PHOTOCHEMICAL MODELING IN SUPPORT OF

ATTAINING THE FEDERAL 8-HOUR OZONE

AIR QUALITY STANDARD IN CENTRAL CALIFORNIA

Volume 2:
8-hour Ozone
Future Year Design Value and
Carrying Capacity Calculations
for the
Sacramento Non-Attainment Area

California Air Resources Board
Planning and Technical Support Division
Sacramento, California 95814

Preliminary Draft Date 9/25/06
Revised Draft Date 6/6/08
(Provided for District Review and Comment)

DRAFT - DO NOT CITE, QUOTE, OR DISTRIBUTE

TABLE OF CONTENTS

1 APPROACH 5

1.1 Description of Methodology 5

2 FUTURE YEAR RESULTS 13

2.1 Base-Year Design Values 13

2.2 Future Year Design Value and Carrying Capacity Estimates 13

3 ANALYSIS OF MODEL-SIMULATED, UNMONITORED PEAKS 18

4 REFERENCES 18

5 **APPENDICES** 19

5.1 Future Year 2018 19

For District review purposes, this document summarizes modeling-based calculation procedures to estimate future year design values in support of determining future year carrying capacity. Chapter 1 of this document describes the approach utilized while Chapter 2 presents the associated results using the model simulations presented in the Volume 1 document, which describes model performance results for 8-hour ozone model simulations of the July 1999 and July-August, 2000, episodes.

As indicated in the Volume 1 documentation and repeated here, sub-regional model performance was conducted for 5 days per episode (10 days total) for each of the 15 sub-regions (Figure 1). Table 1 summarizes the number of modeled days that satisfied model performance criteria. With the exception of the North Coast (0 days), 2-9 days of the possible 10 days per sub-region are available for consideration in calculating future year design values.

Table 1. Combined Number of Available Days Per Sub-region Under 8-hour Metrics

Region Name	July 1999	July-Aug 2000	Total
North Coast	1	0	**1**
BAAQMD	1	2	**3**
MBAQMD	1	2	**3**
Sacramento Valley North	4	4	**8**
Sacramento Region	5	3	**8**
SJVAPCD Central	3	5	**8**
SJVAPCD Kern	4	5	**9**
SJVAPCD North	3	2	**5**
Sierra Nevada Central	2	3	**5**
SJVAPCD Above 3000 ft	3	4	**7**
South Central Coast	3	1	**4**
Sierra Nevada North	3	5	**8**
Desert	1	5	**6**
Nevada	3	0	**3**
Total	**37**	**41**	**78**

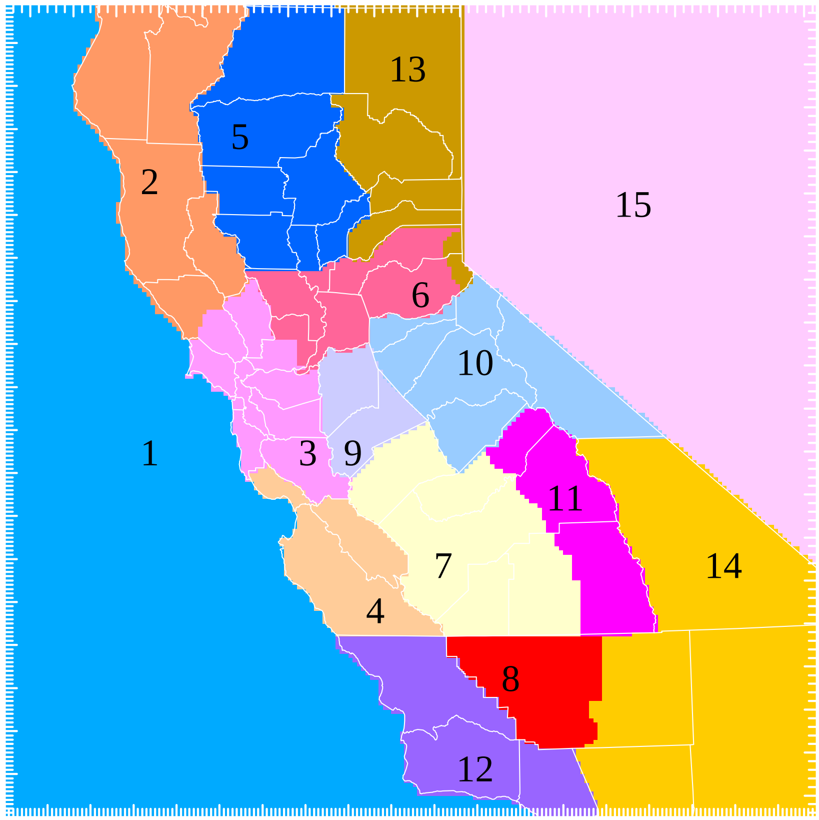


Figure 1. Sub-regions used in the air quality model performance evaluation (3: Bay Area region, 6: Sacramento Metro region, 7: Central San Joaquin Valley region , 8 Southern San Joaquin Valley region, 9: Northern San Joaquin Valley region).

1 Approach

This Chapter describes ARB's proposed procedures, based on USEPA guidance, for calculating and applying RRFs for California's 8-hour ozone State Implementation Plans. The information in this section was previously provided to the Sacramento Metropolitan Air Quality Management District for review and comment.

1.1 Description of Methodology

While the emphasis of this discussion is on site-specific RRFs, it is noted that the USEPA (2005) also requires an analysis to demonstrate that high ozone concentrations occurring away from monitors (e.g., unpaired in space) will also be controlled in future years to meet air quality standards. This issue is addressed as well.

The application of photochemical ozone models has a long history in California, for uses ranging from the preparation of State Implementation Plans to research activities to regulatory development. The modeling community has applied these tools in the State for over 30 years, and much has been learned about their proper uses and limitations.

One of the fundamental understandings that has been learned about photochemical models is that they are best used to estimate the relative difference between scenarios, rather than for absolute concentration estimates. That is, their strength is in estimating the relative change in concentration levels from a baseline condition (e.g., a current year) to an alternative scenario (e.g., a future year), rather than predicting the exact concentration level that will result from the alternative scenario.

The USEPA's guidance on the use of models for attainment demonstrations in support of 8-hour ozone planning (USEPA, 2005) is consistent with the fundamental strength of models described above. USEPA's recommended modeled attainment test is to utilize relative model response on a site-by-site basis, in the form of a relative response factor (RRF), to predict future-year 8-hour ozone design values. This methodology relies on the base year for the modeling for conducting model performance analyses, a reference year of 2002 for projecting forward site-specific design values, and a future year for the attainment test.

$$\mathbf{DV_F = (RRF)\ (DV_R)}$$

where DV_R = *a reference year (2002) concentration (design value) measured at a monitoring site*

DV_F = *the estimated future year design value at the same site*

RRF = *the relative response factor at the same site*

The RRF is calculated as the ratio of future year to reference year modeled ozone concentrations at a site:

$$\mathbf{RRF} = \frac{\mathbf{FY_{8-hr}}}{\mathbf{RY_{8-hr}}}$$

where RRF = *the relative response factor for a monitor*

$FY_{8\text{-}hr}$ = *the modeled future year 8-hour daily maximum concentration predicted near the same monitor*

$RY_{8\text{-}hr}$ = *the modeled reference year 8-hour daily maximum concentration predicted near the same monitor*

In principle, this concept is simple. Unfortunately, it can be confounded by a number of factors, including the limited number of modeled days available, the choice of year(s) to use for specification of the reference year design value, the uncertainties inherent in air quality modeling, and the presence of a non-zero background level of ozone. As a result of this, EPA technical staff have indicated that there is flexibility in the application of RRFs, as long as the methodology is technically sound and is properly documented.

1.1.1 Estimating Reference Year (2002) Design Values

Specification of the reference year design value is a key consideration in the modeled attainment test, since this is the value that is projected forward and used to test for attainment at each site. Since the reference design value is presumably reflective of conditions in the reference year, it should be representative of the emissions used for that year. However, many areas experience fluctuations in their year-to-year meteorology, as well as emissions levels. In recognition of this year-to-year variability, the reference design value should in some fashion also reflect this variability. A standard methodology for minimizing the influence of year-to-year variations is to calculate an average value over multiple years. Therefore, the following methodology is recommended for specification of the reference design value at each monitoring site:

> **The reference design value (DV_R) will be calculated as the average of the three design values for the three years commencing with the reference year of the modeling. The reference year for modeling in support of the 8-hour ozone SIPs is 2002. Therefore, the reference**

design value will be calculated at each monitoring site as the average of the design values for 2002, 2003, and 2004.

California design values are calculated as the three-year average of the 4th highest 8-hour ozone peak values, and are assigned to the last year. Thus, a design value for 2002 would be based on data for 2000-2002. The recommendation above implies that the reference design value at each monitoring site will be calculated as the average of nine design values over five years: the three years which make up the 2002 design value (2000-2002), the 2003 design value (2001-2003), and the 2004 design value (2002-2004). This gives the greatest weight to 2002, since that year is included in the calculation of the design value for all three years.

The following table summarizes the recommended process for calculating the reference design value at each monitoring site.

Year	Years Averaged for Design Value				
2002	2000	2001	2002		
2003		2001	2002	2003	
2004			2002	2003	2004
	Yearly Weighting for Average Design Value for Modeled Attainment Test				
2002-2004 Average	$DV_R = \frac{Year_{2000} + (2)(Year_{2001}) + (3)(Year_{2002}) + (2)(Year_{2003}) + Year_{2004}}{9}$				

1.1.2 Relative Response Factors

As discussed above, the relative response factor (RRF) is a monitor-specific value that is calculated based on daily peak 8-hour ozone concentrations simulated in a future year, divided by daily peak concentrations simulated in the reference year. To be consistent with the principle that the modeled attainment test and design values should be robust and stable over a number of different types of meteorology, the RRF should be based on multiple simulated days. The following methodology will be used to calculate site-specific RRFs:

Site-specific RRFs will be calculated as the ratio of the average daily peak 8-hour modeled ozone concentration in the future year, divided by the average daily peak 8-hour modeled ozone concentration in the reference year. Only those days satisfying the model performance and threshold criteria described below shall be included in the RRF calculation.

$$\mathbf{RRF_{AVG}} = \frac{(\mathbf{FY_{8-hr}})_{\mathbf{AVG}}}{(\mathbf{RY_{8-hr}})_{\mathbf{AVG}}}$$

where RRF_{AVG} = *the average relative response factor for a monitor*

$(FY_{8\text{-}hr})_{AVG}$ = *the average future year 8-hour daily maximum concentration predicted near the same monitor, averaged over those days which satisfy model performance and threshold criteria*

$(RY_{8\text{-}hr})_{AVG}$ = *the modeled reference year 8-hour daily maximum concentration predicted near the same monitor, averaged over those days which satisfy model performance and threshold criteria*

1.1.3 Criteria for Use of Modeled Days in RRF Calculations

Adequate model performance is a requirement for use of modeled results. The lack of acceptable performance greatly increases uncertainty in the use of the modeling results, and casts doubt on conclusions based on the modeling. Although it is desirable to include as many days as possible in the RRF calculations, our experience has demonstrated that not all modeled days meet the minimum performance standards, and are thus not suitable for use. Therefore only those days which satisfy the following model performance criteria will be utilized in subsequent RRF calculations.

The USEPA (1991) and ARB (1990) outline a number of procedures for analysis of base year, air quality model performance. These include spatial and time-series plots, and statistical analyses, comparing simulated and observed pollutant concentrations, as well as sensitivity analysis of selected input fields. The purpose of the performance analysis is to provide some confidence that the air quality simulations – which are the basis of future-year ozone concentration estimates – are performing properly.

The application of air quality modeling results to demonstrate attainment of the federal 1-hour ozone standard emphasized the simulated unpaired peak ozone concentration. Three statistical measures were recommended to evaluate model performance: unpaired peak ratio (UPR), paired mean normalized bias (NB), and paired gross error (GE). These statistical measures were calculated for the modeling domain as a whole, and the NB and GE were calculated from all hourly concentrations in excess of 60 ppb (to avoid biasing the statistical measures with low concentrations). To meet performance guidelines, recommendations were that the UPR should be within $\pm$ 20%, NB should be within $\pm$ 15%, and the GE less than 35%. However, California's geography is very complex and modeling domains have evolved to cover large geographic areas. Thus it is recommended that the domains be divided into sub-regions, and that the performance measures be calculated independently for each subregion. The configuration of these sub-regions is somewhat arbitrary; however, they should be configured to isolate "common" regions of higher ozone.

The USEPA (2005) recommends that the emphasis for 8-hour model performance be based on concentrations occurring at, or in the vicinity of, individual monitoring sites. Specifically, modeled concentrations occurring within 15 km of a site are considered to be in the vicinity of the site. The recommended statistical measures to assess simulated versus observed maximum 8-hour ozone concentrations include paired (in space, but not time) peak prediction accuracy (PPPA), paired mean normalized bias (NB), and paired gross error (GE). Although limited performance analysis has been completed for 8-hour ozone modeling in California, it seems prudent at this point to carry forward the 1-hour statistical goals and apply them for the 8-hour standard (UPR within ± 20%, NB within ± 15%, and the GE less than 35%). However, these limits may need to be revised as 8-hour SIP modeling progresses and rigorous model performance evaluations are completed.

While statistical measures for 1-hour model performance were typically calculated independently for each modeled day available, the USEPA also recommends that PPPA, NB, and GE be calculated for each site over all modeled days. However, because the number of episode days available may be very limited, the statistical uncertainties in these latter calculations would be large and they are not recommended herein.

In order to have confidence in future year estimates from air quality models, there must be confidence in the air quality modeling for the base year. That is, days not meeting model acceptance criteria provide high uncertainty, and should not be used for the modeled attainment test.

In addition to the issue of model performance, analyses conducted by the USEPA (2005) suggest that air quality models respond more to emission reductions at higher predicted ozone values. Correspondingly, the model predicts less benefit at lower concentrations. This is consistent with preliminary modeling in support of the 8-hour ozone standard conducted by the ARB and the districts. These results imply that RRF calculations should be restricted to days with predicted high ozone concentrations. It is thus reasonable to establish a minimum threshold for predicted peak 8-hour ozone concentrations in the reference year. Days for which the predicted daily peak 8-hour ozone concentration at a site is less than the threshold, would not be used for calculating RRFs at that site. Consistent with USEPA’s recommendation, we propose to use a value of 85 ppb for the reference year threshold.

Based on the above discussion, we propose the following methodology for determining sites and modeled days to be used in the RRF calculations:

Only those modeled days meeting the following criteria will be used to calculate site-specific RRFs:

1) **The modeled daily 8-hour peak ozone concentration within 15 km of the site for the base year of the modeling must be within ± 20% of the observed value at the site.**
2) **The modeled daily 8-hour peak ozone concentration within 15 km of the site in the reference year must be 85 ppb or greater.**
3) **The sub-regional 1-hour and 8-hour statistical measures of NB and GE must fall within the thresholds of ± 15% and 35%, respectively.**

1.1.4 Estimating Future-Year Design Values

As discussed above, the USEPA's 8-hour modeling guidance recommends utilizing relative model response on a site-by-site basis, in the form of an average relative response factor (RRF_{AVG}), to predict future-year 8-hour design values for attainment planning. The average RRF is then multiplied by a site-specific design value to estimate the future-year design value. One of the confounding factors in this approach is consideration of the effects that background levels have on the effectiveness of emission control programs.

There is a large body of information that suggests that ambient concentrations consist of some (perhaps nonlinear) background value and a contribution due to anthropogenic emissions. That is, if all man-made emissions could be zeroed out, ozone concentrations would not go to zero but rather some finite value. The literature suggests that 40 ppb is a reasonable global background ozone value, and it is quite likely that continental background is some other, somewhat higher, value. One possibility for estimating background ozone values in a given modeling domain would be to exercise the model without anthropogenic emissions, and to thus develop a gridded "background" ozone field. One concern with this approach is that at such low levels, the model's boundary conditions exert a large influence, and appropriate temporally- and spatially-resolved data to specify boundary conditions rarely exist. Thus boundary conditions can be subjective and uncertain. Whether the background value is established at some finite value (e.g., 40 ppb) or is model-derived, it represents that portion of a site's ozone problem that cannot be mitigated by anthropogenic emission controls.

According to EPA's 8-hour ozone modeling guidance, the modeled attainment test requires that a future year Design Value (DV_F) be calculated at each site and compared to the standard to determine if the site is predicted to be in attainment. To calculate the future year Design Value, the Design Value for the reference year (DV_R) is multiplied by RRF_{AVG}. Although EPA's guidance says nothing about background ozone, we propose to calculate the future year Design Value with consideration of background. The Table below illustrates calculation of the DV_F with and without background.

Calculation of the Average Relative Reduction Factor with and without Consideration of Background Ozone

Without consideration of background	With consideration of background
$RRF_{AVG} = \frac{(FY)_{AVG}}{(RY)_{AVG}}$ $DV_F = (RRF_{AVG}) \times (DV_R)$	$RRF_{AVG} = \frac{(FY - BG)_{AVG}}{(RY - BG)_{AVG}}$ $DV_F = [(RRF_{AVG}) \times (DV_R - BG)] + BG$
Definitions DV_R = Design Value for the reference year RY = reference year model prediction FY = future year model prediction BG = background ozone	

Future year design values will be calculated with consideration of background ozone. Because the model's boundary conditions exert a large influence on modeled background ozone levels, 40 ppb will be used to represent background ozone concentrations.

1.1.5 Unpaired Peak Concentrations

The USEPA (2005) recommends that maximum simulated and observed 8-hour ozone concentrations be investigated and combined to demonstrate attainment for all areas in a region. This can be cause for concern because peak simulated ozone concentrations rarely occur at the exact location of a monitoring site. Conceptually, a design value for the location of the unpaired peak can be determined by extrapolation from existing monitoring sites. However, this could lead to design value ozone concentrations that are greater than those that have been measured and may be the limiting factor in an attainment demonstration.

California's modeling domains include extreme variations in terrain and meteorology. Even during the most intense of field studies, the monitoring network is not sufficient to capture all of the gradients in the ozone concentration field. The modeling is subject to inaccuracies in the input data, and terrain gradients are smoothed over the spatial resolution of the model. However, the modeling does provide information on concentration gradients throughout the domain. To take advantage of the strengths of the modeling and the monitoring network, we propose the following approach for addressing unmonitored peak areas.

An unmonitored design value for the reference year and for each sub-region will be estimated by averaging the sub-regional maximum 8-hour ozone concentrations for all days which satisfy the model performance criteria described earlier. A sub-regional RRF will be calculated by averaging all site-specific RRFs in the sub-region. The estimated unmonitored design value and sub-regional RRF will then be used in the attainment test.

This approach to the unpaired peak 8-hour ozone concentration differs from that described in the USEPA (2005) guideline document. However, we believe the approach described above is consistent with use of the modeled and monitoring data, and provides a reasonable alternative to EPA's methodology.

1.1.6 Other Potential Technical Issues

The process outlined above for calculating site-specific RRFs seems straightforward. However, in practice, the process may turn out to be tedious and cumbersome; especially if a large number of sites need to be evaluated, and for different years. The greatest difficulty may be that the number of days used for the calculation of the RRF for each site may vary. The days used for each site in the future year must match those used in the reference year. Because the selection of these days is based, in part, on model performance statistical measures, it may be necessary to do much of this work by hand.

Another problem that is almost certain to arise is that for some sites either the model performance or the observed and simulated concentrations will fail to meet the recommended guidelines on all of the available episode days. This may result in situations wherein the day of the peak ozone concentration is not used in the calculation of the RRF and days with lesser concentrations are. The risk is that if the episode and simulation results do not adequately represent high ozone concentrations at a site, the simulation results may overstate the emissions reductions necessary to reach attainment for the ozone air quality standards due to the model's relatively limited response to controls at lower concentrations. In addition, the process of estimating a future year design value at an unmonitored peak location will always be subject to great uncertainty.

Some of the above difficulties may be avoided if a more simple and straightforward approach was used. For example, an RRF could be calculated from the reference- and future-year sub-regional maximum 8-hour daily maximum ozone concentrations. The RRF could then be multiplied by the maximum design value within the control district or attainment area. This would deviate from the USEPA (2005) guidelines in a number if respects. But, it would greatly simplify the required calculations. A lot more study of this approach would be necessary to understand the implications of such an approximation. This would also have to be vetted with the USEPA.

2 Future Year Results

This chapter presents draft reference year design values and describes the future year design values and carrying capacity results contained in the Appendices.

2.1 Base-Year Design Values

Chapter 1 (Section 1.1.1) discusses a proposed approach for calculating future year design values. Based on this recommended approach, Table 2 presents the results of reference year design value calculations for the Sacramento Non-Attainment Area.

Table 2. Sacramento Non-Attainment Area Design Values for 2002-2004 (Non-Attainment Sites Only)

Site	8-Hour Ozone Design Values			
	2002	2003	2004	2002-04 Avg.
El Dorado County				
Coo l -Highway 193	106	107	102	105
Placerville - Gold Nugget Way	94	95	94	94
Placer County				
Auburn - Dewitt-C Avenue	101	99	95	98
Roseville - N Sunrise Blvd	92	90	87	90
Sacramento County				
Folsom - Natoma Street	100	100	97	99
North Highlands - Blackfoot Way	92	91	85	89
Sacramento - Del Paso Manor	95	97	95	96
Sloughhouse	95	95	94	95

2.2 Future Year Design Value and Carrying Capacity Estimates

Data processing programs are used to generate reports from modeling results to illustrate future year design values and carrying capacities. These reports are generated for each 8-hour ozone non-attainment monitoring station following the methodology described in Chapter 1, sections 1.1.3 and 1.1.4. For illustration purposes, this section discusses the information contained on a sample report page (Figure 2). The Appendices contain future-year-specific results for specific years in the same form as the sample format.

Report Header. At the top of the report, three header lines provide a variety of information, including the subject future year (2012), the station (site) name, the associated sub-region (per Figure 1, Chapter 1), and the 8-hour ozone design value for the USEPA-defined reference year of 2002 (98 ppb) from Table 2, shown previously in Section 2.1).

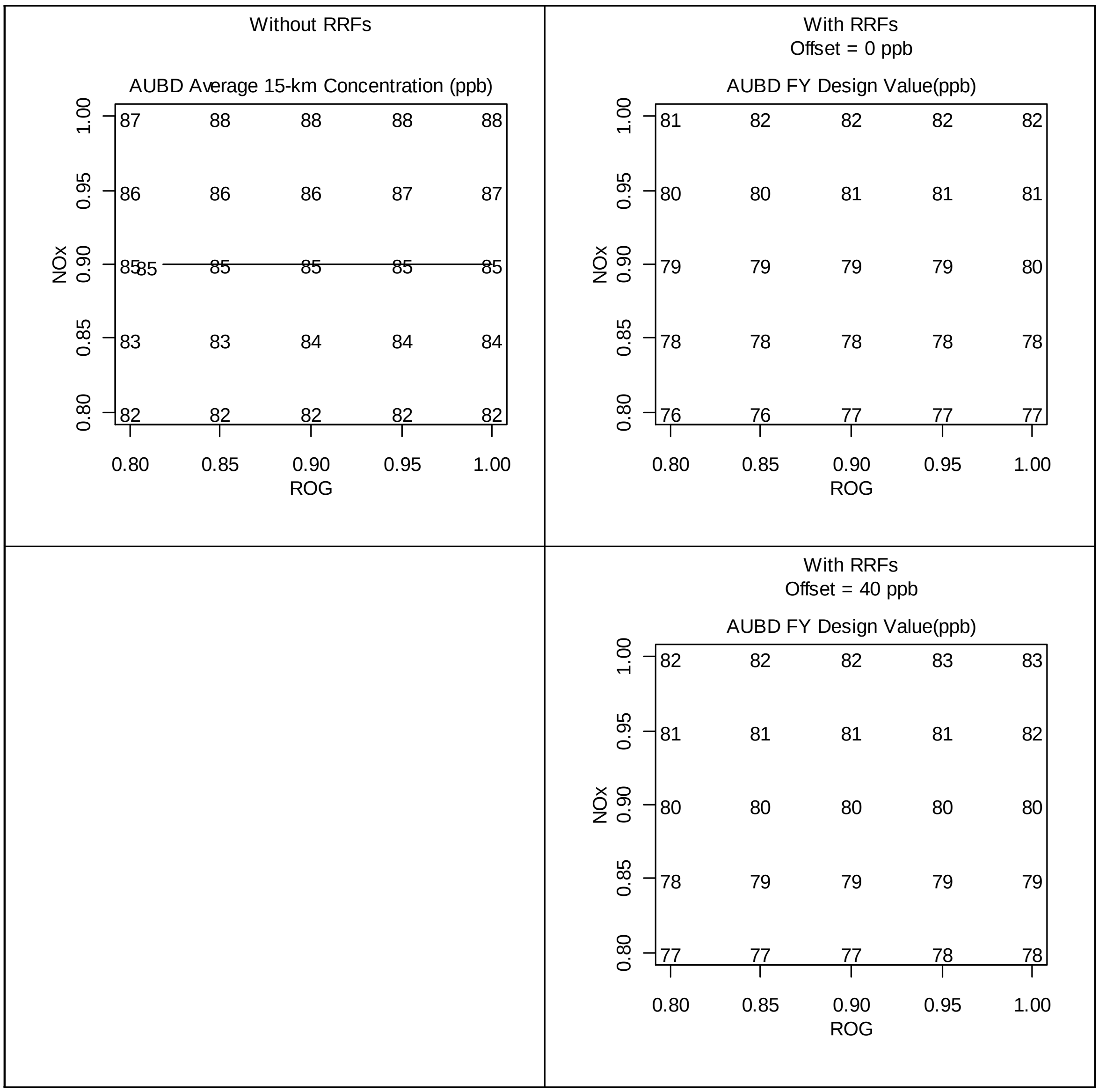
Report Table. The mid-section of the report contains a table with 8 rows: a header row, plus 7 rows of information. For specific episode days (columns), this table contains a pass/fail summary of sub-regional model performance results for the site (row 2), a variety of concentration data (rows 3-7), and a yes/no assessment as to whether the station data are useable in the RRF analysis (row 8). A "-99" value in rows 3-7 indicates that acceptable data are not available. The purpose of each row is described below:

- **Row 1**: *Header*. Columns represent episode days via two digit year followed by three digit day-of-year, or Julian day.
- **Row 2**: *Performance Status*: This line lists the model performance status for each of the episode days. The model performance status is a pass/fail designation as to whether the model performance for the sub-region within which the monitoring station is located meets both the 1-hour and the 8-hour statistical model performance criteria, per Section 1.1.3 and the Volume 1 report. Per the Figure 2 report header, Auburn is located in Region 6.
- **Row 3**: *Peak Observed 8-hour Ozone*. These data represent the peak, measured 8-hour ozone concentrations at the Auburn station for each specific day. These 8-hour ozone concentrations need to be above 70 ppb to be used in the RRF calculation (U.S. EPA guidance recommends excluding days with concentrations less than 70 ppb from RRF calculations to avoid a strong RRF dependence on the predicted baseline maximum concentrations).
- **Row 4**: *Peak Simulated 8-hour Ozone*. These are the model-simulated, peak 8-hour ozone concentrations occurring in the modeling grid cell within which the station (Auburn in this case) is geographically located. Per Section 1.1.3, simulated concentrations must be 85ppb or greater to be used in the RRF calculation.

Figure 2. Sample Report Page for the Auburn monitoring site.

Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: AUBD - Auburn-Dewitt-C Avenue **Subregion:** 6 **Reference Year Design Value:** 98 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	105	103	107	102	91	-99	80	82	95	107
Peak Simulated 8-hour Ozone	87	80	86	77	73	71	78	74	93	104
Peak Simulated 8-hour Ozone within 15 km	106	84	101	84	77	79	86	83	106	106
Reference Year 15-km, 8-hour Average Ozone	105									
Future Year 15-km, 8-hour Average Ozone	89	73	83	71	67	70	75	74	91	90
Use in RRF Analysis?	Yes	No	Yes	No	No	No	No	No	Yes	Yes



- **Row 5**: *Peak Simulated 8-hour Ozone within 15km*. These values represent the model-simulated, daily 8-hour peak ozone concentration within 15 km of the site for the base year of the modeling. Per Section 1.1.3, these concentrations must be 85 ppb or greater and within ± 20% of the observed value at the site.
- **Row 6**: *Reference Year, 15km, 8-hour Average Ozone*. This represents the average of the Row 4 values for which the data are useable in RRF analyses (per row 8). For Auburn, since row 8 indicates that only days 99190, 99192, 00214, and 00215 are usable, 105 ppb is calculated from the average of 106, 101, 106, and 106 ppb.
- **Row 7**: *Future Year, 15km, 8-hour Average Ozone*. This represents the average, future-year simulated concentrations within 15 km of the site.
- **Row 8**: Use in RRF Analysis? This YES/NO field represents whether data for the days can be used in calculating the RRF. As indicated in Section 1.1.3 and in the row descriptions above, the criteria for selecting which days will be used in the RRF calculation include an assessment of sub-regional model performance as well as concentration thresholds for observed and simulated 8-hour ozone concentrations. That is, in addition to meeting model performance criteria, the observed base-year ozone concentration must be 70 ppb or greater and the maximum simulated ozone concentration for the year 2002 must be 85 ppb or greater.

RRF Calculation Example. Of the 10 available episode days reported in Figure 2 for Auburn, six of the days fail to meet the 1-hour and/or the 8-hour model performance criteria ('99191', '99193', '99194', '00211', ‘00212’, and '00213'). The simulation results from the remaining four days are used in the RRF calculation: days '99190', ‘99192’, ‘00214’, and '0215' (per row 8). Per Section 1.1.4 the sample RRF for Auburn, without a background offset, is calculated as follows:

$$RRF_{AVG} = \frac{(FY)_{AVG}}{(RY)_{AVG}} = ((89+83+91+90)/4) / ((106+101+106+106)/4) = (88/105) = 0.84$$

Also per Section 1.1.4, with a 40 ppb background offset, the RRF is calculated as:

$$RRF_{AVG} = \frac{(FY - BG)_{AVG}}{(RY - BG)_{AVG}} = (88-40)/(105-40) = 0.74$$

Reported Design-Value-Based Carrying Capacity Diagrams. The lower half of the page for each report contains four design-value-based carrying capacity diagrams. These diagrams are intended to characterize the effect of domain-wide emission changes on a design value, based upon multiple model simulations. The diagrams are based on model response to 25 future year emission scenarios for which baseline, domain-wide NO_x and ROG emissions for the 2018 future year are scaled by factors ranging from 0.80 to 1.00 in increments of 0.05 (i.e. 5% NO_x and/or ROG reductions at a time).

The diagram on the left side of the report is based on the average of the "Future Year 15-km, 8-hour Average Ozone" values reflected in row 6 of the report table, for those days that meet all the criteria for RRF application. However, no RRF is applied. Thus the future year design value indicated at the top right of each diagram is calculated as follows:

$$DV_F = (89+83+91+90) / 4 = 88 \text{ ppb}$$

The two diagrams on the right incorporate RRFs, without consideration of background ozone (top diagram) and with consideration of background (bottom diagram). The future year design value indicated at the top right of the top diagram on the right is calculated as follows, using the RRFs discussed above:

$$DV_F = (RRF_{AVG}) \times (DV_R) = 0.84 \times 98 \text{ ppb} = 82 \text{ ppb}$$

Similarly, the future year design value indicated at the top right for the bottom right diagram is calculated as follows, using the background-adjusted RRFs discussed previously and equations in section 1.1.4:

$$DV_F = [(RRF_{AVG}) \times (DV_R – BG)] + BG = [\ 0.74 \times (\ 98 – 40\ )\ ] + 40 = 83 \text{ ppb}$$

3 Analysis of Model-Simulated, Unmonitored Peaks

This work will be reported separately.

4 References

Air Resources Board, 1990. “TECHNICAL GUIDANCE DOCUMENT: Photochemical Modeling”.

USEPA, 1991. "Guideline for Regulatory Application of the Urban Airshed Model". EPA-450/4-91-013. USEPA, OAQPS. Research Triangle Park, NC 27711. July, 1991.

USEPA, 2005. "Guidance on the Use of Models and Other Analysis in the Attainment Demonstration for the 8-Hour Ozone NAAQS". Final Draft. USEPA, OAR/OAQPS, Research Triangle Park, NC 2771. February, 2005.

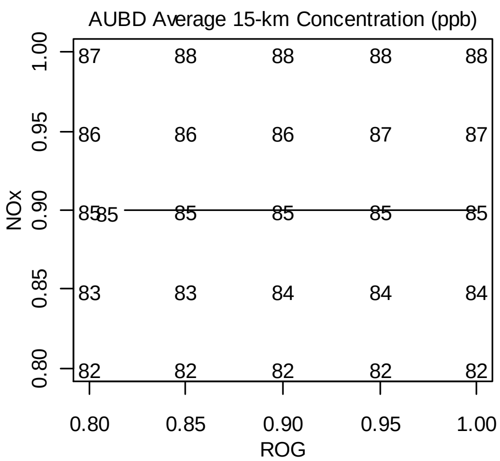
5 Appendices

5.1 Future Year 2018

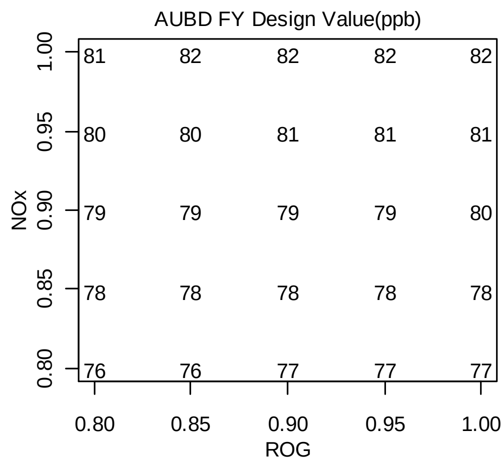
Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: AUBD - Auburn-Dewitt-C Avenue **Subregion:** 6 **Reference Year Design Value:** 98 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	105	103	107	102	91	-99	80	82	95	107
Peak Simulated 8-hour Ozone	87	80	86	77	73	71	78	74	93	104
Peak Simulated 8-hour Ozone within 15 km	106	84	101	84	77	79	86	83	106	106
Reference Year 15-km, 8-hour Average Ozone	105									
Future Year 15-km, 8-hour Average Ozone	89	73	83	71	67	70	75	74	91	90
Use in RRF Analysis?	Yes	No	Yes	No	No	No	No	No	Yes	Yes

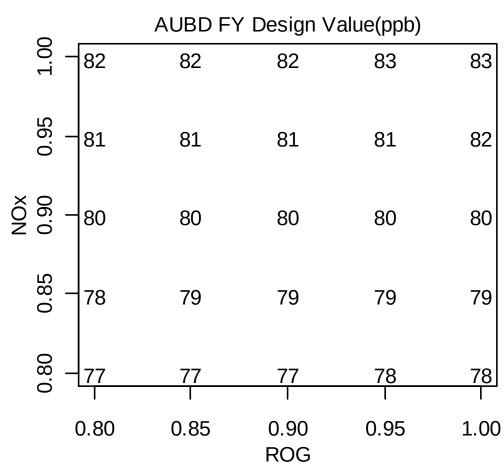
Without RRFs



With RRFs
Offset = 0 ppb



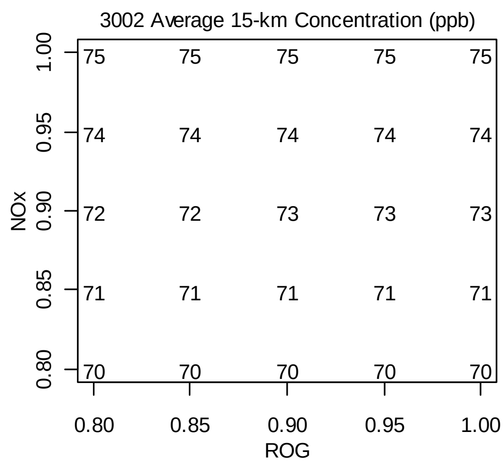
With RRFs
Offset = 40 ppb



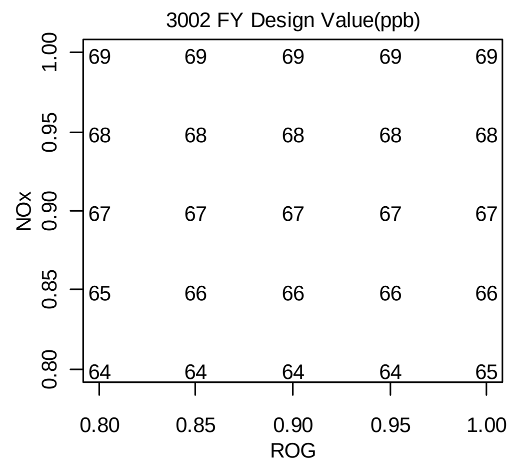
Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: 3002 - Colfax-City Hall **Subregion:** 6 **Reference Year Design Value:** 85 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	89	86	87	82	69	-99	-99	-99	-99	-99
Peak Simulated 8-hour Ozone	81	75	83	75	69	75	78	74	85	100
Peak Simulated 8-hour Ozone within 15 km	92	80	91	82	74	78	83	79	92	105
Reference Year 15-km, 8-hour Average Ozone	91									
Future Year 15-km, 8-hour Average Ozone	76	70	75	69	65	70	73	69	79	89
Use in RRF Analysis?	Yes	No	Yes	No	No	No	No	No	No	No

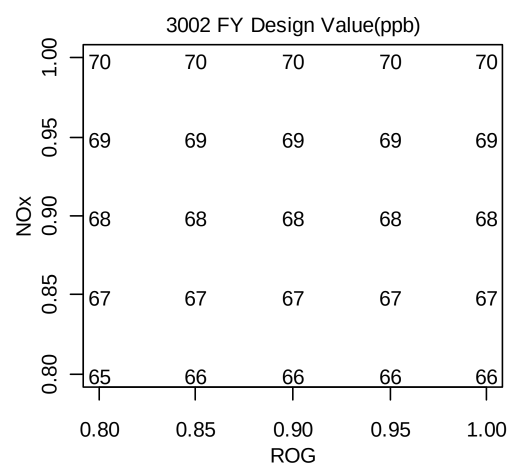
Without RRFs



With RRFs
Offset = 0 ppb



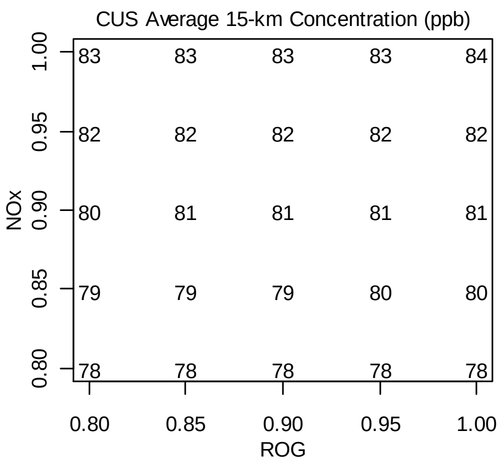
With RRFs
Offset = 40 ppb



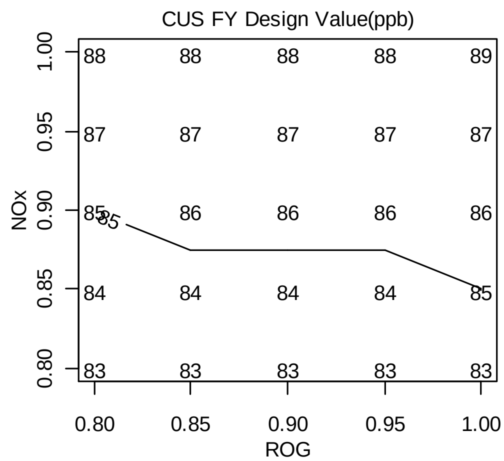
Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: CUS - Cool Stn (1400 American **Subregion:** 6 **Reference Year Design Value:** 105 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	116	114	118	100	94	94	87	90	99	104
Peak Simulated 8-hour Ozone	95	82	93	83	76	75	83	78	92	100
Peak Simulated 8-hour Ozone within 15 km	111	86	106	85	79	81	88	85	98	105
Reference Year 15-km, 8-hour Average Ozone	98									
Future Year 15-km, 8-hour Average Ozone	93	75	87	72	69	72	76	72	85	89
Use in RRF Analysis?	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes

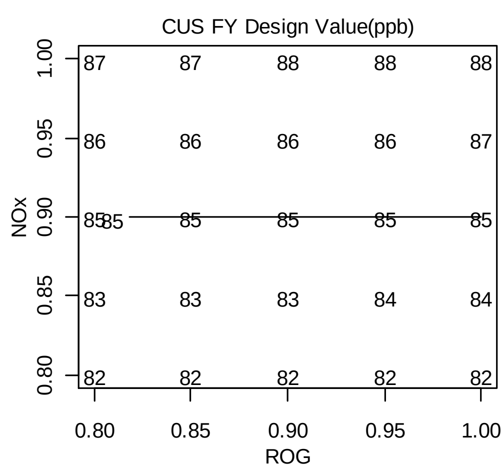
Without RRFs



With RRFs
Offset = 0 ppb



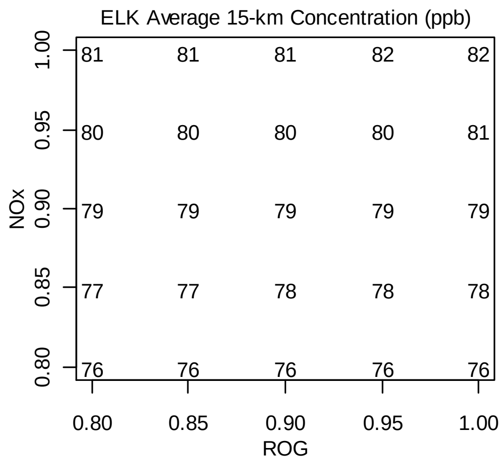
With RRFs
Offset = 40 ppb



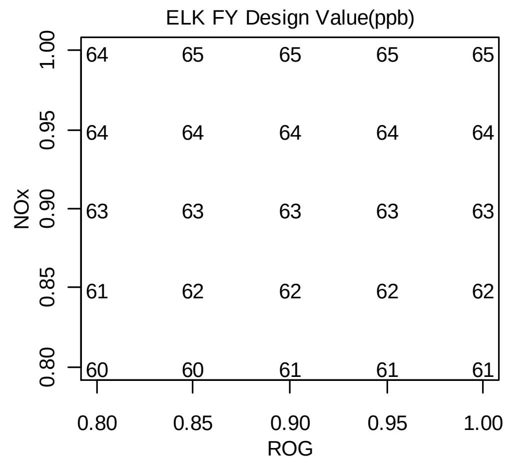
Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: ELK - Elk Grove Stn (Brucevil **Subregion:** 6 **Reference Year Design Value:** 77 ppb

Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	75	93	97	95	78	64	50	64	66	63
Peak Simulated 8-hour Ozone	76	89	83	91	86	81	85	99	96	86
Peak Simulated 8-hour Ozone within 15 km	80	99	95	102	88	91	91	110	100	87
Reference Year 15-km, 8-hour Average Ozone	96									
Future Year 15-km, 8-hour Average Ozone	76	84	80	84	79	83	83	97	88	80
Use in RRF Analysis?	No	Yes	Yes	Yes	Yes	No	No	No	No	No

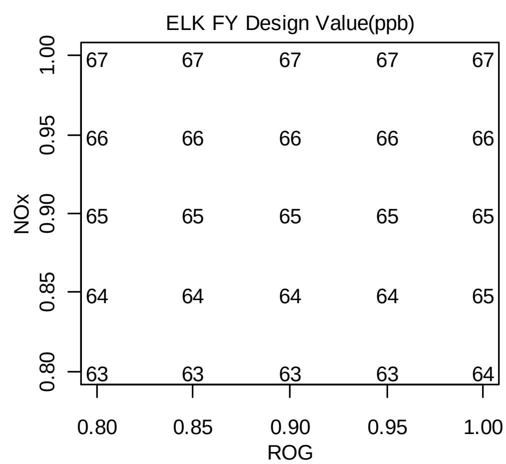
Without RRFs



With RRFs
Offset = 0 ppb



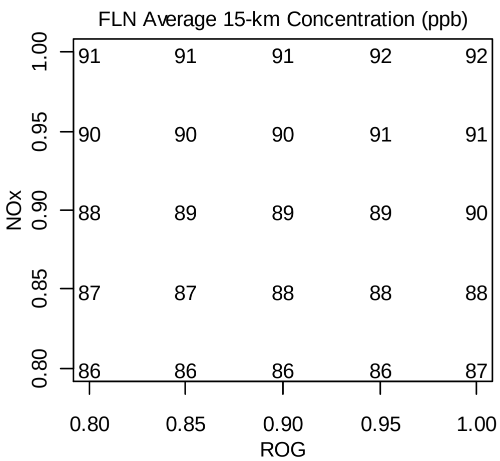
With RRFs
Offset = 40 ppb



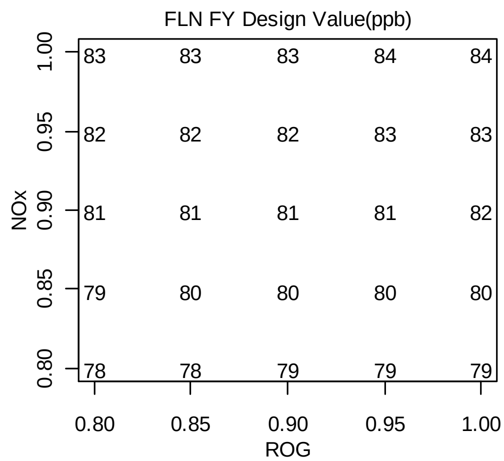
Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: FLN - Folsom Stn (Natoma St.) **Subregion:** 6 **Reference Year Design Value:** 99 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	109	129	124	102	86	70	66	43	-99	95
Peak Simulated 8-hour Ozone	109	96	121	87	87	88	97	84	105	88
Peak Simulated 8-hour Ozone within 15 km	115	114	125	98	98	101	107	92	116	104
Reference Year 15-km, 8-hour Average Ozone	108									
Future Year 15-km, 8-hour Average Ozone	102	96	101	80	87	88	96	82	98	90
Use in RRF Analysis?	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes

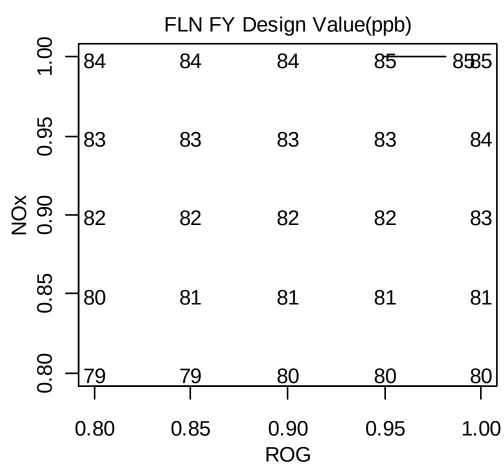
Without RRFs



With RRFs
Offset = 0 ppb



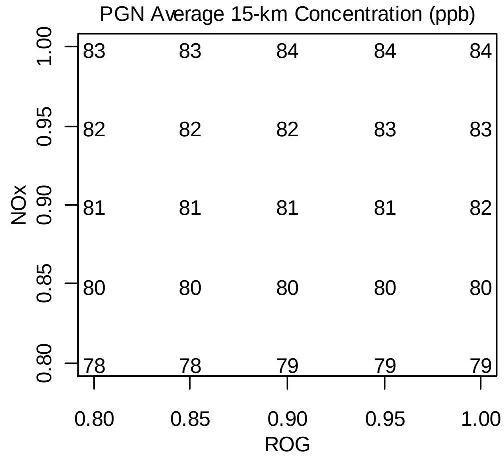
With RRFs
Offset = 40 ppb



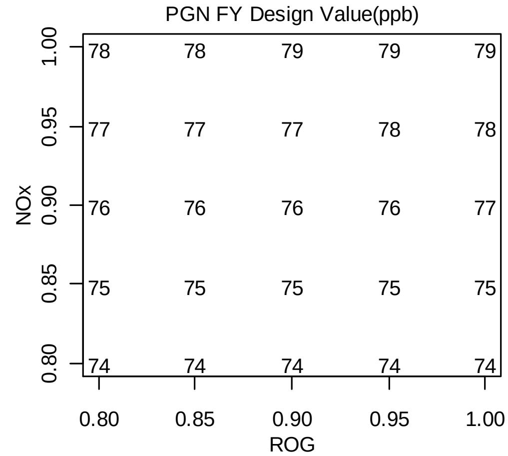
Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: PGN - Placerville Stn (Gold N **Subregion:** 6 **Reference Year Design Value:** 94 ppb

Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	110	119	111	98	92	97	93	82	89	88
Peak Simulated 8-hour Ozone	107	88	94	89	74	80	85	83	85	79
Peak Simulated 8-hour Ozone within 15 km	115	106	106	95	92	97	94	86	93	91
Reference Year 15-km, 8-hour Average Ozone	99									
Future Year 15-km, 8-hour Average Ozone	98	89	87	78	78	83	82	75	81	78
Use in RRF Analysis?	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes

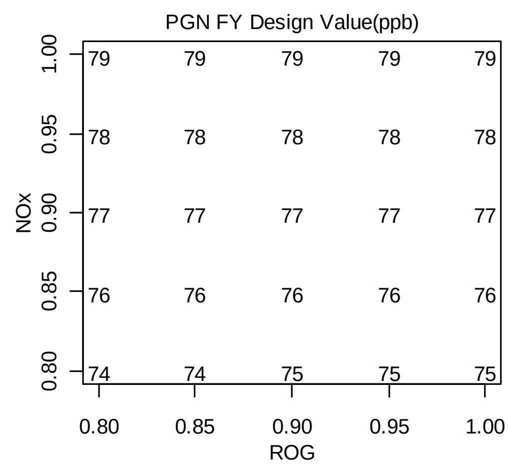
Without RRFs



With RRFs
Offset = 0 ppb

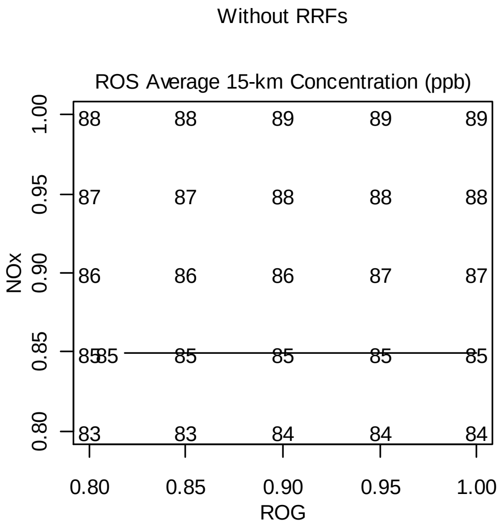


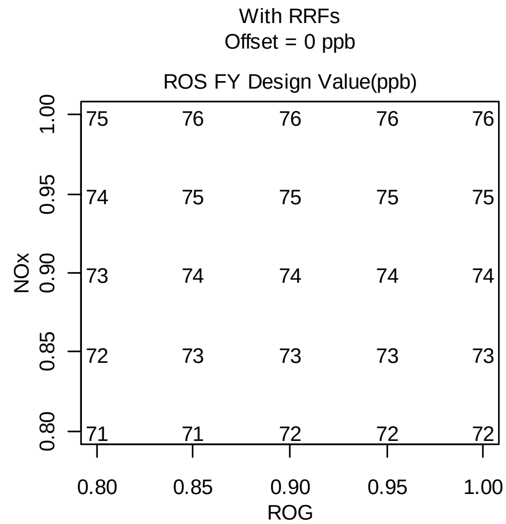
With RRFs
Offset = 40 ppb

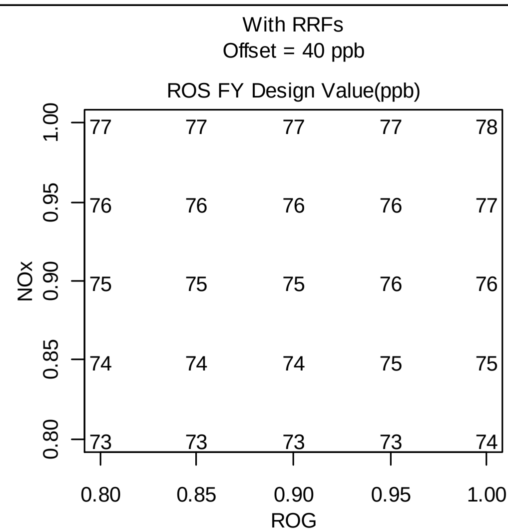


Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: ROS - Roseville Stn (151 N Su **Subregion:** 6 **Reference Year Design Value:** 89 ppb

Episode Days	99190	99191	99192	99193	99194	00211	00212	00213	00214	00215
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	86	107	113	88	86	90	85	70	93	97
Peak Simulated 8-hour Ozone	92	83	86	71	73	75	83	80	107	102
Peak Simulated 8-hour Ozone within 15 km	111	101	125	89	90	92	107	85	113	106
Reference Year 15-km, 8-hour Average Ozone	103									
Future Year 15-km, 8-hour Average Ozone	102	86	101	74	80	81	94	76	97	92
Use in RRF Analysis?	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes





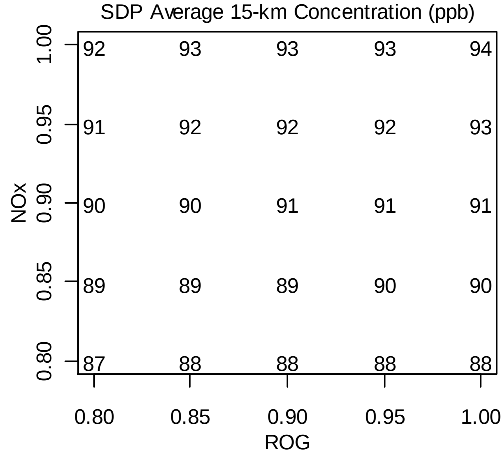


Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: SDP - Sacramento Stn (Del Pas **Subregion:** 6 **Reference Year Design Value:** 95 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	78	111	107	95	77	92	93	74	101	80
Peak Simulated 8-hour Ozone	81	100	100	78	85	84	107	84	105	90
Peak Simulated 8-hour Ozone within 15 km	103	113	124	102	95	99	110	99	115	102
Reference Year 15-km, 8-hour Average Ozone	107									
Future Year 15-km, 8-hour Average Ozone	100	97	101	84	88	89	100	92	98	92
Use in RRF Analysis?	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes

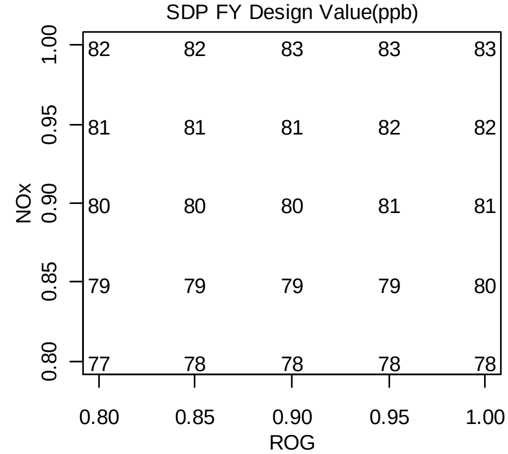
Without RRFs

SDP Average 15-km Concentration (ppb)



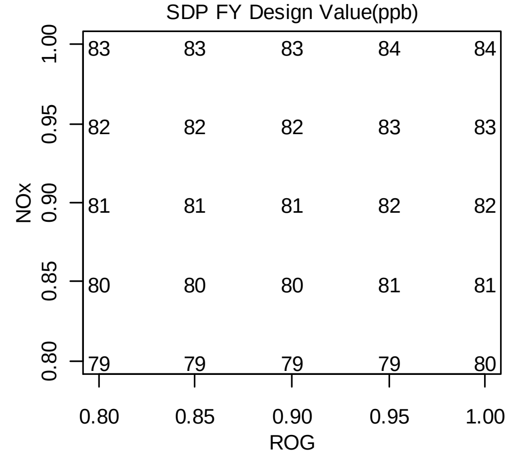
With RRFs
Offset = 0 ppb

SDP FY Design Value(ppb)



With RRFs
Offset = 40 ppb

SDP FY Design Value(ppb)

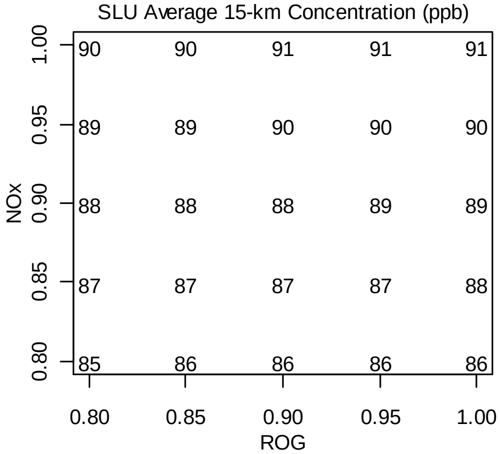


Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: SLU - Sloughouse Rd. Stn **Subregion:** 6 **Reference Year Design Value:** 94 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	-99	-99	-99	-99	-99	96	91	83	109	91
Peak Simulated 8-hour Ozone	85	111	106	102	94	98	87	99	110	87
Peak Simulated 8-hour Ozone within 15 km	99	116	125	107	99	102	110	110	116	91
Reference Year 15-km, 8-hour Average Ozone	103									
Future Year 15-km, 8-hour Average Ozone	94	98	101	87	88	90	100	97	98	85
Use in RRF Analysis?	No	No	No	No	No	Yes	No	No	Yes	Yes

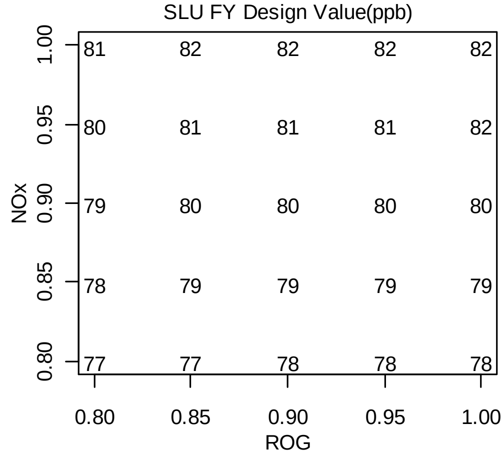
Without RRFs

SLU Average 15-km Concentration (ppb)



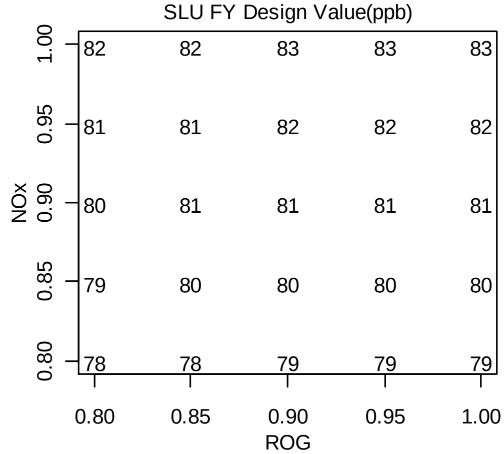
With RRFs
Offset = 0 ppb

SLU FY Design Value(ppb)



With RRFs
Offset = 40 ppb

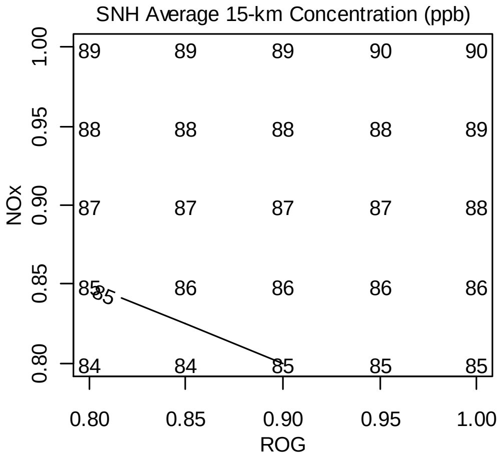
SLU FY Design Value(ppb)



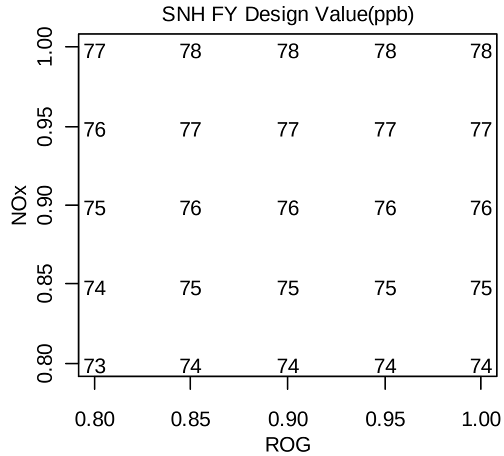
Year: 2018 **Model:** CAMX/MM5/SAPRC99
Site: SNH - Sacramento-North Highla **Subregion:** 6 **Reference Year Design Value:** 89 ppb

Episode Days	**99190**	**99191**	**99192**	**99193**	**99194**	**00211**	**00212**	**00213**	**00214**	**00215**
Performance Status	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Pass
Peak Observed 8-hour Ozone	53	79	69	64	80	89	81	77	100	87
Peak Simulated 8-hour Ozone	90	88	79	72	78	78	85	79	103	102
Peak Simulated 8-hour Ozone within 15 km	103	105	124	85	90	94	110	87	113	105
Reference Year 15-km, 8-hour Average Ozone	101									
Future Year 15-km, 8-hour Average Ozone	100	91	101	72	84	84	99	78	98	92
Use in RRF Analysis?	No	Yes	No	No	Yes	Yes	No	No	Yes	Yes

Without RRFs



With RRFs
Offset = 0 ppb



With RRFs
Offset = 40 ppb