Harrington Station Power Plant

Amarillo, Texas

Evaluation of Compliance with the 1-hour NAAQS for SO_2

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1. Introduction

Wingra Engineering, S.C. was hired by the Sierra Club to conduct an air modeling impact analysis to confirm that the Harrington Station Power Plant located in Amarillo, Texas is causing monitored exceedances of the 1-hour sulfur dioxide (SO_2) national ambient air quality standard (NAAQS), and to identify the likely extent of those exceedances.[1] This document describes the results and procedures for evaluating the extent and concentration of SO_2 impacts from Harrington Station Power Plant.

The dispersion modeling analysis predicted ambient air concentrations for comparison with the 1-hour SO_2 NAAQS. The modeling was performed using the most recent version of AERMOD, AERMET, and AERMINUTE, with data provided to the Sierra Club by regulatory air agencies and through other publicly-available sources as documented below. The analysis was conducted in adherence to all available USEPA guidance for evaluating source impacts on attainment of the 1-hour SO_2 NAAQS via aerial dispersion modeling, including the AERMOD Implementation Guide; USEPA's Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010; modeling guidance promulgated by USEPA in Appendix W to 40 CFR Part 51; USEPA's March 2011 Modeling Guidance for SO_2 NAAQS Designations;[2] and, USEPA's August 2016 SO_2 NAAQS Designations Technical Assistance Document.[3]

To improve the accuracy of this modeling analysis, it incorporates the following procedures:

a) The most current versions of the AERMOD modeling system v. 19191 were used for the analysis.

b) Actual hourly emission rates were used for the modeling analysis. Because emission rates from the facility's continuous emissions monitoring system (CEM) were not publicly available, this report relies on hourly emissions data from EPA's *Clean Air Markets Program Database (CAMD)* for the 2017-19 period.[4]

c) Stack parameters including location, height, diameter and temperature were obtained from the annual survey compiled by the U.S. Energy Information Administration.[5] Stack locations were verified using aerial photographs, air modeling EPA conducted for evaluating the facility's impacts under the Clean Air Act's regional haze program,[6] and a modeling protocol

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[1]On May 5, 2020, EPA determined that the 2017-2019 design value for the Amarillo Xcel El Rancho monitor AQS Site ID 483751077 is 114 ppb.
[2] http://www.epa.gov/scram001/so2_modeling_guidance.htm
[3] https://www.epa.gov/sites/production/files/2016-06/documents/so2modelingtad.pdf
[4] http://ampd.epa.gov/ampd/
[5] http://www.eia.gov/electricity/data/eia860/
[6] Technical Support Document Our Strategy for Assessing which Units are Subject to BART for the Texas Regional Haze BART Federal Implementation Plan (BART Screening TSD), November 2016.

provided to TCEQ earlier this year for evaluating SO_2 emissions from the Harrington Station.[7]

d) Since actual hourly SO_2 emissions were used for the modeling analysis, hourly stack exit velocities and temperatures were also employed. This approach is recommended by USEPA[8] and has been used for prior modeling analyses to determine compliance with the NAAQS. Actual hourly stack flow rates, exit velocities and temperatures from the facility CEM were not publicly available. These were instead estimated based on information available for Harrington Station using the following steps: Step 1) The hourly heat input and exhaust flow rates provided by USEPA for 2012-14 period in its Emissions Modeling Clearinghouse were used to calculate a standard cubic feet (scf) per mmbtu ratio for each of the units at Harrington Station. For Units 061B, 062B and 063B, the calculated ratios were 15,267, 14,617, and, 15,096, respectively. Step 2) These flow to heat input ratios were applied to the hourly heat input for the 2017-19 period provided by the USEPA CAMD to determine the hourly flow rates. Step 3) The temperature calculated for each hour was applied to the flow rate in standard cubic feet for each hour to determine the flow rate in actual cubic feet. Stack exit temperatures at 100% and 50% load were provided by the USEIA annual power plant survey. For Units 061B, 062B and 063B, these temperatures were: 326 and 263 ºF; 313 and 250 ºF; and, 300 and 240 ºF, respectively. All loads below 50% were assumed to have the same temperature as 50% load. Between 50% and 100% load, the temperature was assumed to increase proportionally with load. The % load for each hour was calculated from the heat input provided in the USEPA CAMD.

e) The downwash effects of nearby buildings and structures were used for the modeling analysis. Photographs of Harrington Station show the three boiler stacks are relatively short and likely affected by downwash effects from nearby buildings and structures. No building dimensions were publicly available. To incorporate downwash effects, these dimensions were estimated using aerial and facility photographs.

f) Concurrent meteorology for the 2017-19 period were used for the modeling analysis. These were processed using the current version of AERMET following similar procedures used by TCEQ for the meteorology data it provides for modeling analyses. As recommended by TCEQ for Potter County, meteorology data for the Amarillo International Airport were used for the analysis.

g) The background SO_2 concentration used for the modeling analysis is the lowest design value for the 2017-19 period from all ambient monitors in Texas. This is the concentration of 1.8

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[7] AER, Modeling Protocol, Southwestern Public Service Company Harrington Station Power Plant in Potter County Texas, Task 3: Site-Specific Modeling Protocols for the 2010 One-Hour SO_2 NAAQS, February 7, 2020.
[8] USEPA, SO_2 NAAQS Designations Modeling Technical Assistance Document, August 2016 (Draft).

ppb or 4.7 μg/m^3 which was measured at the Milam County monitor identified as the Rockdale John D. Harper Road Monitor located at 3990 John D Harper Road (Coordinates: 30.569534, -97.076294). It has USEPA ID #483311075. Based on measured actual hourly emissions, stack temperatures, and variable stack velocities Harrington Station is estimated to cause SO_2 concentrations which exceed the 1-hour NAAQS under all scenarios. Harrington Station is predicted to exceed the NAAQS regardless of the background concentration used for this analysis.[9]

2. Compliance with the 1-hour SO_2 NAAQS

2.1 1-hour SO_2 NAAQS

The 1-hour SO_2 NAAQS takes the form of a three-year average of the 99th percentile of the annual distribution of daily maximum 1-hour concentrations, which cannot exceed 75 parts per billion (ppb).[10] Compliance with this standard was verified using USEPA's AERMOD air dispersion model, which produces air concentrations in units of μg/m^3. The 1-hour SO_2 NAAQS of 75 ppb equals 196.2 μg/m^3, and this is the value used for determining whether modeled impacts exceed the NAAQS.[11] The 99th percentile of the annual distribution of daily maximum 1-hour concentrations corresponds to the fourth-highest value at each receptor for a given year.

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[9] There are two monitors in Potter County. The Amarillo 24th Avenue monitor has ID #483751025 and is located in Amarillo at 4205 NE 24th Avenue (Coordinates: 35.236736, -101.787405) approximately 7.8 km southwest of Harrison State. The Amarillo Xcel El Rancho monitor has ID #483751077 and is located in Amarillo at Folsom and El Rancho Roads (Coordinates: 35.316500, -101.741800) approximately 2.0 km northeast of Harrington Station. Based on prevailing wind directions, the Amarillo 24th Avenue monitor is generally upwind of the plant and the Amarillo Xcel El Rancho monitor is downwind of the plant. Neither monitor was used to obtain a background concentration due to likely influence from SO_2 emissions from Harrington Station.

[10] USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010.

[11] The ppb to μg/m^3 conversion is found in the source code to AERMOD v. 19191, subroutine Modules. The conversion calculation at 25 °C is 75/0.3823 = 196.2 μg/m^3. This conversion has been used for consistency with prior modeling reports. While USEPA has recently converted the 75 ppb standard to 196.5 μg/m^3, the alternative USEPA concentration does not change the conclusions of this report.

2.2 Modeling Results

Modeling results for Harrington Station are summarized in Tables 1.

Table 1 - SO_2 Modeling Results for Harrington Station

Emission Rates	Averaging Period	99th Percentile 1-hour Daily Maximum (µg/m³)				Complies with NAAQS?
		Impact	Background	Total	NAAQS	
Actual 2017-19	1-hour	385.9	4.7	390.6	196.2	No

Figure 1 shows the full extent of predicted exceedances of the 1-hour NAAQS for SO_2, the locations of the two monitoring stations and Harrington Station.

Figure 2 shows the highest predicted exceedances close to Harrington Station.

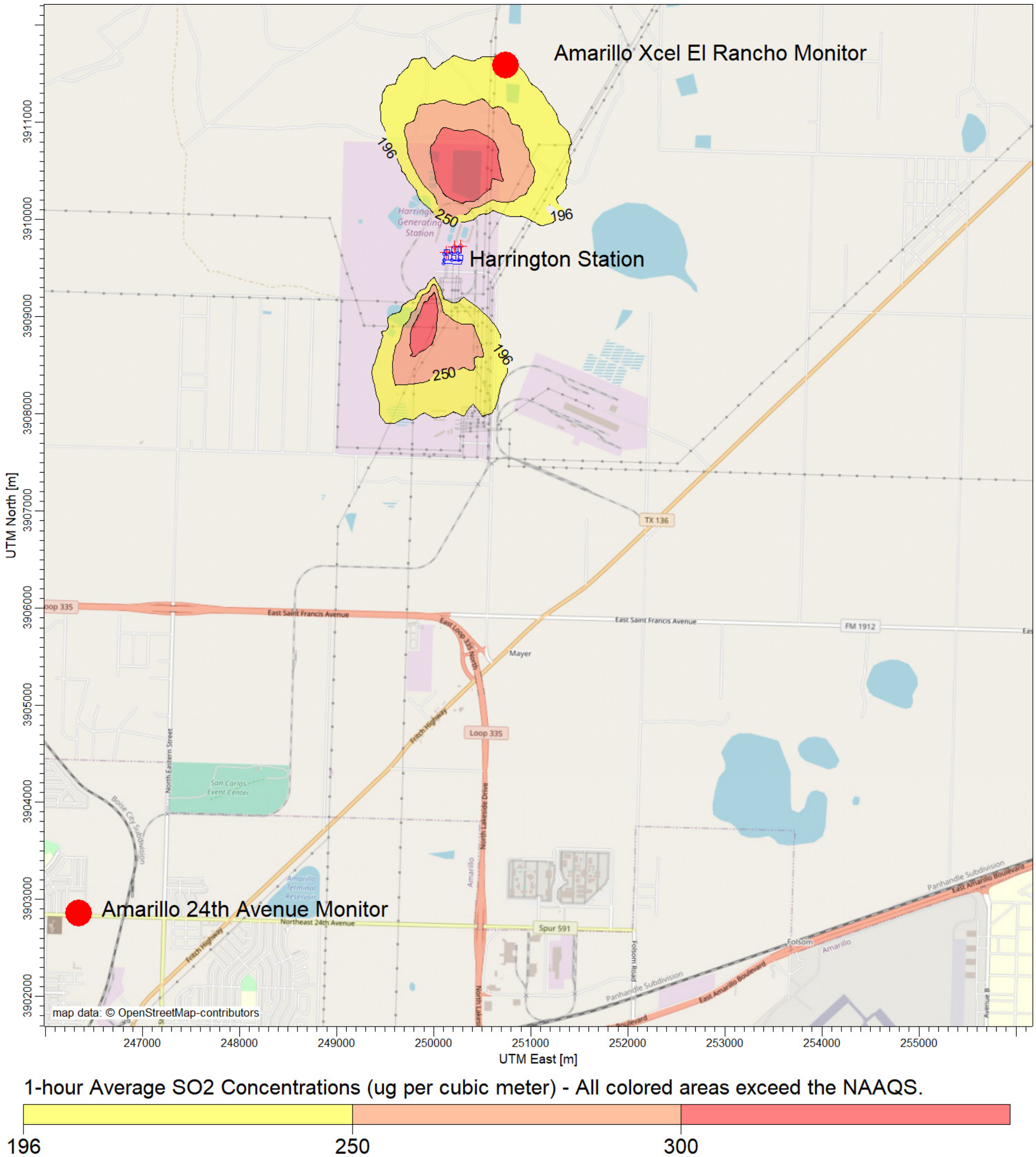

Figure 1 – Regional View of NAAQS Exceedances for 2017-19 Period

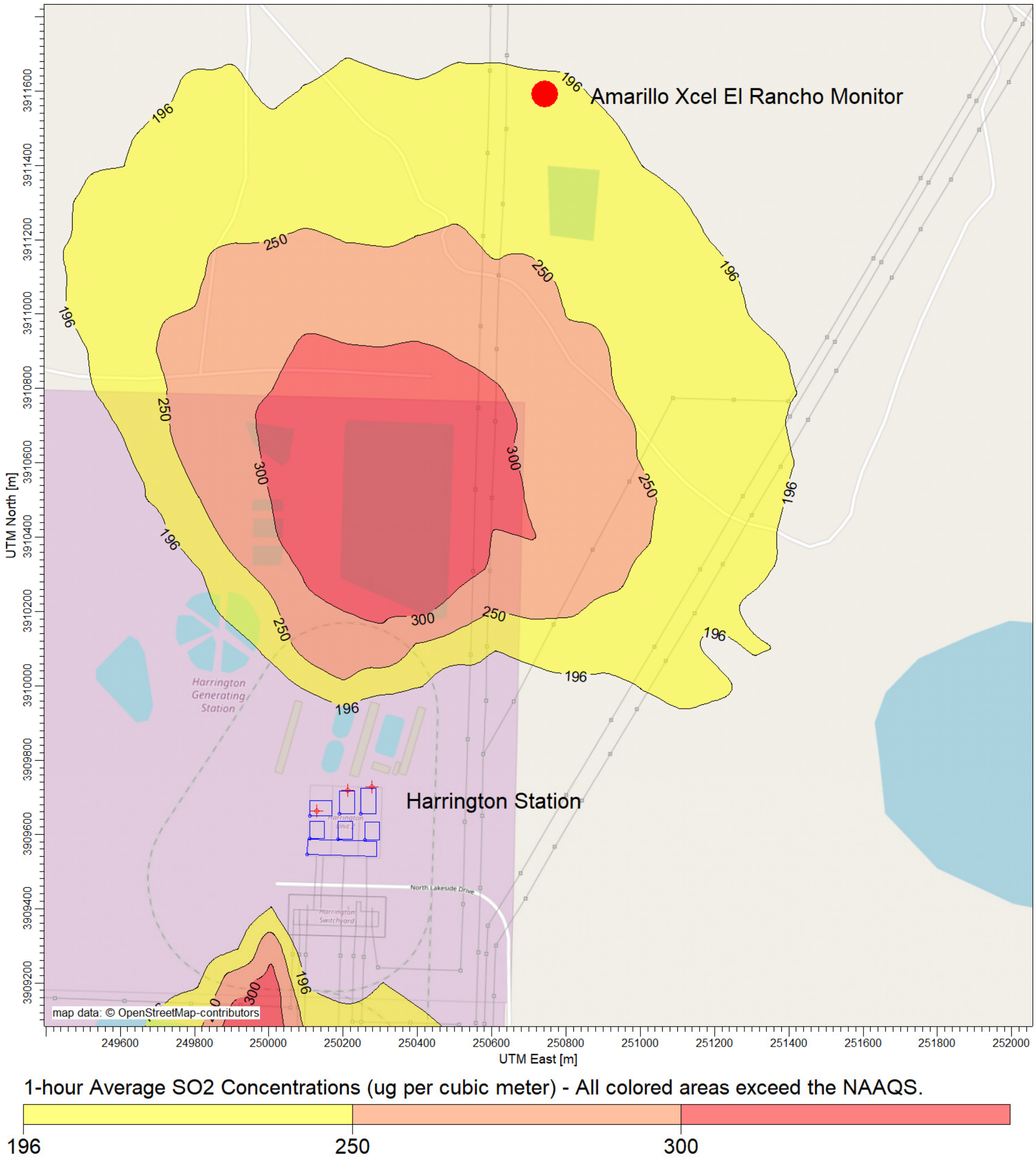

Figure 2 – Close-up View of NAAQS Exceedances for 2017-19 Period

2.3 Comparison with Ambient Monitoring Measurements

Predicted Concentration at Monitor Location - For the 2017-19 period, the downwind Amarillo Xcel El Rancho monitor located 2.0 km northeast from Harrington Station measured a design value of 298.2 µg/m^3, well above the 1-hour NAAQS for SO2 of 196.2 µg/m^3. The modeling analysis predicted a design value of 201.9 µg/m^3 at this monitor location, approximately 96.3 µg/m^3 and 32% less than the actual monitored value. This suggests the modeling analysis is under-predicting the impacts of SO_2 emission from Harrington Station.

Predicted Maximum Concentration - The maximum design value predicted by the modeling analysis is 390.6 µg/m^3. This occurs approximately 1.6 km southeast of the Amarillo Xcel El Ranch monitor. This suggests the Amarillo Xcel El Rancho monitor is not located where the maximum impacts of SO_2 emissions from Harrington Station occur.

2.4 Conservative Modeling Assumptions

A dispersion modeling analysis requires the selection of numerous parameters which affect the predicted concentrations. Some were selected which under-predict facility impacts.

Assumptions used in this modeling analysis which likely under-estimate concentrations include the following:

- Hourly stack exit velocity and temperature as measured by the facility CEM were not publicly available. Instead these were estimated using publicly available information. If the actual exit velocities and temperatures are lower than those estimated for this analysis, the modeled concentrations would be conservatively low.
- Dimensions of facility buildings and structures were not publicly available. Instead these were estimating using publicly available photographs. If the actual dimensions are larger than those estimated for this analysis, the modeled concentrations would be conservatively low.
- To evaluate the full extent and concentration of impacts caused by Harrington Station, it is recommended that USEPA obtain building parameters, actual values for hourly emissions, exit velocities, and temperatures from the CEM measurements collected at Harrington Station, and incorporate those inputs into AERMOD. As noted, the use of actual hourly temperature and exit velocity would likely result in decreased plume dispersion and higher modeled impacts over a larger geographic area.

3. Modeling Methodology

3.1 Air Dispersion Model

The modeling analysis used the most recent version of USEPA's AERMOD program, v. 19191. AERMOD, as available from the Support Center for Regulatory Atmospheric Modeling (SCRAM) website, was used in conjunction with a third-party modeling software program, *AERMOD View*, sold by Lakes Environmental Software.

3.2 Control Options

The AERMOD model was run with the following control options:

- 1-hour average air concentrations
- Regulatory defaults
- 1.5 meter flag pole receptor height

An evaluation was conducted to determine if the modeled facility was located in a rural or urban setting using USEPA's methodology outlined in Section 7.2.3 of the Guideline on Air Quality Models.[12] For urban sources, the URBANOPT option is used in conjunction with the urban population from an appropriate nearby city and a default surface roughness of 1.0 meter. Methods described in Section 4.1 were used to determine whether rural or urban dispersion coefficients were appropriate for the modeling analysis.

3.3 Output Options

The AERMOD analysis was based on recent meteorological data. The modeling analysis was conducted using sequential meteorological data from the 2017-19 period. Consistent with USEPA's Modeling Guidance for SO_2 NAAQS Designations, AERMOD provided a table of fourth-high 1-hour SO_2 impacts concentrations consistent with the form of the 1-hour SO_2 NAAQS.[13]

Please refer to Table 1 for the modeling results.

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[12] 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.
[13] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, pp. 24-26.

4. Model Inputs

4.1 Geographical Inputs

The air dispersion modeling analysis used 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.

The Universal Transverse Mercator (UTM) NAD83 coordinate system was used for identifying the easting (x) and northing (y) coordinates of the modeled sources and receptors.

The facility was evaluated to determine if it should be modeled using the rural or urban dispersion coefficient option in AERMOD. A GIS was used to determine whether rural or urban dispersion coefficients apply to a site. Land use within a three-kilometer radius circle surrounding the facility was considered. USEPA guidance states that urban dispersion coefficients are used if more than 50% of the area within 3 kilometers has urban land uses. Otherwise, rural coefficients are used.[14]

USEPA's AERSURFACE v. 20060 was used to develop the meteorological data for the modeling analysis. This model was also used to evaluate surrounding land use within 3 kilometers of Harrington Station. Based on the output from the AERSURFACE, approximately 6% of surrounding land use around the station was of urban land use types including Types 22, 23 and 24 which are Low, Medium and High Intensity Development.

This is less than the 50% value considered appropriate for the use of urban dispersion coefficients. Based on the AERSURFACE analysis, it was concluded that the rural option would be used for the modeling summarized in this report. Please refer to Section 4.5.3 for a discussion of the AERSURFACE analysis.

4.2 Emission Rates and Source Parameters

Actual hourly emission rates were used for the modeling analysis. Emission rates from the facility continuous emissions monitoring system (CEM) were not publicly available. These were instead obtained from EPA's Clean Air Markets Program Database (CAMD) for the 2017-19 period.

Stack parameters including location, height, diameter and temperature were obtained from the annual survey compiled by the U.S. Energy Information Administration. Stack locations were

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[14] 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, Section 7.2.3.

verified using aerial photographs, air modeling EPA conducted for evaluating the facility's impacts under the Clean Air Act's regional haze program, and a modeling protocol provided to TCEQ earlier this year for evaluating SO_2 emissions from the Harrington Station.

Hourly stack exit velocities and temperatures were used for the modeling analysis. Actual hourly stack flow rates, exit velocities and temperatures from the facility CEM were not publicly available. These were instead estimated based on information available for Harrington Station.

Table 2 – Facility Stack Parameters

Facility	Harrington Station		
Stack	S01 (061B)	S02 (062B)	S03 (063B)
Description	Unit 1	Unit 2	Unit 3
X Coord. [m]	250129.00	250211.82	250277.97
Y Coord. [m]	3909662.00	3909718.89	3909727.94
Base Elevation [m]	1085.7	1084.93	1084.82
Release Height [m]	76.2	91.44	91.44
Inside Diameter [m]	5.7912	5.7912	5.7912
Gas Exit Temperature [°K]	Hourly Values		
Gas Exit Velocity [m/s]			
Actual Emission Rate [g/s]			

4.3 Building Dimensions and GEP

The downwash effects of nearby buildings and structures were used for the modeling analysis. Photographs of Harrington Station show the three boiler stacks are relatively short and likely affected by downwash effects from nearby buildings and structures. No building dimensions were publicly available. To incorporate downwash effects, these dimensions were estimated using aerial and facility photographs.

4.4 Receptors

For Harrington Station, three receptor grids were employed:

1. A 100-meter Cartesian receptor grid centered on the station and extending out 5 kilometers.
2. A 500-meter Cartesian receptor grid centered on the station and extending out 10 kilometers.
3. A 1,000-meter Cartesian receptor grid centered on the station and extending out 50 kilometers. 50 kilometers is the maximum distance accepted by USEPA for the use of the

AERMOD dispersion model.[15]

To reflect a representative inhalation level, a flagpole height of 1.5 meters was used for all modeled receptors. Although EPA has, in the past, expressed concern about using a elevated receptor height, it does not materially affect the outcome of the modeling.

Elevations for Receptor Grid #1 receptors were obtained from National Elevation Dataset (NED) GeoTiff data. GeoTiff is a binary file that includes data descriptors and geo-referencing information necessary for extracting terrain elevations. These elevations were extracted from 1 arc-second (30 meter) resolution NED files. The software program AERMAP v. 18081 is used for these tasks.

4.5 Meteorological Data

To ensure the accuracy of the modeling analysis, recent meteorological data for the 2017-19 period were prepared using the USEPA's program AERMET which creates the model-ready surface and profile data files required by AERMOD. Required data inputs to AERMET included surface meteorological measurements, twice-daily soundings of upper air measurements, and the micrometeorological parameters surface roughness, albedo, and Bowen ratio. One-minute ASOS data were available so USEPA methods were used to reduce calm and missing hours.[16] The USEPA software program AERMINUTE v. 15272 is used for these tasks.

This section discusses how the meteorological data was prepared for use in the 1-hour SO_2 NAAQS modeling analyses. The USEPA software program AERMET v. 19191 is used for these tasks.

4.5.1 Surface Meteorology

Surface meteorology was obtained for Amarillo International Airport located near the Harrington Station. Integrated Surface Hourly (ISH) data for the 2017-19 period were obtained from the National Climatic Data Center (NCDC). The ISH surface data was processed through AERMET Stage 1, which performs data extraction and quality control checks.

4.5.2 Upper Air Data

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

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[15] 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, Section A.1.(1), November 9, 2005.
[16] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, p. 19.

surface. The measuring and transmitting device is known as either a radiosonde, or rawindsonde. Data collected and radioed back include: air pressure, height, temperature, dew point, wind speed, and wind direction. The upper air data were processed through AERMET Stage 1, which performs data extraction and quality control checks.

For Harrington Station, the concurrent 2017-19 upper air data from twice-daily radiosonde measurements obtained at the most representative location were used. This location was the measurement station at the Amarillo International Airport. These data are in Forecast Systems Laboratory (FSL) format and were downloaded in ASCII text format from NOAA's FSL website.[17] All reporting levels were downloaded and processed with AERMET.

4.5.3 AERSURFACE

AERSURFACE is a program that extracts surface roughness, albedo, and daytime Bowen ratio for an area surrounding a given location. AERSURFACE uses land use and land cover (LULC) data in the U.S. Geological Survey's National Land Cover Dataset to extract the necessary micrometeorological data. The current version of AERSURFACE v. 20060. It was used with National Land Cover Database for 2016 including land cover, canopy and impervious surfaces.

AERSURFACE was used to develop surface roughness, albedo, and daytime Bowen ratio values in a region surrounding the meteorological data collection site. AERSURFACE was used to develop surface roughness in a one-kilometer radius surrounding the data collection site. Bowen ratio and albedo were developed for a 10-kilometer by 10-kilometer area centered on the meteorological data collection site. These micrometeorological data were processed for seasonal periods using 30-degree sectors.

The meteorological data for each year were processed separately. This allowed the level of precipitation suitable for each year to be process by AERSURFACE. For the years processed, 2017, 2018 and 2019, the levels of precipitation were Wet, Dry and Wet, respectively. These were based on annual levels for the Amarillo International Airport.18 For all years, winter months were assumed to have no continuous snow cover.

4.5.4 Data Review

Missing meteorological data were not filled as the data file met USEPA's 90% data completeness requirement.[19] The AERMOD output file shows there were 1.1% missing data across the entire

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[17] Available at: http://esrl.noaa.gov/raobs/
[18] https://www.ncdc.noaa.gov/cdo-web/search
[19] USEPA, Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-05, February 2000, Section 5.3.2, pp. 5-4 to 5-5.

2017-19 meteorological period.

To confirm the representativeness of the airport meteorological data, the surface characteristics of the airport data collection site and the modeled source location were compared. Since the Longview Texas Regional Airport is located close to Harrington Station, this meteorological data set was considered appropriate for this modeling analysis. [20] Additionally, this weather station provided high quality surface measurements, and had similar land use, surface characteristics, terrain features and climate.

Finally, TCEQ provides pre-processed meteorological data suitable for modeling for each county.[21] For Potter County, TCEQ recommends using data from the same surface and upper air stations used for this modeling analysis. The TCEQ data were not used for this project because TCEQ staff recommended processing the three years required for this project with AERMET.

5. Background SO_2 Concentrations

Background concentrations were determined consistent with USEPA's Modeling Guidance for SO_2 NAAQS Designations.[22, 23] To preserve the form of the 1-hour SO_2 standard, based on the 99th percentile of the annual distribution of daily maximum 1-hour concentrations averaged across the number of years modeled, the background fourth-highest daily maximum 1-hour SO_2 concentration was added to the modeled fourth-highest daily maximum 1-hour SO_2 concentration.[24]

The background SO_2 concentration used for the modeling analysis is the lowest design value for the 2017-19 period from all ambient monitors in Texas. This is the concentration of 1.8 ppb or 4.7 $\mu g/m^3$ which was measured at the Milam County monitor identified as the Rockdale John D. Harper Road Monitor located at 3990 John D Harper Road (Coordinates: 30.569534, -97.076294). It has USEPA ID #483311075.

6. Reporting

All files from the programs used for this modeling analysis are available to regulatory agencies. These include analyses prepared with AERSURFACE, AERMET, AERMAP, and AERMOD.

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[20] USEPA, AERMOD Implementation Guide, March 19, 2009, pp. 3-4.
[21] Texas Commission on Environmental Quality, Meteorological Data for Air Dispersion Modeling, https://www.tceq.texas.gov/permitting/air/nav/datasets.html Last updated April 29, 2020.
[22] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, pp. 20-23.
[23] USEPA, SO_2 NAAQS Designations Modeling Technical Assistance Document, August 2016, DRAFT.
[24] USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010, p. 3.