

**Air Dispersion Modeling Analysis**  
**For Verifying Compliance of Permitted Emissions**  
**with the One-Hour SO<sub>2</sub> and NO<sub>2</sub> NAAQS:**  
**Suncor Refinery**  
**Commerce City, Colorado**

**Prepared by:**

**Lindsey Meyers**

**May 10, 2021**

## TABLE OF CONTENTS

1.	Introduction.....	3
2.	Modeling Methodology .....	5
2.1	Air Dispersion Model .....	5
2.2	AERMOD Input Control Options .....	5
2.3	Output Options .....	6
2.4	NO <sub>2</sub> Modeling Methodology .....	6
3.	Model inputs .....	7
3.1	Geographical Inputs .....	7
3.2	Emission Rates and Source Parameters .....	7
3.2.1	Flare Stack Parameters.....	10
3.2.2	Sources not Modeled in this Analysis.....	11
3.3	Building Dimensions for Downwash.....	11
3.4	Receptors.....	12
3.5	Meteorological Data.....	14
3.5.1	Surface Meteorological Data .....	15
3.5.2	Upper Air Meteorological Data .....	15
3.5.3	AERSURFACE and Final Processing .....	16
4.	Background Air Concentrations .....	17
5.	Modeling Results .....	17
5.1	Sulfur Dioxide.....	17
5.2	Nitrogen Dioxide .....	18
6.	Conclusion .....	18

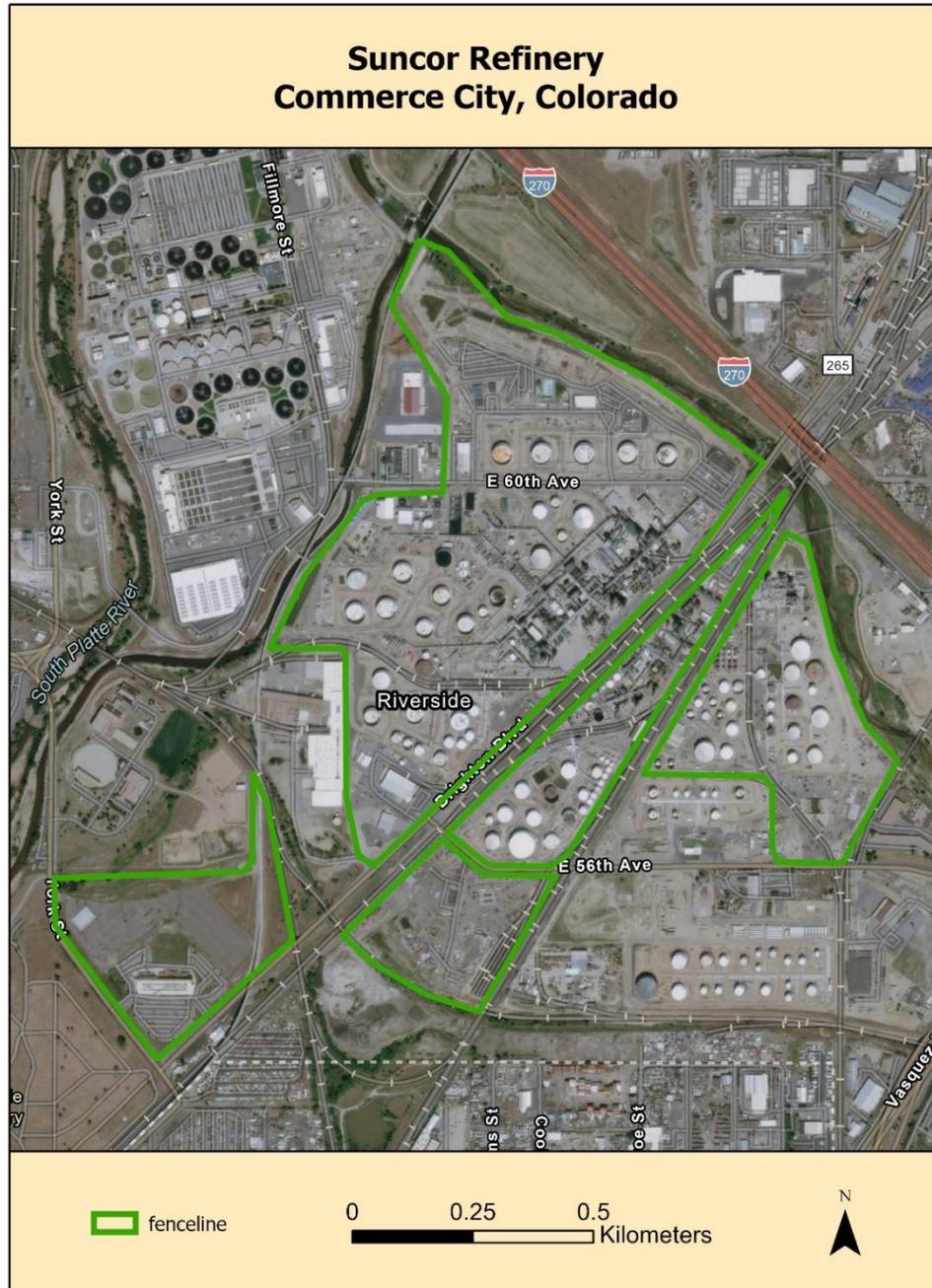
## 1. Introduction

Suncor operates a major petroleum refinery located in Commerce City, Colorado (Figure 1). It is centered in an urban area just north of Denver and has caught attention as a major source of environmental justice concern. Suncor currently has a Title V Operating Permit for their Plant 2 section of the refinery up for renewal and out for public comment.

In response to the Title V permit renewal application, I was asked by the Center for Biological Diversity, on behalf of Elyria-Swansea Neighborhood Association, Colorado Latino Forum, GreenLatinos, Sierra Club, and Earthjustice, to verify whether Suncor's current permitted Sulfur Dioxide (SO<sub>2</sub>) and Nitrogen Oxides (NO<sub>x</sub>) emissions would cause or contribute to 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 SO<sub>2</sub> and Tier 3 NO<sub>2</sub> air concentrations for permitted emissions from the refinery. These modeled impacts are then compared with the one-hour SO<sub>2</sub> and NO<sub>2</sub> NAAQS, respectively. My modeling methods and results will be discussed in further detail in the following report. My modeling files can be downloaded [here](#).

I have broad experience as a consultant. I hold a master's degree in Geography (2012) 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 an assortment of 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](#).

**Figure 1: Suncor Refinery**



## 2. Modeling Methodology

The 2010 one-hour SO<sub>2</sub> NAAQS takes the form of a three-year average of the 99<sup>th</sup>-percentile of the annual distribution of daily maximum one-hour concentrations, which cannot exceed 75 ppb.<sup>1</sup> This standard is to be verified using USEPA's AERMOD air dispersion model, which produces air concentrations in units of µg/m<sup>3</sup>. The one-hour SO<sub>2</sub> NAAQS of 75 ppb equals 196.2 µg/m<sup>3</sup>, and this is the value I used for determining whether modeled permitted impacts from Suncor's operations exceed the one-hour SO<sub>2</sub> NAAQS. The 99<sup>th</sup>-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 NO<sub>2</sub> NAAQS takes the form of a three-year average of the 98<sup>th</sup>-percentile of the annual distribution of daily maximum one-hour concentrations, which cannot exceed 100 ppb.<sup>2</sup> The one-hour NO<sub>2</sub> NAAQS of 100 ppb equals 188 µg/m<sup>3</sup>. This is the value I used to determine Suncor's compliance with the one-hour NO<sub>2</sub> NAAQS. The 98<sup>th</sup>-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 in my modeling analysis.

### 2.1 Air Dispersion Model

I performed one-hour SO<sub>2</sub> and NO<sub>2</sub> NAAQS modeling with 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.<sup>3</sup> Version 19191 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

---

<sup>1</sup> USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO<sub>2</sub> National Ambient Air Quality Standard, August 23, 2010.

<sup>2</sup> USEPA, Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO<sub>2</sub> National Ambient Air Quality Standard, March 1, 2011.

<sup>3</sup> 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.

- Regulatory defaults
- Urban dispersion coefficients

These input control options are consistent with previous modeling analyses performed by the Colorado Department of Public Health and Environment (CDPHE). They are appropriate input options for one-hour SO<sub>2</sub> and NO<sub>2</sub> NAAQS modeling in the area surrounding Suncor.

The Suncor refinery is located in a highly industrialized area. Methodology outlined in Section 7.2.3 of the Guideline on Air Quality Models<sup>4</sup> indicates that facilities in industrial areas should be classified as urban if more than 50% of the area within a three-kilometer radius of the facility is considered to be built upon. According to an analysis of 2016 National Landcover Database (NLCD) data, 62% of the area within a three-kilometer radius of the Suncor refinery is identified as “impervious surface.” Accordingly, I used urban dispersion coefficients when running AERMOD, with an URBANOPT population of 441,603 (the 2010 population of Adams County, Colorado).

### **2.3 Output Options**

My AERMOD modeling analysis of the Suncor facility includes three different five-year meteorological data scenarios, both with and without adj-u\*. Meteorological data will be discussed further in section 3.5.

I generated tables, plot files, and summary files appropriate for one-hour SO<sub>2</sub> and NO<sub>2</sub> NAAQS modeling.

### **2.4 NO<sub>2</sub> Modeling Methodology**

NO<sub>2</sub> NAAQS modeling involves a three-tiered approach, as described by USEPA<sup>5</sup>:

“Tier 1 – assume full conversion of NO to NO<sub>2</sub>, where total NO<sub>x</sub> 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 NO<sub>2</sub>/NO<sub>x</sub> ratios, with 0.75 as the national default ratio for annual NO<sub>2</sub> (Chu and Meyer, 1991) and 0.80 as the

---

<sup>4</sup> USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO<sub>2</sub> National Ambient Air Quality Standard, August 23, 2010, Section 7.2.3.

<sup>5</sup> USEPA, Memorandum: Applicability of Appendix W Modeling Guidance for the 1-hour NO<sub>2</sub> National Ambient Air Quality Standard, June 28, 2010, pp. 1-2

national default ratio for hourly NO<sub>2</sub> (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 modeled using both the Tier 3 Ozone Limiting Method (OLM) and Plume Volume Molar Ratio Method (PVMRM) to evaluate NO<sub>2</sub> NAAQS compliance. I used the AERMOD default value for the ambient equilibrium NO<sub>2</sub>/NO<sub>x</sub> ratio (NO<sub>2</sub>EQUIL = 0.9).<sup>6</sup> And since there were no in-stack NO<sub>2</sub>/NO<sub>x</sub> ratio data available for modeling the Suncor facility, I used the USEPA default value of NO<sub>2</sub>STACK = 0.5 for all sources.<sup>7</sup>

### **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.

I used the Universal Transverse Mercator (UTM) NAD83 zone 13 coordinate system for identifying the easting (x) and northing (y) coordinates of the modeled sources and receptors. I obtained the source locations from the facility APENs.

#### **3.2 Emission Rates and Source Parameters**

My modeling analyses are limited to SO<sub>2</sub> and NO<sub>x</sub> permitted emissions for the Suncor

---

<sup>6</sup> USEPA, User's Guide for the AMS/EPA Regulatory Model (AERMOD), EPA-454/B-19-027, August, 2019, p. 3-66.

<sup>7</sup> USEPA, Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO<sub>2</sub> National Ambient Air Quality Standard, September 40, 2014, p. 8.

refinery. I modeled 33 sources of SO<sub>2</sub> and NO<sub>x</sub>. 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).<sup>8</sup>

I obtained stack release parameters for 31 of the 33 sources from the facility APENs. It should be noted that the parameters described in the APENs may represent conditions during normal operations, and that conditions during start-up and shut-down for these 31 sources could result in higher modeled concentrations. The parameters I used for the other two sources, F1 - Main Plant Flare and the Plant 2 Main Plant Flare (Refinery Flare), are described in further detail in section 3.2.1. I extracted terrain elevations for each source from NED files using USEPA's AERMAP program with 1/3<sup>rd</sup> arc-second (10 meter horizontal) resolution.

The following table details the permitted emissions and stack parameters included in this modeling analysis:

Source	NO <sub>x</sub> Emissions (g/s)	SO <sub>2</sub> Emissions (g/s)	plant	UTM E	UTM N	Elevation (m)	Stack Height (m)	Stack Temp (K)	Exit Velocity (m/s)	Stack Diameter (m)
H-6	0.0880	0.0475	W	504632	4405910	1571.96	19.81	649.82	6.89	0.81
H-10	0.4203	0.1119	W	504741	4405994	1572.53	19.81	533.15	5.46	1.22
H-11	0.3676	0.0978	W	504623	4405894	1571.94	13.11	755.37	6.77	1.22
H-13	0.0831	0.0250	W	504947	4405955	1572.40	15.18	666.48	6.49	0.56
H-16	0.0742	0.0198	W	504972	4405612	1574.16	9.14	533.15	0.91	0.91
H-17	0.7143	0.2143	W	504989	4405977	1571.86	27.43	516.48	12.80	1.52
H-18	0.0742	0.0198	W	504972	4405600	1574.22	7.62	533.15	2.13	0.61
H-19	0.4413	0.0990	W	504702	4405954	1572.46	21.03	533.15	3.32	1.45
H-22	0.7382	0.1907	W	504657	4405919	1572.17	39.62	827.59	2.44	1.46
H-27	0.9447	0.2514	W	504626	4405877	1572.00	45.72	472.04	1.28	2.29
H-28	0.1956	0.1007	W	504779	4406040	1571.95	28.65	788.71	9.36	1.83

<sup>8</sup> USEPA, USEPA, User's Guide for the AMS/EPA Regulatory Model (AERMOD), EPA-454/B-19-027, August, 2019, p. 3-66, pp. 3-88 – 3-90.

Suncor Permitted One-Hour SO<sub>2</sub> and NO<sub>2</sub> NAAQS Analysis

May 10, 2021

Page - 9

H-29	0.1956	0.1007	W	504779	4406040	1571.95	28.65	788.71	9.36	1.83
H-30	0.1956	0.1007	W	504779	4406040	1571.95	28.65	860.93	10.21	1.83
H-31* H-32*	0.9277	0.2204	W	504529	4405847	1571.40	17.25	699.82	13.72	0.91
H-33* H-37*	0.7566	0.2382	W	504989	4405984	1571.77	30.78	739.26	10.94	1.51
H-1716* H-1717*	0.3653	0.2963	W	504519	4405819	1571.43	45.72	491.48	4.21	1.74
H-2101	1.5014	0.2934	W	504657	4406078	1572.36	30.48	449.82	12.47	2.31
H-2410	0.2733	0.0791	W	504647	4406085	1572.36	60.81	539.82	16.76	1.75
B-4	4.4966	0.4275	W	504695	4405993	1572.40	18.29	444.26	4.82	1.52
B-6	0.5595	0.3653	W	504686	4405998	1572.33	15.24	463.71	15.82	1.21
B-8	0.8115	0.5293	W	504700	4406024	1572.31	15.24	449.82	7.32	1.45
P101, P102 & H-25 – No. 1 and No. 2 SRUs with TGU & Incinerator (H-25)	0.0567	1.7174	W	504692	4406039	1572.35	45.72	838.71	16.15	1.22
P103-FCCU	1.5100	0.7508	W	504654	4405936	1572.19	59.13	502.04	76.66	0.81
F1-Main Plant Flare	0.3556	2.9791	W	504174	4406060	1565.31	30.48	1273.00	20.00	2.08
Crude Heater	1.6066	0.5112	E	504691	4405722	1572.38	18.29	422.04	4.30	2.59
Vacuum Heater H-103	0.2928	0.1763	E	504688	4405713	1572.41	15.24	905.37	5.58	1.50
FCCU Preheater H-201	0.6674	0.2014	E	504753	4405880	1572.88	28.04	688.71	6.52	1.68
FCCU Regenerator	1.5275	0.8860	E	504769	4405893	1573.18	58.98	908.71	36.27	1.04
Heaters 1, 2 & 3	1.7951	0.7479	E	504728	4405748	1572.39	46.94	477.59	6.00	2.39
SRUs Claus Plant, Amine Unit, SWS routed to TG incinerator	1.4657	7.7959	E	504740	4405820	1572.52	45.72	1042.04	2.94	0.25
Boiler 504	1.0471	0.3653	E	504711	4405566	1573.19	22.86	430.93	16.86	1.42
Boiler 505	1.0471	0.3653	E	504724	4405580	1573.87	22.86	430.93	16.86	1.42
Refinery Flare	0.4833	0.5264	E	504590	4405681	1571.75	60.35	1273.00	20.00	1.76

### 3.2.1 Flare Stack Parameters

Flare emissions are not associated with a measured stack diameter and stack velocity. This is because during flaring, the volume of gas is combusted outside of the physical flare stack. The AERMOD air dispersion model, however, requires specific inputs of stack diameter and stack velocity to calculate volumetric flow rate, which is necessary for calculating buoyancy flux and plume rise in the model.

The Texas Commission on Environmental Quality (TCEQ) has developed procedures for assisting in calculating the buoyancy flux from flare stack emissions.<sup>9</sup> This appears to be the approach CDPHE has taken in previous modeling analyses. In essence, the TCEQ procedures calculate equivalent stack parameters (temperature, exit velocity, and diameter) for input to AERMOD. These equivalent stack parameters are used by AERMOD for determining buoyancy flux and plume rise for flare emissions. It is important to note that flares are not the same as incinerators or thermal oxidizers.<sup>10</sup>

As a first step, the TCEQ procedures specify a fixed flare stack gas temperature of 1273 Kelvin (K) and a set flare gas exit velocity of 20 meters/second (m/s). An equivalent stack diameter (in meters) is then calculated using the net heat release of the flare (in calories/second) and the estimated mean molecular weight of the gas being flared. Since a mean molecular weight of the gas being flared was not provided in the permit documents, an estimated value of 20 g/mol was used for this calculation (for comparison, the molecular weight of methane is 16.04 g/mol).

The two main flares at the Suncor facility were modeled for this analysis, namely the F1 - Main Plant Flare and the Plant 2 Main Plant Flare (Refinery Flare). For each of these flares, the gross heat release ( $q$ , in calories/second) was calculated using data provided on the source air pollution emission notice (APEN) forms.

The next step in the TCEQ procedures is to calculate the net heat release ( $q_n$ , in calories/second) using the following equation:

$$q_n = q * (1 - 0.048 * \text{SQRT}(MW)), \text{ where:}$$

$$q = \text{gross heat release (calories/second)}$$

---

<sup>9</sup> Texas Commission on Environmental Quality, Technical Basis for Flare Parameters, September 10, 2004. Available at: <https://www.tceq.texas.gov/assets/public/permitting/air/memos/flareparameters.pdf>.

<sup>10</sup> USEPA, VOC Controls, Chapter 1: Flares, August 2019, p. 1-3. Available at: [https://www.epa.gov/sites/production/files/2019-08/documents/flarescostmanualchapter7thedition\\_august2019vff.pdf](https://www.epa.gov/sites/production/files/2019-08/documents/flarescostmanualchapter7thedition_august2019vff.pdf).

$q_n$  = net heat release (calories/second)

MW = estimated mean molecular weight of the gas being flared

SQRT = square root

The equivalent flare stack diameter (DS, in meters) is then calculated as:

$$DS = 0.001 * SQRT (q_n)$$

For flare the F1 Main Plant Flare, the calculated equivalent stack diameter is 2.08 meters; for the Plant 2 Main Plant Flare (Refinery Flare), the calculated equivalent stack diameter is 1.76 meters. The physical stack height for these two flares was obtained from the applicable APEN forms.

### **3.2.2. Sources not Modeled in this Analysis**

Four additional smaller flares were considered, but were omitted from this modeling analysis (the four flares are: F2-Asphalt Unit Flare, F3-GBR Unit Flare, Truck loading docks w/flare, and Rail Track Flare). These sources were not modeled due to one or more of the following reasons: the lack of a source APEN, the lack of flare gas heat release information, or the flare was a very small contributor to the overall facility emissions.

In addition, two other sources were omitted from this modeling analysis due to the lack of an associated source APEN (the two sources are: H-20 and the Thermal Oxidizer for Tank Cleaning).

### **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/PRM 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.<sup>11</sup>

CDPHE provided me with several BPIP/PRM input files with building heights and locations for structures within the Suncor facility. I verified the data within the input files using ArcGIS Pro and Google Earth and found that many of the older BPIP/PRM input files included severely flawed data including incorrect building location coordinates and incorrect building heights. However, there

---

<sup>11</sup> USEPA, User's Guide to the Building Profile Input Program, EPA-454/R-93-038, April 21, 2004.

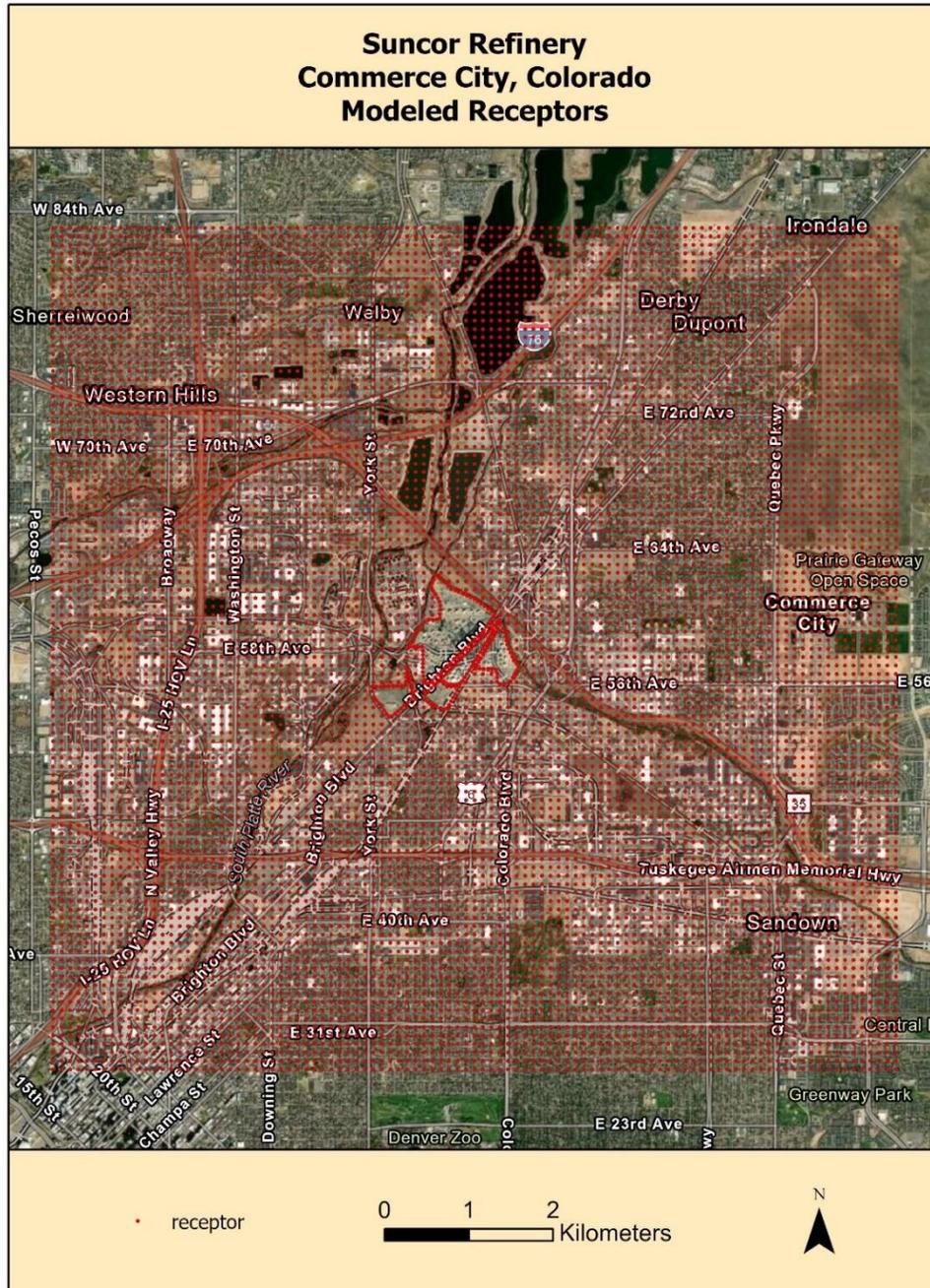
was one more recent input file associated with the CDPHE's HCN analysis that included accurate building heights and locations for 31 structures located centrally to the sources I modeled. I used the data in this file to run BPIPFRM and calculate building downwash parameters for my 33 modeled sources and included those parameters in my own modeling analysis.

### **3.4 Receptors**

I modeled a grid of 10,306 receptors with 100-meter spacing centered at the refinery and extending 5 km in each direction. Receptors are not included for the facility property, and fenceline receptors are included at 50-meter intervals (Figure 2). I verified fenceline locations based on the point locations of fenceline monitors that were previously set up to sample benzene.

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 refinery 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 1/3<sup>rd</sup> arc-second (10 meter horizontal) resolution.

**Figure 2: Modeled Receptors**



### 3.5 Meteorological Data

CDPHE provided two sets of meteorological data for me to model. One set includes data from 1990-1994 from the Denver Stapleton International Airport, about 7 kilometers southeast of the Suncor refinery. The other includes onsite data for 1993, 1994, 1998, 1999, and 2000 from the Asarco facility about 3 kilometers to the west of the refinery. I was given data both with and without adj-u\*. The data was processed with AERMET v. 19191, which is currently the most recent version of AERMET. When considering results from both sets of data, CDPHE's meteorological determination process states that "the design concentration will be ascertained from the modeled meteorological data set with the highest impacts using the form of the NAAQS for the pollutant and averaging period being modeled."<sup>12</sup>

USEPA's definition of preferred meteorological data includes the most recent five years of National Weather Service (NWS) data.<sup>13</sup> Currently, this condition is satisfied using 2016 through 2020 Automated Surface Observing Station (ASOS) data collected at the most site-appropriate airport. I processed my own meteorological data for this timespan from Denver International Airport (KDEN). For comparison, I modeled all three meteorological datasets (2016-2020 from KDEN, 1993-1994 and 1998-2000 from Asarco, and 1990-1994 from Denver Stapleton International Airport) both with and without adj-u\*.

The meteorological data required by AERMOD is prepared by AERMET. Required data inputs to AERMET are: surface meteorological data, twice-daily soundings of upper air data, and the micrometeorological parameters surface roughness, albedo, and Bowen ratio.<sup>14</sup> AERMET creates the model-ready surface and profile data files required by AERMOD. Using AERMET v. 19191, I created an AERMOD-ready meteorological data set to model permitted emissions from the Suncor refinery. This data set covers five years, 2016 through 2020, and is summarized as follows:

---

<sup>12</sup> CDPHE, Meteorological Determinations and Application of Dispersion Models, available here:

<https://www.colorado.gov/airquality/permits/MeteorologicalDetermination.pdf>

<sup>13</sup> 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.

<sup>14</sup> Albedo is the fraction of total incident solar radiation reflected by the surface back to space (whiter surfaces have higher albedo). The Bowen ratio is an indicator of surface moisture. It is the ratio of sensible heat flux to latent heat flux and drier areas have a higher Bowen ratio. Surface roughness, shown in shorthand as ("z<sub>0</sub>"), is an essential parameter in estimating turbulence and diffusion. Technically, it's the height above the ground that the log wind law extrapolates to zero. For our purposes, z<sub>0</sub> can be thought of as a measure of how much the surface characteristics interfere with the wind flow. Very smooth surfaces, like short grass or calm ponds, have very low values of z<sub>0</sub> -- on the order of 0.01 meter or less. Tall and irregular surfaces, which are a greater obstacle to wind flow, have higher values of z<sub>0</sub> -- up to 1.0 meter or more for forests.

Surface data: Denver International Airport (KDEN);  
Upper air data: Denver Stapleton International Airport (KDNR).

I will discuss my methodology for preparing 2016-2020 KDEN meteorological data in the following sections.

### **3.5.1 Surface Meteorological Data**

I used 2016 through 2020 Integrated Surface Hourly (ISH) data obtained from the National Climatic Data Center (NCDC). From the ISH dataset, I extracted ASOS data from KDEN.

I also obtained 2016 through 2020 one-minute ASOS wind data from KDEN, which I processed with AERMINUTE v. 15272. I downloaded these one-minute data from the NCDC.<sup>15</sup> I input the ice-free wind instrument start date (September 12, 2005) and used default settings with AERMINUTE. As a quality assurance measure, I compared values developed from the one-minute data with the corresponding ISH data file.

I processed the ISH data through AERMET Stage 1, which performs data extraction and quality control checks. I merged the AERMINUTE output files with the processed AERMET Stage 1 ISH and upper air data in AERMET stage 2.

### **3.5.2 Upper Air Meteorological Data**

I used 2016 through 2020 upper air data from twice-daily radiosonde measurements obtained from Denver Stapleton International Airport. These data are in Forecast Systems Laboratory (FSL) format which I downloaded in ASCII text format from NOAA's FSL website.<sup>16</sup> I downloaded and processed all reporting levels with AERMET.

Upper-air data are collected by a "weather balloon" that is released twice per day at selected locations. As the balloon is released, it rises through the atmosphere, and radios the data back to the surface. The measuring and transmitting device is known as either a radiosonde, or rawinsonde. Data collected and radioed back include: air pressure, height, temperature, dew point, wind speed,

---

<sup>15</sup> See: <ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin/>

<sup>16</sup> Available at: <http://esrl.noaa.gov/raobs/>

and wind direction. I processed the FSL upper air data through AERMET Stage 1, which performs data extraction and quality control checks.

### **3.5.3. AERSURFACE and Final Processing**

I used AERSURFACE v. 20060 to develop surface roughness, albedo, and daytime Bowen ratio values in a region surrounding the meteorological data collection site (KDEN). Using AERSURFACE and 2016 NLCD land cover data, I extracted surface roughness in a one-kilometer radius surrounding the data collection site. I also extracted Bowen ratio and albedo for a 10-kilometer by 10-kilometer area centered on the meteorological data collection site. I processed these micrometeorological data for monthly periods using two VARYAP sectors defined by the observed surface characteristics at KDEN. Sector 1 comprises the directions between 350 and 190 degrees, and Sector 2 comprises the directions between 190 and 350 degrees.

I determined moisture conditions for each year using NCDC monthly rainfall records from Denver Stapleton. For years 1991-2020, the average annual rainfall for this location was 15.32”, while the 30<sup>th</sup> percentile annual rainfall was 12.61” and the 70<sup>th</sup> percentile value was 16.81” of rain. Years with annual rainfall less than the 30<sup>th</sup> percentile were treated as dry in AERSURFACE, and years above the 70<sup>th</sup> percentile were processed as wet. Years with annual rainfall between the 30<sup>th</sup> and 70<sup>th</sup> percentiles were processed with average conditions.<sup>17</sup>

Using NCDC monthly snow cover data, I examined whether any months during the period 2016 through 2020 had continuous snow cover, which is defined as a “calendar month during which the ground was covered with snow more than 50% of the time.”<sup>18</sup> No month during the period 2016 through 2020 met this criterion, so the NOSNOW specification in AERSURFACE was used for all months.

I applied the AERSURFACE outputs in Stage 3 AERMET processing. At this point, I also incorporated a 0.5 meter/second threshold velocity for one-minute ASOS winds that had been processed with AERMINUTE. I did not fill missing hours in the meteorological data sets as the data files exceed USEPA’s 90% data completeness requirement.<sup>19</sup>

---

<sup>17</sup> USEPA, User’s Guide for AERSURFACE Tool, February 2020, p. 3-11.

<sup>18</sup> Id., p. 3-12.

<sup>19</sup> USEPA, Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-05, February 2000, Section 5.3.2, pp. 5-4 – 5-5. <http://www.epa.gov/ttn/scram/guidance/met/mmgrma.pdf>

#### 4. Background Air Concentrations

CDPHE provided a single-value background concentration for SO<sub>2</sub> of 26.2 µg/m<sup>3</sup> and season-by-hour ozone background data from La Casa, and season-by-hour NO<sub>2</sub> background data from Globeville that I incorporated into my modeling analysis.

While these numbers represent the general background levels in the greater Commerce City area, they may not adequately represent the actual conditions directly around the refinery. The Suncor refinery is in a highly industrial area that includes a natural gas power plant, highly trafficked interstate highways, and other facilities that presumably contribute more background pollution in the area than the La Casa and Globeville data indicates. Consequently, my modeled results are likely an underestimate of concentrations in these industrial areas very near the refinery.

#### 5. Modeling Results

I modeled permitted emissions of both SO<sub>2</sub> and NO<sub>x</sub> with various meteorological datasets. I will discuss the results in the following sections.

##### 5.1 Sulfur Dioxide

For this analysis, the one-hour SO<sub>2</sub> ambient air impacts (Facility H4H – highest fourth high value) are based on the 99<sup>th</sup> 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 SO<sub>2</sub> ambient air impacts for each meteorological scenario are as follows:

Sulfur dioxide (SO <sub>2</sub> )					
Meteorological Data	UTM X (m)	UTM Y (m)	Facility H4H Conc. (µg/m <sup>3</sup> )	NAAQS (µg/m <sup>3</sup> )	NAAQS exceedance?
Asarco without adj-u*	504802	4405729	230.52	196.2	YES
Asarco with adj-u*	504802	4405729	230.52	196.2	YES
Stapleton without adj-u*	504776	4405686	220.48	196.2	YES
Stapleton with adj-u*	504776	4405686	220.48	196.2	YES
Denver Intl Airport without adj-u*	504793	4405934	197.82	196.2	YES
Denver Intl Airport with adj-u*	504793	4405934	197.82	196.2	YES
A background concentration of 26.2 µg/m <sup>3</sup> was added to the modeled results.					

## 5.2 Nitrogen Dioxide

For this analysis, the one-hour NO<sub>2</sub> ambient air impacts (Facility H8H – highest eighth high value) are based on the 98<sup>th</sup> 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 and OLM one-hour NO<sub>2</sub> ambient air impacts for each meteorological scenario are as follows:

Nitrogen Dioxide (NO <sub>2</sub> )						
Meteorological Data	Tier 3 Method	UTM X (m)	UTM Y (m)	Facility H8H Conc. (µg/m <sup>3</sup> )	NAAQS (µg/m <sup>3</sup> )	NAAQS exceedance?
Asarco without adj-u*	OLM	504670	4405876	231.24	188	YES
Asarco with adj-u*	OLM	504670	4405876	231.24	188	YES
Stapleton without adj-u*	OLM	504772	4405864	235.21	188	YES
Stapleton with adj-u*	OLM	504772	4405864	235.21	188	YES
Denver Intl Airport without adj-u*	OLM	504840	4406057	253.04	188	YES
Denver Intl Airport with adj-u*	OLM	504840	4406057	253.04	188	YES
Asarco without adj-u*	PVMRM	504877	4405926	208.52	188	YES
Asarco with adj-u*	PVMRM	504877	4405926	215.39	188	YES
Stapleton without adj-u*	PVMRM	504708	4405562	212.07	188	YES
Stapleton with adj-u*	PVMRM	504708	4405562	212.07	188	YES
Denver Intl Airport without adj-u*	PVMRM	504870	4406097	218.89	188	YES
Denver Intl Airport with adj-u*	PVMRM	504870	4406097	218.89	188	YES
All scenarios modeled with season-by-hour background NO <sub>2</sub> concentrations.						

## 6.0 Conclusion

My modeling analysis reveals that the Title V permitted emissions for the Suncor refinery would result in exceedances of both the one-hour SO<sub>2</sub> and NO<sub>2</sub> NAAQS. This is the case when looking at three different meteorological datasets, both with and without adj-u\*. Both Tier 3 NO<sub>2</sub> methods, OLM and PVMRM, resulted in concentrations above the one-hour NO<sub>2</sub> NAAQS. Furthermore, my modeled results are likely an underestimation of concentrations from permitted

emissions because my modeling analysis does not include modeling of other nearby sources. Based on these conclusions, Suncor's Plant 2 Title V permit as currently drafted must not be renewed.