APPENDIX A

DISPERSION MODELING

Dispersion Modeling

1 Modeling Framework and Background

The air dispersion modeling techniques used to assess the impacts from the proposed Ohio River Clean Fuels (ORCF) Project were submitted in a modeling protocol to Ohio Environmental Protection Agency (Ohio EPA) in June 2007. Dialogue/comments based on review of the protocol were received from the Ohio EPA and adopted in the modeling approach.

The air permitting for the ORCF project includes a Prevention of Significant Deterioration (PSD) [40 Code of Federal Regulations (CFR) Part 52.21] / New Source Review (NSR) permit application and air quality impact modeling analysis for submittal to the Ohio EPA. Columbiana County has recently been classified as attainment for all relevant criteria contaminant standards and Jefferson County, OH, has been designated non-attainment for the $PM_{2.5}$ standard only.

The modeling methodology used to demonstrate compliance with the National Ambient Air Quality Standards (NAAQS) and PSD Increment for criteria contaminants is described in this section. Based on U.S. EPA modeling guidance, the PSD air quality analysis is conducted in two stages: the significance analysis and the full impact analysis. If impacts from the proposed emission increase are less than significant impact levels, a full impact analysis is not required.

1.1 Significance Analysis

The impacts from the proposed project sources, as estimated with the AERMOD model, are compared to the modeling significance levels for Class II areas. If any of the impacts equal or exceed the modeling significance levels for a particular pollutant, a full impact analysis will be performed.

The determination of preliminary impacts for the proposed project sources are made using the highest modeled impact for each pollutant and averaging period. Although 8-hour CO concentrations are properly determined with a running average rather than a block average, the AERMOD model reports 8-hour concentrations as block averages (i.e. only 8-hour periods ending at 0800, 1600, or 2400 hours).

New emissions of toxics will be evaluated to determine the maximum incremental impact of these emissions for comparison with the Maximum Acceptable Ground Level Concentration (MAGLC) as described in the Ohio EPA's current procedure for reviewing new sources of air toxics.

It is not proposed that modeling be done for $PM_{2.5}$ but is done for PM_{10}. Ozone is a secondary contaminant that is not well characterized by AERMOD. Ozone and volatile organic compounds (VOCs) are not modeled explicitly. NO_x emissions and impacts for NO_2 are quantitatively analyzed in the application.

1.2 Background Concentrations

Background concentrations used for the near-field dispersion modeling represent all current air pollution sources other than those that are explicitly modeled. Commonly, the impacts of distant background sources are accounted for by using appropriate, monitored air quality data (i.e., a background concentration). If a full impact analysis is required for a particular pollutant to demonstrate compliance with NAAQS, suitable background concentration data will be used. These data will be included in the PSD application.

To demonstrate compliance with the ambient air quality standards, the predicted air quality impacts are added to the existing background concentrations. The United State EPA maintains the AIRS database (http://www.epa.gov/air/data/geosel.html) that includes air monitoring site information for various regions throughout the United States. A total of 14 ambient PM_{10} air quality monitoring stations are located within about 50 km of the proposed site. A number of other criteria contaminants are measured in the vicinity as well.

A summary of the most recent year of ambient concentrations of all criteria pollutants from the closest monitoring stations, as found on the AIRS website, are presented in Table 1. The AIRS website can be used to identify local air quality monitoring stations and obtain summaries of historical air quality data. This system provides summaries of air quality data for varying averaging periods and compares the results to the applicable federal and state ambient air quality standards. The highest short-term ambient concentrations are used for the short-term averaging periods and the mean of the short-term ambient concentrations are used for the long-term (annual) averaging period.

TABLE 1
Background Air Concentrations in Study Area 2006

Pollutant	Avg Time	NAAQS[1]	2006 Conc. (ppm)	2006 90th percentile (ppm)	Background Conc. (μg/m³)	Station ID
NO_2 [a]	Annual	**0.053 ppm**	0.0054	0.011	10.2	421255001
SO_2 [b]	3 hour [2]	**0.5 ppm**	0.09	-	235.5	540290008
	24-hour	**0.14 ppm**	0.05	-	130.8	
	Annual	**0.03 ppm**	0.0074	0.016	19.4	
CO [c]	1-hour	**35 ppm**	10.8	-	13247	540291004
	8-hour	**9 ppm**	3.6	-	4416	
PM_{10} [d]	24-hour	**150 μg/m³**	52	-	52	390290022
	Annual	**50 μg/m³**	25.3	-	25.3	

[1] Source of data: http://epa.gov/air/criteria.html
[2] Secondary standard, which pertains to societal welfare rather than health.
[a] Arithmetic average of 1-hour NO_2 concentration values for the year in ppm.
[b] Highest 3-hour average SO_2 concentration in the year in ppm; highest 24-hour average SO_2 concentration in the year in ppm; and arithmetic average of 1-hour SO_2 concentration values for the year in ppm.
[c] Highest 1-hour average CO concentration in the year in ppm and highest 8-hour average CO concentration in the year in ppm;
[d] Highest 24-hour average PM_{10} concentration values for the year in μg/m³ and arithmetic mean of 24-hour values in μg/m³ for annual concentration.
- No data available

2 Dispersion Modeling Methodology

The dispersion modeling analysis for this project was conducted using the latest version of the AMS/EPA Regulatory Model (AERMOD – Version 07026) to estimate maximum ground-level concentrations. AERMOD is a steady-state plume model that incorporates planetary boundary layer (PBL) theory to define ambient turbulence parameters. AERMOD is the recommended model for use in regulatory industrial source modeling as defined in the Guideline on Air Quality Modeling (40 CFR 51, Appendix W) and the Ohio EPA Engineering Guide #69: Air Dispersion Modeling Guidance.

The analysis includes an evaluation of the possible effects of elevated terrain, and aerodynamic effects (downwash) due to nearby building(s) and structures on plume dispersion and ground-level concentrations. The model combines simple and complex terrain algorithms, and includes the Plume Rise Model Enhancement (PRIME) algorithms to account for building downwash and cavity zone impacts.

The required emission source data inputs to AERMOD include source location, source elevation, stack height, stack diameter, stack exit temperature, stack exit velocity, and pollutant emission rates. The source locations are specified for a Cartesian (x, y) coordinate system where x and y are distances east and north in meters, respectively. The Cartesian coordinate system used for these analyses is the Universal Transverse Mercator Projection (UTM), 1983 North American Datum (NAD 83).

The AERMOD models were used with regulatory default options as recommended in the EPA Guideline on Air Quality Models as listed below:

- Accept terrain elevations and hill height input
- Use stack-tip downwash
- Perform meteorological data checking

The complete AERMOD modeling system is comprised of three parts: the AERMET pre-processor, the AERMAP pre-processor, and the AERMOD model. The AERMET pre-processor compiles the surface and upper-air meteorological data and formats the data for AERMOD input. The AERMAP pre-processor is used to obtain elevation and controlling hill heights for AERMOD input.

2.1 Meteorological Data

The nearest meteorological station to the prospective ORCF is the Pittsburgh, Pennsylvania airport approximate 40 km to the southwest. This is the recommended station according to OEPA EG#69, Air Dispersion Modeling Guidance, 2003. Surface meteorological data from the Pittsburgh International Airport (station number 94823) are used in the analysis. Five years of surface observations for years 2001 through 2005 are used.

In addition to surface weather observations, dispersion modeling requires an estimation of mixing height, the upper boundary of the surface mixing layer. This layer caps the mixing of plumes vertically. The meteorological data were processed using the AERMET (Version 06341) preprocessor routine. Preprocessing of the raw observations was done using the surface parameters presented in Table 2. AERMET writes two files for input to AERMOD: a file of hourly boundary layer parameter estimates and a file of multiple-level (when the data are available) observations of wind speed and direction, temperature, and standard deviation of the fluctuating components of the wind direction.

2.2 Surrounding Land Use

The land use surrounding the Airport meteorological station is similar to that of the ORCF site: namely, it is a predominately rural area generally surrounded by forested area, along with small pockets of grassland and small urban and residential developments.

The surface parameters used for the AERMET preprocessing were consistent with the Pittsburgh airport site. As shown in Figure 1, the area around the Pittsburgh airport site is predominantly forested. Seasonal variations in albedo, surface roughness, and Bowen ratio consistent with these land use classifications were included into the AERMET. Table 2 lists the seasonal AERMET land-use parameters used in the input files.

FIGURE 1
Arial Photograph of Area Surrounding Surface Weather Station

TABLE 2
Seasonal AERMET Surface Parameters for Pittsburgh Airport Meteorological Station

Sector†/Land Use	Albedo				Bowen Ratio (average moisture)				Surface Roughness			
	Season				Season				Season			
	1	2	3	4	1	2	3	4	1	2	3	4
1 Deciduous Forest	0.50	0.12	0.12	0.12	1.5	0.70	0.30	1.0	0.50	1.0	1.3	0.80

1 – Winter
2 – Spring
3 – Summer
4 – Fall

These land use parameters are:

- Surface roughness length – is a measure of surface friction and is derived from the specific land use characterization of the surrounding area.
- Albedo – is a ratio of the reflected radiation to the total incident radiation and is derived from the brightness or darkness of a surface.
- Bowen ratio – is a measure of the sensible heat flux and is derived from estimates of surface soil moisture.

The use of urban or rural dispersion coefficients is determined by the land use surrounding the ORCF site near Wellsville, Ohio. The land use within the circle was characterized according to the methodology proposed by Auer (1978). If more than 50% of the surrounding land use is characterized as urban, the population of the urban area is entered into AERMOD. It was determined that the land use is less than 50% urban and the rural dispersion coefficients were used in the modeling analysis.

2.3 Receptor Grids

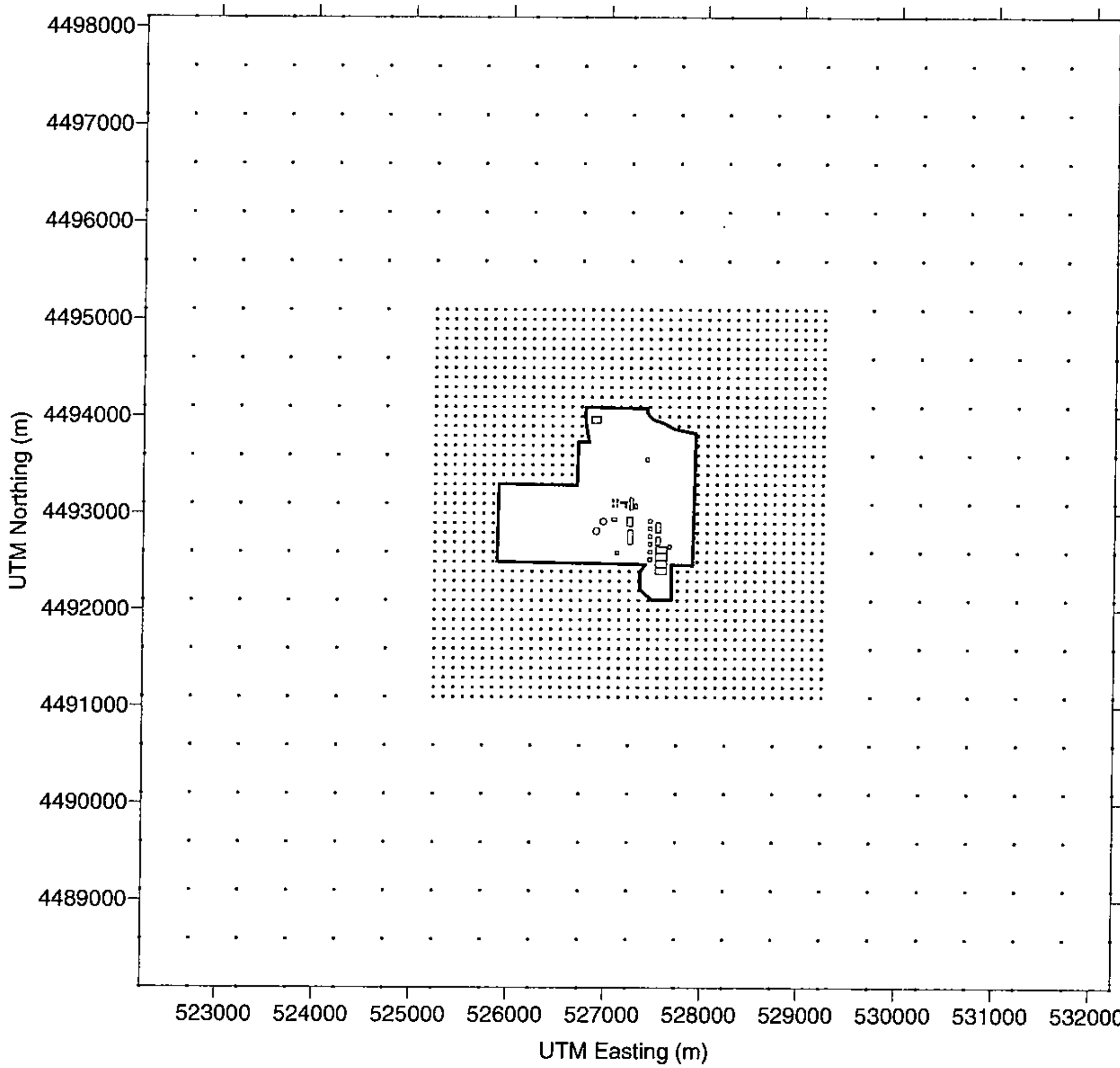
The base modeling receptor grid for AERMOD modeling consisted of receptors that were placed at the ambient air boundary and Cartesian-grid receptors that were placed beyond the boundary at spacing that increases with distance from the origin. The ORCF property boundary was used as the ambient air boundary.

A 10 km by 10 km grid centered on the site was sufficient to capture the contaminant maxima as well as have the estimated concentrations near the grid border be less than the Significant Impact Levels (SILs). Screening runs confirmed that maximum predicted concentrations were in close proximity to the property boundary. The site boundary receptors were spaced at 15-meter intervals. Beyond the property boundary, receptor spacing was as follows:

- 100-meter spacing out to a distance of 1 km from the approximate center of the facility
- 250-meter spacing a distance 3 km from the approximate center of the facility

Figure 2 shows the receptor grid used in the significance modeling analysis. For the full impact analysis only receptors within the significance impact radius were used.

FIGURE 2
Receptor Grid Used in the Modeling Analysis



2.4 Terrain

Terrain in the vicinity of the project was accounted for by assigning base elevations to each receptor. Data at 7.5-minute intervals from the U.S. Geological Survey (USGS) Digital Elevation Model (DEM) were used in conjunction with the AERMAP pre-processor (version 06341) to determine receptor elevations. The NAD83 Universal Transverse Mercator (UTM) Zone 17 coordinate datum was used for all the modeling.

On-site source and building elevations were determined from preliminary design maps and other survey data, not from the DEM data. Elevations of all receptors were derived from DEM maps.

2.5 Building Downwash Effects

Buildings or other solid structures may affect the flow of air in the vicinity of a source and cause building downwash (*e.g.*, eddies on the downwind side), which have potential to reduce plume rise and increase dispersion.

For dispersion modeling purposes, building downwash effects were considered for sources at the ORCF facility. A total of 30 buildings in the vicinity of the modeled sources were used in the analysis and include all buildings that could influence the dispersion of source emissions. The Building Profile Input Program (BPIP) is used to calculate controlling building profiles on a direction specific basis for each point source. Building influences are not accounted for volume and area sources.

3 Modeled Emission Sources

The current facility design is for 6 coal gasifiers, 3 Fischer-Trope reactors, and 1 "refinery" to produce a total of approximately 50,000 barrels per day (bpd) of liquid hydrocarbons. The project also includes a 600 MW syngas-fired combined cycle power plant, and ancillary operations to support the plant. Emissions from the ORCF project were summarized in Table 3.

TABLE 3
Emission Sources from the ORCF Project

Process Areas	Emission Sources	Source Type
Coal Storage	Storage Piles	Area Sources
Coal Processing	Transfer Towers, Stacker / Reclaimer Conveyors, Crusher House Coal Silos, Coal Bunkers Roller Mills Coal Milling and Drying Stack	Point Sources
Gasification Plant	S/S/M Venting to Flare	Point Sources
Slag and Fly Ash Handling	Slag Storage Silo Fly Ash Storage Silo Slag and Ash Loadout	Volume and Area Sources
Fischer-Tropsch and Product Workup	Process Heaters S/S/M Venting to Flare Fugitive VOC Equipment leaks	Point Sources
Product Storage and Loading	Storage Tank Farm Loading rack for Liquid Products	Point Sources
Combined Cycle Plant	Gas Turbines Heat Recovery Steam Generators Steam Turbines	Point Sources
Circulating Water Systems	Process Cooling Towers	Point Sources
Emergency Generators	Diesel Fired Generators	Point Sources
Roadways and Parking	Fugitive PM from vehicle traffic	Series of Volume Sources and Area Source

4 Modeling Results

The following sections detail the results of the air quality modeling analyses.

4.1 Significance Analysis

In the significance analysis, the proposed plant emissions are modeled and the resulting maximum concentrations are compared to the MSL to determine if a full impact analysis is required. The results of the significance analysis are summarized in Table 4.

TABLE 4
Maximum Concentrations Calculated in the Significance Analysis

Pollutant	Averaging Period	Receptor Grid	UTM East (m)	UTM North (m)	Max. Modeled Concentration (μg/m³)	MSL (μg/m³)
PM10	24 hr	Fence Line	527906.2	4493572	14.1	5
	Annual	Fence Line	527903.1	4493392.0	2.62	1
CO	1 hr	Fence Line	527345.3	4492329	4585	2,000
	8 hr	Fence Line	527308.4	4492475	1744	500
NO_2	Annual	Fence Line	527338.3	4492474	5.5	1
SO_2	3 hr	Fence Line	527069.5	4492479	52.8	25
	24 hr	Fence Line	527099.4	4492479	23.5	5
	Annual	Fence Line	527144.1	4492478	2.8	1

The maximum modeled concentrations are greater than the MSL, and therefore a full impact analysis is required for all of the criteria contaminant listed in Table 4. Although the predicted impacts appears to be much greater than the MSL, the radius of impact within which predicted impacts exceed the MSL is about 2,000 meters for the worst-case contaminant (PM_{10}).

The radius of impact for PM_{10} is defined as the distance to the furthest receptor that has an annual average concentration greater than 1.0 ug/m³. For this analysis, the most distant receptor is located to the north-northeast about 1 kilometer to the northeast of the facility site. A summary of the PSD increment and NAAQS analysis are presented below.

4.2 PSD Increment Consumption

The Prevention of Significant Deterioration (PSD) program was established to allow emission increases (increments of consumption) that do not result in significant deterioration of ambient air quality in areas where criteria pollutants have not exceeded the National Ambient Air Quality Standards (NAAQS). For the purposes of determining applicability of the PSD program requirements, the following regulatory procedure is used. Increments are the maximum increases in concentration that are allowed to occur above the baseline concentration. Class II areas are regions that allow for economic growth in a manner consistent with the preservation of existing clean air resources and include all areas not other wise designated as Class I areas

Table 5 compares the maximum modeling impact to the Class II PSD increment for each of the criteria contaminants. Also shown are the Ohio Acceptable Increment Impact taken from the Ohio EPA Engineering Guide #69, 2003. This comparison shows that the modeled impacts are below the Class II PSD and Ohio Acceptable increment consumption level for all contaminants.

TABLE 5
PSD Increment Consumption Results

Pollutant	Averaging Time	Class II PSD Increment ($\mu g/m^3$)	Ohio Acceptable Increment Impact ($\mu g/m^3$)	Maximum Project Impact ($\mu g/m^3$)
PM_{10}	24 hr	30[b]	15[b]	13.1[c]
	Annual	17	8.5	2.6
NO_2	Annual	25	12.5[a]	5.5[d]
SO_2	3 hr	512[b]	256[b]	49.4[c]
	24 hr	91[b]	45.5[b]	22.1[c]
	Annual	25[a]	10[a]	2.8[d]
CO	1 hr	NA	10,000[b]	4585
	8 hr	NA	2,500[b]	1744

Source: EPA(2007), OEPA , Engineering Guide #69 (2003)

[a] Not to be exceeded

[b] Not to be exceeded more than once per year

[c] High Second-High 24-hr concentration

[d] Maximum Concentration

All increment-affecting sources that are located within the significant impact area of a proposed new major source need to be modeled as part of the increment analysis. EPA guidance states that increment-affecting stationary sources are those with actual emissions changes occurring since the minor source baseline date. Increment-affecting sources located within 50 km of the significant impact area may be modeled if they affect the amount of PSD increment consumed (EPA, 1990). This next phase of modeling will begin when the affecting source inventory is finalized.

4.3 NAAQS Impact Analysis

Table 6 compares the maximum modeled criteria pollutant impacts for all on-site sources. The representative background concentration presented in Table 1 was also added to the maximum impact shown in Table 6. This comparison shows that the modeled impacts are well below the NAAQS.

TABLE 6
NAAQS IMPACT ANALYSIS RESULTS

Pollutant	Averaging Period	Modeled Concentration (μg/m³)	Background Concentration (μg/m³)	Combined Concentration (μg/m³)	National Ambient Air Quality Standards (μg/m³)
PM10	24 hr	13.1	52	65.1	150
	Annual	2.62	25.3	27.9	Revoked
CO	1 hr	4,585	13,247	17,832	40,000
	8 hr	1,744	4,416	6,160	10,000
NO2	Annual	5.5	10.2	15.7	100
SO2	3 hr	49.4 c	235.5	288.3	1,300
	24 hr	22.1 c	130.8	152.9	365
	Annual	2.8 d	19.4	22.2	80

The location of the maximum impact for the significance, PSD increment and NAAQS analyses all occur on the eastern property line, just east of the coal storage piles.

4.4 Class I Area Impact Analysis

Using a screening method of total SO2 and NOx (in tons per year) divided by the distance to the closest Class I area; Ohio EPA has determined that ORCF does not need to perform a Class I modeling analysis. At this time, the Ohio EPA is not requesting a Class I analysis to determine visibility and deposition impacts as part of their permit application. Should ORCF choose to perform a Class I analysis Ohio EPA requests that the current regulatory version of CALPUFF be used to evaluate these impacts. In addition, all current regulatory versions of the pre-processors should be used.