APPENDIX E
SENSITIVITY OF OZONE IN ATLANTA TO NOx AND VOC EMISSIONS

As part of the **S**outh**E**astern **M**odeling, **A**nalysis, and **P**lanning (SEMAP) project, Georgia Tech performed an analysis of the sensitivity of ozone concentrations in the Eastern U.S. to reductions in emissions of both nitrogen oxides (NOx) and volatile organic compounds (VOCs). This analysis was based off of the 2007 and 2018 SEMAP modeling which used CMAQ version 5.01 with updates to the vertical mixing coefficients and land-water interface. The entire "ozone season" was modeled (May 1 – September 30) using a 12-km modeling grid that covered the Eastern U.S. Details of the modeling platform set-up and the detailed modeling results can be found in Appendix C.

Sensitivities were modeled relative to 2018 emissions to evaluate the impact of NOx and VOC reductions on daily 8-hour maximum ozone concentrations. Each emission sensitivity run reduced the 2018 anthropogenic NOx or VOC emissions (point, area, mobile, NONROAD, marine/aircraft/rail) within a specific geographic region by 30%. The 14 geographic regions included Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia, Maryland, MANE-VU (minus MD), LADCO, and CENRAP. This resulted in a total of 28 model runs (2 precursors x 14 regions). The NOx and VOC sensitivities were evaluated at every ozone monitor in the domain.

GA EPD used the SEMAP NOx and VOC sensitivity modeling to examine the normalized sensitivities of NOx and VOC emissions on 8-hour daily maximum ozone concentrations (part per billion ozone/ton per day, ppt/TPD) at 9 ozone monitors in Atlanta. This analysis started with the day-by-day NOx and VOC emission sensitivities (ppb) for May 1 – September 30. Not all modeled days were used in the calculations. The criteria for selecting days to include in the calculation generally follows the approach used by EPA to select days to include in the relative response factor (RRF) calculation as described in EPA's "Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze" (December 3, 2014). For our analysis, the 10 highest modeled days in 2018 were selected to be included in the average sensitivity calculation at each monitoring site to address the 2008 and 2015 ozone NAAQS.

The average absolute sensitivity was calculated for NOx and VOCs at each Atlanta ozone monitor location (Table 1). The average absolute NOx sensitivity across Atlanta is **6.487 ppb** for a 30% reduction in NOx emissions across Georgia and the average absolute VOC sensitivity across Atlanta is **0.351 ppb** for a 30% reduction in VOC emissions across Georgia.

Next, the average absolute sensitivity at each monitor was normalized by the emission reduction to give the normalized sensitivity (ppb/TPD). The SEMAP 30% emission reductions were statewide, but the ozone impacts at the Atlanta monitors will mostly results from the local NOx and VOC emission reductions in the nearby 15 ozone nonattainment counties. Therefore, it was not appropriate to normalize the local NOx and VOC sensitivity results by the statewide emission reduction. Instead, a conservative approach would be to assume the ozone impacts at the 9 Atlanta monitors resulted solely from the local NOx and VOC emission reductions in the nearby 15 ozone nonattainment counties. Therefore, the average absolute sensitivity was normalized by the emission reductions from NOx and VOC reductions in the nearby 15 ozone nonattainment counties. The anthropogenic NOx emissions in the 15 ozone maintenance counties are 281.5 TPD, so a 30% reduction is 84.5 TPD. The anthropogenic VOC emissions in the 15 ozone maintenance counties are 280.0 TPD, so a 30% reduction is 84.0 TPD. The normalized sensitivity was calculated for NOx and VOCs at each Atlanta

ozone monitor location (Table 2). The average normalized NOx sensitivity across Atlanta is **0.07680 ppb/TPD** and the average normalized VOC sensitivity across Atlanta is **0.00417 ppb/TPD**.

Table 1. Absolute NOx and VOC sensitivity at 9 Atlanta ozone monitors.

AIRS ID	County	Site Name	30% NOx (ppb)	30% VOC (ppb)
13-067-0003	Cobb, GA	Kennesaw	-6.260	-0.412
13-077-0002	Coweta, GA	Newnan	-6.807	-0.148
13-085-0001	Dawson, GA	Dawsonville	-4.333	-0.005
13-089-0002	DeKalb, GA	South DeKalb	-7.385	-0.576
13-097-0004	Douglas, GA	Douglasville	-6.732	-0.350
13-121-0055	Fulton, GA	Confederate Ave.	-5.428	-0.884
13-135-0002	Gwinnett, GA	Gwinnett	-6.440	-0.222
13-151-0002	Henry, GA	McDonough	-7.341	-0.282
13-247-0001	Rockdale, GA	Conyers	-7.655	-0.277
		AVERAGE (ppb)	**-6.487**	**-0.351**

Table 2. Normalized NOx and VOC sensitivity at 9 Atlanta ozone monitors.

AIRS ID	County	Site Name	30% NOx (ppb/TPD)	30% VOC (ppb/TPD)
13-067-0003	Cobb, GA	Kennesaw	-0.0741	-0.0049
13-077-0002	Coweta, GA	Newnan	-0.0806	-0.0018
13-085-0001	Dawson, GA	Dawsonville	-0.0513	-0.0001
13-089-0002	DeKalb, GA	South DeKalb	-0.0874	-0.0069
13-097-0004	Douglas, GA	Douglasville	-0.0797	-0.0042
13-121-0055	Fulton, GA	Confederate Ave.	-0.0643	-0.0105
13-135-0002	Gwinnett, GA	Gwinnett	-0.0763	-0.0026
13-151-0002	Henry, GA	McDonough	-0.0869	-0.0034
13-247-0001	Rockdale, GA	Conyers	-0.0906	-0.0033
		AVERAGE (ppb/TPD)	**-0.07680**	**-0.00417**

These results show that NOx emission reductions are generally 15-25 times more effective than VOC emission reductions at reducing ozone concentrations. VOC emission increases can be converted into equivalent NOx emission reductions by taking the ratio of the Atlanta average normalized sensitivity to NOx emissions divided by the Atlanta average normalized sensitivity to VOC emissions:

- (0.07680 ppb/TPD NOx)/(0.00417 ppb/TPD VOC) = **18.4 TPD VOC/TPD NOx**

In other words, a 18.4 TPD increase in VOC emissions is equivalent to a 1.0 TPD increase in NOx emissions. Hence, a 18.4 TPD increase in VOC emissions can be offset with a 1.0 TPD reduction in NOx emissions.