Staff Report

CARB Review of the Sacramento Regional 2008 NAAQS 8-Hour Ozone Attainment and Reasonable Further Progress Plan

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CALIFORNIA
AIR RESOURCES BOARD

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I. EXECUTIVE SUMMARY

The *Sacramento Regional 2008 NAAQS 8-Hour Ozone Attainment and Reasonable Further Progress Plan* (Ozone Plan) is designed to satisfy requirements under the federal Clean Air Act (Act) with respect to attainment of the 75 parts per billion (ppb) 8-hour ozone national ambient air quality standard (75 ppb ozone standard) for the Sacramento Metro Nonattainment Area (Sacramento Region). The Ozone Plan relies on the future emissions reductions of existing control measures to attain the 75 ppb ozone standard promulgated by the U.S. Environmental Protection Agency (U.S. EPA) on March 27, 2008.

U.S. EPA designated the Sacramento Region as a Severe ozone nonattainment area for the 75 ppb ozone standard effective July 20, 2012. The attainment date for Severe nonattainment areas is July 20, 2027. Modeling by the California Air Resources Board (CARB) of ozone levels led the Sacramento Region local air districts to select July 20, 2025 as the expected attainment year for this standard. The Ozone Plan demonstrates attainment by July 20, 2025 satisfying the Act requirement to attain air quality standards as expeditiously as practicable.

CARB staff's analysis indicates that the emission reductions achieved from existing control measures will be sufficient to attain the 75 ppb ozone standard by July 20, 2025. This staff report provides information needed to support U.S. EPA approval of the Ozone Plan for attainment of the 75 ppb ozone standard.

State law assigns CARB the primary responsibility to ensure California's compliance with the Act. Traditionally, CARB shares that responsibility with local air districts through regulatory actions, incentive programs, and defined SIP commitments for further action to achieve emission reductions necessary for attainment. CARB and the Sacramento Air Districts are implementing SIP commitments approved by U.S. EPA for prior ozone standards. The Ozone Plan shows that these regulations will provide the emission reductions needed to demonstrate attainment.

The Ozone Plan addresses all the Act planning requirements. The summer planning emission inventories account for the continued implementation of adopted control measures and updated transportation activity projections. The modeling analysis documents that July 20, 2025 is the most expeditious attainment date practicable. The control measure analysis is designed to satisfy Reasonably Available Control Measure (RACM) and Transportation Control Measure (TCM) Act requirements. The Reasonable Further Progress (RFP) analysis demonstrates compliance with progress goals required by the Act. Transportation conformity budgets incorporate the latest planning assumptions and include a safety margin for contingent growth. An ozone vehicle miles traveled (VMT) offset demonstration complies with the Act and the August 2012 U.S.EPA guidance.

Staff recommends that the Board approve the Sacramento Regional 2008 NAAQS 8-Hour Ozone Attainment and Reasonable Further Progress Plan as a revision to the California State Implementation Plan.

II. BACKGROUND

A. Profile of Sacramento

The Sacramento Region is comprised of all of Sacramento and Yolo Counties and includes portions of El Dorado, Placer, Solano and Sutter Counties (see Figure 1). On the westernmost edge, it extends to the inland side of the California Coastal Range, and continues to the border of the Lake Tahoe air basin to the east, taking in portions of the Sierra Nevada Mountain Range. It extends southward to the Sacramento Delta Region and northward to include the southern portion of Sutter County; the elevation in the region varies from near sea level to over 7000 feet.

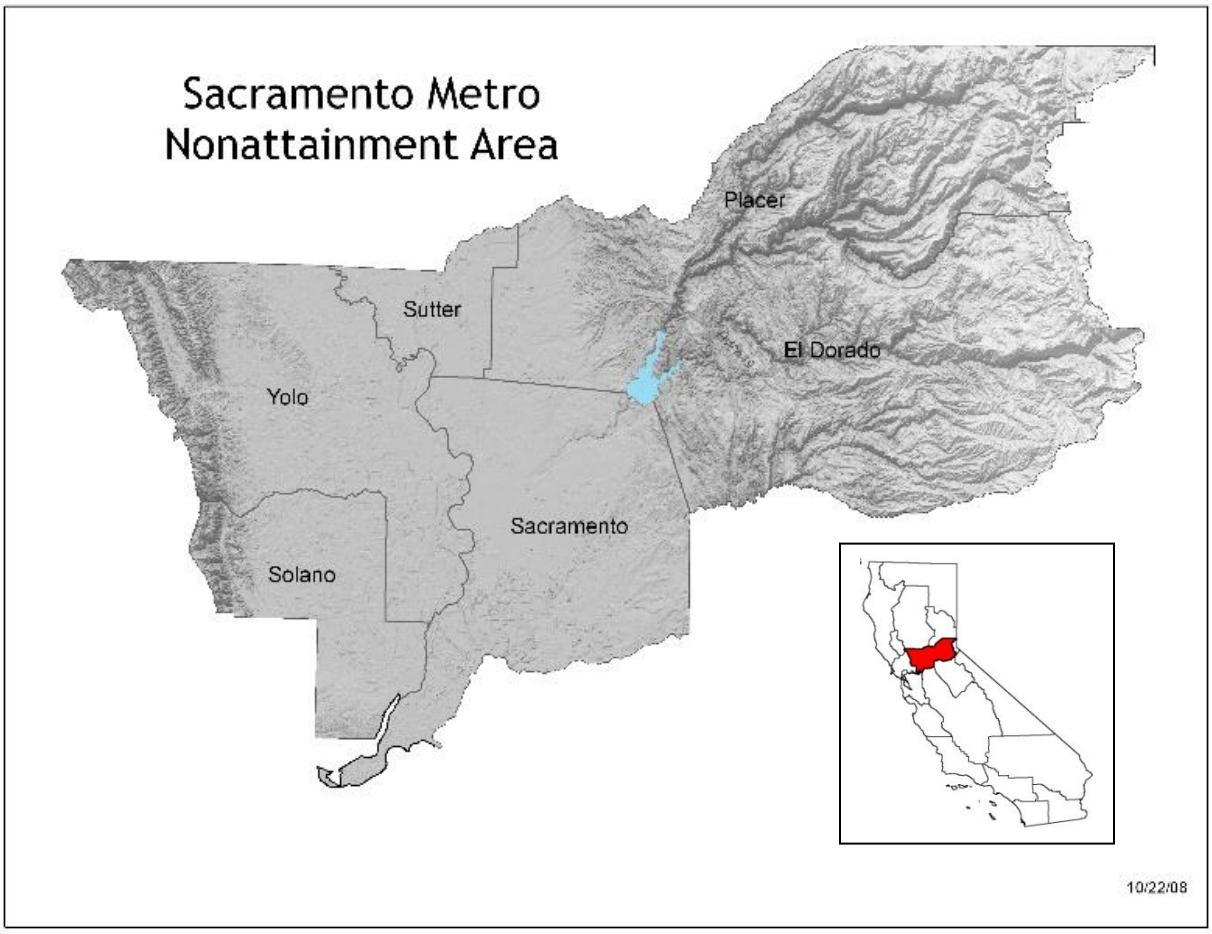
The area includes mountainous terrain, agricultural land, lakes and rivers, as well as one of California's larger urban areas. While winters in the valley are mild, summer generally brings very hot weather to the valley floor, with temperatures routinely exceeding 100°F. Mountainous areas are considerably cooler in both summer and winter. Air quality in the region is affected by both local emissions and ozone and ozone precursor emissions transported from upwind areas.

B. Health Effects of Ozone

Ozone is a highly reactive gas that can damage the tissues of the respiratory tract, causing inflammation and irritation, and resulting in symptoms such as coughing, chest tightness, and worsening of asthma symptoms. Ozone exposure can also lead to decreased lung function.

Considerable research conducted over the past 40 years has shown that ozone can lead to inflammation and irritation of the tissues lining human airways. This causes the muscle cells in the airways to spasm and contract, thus reducing the amount of air that can be inhaled. Symptoms and responses to ozone exposure vary widely, even when the amount inhaled and length of exposure is the same. Typical symptoms include cough, chest tightness, and increased asthma symptoms. Ozone in sufficient doses can also increase the permeability ("leakiness") of lung cells, making them more susceptible to damage from environmental toxins and infection.

Figure 1. Sacramento Metro Nonattainment Area



C. Historical Air Quality

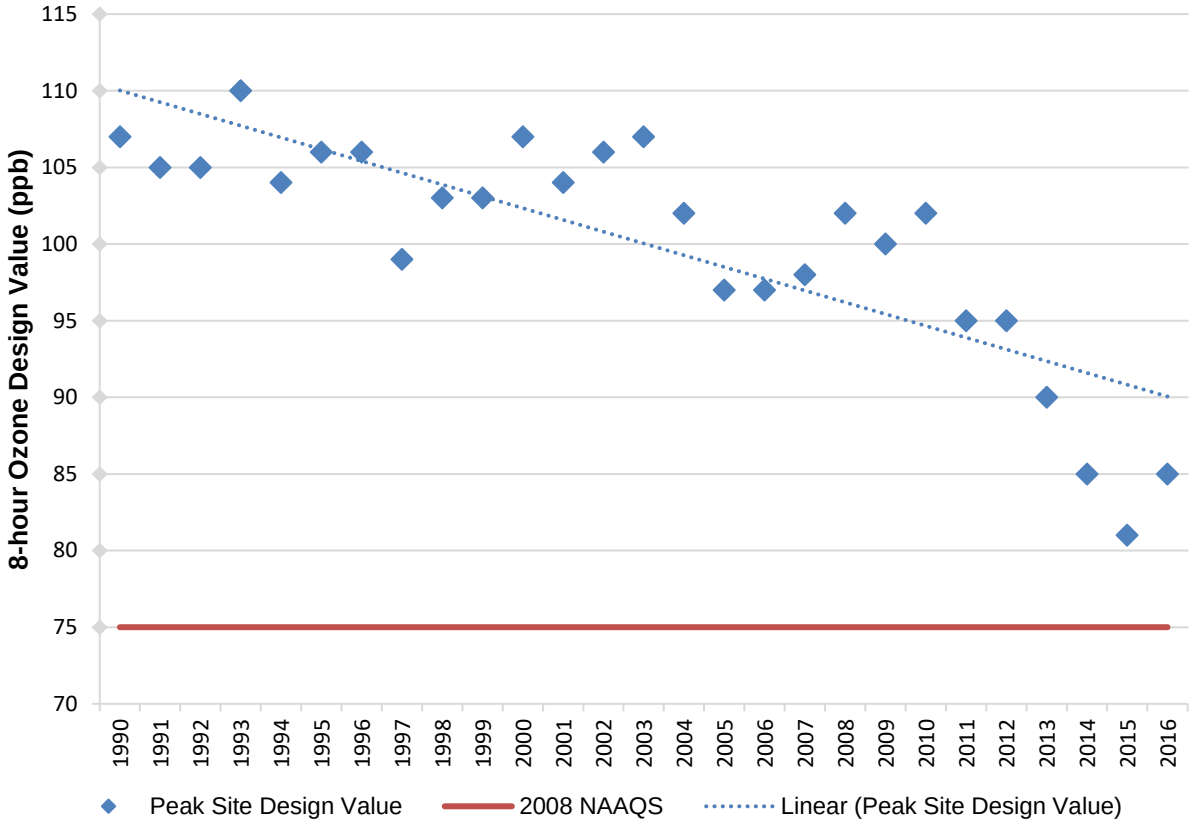
The number of days over the standard (exceedance days) is an indication of how frequently the population is exposed to unhealthful air quality. Exceedance days for the 75 ppb ozone standard have dropped dramatically at all monitoring sites between 1990 and 2016. As shown in Appendix A, about one third of stations now record no exceedances at all.

Ozone "design values" are used to characterize a region's air quality in relationship to the air quality standard. The design value is the three-year average of the annual fourth highest daily maximum 8-hour ozone concentrations. The use of the three-year average helps minimize the year-to-year influence of meteorology. In the Sacramento Region, design values have declined at all stations between 1990 and 2016, and about one third of stations now have design values below the 75 ppb ozone standard.

The air quality monitors located in Placerville in El Dorado County, Auburn in Placer County, and Folsom in Sacramento County have recorded the region's highest design values for the last ten years. These monitoring sites are all in the eastern portion of the

nonattainment area, in the foothills of the Sierra Nevada Mountains, and are impacted by emissions from the urban areas to the west. Figure 2 graphically illustrates the trend of the peak design values between 1990 and 2016. To meet the 75 ppb ozone standard, all of the monitoring sites will have to be at or below the standard.

Figure 2. Sacramento Region 8-Hour Standard Design Values Trend



III. AIR QUALITY PLANNING

A. Air Quality Planning Background

The Act establishes planning requirements for those areas that routinely exceed the health-based National Ambient Air Quality Standards (NAAQS or standards). These nonattainment areas must develop and enact State Implementation Plans (SIP) that demonstrate how they will attain the standards by specified dates.

In California, local air quality agencies that have jurisdication over the nonattainment area in coordination with CARB prepare the SIPs to ultimately be submitted to U.S. EPA. The local air quality agencies that prepared the Ozone Plan are the El Dorado County Air Quality Management District, Feather River Air Quality Management District, Placer County Air Pollution Control District, Sacramento

Metropolitan Air Quality Management District, and Yolo Solano Air Quality Management District (Sacramento Air Districts).

B. 8-hour Ozone Standard Planning Requirements

In March 2008, U.S. EPA promulgated a NAAQS for ozone that requires that ozone concentrations not exceed 75 ppb averaged over an 8-hour period. Effective July 20, 2012, U.S. EPA designated the Sacramento Region as a Severe ozone nonattainment area.[1] On the same day, U.S. EPA finalized the attainment deadlines implementation rule for the 75 ppb ozone standard, which set the attainment deadline for the Sacramento Region at July 20, 2027 or as expeditiously as practicable.[2]

On March 6, 2015, U.S. EPA approved the implementation rule for the 75 ppb ozone standard (Rule). The Rule identified planning requirements that severe nonattainment areas must address in their SIPs, including:

- Emission inventories;
- Reasonably Available Control Technology (RACT);
- Reasonably Available Control Measures (RACM);
- Reasonable Further Progress (RFP);
- Attainment demonstration including Weight of Evidence analysis;
- Transportation conformity emission budgets;
- VMT offset demonstration; and
- Contingency measures.

CARB staff has reviewed the Ozone Plan and determined that it includes all of the required elements listed above.

IV. PLAN EVALUATION

The Ozone Plan is the latest step in the air quality planning process that over the years has helped define new actions to improve the Sacramento Region's air quality. The Sacramento Air Districts released their draft Ozone Plan on July 24, 2017. The governing boards of all five local air districts approved the plan at duly noticed public hearings on August 24 (Sacramento Metropolitan), September 12 (El Dorado County), October 2 (Feather River), October 11 (Yolo-Solano), and October 12, 2017 (Placer County).

A. Baseline Emissions Inventory

The Sacramento Region's main sources of emissions are on-road vehicles, including passenger vehicles and heavy-duty diesel trucks, reflecting the region's large urban and suburban population, as well as its role as a goods movement hub. Though the region

[1] Federal Register: May 21, 2012 (Volume 77, Number 98, pages 30088-30160)
[2] Federal Register: May 21, 2012 (Volume 77, Number 98, pages 30160-30171)

does have bus and light rail service, particularly in the downtown Sacramento area, the primary mode of transportation is passenger vehicles.

Other large sources of ozone precursor emissions are off-road agricultural and construction equipment, recreational boats, and consumer products. Emissions from industrial activities make up a much smaller portion of the inventory.

Tables 1 and 2 show the reactive organic gases (ROG) and oxides of nitrogen (NOx) emission inventories, respectively, for the 2012 base year and the 2018, 2021, and 2024 future years. The tables demonstrate that emissions of both precursors will decline markedly by the attainment year.

Table 1. Sacramento Region ROG Emissions (Summer Planning Inventory in Tons per Day)

	2012	2018	2021	2024
STATIONARY	22	22	23	23
AREAWIDE	29	29	30	31
ON-ROAD MOTOR VEHICLE	34	20	16	14
OTHER MOBILE SOURCES	26	20	18	17
TOTAL	110	91	87	84

Source: (SMAQMD, 2017), does not include 5 tpd of ROG ERCs
[a] TOTAL EMISSIONS are the rounded sum of reported emissions

Table 2. Sacramento Region NOx Emissions (Summer Planning Inventory in Tons per Day)

	2012	2018	2021	2024
STATIONARY	8	7	7	7
AREAWIDE	3	2	2	2
ON-ROAD MOTOR VEHICLE	61	35	26	19
OTHER MOBILE SOURCES	30	26	23	21
TOTAL	101	69	58	49

Source: (SMAQMD, 2017), does not include 4 tpd of NOx ERCs
[a] TOTAL EMISSIONS are the rounded sum of reported emissions

The Sacramento Region's ozone attainment strategy relies on these reductions of both ROG and NOx to meet the 8-hour ozone standards. Because mobile sources are the largest contributors to ozone-forming emissions, reducing emissions from passenger vehicles, trucks, and a variety of off-road engines is key to attaining the ozone standards. In developing the Ozone Plan for meeting the 8-hour standard by July 20, 2025, the biggest challenge has been cleaning up the existing fleets of legacy

diesel engines. This challenge was addressed by the adoption of CARB's in-use fleet rules for on-road trucks and off-road equipment.

These emission inventories do not include emission reduction credits (ERC) that can be converted into real emissions through the permitting of new or modified stationary sources. The ERCs – totaling 5 and 4 tons per summer day (tpd) of ROG and NOx, respectively – were added to the inventories for the purpose of air quality modeling. Because ERCs are modeled as actual emissions for attainment demonstration purposes, the ERCs that have been banked with the Sacramento Air Districts were allocated across the stationary and area-wide source categories in the modeling inventory. For the purpose of the attainment, contingency and reasonable further progress demonstrations in this update, the credits are shown as separate line items.

The Act requires the adoption and implementation of an emission statement rule for each ozone nonattainment area. Under these rules, the owners or operators of major stationary sources within the nonattainment area are required to annually report actual emissions of NOx and ROG from those sources. All of the Sacramento Air Districts have adopted, and U.S. EPA has approved, emission statement rules applicable to the Sacramento Region.[3] These rules are appropriate for the 75 ppb ozone standard since ozone nonattainment boundaries have not changed since U.S. EPA's original approval and the reporting threshold remains appropriate.

B. Attainment Demonstration

The Ozone Plan relies on photochemical modeling conducted by CARB staff to demonstrate that the estimated emission reductions from existing mobile source measures will allow the Sacramento Region to attain the 75 ppb ozone standard by July 20, 2025. The modeled attainment demonstration in this SIP was prepared using photochemical dispersion and meteorological modeling tools developed in response to U.S. EPA modeling guidelines,[4] and recommendations from air quality modeling experts. The modeling uses emission inventories, with measurements of meteorology and air quality, to establish the relationship between emissions and air quality. Additional information and a detailed description of the procedures employed in this modeling are available in Appendix B of the Ozone Plan.

The year 2012 was chosen as the baseline (also called reference year or base year) for attainment modeling. As recommended in the U.S. EPA modeling guidelines, the baseline design value (DV) was based on the average of DVs from the base year (2012) and the subsequent two year periods (2013 and 2014). Modeling was initially performed to forecast the DV in 2026, the last full ozone season prior to the attainment deadline of July 20, 2027. As shown in Table 3, the preliminary forecast for the 2026 design value was 70.7 ppb at the peak monitoring site, comfortably below the 75 ppb

[3] Federal Register: May 26, 2004 (Volume 69, Number 102, pages 29880-29882); Federal Register: June 6, 2006 (Volume 73, Number 110, pages 32240-32241)

[4] U.S. EPA, 2014, Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5 and Regional Haze, available at https://www.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf

standard. Based on the air quality data and emissions inventory trends, CARB and the Sacramento Air Districts decided to investigate 2022 as an alternate future year to show attainment. The 2022 modeled DV was forecast to be 75.2 ppm, which is very close to the standard. Based on this information, the Sacramento Air Districts selected 2024 as the year in which the DV would demonstrate attainment as expeditiously as practicable. This corresponds to an attainment deadline of July 20, 2025.

U.S. EPA modeling guidance requires that modeled attainment demonstrations be accompanied by a weight of evidence analysis (WOE) to provide a set of complementary analyses. Examining an air quality problem in a variety of ways provides a more informed basis for the attainment strategy as well as better understanding of the overall problem and the level and mix of emissions controls needed for attainment. CARB staff prepared the WOE, which is provided in Appendix B of this Staff Report. WOE analyses include assessments of trends in ozone air quality, ozone precursor emission trends, meteorology impacts on ozone air quality trends, and a summary of corroborating analyses. The WOE indicates that the Sacramento Region is on track to attain the 75 ppb ozone standard by July 20, 2025, which is consistent with DV projections derived from the photochemical modeling assessment.

Table 3. Baseline and Forecasted 8-Hour Ozone Design Values (ppb)

Site	Base Year 2012	Future Year 2022	Future Year 2026
Folsom - Natoma Street	90.0	75.2	70.7

C. Control Measures

The ongoing emission reductions from continued implementation of CARB and the Sacramento Air Districts control strategies developed to meet prior standards provide the attainment control strategy for the Ozone Plan. The following sections highlight ongoing CARB control programs and local measures that provide the emission reductions included in the attainment demonstration.

1. CARB Control Program

Given the severity of California's air quality challenges, CARB has implemented the most stringent mobile source emissions control program in the nation. CARB's comprehensive strategy to reduce emissions from mobile sources consists of emissions standards for new vehicles, in-use programs to reduce emissions from existing vehicle and equipment fleets, cleaner fuels, and incentive programs to accelerate the penetration of the cleanest vehicles beyond that achieved by regulations alone. A detailed description of the mobile source control programs and a comprehensive list of CARB regulations are included in Chapter 7 of the Ozone Plan.

2. Sacramento Air Districts Control Programs

Consistent with their regulatory authority, the Sacramento Air Districts have adopted and implemented rules for reducing emissions from a broad range of stationary and area sources. These already adopted rules are enforced to maintain controls on existing sources and to specify the limits on future new sources or modifications to existing sources.

To satisfy the Act requirements for the implementation of RACT, the Sacramento Air Districts have committed to adopt additional rules. The rule adoption and implementation commitments included in RACT SIPs submitted to U.S. EPA over the past two years include:

- Miscellaneous Plastic Parts, Automotive/Transportation Plastic Parts, Business Machine Plastic Parts, and Pleasure Craft (Sacramento Metropolitan AQMD);
- Gas-Fired Ovens/NOx (Sacramentro Metropolitan AQMD); and
- Offset Lithographic Printing and Letterpress Printing (Yolo Solano AQMD).

3. Reasonable Further Progress

The Act and the Rule specify that each ozone nonattainment area must demonstrate ongoing emission reductions relative to the planning inventory base year. The Rule requires areas classified as Serious and above to submit a RFP plan that shows a ROG (and/or NOx) emission reduction of at least 18 percent over the first 6 years after the 2012 baseline year (i.e., from 2012 to 2018) and 3 percent per year, averaged over each consecutive 3-year period, until attainment is achieved. The total emission reductions required from the base year of 2012 to the future year of 2024 is 36 percent.

CARB staff analyzed the emission reductions forecast in the Sacramento Region to and determined that they comply with the RFP requirement. The analysis incorporates the ROG and NOx ERCs that can be converted into real emissions through the stationary source permitting process, and an on-road mobile source emission safety factor of 0.5 tpd NOx that is added by the Sacramento Air Districts to the 2021 NOx emission inventory to assure for transportation conformity.

4. Reasonably Available Control Measures

As specified in the Act, SIPs shall provide for the implementation of RACM as expeditiously as practicable to provide for attainment of the ozone standard. U.S. EPA has interpreted RACM as those emission control measures that are technologically and economically feasible that, when implemented together, would advance the attainment date by at least one year. Sources of potentially reasonable measures include measures adopted in other nonattainment areas and measures that U.S. EPA has identified in guidelines or other documents.

The Ozone Plan contains a RACM analysis that demonstrates no new measures were identified that together would advance attainment. Tabulations of the measures identified and evaluated in the RACM analysis are found in Appendix E of the Ozone Plan.

5. Contingency Measures

The Act requires contingency measures to provide additional emission reductions in the event a nonattainment area fails to achieve RFP targets or attain by the deadline (Act sections 172(c)(9), 182(c)(9).) A recent Ninth Circuit decision, Bahr v. U.S. EPA, (9th Cir. 2016) 836 F.3d 1218, found that U.S. EPA approval of certain types of contingency measures in an Arizona particulate matter SIP were not consistent with the Act's contingency requirements.

CARB staff expects that U.S. EPA will revise its guidance on contingency requirements in light of the Bahr decision. The contingency measure described above meets U.S. EPA's existing guidance. CARB staff will work with the Sacramento Air Districts and the U.S. EPA to provide any additional documentation or develop any needed SIP revisions to support U.S. EPA approval of the Ozone Plan.

For RFP contingency, U.S. EPA has interpreted this requirement to represent one year's worth of RFP, amounting to three percent of reductions from measures that are already in place or that would take effect without further rulemaking action. The Sacramento Region meets the RFP targets in the milestone years of 2018, 2021, and the attainment calendar year of 2024 with a three percent contingency set aside in 2018 and carried through to 2024 per the requirements of the Rule.

To meet the three percent emission reduction for attainment contingency, the Ozone Plan relies on additional reductions occurring between 2024 and 2025 from continued implementation of the control program, including the turnover in the mobile source fleet. CARB's ongoing mobile source control program will provide emission reductions beyond a 2024 attainment year for the Sacramento Region as newer vehicles replace older, higher emitting vehicles. The Ozone Plan relies on these continuing emission reductions to fulfill the contingency requirements, should the Sacramento Region fail to attain the 75 ppb ozone standard in 2024. This is discussed in Chapters 8 and 12 of the Ozone Plan and summarized in Table 8-2 of the Ozone Plan.

V. OTHER CLEAN AIR ACT PLANNING REQUIREMENTS

This section provides an overview of the other SIP requirements contained in the Act for Severe ozone nonattainment areas and how these requirements are addressed in the Ozone Plan. These requirements include reasonably available control technology, transportation conformity budgets, vehicle miles-travelled offsets, general conformity, pollutant transport analysis, and milestone reports.

A. Transportation Conformity Budgets

Under Section 176(c) of the Act, transportation plans, programs, and projects that receive federal funding or approval must be fully consistent with the SIP before being approved by a Metropolitan Planning Organization (MPO). U.S. EPA's transportation conformity rule[5] details requirements for establishing motor vehicle emission budgets (budgets) in SIPs for the purpose of ensuring the conformity of transportation plans and programs with the SIP.

The Ozone Plan establishes on-road motor vehicle emission budgets for each RFP milestone year, as well as for the attainment year. Table 4 summarizes the motor vehicle emissions budgets for transportation conformity purposes under a Severe ozone nonattainment classification. The emission budgets will apply to all subsequent transportation conformity years, per the federal transportation conformity regulation. Emission budgets for NOx and ROG were calculated using EMFAC2014 with Sacramento Area Council of Governments (SACOG) modeled VMT and speed distributions. Once U.S. EPA approves the emission budgets established in the Ozone Plan, these budgets will serve as the upper limits of on-road motor vehicle emissions to which future Sacramento Region transportation plans must conform. Additional information on the on-road motor vehicle emission budgets can be found in Chapter 10 of the Ozone Plan.

Table 4. Sacramento Region Transportation Conformity Budgets (Summer Planning Inventory in Tons per Day)

	2018		2021		2024	
	ROG	**NOx**	**ROG**	**NOx**	**ROG**	**NOX**
Baseline Emissions	19.85	35.38	16.24	26.96	14.03	19.55
Safety Magrin				0.50		
Total	19.85	35.38	16.24	27.46	14.03	19.55
Conformity Budget	20	36	17	28	15	20

Note: The budgets are calculated with EMFAC2014 using SACOG 2016 MTP activity and MTC data for Eastern Solano County. The budgets reflect the latest regional and state strategies described in Chapter 7 of the Ozone Plan. Budgets are rounded up to the nearest ton.

B. Vehicle Miles-Travelled Offsets

Section 182(d)(1)(A) of the Act applies to ozone nonattainment areas classified as Severe or Extreme. The Sacramento Region is currently designated Severe for the 75 ppb ozone standard and is therefore subject to the requirement to offset any growth in emissions resulting from an increase in VMT. The VMT offset demonstration for the Ozone Plan was prepared by CARB staff and is included in Appendix C of the Ozone

[5] Federal transportation conformity regulations are found in 40 CFR Part 51, subpart T – Conformity to State or Federal Implementation Plans of Transportation Plans, Programs, and Projects Developed, Funded or Approved Under Title 23 U.S.C. of the Federal Transit Laws. Part 93, subpart A of this chapter was revised by the EPA in the August 15, 1997 Federal Register.

Plan. The analysis shows that the existing transportation control strategies are sufficient to offset the emissions increase due to growth in VMT and demonstrates compliance with the requirements of Section 182(d)(1)(A).

C. Milestone Reports

Section 182(g) of the Act requires that progress (milestone) report be prepared to evaluate whether actual emission reductions meet the minimum reasonable further progress targets. Typically, air districts in nonattainment areas prepare milestone reports for review by CARB and submittal to U.S. EPA.

VI. ENVIRONMENTAL IMPACTS

The California Environmental Quality Act (CEQA) requires that State and local agency projects be assessed for potential environmental impacts. An air quality plan is a "project" that is potentially subject to CEQA requirements. The Sacramento Air Districts found that the Ozone Plan will not result in any potentially significant adverse effects on the environment and is exempt from CEQA under the provisions of section 15308 (actions taken by a regulatory agency for protection of the environment) of the CEQA Guidelines.

CARB has determined that its review and approval of the Ozone Plan submitted by the District for inclusion in the California SIP is a ministerial activity by CARB for purposes of CEQA (14 CCR § 15268). A "ministerial" decision is one that involves fixed standards or objective measurements, and the agency has no discretion to shape the activity in response to environmental concerns. (14 CCR § 15369; *San Diego Navy Broadway Complex Coalition v. City of San Diego* (2010) 185 Cal.App.4th 924, 934.)

This CARB Review of the Ozone Plan includes supplemental air quality analyses to support air quality modeling results, referred to in U.S. EPA modeling guidance as a "Weight of Evidence" (WOE) analysis, which was made available for public review at least 30 days prior to the CARB public hearing;

CARB has determined that approval of the WOE is exempt from CEQA under California Code of Regulations, title 14, section 15061(b)(3) (the general rule that CEQA only applies to projects which have the potential for causing a significant effect on the environment) and under California Code of Regulations, title 14, section 15308 (actions taken by a regulatory agency to assure the maintenance, restoration, enhancement, or protection of the environment) and the WOE will not result in any potentially significant adverse effects on the environment;

VII. STAFF RECOMMENDATIONS

CARB staff recommends that the Board approve the *Sacramento Regional 2008 NAAQS 8-Hour Ozone Attainment and Reasonable Further Progress Plan* and the WOE as a revision to the California SIP. Staff further recommends that the Board direct

the Executive Officer to submit the *Sacramento Regional 2008 NAAQS 8-Hour Ozone Attainment and Reasonable Further Progress Plan* and the WOE to U.S. EPA as a revision to the California SIP.

Appendix A

Sacramento Region Ozone Standard Exceedance Days and Design Value

Table A-1. 8-Hour Standard Exceedance Days at the Sacramento Region Monitoring Sites

The site with the highest number of exceedance days for the year is highlighted in yellow.

County	Monitoring Site	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
El Dorado	Cool							53	27	48	64	48	54	77	44	27	39	55	29	29	21	6	24	8	4	10	6	15
El Dorado	Echo Summit											2	4	8	3	1		3	3	5	0	0	0	1	0	0		0
El Dorado	Placerville			61	34	50	48	56	37	34	50	38	46	41	40	24	31	45	9	36	20	8	5	20	11	12	7	28
Placer	Auburn [1]	70	48	56	32	50	34	50	9	35	43	39	36	36	27	31	29	56	9	21	14	10	18	13	1	6	10	15
Placer	Colfax [2]	36		36	17	32	23	15	5	23	31	0	3	37	32	26	31	39	10	16	3	3	2	7	1	2	3	9
Placer	Rocklin [3]	23	26	48	18	34	28	40	17	22	25	22	25	29	Site Closed													
Placer	Roseville				17	23	20	29	8	27	19	15	17	25	16	8	18	25	8	22	19	15	15	13	2	10	3	8
Placer	Lincoln																							5	0	1	2	8
Sacramento	Citrus Heights	18	20	17	Ozone monitoring ended in 1993 and site closed in 1996.																							
Sacramento	Elk Grove [4]	30	18	6	3	10	18	30	5	13	16	2	16	2	14	6	12	17	5	7	5	2	1	5	0	0	1	0
Sacramento	Folsom [5]	3	59	43	32	38	34	45	29	38	34	27	44	40	42	23	30	42	21	50	35	19	33	38	6	14	5	13
Sacramento	North Highlands	11	17	12	6	19	24	33	10	23	18	22	15	24	11	5	6	24	2	2	7	3	9	11	0	3	3	7
Sacramento	Sacramento-Del Paso	25	25	28	17	23	32	36	11	25	17	15	12	46	31	14	19	24	10	18	15	5	3	12	3	1	5	4
Sacramento	Sacramento-Goldenland Ct [6]	12	24	19	4	2	20	21	5	17	10	9	6	6	3	0	3	5	4	9	5	1	1	4	0	1	1	3
Sacramento	Sacramento-T Street	5	7	10	4	5	7	11	1	10	9	3	4	7	5	0	4	6	2	9	4	0	1	4	0	0	1	0
Sacramento	Sloughhouse								7	36	39	30	27	30	34	21	19	32	10	19	24	8	19	18	2	5	6	6
Sutter	Pleasant Grove	2	11	18	6	2	11	16	2	15	20	12	9	12	Site Closed.													
Solano	Vacaville [7]	2					4	12	3	14	14	3	1	2	2	1	2	6	2	4	2	1	0	1	0	0	0	0
Yolo	UC Davis	11	1	13	4	4	6	12	1	17	14	7	3	4	5	0	3	4	3	5	1	0	1	1	0	0	0	0
Yolo	Woodland [8]	7	6	15	1	5	9	15	2	12	18	7	5	13	10	0	6	14	2	4	3	0	0	2	0	0	0	0
	Peak Site	**70**	**59**	**61**	**34**	**50**	**48**	**56**	**37**	**48**	**64**	**48**	**54**	**77**	**44**	**31**	**39**	**56**	**29**	**50**	**35**	**19**	**33**	**38**	**11**	**14**	**10**	**28**

Data source: Sacramento Regional 2008 NAAQS 8-Hour Ozone Attainment and Reasonable Further Progress Plan

[1] Auburn monitor was moved from 108 C Ave, Auburn to 11645 Atwood St, Auburn in 2011.

[2] Colfax monitor was moved from 10 West Church St. to 33 South Main St in 1992.

[3] Rocklin monitor was moved from Sierra College to 5000 Rocklin Road in 1992. The Rocklin Road monitor ceased operations in 2003.

[4] Elk Grove monitor was moved from 2800 Meadowview Road to Bruceville Blvd in 1992.

[5] Folsom monitor was moved from City Corp Yard to 50 Natoma Street in 1996.

[6] Sacramento-Goldenland Ct monitor was moved from Airport Road in 2009 and subsequently moved to 7926 Earhart Drive in 1998.

[7] Vacaville monitor was moved from 1001 Allison Drive to 2012 Ulatis Drive in 2003.

[8] Woodland monitor was moved from 177 West Main Street to 40 Sutter Street in 1992 and subsequently moved to 41929 East Gibson Road in 1998

Table A-2. 8-Hour Standard Design Values (ppb) for Sacramento Region Monitoring Sites

The peak site for the year is highlighted in yellow.

County	Monitoring Site	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
El Dorado	Cool							na	na	103	103	107	104	106	107	102	97	95	96	98	93	89	84	83	81	80	79	82
El Dorado	Echo Summit											na	na	75	76	75	na	na	na	76	na	71	67	69	69	69	na	na
El Dorado	Placerville			na	na	97	99	103	99	98	98	99	96	94	95	94	94	94	93	96	92	90	80	81	82	84	81	85
Placer	Auburn [1]	107	105	105	101	102	105	103	95	95	97	102	101	101	99	95	92	93	89	90	86	87	80	na	79	78	79	83
Placer	Colfax [2]	na	76	na	na	92	92	91	86	86	86	79	na	77	88	92	91	97	94	89	79	78	74	75	73	73	73	76
Placer	Rocklin [3]	na	76	na	101	103	100	100	95	94	92	93	91	92	Site Closed.													
Placer	Roseville				na	na	97	96	93	93	89	93	90	92	90	87	86	89	89	90	89	90	86	85	81	81	77	80
Placer	Lincoln																							na	na	na	69	74
Sacramento	Citrus Heights	98	94	97	80	na	na	Ozone monitoring ended in 1993 and site closed in 1996.																				
Sacramento	Elk Grove [4]	95	97	91	83	na	81	87	87	87	88	85	84	75	80	77	82	82	83	82	79	77	74	na	71	70	66	68
Sacramento	Folsom [5]	101	100	101	110	104	106	106	na	91	101	104	99	100	100	97	97	97	98	102	100	102	95	95	90	85	80	83
Sacramento	North Highlands	87	82	88	87	87	88	91	88	89	87	89	89	92	91	85	80	82	80	76	na	na	77	77	76	75	73	77
Sacramento	Sacramento-Del Paso	96	94	100	99	92	96	100	97	95	91	95	92	95	97	95	92	90	90	87	86	85	81	78	77	77	76	77
Sacramento	Sacramento-Goldenland Ct [6]	na	87	88	84	79	80	83	84	na	na	82	79	78	77	na	na	na	76	78	na	na	69	69	70	71	69	71
Sacramento	Sacramento-T Street	na	76	79	79	78	78	80	77	79	80	82	80	79	79	75	73	76	78	79	77	75	71	71	69	69	67	69
Sacramento	Sloughhouse								na	na	100	105	98	95	95	94	94	96	93	95	91	92	87	88	84	80	76	79
Sutter	Pleasant Grove	82	76	79	82	81	82	83	82	81	81	84	83	82	na	na	Site Closed.											
Solano	Vacaville [7]						na	na	76	82	85	85	77	72	na	na	na	73	74	75	72	71	68	69	67	66	66	67
Yolo	UC Davis	na	na	80	78	79	78	82	79	80	81	85	81	77	76	74	73	74	75	76	74	72	70	70	66	64	62	64
Yolo	Woodland [8]	80	77	na	na	79	78	81	79	na	na	84	82	83	83	79	77	79	80	79	74	72	69	69	69	68	67	69
	Peak Site	**107**	**105**	**105**	**110**	**104**	**106**	**106**	**99**	**103**	**103**	**107**	**104**	**106**	**107**	**102**	**97**	**97**	**98**	**102**	**100**	**102**	**95**	**95**	**90**	**85**	**81**	**85**

Data source: Sacramento Regional 2008 NAAQS 8-Hour Ozone Attainment and Reasonable Further Progress Plan

[1] Auburn monitor was moved from 108 C Ave, Auburn to 11645 Atwood St, Auburn in 2011.

[2] Colfax monitor was moved from 10 West Church St. to 33 South Main St in 1992.

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na Insufficient data to determine the design value.

Appendix B

Weight of Evidence Analysis

Sacramento Metropolitan Nonattainment Area Weight of Evidence

Introduction

The Sacramento Metropolitan Federal Ozone Nonattainment Area (Sacramento Region) includes all of the Sacramento Metropolitan Air Quality Management District (SMAQMD) and Yolo-Solano Air Quality Management District (YSAQMD) and portions of counties within the Placer County Air Pollution Control District (PCAPCD), El Dorado County Air Quality Management District (EDCAQMD), and Feather River Air Quality Management District (FRAQMD). Each district manages the part of the nonattainment area that lies within their jurisdiction. The Sacramento Region is currently classified as a severe nonattainment area for the 0.075 parts per million (ppm) federal 8-hour ozone standard (0.075with a July 20, 2027 attainment deadline[6]. For areas classified as moderate nonattainment or above, photochemical modeling is a required element of the State Implementation Plan (SIP) to ensure that existing and planned control strategies provide the reductions needed to meet the 0.075 ppm ozone standard by the attainment deadline.

To address the uncertainties inherent to modeling assessments, U.S. Environmental Protection Agency (U.S. EPA) guidance, *Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze,* recommends that supplemental analyses accompany all modeled attainment demonstrations. To complement the regional photochemical modeling analyses included in the Sacramento Region SIP, the following Weight of Evidence (WOE) demonstration includes detailed analyses of anthropogenic emissions, monitored ozone data and population exposure trends. Analyses of the number of exceedances on weekends versus weekdays and meteorological patterns coincident with elevated ozone in three subregions within the Sacramento Region are also presented.

In 2016, data indicate that 8 out of 17 monitoring sites in the Sacramento Region were in attainment with the 0.075 ppm standard and design values exceeded the 0.075 ppm standard at the remaining nine monitoring sites by 1 to 13 percent. Photochemical modeling analyses conducted by the California Air Resources Board (CARB)

[6] Since the July 20, 2027 attainment deadline falls in the middle of the ozone season (January 1 though December 31), attainment is determined by the ozone measurements recorded during the prior year. Thus, in order to meet the ozone standard by July 20, 2027, the monitors must be in attainment of the standard in the calendar year of 2026.

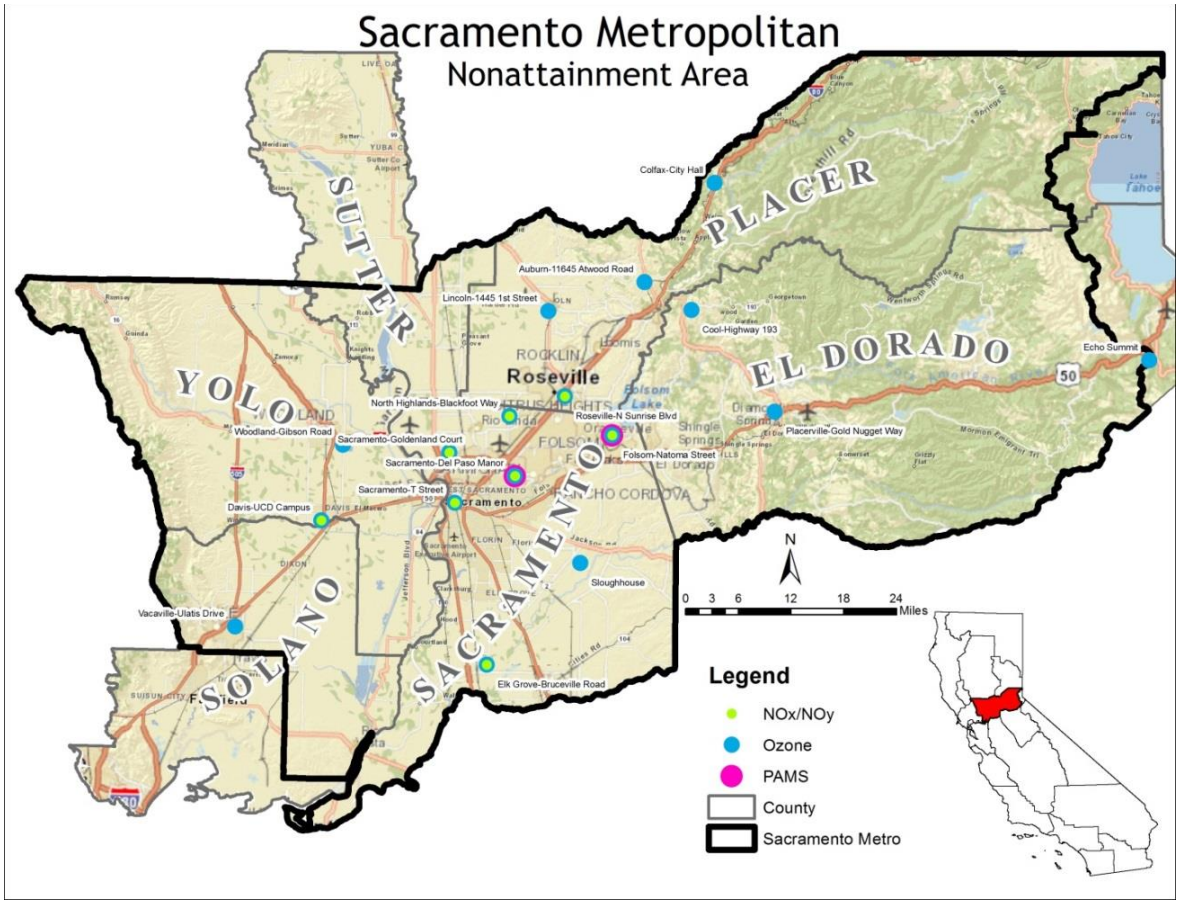
demonstrate that control measures currently in place are adequate for all sites in the Sacramento Region to meet the 0.075 ppm federal standard by 2024, two years prior to 2026, the year air quality needs to meet the standard in order to attain by the July 20, 2027 attainment deadline.

Analyses of air quality data from the past 15 years show that progress is being made at all monitoring sites. However, the extent of progress varies considerably by site and by indicator. The presence of varied terrain, persistent summertime climatological patterns, and diverse precursor emission sources highlights the complex nature of the ozone problem in the Sacramento Region and underscores the utility of examining multiple indicators.

Area Description

The Sacramento Region encompasses all of Sacramento and Yolo Counties; the eastern-half of Solano County, the southern portion Sutter County, and large portions of Placer and El Dorado Counties on the eastern side of the region (Figure 1). Topographically, the Sacramento Region is located at the southern end of the north-to-south running Sacramento Valley and stretches from the Coastal Range Mountains in the west to the crest of the Sierra Nevada Mountains in the east. The Sacramento Region encompasses an area of nearly 7,000 square miles, with elevations ranging from near sea level in the southwestern Sacramento River Delta (the Delta) portion of the region to over 7,000 feet above sea level in the east.

Figure 1: Location of Monitoring Sites in the Sacramento Region



The Sacramento Region is home to nearly 2.5 million people, based on the 2010 U.S. Census, and is located at the intersection of three major highways in northern California, namely Interstate 80, Interstate 5, and State Route 99. Consequently, the movement of goods and people is a significant source of emissions in the region. As shown in Figure 1, the Sacramento Region hosts a few major freeways to accommodate the millions of vehicle miles driven in the region each year. Nearly 60 percent of all truck traffic consists of heavy duty trucks transporting goods on Interstate 80, Interstate 5, and State Route 99[7]. Sacramento also sees nearly 450,000 tons of goods brought through the Port of West Sacramento on the Sacramento River Deep Water Channel[8]. Furthermore, Sacramento's airports saw an average of 132,000 tons of goods moved each year over the previous ten years[9].

[7] http://www.dot.ca.gov/trafficops/census/docs/2015_aadt_truck.pdf
[8] http://www.dot.ca.gov/dist3/departments/planning/Systemplanning/gmstudy/CaltransD3GoodsMovementStudyFinalReport2015.pdf
[9] http://dot.ca.gov/hq/planning/aeronaut/documents/statistics/paxstats.htm

Beyond the developed city areas within the Sacramento Region, a large portion of the area contains substantial agricultural operations consisting of numerous crop types that use a wide range fossil-fueled equipment throughout the year. Many of the undeveloped land areas also allow for off-road recreation vehicle use, while the numerous lakes and rivers allow for the use of motor boats.

Most of the population and anthropogenic emissions are concentrated in the central portion of the Sacramento Region, which is bounded by mountains on two sides. In addition, semi-permanent high pressure systems over the eastern Pacific Ocean and western U.S. lead to stable weather patterns, sunny skies, and limited wind flow during the late spring, summer, and early fall months. These conditions are highly conducive to the accumulation of emissions and subsequent photochemical production of ozone. A regional, thermally driven sea breeze pattern between the Pacific Ocean and Sacramento also promotes a large gradient in ozone concentrations across the Sacramento Region. The lowest concentrations are typically measured at the upwind sites on the western and southwestern side of the region and the highest concentrations are typically measured in eastern Sacramento County and at the foothill sites in El Dorado and Placer Counties. To characterize ozone air quality, CARB and the air districts of the Sacramento Region, including the SMAQMD, YSAQMD and PCAPCD, share monitoring responsibilities across the Sacramento Region through the operation of an extensive monitoring network that included 17 ozone monitoring sites in 2016. These monitoring sites are shown in Figure 1 and listed in Table 1.

Table 1: Recent Ozone Design Values at Sites in the Sacramento Region

	Site Name	AQS ID	County	2015 Design Value (ppm)	2016 Design Value (ppm)	Percent of 0.075 ppm Standard (2016 Design Value)	2016 Design Value Meets Standard
	Elk Grove-Bruceville Road	060670011	SAC	0.066	0.068	91%	Yes
	Vacaville-Ulatis Dr.	060953003	SOL	0.066	0.067	89%	Yes
	Davis-UCD Campus	061130004	YOL	0.062	0.064	85%	Yes
	Woodland-Gibson Rd.	061131003	YOL	0.067	0.069	92%	Yes
	Roseville-N Sunrise Blvd	060610006	PLA	0.077	0.080	107%	No
	Lincoln-1445 1st Street	060612002	PLA	0.069	0.074	99%	Yes
	North Highlands-Blackfoot Way	060670002	SAC	0.074	0.077	103%	No
	Sacramento-Del Paso Manor	060670006	SAC	0.076	0.077	103%	No
	Sacramento - 1309 T Street	060670010	SAC	0.068	0.069	92%	Yes
	Folsom-Natoma Street	060670012	SAC	0.080	0.083	111%	No
	Sacramento-Goldenland	060670014	SAC	0.069	0.071	95%	Yes
	Sloughhouse	060675003	SAC	0.076	0.079	105%	No
	Auburn - Atwood Rd	060610003	PLA	0.079	0.083	111%	No
	Colfax-City Hall	060610004	PLA	0.073	0.076	101%	No
	Placerville-Gold Nugget Way	060170010	ELD	0.081	0.085	113%	No
	Echo Summit	060170012	ELD	n/a	n/a	n/a	Yes*
	Cool	060170020	ELD	0.079	0.082	109%	No

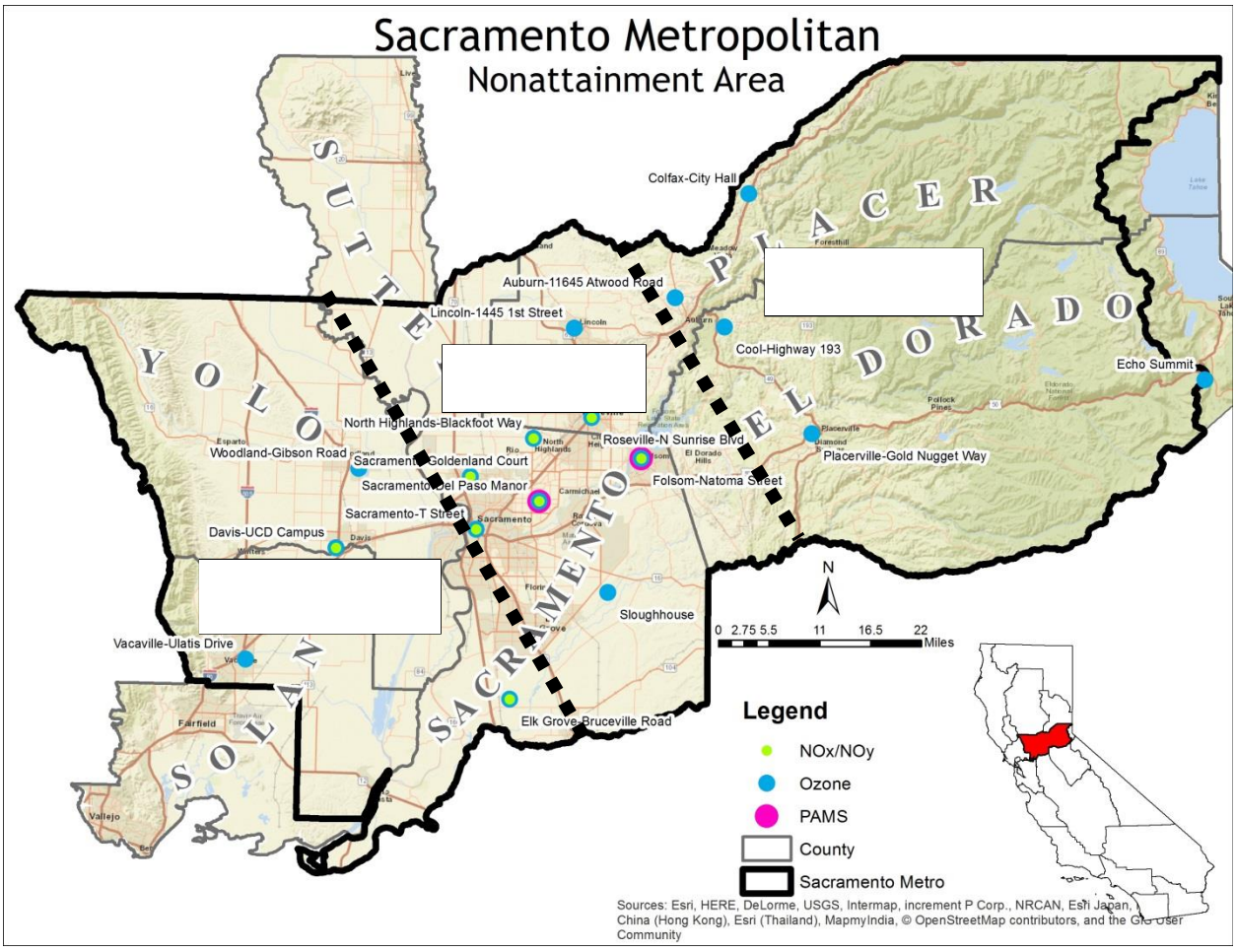
Note: Some of the monitoring sites were combined in this document as follows:

- Vacaville: Vacaville-Elmira Rd (2001-2003) and Vacaville-Ulatis Dr. (2003-2016)
- Lincoln: Lincoln-L St (2012) and Lincoln-1445 1st St (2012-2016)
- Sacramento-Goldenland: Sacramento-Airport Rd (2001-2008) and Sacramento-Goldenland Court (2008-2016)
- Auburn: Auburn-Dewitt C Ave (2001-2011) and Auburn-Atwood Rd. (2011-2016)

* While Echo Summit did not operate in 2015, the fourth-highest concentrations in 2014 and 2016 were well below the 0.075 ppm standard and previous design values have met the standard since 2009

Because the Sacramento Region consists of distinct topographic features, a varied distribution of population, and limited wind flow patterns due to the mountains, it is logical to subdivide the Sacramento Region for analytical and discussion purposes. As shown in Figure 2 below, the Sacramento Region monitoring sites have been subdivided into western, central, and eastern areas based on their location relative to the main population center of Sacramento; the predominant wind flow direction in the summer months, which is southwest to northeast; and annual ozone design value concentrations. Table 1, above, lists the monitoring sites located within each of the subregions and indicates which sites have design values currently meeting the 0.075 ppm ozone standard.

Figure 2: Map of Subregions within the Sacramento Region



Conceptual Model

Local anthropogenic emissions, varied terrain, and favorable meteorological conditions for the formation of ozone contribute to the ozone air quality challenges in the Sacramento Region.

Emissions

Ozone is a secondary pollutant that is produced in the atmosphere through a complex series of photochemical reactions involving oxides of nitrogen (NOx) and reactive organic gases (ROG). The concentrated population in the central portion of the Sacramento Region, the extensive use of automobiles and agricultural equipment, and the availability of biogenic ROG produced by plants and trees in the foothills of the eastern portion of the region provide a setting in which the suite of anthropogenic emissions and biogenic emissions is quite favorable for ozone formation.

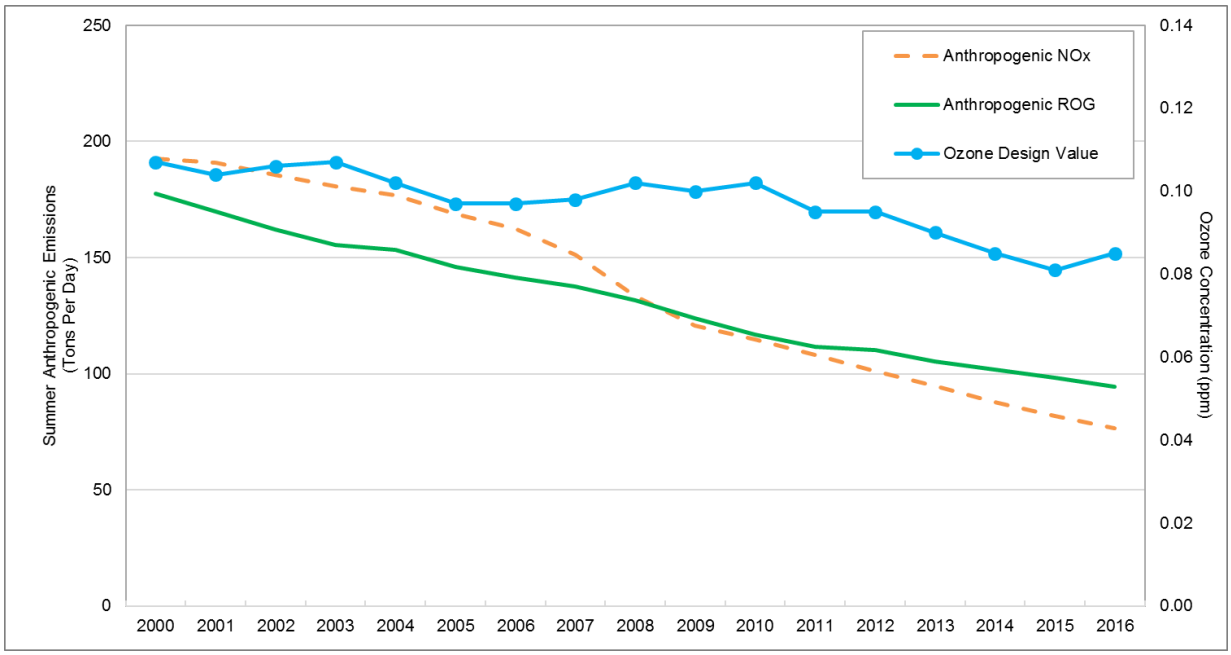
Anthropogenic ozone precursors in the Sacramento Region are largely derived from mobile source emissions, which include passenger vehicles, heavy-duty diesel trucks, recreational boats, and off-road and agricultural equipment, as well as consumer products, which include hair spray, personal fragrance, and all-purpose cleaners. Stationary sources are scattered throughout the Sacramento Region, with all but a few being considered minor sources. Controlling emissions in the Sacramento Region demands a coordinated, multi-faceted approach at the local, state, and federal levels.

A combination of federal, State, and local emission control programs have significantly reduced emissions in the Sacramento Region during the past 15 years. As shown in Figure 3, ozone design values have persistently declined in response to precursor emissions reductions. The Sacramento Region is not typical of most urban areas with high ozone concentrations, which tend to have abundant NOx emission sources and limited ROG emissions. This region has abundant anthropogenic NOx emissions and abundant ROG emissions from biogenic sources. In fact, biogenic ROG emissions are more than ten times the anthropogenic ROG emission in the Sacramento Region. This mixture of sources, some of which can be controlled and other which cannot, creates a challenging scenario for reducing ozone concentrations.

As the Sacramento Region has progressed towards attainment, the quantity and composition of precursors has changed. In recent years, NOx has been the primary focus of control efforts. State of the art photochemical modeling assessments are necessary to understand the current and future mechanisms that will control ozone concentrations in the Sacramento Region. The most recent modeling indicates that the dominant precursor controlling ozone production is still NOx, and that by means of a

NOx-focused control strategy the Sacramento Region will be able to achieve the 0.075 ppm standard, as well as the recently adopted 0.070 ppm standard.

Figure 3: Sacramento Region Precursor Emissions and Ozone Design Values



Meteorology and Complex Terrain

Statewide Weather Patterns

The weather throughout most of California is dominated by an extensive area of high pressure over the eastern Pacific Ocean, which generally produces mild weather year round. Along the California coast, daily sea breezes and a marine layer are a common occurrence. Summer days in the inland portions of the State tend to experience clear skies, light winds, cool morning and warm afternoon temperatures, and limited vertical mixing due to persistent temperature inversions. Occasionally, the Pacific High will weaken or move to the south, allowing the storm track to shift over California, producing cloudy skies, moderate-to-strong winds, rain, and thorough mixing of the atmosphere. The stormy periods tend to last not more than a few days and typically occur between the months of October and March.

During the transitional spring and fall months, another pattern often develops, lasting for one to three days, which is defined primarily by northerly winds that tend to be strong and gusty. The winds are produced by storm systems passing California to the north and swinging down into the Great Basin, east of California. Under this pattern, skies tend to be clear and the atmosphere is well mixed, but wind-blown dust and wildland fires and smoke can be an issue. While these broad, generalized weather patterns are

relevant to most of the State, localized weather features and topography play a critical role in the air quality within the Sacramento Region.

Sacramento Region Weather Patterns

As previously discussed, the Sacramento Region is directly bounded by mountains to the west and east, and to a lesser extent, to the north at the northern end of the Sacramento Valley by the Cascade Mountains near Redding. The mountain ranges act as large barriers to wind flow in the west-to-east direction and have a profound impact on vertical mixing within the lower levels of the atmosphere and the buildup and transport of air pollution within the Sacramento Region. The terrain constrains air flow within the Sacramento Region to either winds from the south, which flow northward or northeastward from the Delta (Delta breeze), or winds from the north that travel southward through the Sacramento Region toward the Delta. As a result, even under moderate wind speeds, pollutants tend to remain within the Sacramento Region and are transported between the various counties in the nonattainment area. The Delta breeze also transports emissions toward the eastern portion of the Sacramento Region, where the highest ozone concentrations have been observed during the past 15 years.

The Coastal Range on the western side of the Sacramento Region prevents the cooler, humid, ocean air from flowing freely into the region, resulting in hot temperatures in the summer that are conducive to ozone formation. However, the lack of a mountain barrier at the southern end of the region enables ocean air to flow into the Sacramento area via the Carquinez Strait under certain weather patterns, providing occasional Delta breeze ventilation within the Sacramento Region. Due to the frequent separation of the Sacramento Region from the marine influence and prevailing upper-level high pressure producing general sinking motion and clear skies over California, the Sacramento Region experiences low relative humidity and large diurnal temperature swings during much of the year.

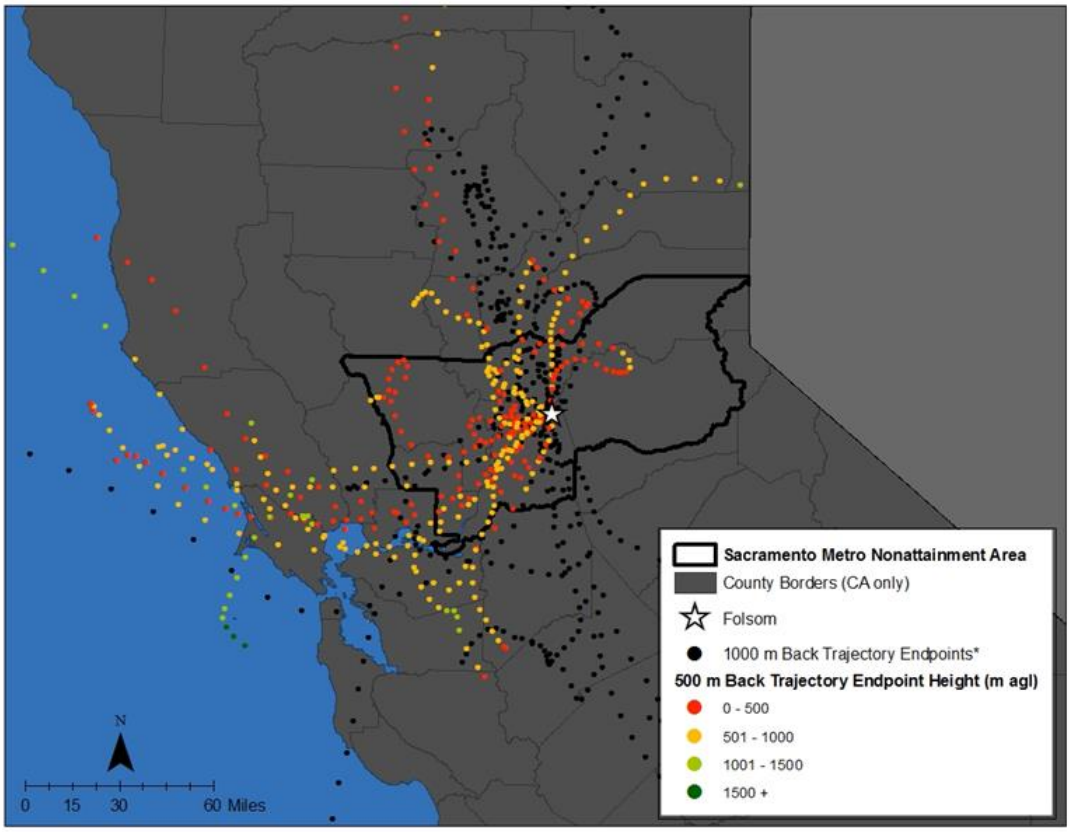
Another key meteorological factor for air quality in the Sacramento Region is the formation of ground-based temperature inversions, which are indicated by temperatures warming with height in the atmosphere rather than the expected cooling with height. Since warmer air is above cooler air in this situation, the atmosphere is very stable and vertical mixing is limited. In the summer, the inversions extend up to around 1,500 feet above ground level and are typically strong and persistent, preventing vertical mixing on most hot summer days and allowing pollutant concentrations to build underneath them.

During the summer days, pollutant emissions within the Sacramento region react in plentiful sunlight to form ozone, which becomes trapped under a temperature inversion on most days. During the afternoons, the light Delta breeze helps mix the atmosphere under the inversion while transporting the emissions and ozone into eastern portion of

the region, where there are fewer fresh NOx emissions available for breaking down ozone and more ROG from biogenic sources to enhance ozone production. Soon after sundown, the Delta breeze usually weakens and the air in the foothills begins to cool, causing the air to flow back down into the Sacramento area and making the pollutants available for increased ozone formation potential and higher concentrations the next day.

Both of these wind flow patterns can be observed in Figure 4, where backward trajectories were prepared for 19 days in 2014 and 2015 on which the Folsom ozone monitor exceeded 0.075 ppm. The trajectories were run at two heights: 500 meters (m), to represent air within the boundary layer and typically below the temperature inversion and, 1,000 m, to represent air in the mostly free atmosphere above the inversion. The trajectories coming from the southwest are the Delta breeze days and the looping in the trajectories on the eastern side of Folsom indicate the recirculation pattern. The trajectories to the north indicate that high ozone concentrations are possible on days with light northerly wind flow as well.

Figure 4: Back Trajectories on Ozone Exceedance Days in 2014 and 2015 at the Folsom-Natoma Street Monitoring Site



The upslope/downslope recirculation pattern is very pronounced in the Sacramento Region and is a key factor during multi-day, high ozone concentration episodes. The recirculation is also a key mechanism in the transport of pollutants such as wildfire smoke from the foothills down into the valley floor during overnight periods. This can be an issue since wildfire smoke can contain large amounts of ozone precursor emissions.

Diurnal Ozone Patterns

The diurnal ozone patterns for the three Sacramento subregions are discussed in this section. The typical diurnal (midnight to midnight) pattern in ozone concentrations measured at individual locations provides additional insight into the general processes that contribute to ozone air quality in the Sacramento Region.

Diurnal patterns at monitoring sites in large urban core areas, which are densely populated, are often characterized by narrow periods of peak concentrations coincident with peak solar insolation. Nighttime/early morning minimum concentrations are typically at, or near, zero due to availability of NOx for titration, or the breakdown of ozone, thereby suppressing ozone concentrations. In suburban and rural locations, peak concentrations are typically higher than in urban core areas, occur later in the day, and persist for an extended period resulting in a broader peak. The nighttime/early morning minimum concentrations are dependent on each monitoring site's distance from the urban core and other site characteristics, but do not typically reach zero in suburban/rural areas.

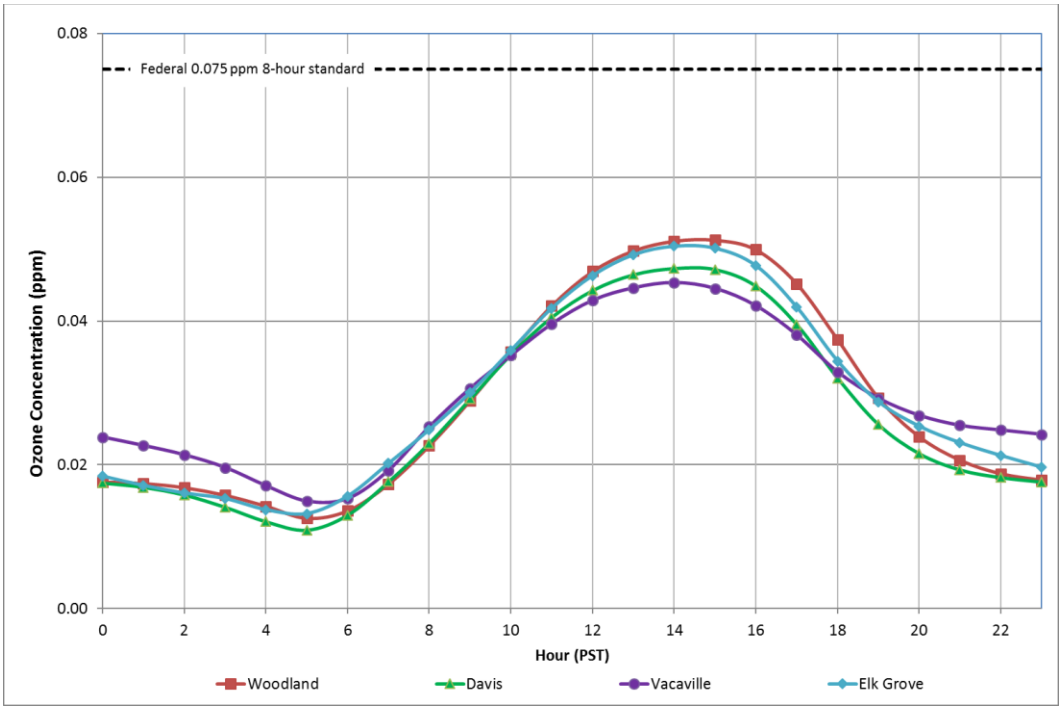
The Sacramento Region is comprised of a few small urban cores and many suburban and rural communities. Therefore, most of the monitoring sites exhibit suburban/rural site characteristics. However, under certain meteorological conditions and emission patterns, even those sites could have short-term, nighttime NOx concentrations near zero.

In an effort to represent the current state of air quality dynamics in the Sacramento Region, as well as maintain a large sample size to compensate for inter-annual variability, the five-year period of 2012 through 2016 was selected for evaluation. Furthermore, to focus the analyses presented here on periods when high ozone concentrations typically occur, the hourly data shown in the following figures were limited to the warm, summer months of May through October for those same years.

In the western portion of the Sacramento Region, the average diurnal profiles were similar among sites and were characterized by broad peaks between 1300 and 1500 PST that included maxima ranging from 0.045 ppm to 0.051 ppm (Figure 5). Among monitoring sites, the average nighttime minima decreased with distance from the Suisun and San Pablo Bays in the Delta, but remained above zero, on average, at all sites. The western subregion is largely rural with isolated suburban centers and the

overall profile of the peaks is somewhat broad, as expected for non-urban core locations. Due to the western subregion's proximity to the coastal bays and limited emission sources, more frequent Delta breezes suppress peak temperatures and disperse pollutants, limiting ozone buildup. At Woodland, which is the furthest inland site, the profile, with its higher peak and low minimum concentration, is more consistent with a site in a downwind area with slightly more emissions and warmer temperatures.

Figure 5: Average Diurnal Profiles for 1-Hour Ozone Concentrations at Western Subregion Sites (May-October 2012-2016)

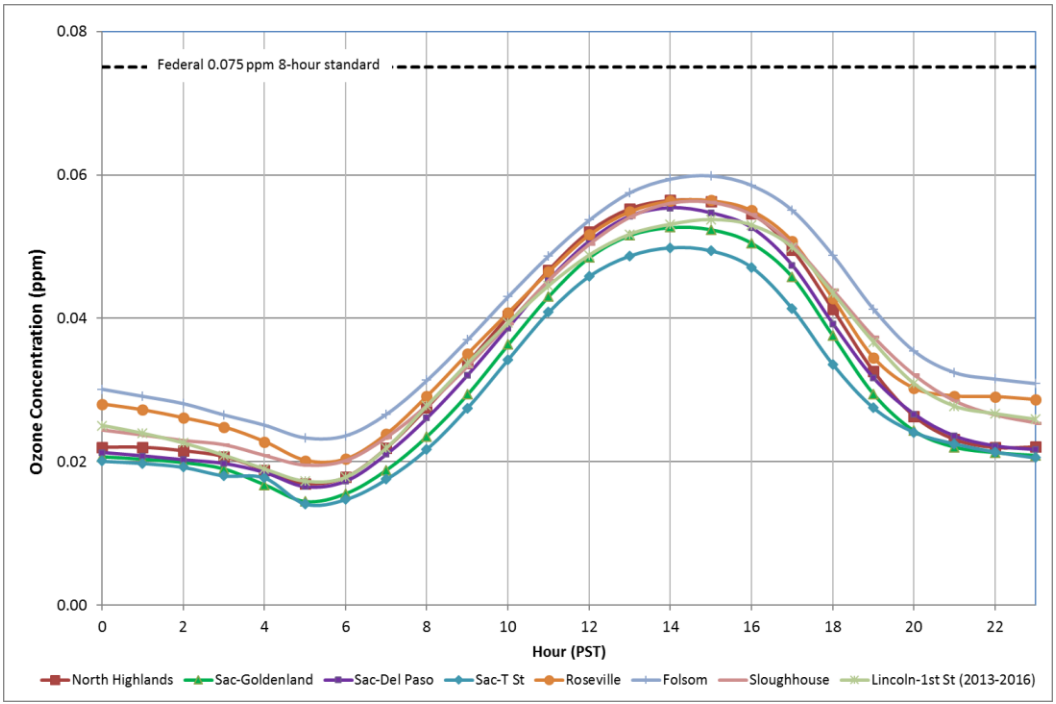


In the central portion of the Sacramento Region, the average diurnal profiles were generally similar among sites and were characterized by broad peaks between 1400 and 1500 PST that included maxima ranging from 0.050 ppm to 0.060 ppm (Figure 6). Among monitoring sites, the average nighttime minima increased with distance from the Delta region, but remained above zero at all sites. In addition, the large Sacramento urban and suburban area were characterized by a profile of lower ozone peaks on the western edge and higher, time-delayed peaks in the north and northeastern portion. This spatial distribution is borne out by Sacramento-T Street's (western edge) peak concentration of 0.050 ppm, North Highlands' (to the north) peak of 0.056 ppm, Roseville's (to the northeast) peak of 0.056 ppm, and Folsom's (to the northeast) peak of 0.060 ppm.

The increasing ozone concentrations from the western edge to the northeastern portion of this subregion demonstrates the role of meteorology in the diurnal ozone cycle. The

daily summertime Carquinez to Sacramento Valley Delta breeze transports the region's highest ozone precursor emissions, located within Sacramento's central business district, to the north and east. Additional emissions along the urban transport path enhance the downwind ozone concentrations. Finally, ozone concentrations are enhanced by higher temperatures downwind due to the greater distance from the moderating effect of the ocean, coastal bays, and Delta, as well as substantial biogenic ROG emissions associated with the foothills on the eastern side and which increase as temperature increases.

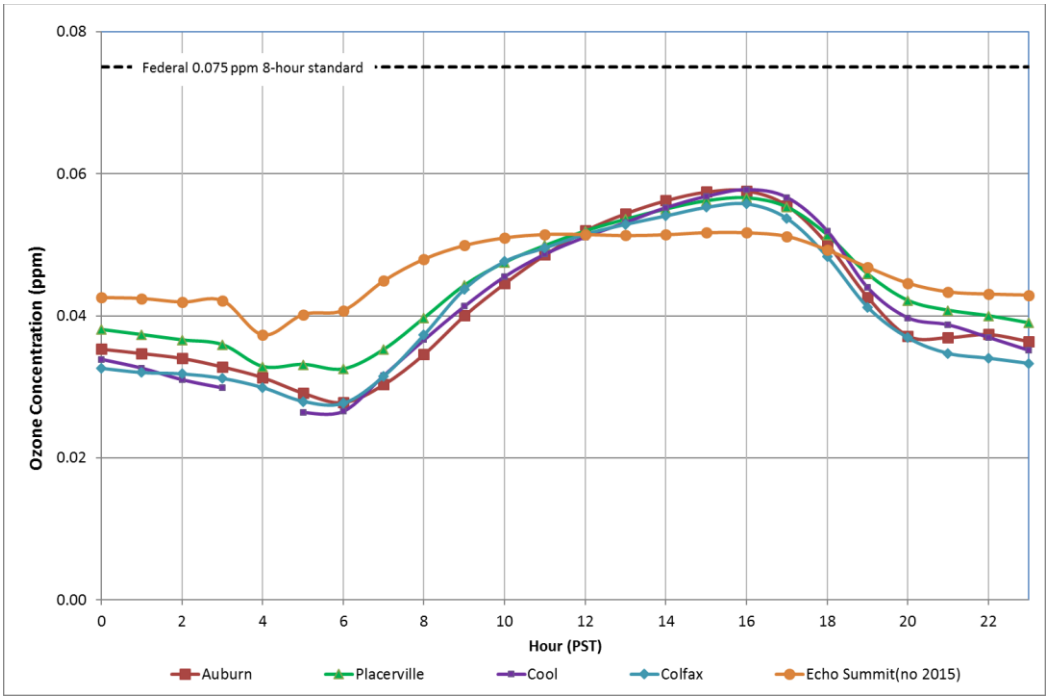
Figure 6: Average Diurnal Profiles for 1-Hour Ozone Concentrations at Central Subregion Sites (May-October 2012-2016)



In the eastern portion of the Sacramento Region, the diurnal profiles differ from those in the other two subregions. The eastern sites were characterized by very broad peaks between 1500 and 1600 PST and included maximum concentrations ranging from 0.052 ppm to 0.060 ppm (Figure 7). In addition, they were characterized by slower growing mid-day profiles than the central subregion sites. Among the eastern sites, the average nighttime minimum increased with distance downwind of Sacramento on the Highway 50 corridor (Placerville and Echo Summit), while remaining flat along the I-80 corridor (Auburn, Cool, and Colfax). The nighttime minimum remained above zero, on average, at all sites. The mid-afternoon peak profiles were characteristic of downwind rural areas impacted by ozone transport and highlight the significant role of transport within the Sacramento Region.

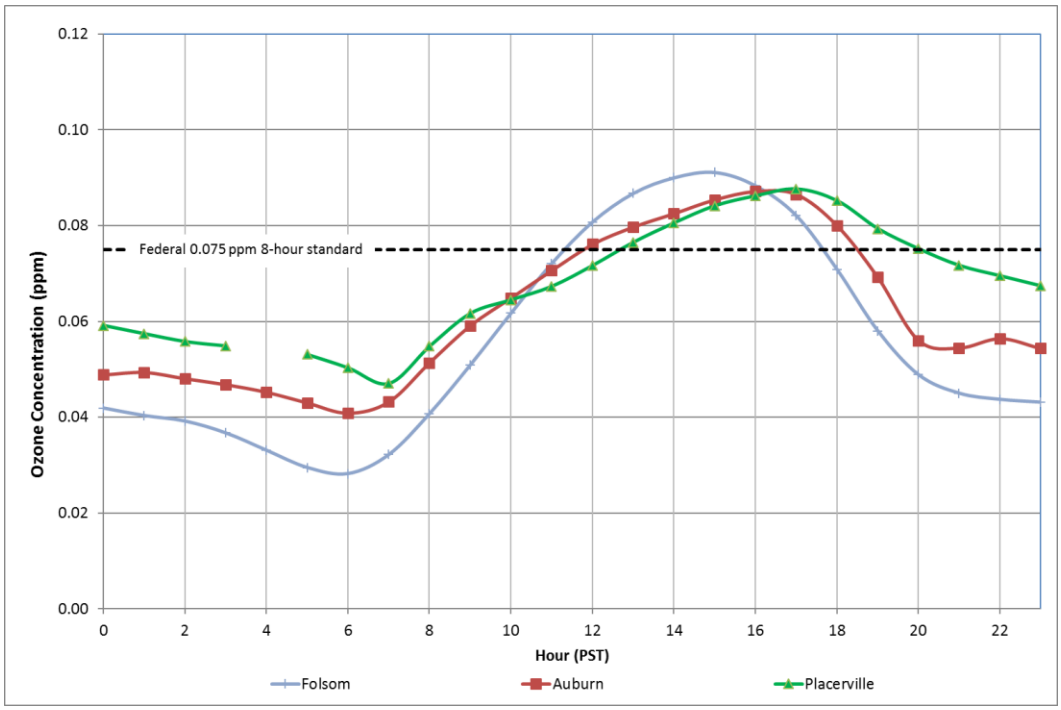
The average diurnal profiles were consistent among sites, except for Echo Summit, which exhibits much lower ozone concentrations and a very broad peak compared to the other sites in the subregion. This result is largely due to that site's location far downwind of urban and suburban areas and closer proximity to the Lake Tahoe Air Basin than sites close to the Sacramento urban area. Echo Summit was sited to intercept transport entering the Lake Tahoe Air Basin.

Figure 7: Average Diurnal Profiles for 1-Hour Ozone Concentrations at Eastern Subregion Sites (May-October 2012-2016)



The central and eastern subregion monitoring sites of Folsom, Placerville and Auburn, in particular, pose a key challenge for attainment due to their high late night/early morning ozone concentrations, especially at Placerville, and the number of hours that ozone concentrations frequently persist above the 0.075 ppm federal 8-hour ozone standard on high ozone days (Figure 8). Both the Placerville and Auburn sites have seven or more hours with concentrations above 0.075 ppm, which will need to be reduced in order for these sites to attain the standard. This is in contrast to Folsom, which has fewer hours above 0.075 ppm, but also has a higher peak, on average. This also reflects the differential progress seen in the Sacramento Region. Folsom, the previous design site, has seen a much more rapid decline in design values than Placerville or Auburn. (Design value trends are discussed later in this document). Due to the rapid progress at Folsom, Placerville has been the design site for the last two years and is anticipated to remain among the highest ozone sites in the Sacramento Region as the area approaches attainment.

Figure 8: Average Diurnal Profiles for 1-Hour Ozone Concentrations at Folsom, Auburn, and Placerville on Days with Peak 8-Hour Ozone Concentrations > 0.075 ppm (May-October 2012-2016)



Conceptual Model Summary

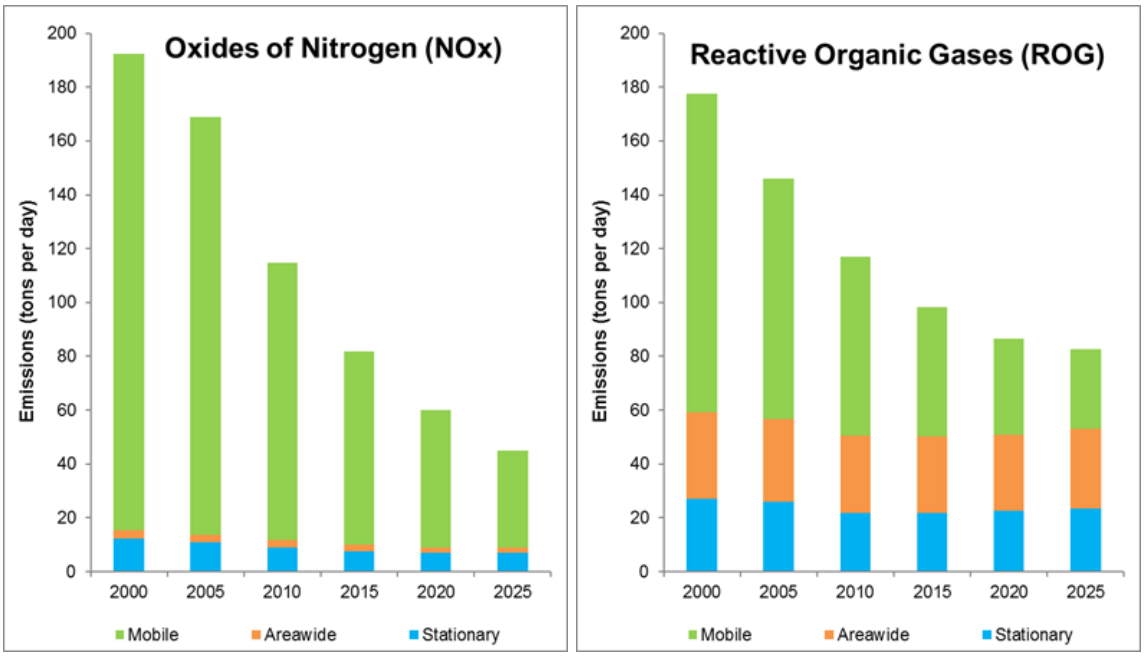
Meeting the 0.075 ppm ozone standard is a complex challenge in the Sacramento Region. A diverse suite of precursor emissions results from central urban core surrounded by heavily-traveled highways and major agricultural activities. The area is characterized by varied terrain, which limits dispersion and effectively traps emissions in the region. Furthermore, meteorological conditions are dominated by a semi-permanent high pressure system, which enhances the trapping effect of the local terrain; and a thermally driven afternoon Delta breeze wind and a nighttime, downslope drainage flow recirculation pattern, which serves to routinely transport emissions from the central portion of the region up into the foothills in the eastern portion during the day and then back down toward the valley floor overnight. State of the art photochemical modeling, supported by extensive monitoring and research efforts, indicates that the path towards attainment of the 0.075 ppm standard is with a NOx-focused control strategy.

Anthropogenic Emissions

Data from the CARB 2016 Ozone SIP Inventory for Summer (version 1.05) were used to evaluate trends in anthropogenic emissions of ozone precursors, NOx and ROG. Federal, State, and local programs have yielded significant overall reductions in emissions of ozone precursors in the Sacramento Region. Most recently, between 2000 and 2015, the Sacramento Region achieved substantial reductions in ozone precursor emissions (Figure 9), where:

- Total NOx emissions decreased by 58 percent; and
- Total ROG emissions decreased by 45 percent.

Figure 9: Inventory of Emissions in the Sacramento Region



Between 2000 and 2015, the top three NOx emission inventory subcategories were heavy heavy-duty diesel trucks, off-road equipment, and farm equipment (Figure 10). The top three ROG emission inventory subcategories during this period were light-duty passenger automobiles, consumer products, and recreational boats. The range of emission sources, for the top ROG subcategories in particular, highlights the complexity of emission sources in the Sacramento Region. However, consistent with the population distribution and the road network, mobile sources dominate the emission inventories of ozone precursors, shown in Figure 9. The emissions inventory indicates that mobile sources accounted for 88 percent of NOx emissions and 49 percent of ROG emissions in 2015.

In 2000, the largest mobile source subcategories for NOx emissions in the Sacramento Region were heavy heavy-duty diesel trucks, light-duty automobiles, light-duty trucks,

and off-road equipment. Between 2000 and 2015, NOx emissions from heavy heavy-duty diesel trucks declined by 62 percent, whereas NOx emissions from light-duty passenger, light-duty trucks, and off-road equipment declined by 83 percent, 82 percent, and 49 percent, respectively.

Going forward from 2015, current control programs will further reduce emissions by 2025, namely:

- Total NOx emissions will decrease an additional 45 percent; and
- Total ROG emissions will decrease an additional 16 percent.

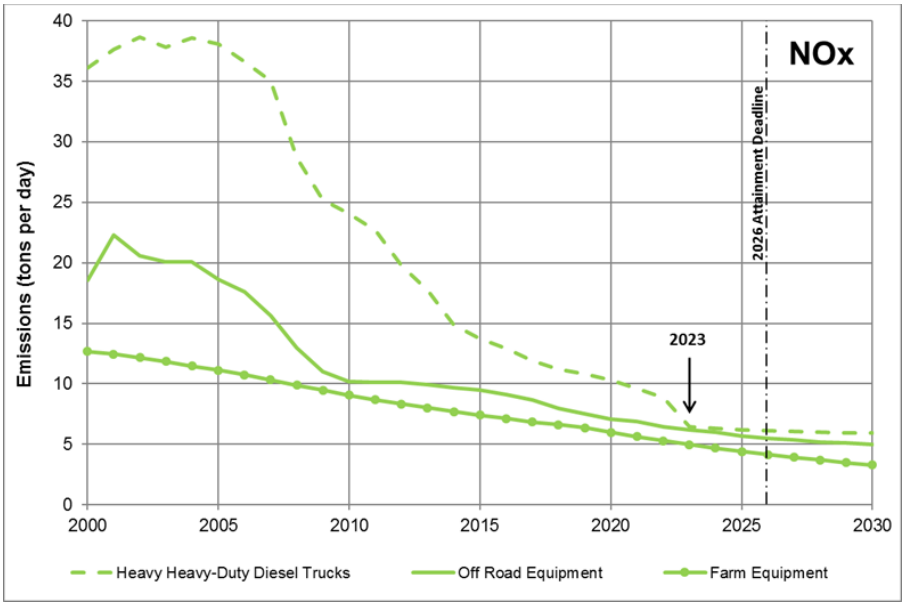
Comparing these future reductions to those obtained between 2000 and 2015, both NOx and ROG reduction rates are slowing, but the NOx reductions will be much greater than those for ROG. This supports the concept that the Sacramento Region is a NOx-limited ozone production regime and that NOx control strategies will continue to be the most effective method for reducing ambient ozone concentrations.

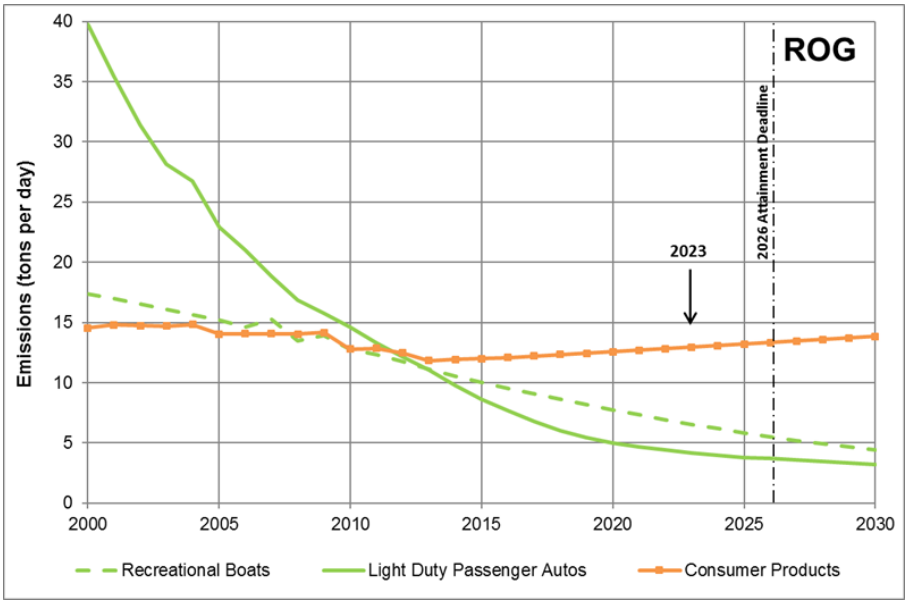
On a sector basis, due to the implementation of adopted control measures, by 2025, projections indicate that NOx emissions from heavy heavy-duty diesel trucks, light-duty automobiles, light-duty trucks, and off-road equipment, will decline from 2015 levels by an additional 55 percent, 63 percent, 67 percent, and 40 percent, respectively.

The majority of the declines projected between 2015 and 2025 will occur prior to 2023. With the implementation of the final increment of the truck and bus rule, a sharp decline in heavy heavy-duty truck emissions is expected between 2021 and 2023. However, following 2023, projections indicate that the rate of decline for these mobile source sectors will slow without additional control programs. Furthermore, projections indicate that by 2023, heavy heavy-duty diesel trucks and off-road equipment will represent the top two mobile source categories, and in 2025, will collectively account for more than 24 percent of the 50 tons/day NOx carrying capacity estimated by the Sacramento Metropolitan AQMD as necessary to meet a 0.075 ppm.

In 2000, within the mobile source category, light-duty passenger automobiles, light-duty trucks, recreational boats, and off-road equipment account for the largest quantities of ROG emissions. As shown in Figure 10, between 2000 and 2015, ROG emissions declined across these categories with reductions amounting to 78 percent for light-duty automobiles, 70 percent for light-duty trucks, 42 percent for recreational boats, and 35 percent for off-road equipment. Between 2015 and 2025, ROG emissions are projected to continue to decline. In 2025, projections indicate that ROG emissions will be 56 percent, 51 percent, 42 percent, and 14 percent lower than 2015 levels for light-duty automobiles, off-road equipment, light-duty trucks, and recreational boats, respectively.

Figure 10: NOx and ROG Emissions in the Sacramento Region (2000-2030)





On a subregional scale, the Sacramento County portion of the area accounts for the largest portion of anthropogenic NOx and ROG emissions, followed by the Sacramento Region portion of Placer County, Yolo County, and the Sacramento Region portions of Solano, El Dorado, and Sutter Counties. As shown in Figures 11 and 12, Sacramento County NOx and ROG emissions in 2000 were more than two and three times greater, respectively, than emissions in other counties in the Sacramento Region. Sacramento County NOx emissions remained more than two times greater than other Sacramento Region counties in 2015, whereas ROG emissions were more than triple those in other Sacramento Region counties. However, NOx and ROG emissions

declined in all counties between 2000 and 2015; and the magnitude of decline was largest in Sacramento County. Like the basinwide emissions inventory, mobile sources dominate the county-level inventories of NOx and ROG emissions. Projections for 2025, shown in Figure 9, indicate that mobile sources will continue to dominate the NOx

Figure 11: County-Level Anthropogenic NOx Emissions in the Sacramento Region

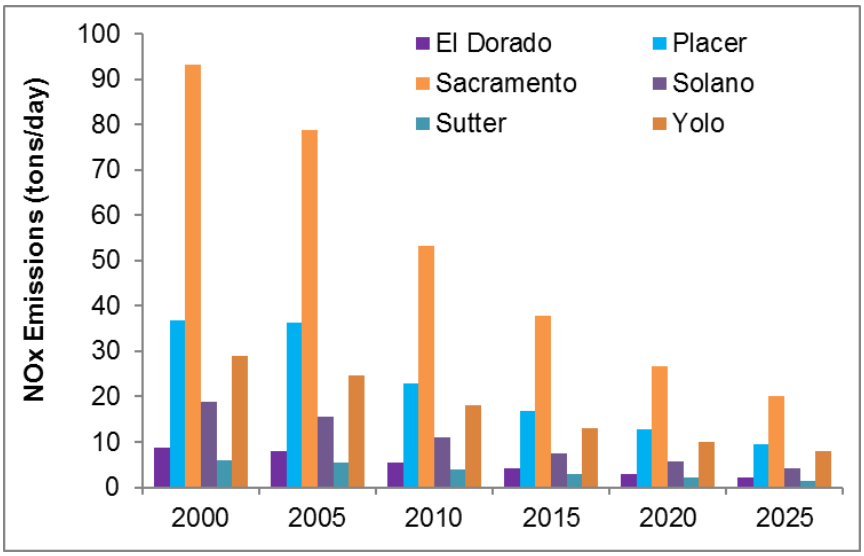
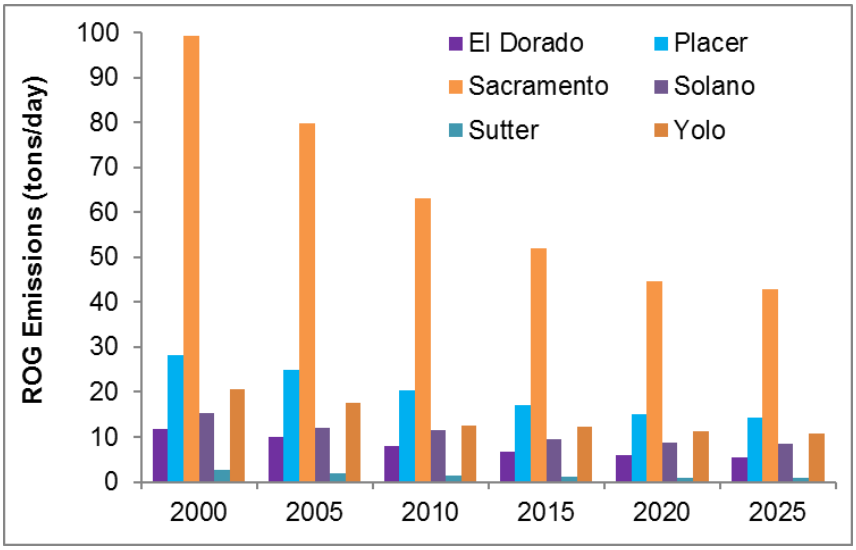


Figure 12: County-Level Anthropogenic ROG Emissions in the Sacramento Region



inventory, whereas stationary, areawide, and mobile sources will make nearly equal contributions to the ROG inventory in all counties.

The county-level differences in emissions, shown in Figures 11 and 12, are consistent with the spatial distribution of emissions derived from regional chemical transport modeling. Regional modeling by CARB staff indicates that peak emission areas for NOx and ROG are closely aligned with the major freeways and the Sacramento urban core. As discussed earlier, prevailing southwesterly winds provide a persistent mechanism by which emissions from these areas are routinely transported eastward into the foothills, disproportionately promoting elevated ozone at sites downwind of these peak emission areas.

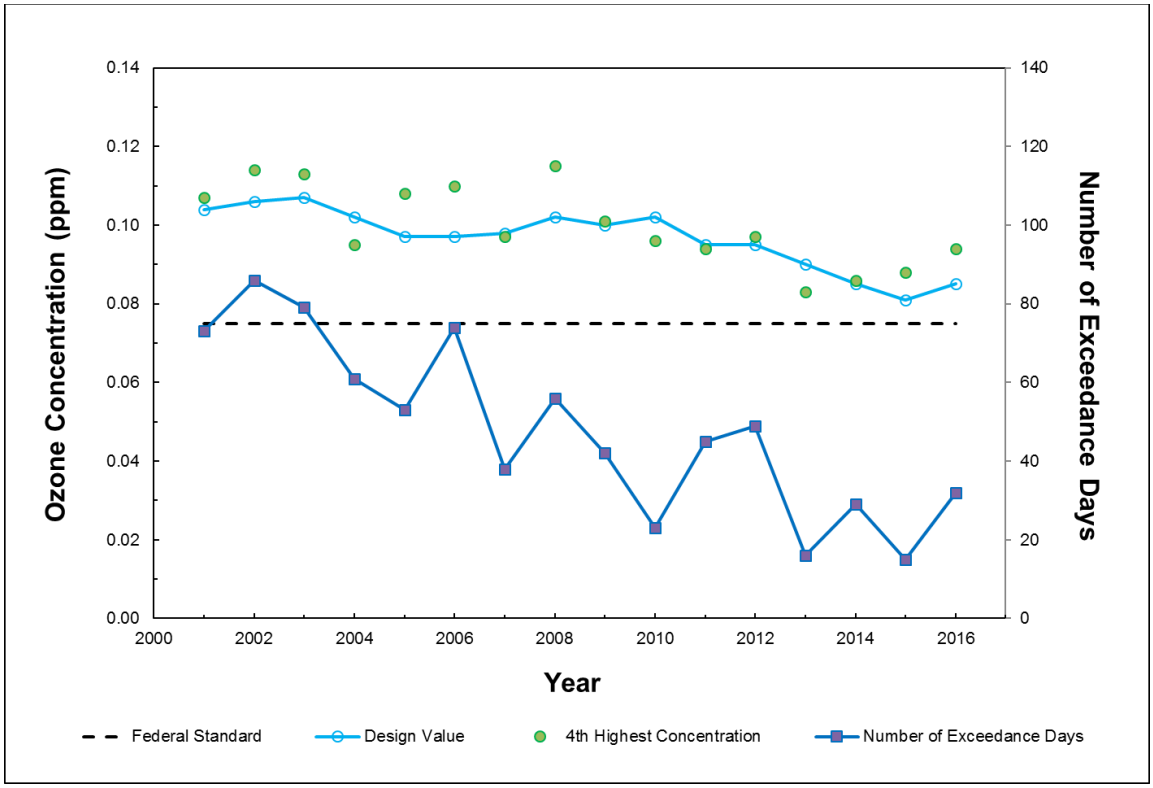
Ozone Air Quality

The design value is the key metric for assessing the state of ozone air quality in a region and it can be directly compared to the federal ozone standard for the purpose of determining attainment status. The design value is computed as the three-year average of the fourth-highest concentration from each year and is determined for each monitoring site. When the design value is evaluated across all sites within area, the Sacramento Region in the case of this WOE, a region-wide design value is determined.

Ozone air quality within the Sacramento Region has significantly improved during the past 15 years. As shown in Figure 13, the Sacramento Region's design value decreased by 18 percent between 2001 and 2016, from 0.104 ppm to 0.085 ppm. During this same period, the annual fourth-highest daily maximum 8-hour average ozone concentration decreased by 18 percent, from 0.107 ppm in 2001, to 0.094 ppm in 2016. Exceedance days decreased by 56 percent from the year 2001, when the 0.075 ppm standard was exceeded on 73 days, to the year 2016, when there were 32 exceedance days. The substantial reductions in design values, fourth-highest concentrations, and exceedance days demonstrate that the area is well on its way towards attainment of the 0.075 ppm federal 8-hour ozone standard. However, there have been different rates of progress in the western, central, and eastern subregions.

The following sections will focus on long-term trends in design value concentrations throughout the Sacramento Region and briefly discuss impacts that year-to-year variability in meteorology have had on design values, including the increase in design values at most site in 2016. In addtion, the spatial variability of air quality and population exposure is examined to provide insight on the extent of progress towards attainment. Lastly, analysis of the top 25 concentration days from two periods, 2001-2003 and 2014-2016, will be discussed to show further evidence of progress.

Figure 13: Ozone Air Quality in the Sacramento Region



Ozone Design Values

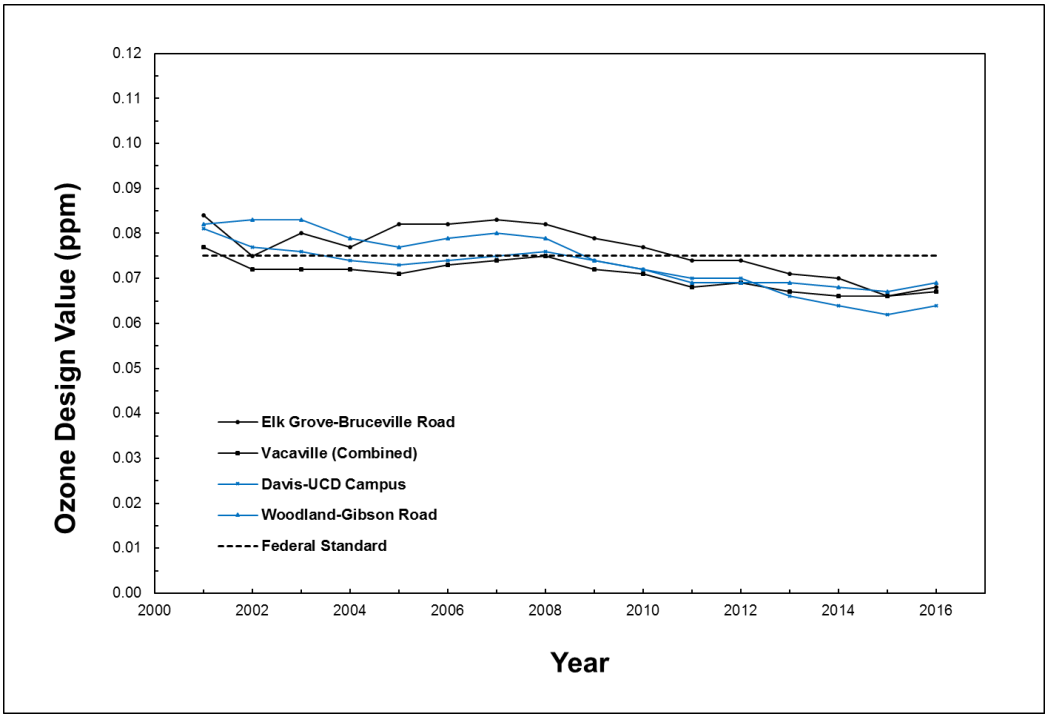
As previously discussed, ozone air quality in the Sacramento Region varies between the western, central, and eastern regions. In the western region, 2016 design values at all four sites met the 0.075 ppm federal standard with values ranging from 0.064 to 0.069 ppm. In the central region, 2016 design values met the 0.075 ppm federal standard at some sites, but exceeded the 0.075 ppm standard at other sites with values ranging from 0.069 ppm to 0.083 ppm. In the eastern region, 2016 design values at all four sites exceeded the 0.075 ppm federal standard with values ranging from 0.076 to 0.085 ppm.

Between 2001 and 2016, ozone design values followed a decreasing trend at most sites in the Sacramento Region. Linear regression analyses were used to provide a quantitative estimate of the trend in design values at the Sacramento Region sites between 2001 and 2016. The p-values associated with each regression analysis, shown in Attachment 1, were used to identify the significance of the trend. The p-value represents the specific probability that the observed values would occur as a result of something other than the detected trend. To avoid reporting a false trend, only trends with an associated p-value less than 0.001 were considered significant. Trends were

only evaluated at sites with a record of five years or more of design values to ensure an adequate sample size for statistical analyses.

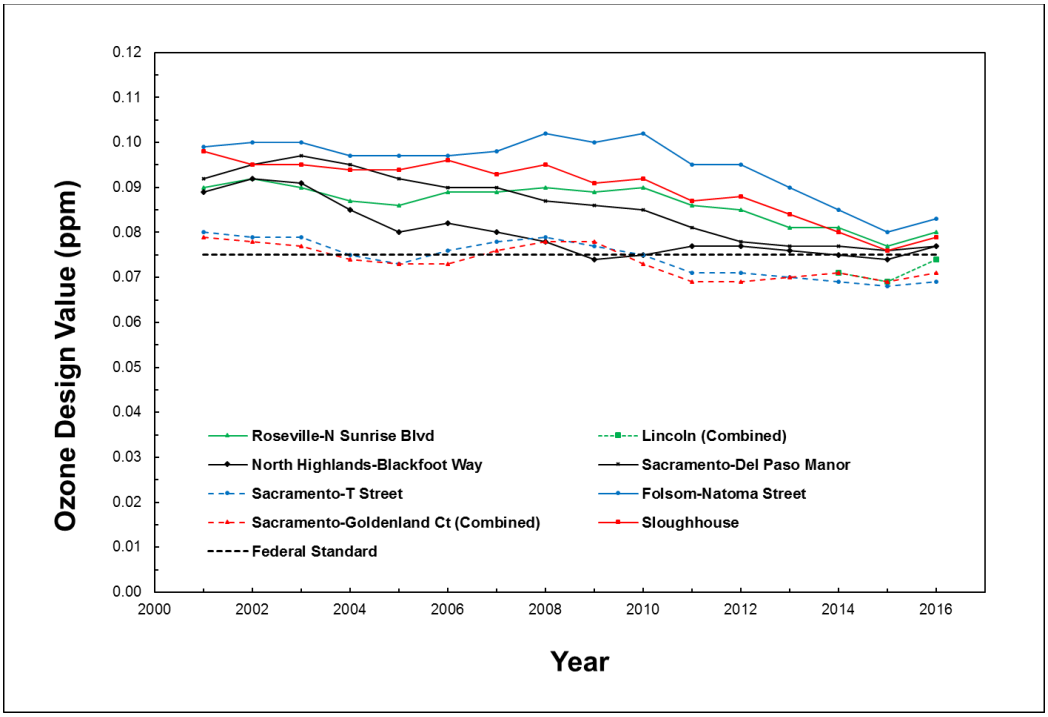
In the western subregion, the downward trend of design values at all four sites was statistically significant from 2001 to 2016. Although the design value trends remained relatively flat from 2001 to 2008 (Figure 14), since 2008, they have decreased more rapidly. All four sites have remained in attainment for the 0.075 ppm federal standard since 2011.

Figure 14: 2001-2016 Design Values at Sites in the Western Subregion



In the central subregion, design values have declined since 2001, but similar to the western subregion, the most rapid decreases have occurred since 2010 (Figure 15). Most notably, Folsom, the design site for many years, showed rapid progress with a 12 percent decline in the design value since 2010. Other high ozone concentrations sites in the central subregion also showed similar progress, including Sloughhouse (14 percent) and Sacramento-Del Paso Manor (9 percent). Most of the monitoring sites in the central region are close to, or meet, the 0.075 ppm standard, except for Folsom. Design values at the Sacramento- T Street and Sacramento-Goldenland sites followed similar trends and are the only two sites in the central subregion that have remained attainment for the 0.075 ppm standard since 2010.

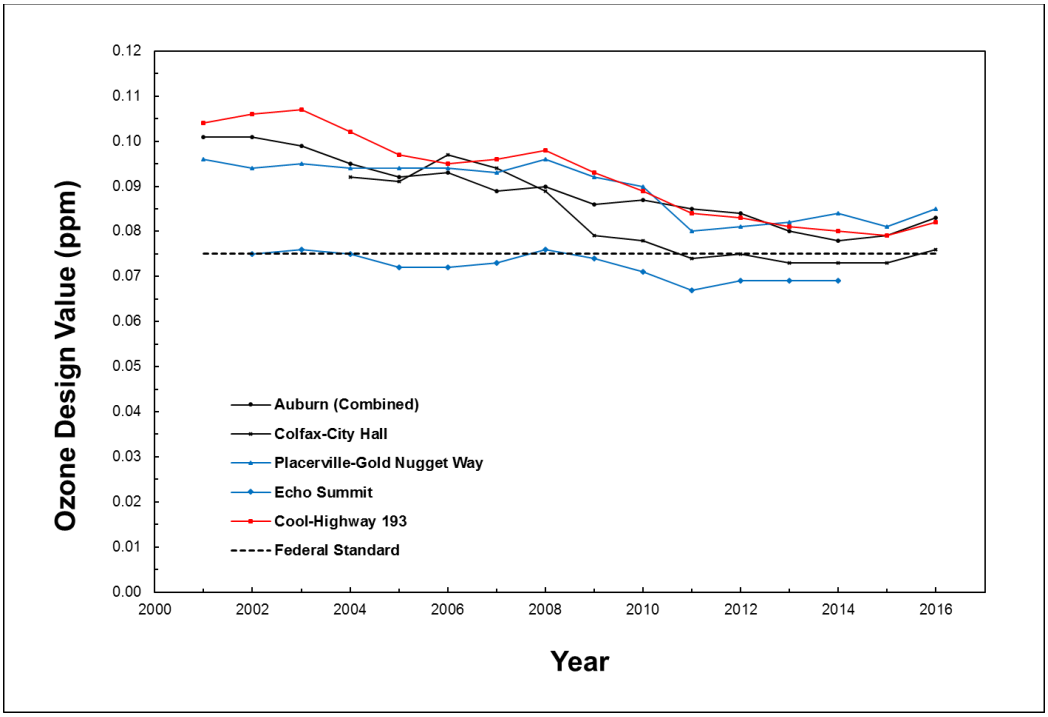
Figure 15: 2001-2016 Design Values at Sites in the Central Subregion



In the eastern subregion, design values at all sites showed a statistically significant downward trend from 2001 until 2014, but then has remained relatively flat during the past two years (Figure 16). The downward trend slowed and leveled off likely because of variations in large-scale meteorological patterns during the summer months. Some of the variability in the design values during the past five years can be attributed to two of the cleanest years ever for ozone in the Sacramento Region in 2013 and 2015, when large-scale weather patterns for both years favored moderate to strong Delta breezes, cooler temperatures, and increased dispersion of emissions.

However, in 2014 and 2016, broad high pressure systems over the western U.S. limited vertical mixing in the atmosphere, weakened the Delta breeze, and increased temperatures, which led to more stagnation and extended high ozone episodes. For instance, half of the exceedance days in 2016 were concentrated during a five-day period in July and an 11-day period in mid-August. These two periods resulted in that summer having a higher than average number of exceedances, which combined with the cleaner 2013 dropping out of the three-year design value calculation, caused the 2016 design values to increase at most of the sites in the Sacramento Region. This kind of variability is expected and is why a minimum of three to five years was chosen for all analyses in this WOE.

Figure 16: 2001-2016 Design Values at Sites in the Eastern Subregion



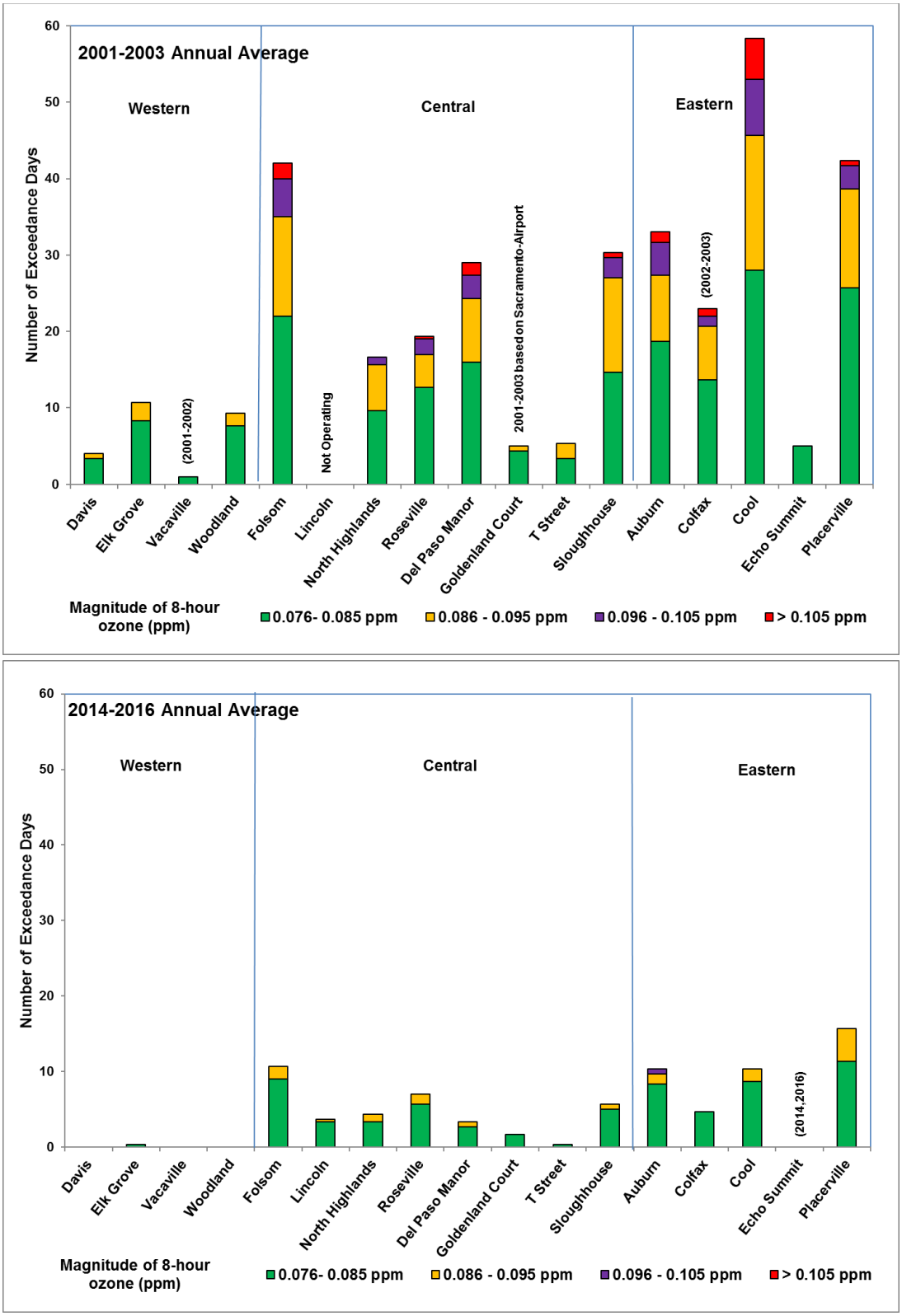
Based on Figures 15 and 16 above, it is evident that not all sites experience progress during the same years or the same rate. For example, Folsom and Placerville are significantly different beginning in 2011, when Folsom began a steep decline in design values while Placerville maintained a fairly flat line. However, Placerville experienced a significant decrease in the design value during the few years prior to 2011, while Folsom was flat at that time. Despite the differing rates of progress, both had similar design values by 2016.

Since 2010, the Sacramento Region has seen rapid progress in the central subregion, with slower progress in the eastern subregion. The higher biogenic emissions in the Sacramento Region, which are concentrated in the eastern portion of the area, add a much greater challenge to attainment. In addition, there is considerable year-to-year variability, especially pronounced in the eastern region, due to yearly meteorological differences which impact the amount of transport into the eastern subregion from the other parts of the nonattainment area.

Exceedance Days

Significant progress has occurred in reducing the frequency, magnitude and spatial extent of 8-hour average ozone exceedance days in the Sacramento Region over the last 15 years (Figure 17). In terms of frequency, the average annual number of exceedance days for the Sacramento Region decreased by 68 percent from 79 in the

Figure 17: Average Annual Number of 8-hour Ozone Exceedance Days



period of 2001-2003 to 25 in the more recent period of 2014-2016. On a subregion basis, all three subregions saw a dramatic decrease in exceedance days:

- Western: average annual number of exceedance days for 2001-2003 ranged from 1 to 11, but decreased to less than 1 day at all sites for 2014-2016
- Central: average annual number of exceedance days for 2001-2003 ranged from 5 to 42, but decreased to a range of less than 1 up to 11 days for 2014-2016
- Eastern: average annual number of exceedance days for 2001-2003 ranged from 5 to 58, but decreased to 0 to 16 days for 2014-2016

Figure 17 illustrates the dramatic progress made in reducing the number of exceedance days and the magnitude of ozone concentrations on those days. In 2016, there were virtually no exceedances in the western subregion, with declines of two-thirds or more in the other two subregions, as discussed earlier. The magnitude of exceedance days has declined significantly with the majority of exceedances falling below 0.085 ppm.

For all Sacramento Region sites in 2001-2003, the magnitude of the average annual peak concentrations ranged from 0.079 ppm (Vacaville) to 0.123 ppm (Cool), as shown in Table 2. Comparatively, the magnitude of average annual peak concentrations for 2014-2016 ranged from 0.071 ppm (Vacaville and Davis) to 0.094 ppm (Auburn). Moreover, for 2001-2003, nine Sacramento Region sites had an average annual peak 8-hour ozone concentration greater than 0.096 ppm. However, by the period 2014-2016, there were no Sacramento Region sites with an average annual peak 8-hour ozone concentration greater than 0.096 ppm. In addition, by this same period, Auburn was the only site to have annual peak 8-hour ozone concentrations in the 0.096 ppm-0.105 ppm range.

Table 2: Average Annual Peak 8-hour Ozone Concentrations

	Site Name	2001	2002	2003	2001-2003 Average	2014	2015	2016	2014-2016 Average
	Elk Grove-Bruceville Road	0.092	0.082	0.089	0.088	0.072	0.082	0.072	0.075
	Vacaville-Ulatis Dr.	0.081	0.077	--	0.079	0.072	0.070	0.072	0.071
	Davis-UCD Campus	0.093	0.088	0.082	0.088	0.067	0.071	0.074	0.071
	Woodland-Gibson Rd.	0.089	0.091	0.084	0.088	0.071	0.071	0.075	0.072
	Roseville-N Sunrise Blvd	0.102	0.105	0.109	0.105	0.086	0.084	0.092	0.087
	Lincoln-1445 1st Street	--	--	--	--	0.086	0.082	0.083	0.084
	North Highlands-Blackfoot Way	0.094	0.101	0.094	0.096	0.084	0.089	0.089	0.087
	Sacramento-Del Paso Manor	0.107	0.114	0.113	0.111	0.077	0.089	0.090	0.085
	Sacramento-1309 T Street	0.094	0.091	0.091	0.092	0.072	0.076	0.074	0.074
	Folsom-Natoma Street	0.108	0.120	0.118	0.115	0.084	0.093	0.094	0.090
	Sacramento-Goldenland	0.091	0.081	0.085	0.086	0.076	0.079	0.082	0.079
	Sloughhouse	0.097	0.105	0.107	0.103	0.079	0.094	0.088	0.087
	Auburn-Atwood Rd	0.107	0.115	0.111	0.111	0.084	0.100	0.099	0.094
	Colfax-City Hall	--	0.113	0.097	0.105	0.080	0.085	0.085	0.083
	Placerville-Gold Nugget Way	0.100	0.111	0.114	0.108	0.090	0.090	0.094	0.091
	Echo Summit	0.084	0.079	0.079	0.081	0.072	--	0.072	0.072
	Cool	0.109	0.137	0.122	0.123	0.087	0.092	0.094	0.091

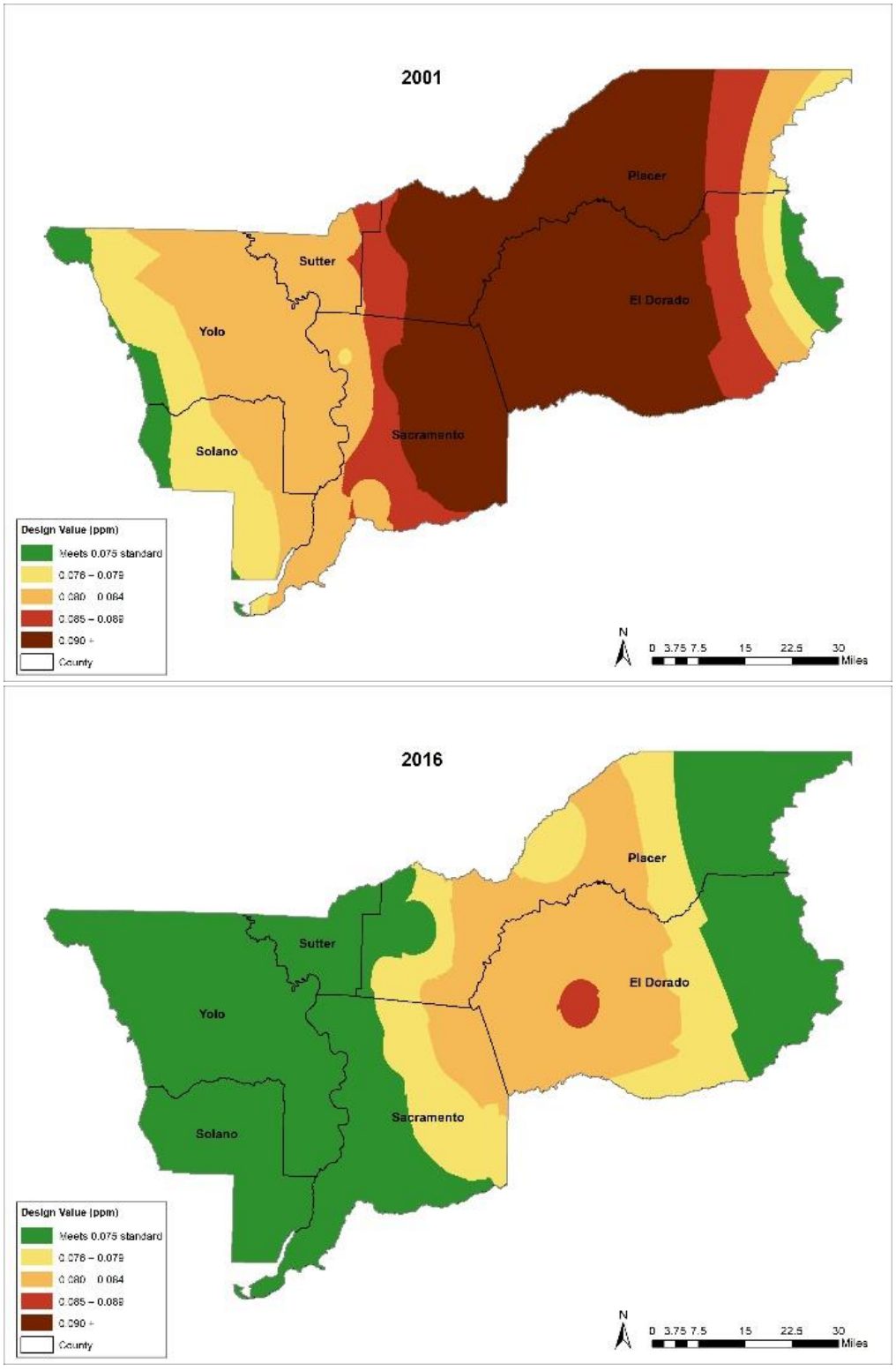
"--" indicates that no data were available

Population Exposure

To spatially and temporally evaluate ozone air quality across the Sacramento Region, maps showing interpolated 8-hour average ozone design values for the years 2001 and 2016 were produced using an inverse distance weighting (IDW) method for the contouring (Figure 18). In 2001, the entire Sacramento Region, except for the far eastern monitor at Echo Summit, exceeded the 0.075 ppm federal 8-hour ozone standard, with a majority of the most populated areas of the region also exceeding the prior 0.08 ppm federal 8-hour ozone standard.

In contrast, by 2016 ozone air quality dramatically improved as evidenced by the large geographic area below the 0.075 ppm threshold in Figure 18. Areas where the design

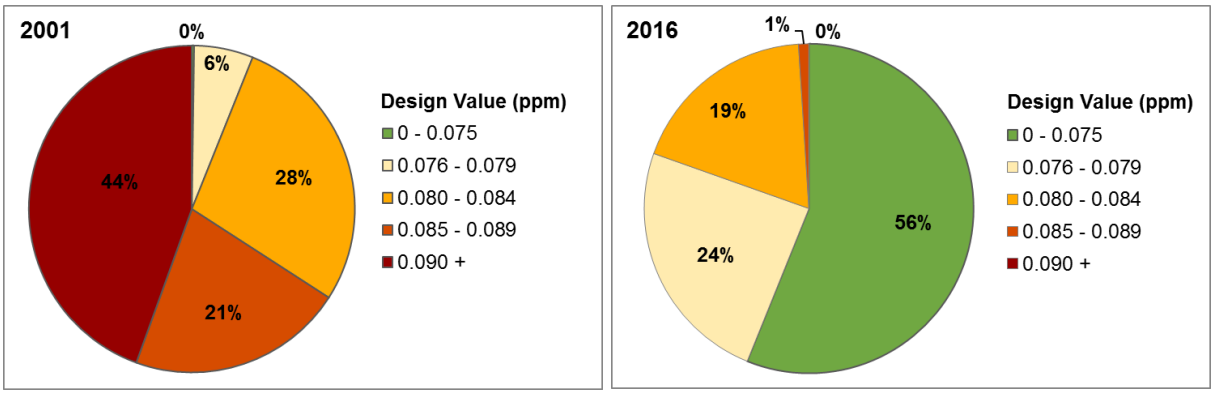
Figure 18: Contour Maps of Design Values in the Sacramento Region



values were greater than 0.075 ppm were mostly limited to eastern Sacramento County and the foothill areas of Placer and El Dorado Counties, with only one localized area slightly above 0.084 ppm.

Interpolated design values derived using IDW were overlaid with U.S. 2010 population census data to provide the quantitative estimates of population exposure in the Sacramento Region (Figure 19). In 2001, only 0.2 percent of people within the Sacramento region lived in areas where the ozone design values were at or below 0.075 ppm. However, by 2016, the percentage of the population living in areas with ozone design values below 0.075 ppm increased to 56 percent, indicating a major improvement in ozone air quality during the 15-year period.

Figure 19: Population Exposure to Ozone in the Sacramento Region



Analysis of design values provides significant insight into the compliance status of a region as well as specific monitoring sites. However, design values are limited in their ability to assess all aspects of ozone air quality progress within a large area, such as Sacramento, that has terrain and complex, localized meteorological patterns which impact ozone formation and buildup. Thus, looking beyond the design values provides a more thorough evaluation of the nature of progress and the factors that contribute to exceedances of ozone air quality standards in a region.

Top 25 Analysis

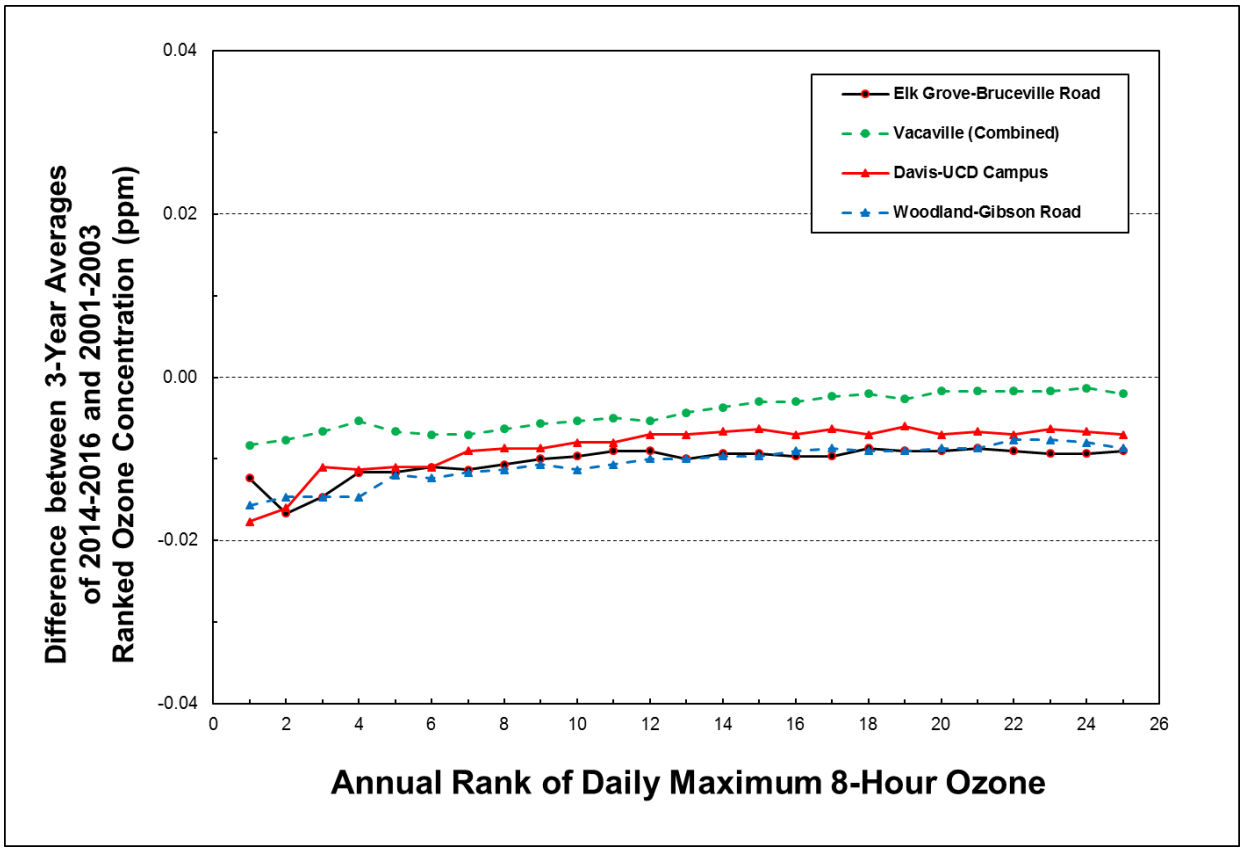
To complement the design value analyses, which indicated a widespread improvement in air quality from 2001 and 2016, the 3-year averages of the Top 25 daily maximum 8-hour average ozone concentrations in 2014-2016 were compared to those measured in 2001-2003.

The comparison of ranked values provides insight as to the extent to which the highest ozone concentrations are responding to control measures over time without relying on any assumptions regarding the distribution of the data. In Figures 20 through 22, markers below the zero line indicate that 2014-2016 ranked concentrations were lower

than 2001-2003 ranked concentrations. Conversely, markers above the zero line indicate 2014-2016 concentrations were higher than 2001-2003 concentrations with the same rank. Markers on the zero line indicate that concentrations were the same in 2001-2003 and 2014-2016. In general, analyses indicate that concentrations on days in the upper end of the Top 25 improved more than the concentrations on days in the lower end of the Top 25.

In the western portion of the Sacramento Region, all markers are below the zero lines (Figure 20), indicating all four sites made progress in improving ozone air quality. Progress made from 2001-2003 to 2014-2016 at Vacaville was the least among all four sites in the western Sacramento subregion, while progress made at other three western sites, namely Elk Grove, Davis and Woodland, was similar. It should be noted that almost all of the 2016 average concentrations were below the 0.075 ppm federal ozone standard.

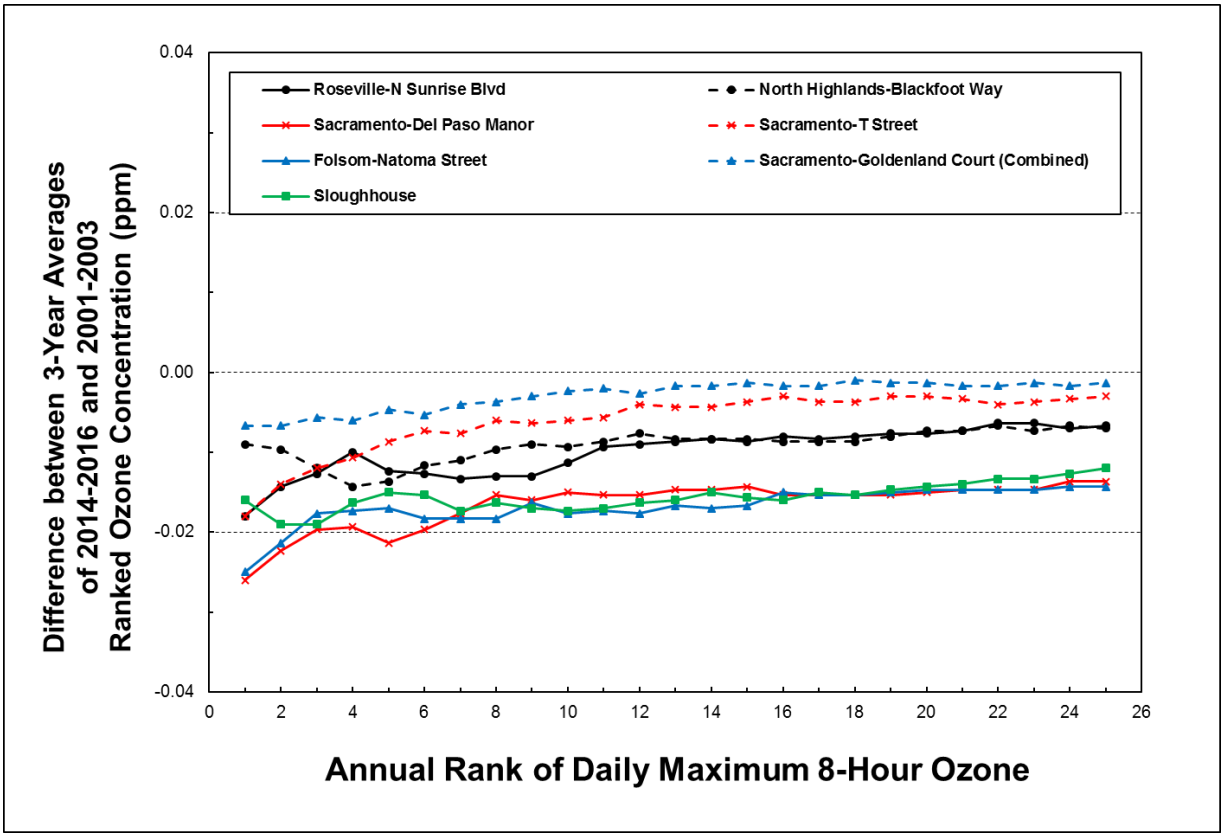
Figure 20: Comparison of Top 25 days in 2001-2003 and 2014-2016 at Sites in the Western Sacramento Subregion



In the central Sacramento subregion, progress has been made at all seven sites from 2001-2003 to 2014-2016 (Figure 21), with the greatest progress made at Folsom, Sloughhouse and Sacramento-Del Paso Manor; moderate progress made at Roseville

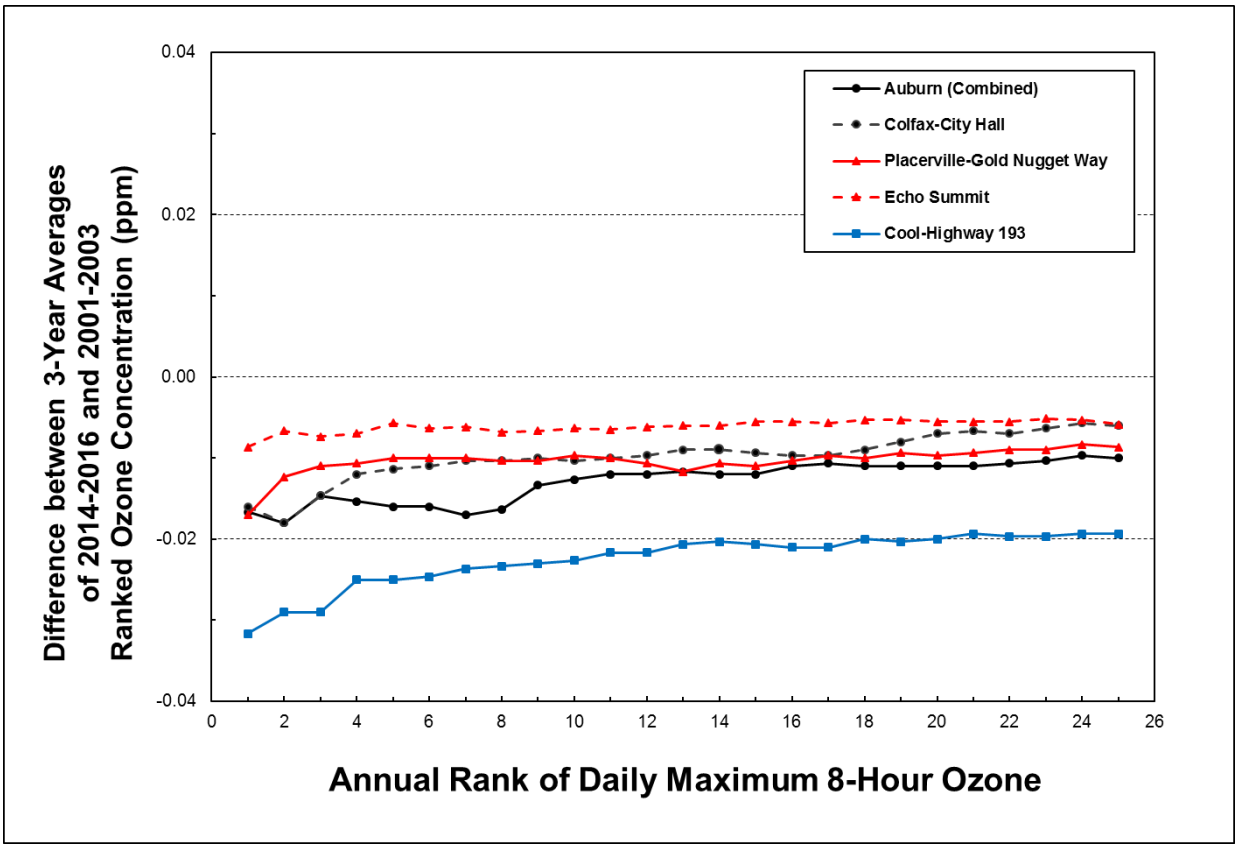
and North Highlands; and the least progress made at Sacramento-T street and Sacramento-Goldenland due to their concentrations consistently being some of the lowest in the region during the past 15 years.

Figure 21: Comparison of Top 25 days in 2001-2003 and 2014-2016 at Sites in the Central Sacramento Subregion



In the eastern Sacramento subregion, progress has also been made at all five sites from 2001-2003 to 2014-2016 (Figure 22), with the greatest progress made at Cool and moderate progress made at Auburn, Colfax and Placerville. The limited progress indicated at the Echo Summit site is largely due to the site having low ozone concentrations in both the 2001-2003 and 2014-2016 time periods. In addition, Echo Summit, a remote, transport-dominated location, has consistently had one of the lowest design values in the Sacramento Region. Additional progress toward reducing ozone concentrations is therefore challenging.

Figure 22: Comparison of Top 25 days in 2001-2003 and 2014-2016 at Sites in the Eastern Sacramento Subregion



Overall, the Top 25 ozone concentrations in 2014-2016 were all lower than those in 2001-2003 at all sites in the Sacramento Region, which is another good indication that ozone air quality has significantly improved across the entire area during the past 15 years.

Summary of Ozone Air Quality

The assessment of long-term design value trends between 2001 and 2016 indicated a major improvement in ozone air quality across the entire Sacramento Region. While a few site-specific design values indicate a near-term slowing in progress, the overall trends during the past 15 years are downward. To examine the trends beyond the design values, additional indicators were considered to provide further insight into ozone air quality in the Sacramento Region.

Decreases in the number of annual exceedance days, the magnitude of ozone concentrations on exceedance days, and the Top 25 annual concentrations were all consistent with the decreases in design values, and confirmed that the design value trends were reflective of the improvement in overall ozone air quality.

Weekend/Weekday Differences

The weekend/weekday differences are the occurrence of higher ozone concentrations on weekends than on weekdays (Air Resources Board 2003). These differences have been documented in many urban areas and have been extensively studied and discussed in the scientific literature for decades. Higher weekend than weekday concentrations are usually associated with lower NOx emissions on weekends than on weekdays. Peer reviewed scientific studies conducted within the Sacramento Region and downwind Mountain Counties Air Basin (MCAB) indicated the presence of differences in the 1985 to 2002 period (Blanchard and Fairley 2001, Marr and Harley 2002, Murphy et al 2006, and Murphy et al 2007), but more recent analyses by CARB staff indicate that the weekend/weekday differences have diminished and that there is no discernible difference in the Sacramento Region. In fact, at all sites evaluated in the analysis below, more ozone exceedances occurred on weekdays than on the weekends.

Day of the Week: Exceedance Days

Past work has used a number of different classification schemes and metrics to evaluate the magnitude and extent of weekend/weekday differences. In this WOE, the distribution of the day of the week on which exceedance days occurred was evaluated. The focus was on the central and eastern subregions because these areas potentially drive attainment in the Sacramento Region. In addition, there were too few exceedances at a few of the central subregion sites (Sacramento-T Street, Sacramento-Goldenland, Lincoln-1445 1st Street) and in the western subregion to evaluate monitors for differences. The period considered was 2012 to 2016, which had a similar design value trend for many of the sites in the Sacramento Region.

As shown in Figure 23, exceedance days in the central subregion occurred predominantly on weekdays. Similarly, exceedance days in the eastern subregion also occurred much more frequently during the week (Figure 24). Based on a review of exceedance days for 2012-2016, there are no notable weekend/weekday differences, as exceedance days occur predominantly on weekdays. The lack of weekend/weekday differences is expected as Sacramento is in a NOx limited regime.

Figure 23: Distribution of Exceedance Days by Day of the Week at Sites in the Central Sacramento Subregion (2012-2016)

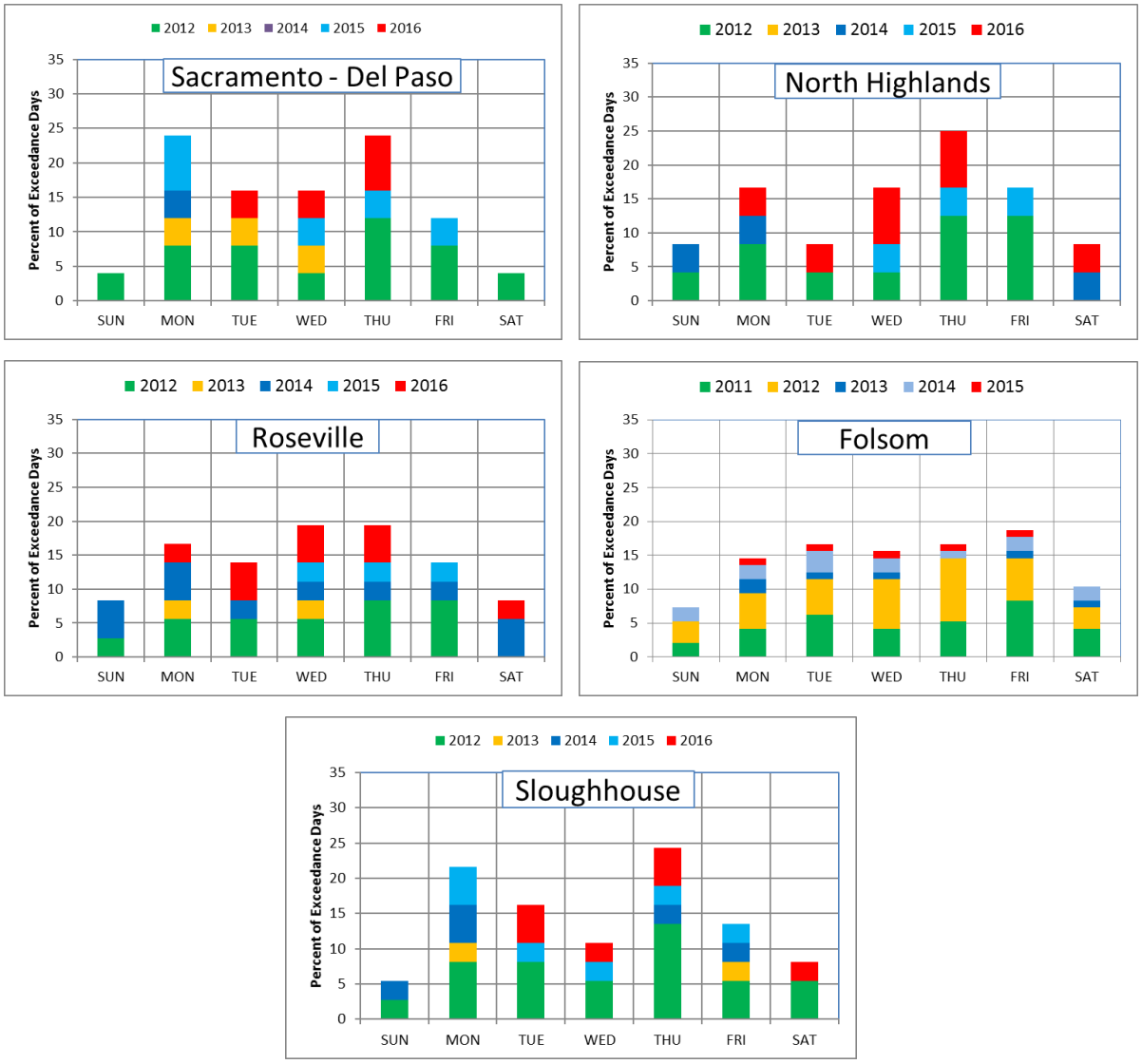
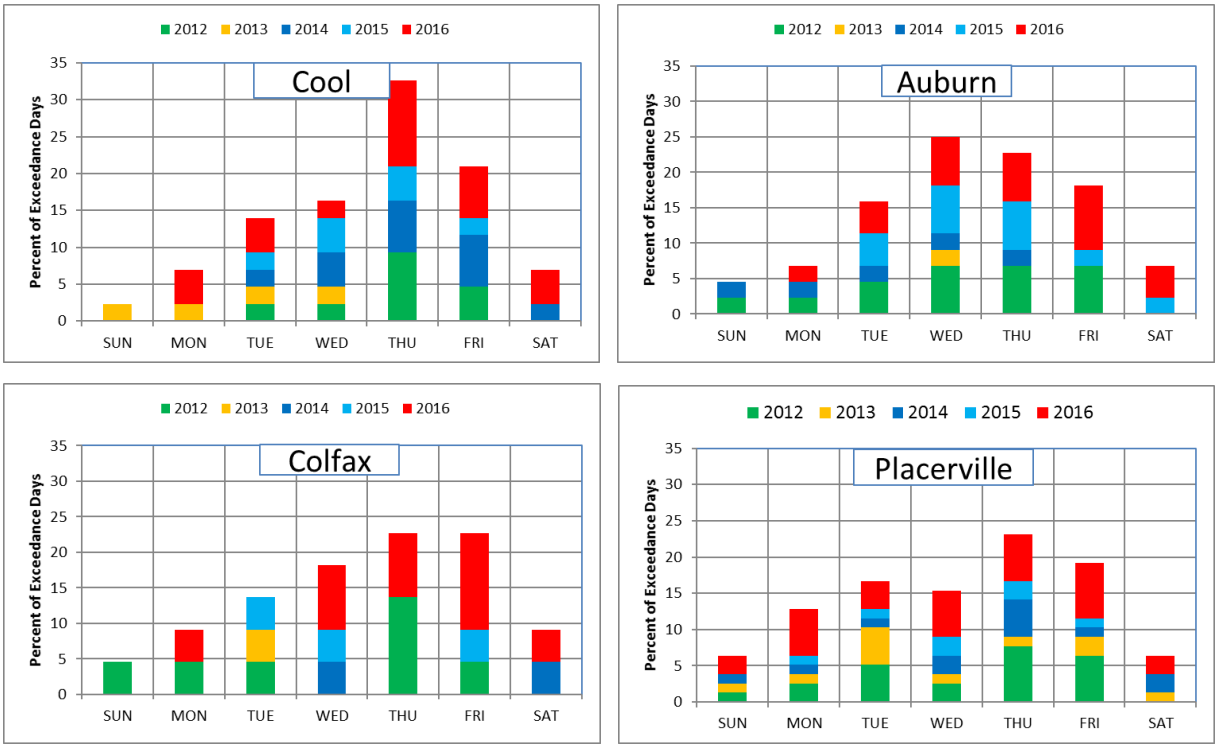


Figure 24: Distribution of Exceedance Days by Day of the Week at Sites in the Eastern Sacramento Subregion (2012-2016)



Attainment Projections

With implementation of controls and improvements in ozone air quality over the past several decades (as shown in the discussion of ozone air quality trends), photochemical modeling demonstrates that the path to attainment is a NOx-focused control strategy. As a result, the rate of NOx and ROG reductions is expected to shift in the post-2015 time frame. NOx and ROG reductions will both continue, albeit the rate of ROG reductions will be increasingly modest compared to NOx reductions.

Sacramento Region Attainment Modeling

As shown in Table 1, 8 out of 17 regional ozone monitoring sites met the 0.075 ppm standard in 2016. Photochemical modeling indicates that scenarios where control measures are limited to those that have already been adopted (baseline) lead to Sacramento Region-wide attainment by 2022 (July 20, 2023 attainment deadline), with the region continuing in attainment through 2026 (July 20, 2027 attainment deadline). To allow for a margin of uncertainty, the air districts of the Sacramento Region are requesting to show attainment in the calendar year of 2024 resulting in an attainment

deadline of July 20, 2025. A methodology was developed to estimate the 2024 calendar year design value based on modeled design values of 75.2 parts per billion (ppb) for the year 2022 and 70.7 ppb for the year 2026. This methodology used modeled changes in NOx and ROG and established relationships between the two emission types to estimate a 2024 design value of 72.1 ppb for Folsom, the Sacramento Region design value site during the model baseline year of 2012.

Summary

As discussed in this WOE, ozone production is a non-linear process and the drivers of production can vary over relatively short spatial and temporal scales. The rate of historical ozone air quality improvements has varied over time in response to the change in composition and quantity of NOx and ROG emissions across the Sacramento Region. Therefore, the rate at which ozone air quality improvements are accomplished leading up to attainment will be expected to vary as controls are implemented within a NOx-limited ozone production regime. Photochemical modeling projects that all sites will be able to meet the standard in 2022 (July 20, 2023 attainment deadline) and will continue to meet the standard in 2026 (July 20, 2027 attainment deadline).

Conclusions

The Sacramento Region is currently classified as a severe ozone nonattainment area with an attainment deadline of July 20, 2027 for the 0.075 ppm federal 8-hour ozone standard. This WOE evaluated ambient air quality and emission trends to complement the regional photochemical modeling analyses conducted to assess the Sacramento Region's progress toward meeting the this deadline.

Photochemical modeling analyses indicate that the Sacramento Region will be able to meet the July 20, 2027 attainment deadline with the currently adopted control measures; no new emission control measures are required for attainment. Furthermore photochemical modeling and this WOE support a July 20, 2025 deadline, two years earlier than the mandated July 20, 2027 deadline.

- The Sacramento Region is characterized by varied terrain, which limits dispersion and effectively traps emissions in the region. Furthermore, meteorological conditions are dominated by a semi-permanent high pressure system, which enhances the trapping effect of the local terrain; and a thermally driven afternoon Delta breeze wind and a nighttime, downslope drainage flow recirculation pattern serves to routinely transport emissions between the central portion of the region and the foothills in the eastern portion.

- The Sacramento Region is home to nearly 2.5 million people and is located at the intersection of three major highways in northern California. Consequently, the movement of goods and people is a significant source of emissions in the region.

- Ozone forming emissions in the Sacramento Region are largely derived from mobile source emissions, which include passenger vehicles, heavy-duty diesel trucks, recreational boats, and off-road and agricultural equipment; to consumer products, which include hair spray, personal fragrance, and all-purpose cleaners.

- Emissions of ozone precursors have declined substantially. Between 2000 and 2015, total NOx emissions in the Sacramento Region declined by 58 percent and total ROG emissions declined by 45 percent.

- The Sacramento Region is well on its way to attainment. Currently, 8 out of 17 monitoring sites already meet the standard. The remaining sites are within 13 percent of the standard.

- Long-term ozone trends demonstrate that ozone has declined substantially in the last 15 years (2001 to 2016) in the Sacramento Region. Both the design value and the annual fourth-highest ozone concentration decreased by 18 percent. During this same period population exposure has also shown dramatic improvement, with an estimated 56 percent of people living in areas meeting the standard in 2016, compared to only 0.2 percent in 2001.

- Both the frequency of exceedance days and the magnitude of concentrations on exceedance days, which are measures of population exposure, have also greatly improved. The annual average number of exceedance days declined by 68 percent from the period 2001-2003 to the period 2014-2016. Also, peak concentrations on exceedance days declined from 0.123 ppm to 0.094 ppm (a decline of 24 percent), with most exceedance days having concentrations of 0.085 ppm or less. In addition, the highest average ozone concentrations, as measured by the Top 25, were all lower in 2014-2016 than in 2001-2003.

- Studies conducted within the Sacramento Region and downwind Mountain Counties Air Basin have indicated differences in the number of exceedances occurring on weekends versus weekdays between 1985 and 2002 (Blanchard and Fairley 2001, Marr and Harley 2002, Murphy et al 2006, and Murphy et al 2007), but more recent analyses by CARB staff indicate that there is no notable weekend/weekday difference in the Sacramento Region.

- State of the art photochemical modeling, supported by extensive monitoring and research efforts, indicate that the path towards attainment of the 0.075 ppm standard is with a NOx-focused control strategy. The Sacramento Region has

been in a NOx-limited regime in recent years, which is consistent with the lack of notable differences in the number of ozone exceedances between weekends and weekdays.

- The photochemical modeling indicates that, based on adopted control measures, the Sacramento Region-wide will reach attainment by July 20, 2023. Modeling for the calendar year 2026 indicates that ozone concentrations are projected to drop further. To allow for a margin of uncertainty, the Sacramento Region is requesting an attainment date of July 20, 2025.

Collectively, the air quality analyses included in this WOE indicate that substantial progress has been accomplished in the Sacramento Region and that no additional control measures are needed to meet the 0.075 ppm standard at all sites by an attainment deadline of July 20, 2025.

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ATTACHMENT 1

Figure 1: Results of linear least squares regression for 2001-2016 Design Values at Sacramento Region Sites

	Site Name	AQS ID	County	Slope (ppb/yr)	Intercept	R^2	p-value
	Elk Grove-Bruceville Road	060670011	SAC	-0.9382	1960.9	0.6261	0.0002
	Vacaville-Ulatis Dr.	060953003	SOL	-0.5735	1222.7	0.6861	< 0.0001
	Davis-UCD Campus	061130004	YOL	-1.0382	2157.0	0.8503	< 0.0001
	Woodland-Gibson Rd.	061131003	YOL	-1.1662	2417.2	0.8876	< 0.0001
	Roseville-N Sunrise Blvd	060610006	PLA	-0.7618	1616.4	0.6716	< 0.0001
	Lincoln-1445 1st Street	060612002	PLA	Less than 5 years of DV data			
	North Highlands-Blackfoot Way	060670002	SAC	-1.0824	2254.0	0.7325	< 0.0001
	Sacramento-Del Paso Manor	060670006	SAC	-1.4897	3078.0	0.9191	< 0.0001
	Sacramento - 1309 T Street	060670010	SAC	-0.7544	1589.5	0.7402	< 0.0001
	Folsom-Natoma Street	060670012	SAC	-1.0912	2286.6	0.5750	0.0005
	Sacramento-Goldenland	060670014	SAC	-0.5824	1243.3	0.5890	0.0003
	Sloughhouse	060675003	SAC	-1.2956	2692.0	0.8314	< 0.0001
	Auburn - Atwood Rd	060610003	PLA	-1.5118	3125.3	0.9231	< 0.0001
	Colfax-City Hall	060610004	PLA	-2.0769	4256.5	0.7729	< 0.0001
	Placerville-Gold Nugget Way	060170010	ELD	-1.0838	2266.3	0.7184	< 0.0001
	Echo Summit	060170012	ELD	-0.6099	1296.8	0.6286	0.0008
	Cool	060170020	ELD	-1.9794	4067.9	0.9257	< 0.0001

County abbreviations: SAC (Sacramento), SOL (Solano), YOL (Yolo), PLA (Placer), and ELD (El Dorado)

Linear regression analyses were used to provide a quantitative estimate of the trend in design values at Sacramento Region sites between 2001 and 2016. The p-values associated with each regression analysis and derived using the Pearson correlation test

were used to identify the significance of the trend. The p-value represents the specific probability that the observed values would occur as a result of something other than the detected trend. To avoid reporting a false trend, only trends with an associated p-value less than 0.001 were considered significant. Trends were only evaluated at sites with a record of 5 years or more of design values to ensure an adequate sample size for statistical analyses.



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