EVALUATION OF A REGULATORY SYSTEM DESIGNED TO CONTROL INDUSTRIAL AIR EMISSIONS AND AN ANALYSIS OF AN AIR DISPERSION MODEL CASE STUDY

by

Eric Luis Henson

Project submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

MASTERS OF SCIENCE

in

Systems Engineering

APPROVED:

J.M. Hughes, Chairman

B.S. Blanchard

A.M. Dietrich

December, 1993

Blacksburg, VA

EVALUATION OF A REGULATORY SYSTEM DESIGNED TO CONTROL INDUSTRIAL AIR EMISSIONS AND AN ANALYSIS OF AN AIR DISPERSION MODEL CASE STUDY

By

Eric Luis Henson

Committee Chairman: J. M. Hughes
Systems Engineering

(ABSTRACT)

A system designed to control industrial emissions while protecting the environment has evolved from the Clean Air Act Amendments. The system's primary components are the pollution sources, government, economy, environment, and public influence. The functional relationship between all of the system's components manifests itself in the form of requirements for pollution permits. The pollution permits limit the environmental impact of the pollution sources while in general do not impose undue economic burdens on the sources. The environmental impact is determined by analyzing the source's pollution concentration distributions against the systems functional criteria which establish threshold limits for pollution concentrations. A computer model, a detail design component of the system, predicts ambient air concentration distributions around a proposed facility based on Gaussian Dispersion principles.

A case study of four sources in Giles County, Virginia served to illustrate the functional relationships of the system's components. A computer program, the Integrated Gaussian Model (IGM), predicted ambient air concentrations of pollutants resulting from the emissions by the four sources in the case study. The model application provided an opportunity to evaluate actual data produced by one of the system's primary detailed design components. Analysis of the results indicated that at least two of the Giles County

sources in the region exceed the limits imposed by the system's criteria and thus have adverse impact on the environment.

ACKNOWLEDGMENTS

I would like to thank the committee members for their efforts on this report. Particularly, the help of Dr. J. Martin Hughes, who provided endless guidance on this project. I would also like to thank my family for their support.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 Identification of Need

Society's attention to environmental concerns increases with the increased demand for goods whose production and use deplete and damage natural resources such as environmental quality. The exponential increase in the world's population underlies the cause of environmental deterioration. As the world's population increases, the activities required to serve society increase. Unfortunately, these activities are often the same activities that stress the natural environment. Although organizations and governments attempt to address world population problems, a solution does not seem to exist in the foreseeable future. In view of this reality, systems for modeling and controlling environmental deterioration must become more effective.

The government of the United States attempts to control environmental deterioration by the delegation of power to the United States Environmental Protection Agency (EPA). The EPA works with state and local governments to achieve environmental protection. A major area of environment protection concerns air resources. The Clean Air Act Amendments (CAAA), a series of federal legislative actions, address air quality preservation.[1] This projects general focus is air quality preservation, with the impact of air emissions from industrial sources being the major concern. The EPA and the CAAA provide a system designed to control industrial air emissions. The system's primary goals are to protect the environment and human health while not inhibiting economic vitality. This project examines this system to see if the goals are being met by carrying out a case study. The case study used a computer model to predict air pollution concentration distributions of Sulfur Dioxide (SO_2). The predicted SO_2 concentrations allow a determination to be made as to the system's success in meeting the primary goals and the need for further reduce SO_2 emissions

2.0 Systems Engineering Application

The world consists of many man-made and natural systems. A system may be defined as a group of elements functionally working together to accomplish a common goal.[2] Systems engineering involves the process that brings systems into existence, in an orderly efficient manner. The systems engineering process consists of six life cycle phases; (1) conceptual design, (2) preliminary design, (3) detail design and development, (4) production/construction, (5) utilization/support, and (6) phaseout, illustrated in Figure 2.0.1. The first section of this report, defines the need and identifies an approach to satisfy the need. The system's conceptual design includes the first steps toward the development of the systems preliminary design. In the case of the system discussed in this project, the conceptual design includes the recognition of the need for an environmental control system required to preserve the air. The preliminary design involves the development of the system's functional design including the system's design criteria. The development of the ambient air quality standards for the system of this project illustrates typical preliminary design considerations. The system's detail design and development takes the broad design requirements of the preliminary design and defines the system's detail design such as the required hardware, software, and operations. The conceptual development of the dispersion model is an example of the detail design development. Besides the system's physical development, the production/construction phase includes the assessment, analysis, and evaluation of the systems elements and operation. The physical development of the dispersion model and the evaluation of it's operation is a typical process of the production/construction life cycle phase. The utilization/support phase includes the evaluation of existing systems. The system of this report exists, thus evaluation of the system at this point in it's life cycle leads to system improvements in the form of feedback to the system's detail design. The system phaseout and disposal is the final life cycle phase.[3] The systems phases overlap and provide feedback to each other. For example the latter phase of conceptual design simultaneously occurs during the beginning of preliminary design. An example of feedback are the results of the production/construction analysis leading to changes in the system's detail design and development.

The systems engineering process is tailored to the characteristics of each system. Tailoring the system's engineering process to the existing system of this report emphasizes the system's utilization/support phase. Analysis of the systems operations, benefits the system's design by identifying deficiencies and improvement areas. The evaluation of the system in the utilization/support phase produces results which provide feedback to the system's design and operation.

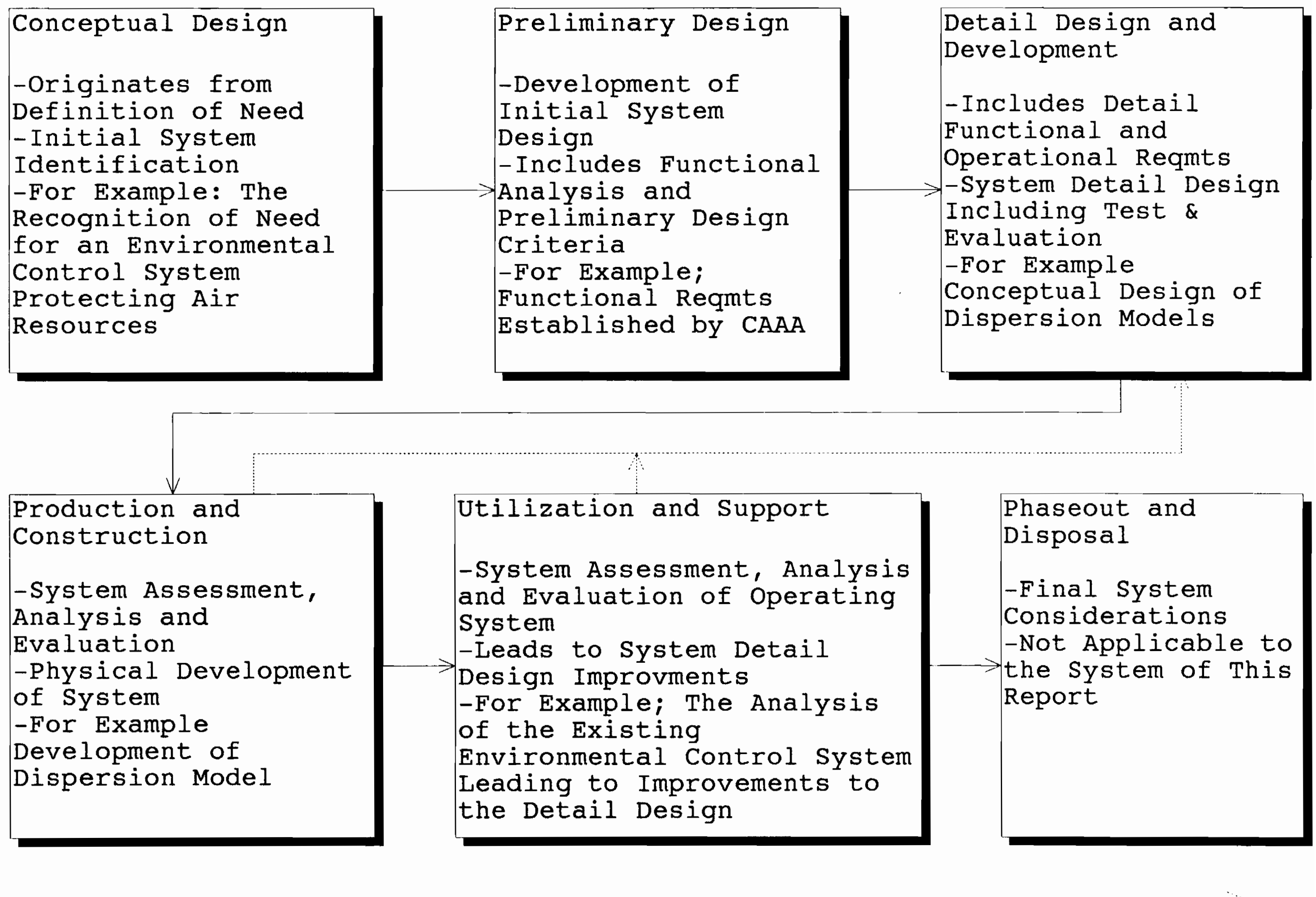


Figure 2.0.1 Systems Engineering Life-Cycle Process

3.0 System Identification

The system identification, an element of the system's preliminary design, synthesizes the system's definition. The 1990 CAAA mandates increased control and regulation of pollution sources. Environmental regulations imposed by governments on pollution sources protect the public health, the natural environment, and resources for future generations. Environmental regulations also, monetarily impact everything from the nations economy to the incomes of individual workers and consumers. The influence of government regulations on the environment and the economy leads to the identification of the system's primary components. The primary system include the following elements; (1) pollution sources, (2) government, (3) economy, (4) environment, and (5) public influence. In the grand scheme, pollution sources include stationary and mobile sources. For this project, major stationary point sources were the primary pollution source focus.

The basic functional requirement which influences each system element is the requirement for pollution sources to obtain air pollution permits. Air pollution permits are elements of the State Implementation Plan (SIP). The EPA requires each state to modify SIPs to respond to mandates of the CAAA. SIPs define regulatory systems that determine how a state's air resource will be managed. As a result of typical SIP requirements some pollution sources will take emission control measures to obtain permits from their state's air regulatory agency. Usually, these costly control measures must be passed on to consumers , shifting the primary system's economic balance.

4.0 Functional Requirements

The functional requirements define the criteria that the system must achieve to meet the objectives. The functional requirements help define the systems specific requirements during the system's preliminary design. Air pollution permits involve the basic functional relationship influencing each system element. An example of functional requirements are the standards air pollution permits use to determine compliance.

The CAAA requires all major air pollution sources to obtain an operating permit. Major sources are classified by two criteria "(1) one of the 28 named source categories listed in section 169 of the CAA that have the potential to emit at levels exceeding 100 tons per year of any pollutant regulated by the EPA under the CAA subject to Prevention of Significant Deterioration (PSD) review, or (2) not be in one of the 28 listed source categories and have controlled emissions exceeding 250 tons per year of any EPA regulated pollutant subject to PSD review."[4] Air pollution permits depend, in part, on the predictions of air dispersion models. Air dispersion models predict down wind, ground level concentrations from major sources using Gaussian distribution principles. There are many air dispersion models, some of which the EPA endorses for the permit application process.

The concentrations calculated by air dispersion models must comply with National Ambient Air Quality Standard (NAAQS) and PSD increment standards in order for permit applications to be approved. A source whose predicted model concentrations exceed NAAQS and PSD increments for a given pollutant, must implement design changes which reduce source emissions before a permit applicant is favorably approved. These design considerations may include the installation of air pollution control equipment or improvement to the operation's efficiency, such as burning higher grade fuels.

4.1 NAAQS and PSD Increments

The NAAQS specify "maximum concentrations for various averaging time periods below which the air quality is considered acceptable. The NAAQS standards include a margin of safety. NAAQS limitations include both primary and secondary standards."[5] Primary standards strive to protect human health where secondary standards seek to protect environmental aesthetics, such as visibility and vegetation.[6] The PSD increment is the allowable increase in ambient air concentration permitted by a new source or modified source. PSD increments consist of classes. Class I applies to pristine areas, such as

Table 4.1.1 NAAQS and PSD Increments

		NAAQS		PSD Increments	
Pollutant	Averaging Period	Primary $\mu g/m^3$	Secondary $\mu g/m^3$	Class I $\mu g/m^3$	Class II $\mu g/m^3$
SO_2	3-hour	None	1300	25	512
	24-hour	365	None	5	91
	Annual	80	None	2	20
PM_{10}	24-hour	150	150	*	*
	Annual	50	50	*	*
TSP	24-hour	150	150	10	37
	Annual	75	60	5	19
NO_2	Annual	100	100	2.5	25
CO	1-hour	40,000	40,000	None	None
	8-hour	10,000	10,000	None	None
Pb	3-month	1.5	1.5	None	None

*Simultaneously with the promulgation of the PM_{10} NAAQS, EPA announced that it would develop PM_{10} increments to replace the TSP increments. However, such increments have not yet been promulgated. Thus, the national PSD increment system for particulate matter is still based on the TSP indicator.[7]

national parks, Class II applies to areas with some industrial activity, like Roanoke, VA.[8] Toxic pollutants, regulated by the Virginia Department of Environmental Quality (DEQ), are based on hourly and annual emissions.[9] Table 4.1.1 contains the NAAQS and PSD increments for the six criteria pollutants.

Major sources are subject to PSD increments, however, if the PSD increment of a new source exceeds the NAAQS limit, the NAAQS limit is enforced. Major sources undergoing major modifications are subject to PSD review if emissions are increased by set values for certain pollutants. The modified source emission rate criteria for selected pollutants follows:[10]

Pollutant	Emission Rate (tons/year)
CO	100
SO_2	40
NO_2	40
PM (TSP)	25
PM_{10}	15
Ozone (VOC)	40 (of VOCs)
Pb	0.6

5.0 System Functional Analysis

The system functional analysis provides a description of the functional relationship of the systems primary components. The two primary functional goals of the system are to maximize the economic benefits from industrial activity and to preserve natural resources. The system is loosely organized and difficult to classify in terms of a defined organization, but, the system does have components which receive inputs, perform functions, and produce outputs influencing the other system components. In addition, some of the system components are designed with regard to the full system life cycle and can be described in that context. Figure 5.0.1 is a functional flow diagram of the primary system which includes two tiers of components designed to achieve the two competing goals. The following is a basic description of the system's components and their relationships.

The pollution sources element of Figure 5.0.1 consists of industries, utilities, and other major stationary point sources that contribute pollutants to the air resource. Pollution sources is a subsystem of the overall system. The source may be defined by a specific organization and goal. Typically, the goal of an industry or utility is to produce goods or services. The production of the good or service uses the systems engineering life cycle process described in Section 2.0. Examples of industries applicable to Figure 5.0.1 are the four Giles County facilities which consist of a power plant, a chemical plant, and two lime plants. The basic functional operation of the sources include the inputs, the processes, and the outputs. The inputs include raw materials, fuels, and information. The processes consist of the activities which produce the outputs; goods, services, and waste. Other significant elements of industry are the employees, employers, vendors, and consumers.

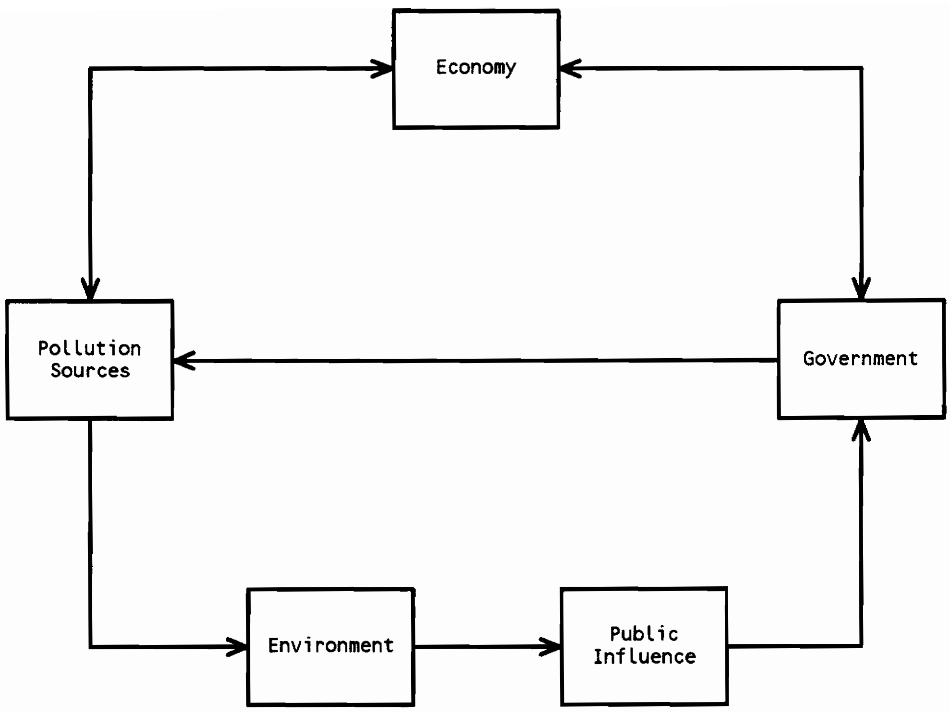


Fig. 5.0.1 Functional Flow Diagram

The economy, a second system element in Figure 5.0.1, can not be easily described as a concise organization, like the overall system. However, the effects of sources on the economy and of the economy on the government are significant. The primary elements of the economy are jobs, taxes, consumers, suppliers, and the producing and selling of goods. The scope of an economy may vary from the economy of a nation, as would be considered for the automobile industry, to the economy of a small town dependent on a primary source, similar to Blacksburg, VA and Virginia Tech. However, unlike pollution sources there is little control over the inputs, processes, and outputs of the economy. Certain actions can be consciously imposed on economies to precipitate certain reactions, but for the most part the elements influencing the fate of economies are external to the system.

The relationship between industrial activities and their influence on the economy mostly result in fluctuations in the above economic elements.

Like the sources, the government may be defined in terms of an organization with a purpose. The inputs to the government include economic indicators, tax revenue, and public influence. The processes of the government are performed by the decision mechanisms, the legislative, executive, and judicial branches at the local, state, and federal levels. The outputs are the decisions of government such as statutes, executive orders, and judicial rulings. To achieve the goal of maximum economic benefits from industrial activities, governments take actions such as tax incentives and open trade markets to encourage industrial activities.

The second tier of Figure 5.0.1, shares two components of the first tier, pollution sources and government. The significant product of sources in the second tier, is waste, including air pollution. Controlling industrial activities, the processes contributing to air pollution, is critical to preserving public health and natural resources. Air pollution, an industry output, is an environmental input.

Environmental deterioration results from mismanagement and wasteful utilization of natural resources. Although the environment is a natural system, it can be described in functional terms; inputs, processes, and outputs. The inputs consist of the unnatural waste from human activities. The processes of the environment include the mechanisms which restore natural resources. Dispersion of air pollutants and atmospheric processes are examples of natural resource restoring mechanisms. The output of the environments functional system is either the restoration or depletion of natural resources. Over utilization of natural resources results in saturation of the restoring processes and the deterioration of the environment. The public observes environmental deterioration and pressures organizations and governments to act. The government actions designed to control environmental pollution result from the pressure of the public and awareness organizations. The government's response to public pressure, takes the form of laws and regulations to control source emissions.

5.1 Case Study Functional Analysis

The system previously discussed applies to sources throughout the United States. Specifically, the system applies to the Pearisburg, Virginia area, located in Giles County in the southwest portion of the state. Within a ten mile radius of Pearisburg there are four major air pollutant sources. In terms of the general functional analysis, the pollution sources are a coal fired power plant operated by the Appalachian Power Company, a chemical/fiber producing plant operated by Hoechst Celanese Corporation, and two lime producing plants operated by APG Lime Corporation and Eastern Ridge Lime Company. The operations of these facilities consume and produce goods and services which significantly contribute to the regions economy. Their activities generate major air pollution emissions which impact the environment. The federal, state, and local governments, as well as the management personnel of the facilities, strive to protect the air resource of the area while promoting the regions economic vitality. The governments encourage industrial activities through tax incentives and other support mechanisms. At the same time, the governments require these facilities to control air emissions through air pollution permits for the industries' operations.

The inputs to the four sources of the case study are raw materials, fuels, employees, and services required for the industrial operations. The processes of the industries are the plant operations. The outputs from the plant operations are electricity, chemical products, lime stone products, jobs, purchases of goods and services, and pollution emissions to the atmosphere. For this case study SO_2 concentrations become the primary environmental focus.

The economy of the region surrounding Pearisburg, includes the factory jobs to local residents, taxes paid to governments, purchases of goods and services, and the goods and services available to local residents (electricity from the Appalachian Power Company). Since the region is rural, plant operations are significant to the region's economy. Fluctuations in industrial activities can impact the regions economy. The local, state, and federal governments are all concerned with the regions economy and the prosperity of the regions industries. Fluctuations in regional economic indicators influence government expenditures and decisions.

Environmentally, the four plants utilize the region's natural resources. All of the plants burn natural fuels, the lime plants mine lime reserves, the chemical and power plant depend on the New River, and all emit waste to the environment. Solid, water, and air resources are limited and can be viewed as being depleted when pollutants are emitted. The NAAQS and PSD increments are based on the premise that the environment can only deal with a finite amount of waste safely, so that exceeding some threshold, results in environmental harm. The national awareness of environmental deterioration in recent years has repercussions to the activities of the four Giles County sources. Such awareness directly influences the four industries through federal legislation, such as the 1990 CAAA.

6.0 Detailed Operational Requirements

The detailed operational requirements define the detailed system requirements and components. The detailed operational requirements relate to the systems detailed design and development. The systems detail design is primarily dependent on the principles and characteristics of the Gaussian Dispersion Equation.

6.1 Gaussian Dispersion Equation

EPA approved air pollution models are based on the Gaussian dispersion equation.[11] The equation is based on the natural dispersion of pollutants in the atmosphere. The dispersion of gasses in the atmosphere from point sources is analogous to smoke rising from a home fireplace and diffusing as the wind blows the plume of smoke away from a chimney. Pollutants released to the atmosphere, particularly from a stack, rise vertically due to stack exit velocity and stack gas buoyancy then travel horizontally with the wind.[12] As the plume moves from the source, vertical and horizontal dispersion continue until at some downwind distance, pollutant concentrations are negligible. Dispersion is a function of both diffusion and fluid mixing in turbulent flow.[13] Eddies, swirls of wind in the atmosphere, mix parcels of clean air with parcels of polluted plume air. The eddies are a function of thermal and mechanical influences. Thermal eddies are created by the conduction/convection of heat released from the solar energy absorbed at ground level. Mechanical eddies are formed by shear forces produced when the wind moves across rough surfaces. The eddies size increases as the terrain roughness increases.[14] Changes of wind direction and wind speed also contribute to plume dispersion. Over a long period of time the downwind concentrations from a single source will spread over a large area due to changes in atmospheric stability, wind directions, and wind speed.[15]

The dispersion of pollutants from a source and the resulting downwind concentration distribution can be estimated using a number of equations. The EPA approved approach for predicting downwind concentrations is based on the Gaussian Dispersion Modeling Equation. The Gaussian Dispersion Equation is based on the statistical nature of plume dispersion which is best represented as a normal statistical distribution of pollutants in the horizontal and vertical directions. Pasquill demonstrated that the dispersion of stack gasses is well modeled by the following Bi-normal Gaussian Equation:[16]

$$C = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left(-\frac{1y^2}{2\sigma_y^2}\right)\left\{\exp\left(-\frac{1}{2}\frac{(z-H)^2}{\sigma_z^2}\right) + \exp\left(-\frac{1}{2}\frac{(z+H)^2}{\sigma_z^2}\right)\right\} \quad (1)$$

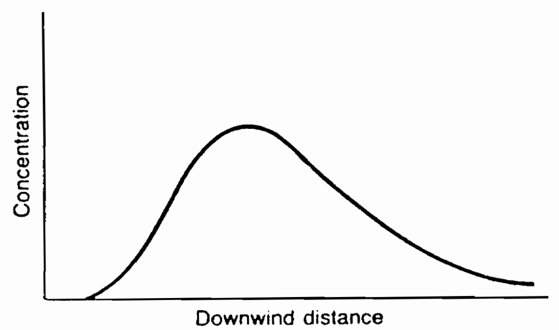
C	=	steady-state pollution concentration at a point x, y, z away from the source, ($\mu g/m^3$)
Q	=	emission rate, (μg/s), (source strength)
σ_y, σ_z	=	horizontal and vertical dispersion parameters, (m), (function of distance x from source and atmospheric stability)
u	=	average wind speed at stack height, (m/s)
y	=	horizontal distance measured to plume center line, (m)
z	=	vertical distance from ground level, (m)
h	=	physical stack height, (m)
Δh	=	plume rise, (m)
H	=	h + Δh, H is effective stack height, (m)

The steady state pollution concentration, C, is calculated at each receptor (x, y, z point). The emission rate, Q, is a function of polluting gas density, temperature, and stack inside diameter dimension. The values of σ_y and σ_z are functions of atmospheric stability and distance, x, from the source. The atmospheric stability is an indicator of atmospheric turbulence and mixing. Stability is a function of changes in atmospheric temperature with height, heating of ground level air, wind speed turbulence, and surface roughness. The stability categories range from A to F where A is the most unstable and F is the most stable. As described by Alley, the vertical mixing of air increases as unstability increases.[17] The unstability categories, A & B, generally lead to greater mixing. Stability decreases with solar insulation, surface heating, and subsequent heating of atmospheric layers near the surface. The Pasquill-Gifford system for estimating rural dispersion coefficients, σ_y and σ_z, is the most widely used system, and is based on the estimation of stability categories.[18] Several methods are available to estimate stability categories and are outlined in the On-Site Meteorological Program Guidance for Regulatory Modeling Applications (EPA-450/4-87-013).

Wind speed, u, is a meteorological measurement, averaged for each hour of meteorological data. The horizontal distance, y, from the plume center line and the vertical distance, z, from the ground define the receptor location. The distance from the source, x, is used to determine the dispersion coefficients, σ_y and σ_z. The effective stack height, H, is the combination of physical stack height, h, and plume rise, Δh.

Plume rise results primarily from the gas momentum at stack exit and buoyancy arising from the flue gas temperature.[19] Predicting plume rise presents a difficult task for which several different equations have been developed, often leading to different results.[20] The method approved by the EPA is the Briggs plume rise model. The Briggs plume model is a complicated set of equations which mainly depends on buoyancy flux term. According to Cooper and Alley "Briggs recognized that even after a plume was bent over by the wind it continued to rise, owing to its thermal buoyancy flux term F_B (which is usually dominated by thermal buoyancy), wind speed, and distance downwind. After sufficient travel time (or distance downwind), the plume reaches its final rise."[21]

The following characteristics describe the behavior of the concentrations predicted by the Gaussian Dispersion Equation. A true Gaussian representation disperses gasses normally in the vertical plane, infinitely. The second exponential z term accounts for the ground which can not be penetrated by the plume gases. The second z term is a virtual underground image source of the original source. Effectively, the image source simulates a reflection of the plume impact with the ground.[22] Downwind concentrations are directly proportionally to source strength, Q, in Equation (1).[23] Generally, the downwind concentrations are inversely proportional to the wind speed, however, in certain circumstances down wash and stability factors may cause higher downwind concentrations from higher wind speeds.[24] The dispersion parameters σ_y and σ_z increase as atmospheric instability increases.[25] As the effective stack height, H, increases the maximum downwind ground level concentration decreases.[26] The ground level concentration is negligible near the source, increases and reaches a maximum away from the source, and then decreases to a negligible concentration at large downwind distances, as illustrated by Figure 6.1.1.[27]



Adapted from Cooper and Alley

Fig. 6.1.1 Variation of Downwind Centerline Concentrations

Although the Gaussian Dispersion Equation is not terribly complicated, the number of calculations required to predict downwind source concentrations can become immense.

For modeling purposes wind speed, stack exit velocity, and emission rate are treated as constants. However, the horizontal and vertical dispersion parameters, the effective stack height, and plume rise are calculated for each receptor. The general flow of model calculations is basic but repetitive. At a receptor, stack parameters, one hour of meteorological data, and the receptor location and elevation are entered into the Briggs and Gaussian equations to determine the receptor concentration. The procedure is repeated for each stack at each source. All of the above repeats at each receptor for each hour of meteorological data for a complete year. The number of calculations performed by a model greatly increases with increases in the number of sources and receptors. Only in the last couple of years has it become possible for PCs to efficiently accomplish the task. For the model used in this project, a 486, 50 MHz PC required over twenty hours to complete a single run.

6.2 Permit Requirements

The remainder of this section describes the systems detail design requirements. As stated, much of the detail design is dependent on the Gaussian Dispersion principles. Title V of the 1990 CAAA requires all sources exceeding certain emission thresholds to obtain an operating permit.[28] In general, those sources emitting over 100 tons per year of criteria pollutants are subject to permit application requirements.[29] The following identifies some of the procedures and requirements of the air permit application and the modeling execution as suggested by the Proposed Virginia PSD Air Quality Modeling Guideline.

6.2.1 Pre-Application Meeting

Each permit application involves many variables unique to the individual application. To clarify questions and procedures, the Virginia DEQ suggests that each permit applicant schedule a pre-application meeting between the permit applicant and the Air Division staff of the DEQ at the regional DEQ office. The meeting is intended to define air permit requirements for the proposed facility and to discuss items such as monitoring and modeling protocol which requires written approval prior to the permit application.[30]

6.2.2 Protocol Requirement

The modeling protocol includes all of the procedures and elements which the applicant, or the applicant's consultant, will follow while assessing projected are quality. This includes the applicant stating the procedures to be followed, the data to be collected, the model and model options, and the analysis required of the generated concentration data. The modeling protocol must include the Universal Transverse Mercator (UTM) coordinates of the facility area, topographic map of the facility, terrain definition (simple, intermediate, complex), model identification for different terrain, emission and stack parameters, receptor grids for source modeling, NAAQS considerations (primary, secondary), PSD considerations (Class I, Class II), violation analysis (how will violations be identified and reported), alternate load analysis (load scenarios i.e., 75%, 100%), type of meteorological data collected, pre-construction monitoring, Good Engineering Practice (GEP) analysis (building down wash considerations), rural/urban considerations, receptor locations, intermediate terrain treatment, fenceline/public access considerations, and additional impact analysis (vegetation growth, visibility etc.). Refined air quality modeling requires certain input data which may be separated into three distinct areas (1) meteorological, (2) source, and (3) receptor.

6.2.3 Receptor and Source Considerations

Source data is fairly straight forward and basically consists of the facility parameters. For point sources these include the facility's UTM coordinates, site elevation, stack height, stack inside diameter, stack gas exit velocity, stack gas temperature, and stack emission rates for different pollutants. Volume sources require source emission rate, UTM source center, base elevation, height to source center, and initial dispersion parameters, σ_y and σ_z. The area source requires the source emission rate, UTM coordinate of the southwest corner, base elevation, effective release height, and area source width. The receptor data base consists of the UTM coordinates and elevations for all of the grid receptors. The Virginia DEQ suggests a polar grid centered at the source, with 36 radials. The increments of receptors along the radials is suggested by Table 6.2.3.1.[31]

Table 6.2.3.1 Receptor Spacing For Polar Grid

Distance from Source (m)	Increment (m)
0 - 1000	100
1000 - 2000	200
2000 - 5000	500
5000 - insignificant	1000

Adapted from the Proposed Virginia PSD Air Quality Modeling Guideline

6.2.4 Meteorological Considerations

Unlike the receptor and source data bases the meteorological data base is somewhat more complicated and difficult to obtain. Meteorological data originates from three sources (1) data collected on-site, (2) National Weather Station (NWS) data, and (3) synthetic data.[32] On-site data is collected in close proximity of the source and consists of surface meteorological conditions, averaged hourly for one year. On-site data is collected by the applicant, at the applicants expense. One years worth of on-site meteorological data cost Eastern Ridge Lime Company approximately $25,000. NWS stations are located throughout the country and record similar meteorological data. NWS data may be obtained from the National Climatic Data Center (NCDC). Normally, synthetic meteorological data is based on algorithms generating worst case meteorological conditions. Synthetic data produces conservative results which most major sources find to be overly restrictive when meeting PSD increment requirements.

According to the Guideline On Air Quality Models (EPA-450/2-78-027R) "The representativeness of the data is dependent on: (1) the proximity of the meteorological monitoring site to the area under consideration; (2) the complexity of the terrain; (3) the exposure of the meteorological monitoring site; and (4) the period of time during which the data are collected."[33] The EPA and Virginia DEQ require at least one year of on-site data or five years of NWS data for most model applications.[34] On-site data records the hourly average of surface data where NWS data is recorded on an hourly basis. "For 1-hour averages, the sampling duration should be at least 3 minutes and up to 60 minutes."[35] NWS data is available for specific National Weather Stations across the country, however, unless the source is in the immediate vicinity of the NWS station the meteorological data will not be representative of the specific model area.

The meteorological data required for modeling purposes consists of wind speed, wind direction, atmospheric stability, and mixing heights. Wind speed influences plume dilution, plume rise, down wash calculations, and is used to calculate stability categories. Wind speeds are typically measured by anemometers positioned 10 m above the ground surface and are adjusted to stack height for model calculations using the power law equation:[36]

$$U_Z = U_{10}\ (Z/10)^P$$

where:
U_{10} = 10 meter wind speed
U_Z = wind speed at stack height
Z = stack height
P = power law exponent

Wind direction determines plume transport, and over prolonged time periods is the primary factor in determining ground level concentrations.

Other meteorological considerations are mixing height and ambient temperature. Mixing height "determines the distance above ground to which relative unrestricted vertical mixing occurs in the atmosphere."[37] The ambient temperature relative to stack gas temperature contributes to plume buoyancy. "Plume rise is proportional to a fractional power of the temperature difference between the stack gas and the ambient air."[38] The meteorological data is submitted to the DEQ. The applicant must submit a minimum of five copies of pre-processed data in binary format, and one copy of the raw data in ASCII format.

6.2.5 Terrain Considerations

The particular model selected for an application depends primarily on the terrain topography. The Proposed Virginia PSD Air Quality Modeling Guideline defines simple terrain as terrain below stack height, complex terrain as terrain above stack height, and intermediate terrain as terrain between stack height and maximum plume rise. The EPA recommends specific models for simple and complex terrain, and two modeling schemes for intermediate terrain.

6.2.6 Urban/Rural Classifications

The urban/rural classification is significant to the model diffusion coefficient selection particularly to the refined simple terrain model. There are two procedures for making the rural/urban classification, one based on land use the other on population density. The land use procedure states "if land use types heavy industry (I1), light-moderate industry (I2), commercial (C1), compact residential (single family, some multiple family dwellings, (R2)), and compact residential (old multi-family dwellings, (R3)) account for 50 percent or more of the land used within 3 kilometers of the source, then the modeling regime is considered urban."[39] The population density procedure states that if the population density exceeds 750 people/km^2 for a 3 kilometer radius circle around the source, the modeling regime is considered urban.[40]

6.2.7 Good Engineering Practice Considerations

GEP analysis is conducted to determine if building down wash considerations are required for the model development. GEP calculations are performed for each stack at each source. GEP adjusts stack height for stacks located near large buildings which alter typical plume dispersion. To determine if GEP analysis is required, the dimensions of the buildings located near the facility are required. A complete GEP description, including the required calculations, is provided in attachment D of the Proposed Virginia PSD Air Quality Modeling Guideline.

6.3 EPA Dispersion Models

The EPA recommended models for simple terrain are SCREEN and Industrial Source Complex Short Term (ISCST2). SCREEN, as the name suggests, is used for screening purposes, is easy to use, and is based on conservative assumptions such as worst case meteorological conditions and worst case ground/plume reaction. Sources which satisfy NAAQS and PSD increments using the SCREEN model, are not required to proceed to a refined model. The ground level concentrations predicted by SCREEN are considerably higher than actual concentrations. The SCREEN model does not accept on-site or NWS meteorological data. ISCST2 is the primary refined model for simple terrain. ISCST2, while capable of processing synthetic meteorological data, is most often used with on-site or NWS meteorological data.

The following EPA recommended models are used for screening in complex terrain: VALLEY, COMPLEX I, Complex Terrain SCREEN (CTSCREEN), SHORTZ/LONGZ, and Rough Terrain Dispersion Model (RTDM).[41] CTSCREEN is based on the Complex Terrain Dispersion Model Plus (CTDMPLUS) algorithm.[42] The EPA has recently issued Settlement B, the first revision to the 1987 version of the Guideline on Air Quality Modeling, which includes the classification of CTDMPLUS as the preferred refined model for complex terrain.[43] Prior to Settlement B, COMPLEX I, CTSCREEN and CTDMPLUS were the most commonly used models for complex terrain. Typically, COMPLEX I and CTDMPLUS are used with on-sight meteorological data and CTSCREEN is used with synthetic meteorological data.

The EPA recommends either of two procedures for modeling intermediate terrain. When modeling with CTSCREEN or CTDMPLUS no additional calculations are required for determining intermediate terrain concentrations.[44] IF COMPLEX I or RTDM are used for modeling complex terrain, "the applicant must perform an hour by hour, receptor by receptor comparison between COMPLEX I or RTDM and ISCST2." The higher concentration for that particular hour and receptor is chosen.[45] The policy is somewhat complicated in multiple source situations. For instance, a particular facility may have two stacks of different heights and sizes resulting in different effective plume heights. It is possible for a receptor to be considered in simple terrain for the larger stack but intermediate or complex terrain for the shorter stack. Such situations raise questions as to the appropriate receptor classification. In a policy interpretation memo issued by the EPA, Office of Air Quality Planning and Standards (OAQPS), such situations require the receptor to be modeled as if it is in intermediate terrain.[46]

The EPA OAQPS offers a Bulletin Board Service (BBS) accessible to the general public. The BBS is called the OAQPS Technology Transfer Network (TTN). Within the TTN BBS, is the Support Center for Regulatory Air Models (SCRAM) section. SCRAM provides access to the source code of all of the regulatory models, test data, utility programs, bulletins, news messages, and electronic mail service for the users. The BBS phone number is (919) 541-5742, the help line is (919) 541-5384, and the service is free. To avoid long distance phone calls the Internet System may be used. The Internet code for public use is TTN BBS. RTPNC. EPA. GOV.

7.0 IGM

The remainder of this report relates to the utilization/support of the systems detail design. The description of the dispersion model and its application to the case study is typical of the system's detail operations. The remaining sections focus on the analysis of this specific aspect of the system's detail operations. The dispersion model used for this application is the Integrated Gaussian Model (IGM), developed by United Engineers & Constructors, Inc., a division of Raytheon. Mark Garrison of United Engineers provided the software and users manual which costs $75.00. Mark Garrison may be reached at (215) 422-3599. IGM, a PC based Gaussian dispersion model, has been demonstrated to be equivalent to some of the primary EPA recommended dispersion models. Equivalence approval letters, provided in Appendix A, have been issued by the EPA, to United Engineers, stating that the concentrations computed by IGM are equivalent to ISCST2, COMPLEX-I, RTDM, and SHORTZ.[47] The evaluation consisted of both regulatory and developmental equivalence. Regulatory equivalence is demonstrated by reproducing concentrations within a 2 % criteria, for maximum concentrations at each receptor. Within this guideline equivalence for intermediate terrain was completed. The developmental equivalence is designed to demonstrate equivalence on an hourly basis. The demonstration equivalence consisted of millions of direct source/receptor/ meteorological comparisons.[48] It should be noted that although IGM has been demonstrated to be equivalent to ISCST2, unlike ISCST2, IGM can not calculate particle settling and deposition. IGM has met EPA requirements, therefor an analysis in this report of the IGM algorithms and predictions would be redundant and not as thorough as the United Engineers' demonstration. Part 2 of the IGM Users Guide contains the complete equivalence analysis. For this report, the results of the IGM model are assumed to be accurate and consistent with regulatory models.

IGM, first released to the EPA on June 28, 1991, has been updated several times. The latest IGM version, released June 19, 1993, has no file format changes and is the model used in this report. Operationally, there are no changes from the last EPA approved IGM version, Update 1 released August 24, 1992. The standard operating environment for IGM is an IBM compatible, 386 or 486 PC, with math co-processor.[49]

The primary purpose for the development of IGM, was to facilitate regulatory modeling within one overall framework, particularly inputs and outputs. There are a number of options available through IGM, enabling model tailoring to each individual application. The primary capability featured by IGM is for intermediate terrain calculations. United Engineers developed IGM to address the intermediate terrain requirement through one computer program. Specifically, United Engineers were contracted to perform the air pollution modeling analysis of the Clover Power Plant, proposed for construction in Clover, Virginia. The power plant represents a major construction effort in south central Virginia, with financing outlays of approximately $1.2 billion. Pollution control demanded roughly one third of the total cost. The terrain surrounding the plant ranged from simple to complex requiring, the appropriated models. ISCST2 was used for the simple terrain, COMPLEX I for complex terrain, and both ISCST2 and COMPLEX I for intermediate terrain.

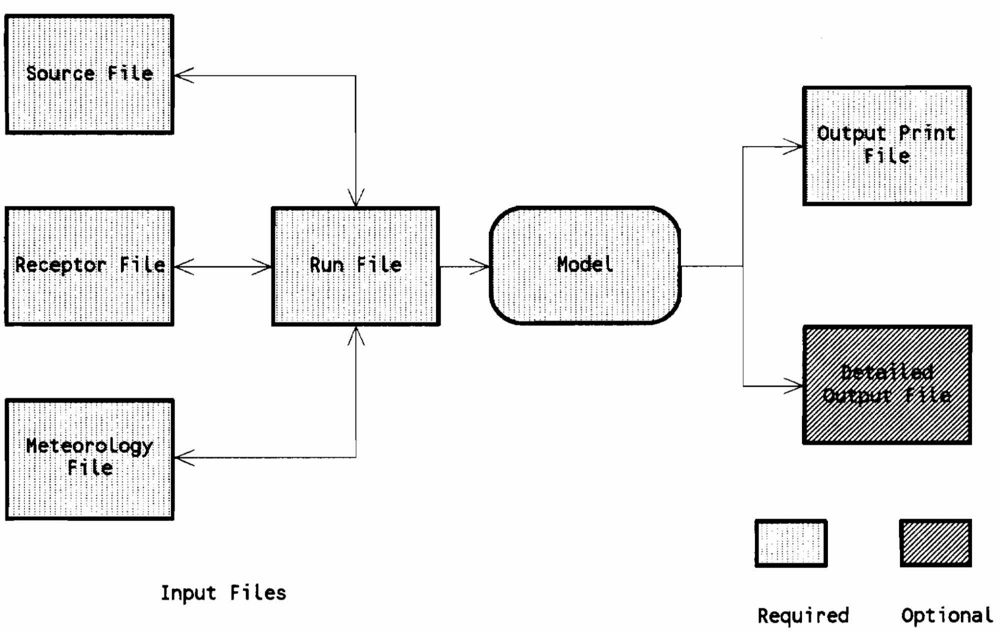
In addition to the intermediate terrain capability, IGM offers several other features. The model allows for source specific contributions. For model runs with multiple sources, IGM can group individual sources to obtain a group contribution to a predicted concentration. For example Hoechst Celanese has 15 significant SO_2 sources. Instead of having 15 individual source contributions at each receptor, a total group contribution for Hoechst Celanese is calculated. IGM can produce four basic output types, receptor based (type B - independent of time), rank based (type D - independent of space and time), concentration based (type C), and sequential.[50] Receptor based output provides the highest, second highest, third highest etc. concentration value for each receptor for any desired time period (annual, 24 hour, three hour, one hour). Rank based output ranks the highest concentrations attributed to total and individual source groups. For example, the highest fifteen, annual average, receptor concentrations attributed to Hoechst Celanese were collected. Concentration based output was most valuable for PSD incremental analysis where all concentrations above a certain PSD increment were listed. Type C analysis did not allow for output size limitations and can lead to tremendous file sizes. For this reason type C analysis was not used for this application.

IGM automatically assigned calm hour data to missing meteorological data. This alleviated the need to insert artificial data into an incomplete meteorological data base. IGM accessed different models within a model run. For example, IGM may be configured to use ISCST2/COMPLEX I for one source and ISCST2/RTDM for another source. Finally, IGM has a regulatory default switch, taking the algorithm choices out of the users hands.[51]

IGM used the same Gaussian plume assumptions as the regulatory models. IGM required hourly meteorological values for wind speed, wind direction, stability, mixing height, and temperature. Wind speed profile exponents and vertical temperature gradient were assigned regulatory default values, however, could be input by the user. A wind speed test determined calm hours. For wind speeds less than one meter per second, the model defined that hour of meteorological data as calm and defaulted the wind speed to one meter per second. The exception was NWS data, where calm wind speeds were set equal to zero.[52]

IGM used the Briggs, 1969-1975, equations for plume rise calculations. Cramer plume rise formulas were available for (SHORTZ). Area and volume sources do not use plume rise calculations, only point sources use plume rise. Stack tip down wash was included for applicable regulatory settings. Dispersion parameters for rural, urban (Briggs 1973/ASME 1979), or Cramer were default settings for specific applications. Plume interaction with terrain included choices consistent with ISCST2, COMPLEX I, RTDM, or SHORTZ. Using regulatory default settings for the IGM parameters insured that predicted concentrations will be consistent with ISCST2, COMPLEX I, RTDM, and SHORTZ.[53]

The preparation required for a single model run was significant. The template file approach utilized by IGM simplifies the model preparation. Figure 7.0.1 illustrates the required and optional files used for this model application.



Adapted from the IGM Users Guide

Fig. 7.0.1 IGM Files

Of the four required input files the run, source, and receptor files were template files. The meteorological file, a pre-processed file, come in one of four formats. Template files are existing input files, used simply by inserting applicable model parameters in the appropriate locations. Each input file consisted of hot zones and information zones. Hot zones were the input file areas read for data calculations. These areas required careful attention and accuracy. The saying "garbage in garbage out" applied to this area of the computer model. The information zones described the model data required for each hot zone. Unlike the hot zones, the information zones alter in size and content, and can be changed for clarity and convenience. However, using altered files as template files requires user caution. Appendix B contains the run file, source file, and portions of the receptor files for the Hoechst Celanese data run. All of the input files used in each data run contain the same basic information as the Hoechst Celanese data run.

8.0 Case Study Application

The application of the case study demonstrated the detailed operation of one of the systems specific components. The output of the dispersion model provided results which led to critical analysis of the systems elements and their relationship to the system's other components. In this instance, the IGM computer program was applied to the case study area, producing actual results. The analysis of these results may lead to system modifications. The application of IGM also provided insight to the operation of one detailed system function. This insight can be used to analyze this detailed function, leading to improvements which may be implemented in the utilization/support phase of this system.

The four plants surrounding Pearisburg were constructed prior to the 1990 CAAA. The Hoechst Celanese plant has expanded on different occasions, obtaining air pollution permits for those operations. In the case of Hoechst Celanese, modifications to plant operations subjected the facility to the modified source criteria of Section 4.1. Prior to the 1990 CAAA, the three other facilities did not require air pollution permits. Under title V of the 1990 CAAA, APG Lime Corporation and Eastern Ridge Lime Company require air pollution permits.[54] APG Lime and Eastern Ridge Lime are currently collecting meteorological data to perform the refined air dispersion model. Title IV of the 1990 CAAA, acid rain provisions, provided the nations power plants two options for compliance. Utilities may either add pollution control equipment (i.e., scrubbers, baghouses) or burn low sulfur coal.[55] Appalachian Power Company is opting for the later alternative.

This study modeled the SO_2 emissions of the Giles County sources and charted the results in contour maps. The contour maps visual illustrate the distribution of SO_2

concentrations throughout the region. SO_2 emission from major point sources significantly contributes to acid rain.

8.1 Pearisburg Model Development

During the development of this project, several areas were considered as possible air pollution modeling sites. Don Shepard, of the Roanoke Regional Office, Air Pollution Control, DEQ, suggested an air pollution model of Giles County, Virginia. The area's isolation from other major point sources provided a convenient modeling subject area. Three meteorological data files were available; (1) Hoechst Celanese on-site meteorological data, (2) Huntington, WV NWS meteorological data, and (3) Eastern Ridge Lime meteorological data. A separate and independent air pollution modeling effort was completed for each meteorological data file. For convenience, the three independent modeling efforts are collectively referred to as the "Pearisburg Run".

8.2 Run File

Each meteorological data run required a separate run file. The run file determined the IGM configuration and scope. The run file parameters were the same for each run, except the parameters pertaining to the specific meteorological data file. As a run file example, Appendix B contains the run file for the Hoechst Celanese meteorological data. The first run file section, the file specification section, identified the names of the input and output files. File names were required for the meteorological data file, receptor file, source file, and output print file. The output print file contained the general output data generated by the model. An optional output file, the detailed output file, was also identified. The printout control section specified the separation of output reports. In the post-processing options sections receptor based output, type B, and rank based outputs, type D, were selected for the detailed output report. The averaging times options section determined the averaging times (annual, 24 hr, 3 hr), the number of ranks for type B calculations (highest calculated concentration for each averaging time period), and the number to be ranked in the type D calculations (15 grouped by individual and total sources). The model selection section selected regulatory models for model runs. The primary model chosen for simple and intermediate terrain was ISCST2 (rural), and the optional model chosen for intermediate and complex terrain was COMPLEX I (rural). Population based criteria designated the land as rural. Land use information for the study area could not be readily obtained. The meteorological data format section, unique to each run, defines the meteorological file format and wind speed measurement height (10 m). The analysis scope section - meteorology, defined the number of meteorological days selected.

The Pearisburg Run did not utilize the remainder of the run file sections. These sections included the analysis scope section - receptors, analysis scope section - source groups & totals, source group selection section, group totals section, and concentration threshold based section. The above sections contained default options selected in the receptor and source input files. The concentrations threshold option is the type C output selection.

8.3 Source File

The three individual runs of the Pearisburg Run used the same source file. Ken McBee, Modeling Section Chief, Technical Evaluation, DEQ, Commonwealth of Virginia provided the emission and stack data for all major SO_2 sources in the Pearisburg area. The source input file required ten parameters for point sources; (1) group number, (2) source name, (3) source emission rate (g/s), (4) latitude (m), (5) longitude (m), (6) elevation (ft), (7) stack height (m), (8) stack gas temperature (K), (9) stack gas exit velocity (m/s), and (10) stack diameter (m). The stack height, stack diameter, stack gas temperature, and stack gas exit velocity were in engineering units, requiring conversion to metric units . In addition, to the ten point source parameters, IGM included the option to input emission scalars (i.e., season dependent emissions), source building dimensions, and building down wash dimensions. IGM's area and volume source modeling were not required for the Pearisburg Run.

The Virginia DEQ source data come in two forms. Source parameters may be independently listed for each stack at a source or grouped together as one effective source, known as a "bubble". The six stacks emitting SO_2 at Eastern Ridge Lime are bubbled to one effective site stack. The other three sources have separate data for each stack. Appendix B contains the source file used for the Pearisburg Run.

8.4 Meteorological File

IGM accepted four meteorological data formats; (1) RAMMET unformatted, (2) RAMMET binary, (3) IGM Hourly-ASCII, and (4) ISCST2 default ASCII. IGM accepted any anemometer level for surface data. IGM may use both low level surface data and upper air data for different stack heights in the same model run. IGM may model short stacks with low level surface data and tall stacks with upper air data. The Pearisburg Run did not use this capability. The first 24 hours of meteorological data for the three data files is included in Appendix C.

The pre-processed Hoechst Celanese meteorological data was collected on-site from 3/29/91 to 3/31/92. Hoechst Celanese data format was ISCST2-ASCII. ISCST2-ASCII format utilized wind vectors as opposed to wind directions. The IGM users guide defined wind vectors as the direction the wind travels and wind direction as the wind's originating direction. The most commonly used definition for wind travel is wind direction. The pre-processed Hoechst Celanese data format follows: year, month, day, hour, wind direction, wind speed, temperature, urban, and rural mixing heights.

The SCRAM BBS provided NWS meteorological for locations across the country and selected years. There were two NWS sites approximately the same distance from the study area, Greensboro, NC and Huntington, WV. From a topographical standpoint the terrain of Huntington, WV most resembled that of the Pearisburg area. The most recent meteorological data available on the SCRAM BBS was 1989. The SCRAM BBS contained PCRAMMET, a PC version of RAMMET. PCRAMMET processed the raw NWS meteorological data into an appropriate ISCST2 model format.

The raw NWS data consisted of two separate files, (1) hourly surface observations and (2) twice daily upper air observations. The output of PCRAMMET, a binary post-processed meteorological data set, combined the surface and upper air data. However, ISCST2 models compiled by a different compiler than the one used by the SCRAM BBS may result in an incompatible meteorological data file and model. For the Pearisburg Run the compilers for the SCRAM BBS and the IGM model were different and incompatible. There were two alternatives to "fix" the meteorological data files. IGM contains two utility programs, TSTMET and FIXMET, designed to make binary RAMMET files compatible with IGM. TSTMET tests the binary output file to determine the appropriate file changes. FIXMET processes the data to a compatible format.[56] The alternative to IGM's utility files was BINTOASCII, available on the SCRAM BBS. BINTOASCII, as the name suggests, converts binary files to ASCII files. The Pearisburg Run used the BINTOASCII program so that the data can be viewed or edited by any common editor. Like the Hoechst Celanese data, the Huntington, WV format was ISCST2-ASCII, which included wind vectors verse wind directions.

Eastern Ridge Lime provided approximately four months of hourly meteorological data and continues to collect 12 months of data. The unprocessed Eastern Ridge Lime meteorological data file covers the 3/5/92 through 6/30/93 period. The raw Eastern Ridge Lime data required substantial processing before being entering into the model. The Eastern Ridge Lime data, in Lotus 123 format, contained the following meteorological data sequence: month, year, Julian day, hour, 10 meter wind speed, 10 meter wind direction, 10 meter sigma theta, 60 foot wind speed, 60 foot wind direction, 60 foot sigma theta, and 2 meter ambient temperature. Sigma theta was a measurement of lateral wind turbulence and can be used to estimate the stability category.[57] Tables 6-6a and 6-6b of the On-Site Meteorological Program Guidance for Regulatory Modeling Applications outlined the criteria for estimating the Pasquill stability categories. A FORTRAN program based on Tables 6-6a and 6-6b calculated the stability category for each hour of Eastern Ridge Lime data. The FORTRAN program and Tables 6-6a and 6-6b are included in Appendix D.

ISCST2 models required urban and rural mixing heights. The Eastern Ridge Lime data did not include mixing height values and could not be used to calculate mixing height values. There were several ways to estimate or measure mixing height values for a specific site, however, the most accurate were prohibitively expensive and the least accurate were exceptionally crude. Mixing height values may be directly measured on-site using weather balloons twice daily or Doppler SODAR (Sound Detection and Ranging). The upper air soundings measure the atmospheric lapse rate and determine the mixing height of the region. Of all of the models and meteorological data bases encountered during this project none used on-site methods to determine mixing height values.

The alternative to on-site mixing height values was NWS upper air data. For instance, the Clover Project used on-site meteorological surface data and upper air soundings from the Greensboro, NC NWS, for mixing heights. For this project the same approach was explored by possibly using the Huntington, WV NWS upper air data for the same time period as the Eastern Ridge Lime data. Unfortunately, upper air data for 1993 was not available on the SCRAM BBS. The only way to obtain 1993 upper air data for Huntington, WV was directly from the NCDC. The cost for 1993 Huntington, WV upper air data was $250. For this study the cost for the data was not justifiable, particularly since the data was not a direct measurement of the Eastern Ridge Lime site.

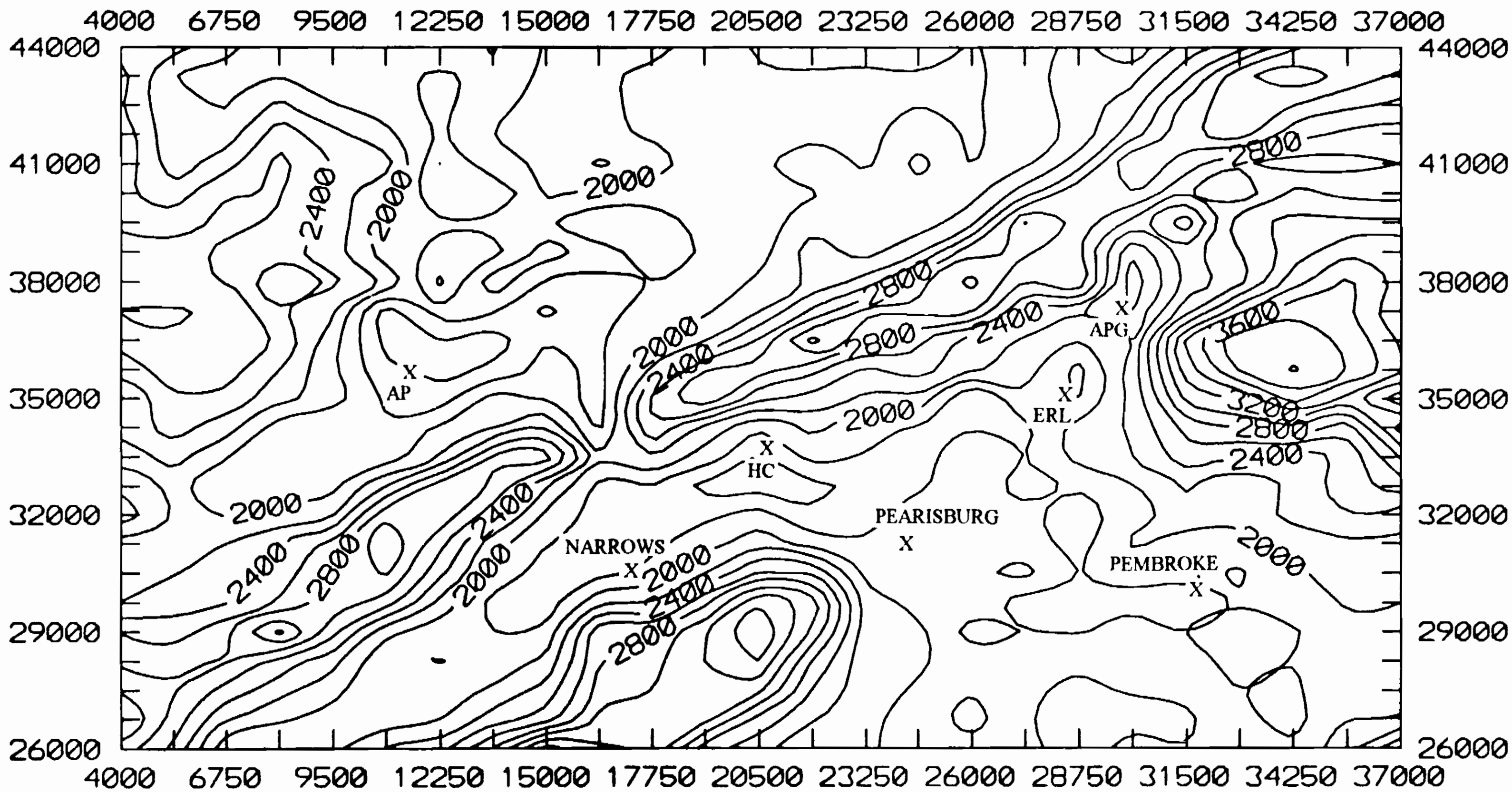
This study used a third approach to obtain mixing heights. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, by George C. Holzworth, Department of Meteorology, EPA, May 1971, measured and documented mean morning and afternoon mixing heights for each season.[58] Holzworth's work is still used as the basis for processing mixing height data in RAMMET and MPRM, the EPA's recommended meteorological pre-processors for NWS data. RAMMET estimates morning and afternoon mixing heights based on Holzworth and the upper air soundings of the NWS data. The RAMMET algorithms interpolate between morning and afternoon mixing heights for each hour of the day. For the Pearisburg Run, a linear interpolation between the average morning and afternoon mixing heights recorded by Holzworth were used for the applicable seasons. This type of data processing, under normal permit application circumstances, would be negotiated during the protocol process.

8.5 Receptor File

The receptor file, the same for each run, consisted of UTM coordinates and an elevation for each receptor. IGM accepts polar or cartesian receptor grids. Since, this study concerns more than one source, using the polar scheme suggested by the DEQ was not practical. The receptor file used a cartesian grid based on the DEQ's suggested space increments. Relative to each source, receptors were incremented every 100 meters, for a 1000 meter radius. Similarly, receptors were spaced every 200 meters from the 1000 meter radius to the 2000 meter radius. Beyond the 2000 meter radius, receptors were spaced every 500 meters up to 5000 meters. Beyond 5000 meters receptors were spaced every 1000 meters.

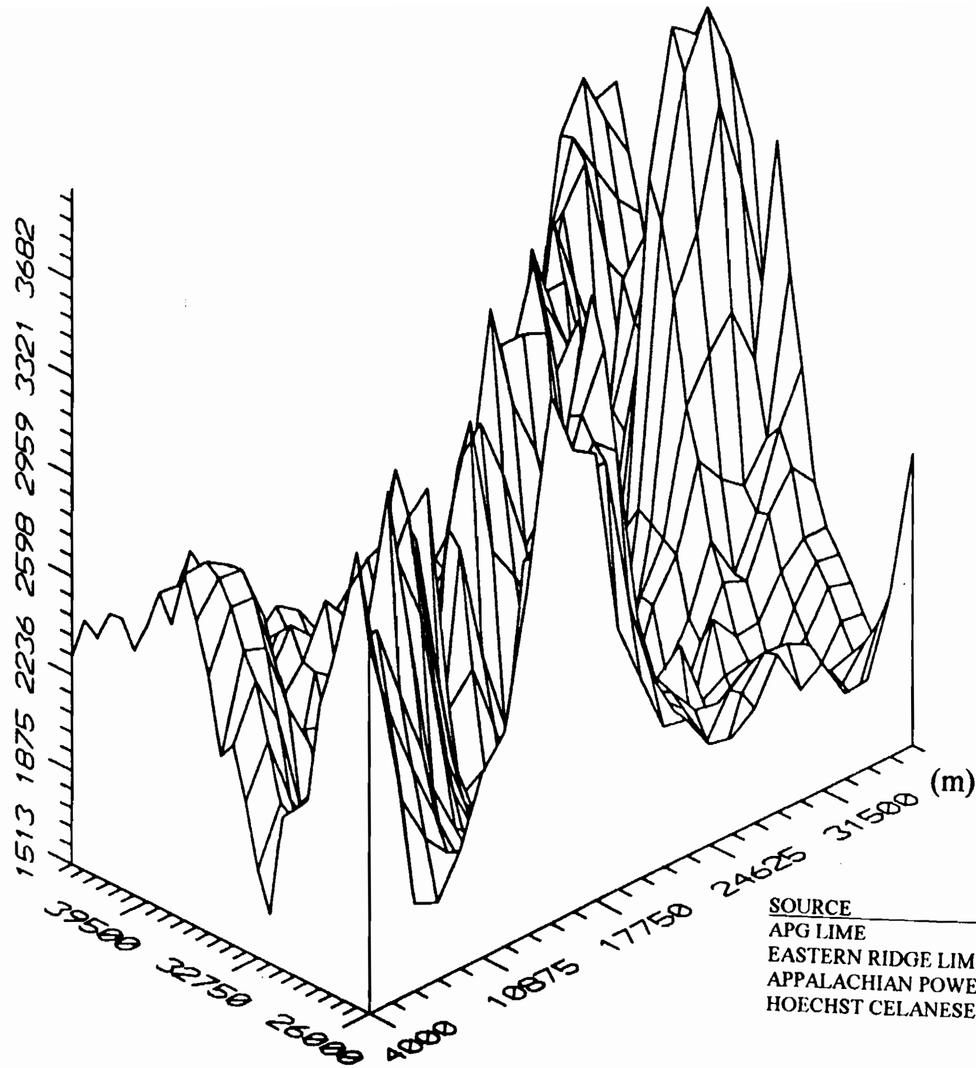
Determining the receptor spacing was easy, obtaining receptor elevations at the grid points was the challenge. Digital elevation data may be obtained in several different ways, however, all were costly and time consuming. The United States Geological Survey (USGS) is currently digitizing the 7.5 minute topographic maps for the entire United States. The USGS had digitized approximately 40 % of the United States, including the Pearisburg area. The USGS scans elevations for every 30 meter by 30 meter coordinate using the Digital Elevation Model. The USGS claims a scanned elevation accuracy within ± 7 meters. Unfortunately, the digitized data was available only on 9 track tape, required four to six weeks for delivery, and cost $146. Alternatively, aerial photographs of the region may be scanned to obtain digitized coordinates and elevations. The USGS aerial photographs of the entire United States, required 4-6 weeks for delivery and cost up to $65 per photograph. The Pearisburg Run required approximately six photographs. Another option, were scanners capable of digitizing coordinates and elevations from the USGS topographic maps. Although, such devices do exist, access to one for this project did not materialize. The final alternative, the brute force method, was to read elevations directly from the topographic maps themselves and enter them in the receptor file. The USGS in Reston, VA, sells the 7.5 minute topographic maps for the entire US, for $2.50 a piece. Fortunately, Blue Ridge Outdoors in Blacksburg, VA has selected 7.5 minute topographic maps for the Shenandoah area, including the eight maps required for the

Pearisburg Run. The receptor file consisted of coordinates and elevations for 3,572 receptors. Figure 8.5.1 is an isopleth map of the terrain generated from the x, y, and z values entered in the receptor input file. Figure 8.5.2 is a 3-D depiction of the terrain.



APG LIME	APG
EASTERN RIDGE LIME	ERL
APPALACHIAN POWER	AP
HOECHST CELANESE	HC

Figure 8.5.1 Isopleths of Pearisburg Terrain (200' interval)



SOURCE	X	Y	Z
APG LIME	29800	37100	1820
EASTERN RIDGE LIME	28600	35100	1700
APPALACHIAN POWER	12100	35700	1530
HOECHST CELANESE	21000	33000	1600

Figure 8.5.2 Pearisburg Terrain (3-D)

8.6 Output Print File

The output print file, the general output file, contained checks on model calculations and concentration results. Most of the output print file regurgitated the input file data to insure data accuracy. The output print file listed the general run parameters, printout control options, and time period matrix. The output print file also included the results of the meteorological data check. The meteorological data check reported the wind speed measuring height (10 m), the defined calm wind speed (1 m/s), the meteorological file data name and format, the first 24 hours of meteorological data, the selected Julian, and a Julian day count. The Easter Ridge Lime data consisted of 118 days of meteorological data.

The output print file provided a receptor check which included the number of receptors (3572) and the minimum and maximum for latitude, longitude, and elevation. The source check included the number of source groups (4), the number of point sources (15), the number of volume sources (0), and the number of area sources (0). The source check also contained the minimum and maximum ranges for the source parameters. The output check reported the time periods selected and the ranks selected for type B and type D reports. For the Pearisburg Run, the maximum concentration for each receptor was selected for the total time period, the 24 hour average, and the 3 hour average. For type D output the top 15 receptor concentrations were recorded.

The next element of the output print file was the model check. The model check reported the selected models, ISCST2 for simple terrain, and COMPLEX I for complex terrain. The model check also reported the model options for the selected models. The Pearisburg Run used the regulatory default option. The output print file contained the source and source groups which checks the model interpretation of the source file. For the Pearisburg Run, all of the source information was read correctly and the sources are grouped in the appropriate four groups. The output print file provided a point source plume height table which shows the final plume rise for each source based on stability category and wind speed. The plume rise was provided in meters and feet. A second meteorological data check listed the minimum and maximum for each meteorological parameter. The output print file contained an intermediate terrain analysis for each source. The summaries of the receptor based, type B, and rank based, type D, results follow. The final section of the output file was the meteorological data comparison for arbitrarily selected days.

8.7 Detailed Output File

The detailed output file contained the results of the type B receptor based results and the type D rank based results. The type B output listed the total maximum concentration for each receptor grouped by time period. Each receptor also contained the group contribution from each of the four groups to the total maximum concentration. The type B results were used to develop nine isopleth maps presented in Section 9.0. The nine isopleth maps presented the highest concentrations for the three time periods (total time period, 24 hour, 3 hour) for each of the three meteorological data files.

The type D output listed the top 15 concentrations for the total run and each source group. The top concentrations were further separated for each time period. The type D reports identified possible NAAQS and PSD increment violations. To illustrate the contents of the type D report Figure 8.7.1 contains the top 15 concentrations for the Hoechst Celanese meteorological data file, for all groups and the complete time period. Chi is the total concentration for the receptor. Concentrations exceeding the NAAQS limitations represent possible violations. PSD increment violations are identified by the source contribution. Section 9.0 analyzes the type B and type D output reports.

Rank-Based (Type D) output for Total no. 1: Total over all groups
Time period averages; 8783 hours processed

Rank |<------ Receptor ------>|					Total	Group Contr...			
Rnk	GR	No.	x-m	y-m	z-ft	Chi	APG	ERL	AP	HC
1	1	2819	28800	35100	1750	303.37	0.07	292.63	2.99	7.68
2	1	2818	28700	35100	1740	300.31	0.07	290.74	2.94	6.56
3	1	2793	28200	35200	1830	245.93	0.21	231.51	3.93	10.27
4	1	2820	28900	35100	1760	238.82	0.06	227.50	3.34	7.91
5	1	2814	28200	35100	1830	235.10	0.20	219.97	3.93	11.00
6	1	2801	29000	35200	1890	231.19	0.20	215.27	4.23	11.47
7	1	2821	29000	35100	1800	216.91	0.07	203.01	3.57	10.25
8	1	2822	29100	35100	1900	206.70	0.20	190.16	4.31	12.03
9	1	2800	28900	35200	1800	200.86	0.09	187.26	3.58	9.93
10	1	2794	28300	35200	1800	198.83	0.16	185.10	3.69	9.89
11	1	2792	28100	35200	1860	195.75	0.29	180.30	4.19	10.97
12	1	2813	28100	35100	1850	188.55	0.25	172.92	4.11	11.27
13	1	2802	29100	35200	1840	187.09	0.09	172.57	3.82	10.61
14	1	2531	29000	35000	1870	177.34	0.12	161.50	4.09	11.63
15	1	2839	28800	35000	1860	164.35	0.15	148.42	4.06	11.73

Rnk - Rank
GR - Group
No. - Receptor Number
x,y,z - receptor coordinates and elevation
Chi - SO_2 Concentration
APG - Lime Corporation
ERL - Eastern Ridge Lime Corporation
AP - Appalachian Power Company
HC - Hoechst Celanese Corporation

Figure 8.7.1 Type D Output for Hoechst Celanese Data - Annual Average, All Groups

9.0 Results

The model output provided actual dispersion concentration results for Giles County SO_2 pollution. As stated the results provided insight to the operation of a key component of the system's detail design.

9.1 Type D Results

The type D results provided in Appendix E, are separated by meteorological data file. Tables 9.1.1, 9.1.2, and 9.1.3 summarize the type D results. The SO_2 annual average, PSD increment for Class II areas is 20 $\mu g/m^3$. The 24 hr PSD increment is 91 $\mu g/m^3$, and the 3 hr increment is 512 $\mu g/m^3$. The NAAQS annual and 24 hr primary limits are 80 $\mu g/m^3$ and 365 $\mu g/m^3$. The 3 hr secondary NAAQS standard is 1300 $\mu g/m^3$. For each meteorological data file, the top 15 concentrations were recorded for each source group and time period. Table 9.1.1 summarizes the results of the Hoechst Celanese data. The table lists the number of receptors whose values exceed the PSD or NAAQS standard for particular time periods. For example in Table 9.1.1, 12 of the 15 receptor concentrations, attributed to Appalachian Power, exceed the PSD annual average increment. Tables 9.1.2 and 9.1.3 provide similar results for Huntington, WV and Eastern Ridge Lime meteorological data, respectively. It should be noted that the Eastern Ridge Lime data did not include a full years worth of meteorological data and a comparison of annual averages was not conclusive.

Table 9.1.1 Number Receptors Exceeding Standards for Type D Results (Hoechst Celanese Data)

Hoechst Celanese Meteorological File								
	Eastern Ridge		APG Lime		Appalachian Pwr		Hoechst Celanese	
Time Period	PSD	NAAQS	PSD	NAAQS	PSD	NAAQS	PSD	NAAQS
Annual	15	15	15	1	12	0	15	0
24 Hr	15	15	15	15	15	0	15	9
3 Hr	15	15	15	15	15	0	15	15

Table 9.1.2 Number of Receptors Exceeding Standards for Type D Results (Huntington, WV Data)

Huntington, WV Meteorological File								
	Eastern Ridge		APG Lime		Appalachian Pwr		Hoechst Celanese	
Time Period	PSD	NAAQS	PSD	NAAQS	PSD	NAAQS	PSD	NAAQS
Total	15	15	15	0	2	0	15	0
24 Hr	15	15	15	13	15	2	15	15
3 Hr	15	15	15	15	15	1	15	15

Table 9.1.3 Number of Receptors Exceeding Standards for Type D Results (Eastern Ridge Data)

Eastern Ridge Lime Meteorological File								
	Eastern Ridge		APG Lime		Appalachian Pwr		Hoechst Celanese	
Time Period	PSD	NAAQS	PSD	NAAQS	PSD	NAAQS	PSD	NAAQS
Total	15	15	15	0	2	0	15	15
24 Hr	15	15	15	5	15	0	15	15
3 Hr	15	15	15	7	15	0	15	15

9.2 Type B Results

The type B output contained over 3,500 lines of data for each meteorological data file and time period. Presenting the type B results in this reports was impossible, however, isopleth maps generated from the type B results were included. The isopleth maps visually illustrate the type B results. The Virginia Tech Mining and Engineering Department provided access to a PC based plotting program, Surfer. The Surfer program plotted x, y, and z values in isopleth and three dimensional maps. By entering concentration values in place of the z value, isopleth and 3-D maps were created for SO_2 concentrations. Figures 9.2.1 through 9.2.18 are the nine isopleth maps and the corresponding 3-D depiction's for each meteorological data set and time period.

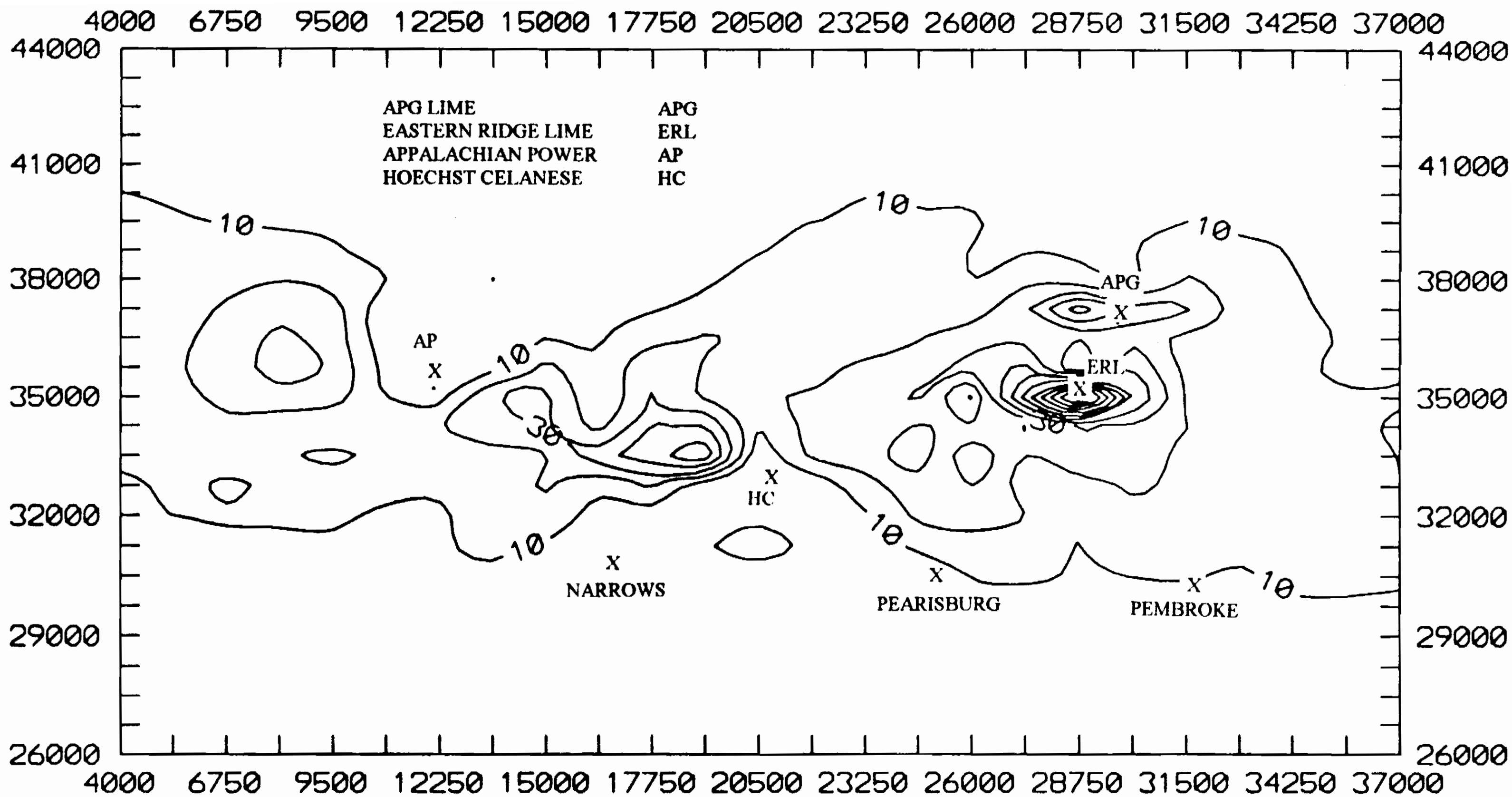
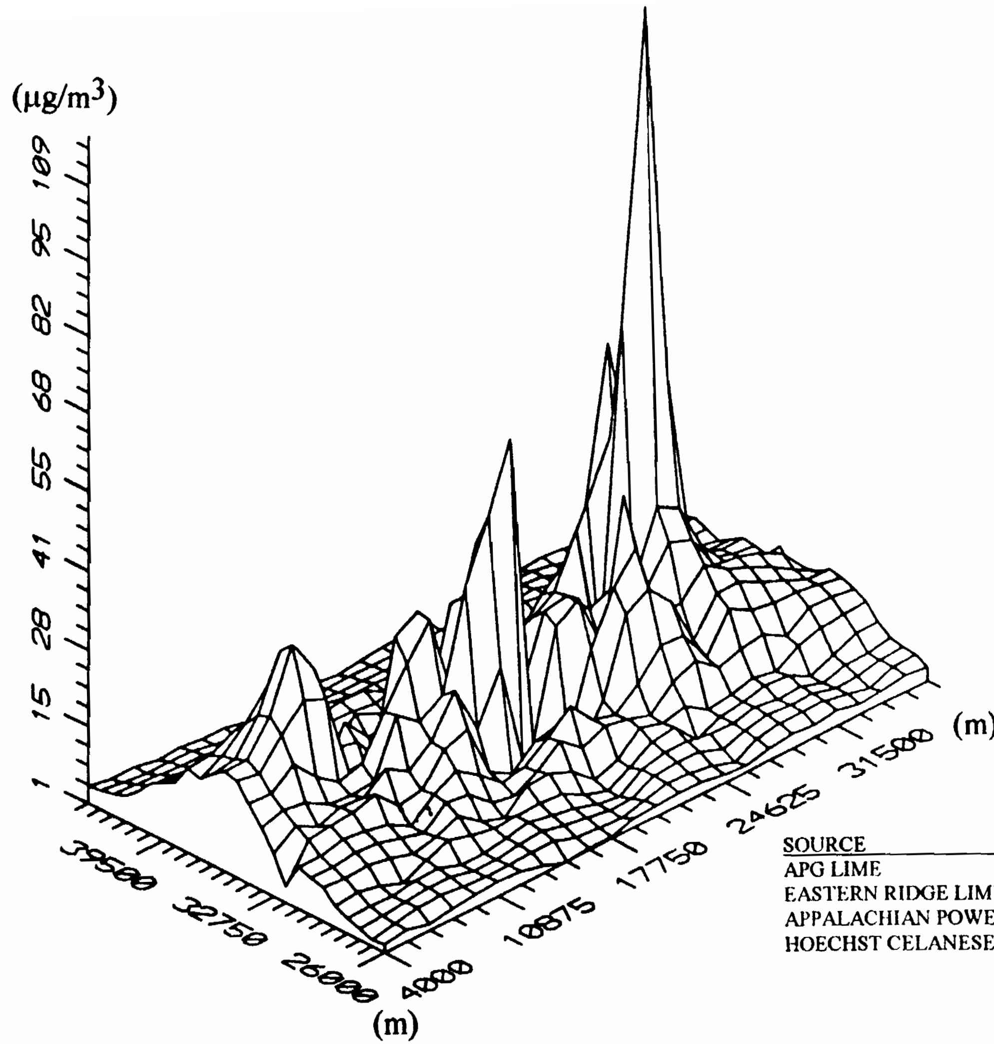


Figure 9.2.1 SO_2 Concentration Isopleths for Hoechst Celanese Data - Annual Average (10 μg/m^3 interval)



SOURCE	X	Y
APG LIME	29800	37100
EASTERN RIDGE LIME	28600	35100
APPALACHIAN POWER	12100	35700
HOECHST CELANESE	21000	33000

Figure 9.2.2 SO_2 Concentration for Hoechst Celanese Data (3-D) - Annual Average

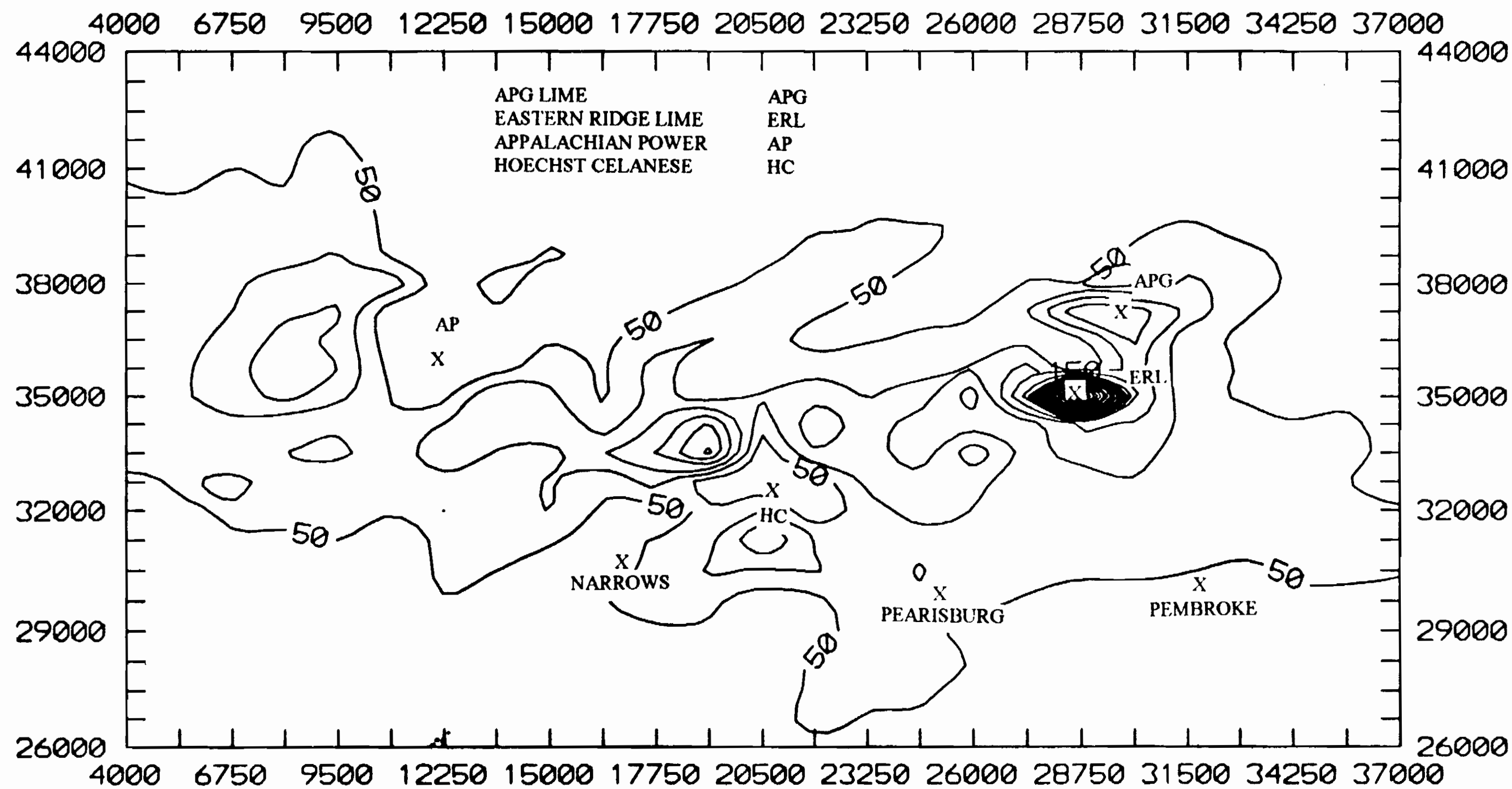
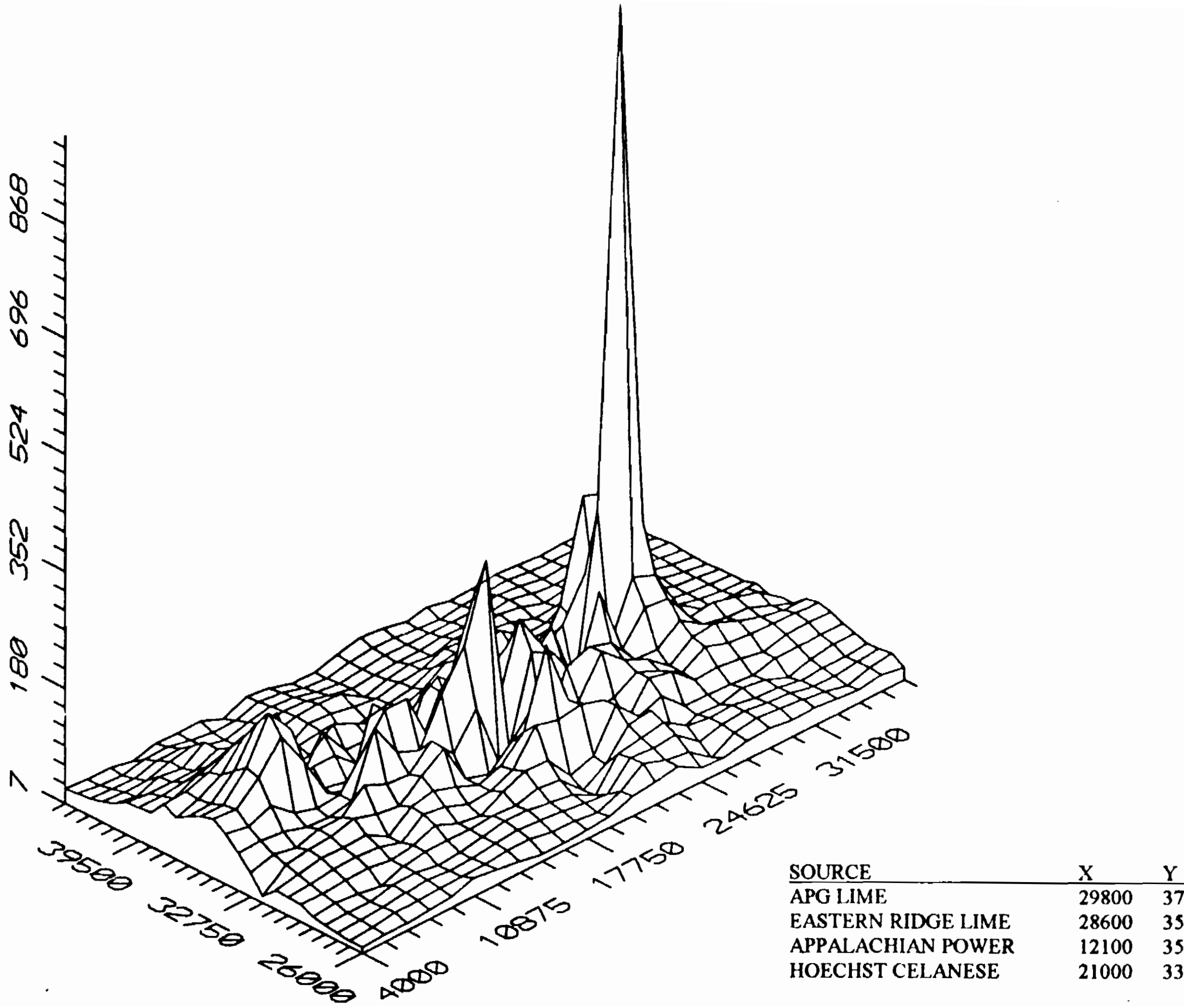


Figure 9.2.3 SO_2 Concentration Isopleths for Hoechst Celanese Data - 24 Hr Average (50 μg/sec interval)



SOURCE	X	Y
APG LIME	29800	37100
EASTERN RIDGE LIME	28600	35100
APPALACHIAN POWER	12100	35700
HOECHST CELANESE	21000	33000

Figure 9.2.4 SO_2 Concentration for Hoechst Celanese Data (3-D) - 24 Hr Average

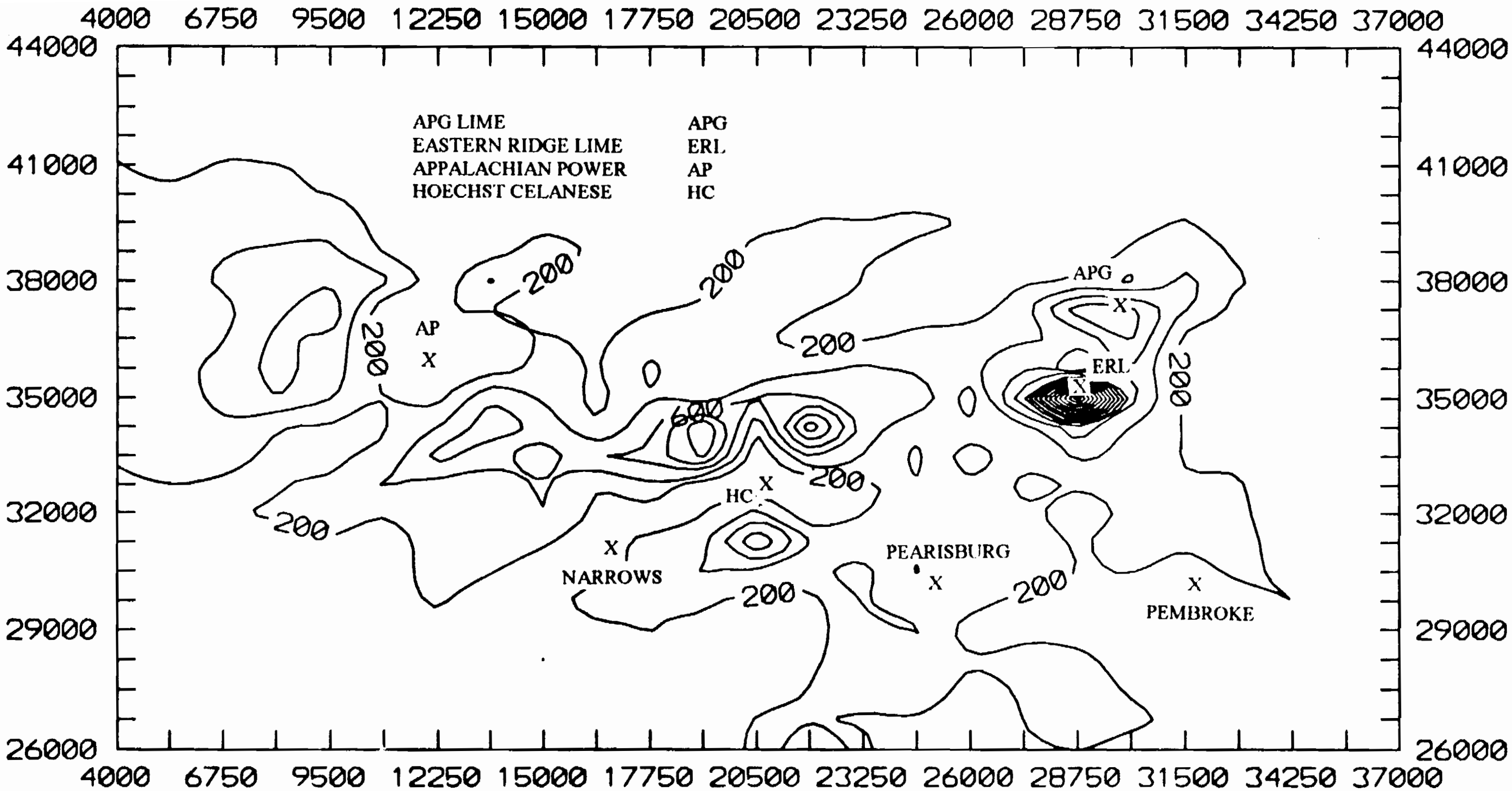
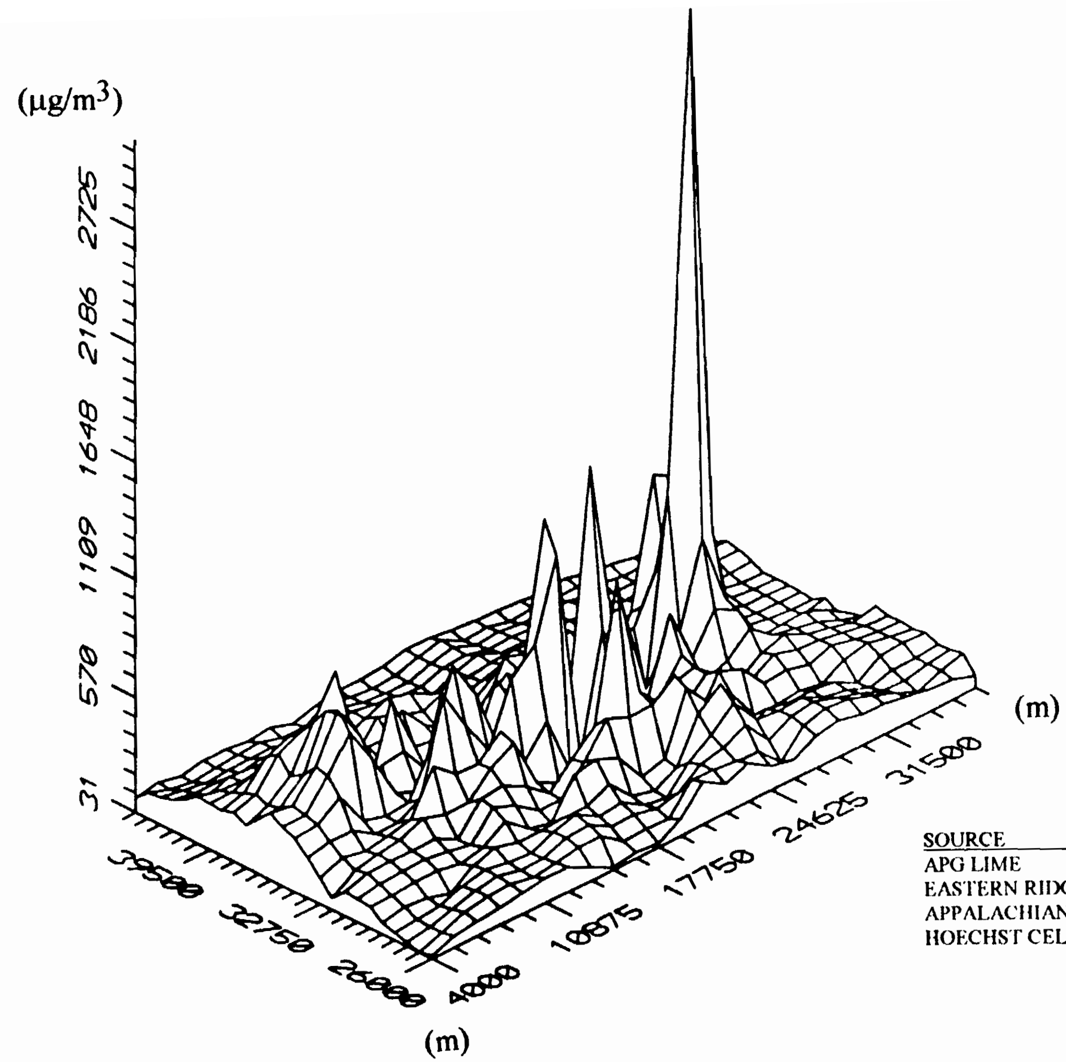


Figure 9.2.5 SO_2 Concentration Isopleths for Hoechst Celanese Data - 3 Hr Average (200 µg/m^3 interval)



SOURCE	X	Y
APG LIME	29800	37100
EASTERN RIDGE LIME	28600	35100
APPALACHIAN POWER	12100	35700
HOECHST CELANESE	21000	33000

Figure 9.2.6 SO_2 Concentration for Hoechst Celanese Data (3-D) - 3 Hr Average

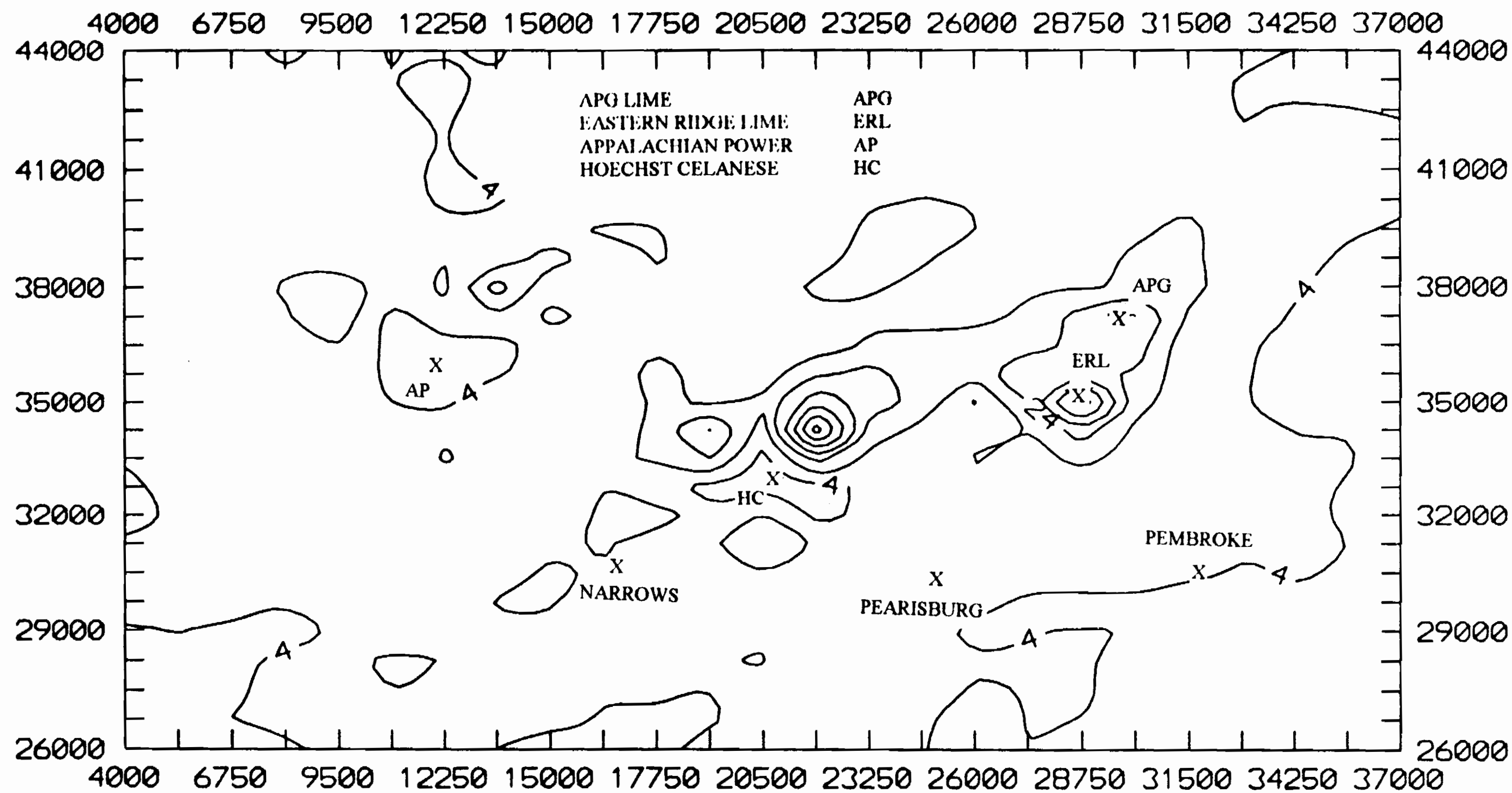
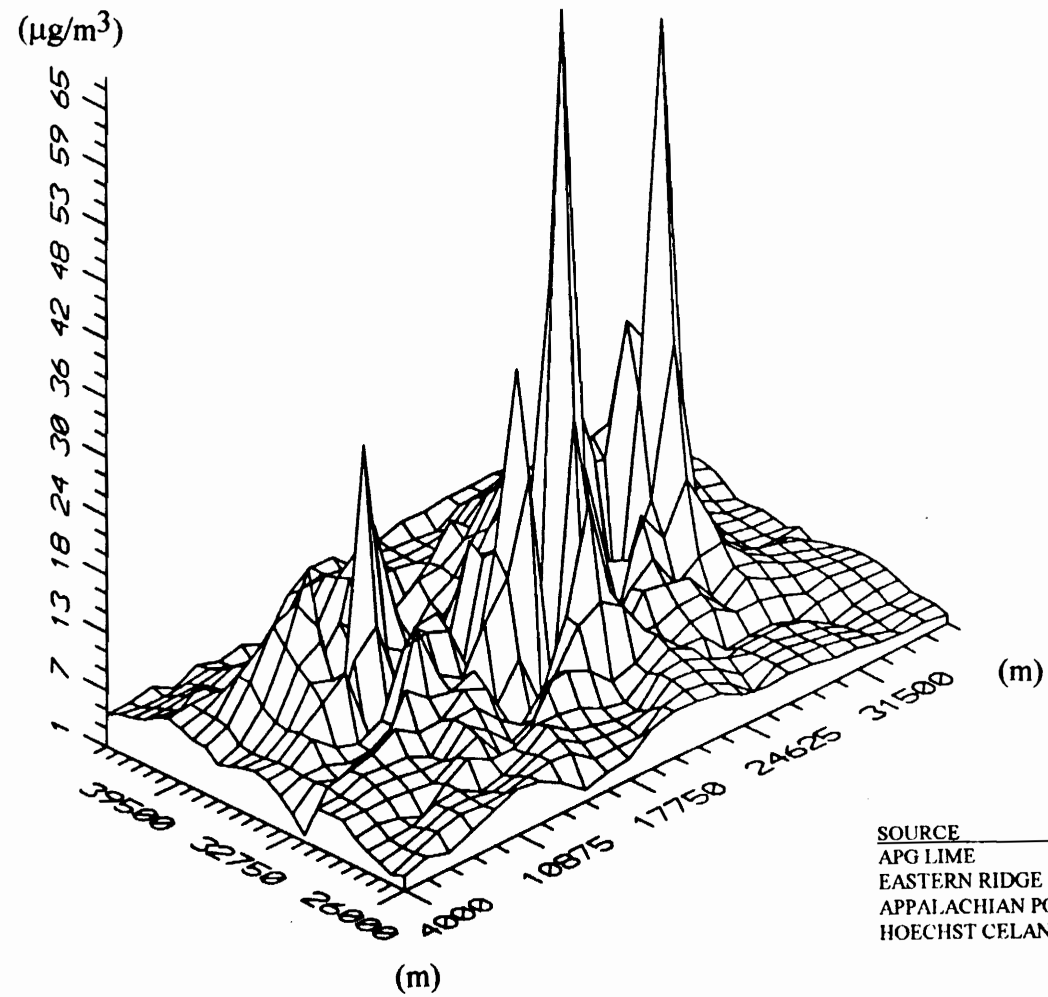


Figure 9.2.7 SO_2 Concentration Isopleths for Huntington, WV Data - Annual Average (10 $\mu g/m^3$ interval)



SOURCE	X	Y
APG LIME	29800	37100
EASTERN RIDGE LIME	28600	35100
APPALACHIAN POWER	12100	35700
HOECHST CELANESE	21000	33000

Figure 9.2.8 SO_2 Concentration for Huntington, WV Data (3-D) - Annual Average

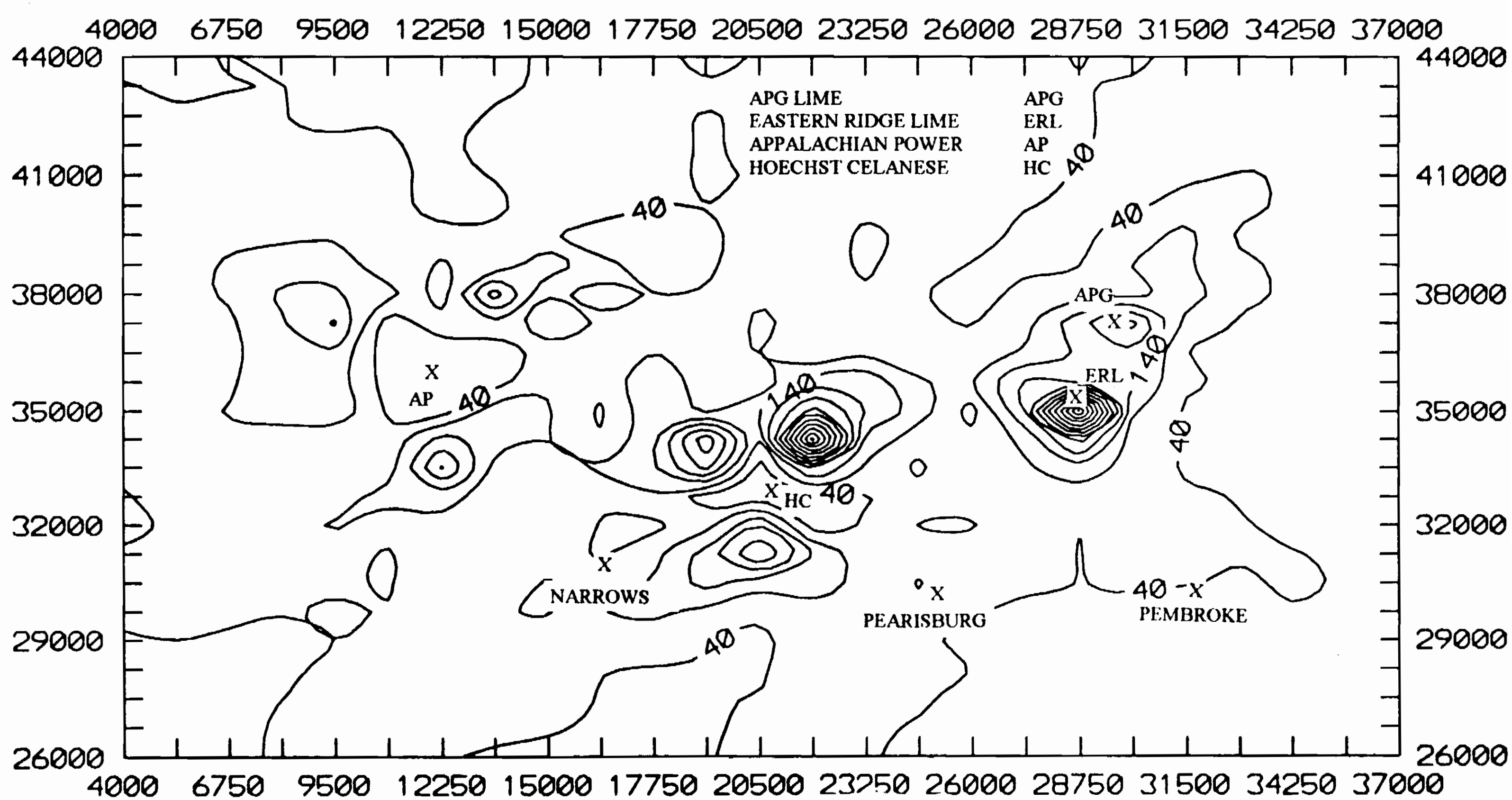
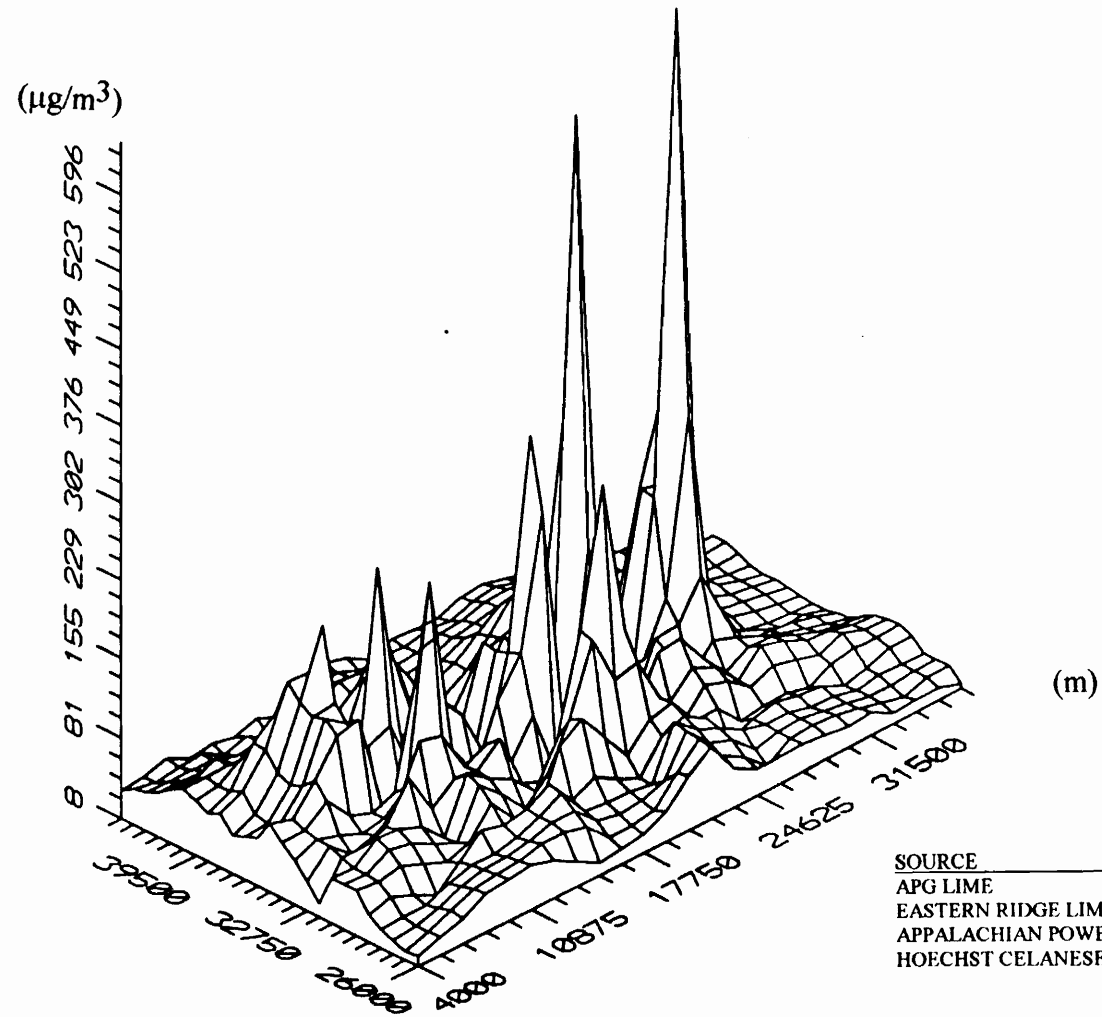


Figure 9.2.9 SO_2 Concentration Isopleths for Huntington, WV Data - 24 Hr Average (50 μg/m^3 interval)



SOURCE	X	Y
APG LIME	29800	37100
EASTERN RIDGE LIME	28600	35100
APPALACHIAN POWER	12100	35700
HOECHST CELANESE	21000	33000

Figure 9.2.10 SO_2 Concentration for Huntington, WV Data (3-D) - 24 Hr Average

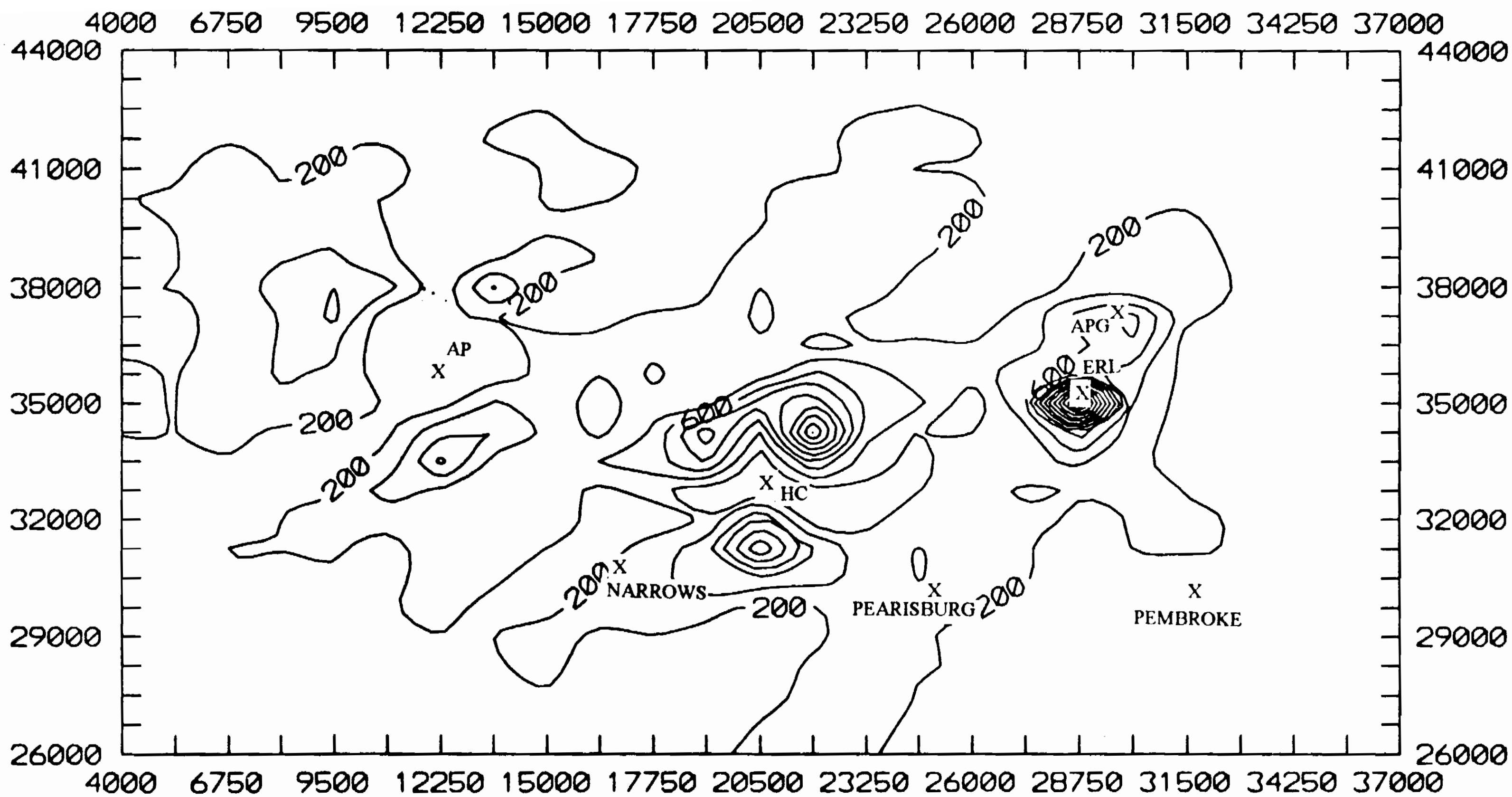
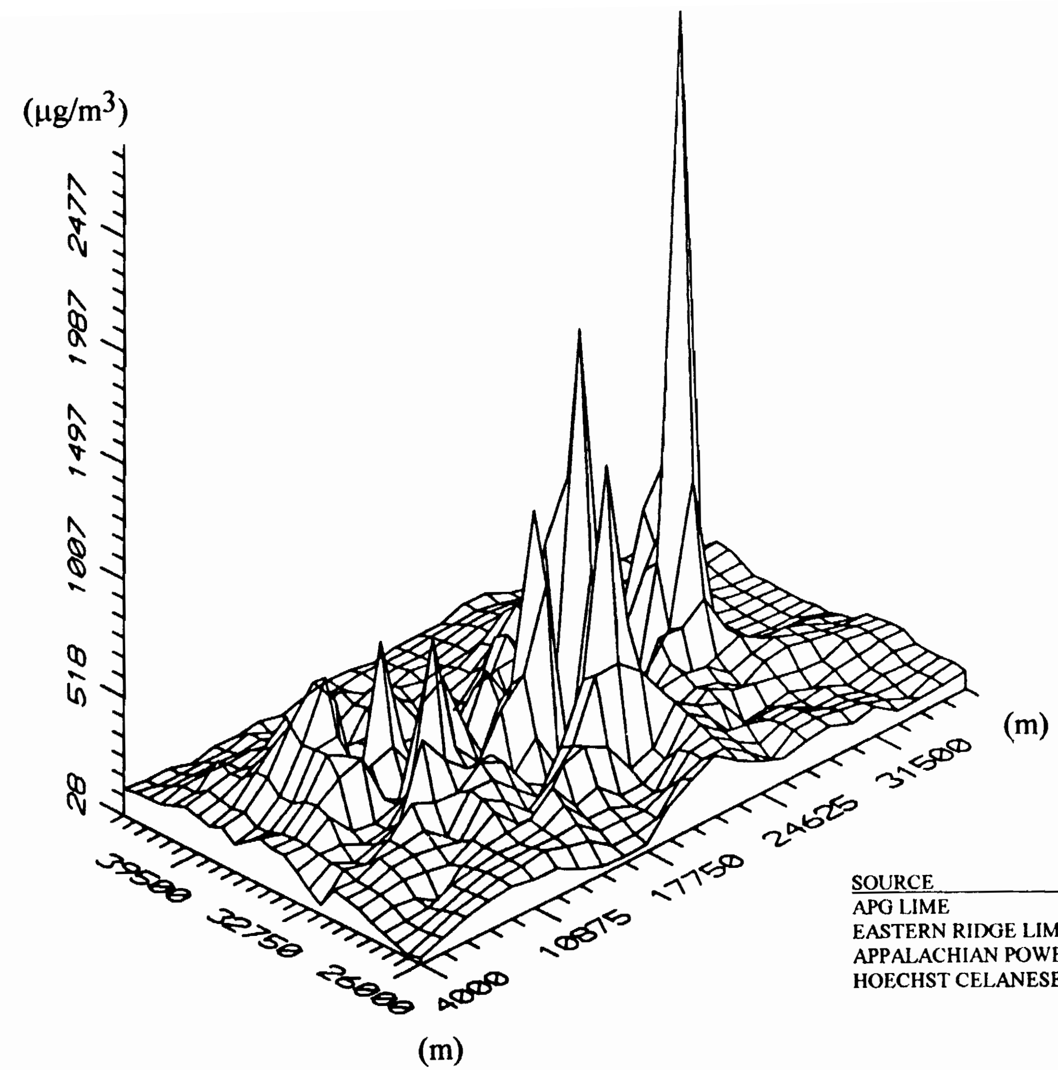


Figure 9.2.11 SO_2 Concentration Isopleths for Huntington, WV Data - 3 Hr Average (200 µg/m^3 interval)



SOURCE	X	Y
APG LIME	29800	37100
EASTERN RIDGE LIME	28600	35100
APPALACHIAN POWER	12100	35700
HOECHST CELANESE	21000	33000

Figure 9.2.12 SO_2 Concentration for Huntington, WV Data (3-D) - 3 Hr Average

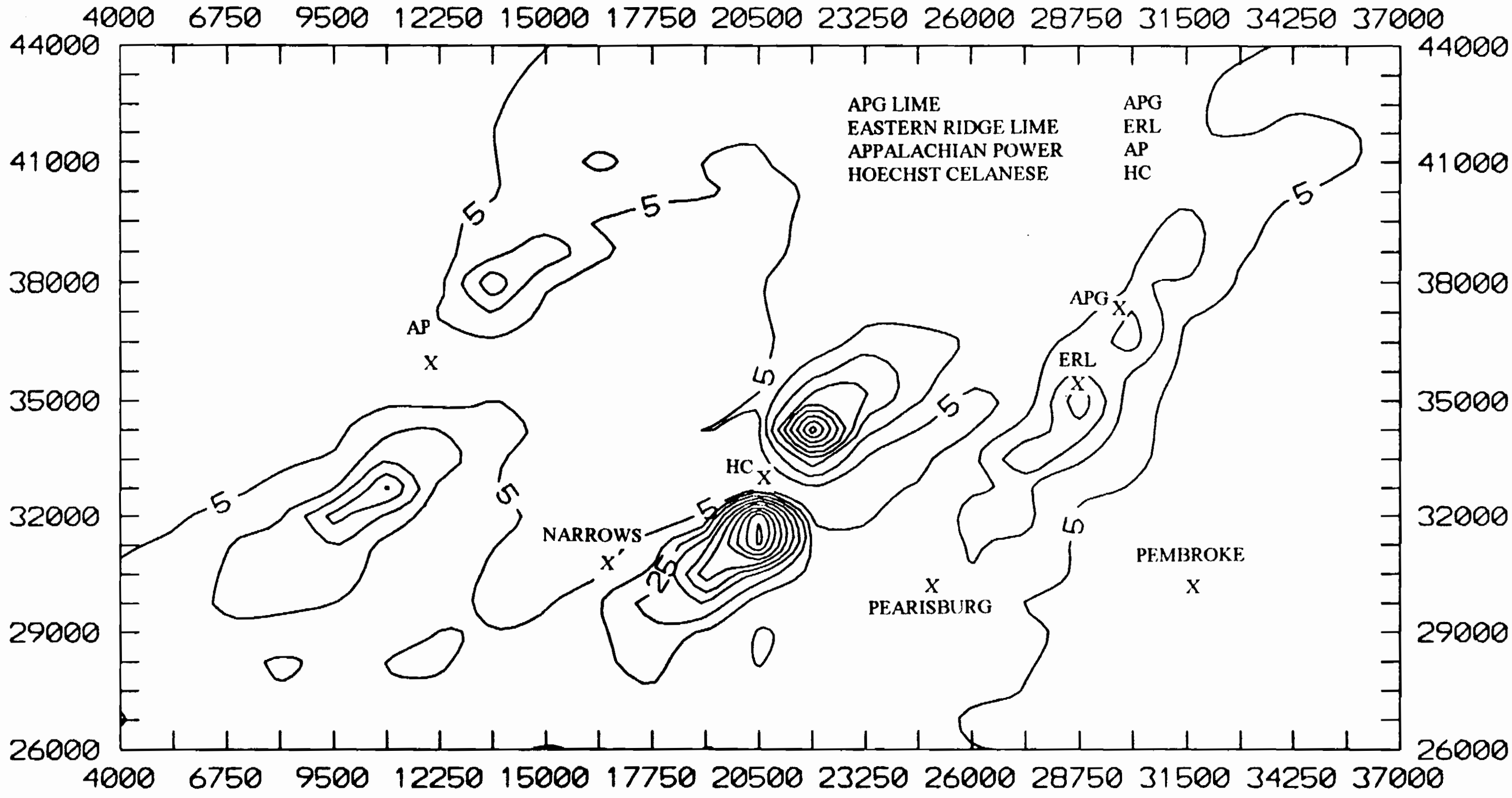
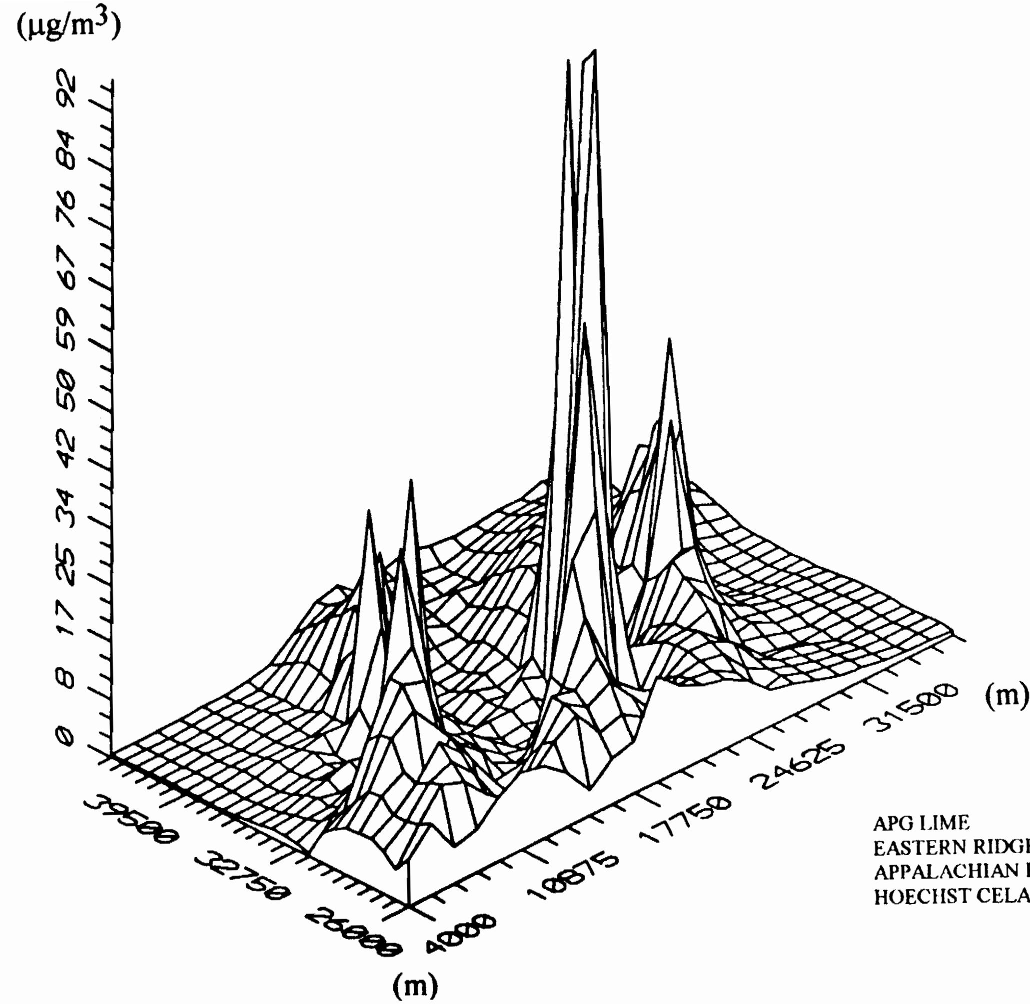


Figure 9.2.13 SO_2 Concentration Isopleths for Eastern Ridge Lime Data - Annual Average (10 µg/m^3 interval)



APG LIME APG
EASTERN RIDGE LIME ERL
APPALACHIAN POWER AP
HOECHST CELANESE HC

Figure 9.2.14 SO_2 Concentration for Eastern Ridge Lime Data (3-D) - Annual Hr Average

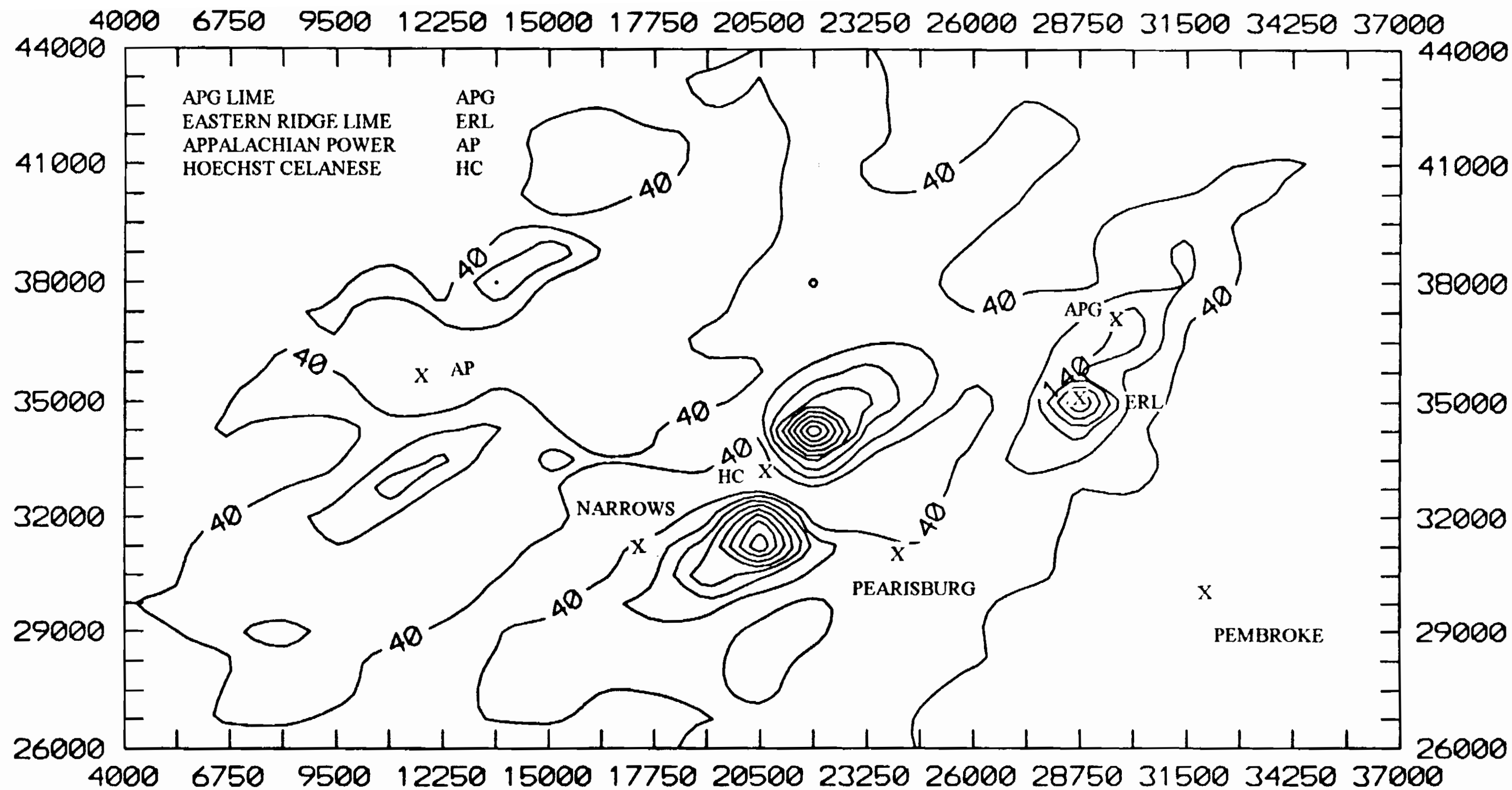
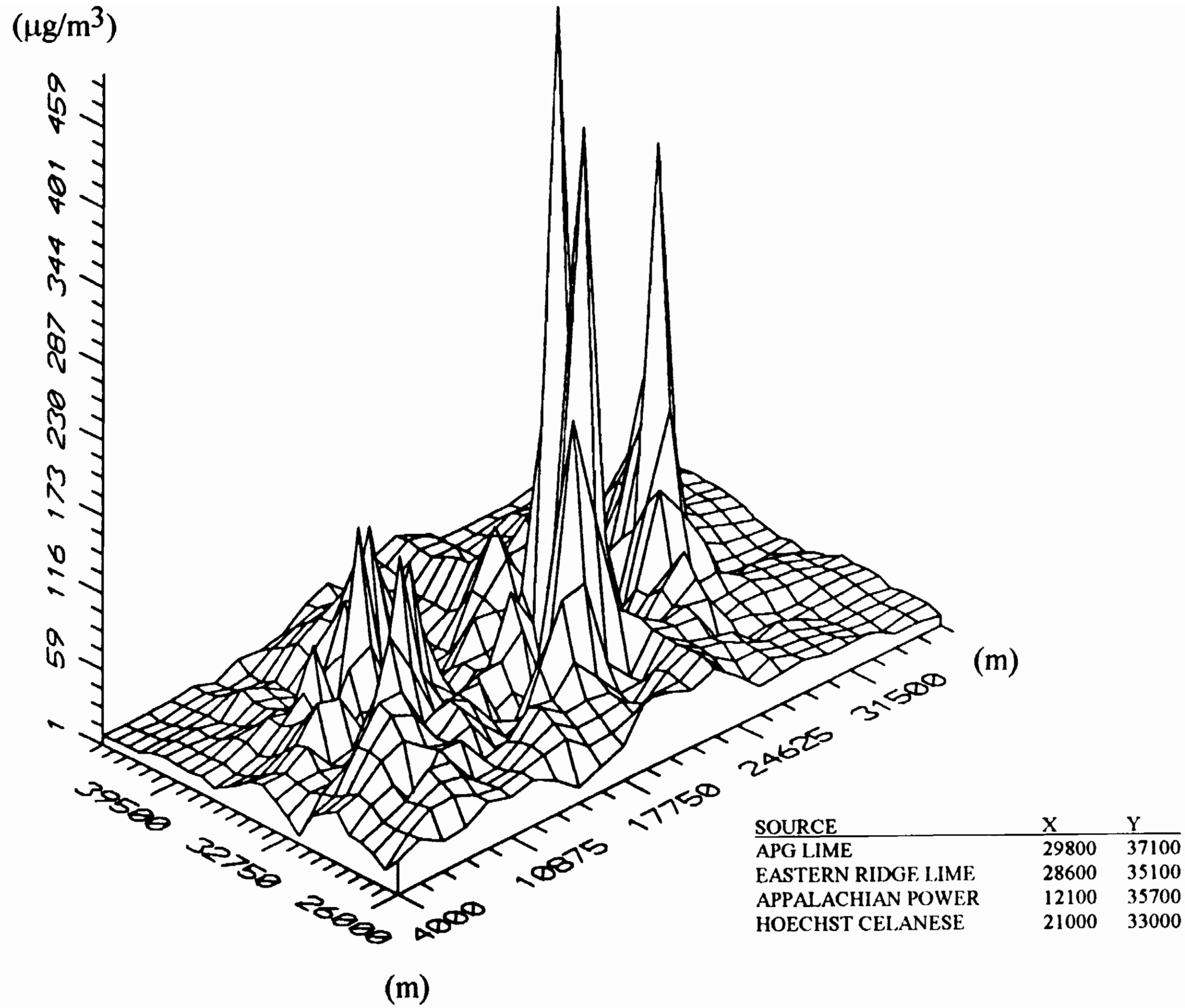


Figure 9.2.15 SO_2 Concentration Isopleths for Eastern Ridge Lime Data - 24 Hr Average (50 μg/m^3 interval)



SOURCE	X	Y
APG LIME	29800	37100
EASTERN RIDGE LIME	28600	35100
APPALACHIAN POWER	12100	35700
HOECHST CELANESE	21000	33000

Figure 9.2.16 SO_2 Concentration for Eastern Ridge Lime Data (3-D) - 24 Hr Average

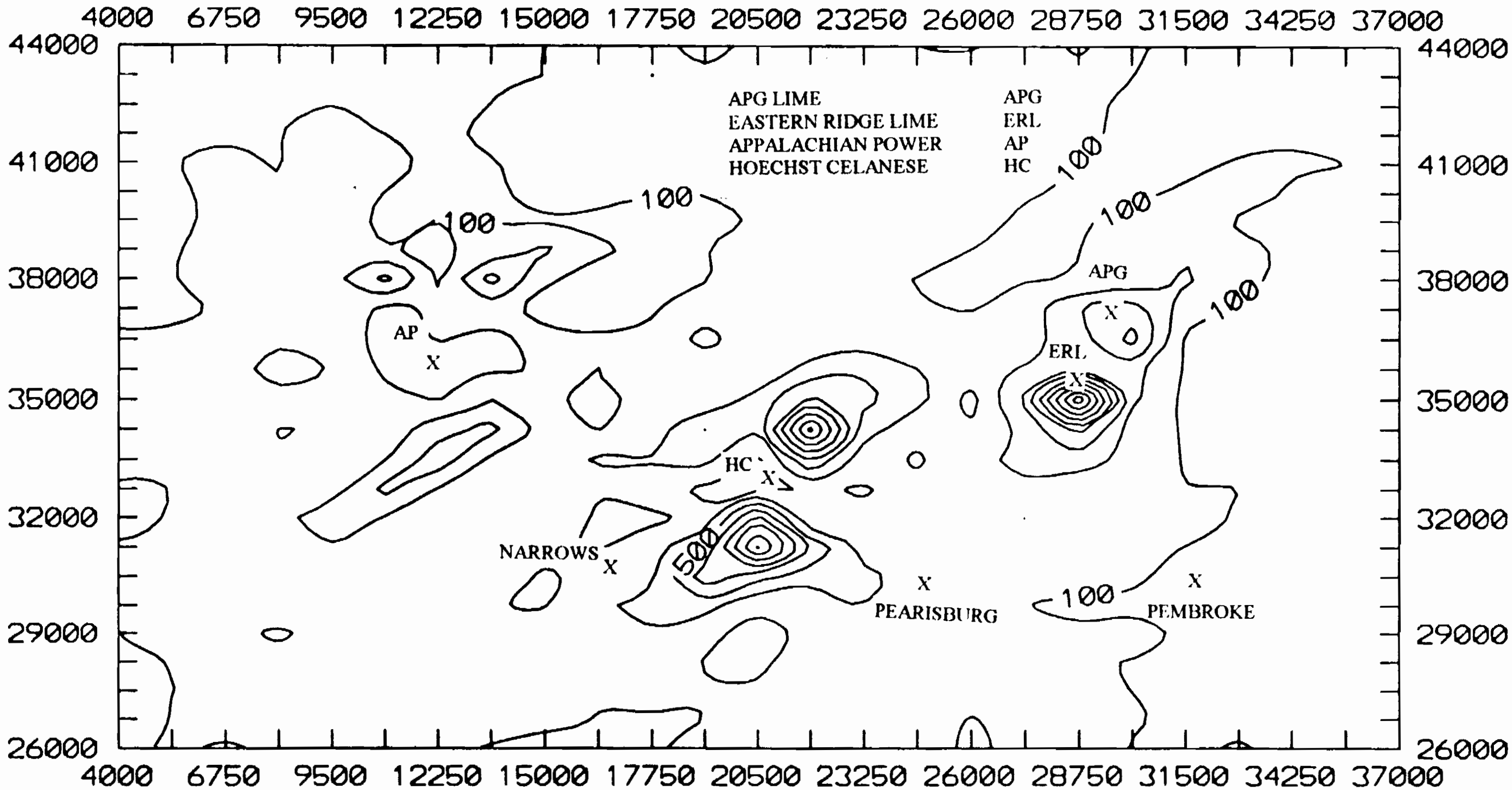
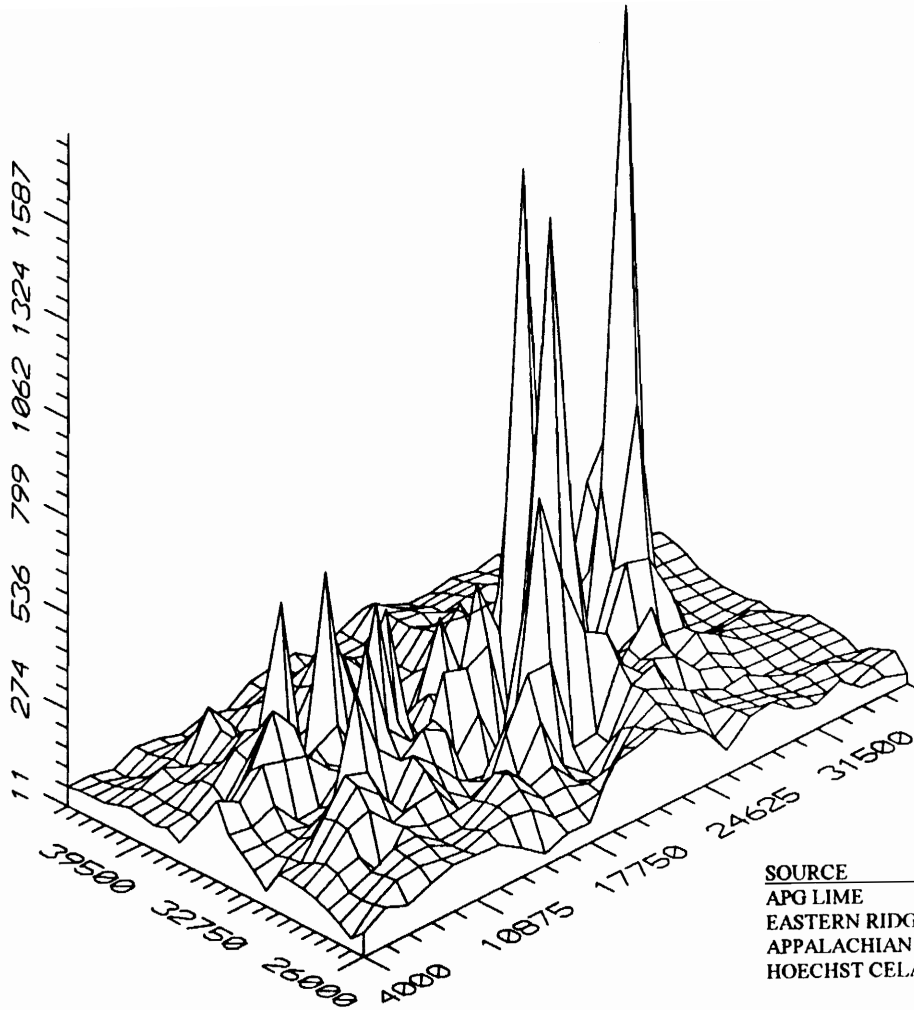


Figure 9.2.17 SO_2 Concentration Isopleths for Eastern Ridge Lime Data - 3 Hr Average (200 µg/m^3 interval)



SOURCE	X	Y
APG LIME	29800	37100
EASTERN RIDGE LIME	28600	35100
APPALACHIAN POWER	12100	35700
HOECHST CELANESE	21000	33000

Figure 9.2.18 SO_2 Concentration for Eastern Ridge Lime Data (3-D) - 3 Hr Average

10.0 Analysis

The most obvious analysis from the model results was the sensitivity to meteorological data. The isopleths showed distinct differences in the concentrations patterns for each meteorological data set. However, the concentration pattern repeated for each time period within a meteorological data set. Figures 9.2.1, 9.2.7, and 9.2.13, the annual average SO_2 isopleths for the three meteorological data sets, show a clear difference in concentration patterns. Figures 9.2.1, 9.2.2, and 9.2.3 illustrate the similarities of isopleth patterns for the different time periods in the same meteorological data set.

10.1 Hoechst Celanese Analysis

The annual isopleths of the Hoechst Celanese meteorological data showed the greatest SO_2 concentration surrounding the Eastern Ridge Lime plant. The bulk of the concentration was above the annual average PSD increment, illustrated by Figure 9.2.2. There were three other significant SO_2 concentration groups; (1) immediately west of APG Lime, (2) between Hoechst Celanese and Appalachian Power, and (3) west of Appalachian Power. The APG Lime plant contributed to a small concentration grouping above the PSD increment. The concentration group between Hoechst Celanese and Appalachian Power contained a significant contour line above 20 $\mu g/m^3$ which could not be conclusively attributed to either source. Each source possibly contributed enough to the concentration grouping that both source's concentrations were within annual average PSD increments. The concentration grouping to the west of Appalachian Power included a small area above the annual PSD increment.

Each concentration group had an oval shape spreading in the east and west directions. This seemed to be the result of east/west prevailing winds. The Hoechst

Celanese plant is located on the New River in the river valley. The portion of the river closest to Hoechst Celanese flows in the east to west direction. Note that meteorological data collected at this site, records winds primarily traveling along the valley, east and west, as opposed to north and south over valley ridges.

10.2 Huntington, WV Analysis

There were two significant concentration groupings, northeast of Hoechst Celanese and immediately south of Eastern Ridge Lime. Although the type D output indicated that the Eastern Ridge Lime concentrations far exceed the Hoechst Celanese output (see Appendix E), Figures 9.2.7 and 9.2.8 showed nearly equal SO_2 concentrations attributed to Hoechst Celanese and Eastern Ridge Lime. In fact, it appeared that the Hoechst Celanese concentration group was slightly higher than Eastern Ridge Lime concentration group. This illustrated the value of the isopleths which provided an overall visual perspective of the SO_2 concentrations in the area.

The concentration groupings were circular in the Huntington, WV isopleths, indicating evenly distributed prevailing winds. A fairly large ridge to the northeast of Hoechst Celanese contributed to the corresponding concentration grouping. The concentration grouping to the south of Eastern Ridge Lime was more complicated. A ridge to the south of Eastern Ridge Lime exists, however, a larger ridge east of the plant running northeast towards the APG Lime plant dominates. A large 24 $\mu g/m^3$ contour line around both APG Lime and Eastern Ridge Lime, resulted from the combination of the ridge to the south and the ridge running to the northeast. The shape of the large concentration resulted from a combination of terrain, prevailing winds, and stability.

10.3 Eastern Ridge Lime Analysis

The concentration groupings were spread in the northeast and southwest directions, the same direction as the valley of the Eastern Ridge Lime plant. Like the Hoechst Celanese data, the predominate Eastern Ridge Lime winds traveled along the valley. The oval spreading was not as dramatic as the Hoechst Celanese meteorological data because of a slight ridge to the south of the Eastern Ridge Lime Plant creating a blocked valley. The two largest concentration groupings were to the northeast and southwest of Hoechst Celanese, due to a combination of the predominate winds and the valley ridges, north and south of the site. The two concentration groupings were well above the PSD increment. The two SO_2 concentration groupings to the northeast and southwest of Appalachian Power, further support the predominate wind theory. The Appalachian Power concentration groupings contain small bands above PSD increments. Interestingly, the groupings were a fair distance away from Appalachian Power. This resulted from the tall stacks of Appalachian Power leading to longer pollutant transport before ground level concentrations maximize. The concentration grouping surrounding Easter Ridge Lime and APG Lime covered the valley of the two plants. This concentration group contained small areas exceeding 25 $\mu g/m^3$.

The type D output suggested that the Eastern Ridge Lime and Hoechst Celanese concentrations were nearly equal. Appendix E, Eastern Ridge Lime meteorological data, annual average concentrations for all groups, showed that seven of the fifteen concentrations were predominately attributed to Eastern Ridge Lime, the remainder belong to Hoechst Celanese. The isopleths clearly portrayed a different story.

11.0 Conclusions

The model results led to certain specific conclusions. The first conclusion relates to the observed environmental impact of the sources and the likely causes of those impacts. Conclusions on the effect of meteorological data on the model results are discussed next. The final conclusion relates to the cause for Eastern Ridge Lime concentrations and possible alternatives. In the systems engineering process, these conclusions are elements of the systems utilization/support phase, designed to make system modifications and improvements where applicable.

The type D output indicated that each source exceeded PSD increments at several receptors for each time period. Since on-site meteorological data was provided for Hoechst Celanese and Eastern Ridge Lime, only conclusions about their possible environmental impacts were appropriate. The results of the Hoechst Celanese source with on-site meteorological data was considered first. The Hoechst Celanese results, listed 15 receptor concentrations, attributed to Hoechst Celanese, above the PSD increment, for each time period; annual, 24 hr, and 3 hr average. Nearly all of the receptor concentrations for each time period were to the west of Hoechst Celanese. These receptors corresponded to the large concentration group to the left of Hoechst Celanese, as illustrated in Figures 9.2.1, 9.2.2, and 9.2.3. The concentration group attributed to Hoechst Celanese is definitely a concern, particularly since the concentration group is near Narrows, VA.

The first consideration of the Eastern Ridge Lime output was that the meteorological data set was incomplete. Only meteorological data for four months is used to create the Eastern Ridge Lime dispersion model output. A full year of meteorological data will likely produce different annual concentration isopleths. All fifteen of the total time period receptor concentrations attributed to Eastern Ridge Lime far exceed the annual PSD increment. However, the concentrations illustrated in Figure 9.2.13 and 9.2.14, does not show a tremendous concentration group above the PSD increment. Meteorological data collected over a year may decrease the annual average for these receptors, drawing conclusions on annual averages concentrations with four months of data was not appropriate. However, the 24 hour and 3 hour averages led to significant conclusions. The highest concentrations for 24 hr and 3 hr time periods can only increase with a full year of meteorological data. The fifteen 24 hr receptor concentrations attributed to Eastern Ridge Lime far exceed the PSD increment. The same was true for the 3 hr concentrations. All of the receptors for both time periods were immediately northeast of the site, within a few hundred meters. Those receptors located on Eastern Ridge Lime property would not be subject to ambient air standards. In either case, the high SO_2 concentrations are significant and of concern.

The Hoechst Celanese and Eastern Ridge Lime dispersion models clearly illustrated the value of on-site meteorological data to the applicant. The concentration groupings attributed to the Hoechst Celanese site were less dramatic for the dispersion model developed with the on-site Hoechst Celanese meteorological data. Eastern Ridge Lime portrayed similar results for it's on-site meteorological data. The isopleths show that the sources would not want to use each others on-site meteorological data. The annual average isopleth for Eastern Ridge Lime, using the Hoechst Celanese meteorological data, resulted in tremendous SO_2 concentration. An air pollution permit would not be granted to Eastern Ridge Lime with these results. The same is true for Hoechst Celanese and the Eastern Ridge Lime meteorological data.

The NWS meteorological data did not seem to be applicable to any of the four sources in this application. In each case, the Huntington, WV meteorological data produced several concentrations for each time period exceeding PSD increments. The

Huntington, WV meteorological data could be useful for major sources whose emissions were not as significant and could get by with conservative dispersion outputs. NWS meteorological data is significantly less expensive and time consuming than on-site meteorological data.

The isopleths illustrate that the SO_2 concentrations attributed to APG Lime were not as great as Eastern Ridge Lime, even though APG Lime emits 883 tons/year of SO_2 compared to 495 tons/year by Eastern Ridge Lime. This was due in a large part to the shorter Eastern Ridge Lime stacks and the significantly lower stack gas temperature. Eastern Ridge Lime stack gas temperatures were 160 °F, where the APG Lime stack gas temperatures exceeded 450 °F. These lower gas temperatures and shorter stacks led to a lower Eastern Ridge plume rise. The lower stack temperatures for Eastern Ridge Lime were attributed to the wet scrubbers used to control emissions. The water used by the scrubbers reduce the stack gas temperature. The APG Lime plant used baghouses to control emissions. The advantage of the APG Lime control equipment were the higher gas temperatures and the SO_2 absorption by the product. Typically, scrubbers use lime to remove SO_2 from stack gases. In this instance the product, lime, absorbed SO_2 which was subsequently removed by the baghouse. Eastern Ridge Lime may consider the dry scrubbers and baghouses to control emissions.

12.0 Recommendations

The recommendations section provides observations of the model application. These observations are examples of feedback to the systems detail design which could result in system modifications. These observations include the model operation, the project execution, and system improvements, specifically with regards to data gathering.

The most critical aspect of the system's detail design was the data accuracy. As illustrated by the results of on-site meteorological data compared to NWS or off-site meteorological data, the accuracy of the input data significantly affected the accuracy of the output data. The conclusions determined from the output data may result in the situation where control equipment for a facility is required. Beneficial improvements in the system can be made realized by developing more accurate methods for collecting and computing data. For example, the PSD increments were the basis of the systems decisions. If the standards were less stringent than they should be, then pollutants are being released to the atmosphere which will harm the environment. If the PSD increments were overly protective, then the industries wasted resources on efforts to protect an already protected environment. In the same context, the dispersion model accuracy was just as important as the standards. The area of the model application which would improve the model accuracy the most related to the meteorological data file. A model that integrated on-site meteorological data files for each source would provide the most accurate model results. More accurate dispersion results lead to better system decisions, particularly by the source management and the government.

Several areas of the project execution could be improved. The receptor data base was some what inaccurate. Entering over 3500 receptors manually left room for error. Fourteen receptors were found to be entered incorrectly. Twelve of the receptors were recalculated and reentered. Two receptor results were discarded. There certainly may be more receptors with incorrect entries. Data concerning on-site building dimension was not included in this project and would have been useful for building down wash considerations.

The IGM model has a couple of areas which could be improved. Integrating CTDMPLUS as the refined complex terrain model would be the greatest improvement. A second improvement would be to include meteorological data file processor programs which can accept a variety of raw data. This processor program could be based on the On-Site Meteorological Program Guidance for Regulatory Modeling Application.

Finally, there was no definitive way to get mixing height data for unprocessed meteorological files. Using NWS data was an option, however, the data was not particularly applicable to on-site meteorological data. Regulatory personnel at the state and federal level were contacted with regard to getting mixing height data for the Eastern Ridge Lime, and none could offer a clear approach for getting mixing height data. Lastly, a better method for receptor elevations is needed. It seemed that there were technologies to digitally and accurately obtain the data, however, none were easily accessible.

Endnotes

1. C. David Cooper and F. C. Alley, Air Pollution Control A Design Approach (Waveland Press, Inc., 1986), p. 7.
2. Benjamin S. Blanchard and Wolter J. Fabrycky, Systems Engineering and Analysis (Prentice Hall, Inc., 1990), p. 2.
3. Blanchard and Fabrycky, p. 1.
4. Department of Environmental Quality (DEQ), Commonwealth of Virginia, Proposed Virginia PSD Air Quality Modeling Guideline (1993), p. 5.
5. DEQ, p. 2.
6. DEQ, p. 2.
7. DEQ, p. 2,3.
8. DEQ, p. 5.
9. DEQ, p. 4.
10. DEQ, p. 7.
11. Cooper and Alley, p. 552.
12. Cooper and Alley, p. 520.
13. Cooper and Alley, p. 521
14. Cooper and Alley, p. 521
15. Cooper and Alley, p. 523.
16. Cooper and Alley, p. 523.
17. Cooper and Alley, p. 527.
18. Cooper and Alley, p. 527.
19. Cooper and Alley, p. 541.
20. Cooper and Alley, p. 541.
21. Cooper and Alley, p. 541.
22. Cooper and Alley, p. 543.
23. Cooper and Alley, p. 525.
24. Cooper and Alley, p. 525.
25. Cooper and Alley, p. 526, 527.
26. Cooper and Alley, p. 527.
27. Cooper and Alley, p. 525, 526.
28. Trinity Consultants, Air Issues Review, #5 (Trinity Consultants, Inc. Sept. 1993), p. 4.
29. DEQ, p. 5.
30. DEQ, p. 1.
31. DEQ, p. 19.
32. DEQ, p. 10.
33. Office of Air Quality Planning and Standards (OAQPS), EPA, Guideline On Air Quality Models (Revised), (NTIS, July 1986) p. 9-10.
34. DEQ, p. 10.

35. Office of Air Quality Planning and Standards (OAQPS), EPA, On-Site Meteorological Program Guidance (OMPG) for Regulatory Modeling Applications, (NTIS, June 1987)
p. 6-31.
36. Cooper and Alley, p. 499.
37. DEQ, p. 13.
38. DEQ, p. 13.
39. DEQ, p. 16.
40. DEQ, p. 16.
41. Trinity Consultants, p. 5.
42. Trinity Consultants, p. 5.
43. Trinity Consultants, p. 5.
44. DEQ, p. 16.
45. DEQ, p. 16.
46. DEQ, Attachment B.
47. IGM User's Guide (United Engineers & Constructors, Inc. 1993), p. 1-1.
48. IGM User's Guide, p. 1-1.
49. IGM User's Guide, p. 1-3.
50. IGM User's Guide, p. 1-2.
51. IGM User's Guide, p. 1-1.
52. IGM User's Guide, p. 2-1.
53. IGM User's Guide, p. 2-2.
54. Trinity Consultants, p. 4.
55. Dr. C. Haycocks, Clean Air Act Amendments of 1990, Acid Rain Provisions (VPI & SU, Dept. of Mining and Minerals Engineering, 1992), p. 2.
56. IGM User's Guide, p. C-13.
57. OAQPS, OMPG, p. 6-21.
58. George C. Holzworth, Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, (USEPA, 1971) pgs. 45, 46, 50, 51.

References

Air Pollution Control A Design Approach. C. David Cooper and F. C. Alley. Prospect Heights, Illinois: Waveland Press, Inc., 1986.

Systems Engineering and Analysis. Benjamin S. Blanchard and Wolter J. Fabrycky. Englewood, New Jersey: Prentice Hall, Inc., 1990.

Proposed Virginia PSD Air Quality Modeling Guideline. Department of Environmental Quality (DEQ), Commonwealth of Virginia. Richmond, VA: 1993.

Guideline On Air Quality Models (Revised). Office of Air Quality Planning and Standards (OAQPS), EPA. NTIS, July 1986) p. 9-10.

Office of Air Quality Planning and Standards (OAQPS), EPA, On-Site Meteorological Program Guidance (OMPG) for Regulatory Modeling Applications, (NTIS, June 1987) p. 6-31.

IGM User's Guide (United Engineers & Constructors, Inc. 1993), p. 1-1.

Dr. C. Haycocks, Clean Air Act Amendments of 1990, Acid Rain Provisions (VPI & SU, Dept. of Mining and Minerals Engineering, 1992), p. 2.

George C. Holzworth, Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, (USEPA, 1971) pgs. 45, 46, 50, 51.

Trinity Consultants, Air Issues Review, #5 (Trinity Consultants, Inc. Sept. 1993), p. 4.

Appendix A

A.1 Equivalence Approval Letters

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

1 8 NOV 1992

George G. McComb, Jr.
Chief, Air Quality and Meteorology
United Engineers and Constructors
30 South 17th Street
Post Office Box 8223
Philadelphia, Pennsylvania 19101

Dear Mr. McComb:

We have reviewed the portion of the demonstration of equivalence of the Integrated Gaussian Model (IGM), Version 92120, as it relates to the Industrial Source Complex Short Term (ISCST2) Model, the Complex I Model, and the Rough Terrain Dispersion Model (RTDM). We are currently reviewing the portion of the equivalence demonstration that relates to the use of the SHORTZ Model, which we expect to complete in a few weeks.

IGM is intended to: (1) replicate ISCST2 for terrain below stack height, (2) replicate the Complex I Model, RTDM, and SHORTZ for complex terrain, and (3) implement the EPA guidance for intermediate terrain. We find that IGM has been adequately demonstrated to be equivalent to ISCST2 for flat (and rolling) terrain, equivalent to Complex I and RTDM for complex terrain, and to properly implement the EPA Intermediate Terrain Policy in its use of ISCST2, Complex I, and RTDM. IGM may be used as an equivalent to those EPA models and procedures.

The demonstration of equivalence can be divided into three parts: (1) equivalence to the regulatory flat terrain model, (2) equivalence to one or more regulatory complex terrain models, and (3) correct implementation of the EPA Intermediate Terrain Guidance.

First, IGM was tested for equivalence to ISCST2 for flat and rolling terrain, using model to model comparisons for an area source, a volume source and point sources in flat terrain having stack heights of 35, 100, and 200 meters, for a point source of 200 meter stack height and rolling terrain below stack height, and a 35 meter stack with terrain exceeding stack height. The last test was included to verify that "terrain chopping" is properly implemented. This is essential for the correct implementation of the intermediate guidance. One year each of meteorological data for Pittsburgh (1964) and Oklahoma City (1984) were used.

Second, IGM was tested for equivalence to the Complex I, RTDM, and SHORTZ models using data sets developed for the equivalence demonstration of the previous version of IGM. A 35 meter stack was used, with terrain data consistent with the terrain used in the "terrain chopping test" which was conducted for ISCST2 (see above). This consistency allows the same data sets to be used for the intermediate terrain test described below.

Third, IGM was tested to be certain it correctly implemented the EPA intermediate terrain procedures. Several days of individual data output from each part of the model (ISCST2, Complex I, RTDM, and SHORTZ) were reviewed on an hour-by-hour basis to verify that the correct value was selected in each case by IGM.

Sincerely,

Russell F. Lee
Meteorologist
Source Receptor Analysis Branch

Enclosure

cc: J. Tikvart
D. Wilson
Regional Modeling Contact, Regions I-X

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

2 1 JAN 1993

George G. McComb, Jr.
Chief, Air Quality and Meteorology
United Engineers and Constructors
30 South 17th Street
Post Office Box 8223
Philadelphia, Pennsylvania 19101

Dear Mr. McComb:

We have completed our review of your demonstration of equivalence of the Integrated Gaussian Model (IGM), Version 92120, as it relates to the SHORTZ model. As you know, we have previously reviewed the portion of the demonstration of equivalence of the IGM, Version 92120, as it relates to the Industrial Source Complex Short Term (ISCST2) model, the complex terrain screening models, Complex I and Rough Terrain Dispersion Model (RTDM).

We find that IGM has been adequately demonstrated to be equivalent to the ISCST2 simple terrain model; to be equivalent to the Complex I, RTDM, and SHORTZ complex terrain models; and to properly implement the Environmental Protection Agency (EPA) intermediate terrain procedures (memorandum from Joseph A. Tikvart to Alan J. Cimorelli, dated June 8, 1989, enclosed) in its use of ISCST2 with Complex I, RTDM, and SHORTZ.

The demonstration of equivalence can be divided into three parts: (1) equivalence to a regulatory simple terrain model, (2) equivalence to one or more regulatory complex terrain screening models, and (3) correct implementation of the EPA intermediate terrain guidance. IGM is intended to: (1) replicate the ISCST2 model for simple terrain, (2) replicate the Complex I, RTDM, and SHORTZ models for complex terrain, and (3) implement the EPA intermediate terrain procedures.

First, IGM was tested for equivalence to the ISCST2 model, using model to model comparisons for an area source, a volume source and point sources in flat terrain having stack heights of 35, 100, and 200 meters, for a point source of 200 meter stack height and rolling terrain below stack height, and a 35 meter stack with terrain exceeding stack height. The last test was included to verify that "terrain chopping" is properly implemented. This is essential for the correct implementation of the intermediate terrain guidance. One year each of meteorological data for Pittsburgh (1964) and Oklahoma City (1984) were used.

Second, IGM was tested for equivalence to Complex I, RTDM, and SHORTZ using data sets developed for the equivalence demonstration of the previous version of IGM. A 35 meter stack was used, with terrain data consistent with the terrain used in the "terrain chopping test" which was conducted for ISCST2 (see above). This consistency allows the same data sets to be used for the intermediate terrain test described below.

Third, IGM was tested to be certain it correctly implemented the EPA Intermediate Terrain Policy. Several days of individual data output from each part of the model (ISCST2, Complex I, RTDM, and SHORTZ) were reviewed on an hour by hour basis to verify that the correct value was selected in each case by IGM consistent with EPA Policy regarding intermediate terrain.

Sincerely,

Russell F. Lee

Russell F. Lee
Meteorologist
Source Receptor Analysis Branch

Appendix B

B.1 Run File for Pearisburg Run - Hoechst Celanese Met Data

```
        |**************************************|
        |    FILE SPECIFICATION SECTION        |
        |**************************************|

Fa-----------------------------------|
PCEL.MET                          * I REQ Meteorological data input file
P1.REC                            * I REQ Receptor file
P1.SRI                            * I REQ Source file
n/a                               * I OPT Optional run file
n/a                               * I OPT Terrain profiles (REQ for RTDM)
PCEL.OFP                          * O REQ Output print file - ASCII
n/a                               * O OPT Type C disk output - binary
PCEL.DET                          * O OPT Detailed report file - ASCII
n/a                               * O OPT Processed conc. output - binary

        |**************************************|
        |     GENERAL RUN SET-UP SECTION      *|
        |**************************************|

Fi-----|
   0  istask  Stop & ask (0) or proceed directly (1)
   0  istat   Status: -1=none, 0=screen only, 1=day, 2=hr, 3=srce, 4=rec;
   0  ioprno  Use optional run file y(1) or n(0)
Fa--------------------|
 PEARISBURG RUN        :24-character Run i.d.

        |**************************************|
        |    PRINTOUT CONTROL SECTION         *|
        |**************************************|

Fi-----|
   2  iopdet  Detailed reports? y(1) n(0) sep(2) (incl.mn excl.-mn) |m=1or2
   0  iprgrp  Print source groups together(0) or separately(1)      |n=1,2or3
   0  isprcp  Suppress prt detailed receptor data     y(1) n(0)     |y=B,DorC
   0  ispsrc    "    "  detailed source data        y(1) n(0)
   0  ispdmo    "    "  model tech options          y(1) n(0)
   0  isprsd    "    "  source/rec min. dist        y(1) n(0)
   0  ispsrg    "    "  src groups/totals summ      y(1) n(0)
```

```
|*************************************|
|*      POINT SOURCE SECTION         *|
|*        (npsorc lines)             *|
|*************************************|
```

R S Vi	NUM a	Source Name	Q g/sec r	XS (m)	YS (m)	ZS (ft)	Hs (m)	Ts (K)	Vs (m/s)	D (m)	HB (m)	PW (m)
1	0001	APG LIME #1	7.2	29800	37100	1820	17.7	533.3	5.56	3.35	0.0	0.0
1	0002	APG LIME #2	7.5	29800	37100	1820	20.4	513.9	25.12	1.68	0.0	0.0
1	0003	APG LIME #3	10.7	29800	37100	1820	24.4	522.2	15.16	2.44	0.0	0.0
2	0001	ER LIME	14.2	28600	35100	1700	9.1	344.4	7.21	1.22	0.0	0.0
3	0001	AP PWR #1	24.0	12100	35700	1530	68.6	424.4	13.46	5.18	0.0	0.0
3	0002	AP PWR #2	21.2	12100	35700	1530	68.6	424.4	13.46	5.18	0.0	0.0
3	0003	AP PWR #3	205.5	12100	35700	1530	132.6	387.8	18.34	5.18	0.0	0.0
4	0001	HC #1	9.3	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0002	HC #2	24.5	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0003	HC #3	32.3	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0004	HC #4	9.1	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0005	HC #5	24.4	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0006	HC #6	30.6	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0007	HC #7	33.9	21000	33000	1600	45.7	444.4	17.78	2.01	0.0	0.0
4	0008	HC #8	0.1	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0

```
|******************************************|
|*      VOLUME SOURCE SECTION             *|
|*        (nvsorc lines)                  *|
|******************************************|
```

SNUM	Q G	W MF	Q	Source Name	Q (g/sec)	Xctr (m)	Yctr (m)	ZS (ft)	Hctr (m)	SGZ0 (m)	SGY0 (m)

```
|*************************************|
|*      AREA SOURCE SECTION          *|
|*        (nasorc lines)             *|
|*************************************|
```

SNUM	Q G	W MF	Q	Source Name	Q (g/s/m2)	XSw (m)	YSw (m)	ZS (ft)	Heff (m)	Width (m)

```
        |*******************************************|
        |* METEOROLOGICAL DATA FORMAT SECTION    *|
        |*******************************************|
Fi-----|
    2  iopfm  Met data format:        1=RAMMET unformatted; -1=RAMMET binary
                                      2=IGM Hourly-ASCII;  -2=ISCST2 default ASCII
Fr-----|
  10.00  ranht  Wind speed measurement height, meters
   0.00 bsmetf  Base elevation of met measurements (feet); applicable only with SHORTZ
        |*******************************************|
        |* ANALYSIS SCOPE SECTION: METEOROLOGY    *|
        |*******************************************|
Fi-----|
   118  njdyp  Number of jdys or ranges to process (0=process all met data)
Vi-|---|  -->enter minimum (1,njdyp) lines below in ascending order;
      0  jdp1,jdp2: if jdp2=0, jdp1 is indiv day, otherwise, range jdp1-jdp2

        |*************************************|
        |*  ANALYSIS SCOPE SECTION: RECEPTORS  *|
        |*************************************|
Fi-----|
    0  ngrslc Number of grids to select from rec file (0=default to receptor file)
Vi-----|  -->enter minimum (1,ngrslc) lines
    1  Grid number to select

        |*************************************|
        |*     ANALYSIS SCOPE SECTION          *|
        |*     SOURCE GROUPS & TOTALS          *|
        |*************************************|

Fi-----|
    0  ngrpsl Number of groups to select from src file (0=default to src file)
    0  ngtots Number of totals to create            (0=default to src file)

        |*******************************|
        |*   Source Group Selection Section      *|
        |*******************************|
|
|Group  Source--->A non-zero source i.d. will create a new group with this
| i.d.   i.d.     one source (cannot add groups if ngroup in src file is 0)
Vi---|i----|
   0    0
```

```
          |*********************************|
          |*       Group Totals Section    *|
          |*          (ngtots lines)       *|
          |*********************************|
|
|                         num-  Group numbers that define total    |
|       Total Name(s)       num   (max. 99-enter numnum/10 lines)    |
Va----------------------------------|i|i--|---|---|---|---|---|---|---|---|---|
(Total name template)           0  0  0  0  0  0  0  0  0  0  0  1

          |***************************************|
          |*   CONC. THRESHOLD-BASED SECTION    *|
          |*          (TYPE C)                   *|
          |*     (numcsc cases/blocks)           *|
          |***************************************|

Fi-----|
     0  numcsc  Number of conc. threshold-based cases (numcs blocks below)
  1000  maxtpc  Maximum allowed size of threshold-based (Type C) file, K-bytes
Bi-----|
     0  ktcsc   Total to which this threshold case applies
     0  ncntc   Number of threshold testing conditions (1 or 2)
     0  ngrc1   Number of groups to sum for condition 1 (0=all grps in total)
     0  ngrc2   Number of groups to sum for condition 2 (0=all grps in total)
     0  igwrt   Include group contributions in file & printout y(1) n(0)
     0  iusth2  Use of second threshold testing condition:
        (1)     To create a summary ("significant impact") report that is
                      based on both concentration sums exceeding the applicable
                      threshold criteria. Concentrations written to the "Type C"
                      file, and in the detailed report (if selected), are based
                      on meeting the first threshold criterion only
        (2)     To limit concentrations written to file, and in the
                      detailed report (if selected), to only those that meet
                      both threshold criteria
fi------|--------|--------|-------|
      0       0       0       0  Averaging period: 1 (process) or 0 (do not)
fr------|--------|--------|-------|
    0.0     0.0     0.0     0.0  Threshold chi, cond. 1 (negative=test abs val)
    0.0     0.0     0.0     0.0  Threshold chi, cond. 2 (negative not allowed)
vi-|---|---|---|---|---|---|---|---|---| ->Group ids for ngrpc1/2 not = 0
  0   0   0   0   0   0   0   0   0   0 cond 1 (repeat lines as necessary)
  0   0   0   0   0   0   0   0   0   0 cond 2 (repeat lines as necessary)
```

B.2 Source File for Pearisburg Run - Hoechst Celanese Met Data

```
         |**********************************|
         |*      FILE SIZING SECTION        *|
         |**********************************|

Fi-----|
   4  ngroup  Number of source groups (0=each source is a group)
   0  ngtots  Number of totals (0=one total over all groups)
  15  npsorc  Number of point sources
   0  nvsorc  Number of volume sources
   0  nasorc  Number of area sources
   0  nsdsbd  Number of sets of direction-specific building dimensions
   0  nqf1    Number of "Qflag-1" arrays (vary seasonally)
   0  nqf2    Number of "Qflag-2" arrays (vary by month)
   0  nqf3    Number of "Qflag-3" arrays (vary by hour of day)
   0  nqf4    Number of "Qflag-4" arrays (vary by stability & wind speed)
   0  nqf5    Number of "Qflag-5" arrays (vary by season and hour of day)

         |**********************************|
         |*      GROUP TOTALS SECTION       *|
         |*        (ngtots lines)           *|
         |**********************************|

|                          num-  Group numbers that define total         |
|       Total Name(s)        num   (max. 99-enter numnum/10 lines)|
Va-----------------------------------|i|i--|---|---|---|---|---|---|---|---|---|
(Total name)                   0  0  0  0  0  0  0  0  0  0  0

         |*****************************************|
         |*      SOURCE GROUPING SECTION           *|
         |*         (ngroup lines)                 *|
         |*****************************************|

|                          Group  Short  -(Group # assigned to
|       Group Name(s)             i.d. Name(s)   sh name if blank)
Va-----------------------------------------|i-|a----------|
APG LIME CO                          1      ALC
EASTERN RIDGE LIME CO                2      ERL
APPALACHIAN POWER CO                 3       AP
HOECHST CELANESE                     4       HC
```

|***********************************|
|* POINT SOURCE SECTION *|
|* (npsorc lines) *|
|***********************************|

R S Vi	NUM	Source Name	Q g/sec	XS (m)	YS (m)	ZS (ft)	Hs (m)	Ts (K)	Vs (m/s)	D (m)	HB (m)	PW (m)
1	0001	APG LIME #1	7.2	29800	37100	1820	17.7	533.3	5.56	3.35	0.0	0.0
1	0002	APG LIME #2	7.5	29800	37100	1820	20.4	513.9	25.12	1.68	0.0	0.0
1	0003	APG LIME #3	10.7	29800	37100	1820	24.4	522.2	15.16	2.44	0.0	0.0
2	0001	ER LIME	14.2	28600	35100	1700	9.1	344.4	7.21	1.22	0.0	0.0
3	0001	AP PWR #1	24.0	12100	35700	1530	68.6	424.4	13.46	5.18	0.0	0.0
3	0002	AP PWR #2	21.2	12100	35700	1530	68.6	424.4	13.46	5.18	0.0	0.0
3	0003	AP PWR #3	205.5	12100	35700	1530	132.6	387.8	18.34	5.18	0.0	0.0
4	0001	HC #1	9.3	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0002	HC #2	24.5	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0003	HC #3	32.3	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0004	HC #4	9.1	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0005	HC #5	24.4	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0006	HC #6	30.6	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0
4	0007	HC #7	33.9	21000	33000	1600	45.7	444.4	17.78	2.01	0.0	0.0
4	0008	HC #8	0.1	21000	33000	1600	48.8	485.6	12.43	3.51	0.0	0.0

|**|
|* VOLUME SOURCE SECTION *|
|* (nvsorc lines) *|
|**|

SNUM	Q G	W MF	Q	Source Name	Q (g/sec)	Xctr (m)	Yctr (m)	ZS (ft)	Hctr (m)	SGZ0 (m)	SGY0 (m)

|***********************************|
|* AREA SOURCE SECTION *|
|* (nasorc lines) *|
|***********************************|

SNUM	Q G	W MF	Q	Source Name	Q (g/s/m2)	XSw (m)	YSw (m)	ZS (ft)	Heff (m)	Width (m)

```
|DIRECTION-SPECIFIC BUILDING DIMENSION INPUTS (NSDSBD/5 BLOCKS)|
|NOTE THAT A VALUE OF -1.0 REPEATS THE VALUE FROM THE LAST FLOW|
|VECTOR ALSO NOTE THAT WAKE FLAGS ARE USED ONLY IF TECH         |
|OPTION IWKFLG IS IWKFLG IS = 1 **.LowerBound                   |
| N=  0   SET N+1      SET N+2      SET N+3      SET N+4      SET N+5 . Wake|
|      BH    BPW    BH    BPW    BH    BPW    BH    BPW    BH    BPW.Flags|
| FV                                                     .12345|
Bi-|r-------|-------|---------|-------|-------|--------|--------|-------|--------|------------||||||
 10   0.00  0.00   0.00  0.00   0.00  0.00   0.00   0.00   0.00  0.0000000
 20  -1.00 -1.00  -1.00 -1.00  -1.00 -1.00  -1.00  -1.00  -1.00 -1.0000000
 30  -1.00 -1.00  -1.00 -1.00  -1.00 -1.00  -1.00  -1.00  -1.00 -1.0000000
 40  -1.00 -1.00  -1.00 -1.00  -1.00 -1.00  -1.00  -1.00  -1.00 -1.0000000
 50  -1.00 -1.00  -1.00 -1.00  -1.00 -1.00  -1.00  -1.00  -1.00 -1.0000000
CONTINUES TO 360

          |****************************************|
          |*     EMISSION SCALAR SECTION          *|
          |****************************************|
|
|QFLAG = 1 (Seasonal variation) - 1 line per nqf1|
Vr---|-----|------|-----|
  1.0  1.0  1.0  1.0 1
|
|QFLAG = 2 (Monthly variation) - 1 line per nqf2|
Vr---|-----|------|-----|------|-----|------|-----|-----|------|------|-----|
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1
|
|QFLAG = 3 (Hour of Day variation) - 2 lines per nqf3|
Br---|-----|------|-----|------|-----|------|-----|------|-----|------|-----|
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1  1-12
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1 13-24
|
|QFLAG = 4 (Stability and wind speed variation)|
Fr----|------|------|------|------|
 0.00 0.00 0.00 0.00 0.00      :UCATS (wind speed categories)
Br---|-----|------|-----|------|-----|
  1.0  1.0  1.0  1.0  1.0  1.0 1 KST A   6 lines per nqf4
  1.0  1.0  1.0  1.0  1.0  1.0 1 KST B
  1.0  1.0  1.0  1.0  1.0  1.0 1 KST C
  1.0  1.0  1.0  1.0  1.0  1.0 1 KST D
  1.0  1.0  1.0  1.0  1.0  1.0 1 KST E
  1.0  1.0  1.0  1.0  1.0  1.0 1 KST F
```

```
|QFLAG = 5 (Season (S1-S4) and hour of day variation) - 8 lines per nqf5|
Br---|-----|------|-----|-----|------|------|-----|------|-----|-----|------|
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1 1 1-12
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1 1 13-24
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1 2 1-12
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1 2 13-24
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1 3 1-12
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1 3 13-24
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1 4 1-12
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 1 4 13-24
```

B.3 Receptor File for Pearisburg Run - Hoechst Celanese Met Data

```
PEARISBURG RUN (Receptors)
Fi-----|
     0  iuzfl   Use ZFLAG (flagpole receptor heights) ? 1=yes, 0=no
     1  nrgrds  Number of receptor grids (max. 99)


|rs     X          Y          Z       ZFLAG  Hill     Receptor|
|d   (meters)   (meters)      (ft)     (ft)   (ft)    Name-8ch|
V||r----------|-----------|-----------|--------|--------|a----------|
 1 1    4000.0   44000.0    2560.0                    LR 04 44
 1 1    5000.0   44000.0    2520.0                    LR 05 44
 1 1    6000.0   44000.0    1870.0                    LR 06 44
 1 1    7000.0   44000.0    2090.0                    LR 07 44
 1 1    8000.0   44000.0    1840.0                    LR 08 44
 1 1    9000.0   44000.0    2060.0                    LR 09 44
 1 1   10000.0   44000.0    2010.0                    LR 10 44
 1 1   11000.0   44000.0    1930.0                    LR 11 44
 1 1    4000.0   43000.0    2530.0                    LR 04 43
 1 1    5000.0   43000.0    1800.0                    LR 05 43
 1 1    6000.0   43000.0    2020.0                    LR 06 43
 1 1    7000.0   43000.0    1850.0                    LR 07 43
 1 1    8000.0   43000.0    1960.0                    LR 08 43
 1 1    9000.0   43000.0    2120.0                    LR 09 43
 1 1   10000.0   43000.0    1190.0                    LR 10 43
 1 1   11000.0   43000.0    1870.0                    LR 11 43
 1 1    4000.0   42000.0    2630.0                    LR 04 42
 1 1    5000.0   42000.0    1920.0                    LR 05 42
```

The receptor file continues for 3572 receptors

Appendix C

C.1 Hoechst Celanese Meteorological Data (24 Hrs)

YR	MN	DY	HR	WD DR	WD SPD	TMP	STAB	MH R	MH U
91	3	29	1	109.4	1	287	6	1416	1598
91	3	29	2	142.9	1.7	285.3	6	1433	1598
91	3	29	3	269.9	1.6	283.7	6	1451	1598
91	3	29	4	283.9	1	282.6	6	1468	1598
91	3	29	5	86.8	1	282.3	6	1486	1598
91	3	29	6	303.1	1	282.4	6	1503	1598
91	3	29	7	287.2	1.9	282.5	5	146	1602
91	3	29	8	275.8	1.9	282.2	4	360	1608
91	3	29	9	280.2	1.7	282.4	3	573	1614
91	3	29	10	306.1	1.4	282.6	3	787	1620
91	3	29	11	255.1	2	283.1	2	1001	1625
91	3	29	12	320.9	1.8	283.3	2	1215	1631
91	3	29	13	269.1	2.3	283.3	3	1429	1637
91	3	29	14	230	5.4	283.4	4	1643	1643
91	3	29	15	232.9	3.8	283.4	4	1643	1643
91	3	29	16	218.9	3.6	283.5	4	1643	1643
91	3	29	17	346.9	1.4	283.9	3	1643	1643
91	3	29	18	282.9	2.1	284	2	1643	1643
91	3	29	19	279.9	3.8	284	3	1650	1650
91	3	29	20	259.9	3.8	284	4	1667	1667
91	3	29	21	232.9	3.3	283.3	4	1685	1685
91	3	29	22	247	4.3	283.1	4	1703	1703
91	3	29	23	220.8	4.4	283	4	1720	1720
91	3	29	24	207	3.4	282.9	4	1738	1738

C.2 Huntington, WV Meteorological Data (24 Hrs)

YR	MN	DY	HR	WD DR	WD SPD	TMP	STAB	MH R	MH U
89	1	1	1	271	2.0578	277	4	737.1	737.1
89	1	1	2	288	2.0578	277	4	689.9	689.9
89	1	1	3	264	2.5722	277.6	5	642.8	325
89	1	1	4	163	2.5722	277	4	595.6	595.6
89	1	1	5	183	2.0578	276.5	4	548.5	548.5
89	1	1	6	102	2.0578	276.5	4	501.3	501.3
89	1	1	7	85	1.0289	276.5	4	454.1	454.1
89	1	1	8	123	2.0578	276.5	4	407	407
89	1	1	9	57	2.0578	277	4	359.8	359.8
89	1	1	10	101	2.0578	278.2	4	312.6	312.6
89	1	1	11	94	2.0578	277.6	4	265.5	265.5
89	1	1	12	86	3.0866	277.6	4	218.3	218.3
89	1	1	13	83	2.5722	277	4	171.2	171.2
89	1	1	14	69	2.5722	277	4	124	124
89	1	1	15	72	2.5722	277	4	124	124
89	1	1	16	74	2.0578	277	4	124	124
89	1	1	17	81	2.0578	277	4	124	124
89	1	1	18	77	2.0578	277	4	124	124
89	1	1	19	94	2.0578	277	4	124	124
89	1	1	20	107	2.0578	277	4	124	124
89	1	1	21	80	2.5722	277	4	124	124
89	1	1	22	82	2.0578	277	4	124	124
89	1	1	23	60	2.0578	277	5	120.7	534.2
89	1	1	24	80	2.0578	277	4	116.3	116.3

C.3 Eastern Ridge Lime Meteorological Data (24 Hrs)

YR	MN	DY	JD	HR	STAB	WD SPD	WD DR	MH R	MH U	TEMP
93	3	5	64	12	1	1.4	189.5	825	825	275.2
93	3	5	64	13	1	2.24	208.4	917	917	275.4
93	3	5	64	14	1	2.5	207.2	1008	1008	275.2
93	3	5	64	15	1	2.31	193.4	1100	1100	275.1
93	3	5	64	16	1	1.92	219.7	1100	1100	274.9
93	3	5	64	17	1	2.05	7.2	1100	1100	274.5
93	3	5	64	18	1	2.22	345.7	1100	1100	274.5
93	3	5	64	19	6	2.05	337.4	1100	1100	274.1
93	3	5	64	20	6	2.26	346.6	1100	1100	273.9
93	3	5	64	21	6	2.6	347.1	1100	1100	273.5
93	3	5	64	22	6	2.41	289	1008	1008	273.6
93	3	5	64	23	6	2.11	253.5	917	917	273.6
93	3	5	64	24	6	1.88	303.8	825	825	273.1
93	3	6	65	1	6	2.2	300.6	733	733	273.2
93	3	6	65	2	6	2.66	335.5	642	642	273.2
93	3	6	65	3	6	2.45	309.8	550	550	273
93	3	6	65	4	6	2.62	343.2	550	550	273
93	3	6	65	5	6	1.91	315.8	550	550	273.2
93	3	6	65	6	6	1.87	349.5	550	550	273.2
93	3	6	65	7	1	1.32	136.2	550	550	273.4
93	3	6	65	8	1	1.71	179.1	550	550	273.3
93	3	6	65	9	1	1.27	35.6	550	550	273.4
93	3	6	65	10	1	1.12	93	642	642	273.4
93	3	6	65	11	1	1.89	208.7	733	733	274

Appendix D

D.1 FORTRAN Program to Compute Stability From Sigma Theta

```
* program p1
C234567890
*   DEFINE VARIABLES
      integer month, day, year, julian, hour, stab
      real speed, dir, sigmat, temp, mh
*
*   OPEN AND READ FILES AND VARIABLES
*
      open(1,file='p1.dat')
      open(3,file='p2.dat')
*
   90 read(1,*)
month,day,year,julian,hour,mh,speed,dir,sigmat,temp
      if (month.eq.0) goto 900
*
*   DETERMINE INITIAL STABILITY
*
      if (sigmat.lt.3.8) goto 21
      if (sigmat.lt.7.5) goto 22
      if (sigmat.lt.12.5) goto 23
      if (sigmat.lt.17.5) goto 24
      if (sigmat.lt.22.5) goto 25
      if (sigmat.lt.700.0) goto 26
      stab = 10
      goto 100
   21 stab = 6
      goto 101
   22 stab = 5
      goto 101
   23 stab = 4
      goto 101
   24 stab = 3
      goto 101
   25 stab = 2
      goto 101
   26 stab = 1
      goto 101
*             CHECK FOR DAYTIME OR NIGHTIME
  101 if (hour.le.18.and.hour.gt.6) goto 102
*
*             NIGHTIME CORRECTION FOR STABILITY
*
      if (stab.eq.6.and.speed.lt.3.0) goto 31
      if (stab.eq.6.and.speed.lt.5.0) goto 32
      if (stab.eq.6) goto 33
      if (stab.eq.5.and.speed.lt.5.0) goto 34
      if (stab.eq.5) goto 35
```

```
      if (stab.eq.4) goto 36
      if (stab.eq.3.and.speed.lt.2.4) goto 37
      if (stab.eq.3) goto 38
      if (stab.eq.2.and.speed.lt.2.4) goto 39
      if (stab.eq.2.and.speed.lt.3.0) goto 40
      if (stab.eq.2) goto 41
      if (stab.eq.1.and.speed.lt.2.9) goto 42
      if (stab.eq.1.and.speed.lt.3.6) goto 43
      if (stab.eq.1) goto 44
      stab = 11
      goto 100

   31 stab = 6
      goto 100
   32 stab = 5
      goto 100
   33 stab = 4
      goto 100
   34 stab = 5
      goto 100
   35 stab = 4
      goto 100
   36 stab = 4
      goto 100
   37 stab = 5
      goto 100
   38 stab = 4
      goto 100
   39 stab = 6
      goto 100
   40 stab = 5
      goto 100
   41 stab = 4
      goto 100
   42 stab = 6
      goto 100
   43 stab = 5
      goto 100
   44 stab = 4
      goto 100
*
*  DAY TIME CORRECTIONS FOR STABILITY
*
  102 if (stab.eq.4.or.stab.eq.5.or.stab.eq.6) goto 51
      if (stab.eq.3.and.speed.lt.6.0) goto 52
      if (stab.eq.3) goto 53
      if (stab.eq.2.and.speed.lt.4.0) goto 54
      if (stab.eq.2.and.speed.lt.6.0) goto 55
      if (stab.eq.2) goto 56
      if (stab.eq.1.and.speed.lt.3.0) goto 57
      if (stab.eq.1.and.speed.lt.4.0) goto 58
```

```
      if (stab.eq.1.and.speed.lt.6.0) goto 59
      if (stab.eq.1) goto 60
      stab = 12
      goto 100
   51 stab = 4
      goto 100
   52 stab = 3
      goto 100
   53 stab = 4
      goto 100
   54 stab = 2
      goto 100
   55 stab = 3
      goto 100
   56 stab = 4
      goto 100
   57 stab = 1
      goto 100
   58 stab = 2
      goto 100
   59 stab = 3
      goto 100
   60 stab = 4
*
*  WRITE DATA TO MET FILE USED BY IGM
*
  100 if(julian.GT.80) goto 120
      if(hour.ge.3.and.hour.le.9) mh=550
      if(hour.ge.15.and.hour.le.21) mh=1100
      if(hour.eq.22.or.hour.eq.14) mh=1008
      if(hour.eq.23.or.hour.eq.13) mh=917
      if(hour.eq.24.or.hour.eq.12) mh=825
      if(hour.eq.1.or.hour.eq.11) mh=733
      if(hour.eq.2.or.hour.eq.10) mh=642
      goto 199
*
  120 if(julian.gt.172) goto 130
      if(hour.ge.3.and.hour.le.9) mh=600
      if(hour.ge.15.and.hour.le.21) mh=1800
      if(hour.eq.22.or.hour.eq.14) mh=1600
      if(hour.eq.23.or.hour.eq.13) mh=1400
      if(hour.eq.24.or.hour.eq.12) mh=1200
      if(hour.eq.1.or.hour.eq.11) mh=1000
      if(hour.eq.2.or.hour.eq.10) mh=800
      goto 199

  130 if(hour.ge.3.and.hour.le.9) mh=400
      if(hour.ge.15.and.hour.le.21) mh=1800
      if(hour.eq.22.or.hour.eq.14) mh=1567
      if(hour.eq.23.or.hour.eq.13) mh=1333
      if(hour.eq.24.or.hour.eq.12) mh=1100
```

```
      if(hour.eq.1.or.hour.eq.11) mh=867
      if(hour.eq.2.or.hour.eq.10) mh=633
*
  199 write
(3,200)year,month,day,julian,hour,stab,speed,dir,mh,
     $mh, temp
  200
format(1x,i2,1x,i2,1x,i2,1x,i3,1x,i3,1x,i2,1x,f6.2,1x,f5.1,1
x,
     $f6.1
     $,1x,f6.1,1x,f5.1)
      goto 90
  900 stop
      end
```

D-2 Stability Guideline for Sigma Theta

Table 6-6a. Lateral Wind Direction Turbulence Criteria for Initial Estimate of Pasquill Stability Category. Use with Table 6-6b.

Initial estimate of Pasquill stability category	Standard deviation of horizontal wind direction fluctuations, σ_A, in degrees
A	$22.5 \leq \sigma_A$
B	$17.5 \leq \sigma_A < 22.5$
C	$12.5 \leq \sigma_A < 17.5$
D	$7.5 \leq \sigma_A < 12.5$
E	$3.8 \leq \sigma_A < 7.5$
F	$\sigma_A < 3.8$

Table 6-6b. Wind Speed Adjustments for Determining Final Estimate of Pasquill Stability Category from σ_A. Use with Table 6-6a.

	Initial estimated category	10m scalar wind speed (US) (m/s)	Final estimate of stability category
Daytime	A	US < 3	A
		3 ≤ US < 4	B
		4 ≤ US < 6	C
		6 ≤ US	D
	B	US < 4	B
		4 ≤ US < 6	C
		6 ≤ US	D
	C	US < 6	C
		6 ≤ US	D
	D,E or F	ANY	D
Nighttime	A	US < 2.9	F
		2.9 ≤ US < 3.6	E
		3.6 ≤ US	D
	B	US < 2.4	F
		2.4 ≤ US < 3.0	E
		3.0 ≤ US	D
	C	US < 2.4	E
		2.4 ≤ US	D
	D	ANY	D
	E	US < 5.0	E
		5.0 ≤ US	D
	F	US < 3.0	F
		3.0 ≤ US < 5.0	E
		5.0 ≤ US	D

Appendix E

E.1 Hoechst Celanese Type D results

" Integrated Gaussian Model, V92120 UPDT 1; United Engineers & Constructors, Inc.
PEARISBURG RUN MON SEP 27 1993 20:10"

Rank-Based (Type D) output for Total no. 1: Total over all groups
Time period averages; 8783 hours processed

Rank |<---------------		Receptor	----->|		Total	Group Contr...			
G	R	No.	x-m	y-m	z-ft	Chi	ALC	ERL	AP	HC
1	1	2819	28800	35100	1750	303.37	0.07	292.63	2.99	7.68
2	1	2818	28700	35100	1740	300.31	0.07	290.74	2.94	6.56
3	1	2793	28200	35200	1830	245.93	0.21	231.51	3.93	10.27
4	1	2820	28900	35100	1760	238.82	0.06	227.5	3.34	7.91
5	1	2814	28200	35100	1830	235.1	0.2	219.97	3.93	11
6	1	2801	29000	35200	1890	231.19	0.2	215.27	4.23	11.47
7	1	2821	29000	35100	1800	216.91	0.07	203.01	3.57	10.25
8	1	2822	29100	35100	1900	206.7	0.2	190.16	4.31	12.03
9	1	2800	28900	35200	1800	200.86	0.09	187.26	3.58	9.93
10	1	2794	28300	35200	1800	198.83	0.16	185.1	3.69	9.89
11	1	2792	28100	35200	1860	195.75	0.29	180.3	4.19	10.97
12	1	2813	28100	35100	1850	188.55	0.25	172.92	4.11	11.27
13	1	2802	29100	35200	1840	187.09	0.09	172.57	3.82	10.61
14	1	2531	29000	35000	1870	177.34	0.12	161.5	4.09	11.63
15	1	2839	28800	35000	1860	164.35	0.15	148.42	4.06	11.73

Rank-Based (Type D) output for Total no. 1: Total over all groups
Averaging period: 24-hr.

Rnk|<------		Receptor	----->|		Date	Total	Group Contr...			
G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	ALC	ERL	AP	HC
1	1	2818	28700	35100	1740	31524	3731.35	0	3711.76	16.27	3.32
2	1	2818	28700	35100	1740	7124	2438.81	0	2428.89	9.92	0
3	1	2818	28700	35100	1740	12224	2085.27	0	2067.98	12.07	5.22
4	1	2818	28700	35100	1740	8824	2081.01	0	2065.47	14.28	1.26
5	1	2818	28700	35100	1740	8724	1983.81	0	1969.2	14.45	0.16
6	1	2818	28700	35100	1740	11124	1890.54	0	1878.87	11.67	0
7	1	2818	28700	35100	1740	6824	1871.53	0	1850.22	21.29	0.02
8	1	2818	28700	35100	1740	27924	1860.09	0	1847	13.09	0
9	1	2819	28800	35100	1750	6824	1795.5	0	1773.57	21.54	0.39
10	1	2818	28700	35100	1740	10024	1662.7	0	1649.6	9.52	3.58

11	1	2818	28700	35100	1740	3224	1635.93	0	1624.68	11.24	0
12	1	2818	28700	35100	1740	18924	1601.17	0	1572.64	10.15	18.39
13	1	2818	28700	35100	1740	11224	1525.65	0.01	1509.3	13.21	3.12
14	1	2819	28800	35100	1750	8724	1454.96	0	1439.88	14.58	0.5
15	1	2819	28800	35100	1750	624	1452.07	0	1438.36	7.7	6.01

Rank-Based (Type D) output for Total no. 1: Total over all groups
Averaging period: 3-hr.

Rnk|<---------		Receptor	-----------------	>|		Date	Total	Group Contr...			
G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	ALC	ERL	AP	HC
1	1	2818	28700	35100	1740	31521	5632.95	0	5609.34	23.61	0
2	1	2818	28700	35100	1740	31518	5523.93	0	5507	16.92	0
3	1	2818	28700	35100	1740	31512	5224.59	0	5200.73	23.86	0
4	1	2839	28800	35000	1860	18724	5118.98	0	5067.45	3.87	47.67
5	1	2839	28800	35000	1860	106 3	5050.48	0	5001.61	3.94	44.93
6	1	2839	28800	35000	1860	292 6	5028.1	0	4973.14	0	54.95
7	1	2839	28800	35000	1860	106 6	4985.21	0	4981.2	4.01	0
8	1	2818	28700	35100	1740	123 9	4801.2	0	4773.03	28.17	0
9	1	2839	28800	35000	1860	138 3	4759.16	0	4752.43	6.73	0
10	1	2818	28700	35100	1740	27912	4741.66	0	4715.94	25.73	0
11	1	2818	28700	35100	1740	31515	4689.57	0	4672.22	17.34	0
12	1	2818	28700	35100	1740	9215	4600.08	0	4575.28	24.79	0
13	1	2818	28700	35100	1740	364 6	4537.01	0	4523.75	13.12	0.15
14	1	2818	28700	35100	1740	100 6	4364.93	0	4346.65	18.26	0.01
15	1	2839	28800	35000	1860	301 6	4321.19	0	4313.86	0	7.33

Rank-Based (Type D) output for Group no. 1: APG LIME CO

Time period averages; 8783 hours processed

Rank |<------		Receptor	----->|			Total	Source Contr...		
G	R	No.	x-m	y-m	z-ft	Chi	S10001	S10002	S10003
1	1	2052	30300	37100	2200	81.81	27.43	25.07	29.31
2	1	2073	30300	37200	2180	73.85	24.54	22.99	26.32
3	1	2072	30200	37200	2120	67.19	24.65	21.67	20.87
4	1	2053	30400	37100	2280	66.8	21.69	20.23	24.88
5	1	2074	30400	37200	2270	66.78	21.22	20.31	25.25
6	1	2063	29300	37200	2100	64.53	23.84	20.91	19.78
7	1	2082	29200	37300	2220	61.61	19.53	18.81	23.27
8	1	2083	29300	37300	2140	59.29	20.37	18.86	20.06
9	1	2220	30400	37000	2270	58.29	19.08	17.61	21.59
10	1	2081	29100	37300	2160	57.29	19.01	17.95	20.33

11	1	2219	30300	37000	2140	56.08	20.18	17.53	18.38
12	1	2054	30500	37100	2300	55.43	18.07	16.78	20.57
13	1	2075	30500	37200	2340	55.15	17.66	16.76	20.73
14	1	2094	30400	37300	2240	51.5	16.35	15.77	19.38
15	1	2218	30200	37000	2100	51.34	19.69	16.02	15.63

Rank-Based (Type D) output for Group no. 1: APG LIME CO

Averaging period: 24-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S10001	S10002	S10003
1	1	2072	30200	37200	2120	21724	564.88	194.39	181.17	189.33
2	1	2073	30300	37200	2180	25524	485.18	160.38	152.55	172.25
3	1	2074	30400	37200	2270	18224	479.51	149.98	145.76	183.77
4	1	2072	30200	37200	2120	15024	468.73	171.11	152.71	144.91
5	1	2073	30300	37200	2180	3024	458.82	149.37	142.79	166.66
6	1	2220	30400	37000	2270	18224	450.51	141.13	136.97	172.41
7	1	2094	30400	37300	2240	21724	435.38	134.68	131.69	169.01
8	1	2072	30200	37200	2120	20324	432.81	155.32	140.41	137.07
9	1	2074	30400	37200	2270	25524	423.77	130.52	128.39	164.86
10	1	2073	30300	37200	2180	18224	423.13	134.64	129.77	158.72
11	1	2093	30300	37300	2200	20124	422.3	133.15	129.27	159.88
12	1	2094	30400	37300	2240	20124	421.77	131.65	127.95	162.17
13	1	2082	29200	37300	2220	29524	412.49	128.18	125.03	159.29
14	1	2072	30200	37200	2120	24724	410.87	143.69	131.92	135.26
15	1	2072	30200	37200	2120	2824	410.53	148.87	133.16	128.49

Rank-Based (Type D) output for Group no. 1: APG LIME CO

Averaging period: 3-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S10001	S10002	S10003
1	1	2052	30300	37100	2200	228 3	2050.39	659.79	633.15	757.45
2	1	2073	30300	37200	2180	203 6	1999.23	648.17	620.45	730.61
3	1	2073	30300	37200	2180	150 3	1988.95	643.05	616.76	729.15
4	1	2073	30300	37200	2180	30 6	1883.88	597.05	577.96	708.87
5	1	2072	30200	37200	2120	150 3	1828.72	667.47	596.1	565.14
6	1	2072	30200	37200	2120	203 6	1827.53	667.52	595.98	564.03
7	1	2052	30300	37100	2200	247 6	1822.79	568.06	553.55	701.18

8	1	2072	30200	37200	2120	247 6	1820.97	654.28	590.99	575.69
9	1	2073	30300	37200	2180	9224	1818.84	591	563.31	664.53
10	1	2072	30200	37200	2120	363 9	1809.3	655.37	587.04	566.89
11	1	2092	30200	37300	2130	363 9	1799.22	640.02	581.11	578.09
12	1	2073	30300	37200	2180	247 6	1795.36	564.81	548.96	681.58
13	1	2072	30200	37200	2120	9224	1780.53	643.79	577.19	559.55
14	1	2092	30200	37300	2130	291 6	1773.12	621.33	574.08	577.71
15	1	2083	29300	37300	2140	237 6	1762.06	592.3	560.36	609.4

Rank-Based (Type D) output for Group no. 2: EASTERN RIDGE LIME CO

Time period averages; 8783 hours processed

Rank |<------ Receptor ----->| Total Source Contr...

G	R	No.	x-m	y-m	z-ft	Chi	S20001
1	1	2819	28800	35100	1750	292.63	292.63
2	1	2818	28700	35100	1740	290.74	290.74
3	1	2793	28200	35200	1830	231.51	231.51
4	1	2820	28900	35100	1760	227.5	227.5
5	1	2814	28200	35100	1830	219.97	219.97
6	1	2801	29000	35200	1890	215.27	215.27
7	1	2821	29000	35100	1800	203.01	203.01
8	1	2822	29100	35100	1900	190.16	190.16
9	1	2800	28900	35200	1800	187.26	187.26
10	1	2794	28300	35200	1800	185.1	185.1
11	1	2792	28100	35200	1860	180.3	180.3
12	1	2813	28100	35100	1850	172.92	172.92
13	1	2802	29100	35200	1840	172.57	172.57
14	1	2531	29000	35000	1870	161.5	161.5
15	1	2839	28800	35000	1860	148.42	148.42

Rank-Based (Type D) output for Group no. 2: EASTERN RIDGE LIME CO

Averaging period: 24-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S20001
1	1	2818	28700	35100	1740	31524	3711.76	3711.76
2	1	2818	28700	35100	1740	7124	2428.89	2428.89
3	1	2818	28700	35100	1740	12224	2067.98	2067.98
4	1	2818	28700	35100	1740	8824	2065.47	2065.47
5	1	2818	28700	35100	1740	8724	1969.2	1969.2

6	1	2818	28700	35100	1740	11124	1878.87	1878.87
7	1	2818	28700	35100	1740	6824	1850.22	1850.22
8	1	2818	28700	35100	1740	27924	1847	1847
9	1	2819	28800	35100	1750	6824	1773.57	1773.57
10	1	2818	28700	35100	1740	10024	1649.6	1649.6
11	1	2818	28700	35100	1740	3224	1624.68	1624.68
12	1	2818	28700	35100	1740	18924	1572.64	1572.64
13	1	2818	28700	35100	1740	11224	1509.3	1509.3
14	1	2819	28800	35100	1750	8724	1439.88	1439.88
15	1	2819	28800	35100	1750	624	1438.36	1438.36

Rank-Based (Type D) output for Group no. 2: EASTERN RIDGE LIME CO

Averaging period: 3-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S20001
1	1	2818	28700	35100	1740	31521	5609.34	5609.34
2	1	2818	28700	35100	1740	31518	5507	5507
3	1	2818	28700	35100	1740	31512	5200.73	5200.73
4	1	2839	28800	35000	1860	18724	5067.45	5067.45
5	1	2839	28800	35000	1860	106 3	5001.61	5001.61
6	1	2839	28800	35000	1860	106 6	4981.2	4981.2
7	1	2839	28800	35000	1860	292 6	4973.14	4973.14
8	1	2818	28700	35100	1740	123 9	4773.03	4773.03
9	1	2839	28800	35000	1860	138 3	4752.43	4752.43
10	1	2818	28700	35100	1740	27912	4715.94	4715.94
11	1	2818	28700	35100	1740	31515	4672.22	4672.22
12	1	2818	28700	35100	1740	9215	4575.28	4575.28
13	1	2818	28700	35100	1740	364 6	4523.75	4523.75
14	1	2818	28700	35100	1740	100 6	4346.65	4346.65
15	1	2839	28800	35000	1860	301 6	4313.86	4313.86

Rank-Based (Type D) output for Group no. 3: APPALACHIAN POWER CO

Time period averages; 8783 hours processed

Rank |<------ Receptor ----->| Total Source Contr...

G	R	No.	x-m	y-m	z-ft	Chi	S30001	S30002	S30003
1	1	136	9000	36000	2530	39.35	4.36	3.85	31.15
2	1	256	8500	36000	2540	33.06	3.66	3.23	26.18
3	1	262	9000	35500	2240	31.57	4.04	3.57	23.97

4	1	261	8500	35500	2440	29.38	3.28	2.9	23.2
5	1	135	8000	36000	2500	29.33	3.24	2.86	23.23
6	1	62	9000	37000	2200	25.28	3.55	3.13	18.6
7	1	1624	15000	35500	2080	23.68	4.45	3.93	15.31
8	1	121	8500	37000	2640	23.35	2.54	2.24	18.57
9	1	260	8000	35500	2200	22.73	3.14	2.78	16.82
10	1	263	9500	35500	2120	22.47	4.65	4.11	13.71
11	1	255	7500	36000	2740	21.61	2.35	2.08	17.17
12	1	61	8000	37000	2720	20.98	2.26	2	16.72
13	1	259	7500	35500	2600	19.98	2.22	1.96	15.81
14	1	1642	17500	35000	2410	19.67	2.3	2.03	15.34
15	1	120	7500	37000	2760	19.58	2.1	1.85	15.63

Rank-Based (Type D) output for Group no. 3: APPALACHIAN POWER CO

Averaging period: 24-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S30001	S30002	S30003
1	1	262	9000	35500	2240	35724	270.72	33.9	29.94	206.89
2	1	261	8500	35500	2440	35724	222.84	23.71	20.94	178.19
3	1	262	9000	35500	2240	5324	214.24	26.86	23.73	163.66
4	1	1080	13700	34700	2230	29224	205.97	26.92	23.78	155.27
5	1	136	9000	36000	2530	33224	201.22	20.8	18.37	162.05
6	1	1118	13300	34100	2260	2824	199.13	23.64	20.88	154.6
7	1	1066	13900	34900	2180	10624	198.54	34.6	30.56	133.39
8	1	1101	12500	34300	2170	23924	197.66	36.77	32.48	128.4
9	1	1648	14500	34500	2260	10624	193.88	22.81	20.15	150.93
10	1	1080	13700	34700	2230	18724	191.82	27.73	24.49	139.6
11	1	1125	12500	33900	2220	5224	189.27	26.71	23.59	138.97
12	1	136	9000	36000	2530	33324	186.06	19.21	16.97	149.88
13	1	261	8500	35500	2440	5324	181.37	18.83	16.64	145.9
14	1	136	9000	36000	2530	5324	177.42	18.12	16	143.3
15	1	1080	13700	34700	2230	13824	177.31	24.53	21.67	131.11

Rank-Based (Type D) output for Group no. 3: APPALACHIAN POWER CO

Averaging period: 3-hr.

Rnk|<------ Receptor ------>| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S30001	S30002	S30003
1	1	1080	13700	34700	2230	18724	1100.03	138.69	122.51	838.84
2	1	1118	13300	34100	2260	96 6	1073.1	125.49	110.85	836.76
3	1	1118	13300	34100	2260	2824	1055.84	125.21	110.6	820.04
4	1	1118	13300	34100	2260	52 9	1043.79	125.01	110.43	808.35
5	1	1080	13700	34700	2230	106 6	1041.05	137.77	121.69	781.59
6	1	1080	13700	34700	2230	292 6	1036.7	137.7	121.63	777.37
7	1	1080	13700	34700	2230	138 3	1035.09	128.04	113.11	793.94
8	1	1659	13500	34000	2400	96 6	914.16	98.92	87.38	727.86
9	1	1659	13500	34000	2400	2824	911.22	98.74	87.22	725.26
10	1	1659	13500	34000	2400	52 9	909.19	98.61	87.11	723.47
11	1	1128	12100	33700	2200	18824	905.73	132.68	117.2	655.85
12	1	1104	13100	34300	2180	96 6	896.34	159.74	141.11	595.49
13	1	1666	12000	33500	2220	18824	887.8	116.67	103.06	668.06
14	1	1101	12500	34300	2170	27221	875.63	191.85	169.46	514.32
15	1	1104	13100	34300	2180	2824	874.56	159.32	140.74	574.5

Rank-Based (Type D) output for Group no. 4: HOECHST CELANESE
Time period averages; 8783 hours processed

Rank |<------ Receptor ------>| Total Source Contr...

G	R	No.	x-m	y-m	z-ft	Chi	S40001	S40002	S40003	S40004	S40005
1	1	1680	19000	33500	2010	78.34	4.01	10.57	13.93	3.93	10.53
2	1	1679	18500	33500	2200	63.16	3.4	8.96	11.82	3.33	8.93
3	1	1502	19200	33600	1970	60.83	2.92	7.7	10.15	2.86	7.67
4	1	1494	19600	33800	2100	53.05	2.81	7.41	9.77	2.75	7.38
5	1	1510	19200	33400	1900	47.49	2.02	5.31	7.01	1.97	5.29
6	1	1495	19800	33800	2060	47.23	2.47	6.52	8.59	2.42	6.49
7	1	1678	18000	33500	2460	45.61	2.47	6.51	8.59	2.42	6.49
8	1	678	19000	34000	2080	43.51	2.32	6.11	8.05	2.27	6.08
9	1	1664	18500	34000	2280	43.27	2.34	6.16	8.13	2.29	6.14
10	1	3280	23500	33500	1950	40.18	1.83	4.82	6.35	1.79	4.8
11	1	1478	19400	34000	2040	38.98	2.04	5.36	7.07	1.99	5.34
12	1	676	17000	34000	2060	37.94	2.04	5.39	7.1	2	5.36
13	1	688	18000	33000	1940	37.05	1.75	4.62	6.09	1.72	4.6
14	1	677	18000	34000	2400	36.9	2	5.28	6.96	1.96	5.25
15	1	1677	17500	33500	1940	36.62	1.77	4.67	6.16	1.74	4.66

* Note: Only the first five Hoechst Celanese Source Outputs Are Listed

Rank-Based (Type D) output for Group no. 4: HOECHST CELANESE
Averaging period: 24-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S40001	S40002	S40003	S40004
1	1	1680	19000	33500	2010	29524	456.93	24.44	64.39	84.9	23.92
2	1	1680	19000	33500	2010	10724	435.02	23.01	60.62	79.92	22.52
3	1	1502	19200	33600	1970	29524	413.69	20.87	54.97	72.47	20.42
4	1	1680	19000	33500	2010	35424	412.62	21.77	57.35	75.61	21.3
5	1	1495	19800	33800	2060	5224	409.23	21.43	56.45	74.42	20.97
6	1	1680	19000	33500	2010	33224	407.67	21.54	56.74	74.81	21.08
7	1	1494	19600	33800	2100	34124	393.35	21.68	57.1	75.28	21.21
8	1	1495	19800	33800	2060	34124	385.16	21.02	55.38	73	20.57
9	1	1494	19600	33800	2100	25324	376.6	20.21	53.25	70.21	19.78
10	1	1680	19000	33500	2010	5424	359.48	18.55	48.86	64.41	18.15
11	1	1494	19600	33800	2100	10424	359.46	19.63	51.71	68.18	19.21
12	1	1680	19000	33500	2010	33324	353.5	17.94	47.27	62.32	17.56
13	1	1494	19600	33800	2100	29524	353.02	19.21	50.6	66.7	18.79
14	1	1680	19000	33500	2010	5324	350.56	18.03	47.49	62.61	17.64
15	1	1502	19200	33600	1970	10724	344.06	16.85	44.4	58.54	16.49

* Note: Only the first four Hoechst Celanese Source Outputs Are Listed

Rank-Based (Type D) output for Group no. 4: HOECHST CELANESE
Averaging period: 3-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S40001	S40002	S40003	S40004
1	1	1587	20800	31600	2040	18824	1945.97	105.63	278.26	366.85	103.36
2	1	1473	21200	34200	2040	148 3	1929.24	101.22	266.65	351.54	99.04
3	1	1495	19800	33800	2060	8 9	1924.82	98.47	259.42	342.01	96.36
4	1	1495	19800	33800	2060	29 6	1916.16	105.02	276.65	364.73	102.76
5	1	1494	19600	33800	2100	8 9	1848.68	99.14	261.16	344.31	97
6	1	1495	19800	33800	2060	5224	1787.26	98.16	258.6	340.93	96.05
7	1	1588	21000	31600	2010	18824	1779.94	92.56	243.85	321.48	90.57
8	1	1479	19600	34000	2220	8 9	1754.87	98	258.16	340.35	95.89
9	1	1495	19800	33800	2060	256 9	1721.76	90.36	238.04	313.83	88.42
10	1	1480	19800	34000	2100	29 6	1714.44	94.51	248.98	328.25	92.48

11	1	1459	21200	34400	2160	148 3	1709.18	94.55	249.08	328.39	92.52
12	1	1509	22000	33600	1940	291 6	1691.42	73.54	193.74	255.42	71.96
13	1	1599	20800	31400	2060	18824	1690.33	92.81	244.5	322.34	90.81
14	1	1495	19800	33800	2060	34124	1684.13	92.56	243.84	321.47	90.57
15	1	1494	19600	33800	2100	22 6	1650.83	91.05	239.86	316.22	89.09

* Note: Only the first four Hoechst Celanese Source Outputs Are Listed

E.2 Huntington, WV Type D results

" Integrated Gaussian Model, V92120 UPDT 1; United Engineers & Constructors, Inc.
PEARISBURG RUN WED SEP 29 1993 13:19"

Rank-Based (Type D) output for Total no. 1: Total over all groups
Time period averages; 8760 hours processed

Rank	|<------ Receptor	----->|		Total	Group Contr...			
G	R	No.	x-m	y-m	z-ft	Chi	ALC	ERL	AP	HC
1	1	2774	28300	35300	1840	124.46	0.45	118.57	0.82	4.61
2	1	2780	28900	35300	1800	116.71	0.38	111.47	0.74	4.13
3	1	2800	28900	35200	1800	108.11	0.37	102.98	0.73	4.02
4	1	2762	29000	35400	1810	105.11	0.4	99.95	0.76	4
5	1	2773	28200	35300	1890	102.71	0.76	95.92	0.92	5.11
6	1	2775	28400	35300	1810	99.74	0.38	94.27	0.77	4.32
7	1	2743	29000	35500	1810	96.47	0.4	91.29	0.76	4.03
8	1	2794	28300	35200	1800	94.68	0.36	89.09	0.76	4.47
9	1	2799	28800	35200	1760	94.37	0.31	90.37	0.68	3.01
10	1	2781	29000	35300	1810	93.7	0.4	88.38	0.75	4.17
11	1	2779	28800	35300	1760	90.8	0.31	86.85	0.68	2.96
12	1	2754	28200	35400	1900	90.7	0.82	83.5	0.96	5.42
13	1	2801	29000	35200	1890	89.5	0.85	83.14	0.88	4.64
14	1	2793	28200	35200	1830	85.37	0.42	79.37	0.81	4.77
15	1	2725	29000	35600	1810	84.84	0.4	79.41	0.77	4.27

Rank-Based (Type D) output for Total no. 1: Total over all groups
Averaging period: 24-hr.

Rnk|<------	Receptor	----->|			Date	Total	Group Contr...			
G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	ALC	ERL	AP	HC
1	1	2818	28700	35100	1740	11524	1062.35	0.07	1050.5	3.58	8.19
2	1	2774	28300	35300	1840	2324	1062.1	0	1062.1	0	0
3	1	2775	28400	35300	1810	24824	1030.95	0	1030.95	0	0
4	1	2774	28300	35300	1840	35124	940.31	0	936.76	3.32	0.23
5	1	2798	28700	35200	1730	31724	893.51	0	892.2	0.01	1.31
6	1	2793	28200	35200	1830	30024	862.83	0.98	861.85	0	0
7	1	2774	28300	35300	1840	524	858.17	0	858.17	0	0
8	1	2794	28300	35200	1800	30024	842.95	1.18	841.77	0	0
9	1	2774	28300	35300	1840	24824	828.6	0	828.6	0	0
10	1	2839	28800	35000	1860	30624	825.3	1.58	822.62	1.1	0
11	1	2773	28200	35300	1890	35124	822.09	0	817.54	4.35	0.21
12	1	2894	28600	34700	1900	27724	797.73	0.19	797.44	0.1	0

13	1	2839	28800	35000	1860	22024	791.37	2.03	779.84	3.68	5.82
14	1	2774	28300	35300	1840	2824	778.59	0.06	769.75	0	8.78
15	1	1488	21400	34000	1980	32824	773.69	0	0	0	773.69

Rank-Based (Type D) output for Total no. 1: Total over all groups
Averaging period: 3-hr.

Rnk|<------	Receptor	----->	|	Date	Total	Group Contr...					
G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	ALC	ERL	AP	HC
1	1	2839	28800	35000	1860	30612	4241.77	0	4241.77	0	0
2	1	2774	28300	35300	1840	28 6	3350.78	0	3350.78	0	0
3	1	2818	28700	35100	1740	8718	3260.78	0	3241.87	4.85	14.07
4	1	2818	28700	35100	1740	15215	3258.35	0	3248.01	10.28	0.06
5	1	2774	28300	35300	1840	23 6	3162.33	0	3162.33	0	0
6	1	2798	28700	35200	1730	31715	3161.5	0	3161.5	0	0
7	1	1474	21400	34200	2120	345 6	3161.23	0	0	0.00	3161.23
8	1	2774	28300	35300	1840	23 9	3096.81	0	3096.81	0	0
9	1	2774	28300	35300	1840	115 6	3044.58	0	3044.58	0	0
10	1	2775	28400	35300	1810	23 9	3042.18	0	3042.18	0	0
11	1	2858	28800	34900	1960	355 6	3032.2	0	3032.2	0	0
12	1	1488	21400	34000	1980	345 6	2937.33	0	0	0	2937.33
13	1	2774	28300	35300	1840	5 6	2908.51	0	2908.51	0	0
14	1	2818	28700	35100	1740	33615	2875.75	0	2862.56	12.82	0.38
15	1	1474	21400	34200	2120	328 6	2846.88	0	0	0	2846.88

Rank-Based (Type D) output for Group no. 1: APG LIME CO

Time period averages; 8760 hours processed

Rank |<------	Receptor	----->	|	Total	Source Contr...		
G	R	No.	x-m	y-m	z-ft	Chi	S10001	S10002	S10003
1	1	2111	30200	37400	2120	49.97	16.77	15.73	17.47
2	1	2092	30200	37300	2130	41.88	14	13.11	14.76
3	1	2083	29300	37300	2140	38.74	12.64	12.03	14.07
4	1	2131	30300	37500	2120	36.82	12.25	11.55	13.02
5	1	2112	30300	37400	2200	36.53	11.56	11.13	13.84
6	1	2149	30300	37600	2120	36.02	11.99	11.3	12.74
7	1	2093	30300	37300	2200	34.36	10.93	10.47	12.96
8	1	2150	30400	37600	2200	33.69	10.68	10.29	12.73
9	1	2102	29300	37400	2120	33.66	11.26	10.63	11.76
10	1	2072	30200	37200	2120	33.1	11.4	10.42	11.28
11	1	2165	30300	37700	2100	31.69	10.93	10.08	10.68
12	1	2166	30400	37700	2160	31.44	10.07	9.68	11.69

13	1	2101	29200	37400	2220	31.25	9.75	9.47	12.03
14	1	2121	29300	37500	2180	29.55	9.29	9.02	11.24
15	1	2082	29200	37300	2220	29.4	9.18	8.92	11.3

Rank-Based (Type D) output for Group no. 1: APG LIME CO

Averaging period: 24-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S10001	S10002	S10003
1	1	2291	29900	36600	2140	27724	492.35	156.24	150.54	185.57
2	1	2218	30200	37000	2100	4324	437.18	143.3	136.47	157.41
3	1	2083	29300	37300	2140	35124	433.91	139.4	133.21	161.31
4	1	2102	29300	37400	2120	2324	423.77	140.26	133.32	150.18
5	1	2092	30200	37300	2130	35824	423.03	151.56	136.32	135.15
6	1	2093	30300	37300	2200	35824	411.88	129.48	125.26	157.15
7	1	2083	29300	37300	2140	24924	408.64	128.76	124.75	155.13
8	1	2273	29900	36700	2080	27724	406.74	145.62	131.9	129.22
9	1	2073	30300	37200	2180	35824	401.08	128.25	123.72	149.11
10	1	2121	29300	37500	2180	2324	400.11	125.41	121.34	153.36
11	1	2111	30200	37400	2120	15224	378.95	123.92	118.35	136.67
12	1	2072	30200	37200	2120	35824	378.91	138.51	122.75	117.65
13	1	2149	30300	37600	2120	1724	376.81	122.19	117.22	137.4
14	1	2082	29200	37300	2220	35124	361.94	112.69	109.57	139.67
15	1	2219	30300	37000	2140	4324	360.01	113.03	109.34	137.63

Rank-Based (Type D) output for Group no. 1: APG LIME CO

Averaging period: 3-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S10001	S10002	S10003
1	1	2092	30200	37300	2130	241 6	1624.11	536.19	510.71	577.22
2	1	2083	29300	37300	2140	23 6	1529.3	485.58	467.55	576.17
3	1	2092	30200	37300	2130	235 3	1513.14	495.33	472.57	545.24
4	1	2111	30200	37400	2120	152 6	1508.37	492.98	475.43	539.96
5	1	2092	30200	37300	2130	19 6	1500.04	471.62	456.85	571.56
6	1	2256	30100	36800	2150	355 6	1492.67	490.7	470.13	531.84
7	1	2073	30300	37200	2180	358 3	1463.98	464.59	447.67	551.72
8	1	2072	30200	37200	2120	358 3	1414.05	515.57	457.71	440.76
9	1	2092	30200	37300	2130	358 6	1410.39	505.35	454.44	450.59

10	1	2092	30200	37300	2130	358 3	1409.8	505.06	454.36	450.38
11	1	2093	30300	37300	2200	358 6	1372.96	431.59	417.52	523.84
12	1	2093	30300	37300	2200	358 3	1372.82	431.54	417.51	523.78
13	1	2093	30300	37300	2200	241 6	1367	424.22	414.16	528.63
14	1	2122	29400	37500	2140	23 9	1359.93	448.02	422.89	489.02
15	1	2072	30200	37200	2120	132 9	1358.08	473.94	438.38	445.75

Rank-Based (Type D) output for Group no. 2: EASTERN RIDGE LIME CO

Time period averages; 8760 hours processed

Rank	|<------ Receptor	----->|			Total	Source Contr...
G R	No.	x-m	y-m	z-ft	Chi	S20001
1 1	2774	28300	35300	1840	118.57	118.57
2 1	2780	28900	35300	1800	111.47	111.47
3 1	2800	28900	35200	1800	102.98	102.98
4 1	2762	29000	35400	1810	99.95	99.95
5 1	2773	28200	35300	1890	95.92	95.92
6 1	2775	28400	35300	1810	94.27	94.27
7 1	2743	29000	35500	1810	91.29	91.29
8 1	2799	28800	35200	1760	90.37	90.37
9 1	2794	28300	35200	1800	89.09	89.09
10 1	2781	29000	35300	1810	88.38	88.38
11 1	2779	28800	35300	1760	86.85	86.85
12 1	2754	28200	35400	1900	83.5	83.5
13 1	2801	29000	35200	1890	83.14	83.14
14 1	2725	29000	35600	1810	79.41	79.41
15 1	2793	28200	35200	1830	79.37	79.37

Rank-Based (Type D) output for Group no. 2: EASTERN RIDGE LIME CO
Averaging period: 24-hr.

Rnk|	<------ Receptor	----->|			Date	Total	Source Contr...
G R	No.	x-m	y-m	z-ft	jdyhr	Chi	S20001
1 1	2774	28300	35300	1840	2324	1062.1	1062.1
2 1	2818	28700	35100	1740	11524	1050.5	1050.5
3 1	2775	28400	35300	1810	24824	1030.95	1030.95
4 1	2774	28300	35300	1840	35124	936.76	936.76
5 1	2798	28700	35200	1730	31724	892.2	892.2
6 1	2793	28200	35200	1830	30024	861.85	861.85
7 1	2774	28300	35300	1840	524	858.17	858.17
8 1	2794	28300	35200	1800	30024	841.77	841.77
9 1	2774	28300	35300	1840	24824	828.6	828.6

10	1	2839	28800	35000	1860	30624	822.62	822.62
11	1	2773	28200	35300	1890	35124	817.54	817.54
12	1	2894	28600	34700	1900	27724	797.44	797.44
13	1	2839	28800	35000	1860	22024	779.84	779.84
14	1	2774	28300	35300	1840	2824	769.75	769.75
15	1	2775	28400	35300	1810	14224	749.82	749.82

Rank-Based (Type D) output for Group no. 2: EASTERN RIDGE LIME CO
Averaging period: 3-hr.

Rnk|<------	Receptor	----->|			Date	Total	Source Contr...
G R	No.	x-m	y-m	z-ft	jdyhr	Chi	S20001
1 1	2839	28800	35000	1860	30612	4241.77	4241.77
2 1	2774	28300	35300	1840	28 6	3350.78	3350.78
3 1	2818	28700	35100	1740	15215	3248.01	3248.01
4 1	2818	28700	35100	1740	8718	3241.87	3241.87
5 1	2774	28300	35300	1840	23 6	3162.33	3162.33
6 1	2798	28700	35200	1730	31715	3161.5	3161.5
7 1	2774	28300	35300	1840	23 9	3096.81	3096.81
8 1	2774	28300	35300	1840	115 6	3044.58	3044.58
9 1	2775	28400	35300	1810	23 9	3042.18	3042.18
10 1	2858	28800	34900	1960	355 6	3032.2	3032.2
11 1	2774	28300	35300	1840	5 6	2908.51	2908.51
12 1	2818	28700	35100	1740	33615	2862.56	2862.56
13 1	2876	28700	34800	1920	261 9	2831.28	2831.28
14 1	2818	28700	35100	1740	11515	2826.68	2826.68
15 1	2775	28400	35300	1810	309 9	2808.04	2808.04

Rank-Based (Type D) output for Group no. 3: APPALACHIAN POWER CO
Time period averages; 8760 hours processed

Rank |<------	Receptor	----->|			Total	Source Contr...		
G R	No.	x-m	y-m	z-ft	Chi	S30001	S30002	S30003
1 1	596	13500	38000	2200	26.85	3.45	3.05	20.35
2 1	386	14000	38000	2220	26.07	3.12	2.76	20.2
3 1	118	9500	37500	2320	18.15	1.98	1.75	14.42
4 1	606	13500	37500	2060	18.01	4.61	4.07	9.33
5 1	1113	12300	34100	2250	17.15	2.03	1.8	13.32
6 1	122	9500	37000	2160	17.02	2.55	2.25	12.23
7 1	579	14500	39000	2150	16.48	2.37	2.09	12.03
8 1	62	9000	37000	2200	16.44	2.09	1.84	12.51
9 1	589	15000	38500	2160	16.24	2.23	1.97	12.04
10 1	117	9000	37500	2220	15.9	1.91	1.69	12.31

11	1	588	14500	38500	2120	15.46	2.5	2.21	10.74
12	1	1114	12500	34100	2340	15.25	1.71	1.51	12.03
13	1	240	10300	35100	2140	14.83	2.6	2.29	9.94
14	1	1101	12500	34300	2170	14.32	2.15	1.9	10.27
15	1	376	15000	39000	2150	14.28	2	1.76	10.52

Rank-Based (Type D) output for Group no. 3: APPALACHIAN POWER CO
Averaging period: 24-hr.

Rnk|	<------ Receptor			----->|	Date	Total	Source Contr...		
G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S30001	S30002	S30003
1	1	1113	12300	34100	2250	27724	405.35	45.34	40.05	319.97
2	1	1125	12500	33900	2220	27724	391.12	44.98	39.74	306.4
3	1	1124	12300	33900	2210	27724	348.05	40.91	36.13	271.02
4	1	1114	12500	34100	2340	27724	301.15	32.69	28.87	239.59
5	1	1128	12100	33700	2200	27724	285.39	34.68	30.64	220.07
6	1	1667	12500	33500	2260	27724	274.58	30.51	26.95	217.12
7	1	1113	12300	34100	2250	5924	264.3	30.71	27.13	206.46
8	1	1666	12000	33500	2220	27724	262.97	30.51	26.95	205.51
9	1	1113	12300	34100	2250	26124	261.1	30.07	26.56	204.48
10	1	596	13500	38000	2200	18824	252.66	31.8	28.09	192.76
11	1	1128	12100	33700	2200	22324	244.97	31.62	27.94	185.41
12	1	1114	12500	34100	2340	26324	240.54	25.69	22.69	192.16
13	1	386	14000	38000	2220	1724	239.62	28.06	24.78	186.78
14	1	1113	12300	34100	2250	1324	235.88	27.7	24.47	183.72
15	1	1113	12300	34100	2250	5524	235.3	26.24	23.18	185.88

Rank-Based (Type D) output for Group no. 3: APPALACHIAN POWER CO

Averaging period: 3-hr.

Rnk|	<------ Receptor			----->|	Date	Total	Source Contr...		
G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S30001	S30002	S30003
1	1	1113	12300	34100	2250	175 6	1380.02	159.6	140.98	1079.43
2	1	1113	12300	34100	2250	261 6	1179.8	135.14	119.38	925.28
3	1	1113	12300	34100	2250	316 6	1178.21	128.62	113.61	935.98
4	1	1114	12500	34100	2340	261 9	1124.39	121.53	107.35	895.51
5	1	1115	12700	34100	2260	261 9	1119.05	125.26	110.64	883.16
6	1	1128	12100	33700	2200	223 9	1109.63	134.91	119.17	855.55
7	1	1113	12300	34100	2250	1312	1108.68	120.91	106.8	880.96
8	1	1114	12500	34100	2340	316 6	1067.13	115.07	101.64	850.42
9	1	1113	12300	34100	2250	26912	1048.14	112.65	99.51	835.98
10	1	1666	12000	33500	2220	223 9	1045.8	118.22	104.43	823.16

11	1	1124	12300	33900	2210	175 6	1044.7	144.18	127.36	773.17
12	1	1102	12700	34300	2190	261 9	1030.42	151.84	134.13	744.45
13	1	1114	12500	34100	2340	263 9	1022.46	108.4	95.75	818.31
14	1	1113	12300	34100	2250	223 9	1020.1	111.48	98.48	810.14
15	1	1124	12300	33900	2210	316 6	1016.82	115.77	102.27	798.78

Rank-Based (Type D) output for Group no. 4: HOECHST CELANESE
Time period averages; 8760 hours processed

Rank |<------ Receptor ----->| Total Source Contr...

G	R	No.	x-m	y-m	z-ft	Chi	S40001	S40002	S40003	S40004	S40005
1	1	1488	21400	34000	1980	71.5	3.59	9.46	12.47	3.51	9.42
2	1	1476	21800	34200	2020	70.73	3.74	9.84	12.98	3.66	9.8
3	1	1475	21600	34200	2020	70.56	3.71	9.78	12.89	3.63	9.74
4	1	1477	22000	34200	1980	63.99	3.29	8.66	11.42	3.22	8.63
5	1	1474	21400	34200	2120	60.91	3.25	8.57	11.3	3.18	8.54
6	1	1462	21800	34400	2120	60.58	3.25	8.56	11.28	3.18	8.52
7	1	1463	22000	34400	2150	59.3	3.18	8.38	11.04	3.11	8.34
8	1	1191	21500	33500	1880	56.16	2.15	5.68	7.48	2.11	5.65
9	1	1209	21500	33400	1880	55.72	2.13	5.62	7.4	2.09	5.59
10	1	3180	22200	34200	1980	55.56	2.85	7.52	9.91	2.79	7.49
11	1	1461	21600	34400	2220	54.71	2.93	7.71	10.16	2.86	7.68
12	1	1495	19800	33800	2060	54.12	2.92	7.68	10.13	2.85	7.65
13	1	3179	22200	34400	2170	52.61	2.82	7.43	9.8	2.76	7.4
14	1	1509	22000	33600	1940	50.99	2.38	6.27	8.27	2.33	6.25
15	1	1450	22000	34600	2280	50.02	2.68	7.06	9.3	2.62	7.03

Rank-Based (Type D) output for Group no. 4: HOECHST CELANESE
Averaging period: 24-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S40001	S40002	S40003	S40004
1	1	1488	21400	34000	1980	32824	773.69	39.48	104	137.11	38.63
2	1	1475	21600	34200	2020	18824	716.07	38.9	102.47	135.1	38.06
3	1	1474	21400	34200	2120	32824	712.36	39.07	102.92	135.68	38.23
4	1	1488	21400	34000	1980	34524	686.28	32.58	85.82	113.14	31.88
5	1	1476	21800	34200	2020	1724	673.22	36.86	97.1	128.02	36.07
6	1	1474	21400	34200	2120	34524	658.62	36.22	95.41	125.79	35.44
7	1	1476	21800	34200	2020	18824	656.72	35.73	94.11	124.08	34.96
8	1	1576	21200	31800	1980	27724	645.49	34.46	90.77	119.67	33.71
9	1	1495	19800	33800	2060	2324	640.66	35.3	92.99	122.6	34.54
10	1	1191	21500	33500	1880	33524	599.77	23.67	62.35	82.2	23.16
11	1	1477	22000	34200	1980	1724	595.61	31.78	83.73	110.39	31.1

12	1	1476	21800	34200	2020	1824	591.81	32.7	86.16	113.58	32
13	1	1488	21400	34000	1980	18824	589.44	30.54	80.46	106.08	29.89
14	1	1474	21400	34200	2120	28924	583.97	31.7	83.51	110.1	31.02
15	1	1191	21500	33500	1880	1724	577.89	22.34	58.85	77.59	21.86

Rank-Based (Type D) output for Group no. 4: HOECHST CELANESE
Averaging period: 3-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S40001	S40002	S40003	S40004
1	1	1474	21400	34200	2120	345 6	3161.23	173.84	457.97	603.77	170.1
2	1	1488	21400	34000	1980	345 6	2937.33	140.21	369.36	486.95	137.19
3	1	1474	21400	34200	2120	328 6	2846.88	156.68	412.75	544.16	153.31
4	1	1488	21400	34000	1980	328 6	2816.6	138.4	364.61	480.7	135.43
5	1	1488	21400	34000	1980	289 6	2635.63	135.61	357.25	470.99	132.69
6	1	1488	21400	34000	1980	315 6	2589.59	135.7	357.48	471.29	132.78
7	1	1488	21400	34000	1980	228 6	2449.96	121.88	321.09	423.32	119.26
8	1	1460	21400	34400	2260	345 6	2382.41	131.54	346.54	456.87	128.71
9	1	1474	21400	34200	2120	289 6	2375.58	130.87	344.78	454.54	128.06
10	1	1488	21400	34000	1980	31 3	2362.3	125.48	330.56	435.8	122.78
11	1	1461	21600	34400	2220	345 6	2340.03	129.2	340.37	448.73	126.42
12	1	1475	21600	34200	2020	289 6	2275.52	123.33	324.91	428.35	120.68
13	1	1488	21400	34000	1980	18 3	2274.5	124.32	327.5	431.77	121.64
14	1	1473	21200	34200	2040	345 6	2242.68	121.45	319.94	421.8	118.84
15	1	1475	21600	34200	2020	228 6	2224.12	119.32	314.33	414.41	116.75

E.3 Eastern Ridge Lime Type D results

Rank-Based (Type D) output for Total no. 1: Total over all groups
Time period averages; 2821 hours processed

Rank |<------ Receptor ----->| Total Group Contr...

G	R	No.	x-m	y-m	z-ft	Chi	ALC	ERL	AP	HC
1	1	2798	28700	35200	1730	219.45	1.12	217.35	0.22	0.75
2	1	2779	28800	35300	1760	188.5	1.31	185.93	0.26	1
3	1	1560	20400	32000	1940	174.86	0.69	0.51	0.49	173.17
4	1	2760	28800	35400	1760	168.34	1.31	165.74	0.26	1.03
5	1	2778	28700	35300	1720	156.74	1.09	154.66	0.22	0.77
6	1	1585	20400	31600	2000	156.45	0.82	0.6	0.73	154.31
7	1	1573	20600	31800	1980	149.75	0.8	0.61	0.68	147.66
8	1	1595	20000	31400	2120	144.39	0.96	0.51	1.12	141.81
9	1	2780	28900	35300	1800	143.45	1.6	140.23	0.28	1.33
10	1	1597	20400	31400	2040	137.98	0.98	0.59	0.85	135.55
11	1	1572	20400	31800	1930	132.72	0.67	0.55	0.47	131.03
12	1	2743	29000	35500	1810	132.54	1.79	129.03	0.28	1.43
13	1	2761	28900	35400	1770	132.52	1.43	129.5	0.26	1.32
14	1	1586	20600	31600	2120	129.64	1.06	0.57	0.9	127.11
15	1	1551	20200	32200	1940	128.89	0.62	0.45	0.54	127.29

Rank-Based (Type D) output for Total no. 1: Total over all groups
Averaging period: 24-hr.

Rnk|<------ Receptor ----->| Date Total Group Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	ALC	ERL	AP	HC
1	1	2798	28700	35200	1730	8224	920.69	0.15	920.54	0	0
2	1	2780	28900	35300	1800	12424	827.95	0	827.52	0	0.43
3	1	2778	28700	35300	1720	10524	799.12	0	799.12	0	0
4	1	2762	29000	35400	1810	12424	788.63	0	788.17	0	0.47
5	1	2780	28900	35300	1800	12324	774.19	0	770.56	0	3.63
6	1	1209	21500	33400	1880	12424	764.17	0	0	0	764.17
7	1	2798	28700	35200	1730	7524	755.29	0	755.29	0	0
8	1	2798	28700	35200	1730	9924	742.52	0	742.51	0	0.01
9	1	2778	28700	35300	1720	11424	736.32	0.01	736.3	0	0
10	1	1191	21500	33500	1880	12424	711.75	0	0	0	711.75
11	1	2798	28700	35200	1730	15924	703.44	0.11	703.25	0	0.07
12	1	2779	28800	35300	1760	8224	694.28	0.27	694.01	0	0
13	1	2779	28800	35300	1760	7524	693.3	0	693.3	0	0
14	1	2760	28800	35400	1760	10524	678.62	0	678.62	0	0
15	1	2743	29000	35500	1810	12424	663.19	0	662.65	0	0.54

Rank-Based (Type D) output for Total no. 1: Total over all groups
Averaging period: 3-hr.

Rnk|<------ Receptor ----->| Date Total Group Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	ALC	ERL	AP	HC
1	1	2858	28800	34900	1960	95 6	2843.47	0	2843.47	0	0
2	1	2857	28700	34900	1800	12521	2748.77	0.02	2748.75	0	0
3	1	2839	28800	35000	1860	6424	2593.63	0	2551.37	0	42.26
4	1	2839	28800	35000	1860	88 3	2544.29	0	2494.51	0	49.78
5	1	2876	28700	34800	1920	6421	2370.8	0	2370.8	0	0
6	1	2894	28600	34700	1900	119 6	2355	0	2355	0	0
7	1	2780	28900	35300	1800	12421	2325.47	0	2325.47	0	0
8	1	2814	28200	35100	1830	86 3	2282.98	0	2282.98	0	0
9	1	2780	28900	35300	1800	12324	2281.25	0	2252.24	0	29.01
10	1	1573	20600	31800	1980	68 6	2267.64	0	0	0	2267.64
11	1	2839	28800	35000	1860	7321	2227.14	0	2227.14	0	0
12	1	2894	28600	34700	1900	103 6	2218.66	5	2213.66	0	0
13	1	1473	21200	34200	2040	67 3	2174.8	0	0	0	2174.8
14	1	1573	20600	31800	1980	16124	2148.34	0	0	0	2148.34
15	1	1573	20600	31800	1980	17321	2144.69	0	0	0	2144.69

Rank-Based (Type D) output for Group no. 1: APG LIME CO

Time period averages; 2821 hours processed

Rank |<------ Receptor ----->| Total Source Contr...

G	R	No.	x-m	y-m	z-ft	Chi	S10001	S10002	S10003
1	1	2111	30200	37400	2120	65.05	21.86	20.51	22.68
2	1	2149	30300	37600	2120	56.23	18.78	17.65	19.79
3	1	2131	30300	37500	2120	52.77	17.56	16.59	18.62
4	1	2166	30400	37700	2160	49.36	15.88	15.23	18.25
5	1	2150	30400	37600	2200	48.61	15.46	14.89	18.26
6	1	2165	30300	37700	2100	48.53	16.73	15.48	16.32
7	1	2167	30500	37700	2170	41.91	13.34	12.86	15.71
8	1	2181	30400	37800	2100	41.57	14.19	13.21	14.18
9	1	2322	29700	36400	2140	41.07	13.27	12.72	15.08
10	1	2112	30300	37400	2200	40.4	12.83	12.36	15.2
11	1	2182	30500	37800	2120	39.2	12.96	12.28	13.96
12	1	2132	30400	37500	2220	37.66	11.95	11.51	14.19
13	1	2151	30500	37600	2200	36.72	11.65	11.23	13.83
14	1	2433	30600	37800	2160	36.02	11.48	11.06	13.47
15	1	2306	29700	36500	2060	33.04	12.22	10.71	10.1

Rank-Based (Type D) output for Group no. 1: APG LIME CO

Averaging period: 24-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S10001	S10002	S10003
1	1	2111	30200	37400	2120	12424	561.17	182.93	174.44	203.8
2	1	2111	30200	37400	2120	12324	435.38	142.06	135.7	157.62
3	1	2131	30300	37500	2120	12424	430.27	139.5	133.4	157.37
4	1	2149	30300	37600	2120	12424	378.54	122.6	117.17	138.77
5	1	2111	30200	37400	2120	9024	375.95	120.28	115.8	139.86
6	1	2150	30400	37600	2200	12424	350.64	109.41	106.48	134.75
7	1	2111	30200	37400	2120	9224	341.36	110.88	106.66	123.83
8	1	2166	30400	37700	2160	12424	315.69	99.52	96.42	119.76
9	1	2151	30500	37600	2200	12424	304.7	94.77	92.32	117.61
10	1	2092	30200	37300	2130	8524	296.82	99.22	93.19	104.41
11	1	2167	30500	37700	2170	12424	293.4	91.97	89.45	111.98
12	1	2165	30300	37700	2100	12424	291.9	96.83	91.53	103.54
13	1	2112	30300	37400	2200	12324	290.99	90.77	88.18	112.03
14	1	2131	30300	37500	2120	12324	284.36	92.35	88.28	103.73
15	1	2131	30300	37500	2120	9024	284.23	90.5	87.36	106.37

Rank-Based (Type D) output for Group no. 1: APG LIME CO

Averaging period: 3-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S10001	S10002	S10003
1	1	2256	30100	36800	2150	95 6	1444.8	460.44	443.34	541.02
2	1	2092	30200	37300	2130	164 6	1414.34	500.31	456.82	457.2
3	1	2111	30200	37400	2120	9221	1376.88	442.87	426.7	507.31
4	1	2273	29900	36700	2080	6421	1372.95	479.33	445.8	447.82
5	1	2111	30200	37400	2120	12424	1348.07	464.36	428.75	454.97
6	1	2111	30200	37400	2120	12421	1323.58	419.22	404.82	499.53
7	1	2111	30200	37400	2120	12324	1322.89	422.35	408.17	492.37
8	1	2111	30200	37400	2120	123 3	1295.22	425.39	405.35	464.48
9	1	2111	30200	37400	2120	9024	1198.64	384.48	371.57	442.59
10	1	2111	30200	37400	2120	12224	1172.35	381.07	363.36	427.91
11	1	2111	30200	37400	2120	9021	1117.09	349.97	339.28	427.84
12	1	2092	30200	37300	2130	123 3	1113.75	352.79	340.8	420.16
13	1	2112	30300	37400	2200	123 3	1107	342.92	334.77	429.31

14	1	2072	30200	37200	2120	7121	1092.38	394.74	353.91	343.73
15	1	2292	30000	36600	2180	6421	1086.76	339.37	328.83	418.55

Rank-Based (Type D) output for Group no. 2: EASTERN RIDGE LIME CO

Time period averages; 2821 hours processed

Rank |<------	Receptor	----->|			Total	Source Contr...
G	R	No.	x-m	y-m	z-ft	Chi	S20001
1	1	2798	28700	35200	1730	217.35	217.35
2	1	2779	28800	35300	1760	185.93	185.93
3	1	2760	28800	35400	1760	165.74	165.74
4	1	2778	28700	35300	1720	154.66	154.66
5	1	2780	28900	35300	1800	140.23	140.23
6	1	2761	28900	35400	1770	129.5	129.5
7	1	2743	29000	35500	1810	129.03	129.03
8	1	2762	29000	35400	1810	120.38	120.38
9	1	2725	29000	35600	1810	113.69	113.69
10	1	2741	28800	35500	1730	98.45	98.45
11	1	2726	29100	35600	1840	96.73	96.73
12	1	2744	29100	35500	1860	92.45	92.45
13	1	2742	28900	35500	1740	92.15	92.15
14	1	2709	29100	35700	1820	86.83	86.83
15	1	2708	29000	35700	1800	80.47	80.47

Rank-Based (Type D) output for Group no. 2: EASTERN RIDGE LIME CO

Averaging period: 24-hr.

Rnk|<------	Receptor	----->|			Date	Total	Source Contr...
G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S20001
1	1	2798	28700	35200	1730	8224	920.54	920.54
2	1	2780	28900	35300	1800	12424	827.52	827.52
3	1	2778	28700	35300	1720	10524	799.12	799.12
4	1	2762	29000	35400	1810	12424	788.17	788.17
5	1	2780	28900	35300	1800	12324	770.56	770.56
6	1	2798	28700	35200	1730	7524	755.29	755.29
7	1	2798	28700	35200	1730	9924	742.51	742.51
8	1	2778	28700	35300	1720	11424	736.3	736.3
9	1	2798	28700	35200	1730	15924	703.25	703.25
10	1	2779	28800	35300	1760	8224	694.01	694.01

11	1	2779	28800	35300	1760	7524	693.3	693.3
12	1	2760	28800	35400	1760	10524	678.62	678.62
13	1	2743	29000	35500	1810	12424	662.65	662.65
14	1	2778	28700	35300	1720	11524	649.56	649.56
15	1	2798	28700	35200	1730	12424	641.15	641.15

Rank-Based (Type D) output for Group no. 2: EASTERN RIDGE LIME CO

Averaging period: 3-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S20001
1	1	2858	28800	34900	1960	95 6	2843.47	2843.47
2	1	2857	28700	34900	1800	12521	2748.75	2748.75
3	1	2839	28800	35000	1860	6424	2551.37	2551.37
4	1	2839	28800	35000	1860	88 3	2494.51	2494.51
5	1	2876	28700	34800	1920	6421	2370.8	2370.8
6	1	2894	28600	34700	1900	119 6	2355	2355
7	1	2780	28900	35300	1800	12421	2325.47	2325.47
8	1	2814	28200	35100	1830	86 3	2282.98	2282.98
9	1	2780	28900	35300	1800	12324	2252.24	2252.24
10	1	2839	28800	35000	1860	7321	2227.14	2227.14
11	1	2894	28600	34700	1900	103 6	2213.66	2213.66
12	1	2780	28900	35300	1800	123 3	2123.56	2123.56
13	1	2780	28900	35300	1800	12224	2036.89	2036.89
14	1	2780	28900	35300	1800	9221	2016.57	2016.57
15	1	2737	28400	35500	1870	106 6	2011.8	2011.8

Rank-Based (Type D) output for Group no. 3: APPALACHIAN POWER CO

Time period averages; 2821 hours processed

Rank |<------ Receptor ----->| Total Source Contr...

G	R	No.	x-m	y-m	z-ft	Chi	S30001	S30002	S30003
1	1	291	10500	33000	2250	66.35	7.78	6.87	51.7
2	1	162	11000	33000	2180	54.97	7.63	6.74	40.6
3	1	299	10500	32500	2380	52.38	5.64	4.98	41.75
4	1	298	10000	32500	2220	49.94	6.18	5.46	38.3
5	1	169	10000	32000	2440	43.69	4.66	4.12	34.92
6	1	386	14000	38000	2220	43.01	5.07	4.47	33.47
7	1	300	11000	32500	2550	40.38	4.28	3.78	32.31
8	1	311	10000	33500	2700	39.34	4.08	3.6	31.66

9	1	303	9500	32000	2200	37.93	4.88	4.31	28.74
10	1	312	10500	33500	3060	37.1	3.45	3.05	30.61
11	1	1681	11500	33000	2520	36.02	3.87	3.41	28.74
12	1	596	13500	38000	2200	35.29	4.25	3.75	27.29
13	1	304	10500	32000	2620	35.16	3.68	3.25	28.23
14	1	1007	11600	34900	1940	33.78	13.82	12.21	7.75
15	1	606	13500	37500	2060	32.97	6.75	5.96	20.26

Rank-Based (Type D) output for Group no. 3: APPALACHIAN POWER CO

Averaging period: 24-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S30001	S30002	S30003
1	1	386	14000	38000	2220	12424	234.58	26.97	23.83	183.78
2	1	291	10500	33000	2250	13224	217.41	27.7	24.47	165.24
3	1	1101	12500	34300	2170	6524	215.57	27.97	24.71	162.89
4	1	386	14000	38000	2220	12524	204.42	24.63	21.75	158.04
5	1	1128	12100	33700	2200	14024	201.78	27.09	23.93	150.76
6	1	1113	12300	34100	2250	13924	201.75	23.33	20.6	157.82
7	1	162	11000	33000	2180	17324	200.55	26.71	23.6	150.24
8	1	162	11000	33000	2180	12624	200.39	25.64	22.65	152.1
9	1	162	11000	33000	2180	16124	199.94	28.68	25.34	145.92
10	1	1102	12700	34300	2190	6424	199.55	22.9	20.23	156.43
11	1	1101	12500	34300	2170	6424	196.53	24.65	21.77	150.1
12	1	291	10500	33000	2250	8324	194.78	25.57	22.59	146.62
13	1	1113	12300	34100	2250	11924	193.67	22.23	19.63	151.81
14	1	1115	12700	34100	2260	6524	193.59	21.08	18.62	153.89
15	1	1114	12500	34100	2340	6524	193.06	20.79	18.36	153.91

Rank-Based (Type D) output for Group no. 3: APPALACHIAN POWER CO
Averaging period: 3-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S30001	S30002	S30003
1	1	1113	12300	34100	2250	119 6	1226.58	140.78	124.35	961.45
2	1	1102	12700	34300	2190	6421	1147.4	132.42	116.97	898.01
3	1	1101	12500	34300	2170	6421	1121.33	142.13	125.55	853.65
4	1	1115	12700	34100	2260	6421	993.89	108.34	95.7	789.85
5	1	1102	12700	34300	2190	12521	993.05	128.05	113.11	751.89
6	1	1114	12500	34100	2340	6421	971.13	104.84	92.61	773.68

7	1	1115	12700	34100	2260	12521	965.16	105.28	92.99	766.89
8	1	1124	12300	33900	2210	119 6	934.43	127.12	112.29	695.02
9	1	1125	12500	33900	2220	6421	927.72	102.32	90.38	735.02
10	1	1126	12700	33900	2240	6421	886.86	97.04	85.72	704.11
11	1	1127	12900	33900	2240	6421	846.14	92.64	81.83	671.67
12	1	1127	12900	33900	2240	12521	818.69	90.32	79.78	648.59
13	1	1128	12100	33700	2200	119 6	799.02	113.96	100.67	584.39
14	1	1666	12000	33500	2220	119 6	778.94	100.13	88.45	590.36
15	1	1128	12100	33700	2200	103 6	776.61	110.43	97.54	568.64

Rank-Based (Type D) output for Group no. 4: HOECHST CELANESE
Time period averages; 2821 hours processed

Rank |<------ Receptor ----->| Total Source Contr...

G	R	No.	x-m	y-m	z-ft	Chi	S40001	S40002	S40003	S40004	S40005
1	1	1560	20400	32000	1940	173.17	8.04	21.17	27.91	7.86	21.09
2	1	1585	20400	31600	2000	154.31	8.13	21.42	28.24	7.96	21.33
3	1	1573	20600	31800	1980	147.66	7.58	19.96	26.31	7.41	19.88
4	1	1595	20000	31400	2120	141.81	7.8	20.56	27.1	7.64	20.47
5	1	1597	20400	31400	2040	135.55	7.35	19.37	25.54	7.2	19.29
6	1	1572	20400	31800	1930	131.03	6.05	15.93	21	5.92	15.86
7	1	1551	20200	32200	1940	127.29	5.96	15.7	20.7	5.83	15.64
8	1	1586	20600	31600	2120	127.11	6.94	18.28	24.1	6.79	18.21
9	1	1596	20200	31400	1980	125.49	6.49	17.08	22.52	6.35	17.01
10	1	1584	20200	31600	1940	122.97	5.88	15.49	20.42	5.75	15.43
11	1	1606	20200	31200	2100	120.6	6.62	17.45	23	6.48	17.38
12	1	1594	19800	31400	2070	119.76	6.55	17.25	22.75	6.41	17.18
13	1	1571	20200	31800	1920	114.39	5.19	13.67	18.02	5.08	13.62
14	1	1410	20500	32200	1880	113.99	4.6	12.12	15.98	4.5	12.07
15	1	1191	21500	33500	1880	104.42	4.23	11.15	14.7	4.14	11.1

Rank-Based (Type D) output for Group no. 4: HOECHST CELANESE
Averaging period: 24-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S40001	S40002	S40003	S40004
1	1	1209	21500	33400	1880	12424	764.17	30.72	80.94	106.7	30.06
2	1	1191	21500	33500	1880	12424	711.75	29.13	76.75	101.19	28.51
3	1	1473	21200	34200	2040	6724	655.67	35.75	94.19	124.18	34.99
4	1	1573	20600	31800	1980	17324	651.58	33.8	89.04	117.39	33.07
5	1	1573	20600	31800	1980	12624	648.46	34.16	89.99	118.64	33.43
6	1	1573	20600	31800	1980	16124	641.53	32.49	85.6	112.86	31.8

7	1	1573	20600	31800	1980	8824	631.14	34.61	91.16	120.19	33.86
8	1	1585	20400	31600	2000	13224	605.33	30.95	81.55	107.51	30.29
9	1	1573	20600	31800	1980	6824	583.91	30.03	79.1	104.28	29.38
10	1	1585	20400	31600	2000	6824	581.02	30.63	80.69	106.38	29.97
11	1	1476	21800	34200	2020	9124	576.92	30.52	80.4	105.99	29.86
12	1	1586	20600	31600	2120	8824	559.33	31.02	81.72	107.73	30.35
13	1	1585	20400	31600	2000	16124	559.25	29.55	77.84	102.62	28.91
14	1	1585	20400	31600	2000	17324	554.66	29.6	77.99	102.82	28.97
15	1	1586	20600	31600	2120	16124	553.44	30.52	80.4	106	29.86

Rank-Based (Type D) output for Group no. 4: HOECHST CELANESE
Averaging period: 3-hr.

Rnk|<------ Receptor ----->| Date Total Source Contr...

G	R	No.	x-m	y-m	z-ft	jdyhr	Chi	S40001	S40002	S40003	S40004
1	1	1573	20600	31800	1980	68 6	2267.64	115.76	304.97	402.06	113.27
2	1	1473	21200	34200	2040	67 3	2174.8	119.3	314.28	414.34	116.73
3	1	1573	20600	31800	1980	16124	2148.34	109.21	287.7	379.29	106.86
4	1	1573	20600	31800	1980	17321	2144.69	111.61	294.02	387.63	109.21
5	1	1586	20600	31600	2120	68 6	2137.84	117.99	310.83	409.78	115.45
6	1	1585	20400	31600	2000	68 6	1989.51	105.93	279.06	367.9	103.65
7	1	1473	21200	34200	2040	67 6	1963.24	107.96	284.42	374.97	105.64
8	1	1586	20600	31600	2120	17321	1921.53	106.1	279.51	368.5	103.82
9	1	1585	20400	31600	2000	16124	1870.04	98.93	260.61	343.58	96.8
10	1	1597	20400	31400	2040	68 6	1855.15	102.19	269.22	354.93	100
11	1	1585	20400	31600	2000	17321	1843.42	99.19	261.31	344.51	97.06
12	1	1573	20600	31800	1980	12621	1836.39	99.93	263.24	347.05	97.78
13	1	1560	20400	32000	1940	15421	1820.9	89.11	234.75	309.49	87.19
14	1	1595	20000	31400	2120	6524	1773.28	98.15	258.57	340.89	96.04
15	1	1597	20400	31400	2040	16124	1769.81	97.39	256.58	338.26	95.3