Tennessee Valley Authority, 1101 Market Street, BR 4A, Chattanooga, Tennessee 37402-2801

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October 31, 2016

Ms. Michelle Walker Owenby, Director
Division of Air Pollution Control
Tennessee Department of Environment
and Conservation
William R. Snodgrass TN Tower
312 Rosa L Parks Avenue, 15th Floor
Nashville, Tennessee 37243

Dear Ms. Owenby:

TENNESSEE VALLEY AUTHORITY (TVA) – ALLEN FOSSIL PLANT (ALF) – FINAL REPORT FOR 1-HOUR SO_2 MODELING RESULTS

Please find enclosed a report that describes the air dispersion modeling methodology and presents modeling results that demonstrate attainment with the 1-hour SO_2 NAAQS for designation purposes in the area surrounding ALF. Also enclosed is a disc containing the data referenced in the report.

If you have any questions or comments, please contact Cassi Wylie in Knoxville at (865) 632-7933.

Sincerely,

J. Thomas Waddell
Senior Manager
Air Permits, Compliance, and Monitoring

Enclosures
cc: Mr. Robert Rogers
Technical Manager, Pollution Control
Shelby County Health Department
814 Jefferson Ave.
Memphis, Tennessee 38105

TVA

ALLEN FOSSIL PLANT

MODELING RESULTS
1-HOUR SO_2 NAAQS DESIGNATION

MEMPHIS, TENNESSEE
OCTOBER 2016

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1.0 PURPOSE AND BACKGROUND

The purpose of this document is to present the dispersion modeling results that were performed to assess compliance with the 1-hour SO_2 NAAQS for designation purposes. The primary objective of the modeling analysis was to demonstrate that SO_2 emissions from TVA Allen Fossil Plant (ALF) did not cause or contribute to a violation of the 1-hour SO_2 NAAQS. This analysis is being performed to characterize the designation status of Shelby County, Tennessee, and surrounding areas. The modeling analysis was performed following the recommendations outlined in the SO_2 NAAQS Designations Modeling Technical Assistance Document (TAD), with reliance on all other applicable USEPA guidance documents (USEPA, 2016). Modeling methods and assumptions – such as model selection and options, source parameters, and meteorological data – were presented in the ALF modeling protocol for review by the Tennessee Department of Environment and Conservation (TDEC) in February 2016. This report presents modeling which incorporates changes in response to USEPA Region 4 and TDEC's comments on the modeling protocol.

2.0 SOURCE DESCRIPTION

ALF is located in Memphis, Tennessee, on the southern bank of Lake McKellar. The plant consists of three (3) coal-fired boilers (ALF01-03), 20 oil- and natural gas-fired combustion turbines (ACT01-20), two (2) black-start diesel engines (DE01-02) for ACT01 and ACT09, one (1) natural gas-fired auxiliary boiler (AB), fuel storage tanks, a solid-fuel handling system, and an ash handling system. A site locality map (Figure 1) and a topographic map (Figure 2) provide details of the location and property boundaries.

The coal-fired boilers combust a low-sulfur (less than two weight-percent) coal blend and ultra-low sulfur (15 parts per million by weight) fuel oil. All three coal-fired boilers are scheduled to be retired by June 2018 and will be replaced with a natural gas-fired, two-on-one combined cycle plant.

3.0 MODELING ANALYSIS

To determine maximum design impacts on 1-hour ambient SO_2 levels for Shelby County, Tennessee, and surrounding areas, the modeling analysis focused on the contributions of SO_2 from the three (3) coal-fired boilers and 20 combustion turbines at ALF, along with other nearby sources (TVA, 2016). The inputs used in the modeling analysis are detailed in the subsequent sections.

3.1 EMISSIONS

Actual-hourly emissions for the three-year period from 2012 to 2014 were modeled for ALF. The coal-fired boilers' hourly continuous emissions monitoring system (CEMS) data were obtained from a USEPA's website supporting 1-hour SO_2 modeling[1]. Volumetric flow rates provided therein were reported in standard cubic feet per hour (scfh)[2]. Assuming pressure found at the stack exit is equal to pressure at standard conditions, the volumetric flow rates in scfh were converted to actual cubic feet per hour (acfh) as followed:

$$V_a = V_S \times \frac{(T_a + 459.67°R)}{(T_S + 459.67°R)} \quad [1]$$

1 https://www.epa.gov/air-emissions-modeling/state-level-hourly-sulfur-dioxide-so2-data/

2 40 CFR Part 72 Subpart A (Acid Rain Program General Provisions) defines standard conditions as 68°F and 29.92 inches of mercury (i.e., 29.92 in Hg). This definition is applicable to data collected under 40 CFR Part 75 (Continuous Emission Monitoring) [see Part 75, Subpart A, §75.3].

where V_a is the stack-exit volumetric flow in acfh, V_s is the stack-exit volumetric flow at standard conditions, T_a is the actual stack-exit temperature (°F), and T_s is the stack-exit temperature at standard conditions (68°F). The hourly stack-exit velocities were subsequently calculated from the actual volumetric flow rates using the stack-exit cross-sectional area. Utilizing acfh more accurately represents stack-exit volumetric flow. Static stack parameters (e.g., height, diameter, and exit temperature) are provided in Table 1.

Table 1
ALF Coal-Fired Boilers Routine-Operation Stack Parameters [1]

Parameter	Units	ALF01	ALF02	ALF03
UTM Zone 15 Easting (NAD83)	m	759929	759983	760030
UTM Zone 15 Northing (NAD83)	m	3884991	3884988	3884985
Base Elevation	m	72.5	72.5	72.5
Stack Height	m	121.9	121.9	121.9
Stack Inside Diameter	m	3.9	3.9	3.9
Stack-Exit Temperature	K	409	409	409

Notes:
1. ALF has three (3) identical coal-fired boilers (ALF01-ALF03). Each boiler exhausts to the atmosphere via its own stack.

ALF's October 2011 Title V permit renewal application stack-exit temperatures were used because stack-exit temperatures are not recorded by the CEMS. Averaged actual stack-exit temperatures recorded by unit-specific process thermocouples indicate less than three (3) percent difference from the Title V values. Therefore, the Title V permit application stack-exit temperatures were deemed representative of actual temperatures operations from 2012-2014 (Table 2).

Table 2
Comparison of Modeled and Measured ALF Stack-Exit Temperatures

Parameter	Units	Stack-Exit Temperature		
		ALF01	ALF02	ALF03
Modeled Stack-Exit Temp. [1]	K	409.0	409.0	409.0
2012-2014 Avg. Actual Stack-Exit Temp. [2]	K	419.6	410.7	416.1
Difference	K	10.6	1.7	7.1
Percent Difference	%	2.6	0.4	1.7

Notes:
1. Title V Permit Renewal Application, ALF, Memphis, Tennessee, October 2011.
2. Stack-exit temperatures measured by process thermocouples.

Emissions from on-site combustion turbines, ACT01-20, were also modeled. There are two sets of combustion turbines at ALF: ACT01-16 are identical and were installed in 1971; ACT17-20 are identical and were installed in 1972. ACT01-16 are not subject to 40 CFR Part 75 - Continuous Emission Monitoring requirements. Consequently, ACT01-16 emissions (Table 3) were conservatively based on oil-fired operations at maximum heat-input capacity (365.8×10^6 Btu/CT-hr at 0°F[3]). The worst-case emission rates were used for every hour of the three-year period to ensure that the maximum short-term impact was captured.

[3]Title V Permit Renewal Application, ALF, Memphis, Tennessee, October 2011.

Table 3
ACT01-16 Maximum SO_2 Emission Estimates [1]

Year	Fuel Oil Sulfur Content (%)	Fuel Oil Heat Content (Btu/gal)	SO_2 Emission [2] Factor (lb/10^6 Btu)	Max SO_2 Emission Rate (g/CT-s)
2012	0.00148	137,988	0.00144	0.0664
2013	0.00133	138,056	0.00129	0.0595
2014	0.00088	138,056	0.000853	0.0393

Notes:
1. Fuel oil sulfur content and heat content obtained from plant's annual fuel-oil analysis.
2. Emission factor is adjusted for five (5) percent formation of SO_3.

For ACT17-20, actual hourly emissions obtained from EPA's Clean Air Markets – Air Markets Program Data (CAMD) were modeled (see included optical disc). Stack parameters for ACT01-20 are provided in Table 4.

Table 4
ACT01-20 Stack Parameters [1]

CT Source	UTM Zone 15 Easting (NAD83)	UTM Zone 15 Northing (NAD83)	Base Elevation (m)	Stack Height (m)	Stack Diameter (m) [2]	Stack-Exit Velocity (m/s)	Stack-Exit Temp (K)
ACT01	760258.8	3884765.7	72.5	15.8	5.70	8.32	811
ACT02	760266.3	3884765.2	72.5	15.8	5.70	8.32	811
ACT03	760277.5	3884764.5	72.5	15.8	5.70	8.32	811
ACT04	760285.0	3884764.0	72.5	15.8	5.70	8.32	811
ACT05	760296.2	3884763.3	72.5	15.8	5.70	8.32	811
ACT06	760303.7	3884762.8	72.5	15.8	5.70	8.32	811
ACT07	760314.9	3884762.0	72.5	15.8	5.70	8.32	811
ACT08	760322.4	3884761.6	72.5	15.8	5.70	8.32	811
ACT09	760333.7	3884760.8	72.5	15.8	5.70	8.32	811
ACT10	760341.1	3884760.3	72.5	15.8	5.70	8.32	811
ACT11	760352.4	3884759.6	72.5	15.8	5.70	8.32	811
ACT12	760359.8	3884759.1	72.5	15.8	5.70	8.32	811
ACT13	760371.1	3884758.4	72.5	15.8	5.70	8.32	811
ACT14	760378.5	3884757.9	72.5	15.8	5.70	8.32	811
ACT15	760389.8	3884757.2	72.5	15.8	5.70	8.32	811
ACT16	760397.2	3884756.7	72.5	15.8	5.70	8.32	811
ACT17	760434.1	3884764.4	72.5	9.60	8.28	7.75	808
ACT18	760439.9	3884764.0	72.5	9.60	8.28	7.75	808
ACT19	760480.1	3884761.4	72.5	9.60	8.28	7.75	808
ACT20	760485.9	3884761.0	72.5	9.60	8.28	7.75	808

Notes:
1. Title V Permit Renewal Application, ALF, Memphis, Tennessee, October 2011.
2. Equivalent diameter; stack-exit is rectangular.

The ancillary combustion sources – the two (2) black-start diesel engines (DE01-02) and the one (1) natural gas-fired auxiliary boiler (AB) – were excluded from modeling. According to Section 5.5 of the

TAD, only sources that are continuous or frequent enough to contribute significantly to the annual distribution of maximum daily 1-hour concentrations should be considered. From 2012 to 2014, the two (2) black-start diesel engines operated less than two (2) percent of the year, and the one (1) natural gas-fired auxiliary boiler is permitted to operate less than 23 percent of the year. The ancillary combustion sources are limited to operate intermittently and produce very low emissions (see Table 5) that will not impact modeling results.

Table 5
ALF Ancillary Combustion Sources' SO_2 Emissions (tons per year) [1]

Year	DE01-02	AB [2]
2012	6.29×10^{-6}	3.08×10^{-3}
2013	5.68×10^{-6}	3.08×10^{-3}
2014	7.50×10^{-6}	3.08×10^{-3}

Notes:
1. Total obtained from EPA's Clean Air Markets – Air Markets Program Data (CAMD), which is provided on the enclosed optical disc
2. Actual emissions not available. Unit runs as needed with nominal annual operations predicted to be 2,000 hours. Permitted SO_2 emissions are provided.

3.2 DOWNWASH

Actual stack heights were used for the ALF modeling analysis in accordance with the SO_2 TAD. In addition, building downwash was included in the modeling, with building parameters calculated using the USEPA's Building Profile Input Program for PRIME, BPIPPRM, Dated 04274 (USEPA, 2004d). According to the GEP technical support document, a structure is considered nearby if it is within 5L of the emissions source, where L is the lesser dimension (height or projected width) of the nearby structure (USEPA, 1985). The nearby major structures within the ALF boundary are the following:

- Precipitators;
- Powerhouse;
- SCRs;
- Combustion Turbine Structures and Enclosures.

The direction-specific effective building widths and heights required by AERMOD were calculated using BPIPPRM. The BPIPPRM input stack and building parameters for ALF01-03 are provided in Table 6, and the building locations are shown in Figure 3.

Table 6
BPIPPRM Input Structures for ALF01-03

Building	BPIPPRM ID	Building No.[4]	Height (feet)	Height (m)
Office Wing	OWING	1	45.00	13.72
Turbine Bay (Powerhouse)	TBAY	2	55.17	16.81
South Bunker Bay (Powerhouse)	SBNKBAY	3	124.08	37.82
Conveyor Head House (Tower structure on South Bunker Bay, Powerhouse)	SBNKBAYT	4	146.04	44.51
Boiler Bay (Powerhouse)	BLRBAY	5	175.04	53.35
North Bunker Bay (Powerhouse)	NBNKBAY	6	124.08	37.82
Conveyor Head House (Tower structure on North Bunker Bay, Powerhouse)	CLCONVIN	7	153.42	46.76
Selective Catalytic Reduction System Unit 1	SCR1	8	146.00	44.50
Heater Extension Bay Unit 1 & Unit 2	PHNLT1	9	72.83	22.20
Selective Catalytic Reduction System Unit 2	SCR2	10	146.00	44.50
Selective Catalytic Reduction System Unit 3	SCR3	11	146.00	44.50
Heater Extension Bay Unit 3	PHNLT2	12	72.83	22.20
Powerhouse Elevator	PHELVTR	13	155.00	47.24
Maintenance & Power Stores Facility (Tier 1)	MPST1	14	17.67	5.39
Maintenance & Power Stores Facility (Tier 2)	MPST2	15	37.83	11.53
I.D. Fan Duct Unit 3 (Low/East section)	IDF3LE	16	45.00	13.72
I.D. Fan Duct Unit 3 (High/East section)	IDF3HE	17	52.00	15.85
Precipitator Unit 3 Inlet/Outlet	PPTR3IO	18	62.00	18.90
Precipitator Unit 3	PPTR3	19	83.57	25.47
I.D. Fan Duct Unit 3 (High/West section)	IDF3HW	20	52.00	15.85
I.D. Fan Duct Unit 3 (Low/West section)	IDF3LW	21	45.00	13.72
I.D. Fan Duct Unit 2 (Low/East section)	IDF2LE	22	45.00	13.72
I.D. Fan Duct Unit 2 (High/East section)	IDF2HE	23	52.00	15.85
Precipitator Unit 2 Inlet/Outlet	PPTR2IO	24	62.00	18.90
Precipitator Unit 2	PPTR2	25	83.57	25.47
I.D. Fan Duct Unit 2 (High/West section)	IDF2HW	26	52.00	15.85
I.D. Fan Duct Unit 2 (Low/West section)	IDF2LW	27	45.00	13.72
Switchgear/Electrical Equipment Building	SGB	28	20.00	6.10
Water Treatment Building	WTB	29	20.00	6.10
I.D. Fan Duct Unit 1 (Low/East section)	IDF1LE	30	45.00	13.72
I.D. Fan Duct Unit 1 (High/East section)	IDF1HE	31	52.00	15.85
Precipitator Unit 1 Inlet/Outlet	PPTR1IO	32	62.00	18.90
Precipitator Unit 1	PPTR1	33	83.57	25.47
I.D. Fan Duct Unit 1 (High/West section)	IDF1HW	34	52.00	15.85
I.D. Fan Duct Unit 1 (Low/West section)	IDF1LW	35	45.00	13.72
(Continued on the Next Page)				

[4] Building numbers are referenced in Figure 3.

Table 6 (Continued)
BPIPPRM Input Structures for ALF01-03

Building	BPIPPRM ID	Building No.	Height (feet)	Height (m)
Crusher Building (Tier 1)	OCBT1	36	76.00	23.16
Crusher Building (Tier 2)	OCBT2	37	110.25	33.60
Fuel Switch/Crusher Building (Tier 1)	NCBT1	38	61.00	18.59
Fuel Switch/Crusher Building (Tier 2)	NCBT2	39	99.19	30.23
Fuel Switch/Crusher Building Electrical Equipment Room	NCBW	40	19.00	5.79

The results from BPIPPRM showed that the Boiler Bay (Powerhouse) is the influencing structure affecting dispersion and plume rise in the stacks. A summary of the BPIPPRM results for the coal-fired boilers, including the GEP building parameters used by AERMOD, is provided in Table 7.

Table 7
BPIPPRM Results for ALF01-03

Stack	Actual Stack Height (m)	GEP Stack Height (m)	GEP Building Height (m)	GEP Projected Building Width (m)	GEP Equation Height (m)
ALF01	121.92	133.38	53.35	71.81	133.38
ALF02	121.92	133.38	53.35	96.31	133.38
ALF03	121.92	133.38	53.35	72.62	133.38

The BPIPPRM input stack and building parameters for ACT01-20 are provided in Table 8, and building locations are shown in Figure 4.

Table 8
BPIPPRM Input Structures for ACT01-20

Building	BPIPPRM ID	Building No.[5]	Height (feet)	Height (m)
ALF Powerhouse Building Boiler Bay	ALFBLRBY	1	175.04	53.35
SC Unit 1 Turbine Generator Air Intake Enclosure	U1TGAIE	2	25.00	7.62
SC Units 1 & 2 Turbine Generator Enclosure	U1U2TGE	3	14.00	4.27
SC Unit 2 Turbine Generator Air Intake Enclosure	U2TGAIE	4	25.00	7.62
SC Unit 3 Turbine Generator Air Intake Enclosure	U3TGAIE	5	25.00	7.62
SC Unit 3 and 4 Turbine Generator Enclosure	U3U4TGE	6	14.00	4.27
SC Unit 4 Turbine Generator Air Intake Enclosure	U4TGAIE	7	25.00	7.62
SC Unit 5 Turbine Generator Air Intake Enclosure	U5TGAIE	8	25.00	7.62
SC Units 5 & 6 Turbine Generator Enclosure	U5U6TGE	9	14.00	4.27
SC Unit 6 Turbine Generator Air Intake Enclosure	U6TGAIE	10	25.00	7.62
SC Unit 7 Turbine Generator Air Intake Enclosure	U7TGAIE	11	25.00	7.62
SC Units 7 & 8 Turbine Generator Enclosure	U7U8TGE	12	14.00	4.27
SC Unit 8 Turbine Generator Air Intake Enclosure	U8TGAIE	13	25.00	7.62
(Continued on the Next Page)				

[5] Building numbers referenced in Figure 4.

Table 8 (Continued)
BPIPPRM Input Structures for ACT01-20

Building	BPIPPRM ID	Building No.	Height (feet)	Height (m)
SC Unit 9 Turbine Generator Air Intake Enclosure	U9TGAIE	14	25.00	7.62
SC Units 9 & 10 Turbine Generator Enclosure	U910TGE	15	14.00	4.27
SC Unit 10 Turbine Generator Air Intake Enclosure	U10TGAIE	16	25.00	7.62
SC Unit 11 Turbine Generator Air Intake Enclosure	U11TGAIE	17	25.00	7.62
SC Units 11 & 12 Turbine Generator Enclosure	U1112TGE	18	14.00	4.27
SC Unit 12 Turbine Generator Air Intake Enclosure	U12TGAIE	19	25.00	7.62
SC Unit 13 Turbine Generator Air Intake Enclosure	U13TGAIE	20	25.00	7.62
SC Units 13 & 14 Turbine Generator Enclosure	U1314TGE	21	14.00	4.27
SC Unit 14 Turbine Generator Air Intake Enclosure	U14TGAIE	22	25.00	7.62
SC Unit 15 Turbine Generator Air Intake Enclosure	U15TGAIE	23	25.00	7.62
SC Units 15 & 16 Turbine Generator Enclosure	U1516TGE	24	14.00	4.27
SC Unit 16 Turbine Generator Air Intake Enclosure	U16TGAIE	25	25.00	7.62
Fuel Storage Fire Protection System Building	FSFPSBLD	26	14.00	4.27
CC Unit 17 Turbine Generator Air Intake Enclosure	U17TGAIE	27	28.00	8.53
CC Unit 17 Turbine Generator Enclosure and Exhaust Plenum	U17TGEEP	28	20.00	6.10
CC Unit 18 Turbine Generator Air Intake Enclosure	U18TGAIE	29	28.00	8.53
CC Unit 18 Turbine Generator Enclosure and Exhaust Plenum	U18TGEEP	30	20.00	6.10
CC Unit 19 Turbine Generator Air Intake Enclosure	U19TGAIE	31	28.00	8.53
CC Unit 19 Turbine Generator Enclosure and Exhaust Plenum	U19TGEEP	32	20.00	6.10
CC Unit 20 Turbine Generator Air Intake Enclosure	U20TGAIE	33	28.00	8.53
CC Unit 20 Turbine Generator Enclosure and Exhaust Plenum	U20TGEEP	34	20.00	6.10
CT Storage Building	STRGBLD	35	19.00	5.79
Kelley Building	KELBLD	36	14.00	4.27
Operations Maintenance and Control Building (Tier 1)	OMCBLDT	37	22.00	6.71
Operations Maintenance and Control Building (Tier 2)	OMCBLDT	38	13.00	3.96

A summary of the BPIPPRM results for the CT stacks is provided in Table 9. The table shows the GEP building parameters used by AERMOD, as well as the influencing structures affecting dispersion and plume rise from the CT stacks.

Table 9
BPIPPRM Results for ACT01-20

Stack	Actual Stack Height (m)	GEP Stack Height (m)	GEP Building Height (m)	GEP Projected Building Width (m)	GEP Equation Height (m)	Influencing Structure
ACT01	15.85	133.38	53.35	94.52	133.38	ALFBLRBY
ACT02	15.85	133.38	53.35	94.52	133.38	ALFBLRBY
ACT03	15.85	65.00	7.62	7.64	19.05	U3TGAIE
ACT04	15.85	65.00	7.62	7.62	19.05	U4TGAIE
ACT05	15.85	65.00	7.62	7.62	19.05	U5TGAIE
ACT06	15.85	65.00	7.62	7.64	19.05	U6TGAIE
ACT07	15.85	65.00	7.62	7.62	19.05	U7TGAIE
ACT08	15.85	65.00	7.62	7.62	19.05	U8TGAIE
ACT09	15.85	65.00	7.62	7.62	19.05	U9TGAIE
ACT10	15.85	65.00	7.62	7.64	19.05	U10TGAIE
ACT11	15.85	65.00	7.62	7.64	19.05	U11TGAIE
ACT12	15.85	65.00	7.62	7.64	19.05	U12TGAIE
ACT13	15.85	65.00	7.62	7.62	19.05	U13TGAIE
ACT14	15.85	65.00	8.53	17.99	21.34	U17TGAIE
ACT15	15.85	65.00	8.53	17.99	21.34	U17TGAIE
ACT16	15.85	65.00	8.53	17.99	21.34	U17TGAIE
ACT17	9.60	65.00	8.53	13.38	21.34	U17TGAIE
ACT18	9.60	65.00	8.53	13.41	21.34	U18TGAIE
ACT19	9.60	65.00	8.53	13.36	21.34	U19TGAIE
ACT20	9.60	65.00	8.53	13.41	21.34	U20TGAIE

3.3 NEARBY SOURCES

In addition to ALF's contribution to the impacts of the 1-hr SO_2 NAAQS, emissions from nearby sources were evaluated. A 2014 emissions inventory provided by TDEC and the Memphis Shelby County Health Department (MSCHD) was assessed using the following criteria to determine which nearby sources needed to be modeled: 1) sources located within 10 km of ALF with emissions of at least one hundred (100) tons per year; and 2) sources located between 10 km and 50 km of ALF with a Q/D (annual emissions in tons / distance in km) greater than 20. Sources with a Q/D less than 20 and sources beyond 50 km were indirectly accounted for in the background monitored concentration. As discussed in Section 3.7, the SO_2 observations from the Shelby Farms NCore Monitoring Site (AIRS ID 47-157-0075) in Shelby County (Memphis), Tennessee, were used to account for the potential impacts of other natural sources, nearby small sources, and distant major sources.

Nearby sources with emissions greater than five (5) tpy within 50 km of ALF are shown in Figure 5 and Table 10. Most of the sources did not meet the screening criteria or had undergone recent plant modifications that significantly reduced or eliminated major sources of SO_2 emissions. The Cargill Incorporated (Cargill) facility retired most of its SO_2 sources in September 2016[6]. In addition, their two

[6] September 30, 2016, Revision to Permit to Operate Title V - Major Source (Permit No.: 00045-01TV(R)).

largest SO_2 sources, the Stoker boiler and PC Boiler, switched from coal to natural gas in June 2015[7]. After these modifications, Cargill plant total allowable SO_2 emissions are 0.7 tpy[8].

Only one nearby source - the Nucor Steel Memphis (Nucor) facility - met the screening criteria. Based on TDEC comments provided in March 2016 regarding the ALF modeling protocol[9], the two (2) largest Nucor sources were modeled. The other Nucor sources are ancillary combustion sources and fugitive sources that operate intermittently and were excluded per Section 5.5 of the TAD (USEPA, 2016). There were no clusters of sources within 50 km which, when combined, would potentially have an impact on the concentrations in the area.

Table 10
Nearby Sources with Emissions of at Least Five (5) Tons per Year (tpy) [1]

Nearby Source	Distance from ALF (km)	2014 Total Annual Emissions (tons) [2]	Maximum Q/D [3]
BFI Waste Systems of North America, Inc.	22.9	6.0	0.3
Cargill Incorporated (Cargill)[4]	1.4	3,375.1	2,100.3
Chemours Memphis Plant (Dupont)	26.3	5.1	0.2
Federal Express Corporation	16.5	5.0	0.3
Lucite International, Inc.	27.2	341.8	12.6
Nucor Steel Memphis	3.0	174.9	53.9
Owens Corning Roofing and Asphalt, LLC	3.2	46.5	14.7
Valero Refining Company - Tennessee, LLC	5.5	64.9	10.9

Notes:
1. Provided by TDEC and MSCHD.
2. Annual emissions reflect facility-wide total of all SO_2 emission sources.
3. Maximum Q/D reflects the facility's total SO_2 emissions divided by the minimum distance to ALF.
4. Cargill Incorporated has since reduced their allowable SO_2 emissions to 0.7 tpy.

Stack and emission parameters for the modeled Nucor sources are provided in Table 11. The TDEC and MSCHD emissions inventory provided hourly emission rates (in pounds / hour [lb/hr]) for the Nucor sources; for conservativism, these emission rates were used and converted to grams / second (g/s).

Table 11
Stack Parameters for Nucor Sources Included in the Modeling Analysis [1, 2]

Nucor Unit ID	UTM 15 Easting (NAD83)	UTM 15 Easting (NAD83)	Base Elev. (m) [3]	Stack Height (m)	Stack Diam. (m)	Stack-Exit Vel. (m/s)	Stack-Exit Temp. (K)	SO_2 Emission Rate (g/s)
MB-1.1 (EAF)	758499.8	3882094.8	65.7	52.7	6.1	19.0	377.6	5.67E+00
VD-1.1 (VTD Flare)	758599.5	3882119.8	65.2	42.7	0.3	20.1	1272.0	1.26E-01

Notes:
1. Provided by the TDEC and the MSCHD.
2. No building downwash was performed for these sources.
3. Base elevation determined from AERMAP.

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7 Cargill Withdrawal of Title V Permit Cancellation Request. 20160115.pdf.
8 0045-Emission summary Table-062316 (Post Corn Milling Closure).xls provided by MSCHD.
9 TDEC Correspondence to TVA, March 18, 2016: "RE: TVA ALF, CUF and JOF SO2 1-Hour Modeling Protocols."

3.4 MODEL SELECTION AND OPTIONS USED

For area designations under the 1-hour SO_2 primary NAAQS, the American Meteorological Society / Environmental Protection Agency Regulatory Model (AERMOD) should be used unless use of an alternative model can be justified (USEPA, 2005). Air quality dispersion modeling was performed using AERMOD (Version 15181) to obtain estimates of maximum ambient impacts (USEPA, 2004a; USEPA, 2015b).

The options used within the model were the recommended default regulatory options, which included the following:

- Appropriate treatment of calms and use of missing meteorological data routines;
- Inclusion of actual receptor elevations;
- Incorporation of complex / intermediate terrain algorithms;
- Calculations of stack tip downwash;
- Calculation of direction-specific building downwash.

According to the SO_2 TAD, the "urban" or "rural" determination of a source is important in determining the boundary layer characteristics that affect AERMOD's prediction of downwind concentrations as well as the possible invocation of the 4-hour half-life for urban SO_2 sources (USEPA, 2016). In order to determine the rural / urban characterization of a modeling study area and the dispersion coefficients to use in AERMOD, a land use analysis is required (USEPA, 2005). The USEPA guidance recommends the use of the Auer land use scheme within three (3) kilometers of a source to classify the predominant dispersion regime (USEPA, 2005). If the percentage of land use types that are characteristic of heavy industrial, light-moderate industrial, commercial, or compact residential account for 50 percent or more within the three kilometers, the modeling area is classified as urban, and the urban dispersion options in AERMOD should be used. Otherwise, the area is classified and modeled as rural.

The Auer method was used to determine the land use status of the area around ALF. A three-kilometer radius was centered on the ALF02 stack, and the land use was categorized based on the Auer classifications (Auer, 1978). The data source for the land cover was the 2011 National Land Cover Database (NLCD), with a data cell size (raster) of 30 meters by 30 meters. The results of the Auer land use analysis for the ALF study area are presented in Figure 6 and Table 12. The analysis indicates that the ALF study area is approximately 91.5% rural and 8.5% urban. Therefore, the rural option was used in AERMOD.

Table 12
Auer Land Use Percentages by Category: ALF Study Area

SO_2 NAA Modeling Auer's Analysis - NLCD 2011				Allen - 3 km Ring		
NLCD Value	NLCD 2011 Descriptions	Auer's Code	Auer's Class	Area (Sq. Meters)	Pecentage	Totals
23	Developed, Medium Intensity	R2/R3	Urban	1,328,665.15	4.70%	8.51%
24	Developed, High Intensity	I1/I2/C1		1,076,188.95	3.81%	
11	Open Water	A5	Rural	5,842,863.78	20.67%	91.49%
21	Developed, Open Space	A1/R4		1,091,624.87	3.86%	
22	Developed, Low Intensity	R1		825,810.56	2.92%	
31	Barren Land (Rock/Sand/Clay)	A3		296,972.31	1.05%	
41	Deciduous Forest	A4		1,702,781.59	6.02%	
43	Mixed Forest	A4		41,379.35	0.15%	
52	Shrub/Scrub	A4		90,121.67	0.32%	
71	Grassland/Herbaceous	A3		93,256.61	0.33%	
81	Pasture/Hay	A3		112,408.71	0.40%	
82	Cultivated Crops	A2		10,164,490.77	35.95%	
90	Wood Wetlands	A4		5,253,167.67	18.58%	
95	Emergent Herbaceous Wetlands	A3		353,346.81	1.25%	
Analysis based on 30 meter by 30 meter raster cells extracted for each area.			*Grand Totals:*	*28,273,078.80*	*100.00%*	

3.5 METEOROLOGY

Given that site-specific meteorological data are not available for the ALF site, surface data collected by the National Weather Service (NWS) at the Memphis International Airport (MEM) in Memphis, Tennessee, were used. Data for the three-year period from 2012 to 2014 were used. Twice daily upper-air soundings for the same time period from the NWS at the North Little Rock airport (LZK) in Little Rock, Arkansas, were used for the upper air data.

The data were processed using the AERMET (Version 15181) meteorological data preprocessor for AERMOD (USEPA, 2004b; USEPA, 2015a). In addition, 1-minute ASOS wind data available from the National Climatic Data Center (NCDC) for the MEM NWS site was processed with AERMINUTE (Version 15272) to generate hourly averaged wind speed and wind direction to supplement the standard hourly NWS observations. Because the MEM NWS site is an Ice Free Wind (IFW) station with a commission date of October 6, 2008, AERMINUTE flagged the 2012-2014 winds as non-calm. The wind speeds were converted from knots to meters per second (m/s) because the threshold for sonic anemometers is effectively zero. No minimum wind speed threshold values were set in AERMET.

Two sets of meteorology were modeled, one set using onsite surface characteristics and one using the surface characteristics of the NWS station. Details of the meteorological processing are provided in the modeling protocol (TVA, 2016).

3.6 MODELING DOMAIN AND RECEPTORS

For the purposes of 1-hour SO_2 designation determination, the modeling domain was a Cartesian grid centered at the ALF site which extended out 10 km in each direction. The extent of this grid was sufficient to capture maximum impacts from ALF and nearby sources.

The modeling was performed using a series of nested gridded receptor sets. Boundary receptors were also placed along the perimeter of the fenced area of the ALF property and spaced 50 meters (m) apart. These boundary receptors corresponded to a permanent fence surrounding the property.

The nested receptor grids surrounded the ALF site with the exception of those falling inside the fenced boundary area, which were removed. Because concentration gradients are most pronounced near a source, the receptor spacing varied with distance from the site with those nearest the site more closely spaced than those further away. The origin of each grid was located in the southwest corner. The receptor spacing is provided in Table 13.

Table 13
Receptor Grid Size and Spacing

Receptor Spacing (m)	Grid Size (km)	Grid Origin (km south and west of site)
100	6 × 6	3
250	10 × 10	5
500	20 x 20	10

Elevations for all receptors were extracted from U.S. Geological Survey (USGS) National Elevation Dataset (NED) files using the AERMAP terrain processor (Version 11103) of the AERMOD modeling system (http://nationalmap.gov/elevation.html) (USEPA, 2004c). A receptor elevation plot is presented in Figure 7.

3.7 BACKGROUND AIR QUALITY

The SO_2 TAD states that the inclusion of ambient monitored background concentrations in the model results is important in determining the cumulative impact of the target source and other contributing nearby sources impacts (USEPA, 2016).

In order to capture the impact of natural sources, minor nearby sources, and distant major sources which were not included in the modeling, ambient SO_2 concentrations measured at the nearby Shelby Farms NCore monitoring site in Shelby County (Memphis), Tennessee, were used to account for background concentrations. This monitor is located approximately 17 miles northeast of the ALF site (Figure 1). It is located just outside of the Memphis urban core and is influenced by the heavier industrial and urban-related sources. It is also located near the large SO_2 sources which were included in the modeling analysis. Therefore, the background concentrations likely "double count" some of the impacts of the modeled sources. The Shelby Farms NCore monitoring site is the best choice for representing background SO_2 concentrations, because it is close to ALF, meets the data completeness requirements for 2012-2014, and it is representative of the air quality in the vicinity of ALF.

Following TAD guidance, the three-year average of the 99^{th} percentile of the daily maximum 1-hour SO_2 concentrations from 2012-2014 was used to capture the impact of sources in the vicinity of ALF which were not included in the modeling (Table 14). No wind directions were excluded to remove the impacts of ALF or other sources on the monitor.

Table 14
Ambient SO_2 Concentrations Measured at Shelby Farms NCore Site [1,2]

Year	Monitored Background SO_2 Design Concentration (ppb)
2012	8
2013	9
2014	11
3-year Average	9.3

Notes:
1. USEPA Air Quality System (AQS) Data Mart: http://www3.epa.gov/airquality/airdata/
2. No data excluded to remove impact of ALF on the monitor.

4.0 MODELING RESULTS AND CONCLUSION

For both meteorological scenarios, the 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour average SO_2 concentrations was calculated for each receptor. The value for the receptor with the highest concentration is presented in Table 15. These values include modeled impacts from ALF, nearby sources, and background concentrations. The results of the modeling analysis show that maximum impacts from actual hourly emissions from ALF from 2012 to 2014 resulted in maximum predicted impacts well below the 1-hour SO_2 NAAQS.

Table 15
Maximum Modeled Impacts of Actual Emissions (2012-2014)

Met Surface Characteristics	Receptor Location			1-hour SO_2	
	UTM 15 Easting (m)	UTM 15 Northing (m)	Elevation (m)	Maximum Modeled Impact (ppb) [1,2]	NAAQS (ppb) [2]
Onsite	759829	3886491	63.6	60.8	75
MEM	760329	3886391	72.0	66.0	75

Notes:
1. Modeled concentrations include the impact of actual emissions from ALF and Nucor; and background concentrations from the NCore Shelby Farms monitor.
2. 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour SO_2 concentrations.

A plot of the 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour average SO_2 concentrations for the onsite surface characteristics is presented in Figure 8. A similar plot for the NWS surface characteristics is shown in Figure 9. The distance from ALF to the receptor with the highest concentration was 1.50 km for the onsite surface characteristics and 1.46 km for the NWS surface characteristics.

The input and output files for the AERMOD model runs provide additional details on the dispersion modeling and are included on the enclosed optical disc.

This modeling shows that SO_2 emissions from ALF and nearby sources result in maximum predicted impacts below the 1-hour SO_2 NAAQS. Based on this and the consideration of other SO_2 sources in the area, an attainment designation for Shelby County is recommended.

5.0 REFERENCES

Auer, 1978: Correlation of Land Use and Cover with Meteorological Anomalies. Journal of Applied Meteorology, 17(5), 636-643.

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USEPA, 2004b: User's Guide for the AERMOD Meteorological Preprocessor (AERMET). EPA-454/B-03-001. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

USEPA, 2004c: User's Guide for the AERMOD Terrain Preprocessor (AERMAP). EPA-454/B-03-003. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

USEPA, 2004d: User's Guide to the Building Profile Input Program (BPIPPRM). EPA-454/R-93-038. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

USEPA, 2005: Guideline on Air Quality Models. 40 CFR Part 51 Appendix W.

USEPA, 2011: Addendum User's Guide for the AERMOD Terrain Preprocessor (AERMAP). EPA-454/B-03-002. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711

USEPA, 2015a: Addendum User's Guide for the AERMOD Meteorological Preprocessor (AERMET). EPA-454/B-03-002. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

USEPA, 2015b: Addendum User's Guide for the AMS/EPA REGULATORY MODEL - AERMOD. EPA-454/B-03-001. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

USEPA, 2016: SO_2 NAAQS Designations Modeling Technical Assistance Document, August 2016. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

Figure 1
Site Locality Map

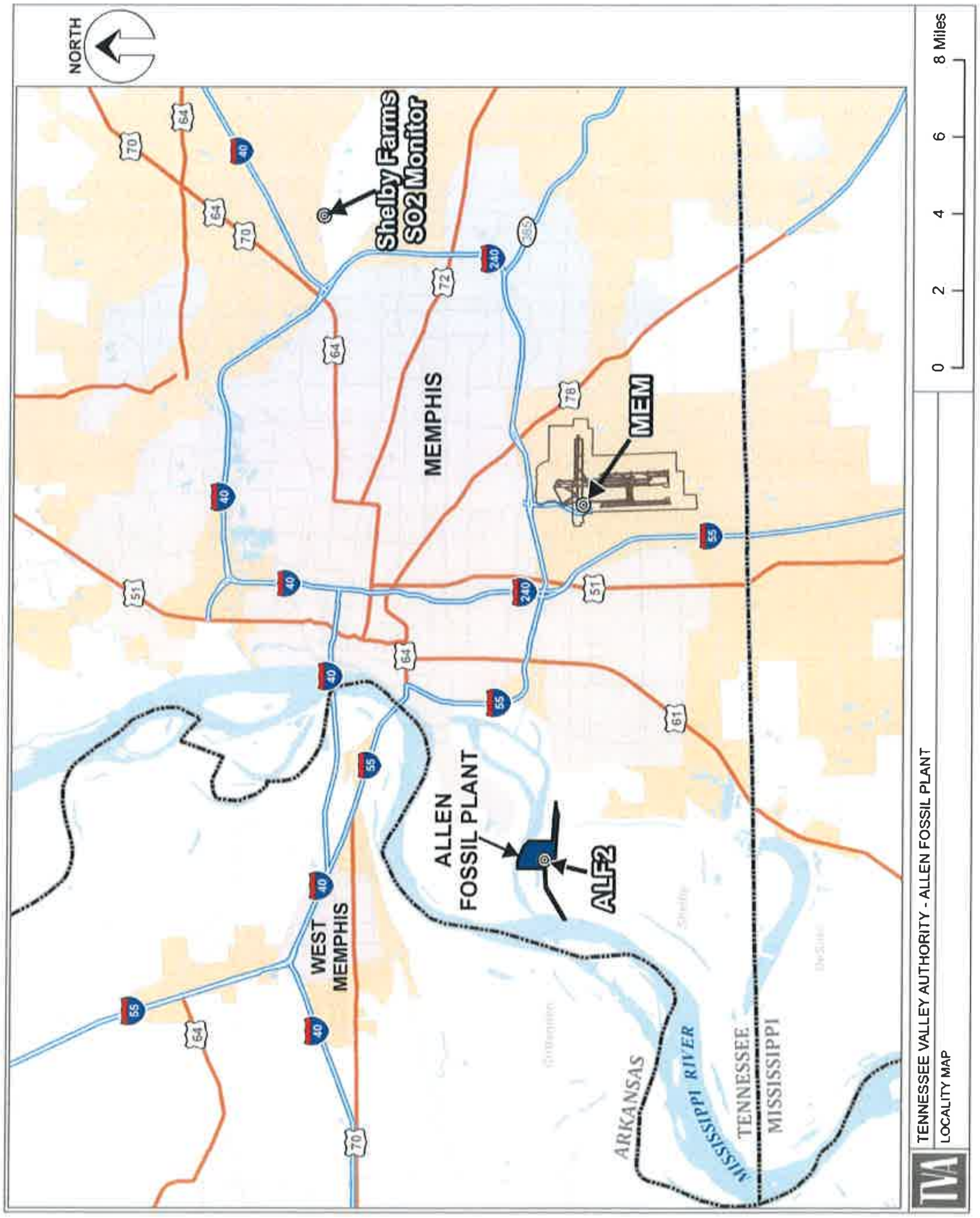

Figure 2
Topographical Map

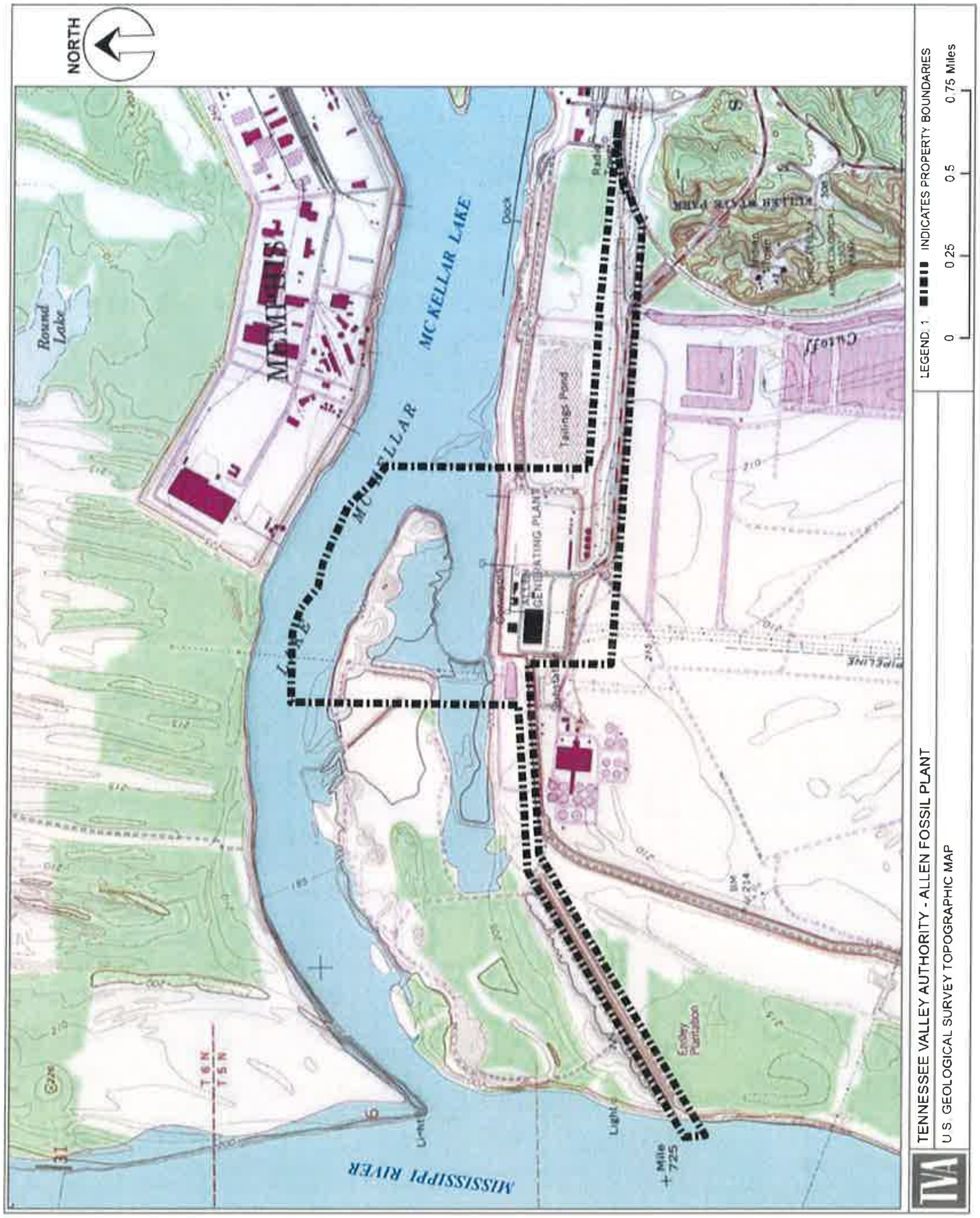

Figure 3
Building Locations for Stack Downwash Analysis

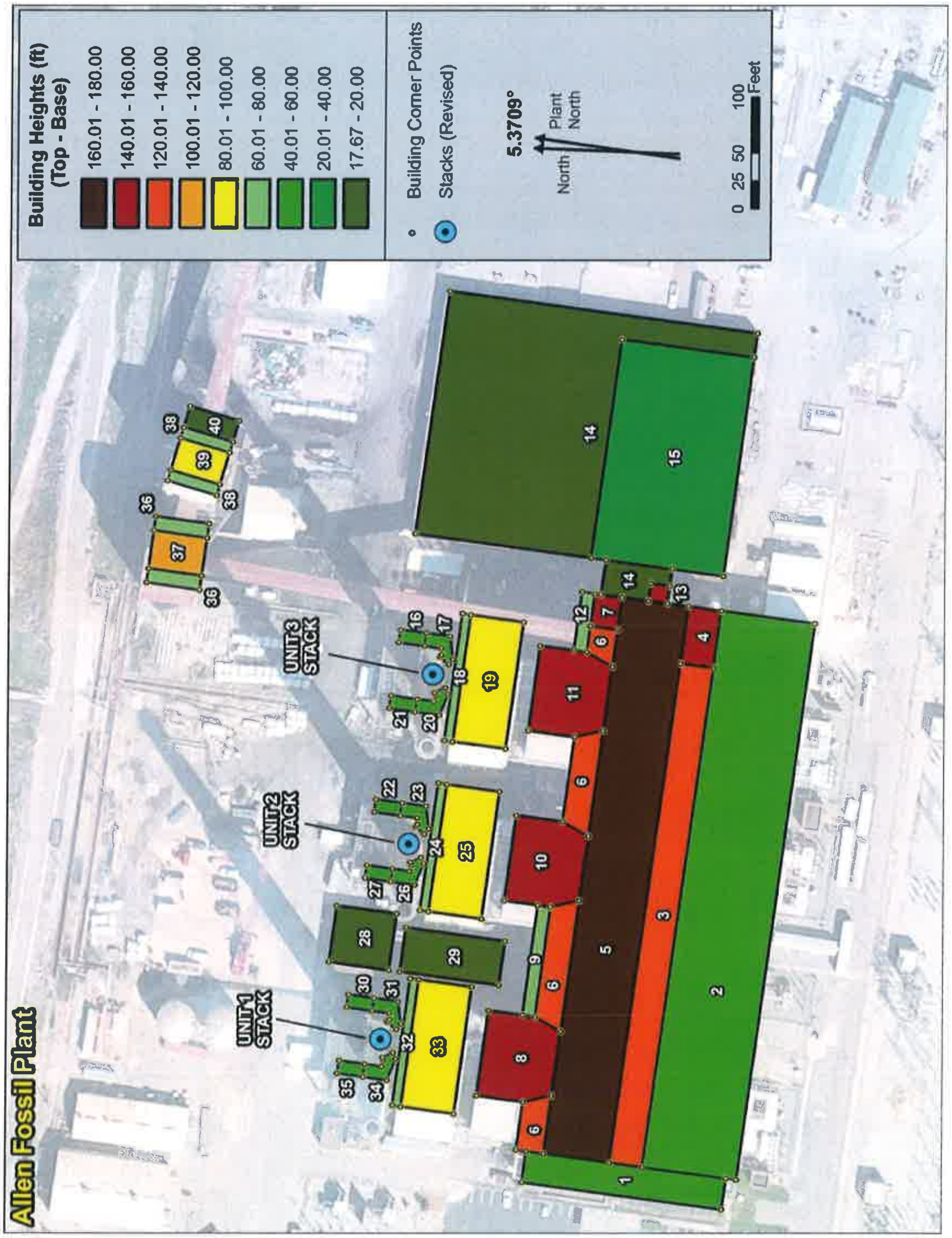

Figure 4
CT Building Locations for Stack Downwash Analysis

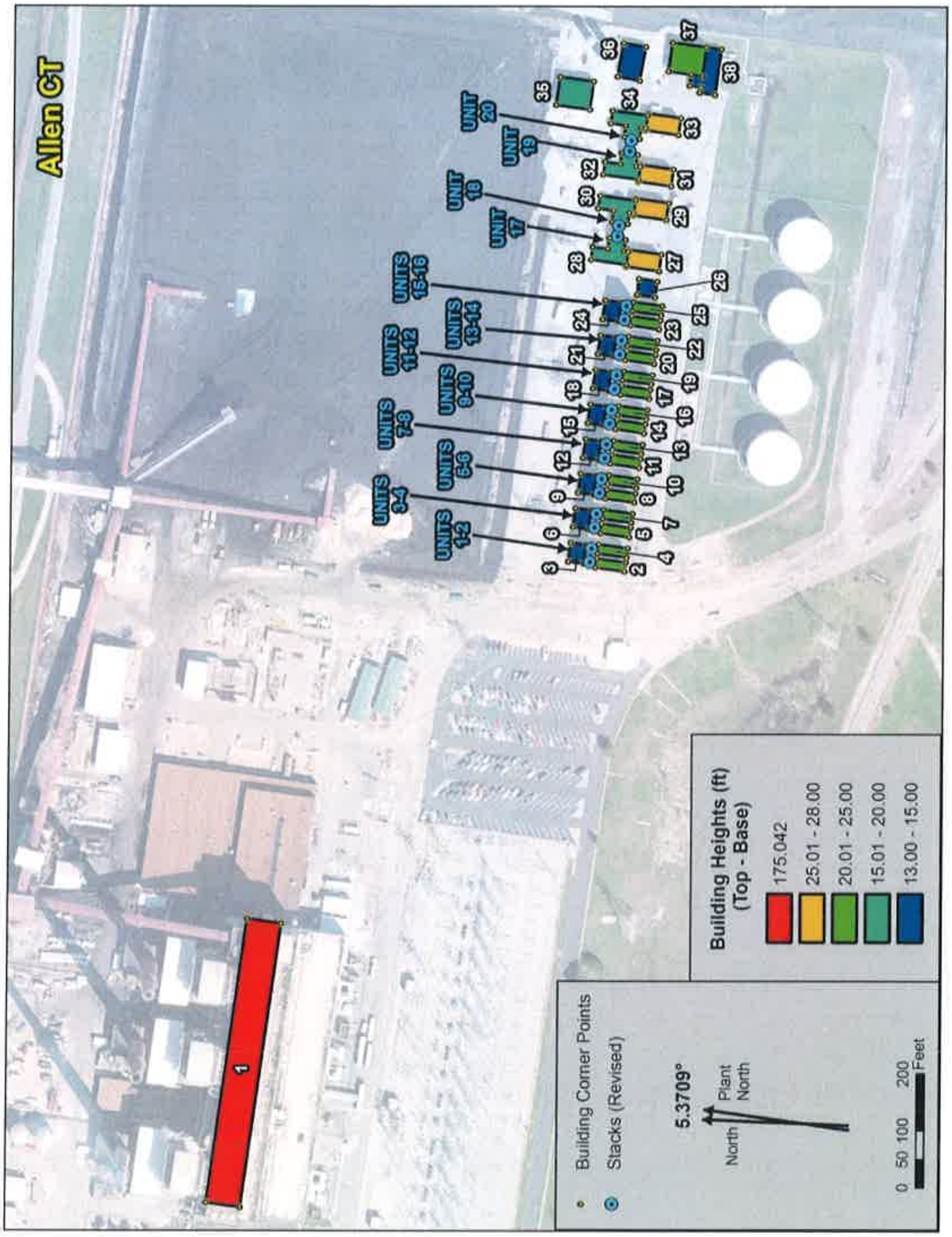

Figure 5
Nearby SO_2 Sources within 50 km of ALF

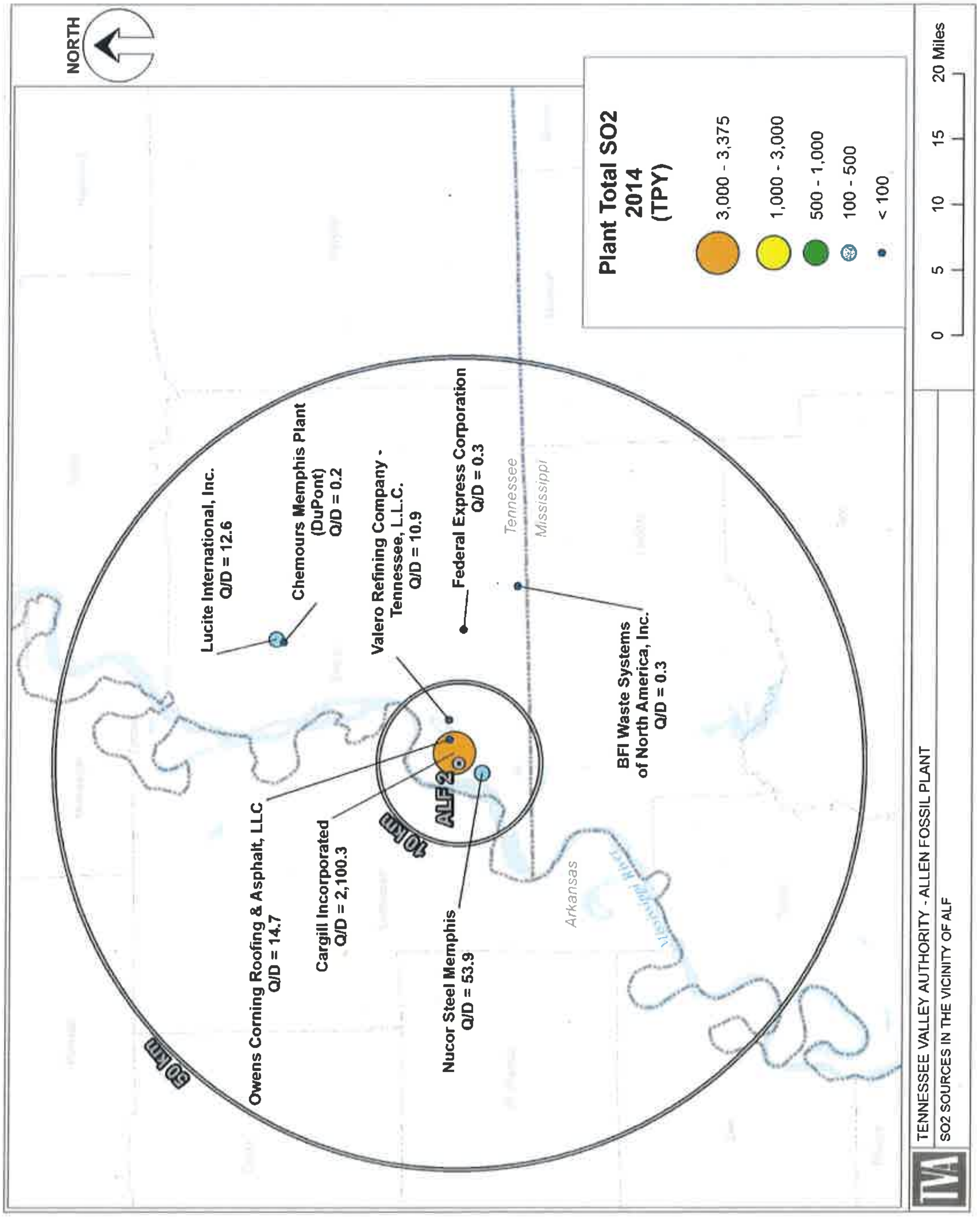

Figure 6
Auer Land Use Analysis - ALF Study Area

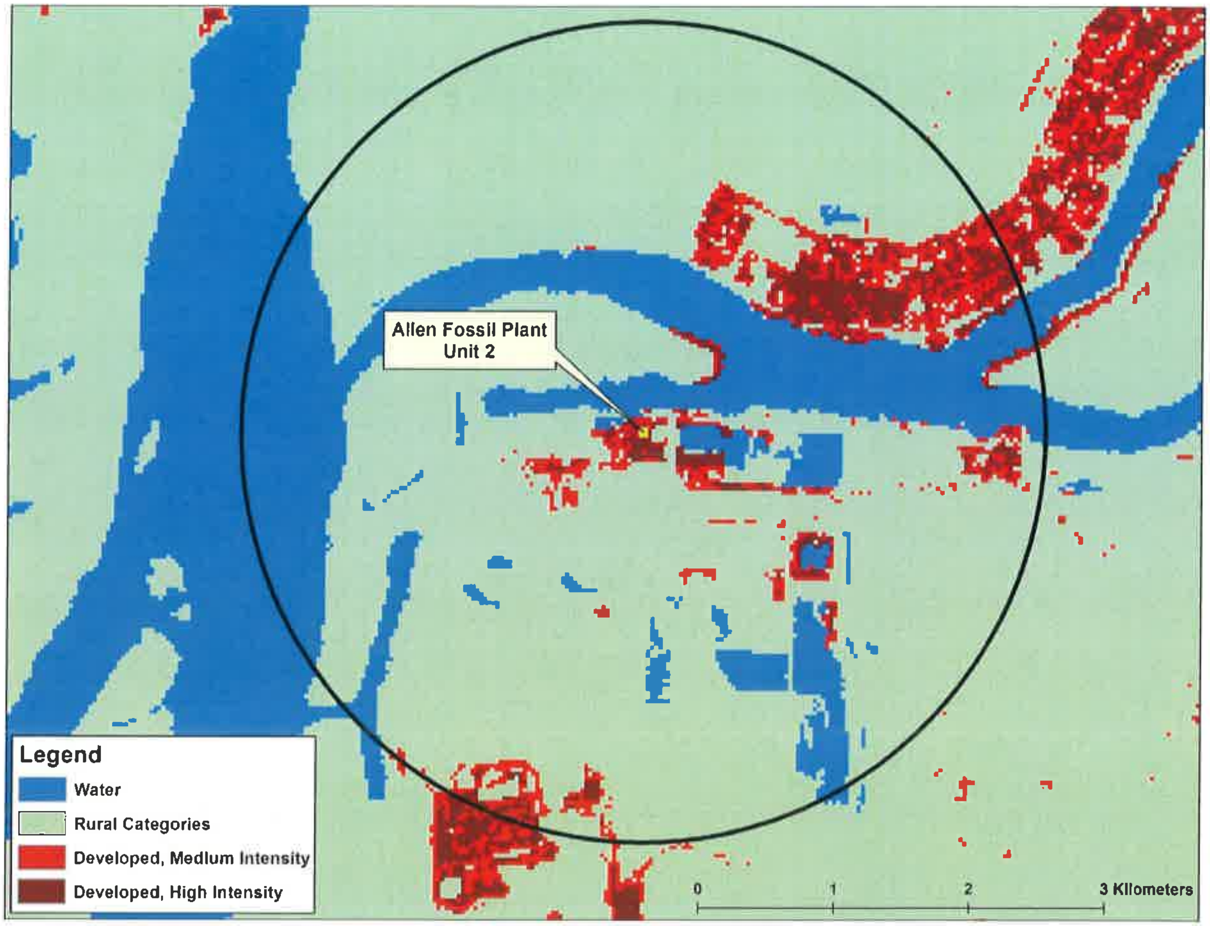

Figure 7
ALF Receptor Elevation Plot

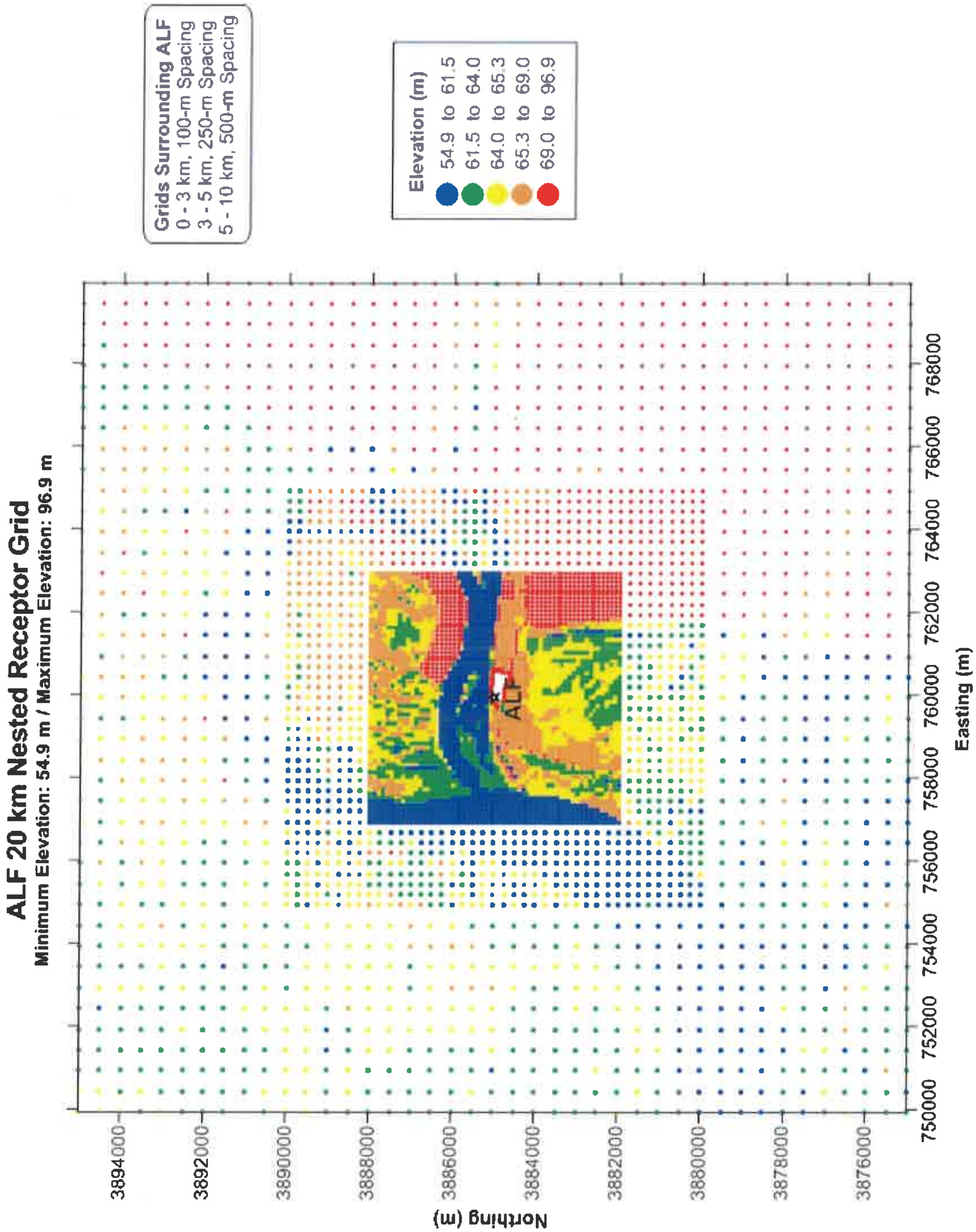

Figure 8
99th Percentile 1-hour SO_2 Concentration Plot using Onsite Surface Characteristics

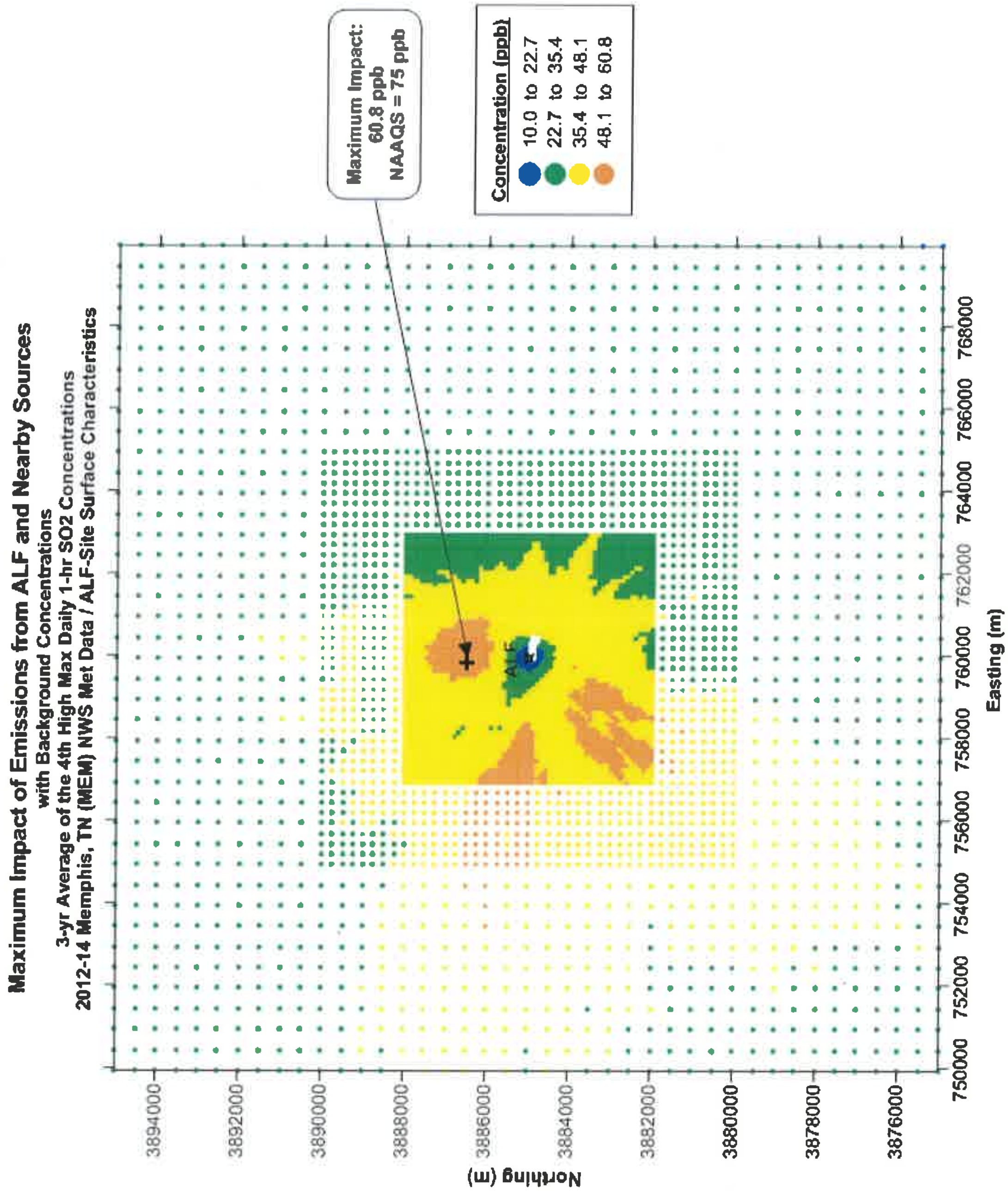

Figure 9
99th Percentile 1-hour SO_2 Concentration Plot using NWS Surface Characteristics