozone NAAQS on October 1, 2015. EPA recommends that NCore sites in CBSAs with over 1 million people collect PAMS measurements. Sacramento-Del Paso Manor is part of the NCore network as well as a Type II PAMS monitoring station.

Along with the revisions to the PAMS network requirements, EPA is requiring that surface meteorological parameters at newly required PAMS stations collect wind speed, wind direction, temperature, relative humidity, barometric pressure, precipitation, solar and ultraviolet radiation data. Sacramento-Del Paso Manor currently collects all of these measurements with the exception of barometric pressure, precipitation, and ultraviolet radiation. It is recommended that these additional measurements be made at Sacramento-Del Paso Manor.

Currently SMAQMD operates a 915 MHz wind profiler equipped with a radio acoustic sounding system. This system is capable of measuring mixing height, which is a new requirement under EPA's required modifications to the PAMS monitoring network. The wind profiler is operated at the Elk Grove-Bruceville monitoring station which is located approximately 35 km (approximately 22 miles) south of the NCore site. The profiler provides valuable continuous upper air wind and temperature data which are used for photochemical modeling for ozone and $PM_{2.5}$. Should the profiler fail, need replacement, or need to be decommissioned due to poor performance, it is recommended that SMAQMD add a ceilometer at the Sacramento-Del Paso Manor NCore site. Until the profiler is decommissioned, it is recommended that SMAQMD include upper air measurements made by the profiler in the ozone monitoring Enhanced Monitoring Plan (EMP) required under the final ozone NAAQS rule.

Are there redundant sites? Are there locations where new monitors could be placed?

The Sacramento-Health Department monitoring site collects particulate data (both PM_{10} and $PM_{2.5}$). $PM_{2.5}$ data are collected with a filter-based (FRM) system and 24-hour concentrations over the past 10 years (2005-2014) show highly correlated concentration data with Sacramento-Del Paso Manor and Sacramento-T Street, with R^2 values of 0.903 and 0.944, respectively. Sacramento-Health Department is located 3 km from Sacramento-T Street and is considered a redundant site.

Goldenland Court is located in the contiguous urbanized area with Sacramento-Del Paso Manor, Sacramento-T Street, and North Highlands-Blackfoot (within 13 kilometers or 8 miles of each of these sites), characterizing air quality in an area with many of the same emissions sources. Hourly concentration data collected at Goldenland Court for the past 10 years were highly (greater than 80 percent) or exceptionally (greater than 90 percent) well correlated with each of the nearby sites for ozone, NO_2, and PM_{10}, which could justify the site as being redundant. Should SMAQMD decide to remove the Goldenland Court monitoring site, there are a sufficient number of monitors within the network to meet minimum monitoring requirements and monitoring objectives.

The southeast portion of the county (near the Rancho Seco monitoring site) is an area which lacks ambient and meteorological monitoring. Sloughhouse to the north, Elk Grove-Bruceville to the east, and the seasonal $PM_{2.5}$ special purpose monitor at Rancho Seco are the only monitoring sites representing this portion of the county. Sloughhouse and Elk Grove-Bruceville are located in more rural areas of the county, which is congruent with the southeast portion of the county, and could be considered representative if these two sites are considered regional scale monitors. From the analysis, there is not a significant amount of population growth or significant amount of emissions in this area of the county and, thus, would solely be used for regional background and transport monitoring.

5.0 REFERENCES

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APPENDIX A: SMAQMD MONITOR DATA CAPTURE ANALYSIS

Ozone Data Capture

Quarter-Year	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Elk Grove-Bruceville	Folsom-Natoma	Sacramento-Goldenland Court	Sloughhouse[a]
Q1-2005	93%	96%	100%	99%	96%	--	--
Q2-2005	84%	93%	99%	99%	97%	--	98%
Q3-2005	97%	96%	100%	98%	97%	--	98%
Q4-2005	96%	98%	98%	99%	97%	--	34%
Q1-2006	98%	98%	90%	97%	100%	--	--
Q2-2006	99%	92%	100%	99%	95%	--	100%
Q3-2006	97%	99%	95%	99%	100%	--	100%
Q4-2006	97%	93%	100%	97%	98%	--	34%
Q1-2007	98%	99%	92%	98%	97%	--	--
Q2-2007	78%	100%	100%	100%	98%	--	99%
Q3-2007	99%	98%	96%	99%	95%	--	95%
Q4-2007	99%	100%	87%	97%	99%	--	34%
Q1-2008	96%	99%	100%	99%	99%	--	--
Q2-2008	78%	95%	99%	97%	97%	--	99%
Q3-2008	49%	93%	95%	99%	99%	--	100%
Q4-2008	76%	100%	91%	100%	97%	45%	33%
Q1-2009	100%	100%	97%	100%	97%	89%	--
Q2-2009	97%	100%	99%	100%	97%	84%	86%
Q3-2009	99%	100%	97%	99%	99%	95%	98%
Q4-2009	95%	97%	98%	99%	96%	92%	34%
Q1-2010	98%	99%	99%	83%	94%	87%	--
Q2-2010	93%	99%	100%	81%	98%	98%	81%
Q3-2010	92%	100%	100%	91%	99%	90%	77%
Q4-2010	97%	86%	84%	89%	82%	87%	32%
Q1-2011	98%	99%	98%	83%	82%	98%	--
Q2-2011	93%	98%	93%	91%	99%	89%	92%
Q3-2011	99%	98%	99%	93%	91%	91%	100%
Q4-2011	90%	98%	97%	97%	97%	87%	92%
Q1-2012	93%	98%	98%	84%	95%	82%	89%
Q2-2012	77%	99%	88%	92%	99%	91%	89%
Q3-2012	97%	99%	96%	92%	97%	93%	100%
Q4-2012	92%	98%	98%	93%	98%	89%	100%
Q1-2013	96%	100%	100%	94%	87%	93%	88%
Q2-2013	93%	99%	99%	95%	99%	91%	92%
Q3-2013	99%	99%	95%	92%	91%	86%	100%
Q4-2013	95%	97%	92%	96%	98%	89%	88%
Q1-2014	93%	98%	98%	93%	96%	94%	60%
Q2-2014	96%	93%	95%	91%	97%	96%	96%
Q3-2014	98%	93%	99%	93%	97%	84%	99%
Q4-2014	98%	90%	89%	79%	97%	96%	88%

[a]Sloughhouse collected data during ozone season (March – October) from 2005 until mid-2011.

$PM_{2.5}$ Data Capture

Quarter-Year	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Elk Grove-Bruceville	Folsom-Natoma	Sacramento-Health Dept	Sloughhouse
Monitor type	FRM	FRM	Non-FEM	FEM	FRM	Non-FEM
Q1-2005	97%	88%	97%	--	267%	--
Q2-2005	100%	89%	71%	--	97%	--
Q3-2005	97%	93%	21%	--	97%	--
Q4-2005	99%	97%	59%	--	281%	--
Q1-2006	97%	87%	64%	--	293%	--
Q2-2006	100%	65%	88%	--	100%	--
Q3-2006	100%	97%	96%	--	81%	--
Q4-2006	99%	92%	88%	--	290%	--
Q1-2007	100%	94%	93%	--	297%	--
Q2-2007	97%	96%	100%	--	100%	--
Q3-2007	97%	77%	73%	--	90%	--
Q4-2007	100%	87%	96%	--	100%	--
Q1-2008	100%	97%	99%	--	97%	--
Q2-2008	100%	93%	97%	--	100%	--
Q3-2008	94%	81%	100%	--	94%	--
Q4-2008	100%	93%	100%	--	100%	--
Q1-2009	97%	97%	100%	--	97%	--
Q2-2009	100%	100%	100%	--	100%	--
Q3-2009	97%	100%	100%	--	100%	--
Q4-2009	97%	94%	97%	--	97%	--
Q1-2010	100%	93%	98%	--	97%	--
Q2-2010	97%	100%	57%	--	93%	--
Q3-2010	97%	100%	95%	--	100%	--
Q4-2010	97%	100%	70%	--	90%	--
Q1-2011	97%	100%	100%	--	100%	--
Q2-2011	97%	100%	96%	--	100%	--
Q3-2011	100%	100%	100%	--	100%	--
Q4-2011	93%	100%	99%	--	100%	--
Q1-2012	97%	100%	98%	--	100%	--
Q2-2012	100%	93%	98%	--	100%	--
Q3-2012	97%	100%	93%	--	100%	--
Q4-2012	97%	93%	98%	--	97%	--
Q1-2013	97%	97%	100%	--	90%	--
Q2-2013	97%	100%	100%	92%	100%	--
Q3-2013	99%	93%	100%	97%	100%	--
Q4-2013	90%	97%	95%	99%	87%	61%
Q1-2014	94%	97%	100%	99%	100%	100%
Q2-2014	96%	97%	100%	100%	100%	100%
Q3-2014	93%	100%	100%	100%	97%	100%
Q4-2014	91%	100%	95%	96%	100%	89%

PM_{10} Data Capture

Quarter-Year	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Sacramento-Goldenland Court	Branch Center Road	Sacramento-Health Dept.
Q1-2005	93%	100%	100%	--	--	100%
Q2-2005	100%	100%	100%	--	--	100%
Q3-2005	100%	100%	100%	--	--	87%
Q4-2005	100%	100%	94%	--	--	100%
Q1-2006	93%	84%	93%	--	--	99%
Q2-2006	100%	93%	80%	--	87%	92%
Q3-2006	100%	100%	93%	--	100%	93%
Q4-2006	100%	98%	106%	--	100%	98%
Q1-2007	100%	96%	100%	--	100%	96%
Q2-2007	93%	95%	93%	--	93%	93%
Q3-2007	100%	100%	100%	--	100%	100%
Q4-2007	93%	100%	100%	--	100%	98%
Q1-2008	81%	96%	100%	--	100%	98%
Q2-2008	67%	89%	100%	--	87%	97%
Q3-2008	87%	98%	100%	--	100%	100%
Q4-2008	93%	100%	100%	100%	100%	100%
Q1-2009	93%	97%	100%	100%	100%	100%
Q2-2009	94%	100%	106%	100%	100%	100%
Q3-2009	100%	100%	100%	100%	100%	98%
Q4-2009	100%	95%	100%	100%	100%	96%
Q1-2010	100%	100%	100%	100%	93%	92%
Q2-2010	100%	100%	100%	100%	100%	56%
Q3-2010	100%	100%	100%	87%	94%	100%
Q4-2010	100%	107%	100%	85%	100%	100%
Q1-2011	100%	100%	100%	68%	93%	100%
Q2-2011	100%	100%	100%	100%	100%	98%
Q3-2011	100%	100%	94%	90%	94%	100%
Q4-2011	100%	100%	100%	91%	100%	100%
Q1-2012	100%	100%	107%	99%	100%	180%
Q2-2012	100%	100%	100%	60%	100%	100%
Q3-2012	100%	100%	100%	99%	100%	94%
Q4-2012	100%	100%	100%	100%	93%	93%
Q1-2013	100%	100%	100%	100%	100%	100%
Q2-2013	100%	100%	92%	100%	93%	100%
Q3-2013	100%	100%	100%	100%	87%	93%
Q4-2013	100%	100%	99%	59%	94%	94%
Q1-2014	100%	100%	92%	100%	100%	100%
Q2-2014	100%	100%	97%	100%	100%	100%
Q3-2014	100%	100%	100%	100%	100%	93%
Q4-2014	75%	100%	88%	100%	100%	100%

NO_2 Data Capture

Quarter-Year	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-1309 T Street	Elk Grove-Bruceville	Folsom-Natoma	Sacramento-Goldenland Court
Q1-2005	99%	98%	100%	100%	99%	--
Q2-2005	69%	99%	99%	89%	98%	--
Q3-2005	71%	99%	100%	91%	86%	--
Q4-2005	100%	100%	98%	100%	100%	--
Q1-2006	100%	100%	100%	99%	100%	--
Q2-2006	78%	100%	100%	89%	98%	--
Q3-2006	34%	99%	95%	46%	100%	--
Q4-2006	41%	97%	100%	98%	100%	--
Q1-2007	100%	81%	97%	98%	100%	--
Q2-2007	100%	100%	100%	97%	99%	--
Q3-2007	40%	100%	96%	96%	98%	--
Q4-2007	73%	98%	96%	96%	84%	--
Q1-2008	99%	100%	100%	99%	90%	--
Q2-2008	70%	96%	93%	97%	97%	--
Q3-2008	47%	91%	93%	100%	100%	--
Q4-2008	75%	100%	92%	100%	100%	50%
Q1-2009	100%	100%	99%	100%	94%	97%
Q2-2009	96%	100%	100%	89%	100%	90%
Q3-2009	100%	100%	99%	82%	100%	99%
Q4-2009	95%	100%	99%	98%	99%	97%
Q1-2010	94%	100%	99%	94%	100%	91%
Q2-2010	97%	96%	100%	80%	100%	95%
Q3-2010	95%	89%	100%	95%	98%	89%
Q4-2010	100%	92%	92%	92%	91%	95%
Q1-2011	100%	98%	97%	92%	79%	100%
Q2-2011	93%	100%	99%	92%	100%	95%
Q3-2011	100%	100%	100%	99%	98%	98%
Q4-2011	97%	92%	91%	99%	77%	92%
Q1-2012	96%	98%	99%	96%	97%	88%
Q2-2012	78%	100%	87%	97%	100%	97%
Q3-2012	100%	99%	92%	98%	100%	96%
Q4-2012	95%	95%	97%	98%	100%	97%
Q1-2013	98%	41%	100%	98%	93%	94%
Q2-2013	97%	66%	93%	97%	55%	55%
Q3-2013	99%	100%	100%	96%	96%	97%
Q4-2013	98%	99%	93%	99%	39%	86%
Q1-2014	94%	98%	93%	98%	94%	98%
Q2-2014	97%	97%	98%	97%	100%	29%
Q3-2014	99%	95%	100%	98%	100%	58%
Q4-2014	97%	93%	84%	86%	98%	99%

CO Data Capture

Quarter-Year	North Highlands-Blackfoot	Sacramento-Del Paso Manor	Sacramento-Goldenland Court
Q1-2005	95%	95%	--
Q2-2005	95%	94%	--
Q3-2005	94%	97%	--
Q4-2005	95%	95%	--
Q1-2006	95%	95%	--
Q2-2006	94%	95%	--
Q3-2006	95%	91%	--
Q4-2006	94%	93%	--
Q1-2007	95%	94%	--
Q2-2007	92%	96%	--
Q3-2007	6%	95%	--
Q4-2007	95%	91%	--
Q1-2008	95%	88%	--
Q2-2008	95%	92%	--
Q3-2008	55%	95%	--
Q4-2008	78%	87%	27%
Q1-2009	94%	95%	93%
Q2-2009	94%	96%	92%
Q3-2009	93%	95%	95%
Q4-2009	94%	96%	93%
Q1-2010	95%	96%	89%
Q2-2010	92%	97%	97%
Q3-2010	94%	97%	92%
Q4-2010	95%	92%	95%
Q1-2011	95%	96%	97%
Q2-2011	93%	93%	95%
Q3-2011	95%	95%	90%
Q4-2011	91%	96%	92%
Q1-2012	88%	63%	91%
Q2-2012	77%	98%	95%
Q3-2012	95%	97%	96%
Q4-2012	93%	97%	86%
Q1-2013	95%	98%	96%
Q2-2013	94%	97%	95%
Q3-2013	95%	93%	96%
Q4-2013	94%	97%	66%
Q1-2014	93%	97%	97%
Q2-2014	94%	96%	95%
Q3-2014	95%	94%	85%
Q4-2014	95%	96%	97%

SO_2 Data Capture

Quarter-Year	Sacramento-Del Paso Manor
Q1-2005	98%
Q2-2005	99%
Q3-2005	97%
Q4-2005	100%
Q1-2006	100%
Q2-2006	100%
Q3-2006	99%
Q4-2006	92%
Q1-2007	100%
Q2-2007	100%
Q3-2007	100%
Q4-2007	100%
Q1-2008	100%
Q2-2008	48%
Q3-2008	97%
Q4-2008	100%
Q1-2009	100%
Q2-2009	100%
Q3-2009	93%
Q4-2009	100%
Q1-2010	100%
Q2-2010	99%
Q3-2010	100%
Q4-2010	95%
Q1-2011	100%
Q2-2011	100%
Q3-2011	100%
Q4-2011	86%
Q1-2012	98%
Q2-2012	65%
Q3-2012	95%
Q4-2012	96%
Q1-2013	98%
Q2-2013	98%
Q3-2013	97%
Q4-2013	90%
Q1-2014	98%
Q2-2014	96%
Q3-2014	93%
Q4-2014	89%

Pb Data Capture

Rolling 3-month Capture Rate (MM-YYYY)	Sacramento-Del Paso Manor
01-2012	--
02-2012	--
03-2012	--
04-2012	--
05-2012	--
06-2012	100%
07-2012	100%
08-2012	100%
09-2012	100%
10-2012	100%
11-2012	107%
12-2012	100%
01-2013	100%
02-2013	93%
03-2013	100%
04-2013	100%
05-2013	100%
06-2013	100%
07-2013	100%
08-2013	100%
09-2013	100%
10-2013	100%
11-2013	100%
12-2013	100%
01-2014	100%
02-2014	100%
03-2014	100%
04-2014	100%
05-2014	100%
06-2014	100%
07-2014	100%
08-2014	100%
09-2014	100%
10-2014	100%
11-2014	100%
12-2014	94%

Meteorological Data Capture

Quarter-Year	Sacramento-Del Paso Manor				Sacramento-1309 T Street				Elk Grove-Bruceville			
	WS	WD	Temp	RH	WS	WD	Temp	RH	WS	WD	Temp	RH
Q1-2005	93%	93%	100%	100%	100%	100%	100%	100%	50%	50%	100%	100%
Q2-2005	99%	99%	100%	100%	100%	98%	100%	100%	94%	94%	100%	100%
Q3-2005	100%	100%	100%	100%	100%	93%	100%	100%	100%	100%	100%	100%
Q4-2005	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Q1-2006	100%	100%	100%	100%	100%	100%	100%	100%	99%	99%	100%	99%
Q2-2006	37%	37%	100%	100%	100%	100%	100%	100%	97%	97%	100%	100%
Q3-2006	27%	27%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Q4-2006	100%	100%	100%	100%	100%	100%	100%	100%	99%	99%	100%	100%
Q1-2007	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Q2-2007	98%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Q3-2007	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Q4-2007	100%	100%	100%	100%	99%	99%	100%	100%	100%	100%	100%	100%
Q1-2008	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	67%
Q2-2008	100%	100%	100%	100%	99%	100%	100%	52%	100%	100%	100%	91%
Q3-2008	99%	99%	100%	100%	100%	100%	100%	99%	100%	100%	100%	100%
Q4-2008	96%	96%	96%	100%	100%	100%	99%	99%	100%	100%	100%	65%
Q1-2009	97%	97%	100%	100%	99%	99%	99%	99%	100%	100%	100%	44%
Q2-2009	99%	99%	100%	100%	94%	94%	94%	94%	100%	100%	100%	100%
Q3-2009	100%	100%	100%	100%	90%	90%	100%	100%	100%	100%	100%	100%
Q4-2009	88%	100%	100%	100%	0%	0%	100%	97%	91%	98%	100%	100%
Q1-2010	100%	100%	100%	100%	0%	0%	100%	100%	100%	100%	100%	35%
Q2-2010	99%	99%	99%	99%	0%	0%	100%	100%	95%	95%	95%	0%
Q3-2010	100%	100%	100%	100%	0%	0%	100%	100%	96%	65%	75%	61%
Q4-2010	99%	99%	99%	99%	0%	0%	100%	100%	95%	57%	91%	95%
Q1-2011	100%	100%	100%	100%	0%	0%	100%	100%	97%	97%	97%	97%
Q2-2011	99%	99%	100%	99%	0%	0%	100%	100%	97%	97%	98%	97%
Q3-2011	100%	100%	100%	100%	0%	0%	100%	100%	100%	100%	100%	100%
Q4-2011	100%	100%	100%	100%	0%	0%	100%	100%	92%	91%	98%	98%
Q1-2012	97%	97%	98%	98%	0%	0%	100%	76%	98%	98%	98%	98%
Q2-2012	100%	100%	100%	100%	0%	0%	100%	100%	98%	98%	99%	99%
Q3-2012	100%	100%	100%	100%	61%	61%	100%	100%	100%	100%	100%	100%
Q4-2012	100%	100%	100%	100%	100%	100%	100%	32%	99%	99%	100%	99%
Q1-2013	100%	100%	100%	100%	34%	34%	34%	0%	100%	100%	100%	100%
Q2-2013	49%	49%	100%	100%	100%	100%	100%	0%	100%	100%	100%	100%
Q3-2013	100%	100%	100%	100%	100%	100%	100%	0%	100%	100%	100%	100%
Q4-2013	91%	90%	100%	100%	99%	99%	99%	0%	100%	100%	100%	100%
Q1-2014	99%	99%	99%	99%	100%	100%	100%	0%	100%	100%	100%	100%
Q2-2014	100%	100%	100%	100%	100%	100%	100%	0%	99%	99%	99%	99%
Q3-2014	97%	97%	97%	97%	100%	100%	100%	0%	100%	100%	100%	100%
Q4-2014	96%	96%	98%	98%	44%	44%	44%	0%	98%	98%	98%	97%

Meteorological Data Capture (Continued)

Quarter-Year	Folsom-Natoma				Sacramento-Goldenland Court				Sloughhouse	
	WS	WD	Temp	RH	WS	WD	Temp	RH	WS	WD
Q1-2005	100%	100%	100%	100%	--	--	--	--	0%	0%
Q2-2005	100%	100%	100%	100%	--	--	--	--	86%	0%
Q3-2005	100%	100%	100%	100%	--	--	--	--	100%	0%
Q4-2005	100%	100%	100%	100%	--	--	--	--	34%	0%
Q1-2006	93%	93%	100%	100%	--	--	--	--	0%	0%
Q2-2006	100%	100%	100%	100%	--	--	--	--	100%	0%
Q3-2006	100%	100%	100%	100%	--	--	--	--	100%	0%
Q4-2006	100%	100%	100%	100%	--	--	--	--	34%	0%
Q1-2007	100%	100%	100%	100%	--	--	--	--	0%	0%
Q2-2007	100%	100%	100%	100%	--	--	--	--	100%	0%
Q3-2007	100%	100%	100%	100%	--	--	--	--	100%	0%
Q4-2007	100%	100%	100%	100%	--	--	--	--	33%	0%
Q1-2008	94%	94%	100%	99%	--	--	--	--	0%	0%
Q2-2008	98%	98%	98%	98%	--	--	--	--	100%	2%
Q3-2008	100%	100%	100%	100%	--	--	--	--	100%	100%
Q4-2008	96%	96%	100%	100%	80%	80%	80%	80%	66%	66%
Q1-2009	98%	98%	99%	99%	99%	99%	98%	100%	1%	1%
Q2-2009	100%	100%	100%	100%	99%	99%	47%	32%	99%	99%
Q3-2009	100%	100%	100%	100%	99%	99%	100%	100%	100%	100%
Q4-2009	100%	100%	100%	100%	96%	96%	92%	88%	33%	33%
Q1-2010	100%	99%	99%	100%	95%	92%	95%	95%	32%	32%
Q2-2010	100%	100%	100%	100%	100%	100%	100%	100%	93%	93%
Q3-2010	100%	100%	100%	100%	95%	95%	96%	96%	100%	100%
Q4-2010	97%	97%	97%	97%	93%	93%	98%	99%	33%	33%
Q1-2011	99%	99%	99%	99%	100%	100%	100%	100%	1%	1%
Q2-2011	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Q3-2011	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Q4-2011	99%	99%	99%	99%	98%	98%	98%	98%	100%	100%
Q1-2012	98%	98%	98%	98%	91%	91%	98%	98%	98%	98%
Q2-2012	100%	100%	100%	100%	81%	81%	100%	93%	100%	100%
Q3-2012	100%	100%	100%	100%	99%	99%	99%	99%	100%	100%
Q4-2012	100%	100%	100%	100%	67%	67%	99%	99%	100%	100%
Q1-2013	100%	100%	100%	100%	62%	62%	100%	100%	100%	100%
Q2-2013	92%	92%	92%	92%	89%	89%	100%	100%	100%	100%
Q3-2013	93%	93%	98%	98%	92%	92%	99%	97%	100%	100%
Q4-2013	100%	100%	100%	100%	99%	99%	87%	99%	100%	100%
Q1-2014	100%	100%	100%	100%	100%	100%	99%	100%	100%	100%
Q2-2014	100%	100%	100%	100%	100%	100%	99%	100%	100%	100%
Q3-2014	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Q4-2014	97%	97%	98%	98%	98%	98%	98%	98%	98%	98%

TNMHC Data Capture

Quarter-Year	Sacramento-Del Paso Manor	Elk Grove-Bruceville	Folsom-Natoma	Sacramento-Goldenland Court
Q1-2005	91%	87%	90%	--
Q2-2005	8%	95%	89%	--
Q3-2005	91%	90%	73%	--
Q4-2005	95%	76%	15%	--
Q1-2006	64%	56%	45%	--
Q2-2006	12%	71%	93%	--
Q3-2006	93%	94%	87%	--
Q4-2006	93%	91%	81%	--
Q1-2007	92%	95%	93%	--
Q2-2007	96%	6%	95%	--
Q3-2007	91%	83%	95%	--
Q4-2007	95%	85%	95%	--
Q1-2008	92%	68%	86%	--
Q2-2008	92%	23%	4%	--
Q3-2008	86%	0%	0%	--
Q4-2008	0%	0%	0%	--
Q1-2009	43%	0%	0%	78%
Q2-2009	76%	5%	56%	87%
Q3-2009	94%	25%	94%	89%
Q4-2009	90%	0%	90%	84%
Q1-2010	96%	0%	94%	88%
Q2-2010	94%	0%	51%	85%
Q3-2010	86%	12%	95%	90%
Q4-2010	91%	40%	73%	84%
Q1-2011	25%	75%	80%	97%
Q2-2011	9%	47%	64%	93%
Q3-2011	94%	87%	94%	69%
Q4-2011	87%	92%	88%	91%
Q1-2012	96%	82%	94%	85%
Q2-2012	97%	70%	92%	78%
Q3-2012	92%	86%	97%	74%
Q4-2012	96%	95%	67%	75%
Q1-2013	84%	96%	75%	84%
Q2-2013	43%	96%	37%	70%
Q3-2013	96%	91%	46%	95%
Q4-2013	97%	93%	64%	91%
Q1-2014	97%	94%	81%	94%
Q2-2014	89%	89%	87%	95%
Q3-2014	90%	92%	87%	83%
Q4-2014	90%	84%	72%	97%

VOC Data Capture

Quarter-Year	Sacramento-Del Paso Manor	Elk Grove-Bruceville[a]	Folsom-Natoma
Q1-2005	--	--	--
Q2-2005	--	--	--
Q3-2005	105%	7%	110%
Q4-2005	--	--	--
Q1-2006	--	--	--
Q2-2006	--	--	--
Q3-2006	100%	6%	111%
Q4-2006	--	--	--
Q1-2007	--	--	--
Q2-2007	--	--	--
Q3-2007	106%	5%	113%
Q4-2007	--	--	--
Q1-2008	--	--	--
Q2-2008	--	--	--
Q3-2008	94%	8%	98%
Q4-2008	--	--	--
Q1-2009	--	--	--
Q2-2009	--	--	--
Q3-2009	100%	0%	102%
Q4-2009	--	--	--
Q1-2010	--	--	--
Q2-2010	--	--	--
Q3-2010	106%	13%	119%
Q4-2010	--	--	--
Q1-2011	--	--	--
Q2-2011	--	--	--
Q3-2011	105%	13%	120%
Q4-2011	--	--	--
Q1-2012	--	--	--
Q2-2012	--	--	--
Q3-2012	99%	3%	103%
Q4-2012	--	--	--
Q1-2013	--	--	--
Q2-2013	--	--	--
Q3-2013	100%	12%	113%
Q4-2013	--	--	--
Q1-2014	--	--	--
Q2-2014	--	--	--
Q3-2014	98%	0%	100%
Q4-2014	--	--	--

[a]Elk Grove-Bruceville collects episodic speciated VOC data.

NO_y Data Capture

Quarter-Year	Sacramento-Del Paso Manor	Folsom-Natoma
Q1-2005	--	--
Q2-2005	--	--
Q3-2005	--	--
Q4-2005	--	--
Q1-2006	--	--
Q2-2006	--	--
Q3-2006	--	--
Q4-2006	--	--
Q1-2007	--	--
Q2-2007	--	--
Q3-2007	--	--
Q4-2007	--	--
Q1-2008	--	--
Q2-2008	--	--
Q3-2008	--	--
Q4-2008	--	--
Q1-2009	--	--
Q2-2009	--	--
Q3-2009	--	--
Q4-2009	--	--
Q1-2010	--	--
Q2-2010	--	--
Q3-2010	--	--
Q4-2010	--	--
Q1-2011	--	--
Q2-2011	--	--
Q3-2011	99%	62%
Q4-2011	99%	97%
Q1-2012	97%	64%
Q2-2012	97%	97%
Q3-2012	98%	97%
Q4-2012	99%	100%
Q1-2013	99%	100%
Q2-2013	99%	100%
Q3-2013	99%	90%
Q4-2013	99%	99%
Q1-2014	97%	98%
Q2-2014	98%	98%
Q3-2014	95%	98%
Q4-2014	98%	97%

APPENDIX B: EXAMPLE CALCULATION OF THE MODIFIED SUPPLEMENTARY DEMOGRAPHIC INDEX (MSDI)

Below is an example calculation of the Modified EJScreen Supplementary Demographic Index (MSDI) for two Census blocks. The MSDI is calculated for each block group in Sacramento County and utilizes the EJScreen SDI and asthma prevalence in persons between the ages of 5 and 64 years. The 2015 EJScreen Supplementary Demographic Index (SDI) evaluates demographic characteristics from the American Community Survey (ACS) 2008 through 2012 summary file to represent the "social vulnerability" of a disadvantaged population. SDI is an average of six demographic indicators (% minority, % low-income, % less than high school education, linguistic isolation, % of individuals under age 5, and % individuals over age 64). California Breathing program within the California Department of Public Health's Environmental Health Investigations Branch has published asthma prevalence data in 2011 through 2012 by age, by county. These data show the rate of active prevalent asthma for people between 5 and 64 in Sacramento County is an average of 9.2%. Equation 1 provides the calculation of the MSDI and Table B-1 presents an example calculation for two Census block groups using data from EJScreen.

$$MSDI = SDI + (1 - SDI) * AP_{5-64}$$

Where: $AP_{5\text{-}64}$ = is the percent of total population with active asthma for ages 5 to 64.

Table B-1
Example MSDI Calculation for Two Census Block Groups

Parameter	Test Block #1	Test Block #2
FIPS (Block Group ID)	060679883001	060670071041
Lat (Centroid)	38.6948	38.6733
Lon (Centroid)	-121.1553	-121.5166
Population	8219	5352
# Minority	6080	3242
% Minority	***73.97%***	***60.58%***
# Low Income	0	1150
% Low Income	***0.00%***	***21.49%***
# Less than HS Ed.	2516	125
% Less than HS Ed.	***37.47%***	***3.92%***
# Liguistic Isolation	0	81
% Linguistic Isolation	***0.00%***	***4.36%***
# Over Age 25	6715	3192
# Under Age 5	0	686
% Under Age 5	***0.00%***	***12.82%***
# Over Age 64	69	106
% Over Age 64	***0.84%***	***1.98%***
EJ Screen Demographic Index (DI)	0.37	0.41
DI*Population	3040	2196
EJ Screen Supp. Demo. Index (SDI)	**0.187**	**0.175**
SDI*Population	1538	938
MSDI	**0.262**	**0.251**
Number of Persons Within Demographic Index		
SDI Persons (SDI*Population)	**1538**	**938**
MSDI Persons (MSDI*Population)	**2153**	**1344**

This Appendix presents the gridded data layers used in the suitability modeling analyses for each pollutant. Some layers were used in multiple analyses, as indicated in parentheses in the figure title.

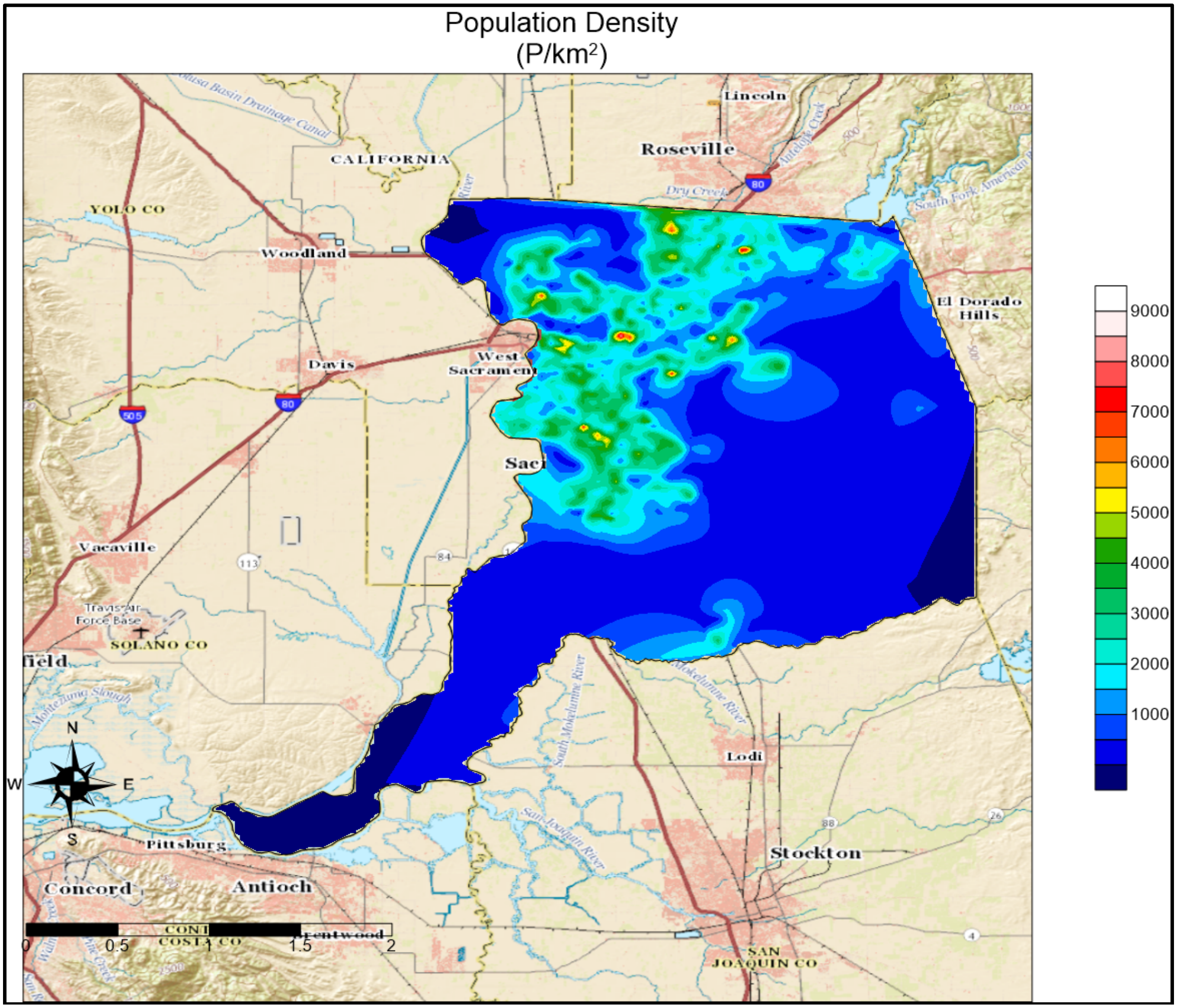

Figure C.1 Population Density Grid Layer (All Analyses)

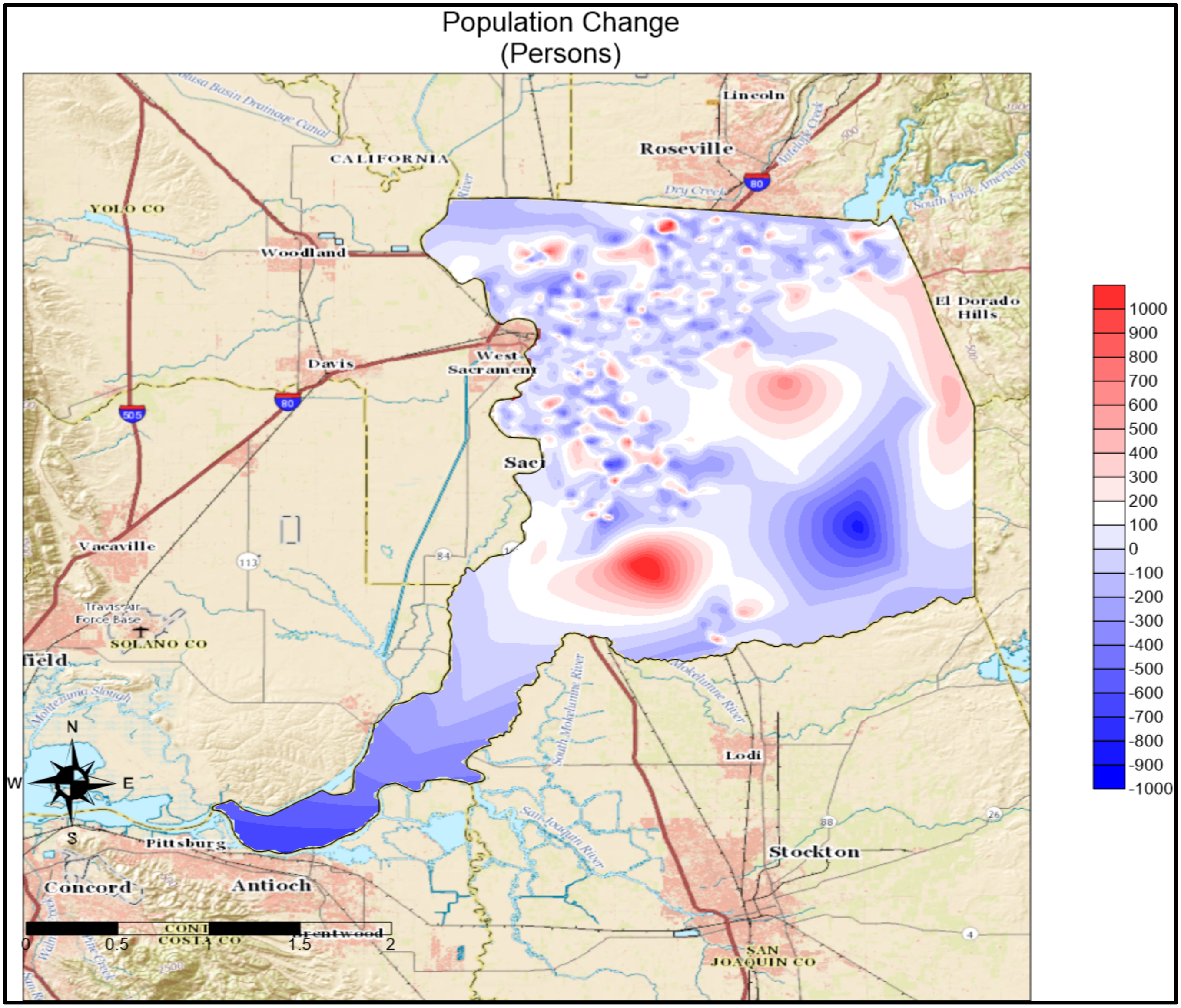

Figure C.2 Population Change Grid Layer (All Analyses)

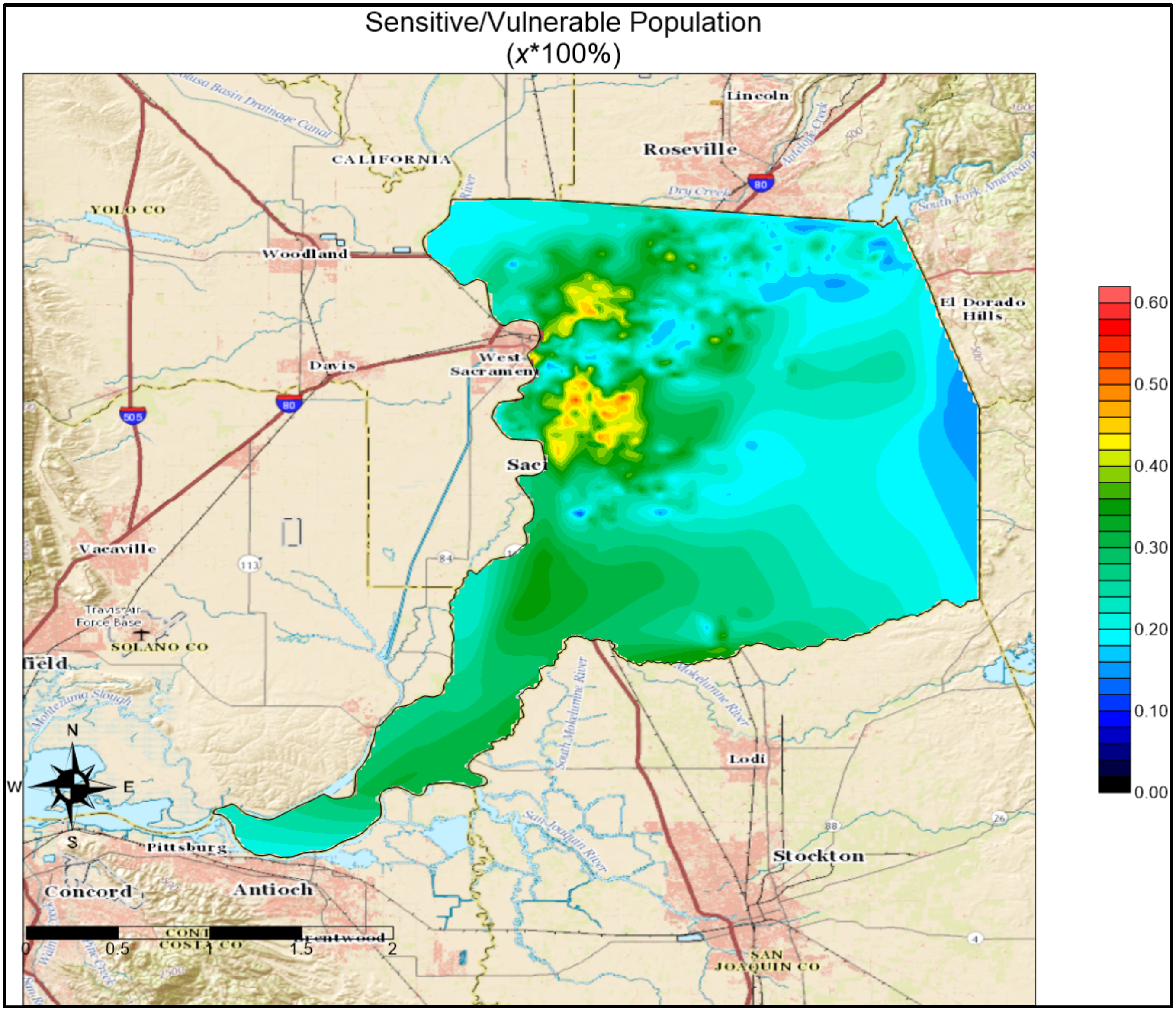

Figure C.3 MSDI (Sensitive/Vulnerable Population) Grid Layer (All Analyses)

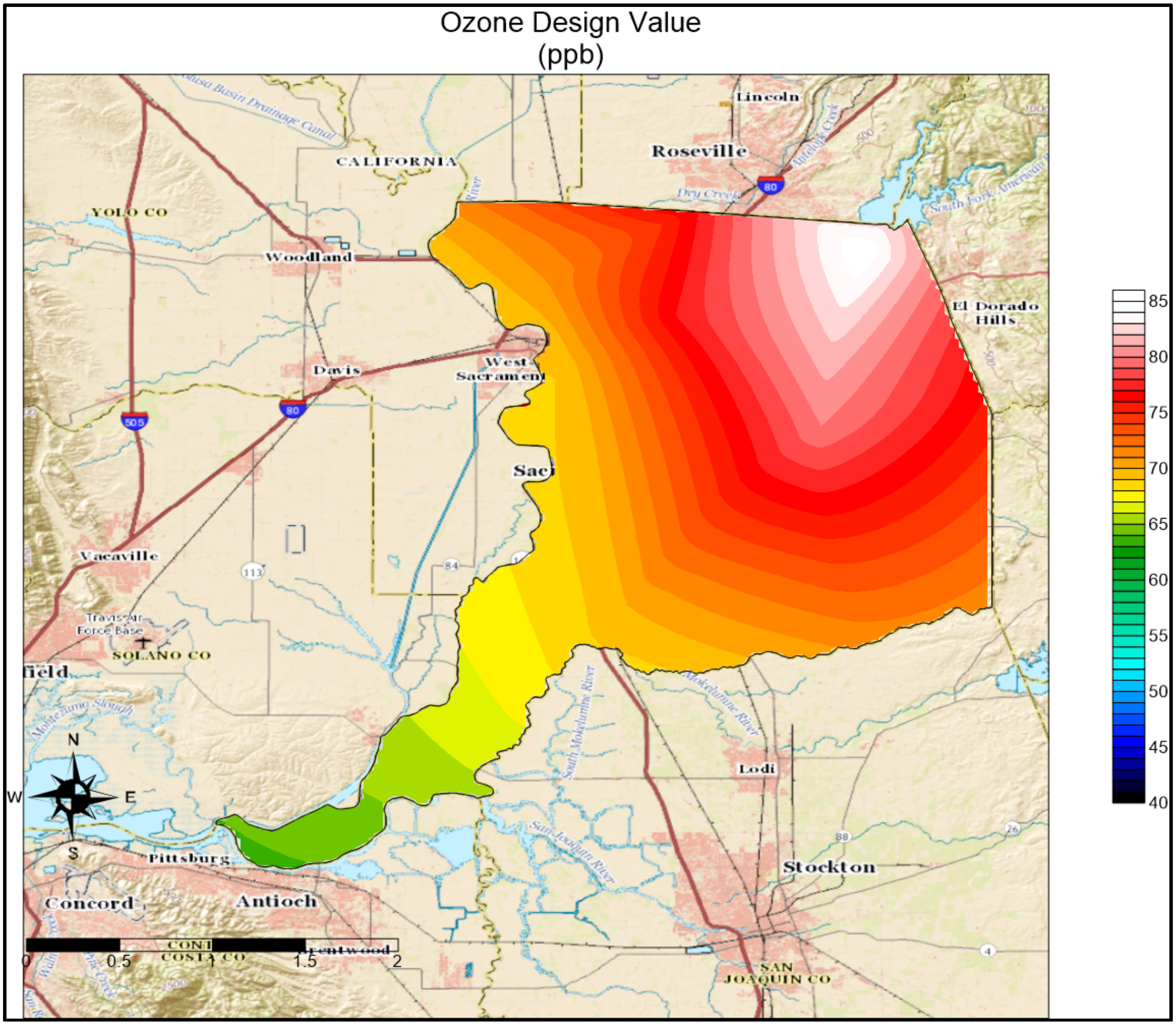

Figure C.4 Ozone Design Value Concentration Grid Layer (Ozone, PAMS)

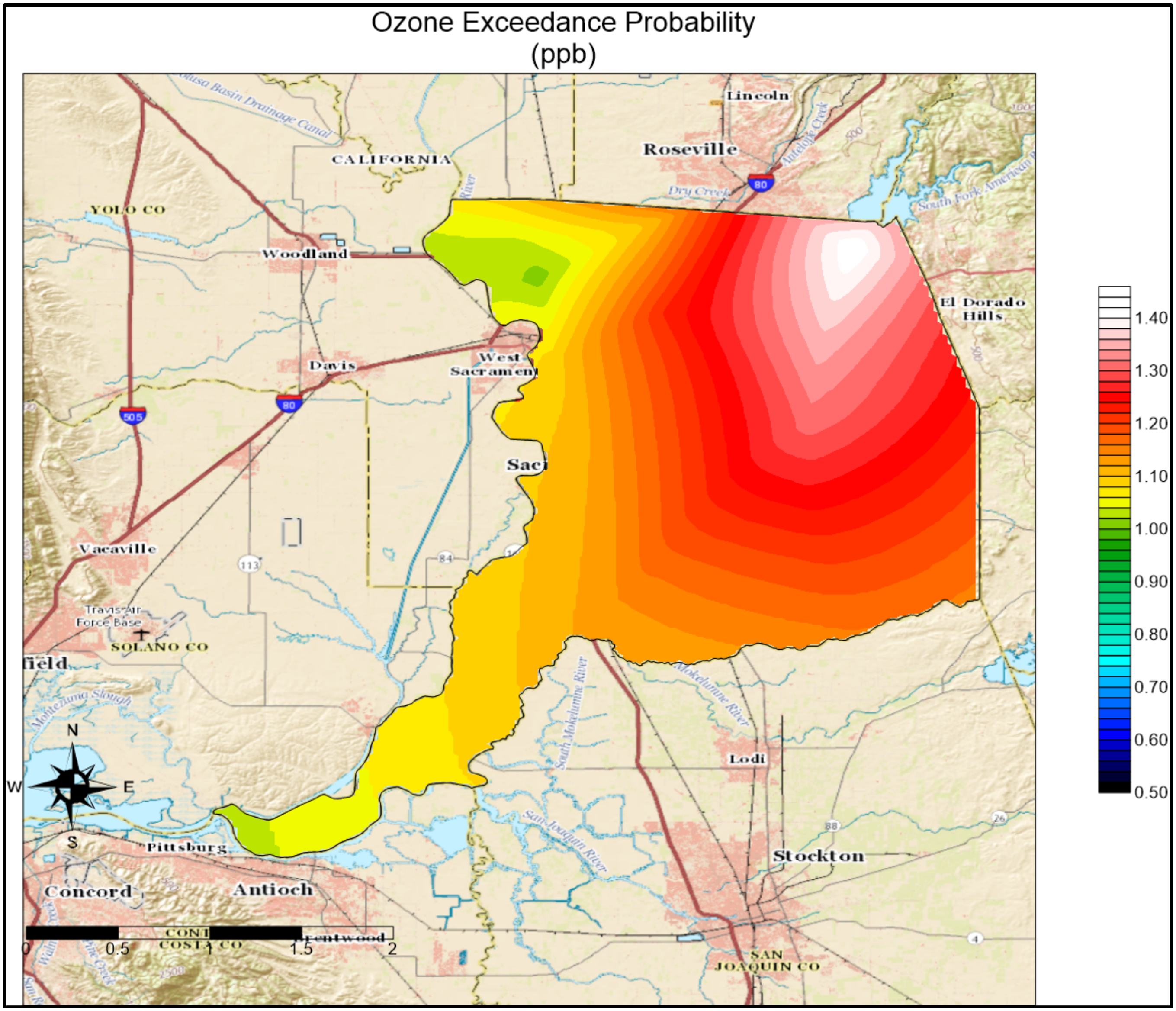

Figure C.5 Ozone Exceedance Probability Grid Layer (Ozone)

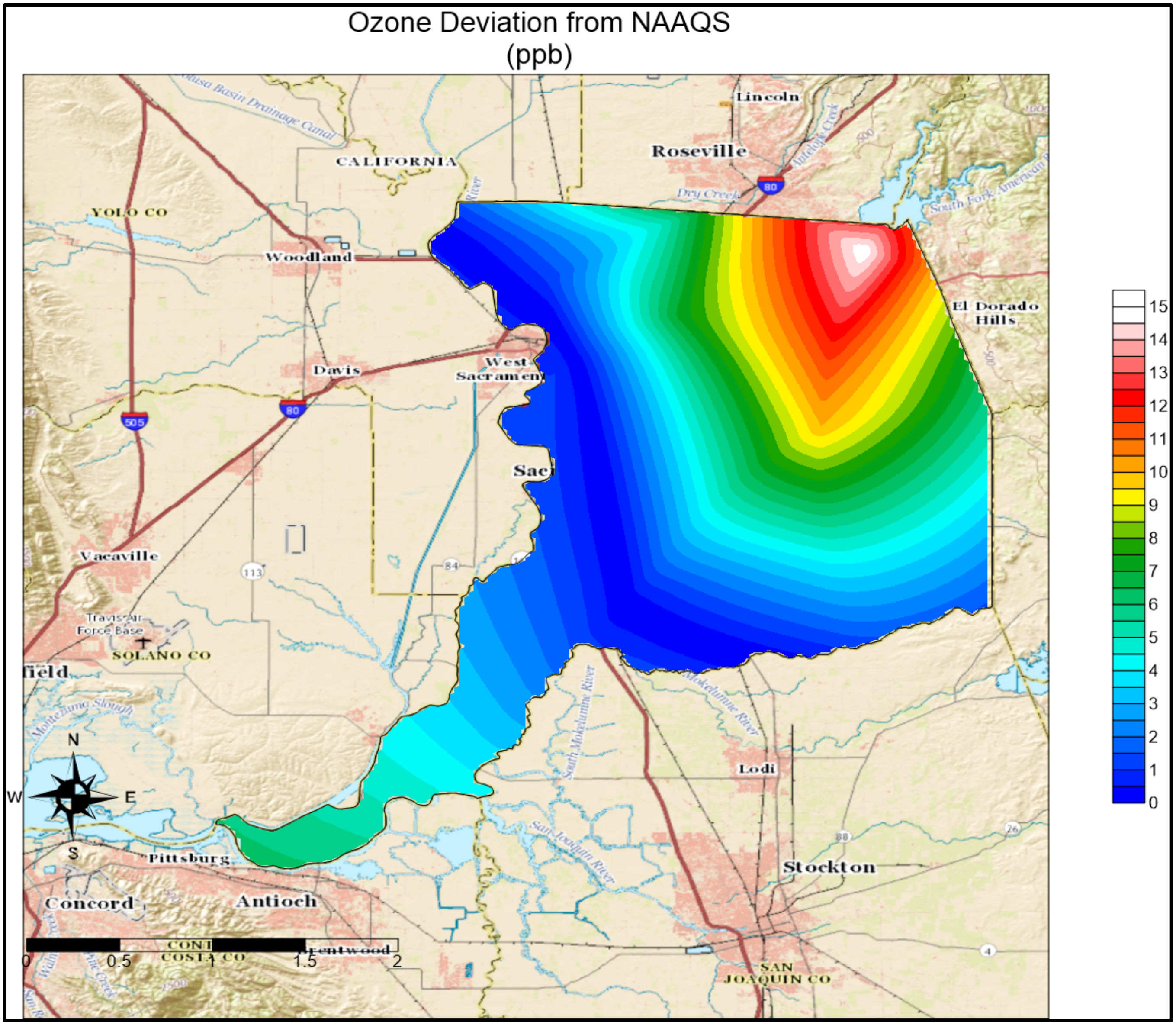

Figure C.6 Ozone Deviation from NAAQS Grid Layer (Ozone)

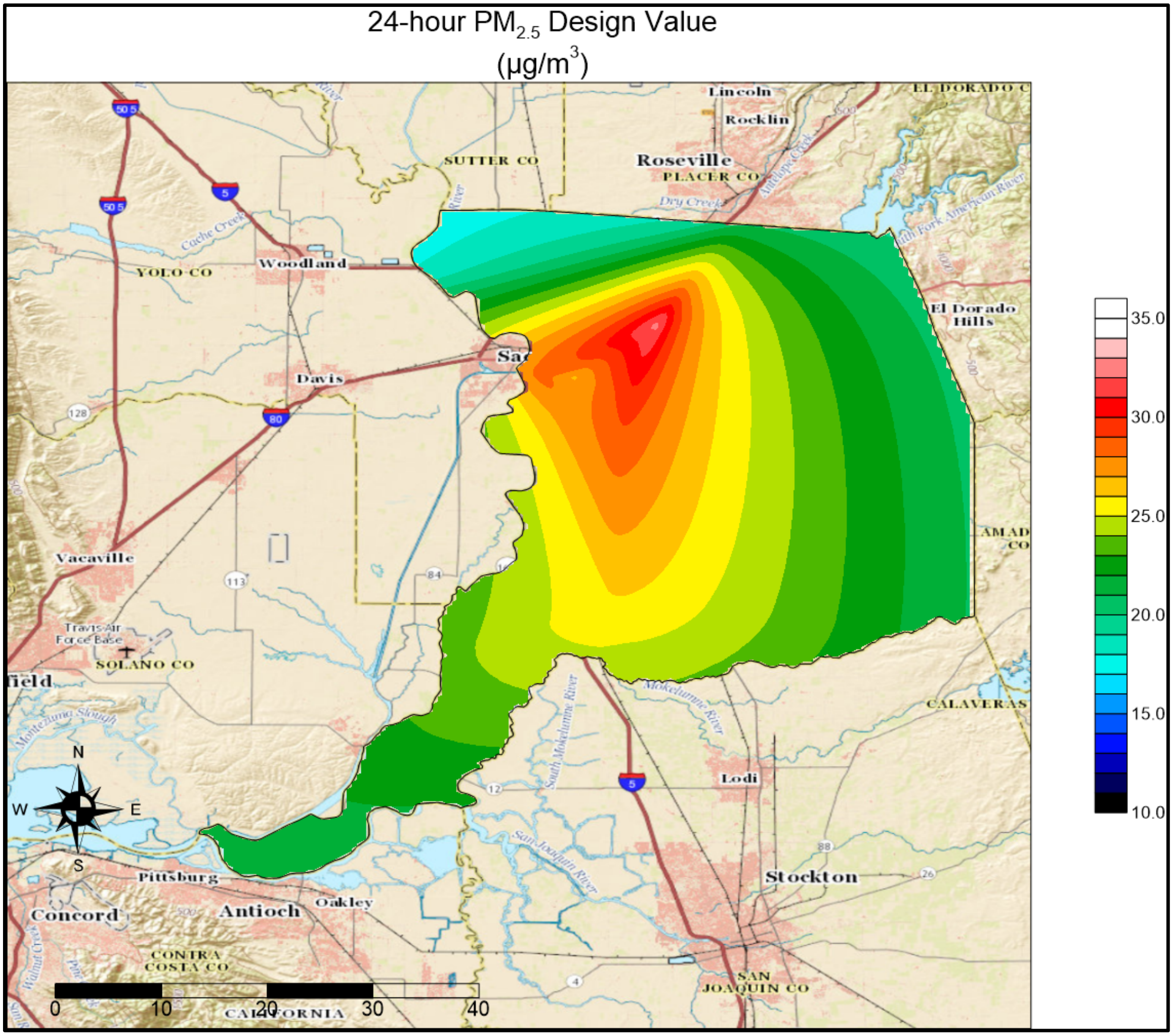

Figure C.7 PM$_{2.5}$ 24-hour Design Value Concentration Grid Layer (24-hour PM$_{2.5}$)

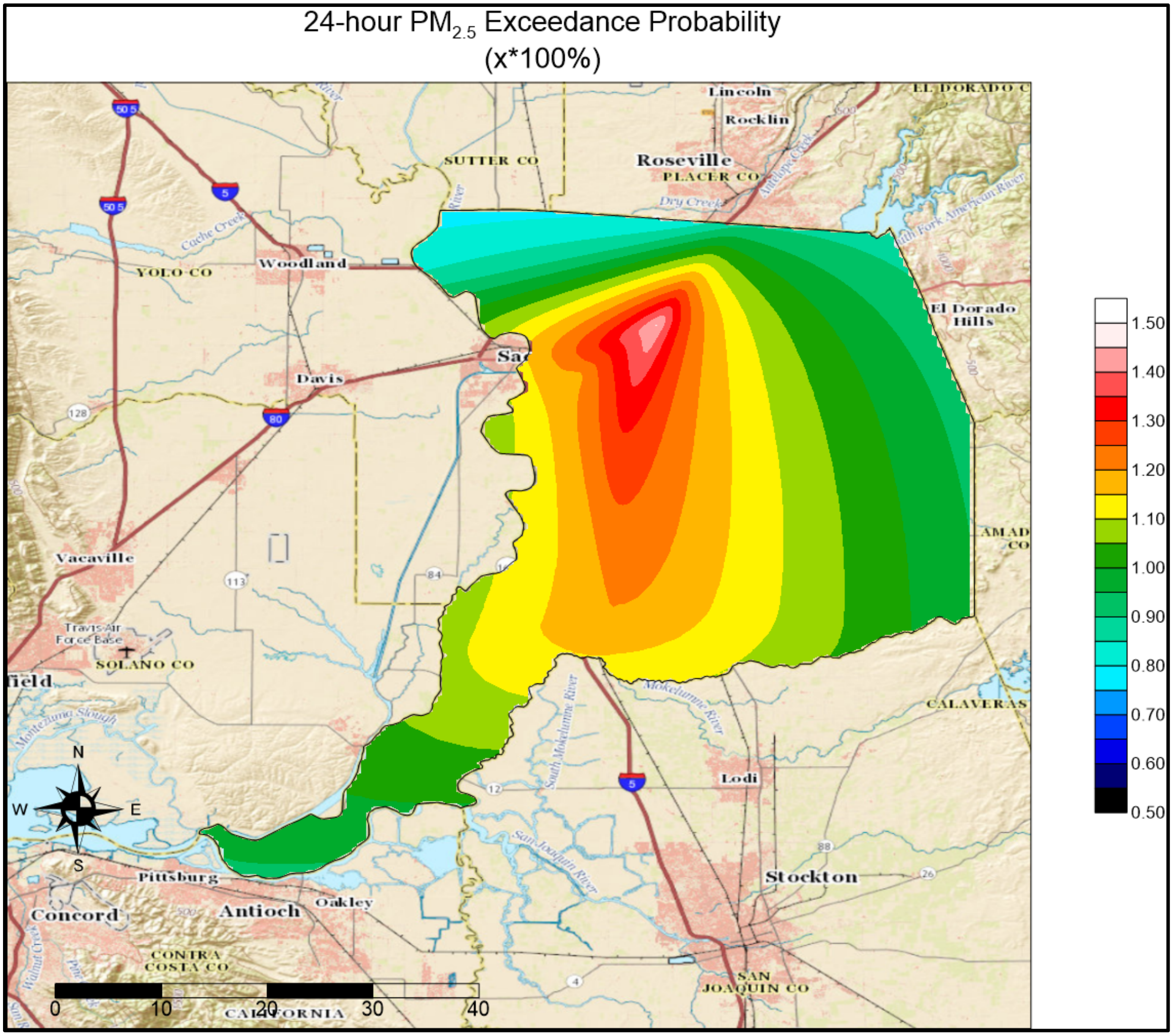

Figure C.8 $PM_{2.5}$ 24-hour Exceedance Probability Grid Layer (24-hour $PM_{2.5}$)

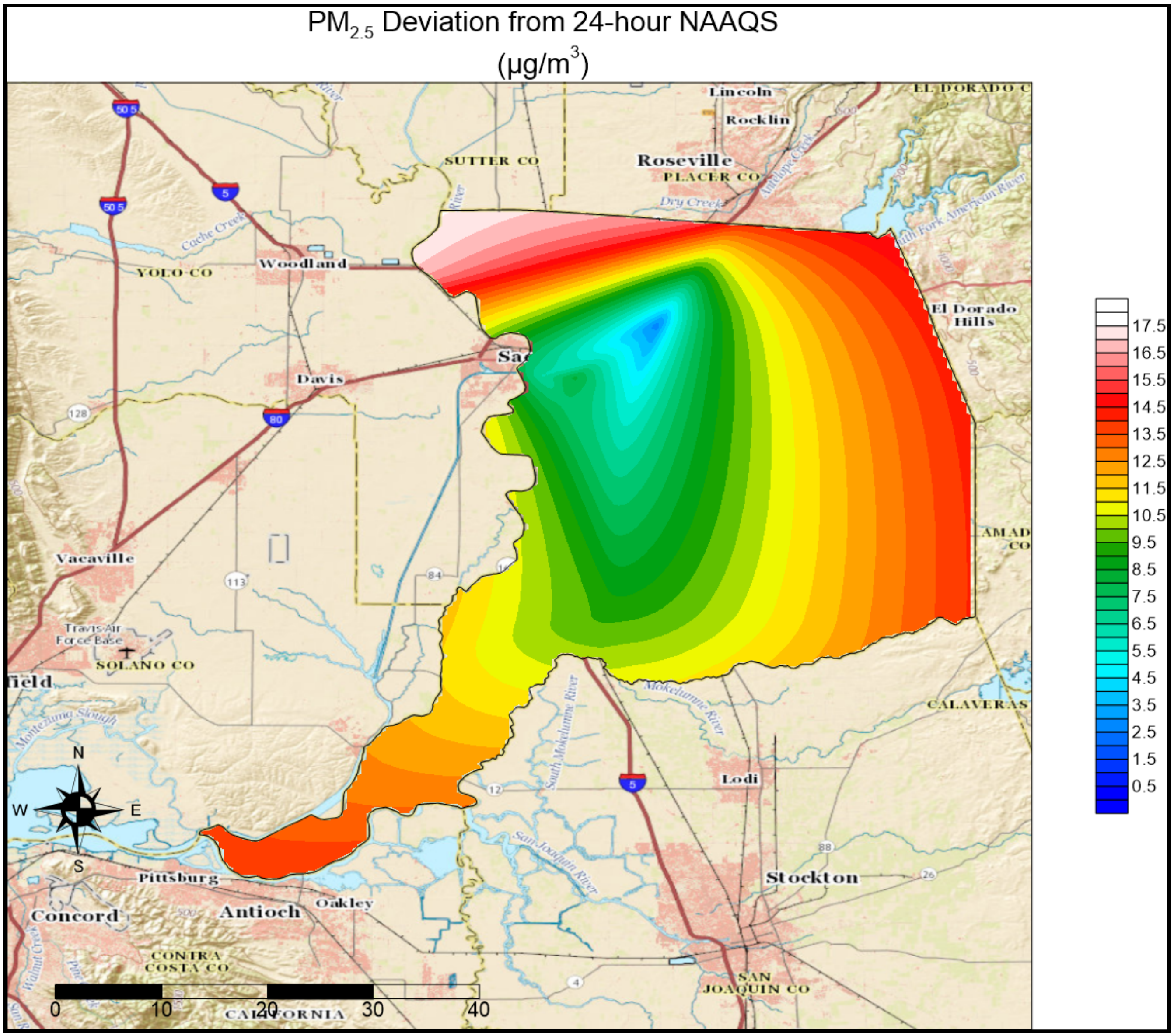

Figure C.9 $PM_{2.5}$ 24-hour Deviation from NAAQS Grid Layer ($PM_{2.5}$)

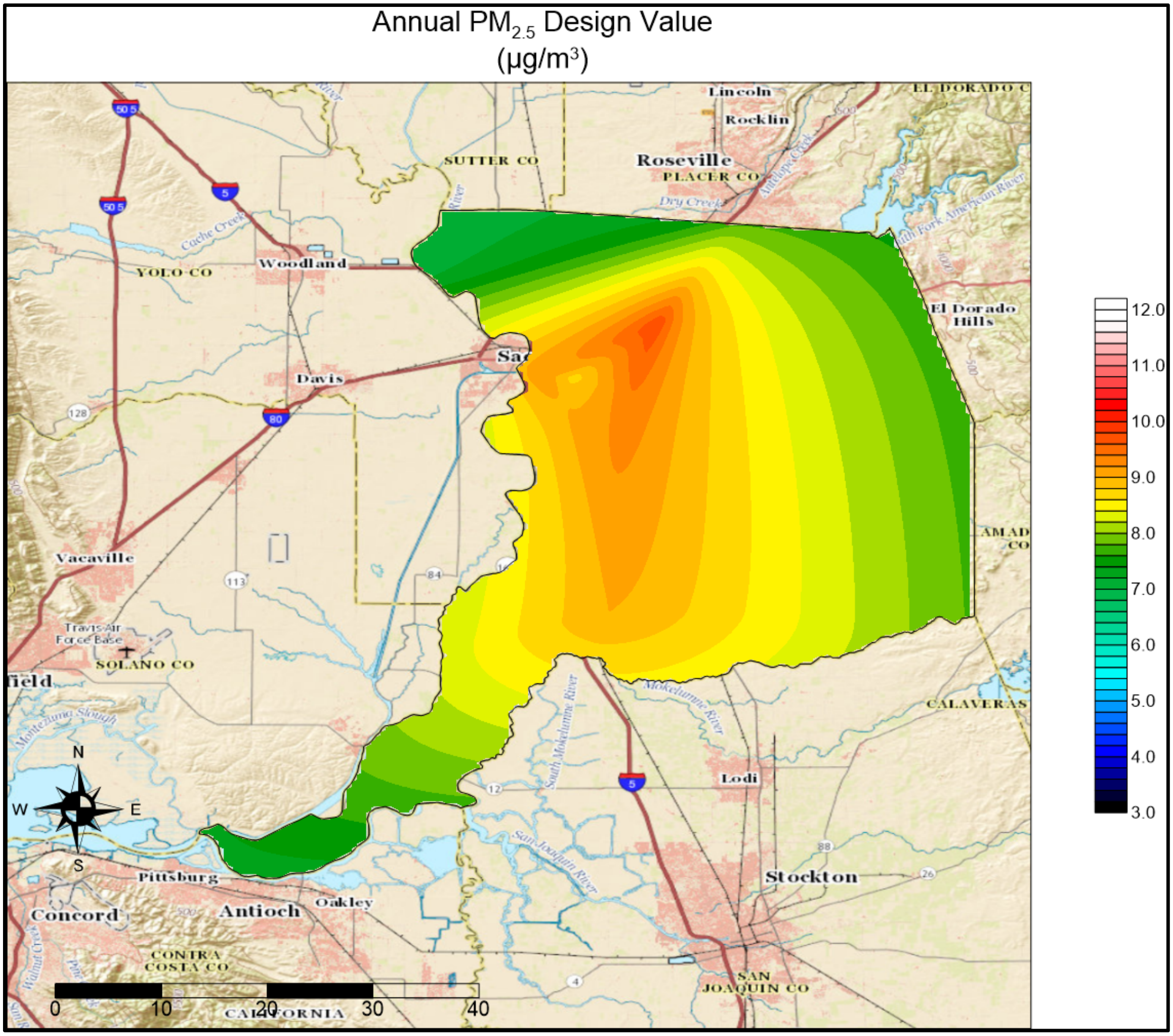

Figure C.10 $PM_{2.5}$ Annual Design Value Concentration Grid Layer (Annual $PM_{2.5}$)

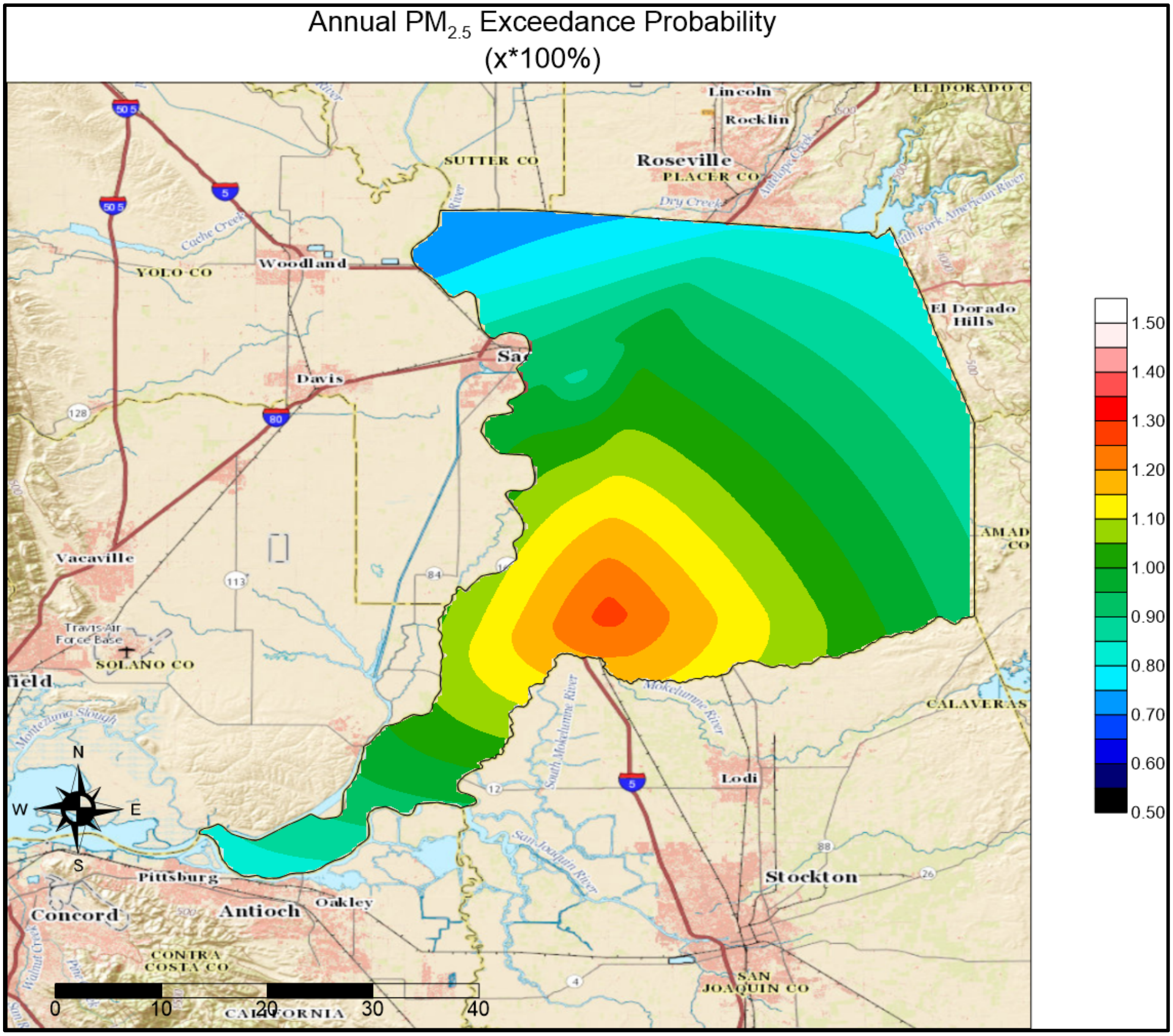

Figure C.11 $PM_{2.5}$ Annual Exceedance Probability Grid Layer (Annual $PM_{2.5}$)

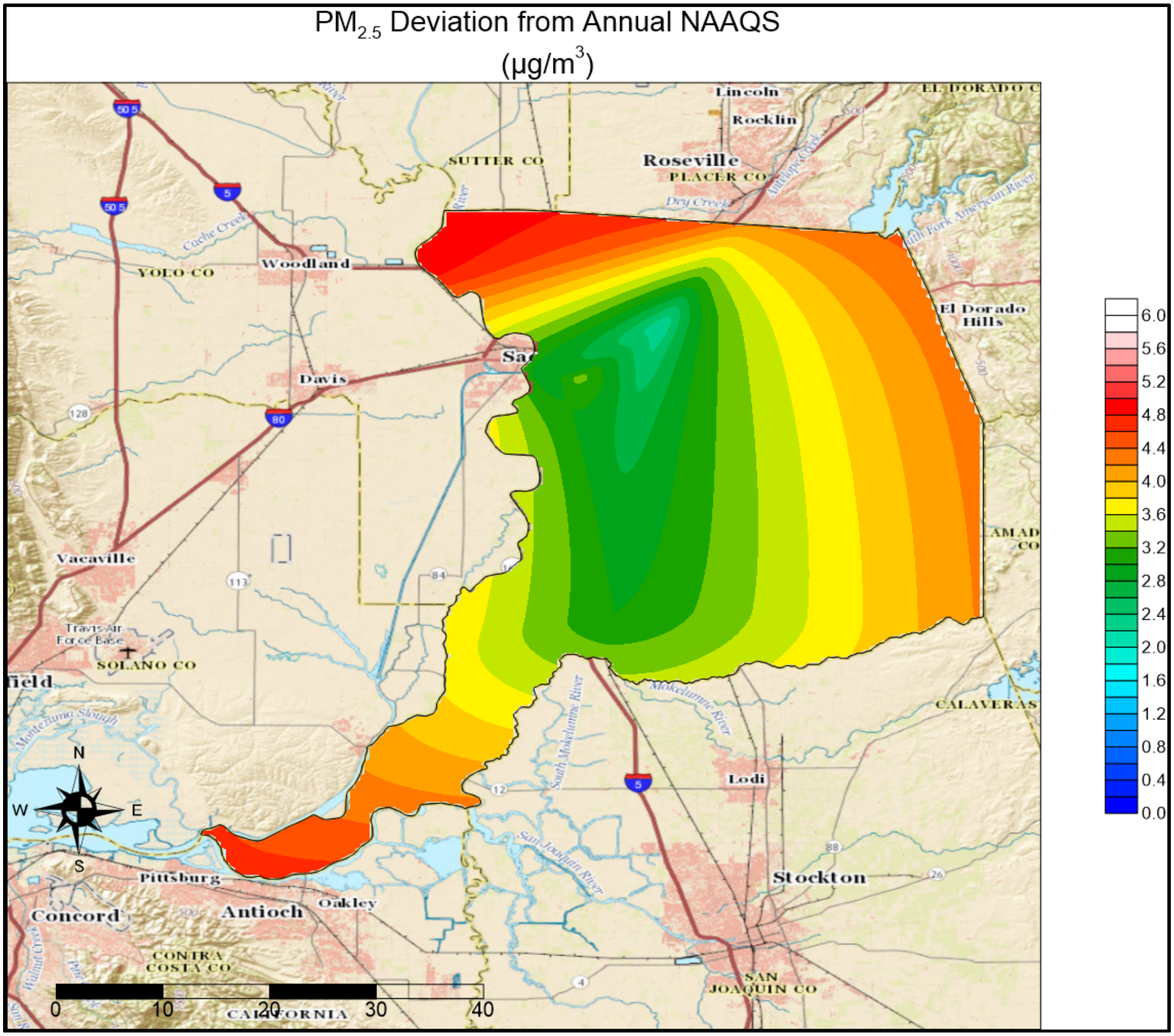

Figure C.12 PM$_{2.5}$ Annual Deviation from NAAQS Grid Layer (Annual PM$_{2.5}$)

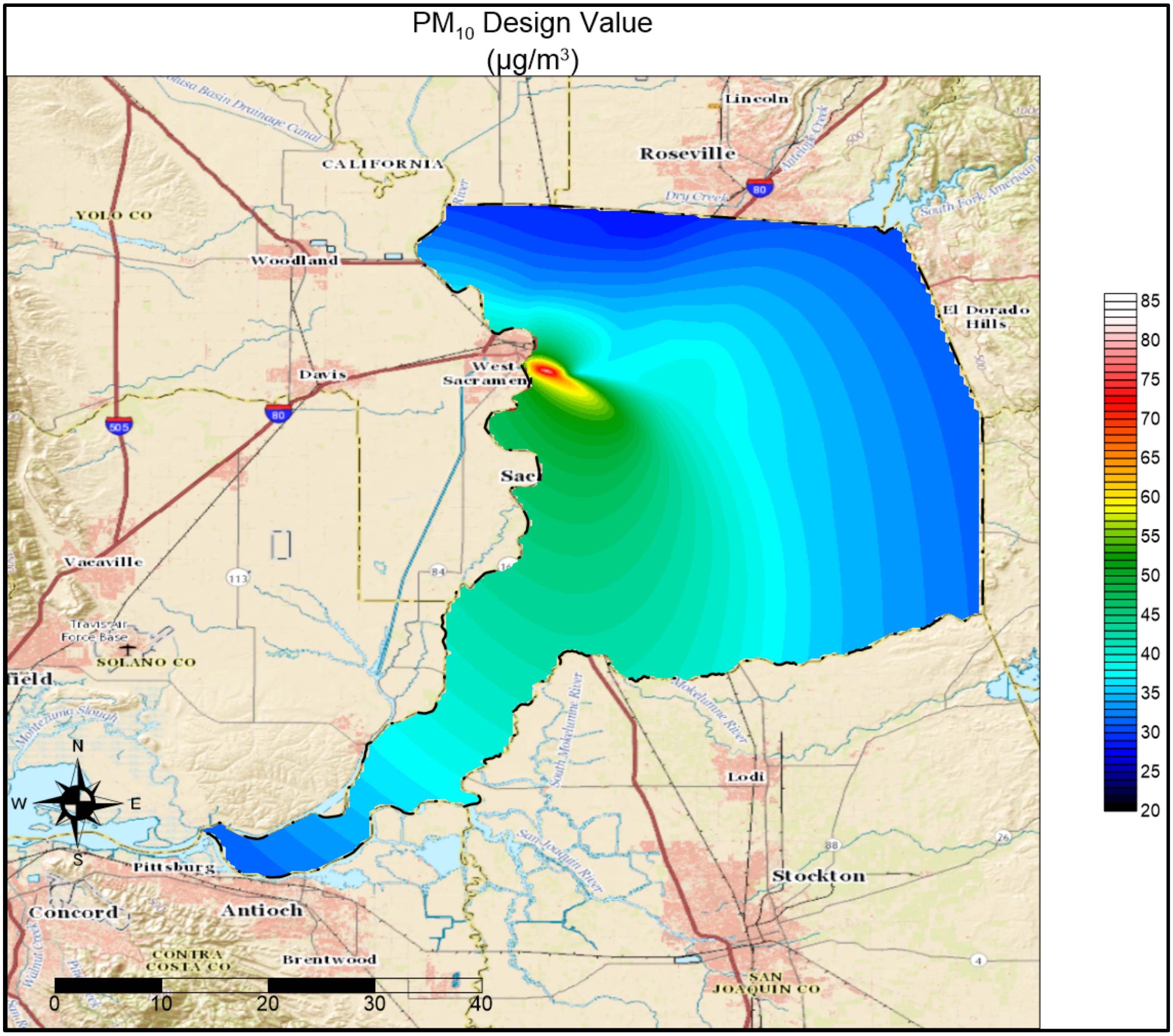

Figure C.13 PM$_{10}$ Design Value Concentration Grid Layer (PM$_{10}$)
Figure C.14 PM$_{10}$ Exceedance Probability Grid Layer (PM$_{10}$)

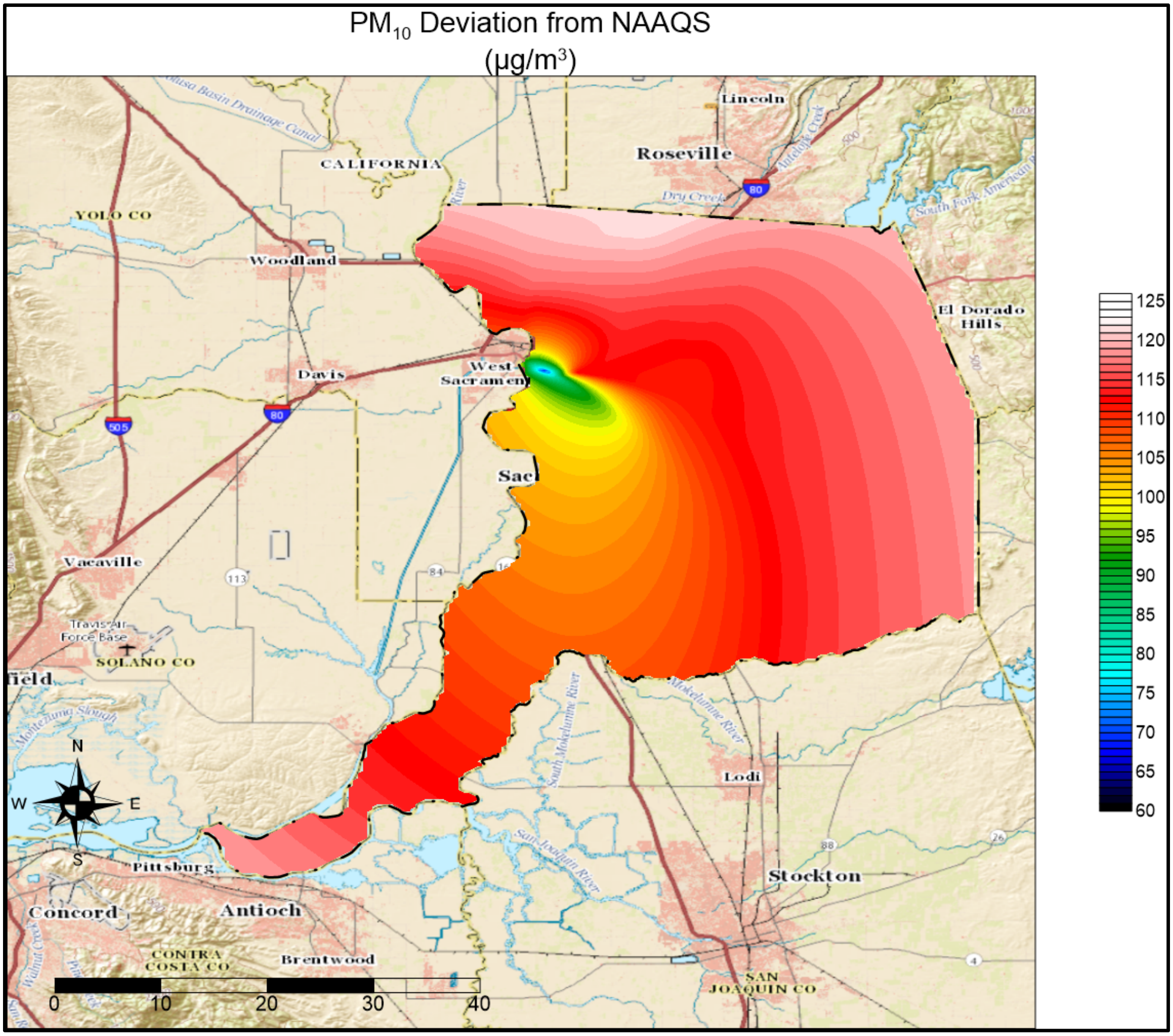

Figure C.15 PM$_{10}$ Deviation from NAAQS Grid Layer (PM$_{10}$)

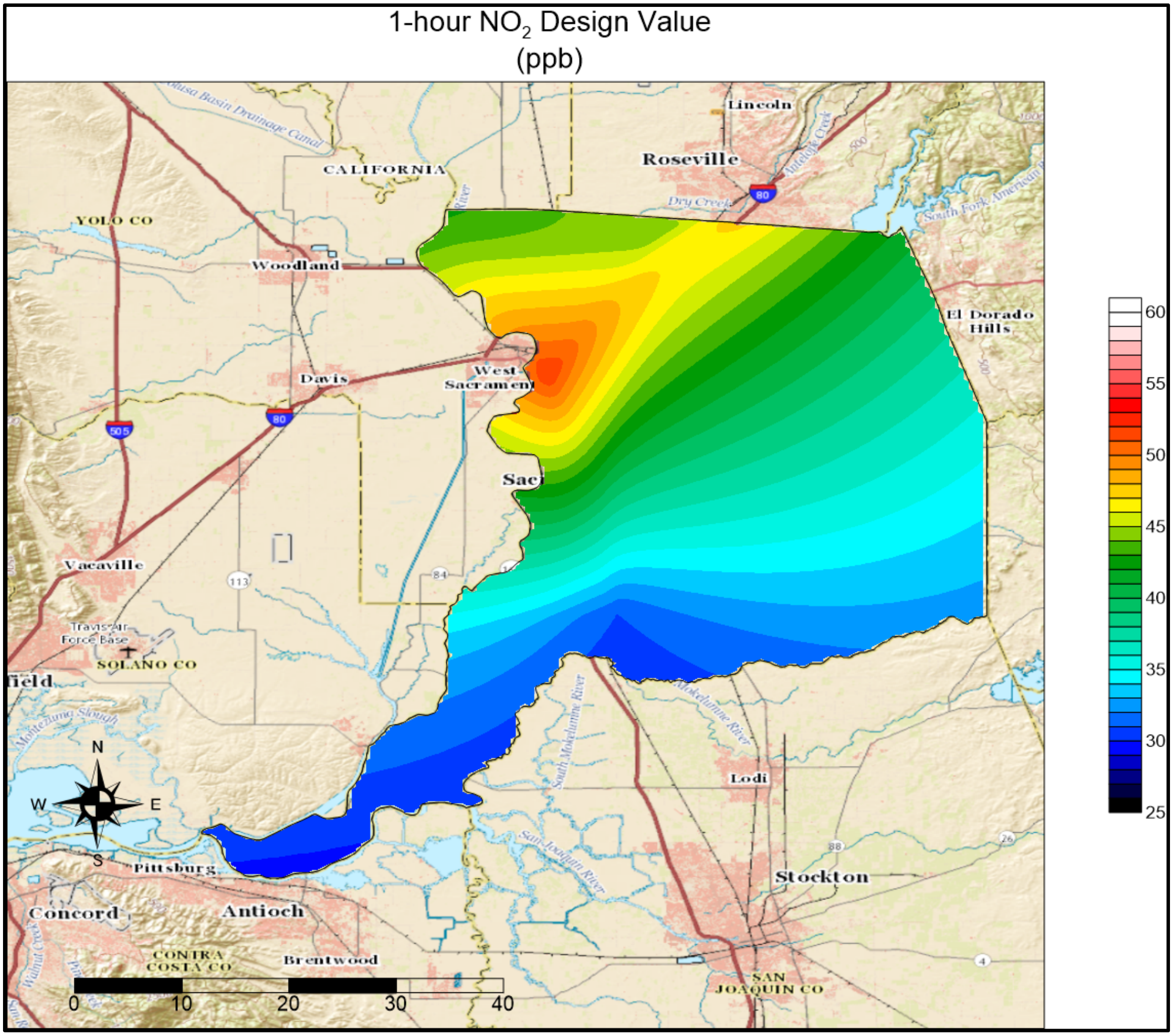

Figure C.16 1-hour NO_2 Design Value Concentration Grid Layer (1-hour NO_2)

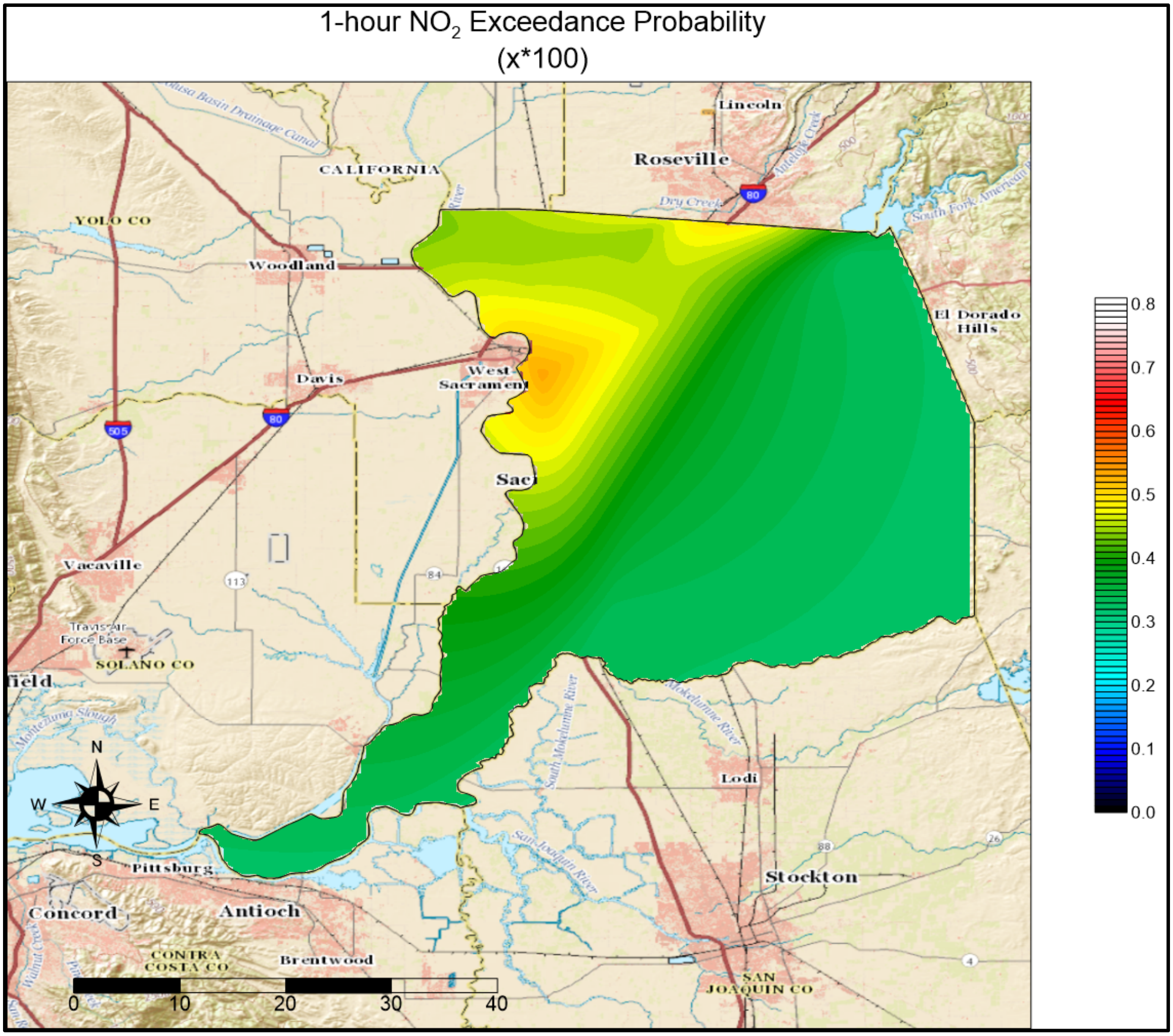

Figure C.17 1-hour NO_2 Exceedance Probability Grid Layer (1-hour NO_2)

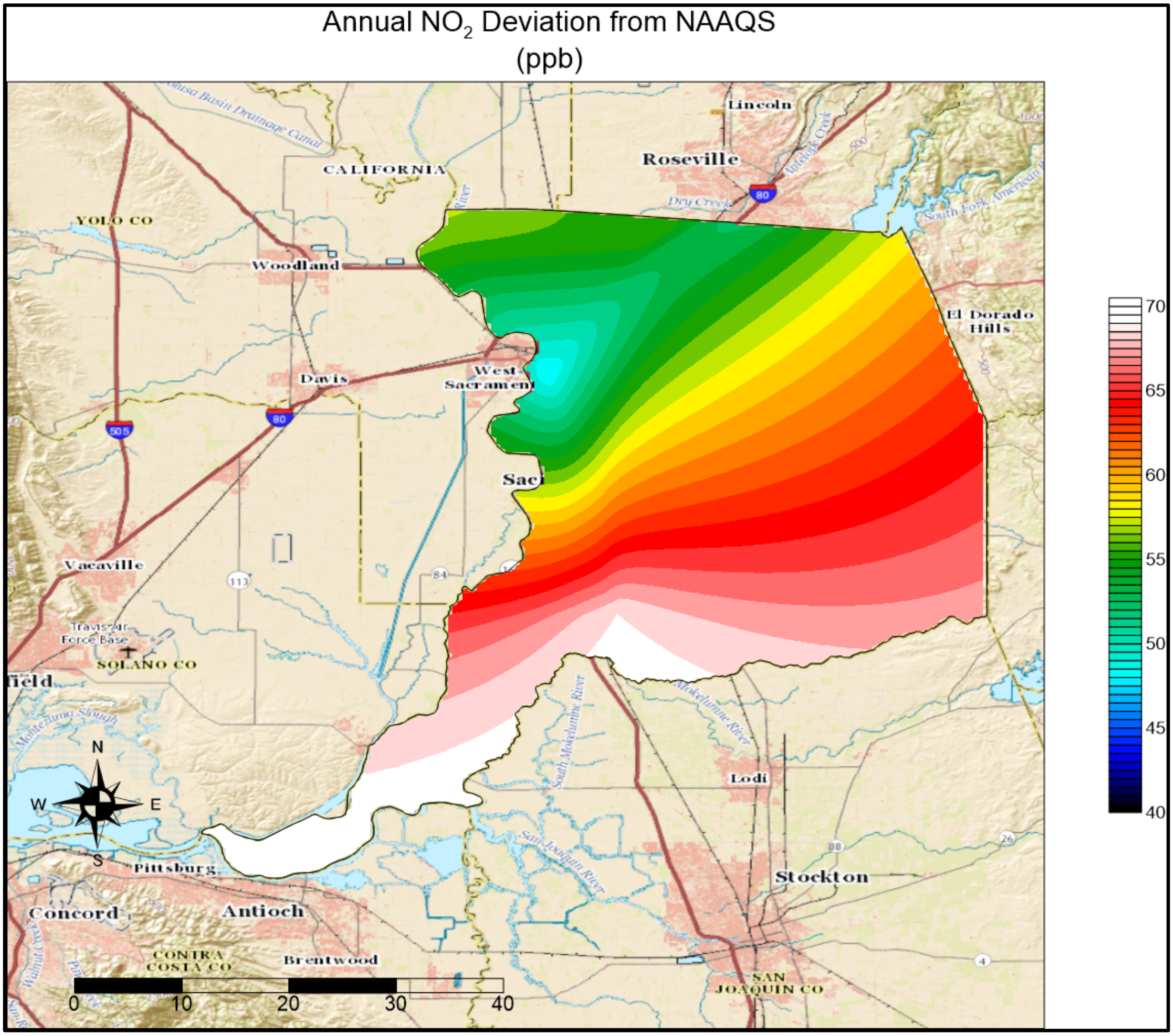

Figure C.18 1-hour NO_2 Deviation from NAAQS Grid Layer (1-hour NO_2)

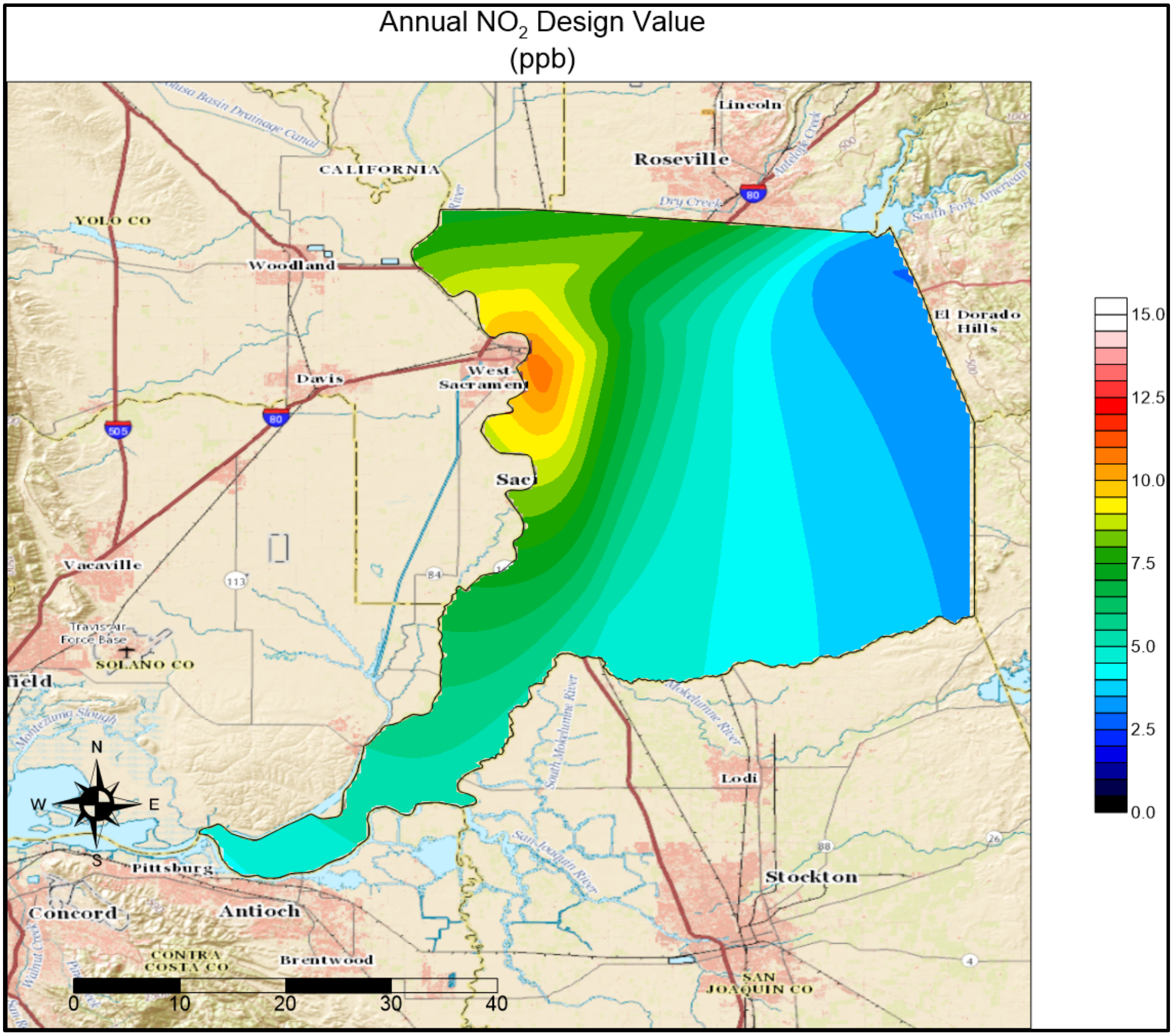

Figure C.19 Annual NO_2 Design Value Concentration Grid Layer (Annual NO_2)

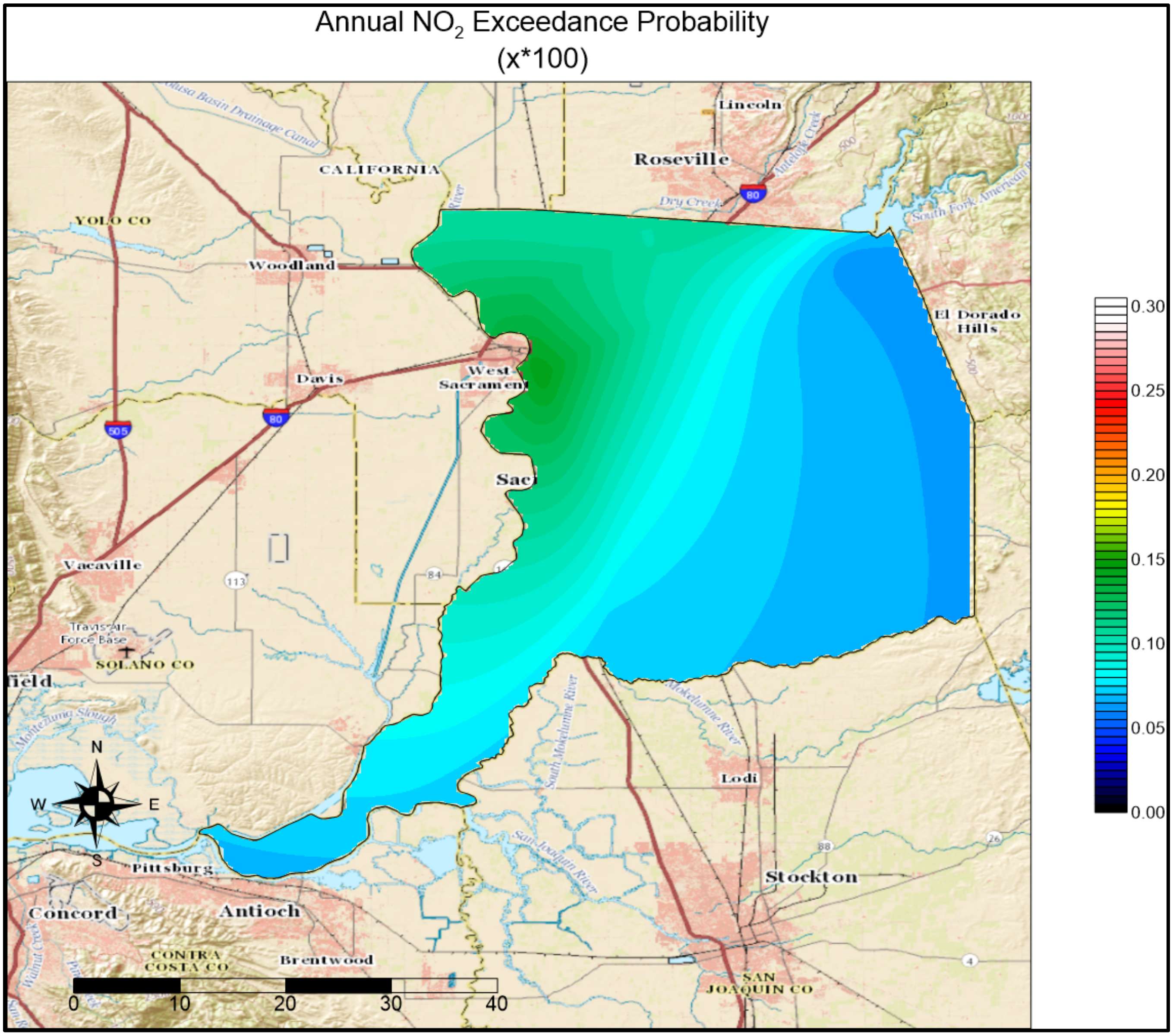

Figure C.20 Annual NO_2 Exceedance Probability Grid Layer (Annual NO_2)

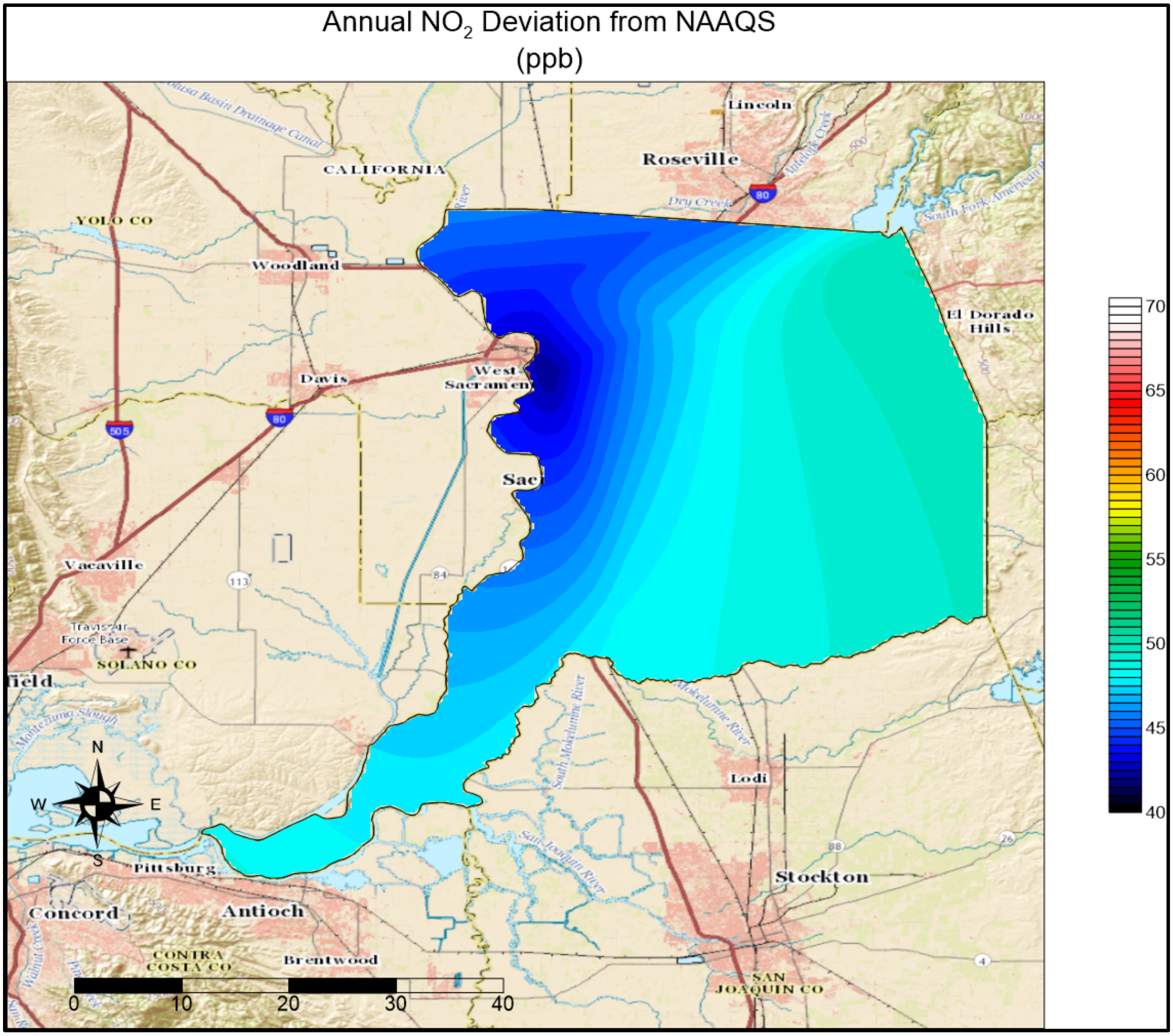

Figure C.21 Annual NO_2 Deviation from NAAQS Grid Layer (Annual NO_2)

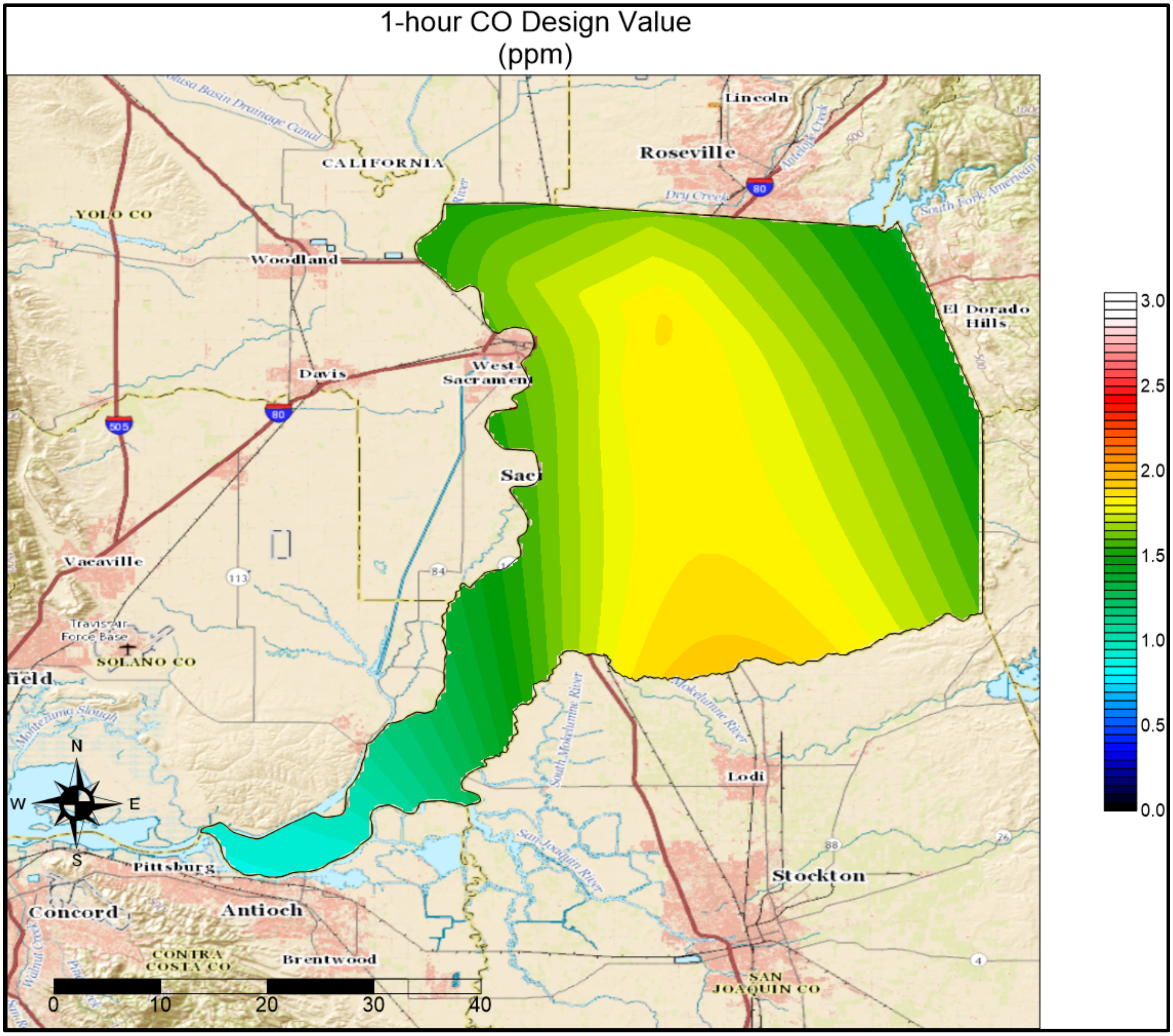

Figure C.22 1-hour CO Design Value Concentration Grid Layer (1-hour CO)

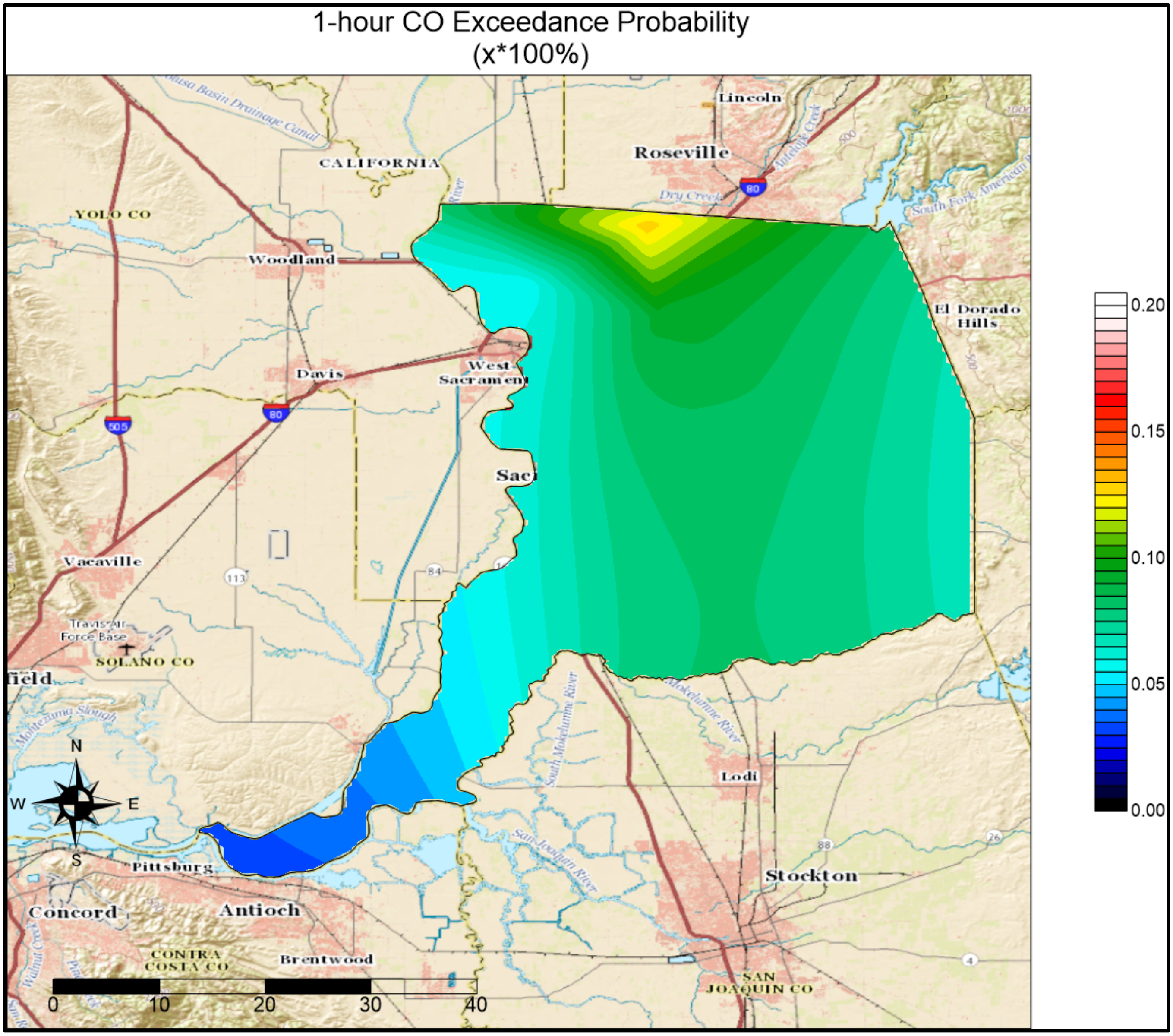

Figure C.23 1-hour CO Exceedance Probability Grid Layer (1-hour CO)

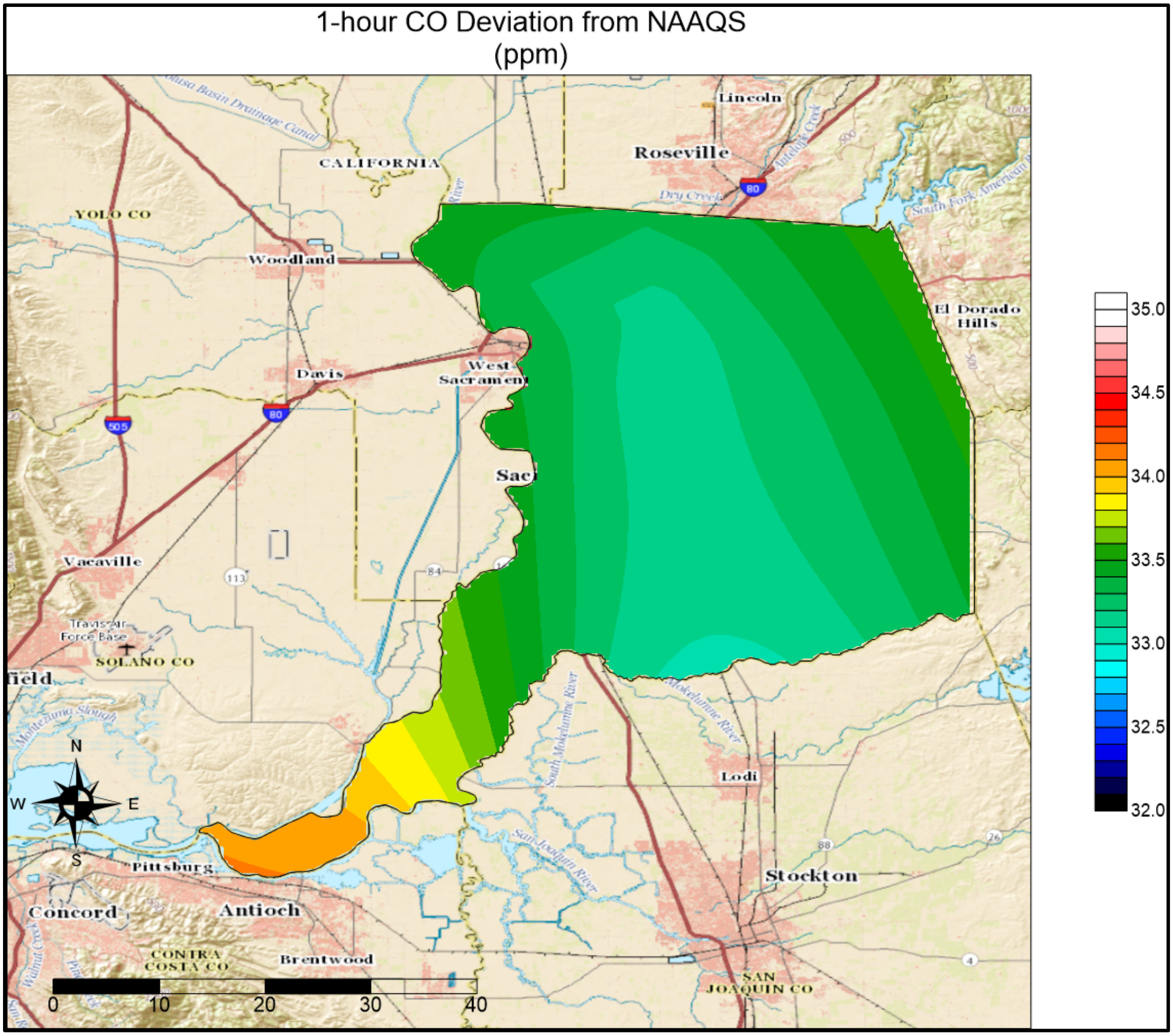

Figure C.24 1-hour CO Deviation from NAAQS Grid Layer (1-hour CO)

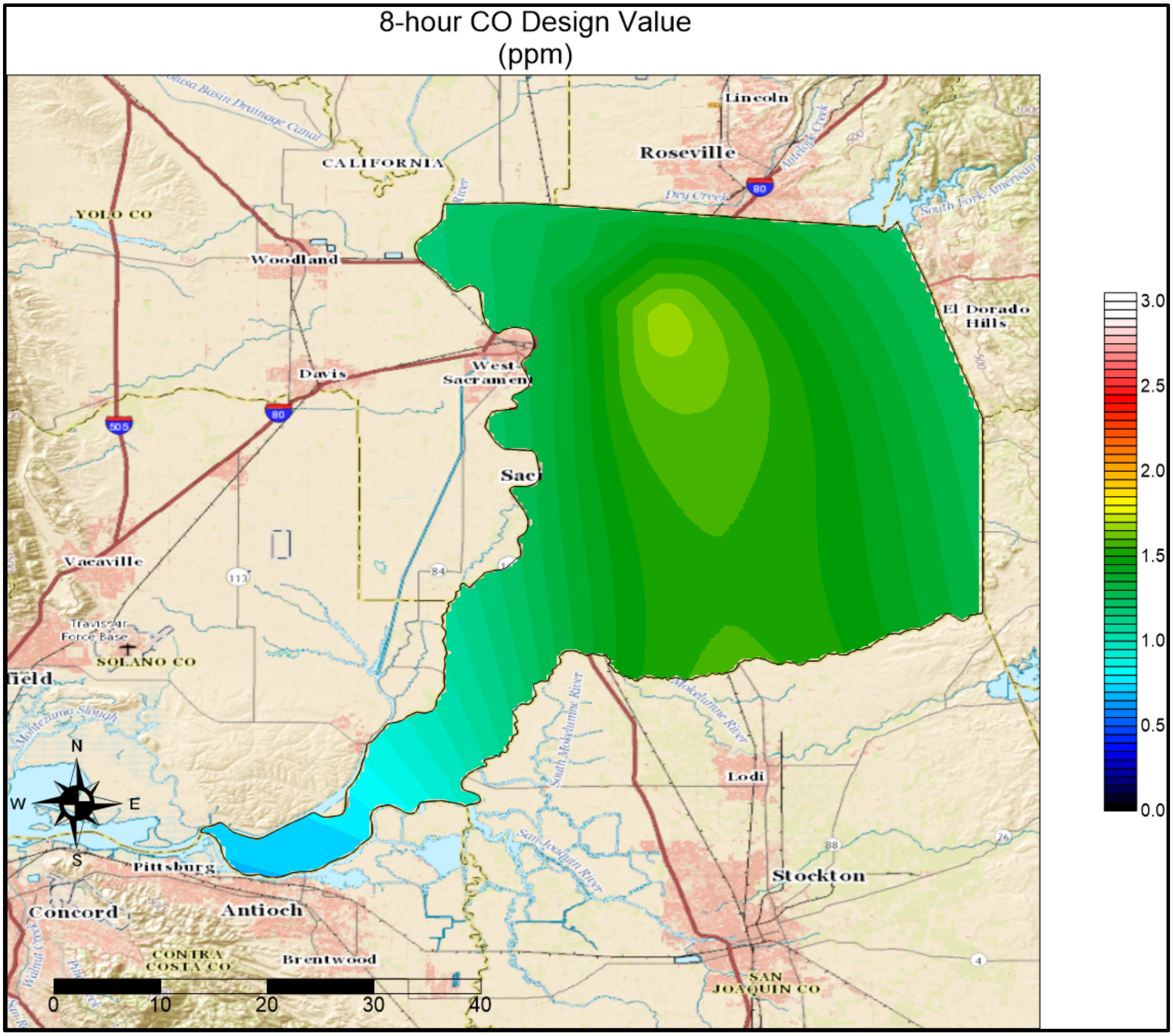

Figure C.25 8-hour CO Design Value Concentration Grid Layer (8-hour CO)

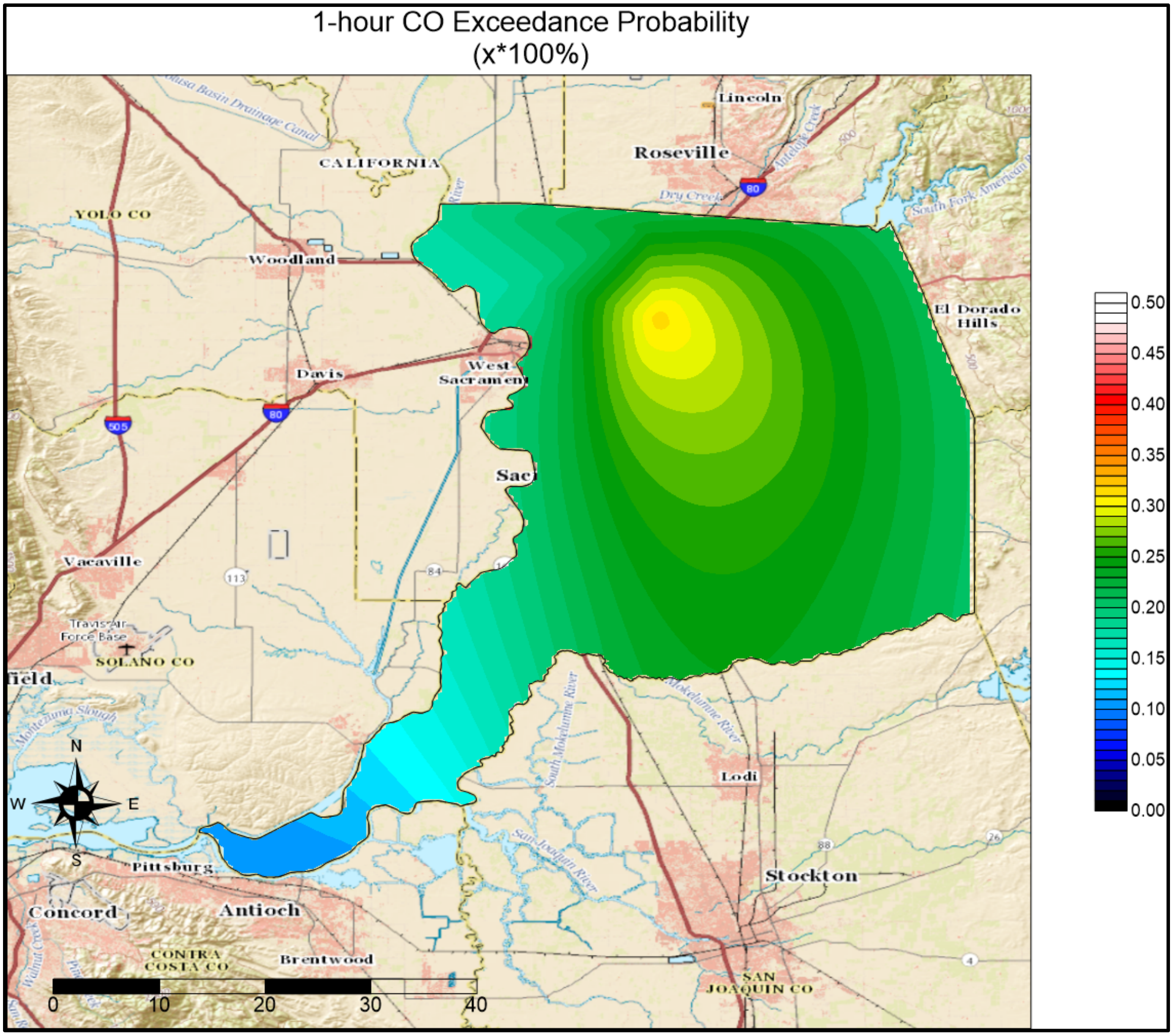

Figure C.26 8-hour CO Exceedance Probability Grid Layer (8-hour CO)

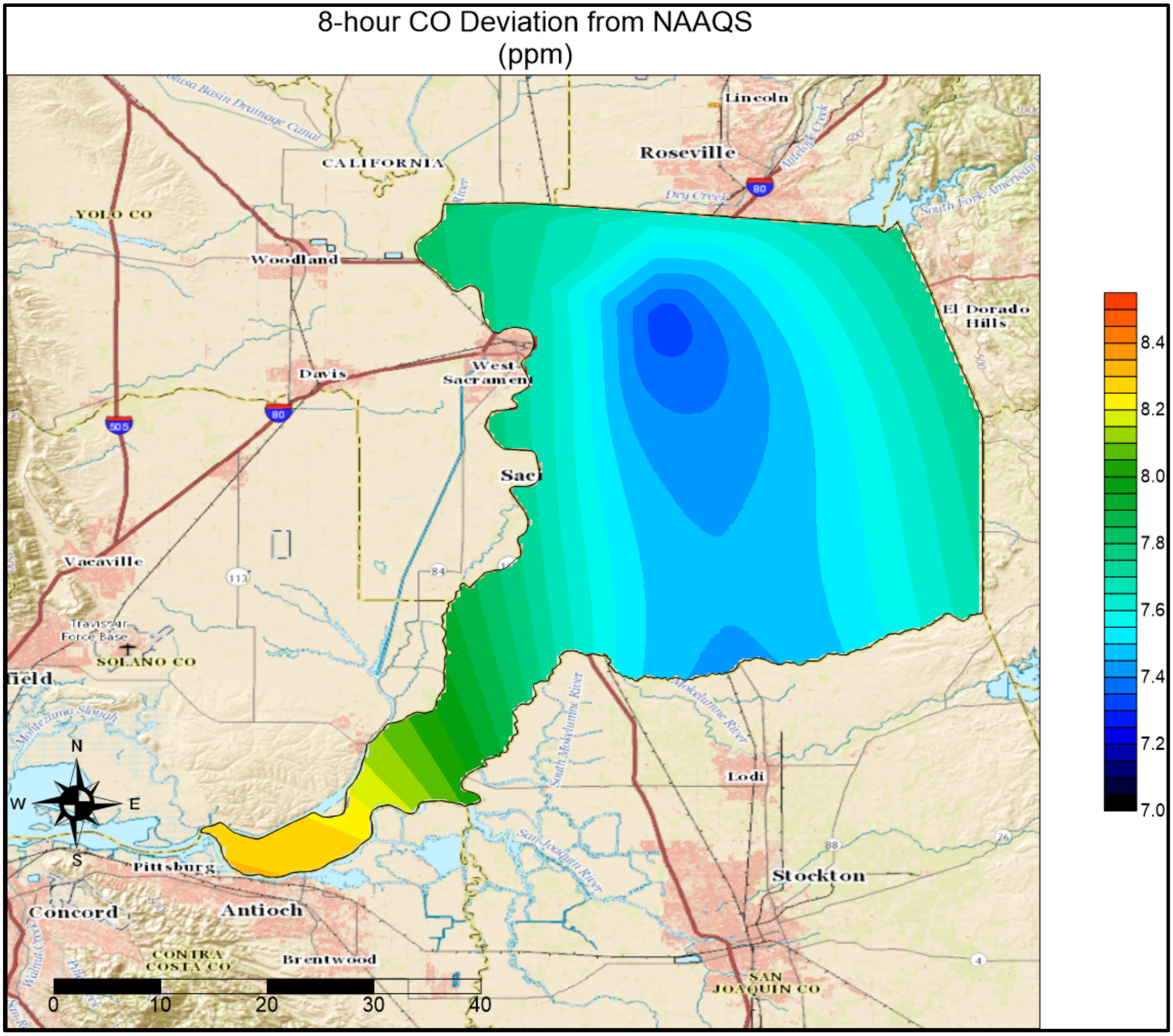

Figure C.27 8-hour CO Deviation from NAAQS Grid Layer (8-hour CO)

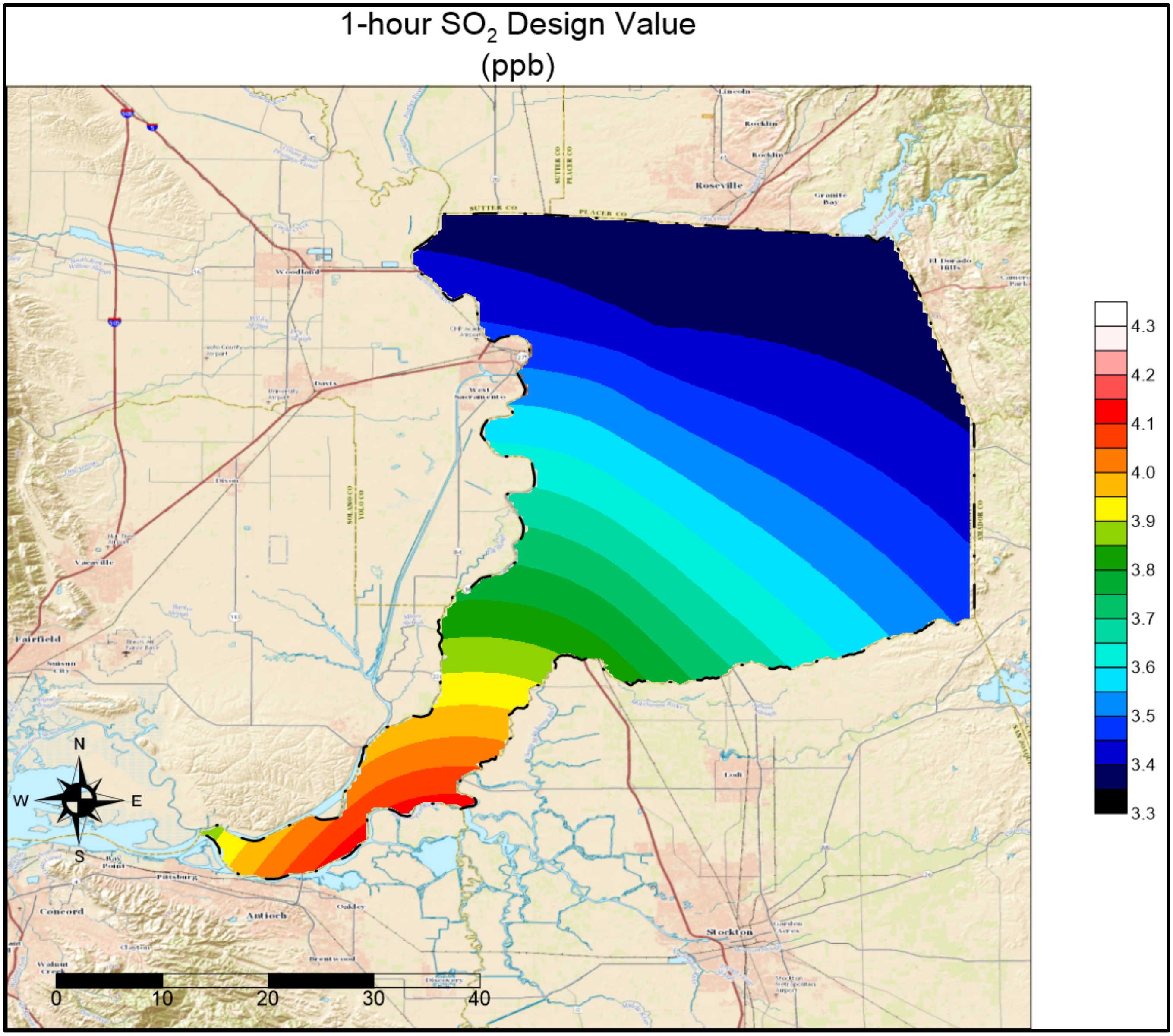

Figure C.28 1-hour SO_2 Design Value Concentration Grid Layer (1-hour SO_2)

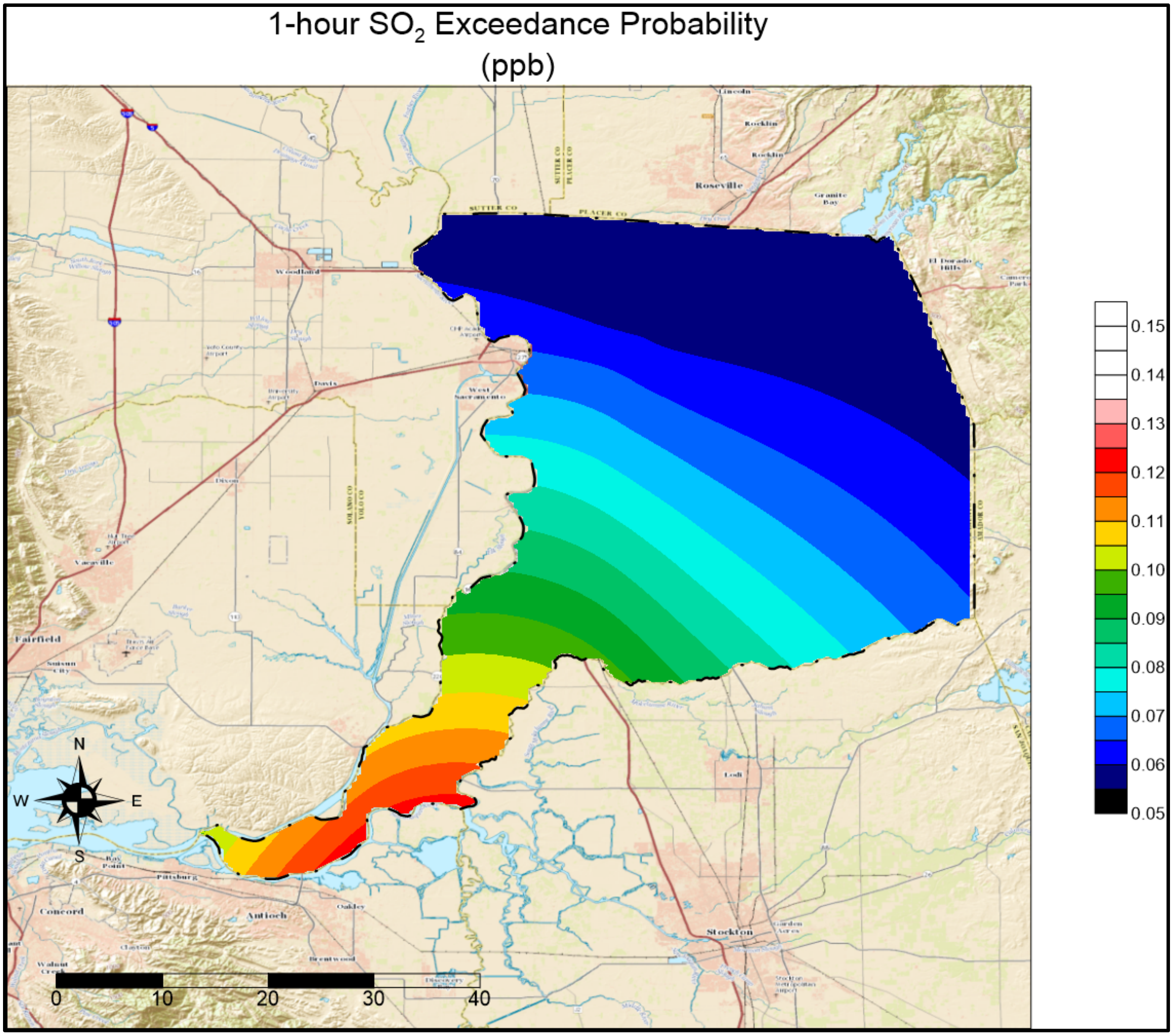

Figure C.29 1-hour SO_2 Exceedance Probability Grid Layer (1-hour SO_2)

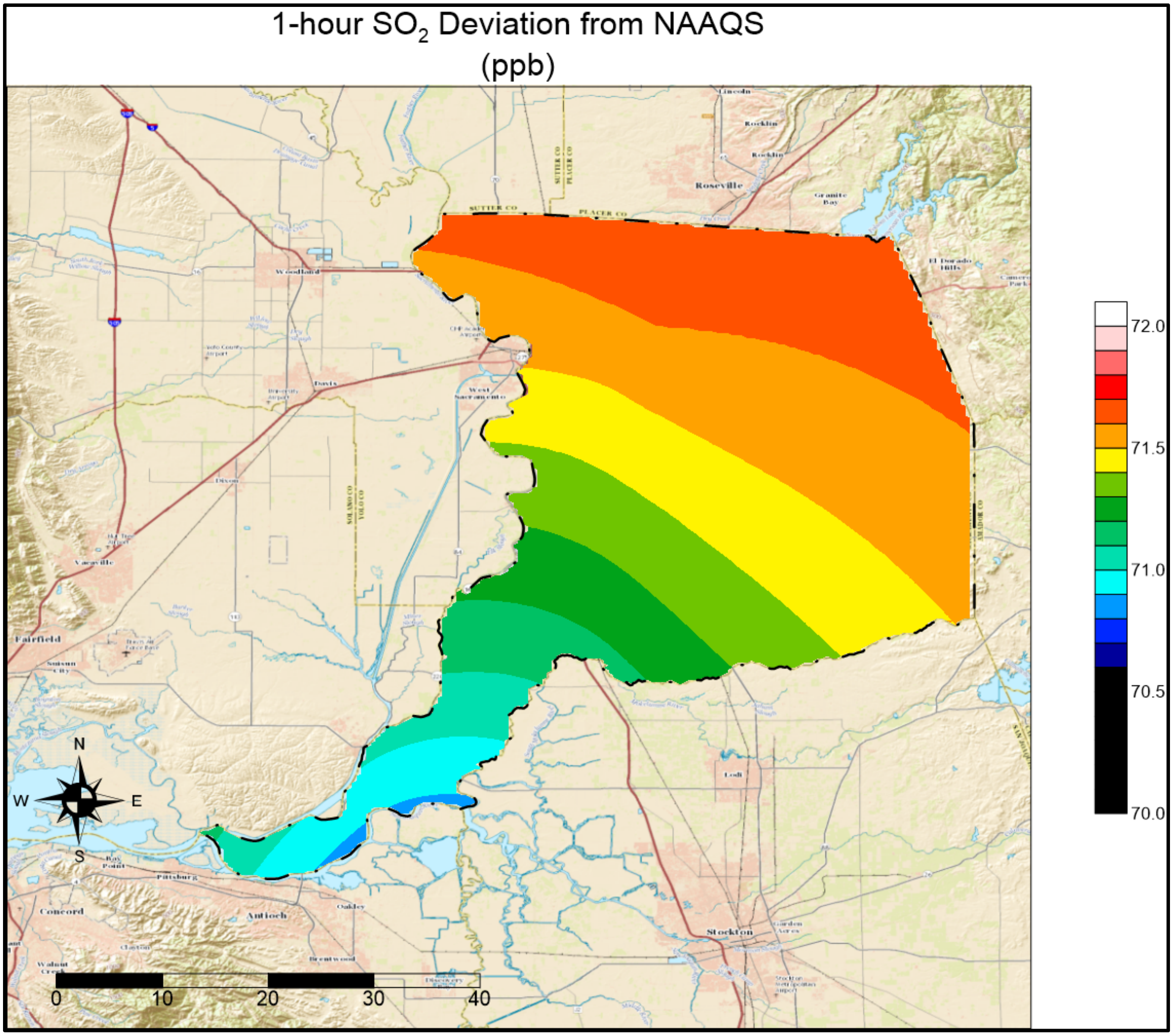

Figure C.30 1-hour SO_2 Deviation from NAAQS Grid Layer (1-hour SO_2)

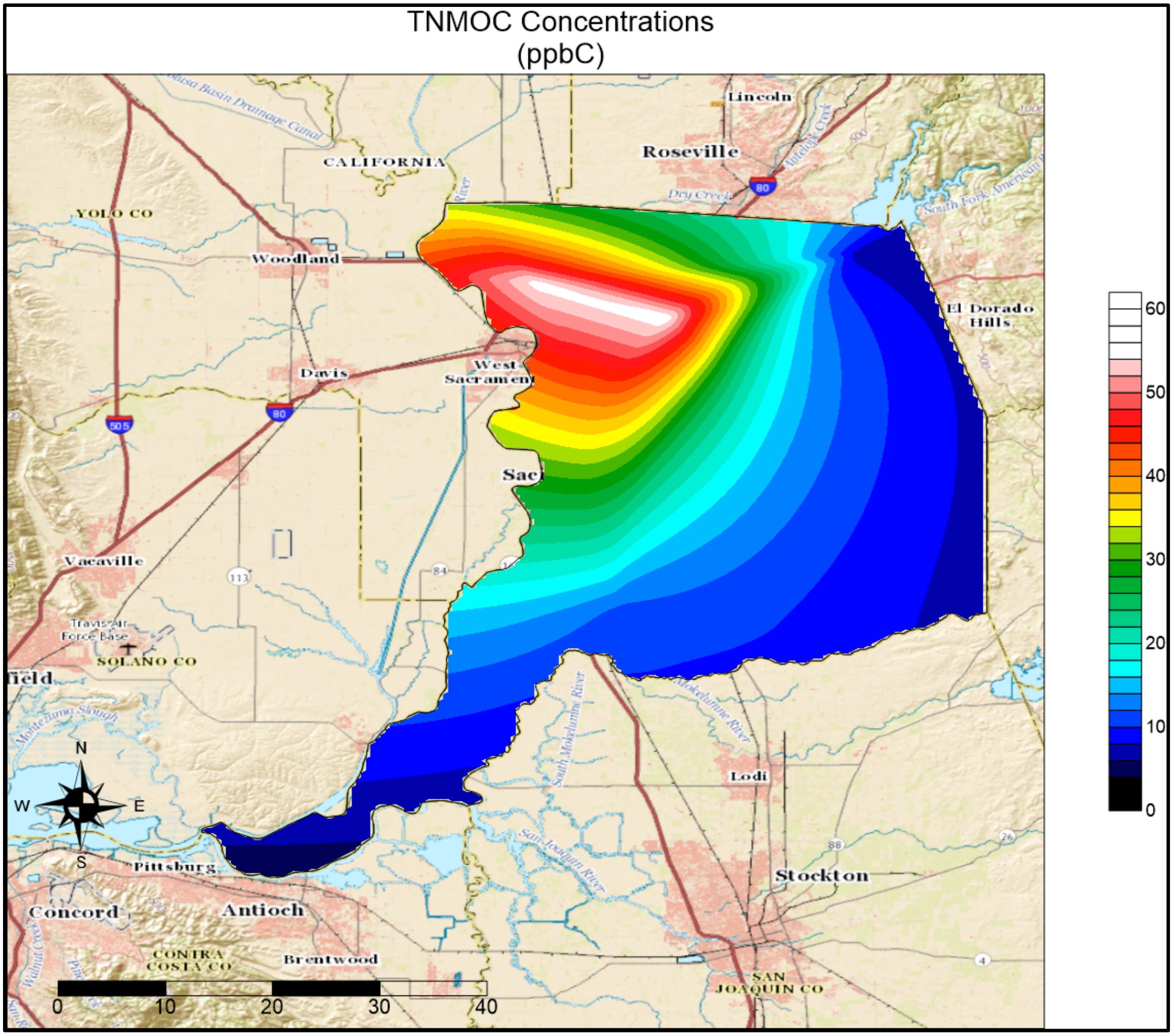

Figure C.31 TNMHC Concentration Grid Layer (PAMS)

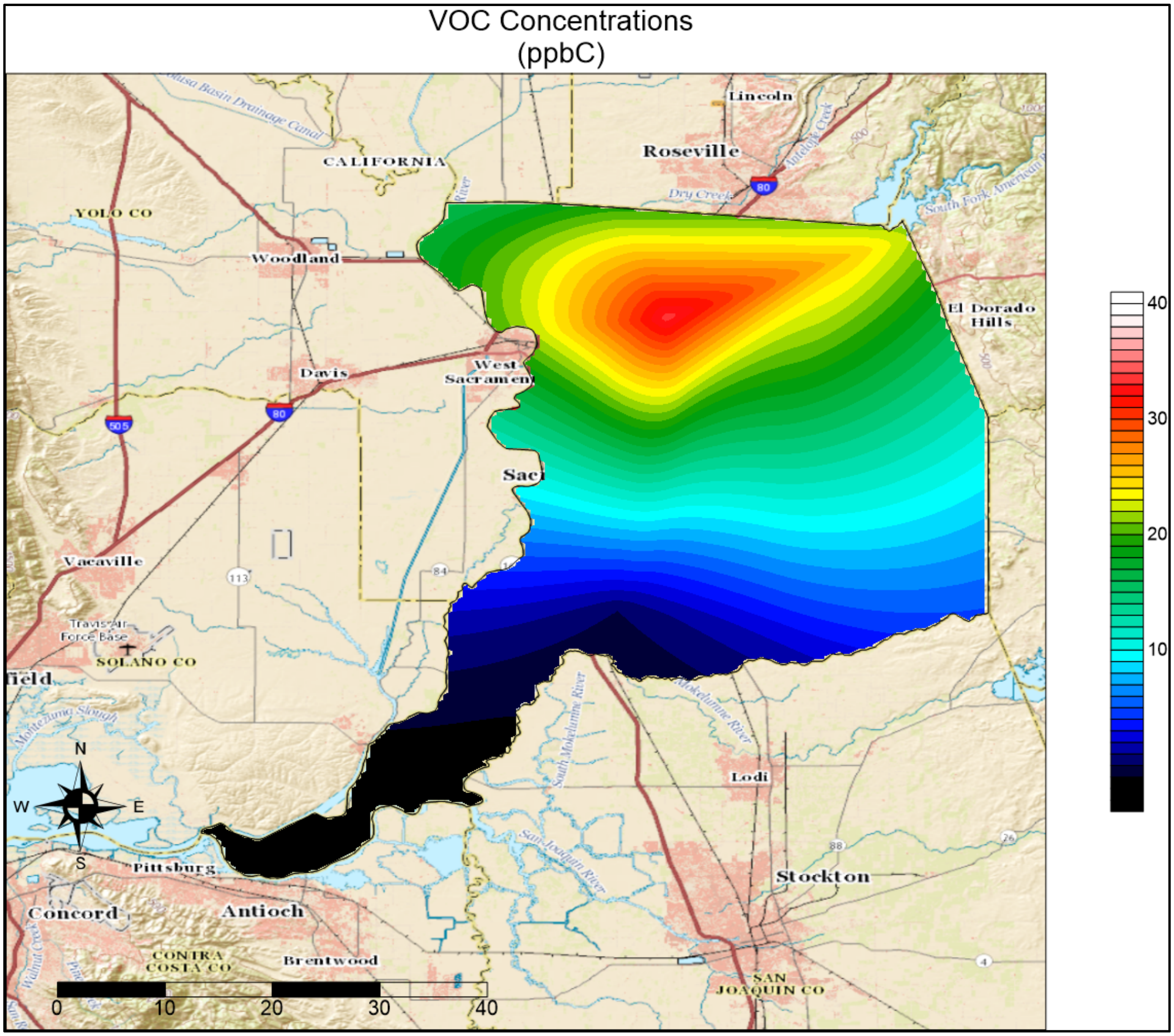

Figure C.32 VOC Concentration Grid Layer (PAMS)

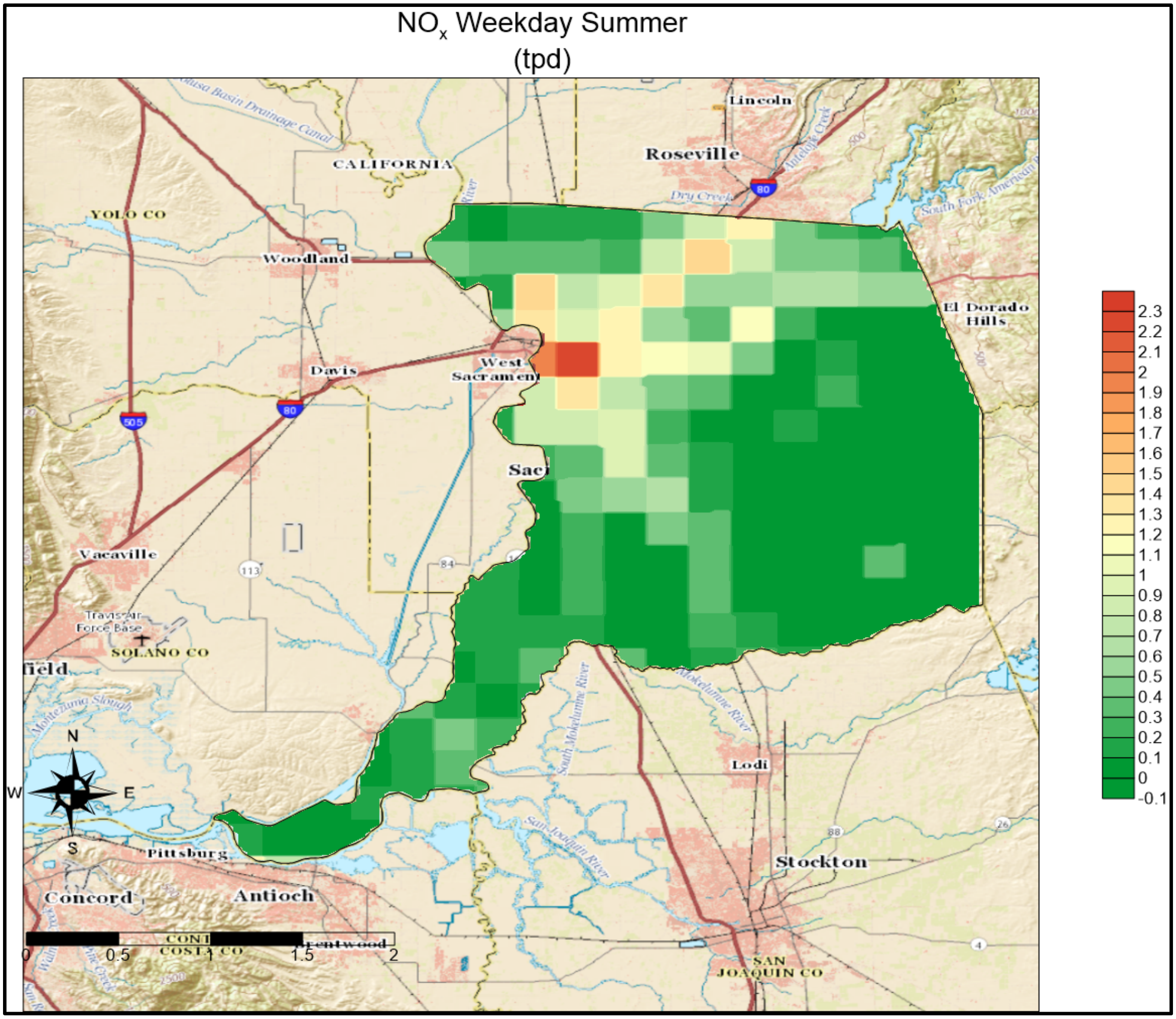

Figure C.33 NO_x Summer Weekday Emissions Grid
(1-hour NO_2, Annual NO_2, Annual $PM_{2.5}$, Ozone, PAMS)

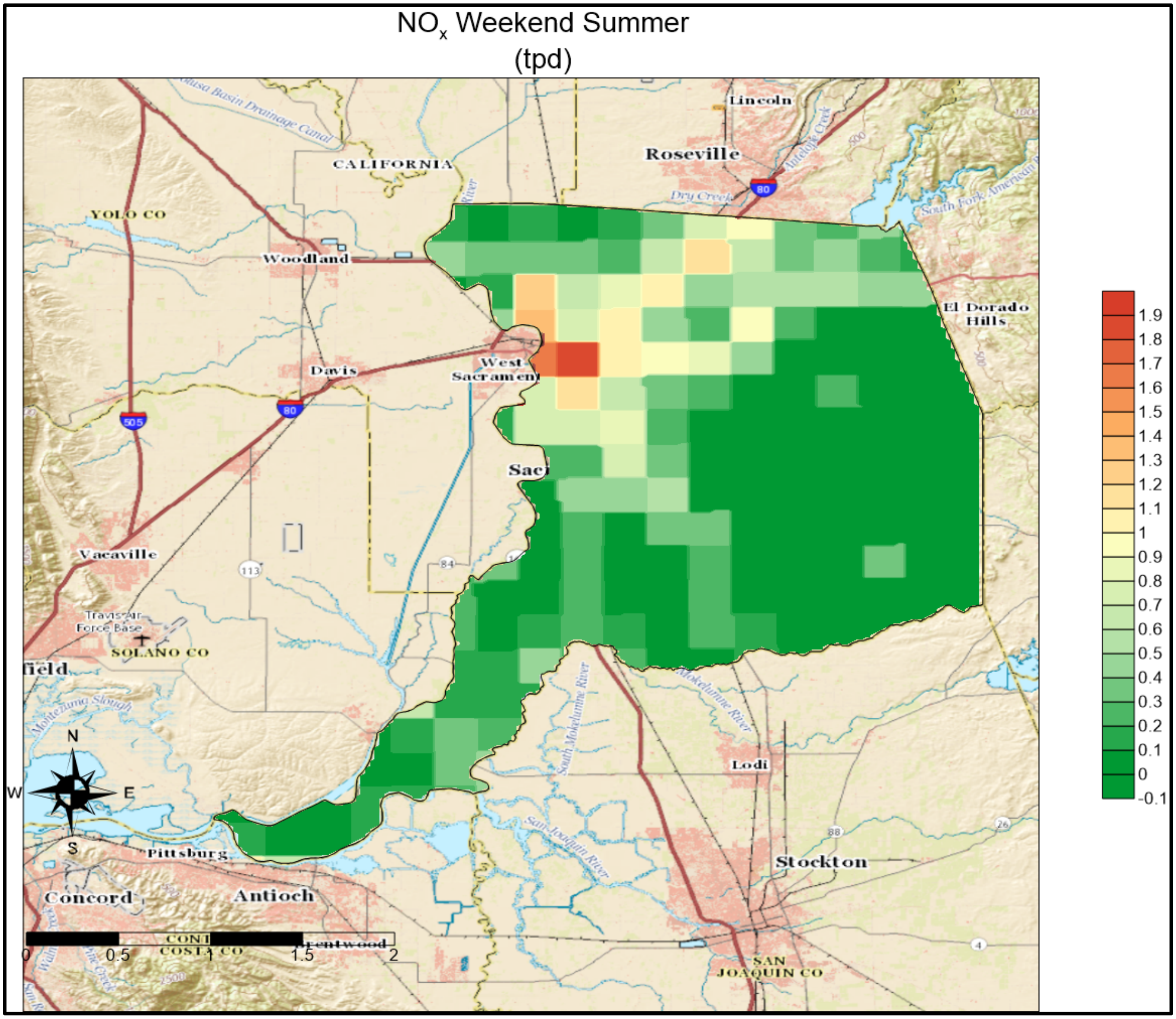

Figure C.34 NO_x Summer Weekend Emissions Grid
(1-hour NO_2, Annual NO_2, Annual $PM_{2.5}$, Ozone, PAMS)

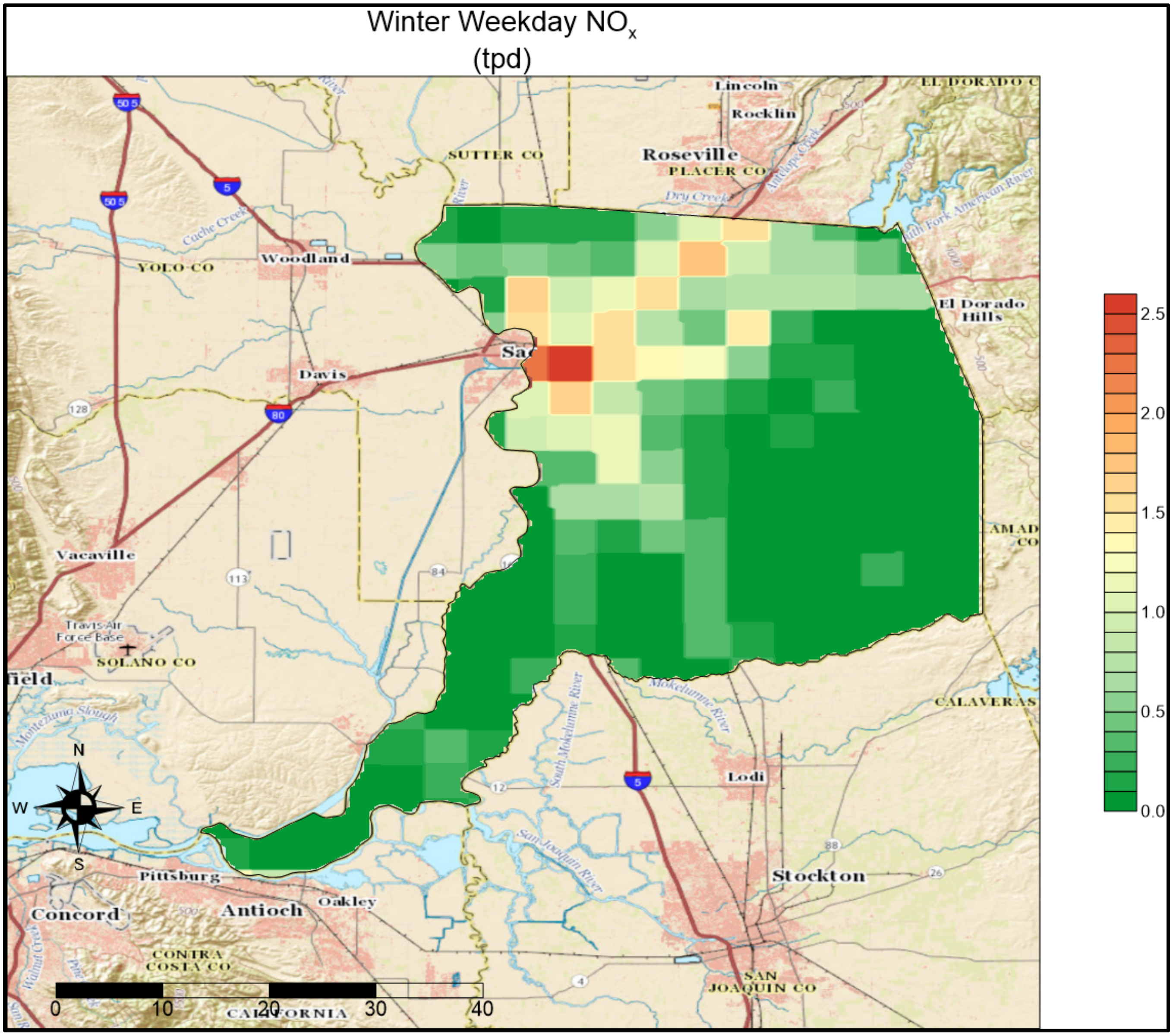

Figure C.35 NO_x Winter Weekday Emissions Grid
(1-hour NO_2, Annual NO_2, 24-hour $PM_{2.5}$, Annual $PM_{2.5}$)

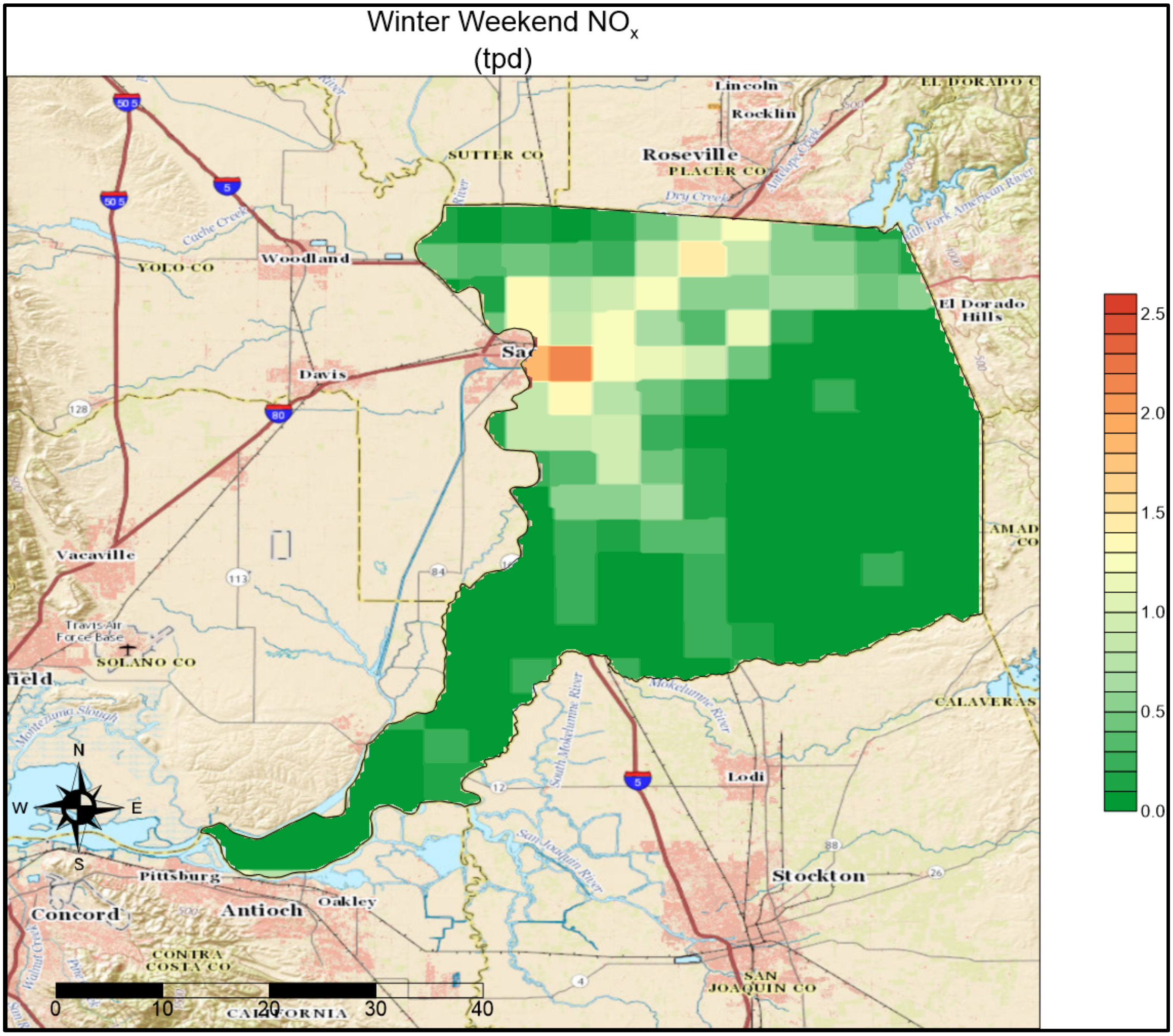

Figure C.36 NO_x Winter Weekend Emissions Grid
(1-hour NO_2, Annual NO_2, 24-hour $PM_{2.5}$, Annual $PM_{2.5}$)

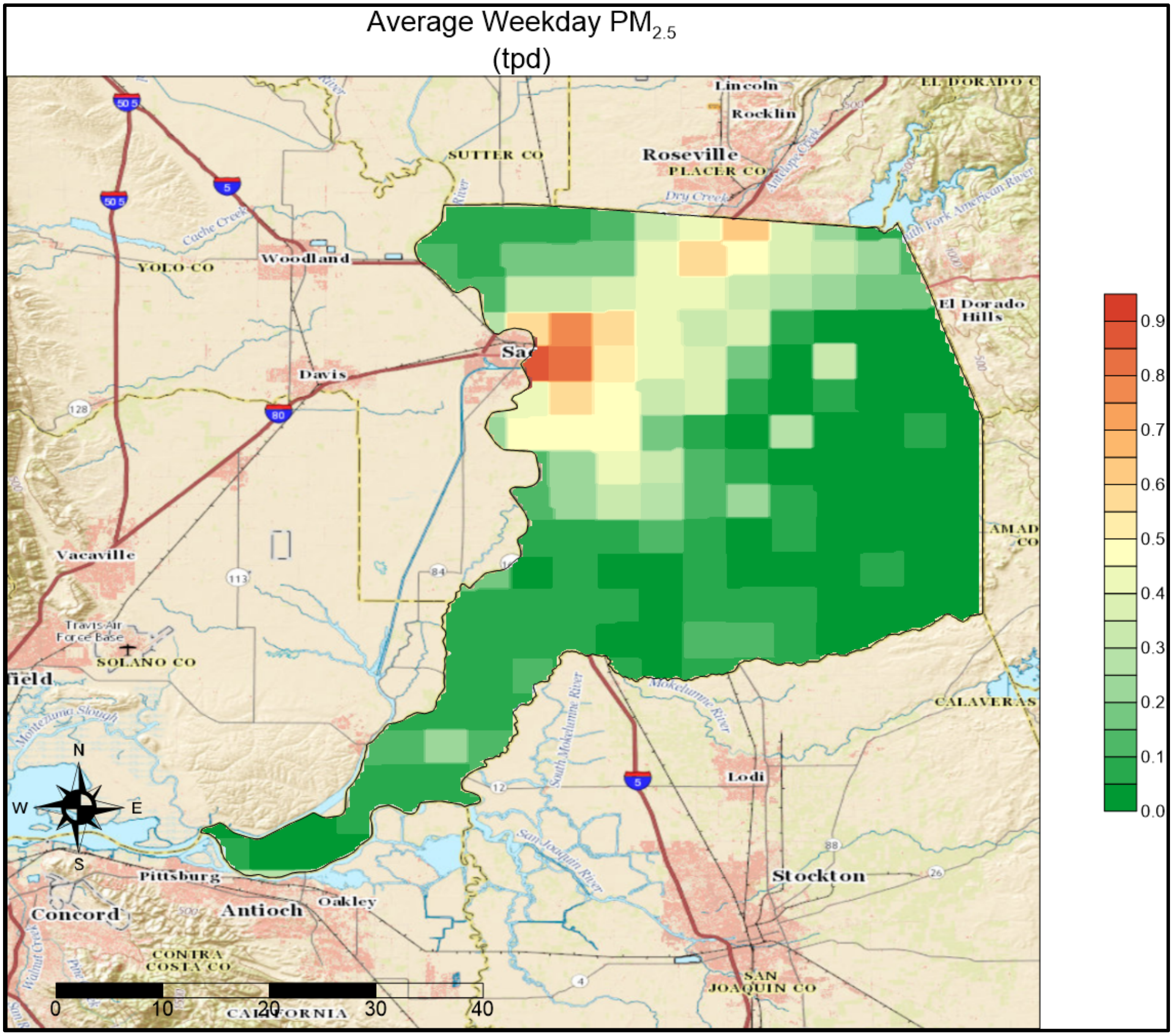

Figure C.37 $PM_{2.5}$ Average Weekday (Summer & Winter) Emissions Grid (Annual $PM_{2.5}$)

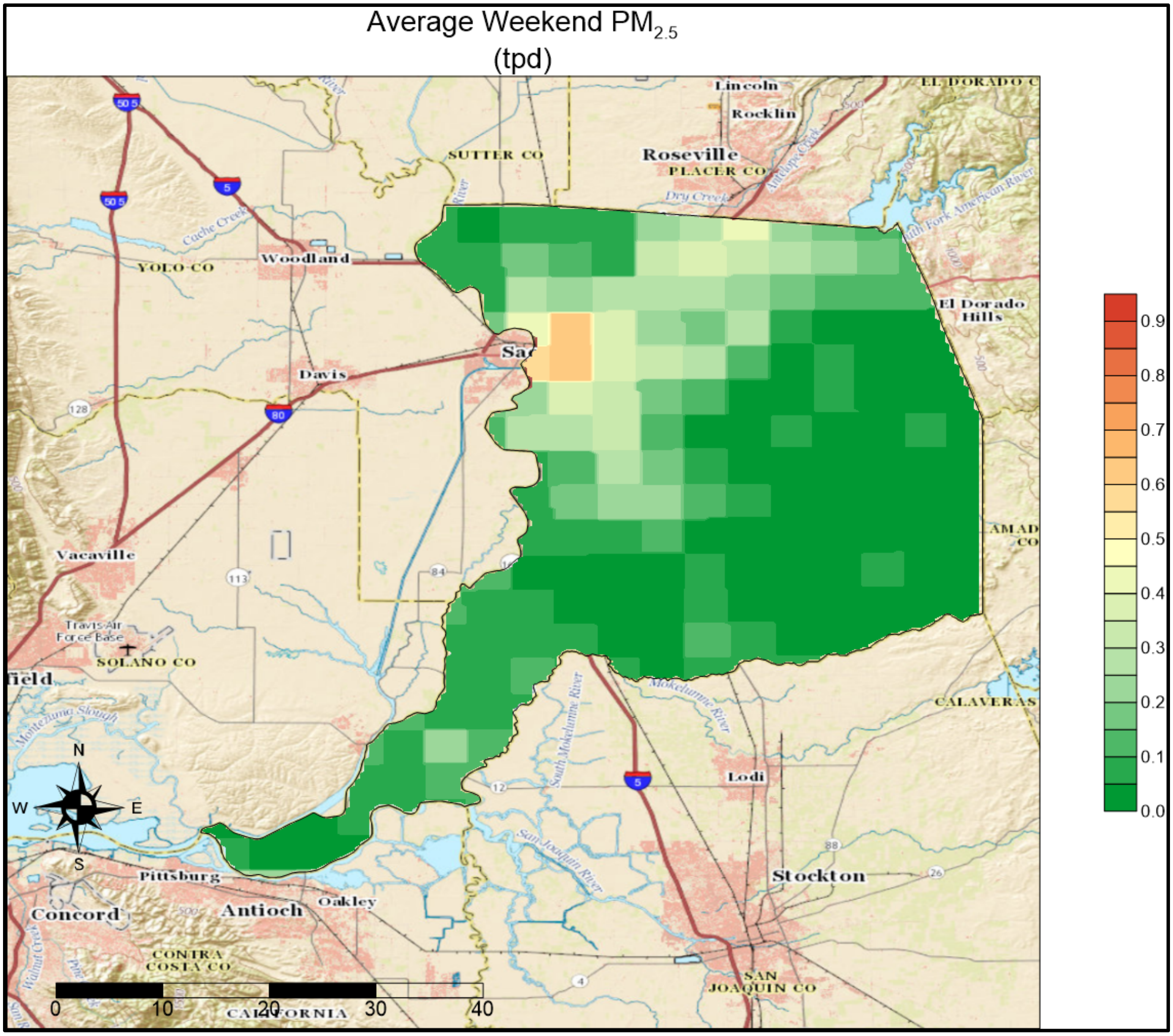

Figure C.38 $PM_{2.5}$ Average Weekend (Summer & Winter) Emissions Grid (Annual $PM_{2.5}$)

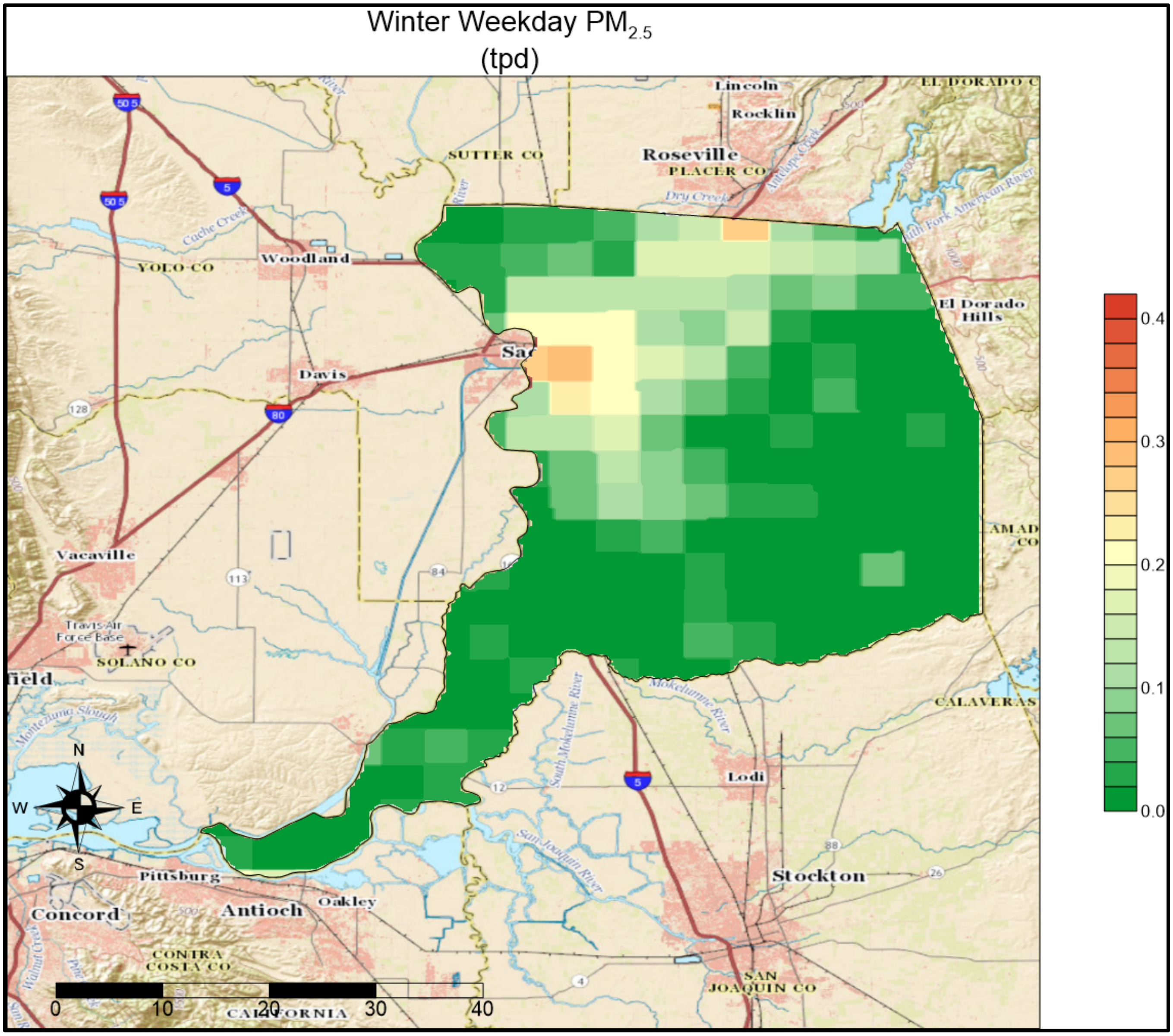

Figure C.39 $PM_{2.5}$ Winter Weekday Emissions Grid (24-hour $PM_{2.5}$)

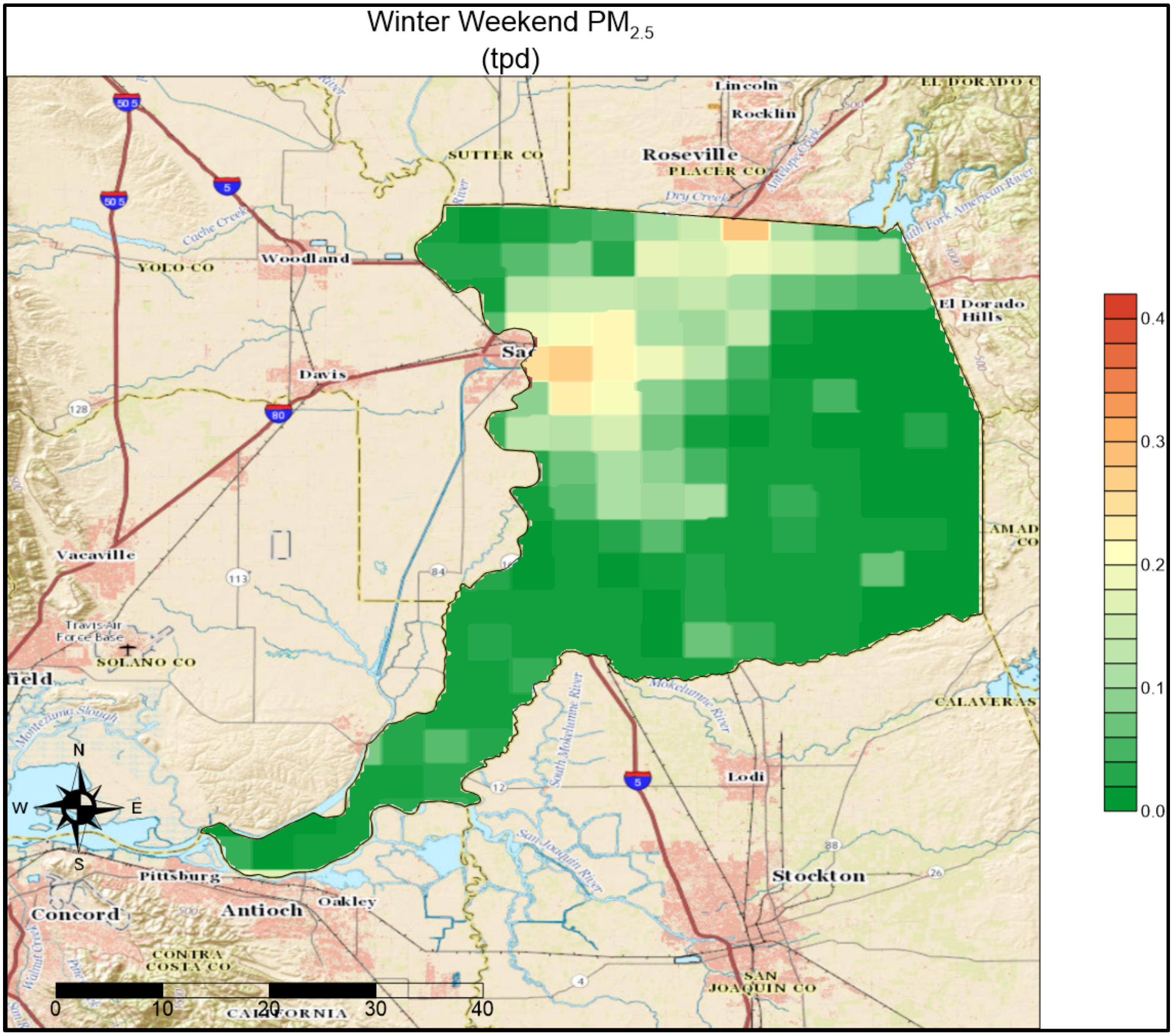

Figure C.40 $PM_{2.5}$ Winter Weekend Emissions Grid (24-hour $PM_{2.5}$, Annual $PM_{2.5}$)

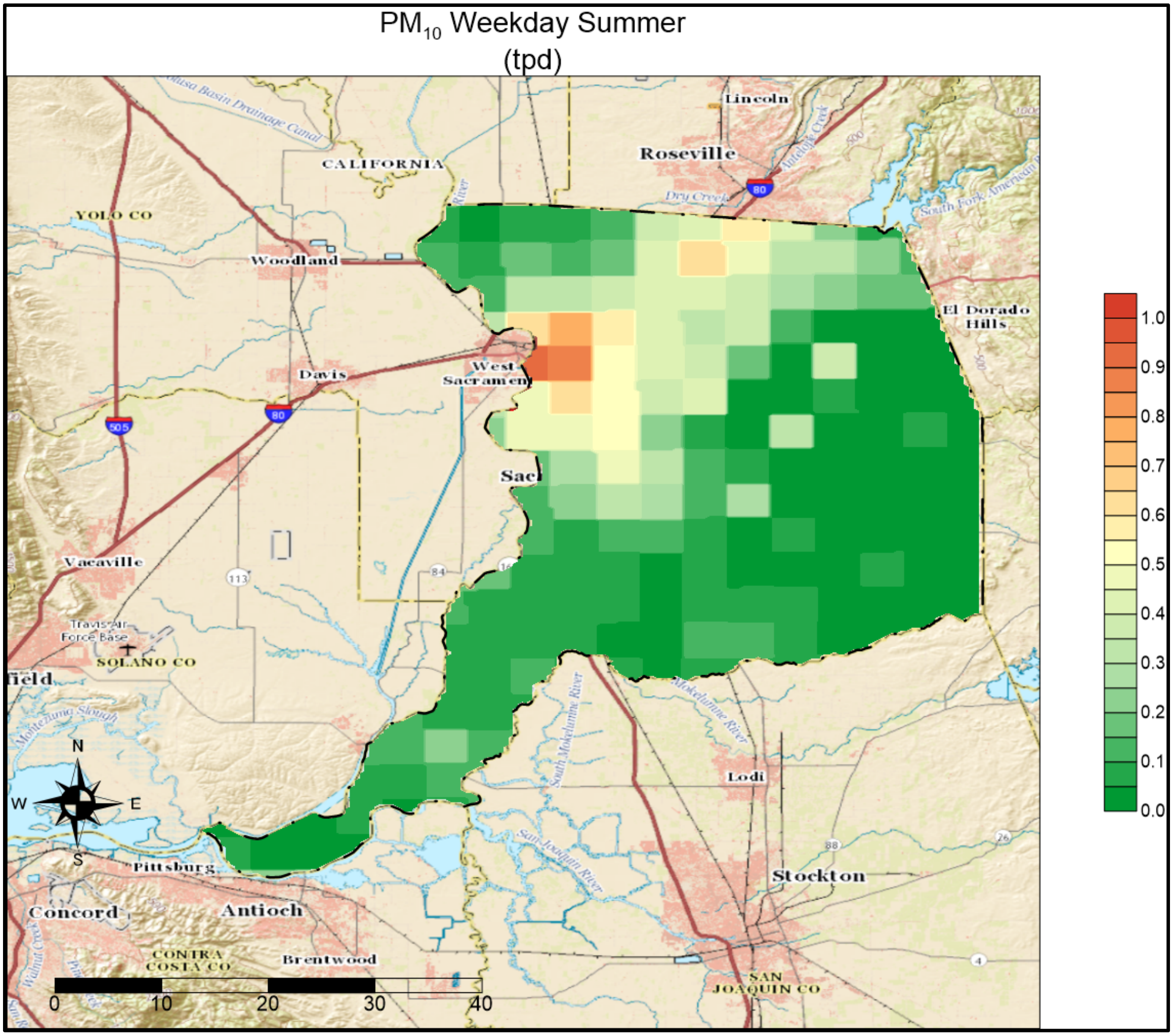

Figure C.41 PM$_{10}$ Summer Weekday Emissions Grid (PM$_{10}$)

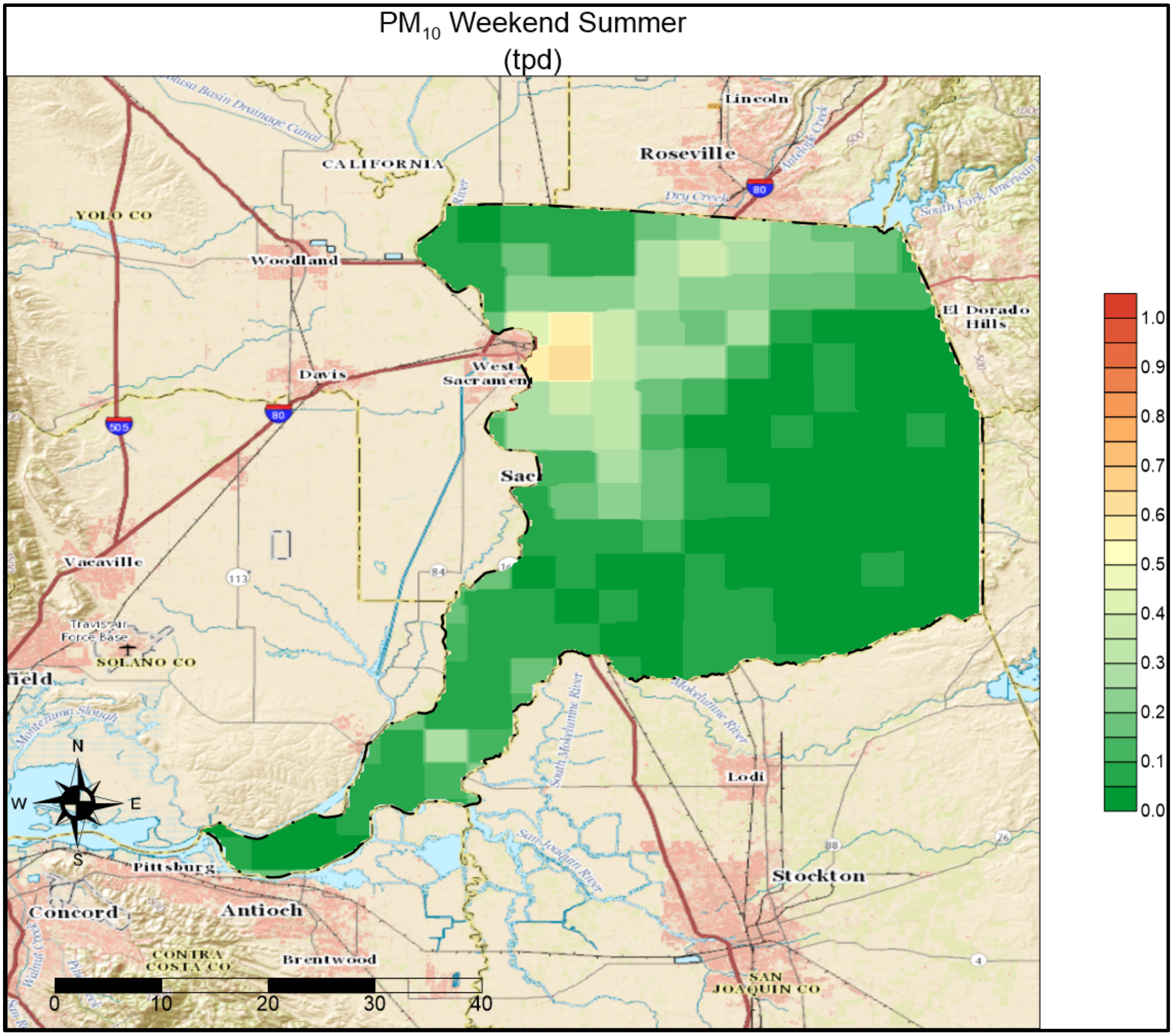

Figure C.42 PM_{10} Summer Weekend Emissions Grid (PM_{10})

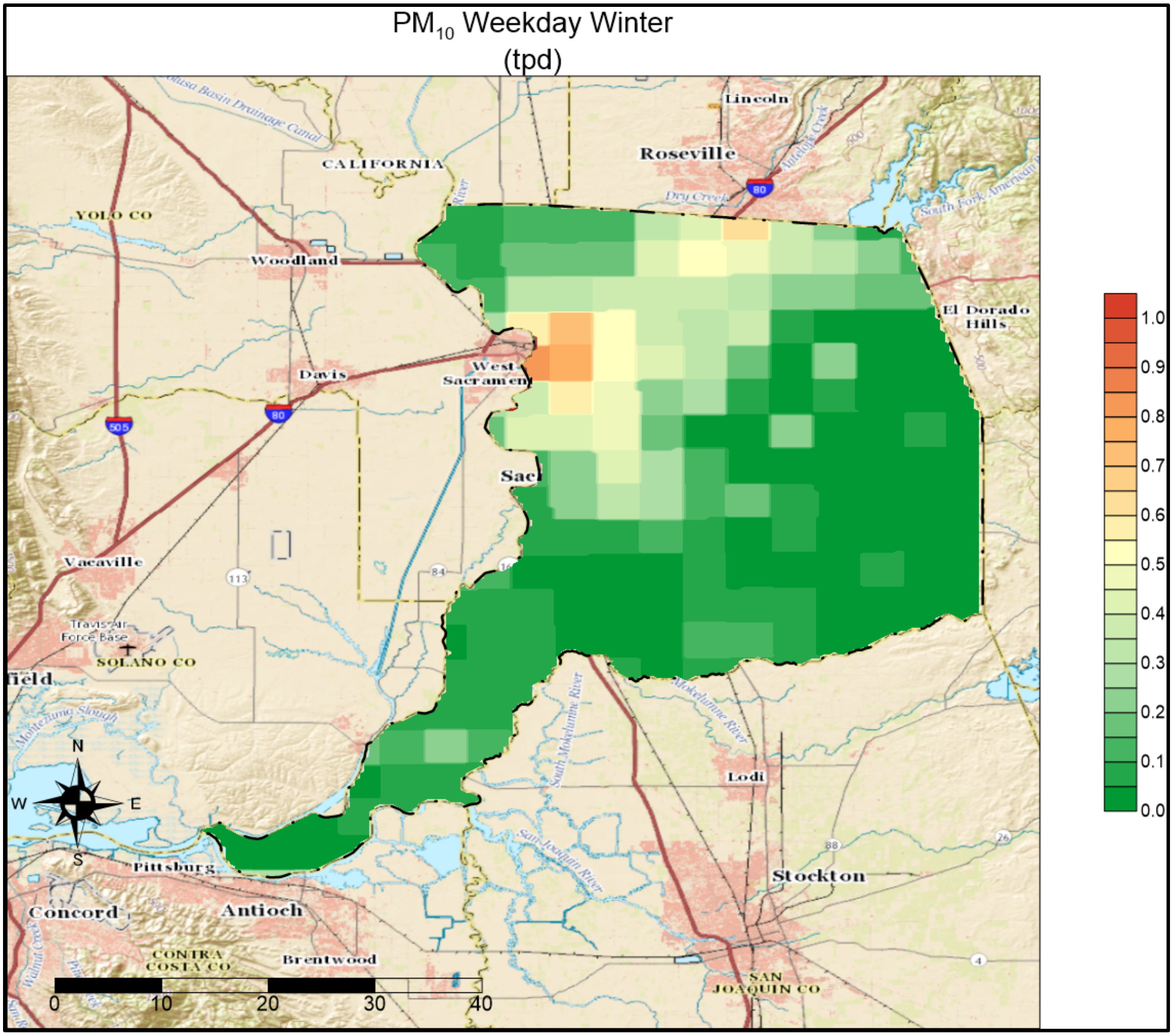

Figure C.43 PM_{10} Winter Weekday Emissions Grid (PM_{10})

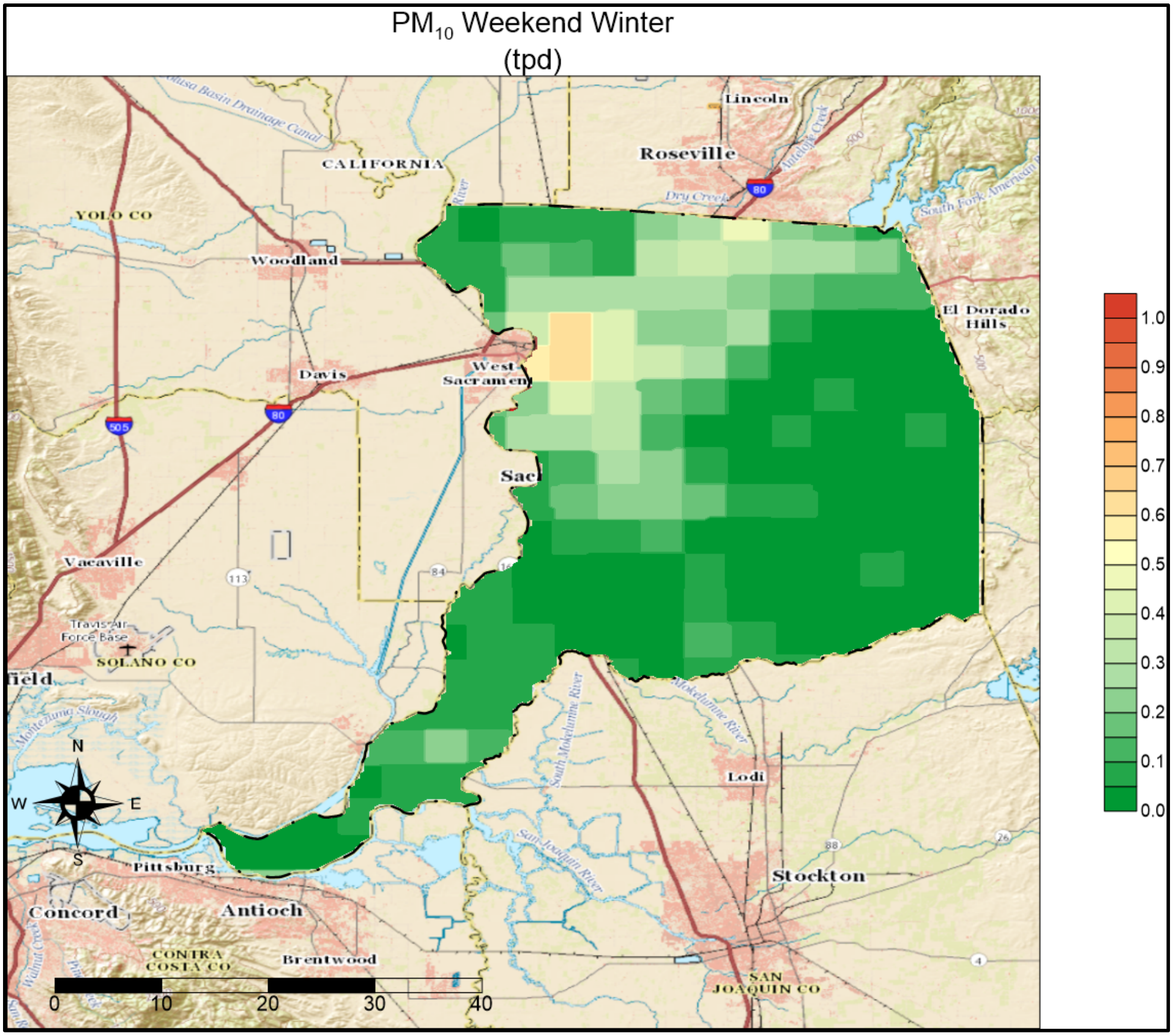

Figure C.44 PM_{10} Winter Weekend Emissions Grid (PM_{10})

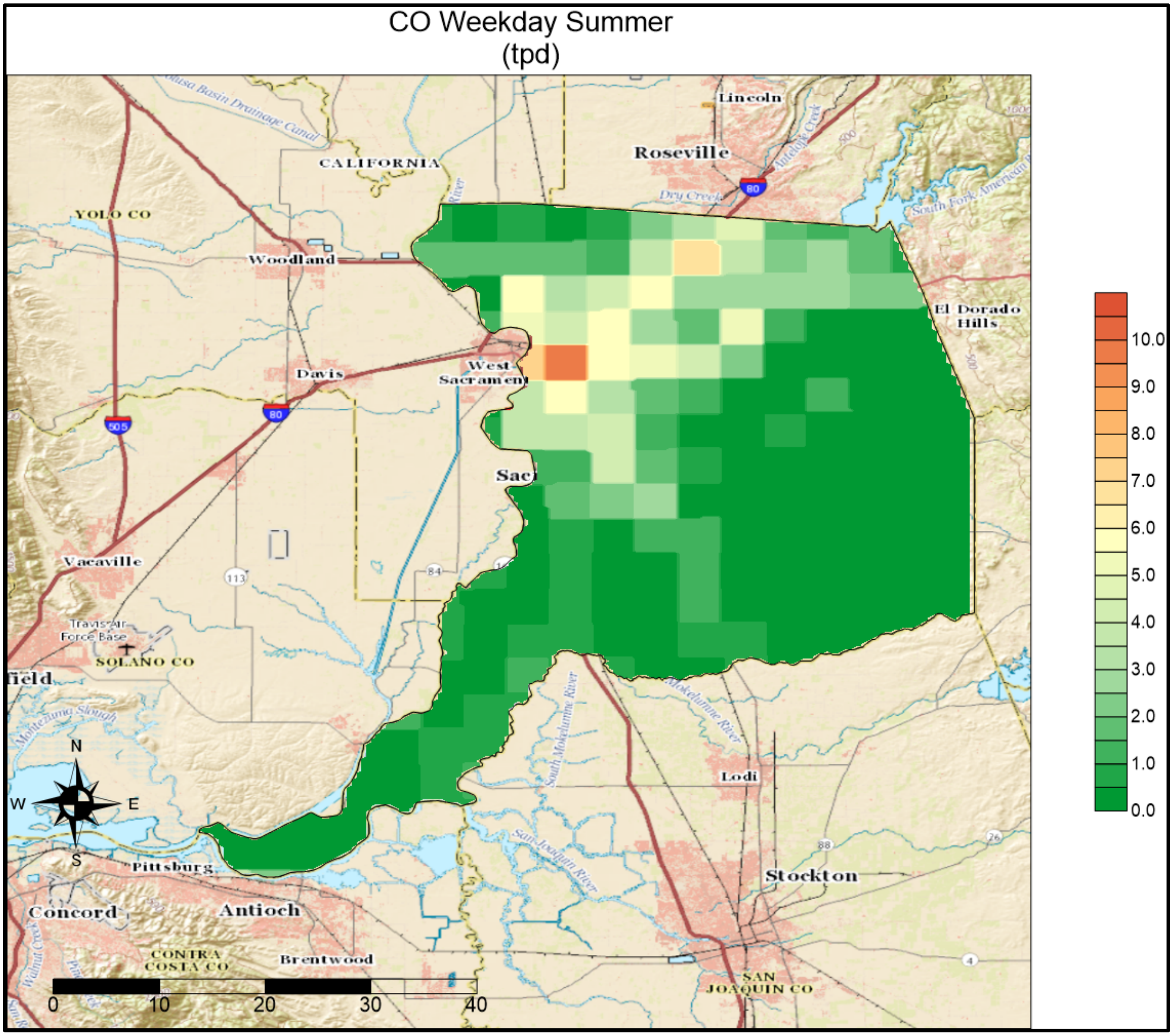

Figure C.45 CO Summer Weekday Emissions Grid (1-hour CO, 8-hour CO)

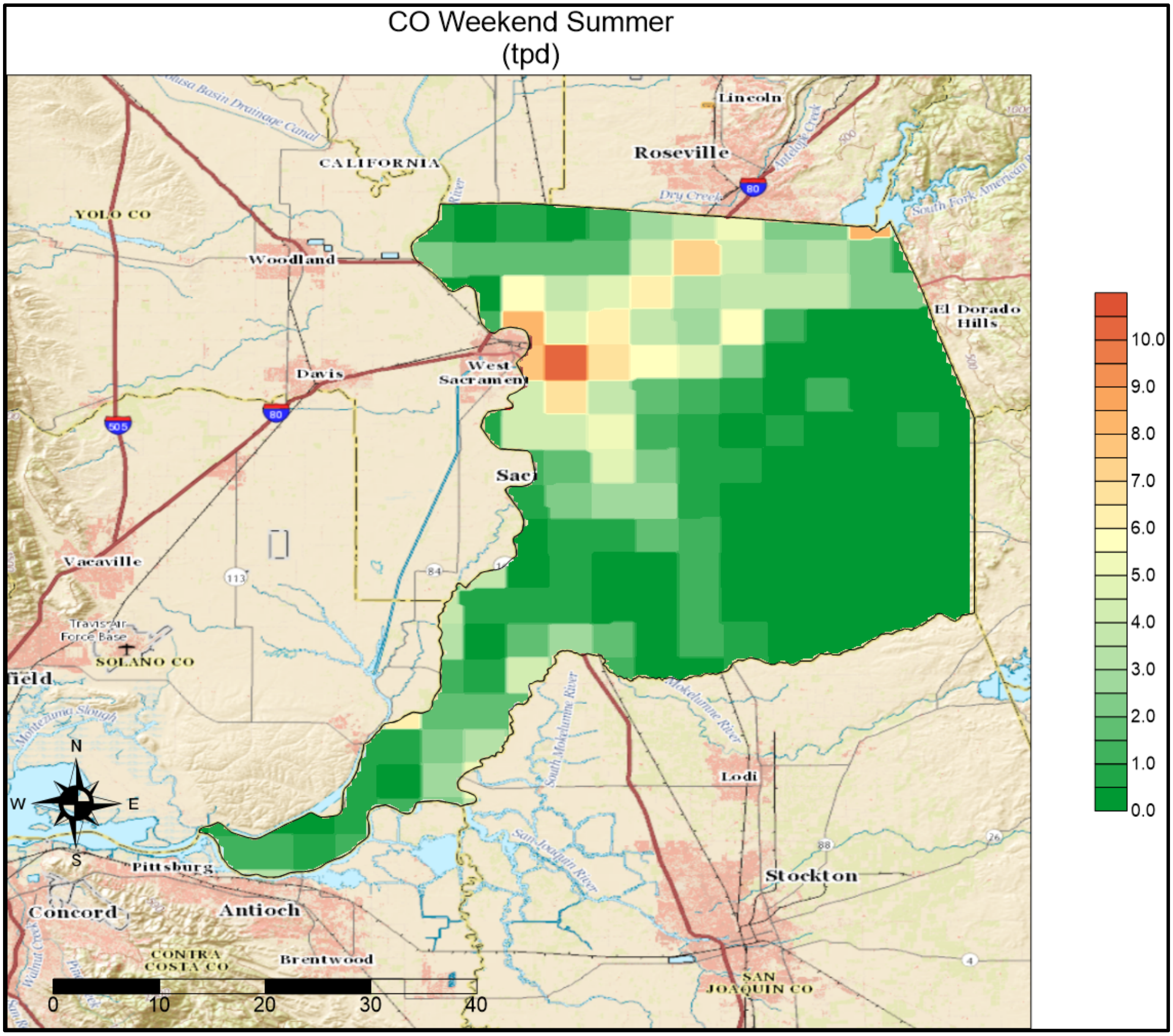

Figure C.46 CO Summer Weekend Emissions Grid (1-hour CO, 8-hour CO)*

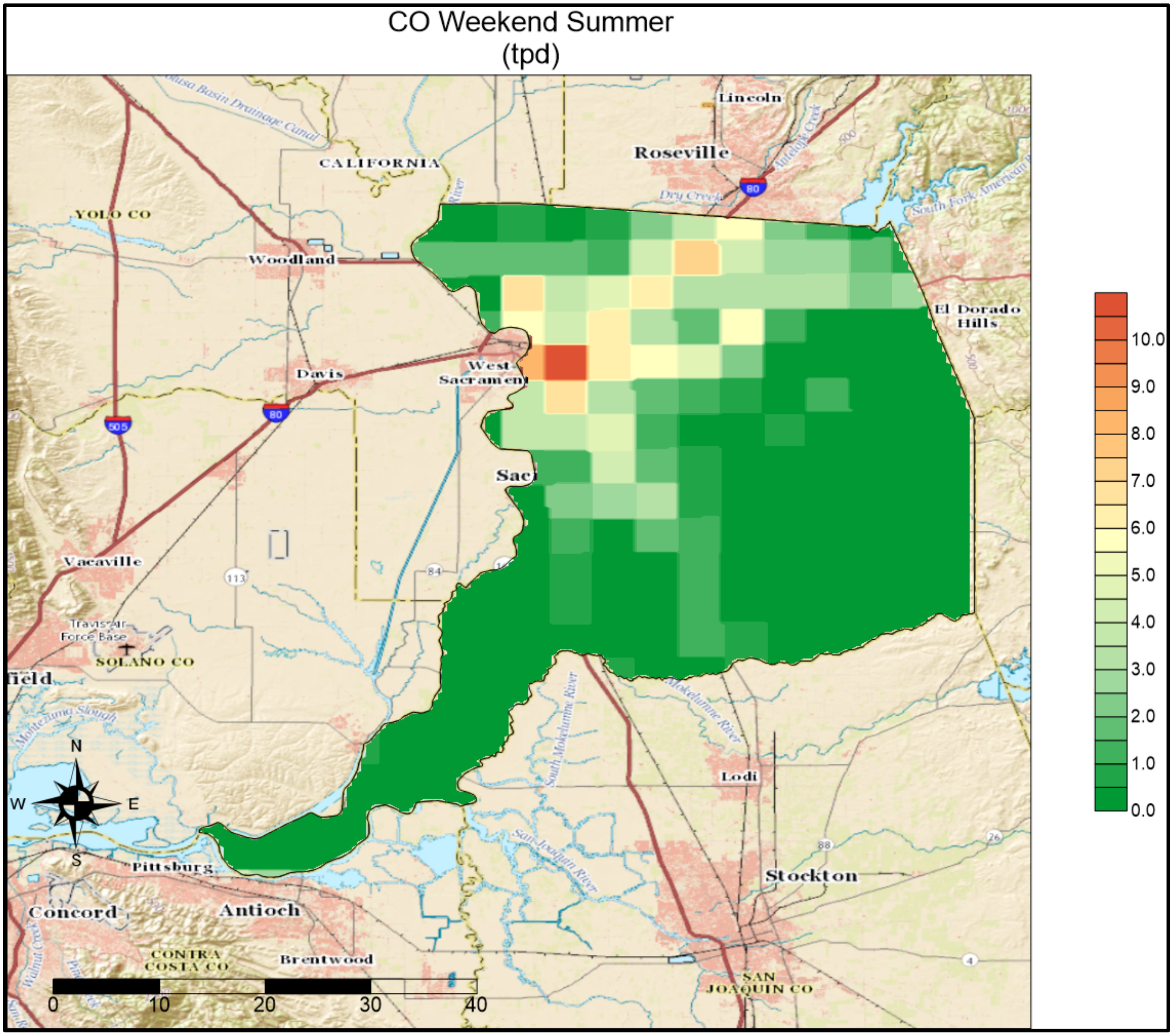

Figure C.47 CO Winter Weekday Emissions Grid (1-hour CO, 8-hour CO)

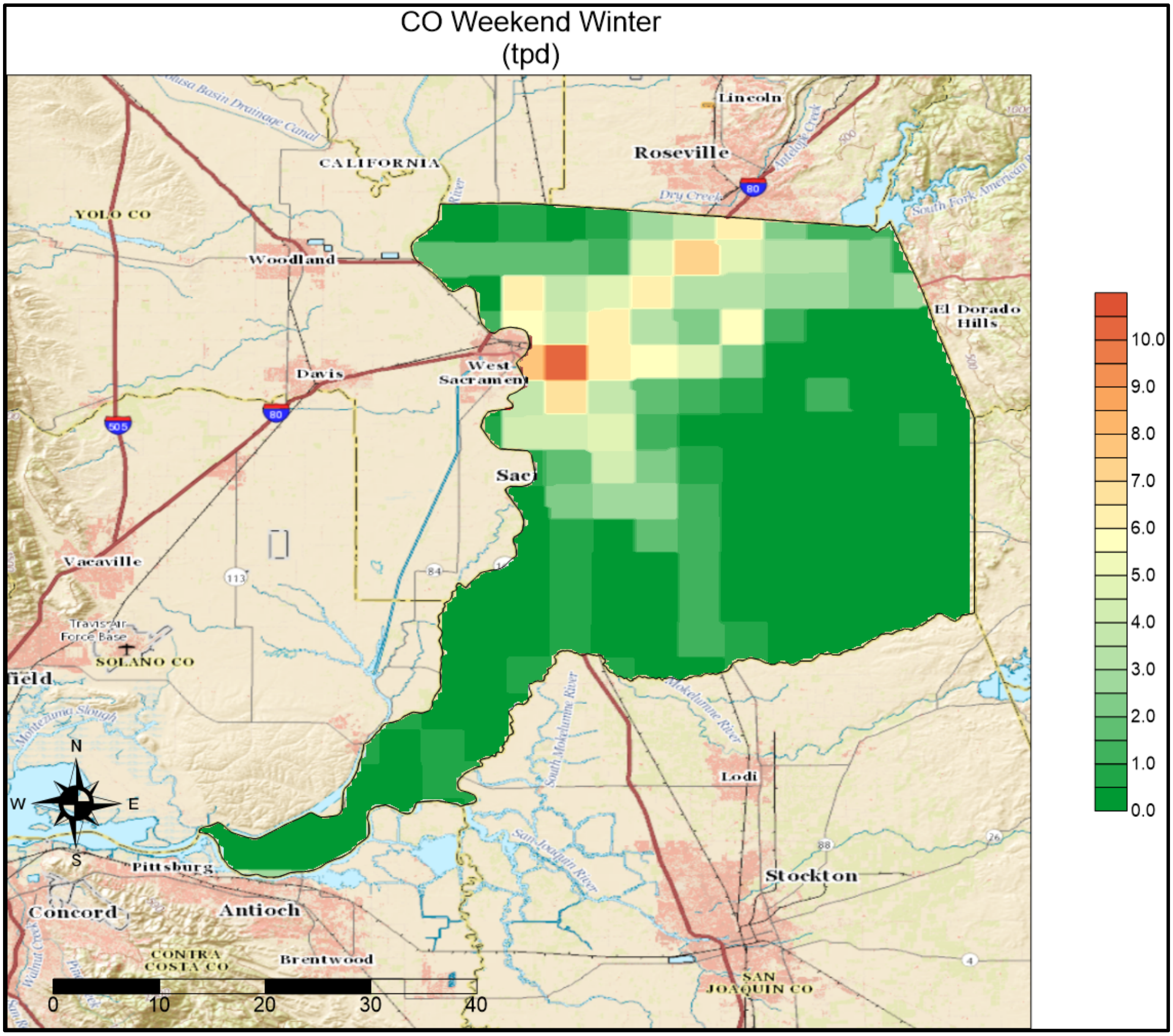

Figure C.48 CO Winter Weekend Emissions Grid (1-hour CO, 8-hour CO)

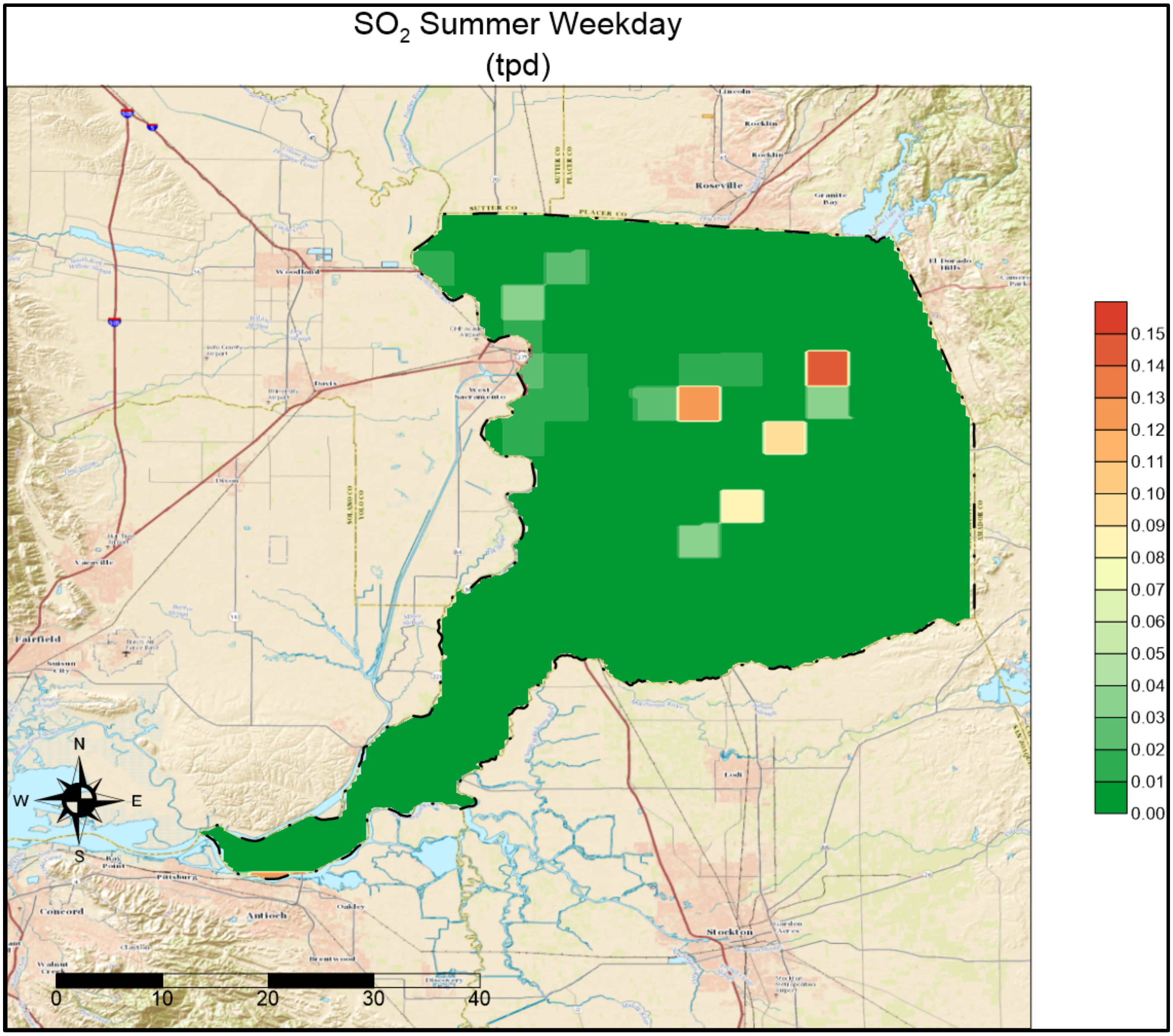

Figure C.49 SO_2 Summer Weekday Emissions Grid (1-hour SO_2)

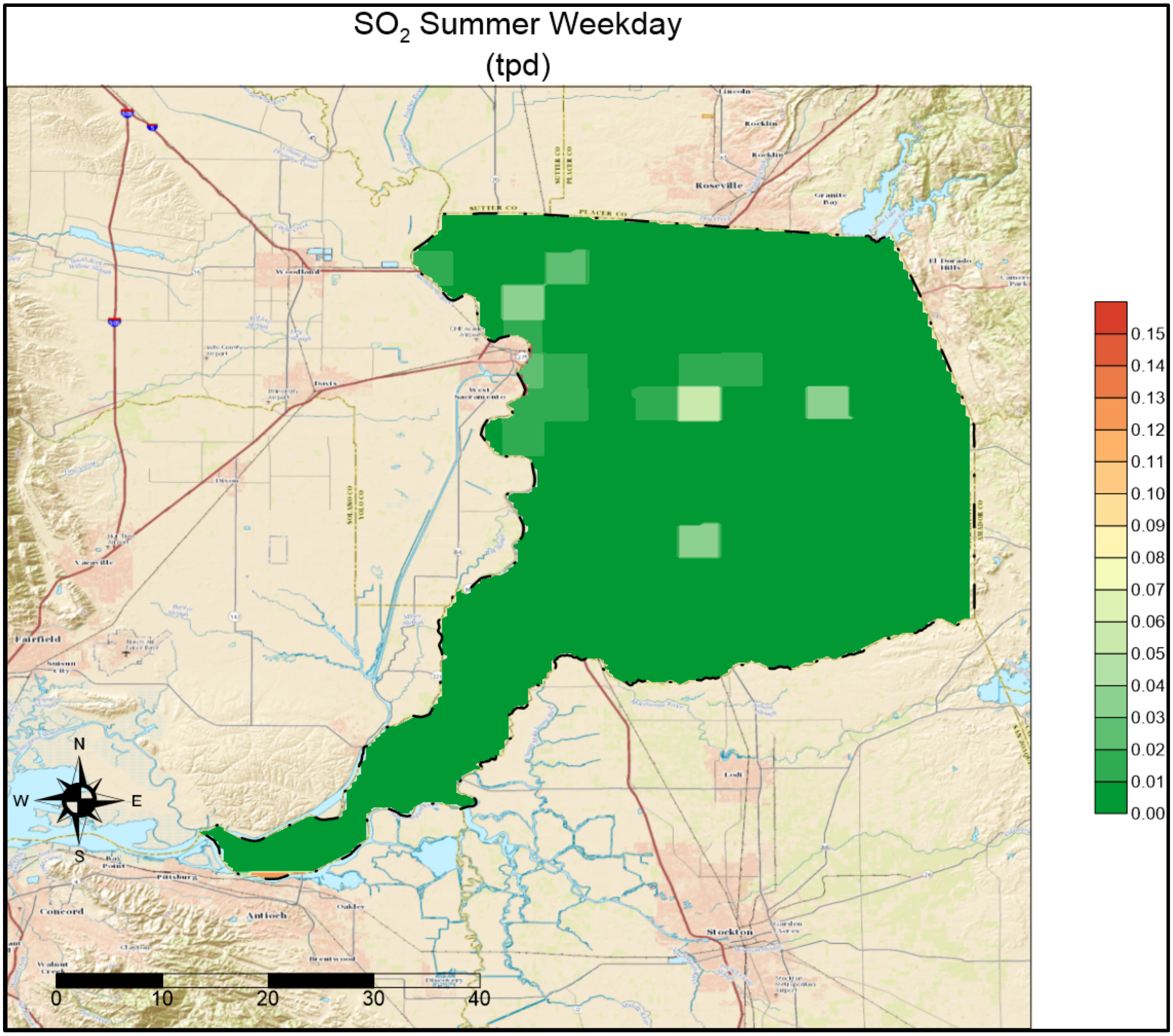

Figure C.50 SO_2 Summer Weekend Emissions Grid (1-hour SO_2)

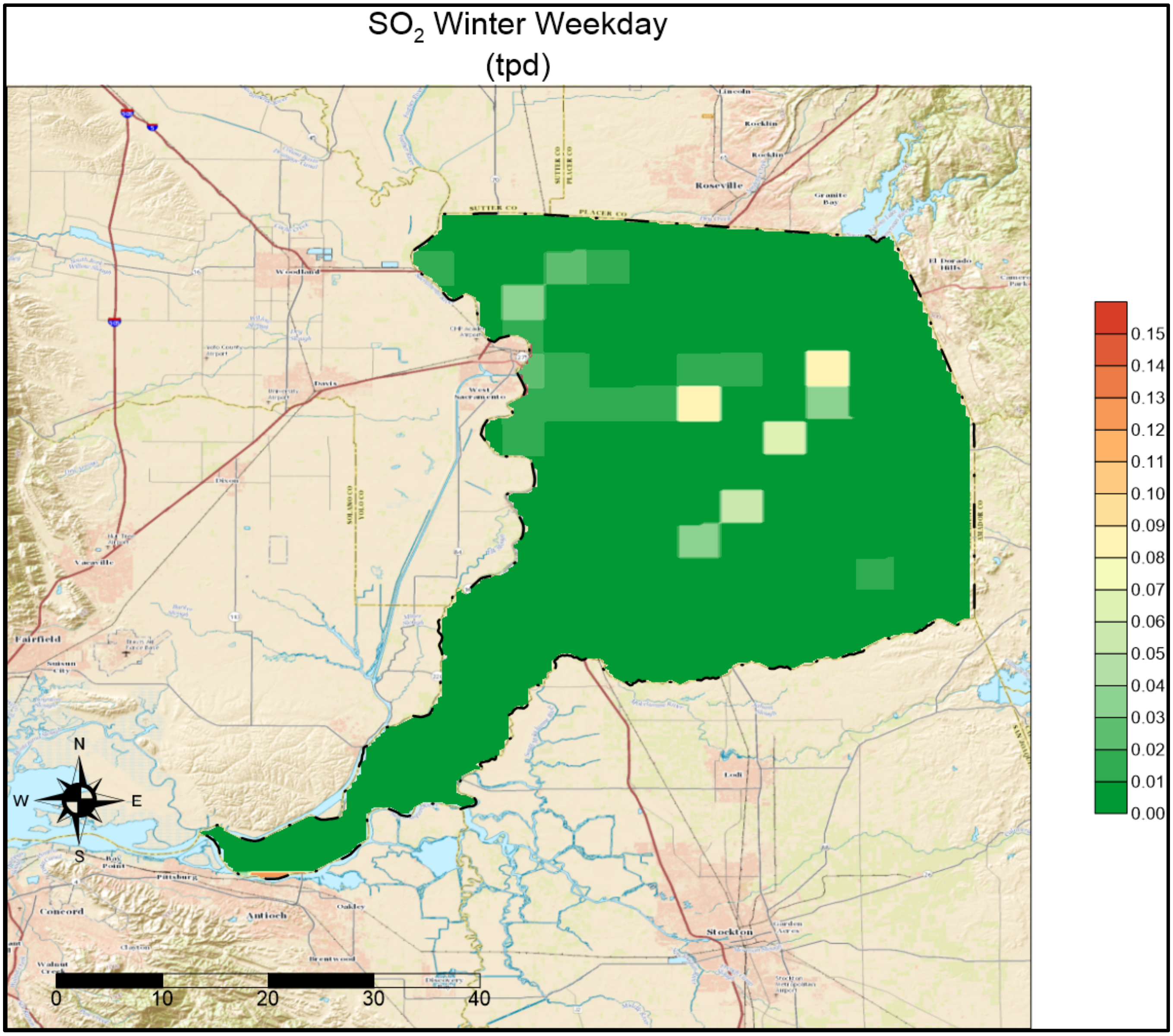

Figure C.51 SO_2 Winter Weekday Emissions Grid (1-hour SO_2)

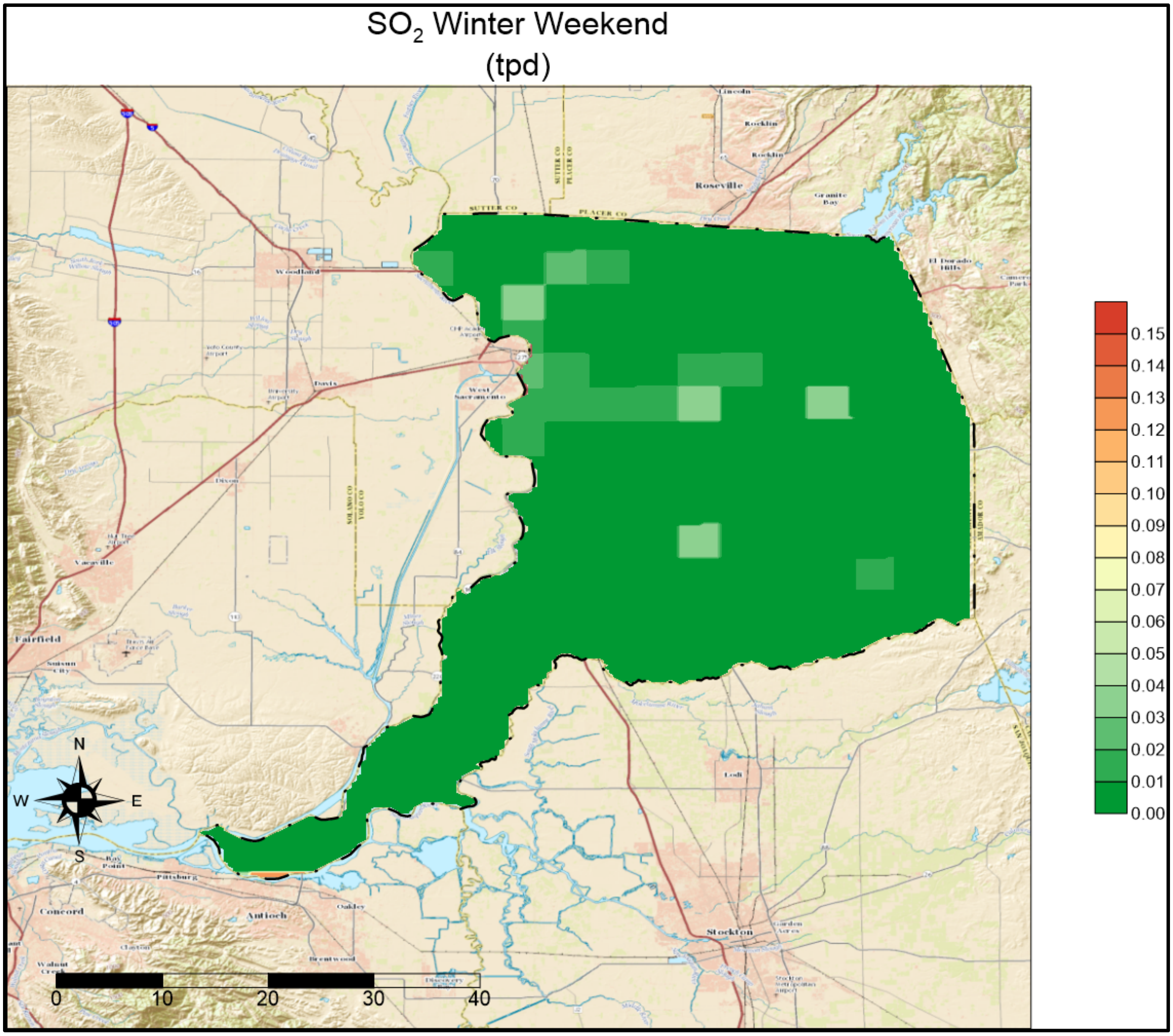

Figure C.52 SO$_2$ Winter Weekend Emissions Grid (1-hour SO$_2$)

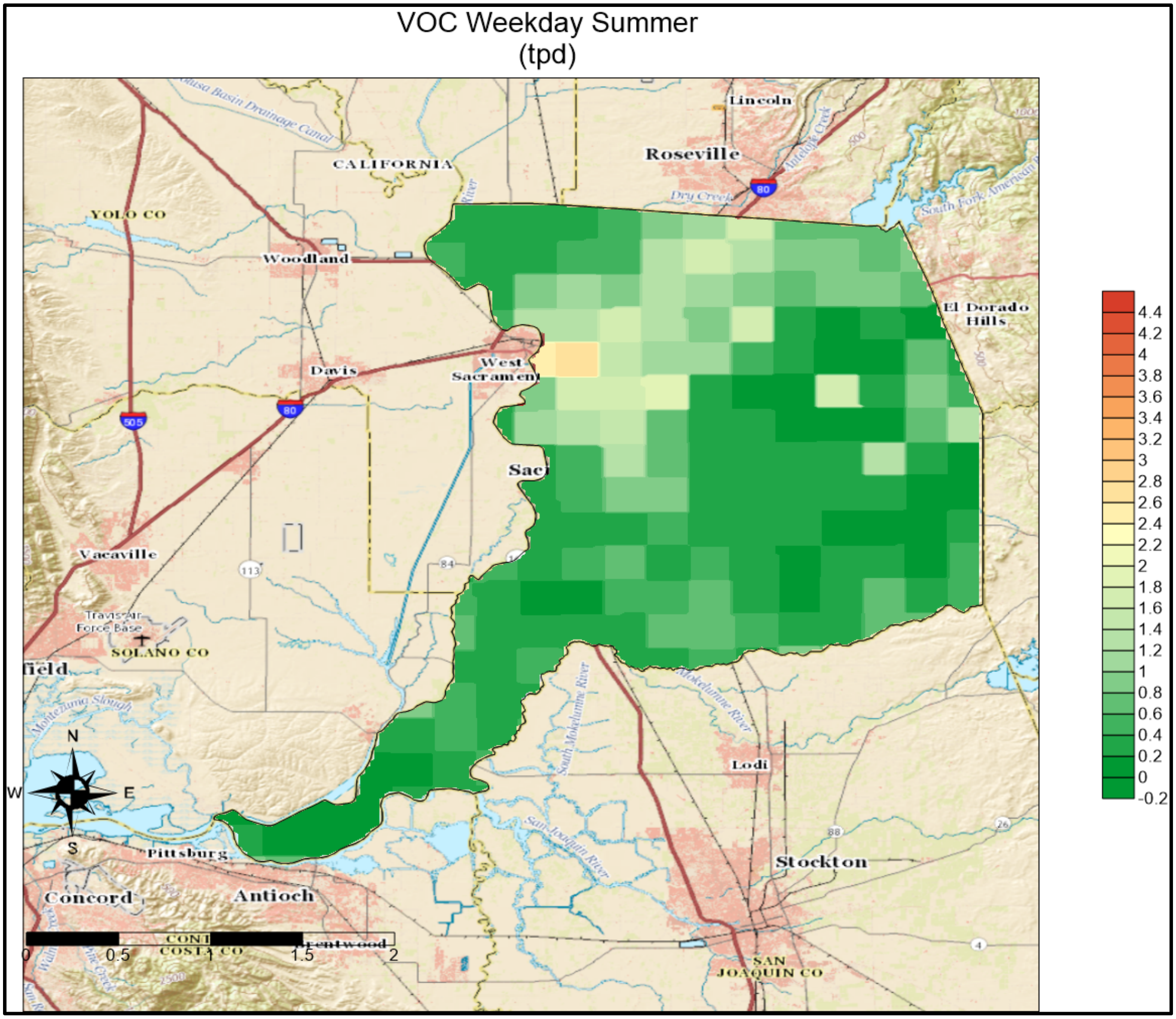

Figure C.53 VOC Summer Weekday Emissions Grid (Ozone, Annual $PM_{2.5}$, PAMS)

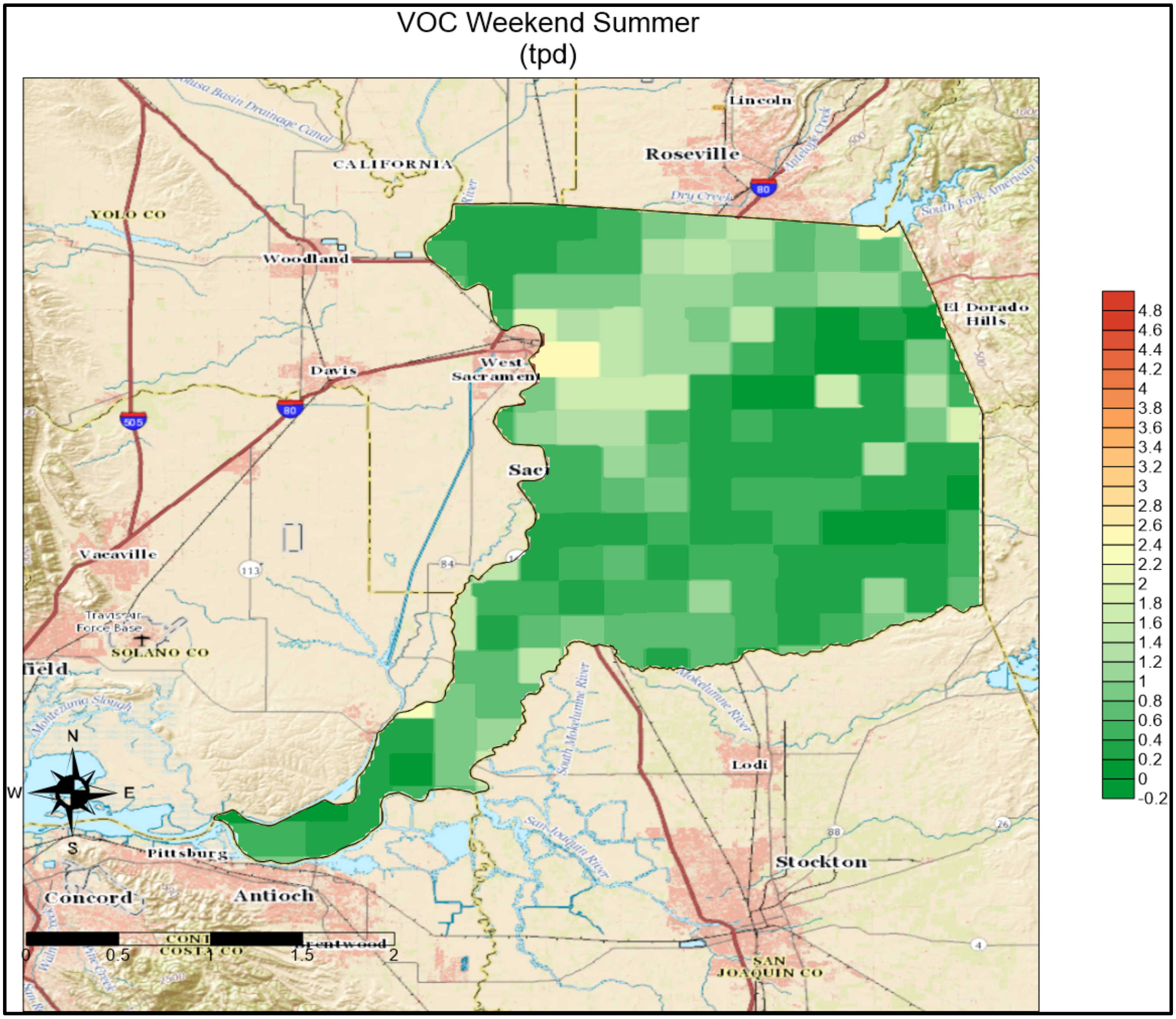

Figure C.54 VOC Summer Weekend Emissions Grid (Ozone, Annual $PM_{2.5}$, PAMS)

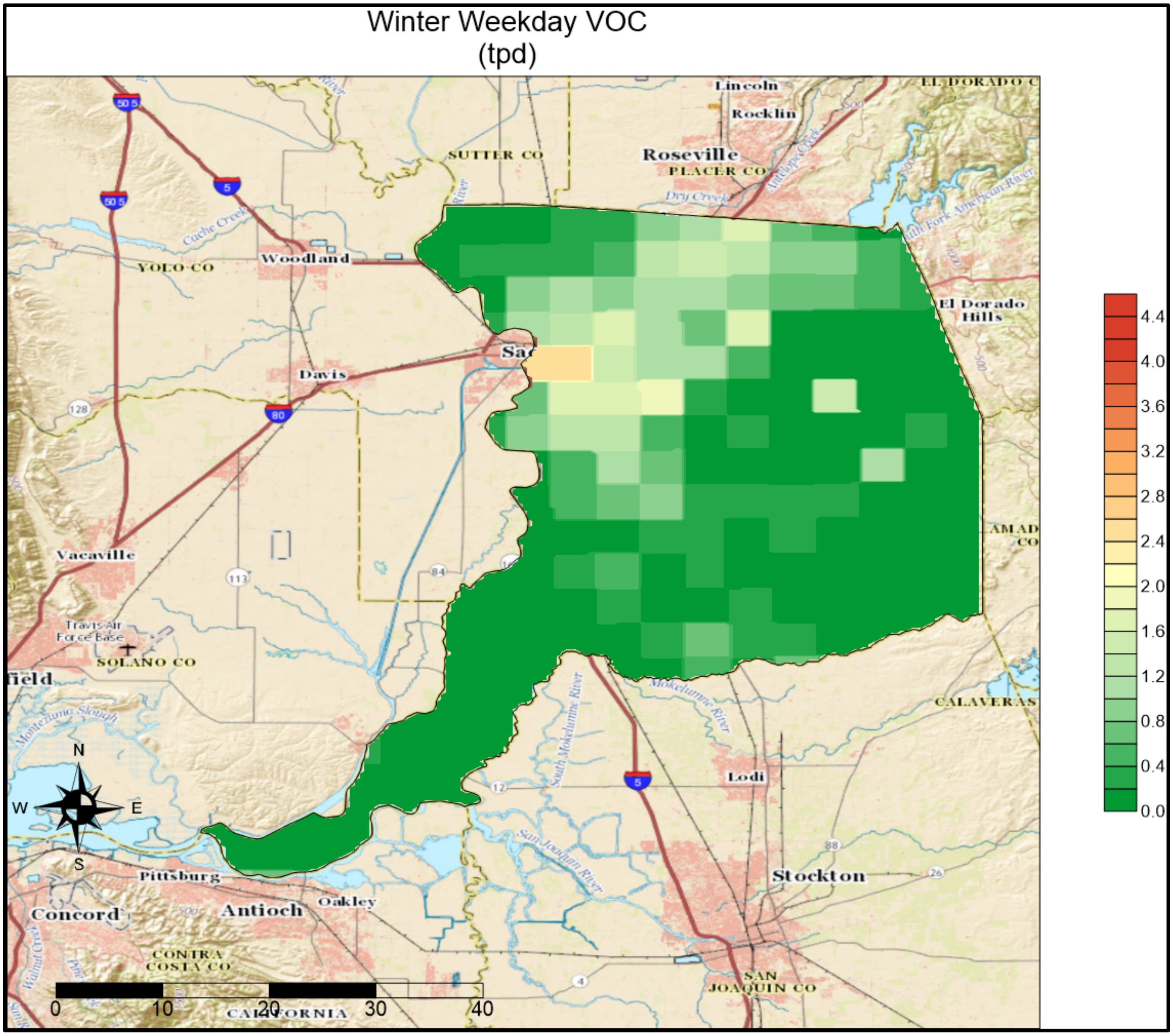

Figure C.55 VOC Winter Weekday Emissions Grid (24-hour $PM_{2.5}$, Annual $PM_{2.5}$)

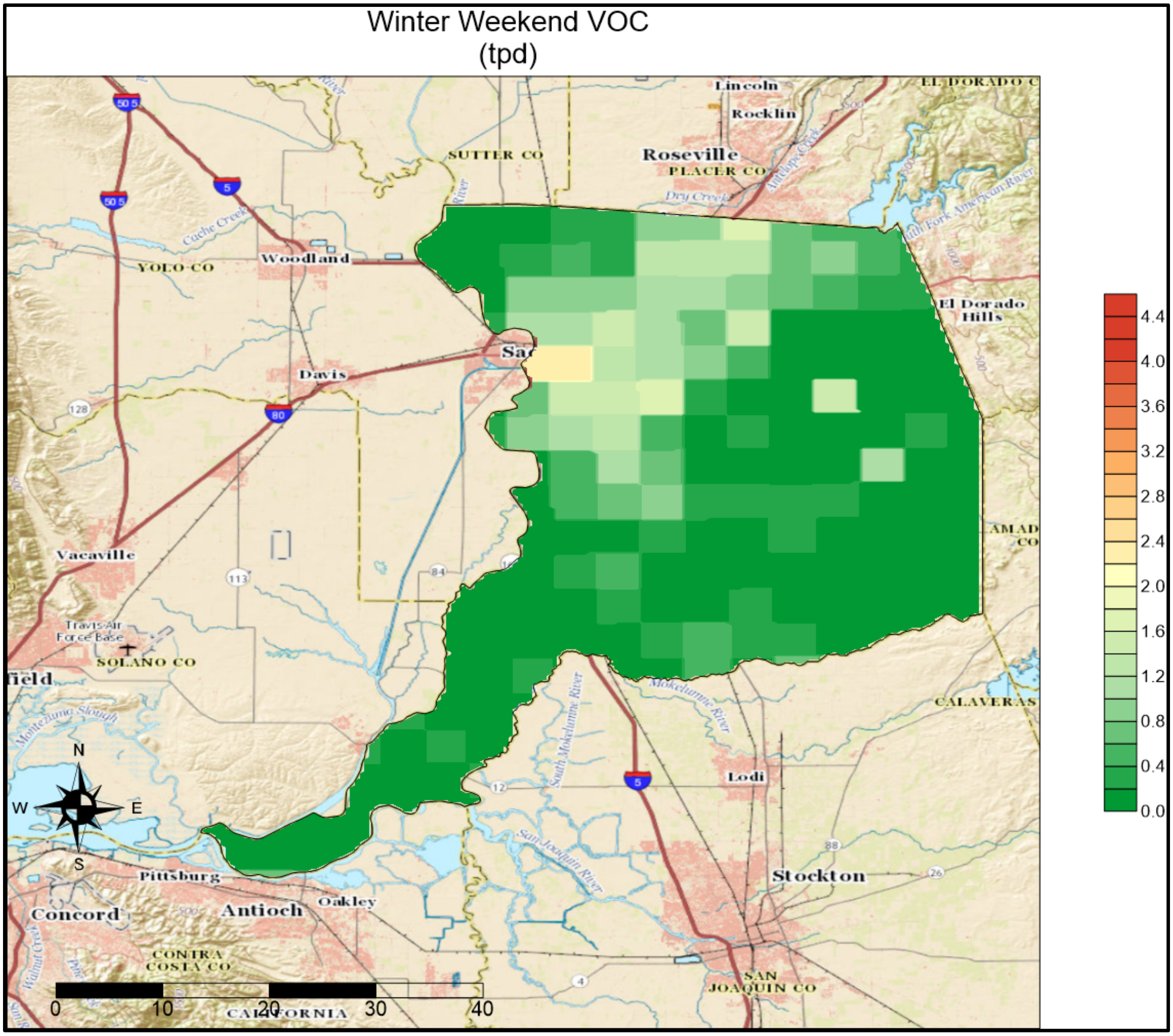

Figure C.56 VOC Winter Weekend Emissions Grid (24-hour $PM_{2.5}$, Annual $PM_{2.5}$)

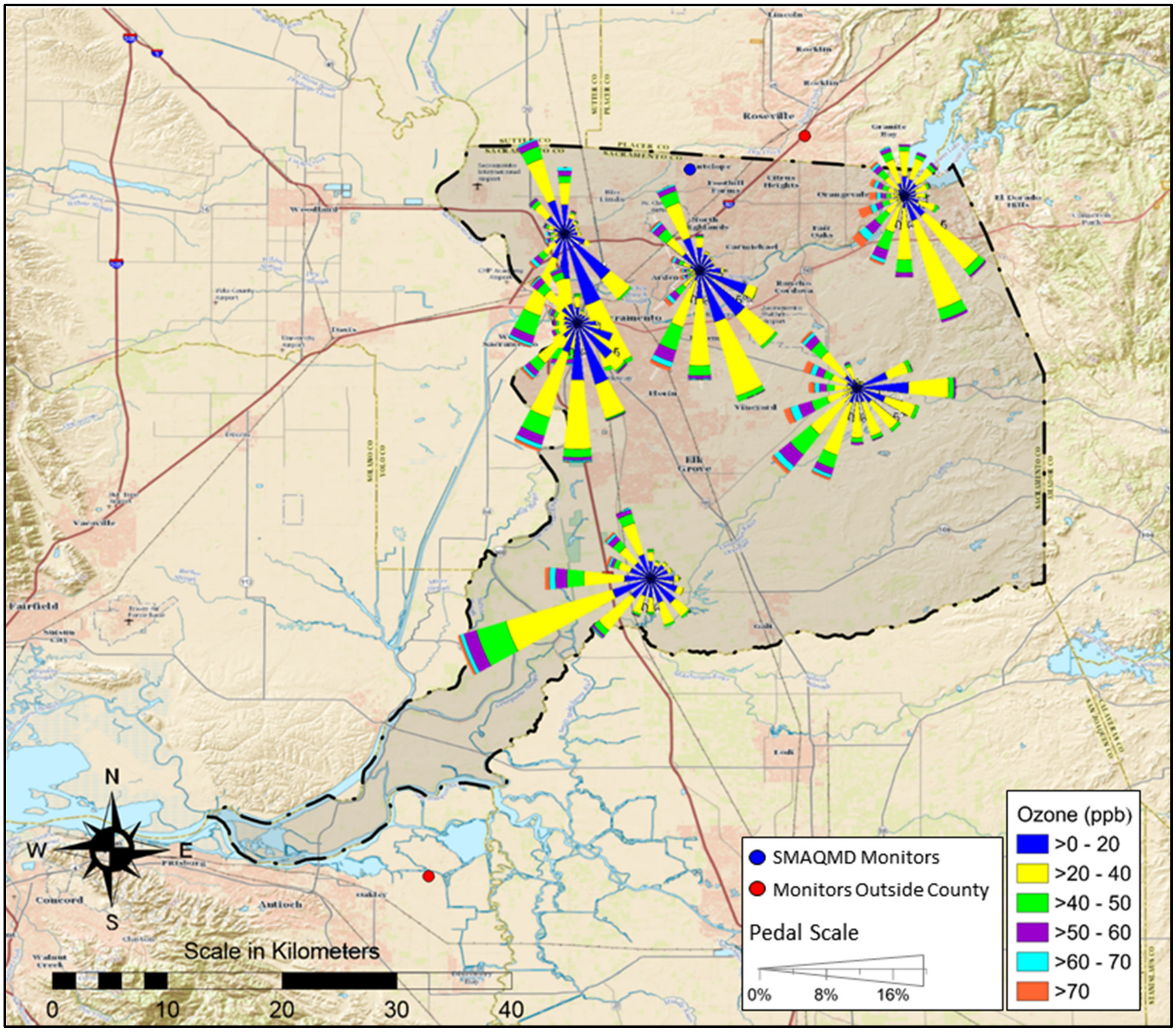

Figure D.1 Ozone Pollutant Rose (Annual)

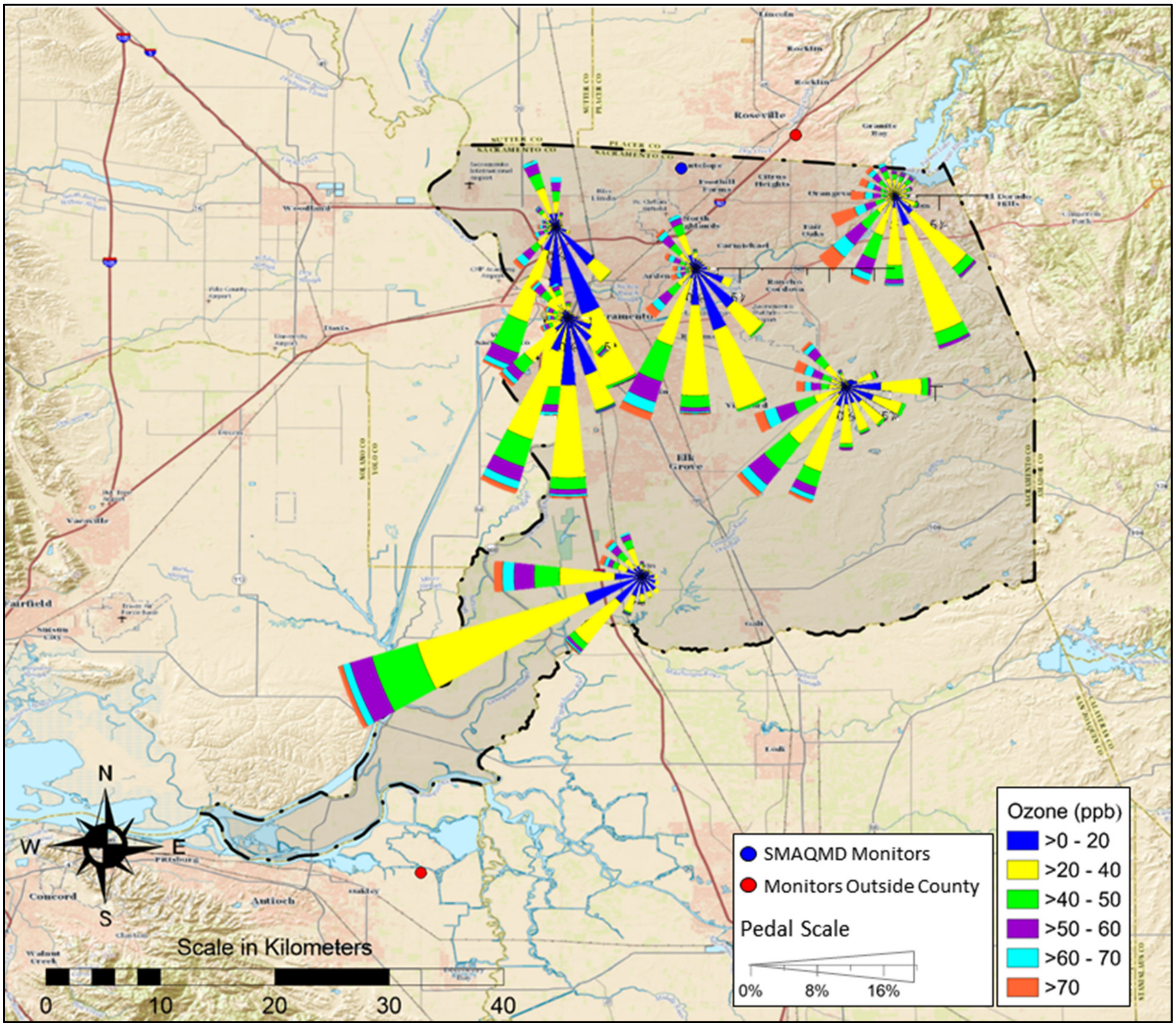

Figure D.2 Ozone Pollutant Rose (Summer)

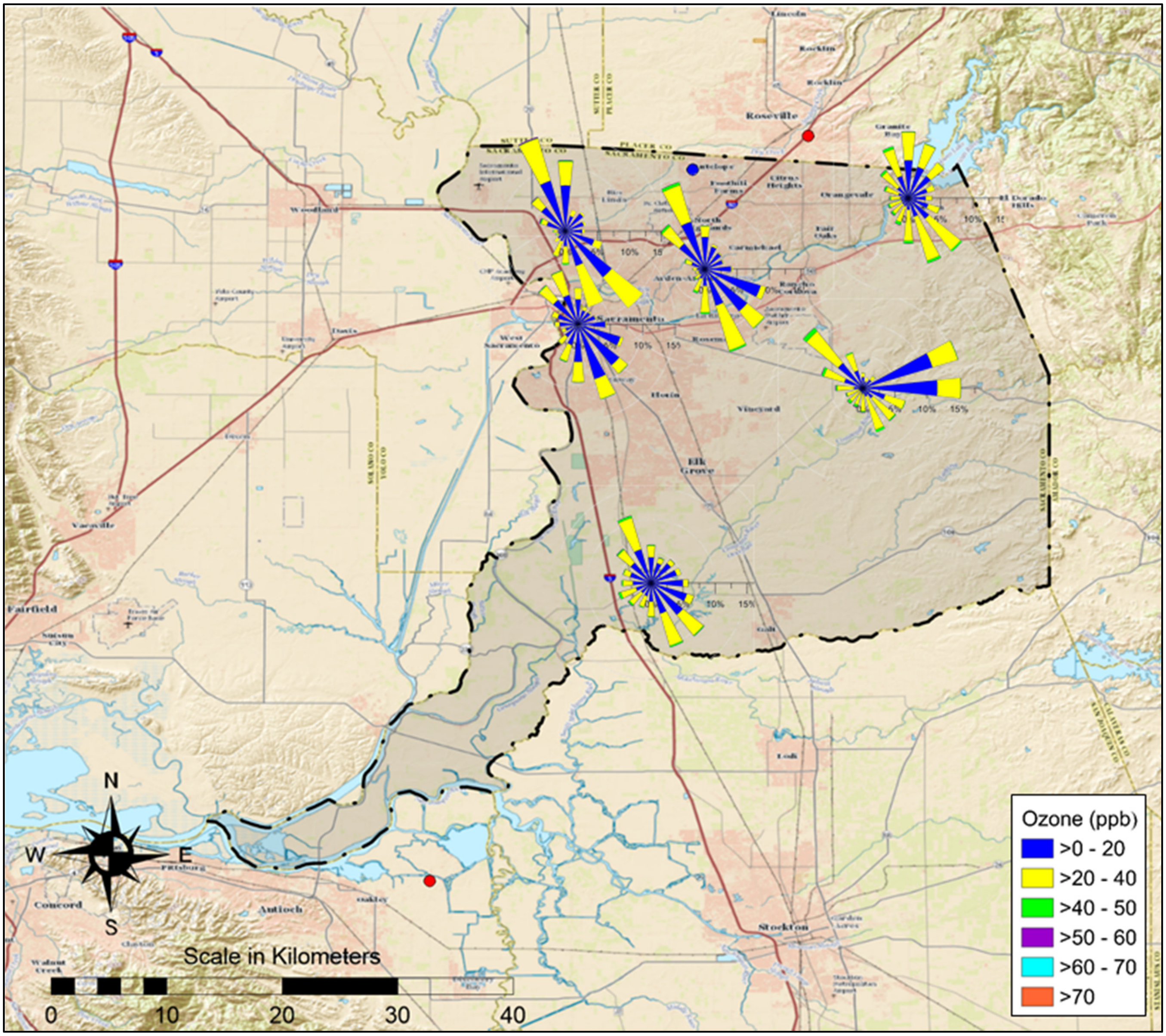

Figure D.3 Ozone Pollutant Rose (Winter)

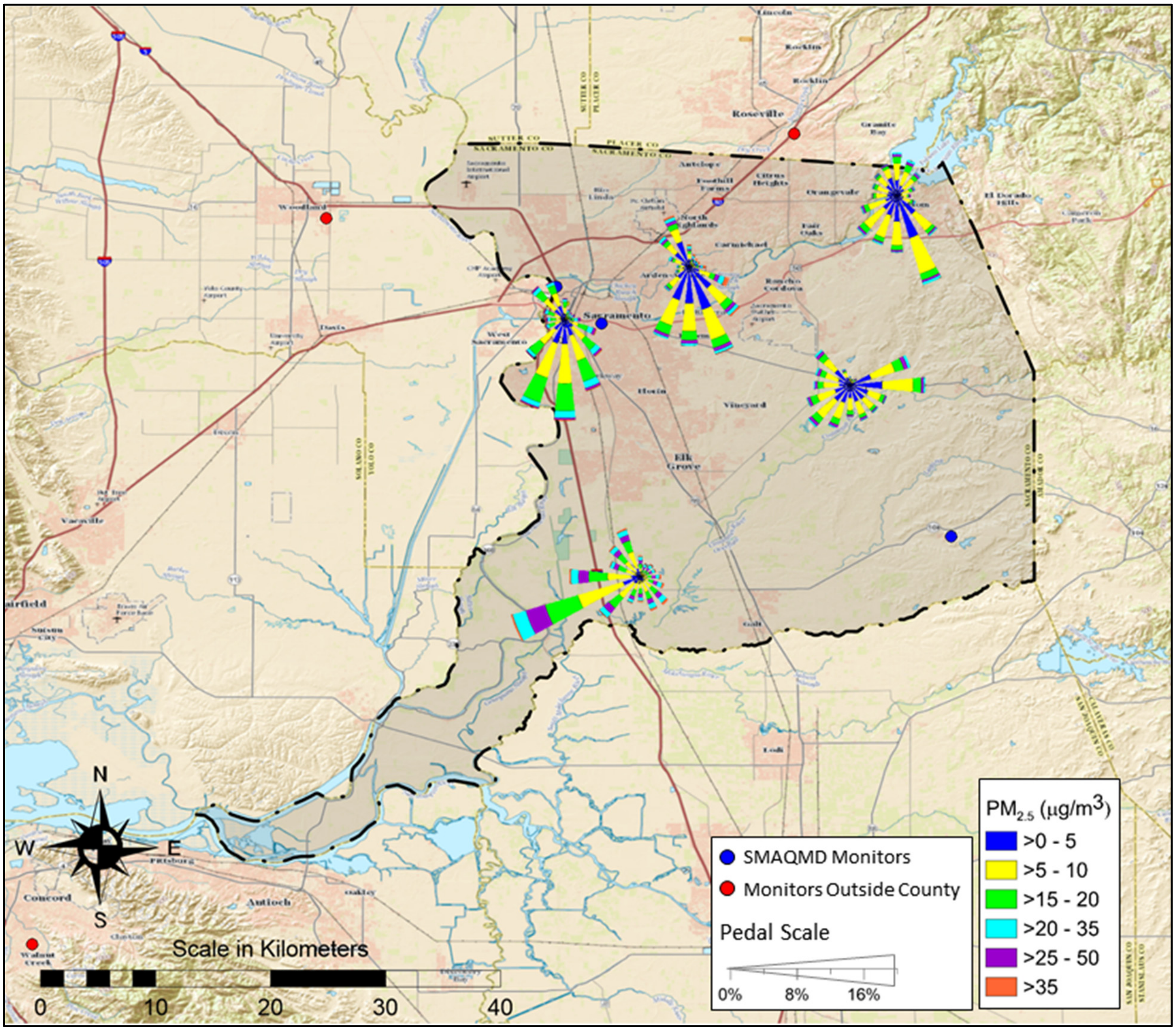

Figure D.4 PM$_{2.5}$ Pollutant Rose (Annual)

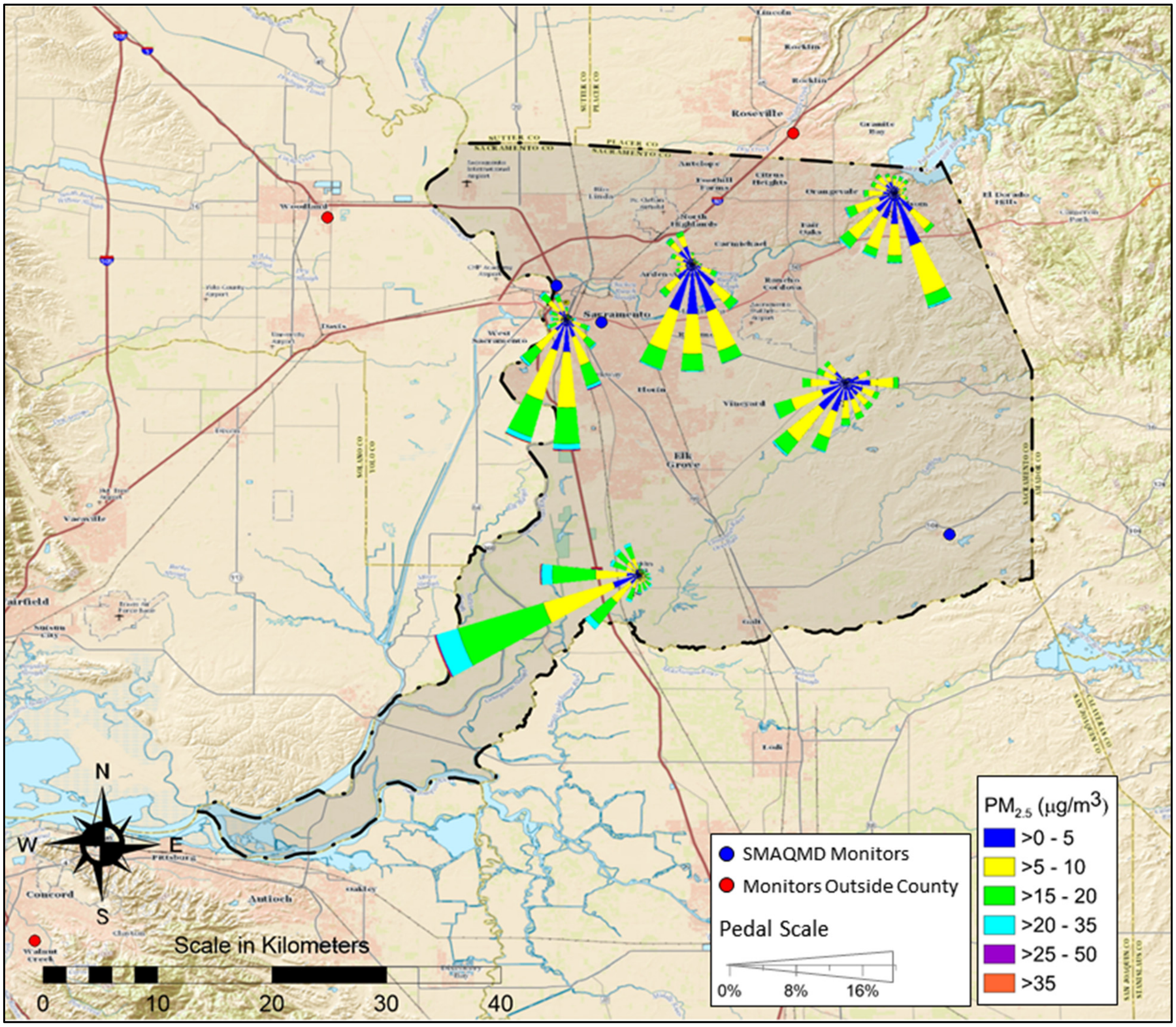

Figure D.5 PM$_{2.5}$ Pollutant Rose (Summer)

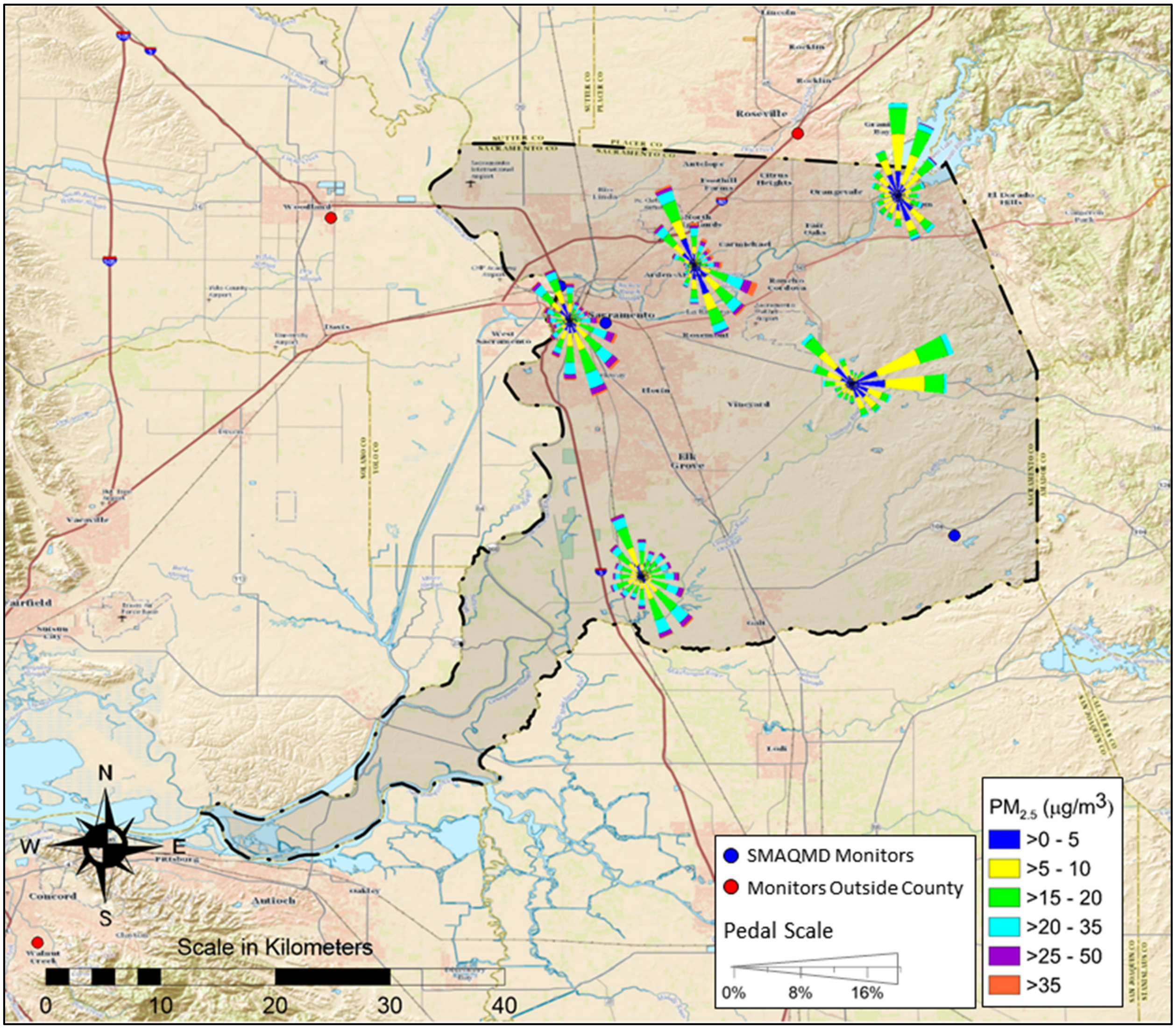

Figure D.6 $PM_{2.5}$ Pollutant Rose (Winter)

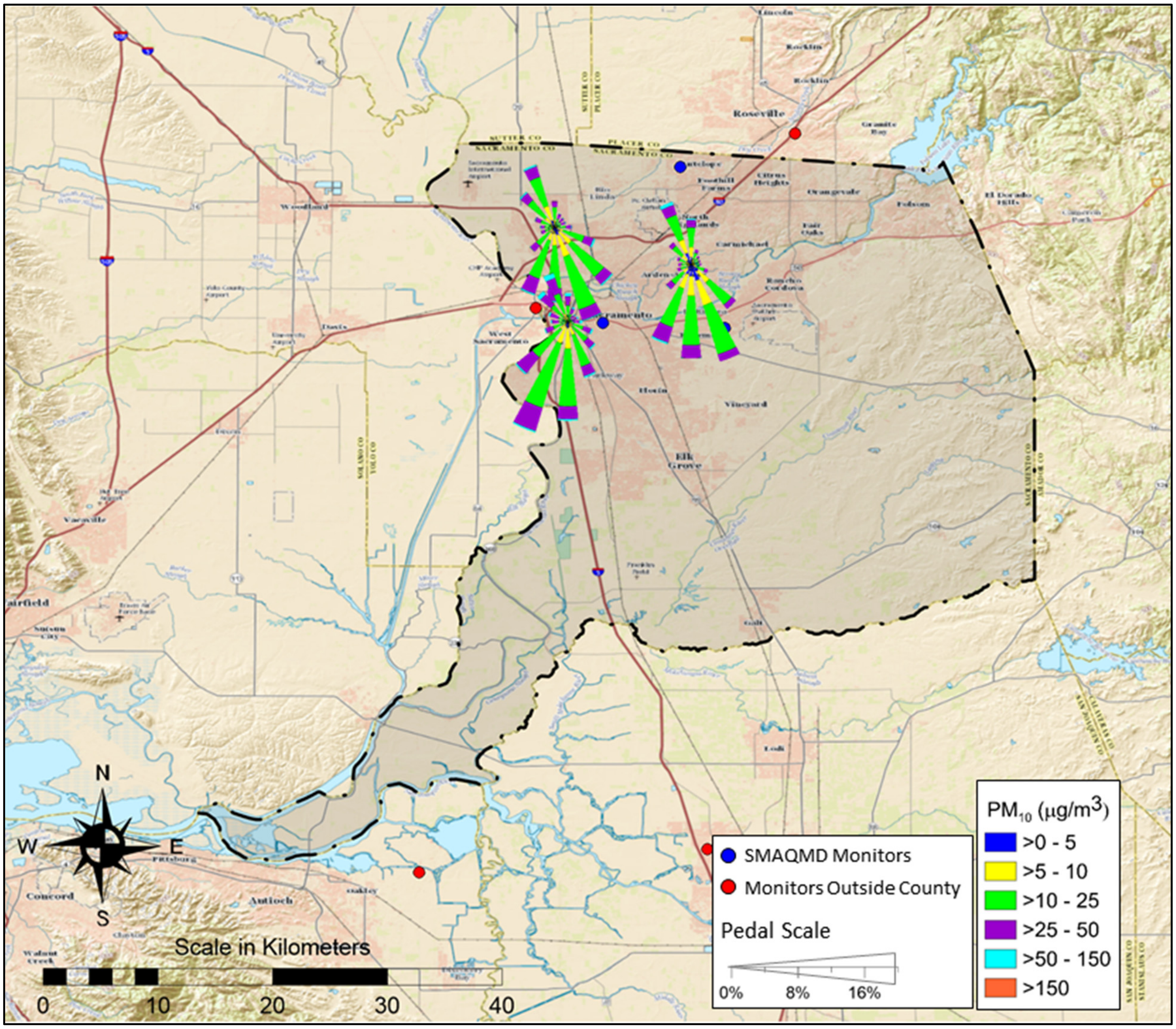

Figure D.7 PM$_{10}$ Pollutant Rose (Annual)

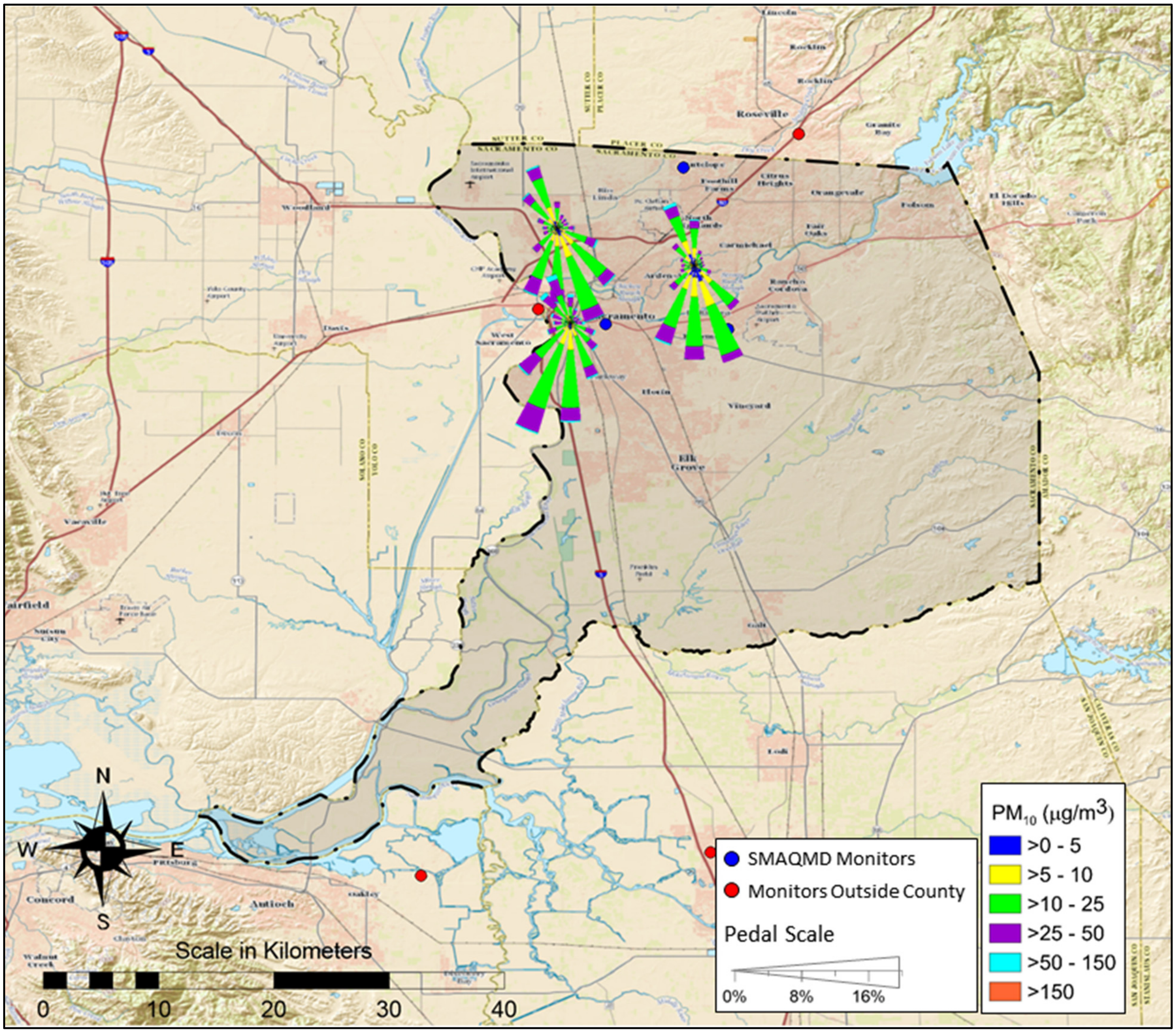

Figure D.8 PM_{10} Pollutant Rose (Summer)

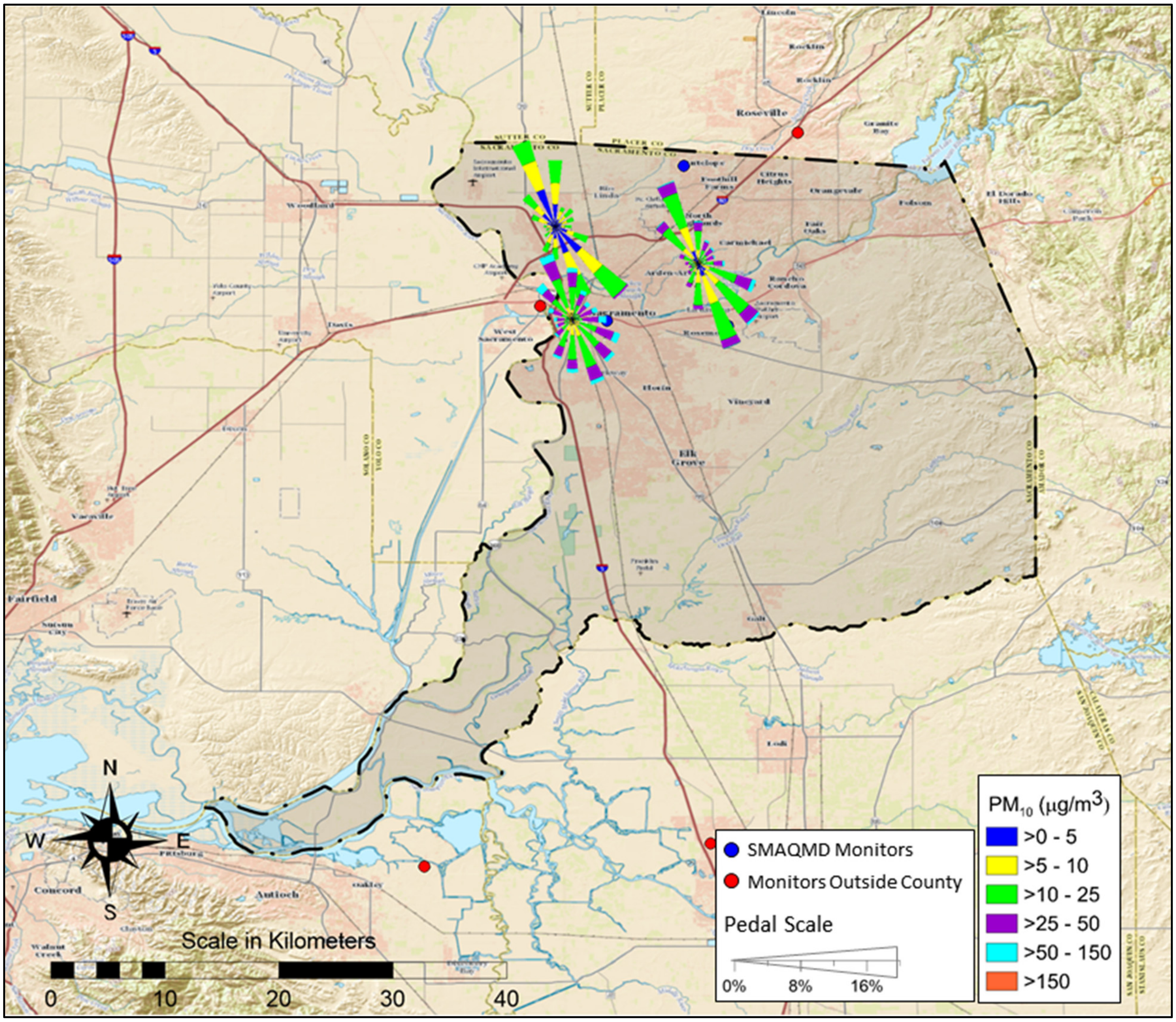

Figure D.9 PM$_{10}$ Pollutant Rose (Winter)

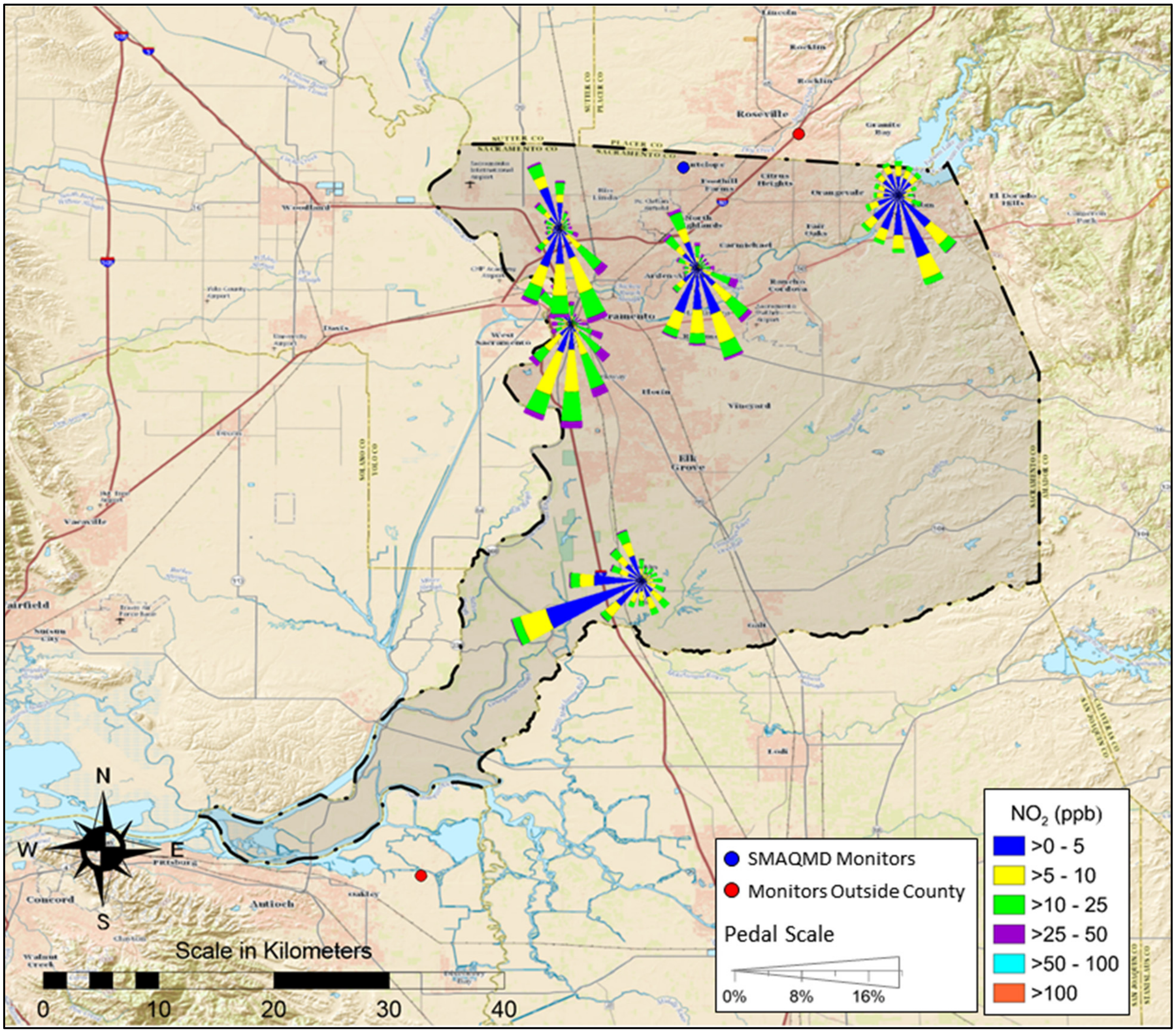

Figure D.10 NO_2 Pollutant Rose (Annual)

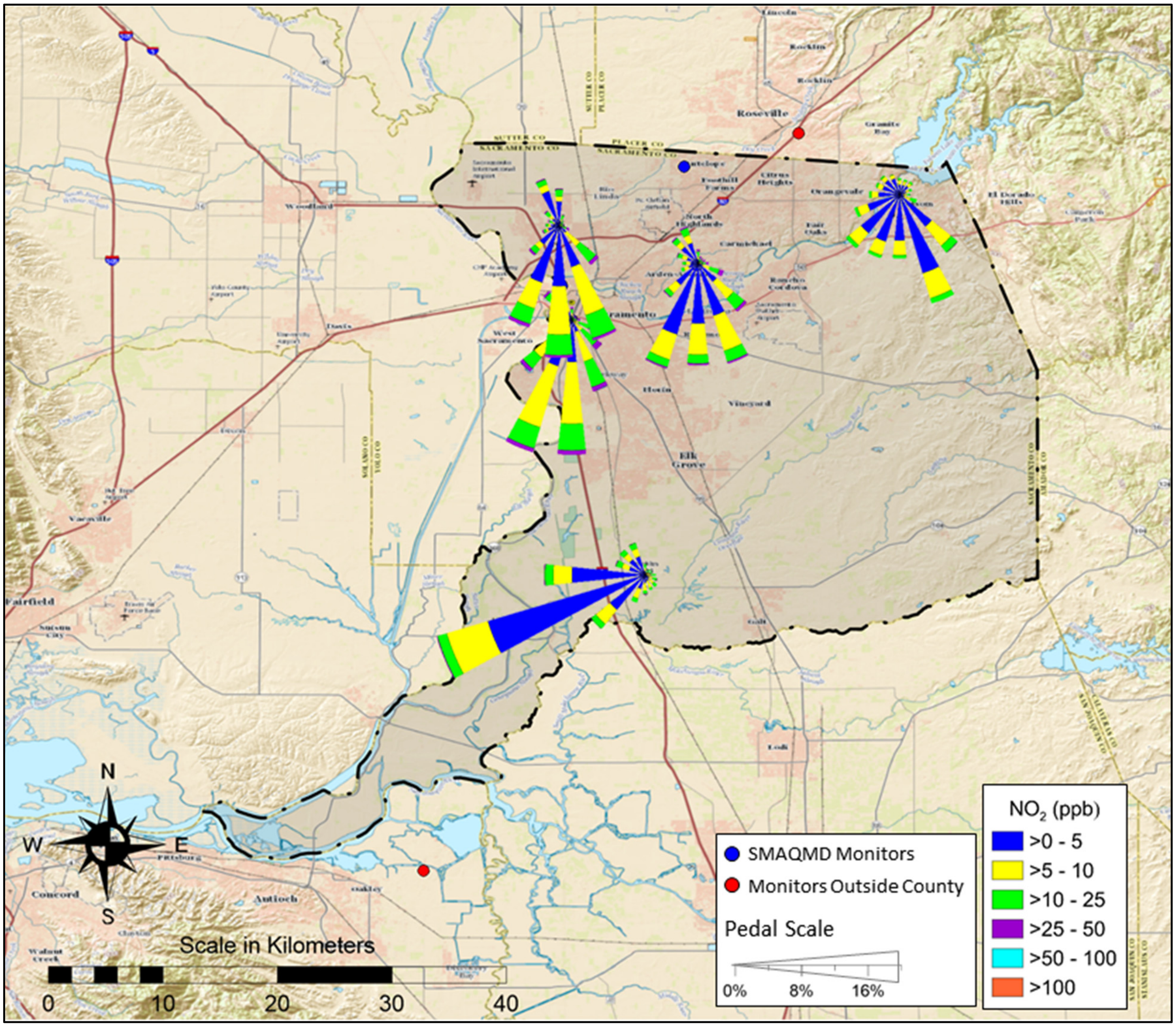

Figure D.11 NO_2 Pollutant Rose (Summer)

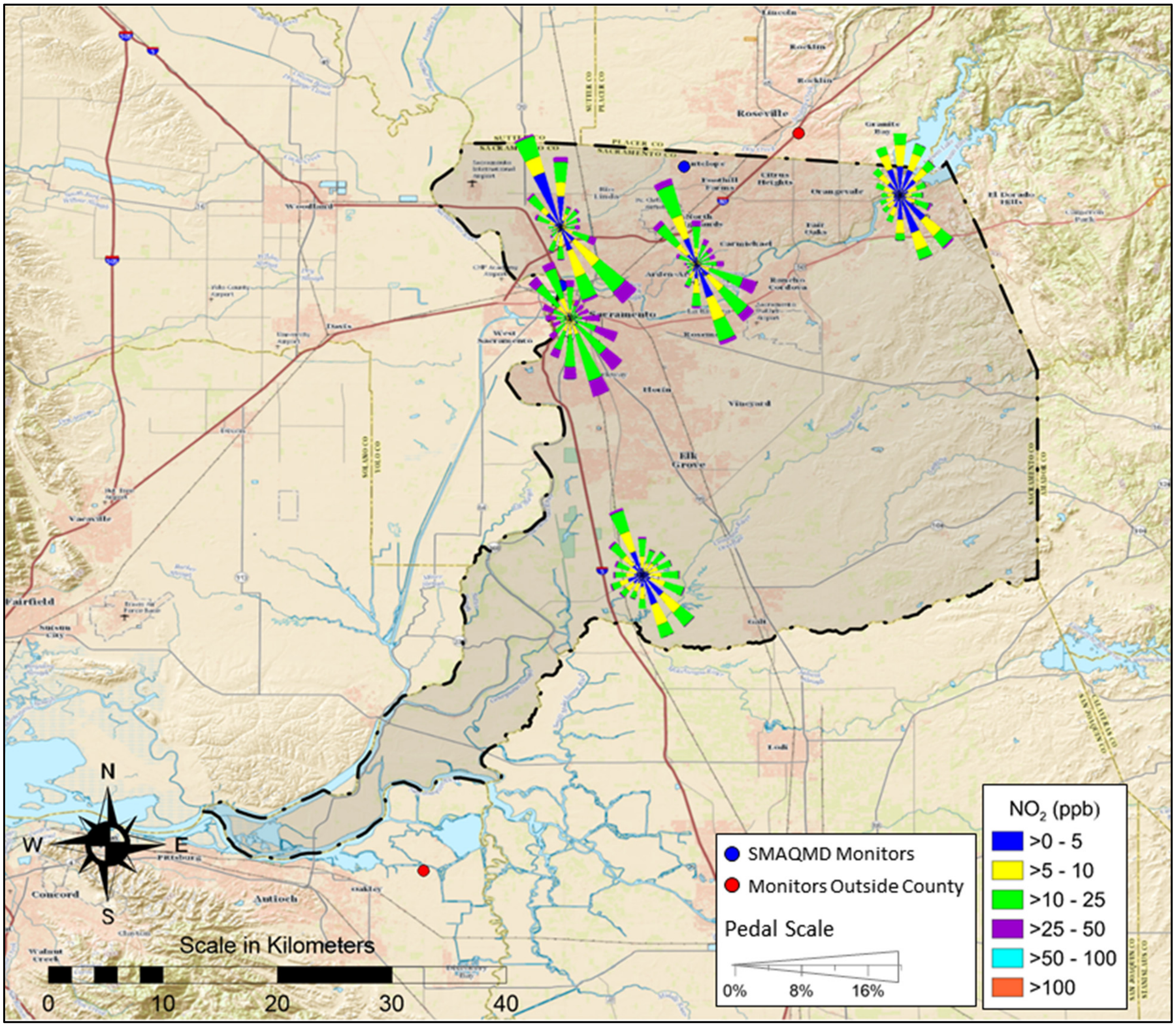

Figure D.12 NO_2 Pollutant Rose (Winter)

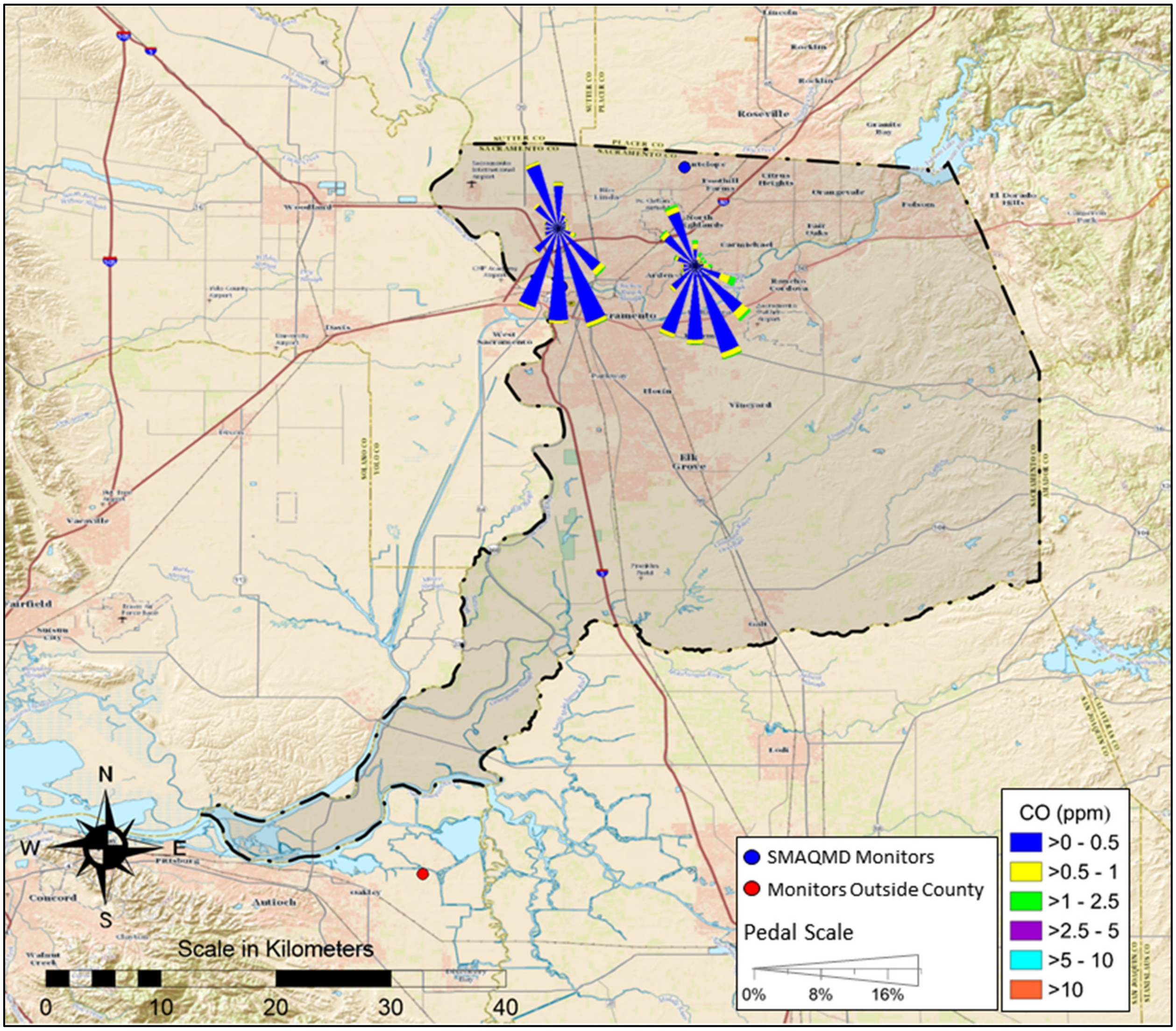

Figure D.13 CO Pollutant Rose (Annual)

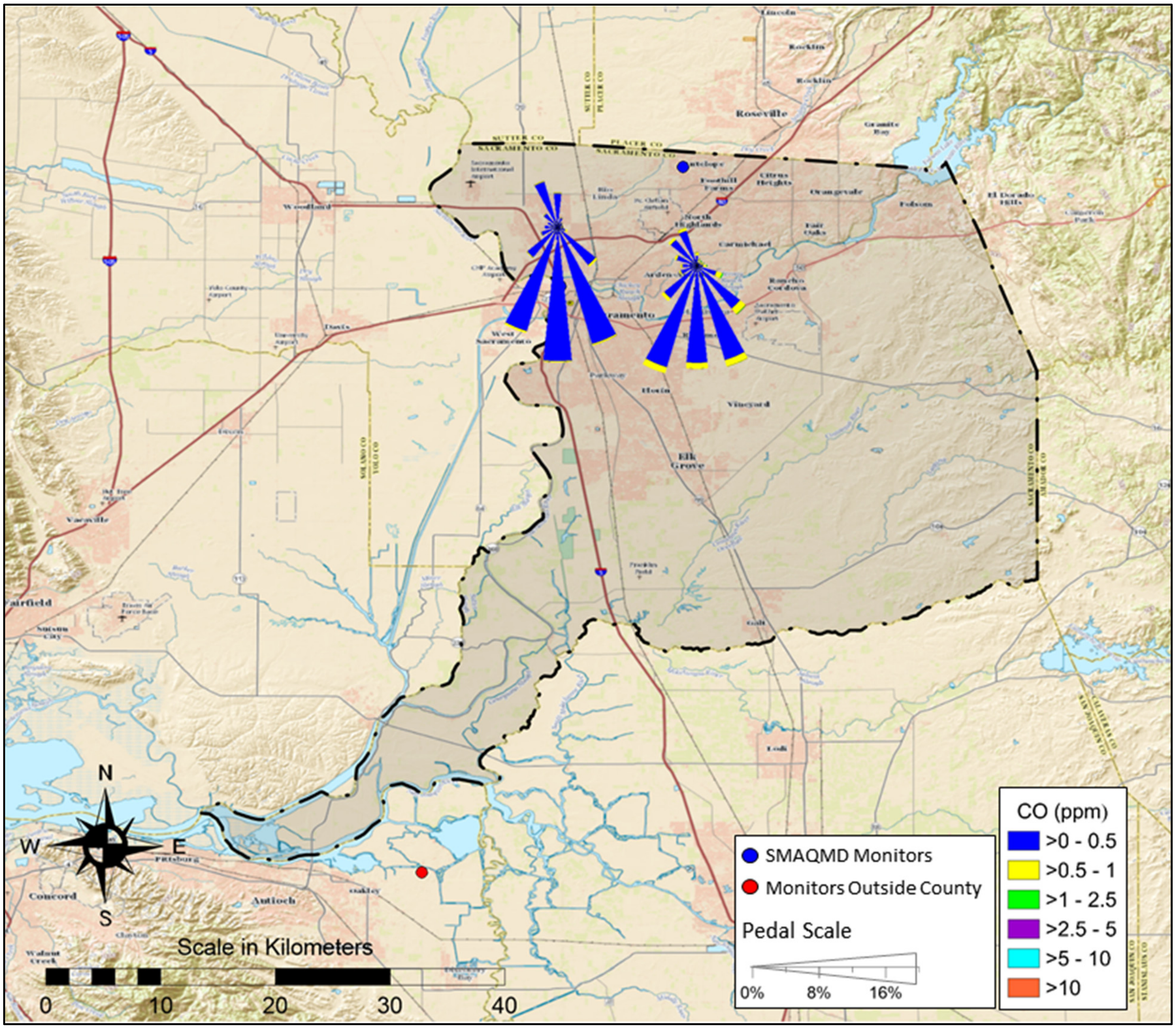

Figure D.14 CO Pollutant Rose (Summer)

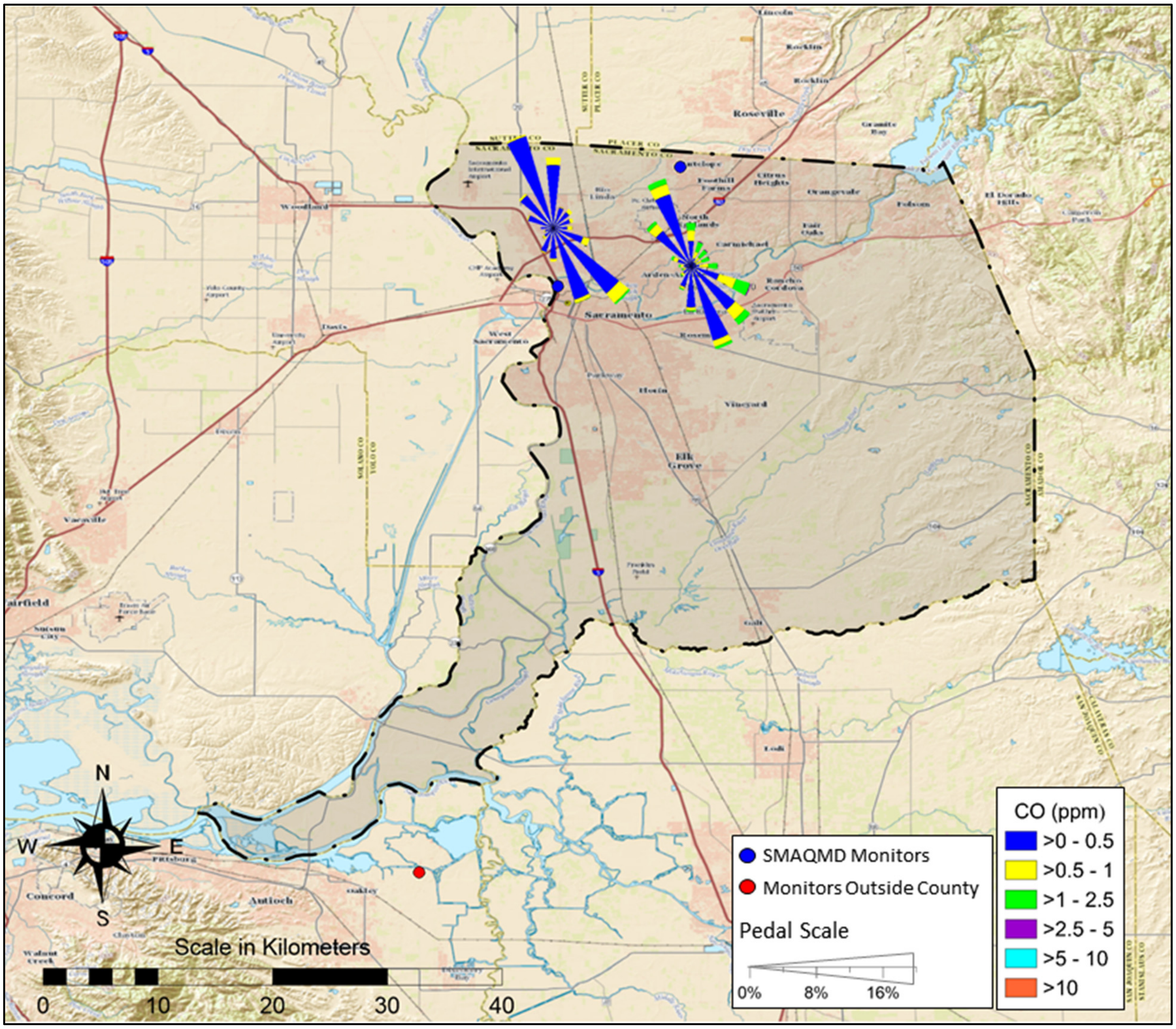

Figure D.15 CO Pollutant Rose (Winter)

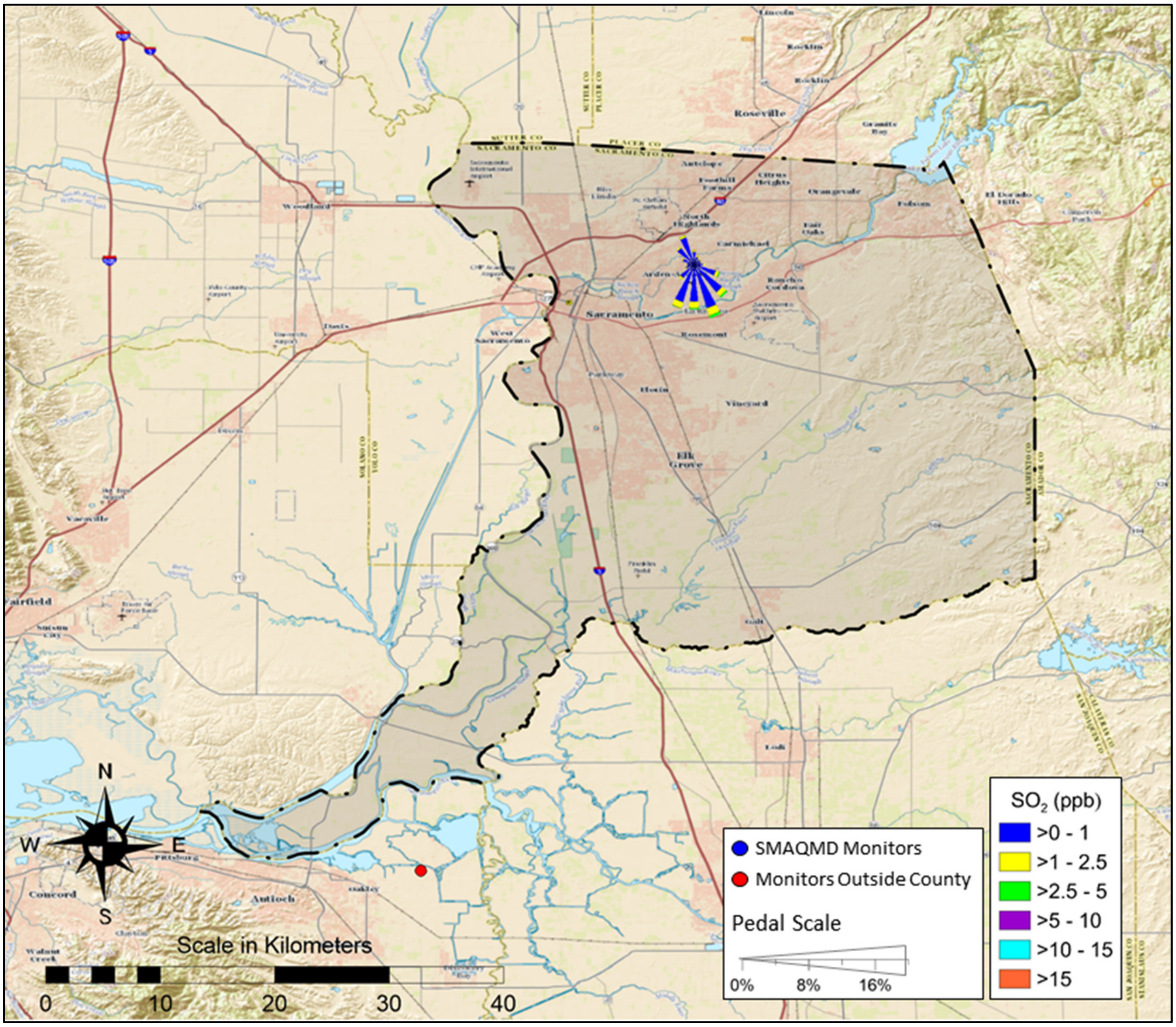

Figure D.16 SO_2 Pollutant Rose (Annual)

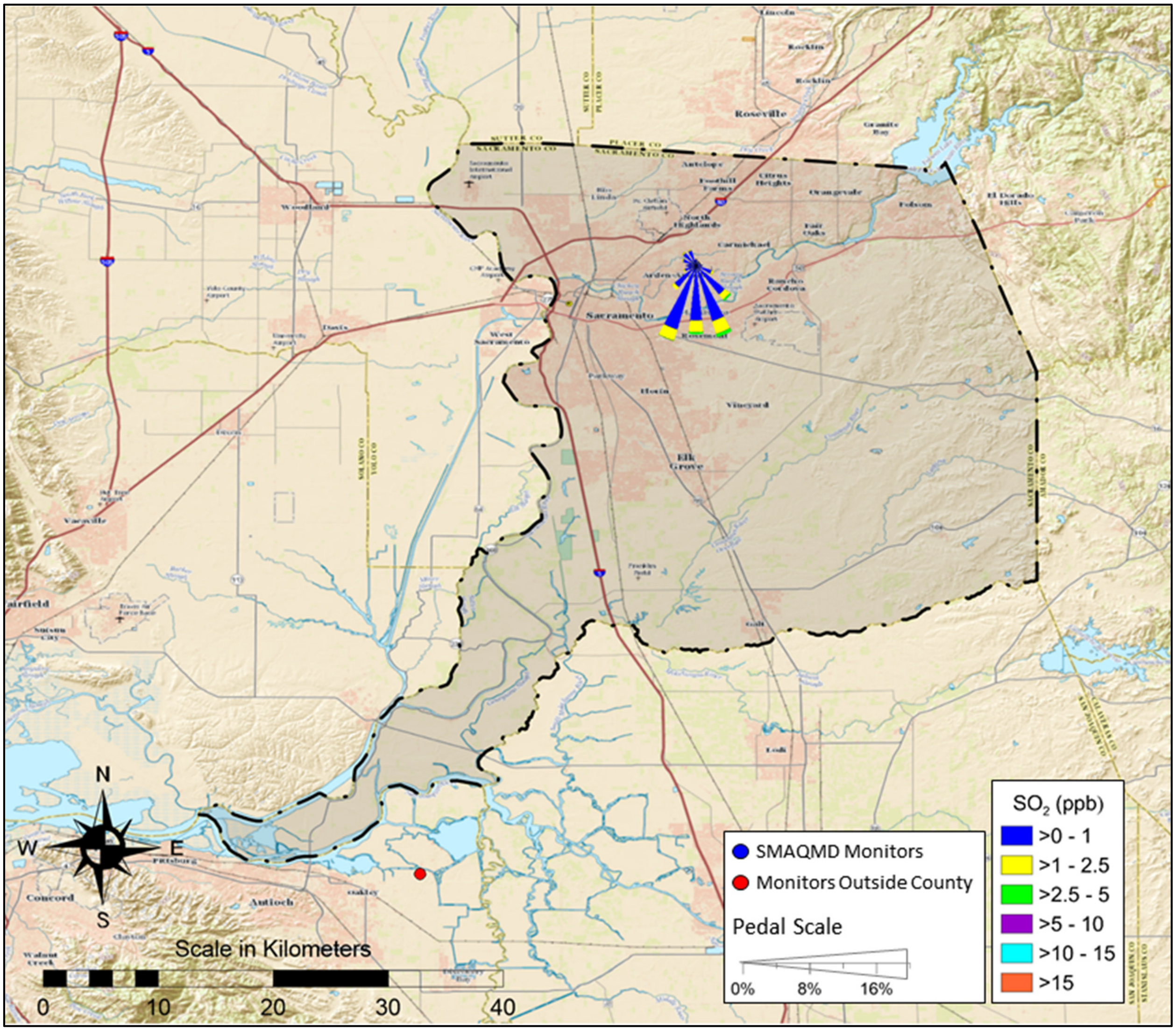

Figure D.17 SO_2 Pollutant Rose (Summer)

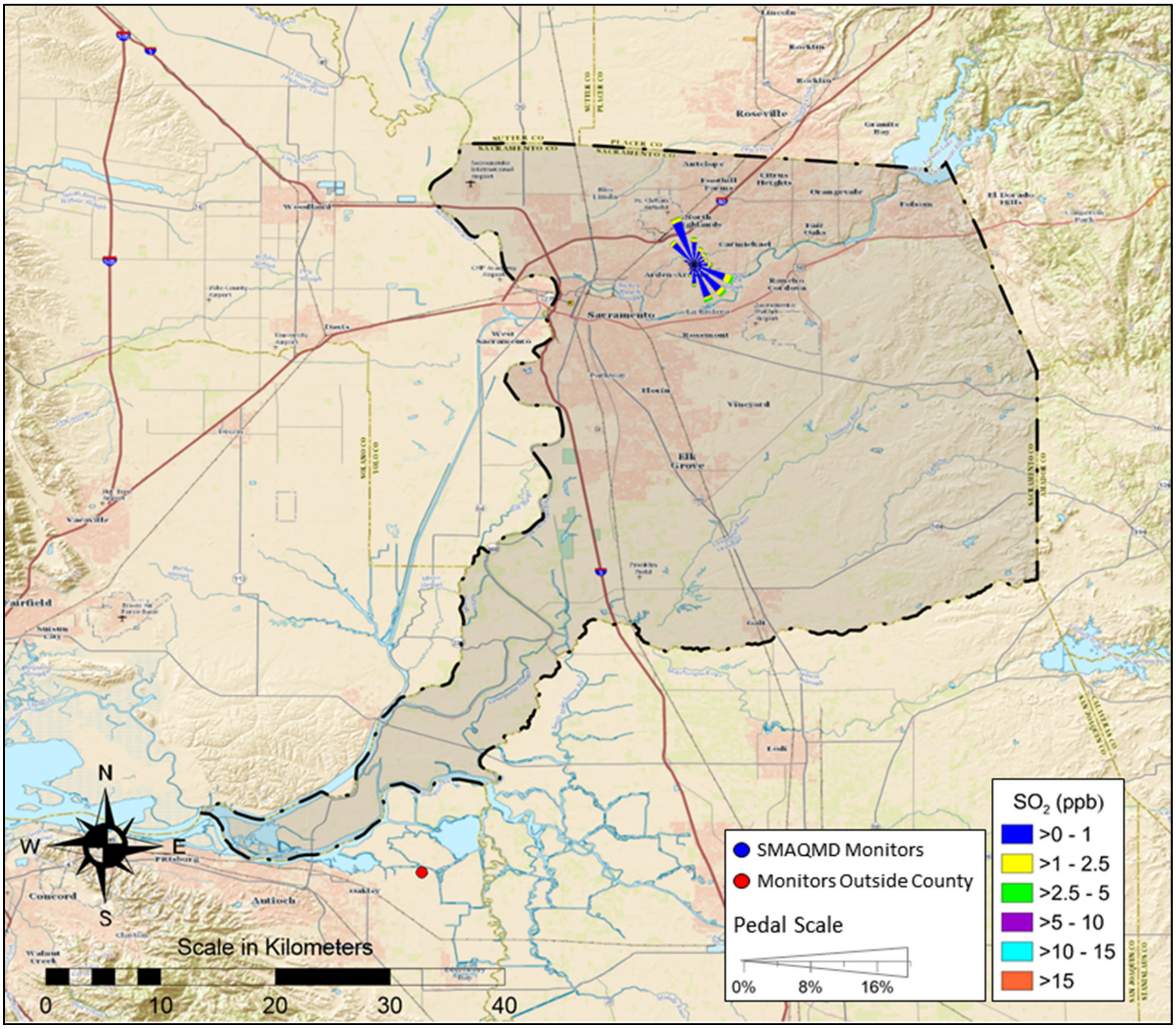

Figure D.18 SO_2 Pollutant Rose (Winter)

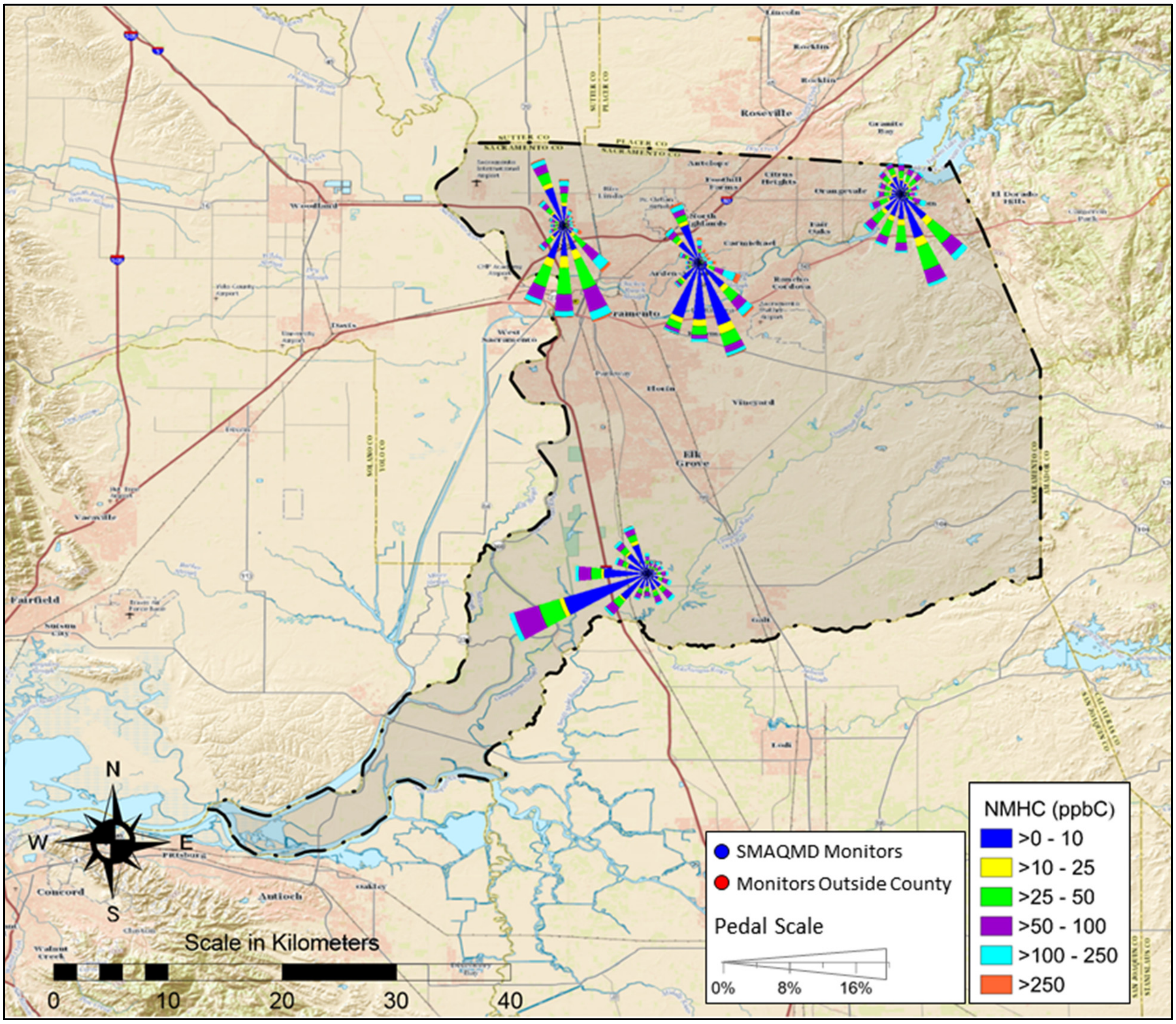

Figure D.19 TNMHC Pollutant Rose (Annual)

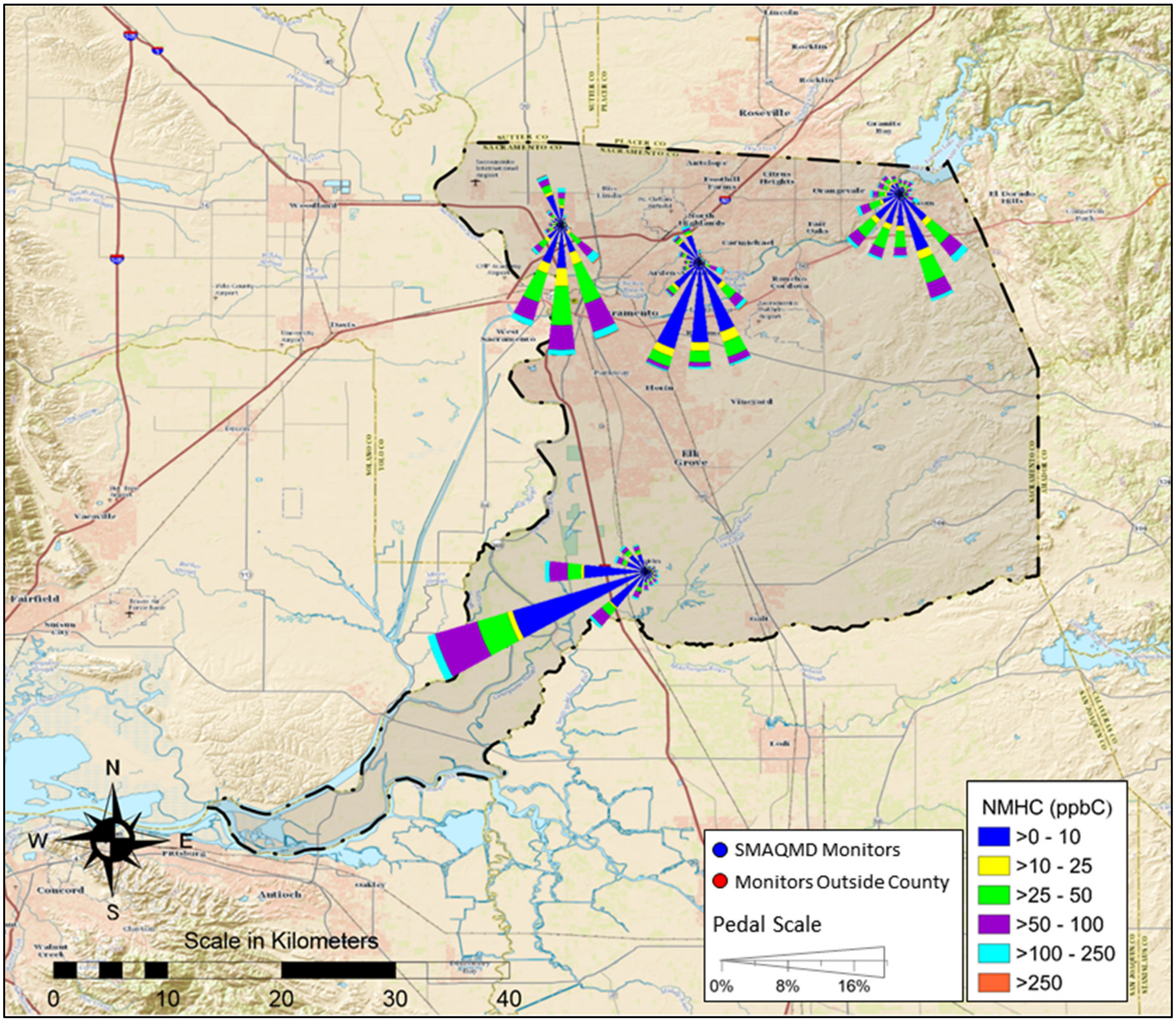

Figure D.20 TNMHC Pollutant Rose (Summer)

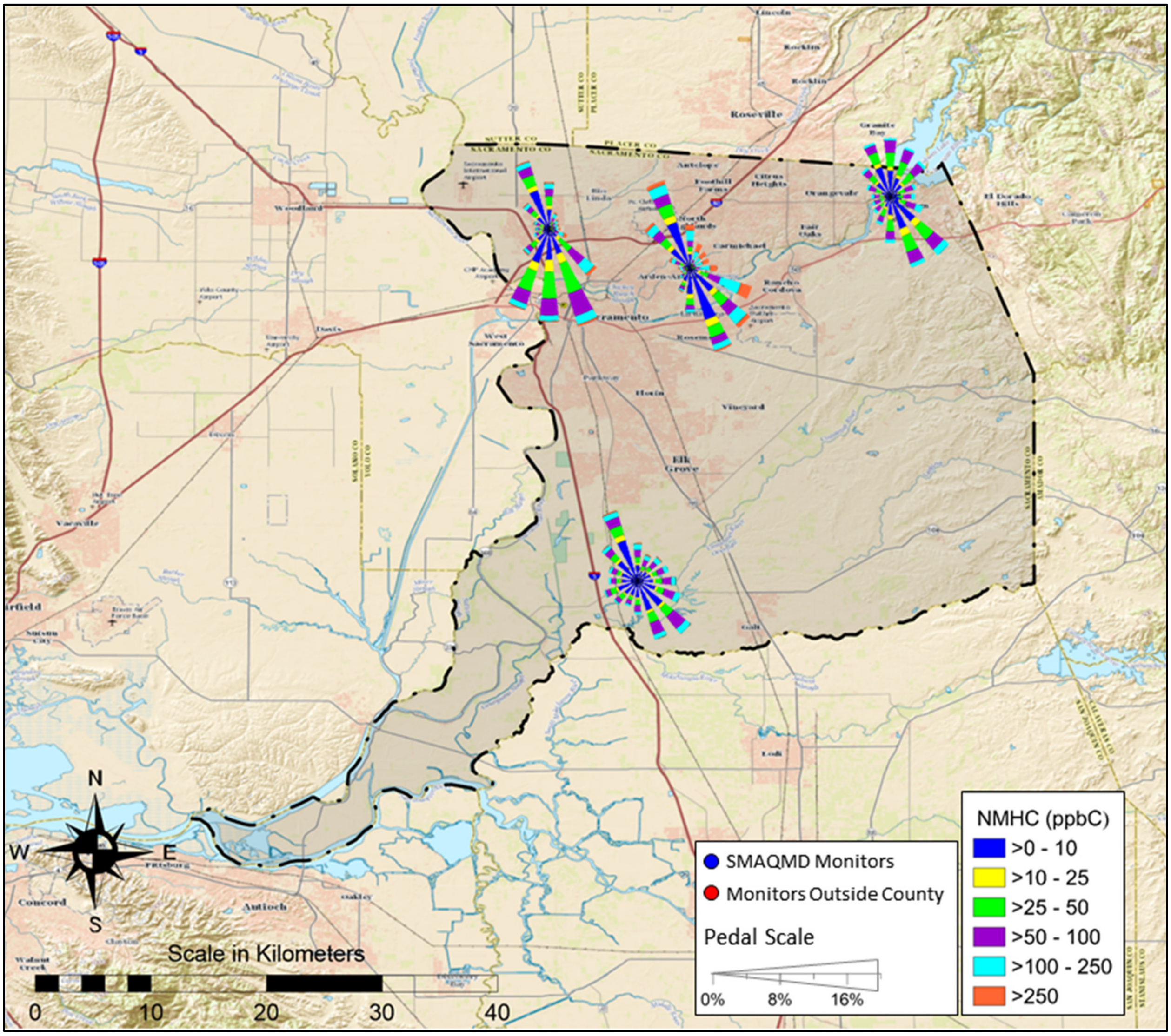

Figure D.21 TNMHC Pollutant Rose (Winter)