

Air Dispersion Modeling Analysis
For Verifying Compliance of Allowable Emissions
with the One-Hour SO₂ and NO₂ NAAQS:
UNC Manning and Cogeneration Power Plants

Prepared by:

Lindsey Meyers

October 24, 2018

TABLE OF CONTENTS

1.	Introduction.....	3
2.	Modeling Methodology	3
2.1	Air Dispersion Model	4
2.2	AERMOD Input Control Options	4
2.3	Output Options	4
2.4	NO ₂ Modeling Methodology	5
3.	Model inputs	5
3.1	Geographical Inputs	5
3.2	Emission Rates and Source Parameters	6
3.3	Building Dimensions for Downwash.....	8
3.4	Receptors.....	8
3.5	Meteorological Data.....	8
4.	Background Air Concentrations	9
5.	Modeling Results	9
5.1	Sulfur Dioxide.....	9
5.2	Nitrogen Dioxide	13
6.	Conclusion	16

FIGURES

1. UNC Manning/Cogeneration: Allowable SO₂ Concentrations, Boilers 6-10 and 2 Generators, Modeled with 2013-2017 met data
2. UNC Manning: Allowable SO₂ Concentrations, Boilers 6 and 7, Modeled with 2013-2017 met data
3. UNC Manning/Cogeneration: Allowable NO₂ Concentrations, Boilers 6-10 and 2 Generators, Modeled with 2013-2017 met data and PVMRM with a 0.2 NO₂/NO_x in-stack ratio
4. UNC Manning/Cogeneration: Allowable NO₂ Concentrations, Boilers 6-10 and 2 Generators, Modeled with 2013-2017 met data and PVMRM with a 0.5 NO₂/NO_x in-stack ratio

ATTACHMENTS

1. Curriculum Vitae

1. Introduction

The University of North Carolina at Chapel Hill (UNC) owns and operates two power plants: one on Manning Drive (Manning) adjacent to the UNC Hospital, and the Cogeneration facility (Cogeneration) on Cameron Avenue just off of the main campus. These plants have various emission sources including coal, natural gas, wood, and distillate oil-fired boilers and generators. UNC currently is in the process of applying for a Title V permit renewal.

In response to the Title V permit renewal application, I was asked by the Center for Biological Diversity to verify whether UNC's current allowable SO₂ and NO_x emissions would cause air impacts that exceed the one-hour National Ambient Air Quality Standard (NAAQS) for these pollutants. I prepared air dispersion modeling analyses for calculating potential ambient SO₂ and Tier 3 NO₂ air concentrations for allowable emissions from the UNC facilities. These modeled impacts are then compared with the one-hour SO₂ and NO₂ NAAQS, respectively. My modeling methods and results will be discussed in further detail in the following report. My modeling files can be found at this [link](#).

I have broad experience as a consultant. I hold an M.A. (2012) degree in Geography from California State University, Northridge, where I specialized in GIS and air dispersion modeling. I have performed numerous air quality modeling analyses using AERMOD and other air dispersion models, prepared meteorological data using AERMET, performed health risk assessments, and created many detailed maps and graphics. I have experience preparing analyses of various emission types from many sources and facilities including natural gas and coal-fired power plants, agricultural fields, and mobile sources. My curriculum vitae can be found as Attachment 1.

2. Modeling Methodology

The 2010 one-hour SO₂ NAAQS takes the form of a three-year average of the 99th-percentile of the annual distribution of daily maximum one-hour concentrations, which cannot exceed 75 ppb.¹ This standard is to be verified using USEPA's AERMOD air dispersion model, which produces air concentrations in units of µg/m³. The one-hour SO₂ NAAQS of 75 ppb equals 196.2 µg/m³, and this is the value I used for determining whether modeled UNC Manning and Cogeneration impacts exceed the NAAQS. The 99th-percentile of the annual distribution of daily maximum one-hour concentrations corresponds to the fourth-highest value at each receptor for a given year.

The 2010 one-hour NO₂ NAAQS takes the form of a three-year average of the 98th-percentile of the

¹USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO₂ National Ambient Air Quality Standard, August 23, 2010.

annual distribution of daily maximum one-hour concentrations, which cannot exceed 100 ppb.² The one-hour NO₂ NAAQS of 100 ppb equals 188 µg/m³. The 98th-percentile of the annual distribution of daily maximum one-hour concentrations corresponds to the eighth-highest value at each receptor for a given year.

This section describes the dispersion model, control options, and output options I used for verifying UNC's compliance with the one-hour SO₂ and NO₂ NAAQS.

2.1 Air Dispersion Model

I performed one-hour SO₂ and NO₂ NAAQS modeling with USEPA's AERMOD program, version 18081, obtained from the Support Center for Regulatory Atmospheric Modeling (SCRAM) website. AERMOD is the USEPA preferred air dispersion model for determining air impacts within 50 kilometers of air pollution emission sources.³ Version 18081 is the latest version of the AERMOD model.

2.2 AERMOD Input Control Options

I ran AERMOD with the following control options:

- One-hour average air concentrations
- Regulatory defaults for SO₂
- PVMRM for NO₂
- Rural dispersion coefficients

These input control options are consistent with previous modeling analyses provided by the North Carolina Division of Air Quality (NCDAQ). They are appropriate input options for one-hour SO₂ and NO₂ NAAQS modeling in the area surround UNC according to USEPA's methodology outlined in Section 7.2.3 of the Guideline on Air Quality Models.⁴

2.3 Output Options

My AERMOD modeling analyses of the UNC facilities includes five years of meteorological data –

² USEPA, Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO₂ National Ambient Air Quality Standard, March 1, 2011.

³ USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005.

⁴ Id., Section 7.2.3.

years 2013 through 2017. Meteorological data will be discussed further in section 3.5.

I generated tables, plot files, and summary files appropriate for 1-hour SO₂ and NO₂ NAAQS modeling.

2.4 NO₂ Modeling Methodology

NO₂ NAAQS modeling involves a three-tiered approach, as described by USEPA⁵:

“Tier 1 – assume full conversion of NO to NO₂, where total NO_x concentrations are computed with a refined modeling technique specified in Section 4.2.2 of Appendix W.

Tier 2 – multiply Tier 1 results by empirically derived NO₂/NO_x ratios, with 0.75 as the national default ratio for annual NO₂ (Chu and Meyer, 1991) and 0.80 as the national default ratio for hourly NO₂ (Want, et al, 2011; Janssen, et al, 1991), as recommended in U.S. EPA, 2011.

Tier 3 – detailed screening methods may be used on a case-by-cases basis. At this time, OLM (Cole and Summerhays, 1979) and the PVMRM (Hanrahan, 1999) are considered to be appropriate as detailed screening techniques.”

In this modeling analysis, I used the Tier 3 Plume Volume Molar Ratio Method (PVMRM), consistent with previous modeling analyses provided NCDAQ.

3. Model inputs

The AERMOD air dispersion model requires a lengthy list of input values. Key inputs to this dispersion model include local geography, air emission rates of the released pollutant, source parameters (how and where the material is released to the air), receptors (locations where the offsite concentrations are calculated), and meteorological data (determines how and where the material is dispersed in the air). Each of these inputs is discussed below.

3.1 Geographical Inputs

The “ground floor” of all air dispersion modeling analyses is establishing a coordinate system for identifying the geographical location of emission sources and receptors. These geographical locations are used to determine local characteristics (such as land use and elevation), and also to ascertain source to receptor distances and relationships.

⁵ USEPA, Memorandum: Applicability of Appendix W Modeling Guidance for the 1-hour NO₂ National Ambient Air Quality Standard, June 28, 2010, pp. 1-2

I used the Universal Transverse Mercator (UTM) NAD83 zone 17 coordinate system for identifying the easting (x) and northing (y) coordinates of the modeled sources and receptors. I obtained the source locations from previous modeling files provided by NCDAQ. I verified the source coordinates using Google Earth Pro orthoimagery, which ensures consistency with the UTM NAD83 coordinate system.

3.2 Emission Rates and Source Parameters

My modeling analyses are limited to SO₂ and NO_x allowable emissions for UNC's Cogeneration and Manning facilities, as discussed in the Introduction.

I modeled two scenarios for SO₂. For the first SO₂ scenario, I modeled allowable emissions for boilers #6, #7, and #8 at Cogeneration, boilers #9 and #10 at Manning, and two non-emergency generators located at Cogeneration. For the second SO₂ scenario, I modeled allowable emissions for only boilers #6 and #7 at Cogeneration.

I also modeled two scenarios for NO₂. For both scenarios, I modeled allowable emissions for boilers #6, #7, and #8 at Cogeneration, boilers #9 and #10 at Manning, and two non-emergency generators located at Cogeneration. In one modeling scenario, I modeled with Tier 3 PVMRM and a 0.2 in-stack ratio, consistent with previous modeling provided by NCDAQ. For the second modeling scenario, I modeled with Tier 3 PVMRM and a 0.5 in-stack ratio, which is the default value recommended by USEPA.⁶

The allowable emissions I modeled are as follows⁷:

Boiler #6 and #7 (B67S: common stack)

SO₂: 323.17 MMBTU/hr * 2.3 lb/MMBTU = 743.3 lb/hr each

NO_x: 323.17 MMBTU/hr * 0.6 lb/MMBTU = 193.9 lb/hr each

Boiler #8 (STK4)

SO₂: 338 MMBTU/hr * 2.3 lb/MMBTU = 777.4 lb/hr

NO_x: 338 MMBTU/hr * 0.2 lb/MMBTU = 67.6 lb/hr

⁶ USEPA, Memorandum: Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO₂ National Ambient Air Quality Standard, March 01, 2011, p. 7

⁷ NCDAQ, Title V Air Quality Permit No. 03069T34, June 16, 2016

Boiler #9 and #10 (MANNING: common stack)

SO₂: 249 MMBTU/hr * 2.3 lb/MMBTU = 572.7 lb/hr each

NO_x: 249 MMBTU/hr * 0.2 lb/MMBTU = 49.8 lb/hr each

Two Non-Emergency Generators (GEN1 and GEN2)

SO₂: 6.826 MMBTU/hr * 2.3 lb/MMBTU = 15.7 lb/hr each

NO_x: 40.56 lb/hr each

These sources are treated as point sources in AERMOD. Point sources are modeled with the following stack parameters:

- Source Location X (Easting) coordinate (UTM NAD83);
- Source Location Y (Northing) coordinate (UTM NAD83);
- Source base elevation (meters above sea level);
- Stack emission rate (g/s);
- Stack height (meters);
- Stack gas exit temperature (Kelvin);
- Stack gas exit velocity (meters/second);
- Stack diameter (meters).⁸

I obtained stack release parameters from modeling files provided by NCDAQ. I modeled the following allowable emissions and stack parameters:

Source ID	XUTM (meters)	YUTM (meters)	Base Elevation (meters)	SO ₂ Emission Rate (g/s)	NO _x Emission Rate (g/s)	Release Ht. (meters)	Stack Temp. (K)	Stack Exit Vel. (m/s)	Stack Diam. (m)
B67S	674918.6	3975245.2	139.55	187.31	48.86	67.06	463.71	21.91	2.74
STK4	674859.6	3975318.2	145.03	97.95	8.52	63.40	444.26	18.10	1.83
MANNING	676113.1	3974838.4	137.16	144.32	12.55	35.05	441.48	13.41	2.74
GEN1	674867.0	3975319.0	144.46	1.98	5.11	14.94	749.81	36.81	0.51
GEN 2	674849.4	3975315.5	144.04	1.98	5.11	14.94	749.81	36.81	0.51

⁸ USEPA, User's Guide for the AMS/EPA Regulatory Model – AERMOD, EPA-454/B-03-101, September 2004 (with revisions), pp. 3-16 – 3-18.

3.3 Building Dimensions for Downwash

Adjacent buildings and other structures may cause plume downwash, a condition where plumes can be dispersed towards the ground in the downwind wake-effect from these buildings. USEPA's Building Profile Input Program (BPIP v. 04274 with Plume Rise Model Enhancement (PRIME)) is used to determine stack-specific good engineering practice (GEP) values and wind direction-specific building downwash parameters for each 10-degree azimuth.⁹

Modeling files provided by NCDAQ for the UNC's Cogeneration and Manning facilities included building downwash input parameters. I used these same building downwash input parameters in my modeling analysis.

3.4 Receptors

The receptor grid used in the modeling provided by NCDAQ did not include some receptors within the UNC campus that are in areas with ambient air. For my modeling analysis, I used this same receptor grid but filled in the missing receptors. The 5,415 receptors cover a grid of approximately 6.7 km by 6.2 km, with the UNC campus roughly in the middle. There are receptors spaced every 20-25 m along the campus boundary. Receptors within the campus boundary are spaced every 50 m, while receptors outside of the campus boundary are spaced every 100m.

Modeled receptor locations require terrain elevation data, in meters above sea level. I obtained terrain elevation data for these locations using National Elevation Dataset (NED) GeoTiff data for the area encompassing the UNC facilities and the modeled receptors. GeoTiff is a binary file that includes data descriptors and geo-referencing information necessary for extracting terrain elevations. I extracted terrain elevations from the NED files using USEPA's AERMAP program with 1/3rd arc-second (10 meter horizontal) resolution.

3.5 Meteorological Data

USEPA's definition of preferred meteorological data includes the most recent five years of National Weather Service (NWS) data.¹⁰ Currently, this condition is satisfied using 2013 through 2017 Automated Surface Observing Station (ASOS) data collected at the most site-appropriate airport. For use in my modeling analysis, I obtained pre-processed 2013-2017 meteorological data from the North Carolina Department of Environmental Quality with Chapel Hill surface data and

⁹ USEPA, User's Guide to the Building Profile Input Program, EPA-454/R-93-038, April 21, 2004.

¹⁰ USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005.

Greensboro upper air data.

4. Background Air Concentrations

I did not add background air concentrations to the modeled results. Therefore, the modeling results do not include impacts from other nearby SO₂ and NO₂ NAAQS-consuming sources, nor do they include regional background levels. Accordingly, these modeled impacts are likely under-estimating actual total air concentrations. Moreover, the modeled impacts presented below are caused solely by UNC's SO₂ and NO_x emissions.

5. Modeling Results

As discussed above, I modeled allowable emissions for both SO₂ and NO_x with two scenarios each.

5.1 SO₂ Modeling Results

The 99th percentile modeled one-hour SO₂ ambient air impacts from UNC's allowable emissions are presented in the table below. Concentrations are for surface-based receptors and are in the form of the NAAQS. Both scenarios result in NAAQS exceedances.

For this analysis, the one-hour SO₂ ambient air impacts (Facility H4H – highest fourth high value) are based on the 99th percentile of the annual distribution of daily maximum one-hour concentrations averaged across the five years of modeled meteorological data. The peak modeled one-hour SO₂ ambient air impacts, using 2013 through 2017 meteorological data and no background SO₂ concentrations, are as follows:

Sulfur dioxide (SO ₂) KIGX 2013-2017 met					
Scenario	Facility		H4H Conc. (µg/m ³)	NAAQS (µg/m ³)	NAAQS exceedance?
	UTM X (m)	UTM Y (m)			
Allowable Emissions: Boilers #6-10 and Two Non-Emergency Generators	675733	3974944	1170.96	196.2	YES
Allowable Emissions: Boilers #6 and #7 only	675783	3974994	758.02	196.2	YES
No background concentrations were added to modeling results					

The modeled impacts can also be shown graphically. Figures 1 and 2 are maps showing isopleths (lines of equal air concentration) overlaid onto ESRI street maps. I created the isopleths using

AERMOD output plotfiles and Golden Software's Surfer, v. 10. I used kriging algorithms to grid the data for the isopleths. Figure 1 shows modeled one-hour SO₂ concentrations from allowable emissions from Boilers #6-10 and the two non-emergency generators. Figure 2 shows modeled one-hour SO₂ concentrations from allowable emissions from Boilers #6 and #7 only.

Figure 1:

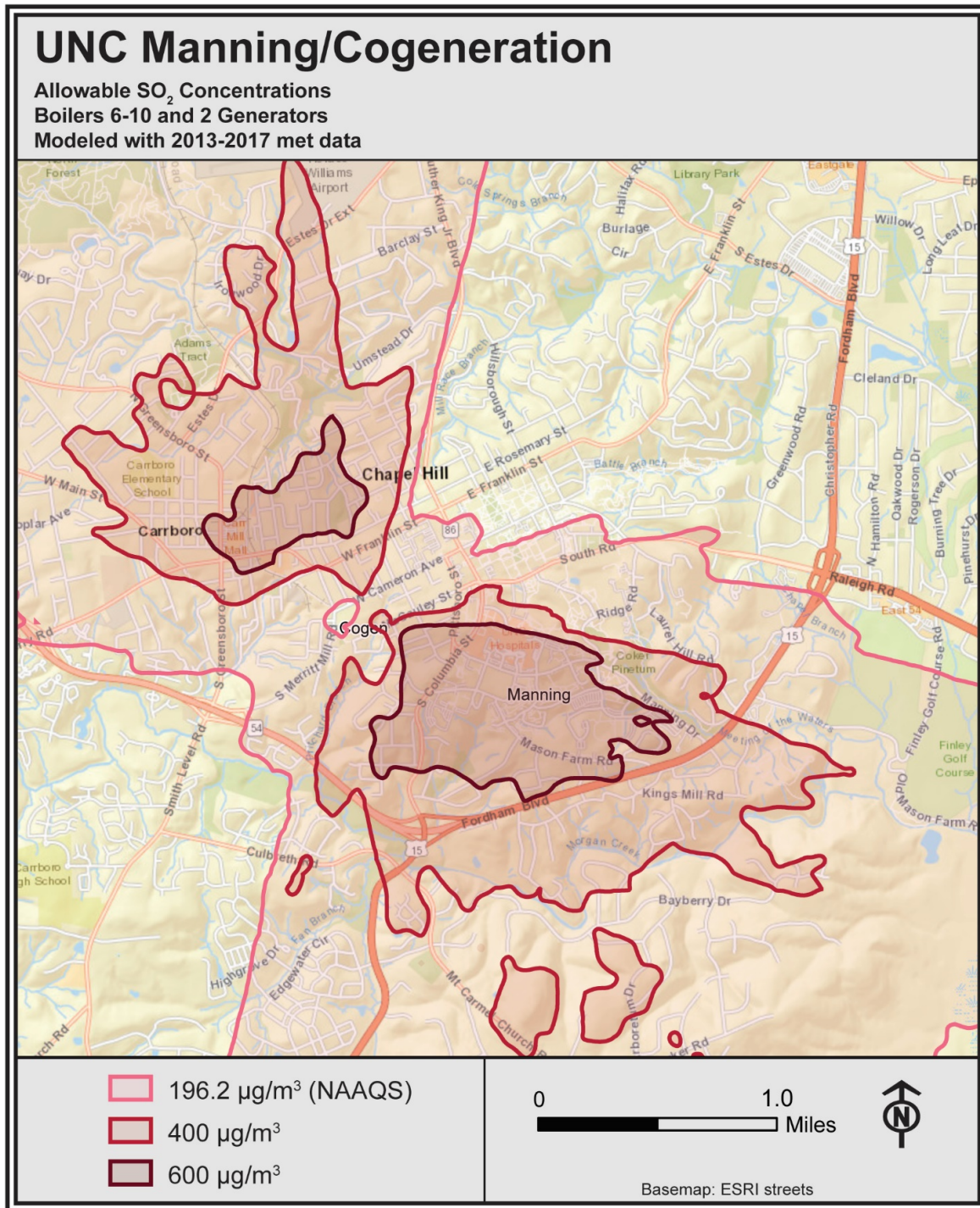
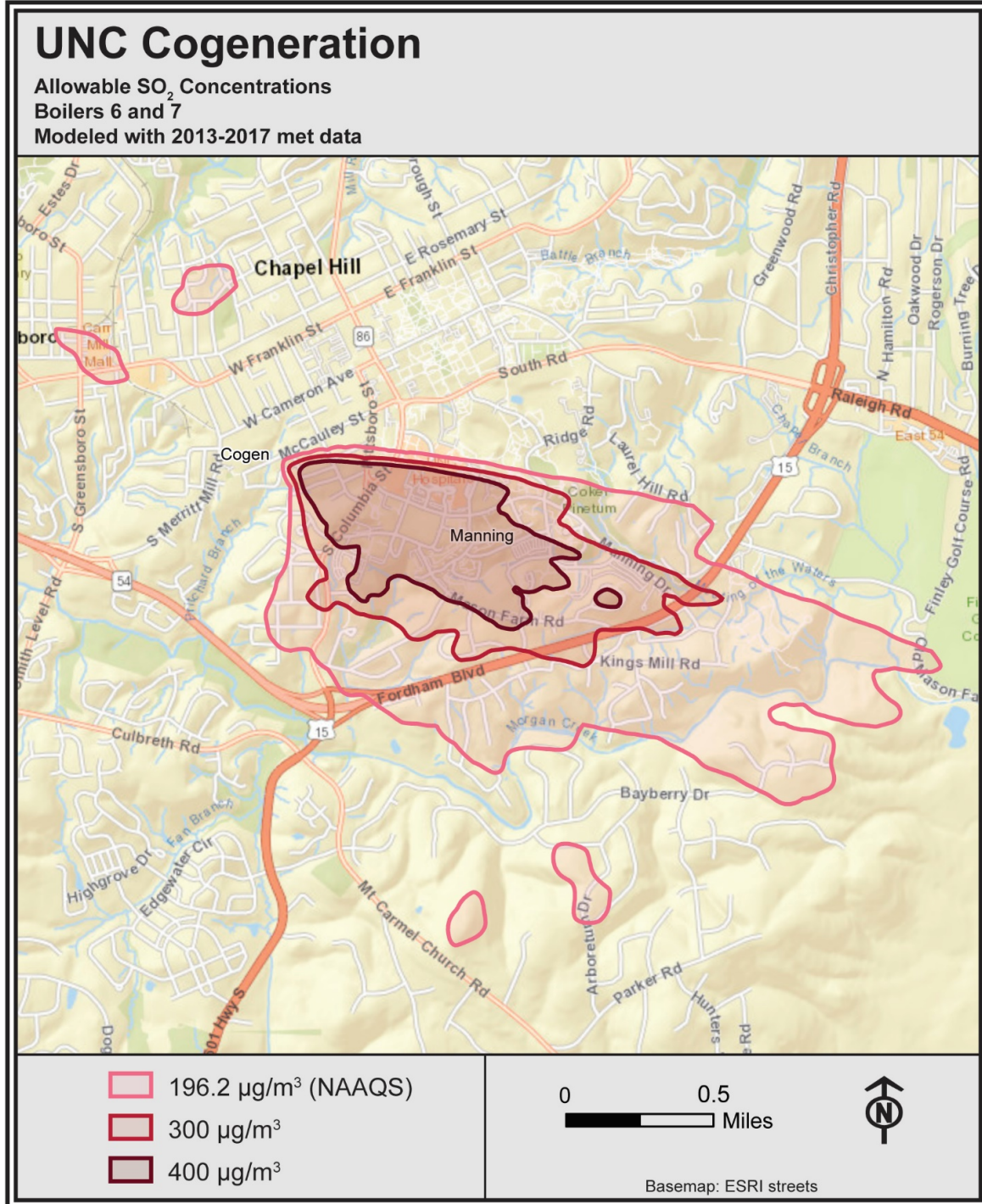


Figure 2:



5.2 NO₂ Modeling Results

The 98th percentile modeled one-hour NO₂ ambient air impacts from UNC’s allowable emissions are presented in the table below. Concentrations are for surface-based receptors and are in the form of the NAAQS. Both scenarios result in NAAQS exceedances.

For this analysis, the one-hour NO₂ ambient air impacts (Facility H8H – highest eighth high value) are based on the 98th percentile of the annual distribution of daily maximum one-hour concentrations averaged across the five years of modeled meteorological data. The peak modeled Tier 3 (PVMRM) one-hour NO₂ ambient air impacts, using 2013 through 2017 meteorological data and no background NO₂ concentrations, are as follows:

Tier 3 (PVMRM) Nitrogen Dioxide (NO ₂) KIGX 2013-2017 met					
Scenario	UTM X (m)	UTM Y (m)	Facility H8H Conc. (µg/m ³)	NAAQS (µg/m ³)	NAAQS exceedance?
Allowable Emissions: Boilers #6-10 and Two Non-Emergency Generators, with a 0.2 in-stack ratio	675053	3975342	330.23	188	YES
Allowable Emissions: Boilers #6-10 and Two Non-Emergency Generators, with a 0.5 in-stack ratio	675053	3975342	763.75	188	YES
No background concentrations were added to modeling results					

The modeled impacts can also be shown graphically. Figures 3 and 4 are maps showing isopleths (lines of equal air concentration) overlaid onto ESRI street maps. I created the isopleths using AERMOD output plot files and Golden Software’s Surfer, v. 10. I used kriging algorithms to grid the data for the isopleths. Figure 3 shows modeled one-hour NO₂ concentrations from allowable emissions from Boilers #6-10 and the two non-emergency generators with a 0.2 in-stack ratio. Figure 4 shows modeled one-hour NO₂ concentrations from allowable emissions from Boilers #6-10 and the two non-emergency generators with a 0.5 in-stack ratio.

Figure 3:

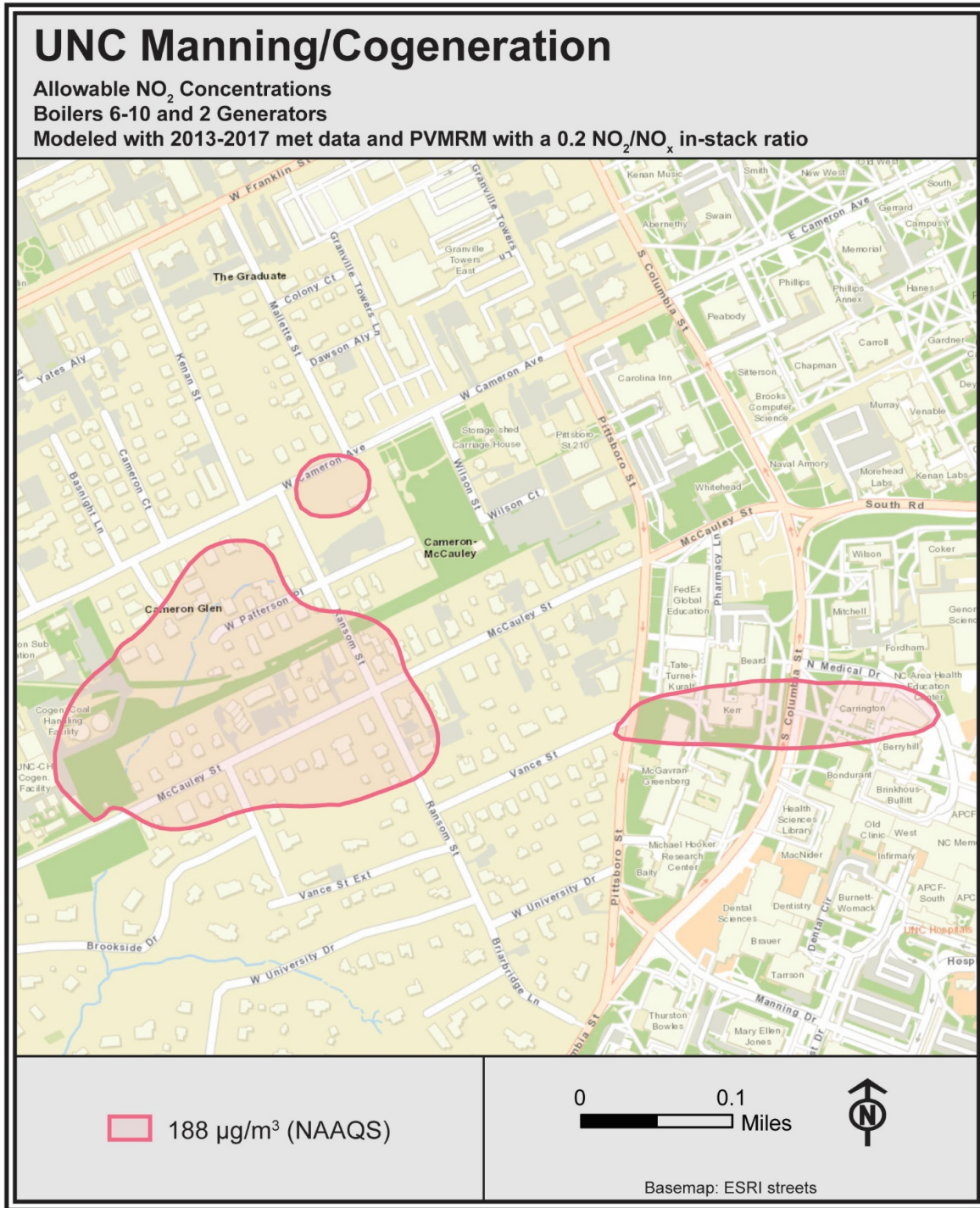
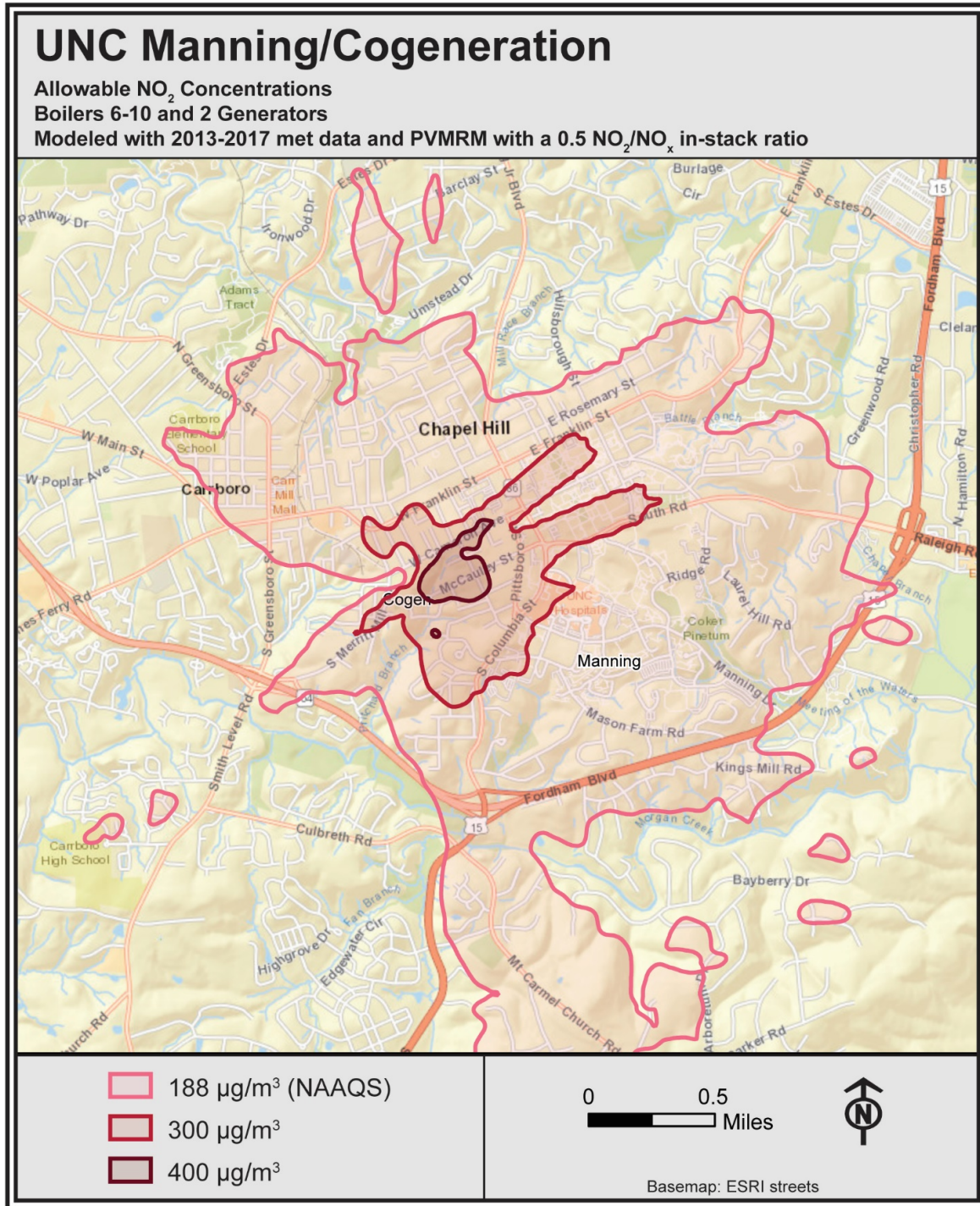


Figure 4:



6.0 Conclusion

My modeling analysis reveals that the Title V allowable emissions for UNC's Manning and Cogeneration facilities would result in exceedances of both the SO₂ and NO₂ NAAQS. I found SO₂ NAAQS exceedances even when only accounting for allowable emissions for Boilers #6 and #7. I found NO₂ NAAQS exceedances for allowable emissions when using Tier 3 PVMRM modeling methods with a 0.5 in-stack ratio as well as with a 0.2 in-stack ratio. These potential NAAQS exceedances occur in highly populated areas with residences, hospital facilities, and elevated terrain such as open-top parking lots within several hundred feet of UNC's facilities. These conservative results also do not take ambient background levels or emissions from any nearby sources into account.

UNC's Title V allowable emissions need to be reduced significantly to comply with the one-hour SO₂ and NO₂ NAAQS. For example, according to my modeling methods and results, allowable SO₂ emissions from Boilers #6 and #7 would need to be reduced from 2.3 lb/MMBTU to 0.59 lb/MMBTU in order to comply with the one-hour SO₂ NAAQS. This is the case when considering Boilers #6 and #7 only, and needs to be confirmed by further modeling that would include emissions from other nearby sources and ambient background SO₂ levels.

Attachment 1: Curriculum Vitae

Lindsey Meyers

6895 SW 169th Pl
Beaverton, OR 97007

(805) 798-4646
LindseyMeyers121@gmail.com

EDUCATION

California State University, Northridge

M.A. in Geography, with distinction

2012

Emphasis in GIS

Thesis: "Diesel Trucks: Health Risk and Environmental Equity"

- I used USEPA's AERMOD model to determine concentrations of diesel particulate matter (DPM) around several Southern California freeways, focusing on pollution from port-related diesel truck traffic. I also performed population analyses, examining inequities related to race and income groups exposed to DPM.

California State University, Northridge

B.M. in Oboe Performance, cum laude

2007

SOFTWARE SKILLS

Microsoft Office
Adobe Creative Suite
AERMOD
ArcGIS
Golden Software Surfer
Google Earth Pro
ERDAS Imagine
SPSS

EXPERIENCE

Consultant

2009 - Present

- ❖ Providing GIS analyses including creating, gathering, integrating, and interpreting spatial data
- ❖ Air Quality modeling using dispersion models such as USEPA's AERMOD
- ❖ Designing maps and graphics

Publications:

- ❖ Fox, P., Hutton, P. H., Howes, D. J., Draper, A. J., and Sears, L.: *Reconstructing the natural hydrology of the San Francisco Bay-Delta watershed*, Hydrol. Earth Syst. Sci., 19, 4257-4274, doi:10.5194/hess-19-4257-2015, 2015.

Past projects include:

- Geocoded, mapped, and performed a distance analysis of plaintiff locations in Missouri
- Modeled and mapped NO₂ concentrations for a proposed power plant in Santa Paula, CA
- Modeled and mapped mercury deposition rates around an alumina manufacturing facility in Louisiana
- Performed a GIS population analysis of the Beaverton and Portland, OR areas for the Beaverton Symphony Orchestra marketing team
- Modeled and mapped NO₂ concentrations for a proposed power plant in Oxnard, CA
- Prepared modeling files and modeled unpaved road sources at a Pacific Northwest coal terminal using AERMOD
- Modeled and mapped pesticide drift adjacent to schools and neighborhoods in Oxnard, CA
- Prepared detailed source locations for paved and unpaved roads at a facility in Alabama for analysis in AERMOD
- Prepared CONTAM project files for indoor air quality modeling analyses
- Mapped soil concentrations of hexavalent chromium using high-resolution orthoimagery for a site in New Jersey
- Calculated health risk for a proposed fueling station in Sacramento, CA
- Mapped hexavalent chromium in Newport Beach using high-resolution orthoimagery
- Modeled and mapped actual SO₂ concentrations around two power plants (both combined and separately) in Ohio
- Modeled and mapped SO₂ concentrations around Hunter Station Power Plant (Castle Dale, UT)
- Modeled and mapped SO₂ concentrations around Seward Power Station (Seward, PA)
- Georeferenced, digitized, and analyzed historic California vegetation maps for publication
- Modeled and mapped SO₂ concentrations around OG&E Muskogee Power Plant (Muskogee, OK)
- Modeled and mapped SO₂ concentrations around OG&E Sooner Power Plant (Red Rock, OK)
- Mapped Thorium and Uranium soil deposition around Coldwater Creek in Missouri
- Prepared maps and population analysis for the AEP Rockport

Facility in Indiana

- Mapped SO₂ concentrations for the Potomac River Generating Station (Alexandria, VA)
- Prepared MET data to be used in AERMOD for Baton Rouge, LA
- Modeled and mapped PM₁₀ concentrations in Waimea, Kauai County, HI
- Modeled and mapped SO₂ and NO₂ concentrations around Colstrip Power Plant
- Analyzed land cover/population and prepared MET data to be used in AERMOD for Colorado Springs, CO
- Prepared maps showing SO₂ concentrations around the E.D. Edwards and Wood River power plants in IL
- Analyzed land cover/population density and mapped SO₂ concentrations around several Michigan power plants including MSU, J.R. Whiting, and St. Clair/Belle River
- Prepared maps of natural gas pipelines in North Dakota and Berkeley, CA
- Mapped SO₂ concentrations around the Homer City, PA power plant
- Mapped SO₂ and PM_{2.5} concentrations around the proposed Taylorville Energy Center facility in IL
- Mapped SO₂ concentrations around Ashtabula, Avon Lake, and Lakeshore power plants in OH
- Mapped SO₂ concentrations around six Illinois Midwest Generation coal plants including detailed maps of Crawford and Fisk
- Mapped pesticide exposure in Oahu, HI
- Geocoded addresses and created Google Earth layers representing residents in Kauai County, HI