Air Dispersion Modeling Analysis For Verifying Compliance with the One-Hour NO_2 NAAQS: JBS Swift Beef Company Greeley, Colorado

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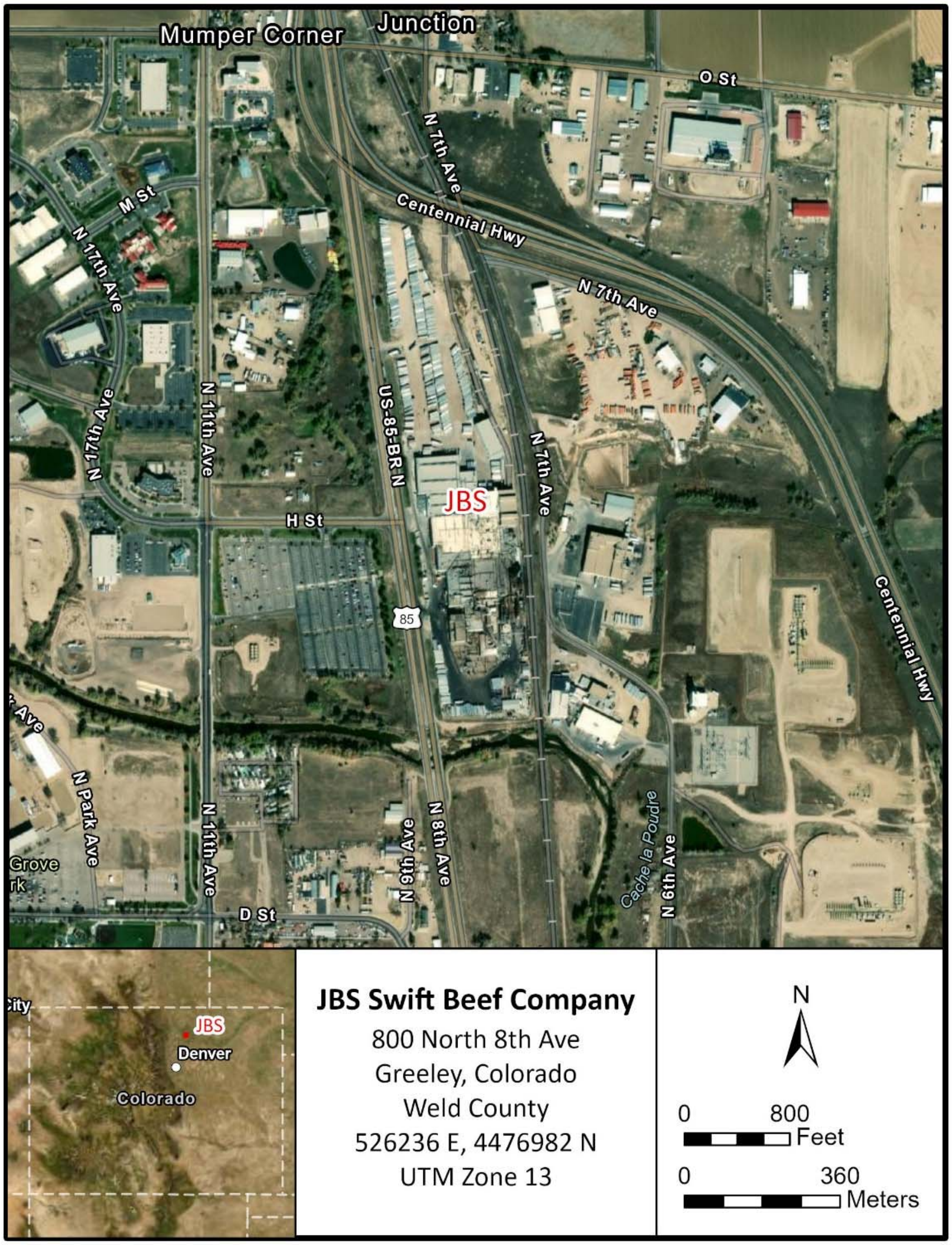
1. INTRODUCTION

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 broad experience as a consultant. 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 downloaded here.

The Center for Biological Diversity recently asked me to perform a Tier 3 NO_2 modeling analysis of JBS Swift Beef Company in Greeley, Colorado. JBS currently has a draft construction permit out for public comment.


Mumper Corner
Junction
O St
N 7th Ave
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JBS
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N Park Ave
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N 9th Ave
N 8th Ave
Cache la Poudre
N 6th Ave
D St
City
JBS
Denver
Colorado
JBS Swift Beef Company
800 North 8th Ave
Greeley, Colorado
Weld County
526236 E, 4476982 N
UTM Zone 13
N
0
800
Feet
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360
Meters

2. MODELING METHODOLOGY

The one-hour NO_2 NAAQS takes the form of a three-year average of the 98^{th}-percentile of the annual distribution of daily maximum one-hour concentrations, which cannot exceed 100 ppb.[1] The one-hour NO_2 NAAQS of 100 ppb equals 188 μg/m^3.[2] The 98^{th}-percentile of the annual distribution of daily maximum one-hour concentrations corresponds to the eighth-highest value at each receptor for a given year.

The USEPA describes a three-tiered screening process for modeling NO_2:

> "Tier 1 – assume full conversion of NO to NO_2, 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 NO_2 (Chu and Meyer, 1991) and 0.80 as the national default ratio for hourly NO_2 (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." [3]

For this analysis, I implemented a Tier 3 modeling approach. I modeled using USEPA's AERMOD program, version 19191, 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.[4] Version 19191 is the latest version of the AERMOD model.

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[1] USEPA, Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard, March 1, 2011.
[2] The ppb to μg/m^3 conversion is found in the source code to AERMOD v. 12060, subroutine Modules. The conversion calculation is 100/0.5319 = 188.0 μg/m^3.
[3] USEPA, Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the N02 National Ambient Air Quality Standard, September 30, 2014
[4] 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.

a. Ozone Background Concentration

Tier 3 NO_2 modeling requires background levels of ozone. In my modeling analysis, I used a seasonal - hourly background concentration profile provided by CDPHE with data from the Weld County Tower ozone monitor. The data is from years 2017 – 2019.

b. NO_2 Chemistry

I used the Tier 3 NO_2 Ozone Limiting Method (OLM) with an equilibrium ratio of 0.9 and an in-stack ratio (ISR) of 0.1579 for all sources at the JBS Swift Beef Company facility. This value is the highest ISR value found for boilers on EPA's NO2 ISR database, and it is a very conservative value that would be applicable for all the boilers at the JBS facility.

c. Meteorology

CDPHE provided me with two sets of meteorological data. One set is five years of surface data (1993-1997) from the Kodak station in Windsor, CO, processed with AERMET v19191. The Kodak station is approximately 15 kilometers west of the JBS facility. Upper air data is from the Denver Stapleton Airport (KDEN) station in Denver, CO. The other set is 2009 data from the Fort St. Vrain station in Platteville, CO, also processed with AERMET v19191. Fort St. Vrain is approximately 25 kilometers southwest of the JBS facility. I was given datasets both with and without adjusted u* for each station. I modeled all four meteorology scenarios.

d. Source Locations

The coordinates and base elevations for most sources at the JBS Swift Beef Company facility can be found in the corresponding Air Pollutant Emissions Notices (APENs). For those APENs that did not include this information, the location was estimated from a Google Earth image of the facility and the terrain elevation was assumed to be the same across the entire plant given that the terrain is graded.

e. Building Downwash

I did not consider the downwash effect on JBS facility's emissions in my analysis because there was no information available for the coordinates and dimensions of the buildings and structures at the plant.

f. Receptor Grid

I modeled a grid of 1,608 receptors with 50-meter spacing centered at the JBS Swift Beef Company facility, outside the apparent fence line of the facility, and extending 1 km in each direction. Terrain elevations were processed with AERMAP v18081 using 1/3 arc-sec resolution USGS NED files.

g. Emissions

I modeled emissions derived from information in the APENs (AIRS ID 123-0018) and the permit (95WE757). The facility has the potential to emit close to 100 tpy of NO_x, which would make it a major source given its location in a serious ozone nonattainment zone. However, the company has accepted an annual NO_x emission limit of 33 tpy, thus becoming a synthetic minor source. This emission limit would force some of the emissions units (i.e., pieces of equipment) to either operate at less than full capacity or less than full time (i.e., 8750 hours/year). However, the permit does not include any restriction on the operating schedule or on the operating mode of the units (i.e., load percentage of full capacity), so these units are capable of operating at full capacity for 24 hours/day for many days of the year without exceeding the annual NO_x emissions limit. Therefore, because this modeling exercise is for an hourly ambient air standard, to account for those hours and days in which the units can operate at full capacity, the maximum allowable hourly emissions were used to model the 1-hr NO_2 NAAQS. These maximum hourly emission rates were calculated as described below based on the rating of the unit, the heat content of the fuel, and the CDPHE-approved emissions factor as reported in the corresponding APENs:

BOILER 001:

21 MMBTU/hr x 1 MMSCF/1020 MMBTU x 100 lbs/MMSCF x 454 g/lb x 1 hr/3600 sec = 0.259 g/s

ROTARY DRYER 003 (Low NO_x burner):

30 MMBTU/hr x 1 MMSCF/1020 MMBTU x 50 lbs/MMSCF x 454 g/lb x 1 hr/3600 sec = 0.1855 g/s

ROTARY BLOOD DRYER 004:

3 MMBTU/hr x 1 MMSCF/1020 MMBTU x 100 lbs/MMSCF x 454 g/lb x 1 hr/3600 sec = 0.037 g/s

STEAM UNIT #2 006:

62.756 MMBTU/hr x 1 MMSCF/1020 MMBTU x 100 lbs/MMSCF x 454 g/lb x 1 hr/3600 sec = 0.7759 g/s

BOILER 011 (low NO_x burner):

51.7 MMBTU/hr x 1 MMSCF/1020 MMBTU x 50 lbs/MMSCF x 454 g/lb x 1 hr/3600 sec = 0.3196 g/s

STEAM UNIT #4 013:

62.756 MMBTU/hr x 1 MMSCF/1020 MMBTU x 100 lbs/MMSCF x 454 g/lb x 1 hr/3600 sec = 0.7759 g/s

STEAM UNIT #3 017:

61.236 MMBTU/hr x 1 MMSCF/1020 MMBTU x 100 lbs/MMSCF x 454 g/lb x 1 hr/3600 sec = 0.757 g/s

STEAM UNIT #5 018:

62.756 MMBTU/hr x 1 MMSCF/1020 MMBTU x 100 lbs/MMSCF x 454 g/lb x 1 hr/3600 sec = 0.7759 g/s

BONE DRYER 019:

30 MMBTU/hr x 1 MMSCF/1020 MMBTU x 100 lbs/MMSCF x 454 g/lb x 1 hr/3600 sec = 0.3709 g/s

EVAPORATOR 020 (Low NO_x burner):

9.9 MMBTU/hr x 1 MMSCF/1020 MMBTU x 50 lbs/MMSCF x 454 g/lb x 1 hr/3600 sec = 0.0612 g/s

h. Stack Parameters

Stack parameters were extracted from the APENs. Four sources were not included in the modeling because the APENs did not include any stack parameters: Units with Airs ID 123-

0018-002, 123-0018-005, 123-0018-007, and 123-0018-009.

JBS Source Parameters and Emissions							
Source	UTM Easting	UTM Northing	NO_x Emission Rate (g/s)	Release Height (m)	Temp. (degrees K)	Exit Velocity (m/s)	Stack Diameter (m)
Boiler 001	526215.83	4476937.80	0.259	7.62	449.82	4.13	0.6096
Rotary Dryer 003	526226.00	4476953.00	0.1855	11.2776	394.26	4.79	1.58
Rotary Blood Dryer 004	526195.48	4476961.03	0.037	12.192	366.48	7.55	0.6604
Steam Unit #2 006	526215.13	4476943.57	0.7759	6.7056	449.82	8.26	0.9144
Boiler 011	526232.00	4476921.00	0.3196	6.7056	449.82	6.096	0.9144
Steam Unit #4 013	526221.44	4476932.15	0.7759	6.7056	449.82	7.19	0.9144
Steam Unit #3 017	526224.83	4476932.94	0.757	6.7056	449.82	6.096	0.9144
Steam Unit #5 018	526229.31	4476937.39	0.7759	6.7056	449.82	7.19	0.9144
Bone Dryer 019	526264.64	4477008.97	0.3709	11.2776	394.26	4.79	0.9144
Evaporator 020	526216.99	4476886.19	0.0612	7.3152	354.82	3.25	0.4572

i. Background Concentrations

There are 303 facilities within a 20-kilometer radius of the JBS Swift Beef Company. Those 303 facilities emit a total of 3,128 tpy of NO_x and most include multiple emissions sources making for approximately 2,000 individual sources to be modeled. Modeling this large number of sources is an extremely time-consuming task. This modeling exercise does not include any nearby sources and instead I have added a conservative background level to the impacts caused by the JBS facility as indicated by CDPHE.

I modeled with a seasonal - hourly background concentration profile provided by CDPHE with data from the CAMP monitoring site in Globeville. The data is from years 2017-2019.

3. MODELING RESULTS

Each of the four meteorology scenarios that I modeled indicated NO_2 levels in exceedance of the 1-hour NO_2 NAAQS of 100 ppb or 188 µg/m^3. Neither the meteorology station location nor the use of adjusted u* significantly changed the concentration nor location of the peak modeled results. The following results are in accordance with EPA's guidance that NO_2 concentrations should be modeled as the highest eighth high value, which corresponds to the 98th percentile of the maximum daily concentration averaged across the years of meteorological data. The results include conservative background NO_2 concentrations.

Nitrogen dioxide (NO_2)			Tier 3 OLM
Meteorology Scenario	Facility highest 98th percentile concentration (µg/m^3)	XUTM (m)	YUTM (m)
Kodak/KDEN 1993-1997 with adj u*	224.95	526186	4476732
Kodak/KDEN 1993-1997 without adj u*	223.35	526136	4476732
Ft. St. Vrain/KDEN 2009 with adj u*	230.56	526286	4476732
Ft. St. Vrain/KDEN 2009 without adj u*	222.40	526286	4476732

The results of this modeling exercise are likely underestimating real impacts for several reasons:

- Four emissions sources at the JBS facility were not included because of the lack of data in the corresponding APENs. Adding these sources will increase the emissions and the modeled impact.

- The downwash effect caused by the JBS buildings and structures were not included because of the lack of information about the dimensions of these buildings. The downwash effect tends to create areas of higher concentrations in the vicinity of the facility and therefore the impacts are expected to be higher.

- There are 20 facilities in the immediate vicinity of the JBS facility, within a 5-kilometer radius, emitting 355 tpy of NO_x. Among those facilities are included two large ones: the DCP Lucerne Gas Plant which emits 188 tpy of NO_x, and the Leprino Foods Company which emits 57 tpy of NO_x. The background concentrations would generally account for the transport of emissions from the larger area and therefore would account for the contribution of the majority of the nearby facilities, but it is unlikely to account for the combined impact of emissions coming from facilities that are located in very close proximity of the JBS plant. Including these 20 facilities in the model along with an adequate background would likely result in higher impacts.