APPENDIX H

Air Dispersion Modeling Demonstration from Trinity Consultants

AIR DISPERSION MODELING REPORT

1-hour SO_2 NAAQS
Henderson-Webster Nonattainment Area SIP

For:

Century Aluminum Sebree, LLC
9404 State Route 2096
Robards, Kentucky 42452
(Agency Interest #1788)

Prepared By:

Brian Otten – Senior Consultant
Tony Schroeder, CCM, QEP, CM – Principal Consultant

TRINITY CONSULTANTS
909 Wright's Summit Pkwy, Ste 230
Covington, Kentucky 41011
(859) 341-8100

August 7, 2024

Project 231801.0017

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX: LIST OF FIGURES

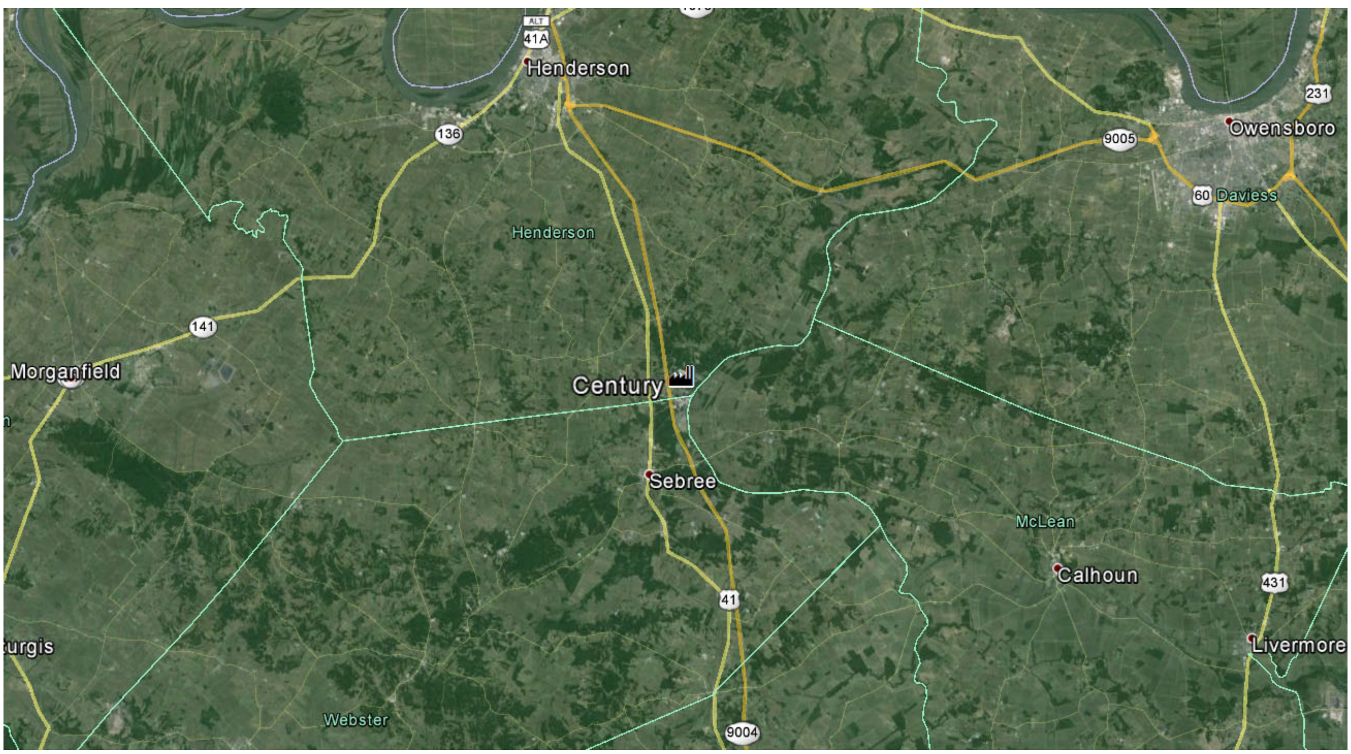
APPENDIX: LIST OF TABLES

1. INTRODUCTION

On behalf of Century Aluminum Sebree, LLC (Century), Trinity Consultants (Trinity) has prepared and is submitting this dispersion modeling report to the Kentucky Division for Air Quality (Division). This report documents the air quality modeling attainment demonstration analysis conducted for sulfur dioxide (SO_2) emissions from Century's facility in Sebree, Kentucky (Sebree Plant) and other sources in the surrounding area. The Sebree Plant is located on State Highway Junction 2096/2097, 3.8 miles (6.1 km) northeast of the city center of Sebree, Kentucky. Figure 1-1 shows the location of the Sebree Plant in western Kentucky at the confluence of Webster, McLean, and Henderson counties approximately 27 km south of Henderson, Kentucky and the Kentucky-Indiana border.

The area in the vicinity of the Sebree Plant, specifically portions of Henderson and Webster Counties, was designated as nonattainment with respect to the 1-hour SO_2 National Ambient Air Quality Standard (NAAQS) effective April 30, 2021. The modeling exercise covered by this report was conducted in support of the Division's efforts to prepare a State Implementation Plan (SIP) revision with respect to the 1-hour SO_2 NAAQS in response to this nonattainment designation.

Figure 1-1. Location of Sebree Plant Northeast of Sebree, KY

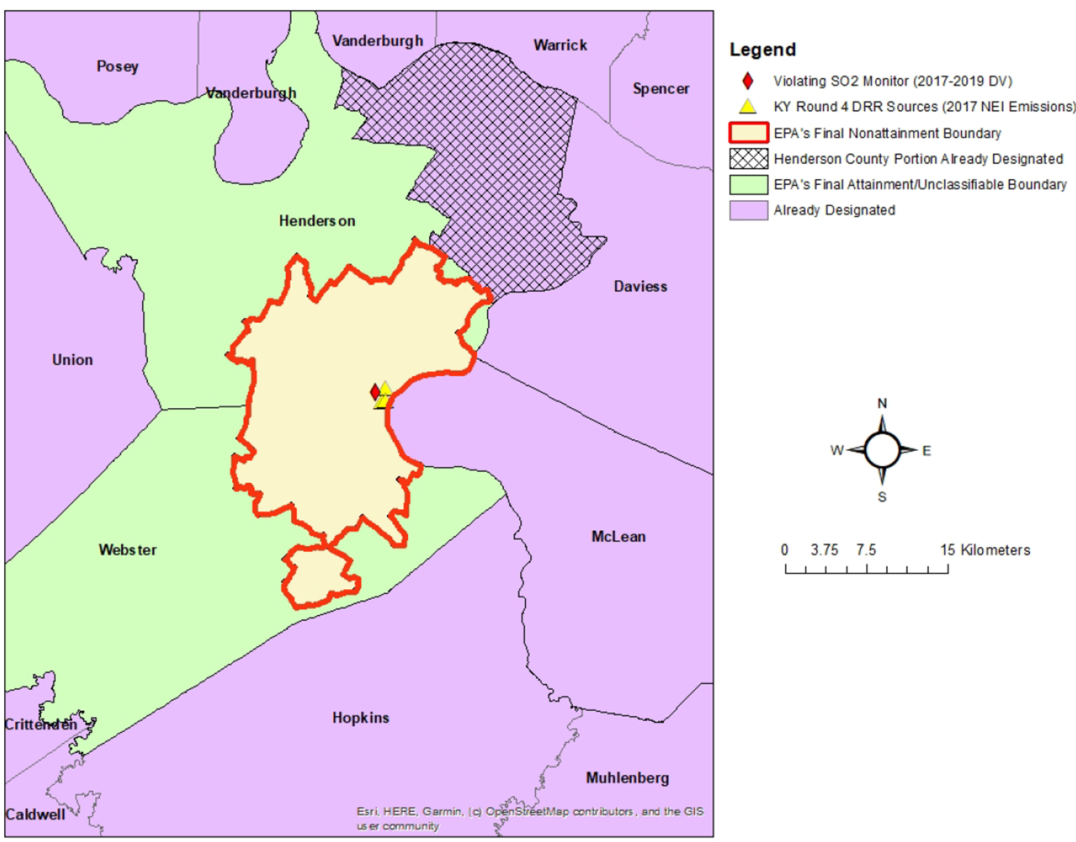


1.1 Background

The U.S. Environmental Protection Agency (EPA) promulgated the current 1-hour SO_2 NAAQS at 75 parts per billion (ppb) on June 22, 2010.[1] Compliance with the 1-hour SO_2 NAAQS is determined based on monitor data using the three-year average of the 4th highest daily maximum concentration. In August 2015, EPA promulgated the SO_2 Data Requirements Rule (DRR).[2] The DRR required certain sources to confirm that surrounding areas were in attainment with respect to the 1-hour SO_2 NAAQS based on either air dispersion modeling or the placement and operation of ambient SO_2 monitors if existing monitors did not already adequately characterize SO_2 concentrations near the sources. Century and the Division chose to install and operate an ambient monitoring station near the Sebree Plant with operation beginning before January 1, 2017. The design concentrations calculated from SO_2 concentration data collected over the period of 2017-2019 exceeded the NAAQS. Therefore, the area was designated as nonattainment with respect to the 1-hour SO_2 NAAQS effective in April 2021.[3]

The nonattainment area includes portions of Henderson and Webster Counties in Kentucky as shown in Figure 1-2. Historically, the two largest sources of SO_2 emissions in the nonattainment area have been Century Sebree and Big Rivers Electric Company (BREC), which is located south of Century Sebree.

Figure 1-2. SO_2 Nonattainment Area Boundary



[1] 75 FR 35520, June 22, 2010.

[2] 80 FR 51052, August 21, 2015.

[3] 86 FR 16055, March 26, 2021.

1.2 SIP Revision and Purpose of Modeling Report

The nonattainment designation triggers the requirement for the Division to develop a revision to the Kentucky SIP to demonstrate that attainment with the 1-hour SO_2 will be achieved as quickly as possible, but no later than 5 years after the effective date of the designation (i.e., by April 30, 2026). One component of the SIP is a modeling analysis demonstrating that the NAAQS will be attained. Trinity has prepared this dispersion modeling report to describe the SIP modeling analysis conducted for the Sebree plant. The report documents the data and procedures that were used to complete the dispersion modeling analyses and the results. As discussed in Section 4 of this report, a weight of evidence analysis is provided to demonstrate that compliance with the 1-hour SO_2 NAAQS can be expected following certain planned changes to Sebree Plant operations and the imposition of new limits on potential SO_2 emissions from Sebree Plant emission units. The modeling analysis was conducted in accordance with the modeling protocol that was originally submitted to the Division on October 31, 2023, revised to address comments from the Division and EPA, and resubmitted on February 9, 2024.

2. SIP DISPERSION MODELING METHODOLOGIES

The purpose of the SIP air dispersion modeling analysis is to demonstrate that compliance with the 1-hour SO_2 NAAQS will be achieved throughout the nonattainment area (via the emission reductions or other measures to be implemented to reduce ambient SO_2 concentrations). The purpose of this report is to demonstrate that ambient air concentrations will meet the 1-hour SO_2 NAAQS throughout the Henderson-Webster SO_2 nonattainment area when the stack configuration planned by Century are implemented and when SO_2 emission rates are at or below those represented in the modeling analysis. The Title V air permit for the Sebree Plant (V-19-010 R2)[4] will be amended to include federally enforceable conditions governing the stack configuration and emission limits that are relied upon in the modeling demonstration. These stack and emission changes are further detailed in Section 2.8 of this report.

The remainder of this section describes the tools and methods that were employed to conduct the SO_2 NAAQS dispersion modeling analysis.

2.1 Model Selection

For nonattainment SIP modeling, a number of guidance documents and resources are available to facilitate and provide detail on the methodologies required for conducting dispersion modeling. While no Kentucky-specific guidance is available, Trinity has prepared protocols and modeling reports for several industrial permitting activities within Kentucky over the past fifteen years and thus is familiar with the methods that are generally acceptable by the Division. As documented in the modeling protocol submitted for this SIP demonstration analysis, the dispersion modeling methodologies followed are consistent with EPA procedures specified in the *Guideline on Air Quality Models (Guideline)*.[5] These guidelines are cited by reference in the Kentucky Administrative Regulations (refer to 401 KAR 51:017, Section 10).[6] Additional EPA guidance, specific to 1-hour SO_2 nonattainment area SIP submissions, was also followed.[7] In general, as documented in the February 9, 2024 modeling protocol, the air dispersion modeling analyses conducted were in accordance with applicable EPA guidance documents, including the following:

- ► EPA's *Guideline on Air Quality Models,* 40 CFR Part 51, Appendix W (Published, January 17, 2017), which Kentucky cites by reference in Section 10 of 401 KAR 51:017.
- ► EPA's AERMOD Implementation Guide (October 2023)[8]
- ► EPA's User's Guide for the AMS/EPA Regulatory Model – AERMOD (October 2023)[9]
- ► EPA's Guidance for 1-Hour SO_2 Nonattainment SIP Submissions (April 2014)

---

[4] An application to renew the Title V permit was submitted by Century to the Kentucky Division for Air Quality on May 9, 2024.

[5] 40 CFR 51, Appendix W, Guideline on Air Quality Models

[6] 40 CFR 51, Appendix W, *Guideline on Air Quality Models* cited in 401 KAR 51:017 at http://www.lrc.ky.gov/kar/401/051/017.htm.

[7] Guidance for 1-Hour SO_2 Nonattainment SIP Submissions, Memorandum from Stephen D. Page, Director, to Regional Air Division Directors, Regions 1-10, dated April 23, 2014. https://www.epa.gov/sites/default/files/2016-06/documents/20140423guidance_nonattainment_sip.pdf

[8] EPA, *AERMOD Implementation Guide*, October 2023, available at https://gaftp.epa.gov/Air/aqmg/SCRAM/models/preferred/aermod/aermod_implementation_guide.pdf

[9] *User's Guide for the AMS/EPA Regulatory Model (AERMOD)*, EPA-454/B-23-008, EPA, OAQPS, Research Triangle Park, NC, October 2023.

Given these guidance documents and typical modeling practices, Century used the EPA-recommended AERMOD Model in its most recent Version 23132 released in October 2023. AERMOD is a refined, steady-state (both emissions and meteorology are constant over a one hour time step), multiple source, dispersion model and was promulgated by EPA in December 2005 as the preferred model to use for industrial sources in this type of air quality analysis.[10] AERMOD was used to model each stack and other types of sources at the Century Sebree facility as well as other nearby sources. Century applied AERMOD using the regulatory default options in all cases.

2.2 Rural/Urban Option Selection in AERMOD

For any dispersion modeling exercise, the "urban" or "rural" determination of the area surrounding the subject source is important in determining the applicable atmospheric boundary layer characteristics that affect a model's calculation of ambient concentrations. Thus, a determination must be made of whether the area in the modeling domain should be treated as urban or rural to yield the most accurate simulation of dispersion of emissions from the subject facilities.

The first method for selecting the urban or rural designation discussed in Section 5.1 of the *AERMOD Implementation Guide* (also referring therein to Section 7.2.1.1 of the Guideline on Air Quality Models, Appendix W) is called the "land use" technique because it examines the various land use within 3 km of a source and quantifies the percentage of area in various land use categories. If greater than 50% of the land use in the prescribed area is considered urban, then the urban option is recommended for use in AERMOD. However, EPA cautions that the use of this technique may not be appropriate in all cases, such as for sources close to a body of water because the water body may result in a predominately rural land use classification despite being located in an urban area, and that professional judgment is necessary to make an appropriate urban or rural determination. If necessary, the second recommended urban/rural classification method in Appendix W Section 7.2.1.1.b is the Population Density Procedure. This technique evaluates the total population density within 3-kilometers of a source. If the population density is greater than 750 people per square kilometer, then EPA recommends the use of urban dispersion coefficients.

Based on aerial imagery of the area surrounding the Century Sebree Plant, the nearby land use is primarily rural (approximately 95% rural and 5% urban based on the Auer land use method). However, certain types of industrial facilities are of sufficient size and generate sufficient heat to create localized "heat islands", which can cause similar atmospheric dispersion conditions to those generated by urban areas. Primary aluminum smelters use a large quantity of electricity in the smelting operation, a good portion of which (up to 50%) is dissipated as heat loss from the aluminum production cells.[11] This heat loss results in continued heating of the atmosphere above the plant, even during nighttime conditions, such that the atmosphere remains more unstable at night compared with nearby, rural areas in much the same manner as urban areas. The presence of a "heat island" in the vicinity of the Century Sebree Plant is confirmed through the use of satellite thermal imagery,[12] as shown in Figure 2-1.

In these cases where industrial facilities result in large heat releases to the atmosphere, the urban option can be employed in AERMOD to better characterize atmospheric turbulence whereas rural dispersion can be

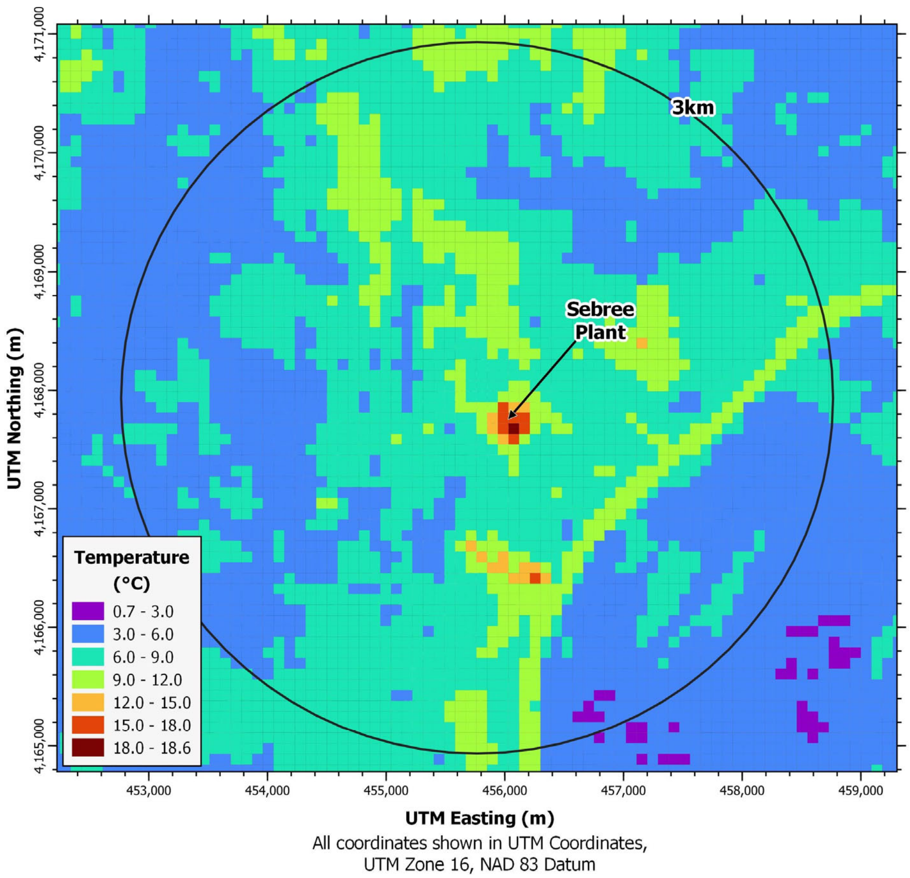
[10] 40 CFR 51, Appendix W–*Guideline on Air Quality Models*, Appendix A.1– AMS/EPA Regulatory Model (AERMOD).

[11] http://www.tms.org/pubs/journals/JOM/9905/Welch-9905.html.

[12] Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Level 1 Precision Terrain Corrected Registered At-Sensor Radiance (AST_L1T) imagery, taken November 17, 2016 at 3:51AM. AST_L1T thermal imagery was queried from USGS Earth Explorer.

assumed for other emission sources in the model. This technique has been the subject of at least one peer-reviewed journal article[13] and has been employed in EPA-approved modeling completed under the SO_2 DRR for another primary aluminum smelter located in the Ohio River valley.[14]

Figure 2-1. Satellite Thermal Imagery of Century Sebree Plant (November 17, 2016)



An additional input to AERMOD necessary for implementation of the urban option is the estimated population of the urban area. As discussed in Section 5.9 of the AERMOD Model Formulation,[15] the difference in temperature between a nearby urban and rural area can be expressed as a function of the population of the urban area as follows.

$$\Delta T_{u-r} = \Delta T_{max}[0.1\ ln(P/Po) + 1.0]$$

where ΔT_{max} = 12°C, Po = 2,000,000, and P is the population of the urban area being modeled.

---

[13] Paine, R., L. Warren, G. Moore, 2016. Source Characterization Refinements for Routine Modeling Applications. *Atmospheric Environment,* **129**, 55-67.

[14] Technical Support Document, Final Round 3 Area Designations for the 2010 1-Hour SO_2 Primary National Ambient Air Quality Standard for Indiana. https://www.epa.gov/sites/default/files/2017-12/documents/13-in-so2-rd3-final.pdf

[15] EPA, AERMOD Model Formulation, EPA-454/B-23-010, October 2023. https://gaftp.epa.gov/Air/aqmg/SCRAM/models/preferred/aermod/aermod_mfd.pdf

This empirical formula was developed based on data collected by Oke[16,17] for a number of cities with varying populations. These data represent the maximum urban effect for each city because they were collected during ideal conditions of clear skies, low winds, and low humidity values.

This equation can be rearranged to solve for P, yielding:

$$P = Po\ exp[10(\Delta T_{u-r}/\Delta T_{max} - 1.0)]$$

Figure 2-1 represents the ASTER satellite image available with maximum temperature difference between Century Sebree and nearby rural areas over the years 2000-2022. The difference in temperature between the center of the plant and nearby rural areas shown in Figure 2-1, is approximately 12˚C. The temperature difference is estimated based on the difference in temperature at the plant (18˚C) and the mid-point of the majority of pixels within 3 km of the plant. The majority of the pixels are in the 3 to 6˚C or 6 to 12˚C temperature range. Using the mid-point of this range of 6˚C yields a temperature difference between the plant and nearby rural areas of 12˚C. Using this temperature difference in the equation above yields an equivalent population of 2,000,000.

Use of this image, presenting the maximum temperature difference between the plant and nearby locations, is consistent with the data used to develop the empirical relationship in the equations above, which were taken under ideal conditions to maximize the urban-rural temperature difference. This method is likely to result in a conservative under representation of the maximum temperature difference between the smelter and nearby areas because the dates of the satellite images available do not necessarily capture days with clear skies, low winds, and low relative humidity. A total of 24 nighttime images of the area around the Sebree Plant are available from 2000-2022. The extracted temperatures from the thermal imagery are presented in Table 2-1 for comparison. As provided beside Table 2-1, the temperature differential of 12˚C represents the maximum of the 13 available temperature differentials. Relatively few clear nighttime images were available over the time period included in this analysis. Therefore, it is very likely that situations occurred with larger temperature differences between the plant and nearby areas, meaning that the use of the 12˚C temperature differential is a conservative assumption.

An AERMOD model performance evaluation is presented in Appendix A that documents the more realistic, but conservatively high, model output concentrations versus monitored data collected near the Century Sebree facility with use of the urban option. This evaluation shows that the use of AERMOD with the urban option selected and a population of 2,000,000 provides more realistic, but still conservatively high, model output concentrations for the Century Sebree SO_2 emission sources to be included in this SIP modeling analysis compared with the use of rural dispersion characteristics.

Based on the analysis presented, Century used the urban option for all Century Sebree sources with an equivalent population of 2 million, and rural dispersion characteristics for other modeled sources.

[16] Oke, T.R., 1973: City size and the urban heat island. *Atmospheric Environment*, **7**, 769-779.

[17] Oke, T.R., 1982: The energetic basis of the urban heat island. *Quart. J. Roy. Meteor. Soc.*, **108**, 1-24.

Table 2-1. Thermal Imagery Data for Sebree Plant

Year	Month	Day	Max Temp. at Sebree Plant[1] (°C)	Surrounding Area Temperature (°C)	Temperature Differential[2] (°C)
2003	06	30	7.8	2.5	5.3
2003	06	30			
2006	11	13			
2006	11	13			
2007	02	10			
2011	10	03	17.1	5.9	11.2
2012	10	21			
2015	05	07			
2015	08	27	23.1	14.9	8.2
2016	10	16			
2016	11	17	18.6	6.6	12.0
2017	05	19	24.3	17.0	7.3
2017	05	19			
2017	10	03	21.5	15.6	5.9
2017	11	20	4.9	-3.5	8.4
2018	02	08	-0.6	-6.2	5.6
2018	09	20	25.0	18.0	7.0
2019	01	10	3.3	-4.0	7.3
2020	05	04			
2021	08	18			
2021	09	28	22.8	17.0	5.8
2022	05	10	24.9	17.9	7.0
2022	07	13			
2022	10	01	23.1	17.1	6.0

Min	Avg	Max	95th Perc.	90th Perc.	75th Perc.
5.3	7.5	12.0	11.5	10.7	8.2

[1] In some instances, the Sebree Plant was not located within the boundaries of the image, despite the USGS download utility indicating such. For these instances and for images with clouds covering the Sebree Plant, the table entries are grayed out.
[2] The temperature difference is estimated based on the difference in temperature at the plant and the mid-point of the majority of pixels within 3 km of the plant based on random sampling of data points.

2.3 Building Downwash

The *Guideline* requires the evaluation of the potential for physical structures to affect the dispersion of emissions from stack sources. The exhaust from stacks that are located within specified distances of buildings may be subject to "aerodynamic building downwash" under certain meteorological conditions. This determination is made by comparing actual stack height to the Good Engineering Practice (GEP) stack height. The modeled emission units at the Century Sebree facility and the BREC facility were evaluated in terms of their proximity to nearby structures.

In accordance with recent AERMOD updates, an emission point is assumed to be subject to the effects of downwash at all release heights even if the stack height is above the EPA formula height, which is defined by the following formula:

$$H_{GEP} = H + 1.5L, \text{ where:}$$

where,

H_{GEP}	=	GEP stack height,
H	=	structure height, and
L	=	lesser dimension of the structure (height or maximum projected width).

This equation is limited to stacks located within 5L of a structure. Stacks located at a distance greater than 5L are not subject to the wake effects of the structure.

Direction-specific equivalent building dimensions used as input to the AERMOD model to simulate the impacts of downwash were calculated using the EPA-sanctioned Building Profile Input Program (BPIP-PRIME), version 04274 and used in the AERMOD Model.[18] BPIP-PRIME is designed to incorporate the concepts and procedures expressed in the GEP Technical Support document, the Building Downwash Guidance document, and other related documents and has been adapted to incorporate the PRIME downwash algorithms.[19]

A GEP analysis of all modeled point sources at the Century and BREC facilities in relation to each building was performed to evaluate which building has the greatest influence on the dispersion of each stack's emissions. The GEP height for each stack calculated using the dominant structure's height and maximum projected width was also determined.

According to EPA dispersion modeling guidance,[20] stacks with actual heights greater than either 65 meters or the calculated GEP height, whichever is greater, generally cannot take credit for their full stack height in a SIP modeling analysis. All modeled source stacks at the Century Sebree facility are less than 65 meters tall and therefore meet the requirements of GEP and credit for the entire actual height of each stack was used in this modeling analysis. Some stacks at BREC are greater than 65 meters tall; therefore, a GEP stack height analysis was also completed for BREC stacks to determine the heights that could be modeled.

2.4 Elevated Terrain

Terrain elevations were considered in the modeling analysis. The elevations of receptors, buildings, and sources impact modeled concentrations in cases where there are sources at one elevation and receptor locations at various other elevations at the ambient air boundary and beyond. Elevation data were processed for input to AERMOD through the use of the AERMOD terrain preprocessor called AERMAP (latest version 18081), which generates base elevations above mean sea level of sources, buildings, and/or receptors as specified by the user. For all receptors, AERMAP was used to determine an effective hill height

[18] Earth Tech, Inc., Addendum to the ISC3 User's Guide, The PRIME Plume Rise and Building Downwash Model, November 1997, http://www.epa.gov/scram001/7thconf/iscprime/useguide.pdf.

[19] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *Guidelines for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) (Revised),* Research Triangle Park, North Carolina, EPA 450/4-80-023R, June 1985.

[20] Section 7.2.2.1 of 40 CFR 51, Appendix W.

scale that determines the magnitude of each source plume-elevated terrain feature interaction. AERMOD uses both of these receptor-related values to calculate the effect of terrain on each plume. Base elevations for select sources and buildings, terrain elevations for receptors, and other regional source base elevations input to the model were read and interpolated from 1 arc second (approximately 30-meter resolution) National Elevation Dataset (NED) data obtained from the U.S. Geological Survey (USGS).[21]

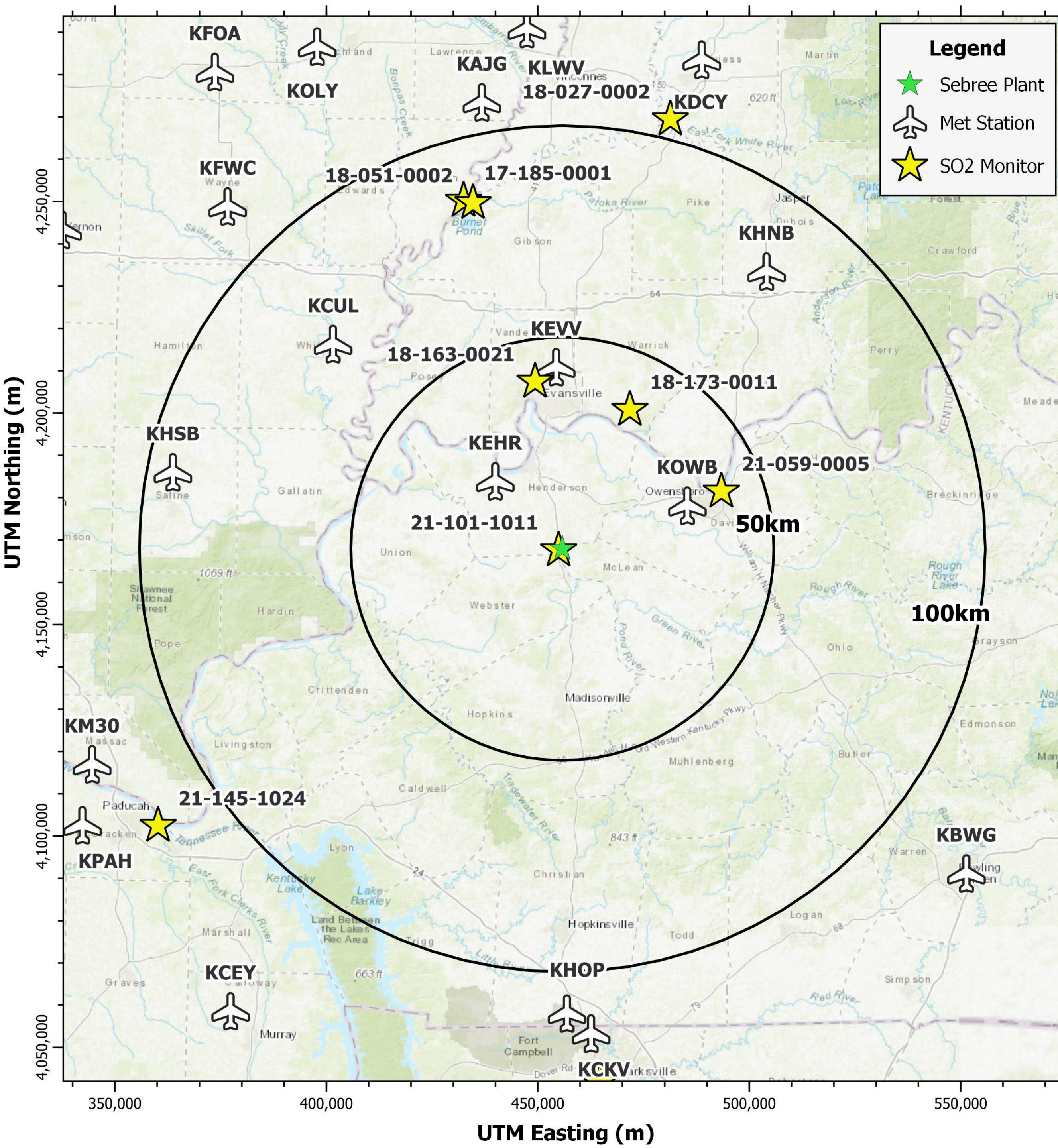
2.5 Meteorological Data

To perform modeling in AERMOD, meteorological data must be preprocessed to input in a format that AERMOD can use. This was accomplished using the AERMET processor (Version 23132) along with nearby sets of site-specific meteorological data and National Weather Service (NWS) data from surface and upper air stations. Since the time that the Sebree SO_2 monitor began operation the beginning of 2017, Century has also operated a meteorological tower, which has collected continuous, site-specific meteorological data. The meteorological tower is located approximately 350 ft east-southeast of the SO_2 monitor. The tower collects data on wind speed and direction, temperature, net and solar radiation, barometric pressure, and relative humidity. The tower was originally installed by Trinity Consultants' Ambient Monitoring Services group and continues to be serviced and calibrated by Trinity. Data collected at this meteorological station were used as the primary surface data for input to AERMET. These data were supplemented with surface data from a representative NWS station. Upper air data were obtained from a nearby station at which radiosonde observations are taken. The most recent, readily available three full years of meteorological data from the site-specific station that were available at the time that the modeling protocol for this analysis was submitted are from 2020 through 2022. Therefore, these years were used in conjunction with NWS data from the same time period.

An evaluation of the NWS meteorological data sites within approximately 120 km of the Sebree Plant reveals that several airports are located in the region (other non-airport data sets were determined to be deficient in terms of data collection and quality). Figure 2-2 shows the locations of the airports (indicated by four letter designations beginning with K) having meteorological data sets that were considered to supplement the site-specific surface data for this modeling. Unfortunately, most of the airports within the vicinity of Sebree Plant do not utilize Automated Surface Observing Systems (ASOS) to record 1-minute data for use in the AERMINUTE preprocessor. Proximity of the meteorological station to the modeled facility is also an important consideration in meteorological station selection. The only meteorological station sites utilizing ASOS one-minute recording systems and falling within 120 km of Sebree Plant were the Evansville Regional Airport (KEVV, 22.3 km north of Sebree Plant) and the Clarksville (TN) Regional Airport/Outlaw Field (KCKV, 114.6 km south of Sebree Plant). Table 2-2 presents the results of an NWS identification and selection analysis based on proximity to Sebree Plant where meteorological stations without adequate data are designated with gray highlighting and candidate stations for the modeling analysis are designated without highlighting.

[21] U.S. Geological Survey, USGS 3D Elevation Program (3DEP), accessed October 21, 2021 at https://apps.nationalmap.gov/downloader/#/

Figure 2-2. Meteorological Stations and SO_2 Monitors in the Area Near Sebree Plant



All coordinates shown in UTM Coordinates,
UTM Zone 16, NAD 83 Datum

Table 2-2. Proximity Analysis of Meteorological Stations to Sebree Plant

Station Name	WBAN Station ID	Station Call Sign	Lat.	Long.	ASOS One Minute Data Available	Distance to Sebree Plant (km)
Henderson City-County Airport	53886	KEHR	37.800	-87.683	No	22.5
Owensboro-Daviess County Airport	53803	KOWB	37.750	-87.167	No	31.2
Evansville Regional Airport	93817	KEVV	38.044	-87.521	Yes	43.0
Carmi Municipal Airport	63840	KCUL	38.089	-88.123	No	72.7
Huntingburg Airport	53896	KHNB	38.249	-86.954	No	81.4
Harrisburg-Raleigh Airport	53897	KHSB	37.811	-88.549	No	93.7
Mount Carmel Municipal Airport	63853	KAJG	38.607	-87.727	No	107.4
Campbell AAF Airport	13806	KHOP	36.667	-87.483	No	110.1
Fairfield Municipal Airport	53891	KFWC	38.379	-88.413	No	113.2
Clarksville Regional/Outlaw Field Airport	3894	KCKV	36.624	-87.419	Yes	115.1

2.5.1 Meteorological Data Processing – Site Specific Data

Hourly average meteorological parameters were used in AERMET derived from the data collected at the site-specific monitor described earlier. The following parameters were input: wind speed and wind direction at 10 meters above ground level, temperature at 2 meters and 10 meters above ground level, relative humidity, solar radiation, net radiation, barometric pressure, and precipitation. The default ADJ_U* option was used in the meteorological data processing because full site-specific turbulence parameter data are not collected.

The Quality Assurance Project Plan (QAPP) for the site-specific meteorological station is provided in Appendix B of this modeling report. The QAPP was implemented and semi-annual calibrations and performance audits were completed such that either a calibration or audit was completed each calendar quarter. The only exceptions to quarterly audits or calibrations were during the 1st and 2nd quarters of 2020 when travel was restricted due to COVID19, and calibrations and performance audits could not be performed. However, the 3rd quarter 2020 calibration, which was completed in September 2020, found no issues with the instrumentation that would invalidate the data collected between the December 2019 and September 2020 calibrations. Additionally, during the August 4, 2022 calibration, the wind direction and temperature sensors were determined to be outside acceptance tolerances. Therefore, these sensors were replaced and data for these sensors since the previous calibration were flagged as invalid and not used in the met data processing.

2.5.2 Meteorological Data Processing – NWS Surface Data

Unprocessed hourly surface meteorological field data were obtained from the U.S. National Climatic Data Center (NCDC) for the Evansville Regional Airport (KEVV) for 2020-2022 in the standard ISHD (integrated surface hourly data) format[22]. These data were supplemented with TD-6405 (so-called "1-minute") wind data for the station[23] and processed using the latest version of the AERMINUTE pre-processing tool (version 15272). A threshold wind speed of 0.5 m/s was used in AERMET as per EPA guidance. The "Ice-Free Winds

[22] ftp://ftp.ncdc.noaa.gov/pub/data/noaa/

[23] ftp://ftp.ncdc.noaa.gov/pub/data/asos-onemin

Group" AERMINUTE option was selected due to the fact that a sonic anemometer has been installed at KEVV since September 26, 2006[24].

2.5.3 Meteorological Data Processing - Upper Air Data

In addition to surface meteorological data, AERMET requires the use of data from an upper air sounding to estimate mixing heights. Upper air data from the nearest representative U.S. National Weather Service (NWS) radiosonde equipped station were utilized in the modeling analysis. In this case, two upper air stations were considered, namely, from the Nashville International Airport (KBNA, WBAN No. 13897), which is about 176 km south of the Sebree Plant, and from the Lincoln-Logan County Airport (KILX, WBAN No. 04833), which is about 318 km northwest of the Sebree Plant. The proximity of the Nashville station compared with the Lincoln station makes the Nashville station the most representative choice for the Sebree area. Data were obtained from the National Oceanic and Atmospheric Administration (NOAA) in FSL (Forecast Systems Laboratory) format[25] for the same period of record, namely, 2020-2022.

2.5.4 Meteorological Data Processing – Land Use Analysis

Parameters derived from analysis of land use data (surface roughness parameter, Bowen ratio, and albedo) are also required by AERMET. In accordance with EPA guidance, these values were determined using the latest version of the AERSURFACE tool (version 20060)[26] for both the site-specific surface station and the Evansville Regional Airport (KEVV) surface station using NLCD 2016 data including land cover, canopy, and impervious surface data. AERSURFACE reads gridded land use and land cover data as provided by the United States Geological Survey (USGS)[27] and associates such data with representative values of the three parameters listed above. The parameters were defined using a 1 km radius for surface roughness and seasonally varying characteristics for all parameters. The surface roughness was defined using customized sectors for both the site-specific station and KEVV, as shown in Figure 2-3 and Figure 2-4. Using professional judgement, these customized sectors were determined based on an evaluation of aerial imagery, tree canopy data, impervious surface data, and land use categories within a 1 km radius of the meteorological data towers. All sectors at the site-specific station were defined as "non-airport" sectors. Sectors from 0-30 degrees, and 216-261 degrees were defined as "airport" sectors at KEVV and the remaining sectors were defined as "non-airport" sectors.

---

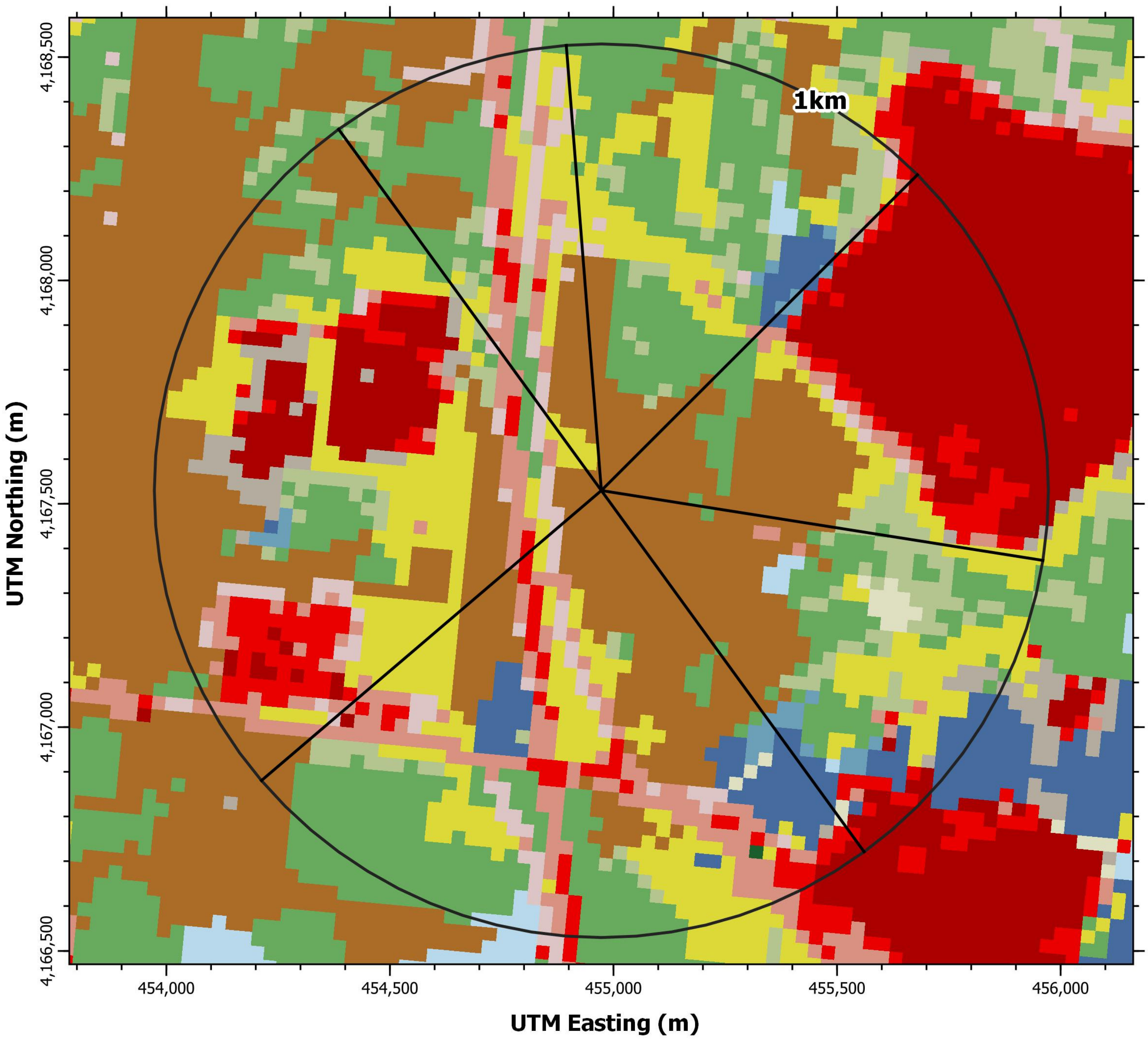
24 http://www.nws.noaa.gov/ops2/Surface/documents/IFW_stat.pdf

25 http://www.esrl.noaa.gov/raobs/

26 U.S. Environmental Protection Agency. 2020. "AERSURFACE User's Guide." EPA-454/B-20-008, Revised February 2020. Available Online: https://gaftp.epa.gov/Air/aqmg/SCRAM/models/related/aersurface/aersurface_ug_v20060.pdf

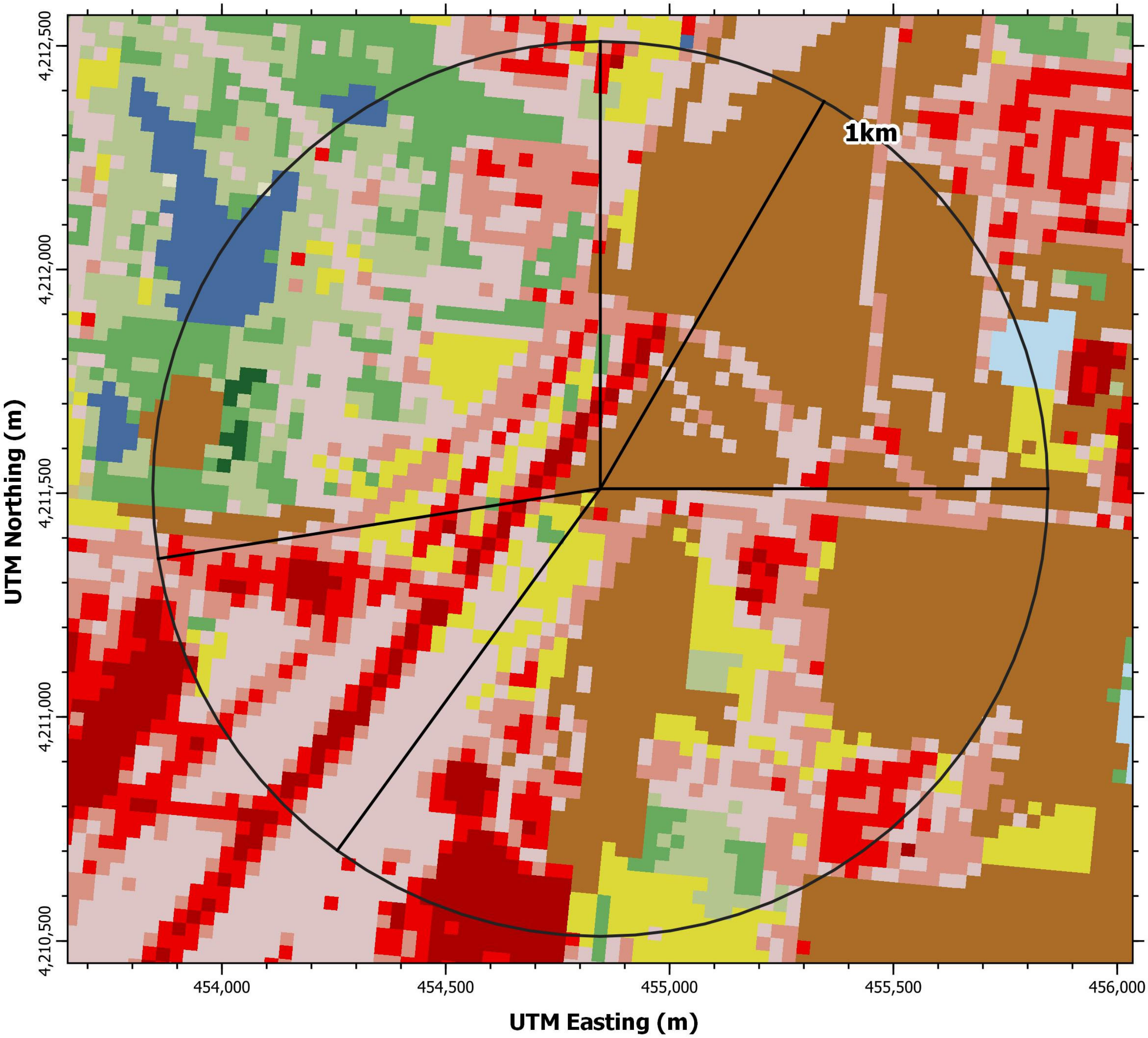
27 http://www.mrlc.gov/viewerjs/

Figure 2-3. Land Use and Surface Roughness Sectors for Site-Specific Station



All coordinates shown in UTM Coordinates,
UTM Zone 16, NAD 83 Datum

Figure 2-4. Land Use and Surface Roughness Sectors for KEVV



The land use-related parameters can be varied based on moisture conditions (wet, dry, or average) at the location of the surface meteorological data station. To make the moisture conditions determination, the annual precipitation in each modeled year (2020 through 2022) is compared to the 1991-2020 climatological record.[28] Table 2-3 shows the 30-year precipitation by month for KEVV along with the seasonal totals, averages, and 30th percentile high and low values. These were compared to the actual rainfall in each season for each year of the 2020-2022 modeling period which determined the average, wet, or dry

[28] For Evansville Regional Airport annual and daily rainfall data were retrieved from the National Climatic Data Center. The 2020 Local Climatological Data (LCD) Report was accessed by https://www.ncdc.noaa.gov/IPS/lcd/lcd.html. Missing data from the LCD report was filled using daily precipitation data accessed through https://www.ncdc.noaa.gov/cdo-web/datatools/lcd.

precipitation option in AERSURFACE. Other specific AERSURFACE settings were used that represent the locations of the site-specific meteorological tower and KEVV. These settings include location coordinates, monthly versus seasonal differentiation, aridity, and, of course, the surface moisture determination which was just discussed. This determination is used in AERSURFACE to adjust the Bowen ratio estimated by AERSURFACE, which in turn affects the calculation of the daytime mixing heights calculated in AERMET and used in AERMOD.

Table 2-3. Moisture Calculation for Evansville Regional Airport, KEVV (inches of precipitation)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	Winter	Spring	Summer	Fall
1993	3.57	2.61	3.23	4.38	4.20	4.65	2.37	2.17	5.59	3.76	6.62	2.68	45.83	8.86	11.81	9.19	15.97
1994	3.18	2.32	1.88	5.77	0.94	3.45	2.30	2.52	2.61	2.67	6.52	2.59	36.75	8.09	8.59	8.27	11.8
1995	2.82	2.98	2.53	5.59	13.51	4.56	2.88	3.60	0.47	2.01	2.32	3.19	46.46	8.99	21.63	11.04	4.8
1996	3.51	1.50	5.19	11.83	7.32	7.78	4.56	1.20	8.45	2.53	6.66	3.50	64.03	8.51	24.34	13.54	17.64
1997	4.20	3.35	6.90	4.16	7.57	6.12	1.71	4.02	1.31	1.73	4.17	2.34	47.58	9.89	18.63	11.85	7.21
1998	2.24	2.71	3.07	8.50	5.91	5.31	3.89	3.91	0.49	3.38	2.78	3.48	45.67	8.43	17.48	13.11	6.65
1999	6.00	1.94	4.30	6.15	3.21	6.27	2.00	0.64	0.39	2.80	0.51	5.13	39.34	13.07	13.66	8.91	3.7
2000	4.36	7.26	3.21	2.35	2.60	5.86	4.14	5.60	5.03	0.59	3.43	4.12	48.55	15.74	8.16	15.6	9.05
2001	1.29	3.26	2.23	1.60	3.82	3.82	5.54	6.09	2.40	7.27	5.40	7.16	49.88	11.71	7.65	15.45	15.07
2002	3.72	0.74	6.20	8.58	5.70	2.86	4.32	0.63	5.22	3.75	2.97	5.65	50.34	10.11	20.48	7.81	11.94
2003	0.90	4.92	2.60	3.91	6.48	4.50	4.38	1.88	3.17	1.61	4.36	1.20	39.91	7.02	12.99	10.76	9.14
2004	2.95	0.59	2.17	1.91	9.31	1.66	7.56	3.08	0.09	5.62	6.23	2.31	43.48	5.85	13.39	12.3	11.94
2005	4.59	2.77	2.85	2.13	2.33	4.88	2.69	8.51	2.00	0.73	5.93	1.76	41.17	9.12	7.31	16.08	8.66
2006	4.09	2.17	9.36	3.44	5.77	3.73	6.46	7.41	8.75	5.46	4.95	4.59	66.18	10.85	18.57	17.6	19.16
2007	5.47	3.41	2.66	2.88	2.73	2.71	1.97	0.99	2.22	4.64	1.77	6.34	37.79	15.22	8.27	5.67	8.63
2008	3.97	5.97	12.34	5.07	8.07	3.09	3.90	0.52	1.16	1.61	3.42	4.76	53.88	14.7	25.48	7.51	6.19
2009	2.85	2.76	3.32	6.01	6.47	2.20	6.46	1.91	5.17	8.21	1.22	3.62	50.20	9.23	15.8	10.57	14.6
2010	2.41	1.58	3.97	3.27	3.03	2.49	3.51	0.84	0.36	1.06	8.46	1.80	32.78	5.79	10.27	6.84	9.88
2011	1.65	4.52	5.34	11.77	7.90	6.52	6.66	0.62	8.20	2.49	8.32	6.04	70.03	12.21	25.01	13.8	19.01
2012	3.39	1.75	2.51	1.44	2.29	0.15	2.34	4.10	7.60	2.90	1.19	3.47	33.13	8.61	6.24	6.59	11.69
2013	6.76	2.77	4.08	3.86	5.08	7.55	3.59	1.64	2.81	6.07	2.04	7.33	53.58	16.86	13.02	12.78	10.92
2014	1.69	2.26	2.85	10.97	3.72	3.87	4.02	4.80	2.55	4.20	2.85	3.43	47.21	7.38	17.54	12.69	9.6
2015	2.97	2.56	6.85	6.62	3.44	7.39	4.67	3.06	1.05	3.01	5.12	5.20	51.94	10.73	16.91	15.12	9.18
2016	**2.00**	4.34	5.87	5.49	4.05	4.37	9.20	3.14	4.01	0.49	2.70	3.92	49.58	10.26	15.41	16.71	7.2
2017	2.27	1.00	3.85	9.89	3.99	3.60	5.66	2.15	3.24	3.71	1.70	2.42	43.48	5.69	17.73	11.41	8.65
2018	**2.97**	9.24	5.22	3.76	5.75	**5.16**	3.75	0.95	7.00	2.15	4.14	**6.15**	56.24	18.36	14.73	9.86	13.29
2019	4.05	7.34	7.27	5.46	5.63	7.53	3.53	5.19	0.08	6.26	5.95	2.93	61.22	14.32	18.36	16.25	12.29
2020	5.58	3.76	7.36	3.59	6.03	7.08	6.45	6.02	2.43	6.85	3.45	2.01	60.61	11.35	16.98	19.55	12.73
2021	3.41	4.69	4.57	2.87	3.04	2.36	4.01	6.74	4.82	**3.36**	1.61	4.12	45.60	12.22	10.48	13.11	9.79
2022	3.84	7.29	4.97	3.85	3.75	0.97	5.93	2.46	6.13	1.37	1.16	3.60	45.32	14.73	12.57	9.36	8.66

* Bolded values were either blank or unavailable in the 2022 30-yr LCD Report for KEVV. As such, daily data was downloaded and summed for the appropriate month. Source: https://www.ncdc.noaa.gov/cdo-web/datatools/lcd

	Winter	Spring	Summer	Fall
Upper 30th	12.21	17.60	13.62	12.05
Lower 30th	8.79	12.34	9.71	8.66
2017	D	W	A	D
2018	W	A	A	W
2019	W	W	W	W
2020	A	A	W	W
2021	W	D	A	A
2022	W	A	D	D

A = Average Precipitation
D = Dry Precipitation
W = Wet Precipitation

As shown in Table 2-4, the surface data used in AERMOD is greater than 90% complete (i.e., less than 10% missing) each year. The number of calm and missing hours from are shown for each year in Table 2-4.

Table 2-4. Meteorological Data Valid Hours

Year	Number of Calm Hours	Number of Missing Hours	Missing Hours (%)
2020	8	405	4.61%
2021	22	469	5.35%
2022	81	464	5.30%

2.6 Coordinate System

In this modeling analysis, the location of emission sources, structures, and receptors were represented in the Universal Transverse Mercator (UTM) coordinate system. The UTM grid divides the world into coordinates that are measured in north meters (measured from the equator) and east meters (measured from the central 500 km meridian of each UTM zone, where the world is divided into 36 north-south zones). The datum for the Century and BREC modeling analysis is based on North American Datum 1983 (NAD 83). UTM coordinates for this analysis all reside within UTM Zone 16, which served as the reference point for all Century Sebree data as well as all regional receptors and sources.

2.7 Receptor Grids

Ground-level concentrations of SO_2 were calculated on a receptor grid that covers the Henderson-Webster SO_2 nonattainment area and extend outside the nonattainment area to the east of the Green River adjacent to the Century Sebree and BREC plants. The following nested grids were used:

- **Ambient Air Boundary Grid:** "Ambient air boundary line" grid consisting of evenly spaced receptors 50 meters apart placed along the ambient air boundary for the Century Sebree and BREC plants,
- **Fine Cartesian Grid:** A "fine" grid containing 100-meter spaced receptors extending approximately 3 km from the center of the property and beyond the ambient air boundary within the nonattainment area (including within BREC property),
- **Medium Cartesian Grid:** A "medium" grid containing 250-meter spaced receptors within the nonattainment area extending from 3 km to 5 km from the center of the Century Sebree plant, exclusive of receptors on the fine grid,
- **Coarse Cartesian Grid:** A "coarse grid" containing 500-meter spaced receptors within the nonattainment area extending from 5 km to 10 km from the center of the Century Sebree plant, exclusive of receptors on the fine and medium grids, and
- **Very Coarse Cartesian Grid:** A "very coarse grid" containing 1,000-meter spaced receptors within the nonattainment area extending from 10 km to 20 km from the center of the Century Sebree plant, exclusive of receptors on the fine, medium, and coarse grids.

This configuration and extent captured the area of maximum modeled concentrations. The receptor grid is shown in Figure 2-5.

The ambient air boundary grid, shown in Figure 2-6, surrounds the property owned, secured, and patrolled by Century. Because access by the general public is precluded, these areas are not considered "ambient air". A permanent fence is currently in place on the western property boundary from Moss and Moss Road (an east-west road traversing the property) down to the main plant entrance. Century is currently in a process of extending the permanent fence down along the remaining western property boundary and then east over to the river. This new extended fencing is anticipated to be in place by the time the nonattainment SIP to be submitted by the Division is approved by EPA.

As shown in Figure 2-6, the entire southeast edge of the Century property runs along the river, which itself acts as a barrier to access. To the south and directly adjacent and abutting the Century property, the entire BREC property is fenced restricting public access.

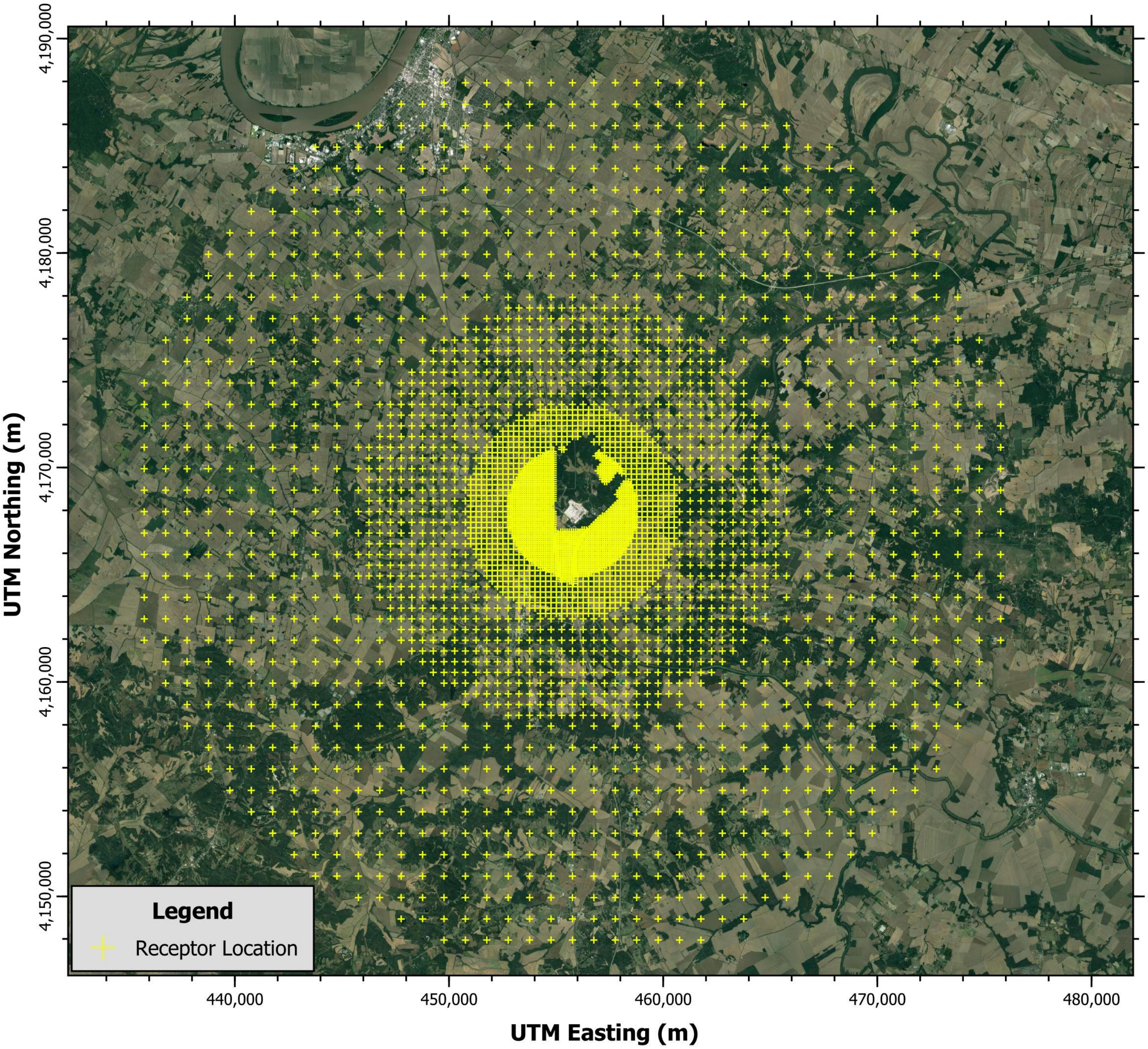
The areas of Century property north of Moss and Moss Road are not fenced. However, these property boundaries exist along areas of dense vegetation that preclude access to the general public from these undeveloped areas of the property.

Century does allow certain non-industrial uses of its property (e.g., farming) by individuals not directly employed by Century; however, these individuals are only granted access based on the conditions of a contractual agreement with Century which makes them not part of the "public" that the NAAQS are designed to protect.

The ambient air boundary for Century Sebree as represented in Figure 2-6 is consistent with that approved for modeling conducted as part of the Prevention of Significant Deterioration (PSD) permits issued in 2007 and 2010 for the facility. It is also consistent with the latest EPA guidance on "ambient air".[29]

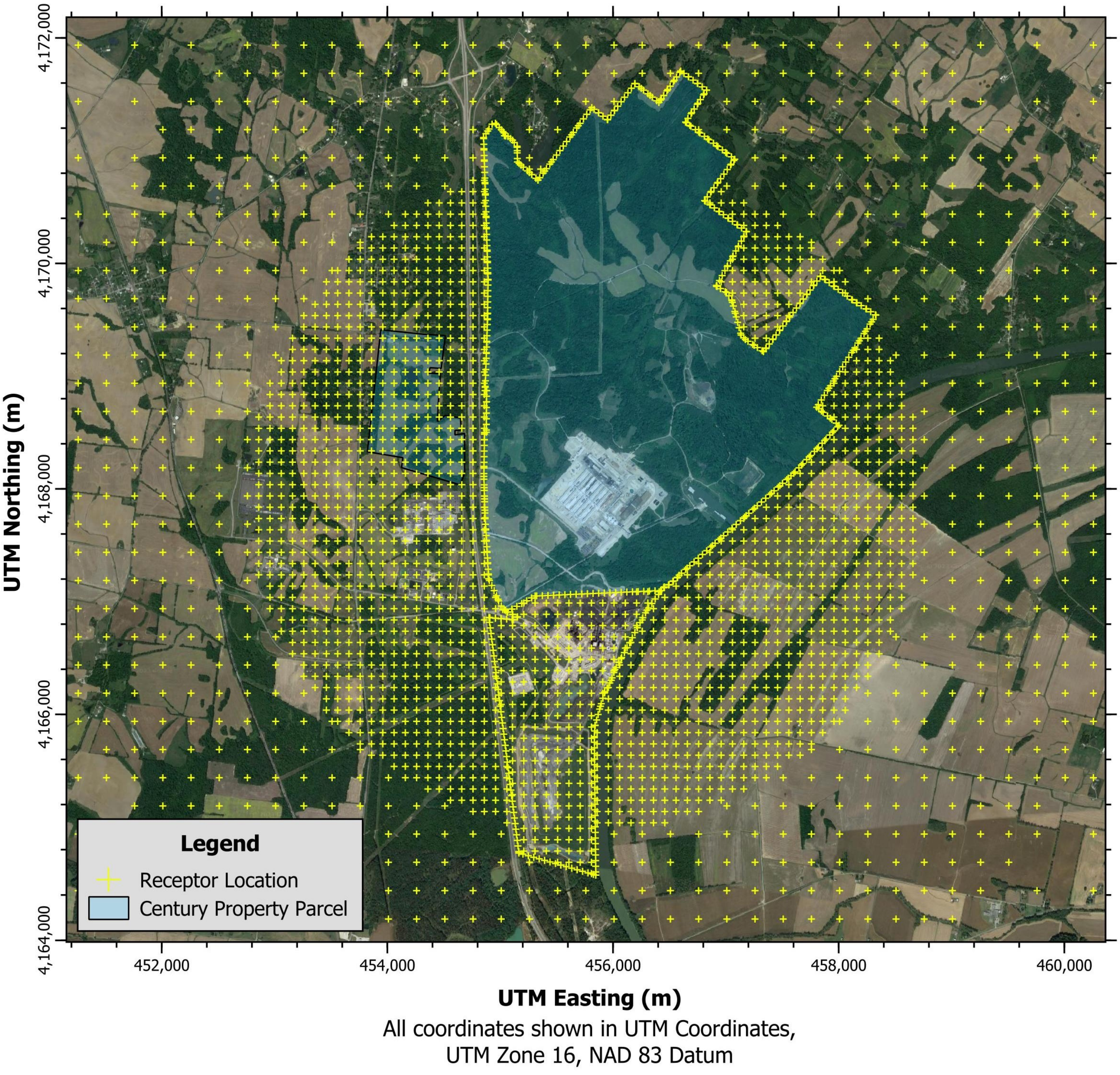
[29] https://www.epa.gov/sites/default/files/2019-12/documents/revised_policy_on_exclusions_from_ambient_air.pdf

Figure 2-5. Receptor Grid



All coordinates shown in UTM Coordinates,
UTM Zone 16, NAD 83 Datum

Figure 2-6. Ambient Air Boundary View of Receptor Grid and Property



2.8 Century Sebree Emission and Release Inventories

At the Sebree Plant, Century produces primary aluminum through the electrolytic reduction of raw alumina (Al_2O_3) in vessels termed reduction cells or "pots". Century operates three nearly identical potlines at the Sebree plant. Each pot is constructed as a complete electrolytic circuit with anode, cathode, and electrolyte. When electric current is applied through metal rods to the carbon anodes, alumina is reduced producing molten aluminum metal and carbon dioxide (CO_2). Pots are periodically tapped and molten aluminum is either transferred in crucibles to customers or is first cast into aluminum sows, billets, ingots or other hard forms and then shipped off-site.

Raw material inputs to the pots include alumina, bath, carbon anodes, and various other additives to the aluminum production process such as aluminum fluoride. Each potline is composed of two potrooms that each contain 64 reductions cells for a total of 128 cells per potline. The emissions from the reduction cells in each potline are captured through hooding systems and are sent to two Alcoa A-398 alumina fluidized bed dry scrubbers, each of which has five reactors. Emissions from the pots not captured by the hooding system are released as secondary emissions through the centerline roof vent of each potroom building.

To provide baked carbon anodes to the reduction cells, Century operates an anode paste mixing and forming operation and an anode bake furnace, in which the "green anodes" are baked. The green anodes are formed from petroleum coke, recycled spent anode material, and pitch, which serves as a binder. The formed anodes are compressed and placed within the bake furnace, where they are baked to remove volatiles, leaving a solid carbon block. The emissions from the paste mixing and anode forming units are vented to a common control device, a Procedair dry coke scrubber. The emissions from the anode bake furnace are sent to an Alcoa A-446 alumina fluidized bed scrubber.

The Sebree Plant has a number of miscellaneous sources of SO_2 emissions, including a natural gas fired Remelt Furnace, two groups of natural gas fired Holding Furnaces, four Homogenizing Furnaces, small natural gas boilers and pre-heaters, and six emergency generators. However, these emission sources make up less than one tenth of one percent (0.1%) of the total SO_2 emissions at the Sebree Plant. **The vast majority of SO_2 emissions (>99.9%) are emitted from the potlines and anode bake furnace.**

2.8.1 Emission Sources Modeled

The SO_2 emission units at the facility (and their corresponding Subject Item Designations) included in the modeling analysis are the following:

1. Potlines 1-3 (E1, E3, and E5)
2. Remelt Furnace (A6-90)
3. Holding Furnaces (F1 & F2)
4. Homogenizing Furnaces (H1-H4)
5. Anode Bake Furnace (N2)
6. Indirect Heat Exchanger (S6)[30]
7. Green Mill Boiler (S7)
8. Small Natural Gas Boilers (A3, A4, A7, A9, I4)[31]
9. Five (5) Crucible Pre-Heater Stations (Insignificant Activities)
10. Auto Sow Casting Pre-Heater Stations (Insignificant Activities)

All of these sources were modeled as point sources except for the crucible pre-heater stations, auto-sow casting pre-heater stations, and potline roof vents. The crucible pre-heater stations and auto sow casting pre-heater stations are located inside the casting building and do not have dedicated stacks. Therefore, each of these sources were modeled as a single volume source based on the building dimensions. The potline roof vents were modeled as buoyant line sources.

Source parameters for each Century Sebree source used in the modeling analysis are listed in Appendix C.

---

[30] Note that in the model files, this unit is referenced as the Electrode Boiler (S5). The Electrode Boiler has been removed but has identical heat input capacity and stack parameters to the Indirect Heat Exchanger (S6); therefore, the model represents emissions from S6.

[31] The Building 004 Water Heater (A7) and Building 004 Miller Pickling Boiler (A9) have been removed from service. However, they are retained in the model files to remain consistent with the previously submitted modeling protocol.

2.8.2 Planned Replacement of Stack for Anode Bake Furnace

The source parameters for the Anode Bake Furnace (ABF) take into account the planned redirect of the exhaust from the three existing adjacent 4.2-ft diameter, 70-ft tall stacks on the A-446 scrubber modules to a new 213.2-ft tall, 8.5-ft diameter stack to be situated adjacent to the existing A-446 scrubber system. This stack change along with the establishment of new lower limits on allowable SO_2 emissions from the ABF and potlines are the primary measures being proposed to reduce ambient SO_2 concentrations surrounding the Sebree Plant.

2.8.3 Potline Roof Vents

To account for the buoyancy of the emissions from the potline roof vents, the buoyant line source type requires the following parameters. Values used in the modeling analysis for the Century Sebree potline roof vents are provided with each parameter.

- Average Building Width, Length, and Height (19.81, 369.11, and 14.78 m, respectively);
- Average Line Source Width (2.44 m);
- Average Separation Between Buildings (35.0 m); and
- Average Buoyancy Parameter, which is a function of line source width, average building length, exit velocity, vent temperature, and ambient temperatures (330.0 m^4/s^3).

Periodic performance testing of the roof vents is required under Century's current Title V air permit. Potline roof vent parameters were derived from performance tests conducted during the three-year period modeled (i.e., 2020-2022). Although the buoyancy parameter for the roof vents would be subject to seasonal variations, the performance tests on the roof vents are conducted semi-annually at regular intervals. As such, insufficient data was available to derive a monthly or seasonally varying buoyancy parameter, so an annual average buoyancy parameter was selected for the modeling analysis. Physical dimensions of the roof vents and potroom buildings were taken from the design drawings and the average separation between buildings was measured from aerial imagery.

2.8.4 Alumina Fluidized Bed Dry Scrubbers

The A-398 alumina fluidized bed dry scrubbers for Potlines 1 and 2 each consist of five reactors and are configured with ten stacks, two for each reactor, located in close proximity to one another as illustrated in Figure 2-7.[32] As there is a separate dry scrubber for the north and south sides of the potrooms of each potline, there are two groups of stacks associated with Potline 1 (a north group and a south group) and two groups of stacks associated with Potline 2 (north and south groups) with each group having ten stacks. The close proximity of these stacks can result in enhanced plume rise due to the merging of the plumes compared with modeling each stack individually in AERMOD, which does not account for plume interaction. For each group of A-398 scrubber stacks (four groups total between Potlines 1 and 2), the common stack height and exit velocity were retained and entered into AERMOD. However, an equivalent stack diameter was input to AERMOD based on the combined stack top area of the A-398 stacks.[33] A similar approach has been employed in EPA approved modeling completed under the SO_2 DRR for another primary aluminum

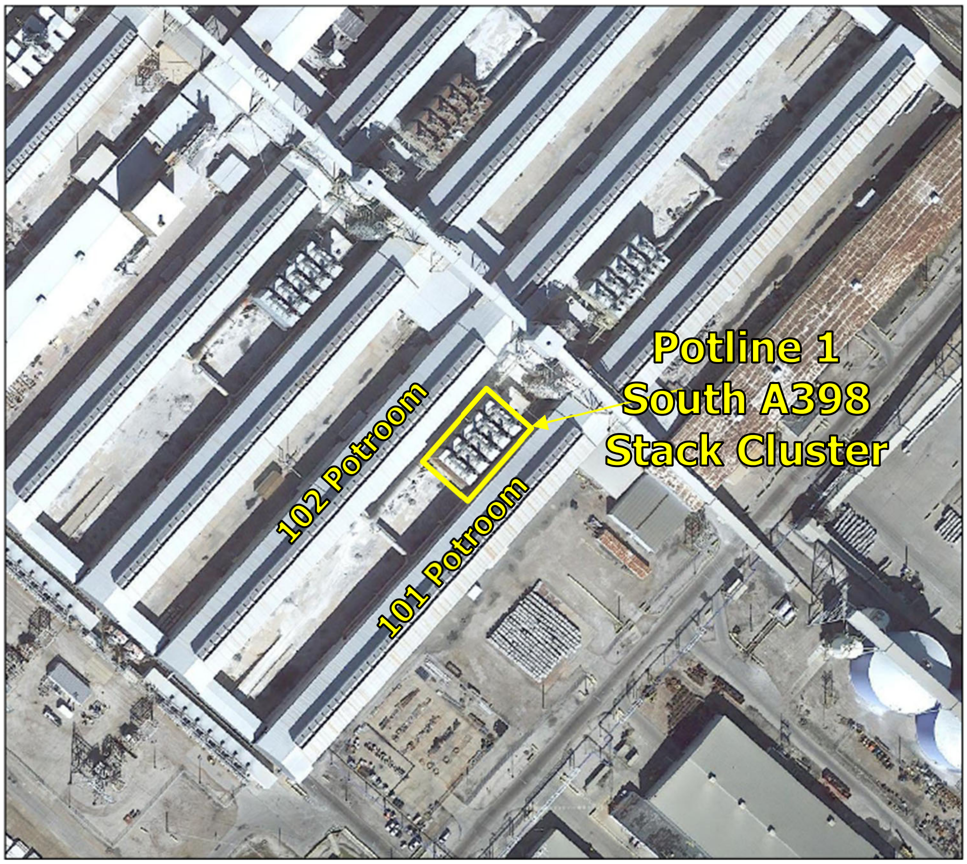
[32] Each stack has a diameter of 1.21 meters and is located approximately 6 meters from its nearest neighboring stack.

[33] Each stack is round with a diameter of 1.21 meters and an exhaust exit area of 1.155 m^2 based on the formula for the area of a circle ($\pi \times (D/2)^2$). The equivalent area of ten stacks would be 11.55 m^2 (i.e., 1.155 $m^2 \times 10$). Using the formula for the area of a circle ($D = 2 \times \mathrm{SQRT}(A/\pi)$), the equivalent diameter for the ten stacks is 3.84 m.

smelter located in the Ohio River valley.[34] Additionally, the AERMOD model performance evaluation presented in Appendix A documents more realistic model output concentrations versus monitored data collected near the Century Sebree facility when the stack merging technique is used.

Potline 3 has a different exhaust configuration for the A-398 scrubbers compared with Potlines 1 and 2. There are two groups of scrubbers associated with Potline 3 (north and south groups), but all five of the scrubber reactors associated with each group exhaust to a common stack. The common stack is located in the center of the yellow rectangle shown in Figure 2-8. For this reason, the A-398 scrubbers associated with Potline 3 are modeled as a single points source for each of the two A-398 scrubbers associated with Potline 3 (one for the north A-398 and one for the south A-398).

Figure 2-7. Aerial Image of Potline 1 South A-398 Stack Configuration



[34] Technical Support Document, Final Round 3 Area Designations for the 2010 1-Hour SO_2 Primary National Ambient Air Quality Standard for Indiana. https://www.epa.gov/sites/default/files/2017-12/documents/13-in-so2-rd3-final.pdf

Figure 2-8. Aerial Image of Potline 3 South A-398 Stack Configuration

2.8.5 Intermittent Sources

The remaining sources of SO_2 emissions are emergency use engines (termed intermittent sources) and thus, do not normally contribute to the annual distribution of daily maximum 1-hour SO_2 concentrations. The engines are typically only run for testing and maintenance purposes, which does not occur simultaneously for multiple engines. The list of emergency use engines and their associated maximum hours of operation in the 5 years from 2018 to 2022 is presented below.

1. Natural Gas Emergency Generator (Z2) – 1.1 hours/year
2. Cummins Propane Generator (Z3) – 24.5 hours/year
3. Detroit Diesel Fire Pump Engine (Z4) – 14.8 hours/year
4. Building 001 Natural Gas Emergency Generator (Z5) – 11.5 hours/year
5. Rock House Natural Gas Emergency Generator (Z6) – 18.1 hours/year
6. Lift Station Propane-Fired Emergency Generator (Z7) – 29.8 hours/year
7. Building 044 Natural Gas Emergency Generator (Z8) – 4.8 hours/year
8. Building 001 IT Generator – 7.4 hours/year

Due to their infrequent operation, these engines were excluded from the modeling analysis in accordance with EPA's guidance on intermittent source modeling for the 1-hour SO_2 NAAQS.[35]

[35] Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard, Memorandum from Tyler Fox, Leader, Air Quality Modeling Group, to Regional Air Division Directors, date March 1, 2011.

2.8.6 SO_2 Emission Rates

Emission rates representative of future allowable SO_2 emission rates were used for all Century Sebree sources consistent with requirements specified in Section 6.1 of Appendix A to EPA's Nonattainment SIP Guidance.[36]

Century utilizes a mass balance approach, as required by the current Title V permit, to quantify 12-month rolling total SO_2 emissions from the potlines and ABF combined. This approach has been reviewed and scrutinized by the Division as part of two past PSD permit actions as well as several Title V permit actions and yields accurate estimates of total monthly emissions. With regard to variability of emissions within a month, because each potline has numerous pots (128 per potline) in continuous operation, even while each pot individually operates on a batch cycle, it is reasonable to treat each potline as a whole as operating in a continuous, steady-state manner. It is further reasonable to expect that the SO_2 emission rate from the potlines is relatively stable and that short-term variability in SO_2 emissions from the potlines is relatively low. In a similar vein, although the anodes within a given pit in the ABF are processed on a batch cycle, because there are multiple firing trains in operation continuously and so many pits moving stepwise through their respective baking cycle, a relatively stable SO_2 emission rate from the ABF is also assumed.

In parallel with work on the model attainment demonstration, Century will be working with the Division to facilitate the issuance of a Title V permit significant revision, and through this process Century anticipates that a new set of 30-day average SO_2 emission limits will be set along with appropriate compliance demonstration methods. However, rather than modeling SO_2 emissions at these proposed allowable emission rates, the values modeled for the SIP modeling demonstration were inflated in consideration of the short-term (1-hour) form of the SO_2 NAAQS. Due to this form, EPA's Nonattainment SIP Guidance suggests that while a 30-day average emission rate is suitable for the purpose of establishing enforceable emission limits, the 30-day average values should be inflated (adjusted upward) to define a conservative 1-hour emission rate for the modeling analysis.

In the case of the Century Sebree SO_2 emission sources, the actual spread between the minimum and maximum 1-hour emission rates in a 30-day period should be relatively small as a percentage of the average. Also, it is statistically improbable that a peak 1-hour emission rate occurring from one of the dry alumina scrubber systems (i.e., two separate systems for each potline half and one for the ABF) would coincide with a peak occurring in the same hour at another scrubber system at the plant. Regardless, in spite of the expected relatively steady-state nature of SO_2 emissions from the key Century emission units (i.e., the potlines and ABF), in line with EPA's Nonattainment SIP Guidance and as documented in the modeling protocol for this SIP demonstration analysis, an inflation factor was applied to the proposed 30-day average SO_2 emission limits to yield higher 1-hour emission rates for input to the AERMOD model. Specifically, Century used the 30-day to 1-hour ratio of 0.79 specified for uncontrolled SO_2 sources in Appendix C of the Nonattainment SIP Guidance to define the 1-hour emission rates that are input to AERMOD for the potlines and ABF (i.e., emission rates used in the AERMOD model are 1.266 times the 30-day average emission limit values). The inflated modeled emission rates are documented in Appendix C of this report.

While Century is proposing to establish new federally enforceable 30-day average emission limits on the ABF and potlines combined, it is necessary to account for month-to-month variability in the distribution of SO_2 emissions between the ABF and potlines. Emissions variability can be affected by numerous process factors

---

[36] Guidance for 1-Hour SO_2 Nonattainment SIP Submissions, Memorandum from Stephen D. Page, Director, to Regional Air Division Directors, Regions 1-10, dated April 23, 2014.

such as variations in green anode sulfur content, anode bake furnace performance, and potline anode consumption rates. Therefore, Century will be proposing one combined 30-day average emission limit for both the potlines and ABF based on a normal expected distribution of emissions between the two sources. Then, in anticipation of a determination from the Division that individual emissions limits on each source (ABF and potlines) will also be needed, the individual emission limits for the ABF and potlines will be set at expected source-specific maximums to account for the month-to-month variability. Because SO_2 emissions combined will be capped, in months when the SO_2 emissions from the ABF are higher, the SO_2 from the potlines will necessarily be lower, and in months when the SO_2 emissions from the potlines are higher, the SO_2 from the ABF will necessarily be lower. Separate "highest ABF" and "highest potline" emission scenarios are represented in Table 2-5. Modeling was performed for each of these three emissions scenarios: base, highest ABF, and highest potline.

Table 2-5. 30-Day Average Allowable Emission Rates for Three Modeling Conditions

Emissions Scenario	ABF (lb/hr)[a]	Potline A398 (lb/hr each)	Potline Potroom Building (lb/hr each)	Potlines (lb/hr total)[a]	ABF + Potlines (lb/hr total)[a]	ABF + Potlines (tpy)
Base (Normal Emissions)	157.77	158.65	3.24	971.35	**1,129.12**	4,945.54
Highest ABF Emissions	**237.12**	145.69	2.97	892.00	1,129.12	4,945.54
Highest Potline Emissions	110.65	166.35	3.39	**1,018.47**	1,129.12	4,945.54

a. Bolded values in table correspond to the anticipated 30-day average emission limits to be established in the Century Title V permit. The emission rates modeled were inflated by a factor of 1.266 as documented in this section to account for the 1-hour form of the SO_2 NAAQS.

2.9 BREC Emission and Release Inventories

SO_2 emissions from BREC sources were also modeled as allowable emission rates. Operations at BREC have changed over recent years. These changes, which include permanent shutdowns of certain emission units and fuel conversions of others, were considered in the SIP modeling analysis. After consideration of these changes, the following emission units at BREC were included in the analysis:

1. Green Unit #1
2. Green Unit #2
3. Green Fuel Gas Heater
4. Reid Combustion Turbine

All of these sources were modeled as point sources. Source parameters for each BREC source are shown in Appendix D.

The remaining sources of SO_2 emissions at BREC are emergency use engines (termed intermittent sources) and thus, do not normally contribute to the annual distribution of daily maximum 1-hour SO_2 concentrations. The engines are typically only run for testing and maintenance purposes, which does not occur simultaneously for the two engines. The list of emergency use engines and their associated maximum hours of operation for 2019 to 2022 is presented below.

1. Cummins Fire Pump Engine (EU09) – 35.8 hours/year
2. Generac Emergency Generator (EU10) – 30.2 hours/year

Due to their infrequent operation, these engines were excluded from the modeling analysis in accordance with EPA's guidance on intermittent source modeling for the 1-hour SO_2 NAAQS.[37]

2.10 Background Concentrations

As described in Section 8.3 of the *Guideline*, background concentrations consist of two categories: 1) nearby sources and 2) other sources. "Nearby sources" are those individual sources located in the vicinity of the sources that are the primary focus on the modeling analysis that are not adequately represented by ambient monitoring data. These sources should be few in number (*Guideline* Section 8.3.3(b)(iii)) and are accounted for by explicitly modeling their emissions. "Other sources" are that portion of the background attributable to natural sources, other unidentified sources in the vicinity, and regional transport contributions from more distant sources. Other sources are typically accounted for through the use of ambient monitoring data.

2.10.1 Other Sources

As described in Section 8 of Appendix A to EPA's Nonattainment SIP Guidance, the inclusion of background ambient monitored concentrations as part of the modeled concentrations is important in determining and deciphering the cumulative ambient air impacts. The monitor located near Century Sebree is source oriented and therefore does not represent background. Therefore, a regional site was appropriate for use to characterize the background concentrations. An appropriate and suggested technique in EPA's Nonattainment SIP Guidance is to generate a temporally varying background. This is based on the 99th percentile monitored concentrations by hour of day and season or month. For example, each season may have a 24-hour sequence of concentrations used for every hour and day in the appropriate season.

The background concentrations, thus, considered the above-mentioned factors. Figure 2-2 shows the locations of the nearest ambient monitors. The closest continuous and operating SO_2 monitor in the area is the Evansville-Buena Vista monitor (18-163-0021) located about 40 km north of the Sebree Plant.[38] Choosing a monitor located in the near vicinity of a large town or city would mean city-related sources influencing the monitoring data and therefore providing a conservative estimate of the background sources in the area surrounding the Sebree Plant. The Evansville-Buena Vista monitor is also located in the general vicinity of several larger sources of SO_2 emissions located in Indiana north of Century Sebree, as shown in Figure 2-9 (namely SIGECO A.B. Brown, Alcoa Warrick Power Plant, SIGECO F.B Culley, and Warrick Newco LLC). These sources are not, however, located so close to the monitor that it is considered source-oriented and such that the monitor would be too heavily influenced by a particular source to serve as a reasonable background monitor. SO_2 concentrations at this monitor likely are influenced by combined emissions from these Indiana sources and the monitor can be used to account for both background and concentrations resulting from operation of these sources, as discussed further in the next section.

The next closest operating SO_2 monitor is the Owensboro Primary (21-059-0005) monitor located about 40 km east northeast of Sebree Plant. The Owensboro monitor is located approximately 2 km from the Owensboro Utilities Elmer Smith Station and is therefore likely heavily influenced by emissions from this facility and would not provide a representative picture of background concentrations in the area surrounding the Sebree Plant. The Elmer Smith Station permanently shut down on June 1, 2020, but the three calendar

[37] Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard, Memorandum from Tyler Fox, Leader, Air Quality Modeling Group, to Regional Air Division Directors, date March 1, 2011.

[38] A closer monitor, located at the Baskett Fire Department approximately 25 km north of Sebree Plant, operated until 2019 but is no longer operational.

year period of ambient concentrations from this monitor for 2020 to 2022 would continue to be influenced by the Elmer Smith Station.

2.10.2 Nearby Sources

Other sources of SO_2 emissions in the area surrounding the Century Sebree Plant that are not adequately characterized by ambient monitor data were included, as required, in the modeling. Sources within approximately 20 km of the Sebree Plant were considered for inclusion and were derived from available inventories from the Division and IDEM. In the interest of being complete, significant sources in the 20 km to 50 km distance range from Sebree Plant (i.e., those with Q/d > 1) were also reviewed to determine if they should be included in the modeling (i.e., if they are not adequately characterized by monitor data) and were derived from the same inventories. Figure 2-9 shows an assessment of nearby source locations as well as an SO_2 emissions magnitude indicator (size and color of the source marker on the map). The inner black ring shows SO_2 sources located within 20 km of Century Sebree and the outer black ring shows sources located within 50 km of Century Sebree.

The inventory of sources for regional consideration was pared down by eliminating very small sources or very distant sources using the "20D method". The 20D method says that if the ratio of the emissions to the distance between sources is less than 20 (Q/d < 20), a source does not need to be included in the modeling. The specification of the variables in the 20D analysis include:

Q = Source emissions in tons/year
d = Distance from the target source in kilometers

Every effort was made to ensure emission datasets are as up-to-date as possible for the modeling analysis, including the use of the most recent statewide emission inventories provided by the Division and IDEM, as well as incorporating any novel SO_2 permit limits for regional sources. The actual emission rates, distances from Century Sebree, and the Q/d values are also shown in Table 2-6. As can be seen, the majority of the sources have resulting Q/d values that are considerably less than 20. While this Q/d threshold is not a bright line, it can provide an indication of the expected relative magnitude of concentrations expected near the location of peak modeled concentrations near the Century Sebree and BREC plants.

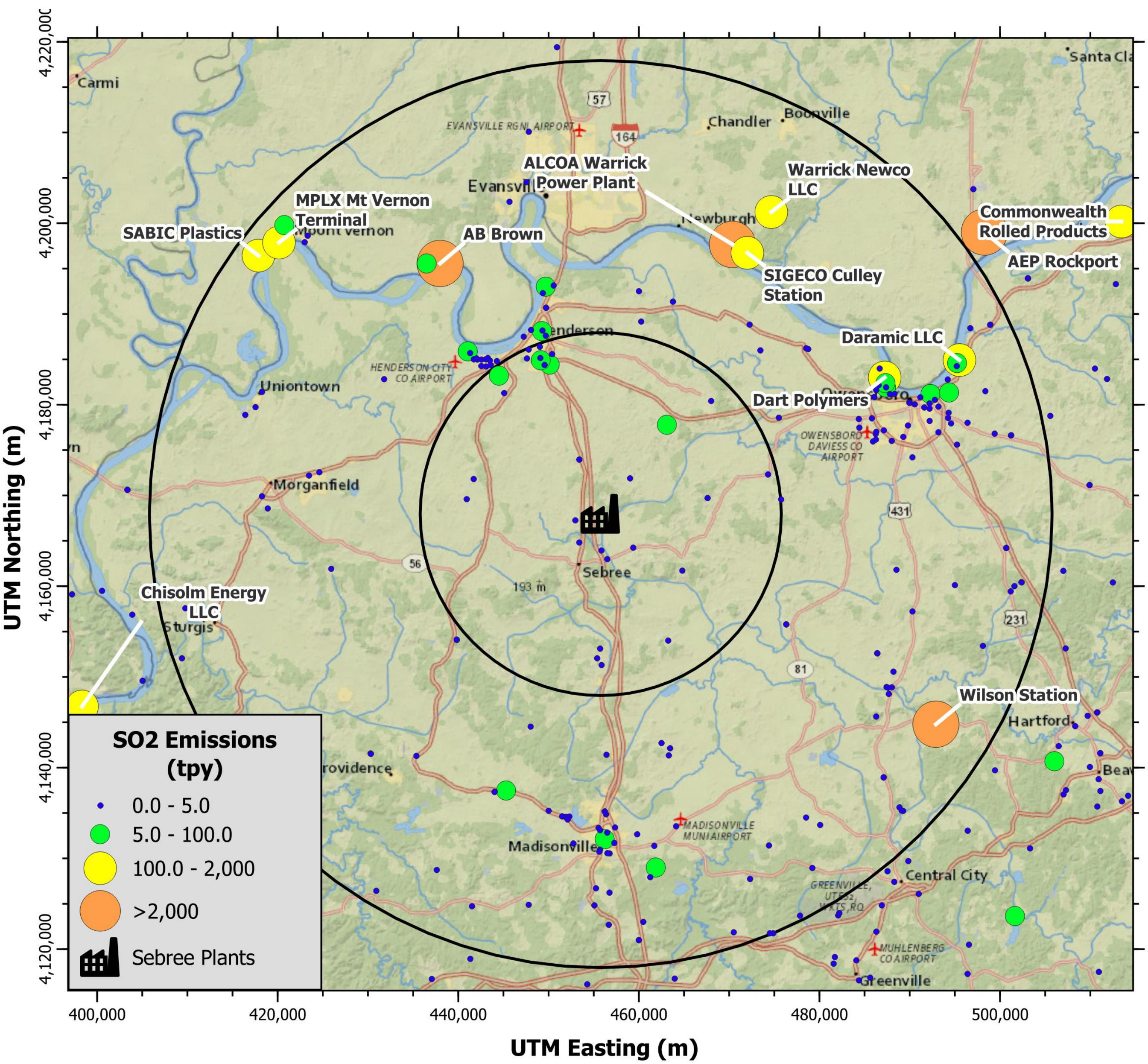
A review of emissions data and distance from Century Sebree yields the following list of sources that do not screen out using the 20D method.

- SIGECO A.B. Brown (32.9 km from Century)
- Alcoa Warrick Power Plant (33.1 km from Century)
- SIGECO F.B Culley (33.1 km from Century)
- Warrick Newco LLC (38.3 km from Century)
- Big Rivers Electric Corp. – Wilson Station (43.7 km from Century)

SIGECO retired the coal-burning units at the A.B. Brown Station in October 2023, leaving only smaller SO_2 sources at the facility. However, at this time SIGECO A.B. Brown retains a permit to operate the coal-burning units. As indicated in the nearby source map (Figure 2-9), A.B. Brown Station can be seen as the orange dot southwest of Evansville and north of the Ohio River. For comparison, the wind rose for Evansville Regional Airport (KEVV) is provided in Figure 2-10. As indicated in the wind rose, a significant portion (approximately 6.5%) of the winds in Evansville blow from the southwest. As such, the Evansville monitor is frequently impacted by SIGECO A.B. Brown Station at a distance of 16.3 kilometers. Due to the distance between Century and the SIGECO A.B. Brown Station (33.4 km), it is reasonable to conclude that the SIGECO A.B. Brown Station is adequately captured in the Evansville-Buena Vista monitor background.

The source release data that were modeled for each of the remaining facilities are provided in Appendix E. The emissions from all explicitly modeled regional sources represented the maximum hourly SO_2 emission rate as provided by either the Division or IDEM. This is a more conservative approach than allowed by Table 8-1 of the *Guideline*, which allows the use of emissions based on the temporally representative level of operation for each unit for "nearby sources".

Figure 2-9. Map Showing Nearby Sources and SO_2 Emissions Magnitude Near Sebree Plant



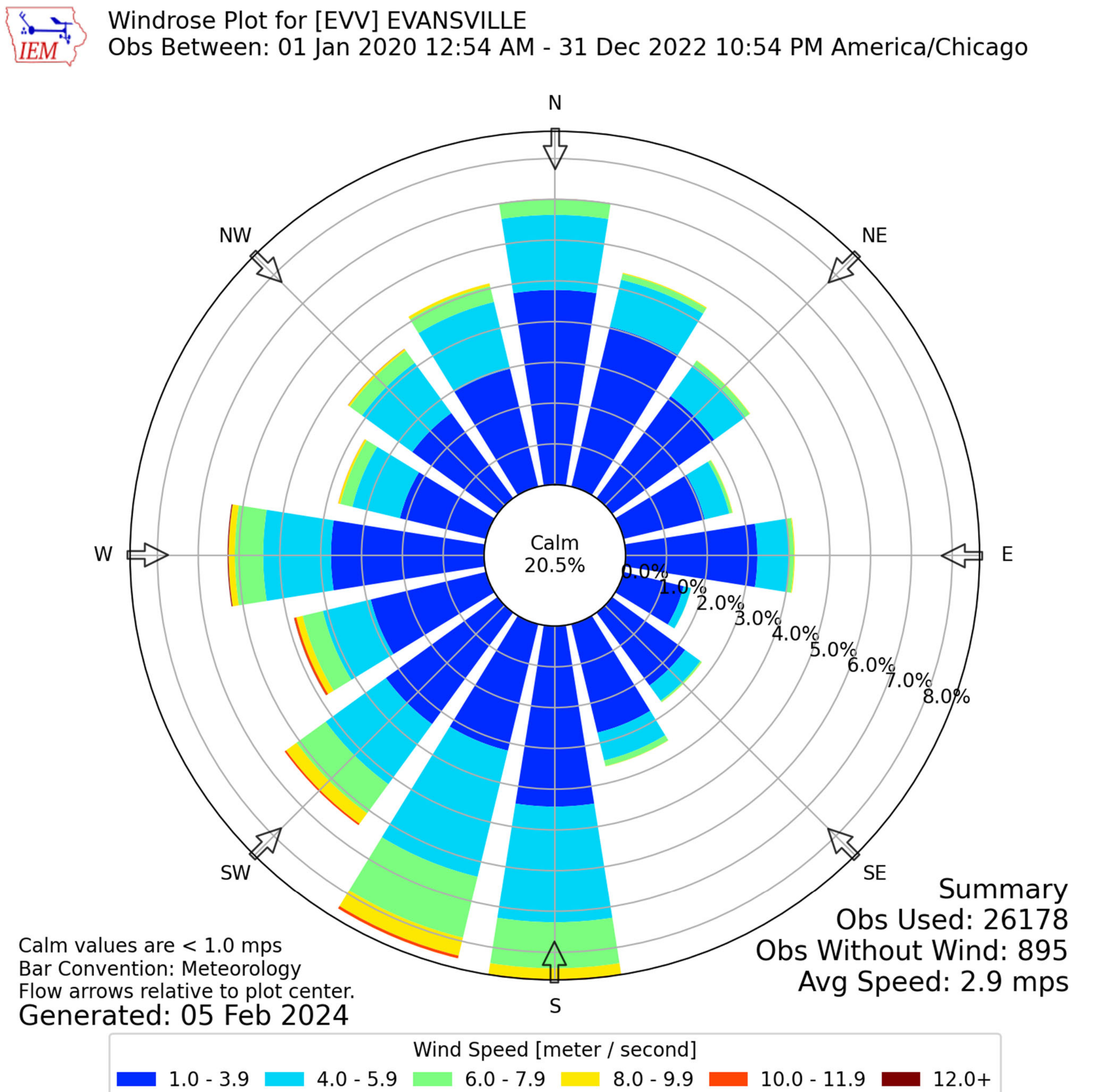
All coordinates shown in UTM Coordinates,
UTM Zone 16, NAD 83 Datum

Table 2-6. Sources within 50 km of Century Sebree (Excluding BREC)

AI ID	Facility Name	UTM East (m)	UTM North (m)	Distance to Century, (d) (km)	Plant-wide Potential Emissions (Q) (tpy)	Q/d (tpy/km)	Screened Out?	Basis for Screening
894	Daramic LLC	495,506	4,184,910	43.2	333.3	7.7	Y	A
895	Dart Polymers Inc	487,221	4,182,989	34.9	363.1	10.4	Y	A
939	Owensboro Grain Edible Oils	487,370	4,181,892	34.6	89.0	2.6	Y	A
978	Yager Materials Inc - Owensboro Paving Co	495,235	4,184,578	42.8	85.9	2.0	Y	A
1786	Accuride Corp Henderson	450,105	4,184,409	17.4	93.5	5.4	Y	B
1820	AMG Aluminum North America LLC	452,954	4,167,240	2.9	0.1	<0.1	Y	B
1833	Rogers Group Henderson Asphalt Plant	449,117	4,184,892	18.2	13.0	0.7	Y	B
3240	Texas Gas Transmission LLC - Dixie Transmission Station	440,919	4,169,576	14.9	0.1	<0.1	Y	B
3319	Big Rivers Electric Corp - Wilson Station	492,898	4,144,764	43.8	8,865.2	202.5	N	--
5506	International Paper Company	447,589	4,185,090	19.0	0.8	<0.1	Y	B
11663	Tyson Food Hatchery	459,366	4,164,226	5.2	0.8	0.2	Y	B
38551	Madisonville State Office	456,200	4,132,089	35.8	69.9	2.0	Y	A
40143	Tyson Chicken Inc - Sebree Feed Mill	453,388	4,164,799	3.9	0.1	<0.1	Y	B
40591	Powerscreen - Metrotrack Portable Plant	449,075	4,185,136	18.5	1.6	<0.1	Y	B
44049	ANR Pipeline Co - Madisonville Transmission Station	445,278	4,137,458	32.2	73.0	2.3	Y	A
44327	Texas Gas Transmission LLC - Slaughters Compressor Station	455,858	4,151,291	16.6	0.7	<0.1	Y	B
45238	Tyson Chicken Inc - Robards Facility	454,623	4,167,819	1.1	2.6	2.3	Y	B
116288	American Tower Corp - Audubon Cell Tower Engine	463,090	4,177,776	12.3	19.6	1.6	Y	B
130997	JH Rudolph & Co Inc - Portable Asphalt Plant	441,031	4,185,870	23.2	41.2	1.8	Y	A
169648	Pratt Paper (KY) LLC/ Pratt (Henderson Corrugating) LLC	444,485	4,183,196	19.0	8.7	0.5	Y	B
18129-00002	SABIC Innovative Plastics Mt Vernon LLC	417,845	4,196,428	47.4	582.5	12.3	Y	A
18129-00005	MPLX Terminals LLC - Mt Vernon Terminal	420,117	4,197,868	46.5	349.7	7.5	Y	A
18129-00010	SIGECO AB Brown Generating Station	437,970	4,195,565	32.9	3,904.3	118.8	N	C
18129-00050	Green Plains Mount Vernon LLC	436,479	4,195,559	33.7	47.2	1.4	Y	A
18173-00001	SIGECO - FB Culley Generating Station	472,005	4,196,736	33.1	1,519.1	45.9	N	--
18173-00002	ALCOA Power Generating Inc Warrick Powe	470,354	4,197,663	33.1	2,663.7	80.4	N	--
18173-00007	Warrick Newco LLC	474,656	4,201,231	38.3	1,736.9	45.4	N	--

A - Source is beyond 20km distant from Century and has a relatively small Q/d, indicating SO2 emissions from the source are unlikely to significantly impact receptors in the vicinity of the Sebree Plant.
B - Source is within 20km from Century, however the source has a relatively small Q/d, indicating SO2 emissions from the source are unlikely to significantly impact receptors in the vicinity of the Sebree
C - Coal units (major SO2 emission sources) at facility will be shut down in late 2023.

Figure 2-10. Evansville Regional Airport Meteorological Tower Wind Rose 2020-2022



2.11 Modeling Files

All modeling files will be provided to the Division in electronic format via email. Specifically, as documented in Appendix F, all model and processor input, output, and data files will be provided. Spreadsheets tabulating source, emission, and other input data sets will also be provided.

3. MODEL RESULTS

The purpose of the SIP air dispersion modeling analysis is to demonstrate that compliance with the 1-hour SO_2 NAAQS will be achieved throughout the nonattainment area (via the emission reductions and other measures to be implemented to reduce ambient SO_2 concentrations). As discussed further in Section 4, this can be accomplished through a weight of evidence analysis that includes, among other data, an air dispersion modeling analysis.

This section of this report presents the modeling results of the 1-hour SO_2 dispersion modeling while Section 4 provides the additional weight of evidence analysis to reach a determination of compliance.

3.1 1-hour SO_2 NAAQS Modeling Results

Table 3-1 summarizes the 1-hour SO_2 NAAQS dispersion modeling results. As shown in the table, the 3-year average of the maximum highest 4th high (H4H) impacts modeled using AERMOD are above the NAAQS. Section 4 of this report explains how these results are overly conservative and how weight of evidence is employed to demonstrate compliance with the NAAQS.

Table 3-1. 1-hour SO_2 NAAQS Results Summary

Averaging Period	Year for Meteorological Data	NAAQS ($\mu g/m^3$)	Emissions Scenario	Model Impact[a,b] ($\mu g/m^3$)	UTM East[c] (m)	UTM North[c] (m)
1-hour	Maximum 3-Year Average from 2020-2022	196	Base	222.3	455,871.9	4,167,073.1
			Highest ABF	212.1	454,859.2	4,167,934.8
			Highest Potline	230.2	455,871.9	4,167,073.1

a. The highest 4th high (H4H) impact is compared against the standard.

b. Background concentrations of SO_2 were incorporated into AERMOD based on data from the Evansville-Buena Vista monitor (AQS ID 18-163-0021).

c. UTM coordinates are in NAD83.

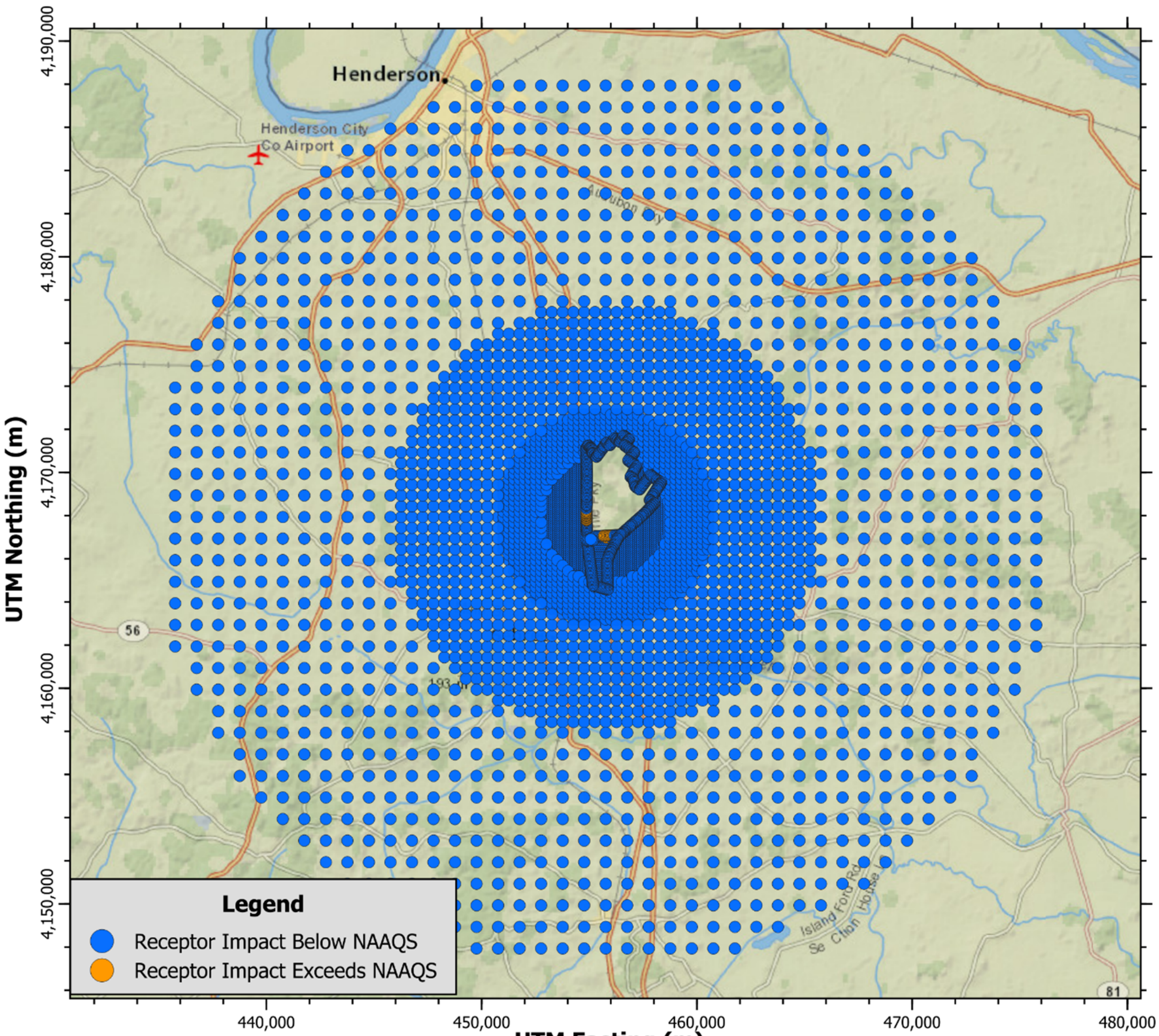
As shown in Table 3-2, the area (by fraction of total receptors modeled) of which there were modeled ambient concentrations above the NAAQS is minimal. For instance, in the base emissions scenario, there were only thirty (30) receptors where modeled concentrations exceeded the NAAQS; this is less than 0.6% of receptors included in the modeling analysis. As shown in Figure 3-1 and Figure 3-2, the exceedances (i.e., orange dots) all occur on or very near the Century Sebree property line for the base emissions scenario. The locations of the exceedances for the highest ABF and highest potline emissions scenario are similar to the locations of the exceedances for the base emissions scenario. Even with model overprediction of the results, the modeled exceedances are very limited and occur at locations that the public are not expected to access.

Table 3-2. Number of Receptors with Modeled Exceedances

Total Receptors	Emissions Scenario	Exceeded Receptors[a]	Percent of Exceeded Receptors
5,306	Base	30	0.57%
	Highest ABF	20	0.38%
	Highest Potline	35	0.66%

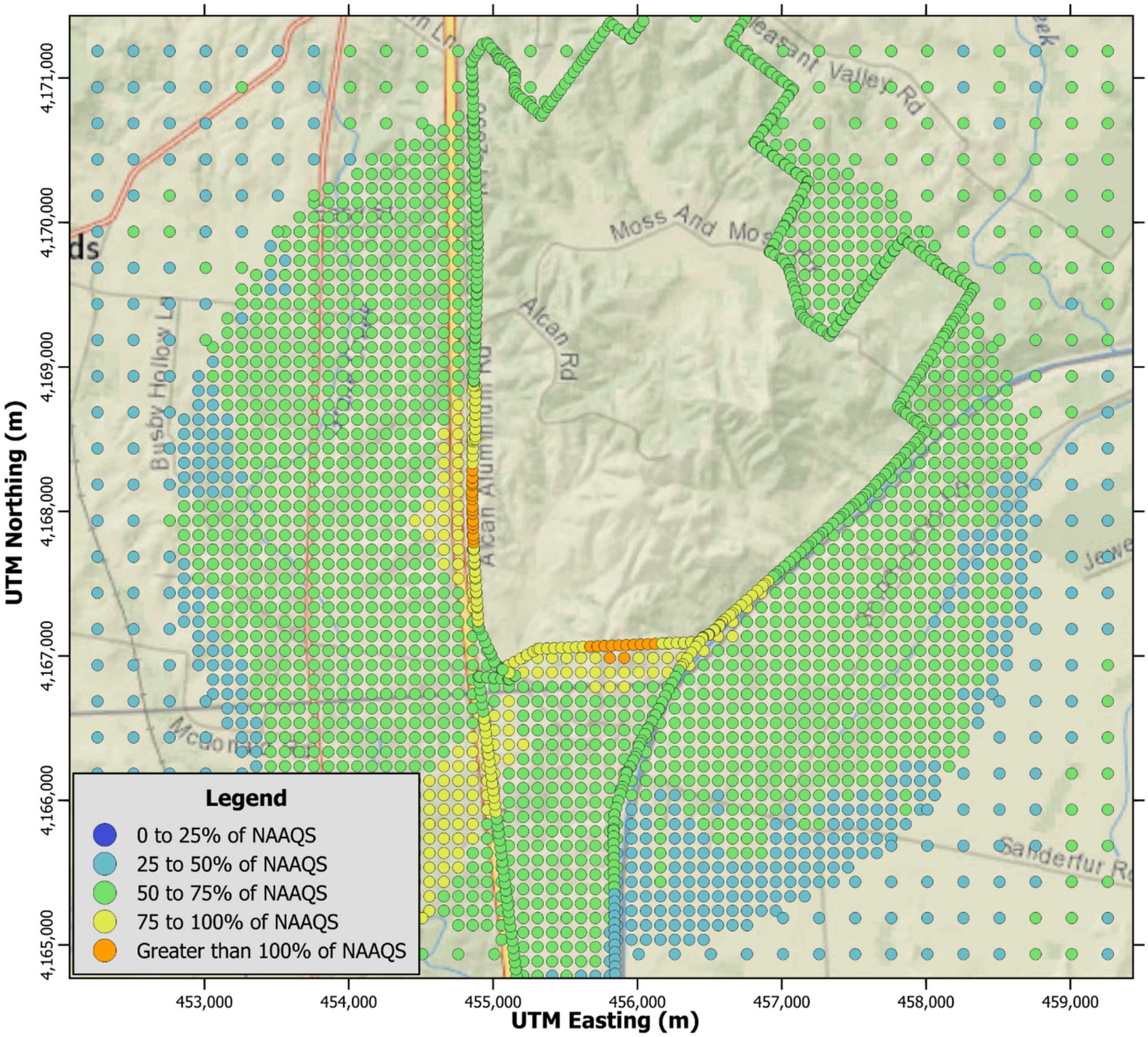
a. Number of receptors at which the model impact exceeded the 1-hour SO_2 NAAQS.

Figure 3-1. Base Emissions Scenario Modeled Impacts (Full Extent)



All coordinates shown in UTM Coordinates,
UTM Zone 16, NAD 83 Datum

Figure 3-2. Base Emissions Scenario Modeled Impacts (Zoomed)



All coordinates shown in UTM Coordinates,
UTM Zone 16, NAD 83 Datum

4. WEIGHT-OF-EVIDENCE ANALYSIS

In many SIP modeling demonstration analyses, the determination that compliance will be achieved is made solely via an air dispersion modeling analysis using AERMOD that shows modeled results below the NAAQS. However, a weight-of-evidence analysis can also be used to show that compliance with the NAAQS can be expected even if some maximum ambient concentration values predicted in a "standard" overly conservative AERMOD modeling analysis are above the NAAQS.

In the "stipulations" for Part 51 of EPA's *Guideline on Air Quality Models*, there is flexibility in attainment demonstration plans wherein EPA states that nothing in Part 51 will be construed in any manner:

> *…to preclude a State from employing techniques other than those specified in this part for purposes of estimating air quality or demonstrating the adequacy of a control strategy, provided that such other techniques are shown to be adequate and appropriate for such purposes.*[39]

Therefore, any means of estimation of air quality is acceptable in attainment demonstration plans as long as it is "adequate and appropriate" for the purposes.

In the following three court cases for attainment demonstration plans, the modeled concentrations were above the NAAQS. In two of the cases, the model was overpredicting the monitor, and the states and EPA adjusted the model. EPA also adopted a "weight of the evidence" approach to consider other information even if the model continued to not demonstrate attainment. Note that all three of these cases deal with ozone attainment plans; however, the concepts and resulting court approvals apply equally to any modeling demonstration.

1. **2004 D.C. Circuit Case – Washington D.C. Ozone Nonattainment**[40]
   EPA determined that the model overpredicted known ozone concentrations by an average of 19%. EPA therefore adjusted the model's calculations using a variety of supplemental statistical techniques including a "relative reduction factor" to correct the overpredictions under a "weight of evidence" approach. The Court went on to state that "the adjustments were necessary to ensure consistency with real-world observations and thus to ensure reliable prognostications about the future."

2. **2001 Fourth Circuit Case – Maryland Ozone Nonattainment**[41]
   In comparing base case modeling to monitors, EPA determined the models overpredicted the monitors by 22%. After EPA accounted for the model over-prediction, local scale modeling still identified concentrations above the standard. EPA concluded that the local scale modeling results were close enough to attainment to warrant consideration of "weight of evidence" arguments to support a demonstration of attainment. EPA defined the "weight of evidence" determination as "a diverse set of technical analyses performed to assess the confidence one has in modeled results and to help assess the adequacy of a proposed strategy when the outcome of local scale modeling is close to attainment." EPA thereafter employed "adjustment factors" as well as consideration of other emissions reductions that were not modeled. The court cited EPA statements that if the "weight of evidence" approach leads

[39] 40 CFR 51, Appendix W–*Guideline on Air Quality Models*, § 51.101(c)

[40] *Sierra Club v. EPA*, 356 F.3d 296 (D.C. Cir. 2004)

[41] *1000 Friends of Maryland v. Browner*, 265 F.3d 216 (4th Cir. 2001)

to compelling evidence that attainment is likely, then EPA will conclude that attainment has been demonstrated even if the modeled levels are too high.

3. **2003 Fifth Circuit Court Case – Texas Ozone Nonattainment**[42]
Texas' modeled control strategy alone did not demonstrate attainment. Texas therefore employed a "weight of evidence" approach. Texas used a quadratic equation to calculate the gap in NO_X emissions reductions between those achieved by the modeled control strategy and the levels required to achieve the NAAQS. Texas then revised its control strategy to eliminate the gap and achieve attainment. The court held that the Clean Air Act allows for a "weight of evidence" analysis, and that "Congress could not have intended to bar EPA from considering data in addition to modeled results." The court noted EPA's position that the modeling results constitute the principal component of the agency's analysis, "with supplemental information designed to account for uncertainties in the model." The court therefore upheld EPA's approach with the attainment demonstration plan.

EPA has more recently used a "weight of evidence" approach in other attainment contexts, including for SO_2 attainment. For example, in 2022 EPA employed a "weight of evidence" approach to address the SO_2 nonattainment for an area in Iowa.[43] EPA stated that it did not have evidence (including modeling) to determine if the monitors were located in the area of highest concentration, and that the available modeling of permitted allowable emissions did not on its own provide a basis for determining attainment. To determine attainment, EPA therefore relied upon: "SO_2 emissions data and trends, relevant air monitoring data and trends, SO_2 monitoring data incorporated with local meteorological data, as well as available modeling information."

In consideration of these and other precedents, it is appropriate for Kentucky to include in the attainment demonstration plan a model that does not overpredict the monitor that is located in the area of maximum concentration. Through the Clean Air Act, EPA has the authority to approve such a plan, as supported by several Courts of Appeals. To the contrary, use of a model that substantially overpredicts the monitor and results in significant unnecessary expenditures by Century would be arbitrary and unlawful. Any potential uncertainty with using a weight of evidence approach can be addressed in the contingency plan submitted with the attainment demonstration plan.

As documented in the following sections, the weight of evidence in this case demonstrates that the 1-hour SO_2 NAAQS will be achieved in the Henderson-Webster SO_2 nonattainment area following implementation of the represented changes in emissions and stacks at the Century Sebree facility.

4.1 Historical Monitor Data

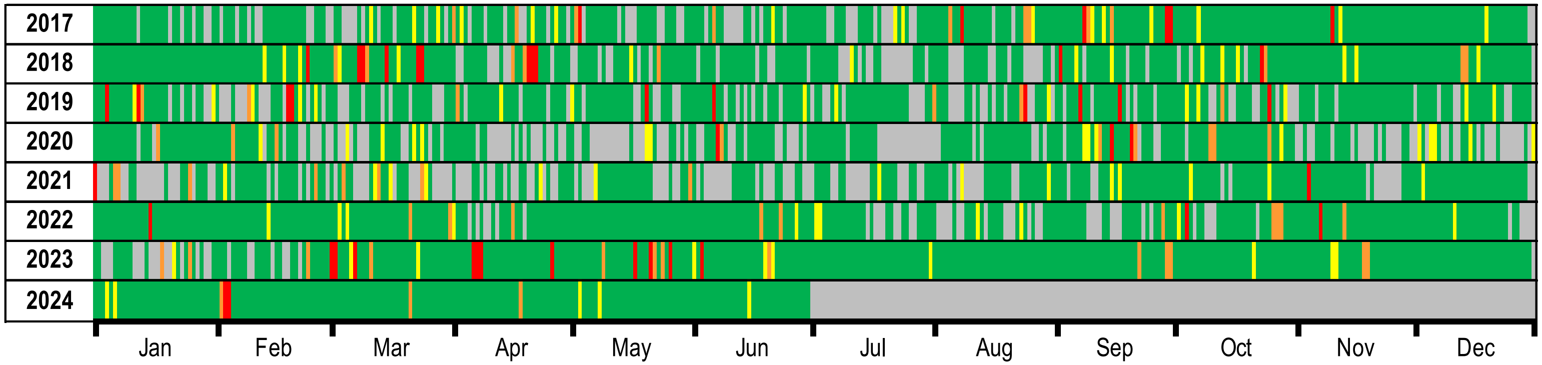
The Division commenced collection of SO_2 concentration data at the Sebree ambient monitoring station in January 2017. At the time of writing this report, SO_2 data is available through June 2024. The monitored maximum daily 1-hour SO_2 data measured over this time period is summarized in Figure 4-1 and Figure 4-2. As revealed in these figures, the frequency of measured SO_2 concentrations greater than the magnitude of the 1-hour SO_2 NAAQS has been generally trending down since 2017. One short-term exception to this trend is the higher frequency of elevated SO_2 concentrations observed in the first half of 2023. There are numerous factors that could potentially influence measured SO_2 concentrations year by year, including variations in operational parameters at the Sebree Plant, actual emissions at the Sebree Plant and nearby

[42] *BCCA Appeal Group v. EPA*, 355 F.3d 817 (5th Cir. 2003)

[43] 67 Fed. Reg. 20329 (April 7, 2022).

sources, wind frequencies, and other meteorological parameters. Regardless, Century has reviewed operational data for 2023 to seek an explanation for the elevated SO_2 concentrations measured in the first half of the year. Based on this review, Century determined that the likely reason for the elevated SO_2 concentrations was the use of anode material recycled from the Century Hawesville Plant (which was idled in June 2022) in the production of anodes at the Sebree Plant. The recycled anode material from the Hawesville Plant elevated the SO_2 content in the green anodes. The elevated SO_2 content caused higher SO_2 emissions and in turn elevated SO_2 concentrations at the Sebree monitor during the first half of 2023. Although Century would like to recover additional material from the Hawesville Plant, the processing of recycled anode material ceased in June 2023 due to elevated SO_2 concentrations observed at the Sebree monitor. Since that time, nearly a full year has passed and only two maximum daily concentrations have been measured above the magnitude of the 1-hour SO_2 NAAQS. The frequency of measured SO_2 concentrations above 75% of the magnitude of the 1-hour SO_2 NAAQS has similarly decreased. As indicated in Table 4-2, if the SO_2 data measured during the first half of 2023 were excluded from the 99th percentile calculation for that year, the design value for 2021-2023 would have complied with the 1-hour SO_2 NAAQS.

Figure 4-1. Tile Plot for Historical Max Daily SO_2 Data[1]



1. The frequency of "zero or missing" data indicated in Figure 4-1 is significant. However, the majority of these data points are measured SO_2 concentrations of zero (or rounded to zero) ppb. More than 98.5% of all hourly data recorded at the Sebree monitor during the 2017 through 2023 time period was valid data, as defined in 40 CFR 50, Appendix T.

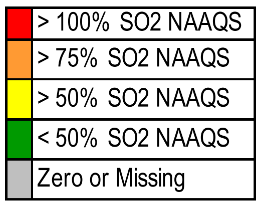
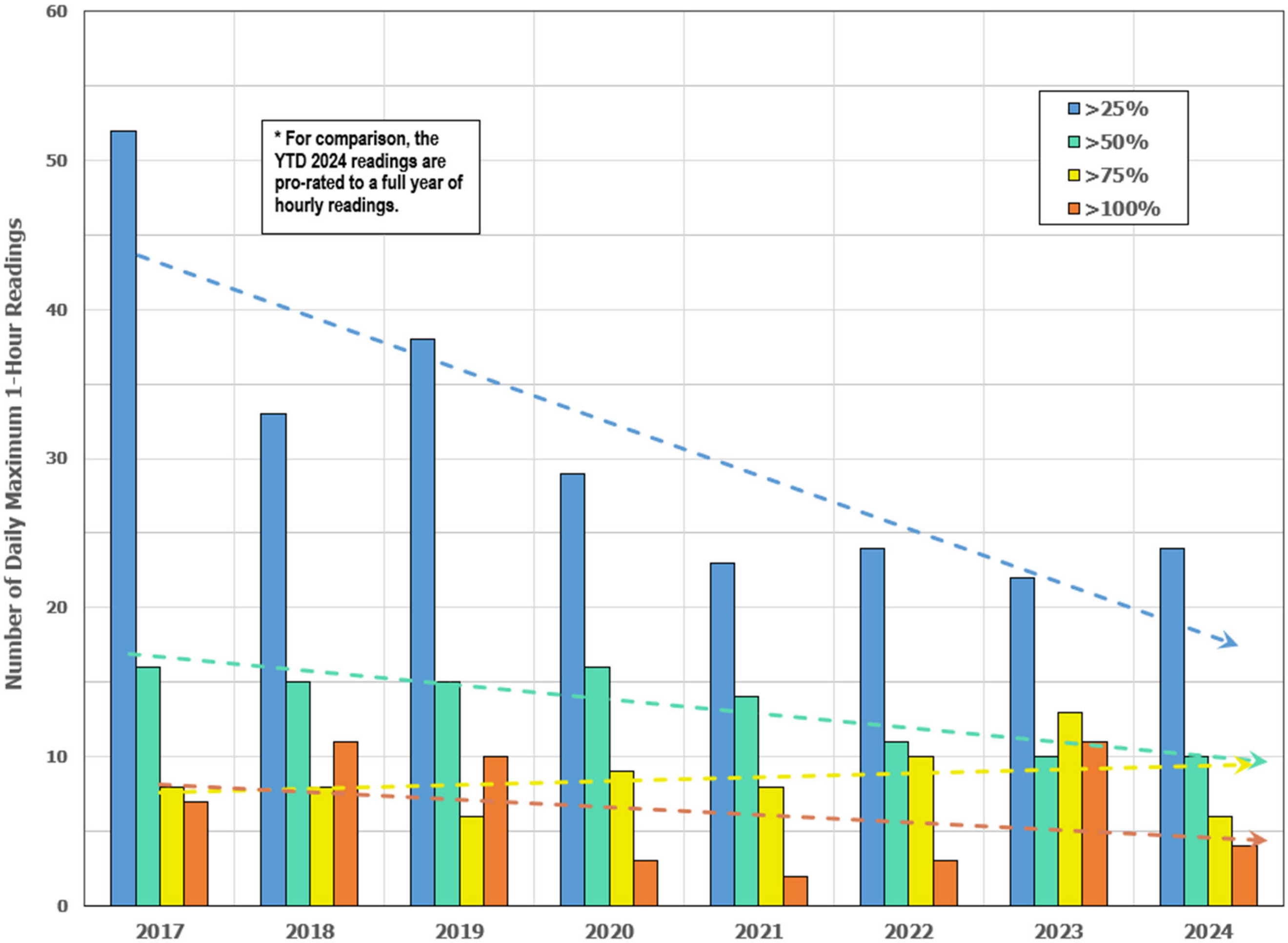


Figure 4-2. Counts of Max Daily Monitored SO_2 Data by Year[1]



1. The full 2024 dataset is not yet available. As such, for comparison purposes, it was assumed that the average concentration frequencies for 2024 year-to-date continue for the remainder of the year. In other words, if 9 maximum daily 1-hour concentrations above 50% of the magnitude of the NAAQS occurred over the January to June 2024 time frame, then it was assumed that a total of 18 concentrations (=9 events / 182 days x 365 days) above 50% of the magnitude of the NAAQS will occur in 2024.

Table 4-1. Historical SO_2 Design Value Concentrations for Sebree Monitor

High Rank	Year	Date	Daily Maximum 1-hr Concentration (ppb)	Design Value (ppb)	Design Value (μg/m³)	Percent of NAAQS[a]
4	2017	10/1/17	94.0	--	--	--
4	2018	3/10/18	102.0	--	--	--
4	2019	9/8/19	99.0	98.3	257.0	131.1%
4	2020	1/17/20	**73.0**	91.3	238.7	121.8%
4	2021	2/26/21	**68.0**	80.0	209.1	106.7%
4	2022	3/22/22	**72.6**	**71.2**	**186.1**	**94.9%**
4	2023	3/8/23	94.3	78.3	204.6	104.4%

[a] The 1-hour National Ambient Air Quality Standard (NAAQS) for sulfur dioxide is 75 ppb (196 μg/m³), which is applied in the form of the 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour concentrations.

Table 4-2. Historical SO_2 Design Values Excluding 1st Half 2023 Data

High Rank	Year	Date	Daily Maximum 1-hr Concentration[a] (ppb)	Design Value (ppb)	Design Value (μg/m³)	Percent of NAAQS
4	2017	10/1/17	94.0	--	--	--
4	2018	3/10/18	102.0	--	--	--
4	2019	9/8/19	99.0	98.3	257.0	131.1%
4	2020	1/17/20	**73.0**	91.3	238.7	121.8%
4	2021	2/26/21	**68.0**	80.0	209.1	106.7%
4	2022	3/22/22	**72.6**	**71.2**	**186.1**	**94.9%**
2	2023	10/1/23	**62.8**	**67.8**	**177.2**	**90.4%**

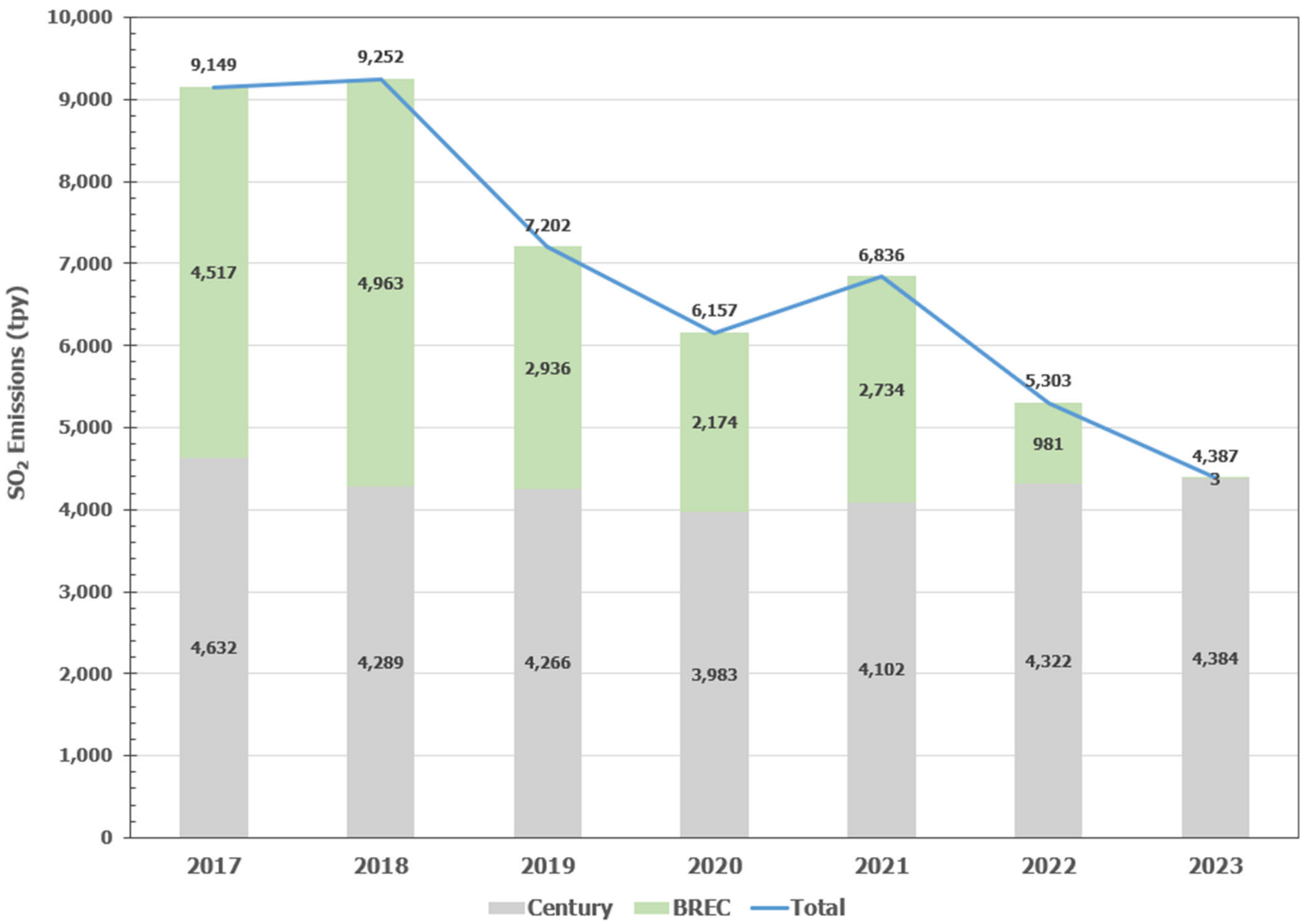
[a] The 99th percentile (2nd-high) monitored SO_2 concentration for 2023 excludes all data for the 1st half of 2023 as this was the time period when material recycled from the Century Hawesville Plant was being processed.

4.2 Historical Emissions Trends

Although other factors may influence the measured concentrations at the Sebree monitor, the principal element influencing measured SO_2 concentrations is SO_2 emissions released in the surrounding area. Century and BREC have historically been the only sources of significant SO_2 emissions near the Sebree monitor. However, as shown in Figure 4-3, the overall SO_2 emissions in the area have dropped substantially. This is due to the shutdown of the Henderson Municipal Power & Light (HMP&L) coal-fired boilers in 2019 and the conversion of the coal-fired boilers at the Green Station to natural gas in 2022. In addition to the substantial reductions in SO_2 emissions from BREC, SO_2 emissions at Century Sebree also decreased by 14% from 2017 to 2020. The trend in emission reductions overlaps to some degree with the trend reductions in the absolute magnitude of high monitored SO_2 concentrations as well as the frequency of higher monitored SO_2 concentrations.

Between 2020 and 2022 during which time the 3-year design value achieved compliance with the NAAQS (see Table 4-1 above and Appendix Figure A-3), SO_2 emissions from Century trended back up slightly but remained below 4,322 tpy. Actual SO_2 emissions in the future are likely to remain consistent within the same range as occurred during the past five years. Thus, even without any stack improvements, the monitor data shows that attainment of the NAAQS is likely to be achieved. Although Century is proposing to establish a new federally enforceable allowable SO_2 emission limit equivalent to an annual emissions level of 4,946 tpy (down from 5,853 tpy currently), it is unlikely actual SO_2 emissions will reach these levels. However, even at these allowable levels, the following sections identify that with the planned stack change for the Anode Bake Furnace, attainment of the NAAQS will still be maintained.

Figure 4-3. Century and BREC - Annual SO_2 Emissions Trend



4.3 AERMOD Modeling with Correction for Overprediction

As discussed in Section 2.2 and presented in Appendix A, the use of the rural option in AERMOD results in a very large overprediction compared with the ambient data collected at the SO_2 monitor located near Century Sebree. The use of AERMOD with the urban option selected and a population of 2,000,000 provides improved performance versus the monitor data, but still overpredicts concentrations recorded by the ambient monitor. In the performance evaluation presented in Appendix A, the urban 2 million AERMOD model outputs are shown to overpredict the 1-hour SO_2 impacts from the Sebree Plant by 1.21 times when compared to the Sebree monitor values. This overprediction value is based on the ratio of the average of the four most-recently available three-year average design concentrations predicted by the model (269.6 μg/m^3) to the average of the four three-year average design value concentrations at the monitor (222.7 μg/m^3), as shown in Table 4-3.

Table 4-3. Ratio of Model Concentration to Monitor Concentration

Average Monitor Concentration[a,c] (μg/m^3)	**Average Model Concentration**[b,c] (μg/m^3)	**Model to Monitor Ratio**
222.7	269.6	1.21

a. The average of the design concentrations of the 4th highest daily maximum 1-hour SO_2 concentration recorded at the Sebree monitor (Site No. 21-101-1011) each year from 2017 to 2022.
b. The average of the design concentrations of the 4th highest daily maximum 1-hr SO_2 concentration modeled using an urban 2 million population and merged A-398 stack set plumes for Potlines 1 and 2 each year from 2017 to 2022.
c. Refer to the performance evaluation in Appendix A for the data behind the average design value concentrations listed here.

To evaluate compliance with the NAAQS in the absence of this model overprediction, in Table 4-4, the model-to-monitor ratio is applied to the model impacts from Table 3-1 resulting in a set of "data-corrected" future maximum impacts that account for the removal of the model overprediction. This result shows that with the planned stack change for the ABF and at the proposed reduced maximum allowable SO_2 emission levels, the area will be in attainment under all Century emissions scenarios. Specifically, the data-corrected future maximum impact, assuming the maximum allowable SO_2 emissions permissible from every source occurred continuously (something that will not actually occur in practice), is 183.6 μg/m^3, 6.3% below the NAAQS for the base emissions scenario (i.e., expected normal distribution of SO_2 emissions between the ABF and potlines). Similarly, the data-corrected impact for the highest ABF and highest potline emissions scenarios are less than the NAAQS.

Table 4-4. Data Corrected Future Predicted Modeled SO_2 Ambient Concentrations

Emissions Scenario	**Model Impact**[a] (μg/m^3)	**Model to Monitor Ratio**[b]	**NAAQS** (μg/m^3)	**Data Corrected Impact**[c] (μg/m^3)	**Exceeds NAAQS?**
Base	222.3	1.21	196	**183.6**	No
Highest ABF	212.1			**175.2**	No
Highest Potline	230.2			**190.1**	No

a. 4th highest daily maximum 1-hour SO_2 model impact as presented in Table 3-1. Modeling methodology uses urban 2 million population, merged A-398 stack set plumes for Potlines 1 and 2, and future increased height of ABF stack.
b. Ratio from Table 4-3.
c. Applies ratio of model to monitor data to the model impact.

4.4 Response Factor Applied to Monitor Data

While the analysis of data-corrected modeled impacts identify that the NAAQS will be achieved, an alternative approach for refining the model predicted data using model response factors is presented in this section. The concept of model response factors has been used by EPA for decades in modeling analyses supporting SIP planning. For example, in the 2004 D.C. Circuit Case discussed at the beginning of this section, a "relative reduction factor", or relative response factor, used the relationship between the modeled peak predictions in the base year and the attainment year to determine the decrease in ozone concentrations predicted to result from the control measures. This relationship was then applied to the measured base year design value concentration to estimate the design value in the attainment year. The response factor therefore corrected the overpredicting model to correspond to the monitor. As per the EPA's *Modeling Guidance for Demonstrating Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze*[44], relative response factors are the ratios in air pollutant concentrations between the model future year and model base year. The recommended method uses model estimates in a "relative" rather than "absolute" sense to estimate future year design values.

To provide additional evidence that changes proposed to the Sebree Plant will result in future monitored compliance with the 1-hour SO_2 NAAQS, a response factor analysis is presented here. For this analysis, the AERMOD modeling for the "base" emission scenario presented in Section 3.1 has been modified to reflect the proposed limited SO_2 emissions with the current ABF stack parameters to provide a base scenario (i.e., "Current Stack Configuration"). The ratio of the future stack configuration modeled concentration (i.e., result presented in Table 3-1) to the current stack configuration modeled concentration defines the relative response factor. This represents the expected relative reduction in future ambient concentrations that is associated specifically with the planned installation of the new ABF stack. As shown in Table 4-5, the response factor is determined to be 0.73. Multiplying the most recent (i.e., 2021-2023) monitor design concentration by this response factor yields the expected future design concentration, which is shown in Table 4-6.

Table 4-5. Ratio of Current to Future Stack Configuration Model Concentrations

Current Stack Configuration Model Impact[a] ($\mu g/m^3$)	**Future Stack Configuration Model Impact**[b] ($\mu g/m^3$)	**Relative Reponse Factor**[c]
303.0	222.3	0.73

a. 2021-2023 4th highest daily maximum 1-hour SO_2 model impact using urban 2 million population, merged A-398 stack set plumes for Potlines 1 and 2, and current stack for ABF at proposed limited PTE.
b. 2021-2023 4th highest daily maximum 1-hour SO_2 model impact as presented in Table 3-1. Modeling methodology uses urban 2 million population, merged A-398 stack set plumes for Potlines 1 and 2, and new stack for ABF at proposed limited PTE.
c. Ratio of future stack configuration model impact to current stack configuration model impact.

Table 4-6. Predicted Future Design Concentration

2021-2023 Monitor Design Concentration[a] ($\mu g/m^3$)	**Relative Response Factor**	**Predicted Future Design Concentration**[b] ($\mu g/m^3$)
204.6	0.73	**150.1**

a. The 3-year average of the 4th highest daily maximum 1-hour SO_2 concentration recorded at the Sebree monitor (Site No. 21-101-1011) from 2021-2023.
b. Applies ratio to the future model impact.

Based on the relative response factor of 0.73, which takes into account the predicted beneficial impact of the planned installation of a new stack for the Anode Bake Furnace, the predicted future design

[44] Modeling Guidance for Demonstrating Air Quality Goals for Ozone, PM2.5, and Regional Haze, Memorandum from Richard A. Wayland, Division Director, to Regional Air Division Directors, Regions 1-10, dated November 29, 2018.

concentration is 150.1 µg/m^3. This is 23.4% below the 1-hour SO_2 NAAQS of 196 µg/m^3. Thus, based on the relative response factor analysis, the area will be in attainment of the 1-hour SO_2 NAAQS.[45]

4.5 Conclusion

Based on the technical assessments provided in this section, the 1-hour SO_2 NAAQS will be achieved in the Henderson-Webster SO_2 nonattainment area following implementation of proposed changes at Century Sebree (i.e., establishment of new reduced allowable SO_2 emission limits and construction of new stack for the Anode Bake Furnace). This conclusion is demonstrated using historical monitoring data and modeling of the future limited emissions and stack configuration for Century Sebree.

Even under the current stack configuration and at representative actual SO_2 emission levels, which are not expected to substantively increase, the area around the Century Sebree facility already reached attainment level SO_2 concentrations for the 2020-2022 period. Excluding a short period in the first half of 2023, when elevated emissions occurred due to a well-intentioned effort to recycle anode material from the idled Century Hawesville plant in the making of green anodes, the 2021-2023 period would have also shown attainment. These analyses are without any stack changes or reductions in SO_2 emissions from current levels. Thus, any benefit in reductions of maximum ambient impacts due to installation of a new ABF stack simply provides even greater assurance that attainment will be achieved and maintained.

Even if the proposed future allowable emission rates (equivalent to an annual emission rate of 4,945.5 tpy), which are significantly reduced from the current allowable emission rate (5,853 tpy), are assumed to occur from all sources simultaneously 8,760 hours per year, then the model predicted impacts (taking into account the presence of a new stack on the ABF), and corrected to account for the multi-year consistent overprediction of the AERMOD model relative to actual monitored concentrations in the separate performance evaluation study (see Appendix A), are below the NAAQS with an over 6.3% margin. In reality, the margin can be expected to be higher because actual SO_2 emissions (which are currently 13.7% lower than the proposed annual allowable SO_2 emissions) are expected to trend consistent with actual emissions from the past 4 years. As additional buttressing evidence, if the model-predicted benefits of the installation of a new ABF stack (i.e., the relative response factor) are applied to the latest three-year monitor design concentration (2021-2023), the predicted results are also well below the NAAQS, even if they are scaled up to account for the difference between the future allowable SO_2 emission rate and actual SO_2 emission rates during the time the monitor data was collected.

[45] Consistent with EPA's methodology, the relative response factor is applied to the actual monitor design concentration, which reflects historical actual emission levels rather than potential future allowable emission levels. However, even if predicted future design concentration was scaled up by the ratio of the proposed allowable annual SO_2 emissions (4,945.5 tpy) to the 2021-2023 average actual SO_2 emissions (4,269.3 tpy), the predicted future design concentration would still only be 173.9 µg/m^3, which is approximately 11% below the NAAQS.

APPENDIX A. SITE-SPECIFIC MODEL OPTIONS EVALUATION

This appendix provides a description and results of a site-specific model evaluation completed for Century Sebree. In this analysis, actual emissions of SO_2 are modeled from Century Sebree and other nearby sources for comparison with monitored SO_2 concentrations observed at the Kentucky Division for Air Quality (Division) run SO_2 monitor located just inside the fenceline of the Century Sebree property. Model performance is evaluated for different combinations of model options, including the "urban" option and source parameters for stacks associated with A-398 scrubbers for Potlines 1 and 2 at Century Sebree.

Modeling Options Evaluation Scope

This AERMOD performance evaluation includes model scenarios designed to test differing model inputs relating to the urban option and to plume rise for potline stacks. The latest version of the AERMOD model (Version 23132) was used for this performance evaluation.

Urban Option Evaluation

As discussed in Section 2.2 of this report, the "urban" or "rural" determination of the area surrounding the subject source is important in determining the applicable boundary layer characteristics that affect a model's calculation of ambient concentrations. In many cases, EPA recommends that this determination be completed based on the population of the area surrounding the source or the land use of the area. However, certain types of industrial facilities are of sufficient size and generate sufficient heat to create localized "heat islands", which can cause similar atmospheric dispersion conditions to those generated by urban areas. Primary aluminum smelters are one type of source to which the urban option has been applied even in locations where a traditional population or land use analysis would suggest use of rural dispersion characteristics.

The following scenarios were modeled in AERMOD (version 23132) to evaluate AERMOD performance for Century Sebree with and without the use of the urban option:

- **Rural:** no urban option selected
- **Urban with 1 million population:** urban option selected with 1,000,000 input for the equivalent population[46]
- **Urban with 2 million population:** urban option selected with 2,000,000 input for the equivalent population

In the urban option analyses, the urban option was used for Century Sebree sources, and rural dispersion characteristics for other modeled sources.

[46] Note that an evaluation of the temperature differences between Century Sebree and nearby areas indicates that a population of 2,000,000 is appropriate for input to AERMOD, as discussed in Section 2.2. However, a smaller population is included in this scenario to provide information on the performance of AERMOD with varying input populations.

Potline Stack Representation Evaluation

As discussed in Section 2.8.3 of this report, the A-398 alumina fluidized bed dry scrubbers for Potlines 1 and 2 are configured with ten stacks located in close proximity to one another. Potlines 1 and 2 each have two groups of reactors (identified as north and south); therefore, there are four total groups of stacks associated with the Potline 1 and 2 A-398 scrubbers. The close proximity of these stacks can result in enhanced plume rise due to the merging of the plumes compared with modeling each stack individually in AERMOD, which does not account for plume interaction. For each group of A-398 scrubber stacks, an iteration was first completed with the emissions modeled assuming that the plumes for each stack on an A-398 do not interact. In this case, all emissions for each A-398 associated with Potlines 1 and 2 are modeled from one stack with source parameters representative of a single stack. In this iteration, a total of four stacks were modeled, each representing one of the four total A-398s associated with Potlines 1 and 2. A second iteration was then completed with ten stacks modeled for each A-398 for a total of 40 stacks representing the Potlines 1 and 2 A-398. For this second iteration, emissions were divided evenly amongst the ten stacks associated with each A-398. A third iteration was then completed with stack parameters representative of a combined plume from each A-398 for Potlines 1 and 2, with a total of four stacks representing the Potline 1 and 2 A-398s. For each group of A-398 scrubber stacks for Potlines 1 and 2, the common stack height, temperature, and exit velocity was retained and entered into AERMOD. An equivalent stack diameter was input to AERMOD based on the combined stack top area of the A-398 stacks as discussed in Section 2.8.3 of this report.

The A-398 stack parameters modeled for each scenario in this evaluation are shown in Appendix Table A-1.

Appendix Table A-1. Century Sebree A-398 Stack Parameters

Model ID	Description	Stack Height (m)	Stack Temp (K)	Stack Velocity (m/s)	Stack Diameter (m)
E1_02N	North Potline #1 A-398 Scrubbers (Single Representative Stack)	24.57	372.04	10.54	1.21
E1_02S	South Potline #1 A-398 Scrubbers (Single Representative Stack)	24.57	372.04	10.58	1.21
E3_02N	North Potline #2 A-398 Scrubbers (Single Representative Stack)	24.57	372.04	11.72	1.21
E3_02S	South Potline #2 A-398 Scrubbers (Single Representative Stack)	24.57	372.04	11.76	1.21
E1_02N1-10	North Potline #1 A-398 Scrubbers (Each of 10 Modeled Stacks)	24.57	372.04	10.54	1.21
E1_02S1-10	South Potline #1 A-398 Scrubbers (Each of 10 Modeled Stacks)	24.57	372.04	10.58	1.21
E3_02N1-10	North Potline #2 A-398 Scrubbers (Each of 10 Modeled Stacks)	24.57	372.04	11.72	1.21
E3_02S1-10	South Potline #2 A-398 Scrubbers (Each of 10 Modeled Stacks)	24.57	372.04	11.76	1.21
E1_02N	North Potline #1 A-398 Scrubbers (Merged)	24.57	372.04	10.54	3.84
E1_02S	South Potline #1 A-398 Scrubbers (Merged)	24.57	372.04	10.58	3.84
E3_02N	North Potline #2 A-398 Scrubbers (Merged)	24.57	372.04	11.72	3.84
E3_02S	South Potline #2 A-398 Scrubbers (Merged)	24.57	372.04	11.76	3.84

Model Inputs

This section describes the procedures and data resources utilized in the air dispersion modeling analysis.

Emission Sources

Actual emissions from Century Sebree and BREC sources were modeled for each year from 2017 to 2022. SO_2 emissions from Century Sebree are based on the mass balance SO_2 calculation methodology required by Century's Title V permit, which accurately defines actual SO_2 emissions based on known information on sulfur inputs to and outputs from the processes. This calculation methodology provides monthly emissions, which were then formatted into an hourly emission rate file for input to AERMOD (with hourly emission rates varying for each month based on that month's monthly emissions). SO_2 emissions from BREC sources are based on hourly varying data from the Clean Air Markets Division (CAMD) database. Emissions for other nearby sources (e.g., Big Rivers Electric Corp. – Wilson Station) were based on actual emissions data obtained from Kentucky Emission Inventory System (EIS) reports submitted by the facilities or, in the case of sources located in Indiana, from IDEM's NAAQS inventory.

All sources were modeled as point sources with the exception of the Century Sebree potline roof vents, which were modeled using the buoyant line source type. Input parameters for the buoyant line sources were consistent with those discussed in Section 2.8.2 of this report. Source parameters for the sources included in the modeling analysis are shown in Appendix Table A-2 to Appendix Table A-5.

Appendix Table A-2. Century Sebree Point Source Input Parameters

Model ID	Description	UTM Easting (m)	UTM Northing (m)	Elevation (m)	Stack Height (m)	Stack Temp[3] (K)	Stack Velocity[3] (m/s)	Stack Diameter[2] (m)
A6_02	Remelt Furnace (90); Gas Burners	455802.4	4168312.8	135.94	13.11	719.82	7.35	1.50
F1_01	Holding Furnaces (I1); Metal Processing	456128.7	4167785.8	135.94	27.43	431.48	7.83	0.97
F1_02	Holding Furnaces (I2); Metal Processing	456139.3	4167798.0	135.94	27.43	431.48	7.83	0.97
F1_03	Holding Furnaces (I3); Metal Processing	456161.3	4167821.1	135.94	27.43	431.48	7.83	0.97
F1_04	Holding Furnaces (I4); Metal Processing	456173.5	4167834.6	135.94	27.43	431.48	7.83	0.97
F1_05	Holding Furnaces (I5); Metal Processing	456189.8	4167853.6	135.94	27.43	431.48	7.83	0.97
F1_06	Holding Furnaces (I6); Metal Processing	456200.8	4167865.9	135.94	27.43	431.48	7.83	0.97
F2_01	Holding Furnaces (I7); Metal Processing	456217.4	4167883.3	135.94	27.43	431.48	7.83	0.97
F2_02	Holding Furnaces (I8); Metal Processing	456227.6	4167894.9	135.94	27.43	431.48	7.83	0.97
H1_01	Homogenizing Furnace (1I)	456219.8	4167811.4	135.94	18.90	755.37	12.53	1.22
H2_01	Homogenizing Furnace (2I)	456229.2	4167822.1	135.94	18.90	755.37	12.53	1.22
H3_01	Homogenizing Furnace (3I)	456238.3	4167832.8	135.94	18.90	755.37	12.53	1.22
H4_01	Homogenizing Furnace (I3I)	456287.5	4167896.2	135.94	21.34	794.26	17.53	0.46
N2_02	Anode Bake Furnace (261 Furnace)	456070.9	4168064.0	135.94	21.34	360.93	11.93	1.28
S5_01	Electrode Boiler (S5) (EI)	455952.2	4168046.4	135.94	29.87	433.15	2.13	0.91
S7_01	Green Mill Boiler	455953.7	4168044.3	135.94	29.87	433.15	2.13	0.91
E1_02N	North Potline #1 A-398 Scrubbers	455864.8	4167888.6	134.21	24.57	372.04	10.54	--
E1_02S	South Potline #1 A-398 Scrubbers	455807.6	4167824.3	134.21	24.57	372.04	10.58	--
E3_02N	North Potline #2 A-398 Scrubbers	455796.7	4167949.7	134.21	24.57	372.04	11.72	--
E3_02S	South Potline #2 A-398 Scrubbers	455740.1	4167885.5	134.21	24.57	372.04	11.76	--
E5_02N	North Potline #3 A-398 Scrubbers	455694.3	4168040.9	134.21	31.98	366.48	12.61	3.44
E5_02S	South Potline #3 A-398 Scrubbers	455636.0	4167975.9	134.21	31.98	366.48	12.56	3.44

[1] Emission rates for the potlines and anode bake furnace are derived from monthly SO2 mass balance calculations and input to AERMOD through an hourly emissions file. As such, the table above does not provide a single emission rate for these emission sources.

[2] As indicated in Table A-1, the stack diameters for the A-398 scrubbers vary depending on whether plume merging is considered.

[3] For the Anode Bake Furnace (N2_02) and the Potline A-398 Stacks (E1-02N/S,E3-02N/S,E5-02N/S), the average flow rates and temperatures recorded from the stack testing events during the past 6 years covering 2017-2022 are used in the modeling analyses. Annual stack testing is required on these units for PMACT compliance, which means at least one set of test data for each year was used to determine the averages.

Appendix Table A-3. Century Sebree Buoyant Line Source Input Parameters

Model ID	Description	UTM Easting (m)	UTM Northing (m)	Elevation (m)	Release Height (m)	End X Coordinate (m)	End Y Coordinate (m)
E1_01A	E1-1- Potroom 101 Roof Vent	455735.6	4167704.8	135.9	14.8	455977.1	4167978.0
E1_01B	E1-1- Potroom 102 Roof Vent	455698.4	4167737.8	135.9	14.8	455939.3	4168011.0
E3_01A	E3-1- Potroom 103 Roof Vent	455668.0	4167765.0	135.9	14.8	455909.4	4168038.0
E3_01B	E3-1- Potroom 104 Roof Vent	455631.3	4167797.5	135.9	14.8	455871.8	4168071.0
E5_01A	E5-1- Potroom 105 Roof Vent	455566.6	4167854.3	135.9	14.8	455808.1	4168127.0
E5_01B	E5-1- Potroom 106 Roof Vent	455529.5	4167887.3	135.9	14.8	455770.1	4168161.0

[1] Emission rates for the potline roof vents are derived from monthly SO2 mass balance calculations and input to AERMOD through an hourly emissions file. As such, the table above does not provide a single emission rate for these emission sources.

[2] Refer to Appendix C for derivation of buoyancy flux parameter.

Appendix Table A-4. BREC Point Source Input Parameters

Model ID	Description	UTM Easting (m)	UTM Northing (m)	Elevation (m)	Stack Height (m)	Stack Temp[2] (K)	Stack Velocity[2] (m/s)	Stack Diameter (m)
GREEN1	Green Unit #1	455889.8	4166717.6	125.58	106.68	327.04	22.01	4.57
GREEN2	Green Unit #2	455835.9	4166726.9	125.58	106.68	327.04	26.00	4.57
HMPL1	Henderson Power & Light Unit #1	455632.6	4166794.6	130.15	106.68	329.82	15.00	4.88
HMPL2	Henderson Power & Light Unit #2	455632.6	4166788.3	130.15	106.68	332.04	15.00	4.88
REIDTURB	Reid Combustion Turbine (Diesel Combustion)	455595.4	4166758.2	130.15	33.53	844.26	9.57	4.88

[1] Emission rates for the Big Rivers emission units were retrieved from Clean Air Markets Database and input to AERMOD through an hourly emissions file. As such, the table above does not provide a single emission rate for these emission sources.

[2] Hourly stack temperatures and exit velocities derived from CEMS data for the Green units and HMP&L units were provided by Big Rivers and included in the hourly emissions file input to AERMOD. The temperatures and exit velocities indicated in the table above for these units are based on maximum potential operating conditions.

Appendix Table A-5. Nearby Source Input Parameters

Stack ID	Model ID	Description	UTM East[2] (m)	UTM North[2] (m)	Elevation[1] (m)	SO2 Emission Rate[2] (g/s)	Stack Height[2] (m)	Stack Temperature[2] (K)	Exit Velocity[2] (m/s)	Diameter[2] (m)
3319-EU 01-1	REG01	Big Rivers Electric Corp - Wilson Station	492898	4144764	119.13	2.058939E+02	182.88	325.93	7.59	10.36
3319-EU 06-1	REG02	Big Rivers Electric Corp - Wilson Station	492898	4144764	119.13	6.652682E-05	2.36	836.48	45.64	0.13
18173-00001-4-18173	REG03	SIGECO - FB Culley Generating Station	472005	4196736	120.93	4.369917E+01	152.10	326.48	18.59	6.10
18173-00001-EDF-18173	REG04	SIGECO - FB Culley Generating Station	472005	4196736	120.93	6.391554E-04	3.05	0.00	0.001	0.001
18173-00002-070-18173	REG05	ALCOA Power Generating Inc Warrick Powe	470354	4197663	118.54	1.142030E-03	3.05	0.00	0.001	0.001
18173-00002-10-18173	REG06	ALCOA Power Generating Inc Warrick Powe	470354	4197663	118.54	1.556315E+01	152.40	327.04	20.16	5.79
18173-00002-4-18173	REG07	ALCOA Power Generating Inc Warrick Powe	470354	4197663	118.54	5.710148E-04	3.05	0.00	0.001	0.001
18173-00002-6-18173	REG08	ALCOA Power Generating Inc Warrick Powe	470354	4197663	118.54	1.713044E-03	3.05	0.00	0.001	0.001
18173-00002-65-18173	REG09	ALCOA Power Generating Inc Warrick Powe	470354	4197663	118.54	5.710148E-04	3.05	0.00	0.001	0.001
18173-00002-7-18173	REG10	ALCOA Power Generating Inc Warrick Powe	470354	4197663	118.54	2.580395E+01	115.82	328.15	18.88	4.22
18173-00002-8-18173	REG11	ALCOA Power Generating Inc Warrick Powe	470354	4197663	118.54	2.032373E+01	115.82	327.59	19.73	4.11
18173-00002-9a-18173	REG12	ALCOA Power Generating Inc Warrick Powe	470354	4197663	118.54	1.493002E+01	115.82	327.59	19.87	4.11
18173-00007-102-18173	REG13	Warrick Newco LLC	474656	4201231	136.92	3.252434E+00	28.96	350.93	49.18	1.17
18173-00007-162-18173	REG14	Warrick Newco LLC	474656	4201231	136.92	1.470600E+01	60.66	359.82	7.74	6.10
18173-00007-163-18173	REG15	Warrick Newco LLC	474656	4201231	136.92	1.589579E+01	60.66	359.82	7.74	6.10
18173-00007-164-18173	REG16	Warrick Newco LLC	474656	4201231	136.92	1.610923E+01	14.94	357.04	7.01	6.10

[1] Imported sources into AERMOD and ran AERMAP with 1-arc second (approximately 30 meter resolution) NED data to get source elevations.

[2] Actual emission rate, source locations, and stack parameters retrieved from 2021 KYEIS for sources located in Kentucky and from IDEM's 2022 NAAQS inventory for sources located in Indiana.

Meteorological Data

Meteorological data for 2017 to 2022 were used in the model evaluation study to correspond with the years of available monitor data. The meteorological data were obtained from the site-specific meteorological tower operated at Century Sebree and supplemented with National Weather Service data obtained from the Evansville Regional Airport (KEVV). Upper air data were obtained from Nashville International Airport (KBNA). The AERMET processing was completed with the input options discussed in Section 2.5 of this modeling report.

Building Downwash

Direction-specific equivalent building dimensions used as input to the AERMOD model to simulate the impacts of downwash were calculated using the EPA-sanctioned Building Profile Input Program (BPIP-PRIME), version 04274 and used in the AERMOD Model.[47] BPIP-PRIME is designed to incorporate the concepts and procedures expressed in the GEP Technical Support document, the Building Downwash Guidance document, and other related documents and has been adapted to incorporate the PRIME downwash algorithms.[48]

Receptors

The receptors used in this evaluation are consistent with those described in Section 2.7 of this modeling report. Receptors covered the nonattainment area (plus an area outside the nonattainment area to the east of Century Sebree) with variable density with finer resolution closest to Century Sebree and BREC.

Background

Background concentrations of SO_2 were incorporated into AERMOD based on data from the Evansville-Buena Vista monitor (AQS ID 18-163-0021). Data for the most recent three-year period (2020-2022) were processed to provide seasonal and hour-of-day varying backgrounds. These background concentrations are shown in Appendix Table A-6.

Appendix Table A-6. Seasonal and Hour-of-Day Varying Backgrounds (μg/m^3)

Season	Hour of Day											
Season	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**
Winter	6.97	7.32	5.40	5.92	8.10	7.06	7.40	7.32	9.58	10.19	10.10	11.15
Spring	5.92	6.18	6.71	6.01	6.88	6.71	7.58	9.93	11.76	11.85	13.85	11.32
Summer	6.62	6.01	6.36	6.18	6.36	6.01	7.93	10.02	9.76	12.72	9.76	8.71
Fall	4.97	5.66	6.36	4.97	5.31	5.14	5.05	5.40	7.58	13.07	13.42	14.20
Season	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Winter	13.68	10.37	12.37	10.45	8.97	7.06	9.23	7.14	7.75	7.14	6.53	6.01
Spring	10.19	10.02	8.97	9.67	9.41	11.50	14.02	7.93	6.88	9.23	6.01	6.97
Summer	8.28	8.36	7.75	8.97	8.97	10.89	9.50	6.97	5.84	5.31	5.40	5.05
Fall	14.20	9.84	8.28	10.02	12.46	10.63	5.75	4.18	5.14	5.84	6.45	6.88

[47] Earth Tech, Inc., Addendum to the ISC3 User's Guide, The PRIME Plume Rise and Building Downwash Model, November 1997, http://www.epa.gov/scram001/7thconf/iscprime/useguide.pdf.

[48] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *Guidelines for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) (Revised),* Research Triangle Park, North Carolina, EPA 450/4-80-023R, June 1985.

Monitor Data

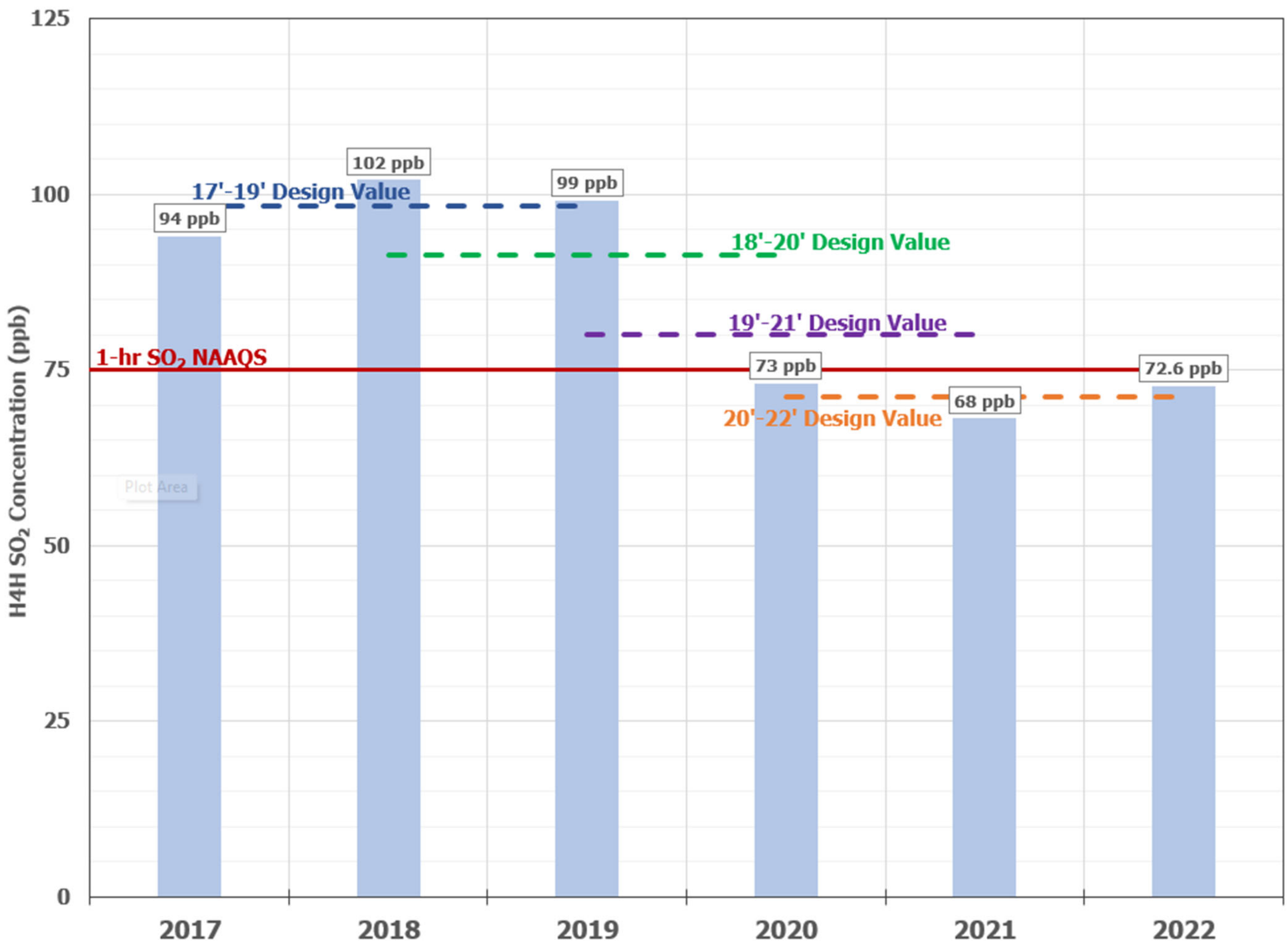
Beginning in January 2017, 5-minute and 1-hour average SO_2 concentration data has been collected by the Division at the Sebree monitoring site (Site No. 21-101-1011), which is located on the Century Aluminum property at the southeast corner of the intersection of Alcan-Aluminum Road (State Route 2096) and the Big Rivers coal haul access road. Century reviews the SO_2 concentration data monthly as it is made available. The concentration data is analyzed in conjunction with the meteorological data from the co-located meteorological data station. Appendix Figure A-1 and Appendix Figure A-2 show the location of the meteorological and SO_2 monitoring station locations in relation to the Century Aluminum Sebree Plant and the BREC Facility.

Appendix Figure A-1. Area Surrounding the Century Sebree and BREC Facilities

Appendix Figure A-2. Close Up View of the Location of the Meteorological and SO_2 Monitoring Stations

Appendix Figure A-3 summarizes the 4th highest daily maximum 1-hour SO_2 concentration recorded at the monitor each year since 2017 through 2022. The concentration trend has been generally downward over this 5-year period.

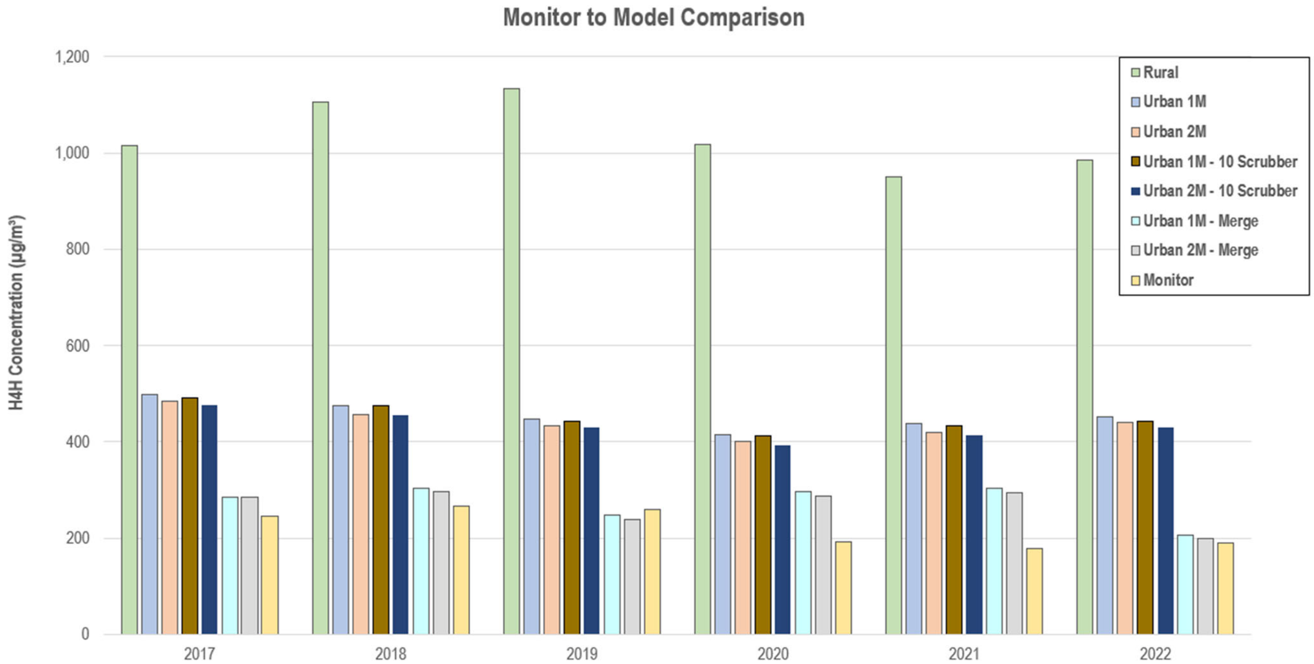
Appendix Figure A-3. 4th Highest Daily Maximum 1-hour SO_2 Concentrations at the Sebree Monitor



Results

The results of the model performance evaluations for the 4th-highest daily maximum concentrations are shown in Appendix Table A-7 and Appendix Table A-8. The maximum modeled 4th highest daily maximum 1-hour SO_2 modeled concentration from each year over the receptor grid is compared with the 4th highest daily maximum 1-hour SO_2 concentration recorded at the Sebree monitor for each year. The evaluation of the use of the urban option shows considerably better model performance, but continued overprediction, with both 1 million and 2 million population. Without the use of the urban option, AERMOD is overpredicting the 4th highest daily maximum 1-hour SO_2 concentration on average by 4.7 times. Through the use of the urban option, this overprediction is reduced to 2.0 times on average. The 2 million population scenario results in slightly better agreement with the monitored concentrations (1.9 times overprediction) compared with the 1 million population scenario (2.0 times overprediction). The results of the analyses with the urban option including 10 stacks per A-398 for Potlines 1 and 2 show results slightly lower than concentrations with one representative stack per A-398. These analyses continue to show an overprediction of 1.9 to 2.0 times on average. When A-398 potline stack merging is added to the urban option scenarios, model performance is further improved compared with monitored concentrations, resulting in average overprediction of the 4th highest daily maximum 1-hour SO_2 concentration of 1.2 times.

Appendix Figure A-4. Model Performance Evaluation Graph



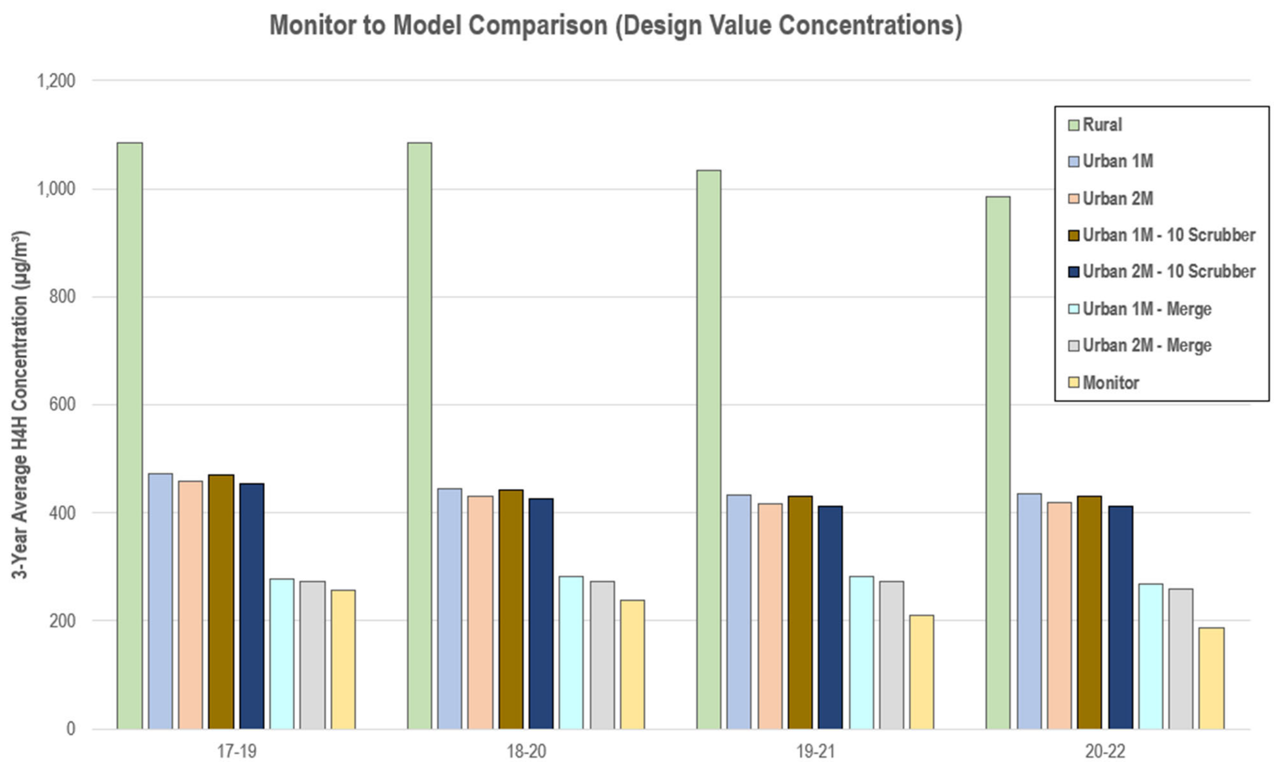
Appendix Table A-7. Model Performance Monitor to Model Ratios

Description	2017	2018	2019	2020	2021	2022	Average
	H4H Concentration (µg/m^3)						
Monitor	245.7	266.6	258.7	190.8	177.7	189.7	221.5
Rural	1014.4	1105.1	1133.3	1018.2	950.1	985.2	1034.4
Urban 1M	497.5	474.6	446.2	415.0	438.3	451.3	453.8
Urban 2M	483.6	456.4	433.1	400.0	418.0	440.2	438.6
Urban 1M - 10 Scrubber	490.9	474.3	441.8	412.7	434.1	442.4	449.4
Urban 2M - 10 Scrubber	477.0	455.8	429.2	392.7	412.4	430.5	432.9
Urban 1M - Merge	283.6	303.0	247.3	296.6	303.4	204.8	273.1
Urban 2M - Merge	283.6	295.4	238.2	286.2	294.2	199.8	266.2
Description	**Ratio to Actual Monitor**						
Monitor	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rural	4.1	4.1	4.4	5.3	5.3	5.2	4.8
Urban 1M	2.0	1.8	1.7	2.2	2.5	2.4	2.1
Urban 2M	2.0	1.7	1.7	2.1	2.4	2.3	2.0
Urban 1M - 10 Scrubber	2.0	1.8	1.7	2.2	2.4	2.3	2.1
Urban 2M - 10 Scrubber	1.9	1.7	1.7	2.1	2.3	2.3	2.0
Urban 1M - Merge	1.2	1.1	1.0	1.6	1.7	1.1	1.3
Urban 2M - Merge	1.2	1.1	0.9	1.5	1.7	1.1	1.2

* H4H indicates the highest fourth high (or 99th percentile) of the daily maximum hourly concentrations.

In addition to evaluating the individual 4th-highest daily maximum concentrations, the 3-year average of the 4th-highest daily maximum concentrations (form of the 1-hour SO_2 NAAQS) was also reviewed. As shown in Appendix Figure A-5 and Appendix Table A-8 below, the modeled design value concentrations most nearly matched the monitor design value concentration when the urban modeling option (2,000,000 population) and the A-398 potline stack merging were used in the modeling analysis.

Appendix Figure A-5. Model Performance Design Value Evaluation Graph

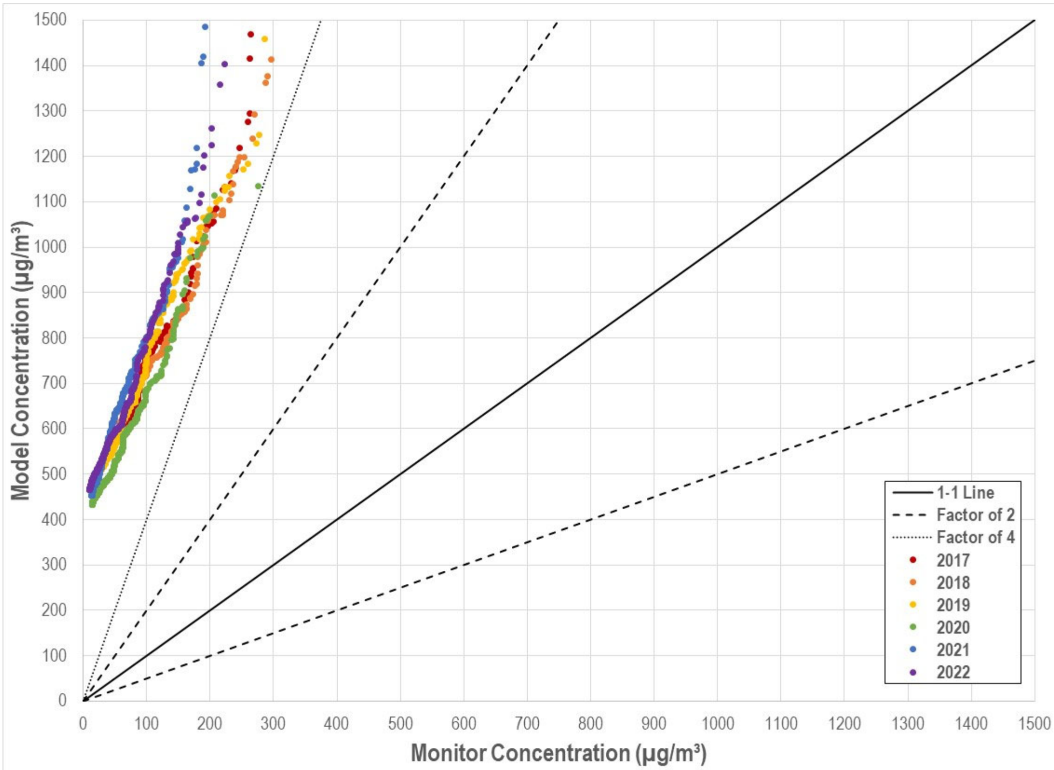


Appendix Table A-8. Design Value Model Performance Monitor to Model Ratios

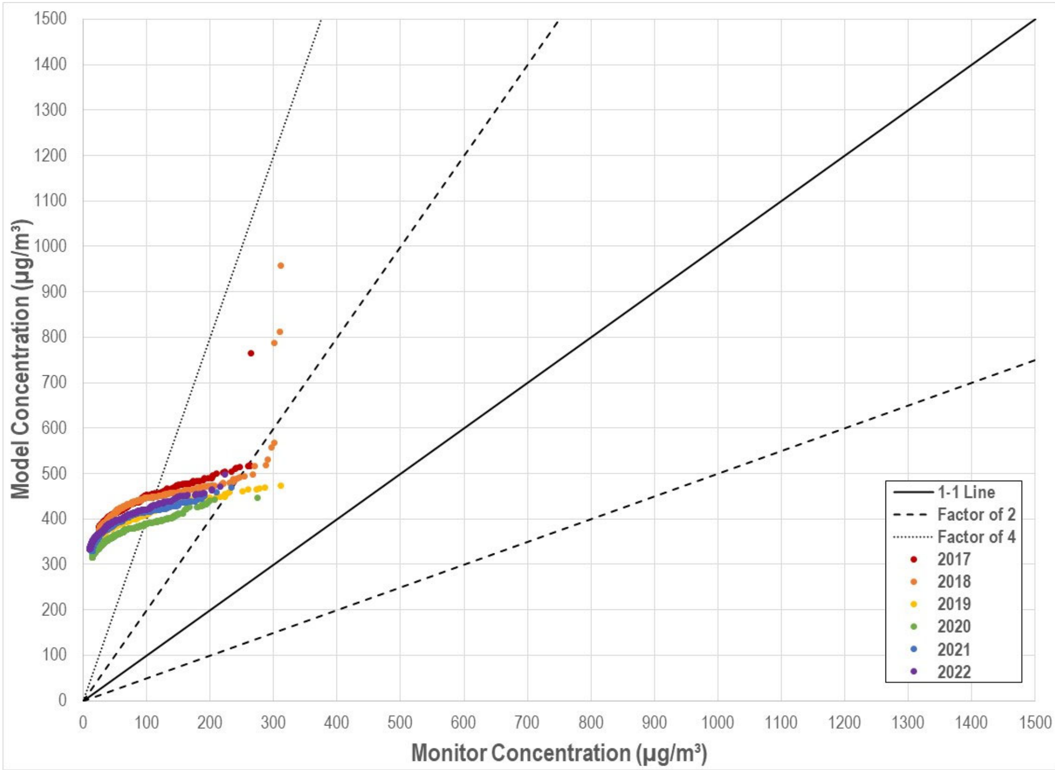
Description	17-19	18-20	19-21	20-22	Average
	3-Year Average H4H Concentration (µg/m^3)				
Monitor	257.0	238.7	209.1	186.1	222.7
Rural	1084.3	1085.5	1033.9	984.5	1047.0
Urban 1M	472.8	445.3	433.2	434.9	446.5
Urban 2M	457.7	429.8	417.0	419.4	431.0
Urban 1M - 10 Scrubber	469.0	442.9	429.6	429.7	442.8
Urban 2M - 10 Scrubber	454.0	425.9	411.4	411.9	425.8
Urban 1M - Merge	278.0	282.3	282.5	268.3	277.8
Urban 2M - Merge	272.4	273.3	272.9	260.0	269.6
Description	**Ratio to Actual Monitor**				
Monitor	1.0	1.0	1.0	1.0	1.0
Rural	4.2	4.5	4.9	5.3	4.7
Urban 1M	1.8	1.9	2.1	2.3	2.0
Urban 2M	1.8	1.8	2.0	2.3	1.9
Urban 1M - 10 Scrubber	1.8	1.9	2.1	2.3	2.0
Urban 2M - 10 Scrubber	1.8	1.8	2.0	2.2	1.9
Urban 1M - Merge	1.1	1.2	1.4	1.4	1.2
Urban 2M - Merge	1.1	1.1	1.3	1.4	1.2

Quantile-quantile (Q-Q) plots are also useful for evaluating performance of models that predict a peak or near-peak value at an unspecified time, such as AERMOD. The Q-Q plots shown in Appendix Figure A-6 to Appendix Figure A-12 were developed by ranking the top 500 peak modeled (removing duplicate hours) and monitored hourly concentrations for each year and then plotting the resulting pairs that are unpaired in time and space. The Q-Q plots show that use of AERMOD without the urban option for Century Sebree results in model overprediction generally outside the factor of four line across the range of the top 500 peak concentrations. With the use of the urban option, with the exception of a few outliers, peak hourly concentrations are within a factor of 2 of monitored concentrations, but still consistently overpredicted. Adding the stack merging for the Potline 1 and 2 A-398 stacks to the urban option (with 2 million population) results in better agreement of modeled and monitored peak hourly concentrations with a slight underprediction for few peak pairs seen for 2019. All other years continue to show overprediction by the model, resulting in average model overprediction remaining with use of the stack merging technique.

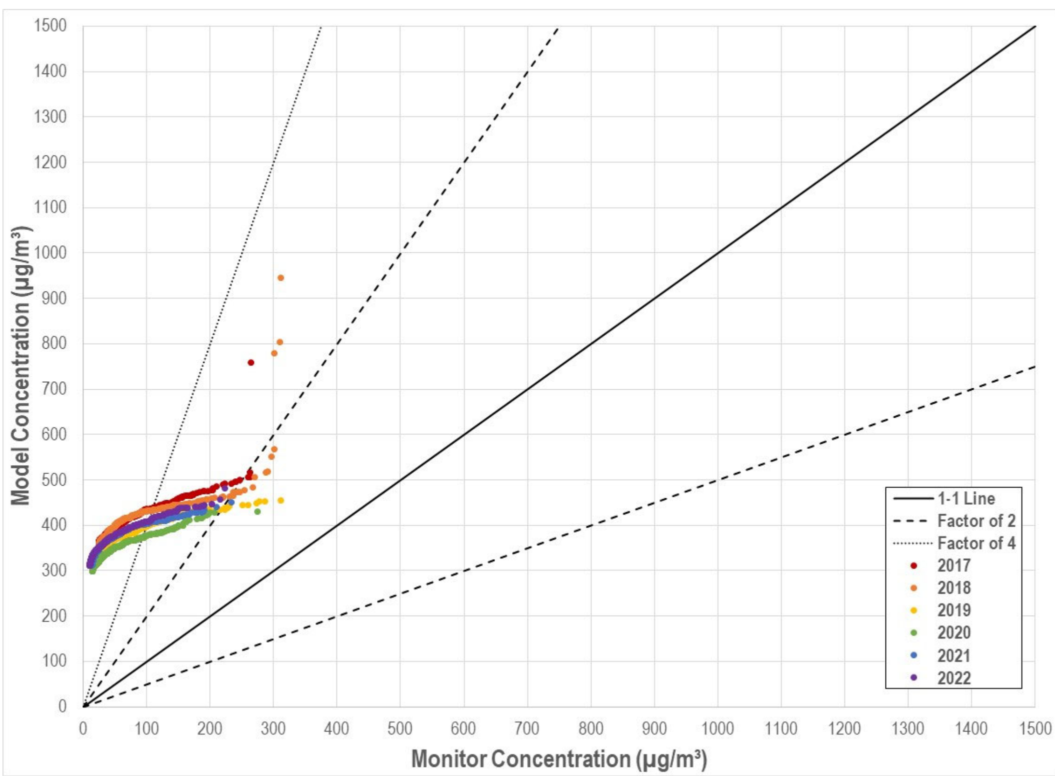
Appendix Figure A-6. 1-Hour SO_2 Q-Q Plot for Rural Scenario



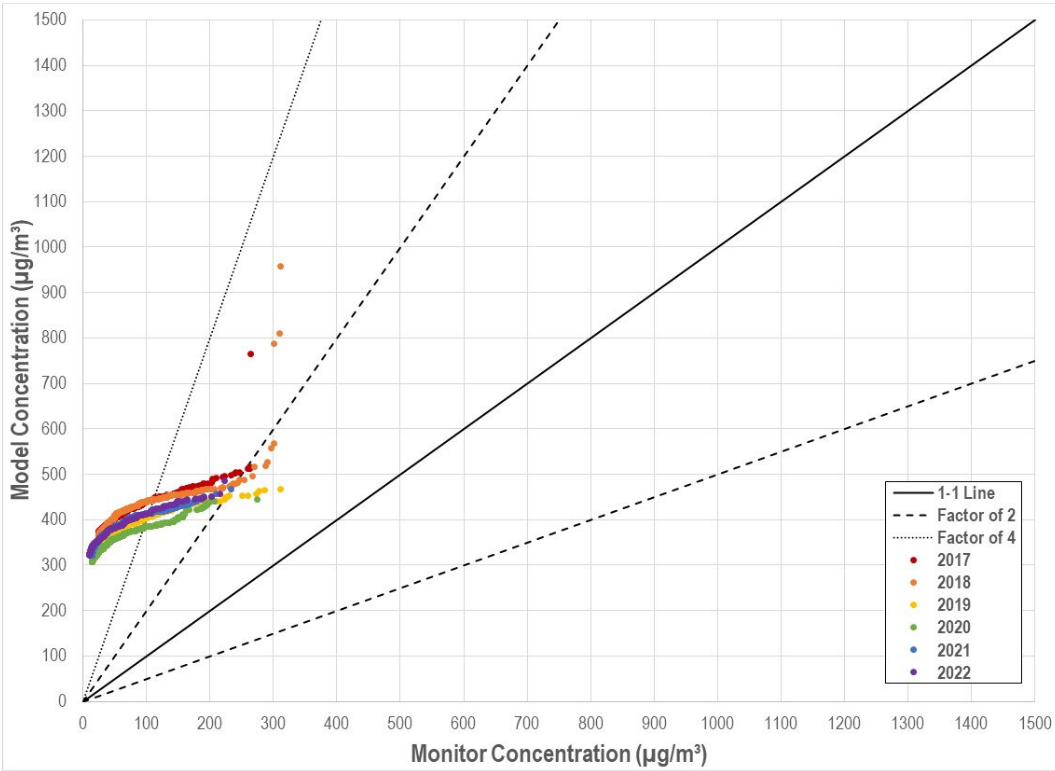
Appendix Figure A-7. 1-Hour SO_2 Q-Q Plot for Urban Scenario (1,000,000 Population)



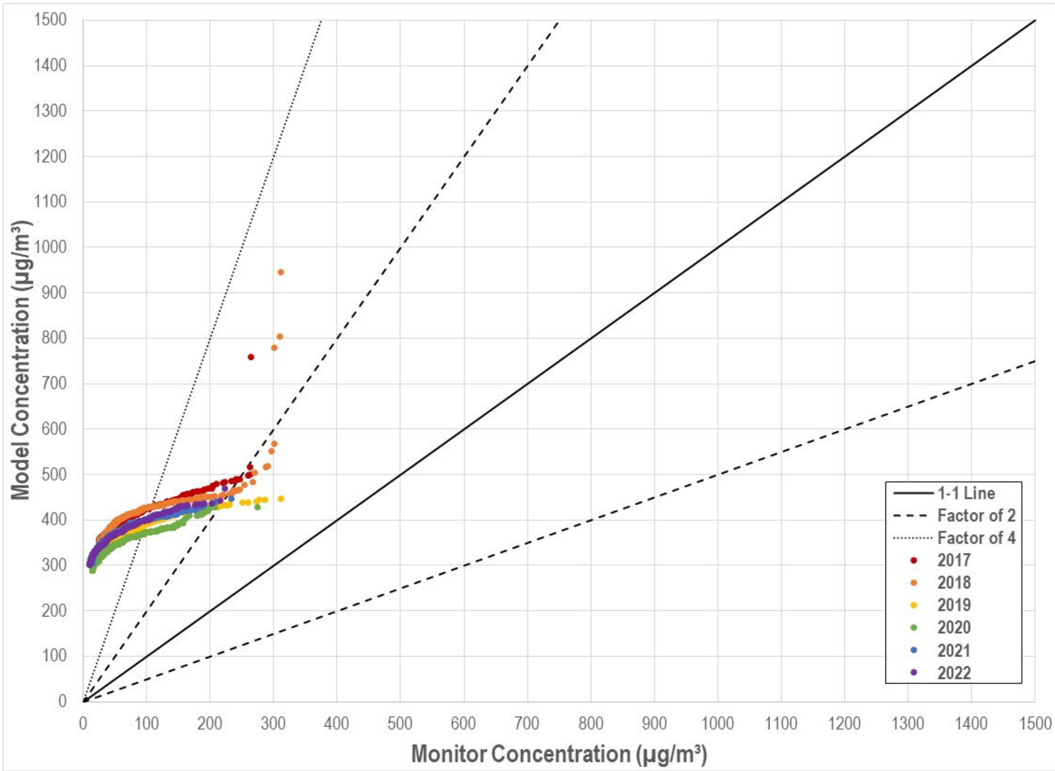
Appendix Figure A-8. 1-Hour SO_2 Q-Q Plot for Urban Scenario (2,000,000 Population)



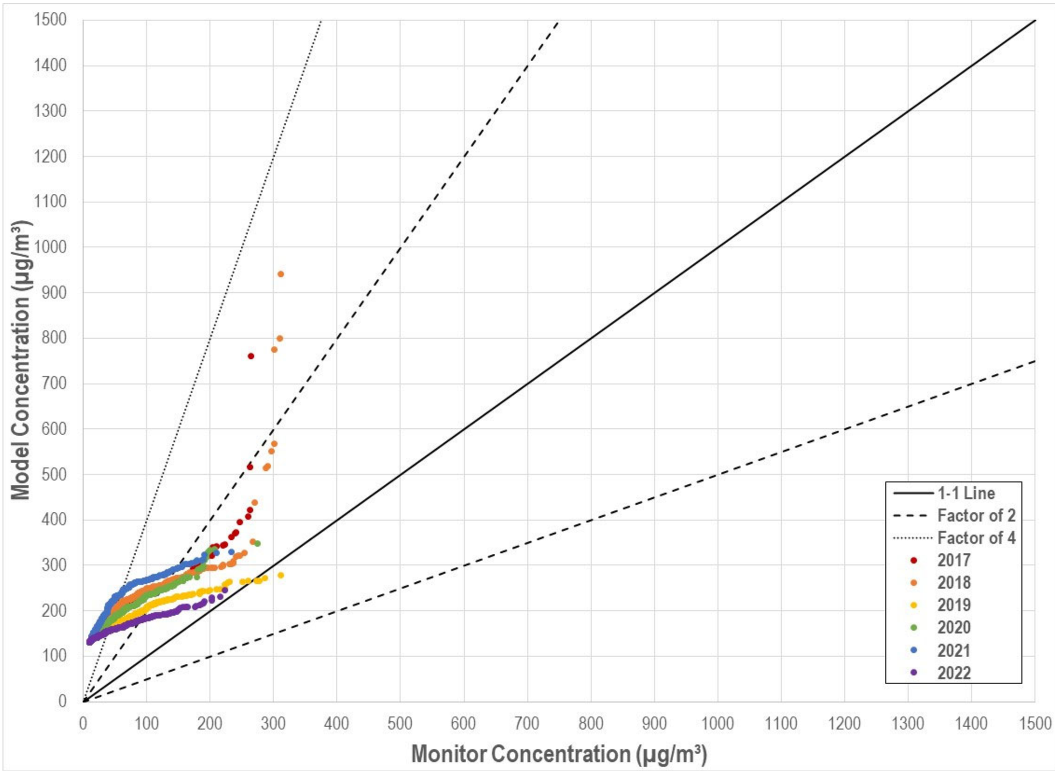
Appendix Figure A-9. 1-Hour SO_2 Q-Q Plot for Urban (1M Population) with A398 10 Stack Configuration



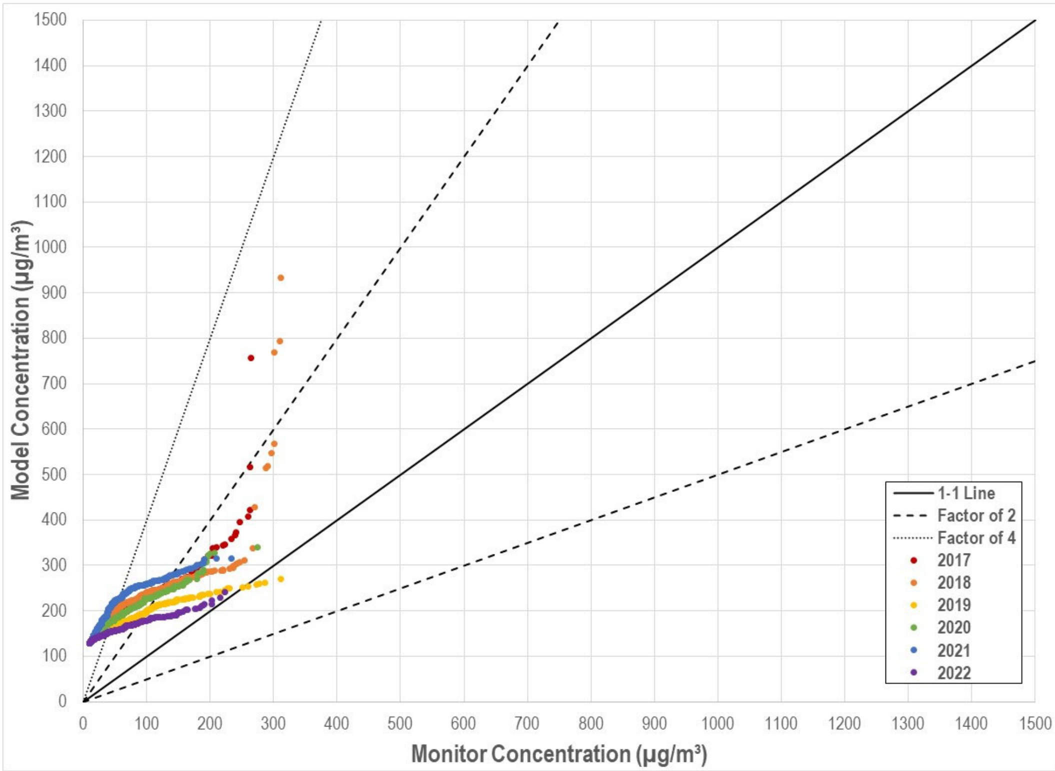
Appendix Figure A-10. 1-Hour SO_2 Q-Q Plot for Urban (2M Population) with A398 10 Stack Configuration



Appendix Figure A-11. 1-Hour SO_2 Q-Q Plot for Urban (1M Population) Including Merged A-398 Stacks



Appendix Figure A-12. 1-Hour SO2 Q-Q Plot for Urban (2M Population) Including Merged A-398 Stacks



Conclusions

An evaluation of AERMOD performance for 1-hour SO_2 modeled versus monitored concentrations was completed. The base scenario without the use of the urban option yielded considerable overprediction (>4 times for the 99th percentile of daily maximums) by AERMOD compared with monitored concentrations. AERMOD performance was improved considerably through the use of the urban option to represent dispersion for Century Sebree sources, but still yielded conservatively high results (~1.7-2.5 times for the 99th percentile of daily maximums) compared with monitor data. The performance was better with a population of 2,000,000 compared with a population of 1,000,000 used as input to AERMOD. AERMOD performance was further improved, but with continued model overprediction (1.2 times on average for the 99th percentile of daily maximums) with the use of alternative stack diameters to represent interaction between the plumes emitted from the individual stacks located on the Potline 1 and 2 A-398 scrubber systems.

APPENDIX B. QUALITY ASSURANCE PROJECT PLAN (QAPP)

METEOROLOGICAL QUALITY ASSURANCE PROJECT PLAN FOR CENTURY ALUMINUM/BIG RIVERS ELECTRIC CORPORATION MONITORING STATION

Prepared for:

Big Rivers Electric Corporation
201 Third Street
Henderson, Kentucky 42420

Century Aluminum
9404 State Route 2096
Robards, Kentucky 42452

By

Meteorological Solutions Inc.
Project No. 09161685

September 2016

Revision 0

Meteorological Solutions Inc.
A Trinity Consultants Company

METEOROLOGICAL QUALITY ASSURANCE PLAN FOR CENTURY ALUMINUM/BIG RIVERS ELECTRIC CORPORATION MONITORING STATION

A PROJECT MANAGEMENT ELEMENTS

A.1 Approvals Signatures

Date: 11/10/2016
Mr. John Knight
Environmental Technician, Century Aluminum

Date: 12/6/2016
Mr. Thomas Shaw
Environmental Director, Big Rivers Electric Corporation

Date: 10/12/2016
Mr. George Wilkerson
Project Director, MSI Trinity

Date: 10/12/2016
Mr. Casey Lenhart
Project Manager, MSI Trinity

Date: 10/12/2016
Ms. Linda Conger
Project Quality Assurance Officer, MSI Trinity

A.2 Table of Contents

List of Tables

List of Figures

Appendices

A.3 Distribution List

The following individuals have been provided a copy of this Meteorological Quality Assurance Project Plan (QAPP).

Table A-1 Distribution List for QAPP

Personnel	Organization	Email Address	Business Address	Telephone Number
John Knight	Century Aluminum	john.knight@centuryaluminum.com	Century Aluminum 9404 State Route 2096 Robards, KY 42452	270-521-7811
Thomas Shaw	Big Rivers Electric Corp.	Tom.Shaw@Bigrivers.com	P. O. Box 24 Henderson, KY 42419	270-844-6031
George Wilkerson	MSI Trinity	gww@metsolution.com	MSI Trinity 4525 Wasatch Blvd., Suite 200 Salt Lake City, Utah 84124	801-272-3000 Ext. 304
Casey Lenhart	MSI Trinity	ccl@metsolution.com	MSI Trinity 4525 Wasatch Blvd., Suite 200 Salt Lake City, Utah 84124	801-272-3000 Ext. 307
Linda Conger	MSI Trinity	lec@metsolution.com	MSI Trinity 4525 Wasatch Blvd., Suite 200 Salt Lake City, Utah 84124	801-272-3000 Ext. 305

A.4 Project/Task Organization

Mr. John Knight is an environmental technician for Century Aluminum and he, in coordination with Mr. Thomas Shaw the environmental director for Big Rivers Electric Corporation will direct the monitoring activities for Century Aluminum/Big Rivers.

George Wilkerson will be MSI Trinity's Project Director for negotiating and overseeing contractual and financial arrangements.

Mr. Casey Lenhart will serve as MSI Trinity's Project Manager who is responsible for the oversight of all field activities including equipment installation, routine monitoring operations, routine equipment maintenance, equipment calibrations, and will assist with data validation.

Ms. Linda Conger is responsible for MSI Trinity's quality control/quality assurance activities and will maintain the official approved QA Project Plan. Ms. Conger will be assisted by Mr. Dan Risch who will perform the initial quality control and quality assurance of the data and monitoring activities as well as prepare the data report. Mr. Scott Adamson is in charge of data management for this project.

Mr. Mike Peterson, Mr. Isaac Legare, and/or Mr. Tyler Ward will perform the routine maintenance and instrument calibrations. Mr. Adam Lenkowski, MSI Trinity's independent auditor will perform the semi-annual quality assurance performance audits. Figure A.1 presents the organizational chart that shows the lines of responsibility and information flow for activities under this project. A list of specific responsibilities for specific positions follows.

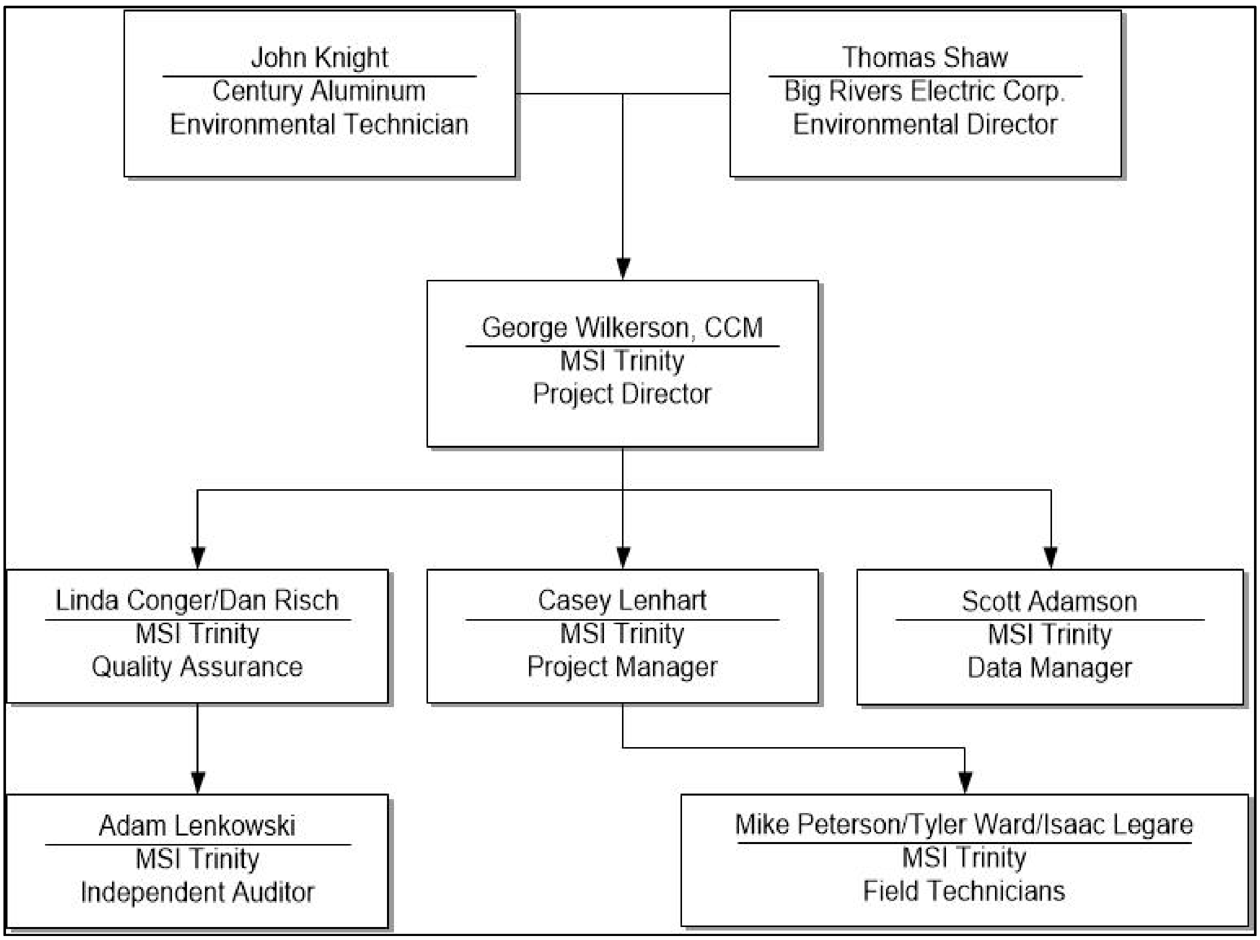


Figure A.1 Organizational Chart

A.4.1 Century Aluminum Environmental Technician

Mr. John Knight will act as the Century Aluminum monitoring project manager and will be responsible for all monitoring activities related to Century Aluminum's portion of the monitoring program.

A.4.2 Big Rivers Electric Corporation Environmental Director

Mr. Thomas Shaw will act as the Big Rivers Electric Corporation's monitoring project manager and will be responsible for all monitoring activities related to Big Rivers Electric Corporation's portion of the monitoring program.

A.4.3 MSI Trinity Project Director

Mr. George Wilkerson will be MSI Trinity's Project Director who will negotiate contractual arrangements and will provide oversight and consulting expertise to the project.

A.4.4 MSI Trinity Project Manager

Mr. Casey Lenhart will be MSI Trinity's Project Manager and will be responsible for overseeing the station installation, day-to-day operations, routine and preventive maintenance, data collection and data validation activities.

A.4.5 MSI Trinity Field Technicians/Calibration

Mr. Mike Peterson will perform the role as site operator and will perform routine maintenance and instrument calibrations. He will be assisted by Mr. Isaac Legare and Mr. Tyler Ward, as necessary.

A.4.6 MSI Trinity Quality Assurance Manager

Ms. Linda Conger is responsible for oversight of MSI Trinity's quality assurance/quality control activities from field measurements to data validation, data reporting, and implementation of quality assurance policies and procedures. She will be responsible for maintaining the official, approved QA Project Plan for MSI Trinity. Ms. Conger will be assisted by Mr. Dan Risch.

A.4.7 MSI Trinity Data Management

Mr. Scott Adamson will perform data management. MSI Trinity's data manager is responsible for ensuring timely data collection, posting data for review and preparation of data summaries for reports. Final data validation is the responsibility of the MSI Trinity project manager, the reviewing meteorologist, and the quality assurance officer.

A.4.8 Quality Assurance Performance Audits

The quality assurance performance audits for this project will be conducted by MSI Trinity independent auditor, Adam Lenkowski.

A.5 Problem Definition/Background

This quality assurance project plan has been prepared on behalf of the Century Aluminum/Big Rivers Electric Corporation and details the methodologies to establish continuous and accurate meteorological measurements at Century Aluminum and Big Rivers Electric Corporations facilities located near Robards and Sebree Kentucky. Monitoring data will be collected to document meteorological parameters in conformance with US EPA Prevention of Significant Deterioration (PSD) monitoring requirements.

The primary objective of this monitoring station is to obtain meteorological data to characterize the meteorology in the area. Data collected at this station may also be used for AERMOD modeling and comparison with other ambient air monitoring data.

A.5.1 Area Climate and Topography

The following sections describe the climate and topography around Robards and Sebree, Kentucky.

A.5.1.1 Climate

The climate of this area is considered humid subtropical based on the Köppen climate classification and, as such, the climate is mild, generally warm and temperate. Kentucky's inland location contributes to a continental influences which tends to produce a large seasonal temperature range between summer and winter. Kentucky's position north of the Gulf of Mexico contributes a tropical marine influence yields ample precipitation.

Historical weather data for Robards/Sebree area was obtained from the website, Climate-data.org[1]. Summer months (June - August) see average maximum temperatures range from approximately 86°F to 88.9°F with July being the hottest month with an average maximum temperature of 88.9°F and an average daily temperature of approximately 78°F. Extreme temperatures can reach into the 100° to 106°F range during the summer months. During the summer months, monthly precipitation averages 3.6 inches in June, 4.1 inches in July, and to 3.4 inches in August.

During the fall months of September – November, the average high temperatures drop from around 82°F in September to near 57°F in November. Average minimum temperatures drop to approximately 37°F by November. November is the wettest fall month averaging 4.1 inches of precipitation; precipitation is lowest in October, with an average of 2.8 inches of rain.

During the winter months (December – February), average maximum temperatures range from approximately 46°F in December to 46.6°F in February with lows temperatures during the winter months in the mid-20's°F. January is typically the coldest month. Precipitation averages between 3.1 to 3.9 inches during the winter months.

The average high temperatures during the spring months (March – May)'s range from 57.4° F in March to 77.7°F in May. Average low temperatures range from approximately 36°F in March to 55°F in May.

[1] http://en.climate-data.org/location/134692

Precipitation increases in spring with March as the wettest month of the year averaging 4.8 inches of precipitation.

The average temperature in the area is approximately 57°F. The area averages 45.6 inches of precipitation, annually.

A.5.1.2 Topography

The topography around the Century Aluminum and Big Rivers Electric Corporation facilities is fairly flat with a few nearby hills with abundant vegetation. The Ohio River is located approximately 12 miles north of the two facilities.

A.6 Project/Task Description

All meteorological sensors to be operated at the Century Aluminum/Big Rivers monitoring station will meet PSD monitoring requirements[2]. The operating range of the sensors and monitors will easily bracket the range of environmental conditions expected at the site.

A.6.1 Century Aluminum/Big Rivers Meteorological Monitoring Station

The meteorological tower is equipped to measure wind direction and wind speed at 10 meters, temperature at 2 and 10 meters, relative humidity, solar and net radiation at 2 meters, and barometric pressure at the base of the tower. Atmospheric stability is being calculated using the solar radiation - delta temperature (SRDT) and sigma theta ($\sigma\theta$) methods.

The Century Aluminum facility is located approximately 2.7 miles southeast of Robards and approximately 3.5 miles northeast of Sebree, Kentucky. The Big River Electric Corporation facility is located approximately 0.75 miles south of the Century Aluminum plant and approximately 0.3 miles south of Robards, Kentucky. The meteorological tower is located approximately 0.5 miles west of the Century Aluminum facility, approximately 200 feet northeast of the ambient SO_2 monitoring shelter, approximately 300 feet east of Alcan Aluminum Road. The latitude and longitude coordinates, based on WGS84, for the Century Aluminum/Big Rivers Electric Corporation meteorological monitoring station are:

- 4167572.00 meters North
- 454933.00 meters East

The location of the Century Aluminum/Big Rivers Electric Corporation meteorological monitoring tower is presented by Google Earth in Figure A.2. A summary of the meteorological instrumentation installed at the Century Aluminum/Big Rivers Electric Corporation monitoring site is presented in Table A-2.

[2] EPA's Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Meteorological Measurements, March 2008.

Figure A.2 Location of Century Aluminum/Big Rivers Electric Corporation Meteorological Monitoring Tower

Table A-2 Meteorological Instrumentation at Century Aluminum/Big Rivers Electric Corporation Monitoring Station

Parameter	Equipment Manufacturer	Model Number	Sensor Height (meters)
Wind Direction	RM Young	05305	10
Wind Speed	RM Young	05305	10
Temperature	RM Young	41342	2,10
Motor aspirated radiation shield	RM Young	43502	2,10
Net Radiation	Kipp & Zonen	NR-Lite	2
Solar Radiation	Hukseflux	LP02	2
Barometric Pressure	Vaisala	PTB110	1.5
Relative Humidity	Rotronic	HC253	2
Data Acquisition System	Campbell Scientific	CR1000	NA

A.6.2 Sampling Frequency

Data from the instruments listed in Table A-2 are collected and stored by a Campbell Scientific Inc. Model CR1000 data logger. Meteorological data are sampled every second and recorded as five-minute averages on the data logger.

A.6.3 Project Schedule

Personnel working on this project will be fully qualified, trained, and capable to perform their assigned duties. Work schedules include: daily data review; semi-annual meteorological equipment calibrations; quarterly data summaries within 60 days of quarter completion; semi-annual performance audits; and maintenance and corrective action, as needed. Table A-3 presents the project schedule.

Table A-3 Project Schedule

Task	Time
Monitoring Plan	Start of contract and as needed to reflect changes in equipment or monitoring requirements.
Monitoring Operations	Calibrations – start of contract, semi-annually for meteorological sensors, and whenever an instrument exceeds specified control limits or undergoes major maintenance or repair.
Quality Assurance	Meteorological performance audits and system audits are performed by independent auditor semi-annually for meteorological sensors.

A.6.4 Project Reports

Table A-4 presents the reports that will be produced as part of this project.

Table A-4 Project Reports

Reports	Frequency	Content	Responsible Position	Distribution
Quarterly Meteorological Data Summaries	Quarterly	Summarize data following EPA guidelines	Scott Adamson MSI Trinity Data Manager	See Section A.3 Distribution list
Corrective Action Reports	As Needed	Summarizes corrective actions taken to return the monitoring station to compliant status	Casey Lenhart MSI Trinity Project Manager	See Section A.3 Distribution list
Response to Corrective Action Reports	As Needed	Reports the results of the corrective actions taken	Casey Lenhart MSI Trinity Project Manager	See Section A.3 Distribution list

A.7 Quality Objectives and Criteria for Measurement of Data

Presented in this section are the Measurement Quality Objectives (MQOs) for the meteorological measurements. MQOs are designed to evaluate and control various phases (sampling, preparation, and analysis) of the measurement process to ensure that total measurement uncertainty is within the range prescribed by the data quality objectives. MQO's can be defined in terms of the following data quality indicators: precision; accuracy; representativeness; detectability; completeness; and comparability. For the monitoring project, the meteorological MQO's are presented in Tables A-5 and A-6. Calibration and accuracy criteria are presented in Table A-7. Measurements that do not meet the MQO's presented in Table A-5 will be invalidated unless justification can be identified for not doing so. In addition, data will be invalidated if a sensor fails a performance audit and further investigation confirms the audit results. These data will be invalidated back to the last good check or calibration of the equipment.

Precision for the meteorological measurements will be determined based on performance audit results. The accuracy and bias of the sensor measurements is determined through sensor calibrations.

Meteorological measurements recorded are subject to and consistent with the quality assurance requirements as found in the following documents:

- EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV*, Meteorological Measurements, EPA March 2008; and
- EPA's Meteorological *Monitoring Guidance for Regulatory Modeling Applications*, EPA-454/R-99-005, February, 2000.

Table A-5 Meteorological Measurement Quality Objectives

Parameter (Manufacturer/ Model)	Specified Accuracy	Required Accuracy	Sensor Resolution in System	Required Resolution	Data Completeness
Wind Speed R.M. Young Model 05305 Wind Monitor AQ	±0.20 m/s or 1% of reading	±0.20	0.01 m/s	0.1 m/s	90%
Wind Direction R.M. Young Model 05305 Wind Monitor AQ	±3 degrees	±5 degrees	0.01	1.0	90%
Temperature RM Young Platinum RTD Model 41342	±0.1°C	±0.5°C	0.01°C	0.1°C	90%
Vertical temperature difference	±0.05°C	±0.1°C	0.01°C	0.01°C	90%
Barometric Pressure Vaisala Model PTB110	±0.3 mb @ +20°C	±3 mb	0.1 mb	0.1	90%
Solar Radiation Hukseflux LP02	±5%	±5%	1.0 W/m^2	1 W/m^2	90%
Net Radiation Kipp & Zonen NR Lite 2	±5%	±5%	1.0 W/m^2	1 W/m^2	90%
Relative Humidity Rotronic Model HC253	±0.8% RH @ 23°C	±7% RH	0.1%	0.5%	90%

Table A-6 Meteorological Measurement Methods and Response Characteristics

Parameter	Measurement Method	Sensor Response Characteristic	EPA-Required Response Characteristics [3]
Wind Speed – R.M. Young Model 05305 Wind Monitor AQ	Propeller rotation produces AC signal with frequency output proportional to wind speed	Operating Range: 0-50 m/s (112 mph) Starting Threshold: 0.4m/s Distance Constant:2.1m	Starting Threshold = ≤0.5m/s Distance Const. ≤5m
Wind Direction – R.M. Young Model 05305 Wind Monitor AQ	Precision potentiometer	Operating Range: 0 to 360° Starting Threshold: 0.5 m/s @10° displacement Delay Distance: 1.2 m Damping Ratio: 0.45	Starting Threshold ≤0.5m/s Delay Distance ≤5m Damping Ratio=0.4 to 0.7
Temperature/Δ Temperature - RM Young 41342	Platinum RTD	Operating Range: ±50°C Time Constant: 10 sec	Time Constant ≤1 min.
Barometric Pressure Vaisala Model PTB101B	Silicon capacitive sensor	Operating Range: 500 to 1100 hPa Response Time: <100 ms	NA
Solar Radiation – Hukseflux Model LP02	Silicon photovoltaic detector	Operating Range: -40°C to +80°C Spectral Range: 305 to 2800 nm Sensitivity: 15μV/W/m^2	Time Constant = 5 sec Operating Range = -20°C to +40°C Spectral Range = 285 nm to 2800 nm
Net Radiation – Kipp & Zonen Model NR Lite 2	High output thermopile	Operating Range: ±2000 W/m^2 Response Time: 20 secs Spectral Response: 0-100 μm	NA
Relative Humidity - Rotronic Model HC253	IN1 capacitive sensor	Operating Range: 0 to 100% Response Time: 22 secs	≤30 minutes

NA – Not Applicable

[3] EPA's Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Meteorological Measurements, March 2008, Appendix C.

Table A-7 Meteorological Measurement Calibration and Accuracy Criteria

Parameter	Calibration			Accuracy		
	Type	Acceptance Criteria	Frequency	Type	Acceptance Criteria	Frequency
Wind Speed	NIST-traceable synchronous motor	±0.20 m/s	6 month intervals	NIST-traceable synchronous motor	±0.20 m/s	6 month intervals
Wind Direction	Compass System Orientation plus Linearity	±5°	6 month intervals	Compass System Orientation plus Linearity	±5°	6 month intervals
Temperature	3 pt. water bath with NIST-traceable thermometer	±0.5°C	6 month intervals	3 pt. water bath with NIST-traceable thermometer	0.5°C	6 month intervals
Vertical Temperature Difference	Both sensors simultaneously in 3 pt. water bath with NIST-traceable thermometer	±0.1°C for 2-10 m	6 month intervals	Both sensors simultaneously in 3 pt. water bath with NIST-traceable thermometer	±0.1°C for 2-10 m	6 month intervals
Relative Humidity	Collocated NIST-certified RH sensor	±7%RH	6 month intervals	NIST- certified RH sensor	±7% RH	6 month intervals
Solar Radiation	Collocated NIST-traceable reference pyranometer	±5%	6 month intervals	NIST-traceable pyranometer	±5%	6 month intervals
Net Radiation	Collocated NIST-traceable reference net radiometer	±5%	6 month intervals	NIST-traceable net radiometer	±5%	6 month intervals
Barometric Pressure	NIST-traceable reference barometer	±3 mbar	6 month intervals	NIST-traceable reference barometer	±3 mbar	6 month intervals

A.7.1 Representativeness of the Meteorological Measurements

Site selection followed guidelines presented in the following US EPA documents to assure that measurements are representative of meteorological monitoring conditions at Century Aluminum/Big Rivers monitoring site:

- *Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. IV: Meteorological Measurements* March 2008;
- *40 CFR Part 58, Appendix A Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS)*; and
- *Meteorological Monitoring Guidance for Regulatory Modeling Applications* EPA-454/R-99-005.

A.8 Special Training/Certifications

Personnel assigned to meteorological monitoring activities will be thoroughly trained in the proper operation, calibration, and maintenance of the equipment to ensure continued collection of valid, representative data. The MSI Trinity Project Manager will document the type of training conducted and when the training was performed. This documentation is kept in MSI Trinity's personnel file by employee. These personnel have met the educational, work experience, responsibility, and training requirements for their position. Meteorological monitoring professionals with several years of experience will have responsibility for conducting the significant quality control and quality assurance activities on site.

MSI Trinity personnel will be the site operators for the Century Aluminum/Big Rivers monitoring site. These operators have been trained by MSI Trinity monitoring management in the proper operation, calibration, and maintenance of the equipment. Per MSI Trinity's Standard Operation Procedure 109, hands-on training is conducted in MSI Trinity's ambient monitoring laboratory and in the field by the Monitoring Manager or his designated experienced instrumentation specialists.

A.9 Documents and Records

The meteorological monitoring program is committed to fully documenting all activities related to data collection, analysis, validation, and reporting. Table A-8 contains a list of the records maintained by the air monitoring program. These records can be electronic, bound in notebooks, logbooks, e-logbooks, and/or forms that are used for specific applications. Copies of the field and e-logbook are kept by MSI Trinity QA personnel and are included as part of MSI Trinity's project specific file.

Table A-8 Documentation and Reports

Documentation Type	Frequency	Report Submission	Archive	Retention Period
Monitoring Data	Daily Downloads	MSI Trinity Data Manager	MSI Trinity Server (with backup)	> 5 years
QAPP	Updated as needed	MSI Trinity QA Manager (See Distribution List in A-1)	MSI Trinity	> 5 years
Copies of Field and e-Logbook	After each site visit	MSI Trinity QA personnel	MSI Trinity	> 5 years
Quarterly Reports	Quarterly	Century Aluminum/Big Rivers Corporation	MSI	> 5 years

Primary data collection at the meteorological monitoring site will be accomplished through the use of Campbell Scientific CR1000 data logger. Meteorological data will be stored in the data logger memory as 5-minute and hourly averages computed from secondly values. Remote data management will be accomplished by remotely interrogating the monitoring site from MSI Trinity's Salt Lake City office daily to maximize data recovery and identify problems in a timely manner.

MSI Trinity will host a password-protected project web-site which would be updated after every successful download. The site will contain current meteorological chart graphics, daily minimum, maximums, and averages, quality assurance station notes, and wind roses. Historical data will also be available for review from the web site.

Stacked parameter plots will be generated which consist of every data point downloaded since the last site interrogation and reviewed by a qualified meteorologist for consistency and possible problems. These data will be reviewed on a daily basis to determine if the measurements appear normal as well as identify instrumentation problems in a timely manner.

Quarterly meteorological data reports will be compiled by MSI Trinity and submitted to the Century Aluminum/Big Rivers Corporation no later than forty five (45) days of the end of each calendar quarter. The following data and quality assurance results will be contained in the quarterly summary reports:

- Monthly printouts with valid hourly and daily averages.
- Monthly, quarterly, and annual wind roses.
- Monthly and quarterly percent data recovery by parameter.
- Results of calibration (by make, model, and serial number for each sensor and reference calibration equipment) and quality control checks.
- Problems and corrective actions/resolved.
- QAPP revisions, if necessary.

QAPP revisions will be forwarded to the individuals on the distribution list in electronic or hard-copy format. MSI Trinity's QA officer will be responsible for QAPP distribution. All monitoring data, reports and project documentation will be retained by MSI Trinity for a minimum of five (5) years.

B. MEASUREMENT AND DATA ACQUISITION

This section describes the project design and implementation of the Century Aluminum/Big Rivers monitoring project, including sampling methods, sample collection, data handling and analysis, quality control requirements, equipment testing, inspection, calibration and maintenance, and managing and validating data.

B.1 Sampling Process Design

The purpose for the meteorological measurements is to provide a continuous data record of meteorological conditions in the vicinity of the Century Aluminum/Big Rivers Power Plant to characterize the meteorology of the area. Data collected at this station may also be used for dispersion modeling. The monitoring methods and equipment implemented will provide PSD quality meteorological data. All of the sensors in the system meet or exceed PSD requirements (see Table B-2). Each instrument produces a signal transmitted to the data acquisition system where it is digitized and converted to engineering units and stored in electronic memory.

The site selection criteria, as found in EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems Volume IV: Meteorological Measurements Version 2.0* and *Meteorological Monitoring Guidance for Regulatory Modeling Applications* was followed in considering placement of the tower. The tower was installed at a distance beyond the influence of obstructions, such as buildings and trees. Accessibility and site security were also considered in the placement of the tower. The meteorological measurements at this location will be representative of the meteorological conditions in this area of interest. More detailed site information with a map and a photograph of the monitoring site is presented in Section A.6.

To access the Century Aluminum/Big Rivers meteorological monitoring station from Sebree, travel north on US-41 for approximately three miles then head east on KY-2097 for 0.8 miles. Head north on KY-2096 for 0.5 miles and the tower is located 300 feet to the east. Access to the tower and equipment is made via foot. MSI Trinity technicians can drive to the site in the winter months.

B.2 Sampling Monitoring Equipment and Methods Description

This section summarizes the meteorological instrumentation being used for the Century Aluminum/Big Rivers monitoring program. The operating range of the sensors easily brackets the range of environmental conditions expected at the site. The equipment manufacturer, model, and sampling height for each piece of equipment installed on the meteorological tower is presented in Table A-2. The standard operating procedures followed to calibrate and operate the equipment in Table A-2 are presented in Table B-2.

B.2.1 Meteorological Equipment Description

A brief description of each meteorological sensor installed at the Century Aluminum/Big Rivers monitoring station is discussed in this section. Full specifications for each piece of equipment can be found in Appendix A.

B.2.1.1 Wind Direction and Wind Speed

The R.M. Young Model 05305 Wind Monitor AQ is a high resolution wind sensor designed specifically for air quality applications and made of UV-stabilized plastic with stainless steel and anodized aluminum fittings. Precision grade, stainless steel ball bearings are used. Transient protection and cable terminations are in a convenient junction box.

The wind speed sensor is a four blade helicoid propeller. Propeller rotation produces an AC sine wave voltage signal with frequency directly proportional to wind speed. The starting threshold is 0.4 m/s.

The wind direction sensor is a rugged yet lightweight vane with a sufficiently low aspect ratio to assure good fidelity in fluctuating wind conditions. Vane angle is sensed by a precision potentiometer housed in a sealed chamber. With a known excitation voltage applied to the potentiometer, the output voltage is directly proportional to vane angle. A mounting orientation ring assures correct alignment of the wind direction reference when the instrument is removed for maintenance. The vane starting threshold is 0.5 m/s at 10 degrees displacement.

B.2.1.2 Temperature and Delta-Temperature

RM Young Platinum RTD Model 41342 ambient temperature sensors, to be used at the 2- and 10-meter levels, utilize a precision, extended range thermistor to measure ambient air temperature. The temperature sensor will be operated in a motor-aspirated radiation shield with flow interrupt indicators. With an NIST-traceable factory calibration, the sensor has an absolute accuracy of ±0.1°C. The sensor accuracy for delta-T is ±0.1°C.
Each temperature sensor will be mounted in a R.M. Young Model 43502 aspirated radiation shield. The aspirated radiation shield provides maximum sensor protection from incoming short wave and outgoing long wave radiation The shield employs a triple walled intake tube and multiple canopy shades to effectively isolate the sensor from precipitation and solar radiation. A continuous duty DC blower provides constant flow of ambient air over the sensor.

B.2.1.3 Relative Humidity

The Rotronics HC2S3 is a rugged, accurate temperature/RH probe that is ideal for long-term, unattended applications. The HC253 uses an advanced capacitive sensor for the relative humidity measurement. The relative humidity sensor has an accuracy of ±0.8%.

B.2.1.4 Solar Radiation

The Hukseflux LP02 is an ISO second-class pyranometer that measures solar radiation with a high quality blackened thermopile protected by a dome. The blackened thermopile provides a flat spectral response for the full scale spectrum range (305 to 2800 nm).

B.2.1.5 Net Radiation

The Kipp & Zonen NR-LITE 2 net radiometer measures the energy balance between incoming short-wave and long-wave IR radiation relative to surface reflected short-wave and outgoing long-wave IR radiation. This net radiometer includes two black conical absorbers, one facing upward and the other facing downward. Both absorbers are calibrated to an identical sensitivity coefficient. The net radiometer outputs a millivolt signal that is measured directly by the datalogger.

B.2.1.6 Barometric Pressure

The Vaisala PTB110 uses a BAROCAP sensor, a silicon capacitive absolute pressure sensor to measure barometric pressure over a 500 to 1100 millibar range.

B.2.1.7 Data Acquisition System

A Campbell Scientific CR1000 data acquisition system (DAS) is used to store data from the sensors. The DAS uses one-second data values to compute and stores 5-minute averages of temperature, delta temperature, scalar wind speed, unit vector wind direction, sigma theta of wind direction, solar and net radiation, and barometric pressure. The DAS is capable of being polled locally through a RS232 connector or remotely via modem. An on-site display allows users to view current values of the parameters being measured.

B.2.1.8 10-Meter Aluminum Tower

The meteorological sensors will be secured to a Model UT30 10-meter guyed aluminum tower. The UT30 includes a mounting base secured in concrete. Lightning protection will be mounted to the tower. The tower tilts down to ground level which eliminates the need to climb the tower for servicing.

B.2.1.9 Telecommunications

Telecommunications to the station are accomplished with a Sierra Wireless Raven modem with a Verizon wireless connection will be utilized for remote access to site datalogger to download data and check the status of on-site equipment. The site will be securely available via a password protected static IP address and be available for data collection and interrogation 24/7/365.

Table B-1 presents the equipment specifications and the PSD criteria for meteorological sensors.

Table B-1 Meteorological Equipment Specifications

Parameter	Specifications	EPA PSD Criteria	Selected Site Sensor Specifications
Wind Speed	Starting Threshold	WS ≤0.5 m/s	WS = 0.22 m/s
	Accuracy	±0.2 m/s	±0.07 m/s (0.15 mph)
	Distance Constant	≤0.5 m @ 1.2 kg/m^3	1.5m
Wind Direction	Starting Threshold	≤0.5 m/s @ 10 degrees	0.22 m/s
	Damping Ratio	0.4 to 0.70 @1.2 kg/m^3	0.6
	Accuracy	±5 degrees	±3 degrees
Temperature	Accuracy	±0.5°C	±0.1 °C
Vertical Temperature Difference	Accuracy	±0.1 °C	0.05 °C
Shield (Motor Aspirated)	Aspiration rate	>3.0 m/s	3.4 to 7.6 m/s
Relative Humidity	Accuracy	±7%RH	±2% (0 to 90% RH) ±3% (90-100% RH)
Solar Radiation	Accuracy	±5%	±3% typical ±5% maximum
Net Radiation	Accuracy	±5%	±5%
Barometric Pressure	Accuracy	±3.0 mb (0.3 kPa)	±0.5 mb @ +20°C ±1.5 mb @ 0° to 40°C ±2.0 mb @ -20° to +45°C ±3.0 mb @ -40° to +60°C

B.2.2 Standard Operating Procedures

Standard operating procedures have been developed to provide instructions to the site operators regarding routine operation of the meteorological equipment. These SOP's range from inventory of equipment, equipment inspection and acceptance testing, visual inspections, preventive maintenance, and calibrations. Table B-2 presents the SOPs used for this program. Copies of these SOP's can be found in Appendix B.

Table B-2 Standard Operating Procedures

MSI SOP No.	Revision No. and Date	SOP Title	Regulatory Citation
SOP 69	Rev. 4 09/18/2014	Calibration and Audit Equipment Certification	1
SOP 106	Rev. 2 09/18/2014	In-House Calibration of Test Equipment	1
SOP 107	Rev. 2 09/18/2014	Equipment Inventory Procedure	NA
SOP 113	Rev 2. 09/18/2014	Visual Inspection of Meteorological Equipment	1
SOP 114	Rev. 1 10/15/2014	Data Collection and Initial Processing	1
SOP 115	Rev. 1 10/15/2014	Level 1 Data Validation	1
SOP M11	Rev 6. 09/18/2014	Wind Direction Calibration	1
SOP M12	Rev 4. 09/18/2014	Wind Speed Calibration	1
SOP M13	Rev 4. 09/18/2014	Temperature	1
SOP M15	Rev 4. 09/18/2014	Relative Humidity Calibration Procedures	1
SOP M16	Rev 4. 09/30/2014	Solar Radiation Calibration	1
SOP M17	Rev 3. 09/30/2014	Barometric Pressure Calibration	1
SOP M18	Rev. 4 10/14/2014	Net Radiation Calibration	1

[1] Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. IV: Meteorological Measurements Version 2.0 (Final).

Conditions adverse to quality will be identified promptly by the Data Manager or site technician and the Project Manager will be notified. Once an issue that is adverse to quality has been identified by the Data manager, the Project manager or his designate will troubleshoot the issue to identify the cause and the issue will be corrected as soon as possible. The Project Manager will initiate a Corrective Action Report (Appendix C) which includes the date and time when the problem was identified, the proposed corrective action to resolve the issue, and the date and time of the results of the proposed action.

B.3 Sample Handling and Custody

Not applicable.

B.4 Analytical Methods

Not applicable.

B.5 Quality Control Requirements

This section describes the routine quality control procedures used for the Century Aluminum/Big Rivers meteorological monitoring program. All procedures have been specifically designed to provide the appropriate quality control and ensure that valid data recovery meets or exceeds the data recovery requirements of 90 percent per quarter for meteorological parameters.

The meteorological monitoring program will follow the quality control guidelines as stated in the following documents:

- *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV*: Meteorological Measurements, March 2008; and
- *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, 2000.

Table B-3 presents quality control procedures and frequency.

Table B-3 Quality Control Procedures

Procedure	Frequency	Requirement
1. Visual Inspection of Equipment	Routine or Emergency Site Visits	Meets MQO (Table A-5)
2. Remote interrogation of monitoring station and inspection of data	Daily	QC Checks for data screening (Section B.10)
3. Routine calibration	Semi-annually	Meets MQO (Table A-5)
4. Calibration reference standard certification	Annually	NIST-traceable or A2LA, if applicable
5. Equipment Maintenance	Annually or as needed	Section B.5.8
6. Personnel Training	On-going	MSI SOP 109
7. Data validation	Daily and monthly	Electronic data screening Time/Parameter Plot visual check
	Quarterly	Data processing calculation check Missing data confirmed Off-line periods confirmed Data validation checklist

B.5.1 Visual Inspection of Equipment

The meteorological equipment is mounted on a 10-meter tower. Visual inspections of the tower will be performed semi-annually by the site technician. Maintenance will be performed as needed. A site check form will be completed during each visit. A sample Site Check Form is found in Appendix D.

B.5.2 Remote Interrogation of Monitoring Station and Inspection of Data

The DAS at the Century Aluminum/Big Rivers site will be interrogated daily via modem to download and process the data. Computerized inspection and visual inspection of these data will be performed daily using an outlier program. Values that fall outside of prescribed limits will be evaluated by a qualified air quality specialist or meteorologist and corrections to data will be documented. Abnormal data values or problems will be reported as soon as possible to the Project Manager and Project Quality Assurance Manager who will initiate corrective action and determine if a special site visit is required.

Should corrective action be necessary, the Project Manager will initiate the process by preparing a Corrective Action Form to document the issue, time of discovery, the affected measured parameters, and the recommended course of action. The Project Manager will notify project participants via email or telecommunications of any planned corrective action that cannot be immediately resolved and may result in data loss. A copy of the Correction Action Form is presented in Appendix C.

The Project Manager will be responsible for verifying that corrective actions are appropriate and were performed correctly and in a timely manner. The Project Manager is responsible for maintaining and tracking the Corrective Action Form to document completion of work. All final Corrective Actions Forms will be signed by the Project manager once all work is completed. Copies of the completed Corrective Action Forms will be included in the quarterly data summaries.

B.5.3 Equipment Calibration

Meteorological equipment calibrations will be performed when problems are noted and semi-annually. Sensors which do not meet calibration specifications or fail performance audits will be repaired and recalibrated.

B.5.4 Calibration Reference Standard Certification

Reference standards used for calibration of meteorological sensors will be certified annually and will be traceable to National Institute of Standards and Technology (NIST) standards. Calibration certificates are on file at MSI Trinity's office and are included with each calibration report. Reference standards will be certified over the ambient measurement range expected at the Century Aluminum/Big Rivers monitoring station.

B.5.5 Equipment Maintenance

Manufacturer's recommendations for maintenance of the meteorological sensors will be followed. Instrument instruction manuals are available for reference of preventive and remedial maintenance procedures. Preventive and corrective maintenance will be documented on the calibration forms completed immediately after any maintenance.

B.5.6 Personnel Training

Personnel operating the meteorological equipment will be thoroughly trained in the proper operation, calibration, and maintenance of the equipment to ensure continued collection of valid, representative data.

B.5.7 Data Validation Criteria

The criteria presented in Table A-7 are deemed critical to maintaining the integrity of the data. Data that do not meet the verification/calibration and accuracy criteria will be invalidated unless compelling reason or justifications exist for not doing so. The cause for not operating within the acceptable range will be investigated and corrective action taken to remedy the problem such that additional data will be invalidated. The Project Manager will be alerted by the Data Manager or site technician when critical criteria are exceeded. Project Manager will notify Century Aluminum/Big Rivers when critical criteria are exceeded causing data to be invalidated.

B.6 Instrument/Equipment Testing, Inspection and Maintenance

The procedures to be followed for equipment testing, inspection, and maintenance are discussed below.

B.6.1 Acceptance Testing of Instrumentation and Equipment Integration

Prior to installation, acceptance testing of instrumentation will be performed to verify that the instruments meet the required US EPA performance specifications. Sensors that fail to meet specifications will be returned to the manufacturer. After installation, the meteorological sensors are calibrated according to the procedures presented in each respective operating manual. To ensure that the meteorological equipment continue to operate properly during monitoring, checks of the instruments will be conducted during each site visit or at least semi-annually. Preventive maintenance and quality assurance procedures will be conducted on a routine basis.

B.6.2 Site Surveillance and System Check Procedures

At least semi-annually or as needed, a site technician will visit the monitoring station to inspect the meteorological tower and sensors. During each site visit, entries will be made in the site logbook or in an e-logbook documenting all site activities conducted. These entries will include the date of the visit, reason for the visit, and the maintenance or calibration activities performed. If changes are made to the equipment or configuration of the system, these changes will also be entered in the site logbook. Entries will be made when: (1) sensors are replaced, or (2) any change is made to the station's configuration.

Personnel operating the meteorological equipment are thoroughly trained in the proper operation, calibration, and maintenance of the equipment to ensure continued collection of valid, representative data.

B.6.3 Site and Equipment Maintenance

Manufacturer's recommendations for maintenance of the sensors will be followed, as required. Preventative and corrective maintenance will be documented on the calibration forms completed immediately after any maintenance. The routine maintenance to be performed at the Century Aluminum/Big Rivers monitoring site is presented in Table B-4.

Table B-4 Routine Maintenance

Item	Schedule
Wind Monitor AQ	
Wind Speed Bearings Replacement	Biannually or As needed
Wind Direction Bearings Replacement	Biannually or As needed
Wind Direction Potentiometer Replacement	As Needed
Carbon Fiber Propeller Replacement	As Needed
Motor Aspirated Temperature	
Blower Motor Replacement	As needed
Solar Radiation Sensor	
Dome Cleaning	Biannually or As Needed
Relative Humidity	
Particulate Filter & Cap Cleaning or Replacement	As Needed

Additional maintenance to be performed on the relative humidity sensor semi-annually or more frequently, as needed, includes: (1) checking to see if the radiation shield is free of debris; (2) the black screen at the end of the sensor is checked for contaminants; and (3) the Teflon membrane filter checked and cleaned, if necessary, for contaminant buildup. Preventive and corrective maintenance will be documented. The guy wires will be inspected during each site visit. Guy anchors will be checked at least annually.

B.6.4 Spare Parts

Spare parts, such as bearings, cups, and propellers, will be retained and stored at MSI Trinity in a secure area in case they are needed.

B.7 Instrument/Equipment Calibration and Frequency

B.7.1 Meteorological Calibration Procedures

Meteorological equipment calibrations will be performed semi-annually with equipment that is in current calibration and is traceable to NIST or A2LA standards. Sensors which do not meet calibration specifications or fail performance audits will be repaired and re-calibrated. Calibration certifications and records remain on file at MSI Trinity's Salt Lake City office. Calibration procedures for the meteorological sensors are presented below. Standard Operating Procedures for meteorological sensor calibration are provided in Appendix E.

B.7.1.1 Wind Direction

The cross arm orientation will be checked using a professional compass. The wind vane will be aligned with the cross arm and set to true north. True north is distinguished from magnetic north by reading a magnetic compass and applying a correction factor for the magnetic declination. The declination will be determined from a declination calculation computer program. If the overall wind direction error (orientation plus linearity) exceeds ±5 degrees from true North, the sensor will be re-calibrated.

The wind direction sensor starting threshold will be checked using a torque gauge. The torque gauge is placed on the sensor shaft and the torque is measured. If the sensor starting threshold is greater than 0.5 meters per second (m/s), the bearings will be replaced and the sensor will be re-calibrated.

The wind direction linearity will be checked using a direction template. The sensor response will be checked at a minimum at 30 degree increments in both clockwise and counterclockwise rotations and compared with the DAS readings. If the indicated wind direction linearity plus orientation error exceeds ±5 degrees, the sensor will be repaired and re-calibrated.

B.7.1.2 Horizontal Wind Speed

Horizontal wind speed response checks will be performed using a synchronous motor. Sensor readings taken from the DAS will be compared to calibration values obtained from transfer functions provided in the sensor manufacturer's specifications. If the horizontal wind speed error exceeds ±0.20 m/s, then the instrument will be recalibrated.

The horizontal wind speed sensor starting threshold will be checked using a torque gauge or a torque disc. The torque device is placed on the sensor shaft and the torque is measured. If the measured torque exceeds manufacturer's tolerance specifications for wind speed sensor starting threshold of 0.5 m/s, then the bearings will be replaced and the instrument will be recalibrated.

B.7.1.3 Temperature

Temperature sensor calibration will be verified by direct comparison of sensor outputs to a collocated calibrated reference standard thermometer encompassing the measurement range expected at that particular site. If the sensor output is more than 0.5 degrees Centigrade (°C) different from the reference, the sensor will be repaired and re-calibrated. Sensors at different levels will be checked simultaneously in the same medium so that the delta temperature (ΔT) function can be verified.

If the vertical temperature difference differs by more than 0.1°C for 2-10 meters, the sensors will be repaired/replaced and re-calibrated.

B.7.1.4 Relative Humidity

The relative humidity sensor calibration will be verified by comparison of station sensor outputs with a relative humidity reference sensor collocated at ambient conditions. If the site sensor output differs by more than ±7 percent relative humidity from the reference, the sensor will be recalibrated.

B.7.1.5 Solar Radiation

The solar radiation pyranometer outputs will be verified by collocation of a calibrated pyranometer adjacent to the system sensor. Readings from the reference pyranometer will be compared directly to the site's pyranometer readings recorded on the DAS. If the sensor output differs by more than ±5% from the reference, the sensor will be recalibrated.

B.7.1.6 Net Radiation

Net radiation outputs will be verified by collocation of a calibrated net radiometer adjacent to the system sensor. Readings from the reference pyranometer will be compared directly to the site's net radiometer's readings recorded on the DAS. If the sensor output differs by more than ±5% from the reference, the sensor will be recalibrated.

B.7.1.7 Barometric Pressure

The barometric pressure sensor calibration will be verified by collocation of a certified reference barometer and comparing the reference output with sensor outputs recorded on the data acquisition system. If the site sensor output differs from the reference by more than ±3 mb, the sensor will be re-calibrated.

The equipment used to perform meteorological sensor calibrations is listed in Table B-5.

Table B-5 Meteorological Calibration Equipment

Parameter	Equipment	Serial Number
Wind Direction	Brunton Model 5008 Pocket Transit RM Young Model 18331 Vane Torque Gauge Met One Model 040 Direction Template	5081005174 NA DIR 06
Wind Speed	RM Young Model 18802 Anemometer Drive RM Young Torque Disc Model 18310	CAO2014 NA
Temperature (2 and 10 meter)	Brooklyn Digital Model 6661S Thermometer	C466800
Barometric Pressure	Vaisala Model PTB110	G0770046
Solar Radiation	LiCor Model 200X	PY56373
Net Radiation	REBS Q-7.1	Q01013
Relative Humidity	Vaisala HMP45AC	W1630084

B.7.2 Calibration Forms

Meteorological sensor calibration forms are included in Appendices D.

B.7.3 Calibration Frequency

Meteorological instrument calibrations will be performed semi-annually and whenever an instrument exceeds specified control limits or undergoes major maintenance or repair. If a sensor fails a performance audit, calibration verification will be documented and then it will be replaced or repaired and re-calibrated. If possible, an as found calibration checks will be documented and then an after maintenance calibration check will follow.

B.8 Inspection/Acceptance of Supplies and Consumables

Spare parts will be purchased only from the instrumentation manufacturer. They will be inspected by MSI Trinity's Project Manager for shipping damage upon receipt. The use of spare parts will be documented on calibration forms.

B.9 Non-direct Measurements

To insure accuracy of the measurements, measuring and test equipment will be calibrated against verified instruments having known relationships to nationally recognized standards. For example, reference standards used for calibration of meteorological instrumentation will be traceable to NIST standards. Barometric pressure sensors may be verified against location National Weather Service reference aneroid barometers.

Sigma theta will be calculated by the data logger using the Yamartino Method. The site location will be verified with a GPS.

B.10 Data Management

The proper management of all data is critical to assuring the quality and usability of the monitoring results. As such, procedures have been implemented to ensure robust data acquisition, validation, reduction, reporting, and storage of electronic data. Meteorological monitoring data will be recorded and stored on site using a Campbell Scientific CR1000 data logger. Meteorological data will be retrieved from the monitoring site daily via cellular modem. The modem can be called from any computer having the correct software and the IP address.

All electronic calculations and statistical analyses will be performed using standard software (Microsoft Excel) that can be easily verified. All project documentation, records, data, and reports will be stored for at least five years following project completion. The data are stored on a personal computer at MSI Trinity which is backed up to a network storage unit nightly and will be archived at two separate locations.

Meteorological data will be reviewed routinely by the MSI Trinity Data Manager and by the project meteorologist assigned to this project. These data will be subjected to several levels of quality control, validation and quality assurance as discussed in Section D. Validated data are compiled into the final database for further analysis and report preparation. The final database is processed and stored on a personal computer and then archived on various storage media and maintained in duplicate in more than one location for protection.

The Data Manager will archive data on MSI Trinity's network and on storage hard drives which are stored off-site. The overall flow of data management is illustrated in Figure B.1.

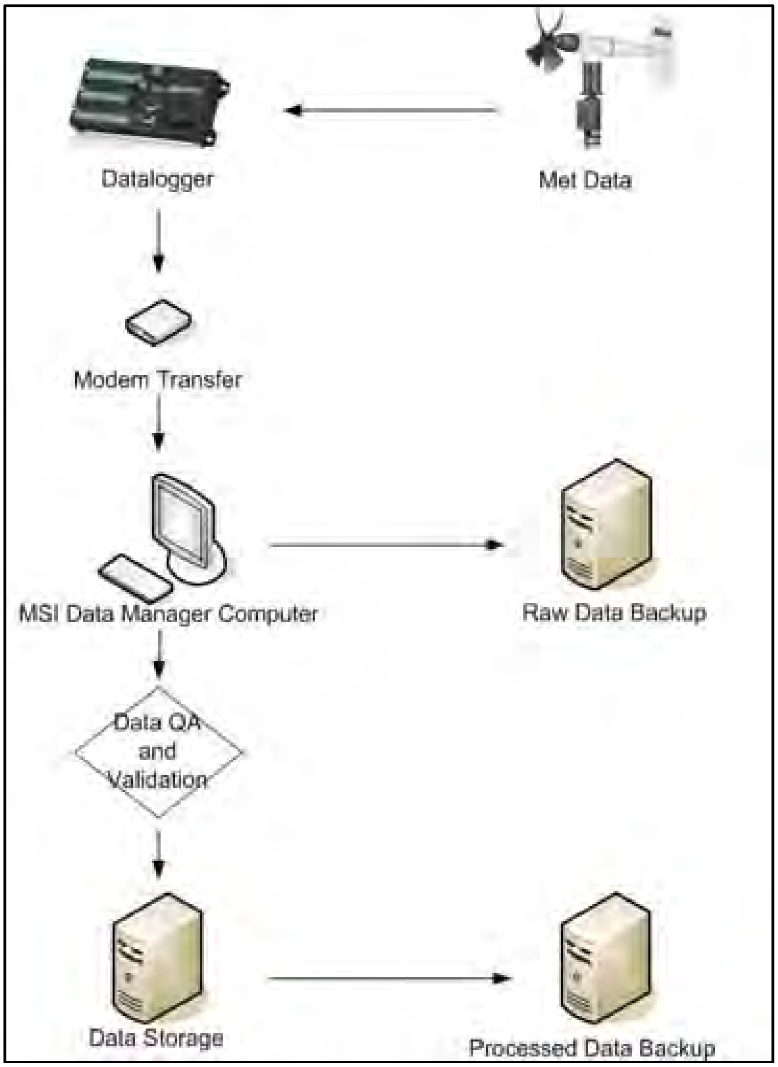


Figure B.1 Data Management Flow Chart

The meteorological data will be summarized in monthly tables and reported quarterly. The quarterly report will conform to EPA guidance.

B.10.1 Data Retrieval

Data is retrieved from the site by connecting to the DAS via remote telemetry.

B.10.2 Raw Data

Raw data are records, notes, memoranda, worksheets or exact copies and are the result of original observations and activities of the monitoring project. Raw data include data from the DAS and data entered directly into a system.

B.10.3 Data Transfer

The sensors produce an analog voltage that is collected by a DAS and averaged for a particular time period. The data are stored on a network and are validated quarterly.

B.10.4 DAS Data Review

Data review is performed by a meteorologist. The review of the data includes reviewing the calibration information, hourly data, and recording any information that might be vital to proper review of the data. Information used in the review and which may be used to invalidate data are input to Excel spreadsheets. This spreadsheet contains data and time of suspect data by parameter, potential reason for data being suspect, and any pertinent comments that relate to this data value.

The data report QA checklist is also used which is presented in Appendix F. This list provides a reminder for the reviewing meteorologist to verify missing data periods, percent data recovery, data table calculations, to name a few. Data review also includes documentation of suspect data or invalidations that occurred.

B.10.5 Data Validation

Data validation ensures that data processing operations have been carried out correctly and that the quality of field operations has been performed properly and in accordance with written procedures. Once data validation has identified problems, the data can be corrected, flagged or invalidated and correction actions can be taken when necessary. In the event of a failed audit or out of range calibration, the meteorologist will be responsible for checking or invalidating data. Data validation procedures are described in detail in Section D.

B.10.6 Data Transmittal

Data transmittal occurs when data are transferred from one location to another or from one person or group to another. An example of data transfer is the electronic transfer of data over a telephone or computer network.

B.10.7 Data Processing

Data processing includes the aggregating and summarizing of results so they can be easily understood and interpreted in various ways. EPA requires that meteorological data be reported on a regular basis.

B.10.8 Data Flagging

Data will be flagged if a numeric result was available but it has been qualified in some respect related to the validity of the result. Null data codes will be generated for invalid data. See Section D.2.3 for details on data flagging.

B.10.9 Data Storage and Retrieval

Electronic copies of the data will be stored at MSI Trinity's office in Salt Lake City.

C. ASSESSMENTS AND OVERSIGHT

C.1 Assessments and Response Actions

Performance audits of the meteorological sensors will be conducted semi-annually by MSI Trinity's independent auditor. Performance audits for the meteorological sensors will be conducted by challenging the sensors with known inputs or collocating audit meteorological sensors with those being used for the monitoring program. Performance audits will serve the monitoring program with a measure of quality assurance for meteorological sensors and a means to produce a defensible data set. Audit procedures and techniques will follow established EPA audit guidelines.

C.1.1 Data Quality Audits

Data review is conducted daily utilizing electronic and visual scanning to identify outliers and determine whether data are reasonable and representative. The systems audit includes a confirmation of the integrity of transmitted data from sensor outputs to data reporting.

C.1.2 Corrective Actions

All deficiencies identified during routine data surveillance, performance audits and/or site surveillances will be documented and reported to the Project Manager no later than one working day of discovery and, depending on the nature of the deficiency, corrective action will be made no later than seven working days of the notification. The corrective action report will be initiated by MSI Trinity's Data Manager or MSI Trinity's Project Manager. The Data Manager will report to MSI Trinity's Project Manager when corrective action has been completed and the issue resolved.

Corrective actions to deficiencies will be addressed and documented in the station logbook and on a Corrective Action Report. Follow-up action shall be taken to verify implementation of the corrective action. A corrective action report form will be filled out that identified the problem or deficiency, the proposed corrective action, and the results of the corrective action. MSI Trinity's Project Manager will verify corrective actions and sign off on the completion of the work. MSI Trinity's Project Manager will notify the Century Aluminum/Big Rivers environmental managers when the work has been completed to resolve the issue that needed to be corrected. An example copy of a Corrective Action Report is presented in Appendix C.

C.1.3 QAPP Revisions

The QAPP will be revised any time there are significant changes to the program and will be submitted to the Century Aluminum/Big Rivers for review and approval. If the QAPP spans more than one year, the QAPP will be reviewed annually, with new signatures acquired. If there are no significant changes, an annual review will be conducted and will be documented by Century Aluminum/Big Rivers.

QAPP revisions will be forwarded to the individuals on the distribution list in electronic or hard-copy format. New signatures will be obtained for each revision. MSI Trinity's Project Manager will alert MSI Trinity's QA officer when significant changes are made to the program. MSI Trinity's QA officer will be responsible for revising and distributing the QAPP.

C.2 Reports to Management

MSI Trinity Project Manager is responsible for overseeing the completion of any reports and distribution of the reports and data to Century Aluminum/Big Rivers. A summary of the reports to be generated is presented in Table C-1.

Table C-1 Reports to Management

Reports	Frequency	Content	Responsible Position/ Individual	Distribution
Quarterly Summaries	Quarterly	Summarize Data for Quarterly Summaries	MSI Trinity Data Manager Scott Adamson	See Section A.3 Distribution List
Corrective Action Reports	As Needed	Summarizes Corrective Actions Taken to Return the Meteorological Monitoring Station into Compliant Status	MSI Trinity Project Manager Casey Lenhart	See Section A.3 Distribution List
Response to Corrective Action Reports	As Needed	Reports the results of the Corrective Actions Taken	MSI Trinity Program Manager George Wilkerson	See Section A.3 Distribution List
Performance Audit Reports	Quarterly	Reports the results of the Quality Assurance Performance Audits	Independent auditor	See Section A.3 Distribution List

Quarterly summaries will be submitted to Century Aluminum/Big Rivers by MSI's Project Manager within 60 days of the end of the monitoring quarter. The quarterly reports will detail the operation of the meteorological monitoring activities as well as any maintenance and service work performed. These reports will contain: (1) detailed data summaries for each monitoring parameter; (2) a summary of any problems encountered, the status of any current problems, and the corrective action taken; (3) a summary of any meetings or correspondence: (4) a synopsis of percent recovery including brief explanations of missing data; (5) overall data recovery; (6) quality control; and (7) all quality assurance documentation.

D. DATA VALIDATION AND USABILITY

D.1 Data Review, Validation, and Verification Requirements

The criteria and process for determining the validity of meteorological data will be based on the US EPA *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV (March 2008)*, and US EPA's *Meteorological Monitoring Guidance for Regulatory Modeling Applications (February 2000)*, including recommended system accuracies and response characteristics for meteorological sensors and other applicable US EPA guidance.

The MSI Trinity Project Manager and site technicians are responsible for verifying proper operation of the meteorological monitoring equipment. During each quarter, the data will be reviewed again by a qualified meteorologist appointed by the QA Manager to ensure that the data are complete, accurate, and representative and that erroneous data have been removed in preparation for the final data report.

MSI Trinity has developed and implemented software which conducts live inspection of monitoring site data. The program is called MSI Trinity Data Scanning and Alert System (DSAS) and is used as a tool to assist MSI Trinity staff identify data outliers, problems with site equipment, or site communication issues. Once every minute, MSI Trinity DSAS scans all raw data files downloaded from the monitoring site to see if new data have arrived for interrogation. Data downloaded from the samplers are one-hour averages.

After the data collection, MSI Trinity DSAS conducts a computerized inspection of the data using pre-defined quality control checks. The quality control checks include data outliers, spikes in data, and data constancy. If parameters fail these tests, the parameter is flagged in the software and MSI Trinity staff is alerted.

A user interface for the MSI Trinity DSAS software was developed for visual and audio cues to alert MSI Trinity staff when a parameter fails a quality control check. The user interface is displayed on a touchscreen monitor near MSI Trinity's data management section. The user interface displays a matrix listing all the meteorological and air quality stations in rows as well as associated parameters listed in columns. Each cell represents a parameter being measured at a monitoring site and will be colored with green, yellow, orange, or red depending on the severity of the failure. For example, a green cell indicates no problems were detected. To analyze the failure indicated by the visual cue (red for example), MSI Trinity staff are able to click on the indicated cell to get specific details of the error or double click the cell to look at plots of the data.

The Data Manager will routinely check for irregularities during the daily data review. Data review includes evaluation of the raw data, maintenance records, calibration and audit data. Any abnormalities in the data will be flagged and noted on the appropriate checklists. Any suspect data will be brought to the attention of the Project Manager as soon as possible. All other documentation pertaining to the project (i.e. station logs, field notes, calibration and audit sheets) will be reviewed to insure that erroneous data are identified and removed, as necessary from the final data set.

Calibration procedures for the meteorological equipment are presented in Section B.7 of this QAPP. For the meteorological data, data will be considered valid when the system response indicated precision, bias and accuracy goals are being achieved.

D.1.1 Data Acceptance Limits for Meteorological Parameters Based on Audits

In accordance with data acceptance criteria established by the EPA, data will be acceptable if quality assurance performance audits show the following results for accuracy:

- The wind direction error (orientation plus linearity) does not exceed ±5 degrees from true north, and the sensor starting threshold is less than 0.50 m/s wind speed;
- The horizontal wind speed average absolute error does not exceed ±0.20 m/s. The sensor starting threshold must be less than 0.50 m/s wind speed for horizontal wind speed;
- The ambient absolute temperature sensor average absolute error does not exceed ±1.0°C;
- Vertical temperature difference cannot exceed the required ±0.1°C for 2-10 meter when the sensors are placed in the same medium;
- The barometric pressure sensor average absolute error does not exceed the acceptable tolerance of ±3 mb;
- Solar radiation sensor average percent difference does not exceed the acceptable tolerance of the greater ±5%;
- Relative humidity sensor absolute average percent difference does not exceed the acceptable tolerance of ±7% relative humidity; and,
- Net radiation sensor average percent difference does not exceed the acceptable tolerance of the greater ±5%.

The sampling frequency will be one second for all meteorological parameters.

D.2 Data Validation and Verification Methods

Meteorological data will be stored by a CSI CR1000 data logger. Data will be stored in the data logger memory as five-minute and hourly averages computed from secondly values. Data validation will be performed on the hourly average data. An hourly average will be computed when at least nine five-minute averages are available for the hour.

The MSI Trinity Project Manager, Data Manager and QA Manager are responsible for verifying the proper operation of the meteorological equipment by reviewing calibration records, audit results, and field notes form the site technicians prior to formal acceptance of these data. The Project and Data Managers will use the validation templates (Section B.5) to ensure that the reported data meets the appropriate data quality objectives.

D.2.1 Level 0 Data Validation

Level 0 data validation is essentially raw data obtained directly from the data acquisition systems in the field. These data have not received any adjustments for known biases or problems that may have been identified during preventive maintenance checks or audits. Level 0 data validation is accomplished by:

- Collecting data via modem, and
- Initially screening the daily data for anomalies using MSI Trinity's QC software (Section D.2.2).

Stacked parameter plots will be generated which consist of every data point downloaded since the last site interrogation and reviewed by a qualified meteorologist or air monitoring specialist for consistency and possible problems. This redundancy assures that problems that might go unnoticed by the software will always be caught by the reviewer.

To aid in data validation, a password-protected project web-site will be hosted which will be updated daily. The site contains 24-hour meteorological chart graphics, daily minimum, maximums, and averages, quality assurance reports and wind roses. Historical data can also be reviewed at this web-site. Figures D.1 and D.2 present examples of these graphics. By using this approach, data collection percentages are greatly enhanced and data management personnel can quickly note and resolve any potential instrumentation problems.

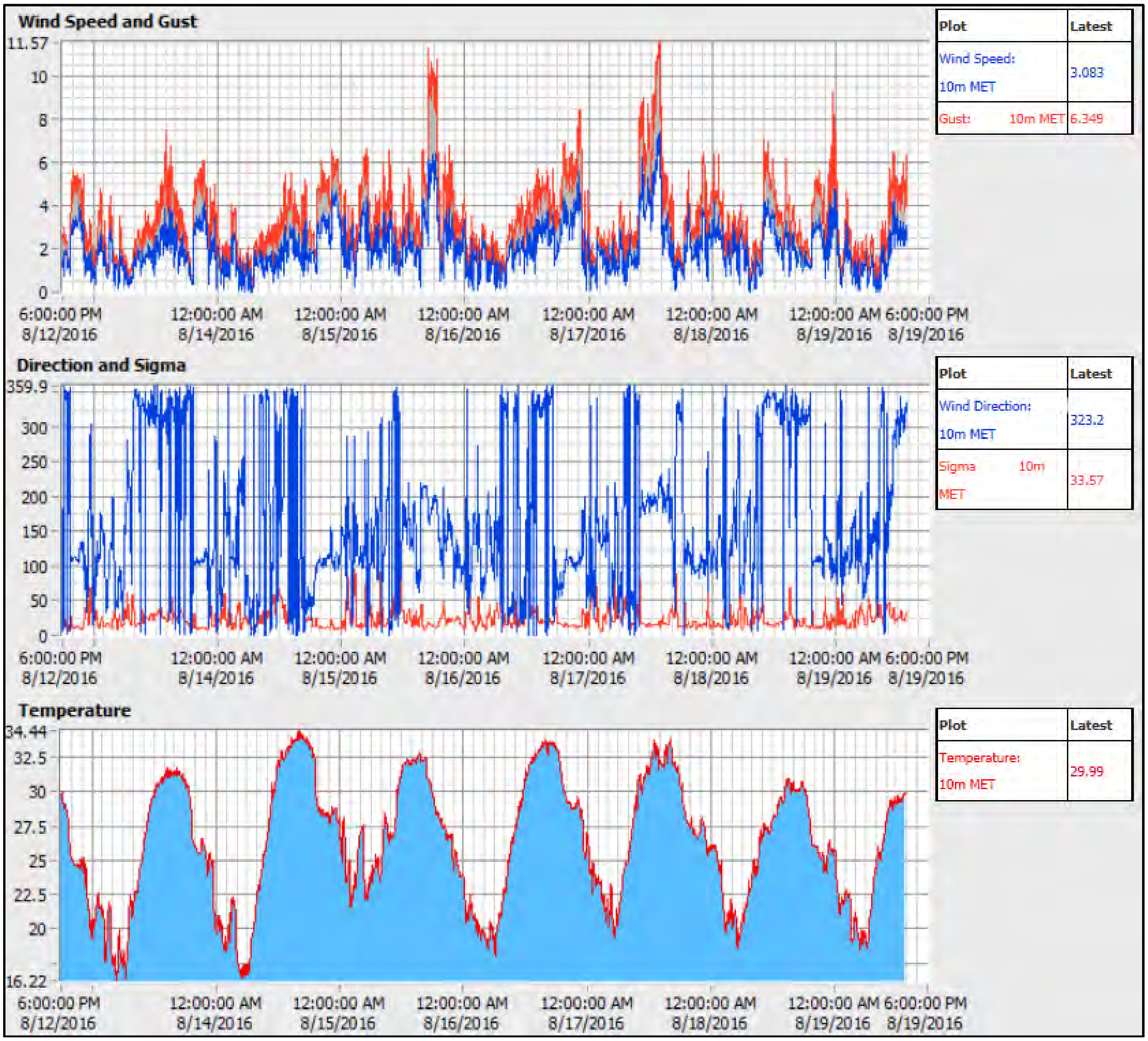


Figure D.1 Example Real-Time Wind and Temperature Display

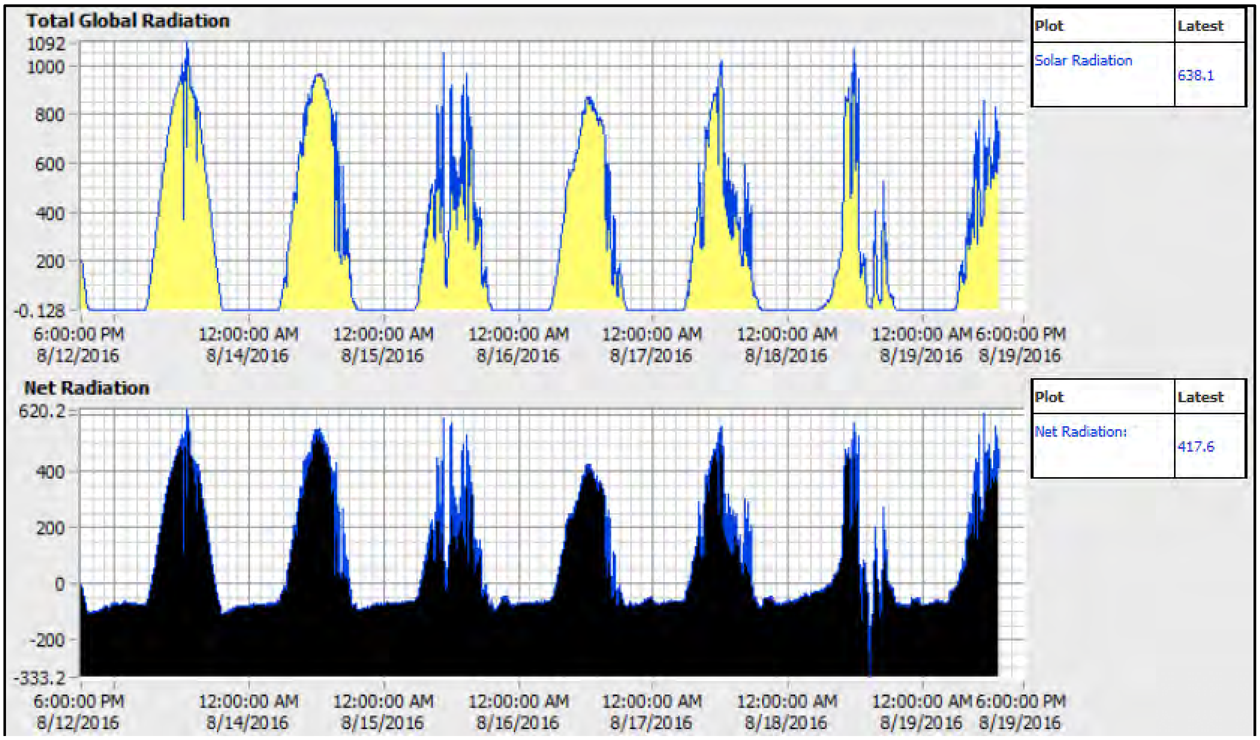


Figure D.2 Example Real-Time Solar and Net Radiation Display

D.2.2 Quality Control Checks for Data Validation

Once data are downloaded via modem, they will be subjected to a series of quality control checks by a software package. The software package performs extensive quality control checks of the data, generates a data summary report which lists means, maximums, minimums, time of occurrence, data values which fall outside of prescribed ranges, periods of constant values, and periods of rapid value changes. This software uses selected data flagging criteria. Example criteria that will cause a data flag in the meteorological data include:

- Wind speed >25 m/s for a 5-minute average;
- Temperature change exceeds 4°C in a 5-minute period;
- Time increments greater than 5 minutes between data records;
- Ambient temperature exceeds 35°C;
- Ambient temperature falls below -30°C;
- Delta temperature <-2°C or > 4°C;
- Wind direction unchanged for 1 or more hours;
- Horizontal wind speed unchanged for 1 or more hours;
- Temperature unchanged for 1 or more hours;
- Temperature difference >7°C or <-1.5°C;
- Battery voltage <11 volts;
- Change in pressure more than 1 mb in 5 minutes;
- Solar radiation <-5 watts/m^2;
- Solar radiation >1600 watts/m^2;
- Relative humidity >100%;
- Relative humidity <5%;

- Pressure is >795 mb; and,
- Pressure is <765 mb.

These criteria may be adjusted as data are collected to more accurately encompass site-specific conditions.

The QA Manager or her designates will be responsible for performing the verification/validation actions. The quality assurance software is used to generate flags or warnings that the parameter value is outside of a normally acceptable range. The outlier program does not invalidate data or erase file records on the basis of these outlier tests. Raw data files are never modified and are archived. It will be left to a qualified meteorologist to review the results of the outlier program in conjunction with the data parameter plots and initiate corrective actions if warranted (site visit or data invalidation).

D.2.3 Level 1 Data Validation

After the QC software is run, visual inspection of the data are performed to identify suspect data values that warrant further investigation. These values will be flagged by the Data Manager. Final data validation will be performed by the QA Manager or her designates who have the necessary skills and training to perform this task.

Per EPA's Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Quality Monitoring Program, EPA recommends the use of flags or result qualifiers to identify potential problems with data (or a sample). According to EPA, a flag is an indicator of the fact and the reason that a data value (a) did not produce a numeric result, (b) produced a numeric result but it is qualified in some respect relating to the type or validity of the result, or (c) produced a numeric result but for administrative reasons is not to be reported outside the organization.

Thus, quality control flags and codes, consisting of a letter and value will be assigned to each datum to indicate its quality. Multiple flags will be applied to each invalid data point such as data invalid due to calibration. Table D-1 presents the data flags and codes that will be applied to the data.

Table D-1 Data Flags

Flag	Code	Description
V	0	Valid
C	1	Corrected or Estimated
S	7	Suspect: data appears to be a data spike or outside normal data range
I	8	Invalid data
M	9999	Missing data: measurement not taken
BJ	9963	Operator Error
AC	9969	Construction in Area
AL	9978	Voided by Operator
AM	9979	Miscellaneous Void
AN	9980	Instrument Malfunction
AP	9982	Vandalism
AQ	9983	Collection Failure
AS	9985	Poor QA Results
AT	9986	Calibration
AV	9988	Power Failure
AW	9989	Wildlife Damage
AZ	9992	QC Audit
BA	9993	Maintenance
BB	9994	Unable to Reach Site
BC	9995	Multi-Point Calibration

To assist in data validation, a copy of the site logbook will be examined to confirm periods when instrumentation may have been off-line due to power outages, maintenance or repair, audits, or other quality assurance activities. Significant events will be checked against the graphs for consistency.

Especially high values will be checked to be sure that audit or calibration data were not inadvertently included. Suspect data will be reported but flagged as suspect. Missing data will be left missing.

It is important to maintain detailed, accurate records of changes to the data. The justification for all data invalidations will be permanently documented in a data validation summary spreadsheet. Suspect data will also be documented on a Quality Assurance/Data Validation Log (Appendix F).

D.2.4 Minimum Acceptable Data Recovery Percentage

To be considered valid, each hour of meteorological data must consist of at least 45 minutes of valid data. Data recovery for meteorological parameters will be 90 percent per quarter[4].

[4] EPA, Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-005, Feb. 2000.

D.2.5 Data Report QA Checklist

As part of the data validation process to prepare data for reports, report table content versus data files, missing data, off-line periods, percent data recovery and mathematical calculations are routinely verified. Cross-checks are documented on the Data Report QA Checklist presented in Appendix F.

D. 3 Reconciliation with User Requirements

The primary objective of the Century Aluminum/Big Rivers meteorological monitoring station will be used to gather meteorological data to provide accurate and representative meteorological conditions around the Century Aluminum/Big Rivers facilities. Following the procedures described in this QAPP will ensure that the data quality objectives are met and the data will be representative of local meteorological conditions and be of acceptable PSD quality accuracy, precision and completeness.

APPENDIX A

Meteorological Equipment Specifications

wind

High Performance Wind Sensor

YOUNG

Model 05103

Wind Monitor

The Wind Monitor is a high performance, rugged wind sensor. Its simplicity and corrosion-resistant construction make it ideal for a wide range of wind measuring applications.

The wind speed sensor is a four blade helicoid propeller. Propeller rotation produces an AC sine wave voltage signal with frequency directly proportional to wind speed. Slip rings and brushes are eliminated for increased reliability.

The wind direction sensor is a rugged yet lightweight vane with a sufficiently low aspect ratio to assure good fidelity in fluctuating wind conditions. Vane angle is sensed by a precision potentiometer housed in a sealed chamber. With a known excitation voltage applied to the potentiometer, the output voltage is directly proportional to vane angle. A mounting orientation ring assures correct realignment of the wind direction reference when the instrument is removed for maintenance.

The instrument is made of UV stabilized plastic with stainless steel and anodized aluminum fittings. Precision grade, stainless steel ball bearings are used. Transient protection and cable terminations are in a convenient junction box. The instrument mounts on standard 1 inch pipe.

For offshore and marine use, **Model 05106, Wind Monitor-MA** features special waterproof bearing lubricant and a sealed, heavy duty cable pigtail in place of the standard junction box. Separate signal conditioning for voltage or current outputs is available.

The Wind Monitor is available with two additional output signal options. **Model 05103V** offers calibrated 0-5 VDC outputs, convenient for use with many dataloggers. **Model 05103L** provides a calibrated 4-20 mA current signal for each channel, useful in high noise areas or for long cables (up to several kilometers). Signal conditioning electronics are integrated into the sensor junction box.

Ordering Information

	MODEL
WIND MONITOR	**05103**
WIND MONITOR 0-5 VDC OUTPUTS	**05103V**
WIND MONITOR 4-20 mA OUTPUTS	**05103L**
WIND MONITOR-MA (MARINE MODEL)	**05106**
WIND SENSOR INTERFACE (FOR USE WITH 05106) 0-5 VDC	**05603C**
WIND LINE DRIVER (FOR USE WITH 05106) 4-20 mA	**05631C**

Specifications

Range:
Wind speed: 0-100 m/s (224 mph)
Azimuth: 360° mechanical, 355° electrical (5° open)

Accuracy:
Wind speed: ±0.3 m/s (0.6 mph) or 1% of reading
Wind direction: ±3 degrees

Threshold:*
Propeller: 1.0 m/s (2.2 mph)
1.1 m/s (2.4 mph) 05106
Vane: 1.1 m/s (2.4 mph) 05103

Dynamic Response:*
Propeller distance constant (63% recovery) 2.7 m (8.9 ft)
Vane delay distance (50% recovery) 1.3 m (4.3 ft)
Damping ratio: 0.3
Damped natural wavelength: 7.4 m (24.3 ft)
Undamped natural wavelength: 7.2 m (23.6 ft)

Signal Output:
Wind speed: magnetically induced AC voltage, 3 pulses per revolution. 1800 rpm (90 Hz) = 8.8 m/s (19.7 mph)
Azimuth: analog DC voltage from conductive plastic potentiometer – resistance 10K Ω, linearity 0.25%, life expectancy – 50 million revolutions

Power Requirement:
Potentiometer excitation: 15 VDC maximum

Dimensions:
Overall height: 37 cm (14.6 in)
Overall length: 55 cm (21.7 in)
Propeller: 18 cm (7 in) diameter
Mounting: 34 mm (1.34 in) diameter (standard 1 inch pipe)

Weight:
Sensor weight: 1.0 kg (2.2 lbs)
Shipping weight: 2.3 kg (5 lbs)

**Nominal values, determined in accordance with ASTM standard procedures.*

MODEL 05103V **0-5 VDC outputs**

Power Requirement:
8-24 VDC (5 mA @ 12 VDC)

Operating Temperature:
-50 to 50° C

Output Signals:
0-5.00 VDC full scale

MODEL 05103L **4-20 mA outputs**

Power Requirement:
8-30 VDC (40 mA max.)

Operating Temperature:
-50 to 50° C

Output Signals:
4-20 mA full scale

CE *Complies with applicable CE directives.*
Specifications subject to change without notice.

R.M. YOUNG COMPANY
2801 Aero Park Drive
Traverse City, Michigan 49686 USA
TEL: (231) 946-3980 FAX: (231) 946-4772
E-mail: met.sales@youngusa.com
Web Site: www.youngusa.com

MODEL 41342
PLATINUM TEMPERATURE PROBE

INSTRUCTION SHEET 41342-90
REV B062309

INTRODUCTION

The Model 41342 Platinum Temperature Probe is an accurate 1000 ohm Platinum RTD temperature sensor mounted in a weatherproof junction box. The probe is designed for easy installation in YOUNG Multi-plate and Aspirated Radiation Shields.

INSTALLATION

For accurate measurements, the temperature probe should be installed in a protective radiation shield. Use of the probe without a radiation shield may result in large errors due to solar heating. The probe installs easily in YOUNG naturally ventilated or aspirated shields. For best performance, the probe and shield should be placed in a location with good air circulation clear of large masses (buildings, pavement, solar panels...), exhaust vents, electrical machinery, motors, water fountains and sprinklers

MAINTENANCE

The temperature probe is designed to offer years of service with minimal maintenance. If necessary, the probe may be periodically checked or recalibrated using normal bath calibration methods. NIST traceable calibration is available from YOUNG at additional cost.

NOTE: The terminal marked "EARTH GND" should be connected to properly grounded tower or grounding conductor as close to the sensor as possible. Failure to do so may result in damage due to static discharge.

CE COMPLIANCE

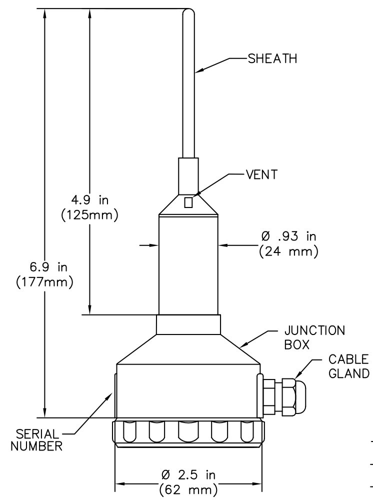
This product has been tested and shown to comply with European CE requirements for the EMC Directive. Please note that shielded cable must be used.

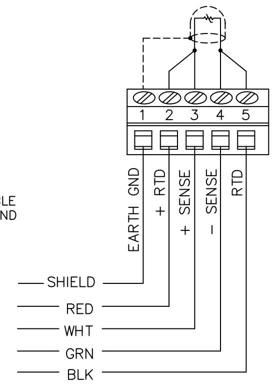
Resistance vs. Temperature for 1000Ω nominal probe
Temperature Coefficient = 0.00375 Ω/Ω/°C

Resistance Ω	°F
1226.445	140
1205.659	130
1184.837	120
1163.978	110
1143.081	100
1122.148	90
1101.177	80
1080.169	70
1059.124	60
1038.042	50
1016.922	40
995.766	30
974.572	20
953.340	10
932.069	0
910.759	-10
889.407	-20
868.013	-30
846.576	-40
825.093	-50

°C	Resistance Ω
60	1226.445
50	1189.005
40	1151.445
30	1113.764
20	1075.963
10	1038.042
0	1000.000
-10	961.837
-20	923.550
-30	885.132
-40	846.576
-50	807.873

Transfer function calculated from manufacturer's data:
$C° = (1.1279 \times 10^{-5} \cdot R^2) + (2.3985 \times 10^{-1} \cdot R) - 251.1326$
$F° = (2.0302 \times 10^{-5} \cdot R^2) + (4.3174 \times 10^{-1} \cdot R) - 420.0387$





WARRANTY

This product is warranted to be free of defects in materials and construction for a period of 12 months from date of initial purchase. Liability is limited to repair or replacement of defective item. A copy of the warranty policy may be obtained from R. M. Young Company.

SPECIFICATIONS

Measuring range: -50 to +50°C
-50 to +150°F

Accuracy at 0°C: ±0.3°C
±0.1°C (optional)

Time Constant: 42 seconds in 43408 shield.

Sensor type: 1000Ω Platinum RTD

Output signal: 4 wire RTD

Recommended Cable: 2 pair shielded, 22 AWG (#18723)

Recommended Radiation Shields:
- Model 41502 Compact Aspirated Radiation Shield
- Model 41003P Multi-Plate Radiation Shield

Declaration of Conformity

R. M. Young Company
2801 Aero Park Drive
Traverse City, MI 49686 USA

Model 41342 PLATINUM TEMPERATURE PROBE

The undersigned hereby declares on behalf of R. M. Young Company that the above-referenced product, to which this declaration relates, is in conformity with the provisions of:

Council Directive 2004/108/EC (December 15, 2004) on Electromagnetic Compatibility

David Poinsett
R&D Manager

CAMPBELL® SCIENTIFIC
WHEN MEASUREMENTS MATTER

HC2S3

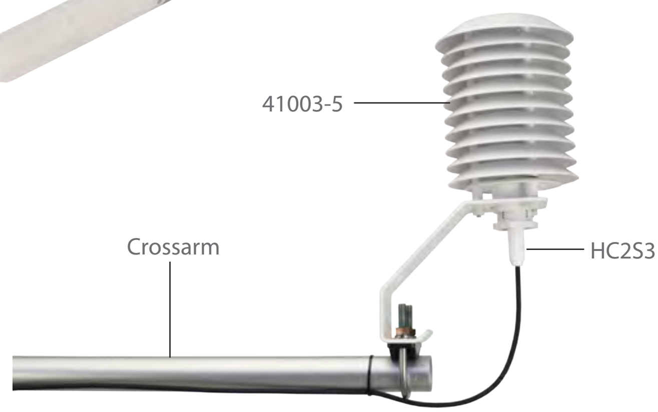
Temperature and RH Sensor

The HC2S3 is a rugged, accurate temperature/RH probe that is ideal for long-term, unattended applications. The probe uses a Rotronic's IN1 capacitive sensor to measure RH and a 100 ohm PRT to measure temperature. For optimum results, the HC2S3 should be recalibrated annually.

The HC2S3 comes with a polyethylene filter that protects its sensor from fine dust and particles and minimizes water absorption and retention. Alternatively, a teflon filter is available for marine environments. The response time is slower when using the teflon filter.

Sensor Mounts

The 41003-5 radiation shield should be used when the HC2S3 is exposed to sunlight. The 41003-5 can attach directly to a mast or tower leg or to a CM202, CM204, or CM206 crossarm.



Ordering Information

Air Temperature and Relative Humidity Probe

HC2S3-L Rotronics Temperature/RH Probe with user-specified cable length. Enter cable length, in feet, after the -L. Maximum cable length is 1000 ft (300 m) with 12 V power, or 10 ft (3 m) with 5 V power. Must choose a cable termination option (see below).

Cable Termination Options (choose one)

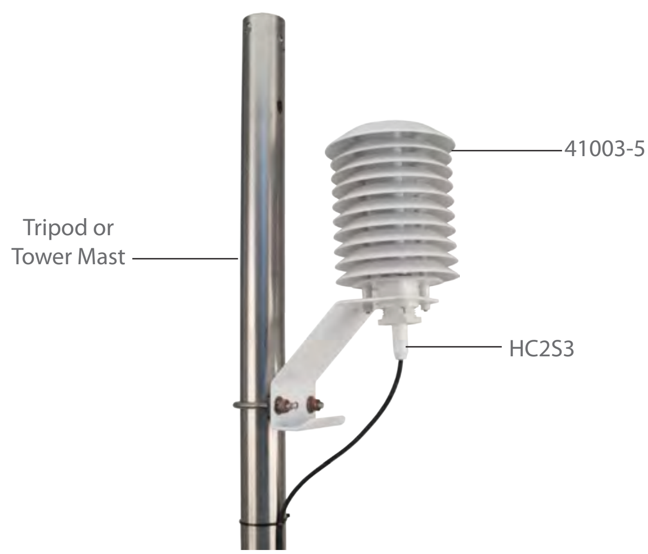
-PT Cable terminates in stripped and tinned leads for direct connection to a datalogger's terminals.

-PW Cable terminates in connector for attachment to a prewired enclosure.

-CWS Cable terminates in a connector for attachment to a CWS900-series interface. Connection to a CWS900-series interface allows this sensor to be used in a wireless sensor network.

-C Cable terminates in a connector for attachment to a CS110 Electric Field Meter or ET107 weather station.

-RQ Cable terminates in a connector for attachment to a RAWS-P Permanent Remote Automated Weather Station.



Common Accessories

41003-5 10-Plate Gill Radiation Shield to house the HC2S3

27755 Teflon Filter for marine environments.

Recommended Cable Lengths

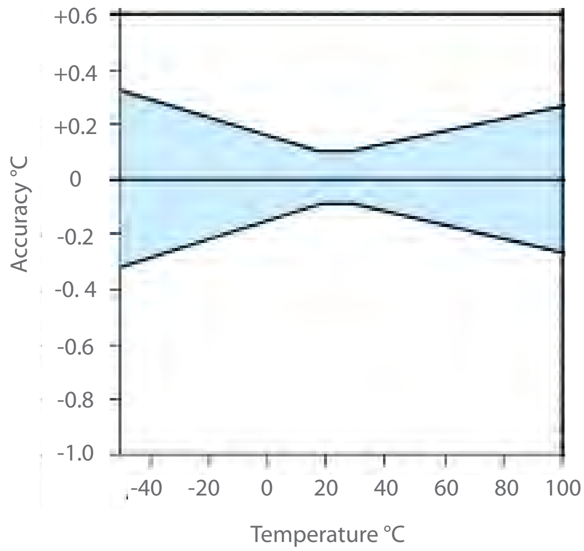
2-m Height		Atop a tripod or tower via a 2-ft crossarm such as the CM202								
Mast/Leg	CM202	CM6	CM106	CM10	CM110	CM115	CM120	UT10	UT20	UT30
9 ft	11 ft	11 ft	14 ft	14 ft	14 ft	19 ft	24 ft	14 ft	24 ft	37 ft

***Note:** Add two feet to the cable length if mounting the enclosure to the leg base of a CM106, CM110, CM115, or CM120 tripod.*

Specifications

Electronics	
Operating Limits:	-40° to +100°C
Storage Temperature:	-50° to +100°C
Dimensions	
Diameter:	15 mm (0.6 in.)
Length w/o connector:	85 mm (3.3 in.)
Length w/connector:	183 mm (7.25 in.)
Weight:	10 g (0.35 oz)
Filter	
Standard:	Polyethylene
Optional:	Teflon (ordered separately; see Ordering Information)
Current Consumption:	<4.3 mA @ 5 Vdc <2.0 mA @ 12 Vdc
Supply Voltage:	5 to 24 Vdc
Startup Time:	1.5 s typical[1]
Maximum Startup Current:	<50 mA for 2 µs
Analog Outputs	
Offset at 0 V:	±3 mV (maximum)
Deviation for Digital Signal:	< ±1 mV (0.1°C, 0.1% R. H.)

Temperature Accuracy Graph



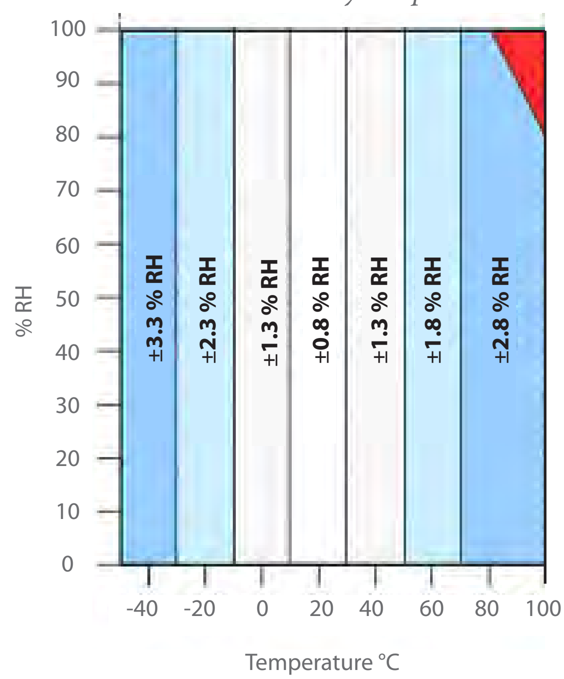
Temperature

Temperature Sensor:	PT100 RTD, IEC 751 1/3 Class B
Measurement Range:	-50° to +100°C (default to -40° to +60°C)
Output Signal Range:	0 to 1 V
Accuracy at 23°C:	±0.1°C with standard configuration settings
Long Term Stability:	<0.1°C/year
Sensor Time Constant [63% step change (1 m/s air flow at sensor)]	
Standard PE Filter:	≤ 22 s
Optional Teflon Filter:	≤ 30 s
Temperature Accuracy:	see graph at top right

Relative Humidity (RH)

Sensor:	ROTRONIC Hygromer® IN-1
Measurement Range:	0 to 100% RH, non-condensing
Output Signal Range:	0 to 1 Vdc
Accuracy at 23°C:	±0.8% RH with standard configuration settings
Long-Term Stability:	<1% RH per year
Sensor Time Constant [63% of a 35 to 80% RH step change (1 m/s air flow at sensor)]	
Standard PE Filter:	≤ 22 s
Optional Teflon Filter:	≤ 30 s
RH Accuracy over Temperature:	see graph at bottom right

RH Accuracy Graph



Notes:

[1] The startup time is Rotronics specification. Campbell Scientific recommends 2 s at 60°C, 3 s at 0°C, and 4 s at -40°C.

[1] The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FM-VSS302. Local fire codes may preclude its use inside buildings.

Hukseflux
Thermal Sensors

LP02

Second class pyranometer

LP02 is a solar radiation sensor that is applied in most common solar radiation observations. It complies with the second class specifications of the ISO 9060 standard and the WMO Guide. LP02 pyranometer is widely used in (agro-)meteorological applications and for PV system performance monitoring.

Figure 1 *LP02 second class pyranometer*

Figure 2 *pyranometer in use with LI19 read-out unit*

Introduction

LP02 is a solar radiation sensor that is applied in general observations. It measures the solar radiation received by a plane surface from a 180° field of view angle. This quantity, expressed in W/m^2 , is called “hemispherical” solar radiation. LP02 pyranometer can be employed outdoors under the sun, as well as indoors with lamp-based solar simulators. Its orientation depends on the application and may be horizontal, tilted (for plane of array radiation) or inverted (for reflected radiation).

LP02 pyranometer is a very good alternative to silicon cell (photodiode-based) pyranometers, which do not comply to the ISO 9060 standard.

Operation

Using LP02 is easy. The pyranometer can be connected directly to commonly used data logging systems.
The irradiance in W/m^2 is calculated by dividing the LP02 output, a small voltage, by the sensitivity. This sensitivity is provided with LP02 on its calibration certificate.

Uncertainty evaluation

The uncertainty of a measurement under outdoor conditions depends on many factors. Guidelines for uncertainty evaluation according to the “Guide to Expression of Uncertainty in Measurement” (GUM) can be found in our manuals. We provide spreadsheets to assist in the process of uncertainty evaluation of your measurement.

Suggested use

- general meteorlogical observations
- agricultural networks
- PV system performance monitoring

Hukseflux
Thermal Sensors

LP02 design

LP02 pyranometer employs a thermal sensor with black coating, a single glass dome and an anodised aluminium body.

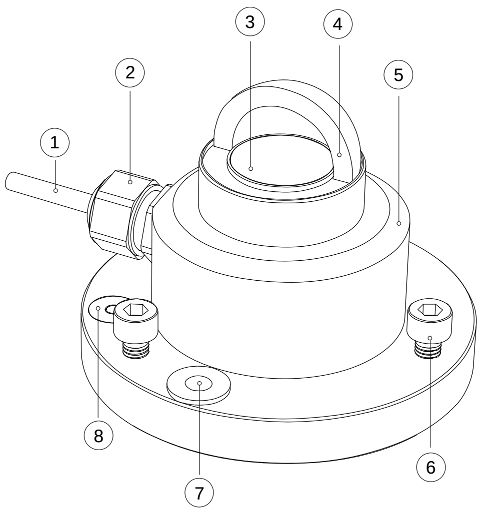


Figure 3 *overview of LP02:*
(1) cable, (2) cable gland, (3) thermal sensor with black coating, (4) glass dome, (5) sensor body, (6) levelling feet, (7) mounting hole, (8) bubble level

Use as sunshine duration sensor

WMO has approved the "pyranometric method" to calculate sunshine duration from pyranometer measurements in WMO-No. 8, Guide to Meteorological Instruments and Methods of Observation. This implies that LP02 may be used, in combination with appropriate software, to estimate sunshine duration. This is much more cost-effective than using a dedicated sunshine duration sensor. Ask for our application note.

Choosing the right instrument

Pyranometers are subject to classification in three classes according to ISO 9060.
From second class to first class and from first class to secondary standard, the achievable accuracy improves by a factor 2.
Measurement accuracy does not only depend on instrument properties, but also on measurement conditions. A very accurate instrument will quickly underperform without a regular schedule of maintenance.
Our pyranometer selection guide assists you in choosing the right instrument.
Whatever your application is: Hukseflux offers the highest accuracy in every class at the most attractive price level.

LP02 specifications

Measurand	hemispherical solar radiation
ISO classification	second class pyranometer
Calibration uncertainty	< 1.8 % (k = 2)
Calibration traceability	to WRR
Spectral range	285 to 3000 x 10^{-9} m
Sensitivity (nominal)	15 x 10^{-6} V/(W/m^2)
Rated operating temperature range	-40 to +80 °C
Temperature response	< ± 3 % (-10 to +40 °C)
Standard cable length	5 m

Options

- longer cable, in multiples of 5 metres
- sun screen
- LP02-LI19, including read-out unit / datalogger LI19

See also

- LP02-TR with 4-20 mA transmitter
- SR03 fast response pyranometer
- SR11, SR12 and SR20 pyranometers for higher accuracy measurements
- SRA01 for albedo measurements
- view our complete product range of solar sensors

Standards

Applicable instrument classification standards are ISO 9060 and WMO-No. 8. Calibration is according to ISO 9847. PV related standards are ASTM E2848 and IEC 61724.

About Hukseflux

Hukseflux Thermal Sensors, founded in 1993, aims to advance thermal measurement. We offer a complete range of sensors and systems for measuring heat flux, solar radiation and thermal conductivity. We also provide consultancy and services such as performing measurements and designing instrumentation according to customer requirements. Customers are served through the main office in Delft in the Netherlands, and locally owned representations in the USA, China and Japan.

Interested in this product?
E-mail us at: info@hukseflux.com

Net Radiometers

FOR MEASUREMENT OF THE ENERGY BALANCE

One-component and four-component instruments
Reliable all-weather performance
Light weight and robust
Unique ventilation system

Introduction

Net radiation is the balance between incoming radiation from the sun and sky and outgoing radiation from the ground. Short-wave radiation of 0.3 to 3 µm wavelength reaches the Earth's surface, where some is reflected and the rest of the energy is absorbed by the surface. Incoming long-wave Far Infrared (FIR) radiation from 4.5 to more than 40 µm is also absorbed by the surface, which heats up and emits FIR back to the sky.

The four components of net radiation are the incoming and reflected solar radiation, from which the Albedo can be calculated; and the downward and upward infrared radiation. These parameters can be measured using a pair of pyranometers and a pair of pyrgeometers, but more commonly a net radiometer is used that conveniently combines four sensors into one compact instrument.

The simplest type of net radiometer uses a single sensor to measure the sum of the four net radiation components. This type of instrument is sometimes referred to as a net pyrradiometer.

Applications

The main applications for net radiometers are in agro-meteorology, in particular for the study of evapo-transpiration and in climatology, meteorology and hydrology for the measurement of the radiation balance. Monitoring over glaciers and ice fields is of particular interest to global warming studies. Net radiometers are often used in conjunction with a small automatic weather station and need to be easily portable.

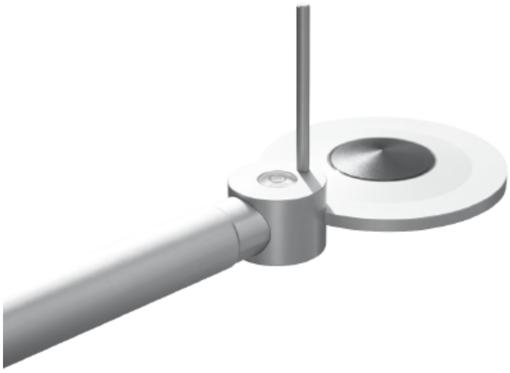
Choice of Net Radiometer

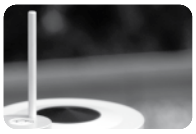
Kipp & Zonen offers a range of robust, lightweight, net radiometers that do not require power to operate. A mounting rod, bubble level and calibration certificate are always included.

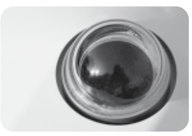
NR Lite2 has a single output for total net radiation. CNR 4 measures all four components separately. Whatever the application, Kipp & Zonen can supply a suitable net radiometer.

NR Lite2 is a single-component net radiometer widely used in agriculture and hydrology. The thermopile detector is fitted with black PTFE coated conical absorbers on both sides that have a very wide spectral response from the ultraviolet (UV) to the far infrared (FIR). The signal output is the difference between the sun and sky radiation and the ground radiation and can be positive or negative, depending upon the conditions.

There is an integral mounting rod for fitting to masts and poles, a bubble level, 15 m long signal cable, and a stick to prevent birds settling on the instrument. The single output means that the short-wave and long-wave components and the upwards and downwards components cannot be separated. For this, use our four-component CNR 4 net radiometer.

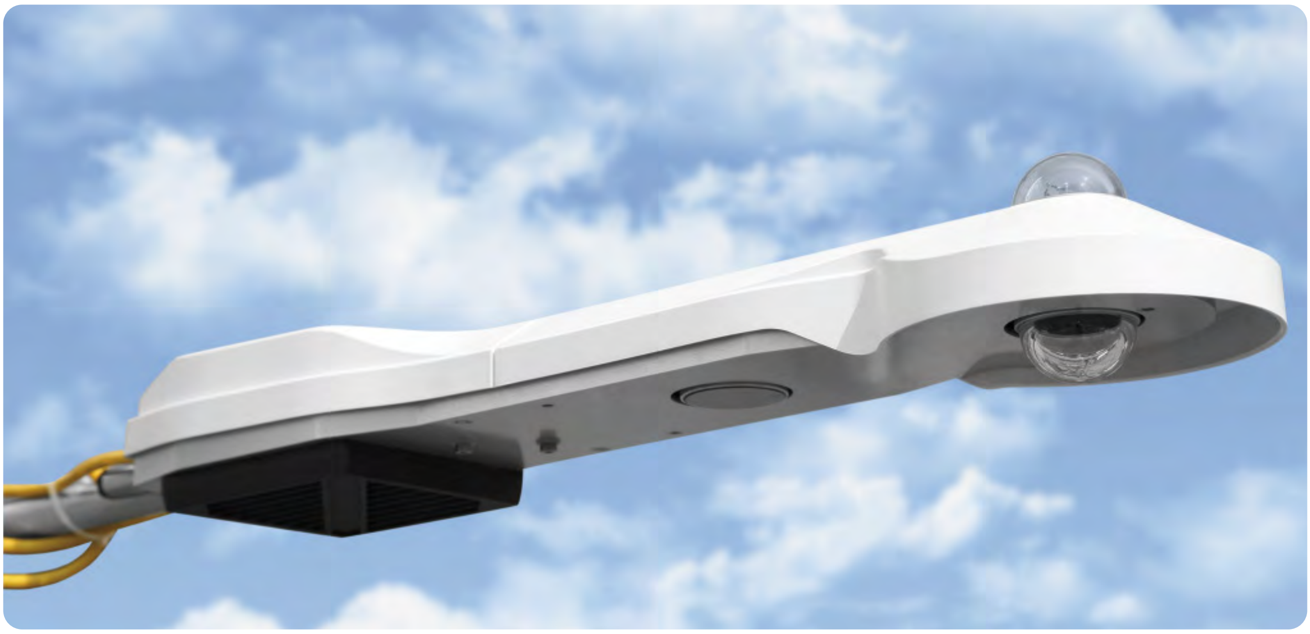






CNR 4 is a four-component net radiometer for accurate and reliable measurements and can be used as the reference instrument for a network of lower performance net radiometers. There are four separate signal outputs and the integrated temperature sensors can be used to calculate the FIR radiation. The screw-in mounting rod, bubble level, and cables with waterproof connectors, make installation easy. The white sun shield reduces solar heating of the instrument body.

CNR 4 combines two ISO 9060 Second Class pyranometers for solar radiation with two pyrgeometers for infrared measurements, all integrated into the instrument body. The upper pyrgeometer has a silicon meniscus dome so that water rolls off and the field of view is 180 °. The design is very light weight and includes a mounting rod as standard. An optional heated ventilation unit, the CNF 4, is available to minimise offsets, maximize stability and remove precipitation.



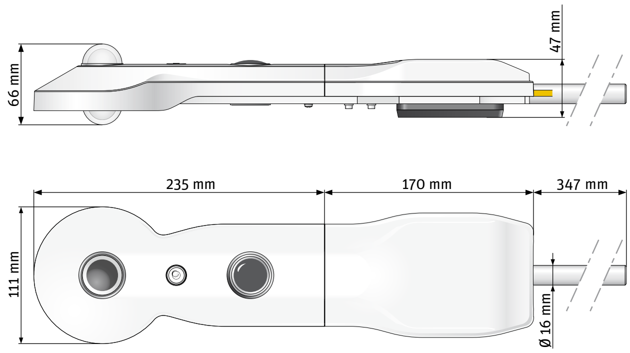
Accessories

CNF 4 Ventilation Unit

The Kipp & Zonen CNR 4 net radiometer is produced as the standard instrument or with an integrated ventilation unit and heater. The CNF 4 ventilation unit can also be bought as a kit for retro-fitting to a CNR 4 that was purchased without it.

CNF 4 provides a clean air flow over all four of the CNR 4 radiometer domes and windows and is designed to operate under all weather conditions. The only part that needs maintenance is the air inlet filter, which should be checked at regular intervals and cleaned or replaced when necessary.

The integrated 10 W heating can be switched on by the operator when required. This raises the temperature of the domes and windows slightly above ambient to prevent the formation of dew and frost and to disperse precipitation. The ventilation fan and heater run from 12 VDC and can be operated by the accessory CVP 2 universal AC-DC power adaptor.

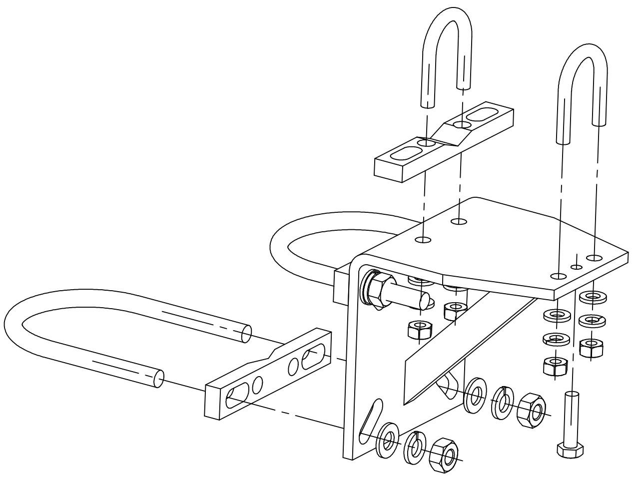


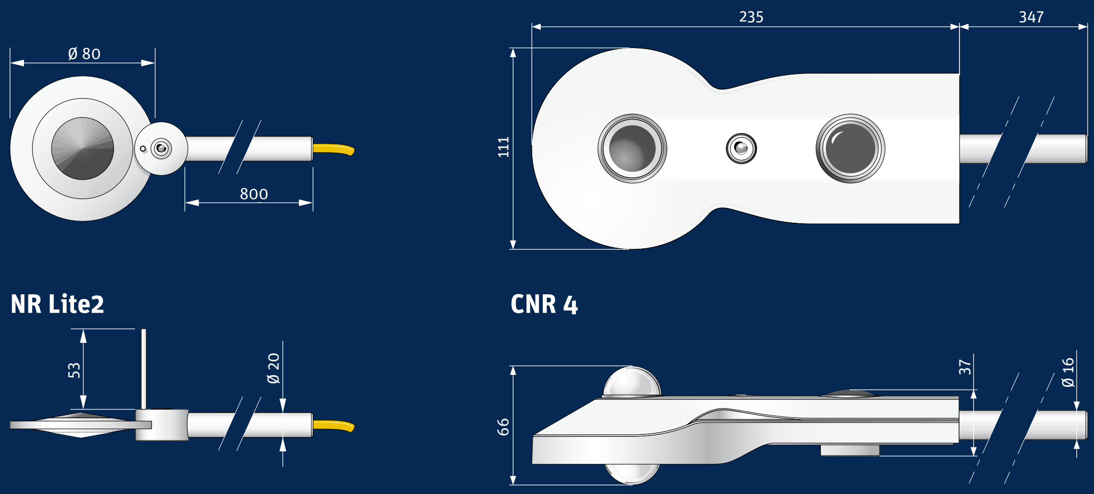
Specifications CNF 4

Ventilator fan power	5 W continuously
Heater power	10 W
Operating temperature	-40 °C to +70 °C
Cable voltage drop	0.07 V/m (with heater)
Power required	12 Volt DC, 1.3 A (with heater)
Weight	500 g

CMB 1 Mounting Bracket

For attaching mounting rods of 12 to 20 mm diameter to poles, masts or walls. The radiometer can be levelled by rotating and tilting the rod. The bracket includes u-bolts for fixing to poles and masts from 22 to 60 mm diameter.





All dimensions in mm

Specifications	NR Lite2	CNR 4
Number of signal outputs	1 - net total radiation	4 - incoming and reflected short-wave radiation downward and upward long-wave radiation
Pyrgeometer temperature sensors	N/A	10 K thermistor and Pt-100
Response time (95 %)	< 60 s	< 18 s
Non-linearity (over full range)	< 1 %	< 1 %
Temperature dependence of sensitivity	- 0.1 % / °C (typical)	< 5 % from -10 °C to +40 °C
Sensitivity	10 µV/W/m² (nominal)	7 to 20 µV/W/m² short-wave 5 to 10 µV/W/m² long-wave
Operating temperature	-40 °C to +80 °C	-40 °C to +80 °C
Spectral range (50 % points)	200 nm to 100 µm	300 to 2800 nm short-wave 4.5 to 42 µm long-wave
Field of view	180 ° upper and lower sensor	180 ° short-wave upper sensor 170 ° short-wave lower sensor 180 ° long-wave upper sensor 150 ° long-wave lower sensor
Mounting rod	Fixed, 800 mm long x 20 mm Ø	Screw-in, 350 mm long x 16 mm Ø
Standard cable	15 m fixed cable	10 m with connector
Cable lenght options	N/A	25 m, 50 m
Weight with rod (excluding cable(s))	490 g	850 g

Note: The performance specifications quoted are worst-case and/or maximum values

KIPP & ZONEN
SINCE 1830

Go to www.kippzonen.com for your local distributor

HEAD OFFICE

Kipp & Zonen B.V.
Delftechpark 36, 2628 XH Delft
P.O. Box 507, 2600 AM Delft
The Netherlands
T: +31 (0) 15 2755 210
F: +31 (0) 15 2620 351
info@kippzonen.com

4414391 - V1302

CS106

Barometric Pressure Sensor

The CS106 barometer uses Vaisala's BAROCAP silicon capacitive sensor to measure barometric pressure over a 500 to 1100 millibar range. The CS106 outputs a linear signal of 0 to 2.5 Vdc, allowing it to be directly connected to Campbell Scientific dataloggers. The CS106 is compatible with all of our contemporary dataloggers and many of our retired dataloggers (e.g., CR510, CR10(X), CR23X).

The CS106 includes a switching circuit that allows the datalogger to power the barometer only during measurement, which reduces power consumption. Sensor warm-up and measurement time is one second minimum.

Construction and Mounting

The CS106 is encased in a plastic shell (ABS/PC blend) fitted with an intake valve for pressure equilibration. It includes a 2.5 ft cable and a terminal strip for datalogger power and signal connections. The CS106 is typically mounted next to the datalogger inside an ENC12/14 or larger enclosure. The ENC100 is available for housing the CS106 in its own enclosure.

Ordering Information

Barometric Pressure Sensor	
CS106	Vaisala PTB110 Barometer (500 to 1100 mb), with 30 in. cable.

Accessories

The following accessories are used when the barometer will be housed in a different enclosure than the datalogger.

ENC100	6.7 in. by 5.5 in enclosure for housing only the CS106.
CABLE5CBL-L	5-conductor, 24 AWG cable with drain wire and Santoprene jacket. Enter cable length, in feet, after the -L. Must choose a cable termination option (see below).

Cable Termination Options (choose one)	
-PT	Cable terminates in pigtails for direct connection to datalogger's terminals.
-PW	Cable terminates in a connector for attachment to a prewired enclosure.

The ENC100 is a very small enclosure that can house one CS106. It includes a backplate, compression fitting, vent, and mounting bracket.

Manufacturer's Specifications

Total Accuracy[1]:	±0.3 mb @ +20°C ±0.6 mb @ 0° to 40°C ±1.0 mb @ -20° to +45°C ±1.5 mb @ -40° to +60°C
Linearity:	±0.25 mb
Hysteresis:	±0.03 mb
Repeatability:	±0.03 mb
Calibration Uncertainty:	±0.15 mb
Long-Term Stability:	±0.1 mb per year
Operating Temperature:	-40° to +60°C
Dimensions:	2.7" x 3.8" x 1.1" (6.8 cm x 9.7 cm x 2.8 cm)
Weight:	3.2 oz (90 g)
Supply Voltage:	10 to 30 Vdc
Current Consumption:	<4 mA (active), <1 µA (quiescent)
Settling Time:	1 second to reach full accuracy after power-up
Response Time:	500 ms to reach full accuracy after a pressure step

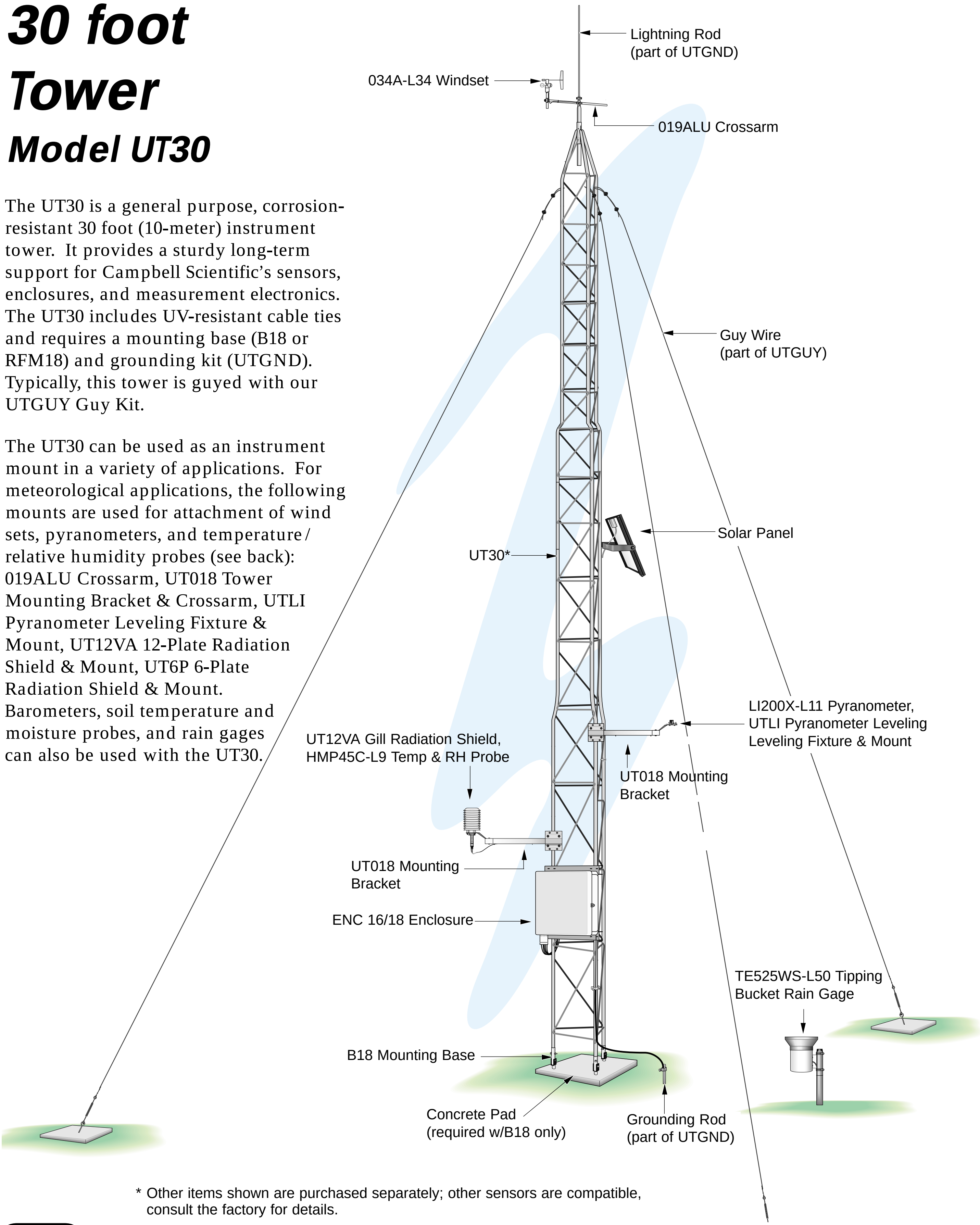
[1] *The root sum squared (RSS) of end point non-linearity, hysteresis, repeatability, and calibration uncertainty.*

30 foot Tower

Model UT30

The UT30 is a general purpose, corrosion-resistant 30 foot (10-meter) instrument tower. It provides a sturdy long-term support for Campbell Scientific's sensors, enclosures, and measurement electronics. The UT30 includes UV-resistant cable ties and requires a mounting base (B18 or RFM18) and grounding kit (UTGND). Typically, this tower is guyed with our UTGUY Guy Kit.

The UT30 can be used as an instrument mount in a variety of applications. For meteorological applications, the following mounts are used for attachment of wind sets, pyranometers, and temperature/relative humidity probes (see back): 019ALU Crossarm, UT018 Tower Mounting Bracket & Crossarm, UTLI Pyranometer Leveling Fixture & Mount, UT12VA 12-Plate Radiation Shield & Mount, UT6P 6-Plate Radiation Shield & Mount. Barometers, soil temperature and moisture probes, and rain gages can also be used with the UT30.



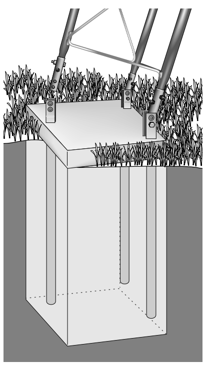
* Other items shown are purchased separately; other sensors are compatible, consult the factory for details.

CAMPBELL SCIENTIFIC, INC.
815 W. 1800 N. • Logan, Utah 84321-1784 • (435) 753-2342 • FAX (435) 750-9540 • www.campbellsci.com

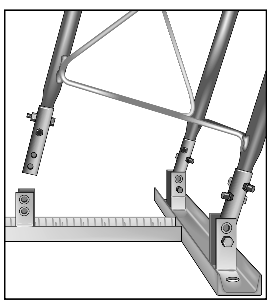
Specifications

Crossarm measurement height:	33 ft (10 m)
Shipping weight:	65 lbs (29 kg)
Material:	Hardened Drawn 6063-T832 aluminum
OD of vertical pipe:	1” (2.5 cm)
OD of cross support pipes:	0.375” (0.953 cm)
Guyed tower area requirements:	~34 ft diameter
Required concrete pad dimensions (B18 base only):	36”L x 36”W x 48”D (91 x 91 x 122 cm) This assumes heavy soil; light shifting, or sandy soils require a larger concrete pad.

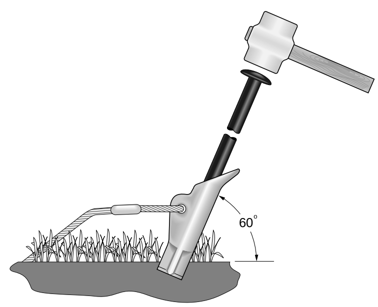
UT30 Accessories



B18

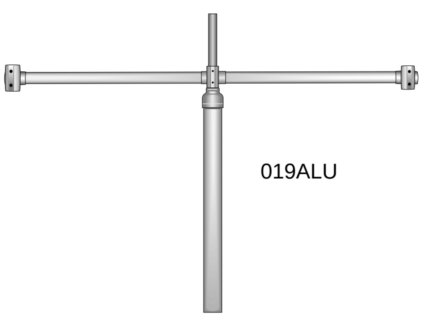


RFM18

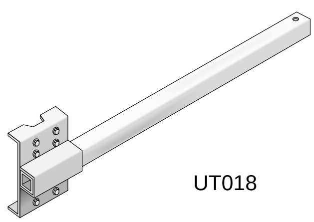


UTDUK

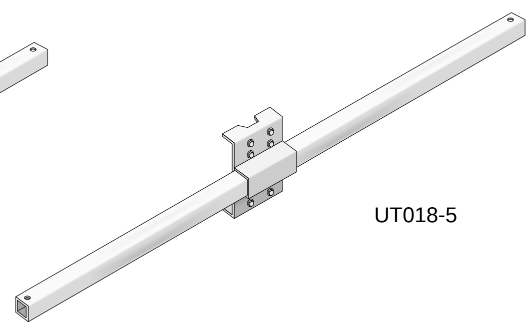
UTEYE



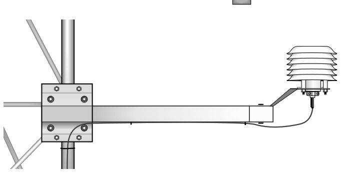
019ALU



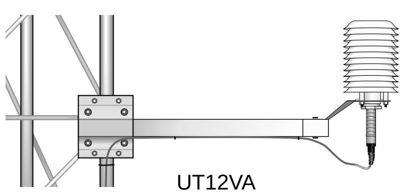
UT018



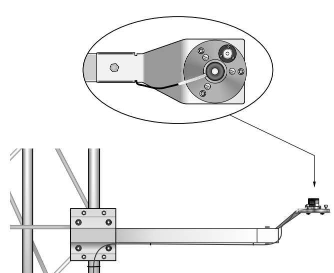
UT018-5



UT6P



UT12VA



UTLI

CAMPBELL SCIENTIFIC, INC.
815 W. 1800 N. • Logan, Utah 84321-1784 • (435) 753-2342 • FAX (435) 750-9540
Offices also located in: Australia • Brazil • Canada • England • France • South Africa

Printed June, 2000

CR1000 Specifications

Electrical specifications are valid over a -25° to +50°C, non-condensing environment, unless otherwise specified. Recalibration recommended every three years. Critical specifications and system configuration should be confirmed with Campbell Scientific before purchase.

PROGRAM EXECUTION RATE

10 ms to one day @ 10 ms increments

ANALOG INPUTS (SE1-SE16 or DIFF1-DIFF8)

8 differential (DF) or 16 single-ended (SE) individually configuredinput channels. Channel expansion provided by optional analog multiplexers.

RANGES and RESOLUTION: Basic resolution (Basic Res) is the A/D resolution of a single A/D conversion. A DIFF measurement with input reversal has better (finer) resolution by twice than Basic Res.

Range (mV)[1]	*DF Res (µV)*[2]	*Basic Res (µV)*
±5000	667	1333
±2500	333	667
±250	33.3	66.7
±25	3.33	6.7
±7.5	1.0	2.0
±2.5	0.33	0.67

[1]Range overhead of ~9% on all ranges guarantees that full-scale values will not cause over range.
[2]Resolution of DF measurements with input reversal.

ACCURACY[3]:
±(0.06% of reading + offset), 0° to 40°C
±(0.12% of reading + offset), -25° to 50°C
±(0.18% of reading + offset), -55° to 85°C (-XT only)

[3]Accuracy does not include the sensor and measurement noise. Offsets are defined as:
Offset for DF w/input reversal = 1.5•Basic Res + 1.0 µV
Offset for DF w/o input reversal = 3•Basic Res + 2.0 µV
Offset for SE = 3·Basic Res + 3.0 µV

ANALOG MEASUREMENT SPEED:

Integration Type/Code	*Integra-tion Time*	*Settling Time*	*Total Time*[4] *SE w/ No Rev*	*DF w/ Input Rev*
250	250 µs	450 µs	~1 ms	~12 ms
60 Hz[5]	16.67 ms	3 ms	~20 ms	~40 ms
50 Hz[5]	20.00 ms	3 ms	~25 ms	~50 ms

[4]Includes 250 µs for conversion to engineering units.
[5]AC line noise filter.

INPUT NOISE VOLTAGE: For DF measurements with input reversal on ±2.5 mV input range (digital resolution dominates for higher ranges).
250 µs Integration: 0.34 µV RMS
50/60 Hz Integration: 0.19 µV RMS

INPUT LIMITS: ±5 Vdc

DC COMMON MODE REJECTION: >100 dB

NORMAL MODE REJECTION: 70 dB @ 60 Hz when using 60 Hz rejection

INPUT VOLTAGE RANGE W/O MEASUREMENT CORRUPTION: ±8.6 Vdc max.

SUSTAINED INPUT VOLTAGE W/O DAMAGE: ±16 Vdc max.

INPUT CURRENT: ±1 nA typical, ±6 nA max. @ 50°C; ±90 nA @ 85°C

INPUT RESISTANCE: 20 GΩ typical

ACCURACY OF BUILT-IN REFERENCE JUNCTION THERMISTOR (for thermocouple measurements):
±0.3°C, -25° to 50°C
±0.8°C, -55° to 85°C (-XT only)

ANALOG OUTPUTS (VX1-VX3)

3 switched voltage, sequentially active only during measurement.

RANGE AND RESOLUTION:

Channel	*Range*	*Resolution*	*Current Source/Sink*
(VX 1–3)	±2.5 Vdc	0.67 mV	±25 mA

ANALOG OUTPUT ACCURACY (VX):
±(0.06% of setting + 0.8 mV), 0° to 40°C
±(0.12% of setting + 0.8 mV), -25° to 50°C
±(0.18% of setting + 0.8 mV), -55° to 85°C (-XT only)

VX FREQUENCY SWEEP FUNCTION: Switched outputs provide a programmable swept frequency, 0 to 2500 mv square waves for exciting vibrating wire transducers.

PERIOD AVERAGE

Any of the 16 SE analog inputs can be used for period averaging. Accuracy is ±(0.01% of reading + resolution), where resolution is 136 ns divided by the specified number of cycles to be measured.

INPUT AMPLITUDE AND FREQUENCY:

Voltage Gain	*Input Range (±mV)*	*Signal (peak to peak) Min. (mV)*[6]	*Max (V)*[7]	*Min Pulse Width (µV)*	*Max*[8] *Freq (kHz)*
1	250	500	10	2.5	200
10	25	10	2	10	50
33	7.5	5	2	62	8
100	2.5	2	2	100	5

[6]Signal centered around Threshold (see PeriodAvg() instruction).
[7]With signal centered at the datalogger ground.
[8]The maximum frequency = 1/(twice minimum pulse width) for 50% of duty cycle signals.

RATIOMETRIC MEASUREMENTS

MEASUREMENT TYPES: Provides ratiometric resistance measurements using voltage excitation. 3 switched voltage excitation outputs are available for measurement of 4- and 6-wire full bridges, and 2-, 3-, and 4-wire half bridges. Optional excitation polarity reversal minimizes dc errors.

RATIOMETRIC MEASUREMENT ACCURACY:[9,10,11]
±(0.04% of Voltage Measurement + Offset)

[9]Accuracy specification assumes excitation reversal for excitation voltages < 1000 mV. Assumption does not include bridge resistor errors and sensor and measurement noise.
[10]Estimated accuracy, ΔX (where X is value returned from the measurement with Multiplier = 1, Offset = 0):
BrHalf() instruction: $\Delta X = \Delta V_1/V_X$
BrFull() instruction $\Delta X = 1000 \cdot \Delta V_1/V_X$, expressed as $mV \cdot V^{-1}$.
ΔV^{-1} is calculated from the ratiometric measurement accuracy. See Resistance Measurements Section in the manual for more information.
[11]Offsets are defined as:
Offset for DIFF w/input reversal = 1.5•Basic Res + 1.0 µV
Offset for DIFF w/o input reversal = 3•Basic Res + 2.0 µV
Offset for SE = 3•Basic Res + 3.0 µV
Excitation reversal reduces offsets by a factor of two.

PULSE COUNTERS (P1-P2)

2 inputs individually selectable for switch closure, high frequency pulse, or low-level ac. Independent 24-bit counters for each input.

MAXIMUM COUNTS PER SCAN: 16.7×10^6

SWITCH CLOSURE MODE:
Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 6 ms
Max. Bounce Time: 1 ms open w/o being counted

HIGH-FREQUENCY PULSE MODE:
Maximum Input Frequency: 250 kHz
Maximum Input Voltage: ±20 V
Voltage Thresholds: Count upon transition from below 0.9 V to above 2.2 V after input filter with 1.2 µs time constant.

LOW-LEVEL AC MODE: Internal ac coupling removes ac offsets up to ±0.5 Vdc.
Input Hysteresis: 12 mV RMS @ 1 Hz
Maximum ac Input Voltage: ±20 V
Minimum ac Input Voltage:

Sine Wave (mV RMS)	*Range(Hz)*
20	1.0 to 20
200	0.5 to 200
2000	0.3 to 10,000
5000	0.3 to 20,000

DIGITAL I/O PORTS (C1-C8)

8 ports software selectable, as binary inputs or control outputs. Provide on/off, pulse width modulation, edge timing, subroutine interrupts / wake up, switch closure pulse counting, high frequency pulse counting, asynchronous communications (UARTs), and SDI-12 communications. SDM communications are also supported.

LOW FREQUENCY MODE MAX: <1 kHz

HIGH-FREQUENCY MODE MAX: 400 kHz

SWITCH-CLOSURE FREQUENCY MAX: 150 Hz

EDGE TIMING RESOLUTION: 540 ns

OUTPUT VOLTAGES (no load): high 5.0 V ±0.1 V; low <0.1

OUTPUT RESISTANCE: 330 Ω

INPUT STATE: high 3.8 to 16 V; low -8.0 to 1.2 V

INPUT HYSTERESIS: 1.4 V

INPUT RESISTANCE: 100 kΩ with inputs <6.2 Vdc
220 Ω with inputs ≥6.2 Vdc

SERIAL DEVICE/RS-232 SUPPORT: 0 TO 5 Vdc UART

SWITCHED 12 VDC (SW-12)

1 independent 12 Vdc unregulated source is switched on and off under program control. Thermal fuse hold current = 900 mA at 20°C, 650 mA at 50°C, 360 mA at 85°C.

CE COMPLIANCE

STANDARD(S) TO WHICH CONFORMITY IS DECLARED:
IEC61326:2002

COMMUNICATIONS

RS-232 PORTS:
DCE 9-pin: (not electrically isolated) for computer connection or connection of modems not manufactured by Campbell Scientific.
COM1 to COM4: 4 independent Tx/Rx pairs on control ports (non-isolated); 0 to 5 Vdc UART
Baud Rates: selectable from 300 bps to 115.2 kbps.
Default Format: 8 data bits; 1 stop bits; no parity
Optional Formats: 7 data bits; 2 stop bits; odd, even parity

CS I/O PORT: Interface with telecommunications peripherals manufactured by Campbell Scientific.

SDI-12: Digital control ports C1, C3, C5, and C7 are individually configured and meet SDI-12 Standard v 1.3 for datalogger mode. Up to 10 SDI-12 sensors are supported per port.

PERIPHERAL PORT: 40-pin interface for attaching CompactFlash or Ethernet peripherals

PROTOCOLS SUPPORTED: PakBus, AES-128 Encrypted PakBus, Modbus, DNP3, FTP, HTTP, XML, HTML, POP3, SMTP, Telnet, NTCIP, NTP, Web API, SDI-12, SDM.

SYSTEM

PROCESSOR: Renesas H8S 2322 (16-bit CPU with 32-bit internal core running at 7.3 MHz)

MEMORY: 2 MB of flash for operating system; 4 MB of battery-backed SRAM for CPU usage and final data storage; 512 kB flash disk (CPU) for program files.

REAL-TIME CLOCK ACCURACY: ±3 min. per year. Correction via GPS optional.

REAL-TIME CLOCK RESOLUTION: 10 ms

SYSTEM POWER REQUIREMENTS

VOLTAGE: 9.6 to 16 Vdc

INTERNAL BATTERIES: 1200 mAh lithium battery for clock and SRAM backup that typically provides three years of backup

EXTERNAL BATTERIES: Optional 12 Vdc nominal alkaline and rechargeable available. Power connection is reverse polarity protected.

TYPICAL CURRENT DRAIN at 12 Vdc:
Sleep Mode: < 1 mA
1 Hz Sample Rate (1 fast SE meas.): 1 mA
100 Hz Sample Rate (1 fast SE meas.): 6 mA
100 Hz Sample Rate (1 fast SE meas. w/RS-232 communication): 20 mA
Active external keyboard display adds 7 mA (100 mA with backlight on).

PHYSICAL

DIMENSIONS: 23.9 x 10.2 x 6.1 cm (9.4 x 4 x 2.4 in); additional clearance required for cables and leads.

MASS/WEIGHT: 1 kg / 2.1 lb

WARRANTY

3 years against defects in materials and workmanship.

APPENDIX B

Standard Operating Procedures for Meteorological Sensors

<table>
<tr><td rowspan="3">Meteorological Solutions Inc.
A Trinity Consultants Company</td><td rowspan="3">STANDARD OPERATING PROCEDURE</td><td colspan="2">Title: Calibration and Audit Equipment Certification</td></tr>
<tr><td>Number: SOP 69</td><td>Page: 1 of 1</td></tr>
<tr><td>Revision Number: 4</td><td>Effective Date:
09/18/2014
01/05/2010 (Rev 3)</td></tr>
<tr><td colspan="3">Approval:
Date:</td><td>Concurred By:</td></tr>
</table>

All calibration and audit equipment will be certified annually or more frequent, as necessary, against National Institute of Standards and Technology (NIST), A2LA, or NVLAP certified or traceable standards. Copies of all equipment certifications will be kept in hard copy and in electronic form. An equipment re-certification schedule will be kept and updated regularly. This schedule will include the audit/calibration equipment make, model, serial number, certification date, and date when certifications are due.

No meteorological sensors or air quality equipment will be calibrated or audited with uncertified equipment.

Calibration and audit equipment will be clearly marked with who performed the calibration, date of the calibration, date due for calibration, and equipment ID number.

Calibration or audit equipment found to be out of calibration will be tagged and segregated and not used until it is re-calibrated.

<table>
<tr><td rowspan="3"></td><td rowspan="3">STANDARD OPERATING PROCEDURE</td><td colspan="2">Title: In-House Calibration of Test Equipment</td></tr>
<tr><td>Number: SOP 106</td><td>Page: 1 of 1</td></tr>
<tr><td>Revision No: 2</td><td>Effective Date:
09/18/2014
01/05/2010 (Rev 1)</td></tr>
<tr><td colspan="3">Approval:
Date:</td><td>Concurred By:</td></tr>
</table>

Measuring devices such as thermometers and relative humidity devices will be calibrated at prescribed times and whenever the accuracy of the device appears to be suspect. Calibrations shall be against and traceable to certified equipment or reference standards having known valid relationships to recognized standards. Testing equipment which is new and which has not been certified against a known reference standard or is out of calibration shall be segregated and not used until a calibration has been established.

A record of the calibration will be established and will include documentation of all necessary information.

<table>
<tr><td rowspan="3">Meteorological Solutions Inc.
A Trinity Consultants Company</td><td rowspan="3">STANDARD OPERATING PROCEDURE</td><td colspan="2">Title: Equipment Inventory Procedure</td></tr>
<tr><td>Number: SOP 107</td><td>Page: 1 of 1</td></tr>
<tr><td>Revision No: 2</td><td>Effective Date:
09/14/2014
02/10/2011 (Rev 0)</td></tr>
<tr><td colspan="3">Approval:
Date:</td><td>Concurred By:</td></tr>
</table>

Once procured equipment arrives at MSI Trinity's instrument laboratory, the packing slip is removed from the box and compared against the purchase requisition form. By project, an equipment inventory form is filled which documents the components ordered, date received, and equipment serial number. Copies of the project equipment inventory forms are distributed to the project manager; the original is placed in the project file. Packing slips are also placed in the project file.

MSi Meteorological Solutions Inc. A Trinity Consultants Company	**STANDARD OPERATING PROCEDURE**	Title: Visual Inspection of Meteorological Equipment	
		Number: SOP 113	Page: 1 of 1
		Revision Number: 2	Effective Date: 09/18/2014 01/05/2010
Approval: Date:			Concurred By:

Upon arrival at site, a visual inspection of the tower and sensors will be performed. The Meteorological Station Visual Inspection Checklist shall be filled out completely, signed and dated.

If problems are noted, contact project manager and initiate a corrective action report (SOP 108), if needed.

Meteorological Station Visual Inspection Checklist

Meteorological Station ID:		
Date:	**Time:**	
Checks	**Yes**	**No**
1. Tower, guy wires, and anchors in good condition?		
2. Anemometer cup assemblies at all levels undamaged?		
3. Anemometers at all levels rotating freely?		
4. Wind direction vanes at all levels undamaged?		
5. Wind direction vanes at all levels rotating freely?		
6. Aspiration shields at all levels undamaged?		
7. Precipitation gauge funnel free of debris?		
8. Ground fault circuit interrupter outlet at precipitation gauge reset?		
9. Instrument cables and power cords secure with no evidence of damage or wear?		
10. There is no evidence of icing on any of the instruments?		
Comments:		
Signature	Date	

<table>
<tr><td rowspan="3">Meteorological Solutions Inc.
A Trinity Consultants Company</td><td rowspan="3">STANDARD OPERATING PROCEDURE</td><td colspan="2">Title: Data Collection and Initial Processing</td></tr>
<tr><td>Number: SOP 114</td><td>Page: 1 of 2</td></tr>
<tr><td>Revision Number: 1</td><td>Effective Date:
10/15/2014
12/29/2009 (Rev. 0)</td></tr>
<tr><td colspan="2">Approval:</td><td>Date:</td><td>Concurred By:</td></tr>
</table>

This SOP describes the steps taken by MSI's data management personnel to collect ambient air quality and meteorological data via telephone, cellular, or satellite modems. The primary purpose of daily data collection is to assure quality data capture and minimize loss by:

- Calling the datalogger at each station via telephone, cellular or satellite modem and downloading the past day's data into site-specific daily files.
- Reviewing the daily error and stacked plots to verify complete data collection or to identify problems.

RESPONSIBILITIES OF DATA ANALYST

The data analyst shall on a daily basis:

- Maintain the automatic data collection programs and support information
- Ensure that the workstation used for automatic data collection is properly configured for daily data poll.
- Review the status of the automatic data collection each morning to verify complete, error-free data collection, assure the integrity of the monitoring systems, identify problems, and initiate corrective action.
- Perform data retries as necessary.
- Review collected data files.
- Provide technical support to site operators, as needed.
- Ensure proper archive and storage of final raw data files.

Starting the Auto Poll Process

The polling schedule is set in LoggerNet scheduler. Care should be taken not to overlap polling existing stations. Verify that the scheduled task is properly set up by attempting a manual poll at project start.

Manual Data Polling

Manual data polling is conducted when the automatic data collection process has failed. To run manual poll:

- Select site.
- Click the COLLECT NOW button in LoggerNet.
- Confirm connection and data bytes received.
- Retry as necessary if connection is unsuccessful.
- Contact internal support and then site operator as needed.

Data Naming and Storage

Each download is saved in a separate file and are named in accordance with these conventions: PPyymmdd.raw. PP indicates project identifier, mm month, dd date, and yy for year. These files are the raw, non-QC'd data obtained directly from the dataloggers in the field. No editing of these files is to be performed. These raw files should be archived for future reference, if needed. The daily files are written to a monthly file called PPyymm.raw which lives in the same directory. At the end of the month, this file is copied to PPyymm.dat and can be modified, as necessary.

Level 0 Data Validation

Level 0 data validation is essentially raw data obtained directly from the data acquisition systems in the field. Level 0 data have been reduced and possibly reformatted, but are unedited and un-reviewed. These data have not received any adjustments for known biases or problems that may have been identified during preventive maintenance checks or audits. These data are used to monitor the instrument operations daily, but should not be used for regulatory purposes.

Level 0 data validation is accomplished by:

- Collecting data via modem, and
- Initially screening the daily data for anomalies.

Data Management

Managing the data collected is just as important as correctly collecting the data. Generally, data is to be retained for a period of 3 years after final submittal. All information collected in any ambient air monitoring program should be organized in a logical and systematic manner.

<table>
<tr><td rowspan="3">MSi Meteorological Solutions Inc. A Trinity Consultants Company</td><td rowspan="3">STANDARD OPERATING PROCEDURE</td><td colspan="2">Title: Level 1 Data Validation</td></tr>
<tr><td>Number: SOP 115</td><td>Page: 1 of 8</td></tr>
<tr><td>Revision Number: 1</td><td>Effective Date:
10/15/2014
12/01/2009 (Rev. 0)</td></tr>
<tr><td>Approval:</td><td colspan="2">Date:</td><td>Concurred By:</td></tr>
</table>

Level 1 data validation involves quantitative and qualitative reviews for accuracy, completeness, and internal consistency. Quantitative checks are performed by MSI's software screening program. Qualitative checks are performed by meteorologists or trained personnel who manually review the data for outliers and problems.

After daily download, data are processed through MSI's quality control screening software to identify values that do not meet acceptance criteria. Raw data are graphed as stacked plots and are visually reviewed. Daily stacked plots of the raw data will be output to .pdf's. There would be one .pdf per day per station. Acceptance criteria that raw data are compared against are based on State, EPA and sensor/analyzer manufacturer recommendations.

Data Screening Procedures

Screening procedures generally include comparisons of measured values to upper and lower limits; these may be physical limits, such as an instrument threshold, or may be established based on experience or historical data. Other types of procedures employed in screening include assessments based on the rate of change of a variable (in these, data that change too rapidly or not at all are flagged as suspect) and assessments based on known physical principles relating two or more variables (e.g., the dew point should never exceed the dry-bulb temperature).

Screening may be regarded as an iterative process in which range checks and other screening criteria are revised as necessary based on experience. For example, an initial QA pass of a data set using default criteria may flag values which upon further investigation are determined to be valid for the particular site. Data which fail the screening test should be flagged for further investigation.

Recommended meteorological data screening criteria, as found in EPA's Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. IV: Meteorological Measurements, Version 2.0 Final, March 2008 is presented below in Table 1. Table 2 presents the air quality recommended data screening criteria as found in EPA's Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. II: Ambient Air Quality Monitoring Program. These are just examples to begin with and should be expanded upon and modified to be project specific for each monitoring station.

Table 1 Meteorological Data Screening Criteria

Parameter	Criteria	Acceptance Range
WS/VWS	Hourly recorded WS/VWS	0 m/s ≥WS≥25 m/s WS varies ≤0.1 m/s for 3 consecutive hours WS varies ≤0.5 m/s for 12 consecutive hours
WD/VWD	Hourly recorded WD/VWD	0º≥WD≤360º WD varies ≥1º for 3 consecutive hours
Temperature	Hourly recorded Temp.	Local record low≥temp≤local record high Temp.≤5ºC from previous hour Temp. varies ≥0.5ºC for 12 consecutive hours
10m-2m ΔT	Hourly recorded 10m-2m difference	Daytime ΔT<0.1ºC/m Nighttime ΔT>-0.1 ºC/m -3.0ºC>ΔT<5.0ºC
RH/Dew Pt.	Hourly recorded RH	Dew pt. temp.≤amb. temp Dew pt. temp. < 5ºC change from previous hour Dew pt. temp. ≥0.5ºC from previous hour and dew pt. temp < ambient temp. for 12 consecutive hours
Solar Rad.	Hourly recorded solar rad.	Nighttime SR = 0 Daytime SR < max. SR for date and latitude
Bar. Press.	Hourly recorded Bar. Press.	BP<1050 mb (sea level) or per site climatology BP > 945 mb (sea level) or per site climatology

Table 2 Air Quality Data Screening Criteria

Requirement	Frequency	Acceptance Criteria
Ozone		
One point QC check	1 /2 weeks	≤±7% percent difference
Zero/span check	1 /2 weeks Daily	Zero drift: ≤±5 ppb Zero drift: ≤±3 ppb Span drift: ≤±7%
Shelter Temperature	Daily	20-30ºC (hourly avg.) or manufacturer specs.
Carbon Monoxide		
Precision	1 /2 weeks	±10% percent difference
Zero/span check	1 /2 weeks Daily	Zero drift: 0.6 ppm Zero drift: 0.4 ppm Span drift: 10%
Shelter Temperature	Daily	20-30ºC (hourly avg.) or manufacturer specs.
Sulfur Dioxide		
Precision	1 /2 weeks	±10% percent difference
Zero/span check	1 /2 weeks Daily	Zero drift: ≤±5 ppb Zero drift: ≤±3 ppb Span drift: 10%
Shelter Temperature	Daily	20-30ºC (hourly avg.) or manufacturer specs.

Table 2 Air Quality Data Screening Criteria (Continued)

Requirement	Frequency	Acceptance Criteria
NO_2		
One Point QC Check	1/ 2 weeks	±≤15% (percent difference)
Zero/span check	1/ 2 weeks Daily	Zero drift ≤±5 ppb Zero drift ≤±3 ppb Span drift≤±10%
Converter Efficiency	1 /2 weeks	96 – 104%
Shelter Temperature	Daily	20-30ºC (hourly avg.) or manufacturer specs.
PM_{10} Continuous		
Sampling period - 24 hours	Each sample period	1380-1500 minutes midnight to midnight
Average flow rate	Every 24 hours	Average within 5% of 16.67 liters/min
One-point flow rate verification	Monthly	±4% of transfer standard and 5% of design
$PM_{2.5}$ Continuous		
Sampling period - 24 hours	Each sample period	1380-1500 minutes
Hour estimate	Every hour	Instrument dependent
Average flow rate	Every 24 hours	Average within 5% of 16.67 liters/min
Variability in flow	Every 24 hours	CV ≤2%
One-point flow rate verification	Monthly	±4% of transfer standard and 5% of design

Data Quality Control Flags

Per EPA's Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Quality Monitoring Program, EPA recommends the use of flags or result qualifiers to identify potential problems with data (or a sample). According to EPA, a flag is an indicator of the fact and the reason that a data value (a) did not produce a numeric result, (b) produced a numeric result but it is qualified in some respect relating to the type or validity of the result, or (c) produced a numeric result but for administrative reasons is not to be reported outside the organization.

Thus, quality control flags, consisting of a letter will be assigned to each datum to indicate its quality. Multiple flags can be applied to each data point such as data invalid due to calibration (I, CA). It is preferred to assign multiple flags if problem is known. A list of the quality control codes to be assigned to the data points are presented in Table 3.

Table 3 Data Flags

Flag	Code	Description
V	0	Valid
BC/AT	9995/9986	Multi-point Calibration/ Calibration
AN	9980	Instrument Malfunction
AO	9981	Acts of Nature
BH	9965	Local Interference
BA	9993	Maintenance
BJ	9963	Operator Error
AZ	9992	Performance Audit
AX	9990	Precision Check
AV	9988	Power Failure
AQ	9983	Datalogger or Collection Failure
AE	9971	Shelter Temperature High
AE	9971	Shelter Temperature Low
TO	9961	Datalogger Time Off
BF	9998	Zero/span
AP	9982	Site Vandalism
AH	9974	Sample Flow Rate out of Limits
AI	9975	Insufficient Data (cannot calculate)
AL	9978	Voided by Operator
AM	9979	Miscellaneous Void
AS	9985	Poor Quality Assurance Results
AY	9991	QC Control Points (zero/span)
BE	9997	Building/Site Repair
BK	9962	Site computer/ datalogger down
DA	9951	Aberrant Data

All necessary supporting material, such as audit or calibration field sheets, and any site logs, should be used for the level 1 validation. Access to a daily weather archive should also be reviewed for use in relating suspect data with to local and regional meteorological conditions. Any problem data, such as data flagged in an audit, should be indicated as such. Data values considered questionable should be flagged for verification.

Data Validation Steps

The various steps involved in data validation are summarised below. Note that not all steps apply to all types of data:

- Check any incident log files, in the cases of loggers that automatically produce such files;
- Check for power failures;
- Check traces exhibiting noise, spikes, non-varying data, or influences of other equipment (e.g. air conditioner);
- Check for uncharacteristic shapes of calibration curves;
- Review of zero, span, one point QC verification information;
- Create and examine 'calibration control plots' of zero and span outputs from calibrations as a function of time, and compare these against the expected range of variability;
- Invalidate data associated with any calibration run which produces readings of zero or span outside the specified tolerance;
- Use linear interpolation to correct for observed zero drift, span drift or clock error;
- Check for data outside the plausible range;
- Check for data that are inconsistent with measurements of other pollutants at the same site, for example NO and O_3 cannot coexist at high concentrations, ozone formation is a function of temperature and solar radiation, and neither NO_2 nor NO levels can ever exceed NO_x levels;
- Investigate the cause of unexpected outlier measurements;
- Check measurements for consistency with other monitoring stations in the region if available;
- Conduct simple statistical tests on each month's data;
- Flag data that are missing, questionable etc.; and
- Record all validation steps for quality control.

Air Quality Data Reduction Using Calibration Information

An analyzer's response calibration curve relates the analyzer response to actual concentration units of measure, and the response of most analyzers tends to change (drift) unpredictably with passing time. These two conditions must be addressed in the mechanism that is used to process the raw analyzer readings into final concentration measurements. According to EPA, three practical methods are described below. They are listed in order of preference:

1) Universal Calibration. A fixed, "universal" calibration is established for the analyzer and used to calculate all ambient readings. All verifications and checks are used to measure the deviation of the current analyzer response from the universal calibration. Whenever this deviation exceeds the established zero and span adjustment limits, the analyzer is recalibrated.

2) Major Calibration Update. In this method, the calibration slope and intercept used to calculate ambient measurements are updated only for "major" calibration (multi-point verification/calibrations). All ambient measurements are calculated from the most recent major calibration. Between major calibrations, periodic zero and span calibrations are used to measure the difference between the most recent major calibration and the current instrument response.

3) Step-Change Update. The adjusted slope and intercept of the most recent calibration are used to calculate all subsequent ambient readings until updated by another calibration (i.e., no interpolation). No unadjusted zero or span readings are used, and ambient measurements can be calculated in real time if desired.

Validation of Ambient Data Based on Calibration Information

When a zero or span drift check is determined to have failed the limits listed in Table 2, additional checks are performed to determine the cause of the failure. The following items are reviewed or performed:

1) Is the failure due to the automated system;
2) Check to see if failure is an outlier;
3) Re-run failed point concentration to verify failure;

If it is determined that a zero or span check does exceed the limits in table 2, then a multi-point calibration to correct the issue is conducted and the data are invalidated, if necessary back to the previous passing check.

Indicated failures which do not lead to invalidation include:

- Calibration system issue;
- Points are in tolerance after being rerun;
- Multipoint calibration indicates no need for adjustment of the analyzer (i.e. “as found” in tolerance).

Dealing with Data near Detection Limits

Every instrument has an uncertainty associated with each measurement. This is normally described as ± a specific value. This means that at very low ambient concentrations, it is conceivable that an analyzer will report a negative value. In addition, most calibration and datalogging systems will also have an uncertainty measurement. It is necessary to calculate the total of all the uncertainties for the entire operation to determine what the overall uncertainty for the data is.

Occasionally, large negative spikes may occur due to instrumental error. These negative (and positive) spikes should be reviewed during the data analysis process to evaluate whether they are real or spurious. Inadequate or faulty heating of the inlet air on some particulate monitors (most commonly seen on BAMs) can allow moisture to affect the sample, giving rise to large positive spikes, normally followed by large negative spikes. It is recommended that both spikes be removed as invalid data, the temperature sensors checked for faults, and the inlet temperature reset. Unless there is good evidence to remove a value, it should be left in but flagged as suspicious.

In some situations the concentration of the pollutant being measured may be very near zero, in which case the measured value (after adjusting for drift of zero and span) may be less than the measurement limit of detection. In this situation, various practices have been adopted in the past. For example, the measurements could be reported as:

(i) below the detection limit;
(ii) zero;
(iii) some value between zero and the detection limit, and;
(iv) the actual measured value (positive or negative) whether or not it is below the detection limit.

EPA recommends the use of (iv). Even negative concentration readings should be retained, provided they lie within the range of expected instrument fluctuations. Any negative reading that is too large to be explained by normal instrument fluctuations should serve as an indication of faulty calibration or instrument operation, and should prompt further investigation.

In particular, if a negative value is found with a magnitude greater than the maximum daily zero-drift specified, the instrument is probably not complying with the required performance requirements. Unless such an anomaly can be resolved, the measurement system should be deemed faulty and all data should be invalidated back to a calibration that is free of doubt.

The minimum detection limits for several currently operated air quality analysers is presented in Table 4.

Table 4 Minimum Detection Limit for Air Quality Analysers

Analyser	Minimum Detection Limit
Teledyne API Ozone 400A or 400E	<0.6 ppb
Teledyne API $NO/NO_2/NO_x$ 200E	<0.4 ppb
Teledyne API $NO/NO_2/NO_x$ 200EU	50 ppt
Teledyne API SO_2 100A and 100E	<0.4 ppb
Teledyne API CO 300E	0.04 ppm
TEOM 1400ab	0.06 µg/m^3 (1-hour average)

Missing Data

Interpolation or extrapolation to fill in missing data should not be used in the process of producing a basic quality-assured data set.

Data Validation Summary Spreadsheet

It is important to maintain detailed, accurate records of changes to the data. The justification for all data invalidations will be permanently documented in a data validation summary spreadsheet. These records will save time and effort if questions arise about specific data at a later date.

At the end of each month, a data validation summary spreadsheet will be compiled indicating the following:

- Measured parameters with suspicious or invalid data
- Date and time of this data
- Identification of data points that were flagged as suspect or invalid, and the reason why they were flagged
- Systematic problems that affected the data
- Any adjustments, deletions, or modifications, with a justification or reason for the change
- Listing of values and value changes
- Who performed the data validation and when

Hourly data files will be prepared for final quality assurance. These data files will contain only validated data and will have a .hry extension.

Reporting Intervals

Currently, hourly averages are the reporting interval for continuous particulate and gaseous data. These are the reporting intervals for AQS**.** These reporting intervals will meet most of the multiple objectives for supporting health effects studies, trends, NAAQS attainment decisions, and accountability of control strategies. However, with these objectives also comes the desire for data at finer time resolutions: 5 minute averages for gaseous pollutants and sub-hourly averages for certain particulate matter monitors. Examples of this need for finer time resolution of data include, but are not limited to: tracking air pollution episodes, providing data for exposure studies, model evaluation, and evaluating shorter averaging periods for potential changes to the NAAQS.

With this generation of data having a shorter averaging interval, the challenge becomes validation of all the data. EPA's historical perception has been that each criteria pollutant measurement needs to be verified and validated manually. To provide a consistent approach for the reporting interval of data, EPA has taken a tiered approach to data reporting. At the top tier, hourly data intervals will remain the standard for data reporting. Long term, networks will be capable of providing at least 5-minute intervals for those methods that have acceptable data quality at those averaging periods.

APPENDIX C

Corrective Action Report

MSi Meteorological Solutions Inc. A Trinity Consultants Company	**STANDARD OPERATING PROCEDURE**	Title: Corrective Action Procedures	
		Number: SOP 54	Page: 1 of 1
		Revision Number: 2	Effective Date: 08/29/2016 01/05/2010 (Rev. 1)
Approval:	Date:		Concurred By:

Conditions adverse to quality will be identified promptly and will be corrected as soon as possible. The identification, cause, and corrective action for conditions adverse to quality will be documented and reported to the appropriate levels of management. Follow-up action shall be taken to verify implementation of the corrective action. A corrective action report form will be filled out that identified the problem or deficiency, the proposed corrective action, and the results of the corrective action.

APPENDIX D

Site Check Form

SITE VISIT CHECKLIST

MSi
Meteorological Solutions Inc.
A Trinity Consultants Company

Operator ________________ Date ________________

Site Name ________________ Stn ID ________________

Project ________________ Time ________________

Visit Type: Weekly ________ Unscheduled: ________

	Yes	No
Tower Straight		
Guy wires taut, secured		
Wind Sensors Intact (Propeller Blades, Vane Tail)		
Temperature Aspirators Operational		
Solar Panel Clean and Properly Oriented		
Rain Gauge Funnel Clear of Debris/Snow/Ice		
Signs of Sensor Damage		
Sensors Leval and Oriented Correctly		
Datalogger Date/Time Correct		
Boom Orientation OK		
Sensor Outputs Checked and Functioning Properly		
Grounding System Intact		
Cellular Antenna Correctly Oriented		
Area Free of Vandalism		

Site Visit By: ________________________________

APPENDIX E

Standard Operating Procedures for Meteorological Sensor Calibration

STANDARD OPERATING PROCEDURE	Title: Wind Direction Calibration	
	Number: SOP M11	Page: 1 of 3
	Revision Number: 6	Effective Date: 09/18/2014 06/20/2008 (Rev. 5)
Approval: Date:		Concurred By:

The wind direction calibration will be performed by comparing the wind direction sensor readouts on the DAS and chart recorder with known wind directions established by using a theodolite or precision compass. Several points over the measurement range are verified using a direction template, assigned compass reference points, or established distant sighting targets. Differences between reference and sensor measured directions are recorded. Direction vane starting threshold will be checked using a torque disc or torque watch gauge.

Calibration Personnel Responsibilities

The person performing the calibration is responsible for the certification of the calibration standard before conducting calibrations. The calibration technician will calculate the results of the calibration and will inform the Project Manager of the preliminary findings.

Calibration Instrumentation and Forms

The calibration technician conducting the calibration will bring the following equipment to the site:

1. Professional classic pocket transit or precision compass with tripod,

2. R.M. Young Model 18212 Vane Angle Fixture,

3. R.M. Young Model 18331 Vane Torque Gauge,

4. Current magnetic declination angle for site to be calibrated,

5. Calibration field data sheets, and

6. (optional) Theodolite and True North solar angle program for computer.

Procedures

Calibration procedures are in accordance with the guidelines of the EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Version 2.0 Final (EPA, March 2008).

1. For wind direction instruments that have crossarms, prior to lowering the tower or the crossarm, determine the crossarm alignment by sighting along it using a precision compass corrected for magnetic declination. Current magnetic declination is obtained using the latitude/longitude or UTM coordinates of the site and a magnetic declination calculation computer program. Optionally, if a solar viewing is possible, a theodolite can be set up and oriented using a solar angle computer program. The calibration person views the crossarm through the theodolite to verify alignment with reference to True North.

2. Once the crossarm is lowered, the person conducting the calibration positions the wind vane exactly parallel to the crossarm and records the reading.

3. Determine accuracy and linearity by mounting a direction template or calibration fixture and fixing the vane in at least the four cardinal directions. The vane is rotated sequentially through at least the four directions clockwise and then counter clockwise and the DAS readouts are recorded. (The tip and then the tail of the vane may also be pointed at established distant sighting targets.)

4. The difference between the station and calibration wind directions is calculated using the following equation:

   Diff. = System Wind Direction - Calibration Wind Direction

   The differences calculated above are compared with the EPA PSD recommended criteria of ±5% for the entire system (orientation plus linearity). If results exceed these criteria, the calibration person should recommend recalibration of the sensor or replacement of the potentiometer.

5. Determine starting threshold of the wind vane by measuring shaft rotational torque of the sensor using a torque gauge or disc. The measured torque should be less than the maximum allowable torque provided by the manufacturer corresponding to a 0.5 m/s wind speed threshold.

If the measured torque exceeds this value, the calibrator should recommend bearing and/or potentiometer replacement. If necessary, calculate the torque value that corresponds to the starting threshold of 0.5 m/s for a 10° deflection using the "k" value provided by the manufacturer and the following equation:

$$T = kU^2$$

Where: T = torque in gm-cm

U = wind speed in m/s

and k = constant

The torque gauge test determines if the wind vane starting threshold is less than or equal to the required specifications. The wind vane is considered to be within the recommended criteria if the indicated torque value is less than or equal to the calculated or stated maximum starting torque value. If the wind vane fails the test, the calibrator should recommend that the bearings and/or potentiometer be replaced.

<table>
<tr><td rowspan="3"></td><td rowspan="3">STANDARD OPERATING PROCEDURE</td><td colspan="2">Title: Wind Speed Calibration</td></tr>
<tr><td>Number: SOP M12</td><td>Page: 1 of 2</td></tr>
<tr><td>Revision Number: 4</td><td>Effective Date:
09/18/2014
06/20/2008 (Rev. 3)</td></tr>
<tr><td colspan="3">Approval:
Date:</td><td>Concurred By:</td></tr>
</table>

The wind speed calibration will be performed by temporarily replacing the anemometer cups or propeller with a constant RPM or synchronous motor and comparing the speed corresponding to the rotation rate as supplied by the manufacturer with the equivalent wind speed displayed by the instrument. Starting thresholds will be checked using a torque disk or torque watch gauge to measure shaft rotational torque.

Calibration Personnel Responsibilities

The calibration technician is responsible for the certification of the calibration standard before conducting calibrations. The calibration technician will calculate the results of the calibration and will report the preliminary findings to the Project Manager.

Calibration Instrumentation and Forms

The calibration technician will bring the following equipment to the site:

1. RM Young Model 18810 anemometer drive SN CAO1889.

2. RM Young Model 18310 Torque Disc.

3. Calibration field data sheets.

Procedures

Calibration procedures conform to the guidelines of the EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Version 2.0 Final (EPA, March 2008).

1. Starting threshold is calibrated by checking sensor shaft rotational torque with a torque disc.

A. R.M. Young Model 18310 Torque Disc

With the anemometer sensor in the horizontal position, remove the anemometer cups or propeller and install the torque disc on the anemometer shaft. Use manufacturer-provided allowable torque values or calculate the torque value that corresponds to the starting threshold of 0.5 m/s using the "k" value provided by the manufacturer and the following equation:

$$T = kU^2$$

Where: T = torque in gm-cm

U = wind speed in m/s

and k = constant (from manufacturer)

Install the 0.1 gm screw weight in the appropriate hole of the torque disc that corresponds to the calculated torque value, and position the weight so that it is level with the anemometer shaft. Release the weight and note if the torque disk and anemometer shaft rotate freely. To measure the actual starting torque, change the position of the screw weight starting at the location closest to the shaft and move outward until the weight rotates freely from the horizontal. The weight of the screw times the distance from the shaft equals the torque in gm-cm.

2. The accuracy of wind speed measurements is tested at zero and at least two speeds within the operational range of the sensor. R.M. Young Model 18810 selectable speed anemometer drive will be used to generate stable calibration input speeds over the range of the sensor.

   The calibration person removes the anemometer cups or propeller and joins the wind speed sensor shaft to the calibration motor with a coupling device.

3. Calculate the difference between the system and calibration wind speeds using the following equation:

   Diff. = System Wind Speed - Calibration Wind Speed

   The differences calculated above are compared with the USEPA.PSD recommended criteria of ± 0.2 m/s.

<table>
<tr><td rowspan="3">Meteorological Solutions Inc.
A Trinity Consultants Company</td><td rowspan="3">STANDARD OPERATING PROCEDURE</td><td colspan="2">Title: Temperature Calibration</td></tr>
<tr><td>Number: SOP M13</td><td>Page: 1 of 2</td></tr>
<tr><td>Revision Number: 4</td><td>Effective Date:
09/18/2014
06/20/2008 (Rev. 3)</td></tr>
<tr><td colspan="2">Approval:</td><td>Date:</td><td>Concurred By:</td></tr>
</table>

Calibration Personnel Responsibilities

The calibration technician is responsible for the certification of the calibration standard before conducting calibrations. He/She provides the method for calibrating the equipment. The calibration technician will calculate the results of the calibration and will report preliminary findings to the Project Manager.

Calibration Equipment

- Mercury-in-glass thermometer or digital thermometer calibrated with a laboratory NIST-traceable thermometer.
- Thermos bottles - one with hot water, one warm water, and one ice bath or aluminum blocks at different temperatures.
- Calibration forms.

Equipment Setup and Calibration Procedures

Calibration procedures are in accordance with the guidelines of the EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Version 2.0 Final (EPA, March 2008).

Temperature sensing systems are calibrated by collocated intercomparison with a calibrated reference standard. If immersion in water is possible, the station temperature sensing system thermistor and the calibrated thermometer are immersed in a common water bath and the readings are compared at temperatures of approximately 0°, 20°, and 40°C (or 3 points over the expected measurement range at the site) or by using aluminum blocks inserted into wide-mouth thermos bottles to provide the medium for various reference temperatures. If delta-temperature is measured, the delta-temperature is checked by simultaneous insertion of delta-temperature sensors in the same medium and comparing outputs.

Data Reduction and Interpretation

Calculate the difference between the sensor and calibration temperatures using the equation:

Diff. = System Temperature - Calibration Temperature

The differences calculated above are then compared with the EPA recommended criteria of ±0.5°C and ±0.1ºC for delta-temperature when the sensors are checked in the same medium.

<table>
<tr><td rowspan="3"></td><td rowspan="3">STANDARD OPERATING PROCEDURE</td><td colspan="2">Title: Relative Humidity Calibration Procedures</td></tr>
<tr><td>Number: SOP M15</td><td>Page: 1 of 2</td></tr>
<tr><td>Revision Number: 4</td><td>Effective Date:
09/18/2014
06/20/2008 (Rev. 3)</td></tr>
<tr><td colspan="3">Approval:
Date:</td><td>Concurred By:</td></tr>
</table>

Calibration Personnel Responsibilities

The calibration technician is responsible for the certification of the calibration standard before conducting calibrations. The calibration person will calculate the results of the calibration and will inform the Project manager of the preliminary findings.

Calibration Equipment

- Rotronic or other calibrated digital RH probe - or - a Sato or similar motor aspirated psychrometer.
- Booklet of psychometric tables.
- Water.
- Large plastic bucket (approx. 5 gallon size).
- Calibration forms.
- Portable barometer if using psychometric tables.

Equipment Setup and Calibration Procedures

Calibration procedures are in accordance with the guidelines of the EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Version 2.0 Final (EPA, March 2008).

Relative humidity sensors are calibrated using one of two methods.

1) Collocating the station RH sensor and the calibrated RH sensor inside a plastic bucket where water can be added in the bottom of the bucket to provide several different calibration points.

2) Collocating the calibrated RH sensor or motor-aspirated psychrometer adjacent to the site sensor to sense the ambient conditions. Multiple readings are taken over several hours (wet bulb, dry bulb) and converted into RH using the manufacturer's tables.

Data Reduction and Interpretation

Calculate the difference between the station and calibration relative humidity's using the equation:

$$\% \text{ Diff.} = \frac{\text{Station \% RH - Calibration \% RH}}{\text{Calibration \% RH}}$$

The mean of the percent differences calculated above is then compared with the EPA recommended criteria of ±7 percent relative humidity.

	STANDARD OPERATING PROCEDURE	Title: Solar Radiation Calibration	
		Number: SOP M16	Page: 1 of 2
		Revision Number: 4	Effective Date: 9/30/2014 6/20/2008 (Rev. 3)
Approval: Date:			Concurred By:

Calibration Personnel Responsibilities

The calibration technician is responsible for the certification of the calibration standard before conducting equipment calibrations. The calibration technician will calculate the results of the calibration and will inform the Project Manager of the preliminary findings.

Calibration Equipment

- Certified Reference Standard Pyranometer
- Data Acquisition System with appropriate datalogger program
- Tripod mount for pyranometer

Equipment Setup and Calibration Procedures

Calibration procedures are in accordance with the guidelines of the EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Version 2.0 Final (EPA, March 2008).

Solar radiation sensor calibrations are conducted by collocation of a certified reference pyranometer with the site pyranometer. A separate datalogger is utilized for the reference pyranometer and it is time-synchronized with the site data acquisition system prior to intercomparison. Averaging times of stored output data in the calibration datalogger must include at least the same outputs as in the site DAS. Periodic output readings from the site sensor and the reference are manually recorded during at least a three-hour or longer intercomparison period. To confirm the DAS output during darkness, the site sensor should be covered sufficiently to allow no light to penetrate and the sensor output should be verified to assure a near-zero value is recorded.

Data Reduction and Interpretation

The station solar radiation outputs from the DAS and the corresponding calibration solar radiation values are intercompared by calculating the percent difference using the equation:

$$\text{Percent Diff.} = \frac{\text{Station solar radiation - Calibration solar radiation}}{\text{Calibration Solar Radiation}} * 100$$

The mean of the percent differences is then compared with the EPA recommended criteria of ±5 percent of the calibration reference or ±25 watts/m^2.

Meteorological Solutions Inc. A Trinity Consultants Company	**STANDARD OPERATING PROCEDURE**	Title: Barometric Pressure Calibration	
		Number: SOP M17	Page: 1 of 1
		Revision Number: 3	Effective Date: 09/30/2014 8/27/2007 (Rev. 2)
Approval:	Date:		Concurred By:

Calibration Personnel Responsibilities

The calibration technician is responsible for the certification of the calibration standard before conducting equipment calibrations. The calibration technician will calculate the results of the calibration and informs the Project Manager of the preliminary findings.

Calibration Equipment

- Certified Digital Barometer or digital or aneroid barometer standardized to local National Weather Service reference.

Equipment Setup and Calibration Procedures

Collocate calibration reference barometer with station barometric pressure sensor and record readings for intercomparison.

Data Reduction and Interpretation

Calculate the difference between the station and calibration reference barometric pressure (BP) using the equation:

$$\text{Difference} = \text{Station BP} - \text{Calibration BP}$$

The mean of the calculated differences is then compared with the EPA recommended criteria within of ±3 mb of the calibration reference.

<table>
<tr><td rowspan="3">Meteorological Solutions Inc.
A Trinity Consultants Company</td><td rowspan="3">STANDARD OPERATING PROCEDURE</td><td colspan="2">Title: Net Radiation Calibration</td></tr>
<tr><td>Number: SOP M18</td><td>Page: 1 of 2</td></tr>
<tr><td>Revision Number: 4</td><td>Effective Date:
10/14/2014
6/20/2008 (Rev. 3)</td></tr>
<tr><td colspan="3">Approval:
Date:</td><td>Concurred By:</td></tr>
</table>

Calibration Personnel Responsibilities

The calibration technician is responsible for the certification of the calibration standard before conducting calibrations. The calibration technician will calculate the results of the calibration and report the preliminary findings to the Project Manager.

Calibration Equipment

- Certified Reference Standard Net Radiometer
- Data Acquisition System with appropriate datalogger program
- Tripod mount for net radiometer
- Calibration field data sheets

Equipment Setup and Calibration Procedures

Calibration procedures are in accordance with the guidelines of the EPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV, Version 2.0 Final (EPA, March 2008).

Net radiation sensor calibrations are conducted by collocation of a certified reference net radiometer with the site net radiometer. A separate datalogger is utilized for the reference radiometer and it is time-synchronized with the site data acquisition system prior to intercomparison. Averaging times of stored output data in the calibration datalogger must include at least the same outputs as in the site DAS. Periodic output readings from the site sensor and the reference are manually recorded during at least a three-hour or longer intercomparison period.

Data Reduction and Interpretation

The station net radiation outputs from the DAS and the corresponding calibration net radiation values are intercompared by calculating the percent difference using the equation:

$$\text{Percent Diff.} = \frac{\text{Station net radiation - Calibration net radiation}}{\text{Calibration Net Radiation}} * 100$$

The mean of the percent differences is then compared with the EPA recommended criteria of ±5 percent of the calibration reference or ±25 watts/m^2.

APPENDIX F

Quality Assurance/Data Validation Logs, and Data Report Quality Assurance Checklist

Meteorological Solutions Inc.
A Trinity Consultants Company

DATA VALIDATION SITE ACTIVITY LOG

Site Name:

Activity:
Calibration
Maintenance
Sensor Replacement
Sensor Malfunction
Performance Audit
Other

Measurement Off-Line

Parameter	Level	From Datalogger Date/Time	To Datalogger Date/Time

Meteorological Solutions Inc.
A Trinity Consultants Company

DATA INVALIDATION LOG

Project	Date	Time	Parameter	Level	Reason for Invalidation

4525 Wasatch Blvd. | Suite 200 | SLC, UT 84124
Phone: 801-272-3000 | Fax: 801-272-3040
www.metsolution.com | info@metsolution.com

DATA REPORT
QA CHECKLIST

Meteorological Solutions Inc.
A Trinity Consultants Company

Client ______________________________
Site Name ______________________________
MSI Project # ______________________________
Report Date ______________________________
Check by: ______________________________

Summary Tables/Data File Check:											
Parameter:	10 WS	10 WD	2m Temp.	10m Temp.	ΔT	RH	SR	NR	BP	Prec.	Comments
Verify Missing Data											
Verify Off-Line Periods											
Verify Percent Recovery											
Verify Table Data Calculations											
Report Text Check											
Report Tables Check											
TOC Check											
Data Statistics Check											
Calibration Review											

APPENDIX C. CENTURY SEBREE SOURCE CHARACTERISTICS FOR SIP DEMONSTRATION

C-1. Modeled Release Parameters - 1-Hour SO2 NAAQS Modeling

Table C-1.1. List of Century Point Source Stack Parameters for 1-Hour SO2 NAAQS Modeling

Stack ID	Description	UTM East (m)	UTM North (m)	Elevation[1] (m)	Stack Orientation[2]	Emission Rate[4,5] (g/s)	Stack Height (m)	Stack Temp.[3] (K)	Exit Velocity[3] (m/s)	Stack Diameter (m)
A6_02	Remelt Furnace (90); Gas Burners	455,802	4,168,313	135.9	V	1.6920E-03	13.1	719.8	7.35	1.50
F1_01	Holding Furnaces (I1); Metal Processing	456,129	4,167,786	135.9	V	1.1355E-03	27.4	431.5	7.83	0.97
F1_02	Holding Furnaces (I2); Metal Processing	456,139	4,167,798	135.9	V	1.1355E-03	27.4	431.5	7.83	0.97
F1_03	Holding Furnaces (I3); Metal Processing	456,161	4,167,821	135.9	V	1.1355E-03	27.4	431.5	7.83	0.97
F1_04	Holding Furnaces (I4); Metal Processing	456,174	4,167,835	135.9	V	1.1355E-03	27.4	431.5	7.83	0.97
F1_05	Holding Furnaces (I5); Metal Processing	456,190	4,167,854	135.9	V	1.1355E-03	27.4	431.5	7.83	0.97
F1_06	Holding Furnaces (I6); Metal Processing	456,201	4,167,866	135.9	V	1.1355E-03	27.4	431.5	7.83	0.97
F2_01	Holding Furnaces (I7); Metal Processing	456,217	4,167,883	135.9	V	1.1355E-03	27.4	431.5	7.83	0.97
F2_02	Holding Furnaces (I8); Metal Processing	456,228	4,167,895	135.9	V	1.1355E-03	27.4	431.5	7.83	0.97
H1_01	Homogenizing Furnace (1I)	456,220	4,167,811	135.9	C	1.0085E-03	18.9	755.4	12.53	1.22
H2_01	Homogenizing Furnace (2I)	456,229	4,167,822	135.9	C	1.0085E-03	18.9	755.4	12.53	1.22
H3_01	Homogenizing Furnace (3I)	456,238	4,167,833	135.9	C	1.0085E-03	18.9	755.4	12.53	1.22
H4_01	Homogenizing Furnace (I3I)	456,288	4,167,896	135.9	C	1.0458E-03	21.3	794.3	17.53	0.46
N2_213[6]	Anode Bake Furnace (261 Furnace)	456,090	4,168,046	135.9	V	2.5164E+01	65.0	360.9	8.77	2.59
S5_01[7]	Electrode Boiler (S5) (EI)	455,952	4,168,046	135.9	V	9.3377E-04	29.9	433.2	2.13	0.91
S7_01	Green Mill Boiler	455,960	4,168,051	135.9	C	9.4124E-04	29.9	433.2	2.16	0.91
E1_02N	Potline #1 (E1); Potline #1 A-398 Scrubbers	455,865	4,167,889	134.2	V	2.5304E+01	24.6	372.0	10.54	3.84
E1_02S	Potline #1 (E1); Potline #1 A-398 Scrubbers	455,808	4,167,824	134.2	V	2.5304E+01	24.6	372.0	10.58	3.84
E3_02N	Potline #2 (E3); Potline #2 A-398 Scrubbers	455,797	4,167,950	134.2	V	2.5304E+01	24.6	372.0	11.72	3.84
E3_02S	Potline #2 (E3); Potline #2 A-398 Scrubbers	455,740	4,167,886	134.2	V	2.5304E+01	24.6	372.0	11.76	3.84
E5_02N	Potline #3 (E5); Potline #3 A-398 Scrubbers	455,694	4,168,041	134.2	V	2.5304E+01	32.0	366.5	12.61	3.44
E5_02S	Potline #3 (E5); Potline #3 A-398 Scrubbers	455,636	4,167,976	134.2	V	2.5304E+01	32.0	366.5	12.56	3.44
A3	Building 004 Security Boiler	455,798	4,167,624	135.9	C	9.4124E-05	7.0	477.6	2.08	0.41
A4	Building 044 Main Building Boiler	455,884	4,167,671	135.9	C	1.2550E-04	4.6	477.6	2.19	0.46
A7[8]	Building 004 Water Heater	455,794	4,167,627	135.9	C	1.6546E-04	7.0	477.6	3.65	0.41
A9[8]	Building 004 Miller Picking Boiler	455,798	4,167,629	135.9	C	1.3446E-04	7.3	477.6	21.11	0.15

Stack ID	Description	UTM East (m)	UTM North (m)	Elevation[1] (m)	Stack Orientation[2]	Emission Rate[4,5] (g/s)	Stack Height (m)	Stack Temp.[3] (K)	Exit Velocity[3] (m/s)	Stack Diameter (m)
I4	Building 134F Boiler	456,161	4,167,876	135.9	C	1.4119E-04	3.7	477.6	2.46	0.46

[1] Elevation of the plant grade.

[2] A stack orientation of "V" indicates a vertical unobstructed release and is modeled as a standard point source in AERMOD using the 'POINT' keyword in the source pathway. A stack orientation of "C" indicates an obstructed or "capped" release and is modeled as a capped point source in AERMOD using the regulatory default 'POINTCAP' keyword in the source pathway.

[3] For the Anode Bake Furnace (N2_213) and the Potline A-398 Stacks (E1-02N/S,E3-02N/S,E5-02N/S), the average flow rates and temperatures recorded from the stack testing events during the past 6 years covering 2017-2022 are used in the modeling analyses. Annual stack testing is required on these units for PMACT compliance, which means at least one set of test data for each year was used to determine the averages.

[4] Emissions for the Anode Bake Furnace (N2_213) and the Potline A-398 Stacks (E1-02N/S,E3-02N/S,E5-02N/S) are inflated by 1.266 relative to proposed 30-day average hourly emission rates in consideration of the 1-hour form of the SO_2 NAAQS. (Refer to Section 2.8.6 in the report.)

[5] Emission rates represent base emissions scenario. For the highest ABF emissions scenario, the Anode Bake Furnace (N2_213) and the Potline A-398 Stacks (E1-02N/S,E3-02N/S,E5-02N/S) emission rates are 3.7818E+01 g/s and 2.3237E+01 g/s per potline stack, respectively. For the highest Potline emissions scenario, the Anode Bake Furnace (N2_213) and the Potline A-398 Stacks (E1-02N/S,E3-02N/S,E5-02N/S) emission rates are 1.7649E+01 g/s and 2.6532E+01 g/s per potline stack, respectively.

[6] The Anode Bake Furnace stack height and diameter take into account the planned replacement of the existing 70-ft tall, 4.2-ft diameter stack with a new 213.2-ft tall, 8.5-ft diameter stack to be situated adjacent to the existing stack.

[7] Note that in the modeling report, this unit is referenced as the Indirect Heat Exchanger (S6). The Electrode Boiler (S5) has been removed, but has identical heat input capacity and stack parameters to the Indirect Heat Exchanger (S6); therefore, the model represents emissions from S6.

[8] The Building 004 Water Heater (A7) and Building 004 Miller Pickling Boiler (A9) have been removed from service. However, they are retained in the model files to remain consistent with the previously submitted modeling protocol.

C-1. Modeled Release Parameters - 1-Hour SO2 NAAQS Modeling

Table C-1.2. List of Century Buoyant Line Source Parameters for 1-Hour SO2 NAAQS Modeling

Stack ID	Description	UTM East (m)	UTM North (m)	Elevation[1] (m)	Emission Rate[2,3] (g/s)	Release Height (m)	End UTM East (m)	End UTM North (m)
E1_01A	E1-1- Potroom 101 Roof Vent	455,736	4,167,705	135.9	5.1641E-01	14.80	455,977	4,167,978
E1_01B	E1-1- Potroom 102 Roof Vent	455,698	4,167,738	135.9	5.1641E-01	14.80	455,939	4,168,011
E3_01A	E3-1- Potroom 103 Roof Vent	455,668	4,167,765	135.9	5.1641E-01	14.80	455,909	4,168,038
E3_01B	E3-1- Potroom 104 Roof Vent	455,631	4,167,798	135.9	5.1641E-01	14.80	455,872	4,168,071
E5_01A	E5-1- Potroom 105 Roof Vent	455,567	4,167,854	135.9	5.1641E-01	14.80	455,808	4,168,127
E5_01B	E5-1- Potroom 106 Roof Vent	455,530	4,167,887	135.9	5.1641E-01	14.80	455,770	4,168,161

[1] Elevation of the plant grade.

[2] Emissions are inflated in consideration of the 1-hour form of the SO_2 NAAQS. Refer to Section 2.8.6 in the report.

[3] Emission rates represent base emissions scenario. For the highest ABF and highest potline emissions scenarios, the emission rates are 4.7423E-01 g/s per roof vent and 5.4146E-01 g/s per roof vent, respectively.

Parameter	Description	Value	Units	Basis
XL	Average Building Length	369.11	meters	Design Drawings
HBL	Average Building Height	14.78	meters	Design Drawings
WBL	Average Building Width	19.81	meters	Design Drawings
WML	Average Line Source Width	2.44	meters	Design Drawings
DXL	Average Separation Between Buildings	35.0	meters	Measured from Aerial Imagery
w	Exit Velocity	0.84	m/s	Semiannual PMACT Testing Events (2020-2022)
Ts	Exit Temperature	299.6	K	Semiannual PMACT Testing Events (2020-2022)
Ts-Ta	Delta Temperature	13.28	K	Ibid. and Century Met Tower Data
g	Gravitational Acceleration	9.81	m/s^2	Constant
FPRIMEL	Average Buoyancy Parameter	330.0	m^4/s^3	= g*XL*WML*w*(Ts-Ta)/Ts

C-1. Modeled Release Parameters - 1-Hour SO2 NAAQS Modeling

Table C-1.3. List of Century Volume Source Parameters for 1-Hour SO2 NAAQS Modeling

Stack ID	Description	UTM East (m)	UTM North (m)	Elevation[1] (m)	Emission Rate (g/s)	Release Height (m)	Initial Lat. Dim. (m)	Initial Vert. Dim. (m)
IA20	Five Crucible Pre-Heater Stations (< 1 MMBtu/hr each)	456,160	4,167,824	135.9	3.7351E-04	7.62	13.47	7.09
IA21	Auto Sow Casting Pre-Heater Stations (0.5 MMBtu/hr each)	456,160	4,167,824	135.9	1.4940E-04	7.62	13.47	7.09

[1] Elevation of the plant grade.

APPENDIX D. BREC SOURCE CHARACTERISTICS FOR SIP DEMONSTRATION

D-1. Modeled Release Parameters - 1-Hour SO2 NAAQS Modeling

Table D-1.1. List of Big Rivers Point Source Stack Parameters for 1-Hour SO2 NAAQS Modeling

Stack ID	Description	UTM East (m)	UTM North (m)	Elevation[1] (m)	Stack Orientation	Emission Rate (g/s)	Stack Height[2] (m)	Stack Temp. (K)	Exit Velocity (m/s)	Stack Diameter (m)
GREEN1	Green Unit #1	455,890	4,166,718	129.5	V	1.7292E+01	88.6	327.0	22.00	4.57
GREEN2	Green Unit #2	455,836	4,166,727	129.5	V	1.7292E+01	88.6	327.0	26.00	4.57
GREEN11	Green Fuel Gas Heating	455,392	4,166,639	128.9	V	1.3253E-01	6.1	322.0	4.08	0.91
REIDTURB	Reid Combustion Turbine (Diesel Combustion)	455,595	4,166,758	130.2	V	5.5220E+01	33.5	844.3	9.57	4.88

[1] Elevation of the plant grade.

[2] Stack heights for Green Units #1 and #2 are based on Good Engineering Practice (GEP) height.

APPENDIX E. NEARBY SOURCE CHARACTERISTICS FOR SIP DEMONSTRATION

E-1. AERMOD Model Inputs: 1-hour SO2 NAAQS Inventory Sources

Table E-1.1. Regional Inventory Sources Modeled as Point Sources for 1-Hour SO2 NAAQS Analysis

Stack ID	Model ID	Description	UTM East[2, 3] (m)	UTM North[2, 3] (m)	Elevation[1] (m)	SO2 Emission Rate[2, 4] (g/s)	Stack Height[2, 3] (m)	Stack Temperature[2, 3] (K)	Exit Velocity[2, 3] (m/s)	Diameter[2, 3] (m)
3319-EU 01-1	REG01	Big Rivers Electric Corp - Wilson Station	492898	4144764	119.13	2.550156E+02	182.88	325.93	7.59	10.36
3319-EU 06-1	REG02	Big Rivers Electric Corp - Wilson Station	492898	4144764	119.13	5.614864E-03	2.36	836.48	45.64	0.13
3319-EU 07-1	REG03	Big Rivers Electric Corp - Wilson Station	492898	4144764	119.13	8.617836E-05	2.36	836.48	45.64	0.13
CULLEY3	REG04	SIGECO - FB Culley Generating Station	471448	4195764	113.00	1.349731E+02	152.10	326.00	13.04	6.1
P01	REG05	Warrick Newco	470698	4196856	119.00	2.459479E+01	60.66	359.67	15.49	6.1
P02M01	REG06	Warrick Newco	471118	4196959	119.00	6.148697E+00	14.94	355.22	14.79	1.89
P02M02	REG07	Warrick Newco	471133	4196954	119.00	6.148697E+00	14.94	355.22	14.79	1.89
P02M03	REG08	Warrick Newco	471112	4196939	119.00	6.148697E+00	14.94	355.22	14.79	1.89
P02M04	REG09	Warrick Newco	471129	4196934	119.00	6.148697E+00	14.94	355.22	14.79	1.89
P03M01	REG10	Warrick Newco	470771	4196912	119.00	4.099131E+00	14.94	350.22	18.82	1.54
P03M02	REG11	Warrick Newco	470768	4196902	119.00	4.099131E+00	14.94	350.22	18.82	1.54
P03M03	REG12	Warrick Newco	470765	4196891	119.00	4.099131E+00	14.94	350.22	18.82	1.54
P03M04	REG13	Warrick Newco	470762	4196882	119.00	4.099131E+00	14.94	350.22	18.82	1.54
P03M05	REG14	Warrick Newco	470759	4196871	119.00	4.099131E+00	14.94	350.22	18.82	1.54
P03M06	REG15	Warrick Newco	470756	4196861	119.00	4.099131E+00	14.94	350.22	18.82	1.54
P04M01	REG16	Warrick Newco	470750	4196918	119.00	4.099131E+00	14.94	350.78	15.65	1.54
P04M02	REG17	Warrick Newco	470748	4196908	119.00	4.099131E+00	14.94	350.78	15.65	1.54
P04M03	REG18	Warrick Newco	470745	4196898	119.00	4.099131E+00	14.94	350.78	15.65	1.54
P04M04	REG19	Warrick Newco	470742	4196887	119.00	4.099131E+00	14.94	350.78	15.65	1.54
P04M05	REG20	Warrick Newco	470739	4196877	119.00	4.099131E+00	14.94	350.78	15.65	1.54
P04M06	REG21	Warrick Newco	470736	4196867	119.00	4.099131E+00	14.94	350.78	15.65	1.54
P05W	REG22	Warrick Newco	471749	4196703	119.00	1.229739E+01	22.25	350.96	16.10	1.64
P5E1	REG23	Warrick Newco	471758	4196701	119.00	1.229739E+01	22.25	350.96	16.10	1.17
WPP1_3	REG24	Alcoa Power Plant	470738	4196346	119.00	9.096011E+01	115.82	329.00	16.48	7.12
WPP4	REG25	Alcoa Power Plant	470710	4196364	119.00	5.644015E+01	115.82	329.00	15.80	6.1

[1] For Wilson Station imported sources into AERMOD and ran AERMAP with 1-arc second (approximately 30 meter resolution) NED data to get source elevations. For other sources, used elevations from model data provided by IDEM.

[2] For nearby sources located in Kentucky (Wilson Station sources), potential emission rate, source locations, and stack parameters retrieved from 2021 KYEIS, unless otherwise noted.

[3] Modeling data for nearby sources located in Indiana (FB Culley Generating Station, Warrick Newco, and Alcoa Power Plant) were provided by the Indiana Department of Environmental Management (IDEM) on January 31, 2024.

[4] Emission rates for nearby sources located in Indiana (FB Culley Generating Station, Warrick Newco, and Alcoa Power Plant) were obtained from permit documents. For FB Culley Generating Station and Alcoa Power Plant, the modeled emission rates were from the controlled potential-to-emit (PTE) from the Technical Support Documents (TSD) accompanying latest permits. For Warrick Newco, the modeled emission rates were from Condition D.2.3 limit for the potline stacks from the latest permit.

E-1. AERMOD Model Inputs: 1-hour SO2 NAAQS Inventory Sources

Table E-1.2. Regional Inventory Sources Modeled as Buoyant Line Sources for 1-Hour SO2 NAAQS Analysis

Stack ID	Model ID	Description	UTM East[2] (m)	UTM North[2] (m)	Elevation[1] (m)	SO2 Emission Rate[3] (g/s)	Release Height[2] (m)	End UTM East[2] (m)	End UTM North[2] (m)
L01	REG26	Warrick Newco	471118	4196695	119.00	1.923419E-01	14.02	471199	4196983
L02	REG27	Warrick Newco	471087	4196705	119.00	1.923419E-01	14.02	471167	4196993
L03	REG28	Warrick Newco	471023	4196723	119.00	1.923419E-01	14.02	471105	4197010
L04	REG29	Warrick Newco	470991	4196732	119.00	1.923419E-01	14.02	471072	4197019
L05	REG30	Warrick Newco	470960	4196740	119.00	1.923419E-01	14.02	471040	4197027
L06	REG31	Warrick Newco	470928	4196748	119.00	1.923419E-01	14.02	471008	4197037
L07	REG32	Warrick Newco	470896	4196757	119.00	1.923419E-01	14.02	470975	4197047
L08	REG33	Warrick Newco	470862	4196767	119.00	1.923419E-01	14.02	470943	4197055
L09	REG34	Warrick Newco	470801	4196785	119.00	1.923419E-01	14.02	470879	4197073
L10	REG35	Warrick Newco	470767	4196792	119.00	1.923419E-01	14.02	470847	4197083

[1] Imported sources into AERMOD and ran AERMAP with 1-arc second (approximately 30 meter resolution) NED data to get source elevations.

[2] Modeling data for Warrick Newco were provided by the Indiana Department of Environmental Management (IDEM) on January 31, 2024.

[3] The modeled emission rates for roof vents were calculated using the Condition D.2.3 limit for the potline stacks from the latest permit and an assumption of 98.46% roof vent hood capture, which was reported by Warrick Newco in the Q2 2023 Quarterly Title V Report, to determine an equivalent allowable roof vent emission rate.

APPENDIX F. SITE-SPECIFIC MODEL OPTIONS EVALUATION MODELING FILES

The modeling file zipped directory will be submitted concurrently with this modeling report to Mr. Kevin Davis (Division) via email. The zipped directory will contain all input and output data files used to generate the results from the site-specific model options evaluation presented in this report. The following provides a description of the contents of each folder included in the zipped directory.

AERMAP

- Contains the AERMAP input (.inp), output (.out), receptor (.rec), and source (.src) files for the modeling analysis receptor grids described in **Section 2.7** and the nearby sources described in **Section 2.10**.

MET

- AERMET - Contains the AERMET input and output files that were used to create the model-ready meteorological files based on the Century On-site, Evansville (KEVV) surface, and Nashville (KBNA) upper air characteristics.
- AERMINUTE – Contains the AERMINUTE raw ASOS one-minute data (.dat), raw ASOS five-minute data (.dat), raw hourly ISHD data files (.ish), input files (.inp) and output files (.dat) for the KEVV one-minute data processing.
- AERSURFACE
    - KEVV – Contains the NLCD16 data (.tif) for tree canopy, impervious surfaces, and land cover. AERSURFACE input (.inp) and output (.dat) files for KEVV based on average (AVG), wet (WET), and dry (DRY) moisture conditions.
    - CENTURY – Contains the NLCD16 data (.tif) for tree canopy, impervious surfaces, and land cover. AERSURFACE input (.inp) and output (.dat) files for the Century facility based on average (AVG), wet (WET), and dry (DRY) moisture conditions.
- Model-Ready – Contains the surface (.sfc) and profile (.pfl) meteorological data files based on Century on-site surface characteristics (substituted with KEVV surface characteristics when missing) and KBNA upper air characteristics that were utilized in this modeling analysis.
- On-Site – Contains the hourly on-site data measured at the Century on-site meteorological data tower for the modeling period (2017-2022).

BPIP

- Contains the input (.inp), output (.out), and summary (.sum) files from the building downwash analysis. This analysis includes all modeled sources and buildings.

AERMOD

- Hourly Emissions Files
    - Individual A398 Stacks – Contains the hourly emissions files with each A398 stack modeled individually. These same hourly emissions files were used in those modeling scenarios considering plume merging for the A398 stacks.
    - Representative A398 Stack – Contains the hourly emissions files with each grouping of A398 stacks modeled as a single representative stack.

- The following folders contain the AERMOD input (.ami), output (.aml), highest 4th high plot (.plt) files, and rank files (.rnk) for their respective 1-hour SO_2 modeling analyses as described in **Appendix A**.
    - Rural – No urban option or plume merging were applied in this scenario. Groups of potline stacks are modeled as a single representative stack for each group.

- Urban 1M - Urban option with a population of 1,000,000 and no plume merging were applied in this scenario. Groups of potline stacks are modeled as a single representative stack for each group.
- Urban 1M 10 Stacks - Urban option with a population of 1,000,000 and no plume merging were applied in this scenario. Potline A398 stacks were modelled as individual stacks.
- Urban 1M Merge - Urban option with a population of 1,000,000 and plume merging for the A398 stacks were applied in this scenario. Groups of potline stacks are modeled as a single representative stack for each group.
- Urban 2M - Urban option with a population of 2,000,000 and no plume merging were applied in this scenario. Groups of potline stacks are modeled as a single representative stack for each group.
- Urban 2M 10 Stacks - Urban option with a population of 2,000,000 and no plume merging were applied in this scenario. Potline A398 stacks were modelled as individual stacks.
- Urban 2M Merge - Urban option with a population of 2,000,000 and plume merging for the A398 stacks were applied in this scenario. Groups of potline stacks are modeled as a single representative stack for each group.

► SIP - Contains the 1-hour SO_2 AERMOD input (.ami), output (.aml), and highest 4^{th} high plot (.plt) files for the current and future stack configurations for the base emissions scenario and the files for the future stack configuration for the highest ABF and highest potline emissions scenarios as described in **Section 2** of this report.